UNITED STATES DEPARTMENT OF ENERGY
Albuquerque, New Mexico

Uranium Mill Tailings Remedial Action Project (UMTRAP)

Slick Rock, Colorado

Information for Reviewers

Preliminary Design for Review

March 1988

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

INFORMATION FOR REVIEWERS

FOR

PRELIMINARY DESIGN

STABILIZATION OF URANIUM MILL TAILINGS SITE

SLICK ROCK, COLORADO

MARCH 1988

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CONTENTS

*"Roadmap" to design and supporting documents.

A. OVERVIEW OF DESIGN AND SUPPORTING DOCUMENTS

Introduction

This volume, Information for Reviewers, is the first of a series of volumes, listed in attached Table A.1. The design proper is presented in "Subcontract Documents", which includes the bid schedule (quantities), special conditions (contractual requirements), specifications (technical requirements) and drawings. The remaining volumes in this submittal are: Information for Bidders (5 volumes), which presents the "fact documents"; i.e., data which form the basis for design, and are provided to the prospective bidders for their review; Supporting Calculations and Reports (5 volumes), which include the analyses, computations and studies leading to the design presented; and Cost Estimate, which is an estimate of construction costs for completion of the remedial action.

Background and Design Approach

Contaminated materials at Slick Rock are distributed as follows (See attached Fig. 3.1 (from dRAP) for location of Slick Rock Sites):

Site	Description of Contaminated Material	Volume(c.y.)
North Continent (NC)	Tailings Pile and Dispersed Material	97,000
Union Carbide (UC)	Tailings Pile, Structures & Dispersed Material	565,000
		662,000

The piles at both sites are within the PMF load plain of the Dolores River. In addition, the groundwater in the alluvium beneath the tailings piles is contaminated. The potentials for: 1) movement of the tailings due to erosion, and 2) continued leaching into the groundwater, constitute the primary problems to be solved at Slick Rock.

The general approach to solution of these problems is:

1. Excavate to bedrock or dense cobbles and gravels over a 17-acre area southwest of the UC tailings pile, providing a base above the PMF floodplain (see attached Fig. 4.1 for location).

2. Consolidate all tailngs and other contaminated material into a single embankment, founded on the base prepared in 1. above, with sideslopes of 4.75H:1V, and covered by a 3.5-foot thick, compacted earth, radon/infiltration barrier and a 1.5-foot thick layer of riprap and bedding (see attached Figs. 4.2 and 4.3 for plan and cross-section).

The pile is designed to extend approximately 20 to 30 feet above the surrounding terain, and to resist erosion due to PMF flows from on-pile precipitation, upland watershed runoff, and Dolores River flood, as well as potential gully intrusion from downslope of the pile.

Conceptual Design, Comments and Responses

A conceptual design was presented in "Draft Remedial Action Plan and Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Slick Rock, Colorado", dated April, 1987, and submitted previously. Comments on this document by NRC and the State of Colorado are presented in B. below, along with the DOE responses.

Design Details and Criteria

The general features of the design are presented above in "Background and Design Approach". The key design details and the governing detailed criteria are in Section C, "Revised Section 4 of Remedial Action Plan", included below. The relationship between the design details and criteria and the supporting calculations and reports is shown in attached Table A.2.

TABLE A.1

LIST OF DOCUMENTS IN

PRELIMINARY DESIGN SUBMISSION

I. Information for Reviewers (1 Volume)
   - A. Overview of Design and Supporting Documents*
   - B. Responses to NRC and State of Colorado Comments on Draft Remedial Action Plan
   - C. Revised Section 4 of Remedial Action Plan
   - D. Analysis of Changes from dRAP Design
   - E. Open Issues

II. Subcontract Documents (1 Volume)
   - A. Bid Schedule
   - B. Special Conditions
   - C. Specifications
   - D. Drawings

III. Information for Bidders (4 Volumes)

IV. Supporting Calculations and Reports (5 volumes)
   - A. Permanent Facilities+
   - B. Temporary Facilities
   - C. Quantity Estimates
   - D. Reports

V. Cost Estimate (1 Volume)

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*"Roadmap" to design and supporting documents.

+Critical to meeting EPA Standards

TABLE A.2
RELATIONSHIP BETWEEN DESIGN DETAILS AND
CRITERIA AND SUPPORTING CALCULATIONS AND REPORTS

Design Detail or Criteria	Calculation No.+	Title	Remarks
4.3.3* Pile Location	11-209-02	Site Hydrology - Permanent Drainage	Pile location selected to be out of PMF flood plains.
	11-209-05	Site Hydrology - Corral Draw Wash	
4.3.4 Pile Layout	---	Draft RAP	Sideslopes from 6 to 21% analyzed.
	11-208-05	Quantities and Pay Items	Material balance to avoid importation of general fill.
4.3.5 Geomorphic Considerations	---	"Geomorphology" (Report in App. D of RAP)	Pile set back at least 100 feet from gullies.
4.3.6 Seismicity	---	Site Seismicity and Design - Earthquake Criteria for Slick Rock Site, Colorado (Report in Vol. D of supporting Docs.)	M_b = 6.2, 9.2 miles from site, peak accel. = 0.21g
4.3.7 Geohydrology	---	---	---
4.3.8 Surface Water	---	---	See 4.3.3 and 4.3.
4.3.9 Geotechnical	11-250-04	Embankment Design - Embankment Material Properties	Properties used in stability analyses are shown in Table 4.1 in Revised Section 4 of RAP.
	11-250-06	Embankment Design - Stability Analysis	Results of stability analyses are shown in in Table 4.1 of Revised Section 4 of RAP. Each factor of safety exceeds the minimum required (same table).
	11-225-01	Embankment Design- Settlement and Cover Cracking Analyses	Parameters used in settlement analyses are in Calculation

* Subsection No. in Revised Section 4 of Remedial Action Plan.
+ Reports are identified by title only.

Design Detail or Criteria	Calculation No.	Title	Remarks
	11-225-01 (cont.)		11-225-01. Maximum tensile strain is 0.010% vs 0.05% to cause cracking.
4.3.10 Radon/Infiltration Barrier	11-224-01	Radon Barrier Design - Input Properties for RAECOM Program.	Design thickness of 3.5 feet will limit radon flux to met EPA criteria, including 6-inch allowance for shrinkage cracking.
	11-224-02	Radon Barrier Design - Average Ra-226 Concentration for Various Layers	
	11-224-03	Radon Barrier Design - Design Thickness	
4.3.11 Erosion Protection	11-223-01	Erosion Protection - Embankment Top and Side Slopes	Riprap sizes and layer thicknesses are shown in Table 4.3 in Revised Section 4 of RAP.
	11-223-04	Erosion Protection - Embankment Toe	
	11-229-01	Gully Erosion	
	11-231-02	Erosion Protection - Rock Quality Evaluation	
	11-223-03	Erosion Protection - Gradation Requirements	
4.4 Construction	---	---	Construction aspects of the design temporary drainage, retention basins, decontamination facilities, borrow areas and construction sequencing and schedule are discussed in Subsection 4.4 of Revised Section 4 of Remedial Action Plan.
4.4.11 Construction Schedule	---	---	Construction Schedule is Fig. 4.5 of Revised Section 4 of RAP.
4.4.12 Construction Cost Estimate	---	---	Conceptual Design Cost Estimate is presented in Table 4.4 of Revised Section 4 of RAP. Preliminary Design Cost Estimate is bound in separate volume.

Design Detail or Criteria	Calculation No.	Title	Remarks
Areas to Be Excluded	---	"Areas to be Excluded from Remedial Action" (Report in Vol. D of Supporting Documents	Excludes areas contaminated by ore rather than by tailings.

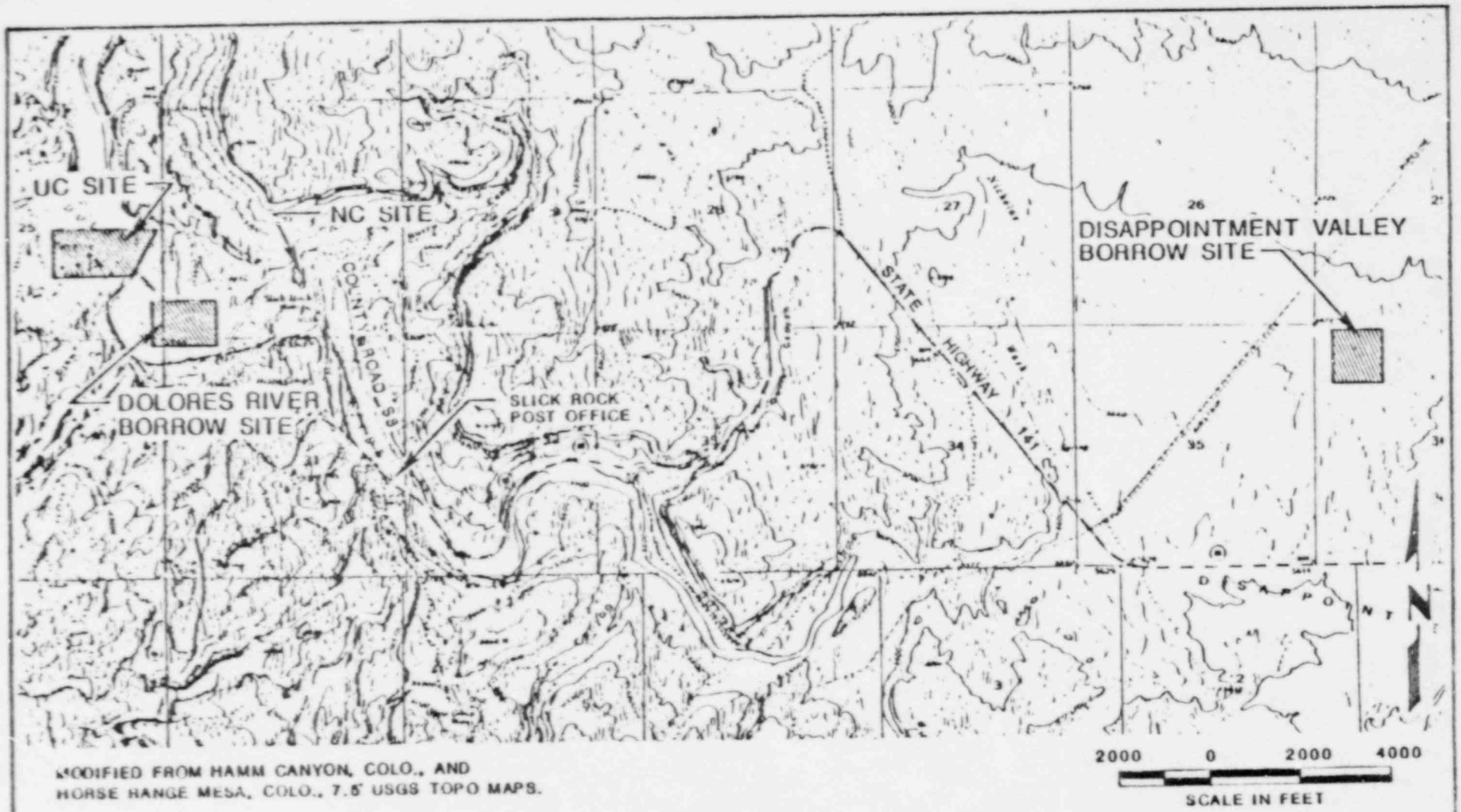

FIGURE 3.1
UNION CARBIDE AND NORTH CONTINENT SITES AND BORROW SITES

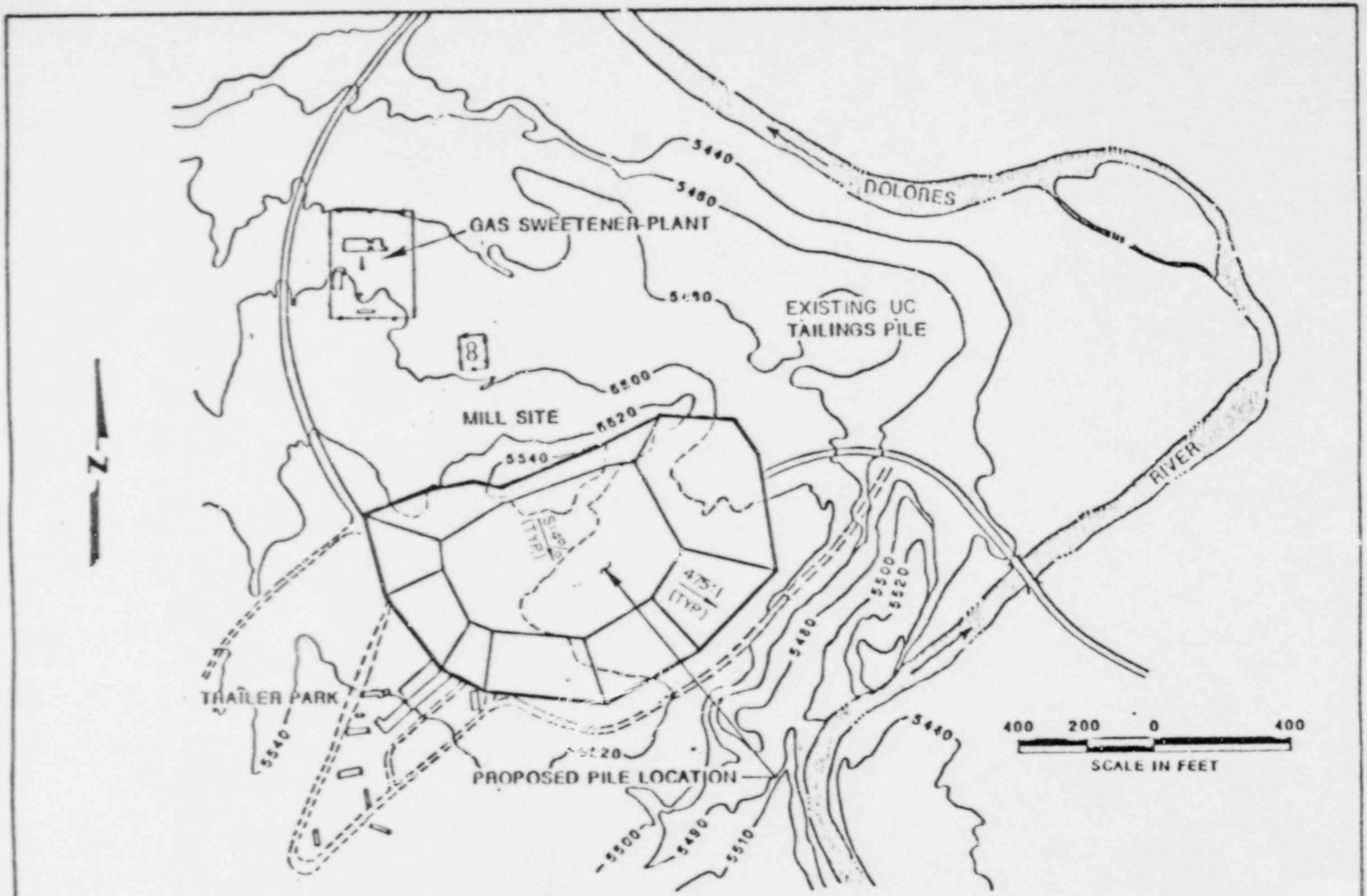

FIGURE 4.1
LOCATION OF THE STABILIZED PILE AT THE UNION CARBIDE SITE
SLICK ROCK, COLORADO

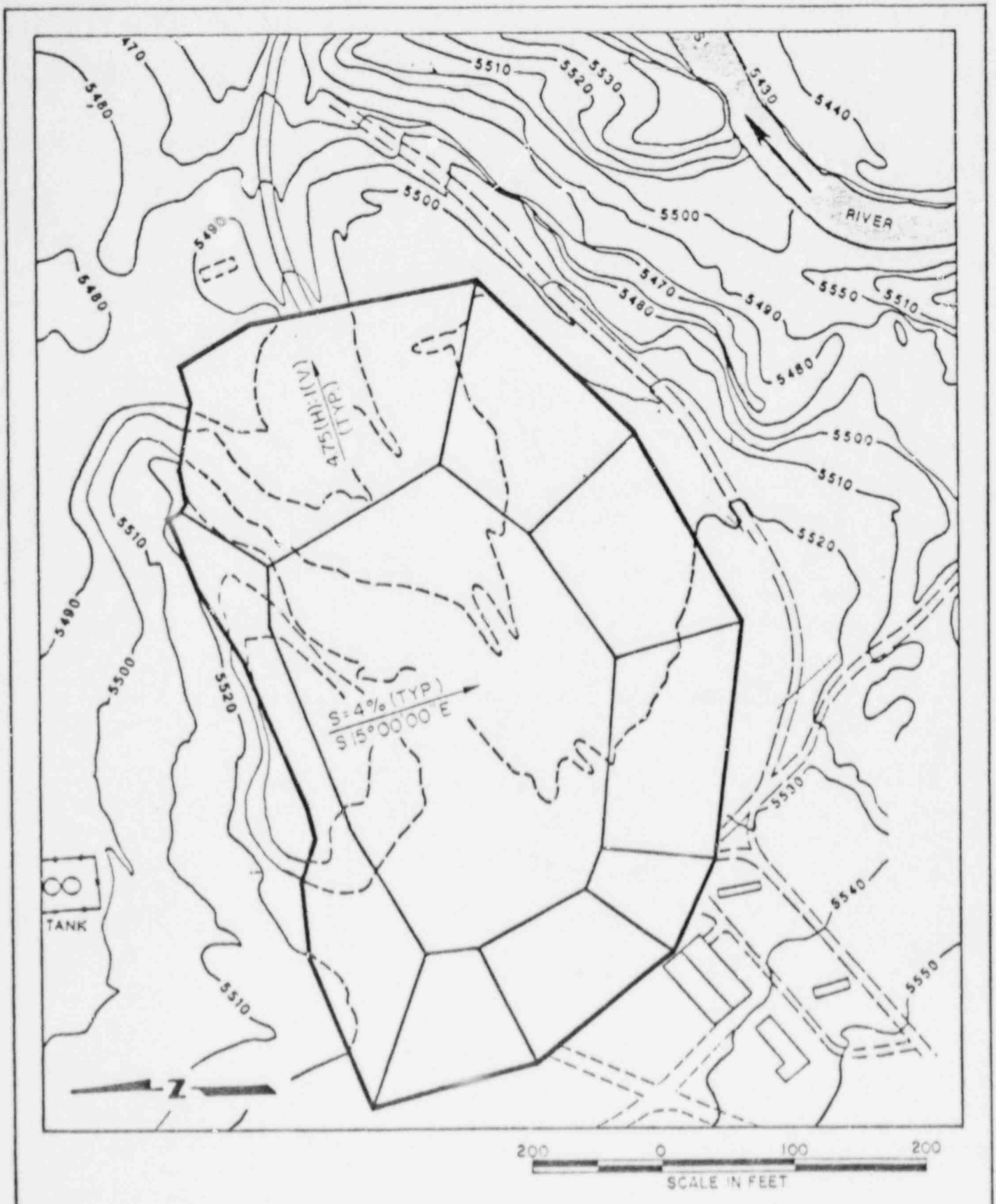

FIGURE 4.2
PROPOSED PILE CONFIGURATION, STABILIZATION ON SITE,
SLICK ROCK, COLORADO

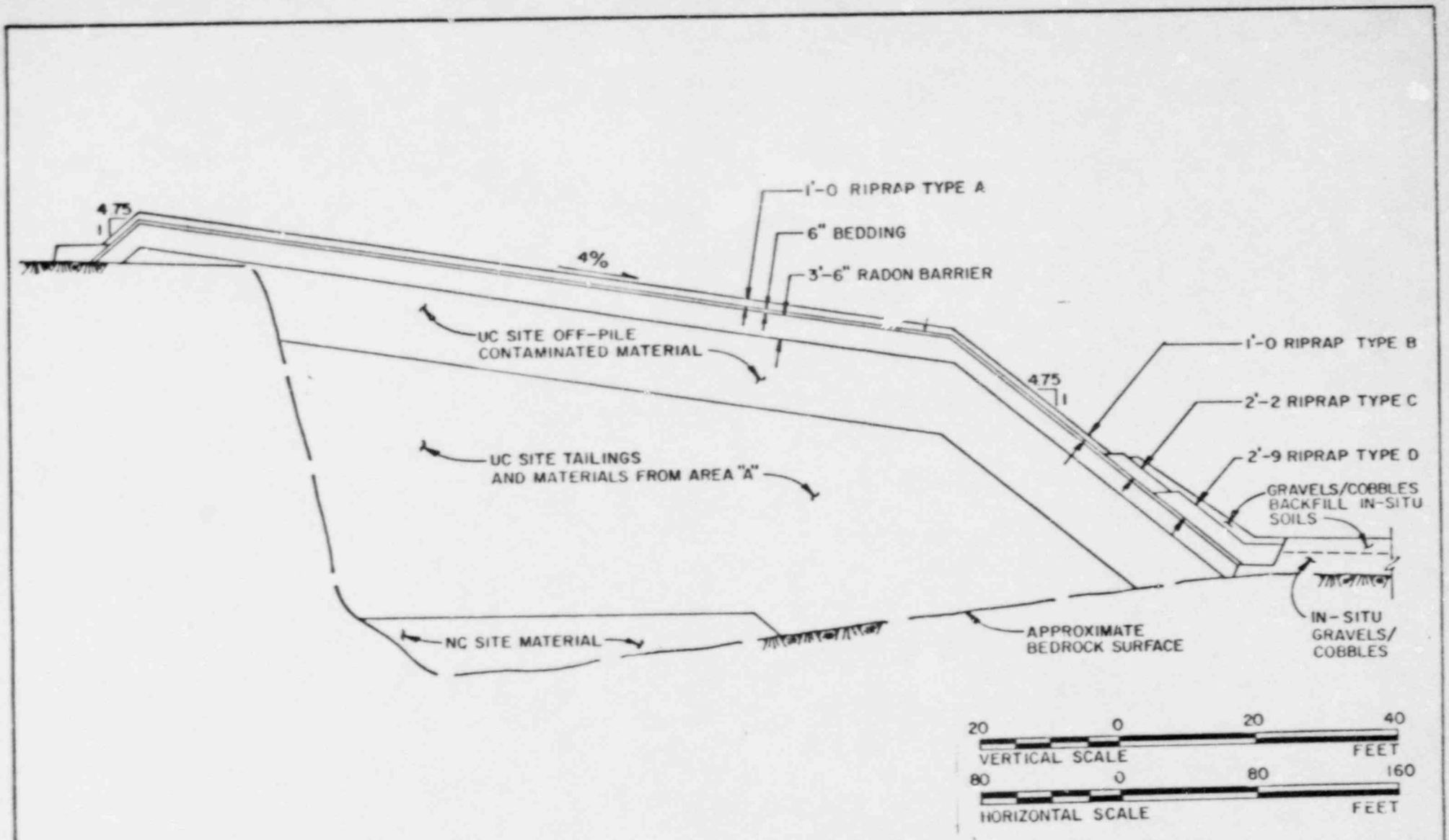

FIGURE 4.3
TYPICAL CROSS SECTION, STABILIZATION ON SITE
SLICK ROCK, COLORADO

B. RESPONSES TO NRC AND STATE OF COLORADO COMMENTS ON DRAFT REMEDIAL ACTION PLAN

[To be provided by Department of Energy]

C. REVISED SECTION 4 OF REMEDIAL ACTION PLAN

REMEDIAL ACTION PLAN AND DESIGN FOR STABILIZATION OF THE INACTIVE URANIUM MILL TAILINGS SITE AT SLICK ROCK, COLORADO

VOLUME 1, CHAPTER 4

APPENDIX B OF THE
COOPERATIVE AGREEMENT
NO. DE-FC04-85AL20533

MARCH, 1988

4.0 DESIGN

4.1 INTRODUCTION

The objective of the design is to meet the requirements of PL95-604 and the EPA standards applicable to the UMTRA Project.

This section is divided into four subsection: 4.1 Introduction; 4.2 Proposed Remedial Action, giving a summary of the design; 4.3 Design Details, giving a detailed description of the various aspects of the remedial work that will be undertaken to stabilize the tailings; and 4.4 Construction, a description of the construction requirements of the remedial action. Subsection 4.3 includes the rationale for the design and specific design criteria.

The section is to be read in conjunction with Appendix D, Site Characterization and five additional volumes, Information for Bidders. These documents present the factual information which forms the basis for the design. Final design drawings and specifications are included in the subcontract documents. The design meets the requirements of PL95-604.

4.2 PROPOSED REMEDIAL ACTION

The principal feature of the design is the stabilization of the tailings and contaminated material from both sites in an excavated area southwest of the UC pile between the pile and the trailer park (Figure 4.1). The base of the excavation will be approximately 50 feet above and 900 feet west of the streambed of the Dolores River. The completed pile will have sideslopes of 21 percent (4.75 horizontal to one vertical) and a topslope of four percent. The tailings and contaminated materials will be covered with a 3-1/2-foot-thick layer of compacted earth to inhibit radon emanation. The topslope and sideslopes will be covered with an 18-inch-thick layer of sand, gravel, and small rock for erosion protection and bedding. The pile will cover approximately 17 acres, measuring roughly 1150 feet by 700 feet. The pile will rise a maximum of 60 feet above bedrock, approximately 20 to 30 feet above the

surrounding terrain. The below-grade excavation will average 22 feet, extending to a maximum of 30 feet below the existing ground surface.

The tailings site will be excavated to bedrock except along the western side, where dense cobbles and gravels will form the pile foundation. The stabilized tailings pile will be surrounded by a rock apron. The rock apron will protect against potential gully intrusion along the sides of the pile. The apron will be from 2.2 to 2.8 feet thick and 20 feet wide, and will extend to bedrock, or to terrace cobbles and gravels. The proposed pile configuration and a typical cross section are shown in Figures 4.2 and 4.3, respectively.

The areas of the existing tailings piles, the former mill site, and ore storage areas will be restored with uncontaminated fill from the disposal site excavation and revegetated. All disturbed areas within the Dolores River floodplain will be restored and revegetated. The final restricted area will cover approximately 20 acres. Following completion of remedial action the remainder of the designated sites will be released for use consistent with existing land use controls.

4.3 DESIGN DETAILS

4.3.1 Introduction

This section provides details of the major components of the design. All design approaches, unless otherwise discussed, are outlined in the Technical Approach Document (TAD) (DOE, 1986). Where applicable, alternatives considered are discussed as justification for the selected design.

4.3.2 General

The design complies with the EPA Standards and all requirements applicable to the UMTRA Project, and with all the criteria, methods, and approaches set out in the TAD (DOE, 1986) and the Standard Review Plan (NRC, 1985).

4.3.3 Pile Location

The proposed remedial action calls for the relocation of all tailings and contaminated material from both sites to an excavation west of the UC pile and out of the Dolores River floodplain. The selection of this approach was the result of (1) a series of reviews by technical specialists and (2) cost considerations.

The proposed Stabilization-On-Site (SOS) location places the tailings pile out of the Probable Maximum Flood (PMF) floodplains of the Dolores River and the washes that flow from Summit Canyon and Corral Draw and onto a relatively flat surface near the former mill area. Advantages of this location are its proximity to the majority of the contaminated material, thus requiring minimal truck haulage, and proximity to existing access roads for importing borrow materials. In addition, the pile will be placed away from the terrace edge overlooking the Dolores River to avoid contact with flood waters during extreme events. Only a small portion of the pile toe protection on the eastern side can be contacted by the Dolores River PMF, and this protection is designed to resist the PMF flows. Likewise, the pile will be set back from the gullies associated with the ephemeral washes flowing from Summit Canyon and Corral Draw.

Alternatives Considered

An alternative site selection process was completed for disposal of the Slick Rock tailings and contaminated materials. Alternate sites were evaluated and disposal options were compared to stabilization in place and SOS. Details are provided in the environmental assessment (DOE, 1987).

The SOS option was the least costly and would present the fewest potential negative impacts to the environment.

4.3.4 Pile Layout

The pile layout, shown in Figure 4.2, is designed to effectively use the site area in order to minimize off-site material requirements. The below-grade disposal was extended to bedrock to minimize the pile's surface area and thus the amount of imported cover material required, while maximizing the reserve capacity available. The uncontaminated excavated material will be used for site restoration therefore eliminating the need to obtain restoration material from off-site sources.

Alternatives Considered

A number of pile layouts were evaluated in determining the proposed design. A range of pile sideslopes from 6 to 21 percent was analyzed. These analyses were made to minimize the aerial extent of the pile while maximizing the below-grade disposal capacity and minimizing the rock sizes required for erosion protection on the pile sideslopes as well as for protection from off-pile flows.

4.3.5 Geomorphic

Geomorphology of the Slick Rock area is detailed in Appendix D, Site Characterization. The geomorphic processes are evaluated in the context of the remedial action and design life. The main geomorphic concerns with respect to site stability are the presence of a shallow wash drainage feature at the trailer park area and surficial erosion along the edge of Corral Draw. Shifting of the Dolores River channel may place a future channel closer to the site than the present channel, but would not reach the actual disposal area. In order to protect the pile from potential impact by on-site erosional processes, a rock apron extending to bedrock or terrace cobbles and gravels and positive surface drainage are included in the design. In addition, adequate minimum setbacks from gullies (as discussed in Appendix D, Site Characterization) are met. The pile is set back at least 100 feet from the area of gully erosion between

the trailer park and the northwest side of Corral Draw. Armoring at this location extends to either bedrock or to terrace cobbles and gravels which are resistant to erosion caused by flows in Corral Draw.

The toe of the pile closest to the Dolores River, founded on bedrock, is set back at least 100 feet from a line running northwest-southeast from the northeast ends of the two sandstone ridges flanking the proposed pile area. A small portion of the pile toe will be exposed to Dolores River PMF flood waters. This portion is adequately armored to prevent erosion.

The base of the pile is on competent sandstone bedrock or terrace cobbles and gravels.

4.3.6 Seismicity

The design earthquake for this site is a magnitude 6.2 event occurring at a distance of 9.3 miles (15 km) from the site. Such an event might occur as a "floating" earthquake not associated with a known tectonic structure. The resulting free field, nonamplified, peak horizontal bedrock acceleration at the site is estimated to be 0.21g. Due to the shallow depth to bedrock this is also considered the site ground-surface acceleration. Details of the studies leading to this conclusion are presented in a Memorandum Report included in "Supporting Calculations and Reports" (Vol. V). Specific seismic parameters used in the design are:

- Long-term slope stability seismic coefficient $k_h = 0.14$.
- Short-term slope stability seismic coefficient $k_h = 0.11$.

Because the ground water is below the pile in sandstone and all the embankment materials will be well compacted, there is no liquefaction potential for this pile.

4.3.7 Geohydrology [Paraphrased from dRAP; only criterion used in design is "permeability of radon barrier not to exceed 10^{-6} cm/sec."]

The following section presents a summary of the ground-water protection aspects of the design. More detailed discussion of the processing site and the disposal area hydrogeology are presented in Appendix D, Site Characterization.

Design Features

The principal design features for ground-water protection are:

- The relocation of the tailings and contaminated materials from the floodplain of the Dolores River onto the unsaturated, low-permeability bedrock.

- Placement of a sloping, low-permeability infiltration barrier that will cover the tailings.

Relocation of the tailings will prevent alluvial ground water from contacting the base of the tailings. Recompacting the tailings and providing the proposed sloping, low permeability cover will reduce the tailings leachate to a level which will prevent further contamination of the alluvial ground water.

Design Rationale

The Entrada Sandstone is unsaturated and will separate the stabilized pile from the underlying, confined Navajo Sandstone aquifer. Depth to water beneath the proposed disposal site is approximately 60 feet. This unsaturated sandstone, conglomerate, mudstone, and shale beneath the site acts as a physical and chemical buffer to any potential tailings seepage. The amount of leachate that may eventually drain out of the stabilized tailings pile will be small and have no significant effect on the quality of water in the alluvial aquifer.

Alternatives Considered

The need for aquifer restoration for contaminated shallow ground water near the processing site was evaluated. It was concluded that aquifer restoration is neither a necessary nor a cost-effective action based on the following considerations:

- Alternative water supplies are readily available and are currently being used.

- The degree of human exposure which is likely to occur is low because there are no known users of the affected ground water, and future use is unlikely.

Design Criteria

The following design criteria have been followed:

- Monitor wells used for characterization of ground water near the processing site which are not required for surveillance and maintenance monitoring are being abandoned in a manner which conforms to the regulations of the State of Colorado.

- The relocated tailings stabilized at the disposal site have a sloped cover of low permeability (saturated hydraulic conductivity less than 1×10^{-6} cm/sec) to promote runoff and minimize infiltration.

- During remedial action, precautions will be taken to ensure that no more water than is necessary is introduced onto or into the tailings. Drainage ditches will divert water away from the tailings during construction.

- During construction of the radon barrier and the erosion protection layers, care will be taken to ensure that the cover material is uniformly sloped with no depressions which would hold water and promote infiltration.

4.3.8 Surface Water

Regional Overview

The disposal area lies approximately 900 feet southwest of and at an elevation approximately 70 feet above the modern floodplain of the Dolores River, a tributary of the Colorado River. The Dolores River basin upstream of the Slick Rock sites comprises approximately 1450 square miles. The river originates in the western San Juan Mountains and drains into the Colorado River approximately 10 miles west of the Colorado-Utah state line. As it flows past the UC tailings site, the river is directed to the northeast by a bedrock ridge approximately 2300 feet upstream of the tailings pile and then to the north and west by steep bedrock cliffs directly across the river from the site.

A Probable Maximum Floor (PMF) analysis of the Dolores River was performed in order to determine the adequacy of the SOS area with regard to major flood flows. The analysis included the consecutive use of Hydrometeorological Report (HMR) No. 49 (Hansen et al., 1977), and the U.S. Army Corps of Engineers HEC-1 (COE, 1981) and HEC-2 (COE, 1982) computer models as detailed in the TAD (DOE, 1986). A discharge of 410,000 cfs was determined for the Dolores River PMF. The majority of the existing pile would be within the PMF floodplain of the Dolores River.

Other surface-water features in the disposal area include the ephemeral washes flowing to the river from Corral Draw upstream of the pile and Summit Canyon downstream of the pile. PMF analyses of these washes were performed using methods discussed in the TAD (DOE, 1986). Results show that the proposed pile location would not be affected by PMF flows from either of the washes. PMF floodplain boundaries are shown in Figure 4.4.

Upland Watershed

The upland watershed tributary to the proposed pile location consists of approximately 35 acres of relatively flat terrain. Flows from this area are presently directed around and through the disposal area by shallow gullies and the drainage channels forming alongside County Road S8 (CR-S8) and the dirt roads near the disposal area.

After remedial action, flow will be directed away from the pile by grading the backfill around the pile. The armoring on the pile face is designed to prevent gully encroachment or erosion due to floods even if all the soils above the terrace cobbles and gravels are eroded away. In this case the discharge resulting from a PMP over the upland area was used to determine the erosion-protection requirements for the rock apron.

The design creates a hydraulic condition in which runoff within adjacent drainage features and from the upland watershed will not adversely affect the integrity of the stabilized pile. In addition, the design incorporates cost-effective, mitigative features designed to eliminate the potential for gully migration toward the stabilized pile. Anticipated runoff volumes from the upland watershed, along with expected flows off the pile, have been used as design parameters for the erosion protection features. The pile design incorporates a planar surface on the top and sides, such that sheet flow will occur over the entire pile surface.

Alternatives Considered

The placement of diversion ditches upstream of the pile was considered but was eliminated because of the following: (1) the ditches and the zones of transition of flow from the ditches to existing channels would require extensive quantities of large size material, (2) the ditches would be exposed to undercutting, and (3) the ditches would require maintenance.

4.3.9 Geotechnical

In order to meet the 1000-year design criteria, slope stability, liquefaction, and settlement were analyzed using material properties determined from laboratory testing or published data.

Stability analyses were performed using the design parameters shown in Table 4.1. The factors of safety for the slope are satisfactory for each design condition, as shown in Table 4.2.

There is no potential for liquefaction at the disposal site, for the following reasons: (1) the ground water is deep within bedrock, (2) the alluvial aquifer does not exist beneath the disposal area, (3) there will be no perched or raised water table in the embankment during the design life, and (4) the tailings will be placed as a compacted and engineered fill having densities well above the threshold of values below which liquefaction occurs.

An evaluation of settlement shows that the maximum differential settlement following construction of the radon barrier is less than one inch. Tensile strains in the radon cover as a result of this settlement will be well below those which could cause cover cracking.

Procedures used in the stability and settlement analyses conform with the TAD (DOE, 1986).

Design Criteria

- The maximum percentage of organics contained within the reshaped pile will not exceed five percent by volume, with the material distributed in a manner that will avoid pockets or layers of organic matter.

- All uncontaminated vegetation and organic material in areas subject to excavation and placement will be disposed of in accordance with local regulations.

- Contaminated demolition debris will be reduced to manageable pieces and carefully placed in the embankment to ensure that no voids or nesting exist around the debris and that the adjacent contaminated materials are compacted to at least 90 percent of the standard Proctor density (ASTM D698).

- Excavation of all off-pile contaminated materials will be carefully monitored to prevent inclusion of unnecessary uncontaminated materials in the pile.

TABLE 4.1

SLOPE STABILITY ANALYSIS - SOIL DESIGN PARAMETERS

Description	Moist Unit Weight (pcf)	STRENGTH PARAMETERS Unconsolidated-Undrained c(psf)	ϕ	Consolidated-Drained c(psf)	ϕ
Sandstone Bedrock	135	--	--	18,000	45 °
NC Site Tailings and Contaminated Soils	112	--	--	0	32.5 °
UC Site Tailings	106	--	--	0	35 °
UC Site Contaminated Soils	110	200	26.5 °	0	35 °
Radon Barrier	126	360	7 °	800	20 °
Bedding Material	123	--	--	0	35 °
Erosion Protection	126	--	--	0	35 °
Apron	126	--	--	0	38 °

TABLE 4.2

RESULTS OF SLOPE STABILITY ANALYSIS

Condition Analyzed	Seismic Coefficient	Calculated Safety Factor	Minimum Required Safety Factor
End of Construction (Static)	0	3.43	1.3
End of Construction (Pseudo-Static)	0.11	2.18	1.1
Long Term (Static)	0	3.43	1.5
Long Term (Pseudo-Static)	0.14	1.98	1.1

- The surface of all areas where fill materials are to be placed will be proof rolled prior to placement of contaminated materials, with soft zones excavated and replaced with competent material.

- The relocated tailings and contaminated materials will be brought to a moisture content between two percent above and two percent below optimum and compacted to a minimum of 90 percent of the standard Proctor density (ASTM D698), using vibratory type compaction for granular materials to prevent the possibility of bulking.

- The radon cover will be brought to a moisture content ranging from optimum to three percent above optimum, and compacted to a minimum of 95 percent of the standard Proctor density (ASTM D698), using a kneading type of compaction.

4.3.10 Radon/Infiltration Barrier

The contaminated materials will be placed in the following three layers: (1) materials from the NC site (placed as the bottom layer of the stabilized pile), (2) materials from the UC tailings pile, (3) all remaining contaminated materials from the UC site including the wind and water-borne contaminated materials and vicinity property material. The intent is to minimize the required thickness of radon cover by covering the more highly contaminated soils with less contaminated soils. This layering creates a pile requiring 3-1/2 feet of radon barrier material to meet the EPA flux limit of 20 $pCi/m^2/s$. This thickness has been determined using procedures outlined in the TAD (DOE, 1986).

4.3.11 Erosion Protection

Embankment Rock Sizing

The rock layer on the pile top and sideslopes is designed to prevent erosion due to runoff resulting from the one-hour PMP on the

pile and flow from the upland area including the potential efects of gullying in the backfill along the western and southern sides. Erosion protection requirements and layer thicknesses for the conceptual design are summarized in Table 4.3. Based on rock quality analysis procedures (MKE, 1988)* riprap types A and B were oversized 15% to account for rock deterioration over time. The rock for riprap types C and D is of good quality and does not require oversizing.

TABLE 4.3
EROSION PROTECTION REQUIREMENTS

Location[a]	Rock Sizes (inches)		Layer Thickness (ft)
	Minimum D_{50}	Maximum D_{100}	
Topslope (Type A)	1.7	3.0	1.0
Sideslope (Type B)	4.0	7.0	1.0
Sideslope and Apron (Type C)	12	20	2.2
Sideslope and Apron (Type D)	17	28	2.8

[a]See Figure 4.3.

Design Rationale

The erosion barrier serves to resist the impacts of wind and water erosion. These forces are greatest during the PMP, which is the design event. The maximum PMP rainfall intensity was determined using charts and tables from Hydrometeorological Report No. 49 (Hansel, et al., 1977). The local one-hour PMP for the site was calculated to be 8.1 inches. This value was converted to a maximum intensity of 41.1 inches per hour based on the time of concentration (t_c) of 2.5 minutes for flow off the pile.

*To be added to reference list.

The required rock sizes were determined using the Safety Factors Method (Stevens et al., 1976). This method is detailed in the TAD (DOE, 1986).

The erosion protection material used will be durable according to the requirements of the NUREG/CR-4620 (NRC, 1986) and subsequent modifications (MKE, 1988).

Rock Sizing for Rock Apron and Buried Sideslopes

A rock apron will be constructed around the entire toe of the pile. This apron will provide toe protection as sheet flow off the sides of the pile continues as overland flow on the natural ground. The buried sideslope protection is designed to prevent headcutting either from gullying of backfill or erosion of in situ soils into the stabilized pile and takes the form of a buried riprap wall extending to competent bedrock or the terrace cobbles gravels. Backfill will be placed against the face of the wall.

4.4 CONSTRUCTION

4.4.1 Introduction

Construction activities will take place at the existing UC and NC tailings piles areas, in the disposal area, at the borrow sites, and along the haul roads where required. The following is a statement of construction activities and related criteria.

4.4.3 Drainage, Erosion Control, and Waste-water Retention Basins

During remedial action construction, all contaminated drainage at both sites will be contained. Contaminated disturbed areas will be graded so that runoff drains to waste-water retention basins. Uncontaminated disturbed areas will be graded to divert runoff away from contaminated areas.

Waste-water and diversion ditches are designed to carry the peak flow resulting from a 10-year one-hour storm event. The diversion ditches will prevent uncontaminated runoff from entering contaminated areas.

The waste-water retention basins will receive waters from:

- Runoff from contaminated areas.
- Decontamination activities including equipment and truck washdown.
- Laundry, shower, and wash basin facilities.

The retention basins are designed to retain the runoff resulting from a 10-year, 24-hour storm event as well as waste waters generated from the remedial action activities and runoff from snowmelt, and all sediment inflow during the project life, without need for removal.

The NC site basin will be in use for about 3 months. Thereafter, this basin will remain empty and serve as a back-up for the UC site, in case the capacity of the UC basin is exceeded.

The emergency outlets from the basins are designed to safely discharge the peak runoff from the 25-year, one-hour storm, with a minimum freeboard of one foot.

4.4.4 Waste-water Treatment

Waste water generated from sources mentioned in Section 4.3.4 will be directed to waste water retention basins which will provide primary settling as well as flow and contaminant equalization. Some of this water will be used for dust control at contaminated areas, and for water for compaction of contaminated materials.

It is not anticipated that a waste-water treatment plant will be necessary for the remedial action. The volumes of contaminated water generated during construction are expected to be exceeded by evaporation losses and demands for dust control and compaction moisture.

All water will meet acceptable Federal and State of Colorado water-quality standards prior to discharge.

4.4.5 Equipment Decontamination Pad

To prevent contaminated materials from being carried out of the construction area, a decontamination pad with a holding pond and pump will be provided at the UC site to wash contaminated equipment, as required.

4.4.6 Tailings Transportation

For estimating and planning purposes, it has been assumed that the NC tailings and contaminated material will be transported to the disposal area by 20-cubic-yard capacity trucks. The trucks will be equipped with gate seals to prevent leakage. The trucks will be loaded at the NC site and the contaminated material will be covered with a tarpaulin.

The contaminated material from the NC site will be transported along County Road CR-S9. The county road will be blocked for public use during hauling operations. After the hauling is complete the road will be cleared of contamination and reopened to the public. Where haul trucks cross the temporary detour of County Road CR-S8 a concrete pad and collection drain will be constructed to wash down the road crossing if there is contamination.

4.4.7 Dust Control

Dust generated by excavation, earth movement, vehicle use, temporary materials stockpiling, and similar activities will be

controlled and minimized by the use of water and water-based surfactants sprayed from hoses or trucks. Special care will be taken to control dust created by building decontamination and the temporary stockpiling of contaminated materials.

The sources for dust suppression water include recycled water from the waste-water retention reservoir. Only uncontaminated water will be used to control dust in clean areas.

The schedules for spraying the roads and pile areas will vary daily and will be determined on an as-needed basis. The frequency of spraying will increase when combinations of low soil moisture and high wind speed are encountered.

4.4.8 Utilities

All utilities in areas of excavation will be either relocated or abandoned. Existing power lines outside of disturbed areas will be maintained for use during remedial action. The utilities are discussed in detail in Appendix D, Site Characterization.

4.4.9 Borrow Areas

Borrow sources have been identified for all embankment materials.

Radon barrier material will come from Disappointment Valley borrow sites, approximately nine road miles east of the UC tailings site.

Bedding material and smaller size erosion protection (Riprap Types A and B) can come from processed uncontaminated terrace cobbles and gravels from required excavations at the disposal site, or from the Dolores River borrow site, which is approximately 0.75 miles east of the UC site on the opposite bank of the river.

Larger size erosion protection (Riprap Types C and D) may come from a large talus pile at the Barlow Creek borrow site, approximately 100 road miles east of the UC tailing site and 10 miles northeast of Rico, Colorado.

Restoration material will be uncontaminated materials from required excavations at the UC and NC sites.

Further information on the borrow sites is provided in Appendix D and in the Information to Bidders document.

4.4.10 Construction Sequence

The following is proposed as a possible construction sequence for the remedial action. The construction subcontractor will be allowed the flexibility of executing his work as he desires, given certain constraints. Therefore, the actual construction sequence may differ from the following.

1. Mobilize.

2. Perform Stage 1 excavation in tailings embankment area for road detour and gas pipeline relocation.

3. Construct detour for County Road CR-S8.

4. Relocate utilities, firehouse and housing trailers.

5. Erect site perimeter fences and remove existing fences.

6. Seal existing monitor wells.

7. Excavate and stockpile contaminated materials from access control and decontamination pad areas.

8. Construct access control area and decontamination pads.

9. Demolish abandoned structures and utilities encountered and stockpile the debris.

10. Construct retention basin including dikes, spillways and temporary drainage ditches. Stockpile contaminated materials excavated in this process for later disposal in the tailings embankment; stockpile uncontaminated materials excavated for later use as fills. Perform grading required for site drainage.

11. Open borrow sites.

12. Perform Stage 2 excavation in tailings embankment area and stockpile contaminated materials.

13. Complete preparation of the tailings embankment foundation.

14. Excavate and transport the NC contaminated materials to the tailings embankment.

15. Perform final site grading of the NC area excluding retention basin.

16. Excavate and transport the UC contaminated materials to the tailings embankment.

17. Demolish decontamination facilities, including decontamination pad and recirculation sump, and dispose of the debris in the tailings embankment.

18. Dispose of contaminated sediments from the temporary drainage ditches and the waste-water retention basins of the UC and NC areas in the tailings embankment, as required, and dispose of synthetic membrane liner.

19. Construct radon barrier cover over the contaminated material in the tailings embankment. The cover shall consist of selected uncontaminated material obtained from designated borrow areas.

20. Place erosion protection materials over the radon barrier materials. The erosion protection materials shall consist of a layer of bedding material topped by a layer of rock riprap.

21. Site Cleanup: Remove and dispose of Subcontractor's stockpiled materials, close the borrow areas and remove site perimeter fencing.

22. Site Restoration: Grade the UC area, the borrow areas and the stockpile areas to provide drainage including placement of uncontaminated fill and seeding.

4.4.11 Schedule

Remedial action for stabilization of the Slick Rock tailings is planned to commence in 1991 if funding is available. The construction schedule will be refined during the detailed design. Figure 4.5 shows the remedial action schedule. The winter shutdown may be five months or a lesser period of time. The Subcontractor will submit a winterization plan to protect the equipment and completed work during the winter shutdown period.

4.4.12 Cost Estimate

The conceptual design cost estimate is summarized in Table 4.4.

TABLE 4.3
CONCEPTUAL DESIGN COST ESTIMATE SUMMARY
(FY 1987 CONSTANT DOLLARS - DOLLARS IN THOUSANDS)

Item	Cost	
Site acquisition		$ 78
Remedial action (RA)		
Site preparation	$1,580	
Tailings pile	874	
Cover	391	
Erosion protection	360	
Restoration	2,178	
Subtotal subcontractor's remedial action costs[a]	5,383	
MK-F field management	2,056	
Construction management	1,243	
Total processing site RA	8,682	
Processing site engineering[a]		628
TOTAL PROCESSING SITE COST ESTIMATE		$9,388

[a]These costs include the subcontractor's overhead, profit, and five percent contingency.

4.5 REPROCESSING ASSESSMENT

The cost effectiveness of reprocessing the Slick Rock tailings to recover residual uranium and vanadium in the piles has been investigated (FBDU, 1981). The analysis estimated that the capital and operating costs for reprocessing the tailings would be approximately $870 (1981 dollars) per pound of uranium oxide (U_3O_8) produced. The present market value of U_3O_8 is less than $25 per pound and reprocessing is therefore not economically feasible.

4.6 SITE ACQUISITION

The procedures for acquisition of the processing site and disposal site are described in Section 104 of the Uranium Mill Tailings Radiation Control Act (PL95-604) and in the Cooperative Agreement between the DOE and the State of Colorado. In summary, the state is required to acquire the tailings and the processing site or, if the tailings will be relocated, acquire the disposal site. This is to be done at the direction of the DOE with the concurrence of the NRC. Property appraisals are obtained in the initial phase of acquisition. Should the DOE determine that removal of tailings from a processing site would result in windfall profits to the site owner, a recommendation will be made that the state acquire title to that property.

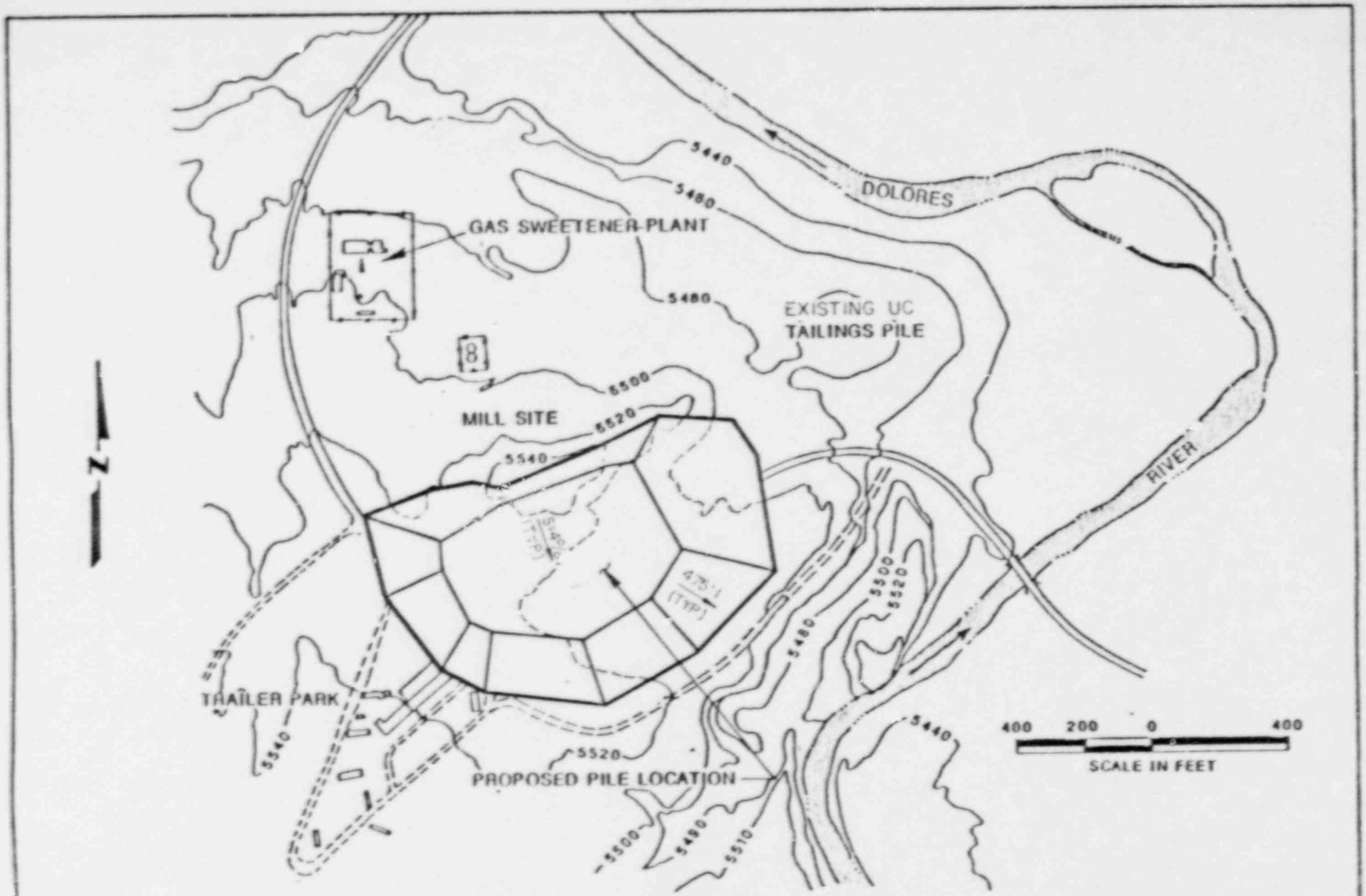

FIGURE 4.1
LOCATION OF THE STABILIZED PILE AT THE UNION CARBIDE SITE
SLICK ROCK, COLORADO

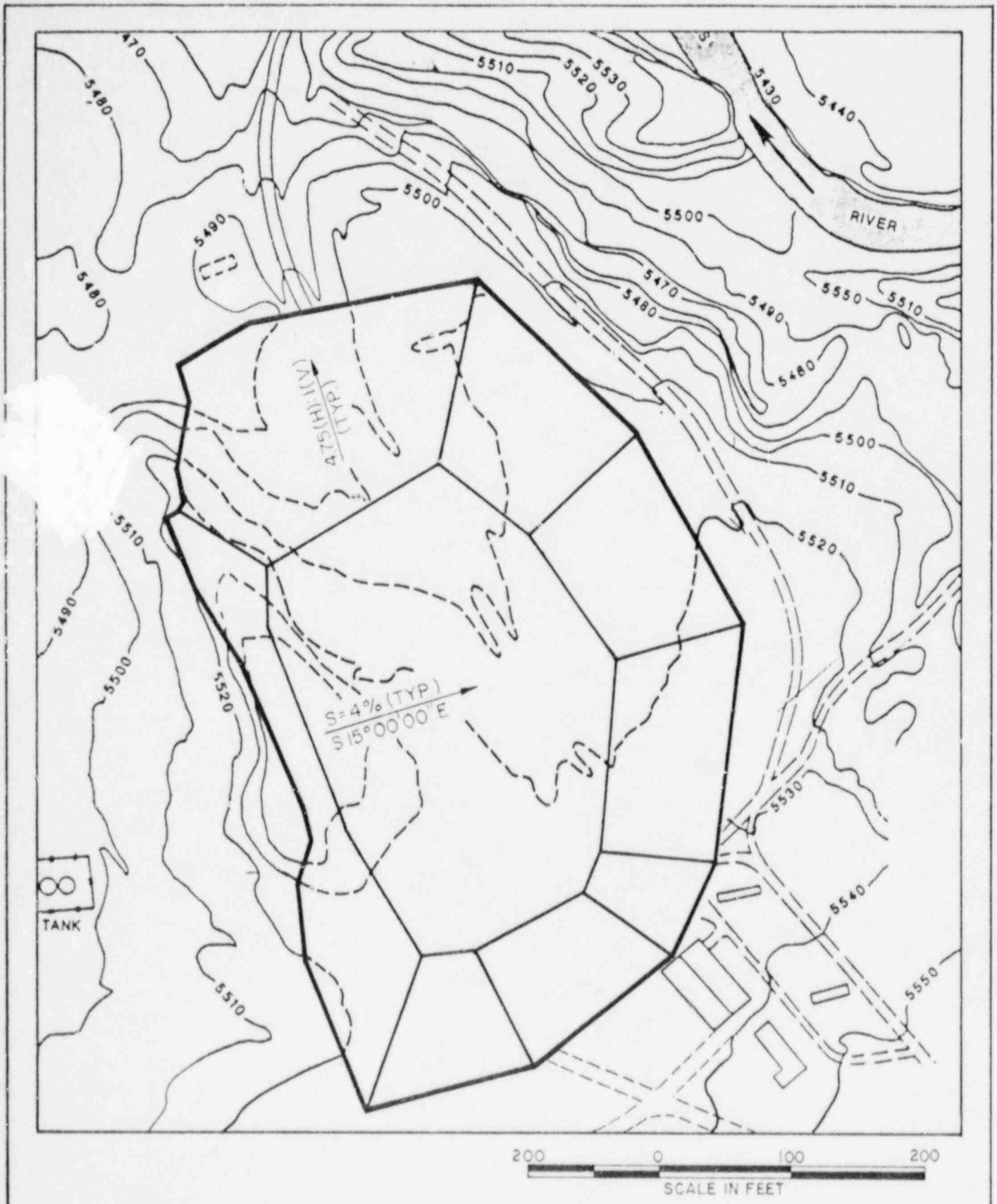

FIGURE 4.2
PROPOSED PILE CONFIGURATION, STABILIZATION ON SITE,
SLICK ROCK, COLORADO

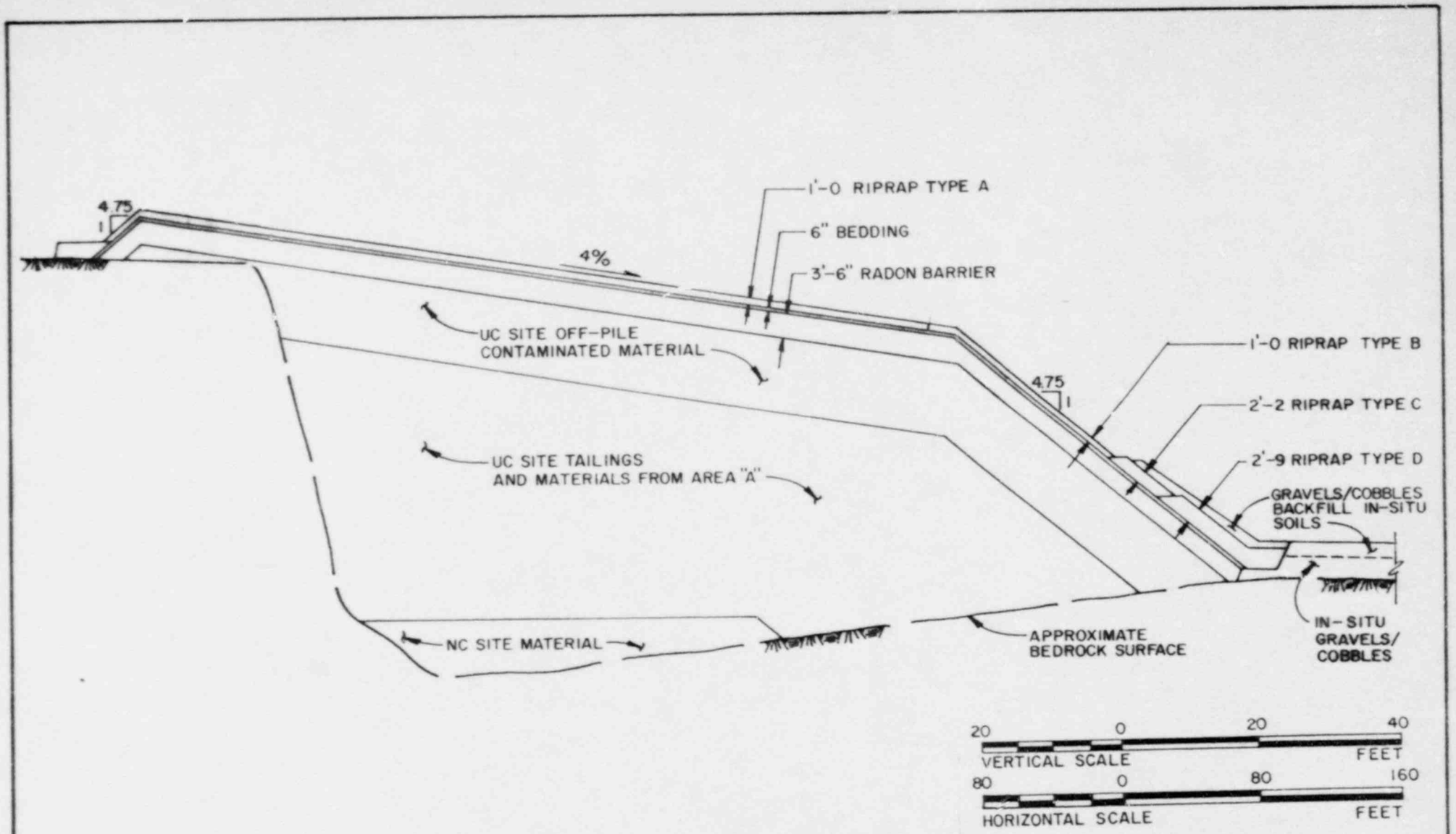

FIGURE 4.3
TYPICAL CROSS SECTION, STABILIZATION ON SITE
SLICK ROCK, COLORADO

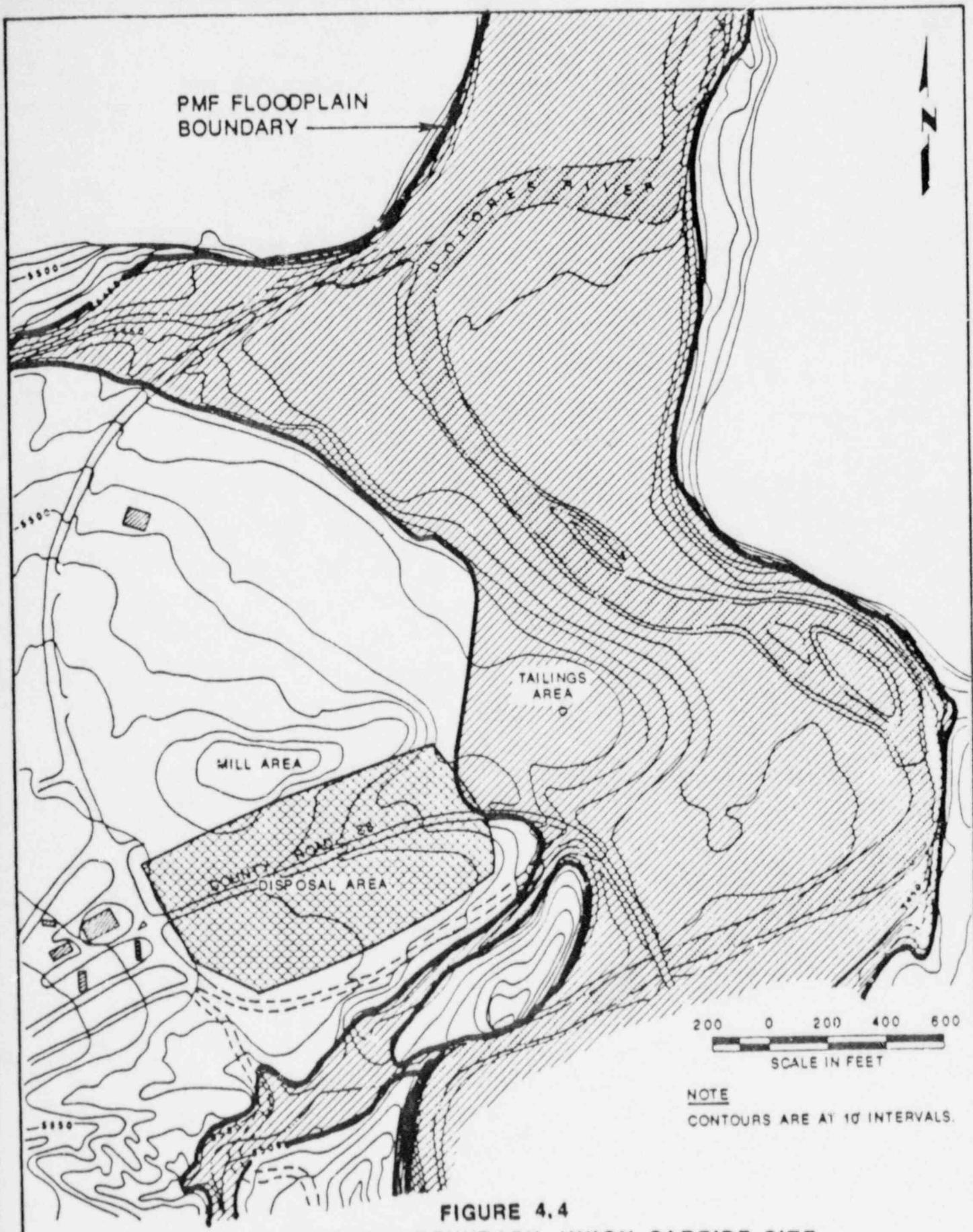

FIGURE 4.4
PMF FLOODPLAIN BOUNDARY, UNION CARBIDE SITE
SLICK ROCK, COLORADO

SECTION D

ANALYSIS OF CHANGE FROM dRAP DESIGN

Design Feature	dRAP Design	Preliminary Design	Description of and Reasons for Change
Location of Pile	Located between the existing UC pile and the trailer park.	Same location.	No change.
Base of excavation	Approximately 60' above the Dolores River.	Approximately 50' above the Dolores River.	Additional investigations show that bedrock is deeper than originally anticipated.
Pile subase	Either on rock or on terrace cobbles and gravels.	Most of pile subgrade is on rock. The western edge is on terrace cobbles and gravel.	No change.
Placement Sequence of Contaminated Materials	1) N.C. site tailings and contaminated materials. 2) U.C. site tailings. 3) U.C. site contaminated materials.	Same, except some highly contaminated materials from the UC site will be placed with the tailings.	No significant change.

Design Feature	dRAP Design	Preliminary Design	Description of and Reasons for Change
Radon Barrier	Two feet thick.	3-1/2 feet thick.	Input parameters to RAECOM program were revised resulting in thicker layer. Thickness may be revised during final design due to additional diffusion coefficient testing.
Erosion Protection Sizes	2 types: Top slope, $D_{50\ min}$ 1.5" Side slope, $D_{50\ min}$ 4.5"	4 types: Top slope, $D_{50\ min}$ 1.7" Side slope, $D_{50\ min}$ 4.0" Armor Type C, $D_{50\ min}$ 12" Armor Type D, $D_{50\ min}$ 17"	Additional armoring is required to protect the buried portions of the pile from either gullying or erosion of backfilled soils.
Erosion Protection Thickness	Bedding - 6" Topslope - 18" Sideslope - 18"	Bedding - 6" Topslope - 12" Sideslope - 12" Type C - 26" Type D - 33"	Top and side slope thickness was reduced. New requirements of Type C and D were developed.
Apron	Apron width - 5'	Apron width - 20'	Aprons were made wider per TAD.

Design Feature	dRAP Design	Preliminary Design	Description of and Reasons for Change
Pile Configuration	Top slope 2-4% from central crown, side slope 5(h):1(v) above backfill, 3(h):1(v) below backfill.	Top slope 4% from northern edge, side slope 4.75(h):1(v)	Top slope 4% from northern edge to prevent ponding or water collection along face of rock outcrop. Side slopes changed to provide more pile capacity and reduce armoring requirements under buried portions.
Geomorphology	1) The base of the pile is on bedrock or terrace cobbles and gravels.	No change.	No change.
	2) Pile is set back at least 100' from gully erosion near the trailer park	Pile is set back approx. 200' from the gully and 100' from Corral Draw.	200' setback allows for relocation of road and pipeline.

Design Feature	dRAP Design	Preliminary Design	Description of and Reasons for Change
	3) At existing ground surface pile is set back at least 100' from a line between the two rock ridges on the Dolores River side.	Pile is set back at least 100' at bedrock surface. (Toe extends to bedrock.)	Since bedrock is lower than originally anticipated, a minor portion of the pile toe will be exposed to the Dolores River PMF. Armoring is provided to prevent erosion in this event.
Seismicity	Design Earthquake is floating earthquake of 6.2 magnitude.	No change.	No change.
Geohydrology (ground water protection)	See dRAP for details.	Not included in preliminary design scope of work.	Since geohydrology was not included no change to the dRAP was made.
Surface Water	Surface water features including Dolores River, Corral Draw and Summit Canyon were analysed. Toe details were not shown.	Armor protection keyed into the terrace cobbles and gravels.	Corral draw was analysed in detail. protection.

Design Feature	dRAP Design	Preliminary Design	Description of and Reasons for Change
	Surface flows - directed away from pile by grading of backfill above bedrock.	Pile excavated to bedrock where practicable, and backfilled side slopes armored below backfill.	Armor extended below backfill to provide positive protection against erosion.
Geotechnical	Soil design parameters based on testing prior to 1987.	Additional testing done in 1987 was incorporated in design.	Soil design parameters were revised.
	Stability analyses done with dRAP configuration and parameters.	Stability analysis done with preliminary design configuration and parameters.	Slopes are stable for all conditions.
Cover Cracking	Tensile strains as a result of settlement would not cause cover cracking.	Settlement analysis was done using revised pile configuration and soil parameters. Cracking due to shrinkage was analyzed.	No cracking due to settlement; 6 inches was added to thickness for potential effects of shrinkage cracking.
Embankment Material Placement	Tailings and contaminated material will be compacted to 90 percent of ASTM D698; radon barrier to 95 percent.	No change.	No change.

Design Feature	dRAP Design	Preliminary Design	Description of and Reasons for Change
Radon Barrier Infiltration	Permeability should be between 10^{-6} to 10^{-7} cm/sec.	The infiltration analysis is not in the current scope of work for preliminary design. Laboratory tests confirm that permeability is less than 10^{-6} cm/sec.	No change; permeabilities required by the draft RAP can be achieved.
Borrow Sources	Riprap from Dolores River borrow site, Radon Barrier from Disappointment Valley.	Types A and B riprap from required excavations or from Dolores River borrow site. Types C and D riprap from Barlow Creek or other sources. Radon Barrier from Disappointment Valley.	There is sufficient cobbles/ gravel material from U.C. site to meet requirements of Types A and B riprap and bedding materials. The cobbles at Dolores River borrow site were not large enough to meet requirements for large size riprap. A potential source is Barlow Creek. Additional testing is needed to confirm that this site is acceptable. Additional investigations were done at Disappointment Valley to confirm that there is suitable acceptable material.

Design Feature	dRAP Design	Preliminary Design	Description of and Reasons for Change
Drainage and	Site to begraded to drain to retention basins. Basins to be designed to hold 10-year, 24-hour, storm, snow melt and waste water.	No change in criteria. One basin was provided at each site. No water treatment plant is anticipated.	No change.
Transportation	Tailings and contaminated materials from the N.C. site should be hauled to the disposal site via a bridge across the Dolores River and County Road CR-S8. Decontamination facilities would be required at the N.C. site.	Tailings and contaminated materials from the N.C. site will be hauled via upgraded County Road CR-S9, on the same side of the river. The road will be closed to the public during hauling and cleaned at the end. No decontamination facilities are needed at the N.C. site. Road decontamination facilities are provided at the intersection of the haul road and detoured County Road CR-S8.	Need for bridge and decontamination facilities at the N.C. site was eliminated.

Design Feature	dRAP Design	Preliminary Design	Description of and Reasons for Change
Utilities	Utilities will either be abandoned or relocated.	Specific utilities have been identified. Excavation in the tailings embankment has been staged to permit relocation of the utilities, including a high pressure gas line and detouring of County Road CR-S8.	Relocation of utilities is a significant portion of the work, requiring staging of construction and placing constraints on the area of the tailings pile.

E. OPEN ISSUES

1. Only specific gravity, absorption, soundness, abrasion, and freeze-thaw testing on four samples from a small source 12 miles from Barlow Creek, the proposed rock source for Riprap Types C and D, have been performed. No rock quality testing has been done on samples from Barlow Creek. Once the site is cleared of snow, rock samples will be obtained from at least 6 separate locations and tested for quality. The testing will include:

   - Specific Gravity determination
   - Absorption
   - Sodium Sulfate Soundness
   - L.A. Abrasion
   - Schmidt Hammer Soundness
   - Tensile Strength
   - Petrographic examinations

   If rock quality scores are less than 80% revisions to riprap on bedding gradations may be required.

2. The Barlow Creek rock source is about 100 road miles from the Slick Rock site. Additional studies will be made to locate potential sources of large size riprap closer to the site. If potential sites have been identified, samples will be obtained and tested as described above.

3. Riprap Types A and B and bedding material will come from either terrace cobbles and gravels from required excavations or from the Dolores River borrow site. Rock quality testing did not include Schmidt Hammer or Tensile Strength Testing. These tests will be added and the rock quality re-evaluated. Changes to oversizing and gradation requirements will be made, if required.

4. Diffusion coefficient testing is being done on radon barrier material. Testing done to date was on similar material outside the borrow source boundary. Once the test results are available the

radon barrier thickness will be re-evaluated and revised if required.

5. Additional triaxial testing (UU and CU) and consolidation testing is currently being done on radon barrier material. Determination of shrinkage limits will also be made. The results will be analyzed, and any calculations, such as settlement/cover cracking and stability analyses, impacted by the new results, will be revised. If required by these analyses, the design will be revised.

6. Supplemental standards will be required for the gas pipeline right-of-way at the UC site, between the county road CR-S8 and the Dolores River. The area covers approximately 19,000 sq. ft. and is shown on Drawing SRK-PS-10-0211, U.C. Site Contaminated Material Excavation Plan. The pipeline in this area cannot be relocated and will remain in operation during cleanup. Removing contaminated material adjacent to a high pressure gas-line presents a clear danger to the workers. The clear risk to workers outweighs the potential future risks of leaving any contaminated materials in place. A formal request for approval of supplemental standards for this area will be submitted before completion of final design.