Department of Energy
Washington, DC 20585

January 18, 2019

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Deputy Director
Mail Stop T8-F5
Washington, DC 20555-0001

Subject: Final *Mexican Hat UMTRCA Disposal Cell Side Slope Cover Depressions Evaluation Report*, Mexican Hat, Utah (Docket No. WM-63)

To Whom It May Concern:

Enclosed are two copies of the final *Mexican Hat UMTRCA Disposal Cell Side Slope Cover Depressions Evaluation Report, Mexican Hat, Utah,* for your records. The final report incorporates updates in accordance with comments received from the Navajo Nation Abandoned Mine Lands/Uranium Mill Tailings Remedial Action Department, the U.S. Nuclear Regulatory Commission, and includes information on desktop and field evaluations related to the cover depression features at the Mexican Hat, Utah, Uranium Mill Tailings Radiation Control Act Title I Disposal Site (site) from March 2016 through January 2018. The final report will be made available to the public on the U.S. Department of Energy Office of Legacy Management (DOE-LM) website.

Updates to the final report include a new section on the available records and specifications pertaining to demolition debris and bulk material placement (Section 2.3.2); the addition of historical photographs during the early stages of surface remediation and contaminated materials placement at the site (Section 2.4); a discussion on subsidence as a potential cause for the depression features (See Executive Summary, Section 3.2, and Section 7.0); further clarification on plans for additional investigations, including plans for assessing bedding layer gradations (See Executive Summary and Section 7.0); and removal of subjective drainage paths previously depicted within the surveyed outline of depression features on Figure 4 titled, "Project Site Plan with Areas of Concern."

Evaluations of the depression features are ongoing. Interim radon barrier protection was performed in May 2018 to address areas with observed radon barrier degradation; these maintenance activities will be documented in a separate report. Additionally, a geotechnical sampling and materials testing work plan has been developed to further evaluate the disposal cell side slope cover components, with a focus on the bedding layer gradations. This work plan was provided to the NRC in November 2018, and DOE-LM intends to perform this work in early 2019 depending on weather and site conditions.

Based on the Long-Term Surveillance Plan for the site, minor erosion or undesirable changes in riprap integrity on the disposal cell are considered to constitute a Priority 5 condition, and should be addressed by conducting an evaluation to assess the associated potential impact(s) followed by the implementation of an appropriate response to address the problem(s). As such, multiple field observations and a series of radiological surveys confirmed the absence of elevated radiological readings; no evidence of a breach through the disposal cell cover has been identified, and the site remains protective of human health and the environment.

NMSS01

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Sincerely,

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File: HAT 0515.02 (records)

Sites\HAT 011719 NRC Depression Eval Report (NRC)

LMS/HAT/S14765

Mexican Hat UMTRCA Disposal Cell Side Slope Cover Depressions Evaluation Report Mexican Hat, Utah

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Abbreviations

CFR	*Code of Federal Regulations*
DBM	Design Basis Memoranda
DOE	U.S. Department of Energy
GHE	Gas Hills East
LiDAR	light imaging, detection, and ranging
LM	Office of Legacy Management
LMS	Legacy Management Support
LTSP	Long-Term Surveillance Plan
NOAA	National Oceanic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
$pCi/m^2/s$	picocuries per square meter per second
PMP	probable maximum precipitation
RCT	radiological control technician
RRM	residual radioactive materials
SME	subject matter expert
SOARS	System Operation and Analysis at Remote Sites
T_c	time of concentration
UMETCO	UMETCO Minerals Corporation
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act

Executive Summary

In 2016, multiple subtle depressions were identified in the rock cover along the toe and lower portions of the northeast side slope of the Mexican Hat Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I disposal cell. Due to concerns regarding the potential impacts of the cover depressions related to disposal cell performance and erosion resistance, evaluations of the depressions and information related to the cell cover design were performed. The evaluations included visual observations of the depressions, and limited small-area manual removals of the rock cover components to scan for radioactivity, to evaluate for conformance with the disposal cell design specifications, and to observe any apparent erosion on the surface of the radon barrier material. Reviews of disposal cell as-built drawings and supporting design calculations for the rock cover components were also included in the evaluations. This report provides the results of the evaluations and identifies a recommended path forward.

Based on multiple field observations and a series of radiological surveys confirming the absence of elevated radiological readings, no evidence of a breach through the disposal cell cover has been identified, and the site remains protective of human health and the environment.

The Mexican Hat disposal cell is located on the Navajo Reservation in southeast Utah. Construction of the 68-acre Mexican Hat disposal cell was completed in 1995. The disposal cell was designed to encapsulate radioactive tailings and other residual radioactive materials (RRM) in a way that minimizes the need for active maintenance and limits radon gas emanation in accordance with UMTRCA. UMTRCA also requires that disposal areas for the control of RRM and their listed constituents be designed to be effective for up to 1000 years to the extent reasonably achievable, and in any case, for at least 200 years.

The Mexican Hat disposal cell cover was constructed with a 2% top slope that transitions to 20% side slopes; runoff from the disposal cell cover flows into a perimeter drainage channel that ultimately discharges into three engineered toe drains along the northern and eastern perimeters of the disposal cell. The disposal cell side slope cover consists of multiple components: a 24-inch-thick low-permeability radon barrier, a 6-inch-thick sandy gravel bedding layer that overlies the radon barrier, and a 12-inch-thick rock riprap surface layer over the bedding layer. The radon barrier was designed to limit radon gas emanation and meteoric water infiltration. The riprap and bedding layers were designed to protect the radon barrier from erosion and to minimize the need for active maintenance of the disposal cell.

The depressions in the Mexican Hat disposal cell cover were initially observed during the 2016 annual site inspection on March 17, 2016. Subsequent site visits between April and August 2016 included the collection of topographic survey data and additional visual observations of the depression areas, radon gas monitoring, and limited hand removal of the riprap and bedding layers to observe the condition of the underlying radon barrier surface. Additional evaluation efforts included a review of as-built drawings to understand the relationship between the protective cover and the underlying tailings material, a review of the original design calculations that were prepared to determine the probable maximum precipitation (PMP) event, and a review of the original design calculations prepared to determine the gradation sizes and thicknesses of the bedding and riprap layers needed to protect the radon barrier from erosion during a PMP event. Calculations were also performed to confirm that the specified bedding materials were properly sized to serve as a filter between the riprap and the radon barrier layers. All calculations are presented in the appendixes.

A variety of site visits were performed in 2017 to further evaluate the depression features:

- An observational site visit in March 2017 and the annual site inspection in April 2017 confirmed previous visual observations from 2016. Observations of the depressions during varying lighting conditions (i.e., varying sun angles) indicated that some previously identified areas of cover depressions along the northeast side slope may be more extensive than previously considered.
- Gamma radiation scans were performed on the riprap surface throughout the northeast side slope in September 2017. No elevated radiological readings were observed at the depression features relative to visually-determined unaffected areas on upper portions of the northeast side slope.
- Additional visual observations of the northeast, north, and west side slopes during various lighting conditions were made during a site visit in October 2017. Surface depressions on the northeast side slope appeared to be similar to those observed in April 2016. What appeared to be minor construction-related surface imperfections were observed on the west side slope, with no similarities to the surface depressions observed on the northeast side slope. No surface depressions were observed on the north side slope.
- A small void extending into the apparent base of the bedding layer and upper portion of the radon barrier was identified near the toe of the northeast side slope within a previously observed depression in December 2017. A follow-up inspection with a radiological control technician confirmed that radiological readings at the void and other depression feature locations were consistent with background levels.

Two subsequent site investigations were conducted in January 2018 to gain knowledge of subsurface conditions beneath observed surface depressions and beneath areas where no surface depressions were visually apparent. Additional surface depressions were observed and investigated on the north, east, and west side slopes. Small test pits were manually excavated by removing the rock cover components to the top of the radon barrier surface. Surface depressions features located on the north, east, and west side slopes were much more subtle compared to those previously observed on the northeast side slope. The majority of test pits located within areas of observed surface depressions on the north and northeast side slopes revealed incisements and voids extending into the radon barrier; no breach through the cover was evident. Test pits located in areas where no surface depressions were visually apparent did not reveal signs of radon barrier degradation. Additionally, the majority of bedding material observed along the lower portions of the north and northeast side slopes did not appear to meet the gradation specifications for the disposal cell; the bedding material in these areas appeared to be highly segregated with only larger gravel aggregate present and little to no fines. Bedding materials observed in other areas of the disposal cell appeared to have the appropriate proportions of fines and coarse-grained materials, but were noted to possibly be overconcentrated in fines. Samples were not collected to perform gradation analyses of these materials. Cementitious material in the top 1–6 inches of the radon barrier was also observed in test pits located near the toe of the north and northeast side slopes. The origin of the cementitious material was not determined. Radiological gamma scans were conducted at all test pit locations, and no elevated readings relative to ambient conditions were observed.

An engineering review of information associated with the Gas Hills East, Wyoming, Disposal Site, an UMTRCA Title II disposal cell, where rill-type erosion occurred at the radon barrier and riprap layer interface, was also performed as part of this evaluation. The initial design of the Gas Hills East disposal cell did not include a bedding layer between the riprap and the radon barrier layers. This configuration was determined to be the root cause of the observed radon barrier erosion. Corrective actions implemented to address radon barrier erosion at the Gas Hills East site included the installation of a bedding layer between the riprap and radon barrier layers. Because the Mexican Hat disposal cell cover design already includes a bedding layer between the riprap and the radon barrier layers, the radon barrier erosion and the associated repairs that occurred at the Gas Hills East site have limited application for evaluating the depression features and radon barrier erosion at the Mexican Hat site.

Review of the original design calculations for the Mexican Hat disposal cell indicates that the specified riprap and bedding layers were properly sized for the PMP event. Test pit observations of the riprap and bedding layers have provided visual confirmation that the installed material thicknesses were installed as identified on the as-built drawings. However, observed segregated bedding materials in some of the test pits do not appear to meet the specified gradations.

Based on the characteristics of the observed voids, piping, and incisements, including their locations towards the lower portions of the north and northeast side slopes, and the lack of fines in the bedding/filter material in these areas (which would allow for higher runoff velocities in the bedding/filter material), it can be reasonably assumed that these features are the result of precipitation-induced erosion. No evidence of subsidence in these areas has been identified.

Further investigation and evaluation of the depression features, including materials sampling and testing in areas within and beyond the areas of depression features, is recommended to determine the cause(s) of distress, and to develop appropriate corrective actions. Materials sampling and testing will be conducted to determine where in situ side slope cell cover components (i.e., riprap, bedding layer, and the radon barrier) conform, or do not conform, with the engineering design and construction specifications. The investigation will focus on bedding layer gradation as well as the spatial distribution of cementitious material that has been observed immediately below the base of the bedding layer in test pits with observed radon barrier degradation; determining if the radon barrier is subject to degradation due to cation exchange, dispersive soils, or both; determining the lateral extent of RRM that was placed beneath the radon barrier near the toe of the northeast and north side slopes and under the drainage apron adjacent to the northeast side slope; and identifying potential sources and impacts of windblown material on the riprap rock surfaces and the sediment deposits in the northeast drainage apron.

Additional recommendations include ground-based light imaging, detection, and ranging (LiDAR) topographical surveys focused on the northeast side slope, aerial LiDAR topographical surveys of the entire disposal cell, aerial thermal surveys of the entire disposal cell, semiannual collection of horizontal and vertical survey data at the existing settlement plates located on the cell cover, procurement of a geotechnical engineering subject matter expert (SME) and a geomorphology SME to provide peer review during the design and future investigations, and performing interim radon barrier protection with suitable fill materials in areas with observed radon barrier degradation. This recommendation also includes the preparation and submittal of survey monitoring status reports subsequent to each combined LiDAR and settlement plate survey event. Survey monitoring status reports would include documentation and analysis of LiDAR and settlement plate survey data, identification of any observed changes in empirical survey data, and a compilation and review of data associated with onsite weather monitoring equipment.

The installation of a System Operation and Analysis at Remote Sites (SOARS)-based weather monitoring station that is equipped with a camera and capable of measuring precipitation totals and intensities has been completed to collect site-specific meteorological data. Data from the SOARS meteorological station are reviewed on a routine basis for rainfall events that have intensities greater than or equal to 0.16 inch in a 5-minute interval for the purpose of triggering an episode-based LiDAR survey to determine if additional materials have been removed as a result of the episodic rainfall event, causing the depressions to deepen or enlarge. Additionally, the SOARS equipment sends notifications when certain precipitation parameters are exceeded.

The Long-Term Surveillance Plan (LTSP) for the Mexican Hat disposal site provides criteria for maintenance and emergency measures at the site. Minor erosion or undesirable changes in riprap integrity on the disposal cell are considered to constitute a Priority 5 condition and should be addressed by conducting an evaluation to assess the associated potential impact(s) followed by the implementation of an appropriate response to address the problem(s). The cover depression features that are the subject of this evaluation were first identified during the annual site inspection in March 2016 and constitute a Priority 5 condition. The recommendation provided is consistent with the response actions for a Priority 5 condition. Based on the language in the LTSP, a breach of the disposal cell is interpreted as a breach of the entire cover (including the radon barrier), which would result in the exposure of RRM. No evidence of a breach has been identified throughout the compilation of this report and associated field activities. However, if there is evidence that erosion is continuing to deepen or enlarge the depression features to the extent that the release of tailings is imminent (Priority 2) or the cover is breached (Priority 1), emergency response actions would be initiated at the U.S. Department of Energy's request to repair the cover.

1.0 Introduction

In 2016, multiple subtle depressions were identified in the rock cover along the toe and lower portions of the northeast side slope of the Mexican Hat Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I disposal cell. Due to concerns regarding the potential impacts of the cell cover depressions related to cell performance and erosion resistance, evaluations of the depressions and information related to the cell cover design were performed. This report provides the results of the evaluations and identifies a recommended path forward.

1.1 Purpose and Scope

The purpose of this evaluation is to assess the depression features and design documentation associated with the Mexican Hat disposal cell in an effort to determine the impacts related to cell cover performance and to identify needs for follow-up actions. The scope of the evaluation included conducting visual observations of the depressions, and limited small-area manual removals of the rock cover components to scan for radioactivity, to evaluate for conformance with the disposal cell design specifications, and to observe any apparent erosion on the surface of the radon barrier material. Reviews of disposal cell as-built drawings and supporting design calculations for the rock cover components were also included in the evaluations. In addition, circumstances that were considered to be similar at the Gas Hills East, Wyoming, UMTRCA Title II Disposal Site were reviewed to ascertain applicability to the Mexican Hat disposal cell cover depression features.

1.2 Site Description

1.2.1 Ownership and Location

The Mexican Hat disposal cell is located on the Navajo Reservation in southeast Utah. The 68-acre disposal cell is located on the approximately 119-acre disposal site. The site is held in trust by the United States of America for the Bureau of Indian Affairs; the Navajo Nation retains title to the land.

The site is located in San Juan County, Utah, in Sections 13 and 24, Township 42 South, Range 18 East, and in Sections 18 and 19, Township 42 South, Range 19 East, Salt Lake Principal Meridian. The disposal site is located approximately 1.5 miles southwest of the town of Mexican Hat, Utah, and 1 mile south of the San Juan River (see Figure 1 and Figure 2). The small Navajo community of Halchita is approximately 0.5 mile southwest of the site.

1.2.2 History

Texas-Zinc Minerals Corporation constructed the Mexican Hat Mill on land leased from the Navajo Nation and operated the facility from 1957 to 1963. In 1963, Atlas Corporation purchased the mill and operated it until it closed in 1965. A sulfuric acid manufacturing plant operated at the site from 1957 to 1970; Atlas continued operating the sulfuric acid manufacturing plant at the site until the lease expired in 1970 and control of the site reverted to the Navajo Nation.

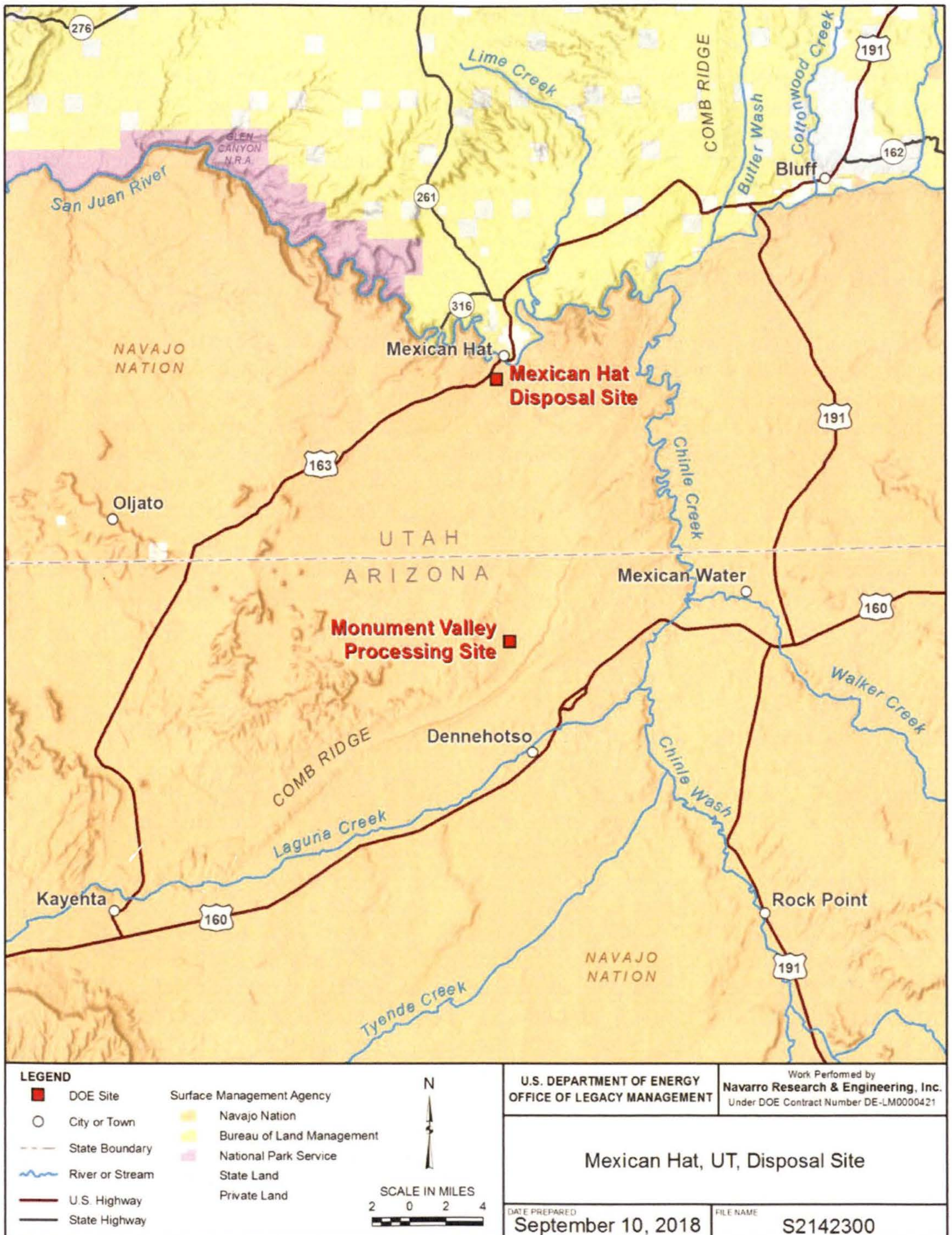

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Figure 1. General Location Map of the Mexican Hat, Utah, Disposal Site

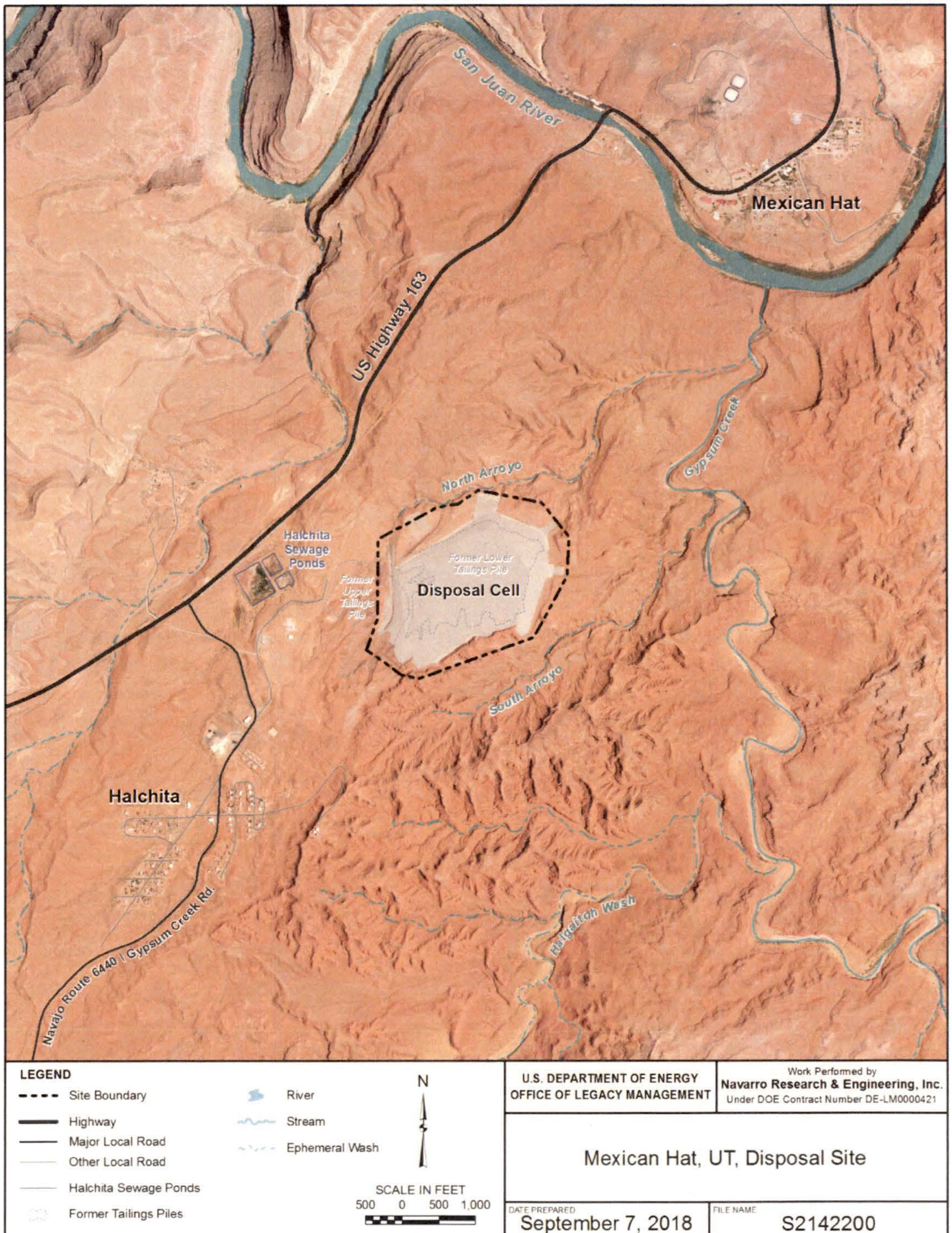

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Figure 2. Mexican Hat, Utah, Disposal Site Vicinity Map

Ore brought to the mill contained a considerable amount of copper sulfide and other sulfide minerals and was processed to recover both copper and uranium. The milling process produced radioactive tailings, a predominantly sandy material. Spent tailings were mixed with process water and pumped through a pipeline to two onsite tailings piles: the former lower tailings pile and the former upper tailings pile (see Figure 2).

1.2.3 Mill Tailings Disposal and Cell Construction

The U.S. Department of Energy (DOE) remediated the site under the Uranium Mill Tailings Remedial Action (UMTRA) Project. Surface remediation and construction of the disposal cell was completed at the site in 1995. The pentagonal-shaped disposal cell was constructed at the location of the preexisting former lower tailings pile (see Figure 2). Radioactive materials from the former upper tailings pile, demolished mill structures, and 11 vicinity properties were relocated and placed on top of the preexisting tailings at the location of the former lower tailings pile. An additional 983,000 cubic yards (1.3 million dry tons) of tailings and associated wastes were subsequently hauled from the Monument Valley, Arizona, UMTRCA Title I Processing Site (located approximately 15 miles south of the site) and placed on top of the contaminated materials from the Mexican Hat site. A total of approximately 3.6 million cubic yards (4.4 million dry tons) of radioactive tailings and other residual radioactive materials (RRM) were ultimately encapsulated in the Mexican Hat UMTRCA Title I disposal cell.

The Mexican Hat disposal cell abuts a rock outcrop on its south side and rises approximately 50 feet above the surrounding terrain to the north, east, and west. The disposal cell was designed to encapsulate radioactive tailings and other RRM in a way that minimizes the need for active maintenance and limits radon gas emanation in accordance with UMTRCA. The cell was constructed with a 2% top slope transitioning to 20% side slopes (Figure 3), which drain into a surrounding rock perimeter channel. The perimeter channel discharges to three engineered toe drains (Figure 4) that drain into existing arroyos to the north and east of the cell.

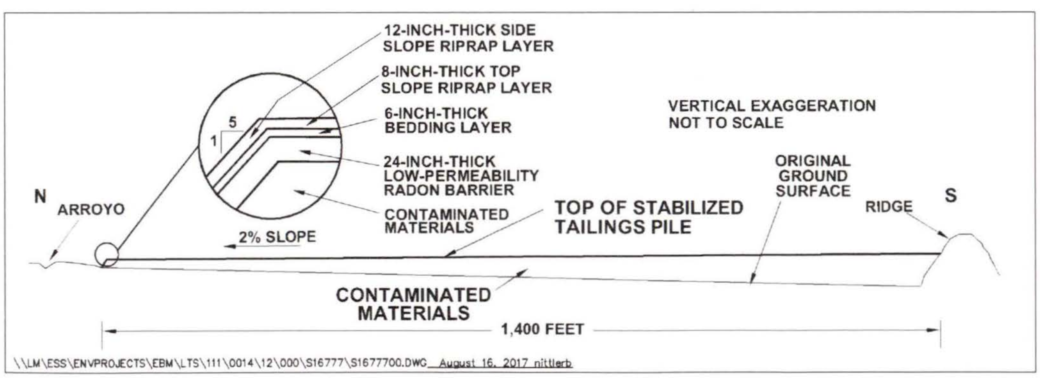

Figure 3. Typical North-South Cross Section of the Mexican Hat Disposal Cell

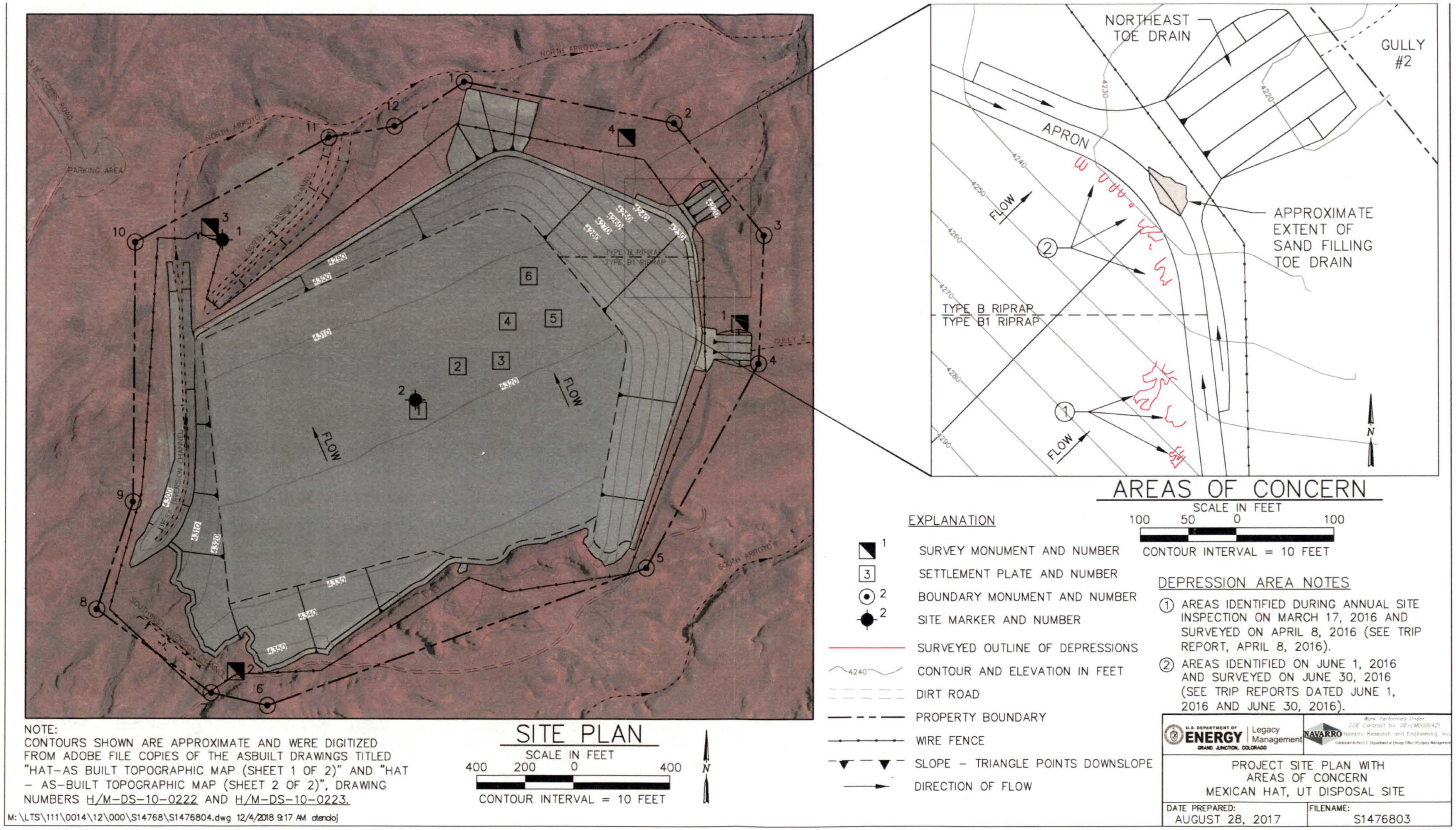

Figure 4. Project Site Plan with Areas of Concern

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The northeast side slope is the longest side slope on the Mexican Hat disposal cell. The longest distance from the top to the bottom of the northeast side slope (draining into the northeast toe drain) is approximately 460 feet. The northeast side slope constitutes an approximate surface area of 7 acres. Since the 2% top slope was contoured to direct runoff in a north to northwesterly direction, only a minor portion of runoff originating from the top slope of the disposal cell ends up on the northeast side slope; run-on to the northeast side slope from the 2% top slope of the disposal cell constitutes approximately 2.7 acres, or 6% of the 46.4-acre top slope. Thus, the combined watershed of the northeast side slope is approximately 10 acres (Figure 4).

1.2.4 Uranium Mill Tailings Radiation Control Act of 1978

UMTRCA was promulgated to protect human health and the environment from the hazards associated with uranium milling waste, and it established requirements for the safe and environmentally sound disposal, long-term stabilization, and control of uranium mill tailings and other RRM for the purposes of minimizing or eliminating radiation health hazards to the public. Title I of UMTRCA addresses processing sites that were no longer in operation when the law was passed. Most or all of the uranium produced at UMTRCA sites was sold to the federal government prior to 1971 (42 USC 7901 et seq.).

UMTRCA Title I sites were remediated by DOE under the UMTRA Project. In accordance with Title 40 *Code of Federal Regulations* Section 192 (40 CFR 192), waste disposal sites that are constructed for the control of uranium mill tailings and other RRM are designed to be effective for up to 1000 years, to the extent reasonably achievable, and in any case, for at least 200 years. Disposal sites are also designed and stabilized in a manner that minimizes the need for future maintenance and limits the release of radon-222 to the atmosphere to an average of no more than 20 picocuries per square meter per second ($pCi/m^2/s$).

The Mexican Hat disposal cell was designed and constructed in accordance with the *control standards* defined in 40 CFR 192. Surface remediation at the site was completed in 1995 to meet the *cleanup standards* defined in 40 CFR 192. When the depression features were identified along the northeast side slope in 2016, the disposal cell was approximately 20 years old, or 1/10th of its minimum design life mandated under UMTRCA.

1.2.5 Long-Term Surveillance Plan

LM manages the site in accordance with the 2007 site-specific Long-Term Surveillance Plan (LTSP) to ensure that the disposal cell and related infrastructure continues to function as designed. The LTSP describes how DOE will fulfill the general license requirements of 10 CFR 40.27 as the long-term custodian of the Mexican Hat UMTRCA Title I disposal site. LM and the Legacy Management Support (LMS) contractor conduct annual site inspections in accordance with the site-specific LTSP to verify the integrity of the disposal cell and its surface features, monitor and evaluate site infrastructure, surveillance, and security features, and perform minor site maintenance as necessary.

Table 3-2 of the 2007 Mexican Hat LTSP (Table 1) provides criteria for maintenance and emergency measures at the site. Based on this table, minor erosion or undesirable changes in riprap integrity on the disposal cell are considered to constitute a Priority 5 condition and should be addressed by conducting an evaluation to assess the associated impact(s) followed by the implementation of an appropriate response to address the problem(s). The cover depression features that are the subject of this evaluation were first identified during the annual site inspection in March 2016 and constitute a Priority 5 condition. Based on the language in the LTSP, a breach of the disposal cell is interpreted as a breach of the entire cover (including the radon barrier), which would result in the exposure of RRM. No evidence of a breach has been identified throughout the compilation of this report and associated field activities. DOE notified the U.S. Nuclear Regulatory Commission (NRC) and the Navajo Nation of the depression features in a letter dated May 5, 2016.

Table 1. DOE Criteria for Maintenance and Emergency Measures

Priority	Description[a]	Example	Response
1	Breach of disposal cells with dispersal of radioactive material.	Seismic event that exceeds design basis and causes massive discontinuity in cover.	Notify NRC. Immediate follow-up inspection by DOE emergency response team. Emergency actions to prevent further dispersal, recover radioactive materials, and repair breach.
2	Breach without dispersal of radioactive material.	Partial or threatened exposure of radioactive materials.	Notify NRC. Immediate follow-up inspection by DOE emergency response team. Emergency actions to repair the breach.
3	Breach of site security.	Human intrusion, vandalism.	Restore security; urgency based on assessment of risk.
4	Maintenance of specific site surveillance features.	Deterioration of signs, markers.	Repair at first opportunity.
5	Minor erosion or undesirable changes in riprap integrity or vegetation.	Erosion not immediately affecting disposal cell, change in riprap protection layer thickness.	Evaluate, assess impact, respond as appropriate to address problem.

Note:
[a] Other changes or conditions will be evaluated and treated similarly on the basis of perceived risk.

Observations and materials sampling and testing results from future site visits will continue to be used to evaluate the prioritization conditions established in Table 3-2 of the 2007 Mexican Hat LTSP (Table 1).

2.0 Components of the Mexican Hat Disposal Cell Cover

This section consists of a review and discussion of the Mexican Hat disposal cell cover component as-builts, and a review of the design calculations and the basis of design supporting the cover system. Photographs of the disposal cell during construction and the placement of cover component materials are also provided to illustrate how the disposal cell was constructed.

2.1 Cover Component As-Builts

The components of the protective cover materials placed over the compacted tailings on the side slopes of the Mexican Hat disposal cell include a radon barrier layer, a bedding/filter layer, and a rock riprap erosion-protection layer as shown in Figure 5. The disposal cell cover system, which includes top slope and side slope configurations and associated drainage structures on the cell apron area, was designed to promote sheet flow runoff during precipitation and snowmelt events and to prevent erosion of the radon barrier. Material descriptions and construction as-builts were obtained from Volume 2 of the Final Completion Report for the Mexican Hat and Monument Valley UMTRCA Title I sites[1]. Review of the final construction as-built drawings (see Appendix C3 pp. 65–84) indicate that contaminated materials (i.e., radioactive tailings and other RRM) may directly underlie the areas where the depression features have been observed. In particular, drawing number H/M-DS-10-0216, Sections C0219 and D0219 (Appendix C3, p. 74), depicts contaminated materials extending all the way to the base of the 20% side slope; section D0219 depicts contaminated materials extending beneath the transition zone from the northeast side slope to a portion of the 4% apron consisting of riprap Type C manufactured limestone that directs runoff to the northeast toe drain.

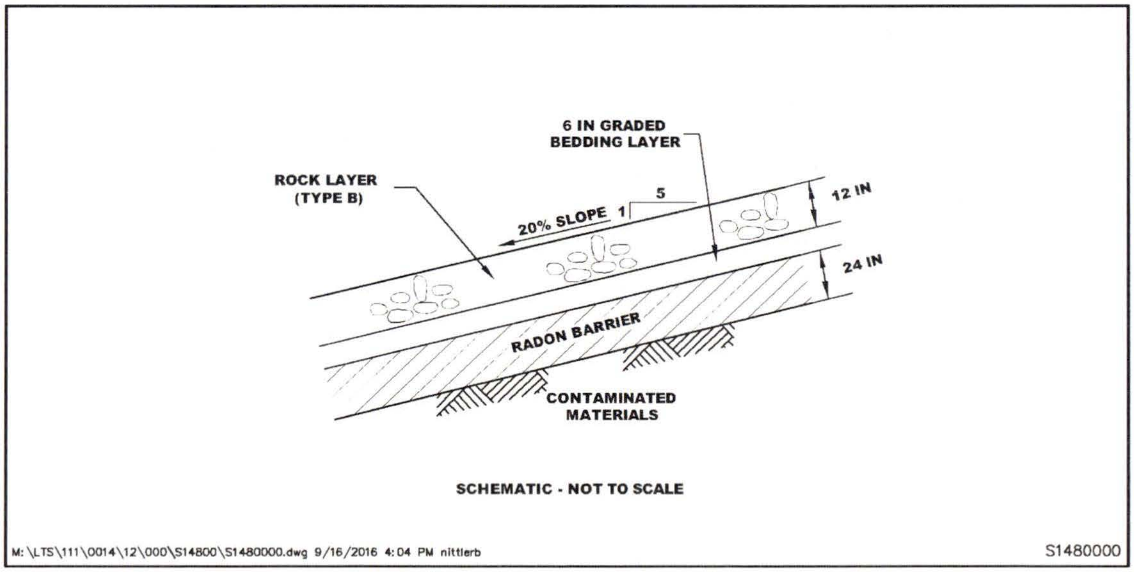

Figure 5. Mexican Hat, Utah, Disposal Cell Cover Components

[1] MK-F (MK-Ferguson Company), 1997. *Mexican Hat, Utah, Monument Valley Arizona, Completion Report*, prepared by MK-Ferguson Company for the U.S. Department of Energy, UMTRA Project Team, Environmental Restoration Division, Albuquerque, New Mexico.

2.1.1 Radon Barrier

The low-permeability radon barrier directly overlies the compacted tailings. It consists of native fine-grained borrow material amended with 10% bentonite. The sources of the borrow material were located approximately 5 miles south of the site, called RB-4 and RB-7. The bentonite was amended to the borrow source material using a pug mill.

The radon barrier was designed to retard the emanation of radon gas from the tailings embankment into the atmosphere in accordance with UMTRCA and to minimize meteoric water infiltration. The radon barrier material is a 24-inch-thick layer that was placed in approximately three equal lifts and compacted to 100% of a reference density determined by the ASTM D698 method. The radon barrier materials were specified to conform to the following gradation limits listed in Table 2[2].

Table 2. Radon Barrier Gradation Specifications for the Mexican Hat, Utah, Disposal Site

U.S. Standard Sieve Size (square openings)	Percent Passing (by weight)
4 inch	100
3/4 inch	70–100
No. 4	50–100
No. 60	15–100
No. 200	5–100

2.1.2 Bedding Layer

The 6-inch-thick bedding/filter layer consists of manufactured materials that were sourced from the Bluff gravel quarry located approximately 30 miles northeast of the site near Bluff, Utah. The bedding layer materials were placed over the radon barrier to act as a construction bedding layer and as a graded filter material prior to placement of the overlying riprap rock layer. The smaller-sized bedding filter material was designed to protect the underlying radon barrier material from particle removal via interstitial flows through the overlying larger riprap material during precipitation and associated runoff events. The bedding layer material is classified as a sandy gravel with few fines (GC or GM), and was specified to conform to the following gradation limits listed in Table 3[3].

[2] Ibid.
[3] Ibid.

Table 3. Bedding Layer Gradation Specifications for the Mexican Hat, Utah, Disposal Site

U.S. Standard Sieve Size (square openings)	Percent Passing (by weight)
3 inch	100
1-1/2 inch	50–100
1 inch	35–70
No. 4	10–30
No. 30	0–10 (0-5)[a]
No. 100	0–5 (0)[a]

Note:
[a] The bedding gradation limits were revised prior to placement by deleting the No. 100 sieve size and modifying the No. 30 sieve size to 0-5 percent passing by weight. (Morrison-Knudsen design calculations 09-418-05-01, page 18 (see Appendix B)

2.1.3 Rock Layer Materials

The riprap rock layer materials are the largest and uppermost components of the disposal cell erosion-protection cover system and directly overlie the bedding layer. The riprap is a screened, river-run material that was sourced from the Bluff gravel quarry located approximately 30 miles northeast of the site near Bluff, Utah. The gradation sizes of the riprap materials vary and were determined based on the slope grades and the final cell geometry. Three types of riprap were used for the finish grade of the disposal cell. Type A riprap was used on the flat (2%) top slopes, and Types B1 and B were used on the 20% side slopes where the surface depressions on the cover have been observed. The 12-inch-thick Types B and B1 riprap materials were specified to conform to the following limits listed in Table 4 and Table 5, respectively[4].

Table 4. Type B Riprap Gradation Specifications for the Mexican Hat, Utah, Disposal Site

U.S. Standard Sieve Size (square openings)	Percent Passing (by weight)
8 inch	100
6 inch	25–100
5 inch	0–100
4 inch	0–25
1 inch	0–5

Table 5. Type B1 Riprap Gradation Specifications for the Mexican Hat, Utah, Disposal Site

U.S. Standard Sieve Size (square openings)	Percent Passing (by weight)
5 inch	100
4 inch	0–100
3 inch	0–50
2 inch	0–25
No. 4	0–5

[4] Ibid.

Figure 4 shows the general layout of the site, including security and surveillance features, engineered drainages and diversion channels, runoff directions, and the observed locations of the depressions in relation to the dividing line between the Type B and Type B1 riprap on the northeast side slope.

2.2 Review of the Design Calculations and Basis of Design

A uranium mill tailings disposal cell is designed and constructed to effectively contain stabilized mill tailings and other RRM for up to 1000 years, to the extent reasonably achievable, and in any case, for at least 200 years (40 CFR 192.02). Additional control standards defined in 40 CFR 192.02 include, among other things, providing reasonable assurance that releases of radon-222 to the atmosphere from uranium mill tailings and other RRM will not exceed an average release rate of 20 $pCi/m^2/s$.

The configuration and composition of a multicomponent UMTRCA disposal cell cover is designed to adhere to the UMTRCA control standards. Radon barriers are designed to limit radon gas emanation and meteoric water infiltration. The overlying riprap and bedding layers are designed to protect the radon barrier from erosion and to minimize the need for active maintenance of the disposal cell.

In the case of the Mexican Hat disposal cell, the radon barrier is composed of local silty sands with a 10% bentonite amendment. The bentonite amendment was added to reduce the permeability of the silty sands that were used for the radon barrier. The erosion-protection cover components at the site (i.e., a sandy gravel bedding/filter layer and an overlying rock riprap layer) were constructed over the radon barrier to protect the radon barrier from wind and water erosion.

The design basis of an UMTRCA disposal cell begins with a review of meteorological data and determination of a probable maximum precipitation (PMP) event. The PMP event is used as a basis for determining the appropriate size(s) and thickness(es) of the erosion-protection cover components. The gradation sizes of the bedding/filter material are determined using accepted procedures to prevent "piping" of soils as discussed in Cedergren (1989)[5] and as specified in the Bureau of Reclamation *Earth Manual* (1980)[6].

The LMS contractor conducted a review of the original design calculations that were used to determine the basis of design for the Mexican Hat Title I disposal cell. The review concluded that both the hydrology and cover design calculations were correct and followed current acceptable standards.

2.2.1 Hydrology Design Calculations Review and Summary

Based on the hydrology design calculations (No. 09-223-01-02, see Appendix A) prepared by Morrison-Knudsen (the remedial action contractor that built the cell), the design storm event used to determine the rainfall intensity and unit discharge sheet flow rates for the Mexican Hat

[5] Cedergren, H.R., 1989. *Seepage, Drainage and Flow Nets*, 3rd ed., John Wiley and Sons, New York.
[6] U.S. Department of Interior, 1980. *Earth Manual*, 2nd ed. Bureau of Reclamation, U.S. Government Printing Office, Washington, D.C.

disposal cell was the probable maximum precipitation (PMP) 1-hour storm. At the Mexican Hat site, a PMP 1-hour storm of 8.1 inches was determined following the procedures provided in Hydrometeorological Report 49 of the National Weather Service. On the basis of procedures outlined in NRC document NUREG-4620[7], the PMP and a calculated time of concentration (T_c) were used to calculate the rainfall intensity. The duration T_c is the time required for a drop of water to flow the longest distance across the disposal cell. The T_c value for the Mexican Hat cell was calculated to be 2.5 minutes; incorporating this T_c value results in a calculated rainfall intensity of 53.5 inches per hour. The 53.5 inches per hour rainfall intensity was then used to calculate the flow velocities that the erosion-protection materials need to resist when developing the design parameters of the Mexican Hat disposal cell.

Review of the hydrology computations indicates that the design rainfall intensities were accurately determined at the time the cell was designed and adhere to current acceptable standards. The design flows generated from these hydrology calculations were used to size the riprap cover materials. Although NRC NUREG-4620 has been superseded by NRC NUREG-1623[8] since the Mexican Hat disposal cell was designed and built, NUREG-1623 provides the same procedure as NUREG-4620 for computing the intensity duration storm event.

2.2.2 Cover Design Calculations Review and Summary

The Mexican Hat cover design calculations prepared by Morrison-Knudsen were obtained from the historical records and reviewed. Sizing calculations for the Types B and B1 rock riprap layers are included in Morrison-Knudsen design calculations No. 09-418-14-00 and No. 09-418-05-01 (see Appendix B, p. 1, and Appendix B, p. 19). These calculations followed the procedures outlined in NUREG-4620 and were the basis for the design criterion for sizing the riprap on preventing erosion under PMP conditions.

Review of the riprap sizing computations indicates that the rock was properly sized following acceptable procedures outlined in the updated NUREG-1623; the calculated sizing was properly reflected in the riprap specifications for both the top slope and side slope materials to accommodate the design PMP event. The updated NUREG-1623 procedure was used to review the calculations, since the superseded NUREG-4620 procedure lacked quantitative criteria for assessing material displacement based on a range of interstitial velocities; NUREG-1623 provides the same procedures for design purposes and provides quantitative criteria.

Calculations supporting the sizing of the bedding/filter layer materials were found in Morrison-Knudsen design calculations 09-418-05-01 (see Appendix B) and were determined to be correct. However, a new calculation check of the filter criteria between the Type B and Type B1 riprap erosion-protection layers and the bedding layer was conducted, confirming that the radon barrier would be adequately protected by the overlying specified bedding and riprap layers based on the disposal cell design specifications (see Section 5.0). Furthermore, a variation between the proposed design gradation in the Morrison-Knudsen calculation and the specified gradation in the project specifications exists at the Nos. 30 and 100 sieve sizes. The original calculation proposed 0–5% passing the No. 30 sieve size, whereas the specified gradation

[7] Nelson, J.D. et al., 1986, *Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Tailings Impoundments*, U.S. Nuclear Regulatory Commission, NUREG/CR-4620.

[8] U.S. Nuclear Regulatory Commission, 2002. *Design of Erosion Protection for Long-Term Stabilization*, NUREG-1623.

allowed for 0–10% passing the No. 30 sieve size. An additional criterion of 0–5% passing the No. 100 sieve size was also added to the specified gradation (see Section 2.1.2). Based on the provided calculations, neither of these sieve size design variations would negatively affect the performance of the bedding/filter layer.

2.3 Construction Material Placement and Quality Control Requirements

2.3.1 Relocation and Placement of RRM and Other Contaminated Material

The Completion Report for the site discusses a work stoppage during the construction of the cell. There is no reason for the stoppage listed, but it does indicate there was no work conducted on the cell from November 1990 until March 1993, a period of approximately 27 months. The report states that at the time of stoppage, RRM and other contaminated materials from the Monument Valley site were still being placed on the cell. Prior to demobilizing from the site during the work stoppage, the exposed contaminated fill surface was treated with a soil sealer. No radon barrier material was placed prior to the work stoppage demobilization. When work began on the cell again in March 1993, the Completion Report states that prior to the placement of any additional materials, the site was recompacted, and compaction was reverified. The Completion Report does not state whether additional contaminated fill was added at that time.

According to the Completion Report, as contaminated material was placed, it was monitored to verify that it was free of excessive organic material and large debris. It was placed in 12-inch loose lifts and then compacted. The compaction criteria were 90% compaction for the interior of the cell and 95% compaction for the top 3 feet of the cell. A total of 2961 compaction tests were administered during the construction of the cell. Of the 2961 tests taken, 180 compaction tests did not pass, and these areas were recompacted and retested until passing results were obtained[9].

2.3.2 Demolition Debris and Bulk Material Placement

The Completion Report does not specify the exact location of the demolition debris or bulk material within the disposal cell. However, the Completion Report states that the demolished mill facilities, including debris and asbestos-containing materials, were placed in the lower lifts of the disposal cell. This is consistent with design specifications that required the larger and more contaminated material to be placed first, in the lower portions of the disposal cell. There is no evidence of larger contaminated material placed near the edges of the side slopes; primarily windblown material was placed on the side slopes (see photographs in Section 2.4 from 1989 construction). Based on information and pictures contained in the Completion Report, it appears that the placement of the contaminated materials adhered to the design and specification requirements.

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[9] MK-F (MK-Ferguson Company), 1997. *Mexican Hat, Utah, Monument Valley Arizona, Completion Report*, prepared by MK-Ferguson Company for the U.S. Department of Energy, UMTRA Project Team, Environmental Restoration Division, Albuquerque, New Mexico.

The Completion Report discusses the design criteria that required NRC, DOE, and Navajo Nation approval and the Design Basis Memoranda (DBM) that assured the design criteria were met (see Appendix F2). The DBM established for the decontamination and the demolition of structures specified the following:

> Foundation and rubble piles be broken up in specific sizes to facilitate their disposal. Debris to be placed in layers, and tailings compacted within and around the individual pieces of debris in order to eliminate voids and nesting, and thereby minimize differential settlement. Organic materials such as wooden demolition debris and grubbed vegetation be evenly distributed throughout the lower portion of the disposal embankment so as not to exceed 5 percent by volume in any lift. Alternately, large volumes of organic materials be buried elsewhere on the site (away from the tailings) where differential settlement is of less concern or be removed from the site if monitored and found safe.

The DBM established for tailings materials excavation and final embankment, contained in Appendix F2, specified the following:

> The relocated contaminated materials placed above the existing lower tailings piles will be densified by compaction or some other means to reduce the potential for long-term differential settlement.
>
> The embankment construction will be sequenced to place lesser contaminated materials over more highly contaminated materials to reduce radon exhalation. The embankment will be comprised as follows, in order from bottom to top:
>
> a. In-situ tailing piles.
>
> b. Relocated materials from the mill area and the ore storage area at Monument Valley; rubble pieces will be placed on the top of the existing tailings embankment and surrounded with compacted relocated soils.
>
> c. Heap leach pad area at Monument Valley.
>
> d. Monument Valley tailings.
>
> e. Relocated, contaminated materials from the windblown and waterborne deposit areas.
>
> f. Contaminated materials from temporary facilities.

The project specification for demolition (02050, page 4), contained in Appendix F1, required the following in regard to the larger pieces of contaminated materials:

> Demolished materials, consisting of steel, concrete, wood, masonry and other man-made materials, rubble, debris and boulders shall be reduced in size to pieces to be no greater than 3 feet in any dimension and no more than 27 cubic feet in volume.
>
> Metal objects with voids shall be crushed to sizes no greater than 27 cubic feet in volume, with the least dimension not exceeding 6 inches.
>
> Any pipe, conduit and ducts shall be cut to sizes no greater than 10 feet in length.

In the Completion Report Appendix E, "Materials Testing Summary Report," the Contaminated Fill Material section (see Appendix F3 of this report) states:

> All contaminated material and debris resulting from demolition of the old Halchita/Mexican Hat Mill foundation, and associated structures, and from off-site vicinity properties during Phase I, were cut or broken into sizes meeting specified requirements before placement in the cell embankment.
>
> Where contaminated fill material contained individual pieces larger than the 12 inch loose lift thickness, the lift thickness was verified as minimum constructible thickness and materials were spread to ensure a void free mass and provide adequate compaction between larger particles.
>
> During placement of contaminated fill material, continuous visual inspection was performed to ensure that organic materials did not constitute more than five percent of the placed volume. Also, demolition debris and organics were evenly distributed throughout the fill to avoid concentrations. Individual linear pieces of wood, steel and plastic were cut or broken into pieces not greater than 10 feet in length; similarly, pieces of concrete, rock, masonry and steel was sized down to be less than 3 feet in any dimension and/or less than 27 cubic feet in volume[10].

Based on the design specifications and review of information contained in the Completion Report, there is no indication that demolition debris or bulk materials were placed in any fashion that would promote subsidence along the side slopes of the disposal cell.

2.3.3 Radon Barrier

The radon barrier material is a 24-inch-thick layer that was placed in 10-inch loose lifts and then compacted to 100% dry density of a reference density determined by the ASTM D698 method. There were 642 compaction tests administered during the construction of the cell. According to the Completion Report, of the 642 tests taken, 102 compaction tests did not pass, and these areas were recompacted and retested until passing results were obtained[11].

2.3.4 Bedding Layer

Photo documentation in the Completion Report indicates that at least some of the bedding material was placed and spread on the side slopes from the top of the slope and pushed to the toe of the slope with a dozer. There is no indication as to how much of the bedding material was placed in this manner, and the Completion Report does not specify how the bedding materials were placed.

Gradation testing was required of the bedding material at a frequency of one test for each 10,000 cubic yards of bedding material placed. There was 59,992 cubic yards of bedding material placed, providing an average test frequency of one gradation test for every 3333 cubic yards of bedding material placed. There were 18 gradation tests taken, with no failing tests. The

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[10] Ibid.

[11] Ibid.

Completion Report does not state where the gradation tests were taken, whether at the gravel pit, onsite, or before or after placement.

The specifications for the project required that the erosion-protection materials be handled, loaded, transported, stockpiled, and placed in a manner that avoided nonconformance with specifications due to segregation and degradation, including materials moved to and from stockpiles. The bedding material was moved twice prior to being placed, according to the Completion Report. It was first moved to a stockpile at the gravel pit using a front-end loader. From the stockpile it was moved with a front-end loader to load double-belly tractor trailer trucks. The trucks then transported the bedding material to the cell, which was subsequently placed directly on the final grade of the radon barrier using a motor grader and a dozer.

Once the bedding material was placed, a dozer was required to make two passes over the placed material as a performance specification. No numerical compaction was specified. The specified depth of the bedding layer was 0.5 foot plus or minus 0.1 foot, for an allowable thickness ranging from 0.4 to 0.6 foot. The depth of the material was tested 156 times, a minimum of one test per 200 foot × 200 foot area, with three depth tests not passing. The areas where the depth did not pass were reworked and retested until passing results were obtained. The average thickness of the bedding material was 0.56 foot, with a low of 0.38 foot and a high of 0.69 foot, according to the Completion Report for the project[12].

2.3.5 Rock Layer Materials

Gradation testing was required as follows: an initial test of the Type B riprap during the early stages of the placement, one test each when approximately one-third and two-thirds of the total volume of material had been placed, and a final test near completion of the placement, for a total of four tests. According to the Completion Report, 20,760 cubic yards of Type B riprap was placed on the disposal cell. A total of eight tests were taken, providing an average test frequency of one gradation test for every 2595 cubic yards of Type B riprap placed. There were no failing tests. The thickness of the Type B riprap was specified to be a minimum depth of 1 foot and a maximum thickness of 135% of the minimum, or 1.35 feet. There were 26 thickness tests taken with an average thickness of 1.11 feet, a low depth of 1.02 feet, and a high depth of 1.29 feet meeting the specification.

According to the Completion Report, the same manner of gradation testing required for the Type B riprap was also required for the Type B1 riprap, for a total of four tests. According to the Completion Report, 25,704 cubic yards of Type B1 riprap was placed on the disposal cell. A total of four tests were taken, providing an average test frequency of one gradation test for every 6426 cubic yards of Type B1 riprap placed. There were no failing tests. The thickness of the Type B1 riprap was specified to be a minimum depth of 1 foot and a maximum thickness of 135% of the minimum, or 1.35 feet. There were 26 thickness tests taken with an average thickness of 1.09 feet, a low depth of 1.04 feet, and a high depth of 1.20 feet, meeting the specification[13].

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[12] Ibid.
[13] Ibid.

2.4 Historical Construction Photographs of Cell Construction/Placement of Bedding and Riprap Materials

The following photographs were taken during the construction of the Mexican Hat disposal cell cover. The equipment and materials shown provide a quick view of the means and methods employed to place the cover component materials. Each photograph is date-stamped and includes a brief description of the activity being performed. Based on the compilation of the available records associated with the disposal cell Completion Report, not all photographs included within the following pages are relevant for the purposes of this evaluation report.

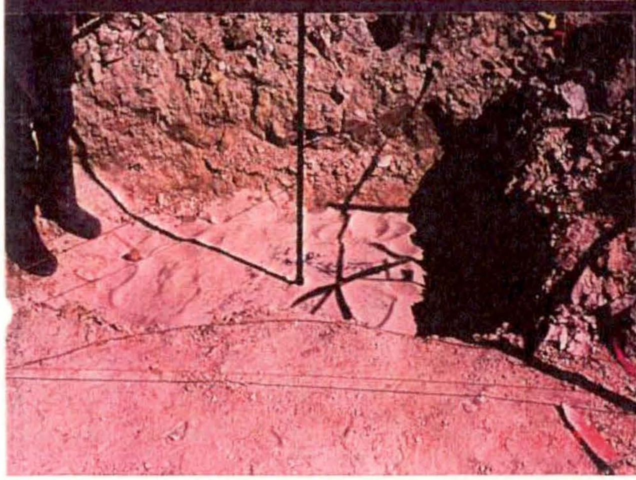
Cell: QC monitoring, loose lift thickness retest after surface was cut by Cat 14G grader — Passed.

5-14 03/02/89

QC-Hat Site-06

Cell, northeast corner: Subgrade surface.

6-1 03/13/89



Cell, Displacement monument: Prior to placing tailings over foundation base.

6-3 03/13/89

Cell, Displacement monument: Contaminated tailings placed over foundation base — Compaction effort.

6-5 03/13/89

Cell, Displacement monument: After compaction of tailings placed over foundation base — QC monitoring, sandcone density test.

6-6 03/13/89

Cell, 5:1 slope area: Cat 631 scraper, delivering and spreading contaminated windblown material.

6-15 03/21/89

Cell, 5:1 slope area: QC verifying contaminated windblown material compaction, sandcone density test.

6-17 03/23/89

QC-Hat Site-07

Hat Site: Health Physics personnel, verification of contaminated windblown material cleanup.

7-6 03/28/89

QC-Hat Site-08

Cell: Cat 65 challenger tractor / 5x5 tag-a-long sheep's-foot roller, compaction effort — Contaminated windblown material. Note excavations for sandcone density testing (visible in distance).

8-13 04/06/89

QC-Hat Site-09

Cell: QC monitoring, loose lift thickness test — Contaminated tailings fill material.

9-14 04/18/89

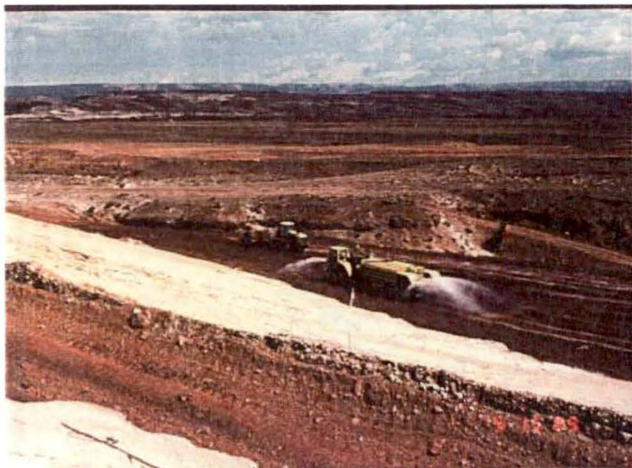
Cell: QC monitoring, sandcone density test.

9-16 04/19/89

QC-Hat Site-10

Cell, 5:1 slope area: Cat 65 challenger tractor / 5x5 tag-a-long sheep's-foot roller, compaction effort — Contaminated windblown material.

10-5 04/25/89



QC-Hat Site-11

Cell, 5:1 slope area: Cat 65 challenger tractor / 5x5 tag-a-long sheep's-foot roller, compaction & Cat 10,000 gallon water-wagon, moisture conditioning efforts — Contaminated windblown material.

11-14 05/15/89

Cell, 5:1 slope area: Cat 631B scraper, delivering and spreading contaminated windblown material.

11-17 05/16/89

Hat Site, Mill-Site: Cat 416 backhoe / hydraulic impact hammer, demolishing contaminated concrete structures.

11-25 05/17/89

QC-Hat Site-79

Hat Site, QC laboratory trailer yard: MK QC personnel, gradation analysis test type C erosion protection material (hand separation via sieving grids).

79-4 05/03/94

Cell: Radon gas flux point #99.

79-19 05/10/94

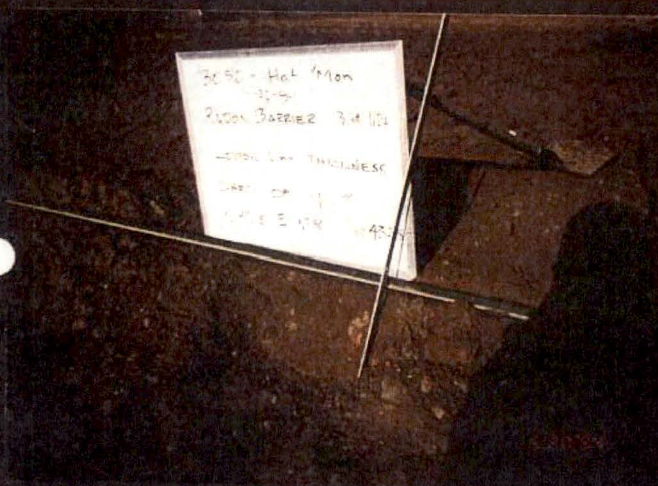
QC-Hat Site-80

Cell, 2% slope area: Semi-trailer-pup belly-dump, delivering bedding material over approved radon barrier material surface.

80-22 05/19/94

Cell, overview of 2% slope area: Semi-trailer-pup belly-dump, delivering bedding material over approved radon barrier material surface.

80-23 05/19/94



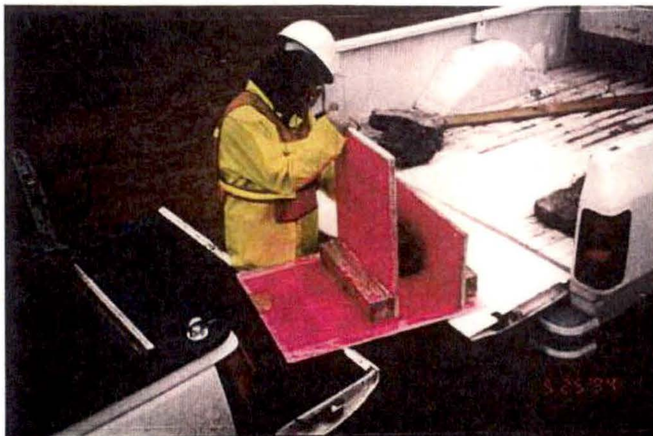
Cell: QC verification, third (final) lift of radon barrier material — Loose lift thickness check.

80-25 05/20/94

QC-Hat Site-81

Cell, north 5:1 slope area: QC person, sandcone density test with type C erosion protection material stockpile in background.

81-3 05/21/94



Hat Site, type C erosion protection material stockpile area: Dimensional analysis — Evaluation of type C erosion protection material.

81-8 05/25/94

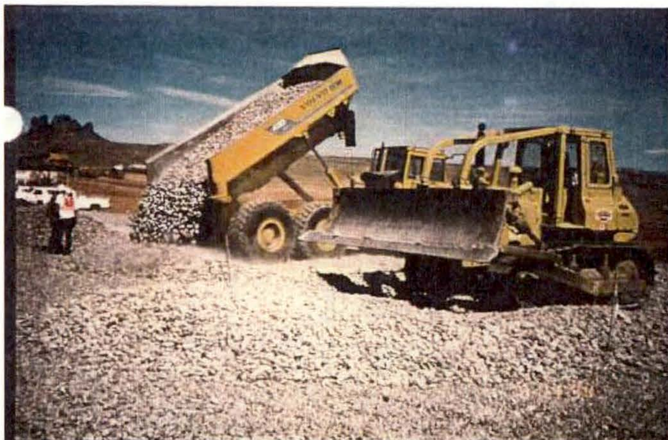
QC-Hat Site (RICOH) 02

Cell, 2% slope area: Dozer, trackwalking compaction efforts on bedding material — Prior to final grade, depth and gradation checks.

(RICOH) 02-3 06/10/94

Cell, test pad area: Dozer, cutting type A erosion protection material to thickness.

(RICOH) 02-5 06/15/94



Cell, 2% slope area: Volvo end-dump articulated rock truck, delivering type A erosion protection material over approved bedding material surface.

(PENTAX) 02-16 06/14/94

QC-Hat Site-83

Cell, displacement monument area: Excavation preparations for installation.

83-18 01/12/94

Cell, displacement monument area: sandcone density test.

83-21 01/13/94

Cell, overview of northeast 5:1 slope radius area: Bedding material application activities over approved radon barrier material surface.

(PENTAX) 05-24 07/09/94

QC-Hat Site-84

Cell, north 5:1 slope area: Cat water-wagon, moisture conditioning radon barrier material.

84-3 07/18/94

Cell, 2% slope area: Dozer / weighted pipe, final grading of type A erosion protection material surface.

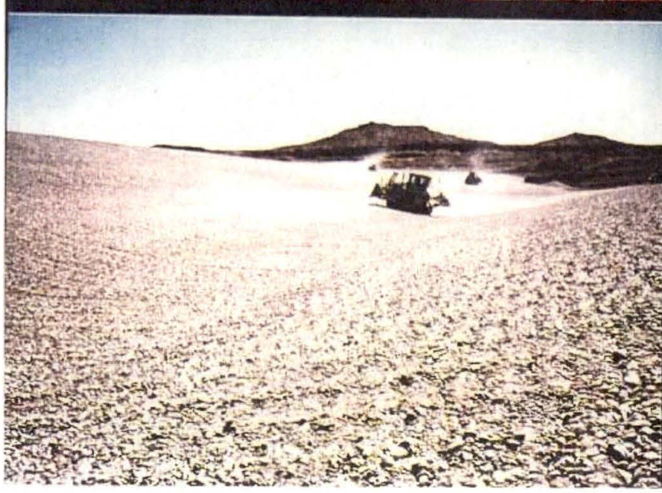
84-7 07/19/94

Cell, south perimeter: Excavation of surface to in-situ bedrock at grade.

87-11 08/27/94

Hat Site, gully 3: Visibly non-testable (according to ASTM standards, >30% retained on ¾" sieve) common fill material.

87-20 08/31/94



QC-Hat Site-88

Hat Site, overview of west ditch: Dozer, trackwalking effort (two passes observed), bedding material placement activities - Approved subgrade surface.

88-9 09/07/94

QC-Hat Site-75

Hat Site, overview Pug Mill: Setting up and stockpiling material for radon barrier material production.

75-4 03/01/94

Hat Site, Pug mill: Production and load out of radon barrier material into scraper, for delivery to cell.

75-22 04/15/94

Cell, west side at 2% — 5:1 slope transition: Finished grade — Before radon barrier material application.

75-23 03/15/94

QC-Hat Site-76

Cell, west 2% slope area: Finished grade — Before radon barrier material application.

76-3 03/16/94

Cell, 2% slope area: QC monitoring, loose lift thickness test — Radon barrier material.

76-4 03/17/94

Cell, 2% slope area: Cat 825 Sheep's-foot roller, compaction effort — Radon barrier material, first of three lifts.

76-5 03/18/94

Hat Site, north side - toe of 5:1 slope: QC personnel, verification of competent in-situ rock — Drilling to refusal with auger drill.

76-14 03/23/94

QC-Hat Site-77

Cell, west 2% slope area: Cat 631 scraper, delivering radon barrier material.

77-19 04/07/94

Cell, west 2% slope area: QC testing — Sandcone density test on second of three lifts of radon barrier material.

77-24 04/12/94

3.0 Existing Mexican Hat Disposal Cell Cover Conditions

This section describes the current conditions of the Mexican Hat disposal cell cover. The current knowledge of existing Mexican Hat disposal cell cover conditions has been gained through annual site inspections and subsequent follow-up site visits to further investigate the cover depression features. Additionally, available precipitation data for the area are summarized in this section.

3.1 Site Inspections and Visits

3.1.1 2016 Annual Inspection, March 17, 2016

The 2016 annual site inspection was conducted on March 17, 2016. This was the first time the depression features were observed on the northeast side slope (see Area 1 on Figure 4). The 2016 Annual Site Inspection Report is included in Appendix C1.

3.1.2 Site Visit Report (Follow-Up to Annual Inspection) April 8, 2016

A follow-up site visit to focus attention on the area where depressions were first observed was made on April 8, 2016 (See Site Visit Report in Appendix C2 and Area 1 on Figure 4). The inspection team identified an area 80 feet × 100 feet to obtain topographic survey information of the observed depressions features. The mapped depression features in Area 1 were approximately 10–50 feet in length.

Radiological scanning for radon gas and gamma radiation was also conducted during this site visit. An Alpha Nuclear model 597-PX3 radon gas monitor was used to determine radon levels at a background location outside the site fence and at the depression areas. Radon readings at the depression areas were consistent with background readings. Similarly, a Mount Sopris model SC-132/EL-0047 crutch scintillometer was used to determine if elevated gamma radiation levels were present at the depression areas. Gamma scans were performed at a range of background locations outside the site fence and then compared with scans conducted at the depression areas. The gamma scans performed at the depression areas did not exhibit differences compared to those observed at the background locations. Based on the radiological scanning performed during this site visit, RRM has not been exposed at the depression areas.

The inspection team also removed the riprap and bedding cover materials by hand to expose a portion of the top of the radon barrier in one location during this follow-up site visit. The top of the radon barrier was exposed in a small area of approximately 10 inches in diameter. The last photograph of the Site Visit Report shown in Appendix C2 (p. 8) appears to show that the bedding layer material is extremely segregated with little fines. In addition, a small erosion channel 6 inches wide × 4–5 inches deep in the radon barrier was observed running parallel to the side slope. However, the overall size of the exposed area was too small to conclude whether or not interstitial velocities are eroding the radon barrier below the bedding layer. The inspection team suggested that additional follow-up site visits were needed.

3.1.3 Engineering Site Visit Trip Report June 1, 2016

Further examination of the cover depression features was performed on June 1, 2016 (see Trip Report in Appendix C3). Similar to the previous site visit, engineering staff manually removed small sections of riprap and bedding materials to view the underlying layers in several depression feature areas. The areas of radon barrier exposed were too small to ascertain whether or not the radon barrier surface was experiencing erosional forces. Photos 7–11 of Appendix C3 (p. 4) show the cover material removal areas. The conclusions of the site visit were that depressions indeed are occurring in the areas originally found and that a larger cover removal area would be required to determine if the cause of the depressions is erosional. A closer look at photos 7–11 in Appendix C3 (p. 4) indicates a red coating of what may be windblown material coating the 12-inch-thick riprap layer. This material is similar in color and composition to the radon barrier material and may be contributing to the collection of fines observed at the low point of the perimeter drainage channel adjacent to gully 2 (Figure 4).

Several additional cover depression features were identified to the north of the depression areas initially observed during the March 2016 annual site inspection (see Area 2 on Figure 4). These areas appeared to be less extensive than the areas identified in March 2016 and were identified for a later survey. No subsurface investigation of these areas was performed during this site visit.

3.1.4 Site Visit Report, June 30, 2016

A site visit was made to locate the additional depression features observed during the previous site visit dated June 1, 2016 (see Appendix C4). Survey-grade equipment was used to map these additional depression feature locations as shown in Area 2 of Figure 4. The mapped depression features in Area 2 were approximately 10–20 feet in length.

3.1.5 Site Visit Report, August 18 and 19, 2016

A site visit was made to both the Monument Valley and Mexican Hat sites to assess potential site damage after a flash flood event occurred in the area (see Appendix C5). According to the National Weather Service Climatological Data for Mexican Hat, Utah, the event occurred on August 6, 2016. The offsite weather station recorded a total precipitation of 0.53 inch for the day. Information that relates to the storm duration or storm intensity was not available. No changes in the cover depression features from this rainfall event were evident.

3.1.6 Observational Site Visit, March 2, 2017

An observational site visit was conducted at the site on March 2, 2017. The purpose of this visit was to familiarize a new LMS staff member to the site and the depression features observed along the northeast side slope. Based on the time of day, this observational site visit provided unique lighting conditions (i.e., angle of the sun) that indicated that some previously identified areas of cover depressions along the northeast side slope may be more extensive than previously considered. Due to the nature of this observational site visit, a site visit report was not prepared.

3.1.7 2017 Annual Inspection, April 11, 2017

The 2017 annual site inspection was conducted on April 11, 2017 (See Appendix C6). No major changes to the areas of observed depression were visually evident during the annual inspection relative to previous visual observations.

3.1.8 Site Visit Trip Report, Radiological Survey, September 21, 2017

A radiological survey was performed by a qualified radiological control technician (RCT) along the northeast side slope utilizing a handheld 2 inch × 2 inch sodium iodide crutch scintillometer to verify the absence of elevated radiological readings in areas of concern (i.e., depression features). Ambient radiological conditions were determined based on an average of readings collected at three areas upslope of depression features on the northeast side slope. Once ambient conditions were determined, the majority of visually identified depression features were surveyed utilizing the scintillometer. Readings were collected at the top of the riprap surface. Overall, the results showed no elevated radiological readings relative to visually determined nondistressed areas located upslope of depression features on the northeast side slope and further support the determination that RRM has not been exposed at the depression areas (see Appendix C7).

3.1.9 Engineering Site Visit Trip Report, October 23–25, 2017

An observational site visit was conducted at the site on October 24–25, 2017. The purpose of this visit was to introduce and familiarize a geotechnical subject matter expert (SME) to the site and the depression features observed along the northeast side slope. The appearance of the depressions on the northeast side slope did not appear to have changed compared to previous visual observations. The other side slopes of the disposal cell were observed, but no depressions similar to the ones seen on the northeast side slope were noted. There was also no apparent accumulation of sediment in the north toe drain, as was observed in the northeast toe drain. Following the site visit to the disposal cell, a site visit was taken to the radon barrier borrow area several miles south of Halchita, Utah (see Appendix C8).

3.1.10 Site Visit Trip Report, December 14, 2017

During this site visit on December 14, 2017, personnel from the Navajo Nation Uranium Mill Tailings Remedial Action/Abandoned Mine Lands Department manually removed small portions of the riprap and bedding layer cover components to facilitate the inspection of linear depressions observed near the toe of the northeast side slope. At one of the locations, near the toe of the northeast side slope, a small void was observed at the apparent base of the bedding layer and upper portion of the radon barrier. The approximate dimensions of the void were 8 inches deep × 12 inches wide. The length of the void was unknown, but it appeared to extend downslope along the interface of the bedding layer and radon barrier. An approximately 6-inch-thick, red cemented layer was observed at the top of the void immediately below the base of the bedding layer. There was no indication that the radon barrier had been breached; hand removal of cover components did not extend into the radon barrier. The bedding layer consisted of almost all coarse gravel materials; fine sand materials were absent. The rock riprap and gravel/bedding materials that were removed were ultimately placed back in the void, and the exposed area was restored. The restored area was marked by wedging a wooden stake between the rock riprap materials, and an orange ribbon was tied to the top of the stake (see Appendix C9).

3.1.11 Site Visit Trip Report, Radiological Survey, December 27, 2017

To obtain ambient radiological condition data to compare to areas of concern on the northeast side slope of the disposal cell, a series of radiological surveys were performed by a qualified RCT. An Alpha Nuclear model 597-PX3 radon monitor was utilized to collect 30-minute continuous samples for radon gas, and a handheld 2 inch × 2 inch sodium iodide crutch scintillometer was utilized to collect gamma radiological readings at a total of seven radiological survey locations throughout the site.

Two upwind locations, one downwind location, and the area of the site marker on the top slope of the disposal cell were surveyed to assess ambient radiological conditions. Three additional locations were surveyed in areas of concern along the northeast side slope of the disposal cell, one of which included the area of the recently discovered void. A series of three separate surveys were performed at the location of the void, and it was reexposed to provide a thorough assessment of radiological conditions at this location.

Overall, the results at all surveyed locations showed no elevated radiological readings relative to ambient radiological conditions. Radiological survey results were below all applicable exposure-based and radon emanation standards, further supporting the determination that RRM has not been exposed at the depression areas (see Appendix C10).

3.1.12 Engineering Site Visit Trip Report, January 9 and 10, 2018

This site visit was made as a follow-up visit to assess the area of the cell where a small void was recently discovered near the toe of the northeast side slope and to assess other areas where the 5:1 rock cover is and is not showing visual signs of depressions on the disposal cell side slopes. Over the 2-day period, a total of six small test pits were hand excavated to expose the bedding material and top of the radon barrier.

All test pit locations were intermittently screened for gamma radiation by an RCT utilizing a handheld 2 inch × 2 inch sodium iodide crutch scintillometer. Test pits were screened before, during, and after disturbance, and no elevated radiological readings relative to ambient conditions were observed throughout the 2 days of field work. No breach through the radon barrier was evident throughout this field work.

Windblown sediment accumulation was present below the immediate riprap surface at all test pit locations. Riprap and bedding layer thicknesses appeared to meet specifications at test pit locations. Cemented material (presumably radon barrier) was observed along the interface of the bedding layer and radon barrier towards the lower portions of the northeast side slope. The cemented material appeared to be thicker towards the toe of the side slope and was not present at upgradient test pits located near the crest of the side slope. Fine aggregates in the bedding layer appeared to be absent towards lower portions of northeast side slope and were possibly overconcentrated near the crest of the northeast side slope. Voids and erosion were observed within the radon barrier material in two of the test pits located near the lower portion of the northeast side slope (see Appendix C11).

3.1.13 Engineering Site Visit Trip Report, January 23–25, 2018

Additional surface depressions observed on the north side slope during the January 9 and 10, 2018, site visit were investigated during this site visit. Other areas of concern where the 5:1 rock cover is showing visual signs of depressions on the north, west, and east side slopes of the disposal cell as well as a discolored area on the top slope of the disposal cell cover were also investigated. A total of seven small test pits were hand excavated to expose the bedding material and the top of the radon barrier over the 2-day period.

All test pit locations were intermittently screened for gamma radiation by an RCT utilizing a handheld 2 inch × 2 inch sodium iodide crutch scintillometer or equivalent radiological screening device. Test pits were screened before, during, and after disturbance, and no elevated radiological readings relative to ambient conditions were observed throughout the 2 days of field work. No breach through the radon barrier was evident throughout this field work, and no elevated radiological readings were observed.

Riprap and bedding layer thicknesses appeared to meet specifications at test pit locations. Windblown sediment accumulation was present below the immediate riprap surface at all test pit locations. Some test pits on the north and east side slopes exhibited radon barrier degradation showing potentially collapsed voids, incisements, and cementation. Signs of incipient radon barrier degradation were observed at one location of the east side slope, but were not as evident as radon barrier degradation observed on the north and northeast side slopes. Aggregate fines in the bedding layer appeared to be absent towards lower portions of north and east side slopes (see Appendix C12).

3.2 Site Visit Observations Summary

Listed below is a summary of observations from the multiple site visits and investigations that have been completed since the depressions on the northeast side slope were first observed:

- No elevated gamma radiation or radon gas readings relative to ambient background conditions were observed during any of the site visits or investigations.
- No breach through the full thickness of the radon barrier is evident.
- Sediment of undetermined origin has accumulated in the northeast toe drain, but sediment has not been observed in the other two toe drains.
- Voids, piping, and incisements in the radon barrier have been observed near the toes of the northeast and north side slopes of the disposal cell. Based on the characteristics observed at these features, including their locations towards the lower portions of the north and northeast side slopes, and the lack of fines in the bedding/filter materials in these areas (which would allow for higher runoff velocities in the bedding/filter material), it can be reasonably assumed that these features are the result of precipitation-induced erosion. No evidence of subsidence in these areas has been identified.
- Windblown sediment accumulation has been observed approximately 6 inches below the immediate riprap surface at all investigation locations.
- Riprap and bedding layer thicknesses appear to meet the original construction specifications at investigation locations.

- Cemented material was observed along the interface of the bedding layer and radon barrier towards the lower portions of the northeast and north side slopes.
- The cemented material appears to be thicker towards the toe of the side slopes and not present at upgradient control points.
- Fine aggregates in the bedding layer appear to be absent towards lower portions of northeast and north side slopes and are possibly overconcentrated at upper portions of the northeast and north side slopes.

The following table provides a synopsis of characteristics that were observed at specific test pit locations that were investigated in January 2018 (Table 6). See Figure 6 for the test pit locations.

3.3 Post-Construction Hydrology Review and Summary

Monthly historical precipitation data from the Western Regional Climate Center Cooperative Climatological Data Summaries for Utah were reviewed for the Mexican Hat, Utah, station (Station ID: 42-5582) to assess the amount of precipitation the local area has been subjected to relative to the disposal cell design PMP event. The Mexican Hat weather station is located about 1 mile north of the disposal site. Daily total precipitation is collected by an observer at this station. According to the available data, the historical average annual precipitation for the area near Mexican Hat, Utah, is 6.58 inches during the 70-year period of record from July 1, 1946, to February 9, 2017. For the 50-year period between 1946 and 1995, the average annual precipitation was 6.14 inches. In the 21 years that followed between 1996 and 2016 (last full year of data), the average annual precipitation increased to 6.74 inches (see Appendix D, p. 1).

Construction of the Mexican Hat disposal cell was completed in 1995. The annual rainfall for 2015 is notably the greatest annual rainfall on record since the onset of data collection in 1946 (see Appendix D, p. 1). Cumulative monthly amounts of greater than 1 inch of precipitation occurred in 5 months throughout calendar year 2015 (i.e., monthly sums of precipitation). Additionally, 5 months of above 1-inch cumulative precipitation totals occurred between the 2015 annual inspection that was performed in early April 2015 and the subsequent March 2016 annual inspection when the depression features were first identified (see Appendix D, p. 2). It is also notable that the greatest annual rainfall accumulations of record were recorded after the disposal cell construction was completed in 1995 (11.50 inches in 2005, 10.56 inches in 2010, and 13.86 inches in 2015) (see Appendix D, p. 1). However, despite indications that annual precipitation amounts have increased since the completion of the Mexican Hat disposal cell, a comparison to determine whether the design PMP event has been exceeded cannot be performed without site-specific rainfall intensity data.

Table 6. January 2018 Disposal Cell Cover Test Pit Observations

Disposal Cell Section	Northeast Side Slope						North Side Slope			West Side Slope	East Side Slope		Top Slope
Test Pit (TP) Identifier	TP1	TP2	TP3	TP4	TP5	TP8	TP6	TP7	TP10	TP11	TP12	TP13	TP9
Elevated Radiological Readings[a]													
Visible Surface Anomalies[b]	✓	✓					✓	✓	✓	✓	✓	✓	
Out of Spec Rip Rap Thickness[c]													
Out of Spec Bedding Thickness[d]													
Fines Absent in Bedding Layer[e]	✓	✓				✓	✓	✓			✓		
Cementation at Base of Bedding Layer[f]	✓	✓				✓	✓	✓					
Radon Barrier Degradation[g]	✓	✓					✓	✓			✓		
Other Cover Deformation[h]													✓

Notes:

[a] All test pits were scanned with a sodium iodide scintillometer or equivalent radiological detection instrument by a qualified radiological control technician (RCT).

[b] Surface depression or rill-like features in riprap surface.

[c] Riprap tolerance on side slope is 1.0–1.35 feet.

[d] Bedding layer tolerance is 0.5 foot ± 0.1 foot (0.4–0.6 foot).

[e] Based on visual observation; indicates only coarse-grained materials were observed. The bedding layer specifications required a sandy gravel gradation.

[f] Cementation varies from well-cemented to weakly cemented. Cementation reacts to hydrochloric acid.

[g] Indicates radon barrier incisement, piping, or collapsed voids.

[h] TP9 was uncovered in an area of red staining on the riprap. Hand excavations in this area revealed differential surface grading on the radon barrier surface.

	NAD 1983 StatePlane Utah South FIPS 4303	
ID	X Coordinate	Y Coordinate
TP1	2115348.524	10017317.281
TP2	2115344.840	10017151.568
TP3	2115138.872	10017038.878
TP4	2114928.670	10017273.578
TP5	2115356.857	10017344.884
TP6	2114525.283	10017597.647
TP7	2114501.049	10017541.092
TP8	2115309.053	10017293.178
TP9	2114034.758	10017171.723
TP10	2113883.564	10017204.353
TP11	2113321.806	10016129.590
TP12	2115341.133	10016742.551
TP13	2115197.593	10016399.766
PTP1	2113376.505	10016280.184

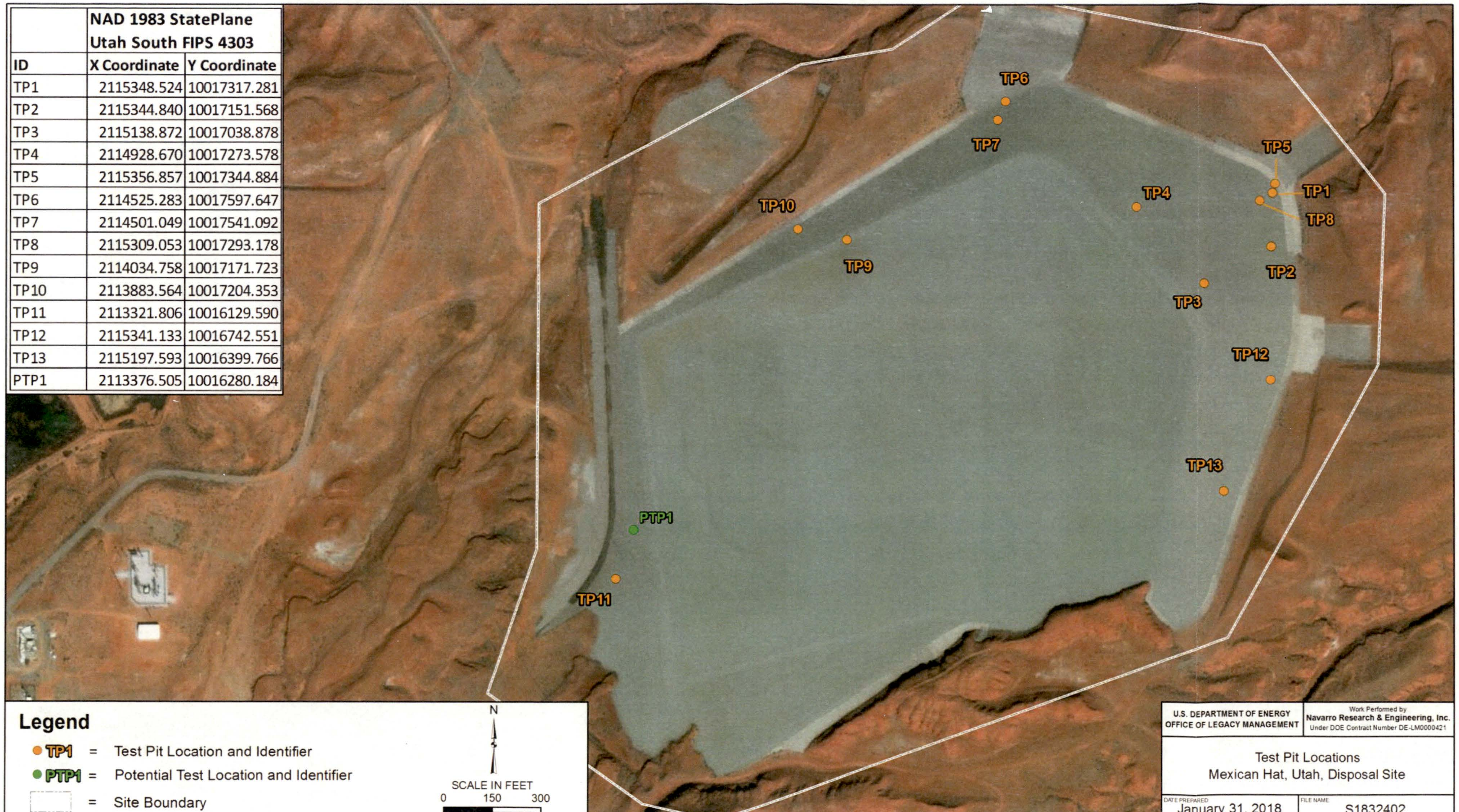


Figure 6. January 2018 Test Pit Locations at the Mexican Hat, Utah, Disposal Site

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4.0 Comparison of Observations with Design

The Mexican Hat disposal cell design requirements were compared with the actual field observations to verify that the cell was constructed in accordance with the design criteria. Precipitation data since the disposal cell was constructed were compared to precipitation data that were used to support the design. The types and thicknesses of the cover materials specified in the disposal cell design requirements were also compared with actual field observations and visually verified.

4.1 Hydrology

The disposal cell was designed to withstand the PMP, which is a 1-hour storm event of 8.1 inches. Since the construction of the disposal cell was completed in 1995, all monthly measurements from the nearby weather station have been consistently less than 4 cumulative inches of precipitation, with the majority of months experiencing less than 1 cumulative inch of precipitation (see Appendix D, p. 2, Monthly Sum of Precipitation (Inches) Post-Cover Completion). Based on this information, past exceedance of the PMP is highly unlikely. However, rainfall intensity data from the Mexican Hat disposal site are needed to determine actual precipitation conditions at the site. The intensity of a storm, or how quickly the cell is exposed to the total amount of precipitation, is what can potentially cause damage to the cover materials.

4.2 Cover Materials

The Type B and Type B1 riprap cover materials observed during recent visits to the site appear to be consistent with the original design specification as stated in Section 2.1.3 of this report. This material, as reported previously, was coated with fines, possibly windblown material across the entire cross section of the areas of investigation. It is likely that these fines collect on the rock surfaces between rainfall events and are subsequently washed out and deposited in low areas of the perimeter channel portion of the cell during precipitation events. However, because the material collecting at the low point of the perimeter drainage channel adjacent to the northeast toe drain (Figure 4) exhibits the same general color and composition as the disposal cell radon barrier material, the origin of this material is not conclusive.

The 6-inch bedding layer material thicknesses were observed to be consistent with the original design specification as provided in Section 2.1.2. However, there were locations near the toes of the northeast and north side slopes where segregation of the fine and coarse materials within the bedding layer had occurred. Segregation within the bedding layer could have occurred during the original material placement, depending on the placement method used, but it also could have occurred from interstitial flow velocities associated with high-intensity precipitation events. On the basis of the hydrology discussion in Section 4.1, it is more likely the segregation occurred during the original placement of the bedding layer material.

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5.0 Supplemental Filter Design Analysis

A supplemental rock riprap–bedding layer filter criteria calculation (Calculation No. S14794, Appendix E) was performed as a supplement to the original Morrison-Knudsen design calculation to confirm that the specified gradations were adequate to protect the radon barrier material from erosion. The results of the additional calculation confirm that both types of riprap were adequately designed to filter the bedding layer from internal erosion and piping, and that the bedding layer was adequately designed to filter the radon barrier from internal erosion and piping due to hydrostatic forces in accordance with design criteria outlined in NUREG-4620. Neither of the two riprap types acts as a filter unto itself; however, this is not a concern due to the fact that the riprap layer is sized to provide erosion protection against wind and the PMP and was not originally designed to serve as a filter.

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6.0 Gas Hills East Cover Rehabilitation Review

The Gas Hills East, Wyoming, Disposal Site (GHE) is an UMTRCA Title II transition site located between Riverton and Casper, Wyoming. The GHE disposal cell was completed in 2006. In 2011, the cover underwent major repairs to correct erosion of the radon barrier that was occurring beneath the rock cover. The GHE circumstances were reviewed to determine if there were any similarities with the Mexican Hat disposal cell depressions and whether there were any lessons learned from the GHE cover failure that would be applicable for the Mexican Hat disposal cell. The differences between the GHE cover design that failed and the Mexican Hat cover design are summarized below.

6.1 Gas Hills East Design Differences

The design and construction of the Gas Hills East disposal cell is regulated under Title II of UMTRCA. The GHE disposal cell was originally constructed as an above-ground tailings impoundment. A cover referred to as the A-9 Repository Erosion Protection cover was installed over the tailings impoundment. Review of the A-9 cover design report (UMETCO Minerals Corporation 2010[14]) indicated that a bedding/filter layer was not necessary to handle interstitial flow velocities in accordance with the accepted procedure established in NRC NUREG/CR-4620[7]. The guidance available at the time of the GHE design in NUREG-4620 provided guidance on the calculation of interstitial velocities, indicating that velocities of up to 2.5 feet per second would not require a bedding/filter layer.

Since the original design interstitial velocities for the GHE disposal cell were calculated to be between 0.6 and 0.8 foot per second, a bedding/filter layer was not installed between the radon barrier and the riprap layers. However, the original design assumptions proved to be inadequate, and in 2011, radon barrier soil erosion was repaired and a bedding/filter layer was installed beneath the rock cover where Type C erosion protection was installed. During the repair activity, erosion gullies were observed within the radon barrier, measuring approximately 1–2 feet wide × 1–2 feet deep.

The GHE cover repair design used the NRC NUREG-1623[2] draft guidance to determine if bedding/filter material was required to accommodate the calculated interstitial velocities (Draft Guidance, February 1999). The NUREG-1623 guidance supersedes NUREG-4620, and states that interstitial velocities of 0.5 foot per second or less may not require a bedding/filter layer. When interstitial velocities are between 0.5 and 1.0 feet per second, the need for a filter layer is dependent on the soil material at the riprap–radon barrier interface. Finally, NUREG-1623 suggests that a filter layer should be provided when interstitial velocities are 1.0 feet per second or greater. It is noted here that one area within the Type C erosion protection had a slope that approached 20%, which was also the steepest slope on the GHE cover. During the original GHE disposal cell construction, a field decision was made to place a 3-inch-thick layer of bedding/filter material beneath the riprap rock in this area. Inspections of this area showed no signs of subgrade erosion, which supports the need for a filter material as determined during the cover redesign.

[14] UMETCO Minerals Corporation, 2010. *Gas Hills Reclamation Project Above Grade Tailings Impoundment and A-9 Repository Erosion Protection Enhancement Design Report*, December 20.

The Mexican Hat disposal cell is regulated under Title I of UMTRCA. At the time the disposal cell was designed, NUREG-4620 provided the recommended methods to determine interstitial velocities but did not provide standard velocity criteria to be used for filter design purposes. The Mexican Hat design calculations estimated that the maximum interstitial velocity would be 0.5 foot per second. Based on the available guidance at the time (NUREG-4620), interstitial velocities less than or equal to 2.5 feet per second may not require a bedding/filter layer. However, despite this the Mexican Hat cell design incorporated a bedding layer.

6.2 GHE Contractor Staff Interview

On July 20, 2016, Navarro personnel and LM representatives met with Mr. Tom Gieck of UMETCO Minerals Corporation (UMETCO) to gain insight into the issue the GHE project experienced with erosion below the riprap layer of the A-9 Repository Cover. According to UMETCO, interstitial surface water flow within the Type C riprap layer caused rill-type erosion at the radon barrier and riprap layer interface. UMETCO faults the lack of a bedding/filter layer as the cause of the erosion, which is supported with the field findings that erosion of the radon barrier was not observed in the area where bedding/filter material was installed during the original GHE disposal cell construction.

6.3 Summary of GHE Findings

Because the Mexican Hat disposal cell cover design already includes a bedding layer between the riprap and the radon barrier layers, the radon barrier erosion and the associated repairs that occurred at the Gas Hills East site have limited application for evaluating the depression features and radon barrier erosion at the Mexican Hat disposal cell. It is interesting to note, however, that no signs of radon barrier erosion were evident where bedding/filter material was placed during the original GHE disposal cell construction, as opposed to the Type C zones where no bedding was used and radon barrier erosion was identified.

7.0 Assessment Summary and Recommended Future Actions

Review of the original design calculations for the Mexican Hat disposal cell indicate that the design specifications for the riprap and bedding layers were properly sized for the PMP event. Field observations (see Section 3.1, Site Inspections and Visits) of the riprap and bedding layers provided visual confirmation that the installed materials would likely meet the required construction specification material thicknesses, but the required gradations for the bedding/filter layer as installed likely do not meet the construction specifications. The fine aggregate material of the specified bedding layer appears to be lacking in the lower portions of the northeast and north side slopes and is possibly overconcentrated near the top of these side slopes.

Voids, piping, and incisements in the radon barrier have been observed near the toes of the northeast and north side slopes of the disposal cell. Based on the characteristics of the observed features, including their locations towards the lower portions of the north and northeast side slopes, and the lack of fines in the bedding/filter materials in these areas (which would allow for higher runoff velocities in the bedding/filter material), it can be reasonably assumed that these features are the result of precipitation-induced erosion. No evidence of subsidence in these areas has been identified. As-built construction drawings of the disposal cell indicate that contaminated materials directly underlie the cell cover components in these areas. However, based on multiple field observations and a series of radiological surveys confirming the absence of elevated radiological readings, no evidence of a breach through the disposal cell cover has been identified, and the site remains protective of human health and the environment.

Actions that have been implemented since the first observation of the cover depressions in 2016 include:

1. Installation of a System Operation and Analysis at Remote Sites (SOARS)-based weather monitoring station that provides real-time 5-minute rainfall intensities to be measured.
2. Installation of a SOARS-based camera that provides real-time observation of the northeast side slope.
3. Initiation of semiannual ground-based light imaging, detection, and ranging (LiDAR) topographic surveys of the northeast side slope.
4. Initiation of aerial LiDAR topographic and other aerial surveys of the entire disposal cell.
5. Initiation of semiannual horizontal and vertical surveys using survey-grade GPS instrumentation of the six settlement plates located on the cell cover to assess if settlement of the cell is occurring.
6. Future preparation of survey monitoring status reports subsequent to each combined LiDAR and settlement plate survey event. Survey monitoring status reports would include documentation and analysis of LiDAR and settlement plate survey data, identification of any observed changes in empirical survey data, and a compilation and review of data associated with the onsite weather monitoring equipment.
7. Initiation of continuous radiological monitoring through the installation of paired radon monitoring cups and thermoluminescent dosimeters at locations inside and outside of the site boundary to develop a suitable data set that provides objective evidence that the disposal cell remains protective of human health and the environment.

Additional actions that have taken place since the 2016 observation of the cover depressions include:

1. Engagement of a geotechnical engineering SME, Mr. Ron Rager, who was the lead geotechnical engineer for the UMTRA program and who was involved with the engineering design of the Mexican Hat disposal cell.
2. Engagement of a geotechnical engineer from the University of Virginia, Dr. Craig Benson, Dean of the School of Engineering and Applied Science, who has extensive experience in the design and long-term performance of disposal cell covers.
3. Collaboration with engineers and scientists from the Navajo Nation Uranium Mill Tailings Remedial Action/Abandoned Mine Lands Department and the Desert Research Institute.

7.1 Precipitation Driver for Episode-Based LiDAR Surveys

Monthly and daily rainfall data collected since the completion of the cell were examined and compared to National Oceanic and Atmospheric Administration (NOAA) Atlas 14-point precipitation frequency estimates for the Mexican Hat weather station to estimate the recurrence interval of rainfall amounts at the disposal cell under various time intervals. Evaluation of rainfall during the monsoon months of July through September since the disposal cell was constructed (see Appendix D, p. 2) indicates a 95% confidence interval that monthly rainfalls during those monsoon months will be between 0.64 and 0.90 inch, which correlates well with the NOAA 90% probability 30-day point precipitation frequency estimate recurrence interval of something less than 1 year. The associated 5-minute rainfall amount for a 1-year recurrence interval is 0.124 inch (see Appendix D, p.3). The highest monthly rainfall measured in February 2015, the wettest year since completion of the cell (see Appendix D, p. 2), was 3.55 inches, which matches up to the NOAA point precipitation frequency estimate recurrence interval of 25–50 years and translates to a 5-minute rainfall amount of 0.342–0.407 inch. The highest daily rainfall during February 2015 was 1.45 inches, suggesting a recurrence interval of 25 years with an associated 5-minute rainfall of 0.342 inch. It is unknown what level of rainfall intensity has actually caused the radon barrier erosion that has been observed to date, but to be conservative, it is recommended that a recurrence interval of 2 years be used as the trigger to initiate an episodic LiDAR survey. The 5-minute rainfall amount for a 2-year storm with a 90% probability of occurrence is 0.16 inch (see Appendix D, p. 3).

Based on this information combined with the original design rainfall intensity of 53.5 inches per hour relating to a 2.5-minute T_c value, as discussed in Section 2.2.1, it is recommended that a site-specific precipitation event of 0.16 inch or more per 5-minute interval, determined by real-time data acquisition via the onsite SOARs meteorological station, be used as the trigger value for initiating episode-based LiDAR surveys.

7.2 Recommendations

Based on the reviews, investigations, and observations documented in this report and to mitigate the potential for erosion-related release of tailings or other RRM, the following actions are recommended.

1. Continue visual and radiological monitoring of the disposal cell with a focus on the north and northeast side slopes to ensure that the site remains protective of human health and the environment.
2. Continue monitoring the disposal cell via the terrestrial or aerial surveys and weather station actions that have been implemented at the site to date.
3. Perform interim radon barrier protection with suitable fill materials in areas with observed radon barrier degradation.
4. Conduct materials sampling and testing at targeted cover depression and non-depression locations on the east, northeast, north, and west side slopes of the disposal cell to determine how in-place materials conform with the original disposal cell construction specifications and determine if there are other material properties that may be contributing to the ongoing radon barrier erosion. Materials sampling and testing will be conducted to determine where in situ cell cover components (i.e., riprap, bedding layer, and the radon barrier) conform, or do not conform, with the engineering design and construction specifications. The investigation will focus on bedding layer gradation as well as the spatial distribution of cementitious material that has been observed immediately below the base of the bedding layer in test pits with observed radon barrier degradation; determining if the radon barrier is subject to degradation due to cation exchange, dispersive soils, or both; determining the lateral extent of RRM that was placed beneath the radon barrier near the toe of the northeast and north side slopes and under the drainage apron adjacent to the northeast side slope; and identifying potential sources and impacts of windblown material on the riprap rock surfaces and the sediment deposits in the northeast drainage apron.
5. Using information from the multiple site visits that have been conducted along with the information collected from the materials sampling and testing, determine the cause(s) of the depression features and identify possible corrective actions and how they would be implemented.
6. Prepare documentation of future materials sampling and testing field activities and results and any analyses associated with developing possible corrective actions.
7. Protect areas with substantial depressions on the northeast side slope as an interim measure while the cause(s) of the depression features are identified and a long-term remedy is developed.
8. Identify and engage a geomorphology SME to assist with the evaluation and development of erosion solutions.
9. Conduct an episodic LiDAR survey if precipitation intensities equal or exceed 0.16 inch per 5-minute interval, and compare episodic survey data to previous survey data to determine if additional materials have been removed as a result of the episodic rainfall event, causing the depressions to deepen or enlarge.

10. In accordance with the LTSP, if there is evidence that erosion is continuing to deepen or enlarge the depression features to the extent that the release of tailings is imminent or the cover is breached, the LMS contractor would, at DOE's request, initiate emergency response actions to repair the cover.

Implementation of the above recommendations is necessary to (1) obtain quantitative topographic information of the cell cover to track potential changes over time as they relate to meteorological events, (2) determine where in situ cell cover components conform, or do not conform, with the engineering design and construction specifications, (3) obtain qualitative and quantitative information to support the identification of the cause(s) of the cover depression features and associated radon barrier erosion, (4) mitigate the potential of a breach through the disposal cell cover that would result in the exposure or dispersal of RRM, (5) document the activities and findings of the recommended actions, (6) develop a path forward to develop a long-term remedy for the disposal cell erosion protection system, and (7) ensure ongoing protection of human health and the environment.

Appendix A

Hydrology Design Calculation

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Calculation Cover Sheet

REVIEWED FOR QUALITY REQUIREMENTS BY: C Ricketts
QA ENTRY NO.

Contract No. 5025-02 Discipline ESCUP

Calc. No. ~~9-223-01~~ 02

No. of Sheets ~~33~~ 34

Project

UMTRA - HAT/MON

Feature

SITE HYDROLOGY at HAT

Item

—

Sources of Data

—

Sources of Formulae & References

SEE SHEET 25

Preliminary Calc. ☒ Final Calc. ☒ Supersedes Calc. No. ______

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
02	SUPERSEDED RAINFALL DISTRIBUTION CALC.	S.E. Bedford	5/9/88	AB Hay	5/9/88	A. Byford	5/9/88
01	Time-Intensity Curve Revised Sheets 23-23A	R.F. Claire	5/7/87	HM	June 10/87	A. Byford	6/10/87
0	—	P.O. GREGORY	6-6-86	HM	8/20/86	A. Byford	8/25/86

IECO Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA-HAT	Contract No. 5025-02	Sheet i
Feature SITE HYDROLOGY	Designed PDG	File No.
Item —	Checked HM	Date 5-21-86
		Date 5/30/86

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A MORRISON KNUDSEN COMPANY

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Feature SITE HYDROLOGY	Designed PQG	File No.
Item —	Checked HM	Date 5-21-86
		Date 8/15/86

1. PURPOSE

This calculation presents the hydrologic parameters required for the design of both temporary and permanent site drainage features. Storm intensities and distributions are developed for the following design storms:

10-year 1-hour storm
25-year 1-hour storm
10-year 24-hour storm
PMP

2. HYDROLOGY FOR TEMPORARY DRAINAGE

a. Requirements

For the design of temporary drainage structures (including all ditches and retention basins) the following design storms are required (DOE 1986, pp. 62-63)

10-year 1-hour storm
25-year 1-hour storm
10-year 24-hour storm

All of the storms can be evaluated using the NOAA Precipitation Frequency Atlas of the US. Volume 6, Utah (DOC, 1973).

b. 10-year, 1-hour storm

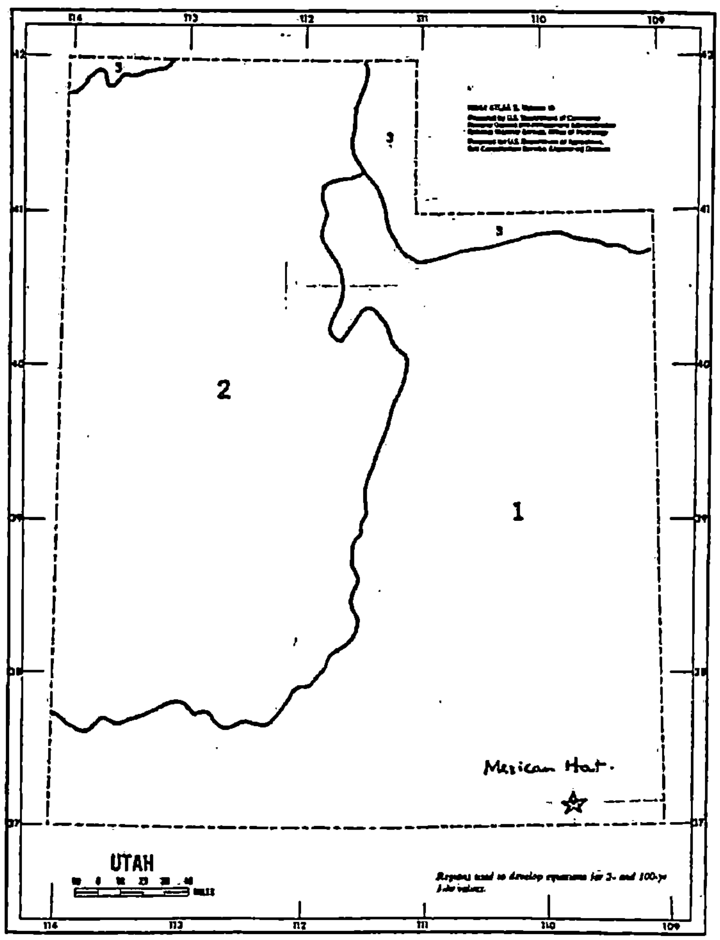
The storms are developed based on the maps and methods given in the Atlas (DOC, 1973).

1) Location of site

From d RAP (DOE, 1986, Appendix D, page D-1)

37° 08' N POG 8-20-86
109° 53' W

2) Select appropriate region — from Fig. 18 (DOC, 1973) use region 1. (see next below)



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Project UMTRA-HAT	Contract No. 5025-02	Sheet 3	File No.:
Feature SITE HYDROLOGY	Designed POG	Date 5-22-86	
Item —	Checked [illegible]	Date [illegible] 15/86	

3) For region 1, the following equations are used:

$$Y_2 = -0.011 + 0.942\,[(X_1)(X_1/X_2)]$$

$$Y_{100} = 0.494 + 0.755\,[(X_3)(X_3/X_4)]$$

These equations are taken from Table 11 (DOC, 1973), which is reproduced below:

Equations for estimating 1-hr values in Utah with statistical parameters for each equation

Region of applicability*	Equation	Corr. coeff.	No. of stations	Mean of computed stn. values (inches)	Standard error of estimate (inches)
Utah south of the Unitas east of Wasatch, and east and south of Boulder and Pine Valley Mountains (1)	$Y_2 = -0.011 + 0.942[(X_1)(X_1/X_2)]$	0.95	86	0.72	0.085
	$Y_{100} = 0.494 + 0.755[(X_3)(X_3/X_4)]$	.90	85	1.96	.290
Most of western Utah (2)	$Y_2 = 0.005 + 0.852[(X_1)(X_1/X_2)]$	.89	65	0.41	.047
	$Y_{100} = 0.322 + 0.789[(X_3)(X_3/X_4)]$	.87	65	1.25	.196
Northeast and northwest corners of Utah (3)	$Y_2 = 0.019 + 0.711[(X_1)(X_1/X_2)] + 0.001Z$	.82	98	0.40	.031
	$Y_{100} = 0.338 + 0.670[(X_3)(X_3/X_4)] + 0.001Z$	.80	79	1.04	.141

* Numbers in parentheses refer to geographic regions shown in figure 18. See text for more complete description.

List of variables
Y_2 = 2-yr 1-hr estimated value
Y_{100} = 100-yr 1-hr estimated value
X_1 = 2-yr 6-hr value from precipitation-frequency maps
X_2 = 2-yr 24-hr value from precipitation-frequency maps
X_3 = 100-yr 6-hr value from precipitation-frequency maps
X_4 = 100-yr 24-hr value from precipitation-frequency maps
Z = point elevation in hundreds of feet

The values of X_1, X_2, X_3, and X_4 are determined from Figs. 19, 25, 24, & 30, respectively (DOC, 1973). The figures are reproduced on the following four sheets. The resulting X-values are given below:

X_1 = 0.8 in (see sht. 4)

X_2 = 1.0 in ✓ (see sht. 5)

X_3 = 2.0 in ✓ (see sht. 6)

X_4 = 2.6 in (see sht 7)

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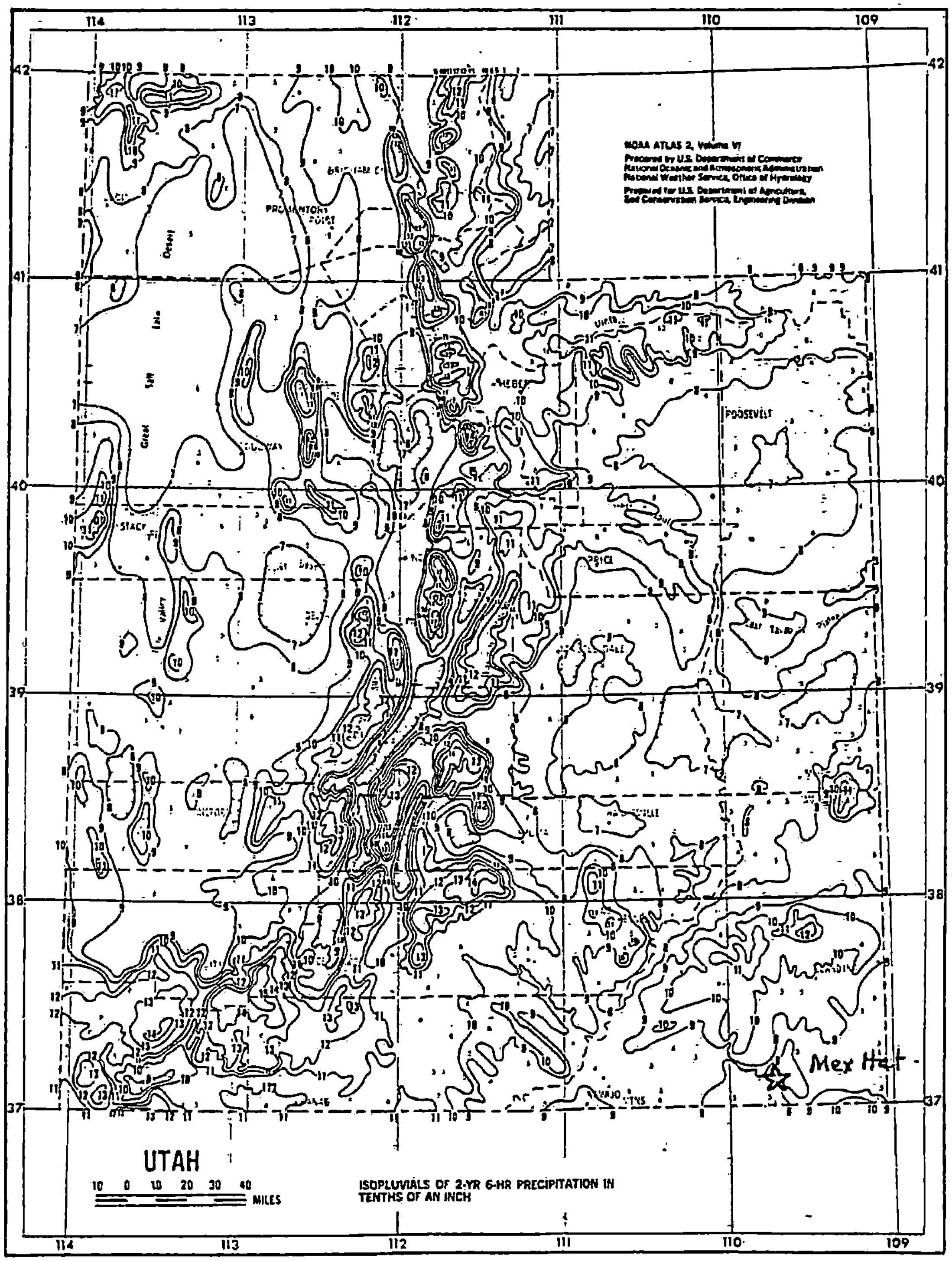
Project UMTRA - HAT	Contract No. 5025-02	Sheet 4	File No.
Feature SITE HYDROLOGY	Designed PDG	Date 5-22-86	
Item —	Checked HM	Date 8/15/86	



MAP FOR DETERMINATION OF X_1 – Fig. 19 (DOC, 1973)

$X_1 = 0.8$ in

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Sheet 5

Project UMTRA-HAT

Contract No. 5025-02

File No.

Feature SITE HYDROLOGY

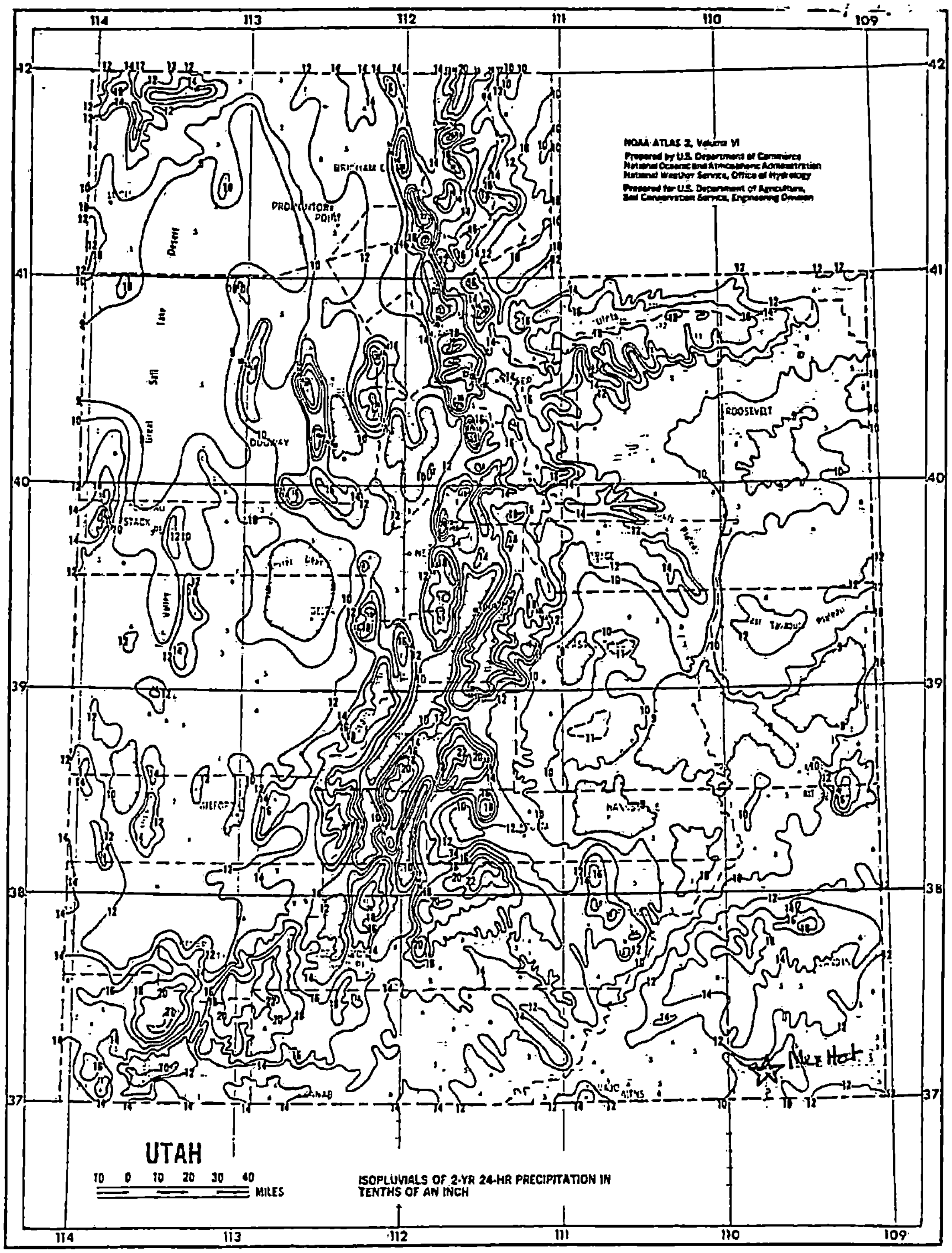
Designed POG

Date 5-22-86

Item —

Checked HM

Date 8/15/86



MAP FOR DETERMINATION OF X_2 - Fig. 25 (DOC, 1973)

$X_2 = 1.0$ in

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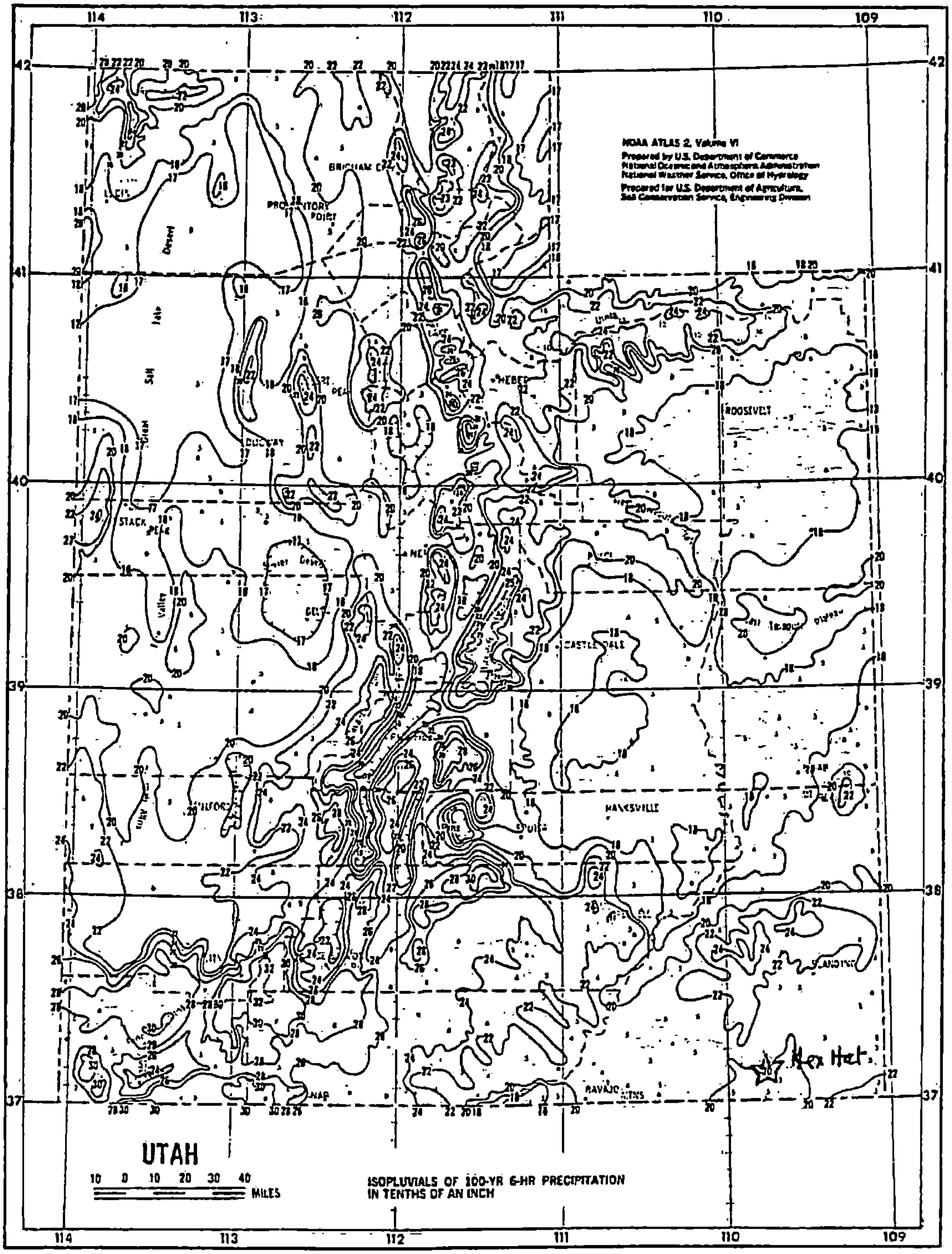
Project	UMTRA-HAT	Contract No. 5025-02	Sheet 6
			File No.
Feature	SITE HYDROLOGY	Designed POG	Date 5-22-86
Item	—	Checked HM	Date 8/15/86



MAP FOR DETERMINATION OF X_3 – Fig. 24 (DOC, 1973)

X_3 = 20 inches

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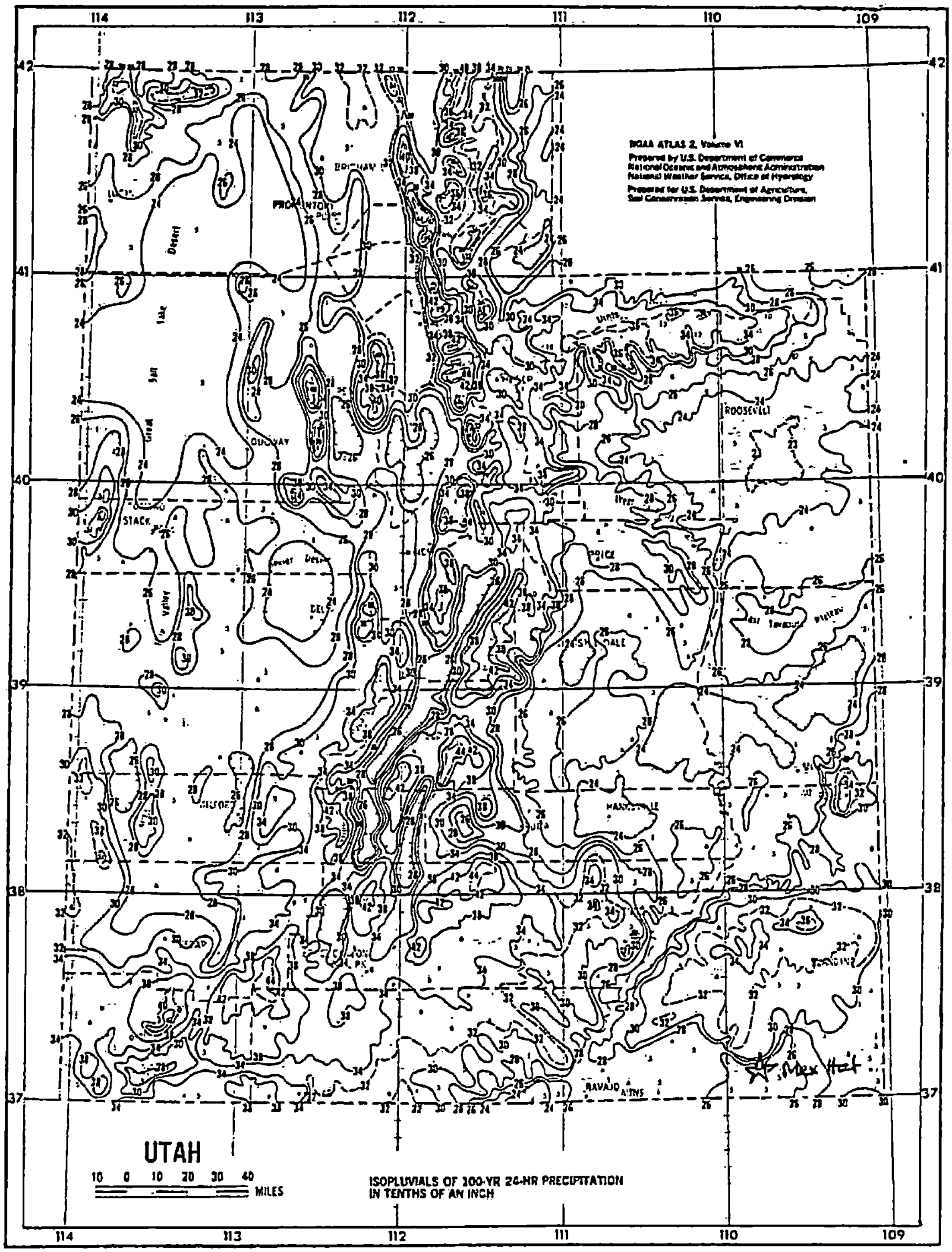
Project	UMTRA - HAT	Contract No. 5025-02	Sheet 7
			File No.:
Feature	SITE HYDROLOGY	Designed POG	Date 5-22-86
Item	—	Checked HM	Date 8/15/86



ISOPLUVIALS OF 100-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

MAP FOR DETERMINATION OF X_4 - Fig. 30 (DOC, 1973)

$X_4 = 2.6$ in

$$\therefore \quad Y_2 = -0.011 + 0.942\left(\frac{0.8 \times 0.8}{1.0}\right) = 0.59 \text{ in}$$

$$Y_{100} = 0.494 + 0.755\left(\frac{2.0 \times 2.0}{2.6}\right) = 1.66 \text{ in}$$

These values are input into Fig. 17A (DOC, 1973) for determination of the 10-year, 1-hour storm as shown below:

Illustration of use of precipitation-frequency diagrams using values from precipitation-frequency maps and relations at Blanding, Utah.

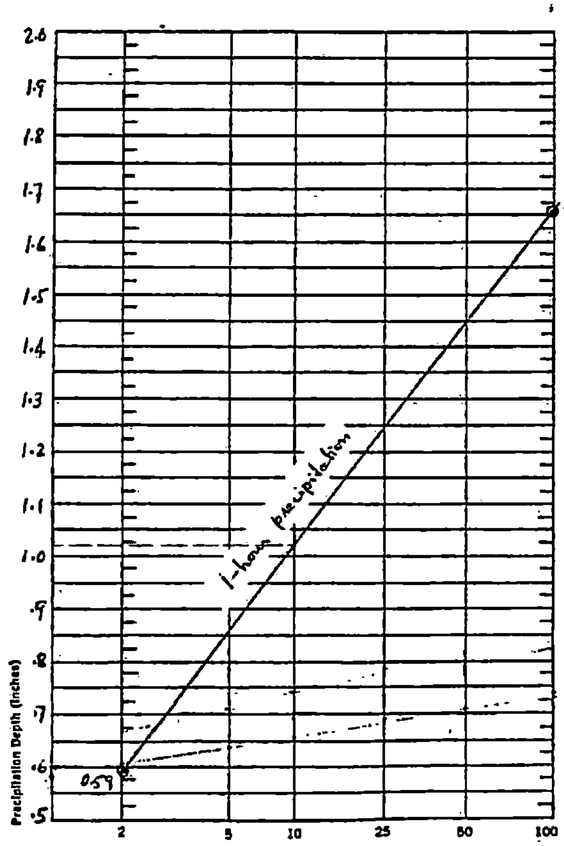


Figure 17A (DOC, 1973)

The 10-year, 1-hr intensity is found to be 1.02 in.
The intensity-duration curve for periods less than 1-hour are developed using Table 12 (DOC, 1973) which is shown on sht. 9.

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Project UMTRA - HAT	Contract No. 5025-02	Sheet 9	File No.
Feature SITE HYDROLOGY	Designed PDG	Date 5-22-86	
Item —	Checked HM	Date 8/15/86	

Duration (min)	5	10	15	30
Ratio to 1-hr	0.29	0.45	0.57	0.79

(Adopted from *U.S. Weather Bureau Technical Paper* No. 40, 1961.)

Table 12. *Adjustment factors to obtain n-min estimates from 1-hr values*

The corresponding values for a 1-hour rainfall of 1.02 in is

Duration	5 min	10 min	15 min	30 min	60 min
Rainfall	0.30"	0.46"	0.58"	0.81"	1.02"
Intensity*	3.6"/hr ✓	2.8"/hr	2.3"/hr	1.6"/hr	1.02"/hr

* Intensity is equal to $\frac{(\text{Rainfall}) \times (60\text{ min})}{(\text{Duration})}$

The intensity duration curve for the 10-year 1-hour storm is plotted on sht. 10.

4) The storm distribution, or hyetograph of the 10-year, 1-hour storm is required for input into the reservoir routing models used in design of the temporary drainage features. The hyetograph is developed based upon those presented by Huff (1967). A second quartile, 50% probability storm distribution is used as these were found to be the most storm typic. The hyetograph for a 1-hour storm is presented in terms of percent total rainfall on sheet 11.

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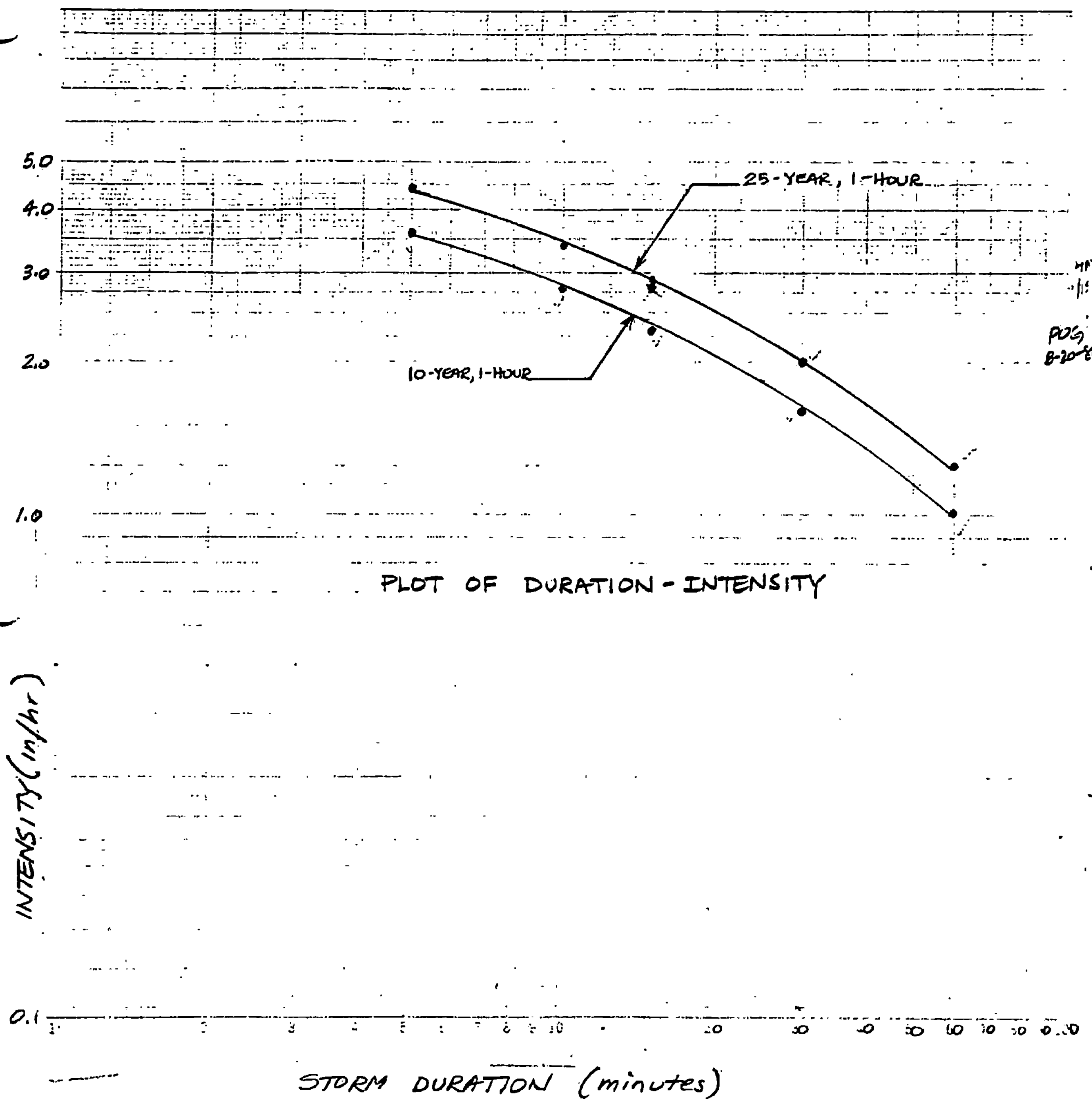
Project: UMTRA - HAT
Feature: SITE HYDROLOGY
Item: —

Contract No. 5025-02
Designed: POG
Checked: HM

Sheet: 10
File No.:
Date: 5-22-86
Date: 8/15/85



PLOT OF DURATION - INTENSITY

MORRISON-KNUDSEN ENGINEERS, INC.
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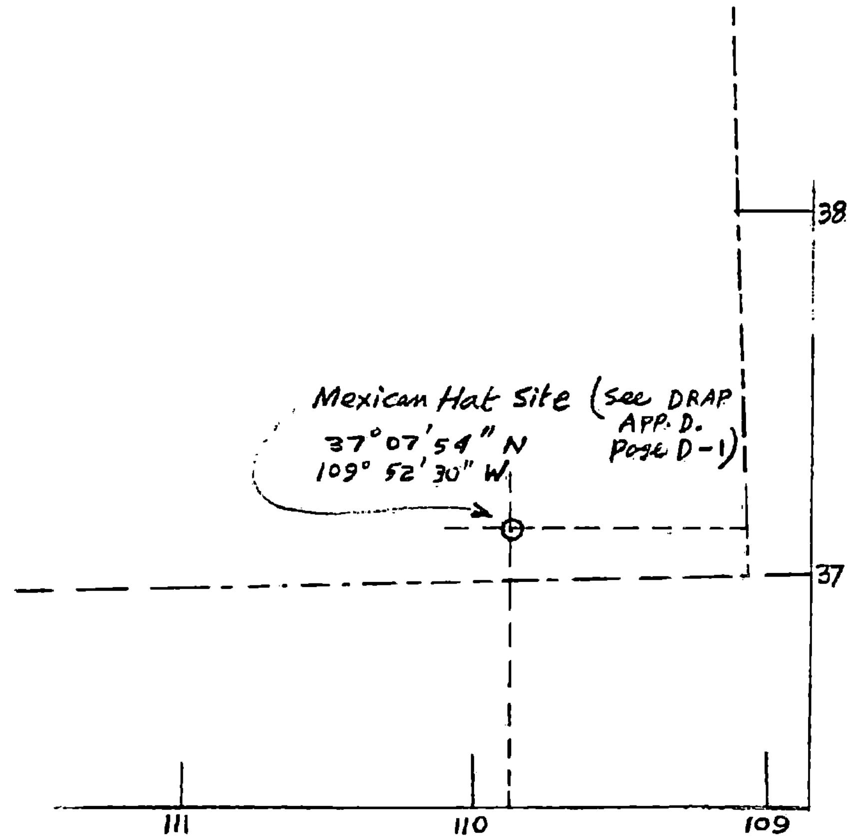
Sheet 10A/1

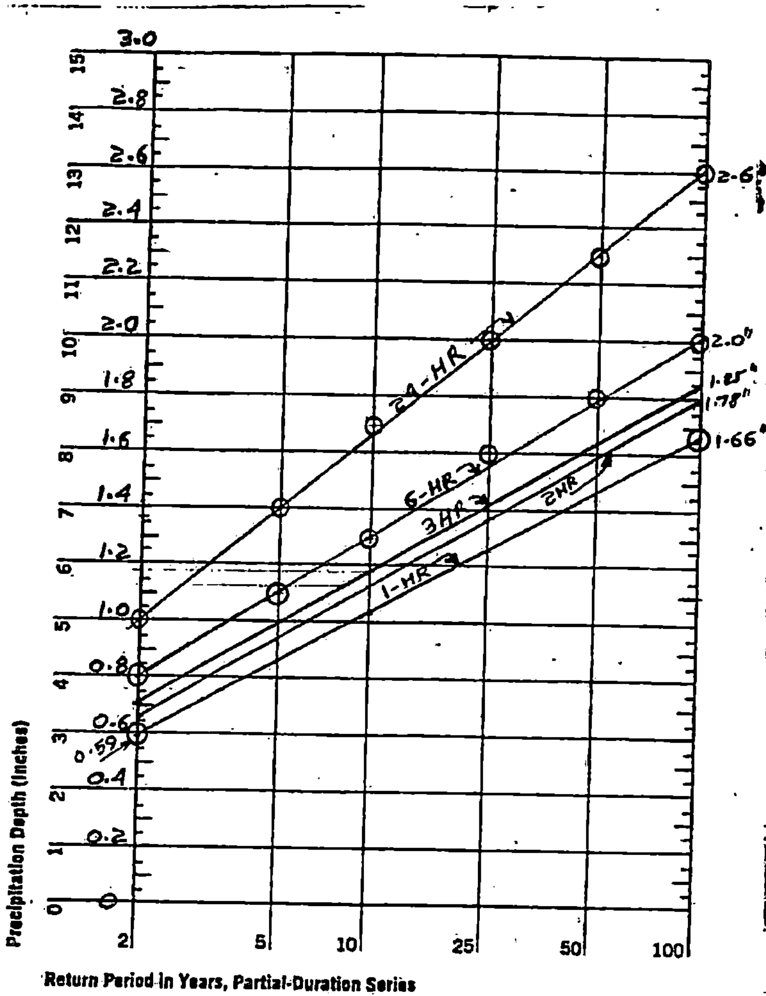
Project UMTRA/HAT — Contract No. 5025-02 — File No.

Feature HYDROLOGY – MEXICAN HAT SITE — Designed HM — Date 8/15/86

Item — Checked PO GREGORY — Date 8-20-86



Recurrence Interval (Year)	Rainfall Depths (Inches) 6 HOUR	24 HOURS
2	0.8" ✓	1.0"
5	1.1" ✓	1.4"
10	1.3" ✓	1.7" ✓
25	1.6" ✓	2.0" ✓
50	1.8" ✓	2.3" ✓
100	2.0" ✓	2.6" ✓



The 6-Hr and 24-Hr rainfall depths at various recurrence intervals (as tabulated on sheet 10A) and also the 1-Hr rainfall depths from Sheet 8 are plotted on the Figure on this sheet.

To estimate 2-Hr and 3-Hr precip values, the following equations are used (DOC, 1973, page 16):

2-Hr = 0.341(6-Hr) + 0.659(1-Hr)
3-Hr = 0.569(6-Hr) + 0.431(1-Hr)

∴ 2-Yr 2-Hr
= 0.341 (6-Hr 2-Yr) + 0.659 (1-Hr 2-Yr)
= 0.341(0.8) + 0.659(0.59)
= 0.66"

2-Yr 3-Hr
= 0.569 (6-Hr 2-Yr) + 0.431 (1-Hr 2-Yr)
= 0.569(0.8) + 0.431(0.59)
= 0.71"

Similary 100-Yr, 2-Hr = 0.341(2.0) + 0.659(1.66)
= 1.78"

and, 100-Yr, 3-Hr = 0.569(2.0) + 0.431(1.66)
= 1.85"

The 2-Hr and 3-Hr values are also plotted on the Figure on this page.

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Project	UMTRA - Mexican Hat	Contract No. 5025	Sheet 10C/
Feature	Site Hydrology ...	Designed ABH	File No. · Date 1/2/86
Item		Checked AS HM	Date 1/10/86 8/20/86

Using NOAA Atlas 2, Vol 6 (Ref. 1), Figs 19, 24, 25 & 30, at Mexican Hat Site (37°09' 08' N & 109°53' W)

X_1: 2-yr, 6-hr precip = 0.8 inch ✓

X_2: 2-yr, 24-hr precip = 1.0 inch ✓

X_3: 100-yr, 6-hr precip = 2.0 inch. ✓

X_4: 100-yr, 24-hr precip = 2.6 inch ✓

Then using Table 11 (Ref. 1), 1-hr precip. values are obtained for the SE region as follows:

Y_2: 2-yr, 1-hr precip

$$= -0.011 + 0.942[X_1 (X_1/X_2)] \checkmark$$

$$= -0.011 + 0.942\left(\frac{0.8 \times 0.8}{1.0}\right) = 0.59 \text{ inches} \checkmark$$

Y_{100}: 100-yr, 1-hr precip

$$= 0.494 + 0.755[X_3 (X_3/X_4)]$$

$$= 0.494 + 0.755\left(\frac{2.0 \times 2.0}{2.6}\right) = 1.66 \text{ inches} \checkmark$$

Then using Fig 17A (Ref. 1) for plotting position, the partial-duration precipitation for return periods between 2- and 100-yrs are obtained. Adjustment factors for n-minute estimates from Table 12 (Ref 1) are then used to calculate fractional-hour precipitations.

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Project UMTRA - HAT
Feature SITE HYDROLOGY
Item —

Contract No. 5025
Designed ABH
Checked AS HM

Sheet 10 D/
File No.
Date 1/6/86
Date 1/10/86 8/20/86

Return Period, Years	Precipitation, inches — Duration, 1-hour	30-min.	15-min	10-min	5-min.
		x.79	x.57	x.45	x.29 ← (Ref 1, Table 12)
2	→ 0.59	0.47	0.34	0.27	0.17
5	0.86	0.68	0.49	0.39	0.25
10	1.02	0.81	0.58	0.46	0.30
25	1.25	0.99	0.71	0.56	0.36
50	1.45	1.15	0.83	0.65	0.42
100	→ 1.66	1.31	0.95	0.75	0.48

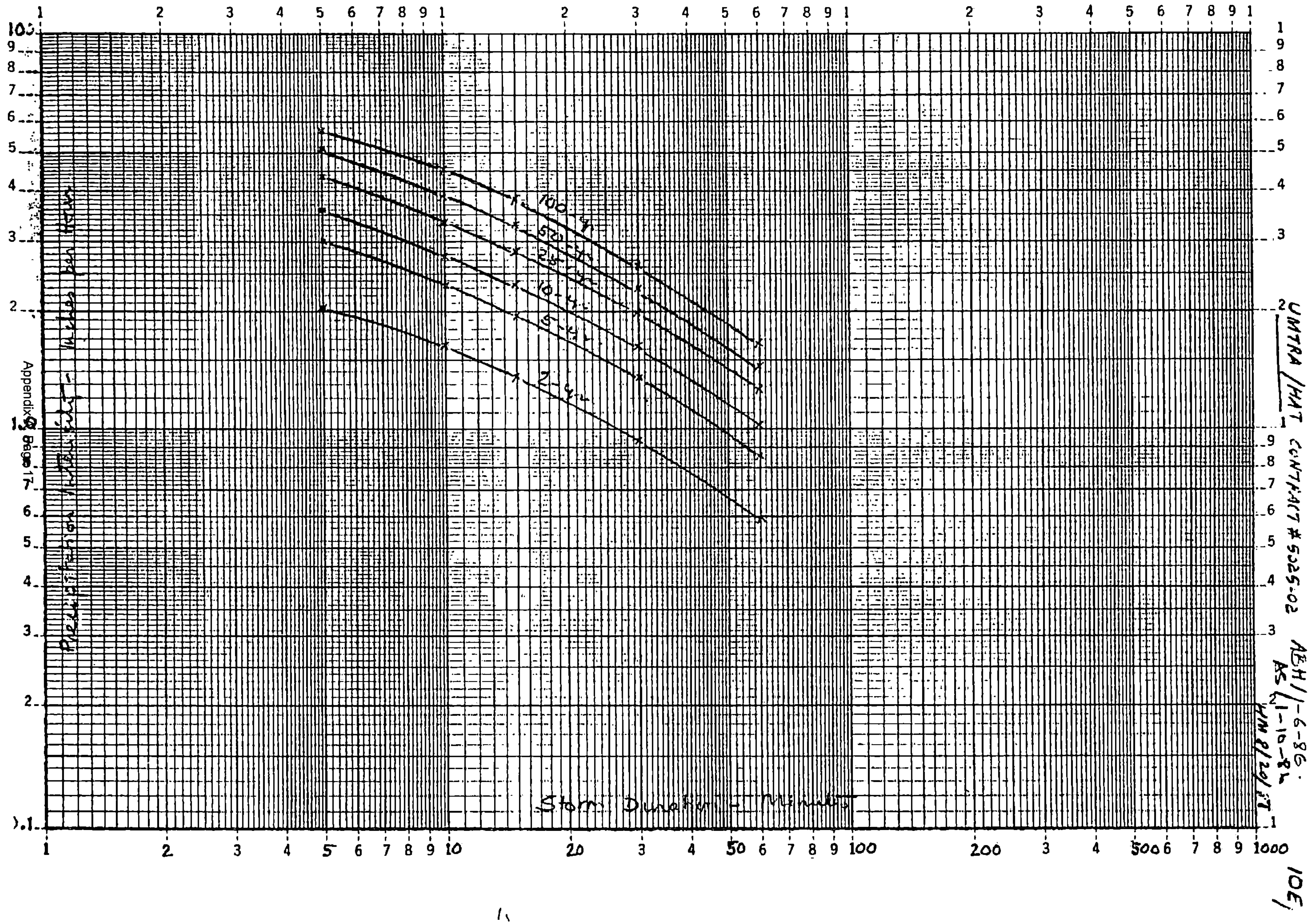
Using Ref 1, Fig 17A.

Alternatively, the precipitation can be expressed as intensity, by dividing by time duration, as follows:

Return Period, Years	Intensity, inches/hour — Duration, 1-hour	30-min	15-min.	10-min.	5-min
2	0.59	0.94	1.36	1.62	2.04
5	0.86	1.36	1.96	2.34	3.00
10	1.02	1.62	2.32	2.76	3.60
25	1.25	1.98	2.84	3.36	4.32
50	1.45	2.30	3.32	3.90	5.04
100	1.66	2.62	3.80	4.50	5.76

K+Σ LOGARITHMIC • 2 X 3 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 7323



K·E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

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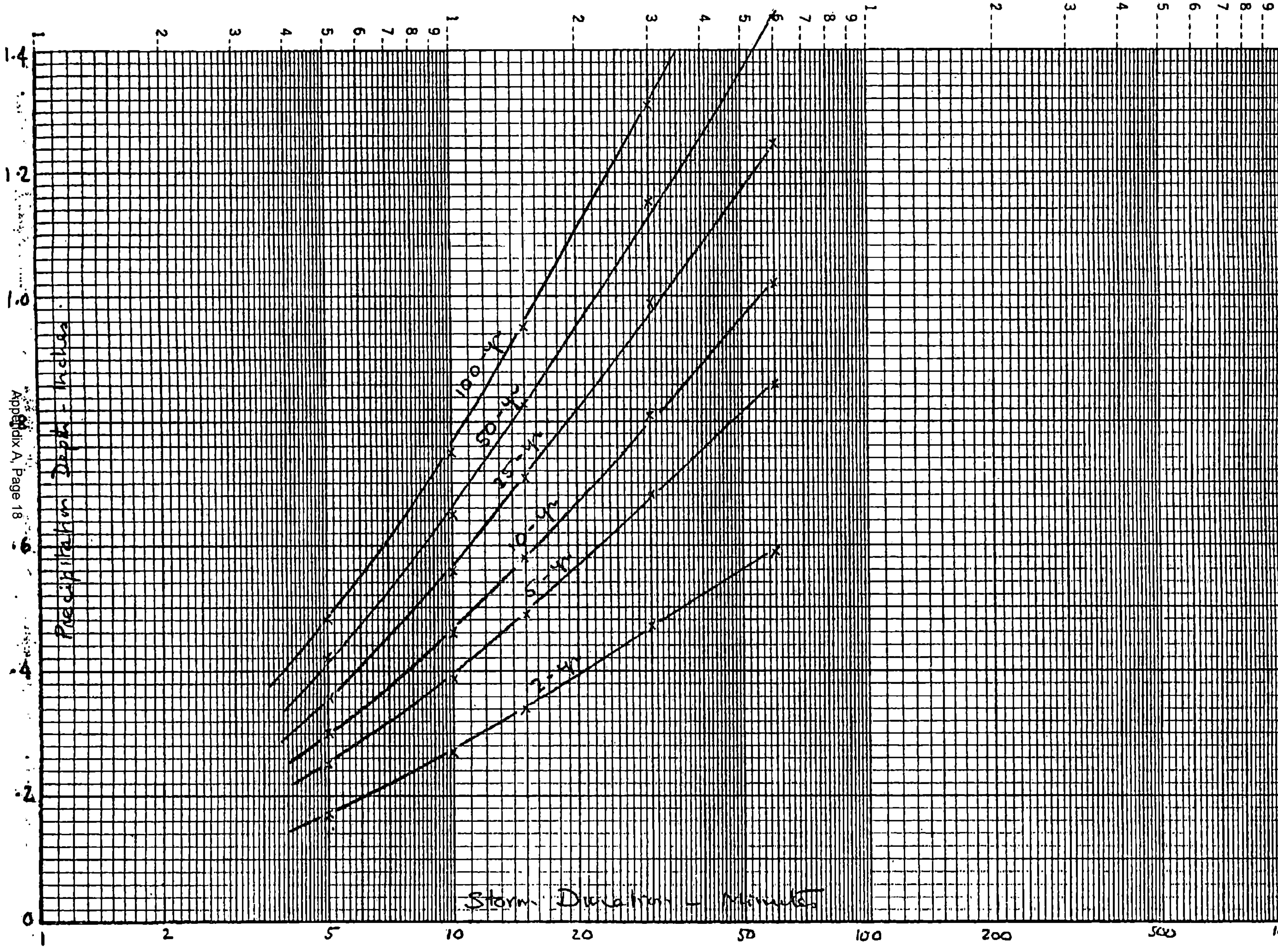

UMTRA/HAI
CONTRACT # 5025-02
ABH/1-6-86
AS 1/10/86
1 OF 1

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Project: UMTRA - HAT	Contract No. 5025-02	Sheet 11	File No.
Feature: Site Hydrology	Designed POG	Date 6-3-86	
Item: —	Checked HM	Date 8/19/86	

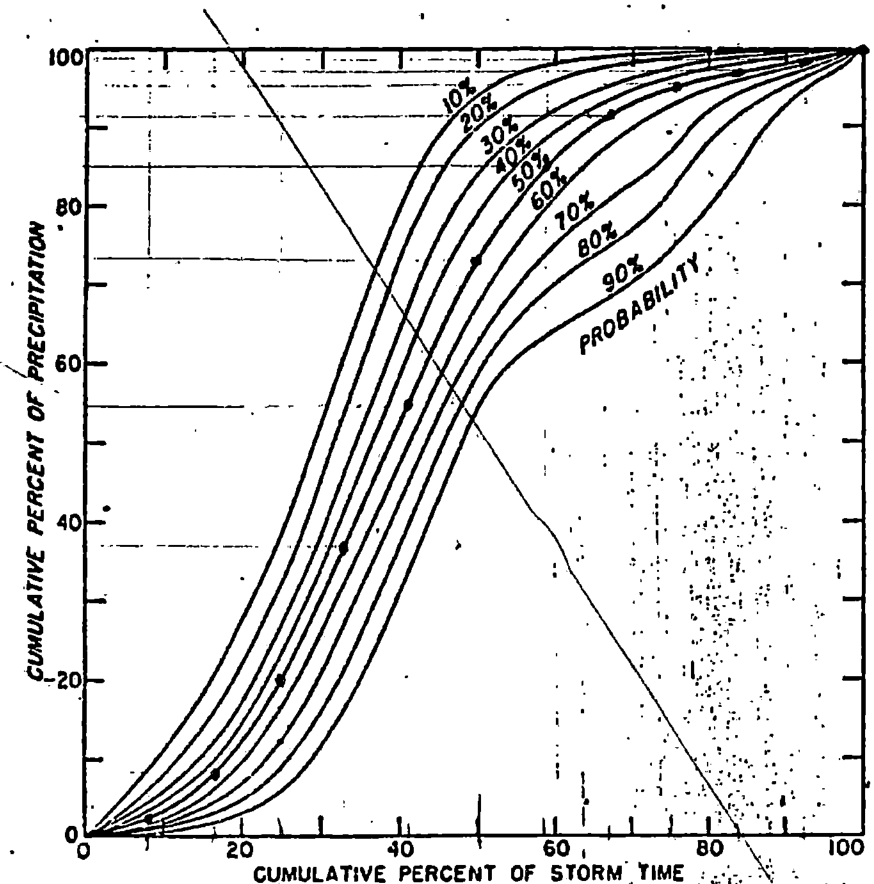

Fig. 4. Time distribution of second-quartile storms.

(from Huff (1967) p. 1010)

TIME	% TOTAL RAINFALL
0	
5 min	3
10	5
15	12
20	17
25	19
30	18
35	12
40	7
45	4
50	2
55	1
60	1

NOT USED
SUPERSEDED
BY CALC
9-230-01
SHEETS 23 AND 24
SLB 5-9-88

c) 25-year, 1-hour storm

The 25-year, 1-hour storm intensity is determined from Fig. 17A (DOC, 1973), as given on sheet 8 and is found to be 1.25 in.

The corresponding values for a 1-hour rainfall of 1.25 in are found using Table 12 on sheet 9:

Duration	5 min	10 min	15 min	30 min	60 min
Rainfall	0.36"	0.56"	0.71"	0.99"	1.25"
Intensity*	4.4"/hr	3.4"/hr	2.8"/hr	2.0"/hr	1.25"/hr

POG 8-20-86

The intensity-duration curve for the 25-year, 1-hour storm is plotted on sheet 10. ✓

d) 10-year 24-hour storm

1) The 10-year, 24-hour precipitation is 1.7 inches (DOE, 1986, p. D-274) POG 8-20-86

2) The rainfall distribution (hyetograph) for this storm is developed using the figure on sheet 11 and is given below.

SUPERSEDED SHB 5-9-88

TIME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
% TOTAL RAINFALL	1	1	2	3	4	8	8	9	9	9	10	8	7	5	4	3	2	2	2	1	1	1	1	1	= 100

* Intensity is equal to $\frac{(\text{Rainfall}) \times (60\ \text{min})}{(\text{Duration})}$

POG 8-20-86

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Project UMTRA-HAT	Contract No. 5025-02	Sheet 13	File No.
Feature SITE HYDROLOGY	Designed POG	Date 6-3-86	
Item —	Checked HM	Date 5/18/85	

3. HYDROLOGY FOR PERMANENT DRAINAGE

a. Requirements

For the design of permanent drainage features, including all permanent drainage ditches and erosion protection, the duration-intensity relationship for the probable maximum precipitation (PMP) is needed. The PMP can be calculated for either (1) a general storm or (2) a local storm (DOC, 1977). Both the general and local PMP need to be determined and compared in order to find the worst case precipitation.

b. General-Storm PMP

The general-storm PMP is calculated using the methods presented in Section 5.C of Hydromet 49 (DOC, 1977). The worksheets for determining the general-storm PMP (Table 6. of Hydromet 49) are included on the following 6 sheets. The resulting monthly general-storm PMP ~~intensities~~ values are tabulated below:

HM 3/19/87

MONTH	6 HOUR	12	18	24	48	72
J	3.3 in	4.9	6.0	6.8	9.0	10.2 ✓
F	3.3	4.9	6.0	6.8	9.0	10.2 ✓
M	3.4	5.0	6.0	6.8	9.0	10.0 ✓
A	3.6	5.2	6.3	7.1	9.3	10.4
M	3.7	5.3	6.4	7.2	9.4	10.4 ✓
J	4.1	5.7	6.7	7.5	9.6	10.6 ✓
J	4.9	6.7	7.7	8.6	10.9	11.9
A	~~6.5~~ 5.5 HM 5/18/85	7.4	8.5	9.4	11.9	12.9
S	5.5 POG 8-20-86	7.4	8.5	9.4	11.9	12.9 ✓
O	5.1	6.9	8.1	9.0	11.5	12.6 ✓
N	~~4.1~~ 4.[illegible]	~~5.9~~ 5.8	~~7.1~~ 7.6	~~8.1~~ 7.9	~~10.7~~ 10.4	~~12.0~~ 11.7
D	3.6	~~5.3~~ 5.[illegible]	~~6.4~~ 6.1	~~7.4~~ 7.0	~~9.9~~ 9.[illegible]	~~11.2~~ 11.5

HM 5/18/85
POG 8-20-86

Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM   Area ________ mi² (km²)

Latitude 37°09'N, Longitude 109°53'W of basin center

Month JAN

Step		Duration (hrs) 6	12	18	24	48	72	
A.	**Convergence PMP**							
1.	Drainage average value from one of figures 2.5 to 2.16 8.4 in. (mm)							
2.	Reduction for barrier-elevation [fig. 2.18] 51 %							
3.	Barrier-elevation reduced PMP [step 1 X step 2] 4.3 in. (mm)							
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].	59	80	92	100	121	134	%
5.	Convergence PMP for indicated durations [steps 3 X 4]	2.5	3.4	4.0	4.3	5.2	5.8	in. (mm)
6.	Incremental 10 mi² (26 km²) PMP [successive subtraction in step 5]	2.5	0.9	0.6	0.3	0.9	0.6	in. (mm)
7.	Areal reduction [select from figs. 2.28 and 2.29]							%
8.	Areally reduced PMP [step 6 X step 7]	2.5	0.9	0.6	0.3	0.9	0.6	in. (mm)
9.	Drainage average PMP [accumulated values of step 8]	2.5	3.4	4.0	4.3	5.2	5.8	in. (mm)
B.	**Orographic PMP**							
1.	Drainage average orographic index from figure 3.11a to d. (Revised) 3 in. (mm)							
2.	Areal reduction [figure 3.20] 100 %							
3.	Adjustment for month [one of figs. 3.12 to 3.17] 83 %							
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3] 2.5 in. (mm)							
5.	Durational variation [table 3.9]	32	59	81	100	132	177	%
6.	Orographic PMP for given durations [steps 4 X 5]	0.8	1.5	2.0	2.5	3.8	4.4	in. (mm)
C.	**Total PMP**							
1.	Add steps A9 and B6	3.3	4.9	6.0	6.8	9.0	10.2	in. (mm)
2.	PMP for other durations from smooth curve fitted to plot of computed data.							
3.	Comparison with local-storm PMP (see sec. 6.3).							

150

Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM   Area < 1.0 mi² (km²)

Latitude 37°09'N, Longitude 109°53'W of basin center

Month FEB

Step		Duration (hrs) 6	12	18	24	48	72	
A.	**Convergence PMP**							
1.	Drainage average value from one of figures 2.5 to 2.16 8.4 in. (mm)							
2.	Reduction for barrier-elevation [fig. 2.18] 51 %							
3.	Barrier-elevation reduced PMP [step 1 X step 2] 4.3 in. (mm)							
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].	59	80	92	100	121	134	%
5.	Convergence PMP for indicated durations [steps 3 X 4]	2.5	3.4	4.0	4.3	5.2	5.8	in. (mm)
6.	Incremental 10 mi² (26 km²) PMP [successive subtraction in step 5]	2.5	0.9	0.6	0.3	0.9	0.6	in. (mm)
7.	Areal reduction [select from figs. 2.28 and 2.29]							%
8.	Areally reduced PMP [step 6 X step 7]	2.5	0.9	0.6	0.3	0.9	0.6	in. (mm)
9.	Drainage average PMP [accumulated values of step 8]	2.5	3.4	4.0	4.3	5.2	5.8	in. (mm)
B.	**Orographic PMP**							
1.	Drainage average orographic index from figure 3.11a to d. (Revised) 3 in. (mm)							
2.	Areal reduction [figure 3.20] 100 %							
3.	Adjustment for month [one of figs. 3.12 to 3.17] 82 %							
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3] 2.5 in. (mm)							
5.	Durational variation [table 3.9]	32	59	81	100	152	177	%
6.	Orographic PMP for given durations [steps 4 X 5]	0.8	1.5	2.0	2.5	3.8	4.4	in. (mm)
C.	**Total PMP**							
1.	Add steps A9 and B6	3.3	4.9	6.0	6.8	9.0	10.2	in. (mm)
2.	PMP for other durations from smooth curve fitted to plot of computed data.							
3.	Comparison with local-storm PMP (see sec. 6.3).							

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Project UMTRA - HAT   Sheet 14
Feature SITE HYDROLOGY   Contract No. 5025-02   File No.
Item   Designed PDS   Date 6-3-86
Checked   Date

Table 6.1.--General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT Area ______ mi^2 (km^2)
Latitude 37°09'N, Longitude 109°53'W of basin center

Month MAR

Step		6	12	18	24	48	72	
A.	**Convergence PMP**							
1.	Drainage average value from one of figures 2.5 to 2.16	8.4						in. (mm)
2.	Reduction for barrier-elevation [fig. 2.18]	51						%
3.	Barrier-elevation reduced PMP [step 1 X step 2]	4.3						in. (mm)
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].	61	81	92	100	120	131	%
5.	Convergence PMP for indicated durations [steps 3 X 4]	2.6	3.5	4.0	4.3	5.2	5.6	in. (mm)
6.	Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	2.6	0.9	0.5	0.3	0.9	0.4	in. (mm)
7.	Areal reduction [select from figs. 2.28 and 2.29]	-	-	-	-	-	-	%
8.	Areally reduced PMP [step 6 X step 7]	2.6	0.9	0.5	0.3	0.9	0.4	in. (mm)
9.	Drainage average PMP [accumulated values of step 8]	2.6	3.5	4.0	4.3	5.2	5.6	in. (mm)
B.	**Orographic PMP**							
1.	Drainage average orographic index from figure 3.11a to d. (Revised)	3						in. (mm)
2.	Areal reduction [figure 3.20]	100						%
3.	Adjustment for month [one of figs. 3.12 to 3.17]	84						%
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	2.5						in. (mm)
5.	Durational variation [table 3.9]	32	59	81	100	152	177	%
6.	Orographic PMP for given durations [steps 4 X 5]	0.8	1.5	2.0	2.5	3.8	4.4	in. (mm)
C.	**Total PMP**							
1.	Add steps A9 and B6	3.4	5.0	6.0	6.8	9.0	10.0	in. (mm)
2.	PMP for other durations from smooth curve fitted to plot of computed data.							
3.	Comparison with local-storm PMP (see sec. 6.3).							

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Table 6.1.--General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM Area <1.0 mi^2 (km^2)
Latitude 37°09'N, Longitude 109°53'W of basin center

HM
PDG
8-20-86

Month APR

Step		6	12	18	24	48	72	
A.	**Convergence PMP**							
1.	Drainage average value from one of figures 2.5 to 2.16	8.8						in. (mm)
2.	Reduction for barrier-elevation [fig. 2.18]	51						%
3.	Barrier-elevation reduced PMP [step 1 X step 2]	4.5						in. (mm)
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].	63	82	93	100	118	128	%
5.	Convergence PMP for indicated durations [steps 3 X 4]	2.8	3.7	4.2	4.5	5.3	5.8	in. (mm)
6.	Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	2.8	0.9	0.5	0.3	0.8	0.5	in. (mm)
7.	Areal reduction [select from figs. 2.28 and 2.29]							%
8.	Areally reduced PMP [step 6 X step 7]	2.8	0.9	0.5	0.3	0.8	0.5	in. (mm)
9.	Drainage average PMP [accumulated values of step 8]	2.8	3.7	4.2	4.5	5.3	5.8	in. (mm)
B.	**Orographic PMP**							
1.	Drainage average orographic index from figure 3.11a to d. (Revised)	3						in. (mm)
2.	Areal reduction [figure 3.20]	100						%
3.	Adjustment for month [one of figs. 3.12 to 3.17]	85						%
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	2.6						in. (mm)
5.	Durational variation [table 3.9]	32	59	81	100	152	177	%
6.	Orographic PMP for given durations [steps 4 X 5]	0.8	1.5	2.1	2.6	4.0	4.6	in. (mm)
C.	**Total PMP**							
1.	Add steps A9 and B6	3.6	5.2	6.3	7.1	9.3	10.4	in. (mm)
2.	PMP for other durations from smooth curve fitted to plot of computed data.							
3.	Comparison with local-storm PMP (see sec. 6.3).							

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Project UMTRA - HAT
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Checked HM Date 8/19/86
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Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM   Area ______ mi^2 (km^2)

Latitude 37°09'N, Longitude 109°53'W of basin center

Month MAY

Step

Step		6	12	18	24	48	72	
A.	Convergence PMP							
1.	Drainage average value from one of figures 2.5 to 2.16	9.0						in. (mm)
2.	Reduction for barrier-elevation [fig. 2.18]	51						%
3.	Barrier-elevation reduced PMP [step 1 X step 2]	4.6						in. (mm)
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].	64	83	93	100	117	126	%
5.	Convergence PMP for indicated durations [steps 3 X 4]	2.9	3.8	4.3	4.6	5.4	5.8	in. (mm)
6.	Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	2.9	0.9	0.5	0.3	0.8	0.4	in. (mm)
7.	Areal reduction [select from figs. 2.28 and 2.29]							%
8.	Areally reduced PMP [step 6 X step 7]	2.9	0.9	0.5	0.3	0.8	0.4	in. (mm)
9.	Drainage average PMP [accumulated values of step 8]	2.9	3.8	4.3	4.6	5.4	5.8	in. (mm)
B.	Orographic PMP							
1.	Drainage average orographic index from figure 3.11a to d. (Revised)	3						in. (mm)
2.	Areal reduction [figure 3.20]	100						%
3.	Adjustment for month [one of figs. 3.12 to 3.17]	85						%
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	2.6						in. (mm)
5.	Durational variation [table 3.9]	32	59	81	100	152	177	%
6.	Orographic PMP for given durations [steps 4 X 5]	0.8	1.5	2.1	2.6	4.0	4.6	in. (mm)
C.	Total PMP							
1.	Add steps A9 and B6.	3.7	5.3	6.4	7.2	9.4	10.4	in. (mm)

Duration (hrs)

2. PMP for other durations from smooth curve fitted to plot of computed data.
3. Comparison with local-storm PMP (see sec. 6.3).

Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM   Area 21.0 mi^2 MM

Latitude 37°09'N, Longitude 109°53'W of basin center

Month JUNE

Step

Step		6	12	18	24	48	72	
A.	Convergence PMP							
1.	Drainage average value from one of figures 2.5 to 2.16	9.7						in. (mm)
2.	Reduction for barrier-elevation [fig. 2.18]	51						%
3.	Barrier-elevation reduced PMP [step 1 X step 2]	4.9						in. (mm)
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].	68	85	94	100	115	122	%
5.	Convergence PMP for indicated durations [steps 3 X 4]	3.3	4.2	4.6	4.9	5.6	6.0	in. (mm)
6.	Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	3.3	0.9	0.4	0.3	0.7	0.4	in. (mm)
7.	Areal reduction [select from figs. 2.28 and 2.29]							%
8.	Areally reduced PMP [step 6 X step 7]	3.3	0.9	0.4	0.3	0.7	0.4	in. (mm)
9.	Drainage average PMP [accumulated values of step 8]	3.3	4.2	4.6	4.9	5.6	6.0	in. (mm)
B.	Orographic PMP							
1.	Drainage average orographic index from figure 3.11a to d. (Revised)	3						in. (mm)
2.	Areal reduction [figure 3.20]	100						%
3.	Adjustment for month [one of figs. 3.12 to 3.17]	85						%
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	2.6						in. (mm)
5.	Durational variation [table 3.9]	32	59	81	100	152	177	%
6.	Orographic PMP for given durations [steps 4 X 5]	0.8	1.5	2.1	2.6	4.0	4.6	in. (mm)
C.	Total PMP							
1.	Add steps A9 and B6	4.1	5.7	6.7	7.5	9.6	10.6	in. (mm)

Duration (hrs)

2. PMP for other durations from smooth curve fitted to plot of computed data.
3. Comparison with local-storm PMP (see sec. 6.3).

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Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM Area ______ mi^2 (km^2)

Latitude 37°09'N, Longitude 109°52'W of basin center

Month JULY

Step		6	12	18	24	48	72	
		Duration (hrs)						
A. Convergence PMP								
1. Drainage average value from one of figures 2.5 to 2.16	11.2 in. (mm)							
2. Reduction for barrier-elevation [fig. 2.18]	51 %							
3. Barrier-elevation reduced PMP [step 1 X step 2]	5.7 in. (mm)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].		71	87	95	100	114	119	%
5. Convergence PMP for indicated durations [steps 3 X 4]		4.0	5.0	5.4	5.7	6.5	6.8	in. (mm)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]		4.0	1.0	0.4	0.3	0.8	0.3	in. (mm)
7. Areal reduction [select from figs. 2.28 and 2.29]								%
8. Areally reduced PMP [step 6 X step 7]		4.0	1.0	0.4	0.3	0.8	[illegible]	in. (mm)
9. Drainage average PMP [accumulated values of step 8]		4.0	5.0	5.4	5.7	6.5	6.8	in. (mm)
B. Orographic PMP								
1. Drainage average orographic index from figure 3.11a to d. (Revised)	3 in. (mm)							
2. Areal reduction [figure 3.20]	100 %							
3. Adjustment for month [one of figs. 3.12 to 3.17]	96 %							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	2.9 in. (mm)							
5. Durational variation [table 3.~~8~~9]		32	59	81	100	152	177	%
6. Orographic PMP for given durations [steps 4 X 5]		0.9	1.7	2.3	2.9	4.4	5.1	in. (mm)
C. Total PMP								
1. Add steps A9 and B6		4.9	6.7	7.7	8.6	10.9	11.9	in. (mm)
2. PMP for other durations from smooth curve fitted to plot of computed data.								
3. Comparison with local-storm PMP (see sec. 6.3).								

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Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM Area < 1.0 mi^2 (km^2)

Latitude 37°09'N, Longitude 109°53'W of basin center HM.

Month AUG

Step		6	12	18	24	48	72	
		Duration (hrs)						
A. Convergence PMP								
1. Drainage average value from one of figures 2.5 to 2.16	12.5 in. (mm)							
2. Reduction for barrier-elevation [fig. 2.18]	51 %							
3. Barrier-elevation reduced PMP [step 1 X step 2]	6.4 in. (mm)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].		71	87	95	100	114	119	%
5. Convergence PMP for indicated durations [steps 3 X 4]		4.5	5.6	6.1	6.4	7.3	7.6	in. (mm)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]		4.5	1.1	0.5	0.3	0.9	0.3	in. (mm)
7. Areal reduction [select from figs. 2.28 and 2.29]		100%						%
8. Areally reduced PMP [step 6 X step 7]		4.5	1.1	0.5	0.3	0.9	0.3	in. (mm)
9. Drainage average PMP [accumulated values of step 8]		4.5	5.6	6.1	6.4	7.3	7.6	in. (mm)
B. Orographic PMP								
1. Drainage average orographic index from figure 3.11a to d. (Revised)	3 in. (mm)							
2. Areal reduction [figure 3.20]	100 %							
3. Adjustment for month [one of figs. 3.12 to 3.17]	100 %							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	3 in. (mm)							
5. Durational variation [table 3.~~8~~9]		32	59	81	100	152	177	%
6. Orographic PMP for given durations [steps 4 X 5] PDG 8-20-86		1.0	1.8	2.4	3.0	4.6	5.3	in. (mm)
C. Total PMP								
1. Add steps A9 and B6		6.5	7.4	8.5	9.4	11.9	12.9	in. (mm)
2. PMP for other durations from smooth curve fitted to plot of computed data.								
3. Comparison with local-storm PMP (see sec. 6.3).								

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Project UMTRA - HAT Contract No. 8025-02 Sheet 17
Feature SITE HYDROLOGY Designed PDG File No. ____ Date 6-5-86
Item — Checked [illegible] Date 8/18/86

Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM Area ______ mi^2 (km^2)
Latitude 37°09'N, Longitude 109°53'W of basin center

Month SEP

Step	6	12	18	24	48	72	Unit
A. Convergence PMP							
1. Drainage average value from one of figures 2.5 to 2.16 — 12.5 in. (mm)							
2. Reduction for barrier-elevation [fig. 2.18] — 51 %							
3. Barrier-elevation reduced PMP [step 1 X step 2] — 6.4 in. (mm)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].	71	87	95	100	114	119	%
5. Convergence PMP for indicated durations [steps 3 X 4]	4.5	5.6	6.1	6.4	7.3	7.6	in. (mm)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	4.5	1.1	0.5	0.3	0.9	0.3	in. (mm)
7. Areal reduction [select from figs. 2.28 and 2.29]	—	—	—	—	—	—	%
8. Areally reduced PMP [step 6 X step 7]	4.5	1.[illegible]	0.5	0.3	0.[illegible]	0.3	in. (mm)
9. Drainage average PMP [accumulated values of step 8]	4.5	5.6	6.1	6.4	7.3	7.6	in. (mm)
B. Orographic PMP							
1. Drainage average orographic index from figure 3.11a to d. (Revised) — 3 in. (mm)							
2. Areal reduction [figure 3.20] — 100 %							
3. Adjustment for month [one of figs. 3.12 to 3.17] — 100 %							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3] — 3 in. (mm)							
5. Durational variation [table 3.9]	32	59	81	100	152	177	%
6. Orographic PMP for given durations [steps 4 X 5]	1.0	1.8	2.4	3.0	4.6	5.3	in. (mm)
C. Total PMP							
1. Add steps A9 and B6	5.5	7.4	8.5	9.4	11.9	12.9	in. (mm)
2. PMP for other durations from smooth curve fitted to plot of computed data.							
3. Comparison with local-storm PMP (see sec. 6.3).							

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Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM Area <1.0 mi^2 (km^2) HM
Latitude 37°09'N, Longitude 109°53'W of basin center

Month OCT

Step	6	12	18	24	48	72	Unit
A. Convergence PMP							
1. Drainage average value from one of figures 2.5 to 2.16 — 11.8 in. (mm)							
2. Reduction for barrier-elevation [fig. 2.18] — 51 %							
3. Barrier-elevation reduced PMP [step 1 X step 2] — 6.0 in. (mm)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].	68	85	94	100	115	122	%
5. Convergence PMP for indicated durations [steps 3 X 4]	4.1	5.1	5.7	6.0	6.9	7.3	in. (mm)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	4.1	1.0	0.6	0.3	0.6	0.4	in. (mm)
7. Areal reduction [select from figs. 2.28 and 2.29]	—	—	—	—	—	—	%
8. Areally reduced PMP [step 6 X step 7]	4.1	1.0	0.6	0.3	0.6	0.4	in. (mm)
9. Drainage average PMP [accumulated values of step 8]	4.1	5.1	5.7	6.0	6.9	7.3	in. (mm)
B. Orographic PMP							
1. Drainage average orographic index from figure 3.11a to d. (Revised) — 3 in. (mm)							
2. Areal reduction [figure 3.20] — 100 %							
3. Adjustment for month [one of figs. 3.12 to 3.17] — 99 %							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3] — 3 in. (mm)							
5. Durational variation [table 3.9]	32	59	81	100	152	177	%
6. Orographic PMP for given durations [steps 4 X 5]	1.0	1.8	2.4	3.0	4.6	5.3	in. (mm)
C. Total PMP							
1. Add steps A9 and B6	5.1	6.9	8.1	9.0	11.5	12.6	in. (mm)
2. PMP for other durations from smooth curve fitted to plot of computed data.							
3. Comparison with local-storm PMP (see sec. 6.3).							

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Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM Area ______ mi^2 (km^2)
Latitude 37°09'N, Longitude 109°53'W of basin center

Month NOV

Step		6	12	18	24	48	72	
A.	**Convergence PMP**							
1.	Drainage average value from one of figures 2.5 to 2.16	10.0 in. (mm)						
2.	Reduction for barrier-elevation [fig. 2.18]	51 %						
3.	Barrier-elevation reduced PMP [step 1 X step 2]	5.1 in. (mm)						
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].	61	81	92	100	120	131	%
5.	Convergence PMP for indicated durations [steps 3 X 4]	3.1	4.1	4.7	5.1	6.1	6.7	in. (mm)
6.	Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	3.1	1.0	0.6	0.4	1.0	0.6	in. (mm)
7.	Areal reduction [select from figs. 2.28 and 2.29]	—	—	—	—	—	—	%
8.	Areally reduced PMP [step 6 X step 7]	3.1	1.0	0.6	0.4	1.0	0.6	in. (mm)
9.	Drainage average PMP [accumulated values of step 8]	3.1	4.1	4.7	5.1	6.1	6.7	in. (mm)
B.	**Orographic PMP**							
1.	Drainage average orographic index from figure 3.11a to d. (Revised)	3 in. (mm)						
2.	Areal reduction [figure 3.20]	100 %						
3.	Adjustment for month [one of figs. 3.12 to 3.17]	92 %						
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	2.8 in. (mm)						
5.	Durational variation [table 3.9]	32	59	81	100	152	177	%
6.	Orographic PMP for given durations [steps 4 X 5]	0.9 ~~1.0~~	1.7 ~~1.8~~	[illegible] ~~2.4~~	[illegible] ~~3.0~~	[illegible] ~~4.6~~	5. ~~5.3~~	in. (mm) HM [illegible] PDG 8-20-86
C.	**Total PMP**							
1.	Add steps A9 and B6	4.0	5.9	~~7.1~~ [illegible]	~~8.1~~ [illegible]	10.7	12.0 [illegible]	in. (mm)

2. PMP for other durations from smooth curve fitted to plot of computed data.
3. Comparison with local-storm PMP (see sec. 6.3).

Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage MEXICAN HAT, NM Area < 1.0 mi^2 (~~km^2~~) [illegible]
Latitude 37°09'N, Longitude 109°53'W of basin center

Month DEC

Step		6	12	18	24	48	72	
A.	**Convergence PMP**							
1.	Drainage average value from one of figures 2.5 to 2.16	8.6 in. (mm)						
2.	Reduction for barrier-elevation [fig. 2.18]	51 %						
3.	Barrier-elevation reduced PMP [step 1 X step 2]	4.4 in. (mm)						
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].	58	80	92	100	121	134	%
5.	Convergence PMP for indicated durations [steps 3 X 4]	2.6	3.5	4.0	4.4	5.3	5.9	in. (mm) PDG 8-20-86
6.	Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	2.6	0.9	0.5	0.4	0.9	0.6	in. (mm)
7.	Areal reduction [select from figs. 2.28 and 2.29]	—	—	—	—	—	—	%
8.	Areally reduced PMP [step 6 X step 7]	2.6	0.9	0.5	0.4	0.9	0.6	in. (mm)
9.	Drainage average PMP [accumulated values of step 8]	2.6	3.5	4.0	4.4	5.3	5.9	in. (mm)
B.	**Orographic PMP**							
1.	Drainage average orographic index from figure 3.11a to d. (Revised)	3 in. (mm)						
2.	Areal reduction [figure 3.20]	100 %						
3.	Adjustment for month [one of figs. 3.12 to 3.17]	83 %						
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	2.6 in. (mm)						
5.	Durational variation [table 3.9]	32	59	81	100	152	177	% ✓
6.	Orographic PMP for given durations [steps 4 X 5]	[illegible] ~~1.0~~	1.5 ~~1.8~~	2.1 ~~2.4~~	2.6 ~~3.0~~	4.0 ~~4.6~~	4.6 ~~5.3~~	in. (mm) HM [illegible]
C.	**Total PMP**							
1.	Add steps A9 and B6	[illegible] ~~3.6~~	5.0 ~~5.3~~	6.1 ~~6.4~~	7.0 ~~7.4~~	9.3 ~~9.9~~	10.5 ~~11.2~~	in. (mm) PDG 8-20-86

2. PMP for other durations from smooth curve fitted to plot of computed data.
3. Comparison with local-storm PMP (see sec. 6.3).

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Date 6-5-86
Date 8/15/86

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA - HAT	Contract No. 5025-02	Sheet	File No.
Feature: SITE HYDROLOGY	Designed: PDG	Date: 6-5-86	
Item: —	Checked: HM	Date: 6/ /86	

C. Local-Storm PMP

The local-storm PMP is calculated using the methods presented in Section 6.3 of Hydromet 49 (DOC, 1977). The worksheets for determining the local-storm PMP (Tables 6.3A & 6.3B of Hydromet. 49) are included on the following two sheets.

The 1-hour, 1-sq. mile local-storm PMP is found to be 8.1 inches.

The durational variation in precipitation for the local-storm durations between 15-min and 6-hour are tabulated below:

Duration	Precipitation	Intensity*
15 min	6.0 in.	24.0 in/hr
30 min	7.2	14.4
45 min	7.7	10.3
60 min	8.1	8.1
2 hr	8.9	4.5
3 hr	9.3	3.1
4 hr	9.6	2.4
5 hr	9.6	1.9
6 hr	9.7	1.6

To determine the intensity variation for times less than 15-minutes, the intensity-duration values tabulated above are plotted on sheet 23. The curve is mathematically modeled by the following equation:

$$i = 10^{[G + H(\log t)^Z]}$$ (See MKE, 1986)

This equation can be used to determine intensities for times less than 15 minutes once the G, H, and Z parameters are determined through extrapolation of the curve drawn on sheet 23

* Intensity = $\left(\frac{\text{Precipitation}}{\text{Duration}}\right) \times 60 \text{ min/hr}$

Project UMTRA - HAT	Contract No. 5025-02	File No.	Sheet 21
Feature SITE HYDROLOGY	Designed POG	Date	
Item —	Checked HM	Date 8/20/85	

Table 6.3A.—Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

Drainage MEXICAN HAT Area <1.5 mi^2 ~~(km^2)~~ HM
Latitude 37°09'N Longitude 109°52'W Minimum Elevation ~~4250~~ ft (m)
41 — HM 8/20/85

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 8.1 in. (mm)

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. 100 %

   b. Multiply step 1 by step 2a. 8.1 in. (mm)

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.20

	Duration (hr) 1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	74	89	95	100	110	115	118	119	120	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	6.0	7.2	7.7	8.1	8.9	9.3	9.6	9.6	9.7	in. (mm)
6. Areal reduction [fig. 4.9].	100%									%
7. Areal reduced PMP [steps 5 X 6].	6.0	7.2	7.7	8.1	8.9	9.3	9.6	9.6	9.7	in. (mm)
8. Incremental PMP [successive subtraction in step 7].				8.1	0.8	0.4	0.3	0.0	0.1	in. (mm)
	6.0	1.2	0.5	0.4	} 15-min. increments					

9. Time sequence of incremental PMP according to: HMR No. 5

   Hourly increments [table 4.7]. 0.4 0.3 0.8 0.1 8.1 0.0 in. (mm)

   Four largest 15-min. increments [table 4.8]. 6.0 1.2 0.5 0.4 in. (mm)

POG 8-20-85

Project	UMTRA - HAT	Contract No.	5025-02	Sheet	22
Feature	SITE HYDROLOGY	Designed	POG	File No.	
Item	—	Checked	HM	Date	
				Date	5/2/85

Table 6.3B.—Local-storm PMP computation, Colorado River and Great Basin, and California drainages. (Giving areal distribution of PMP).

Steps correspond to those in sec. 6.3B.

1. Place idealized isohyetal pattern [fig. 4.10] over drainage adjusted to 1:500,000 scale to obtain most critical placement.
2. Note the isohyets within drainage.
3. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 8.1 in. (mm)
4. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m), 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. 100 %
   b. Multiply step 3 by step 4a. 8.1 in. (mm)
5. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.2
6. Obtain isohetal labels for 15-min incremental and the highest PMP from table 4.5 corresponding 6/1-hr ratio of step 5.

PMP Increment	Isohyet A	B	C	D	E	F	G	H	I	J	
AREA (sq. mi)	1	5	25	55	95	150	220	300	385	500	
Highest 1-hr	100	82	58	44	32	23	16	13	12	11	
Highest 15-min.	74	56	32	21	14	8	7	6	5	4	
2nd "	15	15	15	12	7	6	4	3	3	3	
3rd "	6	6	6	6	5	5	3	2	2	2	in %
4th "	5	5	5	5	4	4	2	2	2	2	

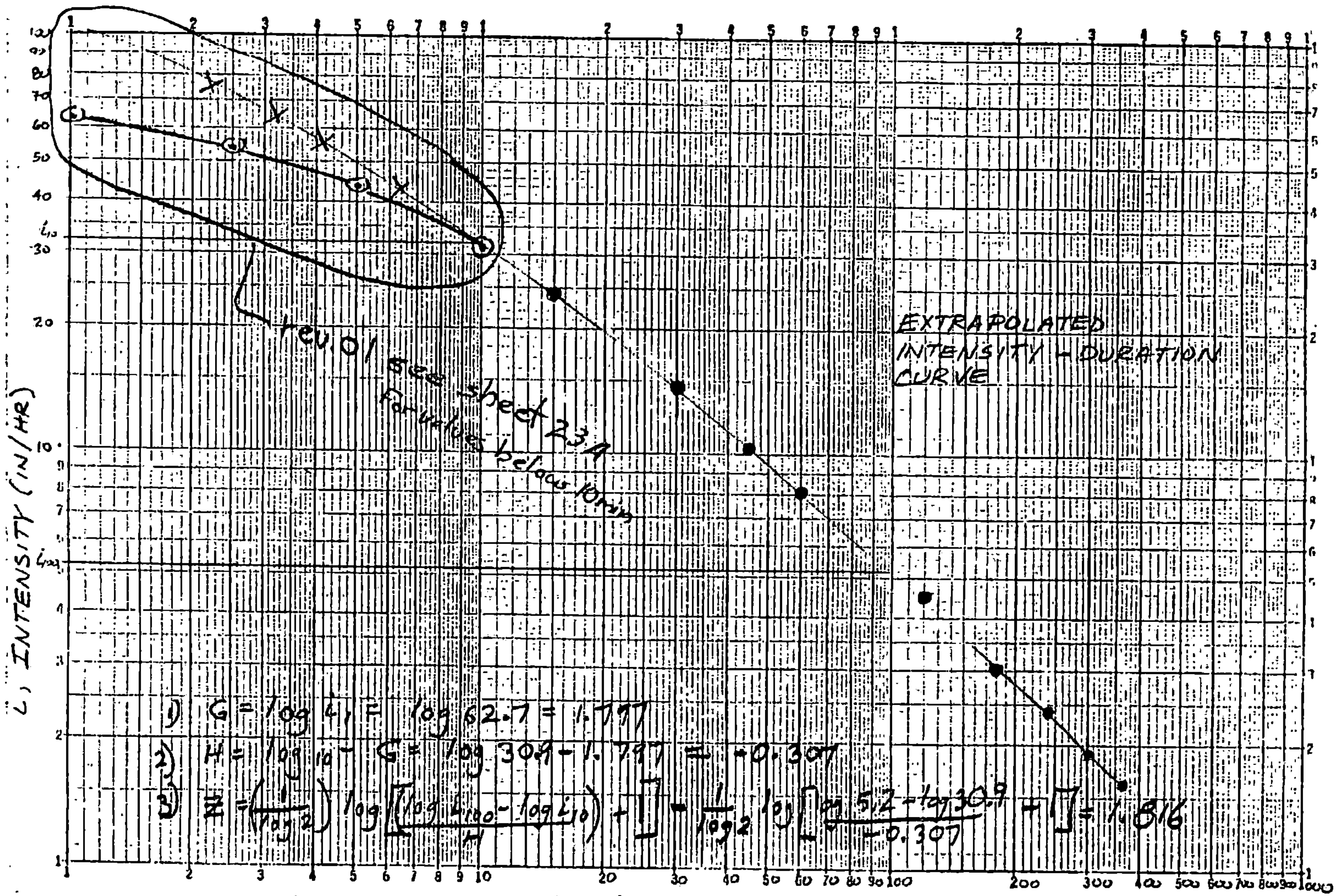
7. Obtain isohyetal labels in % of 1-hr PMP for 2nd to 6th highest hourly incremental PMP values from table 4.6 using 6/1-hr ratio of step 5.

	A	B	C	D	E	F	G	H	I	J	
2nd Highest 1-hr PMP	11	11	11	11	10	8	7	5	5	5	
3rd "	4	4	4	4	4	4	4	4	4	4	
4th "	3	3	3	3	3	3	3	3	3	3	in %
5th "	2	2	2	2	2	2	2	2	2	2	
6th "	1	1	1	1	1	1	1	1	1	1	

8. Multiply steps 6 and 7 by step 4b to get incremental isohyetal labels of PMP.

	A	B	C	D	E	F	G	H	I	J	
Highest 15-min.	6.0	4.5	2.6	1.7	1.1	0.6	0.6	0.5	0.4	0.3	
2nd "	1.2	1.2	1.2	1.0	0.7	0.5	0.3	0.2	0.2	0.2	
3rd "	0.5	0.5	0.5	0.5	0.4	0.4	0.2	0.2	0.2	0.2	
4th "	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	
Highest 1-hr	8.1	6.6	4.5	3.6	2.6	1.9	1.3	1.1	1.0	0.9	in in. (mm)
2nd "	0.9	0.9	0.9	0.9	0.8	0.6	0.6	0.4	0.4	0.4	
3rd "	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
4th "	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
5th "	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
6th "	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	

9. Arrange values of step 8 in time sequence [tables 4.7 and 4.8].



1) $G = \log i_1 = \log 62.7 = 1.797$

2) $H = \log i_{10} - G = \log 30.9 - 1.797 = -0.307$

3) $Z = \left(\frac{1}{\log 2}\right)\log\left[\left(\frac{\log i_{100} - \log i_{10}}{H}\right) + 1\right] = \frac{1}{\log 2}\log\left[\frac{\log 5.2 - \log 30.9}{-0.307} + 1\right] = 1.816$

(1) $G = \cancel{\log i_1 = \log 101 = 2.004} = \log 62.7 = 1.797$

(2) $H = \cancel{\log i_{10} - G = \log 32 - 2.004 = -0.499} = \log 32 - 1.797 = -0.292$

(3) $\cancel{Z = \left(\frac{1}{\log 2}\right)\log\left[\left(\frac{\log i_{100} - \log i_{10}}{H}\right) + 1\right] = \left(\frac{1}{\log 2}\right)\log\left[\frac{\log 5.2 - \log 32}{-0.499} + 1\right] = 1.661}$

Deleted Rev 01

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Project: UMTRA - HAT	Contract No. 5025-02	Sheet 23A	
Feature: SITE HYDROLOGY	Designed Rev.01 RFC	File No.	Date 6/7/86
Item: Intensity Duration Curve.	Checked Rev.01 HM		Date June 10/87

This Sheet is a new sheet and is part of revision 01.

From TAD (Table 3.1 page 29)

Table 3.1 Incremental rainfall duration percentages

Rainfall duration (min) (RD)	Percentage of 1-hr PMP (%)
2.5	27.5
5	45
15	74
30	89
45	95
60	100

% of 1-hr PMP = RD/(0.0089 x RD + 0.0686) R^2 = 0.9998

for 1.0 min % = 1/(0.0089 x 1.0 + 0.0686) = 12.9%

From sheet 20 - 60 min PMP intensity = 8.1"/hr.

From above & Formula 7 (TAD, Page 31)

$$I = PMP_{(t_c)} \times \frac{60}{t_c} \text{ inches/hour. . . . . . .(7)}$$

where $PMP_{(t_c)}$ = the incremental rainfall amount for the time of concentration.

t_c = time of concentration.

(RD)	% of 1-hr PMP	$I = \% \times 8.1'' \times \frac{60}{T_c}$	
1.0 min	12.9	0.129 × 8.1" × 60/1 =	62.7"/hr.
2.5	27.5	0.275 × 8.1" × 60/2.5 =	53.5"/hr.
5	45	0.45 × 8.1" × 60/5 =	43.7"/hr
15	74	0.74 × 8.1 × 60/15 =	24.0"/hr
10	63.5	0.635 × 8.1 × 60/10 =	30.9"/hr

HM June 1/87
RFC 6/10/87

From sheet 23 Intensity including & below 10 min is changed

G = 1.797 changed this revision
H = -0.307 " " "
Z = 1.816 " " "

Note. No change in itensities above 10 min. duration
: minor change from 6 to 10 min duration.

d. Design PMP

After developing both the general-storm and local-storm PMP's for the Mexican Hat site, it is clear that the local-storm PMP represents the worst-case. Therefore, the local storm parameters and intensity-duration characteristics developed in the preceding three sheets will be used in the design of permanent erosion protection.

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Project UMTRA - HAT	Contract No. 4005-05	Sheet 25	File No:
Feature SITE HYDROLOGY	Designed POG	Date	
Item —	Checked HM	Date 8/2?/85	

Rev.01 RFC. 1/7/87
HM June 10/87

5. REFERENCES

DOE (U.S. Department of Energy), 1986, Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Mexican Hat, Utah - Text, Appendices A, B, & C. - Draft, Albuquerque, N.M.

DOC (U.S. Department of Commerce), 1973, Precipitation Frequency Atlas for The U.S. - Volume 6 Utah, National Oceanic and Atmospheric Administration, National Weather Service, Silver Spring, Md.

Huff, F.A., 1967, "Time Distribution of Rainfall in Heavy Storms," Water Resources Research, Vol. 3, No. 4, pp. 1007 - 1019.

MKE, (Morrison-Knudsen Engineers, Inc.), 1986, "Procedure for Determining Curve Parameters for Design Precipitation Intensity," unpublished report prepared for UMTRA project, MKE Document No. 4005-GEN-R-01-02622-00.

[TAD (U.S. Department of Energy), May 1986 "Technical Approach Document" for UMTRA project. MKE Doc. No. 4005-GEN-R-04-02239-01] Rev.01

Appendix B

Riprap and Filter Design Calculation

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MKES Doc. No. 3885-H/M-C-01-02329-01

Calculation Cover Sheet

QUALITY REQUIREMENTS BY C Ricketts

QA ENTRY NO.

Calc. No. 9-418-05-~~00~~ 01

No. of Sheets ~~16~~ ~~17~~ 18

Contract No. 3885-51 Discipline MKES

Project UMTRA - HAT/MON

Feature EROSION PROTECTION

Item OVERSIZING, GRADATION, & THICKNESS

Sources of Data

—

Sources of Formulae & References

(see sheet ii)

Preliminary Calc. ☐ Final Calc. ☒ Supersedes Calc. No. —

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
01	(see sheet iv.)	Jason C. Kuo	2-18-92	Fang H. Wu	2/19/92	[illegible]	2/19/92
00	—	Jason C. Kuo	5-16-91	[illegible] Wong	5-20-91	[illegible]	5/29/91

Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: UMTRA - H/M	Contract No. 3885-58	Sheet: 1	File No.
Feature: Erosion Protection	Designed: JCK	Date: 5-16-91	
Item: Oversizing, Gradation, Thickness	Checked: BYW	Date: 5-28-91	

Summary:

1. Riprap Type A. B. C.:
   - Design gradation limits are shown on sheet 3.
   - Design gradation curves are shown on sheets 4, 5, 6.
   - Design layer thicknesses are shown on sheet 12.

2. Bedding material:
   - Design gradation limit is shown on sheet 10.
   - Design gradation curve is shown on sheet 11
   - Design layer thickness is shown on sheet 12.

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Project UMTRA NAT/MON	Contract No. 3085-58	Sheet ii
Feature Erosion Protection	Designed JCK	File No.
Item Oversizing, gradation, thickness	Checked BYW	Date 5-14-91
	01 JCK FHW	Date 5-28-91 2-18-92 2/19/92

CONTENTS.

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: UMTRA - HAT/MON
Contract No. 3885-58
Sheet: iii
File No.:
Feature: Erosion Protection
Designed: JCK
Date: 5-14-91
Item: Oversizing, Gradation, & Thickness
Checked: BYW
Date: 5-28-91
01 JCK 2-18-92
FHW 2/19/92

REFERENCES:

1. "UMTRA-Mexican Hat: Erosion Protection — Rock Quality Evaluation at Bluff", Cal. # 9-259-05-00, 5/88.
2. MKES, "UMTRA-HAT/MON: Erosion Protection – Riprap Design" MKES Cal. # 9-418-01-~~00~~01, ~~5/91~~ 2/92 01
3. MKE, "UMTRA Design Procedures", Rev. 7. ch 5, 1/89
4. DOE, "Use of Coarse Material in the Bedding Layer on UMTRA Sites", MKE DOC. # 5025-HAT-C-03-01853-00, 11/89
5. J.L. Sherard, et al, "Basic Properties of Sand and Gravel Filters", Journal of Geot. Eng., Vol. 110, No. 6. 6/84
6. T.W. Lambe & R.V. Whitman, "Soil Mechanics", 1978
7. Ven Te Chow, "Open Channel Hydraulics", McGraw Hill, 1959
8. NAVFAC, DM-7.1, "Soil Mechanics", 1982.
9. MKES, "UMTRA HAT/MON: Erosion Protection — Rock Quality Sugarloaf and Lime Ridge", Cal. # 9-418-04-00, 5/91

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON

Project UMTRA- HAT/MON	Contract No. 388558	Sheet iV	File No. -
Feature Erosion Protection	Designed JCK	Date 2-18-92	
Item Oversizing, Gradation, & Thickness	Checked FHW	Date 2/19/92	

(This entire sheet is added for Rev. 01)

• Purpose of Rev. 01.

To include the rounded rock (such as Bluff) as an alternative rock source for the Riprap Type C.

• Summary :

1. sheets revised : ii, iii, 1, 3, 9, 12
sheets added : iV,
sheet superseded : 2, 5.

ENG 375/89 (ENV.)

#4242/89

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA - MAT/MON	Contract No. 3881-58	Sheet 1	File No.
Feature Erosion Protection	Designed JCK	Date 5-14-91	
Item Oversizing, Gradation, & Thickness	Checked BYW	Date 5-28-91	

01 JCK 2-18-92
TNW 2/19/92

1. Introduction:

Currently, the riprap materials for erosion protection at the UMTRA Mexican Hat site, Utah are proposed to be obtained from (1) Bluff quarry and (2) Sugarloaf quarry, Utah. The materials from Bluff quarry are round river cobbles with rock quality scores (RQS) greater than 80% (sheet 1 of Ref 1). These materials will be used as riprap type A, B, C and bedding material. The materials from Sugarloaf quarry are composed of crushed limestone with RQS > 80% and crushed sandstone with RQS ≥ 65% (sheet 1 of Ref 9). This material can be used for riprap type A, B, and C.

The purpose of this calculation set is to determine

1. gradation requirements and layer thicknesses for riprap materials from both borrow sources:

   (1) rounded rock (Bluff quarry): with RQS > 80%.

   (2) Angular rock (Sugarloaf quarry): a conservative RQS = 65% was assumed (sheet 1, Ref 9)

2. Gradation requirements and layer thickness for bedding material.

2. Method:

The required riprap $D_{50,min}$ sizes were determined elsewhere (Ref 2). For riprap material with RQS < 80%, the $D_{50,min}$ need to be oversized as described in Ref. 3. Ref. 3 was also used to determine the gradation requirements and layer thickness. To have a better drainage within the bedding layer, the method used in determining gradation requirements was described on sheet 7.

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet 2	File No. —
Feature Erosion Protection	Designed JCK	Date 2-18-92	
Item Oversizing, Gradation, Thickness	Checked MW	Date 2/19/92	

— (This sheet is part of Rev. 0)

3. Gradation Requirement for Riprap:

3.1 Required Oversizing: (Ref. 3)

- RQS < 80% : oversizing factor (OF) = (80 - RQS) %.
- RQS ≥ 80% : OF = 0 %.

⇒ oversized D_{50} : $D^*_{50,min} = (1 + OF) \times D_{50,min}$.

3.2 Calculating $D^*_{50,min}$:

Riprap type	Rock Source (1)	$D_{50,min}$ (2) (in)	RQS (%)	OF (%)	$D^*_{50,min}$ (in)	Selected $D^*_{50,min}$ (in)
A	rounded	1.5	≥80	0	1.5	1.7
	angular	1.5	65	15	1.7	
B	rounded	4.4	≥80	0	4.4	4.4
	angular	3.4	65	15	3.9	
C	rounded	6.6	≥80	0	6.6	6.9
	angular	6.0	65	15	6.9	

Remarks: (1) Rounded rock from Bluff source.
Angular rock from Sugarloaf source
(2) data from Ref 2.

3.3 Calculating $D_{100,min}$, $D_{100,max}$, $D_{25,min}$

from Ref. 3 :

$$D_{100,min} = 1.26 \times D^*_{50,min}$$
$$D_{100,max} = 1.71 \times D^*_{50,min}$$
$$D_{25,min} = 0.68 \times D^*_{50,min}$$

Therefore,

Riprap Type	$D_{100,min}$ (in)	$D_{100,max}$ (in)	$D_{25,min}$ (in)
A	2.1	2.9	1.2
B	5.5	7.5	3.0
C	8.7	11.8	4.7

ENG 375/89 (ENV.) #4242/89

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: LIMTRA - HAT MON	Contract No. 3882-58	Sheet 3	
Feature: Erosion Protection	Designed: JCK	File No.	Date 5-16-91
Item: Oversizing, Gradation & Thickness	Checked: BJW	Date 5-28-91	

3. Gradation Calculation for Riprap : (cont'd) Rev. 01 JCK 2-18-92 FMW 2/19/92

(B) Summary of gradation Limits:

1. Riprap Type A:

U.S. Standard sieve opening (in)	percentage finer by Weight (%)
3	100
2	0 - 100
$1\frac{1}{2}$	0 - 40
1	0 - 10
$\frac{1}{2}$	0 - 5

2. Riprap Type B:

U.S. Standard Sieve opening (in)	percentage finer by weight (%)
8	100
~~5~~ 6	25 ~~0~~ - 100
~~4~~ 5	0 - ~~40~~ 100
~~3~~ 4	0 - 25
1	0 - 5

Rev 01

3. Riprap Type C:

U.S. Standard Sieve opening (in)	percentage finer by Weight (%)
12	100
9	0 - 100
7	0 - 50
5	0 - 25
2	0 - 5

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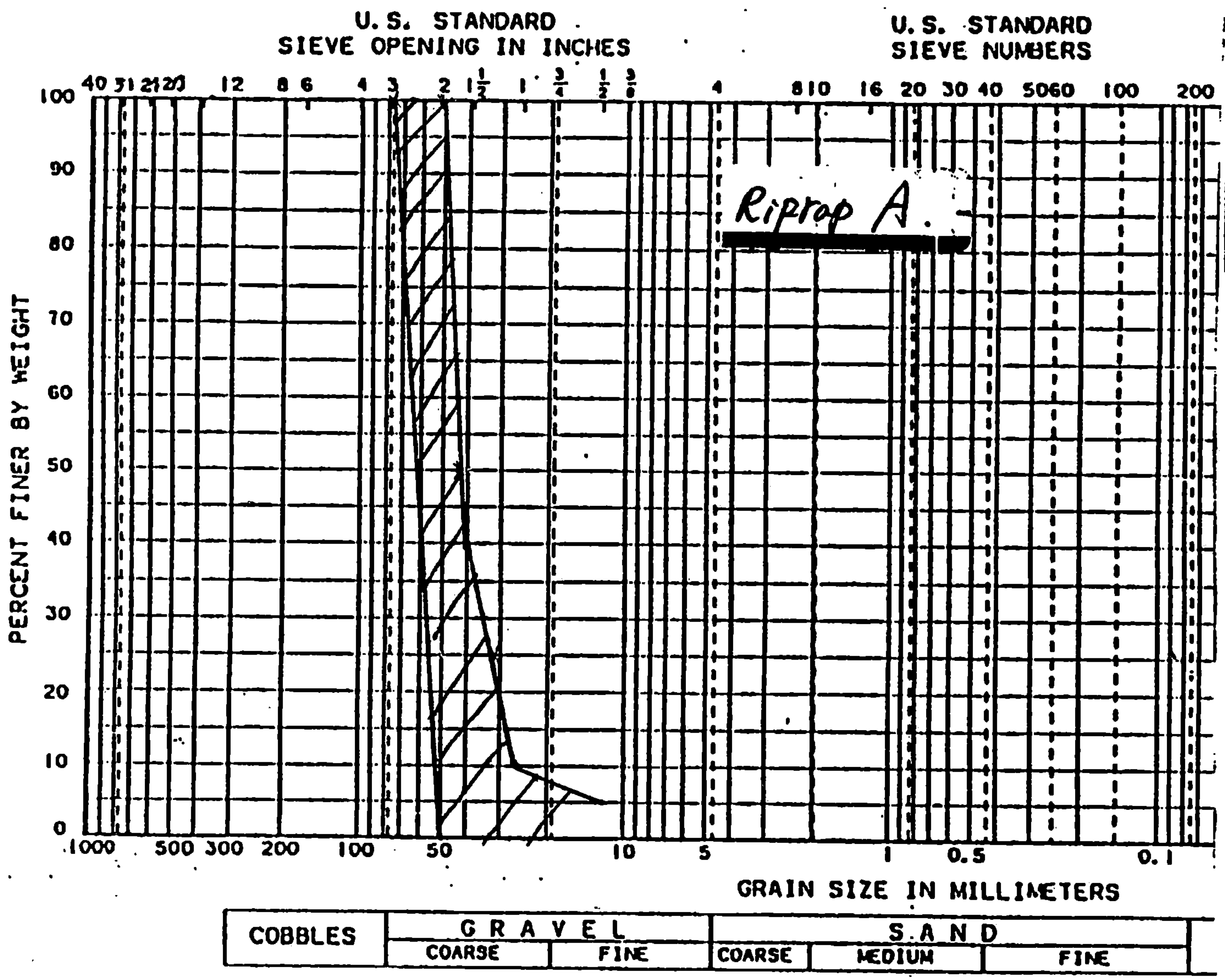
Project: UMTRA - HAT/MON
Feature: Erosion Protection
Item: Oversizing, gradation, & Thickness

Contract No. 3885-58
Designed: Jck
Checked: BYW

Sheet: 6
File No.
Date: 5-16-91
Date: 5-28-91

3. Gradation Calculation for Riprap : (cont'd)

(c) gradation Curves :



MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON

Project UMTRA - NAT/MON Contract No. 3885-58 Sheet 5

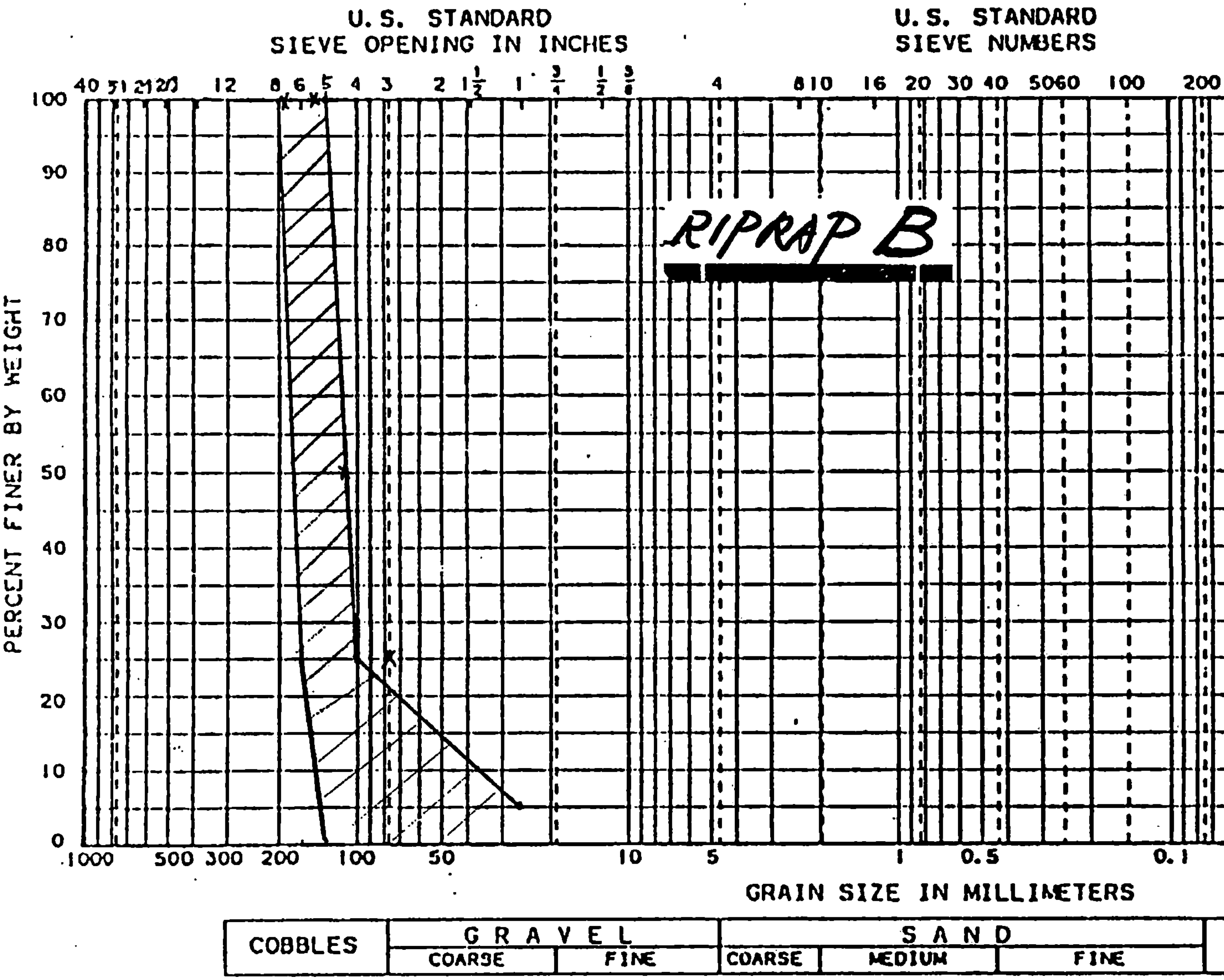
Feature Erosion Protection Designed JCK Date 2-18-92 File No.

Item Oversizing gradation & thickness Checked JAW Date 2/19/92

3. Gradation Calculations for Riprap (cont'd)

(c) Gradation Curves

(This sheet is for Rev. 01)



MORRISON-KNUDSEN ENGINEERS, INC.
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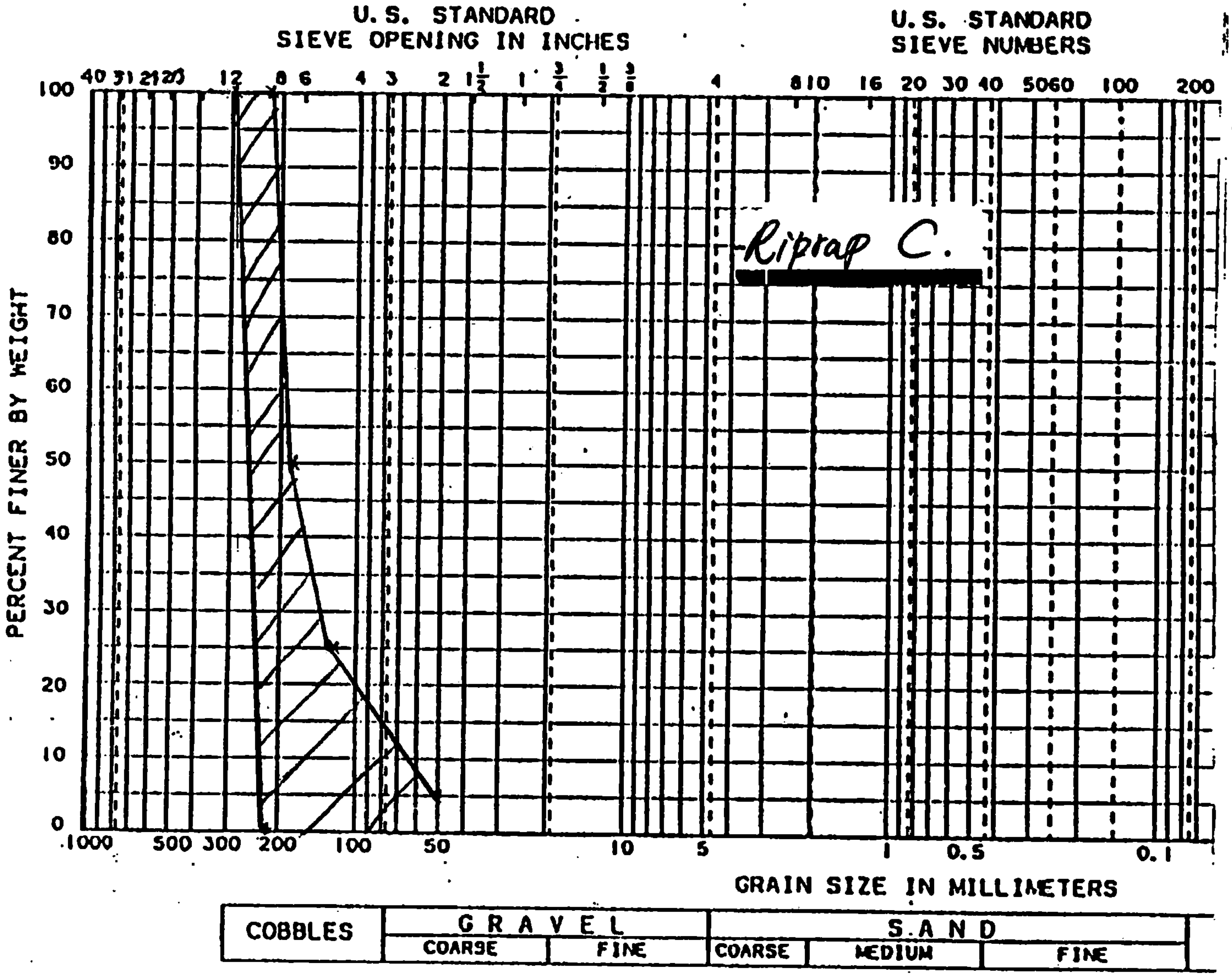
Project UMTRA HAT/MON Contract No. 3885-58 Sheet 6
Feature Erosion Protection Designed JCK File No. Date 5-16-91
Item Oversizing, gradation, & Thickness Checked BJW Date 5-28-91

3. Gradation Calculations for Riprap : (cont'd)

(c) Gradation Curve :



4. Gradation Calculation for Bedding Material:

A) Grain Size Requirements for Better Drainage:

As indicated on sheet 13: "The DOE agrees with the TAC recommendation to coarsen the bedding layer at the Mexican Hat Site". (Ref. 4). The following approach was taken to permit better drainage in the bedding layer:

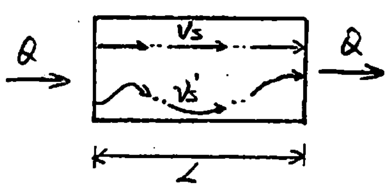
1. Method:

① By assuming Darcy's Law, the seepage velocity

$V_s = \frac{K \cdot i}{n}$ (p. 52 of Ref. 6)

where
- V_s – seepage velocity, assumed a straight flow path (cm/sec)
- K – permeability (cm/sec)
- i – gradient
- n – porosity, assume 0.3

② Actual seepage velocity:



V_s is a fictitious velocity:
The actual seepage velocity V_s' is that the water travels along an irregular path with a greater distance L'.

$T = L'/L \approx 1.5$ (p. 694 of Ref. 5)

Since $\frac{L}{V_s} = \frac{L'}{V_s'}$ $\Rightarrow$ $V_s' = V_s \cdot \frac{L'}{L} = V_s T$

$\therefore V_s' = \frac{K \cdot i}{n} \cdot T$ where T: tortuosity factor.

③ $K = 0.35 \cdot (D_{15})^2$ (eq 2. of Ref 5)

where D_{15}: grain size which 15% of the total soil particles are small (cm)

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Project: ZIATRA HAT/MON Contract No. 3885-58 Sheet 8 File No.
Feature: Erosion Protection Designed JCK Date 5-18-91
Item: Oversizing, Gradation, Thickness Checked BJW Date 5-28-91

4. Gradation Calculations for Bedding Material : (cont'd)

(A) Grain Size Requirements for Better Drainage : (cont'd)

2. Calculations.

A. D_{15} upperbound :

- The maximum seepage velocity that will not cause erosion for very fine material in Ref. 7 is 0.5 ft/sec (Ref. 7 Fig 7-3) Assuming subgrade soil is non-dispersive.
- The max. slope of riprapped areas for Mexican Hat Site is 20%

From $V_s = \frac{K \cdot i}{n} \cdot T \Rightarrow K = \frac{V_s \cdot n}{i \cdot T} = \frac{0.5 \cdot 0.3}{0.2 \cdot 1.5}$
$= 0.5$ ft/sec
$= 15.2$ cm/sec

From $K = 0.35 (D_{15})^2 \Rightarrow D_{15} = \sqrt{K/0.35} = \sqrt{15.2/0.35} = 6.6$ mm

use $\boxed{D_{15} \leq 6.6 \text{ mm } (0.26'')}$

B. D_{15} lowerbound :

From p7.1-275 of Ref. 8 : "Mixtures of about equal parts gravel with medium to coarse sand have a permeability of approximately 1 fpm" for the drainage materials.

$\Rightarrow K = 1$ fpm $= 0.51$ cm/sec

for $D_{15} = \sqrt{0.51/0.35} = 1.2$ mm

Oversized by 15% for rock quality

$\therefore D_{15} = 1.2 \times 1.15 = 1.4$ mm

use $\boxed{D_{15} \geq 1.4 \text{ mm } (0.06'')}$

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA – HAT/MON
Feature: Erosion Protection
Item: Oversizing, Gradation, Thickness
Contract No. 3885-58
Designed: JCK
Checked: BYW
Sheet 9
File No.
Date 5-16-91
Date 5-28-91

4 Gradation Calculation for Bedding Material (cont'd)

(B) Use "filter criteria with Riprap"

Only one kind of bedding material was proposed to be used for Mexican Hat Site.

A. From Ref 3, p5-14: $\frac{D_{15})_f}{D_{85})_b} \leq 7.5$

("f" denotes riprap layer and "b" denotes bedding layer)

therefor: $D_{85})_b \geq \frac{D_{15})_f}{7.5}$

Riprap Type	A	B ⚠	C
Max. $D_{15})_f$ (1)	2.1"	~~3.5~~" 5.9	9.1"
min. $D_{85})_b$ (2)	0.28"	~~0.73~~" 0.79	1.21

Rev. 01
JCK 2-18-92.
FHW 2/19/92

remarks: (1) obtained from sheets 4 to 6

(2) min. $D_{85})_b$ = max. $D_{15})_f / 7.5$

∴ the governing min $D_{85})_b$ from above table is 1.21"

⟹ say $\boxed{D_{85} \geq 1.2''}$

B. From Ref 3, p5-14, $\boxed{D_{100})_{max} \leq 3''}$

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Project: UMTRA HAT / MON	Contract No. 3885-58	Sheet 10	File No.
Feature: Erosion Protection	Designed: JCK	Date 5-16-91	
Item: Oversizing, Gradation, Thickness	Checked: BGW	Date 5-28-91	

4. Gradation Calculations for Bedding Material: (cont'd)

(C) Summary of Gradation Limits:

A. Calculated grain sizes:

$1.4\,mm\,(0.06") \leq D_{15} \leq 6.6\,mm\,(0.26")$ (from sheet 8)

$1.2" \leq D_{85}$ (from sheet 9)

$D_{100} \leq 3"$ (from sheet 9)

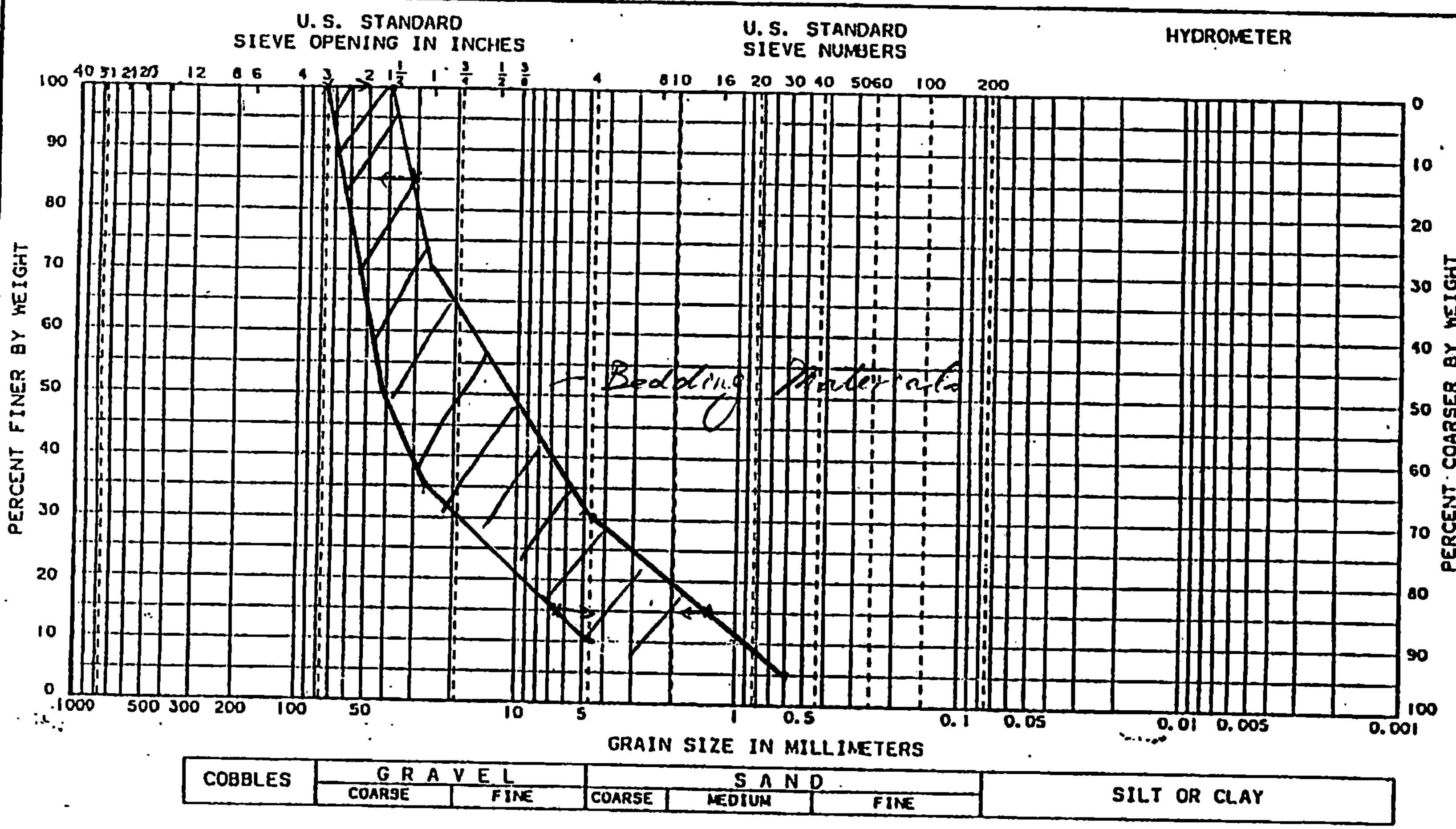
B. Proposed gradation Requirements:

U.S. standard sieve		% passing by weight
No.	Size	
	3"	100
	1 1/2"	50 - 100
	1"	35 - 70
4		10 - 30
30		0 - 5

Gradation limits shown on sheet 11.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY

GRAIN SIZE ANALYSIS



PROJECT	UMTRA - HAT/MON
JOB NO.	3885-58
AREA	Bedding material
HOLE NO.	
DATE	

UMTRA HAT/MON

Sheet 11
JCK 5-16-91
5-28-91

Appendix B-16

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project	UMTRA – HAT/MON	Contract No.	3885-58	Sheet	12
Feature	Erosion Protection	Designed	JCK	File No.	
Item	Oversizing, Gradation, Thickness	Checked	BZW	Date	5-16-91
				Date	5-28-91

5. Thickness for Erosion Protection Layer:

A. Thickness for Riprap layer

(1) Design Criteria. : (Ref. 3, P5-13)

a. $T_{min} \geq 1.9 \cdot D_{50})_{min}$

b $T_{min} \geq 1.5\ D_{50})_{max}$.

c. $T_{min} \geq 12$ inch

(2) Calculation

Riprap Type	A	B	C
min. D_{50} (1)	~~1.6~~ 1.7"	~~4.1~~ 4.4"	7.0"
max D_{50} (1)	~~2.3~~" 2.4"	~~6.0~~" 6.7"	10.0"
$T_{min} \geq 1.9\ D_{50})_{min}$	~~3.0~~" 3.2"	~~7.8~~" 8.4"	13.3"
$T_{min} \geq 1.5\ D_{50})_{max}$	~~3.5~~" 3.6"	~~9.0~~" 10.1"	15"
$T_{min} \geq 12$ in	12"	12"	12"
Required T_{min}	12"	12"	15"

Rev. 01
JCK 2-18-92
FHW 2/19/92

remarks: (1) – data was obtained from sheets 4, 5, 6.

B. Bedding layer:

(1) Design Criteria : (P5-15, Ref. 3)

a. $T_{min} \geq 1.1 \times D_{100})_{max}$.

b. $T_{min} \geq 6"$

(2) Calculation

$D_{100})_{max} = 3" \Rightarrow T_{min} \geq 1.1 \times 3 = 3.3" \leq 6"$

use $\underline{\underline{T_{min} = 6"}}$

Sheet 13

MKE DOC. 5025-HAT-L-03_01853-00

3050-89-1356

JEK 5-16-91
RJW 5-28-91

Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, New Mexico 87115

MK-FERGUSON CO.
ALBUQUERQUE
NOV 3 1989
RECEIVED

NOV 2 1989

RECEIVED - MKE
NOV 10 1989
UMTRA - S.F.

Mr. James G. Oldham
Project Director
MK-Ferguson Company
P.O. Box 9136
Albuquerque, NM 87119

Dear Jim,

Over the last year there has been several discussions held and correspondence prepared between the DOE, TAC, and RAC regarding the use of coarse material in the bedding layer on UMTRA sites and specifically of Mexican Hat, to reduce the amount of water infiltrating into the contaminated materials and reduce the potential for vegetation germination and growth.

Enclosed is a letter and report from the TAC on this subject transmitted to the Project Office on October 27, 1989.

The DOE agrees with the TAC recommendation to coarsen the bedding layer at the Mexican Hat site. Please revise the specification as necessary and submit to the Project Office for review.

If you have any questions or require any additional information please contact Elizabeth Damler of my staff at 846-1224.

Sincerely,

Steve Hamp for

Mark L. Matthews
Acting Project Manager
Uranium Mill Tailings Project Office

Enclosure

cc w/o enclosure:
K. Agogino, JEG
J. Caldwell, MK-F

DIST	PDC	MVH	RAP	MFP	FJF/MKE	GGIPD	JEJ	TBS	DEW	JWS	WAZ	RSW
INFO					✓			✓				
SEP												

DIST	JGO	REC	JEH/GRJ	CDW	JBH	JJD	MDT	IGP	DPB	SJS/DC	ORIG. FILE	WORK FILE
INFO	✓	✓	✓							✓	1.0	HAT

MKES Doc. No. 3885-H/M-C-01-02863-00

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION

UMTRA PROJECT
CALCULATION COVER SHEET
CALC. NO. 9-418-14-00

QA check 5/10/95

Contract No. 3885-58 Discipline CIVIL No. of Sheets 56 (includes cover sheet)

Project

UMTRA - MEXICAN HAT / MONUMENT VALLEY

Feature

EROSION PROTECTION

Item

TAILINGS EMBANKMENT AND SOUTH-EDGE AREAS

Sources of Data

(see references on sheet ii)

Sources of Formulae & References

(see references on sheet ii)

Preliminary Calc. ☐ Final Calc. ☒ Supersedes Calc. No. 9-418-13-00

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
				Checking criteria listed in the MKES UMTRA Project Procedures Manual were used during the checking of all revisions of this calculation.			
00	-	[signature]	11/9/93	[signature]	12/8/93	[signature]	12-10-93

F:\UMTRA\GEN\CALCCOVR.SHT 02/93

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet i
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

Table of Contents

Sheet No.

Appendices

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Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet ii
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

References

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2. MKES Cal. No. 09-418-05-01, "UMTRA-HAT/MON, Erosion Protection, Oversizing,Gradation and Thickness," Feb. 1992.

3. U.S. Department of Energy (DOE), UMTRA-DOE-AL-050425.0002, "Technical Approach Document," Rev. 11, Dec 1989, Figure 4.1, pp. 71.

4. MKES "RPRP/SFST- A Computer Program for Designing Riprap Protection for Sheet Flow using Factor of Safety or Stephenson's Method," Sept. 1987, MKES Document No. 4005-Gen-0-01-03409-00.

5. M.A. Stevens, D.B. Simons & G.L. Lewis, "Safety Factors for Riprap Protection," ASCE Journal of Hydraulics, Vol. 102, HY5, May 1976, pp. 637-655.

6. D. Stephenson,"Rockfill in Hydraulic Engineering", Elsevier Scientific Publication, N.Y., 1979.

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8. Chow, V. T., "Handbook of Applied Hydrology," McGraw-Hill Book Co. Inc., N.Y., 1964.

9. U.S. Army Corps of Engineers (COE), "Hydraulic Design of Spillways," EM1110-2-1603,March 1965, reprint with change 1.

10. Chow, V.T., "Open Channel Hydraulics," McGraw-Hill Book Co. Inc., N.Y., 1959.

11. NRC,NUREG/CR-4651, "Development of Riprap Design Criteria by Riprap Testing in Flumes, Phase I," May 1987, pp. 60.

12. MKES Cal. No. 09-223-01-02, "UMTRA-HAT/MON, Site Hydrology," May 1988.

13. MKES Cal. No. 09-418-06-00, "UMTRA-HAT/MON, Erosion Protection - Rock Quality, Bluff Source(New Areas)," June 1991.

14. MKES Cal. No. 09-418-04-00, "UMTRA-HAT/MON, Erosion Protection - Rock Quality Evaluation at Sugarloaf and Lime Ridge," May 1991.

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Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet iii
		File No. –
Feature EROSION PROTECTION	Designed BYW	Date 11-29-93
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-30-93

15. MKES UMTRA-HAT/MON, "Engineering Geology Report for the Mexican Hat Site," August 1992.

16. U.S. Department of Transportation (DOT), "Hydraulic Design of Energy Dissipitators for Culverts and Channels," Hydraulic Engineering Circular No. 14, Dec. 1975.

17. Davis and Sorensen, "Handbook of Applied Hydraulics," 3rd Ed., McGraw-Hill Book Co., N.Y., 1969

1.0 Introduction and Purpose

Based on the actual quantities of contaminated materials removed at the Monument Valley processing site to date and the estimated remaining quantities, the final disposal embankment (cell) topslope elevation at UMTRA - Mexican Hat site is anticipated to be about 11 feet lower than the current design elevation . Hence the cell configuration has been changed accordingly as shown on sheet 4. This calculation is to perform the erosion protection design for this latest cell configuration. In addition, there is a concern that the approved Bluff borrow source may not have sufficient quantity of material available to meet all the project needs for riprap Type B. Therefore a new Type B1 riprap will be introduced to reduce the wastage and to optimize the volume of raw material to be processed in the Bluff source.

The scope of work in this calculation will include the following:

- Evaluate the stability of Type A (D_{50} = 1.7") riprap to be placed on the 2% cell top slopes.
- Evaluate the stability and the extent of Type B1 (D_{50} = 3.0") and Type B (D_{50} = 4.4") ripraps to be placed on the 20% or flatter embankment side slopes.
- Design the erosion protection along the south edge of the cell. Areas where Type B1, Type B, or Type C (D_{50} = 6.9") ripraps shall be placed will be determined.

The latest cell configuration is anticipated to have no or insignificant adverse effect on the following previously submitted calculations in erosion protection design:

- Calculation No. 9-418-08-00 : erosion protection design along the cell sideslope toe apron (Ref. 1).
- Calculation No. 9-418-05-01 : oversizing, gradation, and thickness for different types of erosion protection materials (Ref. 2).

2.0 Results

- 2 Percent Top Slope

The required min. D_{50} for the top slope is 0.8 inches (see sheet 12) based on the longest critical flow length of 1420 feet. Type A rock, a round river cobble from the Bluff source (Ref. 13), with a min. D_{50} of 1.7 inches (Ref. 2), will be used for the top slope. The average rock quality scores from the Bluff source is greater than 80% and no oversizing is required (Ref. 13).

- Side Slope

Both Type B1 ($D_{50(min)}$ = 3") and Type B ($D_{50(min)}$ = 4.4") rocks will be placed on the side slope. The smaller Type B1 rock with a layer thickness of 12 inches can be placed on the southern portions of the embankment side slopes which have shorter flow lengths (see sheet 4). The gradation requirements were included in Appendix B. The Type B rock should be placed on the northern parts of the embankment side slopes which have longer flow lengths (see sheet 4). Both Type B1 and Type B rocks will also come from the Bluff source, and no oversizing is required.

- South-Edge Upslope Area

1) Type B1 rock will be placed on the slope areas with a slope no steeper than 7(h):1(v) along the western portion of the south-edge upslope area (between points "A" and "B" as shown on sheet 4). A 10-foot wide transition area of about 5.3 % slope with Type B1 rock will be provided between the approximately 7:1 slope area and the 2% top slope. The layer thickness on the upstream apron of the approx. 7:1 slope area should be at least 1 foot deep to protect from local scouring when the existing haul road does not lie on the erosion resistant rock. Otherwise, the upstream portion of the approx. 7:1 rock cover shall tie-in to the erosion resistant rock of the roadway.

2) Type B rock or larger shall be placed along the upstream side of the existing haul road between points "H" and "C" to resist the impact of flow from the short steep upslope ridge (see sheet 4). This area will be graded to drain the runoff across the roadway.

3) A min. 10-foot wide apron consisting of Type B rock connecting the natural ground below the roadway and the 2 % top slope will be placed between points "B" and "C" (see sheet 4). The slope of the apron will be about 5.3 % and the apron will be 12 inches thick at the upstream end.

4) Either Type B rock on a 2.5(h):1(v) slope or Type C rock on a 2(h):1(v) slope should be provided to backfill an existing gully between points "C" and "D" (see sheet 4). The angular Type C rock shall be from the potential borrow source at Sugar Loaf quarry. The $D_{50(min)}$ of the Type C rock is 6.9 inches with a 15% oversizing factor.

5) A min. 10-foot wide apron consisting of Type B rock connecting the short steep south ridge and the 2% top slope will be placed between points "D" and "E" (see sheet 4). The slope of the apron is about 5.3 % and the apron shall be at least 12 inches thick at the upstream end.

6) The erosion protection plan and typical sections revised to incorporate the changes due to a predicted 11-foot lower embankment are shown on sheet 5.

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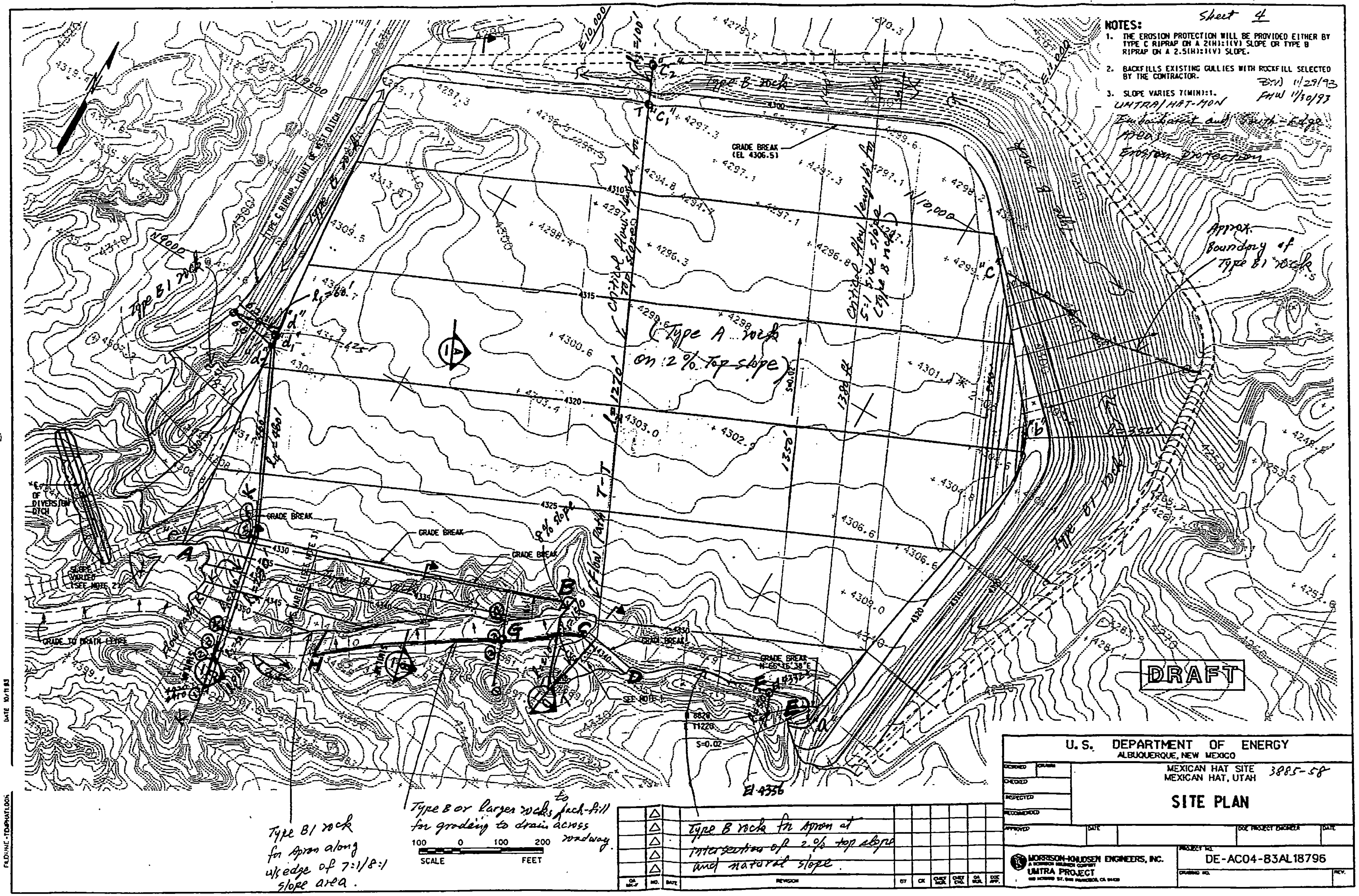
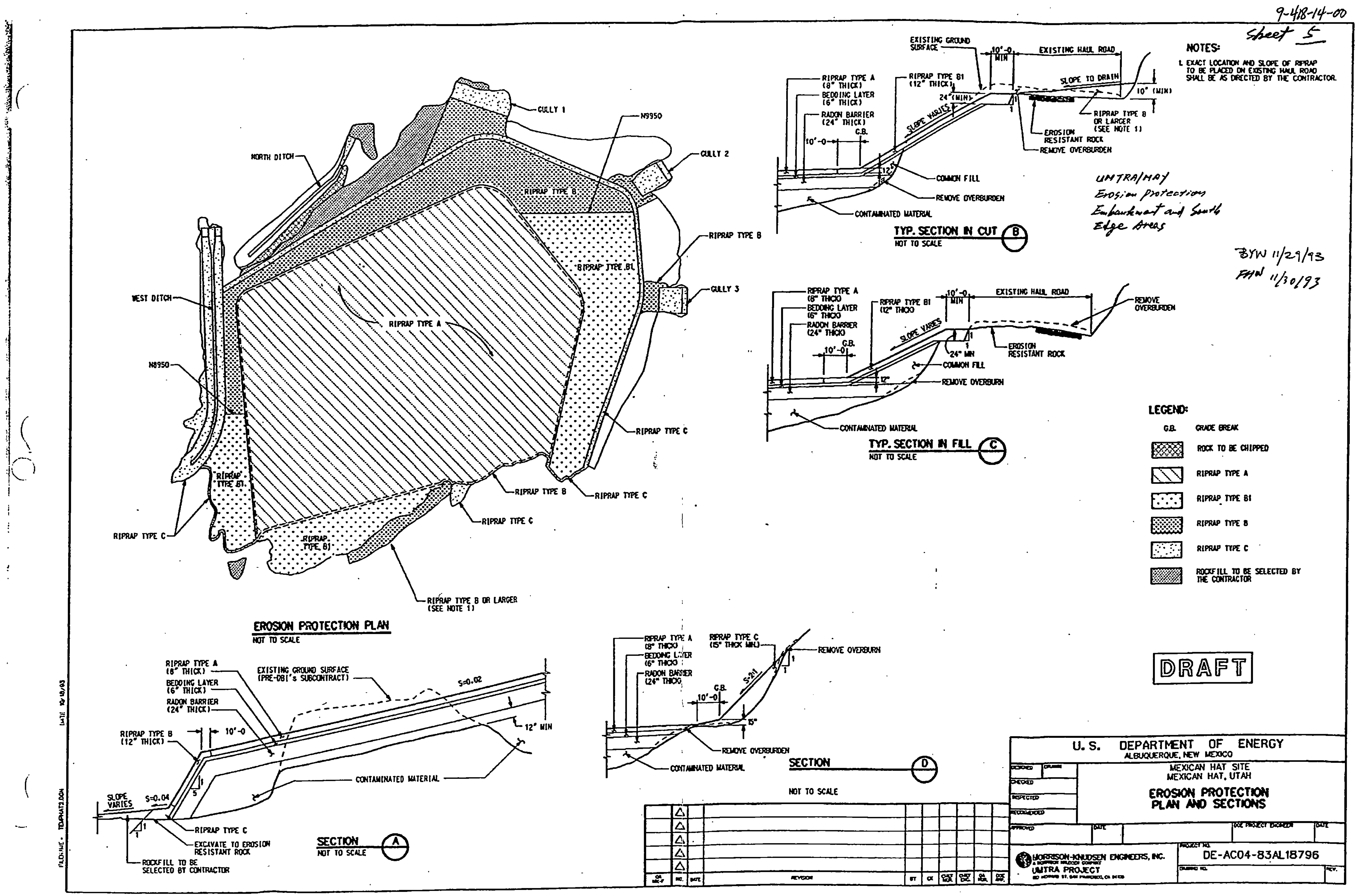
9-418-14-00


Sheet 4
NOTES:
1. THE EROSION PROTECTION WILL BE PROVIDED EITHER BY TYPE C RIPRAP ON A 2(H):1(V) SLOPE OR TYPE B RIPRAP ON A 2.5(H):1(V) SLOPE.
2. BACKFILLS EXISTING GULLIES WITH ROCKFILL SELECTED BY THE CONTRACTOR.
3. SLOPE VARIES 7(MIN):1.
UMTRA/HAT-MON
BYW 11/29/93
FHW 11/30/93
GRADE BREAK (EL 4306.5)
Type A rock on 2% Top slope
Type B rock
Type B1 rock
Approx. Boundary of Type B1 rock
GRADE BREAK
GRADE TO DRAIN LEVEE
DIVERSION DITCH
SEE NOTE 1
S=0.02
El 4356
DRAFT
Type B1 rock for Apron along u/s edge of 7:1/8:1 slope area.
Type B or larger rocks to back-fill for grading to drain across roadway
SCALE
FEET
100 0 100 200
Type B rock for Apron at intersection of 2% top slope and natural slope.
REVISION
U.S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT SITE
MEXICAN HAT, UTAH
3885-58
SITE PLAN
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
DE-AC04-83AL18796


9-418-14-00
Sheet 5
NOTES:
1. EXACT LOCATION AND SLOPE OF RIPRAP TO BE PLACED ON EXISTING HAUL ROAD SHALL BE AS DIRECTED BY THE CONTRACTOR.
UMTRA/MHY
Erosion Protection
Embankment and South Edge Areas
BYW 11/29/93
FHW 11/30/93
GULLY 1
N9950
GULLY 2
NORTH DITCH
RIPRAP TYPE B
RIPRAP TYPE B1
RIPRAP TYPE B
GULLY 3
WEST DITCH
RIPRAP TYPE A
N8950
RIPRAP TYPE C
RIPRAP TYPE B1
RIPRAP TYPE B
RIPRAP TYPE C
RIPRAP TYPE C
RIPRAP TYPE C
RIPRAP TYPE B1
RIPRAP TYPE B OR LARGER (SEE NOTE 1)
EROSION PROTECTION PLAN
NOT TO SCALE
EXISTING GROUND SURFACE
RIPRAP TYPE A (8" THICK)
RIPRAP TYPE B1 (12" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER (24" THICK)
10'-0 MIN
EXISTING HAUL ROAD
SLOPE TO DRAIN
10" (MIN)
24" (MIN)
SLOPE VARIES
C.B.
10'-0
RIPRAP TYPE B OR LARGER (SEE NOTE 1)
EROSION RESISTANT ROCK
REMOVE OVERBURDEN
COMMON FILL
REMOVE OVERBURDEN
CONTAMINATED MATERIAL
TYP. SECTION IN CUT B
NOT TO SCALE
RIPRAP TYPE A (8" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER (24" THICK)
RIPRAP TYPE B1 (12" THICK)
10'-0 MIN
EXISTING HAUL ROAD
REMOVE OVERBURDEN
SLOPE VARIES
24" MIN
EROSION RESISTANT ROCK
C.B.
10'-0
COMMON FILL
12"
REMOVE OVERBURDEN
CONTAMINATED MATERIAL
TYP. SECTION IN FILL C
NOT TO SCALE
LEGEND:
C.B. GRADE BREAK
ROCK TO BE CHIPPED
RIPRAP TYPE A
RIPRAP TYPE B1
RIPRAP TYPE B
RIPRAP TYPE C
ROCKFILL TO BE SELECTED BY THE CONTRACTOR
RIPRAP TYPE A (8" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER (24" THICK)
EXISTING GROUND SURFACE (PRE-DBI's SUBCONTRACT)
S=0.02
12" MIN
RIPRAP TYPE B (12" THICK)
10'-0
CONTAMINATED MATERIAL
SLOPE VARIES
S=0.04
RIPRAP TYPE C
EXCAVATE TO EROSION RESISTANT ROCK
ROCKFILL TO BE SELECTED BY CONTRACTOR
SECTION A
NOT TO SCALE
RIPRAP TYPE A (8" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER (24" THICK)
RIPRAP TYPE C (15" THICK MIN)
REMOVE OVERBURDEN
S=2:1
C.B.
10'-0
15"
REMOVE OVERBURDEN
CONTAMINATED MATERIAL
SECTION D
NOT TO SCALE
DRAFT
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT SITE
MEXICAN HAT, UTAH
EROSION PROTECTION PLAN AND SECTIONS
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
DE-AC04-83AL18796
DATE 10/18/93

3.0 Methods

All the riprap sizing on the upslope toe/apron area in this calculation are based on sheet flow conditions under PMP storms. Thus, measures shall be provided to assure that sheet flow conditions can be achieved for surface flow onto the embankment top slope.

3.1 Top And Side Slopes

The required min. D_{50} will be determined using the computer program "RPRP/SFST" developed by MKES (Ref. 4).

The Safety Factor method (Ref. 5) is used for the slope less than 10 % (Ref. 7), and Stephenson's Method (Ref. 6) is used for the slope greater than or equal to 10 % (Ref. 7).

- Safety Factor Method (Ref. 5)

On a plane slope, the equation is as follows:

$$D_{50} = \frac{21\tau}{\left[(G_s-1)\,\gamma_w \cos\theta \left[\frac{1}{S.F.} - \frac{\tan\theta}{\tan\phi}\right]\right]}$$

where:
S.F. = safety factor = 1.0 for PMP condition
ϕ = angle of repose (in degree) of rock
θ = angle of the plane slope
τ = shear stress (psf)
γ_w = 62.4 pcf
G_s = specific gravity

- Stephenson's Method (Ref. 6)

$$D_{50} = \left[\frac{q\,(\tan\theta)^{\frac{7}{6}}\,(p)^{\frac{1}{6}}}{C\,g^{\frac{1}{2}}[(1-p)\,(G_s-1)\,\cos\theta\,(\tan\phi-\tan\theta)]^{\frac{5}{3}}}\right]^{\frac{2}{3}}$$

where:
p = porosity ≐ 0.33
C = empirical factor
= 0.22 for rounded rock
= 0.27 for angular rock
other parameters are previously defined.

3.2 South-Edge Upslope Area

The critical peak PMP discharge at each different locations along the south-edge area will be estimated from the Rational Formula, Q = C I A (Ref. 8). For a sheet flow condition, the length of the slope will be used to represent the area (i.e. A = length x 1 foot strip.) The longest slope length will be chosen for the design peak discharge.

Stable rock size, D_{50}(min), on the upslope apron will be estimated by the appropriate methods such as the U.S. Army Corps of Engineer's Stilling Basin Method (Ref. 9), Stephenson's Method (Ref. 6), and the Safety Factor Method (Ref. 5). The equations and criteria are described below:

3.2.1 Flow Characteristics (Manning's and other equations)

Based on Manning's Formula and a sheet flow conditions, the flow characteristics (i.e. flow depth, flow velocity, etc ...) are computed with:

$$q = \frac{1.486}{n} y^{\frac{5}{3}} s^{\frac{1}{2}}, \quad \text{or} \quad y = \left[\frac{n\,q}{1.486\, s^{\frac{1}{2}}}\right]^{0.6} \qquad \text{(Ref. 10)}$$

$$v = \frac{q}{y}, \quad Fr = \frac{v}{\sqrt{g\, y \cos\theta}}, \quad \tau = \gamma_w\, y\, s \qquad \text{(Ref. 10)}$$

$n = 0.0456\ (D_{50}\ s)^{0.159}$ for slopes > 10% and D_{50} in inches (Ref.11),

or

$n = \dfrac{y^{1/6}}{(23.85 + 21.95 \log(y/D_{50}))}$ for slopes ≤ 10% and D_{50} in feet (Ref.7)

where, q = flow per unit width (cfs/ft)
y = flow depth (ft)

F:\BYW\HAT\TEXT\PID20

v = flow velocity (fps)
s = energy slope (approximated as side slope)
n = Manning's roughness coeff.
D_{50} = Median diameter of riprap
Fr = Froude number
$\theta = \tan^{-1}(s)$ = slope angle
g = acceleration of gravity (ft/sec^2)

3.2.2 Riprap Sizing for Erosion Protection

The Safety Factor Method and Stephenson Method are the same as described in Sec. 3.1 above. The U.S. Army Corps of Engineers Stilling Basin Method (Ref. 9) is presented below:

$$D_{50} = \frac{v^2}{\left[E^2\ 2\ g\ (G_s - 1)(\cos\theta - \sin\theta)\right]}$$

where:
v = minimum velocity to move the D_{50} rock
(The velocity on the steeper slope will be used.)
E = Empirical constant
= 0.86 for high turbulence
= 1.20 for low turbulence
θ = slope of the apron
G_s = Specific gravity of the rock

4.0 Calculations

4.1 Top and Side Slopes

The calculations were either performed using the computer program "RPRP/SFST" (Ref. 4) or by hand computation. The various assumptions and input parameters used are presented below:

1) PMP rainfall intensity-duration regression equation (Ref. 12 and see sheet A-1) constants are:

$$I = 10^{G - H(\log T)^Z}$$

G=1.797; H=0.307; and Z=1.816

2) Specific gravities of the rocks are 2.64 for rounded rock from Bluff source (Ref. 13) and 2.70 for angular rock from Sugar Loaf source

3) Coefficient in Stephenson's equation C = 0.22 for rounded rock and 0.27 for angular rock.

4) Factor of Safety =1.0

5) No flow through the rock pores is considered (a conservative assumption)

6) Porosity of the rock = 0.30 (assumed)

7) Rock friction angle- estimated from sheet A-2 (Ref. 3)

The rock source for Type A, B, and B1 rocks will be from Bluff source. These rocks will consist of rounded river cobbles with rock quality scores greater than 80%. Therefore no oversizing is required (Ref. 3).

4.1.1 <u>Top Slope</u>

The longest/critical flow length was determined to be line T-T (at point c_1) as shown on sheet 4.

$L_1 = 150'$ $\quad s_1 = 0.4$
$L_2 = 1270'$ $\quad s_2 = 0.02$

Total $L = L_1 + L_2 = 1420'$

Based on computer output (see sheets 11 and 12) and using the round rocks, the required $D_{50(min)}$ is 0.8 inches.

Hence Type A rock is stable on the 2% top slope.

At point "c_1",

$I_{PMP} = 28.3$ in/hr, $q = 0.92$ cfs/ft,
$y = 0.18'$, $v = 4.3$ fps, $n = 0.026$ (see sheet 13)

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet 11
		File No. –
Feature EROSION PROTECTION	Designed BYW	Date 11-18-93
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-19-93

```
HATSP8.OUT                11/12/93                Page 1

 **INPUT FILE PRINTOUT**
            TOP SLOPE
UMTRA/M/H - ~~SIDE~~ SLOPE,ZERO PORE FLOW (FILE:HATSP8.OUT)

HAT   FHW   11-12 1993
  1.797  .307 1.816 2.640  .220      1  .002 1.0
   2    0
   0    0
   3   25
 UPS      150.0  40.0   .30  35.0  ST
 TOP      *****   2.0   .30  37.0  FS
  .5000   1.0   .00065
  .0250   1.0   .00065

 * * * * * * * * * * * END INPUT DATA * * * * * * * * * * *



UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP8.OUT)

 UMTRA/HAT       RUN I.D.=FHW      DATE=11-12 1993

***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***


* * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *


 COEFFICIENTS FOR INTENSITY DURATION CURVE -
         IPMP=10**(G-H*(LOGT)**Z):

         G= 1.797  H= .307  Z=1.816

 RIPRAP STONE SP.GRAVITY= 2.64   C IN STEPHENSONS EQN=  .22

            - - - EMBANKMENT - - -
  AREA
(LOCATION  SEGMENT  LENGTH  SLOPE POROSITY  FRICTION
IN PLAN)             (FT)    (%)            ANGLE
                                            (DEG)
   1         UPS     150.     40.    .30     35.  STEPHENSONS
   1         TOP    1270.      2.    .30     37.  SAFETY FACTOR

* * * * * * * * * * * END INPUT DATA * * * * * * * * * * *
```

Note: Input data here on this sheet are for output on sheet 12

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet 12
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked EHW	Date 11-18-93
		Date 11-19-93

HATSP8.OUT 11/12/93 Page 2

TOP SLOPE DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=TOP LENGTH=1270. FT. SLOPE= 2.%

ASSUMED D50= .0673FT. AT D/S END OF SEGMENT
CORRESPONDING Q= .998CFS/FT AT SEGMENT END BY FS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.035	.000	.035	.62	.06	.203	1.34	1.34
50.	100.	.070	.000	.070	1.05	.07	.137	.79	2.13
100.	150.	.105	.000	.105	1.42	.07	.115	.59	2.72
0.	51.	.141	.000	.141	1.62	.09	.025	.52	3.24
51.	102.	.177	.000	.177	1.80	.10	.025	.47	3.71
102.	152.	.212	.000	.212	1.96	.11	.024	.43	4.14
152.	203.	.248	.000	.248	2.11	.12	.024	.40	4.54
203.	254.	.284	.000	.284	2.24	.13	.024	.38	4.92
254.	305.	.319	.000	.319	2.36	.14	.023	.36	5.28
305.	356.	.355	.000	.355	2.47	.14	.023	.34	5.62
356.	406.	.391	.000	.391	2.58	.15	.023	.33	5.95
406.	457.	.427	.000	.427	2.68	.16	.023	.32	6.26
457.	508.	.462	.000	.462	2.78	.17	.023	.30	6.57
508.	559.	.498	.000	.498	2.87	.17	.023	.29	6.86
559.	610.	.534	.000	.534	2.96	.18	.023	.29	7.15
610.	660.	.569	.000	.569	3.05	.19	.023	.28	7.43
660.	711.	.605	.000	.605	3.13	.19	.022	.27	7.70
711.	762.	.641	.000	.641	3.21	.20	.022	.26	7.96
762.	813.	.676	.000	.676	3.29	.21	.022	.26	8.22
813.	864.	.712	.000	.712	3.37	.21	.022	.25	8.47
864.	914.	.748	.000	.748	3.44	.22	.022	.25	8.72
914.	965.	.783	.000	.783	3.51	.22	.022	.24	8.96
965.	1016.	.819	.000	.819	3.58	.23	.022	.24	9.19
1016.	1067.	.855	.000	.855	3.65	.23	.022	.23	9.43
1067.	1118.	.890	.000	.890	3.71	.24	.022	.23	9.65
1118.	1168.	.926	.000	.926	3.77	.25	.022	.22	9.88
1168.	1219.	.962	.000	.962	3.84	.25	.022	.22	10.10
1219.	1270.	.998	.000	.998	3.90	.26	.022	.22	10.32

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
30.60	30.37

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
UPS	150.	40.0	6.0	.235	2.5	6.00	STEPHENSON
TOP	1270.	2.0	.8	.998	10.3	.30	SAFETY FACTOR

D_{50} (min) required

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON | Contract No. 3885-58 | Sheet 13
Feature EROSION PROTECTION | Designed BYW | File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS | Checked FHW | Date 11-18-93 | Date 11-19-93

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.032	.000	.032	.58	.06	.209	1.43	1.43
50.	100.	.065	.000	.065	1.00	.06	.145	.83	2.26
100.	150.	.097	.000	.097	1.34	.07	.118	.62	2.89
0.	51.	.130	.000	.130	1.38	.09	.032	.61	3.50
51.	102.	.163	.000	.163	1.54	.11	.031	.55	4.05
102.	152.	.196	.000	.196	1.68	.12	.030	.50	4.55
152.	203.	.229	.000	.229	1.80	.13	.030	.47	5.02
203.	254.	.262	.000	.262	1.92	.14	.029	.44	5.46
254.	305.	.295	.000	.295	2.03	.15	.029	.42	5.88
305.	356.	.328	.000	.328	2.13	.15	.028	.40	6.28
356.	406.	.361	.000	.361	2.22	.16	.028	.38	6.66
406.	457.	.394	.000	.394	2.32	.17	.028	.36	7.02
457.	508.	.427	.000	.427	2.41	.18	.028	.35	7.38
508.	559.	.460	.000	.460	2.49	.18	.027	.34	7.72
559.	610.	.493	.000	.493	2.57	.19	.027	.33	8.04
610.	660.	.526	.000	.526	2.65	.20	.027	.32	8.36
660.	711.	.559	.000	.559	2.72	.21	.027	.31	8.67
711.	762.	.592	.000	.592	2.80	.21	.027	.30	8.98
762.	813.	.625	.000	.625	2.86	.22	.027	.30	9.27
813.	864.	.658	.000	.658	2.93	.22	.026	.29	9.56
864.	914.	.691	.000	.691	3.00	.23	.026	.28	9.84
914.	965.	.724	.000	.724	3.06	.24	.026	.28	10.12
965.	1016.	.757	.000	.757	3.12	.24	.026	.27	10.39
1016.	1067.	.790	.000	.790	3.18	.25	.026	.27	10.66
1067.	1118.	.823	.000	.823	3.24	.25	.026	.26	10.92
1118.	1168.	.856	.000	.856	3.30	.26	.026	.26	11.18
1168.	1219.	.889	.000	.889	3.36	.27	.026	.25	11.43
1219.	1270.	.922	.000	.922	3.41	.27	.026	.25	11.68
0.	1.	.922	.000	.922	5.07	.18	.042	.00	11.68
1.	1.	.923	.000	.923	5.07	.18	.042	.00	11.68

← Actual flow condition at end of top slope for $D_{50} = 1.5''$ for a total length of $150 + 1270 = 1420$ ft.

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z))
(INCH/HR) 28.29	(INCH/HR) 28.27

Note: Input data not included, but similar to input data on sheet 11 except assigning $D_{50} = 1.5''$ on top slope input and adding a hypothetical segment.

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
UPS	150.	40.0	6.0	.235	2.5	6.00	STEPHENSON
TOP	1270.	2.0	1.5	2.524 *1	7.0	1.50	SAFETY FACTOR
HYPO *2	1.	20.0	4.2	.923	11.7	.30	STEPHENSON

Remark: *1 This Q is the largest flow that Type A rock $D_{50} = 1.5''$ can sustain. Actual flow rate is 0.92 cfs/ft as shown on above table (underlined)
*2 This very short hypothetical segment is added in order to have the actual flow condition computed as shown on above table (underlined)

4.1.2 Side Slope

Required rock sizes on the embankment side slopes at different locations were evaluated to determine the areas where Type B1 rock can be used to sustain the PMP flow condition and to check the stability of Type B rock at the remainder of the side slope areas.

1) Between "a" and "b" (see sheet 4)

There is no flow contribution from the top slope. Flow is only from the 5:1 side slope itself.

The longest flow length is at "b" with L = 350'.

By Kirpich equation (Ref. 8),

T_c (time of concentration) = $0.0078\ L^{0.77} / s^{0.385} = 1.3$ min, for $s=0.20$

use minimum T_c = 2.5 min., hence I_{PMP} = 53.5 in/hr. (see sheet A-1)

$q = C\ I\ L / 43560 = 1.0\ (53.5)\ (350) / 43560 = 0.43$ cfs/ft

By Stephenson Method:

θ = side slope = 11.31°
For rounded rock, use $\phi \doteq 37°$ (see sheet A-2)

Then $D_{50} = (0.22049\ q)^{2/3} = 0.21' = 2.5"$

This required rock size is less than 3 inches, so use Type B1 rock.

The critical q and longest flow length that the type B1 rock can sustain the PMP flow on the 5:1 side slope alone can be determined as follows:

$q_c = D_{50}^{1.5} / 0.22049$

For D_{50} = 3", q_c = 0.57 cfs/ft.

$q_c = C\ I\ L_c / 43560$

Assume T_c = 2.5 min., I_{PMP} = 53.5 in/hr. (see sheet A-1)

Hence, $L_c = 43560 (0.57) / 53.5 = \underline{465 \text{ ft.}}$

Check $T_c = 0.0078 L^{0.77} / s^{0.385} = 1.6$ min < 2.5 min O.K.

2) Between "b" and "c" (see sheet 4)

This area will have combined flows from 2% top slope and 5:1 side slope. Flow length combination of top and side slopes that will have stable rock size of Type B1 (D_{50} = 3") under PMP sheet flow condition are as follows:

Top Slope	600'	550'	500'	420'	330'	180'	100'
Side Slope	20'	50'	100'	150'	200'	350'	400'
Total Length	620'	600'	600'	570'	530'	530'	500'

Based on these results, the approximate boundary, where Type B1 rock (D_{50} = 3") is stable on the 5:1 side slope between points "b" and "c" under PMP conditions, is shown on sheet 4.

Output for the "RPRP/SFST" computer runs are presented in Appendix C.

3) Between "c", "c_1" and "d" (see sheet 4)

This is the area where Type B rock is required on the 5:1 side slope. A check is made to see if Type B rock is stable on the 5:1 side slope under PMP conditions. Several combined top slope and side slope flow lengths were tested, and the most critical condition is at point "c_2". (flow line T-T):

L_1 = 150' s = 0.4
L_2 = 1270' s = 0.02
L_3 = 100' s = 0.2
Total length = 1520'

The required rock size (D_{50}) is 4.3". Hence Type B rock, D_{50} = 4.4" is stable. Output from the "RPRP/SFST" computer runs are presented on sheets 16 to 18.

At point "c_2",
I_{PMP} = 27.6 in/hr, q = 0.96 cfs/ft, n=0.043
y = 0.19', v = 5.1 fps (see sheet 18)

F:\BYW\HAT\TEXT\PID20

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet 16
		File No. –
Feature EROSION PROTECTION	Designed BYW	Date 11-18-93
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-19-93

For side slope :

HATSP7.OUT 11/12/93 Page 1

```
**INPUT FILE PRINTOUT**

UMTRA/H/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP.OUT)

HAT   FHW   11-12 1993
  1.797  .307 1.816 2.640  .220      1  .002 1.0
   3    0
   0    0    0
   3   25    2
 UPS     150.0  40.0   .30  35.0  ST
 TOP     *****   2.0   .30  37.0  FS
 SIDE    100.0  20.0   .30  37.0  ST
  .5000   1.0   .00065
  .1250   1.0   .00065
  .0250   1.0   .00065

 * * * * * * * * * * * * END INPUT DATA * * * * * * * * * * * *
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UMTRA/H/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP.OUT)

 UMTRA/HAT      RUN I.D.=FHW      DATE=11-12 1993

***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***

* * * * * * * * * * * * INPUT DATA * * * * * * * * * * * * * *

 COEFFICIENTS FOR INTENSITY DURATION CURVE -
         IPMP=10**(G-H*(LOGT)**Z):

         G= 1.797  H= .307  Z=1.816

  RIPRAP STONE SP.GRAVITY= 2.64   C IN STEPHENSONS EQN=  .22

              - - - EMBANKMENT - - -
```

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	UPS	150.	40.	.30	35.	STEPHENSONS
1	TOP	1270.	2.	.30	37.	SAFETY FACTOR
1	SIDE	100.	20.	.30	37.	STEPHENSONS

* * * * * * * * * * * * END INPUT DATA * * * * * * * * * * * *

Note: Input data on this sheet are for output on sheet 17.

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet 17
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-18-93
		Date 11-19-93

For side slope:

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.032	.000	.032	.57	.06	.211	1.46	1.46
50.	100.	.063	.000	.063	.99	.06	.147	.85	2.31
100.	150.	.095	.000	.095	1.32	.07	.119	.63	2.94
0.	51.	.127	.000	.127	1.37	.09	.032	.62	3.56
51.	102.	.160	.000	.160	1.52	.10	.031	.56	4.12
102.	152.	.192	.000	.192	1.67	.12	.030	.51	4.63
152.	203.	.224	.000	.224	1.78	.13	.030	.47	5.10
203.	254.	.256	.000	.256	1.90	.13	.029	.45	5.55
254.	305.	.289	.000	.289	2.01	.14	.029	.42	5.97
305.	356.	.321	.000	.321	2.11	.15	.028	.40	6.37
356.	406.	.353	.000	.353	2.20	.16	.028	.38	6.76
406.	457.	.385	.000	.385	2.30	.17	.028	.37	7.12
457.	508.	.418	.000	.418	2.38	.18	.028	.36	7.48
508.	559.	.450	.000	.450	2.47	.18	.027	.34	7.82
559.	610.	.482	.000	.482	2.55	.19	.027	.33	8.15
610.	660.	.514	.000	.514	2.62	.20	.027	.32	8.48
660.	711.	.547	.000	.547	2.70	.20	.027	.31	8.79
711.	762.	.579	.000	.579	2.77	.21	.027	.31	9.10
762.	813.	.611	.000	.611	2.84	.22	.027	.30	9.40
813.	864.	.643	.000	.643	2.90	.22	.027	.29	9.69
864.	914.	.676	.000	.676	2.97	.23	.026	.29	9.97
914.	965.	.708	.000	.708	3.03	.23	.026	.28	10.25
965.	1016.	.740	.000	.740	3.09	.24	.026	.27	10.53
1016.	1067.	.772	.000	.772	3.15	.25	.026	.27	10.80
1067.	1118.	.805	.000	.805	3.21	.25	.026	.26	11.06
1118.	1168.	.837	.000	.837	3.27	.26	.026	.26	11.32
1168.	1219.	.869	.000	.869	3.32	.26	.026	.25	11.57
1219.	1270.	.901	.000	.901	3.38	.27	.026	.25	11.82
0.	50.	.933	.000	.933	5.06	.18	.043	.16	11.99
50.	100.	.965	.000	.965	5.14	.19	.043	.16	12.15

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA=(43560*Q)/L	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**2))
(INCH/HR)	(INCH/HR)
27.65	27.62

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
UPS	150.	40.0	6.0	.235	2.5	6.00	STEPHENSON
TOP	1270.	2.0	1.5	2.524	7.0	1.50	SAFETY FACTOR
SIDE	100.	20.0	4.3	.965	12.2	.30	STEPHENSON

* D_{50} (min) required

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	18
Feature	EROSION PROTECTION	Designed	BYW	File No.	–
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	FHW	Date	11-18-93
				Date	11-19-93

For Side slope:

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.032	.000	.032	.57	.06	.211	1.46	1.46
50.	100.	.063	.000	.063	.98	.06	.147	.85	2.31
100.	150.	.095	.000	.095	1.32	.07	.119	.63	2.94
0.	51.	.127	.000	.127	1.37	.09	.032	.62	3.56
51.	102.	.160	.000	.160	1.52	.10	.031	.56	4.12
102.	152.	.192	.000	.192	1.66	.12	.030	.51	4.63
152.	203.	.224	.000	.224	1.78	.13	.030	.47	5.10
203.	254.	.256	.000	.256	1.90	.13	.029	.45	5.55
254.	305.	.288	.000	.288	2.01	.14	.029	.42	5.97
305.	356.	.321	.000	.321	2.11	.15	.028	.40	6.37
356.	406.	.353	.000	.353	2.20	.16	.028	.38	6.76
406.	457.	.385	.000	.385	2.30	.17	.028	.37	7.13
457.	508.	.417	.000	.417	2.38	.18	.028	.36	7.48
508.	559.	.450	.000	.450	2.47	.18	.027	.34	7.83
559.	610.	.482	.000	.482	2.55	.19	.027	.33	8.16
610.	660.	.514	.000	.514	2.62	.20	.027	.32	8.48
660.	711.	.546	.000	.546	2.69	.20	.027	.31	8.79
711.	762.	.579	.000	.579	2.77	.21	.027	.31	9.10
762.	813.	.611	.000	.611	2.83	.22	.027	.30	9.40
813.	864.	.643	.000	.643	2.90	.22	.027	.29	9.69
864.	914.	.675	.000	.675	2.97	.23	.026	.29	9.98
914.	965.	.707	.000	.707	3.03	.23	.026	.28	10.26
965.	1016.	.740	.000	.740	3.09	.24	.026	.27	10.53
1016.	1067.	.772	.000	.772	3.15	.25	.026	.27	10.80
1067.	1118.	.804	.000	.804	3.21	.25	.026	.26	11.06
1118.	1168.	.836	.000	.836	3.26	.26	.026	.26	11.32
1168.	1219.	.869	.000	.869	3.32	.26	.026	.26	11.58
1219.	1270.	.901	.000	.901	3.37	.27	.026	.25	11.83
0.	50.	.932	.000	.932	5.02	.19	.043	.17	11.99
50.	100.	.964	.000	.964	5.10	.19	.043	.16	12.16
0.	1.	.965	.000	.965	5.14	.19	.043	.00	12.16

← Actual flow condition at end of 5:1 slope (point C_2 on sheet 4), for a total flow length of 1521 ft.

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z))
(INCH/HR)	(INCH/HR)
27.63	27.60

Note: Input data not included, but similar to input data on sheet 16 except assigning D_{50} = 1.5" & 4.4" on Top + side slope, and also adding a hypothetical segment

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
UPS	150.	40.0	6.0	.235	2.5	6.00	STEPHENSON
TOP	1270.	2.0	1.5	2.524	7.0	1.50	SAFETY FACTOR
SIDE	100.	20.0	4.4	1.007 *1	11.9	4.40	STEPHENSON
HYPO *2	1.	20.0	4.3	.965	12.2	.30	STEPHENSON

Note: *1 This is the largest Q, D_{50} = 4.4" can sustain. Actual flow rate = 0.964 cfs/ft as shown on above table (underlined).
*2 hypothetical segment is added in order to have actual flow condition computed as shown on above table.

4) Between "d" and "e"

At point "d", where Type B1 rock becomes stable on the side slope, was determined by trial-and-error computation.

At point "d_1",

$L_1 = 100$ $\Delta h = 4410\text{-}4360 = 50$	$s_1 = 50/100 = 0.5$
$L_2 = 50$ $\Delta h = 10$	$s_2 = 0.1$
$L_3 = 230$	$s_3 = 1/7 = 0.14286$
$L_4 = 480$	$s_4 = 0.02$
$L_5 = 115$(6.2(h):1(v) side slope)	$s_5 = 18.5/115 = 1/6.2 = 0.1613$

Let part of the length, L_5 of the 6.2(h):1(v) side slope which Type B1 rock can sustain the PMP flow be: $L_s = 60'$.

Therefore Total length = 100+50+230+480+60 = 930

$$T_c = 0.0078\,(\,100^{0.77} / 0.5^{0.385} + 50^{0.77} / 0.1^{0.385} + 230^{0.77} / 0.14286^{0.385} + 480^{0.77} / 0.02^{0.385} + 60^{0.77} / 0.1613^{0.385}) = 6.3 \text{ min}$$

(note: assumed T_c is approximately the sum of T_c from each flow length segments using Kirpich equation)

Using $T_c = 6.3$, $I_{PMP} = 39.5$ in/hr.

$q = 1.0\,(39.5)\,(930) / 43560 = 0.84$ cfs/ft

By Stephenson Method:
Use $\phi = 37°$, $\theta = \tan^{-1}(1/6.2) = 9.16°$, $p = 0.3$, $C = 0.22$, $G_s = 2.64$

Then $D_{50} = (0.15156\ q)^{2/3} = \underline{3.0''}$ (Type B1 rock)

At point "d_2",

$L_1 = 100$	$s_1 = 0.5$	
$L_2 = 50$	$s_2 = 0.1$	
$L_3 = 230$	$s_3 = 0.14286$	
$L_4 = 460$	$s_4 = 0.02$	
$L_5 = 125$		$s_5 = 1{:}6.5 = 0.15385$ (side slope)

Therefore Total length = 100+50+230+460+125 = 965

T_c = 6.3 min, I_{PMP} = 39.5 in/hr.

q = 1.0 (39.5) (965) / 43560 = 0.88 cfs/ft

By Stephenson Method:

Use $\phi = 37°$, $\theta = \tan^{-1}(1/6.5) = 8.75°$, p = 0.3, C = 0.22, $G_s = 2.64$

Then $D_{50} = (0.1402\ q)^{2/3} = \underline{3.0''}$ (use Type B1 rock)

Based on these computations, the approximate boundary of Type B1 rock for side slope on the west side of the embankment is shown on sheet 4.

4.2 South-Edge Upslope Area

4.2.1 Area below haul road between points "A" and "B" with approx.7:1 slope (see sheet 4)

This is the area where 2% top slope will not extend to the existing roadway. A rock cover with slope no steeper than 7(h):1(v) will be provided as transition between the 2% top slope and the roadway.

Based on field investigations and the geology report (Ref. 15), the roadway in this area lies on an erosion resistant rock which can sustain and resist the erosive force of flow from the steep upland area. Thus the roadway can serve as an energy dissipator and disperse the flow downstream; this approximately creates a sheet flow condition downstream of the roadway. Additionally, most of the runoff from the upland in this area will be drained along the upstream side of the roadway and diverted through an open cut area (east of point "H", see sheet 4) toward south-east away from the disposal cell.

Since gullies currently exist below the roadway, the apron area between the 2% top slope and the roadway will be graded with a maximum slope of about 7:1 and armored with Type B1 riprap (if feasible) to further promote evenly distributed flow.

1) Peak discharge

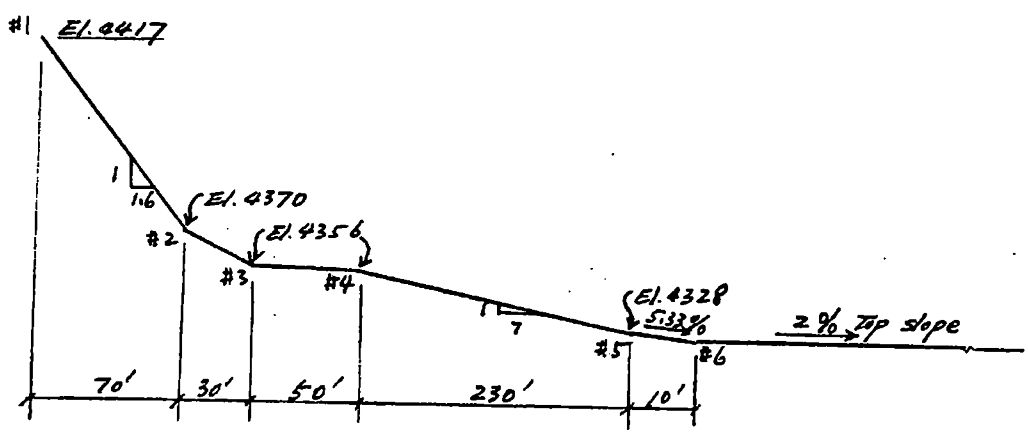
The longest and most critical flow length is selected as the critical condition for the designed peak discharge. The following is a summary table of the condition along this flow path. A profile is also shown on sheet 21.

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet 21
Feature EROSION PROTECTION	Designed BYW	File No. —
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

location#	Elev.	L	ΔL	ΔH	ΔH/ΔL	slope	T_c (min)	I (in/hr)	q (cfs/ft)
1	4415	0							
2	4370	70	70	45	0.643	1.6:1	0.24		
3	4356	100	30	14	0.47	2.1:1	0.40	53.5**	0.12
4	4356	150	50	0	0		*		
5	4328	380	230	28	0.145+	7:1	1.50	53.5**	0.47
6***	4327.47	390	10	0.53	0.0533	18.75:1	1.70	53.5**	0.48

* To be conservative, neglect the T_c for this section.
** Use a minimum T_c = 2.5 minutes.
*** Slope downstream of location #6 is 2% (embankment top slope).
\+ Actual slope is milder, but use 7:1 slope.
\# See flow-path K-K on sheet 4.



2) Flow characteristics at different slope locations

- At location #3 - upstream side of roadway

q = 0.12 cfs/ft (see table above)
s = 0.47 (approximate upstream slope), θ = 25.2°
let n = 0.05 for jagged and irregular rock cut condition (Ref. 10)

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$$y = \left[\frac{n\,q}{1.486\ s^{\frac{1}{2}}}\right]^{0.6} = 0.046'$$

$$v = \frac{q}{y} = 2.6 \text{ fps}, \qquad Fr = \frac{v}{\sqrt{gy\cos\theta}} = 2.3$$

Hydraulic jump occurs at point no. 3

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2}-1\right) = 2.7, \text{ (Ref. 10)} \qquad y_2 = 0.13'$$

$$v_2 = \frac{q}{y_2} = 0.96 \text{ fps}$$

Length of jump $\doteq 5\ y_2 = 0.7'$ (Ref. 10)

Hence, the 25 to 35 feet wide roadway is long enough to spread the flow from the upland slope.

- At location #5 - upstream end of 5.33% transition slope

$q = 0.47$ cfs/ft (see sheet 21)

On upstream 7:1 slope
$s = 0.1429$ and $\theta = 8.13°$
$n = 0.0456\ (D_{50}\ s)^{0.159} = 0.04$ for $D_{50} = 3.0''$

then, $y_1 = 0.13'$, $v = 3.6$ fps and $Fr = 1.8$
$\tau = \gamma_w\ y\ s = 0.96\ \text{lb/ft}^2$

On 5.33% slope
$s = 0.053$, $\theta = 3.05°$; use $n = 0.037$

then, $y_2 = 0.17'$, $v = 2.8$ fps and $Fr = 1.20$
$\tau = \gamma_w\ y\ s = 0.56\ \text{lb/ft}^2$

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.037 \qquad \text{O.K.}$$

- At location #6 - upstream end of 2% top slope

$q = 0.48$ cfs/ft (see sheet 21)

On upstream 5.33% slope

$s = 0.0533$ ($\theta = 3.05°$)
use $n = 0.037$

then, $y = 0.17'$, $v = 2.8$ fps, $Fr = 1.2$
$\tau = \gamma_w\, y\, s = 0.57$ psf

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.037 \qquad \text{O.K.} \qquad (D_{50} = 3.0 \text{ in.})$$

On 2% slope

$s = 0.02$ ($\theta = 1.146°$)
use $n = 0.035$

then, $y = 0.22'$, $v = 2.2$ fps, $Fr = 0.82$
$\tau = \gamma_w\, y\, s = 0.27$ psf

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.035 \qquad \text{O.K.}$$

So, hydraulic jump occurs on the 2% slope :

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2}-1\right) = 1.27$$

$y_2 = 1.27\, y_1 = 1.27\,(0.17) = \underline{0.22'}$

Length of jump $= 5\, y_2 = 5\,(0.22) = 1$ ft (insignificant).

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3) Required riprap sizing

a) At Location #4: upstream of 7:1 slope (see sheet 21).

- Required Rock Size:

l = 150', use T_c = 2.5 min, I_{PMP} = 53.5 in/hr

$q = 1.0\ (53.5)\ (150) / 43560 = 0.184$ cfs/ft

Assume no erosion resistant rock exists at this location.
Assume flow concentration factor (FCF) = 3.0.

Then, $q = 3\ (0.184) = 0.55$ cfs/ft

Using a slope of $s = 0.04$ across the roadway,

$y = [n\ q / (1.486\ s^{0.5})\ ]^{0.6}$, use $n = 0.04$

Then, $y = 0.21'$, $v = 2.6$ fps, $\tau = 0.52$ lb/ft^2

Required rock size on 7:1 slope (By Stephenson's Method):

using $q = 0.55$ cfs and slope of 7:1, $\theta = 8.13°$

$G_s = 2.64$, $\phi = 37°$ (see sheet A-2), $C = 0.22$ for round rock

$D_{50} = (0.12443\ q)^{0.667}$ = 2.0″ (Type B1 rock is O.K.)

- Estimate of local scour depth at location #4: (Assuming no erosion resistant rock exists at this location):

  Depth of apron upstream of 7:1 slope at location #4 will be at least equal to the local scour due to the PMP. Local scour was estimated below:

  Using the DOT empirical equation for scour below culvert outlet (Ref 16):

$$D_s = \alpha\ y_e^{\gamma} \left[\frac{Q}{y_e^{2.5}} \right]^{\beta} (t)^{\theta}, \quad \text{where}$$

D_s = depth of scour in feet
y_e = flow depth or equivalent flow depth in feet
Q = peak flow rate in cfs (for sheet flows, Q=q in cfs per unit width)
t = duration in min with peak flow rate, use 30 min.
α, γ, β, and θ are empirical parameters, and the following values are used:
$\alpha = 0.82$, $\beta = 0.375$, $\theta = 0.1$ and $\gamma = 1.0$ (Ref. 10)

Hence for $y_e = 0.21'$, $Q = q = 0.55$ cfs/ft

$$D_s = 0.82\ (0.21)^{1.0} \left[\frac{0.55}{(0.21)^{2.5}}\right]^{0.375} (30)^{0.1} = 0.84\text{ft.}$$

Using Lacey's regime equation (Ref. 17)

$$R = 0.9 \left(\frac{q^2}{f}\right)^{\frac{1}{3}},\quad q = 0.55\ (\text{FCF} = 3), \qquad \text{where}$$

R = hydraulic radius in feet,
q = cfs/ft
f = Lacey's silt factor $= 1.76\sqrt{D_{50}(\text{min})}$

Assume for very fine sand, $D_{50}(\text{min}) \doteq 1.0$ mm, then $f = 1.76$

$$R = 0.9 \left(\frac{0.55^2}{1.76}\right)^{\frac{1}{3}} = 0.5 \text{ ft}$$

Depth of scour below water surface $= \chi R = 2.25\ (0.5) = 1.13$ ft
($\chi = 1.75$ to 2.25, to be conservative use $\chi = 2.25$)

$\therefore$ Depth of scour below apron = 1.13 - 0.21 = 0.9 ft.

Using the Tractive Force Method (Ref. 10)

It is conservatively assumed that the road surface has the equivalent soil condition as firm loam; thus the critical tractive force is 0.075 lb/ft^2 (Ref. 10). Under the existing slope of 0.04, with n = 0.04, q = 0.55 (FCF = 3) $\tau = 0.52$ lb/ft^2 (see sheet 24) > 0.075

Thus, local scour will reduce the slope until the shear stress is less than 0.075 lb/ft^2:

$$\text{at } s = 0.002, \quad y = \left[\frac{0.04 \times 0.55}{1.486\ (0.002)^{0.5}}\right]^{0.6} = 0.52 \text{ ft}$$

$$\tau = 0.064 \ \ \text{lb/ft}^2 \ < 0.075 \quad \text{ok}$$

Therefore, instantaneous local scour = 0.52 - 0.21 = 0.31 ft.

Based on the above estimate, local scour upstream of the 7:1 slope is within 1 foot, and the upstream apron for the 7:1 slope rock cover will be set at 1 foot.

b) At Location #5: downstream of 7:1 slope and upstream of the transition slope (5.33%) where the shear stress is most critical (see sheet 21).

Based on the COE Stilling Basin Equation (Ref. 9):

$$D_{50} = \frac{v^2}{E^2\ 2\ g\ (G_s-1)\ (\cos\theta - \sin\theta)}$$

use velocity from the 7:1 slope; v = 3.6 fps (see sheet 22)
E = 0.86 (high turbulence) (Ref. 9)
To be conservative, use 7:1 slope, $\theta = \tan^{-1}(1/7) = 8.13°$
$G_s = 2.64$ for round rock (Ref. 10), then
$D_{50} = 0.015\ v^2 = 0.20' = \underline{2.3''}$

Based on Stephenson's equation

$$D_{50} = \left[\frac{q\ (\tan\theta)^{\frac{7}{6}}\ (p)^{\frac{1}{6}}}{C\ g^{\frac{1}{2}}\ [(1-p)\ (G_s-1)\ \cos\theta\ (\tan\phi - \tan\theta)]^{\frac{5}{3}}}\right]^{\frac{2}{3}}$$

use upland slope of 7:1, $\theta = 8.13°$
$p \doteq 0.3$, q = 0.47 cfs (see sheet 21)
$G_s = 2.64$, $\phi = 37°$ (see sheet A-2), C = 0.22
$D_{50} = (0.12443\ q)^{0.667} = 0.15' = \underline{1.8''}$

Therefore, Type B1 riprap, D_{50}(min) = 3.0″ shall be used for area below the roadway and above the 2% top slope (i.e. between points #4 and #6 as shown on sheet 21)

4) Check stability of Type A rock at upstream end of 2% top slope

- Safety Factor Method on a plan slope

$$D_{50} = \frac{21\tau}{\left[(G_s-1)\ \gamma_w\ \cos\theta\ \left[\frac{1}{S.F.} - \frac{\tan\theta}{\tan\phi}\right]\right]}$$

use τ = 0.57 psf from the upstream 5.33% slope (see sheet 23)

On the 2% slope, $\theta = \tan^{-1}(0.02) = 1.146°$

$\phi = 35°$ (see sheet A-2)
$G_s = 2.64$ (rounded rock, Ref. 13)
S.F. = 1.0

then $D_{50} = 0.2113\ \tau = 0.12' = 1.5''$ (D_{50} for Type A rock) O.K.

5) Check required rock size between points "H" and "C" on upstream side of Roadway. The most critical location is at point "G" or point 3 (see sheet 4):

Point	Location EL.	ΔL	Σ Δl	Δh / Δl
1	4391.6			
2	4370.0	75	75	0.288
3	4340.0	30	105	1.000

At point 3 (see sheet 4),

Use T_c = 2.5 min, I_{PMP} = 53.5 in/hr, l = 75+30 = 105'

q = (53.5) (105) / 43560 = 0.129 cfs/ft

use FCF = 3.0, q = 0.129 x 3 = 0.39 cfs/ft

use n = 0.05, s = 1.0, and assume Manning Formula can be applied:

$y = [\ n\ q\ /\ (1.486\ s^{0.5})\ ]^{0.6} = 0.074'$

therefore, v = 5.2 fps

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Using COE Stilling Basin Method

$$D_{50} = \frac{v^2}{E^2\, 2\, g\, (G_s - 1)\, (\cos\theta - \sin\theta)}$$

where $\theta = 2.29°$ ($s = 0.04$), $G_s = 2.64$, and $v = 5.2$ fps

$D_{50} = 0.01335\, v^2 = 0.37' = 4.4''$

Thus, use at least Type B rock with $D_{50} = 4.4''$ or any larger rock size along this area.

4.2.2 Area between points B & C

In this area, the 2% top slope will intercept the existing ground below the haul road (about 8 % slope) with a 10-foot long, 5.33 % slope transition apron. The stable rock size for erosion protection will be estimated based on the most critical flow length as shown on sheet 4.

Required riprap at the most critical location(i.e. at the upstream end of the 5.33% transition slope) will be sized as below:

1) Peak discharge and flow characteristics

Longest flow length at upstream end of 5.3 % slope is 210 feet.
From Kirpich's equation:

$T_c = 1.4$ min, use $T_c = 2.5$ min, and $I = 53.5$ in/hr.

$q = 53.5\,(210) / 43560 = 0.26$ cfs/ft

use FCF = 3, then $q = 3\,(.26) = 0.78$ cfs/ft,
use $n = 0.04$, and use upstream slope $S = 0.08$, then

$y = [\,(0.04 \times 0.78) / (1.486 \times 0.08^{0.5})\,]^{0.6} = 0.21'$
$v = 3.7$ fps, $\tau = \gamma_w\, y\, s = 1.05$ lb/ft^2

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2) Required riprap sizing

Using the Safety Factor Method for a Plane Slope

Use τ = 1.05 lb/ft^2 from the upstream 8 % slope to act on the 5.33% slope.

$\theta = 3.05°$ (5.33% slope)
For rounded rock, $G_s = 2.64$, use $\phi = 38°$ (see sheet A-2)

$D_{50} = 0.221\ \tau = 0.23' = 2.8''$

Therefore, the use of Type B riprap, $D_{50} = 4.4''$, will be stable on the 10-foot long transition zone between the natural ground and the upstream end of the 2% top slope.

- Estimate of local scour depth at upstream end of 5.3 % slope:

Using the DOT empirical equation for scour below culvert outlet (Ref 16):

$$D_s = \alpha\, y_e^{\gamma} \left[\frac{Q}{y_e^{2.5}}\right]^{\beta} (t)^{\theta}, \quad \text{where}$$

D_s = depth of scour in feet
y_e = flow depth or equivalent flow depth in feet
Q = peak flow rate in cfs (for sheet flows, Q=q in cfs per unit width)
t = duration in min with peak flow rate, use 30 min.
α, γ, β, and θ are empirical parameters, and the following values are used:
$\alpha = 0.82$, $\beta = 0.375$, $\theta = 0.1$ and $\gamma = 1.0$ (Ref. 10)

Hence for $y_e = 0.21'$, $Q \doteq q = 0.78$ cfs/ft (use FCF = 3)

$$D_s = 0.82\ (0.21)^{1.0} \left[\frac{0.78}{(0.21)^{2.5}}\right]^{0.375} (30)^{0.1} = 0.84\text{ft.}$$

Using Lacey's regime equation (Ref. 17)

$$R = 0.9 \left[\frac{q^2}{f}\right]^{\frac{1}{3}}, \quad q = 0.78 \ (FCF = 3), \qquad \text{where}$$

R = hydraulic radius in feet,
q = cfs/ft
f = Lacey's silt factor $= 1.76 \sqrt{D_{50}(\text{min})}$

Assume for very fine sand, $D_{50}(\text{min}) \doteq 1.0$ mm, then $f = 1.76$

$$R = 0.9 \left[\frac{0.78^2}{1.76}\right]^{\frac{1}{3}} = 0.63 \text{ ft}$$

Depth of scour below water surface $= \chi R = 2.25\ (0.63) = 1.42$ ft
($\chi = 1.75$ to 2.25, to be conservative use $\chi = 2.25$)

$\therefore$ Depth of scour below apron $= 1.42 - 0.21 = 1.2$ ft.

Using the Tractive Force Method (Ref. 10)

It is assumed that the natural ground surface has the equivalent soil condition as firm loam; thus the critical tractive force is 0.075 lb/ft^2 (Ref. 10). Under the existing slope of 0.08, with $n = 0.04$, $q = 0.78$ (FCF = 3) $\tau = 1.05$ lb/ft^2 (see sheet 29) > 0.075

Thus, local scour will reduce the slope until the shear stress is less than 0.075 lb/ft^2:

Try $s = 0.0015$, then $y = 0.69'$, $\tau = 0.065$ lb/ft^2 < 0.075
Depth of scour $= 0.69 - 0.21 = 0.48'$

Hence local scour depth upstream of the 5.3 % slope is about 1 foot, and the upstream apron for the 5.3 % transition slope rock cover will be set at 1 foot.

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3) Check Stability of Type A rock at Upstream End of 2 % Slope

- Flow characteristics at end of 5.33 % transition zone

$L = 210 + 10 = 220'$
$q = C\,I\,L / 43560 = 1.0\,(53.5)\,(220) / 43560 = 0.27$ cfs/ft
$s = 0.0533$
use $n = 0.049$

then, $y = 0.142'$, $v = 1.9$ fps, and $Fr = 0.89$
$\tau = \gamma_w\, y\, s = 0.47$ psf

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.049 \quad \text{O.K.} \quad (D_{50} = 4.4 \text{ in.})$$

- Rock size required on 2% top slope

Use Safety Factor Method (see sheet 6 for equation)

$\tau = 0.47$ psf from the 5.33% transition slope
$\theta = \tan^{-1}(0.02) = 1.146°$, $G_s = 2.64$ (Ref. 13), $\phi = 35°$ (see sheet A-2)

then $D_{50} = 0.211\,\tau = 0.099' = 1.2'' <$ Type A rock, $D_{50} = 1.5''$ O.K.

4.2.3 Area between points C & D

The upslope area between C and D (see sheet 5) will be regraded in 2.5:1 slope ($s = 0.4$) or 2:1 ($S=0.5$) slope and backfilled with riprap in order to promote sheet flow. The 2.5:1/2:1 slope will intercept the 2% embankment top slope with a 10-foot long transition apron. The stable rock size for erosion protection will be estimated based on the most critical flow length as shown on sheet 4.

Required riprap at the most critical location (i.e at the downstream end of 2.5:1 slope and at the upstream end of the 5.33% transition slope) will be sized as below:

1) Peak Discharge

Longest flow length on the 2.5/2.0 :1 slopes is 150 feet.
From Kirpich's equation:

$$T_c = \frac{0.0078\ (150)^{0.77}}{(0.4)^{0.385}} = 0.5 \text{ min}$$

Since $T_c < 2.5$ min, use $T_c = 2.5$ min, and $I = 53.5$ in/hr.

$q = 53.5\ (150)\ /\ 43560 = 0.18$ cfs/ft

2) Riprap sizing for 2.5:1 slope

- Flow Characteristics:

For $s = 0.4$ ($\theta = 21.8°$),
$n = 0.0456\ (D_{50}\ s)^{0.159} = 0.05$ for slopes > 10%
and $D_{50} = 4.4''$ for Type B rock
$y = [\ (0.05 \times 0.18)\ /\ (1.486 \times 0.4^{0.5})\ ]^{0.6} = 0.06'$
$v = 2.9$ fps, and $Fr = 2.1$
$\tau = \gamma_w\, y\, s = 1.50$ lb/ft^2

The hydraulic jump occurs at the 5.33% transition slope apron:

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2}-1\right) = 2.5, \qquad y_2 = 0.15'$$

Therefore, transition length required = $5\, y_2$ = 1 ft.
Use 10 feet, to be conservative.

- Riprap Sizing:

The critical location is at junction of 2.5:1 slope and 5.33% transition slope

Rounded rock with the following parameters will be used:
$G_s = 2.64$, $c = 0.22$, $p \doteq 0.3$, $\phi = 38°$, $\theta = 21.8°$ ($s = 0.4$ or 2.5:1 slope)

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Using Stephenson's Method

$D_{50} = (1.009\ q)^{0.667} = 3.8''$ for q = 0.18 cfs/ft

Using the COE Stilling Basin Method

E = 0.86 (high turbulence)
$G_s = 2.64$, $\theta = 21.8°$

$D_{50} = 0.0230\ v^2 = 2.3''$ for v = 2.9 fps

Using the Safety Factor Method for a Plane Slope

Use $\tau = 1.50\ lb/ft^2$ from 2.5:1 slope to act on the 5.33% slope.

$\theta = 3.05°$ (5.33% slope)
For rounded rock, $G_s = 2.64$, use $\phi = 38°$ (see sheet A-2)

$D_{50} = 0.221\ \tau = 0.33' = 4.0''$

Therefore, Type B riprap, $D_{50} = 4.4''$, shall be used on the 2.5:1 slope and on the 10-foot long transition zone at the upstream end of the 2% top slope.

3) Riprap sizing for 2:1 slope

- Flow characteristics:

q = 0.18 cfs/ft (see sheet 32)

For s = 0.5 ($\theta = 26.57°$)
$n = 0.0456\ (D_{50}\ s)^{0.159} = 0.054$ for D_{50} =6" (Type C rock)

$y = [n\ q\ /\ (1.486\ s^{0.5})\ ]^{0.6} = 0.06'$, v = 3.0 fps
$\tau = \gamma\ y\ s = 1.87\ lb/ft^2$
Fr = 2.3

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2}-1\right) = 2.77, \qquad y_2 = 0.166'$$

Length of the hydraulic jump = 5 y_2 = 1'.

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Use a transition length of 10 feet, to be conservative.

- Riprap Sizing:

Critical location is at junction of 2:1 slope and 5.33% transition zone

<u>Using Stephenson Method (for angular rock - Type C)</u>

$G_s = 2.7$ (Ref. 14), $C = 0.27$, $p = 0.3$, $\phi = 40°$ (see sheet A-2), and $\theta = 26.57°$ (2:1 slope)

then, $D_{50} = (1.30\ q)^{0.667} = 4.6"$ for $q = 0.18$ cfs/ft

$D_{50,required} = 4.6 \times 1.15 = \underline{5.2"}$ with 15 % oversizing factor (Ref. 14).

<u>Using the Safety Factor Method</u>

$\tau = 1.87\ lb/ft^2$ from the 2:1 slope to act on the 5.33% transition slope.

$\theta = 3.05°$ (5.33% slope)

For angular rock, $G_s = 2.7$, use $\phi = 40°$.

$D_{50} = 0.2117\ \tau = 0.4' = 4.8"$

$D_{50,required} = 4.8 \times 1.15 = \underline{5.5"}$ with 15 % oversizing factor.

<u>Using the COE Stilling Basin Method</u>

$E = 0.86$ (high turbulence), $G_s = 2.7$, $\theta = 26.57$ (2:1)
$v = 3$ fps from 2:1 slope

$D_{50} = 0.0276\ v^2 = 0.249' = 3"$

$D_{50,required} = 3.0 \times 1.15 = \underline{3.4"}$ with 15 % oversizing factor.

Hence <u>use Type C rock</u>, $D_{50} = 6"$ (before oversizing)
$= 6.9"$ (with 15% oversizing factor).

4) Check stability of Type A rock at upstream end of 2% top slope

<u>Flow characteristics on 5.33% transition zone</u>
$L = 150 + 10 = 160'$
$q = C\,I\,L / 43560 = 1.0\,(53.5)\,(160) / 43560 = 0.20$ cfs/ft
$s = 0.0533$
use $n = 0.053$

then, $y = 0.124'$, $v = 1.6$ fps, and $Fr = 0.81$
$\tau = \gamma_w\, y\, s = 0.41$ psf
assume Type B rock, $D_{50} = 4.4$ in.

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.053 \qquad \text{O.K.}$$

<u>Rock size required on 2% top slope</u>

Use Safety Factor Method (see sheet 3 for equation)

$\tau = 0.41$ psf from the 5.33% transition slope
$\theta = \tan^{-1}(0.02) = 1.146°$, $G_s = 2.64$ (Ref. 13), $\phi = 35°$ (see sheet A-2)

then $D_{50} = 0.211\,\tau = 0.09' = 1.0'' <$ Type A rock, $D_{50} = 1.5''$ O.K.

4.2.4 <u>Typical transition to 2% slope between points D and E</u>

As shown on sheet 4, the areas near the east part of the upslopes will not be regraded, and the 2% slope will intercept the existing ground with a 10-foot long 5.33% transition apron. Rock size for this transition apron is determined below.

1) <u>Required transition length</u>

The most critical flow length is, $L = 50'$ at location F (see sheet 4).
The existing slope is about 48% ($\Delta H/L = 0.48$, $\theta = 25.6°$).

$T_c = 0.21$ min < 2.5 min, so use $I = 53.5$ in/hr

$\therefore\ q = C\,I\,L / 43560 = 1.0\,(53.5)\,(50) / 43560 = 0.06$ cfs/ft

By Mannings Formula,
n = 0.05 for jagged and irregular rock cut condition (Ref. 10)
$y = 0.03'$, $v = 2.0$ fps, $Fr = 2.1$
$\tau = \gamma\, y\, s = 0.90\ lb/ft^2$

The hydraulic jump occurs on the 5.33% slope:

$$\frac{y_2}{0.03} = \frac{1}{2}\left(\sqrt{1+8(2.1)^2}-1\right) = 2.56, \qquad y_2 = 0.08'$$

Therefore, transition length required = 5 y_2 = 0.4 ft; and using a transition length of 10 feet is conservative.

2) <u>Riprap sizing at intersection of 48% (existing) and 5.33% slope</u>

- Stephenson's Method

Based on the 48% slope, $\theta = 25.64°$, $q = 0.06$ cfs/ft
For rounded rock, $C = 0.22$, $G_s = 2.64$, and $\phi = 38°$ (Type B riprap), p ≐ 0.3

then $D_{50} = (1.94\ q)^{0.667} = 0.24' = 2.9''$

Use Type B rock, $D_{50} = 4.4''$

The critical q for $D_{50} = 4.4''$ to remain stable would be:

$4.4'' / 12 = (1.94\ q_c)^{0.667}$, $\therefore\ q_c = 0.115$ cfs/ft

This is equivalent to a flow concentration factor, FCF, of q_c / q = <u>1.9</u>

- Safety Factor Method

Assume shear stress acting on the 48% slope will act on the 5.33% transition slope.

$\tau = 0.90\ lb/ft^2$, $\theta = 3.05°$ ($s = 0.0533$), $\phi = 38°$
$G_s = 2.64$

Then, $D_{50} = 0.220\ \tau = 0.2' = 2.4''$

For Type B rock, $\tau_c = D_{50} / 0.22 = 1.67$
$y_c = \tau_c / \gamma s = 1.67 / (62.4 \times 0.48) = 0.0556$
$q_c = 1.486 / 0.05 (0.0556)^{5/3} (0.48)^{1/2} = 0.167$ cfs/ft

$FCF = q_c / q = \underline{2.8}$

- COE Stilling Basin Method

$G_s = 2.64$, θ = slope of apron = 3.05° (s = 0.0533)
E = 0.86 (high turbulence)

then, $D_{50} = 0.01354\ v^2$
for q = 0.06 cfs/ft, v = 2.0 fps, D_{50} = 0.7"

For D_{50} = 4.4" (Type B rock),
$v_c = [\ (4.4/12) / 0.01354\ ]^{0.5} = \underline{5.2 \text{ fps}}$, $v_c = 1.486/n * y^{2/3} * s^{1/2}$,
Hence, $y_c = (n\ v_c / 1.486\ s^{1/2})^{1.5} = 0.127$, $q_c = v_c\ y_c = 0.66$, $FCF = q_c/q = 11$

Hence, the use of Type B rock can sustain a flow concentration factor of 2 to 11.

3) Estimate local scour depth

Assume FCF = 3.0, q = 0.06 x 3 = 0.18 cfs/ft, s = 0.48
use n = 0.05, $y = [n\ q / (1.486\ s^{0.5})\ ]^{0.6} = 0.06'$
v = 3.1 fps, $\tau = \gamma\ y\ s = 1.24$ lb/ft^2

- Using the DOT empirical equation (Ref. 16)

$$D_s = \alpha\ y_c^{\gamma} \left[\frac{Q}{y_c^{2.5}} \right]^{\beta} (t)^{\phi}, \quad \text{where}$$

For y_c = 0.06', Q = q = 0.18 cfs/ft

$$D_s = 0.82\ (0.06)^{1.0} \left[\frac{0.18}{(0.06)^{2.5}} \right]^{0.375} (30)^{0.1} = 0.51\text{ft.}$$

- Using the Tractive Force Method (Ref. 10)

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Use critical shear, $\tau_c = 0.075$ lb/ft^2

q = 0.18 cfs/ft (FCF = 3), n = 0.05

Try s = 0.004, then y = 0.24, $\tau = 0.061 < \tau_c = 0.075$ O.K.

$D_s = 0.24 - 0.06 = 0.2'$

- Using the Lacey's Regime Equation

Assume for very fine sand, D_{50}(min) $\doteq$ 1.0 mm, then f = 1.76

$$R = 0.9 \left[\frac{0.18^2}{1.76}\right]^{\frac{1}{3}} = 0.24 \text{ ft}$$

$D_s = y\,R - y_o = 2.25\,(0.24) - 0.06 = \underline{0.5'}$

Hence scour depth is approximately 0.5 ft, use a depth of at least 1 ft for the rock cover along the edge of the apron.

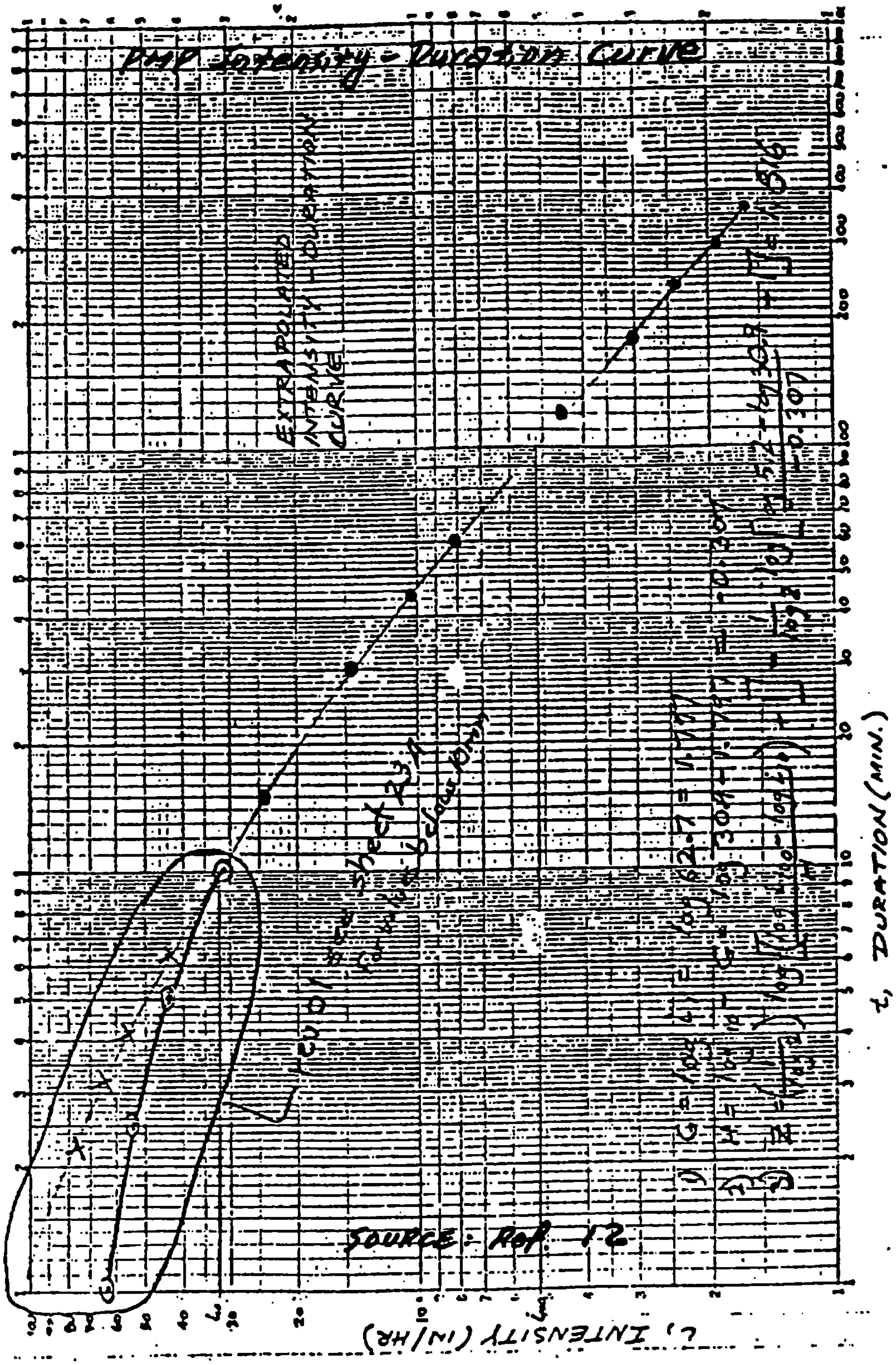
Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet A-0
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

APPENDIX A

REFERENCE CHARTS

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	A-1
Feature	EROSION PROTECTION	Designed	BYW	File No.	–
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	FHW	Date	11-29-93
				Date	11-30-93

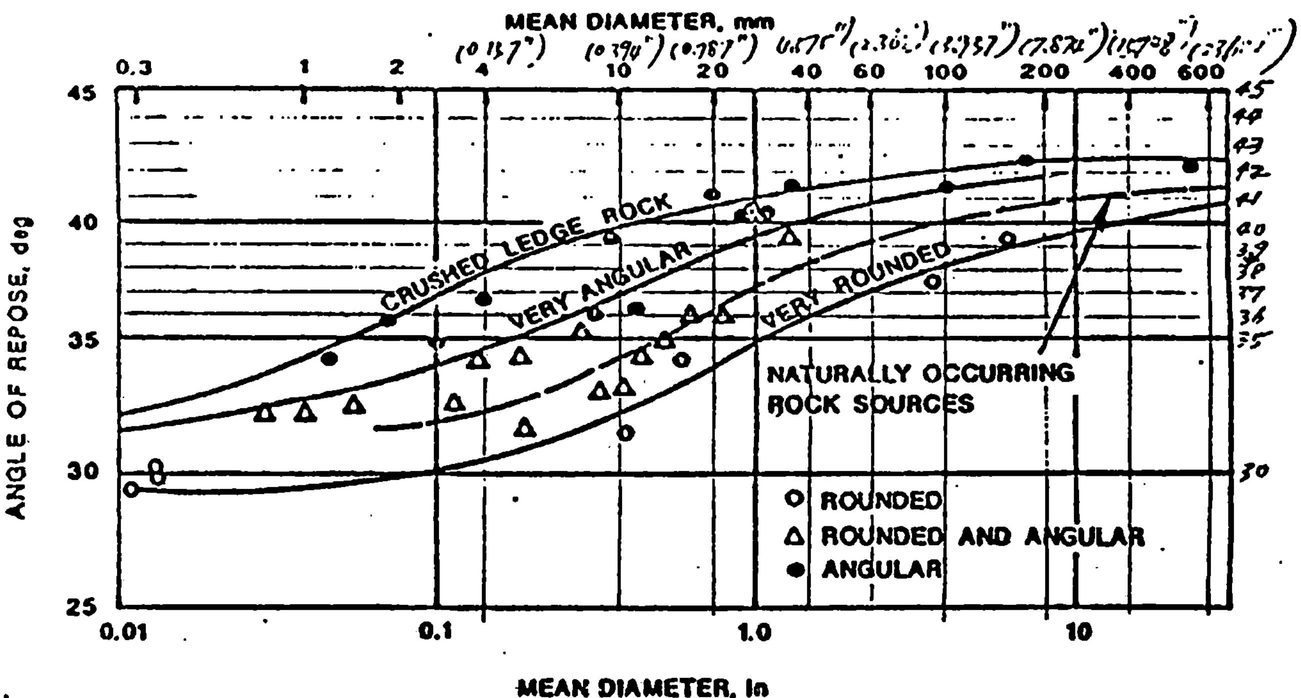


MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON
Feature EROSION PROTECTION
Item EMBANKMENT AND SOUTH-EDGE AREAS

Contract No. 3885-58
Designed BYW
Checked FHW

Sheet A-2
File No. —
Date 11-29-93
Date 11-30-93



Source: Ref. 3

ANGLE OF REPOSE FOR ROCK OF VARIOUS DIAMETERS

APPENDIX B

GRADATION OF TYPE B1 ROCK

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Appendix B -Type B1 Riprap Gradation

1.0 Gradation Requirements:

D_{50}(min) = 3 " (Bluff source with round rock, and no oversizing required, (Ref.13))

D_{100}(max) = 1.71 * D_{50}(min) = 5.1 " = 5.0 " (Ref. 7)

D_{100}(min) = 1.26 * D_{50}(min) = 3.8 " = 4.0 " (Ref. 7)

D_{25}(min) = 0.68 * D_{50}(min) = 2.0 " (Ref. 7)

Based on above values, the upper and lower bounds of gradation curves for the Type B1 rock are developed as shown on sheet B2.

The gradation limits are given below:

U.S. Standard Sieve Opening	% Passing By Weight
5 "	100
4 "	0 - 100
3 "	0 - 50
2 "	0 - 25
#4	0 - 5

2.0 Layer Thickness:

a. T (min) ≥ 1.9 * D_{50}(min) = 5.7 " (Ref. 7)

b. T (min) ≥ 1.5 * D_{50}(max) = 1.5*4.5 = 7 " (Ref. 7)

c. T (min) ≥ 12 " (Ref. 7)

Thus use the layer thickness = 12 ".

3.0 Bedding Layer:

Bedding materials determined in Ref. 2 for all Type A, Type B, Type C rocks can also be used for Type B1 rock since Type B1 rock size is between Type A and Type B rocks.

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ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON
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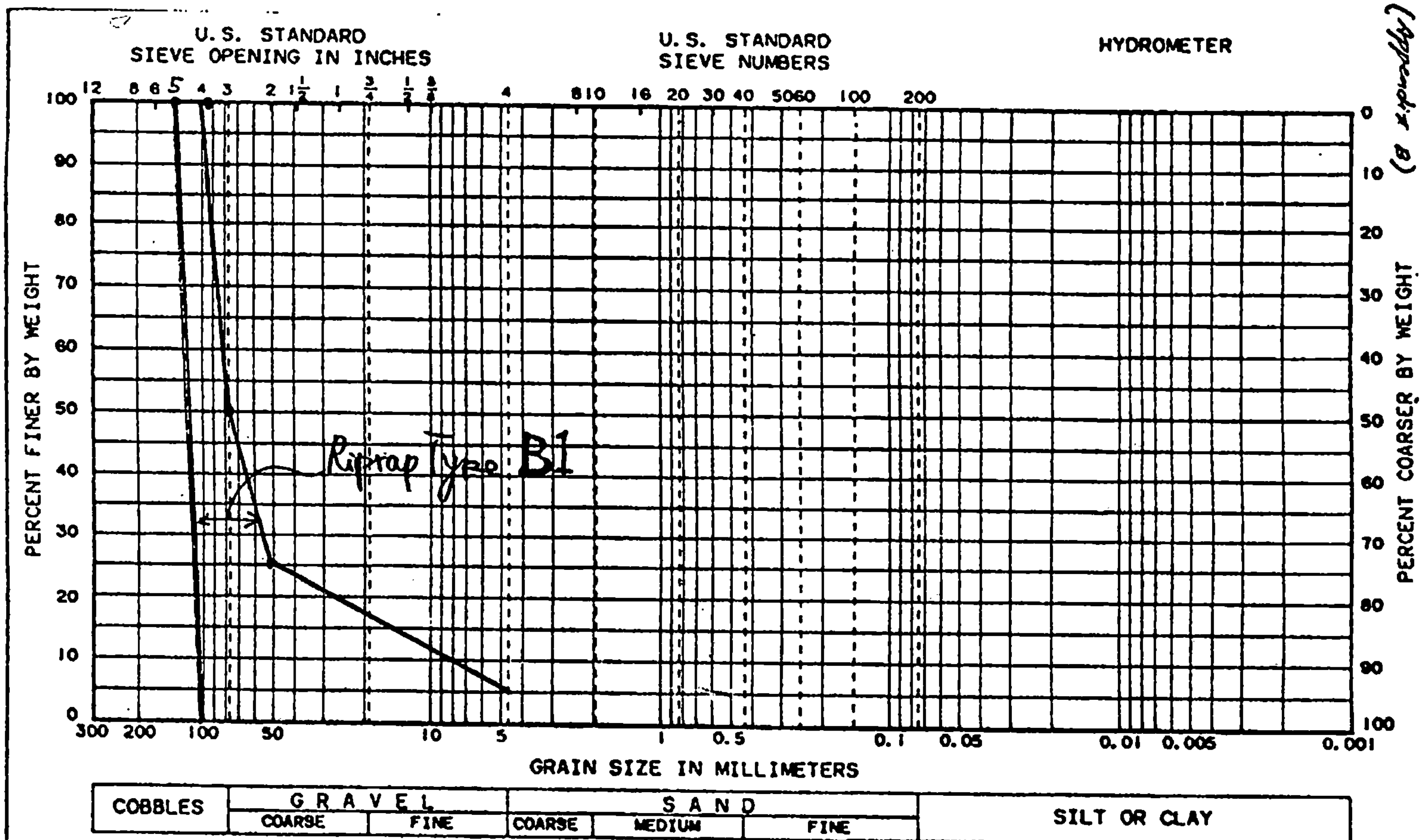
Item EMBANKMENT AND SOUTH-EDGE AREAS

Contract No. 3885-58
Designed BYW
Checked FHW

Sheet B-2
File No. -
Date 11-29-93
Date 11-30-93

(Appendix B)

GRAIN SIZE ANALYSIS



Remarks: ● - required size

PROJECT	
JOB NO.	
AREA	
HOLE NO.	
DATE	

CAB110

APPENDIX C

COMPUTER OUTPUT FROM RPRP/SFST FOR TYPE B1 ROCK EVALUATION ON THE EAST SIDE OF THE EMBANKMENT

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MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet C-1
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
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HATSP1.OUT 11/11/93 Page 1
UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP.OUT)
UMTRA/HAT RUN I.D.=FHW DATE=11-11 1993

SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION
* * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *

COEFFICIENTS FOR INTENSITY DURATION CURVE -
IPMP=10**(G-H*(LOGT)**Z):
G= 1.797 H= .307 Z=1.816

RIPRAP STONE SP.GRAVITY= 2.64 C IN STEPHENSONS EQN= .22
\- - - EMBANKMENT - - -

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	600.	2.	.30	35.	SAFETY FACTOR
1	SIDE	20.	20.	.30	37.	STEPHENSONS
1	HYPO	1.	20.	.30	37.	STEPHENSONS

* * * * * * * * * * * END INPUT DATA * * * * * * * * * * *

DETAILED CALC TABLE WITH FINAL ROCK SIZE
SEGMENT=HYPO LENGTH= 1. FT. SLOPE= 20.%

ASSUMED D50= .2535FT. AT D/S END OF SEGMENT
CORRESPONDING Q= .579CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.047	.000	.047	.83	.06	.038	1.00	1.00
50.	100.	.093	.000	.093	1.17	.08	.034	.71	1.71
100.	150.	.140	.000	.140	1.43	.10	.032	.58	2.30
150.	200.	.186	.000	.186	1.64	.11	.030	.51	2.81
200.	250.	.233	.000	.233	1.82	.13	.029	.46	3.27
250.	300.	.280	.000	.280	1.98	.14	.029	.42	3.69
300.	350.	.326	.000	.326	2.12	.15	.028	.39	4.08
350.	400.	.373	.000	.373	2.26	.16	.028	.37	4.45
400.	450.	.419	.000	.419	2.39	.18	.028	.35	4.80
450.	500.	.466	.000	.466	2.51	.19	.027	.33	5.13
500.	550.	.513	.000	.513	2.62	.20	.027	.32	5.45
550.	600.	.559	.000	.559	2.72	.21	.027	.31	5.75
0.	20.	.578	.000	.578	4.33	.13	.040	.08	5.83
0.	1.	.579	.000	.579	4.34	.13	.040	.00	5.84

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
40.60	40.53

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	600.	2.0	1.5	2.515	2.9	1.50	SAFETY FACTOR
SIDE	20.	20.0	3.0	.578	5.8	1.50	STEPHENSON
HYPO	1.	20.0	3.0	.579	5.8	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet C-2
Feature EROSION PROTECTION	Designed BYW	File No. —
		Date 11-29-93
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-30-93

HATR10.OUT 8/4/93 Page 1

Evaluation of Type B rock

MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RO 3885-58
UMTRA/HAT RUN I.D.=FHW DATE=07/28 1993
SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION

* * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *

COEFFICIENTS FOR INTENSITY DURATION CURVE -
IPMP=10**(G-H*(LOGT)**2):
G= 1.797 H= .307 2=1.816
RIPRAP STONE SP.GRAVITY= 2.64 C IN STEPHENSONS EQN= .22

\- - - EMBANKMENT - - -

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	550.	2.	.30	35.	SAFETY FACTOR
1	SIDE	50.	20.	.30	37.	STEPHENSONS
1	SIDE	350.	20.	.30	38.	STEPHENSONS

DETAILED CALC TABLE WITH FINAL ROCK SIZE
SEGMENT=SIDE LENGTH= 350. FT. SLOPE= 20.%

ASSUMED D50= .2978FT. AT D/S END OF SEGMENT
CORRESPONDING Q= .799CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.042	.000	.042	.79	.05	.039	1.06	1.06
50.	100.	.084	.000	.084	1.12	.08	.034	.75	1.81
100.	150.	.126	.000	.126	1.36	.09	.032	.61	2.42
150.	200.	.168	.000	.168	1.56	.11	.031	.53	2.95
200.	250.	.210	.000	.210	1.73	.12	.030	.48	3.43
250.	300.	.252	.000	.252	1.88	.13	.029	.44	3.88
300.	350.	.295	.000	.295	2.03	.15	.029	.41	4.29
350.	400.	.337	.000	.337	2.15	.16	.028	.39	4.67
400.	450.	.379	.000	.379	2.28	.17	.028	.37	5.04
450.	500.	.421	.000	.421	2.39	.18	.028	.35	5.39
500.	550.	.463	.000	.463	2.50	.19	.027	.33	5.72
0.	50.	.505	.000	.505	4.06	.12	.041	.21	5.93
0.	50.	.547	.000	.547	4.04	.14	.044	.21	6.13
50.	100.	.589	.000	.589	4.19	.14	.043	.20	6.33
100.	150.	.631	.000	.631	4.34	.15	.043	.19	6.52
150.	200.	.673	.000	.673	4.49	.15	.042	.19	6.71
200.	250.	.715	.000	.715	4.63	.15	.042	.18	6.89
250.	300.	.757	.000	.757	4.77	.16	.041	.17	7.07
300.	350.	.799	.000	.799	4.90	.16	.041	.17	7.24

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA=(43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**2)) (INCH/HR)
36.66	36.63

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	550.	2.0	1.5	2.515	2.6	1.50	SAFETY FACTOR
SIDE	50.	20.0	3.0	.570	5.6	.30	STEPHENSON
SIDE	350.	20.0	3.6	.799	7.2	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet C-3
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

HAT&12.OUT 8/4/93 Page 1 3885-58
MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RO
UMTRA/HAT RUN I.D.=FHW DATE=07/28 1993
SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION

Evaluation of Type B1 rock
* * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *

COEFFICIENTS FOR INTENSITY DURATION CURVE -
IPMP=10**(G-H*(LOGT)**Z):
G= 1.797 H= .307 Z=1.816
RIPRAP STONE SP.GRAVITY= 2.64 C IN STEPHENSONS EQN= .22
- - - EMBANKMENT - - -

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE	
1	TOP	500.	2.	.30	35.	SAFETY FACTOR
1	SIDE	100.	20.	.30	37.	STEPHENSONS
1	SIDE	460.	20.	.30	38.	STEPHENSONS

DETAILED CALC TABLE WITH FINAL ROCK SIZE
SEGMENT=SIDE LENGTH= 460. FT. SLOPE= 20.%

ASSUMED D50= .3153FT. AT D/S END OF SEGMENT
CORRESPONDING Q= .871CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.041	.000	.041	.78	.05	.039	1.07	1.07
50.	100.	.082	.000	.082	1.10	.07	.034	.76	1.83
100.	150.	.123	.000	.123	1.34	.09	.032	.62	2.45
150.	200.	.164	.000	.164	1.54	.11	.031	.54	2.99
200.	250.	.205	.000	.205	1.72	.12	.030	.49	3.47
250.	300.	.247	.000	.247	1.86	.13	.029	.45	3.92
300.	350.	.288	.000	.288	2.00	.14	.029	.42	4.34
350.	400.	.329	.000	.329	2.13	.15	.028	.39	4.73
400.	450.	.370	.000	.370	2.25	.16	.028	.37	5.10
450.	500.	.411	.000	.411	2.37	.17	.028	.35	5.45
0.	50.	.452	.000	.452	3.82	.12	.042	.22	5.67
50.	100.	.493	.000	.493	4.00	.12	.041	.21	5.88
0.	46.	.531	.000	.531	3.91	.14	.045	.20	6.07
46.	92.	.569	.000	.569	4.05	.14	.045	.19	6.26
92.	138.	.607	.000	.607	4.19	.14	.044	.18	6.44
138.	184.	.644	.000	.644	4.32	.15	.044	.18	6.62
184.	230.	.682	.000	.682	4.45	.15	.043	.17	6.79
230.	276.	.720	.000	.720	4.58	.16	.043	.17	6.96
276.	322.	.758	.000	.758	4.70	.16	.042	.16	7.12
322.	368.	.796	.000	.796	4.81	.17	.042	.16	7.28
368.	414.	.833	.000	.833	4.93	.17	.042	.16	7.44
414.	460.	.871	.000	.871	5.04	.17	.041	.15	7.59

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
35.81	35.76

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	500.	2.0	1.5	2.515	2.5	1.50	SAFETY FACTOR
SIDE	100.	20.0	3.0	.577	5.4	.30	STEPHENSON
SIDE	460.	20.0	3.8	.871	7.6	.30	STEPHENSON

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Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet C-4	
Feature EROSION PROTECTION	Designed BYW	File No. –	
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93	Date 11-30-93

HATR14.OUT 8/4/93 Page 1
MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RD
UMTRA/HAT RUN I.D.=FHW DATE=07/28 1993
SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION

Evaluation of Type B rock

************ INPUT DATA *************
COEFFICIENTS FOR INTENSITY DURATION CURVE -
IPMP=10**(G-H*(LOGT)**Z):
G= 1.797 H= .307 Z=1.816
RIPRAP STONE SP.GRAVITY= 2.64 C IN STEPHENSONS EQN= .22
- - - EMBANKMENT - - -

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	420.	2.	.30	35.	SAFETY FACTOR
1	SIDE	150.	20.	.30	37.	STEPHENSONS
1	SIDE	370.	20.	.30	38.	STEPHENSONS

DETAILED CALC TABLE WITH FINAL ROCK SIZE
SEGMENT=SIDE LENGTH= 370. FT. SLOPE= 20.%
ASSUMED D50= .3010FT. AT D/S END OF SEGMENT
CORRESPONDING Q= .813CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	47.	.040	.000	.040	.77	.05	.039	1.01	1.01
47.	93.	.081	.000	.081	1.09	.07	.034	.71	1.72
93.	140.	.121	.000	.121	1.33	.09	.032	.58	2.31
140.	187.	.161	.000	.161	1.53	.11	.031	.51	2.81
187.	233.	.202	.000	.202	1.70	.12	.030	.46	3.27
233.	280.	.242	.000	.242	1.85	.13	.029	.42	3.69
280.	327.	.282	.000	.282	1.99	.14	.029	.39	4.08
327.	373.	.323	.000	.323	2.11	.15	.028	.37	4.45
373.	420.	.363	.000	.363	2.23	.16	.028	.35	4.80
0.	50.	.406	.000	.406	3.64	.11	.043	.23	5.03
50.	100.	.450	.000	.450	3.83	.12	.042	.22	5.25
100.	150.	.493	.000	.493	4.01	.12	.041	.21	5.46
0.	62.	.546	.000	.546	4.02	.14	.044	.26	5.71
62.	123.	.599	.000	.599	4.22	.14	.043	.24	5.95
123.	185.	.653	.000	.653	4.41	.15	.043	.23	6.19
185.	247.	.706	.000	.706	4.59	.15	.042	.22	6.41
247.	308.	.759	.000	.759	4.76	.16	.041	.22	6.63
308.	370.	.813	.000	.813	4.92	.17	.041	.21	6.84

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
37.66	37.65

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	420.	2.0	1.5	2.515	2.5	1.50	SAFETY FACTOR
SIDE	150.	20.0	3.0	.563	5.1	.30	STEPHENSON
SIDE	370.	20.0	3.6	.813	6.8	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	C-5
Feature	EROSION PROTECTION	Designed	BYW	File No.	–
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	FHW	Date	11-29-93
				Date	11-30-93

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HATR16.OUT              8/4/93          Page 1
 MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RO
 UMTRA/HAT       RUN I.D.=FHW        DATE=07/28 1993
 ***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***
Evaluation of Type B1 rock
 ***********  INPUT DATA  ***************
  COEFFICIENTS FOR INTENSITY DURATION CURVE -
          IPMP=10**(G-H*(LOGT)**Z):
          G= 1.797  H= .307  Z=1.816
   RIPRAP STONE SP.GRAVITY= 2.64   C IN STEPHENSONS EQN=  .22

              - - - EMBANKMENT - - -
   AREA
 (LOCATION  SEGMENT  LENGTH  SLOPE POROSITY  FRICTION
 IN PLAN)            (FT)    (%)              ANGLE
                                              (DEG)
     1       TOP     330.     2.      .30     35.  SAFETY FACTOR
     1       SIDE    200.    20.      .30     37.  STEPHENSONS
     1       SIDE    300.    20.      .30     38.  STEPHENSONS


          DETAILED CALC TABLE WITH FINAL ROCK SIZE
   SEGMENT=SIDE     LENGTH= 300. FT.  SLOPE= 20.%
          ASSUMED D50=  .2900FT. AT D/S END OF SEGMENT
  CORRESPONDING Q=   .768CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

  SLOPED      *****FLOWS(CFS/FT)**** VEL.  DEPTH  MANNING  TIME OF
  DISTANCE   ALLOC.   PORES   ROCK  (FPS)  (FT)     N      CONC(MIN)
  FROM  TO                                               INT. TOTAL
  (FT)  (FT)
    0.  55.    .051    .000   .051    .87   .06    .037  1.06  1.06
   55. 110.    .102    .000   .102   1.23   .08    .033   .75  1.80
  110. 165.    .153    .000   .153   1.49   .10    .031   .62  2.42
  165. 220.    .204    .000   .204   1.71   .12    .030   .54  2.96
  220. 275.    .255    .000   .255   1.89   .13    .029   .48  3.44
  275. 330.    .305    .000   .305   2.06   .15    .029   .45  3.89
    0.  50.    .352    .000   .352   3.39   .10    .044   .25  4.13
   50. 100.    .398    .000   .398   3.61   .11    .043   .23  4.36
  100. 150.    .444    .000   .444   3.82   .12    .042   .22  4.58
  150. 200.    .491    .000   .491   4.02   .12    .041   .21  4.79
    0.  50.    .537    .000   .537   4.03   .13    .043   .21  4.99
   50. 100.    .583    .000   .583   4.20   .14    .043   .20  5.19
  100. 150.    .629    .000   .629   4.37   .14    .042   .19  5.38
  150. 200.    .676    .000   .676   4.53   .15    .042   .18  5.57
  200. 250.    .722    .000   .722   4.68   .15    .041   .18  5.75
  250. 300.    .768    .000   .768   4.83   .16    .041   .17  5.92

     RAINFALL INTENSITY          RAINFALL INTENSITY
     THAT ASSUMED D50         BASED ON CALCULATED
     CAN WITHSTAND BASED         TIME OF CONC.AND USING
     ON THE EQN I=Q/CA=          INTERPOLATING FUNCTION
 (43560*Q)/L                I=10**(G-H*((LOGT)**Z))
          (INCH/HR)                  (INCH/HR)
            40.32                      40.27


              *******RESULTS SUMMARY******* AREA=1
  SEGMENT  LENGTH  SLOPE  D50     Q AT       TC     STARTING  METHOD OF
            (FT)    (%)  (INCH)  D/S END  (MINUTES) ROCK D50  CALC.
                                 (CFS/FT)            (INCH)
  TOP      330.     2.0   1.5    2.515      2.5       1.50  SAFETY FACTOR
  SIDE     200.    20.0   2.9     .550      4.5        .30  STEPHENSON
  SIDE     300.    20.0   3.5     .768      5.9        .30  STEPHENSON
```

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	C-6
Feature	EROSION PROTECTION	Designed	BYW /	File No.	–
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	FHW	Date	11-29-93
				Date	11-30-93

HATR17.OUT 8/4/93 Page 1
MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RO
UMTRA/HAT RUN I.D.=FHW DATE=07/28 1993
SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION

Evaluation of Type B1 rock

*********** INPUT DATA ***********

COEFFICIENTS FOR INTENSITY DURATION CURVE -
IPMP=10**(G-H*(LOGT)**Z):
G= 1.797 H= .307 Z=1.816
RIPRAP STONE SP.GRAVITY= 2.64 C IN STEPHENSONS EQN= .22

- - - EMBANKMENT - - -

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	180.	2.	.30	35.	SAFETY FACTOR
1	SIDE	350.	20.	.30	37.	STEPHENSONS
1	SIDE	70.	20.	.30	38.	STEPHENSONS

*********** END INPUT DATA ***********

DETAILED CALC TABLE WITH FINAL ROCK SIZE
SEGMENT=SIDE LENGTH= 70. FT. SLOPE= 20.%

ASSUMED D50= .2529FT. AT D/S END OF SEGMENT
CORRESPONDING Q= .626CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	45.	.047	.000	.047	.83	.06	.038	.90	.90
45.	90.	.094	.000	.094	1.18	.08	.034	.64	1.54
90.	135.	.141	.000	.141	1.43	.10	.032	.52	2.06
135.	180.	.188	.000	.188	1.64	.11	.030	.46	2.52
0.	50.	.240	.000	.240	2.74	.09	.048	.30	2.82
50.	100.	.292	.000	.292	3.05	.10	.046	.27	3.10
100.	150.	.344	.000	.344	3.33	.10	.044	.25	3.35
150.	200.	.396	.000	.396	3.58	.11	.043	.23	3.58
200.	250.	.448	.000	.448	3.82	.12	.042	.22	3.80
250.	300.	.500	.000	.500	4.04	.12	.041	.21	4.00
300.	350.	.553	.000	.553	4.25	.13	.040	.20	4.20
0.	70.	.626	.000	.626	4.51	.14	.040	.26	4.46

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA=(43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
45.42	45.39

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	180.	2.0	1.5	2.515	2.5	1.50	SAFETY FACTOR
SIDE	350.	20.0	3.0	.570	4.1	.30	STEPHENSON
SIDE	70.	20.0	3.0	.626	4.5	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet C-7
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

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HATSP.OUT                 11/11/93                 Page 1
UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP.OUT)
UMTRA/HAT      RUN I.D.=FHW       DATE=11-11 1993

***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***

* * * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *

COEFFICIENTS FOR INTENSITY DURATION CURVE -
        IPMP=10**(G-H*(LOGT)**Z):

        G= 1.797  H= .307  Z=1.816

RIPRAP STONE SP.GRAVITY= 2.64   C IN STEPHENSONS EQN=  .22

              - - - EMBANKMENT - - -
```

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	100.	2.	.30	35.	SAFETY FACTOR
1	SIDE	400.	20.	.30	37.	STEPHENSONS
1	HYPO	1.	20.	.30	37.	STEPHENSONS

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* * * * * * * * * * * * END INPUT DATA * * * * * * * * * * * *

          DETAILED CALC TABLE WITH FINAL ROCK SIZE
  SEGMENT=HYPO    LENGTH=   1. FT.  SLOPE= 20.%

          ASSUMED D50=  .2496FT. AT D/S END OF SEGMENT
CORRESPONDING Q=   .566CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD
```

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.056	.000	.056	.91	.06	.037	.91	.91
50.	100.	.113	.000	.113	1.29	.09	.033	.65	1.56
0.	50.	.169	.000	.169	2.27	.07	.053	.37	1.93
50.	100.	.226	.000	.226	2.66	.08	.049	.31	2.24
100.	150.	.282	.000	.282	3.00	.09	.046	.28	2.52
150.	200.	.339	.000	.339	3.30	.10	.044	.25	2.77
200.	250.	.395	.000	.395	3.58	.11	.043	.23	3.00
250.	300.	.452	.000	.452	3.84	.12	.042	.22	3.22
300.	350.	.508	.000	.508	4.08	.12	.041	.20	3.42
350.	400.	.564	.000	.564	4.30	.13	.040	.19	3.62
0.	1.	.566	.000	.566	4.30	.13	.040	.00	3.62

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z))
(INCH/HR)	(INCH/HR)
49.17	49.01

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	100.	2.0	1.5	2.515	2.5	1.50	SAFETY FACTOR
SIDE	400.	20.0	3.0	.565	3.6	1.50	STEPHENSON
HYPO	1.	20.0	3.0	.566	3.6	.30	STEPHENSON

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Appendix C

Site Annual Inspections and Site Visits

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Appendix C1

2016 Annual Inspection of the Mexican Hat, Utah, Disposal Site

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12.0 Mexican Hat, Utah, Disposal Site

12.1 Compliance Summary

The Mexican Hat, Utah, Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I Disposal Site (site) was inspected on March 17, 2016. Linear shallow depressions were observed on the northeast side slope near the toe of the disposal cell. All-terrain vehicle (ATV) tracks were also observed on the top slope of the disposal cell near the West Diversion Channel. The tire tracks were created during vegetation control activities in September 2015 and were repaired during a later visit. Several perimeter signs were missing, and were replaced during a later visit.

A required annual assessment of six designated seeps was conducted during the inspection. Seep 0251 and Seep 0264 had moist conditions. Recent rains left evaporites and pooled water within the North Arroyo, and presumably caused the observed moist conditions. Seep 0248 was dripping; the seep and adjacent Gypsum Creek were sampled on March 15, 2016, and on October 3, 2016. Evaluation of the sample results will be provided in the 2017 compliance report. Groundwater monitoring is not required, and no monitoring wells are present at the site.

The U.S. Department of Energy (DOE) and DOE Legacy Management Support (LMS) contractor personnel conducted a follow-up inspection on April 8, 2016, to further evaluate the depressions identified on the northeast side slope of the disposal cell. A surface radiation survey and land survey of the area were completed. The rock cover was pulled back from one of the deeper depressions revealing small erosion channels in the 6-inch bedding layer of the disposal cell cover. A report summarizing the follow-up inspection with recommendations to address the depressions is being completed and will be transmitted to the U.S. Nuclear Regulatory Commission (NRC) and the Navajo Nation.

12.2 Compliance Requirements

Requirements for the long-term surveillance and maintenance of the site are specified in the site-specific DOE Long-Term Surveillance Plan (LTSP) (DOE 2007) and in procedures DOE established to comply with the requirements of Title 10 *Code of Federal Regulations* Section 40.27 (10 CFR 40.27). Table 12-1 lists these requirements.

Table 12-1. License Requirements for the Mexican Hat Disposal Site

Requirement	Long-Term Surveillance Plan	This Report
Annual Inspection and Report	Sections 3.3 and 3.4	Section 12.4
Follow-Up Inspections	Section 3.5	Section 12.5
Maintenance	Section 3.6	Section 12.6
Emergency Measures	Section 3.6	Section 12.7
Environmental Monitoring	Section 3.7	Section 12.8

12.3 Institutional Controls

The 119-acre disposal site, identified by the property boundary shown in Figure 12-1, is held in trust by the United States for the U.S. Bureau of Indian Affairs. The Navajo Nation retains title to the land. UMTRCA authorized DOE to enter into a Cooperative Agreement (DE-FC04-85AL26731) with the Navajo Nation to perform remedial actions at the former uranium processing sites. DOE and the Navajo Nation executed a Custodial Access Agreement that conveys to the federal government title to the residual radioactive materials stabilized at the repository site and ensures that DOE has perpetual access to the site.

The site was accepted under the NRC general license (10 CFR 40.27) in 1997. DOE is the licensee and, in accordance with the requirements for UMTRCA Title I sites, is responsible for the custody and long-term care of the site. Institutional controls (ICs) at the site include federal custody of the disposal cell and the following physical ICs that are inspected annually: the disposal cell, the entrance gate and sign, perimeter warning signs, a security fence, site markers, and survey and boundary monuments.

12.4 Inspection Results

The site, south of Mexican Hat, Utah, was inspected on March 17, 2016. The inspection was conducted by J. Gillespie of the LMS contractor. A. Denny (DOE site manager) and J. Nofchissey and C. Corley (Navajo Nation Abandoned Mine Lands Program) attended the inspection. The purposes of the inspection were to confirm the integrity of visible features at the site, to identify changes in conditions that might affect site integrity, and to determine the need, if any, for maintenance or additional inspection and monitoring.

12.4.1 Site Surveillance Features

Figure 12-1 shows the locations of site surveillance features. Inspection results and recommended maintenance activities associated with site surveillance features are included in the following subsections. Photographs to support specific observations are identified in the text and in Figure 12-1 by photograph location (PL) numbers.

12.4.1.1 Site Access, Entrance Gate, and Entrance Sign

Access to the site is via a short unmarked dirt road off U.S. Highway 163 that ends at a graded parking area. Erosion continues to occur along the dirt road, but the site continues to be accessible. DOE is not responsible for maintenance of the access road.

The entrance gate consists of a double-leaf swing gate at the northwest corner of the site. The gate was locked and functional. The entrance sign is attached to the gate (PL-1). No maintenance needs were identified.

12.4.1.2 Perimeter Signs and Security Fence

There are 43 perimeter signs, attached to steel posts set in concrete, positioned along the site boundary (PL-2). Each perimeter sign location has a pair of signs: an upper property ownership/no-trespassing sign and a lower sign identifying the site as a radioactive materials disposal site. Several signs have bullet damage but remain legible. One or both of the perimeter signs were missing for perimeter signs P16, P17, P18, P39, P40, P41, and P43; they were replaced during a later visit. No other maintenance needs were identified.

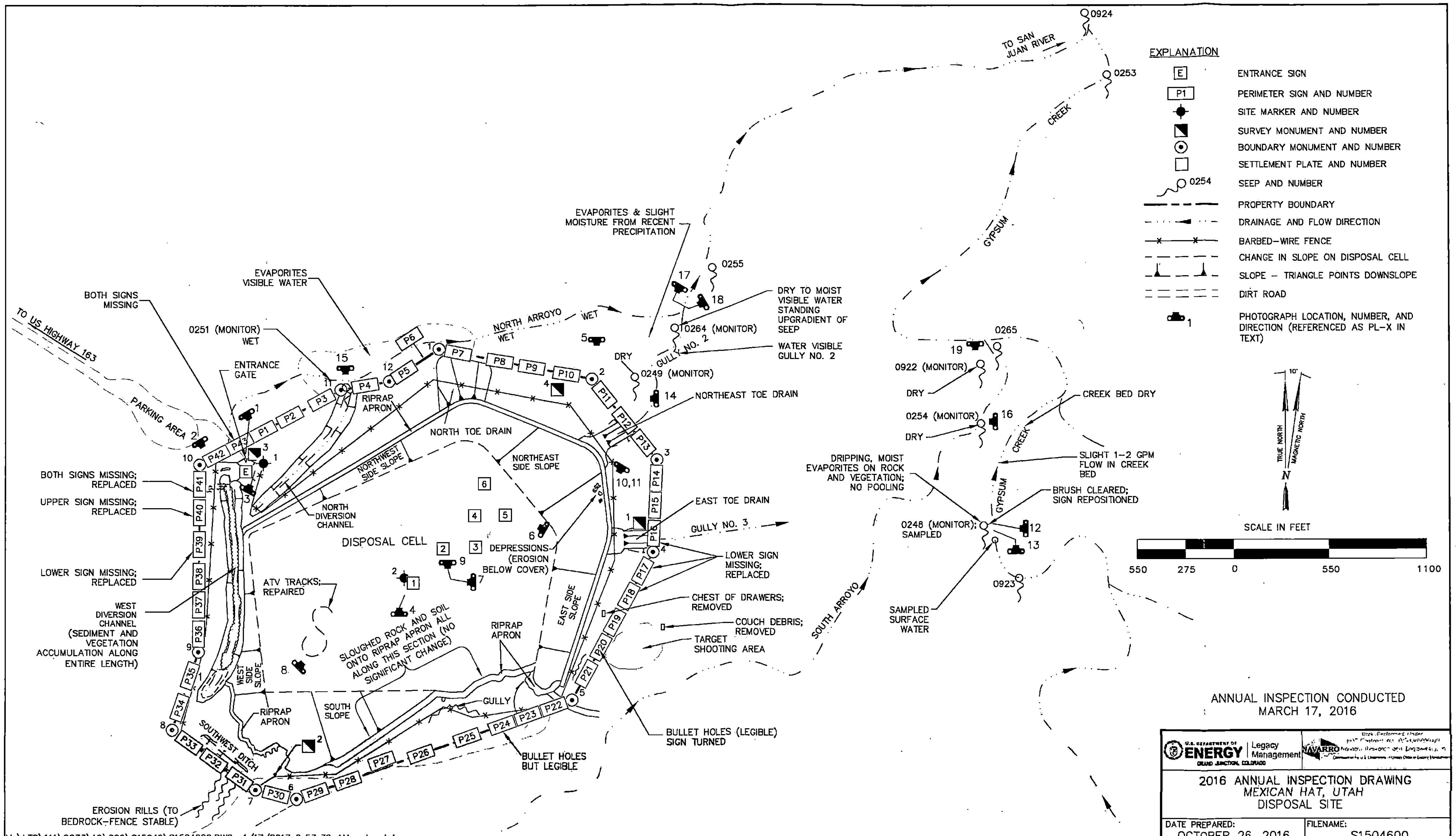

Figure 12-1. 2016 Annual Inspection Drawing for the Mexican Hat Disposal Site

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A barbed-wire fence inside the site boundary encloses the disposal cell. Periodically, the fence is damaged by livestock, erosion, or vandalism and requires repair. No maintenance needs were identified.

12.4.1.3 Site Markers

The site has two granite site markers. Site marker SMK-1 is just inside the security fence near the entrance gate (PL-3). Its concrete base has several minor cracks, but repairs are not necessary at this time. Site marker SMK-2 is on the disposal cell top slope (PL-4). No maintenance needs were identified.

12.4.1.4 Survey and Boundary Monuments

There are four survey monuments that were installed for survey control during disposal cell construction. Twelve boundary monuments mark the site boundary (PL-5). No maintenance needs were identified.

12.4.2 Inspection Areas

In accordance with the LTSP, the site is divided into four inspection areas (referred to as "transects" in the LTSP) to ensure a thorough and efficient inspection. The inspection areas are (1) the disposal cell; (2) the toe drains and diversion channels; (3) the balance of the site and the site perimeter; and (4) the outlying area. Inspectors examined specific site surveillance features within each area and looked for evidence of erosion, settling, slumping, or other modifying processes that might affect the site's integrity, protectiveness, or long-term performance.

12.4.2.1 Disposal Cell

The disposal cell, completed in 1994, occupies 68 acres. The rock-covered top slope of the disposal cell is functioning as designed (PL-6 and PL-7). There was no evidence of erosion, settling, slumping, or other modifying processes on the top of the disposal cell. ATV tracks on the top of the disposal cell near the West Diversion Channel were observed (PL-8). These were created during vegetation control activities in September 2015. The tracks were less than 6 inches deep and were repaired during a later visit. After observing these tracks, the DOE site manager directed that no driving be conducted on the disposal cell.

There was no noticeable increase of sloughed red country rock and soil along the south apron (PL-9). Because the apron in this area is immediately adjacent to the base of the steep, rocky cliff face along the southern edge of the disposal cell cover, it is expected that sediment and unstable rock from the cliff face will continue to fall onto the apron. The accumulated material is not impacting the function of the apron but this area will continue to be monitored.

Linear shallow depressions were observed at the toe of the northeast side slope near the east toe drain (PL-10 and PL-11). A follow-up inspection was performed on April 8, 2016, to further evaluate these depressions. The NRC site manager (D. Orlando) and the Navajo Nation representative (M. Roanhorse) were notified of the observation. No other maintenance needs were identified.

12.4.2.2 Toe Drains and Diversion Channels

The disposal cell toe drains and diversion channels were functioning as designed. Offsite areas to the west of the site continue to erode and transport sediment onto the site and into the west diversion channel. The sediment accumulation has promoted the growth of vegetation in the channel, including perennial grasses and annual weeds; however, the sediment and vegetation are not affecting the performance of the diversion channel. No maintenance needs were identified.

12.4.2.3 Balance of the Site and Site Perimeter

Minor erosion continues to occur in upgradient areas along the west and southwest portions of the site. This is an expected natural process and a result of the site coming to equilibrium with the outlying areas. Inspectors will continue to monitor erosion in these areas, but it is not a concern unless it damages the security fence or impacts the performance of the west diversion channel.

Trespassing occurs just inside the site boundary (outside the security fence) as evidenced by vehicle and ATV tracks and trash accumulation. Vandalism continues, as indicated by new bullet holes in several perimeter signs. This is expected to be an ongoing problem at the site because access to these areas cannot be restricted. Damaged perimeter signs are replaced when they become illegible. No evidence of trespassing has been observed beyond the security fence surrounding the disposal cell. No other maintenance needs were identified.

12.4.2.4 Outlying Area

The area beyond the site boundary for a distance of 0.25 mile was visually observed for erosion, changes in land use, or other phenomena that might affect the long-term integrity of the site. No such impacts were observed.

12.5 Follow-Up Inspections

DOE will conduct follow-up inspections if (1) a condition is identified during the annual inspection or other site visit that requires a return to the site to evaluate the condition, or (2) DOE is notified by a citizen or outside agency that conditions at the site are substantially changed.

DOE and LMS contractor personnel conducted a follow-up inspection on April 8, 2016, to further evaluate the depressions identified on the northeast side slope of the disposal cell. A surface radiation survey and land survey of the area was completed; radiation measurements were within background levels. The rock cover was pulled back from one of the deeper depressions to reveal a shallow erosion channel in the radon barrier of the disposal cell cover. The disposal cell radon barrier is constructed of 24 inches of compacted clay that is protected by a 6-inch bedding layer of small-diameter crushed rock on top of the clay barrier and 12 inches of rounded river rock on top of the bedding layer (Figure 12-2).

A report summarizing the follow-up inspection with recommendations to address the depressions is being completed and will be transmitted to NRC and the Navajo Nation.

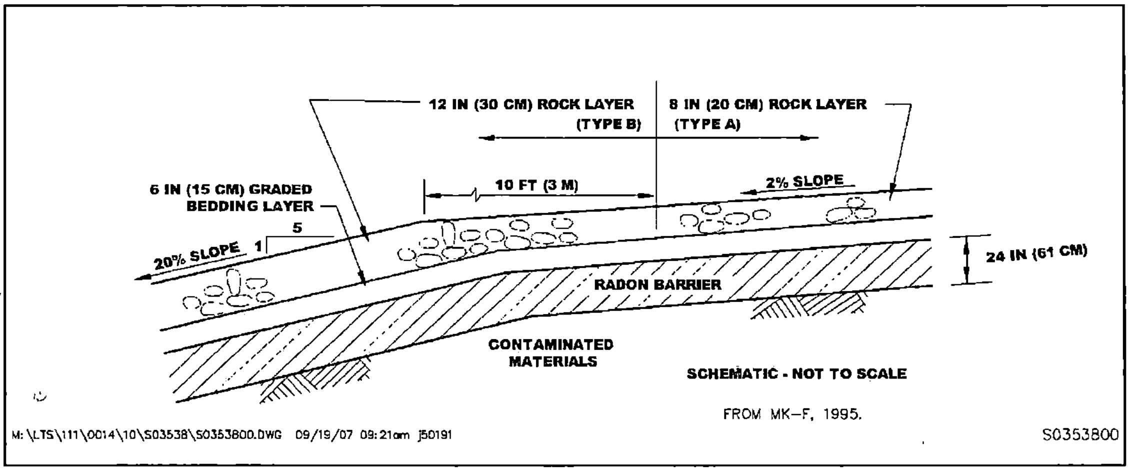

Figure 12-2. Generalized Cross Section of Disposal Cell Cover, Mexican Hat Disposal Site

12.6 Maintenance

One or both of the perimeter signs were missing for perimeter signs P16, P17, P18, P39, P40, P41, and P43, and were replaced during a later visit on August 17, 2016. A couch and parts of a chest of drawers in the vicinity of the offsite informal target shooting area were disposed of during a later visit on August 16, 2016, as a best management practice. Overgrown vegetation at Seep 0248 was removed to provide access for sampling, and the sign was repositioned to face Gypsum Creek. No other maintenance needs were identified.

12.7 Emergency Measures

In accordance with the LTSP, emergency measures are the actions that DOE will take in response to "unusual damage or disruption" that threatens or compromises site safety, security, or integrity in compliance with 10 CFR 40, Appendix A, Criterion 12. The disposal cell side-slope depressions were determined to not require an emergency action at this time; therefore, no need for emergency measures was identified.

12.8 Environmental Monitoring

12.8.1 Groundwater Monitoring

In accordance with the LTSP, groundwater monitoring is not required at this site because the uppermost aquifer is hydrogeologically isolated from contamination in the overlying formation. No groundwater monitoring wells remain at the site.

12.8.2 Seep Monitoring

An annual assessment of six designated seeps was conducted during the inspection in accordance with Section 3.7.2 of the LTSP and an approved monitoring plan (DOE 2006). The seeps locations appear in Figure 12-3. Signs warning against drinking the water are posted at five of the seep locations. Seep 0249 in Gully No. 2 does not have a sign but has historically been dry and is covered by riprap material.

In accordance with the LTSP, seep flow rates are required to be monitored annually through observation through 2016, at which time an evaluation will be conducted to determine whether to continue or discontinue seep monitoring. A seep monitoring evaluation report will be prepared in 2017.

Since 2010, seep flow has been observed only at upgradient (background) Seep 0248. Water was observed dripping from the adjacent evaporites at Seep 0248 at an increased rate from previous years. Seeps 0251 and 0264, hydraulically downgradient of the site, were observed to be moist; in previous years both had been dry. Recent rains left evaporites and pooled water within the North Arroyo, and presumably caused the observed moist conditions and evaporites. Gypsum Creek had evidence of major flash flooding from recent rains. Seeps 0249, 0254, and 0922, also hydraulically downgradient of the site, were dry, which is the same as the previous year. Table 12-2 provides observations and qualitative descriptions of seep flows, along with a reference to photographic documentation.

In 2015 the Navajo Nation requested sampling of Seep 0248 due to increased precipitation in the area. To address this request, Seep 0248 was sampled during August and September 2015. Surface water samples were collected at Seep 0248 and one location in Gypsum Creek upgradient of Seep 0248 on March 15, 2016 (PL-12 and PL-13), and October 3, 2016. Evaluation of the sample results will be provided in the 2017 seep monitoring evaluation report.

Table 12-2. Observations of Seeps near the Mexican Hat Disposal Site

Seep Location Number	Drainage	Photo Location Numbers	Observed Seep Conditions
0248	Gypsum Creek	PL-12, PL-13	Seep was dripping and a pool collected at the base of the cliff. Sample collected from seep and from upgradient location in Gypsum Creek on March 15, 2016.
0249	Gully No. 2	PL-14	Dry conditions (no change from previous year).
0251	North Arroyo	PL-15	Moist conditions with evaporites presumably from recent rains.
0254	South Arroyo	PL-16	Dry conditions (no change from previous year). Location is not posted due to seasonal flash flood conditions in the drainage.
0264	North Arroyo	PL-17, PL-18	Moist conditions with ponding west of the location and evaporites presumably from recent rains.
0922	South Arroyo	PL-19	Dry conditions (no change from previous year). Evidence observed that Gypsum creek experienced flash flooding from recent rains.

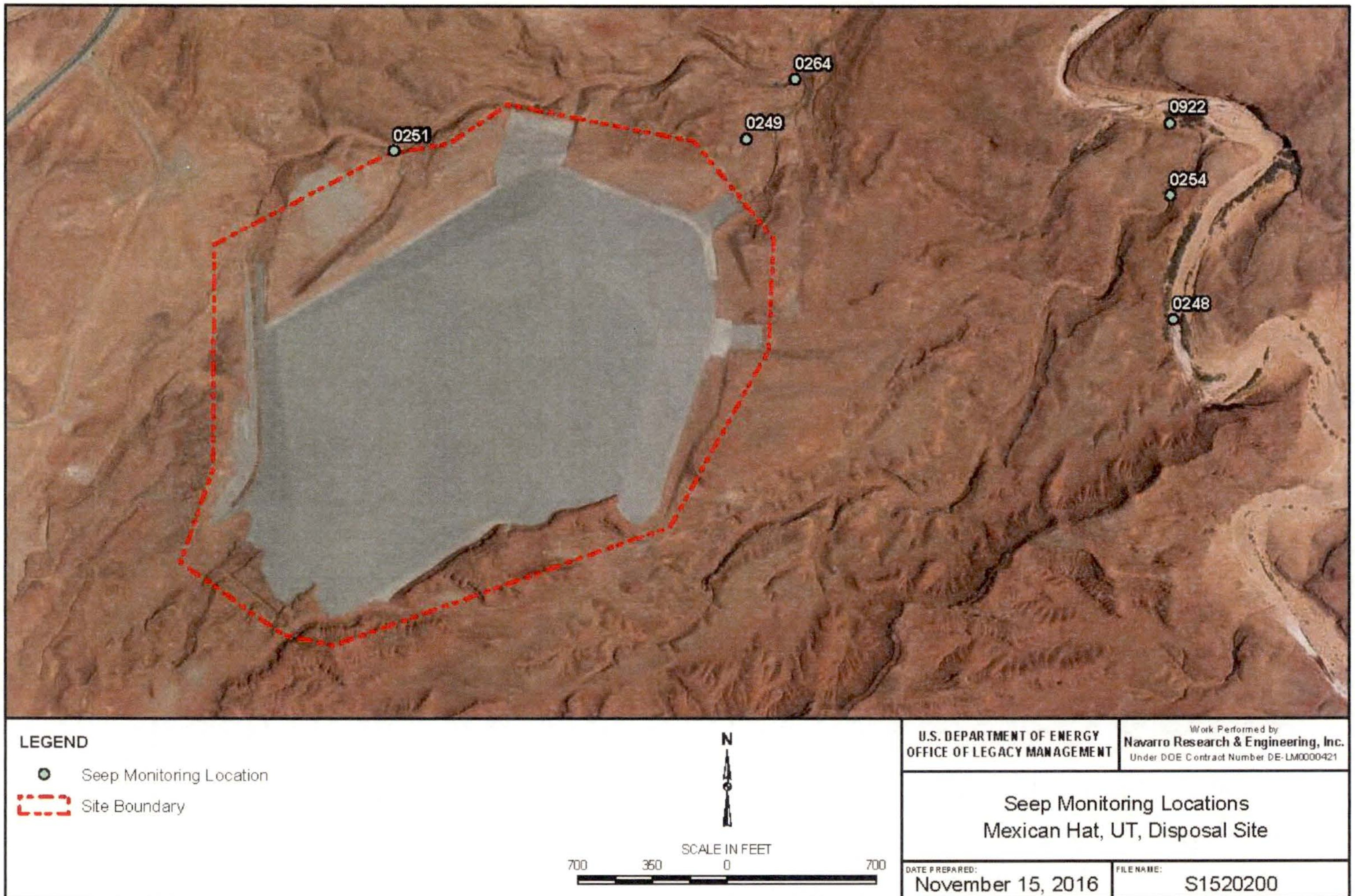

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Figure 12-3. Mexican Hat Disposal Site Seep Monitoring Locations

12.8.3 Vegetation Monitoring

In accordance with the LTSP, vegetation conditions are observed during annual inspections to ensure that undesirable plant species, including deep-rooted plants on the disposal cell cover and noxious weeds, do not proliferate at the site. Natural plant community succession will not adversely impact the performance of the disposal cell features. No vegetation management was required in 2016.

12.9 References

DOE (U.S. Department of Energy), 2006. *Resolution of Seep and Ground Water Monitoring at the Mexican Hat, Utah, UMTRCA Title I Disposal Site,* DOE-LM/GJ1139-2006, March.

DOE (U.S. Department of Energy), 2007. *Long-Term Surveillance Plan for the Mexican Hat, Utah (UMTRCA Title I), Disposal Site, San Juan County, Utah,* DOE-LM/1530-2007, Rev. 3, October.

12.10 Photographs

Photograph Location Number	Azimuth	Photograph Description
PL-1	150	Entrance Gate
PL-2	150	Perimeter Sign P42 Near Boundary Monument BM-10
PL-3	30	Site Marker SMK-1
PL-4	36	Site Marker SMK-2
PL-5	180	Boundary Monument BM-2
PL-6	300	View Northwest Across Disposal Cell Top Slope
PL-7	270	View West Across Disposal Cell Top Slope With Site Marker SMK-2
PL-8	45	View Northeast of ATV Tracks Around Dead Four-Wing Saltbush Shrub
PL-9	180	Sloughed Rock Area Along South Edge of Disposal Cell
PL-10	210	Depressions on Northeast Side Slope Near the Toe of Disposal Cell
PL-11	210	Depressions on Northeast Side Slope Near the Toe of Disposal Cell
PL-12	270	Access to Seep 0248
PL-13	0	Surface Water Sampling Location at Gypsum Creek Upgradient of Seep 0248
PL-14	270	Seep 0249 in Gully No. 2 (Dry)
PL-15	180	Seep 0251 (Moist)
PL-16	180	Seep 0254 (Dry)
PL-17	210	Seep 0264 (Moist)
PL-18	240	Ponded Water West of Seep 0264
PL-19	0	Seep 0922 (Dry)

PL-1. Entrance Gate

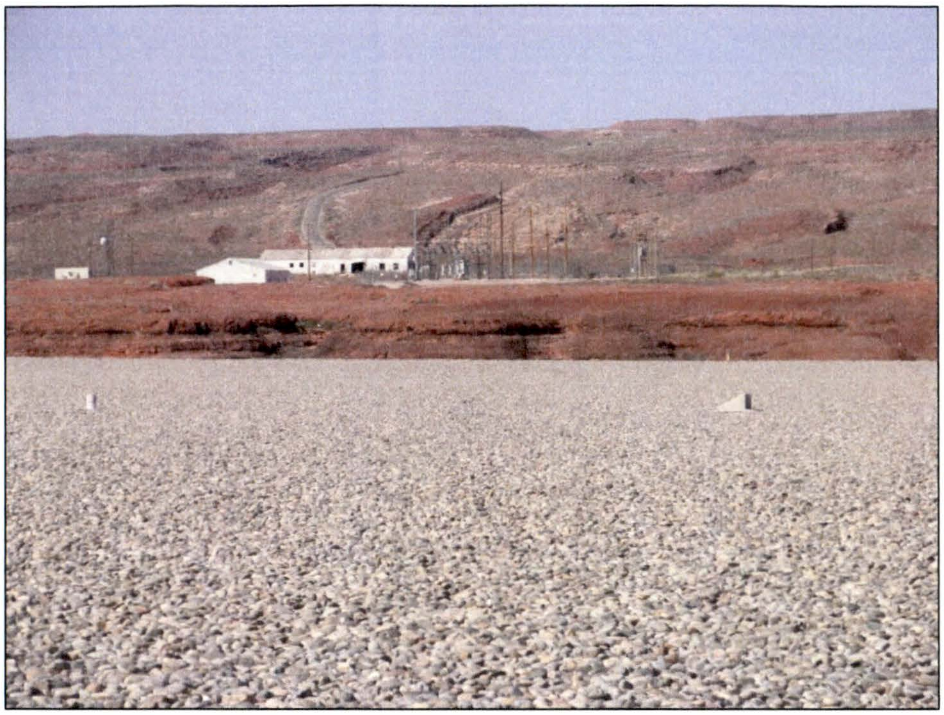
PL-2. Perimeter Sign P42 Near Boundary Monument BM-10

PL-3. Site Marker SMK-1

PL-4. Site Marker SMK-2

PL-5. Boundary Monument BM-2

PL-6. View Northwest Across Disposal Cell Top Slope



PL-7. View West Across Disposal Cell Top Slope With Site Marker SMK-2

PL-8. View Northeast of ATV Tracks Around Dead Four-Wing Saltbush Shrub

PL-9. Sloughed Rock Area Along South Edge of Disposal Cell

PL-10. Depressions on Northeast Side Slope Near the Toe of Disposal Cell

PL-11. Depressions on Northeast Side Slope Near the Toe of Disposal Cell

PL-12. Access to Seep 0248

PL-13. Surface Water Sampling Location at Gypsum Creek Upgradient of Seep 0248

PL-14. Seep 0249 in Gully No. 2 (Dry)

PL-15. Seep 0251 (Moist)

PL-16. Seep 0254 (Dry)

PL-17. Seep 0264 (Moist)

PL-18. Ponded Water West of Seep 0264

PL-19. Seep 0922 (Dry)

Appendix C2

Site Visit Report, April 8, 2016

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Contractor to U.S. Department of Energy Office of Legacy Management

Site Visit Report

Refer to the Quality Assurance Manual *Section 1.5.3.4 for a description of this process.*

Assessment Title *(short title describing process or area examined)*:	**Site** *(include name of building if applicable)*:
Follow up to March 17, 2016 Annual Site Inspection Observations and Radiological Scan of Observations on North East Slope.	Mexican Hat Disposal Cell, Utah

Date(s) Performed: 4/8/2016

Site Manager or Lead: Joey Gillespie

Issued By: Anthony Martinez/ Joey Gillespie **Date Issued:** 4/14/2016

Summary *(brief summary of results including what was examined and what was observed)*:

- Subject Matter Experts on Title I / II cell inspections visited the site on April 8 to view the depressions occurring along the toe of the northeast side slope. Several depressions were noted and surveyed in by Navarro GIS personnel during the site visit. The 80 X 100 feet area surveyed contained approximately rill areas or depressions.
- Anthony Martinez set up a radon monitor in a background area to establish background radon outside of the cell fence and then placed the instrument in one of the observed cell depressions. Results of the instrument scan were negligible difference between the background location and the cell.
- Gamma scan was also performed at a background location around the Mexican Hat disposal cell and in the depressions on the disposal cell. The areas of concern were compared and the results show no difference between the two. The results were provided to the LMS site lead who requested the scan.
- SMEs removed cover material from one of the depressions or rills. Base of the cover material showed the cause of the depressions on the surface to be .caused by erosion of either the 6 inch bedding layer or the very top portion of the 24 inch radon barrier. A small trough of approximately 6 inches wide by 4-5 inches deep was observed by the SMEs after pulling back the rip rap erosional cover.

Purpose and Scope *(reason for site visit assessment and scope of area examined)*:

- Visit by Navarro personnel (SMEs) to observe several slight depressions noted during the March 17th Annual Site Inspection. Depressions were noted along the toe of the northeast slope of the Mexican Hat disposal cell
- Radiological gamma survey of depressions to be performed to determine if radon barrier had been compromised.

Report detail *(detailed description of processes and areas examined. Describe problem areas as well as positive practices. Include action items that were completed during site visit)*:

Setup radon monitors in a background area in the morning and on one of the depressions on the Mexican Hat Disposal cell in the afternoon to collect data for a radon study, results included as attachment.

Gamma scan was done in background around the Mexican Hat disposal cell and scan were done on the indention on the disposal cell the areas of concern and compared, the results show no difference between the two. Information was passed on to site lead who requested the scan.

Travel back from Mexican Hat, UT to the LM Office at Grand Junction, CO on Saturday.

Observations *(examples: Consider repainting door when weather permits. Housekeeping is exceptionally good)*:

See attached photos of the areas .

Action Items *(follow-up with site manager or lead on action items listed. Consider including action items on the Site Problem/Issue Report Log (form LMS 1019) implemented by LMS Project and Programs Manual, Appendix A, "Problem/Issue Reporting.)*:

It was determined that the depressions would need an additional follow up inspection by Navarro

Site Visit Report (continued)

Assessment Title *(short title describing process or area examined)*:	**Site** *(include name of building if applicable)*:
Follow up to March 17, 2016 Annual Site Inspection Observations and Radiological Scan of Observations on North East Slope.	Mexican Hat Disposal Cell, Utah

construction/engineering personnel in order to generate an evaluation summary report to be submitted to DOE LM and then to be submitted to NRC.

Documents/Procedures Reviewed *(reference information or required documents used to prepare for and conduct the site visit)*:

Annual Site Inspection Report Mexican Hat Utah dated March 17, 2016

Job Safety Analysis

Plan of the Day

N/A

Persons Contacted:

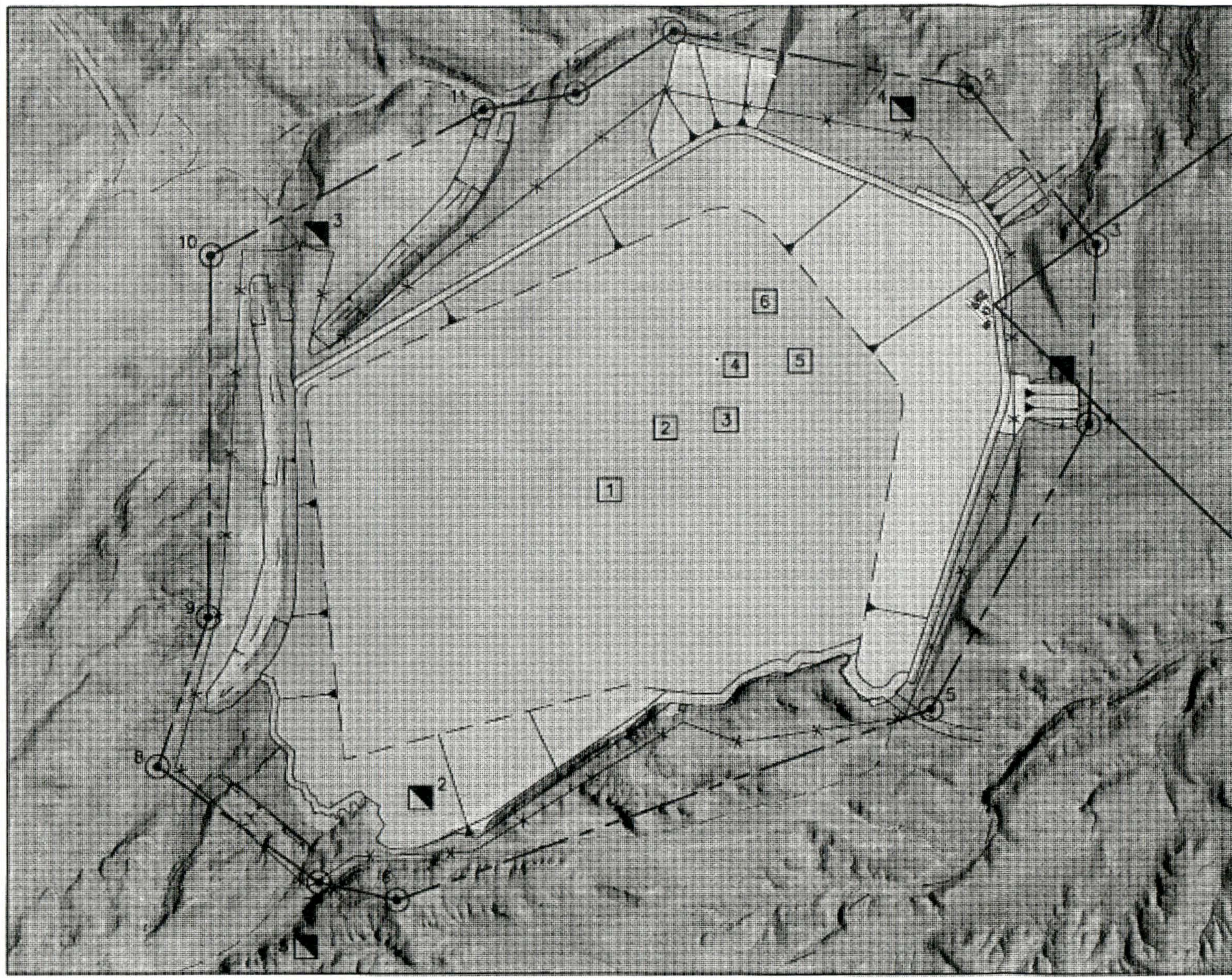
Joey Gillespie / Anthony Martinez, Brendan Nittler, Dick Johnson, Mike Widdop, Steve Hall,(Navarro); Angelita Denny (DOE LM).

Email Distribution *(include site manager or lead, responsible management, affected individuals and CorrectiveAction@lm.doe.gov)*:

Joey Gillespie, Jeff Carman, Sam Marutzky, Beverly Cook, Shelly Gutierrez, CorrectiveAction@lm.doe.gov

See the following attachments:

Site Location Figure
Photos
Radon and Gamma Results



SITE PLAN

N

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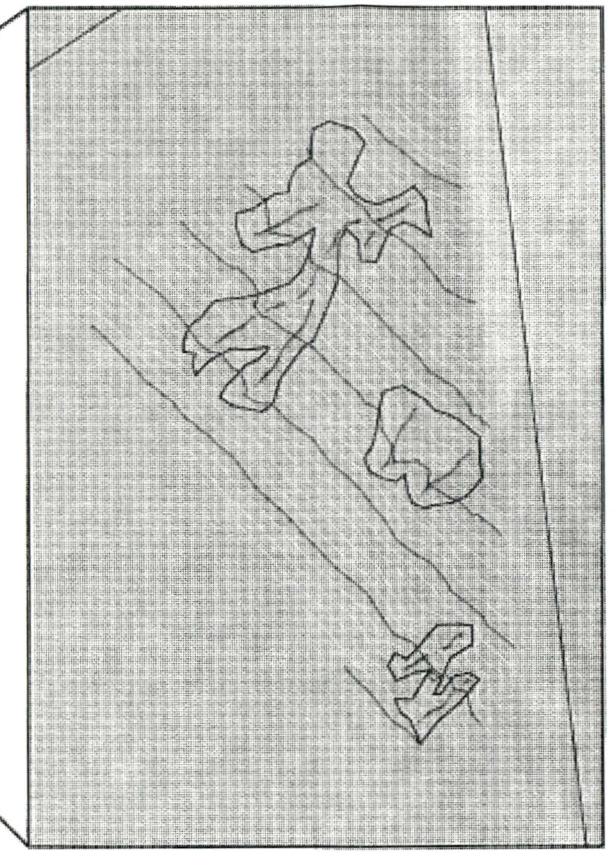

AREA OF CONCERN

N

SCALE IN FEET
30 15 0 30 60 90

T:\Sites\UT\MexicanHatDisposal\GPS\TrimbleBusinessCenter\201604_SettlementSurvey\4_Report\HAT_Final.dwg 4/12/2016 2:13 PM nittlerb

U.S. DEPARTMENT OF ENERGY | Legacy Management
GRAND JUNCTION, COLORADO

NAVARRO
Work Performed Under
DOE Contract No. DE-LM0000421
Navarro Research and Engineering, Inc.
Contractor to the U.S. Department of Energy Office of Legacy Management

Figure 1 AREA OF CONCERN
MEXICAN HAT, UT
DISPOSAL SITE

DATE PREPARED: APRIL 12, 2016

FILENAME: SXXXXXXX

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LEGENDARY
WHITETAILS
COLORADO

Appendix C3

Engineering Site Visit Trip Report, June 1, 2016

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Engineering Site Visit Trip Report

Site	Mexican Hat Disposal Site	**Project**	Rock Cover Inspection
Individuals making trip	Dan Nordeen and Dan Brennecke from Engineering, Doug Collet from Construction		

Purpose:

Evaluate areas of concern where 5:1 rock cover is showing signs of depression and make recommendations to address potential erosion issues.

Basic Itinerary:
(including dates, to and from, travel method, lodging location

06/01/16: Round trip travel from Grand Junction, CO to Mexican Hat, UT in GSA vehicle.

Summary:

- Depressions were subtle and somewhat difficult to identify along the surface of rock as evidenced in some of the photos. Previous personnel site visit on March 17th identified at least 4 areas of concern marked out with rebar embedded into the rock and capped with an orange protective cap. After locating several depressions we inspected 3 of the areas in more detail. The areas are located along the 5:1 northeast side slope roughly between the drainage outlets called Gully's 2 and 3. See attached sketch of the plan view, inset of enlarged area of concern.
- The surface rock designated as Type B1 Riprap was removed first by hand to expose the bedding layer material below and subsequently the radon barrier. Approximate depths can be seen in the photographs. The Type B1 Riprap appeared to be consistent with the specified gradation (5" to No. 4) with a thickness that seemed consistent with the specified tolerance of 0% to +35% (12" to a maximum of 16.2"). (see attached construction specifications for radon barrier and erosion protection) The bedding layer material appeared to be inconsistent with the specified depth of 6" and consisted of segregated material that did not have the specified fines within the bedding material matrix.
- The small areas of radon barrier material exposed in the investigation area did not allow determination of depth variations between the depression area and the adjacent non-depressed area. The radon barrier material exposed was a fine grained material and appeared to be consistent with the specified grading requirements which are very broad and allow material as large as 4 inches.
- Investigated areas were backfilled by hand and left in a slightly depressed condition relative to the adjacent surfaces. Stone mounds which last longer than flagging were made near the center of each location for future location of the areas that were investigated. Measurements were made between the perimeter marked with rebar and the investigated areas so that the investigated areas could be plotted on the map upon return to the office. However, it is recommended that a topographical survey be performed to locate the investigation areas.
- Identified several new areas of depression just above the drainage outlet structure called Gully 2. The riprap material at this location is Type B, a larger graded rock than the Type B1 previously discussed. Type B material can be as large as 8" as opposed to a maximum size of 5" for Type B1 Riprap. These areas were not investigated for subsurface conditions at the time of the investigation.
- Photographs also indicate the identification of a buildup of fine grained material within the type C Riprap where the slope is the lowest just after transition from the Type B1 to the Type C Riprap at Gully 2. (See figure 1 for the approximate location of new areas of concern north of the areas identified in March).

Discussion:

- The June 1st inspection of the riprap surface indicated that there may be erosion of the radon barrier fine grained material that may be causing depressions in the overlying riprap layers, however, there is no assurance that this is the case given the small riprap areas that were removed for subsurface inspection. In order to better inspect the validity of radon barrier fine grained soil loss due to subsurface erosion, a larger area of riprap/bedding material would need to be removed to allow inspection of the radon barrier surface within the areas of concern and the adjacent new areas to determine whether or not a variation in the bedding layer and or radon barrier surface is present. This would involve the use of larger sized, track-hoe style equipment with a skilled operator to carefully remove each layer to the top surface of the radon barrier material. This action carries additional risk of further disturbance to the surface rock each time the track equipment needs to reposition. With proper care, the damage would be easily repaired as the equipment moves off the pile, smoothing and compacting with the bucket along the way.

- Alternatively, other options that can be discussed are:
  - No action – monitor disturbed areas over time to allow more time to evaluate the cause and affectand provide for planning of the work.
  - Regrade the existing riprap surface in the disturbed areas to match adjacent surfaces and then monitor over time to see if the depressions reoccur.
  - Backfill the depressions with new riprap material to match adjacent grades and then monitor over time to see if the depressions reoccur

Included Items:

- The following documents are attached to this Report:
  1. Mexican Hat As-Built drawings
  2. Construction Specification Section 02200 “Earthwork”
  3. Construction Specification Section 02228 “Radon Barrier”
  4. Construction Specification Section 02278 “Erosion Protection”
  5. Figure 1 Sketch over Enlarged Area of Concern map.
  6. Site Photos

Action Items:

- Discuss observances with LMS and LM Site Managers to determine if additional investigation/corrective action is warranted.

Cc:			
	Dan Brennecke	Dick Johnson	Joey Gillespie
	Troy Thomson	Doug Collet	Sam Campbell

Photo 1. View upslope of NE sideslope red outlines areas of concern (approx. 100ft x100ft)

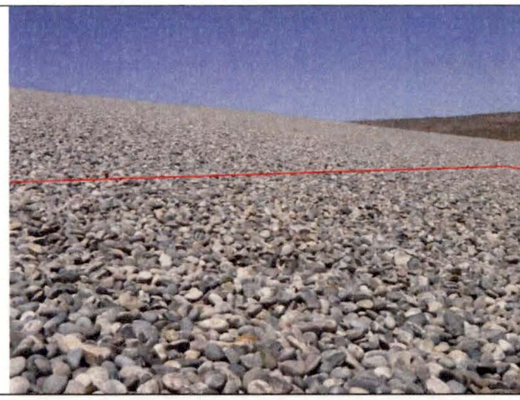


Photo 2. Mid-point along NE side slope of area of concern bounded in red

Photo 3. Across the NE slope west of areas of concern bounded in red (approx. 100ftx100ft area)

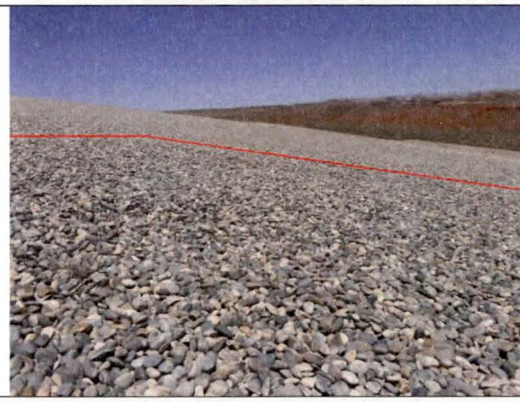


Photo 4. Upslope and view west of the NE slope of areas of concern bounded in red

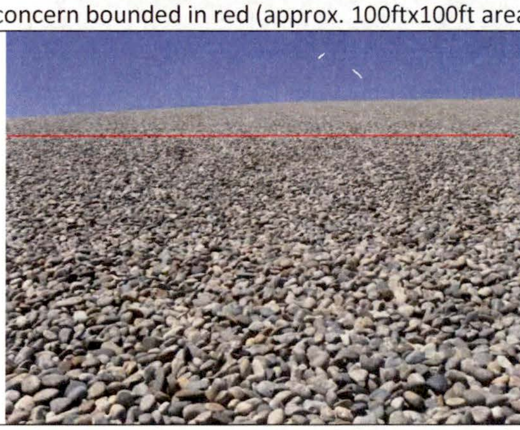


Photo 5.Upslope east view of the NE slope of areas of concern bounded in red

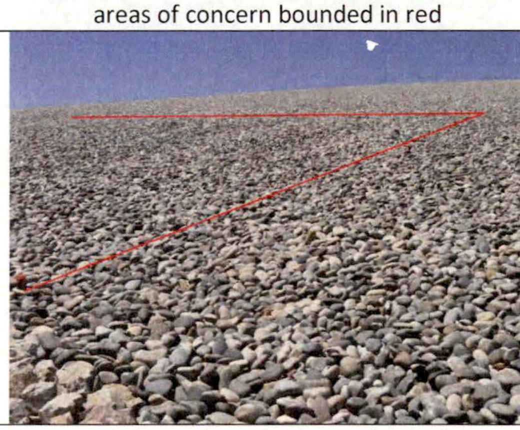


Photo 6. Upslope of west side NE slope of areas of concern bounded in Red (approx. 100ft x 100ft)

Photo 7 - Test Pit 1

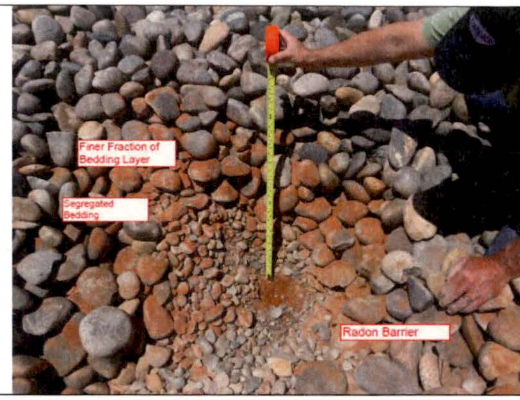


Photo 8 – Test Pit 2

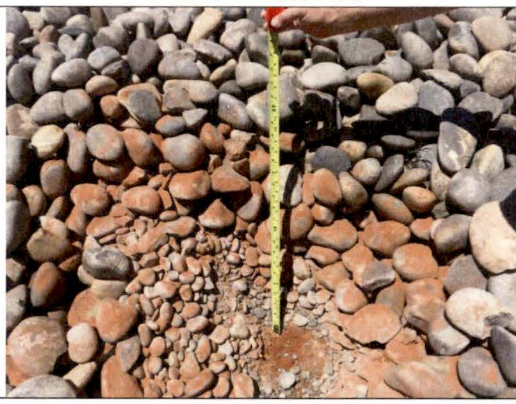


Photo 9 – Test Pit 2

Photo 10 – Test Pit 1 Backfilled

Photo 11 – Test Pit 3

Photo 12 – Rock Mon @ TP1

	
Photo 13 – Rock Mon at TP 2	Photo 14 – Rock Mon @ TP 3

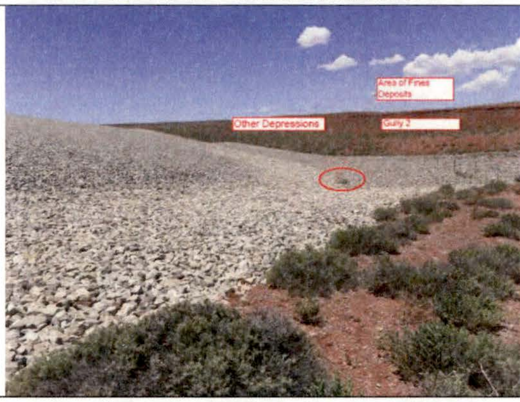



Photo 15 - Rock Drain Low Point	Photo 16 – Rock Drain Low Point

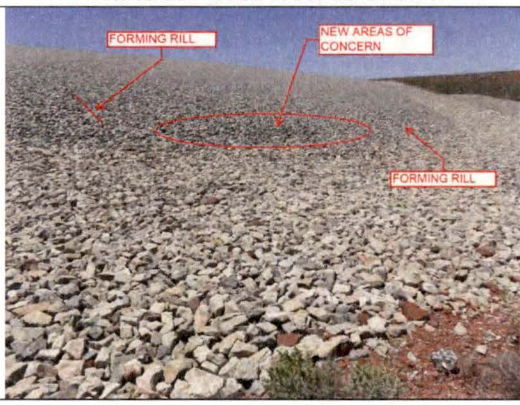
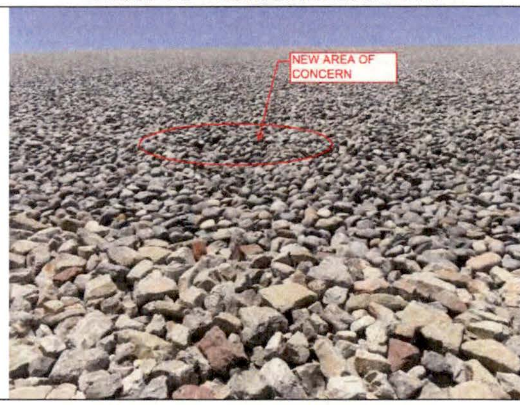

	

Photo 17 - NEW DEPRESSIONS	Photo 18 – NEW DEPRESSIONS

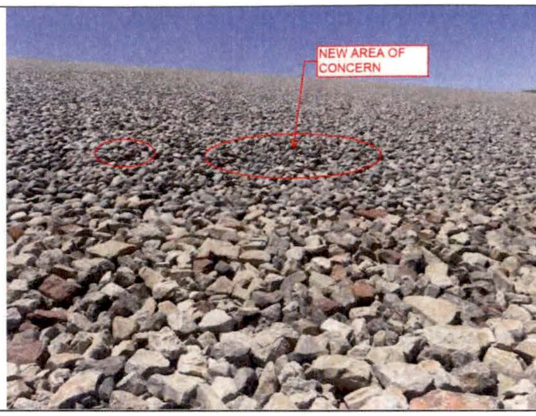
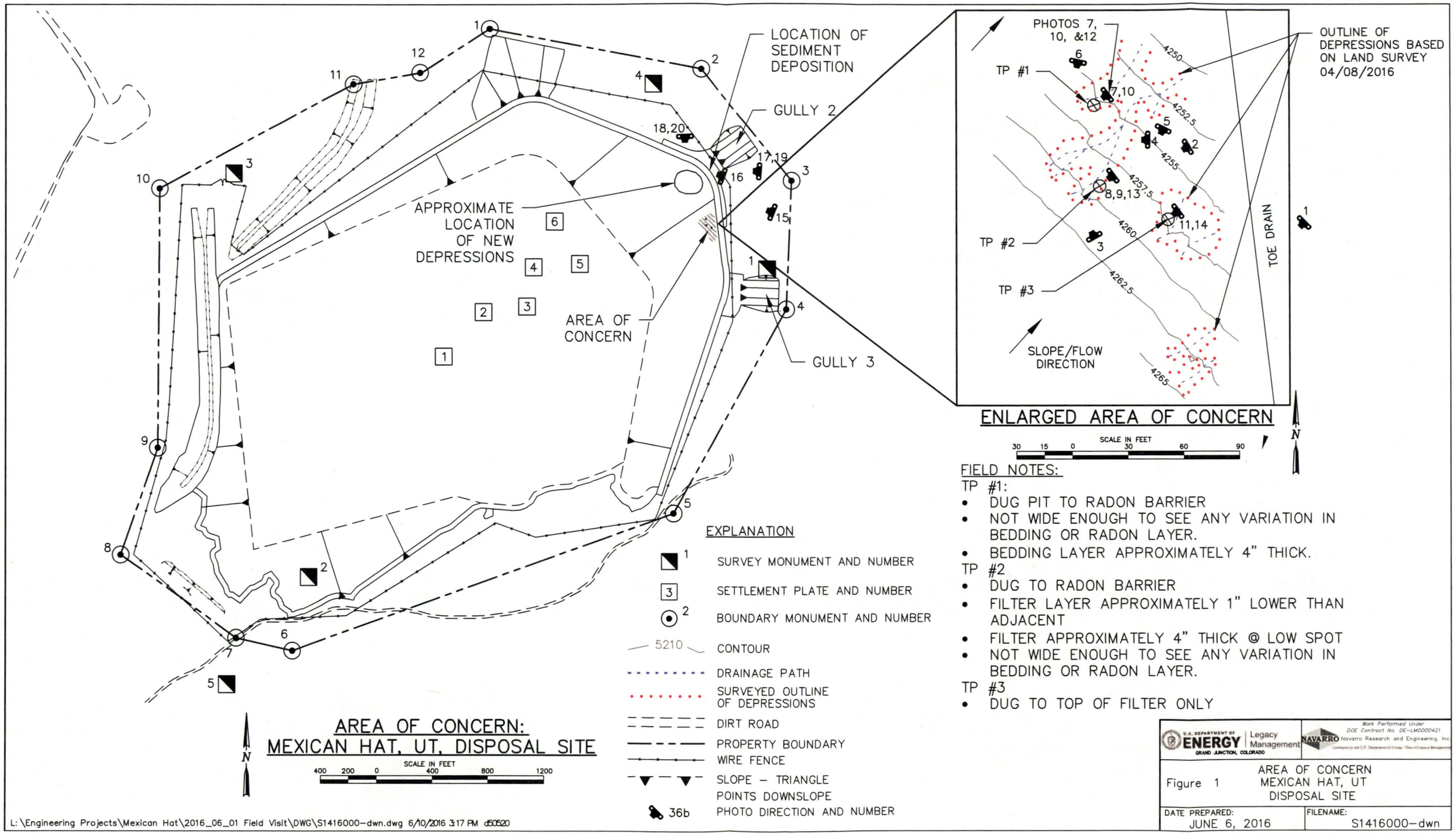


Photo 19 – NEW DEPRESSIONS	Photo 20 - NEW DEPRESSIONS


LOCATION OF SEDIMENT DEPOSITION
GULLY 2
GULLY 3
APPROXIMATE LOCATION OF NEW DEPRESSIONS
AREA OF CONCERN
PHOTOS 7, 10, &12
TP #1
TP #2
TP #3
OUTLINE OF DEPRESSIONS BASED ON LAND SURVEY 04/08/2016
TOE DRAIN
SLOPE/FLOW DIRECTION
ENLARGED AREA OF CONCERN
SCALE IN FEET
FIELD NOTES:
TP #1:
• DUG PIT TO RADON BARRIER
• NOT WIDE ENOUGH TO SEE ANY VARIATION IN BEDDING OR RADON LAYER.
• BEDDING LAYER APPROXIMATELY 4" THICK.
TP #2
• DUG TO RADON BARRIER
• FILTER LAYER APPROXIMATELY 1" LOWER THAN ADJACENT
• FILTER APPROXIMATELY 4" THICK @ LOW SPOT
• NOT WIDE ENOUGH TO SEE ANY VARIATION IN BEDDING OR RADON LAYER.
TP #3
• DUG TO TOP OF FILTER ONLY
EXPLANATION
SURVEY MONUMENT AND NUMBER
SETTLEMENT PLATE AND NUMBER
BOUNDARY MONUMENT AND NUMBER
CONTOUR
DRAINAGE PATH
SURVEYED OUTLINE OF DEPRESSIONS
DIRT ROAD
PROPERTY BOUNDARY
WIRE FENCE
SLOPE – TRIANGLE POINTS DOWNSLOPE
PHOTO DIRECTION AND NUMBER
AREA OF CONCERN: MEXICAN HAT, UT, DISPOSAL SITE
SCALE IN FEET
U.S. DEPARTMENT OF ENERGY | Legacy Management
GRAND JUNCTION, COLORADO
NAVARRO Navarro Research and Engineering, Inc.
Work Performed Under DOE Contract No. DE-LM0000421
Figure 1
AREA OF CONCERN MEXICAN HAT, UT DISPOSAL SITE
DATE PREPARED: JUNE 6, 2016
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SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section covers earthwork for the following:

1. Excavation of contaminated materials from the Mexican Hat and Monument Valley sites.

2. Transportation of contaminated materials from Monument Valley to Mexican Hat.

3. Excavation of uncontaminated common materials.

4. Excavation of uncontaminated rock materials.

5. Construction of the tailings embankment excluding radon barrier and erosion protection which includes disposal of (contaminated and uncontaminated). demolished materials and debris and other contaminated materials including the following in the construction of the tailings embankment:

   a. Existing stockpiles of demolished materials, debris and rubble.

   b. Demolished materials and debris resulting from work specified in Section 02050.

   c. Contaminated cleared vegetation resulting from site clearing specified in Section 02110.

   d. Contaminated sediments from retention basins, dikes and ditches specified in Section 02141.

   e. Stockpiled contaminated vicinity property materials.

6. Construction of permanent drainage ditches.

7. Finish grading of the site, including restoration and regrading of areas occupied by existing temporary drainage ditches, existing wastewater retention basins

and dikes, existing contaminated water recirculation pond, sumps, and temporary facilities areas.

8. Placement of selected rockfill from on-site stockpiles.

9. Furnishing and installing new displacement monuments and extend existing displacement monument as shown on the Subcontract Drawings.

1.2 WORK NOT INCLUDED

A. Earthwork related to the construction of offsite construction facilities specified in Section 01500 is not included in this Section.

B. Earthwork for pipe trenches is not included in this Section.

C. Construction of protective cover of the tailings embankment and for permanent ditches and gullies. Protective cover includes (1) radon barrier materials, (2) bedding materials, and (3) erosion protection materials.

D. Delivery and stockpiling of contaminated vicinity property materials in the tailings embankment by others.

[Text Deleted]*

1.3 RELATED WORK

A. Section 00800 - Special Conditions

B. Section 01300 - Submittals

C. Section 01500 - Construction Facilities

D. Section 01560 - Temporary Controls

E. Section 02050 - Demolition

F. Section 02110 - Site Clearing

G. Section 02141 - Dewatering and Drainage

H. Section 02228 - Radon Barrier

I. Section 02278 - Erosion Protection

1.4 DEFINITIONS

A. Contaminated materials and uncontaminated materials are defined in Article SC-1 of the Special Conditions.

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B. Excavation: Excavation shall include excavation of all materials including silt, clay, sand, gravel, talus, soft or disintegrated rock, boulders or detached pieces of solid rock and rippable rocks (see definition) but shall exclude rocks requiring drilling and blasting operations or grinding and planing. Excavation shall be classified into the following categories:

1. Contaminated Materials Excavation.

2. Uncontaminated Materials Excavation.

C. Contaminated Materials Excavation: Contaminated materials excavation shall include excavation of contaminated materials regardless of the nature (soil or rock) of the materials from the tailings piles, existing and heap leach pads area at Monument Valley, windblown and waterborne areas, the wastewater retention basins, and the dikes.

D. Uncontaminated Materials Excavation: Uncontaminated materials excavation shall include excavations of uncontaminated materials from the various areas of the site including, but not limited to, excavations for permanent drainage ditches and for finish grading. Uncontaminated materials excavation shall be classified into common excavation and rock excavation in accordance with the following designations and classifications:

1. Rock Excavation: Rock excavation shall include excavation by drilling and blasting or by grinding and planing of material classified as rock and shall include the satisfactory removal 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; and conglomerate deposits that are so firmly cemented as to possess the characteristics of solid rock that is impossible to remove without systematic drilling and blasting. The Subcontractor shall not proceed with the excavation of this material until the Contractor has classified the materials as common excavation or rock excavation and cross-sections are taken as required. Failure on the part of the Subcontractor to uncover such material, notify the Contractor, and allow ample time for classification and cross-sectioning of the undisturbed surface of such material will cause the forfeiture of the Subcontractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contractor for the areas of work in which such deposit occurs.

2. Common Excavation: Common excavation shall include the satisfactory removal of all such materials including rippable rocks (see definition below), not materials classified as rock excavation defined above.

E. Overexcavation: Overexcavation is defined as (1) excavation carried out beyond the lines and grades indicated on the Subcontract Drawings or in the Subcontract Specifications or (2) excavation not authorized by the Contractor.

F. Slimes: Slimes are the fraction of the tailings consisting of silty clay, clay and clayey silt, generally defined as containing 70 percent or more of minus No. 200 sieve material.

G. Percent Maximum Density: Percent maximum density is the field dry density expressed as a percentage of the maximum dry density obtained by the test procedure presented in ASTM D698, as applicable.

H. Tailings Embankment: Tailings embankment shall consist of in situ tailings pile materials, contaminated windblown/waterborne materials from the Mexican Hat site, relocated tailings from Monument Valley and other areas of the site, including contaminated materials from windblown and waterborne areas, heap leach pads area, wastewater retention basins, contaminated water recirculation pond, demolished materials and debris, vicinity property materials and the protective cover materials.

I. Subgrade Preparation: Preparation of surfaces of excavations including permanent drainage ditches, backfills, apron, and embankments upon which bedding materials, riprap, or other features are to be constructed. Such surface preparation shall include mixing and manipulation, fine grading, and compaction of materials.

J. Cover: Cover shall consist of the layers of following fill materials placed over the relocated contaminated materials in the tailings embankment as shown on the Subcontract Drawings:

1. Bedding and riprap materials.

2. Radon barrier material.

K. Demolished Materials and Debris:

1. Demolished materials and debris resulting from the demolition work specified under this Subcontract.

2. Stockpiles of Demolished Materials, Debris and Rubble: Existing stockpiles consist of pieces of ore, rock, wood, concrete, steel and debris from demolished work specified under this Subcontract.

L. Finish grading of the site shall include excavation, fill and backfill of the various areas of the site including removal of retention basin dikes (existing), backfilling of temporary drainage ditches (existing), wastewater retention basin (existing), contaminated water recirculation ponds (existing), and temporary facilities (existing) areas as shown on the Subcontract Drawings.

M. Temporary Drainage Ditches: Temporary drainage ditches shall include temporary diversion, collection and interceptor ditches as required by the Subcontractor or as shown on the Subcontract Drawings.

N. Rippable Rock: Rippable rock is defined as mineral matter in place and of such hardness and texture that it can be effectively loosened or broken down by ripping in a single pass with a late model tractor-mounted hydraulic ripper equipped with one digging point of standard manufacturer's design adequately sized for use with and propelled by a crawler-type tractor Caterpillar Model D10N or equal, operating in low gear; or in areas where the use of the ripper described above is impracticable, rippable rock is defined as mineral material of such hardness and texture that it can be loosened or broken down by a 6-pound drifting pick. The drifting pick shall be Class D, Federal Specification GGG-H-506D, with handle not less than 34 inches in length.

O. Disposal of Demolished Materials and Debris: Disposal shall include loading and transporting demolished materials and debris from existing stockpiles or from demolition operations performed under the Subcontract, and unloading, placing and compacting in the final placement location as indicated on the Subcontract Drawings.

P. Frozen Material or Subgrade or Foundation: Material on subgrade or foundation that has a temperature at or below 32°F and/or generally contains a visible amount of water in the form of ice.

Q. Rockfill Selected by the Contractor: Rockfill from existing stockpiles or required rock excavation which is selected by the Contractor. Selected rockfill generally consists of larger size pieces of sound limestone or sandstone which are of a better quality than most of the on-site rock.

1.5 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The Publications are referred to in the text by the basic designation only:

1. American Society for Testing and Materials (ASTM):

D422-63	Test Method for Particle-Size Analysis of Soils Including Percent Passing No. 200 Sieve (and excluding hydrometer analysis)
D698-78	Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb. (2.49-kg) Rammer and 12-in. (305-mm) Drop
D1556-90	Test Method for Density of Soil in Place by the Sand-Cone Method
D2167-84	Test Method for Density and Unit Weight of Soil In-Place by the Rubber-Balloon Method
D2216-90	Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock
D2487-90	Test Method for Classification of Soils for Engineering Purposes
D2922-81	Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
D3017-88	Test Method for Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
D4643-87	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method

2. Blasting practices shall generally be in accordance with the "Blasters Handbook" - 16th Edition by E. I. du Pont de Nemours and Co. (INC) of Wilmington, Delaware 19898.

3. U.S. Federal Specifications (FS):

GGG-H-506D Int AMD 1	Hoe, Mattock and Pick

1.6 PERMITS AND APPLICABLE LAWS

A. All required Federal, State, and local permits for blasting and explosives shall be obtained and paid for by the Subcontractor. Copies of such permits shall be furnished to the Contractor before any blasting operations are started.

B. All blasters and blasting foremen shall be properly qualified and licensed in accordance with the applicable laws and regulations of Federal, State, and local governments.

C. All transportation and storage of explosives shall be in accordance with the applicable laws and regulations of Federal, State and local governments.

1.7 QUALITY ASSURANCE

A. The Contractor will take soil samples and perform moisture-density, gradation and other tests to ascertain that the work is being performed in compliance with these Specifications. Samples may be taken at the place of excavation, stockpiles, or in the fill itself. The Contractor will conduct the density and other tests on the fill and related laboratory testing as frequently as the Contractor considers necessary. The Subcontractor shall remove surface material and render assistance as necessary to enable sampling and testing to be carried out.

B. Methods of Sampling and Testing:

1. In-Place Density: ASTM D1556, D2167, or D2922
2. Particle Size Analysis: ASTM D422
3. Moisture Content: ASTM D2216
4. Laboratory Moisture-Density Relations: ASTM D698
5. Soil Classification: ASTM D2487
6. In-Place Moisture Content: ASTM D3017, or ASTM D4643

C. Suitability of Materials: The suitability of all materials for foundations and backfill will be determined by the Contractor. Fill material will be approved material from borrow areas or required excavations.

D. The Subcontractor shall make his own determination of any processing that may be required and shall perform testing as required to ensure that the materials meet the Specification requirements.

E. The Contractor may direct that inspection trenches or test pits be cut into fills to determine that the Specifications have been met. Such trenches or pits will be of limited depth and size, and shall be backfilled with the material excavated therefrom, or other fill material meeting the requirements for the zones cut into. Backfill shall be compacted to a density at least equal to that of the contiguous fill.

F. When the Contractor directs inspection trenches or test pits to be excavated into fills and backfills and materials are found to meet all Specification requirements, the excavation and refilling shall be paid for as additional work pursuant to the applicable provisions of the General Conditions. Inspection trenches or test pits, and the refilling of the same, shall be at the Subcontractor's expense when it is found that the materials do not meet the Specification requirements.

G. Tolerances: See Specification Section 01052, Article 1.8.

1.8 SUBMITTALS

A. General submittal requirements are specified in Section 01300.

B. At least 90 days before opening borrow areas, the Subcontractor shall submit a mining plan for each separate borrow area. The plan shall include method of stripping and processing of materials, excavation plan, and a site restoration plan.

C. At least 30 days before commencing blasting operations, the Subcontractor shall submit to the Contractor for review a detailed blasting plan covering the area to be blasted. The blasting plan shall contain complete hole layouts, proposed loading, delays and all information required by this Specification. The Contractor may require changes in the blasting plan if the results of blasting do not meet Subcontract requirements.

D. All changes in the blasting plan shall be submitted for approval at least 48 hours prior to the time of the proposed changes.

E. At least 48 hours before blasting within one-quarter mile of a stream course, the Subcontractor shall submit for approval a plan showing all details of his proposed blasting operation and the scheduled time for the blast.

F. The Contractor's review of the Subcontractor's proposed blasting procedures shall not be construed to relieve the Subcontractor of his responsibility to protect existing facilities not to be demolished. Any damage done by the Subcontractor's operations shall be repaired at Subcontractor's expense.

[1.9 SAFETY PROVISIONS FOR BLASTING]*

A. The Subcontractor shall provide and operate at all times an instrument for the detection of approaching electrical storms, including an automatic alarm such as a Litton TSM/C.

B. Electrical Storms: No explosive material shall be handled, transported or in any way made use of during any period of electrical storm or lighting or other electrical phenomenon. In the event that any such condition should appear imminent or occur, or if some known leakage of electricity should occur in the neighborhood of, or in, the work, while the transport, handling, making-up or charging or other use of explosives is being effected, then the work shall be evacuated and abandoned completely until at least thirty minutes after the condition has ceased or the leakage stopped.

C. Detonating Explosive Charges:

1. Only approved exploding devices shall be used for detonating charges. Under no circumstances are lighting and power cables to be used for detonating. All pipes, ducts, track, and other metal shall be properly grounded.

2. An adequate warning system shall be provided by the Subcontractor to ensure that all personnel, staff, visitors and anyone else are at a safe distance before blasting takes place.

3. No radio transmitter shall be operated within 75 feet of the area where electric blasting operations are in progress.

4. No naked lights or sparks are allowed anywhere in the vicinity of blasting operations on the surface.

5. Where detonating is carried out electrically the Subcontractor shall take every precaution necessary to prevent premature explosions and misfires. Before

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connection of the detonating wires to the detonating cable the round shall be tested for electrical continuity in an approved manner with an approved testing device or meter. In the event that this testing should show a lack of continuity then the round shall be retested leaving out one detonator at a time until the fault is identified. Should this procedure identify a faulty detonator then stemming shall be carefully removed from the hole and an additional primer inserted and wired into the circuit in place of the defective one. No attempt shall be made to draw a defective detonator or primer. On satisfactory completion of the circuit all workers other than those immediately necessary shall be withdrawn to a safe distance before detonating wires are connected to the detonating cable, and the connection of the detonating cable to the detonator shall be the last operation:

6. Where detonating is carried out by electricity, following a blast, before any person returns to the work place affected by the operation,

   a. The detonating cables shall be withdrawn from the battery, blasting machine or other source of electricity and shall be short circuited.

   b. The blasting switch shall be locked in the open position.

7. Blasting cables and wires shall be clearly distinguishable from other cables and wires and shall only be used for blasting.

D. Misfires of Explosive Charges:

   1. Should a misfire occur, then the Subcontractor shall warn all persons affected, and no persons other than those required shall enter the workings until the charge has exploded or, in the case of electrical detonating, an interval of at least twenty minutes has elapsed after operation of the exploder.

   2. A misfired detonator may only be removed from the face by means of approved apparatus which permits such an operation to be carried out with absolute safety. Under no circumstance shall charges which have misfired be otherwise tampered with. Should it prove impossible to extract the charge with safety, then the Contractor may authorize the Subcontractor to explode the charge by sympathetic detonation, the greatest care being taken to ensure that no new hole is drilled to intersect an old

one or that the unexploded charge is in any other way affected. After the second shot is detonated, the search shall be made for the unexploded charge.

1.10 PROTECTION

A. The Subcontractor shall preserve and protect the following:

1. Trees, shrubs and other features remaining as a portion of final grading.
2. Bench marks and monuments, existing structures, fences, walks, pavings, curbs, etc. from equipment and vehicular traffic.
3. Utilities not specified for removal.
4. Excavations from cave-in by shoring, bracing, sheet-piling, underpinning or by other methods.
5. Bottoms of excavations and soil adjacent to and beneath foundations from frost.
6. Perimeter of excavation to prevent surface water runoff into excavation.
7. Monitor wells to be saved.
8. Finished work.
9. Existing features not part of this Subcontract, e.g., existing roads or existing wells.
10. Archaeological areas identified by the Contractor or encountered during the work.
11. Displacement monuments.

1.11 EXISTING CONDITIONS

The Subcontractor shall not disturb the existing asbestos-containing materials burial area shown on the Subcontract Drawings.

PART 2 - PRODUCTS

2.1 EXPLOSIVES

A. A record shall be maintained by the Subcontractor for storage and withdrawal of explosive stocks and detonators. The inventory record shall be subject to inspection at all times. The Subcontractor shall provide such reasonable and adequate protective facilities as may be necessary to prevent loss and theft of explosives and to minimize hazards of subversive action or sabotage. Loss or theft of explosives shall be reported to the Contractor immediately. Overnight storage of explosives and detonators outside of the magazine will not be permitted. Only qualified personnel shall be permitted to handle explosives.

2.2 UNCONTAMINATED FILL MATERIALS

A. General:

1. Fill materials shall be obtained from required excavations and from borrow areas shown on the Subcontract Drawings or from other approved borrow areas selected by the Subcontractor and approved by the Contractor.

2. The Subcontractor shall be responsible for obtaining required permits and approvals for Subcontractor-selected borrow areas in accordance with the provisions of Article SC-11 of the Special Conditions. Designation of a borrow area does not indicate that all material within that area meets the Specification requirements specified herein.

   a. The Subcontractor shall make his own determination of any processing or selective excavation that may be required, and shall perform testing as required to meet the Specifications for the various construction materials.

   b. Submittals to the Contractor for approval of sources proposed for use by the Subcontractor shall include boring logs, borrow area maps and supporting laboratory test data. The Subcontractor also shall provide evidence of availability, right of access to private property including access by the Contractor for sampling and testing, and his plan for hauling the materials to the site. Submittals for approval of sources for uncontaminated fill materials shall be received by the Contractor at least 30 days (60 days for radon barrier materials) before use of the material at the site. The Contractor may perform additional tests to determine if the materials meet the requirements specified herein.

c. Approval will be based on evidence of compliance with the requirements specified herein and on verification by the Subcontractor that the volume of materials available is sufficient for construction requirements.

3. Gradations: Gradations specified shall be as determined after delivery to the site, except where normal compaction operations reduce materials to acceptable sizes, in which case in-place gradations shall be acceptable.

B. Uncontaminated Common/General Fill Materials: Uncontaminated common/general fill materials for general fill shall conform to the following requirements. All references to "uncontaminated fill" or "uncontaminated fill materials" shall mean "uncontaminated common/general fill" or "uncontaminated common/general fill materials".

1. Uncontaminated fill materials shall not contain more than 5 percent, by volume, of organic material or other deleterious substances.

2. Maximum particle size shall not be greater than the compacted lift thickness in any dimension, except as noted hereinafter. Individual large stones shall be distributed within the fill materials to provide visual void-free mass, and be able to meet the requirements of Article 3.8. For fill areas under pavement locations, maximum stone dimension allowed in the upper 6 inches of the fill shall be 4 inches. Larger stones may be utilized in initial backfill in the lower layers of finish grading of the site.

2.3 CONTAMINATED FILL MATERIALS

Contaminated materials as defined in Article SC-1 of the Special Conditions resulting from the clearing, stripping and excavation operations in contaminated areas. These materials shall include materials excavated from tailings piles, windblown and waterborne areas, contaminated sediments from drainage ditches and wastewater retention basins, recirculation pond, and any other areas designated by the

Contractor including vicinity properties and demolished materials and debris.

2.4 DEMOLISHED MATERIALS AND DEBRIS

A. The demolished materials and debris shall include the following:

1. Existing stockpiles of contaminated and uncontaminated demolished materials and debris.

2. Contaminated and uncontaminated demolished materials and debris resulting from work specified under Sections 02050 and 02110.

3. Rubble and debris located within the site boundary.

B. For disposal purposes all demolished materials and debris shall be considered as contaminated materials.

2.5 VICINITY PROPERTY MATERIALS

Excavated contaminated materials resulting from cleanup of vicinity properties will be hauled to the site and stockpiled on the tailings embankment by others. The Subcontractor shall make provisions in his schedule and work plan for placement and compaction of vicinity properties materials stockpiled in the tailings embankment by others. The Subcontractor shall make allowances for decontamination of vicinity property subcontractor vehicles.

2.6 ROCKFILL SELECTED BY THE CONTRACTOR

Rockfill selected by the Contractor shall come from either existing stockpiles as designated by the Contractor or from required rock excavations as selected by the Contractor.

PART 3 - EXECUTION

3.1 PROTECTION OF EXPOSED SURFACES

A. During seasonal shutdowns and during other periods of prolonged exposure (more than six weeks) of excavated or filled areas, the Subcontractor shall provide labor, materials and equipment, as required by the Contractor, to maintain and protect exposed surfaces of uncontaminated and contaminated materials against wind erosion and excessive stormwater erosion. Prior to the application of protective erosion control measures, the exposed surfaces shall be sloped to drain and compacted with a smooth drum roller to eliminate ruts and ridges formed by construction equipment. Unless otherwise approved by the Contractor, acceptable methods of erosion protection are as follows:

[1. Spraying with Water containing Chemical Additives: Acceptable chemical additives are CPB-12 as manufactured by Wen-Don Corporation, 206 West 2nd South, Price, Utah 84501; "Soil Seal Concentrate" as manufactured by Soil Stabilization Products Company of Merced, California; "Soil-Sement" as manufactured by Midwest Industrial Supply, Inc. of Canton, Ohio; or approved equal. Mixing and application shall be in accordance with the manufacturer's recommendations.]*

2. Covering exposed surfaces with geotextile fabric such as "Supac" as manufactured by Phillips Fibers Corporation of Sacramento, California, or approved equal. Handling and installation shall be as recommended by the manufacturer of the product.

[B. After removal of contaminated materials and completion of finish grading, the Subcontractor shall provide labor, materials and equipment as required by the Contractor to protect exposed surfaces against erosion. This shall be achieved by spraying with water containing chemical additives such as CPB-12 as manufactured by Wen-Don Corporation, 206 West 2nd South, Price, Utah 84501; "Soil Seal Concentrate", as manufactured by Soil Stabilization Products Company of Merced, California; "Soil-Sement" as manufactured by Midwest Industrial Supply, Inc. of Canton, Ohio; or approved equal. Mixing and application shall be in accordance with the manufacturer's recommendations. Exposed rock surfaces do not require treatment. The soil sealant shall only be applied to areas that are backfilled or where uncontaminated soils remain.]*

[C. Following a seasonal shutdown or period of prolonged exposure of more than six (6) weeks, the Contractor will verify by density test, that the last lift of material placed has been maintained at the applicable minimum specified density. Verification by density test will be performed prior to placing any additional materials on the surface and at frequencies described in Article 3.7. Material failing to meet the specified density requirements shall be removed or reworked to satisfy the minimum specified density requirements.]*

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3.2 EARTHWORK - GENERAL

A. Preparation:

1. Clearing and stripping shall be as specified in Section 02110.

2. Required lines, levels, contours and datum shall be identified before the start of earthwork operations.

3. The Subcontractor shall verify the existing above-ground and underground utilities, identify them, and notify the Contractor immediately of his finding, if any, for appropriate action.

B. Dewatering and Drainage: Prior to commencement of earthwork operations, the Subcontractor shall verify that the dewatering and drainage facilities are constructed and operational in accordance with the requirements of Section 02141.

C. In order to avoid cross-contamination of uncontaminated material, the contaminated and uncontaminated materials shall be kept separated during earthwork operations. Stockpiles of contaminated materials shall be placed on contaminated areas and the drainage collected in the retention basin.

D. Earthwork shall conform to lines and grades indicated on the Subcontract Drawings or specified in this Section.

E. The excavated uncontaminated common materials, where practicable, shall be used as fill in various areas of the sites including general fill, roadway fill, structure fill, backfill, fill for the final grading of the site and for the construction of the tailings embankment, as required.

F. The excavated uncontaminated rock materials shall be placed in the spoil area indicated on the Subcontract Drawings. The Contractor may direct the Subcontractor to place selected excavated uncontaminated rock materials in stockpiles. Rockfill selected by the Contractor shall come from existing or new stockpiles of selected, excavated, uncontaminated rock.

3.3 EXCAVATION

A. General:

1. Excavation shall be carried out to reach the lines and grades indicated on the Subcontract Drawings or specified

herein, or, in the case of contaminated materials, as required by the Contractor's Health Physics Personnel.

2. At all times, the Subcontractor shall conduct his operations in such a manner as to prevent free standing water and contamination of uncontaminated materials. The Subcontractor shall, as a minimum, take the following measures to safeguard against such problems:

   a. Water leaving a contaminated excavation area or contaminated area otherwise disturbed by construction activities shall be routed into the retention basin as specified in Section 02141.

   b. Exposed surfaces of contaminated and uncontaminated materials excavations shall be protected from erosion as specified in Article 3.1 above.

3. The Subcontractor shall remove all excavated material from the excavation site and dispose of it in fills required at the site or use it for other purposes, as approved.

4. Unsuitable or low density subgrade material not readily capable of in-place compaction shall be excavated as directed by the Contractor and disposed of as specified in Article 3.4.

[5. Adequate working space for safety of personnel shall be provided within the limits of the excavation. Extra precautions shall be taken to protect workers when excavating near steep rock faces. Boulders or loose rock on the rock face shall be removed as they become exposed.]*

6. Except as otherwise noted, care shall be exercised to preserve the material below and beyond the lines of all excavation. Where excavation is carried below grade, the Subcontractor shall backfill to the required grade or to indicated invert grade, as specified, and recompact the backfill to meet the existing conditions.

7. Excavation for the convenience of the Subcontractor shall conform to the limits approved by the Contractor and shall be at no additional expense to the Contractor.

8. Excavated material shall be placed at sufficient distance from edge of excavations to prevent cave-ins or bank slides. Slopes of excavated cuts and stockpiles shall

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not be steeper than 2(H) to 1(V) unless indicated otherwise on the Subcontract Drawings.

9. Where practicable, suitable materials removed from excavation shall be used as fill or backfill.

B. Contaminated Materials Excavation:

1. Contaminated materials excavation shall include excavation of (a) contaminated materials from the tailings piles at the Monument Valley site, (b) windblown and waterborne off-pile areas including wet slimes and rippable rock, at both sites, and (c) existing retention basins and dikes and heap leach pads area. The Subcontractor shall minimize the open excavation area of contaminated materials at any time during excavation work. The Subcontractor shall operate from one or two sides at one time, progressing uniformly to opposite sides for completion, unless directed otherwise by the Site Manager. Contaminated materials shall be excavated to the depths indicated on the Subcontract Drawings, or as required by the Contractor, and placed in the proper part of the tailings embankment. Contaminated materials will be excavated generally in priority of its placement in the tailings embankment to minimize rehandling and stockpiling. Excavation shall be carried out to the limits and grades required by the Contractor. Rock requiring drilling and blasting operations shall not be included in this excavation.

[2. The Subcontractor shall remove contaminated material from rippable rock surface to acceptable finish. Examples of an acceptable rock finish are available at each site. The locations of areas with an acceptable rock finish are shown on the Subcontract Drawings. The Subcontractor shall employ whatever equipment methods are necessary in order to achieve an acceptable rock finish, and remove windblown/waterborne contamination from within rock crevices.]*

3. During excavation operation, tests will be performed by the Contractor to determine radioactive contamination of the material to be excavated.

C. Uncontaminated Materials Excavation:

1. General: Uncontaminated materials excavation shall include excavations of uncontaminated materials from the

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various areas of the site. The excavated materials shall be used as fill in various areas of the sites including construction of berms, dikes, general fill, roadway fill, structure fill, backfill, and fill for final grading of site, as required. Uncontaminated excavated material may be stockpiled for later use.

2. Rock Excavation:

   a. The Subcontractor shall perform required rock excavation to the limits shown on the Subcontract Drawings or as directed by the Contractor.

   b. Care shall be exercised to avoid excessive overbreak beyond or below grade lines of excavation.

   c. Blasting methods and procedures shall be such that, upon completion of the excavation, all rock surfaces will be sound and relatively uniform. Explosives shall be of such quantity and power and shall be used in a manner that will minimize opening of seams and disturbing of rock outside the prescribed limits of excavation. As the excavation approaches its final limits, the depths of holes for blasting and the quantity of explosives used for each hole shall be reduced so that the rock underlying or adjacent to the final limits is not shattered or otherwise disturbed.

   d. The Subcontractor shall remove all shattered material and debris from excavation.

   e. Excavated rock materials shall be used as fill, where required, or may be stockpiled in approved locations for later placement as fill.

   f. Where shown on the Subcontract Drawings, rock shall be chipped or ground to final grade. Blasting or ripping of rock within this area will not be permitted.

3. Permanent Drainage Ditches Excavation:

   a. Ditches shall be excavated true to line and grade. Any erosion which occurs to ditch excavation before placing erosion protection materials shall be repaired with compacted backfill. All such repairs shall be at Subcontractor's expense and shall not be included in pay quantities, unless otherwise shown on the Subcontract Drawings.

b. Where the subgrade consists of common fill, the subgrade shall be compacted as specified in Article 3.8 below. After compaction has been completed, finish grading shall be done in such a manner that the sideslopes and bottom are rendered smooth surfaces. All loose rocks, brush, roots, large clods, and other objects shall be removed before placement of the bedding material and the riprap material.

4. Borrow Area Excavation:

a. General:

1) Borrow areas for general fill are indicated on the Subcontract Drawings.

2) Borrow areas shall meet all permit and negotiated requirements as required by the Contractor.

3) Necessary clearing, grubbing, and disposal of debris shall be performed by the Subcontractor as incidental operations to the borrow excavation.

4) After borrow excavations are completed, borrow areas shall be graded to drain. Natural drainage patterns shall be maintained.

5) Where general fill materials are not available in sufficient quantity from the required excavations, such materials shall be obtained from approved offsite borrow areas.

b. The Subcontractor shall notify the Contractor at least 30 days in advance of opening any borrow area so that adequate time will be allowed for testing the material.

3.4 DISPOSAL OF EXCAVATED MATERIALS

A. Contaminated Materials: All contaminated materials excavated from the Mon tailings piles, retention basins, heap leach pads, windblown, and other areas of the site shall be used in the construction of the tailings embankment as specified herein. Contaminated material will be placed in the tailings embankment by priority generally as indicated Article 3.5.B.5. Radiological monitoring of contaminated materials or construction expediency may change this priority, as directed by the Contractor.

B. Uncontaminated Materials:

1. Materials excavated from the sites, including excavations for drainage ditches which do not classify as contaminated materials, shall be used as uncontaminated material fill for construction of various features, or stockpiled for later use for site grading as specified in this Section and as required by the Contractor.

2. Where used in fills, such material shall be transported directly from the excavation and placed in its final position in such fills whenever possible. If required by the Subcontractor's schedule, the material may be placed temporarily in stockpiles at approved locations. Material in stockpile shall be protected from contamination of any kind that would render it unsuitable for use in fills.

3. Clean, sound, unweathered rock, of suitable material, from the required excavation may be incorporated into fills, after processing as necessary, provided it meets the appropriate specifications and as approved by the Contractor.

4. Uncontaminated Common and Rock Materials: See Article 3.2, Paragraphs E and F.

5. Garbage, refuse, debris, oil, and any waste material which is harmful to the environment shall be removed from the job site and disposed of offsite in a manner approved by the authority having jurisdiction over the offsite disposal facility.

6. Excess uncontaminated materials shall be disposed of on site or in the spoil area shown on the Subcontract Drawings as approved by the Contractor.

C. Disposal of Demolished Materials and Debris:

1. Existing stockpiles of demolished materials and debris, and demolished materials and debris resulting from demolition work specified in Section 02050 shall be disposed of in the tailings embankment conforming to the applicable provisions of this Section and as required by the Contractor.

2. During construction of the tailings embankment, provision shall be made to leave required space at proper location

in the embankment for the placement of the demolished materials and debris resulting from the demolition work specified in Section 02050.

3.5 FILL CONSTRUCTION

A. General Requirements:

1. Clearing and stripping shall be as specified in Section 02110.

2. Fill materials shall be placed and compacted to the lines and grades shown on the Subcontract Drawings or as required by the Contractor.

3. Prior to placing of uncontaminated fill materials, the subgrade will be radiologically surveyed by the Contractor to confirm that EPA standards have been met. These radiological surveys may cause delays to backfill operations of up to seven working days. The Subcontractor shall plan his work accordingly.

4. If any portion of the materials placed as fill does not meet the specified requirements, the Subcontractor shall remove such material and replace it with fill materials meeting the specification at no additional cost to the Contractor.

5. Constructed fills shall be maintained to meet the requirements of this Specification until final completion and acceptance of the Work. This shall include all measures to prevent erosion or contamination during construction, including contamination by radioactive material. During seasonal or other extended shutdowns, all exposed surfaces shall be protected with special treatments specified in Article 3.1 above.

B. Placing Requirements:

1. Prior to placement of materials, the in-place density of the subgrade shall be as specified in Article 3.9. Subgrade preparation, where required, shall be as specified in Article 3.8.

2. No material shall be placed on any portion of the subgrade or against or upon any structure until consent to place such fill has been obtained from the Contractor.

3. Fill materials may require moisture conditioning (wetting or drying) prior to compaction. Some tailings slimes particularly will require spreading and extended drying time prior to compaction.

4. Fill materials shall be placed in continuous and approximately horizontal lifts for their full length and width unless otherwise specified or specifically permitted by the Contractor.

5. The following sequence shall be followed in placing materials in the tailings embankment:

   [a. Materials from the heap leach pad area and the old pile area at Monument Valley including demolished materials, boulders, ore and debris.]*

   b. Tailings materials from the new pile area at Monument Valley.

   c. Contaminated materials from windblown, waterborne and off pile areas.

   d. Vicinity property material as delivered to the site and as directed by the Contractor.

   e. Excess uncontaminated materials from required excavations, including retention basin dikes.

   f. Radon barrier material: The entire thickness shall be amended with 10 percent bentonite.

   g. Bedding material.

   h. Riprap protection.

6. Method of dumping and spreading the materials shall ensure uniform distribution of the material.

[7. The loose thickness of each layer shall not be greater than that required to achieve the specified compaction. For material containing particles having a maximum dimension of less than 10 inches the loose lift thickness shall not exceed 12 inches. For material containing particles greater than 10 inches, the loose lift shall be kept to the minimum constructible thickness, as approved by the Contractor. Oversize material shall be placed in

* P.I.D. 09-S-15

accordance with Article 3.5.B.10 and graded to avoid ponding of surface water. Oversize material shall be compacted in accordance with Article 3.5.C.8. Rubble and boulders from Monument Valley shall be broken to a maximum rock size of 36 inches before placing in the tailings embankment.]*

8. Unless otherwise indicated, fill materials shall be placed to a grade no flatter than 2 percent to facilitate drainage of water. In areas where ponding cannot be prevented or ponding has occurred and fill is required to be placed, placing shall begin only after the area is dewatered and permission to place is obtained from the Contractor.

9. Materials shall not be placed on frozen subgrade or frozen fill, nor shall frozen material be used as fill.

10. Bulky (demolished materials and debris) materials shall be disposed of in the lower portion of the tailings embankment fill. The materials shall be placed evenly in each lift to minimize the volume of voids created in the disposal mass and to avoid nesting. Organic matter shall be distributed to provide a concentration of not more than five percent in any area of the embankment.

11. When no longer needed for control of contamination, as determined by the Contractor, the retention basins, recirculation pond, and the like shall be removed and the area restored.

C. Compaction Requirements:

1. Each lift of fill materials shall be compacted to a minimum density specified in Article 3.9.

2. During compaction, the moisture content of fill material shall be maintained to achieve specified density. Uniform moisture distribution shall be obtained by disking, blading, or other methods approved by the Contractor prior to compaction of a lift.

3. If the surface of the prepared foundation or the rolled surface of any lift of fill is too dry or too smooth to bond properly with the lift of material to be placed thereon, it shall be scarified and moistened by sprinkling to the acceptable moisture content prior to placement of the next lift of fill.

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4. If the rolled surface of any lift of the fill in place is too wet for proper compaction of the lift of fill material to be placed thereon, it shall be removed, allowed to dry or worked with harrow, scarifier, or other suitable equipment to reduce the water content to the required amount, and then re-compacted before the next succeeding lift of fill is placed.

5. Fill placed at densities lower than the specified minimum density or at moisture contents that make compaction difficult shall be reworked to meet the density and moisture requirements or removed and replaced by acceptable fill compacted to meet these requirements.

6. Uncontaminated fill material in the stockpile areas shall be placed by spreading with a bulldozer and track walking. Lift thickness before compaction shall not exceed one foot. Compaction shall be accomplished by routing of hauling and spreading equipment units.

7. Unfavorable Weather: Placing, spreading, rolling or compacting fill material that is frozen or thawing, or during unfavorable weather conditions shall not be permitted.

8. Compaction of fill with more than 30 percent retained on a 3/4-inch standard sieve:

   a. Prior to compaction, materials shall be moisture conditioned as approved by the Contractor. If required, moisture addition shall be limited to the amount of water required to lubricate rock particles. When adding moisture, care shall be taken not to increase the moisture content of underlying soils.

   b. Compaction shall be accomplished by any of the following combinations of passes and equipment, or approved equal combination:

Equipment	Minimum No. of Passes for 90% Compaction	Minimum No. of Passes for 95% Compaction
BOMAG Vibratory Roller Model 213D	2	4
CAT CS 553 Vibratory Roller	2	4
CAT Compactor Model 825C	2	4
Raygo Vibratory Roller Model 400A	2	4
Track-Type Tractor with Ground Pressure of at Least 9.8 psi	3	5
Towed 5x5 Sheepsfoot, Fully Ballasted	3	4

c. Depending on soil conditions, the Subcontractor may be required to change the compaction equipment or increase the number of passes to achieve the desired compaction. Approval of a combination of equipment and number of passes suitable for certain soil types and conditions may not apply to different soil conditions.

d. Materials shall not be subject to requirements of Article 3.8.A.

3.6 ROCKFILL PLACEMENT

A. Selected rockfill shall be placed as shown on the Subcontract Drawings or as directed by the Contractor. Rockfill shall be placed by end dumping and may be spread by bulldozers or other suitable equipment.

B. Rockfill shall be placed so that larger stones are well distributed throughout the mesh. Rearranging of individual stones will be required to the extent necessary to obtain a reasonably well graded distribution of stone sizes.

C. Excavated rock other than rockfill selected by the Contractor shall be placed on the designated spoil area or in other areas within the site as designated by the Contractor. Spoiled rockfill shall be compacted by routing tracted construction equipment over the surface.

3.7 FIELD QUALITY CONTROL

A. General: The Contractor will take samples and perform tests throughout the construction period, and the Subcontractor shall cooperate in providing access for the Contractor to areas where testing is to be performed and shall schedule his placing to avoid interference with the testing operations.

B. Tests: The Contractor will perform the following tests on a regular basis.

1. In-place density and moisture content tests where density is specified will be as follows:

    a. A minimum of one test per 1000 cubic yards of contaminated and uncontaminated materials placed excluding radon barrier material. At least two tests shall be performed for each day of material placement in excess of 150 cubic yards.

    b. Foundation and Subgrade: Prior to placing the first layer of material on the foundation, the subgrade will be inspected to assure that it has no sign of deterioration due to frost action, erosion due to rainwater, rutting, areas of subsidence, or drying out of the surface. The inspection shall verify that the foundation surface has been moistened, but there is no standing water on the surface and that the foundation surface of cohesive soils has been scarified or penetrated to ensure proper bonding of overlying material. Unacceptable surface material shall be either removed or excavated and recompacted to Specification requirements.

    [c. A minimum of one test per 30,000 sq.ft. on the surface of previously placed materials after a seasonal shutdown or period of prolonged exposure and prior to placing additional materials.]*

2. The placing and compaction of temporary stockpiles will be subject to the approval of the Contractor.

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3.8 SUBGRADE PREPARATION

A. Subgrade Preparation: Subgrade preparation includes fine grading and compaction of excavations, backfills, embankments (including stockpiles) upon which pavement, surfacing, base, subbase, and riprap or other structures are constructed.

B. The entire surface of the subgrade shall be plowed, harrowed, and mixed to a depth of at least 6 inches. Compaction shall be carried out for the full area below finished subgrade to at least the density specified in Article 3.9 below.

3.9 COMPACTION DENSITIES

A. Subgrade of permanent drainage ditches and embankments, and each layer of embankment and backfill shall be compacted to at least the following percentage of maximum dry density, as determined by ASTM D698 test method:

1.	Subgrade Preparation:	90 percent
2.	Subgrade Preparation for Permanent Drainage Ditches	95 percent
3.	Tailings Embankment Fill Except Top 3 feet	90 percent
4.	Tailings Embankment Fill Top 3 feet Immediately Below the Bottom of Radon Barrier	95 percent
5.	Trench Backfill and Common Fill	95 percent
6.	Site Restoration	90 percent

3.10 DISPLACEMENT MONUMENTS

Displacement monuments shall be furnished and installed by the Subcontractor as shown on the Subcontract Drawings. The Subcontractor shall take precautions not to damage the existing monument or new monuments once they are installed. Damaged monuments shall be replaced by the Subcontractor at no additional cost to the Contractor. The Subcontractor shall add extension rods to existing monuments as the fill is being placed. All displacement monuments shall be permanently protected as shown in the Subcontract Documents.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for the following items of earthwork will be by the cubic yards of material excavated and placed in the disposal cell. The quantities for payment will be computed by average end area method from surveys conducted before and after fill operations. Separate measurement for payment will not be made for excavation of the materials in their original locations. A survey of the existing tailings embankment will be required by the Subcontractor prior to placement of any materials on the embankment.

   1. Placement in the Tailings Embankment of all Contaminated and Other Materials Including Demolished Materials, Debris, Rubble and Vicinity Property Materials (Bid Schedule Item 401)

B. Measurement for payment for the following items of excavation will be by the cubic yards of materials excavated. The quantities for payment will be computed by average end area method from surveys conducted before and after excavation operations:

   1. Rock Excavation for Finish Grading of the Mexican Hat Site Including Ditches and Gullies and Grinding or Planing of Rock Adjacent to the North Ditch (Bid Schedule Item 801)

C. Measurement for payment for the following items of fills will be by the cubic yards of materials placed. The quantities for payment will be computed by average end area method from surveys conducted before and after placement:

   1. Uncontaminated Material Fill for Finish Grading of the Mexican Hat and Monument Valley Sites (Bid Schedule Item 802)

   2. Rockfill Selected by Contractor for Finish Grading of the Mexican Hat Site (Bid Schedule Item 803)

D. Measurement for payment for the following items of work will be by the acre measured in the horizontal plane from surveys conducted before and after the work as shown on the Subcontract Drawings, or by the methods determined by the Contractor:

   1. Fine Grading of Existing Side Slopes of the Tailings Embankment (Bid Schedule Item 402)

2. Cleanup of Rock Surfaces at the Mexican Hat and Monument Valley Sites (Bid Schedule Item 403)

E. Separate measurement for payment will not be made for the following items, and such work will be considered incidental to the related items of work:

1. Subgrade preparation.

2. Stockpiling of excavated materials.

3. Required rehandling of materials.

4. Blasting.

5. Borrow area excavation, restoration, reseeding and incidental activities.

6. Protection of exposed surfaces during shutdown.

F. Overexcavation: Overexcavation for the Subcontractor's convenience or due to error or lack of control by the Subcontractor will not be measured for payment. At the discretion of the Contractor, overexcavation shall be backfilled with compacted uncontaminated fill, as required, at the Subcontractor's expense.

G. Separate measurement for payment will not be made for any other excavations or fills specified in this Section.

H. Measurement for payment for furnishing and installing displacement monuments will be by the number of new monuments installed. The price shall include extending and protecting the existing displacement monuments. (Bid Schedule Item 404)

4.2 PAYMENT

A. Payment for the item of Article 4.1.A above will be by the applicable unit price per cubic yard quoted therefor in the Bid Schedule. The price quoted shall include full compensation for excavating, loading, hauling, unloading, and placing the excavated materials in their final locations including all clearing, stripping, grading, shaping, preparing subgrade, compacting, temporary stockpiling and required rehandling.

B. Payment for the items of Article 4.1.B above will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for excavating, hauling, and placing the excavated materials in temporary stockpiles, or in spoil areas if excess or unsuitable for use as fill, as required, including all clearing, stripping, shaping, and compacting such stockpiles or areas as specified.

C. Payment for the items of Article 4.1.C above will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for hauling the materials from excavated areas or retrieving the materials from temporary stockpiles, and placing and compacting the materials in their final locations including all clearing, stripping, grading, shaping, preparing subgrade, and compacting. The prices quoted shall also include full compensation for furnishing imported uncontaminated materials from the Subcontractor's own sources. No separate payment will be made for temporary stockpiles and rehandling or for moisture/dust controls which are considered included in the Subcontract unit prices.

D. Payment for the items of Article 4.1.D above will be by their applicable unit prices per acre quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for removing the materials from the required areas, as required, and placing the excavated materials in their final locations including all grading, shaping, preparing subgrade, and compacting, as required.

E. Separate payment will not be made for the items mentioned in Article 4.1.E above. All costs for such work will be considered to be included in the prices quoted for the applicable related items of work.

F. Separate payment will not be made for any other excavations or fills specified in this Section. All costs for excavations or for furnishing and placing such fills will be considered to be included in the related items of excavation.

G. Payment for furnishing and installing new displacement monuments will be by the unit price per each quoted therefor in the Bid Schedule.

END OF SECTION 02200

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SECTION 02228

RADON BARRIER

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section covers the following:

1. Production of radon barrier materials by mixing bentonite with uncontaminated soil from borrow areas RB-4 and RB-7.

2. Placement of the radon barrier layer in the construction of the cover for the tailings embankment.

1.2 RELATED WORK

A Section 00800 - Special Conditions

B. Section 01052 - Layout of Work and Surveys

C. Section 01300 - Submittals

D. Section 01500 - Construction Facilities

E. Section 01560 - Temporary Controls

F. Section 02200 - Earthwork

1.3 DEFINITIONS

A. Radon Barrier - The layer constructed on top of the contaminated materials in the tailings embankment consisting of bentonite amended soils from borrow areas RB-4 and RB-7. The purpose of this layer is to retard the emanation of radon gas from the tailings embankment into the atmosphere and to reduce infiltration of incident precipitation into the tailings embankment.

B. Cover - See Section 02200.

1.4 APPLICABLE PUBLICATIONS

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

1. American Society for Testing and Materials (ASTM):

D422-63	Method for Particle-Size Analysis of Soils (R1972)
D698-78	Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb. (2.49-kg) Rammer and 12-in. (305-mm) Drop
D1140-54	Test Method for Amount of Material in Soils Finer than the No. 200 (75-um) Sieve (R1971)
D1556-90	Test Method for Density of Soil in Place by the Sand-Cone Method
D2167-84	Standard Test Method for Density and Unit Weight of Soil In-Place by the Rubber-Balloon Method
D2216-90	Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock
D2922-81	Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
D4643-87	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method

2. American Petroleum Institute (API):

Specification 13A, Section 4, Specification for Oil Well Drilling-Fluid Materials

1.5 QUALITY ASSURANCE

[A. The Contractor will take soil samples and perform moisture, density, gradation and other tests to ascertain that the work is being performed in compliance with these Specifications. Samples will be taken during excavation and on the fill itself. The Contractor will conduct the density and other tests on the fill and related laboratory testing at frequencies described in Article 3.5. The Subcontractor shall remove surface material and render assistance as necessary to enable sampling and testing.]*

B. Methods of Sampling and Testing:

1. Particle Size Analysis including Percentage Passing No. 200 Sieve (and excluding hydrometer analysis): ASTM D422

2. In-Place Density: ASTM D1556, D2167, or D2922

3. Moisture Content: ASTM D2216 or D4643

4. Laboratory Moisture-Density Relations: ASTM D698

C. Suitability of Materials: The suitability of materials for radon barrier will be determined by the Contractor. The materials shall be approved material meeting the requirements of this Specification and obtained from Contractor-approved borrow sources.

D. The Contractor may direct that inspection trenches or test pits be cut into the radon barrier to determine that the Specification requirements have been met. Such trenches or pits will be of limited depth and size, and shall be backfilled with the material excavated therefrom, or other material meeting the requirements for the radon barrier. Backfill shall be compacted to a density at least equal to that specified for radon barrier.

E. When the Contractor directs inspection trenches or test pits to be excavated into compacted radon barrier and materials are found to meet all Specification requirements, the excavation and refilling shall be paid for as additional work pursuant to the applicable provisions of the General Conditions. Inspection trenches or test pits, and the refilling of the same, shall be at the Subcontractor's expense when it is found that the materials do not meet the Specification requirements.

F. Tolerances: See Specification Section 01052, Article 1.8.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Radon barrier materials shall be a mixture of radon barrier soils and bentonite.

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B. Radon Barrier Soils: Radon barrier soils shall be produced by selective excavation of material from borrow areas RB-4 and RB-7. Materials unsuitable for use as radon barrier material which are produced due to over-excavation or removal of overburden shall be stockpiled at the borrow site in areas selected by the Subcontractor and subject to Contractor's approval. Stockpiled materials shall be used later for site grading or borrow area reclamation. The radon barrier soils shall meet the following criteria:

1. Radon barrier soil shall meet the following gradation limits prior to mixing with bentonite:

Sieve Size	% Passing by Weight
4-inch	100
3/4-inch	70-100
No. 4	50-100
No. 60	15-100
No. 200	5-100

2. Radon barrier soil shall not contain more than 5 percent by volume of organic material, roots more than 1/4 inch in diameter or other deleterious substances.

3. The Subcontractor shall perform testing as required to ensure that the materials meet the specification requirements.

4. Clod sizes in radon barrier materials shall be 1 inch or smaller. The Subcontractor shall screen or otherwise process materials as required.

C. Bentonite:

1. Bentonite shall be high swelling, unaltered, sodium montmorilonitic clay. High swelling is defined as the ability of two grams of bentonite, mechanically reduced to 100 mesh, to swell in water to an apparent volume of 10.0 cubic centimeters or more when added a little at a time, to 100 cubic centimeters of distilled water in a graduated cylinder.

2. Colloid content of the base bentonite, mechanically reduced to 100 mesh, shall exceed 33 percent as measured by evaporating the suspended portion of a 2 percent solution after 24 hours of sedimentation in a beaker.

3. Bentonite shall have the following physical properties determined in accordance with the requirements of A.P.I. Specification 13A, Section 4:

Grit Content (plus 200 Mesh wet sieve analysis)	55% maximum
Viscosity (600 RPM)	6 cps minimum
Filtrate (30 minutes)	30 mils maximum
Moisture Content	10% maximum

4. Dry fines of the bentonite shall be:

   100% passing Number 4 sieve by weight

   15% maximum passing Number 200 sieve by weight

5. Bentonite shall be protected from the weather during shipping and storage.

6. A certified material test report (CMTR) or Certificate of Compliance (C of C) shall be furnished with each lot number of bentonite delivered to the site. If a CMTR or C of C is not furnished, testing shall be performed by the Subcontractor to demonstrate that all physical properties required by API and the specifications have been met. All CMTR's, C of C's and/or test results shall verify that each lot of bentonite meets the specified requirements or the material shall be rejected. No bentonite material shall be mixed or placed prior to this verification.

PART 3 - EXECUTION

3.1 GENERAL

A. Protection of exposed surfaces shall be as specified in Article 3.1 of Section 02200.

B. Dust control measures shall be as specified in Section 01560.

C. Clearing and stripping shall conform to Section 02110.

3.2 BORROW AREA EXCAVATION

A. Only portions of the area within the designated borrow area contain material suitable for mixing with bentonite to produce radon barrier material. The material shall meet the requirements specified in Article 2.1.B. Subcontractor shall identify the areas that contain material suitable for radon barrier material prior to the excavation.

B. Excavations shall not be within 50 feet of the shoulders of the existing Navajo Nation road that separates the borrow areas.

C. Excavations for radon barrier soils to be used for mixing with bentonite to produce radon barrier materials shall be carried out in the presence of a qualified technician employed by the Subcontractor.

D. Materials excavated for mixing with bentonite to produce radon barrier shall not be used for other purposes except as approved by the Contractor.

3.3 MIXING OF RADON BARRIER

A. The radon barrier soil shall be thoroughly mixed with bentonite. The bentonite content shall not be less than 10 percent by weight. The percentage shall be determined by dividing the dry weight of bentonite by the dry weight of soil without bentonite.

[B. Mixer: The mixer for mixing bentonite with the radon barrier material shall be capable of thoroughly mixing and controlling the percentage, by weight, of bentonite, soil and water. The mixer shall be the following, or approved equal:]*

1. Pug-mill, Pioneer Model 425P stabilizer plant.

[Text Deleted]*

C. Submittals: Sixty days after award of Subcontract, the Subcontractor shall submit, for approval, a narrative on how the radon barrier material will be mixed, placed and compacted. The narrative shall include the following:

1. Description of equipment used, including manufacturer's specifications.

2. Narrative of mixing operations, including how the bentonite, soil and water will be mixed; how quantities will be determined; and the duration of mixing.

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3. Procedures for calibrating the mixing equipment to show the proper mix is obtained and procedures for verifying calibration during operations. The plant shall be calibrated just before start of operation as well as during operation.

D. If stationary plant is used to mix the radon barrier material, the Subcontractor shall locate the plant so as not to interfere with other operations. At the end of the work, foundations shall be removed and disposed of by the Subcontractor, and the site restored as approved by the Contractor.

E. The Contractor may visually inspect the mixture for uniformity and consistency. Adjustments to mixing or procedures may be required by the Contractor to provide a uniform mix.

3.4 PLACEMENT AND COMPACTION OF RADON BARRIER

A. The radon barrier material shall be laid down in controlled lifts as specified in this Section.

B. Unless otherwise specified or indicated herein or elsewhere in the Subcontract Drawings, placement and compaction of the radon barrier material shall conform to the applicable provisions of Section 02200.

C. Unfavorable Weather: Placing, spreading, rolling or compacting fill material that is frozen or thawing, or during unfavorable weather conditions will not be permitted. If the work of placement of radon barrier material is interrupted by heavy rain or other unfavorable weather, such work shall not be resumed until ascertaining that the moisture content and density of the previously placed soil are acceptable to the Contractor.

D. The Subcontractor shall only work on an area that can be completed in one working day. Completion shall be defined as soil moisture adjustment, spreading of the bentonite, the mixing of the soil with the bentonite, and compaction of the soil bentonite layer.

E. Prior to placing radon barrier material, the final grade of the underlying contaminated materials shall be as shown in the Subcontract Drawings and specified in Section 02200.

F. In placing and working the first layer of radon barrier, care shall be taken to avoid mixing in any of the underlying radiologically contaminated soil.

G. Twenty-four inch thick radon barrier shall be placed in three lifts. The lifts shall be placed in a loose lift of approximately 10 inches to give a compacted thickness of 8 inches. The Subcontractor shall provide survey stakes verifying each 8-inch compacted lift.

H. Compaction of radon barrier shall be accomplished using tamping foot rollers.

I. The radon barrier material shall be compacted to at least 100 percent of maximum dry density as determined by ASTM D698. During compaction of radon barrier materials, moisture content shall be maintained between the optimum moisture content and plus three percent as determined by ASTM D698. The moisture content of the preceeding in-place radon barrier lift, with the exception of the top 2 inches shall be maintained at not less than optimum minus one percent moisture content until the succeeding lift of radon barrier or bedding material is placed.

J. Once minimum specified density is achieved for radon barrier, additional compaction shall not be performed.

K. Moisture added to the radon barrier materials shall be applied in a manner that prevents runoff onto contaminated materials.

L. The top surface of the underlying compacted radon barrier shall be scarified to a depth of 1 inch to 2 inches just prior to placement of the overlying loose lift. Scarification shall be accomplished by suitable equipment capable of accurate depth control.

M. If shrinkage cracks occur on top of each lift prior to placing the next lift, the surface should be scarified to the depths of the crack, moisture conditioned, and recompacted.

N. The top surface of the final layer of radon barrier shall be compacted with a tamping foot roller, then bladed and finished with a grader and a smooth drum roller. The top surface of the final layer of radon barrier shall be free of ruts, depressions, or low areas in which water can accumulate.

O. Upon completion of radon barrier placement and prior to the placement of bedding material, the Contractor will perform required radiological measurements. These measurements generally can be accomplished in 30 hours but may vary depending on atmospheric conditions. Measurements will be taken at approximately 100 evenly spaced locations as determined by the Contractor.

3.5 FIELD QUALITY CONTROL

A. The Contractor will perform the following tests on a regular basis. These tests are a minimum requirement:

1. In-Place Density and Moisture Content Tests: A minimum of one test will be performed per 500 cubic yards of the material placed. At least two tests will be performed for each day of material placement in excess of 150 cubic yards.

[2. Gradation Test: A minimum of one test per 1,000 cubic yards of material placed and a minimum of one test each day of material placement. The gradation tests will be performed on borrow material from RB-4 and RB-7 prior to mixing with bentonite. The Contractor may also do gradation testing on radon barrier materials after being mixed with bentonite.]*

3. Procedures and frequency for calibration of the mixing equipment shall be in accordance with the Contractor-approved plan.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for furnishing and placement of radon barrier material in the embankment cover will be by the cubic yards of compacted material in place. The quantities for payment will be computed by the average end area method from surveys conducted before and after placement and from lines and dimensions as shown on the Subcontract Drawings. (Bid Schedule Item 501)

B. Measurement for payment for furnishing bentonite will be by the ton delivered to the site and used in the radon barrier. (Bid Schedule Item 502)

C. Separate measurement for payment will not be made for the following items, and such work will be considered incidental to the related items of work:

* P.I.D. 09-S-15

1. Dust control.
2. Stripping.
3. Temporary stockpiling of excavated materials.
4. Required rehandling of materials.
5. Borrow area grading for restoration.
6. Erosion protection of exposed surfaces.
7. Temporary storage of bentonite.

4.2 PAYMENT

A. Payment for the excavation and placement of radon barrier material in the embankment cover will be by the unit price per cubic yard quoted therefor in the Bid Schedule. The price quoted shall include full compensation for excavation of the radon barrier material from the specified borrow source and processing, mixing, placement and compaction of the material in its final location.

B. Payment for furnishing bentonite will be by the unit price per ton, delivered to the site and used in the radon barrier, quoted therefor in the Bid Schedule.

C. Separate payment will not be made for the items mentioned in Article 4.1.C above. All costs for such work will be considered to be included in the prices quoted for the applicable related items of Work specified in this Subcontract.

END OF SECTION 02228

SECTION 02278

EROSION PROTECTION

PART 1 - GENERAL

1.1 SCOPE

This Specification Section describes the requirements for furnishing and placing riprap and bedding materials for tailings embankment cover, drainage ditches, apron and gullies.

1.2 WORK NOT INCLUDED

Erosion protection related to the construction facilities specified in Section 01500 is not included in the scope of work of this Specification.

1.3 RELATED WORK

A. Section 01300 - Submittals

B. Section 02200 - Earthwork

C. Section 02228 - Radon Barrier

1.4 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The Publications are referred to in the text by the basic designation only:

1. American Society for Testing and Materials (ASTM):

C88-90	Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C117-90	Test Method for Materials Finer Than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
C127-88	Test Method for Specific Gravity and Absorption of Coarse Aggregate
C131-89	Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

C136-84 Standard Method for Sieve Analysis of Fine and Coarse Aggregates, Rev. A

C295-90 Standard Guide for Petrographic Examination of Aggregates for Concrete

D75-87 Standard Practice for Sampling Aggregates

2. International Society for Rock Mechanics (ISRM), 1981

Rock Characterization Testing and Monitoring, ISRM Suggested Methods, E.T. Brown, Editor, Pergamon Press, New York:

Suggested Method for Determining Indirect Tensile Strength by the Brazil Test, pp. 120-121

Suggested Method for Determination of the Schmidt Rebound Hardness, PP. 101-102

1.5 PERMITS

The Contractor will provide permits for the use of borrow areas shown on the Subcontract Drawings as specified in Article SC-11 of Special Conditions. If the Subcontractor uses other sources for erosion protection materials, he shall be responsible for obtaining all required permits.

1.6 SUBMITTALS

A. During production of riprap and bedding materials, the Subcontractor shall submit gradation test results, in triplicate, in accordance with Article 2.1 below. For riprap and bedding materials, quality and gradation tests for each type material shall be performed a minimum of four times during production. An initial sample shall be obtained and tested during the early stages of production activities. Additional samples shall be obtained and tested when approximately one-third and two thirds of the total volume of material has been produced, and a final sample shall be obtained and tested near completion of the production activities. If the total volume of material for each riprap type or bedding material is greater than 30,000 cubic yards, quality and gradations tests shall be performed for each additional 10,000 cubic yards, or fraction thereof produced. The frequency for performing the quality and gradation tests shall be when approximately 10,000 cubic yards of material has been produced and near completion of production activities.

B. The Subcontractor shall submit, in writing, the name and qualifications of his proposed testing laboratory to the Contractor for approval.

C. The technical submittal covering the production of erosion protection materials shall include, but not be limited to, the following:

1. Narrative acknowledging permit stipulations for each rock borrow source.
2. Mining plan.
3. Use, handling and storage of explosives.
4. Expected quarry breakage or pit analysis.
5. Required combined product gradation.
6. Production analysis.
7. Flow diagram of production plant showing all products and wastage in tons per hour.
8. Plant layout showing individual pieces of equipment.
9. Complete list of equipment with manufacturers' models, capacities, horsepower and expected production curves.
10. Schedule.
11. Manpower required.
12. Handling of finished products.
13. Safety.
14. Maintenance of public and on site haul roads.
15. Dust control.
16. Protection of archaeological sites.
17. Quality control.

D. If the Subcontractor determines to use other sources for erosion protection materials, a site inspection report containing the information specified in Article 2.3 below shall be submitted, in triplicate, to the Contractor for review and approval of the source, in accordance with the requirements of Section 01300.

1.7 QUALITY ASSURANCE

Test Section: [For placement control purposes, one test section for each of Riprap Types A, B1, and B shall be constructed.]* The test sections shall be not less than 30 feet wide by 50 feet long in size, and shall be constructed either on or away from the embankment. Riprap material fully meeting the specified gradations shall be placed in the test sections by the same methods that will be used for production placement. The finished test sections, after testing to ensure that the in-place gradation requirements have been met, shall be used as a visual sample for comparison of production work. After completion of riprap installation, the test sections, if constructed away from the pile, shall be blended into the final grading contours, as approved by the Contractor.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material Sources: Erosion protection materials including riprap and bedding materials shall be obtained from sources approved by the Contractor. [The approved source for Type A, B1, and B erosion protection and bedding materials is the Bluff Gravel Quarry near Bluff, Utah, located approximately 30 miles northeast of the tailings site.]*

B. Subcontractor may propose other sources of materials. The basis for approval of the Subcontractor-proposed sources shall be as specified in Article 2.3. The materials shall meet the requirements of this Specification.

C. Approval of source as a borrow area does not mean that all materials excavated will meet the requirements of this Specification. Processing or selective quarrying may be necessary to meet the quality requirements of this Section. The basis for approval of other sources proposed by the Subcontractor is specified in Article 2.3 below. The Subcontractor shall be responsible for providing the laboratory test results.

D. The materials shall be below the background radioactive level and free from other contamination.

E. Material shall be dense, sound, resistant to abrasion, and shall be free from cracks, seams, and other defects as shown during field inspection as per Article 3.3 below.

* P.I.D. 09-S-20

F. The shape of at least 75 percent of the material, by weight, shall be such that the minimum dimension is not less than one third of the maximum dimension.

G. Quality and Gradation Tests: For record purposes the following tests will be performed by the Contractor:

Test	Designation
Gradation	ASTM C117 ASTM C136
Specific Gravity (Saturated Surface Dry Basis)	ASTM C127
Absorption	ASTM C127
Sodium Sulfate Soundness Soundness (5 Cycles)	ASTM C88 Coarse Aggregate
Abrasion (Los Angeles Machine) (100 Cycles)	ASTM C131
Schmidt Hammer	ISRM Method
Splitting Tensile Strength (Modified-Loading rate shall cause failure in 1 to 3 minutes)	ISRM Method

The frequency of tests shall be in accordance with Article 1.6.A for the total amount produced at each quarry irregardless of number of types of materials produced.

2.2 QUALITY REQUIREMENTS

A. All riprap and bedding materials used shall meet the following requirements:

1. Results of the tests specified in Table 02278-A on samples of each material shall be used to obtain rock quality scores using the criteria given in the table. The frequency of quality testing shall be as specified for gradation testing in Article 1.6.A. The score for each test is determined by multiplying the appropriate weighting factor by the score (0 to 10) based on the specific test result. The final score for each sample is the ratio of the sum of the individual test scores (six tests) to the maximum possible score, expressed as a

percentage. To be acceptable, the minimum final score shall be as follows:

65% for Bedding material and for Riprap Type A.

80% for Riprap Type B1 and Type B material from the Bluff quarry or if the material is rounded. 65% for Riprap Type B1 and Type B material if the material is angular.

65% for Riprap Type C material if the material is angular and 80% if the material is rounded.

The Schmidt Hammer Test and Splitting Tensile Strength Test will not be required on the bedding material or on Type A, Type B1 and Type B Riprap. The scoring of bedding material and Type A, Type B1 and Type B Riprap will be based on the four remaining tests.

2.3 SUBCONTRACTOR-PROPOSED SOURCES

A. The basis for approval of sources proposed by the Subcontractor shall be as follows:

1. A site inspection report by an engineering geologist which will include, as a minimum, an evaluation of soundness, hardness, and durability for three samples representative of the proposed source. The evaluation of durability shall be based in part on petrographic examination of rock types available from the source. The petrographic examination shall be in accordance with ASTM C295. In addition, the material shall meet the quality requirements of Article 2.2 above. Representativeness of samples shall be determined by the Contractor, based on precise location and source of sample taken in relation to the whole borrow area. The site inspection report shall include locations of all samples and methods of sampling.

2. If available, examples of successful uses of the material including riprap that has been in place on other project sites for more than 20 years, rock that has functioned satisfactorily as foundation stone or building facing for 50 years or more, and abandoned quarry faces which have maintained their integrity after not being worked for approximately 50 years or more. Durability shall be indicated by lack of significant weathering or loss of volume and strength over decades of exposure to natural weathering elements.

3. The Subcontractor shall have a qualified laboratory perform the six (6) types of tests listed in Table 02278-A on each sample (minimum of 6 samples) from the proposed source unless existing particle sizes are inadequate to perform Schmidt Hammer or Tensile Strength tests as specified. Special attention shall be given to ensure that the samples are representative of the proposed rock materials. Test samples shall be obtained from within the precise locations of rock deposits from which materials will be produced. To be approved as a source, the final score for each sample shall be obtained and evaluated as specified in Article 2.2.A.1.

4. If selected by the Subcontractor, the Sugarloaf riprap material shall consist of limestone and shall contain no more than 10 percent sandstone by weight.

2.4 GRADATION

A. Riprap materials shall be reasonably well graded within the following limits, and the Contractor reserves the right of inspection while the samples are taken:

U.S. Standard Sieve Size (Square Openings)	Percent Passing (by weight)
Type A	
3-inch	100
2-inch	0-100
1-1/2-inch	0-40
1-inch	0-10
1/2-inch	0-5
Type B1	
5-inch	100
4-inch	0-100
3-inch	0-50
2-inch	0-25
No. 4	0-5
Type B	
8-inch	100
6-inch	25-100
5-inch	0-100
4-inch	0-25
1-inch	0-5

Type C	
12-inch	100
9-inch	25-100
7-inch	5-50
5-inch	0-25
2-inch	0-5

B. Bedding Materials:

1. Bedding materials shall be obtained from the Bluff quarry or other sources as approved by the Contractor. Rock for the bedding material shall meet the quality requirements for riprap materials in Articles 2.1 and 2.2. The Subcontractor shall process the materials to conform with the gradation requirements specified below.

2. Gradation: Bedding materials shall be reasonably well graded within the following limits:

U.S. Standard Sieve Size (Square Openings)	Percent Passing (by weight)
3-inch	100
1-1/2-inch	50-100
1-inch	35-70
No. 4	10-30
No. 30	0-10
No. 100	0-5

2.5 SOURCE QUALITY CONTROL

The Subcontractor shall have a qualified, experienced person present at the quarry during production of rock materials to ensure that only suitable quality rock is processed. The materials may be inspected and tested by the Contractor at the borrow area prior to mining operations to ensure that they meet all requirements of this Specification with the exception of the gradation requirement. The Subcontractor shall assist the Contractor in obtaining samples. Gradation requirements will be tested at the placement location.

PART 3 - EXECUTION

3.1 PLACEMENT AND COMPACTION

A. General: Erosion protection materials shall be handled, loaded, transported, stockpiled and placed in a manner which avoids nonconformance with specifications due to segregation and degradation, including materials moved to and from stockpiles.

B. Subgrade preparation for apron, ditches and gullies shall conform to Specification Section 02200.

   1. Prior to placement of bedding materials, the Contractor will take radiological measurements as described in Specification Section 02228.

C. Where the required bedding material thickness is 6 inches, the bedding material shall be spread and compacted in one layer.

D. Each layer of bedding material shall be track-walked with two passes of a D6 bulldozer or equivalent operating up and down the slope, over the entire area of placement.

E. Dumped riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the drainage material. The larger stones shall be well distributed throughout the mass. The finished riprap shall be free from pockets of small stones and clusters of larger stones. Placing stone in layers will not be permitted. Placing stone by dumping into chutes or by similar methods likely to cause segregation of the various sizes will not be permitted. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry or other source, by controlled dumping of successive loads during final placing, or by other methods of placement which will produce the specified results. Rearranging of individual stones by mechanical equipment or by hand will be required to the extent necessary to obtain a reasonably well graded distribution of stone sizes as specified above.

F. Riprap material may be placed by end-dumping and may be spread by bulldozers or other suitable equipment.

G. Riprap layers placed upon bedding material shall be placed in such a manner which minimizes horizontal displacement of the bedding material.

H. Construction equipment carrying contaminated materials shall not be allowed to move over placed riprap and bedding layers except at equipment crossovers as designated by the Contractor. Each crossover shall be cleaned of all contaminating materials as approved by the Contractor before additional materials are placed in those areas. Other construction equipment may move over placed riprap and bedding layers. The Contractor may restrict such traffic to minimize damage to completed layers. Areas of riprap and bedding layers damaged by construction equipment shall be restored to meet the requirements of the Specifications.

3.2 TOLERANCES

A. The material layers shall be placed generally to the limits and thicknesses shown on the Subcontract Drawings within the following tolerances:

1. The top of the radon barrier or bedding subgrade shall be within ± 0.1 foot of the design grades shown on the Subcontract Drawings.

2. Bedding material shall be within ±0.1 foot of the design grades shown on the Subcontract Drawings.

3. The minimum in-place thickness of riprap material shall not be less than the minimum thickness shown.

4. The maximum in-place thickness of riprap material shall not be more than 135 percent of the thickness shown.

5. Local irregularities not exceeding the limits of Paragraphs 3 and 4 above will be permitted provided that such irregularities do not form noticeable mounds, ridges, swales or depressions which in the opinion of the Contractor could cause concentrations of surface runoff or form ponds or gullies.

3.3 FIELD QUALITY CONTROL

A. The placement of the materials will be inspected and tested by the Contractor during and after placement to ensure that the following requirements are met:

1. Material of the correct type and quality is being placed. Individual pieces or pockets of material greater than or equal to 8 inches in diameter not meeting the requirements noted in Article 2.1.E shall be removed per Paragraph D below. Individual pieces or pockets of

material less than 8 inches in diameter not meeting the requirements of Article 2.1.E may be left in place provided that concentrations of such pieces do not exist as determined by the Contractor.

2. The material being placed is clean and free of unsuitable material.

3. The material is being stockpiled, loaded, transported and placed in a manner which minimizes segregation and degradation.

4. The material is being placed to line and grade within the tolerances and limits designated in Article 3.2 above.

5. The material placed meets the gradation requirements specified.

B. Materials segregated or not placed according to the above requirements shall be regraded or adjusted, using appropriate equipment, to conform with the tolerances and limits given above, at no additional cost to the Contractor.

C. The Subcontractor may place erosion protection material only at his own risk, if durability test results are not available and approved by the Contractor.

D. Materials not meeting the requirements of this Section shall be removed and replaced with specified materials at no additional cost to the Contractor. Rejected materials shall be disposed of offsite as Subcontractor's property at no additional cost to the Contractor. Materials not meeting the grading requirements shall be reprocessed or discarded. The Contractor may require modification of the processing and grading operations to ensure that the specified grading requirements are met.

E. During placement of Type A, B1, B and C riprap materials and bedding materials, the Contractor will perform a minimum of four gradation tests in accordance with Article 2.4 above. An initial sample shall be obtained and tested during the early stages of placement activities. Additional samples shall be obtained and tested when approximately one-third and two-thirds of the total volume of material has been placed, and a final sample shall be obtained and tested near completion of placement activities. If the total volume of material placed for Type A, Type B1 and Type B Riprap and Bedding materials is greater than 30,000 cubic yards, a gradation test shall be performed for each additional 10,000 cubic yards, or fraction thereof placed.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for furnishing and placing the following materials will be by the cubic yards of material placed:

1. Riprap Material, Type A
2. Riprap Material, Type B
3. Riprap Material, Type C
4. Bedding Material

B. The quantities will be calculated from the lines and dimensions shown on the Subcontract Drawings and/or by using average end area methods from surveys conducted before and after placement for the areal extent of the placement.

4.2 PAYMENT

Payment for the items of Article 4.1.A above, will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for furnishing labor, materials, tools, equipment and incidentals and for performing specified work including development of the source (where applicable), obtaining required permits (where applicable), clearing, stripping and excavating; processing the materials; testing and evaluating the materials; transporting to placement locations; placing; compacting and consolidating complete in place.

END OF SECTION 02278

TABLE (78-A
ROCK QUALITY S(.ING CRITERIA

	Weighting Factor			Score										
	Lime-stone	Sand-stone	Igne-ous	10	9	8	7	6	5	4	3	2	1	0
Specific Gravity	12	5	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.30	< 2.3
Absorption (%)	13	5	2	0.1	0.3	0.5	0.67	0.83	1.0	1.5	2.0	2.5	3.0	> 3.0
Sodium Sulfate (%)*	4	3	11	1	3	5	6.7	8.3	10	12.5	15	20	25	> 25
Abrasion (%)**	1	8	1	1	3	5	6.7	8.3	10	12.5	15	20	25	> 25
Schmidt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	< 8
Tensile Strength(psi)	5	4	10	1400	1200	1000	833	666	500	400	300	200	100	< 100

1. Scores derived from Tables 6.2 and 6.7 of Ref. 1.

2. Any rock to be used must be qualitatively rated at least "fair" in a petrographic examination conducted by a geologist experienced in petrographic analysis.

3. Weighting Factors derived from Table 7 of Ref. 2, based on inverse of ranking of test methods for each rock type.

4. Test methods should be standardized (ASTM, e.g.) and should be those used in Ref. 2.

Ref. 1 Lindsey, C.G., Long, L.W., and Begej, C.W. (1982), Long-Term Survivability of Riprap for Armoring Uranium Mill Tailings and Covers: A Literature Review, U.S. Nuclear Regulatory Commission, NUREG/CR-2642.

Ref. 2 De Puy, G.W., "Petrographic Investigations of Rock Durability and Comparisons of Various Test Procedures," Engineering Geology, Vol. 2, No. 2, July 1965.

* 5 Cycles
** 100 Revolutions

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UNITED STATES
DEPARTMENT OF ENERGY

UMTRAP
URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT

AS-BUILT DRAWINGS

MEXICAN HAT, UTAH
AND
MONUMENT VALLEY, ARIZONA

QA REVIEWED FOR QUALITY REQUIREMENTS

QA MK-F	NO.	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	△								
	△								
	△								
—	△	5/9/95	AS-BUILT				DB	CR	—
	△	1/31/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED CLW | DRAWN RBC | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE 1/31/92 | DOE PROJECT ENGINEER | DATE

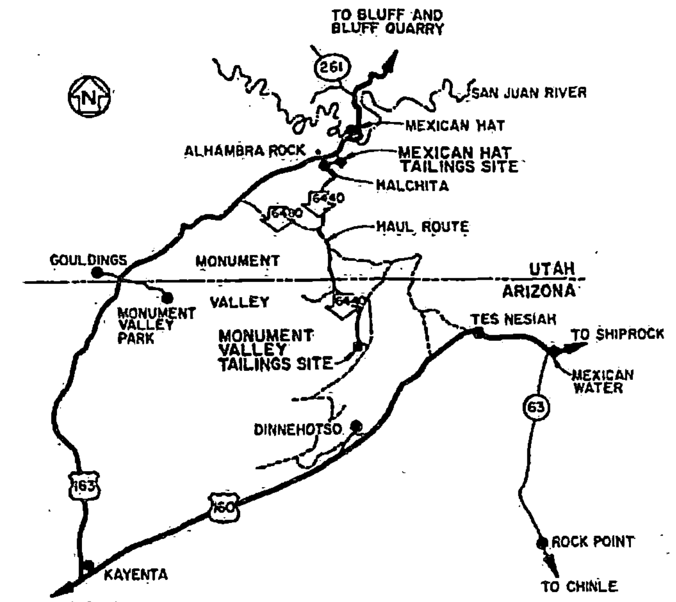
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

TITLE SHEET

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST., SAN FRANCISCO, CA 94105

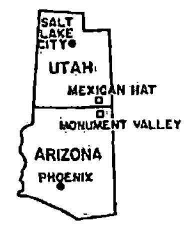
PROJECT NO. DE-AC04-83AL18796

DRAWING NO. H/M-GE-10-0201



LOCATION MAP

SCALE 5 0 5 10 MILES



SITE LOCATION MAP

LEGEND:

- U.S. HIGHWAY
- STATE HIGHWAY
- INDIAN SERVICE ROUTE
- COUNTY ROAD

NOTES:

1. FOR MEXICAN HAT SITE:
   A. HORIZONTAL AND VERTICAL CONTROL POINTS ESTABLISHED BY WESTERN DESIGN CONSULTANTS OF SALT LAKE, UTAH. CONTOURS BASED ON AERIAL PHOTOGRAPHY TAKEN JULY 1990, UNLESS OTHERWISE NOTED.
   B. COORDINATES SHOWN ARE THE PROJECT COORDINATES. PROJECT COORDINATES FOR STA. 4 ARE N 8,000 AND E 9,600. STATE COORDINATES FOR STA. 4 ARE X=2,473,150.34 AND Y=172,750.12, SURVEYED BY SAN JUAN ENGINEERS OF FARMINGTON N.M., JUNE 1987.
2. FOR MONUMENT VALLEY SITE:
   A. ALL INFORMATION SHOWN IS BASED ON "PLANT" COORDINATES UNLESS OTHERWISE NOTED WITH AN ASTERISK (*) WHICH IS BASED ON ARIZONA STATE PLANE COORDINATES.
   B. THE DIFFERENCE BETWEEN THE TWO COORDINATE SYSTEM IS:

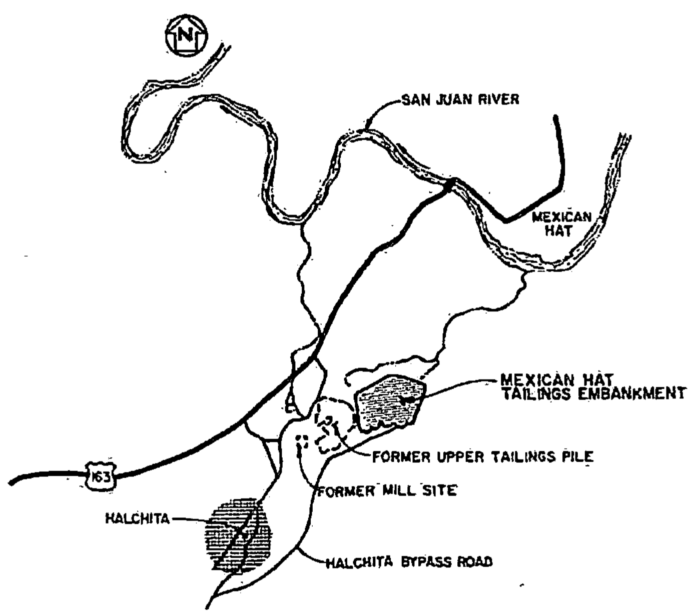
      ARIZONA STATE PLANE COORDINATE SYSTEM NORTH — "PLANT" NORTH — 0°12'32"
   C. TOPOGRAPHIC FEATURES AND GRID SYSTEM ARE TAKEN FROM THE RECORD OF SURVEY FURNISHED BY JACOBS ENGINEERING GROUP, INC. IN MAR. 1984.

LIST OF DRAWINGS

	DRAWING NO.	DRAWING TITLE
GENERAL	H/M-GE-10-0201	TITLE SHEET
GENERAL	H/M-GE-10-0202	VICINITY MAPS, LOCATION MAP AND LIST OF DRAWINGS
GENERAL	** ~~H/M-GE-10-0203~~	~~HAUL ROAD CORRIDOR AND BORROW AREA LOCATIONS~~
GENERAL	** ~~H/M-GE-10-0204~~	~~RIPRAP BORROW AREAS~~
GENERAL	** ~~H/M-GE-10-0205~~	~~RADON BARRIER MATERIAL BORROW AREAS AND GYPSUM WASH CROSSING~~
MEXICAN HAT	** ~~H/M-DS-10-0210~~	~~HAT - SITE PLAN~~
MEXICAN HAT	HAT-PS-10-0955	UPPER TAILINGS PILE EXCAVATION PLAN
MEXICAN HAT	HAT-PS-10-0956	WINDBLOWN MATERIALS EXCAVATION PLAN
MEXICAN HAT	H/M-DS-10-0211	HAT- CONTAMINATED MATERIAL EXCAVATION PLAN
MEXICAN HAT	* H/M-DS-10-0212	TAILINGS EMBANKMENT PLAN
MEXICAN HAT	* H/M-DS-10-0213	TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS
MEXICAN HAT	* H/M-DS-10-0214	HAT - FINAL SITE GRADING PLAN
MEXICAN HAT	H/M-DS-10-0215	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
MEXICAN HAT	H/M-DS-10-0216	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
MEXICAN HAT	H/M-DS-10-0217	HAT - SITE DRAINAGE SECTIONS AND DETAILS (SHEET 1 OF 2)
MEXICAN HAT	H/M-DS-10-0218	HAT - SITE DRAINAGE SECTIONS AND DETAILS (SHEET 2 OF 2)
MEXICAN HAT	H/M-DS-10-0219	HAT- EROSION PROTECTION PLAN AND SECTIONS
MEXICAN HAT	H/M-DS-10-0220	HAT- GULLY DETAILS
MEXICAN HAT	** ~~H/M-DS-10-0221~~	~~HAT - BORING LOCATION PLAN~~
MEXICAN HAT	H/M-DS-10-0222	HAT- AS BUILT TOPOGRAPHIC MAP (SHEET 1 OF 2)
MEXICAN HAT	H/M-DS-10-0223	HAT - AS BUILT TOPOGRAPHIC MAP (SHEET 2 OF 2)
MEXICAN HAT	H/M-DS-10-0240	LOCATION OF MONUMENTS, MARKERS AND SIGNS
MEXICAN HAT		
MONUMENT VALLEY	** ~~H/M-PS-10-0230~~	~~MON - SITE PLAN~~
MONUMENT VALLEY	** ~~H/M-PS-10-0231~~	~~MON - CONSTRUCTION FACILITIES AND SITE DRAINAGE~~
MONUMENT VALLEY	* H/M-PS-10-0232	MON- CONTAMINATED MATERIAL EXCAVATION PLAN (SHEET 1 OF 2)
MONUMENT VALLEY	* H/M-PS-10-0233	MON- CONTAMINATED MATERIAL EXCAVATION PLAN (SHEET 2 OF 2)
MONUMENT VALLEY	** ~~H/M-PS-10-0234~~	~~MON - FINAL SITE GRADING AND DRAINAGE (SHEET 1 OF 2)~~
MONUMENT VALLEY	** ~~H/M-PS-10-0235~~	~~MON - FINAL SITE GRADING AND DRAINAGE (SHEET 2 OF 2)~~
MONUMENT VALLEY	** ~~H/M-PS-10-0236~~	~~MON - BORINGS, TEST PITS AND MONITORING WELLS LOCATION PLAN~~
MONUMENT VALLEY	H/M-PS-10-0237	MON - AS BUILT TOPOGRAPHIC MAP

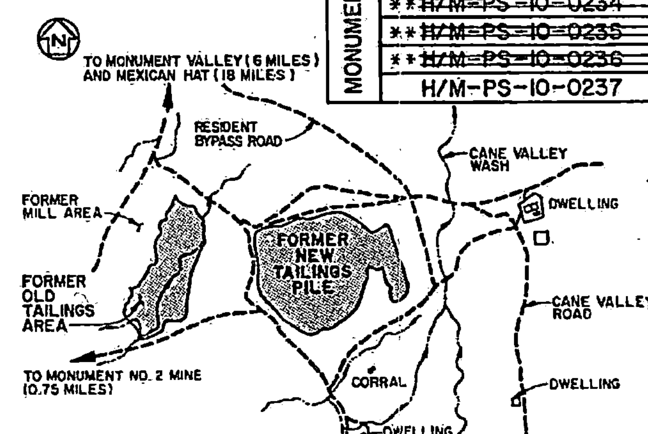
* FOR AS-BUILT TOPOGRAPHY AT HAT DISPOSAL SITE REFER TO DWG. NOS. H/M-DS-10-0222 & 0223. AND AT MON PROCESSING SITE REFER TO DWG. NO. H/M-PS-10-0237.

** FOR CONSTRUCTING PURPOSE ONLY; DRAWINGS ARE NOT INCLUDED.



MEXICAN HAT - VICINITY MAP

SCALE 0 1/2 1 MILE



MONUMENT VALLEY - VICINITY MAP

SCALE 600 0 600 1200 FEET

QA REVIEWED FOR QUALITY REQUIREMENTS

QA MK-F	NO.	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	△								
	△								
–	△	5-9-95	AS-BUILT						–
	△	3-3-92	REVISED AS PER P.I.D. NO. 09-S-15						
	△	1/31/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

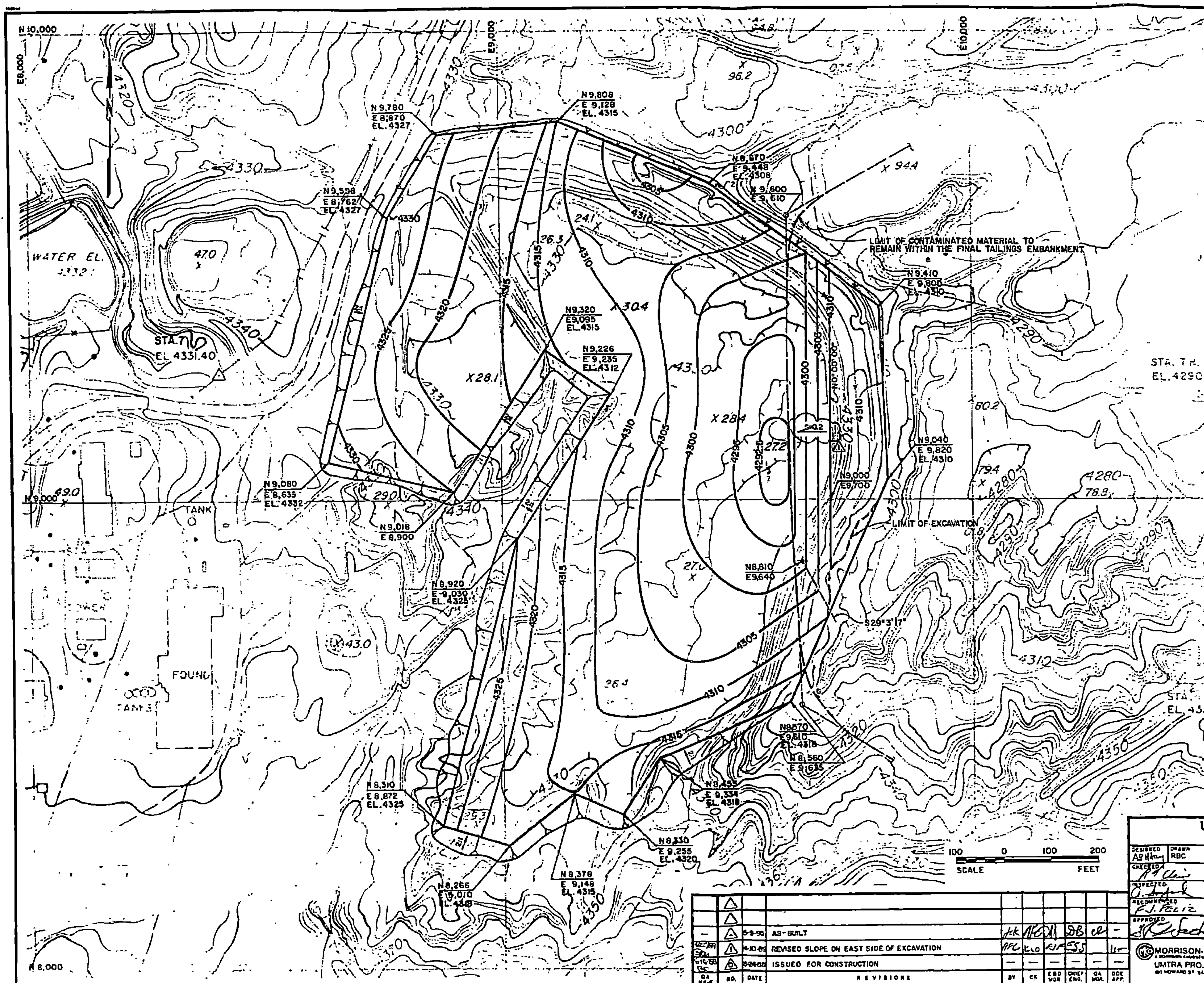
VICINITY MAPS, LOCATION MAP AND LIST OF DRAWINGS

DESIGNED | DRAWN AOM | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE 1/21/92 | DOE PROJECT ENGINEER | DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. H/M-GE-10-0202 REV. –



NOTES:

1. ALL EXCAVATED CUT SLOPES WERE 2(H):1(V) MAXIMUM.
2. EXCAVATION PLAN SHOWN IS APPROXIMATE. ACTUAL DEPTHS AND EXTENT OF EXCAVATION WERE DETERMINED IN THE FIELD BY THE CONTRACTOR BASED ON RADIOLOGICAL SURVEYS.
3. CONTAMINATED MATERIAL WITHIN THE FINAL TAILINGS EMBANKMENT WAS EXCAVATED TO THE LIMITS SHOWN. LIMITS ARE APPROXIMATE.
4. TOPOGRAPHIC SURVEY CONDUCTED BY WESTERN DESIGN CONSULTANTS ON AUG. 11, 1982. ELEVATIONS ARE TWO FEET INTERVALS AND ARE TIED TO DATUM POINT NORTHEAST CORNER SECT. 7. T42S, R19E, SALT LAKE BASE AND MERIDIAN.

REFERENCE DRAWINGS:

HAT-PS-10-0960 FINAL SITE GRADING AND DRAINAGE PLAN
HAT-PS-10-0957 TAILINGS EMBANKMENT PLAN

LEGEND:

LIMIT OF CUT

REGISTERED ENGINEER NO. 4719 EDWIN S. SMITH STATE OF UTAH

QA REVIEWED FOR QUALITY REQUIREMENTS
6-16-88
E.S. Smith

QA MK-F	NO.	DATE	REVISIONS	BY	CK	E&D MGR	CHIEF ENG.	QA MGR.	DOE APP.
	△								
	△								
—	△	5-9-95	AS-BUILT						—
	△	4-10-89	REVISED SLOPE ON EAST SIDE OF EXCAVATION						
	△	5-24-88	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

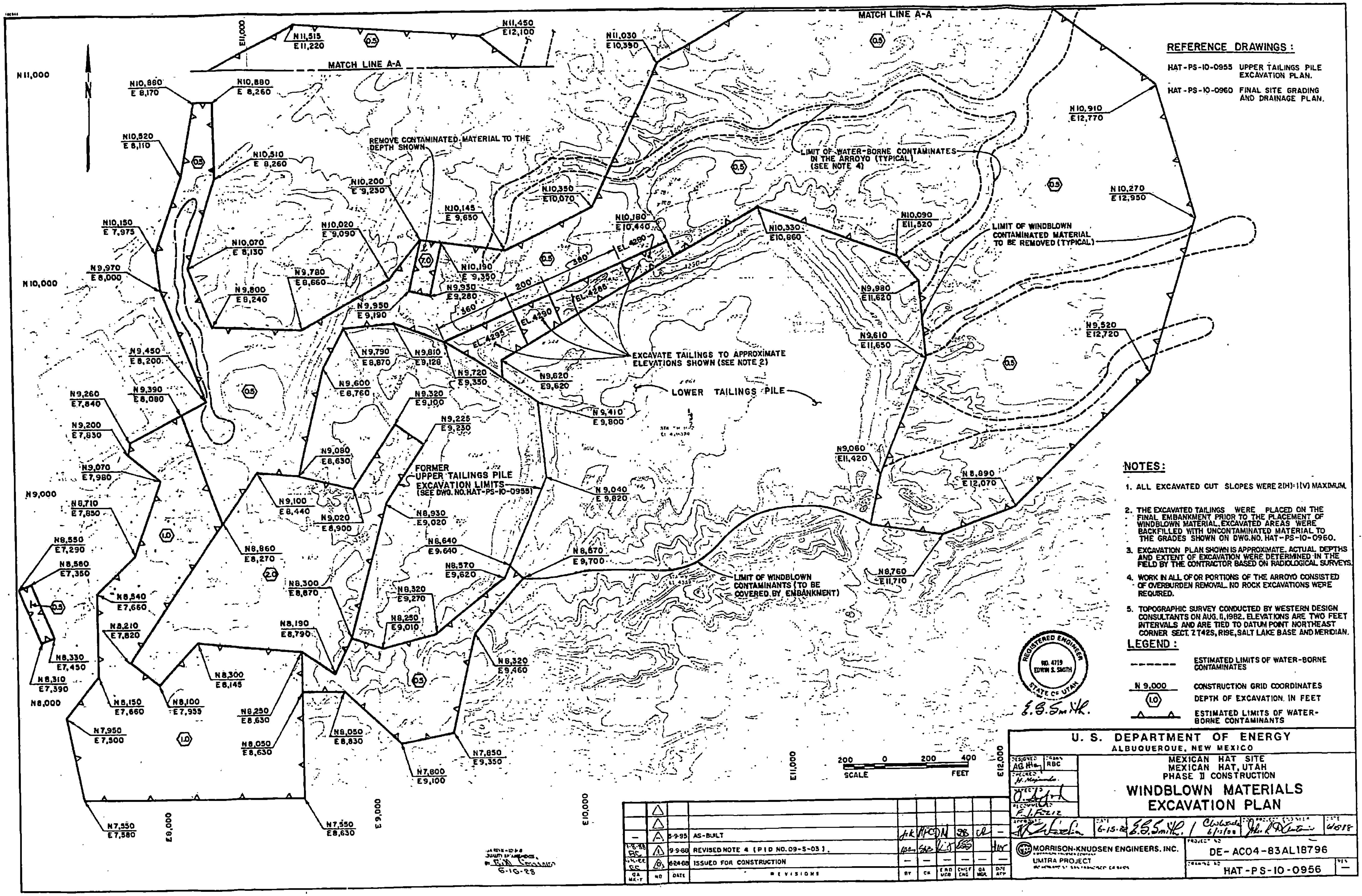
MEXICAN HAT SITE
MEXICAN HAT, UTAH
PHASE II CONSTRUCTION

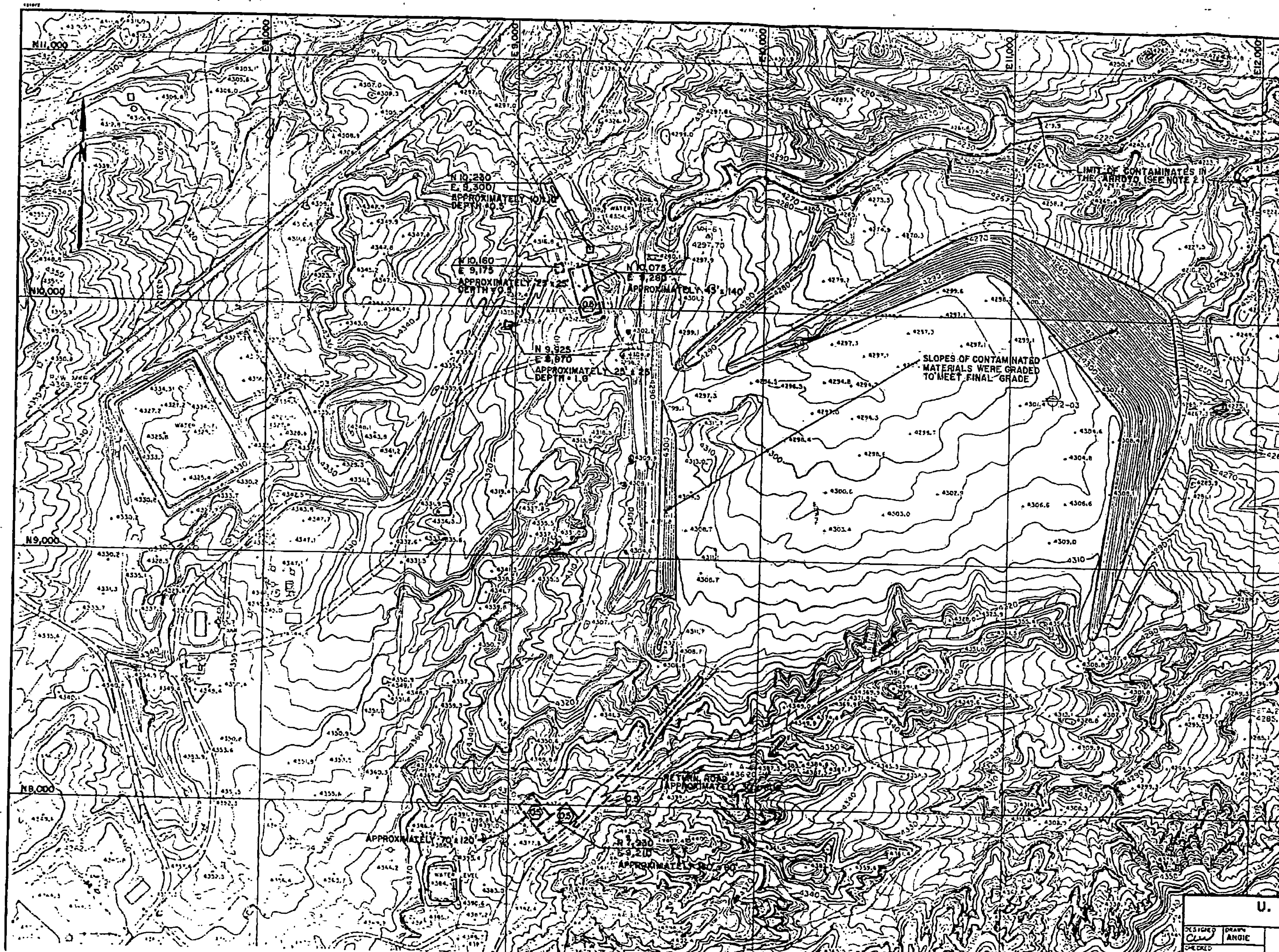
UPPER TAILINGS PILE EXCAVATION PLAN

DESIGNED | DRAWN RBC
CHECKED
INSPECTED
RECOMMENDED F.J. Feliz
APPROVED | DATE 6-15-88 | E.S. Smith | 6/15/88 | DOE PROJECT ENGINEER | DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. HAT-PS-10-0955
REV. —


MATCH LINE A-A
REFERENCE DRAWINGS:
HAT-PS-10-0955 UPPER TAILINGS PILE EXCAVATION PLAN.
HAT-PS-10-0960 FINAL SITE GRADING AND DRAINAGE PLAN.
REMOVE CONTAMINATED MATERIAL TO THE DEPTH SHOWN
LIMIT OF WATER-BORNE CONTAMINATES IN THE ARROYO (TYPICAL) (SEE NOTE 4)
LIMIT OF WINDBLOWN CONTAMINATED MATERIAL TO BE REMOVED (TYPICAL)
EXCAVATE TAILINGS TO APPROXIMATE ELEVATIONS SHOWN (SEE NOTE 2)
LOWER TAILINGS PILE
FORMER UPPER TAILINGS PILE EXCAVATION LIMITS (SEE DWG. NO. HAT-PS-10-0955)
LIMIT OF WINDBLOWN CONTAMINANTS (TO BE COVERED BY ENBANKMENT)
NOTES:
1. ALL EXCAVATED CUT SLOPES WERE 2(H):1(V) MAXIMUM.
2. THE EXCAVATED TAILINGS WERE PLACED ON THE FINAL EMBANKMENT PRIOR TO THE PLACEMENT OF WINDBLOWN MATERIAL. EXCAVATED AREAS WERE BACKFILLED WITH UNCONTAMINATED MATERIAL TO THE GRADES SHOWN ON DWG. NO. HAT-PS-10-0960.
3. EXCAVATION PLAN SHOWN IS APPROXIMATE. ACTUAL DEPTHS AND EXTENT OF EXCAVATION WERE DETERMINED IN THE FIELD BY THE CONTRACTOR BASED ON RADIOLOGICAL SURVEYS.
4. WORK IN ALL OF OR PORTIONS OF THE ARROYO CONSISTED OF OVERBURDEN REMOVAL. NO ROCK EXCAVATIONS WERE REQUIRED.
5. TOPOGRAPHIC SURVEY CONDUCTED BY WESTERN DESIGN CONSULTANTS ON AUG. 11, 1982. ELEVATIONS ARE TWO FEET INTERVALS AND ARE TIED TO DATUM POINT NORTHEAST CORNER SECT. 7 T42S, R19E, SALT LAKE BASE AND MERIDIAN.
LEGEND:
ESTIMATED LIMITS OF WATER-BORNE CONTAMINATES
N 9,000 CONSTRUCTION GRID COORDINATES
DEPTH OF EXCAVATION IN FEET
ESTIMATED LIMITS OF WATER-BORNE CONTAMINANTS
REGISTERED ENGINEER NO. 4719 EDWIN S. SMITH STATE OF UTAH
SCALE FEET
200 0 200 400
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT SITE
MEXICAN HAT, UTAH
PHASE II CONSTRUCTION
WINDBLOWN MATERIALS EXCAVATION PLAN
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
DE-AC04-83AL18796
HAT-PS-10-0956
5-9-95 AS-BUILT
9-9-88 REVISED NOTE 4 (PID NO. 09-5-03)
6-24-88 ISSUED FOR CONSTRUCTION
REVISIONS



NOTES:

1. EXCAVATION PLAN SHOWN IS APPROXIMATE. ACTUAL DEPTHS AND EXTENT OF EXCAVATION WERE DETERMINED IN THE FIELD BY THE CONTRACTOR BASED ON RADIOLOGICAL SURVEYS.
2. WORK CONSISTED OF OVERBURDEN REMOVAL. NO RIPPABLE EXCAVATIONS WERE REQ'D. THE DEPTH OF CONTAMINATION VARIED ALONG THE ARROYO FROM 2'-0 WITH A FEW AREAS NEAR THE RETENTION BASIN EMBANKMENT REACHING A DEPTH OF 3'-0.
3. THE RETENTION BASIN EMBANKMENT MATERIAL ALONG WITH UNDERLYING CONTAMINATED MATERIAL WAS EXCAVATED AND DISPOSED OF IN THE TAILINGS EMBANKMENT PRIOR TO PLACEMENT OF THE RADON BARRIER.
4. DURING REMEDIAL ACTION THE SUBCONTRACTOR MAINTAINED SITE DRAINAGE TO PREVENT RUNOFF FROM CONTAMINATED AREAS FROM LEAVING THE SITE.

REFERENCE DRAWINGS:

LEGEND:

ESTIMATED LIMITS OF OFF-PILE CONTAMINATES

0.5 DEPTH OF EXCAVATION IN FEET (UNLESS NOTED OTHERWISE)

QA REVIEWED FOR QUALITY REQUIREMENTS BY

NO.	DATE	REVISIONS	BY	CK	E&D	CHIEF	QA	DOE
—	5/3/95	AS-BUILT						—
0	1/31/92	ISSUED FOR CONSTRUCTION						—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED | DRAWN ANGIE | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE 1/31/92

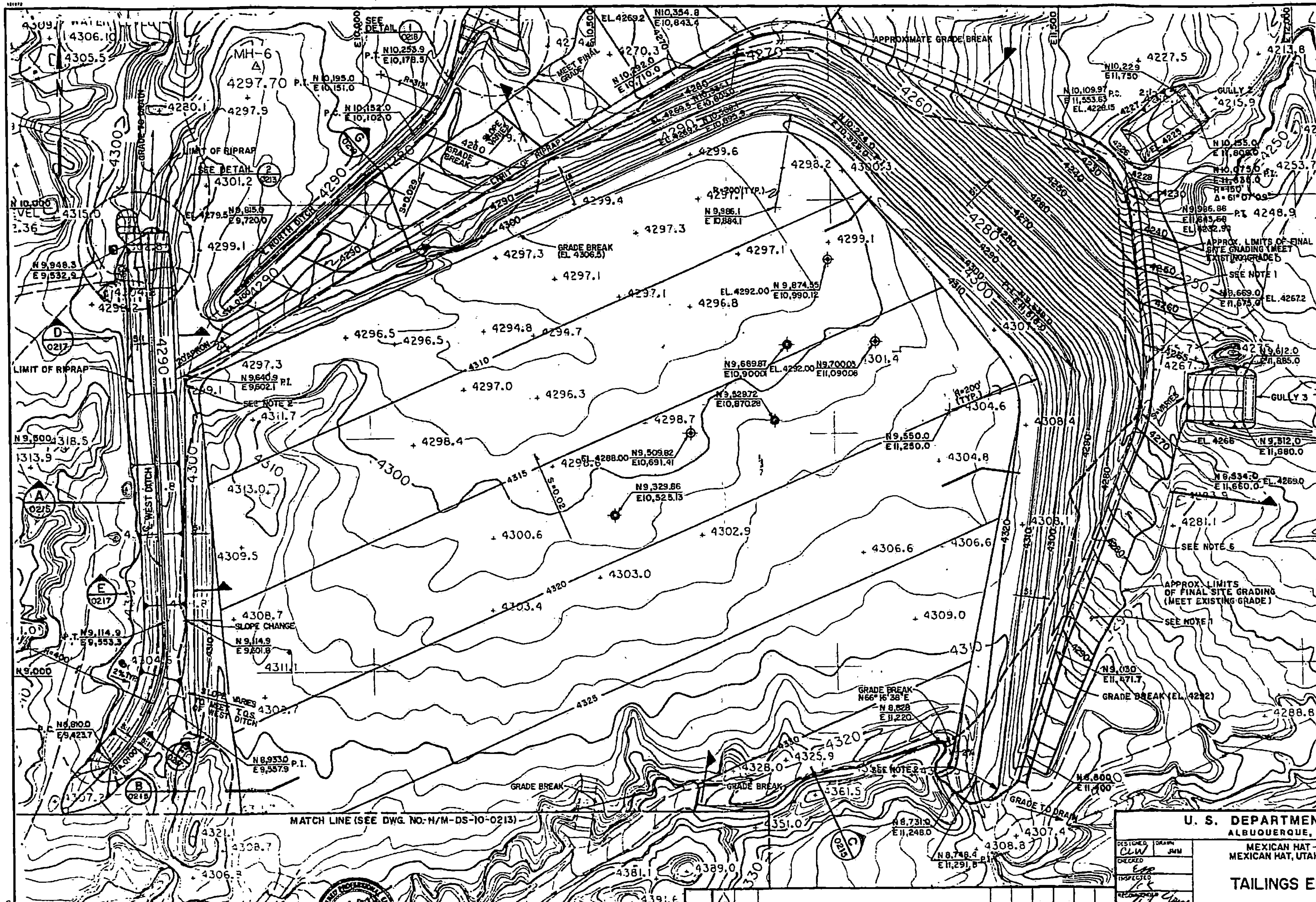
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

HAT-CONTAMINATED MATERIAL EXCAVATION PLAN

DOE PROJECT ENGINEER | DATE 2/3/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796



NOTES:

1. GRADED APRON AREA TO ELIMINATE HIGH SPOTS AND PREVENT FLOW CONCENTRATIONS.
2. CORNER CONTOURS ON THE TAILINGS EMBANKMENT WERE ROUNDED WITH A 50' RADIUS IN THE PLAN VIEW UNLESS NOTED OTHERWISE.
3. FINAL GRADES SHOWN ARE APPROXIMATE.

REFERENCE DRAWINGS:

H/M-DS-10-0215	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0216	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-DS-10-0217	HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0218	HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-DS-10-0219	HAT-EROSION PROTECTION PLAN AND SECTIONS
H/M-DS-10-0213	TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS

LEGEND:

4300	EXISTING CONTOURS
4320	FINAL CONTOURS
	DRAINAGE DITCH
N10,000	CONSTRUCTION GRID COORDINATE
	TOP OF CUT
	TOP OF FILL
	LIMIT OF CONTAMINATED MATERIAL
	DISPLACEMENT MONUMENT LOCATION SIT AT THE BOTTOM OF RADON BARRIER
	DISPLACEMENT MONUMENT LOCATION & ELEVATION OF BASE PLATE AS OF MARCH 1989

QA MK-T	NO.	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
—	4	5-9-95	AS-BUILT						—
	3	3-21-94	REVISED AS PER P.I.D. NO. 09-3-20						
	2	5-18-93	REVISED AS PER P.I.D. NO. 09-5-17						
	1	1/31/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

QA REVIEWED FOR QUALITY ASSURANCE

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

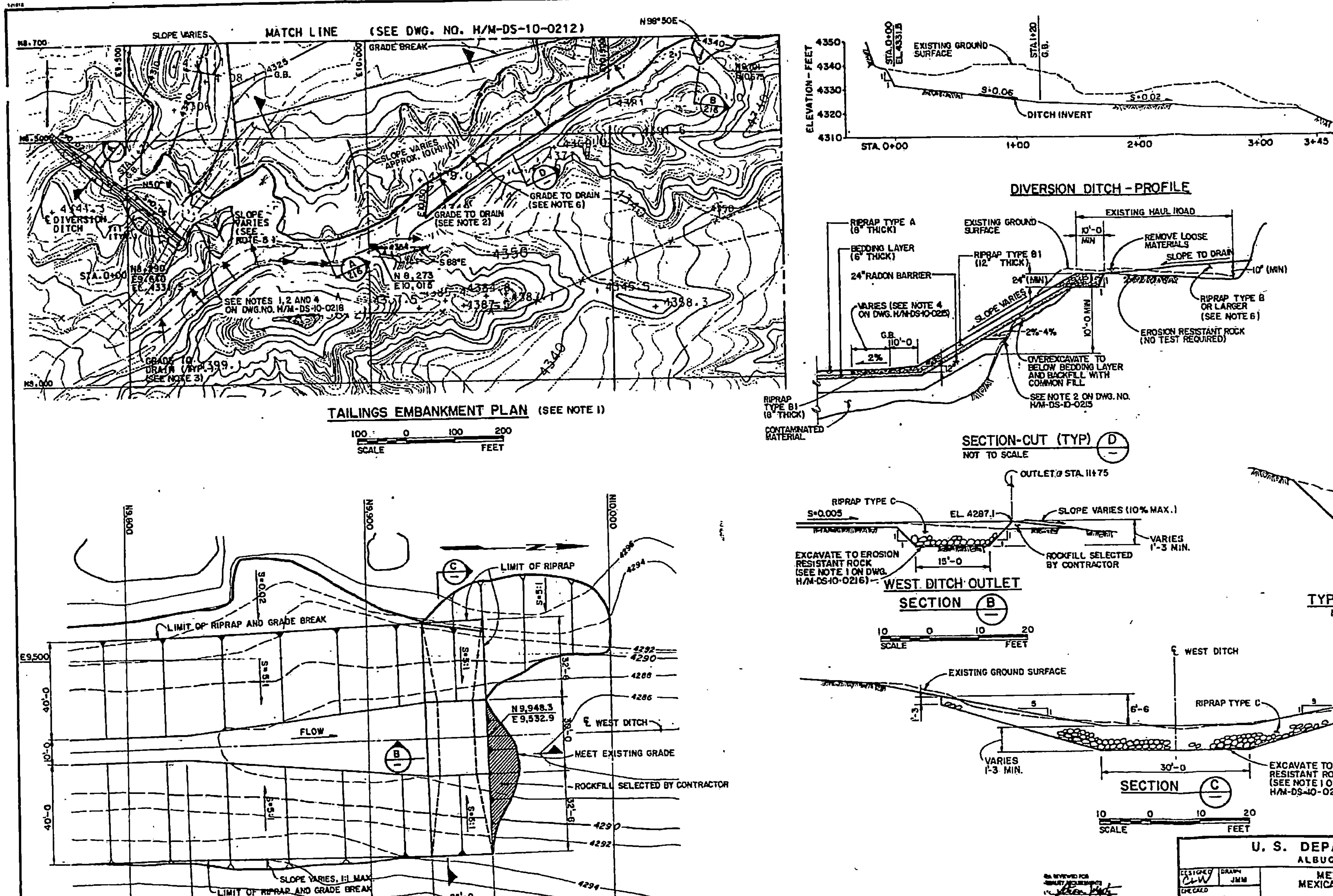
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

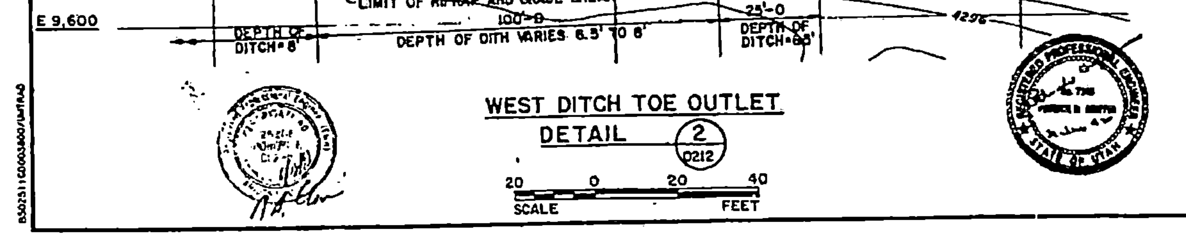
TAILINGS EMBANKMENT PLAN

DESIGNED CLW DRAWN JMM
CHECKED
INSPECTED
RECOMMENDED
APPROVED DATE 1/1/92
DOE PROJECT ENGINEER DATE 2/3/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST., SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. H/M-DS-10-0212
REV. —





NOTES:

1. SEE DWG. H/M-DS-10-0212 FOR ADDITIONAL NOTES AND LEGEND.
2. GRADED EXISTING TERRAIN SOUTH OF PILE AS DIRECTED BY THE CONTRACTOR TO AVOID FLOW CONCENTRATIONS ONTO THE PILE.
3. GRADED EXISTING TERRAIN SOUTHWEST OF PILE.
4. (NCT USED)
5. BACKFILLED EXISTING GULLIES WITH ROCKFILL SELECTED BY CONTRACTOR.
6. GRADED EXISTING HAUL ROAD EAST OF E10,130 TO DRAIN WITH RIPRAP TYPE B.

REFERENCE DRAWINGS:

H/M-DS-10-0212	TAILINGS EMBANKMENT PLAN
H/M-DS-10-0215	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0216	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-DS-10-0218	HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 2 OF 2)

LEGEND:

	TOP OF ROCK
	LIMITS OF ROCKFILL SELECTED BY THE CONTRACTOR
G.B.	GRADE BREAK

QA MR-F	NO.	DATE	REVISIONS	BY	CK	ENG MGR.	CHIEF ENG.	QA MGR.	DOE APP.
—	6	5-9-95	AS-BUILT						—
	5	10-5-94	REVISED AS PER P.I.D. NO. 09-S-24						
	3	4-6-94	REVISED AS PER P.I.D. NO. 09-S-22						
	2	3-21-94	REVISED AS PER P.I.D. NO. 09-S-20						
	1	6-18-93	REVISED AS PER P.I.D. NO. 09-S-17						
	0	1/31/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

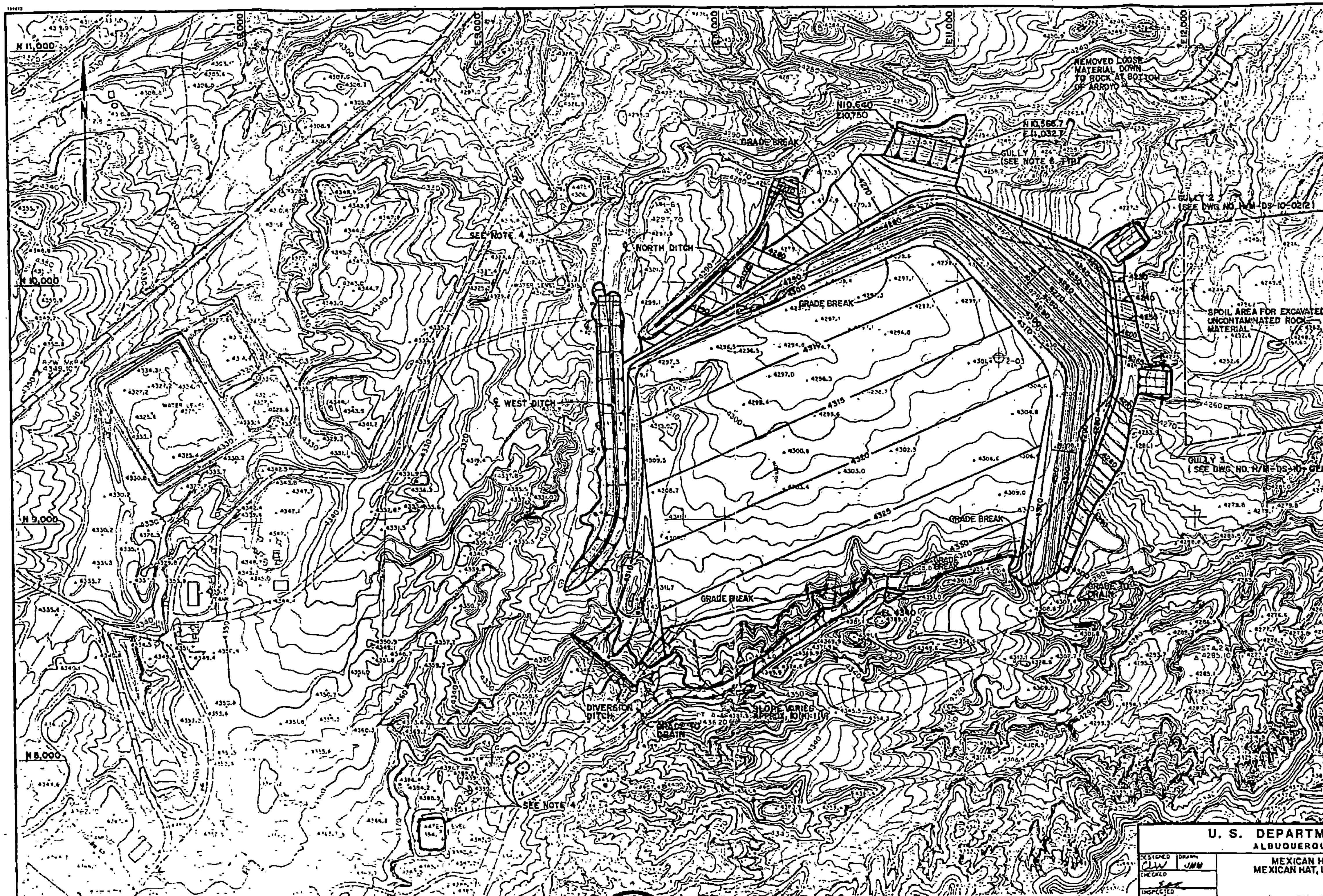
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS

DESIGNED CLW DRAWN JMM CHECKED INSPECTED RECOMMENDED APPROVED DATE 1/21/92 DOE PROJECT ENGINEER DATE 2/3/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. H/M-DS-10-0213



NOTES:

1. SEE DWG. NO. H/M-DS-10-0212 AND H/M-DS-10-0213 FOR FINAL SITE GRADING REQUIREMENTS AROUND DISPOSAL CELL.
2. FINAL GRADES SHOWN ARE APPROXIMATE.
3. (NOT USED)
4. ALL DEPRESSIONS AND LOW SPOTS INCLUDING WATER PONDS WERE BACKFILLED WITH COMMON FILL AND SLOPED TO DRAIN AS DIRECTED BY THE CONTRACTOR.
5. FOR LEGEND, SEE DWG. NO. H/M-DS-10-0212
6. FOR GULLY DETAILS, SEE DWG. NO. H/M-DS-10-0220.

REFERENCE DRAWINGS:

H/M-DS-10-0212	TAILINGS EMBANKMENT PLAN
H/M-DS-10-0213	TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS
H/M-DS-10-0220	HAT - GULLY DETAILS

LEGEND:

TOP OF CUT

TOP OF FILL

FLOWPATH

200 0 200 400
SCALE FEET

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

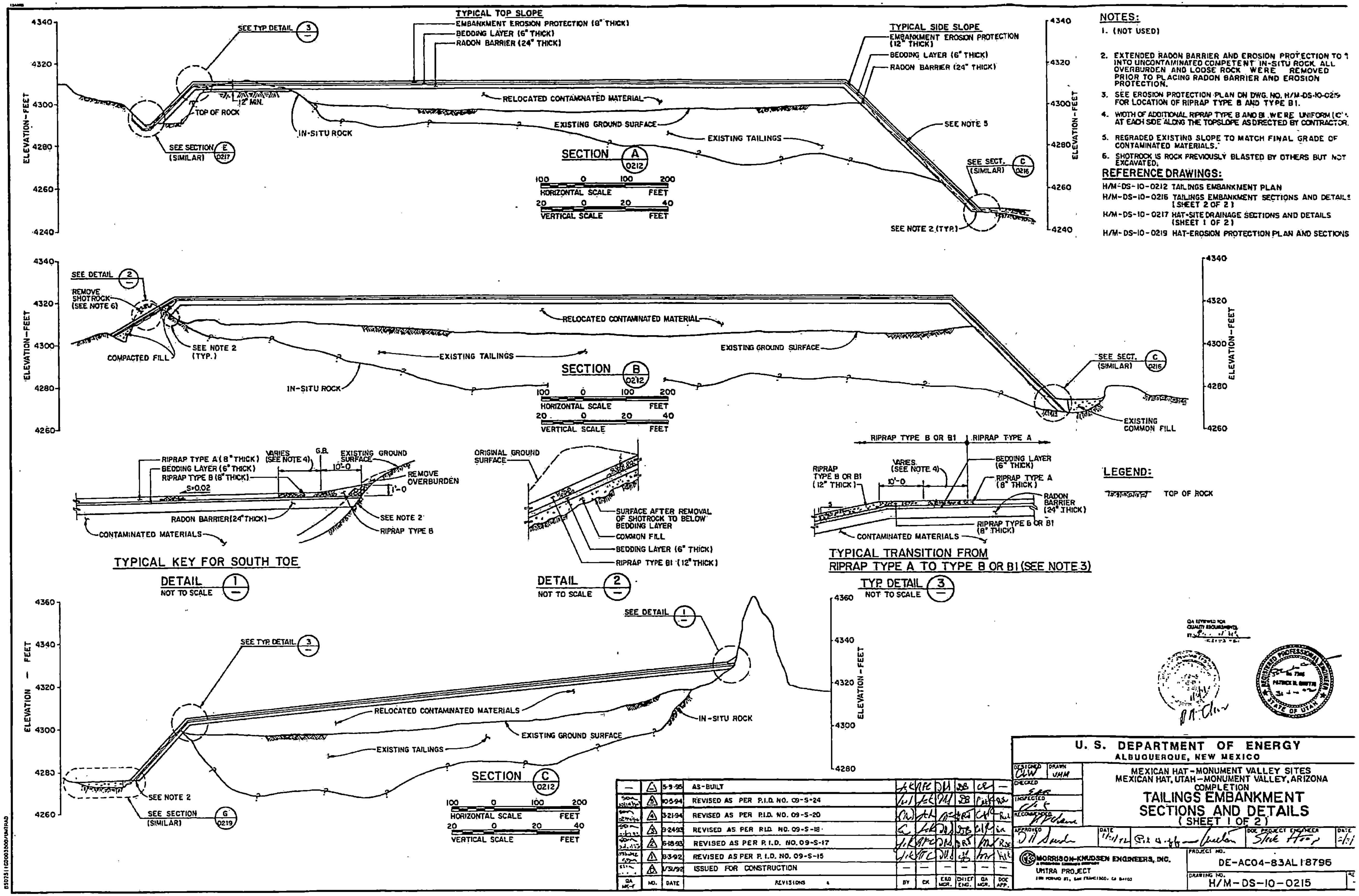
HAT-FINAL SITE GRADING PLAN

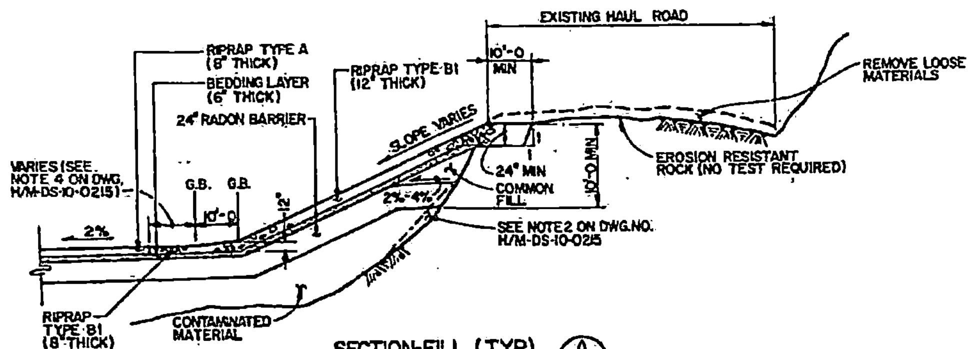
DESIGNED CLW DRAWN JMM
CHECKED
INSPECTED
RECOMMENDED
APPROVED DATE 1/31/92
DOE PROJECT ENGINEER DATE 2/1/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

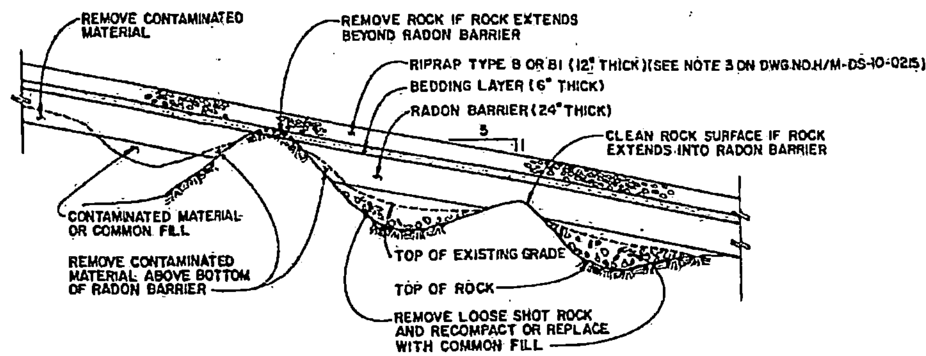
PROJECT NO. DE-AC04-83AL18796
DRAWING NO. H/M-DS-10-0214
REV. —

QA	NO.	DATE	REVISIONS	BY	CK	EGD MGR.	CHIEF ENG.	QA MGR.	DOE APP.
—	△	5-9-95	AS-BUILT						—
	△	3-21-94	REVISED AS PER P.I.D. NO. 09-S-20						
	△	6-18-93	REVISED AS PER P.I.D. NO. 09-S-17						
	△	1/31/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

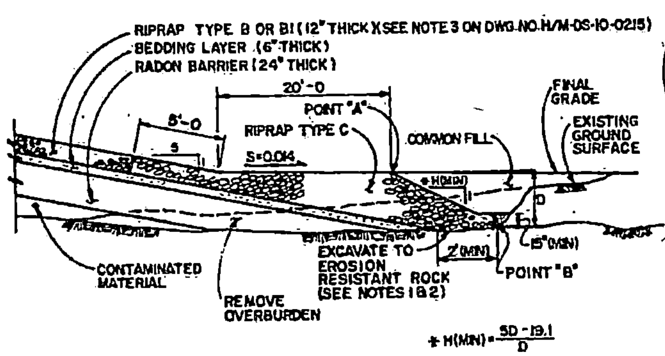

TYPICAL TOP SLOPE
EMBANKMENT EROSION PROTECTION (6" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER (24" THICK)
SEE TYP DETAIL 3
TOP OF ROCK
12" MIN.
IN-SITU ROCK
SEE SECTION E 0217 (SIMILAR)
RELOCATED CONTAMINATED MATERIAL
EXISTING GROUND SURFACE
EXISTING TAILINGS
SECTION A 0212
HORIZONTAL SCALE FEET
VERTICAL SCALE FEET
TYPICAL SIDE SLOPE
EMBANKMENT EROSION PROTECTION (12" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER (24" THICK)
SEE NOTE 5
SEE SECT. C 0216 (SIMILAR)
SEE NOTE 2 (TYP.)
ELEVATION-FEET
NOTES:
1. (NOT USED)
2. EXTENDED RADON BARRIER AND EROSION PROTECTION TO 1' INTO UNCONTAMINATED COMPETENT IN-SITU ROCK. ALL OVERBURDEN AND LOOSE ROCK WERE REMOVED PRIOR TO PLACING RADON BARRIER AND EROSION PROTECTION.
3. SEE EROSION PROTECTION PLAN ON DWG. NO. H/M-DS-10-0219 FOR LOCATION OF RIPRAP TYPE B AND TYPE B1.
4. WIDTH OF ADDITIONAL RIPRAP TYPE B AND B1 WERE UNIFORM (C'-) AT EACH SIDE ALONG THE TOPSLOPE AS DIRECTED BY CONTRACTOR.
5. REGRADED EXISTING SLOPE TO MATCH FINAL GRADE OF CONTAMINATED MATERIALS.
6. SHOTROCK IS ROCK PREVIOUSLY BLASTED BY OTHERS BUT NOT EXCAVATED.
REFERENCE DRAWINGS:
H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN
H/M-DS-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-DS-10-0217 HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0219 HAT-EROSION PROTECTION PLAN AND SECTIONS
SEE DETAIL 2
REMOVE SHOTROCK (SEE NOTE 6)
COMPACTED FILL
SEE NOTE 2 (TYP.)
IN-SITU ROCK
SECTION B 0212
EXISTING COMMON FILL
RIPRAP TYPE A (6" THICK)
BEDDING LAYER (6" THICK)
RIPRAP TYPE B (6" THICK)
S=0.02
VARIES (SEE NOTE 4)
EXISTING GROUND SURFACE
REMOVE OVERBURDEN
RADON BARRIER (24" THICK)
CONTAMINATED MATERIALS
SEE NOTE 2
RIPRAP TYPE B
TYPICAL KEY FOR SOUTH TOE
DETAIL 1
NOT TO SCALE
ORIGINAL GROUND SURFACE
SURFACE AFTER REMOVAL OF SHOTROCK TO BELOW BEDDING LAYER
COMMON FILL
BEDDING LAYER (6" THICK)
RIPRAP TYPE B1 (12" THICK)
DETAIL 2
NOT TO SCALE
RIPRAP TYPE B OR B1
RIPRAP TYPE A
RIPRAP TYPE B OR B1 (12" THICK)
BEDDING LAYER (6" THICK)
RIPRAP TYPE A (6" THICK)
RADON BARRIER (24" THICK)
RIPRAP TYPE B OR B1 (6" THICK)
TYPICAL TRANSITION FROM RIPRAP TYPE A TO TYPE B OR B1 (SEE NOTE 3)
TYP. DETAIL 3
NOT TO SCALE
LEGEND:
TOP OF ROCK
SEE DETAIL 1
RELOCATED CONTAMINATED MATERIALS
EXISTING GROUND SURFACE
EXISTING TAILINGS
IN-SITU ROCK
SEE NOTE 2
SEE SECTION G 0219 (SIMILAR)
SECTION C 0212
ELEVATION - FEET
5-9-95 AS-BUILT
10-5-94 REVISED AS PER P.I.D. NO. 09-S-24
3-21-94 REVISED AS PER P.I.D. NO. 09-S-20
9-24-93 REVISED AS PER P.I.D. NO. 09-S-18
6-18-93 REVISED AS PER P.I.D. NO. 09-S-17
8-3-92 REVISED AS PER P.I.D. NO. 09-S-15
1/31/92 ISSUED FOR CONSTRUCTION
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA
COMPLETION
TAILINGS EMBANKMENT
SECTIONS AND DETAILS
(SHEET 1 OF 2)
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
DE-AC04-83AL18796
H/M-DS-10-0215



SECTION-FILL (TYP) (A / 213)
NOT TO SCALE

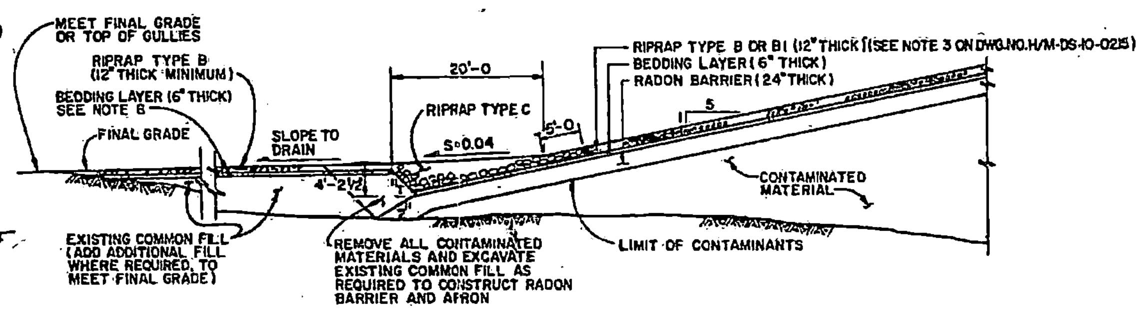


SIDESLOPE GRADING DETAIL
(SEE NOTE 10)
5 0 5 10
SCALE FEET



TYPICAL APRON IN FILL AREAS
(SEE NOTE 9)

SECTION (C)
NOT TO SCALE 0215/0219



TYPICAL APRON IN FILL AREAS
WITH RIPRAP PROTECTION BEYOND 20' APRON

SECTION (D / 0219)
(SEE NOTE 11)
10 0 10 20
SCALE FEET

NOTES:

1. IN THE KEYTRENCH AREA, EROSION RESISTANT ROCK WAS DETERMINED BY REFUSAL OF A POWER AUGER, DRILLING VERTICALLY, USING AN AUGER BIT. TRENCH BOTTOMS WERE TESTED ON MAXIMUM OF 20 FOOT CENTERS. GENERALLY EROSION RESISTANT ROCK IS NATURAL, UNDISTURBED, INTACT ROCK WHICH CANNOT BE READILY RIPPED OR LOOSENED OR BROKEN BY A BACKHOE DURING NORMAL EXCAVATION AND RINGS WHEN STRUCK WITH A GEOLOGISTS ROCK HAMMER
2. WHERE EXCAVATIONS WERE TO GO TO EROSION RESISTANT ROCK, THE SUBCONTRACTOR EXPOSED THE EROSION RESISTANT ROCK FOR INSPECTION AND LOGGED BY THE CONTRACTOR'S GEOLOGIST. ALL LOOSE MATERIAL WAS REMOVED AND THE ROCK SURFACE CLEANED TO THE ACCEPTABLE ROCK CLEANUP SURFACE. BACKFILL WAS NOT PLACED UNTIL CONTRACTOR APPROVED THE ROCK SURFACE AT THE BOTTOM OF THE EXCAVATION.
3. FOR APRON AREAS REQUIRING RIPRAP PROTECTION SEE DWG.NO. H/M-DS-10-0219.
4. LENGTH OF PIPE AND ROD OF EXISTING DISPLACEMENT MONUMENT VARIED ACCORDING TO ELEVATION OF BASE PLATE AS SHOWN ON DWG. NO. H/M-DS-10-0212.
5. WHERE THE BASE PLATE WAS LOCATED AT THE TOP OF THE RELOCATED TAILINGS (UNDERNEATH THE RADON BARRIER) THE PIPE WAS PLACED DIRECTLY ON THE PLATE. PIPES WERE NOT ATTACHED TO PLATES OR RODS.
6. PIPES AND RODS WITH TOTAL LENGTH GREATER THAN FOUR FEET WERE INSTALLED IN 4-FOOT SECTIONS AS FILL CONSTRUCTION PROGRESSES. RODS WERE SECURELY FLUSH-COUPLED AS REQUIRED. PIPES WERE SECURELY COUPLED SUCH THAT INSIDE DIAMETER IS NOT LESS THAN 1 1/2" AT ANY POINT. SUBCONTRACTOR MADE ELEVATION MEASUREMENTS OF TOP OF ROD IMMEDIATELY BEFORE AND AFTER ADDITION OF EACH ROD SECTION. PIPES WERE CAPPED AT ALL TIMES TO PREVENT ENTRANCE OF FOREIGN MATTER.
7. PIPES WERE SUPPORTED BY FILL COMPACTED BY LIGHT WEIGHT TAMPERS WITHIN FIVE FEET OF PIPES TO MEET SAME COMPACTION REQUIREMENTS AS FOR ADJACENT FILL. CARE WAS TAKEN TO ENSURE THAT PIPES REMAIN NOMINALLY CENTERED AROUND RODS.
8. BEYOND THE EMBANKMENT APRON, BEDDING LAYER WAS NOT REQUIRED IF RIPRAP WAS IN CONTACT WITH IN-SITU BEDROCK.
9. THE DEPTH TO EROSION RESISTANT ROCK BELOW POINT "A" VARIED. THE MINIMUM DEPTH WAS 15 INCHES BELOW FINAL GRADE; THE LOCATION OF POINT "A" WAS FIXED. THE SLOPE OF RIPRAP TYPE C EXTENDED TO TOP OF THE EROSION RESISTANT ROCK. LOCATION OF POINT "B" WAS VARIED.
10. SIDE SLOPE DETAIL APPLIED TO AREAS OF EXISTING SIDE SLOPE WHERE ROCK IS AT OR NEAR THE SURFACE.
11. SECTION D - APPLIED BETWEEN THE GULLIES AND THE EMBANKMENT AND OTHER AREAS WHERE DEPTH TO COMPETENT ROCK BELOW FINAL GRADE IS GREATER THAN 4'-2½".

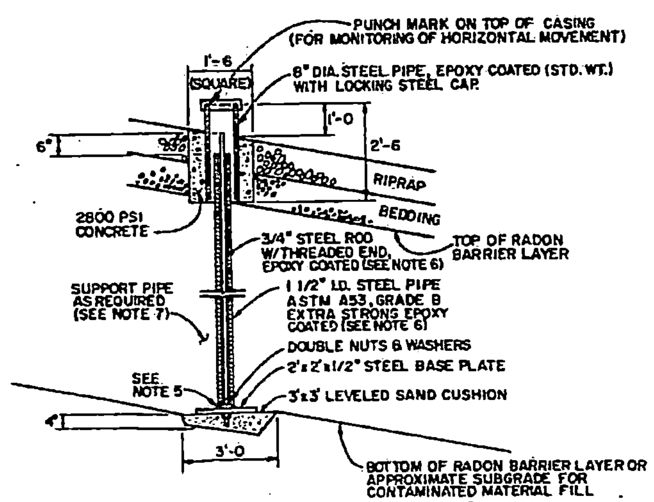
REFERENCE DRAWINGS:

H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN

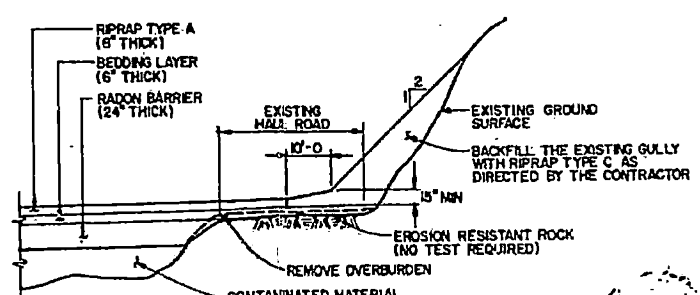
H/M-DS-10-0213 TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS

H/M-DS-10-0215 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)

H/M-DS-10-0219 HAT-EROSION PROTECTION PLAN AND SECTIONS



TYPICAL NEW DISPLACEMENT MONUMENT DETAIL
NOT TO SCALE (H/M-DS-10-0212)



SECTION (B / 213)
NOT TO SCALE

QA REVIEWED FOR QUALITY REQUIREMENTS BY [signature]

QA MK-F	NO.	DATE	REVISIONS	BY	CK	ENG MGR.	CHIEF ENG.	QA MGR.	DOE APP.
–	7	5 9 95	AS-BUILT						–

QA MK-F	NO.	DATE	REVISIONS	BY	CK	ENG MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	6	10-5-94	REVISED AS PER P.I.D. NO. 09-S-24						
	5	4-6-94	REVISED AS PER P.I.D. NO 09-S-22						
	4	3-21-94	REVISED AS PER P.I.D. NO. 09-S-20						
	3	9-24-93	REVISED AS PER P.I.D. NO. 09-S-18						
	2	5-18-93	REVISED AS PER P.I.D. NO. 09-S-17						
	1	5-5-92	REVISED AS PER P.I.D. NO. 09-S-15						
	0	1/3/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

REGISTERED PROFESSIONAL ENGINEER — PATRICK R. EARLY — STATE OF UTAH

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED: CJW | DRAWN: VMM | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE 1/4/92 | DOE PROJECT ENGINEER | DATE 1/3/92

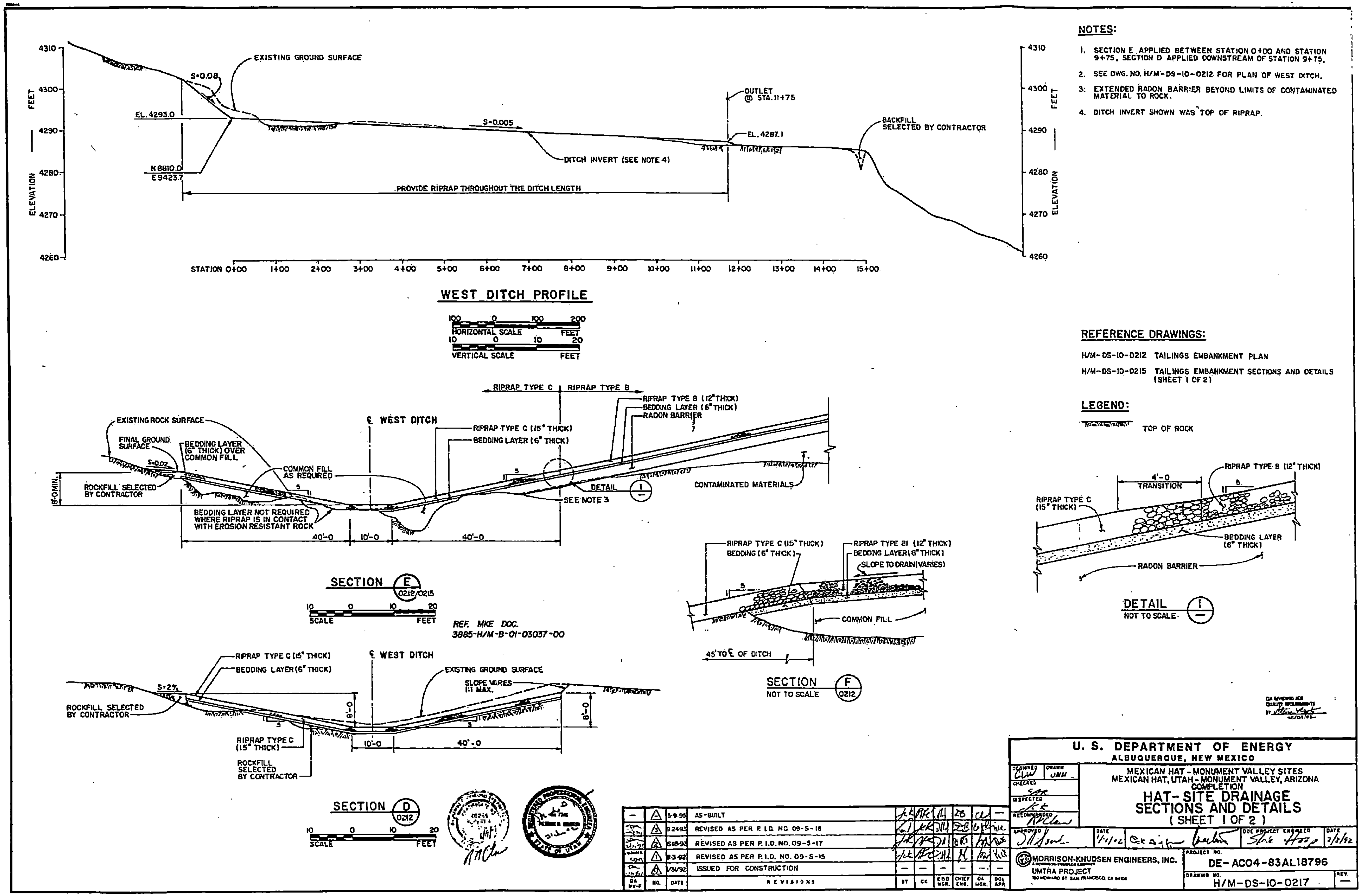
MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA
COMPLETION

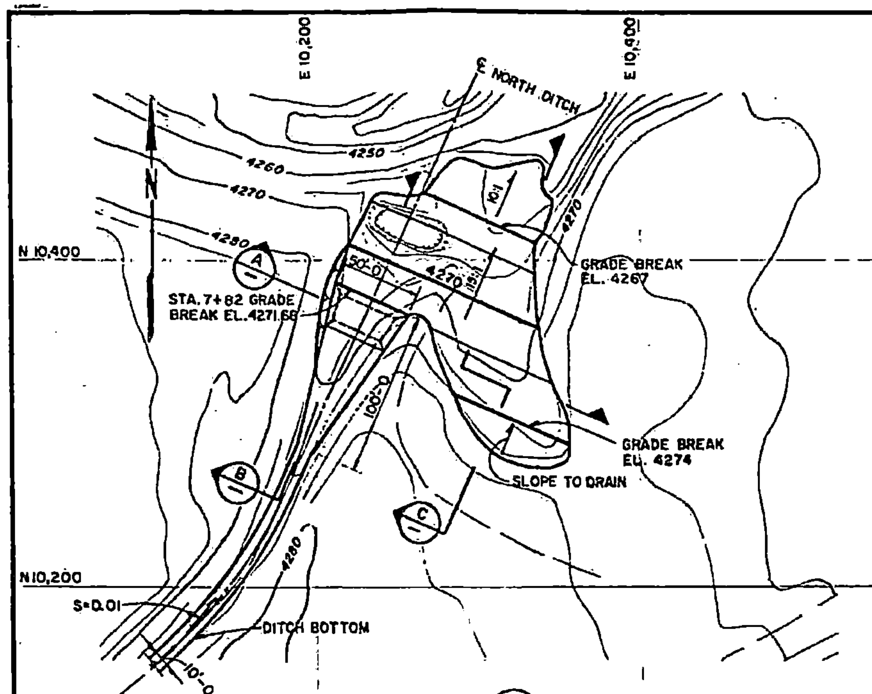
TAILINGS EMBANKMENT SECTIONS AND DETAILS
(SHEET 2 OF 2)

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

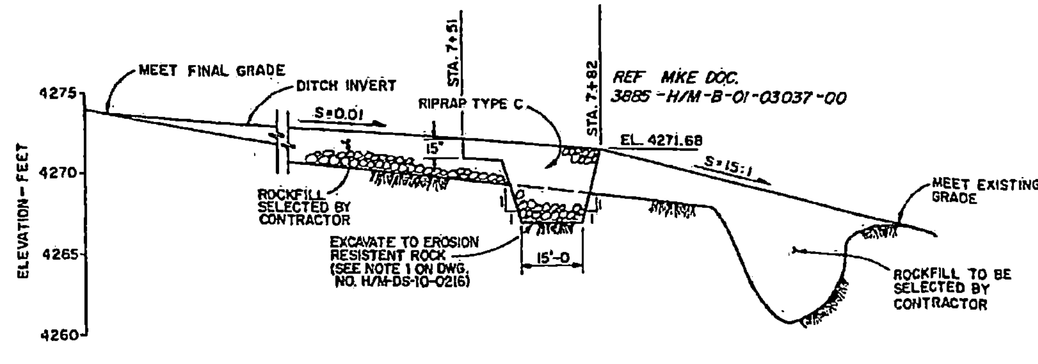
PROJECT NO. DE-AC04-83AL18796

DRAWING NO. H/M-DS-10-0216 REV. —

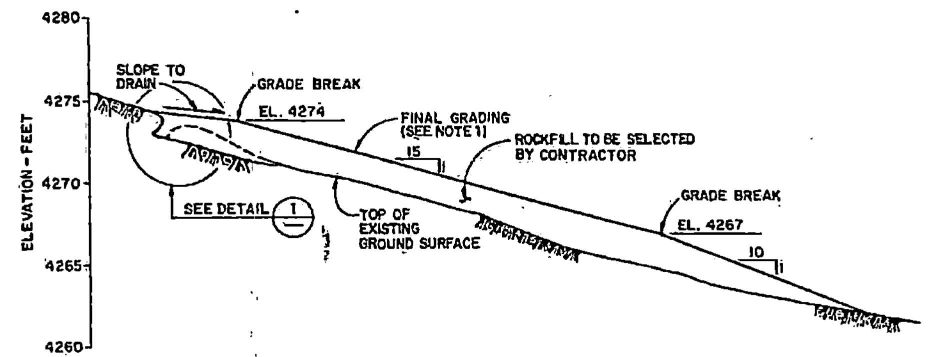

NOTES:
1. SECTION E APPLIED BETWEEN STATION 0+00 AND STATION 9+75, SECTION D APPLIED DOWNSTREAM OF STATION 9+75.
2. SEE DWG. NO. H/M-DS-10-0212 FOR PLAN OF WEST DITCH.
3. EXTENDED RADON BARRIER BEYOND LIMITS OF CONTAMINATED MATERIAL TO ROCK.
4. DITCH INVERT SHOWN WAS TOP OF RIPRAP.
EXISTING GROUND SURFACE
S=0.08
EL. 4293.0
N 6810.0
E 9423.7
S=0.005
OUTLET @ STA. 11+75
EL. 4287.1
BACKFILL SELECTED BY CONTRACTOR
DITCH INVERT (SEE NOTE 4)
PROVIDE RIPRAP THROUGHOUT THE DITCH LENGTH
ELEVATION — FEET
STATION 0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00 13+00 14+00 15+00
WEST DITCH PROFILE
HORIZONTAL SCALE FEET
VERTICAL SCALE FEET
REFERENCE DRAWINGS:
H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN
H/M-DS-10-0215 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
LEGEND:
TOP OF ROCK
RIPRAP TYPE C | RIPRAP TYPE B
RIPRAP TYPE B (12" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER
℄ WEST DITCH
EXISTING ROCK SURFACE
FINAL GROUND SURFACE
BEDDING LAYER (6" THICK) OVER COMMON FILL
RIPRAP TYPE C (15" THICK)
BEDDING LAYER (6" THICK)
COMMON FILL AS REQUIRED
ROCKFILL SELECTED BY CONTRACTOR
DETAIL 1
SEE NOTE 3
CONTAMINATED MATERIALS
BEDDING LAYER NOT REQUIRED WHERE RIPRAP IS IN CONTACT WITH EROSION RESISTANT ROCK
40'-0 10'-0 40'-0
SECTION E 0212/0215
SCALE FEET
REF. MKE DOC. 3885-H/M-B-01-03037-00
RIPRAP TYPE C (15" THICK)
BEDDING (6" THICK)
RIPRAP TYPE B1 (12" THICK)
BEDDING LAYER (6" THICK)
SLOPE TO DRAIN (VARIES)
COMMON FILL
45' TO ℄ OF DITCH
SECTION F 0212
NOT TO SCALE
4'-0 TRANSITION
RIPRAP TYPE B (12" THICK)
RIPRAP TYPE C (15" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER
DETAIL 1
NOT TO SCALE
RIPRAP TYPE C (15" THICK)
BEDDING LAYER (6" THICK)
℄ WEST DITCH
EXISTING GROUND SURFACE
SLOPE VARIES 1:1 MAX.
S=2%
ROCKFILL SELECTED BY CONTRACTOR
RIPRAP TYPE C (15" THICK)
ROCKFILL SELECTED BY CONTRACTOR
8'-0 10'-0 40'-0
SECTION D 0212
SCALE FEET
AS-BUILT
REVISED AS PER P.I.D. NO. 09-5-18
REVISED AS PER P.I.D. NO. 09-5-17
REVISED AS PER P.I.D. NO. 09-5-15
ISSUED FOR CONSTRUCTION
REVISIONS
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION
HAT-SITE DRAINAGE SECTIONS AND DETAILS
(SHEET 1 OF 2)
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
PROJECT NO. DE-AC04-83AL18796
DRAWING NO. H/M-DS-10-0217



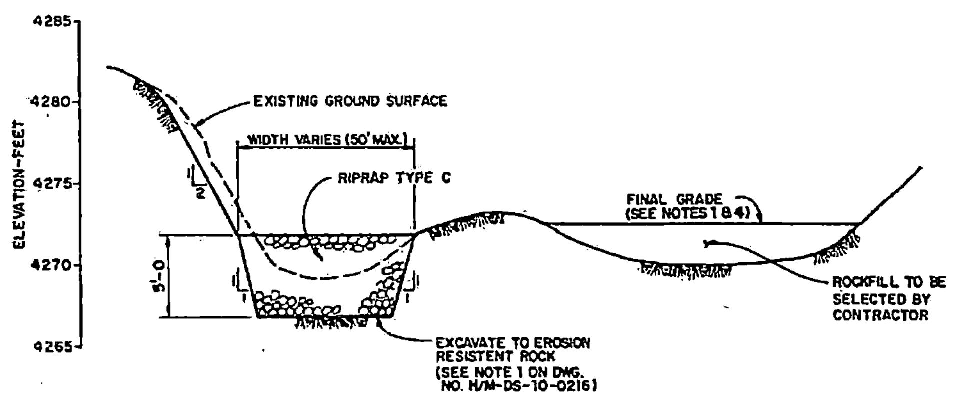
DETAIL 1 (0212)



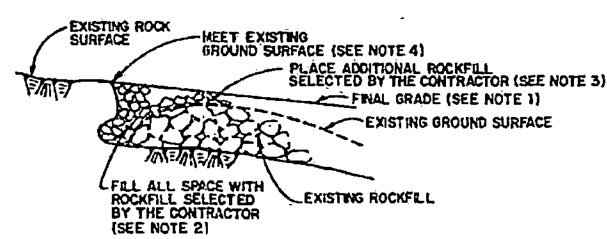
SECTION B



SECTION C



SECTION A



DETAIL 1
NOT TO SCALE

NOTES:

1. FINAL SURFACE OF ROCKFILL TO BE SELECTED BY CONTRACTOR WAS GRADED TO PROMOTE SHEET FLOW. THE SURFACE HAD NO NOTICABLE MOUNDS, RIDGES, SWALES OR DEPRESSIONS AS DETERMINED BY THE CONTRACTOR.
2. ROCKFILL SIZES WERE SELECTED TO FILL ALL SPACES AND TO AVOID NESTING. ROCKFILL SMALLER THAN 1' PIECES WERE PLACED AND COMPACTED ACCORDING TO PROCEDURES APPROVED BY THE CONTRACTOR. ROCKFILL LARGER THAN 1' WERE INDIVIDUALLY PLACED.
3. LARGER PIECES OF ROCKFILL WERE PLACED NEAR THE SURFACE.
4. ROCKFILL WERE PLACED TO MEET EXISTING GRADE AND AVOID FLOW CONCENTRATIONS BETWEEN ROCKFILL SURFACE AND EXISTING TERRAIN.

REFERENCE DRAWINGS:

H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN

H/M-DS-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)

QA MK-F	NO.	DATE	REVISIONS	BY	CK	ENG MGR.	CHIEF ENG.	QA MGR.	DOC APP.
	△								
	△								
—	△	5-9-95	AS-BUILT						—
	△	5-18-93	REVISED AS PER P.I.D. NO. 09-S-17						
	△	1/31/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED CLW | DRAWN JNN | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE 1/-1/92 | DOE PROJECT ENGINEER | DATE 2/3/92

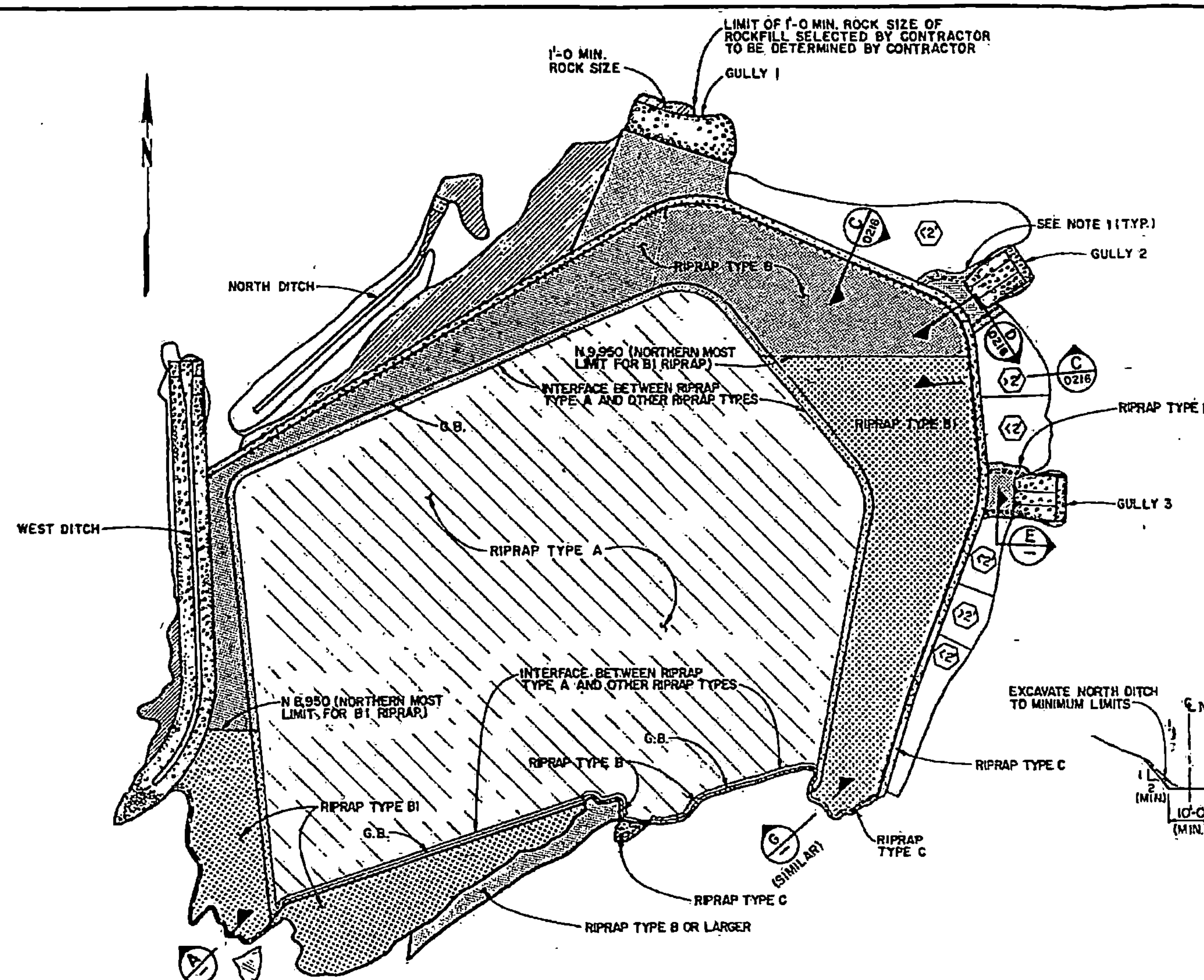
MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

HAT-SITE DRAINAGE SECTIONS AND DETAILS
(SHEET 2 OF 2)

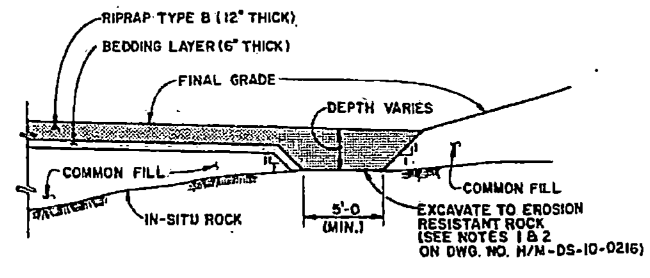
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

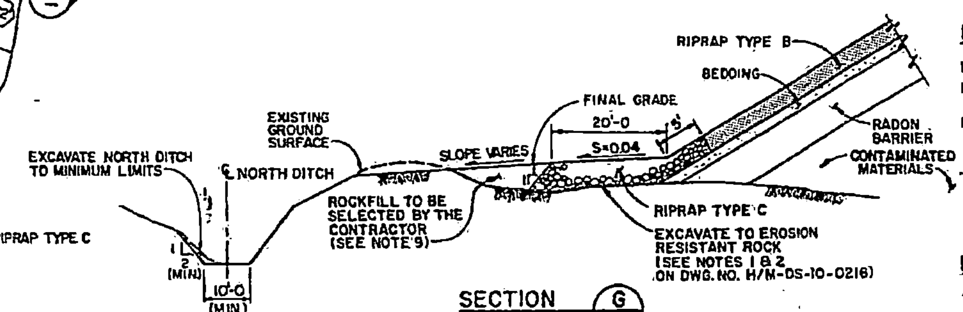
DRAWING NO. H/M-DS-10-0218 REV. —



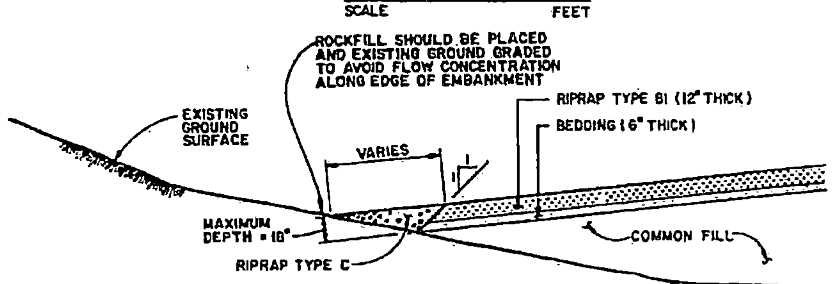
PLAN
EROSION PROTECTION



TYPICAL SECTION (E)
NOT TO SCALE
SEE NOTE 5



SECTION (G) 0212 / 0215
NOT TO SCALE
(SEE NOTE 3)



NOTE: SECTION A APPLIES WHERE EMBANKMENT SIDE SLOPES MEET EXISTING GRADE BETWEEN TOP SLOPE AND TOE OF SIDE SLOPE

SECTION (A)
SEE NOTE 4

5 0 5 10
SCALE FEET

NOTES:

1. THE OUTER LIMIT OF RIPRAP COVER SHOWN IS APPROXIMATE.
2. (NOT USED)
3. SECTION G APPLIED WHERE DEPTH TO ROCK BELOW FINAL GRADE IS 3 FEET OR LESS OR AS DIRECTED BY THE CONTRACTOR.
4. SECTION A APPLIED WHERE THE EMBANKMENT SIDE SLOPE COMES IN CONTACT WITH GROUND SURFACE. DETAIL 1 ON DWG. H/M-DS-10-0215 APPLIED WHERE THE EMBANKMENT TOP SLOPE CAME IN CONTACT WITH GROUND SURFACE.
5. SECTION E APPLIED WHEREVER THERE WAS A TRANSITION BETWEEN EROSION PROTECTION AND COMMON FILL BETWEEN THE EMBANKMENT APRON AND THE GULLIES
6. TOP OF RIPRAP TYPE C WAS GRADED TO PROVIDE SMOOTH TRANSITION TO TOP OF RIPRAP TYPE A.
7. (NOT USED)
8. (NOT USED)
9. ROCKFILL WAS PLACED IN 1 FOOT LIFTS AND COMPACTED BY TRACK WALKING.

REFERENCE DRAWINGS:

H/M-DS-10-0212	TAILINGS EMBANKMENT PLAN
H/M-DS-10-0215	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0216	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)

LEGEND:

TOP OF CUT
TOP OF FILL
TOP OF ROCK
RIPRAP TYPE A
RIPRAP TYPE B1
RIPRAP TYPE B
RIPRAP TYPE C
ROCKFILL TO BE SELECTED BY CONTRACTOR
(>2) APPROXIMATE DEPTH OF EXISTING FILL IN APRON IS LESS THAN 4' BUT GREATER THAN 2'
(<2) APPROXIMATE DEPTH OF EXISTING FILL IN APRON IS LESS THAN 2'

QA REVIEWED FOR QUALITY REQUIREMENTS BY

QA MK-T	NO.	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
—	5	5-9-95	AS-BUILT						—
	4	10-5-94	REVISED AS PER P.I.D. NO. 09-S-24						
	3	3-21-94	REVISED AS PER P.I.D. NO. 09-S-20						
	2	12-4-93	REVISED AS PER P.I.D. NO. 09-S-18						
	1	6-18-93	REVISED AS PER P.I.D. NO. 09-S-17						
	0	1-31-92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

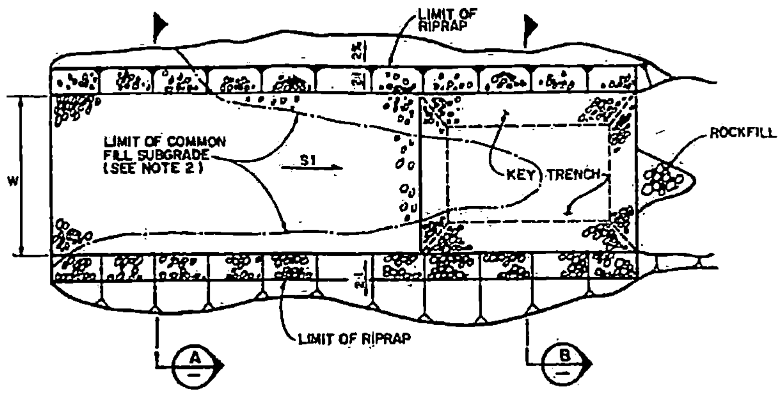
DESIGNED CLW
DRAWN JMM
CHECKED
INSPECTED
RECOMMENDED
APPROVED
DATE 1/31/92
DOE PROJECT ENGINEER
DATE 2/3/92

MEXICAN HAT–MONUMENT VALLEY SITES
MEXICAN HAT, UTAH–MONUMENT VALLEY, ARIZONA
COMPLETION

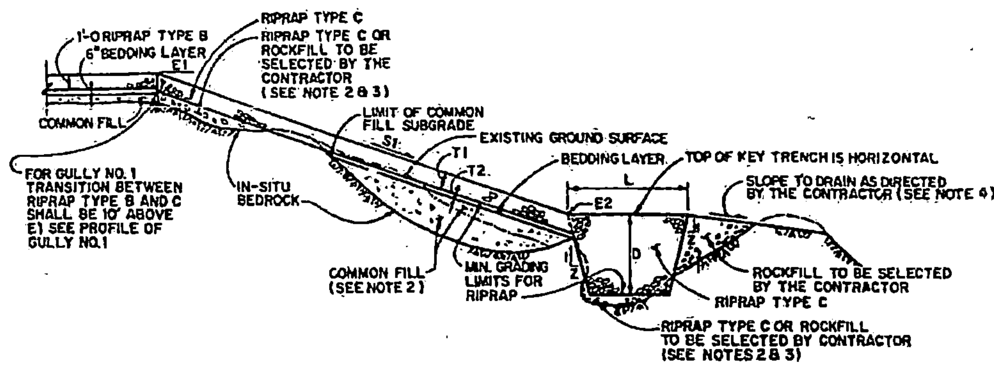
HAT–EROSION PROTECTION PLAN AND SECTIONS

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. H/M-DS-10-0219
REV. —



PLAN
TYPICAL EROSION PROTECTION AT GULLIES
(H/M-DS-10-0219)
NOT TO SCALE



TYPICAL PROFILE AT GULLIES
(SEE TABLE 1 FOR DIMENSIONS)
NOT TO SCALE

TABLE 1–SETTINGS AND DIMENSIONS OF GULLIES

GULLY	GULLIES						KEY TRENCH			SIDE-SLOPE DEPTH (FT)
	WIDTH (FT)	ELEVATION (FT)		SLOPE	THICKNESS (FT)		LENGTH (FT)	THICKNESS (FT)	SIDE-SLOPE	
	W(MIN.) *	E1	E2	S1	T1(MIN)	T2	L	D(MIN) **	Z (MIN)	H
1	292	4262	4245	0.141	1.25	0.5	VARIES	1.25	1	2
2	90	4225	4218	0.049	1.25	0.5	25	1.25	1	2
3	100	4266	4253	0.108	1.25	0.5	25	1.25	1	2

* WIDTH MAY BE WIDER IF EXPOSED SIDE SLOPE EXCAVATIONS WERE ON EROSION RESISTANT ROCK.

** KEY TRENCH WAS EXTENDED DOWN TO EROSION RESISTANT ROCK.

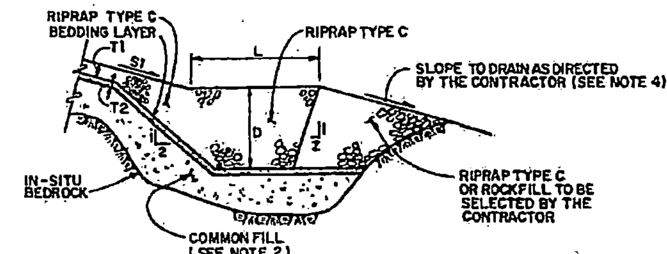
NOTES:

1. THE OUTER LIMIT OF RIPRAP COVER SHOWN WAS APPROXIMATE. FINAL LIMIT WAS DETERMINED BY THE CONTRACTOR IN THE FIELD DURING CONSTRUCTION.
2. WHERE EXISTING SUBGRADE CONSISTED OF COMMON FILL A BEDDING LAYER WAS PLACED BETWEEN THE RIPRAP AND THE FILL. WHERE EXISTING SUBGRADE CONSISTED OF IN-SITU ROCK OR ROCKFILL SELECTED BY THE CONTRACTOR, NO BEDDING LAYER WAS REQUIRED.
3. IN AREAS WHERE EXISTING GRADE WAS ABOVE THE MINIMUM GRADING LIMIT, THE AREA WAS EXCAVATED TO OR BELOW THE MINIMUM LIMIT. WHERE EXISTING GRADE WAS BELOW THE MINIMUM LIMIT, THE AREA WAS BACKFILLED WITH TYPE C RIPRAP OR ROCKFILL TO BE SELECTED BY THE CONTRACTOR AS SHOWN.
4. SLOPE WAS 10% MAX.
5. ALONG GULLY BOTTOM AND SIDESLOPES SURFACES, THERE WAS NO TRANSITION BETWEEN RIPRAP AND INSITU ROCK.
6. ROCKFILL SELECTED BY CONTRACTOR PLACED BELOW GULLY NO. 1 WAS T MINIMUM ROCK SIZE. ROCK PIECES WAS PLACED INDIVIDUALLY TO MINIMIZE VOIDS. IRREGULARITIES IN THE FINISHED SURFACE, CONSISTANT WITH THE ROCK SIZES, WAS ALLOWED.

REFERENCE DRAWINGS:

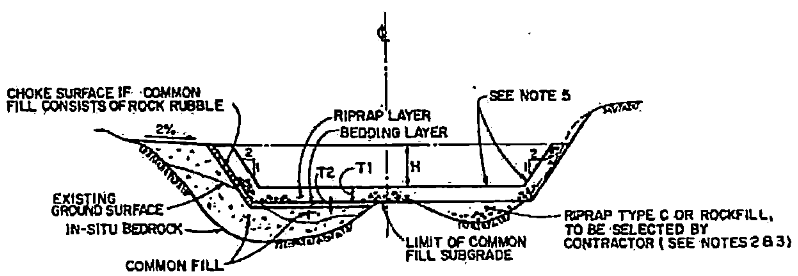
H/M-DS-10-0216 TAILING EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)

H/M-DS-10-0219 HAT-EROSION PROTECTION PLAN AND SECTIONS.

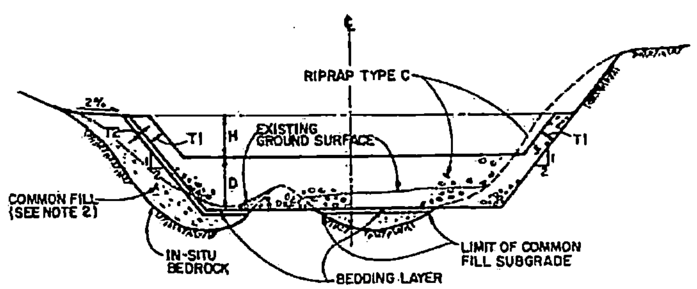


TYPICAL KEY TRENCH DETAIL IN COMMON FILL
(SEE TABLE 1 FOR DIMENSIONS)
NOT TO SCALE

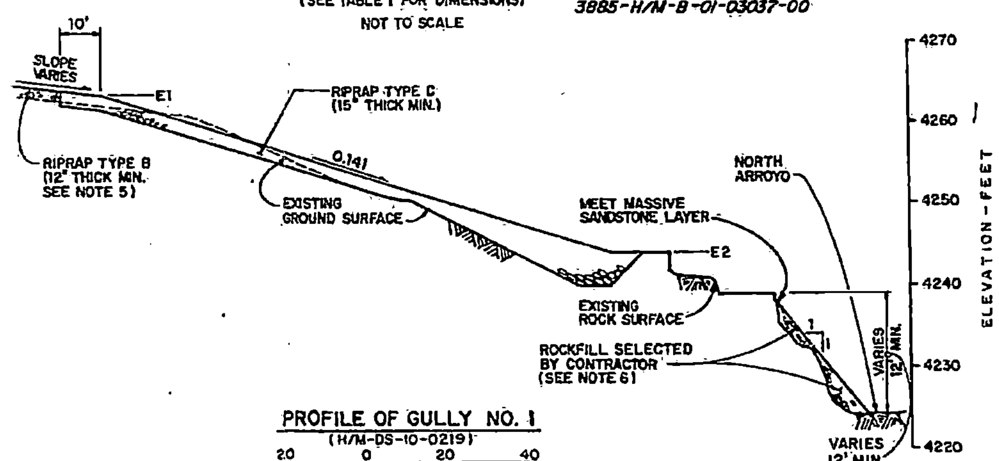
REF. MKE DOC. 3885-H/M-B-01-03037-00



TYPICAL GULLIES SECTION (A)
(SEE NOTE 2)
NOT TO SCALE



TYPICAL KEY TRENCH SECTION (B)
(SEE NOTE 2 AND TABLE 1 FOR DIMENSIONS)
NOT TO SCALE



PROFILE OF GULLY NO. 1
(H/M-DS-10-0219)

20 0 20 40
HORIZONTAL SCALE FEET
10 0 10 20
VERTICAL SCALE FEET

LEGEND:

TOP OF CUT

TOP OF FILL

TOP OF ROCK

	△									
	△									
—	△	5-9-95	AS-BUILT							
	△	5-18-93	REVISED AS PER P.I.D. NO. 09-S-17							
	△	7/31/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—
QA NO.-F	NO.	DATE	REVISIONS	BY	CK	ENG MGR.	CHIEF ENG.	QA MGR.	DOC APP.	

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA
COMPLETION

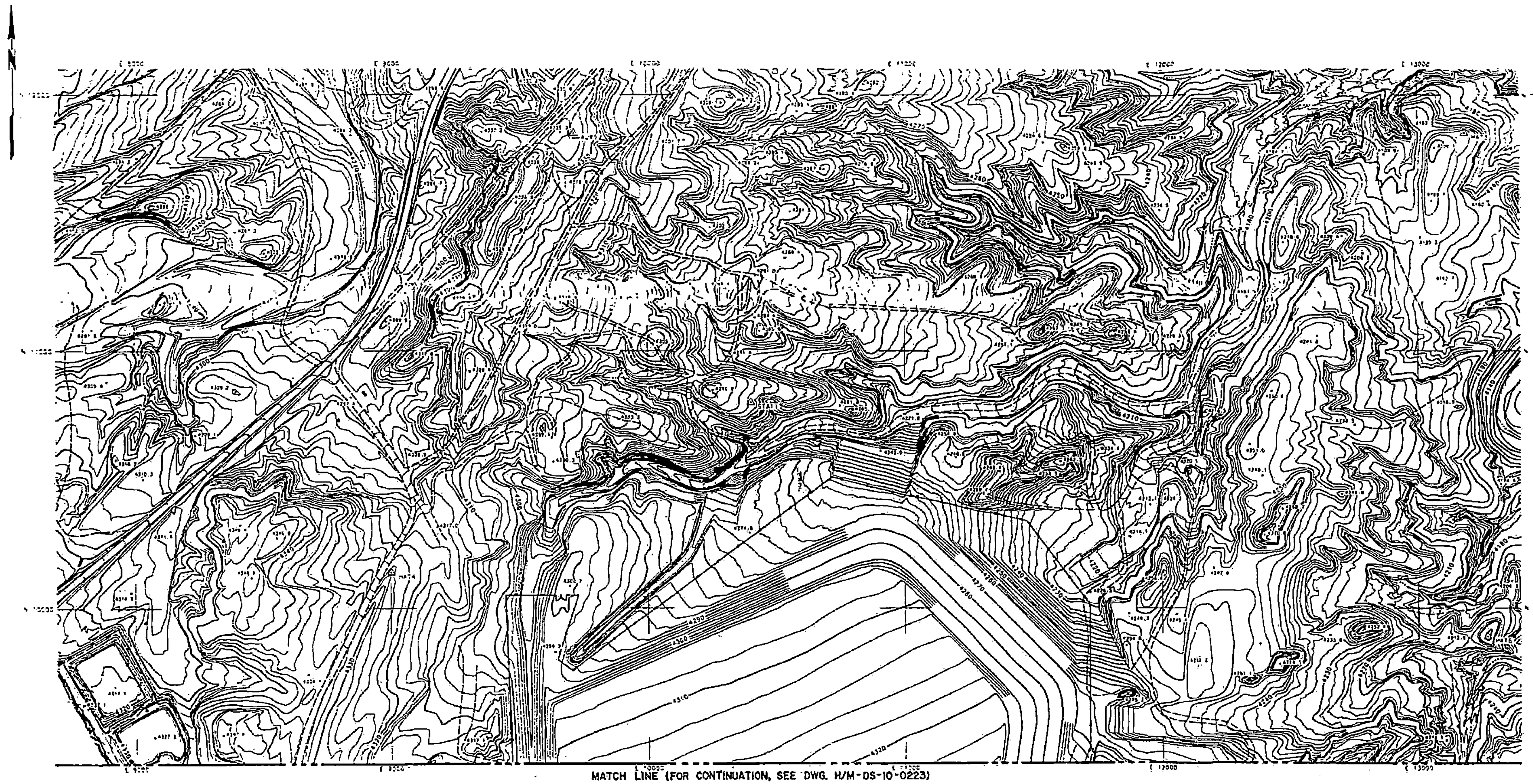
HAT-GULLY DETAILS

DESIGNED | DRAWN RBC | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE | DOE PROJECT ENGINEER | DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. H/M-DS-10-0220



NOTE:

1. TOPOGRAPHY IS PROVIDED BY AERO-GRAPHICS INC., SALT LAKE CITY, UTAH BASED ON AERIAL PHOTOGRAPHY DATED FEBRUARY 23, 1995:

LEGEND:

FENCE

UNIMPROVED ROAD

FLOWPATH.

AUX2 SURVEY CONTROL POINT

UTILITY POLE

REFERENCE DRAWINGS:

H/M-DS-10-0223 HAT AS-BUILT TOPOGRAPHIC MAP (SHEET 2 OF 2)

200 0 200 400
SCALE FEET

—	△	5-9-95	AS-BUILT						—
QA MK-F	NO	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED — DRAWN —
CHECKED —
INSPECTED —
RECOMMENDED —

MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA

HAT - AS BUILT
TOPOGRAPHIC MAP
(SHEET 1 OF 2)

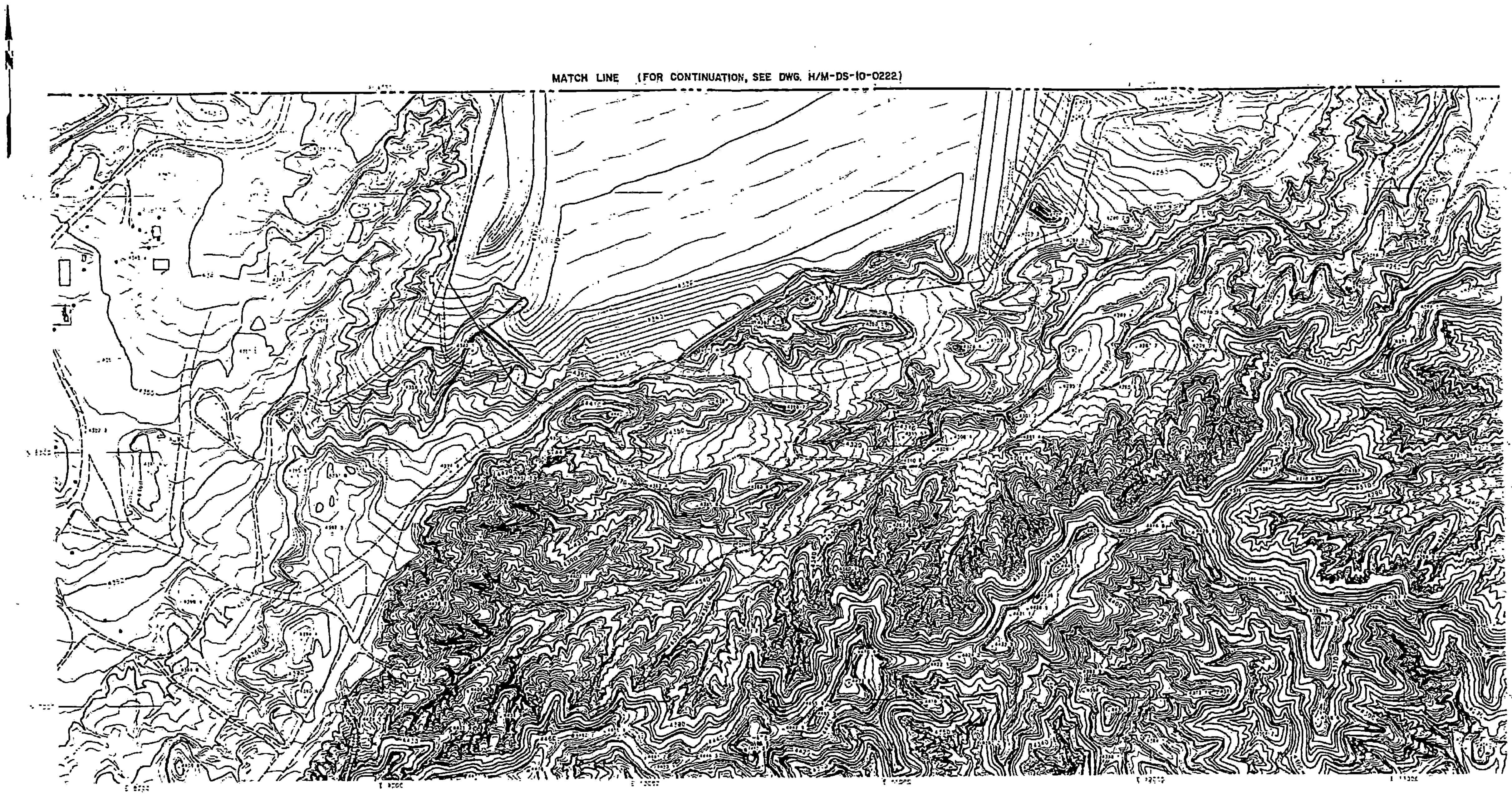
APPROVED — DATE — — DOE PROJECT ENGINEER — DATE —

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796

DRAWING NO H/M-DS-10-0222 REV —

MATCH LINE (FOR CONTINUATION, SEE DWG. H/M-DS-10-0222)



200 0 200 400
SCALE FEET

NOTE:

1. TOPOGRAPHY IS PROVIDED BY AERO-GRAPHICS INC., SALT LAKE CITY, UTAH BASED ON AERIAL PHOTOGRAPHY DATED FEBRUARY 23, 1995.

LEGEND:

FENCE	AUX2 SURVEY CONTROL POINT
UNIMPROVED ROAD	UTILITY POLE
FLOWPATH	

REFERENCE DRAWINGS:

H/M-DS-10-0222 HAT AS-BUILT TOPOGRAPHIC MAP (SHEET 1 OF 2)

QA MK-F	NO	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP
—	△	5-9-95	AS-BUILT						—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

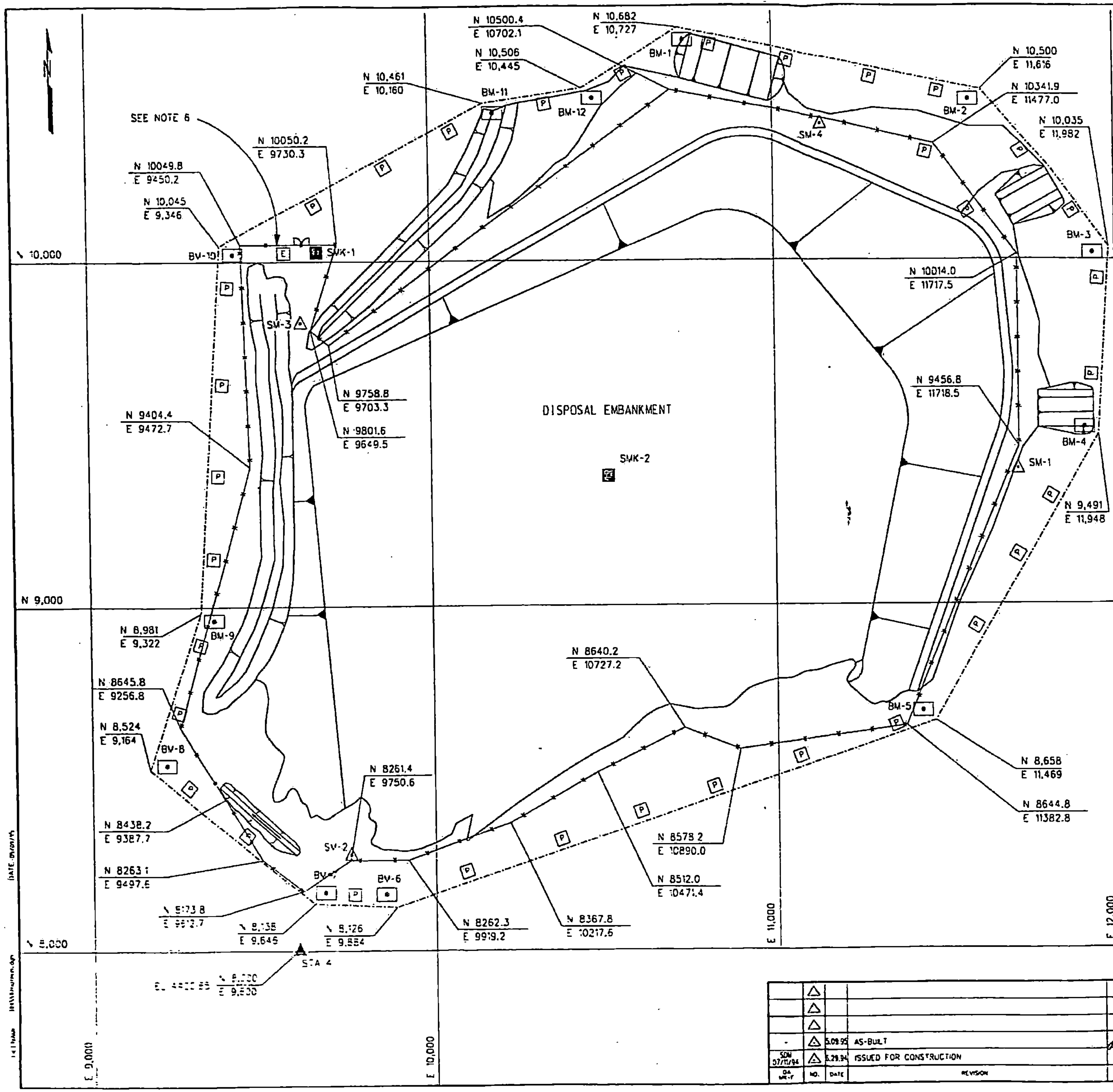
MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA

HAT - AS BUILT TOPOGRAPHIC MAP
(SHEET 2 OF 2)

DESIGNED — DRAWN — CHECKED — INSPECTED — RECOMMENDED — APPROVED — DATE — DOE PROJECT ENGINEER — DATE —

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO H/M-DS-10-0223 REV —



NOTES:

1. SURFACE FEATURES SHOWN ARE APPROXIMATE.
2. FOR DISPLACEMENT MONUMENT LOCATION, SEE DWG. NO. H/M-DS-10-0212.
3. THE BOUNDARY MONUMENTS WERE OFFSET 10 FEET ALONG THE NORTHERLY AND EASTERLY AXIS FROM THE SITE BOUNDARY CORNERS INSIDE THE LEGAL SITE BOUNDARIES.
4. PERIMETER SIGNS WERE LOCATED 5 FEET INSIDE THE DISPOSAL SITE BOUNDARY. THE ENTRANCE SIGN SHALL BE LOCATED IMMEDIATELY ADJACENT TO THE ENTRANCE GATE 5 FEET INSIDE THE FENCE.
5. GRANITE SITE MARKER SMK-1 WERE SET ADJACENT TO THE ENTRANCE AT A DISTANCE OF 10 FEET INSIDE THE FENCE LINE SUCH THAT IT DOES NOT RESTRICT VEHICULAR TRAFFIC.
6. WHERE CROSSING THE WEST DITCH, THE FENCE WERE CONSTRUCTED SUCH THAT POSTS AND WIRES DO NOT OBSTRUCT DITCH FLOW, AS DIRECTED BY THE CONTRACTOR

LEGEND:

△ SM-1	PERMANENT SURVEY MONUMENT
▲ STA 4	EXISTING SURVEY MONUMENT
BM-2	PERMANENT BOUNDARY MONUMENT (SEE NOTE 3)
SMK-2	GRANITE SITE MARKER
P	PERIMETER SIGN (SEE NOTE 4)
E	ENTRANCE SIGN (SEE NOTE 4)
	CHAIN LINK FENCE AND 40' WIDE DOUBLE LEAF SWING GATE
	BARBED WIRE FENCE
	EMBANKMENT
	SITE BOUNDARY

REFERENCE DRAWINGS:

H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN

LOCATION OF MONUMENTS

DESCRIPTION	NORTHING	EASTING	ELEVATION
BM-1	10,672.0	10,737.2	4238.86
BM-2	10,490.1	11,606.0	4240.18
BM-3	10,025.1	11,972.0	4252.01
BM-4	9,501.0	11,938.1	4254.65
BM-5	8,668.1	11,459.1	4301.40
BM-6	8,131.2	9,879.2	4437.75
BM-7	8,188.1	9,646.0	4366.98
BM-8	8,534.2	9,174.1	4315.51
BM-9	8,971.4	9,332.4	4303.84
BM-10	10,035.1	9,356.0	4309.36
BM-11	10,451.0	10,170.0	4270.26
BM-12	10,496.1	10,455.0	7275.18
SMK-1	10,038.8	9,719.6	4300.54
SMK-2	9,376.3	10,514 7	4319.08
SM-1	9,664.5	11,862.4	4274.57
SM-2	8,275.0	9,749.4	4363.84
SM-3	10,072.5	9,717.4	4299.68
SM-4	10,435.1	11,313.0	4269.03

0ft 150 300 450ft
SCALE

QA	NO.	DATE	REVISION	BY	CK	ENG MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	△								
	△								
	△								
-	△	5.09.95	AS-BUILT	J.K	AC	DM	SB	CR	-
SDM 07/11/94	△	6.29.94	ISSUED FOR CONSTRUCTION	-	-	-	-	-	-

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT AND MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, AZ
LONG-TERM SURVEILLANCE PLAN - PART 1

LOCATION OF MONUMENTS, MARKERS AND SIGNS

DESIGNED DRW | DRAWN RGS
CHECKED J. C. KUO
INSPECTED W. LIN
RECOMMENDED R. F. CLARE
APPROVED D.R. SANDERS | DATE 6/29/94 | D. BOLTON 6/29/94 | C. RICKETS 6/29/94 | DOE PROJECT ENGINEER R EDGE | DATE 7/--/94

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO DE-AC04-83AL18796
DRAWING NO H/M-DS-10-0240

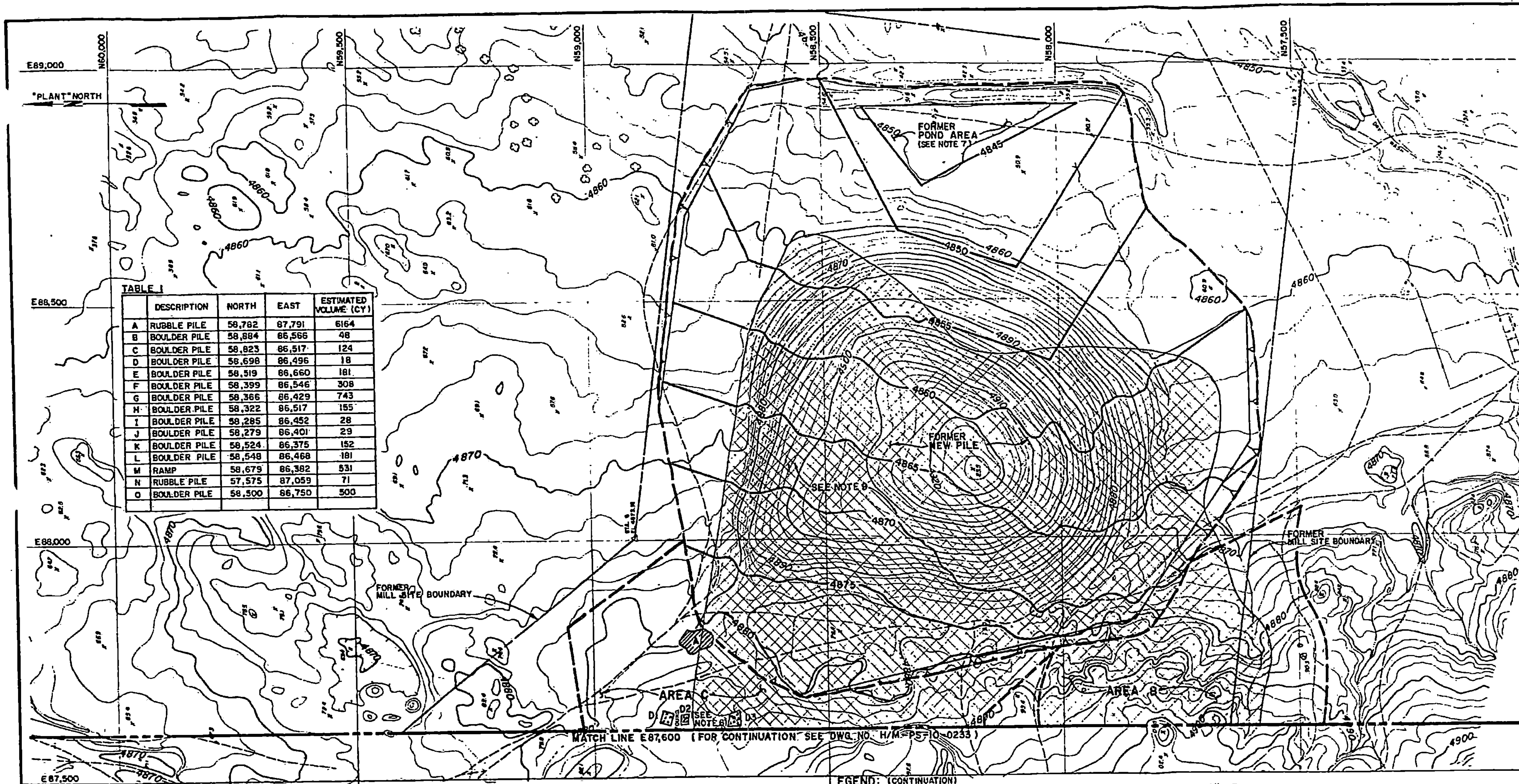


TABLE I

	DESCRIPTION	NORTH	EAST	ESTIMATED VOLUME (CY)
A	RUBBLE PILE	58,782	87,791	6164
B	BOULDER PILE	58,884	86,566	48
C	BOULDER PILE	58,823	86,517	124
D	BOULDER PILE	58,698	86,496	18
E	BOULDER PILE	58,519	86,660	181
F	BOULDER PILE	58,399	86,546	308
G	BOULDER PILE	58,366	86,429	743
H	BOULDER PILE	58,322	86,517	155
I	BOULDER PILE	58,285	86,452	28
J	BOULDER PILE	58,279	86,401	29
K	BOULDER PILE	58,524	86,375	152
L	BOULDER PILE	58,548	86,468	181
M	RAMP	58,679	86,382	531
N	RUBBLE PILE	57,575	87,059	71
O	BOULDER PILE	58,500	86,750	500

NOTES:

1. EXCAVATION OF CONTAMINATED MATERIAL IN AREAS A, B, C, E AND THE OLD PILE WERE AT THE DIRECTION OF THE CONTRACTOR IN THE FIELD. DEPTHS OF CONTAMINATION IN AREAS C, E AND THE OLD PILE AVERAGED 1 FOOT, HOWEVER THE ROCKY TERRAIN PROHIBITED LEVEL EXCAVATION.
2. EXCAVATION PLAN SHOWN IS APPROXIMATE. ACTUAL DEPTHS AND EXTENT OF EXCAVATION WERE DETERMINED IN THE FIELD BY THE CONTRACTOR BASED ON RADIOLOGICAL SURVEYS.
3. EXCAVATED SLOPES WERE NOT EXCEED 2 (H): 1 (V) FOR CUTS IN SOIL. ROCK SLOPES WERE AS DIRECTED BY THE CONTRACTOR.
4. THE AREAS SHOWN WERE BASED ON THE BENDIX REPORT WHICH IS INCLUDED IN THE INFORMATION FOR BIDDERS.
5. LOCATIONS AND QUANTITIES FOR RUBBLE AND BOULDER PILES (SEE TABLE I) SUPERCEDED THE VALUES GIVEN IN THE BENDIX REPORT.
6. LOCATION OF FACILITIES DEMOLISHED WERE APPROXIMATE.
7. THE POND LINER AND ANY UNDERLYING CONTAMINATED MATERIAL WERE REMOVED AFTER ALL OTHER CONTAMINATED MATERIALS AT THE MONUMENT VALLEY SITE HAVE BEEN REMOVED.
8. ALL COORDINATES SHOWN ARE "PLANT" COORDINATES UNLESS NOTED OTHERWISE.
9. SURFACE AND CONDITION OF ROCK UNDER CONTAMINATED MATERIALS WERE IRREGULAR AND VARIED WIDELY.

19

REFERENCE DRAWINGS:

H/M-PS-10-0233 MON-CONTAMINATED MATERIAL EXCAVATION PLAN (SHEET 2 OF 2)

LEGEND:

TOP OF CUT

LEGEND: (CONTINUATION)

—4870— APPROX. BOTTOM CONTOURS OF EXCAVATIONS

LIMIT OF CONTAMINATED AREA

MILL SITE BOUNDARY

(A) NOT TO SCALE RUBBLE OR BOULDER PILE (SEE NOTE 5 AND TABLE I)

DI FACILITY TO BE DEMOLISHED AND ID NUMBERS SEE INFORMATION FOR BIDDERS FOR DETAILS

AREA OF ROCK CLEANUP

SCALE 100 0 100 200 FEET

NO	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	5/9/95	AS-BUILT						—
	1/31/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT – MONUMENT VALLEY SITES
MEXICAN HAT, UTAH – MONUMENT VALLEY, ARIZONA
COMPLETION

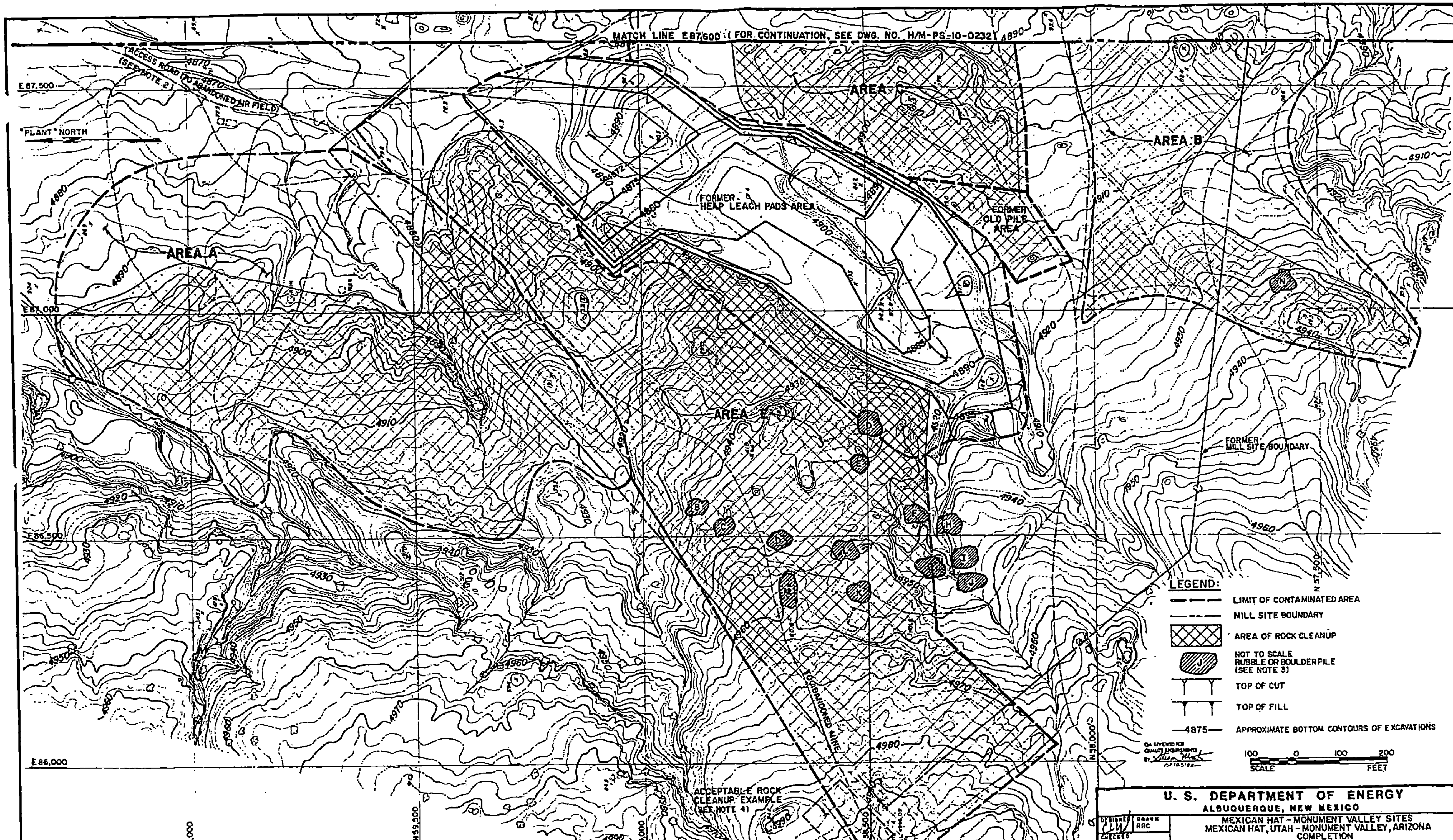
MON-CONTAMINATED MATERIAL EXCAVATION PLAN
(SHEET 1 OF 2)

DESIGNED / DRAWN RBC / CHECKED / INSPECTED / RECOMMENDED / APPROVED / DATE 1/7/92 / DOE PROJECT ENGINEER / DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. H/M-PS-10-0232 REV. —



NOTES:

1. FOR ADDITIONAL NOTES SEE DRAWING NO. H/M-PS-10-0232.
2. CONTAMINATED MATERIALS WERE REMOVED WITHIN 100' FROM THE CENTERLINE OF THE ACCESS ROAD TO THE ABANDONED AIRFIELD TO NORTHING 63,400.
3. SEE TABLE 1 ON DWG. NO. H/M-PS-10-0232 FOR THE COORDINATES AND VOLUMES OF THE RUBBLE AND BOULDER PILES.
4. THE FINAL ROCK SURFACE OF OFF-PILE CLEANUP WAS SIMILAR TO THE ACCEPTABLE ROCK CLEANUP EXAMPLE AREA OR AS APPROVED BY THE CONTRACTOR.
5. EXCAVATION PLAN SHOWN IS APPROXIMATE. ACTUAL DEPTHS AND EXTENT OF EXCAVATION WERE DETERMINED IN THE FIELD BY THE CONTRACTOR BASED ON RADIOLOGICAL SURVEYS.

REFERENCE DRAWINGS:

H/M-PS-10-0232 CONTAMINATED MATERIAL EXCAVATION PLAN (SHEET 1 OF 2)

REGISTERED PROFESSIONAL ENGINEER No. 7346 PATRICK B. BOETTG STATE OF UTAH

QA REVIEWED FOR QUALITY REQUIREMENTS BY

QA MK-F	NO.	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
–		5/5/95	AS-BUILT						–
		3/31/92	ISSUED FOR CONSTRUCTION	–	–	–	–	–	–

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

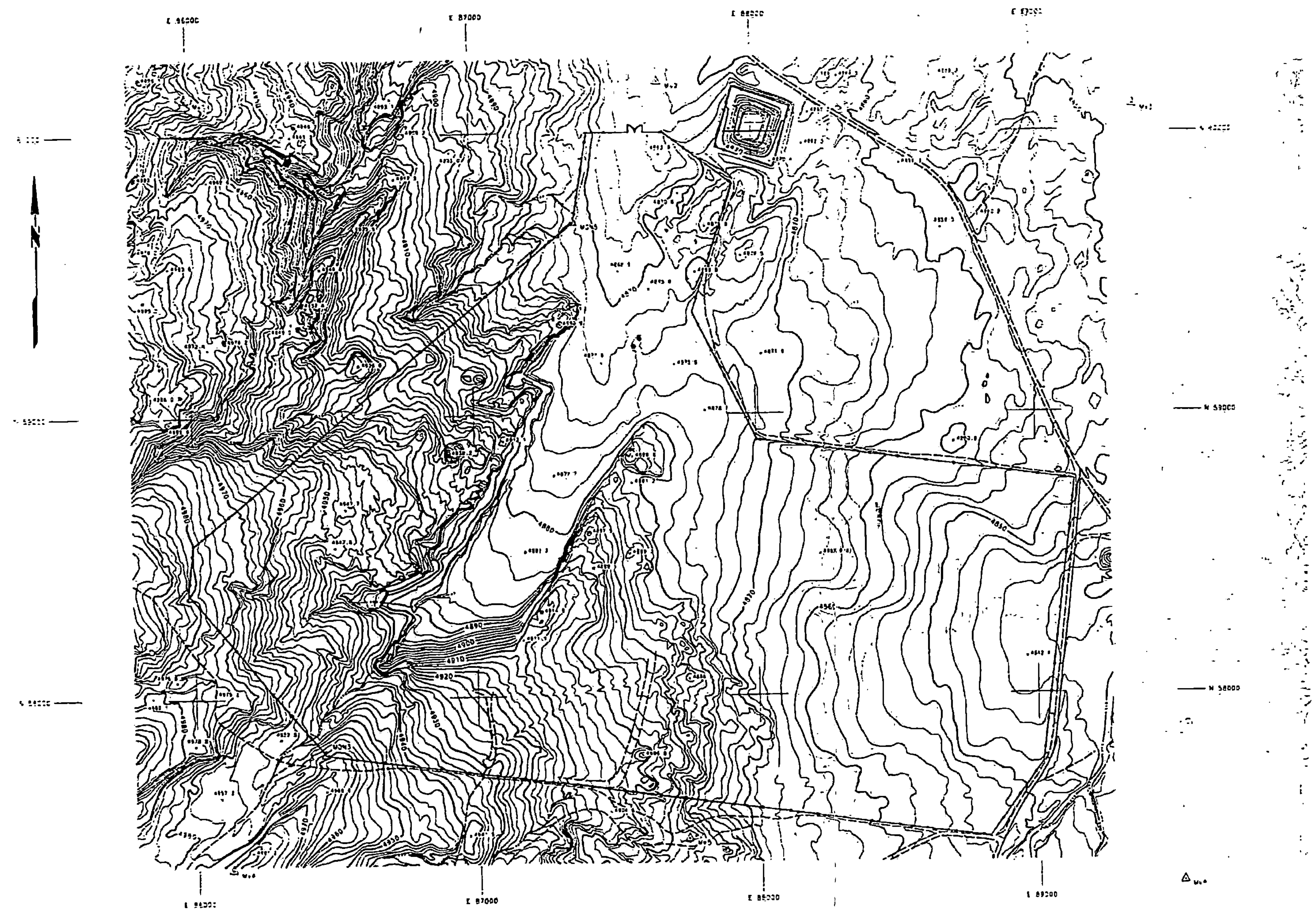
MON-CONTAMINATED MATERIAL EXCAVATION PLAN
(SHEET 2 OF 2)

DESIGNED CLW | DRAWN RBC | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE 1/31/92 | DOE PROJECT ENGINEER | DATE 2/3/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. H/M-PS-10-0233 REV. —



NOTE:

1. TOPOGRAPHY IS PROVIDED BY AERO-GRAPHICS INC., SALT LAKE CITY, UTAH BASED ON AERIAL PHOTOGRAPHY DATED FEBRUARY 23, 1995.

LEGEND:

———	FENCE
═══	UNIMPROVED ROAD
—...—	FLOWPATH
△MV2	SURVEY CONTROL POINT
●	UTILITY POLE

200 0 200 400
SCALE FEET

—	△	5/9/95	AS - BUILT						—
QA MK-F	NO	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA

MON-AS BUILT
TOPOGRAPHIC MAP

DESIGNED — DRAWN — CHECKED — INSPECTED — RECOMMENDED — APPROVED — DATE — DOE PROJECT ENGINEER — DATE —

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO H/M-PS-10-0237 REV —

Appendix C4

Site Visit Report, June 30, 2016

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Site Visit Report

Refer to the Quality Assurance Manual *Section 1.5.3.4 for a description of this process.*

Assessment Title *(Site Visit of NE Slope and Areas east of cell)*:	**Site** *(Mexican Hat Site Mexican Hat UT)*:
Land Survey of additional depressions and meet with Cassandra Bloedel of the NN EPA about areas of concern	Mexican Hat, UT, Site Mexican Hat

Date(s) Performed: June 30 2016

Site Manager or Lead: Joey Gillespie

Issued By: Joey Gillespie **Date Issued:** 7/21/2016

Purpose and Scope *(reason for site visit assessment and scope of area examined)*:

- Meet Navarro land survey crews at the Mexican Hat Disposal cell north east slope to identify and survey in additional depressions at the base of the slope.
- Meet with Navajo Nation EPA Cassandra Bloedel and Frederic Sherman. About areas of elevated radiation readings in the area of the former mill site. Area was previously investigated and deemed clean in 2011

Summary and Results *(brief summary of results including what was examined and what was observed)*:

08:30-09:58 brief crews and NN EPA to the Plan of the Day and JSA

09:58 -11:00 discuss finding of mill balls in 2011;size and shape.;NN EPA points out old haul road as one of the areas of concern also what appears to be stained soil and rock and pushed up dirt against the former haul road edges. NN EPA also mentions that ore could have been spilled from the haul trucks

11:00 -11:16 Branden and Trisha (Navarro Land Surveyors)on site; brief to the JSA and POD and begin setting up for the survey. NN AML Jonie and DOE LM Angelita off site to visit the Monument Valley site. J Gillespie stays with the surveyors. NN EPA off site back to their office.

11:00 – 13:00 Surveyors setting up instruments.

13;00-1530 Surveyors work to tie in the existing and additional cell cover depressions

14:00 all crews off site for the day and headed back to Grand Juncition

Conclusions *(detailed description of processes and areas examined. Describe problem areas as well as positive practices. Include action items that were completed during site visit)*:

Nothing to conclude at this time

Action Items *(follow-up with site manager or lead on action items listed)*:

- Angelita to coordinate with AML and NN EPA for radiation survey of the areas of concern.
- Surveyors to return if necessary to complete land survey of areas of concern
- Review old photographs and drawings to determine location of former haul roads and potential origin of mill balls
- NN EPA to provide photos of the mill balls to Angelita
- Keep Jonie of NN AML informed of site visits and dates of the rad survey.
- Send Construction Completion Reports for Mexican Hat to Jonie at AML:
- Send Gas Hills East reports to Gilbert of NN AML

Observations *(examples: Consider repainting door when weather permits. Housekeeping is exceptionally good)*:

- Dark staining is partially moisture on the top of sediments. Dark staining on the former haul road near the old mill site is attributed to baking by ash and lava during the activity from Mount Ahambra.
- Some former T posts were flagged that potentially outline the former staging area for the surveyors to locate
- No Mill balls or other mill related materials were noted during the walkover

U.S. Department of Energy Office of Legacy Management

Assessment Title *(Site Visit of NE Slope and Areas east of cell)*:	**Site** *(Mexican Hat Site Mexican Hat UT)*:
Land Survey of additional depressions and meet with Cassandra Bloedel of the NN EPA about areas of concern	Mexican Hat, UT, Site Mexican Hat

•

Documents/Procedures Reviewed *(reference information or required documents used to prepare for and conduct the site visit)*:

- Mexican Hat Construction Completion reports
- Prior Areas of Concern Trip Report performed in 2011

Persons Contacted:

Casandra Bloedel NN EPA
Joni Nofchissey NN AML

E-Mail Distribution *(include site manager or lead, responsible manager, program manager and their administrative assistant, Corrective Action, and affected individuals)*:

Angelita.Denny@lm.doe .gov
Joey.gillespie@lm.doe.gove
Gj.rc@lm.doe.gov

	
Photo 1 South over Area of Concern	Photo 2. South and East over Area of Concern
	
Photo 3. Former Mill buildings near Area of Concern	Photo 4 NN EPA Personnel pointing out elevated areas
	
Photo 5. Former Road Bed East of Disposal cell	Photo 6 View East of Access Road and Area of Concern

Photo 7 NN EPA Walking over Darker Soils

Photo 8 Dark staining of soils within Area of Concern

Photo 9. Darker soils near possible haul road east of the cell

Photo 10 Soil accretion within Area of Concern

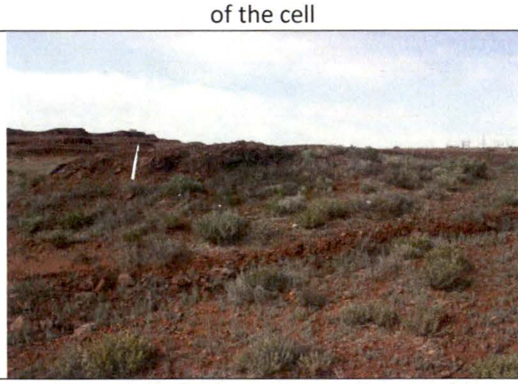


Photo 11. Stained Soil at the end of a possible haul road East of the site

Photo 12. Mexican Hat Disposal cell east of the Area of Concern in foreground

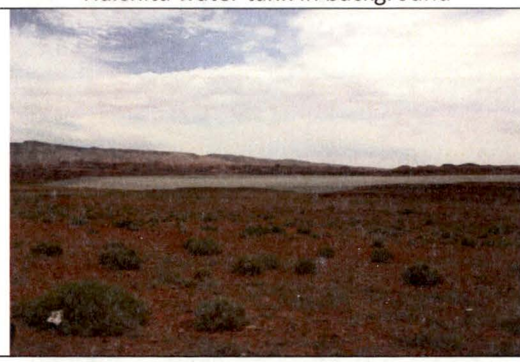
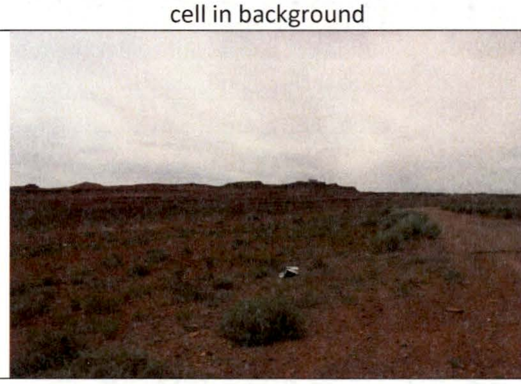
	
Photo 13. View southeast of Area of Concern Disposal Cell to the Left of Photo	Photo 14. View southeast of area of concern with Halchita water tank in background
	
Photo 15. Remnant of steel T post	Photo 16. East of Area of Concern with Disposal cell in background
	
Photo 17. Area of Concern with Disposal Cell in background	Photo 18. Area of Concern along access road east of the Disposal Cell

Photo 19. Surveyors gathering data on existing depressions on the northeast side slope of the Mexican Hat Disposal Cell

Photo 20. Surveyors gathering data on existing depressions on the northeast side slope of the Mexican Hat Disposal Cell

Photo 21 Red outlines of depressions near the toe of northeast slope and Gully #2

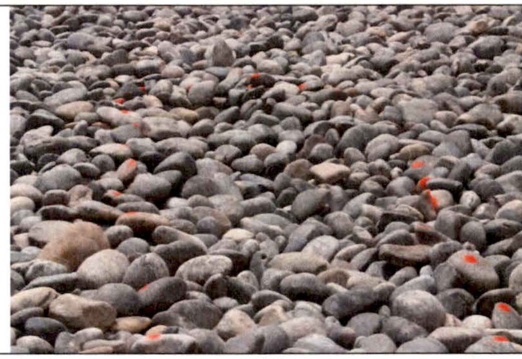


Photo 22 Red outlines of depressions near the toe of northeast slope and Gully #2

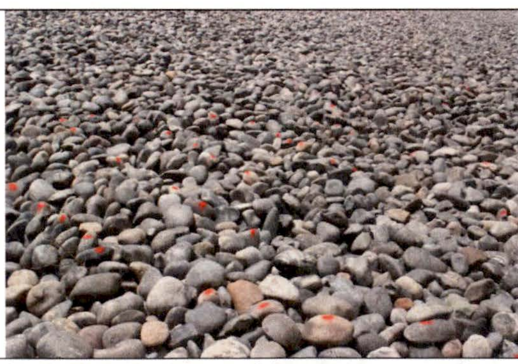


Photo 23 Red outlines of depressions near the toe of northeast slope and Gully #2

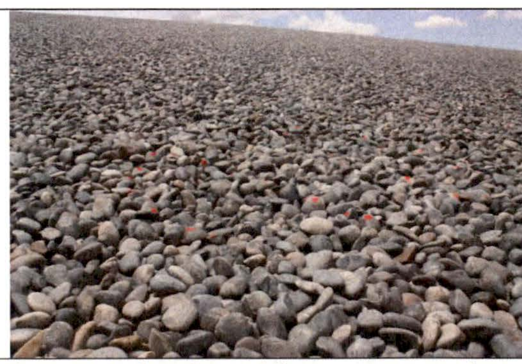


Photo 24 Red outlines of depressions near the toe of northeast slope and Gully #2

	
Photo 25. Sediment filling erosion channel at base of north east slope	Photo 26. Sediment filling erosion channel at base of north east slope
	
Photo 27 Surveyors working on collection of coordinates for depressions above RipRap	Photo 28 Red outlined depressions at contact with erosional channel Rip Rap

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Appendix C5

Site Visit Report, August 18 and 19, 2016

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U.S. Department of Energy Office of Legacy Management

Site Visit Report

Refer to the Quality Assurance Manual *Section 1.5.3.4 for a description of this process.*

Assessment Title *(Site Visit after Flash Flood event)*:	**Site** *(Mexican Hat Site Mexican Hat UT/ Monument Valley AZ)*:
Visit Monument Valley Flooding damage to Fence and then to Mexican Hat to review depressions on north east cell cover	Click here to enter text.

Date(s) Performed: August 18 and 19 2016

Site Manager or Lead: Joey Gillespie DOE LM Manager Angelita Denny

Issued By: Joey Gillespie **Date Issued:** 8/29/2016

Purpose and Scope *(reason for site visit assessment and scope of area examined)*:

- Visit the two sites to observe and document damage from recent precipitation event in early August

Summary and Results *(brief summary of results including what was examined and what was observed)*:

08:30-13:30 Drive with Angelita Denny to Monument Valley Site brief Angelita to the Plan of the Day and JSA

13:30 -15:30 Delineate former evaporative pond area with yellow rope and t-posts with signs requiring a Rad Worker Permit to enter or do work in the former evap pond area. Need additional cord to outline the entire evap pond area

15:30 – 16:30 Review the wash area for flash flood damage at the north end fence crossings. Ben Stanley did what repairs he could but the flash flood areas will need an engineered solution in the future

16:30 off site to Monument Valley Grocery for additional rope.

8/19/2016 Friday

09:00 – 10:00return to Monument Valley in order to meet with Ben Stanley ; Brief to the POD and JSA then visit the south drainage wash area and look at the amount of debri against the fence.

- Ben needs a First Aid Kit and gloves
- Perimeter signs around the perimeter
- Gate or site entrance signs
- Need additional rope to outline the Former Evap Pond Area

10:00-11;50 drive to Mexican Hat and review disposal cell depressions. No real change to the depressions caused by the precipitation event. Install signs below the perimeter signs where they were missing and drive down to Gypsum Creek to view flood damage. It was noted that significant sediment was transported and placed over the Seep location # 0922. Seep is no longer visible and the sign had been washed away. Denny and Gillespie did not hike up the drainage to ck on Seep 0248 due to time constraints.

Mexican Hat

- Seep #0248 is scheduled to be sampled September 26 but this may change
- Ruts were scheduled to be repaired August 25th
- Sign needs to be replaced at Seep # 0922
- Additional debri needs to be carried to the landfill from surrounding the cell
- Entrance road has some erosion occurring that may need attention in the future

11:50-19:00 Drive back to Grand Junction from Mexican Hat.

Conclusions *(detailed description of processes and areas examined. Describe problem areas as well as positive practices. Include action items that were completed during site visit)*:

U.S. Department of Energy Office of Legacy Management

Assessment Title *(Site Visit after Flash Flood event)*: Visit Monument Valley Flooding damage to Fence and then to Mexican Hat to review depressions on north east cell cover	**Site** *(Mexican Hat Site Mexican Hat UT/ Monument Valley AZ)*: Click here to enter text.

Nothing to conclude at this time

Action Items *(follow-up with site manager or lead on action items listed)*:

- Replace the sign at Seep 0922
- Place rock in erosional channel along entrance road at sign P-22

Observations *(examples: Consider repainting door when weather permits. Housekeeping is exceptionally good)*:

- Access to Monument Valley site had significant washouts and culvert damage
- No Change to depressions on the cell cover at Mexican hat(north east side slope) after recent heavy precipitation
- Significant sediment buildup in Gypsum Creek covering Seep # 0922 and removing the sign

Documents/Procedures Reviewed *(reference information or required documents used to prepare for and conduct the site visit)*:

- Job Safety Analysis and Plan of the Day

Persons Contacted:

Ben Stanley at the Monument Valley Site

E-Mail Distribution *(include site manager or lead, responsible manager, program manager and their administrative assistant, Corrective Action, and affected individuals)*:

Angelita.Denny@lm.doe .gov
Joey.gillespie@lm.doe.gove
Gj.rc@lm.doe.gov

	
Photo 1 Northeast slope depressions in foreground	Photo 2 Northeast slope depressions in foreground
	
Photo 3 Overview of the northeast toe and Gully #2	Photo 4 Change in riprap size diagonally across northeast slope
	
Photo 5 Change in rip rap size diagonally across northeast slope	Photo 6 Gypsum creek deposits over seep location 0922

	
Photo 7. Gypsum creek sedment deposition from recent precip event	Photo 8. Gypsum creek sedment deposition from recent precip event

Photo 1. Delineation of the Former Evap Pond at Monument Valley site

Photo 2. Delineation of the Former Evap Pond at Monument Valley site

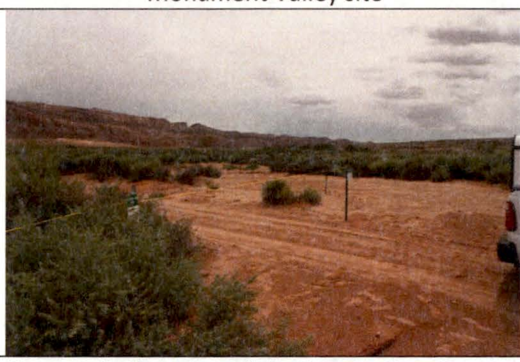

Photo 3. Delineation of the Former Evap Pond at Monument Valley site

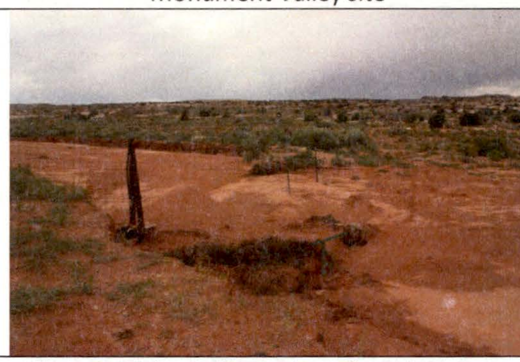

Photo 4. Main drainage sheet flow damage to northern fence crossing

Photo 5 Southern fence crossing of main wash

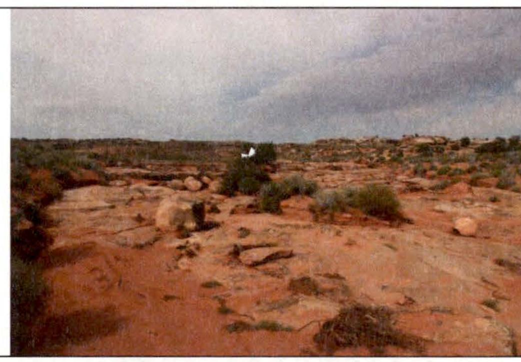

Photo 6 Southern fence crossing of main wash

	
Photo 7 Southern fence crossing of main wash	Photo 8 Southern fence crossing of main wash
	
Photo 9 Southern fence crossing of main wash	Photo 10 Southern fence crossing of main wash
	
Photo 11. Main wash erosional feature	Photo 12. Erosional outwash overlook of northern fence crossing

Appendix C6

2017 Annual Inspection of the Mexican Hat, Utah, Disposal Site

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12.0 Mexican Hat, Utah, Disposal Site

12.1 Compliance Summary

The Mexican Hat, Utah, Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I Disposal Site (site) was inspected on April 11, 2017. Subtle depressions in the riprap cover continue to be observed along the toe and lower portions of the northeast side slope of the disposal cell. Visual observations of the depressions indicate the potential for erosion of the underlying sandy gravel bedding layer, the radon barrier, or both. A report that evaluates the depression features and provides a set of options and a recommended path forward is in development. Inspectors identified several routine maintenance needs but found no cause for a follow-up inspection during the annual inspection.

During a site visit on December 14, 2017, a small void in the disposal cell cover was identified near the toe of the northeast side slope near the previously observed depressions. The small void extended to the apparent base of the bedding layer and upper portion of the radon barrier. A follow-up inspection with a radiation control technician was conducted on December 27, 2017. The follow-up inspection confirmed that radiological readings at the void were consistent with background levels.

The U.S. Department of Energy (DOE) conducted annual observational monitoring (i.e., photographic documentation and observational description) of seven designated seeps during the annual inspection. Seep 0248 was dripping and was the only seep with wet conditions; the remaining seeps were dry. Ephemeral drainages along the perimeter of the site were dry; however, the presence of evaporites in these drainage areas provided evidence of recent surface water. Gypsum Creek had several areas of flowing surface water and contained significant areas of evaporites throughout dry areas within and leading to its flow path. Groundwater monitoring is not required.

12.2 Compliance Requirements

Requirements for the long-term surveillance and maintenance of the site are specified in the site-specific DOE Long-Term Surveillance Plan (LTSP) (DOE 2007) and in procedures DOE established to comply with the requirements of the U.S. Nuclear Regulatory Commission (NRC) general license at Title 10 *Code of Federal Regulations* Section 40.27 (10 CFR 40.27). Table 12-1 lists these requirements.

Table 12-1. License Requirements for the Mexican Hat, Utah, Disposal Site

Requirement	LTSP	This Report	10 CFR 40.27
Annual Inspection and Report	Sections 3.3 and 3.4	Section 12.4	(b)(3)
Follow-Up Inspections	Section 3.5	Section 12.5	(b)(4)
Maintenance	Section 3.6	Section 12.6	(b)(5)
Emergency Measures	Section 3.6	Section 12.7	(b)(5)
Environmental Monitoring	Section 3.7	Section 12.8	(b)(2)

12.3 Institutional Controls

The 119-acre disposal site, identified by the property boundary shown in Figure 12-1, is held in trust by the U.S. Bureau of Indian Affairs. The Navajo Nation retains title to the land. UMTRCA authorized DOE to enter into a Cooperative Agreement (DE-FC04-85AL26731) with the Navajo Nation to perform remedial actions at the former uranium processing sites. DOE and the Navajo Nation executed a Custodial Access Agreement that conveys to the federal government title to the residual radioactive materials stabilized at the repository site and ensures that DOE has perpetual access to the site.

The site was accepted under the general license in 1997. DOE is the licensee and, in accordance with the requirements for UMTRCA Title I sites, is responsible for the custody and long-term care of the site. Institutional controls (ICs) at the site include federal custody of the disposal cell and its engineered features, administrative controls, and the following physical ICs that are inspected annually: the disposal cell and associated drainage features, entrance gate and sign, fence, perimeter signs, site markers, and survey and boundary monuments.

12.4 Inspection Results

The site, 1.5 miles south of the town of Mexican Hat, Utah, was inspected on April 11, 2017. The inspection was conducted by E. Tyrrell and S. Hall of the DOE Legacy Management Support (LMS) contractor. A. Denny (DOE site manager) attended the inspection. The purposes of the inspection were to confirm the integrity of visible features at the site, to identify changes in conditions that might affect conformance with the LTSP, and to determine the need, if any, for maintenance or additional inspection and monitoring.

12.4.1 Site Surveillance Features

Figure 12-1 shows in black the locations of site features, including site surveillance features and inspection areas. Site features that are present but not required to be inspected are shown in italic font. Observations from previous inspections that are currently monitored are shown in blue text, and new observations identified during the 2017 annual inspection are shown in red. Inspection results and recommended maintenance activities associated with site surveillance features are included in the following subsections. Photographs to support specific observations are identified in the text and in Figure 12-1 by photograph location (PL) numbers. The photographs and photograph log are presented in Section 12.10.

12.4.1.1 Site Access, Entrance Gate, and Entrance Sign

Access to the site is from a short unmarked dirt road off U.S. Highway 163 that ends at a graded parking area. Minor erosion continues to occur along the dirt access road, but the site remains accessible. Entrance to the site is through a locked steel entrance gate at the northwest corner of the site (PL-1). The entrance gate was locked and functional. The entrance sign is affixed to a steel post immediately behind the entrance gate (PL-2). The entrance sign listed outdated DOE and Navajo Nation contact information and was replaced during a later site visit; no other maintenance needs were identified.

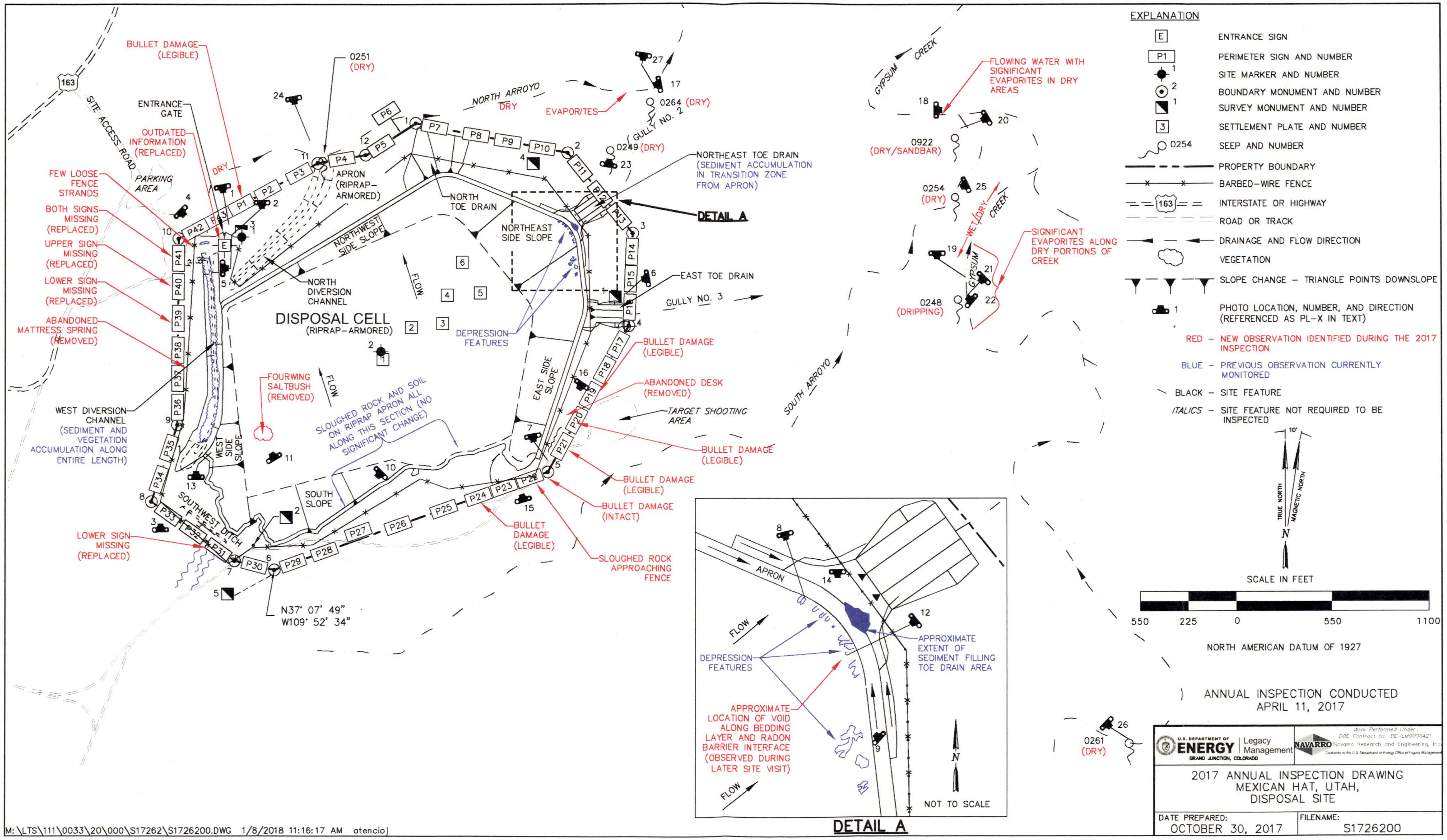

Figure 12-1. 2017 Annual Inspection Drawing for the Mexican Hat, Utah, Disposal Site

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12.4.1.2 Fence and Perimeter Signs

A barbed-wire fence encloses the disposal cell (PL-3). Periodically, the fence is damaged by livestock, erosion, or vandalism and requires repair. Loose fence strands were identified at a few locations across the site, but did not warrant maintenance.

There are 43 pairs of perimeter signs, designated P1 through P43 (each pair consisting of an upper property ownership/no-trespassing sign and a lower sign identifying the site as a radioactive materials disposal site), positioned along the property boundary. Each paired perimeter sign is attached to a single steel post set in concrete. Perimeter signs are typically located outside the fence that encloses the disposal cell (PL-4), but some are affixed directly to the fence or immediately inside the fence. Several perimeter signs (P19, P20, P21, and P24) have bullet damage but remain legible. Additionally, several perimeter signs are bent (presumably due to animal contact) but did not require maintenance during the annual inspection. One or both of the paired perimeter signs were missing during the inspection at perimeter sign locations P31, P39, P40, and P41 and were replaced during a later site visit from May 8–10, 2017; no other maintenance needs were identified.

12.4.1.3 Site Markers

The site has two granite site markers. Site marker SMK-1 is just inside the fence near the entrance gate (PL-5); its concrete base has several minor cracks, but they do not compromise the integrity of the base and repairs are not necessary at this time. Site marker SMK-2 is on the top slope of the disposal cell. No immediate maintenance needs were identified.

12.4.1.4 Survey and Boundary Monuments

Four survey monuments were installed at the site during construction of the disposal cell for survey control. SM-1 was not located during the inspection but was identified on top of a large mound during a later site visit (PL-6). Twelve boundary monuments delineate the property boundary. Bullet damage was identified at BM-5 (PL-7), but repairs are not necessary at this time as the boundary monument remains legible and intact. No immediate maintenance needs were identified.

12.4.2 Inspection Areas

In accordance with the LTSP, the site is divided into four inspection areas (referred to as "transects" in the LTSP) to ensure a thorough and efficient inspection. The inspection areas are (1) the disposal cell, (2) the toe drains and diversion channels, (3) the balance of the site and the site perimeter, and (4) the outlying area. Inspectors examined specific site surveillance features within each area and looked for evidence of settlement, erosion, or other modifying processes that might affect the site's conformance with LTSP requirements.

12.4.2.1 Disposal Cell

The disposal cell, completed in 1994, occupies 68 acres. The disposal cell is armored with riprap to control erosion. No evidence of erosion, settling, slumping, rock degradation, or other modifying processes that might affect the integrity of the disposal cell were present on the top slope of the disposal cell.

Subtle depressions in the riprap cover along the toe and lower portions of the northeast side slope of the disposal cell were identified during the 2016 annual inspection and a subsequent follow-up inspection on April 8, 2016. Additional site visits to further characterize the depression features were completed in 2016. The additional site visits were not identified in the *2016 Annual Site Inspection and Monitoring Report for Uranium Mill Tailings Radiation Control Act Title I Disposal Sites* (DOE 2016) but are detailed in an upcoming northeast slope cover depressions evaluation report. Based on visual observations, no major changes to the depression features were evident during the 2017 annual inspection relative to previous visual observations in 2016 (PL-8 and PL-9).

Evaluations of the depression features as they relate to long-term performance of the disposal cell are ongoing. A radiological survey performed on the northeast side slope in September 2017 did not identify any elevated gamma radiation readings in the areas of observed depressions relative to visually determined unaffected areas of the disposal cell located topographically upgradient of the depression features on the northeast side slope. DOE has initiated supplemental monitoring and evaluation activities related to the depression features, including the installation of an onsite meteorological weather station; performing semiannual ground-based light imaging, detection, and ranging (LiDAR) topographic surveys along the northeast side slope (the first event was performed in October 2017); and semiannual collection of horizontal and vertical GPS grade survey data at the existing settlement plates on the top slope of the disposal cell. A report that provides an evaluation of the depression features as well as a set of options and a recommended path forward is in development and will be distributed to NRC and stakeholders upon completion.

There was no noticeable increase of sloughed red rock and soil along the south apron of the disposal cell (PL-10). Because the apron in this area is immediately adjacent to the base of the steep rocky cliff face along the southern edge of the disposal cell cover, it is expected that sediment and unstable rock from the cliff face will continue to fall onto the apron. The accumulated material is not currently impacting the function of the apron, and this area will continue to be monitored.

A single fourwing saltbush (a deep-rooted plant) was identified growing on the southwest portion of the disposal cell top slope (PL-11) during the inspection. This plant was removed at its base with cutting shears, and the remaining plant and root materials were subsequently treated with herbicide during a later site visit; no other maintenance needs were identified during the 2017 annual inspection.

During a site visit on December 14, 2017, with representatives from the Navajo Nation Uranium Mill Tailings Remedial Action/Abandoned Mine Lands Department, a small portion of the riprap and bedding layer cover components were removed by hand to facilitate inspection of linear depressions observed near the toe of the northeast side slope. At one of the locations, a small void was observed at the apparent base of the bedding layer and upper portion of the radon barrier (PL-12), where a 5 to 6 inch cemented layer was present. The approximate dimensions of the void were 8 inches deep × 12 inches wide. The length of the void was unknown, but it appeared to extend downslope along the interface of the bedding layer and radon barrier. Associated linear depressions observed on the cover in this area are suspected to be associated with this feature and may represent collapsed portions of prior openings with similar conditions. A follow-up inspection was conducted with a radiation control technician on

December 27, 2017, to assess radon and gamma radiation readings at multiple locations across the site, including the area of the observed void. An alphaNUCLEAR Model 597-PX3 radon monitor was used to collect 30-minute continuous samples for radon gas, and a hand-held sodium iodide scintillometer was used to collect gamma radiological readings. All radiological readings were consistent with background levels; no elevated radiological readings were observed. Additional site visits to further evaluate the observed void and to assess the potential for additional areas with similar features are planned for early 2018. NRC was notified of these observations and planned follow-up visits in early January 2018. Subsequent meetings were held with the Navajo Nation Uranium Mill Tailings Remedial Action/Abandoned Mine Lands Department to discuss the findings. Findings from additional site visits and additional information regarding the void will be included in the depression features evaluation report.

12.4.2.2 Toe Drains and Diversion Channels

Upgradient offsite areas continue to undergo erosion, resulting in the transport of sediment onto the site and into the west diversion channel. The sediment accumulation has promoted the growth of vegetation, including perennial grasses and annual weeds, in the west diversion channel (PL-13). However sediment accumulation and associated vegetation have not adversely affected the performance of the west diversion channel.

Sediment accumulation has also been observed along the transition zone from the apron to the northeast toe drain (PL-14). The origin of this material has not been determined. Windblown sediment that settles on the disposal cell cover may be washed out in this area, which is not of concern. However, if the material is related to the observed depression features on the northeast side slope, it would indicate cover erosion, which would be a concern. Minor vegetation has begun to establish in this area, but that does not currently affect the performance of the northeast toe drain. Inspectors will continue to monitor this area concurrent with the observed depression features on the northeast side slope. No maintenance needs were identified.

12.4.2.3 Balance of the Site and Site Perimeter

Minor erosion continues in upgradient areas along the southwest portions of the site. This is an expected natural process as the exposed geology at the site is brittle and subject to weathering. Inspectors will continue to monitor erosion in these areas, but erosion is not a concern unless it damages the fence or impacts the performance of site drainage and diversion features such as the west diversion channel.

Sloughed rock from an overhanging shelf was observed along the southern perimeter of the site. Although this material currently appears to be stable, this rock is approaching the fence between perimeter signs P22 and P23 and will likely need to be removed or secured to protect the fence from damage or a potential breach (PL-15).

Scattered trash (broken glass, bottles, cans, cardboard, and paper containers) continues to accumulate in the more accessible areas of the site where vehicle access is available. The most noticeable accumulations of trash are located along the access road and in the parking area, the areas on the site outside of the fence between perimeter signs P31 and P42, and the southern portion of the site between perimeter signs P22 and P27. Trespassing just inside the site boundary (outside the fence), as evidenced by vehicle and all-terrain vehicle tracks, occurs in the same areas where trash accumulations are present. However, some trash is likely being transported onto the site via wind from nearby locations.

As in previous years, bulk abandoned items were discovered during the inspection. An abandoned wooden desk was identified outside of the fence but within the site boundary near perimeter sign P20 (PL-16). In addition, an abandoned mattress spring was identified outside the fence but within the site boundary between perimeter signs P37 and P38. These bulk abandoned items were removed from the site and properly disposed of during a later site visit.

Vandalism continues to occur at the site, as indicated by new bullet damage in several perimeter signs and on boundary monument BM-5. This is expected to be an ongoing problem due to the remote location of the site and the fact that access to these areas cannot be restricted. Damaged perimeter signs are replaced when they become illegible. No other maintenance needs were identified.

12.4.2.4 Outlying Area

The area beyond the site boundary for a distance of 0.25 mile was visually observed for erosion, changes in land use, or other phenomena that might affect the long-term integrity of the site. No such impacts were identified.

12.5 Follow-Up Inspections

DOE will conduct follow-up inspections if (1) a condition is identified during the annual inspection or other site visit that requires a return to the site to evaluate the condition or (2) DOE is notified by a citizen or outside agency that conditions at the site have substantially changed. DOE conducted a follow-up inspection in response to an observed void identified during a site visit after the 2017 annual inspection. The follow-up inspection was conducted with a radiation control technician on December 27, 2017, to assess radon and gamma radiation readings at multiple locations across the site, including the area of the observed void. All radiological readings were consistent with background levels; no elevated radiological readings were observed. Additional site visits to further evaluate the observed void and to assess the potential for additional areas with similar features are planned for early 2018. NRC was notified of these observations and planned follow-up visits in early January 2018.

12.6 Maintenance

The LMS contractor performed maintenance at the site on May 8–10, 2017. The perimeter signs (P31, P39, P40, and P41) that were missing during the inspection were replaced during this maintenance trip. Breakaway bolts were used to affix the perimeter signs that were replaced to the preexisting metal poles set in concrete in an attempt to prevent future theft. Adhesive labels displaying updated contact information and the Office of Legacy Management website address were affixed to the remaining perimeter signs that were readily accessible during this maintenance trip. The fourwing saltbush that was identified on the top slope of the disposal cell was removed at its base with cutting shears; the remaining plant and root materials were subsequently treated with herbicide. The bulk abandoned items (the wooden desk and mattress spring) that were identified during the annual inspection were removed from the site and disposed of properly. In addition, a significant amount of windblown debris and litter was also removed from within and around the site perimeter. Areas of focus included the entire southern portion of the site along the access road leading to the target shooting area and Gypsum Creek overlook, the southwest ditch, the west diversion channel, and the site access road and parking area leading to the entrance gate. Solid waste from the maintenance trip was transported to the San Juan County Landfill south of Blanding, Utah for disposal. Outdated contact information was identified on the site's entrance sign during the annual inspection, and the sign was replaced at a later date. The warning sign near seep 0248 is partially buried and will be repositioned at a later date; no other maintenance needs were identified.

12.7 Emergency Measures

Emergency measures are the actions that DOE will take in response to unusual damage or disruption that threatens or compromises site safety, security, or integrity in compliance with 10 CFR 40 Appendix A Criterion 12. The depression features identified along the disposal cell's northeast side slope do not meet the criteria for constituting the need for an emergency action; therefore, no need for emergency measures was identified.

12.8 Environmental Monitoring

12.8.1 Groundwater Monitoring

In accordance with the LTSP, groundwater monitoring is not required because the uppermost aquifer is hydrogeologically isolated from contamination in the overlying formation.

12.8.2 Seep Monitoring

In accordance with Section 3.7.2 of the LTSP, DOE conducts observational monitoring of seven designated seeps during annual inspections as specified in an approved monitoring plan (DOE 2006). Observational monitoring consists of visual observations and photographic documentation of the seven seep locations that are specified in the LTSP. The observed seep locations, shown in Figure 12-2, are primarily the result of the infiltration of precipitation into the surrounding formation or perched water that leaked from the former processing site tailings pond. The majority of seeps have exhibited dry conditions over the past 10 years of observational monitoring.

Since 2010, groundwater discharge from seeps has only been observed at cross-gradient seep 0248, which typically exhibits dripping conditions. During the inspection, water was observed dripping from seep 0248. Since the seep was only dripping and did not exhibit steady flow, an estimated flow rate was not determined. The remaining seeps on the annual monitoring plan exhibited dry conditions during the inspection. Table 12-2 documents the conditions of each monitored seep that was observed during the inspection, including the respective drainage in which each seep occurs and a reference to photographic documentation.

The North Arroyo near the base of seep 0264 was slightly moist with visible evaporites extending to topographically upgradient areas of the ephemeral wash (PL-17). The remainder of the North Arroyo was dry during the inspection.

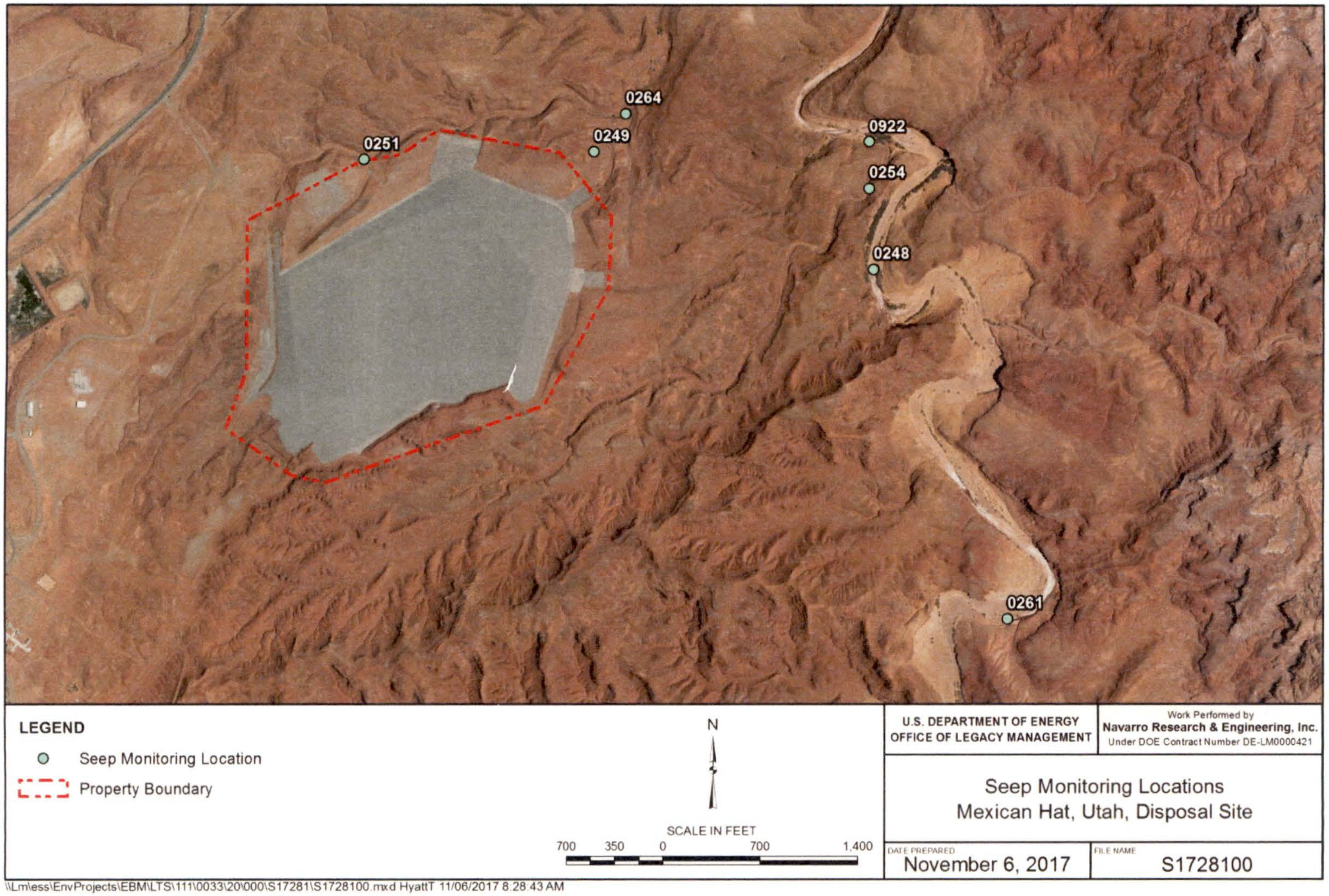


Figure 12-2. Seep Monitoring Locations at the Mexican Hat, Utah, Disposal Site

Table 12-2. Observations of Seeps near the Mexican Hat, Utah, Disposal Site

Seep Location Number	Drainage	Photo Location Numbers	Observed Seep Conditions
0248	Gypsum Creek	PL-21 and PL-22	Seep was dripping and a small pool of water had collected at the base of the cliff (no flow rate measured). Warning sign is partially buried under sediment and will be repositioned at a later date.
0249	Gully No. 2	PL-23	Dry conditions (no evaporites present); seep area is covered with gray limestone, presumably extra riprap apron material from disposal cell construction. Warning sign not posted at this location since this seep has never been documented to be discharging water.
0251	North Arroyo	PL-24	Dry conditions (no evaporites present).
0254	South Arroyo	PL-25	Dry conditions (no evaporites present). Warning sign not posted at this location due to seasonal flash flood conditions in the ephemeral drainage.
0261	Gypsum Creek	PL-26	Dry conditions. This seep is located next to Gypsum Creek, which was flowing at the time of the inspection. Since this seep is considered a background location, no warning sign is posted at this location.
0264	North Arroyo	PL-27	Dry conditions. Ephemeral wash near seep location was moist with intermittent evidence of evaporites, presumably from recent precipitation.
0922	Gypsum Creek	PL-20	Dry conditions (no evaporites present in immediate area). Seep is located along the south side of Gypsum Creek, which had evidence of significant water (more than 10 feet) from an unknown period. Seep location is now covered entirely by a sandbar that has formed along this section of Gypsum Creek.

Gypsum Creek had several areas of flowing surface water during the inspection. Significant amounts of evaporites were also observed throughout Gypsum Creek (PL-18 and PL-19). Gypsum Creek also had evidence of significant flash flooding from an indeterminate period; there was debris more than 10 feet above the ground surface in some areas of the creek. This flood event presumably created the sandbar that is currently covering seep 0922 (PL-20).

In accordance with the LTSP, annual visual observations of the seeps was only required through 2016, at which time the LTSP directed an evaluation to be conducted to determine whether to continue or discontinue observational seep monitoring. A seep monitoring evaluation report is currently in development. Qualitative seep monitoring was continued during the 2017 annual inspection as a best management practice to support the seep monitoring evaluation report.

In accordance with the LTSP, the need to collect water quality samples at the seeps will be evaluated if observed seep flows significantly increase compared to historical seep flow rates. The Navajo Nation requested sampling of seep 0248 in 2015 due to increased precipitation in the area. To address this request, seep 0248 was sampled in September 2015. Water quality samples were collected at seep 0248 and one location in Gypsum Creek upstream of seep 0248 on March 15, 2016. Seep 0248 and Gypsum Creek were sampled again on October 3, 2016. Evaluation of the sample results will be provided in the pending seep monitoring evaluation report.

12.8.3 Vegetation Monitoring

In accordance with the LTSP, vegetation conditions are observed during annual inspections to ensure that undesirable plant species, including deep-rooted plants on the disposal cell cover and noxious weeds, do not proliferate at the site. With the exception of deep-rooted vegetation, natural plant community succession is expected and will not adversely impact the performance of the disposal cell. A single fourwing saltbush plant (a deep-rooted plant) was identified on the top slope of the disposal cell during the inspection and subsequently removed during a later trip. Vegetation growth in the west diversion channel will continue to be monitored during annual inspections to ensure that it does not negatively affect the performance of this surface water diversion structure. No other maintenance needs were identified.

12.9 References

10 CFR 40 Appendix A. U.S. Nuclear Regulatory Commission, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content," *Code of Federal Regulations.*

10 CFR 40.27. U.S. Nuclear Regulatory Commission, "General License for Custody and Long-Term Care of Residual Radioactive Material Disposal Sites," *Code of Federal Regulations.*

DOE (U.S. Department of Energy), 2006. *Resolution of Seep and Ground Water Monitoring at the Mexican Hat, Utah, UMTRCA Title I Disposal Site,* DOE-LM/GJ1139-2006, March.

DOE (U.S. Department of Energy), 2007. *Long-Term Surveillance Plan for the Mexican Hat, Utah (UMTRCA Title I), Disposal Site, San Juan County, Utah,* DOE-LM/1530-2007, Rev. 3, October.

DOE (U.S. Department of Energy), 2016. *2016 Annual Site Inspection and Monitoring Report for Uranium Mill Tailings Radiation Control Act Title I Disposal Sites,* LMS/S15036, March.

12.10 Photographs

Photograph Location Number	Azimuth	Photograph Description
PL-1	170	Entrance Gate
PL-2	180	Entrance Sign with Outdated Contact Information (Replaced)
PL-3	0	Fence Enclosing Southwest Portion of Disposal Cell
PL-4	135	Perimeter Sign P42 and Fence
PL-5	90	Site Marker SMK-1
PL-6	260	Approximate Location of Survey Monument SM-1
PL-7	170	Boundary Monument BM-5 with Bullet Damage
PL-8	165	Depression Features near Toe of Northeast Side Slope (Black Backpack for Scale)
PL-9	315	Depression Features near Toe of Northeast Side Slope (Black Backpack for Scale)
PL-10	225	Sloughed Rock on Riprap Apron near South Slope of Disposal Cell
PL-11	330	Fourwing Saltbush on Top Slope of Disposal Cell (Removed)
PL-12	230	Void Along Bedding Layer and Radon Barrier Interface (Observed During December 14, 2017, Site Visit)
PL-13	0	West Diversion Channel with Vegetation Along Low Points of Drainage
PL-14	180	Sediment Accumulation Along Transition Zone from Apron to Northeast Toe Drain
PL-15	345	Sloughed Rock Approaching Fence
PL-16	215	Abandoned Wooden Desk (Removed)
PL-17	260	North Arroyo (Dry) with Visible Evaporites
PL-18	90	Gypsum Creek (Flowing) with Visible Evaporites
PL-19	180	Gypsum Creek on Approach to Seep 0248 with Significant Evaporites
PL-20	240	Seep 0922 Covered in Sandbar
PL-21	225	Seep 0248 (Dripping) with Partially Buried Warning Sign
PL-22	310	Seep 0248 (Dripping) with Pooled Water at Base of Cliffside
PL-23	10	Seep 0249 (Dry) Covered in Gray Limestone Rock
PL-24	170	Seep 0251 (Dry) with Minor Evaporites Present in North Arroyo
PL-25	245	Seep 0254 (Dry)
PL-26	135	Location of Seep 0261 Based on GPS Data with Evaporites
PL-27	190	Seep 0264 (Dry) with Moist Floor in Adjacent North Arroyo

PL-1. Entrance Gate

PL-2. Entrance Sign with Outdated Contact Information (Replaced)

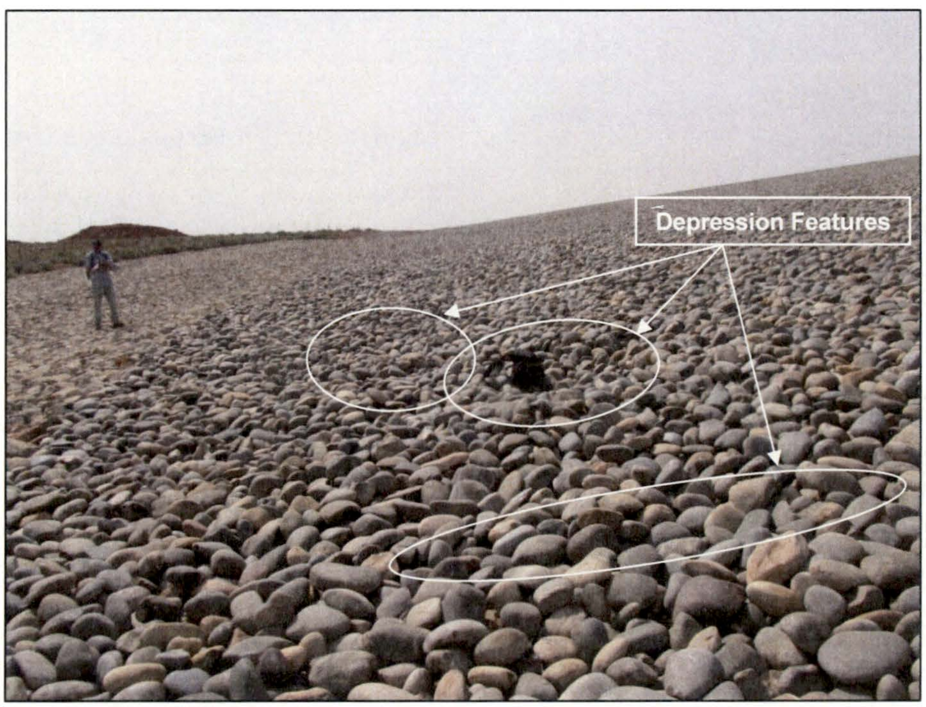
PL-3. Fence Enclosing Southwest Portion of Disposal Cell

PL-4. Perimeter Sign P42 and Fence

PL-5. Site Marker SMK-1

PL-6. Approximate Location of Survey Monument SM-1

PL-7. Boundary Monument BM-5 with Bullet Damage



PL-8. Depression Features near Toe of Northeast Side Slope (Black Backpack for Scale)

PL-9. Depression Features near Toe of Northeast Side Slope (Black Backpack for Scale)

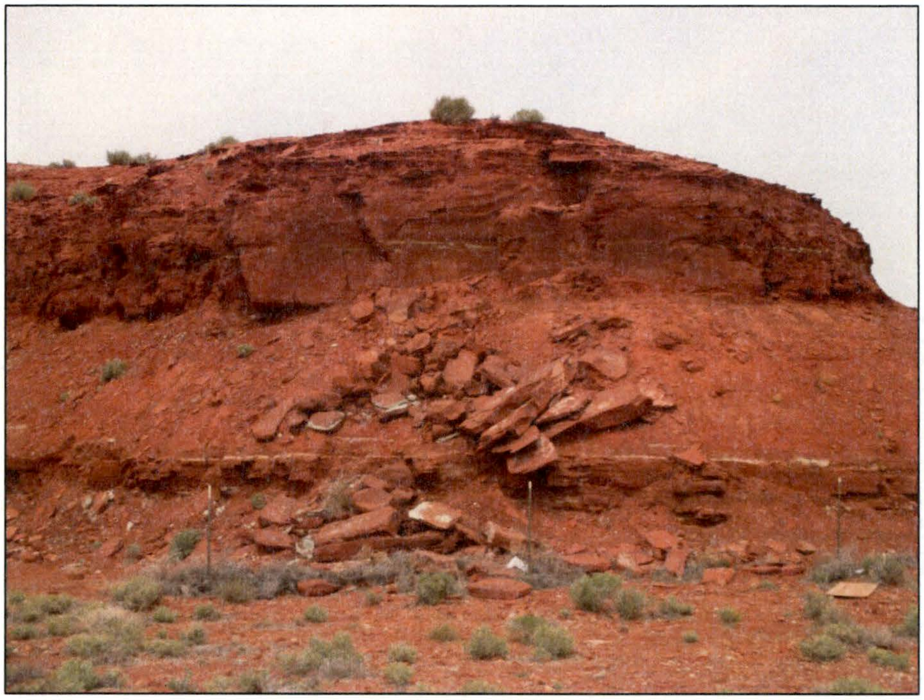
PL-10. Sloughed Rock on Riprap Apron near South Slope of Disposal Cell

PL-11. Fourwing Saltbush on Top Slope of Disposal Cell (Removed)

PL-12. Void Along Bedding Layer and Radon Barrier Interface
(Observed During December 14, 2017 Site Visit)

PL-13. West Diversion Channel with Vegetation Along Low Points of Drainage

PL-14. Sediment Accumulation Along Transition Zone from Apron to Northeast Toe Drain; View to the South



PL-15. Sloughed Rock Approaching Fence

PL-16. Abandoned Wooden Desk (Removed)

PL-17. North Arroyo (Dry) with Visible Evaporites

PL-18. Gypsum Creek (Flowing) with Visible Evaporites

PL-19. Gypsum Creek on Approach to Seep 0248 with Significant Evaporites

PL-20. Seep 0922 Covered in Sandbar

PL-21. Seep 0248 (Dripping) with Partially Buried Warning Sign

PL-22. Seep 0248 (Dripping) with Pooled Water at Base of Cliffside

PL-23. Seep 0249 (Dry) Covered in Gray Limestone Rock

PL-24. Seep 0251 (Dry) with Minor Evaporites Present in North Arroyo

PL-25. Seep 0254 (Dry)

PL-26. Location of Seep 0261 Based on GPS Data with Evaporites

PL-27. Seep 0264 (Dry) with Moist Floor in Adjacent North Arroyo

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Appendix C7

Site Visit Trip Report, September 21, 2017

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U.S. Department of Energy Office of Legacy Management

Site Visit Trip Report

Site	Mexican Hat, Utah, Disposal Site	**Project**	NE Slope Cover Depressions Evaluation
Individuals making trip	Evan Tyrrell, CHMM (Navarro) & Bill Cary, Radiological Control Technician (RCT) (Navarro)		
Date(s) of Site Visit	September 21, 2017		

Purpose:

Perform radiological survey along the northeast side slope to verify the absence of elevated radiological readings.

Summary:

A radiological survey was performed by a qualified radiological control technician (RCT) along the northeast side slope utilizing a handheld 2"x2" sodium iodide crutch scintillometer to verify the absence of elevated radiological readings in areas of concern (i.e., depression features). Ambient radiological conditions were determined to be 150 counts per second (cps) and were based on an average of readings collected at three areas upslope of depression features that have been identified on the northeast side slope. Once ambient conditions were determined, the majority of visually-identified depression features were surveyed utilizing the scintillometer. Readings were collected at the top of the rip rap surface.

Overall, the results showed no elevated radiological readings relative to visually-determined non-distressed areas located upslope of depression features on the northeast side slope.

Included Items:

- The following documents are attached to this Report:
  1. Radiological survey map (raw data)

Cc:	Dan Brennecke	Dan Nordeen	Jeff Carman
	John Manée	Michael McDonald	Bill Cary
	Fred Smith		

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Contractor to the U.S. Department of Energy Office of Legacy Management

Radiological Survey Map

Page 1 of 2

Radiological Work Permit No.: N/A **Purpose:** Radiological survey of areas of possible erosion to cell **Time:** 0945

Site Name: Mexican Hat Site **Location:** Slope above Northeast Toe Drain

Technician: Bill Cary **Date:** 9/21/2017 **Reviewer:** Scott A. Newsom 2018.01.03 11:43:13 -07'00' **Date:**

Instrument 1		Instrument 2		Instrument 3	
Instrument/Probe Model	N/A	Instrument/Probe Model	N/A	Instrument Model	SC-133
Instrument Serial No.		Instrument Serial No.		Instrument Serial No.	13012
Probe Serial No.		Probe Serial No.		Probe Serial No.	13012
Calibration Due		Calibration Due		Calibration Due	7/31/18
Efficiency α β		Efficiency α β		Background	150 cps
BKGD (cpm): α β		BKGD (cpm): α β			
Area Probe Correction Factor		Area Probe Correction Factor			

Standardized Symbols for Surveys

- = Tape press (4"x4") (no. inside)
- = Smears (no. inside)
- = Large area smears
- = Air samples (no. inside)
- = Neutron readings in mrem/hr unless otherwise noted
- — = Gamma readings in µrem/hr unless otherwise noted (beta readings also)
- * = Contact readings (dose rate)
- HS = Hot spot
- SOP = Step-off pad
- K = Reading at knee level (when sources from overhead)
- H = Reading at head level (when sources from overhead)
- ----- = Contaminated area
- XXXXX = Radiation area
- -x-x-x- = Contaminated/radiation area
- RM = Radioactive material area
- ⊗ = Floor drain
- ccpm or ncpm = Corrected or net cpm (gross background) for direct frisk, alpha or beta/gamma specified
- # = Direct frisk

Highest Dose Rates

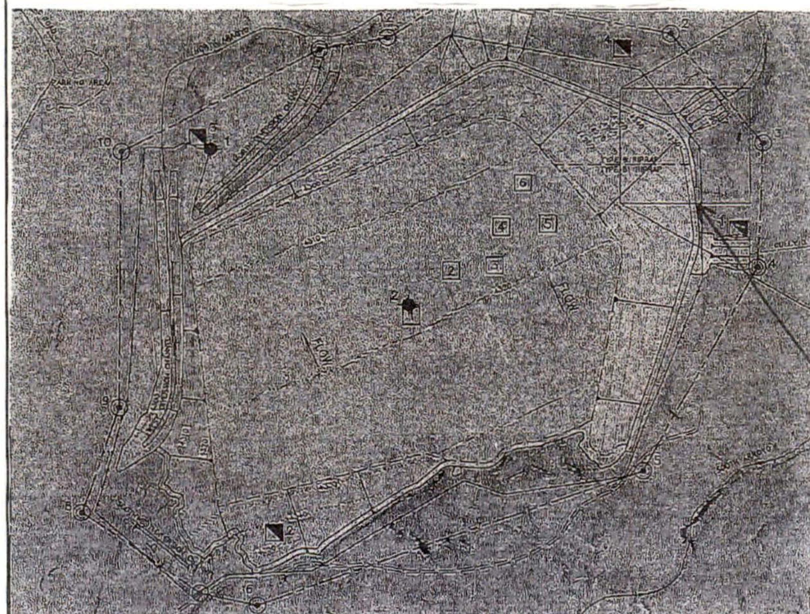
General Area 10.8 µR/hr

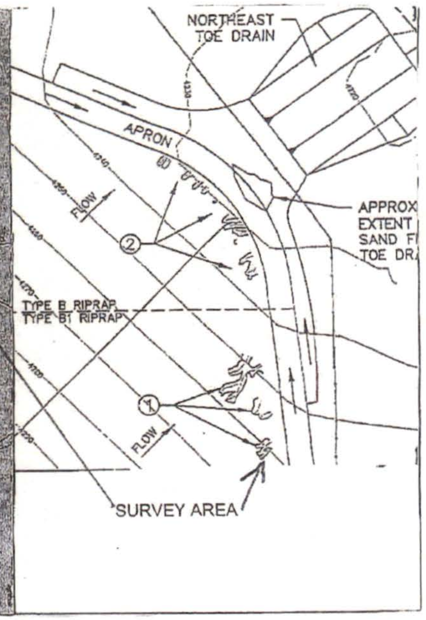
Contact N/A

Highest Contamination Level

Fixed N/A

Loose 156 cps





File Index No.:

NAVARRO

Contractor to the U.S. Department of Energy Office of Legacy Management

Radiological Survey Map (continued)

Item Surveyed	Location Surveyed	Direct Survey — Gross Counts (JC 9/21/17) Beta/Gamma ~~cpm~~	Direct Survey — Gross Counts Alpha cpm	Direct Survey — Net Counts[a] Beta/Gamma ~~cpm~~	Direct Survey — Net Counts[a] Alpha cpm	Direct Survey — Activity[b] Beta/Gamma dpm/100 cm²	Direct Survey — Activity[b] Alpha dpm/100 cm²	Smear Survey — Gross Counts Beta/Gamma cpm	Smear Survey — Gross Counts Alpha cpm	Smear Survey — Net Counts[a] Beta/Gamma cpm	Smear Survey — Net Counts[a] Alpha cpm	Smear Survey — Activity[b] Beta/Gamma dpm/100 cm²	Smear Survey — Activity[b] Alpha dpm/100 cm²	Inst. No. Used
Cell Slope	F. East #1 Depr.	154 cps		4 cps										3
	East #2 w/cairn	153 cps		3 cps										
	East #3 w/cairn	152 cps		2 cps										
	East #4 Rivulet	156 cps		6 cps										
	Center #5 w/cairn	155 cps		5 cps										
	Center #6 w/cairn	128 cps		-22 cps										
	Center #7 Depr.	124 cps		-26 cps										
	Center #8 Depr.	123 cps	N/A	-27 cps										
	West #9 Depr.	123 cps		-27 cps		N/A				N/A				
	West #10 Depr.	123 cps		-27 cps										
	West #11 Depr.	119 cps		-31 cps										
	West #12 Depr.	124 cps		-26 cps										
	West #13 Depr.	119 cps		-31 cps										
	West #14 Rivulet	120 cps		-30 cps										
	West #15 Depr.	124 cps		-26 cps										
	West #16 Rivulet	122 cps		-28 cps										
Cell Slope	Toe Drain #17	122 cps		-28 cps										3
	N/A			N/A										N/A

Applicable Limits (check one for alpha and one for beta)

Alpha (removable/total): ☐ 1000/5000 ☐ 200/1000 ☐ 20/500

Beta (removable/total): ☐ 1000/5000 ☐ 200/1000

[a]Activity Equation

Gross count minus BKGD count = Net count

Net count/Eff = dpm

Dpm x Area Probe Correction Factor (APCF) = dpm/100 cm²

APCF

44-9 = 6.5

FHZ 732 (GM) = 6.5

43-10-1 = 1

Remarks: Daily Instrument Response completed before instrument use. Standard Deviation= 14.92 Backround is average of 3 locations. Survey was performed to determine if there was any elevated radiation in depressions that were discovered in the cell slope. No elevated radioactivity areas were found.

Released To: N/A

Release: ☐ **Unrestricted** ☐ **Restricted** ☒ **Other** (see remarks)

[b]See Table 2-2 of Site Radiological Control Manual I (LMS/POL/S04322).

Appendix C8

Engineering Site Visit Trip Report, October 23–25, 2017

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Engineering Site Visit Trip Report

Site	Mexican Hat Disposal Site	**Project**	Cell Depressions Evaluation
Engineer(s) making trip	Dan Nordeen, Dan Brennecke, Scott DenBaars, Ron Rager. Also in attendance from Navarro was the site lead, Evan Tyrrell. Working separately on the site weather station controls were Ben Potter, Chris Holmes, and Jaron Ragsdale from the AST group of Navarro.		

Purpose:

The intent of this site visit was to introduce and familiarize Mr. Rager to the current cell cover depression features that are presently under evaluation at the Mexican Hat Disposal Site.

Basic Itinerary:
(including dates, to and from, travel method, lodging location

Monday, October 23, 2017 meeting with Ron Rager at the GJO site.

Tuesday, October 24, 2017, traveled from Grand Junction to Mexican Hat via GSA vehicle, checked in at the San Juan Motel, Mexican Hat, conducted site visit in afternoon.

Wednesday, October 25, 2017, completed site visit in morning and visited the radon barrier borrow area that was used in the original construction of the disposal cell, left Mexican Hat and returned to Grand Junction in the afternoon.

Individuals Met With (Name and Company):

Ron Rager (subcontract engineering consultant).

Souder-Miller surveyors Gene Reininger and Schuyler Arensberg were on-site performing a follow–up; second LiDAR scan using advanced technology Trimble TX10 scanning equipment due to problems with overlap and registry that occurred using the older model Trimble TX8 in September 2017.

Summary:

The group met at the San Juan Inn restaurant at noon on October 24th and then traveled to the disposal site from there for Ron's initial overview. The first stop was to do a closer look at the cell cover depressions on the northeast side slope. The surveyors were scanning the side slope of interest so we lagged back until they were done before walking to the depressions areas. We also walked the cover topslope at the northeast corner. While waiting for the surveyors we were able to show Ron the weather station nearby that will be used for collecting precipitation data in close proximity to the disposal cell. We were able to observe the northeast corner sideslope during the changing afternoon lighting conditions to see how the appearance of the depressions changed with the variable lighting. The depressions on the northeast side slope did not appear to have changed from those observed in April 2016 when Engineering (Dan Nordeen and Dan Brennecke) first observed the depressions. The sediment accumulating in the transition zone from the apron to the northeast toe drain was also observed.

The following day, October 25th, the group walked the west side slope mid-morning and observed the north side slope from a distance looking for additional evidence of distress. What appeared to be minor construction related surface imperfections were observed on the west side slope along the entire length. None of these imperfections appeared to be similar to the depression features observed on the northeast side slope. No depressions were observed on the north side slope and no accumulation of sediment was apparent in the north toe drain. The visit ended after touring the location of the radon barrier borrow area several miles south of Halchita.

Discussion:

Overall, Ron Rager thought the cell cover was performing very well. Discussions with Ron Rager were wide ranging and included possible causes for the depression features on the northeast side slopes including the possibility that erosion is occurring below the bedding layer causing radon barrier material to be transported to the toe of slope. Another potential cause discussed was the method of placement by construction equipment implying the depressions may have been a result of the equipment methods used to place the cover components

Telephone/Meeting/Conference Record (continued)

along the northeast side slope. Additional discussions can be found on the attached trip report from Ron Rager.

Action Items:

Several items for follow-up:

1. Review QA/QC data available in completion reports with respect to anomalies during construction. Also look for possible non-conformance issues if available.
2. Ron Rager will try contacting the TAC engineer who worked on the site during final design phases. His name is John MacBee.
3. Ron Rager will look for references to special studies prepared in the 1988-1990 years.
4. Dan Nordeen will provide access to the LM EFT site for transferring large files back and forth.

Cc:			
	Dan Brennecke	Scott DenBaars	Evan Tyrrell
	Jeff Carman	David Miller	

MEMORANDUM

TO: Navarro Research and Engineering, Inc.

FROM: Ron Rager – Consultant to Navarro Research and Engineering, Inc.

SUBJECT: Mexican Hat Site Visit Trip Report—October 23-26, 2017

DATE: December 1, 2017

From 10/23 to 10/26 of 2017 Ron Rager met with a group from Navarro (Contractor to DOE LM) met to discuss and visit the Mexican Hat disposal cell site including:

Dan Nordeen
Dan Brennecke
Scott DenBaars
Evan Tyrrell

The purpose of the trip was to familiarize Ron with the depression features that have been identified in the rock cover at the toe of the northeast side slope and adjacent to the rock apron/ditch of the disposal cell. The LM contractor has written a draft report dated September 2017, which is currently in review by DOE and details the locations and characteristics of the depression features. The draft report also outlines three potential paths forward for further evaluating the depression features. These pathways include: a) continued monitoring of the situation, including deposition of fine grained material in the riprap apron in order to evaluate potential further cover degradation in the impacted areas, b) regrade the cover and monitor the subject area, and c) a targeted cover investigation to inspect selected areas of the depression features down to the top of the radon barrier, including the potential for erosion of the bedding layer and the radon barrier; these cover components cannot be observed at this time because of the riprap covering.

An initial meeting was held at the Grand Junction Navarro office on the afternoon of 10/23 in order to familiarize Ron Rager with the site conditions and to discuss the draft evaluation report. Evan Tyrrell presented a draft color mosaic aerial image of the northeast portion of the disposal cell that was provided by a subcontract survey company and explained that a terrestrial LiDAR survey was being conducted in order to provide a detailed topographic map of the affected areas and the surrounding surfaces.

The potential for rilling (erosion) of the radon barrier and/or bedding layer was discussed along with observations made when a small hand excavation was made in one of the depressed areas. Deposits of fine grained material in the voids of the rip rap below the depressions were also discussed.

A letter from DOE dated 11/2/1989 (Appendix, B Riprap and Filter Design Calculation (from 1991 and 1992)) contained in the original design calculation for the erosion barrier instructing the

Remedial Action Contractor (RAC) to coarsen the bedding layer of the Mexican Hat site was discussed. Ron indicated that the Technical Assistance Contractor (TAC) had performed flume studies at Colorado State University to this effect. These studies were done in relation to a set of "Special Studies" involving such items as sodium bentonite amendment of radon barrier materials, freeze-thaw evaluations of cover materials, and the aforementioned study.

The radon barrier material bentonite amendment was also discussed.

Numerous documents are available from the design period and should indicate how the design was approached and the rational supporting the design criteria.

Following the Grand Junction meeting, Dan Nordeen and Ron visited Greg Smith, a Navarro geotechnical engineering consultant familiar with UMTRA cell designs, to see if he had any of the Special Studies discussed in the meeting. He did not, but indicated that he had checked the bedding gradation as designed by the RAC and found them in compliance with the American Society of Civil Engineers (ASCE) gradation requirements for filters in manmade dams.

The site was inspected on 10/24 and 10/25 to observe existing conditions of the disposal cell with a focus on the northeast side slope where the depression features have been identified. The scope of this trip was limited to visual observations of the disposal cell and area surrounding the cell as well as the original borrow source area for radon barrier material. Weather conditions were excellent, being sunny and warm.

The northeast side slope was inspected during all light conditions from early morning to late afternoon (low to high angle lighting conditions). Several depressions were observed as previously discussed in the draft evaluation report. Conditions appeared to be unchanged from those inspections. Some of the tan fine grained soil coating the stones comprising the riprap was also observed. Limited visual observations confirmed that there is no apparent cause for the formation of the depressions.

In-filling of voids in the riprap-lined drainage located at the transition to the toe outlet apron was inspected. The fine grained material has the appearance of wind blown material and is also similar to that of the radon barrier borrow source. This very fine grained sand and silt is present in drainages and dune formations located to the southeast of the cell.

Other slopes were also inspected for surface depressions. These slopes are of shorter length but receive the runoff from the entire top slope of the cell. Although minor irregularities in the slopes are apparent, none are of the size and depth of those located along the northeast side slope.

During the inspection several possible reasons for the surface depressions were discussed including the possibility that the amended radon barrier was constructed of dispersive soils (some fine grained soils found in the American Southwest exhibit this "colloidal dispersivity" where the finest portion of the soil is eroded by moving water at low gradients). Another possibility is settlement within the disposal cell fill as a result of unintended construction practices such as the positioning of ramps, etc. which might show latent and exaggerated settlement compared to the rest of the pile. Other possible causes may be developed as a result of the proposed targeted investigation of the cover.

The borrow area used for the radon barrier was inspected. The borrow area is located approximately eight miles south of Halchita along the road leading to the former Monument Valley mill site. The material used for the radon barrier appears to be lighter in color than the surrounding red color of the foundation material of the Mexican Hat disposal cell site. Although alluvial in origin, the material looks similar to wind blown deposits present on the adjacent ground surface around the borrow area.

A LiDAR topographic survey was being conducted at the same time this site visit occurred. Maintenance of a rainfall monitoring station was also being conducted.

No firm conclusions were reached and none were sought at this time.

Several action items were discussed:

- Ron Rager will seek to contact John MacBee, the TAC civil/geotechnical engineer who worked on this site during the final design by the RAC. He is in Albuquerque, New Mexico.
- Ron Rager will look for reference to special studies in the RAP and other reports prepared in the 1988-1999 time frame.
- Dan Nordeen will provide access to the LM ftp site and upload the RAP and Completion Report.
- Dan Nordeen will obtain and review the construction quality control reports for any anomalies which might help to explain the depressions.

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Appendix C9

Site Visit Trip Report, December 14, 2017

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U.S. Department of Energy Office of Legacy Management

Site Visit Trip Report

Site	Mexican Hat, Utah, Disposal Site	**Project**	NE Slope Cover Depressions Evaluation
Individuals making trip	Evan Tyrrell, Navarro; Angelita Denny, DOE-LM; Gilbert Dayzie & Joni Tallbull, NNUMTRA/AML		
Date(s) of Site Visit	December 14, 2017		

Purpose:

Perform visual observations of depression features on the northeast side slope of the disposal cell

Summary:

The Department of Energy Office of Legacy Management (DOE-LM) Site Manager coordinated a site visit with Navajo Nation Uranium Mill Tailings Remedial Action/Abandoned Mine Lands Department (NNUMTRA/AML) personnel to observe depression features that had been previously identified along the toe and lower portions of the northeast side slope of the disposal cell. NNUMTRA/AML had received the draft *Mexican Hat UMTRCA Disposal Cell Northeast Slope Cover Depressions Evaluation Report* for review and were interested in viewing the depression features. NNUMTRA/AML representatives arrived onsite prior to the arrival of representation from DOE-LM, and manually removed small portions of the riprap and bedding layer cover components to facilitate inspection of the depressions observed near the toe of the northeast side slope. At one of the locations, near the toe of the northeast side slope, a small void was observed at the apparent base of the bedding layer and upper portion of the radon barrier.

At the time DOE-LM representation arrived at the site, the presence of a small void beneath the rock riprap material was evident in the area where cover components had been removed by NNUMTRA/AML personnel. There was no indication that the radon barrier was breached; manual removal of cover materials did not extend into the radon barrier.

NNUMTRA/AML cleared additional material that had sloughed into the evident void. Repositioning the materials that had sloughed into the opening confirmed the presence of a small void (approximately 8 inches deep × 12 inches wide) that appeared to be present at the apparent base of the bedding layer and upper portion of the radon barrier. The length of the void was unknown, but it appeared to extend downslope along the interface of the bedding layer and radon barrier. An approximately 6-inch-thick, red cemented layer was observed at the top of the void immediately below the base of the bedding layer. The bedding layer consisted of almost all coarse-grained materials; fine-grained materials were absent.

The rock riprap and gravel/bedding materials that were removed were ultimately placed back in the void and the exposed area was restored. The location was marked using a wooden stake with orange flagging. NNUMTRA/AML personnel verbally communicated that an additional area towards the toe of the longest extent of the northeast side slope had been exposed by manually removing cover components and was subsequently restored prior to the arrival of DOE-LM representation. It was also communicated that this additional area did not exhibit the same features (i.e., a void) compared to the area with the small void described above. No additional hand removal of material on the cell occurred that day and no indication of a breach of the radon barrier was evident. However, radiological surveys were not taken during this work as there was no Radiological Control Technician onsite and the work that was performed by NNUMTRA/AML personnel was neither planned nor authorized.

DOE-LM notified the Nuclear Regulatory Commission (NRC) of these events and findings in an email dated January 8, 2018 and NRC issued a response to DOE-LM via email on January 22, 2018. Email correspondence is accessible on the ADAMS NRC website located at http://www.nrc.gov/reading-rm/adams.html.

Included Items:

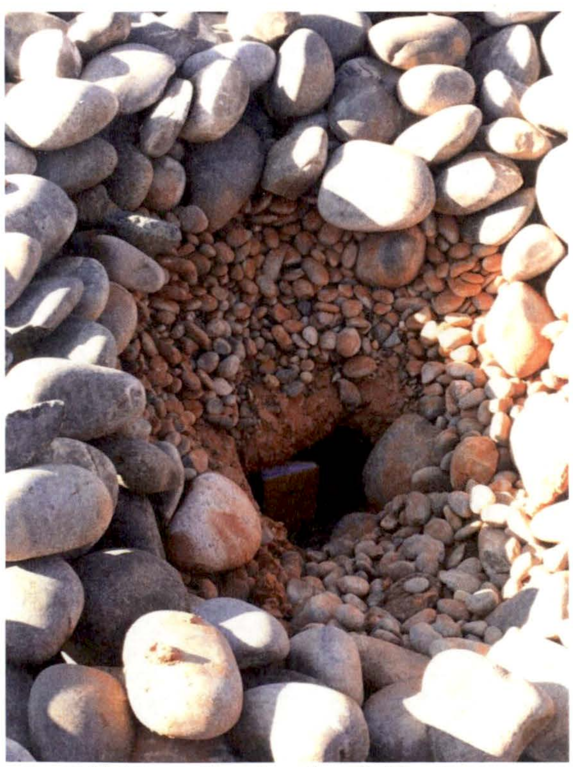
- The following documents are attached to this Report:
  1. Trip Photos

Cc: Dan Brennecke, David Miller, Jeff Carman, John Manée

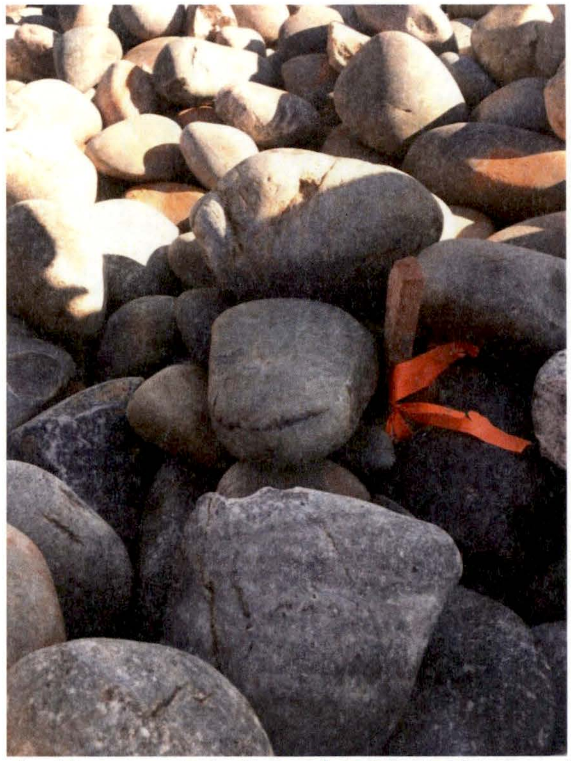
Void near toe of northeast side slope

Location of void relative to toe of northeast side slope

Relative location of void beneath small area of hand removed rip rap and bedding material



Void near toe of northeast side slope



Restored void area marked with wooden stake for future evaluations

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Appendix C10

Site Visit Trip Report, December 27, 2017

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Site Visit Trip Report

Site	Mexican Hat, Utah, Disposal Site	**Project**	NE Slope Cover Depressions Evaluation
Individuals making trip	Evan Tyrrell, CHMM (Navarro) & Bill Cary, Radiological Control Technician (RCT) (Navarro)		
Date(s) of Site Visit	December 27, 2017		

Purpose:

Perform radiological surveys throughout the site to compare to radiological readings at depression features and within the previously discovered void near the toe of the northeast side slope.

Summary:

A series of radiological surveys were performed by a qualified radiological control technician (RCT) in order to obtain ambient radiological conditions to compare to areas of concern on the northeast side slope of the disposal cell. An alphaNUCLEAR Model 597-PX3 radon monitor was utilized to collect 30-minute continuous samples for radon gas and a handheld 2"x2" sodium iodide "crutch" scintillometer was utilized to collect gamma radiological readings at a total of seven (7) radiological survey locations (RSL) throughout the site (RSL-1 through RSL-7). A handheld GPS device was used to collect location data for each radiological survey location. Radiological survey locations are depicted on an enclosed figure.

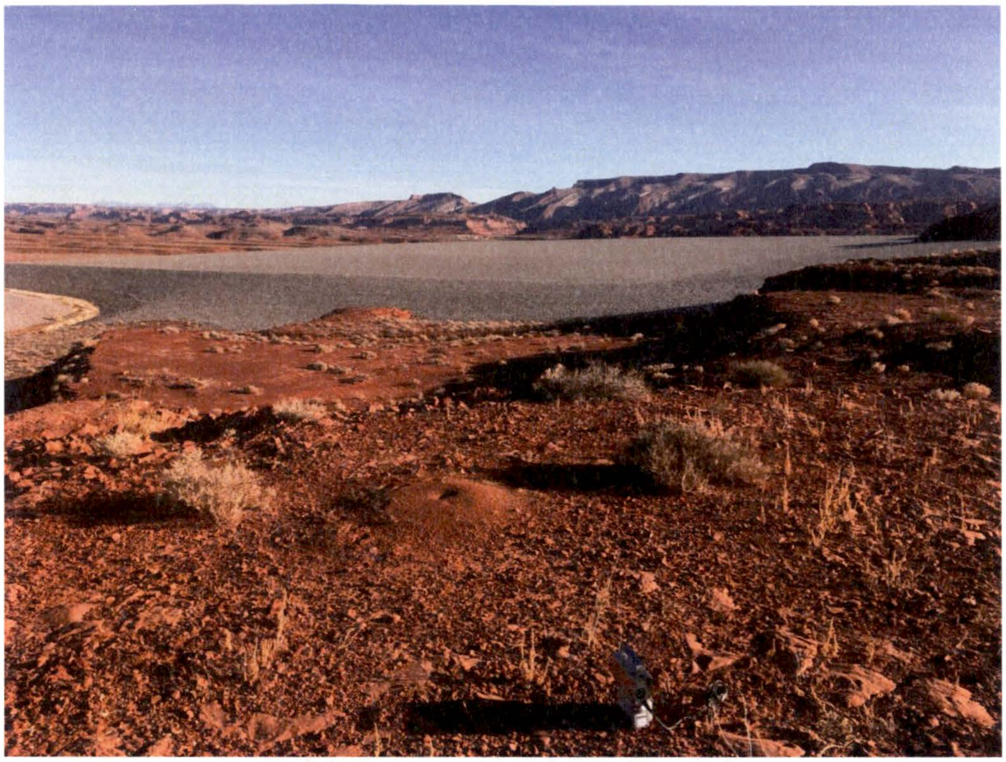
Two upwind locations were surveyed (RSL-1 and RSL-2). RSL-3 was collected on the top slope of the disposal cell next to site marker SMK-1. RSL-4 through RSL-6 were collected in areas of concern along the northeast side slope of the disposal cell. RSL-4 was located at the area of the recently discovered void and a series of three surveys were performed at this location (RSL-4a [before disturbance]; RSL-4b [after re-exposure of void]; and RSL-4c [after restoring the void]). Finally, RSL-7 was collected at a downwind location to the northeast of the disposal cell. At the end of the day, RSL-1 was resurveyed (RSL-1R) for radon to assess for any potential changes in ambient radon concentrations that may have occurred due to changes in meteorological conditions (i.e., barometric pressure, temperature).

Overall, the results showed no elevated radiological readings relative to ambient radiological conditions. In addition, RSL-4a, RSL-4b, and RSL-4c did not show any significant changes based on pre-exposure, re-exposure, and post-restoration activities at the recently discovered void near the toe of the northeast side slope. Finally, radiological survey results were below all applicable exposure-based and radon emanation standards.

Included Items:

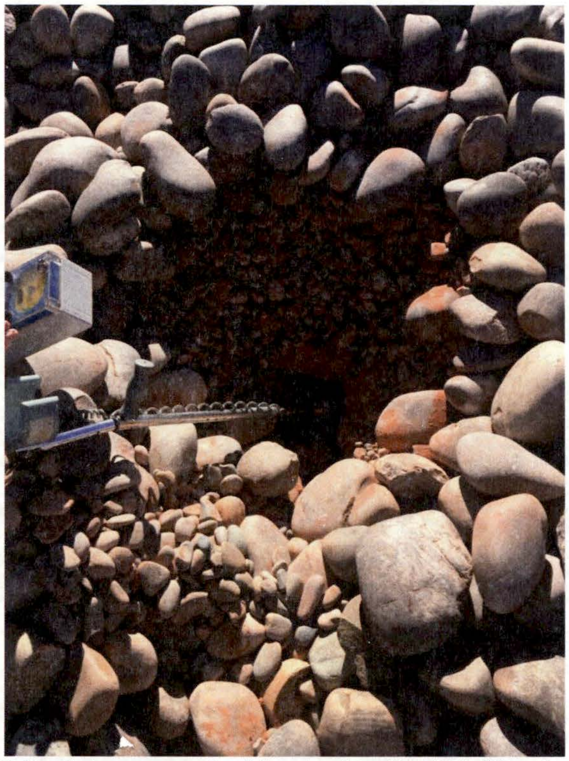
- The following documents are attached to this Report:
  1. Trip Photos
  2. Radiological survey locations map
  3. Radiological survey results table (tabulated data)
  4. Radiological survey results (raw data)

Cc:			
	Dan Brennecke	Dan Nordeen	Jeff Carman
	John Manée	Michael McDonald	Bill Cary
	Fred Smith		



Radiological survey location RSL-1 (upwind)

Ongoing collection of radon data at radiological survey location RSL-2 (upwind) using alphaNUCLEAR Model 597-PX3 radon monitor



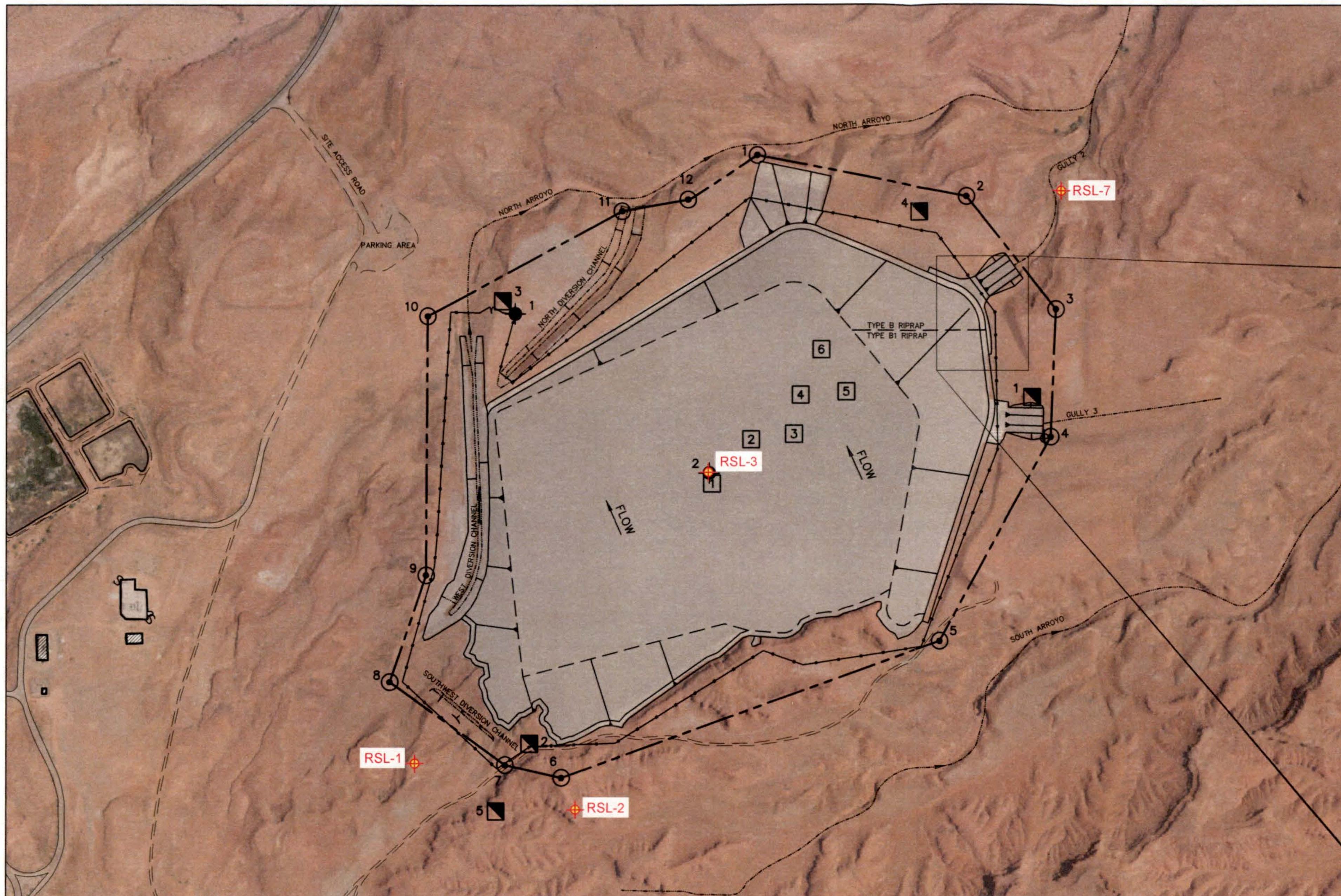
Radiological survey location RSL-4b (re-exposed void) using handheld 2"x2" sodium iodide crutch scintillometer

Radiological survey location RSL-4b (re-exposed void) using alphaNUCLEAR Model 597-PX3 radon monitor


Radiological survey location RSL-7 (downwind)

EXPLANATION

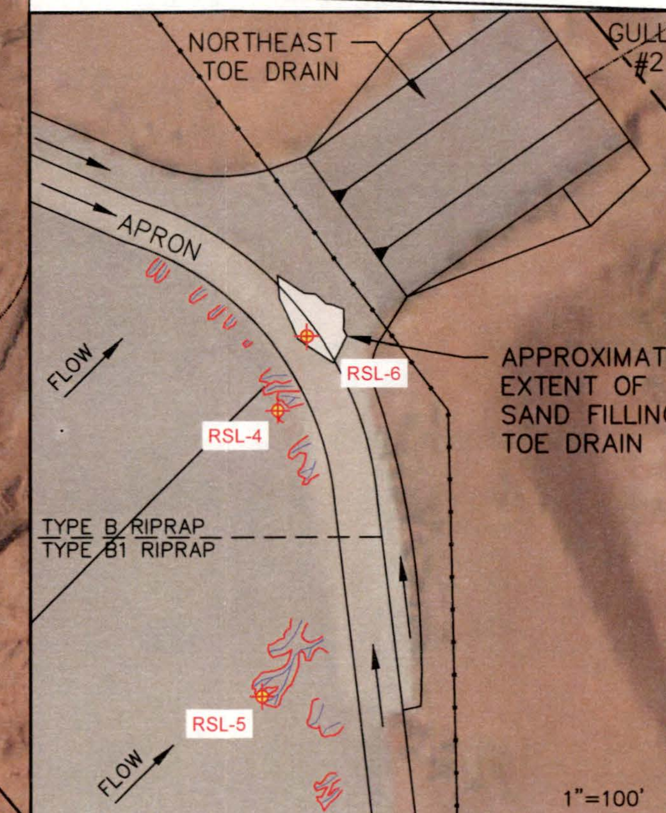
- SURVEY MONUMENT AND NUMBER
- SETTLEMENT PLATE AND NUMBER
- BOUNDARY MONUMENT AND NUMBER
- SITE MARKER AND NUMBER
- DRAINAGE PATH
- SURVEYED OUTLINE OF DEPRESSIONS
- DIRT ROAD
- PROPERTY BOUNDARY
- BARBED–WIRE FENCE
- SLOPE – TRIANGLE POINTS DOWNSLOPE
- DIRECTION OF FLOW
- RSL-4 RADIOLOGICAL SURVEY LOCATION & IDENTIFIER



SITE PLAN

SCALE IN FEET

500 250 0 500



AREAS OF CONCERN

NOTE:

- RSL–4 is located in the area of the recently discovered void.
- Radiological Survey performed on December 27, 2017.

U.S. DEPARTMENT OF ENERGY | Legacy Management
GRAND JUNCTION, COLORADO

Work Performed Under DOE Contract No. DE–LM0000421
NAVARRO Navarro Research and Engineering, Inc.

PROJECT SITE PLAN WITH AREAS OF CONCERN AND DECEMBER 2017 RAD. SURVEY LOCATIONS MEXICAN HAT, UT DISPOSAL SITE

DATE PREPARED:	FILENAME:
January 16, 2018	S1817900

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Radiological Survey Results
December 27, 2017
Mexican Hat, Utah, Disposal Site

Date	Radiological Survey Location (RSL) Identifier	Location Description	Radon (Rn)		Gamma			
			Bq/m³ Average[1]	Rn-222 Working Level (WL) Average[1,2]	Counts per Second (cps) BACKGROUND	Counts per Second (cps) DIRECT	μR/hr BACKGROUND	μR/hr DIRECT
12/27/2017	RSL-1	Upwind of Disposal Cell (background)	35	0.0033	213	NA	12.6	NA
12/27/2017	RSL-1R	Replicate of RSL-1	42	0.01	NA	NA	NA	NA
12/27/2017	RSL-2	Upwind of Disposal Cell (background)	13	0.0033	241	NA	13.5	NA
12/27/2017	RSL-3	Top Slope of Disposal Cell near Site Marker (background)	68	0.01	226	NA	13.5	NA
12/27/2017	RSL-4a	Northeast Side Slope at Void Location (before disturbance)	28	0.0067	162	161	11.0	11.0
12/27/2017	RSL-4b	Northeast Side Slope at Void Location (after re-exposure)	28	0.0033	162	181	11.0	11.6
12/27/2017	RSL-4c	Northeast Side Slope at Void Location (after restoration)	0	0.0	162	165	11.0	11.1
12/27/2017	RSL-5	Northeast Side Slope at Depression Feature	44	0.1	195	180	12.0	11.6
12/27/2017	RSL-6	Northeast Toe Drain Area in Area of Sediment Accumulation	69	0.1	155	133	10.8	10.1
12/27/2017	RSL-7	Downwind of Disposal Cell (background)	74	0.15	181	185	11.6	11.7

Notes

[1] = Average radon values determined by averaging the 10-minute sample intervals at each RSL collected over a 30-minute duration

[2] = UMTRCA Standard of 20 pCi/m²/s is equivalent to a WL of 1.8

NA = Not Applicable

Radon-222 WL Values for Mexican Hat Tailing Pile and surrounding areas

Sample ID	Location (see map)	Radon – WL (RN-222) Average	Location Type
RSL-1	Upwind of cell, (Hill south of cell)	.0033	Background
RSL-2	Upwind of cell, (Tall hill Southeast of cell)	.0033	Background
RSL-3	Site Monument, (Site monument in center of the cell	.01	Background
RSL-7	Downwind of cell, (Toe drain on small hill)	.01	Background
RSL-1R	Upwind of cell, (2nd sample at 1st location later in the day)	.01	Background
RSL-4a	Cell void, (before disturbance)	.0067	Area of concern on cell
RSL-4b	Cell void, (after exposing void)	.0033	Area of concern on cell
RSL-4c	Cell void, (after covering void)	0.0	Area of concern on cell
RSL-5	Eastern Cairn, (above eastern cairn in a small depression)	.01	Area of concern on cell
RSL-6	In toe drain of cell slope, (approx. center of toe drain of cell north of cell)	.01	Near area of concern

1. Radon survey was completed on Mexican Hat tailings pile to try and determine if Rn-222 release rate is exceeding the 20 pCi/m2/s Limit for (inactive UMTRA Title I) sites.
2. The average WL was determined by averaging the 10 minute sample intervals at each location.
3. Th(Bq/m3) values were excluded in average calculation due to Rn-220 being part of the Th-234 decay chain conceder NORM.
4. 20 pCi/m2/s Limit from (Regulatory Guide 3.64 (Task WM 503-4) for (inactive UMTRA Title I) sites.
   20 pCi/m2/s = 1.8 WL/m2
5. The results above in the table were determined from three 10 minute sample intervals, these are results for that given day when measurement were performed. This method is just a **very small** snap shot in time, many variables that can effect sample results (wind, barometric pressure, etc.). I would recommend placing radon cup long term, in background areas and areas of concern(depressions) to get a better understanding of radon emissions.

Conclusion: Survey results indicate that WL (working level) radon emission from the area of concern (voids or depressions) are at background levels.

Radon Concentration Data Log Sheet

Site ID: Mexican Hat Site

Instrument ID: 2144

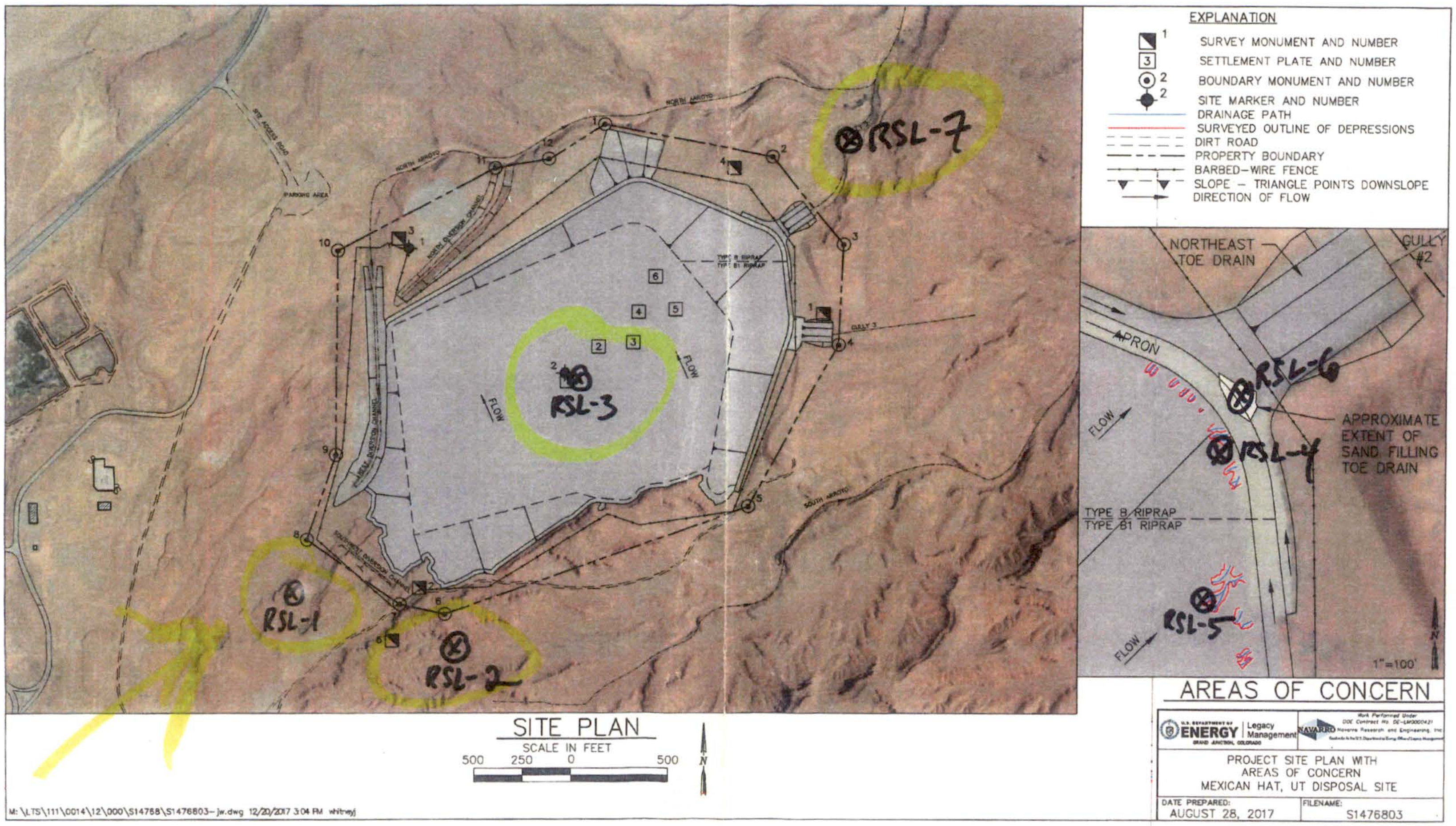
Date: 12/27/17

	Run Time (HHMM)					
	Start	Stop	Location	Sub-location	Feature Type	Comments/Notes
1	0900	0930	RSL-1	Upwind of Cell		Hill South of cell
2	0945	1015	RSL-2	Upwind of cell		Tall Hill Southeast of cell
3	1040	1110	RSL-3	Site Monument		Site Monument in center of the cell
4	1140	1210	RSL-4a	Void		Before disturbance
5	1230	1300	RSL-4b	Void		After exposing Void
6	1310	1340	RSL-4c	Void		After covering Void
7	1350	1420	RSL-5	Eastern Cairn		Above Eastern Cairn in a small depression
8	1425	1455	RSL-6	In Toe Drain of Cell Slope		Approx. Center of Toe Drain of Cell, North of Cell
9	1525	1555	RSL-7	Down wind of Cell		Downwind of Cell Toe Drain on Small Hill
10	1615	1645	RSL-1R	Upwind of Cell		2nd sample at 1st location, Hill South of Cell

Additional Comments

Reviewer: Anthony Martinez / Anthony Martinez

Date: 1/2/18


EXPLANATION
SURVEY MONUMENT AND NUMBER
SETTLEMENT PLATE AND NUMBER
BOUNDARY MONUMENT AND NUMBER
SITE MARKER AND NUMBER
DRAINAGE PATH
SURVEYED OUTLINE OF DEPRESSIONS
DIRT ROAD
PROPERTY BOUNDARY
BARBED-WIRE FENCE
SLOPE – TRIANGLE POINTS DOWNSLOPE
DIRECTION OF FLOW
RSL-7
RSL-3
RSL-1
RSL-2
FLOW
TYPE B RIPRAP
TYPE B1 RIPRAP
NORTHEAST TOE DRAIN
GULLY #2
APRON
RSL-6
RSL-4
RSL-5
APPROXIMATE EXTENT OF SAND FILLING TOE DRAIN
1"=100'
AREAS OF CONCERN
SITE PLAN
SCALE IN FEET
500 250 0 500
U.S. DEPARTMENT OF ENERGY Legacy Management GRAND JUNCTION, COLORADO
NAVARRO
PROJECT SITE PLAN WITH AREAS OF CONCERN MEXICAN HAT, UT DISPOSAL SITE
DATE PREPARED: AUGUST 28, 2017
FILENAME: S1476803
M:\LTS\111\0014\12\000\S14768\S1476803-jw.dwg 12/20/2017 3:04 PM whitneyj

RSL - 1 up wind of cell (Hill South of cell)

Date: 2017-12-27 08:57:55

Run Type: Default Run

Efficiency: 0.0558

Flow Rate: 250.00

mBinsRun: 3

RaA Background Counts: 0

RaC Background Counts: 0

ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 9:07	1	1	0	46	0	0.01	0	488	62678	86
12/27/2017 9:17	1	0	0	38	0	0	0	475	65067	89
12/27/2017 9:27	0	5	0	21	0	0	0	468	59606	90

RSL-2 upwind of cell (Tall hill Southeast of cell)

Date: 2017-12-27 09:43:52
Run Type: Default Run
Efficiency: 0.0558
Flow Rate: 250.00
mBinsRun: 3
RaA Background Counts: 0
RaC Background Counts: 0
ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 9:53	0	1	0	0	0	0	0	463	58477	91
12/27/2017 10:03	1	4	0	18	0	0	0	451	55617	93
12/27/2017 10:13	1	2	0	21	0	0.01	0	444	63450	95

RSL - 3 Site Monument (in center of the cell)

Date: 2017-12-27 10:38:25
Run Type: Default Run
Efficiency: 0.0558
Flow Rate: 250.00
mBinsRun: 3
RaA Background Counts: 0
RaC Background Counts: 0
ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 10:48	2	4	0	94	0	0.01	0	448	60035	94
12/27/2017 10:58	1	5	0	55	0	0.01	0	436	62358	96
12/27/2017 11:08	2	3	0	54	0	0.01	0	428	65344	98

RSL-4a Before disturbance (void)

Date: 2017-12-27 11:38:56

Run Type: Default Run

Efficiency: 0.0558

Flow Rate: 250.00

mBinsRun: 3

RaA Background Counts: 0

RaC Background Counts: 0

ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 11:48	0	1	0	0	0	0	0	443	63450	95
12/27/2017 11:58	2	2	0	36	0	0.01	0	428	55075	98
12/27/2017 12:08	3	4	1	49	111	*0.04 0.01	0	419	55832	99

Not used
due to RN-220

RSL-4b After exposing (void)

Date: 2017-12-27 12:28:48
Run Type: Default Run
Efficiency: 0.0558
Flow Rate: 250.00
mBinsRun: 3
RaA Background Counts: 0
RaC Background Counts: 0
ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 12:38	1	1	0	46	0	0.01	0	440	64532	95
12/27/2017 12:48	0	1	0	17	0	0	0	430	64584	98
12/27/2017 12:58	1	4	0	21	0	0	0	428	63185	98

RSL-4c After Covering (Void)

Date: 2017-12-27 13:10:36
Run Type: Default Run
Efficiency: 0.0558
Flow Rate: 250.00
mBinsRun: 3
RaA Background Counts: 0
RaC Background Counts: 0
ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 13:20	0	4	0	0	0	0	0	440	61172	96
12/27/2017 13:30	0	4	0	0	0	0	0	425	56957	99

RSL-5 Eastern Cairn (Above eastern cairn in small depression)

Date: 2017-12-27 13:48:03
Run Type: Default Run
Efficiency: 0.0558
Flow Rate: 250.00
mBinsRun: 3
RnA Background Counts: 0
RaC Background Counts: 0
ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 13:58	1	2	0	47	0	0.01	0	434	56700	97
12/27/2017 14:08	2	2	0	54	0	0.01	0	418	58737	99
12/27/2017 14:18	0	4	0	32	0	0.01	0	419	57059	99

RSL-6 IN tow Drain of cell slope (Approx. center of Tow Drain of cell, North of cell)

Date: 2017-12-27 14:25:17
Run Type: Default Run
Efficiency: 0.0558
Flow Rate: 250.00
mBinsRun: 3
RaA Background Counts: 0
RaC Background Counts: 0
ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 14:35	1	1	0	46	0	0.01	0	426	57327	98
12/27/2017 14:45	4	5	0	91	0	0.01	0	422	60490	99

RSL-7 Down wind of cell (Down wind of cell Tow Drain on small hill)

Date: 2017-12-27 15:24:09
Run Type: Default Run
Efficiency: 0.0558
Flow Rate: 250.00
mBinsRun: 3
RaA Background Counts: 0
RaC Background Counts: 0
ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 15:34	2	2	0	92	0	0.02	0	433	64249	97
12/27/2017 15:44	1	1	0	55	0	0.01	0	424	62139	99

RSL-1R up wind of cell (2nd sample at 1st location Hill South of cell)

Date: 2017-12-27 16:13:49
Run Type: Default Run
Efficiency: 0.0558
Flow Rate: 250.00
mBinsRun: 3
RaA Background Counts: 0
RaC Background Counts: 0
ThC Background Counts: 0

Time	1.8->6.5 MeV Counts	6.5->8.2 MeV Counts	8.2->9.0 MeV Counts	Rn (Bq/m^3)	Th (Bq/m^3)	WL	Status	Pump Duty Cycle Number	Air Flow Period	Filter Level
12/27/2017 16:23	1	1	0	46	0	0.01	0	432	55741	97
12/27/2017 16:33	1	4	0	35	0	0.01	0	424	63341	99
12/27/2017 16:43	2	1	0	44	0	0.01	0	424	62426	99

Data was saved using Vista Data Vision
Saved: 2017-12-28 17:07:02

Time Period: 2017-12-27 00:00:00 - 2017-12-29 00:00:00

Time	Mexican Hat Met - Hourly: Met_AirTemp_C[°C]	Mexican Hat Met - Hourly: Met_Bar_mmHg_WS700[mm Hg]
12/27/2017 0:00	0.1874403	771.9655
12/27/2017 1:00	-0.6419345	772.5656
12/27/2017 2:00	-1.855468	773.3157
12/27/2017 3:00	-2.808112	773.9908
12/27/2017 4:00	-3.677588	774.7408
12/27/2017 5:00	-4.223851	774.8908
12/27/2017 6:00	-4.397686	775.0409
12/27/2017 7:00	-4.440899	775.6409
12/27/2017 8:00	-4.812047	776.166
12/27/2017 9:00	-5.676641	776.4659
12/27/2017 10:00	-4.208169	776.3159
12/27/2017 11:00	-2.120177	775.0409
12/27/2017 12:00	0.4333776	773.3907
12/27/2017 13:00	3.516268	771.2905
12/27/2017 14:00	6.262809	769.1904
12/27/2017 15:00	7.863207	767.4652
12/27/2017 16:00	9.388597	766.4901
12/27/2017 17:00	10.49793	766.1901
12/27/2017 18:00	10.35917	766.3401
12/27/2017 19:00	8.508809	767.3902
12/27/2017 20:00	5.879426	769.2653
12/27/2017 21:00	3.125354	770.2405
12/27/2017 22:00	1.550704	770.9155
12/27/2017 23:00	0.2653733	771.5155
12/28/2017 0:00	-0.6555852	772.4156
12/28/2017 1:00	-1.530612	772.7156
12/28/2017 2:00	-2.16002	772.8657
12/28/2017 3:00	-2.536813	773.6157
12/28/2017 4:00	-3.264441	774.0657
12/28/2017 5:00	-4.107949	774.5157
12/28/2017 6:00	-4.467507	775.1909
12/28/2017 7:00	-4.794944	775.7159
12/28/2017 8:00	-5.500718	776.3909
12/28/2017 9:00	-6.045571	777.366
12/28/2017 10:00	-4.562256	776.3159

NAVARRO

Contractor to the U.S. Department of Energy Office of Legacy Management

Radiological Survey Map

Radiological Work Permit No.: N/A **Purpose:** Radiological Investigation Survey **Time:** Various

Site Name: Mexican Hat **Location:** Various locations at the Mexican Hat Disposal Cell.

Technician: Bill Cary / [signature] **Date:** 12/27/2017 **Reviewer:** [signature] **Date:** 1-4-18

Instrument 1		Instrument 2		Instrument 3	
Instrument/Probe Model	N/A	Instrument/Probe Model	N/A	Instrument Model	SC-133
Instrument Serial No.		Instrument Serial No.		Instrument Serial No.	13012
Probe Serial No.		Probe Serial No.		Probe Serial No.	13012
Calibration Due		Calibration Due		Calibration Due	7/31/18
Efficiency	α β	Efficiency	α β	Background	Backrounds were taken at various locations; see remarks
BKGD (cpm):	α β	BKGD (cpm):	α β		
Area Probe Correction Factor		Area Probe Correction Factor			

Standarized Symbols for Surveys

- ▢ = Tape press (4"x4") (no. inside)
- ○ = Smears (no. inside)
- ○ = Large area smears
- △ = Air samples (no. inside)
- ▭ = Neutron readings in mrem/hr unless otherwise noted
- — = Gamma readings in μrem/hr unless otherwise noted (beta readings also)
- * = Contact readings (dose rate)
- HS = Hot spot
- SOP = Step-off pad
- K = Reading at knee level (when sources from overhead)
- H = Reading at head level (when sources from overhead)
- ----- = Contaminated area
- XXXXX = Radiation area
- -x-x-x- = Contaminated/radiation area
- RM = Radioactive material area
- ⊗ = Floor drain
- ccpm or ncpm = Corrected or net cpm (gross back-ground) for direct frisk, alpha or beta/gamma specified
- # = Direct frisk

Highest Dose Rates

General Area 13.5 μR/hr

Contact N/A

Highest Contamination Level

Fixed N/A

Loose

N/A

see attached map

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Radiological Survey Map (continued)

Item Surveyed	Location Surveyed	Direct Survey (BL 12/27/17) Gross Counts		Net Counts[a]		Activity[b]		Smear Survey Gross Counts		Net Counts[a]		Activity[b]		Inst. No. Used
		Beta/Gamma ~~cpm~~	Alpha cpm	Beta/Gamma ~~cpm~~	Alpha cpm	Beta/Gamma dpm/100 cm²	Alpha dpm/100 cm²	Beta/Gamma cpm	Alpha cpm	Beta/Gamma cpm	Alpha cpm	Beta/Gamma dpm/100 cm²	Alpha dpm/100 cm²	
RSL-1	Hill south of cell	213cps		N/A										3
RSL-2	Tall hill southeast of cell	241cps		N/A										3
RSL-3	Monument,center of cell	226cps	N/A	N/A										3
RSL-4a	Void before open	161cps		-1cps										3
RSL-4b	Void after open.	181cps		19cps										3
RSL-4c	Void after close	165cps		3cps										3
RSL-5	Depression	180cps		-15cps										3
RSL-6	Toe drain area	133cps		-22cps		N/A				N/A				3
RSL-7	Hill north of cell	185cps		4cps										3
	N/A													N/A

Applicable Limits (check one for alpha and one for beta)
Alpha (removable/total): ☐ 1000/5000 ☐ 200/1000 ☐ 20/500
Beta (removable/total): ☒ 1000/5000 ☐ 200/1000

[a]**Activity Equation**
Gross count minus BKGD count = Net count
Net count/Eff = dpm
Dpm x Area Probe Correction Factor (APCF) = dpm/100 cm²

APCF
44-9 = 6.5
FHZ 732 (GM) = 6.5
43-10-1 = 1

Remarks: Daily Instrument Response completed before instrument use. First 3 locations were backround only. Other backrounds taken adjacent to survey areas. RSL-4 backround 11.0 uR/hr, 162 cps, RSL-5 12.0 uR/hr, 195 cps, RSL-6 10.8 uR/hr, 155 cps, RSL-7 11.6 uR/hr, 181 cps.

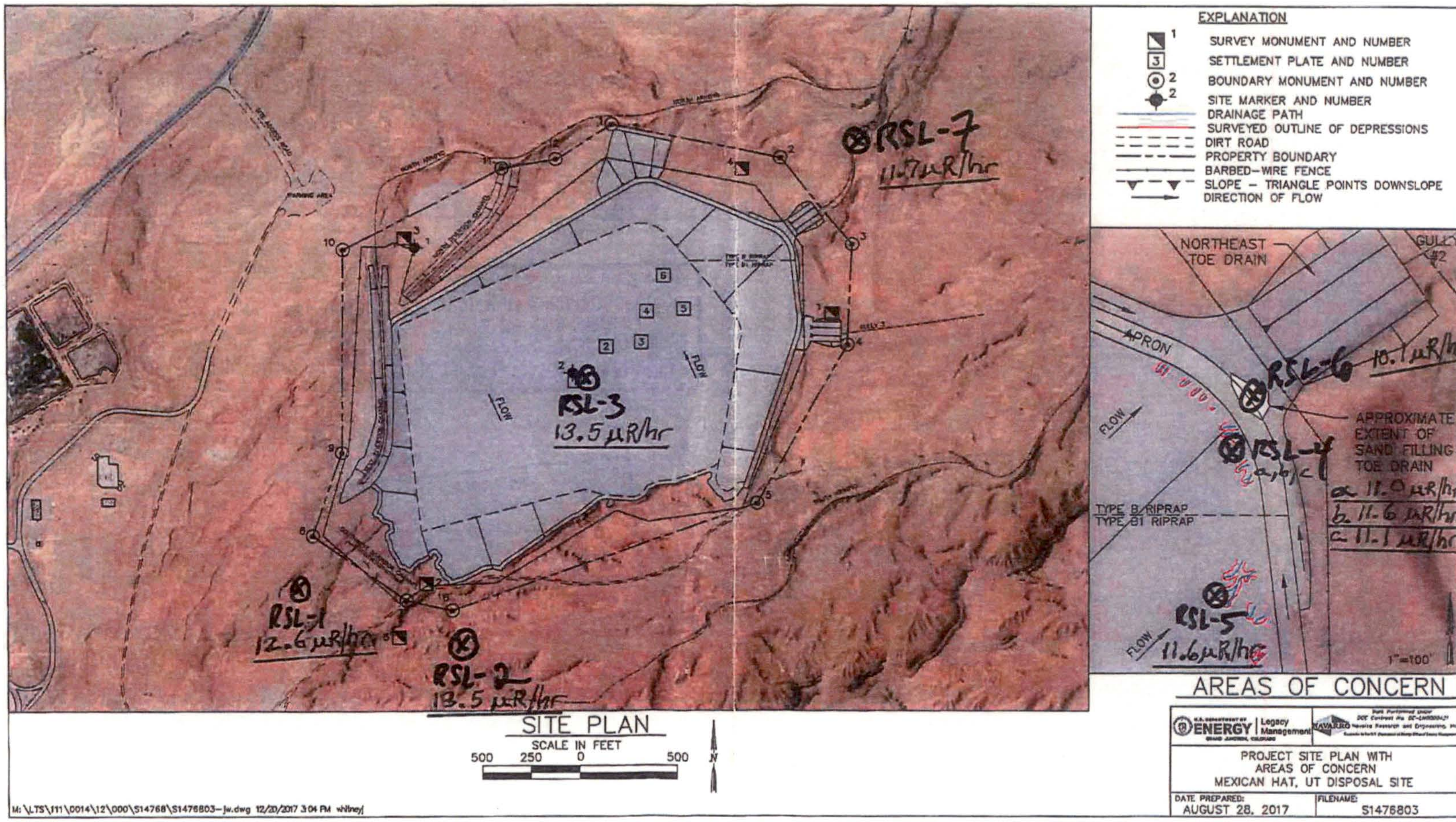
Released To: N/A

Pg 3 of 4

Radiological Survey Map (continued)

Release: ☐ Unrestricted ☐ Restricted ☒ Other (see remarks)

[b]See Table 2–2 of Site Radiological Control Manual I (LMS/POL/S04322).


EXPLANATION
SURVEY MONUMENT AND NUMBER
SETTLEMENT PLATE AND NUMBER
BOUNDARY MONUMENT AND NUMBER
SITE MARKER AND NUMBER
DRAINAGE PATH
SURVEYED OUTLINE OF DEPRESSIONS
DIRT ROAD
PROPERTY BOUNDARY
BARBED-WIRE FENCE
SLOPE – TRIANGLE POINTS DOWNSLOPE
DIRECTION OF FLOW
RSL-7 11.7 μR/hr
RSL-3 13.5 μR/hr
RSL-1 12.6 μR/hr
RSL-2 13.5 μR/hr
FLOW
NORTHEAST TOE DRAIN
GULLY #2
APRON
RSL-6 10.1 μR/hr
APPROXIMATE EXTENT OF SAND FILLING TOE DRAIN
RSL-4
a. 11.0 μR/hr
b. 11.6 μR/hr
c. 11.1 μR/hr
TYPE B RIPRAP
TYPE B1 RIPRAP
RSL-5 11.6 μR/hr
1"=100'
AREAS OF CONCERN
SITE PLAN
SCALE IN FEET
500 250 0 500
U.S. DEPARTMENT OF ENERGY Legacy Management
PROJECT SITE PLAN WITH AREAS OF CONCERN MEXICAN HAT, UT DISPOSAL SITE
DATE PREPARED: AUGUST 28, 2017
FILENAME: S1476803
M:\LTS\111\0014\12\000\S14768\S1476803-jw.dwg 12/20/2017 3:04 PM whitney

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Appendix C11

Engineering Site Visit Trip Report, January 9 and 10, 2018

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Engineering Site Visit Trip Report

Site	Mexican Hat, Utah, Disposal Site	**Project**	NE Side Slope Inspection, January 8-10, 2018
Individuals making trip	Dan Brennecke, Dan Nordeen, John Manée, Jeff Carman, Evan Tyrrell, Nick Kiusalaas, Ryan Hernandez, Treyton Nusbaum-Davis, Curtis Hales, Milton Bluehouse, Chrissy Largo, and Yolanda Harrison from LMS. In attendance from DOE LM for observation were Angelita Denny and Bill Frazier. In attendance from NNUMTRA/AML for observation were Gilbert Dayzie, Joni Tallbull, and Cortasha Upshaw.		

Purpose:

Follow-up visit to assess the area of the cell where a small void was recently discovered near the toe of the northeast side slope, and to assess other areas of concern and areas of no concern (control) where 5:1 rock cover is, and is not, showing visual signs of depressions on the northeast side slope of the disposal cell.

Basic Itinerary:
(including dates, to and from, travel method, lodging location

01/08/18: Travel from Grand Junction, CO to Mexican Hat, UT in GSA vehicle, check in at the San Juan Motel in Mexican Hat, UT.

01/09/18: Evaluate at least four (4) areas 4' x 6' in dimension, at least two showing depressions on the NE slope, and one slightly inside the apron drainage area where sediment accumulation has been observed at the toe of slope.

01/10/18: Complete trip evaluation by opening up one additional area upslope from TP1, travel back to Grand Junction, CO.

Summary:

- Met at the site at 0800 and reviewed all applicable safety and health paperwork and other LMS procedural documentation (e.g., Plan of the Week, JSA, Pre-Job Brief, PPE requirements).
- A total of 6 small test pits (TP1 through TP5, and TP8) were hand excavated to expose the bedding material and top of the radon barrier over the two-day period. All manually-removed materials were placed on tarps to maintain segregation of the riprap rock and bedding layer cover components. Two areas on the north side slope (TP6 and TP7) were flagged as potential test pit follow-up locations. Locations of each test pit were logged with a handheld GPS unit and are shown on the attached test pit locations map. Location specific test pit information is detailed below.
- All disturbed test pits were restored by replacing the removed bedding and riprap materials consistent with the as built conditions encountered during removal. Restored test pit locations were marked in the center of the restored area with a labeled pin flag, and the perimeter of the riprap that was removed at each location was painted with survey marker paint.
- All test pit locations were intermittently screened for gamma radiation by a Radiological Control Technician (RCT) utilizing a handheld 2"x2" sodium iodide "crutch" scintillometer. Test pits were screened before, during, and after disturbance, and no elevated radiological readings relative to ambient conditions were observed throughout the two days of field work.
- <u>TP1 (location of recently discovered void near toe of northeast side slope)</u>: The location was exposed by manually removing Type B riprap to expose the underlying bedding layer material in an area approximately 6' by 4' in size. Windblown material was observed on the riprap layer at approximately 5-inches below the surface. The riprap layer was roughly 12 inches thick. Approximately 4-inches of bedding material was encountered below the riprap materials, which contained little to no fine grained materials and did not appear to meet the gradation specifications in accordance with the cell completion report. An approximately 6-inch-thick, red cemented layer was observed immediately below the base of the bedding layer, where an open void was present. The cemented layer contained limited amounts of bedding material. The void was approximately 8 inches deep by 12 inches wide and appeared to extend through the cemented material, presumably into the radon barrier. The void extended under the cemented layer from 6-inches to 1-foot in all directions. Upon completing the removal of material from the TP1 area, an additional void located downslope from the initial void was discovered, which appeared to be connected to the initial void. The cemented material effervesced in the presence of hydrochloric acid (HCl) (10%) at both locations indicating the

presence of calcium carbonate. The exposed radon barrier below the cemented layer had limited reaction with HCl indicating limited amounts of calcium carbonate. The exposed cemented layer at this location was painted with survey marker paint for future reference. TP1 was restored by first placing large riprap in the voids and subsequently replacing the bedding and riprap materials consistent with the as built conditions encountered during removal.

- TP2 (visually distressed area exhibiting rill-like depressions on riprap surface): The surface rock designated as Type B1 Riprap was removed first by hand to expose the bedding layer material below in an area approximately 6' by 4'. Windblown material was noted approximately 6-inches below the surface. The riprap layer was approximately 16-inches thick. The gradation at the top of the exposed bedding material appeared to be 1-1/2" to 2" diameter washed rounded gravel with little to no fine-grained material. An apparent depressed area (potentially a collapsed void) was observed in the southeast corner of the exposed bedding layer. The bedding layer was removed, and was approximately 4-inches thick and consisted of segregated material with finer ¼-inch gravel at the base of the bedding layer. No fine-grained sand material was observed and the bedding material did not appear to meet the gradation specifications in accordance with the cell completion report. The SE depressed/void area appeared to be a void that had collapsed on itself with bigger rock mixed in with fines. The void was approximately 12-inches deep from the bottom of the bedding layer. The beginning of a linear erosion rill was observed in the radon barrier in the NE corner of the excavation and progressed from 0 to 6 inches deep on the surface of the radon barrier when first exposed. Digging into the rill area exposed moist material with some aggregate mixed in suggesting that maybe the rill was deeper at some previous time. It extended from the upper to lower portion of the exposed radon barrier, indicating it continued downslope of the test pit. Poorly cemented to non-cementitious material was noted at the surface of the radon barrier. Materials at this location effervesced in the presence of 10% HCl, indicating the presence of calcium carbonate (the reaction to HCl was not as strong as at TP1, suggesting the material is less strongly cemented). The exposed radon barrier at this location was painted with survey marker paint for future reference. TP2 was restored by first placing large riprap in the collapsed void and subsequently replacing the bedding and riprap materials consistent with the as built conditions encountered during removal.

- TP3 (control area with no apparent surface depressions in the riprap surface): Similar removal procedures were followed at this location with removal of Type B1 riprap material by hand in a 5' by 7' area, followed by removal of a small portion of the bedding layer below to investigate the bedding layer and expose the radon barrier.. Windblown material was observed at 6-inches below the top of the riprap surface. The riprap layer was approximately 1-foot thick. The bedding layer was approximately 7-inches thick, with substantially more sandy fines compared to TP1 and TP2. No disturbance was noted in the surface of the exposed bedding material at TP3. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.

- TP4 (control area with no apparent surface depressions in the riprap surface): Type B riprap material was removed by hand in an 8' by 3' area, followed by removal of a small portion of the bedding layer to investigate the bedding layer and expose the radon barrier. The riprap layer was 12-inches thick, and bedding layer was 6-inches thick with substantially more sandy fines compared to TP1 and TP2. No disturbance was noted in the surface of the exposed bedding material. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.

- TP5 (limestone riprap apron near transition from northeast side slope where sediment accumulation has been observed): A small area of type C angular limestone riprap was removed from this location, which was located approximately 75-feet downslope and slightly cross gradient from TP1. As riprap was removed, the space between the angular riprap was heavily in-filled with red silty sand that did not display clay-like properties. The physical properties of this material indicated that it appears to be accumulated windblown sediment. Riprap thickness appeared to be approximately 24-inches thick, but the excavation area was too small to properly evaluate. At the 24-inch depth, smaller rounded gravel resembling bedding material was observed but was not confirmed to be bedding material. No signs of cell performance issues were identified at this small excavation area. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.

- TP6 (near the toe of the north side slope in a small observed depression): A very small area of riprap was removed, but a full excavation was not completed at this location. The riprap appeared to be more than 12-inches thick and indicated the potential presence of a collapsed area. Further excavation will be required to evaluate this location. The observed depression in this location was not as evident compared to surface depressions that have been visually identified on the northeast side slope. Restoration of the exposed area proceeded with cover material replacement consistent with the as built conditions encountered during removal.

- TP7 (north side slope): A slight depressed area upslope and slightly west of TP6 was observed, but an excavation was not performed. Again, the observed depression in this location was not as evident compared to surface depressions that have been visually identified on the northeast side slope. This area was denoted TP7 as a potential test pit follow-up location.
- TP8 (located approximately 50-feet upslope of TP1 in an area where a surface depression was not visually evident): This area was excavated similarly to the other test pits, in an 8' by 4' area. The riprap layer was 12-inches thick, with windblown material 6-inches below the surface. The bedding layer was approximately 8-inches thick, with some ¼-inch gravel and no visible fines at the bottom (did not appear to meet gradation specifications). There was 2-inches of cementitious material on the surface of the radon barrier with gravel/sand fines up to ¼-inch diameter mixed in. No degradation of the exposed bedding layer was observed at this location. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during excavation.

Key Findings:

- No breach through the radon barrier was evident throughout this field work and no elevated radiological readings were observed.
- Riprap and bedding layer *thicknesses* appeared to meet specifications at test pit locations.
- Windblown sediment accumulation was present below the immediate riprap surface at all test pit locations.
- Cemented material (presumably radon barrier) was observed along the interface of the bedding layer and radon barrier towards the lower portions of the northeast side slope at TP1, TP2, and TP8. The cemented material appeared to be thicker towards the toe of the side slope and was not present at upgradient control points (i.e., TP3 and TP4).
- Northeast side slope exhibiting radon barrier degradation (piping/voids, incisement, and/or cementation) at TP1 and TP2; cementation was present at TP8.
- Bedding Material
  - Fines appear to be absent towards lower portions of northeast side slope (TP1, TP2, and TP8).
  - Fines could be over-concentrated at upper portions of northeast side slope (TP3 and TP4).

Included Items:

- The following documents are attached to this Report:
  1. Trip Photos
  2. Test Pit Location Map

Cc:	Dan Brennecke	Dan Nordeen	Jeff Carman
	David Miller	Evan Tyrrell	Nick Kiusalaas


TP1 – Bedding Layer/Voids


TP1 - Voids


TP1 – Voids


TP2 – Bedding Layer


TP2 – Bedding Layer


TP2 – Rill after digging out with rock hammer


TP2 – Voids


TP2 - Voids


TP3 – Bedding Layer


TP3 – Bedding Layer Bottom


TP3 – Top of Radon Barrier


TP4 – Top of Radon Barrier


TP5 – Gamma scan of excavation


TP5 – Estimated Bottom of Angular Rip Rap

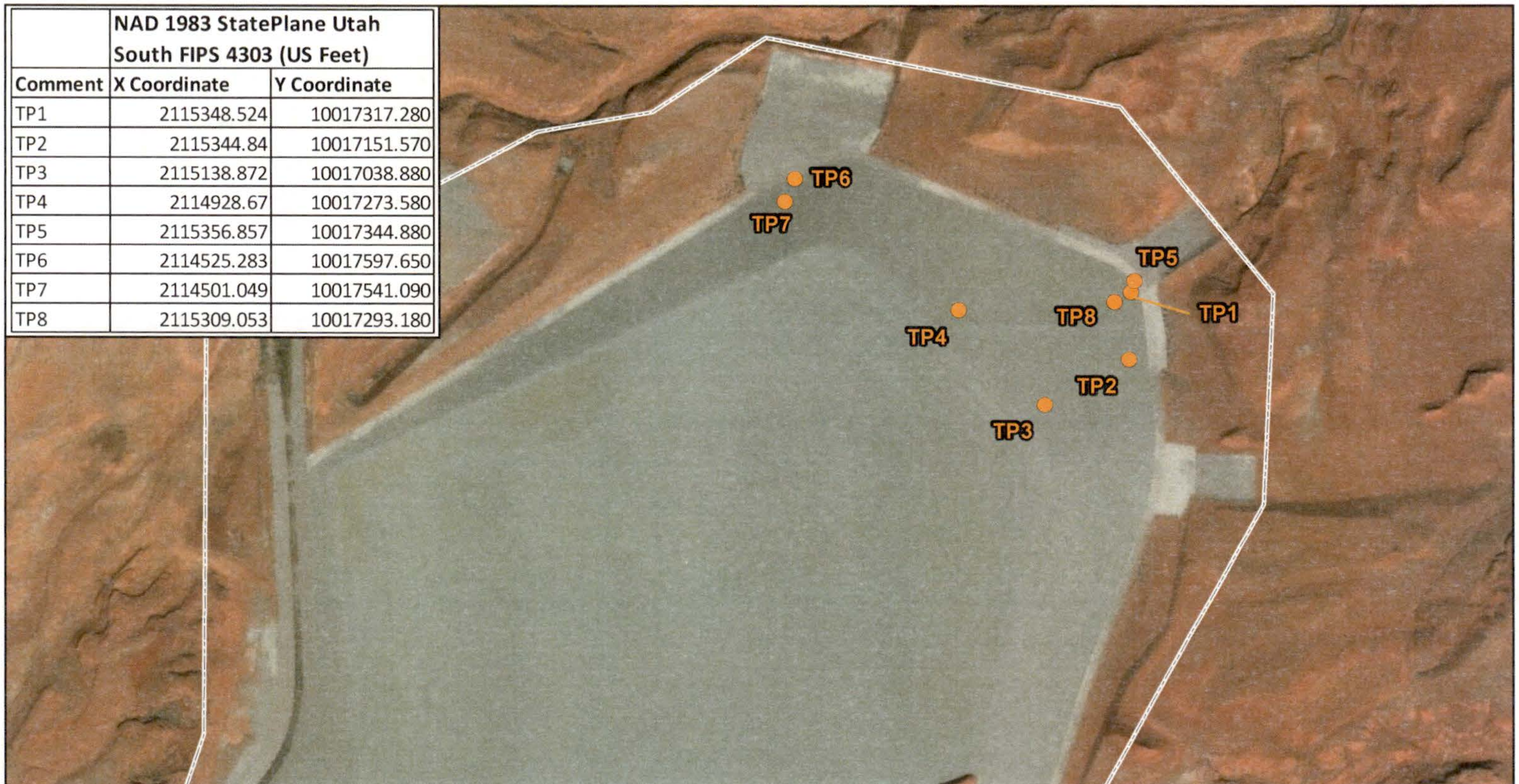

TP8 – Top of Bedding Layer


TP8 – Top of Radon Barrier


TP8 – Bedding Layer and Top of Radon Barrier


TP8 – Top of Radon Barrier

	NAD 1983 StatePlane Utah South FIPS 4303 (US Feet)	
Comment	X Coordinate	Y Coordinate
TP1	2115348.524	10017317.280
TP2	2115344.84	10017151.570
TP3	2115138.872	10017038.880
TP4	2114928.67	10017273.580
TP5	2115356.857	10017344.880
TP6	2114525.283	10017597.650
TP7	2114501.049	10017541.090
TP8	2115309.053	10017293.180



Legend

TP1 = Test Pit Location and Identifier

= Site Boundary

NOTE: TP6 and TP7 flagged as potential test pit follow-up locations

N

SCALE IN FEET

0 250 500

U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT

Work Performed by
Navarro Research & Engineering, Inc.
Under DOE Contract Number DE-LM0000421

Test Pit Locations
Mexican Hat, Utah, Disposal Site

DATE PREPARED: January 19, 2018

FILE NAME: S1832400

\\Lm\ess\EnvProjects\EBM\LTS\111\0014\06\000\S18324\S1832400.mxd HyattT 01/19/2018 12:03:06 PM

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Appendix C12

Engineering Site Visit Trip Report, January 23–25, 2018

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Engineering Site Visit Trip Report

Site	Mexican Hat, Utah, Disposal Site	**Project**	Limited Cover Evaluation, January 23-25, 2018
Individuals making trip	John Manée, Jeff Carman, Evan Tyrrell, Ryan Hernandez, Travis Thoele, Curtis Hales from LMS. In attendance from NNUMTRA/AML for observation was Gilbert Dayzie.		

Purpose:

Follow-up visit to assess the area of the cell where depressions were recently observed and marked near the toe of the north side slope, and to assess other areas of concern where 5:1 rock cover is showing visual signs of depressions on the north, west, and east side slopes of the disposal cell, as well as a discolored area on the top of the disposal cell cover.

Basic Itinerary:
(including dates, to and from, travel method, lodging location

01/23/18: Travel from Grand Junction, CO to Mexican Hat, UT in GSA vehicle, check in at the San Juan Motel in Mexican Hat, UT, walk south, north, west and top slopes to identify potential test pit locations.

01/24/18: Evaluate at least six (6) areas 4' x 6' in dimension showing depressions on the north, west, east, and top slopes of the disposal cell.

01/25/18: Complete limited cover evaluation by evaluating two additional areas on the east side slope, travel back to Grand Junction, CO.

Summary (1/23/2018):

- John Manée and Jeff Carman arrived at the site on 1/23/18 at 1600 and reviewed all applicable safety and health paperwork and other LMS procedural documentation (e.g., Plan of the Week, JSA, Pre-Job Brief, PPE requirements).
- Walked the south, west, north and top slopes to identify areas for possible test pits.
- Left the site at 1745.

Summary (1/24/2018):

- John Manée, Jeff Carman, Evan Tyrrell, Ryan Hernandez, Travis Thoele, and Curtis Hales arrived at the site on 1/24/18 at 0800 and on 1/25/18 at 0730 and reviewed all applicable safety and health paperwork and other LMS procedural documentation (e.g., Plan of the Week, JSA, Pre-Job Brief, PPE requirements). Gilbert Dayzie arrived at about 1600 and was provided a safety and health briefing upon arrival.
- A total of 7 small test pits (TP6, TP7, and TP9 through TP13) were manually excavated to expose the bedding material and the top of the radon barrier over the two-day period. All manually-removed materials were placed on tarps to maintain segregation of the riprap rock and bedding layer cover components. One area on the west side slope (PTP1) was flagged as a potential test pit follow-up location. Locations of each test pit were logged with a handheld GPS unit and are shown on the attached test pit locations map. Location specific test pit information is detailed below.
- All disturbed test pits were restored by replacing the removed bedding and riprap materials consistent with the as built conditions encountered during removal. Restored test pit locations were marked in the center of the restored area with a labeled pin flag, and the perimeter of the riprap that was removed at each location was painted with survey marker paint.
- All test pit locations were intermittently screened for gamma radiation by a Radiological Control Technician (RCT) utilizing a handheld 2"x2" sodium iodide "crutch" scintillometer or equivalent radiological screening device. Test pits were screened before, during, and after disturbance, and no elevated radiological readings relative to ambient conditions were observed throughout the two days of field work.

- TP7 (location of previously marked depression on the north side slope): This location was exposed by manually removing Type B riprap to expose the underlying bedding layer material below in an area approximately 6' by 4' in size. Windblown material was observed on the riprap layer at approximately 6-inches below the surface. The riprap layer was roughly 15-inches thick. Approximately 8-inches of bedding material was encountered below the riprap materials, which contained little to no fine grained materials and did not appear to meet the gradation specifications in accordance with the cell completion report. There was riprap material into the bedding layer on the west side of the pit. An approximate 2-inch-thick, red, weakly-cemented layer was observed immediately below the base of the bedding layer. There appeared to be erosion into the radon barrier in a seam that could be the start of piping. The exposed cemented layer and radon barrier at this location were painted with survey marker paint for future reference. TP7 was restored by replacing the bedding and riprap materials consistent with the as built conditions encountered during removal.
- TP9 (location on northern extent of top slope near the transition to the north side slope within an area of red discoloration): The surface rock designated as Type A riprap was removed by hand to expose the bedding layer material below in an area approximately 6' by 4'. Windblown material was noted approximately 3-inches below the surface. The riprap layer was approximately 8-inches thick, meeting the riprap thickness specifications for the top slope. The surface gradation of the bedding material appeared to be ¼" to 2" diameter washed rounded gravel with fine grained material and appeared to meet the gradation specifications in accordance with the cell completion report. A slight, linear, vertically elevated feature was observed in the north end of the exposed bedding layer. The bedding layer was removed, and was approximately 6-inches thick and consisted of segregated material with finer ¼-inch gravel at the bottom of the layer. The slight, linear, vertically elevated feature had an approximate 2-inch vertical elevation increase in the radon barrier leading towards the north side slope and appeared to continue laterally along the transition area from the top slope to the north side slope. The exposed radon barrier did not show signs of cementation and, with the exception of the slight, linear, vertically elevated feature, appeared to be in good condition. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.
- TP10 (area with minor surface depression on the north side slope): Removed Type B riprap material by hand to expose the underlying bedding material in a 6' by 4' area. Windblown material was observed on the riprap layer at 6-inches below surface. The riprap layer was roughly 8-inches thick on the uphill side and 12-inches thick on the downhill side. An approximate 7-inch-thick layer of bedding material was encountered below the riprap materials, with sandy fines the last 2-inches above the radon barrier, which appeared to meet the gradation specifications in accordance with the cell completion report. The top of the radon barrier appeared to be in good condition, and there was no apparent reason for the surface depression observed on the riprap surface at this test pit location. The exposed radon barrier and bedding layer were painted with survey marker paint for future reference. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.
- TP11 (area with minor surface depression on the west side slope): This location was exposed by manually removing the type B riprap material, followed by manual removal of the bedding layer until the radon barrier was exposed in a 6' by 4' area. Windblown material was noted on the riprap layer approximately 10-inches below the surface. The riprap layer was roughly 16-inches thick, and the bedding layer was approximately 6-inches thick, with sandy, fine-grained material at the bottom of the bedding layer, which appeared to meet the gradation specifications in accordance with the cell completion report. There was no depression noted below the riprap layer, and the bedding material appeared to be uniform in appearance below the riprap layer. There was no apparent reason for the depression noted at the top of the riprap layer and the underlying cover components (i.e., bedding layer and top of the radon barrier) appeared to be in good condition. The exposed radon barrier and bedding layer were painted with survey marker paint for future reference. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.
- PTP1 (possible test pit location on the west side slope): A slight surface depression was observed at this location, with 1-1/2" to 2" round river rock observed near the top of the riprap layer, but an excavation was not performed. The area was denoted as PTP1 as a potential test pit follow-up location. The location was GPS located for possible future excavation.
- TP6 (near the toe of the north side slope in a small observed depression): This location was exposed by manually removing the Type B riprap material to expose the underlying bedding layer material in an approximately 6' by 4' area. The riprap layer was roughly 14-inches thick. Windblown material was observed on the riprap layer at approximately 6-inches below the surface. The top of the bedding layer showed a depression in the bedding material of about 8-inches. An approximate 8-inch-thick layer of bedding material

was encountered below the riprap materials, which contained little to no fine grained materials and did not appear to meet the gradation specifications in accordance with the cell completion report. An approximate 2-inch-thick, red, weakly-cemented layer was observed immediately below the base of the bedding layer. Below the red cemented layer, very soft radon barrier material was noted, with evidence of radon barrier incisement in one area that was easily penetrated with hand tools to over 6-inches in depth. Also noted was a void that extended 3-inches under the cemented layer. The area of depression was about 12-inches wide by 24-inches long. The exposed radon barrier and bedding layer were painted with survey marker paint for future reference. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.

- Completed the test pits at 1630 on 1/24/18. Walked the south, west, and top slopes of the site to review the test pit locations with NNUMTRA/AML personnel. Left the site at 1745.

Summary (1/25/2018):

- John Manée, Jeff Carman, Evan Tyrrell, Ryan Hernandez, Travis Thoele, and Curtis Hales arrived at the site on 1/25/18 at 0715. Gilbert Dayzie arrived at about 0800.
- The intent of the morning was to observe the east side slope as the sun came up, and proceed to the west slope as it continued to rise. The sun was only clearly visible on the top of the east slope for a few minutes, before it became obscured by cloud cover. Cloud cover persisted for the remainder of the morning.
- <u>TP12 (area with minor surface depression on the east side slope)</u>: This area was exposed by manually removing the Type B1 riprap material to expose the underlying bedding layer material in an approximately 6' by 4' area. The riprap layer was roughly 12-inches thick. Windblown material was observed on the riprap layer at approximately 5-inches below the surface. An approximate 4-inch-thick layer of bedding material was encountered below the riprap materials, which contained little to no fine grained materials and did not appear to meet the gradation specifications in accordance with the cell completion report. There was a noted depression at the bedding layer that continued into the radon barrier. This depression was noted to be 2-inches lower on the north side of the test pit compared to the south side. The radon barrier was dry, very soft, and showing beginning signs of possible erosion. No cementation was observed. The exposed radon barrier and bedding layer were painted with survey marker paint for future reference. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.
- <u>TP 13 (south and upslope of TP12)</u>: This area was exposed by manually removing the Type B1 riprap material to expose the underlying bedding layer material in an approximately 3' by 3' area. The riprap layer was roughly 13-inches thick. Windblown material was observed on the riprap layer at approximately 6-inches below the surface. An approximate 6-inch thick layer of bedding material was encountered below the riprap materials. The bedding layer exhibited 1-1/2 to 2-inch material at the top of the layer, with ¼" to ½" material at the lower portion of the layer, showing more fines than most previous locations, and appeared to meet the gradation specifications in accordance with the cell completion report. The fines extended ¾" to 1" from the top of the radon barrier and the top of the radon barrier appeared to be in good condition. Restoration of the test pit proceeded with cover material replacement consistent with the as built conditions encountered during removal.

Key Findings:

- No breach through the radon barrier was evident throughout this field work and no elevated radiological readings were observed.
- Riprap and bedding layer *thicknesses* appeared to meet specifications at test pit locations.
- Windblown sediment accumulation was present below the immediate riprap surface at all test pit locations.
- North and east side slopes exhibiting radon barrier degradation (piping/voids, incisement, and/or cementation) at TP6, TP7, and TP12 with weak-cementation present at TP6 and TP7. Signs of incipient radon barrier degradation were observed at one location of the east side slope (TP12), but were not as evident as radon barrier degradation observed at TP6 and TP7 on the north side slope.
- Bedding Material
    - Fines appear to be absent towards lower portions of north and east side slopes (TP6, TP7, and TP12).

Included Items:

- The following documents are attached to this Report:
  1. Trip Photos
  2. Test Pit Locations Map

Cc:			
	Dan Brennecke	Dan Nordeen	Jeff Carman
	Evan Tyrrell	David Miller	

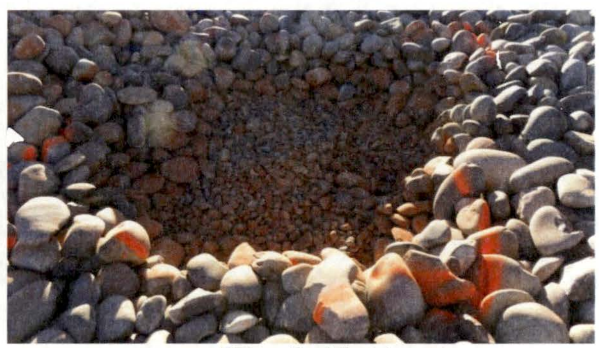

TP6 – Bedding Layer/Depression


TP6 - Bedding Layer/Depression


TP6 – Void


TP6 – Void


TP6 – Depth of Void


TP7 – Bedding Layer


TP7 – Depression


TP7 - Void

TP7 – Voids

TP9 – Top Slope Riprap

TP9 – Bedding Layer

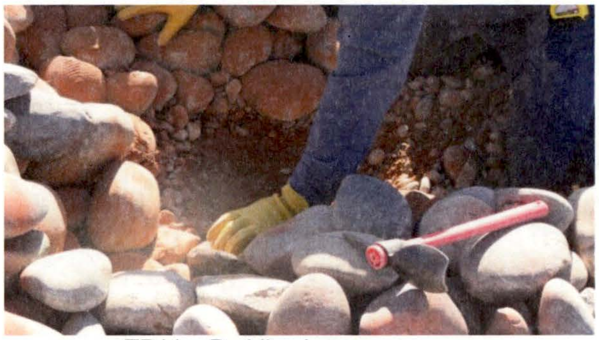
TP9 – Elevated Feature in Bedding Layer

TP9 – Depth to Radon Barrier

TP10 – Top of Bedding Layer

TP10 – Bedding Layer

TP10 – Top of Radon Barrier


TP11 – Bedding Layer


TP11 – Bedding Layer


TP11 – Top of Radon Barrier


TP12 – Top of Bedding Layer


TP12 – Top of Radon Barrier


TP13 – Top of Bedding Layer


TP13 – Top of Radon Barrier

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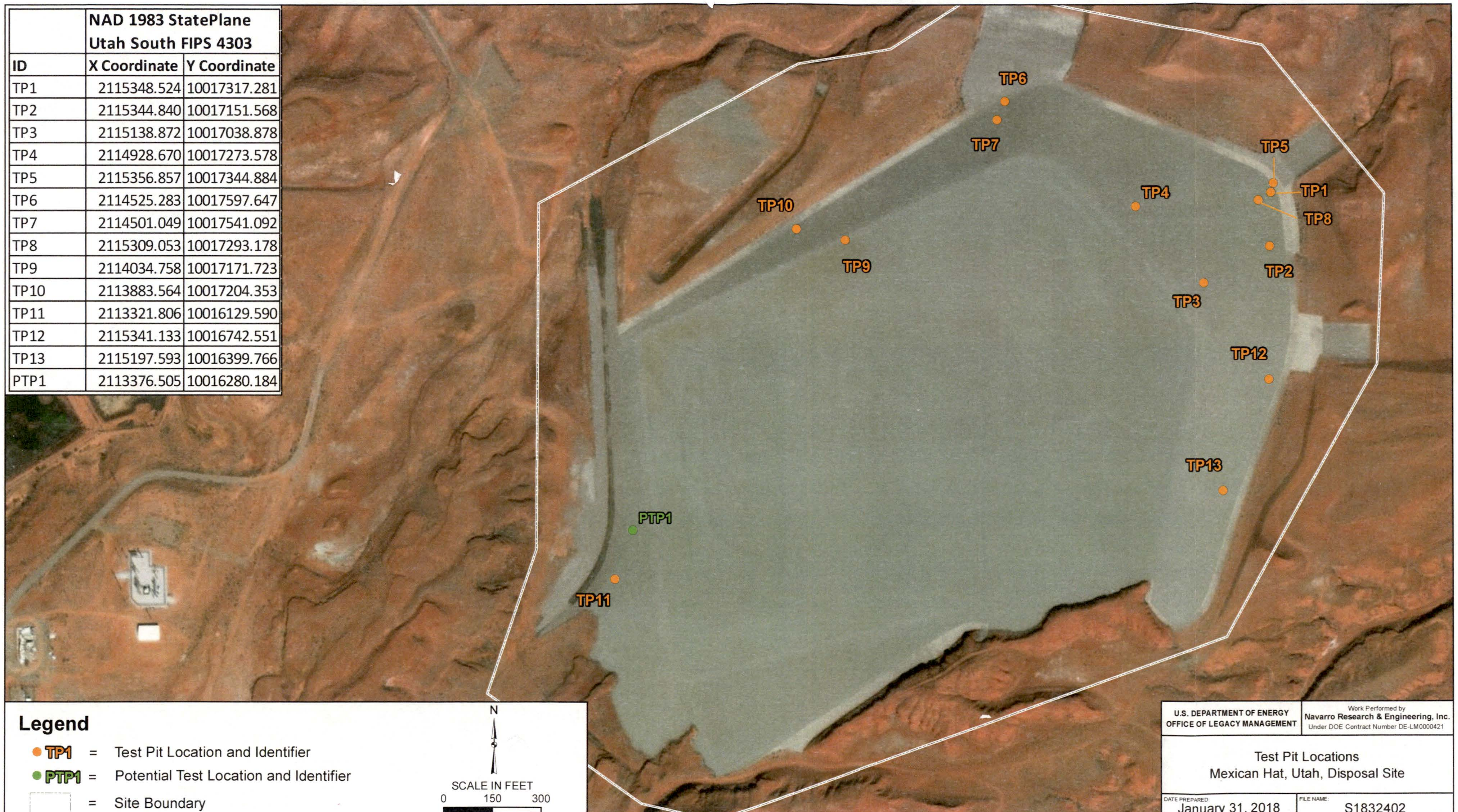
	NAD 1983 StatePlane Utah South FIPS 4303	
ID	X Coordinate	Y Coordinate
TP1	2115348.524	10017317.281
TP2	2115344.840	10017151.568
TP3	2115138.872	10017038.878
TP4	2114928.670	10017273.578
TP5	2115356.857	10017344.884
TP6	2114525.283	10017597.647
TP7	2114501.049	10017541.092
TP8	2115309.053	10017293.178
TP9	2114034.758	10017171.723
TP10	2113883.564	10017204.353
TP11	2113321.806	10016129.590
TP12	2115341.133	10016742.551
TP13	2115197.593	10016399.766
PTP1	2113376.505	10016280.184



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Appendix D

Precipitation Data

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Hydrology Review Data

Mexican Hat Average Annual Rainfall

Prior to Cover Compele

	Year	Ann Rain (in.)
1	1946	4.58
2	1947	7.32
3	1948	7.26
4	1949	8.39
5	1950	1.74
6	1951	2.72
7	1952	8.30
8	1953	4.45
9	1954	4.23
10	1955	2.63
11	1956	3.98
12	1957	9.57
13	1958	3.96
14	1959	4.57
15	1960	5.78
16	1961	6.54
17	1962	4.59
18	1963	3.82
19	1964	3.34
20	1965	9.25
21	1966	7.44
22	1967	4.84
23	1968	6.16
24	1969	4.92
25	1970	6.36
26	1971	5.76
27	1972	9.93
28	1973	6.93
29	1974	5.49
30	1975	4.95
31	1976	4.31
32	1977	3.04
33	1978	9.63
34	1979	7.08
35	1980	7.89
36	1981	7.54
37	1982	8.21
38	1983	9.19
39	1984	6.70
40	1985	7.82
41	1986	7.20
42	1987	8.45
43	1988	5.99
44	1989	3.70
45	1990	6.46
46	1991	4.90
47	1992	9.51
48	1993	8.76
49	1994	4.64
50	1995	6.42
	Average	6.14

After Cover Compele

	Year	Ann Rain (in.)
1	1996	5.43
2	1997	6.54
3	1998	4.99
4	1999	5.03
5	2000	7.11
6	2001	5.11
7	2002	6.56
8	2003	5.75
9	2004	6.67
10	2005	11.50
11	2006	5.75
12	2007	7.60
13	2008	5.93
14	2009	5.80
15	2010	10.56
16	2011	4.70
17	2012	3.77
18	2013	6.73
19	2014	4.08
20	2015	13.86
21	2016	8.07
	Average	6.74

Monthly Sum of Precipitation (Inches) Post Cover Completion

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1995	1.12	0.15	1.50	0.55	1.76	0.17	0.09	0.57	0.27	0.00	0.11	0.13	6.42
1996	0.29	0.14	0.11	0.06	0.66	0.31	0.24	0.10	1.10	0.81	1.41	0.20	5.43
1997	0.82	0.25	0.01	1.25	0.36	0.04	0.23	1.20	1.18	0.85	0.27	0.08	6.54
1998	0.25	1.12	0.65	0.28	0.14	0.00	0.37	0.07	0.55	1.23	0.31	0.02	4.99
1999	0.13	0.03	0.00	0.79	0.53	0.15	1.55	1.25	0.45	0.00	0.01	0.14	5.03
2000	0.42	0.20	1.55	0.13	0.10	0.10	0.85	0.70	0.65	1.99	0.26	0.16	7.11
2001	0.80	0.52	0.65	0.25	0.15	1.15	0.13	0.42	0.16	0.01	0.28	0.59	5.11
2002	0.14	0.00	0.22	0.15	0.01	0.00	0.10	0.41	3.73	1.22	0.36	0.22	6.56
2003	0.22	1.15	0.76	0.02	0.07	0.11	0.22	0.50	1.26	0.37	0.84	0.23	5.75
2004	0.43	1.01	0.02	1.00 f	0.00	0.01	0.64	0.18	2.12	0.22	1.34	0.70	6.67 a
2005	1.60	2.03 c	0.38	0.44	0.13	0.45	0.64	2.80	2.25	0.65	0.10	0.03	11.5
2006	0.48	0.10	1.00	0.02	0.11	0.15	0.87	0.33	0.14	2.11	0.08	0.36	5.75
2007	0.30	0.65	0.24	0.36	0.91	0.20	1.18	1.76	0.36	0.34	0.63	0.67	7.6
2008	1.19	1.31	0.00	0.10	0.37	0.06	0.02	0.25	0.16	0.60	0.76	1.11 a	5.93
2009	0.30	0.15	0.00	0.26	1.63	0.68	0.10	0.11	0.23	0.31	0.31	1.72 a	5.8
2010	1.64	1.16	0.88	0.08	0.78	0.18	0.60	2.20	1.11	1.07	0.07	0.79	10.56
2011	0.00	0.13	0.07	0.43	0.20	0.02	1.36	0.15	0.84	0.53	0.28	0.69	4.7
2012	0.47	0.34	0.10	0.05	0.00	0.00	0.63	0.95	0.43	0.35	0.00	0.45	3.77
2013	1.15	0.12	0.25	0.06	0.40	0.00	0.93	0.63	1.59	0.12	1.31	0.17 a	6.73
2014	0.00	0.28	0.10	0.10	0.29	0.00	0.21	1.01	1.23	0.34	0.11	0.41	4.08
2015	0.82	3.55 a	0.49	0.15	0.48	1.52	2.24	1.12	0.12	2.43	0.63	0.31	13.86
2016	2.70 a	0.47	0.19	0.43	0.32	0.02	0.41	1.30	0.71	0.05	0.55	0.92	8.07

Represents the highest rainfall for a given month since cover construction completed.
Added to show that for 5-months of a single year (2015) the rainfall was greater than one inch.

MEXICAN HAT, UT

Monthly Sum of Precipitation (Inches) 1946 to Present

File last updated on February 09, 2017
a = 1 day missing, b = 2 days missing, c = 3 days, ..etc..,
z = 26 or more days missing, A = Accumulations present
Long-term means based on columns; thus, the monthly row may not
sum (or average) to the long-term annual value.
MAXIMUM ALLOWABLE NUMBER OF MISSING DAYS : 5
Individual Months not used for annual or monthly statistics if more than 5 days are missing.
Individual Years not used for annual statistics if any month in that year has more than 5 days missing.

Note: Data listed in this table represents historical statistics based on measurements that were collected from the beginning (1946) to date.

Period of Record Statistics (1946 to Present)

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	0.58	0.54	0.42	0.33	0.40	0.23	0.65	0.77	0.70	0.81	0.49	0.51	6.58
S.D.	0.60	0.61	0.42	0.33	0.44	0.35	0.58	0.67	0.65	0.90	0.39	0.46	2.14
SKEW	1.46	2.51	1.18	1.22	1.64	2.05	0.97	1.77	1.83	3.34	0.86	0.87	0.76
MAX	2.70	3.55	1.74	1.36	1.76	1.52	2.33	3.74	3.73	6.20	1.62	1.72	13.86
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
YRS	71	70	71	70	71	71	69	70	70	69	69	69	64

Western Regional Climate Center
(https://wrcc.dri.edu)

NOAA Atlas 14, Volume 1, Version 5 MEXICAN HAT
Station ID: 42-5582
Location name: Mexican Hat, Utah, USA*
Latitude: 37.1447°, Longitude: -109.8683°
Elevation:
Elevation (station metadata): 4130 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.124** (0.107-0.144)	**0.160** (0.139-0.187)	**0.216** (0.187-0.253)	**0.266** (0.230-0.312)	**0.342** (0.291-0.403)	**0.407** (0.343-0.480)	**0.480** (0.398-0.572)	**0.563** (0.459-0.679)	**0.687** (0.544-0.844)	**0.795** (0.617-0.994)
10-min	**0.189** (0.163-0.220)	**0.243** (0.211-0.285)	**0.329** (0.285-0.385)	**0.405** (0.349-0.475)	**0.520** (0.443-0.613)	**0.619** (0.521-0.731)	**0.730** (0.606-0.870)	**0.857** (0.699-1.03)	**1.05** (0.829-1.28)	**1.21** (0.939-1.51)
15-min	**0.234** (0.202-0.273)	**0.301** (0.262-0.352)	**0.408** (0.353-0.477)	**0.502** (0.433-0.589)	**0.644** (0.550-0.760)	**0.768** (0.646-0.906)	**0.905** (0.752-1.08)	**1.06** (0.866-1.28)	**1.30** (1.03-1.59)	**1.50** (1.16-1.88)
30-min	**0.315** (0.272-0.367)	**0.405** (0.353-0.475)	**0.549** (0.476-0.643)	**0.676** (0.584-0.793)	**0.868** (0.740-1.02)	**1.03** (0.870-1.22)	**1.22** (1.01-1.45)	**1.43** (1.17-1.72)	**1.75** (1.38-2.14)	**2.02** (1.57-2.53)
60-min	**0.390** (0.336-0.455)	**0.502** (0.436-0.587)	**0.680** (0.589-0.795)	**0.837** (0.722-0.982)	**1.07** (0.916-1.27)	**1.28** (1.08-1.51)	**1.51** (1.25-1.80)	**1.77** (1.44-2.13)	**2.16** (1.71-2.65)	**2.50** (1.94-3.13)
2-hr	**0.464** (0.407-0.539)	**0.589** (0.516-0.683)	**0.792** (0.691-0.915)	**0.968** (0.839-1.11)	**1.24** (1.06-1.43)	**1.48** (1.24-1.71)	**1.75** (1.44-2.04)	**2.06** (1.66-2.42)	**2.54** (1.98-3.02)	**2.97** (2.24-3.56)
3-hr	**0.509** (0.452-0.581)	**0.641** (0.567-0.735)	**0.841** (0.743-0.959)	**1.01** (0.889-1.15)	**1.28** (1.11-1.45)	**1.51** (1.29-1.72)	**1.78** (1.49-2.05)	**2.09** (1.72-2.44)	**2.56** (2.05-3.05)	**2.98** (2.32-3.60)
6-hr	**0.602** (0.545-0.674)	**0.749** (0.676-0.839)	**0.953** (0.858-1.07)	**1.13** (1.01-1.26)	**1.39** (1.23-1.56)	**1.61** (1.41-1.81)	**1.87** (1.61-2.11)	**2.18** (1.84-2.47)	**2.65** (2.18-3.05)	**3.06** (2.46-3.63)
12-hr	**0.702** (0.639-0.777)	**0.875** (0.798-0.970)	**1.09** (0.995-1.21)	**1.27** (1.15-1.40)	**1.52** (1.37-1.68)	**1.72** (1.54-1.90)	**1.93** (1.71-2.15)	**2.19** (1.90-2.50)	**2.67** (2.21-3.08)	**3.09** (2.48-3.67)
24-hr	**0.709** (0.648-0.785)	**0.880** (0.813-0.980)	**1.12** (1.03-1.22)	**1.31** (1.21-1.41)	**1.57** (1.44-1.70)	**1.79** (1.63-1.93)	**2.01** (1.82-2.17)	**2.24** (2.01-2.52)	**2.70** (2.28-3.11)	**3.12** (2.49-3.71)
2-day	**0.769** (0.706-0.833)	**0.966** (0.887-1.05)	**1.21** (1.12-1.31)	**1.40** (1.29-1.52)	**1.67** (1.53-1.80)	**1.88** (1.72-2.03)	**2.09** (1.90-2.26)	**2.31** (2.09-2.55)	**2.73** (2.35-3.14)	**3.15** (2.53-3.74)
3-day	**0.823** (0.759-0.892)	**1.03** (0.952-1.12)	**1.28** (1.19-1.39)	**1.49** (1.37-1.61)	**1.76** (1.62-1.91)	**1.98** (1.80-2.14)	**2.19** (1.99-2.38)	**2.42** (2.19-2.64)	**2.77** (2.44-3.16)	**3.17** (2.62-3.76)
4-day	**0.877** (0.812-0.952)	**1.10** (1.02-1.19)	**1.36** (1.25-1.48)	**1.57** (1.45-1.70)	**1.86** (1.71-2.02)	**2.07** (1.89-2.25)	**2.30** (2.09-2.49)	**2.52** (2.28-2.74)	**2.82** (2.53-3.17)	**3.19** (2.71-3.78)
7-day	**1.01** (0.922-1.10)	**1.26** (1.15-1.37)	**1.55** (1.43-1.69)	**1.79** (1.66-1.94)	**2.10** (1.93-2.27)	**2.34** (2.15-2.53)	**2.57** (2.35-2.78)	**2.81** (2.56-3.04)	**3.12** (2.82-3.38)	**3.35** (3.02-3.82)
10-day	**1.12** (1.03-1.22)	**1.39** (1.28-1.51)	**1.72** (1.58-1.86)	**1.98** (1.83-2.14)	**2.31** (2.13-2.50)	**2.56** (2.35-2.77)	**2.81** (2.56-3.03)	**3.04** (2.77-3.30)	**3.36** (3.04-3.64)	**3.59** (3.23-3.89)
20-day	**1.39** (1.25-1.54)	**1.74** (1.58-1.93)	**2.16** (1.95-2.39)	**2.48** (2.24-2.75)	**2.91** (2.62-3.22)	**3.23** (2.89-3.57)	**3.55** (3.16-3.92)	**3.87** (3.44-4.28)	**4.29** (3.78-4.74)	**4.60** (4.02-5.10)
30-day	**1.63** (1.49-1.80)	**2.05** (1.88-2.25)	**2.53** (2.31-2.79)	**2.90** (2.63-3.18)	**3.37** (3.06-3.70)	**3.71** (3.36-4.07)	**4.05** (3.65-4.45)	**4.39** (3.94-4.82)	**4.81** (4.29-5.28)	**5.12** (4.54-5.63)
45-day	**1.93** (1.76-2.11)	**2.42** (2.21-2.66)	**2.97** (2.73-3.26)	**3.39** (3.10-3.72)	**3.92** (3.58-4.29)	**4.29** (3.92-4.71)	**4.67** (4.24-5.12)	**5.01** (4.54-5.49)	**5.45** (4.92-5.97)	**5.76** (5.19-6.32)
60-day	**2.20** (2.03-2.38)	**2.74** (2.52-2.96)	**3.36** (3.10-3.63)	**3.81** (3.53-4.13)	**4.39** (4.06-4.74)	**4.80** (4.43-5.18)	**5.19** (4.78-5.61)	**5.56** (5.10-6.01)	**6.02** (5.50-6.51)	**6.33** (5.77-6.87)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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Appendix E

Revised Filter Criteria Between Type B Riprap and Bedding Calculations

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Calculation No.:

Technical Task Cover Sheet

Discipline geotechnical/hydrological **Number of Sheets** ________

Project:
Legacy Management

Site:
Mexican Hat, UT

Subject:
Filter Criteria between Type B riprap and Bedding Layer

Sources of Data:

MK Calculation, "UMTRA HAT/MON, Erosion Protection, Oversizing, Gradation & Thickness", No. 9-418-05-01

Calculated by	Date	Checked by	Date	
G. Smith	9/12/2016			Geo • Smith ENGINEERING, LLC

Problem Statement:

Check filter criteria between Type B (&B1) riprap erosion protection and the bedding layer.

Method of Solution

Use open graded filter criteria to check filter compatibility between the two materials.

Assumptions:

As-built materials meet design specifications

Sources of Formulas and References:

Cedergren, Harry, R., 1988. *Seepage, Drainage, and Flow Nets,* 3rd edition, John Wiley and Sons, New York, NY.

Pit Slope Manual, Chapter 9 Waste Embankments, 1979. Mining Research Program, Mining Research Laboratories, CANMET Report 77-01.

Computer Source:

NA

Calculation:

Gradation of the Bedding Layer and Type B and B1 riprap are presented below and shown graphically on Figure No. 1 (ref: MK Calculation HAT/MON, Erosion Protection, Oversizing, Gradation & Thickness", No. 9-418-05-01).

Bedding Layer

Sieve Size (square opening)	% passing (by weight)
3-inch	100
1.5-inch	50-100
1-inch	35-70
No. 4	10-30
No. 30	0-10
No. 100	0-5

Type B Riprap Layer

Sieve Size (square opening)	% passing (by weight)
8-inch	100
6-inch	25-100
5-inch	0-100
4-inch	0-25
1-inch	0-5

Type B1 Riprap Layer

Sieve Size (square opening)	% passing (by weight)
5-inch	100
4-inch	0-100
3-inch	0-50
2-inch	0-25
No. 4	0-5

Open graded filters are required to prevent internal erosion of fine protection material. To be effective the filter must be more permeable than the protected material and its gradation must be that voids are sufficiently small to prevent passage of fine material from the protected material.

Filter criteria has 5 rules as follows (15 and 85 represent effective diameters of magnitude % passing, F is filter material and B represents the protected material) :

Rule #1
$D_{15\,F}/D_{85\,B} < 5$ *piping ratio,*

Rule #2
$D_{15\,F}/D_{15\,B} > 5$ and < 20 *guarantees sufficient permeability and to eliminate hydrostatic forces in filters,*

Rule #3
$D_{50F}/D_{50B} < 25$ *prevents movement of particles through filters,*

Rule #4
$D_{85F}/D_{15F} > 5$ *filter should filter itself and filter should be graded smoothly,*

Rule #5
Filters should not contain more than 5% passing No. 200 sieve.

In this analysis the bedding material is the protected material and Type B and B1 ripraps are the filters.

The following effective diameters for bedding and riprap material are evident from Figure No. 1.

Effective diameters for Material Layers

Material/Effective dia.	D_{15} (mm)	D_{50} (mm)	D_{85} (mm)
Bedding Layer	6 - 1	53 – 9.5	60 - 30
Type B riprap	150 - 50	177 - 108	195 - 122
Type B1 riprap	101 - 35	110 - 76	130 - 95

Type B/Bedding Layer
Rule #1 ; 146/30 = 4.9 < 5 ok
Rule #2 ; 50/6 = 8.33 > 5, <20 ok
Rule #3 ; 177/9.5 = 18.6 < 25 ok
Rule #4 ; 200/50 = 4 ng
Rule #5 ; 0% passing #200 ok

Type B1/Bedding Layer
Rule #1 ; 101/30 = 3.4 < 5 ok
Rule #2 ; 35/6 = 5.8 > 5, <20 ok
Rule #3 ; 110/9.5 = 11.6 < 25 ok
Rule #4 ; 130/35 = 3.7 ng
Rule #5 ; 0% passing #200 ok

Discussion:

Both types of riprap will prevent piping of the bedding layer and are permeable enough to prevent buildup of hydrostatic forces within the riprap. Both riprap material will prevent erosion of the bedding layer through the riprap layers. However, both ripraps do not filter themselves but are free of excessive fines. Both riprap gradations do not contain enough finer rock to be smoothly graded to provide a filter for itself, however the gradations are correctly designed as a uniform rock materials to provide erosion protection.

Conclusion and Recommendations:

Both types of riprap adequately filter the bedding layer from internal erosion and piping. However neither riprap filters itself. This is not a concern due to the fact that the riprap layers are designed to provide erosion protection against wind and water erosion and were not designed as filters. Also the hydraulics to cause removal of riprap material will not arise.

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON

Project UMTRA - MAT/MON	Contract No. 3885-58	Sheet 5 / File No.
Feature Erosion Protection	Designed JCK	Date 2-18-92
Item Oversizing, gradation & thickness	Checked FHW	Date 2/19/92

(This sheet is for Rev. 01)

3. Gradation Calculations for Riprap cont'd)
(c) Gradation Curves

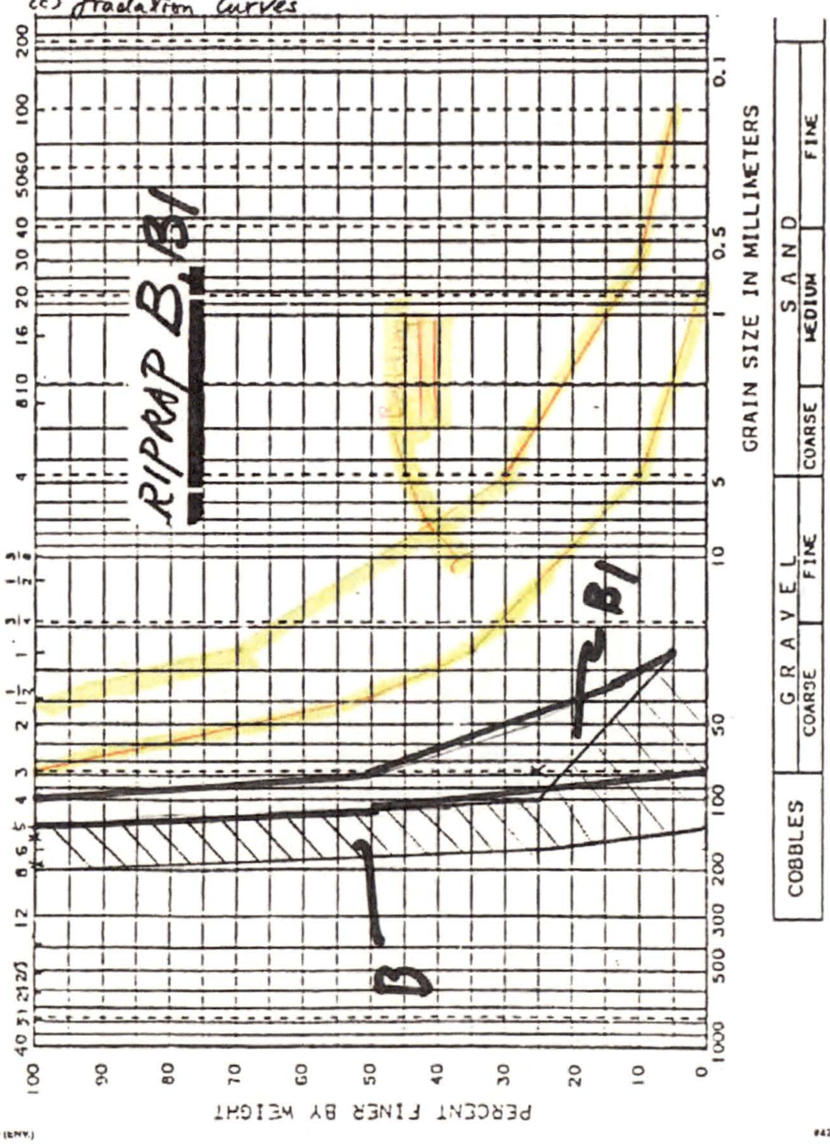

Figure No. 1

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Appendix F

Demolition and Contaminated Material Placement

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Appendix F1

Demolition Specification

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SECTION 02050

DEMOLITION

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for the demolition and disposal of the following facilities:

1. Existing Structures and Facilities:

    a. Concrete structures at the Monument Valley Site.

    b. Steel debris at the Monument Valley Site.

    c. Rubble, boulder and ore piles at Monument Valley Site. The piles are scattered throughout the site in the south, west and northwest areas of the site.

    d. Decontamination pad.

    e. Membrane liners from ditches, retention basins, spillways, collection sumps, recirculation ponds and water supply ponds.

    f. Existing chain link and woven wire fences.

    [g. Miscellaneous debris scattered throughout the site or included in the contaminated material.]*

2. Structures installed/constructed under this Subcontract including Washwater recirculation system including piping, tanks, and new pond liners.

B. Approximate descriptions and data of these facilities are listed in attached Table 02050-A and identified on the Subcontract Documents. Additional details are included in the Information for Bidders.

C. The structures and facilities installed/constructed under this Subcontract are specified under various Specification Sections of this Subcontract and are shown on the Subcontract Drawings. Although these structures are not listed in Table 02050-A, all temporary structures and facilities built at the sites shall be demolished and disposed of.

* P.I.D. 09-S-15

1.2 WORK NOT INCLUDED

Removal and disposal of existing stockpiles of demolished materials and debris is not included in the Scope of Work of this Section. Disposal of demolished materials and debris is specified in Section 02200.

1.3 RELATED WORK

A. Section 00800 - Special Conditions: Articles SC-7 and SC-8

B. Section 01300 - Submittals

C. Section 01500 - Construction Facilities

D. Section 01560 - Temporary Controls

E. Section 02200 - Earthwork: Disposal of demolished materials and debris.

1.4 DEFINITIONS

A. Demolition includes complete dismantling, cutting and breaking up of structures, including all solid contents and associated services and utility lines including their foundations and below grade slabs and footings.

[B. Removal and Disposal of Rubble: This shall consist of the removal of demolition debris, rubble containing wood, concrete, steel and boulders, breaking into specified sizes, loading, transporting to Mexican Hat site, unloading and placing in the tailings embankment as specified in Section 02200. The size and location of rubble piles is described in the Information for Bidders. The location of the rubble piles is also shown on the Subcontract Drawings.]*

[Text Deleted]*

1.5 SUBMITTALS

A. General submittal requirements are specified in Section 01300.

B. Ten days prior to the start of Work, the Subcontractor shall submit to the Contractor, for review, a demolition plan including the following:

* P.I.D. 09-S-15

1. Methods of demolition to be used.
2. Schedule showing dates and structures to be demolished.
3. List of equipment to be used.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.1 DEMOLITION

A. During the execution of this Subcontract, if unidentified waste material is suspected or encountered, the Site Manager shall be immediately notified for identification and subsequent disposition.

B. Locations of structures to be demolished are shown on the Subcontract Drawings and listed in attached Table 02050-A; however, the Subcontract Drawings do not show the locations of all foundations, rubble and debris, concrete pads, and the like, all of which are required to be demolished and removed within the boundaries of the project sites.

C. Pollution Controls:

   1. Water sprinkling, temporary enclosures, and other Contractor-approved methods shall be used to limit the amount of airborne dust and dirt to the lowest practical level. Demolition work shall comply with governing regulations pertaining to environmental protection.

   2. Water shall not be used if it is likely to create hazardous or objectionable conditions such as ice, flooding, or pollution. An approved water-based biodegradable wetting agent (surfactant), such as Dupont "Duponol WAQ" or equal, may be used to reduce the quantity of water required.

D. Demolition work shall be carried out using equipment compatible to the structures to be demolished and by methods required to complete the Work in accordance with governing regulations. The structures shall be demolished, and the materials and debris disposed of as specified in Section 02200.

E. After the completion of the construction phase, the synthetic membranes shall be removed, decontaminated and disposed of as required by the Contractor. If the membrane cannot be decontaminated by practical means, it shall be disposed of by cutting into strips, shredding and placing in the tailings embankment in a manner that would not induce settlement, inhibit water migration, or exceed the 5 percent limit on organic material by volume.

[F. Demolished materials, consisting of steel, concrete, wood, masonry and other man-made materials, rubble, debris and boulders shall be reduced in size to pieces to be no greater than 3 feet in any dimension and no more than 27 cubic feet in volume.]*

G. Metal objects with voids shall be crushed to sizes no greater than 27 cubic feet in volume, with the least dimension not exceeding 6 inches.

H. Grading shall be performed, as required by the Contractor, to restore existing grades to near natural conditions and as specified in Section 02200.

I. Fences and gates shall be removed and disposed of as Subcontractor's property. Concrete footings shall be disposed of in the tailings embankment or as directed by the Contractor.

J. Any pipe, conduit and ducts shall be cut to sizes no greater than 10 feet in length.

3.2 DISPOSAL OF DEMOLISHED MATERIALS AND DEBRIS

[A. Demolished materials, consisting of steel, concrete, wood, masonry and other man-made materials, rubble, debris and boulders shall be transported to the Mexican Hat site and disposed of in the tailings embankment, as specified in Section 02200 and as shown on the Subcontract Drawings.]*

B. Burning of materials resulting from demolition operations will not be permitted.

C. Uncontaminated materials such as fencing, piping membranes, wooden platforms, and stairs for trailers and other materials shall be removed as Subcontractor's property as directed by the Contractor.

D. Water supply facilities designated by the Contractor shall remain in place.

* P.I.D. 09-S-15

[Text Deleted]*

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for demolition and disposal of structures specified in this Section will be on a lump sum basis.

B. Measurement for payment for removal and disposal of rubble specified in this Section will be on a lump sum basis.

[Text Deleted]*

4.2 PAYMENT

[A. Payment for demolition and disposal of structures, removal and disposal of rubble, debris and boulders specified in this Section will be by the respective lump sum prices quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for furnishing all labor, materials, equipment, incidentals, and for performing all work specified including, but not limited to, transportation and placement of demolished materials, debris and boulders in the tailings embankment.]*

B. Separate payment will not be made for any other work specified in this Section. Full compensation for such work will be considered incidental to the applicable related items of work.

END OF SECTION 02050

* P.I.D. 09-S-15

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Appendix F2

Design Basis Memoranda

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UMTRA PROJECT - HAT/MON
DESIGN BASIS MEMORANDUM NO. 09-232-01
DECONTAMINATION AND DEMOLITION OF STRUCTURES

CONTENTS

1. PURPOSE

The purpose of this memorandum is to provide the basic information and set the guidelines for preparation of drawings and specifications for decontamination and demolition at the Mexican Hat and Monument Valley sites (Refs. 1 and 4).

2. SCOPE

This memorandum will establish the criteria for demolishing the foundations and rubble piles at the Monument Valley site.

It will also describe measures required for the demolition of the temporary fencing, retention basins, and the decontamination facilities for both sites.

3. DECONTAMINATION

Specifications for decontamination shall be written to require that:

A. Decontamination be performed by experienced crews supplied with adequate protective equipment (coveralls, respirators, gloves, boots and eye protection).

B. Contaminated water from washdown activities be used as a dust suppressant or monitored and disposed of in the retention basin.

C. Upon completion of remedial action work, other contaminated sediments, sludges and other materials from the bottoms, sides and ditches of the retention basin will be excavated and incorporated into the embankment. The shutdown and clean-up of the retention basin will be guided by applicable sections of 30 CFR Part 816 (Ref. 5).

D. Strict maintenance of the HEPA filter and proper disposal of contents and filters be required where decontamination is performed using nuclear grade industrial vacuum cleaners.

E. Application of contamination fixants prior to demolition be done under the supervision of health physicists, who will specify protective clothing and equipment.

4. DEMOLITION

Specifications for demolition shall require that:

A. Foundations and rubble piles shall be broken up in specified sizes to facilitate their disposal.

B. Protective equipment for personnel be required during the use of cutting torches, jack hammers or other equipment for demolition. Appropriate engineering controls be used to prevent dispersion of contaminated dust during demolition.

C. Open burning not be permitted.

5. PROTECTION AND SAFETY

All work shall be conducted in accordance with the UMTRA Project health and safety program, Reference 3.

6. DISPOSAL OF MATERIAL

Specifications for disposal of material shall require that:

A. Organic materials such as wooden demolition debris and grubbed vegetation be evenly distributed throughout the embankment; alternatively, large volumes of organic materials be buried elsewhere on the site (away from the tailings) where differential settlement is of less concern or be removed from the site if monitored and found safe (Ref. 2, Sec. 2.2.2d).

B. Rubble pieces be placed on the top of the existing pile and surrounded with compacted contaminated materials. Debris not be nested but instead placed in layers and tailings compacted within and around the individual pieces of debris in order to eliminate voids and, thereby, minimize differential settlement (Ref. 2, Sec. 2.2.2d).

C. No salvage of uncontaminated materials by the Subcontractor be allowed unless approved by the RAC.

D. Uncontaminated excavated material from the retention basin shall be stockpiled for restoration purposes. After final removal of contaminated sediments, the retention basin and the disturbed adjacent areas shall be filled, contoured for drainage, or restored to original ground contours, and revegetated.

7. REFERENCES

1. U.S. Department of Energy, "Remedial Action Plan and Conceptual Site Design for the Stabilization of the Inactive Uranium Mill Tailings Site at Mexican Hat, Utah, Draft February 1986, UMTRA-DOE/AL 050509.0000.

2. U.S. Department of Energy, "Design Criteria for Stabilization of Inactive Uranium Mill Tailings Sites", June 1984, UMTRA-DOE/AL-050424.0049.

3. U.S. Department of Energy, UMTRA Project Health and Safety Plan, June 1983, DOE/AL-6.

4. U.S. Department of Energy, "Remedial Action Plan and Conceptual Site Design for the Stabilization of the Inactive Uranium Mill Tailings Site at Monument Valley, Arizona, Draft February 1986, UMTRA-DOE/AL 050519.0000.

5. U.S. Department of Interior, "Code of Federal Regulation, CFR 30, Part 816, Chapter VII, Subchapter K: Permanent Program Performance Standards - Surface Mining Activities, Federal Register, Office of Surface Mining, July 1985.

UMTRA PROJECT - HAT/MON
DESIGN BASIS MEMORANDUM NO. 09-239-01
TAILINGS MATERIALS EXCAVATION AND FINAL EMBANKMENT

CONTENTS

1. PURPOSE

This Design Basis Memorandum presents the basis for design of the tailings materials excavation and the final embankment design for the Mexican Hat and Monument Valley sites.

2. SCOPE

The embankment will be designed to contain all contaminated materials from the Mexican Hat and Monument Valley Sites, including the adjacent areas, to provide long-term stability and radon control. Contaminated materials from the areas to be excavated and relocated to the tailings embankment include: the Monument Valley tailings piles and the heap leach pad areas, the windblown and water-borne deposit areas, spot wind-blown contaminated areas dispersed around the processing site and demolition materials.

3. DESIGN CRITERIA AND GUIDELINES

A. Excavation of Contaminated Materials

Contaminated materials outside of the proposed embankment area will be excavated to levels of contamination which do not exceed 5 picocuries of Ra-226 per gram above background in the top 15 centimeters of soil, and do not exceed 15 picocuries per gram above background averaged in any 15-cm layer below that depth (Ref. 2, Sec. 1.3.f). Excavation limits and depths will be defined on the construction plans based on the available most recent radiological survey data. Final excavation limits will be based on field radiological surveys during construction. The excavated areas will be regraded and revegetated for good drainage.

B. Final Embankment

1. The embankment area and layout will be consistent with the requirement that stabilization controls will be effective for up to 1,000 years, to the extent reasonably achievable, and in any case for at least 200 years (Ref. 2, Sec. 1.3.b).

2. The embankment will contain contaminated materials from existing

tailings piles, and the contaminated materials excavated from mill area, heap leach pad areas, ore storage area at Monument Valley and windblown and waterborne deposit areas at both sites in the vicinity, and any other contaminated materials such as wood, organic debris or demolition debris (Ref. 2, Sec. 2.2.2).

3. The estimated quantity of materials to be placed in the final embankment, as well as its area, will be determined consistent with good engineering practice, the estimated quantity of contaminated materials, economics of construction, and availability of land. The embankment system shall not extend into areas outside the designated site, onto floodplains, or into other areas which will reduce the performance of the remedial action, without prior written approval from the UMTRA Project office of the Department of Energy (Ref. 2, Sec. 2.2.2b).

4. The contaminated materials placed above the existing tailings will be densified by compaction or some other means to reduce the potential for long-term differential settlement.

5. A layer of uncontaminated earthen material designed to provide reasonable assurance that releases of radon-222 from the tailings embankment will not exceed an average release of 20 picocuries per square meter per second will be installed as a cover over the embankment to serve as a radon barrier (Ref. 3, Sec. 2.3).

6. The cover will be protected by a layer of rock, against erosion of the soil cover from the Probable Maximum Precipitation (Ref. 2, Sec. 2.2.2f). One or more filter layers will be required between the radon barrier and rock cover protection (Ref. 4, Ch. 5, Sec. 5.1.7).

7. If practical, embankment side slopes will be 1 vertical to 5 horizontal. The design of embankment sideslope shall be based on detailed analysis of tailings properties, slope stability, and erosion protection requirements (Ref. 3, Sec. 3.1.5). The minimum top slope shall be sufficient to promote drainage and prevent ponding (Ref. 2, Sec. 2.2.2c).

8. If wood or other organic debris is placed within the tailings embankment, it shall be chipped or otherwise reduced in size. It shall then be distributed throughout the lower portion of the tailings so as not to exceed 5 percent by volume in any lift or layer, and thus minimize differential settlement (Ref. 2, Sec. 2.2.2d).

9. The embankment will be designed to withstand the design earthquake.

10. The embankment construction will be sequenced to place lesser contaminated materials over more highly contaminated materials to reduce radon exhalation. The embankment will be comprised as follows, in order from bottom to top:

a. In-situ tailings piles.

b. Relocated materials from the mill area and the ore storage area at Monument Valley; rubble pieces will be placed on the top of the existing tailings embankment and surrounded with compacted relocated soils.

c. Heap leach pad area at Monument Valley.

d. Monument Valley tailings.

e. Relocated, contaminated materials from the windblown and water-borne deposit areas.

f. Contaminated material from temporary facilities.

g. Radon barrier.

h. Filter zone or zones.

i. Rock cover.

4. REFERENCES

1. U.S. Department of Energy, "Remedial Action Plan and Site Conceptual Design for the Stabilization of the Inactive Uranium Mine Tailings Site at Mexican Hat, Utah, Draft", UMTRA-DOE/AL-050509.0000, February 1986.

2. U.S. Department of Energy, "Design Criteria for Stabilization of Inactive Uranium Mill Tailings Sites", UMTRA-DOE/AL-050424.0049, June 1984.

3. U.S. Department of Energy, "Plan for Implementing EPA Standards for UMTRA Sites", January 1984, UMTRA-DOE/AL-163.

4. Morrison-Knudsen Engineers, "UMTRA Design Procedures Manual".

5. U.S. Department of Energy, "Remedial Action Plan and Conceptual Site Design for Stabilization of the Inactive Uranium Mine Tailings Site at Monument Valley, Arizona", UMTRA-DOE/AL-050519.0000, February 1986.

Appendix F3

Completion Report

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CONTAMINATED FILL MATERIAL

- Prior to placement of contaminated fill material the entire contaminated subgrade (existing grade of the tailings embankment) was plowed, harrowed and mixed to a depth of at least six inches, as verified by visual inspection.

- Prior to placement of the first lift, the entire contaminated subgrade surface of the tailings embankment area was compacted by either a Caterpillar 65 Challenger tractor towing a 5x5 sheepfoot compactor, or a Caterpillar 825 sheepfoot compactor. Preparation of the contaminated subgrade surface was inspected and approved in accordance with the Design Specifications.

- All contaminated material and debris resulting from demolition of the old Halchita/Mexican Hat Mill foundation, and associated structures, and from off-site vicinity properties during Phase I, were cut or broken into sizes meeting specified requirements before placement in the cell embankment.

- Contaminated fill materials requiring encapsulation were located and compacted in the cell embankment using the following equipment:

  <u>Phase I</u>

  Excavation: Caterpillar 235 excavator, Caterpillar 988 front end loader, and Caterpillar 631 and 633 scrapers.

Haulage: Caterpillar 631 and 633 scrapers, and 769 off-highway end dump trucks.

Compaction: Caterpillar D8N and D9N dozers, 14G and 140G motor grader, 65 Challenger tractor towing a 5x5 sheepfoot compactor and BG land leveler.

Phase II

Excavation: Caterpillar 235 excavator, 988 front end loader, and Caterpillar 631 and 633 scrapers, and Komatsu WA500 and WA600 front end loaders.

Haulage: Caterpillar 631 and 633 scrapers, 25 ton articulated end dump trucks, Volvo 25 ton and 30 ton articulated rock trucks, International semi-trucks pulling end dump or belly dump trailers or trailer pup units.

Material Placement: Caterpillar 14G and 16G motor graders, and Caterpillar 633 scraper.

Compaction: Caterpillar D8N and D9N dozers, 825 sheepfoot compactor, 65 Challenger tractor towing a 5x5 sheepfoot compactor, vibratory smooth-drum compactor, 825C sheepfoot compactor, Caterpillar D8N dozer, Caterpillar 613 and 633 waterwagons, and international 5,000 gallon waterwagon and trucks.

- Contaminated fill material was placed and verified to not exceed a 12 inch loose lift thickness. Where contaminated fill material contained individual pieces larger than the 12 inch loose lift thickness, the lift thickness was verified as minimum constructable thickness and materials were spread to ensure a void free mass and provide adequate compaction between larger particles.

- During placement of contaminated fill material, continuous visual inspection was performed to ensure that organic materials did not constitute more than five percent of the placed volume. Also, demolition debris and organics were evenly distributed throughout the fill to avoid concentrations. Individual linear pieces of wood, steel and plastic were cut or broken into pieces not greater than 10 feet in length; similarly, pieces of concrete, rock, masonry and steel was sized down to be less than 3 feet in any dimension and/or less than 27 cubic feet in volume.

- There was a total of 2,072,039 cubic yards of contaminated material placed in the cell embankment. Of the total 2,072,039 cubic yards, 185,040 cubic yards (i.e., 10 percent) was concrete, debris material, or large rocky contaminated material that could not be tested in accordance with ASTM D-698. Gradation testing was performed in accordance with ASTM D-698 to determine the testable status of the contaminated material. Materials exceeding 30 percent retatined on the 3/4 inch screen were considered non-testable.

- The contaminated fill material was required to be compacted with a minimum number of passes of an approved piece of equipment. Placement and compaction of the contaminated fill material was verified by visual QC inspections, as required.

- The test frequency for performing gradation testing of non-testable contaminated fill material was not specified in the Design Specifications.

- There were 72 gradation tests performed for the 185,040 cubic yards of non-testable contaminated fill material placed. This provides an average test frequency of one gradation test for each 2,570 cubic yards of material placed.

- The required test frequency for performing maximum dry density determination testing (i.e., ASTM D-698), was prior to placement of material and supplemental testing at a frequency of one test for each 10 to 15 in-place field density tests.

- There were 432 maximum dry density determination tests performed in accordance with ASTM D-698. With a total of 2,961 in-place field density tests performed, the average test frequency was one maximum dry density determination test for each 6.9 in-place density tests performed.

- The required test frequency for performing the one-point proctor check was a minimum of one, one-point proctor check for each five in-place density tests performed.

- There were 901 one-point proctor checks performed to ensure that the correct maximum dry density value was utilized when analyzing in-place field density tests. With 2,961 in-place density tests performed, the average test frequency was one, one-point proctor check for each 3.3 in-place field density tests performed.

- Compaction verification was accomplished by in-place field density testing in accordance with ASTM D-1556.

- Required compaction for contaminated fill material was either 90 percent or 95% percent of maximum dry density determination (as measured per maximum density testing, ASTM D-698). The top/outside three feet of contaminated material under the radon barrier cover material required 95% percent compaction. The interior material required 90% percent compaction.

- The test frequency for performing in-place field density testing was a minimum of one in-place field density test for each 1,000 cubic yards of material placed. In addition, a minimum of two in-place moisture/density tests were required to be performed each day of placement in excess of a 150 cubic yards of testable material placed, and at least one in-place moisture/density test for each lift of material placed and for each full shift of compaction operations.

- There was a total 2,961 in-place density tests performed. Of the 2,961 density tests performed, 715 tests were in areas where 95% of the maximum dry density compaction was required. Average compaction for all in-place density tests were 97.6%. With 1,886,999 cubic yards of testable contaminated fill material placed, the average test frequency was one in-place field density test for each 637.3 cubic yards of contaminated fill material placed. All of the in-place field density test results were in accordance with the Design Specifications. Reference Moisture/Density Test Frequency Charts at end of this section.

- o There were 180 failing in-place density tests within the embankment perimeter. Areas represented by these tests were reworked, retested and passed in accordance with the Design Specifications.

- o Contaminated fill materials were moisture-conditioned at the excavation site or in stockpiles to aid in compaction efforts. This was accomplished by either addition of water or by allowing the material to dry after scarification. Water was not applied to contaminated fill material on the cell embankment, except for environmental dust control purposes, as necessary.

- o Moisture content verification was accomplished by in-place moisture tests in accordance with ASTM D-4643 and ASTM D-2216.

- o For initial control, it was required that a minimum of ten consecutive moisture correlation tests between the conventional oven and the microwave oven be performed. The initial control was performed on contaminated material prior to utilizing the microwave oven method. Thereafter and during placement of uncontaminated material, the required test frequency for performing moisture correlation testing was a minimum of one moisture correlation test by conventional oven dried method for every 10 microwave oven tests performed. The moisture correlation test results were required to be within plus or minus one percent.

- o There were 3,240 microwave oven-dried moisture tests performed, with 774 conventional oven-dried moisture correlation tests. This provides an average test frequency of one conventional oven-dried moisture correlation test for each 4.2 microwave oven-dried moisture tests performed. All correlation test results were within one percent (+/- 1%) of the microwave oven-dried test result.

- o Prior to placement of radon barrier material, the contaminated fill material finish grade was verified to be graded uniform and smooth through visual inspection and survey verification.

- o In addition, there were a minimum of two in-place moisture density tests performed each day of placement in excess of a 150 cubic yards of testable material placed and at least one in-place moisture density test for each lift of material placed and for each full shift of compaction operations. The bulk density of sand-cone density sand was determined twice a day and for each new bag of sand.

- During seasonal shutdowns and other periods of prolonged exposure (lasting six weeks or longer) of any contaminated cell surface area, the exposed contaminated fill surface was protected against erosion with periodic application of water containing a soil sealer. Prior to placement of any additional materials, surface layer compaction in all such areas was reverified by in-place density tests at a minimum of one test per 30,000 square feet. When work was interrupted for seasonal shutdown and during the contract suspension, all exposed surfaces of tailings material were stabilized by application of a tackifier compound to prevent off-site spread of contaminated material by erosion. Surveillance and monitoring of off-site areas verified that dispersement of contaminated material had not occurred.

- All measuring and testing equipment used during remedial action was calibrated against equipment having a known valid relationship to National Institute of Standards & Technology (NIST). Calibrated testing equipment included: scales, proctor molds and hammers, sand-cone funnels and plates, NIST-traceable test weights, calipers and thermometers. All other test equipment was maintained and functionally checked as per the specifications.

- Test frequencies referenced herein were derived from total final material quantity, divided by total number of tests taken for that material. It should be noted that during remedial action activities material quantities were not continuously surveyed during production, placement, and/or compaction. To determine quantities, surveys were completed at various milestones, e.g., completion of first lift, for pay quantities, to verify survey coordinates. Therefore, daily material quantities were <u>estimated</u> by load counts rates until final or cross section surveys were obtained. Reference the Moisture/Density Test Frequency Test Charts at the end of the written text.

- With various design slopes associated with the cell and staggered lift placements, it is feasible to test each lift and, thereby, have certain horizontal elevations void of in-place field density and moisture tests.

- The comparison chart at the end of this section, addresses the governing requirements in this section.

- Tests and inspections were performed in accordance with all specified requirements.

- The following data has been provided identifying each contaminated fill material moisture/density test location: