ENERGY WEST
MINING COMPANY
A SUBSIDIARY OF PACIFICORP

P.O. Box 310
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Huntington, Utah 84528

April 25, 2013

Electronically Submitted

Utah Coal Program
Utah Division of Oil, Gas, and Mining
1594 West North Temple, Suite 1210
P.O. Box 145801
Salt Lake City, Utah 84114-5801

Subj: Amendment to Update Volume 10, Cottonwood Mine Waste Rock Site, PacifiCorp, Cottonwood/Wilberg Mine, C/015/0019, Emery County, Utah.

PacifiCorp, by and through its wholly-owned subsidiary, Energy West Mining Company (Energy West) as mine operator, hereby submits an amendment to reorganize Volume 10 of the Cottonwood/Wilberg MRP to comply with and follow the format of the R645-301 Utah Coal Regulations. The current organization of Volume 10 does not follow this format.

To accomplish this task, Energy West gathered operations information from the existing volume that pertains to each section of the R645-301 regulations. Then it compiled this information and organized it to follow the structure of each Utah Coal Regulation in each section. For example, all information from Volume 10 concerning, say, engineering was gathered from Chapter II, III, and IV. This information was then reorganized according to the format of R645-301-500 Engineering (R645-301-510, R645-301-520, R645-301-530, etc.). Updates to the existing information were also made as needed.

Maps from Volume 10 that did have the current title block or aerial photo have been included with this submittal. Also, Energy West is requesting that Plate 4-6 be removed from Volume 10. This map shows "Phase I" reclamation of the site. Phase I reclamation includes only reclaiming the access road and refuse pile. In the current plan, the pond would be left in place until the vegetation from the two areas establishes sufficiently to control erosion and sedimentation. However, it is Energy West's intent to reclaim the entire site in one phase.

One electronic copy of the reorganized volume is submitted for Division review. C1/C2 forms are included for removal or replacement of items in Volume 10, Wilberg/Cottonwood MRP. Upon approval, Energy West will provide seven (7) new binders along with clean copies of the amended chapters. Maps would then be transferred from the old binders to the new binders. If you have any questions concerning this action, please contact myself at 435-687-4712 or Dennis Oakley at 435-687-4825.

Sincerely,

Kenneth S. Fleck

Kenneth Fleck
Geology and Environmental Affairs Manager

Cc: file

APPLICATION FOR COAL PERMIT PROCESSING

Permit Change ☒ New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

Permittee: PacifiCorp

Mine: Cottonwood/Wilberg Mine **Permit Number:** C/015/0019

Title: Amendment to Update Volume 10, Cottonwood Mine Waste Rock Site, PacifiCorp, Cottonwood /Wilberg Mine, C/015/0019, Emery County, Utah

Description, Include reason for application and timing required to implement:

To bring into compliance with the R645-301 Utah Coal Regulations

Instructions: If you answer yes to any of the first eight (gray) questions, this application may require Public Notice publication.

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: _____ ☐ increase ☐ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes ☒ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☐ Yes ☒ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: _____
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes ☒ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☐ Yes ☒ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☒ Yes ☐ No 15. Does the application require or include soil removal, storage or placement?
☒ Yes ☐ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☒ Yes ☐ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☒ Yes ☐ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☐ Yes ☒ No 19. Does the application require or include certified designs, maps or calculation?
☐ Yes ☒ No 20. Does the application require or include subsidence control or monitoring?
☒ Yes ☐ No 21. Have reclamation costs for bonding been provided?
☐ Yes ☒ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes ☒ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?

Please attach four (4) review copies of the application. If the mine is on or adjacent to Forest Service land please submit five (5) copies, thank you. (These numbers include a copy for the Price Field Office)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

Kenneth Fleck — Kenneth S. Fleck — Manager of Environmental Affairs April 25, 2013
Print Name — Sign Name, Position, Date

Subscribed and sworn to before me this 25th day of April, 2013
Chris M. Christensen
Notary Public
My commission Expires: April 24, 2015
Attest: State of Utah } ss:
County of Emery

NOTARY PUBLIC
CHRIS M CHRISTENSEN
607905
COMMISSION EXPIRES
APRIL 24, 2015
STATE OF UTAH

For Office Use Only:	Assigned Tracking Number:	Received by Oil, Gas & Mining

Form DOGM- C1 (Revised March 12, 2002)

APPLICATION FOR COAL PERMIT PROCESSING
Detailed Schedule Of Changes to the Mining And Reclamation Plan

Permittee: PacifiCorp
Mine: Cottonwood/Wilberg Mine **Permit Number:** C/019/0019
Title: Amendment to Update Volume 10, Cottonwood Mine Waste Rock Site, PacifiCorp, Cottonwood /Wilberg Mine, C/015/0019, Emery County, Utah

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

Add	Replace	Remove	DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☐	☐	☒	Volume 10, Text Sections and Appendicies
☒	☐	☐	Volume 10, Introduction Tab
☒	☐	☐	Volume 10, R645-301-200 Soils (text section and appendices)
☒	☐	☐	Volume 10, R645-301-300 Biology (text section and appendices)
☒	☐	☐	Volume 10, R645-301-400 Land Use and Air Quality (text section and appendices)
☒	☐	☐	Volume 10, R645-301-500 Engineering (text section and appendices)
☒	☐	☐	Volume 10, R645-301-600 Geology
☒	☐	☐	Volume 10, R645-301-700 Hydrology (text section and appendices)
☒	☐	☐	Volume 10, R645-301-800 Bonding
☐	☐	☒	Volume 10, Plate 4-6 (CM-10824-WB)
☐	☒	☐	Volume 10, Plate 4-2 (CM-10821-WB)
☐	☒	☐	Volume 10, Plate 4-8 (CM-10810-WB) 1, 2, 3, 4, 5, and 6 of 6
☐	☒	☐	Volume 10, Plate 4-9 (CM-10820 4-WB)
☐	☒	☐	Volume 10, Plate 4-10 (CM-10811-WB) 1 of 2 and 2 of 2
☐	☒	☐	Volume 10, Plate 4-11A (CM-10815-WB)
☐	☒	☐	Volume 10, Plate 4-11B (CM-10846-WB)
☐	☒	☐	Volume 10, Plate 4-12 (CM-10830-WB)
☐	☒	☐	Volume 10, Plate 4-13 (CM-10837) 1 of 2 and 2 of 2
☐	☒	☐	Volume 10, Plate 7-1 (CM-10818-WB)
☐	☒	☐	Volume 10, Plate 9-1 (CM-10817-WB)
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Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.	Received by Oil, Gas & Mining

INTRODUCTION

The original Cottonwood/Wilberg Waste Rock Storage Area (BLM right-of-way UTU-37642) was filled to design capacity thus making it necessary to construct a new storage facility to handle the on-going disposal needs of the Cottonwood, Des-Bee-Dove and Trail Mountain mines. Calculations have been made, based on past history, the rate and amount of waste rock generated during mining operations, these quantities have been used to formulate the design of the new facility.

The area selected for the "new" Waste Rock Storage Facility is located on public land managed by the US Department of Interior, Bureau of Land Management. The area is located in the southeast quarter of Section 34, Township 17 South, Range 7 East, west of the coal haul road used for the Cottonwood/Wilberg Coal Mine facility. The area was selected because it is close to the mine facilities and has the required capacity to contain all the waste rock generated at both the Cottonwood/Wilberg, Des Bee Dove and Trial Mountain mines for the anticipated life of each mine.

The Waste Rock Storage Facility is designed to fit into the existing topography of the area with as little disturbance as is possible to the existing drainage system. Only one ephemeral drainage channel will require a permanent diversion for the construction and operation at the Waste Rock Storage Facility. When the site is completed, only 17.44 acres will have been disturbed. A sediment pond designed as part of the Waste Rock Storage Facility will catch and treat all the runoff from the site before releasing it back into the natural channel. This volume (Volume 10 of the Cottonwood/Wilberg Mine Permit) includes detailed construction, operation and reclamation plans for the Waste Rock Storage Facility.

RIGHT OF ENTRY

PacifiCorp was granted a BLM right-of-way for the additional permit area (refer to Chapter 1 Appendix A: BLM Right-of-Way Grant UTU-65027). This 27.27 acre site was permitted to replace the "old" Waste Rock Storage Area: UTU-37642 which reached designed capacity. The Right-of-Way grant was issued by the BLM on June 8, 1990. The Right-of-Way UTU-65027 has been modified to accommodate coal bed methane well sites constructed by Texaco Inc. and to reflect as-built conditions. Listed below is a list of the acreage descriptions for the Right-of-Way including original grant, modifications and disturbance associated with the Waste

Rock Storage Facility:

BLM Right-of-Way UTU-65027

Original Grant: 6/8/90	**25.49 acres**
Amendment: 8/15/90 (Staging Area)	**1.78 acres**
Subtotal	**27.27 acres**
1999 Relinquishment (Texaco Well 34-80) Staging Area	**- 1.78 acres**
As-Built Addition (1999)	**0.36 acres**
TOTAL RIGHT-OF-WAY UTU-65027	**25.85 acres**
Disturbed Area (Total Project Life)	**17.44 acres**

During the 1999 Texaco well assessment project, PacifiCorp re-surveyed the disturbed and permit boundaries associated the R/W UTU-65027. Two small areas of disturbance were located outside the original metes and bounds permit boundary description. To rectify this situation, PacifiCorp has revised the R/W description to include all areas of disturbance associated with the Waste Rock Storage Facility. The 1999 relinquished area referred to as the “staging area”, was previously disturbed by oil & gas drilling activities in 1956. PacifiCorp retained access to State Highway 57 and has installed permit and disturbed boundary signs as indicated on map 4-1 (CM-10826). Texaco will re-disturb the staging area with development of well 34-80 and will assume reclamation liabilities.

RIGHT-OF-WAY LEGAL DESCRIPTION

BLM Right-of-Way UTU-65027, issued to PacifiCorp, provides right of entry for the Waste Rock Storage Facility. An updated description is found in the PacifiCorp/Energy West Mining Company, Legal and Financial Volume, Appendix G.

RIGHT-OF-WAY PERMIT TERM

Right-of-Way UTU-65027 will terminate on June 7,2025, thirty five (35) years from its effective date unless, prior thereto, it is relinquished, abandoned, terminated, or modified pursuant to the terms and conditions of this grant or of any applicable Federal law or regulation. A copy of this use permit is found in Appendix A.

MAPS - GENERAL REQUIREMENTS

Land Ownership drawings number CM-10519-WB and CM-10520-WB found in Volume 3 show all boundaries of lands and names of present owners of record of those lands, both surface and subsurface, included in or contiguous to the Waste Rock Storage Facility permitted area.

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R645-301-200: Soils

R645-301-210 Introduction

An on-site soil survey was conducted at the Cottonwood/Wilberg Waste Rock Storage Facility by T.H. Furst in July 1989 (refer to Appendix A). The survey identified that the site correlated well with the Strych soil series and Rockland. The Strych soil series is classified as an Ustollic Calciorthid, loamy-skeletal, mixed, mesic family. This series is a very stony loam, dry, 3-30% slopes, as described in the Carbon-Emery Area Soil Survey, 1970.

The Rockland is comparable to the Badland-Rubbleland-Rock Outcrop complex as described in the Carbon Area Soil Survey of 1970. Refer to the full report of the soils of the Cottonwood/Wilberg Waste Rock Storage Facility in Appendix A.

R645-301-220 Environmental Descriptions

R645-301-221 Prime Farmland Investigation

A prime farmland investigation has been made by the State Agricultural Agent, Dennis Worwood. The results of the investigation found that the land of the Waste Rock Storage Facility shall not be considered prime farmland in that the land:

1. Has not been historically used as cropland.
2. The slope of the land is 10% or greater.
3. The land is not irrigated.
4. Has a very rocky surface,
5. The land has no soil map units that have been designated prime farmland.

Refer to Appendix B for letters from the Utah State Extension and Soil Conservation Service (now Natural Resource Conservation Service).

R645-301-221 Soil Survey

As mentioned above, a complete soil survey conducted by T.H. Furst can be found in Appendix A.

R645-301-222.100

Map CM-10818-WB delineates the different soil types in the area of the Waste Rock Storage Facility. Refer to this map in the Maps Section.

R645-301-230 Operation Plan

The following sections describe the methods for the removal and storage of topsoil and subsoil from the Waste Rock Storage Facility. The construction sequence covers approximately 17 acres that required the removal of topsoil. Subsoil within this area was also removed and stored. The location of the topsoil and subsoil storage areas is found on Plates 4-4 and 4-5 in the Maps Section.

Greater details to the construction and reclamation of the Waste Rock Storage Facility are given in R645-301-500 Engineering.

R645-301-231.100 Methods for Removing and Storing Topsoil and Subsoil

The initial construction of the facility included the construction of the sediment pond, stripping and stockpiling of the topsoil and subsoil, and construction of the initial diversion ditch on the west side of the valley

Topsoil
After the vegetative material was removed from the site the topsoil was stripped and stockpiled as shown on Plates 4-4 and 7-2. Stripping areas and depths were staked to facilitate topsoil excavation. Care was taken to avoid unnecessary compaction of the topsoil material. Following soil placement, the stockpiles were planted with an interim seed mix. Refer to R645-301-300 Vegetation.

Subsoil
Following removal of the topsoil material the remaining material needed for the subsoil stockpile was excavated to the lines and grades specified on the cross-sections. The material was placed, leveled, and compacted in 12" maximum lifts. Rocks larger than the lift thickness were worked into the fill to avoid forming voids. Those rocks that made good rip-rap were separated and hauled and stored for use as rip-rap. Any acid or toxic forming material found was segregated from the stockpile construction and placed on the bottom of the Waste Rock Storage Facility.

R645-301-234 Topsoil Storage

Construction of the Waste Rock Storage Facility commenced as soon as the permit was issued. Sediment control measures were put in place to minimize the effects of the initial construction. Straw bales and silt fences were erected in the natural drainages to treat any runoff during the initial construction period. Interim revegetation was used on the bare slopes of the soil stockpiles and along the roadway to stabilize and prevent erosion. The topsoil stockpiles have been marked as such. Drainage structures have been constructed and will be maintained to ensure that they are in good repair and capable of handling the design flow rates. Silt fences have been constructed at the base of the soil stockpiles outside slopes. These silt fences will also be monitored and repaired as needed to ensure they are in good working order.

R645-301-240 Reclamation Plan

Construction of the refuse pile will incorporate a plan to allow contemporaneous reclamation of the outside slopes of the pile. Refuse material will be used to construct a berm, approximately 10 feet high, to contain the waste material to be deposited.

R645-301-242 Soil Redistribution

As reclamation commences of the waste pile slopes, 18 inches of subsoil and 6 inches to topsoil will be placed on the outside slope of the berm and revegetation of the slope. Successive berms will be constructed on top of the previous berms as the level of the waste material rises. There will be a two to three foot offset of the toe of the upper berm to provide a small terrace to reduce runoff velocities. (See Exhibit XXI in Exhibits Section) Once the waste pile construction is complete, the top surface of the pile will be graded for proper drainage and covered with subsoil and topsoil (18 and 6 inches, respectively), then revegetated.

R645-301-243 Soil Nutrients and Amendments

The procedure for seed bed preparation for all reclaimed slopes of the Waste Rock Storage Facility site is given in R645-301-300 Biology. All reclaimed areas have been or will be fertilized, mulched and seeded to establish a successful vegetative cover.

R645-301-244 Soil Stabilization

Various sized rocks and boulders (litter) will be randomly placed on slopes of reclaimed areas to control slope slippage, promote microhabitats, and provide a natural aesthetic appearance. Where it is deemed necessary, especially on slopes greater than 20%, a soil tackifier (refer to R645-301-300: Biology, Seeding Techniques) will be used during the reclamation process to stabilize soil material.

Rills and gullies which develop in areas that have been regraded and topsoiled and which either; 1) disrupt the approved postmining land use or the reestablishment of the vegetative cover, or 2) cause or contribute to the violation of water quality standards for receiving streams will be filled, regraded, or otherwise stabilized.

R645-301-250 Performance Standards

All topsoil and subsoil will be removed, maintained and redistributed according to the plan given under R645-301-230 and R645-301-240.

All stockpiled topsoil and subsoil will be located, maintained and redistributed according to plans given under R645-301-230 and R645-301-240.

FINAL REPORT

A REPORT ON THE SOILS OF THE WILBERG WASTE ROCK SITE

A soil survey, and physical and chemical

characterization of soils

for

Utah Power and Light Company

Huntington, Utah

by

T. H. Furst, Soils Consultant
649 Southwest Street
Logan, UT 84321
(801) 752-0403

15 September 1989

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A REPORT ON THE SOILS OF THE WILBERG WASTE ROCK SITE

Soil survey

An on-site soil survey and sampling expedition was conducted on 27 and 28 July 1989. The survey phase of the reconnaissance involved ascertaining the approximate boundaries of the soil units at the waste rock site. Four different soil phases (map units) were identified in this study as in Table 1. Pedons 1, 2, 4, and 5 were located on the waste rock site. Pedon 3 was located in a nearby vegetation reference area, and has the same taxonomic classification as Pedon 1. Pedon 2 is classified as an Ustollic Calciorthid, 0-20% slopes, which correlates with similar soil phases recognized by the Soil Conservation Service- National Cooperative Soil Survey in Utah. However, a distinct break in the slope in the Ustollic Calciorthids map unit was used to delineate 0-5% and 10-20% slope phases of Ustollic Calciorthids. The slope phases of Ustollic Calciorthids are listed under Pedon 2 (Table 1), as there are no differences in the horizonation of the soil pedons in these two areas. Thus interpretation of the management and use of these areas is similar and the land use management classification of both units falls within the range of the Strych very stony loam, 3-30% slope in Table 5.

The area represented by Pedon 4 on the soils map has inclusions of a similar soil that contains surficial additions of sandy materials derived from the incorporation of weathered or weathering sandstone boulders and rocks. The inclusions are coarser textured than the fine-silty particle-size class characteristic of Pedon 4, but the distribution of the inclusions is not separable from the major soil. Thus, a thin (10-20 cm) surficial layer of loam-textured material may be differentiated from the predominantly silt loam or silty clay loam textures associated with soils derived from the Mancos shale. In general, the coarser-textured inclusions of Pedon 4 are adjacent to and downslope from the local topographic escarpments at the site and occupy 15-20 percent of the map unit. A survey along these escarpments established that these features formed the boundary between the Ustollic Calciorthids, 0-5% and 10-20% slope phases, and the Lithic Ustic Torriorthents 0-5% and 5-30% slope phases.

Soil phases identified at the waste rock site were correlated with soil series or map units from the Carbon-Emery Area Soil Survey (Swenson, et al. 1970) or the Carbon Area Soil Survey (Jensen et al. 1988). Mr. Thomas J. Reedy, a soil correlator with the Utah State Soil Survey Office, was consulted on the matter of what series the the soils of the waste rock site should be correlated to. Soils at the waste rock site were identified as the Kenilworth very stony sandy loam, 0-20% slopes, eroded, and Rock land, a miscellaneous land type, in the Carbon-Emery Area Soil Survey (Swenson et al. 1970).

The Kenilworth soil series was classified as a Xerollic Calciorthid, loamy-skeletal, mixed, mesic family. Fieldwork for the Carbon-Emery Area Survey was done in the period 1957-1961 and soil names and descriptions were approved in 1965. However, the Kenilworth soil series was never formally accepted by the National Cooperative Soil Survey, and by the publication of the

Carbon-Emery Survey in 1970, the Kenilworth soil series had been discontinued. Correspondence retained in the files of the State Office indicates that the Kenilworth soil series was correlated to the Ildefonso soil series, established in Torrance County, New Mexico. The Ildefonso soil series is classified as an Ustollic Calciorthid, loamy-skeletal, mixed, mesic family. With the publication of the Carbon Area Soil Survey (Jensen et al. 1988), the Strych soil series was established and classified as an Ustollic Calciorthid, loamy-skeletal, mixed, mesic family. Thus, the Strych very stony loam, dry, 3-30% slopes, described in the Carbon Area Soil Survey, will be used to infer land use management options for Pedon 2, 0-20% slopes.

The Rock land, miscellaneous land type map unit of the Carbon-Emery Soil Survey (Swenson et al. 1970) encompasses the area of Pedons 1, 3, and 4, and the Badland-Rubbleland-Rock Outcrop complex described in the Carbon Area Soil Survey (Jensen et al. 1988) is the only map unit comparable to this area. Although taxonomic classifications have been determined for Pedons 1 and 4, it is necessary to realize that both these pedons are marginal soils. The minimum thickness of soil required for classification is 10 cm and the minimum vegetal cover to consider a land area soil is arbitrarily set at 10 percent. Thus, while Pedons 1 and 4 are classified, they exist at the limit of soil and not-soil, and there are no formally recognized similar soils in the immediate survey areas.

Table 1: Classification and correlation of map units at the Waste Rock site.

Pedon	Classification; Slope phase of map unit
1	Fine-silty, mixed, mesic (calcareous) Lithic Ustic Torriorthents; 0-5 % slopes
2	Loamy-skeletal, mixed, mesic Ustollic Calciorthids; 0-20% slopes Two map units: 0-5% slope phase 10-20% slope phase
3	Fine-silty, mixed, mesic (calcareous) Lithic Ustic Torriorthents; 0-5 % slopes
4	Fine-silty, mixed, mesic (calcareous) Lithic Ustic Torriorthents; 5-30 % slopes

Correlation of Waste Rock site map units with currently recognized soil series or map units

Pedon(s)	Soil Series (Map unit) - Classification
1,3,4	Rock land- miscellaneous land type (Swenson et al. 1970) Badland-Rubbleland-Rock Outcrop complex (Jensen et al. 1988)
2	Strych very stony loam, dry, 3 to 30 percent slopes Loamy-skeletal, mixed, mesic Ustollic Calciorthids (Jensen et al. 1988)

Soil description and sampling

Soil pedons (Pedons 1, 2, and 3) were excavated at three sites and described according to the guidelines in Soil Taxonomy (Soil Survey Staff, 1975). Please note the soils map and pedon descriptions for the location of sampling sites. All pedon descriptions are included in Appendix 1 in this report.

Pedons were sampled by horizon and placed in plastic bags and labeled, prior to transport. The 24-90 cm horizon of Pedon 2 was split into two layers for laboratory analyses. Samples were taken from the 24-50 cm depth and the 50-90 cm depth.

A composite sample of the materials on the northwestern, northern, and northeasten midslopes surrounding the drainage head (site of Pedon 1) was taken in 15 cm increments to a depth of 30 cm. This composite sample is reported as Pedon 4 in the laboratory analyses. These samples too, were placed in plastic bags and labeled prior to transport.

Laboratory Methods

All soil samples were submitted to the Utah State University Soil Test Laboratory, Logan, Utah, on 31 July 1989 for physical and chemical analyses. The results of laboratory analyses were obtained from the Utah State University Soil Test Laboratory on the afternoon of 11 September 1989.

All samples were air-dried, ground and passed through a 2 mm sieve. Soil texture was determined by the hydrometer method (Day, 1965; method 43-5). Available Water Capacity was determined by the water retention difference method (USDA-SCS, 1984; method 4C1). Saturation percentage was determined in the preparation of the saturation paste extract (percent by mass). Electrical conductivity, pH, and alkalinity were determined on saturated paste extracts corrected to 25°C (Rhoades, 1982; methods 10-3.3, 10-3.2, and 10-2.3.1, respectively). The sodium adsorption ratio (SAR) was calculated on the water soluble concentrations of Ca, Mg, and Na (Rhoades, 1982; method 10-3.4). Calcium carbonate content was determined by the pressure-calcimeter method (Nelson, 1982; method 11-2.4). Organic carbon content was determined by the Walkley-Black procedure (Nelson and Sommers, 1982; method 29-3.5.2). Phosphorus and potassium content were determined by extraction with sodium bicarbonate at ph 8.5 (Olsen and Sommers, 1982; method 24-5.4). Rock volume (%) of the soil materials was estimated in the field based on a visual estimate of the amount of gravels, cobbles, and rock fragments excavated during sampling. Soil color was measured with a Munsell[1] soil color chart (1975 edition).

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1. "Munsell" is a registered trademark of Munsell Color, Macbeth A Division of Kollmorgen Corporation, 2441 North Calvert Street, Baltimore, Maryland 21218.

Results and Discussion

Soil Physical Analyses

Results of soil physical analyses are shown in Tables 2 and 3. Soil textural analysis confirms the coarser-textured nature of Pedon 2 and also indicates the influence of the sandstone covered small hill adjacent to Pedon 3, in the textures of the 0-2 and 2-22 cm soil horizons. The textures of the upper two horizons of Pedon 3 represent what the textures of the inclusions of Pedon 4 are like. Results of textural analyses for the C-horizons of Pedons 1, 3, and 4, are not indicative of what was observed in the field. These horizons are composed of 2-20 mm diameter, 2-5 mm thick gravel platelets of weathered Mancos shale. Thus, reported textural results for these C-horizons should be recognized as artifacts of the sample preparation method of grinding samples to pass a 2 mm sieve. Estimates of rock volume are in Table 3 and coarse fragments are described in detail in the pedon descriptions in Appendix 1.

Table 2: Particle size and available water percentage of soil materials from the waste rock site.

Pedon	Depth (cm)	Hydrometer: Sand (%)	Silt (%)	Clay (%)	Texture	Available Water, Atmospheres: 1/3 (%)	15 (%)	Saturation Percentage (%)
1	0-2	19	61	20	Silt loam	15.9	6.6	34.4
	2-10	8	60	32	Silty clay loam	16.3	9.0	50.7
	10-26	10	61	29	Silty clay loam	18.4	8.7	53.5
	26-65	16	60	24	Silt loam	18.8	9.0	65.3
2	0-7	72	21	7	Sandy loam	11.2	6.3	43.9
	7-24	76	18	6	Loamy sand	13.5	7.6	44.7
	24-50	61	29	10	Sandy loam	12.8	4.8	30.0
	50-90	60	29	11	Sandy loam	10.3	3.9	30.0
3	0-2	50	34	16	Loam	11.4	5.0	29.1
	2-22	40	32	28	Clay loam	14.6	8.4	35.2
	22-50	14	60	26	Silt loam	18.1	8.6	44.3
4	0-15	14	57	29	Silty clay loam	22.1	12.5	74.7
	15-30	14	57	29	Silty clay loam	22.9	12.0	73.2

The results of saturation percentage analysis, available water retention, and water retention by difference are included in Tables 2 and 3. The saturation percentage ranged from 30-50% for most soil horizons. Again, the saturation percentages for the C-horizon materials of Pedons 1, 3, and 4, are of doubtful validity given the content of coarse fragments in these horizons.

The available water results in Table 2 were used to calculate the values of water retention by difference (Table 3). The available water capacities (% by mass) by water retention difference between 1/3 and 15 atmospheres are shown in Table 3 for all pedons. Values range from 4.9-10.9 percent (mass basis). Conversion of percent water values (% mass) to an inch/inch basis yields the data in the second column under water retention difference in Table 3.[2] In the upper 4 inches (10 cm) of Pedon 1, approximately 0.17 inches of water will be held between 1/3 and 15 atmospheres. In contrast, the upper 9.5 inches (24 cm) of Pedon 2 will hold approximately 0.30 inches of available water or about 1.75 times that of the soil horizons in Pedon 1.

The Munsell soil color (dry) is listed in Table 3. Measurements of moist and dry colors are included in all pedon descriptions in Appendix 1. The color in Pedons 1, 3, and 4 is largely inherited from the Mancos shale. As the value (dry) is greater than or equal to 5 in these pedons, the role of organic matter as a darkening agent is questionable.

Table 3: Color, organic carbon, total nitrogen, sodium bicarbonate extractible phosphorus and potassium, rock volume, and water retention difference of soil materials at the waste rock site.

Pedon	Depth (cm)	Color (dry)	Org C	Total N	-$NaHCO_3$- P	-$NaHCO_3$- K	Rock Volume	Water Retention Difference % mass	Water Retention Difference in/in*
			--------%-------		--mg/kg--		---%--	% mass	in/in*
1	0-2	10YR 6/2	0.92	0.065	4.5	162	2	9.3	.046-.055
	2-10	10YR 5/2	1.22	0.075	2.0	148	2	7.3	.036-.043
	10-26	10YR 6/1	0.99	0.060	0.9	89	>90	9.7	.048-.057
	26-65	10YR 5/1	0.72	0.045	0.6	127	>90	9.8	.048-.058
2	0-7	10YR 6/3	1.77	0.145	5.7	255	>50	4.9	.024-.029
	7-24	10YR 5/3	1.80	0.150	3.3	86	>50	5.9	.029-.035
	24-50	10YR 7/3	0.95	0.045	1.3	39	>50	8.0	.039-.047
	50-90	10YR 7/3	0.65	0.035	1.0	42	>50	6.4	.032-.038
3	0-2	10YR 7/2	0.60	0.050	6.4	103	2-5	6.4	.032-.038
	2-22	10YR 6/3	0.60	0.055	2.4	131	2-5	6.2	.031-.037
	22-50	10YR 6/2	0.66	0.050	4.1	103	.90	9.5	.047-.056
4	0-15	10YR 6/1	1.02	0.070	2.4	177	5-15	9.6	.047-.057
	15-30	10YR 5/1	1.01	0.055	1.8	186	>90	10.9	.054-.064

* Values in this column are calculated by assuming bulk densities of 1.25 g/cm³ and 1.5g/cm³ for the low and high estimates for each depth increment.

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2. From: Hanks and Ashcroft (1980:7-8).
   1. Pw/100= mass water content
   2. Mass water content X [bulk density (g/cm3) / density of water g/cm3)] X 1 cm = cm water/cm soil.
   3. [cm water/cm soil] / [2.54 cm/ 1 inch] = available water (in/in)

Soil Chemical Analyses

The results of organic carbon analysis, total nitrogen, and sodium bicarbonate extractable phosphorus and potassium are included in Table 3. Organic carbon ranges from 0.6-1.8% (roughly 1-3% organic matter) in all horizons analyzed. Total nitrogen in the upper two horizons of Pedon 2 is about 2-3 times greater than the total nitrogen content of any horizons of Pedon 1, 3, and 4.

Phosphorus contents of all soil horizons suggest the need for phosphorus fertilization. The USU Soil Test Lab recommendations suggest the application of 0-50 pounds P_2O_5 per acre for grasses and lawns for soil test levels between 1-10 ppm phosphorus.

Potassium contents of all soil horizons is adequate for plant growth with the highest levels generally in the surface soil horizons of all pedons. The USU Soil Test Lab does not recommend potassium fertilization for grasses, and only recommends potassium fertilization for alfalfa and other intensely managed irrigated crops when soil test levels are below 75 ppm K. Zero to 50 pounds K_2O per acre are recommended for soil test levels of less than 75 ppm K.

The rest of the soil chemical analyses are included in Table 4. The pH ranges from 7.8-8.4 across all horizons. Electrical conductivity values are below 0.6 mmhos/cm except in the Cr2 horizon of Pedon 1 and in both increments of Pedon 4. The sodium adsorption ratio is below 0.83 for all soil pedons except Pedon 4. The soil in Pedon 4 has a SAR which ranges from about 22-26 and this correlates with the highest reported values for ammonium acetate extractable sodium (about 10 meq/liter vs $<$ 1 for all other soil horizons). Calcium carbonate content ranges from approximately 10-14% for Pedons 1, 3, and 4. Pedon 4 has calcium carbonate contents which increase from about 25% in the surface horizon to 34% in the 24-50 cm horizon, and then decreases to roughly 31% in the 50-90 cm depth. Alkalinity ranges from about 1-3 meq/liter across all pedons.

Table 4: pH, electrical conductivity, sodium adsorption ratio, calcium carbonate percentage, alkalinity, and ammonium acetate extractible cations of soil materials from the waste rock site

Pedon	Depth (cm)	pH	ECe (mmhos/cm)	SAR	$CaCO_3$ -%-	--(HCO_3^-)-- Alkalinity (meq/liter)	----------NH_4OAc---------- Ca	Mg (meq/liter)	Na	K
1	0-2	8.0	0.5	0.72	12.7	3.07	22.18	1.53	0.17	0.62
	2-10	7.9	0.3	0.66	12.7	1.86	29.54	1.83	0.17	0.67
	10-26	8.0	0.2	0.67	13.1	1.86	27.79	2.16	0.14	0.48
	26-65	7.8	2.5	0.23	11.9	1.07	92.25	1.91	0.20	0.64
2	0-7	8.0	0.6	0.69	25.1	3.57	35.28	1.04	0.12	0.51
	7-24	8.0	0.5	0.40	27.3	3.07	37.25	1.43	0.11	0.16
	24-50	8.2	0.6	0.68	34.2	2.57	32.29	2.48	0.09	0.19
	50-90	8.4	0.4	0.67	30.8	3.36	33.38	4.29	0.10	0.51
3	0-2	8.2	0.4	0.66	13.9	3.14	25.00	1.19	0.08	0.12
	2-22	8.0	0.3	0.72	12.9	2.14	32.79	1.81	0.09	0.25
	22-50	7.8	0.3	0.83	11.8	1.64	30.36	2.50	0.11	BDL*
4	0-15	7.9	9.2	22.46	10.3	1.86	59.85	3.97	9.16	0.56
	15-30	8.1	10.6	26.22	11.3	1.43	55.29	4.78	10.90	0.34

*- Below detection limit

Soil management and land use of soils at the waste rock site.

Various land management classifications and ratings are presented in Table 5 for Pedons 2 and 5 (Ustollic Calciorthids, 0-5% and 10-20% slopes, respectively) and Pedons 1, 3, and 4 (phases of Lithic Ustic Torriorthents). As can be seen in Table 5, the soils which constitute the phases of Lithic Ustic Torriorthents have a land capability class of VIII. This is the land capability class with the most severe limitations for land use and these lands are traditionally reserved for recreation, wildlife, or aesthetic purposes. The Lithic Ustic Torriorthents are not rated for any other management categories other than wildlife. This is an indication of a severely limited soil resource.

The Ustollic Calciorthids, 0-20 percent slope phase have a land capability class of VII-s. This indicates that the soil has severe limitations that makes it unsuited to cultivation and use is restricted to grazing, woodland, or wildlife. At the waste rock site, the major limiting factor is that more than 50% of the soil volume is occupied by rock. Thus, the available water is cut in half by this factor. Also, the quantity (volume) of topsoil available for stockpiling and revegetation purposes must be discounted by about half. Other than a tendency towards droughtiness, which is characteristic of all coarse-textured soils in arid environments, there is little chemical evidence to suggest major limitations. The most marked feature of this soil is the increasing calcium carbonate content with depth. This could indicate a tendency towards cementation, but indurated cemented layers were not detected during pedon excavation.

Of the soils identified at the waste rock site, the Lithic Ustic Torriorthent, fine-silty, mixed (calcareous) mesic family, 5-30 percent slopes would carry the most severe limitations for land use. Excessive slope, high salts, a high sodium adsorption ratio, and an exchangeable sodium percentage of 12-15 are the main limiting characteristics of this soil. Soil materials in this map unit should not be disturbed or stockpiled for revegetation purposes.

The 0-5 percent slope phases of Lithhc Ustic Torriorthents, fine-silty, mixed (calcareous) mesic family, have a major limitation in terms of soil depth. Four-to-possibly-six inches of soil material overlies the weathered horizons of Mancos shale and in Pedon 1, and increase in salts was detected below 26 cm (10 inches). However, 2.5 mmhos/cm is not a terribly limiting salt concentration in terms of revegetation potential. Low gravel content, an available water content of about 0.036-0.055 in/in, low salts, and low sodium content are favorable characteristics of the upper 10 cm of this soil. The results of soil physical and chemical analysis of the 10-65 cm depths of this pedon suggest that if the natural, gravelly-textured Cr horizons are crushed and passed through a 2 mm sieve, the material has roughly similar physical and chemical characteristics to upper 10 cm of soil. Thus, with crushing, soil material for revegetation could be manufactured from the soil horizons between 10 and 65 cm at this site. The silt content of Pedon 1 (about 60%) could indicate an enhanced potential for soil crusting, but this is a feature naturally characteristic of this soil as seen in the platy structure found in the A1 orizon (see Appendix 1, Pedon descriptions).

Table 5: Land use management classifications for soils of the Waste Rock site.*

Management category	Ustollic Calciorthids, 0-5 & 10-20% slopes/ Strych very stony loam, 3-30 % slopes		Lithic Ustic Torriorthents/ Rockland
Capability Classification[1]			
Non-irrigated	VII-s		VIII-s-3
Irrigated	not rated		not rated
Range Site[2]	Semi-Desert Stony Loam (Utah Juniper-Pinyon)		not rated
Total production			
Kind of year	Dry weight (lbs/acre)	Characteristic vegetation	Composition -%-
Favorable	650	Galleta	10
Normal	500	Needle-and-thread	10
Unfavorable	350	Birchleaf mahogony	10
		Mormon-tea	10
		Black Sagebrush	10
		Salina wildrye	5
		Bottlebrush squirreltail	5
		Indian ricegrass	5
Wildlife Suitability Group[3]	3		3
Textural Classification			
Unified	SM or SM-SC		not rated
AASHO	A-2 or A-4		not rated
Hydrologic group[4]	B		not rated
Erosion factors			
K	0.2		not rated
T (tons/acre/year)	2		not rated
Wind erodibility group[5]	8		not rated
Shrink-swell potential	Low		not rated
Frost action susceptibility	Low		not rated
Suitability as a source of:			
Topsoil	Poor- small stones, area reclaim, slopes		not rated
Sand	Improbable- excessive fines		not rated
Gravel	Improbable- excessive fines		not rated
Roadfill	Fair- large stones		not rated

* All information in this table is taken from interpretive tables and descriptions in Jensen et al. (1988) for the Strych very stony loam, 3-30% slopes (map unit 114), and from Swenson et al. (1970) for the Rockland map unit.

Explanation of management classification groups

1. Capability class VII- Soils have severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife. Capability class VIII- Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to aesthetic purposes. Capability Subclasses: s- shows that the soil is limited mainly because it is shallow, droughty, or stony. Capability Units: 3- inhibiting layer.
2. 60-80% of overstory is Utah juniper, the remainder is pinyon pine (Swenson et al. 1970).
3. Wildlife group 3- wildlife suited to these soils are mule deer, chukar partridge, and cottontail rabbits (Swenson et al. 1970).
4. Hydrologic group B- Soils having moderate (water) infiltration rate when thoroughly wet.
5. Wind erodibility group 8- Stony or gravelly soils, or other soil not subject to wind erosion.

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APPENDIX I.

DESCRIPTIONS OF SOILS

IN THE

WASTE ROCK AREA

Pedon 1

Location: In drainage head on interfluv area, approximately 300 meters SSW of the center of section 34, T 17 S, R 7 E.
Aspect: South.
Slope: 3-5 percent.

Classification: Lithic Ustic Torriorthents, fine-silty, mixed (calcareous) mesic family, 0-5 percent slopes.

Description:
(Colors are for dry soil unless otherwise noted.)

Horizon

A1 — 0-2 cm; Light brownish gray (10YR 6/2), dark grayish brown (10YR 4/2, moist) silt loam; strong, medium to very coarse platy structure; slightly hard, friable, sticky and slightly plastic; strong effervescence; few, very fine roots; abrupt wavy boundary.

A2 — 2-10 cm; Grayish brown (10YR 5/2), very dark grayish brown (10YR 3/2, moist) silty clay loam; moderate, very fine granular structure; loose, loose, sticky and plastic; strong effervescence; few, fine, and few, medium roots; abrupt smooth boundary.

Cr1 — 10-26 cm; Gray to light gray (10YR 6/1), dark gray (10YR 4/1, moist) weathered shale; massive; very hard, extremely firm, very sticky and very plastic; violent effervescence; common fine roots; clear smooth boundary.

Cr2 — 26-65 cm; Gray (10 YR 5/1), very dark gray (10YR 3/1, moist) weathered shale; massive; very hard, extremely firm, very sticky and very plastic; violent effervescence; few very fine roots.

Remarks: Effervescence in Cr1 and Cr2 is due to calcium carbonate coatings on shale fragments. Shale fragments exhibit very little effervescence when broken and the interior is tested with 10% HCl. Shale fragments in Cr1 are fractured to platelets which range from 2-20 mm diameter. Shale fragments in Cr2 range from 20-75 mm diameter and are lighter in color than the Cr1 horizon fragments due to calcium carbonate and/or gypsum accumulation. Gypsum crystals from 2-10 mm diameter were found in the Cr2 horizon.

Pedon 2

Location: Near the 4+00 survey marker for the proposed road for the waste rock site (actually about 3+90); due west of the Wilberg Mine road. In the NW 1/4 of the NE 1/4 of the SW 1/4 of section 34, T 17 S, R 7 E.
Aspect: Southeast.
Slope 1-5 percent.

Classification: Ustollic Calciorthids, loamy-skeletal, mixed, mesic family, 0-20 percent slopes.

Description:
(Colors are for dry soil unless otherwise noted.)

Horizon

A1 — 0-7 cm; Pale brown (10YR 6/3), brown to dark brown (10YR 4/3, moist); very stony sandy loam (Rock volume > 50%); weak, very fine granular structure; loose, loose, nonsticky and nonplastic; strong effervescence; few very fine roots; abrupt smooth boundary.

A2 — 7-24 cm; Brown (10YR 5/3), dark brown (10YR 3/3, moist); very stony loamy sand (Rock volume > 50%); weak, fine and medium subangular blocky structure, breaking to moderate very fine and fine granular structure; soft, friable, nonsticky and slightly plastic; strong effervescence; few fine and common medium roots; abrupt wavy boundary.

C — 24-90 cm; Very pale brown (10YR 7/3), brown (10YR 5/3, moist) very stony sandy loam (Rock Volume > 50%); massive; hard, friable, slightly sticky and slightly plastic; violent effervescence; few fine and few medium roots.

Remarks: Roughly half of this pedon is occupied by rock fragments. Most are cobbles (7.5-25 cm diameter) and stones (>25 cm diameter). Less than 10% of the total rock volume is comprised of gravel-sized particles (2-75 mm diameter). Carbonate coats all surfaces of the rock fragments.

Pedon 3

Location: In reference area (The southeast quarter of the southeast quarter of section 34, T 17 S, R 7 E.), due south of and near the toeslope of a small hill mapped as "Ry" on Map Sheet number 30 in the Carbon-Emery Area Soil Survey (1970).
Aspect: South.
Slope: 3-5 percent.

Classification: Lithic Ustic Torriorthents, fine-silty, mixed (calcareous) mesic family, 0-5 percent slopes.

Description:
(Colors are for dry soil unless otherwise noted.)

Horizon

A1 — 0-2 cm; Light gray (10YR 7/2), brown (10YR 5/3, moist) loam; Strong, medium and coarse platy structure; slightly hard, friable, plastic and sticky; slight effervescence; no roots; abrupt wavy boundary.

A2 — 2-22 cm; Pale brown (10YR 6/3), brown to dark brown (10YR 4/3, moist) clay loam; weak, fine and medium subangular blocky structure breaking to moderate, very fine granular and moderate very fine blocky structures; soft, very friable, very sticky and very plastic; strong effervescence; common fine roots; abrupt wavy boundary.

Cr — 22-50 cm; Light brownish gray (10YR 6/2), dark grayish brown (10YR 4/2, moist) weathered shale; massive; very hard, extremely firm, very sticky and very plastic; violent effervescence; few very fine roots.

Remarks: Shale in Cr horizon is fractured into platelets 2-20 mm diameter, and 1-5 mm thick. Very few, very fine roots penetrate weathered shale along fractures. Most roots are restricted to the A2 horizon.

C O O P E R A T I V E   E X T E N S I O N   S E R V I C E

UTAH STATE UNIVERSITY

EMERY COUNTY OFFICE
Courthouse
Castle Dale, Utah 84513-0847
(801) 748-2381

January 19, 1990

Mr. Val Payne
Utah Power & Light Mining Division
15 N. Main
Huntington, UT 84528

Dear Val:

This is to confirm that the proposed Cottonwood/Wilberg Waste Rock Storage Facility is not located on prime farmland. The Underground Coal Mining Rules, Section UMC 783.27, paragraph b states:

"Land shall not be considered prime farmland where the applicant can demonstrate one or more of the following:

(1) The land has not been historically used as cropland;

(2) The slope of the land is 10 percent or greater;

(3) The land is not irrigated or naturally subirrigated, has no developed water supply that is dependable and of adequate quality, and the average annual precipitation is 14 inches or less;

(4) Other factors exist, such as a very rocky surface, or the land is frequently flooded during the growing season more often than once in two years and the flooding has reduced crop yields; or

(5) On the basis of a soil survey of the lands within the permit area there are not soil map units that have been designated prime farmland by the U.S. Soil Conservation Service."

The site meets all five of the above listed criteria. It cannot be considered farmland, let alone prime farmland, under any stretch of the imagination.

Please contact me if you have further questions about the agricultural capabilities of this site.

Sincerely,

Dennis R. Worwood
USU Extension Agent

utah power
& LIGHT COMPANY
MINING DIVISION
P O Box 310
Huntington, Utah 84528

January 24, 1990

Mr. George Cook
Range Conservationist
United States Department of Agriculture
Soil Conservation Service
350 North 4th East
Price, Utah 84501

Dear Mr. Cook:

Please provide a Prime Farmland determination for the area associated with the proposed Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility as required by the Utah DOGM (see attached memo).

As you are aware, the proposed site is located on public land administered by the Bureau of Land Management. It is located in Section 34, T17S, R7E as indicated on the accompanying drawing, CM-10520-WB.

Attached also, is land use information for the site area. This information is based on the 1988 BLM San Rafael Draft Resource Management Plan and Environmental Impact Statement.

Your assistance and prompt response regarding this matter are greatly appreciated.

If you need additional information please call me at 687-9821.

Sincerely,

Val Payne

Val Payne
Senior Environmental Engineer

VP:do
Enclosure

United States Department of Agriculture

Soil Conservation Service

P. O. Box 11350
Salt Lake City, Utah 84147

February 13, 1990

Mr. Val Payne
Utah Power and Light Company
Mining Division
P. O. Box 310
Huntington, Utah 84528

Dear Mr. Payne:

We have reviewed the project for the Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility.

The area is determined to be excluded from all categories of Important Farmland. A completed form AD-1006 is enclosed.

If we can be of further assistance, please call on us at (801) 524-5064.

Sincerely,

Tom Reedy, for

Ferris P. Allgood
State Soil Scientist

Enclosure

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request: 1/26/90
Name Of Project: Cottonwood/Wilberg Coal Mine Waste	Federal Agency Involved: BLM owns the land
Proposed Land Use: Rock Storage Facility	County And State: Emery, Utah
PART II *(To be completed by SCS)*	Date Request Received By SCS: 1/26/90

Does the site contain prime, unique, statewide or local important farmland? Yes ☐ No ☒
(If no, the FPPA does not apply — do not complete additional parts of this form).

Acres Irrigated: 0 | Average Farm Size: 0

Major Crop(s)	Farmable Land In Govt. Jurisdiction	Amount Of Farmland As Defined in FPPA
None	Acres: %	Acres: %
Name Of Land Evaluation System Used	**Name Of Local Site Assessment System**	**Date Land Evaluation Returned By SCS**
	On Site Investigation	

		Alternative Site Rating			
		Site A	Site B	Site C	Site D
PART III *(To be completed by Federal Agency)*					
A. Total Acres To Be Converted Directly					
B. Total Acres To Be Converted Indirectly					
C. Total Acres In Site		25			
PART IV *(To be completed by SCS)* Land Evaluation Information					
A. Total Acres Prime And Unique Farmland		0			
B. Total Acres Statewide And Local Important Farmland		0			
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted		0			
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value		0			
PART V *(To be completed by SCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*					
PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b))*	Maximum Points				
1. Area In Nonurban Use					
2. Perimeter In Nonurban Use					
3. Percent Of Site Being Farmed					
4. Protection Provided By State And Local Government					
5. Distance From Urban Builtup Area					
6. Distance To Urban Support Services					
7. Size Of Present Farm Unit Compared To Average					
8. Creation Of Nonfarmable Farmland					
9. Availability Of Farm Support Services					
10. On-Farm Investments					
11. Effects Of Conversion On Farm Support Services					
12. Compatibility With Existing Agricultural Use					
TOTAL SITE ASSESSMENT POINTS	160				
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100				
Total Site Assessment *(From Part VI above or a local site assessment)*	160				
TOTAL POINTS *(Total of above 2 lines)*	260				

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☐

Reason For Selection:

10-10.4

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R645-301-300: Biology

R645-301-310 Introduction

R645-301-320: Environmental Descriptions

The following sections of this application contain descriptions, information, and plans to protect the biological, aquatic, and wildlife resources within and in the vicinity of Cottonwood/Wilberg Waste Rock Storage Facility.

R645-301-321: Vegetation Information

The site location for the proposed disturbed area of the Waste Rock Storage Facility is 1.75 miles south of the Wilberg Mine, Emery County, Utah. The township and range of the site is: Township 17 South, Range 7 East, Section 34. Elevation of the Waste Rock Storage Facility ranges between 6,700 ft. and 7,000 ft. above sea level. The slopes are varied between 3 degrees and 36 degrees and are composed of exposures to the east, west and south.

A vegetation survey was conducted on the proposed disturbed area in August 1989 by Mt. Nebo Scientific. The purpose of the survey was to supply meaningful and scientific data that provides accurate standards for future reclamation of the area. Both proposed disturbed and reference areas were surveyed.

Major plant communities found in the general area are typical salt desert shrublands and comprise of communities with the following plant species as dominates and/or subdominates: Pinyon Pine (Pinus edulis), Utah Juniper (Juniperus ostersperma), Mat Saltbush (Atriplex corrugata), Gardner Saltbush (Atriplex gardneri), Shadscale (Atriplex confertifolia), Salina Wildrye (Elymus salinus), and Black Sagebrush (Artemisia nova). The Waste Rock Storage Facility, including the access road, drainage control diversions and sediment pond will occupy approximately 25 acres of land within the following associated vegetation communities:

Pinyon-Juniper	10 acres
Black Sagebrush	4 acres
Gardner Saltbush	11 acres

A complete report of this survey is found in Appendix A.

Proposed Disturbances

The two types of proposed disturbances are planned for the Waste Rock Storage Facility is: 1) a waste rock storage area; and 2) an access road. The proposed disturbances will impact three plant communities. The access road will dissect a Pinyon-Juniper community whereas the Waste Rock Storage Facility disturbance affects Gardner Saltbush and Black Sagebrush/Salina Wildrye plant communities.

Reference Areas

A reference area is used to develop a standard for success at the time of final reclamation for each of the proposed disturbances. These areas were chosen to comply with guidelines provided by DOGM and had similar slopes, soils, exposures, species composition, precipitation, elevations and other environmental variables.

R645-301-321.200 Productivity

Productivity and range condition estimates for the Cottonwood/Wilberg waste rock site were performed by the US Soil Conservation Service (now Natural Resource Conservation Service), Price, Utah in 1990. A letter from the Service is found in Appendix B.

R645-301-322 Fish and Wildlife Information

The Cottonwood/Wilberg Waste Rock Storage Facility occupies portions of an Upper Sonoran/Transition life zone ecotone, within the Wasatch Plateau biogeographic area. A general discussion of wildlife species associated with these ecological zones is contained in Volume 2 of the Cottonwood/Wilberg Coal Mine Permit Application.

The area is ranked by the Utah Division of Wildlife Resources (DWR), as critical deer (Odocoileus hemionus) winter range and limited-value elk Cervus canadensis) winter range. DWR also ranks the area as substantial-value yearlong habitat for the Desert Cottontail (Sylvilagus audubonii).

Wildlife movement occurs throughout the area of the Waste Rock Storage Facility; however, the facility will not pose a barrier to big game movement. The facility is not expected to increase the potential for deer road-kill occurrences. (Personal communication with Larry Dalton, DWR, September 8, 1989.)

The BLM (San Rafael Draft Resource Management Plan/EIS) classifies a portion of the area (approximately 12 acres) as crucial deer winter habitat.

The Waste Rock Storage Facility is within the territories of golden eagles (Aquila chrysaetos) and common ravens (Corvus corax). But, it is outside the buffer zones associated with nest sites of both species. The nearest raptor nests (Raven nests 64A and B) are approximately 0.8 mile from the facility. The golden eagle nest (62) is approximately 1.2 miles from the facility. The nests are included in the raptor monitoring program described in the Cottonwood/Wilberg PAP, Appendix XVI, Part H. Nest 62 was active in 1989 with one (1) young produced. Nests 64A and 64B were inactive in 1989.

R645-301-322.210 Listed Endangered or Threatened Plants and Animals of Emery County

The following plant, fish, and wildlife information tables includes Threatened and Endangered Species, listed in Emery County, Utah, and may be present in the Grimes Wash area. The data from these tables are reference from the Utah Division of Wildlife Resources website at http://www.dwrcdc.nr.utah.gov/ucdc/)

Table 300-1: Endangered or Threatened Plant, Fish, and Animal Species

Common Name	Scientific Name	Status*
Jones Cycladenia	*Cycladenia humilis var jonesii*	T
Last Chance Townsendia	*Townsendia aprica*	T
Barneby Reed-mustard	*Schoenocrambe barnebyi*	E
San Rafael Cactus	*Pediocactus despainii*	T
Winkler Pincushion Cactus	*Pediocactus winkleri*	E
Wright Fishhook Cactus	Sclerocactus wrightiae	E
Humpback Chub	*Gila cypha*	E
Bonytail	*Gila elegans*	E
Colorado Pikeminnow	*Ptychocheilus lucius*	E
Razorback Sucker	*Xyrauchen texanus*	E
Greater Sage-grouse	*Centrocercus urophasianus*	C
Yellow-billed Cuckoo	*Coccyzus americanus*	C
Mexican Spotted Owl	*Strix occidentalis lucida*	T
Black-footed Ferret	*Mustela nigripes*	Extirpated
Canada Lynx *Lynx*	*Lynx canadensis*	T
Gray Wolf	*Canis lupus*	E

*T=Threatened, E=Endangered, C=Canidate

None of the above stated species are found within the area of the Cottonwood/Wilberg Waste Rock Storage Facility. There is no suitable habitat within this area to support the above stated species.

R645-301-323 Maps and Aerial Photographs

Plate 8-1 in the Maps Section displays the vegetation communities within and adjacent to the Waste Rock Storage Facility. Plate 9-1 shows the locations for winter habitat and critical winter habitat for deer and elk within and adjacent to the Waste Rock Storage Facility.

R645-301-323.100 Reference Area Locations

Plate 8-1 in the Maps Section shows the location for the locations of the reference areas for specific plant species in the Waste Rock Storage Facility.

R645-301-320 Operation Plan

The original Cottonwood/Wilberg Waste Rock Storage Area is located south and east of highway 57. This site was filled to its capacity in 1989 (Phase III Bond Release of the original site was granted in July of 2009) making it necessary to construct a new facility to handle the disposal needs of the mine. Calculations have been made, based on past history, the rate and amount of waste rock generated during mining operations, these quantities have been used to formulate the design of a new facility. Refer to R645-301-500 Engineering for these calculations.

The area selected for the Waste Rock Storage Facility is located on public land managed by the US Department of Interior, Bureau of Land Management. The facility is located in the southeast quarter of Section 34, Township 17 South, Range 7 East, west of Highway 57 and used in support of the mining operations. The area was selected because it is close to the mine facilities and has the required capacity to contain all the waste rock generated at the Cottonwood/Wilberg, Des Bee Dove, and Trial Mountain mines for the anticipated life of each mine. Final reclamation has been conducted on the Des Bee Dove mine facilities. These activities were completed in 2006.

R645-301-331 Mitigation Measures

The Waste Rock Storage Facility was constructed and is operated in such a manner as to minimize, to the extent possible, disruption of normal wildlife activities in the area.

The Waste Rock Storage Facility is located approximately two (2) miles northwest of Grimes Wash, an ephemeral stream, and approximately four (4) miles from Cottonwood Creek, the nearest fishery. Therefore, no fish species or fish supporting habitat are present on the site and no streams containing biological communities exist within the site. No riparian habitat or wildlife species associated with such habitat exist on the site.

No electric power lines or other transmission facilities have been constructed to serve the Waste Rock Storage Facility.

Fences have been designed and constructed to allow uninhibited big game passage. It is not anticipated that the sediment pond will contain hazardous concentrations of toxic-forming materials; therefore, exclusion fencing of the pond was not proposed.

No persistent pesticides were used on the area, unless approved by the Division. If it is determined that pest control is needed, approved species-specific control measures will be implemented.

To the extent possible, range or forest fires will be prevented, controlled or suppressed, unless directed otherwise by the Division.

The primary post-mining land use is wildlife habitat and livestock grazing. Final reclamation plant species have been selected for that purpose and generally follow information provided to PacifiCorp by UDWR, which is identified as "Recommended Plant Materials and Rates of Application for Restoration or Enhancement of Wildlife Habitats." Adequate wildlife cover is available adjacent to the waste rock storage site; therefore, plant species were chosen primarily for forage production.

As discussed previously, approximately 25 acres of big game habitat will be displaced by the facility; therefore, mitigation in accordance with procedure was proposed prior to construction. Mitigation was achieved through implementation of procedures outlined in the approved Wildlife Habitat Mitigation Plan which was developed for the original Cottonwood/Wilberg Waste Rock Storage Area and the Des Bee Dove haul road (August 27, 1986).

R645-301-333 Mitigation Procedures

Mitigation sites were selected in the adjacent pinyon-juniper community (see Plate 9-1). Selection was made following consultation with BLM, DWR and DOGM. Prior to site work, an archaeological assessment was performed at the proposed locations. No resource conflicts were identified.

Trees were removed at the selected sites by bulldozer. Clearing work followed the natural contour of the sites (ridge tops). The trees were pushed over, crushed by the bulldozer and left on the site to provide some protection for plant establishment. Access to the sites was restricted by placement of large boulders at potential vehicles access points.

Soil samples were analyzed to determine fertilizer application rates and the need for additional soil amendments. The fertilizer and amendments were broadcast prior to removal of the trees and were incorporated into the soil during the tree removal operation.

Seeding took place between October 1st and November 30th. The following seed mixture was broadcast concurrently with tree removal. The seeds were covered during the tree removal operation.

Table 300-2: Mitigation Area Seed Mix

PLANT MATERIAL		LBS/ACRE (PLS)[1]
GRASSES:		
Smooth brome	*Bromus inermis* - *southern varity*	3
Alkali Sacation	*Sporobolus airoides*	2
Russian wildrye	*Elymus junceus*	2
Indian ricegrass	*Oryzopsis hymenoides*	1
Piute orchardgrass	*Dactylis glomerata*	3
FORBS:		
Utah sweetvetch	*Hedysarum gremiale*	3
Alfalfa	*Medicago sativa* - *ladak*	3
Small Burnett	*Sanguisorba minor*	2
Yellow Sweetclover	*Melilotus officinalis*	1
Palmer penstomen	*Penstemon palmeri*	1
Lewis flax	*Linum lewisii*	2
SHRUBS:		
Antelope bitterbrush	*Purshia tridentata*	1
Wyoming big sagebrush	*Artemisia tridentata wyomingensis*	1
Great Basin sagebrush	*A. t. tridentata*	1
Mountain sagebrush	*A. t. vaseyana*	1
Fourwing saltbush	*Atriplex canescens*	2
Winterfat	*Ceratoides lanata*	1
TOTAL		30

[1] Seed mixture was supplied by DWR

NOTE: See Cottonwood/Wilberg PAP, Vol. 2, for justification of introduced species.

Following seed covering a layer of alfalfa hay mulch was applied at the rate of approximately two (2) tons per acre. The mulch was crimped into the soil. Crimping was done in such a manner that implement tracks will intercept potential runoff water thus improving the potential for vegetation establishment.

Inspection and evaluation of the mitigation measures was made by PacifiCorp, DWR, BLM and DOGM personnel following the first and subsequence growing season.

Deer pellet-group counts were made in 1989 at the Wilberg/Des Bee Dove mitigation areas. Transects were run on the mitigation sites and in the pinyon-juniper community adjacent to the mitigation sites. The results were an average use level of 37 deer days per hectare at the mitigation sites and 25 deer days per hectare in the adjacent areas. This indicates the use level at the mitigation sites is 48% greater than in the adjacent pinyon-juniper. It is assumed that a similar increase in use can be achieved in the vicinity of the Cottonwood/Wilberg Waste Rock facility. Mitigation measures were implemented on 45 acres of pinyon-juniper community to compensate for the disturbance of 25 acres at the facility site.

As has been stated, adequate cover exists in the area of the Waste Rock Storage Facility. The habitat requirements which limit the carrying capacity of the area are forage and water. Therefore, in addition to the forage enhancement measures conducted, a guzzler was also installed within the mitigation area as indicated on Plate 9-1. Specifications for the guzzler and its installation were coordinated with DWR, BLM and DOGM.

R645-301-340 Reclamation Plan

The following discusses the process by which the permitee shall conduct reclamation activities associated with revegetation of the Waste Rock Storage Facility during operations and at final reclamation.

R645-301-341.100 Detailed Scheduled for Revegetation

Table 300-3 shows the timetable by which reclamation will be conducted on the Cottonwood/Wilberg Waste Rock Storage Facility. Many of the reclamation operations will occur simultaneously.

Table 300-3: Cottonwood/Wilberg WRS Reclamation Schedule

#	Project	Estimated Scheduling											
	Months	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1	Structure Removal		•										
2	Hauling, Backfilling & Grading				•	•							
3	Review of Revegation Plan			•	•								
4	Order Seed			•									
5	Seed Bed Preparation				•								
6	Fertilization				•		•	•					
7	Seeding & Mulching							•	•				

Note: Timeframes are approximate and will vary depending on site conditions and the acreage involved.

Table 300-4 shows the scheduled activities throughout the responsibility period.

Table 300-4: Cottonwood/Wilberg WRS Reclamation Schedule: 1st thru 10th Year											
#	**10 Year Revegetation & Monitoring**	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**	**6th Year**	**7th Year**	**8th Year**	**9th Year**	**10th Year**
1	Plant Monitoring Disease & Pest Control *	•	•	•	•	•	•	•	•	•	•
2	Soil Stabilization Rills & Gullies	•	•	•	•	•	•	•	•	•	•
3	Contingent Seeding		•		•						
4	Revegetation Inventory for Bond Release				•				•	•	•

R645-301-341.200 Description of Seeding Methods

<u>Interim Revegetation</u>

Interim revegetation will be implemented on the road embankment slopes, the top and outslopes of the soil stockpiles and the sediment pond banks. Timing of interim revegetation will be in accordance with R645-301-341.100. The Division will be notified prior to the beginning of revegetation activities.

The primary purpose of interim revegetation is soil stabilization: therefore, plant species were selected for their suitability to site conditions, ease of establishment, rate of growth and growth forms. Species selected include some that occur naturally at the site. Refer to Appendix A, “Vegetation of the Cottonwood/Wilberg Waste Rock Site”.

300-5: Interim Revegetation Seed List

PLANT MATERIAL		LBS/ACRE (PLS*)
GRASSES:		
Thickspike Wheatgrass	*Agropyron dasystachyum*	2
Streambank Wheatgrass	*A. riparium*	2
Basin Wildrye	*Elymus cinereus*	3
Indian Ricegrass	*Oryzopsis hymenoides*	2
Bottlebrush Squirreltail	*Sitanion hystrix*	1
Sandberg Bluegrass	*Poa sandbergii*	0.5
Alkali Sacaton	*Sporobolus airoides*	0.25
FORBS:		
Prairie Aster	*Aster tanacetifolius*	0.5
Northern Sweetvetch	*Hedysarum boreale*	1
Yellow Sweetclover	*Melilotus officinalis*	3
Firecracker Penstemon	*Penstemon eatonii*	0.5
Alfalfa	*Medicago sativa var. Ladak*	1
SHRUBS:		
Shadscale	*Atriplex confertifolia*	3
Castle Valley Saltbush	*A. cuneata*	3
Winterfat	*Ceratoides lanata*	3
Basin Big Sagebrush	*Artemisia tridentata*	
	sp. tridentata	0.25
TOTAL		26.00

*PLS = Pure Live Seed

The proposed seed mixture and application rates results in approximately 115 seeds per square foot (55 grass, 45 forb, 15 shrub).

Interim Revegetation Methodology

1. Seedbed Preparation

   Seeding will take place as contemporaneously as practicable following soil placement; therefore, the seedbed will be in a roughened condition suitable for seed application. However, if a surface crust has developed it will be broken up by hand or mechanical tilling to achieve maximum roughness.

2. Seeding
The seed mixture will be hand broadcast with "hurrican spreaders" or applied by hydroseeder at the specified rate. The seed and water slurry will remain in the hydroseeder no longer than two hours. Seeding will take place during late Fall after October 1.

3. Fertilizer Application
The fertilizer will be applied (if found to be needed) by hand broadcasting with "hurricane spreaders" or as a separate operation of hydroseeding. Fertilizer application rates will be determined from soil analysis. The following is an approximate combination and rate:

Ammonium Nitrate	50 lbs/acre
Triple Superphosphate	75 lbs/acre

4. Seed Covering
Following hand broadcasting of the seed mixture and fertilizer, and whenever possible on hydroseeded areas, the sites will be hand or mechanically raked to cover the seeds.

5. Mulch Application
Following hand broadcasting and raking, the seeded areas will be covered with an erosion control mulch blanket or hay mulch (2 tons/acre and netting). The blanket/netting (if used) will be mechanically anchored per the manufacturers specifications.

All seed and hay mulch will be inspected by a State Department of Agriculture inspector prior to application. Copies of inspection certificates will be submitted to the Division.

Following hydroseeding, a wood fiber hydromulch with tackifier will be applied at the rate of approximately 2000 lbs/acre.

The criteria for interim revegetation success will be the establishment of at least 60% ground cover, on the majority of the slope, which prevents or minimizes erosion. This will be determined by spring and fall site inspections. If erosion damage occurs, it will be repaired and revegetated as needed.

Final revegetation

Final revegetation will be implemented on the completed disposal area upon completion of the backfilling and grading activities. Revegetation will follow the scheduled as outlined in the on Tables 300-3 and 300-4.

The potential for re-establishing vegetation is discussed in R645-301-200 Soils, Appendix A, Final Report: A Report on the Soils of the Wilberg Waste Rock Site (pages 7-9 through 7-11). Additionally, the revegetation success achieved at the existing waste rock site is an indicator that revegetation can be achieved.

300-6: Final Revegetation Seed List

PLANT MATERIAL		LBS/ACRE (PLS*)
GRASSES:		
Thickspike Wheatgrass	*Agropyron dasystachym*	2
Streambank Wheatgrass	*A. riparium*	2
Basin Wildrye	*Elymus cinereus*	3
Galleta	*Hilaria jamesii*	1
Indian Ricegrass	*Oryzopsis hymenoides*	2
Sandberg Bluegrass	*Poa sandbergii*	0.5
Bottlebrush Squirreltail	*Sitanion hystrix*	1
Alkali Sacaton	*Sporobolus airoides*	0.25
FORBS:		
Prairie Aster	*Aster tanacetifolius*	0.5
Northern Sweetvetch	*Hedysarum boreale*	1
Yellow Sweetclover	*Hedysarum boreale*	3
Firecracker Penstemon	*Penstemon eatonii*	1
Scarlet Globemallow	*Sphaeralcea coccinea*	0.5
Alfalfa	*Medicago sativa var. Ladak*	1
SHRUBS:		
Black Sagebrush	*Artemisia nova*	1
Fourwing Saltbush	*Atriplex canescens*	5
Shadscale	*A. confertifolia*	3
Castle Valley Saltbush	*A. cuneata*	5
Low Rabbitbrush	*Chrysothamnus viscidiflorus*	1
Green Mormon Tea	*Ephedra viridis*	5
Mat Saltbush	*Atriplex corrugata*	5
Winterfat	*Ceratoides lanata*	2
Basin Big Sagebrush	*Artemisia tridentata*	
	var. tridentata	0.25
TOTAL		43.00

The post-mining land use for the Waste Rock Storage Facility is wildlife habitat, primarily deer and elk winter range and livestock grazing. Therefore, the species selected for final revegetation were chosen for that purpose.

The proposed seed mixture and application rates result in approximately 190 seeds per square foot (62 grass, 58 forbs, 70 shrub). The shrub seeding rate results in approximately 3049 stems per acre (based on an establishment rate of 1:1,000).

Final Revegetation Methodology

1. Seedbed Preparation
   Seeding will take place as contemporaneously as practicable following soil placement; therefore, the seedbed will be in a roughened condition suitable for seed application. However, if a surface crust has developed it will be broken up by hand or mechanical tilling to achieve maximum roughness.

2. Seeding
   The proposed seed mixture will be applied at the specified rates on sloping sites by hand broadcasting with "hurricane spreaders" or with a hydroseeder. The seed and water slurry will remain in the hydroseeder no longer than two hours. Seed application on level areas will be completed by the above methods or through drill seeding. If drill seeding is utilized, the application rates of grasses and forbs will be reduced by fifty (50) percent. Seeding will take place during the late part of the fall season and no earlier than October 1.

3. Fertilizer Application
   The fertilizer will be applied by broadcasting or as a separate operation of hydroseeding. Fertilizer application will be determined from soil analysis. The following is an approximate combination and application rate:

Ammonium Nitrate	50 lbs/acre
Triple Superphosphate	75 lbs/acre

4. Seed Covering
   Following hand broadcasting of the seed mixture and fertilizer, and whenever possible on hydroseeded areas, the sites will be hand or mechanically raked to cover the seeds.

5. Mulch Application
   Following hand broadcasting and raking, the seeded slope areas will be covered with an erosion control mulch blanket or hay mulch (2 tons/acre). The blanket will be mechanically anchored per the manufacturers' specifications.

Following hydroseeding, a wood fiber hydromulch with tackifier will be applied at the rate of approximately 2000 lbs/acre.

Following broadcast seeding, alfalfa hay mulch will be applied at the rate of two (2) tons per acre. The mulch will be mechanically crimped into the soil.

All seed and hay mulch will be inspected by a State Department of Agriculture inspector prior to application. Copies of inspection certificates will be submitted to the Division.

R645-301-350 Performance Standards

Construction/reclamation activities will not take place between December 1st and April 15th.

Signs will be placed around the planted slopes for their protection. The area will be entered only to provide maintenance (as needed) and/or monitoring duties.

Standards for successful revegetation include weed species not more than 10% and no noxious weeds. Weed control will not be undertaken unless it is determined necessary due to weed dominance and delayed rate of succession. All noxious weeds will be eradicated either chemically or physically if they become established on the site. Chemical applications will be approved by UDOGM in consultation with the BLM.

Rodent damage on revegetated areas will be assessed during monitoring periods. Species specific control measures will be implemented as necessary. Control measures must be approved by the Division in consultation with the Utah Division of Wildlife Resources prior to application.

Annual monitoring will also include inspection for rills and gullies. Should these be present, they will be filled and the soil reseeded. Rill and gully repair will follow the regulations set forth in the Coal Rules R645-301-357.360 through R645-301-357.365. As repairs are recognized, the Division will be notified and the affected area will be reported in the annual vegetation report.

All vegetation sampling will be undertaken in the late summer for maximum plant growth. The line intercept or ocular estimation methods will be used to measure cover and species composition. The point-center quarter method will be used to measure shrub and tree density.

Productivity measurements will be a double sampling procedure of clipped plots and ocular estimates. Rectangular plots (6.27 in. x 100 in.) will be randomly located in reference areas and revegetation sites. Sampling will be at the 90% confidence level.

The reference area will be checked to detect any change from natural or man-induced activities and to verify they are in fair or better condition. Sampling of the reference sites at the time of bond release will be conducted concurrently with final reclamation sampling, using the same methodology used to sample the reclaimed areas.

The standards for success to be applied for ground cover and production of living plants on the reclaimed areas at the Cottonwood/Wilberg Waste Rock Storage Facility will be at least equal to 90% (with a 90% confidence level) to that of the corresponding reference area at the time of bond release. Cover in the reclaimed areas will not be less than that required to achieve the approved post-mining land use outlined in R645-301-400: Land Use and Air Quality.

At the time of bond release or after the 10 year responsibility period has passed, similarity between the reclaimed area and corresponding reference area will compare life forms and/or species present in each community by the use of similarity indices. Indices of similarity provide the means of mathematically comparing the plant communities in the two areas. One of, or a combination of the three indices found in the Vegetation Guidelines, February 1992, will be used to determine the similarity between the reclaimed and reference area. If another index (or combination thereof) is used, Division approval will be required. Similarity will be considered successful when the index value is at least 70% of the reference area.

All vegetation monitoring data will be reported annually. This report will contain a narrative of the actual monitoring methods used, results, and a discussion of the overall success or failure of each area. Raw data sheets will also be included in the annual reports. Standards attained at the time of bond release will be approved by the Utah Division of Oil, Gas and Mining (UDOGM).

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SCOPE

The following is a report of the vegetation of an area that is proposed for disturbance for a waste rock storage area for Utah Power and Light Mining Division, Emery County, Utah. this area will be called the "Cottonwood/Wilberg Waste Rock Storage Area" in this report. The primary purpose of this report is to supply meaningful and scientific data that will provide accurate standards for future reclamation of the area. Proposed disturbed areas, and reference areas similar to the proposed disturbed areas, were studied on the site. Studies were performed in accordance to the guidelines supplied by the State of Utah, Division of Oil, Gas and Mining (DOGM).

A METHODS section is included in this report to provide the reviewers with all methodologies used to obtain the data. Within the INTRODUCTION of the report, a General Site Description section is provided to give and overview of the site. The RESULTS section specifically describes each proposed disturbed plant community, reference area, and also supplies summaries of data and statistical analyses from ecological sampling. VEGETATION MAPS of each area were also included in this report.

INTRODUCTION

General Site Description

The study site for the proposed disturbed Waste Rock Storage Area was located 1.75 miles south of the Wilberg Mine, Emery County, Utah. Legal descriptions of the study site was: Township 17 South, Range 7 East, Section 34. Elevation of the study site ranged between 6,700 ft. and 7,00 ft. above sea level. Slopes of the study area varied between 3 degrees and 36 degrees and were composed of exposures to the east, west and south.

Soils of the area were derived primarily from Blue Gate Shale, overlain by Emery Sandstone - both members of the Mancos Shale stratigraphic unit. Major plant communities of the general area were typical salt desert shrublands and comprised of communities with the following plant species as dominates and/or subdominates: Pinyon Pine (Pinus edulis), Utah Juniper (Juniperus ostersperma), Mat Saltbush (Atriplex corrugata), Gardner Saltbush (Atriplex gardneri), Shadscale (Atriplex confertifolia), Salina Wildrye (Elymus salinus), and Black Sagebrush (Artemisia nova).

The waste rock storage facility, including the access road, drainage control diversions and sediment pond will occupy approximately 25 acres of land within the following associated vegetation communities:

Pinyon-Juniper	10 acres
Black Sagebrush	4 acres
Gardner Saltbush	11 acres

Proposed Disturbances

The two types of proposed disturbances that have been planned for the area are: a waste rock storage area and an access road to it. The proposed disturbances will primarily impact 3 plant communities. The access road will dissect a Pinyon-Juniper community, whereas, the waste rock storage area disturbance affects Gardner Saltbush and Black Sagebrush/Salina Wildrye plant communities.

Reference Areas

Reference areas to be used a standards for success at the time of final reclamation were selected for each of the proposed disturbances. These areas were chosen to comply with guidelines provided by DOGM and had similar slopes, soils, exposures, species composition, precipitation, elevations and other environmental variables.

Sample Areas

The following vegetation types and reference areas have been sampled and described in this report:

1. Proposed Disturbed Pinyon/Juniper Community
2. Reference Area Pinyon/Juniper Community
3. Proposed Disturbed Gardner Saltbush Community
4. Reference Area for the Gardner Saltbush Community
5. Proposed Disturbed Black Sagebrush/Grass Community
6. Reference Area for the Black Sagebrush/Grass Community

Summarized sampling results and more descriptive material for each of these communities are included in the following pages of this report.

METHODS

Quantitative and qualitative data were taken on and adjacent to proposed disturbed and reference areas of the waste rock site. Sampling was done July 11- July 14, 1989.

Cover and Composition

Bi-directional random and regular placement of sampling plots were designed to provide unbiased accuracy of the data compiled. Sample locations were located at regular intervals along transect lines. Sample plots were then randomly located at various distances right or left of the transect line. The direction (right or left) and distances were determined by random number selection. Cover estimates were made using ocular methods with meter square quadrats. Species composition and relative frequency were also assessed from the quadrats. Additional information recorded on data sheets were: estimated precipitation, slope, exposure, grazing use, animal disturbance and other appropriate notes.

Woody Species Density

Density of woody plant species were recorded using the point quarter distance method (Cottom and Curtis 1956). In this method, random points were placed on the sample sites and measured into four quarters. The distances to the nearest woody plant species were then recorded in each quarter. The average point-to-individual distance was equal to the square root of the mean area per individual.

Productivity and Range Condition

Productivity and Range Condition estimates for the Cottonwood/Wilberg Waste Rock Storage Areas were performed by the U.S. Soil Conservation Service, Price Utah. Copies of these estimates will be supplied by Utah Power & Light, Mining Division. (see Page 7-19)

Reference Areas

Location and selection for the Pinyon/Juniper community reference area was straightforward. This reference area was located adjacent to the proposed disturbed access road and was actually part of the Pinyon/Juniper community to be disturbed. Reference area selection for remaining proposed disturbance communities, Gardner Saltbush and Black Sagebrush, were not so obvious. These proposed disturbed communities, with their relatively small areas, lie within an atypical depression that will be used as the waste rock area. This depression will be virtually entirely filled with waste rock, leaving almost no portion of the area with identical topography (slope, elevation, exposure, species composition, etc.) for reference areas. Identical plant communities of the proposed disturbance area were difficult to locate in the immediate area, including adjacent canyons i.e. Cottonwood and Huntington Canyons. We therefore selected sites that most closely approximated these communities and were within or near the permit area (see vegetation map for locations).

Selection of these references areas were approved by DOGM (personal communications, B.A. Stettler, July 13, 1989). Justification for the selection for these references were as follows. Firstly, they were the communities that most closely simulate the communities to be disturbed when compared to all other locations observed. Secondly, it may be possible to use the reference area for the Black Sagebrush (or Pinyon/Juniper community) for the Gardner Saltbush community standards at the time of final reclamation because the slopes, elevations and general physiognomy of the area will be changed during mining operations. It is possible that other native plant communities may be more suitable for final reclamation. We have, however, selected reference areas similar to each of those areas to be disturbed. Yet it does leave the possible option of substituting more suitable reference areas at the time of future reclamation if the regulatory agency and operator agree to those terms.

Threatened and Endangered Species

The areas were surveyed on a grid-type system for threatened and endangered plant species. Voucher specimens for many on the species will be filed at the Brigham Young University herbarium. Plant nomenclature follows Welch et al. (1987).

Sample Adequacy and Group Comparison Tests

Sampling adequacy for cover and woody species density was achieved using formulas from Snedocor and Cochran (1980), insuring that 80% of the samples were within 10% of the true mean for the shrub communities of the area. On areas where sample adequacy was not met, the maximum sample size required by DOGM was achieved. Student's t-tests were also employed to compare the proposed disturbance and reference areas of all sites for cover and woody plant species density. Jaccard's Community Coefficient's were used to make species composition comparisons. This was done by listing the species that occurred in the sampling quadrats only (cover and density) and from these, compiling common species lists. All sample means, standard deviations, and sample sizes were included in this report to enable the reviewers to apply further statistical tests if desired.

Vegetation Mapping

Vegetation mapping was done by walking the area and using aerial photos and contour maps. Sampling locations are also shown on these maps.

RESULTS

Proposed Disturbed Pinyon/Juniper Community

The proposed disturbed access road for the waste rock storage area was located within a Pinyon/Juniper plant community. The general slope of the area was 3 degrees with an exposure to the south. The community was composed of 90.26% trees and shrubs (Table 1). Dominant plant species in this community were Pinyon Pine (Pinus edulis), Utah Juniper (Juniperus osteosperma) and Mountain Mahogany (Cercocarpus montanus).

Woody plant species density was 804 individuals per acre (Table 3). Mean total living cover was estimated at 33.45% (Table 1). For a list of species with their relative cover, frequency and composition, refer to Table 2.

Pinyon/Juniper Reference Area

The reference area for the Pinyon/Juniper community was located adjacent to the proposed disturbed community. Its slope and exposure was virtually identical to that community. Reference area sample results show the composition to be 77.21% woody species, 15.29% forbs and 0.00% grasses (Table 4). The dominate species were also Pinyon Pine, Utah Juniper and Mountain Mahogany. Mean total living cover was estimated at 34.08% (Table 4). Woody species density was 776 individuals per acre (Table 6). For a list of the cover and frequency data by species refer, to Table 5.

Proposed Disturbed Gardner Saltbush

A erosional depression with steep slopes and generally level bottomlands formed the proposed waste rock storage area. Gardner Saltbush communities dominated the slopes of the depression. There were a variety of exposures due to the erosional patterns of the area. The transects were placed to dissect this area and include exposure differences to most accurately predict the average cover and species composition. The mean slope of the community was about 25 degrees. The dominate plant species was Gardner Saltbush (Atriplex gardneri), that comprised 93% of the total living cover. Mean total living cover was 24.55% (Table 7). Total density of the area was 5,556 woody plants per acre (Table 9). For a list of species with their relative cover and frequency, refer to Table 8.

Gardner Saltbush Community Reference Area

The community that most closely simulated the proposed disturbed community was also adjacent to the area (refer to the METHODS section for procedures used to select this area for a reference site). The slope of the area was 36 degrees with an eastern exposure. The total living cover was 25.13% (Table 10), and composed of virtually 100% Gardner Saltbush (Table 11). Density of the area was estimated at 4,928 individuals per acre (Table 12).

Black Sagebrush/Grass Community

A Black Sagebrush community exists at the base of the slopes of the depression proposed to be used for the waste rock storage area. The slope of this community was estimated at 3 degrees. Mean total living cover of this community was estimated as 25.25%, with 66.63%

shrubs, 2.88% forbs, and 30.49% grasses (Table 13). Dominate species (Table 14) were Black Sagebrush (Artemisia nova) and Salina Wildrye (Elymus salinus). For a summation of cover by species, refer to Table 14. Density of woody species was estimated at 4,519 individuals per acre (Table 15).

Black Sagebrush/Grass Community Reference Area

A similar community was located approximately 1/4 mile east of the proposed disturbed area (refer to vegetation map). The slope of this area was also approximately 3 degrees with an exposure to the south. The Black Sagebrush Community had a mean total cover of 24.38%, with the same dominate species as the proposed disturbed community, but a slightly different list of component species (refer to the METHODS section for procedures used to select this area for a reference site). For a list of these data, refer to Tables 19-21.

Statistical Analyses

Statistical analyses were employed to compare each proposed disturbed plant with its respective reference area (Tables 19-21). Jaccard's Similarity Coefficients showed the Pinyon/Juniper community to be 74%, the Gardner Saltbush community to be 20%, and the Black Sagebrush/Grass community 64% similar to their reference areas. As described in the METHODS section of this report, the species used for these analyses were composed only of species encountered in the quadrats. If general species lists were compiled and used in the similarity equations, the percent of similarities would undoubtedly been much higher.

When group comparison tests were performed on each of the plant communities, no significant differences were observed between proposed disturbed areas and their reference areas for either cover or density (Tables 19-21).

Threatened and Endangered Plant Species

No threatened or endangered plant species were found during the course of the study. As mentioned previously, voucher specimens will be donated to the herbarium at Brigham Young University.

TABLE 1: Total cover and composition summary for the proposed disturbed Pinyon-Juniper Community for the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover and composition with standard deviations and sample sizes.

TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZES
Total Living Cover*	33.45	23.15	40
Litter	20.13	14.64	40
Bareground	22.25	18.99	40
Rock	24.18	24.46	40
COMPOSITION			
Trees/Shrubs	90.26	22.46	40
Forbs	7.24	17.23	40
Grasses	0.00	0.00	40

* Sample size insures 80% accuracy within 10% of the true mean or maximum samples suggested by the State of Utah, Division of Oil, Gas and Mining.

TABLE 2: Species cover and frequency summary for the proposed disturbed Pinyon-Juniper Community of the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover, standard deviation, sample size and relative frequency by species.

SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
TREES & SHRUBS				
Cercocarpus montanus	3.25	13.99	40	7.50
Ephedra viridus	1.08	2.71	40	15.00
Juniperus osteosperma	6.75	13.00	40	35.00
Opuntia polyacantha	0.13	0.78	40	2.50
Pinus edulis	19.35	24.85	40	50.00
Yucca harrimaniae	1.93	5.02	40	17.50
FORBS				
Cryptantha humilis	0.88	1.58	40	35.00
Erigeron sp.	0.03	0.16	40	2.50
Penstemon mucronatus	0.08	0.26	40	7.50
GRASSES				

TABLE 3: Woody species densities of the proposed disturbed Pinyon-Juniper Community of the Cottonwood/Wilberg Waste Rock Site.

	NUMBER/ACRE*
Artemisia nova	40.19
Cercocarpus montanus	40.19
Ephedra viridus	194.24
Juniperus osteosperma	147.35
Pinus edulis	207.64
Opuntia polyacantha	66.98
Rhus trilobata	6.70
Yucca harrimaniae	100.47
TOTAL	803.76

* Sample size was 30 (n=30) and insured that 80% accuracy within 10% of the true mean.

TABLE 4: Total cover and composition summary for the Pinyon-Juniper Community Reference Area for the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover and composition with standard deviations and sample sizes.

TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZES
Total Living Cover*	34.08	30.91	40
Litter	15.58	11.88	40
Bareground	20.63	20.97	40
Rock	29.73	24.61	40
COMPOSITION			
Trees/Shrubs	77.21	39.40	40
Forbs	15.29	32.98	40
Grasses	0.00	0.00	40

* Sample size insures 80% accuracy within 10% of the true mean or maximum samples suggested by the State of Utah, Division of Oil, Gas and Mining.

TABLE 5: Species cover and frequency summary for the Pinyon-Juniper Community Reference Area of the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover, standard deviation, sample size and relative frequency by species.

SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
TREES & SHRUBS				
Artemisia nova	0.28	1.43	40	5.00
Cercocarpus montanus	2.58	7.70	40	10.00
Ephedra viridus	1.43	5.58	40	7.50
Eriogonum sp.	0.20	0.46	40	17.50
Juniperus osteosperma	12.68	29.05	40	20.00
Opuntia polyacantha	0.25	1.56	40	2.50
Pinus edulis	14.45	24.69	40	37.50
Yucca harrimaniae	0.75	3.96	40	5.00
FORBS				
Cryptantha humilis	1.33	2.84	40	20.00
Penstemon mucronatus	0.15	0.65	40	7.50
GRASSES				

TABLE 6: Woody species densities for the Pinyon-Juniper Community Reference Area of the Cottonwood/Wilberg Waste Rock Site.

	NUMBER/ACRE*
Artemisia nova	25.87
Cercocarpus montanus	97.01
Ephedra viridus	161.61
Juniperus osteosperma	148.74
Pinus edulis	239.29
Opuntia polyacantha	45.27
Yucca harrimaniae	58.20
TOTAL	775.99

* Sample size was 30 (n=30) and insured that 80% accuracy within 10% of the true mean.

TABLE 7: Total cover and composition summary for the proposed disturbed Gardner Saltbush Community for the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover and composition with standard deviations and sample sizes.

TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZES
Total Living Cover*	24.55	9.29	40
Litter	5.28	2.29	40
Bareground	64.15	18.27	40
Rock	6.15	12.91	40
COMPOSITION			
Trees/Shrubs	95.45	12.37	40
Forbs	0.31	1.95	40
Grasses	4.24	12.32	40

* Sample size insures 80% accuracy within 10% of the true mean or maximum samples suggested by the State of Utah, Division of Oil, Gas and Mining.

TABLE 8: Species cover and frequency summary for the proposed disturbed Gardner Saltbush Community of the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover, standard deviation, sample size and relative frequency by species.

SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
TREES & SHRUBS				
Artemisia nova	0.43	2.65	40	2.50
Atriplex corrugata	0.13	0.78	40	2.50
Atriplex gardneri	22.83	9.17	40	100.00
FORBS				
Stanleya pinnata	0.13	0.78	40	2.50
GRASSES				
Elymus salinus	1.05	3.08	40	12.50

TABLE 9: Woody species densities of the proposed disturbed Gardner Saltbush Community of the Cottonwood/Wilberg Waste Rock Site.

	NUMBER/ACRE*
Artemisia nova	46.30
Atriplex gardneri	5,509.82
TOTAL	5,556.12

* Sample size was 36 (n=36) and insured that 80% accuracy within 10% of the true mean.

TABLE 10: Total cover and composition summary for the Gardner Saltbush Community Reference Area for the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover and composition with standard deviations and sample sizes.

TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZES
Total Living Cover*	25.13	9.65	40
Litter	7.75	4.18	40
Bareground	66.63	10.15	40
Rock	0.50	1.87	40
COMPOSITION			
Trees/Shrubs	100.00	0.00	40
Forbs	0.00	0.00	40
Grasses	0.00	0.00	40

* Sample size insures 80% accuracy within 10% of the true mean or maximum samples suggested by the State of Utah, Division of Oil, Gas and Mining.

TABLE 11: Species cover and frequency summary for the Gardner Saltbush Community Reference Area of the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover, standard deviation, sample size and relative frequency by species.

SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
TREES & SHRUBS				
Atriplex gardneri	25.13	9.65	40	100.00
FORBS				
GRASSES				

TABLE 12: Woody species densities for the Gardner Saltbush Community Reference Area of the Cottonwood/Wilberg Waste Rock Site.

	NUMBER/ACRE*
Atriplex gardneri	4,927.60

TOTAL	4,927.60

* Sample size was 36 (n=36) and insured that 80% accuracy within 10% of the true mean.

TABLE 13: Total cover and composition summary for the proposed disturbed Black Sagebrush/Grass Community for the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover and composition with standard deviations and sample sizes.

TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZES
Total Living Cover*	25.25	10.95	40
Litter	6.50	3.57	40
Bareground	53.10	19.07	40
Rock	15.15	14.70	40
COMPOSITION			
Trees/Shrubs	66.63	22.21	40
Forbs	2.88	11.35	40
Grasses	30.49	19.39	40

* Sample size insures 80% accuracy within 10% of the true mean or maximum samples suggested by the State of Utah, Division of Oil, Gas and Mining.

TABLE 14: Species cover and frequency summary for the proposed disturbed Black Sagebrush/Grass Community of the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover, standard deviation, sample size and relative frequency by species.

SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
TREES & SHRUBS				
Artemisia nova	10.90	7.36	40	95.00
Atriplex confertifolia	1.88	3.32	40	30.00
Atriplex gardneri	1.63	6.06	40	10.00
Chrysothamnus nauseosus	0.13	0.78	40	2.50
Chrysothamnus viscidiflorus	0.35	1.17	40	10.00
Eriogonum corymbosum	0.63	2.33	40	7.50
Juniperus osteosperma	1.88	10.94	40	5.00
FORBS				
Eriogonum sp.	0.68	3.30	40	10.00
GRASSES				
Elymus salinus	7.08	4.76	40	85.00
Stipa hymenoides	0.13	0.78	40	2.50

TABLE 15: Woody species densities of the proposed disturbed Black Sagebrush/Grass Community of the Cottonwood/Wilberg Waste Rock Site.

	NUMBER/ACRE*
Artemisia nova	3,012.45
Atriplex confertifolia	1,066.91
Atriplex gardneri	156.90
Chrysothamnus viscidiflorus	31.38
Eriogonum corymbosum	156.90
Juniperus osterosperma	31.38
Opuntia polyacantha	31.38
Sclerocactus whipplei	31.38
TOTAL	4,518,68

* Sample size was 36 (n=36) and insured that 80% accuracy within 10% of the true mean.

TABLE 16: Total cover and composition summary for the Black Sagebrush/Grass Community Reference Area for the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover and composition with standard deviations and sample sizes.

TOTAL COVER	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZES
Total Living Cover*	24.38	9.95	40
Litter	5.48	2.41	40
Bareground	55.60	15.10	40
Rock	14.55	12.49	40
COMPOSITION			
Trees/Shrubs	81.24	21.05	40
Forbs	0.00	0.00	40
Grasses	16.26	16.75	40

* Sample size insures 80% accuracy within 10% of the true mean or maximum samples suggested by the State of Utah, Division of Oil, Gas and Mining.

TABLE 17: Species cover and frequency summary for the Black Sagebrush/Grass Community Reference Area of the Cottonwood/Wilberg Waste Rock Site. The table shows the mean percent cover, standard deviation, sample size and relative frequency by species.

SPECIES	% MEAN COVER	STANDARD DEVIATION	SAMPLE SIZE	RELATIVE FREQUENCY
TREES & SHRUBS				
Artemisia nova	17.53	7.97	40	95.00
Atriplex confertifolia	0.18	0.83	40	5.00
Chrysothamnus viscidiflorus	0.13	0.78	40	2.50
Echinocereus triglochidiatus	1.08	2.93	40	12.50
Juniperus osteosperma	0.63	2.29	40	7.50
Opuntia polyacantha	0.18	0.83	40	5.00
Sclerocactus whipplei	0.05	0.31	40	2.50
FORBS				
GRASSES				
Elymus salinus	3.00	5.79	40	30.00
Stipa hymenoides	1.63	2.77	40	30.00

TABLE 18: Woody species densities for the Black Sagebrush/Grass Community Reference Area of the Cottonwood/Wilberg Waste Rock Site.

	NUMBER/ACRE*
Artemisia nova	4,521.91
Atriplex confertifolia	51.98
Chrysothamnus viscidiflorus	51.98
Echinocereus triglochidiatus	51.98
Juniperus osterosperma	207.90
Pinus edulis	103.95
TOTAL	4,989.70

* Sample size was 24 (n=24) and insured that 80% accuracy within 10% of the true mean.

TABLE 19. Statistical summary sheet for the proposed disturbed and reference areas of the Pinyon-Juniper communities of the Cottonwood/Wilberg Waste Rock Site.

PROPOSED DISTURBED

Total Living Cover	x = 33.45 s = 23.15 n = 40 NMin = 78.47
Density	x = 82.99* s = 30.90 n = 30 NMin = 22.71
Aspect	South
Slope	3 deg.

REFERENCE AREA

Total Living Cover	x = 34.08 s = 30.91 n = 40 NMin = 134.78
Density	x = 87.85* s = 29.16 n = 24 NMin = 18.05
Aspect	South
Slope	3 deg.

Jaccard's Similarity Coefficient = 75.00%

Student's t-value (cover) = -0.103
Degrees of freedom = 78
Significance level = Nonsignificant

Student's t-value (density) = - 0.609
Degrees of freedom = 62
Significance level = Nonsignificant

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x = sample mean, s = sample standard deviation,
n = sample size, NMin = Minimum sample size for statistical adequacy,
p = significance level, N.S. = nonsignificant, * average distance in inches at each sample location.

TABLE 20. Statistical summary sheet for the proposed disturbed and reference areas of the Gardner Saltbush communities of the Cottonwood/Wilberg Waste Rock Site.

PROPOSED DISTURBED	
Total Living Cover	x = 24.55 s = 9.29 n = 40 NMin = 23.46
Density	x = 30.83* s = 13.46 n = 36 NMin = 31.23
Aspect	East & West
Slope	25 deg.
REFERENCE AREA	
Total Living Cover	x = 25.13 s = 9.65 n = 40 NMin = 24.16
Density	x = 33.69* s = 11.93 n = 36 NMin = 20.54
Aspect	East
Slope	36 deg.

Jaccard's Similarity Coefficient = 20.00%

Student's t-value (cover) = - 0.274
Degrees of freedom = 78
Significance level = Nonsignificant

Student's t-value (density) = - 0.954
Degrees of freedom = 70
Significance level = Nonsignificant

x = sample mean, s = sample standard deviation,
n = sample size, NMin = Minimum sample size for statistical adequacy,
p = significance level, N.S. = nonsignificant, * average distance in inches at each sample location.

TABLE 21. Statistical summary sheet for the proposed disturbed and reference areas of the Black Sagebrush/Grass communities of the Cottonwood/Wilberg Waste Rock Site.

PROPOSED DISTURBED

Total Living Cover	x = 25.25 s = 10.95 n = 40 NMin = 30.81
Density	x = 34.12* s = 15.18 n = 36 NMin = 32.43
Aspect	South
Slope	3 deg.

REFERENCE AREA

Total Living Cover	x = 24.38 s = 9.95 n = 40 NMin = 27.29
Density	x = 34.48* s = 8.49 n = 24 NMin = 9.93
Aspect	South
Slope	3 deg.

Jaccard's Similarity Coefficient = 64.29%

Student's t-value (cover) = 0.372
Degrees of freedom = 78
Significance level = Nonsignificant

Student's t-value (density) = - 0.106
Degrees of freedom = 58
Significance level = Nonsignificant

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x = sample mean, s = sample standard deviation,
n = sample size, NMin = Minimum sample size for statistical adequacy,
p = significance level, N.S. = nonsignificant, * average distance in inches at each sample location.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

350 North 4th East Price, Utah 84501

SUBJECT Information on Waste Rock Sites - Cottonwood Wilberg DATE: January 25, 1990

TO: Val Payne
Utah Power & Light
P.O. Box 310
Huntington, Utah 84528

Dear Mr. Payne:

Below is the information on the new waste rock sites - Cottonwood Wilberg:

Sites That Match The Soils:

Strych very stony loam dry - 3-30% slope, which is the Ustollic Calciorthid

Vegetative Type	Ecological Condition	Present Production	Potential Production
Pinyon-Juniper (Waste rock Ref.)	Fair	400 lbs/ac	1200 lbs/ac

Lithic Ustic Torriorthents - 0-5% slopes

Black Sage (Waste rock Ref.)	Faie	250 lbs/ac	500 lbs/ac
Black Sage (Waste rock)	Fair	300 lbs/ac	500 lbs/ac

Lithic Ustic Torriorthents - 5-30% slopes

Saltbrush (Waste rock Ref.)	Good	125 lbs/ac	150 lbs/ac

George S Cook

George S. Cook
Range Conservationist
Soil Conservation Service
Price, Utah

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R645-301-400: Land Use and Air Quality

R645-301-410 Land Use

This chapter includes the general requirements to meet the State of Utah's regulatory requirements to conduct coal mining and reclamation operations at the Cottonwood/Wilberg Waste Rock Storage Facility and operate these facilities in Grimes Wash as part of the Cottonwood/Wilberg Mine and Trail Mountain Mine refuse disposal site. This application includes descriptions of the premining and proposed postmining land uses.

The post mining land uses for the area, based on the BLM Land Resource Management Plan and Emery County Zoning regulations, are wildlife habitat and livestock grazing.

R645-301-411 Environmental Description

The site for the proposed disturbed area of the Waste Rock Storage Facility is located 1.75 miles south of the Cottonwood/Wilberg Mine, Emery County, Utah. The legal description of the site is: Township 17 South, Range 7 East, Section 34. Elevation of the site range between 6,700 ft. and 7,000 ft. above sea level. The slopes are varied between 3 degrees and 36 degrees and are composed of exposures to the east, west and south.

The Cottonwood/Wilberg Waste Rock Storage Facility occupies approximately 25 acres of public land administered by the U.S. Department of the Interior, Bureau of Land Management. It is located in the San Rafael Resource Area of the Moab District, within BLM ecological sites described as follows:

Semi-desert shallow loam

The vegetation associated with the semi-desert shallow loam site consists of Utah juniper and pinyon-pine overstory with black sagebrush and Salina wildrye understory. Slopes range from 15 to 50 percent and vegetative production (air-dry) is poor (100 to 250 pounds/ac.)

Semi-desert stony loam

The vegetation associated with the semi-desert stony loam site consists of Utah juniper and pinyon-pine overstory with black sagebrush and Salina wildrye understory. This site occurs on fan terraces and fan remnants with an average slope of 15 to 50 percent. Vegetative production (air-dry) is from 350 to 700 pounds/ac due to the presence of pinyon and juniper.

Mining has not previously taken place within the Cottonwood/Wilberg Waste Rock Storage

Facility.

The general area is classified by the BLM as Deer Winter Habitat and Crucial Deer Winter Habitat. UDWR classifies the area as Critical Deer Winter Range (Southeast Manti Herd) and Limited-value Elk Winter Range (see Plate 9-1). Further discussion of the wildlife habitat associated with the site can be found in R645-301-300 Biology.

The Waste Rock Storage Facility is located within the West Grimes livestock grazing allotment (754 acres). This allotment is grazed from April 1 to June 10 each year. A total of 477 animal use months (AMU's) are allotted to the West Grimes Wash allotment; however, only 295 AUM's are active.

The mitigation/enhancement measures conducted for the disturbed wildlife habitat (R645-301-300 Biology) will be effective to offset the impacts resulting from the 3 percent (25acres/754 acres) reduction in the livestock grazing allotment. As stated in the Draft RMP/EIS (page 3-20), "…a greater number of water sources are in demand (within the resource area), particularly for wildlife and livestock. More water sources could help redistribute livestock and wildlife and assist in range management."

Section 34 is part of Oil and Gas Lease U-56024 held by Estelle H. Yates. An abandoned well exists approximately 1800 feet northeast of the waste rock facility. The facility will not negatively impact the oil and gas lease.

R645-301-411.130 Land Use Classifications

The area surrounding the Waste Rock Storage Facility is listed as Class IV in the BLM's Visual Resource Management (VRM) classification system. Class IV is described as follows:

"The objective of this class is to provide for management activities that require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements."

The location, design, construction, and operation of the facility are consistent with this VRM class.

The Waste Rock Storage Facility is also located within the Roaded Natural Class according to the BLM Recreation Opportunity Spectrum (ROS) classification. The setting opportunity within the Roaded Natural Class is described as follows:

> "Area is characterized by a generally natural environment with moderate evidence of the sights and sounds of man. Resources modification and utilization practices are evident, but harmonize with the natural environment."

The location, design, construction, and operation of the Waste Rock Storage Facility are compatible with the Roaded Natural ROS class.

R645-301-411.140 Cultural and Historic Resources Information

Archeological-Environmental Research Corporation (AERC) prepared a report in 1987 called "Cultural Resource Evaluation of Potential Subsidence and Escarpment Failure Areas in the East Mountain Locality of Emery County (Project UPL-87-6)". This report was amended in 1989 to include the Cottonwood/Wilberg Waste Rock Storage Facility. AERC prepared and addendum to the 1987 report as a statement that an intensive archeological evaluation was conducted of the proposed waste rock disposal and access road areas. It was reported that no cultural resource sites or isolated cultural material were observed during the evaluation. Refer to this addendum in Appendix A.

R645-301-412 Reclamation Plan

In areas where surface disturbances result from coal mining and reclamation operations, regrading and revegetation will be conducted to restore the areas to their premining conditions which they were capable of supporting prior to mining. Because such a small surface disturbance is planned for the Cottonwood/Wilberg Waste Rock Storage Facility, little or no effect to the past or future land use is anticipated. The land will be reclaimed to the original land use practices of grazing and wildlife habitats.

A detailed reclamation plan has been developed for the Cottonwood/Wilberg Waste Rock Storage Facility and is included in Section R645-301-200 through R645-301-700 of this volume.

R645-301-412.300 Suitability and Compatibility

The reclamation soil sampling will identify any soil that is not suitable. All unsuitable soils will be placed at least 4 feet below the final grade surface. This will ensure suitable growth material for vegetation. All fills will be graded at slopes compatible with the surrounding areas.

R645-301-413 Performance Standards

All disturbed areas will be restored in a timely manner to conditions they were capable of supporting before mining. Liability will be for the duration of the coal mining and reclamation operations and for the period of extended responsibility for achieving successful revegetation. All post mining land use criteria will be satisfied before the bond is fully released.

R645-301-420 Air Quality

Air pollution control measures are described in the Approval Order DAQE-835-91 issued by the Division of Air Quality. This order has conditions that the operator must comply with to control fugitive dust emissions, quantity of refuse hauled, maintenance to road to control fugitive dust emissions, etc. Those emissions will be controlled by typical dust suppressant measures. The Division of Air Quality requires that the Approval Order be in place and complied with by the operator for the life of the facility's operation. Periodic inspections, by the Division of Air Quality, are conducted at the site to verify compliance. This air quality Approval Order is filed at the Energy West Mining offices in Huntington, Utah.

R645-301-421 Clean Air Act

Coal mining and reclamation operations will be conducted in compliance with the requirements of the Clean Air Act (42 U.S.C. Sec. 7401 et seq.) and any other applicable Utah or federal statutes and regulations containing air quality standards.

R645-301-422 Utah division of Air Quality

The operator has coordinated compliance efforts with the State of Utah, Division of Air Quality. The current Approval Order (AO) issued to the operator is DAQE-895-91 and is dated December 16, 1991.

ARCHEOLOGICAL - ENVIRONMENTAL
RESEARCH CORPORATION

P.O. Box 853 Bountiful, Utah 84010
Tel: (801) 292-7061, 292-9668

August 7, 1989

Subject: ADDENDUM REPORT TO "Cultural Resource Evaluation of Potential Subsidence and Escarpment Failure Areas in the East Mountain Locality of Emery County, Utah" dated November 16, 1987 (AERC Project UPL-87-6, Utah State Project No. 87-AF-739b)

To: Mr. Val Payne, Utah Power & Light Company, P.O. Box 1005, Huntington, Utah 84528

Info: Utah State Preservation Office, Division of State History, 300 Rio Grande, Salt Lake City, Utah 84101

In April, 1987, during the evaluations conducted for Utah Power & Light Company relative to the referenced report, F. Richard Hauck of AERC accompanied Mr. Val Payne to a possible waste rock disposal site adjacent to Grimes Creek. Mr. Payne was uncertain at the time whether the site would be needed by Utah Power & Light Company and requested that a report on the archaeological evaluations of the location be differed to a future date.

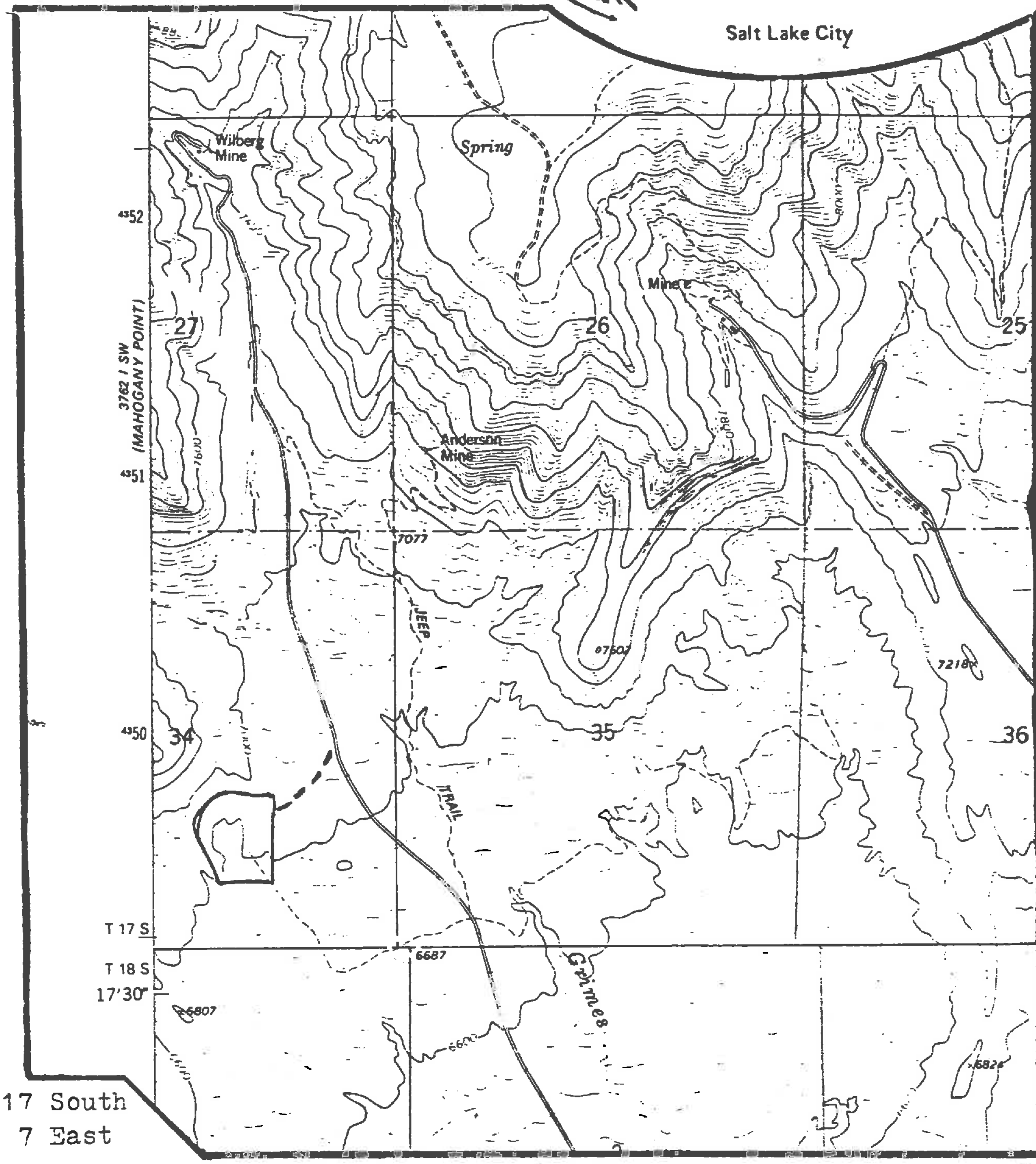
This addendum to the 1987 report is prepared as a statement that an intensive archaeological evaluation was conducted by AERC of the waste rock disposal location and access route as shown in the attached map. No cultural resource sites or isolated cultural material were observed during the evaluation.

AERC recommends that a cultural resource clearance for the development and use of this site be granted to Utah Power & Light Company based upon adherence to the standard stipulations.

F. Richard Hauck, Ph.D.
President

ARCHEOLOGICAL-ENVIRONMENTAL RESEARCH CORPORATION

Salt Lake City



T. 17 South

R. 7 East

Meridian: Salt Lake B. & M.

Project: UPL-87-6

Series: Central Utah

Date: 11-16-87

MAP 3A
Cultural Resource Survey of Potential Disturbance Areas in the East Mountain Locality of Emery County

Quad: Red Point, Utah 7.5 minute-USGS

Legend:

Waste Rock Disposal Site

Access Route

2.64" = 1 mile
Scale

Cultural Resources Stipulations

1. All Vehicular traffic, personnel movement, and construction should be confined to the locations examined as referenced in this report, and to the existing roadways and/or evaluated access routes.

2. All personnel should refrain from collecting artifacts and from disturbing any cultural resources in the area.

3. The authorized official should be consulted should cultural remains from subsurface deposits be exposed during construction work or if the need arises to relocate or otherwise alter the location of the construction area.

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R645-301-500: Engineering

During the operation of the Cottonwood/Wilber and Trail Mountain mines, certain waste products are generated that are not part of the coal product, they include; underground development waste, trommel screen reject, and sediment from the pond and drainages. The fill of the disposal site will comprise of these materials that will be permanently stored within the Cottonwood/Wilberg Waste Rock Storage Facility. This chapter includes the general requirements to meet the State of Utah's regulatory requirements to conduct coal mining and reclamation operations at the Cottonwood/Wilberg Waste Rock Storage Facility and operate these facilities in Grimes Wash as part of the Cottonwood/Wilberg Mine and Trail Mountain Mine refuse disposal site. This application includes descriptions of the Engineering design, operation, and reclamation of the waste rock site and access road area.

R645-301-510 Introduction

The original Cottonwood/Wilberg Waste Rock Storage Area is located south and east of highway 57. This site was filled to its capacity in 1989 (Phase III Bond Release of the original site was granted in July of 2009) making it necessary to construct a new facility to handle the disposal needs of the mine. Calculations have been made, based on past history, the rate and amount of waste rock generated during mining operations, these quantities have been used to formulate the design of a new facility.

The area selected for the Waste Rock Storage Facility is located on public land managed by the US Department of Interior, Bureau of Land Management. The facility is located in the southeast quarter of Section 34, Township 17 South, Range 7 East, west of Highway 57 and used in support of the mining operations. The area was selected because it is close to the mine facilities and has the required capacity to contain all the waste rock generated at the Cottonwood/Wilberg, Des Bee Dove, and Trial Mountain mines for the anticipated life of each mine. Final reclamation has been conducted on the Des Bee Dove mine facilities. These activities were completed in 2006.

R645-301-511 General Requirements

This application includes descriptions of the Waste Rock Storage Facility's operation which includes maps, cross-sections, and plans for its operation and reclamation of the site.

R645-301-512. 100 Cross-Sections and Maps

Maps and cross-sections detailing environmental resources of the area and plans for construction of the site are included in the Maps Section of this Chapter. All design maps and cross-sections have been certified by a qualified, registered professional engineer.

R645-301-512.230 Coal Mine Waste

The professional engineer experienced in the design in the design of similar earth and waste structures has certified the design of the disposal facility according to R645-301-536.

R645-301-512.250 Primary Roads

A primary access road has been planned for entrance into the Waste Rock Storage Facility. The professional engineer has certified the design and construction of the road as meeting the requirements of R645-301-534.200 and R645-301-742.420.

R645-301-514 Inspections

The storage pile will be inspected for stability by a qualified, registered professional engineer at least quarterly and during the following critical construction periods and throughout its operation:

1. Removal of all organic material and topsoil
2. Installation of surface drainage system
3. Construction of soil stockpiles
4. Revegetation
5. Placement and compaction of fill material

The report will be submitted in writing to the Division within the subsequent quarter following the inspection. A copy of the inspection report will be maintained at the Energy West Mining Office for inspection by interested parties.

R645-301-520 Operation Plan

R645-301-521 General

The area selected for the Waste Rock Storage Facility is located on public land managed by the US Department of Interior, Bureau of Land Management. The area is located in the southeast quarter of Section 34, Township 17 South, Range 7 East, west of the coal haul road used for the Cottonwood/Wilberg Coal Mine facility. The area was selected because it is close to the mine facilities and has the required capacity to contain all the waste rock generated at both the Cottonwood/Wilberg, Des Bee Dove and Trial Mountain mines for the anticipated life of each mine. Refer to Plates 1-1, 1-2, and 4-1 for Coal Lease and Ownership map, Surface Ownership map, and Right of Way and Permit Boundary map, respectively

R645-301-521.200 Signs and Markers

Signs and markers will be made of durable material, such as thin sheet metal, and will be maintained during the conduct of all activities to which they pertain or until bond release. Each type of sign and marker will be of uniform design and shape and will be located so as to be easily seen and read.

Perimeter and topsoil markers will be approximately 10" x 14", post mounted and read "Perimeter Do Not Disturb, or Topsoil" respectively.

No stream buffer zone markers are required as there are no streams adjacent to the permit area.

On the day in which blasting occurs, a portable sign which says "Warning: Explosives in Use" will be displayed near the entrance sign.

R645-301-521.240 Mine and Permit Identification Signs

A Waste Rock Storage Facility permit identification sign will be placed at each point of access from public roads to areas of surface operations within the permit area. The sign will state the facility's name, owner/operator address and phone number, Utah Reclamation Permit No., MSHA ID NO., and UPDES Permit No.. The sign size will be approximately 40" wide by 18" high.

Upon cessation of operations or bond release, signs and markers will be removed as appropriate.

R645-301-524 Blasting and Explosives

All blasting operations will be conducted by persons who have been trained, examined and certified as provided by 30 CFR 850 and applicable regulations of the State Industrial Commission. No resident or owner of a dwelling or structure is located within one-half mile of where surface blasting activity will occur.

All blasting will be conducted between sunrise and sunset. Warning and all-clear signals will be given before and after blasting. Access to the area possibly subject to fly rock from blasting shall be regulated. Access to the area shall be blocked until an authorized representative has determined that after blasting no unusual circumstances exist and that access to and travel in or through the area can be safely resumed.

Records of blasting will be kept on file at the PacifiCorp - Energy West Mining office in Huntington. The records shall contain the following:

- Name of Operator - PacifiCorp: Energy West Mining Company
- Location - Cottonwood/Wilberg Waste Rock Site - date and time of blast
- Name, signature and license number of blaster-in-charge
- Direction and distance to nearest structure
- Temperature, wind directions and approximate velocity
- Type of material blasted
- Number of holes, burden and spacing
- Diameter and depth of holes
- Types of explosives used
- Maximum weight of explosives detonated within any 8-millisecond period
- Maximum number of holes detonated within any 8-millisecond period
- Initiation system
- Type and length of stemming
- If applicable - mats or other protection used
- Type of delay detonator and delay periods used
- Sketch of delay pattern
- Number of persons in blasting crew

R645-301-526 Mine Facilities

This section includes the design and operational plans for the facilities that make up the Cottonwood/Wilberg Waste Rock Storage Facility. These facilities include the access road, refuse pile, and sediment pond.

Access Road Design

The access road begins at the intersection with State Road 57 and extends in a southwesterly direction for 1435 feet to the northeast corner of the Waste Rock Storage Facility. The road is constructed through an area dominated by pinyon-juniper vegetation with several natural ephemeral stream channels. The road is used by trucks carrying waste rock materials from Cottonwood/Wilberg, and Trail Mountain mines for disposal in the Cottonwood/Wilberg Waste Rock Storage Facility.

The road is located in Section 34, Township 17 South, Range 7 East, SLBM, on public lands managed by the US Department of the Interior, Bureau of Land Management. The total area disturbed by the road and road construction activities consists of 2.6 acres. Refer to Plate 4-1.

The horizontal and vertical alignment, the cuts and fills and the drainage structures have been designed and located to conform to the existing topography. The overall grade of the road is less than 1.8% with a maximum pitch grade of 3.4%. The road cross-section has a 28 foot wide graveled surface of 6" depth sloped at 1% toward the roadside drainage ditches. Roadside drainage has been constructed to carry road drainage to the cross culverts. Embankment sections have out slopes built on a 1V:1.5H. Cut sections are built on a 1V:1.5H in unconsolidated areas. A locked gate is located at the beginning of the access road, station 2+20, to the Waste Rock Storage Facility. A typical road cross-section is shown in Exhibit I.

All foundations for embankments shall be free from organic material and topsoil. The top layer of the ground underlying the roadway embankment was moistened and scarified to a depth of 6" and then compacted to 90 percent of standard proctor according to AASHTO Designation T-99 Method D. Placement of the embankment material was in 12" maximum lifts. All rocks were worked into the fill to avoid forming voids.

The road base course consists of 10" of pit run gravel. The base course was watered and thoroughly mixed and compacted in one lift to 90% of standard as determined by AASHTO Designation T-99 Method D.

The surface course consists of crushed stone meeting the gradation requirements listed in Table 500-1. The material was thoroughly mixed with water to optimum moisture content. The material was then be placed and compacted in a single lift. This material was compacted to 95 % of standard as determined by AASHTO Designation T-180 Method D. The finished grade was graded smooth and uniform with surface deviations not exceeding 0.5 inch plus or minus in 10 feet.

Maps and drawings associated with the design and construction of the access road are Plates 4-3 (Pre-Existing Topography Map), 4-4 (Initial Construction Map), 4-8 (Access Road Cross-Section Map), and 4-9 (Profile/Centerline of Access Road). Refer to Maps Section.

Table 500-1: Gradation Requirements

UNTREATED ROAD BASE SPECIFICATION		
Sieve Size	**Ideal Gradation (% passing)**	**Ideal Gradation Tolerance**
1 INCH GRADATION		
1 inch	100	0
½ inch	85	± 6
No. 4	55	± 6
No. 16	31	± 4
No. 200	9	± 2
3/4 INCH		
3/4 inch	100	0
3/8 inch	85	± 7
No. 4	61	± 6
No. 16	33	± 5
No. 200	9	± 2

Note:

1. That portion of the material passing the No. 40 sieve shall be non-plastic when tested by AASHTO Designation T-90

2. The above gradation specifications are to be done by AASHTO Designation T-27

3. The aggregate shall be of uniform density and quality and shall have a rodded weight of not less than 75 pounds per cubic foot according to AASHTO Designation T-19.

Access Road Placement and Handling of Materials

The road was designed and laid out to minimize the amount of cut and fill operations required for construction. The cuts were balanced with the fills such little excess material was generated.

Topsoil

The initial step of the road construction was to remove all vegetative matter from the area to be disturbed by road construction. Once the vegetative material was removed, the top soil (where existing in sufficient quantities to allow for mechanical collection) was removed and temporarily stockpiled until it was redistributed on the embankment slopes after their construction. The temporarily stockpiled soil has been placed in an area at the beginning of road construction at the gas well site away from the activities of the road construction.

Silt fences were installed along the toe of the embankment slopes to provide erosion protection until the interim vegetation is established. Refer to R645-301-300 Biology for Interim Vegetation Plan.

Subgrade

Following removal of the topsoil and subsoil, the subgrade material was removed to the lines and grades shown on the plans as required to construct the cuts and fills. Each layer of embankment was placed, leveled and compacted in 12" maximum lifts. Large rocks were worked into the fill to avoid creating voids, etc. in the fills. The subgrade material was monitored during excavation to identify potential acid or toxic forming properties. If aberrant appearing (i.e. accumulated salts, etc.) materials were encountered, it was analyzed to determine if it is potentially toxic or acid forming. No aberrant material was found at the site.

Road Surface

Following the construction of the subgrade, 10 inches of road base gravel was placed and compacted. Then 6 inches of crushed stone will be spread and compacted on the road surface. This serves as the final travel surface. The final configuration of the road was constructed to the lines and grades shown on the plans. Refer to Plates 4-8 Access Road Cross-Sections.

Dust Control

During construction of the road fills and soil stockpiles, water was spread (as needed) over the working level of the fill surface to aid in compaction and to control fugitive dust.

Access Road Drainage Control

The disturbed area consisting of the roadway and associated cuts and fills in an Alternate Sediment Control Area (ASCA) and will have treatment facilities as described below. (See Map 4-2 for area designated as ASCA's.)

The drainage system for the road will consist of road side ditches and cross culverts. The drainage system is designed to safely pass the peak runoff from a 10 year, 6 hour precipitation event. (Refer to Chapter IV Engineering Designs.) The system is designed to minimize to the extent possible, erosion and degradation of surface.

To minimize erosion on the road bed the road cross-section was sloped 1% toward the roadside ditch (refer to Exhibit I). Roadside ditches have been provided along the entire length of the road to channel runoff into the cross culverts (refer to cross-sections on plates 4-8.). Sediment controls, i.e. strawbales and/or silt fences perpendicular to the flow have been placed at no more than 200 foot intervals to prevent additional sediments from entering the natural channel.

All drainage culverts are designed to safely pass the 10 year, 6 hour precipitation event without a buildup of head water at the inlet. The inlet of all culverts has been provided with a rock rip-rap headwall to protect against erosion. The culverts have a minimum of 12 inches of compacted cover and have been installed in line with the natural drainage channel. Refer to Plate 4-4 for location of all culverts.

Operation and Maintenance

On an as needed basis, as the road surface deteriorates due to usage and weather, a blade will be used to recontour the travel surface of the road. The rills and gullies will be backfilled and a smooth surface will be developed with side slopes of 1%. Road base gravel will be added to the surface as needed.

The ditches along the access road will be maintained at the same time as the road surface. A blade will be used to clean sediment and debris from the ditch. In areas where excessive erosion occurs, rock rip-rap will be placed to help control it.

The inlet and outlet works of all culverts will be maintained as needed. Any debris clogging these structures will be removed. Rock rip-rap will be used to control erosion. Any erosion that occurs on the fill or cut slopes will be repaired by either backfilling or in those cases where a small channel has developed, due to drainage concentration, a rip-rap channel will be established.

The silt fences along the toe of the road fill sections or in the roadside ditches will be cleaned of sediment accumulation by backhoe or hand methods. This material will be either used to backfill rills and gullies or disposed in the waste rock site.

Cottonwood/Wilberg Waste Rock Storage Facility Design

The facility is designed to fit into the existing topography of the area with as little disturbance as is possible to the existing drainage system. Only one ephemeral drainage channel required a permanent diversion for the construction and operation at the facility. At completion, only 17.44 acres have been disturbed. A sediment pond designed and constructed as part of the facility catches and treats all the runoff from the site before releasing it back into the natural channel (refer to R645-301-700, Appendix A). The construction, operation, and reclamation of the facility is planned to take place in the following sequence:

1. Installation of sediment control (i.e. silt fence, straw bales, etc.) prior to initial disturbance.
2. Construction of access road.
3. Initial construction of Waste Rock Storage Facility, including the topsoil and subsoil stockpiles, sediment pond dam and the initial diversion ditch.
4. Installation of silt fences at the base of soil stockpiles.
5. Construction of the perimeter fence.
6. Interim revegetation of soil stockpiles and road cut and fill slopes.
7. Placement of underground development waste and sediments, and construct perimeter berms.
8. Cover perimeter berms with soil and revegetate.
9. Construction and maintenance of diversion ditches to be ongoing for the duration of the facility's utilization.
10. Contemporaneous reclamation of outside slopes of berms.
11. Monitoring and cleaning of sediment pond as required.

12. When completed, cover the entire site with 2 feet of soil (18 inches of subsoil and 6 inches of topsoil).
13. Revegetation of soil covered site.
14. Removal of sediment pond and access road and covering each with soil from stockpiles.
15. Construction of permanent diversion from sediment pond area into natural drainage.
16. Revegetation of pond and road areas.
17. Monitoring of revegetation efforts for bond release.

Cottonwood/Wilberg Waste Rock Storage Facility Drainage Control

The drainage of the Waste Rock Storage Facility is confined to a single ephemeral stream at the bottom of a small valley. There is 15.3 acres of undisturbed land which normally drains through the valley that's diverted around the waste pile. This undisturbed runoff and the runoff from 16.0 acres of disturbed land is diverted into a sediment pond where it is retained to remove suspended solids prior to release into the natural channel. Alternative sediment control areas (ASCA) on the outside slopes of the soil stock piles consisting of 0.9 acres are treated through use of silt fences and straw bales. (refer to Area 1D, Plate 4-2.)

Initial Construction

The initial construction of the Waste Rock Storage Facility included the construction of the sediment pond and stripping and stockpiling of the topsoil and subsoil and construction of the initial diversion ditch on the west side of the valley. This diversion ditch was designed to convey the runoff from a 100 year, 6 hour storm event in a V-ditch with a 2% channel slope. This gentle slope keeps the velocity below 5 feet per second to minimize erosion. As the waste material pile grows and encroaches upon the initial diversion ditch and against the western and northern slopes, approximately 10" of soil material will be salvaged across the slopes. The ditch will be reconstructed at the toe of the waste pile to the same specifications as the initial ditch. Interim control of drainage on the surface of the pile will slope in a southwesterly direction. Runoff from the surface of the pile will discharge in a controlled manner into ditch DA and then to the sediment pond as shown on Drawing CM-10877-WB, Plate 4-14. Should water accumulate in depressions on the surface of the waste material, to a level which may affect the stability of the waste pile, this water will be pumped to the sediment pond. When the active surface of the refuse pile reaches an elevation of approximately 6,795 feet, drainage control will be as the following describes. The western diversion ditch, labeled DA on Plate 4-5, will drain the upland undisturbed areas, the top of the waste pile, the west slope of the waste pile and the top and inside slope of the topsoil pile. The eastern diversion ditch (DB) will drain the east slope of the waste pile and top and inside slope of the subsoil stockpile. The total runoff to be collected into the sediment pond is 2.17 acre feet for the 10 year, 24 hour storm event. The estimated annual sediment production for the site is 1.65 acre feet. The actual design of the sediment pond will provide 4.58 acre feet of storage so that there is 2.41 ac. ft. of sediment storage available. The spillway for the sediment pond will safely pass the runoff from the 25 year, 6 hour storm event with the required one foot freeboard.

The outside slopes of the two soil stockpiles have silt fences constructed at their bases to treat the runoff from precipitation and are designated as alternate sediment control area 1D, Plate 4-2. Interim revegetation was accomplished as soon as practical after construction to stabilize the slopes.

Monitoring of these drainage controls will be on a regular basis and maintenance will be scheduled as needed to ensure that they operate as designed. The ditches and silt fences will be cleaned, repaired and reshaped with a backhoe or hand methods as appropriate.

Cottonwood/Wilberg Waste Rock Storage Facility Placement and Handling of Materials

During the operation of the mine, certain waste products are generated that are not part of the coal product, they include; underground development waste, trommel screen reject, and sediment from the pond and drainages. The fill of the disposal site will comprise of these materials that will be permanently stored within the Cottonwood/Wilberg Waste Rock Storage Facility.

<u>Topsoil</u>

After the vegetative material was removed from the site the topsoil was stripped and stockpiled as shown on Plates 4-4 and 7-2. Stripping areas and depths were staked to facilitate topsoil excavation. Care was taken to avoid unnecessary compaction of the topsoil material. Following soil placement, the stockpile was planted with an interim seed mix (refer to R645-301-300 Biology).

<u>Subsoil</u>

Following removal of the topsoil material the remaining material needed for the subsoil stockpile was excavated to the lines and grades specified on the cross-sections. The material was placed, leveled and compacted in 12" maximum lifts. Rocks larger than the lift thickness was worked into the fill to avoid forming voids. Those rocks make good rip-rap and were separated, hauled and stored for future use. No acid or toxic forming materials were found in the materials cut for fill. Any acid or toxic forming materials will be treated as spoil and placed in the Cottonwood/Wilberg Waste Rock Storage Facility. (Refer R645-301-200 Soils for soil information.)

<u>Underground Development Waste</u>
The underground development waste generated during coal mining, sediments from the sediment pond, and trommel rejects will be hauled to the site by truck and dumped. The composition of this material i.e. waste rock will be a mixture from the various sources. The coal rock ratio is estimated to be less than 50/50. As the material is spread and placed in the fill, it will be thoroughly mixed helping to blend the materials.

The mixing action will come as a result of the handling required to get the material delivered to the site and the spreading and leveling actions at the site itself. The underground development waste is picked up and dumped at least three times prior to being deposited on the waste pile. The spreading and leveling is performed with a tracked dozer and will mix all of the dump truck piles of waste material, to dispense any waste which may be of higher concentrations than allowed.

When the quantity of material dumped at the site needs to be leveled it will be spread, placed and compacted in 24" thick horizontal lifts. Large rocks etc., will be worked into the fill to avoid forming voids. As the fill lifts are made, the top working surface will be sloped to allow for drainage. Any acid or toxic forming materials found in the final lift of the waste pile will be buried in the fill with a least 4 feet of non-toxic cover material.

To allow for contemporaneous reclamation of the outside slopes of the waste pile, a phased construction schedule will be implemented. A berm of waste rock materials will be constructed approximately 10 feet high at the outside edge of the waste pile. The waste material will be placed inside of the berm, spread out with a dozer and compacted in place. As the material level reaches the top of the berm, a new berm will be constructed with a 2 to 3 foot offset to provide a small terrace. This process will continue until the first three 10-foot high berms have been filled. Subsequent berms will be set back eight (8) feet from the outside edge of the top of the previously completed berm. This process will continue until site construction is completed. This configuration will result in an overall outslope of approximately 2.5:1 as recommended by Rollins, Brown & Gunnel (Stability Analysis, October 1992). Contemporaneous reclamation activities will progress along with the construction of each berm. See Exhibit XXI, Exhibits Section.

Soil will be salvaged at a depth of approximately 10 inches along the western and northern slopes of the Waste Rock Storage Facility. Once a lift has enough refuse material that leveling beyond the existing ditch line and against the western and northern slope is required, soil material will be salvaged across the slope. The width of material to be salvaged will be determined by the depth of refuse to be leveled to the slope. The ditch line will be constructed in compliance with the permit requirements. These parameters will be followed each time refuse is leveled to the slope.

Salvaged soil material will be handled in the following ways. If the berm is in the process of being constructed, the salvaged soil material will be used in stabilization of the berm. If a berm is not being constructed, the salvaged material will be hauled to the subsoil pile for storage.

During the leveling process, extraneous material, trash and etc. will be separated from the fill material and disposed of in an approved sanitary landfill.

Sediment Pond Sludge

Material removed during cleaning of the Cottonwood and Trail Mountain sediment ponds will be placed in the Waste Rock Storage Facility. Sludge material that is dry enough to be immediately incorporated into the refuse material will be mixed with the waste rock and placed as previously described above. Sludge which contains more moisture than can be properly handled on the refuse pile will be placed in a containment area and allowed to dry. The containment area will be constructed within the refuse disposal area at a location that will allow drying of the sludge and maintain adequate working room for normal operation of the facility. When dry, the sludge material will be excavated and distributed throughout the refuse area for incorporation and compaction. This procedure will help maintain the proper coal-to-rock ratio throughout the site and ensure uniform stability.

R645-301-530 Operational Design Criteria and Plans

R645-301-531 General

This permit application includes a general plan and detailed design plans for each siltation structure, water impoundment, and coal processing waste bank, dam or embankment within the permit area. A discussion and design of the sediment pond and earthened dam is outlined in R645-301-700 Hydrology, Appendix C. Design of the Waste Rock Storage Facility is discussed above in R645-301-526.

R645-301-532 Sediment Control

The Cottonwood/Wilberg Waste Rock Storage Facility covers approximately 17.44 acres of disturbed area. All water within this area is conveyed to ditches, and/or culvert systems. Sediment control allows for undisturbed runoff to bypass the facilities via a diversion ditch and culvert system into the surrounding ephemeral drainage adjacent to the site. Disturbed runoff from the site is diverted to the sediment pond. Refer to R645-301-700 Hydrology for a complete discussion on sediment control.

R645-301-533 Impoundments

As described previously, a sediment pond is utilized to collect storm water runoff from the disturbed area of the Cottonwood/Wilberg Waste Rock Storage Facility. The design of the pond is found in R645-301-700 Hydrology, Appendix C. Pond design encompasses approximately 1.0 acre of disturbed land.

R645-301-533.200 Foundations

The pond is designed as an incised structure. Foundations for embankments and impounding structures are constructed utilizing the information outlined in the Geotechnical Study conducted by Rollins, Brown, and Gunnel September, 1989. Refer to this report in Appendix A of this section. Stability analysis for the construction of the earthen dam is found in Exhibits XII through XVIII in the Exhibits Section.

R645-301-536 Coal Mine Waste

In order to better understand the chemical and physical properties of the rock that will be placed in the waste rock site, over 130 samples from both outcrop and drill cores were analyzed.

Samples were selected that would best represent the material that will be placed in the site over its useful life. The samples were tested individually and the results are summarized in the table in Appendix B according to the common rock types that will be stored in the site.

In addition to these analyses, representative samples were tested for their potential alkalinity, pyrite/marcasite content and clay content. The results are shown below:

Zone Sampled	Number of Samples	pH	Pyrite/Marcasite	Clay Alkalinity	%FeS_2 Potential
Hiawatha roof	3	7.8	3.3	-	218,400
Hiawatha floor	3	7.5	1.3	5.5	127,300
Blind Canyon roof	2	8.1	0.5	-	252,600
Blind Canyon floor	3	8.3	1.3	9.0	3,500

A review of the above data concerning the sodium absorption ratio of the Blind Canyon floor reveals that three out of four samples have values less than 5.0 (4.8, 1.5 and 1.3). One sample has a value of 60.4 which raised the sample mean to 17.36 and created a high standard deviation of 25.14. This indicates that in general the Blind Canyon floor rock will not pose a problem from its high SAR but from time to time higher than average values will be encountered. These concentrations will be diluted by other rocks with low SAR values when stored in the Waste Rock Storage Facility. These results show there is little potential for acid or toxic conditions to exist for the disposed of coal mine waste material.

Analysis results from the roof and floor samples taken at the Trail Mountain Mine are found in the Trial Mountain MPR, Volume 1, Chapter 6 and Appendix 6-2. Similar results are found in these samples.

To identify the acid- or toxic-forming potential of materials disposed of at the Waste Rock Storage Facility prior to covering the refuse pile for final reclamation, the top four (4) feet of the surface will be sampled according to the Division’s “Guidelines for Management of Topsoils and Overburdens” Table 9, June 2003.

R645-301-540 Reclamation Plan

R645-301-541 General

The Cottonwood/Wilberg Waste Rock Storage Facility consists of 17.44 acres of disturbed land to be used for disposal of underground development waste. An access road 1,435 feet long is constructed in conjunction with the site and involves 5 acres of disturbed land. The site is located on public lands managed by the US Department of the Interior, Bureau of Land Management and its principal use is wildlife habitat and livestock grazing. When the facility is completed, reclamation will return the area to these same uses.

Construction of the facility commenced as soon as the permit was issued. Sediment control measures were put in place to minimize the effects of the initial construction. Straw bales and silt fences were erected in the natural drainages to treat any runoff during the initial construction period. Interim revegetation was used on the bare slopes of the soil stockpiles and along the roadway to stabilize and prevent erosion. The tospoil stockpiles were marked as such. Drainage structures were constructed and maintained to ensure that they were in good repair and capable of handling the design flow rates. Silt fences were constructed at the base of the soil stockpiles outside slopes. These silt fences are also monitored and repaired as needed to ensure they are continuously in good working order.

Construction of the waste material pile incorporated a plan to allow contemporaneous reclamation of the outside slopes of the pile. Waste material is used to construct a berm, approximately 10 feet high, to contain the waste material to be deposited.

As contemporaneous reclamation commences, 18 inches of subsoil and 6 inches of topsoil will be placed on the outside slope of the berm and revegetation of the slope will begin. Successive berms will be constructed on top of the previous berms as the level of the waste material rises. There will be a two to three foot offset of the toe of the upper berm to provide a small terrace to reduce runoff velocities. (See Exhibit XXI, Exhibit Section.) When the waste pile construction is complete, the top surface of the pile will be graded for proper drainage. The surface will be covered with subsoil and topsoil (18 and 6 inches, respectively) prior to being revegetated.

At the time of final bond release for the reclaimed areas, all reclamation will have been completed. (Refer to Plate 4-7) This will include removal of the sediment pond dam and access road, diverting the ditches into the natural drainage channel, covering the disturbed area with topsoil and removing the perimeter fence. Temporary sediment controls will again be used to prevent impact on the downstream areas during these construction efforts. Revegetation will take place on all reclaimed disturbed areas. Monitoring and maintenance, as required, will continue until final bond release is approved. Refer to R645-301-300 Biology.

R645-301-542 Narratives, Maps and Plans

A detailed timetable for the completion of each major step in reclamation is outlined in R645-301-300 Biology. Certified contour maps and soil placement maps can be found in the Map Sections of each chapter. A detailed plan for backfilling, soil stabilization, compacting and grading is outlined below in R645-301-553, Backfilling and Grading.

R645-301-542.600 Roads

The site access road will no longer be needed after the refuse pile is reclaimed. The road will be removed and the area reclaimed during the reclamation operations. All drainage structures will be removed and the natural drainage systems through the access road area will be returned to their pre-existing state.

R645-301-550 Reclamation Design Criteria and Plans

Reclamation activities at the Cottonwood/Wilberg Waste Rock Storage Facility includes plans and designs for 1) Permanent features, and 3) Backfilling and grading. These plans and designs are outlined below.

R645-301-552 Permanent Features

Small depressions (pocks) will be constructed to retain moisture, minimize erosion, create and enhance wildlife habitat, and assist revegetation. The pocks will be constructed with a track-hoe or similar machinery and placed in random order. The pocks will measure approximately 1.5 feet deep by 3.0 feet in diameter. Pocking techniques and sediment loss is explained in detail in the Soil and Hydrology sections.

R645-301-553 Backfilling and Grading

Access Road

Final reclamation of the road will take place as detailed below. The gravel road surface material and subgrade material will be removed and placed against the inside cut slope of the road cross-section. The topsoil off the embankment outslope will be removed and temporarily stockpiled in an area at the road construction beginning. The subsoil material from the embankment slopes will then be spread over the road cross-section to obliterate the road. Natural drainageways shall be extended through the reclaimed area and blended in with the downstream segment. The sizing of this channel will be the same as the natural channel. The topsoil material from the temporary stockpile will then be evenly spread over the area and seeded.

Waste Rock Storage Facility

To provide for contemporaneous revegetation, a phased construction program will be implemented. Waste material will be used to construct a berm on the outside of the waste pile. Once the berm is completed and tested for toxic or acid forming materials, subsoil and topsoil materials will be used to cover the outside slope of the berm. Prior to placement of the subsoil, the waste material will be roughened to a depth of 18 inches. The soil materials will be loaded and hauled to the berm and distributed with either a track mounted backhoe or small tracked dozer. The subsoil will be spread to a thickness of 18 inches and the topsoil to 6 inches. Special efforts will be made to minimize the compaction of the topsoil layer. Revegetation will then take place on that portion of the waste pile which has been covered. As the waste pile elevation rises, new berms will be constructed and reclaimed. At the completion of the construction of the waste pile, the top surface will be covered with 18 inches of subsoil and 6 inches of topsoil and then revegetated (refer to R645-301-300 Biology).

The drainage plan for the reclamation of the facility is the same as the Operating Plan. The diversion ditches are sized for 100 year, 6 hour storm event and no changes should be necessary for reclamation. When the final stages of reclamation are initiated, an extension of the diversion ditches will be required to pass through the area of the sediment pond and dam and into the natural channel. The diversion will use the same shape and lining specifications used in Ditch DA except for the channel slope, which will be 10% instead of 20%. Refer to Plate 4-12 for ditch details.

R645-301-553.140 Minimization of Erosion and Water Pollution

Terraces will be provided (refer to Exhibit XXI) to reduce runoff velocities and ultimately erosion. A straw bale and silt fence filter will be constructed in the natural drainage channel during these activities to minimize the impact on the downstream areas.

R645-301-560 Performance Standards

Coal mining and reclamation operations will be conducted in accordance with the approved permit and requirements of R645-301-510 through R645-301-553.

UTAH POWER & LIGHT CO.
Mining Division
Geotechnical Investigation

COTTONWOOD/ WILBERG WASTE ROCK STORAGE FACILITY

1989

ROLLINS, BROWN AND GUNNELL, INC.

Professional Engineers

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September 7, 1989

Utah Power & Light Company Mining Division
P.O. Box 310
Huntington, UT 84528

Attn: Tom Faucheux

Gentlemen:

In accordance with your request, a geotechnical investigation has been completed at the proposed site of the proposed Waste Rock Storage Facility near the Wilberg Mine in Emery County, Utah. The primary objective of this investigation was to define the groundwater conditions throughout the area and to provide foundation recommendations for the Waste Rock Storage Facility. Foundation recommendations for a proposed stacking tube to be located near the Wilberg Mine are also provided. The work has been completed in accordance with a written proposal submitted to your organization for the work and the results of the investigation, along with pertinent recommendations for foundation design, are outlined in the following sections of this report.

The information contained in the report is discussed under the following headings: (1) Existing Site Conditions, (2) Subsurface Soil and Water Conditions, (3) Foundation Considerations and Recommendations, (4) Site Preparation, Excavation Considerations, and Compacted Fill Requirements, and (5) The Results of Field and Laboratory Tests.

1. EXISTING SITE CONDITIONS

The Waste Rock pile will be located on the west side of Wilberg Mine Road approximately 1.5 miles south of the Wilberg Mine. The area where the proposed facility will be located is virgin terrain and the vegetative cover consists of weeds, native grasses, juniper and pine trees. The general configuration of the waste rock pile along with the topography throughout the area is presented in Figure No. 1. It will be observed that most of the site is relatively flat. however, the topography of the site rises quite sharply in the northwest part of the site. It is anticipated that shale will be located relatively close to the ground surface throughout most of the site and that the static groundwater level will be located at a substantial depth below the existing ground surface. It is entirely possible, however, that groundwater may be encountered in the joints and fractures in the bedrock.

As far as we can determine, no manmade fill has been placed throughout the site and all of the subsurface material are natural deposits. No water conveyance water facilities or other water bodies area located in the immediate vicinity of the site which would effect the groundwater level in this area.

The location of the proposed stacking tube is presented in Figure No. 2. Existing facilities including the Silo, the Crusher, the Breaker Building and the Loadout Facility are also shown in Figure No. 2. The topography were the stacking tube will be located is relatively flat, however, the topography rises sharply upward towards the mine offices. Some manmade fill will probably exist in the area where the stacking tube will be located. It will be observed that the topography slopes downward in a southerly direction away from the stacking tube and the silo.

Other than the information outlined above for both the Waste Rock site and the stacking tube site, no environmental conditions appear to exist at this site which would adversely affect foundation performance.

2. SUBSURFACE SOIL AND WATER CONDITIONS

The characteristics of the subsurface material in the area where the Waste Rock Storage Facility will be located were defined by drilling three test borings to a depth of 80 feet at locations as shown on Figure No. 1. The logs for these test holes are presented in Figure Nos. 3 through 6. In Test Borings 1 and 2, a surface silty clay zone, approximately 6 feet thick, covers the area. The remainder of the subsurface material in each of these test holes consists of dark gray shale. In Test Boring No. 3, the subsurface material in the upper 55 feet of the soil profile consisted of unconsolidated material. The gravelly type material in the upper 25 feet of the soil profile was followed by a brown silty clay which extended to a depth of about 55 feet below the ground surface. The remainder of the soil profile in Test Hole No. 3 consisted of a gray shale.

Sampling of the unconsolidated material throughout the soil profile was performed by driving a two-inch split-spoon sampling tube through a distance of 18 inches using a 140-pound weight dropped from a distance of 30 inches. The number of blows to drive the sampling spoon through each 6 inches of penetration is shown on the boring logs. The sum of the last two blow counts, which represents the number of blows to drive the sampling spoon through 12 inches, is defined as the standard penetration value. The standard penetration value provides a reasonable indication of the in-place density of sandy material; however, it only provides an indication of the relative stiffness of the cohesive materials, since the penetration resistance of these materials is a function of the moisture content. If the spoon can be driven through the full distance of 18 inches with reasonable core recovery, the standard penetration value provides a reasonable indication of the in-place density of gravelly-type material. The results of the standard penetration test performed in the gravelly material in Test Hole No. 3 indicates that the gravel is in a relatively dense state and the cohesive material is in a stiff condition.

Undisturbed samples were obtained in the clay material in Test Hole No. 3 by pushing a 2.5-inch, thin-walled shelby tube into the subsurface material using the hydraulic pressure on the drill rig. The location at which the undisturbed samples are obtained are shown on the boring logs. Continuous cores were obtained in all of the bedrock encountered in each of the three test holes. The bedrock was characterized in the drill holes by determining the percent core recovery and the rock quality designation. The rock quality designation is the percent of material in a given run which has a core length greater than 4 inches. It will be observed from the boring logs that the percent core recovery was nearly 100 percent in most of the cores and that the rock quality designation below the weathered zone was greater than about 90 percent.

Field permeability tests were performed in each of the drill holes from 3 to 10 foot intervals. The field permeability tests were performed in accordance with designation E18 of the U.S. Bureau of Reclamation Earth Manual. The permeability coefficient expressed in feet per year is presented on the boring logs. It will be observed that the gravelly material in the upper portion of Drill Hole No. 3 is moderately permeable with permeability coefficients ranging from about 1200 to 2700 feet per year. The shale, however, in all of the test holes had relatively low permeability test characteristics. In Test Boring No. 1, the permeability coefficient varied from no measurable loss to a maximum of about 10 feet per year. The permeability coefficients in the bedrock of the other two holes were similar.

The characteristics of the subsurface material in the area were the stacking tube will be located was defined by drilling one test boring to a depth of about 60 feet at the location shown on Figure No. 2. The log for this test hole is presented in Figure No. 6 and it will be observed that the subsurface material in the upper 35 feet of the soil profile consists of a brown silty sandy gravel. Sampling of both the unconsolidated and the consolidated material in this test hole were performed in a manner similar to the procedures defined for the Waste Rock Facility. The results of the standard penetration test indicate that the gravelly material throughout the profile at this site is in a medium dense condition. The field permeability test performed on the gravelly material above the shale indicated permeability coefficients ranging from 1,200 feet per year to 5,550 feet per year. The permeability of the gray shale was moderately low with values less than 10 feet per year.

Each sample obtained in the field was classified in the laboratory according to the Unified Soil Classification System. The symbol designating the soil type according to this system is presented on the boring logs. A description of the Unified Soil Classification System is presented in Figure No. 7 and the meaning of the various symbols shown on the boring logs can be obtained from this figure. It will be noted that the cohesive material classified as either an ML- or a CL-1-type material while the granular material classified as an SM- or a GM-type soil.

During the subsurface investigation, an attempt was made to evaluate the groundwater conditions at the conclusion of each drilling period. The wash water in the drill hole was bailed out to the bottom of the hole. The elevation of the water in the drill hole, at the beginning of the next drilling period, was measured and recorded. This sequence of operations extended throughout the entire depth drilled. The results of the water level observations are presented in Figure Nos. 8 through 11 for each drill hole. In Drill Hole No. 1, the wash water was bailed down to a depth of approximately 12.5 feet on the evening of July 21. By the morning of July 25, water had risen in the drill hole to a depth of about 11 feet. It was concluded that some water was flowing into the drill hole above the 12.5 foot level. It will also be noted from Figure No. 8 that water flowed into the drill hole after each drilling interval. It appeared to stabilize at a depth of 28 feet below the existing ground surface.

In Drill Hole No. 2, no ground water appeared to exist within the profile above 13 feet, since no groundwater flowed into the drill hole following the bailing operations on July 18. At the end of each drilling period, however, water flowed into the drill hole and in each case rose to an elevation of approximately 7.5 feet below the ground surface. It is apparent from the results of the permeability tests for Drill Hole No. 2, that water under on artesian pressure could be flowing into the drill hole between 13 and 23 feet and between 43 and 53 feet. It is apparent from Figure No. 9 that the groundwater level in Drill Hole No. 2 stabilized at about 7 feet.

In Drill Hole No. 3, water flowed into the drill hole in the interval between 0 and 10 feet below the ground surface. No groundwater appeared to flow into the drill hole, however, in the interval from 10 to 40 feet, since the groundwater failed to rise in this drill hole between July 14 and July 17. It is apparent from Figure No. 10 that water flowed into the drill hole between a depth of 40 and 72 feet, since the water rose in the drill hole after the water level had been bailed down in this hole on July 17. It will be noted that the ground water level appeared to stabilize in this hole at an elevation of about 55 feet. Based upon the results of the field permeability tests in the bore hole as shown on the boring logs, it appears that ground water is entering this hole between a depth of 45 feet and 63 feet.

In Drill Hole No. 4, no ground water appeared to exist within the bore hole above a depth of 9 feet. Water appeared to enter this bore hole, however, between a depth of 9 feet and 35 feet, since the water rose to a height of about 16 feet following the completion of drilling on August 1. No groundwater appeared to enter the drill hole below a depth of 35 feet, since no rise in the groundwater level occurred in the drill hole when the water was bailed down to the bottom of the hole at the end of drilling on August 2.

3. FOUNDATION RECOMMENDATIONS AND CONSIDERATIONS

A. <u>The Waste Rock Storage Facility</u> The location and size of the Waste Rock Storage Facility is present in Figure No. 1 and it will be observed that the rock pile will cover an area approximately 800 feet wide and a 1,000 feet long. We understand that the waste rock pile will have a height of about 140 feet. We also understand that the material within the waste rock pile will consist of particle sizes ranging from sand size material to cobble size material. It is anticipated that the material within the waste rock pile will be densified in a reasonable manner during the construction operations.

It is apparent that within the vicinity of Drill Hole No. 3, as shown in Figure No. 1, the subsurface material beneath the rock pile will consist of overburden material to a depth of about 55 feet. In the middle of the rock pile, however, where Drill Hole Nos. 1 and 2 are located, bedrock was encountered at a depth of about 6 feet below the existing ground surface. It is apparent, therefore, that the south easterly side of the rock pile will be the most critical area in so far as the stability of the rock pile is concerned. A stability analysis has been preformed for the rock pile, assuming that the subsurface soil profile beneath the rock pile is characterized by the subsurface material in Drill Hole No. 3. This section corresponds to section AA shown in Figure No. 1. It will be observed from this test boring that the upper 20 feet of the soil profile consists of a brown silty sandy gravel while the subsurface material between a depth of 25 feet and 53 feet is cohesive material.

The shear strength parameters for the gravelly material in the upper portion of the soil profile have been inferred from the results of the standard penetration tests, while the characteristics of the subsurface material between a depth of 25 feet and 53 feet have been determined from triaxial and direct shear tests. The shear strength parameters for the rock pile have be inferred from our experience with this type of material. The stability analysis has been performed for various site slopes and for various heights of the waste rock pile. The ground water level in the overburden material has assumed to exist at a depth of approximately 55 feet below the existing ground surface.

The stability analysis has been performed using a computer model of Spencer's Method. The computer model, known as UTEXAS2, was developed by Steven Wright at the University of Texas. This model is presently being used by the Corp of Engineers and we believe it is an acceptable method for solving limiting equilibrium problems. The results of the stability analysis is presented in Figure No. 12. The shear strength parameters used for each of the materials with in the embankment and the subsurface profile are shown in this figure. Tables shown in Figure No. 12 indicates the factor of safety for a waster rock pile having various heights and side slopes. Factors of safety were obtained for both shallow failure surfaces and deep failure surfaces. The critical failure surface for side slopes of 2 horizontal to 1 vertical for both shallow and deep failures are shown in Figure No. 12. It is apparent from this table that side slopes of 2 horizontal to 1 vertical will be required to provide a stable slope for a rock pile 140 feet high having a factor of safety of 1.5.

A stability analysis has also been performed for a subsurface profile characteristic of Drill Hole Nos. 1 and 2. This case corresponds to the section designated as BB in Figure No. 1. The results of this analysis is also presented in Figure No. 12. This analysis indicates that side slopes of 2 horizontal to 1 vertical will also be required for a rock pile height of 140 feet. It is recommended, therefore, that the rock pile located as shown in Figure No. 1 been constructed using side slopes of 2 horizontal to 1 vertical.

B. Stacking Tube and Coal Pile It is our understanding that the stacking tube will be 85 feet high and will have a diameter of 14 feet. The stacking tube will be supported on a rectangular concrete cell, which will connect to the reclaim tunnel. The reclaim tunnel will consists of a 13 foot diameter multi-plate conduit a 180 feet long. We understand that the stacking tube will have a weight of 750 kips. It is anticipated that the rectangular cell will be supported on a mat foundation located at least 15 feet below the existing ground surface. It is apparent from the log for Test Hole No. 4, that the zone of significant stress for the mat foundation for the stacking tube will exist primarily within the brown silty sandy gravel.

In order to size the mat foundation for the stacking tube, the bearing capacity chart, shown in Figure No. 13, has been prepared for this site. The ground water level has been assumed to exist at the bottom of the mat. In preparing the bearing capacity chart, consideration has been given to both shear failure and differential settlement. The lines sloping upward to the right define the allowable soil bearing pressure with respect to shear failure using a factor of safety of 2.5. The curve sloping downward to the right defines the allowable soil bearing pressure such that the maximum settlement of any footing will not exceed 1 inch.

If the foundations for the proposed facility are sized in accordance with Figure No. 13, the maximum settlement of any footing will not exceed one inch and differential settlement throughout the structure should not exceed 0.5 inch, which, in our opinion, will be satisfactory for the proposed structure.

The rectangular cell supporting the stacking tube will be subjected to the lateral pressures associated with the granular material. In providing lateral earth pressures for designing the rectangular cell, it has been assumed that the walls of the cell will be restrained from any movement during the backfilling operations. Under these conditions, we recommend that a lateral earth pressure coefficient of 0.45 be used to design the walls of the structure. The lateral earth pressure intensity at any depth along the wall should be calculated using the following equation:

$$P = K\gamma h$$

P = earth pressure intensity at any height
K = earth pressure coefficient
γ = unit weight of the granular backfill
h = height of the earth material above the point on the wall

It is our understanding that the coal pile will be approximately 80 feet high and that the slope of the pile will be approximately equal to the angular repose for the coal which is approximately 1.5 horizontal to 1 vertical. Since the foundation material is granular type soils, the amount of settlement under the weight of the coal pile will not exceed a few inches. It is recommended, however, that the overburden weight associated with the coal pile be used in calculating the total lateral earth pressure per lineal foot of wall for the rectangular cell.

4. SITE PREPARATION, EXCAVATION CONSIDERATIONS, AND COMPACTED FILL REQUIREMENTS

The location where the stacking tube will be located is presented in Figure No. 2. Site preparation for this area will involve the leveling of the site along with the excavation necessary to install the rectangular cell and the reclaim tunnel. As indicated earlier in this report, at the end of the drilling on August 1, the wash water in the drill hole was bailed down to the bottom of the hole at a depth of 35 feet. The following morning, however, the water level in the hole had risen to a depth of approximately 16 to 17 feet below the existing ground surface. If the excavation for the reclaim tunnel and the rectangular cell extends below a depth of 16 to 17 feet, excavation below the ground water level should be anticipated. Side slopes for all excavation in the development area should be at least 1.5 horizontal to 1 vertical. Flatter slopes may be required, however, if the excavation proceeds much below the ground water level.

The onsite material can be used as backfill material around the reclaim tunnel and the rectangular cell. We recommend that all backfill material be densified to an in-place unit weight equal to 90 percent of the maximum laboratory density as determined by ASTM D 1557-78. It is recommended that sufficient quality control be performed during the backfilling operations to insure that the densification recommendations are complied with.

5. THE RESULTS OF FIELD AND LABORATORY TESTS

The field and laboratory tests performed during this investigation to define the characteristics of the subsurface material throughout the proposed site included standard penetration tests, Atterberg Limits, mechanical analyses, unconfined compressive strength, direct shear tests, and triaxial shear tests. The standard penetration tests have been previously discussed and the results of these tests are shown on the boring logs. The Atterberg limits performed on the cohesive material throughout the soil profile at this site indicate that these materials classify as either an ML- or a CL-1-type material. The results of the mechanical analysis performed on a number of the samples obtained from Test Hole No. 3 and 4 indicate that the granular material contained material in the silt and clay size range varying from about 14 percent to about 26 percent.

The unconfined compressive strength of the shale was determined on undisturbed samples obtained from Test Hole No. 1 and 2. The results of these test are shown in Table No. 1 and it will be observed that the unconfined compressive strength of the shale varied from about 2,300 pounds per square inch to about 2,900 pounds per square inch. The shearing strength of the cohesive materials in Test Hole No. 3 were evaluated by performing three consolidated drained direct shear tests on representative samples obtained at a depth of 7.5 to 9.0 feet below the ground surface and three consolidated drained direct shear tests on representative samples obtained at a depth of between 40 and 41.5 feet below the existing ground surface. The results of these tests are presented in the form of a Mohr Envelope in Figure Nos. 14 and 15 and it will be observed that the friction angle of 28 degrees and 31 degrees were obtained, respectively, for these materials.

Consolidated drained triaxial shear test were also performed to define the strength characteristics of the cohesive material in Test Hole No. 3. The results of three consolidated drained triaxial shear tests performed on representative samples obtained form Test Hole No. 3 at depth of between 25 to 26.5 feet are presented in Figure No. 16. Also the results of three consolidated drained triaxial shear test performed on representative samples obtained from Test Hole No. 3 at a depth of 30 to 31.5 feet are shown in Figure No. 17. It will be observed from these two figures that friction angles of 27 degrees and 29 degrees were obtained respectively for these materials. The friction angles for the granular material in Test Hole No. 3 were obtained from correlations between the standard penetration value and friction angle from materials of this type.

The conclusions and recommendations presented in this report are based upon the results of the field and laboratory tests which, in our opinion, define the characteristics of the subsurface material in the development areas in a reasonable manner. It should be recognized that earth and rock fill materials are heterogeneous and that conditions may be encountered between the test borings drilled at this site which could not be completely defined during this investigation. If during construction conditions are encountered which appear to be different than those presented in the report, it is requested that we be advised in order that appropriate action may be taken.

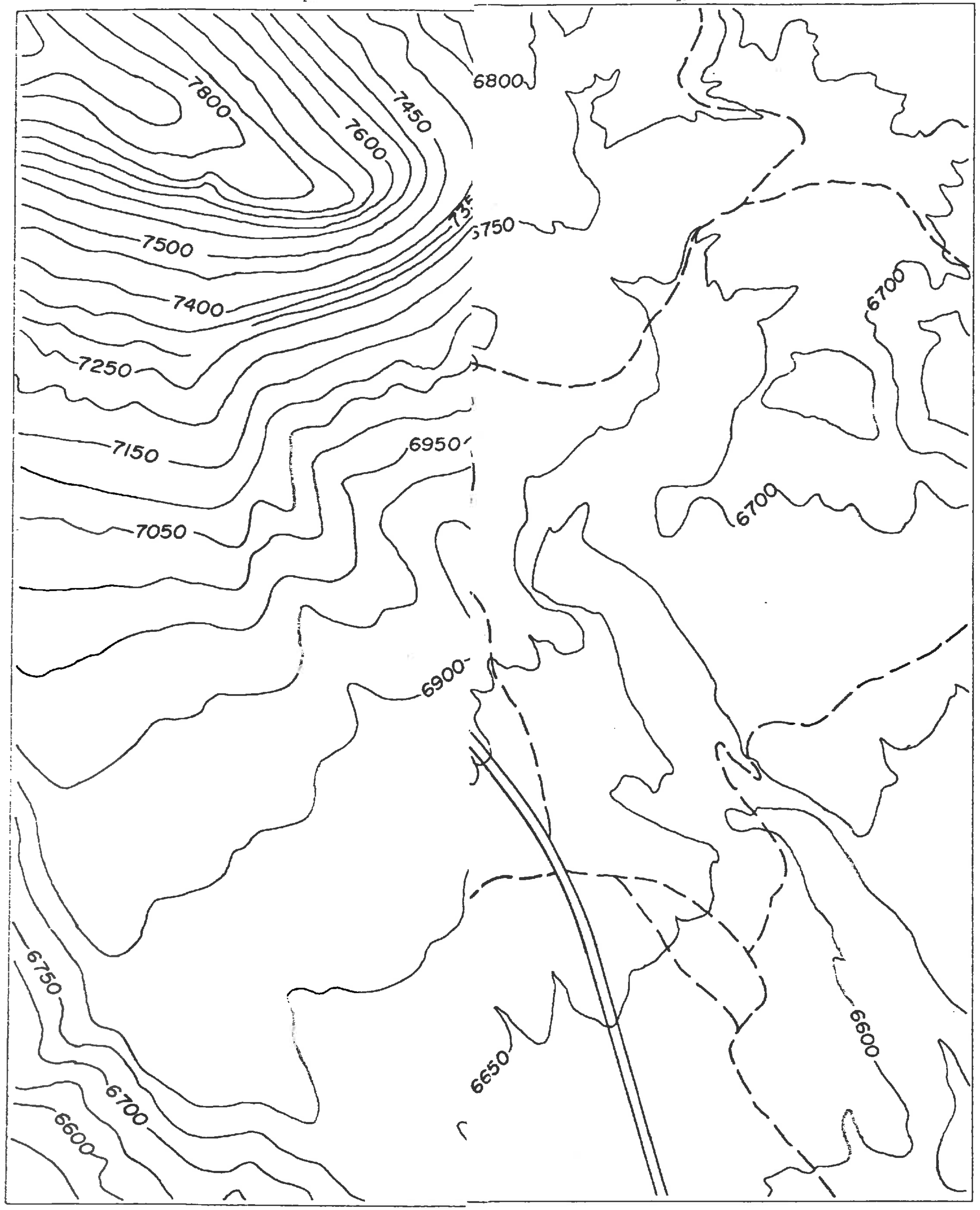
Yours truly,

ROLLINS, BROWN AND GUNNELL, INC.

Ralph L. Rollins

Ralph L. Rollins

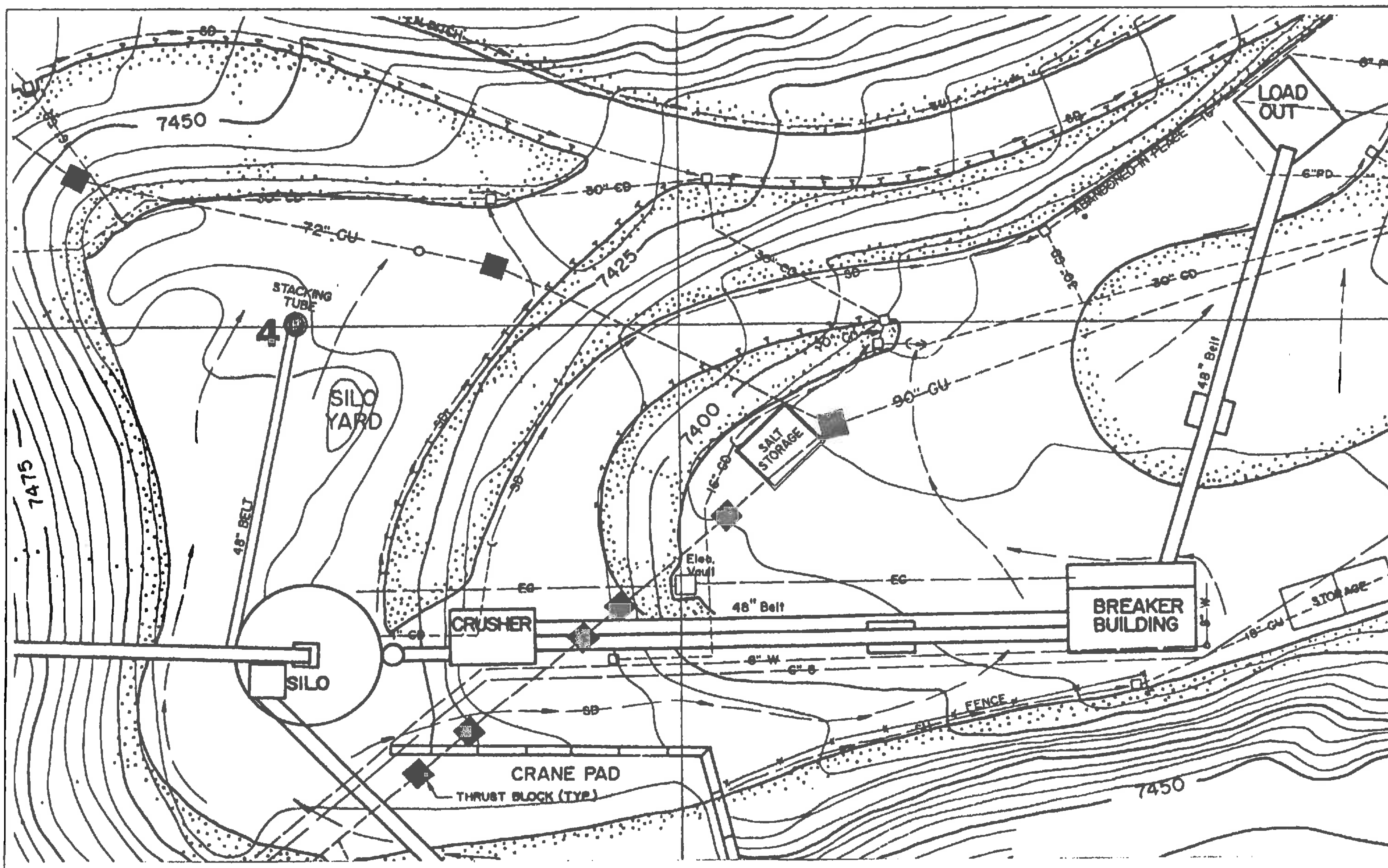
RLR:kch



ROLLINS, BROWN and GUNNELL, INC.

LAN AND DRILL HOLE LOCATIONS

FIGURE NO. 1



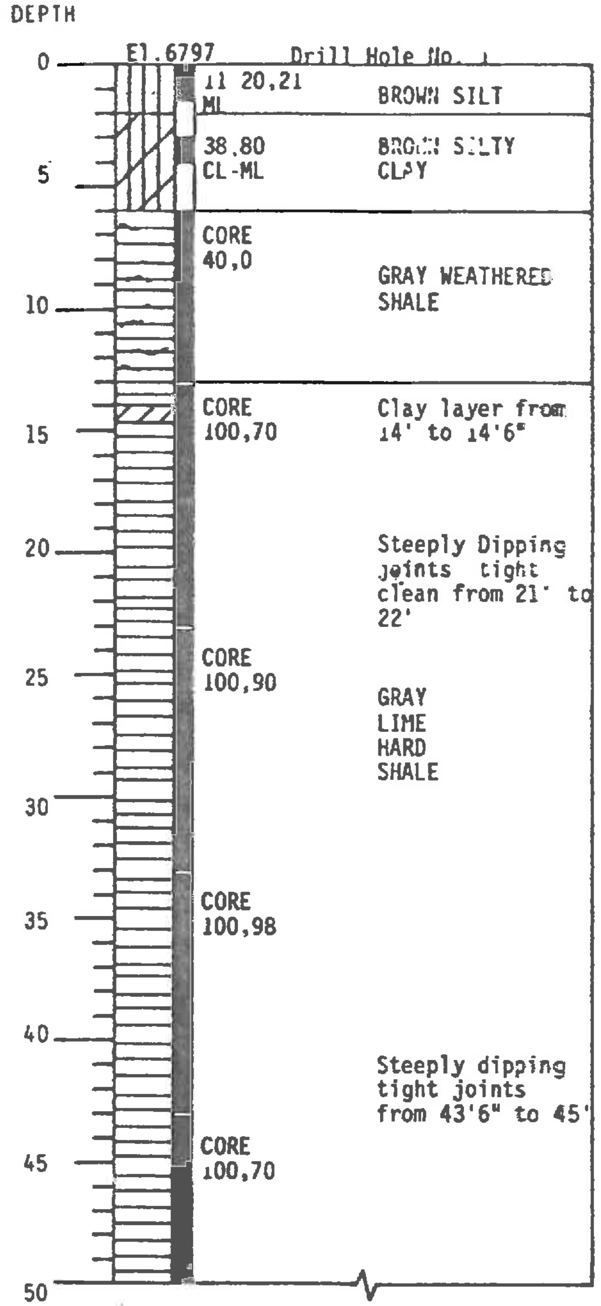
SOURCE: UP&L, "Cottonwood/Wilberg Coal Mine Facilities," Feb. 1989.

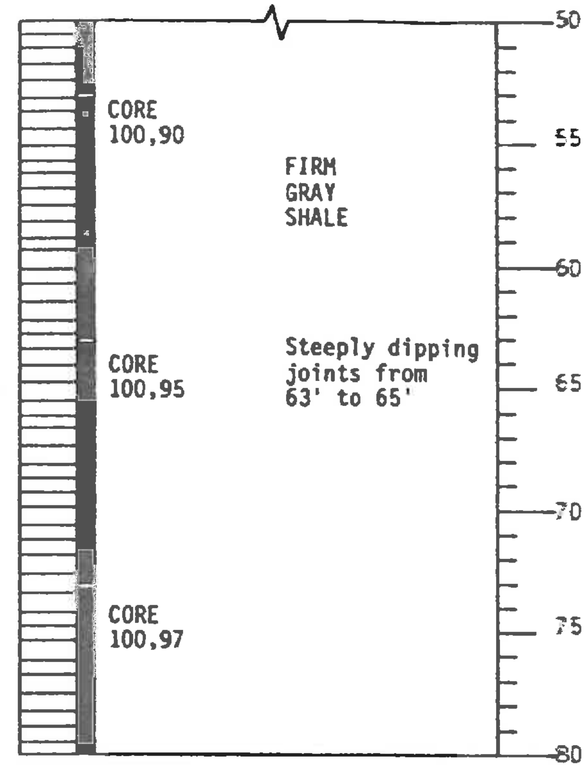
Scale: 1" = 60'

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

SITE PLAN AND DRILL HOLE LOCATION
UP&L Waste Rock Storage Facility
Emery County

FIGURE NO 2

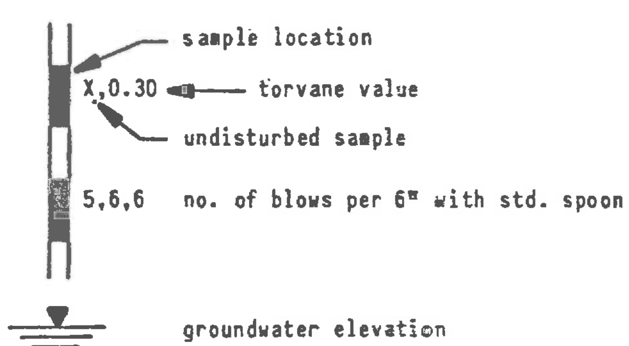




Depth	Permeability (ft/yr)
0'-6'	NML
6'-13'	NML
13'-23'	9.6
23'-33'	6.1
33'-43'	8.7
43'-53'	1.5
53'-63'	8.0
63'-73'	5.2
73'-80'	8.5

NML = No measurable loss

LEGEND



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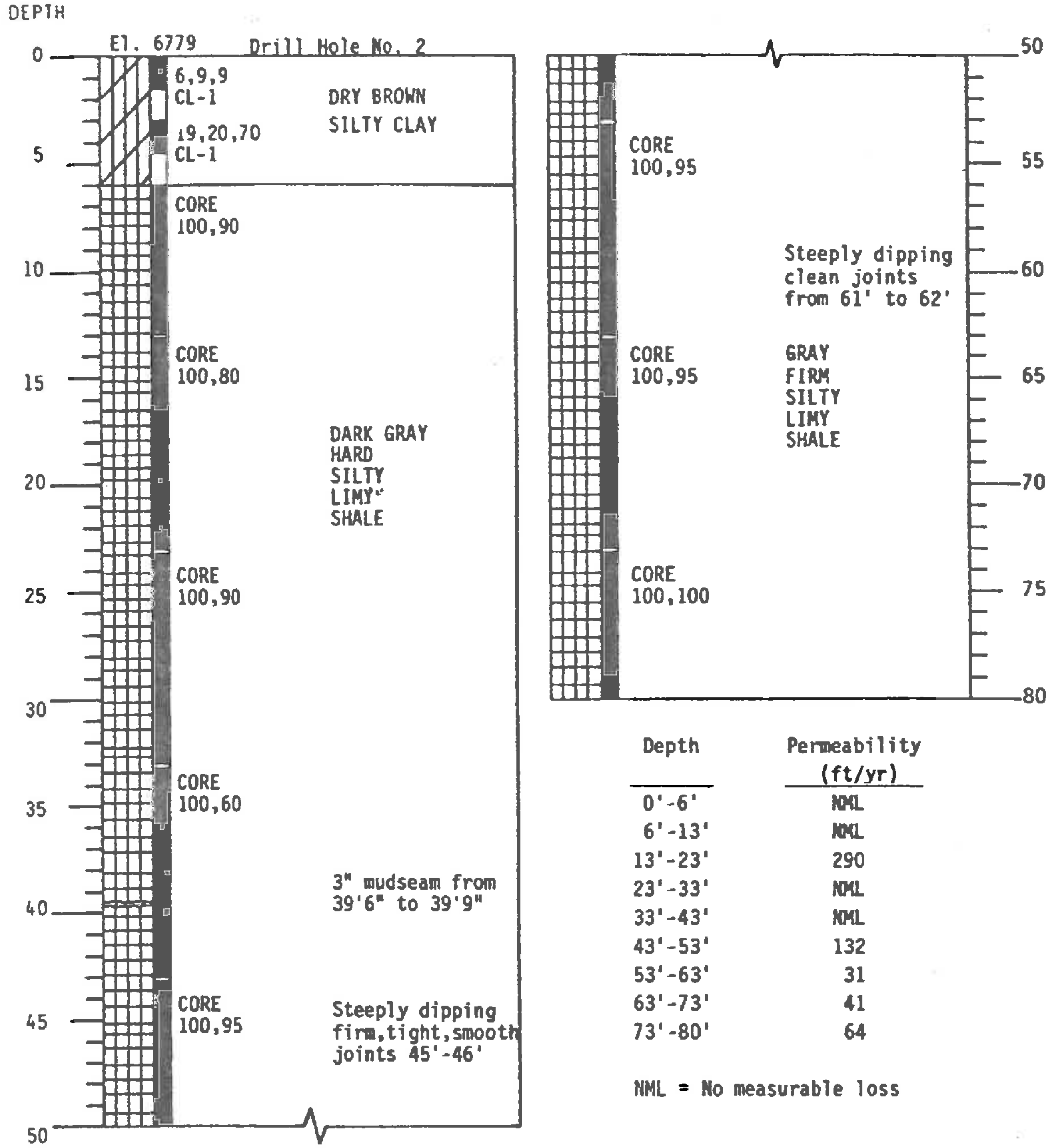
PROFESSIONAL ENGINEERS

Log of Borings for:
UP&L Waste Rock Storage Facility
Emery County

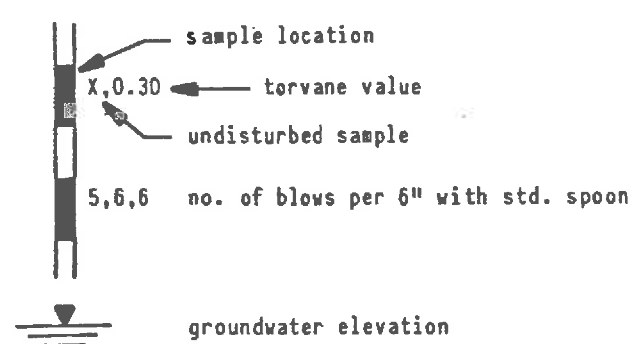
Figure No. 3



Depth	Permeability (ft/yr)
0'-6'	NML
6'-13'	NML
13'-23'	290
23'-33'	NML
33'-43'	NML
43'-53'	132
53'-63'	31
63'-73'	41
73'-80'	64

NML = No measurable loss

LEGEND



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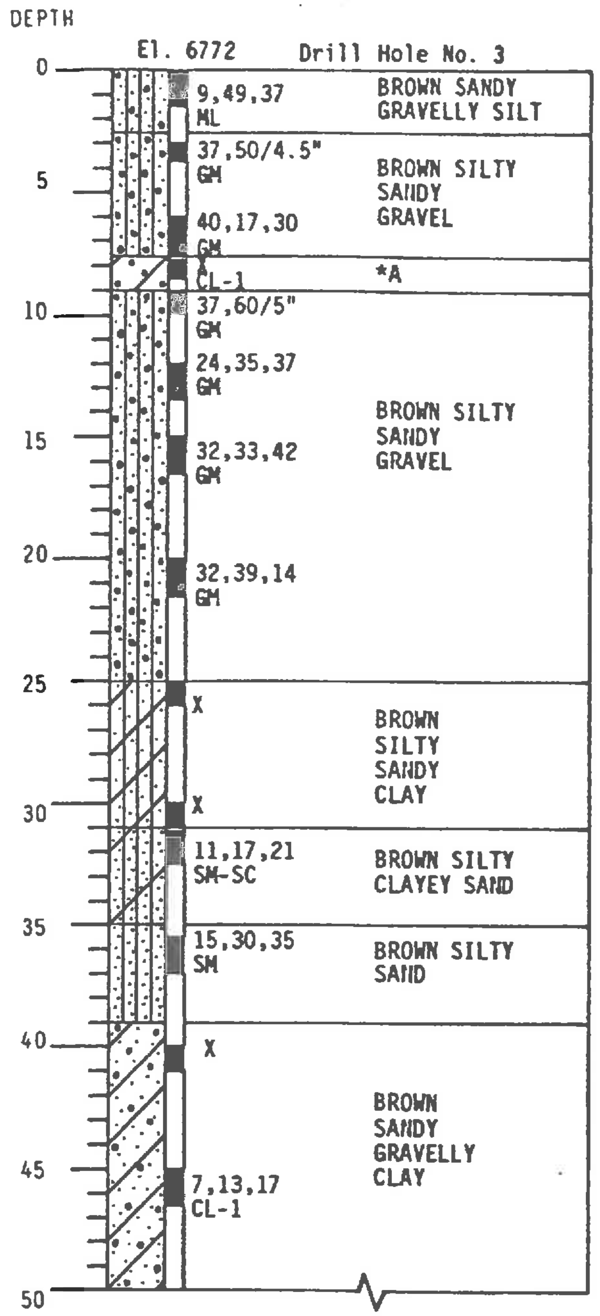
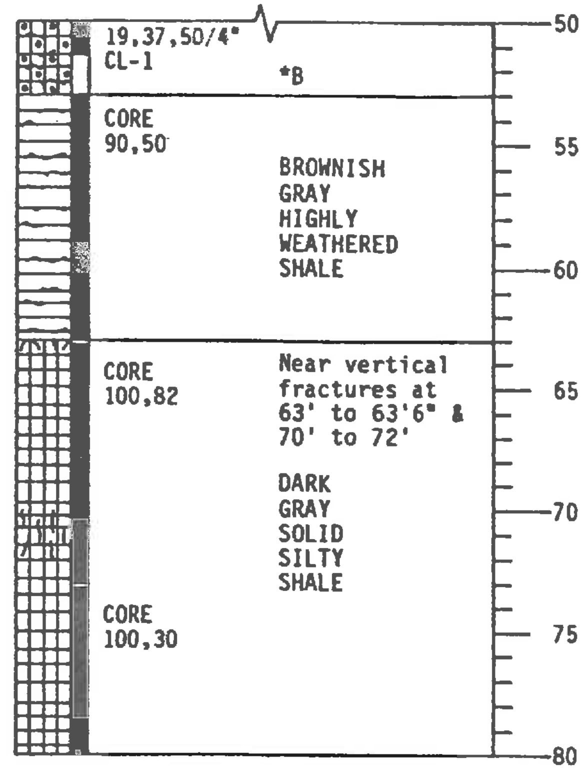
PROFESSIONAL ENGINEERS

Log of Borings for:
UP&L Waste Rock Storage Facility
Emery County

Figure No. 4





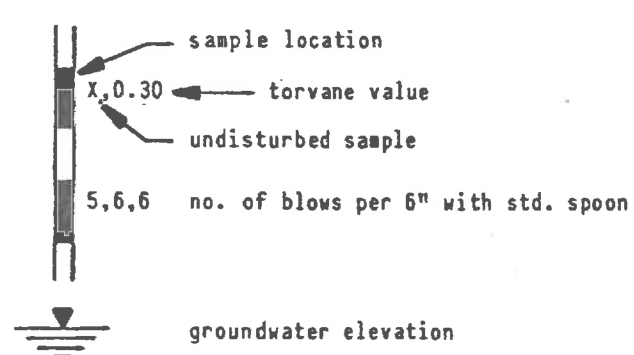
Depth	Permeability (ft/yr)
0'-9'	NML
9'-12'	57
12'-15'	2724
15'-20'	2230
20'-25'	1196
25'-30'	51
30'-35'	147
35'-45'	242
45'-50'	573
50'-63'	561
63'-73'	1.4
73'-80'	1.8

NML= No measurable loss

*A - BROWN GRAVELLY CLAY

*B - BROWN SILTY GRAVEL W/ WEATHERED SHALE

LEGEND



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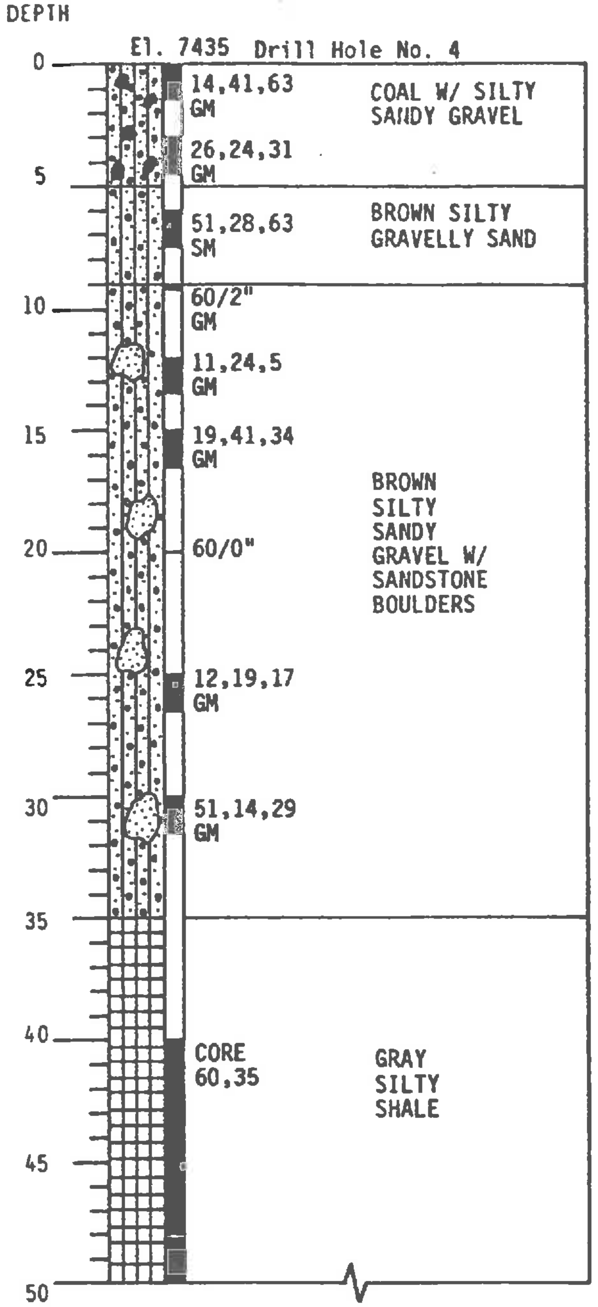
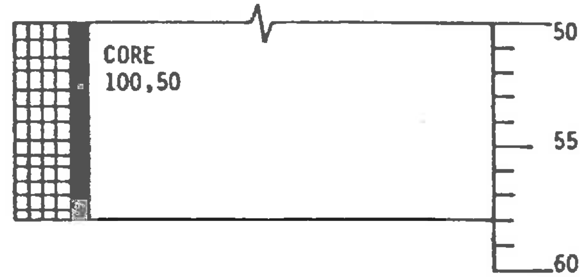
Log of Borings for:
UP&L Waste Rock Storage Facility
Emery County

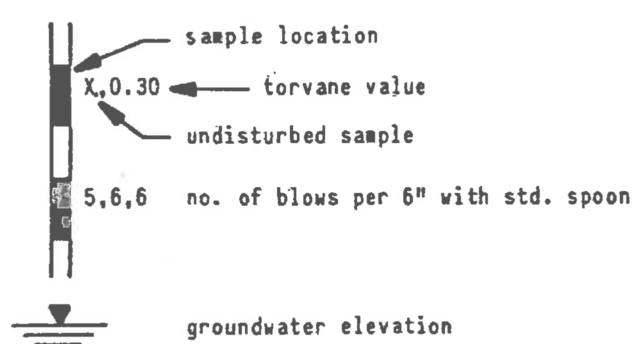
Figure No. 5





Depth	Permeability (ft/yr)
0'-6'	1203
6'-9'	2494
9'-15'	5550
15'-20'	4648
20'-25'	4648
25'-30'	4648
30'-35'	930
35'-40'	23
40'-48'	8.2
48'-58'	6.9

LEGEND



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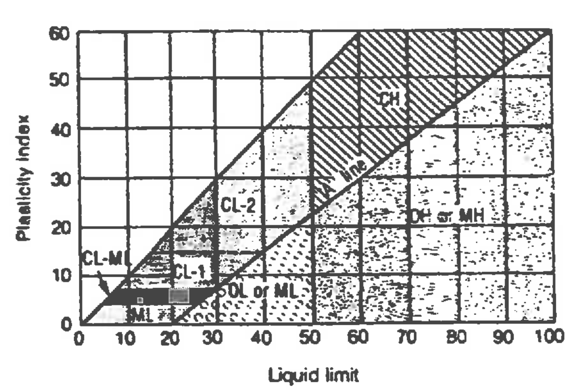
Log of Borings for:
UP&L Waste Rock Storage Facility
Emery County

Figure No. 6

Unified Soil Classification System

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria	
Course-grained Soils: More than half of material is *larger* than No. 200 sieve	Gravels: More than half of coarse fraction is larger than No. 4 sieve size	Clean Gravels (Little or no fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	Determine percentage of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5% ..... GW, GP, SW, SP; More than 12% ..... GM, GC, SM, SC; 5% to 12% ..... *Borderline* cases requiring use of dual symbols**	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW
		Gravels with fines (Appreciable amount of fines)	GM* d / u	Silty gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits below "A" line, or PI less than 4 — Above "A" line with PI between 4 and 7 are *borderline* cases requiring uses of dual symbols
			GC	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, or PI greater than 7
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size	Clean Sands (Little or no fines)	SW	Well graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly graded sands, gravelly sands, little or no fines.		Not meeting all gradation requirements for SW
		Sands with fines (Appreciable amount of fines)	SM* d / u	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line, or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring uses of dual symbols
			SC	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits above "A" line, or PI greater than 7
Fine-grained Soils: More than half of material is *smaller* than No. 200 sieve	Silt and Clays: Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity		
			CL 1 / 2	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silt-clays of low plasticity		
	Silts and Clays: Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
Highly Organic Soils			Pt	Peat and other highly organic soils		

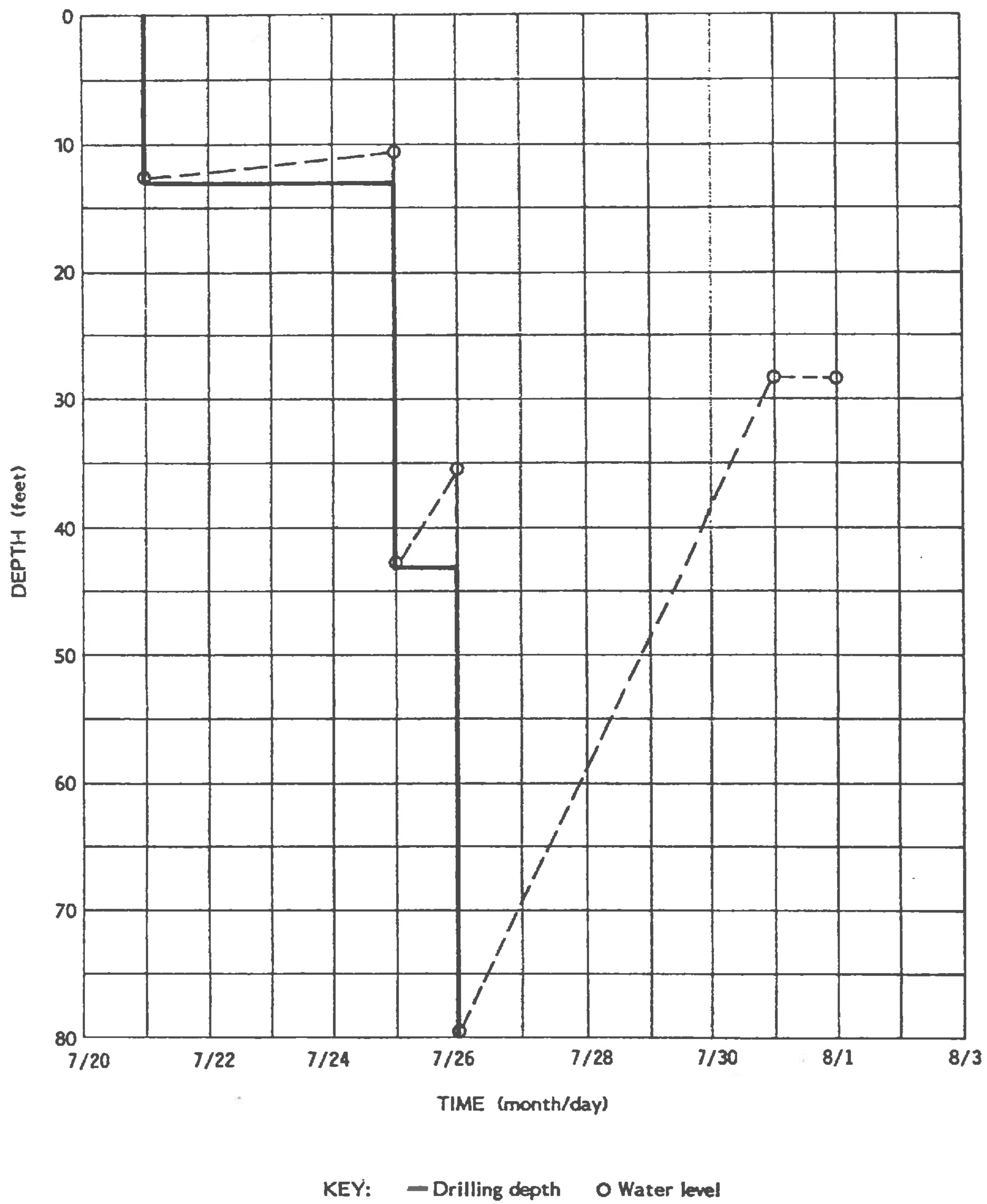


Plasticity Chart
For laboratory classification of fine-grained soils

*Division of GM and SM groups into subdivisions of d and u for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when liquid limit is 28 or less and the PI is 6 or less, the suffix u used when liquid limit is greater than 28.

***Borderline classification:* Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.

Figure No. 7



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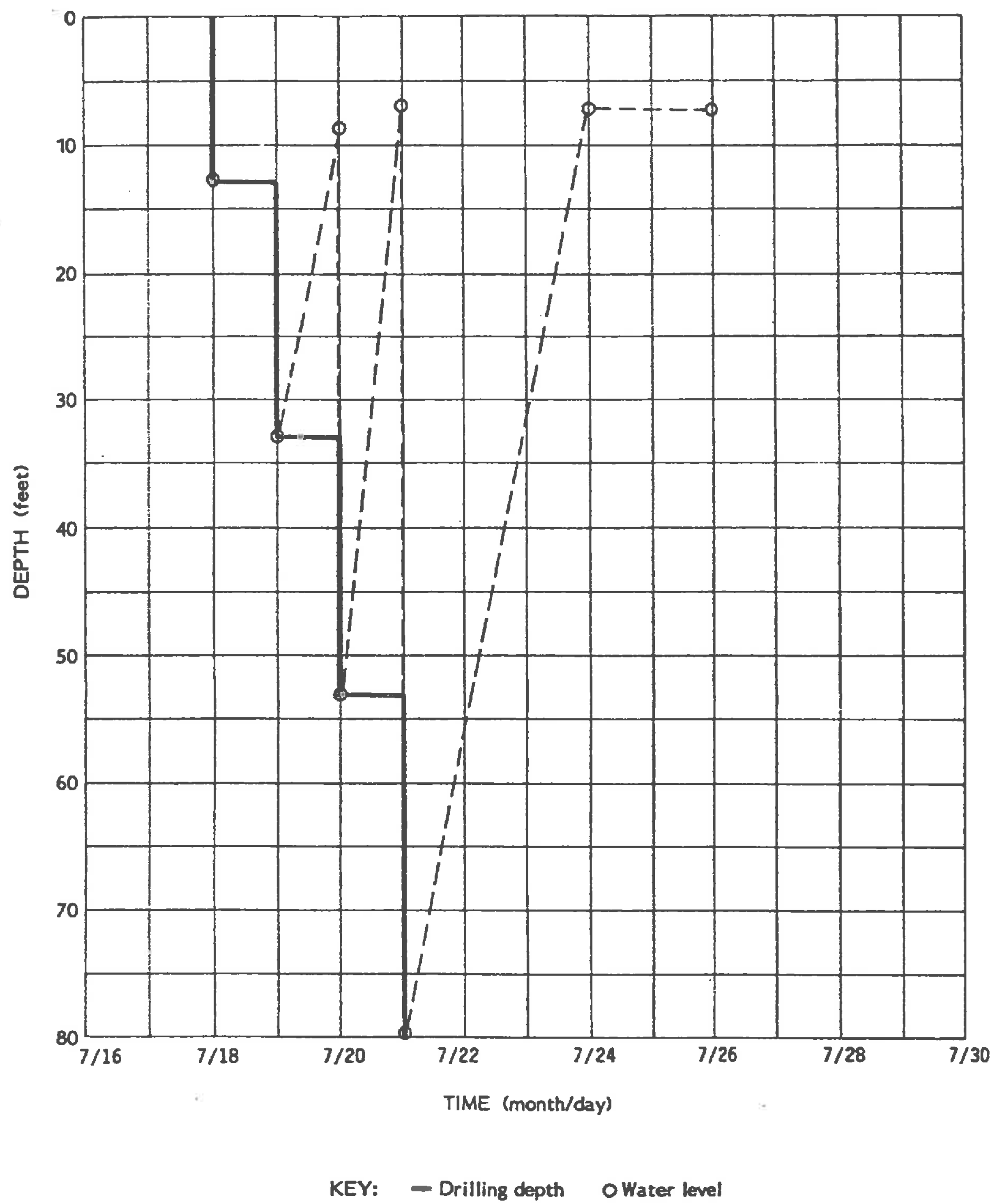
WATER LEVEL RECOVERY
DRILL HOLE NO. 1
UP&L Waste Rock Storage Facility
Emery County

FIGURE NO. 8



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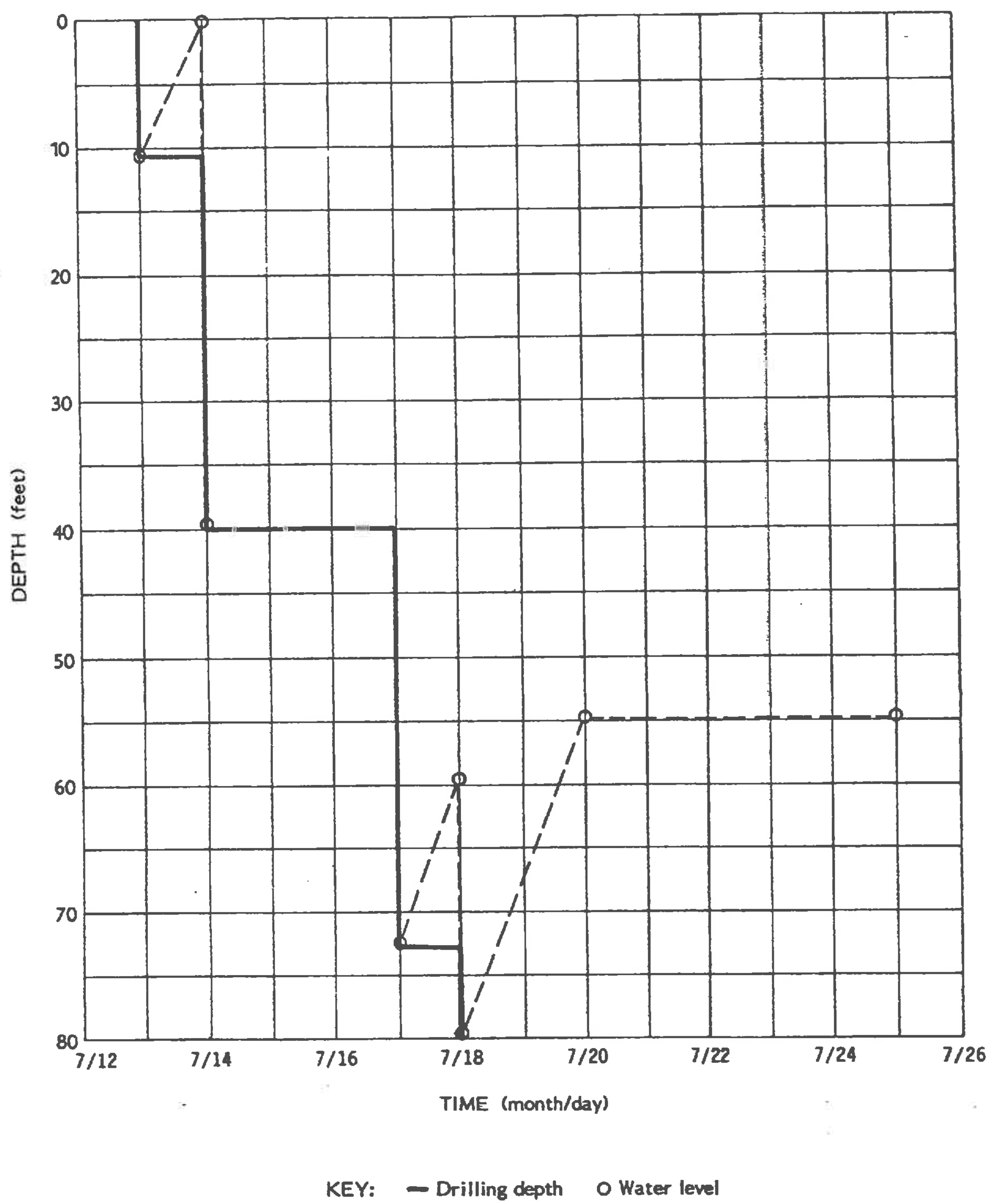
WATER LEVEL RECOVERY
DRILL HOLE NO. 2
UP&L Waste Rock Storage Facility
Emery County

FIGURE NO. 9



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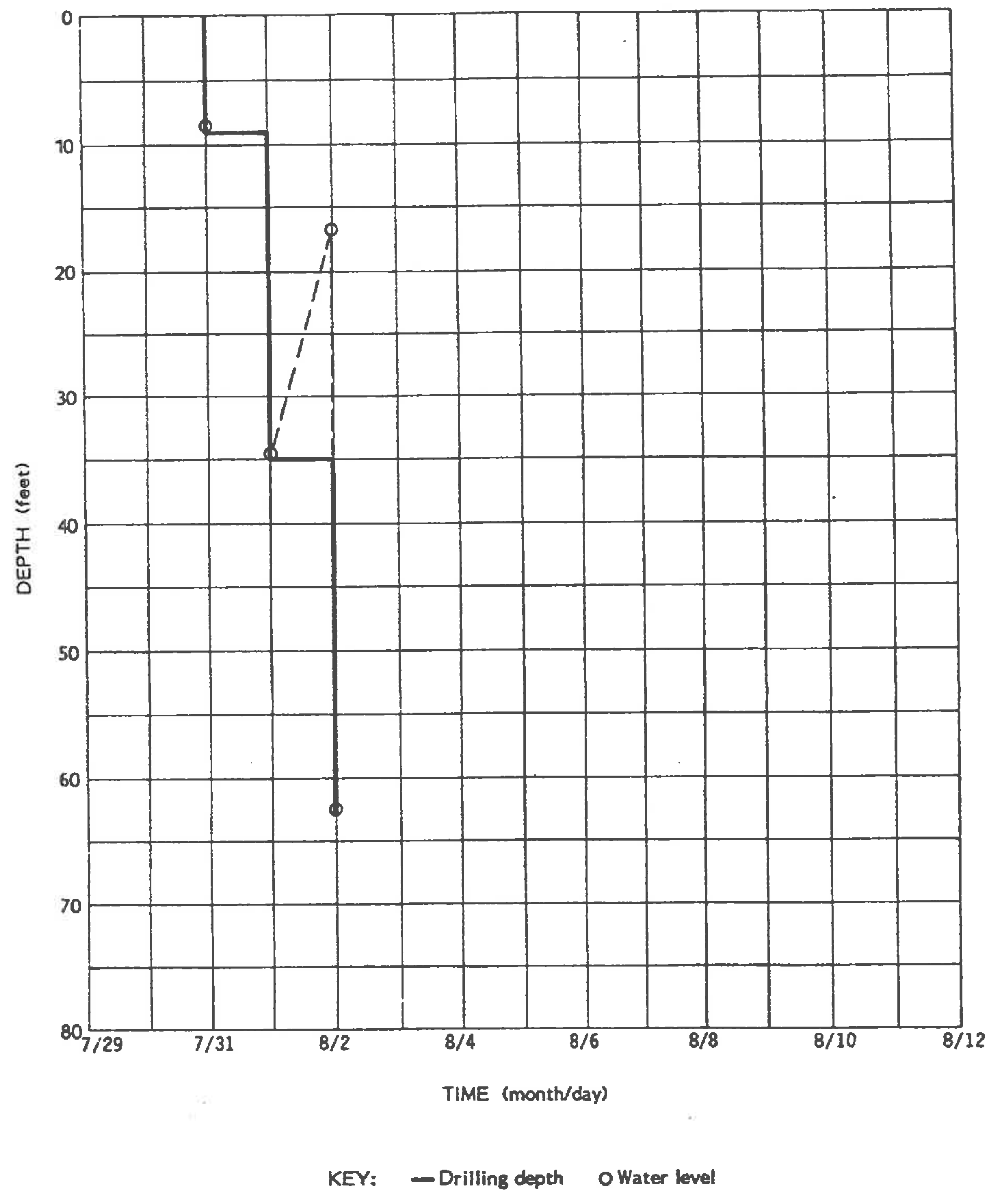
WATER LEVEL RECOVERY
DRILL HOLE NO. 3
UP&L Waste Rock Storage Facility
Emery County

FIGURE NO. 10



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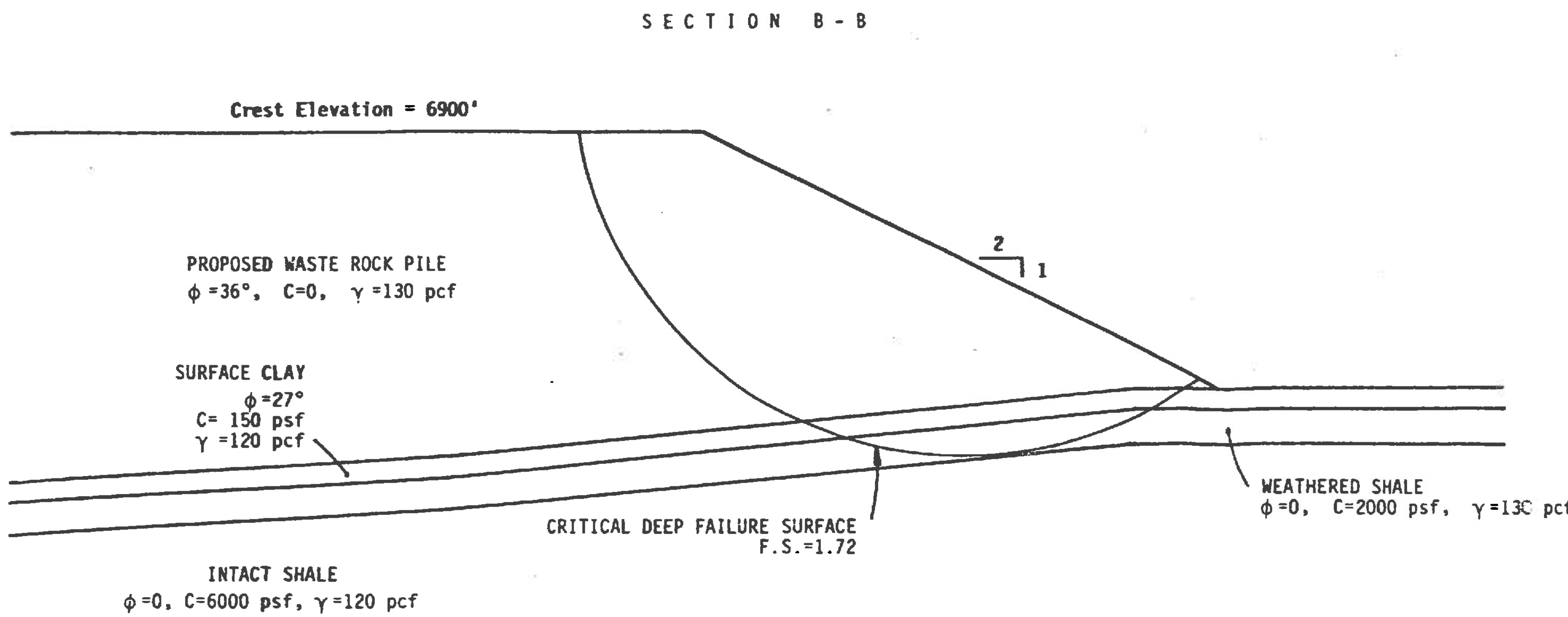
WATER LEVEL RECOVERY
DRILL HOLE NO. 4
UP&L Waste Rock Storage Facility
Emery County

FIGURE NO. 11



SHALLOW FAILURE CIRCLES THROUGH EMBANKMENT

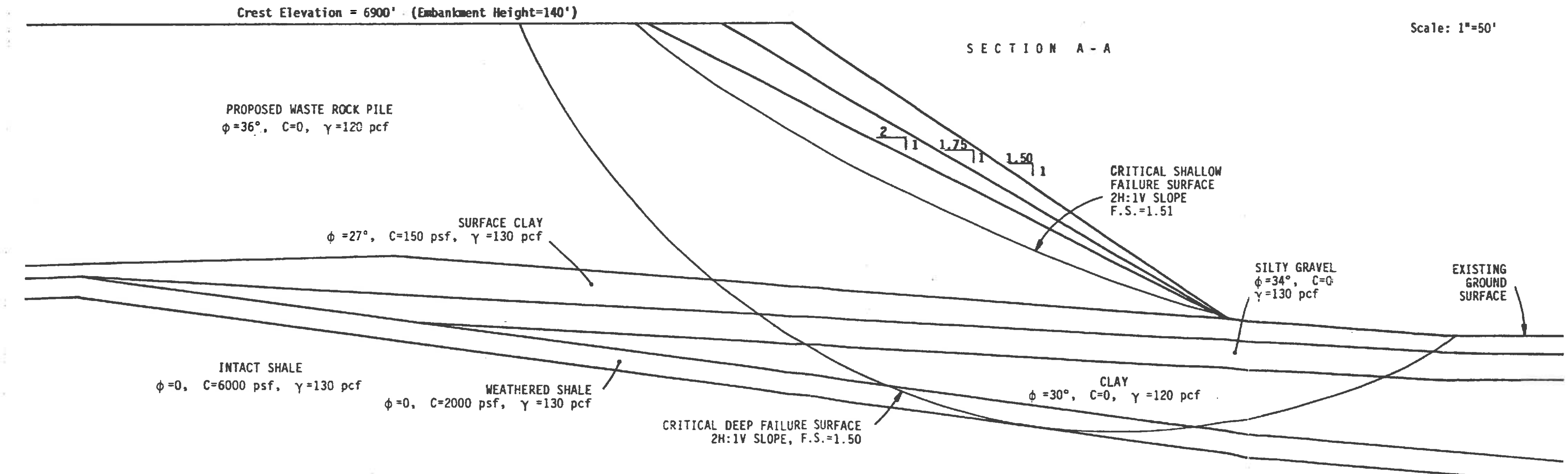
Case	Section	Slope	Embank. hgt.	F.S.
1	AA	2.00H:1V	140'	1.51
2	AA	1.75H:1V	140'	1.34
3	AA	1.50H:1V	140'	1.16

DEEP FAILURE CIRCLES

Case	Section	Slope	Embank. hgt.	F.S.
4	AA	2.00H:1V	140'	1.36
5	AA	2.00H:1V	100'	1.51
6	BB	2.00H:1V	140'	1.72

Notes: 1. Perched water table assumed 5' above base of surface clay layer
2. Static water table assumed 10' above intact clay layer

Scale: 1"=50'



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UP&L Waste Rock Storage Facility
Emery County

STABILITY ANALYSIS

FIGURE 12

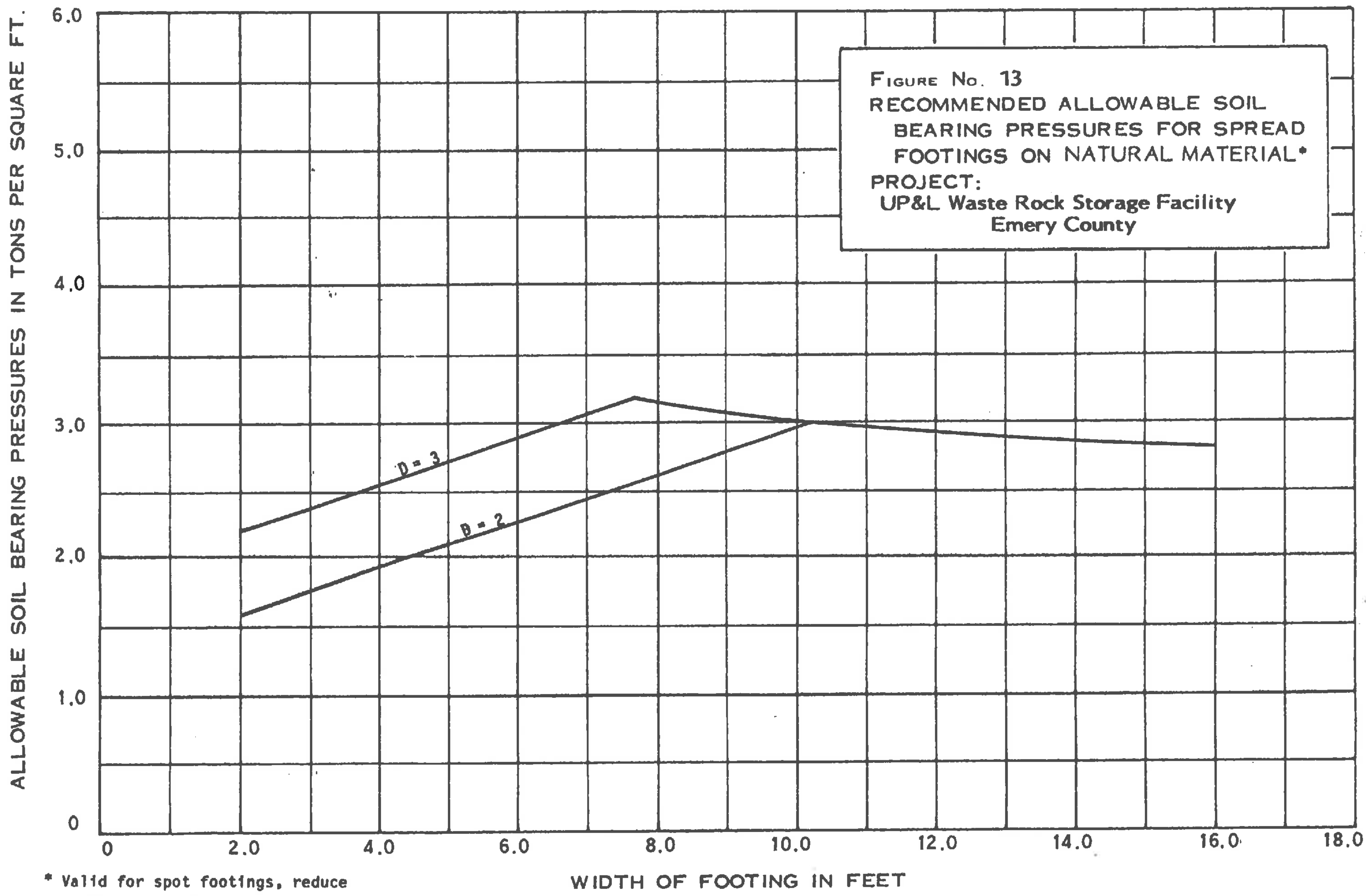

FIGURE No. 13
RECOMMENDED ALLOWABLE SOIL BEARING PRESSURES FOR SPREAD FOOTINGS ON NATURAL MATERIAL*
PROJECT:
UP&L Waste Rock Storage Facility
Emery County

* Valid for spot footings, reduce by 20 percent for continuous footings.

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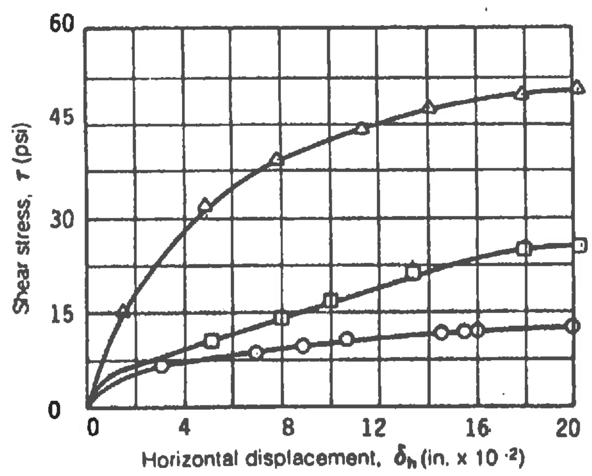

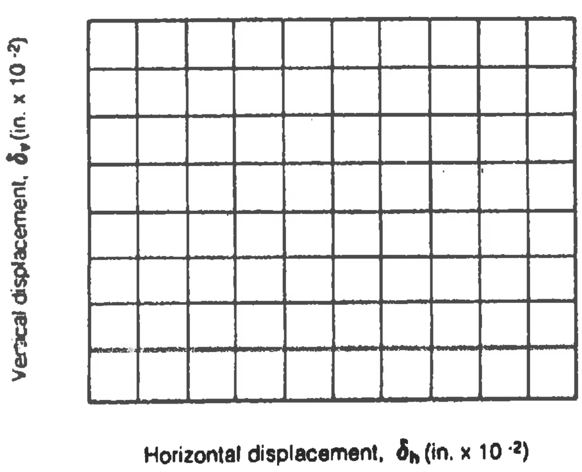

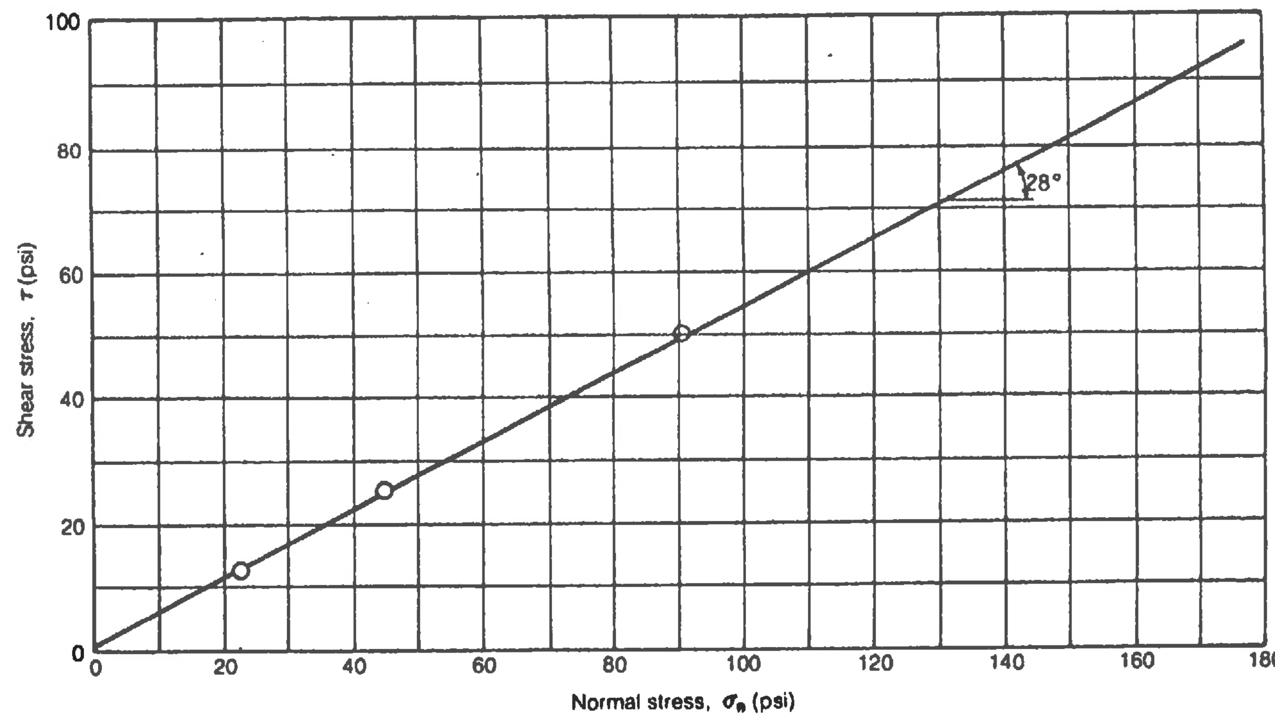

Test no. or symbol	Sample size (inches)	Sample data: Dry density (pcf)	Sample data: Moisture content (%)	Degree of saturation (%)	Normal stress σ_n (psi)	Maximum shear stress τ (psi)	Strain rate (inches / minute)	Shear strength parameters: Friction angle ϕ (degrees)	Shear strength parameters: Cohesion (c / psi)
○	2.375	101.7	10.9	100	22.2	12.5	0.001	28°	1
□	2.375	102.6	12.9	100	44.6	25.3	0.001		
△	2.375	100.4	12.2	100	90.1	50.3	0.001		

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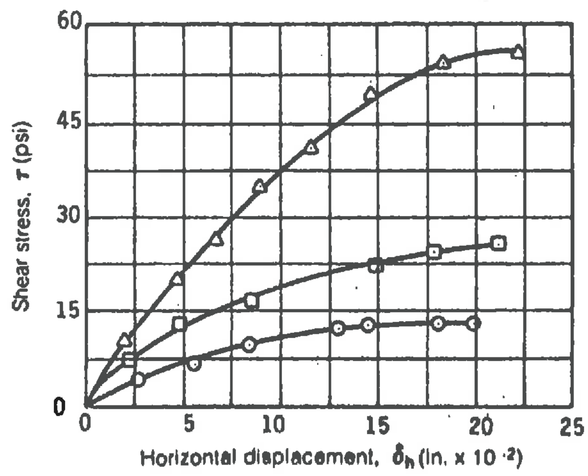
DIRECT SHEAR TEST

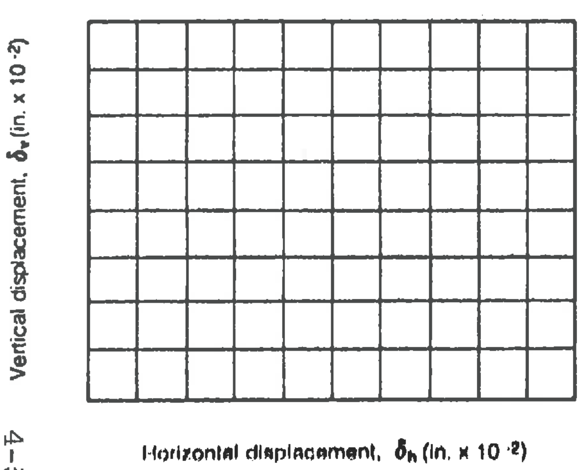
Project: UP&L Waste Rock Storage Facility
Emery County

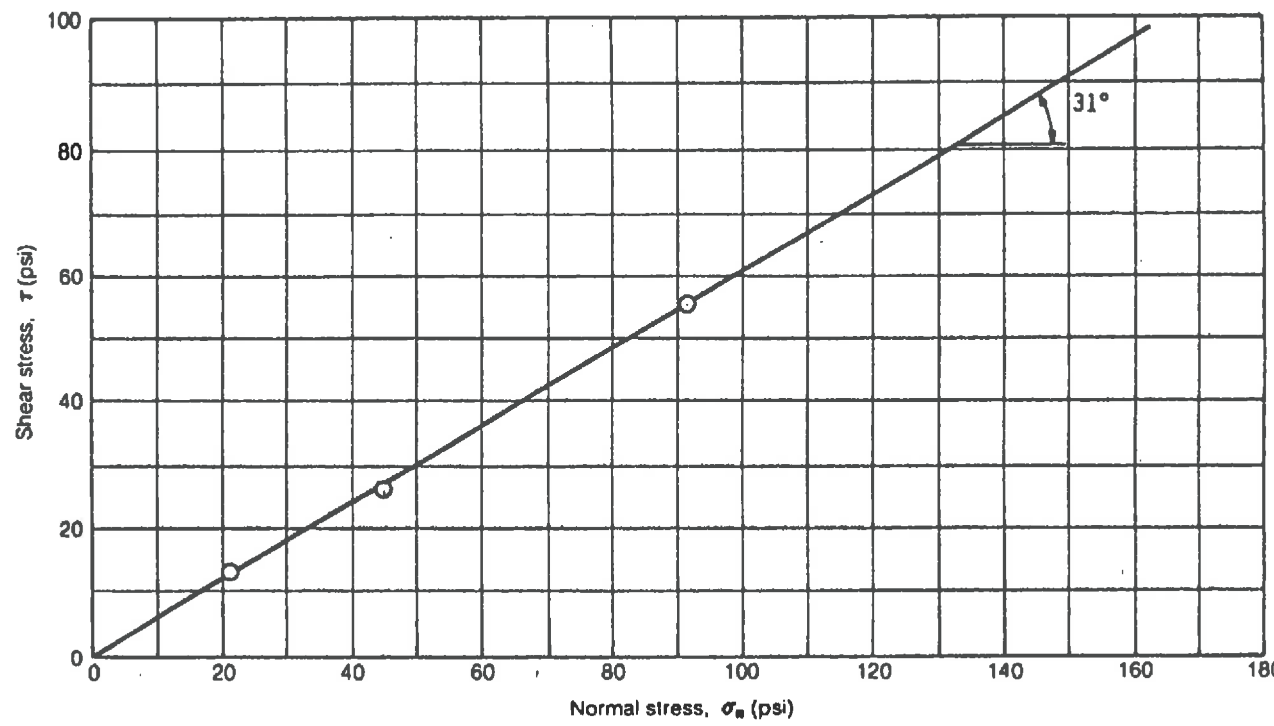
HOLE NO. 3

DEPTH: 7.5'-9.0'

FIGURE NO. 14







Test no. or symbol	Sample size (inches)	Sample data		Degree of saturation (%)	Normal stress σ_n (psi)	Maximum shear stress τ (psi)	Strain rate (inches / minute)	Shear strength parameters	
		Dry density (pcf)	Moisture content (%)					Friction angle φ (degrees)	Cohesion (c / psi)
○	2.375	119.0	10.9	100	21.1	9.98	0.001	31°	0
□	2.375	113.0	13.1	100	44.7	25.80	0.001		
△	2.375	112.2	11.4	100	91.2	55.5	0.001		

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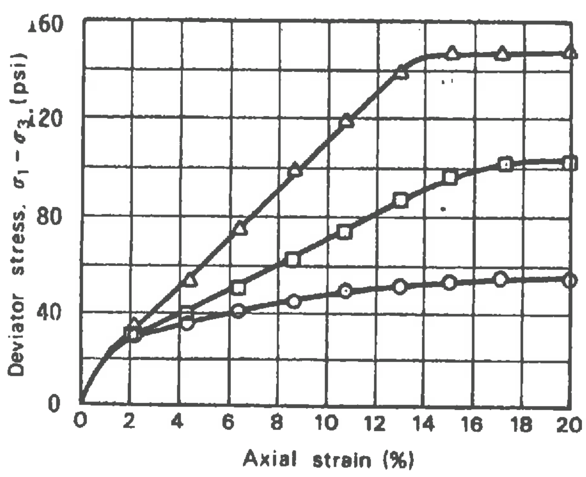
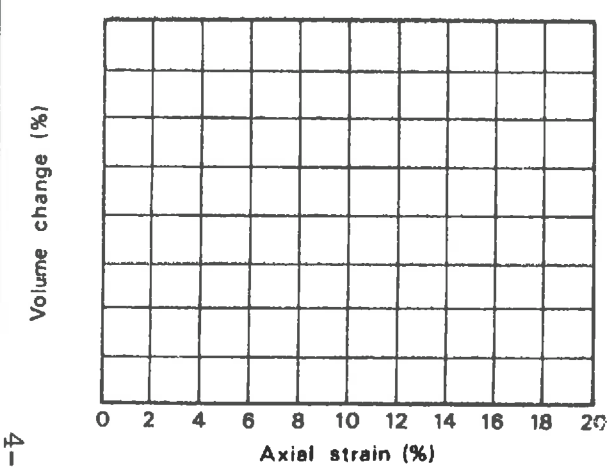
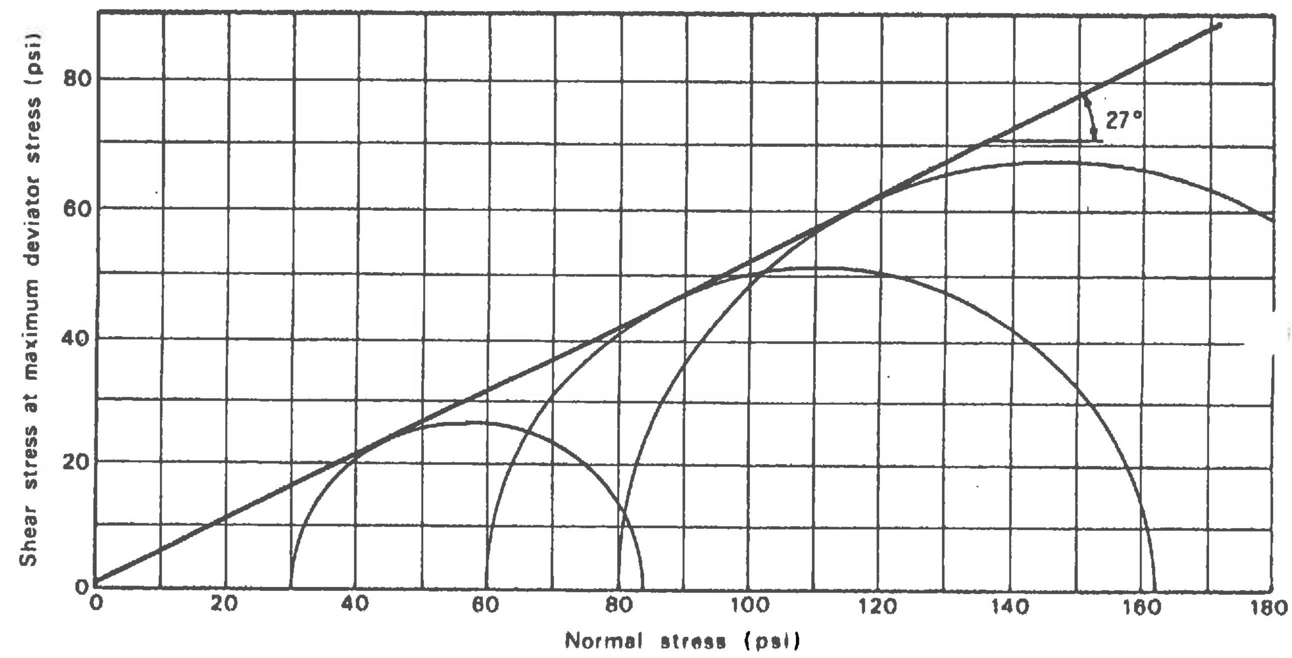
DIRECT SHEAR TEST
Project: UP&L Waste Rock Storage Facility
Emery County

HOLE NO. 3
DEPTH: 40'-41.5'

FIGURE NO. 15







Test no. or symbol	Boring no. or depth	Sample data		Degree of saturation (%)	Confining pressure (psi)	Maximum deviator stress (psi)	Strength values at failure		Sample size, L/D (inches)	Strain rate (inches/minut
		Dry density (pcf)	Moisture content (%)				Friction angle φ (degrees)	Cohesion (c/psi)		
○		108.6	9.4	100	30	54	27°	1	2.8/1.32	.0029
□		109.4	10.2	100	60	102	27°	1	2.8/1.32	.0029
△		107.4	11.4	100	80	147	27°	1	2.8/1.32	.0029

4-58

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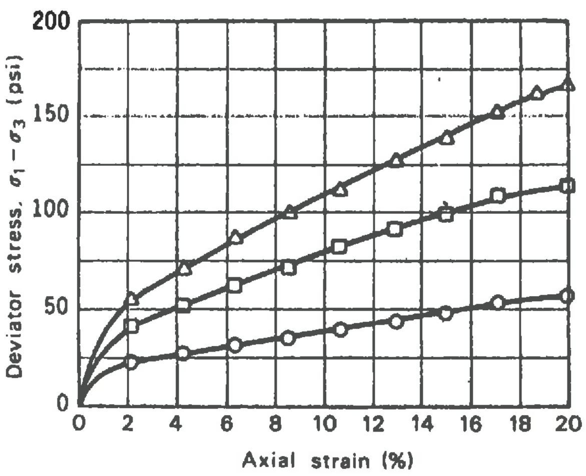
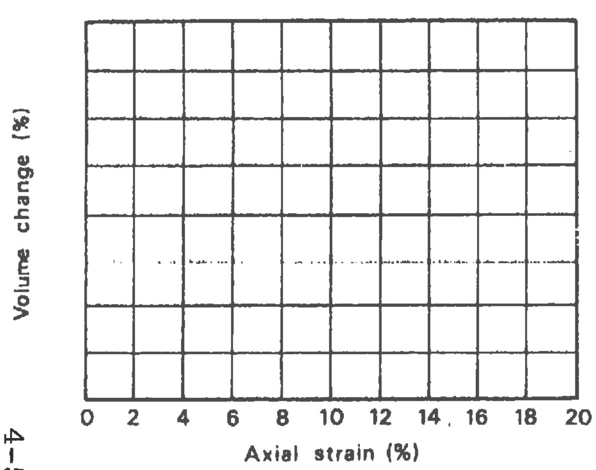
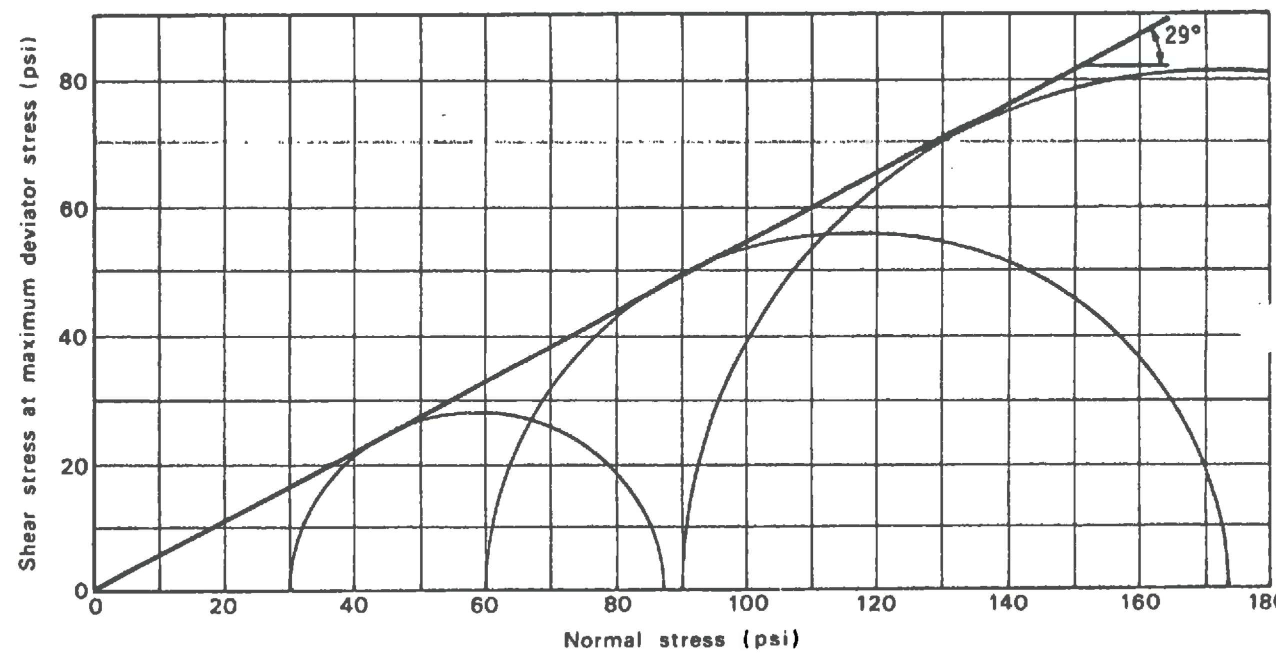
TRIAXIAL SHEAR TEST
Project: UP&L Waste Rock Storage Facility
Emery County

HOLE NO. 3
DEPTH: 25'-26.5'

FIGURE NO. 16







Test no. or symbol	Boring no. or depth	Sample data		Degree of saturation (%)	Confining pressure (psi)	Maximum deviator stress (psi)	Strength values at failure		Sample size, L/D (inches)	Strain rate (inches/minut
		Dry density (pcf)	Moisture content (%)				Friction angle φ (degrees)	Cohesion (c/psi)		
○		107.2	8.4	100	30	57	29.2°	0	2.8/1.32	.0029
□		108.1	9.7	100	60	114	29°	0	2.8/1.32	.0029
△		109.4	10.9	100	90	166	29°	0	2.8/1.32	.0029

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PROFESSIONAL ENGINEERS

TRIAXIAL SHEAR TEST

Project: UP&L Waste Rock Storage Facility
Emery County

HOLE NO. 3
DEPTH: 30'-31.5'

FIGURE NO. 17

Table No. 1 SUMMARY OF TEST DATA

Project UP&L Waste Rock Storage Facility Feature Foundations Location Emery County, Utah

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE			UNCONFINED COMPRESSIVE STRENGTH (lb/ft²)	FRICTION ANGLE φ	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			UNIFIED SOIL CLASSIFICATION SYSTEM
			Dry Unit Weight (lb/ft³)	Moisture (%)	Void Ratio			L.L (%)	P.L. (%)	P.I (%)	% Gravel	% Sand	% Silt & Clay	
1	3-4.5'	118						31	18	13				CL-1
	18.0'					3108								
	26.0'					2940								
	36.0'					2326								
	46.0'					2400								
2	3-4.5'	90						27	16	11				CL-1
	9.0'					2475								
	18.0'					2587								
	26.0'					2717								
3	3-4.5'	37/5",50/45									44.8	36.5	18.7	GM
	6-7.5'	47									34.4	48.2	17.4	GM
	7.5-9'							21	18	3				ML
	9-10.5'	37/6, 60/5									40.0	33.7	26.3	GM
	12-13.5'	72									39.3	37.9	22.8	GM
	15-16.5'	75						21	19	2				
	20-21.5'										40.3	37.4	22.3	

Table No. 1 SUMMARY OF TEST DATA

Project UP&L Waste Rock Storage Facility Feature Foundations Location Emery County, Utah

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE Dry Unit Weight (lb/ft³)	IN-PLACE Moisture (%)	IN-PLACE Void Ratio	UNCONFINED COMPRESSIVE STRENGTH (lb/ft²)	FRICTION ANGLE ϕ	CONSISTENCY LIMITS L.L. (%)	CONSISTENCY LIMITS P.L. (%)	CONSISTENCY LIMITS P.I (%)	MECHANICAL ANALYSIS % Gravel	MECHANICAL ANALYSIS % Sand	MECHANICAL ANALYSIS % Silt & Clay	UNIFIED SOIL CLASSIFICATION SYSTEM
3	25-26.5'							21	19	2				ML
	30-31.5'							19	15	4				ML
	35.5-37'							19	18	1	11.1	40.4	48.5	ML
4	3-4.5'										25.4	60.3	14.3	
	6-7.5'										23.5	58.3	18.2	
	9-10.5'										49.7	41.4	8.9	
	12-13.5'										53.1	32.9	14.0	

September 29, 1989

ROLLINS, BROWN and GUNNELL, INC. professional engineers

Utah Power & Light Company Mining Division
P.O. Box 310
Huntington, UT 84528

ATTN: Tom Faucheux

Gentlemen:

In accordance with your request we have completed the soil testing on four samples for the Waste Rock Storage Facility near the Wilberg Mine in Emery County, Utah. These tests included moisture density tests, laboratory permeability tests, and direct shear tests. The results of the moisture density tests are presented in Figures No. 1 & 2. It will be noted that the material used in the sample defined by Figure No. 1 was a combined sample of samples 1 & 2. The test result shown in Figure No. 2 is a combined sample of samples 3 & 4. It will be observed that the in-place density varied from 118.8 to 123.8 while the optimum moisture content varied from 12.5 percent to 11.6 percent.

The results of the laboratory permeability tests are tabulated below as follows:

Sample Number	Permeability Coefficient (ft/year)
Samples 1 & 2 Combined	0.90
Samples 3 & 4 Combined	0.55

The results of the direct shear tests are presented in Figure Nos. 3 and 4. It will be noted that Figure No. 3 corresponds to Samples 1 and 2 combined while Figure No. 4 corresponds to Samples 3 and 4 combined. It will be noted that Samples 1 and 2 combined had a cohesion of 7 psi and friction angle of 32.7 degrees. Samples 3 and 4 combined has a cohesion of 3 psi and a friction angle of 26.6 degrees. It should be noted that all of the direct shear tests were performed under consolidated drain condition.

Yours truly,

ROLLINS, BROWN AND GUNNELL, INC.

Ralph L Rollins

Ralph L. Rollins, P.E.

Enclosures

1435 WEST 820 NORTH
POST OFFICE BOX 711
PROVO, UTAH 84603

PROVO 374-5771
SALT LAKE CITY 521-5771
AREA CODE 801

ROLLINS, BROWN and GUNNELL, INC. professional engineers
1435 WEST 820 NORTH
POST OFFICE BOX 711
PROVO, UTAH 84603
(801) 374-5771 Provo
(801) 521-5771 SLC

SOIL MOISTURE DENSITY RELATIONSHIP

Project: UP&L Mining Division Waste Rock Storage Facility
Project no. 8901-075
Feature: Sand Silt
Test date: 9-14-89
Job technician: N. Jensen /T. Breakfield
Mailing date: 9-26-89

ASTM D 1557-78
Maximum dry density = 123.8 lbs/ft³
Optimum moisture = 11.6 %

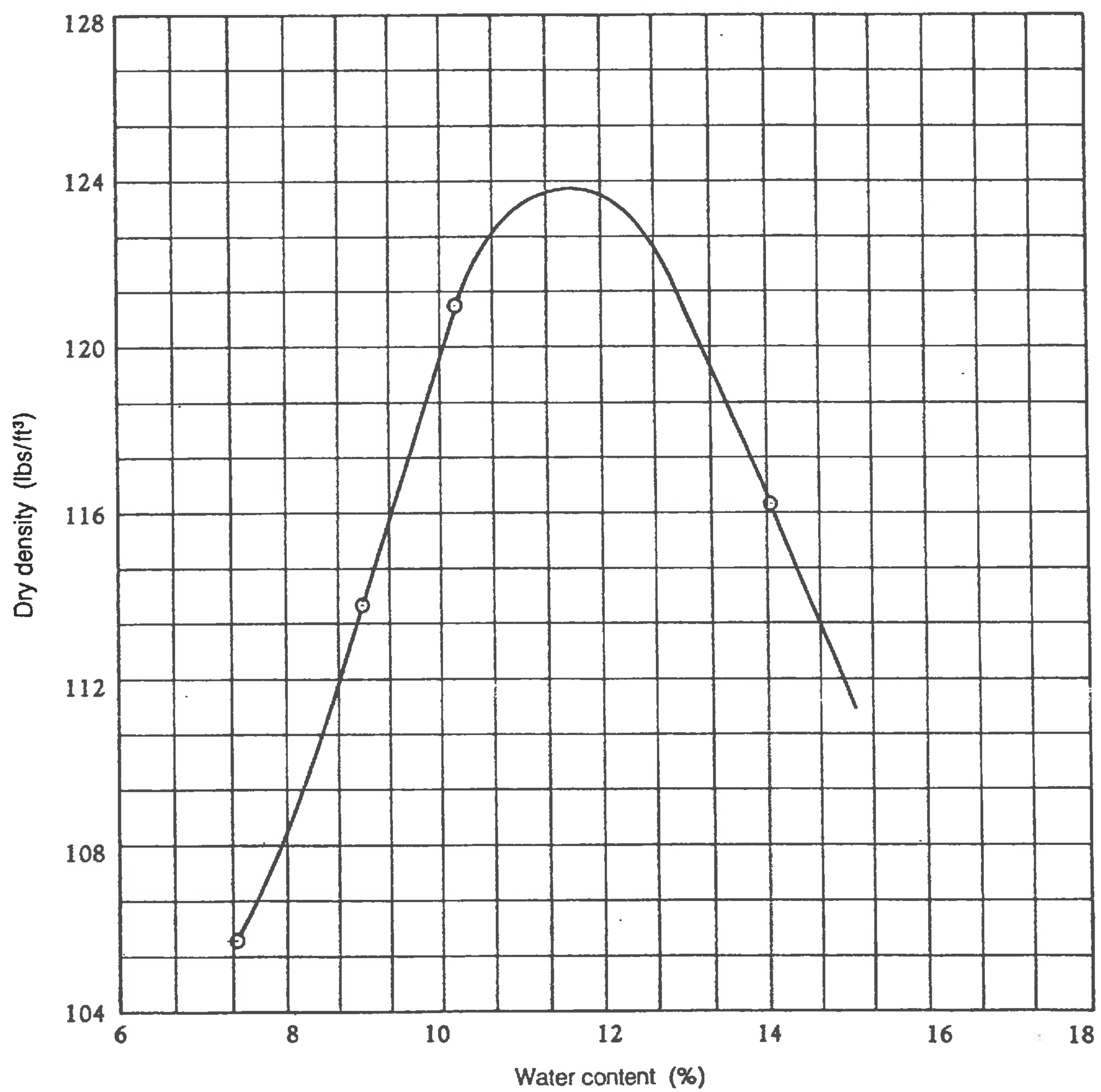


Figure No. 1

ROLLINS, BROWN and GUNNELL, INC. professional engineers
1435 WEST 820 NORTH
POST OFFICE BOX 711
PROVO, UTAH 84603
(801) 374-5771 Provo
(801) 521-5771 SLC

SOIL MOISTURE DENSITY RELATIONSHIP

Project: UP&L Waste Rock Storage Facility
Project no.: 8901-075
Feature: Dark Brown Silt
Test date: 9-22-89
Job technician: N. Jensen
Mailing date: 9-29-89

ASTM D 1557-78
Maximum dry density = 118.8 lbs/ft³
Optimum moisture = 12.5 %

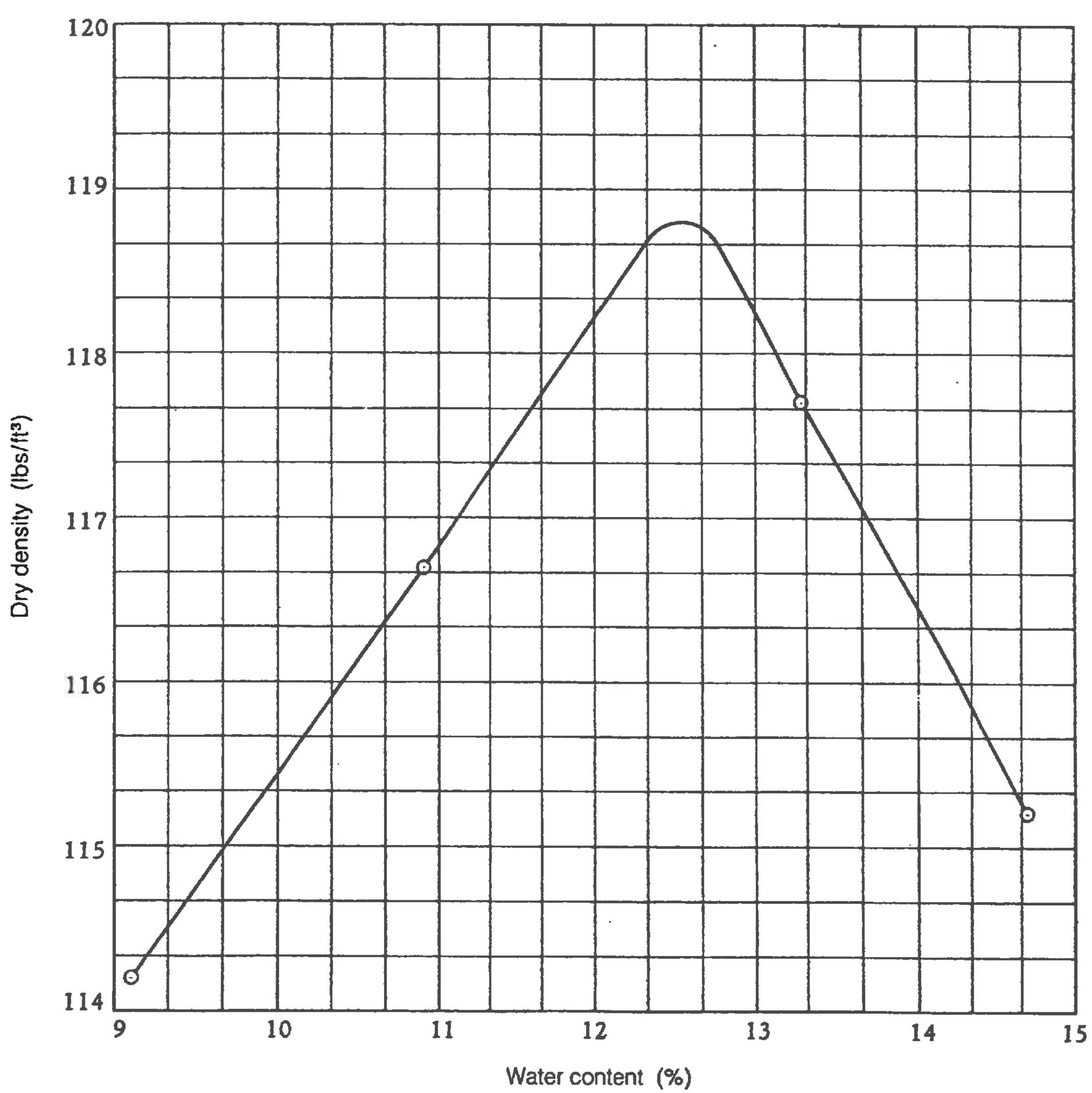
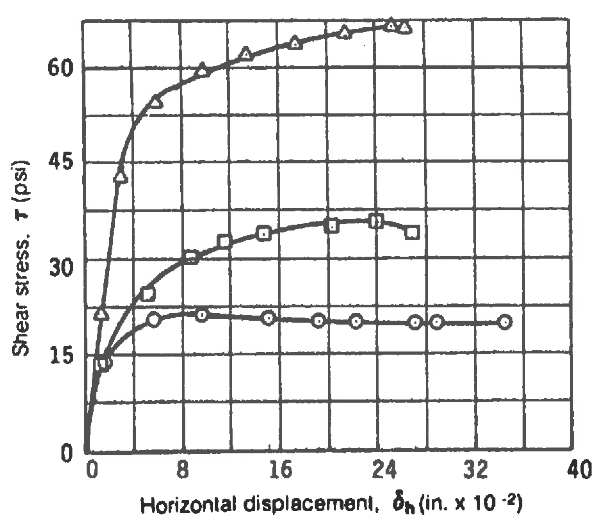
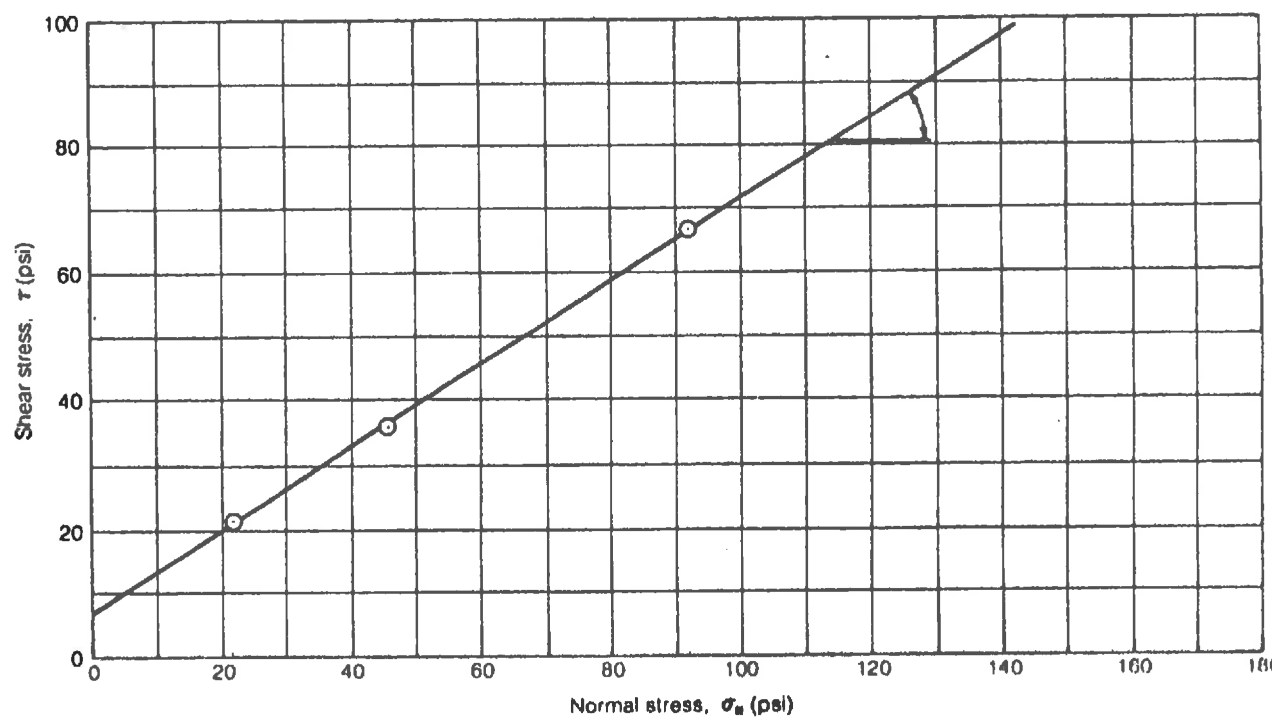
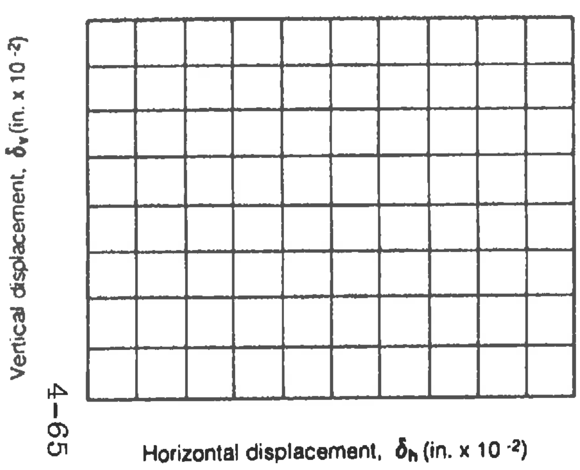


Figure No. 2







Test no. or symbol	Sample size (inches)	Sample data: Dry density (pcf)	Sample data: Moisture content (%)	Degree of saturation (%)	Normal stress σ_n (psi)	Maximum shear stress τ (psi)	Strain rate (inches / minute)	Shear strength parameters: Friction angle φ (degrees)	Shear strength parameters: Cohesion (c / psi)
		117.5	11.6		21.6	20.0		32.7	7
		117.5	11.6		45.6	35.5			
		117.5	11.6		91.9	66.7			

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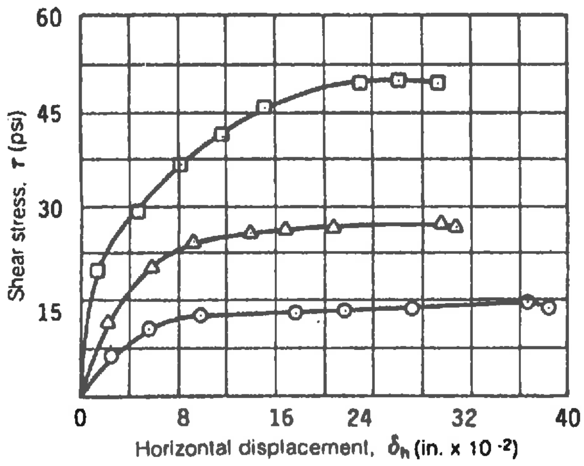
DIRECT SHEAR TEST

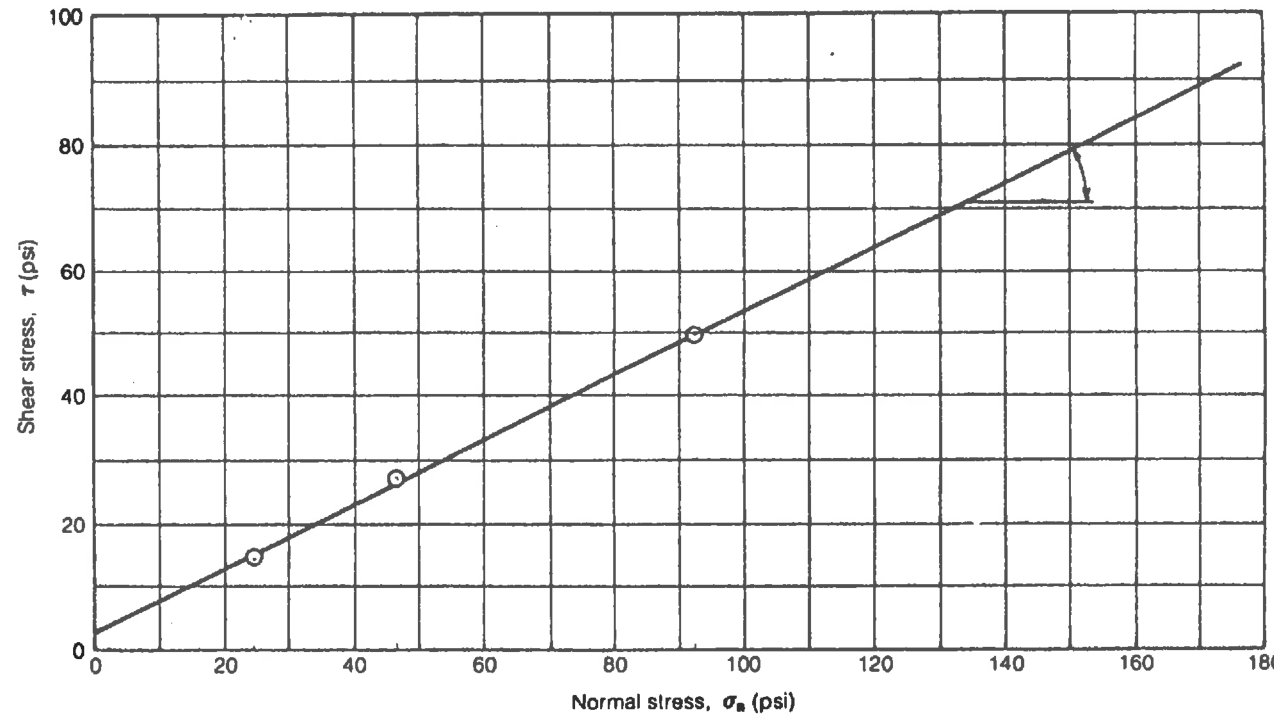
Project: UP&L Waste Rock Storage Facility

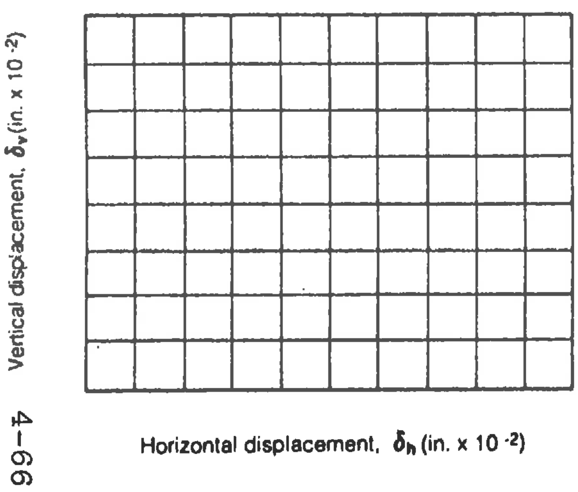
HOLE NO. Samples 1 & 2 Combined

DEPTH: samples taken from Side of valley

FIGURE NO. 3







Test no. or symbol	Sample size (inches)	Sample data: Dry density (pcf)	Sample data: Moisture content (%)	Degree of saturation (%)	Normal stress σ_n (psi)	Maximum shear stress τ (psi)	Strain rate (inches / minute)	Shear strength parameters: Friction angle ϕ (degrees)	Shear strength parameters: Cohesion (c / psi)
○		112.7	12.3		24.7	14.5		26.6	3
△		112.5	12.4		46.6	27.2			
□		112.7	12.3		92.4	50.0			

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PROFESSIONAL ENGINEERS

DIRECT SHEAR TEST

Project: UP&L Waste Rock Storage Facility

HOLE NO. Samples 3 & 4 Combined

DEPTH: Taken from Valley Floor

FIGURE NO. 4

STABILITY ANALYSIS

COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY

Emery County, Utah

October 1992

RB&G ENGINEERING INC.

October 2, 1992

RB&G
ENGINEERING
INC.
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PROVO, UT 84601-1343
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801 521-5771 SLC

Greg Cowan
Energy West Mining Co.
P.O. 310
Huntington, UT 84528

Dear Greg:

In accordance with your request, we have completed a slope stability study for the Waste Rock Pile at the Cottonwood/Wilberg Coal Mine in Emery County, Utah. The purpose of the investigation was to determine the stability of the proposed rock fill slope when the structure has reached the finished height. The investigation has been performed in accordance with a written proposal submitted to you for the work, and the results of the investigation are outlined in the following sections of this report. The information contained in the report is discussed under the following headings: (1) Existing Site Conditions, (2) Subsurface Soil and Water Conditions, (3) The Results of Laboratory Tests, (4) Slope Stability Considerations, and (5) Summary and Conclusions.

1. EXISTING SITE CONDITIONS

The existing waste rock pile is located several miles down slope from the existing Cottonwood/Wilberg Coal Mine. Figure 1 is a contour map showing the area where the waste rock pile is located. This map defines the topography of the area as it presently exists. A steep cliff is located on the north and northwest of the site. A ridge is located along the easterly side of the site, and a sedimentation pond is located downstream from the face of the waste rock pile. It will be observed that the embankment on the downstream side of the sedimentation pond is approximately 20 feet high, and that at the present time, the face of the existing rock pile is about 25 feet high. The location of drainage ditches directing the water towards the sedimentation pond is shown in Figure 1. It appears that the maximum depth of refuse in the rock pile at the present time is about 25 feet.

Figure 2 shows the contours defining the finished rock pile, and it will be observed that the rock pile reaches an elevation of 6855 feet with respect to the site datum. The bottom of the sedimentation pond is at approximately elevation 6755. This means that when the rock pile is finished, the total height of the embankment at the

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sedimentation pond will be about 100 feet. The contour map also indicates that the slope of the waste rock pile near the sedimentation pond is about 2 horizontal to 1 vertical. The material within the refuse pile consists of coal intermixed with angular rock fragments. The coal breaks down rapidly to form a significant percentage of fine grained material intermixed with the gravel size particles. From a textural standpoint, the coal refuse classifies as SM- or GM-type materials.

Water accumulated in the sedimentation pond from time to time from the drainage system, and some small amount of saturation of the rock pile may occur when water backs up in the sedimentation pond. The drainage ditches around the pond appear to intercept any water flowing off of the high ground to the north and northwest so that the only water which reaches the surface of the waste rock pile is the natural precipitation.

2. *SUBSURFACE SOIL AND WATER CONDITIONS*

A subsurface investigation was performed to define the characteristics of the existing rock pile material. Four test pits extending to depths of approximately 12 feet were excavated throughout the area at the locations shown in Figure 1. The logs for these four test pits are presented in Figures 3 and 4. During the subsurface investigation, sampling was performed at 3- to 4-foot intervals at locations shown on the test pit logs. The in-place unit weight and the natural moisture content was determined at each sampling location and the results of these tests are shown on the test pit logs. It will be observed that considerable variation occurred in the in-place unit weight of the refuse material. The dry unit weight varied from about 77.5 to 100.5 pcf. Weathered shale was encountered in Test Pit 1 at a depth of 11 feet below the existing ground surface. Previous drilling in the waste rock pile area by our organization indicates that the shale extends to a substantial depth below the original ground surface.

The test pits were supplemented by drilling three test holes to depths varying from 25 to 31.5 feet. The logs for the three test borings are presented in Figures 5 and 6. The location where the three test holes are located are presented in Figure 1. It should be noted that at the time the drilling was performed, the entire area near the downstream face of the rock pile was covered with large piles of coal refuse. This condition generally necessitated clearing a road through the refuse material to provide access to drilling and test pit sites. It will be observed that Drill Holes 1, 2 and 3 nearly form a straight line. Based upon the three test borings, it appears that the hard gray shale was encountered at a depth of about 18 to 20 feet below the surface of the waste rock pile at the time the drilling was performed.

During the drilling operations, field permeability tests were performed in the bore holes at five to ten-foot intervals. The field permeability tests were performed in accordance with Designation E-18 of the U.S. Bureau of Reclamation Earth Manual. The results of these tests are shown in Figures 5 and 6. It will be observed that the permeability of the coal material was

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relatively high; however, the shale underlying the waste coal material was essentially impervious. This means that any water accumulating in the waste rock pile will move towards the sedimentation pond. Since the main source of water reaching the surface of the waste rock pile will be natural precipitation, it appears unlikely that the waste rock pile will ever be saturated. It is our opinion that the amount of water existing above the shale surface will not be more than a few feet.

During the subsurface investigation, sampling in the drill holes was performed at three-foot intervals throughout the depth investigated. Samples were obtained by driving a 2-inch split spoon sampling tube through a distance of 18 inches using a 140-pound weight dropped from a distance of 30 inches. The number of blows to drive the sampling spoon through each 6 inches of penetration is shown on the boring logs. The sum of the last two blow counts, which represents the number of blows to drive the sampling spoon through 12 inches, is defined as the standard penetration value. The standard penetration value provides a good indication of the in-place density of sandy material; however, it only provides an indication of the relative stiffness of the cohesive material, since the penetration resistance of materials of this type is a function of the moisture content. Considerable care must be exercised in interpreting the standard penetration value in gravelly-type soils, particularly where the size of the granular particle exceeds the inside diameter of the sampling spoon. If the spoon can be driven through the full 18 inches with a reasonable core recovery, the standard penetration value provides a good indication of the in-place density of gravelly-type material. The results of the standard penetration tests indicate that considerable variation occurs in the in-place density of the refuse material.

Each sample of the refuse material obtained in the field was classified texturally according to the Unified Soil Classification System. The symbol designating the type of material according to this system, is presented on the boring logs. A description of the Unified Soil Classification System is presented in Figure 7, and the meaning of the various symbols shown on the boring logs can be obtained from this figure. From a textural standpoint, the refuse material classifies as either SM- or GM-type materials. It should be noted that a thin layer of weathered shale material existed on top of the hard shale. Undisturbed samples of the weathered shale were obtained for laboratory testing.

No groundwater was encountered in any of the test holes or test pits throughout the waste rock pile at the time the investigation was performed, and it is our opinion that the accumulation of water above the shale will only occur to a significant extent when water accumulates in the sedimentation pond downstream from the rock pile slope.

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3. *THE RESULTS OF LABORATORY TESTS*

Laboratory tests performed on the refuse material included mechanical analyses, direct shear tests and triaxial shear tests.

A. *MECHANICAL ANALYSIS*

Two bulk samples of the coal refuse were obtained from Test Pits 1 and 3. Each sample weighed several hundred pounds, and the large size particles were separated by hand in the field. A sample of the minus #4 material was obtained by partial sieving in the field followed by a complete sieve analysis in the laboratory. The results of the particle size distribution analyses for the bulk samples are presented in Figures 8 and 9, and it will be observed that over one-half of the sample consisted of material in the gravel and cobble size range. About one-third of the sample consisted of materials in the sand size range and only 5 to 11% of the material passed a 200 sieve. Mechanical analyses were also performed on small size samples of the refuse material. The results of these tests are shown on Table 1, Summary of Test Data. It should be noted that the particle size distribution performed for the bulk samples is a much better representation of the characteristics of the refuse material than the particle size distribution data obtained from the small samples.

B. *DIRECT SHEAR TESTS*

Three consolidated drained direct shear tests were performed on the thin clay layer overlying the shale to obtain an indication of the shearing strength characteristics of this material. The undisturbed samples in the clay layer were obtained by cutting a block sample of this material in one of the test pits. The results of the direct shear tests plotted in a form of a Mohr Envelope is presented in Figure 10. The stress strain curves associated with the three direct shear tests are also presented in this figure. It will be observed that the subsurface material had a friction angle of 32° and no cohesion. The results of the direct shear tests performed on the clay layer was used in the stability analysis.

C. *TRIAXIAL SHEAR TESTS*

The results of the mechanical analyses performed on the bulk samples of the subsurface material taken from the test pits indicate that the amount of material in the sand size range was only about 30% of the total sample. In order to obtain an indication of the shearing strength of the coal refuse material, three triaxial shear tests were performed on the minus #4 material obtained from the bulk samples. Since the coal refuse appears to break down quite easily under the use of mechanical equipment, it is our opinion that the triaxial shear tests will provide a reasonable indication of the shearing strength of the

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coal refuse. The triaxial shear tests were performed under consolidated drained conditions. The permeability characteristics of the refuse material is relatively high and drainage occurs quite quickly. The results of the triaxial shear tests are plotted in the form of a Mohr Envelope in Figure 11, and it will be noted that a friction angle of 32° and no cohesion was obtained for the refuse material.

4. *SLOPE STABILITY CONSIDERATIONS*

As indicated earlier in this report, Figure 2 represents the contours throughout the waste rock pile when the proposed facility has been completed. A profile through the rock pile slope along line A-A is presented in Figure 12. It will be observed that the waste rock pile has a slope of about 2 horizontal to 1 vertical, and that a thin layer of clay exists between the waste pile refuse and the underlying shale. Field permeability tests performed during the drilling indicate that the coal refuse is relatively pervious, while the shale is relatively impervious.

Stability computations were performed for the waste rock pile at its full height and with (1) no water in either the sediment pond or the waste rock pile, (2) water in both the sedimentation pond and the waste rock pile at elevation 6770, and (3) water in the sedimentation pond at elevation 6770 and with water in the coal refuse pile at elevation 6805. The results of the stability computations are presented in Figures 13 through 15.

Figure 13 indicates that the waste rock pile material had a friction angle of 30° and a cohesion of zero, and that the dry unit weight of the waste rock material was 90 pcf and that the moisture content was 8.9%. Laboratory tests also indicate that the thin clay layer beneath the coal refuse material had a friction angle of 32°, a cohesion of zero, a dry unit weight of 109 pcf and a moisture content of 15.3%. The critical failure surface for each of the three assumed water level conditions are shown in this figure. Factors of safety of 1.21, 1.00 and <1.00 were obtained for the three water levels. It will be observed from Figure 13 that the failure surfaces indicate thin failure zones on the surface of the embankment. This condition frequently occurs in performing stability analyses for granular material, since the normal stress of the subsurface material near the face of the slope is very low resulting in lower resisting forces.

In order to obtain an indication of the effect of the cohesion on the location of the failure surface, a thin surface layer having a vertical depth of 8 feet and a cohesion of 400 psf was assumed to exist on the slope of the waste rock pile. This condition is presented in Figure 14. The factors of safety along with the critical failure surface for each of the water level conditions indicated above are shown in this figure. It will be observed that all of the failure surfaces lie well below the thin surface layer shown in this figure. Factors of safety obtained from each of the failure surfaces are 1.41, 1.31 and <1.00.

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In order to obtain an indication of the effect of the slope of the rock pile on the stability of the rock pile material, stability computations were performed assuming a slope of 2.5 horizontal to 1 vertical and with no thin cohesive layer on the upstream slope. The results of the analysis are presented in Figure 15 for each of the water level conditions previously discussed. It will be observed that a factor of safety of 1.656 was obtained for no water in the sedimentation pond, 1.47 was obtained for the water level at elevation 6770, and < 1.00 was obtained when the water level was at elevation 6805.

5. *SUMMARY AND CONCLUSIONS*

The subsurface material in the waste rock pile area was characterized by excavating four test pits and drilling three test borings in the vicinity of the existing waste rock pile slope near the sedimentation pond. An indication of the dry unit weight, along with the shearing strength parameters of the existing material was obtained for the waste rock pile zone.

A stability analysis was performed for side slopes of 2 horizontal to 1 vertical and 2.5 horizontal to 1 vertical using the shear strength parameters determined during the investigation for water levels in the sedimentation pond of zero, 6770, and 6805. For side slopes of 2 horizontal to 1 vertical, the factor of safety for the sedimentation pond emptied was 1.21. For the water levels at elevations 6770 and 6805, the factor of safety was equal to or less than 1.00.

For side slopes of 2.5 horizontal to 1 vertical, the factor of safety for the sedimentation pond empty and for the water level at elevation 6770 was 1.656 and 1.47 respectively. With the water level at elevation 6805, the factor of safety was less than 1.00.

A stability analysis was also performed for a side slope of 2 horizontal to 1 vertical assuming that the cohesion of a surface layer along the slope had a value of 400 psf. The results of this analysis indicated a factor of safety of 1.41 for the sedimentation pond empty, and 1.31 for the water level in both the sedimentation pond and the waste rock pile at elevation 6770. With the water level at elevation 6805, the factor of safety was < 1.00.

Based upon the information obtained above, it is our opinion that the following conclusions can be made:

A. The proposed rock pile slope will be unstable for side slopes of 2 horizontal to 1 vertical and 2.5 horizontal to 1 vertical if the water level in the rock pile rises to elevation 6805.

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B. For side slopes of 2 horizontal to 1 vertical, the rock pile will have a factor of safety of 1.21 if the sedimentation pond is empty. The proposed rock pile slope will likely experience slumping for side slopes of 2 horizontal to 1 vertical if the water level in the sedimentation pond and the rock pile reach elevation 6770.

C. The proposed rock pile slope will be stable for side slopes of 2.5 horizontal to 1 vertical if the sedimentation pond is either empty or rises to elevation 6770.

D. If the side slopes of the rock pile are 2 horizontal to 1 vertical, and if a surface layer having a vertical depth of 8 feet, a friction angle of 32°, and a cohesion of 400 psf exists on the slope, the factor of safety for the slope will be 1.41 for the sedimentation pond empty, and 1.31 with the water level in the sedimentation pond and the rock pile at elevation 6770.

The cohesion in a surface layer placed on the face of the existing facility could be obtained by placing a layer of earth materials on the surface having the desired characteristics. Figure 16 is a cross-section indicating how the proposed facility will be constructed. If at least half of the berm material consisted of a clayey gravel, and if the clayey gravel was densified to 95% of the maximum laboratory density as determined by ASTM D 1557-91, the surface layer would have sufficient strength to provide a stable structure for the water level in the sedimentation pond and in the waste rock pile at or below elevation 6770.

Cohesion could also be imparted to the surface layer along the slope by using plastic grids extending into the embankment for a horizontal distance of about 16 feet and located at periodic intervals up the slope of the rock pile. The exact spacing of the plastic grids in a vertical dimension would have to be determined.

The results of the field investigations indicate that the coal refuse has moderately high permeability characteristics, and it is our opinion that it is extremely unlikely that water would ever accumulate in the waste rock pile to an elevation greater than 6770, which corresponds to the depth to which water may accumulate in the sedimentation pond.

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In the absence of any measures to increase the cohesion of a surface layer of material along the slope, we recommend that the rock pile slope be flattened to 2.5 horizontal to 1 vertical.

Sincerely,

RB&G ENGINEERING, INC.

Ralph L. Rollins

Ralph L. Rollins, Ph.D., P.E.

Bradford E. Price

Bradford E. Price, P.E.

rlr/jag

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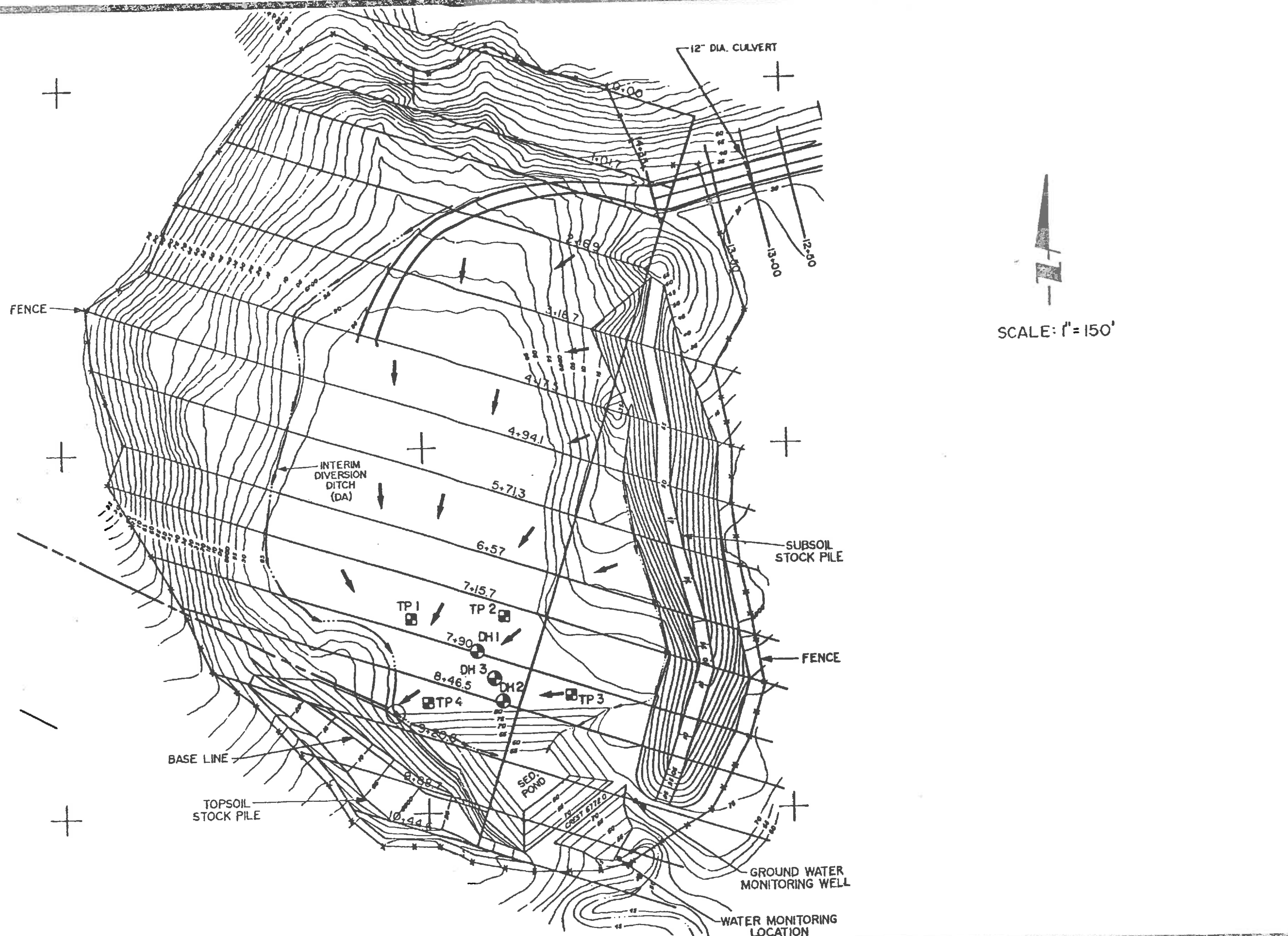

Figure 1

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Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah

PLAN VIEW OF EXISTING WASTE ROCK PILE, AND TEST PIT AND BORING LOCATIONS

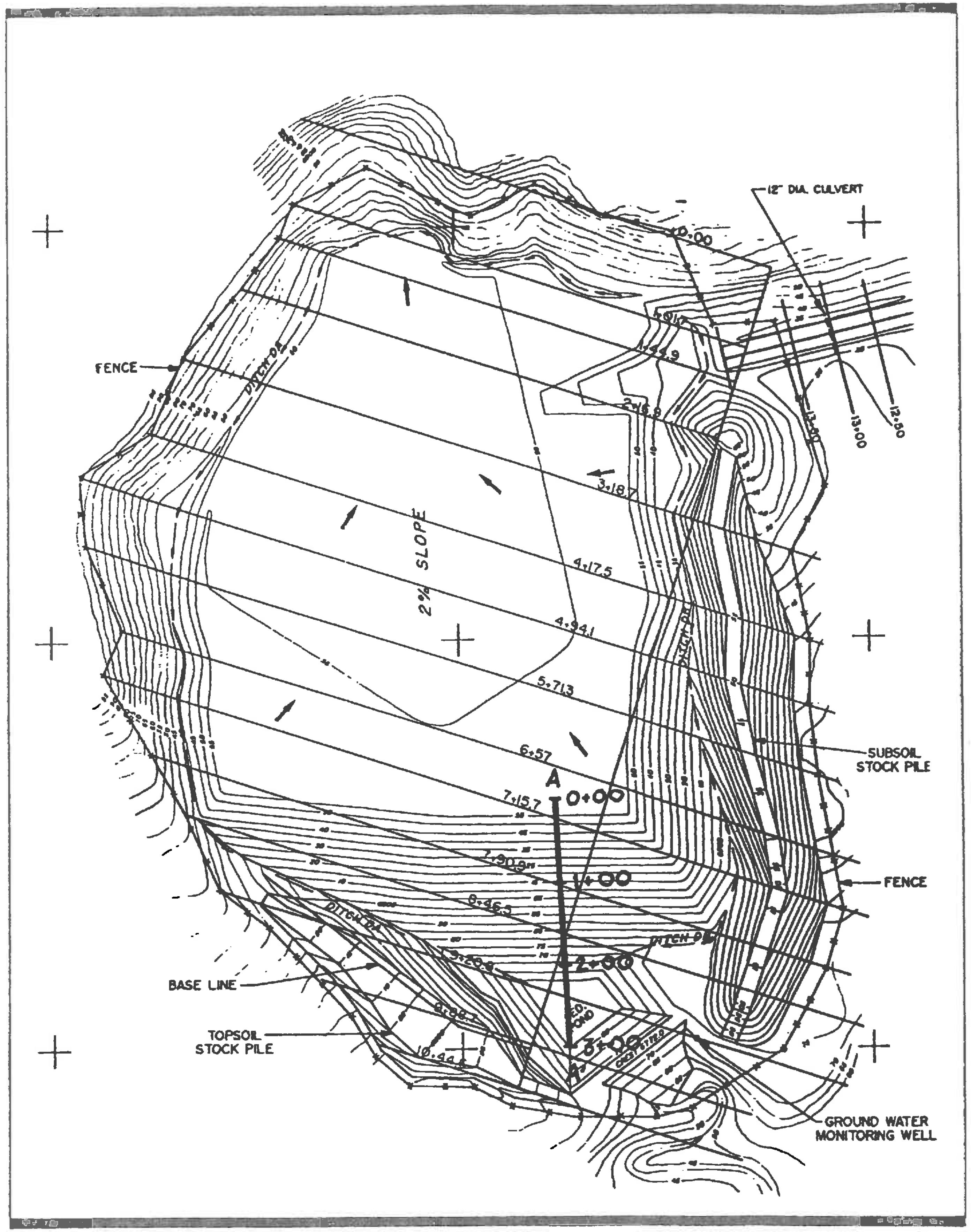

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Figure 2. PLAN VIEW OF WASTE ROCK PILE

Cottonwood/Wilberg Mine
Waste Rock Pile Stability Analysis

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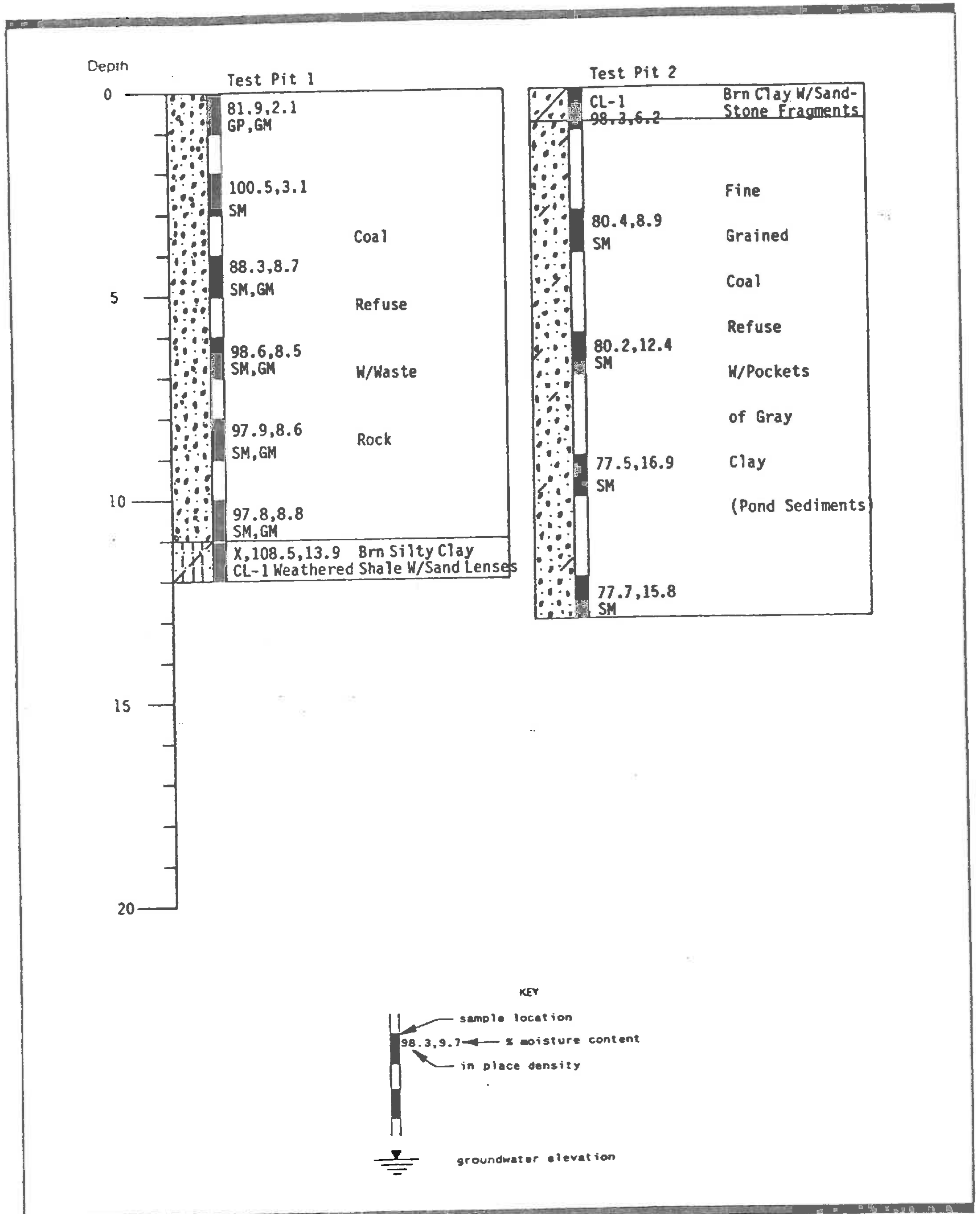

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Figure 3 **TEST PIT LOGS**
Cottonwood/Wilberg Coal Mine Waste Storage Facility
Emery County, Utah

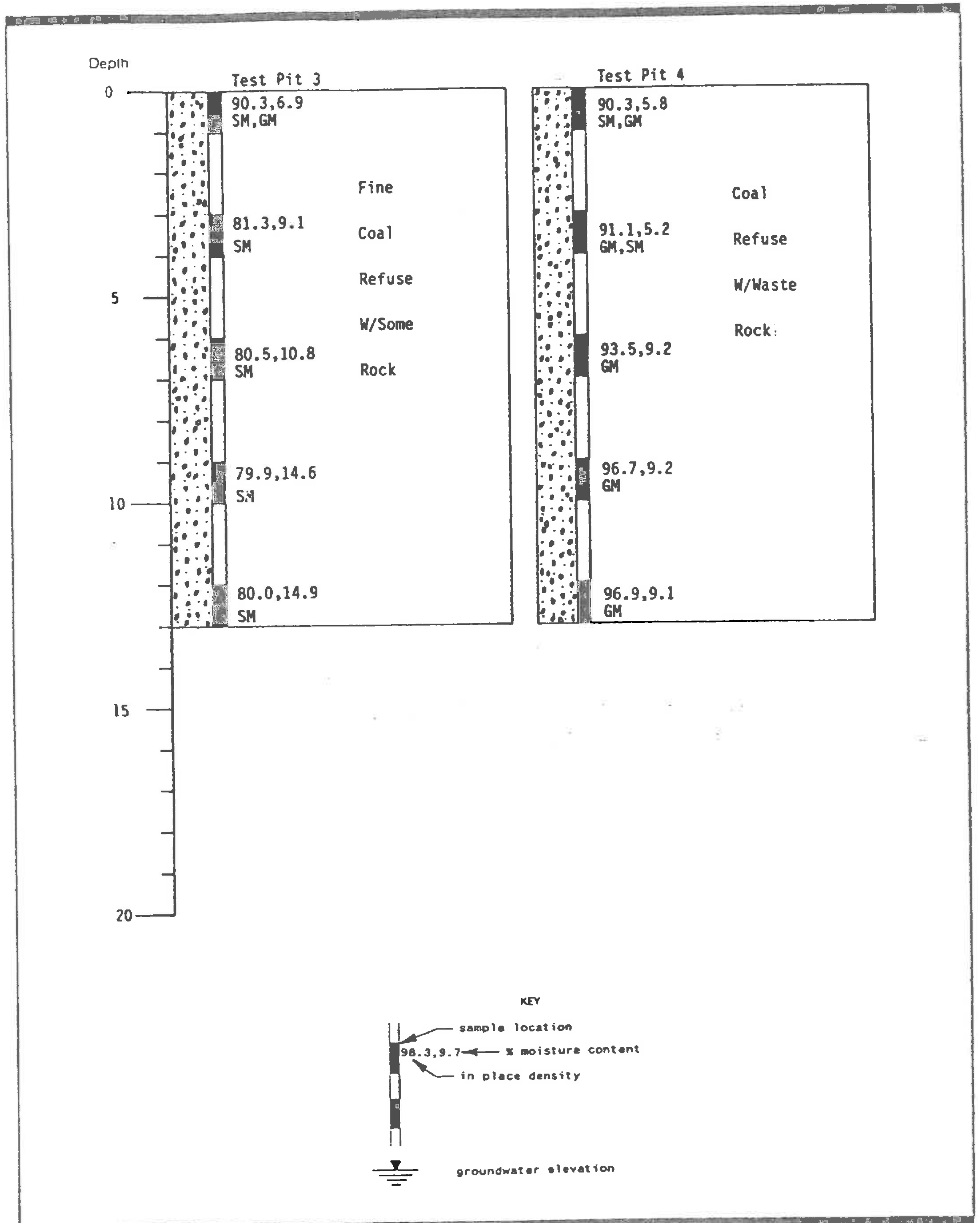

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Figure 4 **TEST PIT LOGS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facilit
Emery County, Utah

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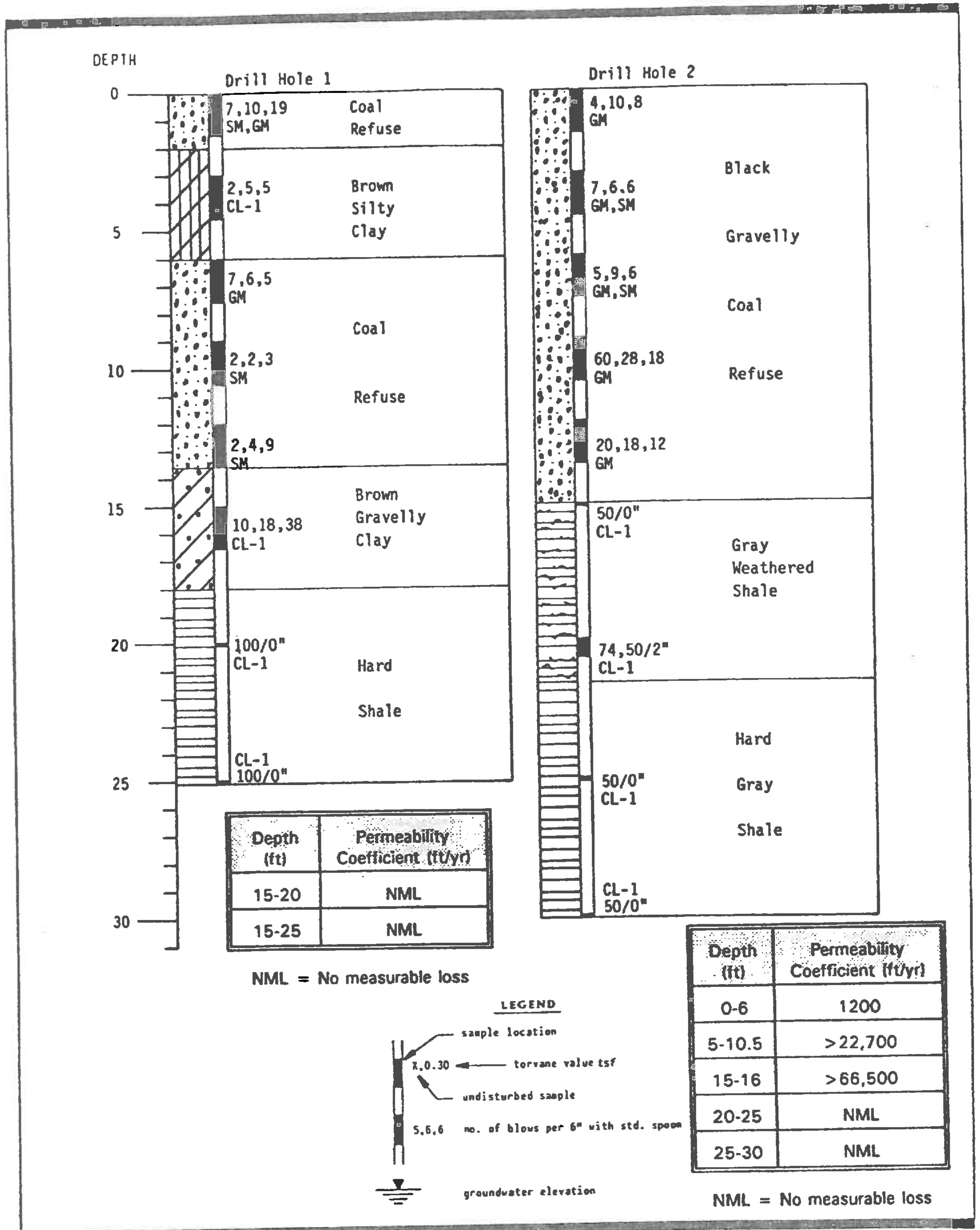

Drill Hole 1:

Depth (ft)	Permeability Coefficient (ft/yr)
15-20	NML
15-25	NML

NML = No measurable loss

Drill Hole 2:

Depth (ft)	Permeability Coefficient (ft/yr)
0-6	1200
5-10.5	>22,700
15-16	>66,500
20-25	NML
25-30	NML

NML = No measurable loss

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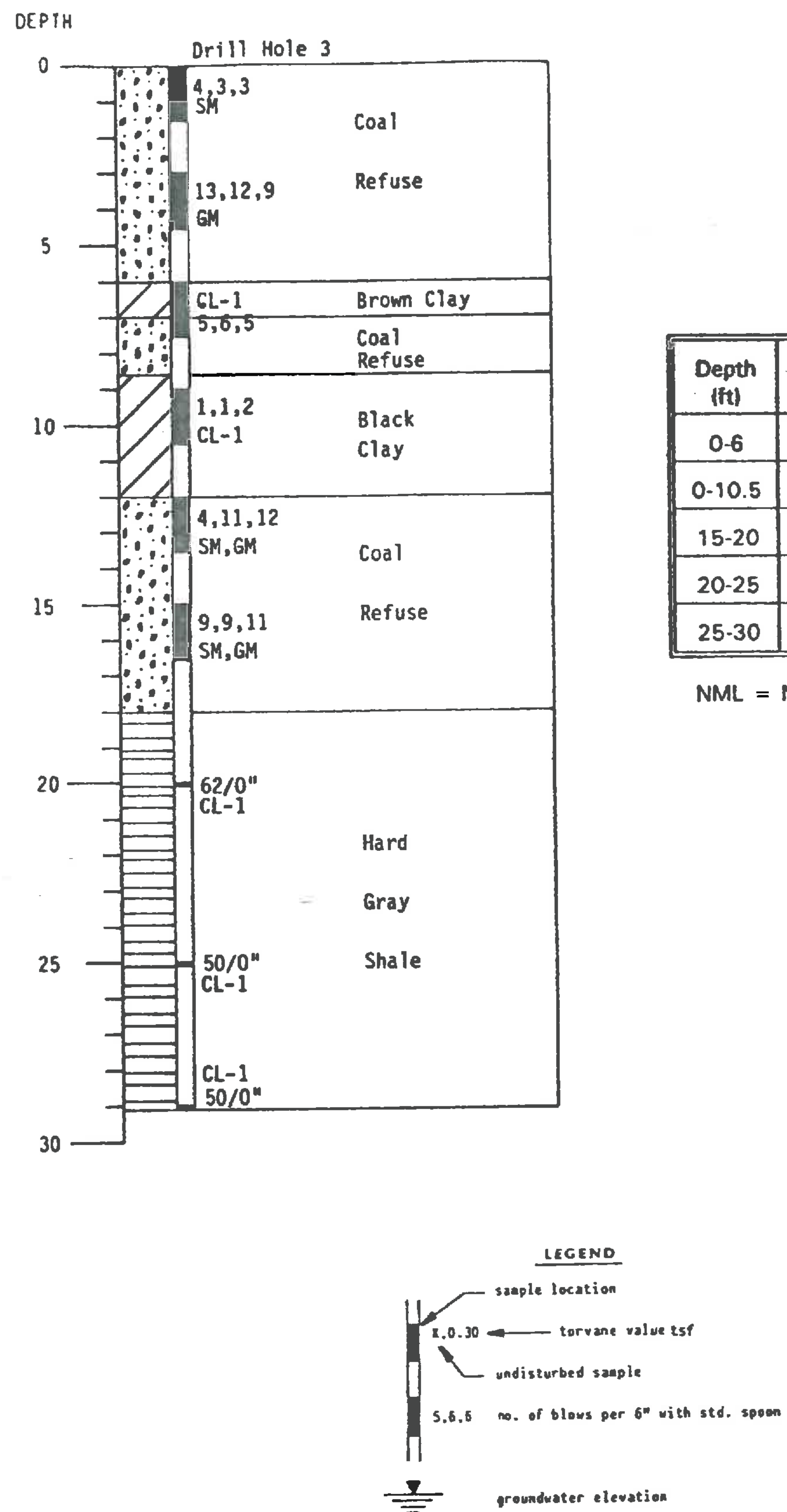
Figure 5 **DRILL HOLE LOGS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facili
Emery County, Utah



Depth (ft)	Permeability Coefficient (ft/yr)
0-6	206
0-10.5	583
15-20	1562
20-25	NML
25-30	NML

NML = No measurable loss

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Figure 6 **DRILL HOLE LOGS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facilit
Emery County, Utah

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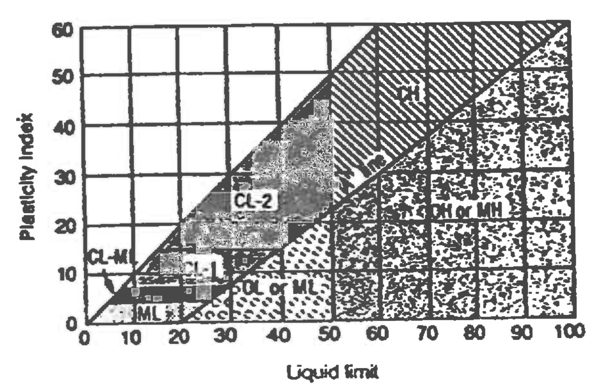
Unified Soil Classification System

Major Divisions			Group Symbols		Typical Names	Laboratory Classification Criteria		
Course-grained Soils More than half of material is larger than No. 200 sieve	Gravels More than half of coarse fraction is larger than No. 4 sieve size	Clean Gravels (Little or no fines)	GW		Well graded gravels, gravel-sand mixtures, little or no fines.	Determine percentage of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5% .... GW, GP, SW, SP More than 12% .... GM, GC, SM, SC 5% to 12% .... Borderline cases requiring use of dual symbols**	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM*	d	Silty gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring uses of dual symbols
				u				
			GC		Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, or *PI* greater than 7	
	Sands More than half of coarse fraction is smaller than No. 4 sieve size	Clean Sands (Little or no fines)	SW		Well graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines.		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM*	d	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring uses of dual symbols
				u				
			SC		Clayey sands, poorly graded sand-clay mixtures		Atterberg limits above "A" line, or *PI* greater than 7	
Fine-grained Soils More than half of material is smaller than No. 200 sieve	Silt and Clays Liquid limit less than 50		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity			
			CL	1	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
				2				
			OL		Organic silts and organic silt-clays of low plasticity			
	Silts and Clays Liquid limit greater than 50		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
Highly Organic Soils			Pt		Peat and other highly organic soils			



Plasticity Chart
For laboratory classification of fine-grained soils

*Division of *GM* and *SM* groups into subdivisions of *d* and *u* for roads and airfields only. Subdivision is based on Atterberg limits; suffix *d* used when liquid limit is 28 or less and the *PI* is 6 or less, the suffix *u* used when liquid limit is greater than 28.

**Borderline classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.

Figure No. 7

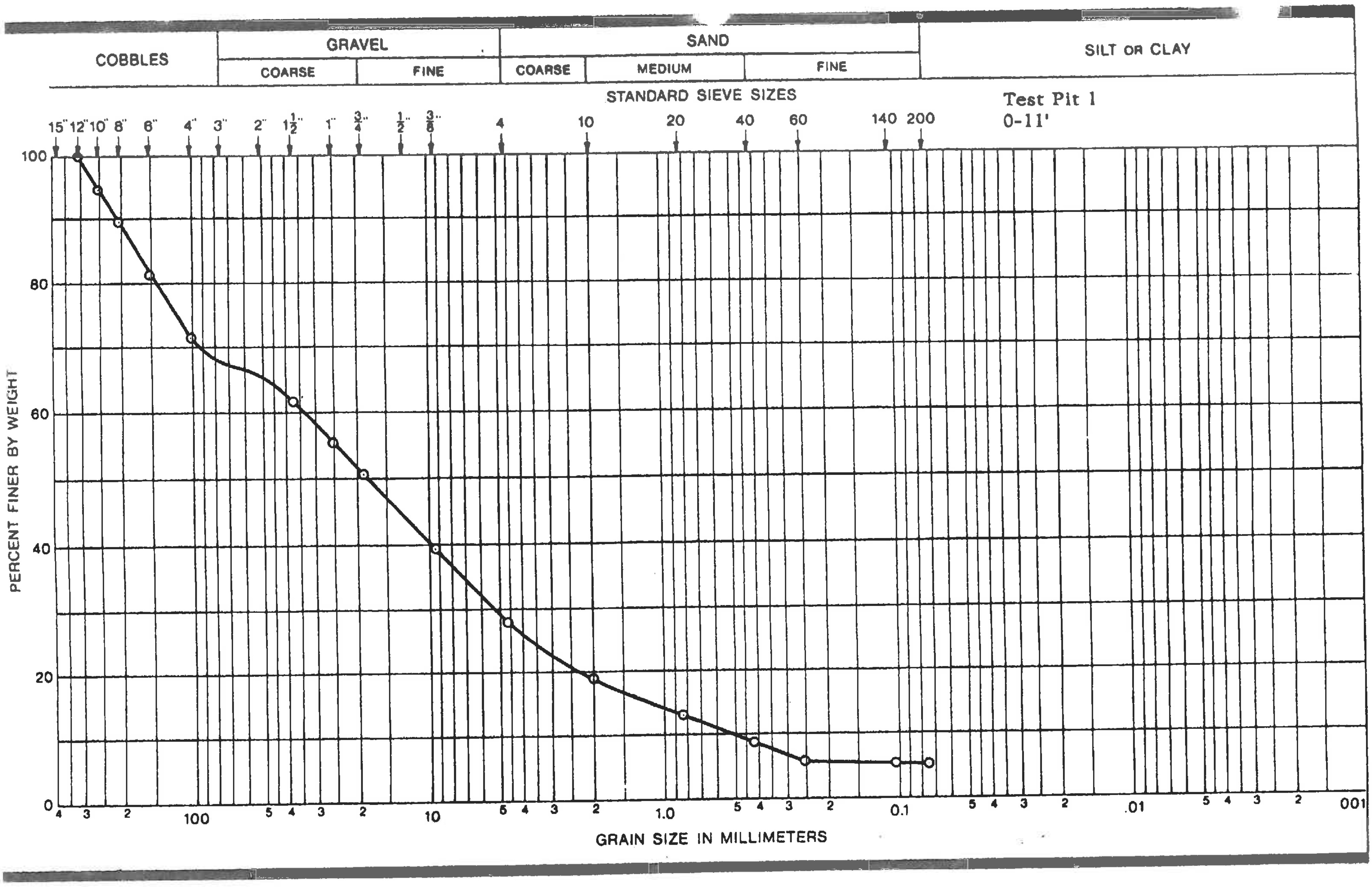


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Figure 8 SIEVE ANALYSIS
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah

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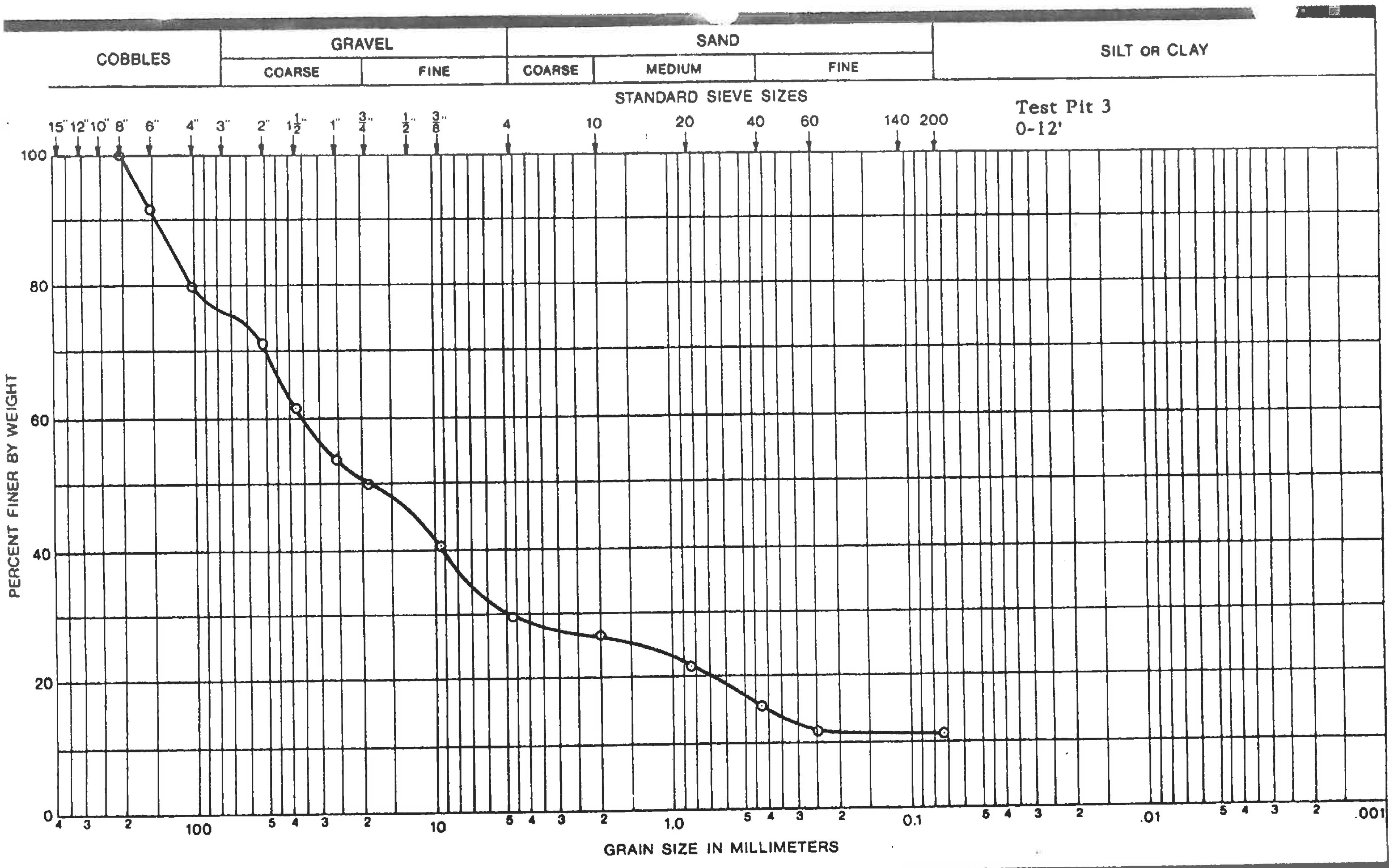

Figure 9 **SIEVE ANALYSIS**
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah

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Provo, Utah

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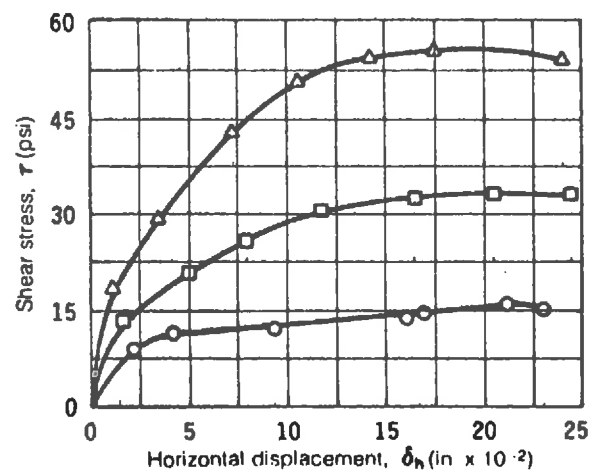
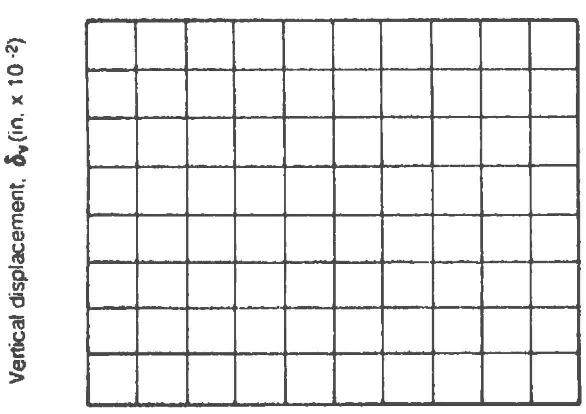
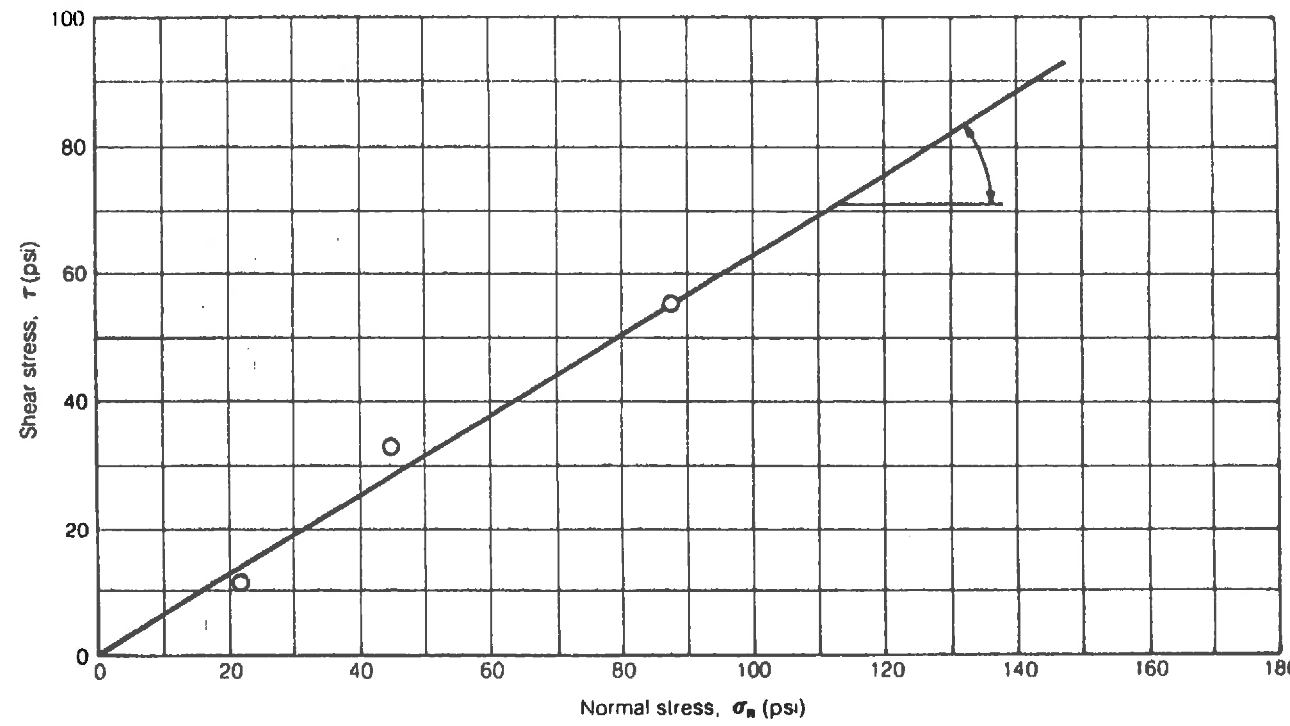






Test no. or symbol	Sample size (inches)	Sample data: Dry density (pcf)	Sample data: Moisture content (%)	Degree of saturation (%)	Normal stress σ_n (psi)	Maximum shear stress τ (psi)	Strain rate (inches / minute)	Shear strength parameters: Friction angle ϕ (degrees)	Shear strength parameters: Cohesion (c / psi)
○	2.35	108.8	15.3	~100	21.7	16.1	.001	32.2	0
□	2.35	109.3	13.4	~100	44.6	33.1.	.001		
△	2.35	108.5	13.9	~100	87.6	55.2	.001		

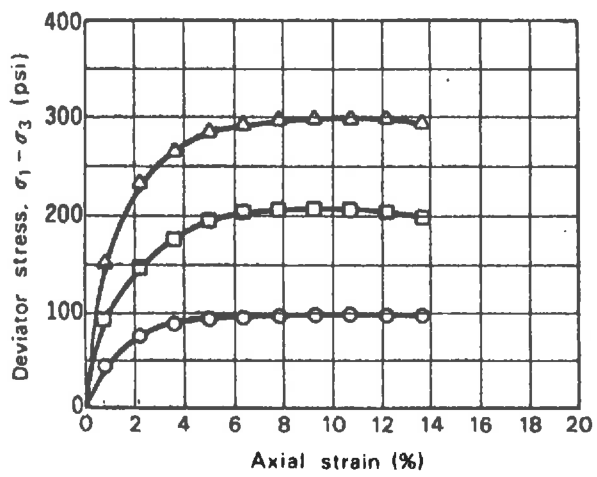
ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

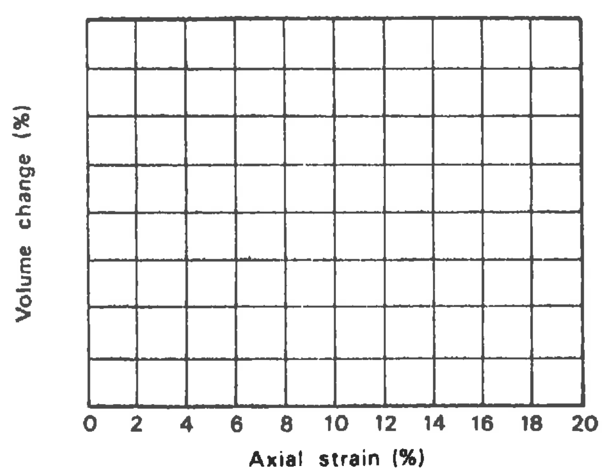
DIRECT SHEAR TEST
Project: Cottonwood/Wilberg Coal Mine
Waste Rock Pile Stability Analysis

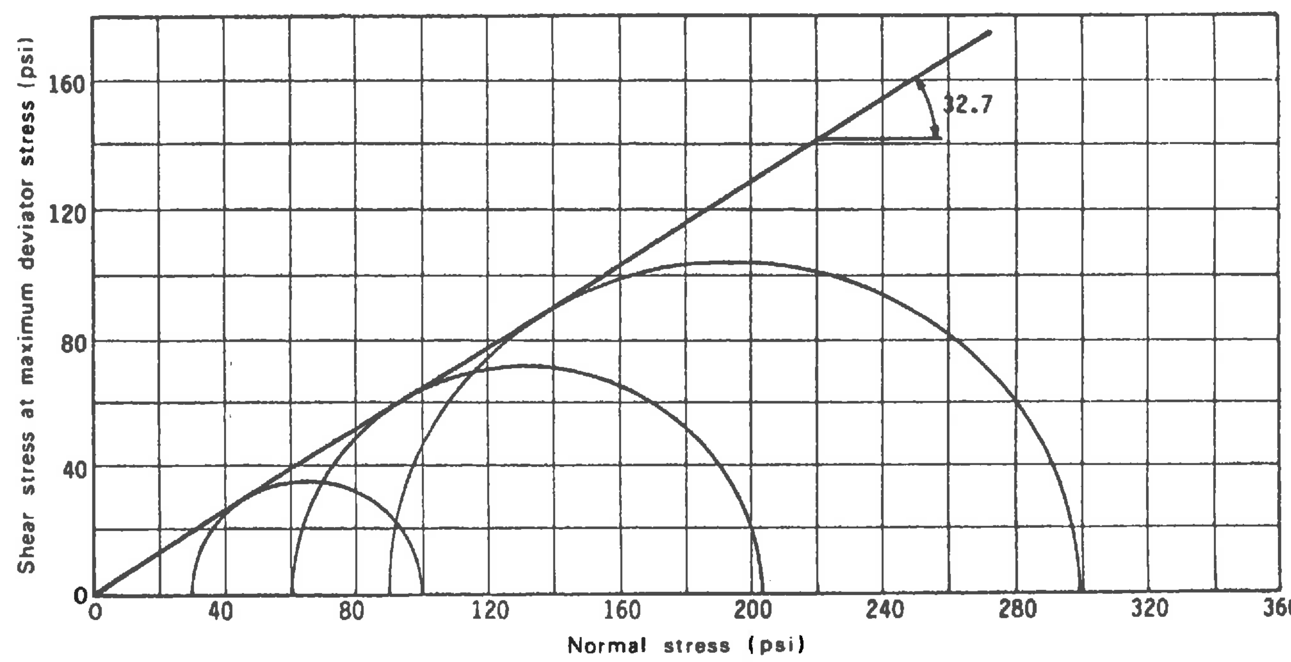
HOLE NO TP1
DEPTH 11'

FIGURE NO 10

ADDED 1/8/[illegible]
4-[illegible]







Test no. or symbol	Boring no. or depth	Sample data		Degree of saturation (%)	Confining pressure (psi)	Maximum deviator stress (psi)	Strength values at failure		Sample size, L/D (inches)	Strain rate (inches/minute)
		Dry density (pcf)	Moisture content (%)				Friction angle φ (degrees)	Cohesion (c/psi)		
○		90.9	8.6	~100	30	99.9	32.7	0	2.8/1.32	.001
□		91.1	8.5	~100	60	203.6			2.8/1.32	.001
△		90.2	8.9	~100	90	299.3			2.8/1.32	.001

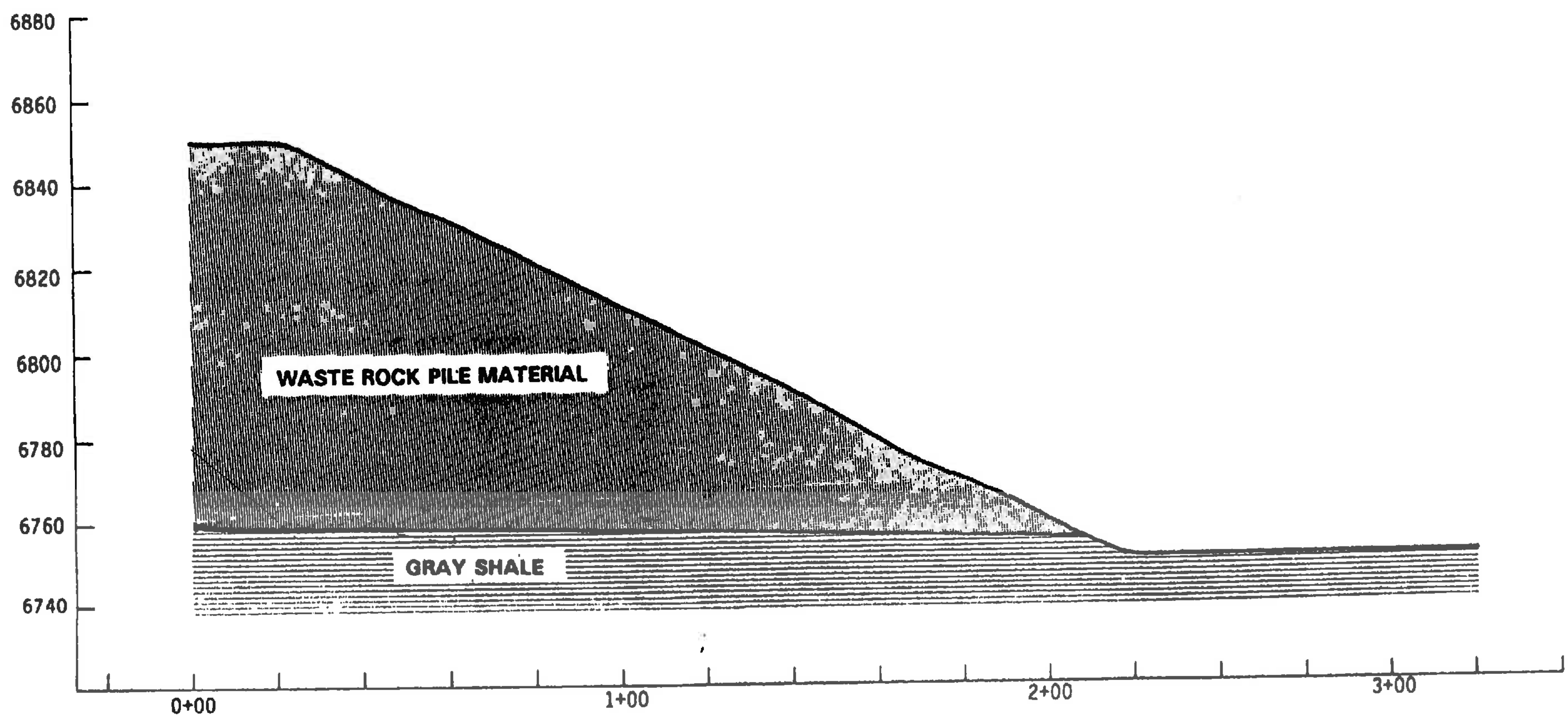
ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

TRIAXIAL SHEAR TEST
Project: Cottonwood/Wilberg Coal Mine Waste Rock Pile Stability Analysis

HOLE NO. TP1
DEPTH: 0-11'

FIGURE NO. 11

ADDED 1/8/9



RB&G ENGINEERING INC.
Provo, Utah

Figure 12. PROFILE THROUGH SECTION A-A'

Cottonwood/Wilberg Mine
Waste Rock Pile Stability Analysis

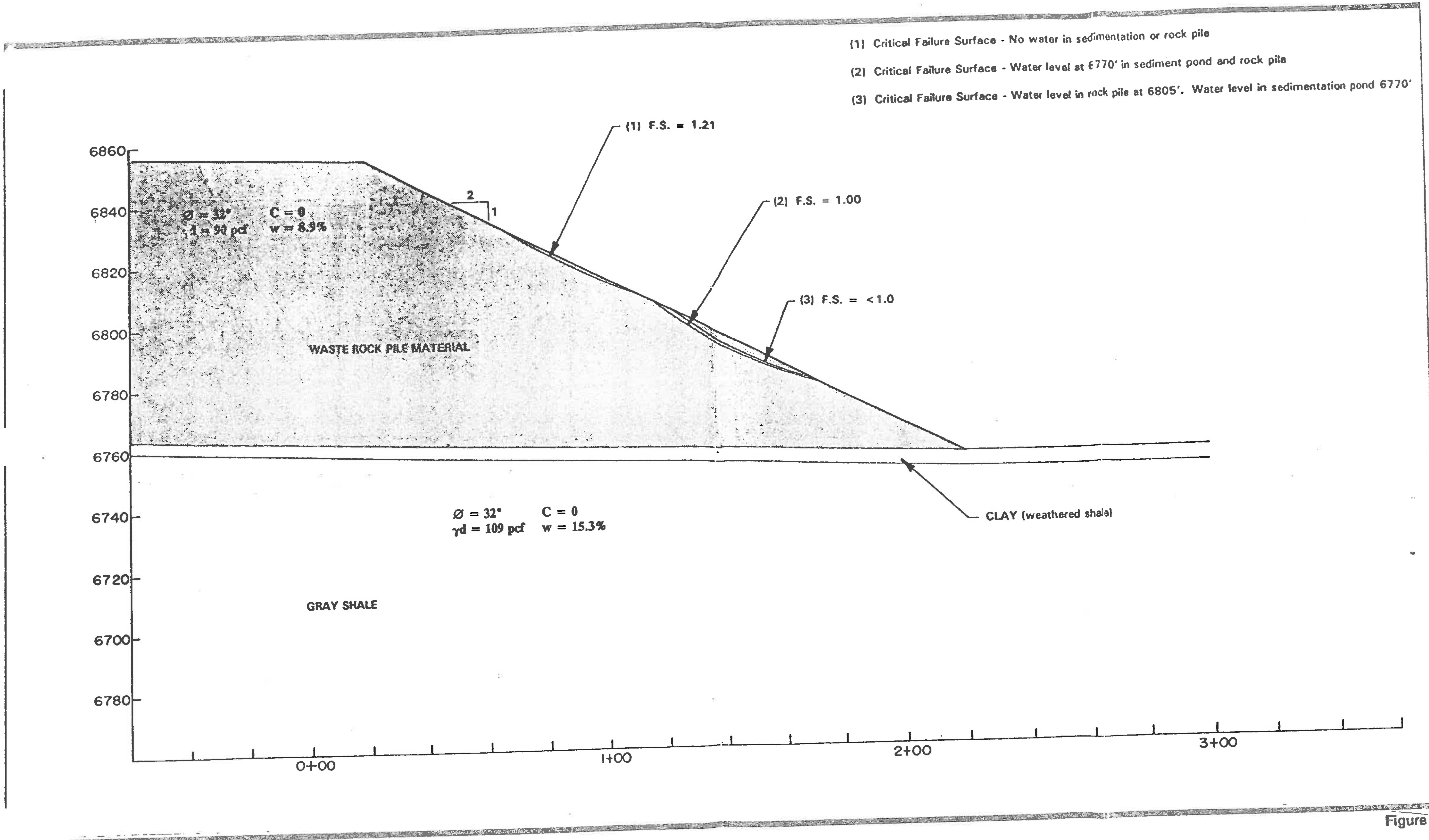


Figure 13

Location of Failure Surfaces and the Factors of Safety for Various Conditions of Saturation and no Cohesion - Side Slope = 2:1

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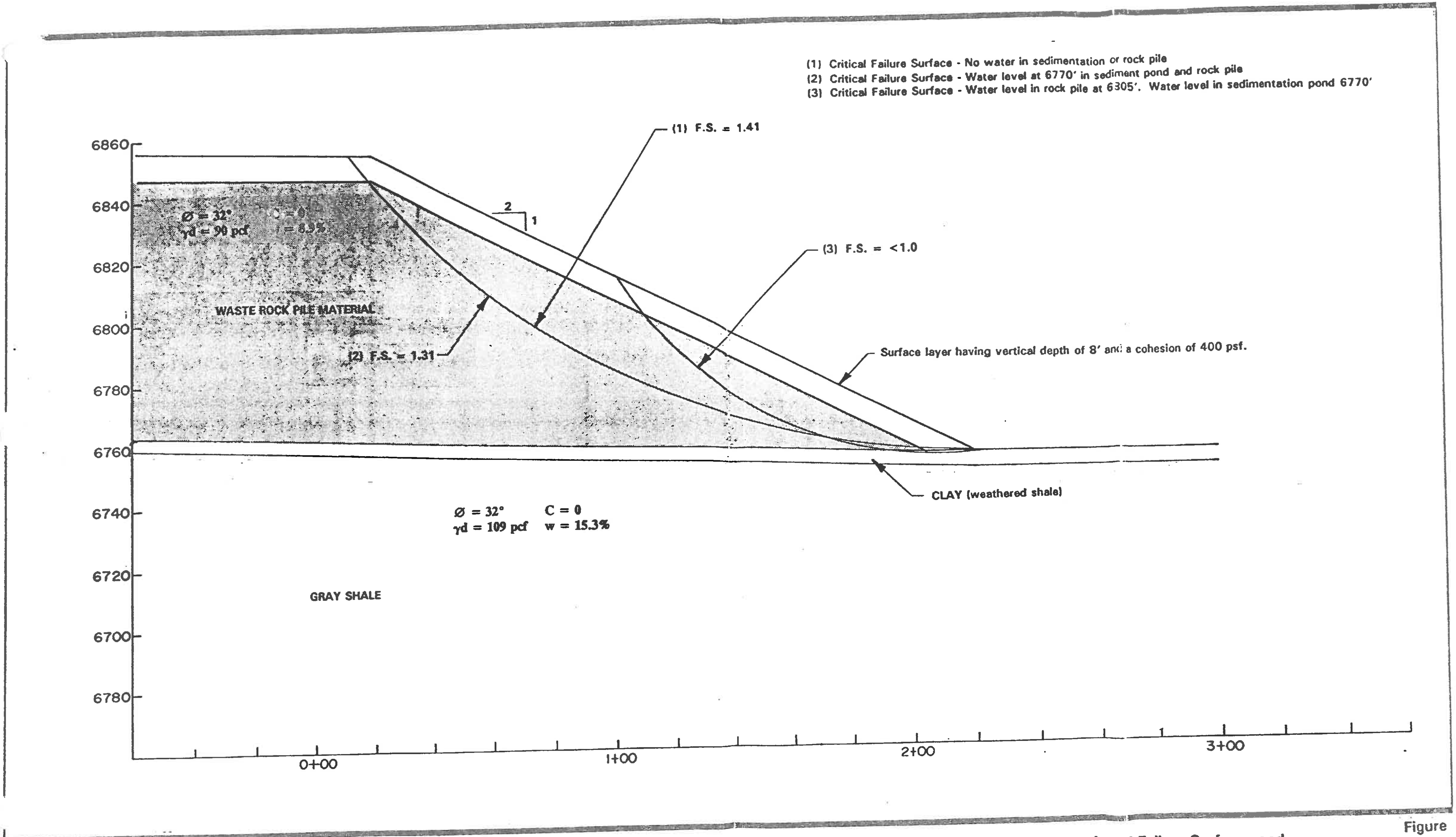
Provo, Utah

COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY
EMERY COUNTY, UTAH

4-88
ADDED 1/8/93



RB&G ENGINEERING

COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY
EMERY COUNTY, UTAH

Location of Failure Surfaces and the Factors of Safety for Various Conditions of Saturation and a Surface Zone Having 400 psf Cohesion - Side Slope = 2:1

Figure 14

4-89
ADDED 1/8/9[illegible]

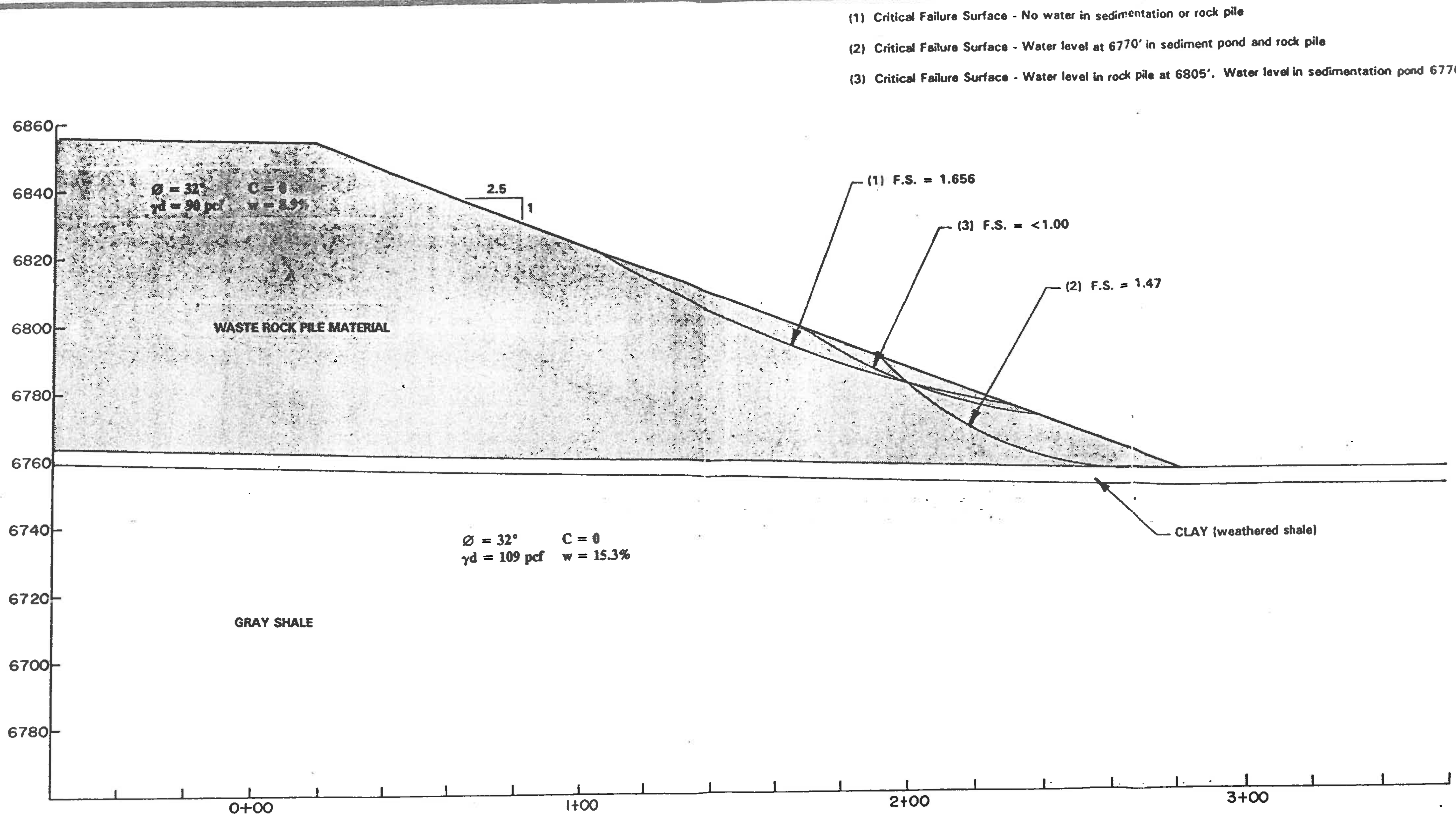


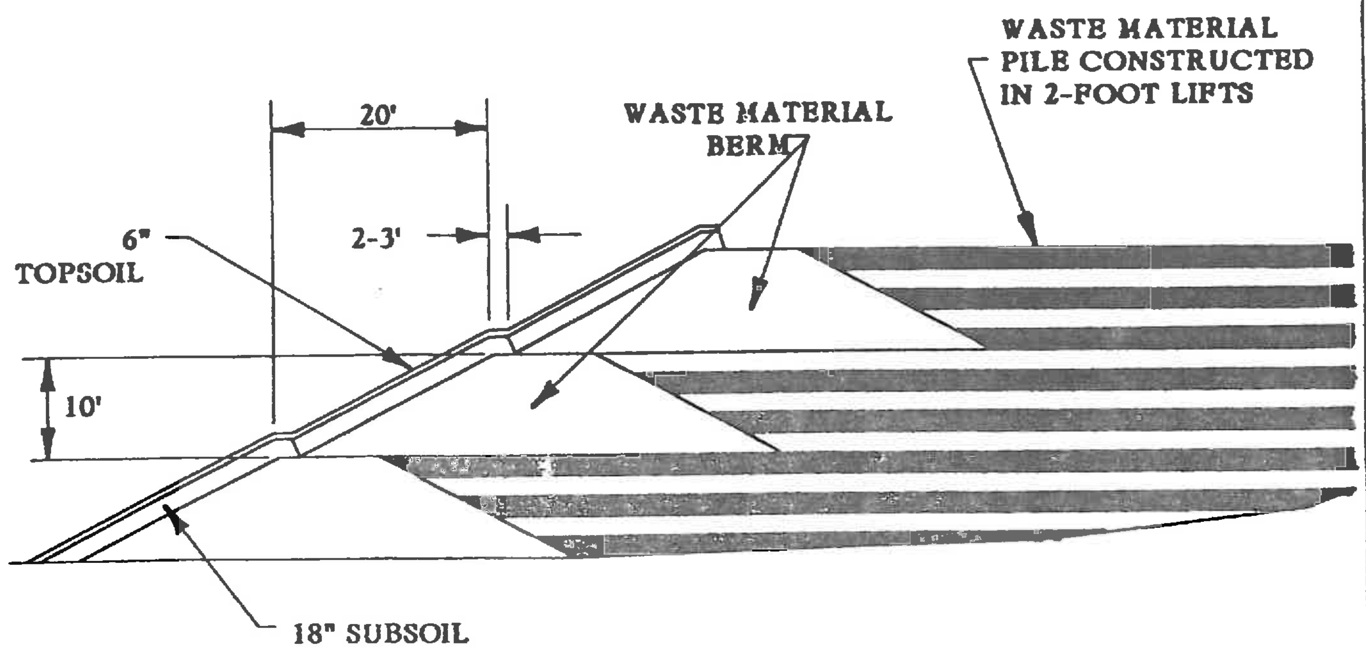
Figure 15

RB&G ENGINEERING INC.
Provo, Utah

COTTONWOOD/WILBERG COAL MINE WASTE ROCK STORAGE FACILITY
EMERY COUNTY, UTAH

Location of Failure Surfaces and the Factors of Safety for Various Conditions of Saturation - Side Slope = 2.5:1

4-90
ADDED 1/8/93



SEQUENCE

1. CONSTRUCT BERM WITH WASTE ROCK MATERIAL FROM MINING OPERATION.
2. COVER OUTSIDE SLOPE OF BERM WITH 18" OF SUBSOIL AND 6" OF TOPSOIL.
3. REVEGETATE OUTSIDE SLOPE.
4. PLACE WASTE MATERIAL INSIDE OF BERM AND COMPACT IN 2' LIFTS.
5. WHEN WASTE MATERIAL LEVEL REACHES TOP OF BERM CONSTRUCT THE NEXT BERM WITH 2' TO 3' OFFSET AT TOE OF NEW BERM.

RB&G ENGINEERING INC.
Provo, Utah

Figure 16 CONSTRUCTION SEQUENCE
Cottonwood/Wilberg Coal Mine Waste Rock Storage Facility
Emery County, Utah

4-91
ADDED 1/8/93

Table 1

SUMMARY OF TEST DATA

PROJECT Cottonwood/Wilberg Coal Mine
Waste Rock Storage Facility

LOCATION Emery County, Utah FEATURE Foundations

TEST PIT NO.	DEPTH BELOW GROUND SURFACE (ft)	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE		UNCONFINED COMPRESSIVE STRENGTH (psf)	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			UNIFIED SOIL CLASSIFICATION SYSTEM (modified)
			DRY UNIT WEIGHT (pcf)	MOISTURE (%)		LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT & CLAY	
1	0-1		81.9	2.1					47.5	44.5	8.0	GP,GM
	2-3		100.5	3.1					29.0	53.8	17.2	SM
	4-5		88.3	8.7					35.1	48	16.9	SM,GM
	6-7		98.6	8.5					27.8	49.4	22.8	SM,GM
	8-9		97.9	8.6					31.0	45.1	23.9	SM,GM
	10-11		97.8	8.8					32.7	42.8	24.5	SM,GM

NP=Nonplastic

RB&G ENGINEERING INC.

October 27, 1992

Greg Cowan
Energy West Mining Co.
P.O. Box 310
Huntington, UT 84528

Dear Greg:

During our recent investigation of the Waste Rock Pile at the Cottonwood/Wilberg Coal Mine in Emery County, Utah, it was concluded that the rock pile should have a slope of 2.5 horizontal to 1 vertical to provide an adequate factor of safety for the water level in both the sedimentation pond and in the rock pile elevation 6770.

An overall slope of 2.5 horizontal to 1 vertical can be achieved if the width of the berm above the elevation of the rock pile at the present time is increased from 3 to 8 feet. The profile of the upstream face of the waste rock pile would have the shape as shown in the attached figure. Since the increase in the horizontal distance in each berm is 5 feet, and there are six berms above the present elevation, the total increase in the horizontal length of the slope would be 30 feet. It should also be noted that the upstream face between berms is 2 horizontal to 1 vertical. We recommend that in order to have a satisfactory factor of safety for the waste rock pile that the rock pile face conform to the shape shown in Figure 17.

Sincerely,

RB&G ENGINEERING, INC.

Ralph L. Rollins

Ralph L. Rollins, Ph.D., P.E.

rlr/jag

1435 WEST 820 NORTH
PROVO, UTAH 84601-1343

PROVO 801-3?4-5??1
SALT LAKE CITY 801-521-5??1

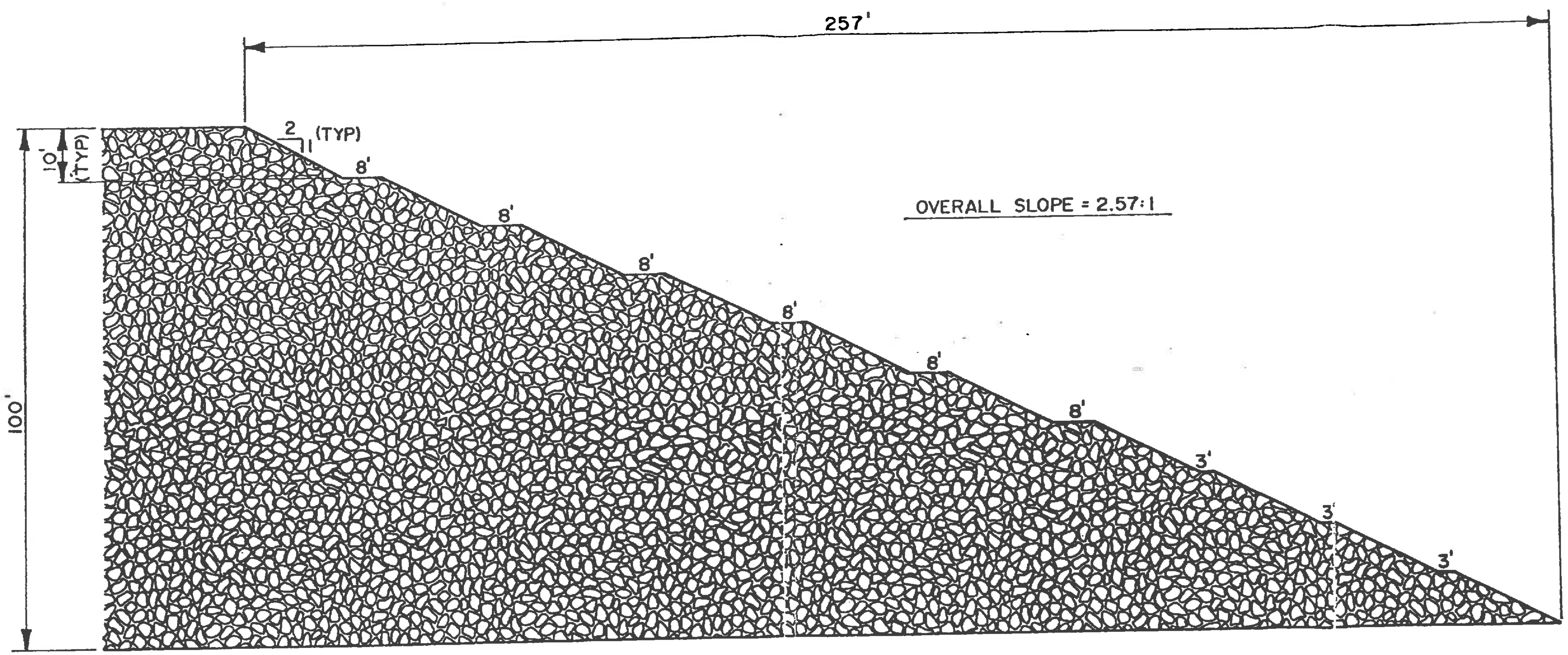


Figure 17

RB&G ENGINEERING INC.
Provo, Utah

COTTONWOOD/WILBERG COAL MINE
WASTE ROCK STORAGE FACILITY
EMERY COUNTY, UTAH

PROPOSED CROSS SECTION

4-94
ADDED 1/8/93

Analytical Summary																			
	Number of Samples		Chemical Tests												Physical Tests				
Lithology	Chemical Tests	Physical Tests	Ca (Meq/L)	Mg (Meq/L)	Na (Meq/L)	SAR[1]	Fe (ppm)	Zn (ppm)	SO_4-S (ppm)	Mo (ppm)	B (ppm)	pH (paste)	E.C.[2] (mmhos/cm)	Sat. (%)	Pyrite FeS_2	Sand (%)	Silt (%)	Clay (%)	Crushed Rock Texture
Sandstone:	35	6																	Sand
Mean			5.43	9.94	2.64	1.04	7488.02	10.65	742.83	<0.1	0.07	7.71	1.83	24.01	-	88.67	6.83	4.5	
S.D.[3]			4.52	7.56	3.02	0.84	6335.5	8.63	1512	0	0.14	1.21	1.09	5.31	-	5.2	4.26	1.76	
Siltstone:	24	5																	Sandy Loam
Mean			3.06	6.24	2.3	1.69	14512.88	38.26	464.41	<0.1	0.18	7.88	1.41	20.81	2.3	71.6	17.8	10.6	
S.D.[3]			2.63	7.23	2.78	3.72	8782.4	21.29	1222.63	0	0.16	1.08	1.72	1.83	0	23.5	16.57	7.7	
Mudstone:	24	4																	Sandy Loam
Mean			3.12	3.13	4.7	4.28	11074.13	70.31	233.96	<0.1	0.28	8	1.1	23.99	-	71.5	20.5	8	
S.D.[3]			2.36	2.89	12.76	12.58	5350.17	79.99	275.18	0	0.23	0.31	1.12	4.88	-	13.77	15.2	3.56	
Interbeds:	15	3																	Loamy Sand
Mean			4.34	7.98	2.79	1.3	10982.13	21.58	346.95	<0.1	0.12	8.05	1.58	20.56	-	75.33	17	7.67	
S.D.[3]			3.13	6.37	1.85	1.36	6584.59	9.97	359.46	0	0.11	0.23	0.92	1.33	-	7.64	9.54	3.06	
Carb Mudstone:	25	3																	Loamy Sand
Mean			6.19	6.51	3.7	2.4	9933.76	58.04	438.86	<0.1	0.42	7.53	1.54	34.76	0.23	73.33	18	5.67	
S.D.[3]			4.85	8.42	4.85	3.98	6112.12	38.94	378.81	0	0.34	0.85	1.14	9.94	3.29	20.6	16.82	1.53	
Coal:	8	0																	
Mean			1.55	1.81	1.68	1.63	2089.38	10.19	103.88	<0.1	0.06	8	0.36	60.66					
S.D.[3]			0.59	2.88	1.35	1.27	2557.56	8.82	66.68	0	0.05	0.25	0.05	18.59					

1 - SAR - Sodium Absorption Ratio
2 - E.C. = Electrical Conductivity
3 - S.C. = Standard Deviation

Appendix B

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R645-301-620 Environmental Description 1
R645-301-624 Geologic Information 2
R645-301-624.100 Description of Geology 3

R645-301-600: Geology

R645-301-610 Introduction

The geology of the Cottonwood/Wilberg Waste Rock Storage Facility is fairly simple and straightforward. This site is located on the southern flanks of East Mountain south of Newberry Canyon. Rocks exposed in the area are marine derived mudstones in the lower portion of the Masuk Member of the Mancos Shale. The Masuk Shale on the bench which adjoins the proposed site on the north and east is covered by a five to twenty foot thick layer of terrace gravel of Quaternary age. North-south treading normal faults has disrupted the strata in the region. However, no faults are known to exist within the area of the Waste Rock Storage Facility.

R645-301-620 Environmental Description

The oldest rocks exposed in the region are part of the marine Mancos sequence deposited in Late Cretaceous time. This formation contains several alternating units of off-shore marine mudstones and near-shore marine sandstones. This discussion will address only the two upper members of the Mancos which are the Emery Sandstone and the Masuk Shale in ascending order.

Emery Sandstone

The Emery Sandstone member of the Mancos Shale is comprised of several upward fining transgressive sandstone deposits. To the east, where the Emery Sandstone is exposed on the surface, it is approximately 800 feet in thickness. However, subsurface data collected from the gas wells near the site indicate that the Emery Sandstone is positioned about 600-800 feet beneath the proposed waste rock site and is probably very thin (100 feet). Regionally, this member is water-bearing and may be classified as a limited regional aquifer. However, its importance as an aquifer is minimal in respect to other major water-bearing formations located at depth (Navajo and Wingate Sandstones).

Masuk Shale

The Masuk Member of the Mancos Shale overlies the Emery Sandstone and consists of light to medium gray marine mudstones. It forms the bedrock in the vicinity of the site. The Masuk Shale is generally devoid of significant water. However, it does transport small amounts of water along fractures present in the rock.

Terrace Gravels

The benches surrounding the north and east sides of the Waste Rock Storage Facility are covered by a Quaternary terrace gravel deposit. These gravels are located on a gentle slope leading down from the base of the southern tip of East Mountain and are thought to be glacial outwash in origin. The gravel deposits are five to twenty feet in thickness and are moderately permeable. Because of this, much of the rainfall percolates into these deposits and flows down dip toward Grimes Wash and Cottonwood Creek.

Alluvial Valley Floors

There are no alluvial valley floors within the Waste Rock Storage Facility. The nearest one is located in Straight Canyon approximately 2 miles to the south. This alluvial valley floor has been shown to contain groundwater but the operation of the waste rock site should have no impact on the quality or quantity of the water it contains due to the impermeability of the Masuk Shale separating the site from the alluvial valley floor.

Structure

The stratum in the area of the waste rock site is dipping gently in a westerly direction into the Straight Canyon Syncline (2 to 3 degrees). The nearest known fault to this area is the Pleasant Valley Fault which is located approximately one mile to the north where its displacement terminates. No faults exist in the area of the proposed site.

Regionally, the stratum contains a set of vertical joints trending in both a northwest and northeast direction. It is hard to identify jointing in the weathered Masuk shale outcrops, but in fresh cuts the joints appear to be wide spaced. Very limited amounts of ground water migrate down these fractures because the clays present in the rock swell when in contact with water, thus sealing the fractures.

R645-301-624 Geologic Information

As part of the preparations to construction of the Waste Rock Storage Facility, a geotechnical investigation was performed by Rollins, Grown and Gunnel Inc. in 1989. This document reports the existing site conditions, subsurface soil and water conditions, foundations considerations and recommendations, site preparations and compacted fill requirements, and results of field and laboratory tests. Refer to this report in R645-301-500 Engineering, Appendix A.

R645-301-624.100 Description of Geology

For a detailed description of the geology of the permit and adjacent areas down to and including the deeper of either the stratum immediately below the lowest coal seam to be mined or any aquifer below the lowest coal seam to be mined which may be adversely impacted by mining, refer to Volumes 1 and 2 of the Cottonwood/Wilberg Mining and Reclamation Plan. This plan will show the lithologic characteristics of the stratum, physical and chemical properties, chemical analysis of those strata as well as the coal seam. Most data will be presented in the appendix volume, Volume 3.

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R645-301-700: Hydrology

R645-301-710 Introduction

R645-301-711.100

A complete description of the regional and local hydrology for the East Mountain and surrounding areas is found in Volume 9.

R645-301-711.200

The Cottonwood/Wilberg Waste Rock Storage Facility encompasses a dry wash which flows water for a short time immediately following a storm. Water from this wash flows into Grimes Wash which is located about 2 miles to the southeast, which in itself is ephemeral. Grimes Wash then flows to the south for approximately 2 1/2 miles where it intersects Cottonwood Creek.

Not all runoff from storms flow into the drainages. Some of the rain water migrates into the terrace gravels, where present, and flows down dip toward Grimes Wash and Cottonwood Creek. The waste rock disposal site should not impact this water occurrence because it is located at a lower elevation than the gravel terraces. Very limited quantities of ground water may be present by way of fractured permeability in the Masuk Shale.

The Mancos Shale typically contains large quantities of soluble minerals such as gypsum thus, any water passing through it or eroding it will be naturally high in dissolved solids.

R645-301-724 Baseline Information

Baseline information for hydrologic, geologic, and climatologic information is found in Volumes 8 and 9.

R645-301-724.100 Ground Water Information

Initially three test wells (drill holes 1, 2 and 3) were drilled within the Waste Rock Storage Facility to identify the soil conditions present (see Map 4-3). At each drill-hole location, water introduced in the hole from drilling was bailed from the drill hole at the end of the day. The next day the water level was checked and in most cases, the water level would rise. Drill holes 1 and 2 were cement filled upon completion to prevent any unnatural groundwater migration to occur, but drill-hole No. 3 was cased. Groundwater in this hole was intersected at the bedrock contact at 50 feet. The upper 55 feet of drill-hole No. 3 consisted of unconsolidated material followed by weathered shale to 63 feet, and the remainder of the hole was a solid gray, silty shale. An attempt to sample the water in drill-hole No. 3 was made on September 11, 1989 but the hole was dry to a depth of 62 feet where the casing was silt blocked. On November 29-30, 1989, an additional hole (No. 4) was drilled adjacent to hole No. 3 (see Map 4-3). Drill-hole No. 4 was drilled to a depth of 87 feet and will serve for groundwater monitoring. The data collected during the original drilling program and subsequent drilling indicate that groundwater enters the hole between a depth of 45 to 63 feet and stabilizes at approximately 56 feet. The hole was cased from 37 feet to 87 feet depth with 1 1/2 inch schedule 80 slotted PVC pipe and with solid riser from 37 feet to the surface. The slotted section was gravel packed and a bentonite seal was placed above the slotted section to prevent cement, utilized to seal the upper portion of the hole, from migrating into the gravel section. A locked well cap was installed to protect against outside contamination.

Baseline analysis was performed after a one-week stabilization period. It was apparent from the first sample that the hole still contained an elevated suspended solid content. In an attempt to reduce the amount of suspended solids the hole was purged with water until the discharge from the well was clear. Baseline analysis was again performed after a one week stabilization period. The suspended solid was still elevated but some improvement was noticed. Due to the suspended solid content, a third sample was collected and filtered before being fixed with acid to improve the accuracy of the results. As anticipated with groundwater associated with the Mancos Shale formation, the dissolved solids were extremely high and dominated by calcium, chloride, magnesium, sodium, and sulfate Refer to Appendix A for application for water well construction, and Appendix B for well water quality sampling results.

Although two years of baseline data have not been collected specifically at the waste rock site, the samples discussed above are consistent with other Mancos influenced samples. To augment the data from the samples taken on-site, sampling continued through construction of the facility; thus providing at least one year's site-specific data prior to actual operation.

<u>Aquifer Characteristics of the Terrace Gravels</u>

The geologic section of the Cottonwood/Wilberg Waste Rock Storage Facility discusses the terrace gravels that surround the Waste Rock Storage Facility. These gravels were deposited by glacial outwash and form a cap on the slopes leading down from East Mountain to the north and west. The thickness of these terrace gravels generally increases as one progresses down slope away from the mountain. Also, the lower contact of the gravels is unconformable and as such its thickness varies with paleotopography. A good example of this is at Test Hole No. 3 where the terrace gravel is 55 feet thick and its base is much lower there than where it is exposed in the dry wash to the west.

Although the terrace gravels are more permeable than the Mancos Shale that they overlay, permeability tests indicate that both soils are impervious (permeability coefficient 0.90 and 0.55 ft/yr respectively, per Rollins, Brown and Gunnel letter dated 24 September, 1989, page 4-62). On the down slope side of the Waste Rock Site, the base of the terrace gravel is exposed. No springs or damp areas exist along this contact which indicates that the limited recharge into this region is not sufficient to cause formation saturation. The recharge is most likely in balance with transpiration that occurs.

The design of the Waste Rock Storage Facility is such that any water that flows into the site either from precipitation or from the terrace gravels will migrate to the southeastern portion of the site where a sedimentation pond is located.

R645-301-724.200 Surface Water Information

The areas around the Waste Rock Storage Facility contain ephemeral washes where surface water flows for short periods of time immediately following a storm event. This surface storm water is diverted around the site where it eventually flows into Grimes Wash approximately two (2) miles to the southeast. Grimes Wash then flows to the south for approximately 2 1/2 miles where it intersects Cottonwood Creek. All storm water which flows within the boundaries of the disturbed areas of the site, is diverted through a sedimentation structure prior to being discharged into the natural drainageways.

The Mancos Shale typically contains large quantities of soluble minerals such as gypsum. Therefore, any water passing through it or eroding it will be naturally high in dissolved solids.

R645-301-724.400 Climatological Information

Rocky Mountain Power has maintained a weather station on East Mountain which is located two miles to the northeast from the Waste Rock Storage Facility since 1979. Historical records collected there show an average of 12.5 inches of precipitation annually. Much of this precipitation comes in the form of late summer thunder showers. This weather station is at a much higher elevation and consequently receives higher precipitation than at the Waste Rock Storage Facility. It is estimated that the site itself receives about 7-9 inches of moisture annually.

Temperatures in the area range from highs in the upper 90's to lows to -10 degrees below zero. The area experiences a frost-free period of about 120-140 days annually.

R645-301-728 Probable Hydrologic Consequences (PHC) Determination

The Waste Rock Storage Facility is located in an area which is very dry from a standpoint of both surface and groundwater. The only time surface water flows is during storm events. Also, the geotechnical study performed by Rollins, Brown and Gunnel Inc. shows that the near surface permeability is very low, being measured in terms of feet/year. The groundwater present in the Mancos Shale strata is high in total dissolved solids as documented in Hydrology of Area 56, Northern Great Plains and Rocky Mountain Coal Provinces, Utah, published by the U. S. Geological Survey in 1983. Rocks from the strata in the Blackhawk formation normally contributes less TDS to the groundwater. Therefore, because of the lack of surface and groundwater in the Waste Rock Storage Facility and the fact that what surface water does occur during storm events will be diverted around the site, this facility will not have any negative impacts on the hydrologic regime of the area. As discussed on earlier, the nearest alluvial valley floor is approximately two (2) miles from the site.

R645-301-730 Operation Plan

R645-301-731.100 Hydrologic Balance Protection

All rain water that falls onto the disturbed area of the Waste Rock Storage Facility and forms surface runoff, shall be collected in diversion ditches and diverted into a sediment pond prior to discharge into the surrounding ephemeral drainage systems.

R645-301-731.220 Surface Water Monitoring

The applicant commits to monitoring the surface waters surrounding the Waste Rock Storage Facility throughout the permit period. This monitoring shall include the measurement of quantity and quality of the water that is discharged from the sediment pond. Reasonable effort shall be made to measure the natural drainage during storm events in that it is almost always dry. The sediment pond discharge samples collected shall be analyzed as specified in UPDES permit (refer to Volume 9 Appendix B).

R645-301-740 Design Criteria and Plans

This permit contains site specific plans that incorporate minimum design criteria for the control of drainage from the disturbed and undisturbed areas. Drainage control is accomplished by means of diversions ditches and a sedimentation pond.

R645-301-742 Sediment Control Measures

Sediment control measures include practices carried out within and adjacent to the disturbed area. The sedimentation storage capacity of practices in and downstream from the disturbed areas will reflect the degree to which successful mining and reclamation techniques are applied to reduce erosion and control sediment. Sediment control measures consist of the utilization of proper mining and reclamation methods and sediment control practices, singly or in combination. Sediment control methods include, but are not limited to:

a. Retaining sediment within disturbed areas;
b. Diverting runoff away from disturbed areas;
c. Diverting runoff using protected channels or pipes through disturbed areas so as not to cause additional erosion;
d. Using best management practices (BMP's) to reduce overland flow velocities, reduce runoff volumes and trap sediment.

R645-301-742.220 Sediment Ponds

Runoff from the area above the Waste Rock Storage Facility will be diverted into a ditch designed for the 100 year, 6 hour storm event. This runoff, as well as runoff from areas within the site will be diverted into a sediment pond which will contain the runoff of a 10 year, 24 hour storm with a spillway designed for the 25 year, 6 hour storm event. Refer to Appendix C for sediment pond design.

R645-301-742.230 Other Treatment Facilities

During the design process it was found that there some disturbed areas which could not be reasonably treated by the sedimentation pond due to remote geographic locations, and which could not meet effluent limitations without treatment. These areas are considered Alternative Sediment Control Areas (ASCA). These areas will be treated by best management practices (BMP's) which include, but are not limited to: silt fences, berms, catch basins, vegetation, sediment filters, rolled erosion control products. ASCA areas present at the Cottonwood/Wilberg Waste Rock Storage Facility include the access road and the subsoil pile. Refer to Plate 4-2 for location of all ASCA areas with this site. Also refer to Appendix C for the design of drainage control structures.

R645-301-747 Disposal of Noncoal Mine Waste

Inherently, noncoal mine waste finds its way into the coal produced from the underground mining process. This waste is transported out of the mine with the produced coal. During breaking and screening (sizing) of the coal product, coal mine waste (refuse) is removed and separated from the final coal product. This waste stream is transported to the Waste Rock Storage Facility for permanent disposal.

As required by R645-301-528.330, noncoal wastes including, but not limited to, grease, lubricants, paints, flammable liquids, garbage,….., and other combustible materials generated during mining activities will be disposed of in a solid waste disposal area. Noncoal wastes found in the storage pile are removed prior to permanent placement of the material. The noncoal waste is temporarily stored at the site until such time it can be transported off-site to a proper solid waste disposal site.

R645-301-748 Casing and Sealing of Wells

The water well located at the Cottonwood/Wilberg Waste Rock Storage Facility shall be cased, sealed, or otherwise managed, as approved by the Division, to prevent acid or other toxic drainage from entering ground or surface water, to minimize disturbance to the hydrologic balance, and to ensure the safety of people, livestock, fish and wildlife, and machinery in the permit and adjacent area.

The well has been provided with a steel casing and cemented in place at the surface. A lockable end cap is installed to prevent unauthorized access to the well.

R645-301-750 Performance Standards

All coal mining and reclamation operations will be conducted to minimize disturbance to the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area and support approved postmining land uses in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302. For the purposes of SURFACE COAL MINING AND RECLAMATION ACTIVITIES, operations will be conducted to assure the protection or replacement of water rights in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302.

R645-301-751 Water Quality Standard and Effluent Limitations

Discharges of water from areas disturbed by coal mining and reclamation operations will be made in compliance with all Utah and federal water quality laws and regulations and with effluent limitations for coal mining promulgated by the U.S. Environmental Protection Agency set forth in 40 CFR Part 434.

If the site receives a storm greater than the designed capacity of the sediment pond, discharge from the sediment pond will be routed through the designed emergency spillway~~s~~ and into the ephemeral drainage. Discharge from the sediment pond would constitute an emergency situation and comply with State of Utah Department of Environmental Quality Division of Water Quality storm water regulations.

R645-301-752 Sediment Control Measures

Sediment control measures will be located, maintained, constructed and reclaimed according to plans and designs given under R645-301-732, R645-301-742 and R645-301-760 (refer to Appendix C: Drainage Control Plan for design, construction and maintenance of sediment controls for the Cottonwood/Wilberg Waste Rock Storage Facility).

752.100 Siltation structures and diversions are located, maintained, constructed and will be reclaimed according to plans and designs given under R645-301-732, R645-301-742 and R645-301-763.

752.200 Road Drainage. Roads are located, designed, constructed, reconstructed, used, maintained and will be reclaimed according to R645-301-732.400, R645-301-742.400 and R645-301-762 and to achieve the following:

752.210 Control or prevent erosion, siltation and the air pollution attendant to erosion by vegetating or otherwise stabilizing all exposed surfaces in accordance with current, prudent engineering practices;

752.220 Control or prevent additional contributions of suspended solids to stream flow or runoff outside the permit area;

752.230 Neither cause nor contribute to, directly or indirectly, the violation of effluent standards given under R645-301-751;

752.240 Minimize the diminution to or degradation of the quality or quantity of surface- and ground-water systems; and

752.250 Refrain from significantly altering the normal flow of water in streambeds or drainage channels.

R645-301-753 Impoundments and Discharge Structures

Impoundments and discharge structures have been located, maintained, constructed and will be reclaimed to comply with R645-301-733, R645-301-734, R645-301-743, R645-301-745 and R645-301-760.

R645-301-755 Casing and Sealing of Wells

All wells will be managed to comply with R645-301-748 and R645-301-765. The water well will be cased, sealed, or otherwise managed, as approved by the Division.

R645-301-760 Reclamation

Before abandoning a permit area or seeking bond release, the PacifiCorp will ensure that all temporary structures are removed and reclaimed, and that all sedimentation ponds, diversions, impoundments and treatment facilities meet the requirements of R645-301 and R645-302 for permanent structures, have been maintained properly and meet the requirements of the approved reclamation plan for permanent structures and impoundments. PacifiCorp will renovate such structures if necessary to meet the requirements of R645-301 and R645-302 and to conform to the approved reclamation plan. For complete discussion related to the reclamation plan for the Cottonwood/Wilberg Waste Rock Storage Facility refer to R645-301-500 Engineering, and Plates 4-7 and 4-12 in the Maps Section.

R645-301-765 Permanent Casing and Sealing of Wells

When no longer needed for monitoring or other use approved by the Division upon a finding of no adverse environmental or health and safety effects, the water well shall be abandoned and provided a watertight barrier to the migration of water in the well bore, in the annular spaces or in fractures and openings adjacent to the well bore. Well abandonment shall be conducted as approved by the Division.

DIVISION OF WATER RIGHTS
REQUEST FOR MONITOR WELL CONSTRUCTION

APPLICANTS NAME Utah Power & Light - Mining Division

APPLICANTS ADDRESS P. O. Box 310, Huntington, UT 84528

INDIVIDUAL CONTACT Charles A. Semborski/Val E. Payne (Name) 687-9821 (Phone)

CURRENT PROPERTY OWNER Utah Power & Light Co.

PROPOSED NUMBER OF WELLS 1 DIAMETERS 3-7/8" APPROX. DEPTHS 87'

TYPE OF COMPLETIONS (Casing, intake, gravel pack, grout, etc.) 2-inch ID slotted pVC pipe

PROJECT ENGINEER/MANAGER Rodger C. Fry (Name)
P. O. Box 310, Huntington, UT 84528 (Address) 687-9821 (Phone)

GENERAL LOCATION DESCRIPTION Cottonwood Mine Waste Rock Storage Site COUNTY Emery

WELLS IN CONJUNCTION WITH (LEAKING) UNDERGROUND STORAGE TANKS ____ Yes X No

NAME OF LICENSED DRILLER N/A LICENSE # ____

PROPOSED CONSTRUCTION DATE November 1989 ANTICIPATED COMPLETION DATE 11/30/89

LOCATION OF WELLS:

1. N/~~S~~ 800 FT. & E/~~W~~ 2100 FT. FRM SE COR. or __1/4__1/4 of SEC. 34 T 17 ~~N~~/S R 7 E/~~W~~ SLBM/~~USM~~
2. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM
3. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM
4. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM
5. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM
6. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM
7. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM
8. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM
9. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM
10. N/S____FT. & E/W____FT. FRM __COR. or __1/4__1/4 of SEC.___T___N/S R__E/W SLBM/USM

(continued on reverse side)

Comments or explanation ____

For office use only

DATE OF REQUEST ____ APP/REJ DATE BY ____
AREA OFFICE ____ AUTHORIZATION # ____

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300
SINCE 1908
Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

December 22, 1989

Job No.: 59 10184

Date Rec'd: December 5, 1989

Date Sampled: December 5, 1989

Sampled By: UP&L

Sample ID: UP&L

COTTONWOOD WASTE ROCK WELL
Depth 57'
FIELD MEASUREMENTS
pH 7.07
D.O. 7.03
Conductivity 10666

Utah Power and Light Co.
P.O. Box 1005
Huntington UT 84528

WATER ANALYSIS

Aluminum	61.00	mg/l	Chromium	0.28	mg/l
12-19-89	14:00 hr.		12-19-89	14:00 hr.	
Alk., Bicarbonate	414	mg/l HCO3	Conductivity	10000	umhos/cm
12-07-89	15:20 hr.		12-07-89	11:00 hr.	
Alk., Carbonate	1<	mg/l CaCO3	Copper	0.320	mg/l
12-07-89	15:20 hr.		12-19-89	15:30 hr.	
Alk., Total	339	mg/l CaCO3	Fluoride	0.85	mg/l
12-07-89	15:20 hr.		12-06-89	15:30 hr.	
Arsenic	0.008	mg/l	Hardness, Total	4037	mg/l CaCO3
12-21-89	9:00 hr.		12-13-89		
Anions, Total	119.73	meq/l	Iron	5.01	mg/l
			12-11-89	12:00 hr.	
Barium	0.03<	mg/l	Lead	0.470	mg/l
12-19-89	14:00 hr.		12-19-89	11:00 hr.	
Boron	1.59	mg/l	Magnesium	292.00	mg/l
12-22-89	14:00 hr.		12-13-89	13:30 hr.	
Cadmium	0.020	mg/l	Manganese	2.48	mg/l
12-19-89	11:00 hr.		12-11-89	12:15 hr.	
Calcium	1135.0	mg/l	Mercury	0.002<	mg/l
12-13-89	13:15 hr.		12-20-89	17:00 hr.	
Cations, Total	120.38	meq/l	Molybdenum	0.15	mg/l
			12-19-89	14:00 hr.	
Chloride	815.0	mg/l	Nickel	0.57	mg/l
12-07-89	13:15 hr.		12-19-89	11:00 hr.	

ANALYST: [signature]

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

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MINING DIV.
FIELD OFFICE

Manager, Huntington Laboratory

6-1.3

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PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

December 22, 1989

Job No.: 59 10184

Date Rec'd: December 5, 1989

Date Sampled: December 5, 1989

Sampled By: UP&L

Sample ID: UP&L

COTTONWOOD WASTE ROCK WELL
Depth 57'
FIELD MEASUREMENTS
pH 7.07
D.O. 7.03
Conductivity 10666

Utah Power and Light Co.
P.O. Box 1005
Huntington UT 84528

WATER ANALYSIS

Nitrogen, Ammonia	1.23	mg/l	Selenium	0.002<	mg/l
12-05-89	16:00	hr.	12-21-89	10:00	hr.
Nitrogen, Nitrate	0.09	mg/l	Sodium	851.00	mg/l
12-08-89	13:00	hr.	12-13-89	13:00	hr.
Nitrogen, Nitrite	0.01<	mg/l	Solids, Dissolved	9316.0	mg/l
12-08-89	13:00	hr.	12-14-89	16:00	hr.
Oxygen, Dissolved	7.4	mg/l	Solids, Suspended	15754.0	mg/l
12-05-89	16:45	hr.	12-14-89	16:00	hr.
pH	7.85	Units	Sulfate	4300.0	mg/l
12-05-89	17:00	hr.	12-14-89	10:15	hr.
Phosphorus, Total	0.80	mg/l	Sulfide	9.80	mg/l
12-06-89	13:00	hr.	12-07-89	08:30	hr.
Potassium	119.10	mg/l	Zinc	1.06	mg/l
12-13-89	14:00	hr.	12-19-89	11:00	

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ANALYST: [signature]

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

[signature]

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PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

January 11, 1990

Job No.: 59 10212

Date Rec'd: December 19, 1990

Date Sampled: December 19, 1990

Sampled By: UP&L

Sample ID: UP&l

COTTONWOOD WASTE ROCK WELL
Rec'd 1630 hr.
Sampled 1500 hr.

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JAN 12 1990
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FIELD OFFICE

Utah Power and Light Co.
P.O. Box 1005
Huntington UT 84528

WATER ANALYSIS

Parameter	Date	Time	Result	Units
Acidity	12-28-89	1500 hr.	10	mg/l CaCO3
Aluminum	01-10-90	1300 hr.	4.00	mg/l
Alk., Bicarbonate	12-28-89	1430 hr.	798	mg/l HCO3
Alk., Carbonate	12-28-89	1430 hr.	1<	mg/l CaCO3
Alk., Total	12-28-89	1430 hr.	654	mg/l CaCO3
Arsenic	01-11-90	1100 hr.	0.006	mg/l
Anions, Total			150.79	meq/l
Barium	01-10-90	1300 hr.	0.03<	mg/l
Boron	01-09-90	1600 hr.	0.69	mg/l
Cadmium	01-10-90	0900 hr.	0.002<	mg/l
Calcium	01-08-90	1415 hr.	563.0	mg/l
Cations, Total			149.93	meq/l
Chloride	12-29-89	1815 hr.	280.0	mg/l
Chromium	01-10-90	1300 hr.	0.05	mg/l
Conductivity	01-08-90	1500 hr.	32000	umhos/cm
Copper	01-10-90	0900 hr.	0.070	mg/l
Fluoride	01-09-90	0930 hr.	0.80	mg/l
Hardness, Total			3354	mg/l CaCO3
Iron	01-08-90	1000 hr.	11.30	mg/l
Iron, Dissolved	01-08-90	1000 hr.	9.00	mg/l
Lead	01-10-90	0900 hr.	0.050<	mg/l
Magnesium	01-08-90	1400 hr.	473.00	mg/l
Manganese	01-08-90	0930 hr.	0.89	mg/l
Mercury	01-11-90	0900 hr.	0.002<	mg/l

ANALYST: D. Tyson

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

6-1.5

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PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

January 11, 1990

Job No.: 59 10212

Sample ID: UP&l

Date Rec'd: December 19, 1990

COTTONWOOD WASTE ROCK WELL
Rec'd 1630 hr.
Sampled 1500 hr.

Date Sampled: December 19, 1990

Sampled By: UP&L

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P.O. Box 1005
Huntington UT 84528

WATER ANALYSIS

Molybdenum	0.10<	mg/l	01-10-90 1300 hr.
Nickel	0.14	mg/l	01-10-90 0900 hr.
Nitrogen, Ammonia	0.14	mg/l	01-04-90 1330 hr.
Nitrogen, Nitrate	0.48	mg/l	01-09-90 1500 hr.
Nitrogen, Nitrite	0.12	mg/l	01-09-90 1500 hr.
Oil and Grease	1.0<	mg/l	12-29-89 1100 hr.
Oxygen, Dissolved	3.3	mg/l	12-19-89 1730 hr.
pH	7.70	Units	12-19-89 1700 hr.
Phosphorus, Total	0.29	mg/l	01-04-90 1105 hr.
Potassium	41.60	mg/l	01-08-90 1315 hr.
Selenium	0.002<	mg/l	01-11-90 1315 hr.
Sodium	1905.00	mg/l	01-08-90 1300 hr.
Solids, Dissolved	8714.0	mg/l	01-03-90 1600 hr.
Solids, Settleable	13.0	mg/l	12-19-89 1645 hr.
Solids, Suspended	8000.0	mg/l	01-03-90 1600 hr.
Sulfate	6200.0	mg/l	01-08-90 1645 hr.
Sulfide	19.80	mg/l	12-29-89 1745 hr.
Zinc	0.35	mg/l	01-10-90 0900 hr.

ANALYST: D. Tyson

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

6-1.6

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PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

January 16, 1990

Job No.: 59 10243

Date Rec'd: January 9, 1990

Date Sampled: January 9, 1990

Sampled By: UP&L

Sample ID: UP&L

COTTONWOOD WASTE ROCK WELL
Depth 56.5'
Rec'd 1645 hr.
Sampled 1350 hr.

Utah Power and Light Co.
P.O. Box 1005
Huntington UT 84528

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FIELD OFFICE

WATER ANALYSIS

Acidity	12	mg/l CaCO3	Chloride	425.0	mg/l
01-12-90	1645 hr.		01-11-90	1545 hr.	
Aluminum	0.01<	mg/l	Chromium	0.02<	mg/l
01-10-90	1300 hr.		01-10-90	1300 hr.	
Alk., Bicarbonate	534	mg/l HCO3	Conductivity	16000	umhos/cm
01-10-90	1130 hr.		01-11-90	1610 hr.	
Alk., Carbonate	1<	mg/l CaCO3	Copper	0.020	mg/l
01-10-90	1130 hr.		01-10-90	0900 hr.	
Alk., Total	438	mg/l CaCO3	Fluoride	0.69	mg/l
01-10-90	1130 hr.		01-15-90	1415 hr.	
Arsenic	0.002	mg/l	Hardness, Total	2345	mg/l CaCO3
01-11-90	1000 hr.				
Anions, Total	144.34	meq/l	Iron	0.21	mg/l
			01-12-90	1400 hr.	
Barium	0.03<	mg/l	Iron, Dissolved	0.19	mg/l
01-10-90	1330 hr.		01-12-90	1400 hr.	
Boron	1.00	mg/l	Lead	0.070	mg/l
01-09-90	1600 hr.		01-10-90	0900 hr.	
Cadmium	0.002<	mg/l	Magnesium	408.00	mg/l
01-10-90	0900 hr.		01-12-90	1445 hr.	
Calcium	266.4	mg/l	Manganese	0.15	mg/l
01-12-90	1430 hr.		01-12-90	1515 hr.	
Cations, Total	146.29	meq/l	Mercury	0.002<	mg/l
			01-09-90	0930 hr.	

ANALYST: D. Tyson

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

6-1.7

F-465

COMMERCIAL TESTING & ENGINEERING CO.
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SINCE 1908
Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TELEPHONE: (801) 653-2311

January 16, 1990

Job No.: 59 10243

Date Rec'd: January 9, 1990

Date Sampled: January 9, 1990

Sampled By: UP&L

Sample ID: UP&L

COTTONWOOD WASTE ROCK WELL
Depth 56.5'
Rec'd 1645 hr.
Sampled 1350 hr.

Utah Power and Light Co.
P.O. Box 1005
Huntington UT 84528

RECEIVED
JAN 16 1990
MINING DIV.
FIELD OFFICE

WATER ANALYSIS

Parameter	Result	Units	Date	Time
Molybdenum	0.10<	mg/l	01-10-90	1300 hr.
Nickel	0.06	mg/l	01-10-90	0900 hr.
Nitrogen, Ammonia	0.20	mg/l	01-15-90	1320 hr.
Nitrogen, Nitrate	9.94	mg/l	01-15-90	1150 hr.
Nitrogen, Nitrite	0.06	mg/l	01-15-90	1150 hr.
Oil and Grease	3.7	mg/l	01-15-90	1525 hr.
Oxygen, Dissolved	4.1	mg/l	01-10-90	1500 hr.
pH	7.50	Units	01-10-90	1425 hr.
Phosphorus, Total	0.06	mg/l	01-11-90	1100 hr.
Potassium	23.80	mg/l	01-12-90	1500 hr.
Selenium	0.002<	mg/l	01-11-90	1000 hr.
Sodium	2300.00	mg/l	01-12-90	1415 hr.
Solids, Dissolved	10170.0	mg/l	01-15-90	1540 hr.
Solids, Settleable	20.0	mg/l	01-10-90	0930 hr.
Solids, Suspended	11064.0	mg/l	01-15-90	1540 hr.
Sulfate	5900.0	mg/l	01-15-90	1100 hr.
Sulfide	0.00	mg/l	01-15-90	1015 hr.
Zinc	0.02	mg/l	01-10-90	0900 hr.

ANALYST: D. Tipon

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

6-1.8

Drainage Control Design

General

The Cottonwood/Wilberg Waste Rock Storage Facility encompasses 16.9 acres of disturbed land and has an access road 1,435 feet long. Drainage along the road will be routed to four culverts which will convey storm runoff safely under the road surface and into the natural drainage channels. Runoff from the waste pile and from the 15.5 undisturbed acres of land which normally drain through the waste rock site will be diverted to a sediment pond where the water will be retained to remove suspended solids before discharging back into the natural drainage.

Sediment Pond Sizing

This section details the methods used to estimate storm runoff volume and mean sediment yield to determine the design volume of the sediment pond.

Storm Runoff Volume

Sediment ponds and other sediment treatment facilities are required to treat the runoff from a 10 year, 24 hour storm event.

The runoff depth resulting from a given rainfall event was determined using the runoff curve number technique, as defined by the USDA Soil Conservation Service (now Natural Resource Conservation Service) in 1972. According to the curve number methodology, the relationship between storm rainfall, soil moisture storage, and runoff can be expressed by the equations:

$$Q = \frac{P - 0.2S\ ^{2}}{P + 0.8S} \qquad (1)$$

$$CN = \frac{1000}{10 + S} \qquad (2)$$

Where:

Q = direct runoff depth, inches
P = storm rainfall depth, inches
S = maximum infiltration depth (defined as Q), inches; and
CN = curve number, dimensionless

Use of equations 1 and 2 requires the selection of a curve number, which is a function of vegetative cover and hydrologic soil groups. Curve numbers for the study area were selected from information provided by the USDA Soil Conservation Service (1972), by US Bureau of Reclamation (1977), and from personal hydrologic judgment following field observation. To determine a representative curve number the 31.3 acres were divided into two nearly homogeneous subareas. The south facing slopes above 6900 feet elevation, consisting of 15.3 acres, are deteriorated shale and sandstone ledges with very little vegetative cover. The sandstone ledges are close to vertical while the shale colluvial slopes range from 1:1 to 2.5:1 with an average of about 1.5:1. Select CN of 86 based on soil type C, 10% ground cover and figure 9.6, Soil Conservation Service National Engineering Handbook Section 4, Exhibit VI. Below 6900 feet elevation, the slopes are less steep with more vegetation including the valley floor. From Figure 9.6 (Exhibit VI), select CN of 80 based in soil type C and 30% ground cover for the 16.0 acres. Therefore a weighted average CN = ((5.3 x 86) + (16.0 x 80)) / (15.3 + 16.0) = 82.9.

Equation 1 is based on the assumption that Ia = 0. 2S, where Ia is the initial abstraction from storm rainfall, defined as the rainfall which must fall before runoff begins (i.e., to satisfy interception, evaporation, and soil-water storage). Therefore, determination of runoff from Equation 1 is valid only when P ~ O. 2S. Below this point, no runoff can occur. Once Q was determined from the above equation, the runoff volume was calculated by multiplying the runoff depth by the drainage area.

Values of precipitation (P) were selected for the design return periods from Volume VI-Utah of the NOAA ATLAS 2 Precipitation-Frequency Atlas of the Western United States, (Miller et.al., 1973). For P equal to 2.2 inches and weighted average curve number of 82.9, the computed runoff is 0.831 inches over 31.3 acres or 2.17 acre feet.

Mean Annual Sediment Yield

The amount of sediment to be deposited in the sediment pond was determined from the Universal Soil loss Equation from B. J. Barfield, R.C. Warner, and C. T. Haan, Applied Hydrology and Sedimentology for Disturbed Areas, Oklahoma State University, Stillwater, Oklahoma, 1981. In accordance with this equation, the annual soil loss due to precipitation related erosion is:

$$A = R \bullet K \cdot LS \cdot CP$$

where:

A = computed amount of soil loss 'in tons/acre/year
R = rainfall factor, average annual value
K = rainfall factor, average annual value
LS = topographic factor
CP = erosion control factor

The R value can be estimated from Equation 5.5, Barfield et.al.

$$R = 27 \times (P_{2,6})^{2.2}$$

Where, $P_{2,6}$ is the 2 year, 6 hour precipitation inches. For the Waste Rock Site, the $P_{2,6}$ is 1.0 inches (NOAA ATLAS Volume VI). Therefore:

$$R = 27\,(1.0)^{2.2} = 27$$

The K - value was taken as 0.03 from the map presented by C. Earl Israelsen, Joel E. Fletcher, Frank W. Haws, and Eugene K. Israelsen, Erosion and Sedimentation in Utah: A Guide for Control. UWRL/H-84/03, 1984 Utah Water Research Laboratory, College of Engineering, Utah State University, Logan, Utah.

LS values are determined for each subarea of the watershed based on equation 5.10, Barefield et.al.

$$LS = \frac{(L)^m}{72.6} \quad 430x^2 + 30x + 0.43 \; /(6.613)$$

where:

L = slope length, feet

M = exponent dependent on the slope

if slope 3% then m = .3

if slope = 4% then m = .4

if slope 5% then m = .5

X = sine of the slope angle

= sin (arc tan (slope %)/100)

The CP values are also determined from Barefield, et.al., from either table 5.8 or table S.A.3.

Table 4.1 summarizes the sediment prediction calculations and references the areas depicted in the map in Exhibit XI.

TABLE 4.1

Description	Subarea ID	Area (Acres)	Length (ft)	Slope (%)	LS	CP	CP Source Table #	A* Tons/Acre/Yr	Annual Sediment Yield
Undisturbed 10% Cover No Canopy	A	14.4	800	62.5	68.8	0.32	5.A.3	178	2570
Undisturbed 10% Cover No Canopy	B	2.0	320	56.2	37.6	0.32	5.A.3	97	195
Undisturbed 30% Cover No Canopy	C	2.8	150	40	15.4	0.15	5.A.3	19	52
Reclaimed Soil Stockpile, 20% cover, No Canopy	D	1.6	100	67	26.7	0.2	5.A.3	43	69
Disturbed, Compacted	E	1.7	100	50	17.7	1.3	5.8	186	317
Disturbed, Compacted	F	6.3	500	2	0.32	1.3	5.8	3.3	21
Disturbed, Compacted	G	1.8	120	50	19.4	1.3	5.8	204	368

*A = R *x* K *x* LS *x* CP = (27) (0.3) LS *x* CP

Total = 3,592 tons/yea

The total sediment yield per year is 3,592 tons. For a density of 100 pounds per cubic foot, that relates to

3,592 tons x 2,000 lbs/ton *x* ft^3/100 lbs *x* Acre foot/43,560 ft^3 = 1.65 Ac. Ft.

Table 4.2 Sediment Pond Design

Precipitation from 10 Year 24 Hour Storm	2.2 inches
Weighted Average Curve Number	82.9
Direct Runoff	0.831 inches
Contributing Area	31.3 acres
Total Collected Runoff per Design Storm	2.17 ac ft
Annual Sediment Production	3,592 tons/year
Total Volume of Annual Sediment	1.65 ac ft
Combined Total Required Pond Volume 2.17 + 1.65	3.82 ac ft
Design Volume of Pond	4.58 ac ft
Additional Sediment Volume Provided (4.58 – 3.82)	0.76 ac ft
Design Sediment Volume (1.65 + 0.76)	2.41 ac ft
Clean out required at 60% of annual sediment production plus Additional sediment volume provided (60% x 1.65) + 0.76	1.75 ac ft

Refer to Exhibit XX Sediment Pond Storage – Capacity and Stage – Discharge Curves.

<u>Spillway Design</u>

A single, non-erodible open channel spillway will be provided to safely discharge from the impoundment without damage to the dam. The peak flow calculated for the 100 year, 6 hour storm event (refer to the section entitled "Peak Flow Determination" below) was 22.13 cubic feet per second. The channel will be concrete lined with random exposed rocks for roughness to achieve a Manning's N value of 0.030 (Chapter 4, State Department of Transportation, Manual of Instruction, Part 4, Road Way Drainage, 1984). The slope of the channel across the 15 foot wide crest is 5%. Manning's equation is used to determine the depth of flow and channel geometry. A six foot wide channel with 2:1 side slopes results in a design depth of six inches. The channel will be continued down the slope of the dam and discharge into the natural channel.

<u>General</u>

Temporary diversions will be constructed at the base of the valley side slopes to collect the runoff from the undisturbed areas and convey it to the sediment pond. As the waste pile grows and expands to cover the initial diversion ditch, new diversions will be constructed to convey the collected runoff to the pond. This process will be repeated until the waste pile reaches its maximum size in plan view and the ditches will not be moved thereafter. (Refer to Exhibit IV) Upon final reclamation, the ditches will become permanent diversions of the natural ephemeral drainage channel.

<u>Sub-Area Divisions</u>

The Cottonwood/Wilberg Waste Rock Storage Facility is divided into four subareas for hydrologic calculations based on the route that runoff takes to enter the sediment pond. (Refer to Map 4-2) The first area, 1A, includes the largest portion of the disturbed area consisting of the top and western slope of the waste pile, the inside slope and top of the topsoil stockpile and the undisturbed areas above the site which will also drain into the sediment pond. The ditch for this area, DA, will be constructed on a 2% slope until it reaches the last 355 feet before the sediment pond. The slope will then change to 18%. The total area to be drained by this ditch is 26.4 acres.

The second area, 1B, totaling 3.4 acres, consists of the eastern slope of the waste pile, the road to the top of the waste pile, and the inside slope and top of the subsoil stockpile. The ditch, DB, will be constructed on grades of 2.5% and 12% until it reaches the sediment pond.

Area 1C consists of the slopes above the sediment pond and the pond itself where runoff will flow directly into the pond without ditches. This area totals 1.6 acres.

The last area, 1D, consists of 0.9 acres including the outside slopes of the two soil stock piles and the dam. Runoff from these areas will not be collected in the sediment pond. Treatment of these areas will be by silt fences and straw bales.

<u>Peak Flow Determination</u>

A unit hydrograph program by Richard Hawkins and Kim Marshall, "Storm Hydrograph Program" Utah State University, 1974, was used to model the rainfall and resulting runoff. The model *is* based on the Soil Conservation Service rainfall runoff function, also called the curve number equation. As such, a curve number was determined for each sub-area along with a time of concentration. See Exhibit 10, Tables 1-A and 1-B for hydrograph results.

Curve numbers were derived based Conservation Service National Engineering Handbook, Section 4 - Hydrology, Chapters 7, 8, and 9.

Time of concentration was based on two methods. For the flow from the undisturbed area, the following relationships from Barfield et.al., were used:

$t_c = t_{l/\cdot 6}$

t_c = time of concentration, hours

t_l = lag time, hours

$t_l = L^{0.8} (S+1)^{0.7} / (1900 \times y^{0.5})$

L = hydraulic length, feet

S = (1000/curve number - 10)

Y = slope in percent

For subarea 1A, the first portion of the travel time for the runoff from the highest point in the subarea to the diversion ditch is 0.0796 hours, or 4.78 minutes, based on a length of 1350 feet, CN = 83 and an average slope of 59%.

The second portion consists of the time required to travel in the ditch to the pond. Manning's equation was used to derive a value for the velocity of the flow in the ditch. Assuming a flow rate of 20 cfs and a V-ditch with 2.5:1 side slopes and channel slope of 2%, Manning's n = 0.035, the velocity was determined to be 4.40 feet/second. The length of the ditch is 1300 feet which gives a travel time of 4.92 minutes. Therefore, the total time of concentration is 4.78 + 4.92 or 9.7 minutes.

The t_c for subarea 1B was similarly determined from 185 feet of overland flow at 50% slope and CN=82 to yield an initial travel time of 0.0182 hours or 1.09 minutes. The travel times for the two foot wide trapezoidal ditch estimated as follows:

1.5 cfs; 400 feet at 2.5% slope = 2.3 fps= 2.90 minutes
2.5 cfs; 320 feet at 12 % slope = 4.6 fps= 1.16 minutes
3.0 cfs; 170 feet at 7.5% slope = 4.1 fps= 0.69 minutes
Total ditch travel time = 4.75 minutes

Therefore the t_c for the Area 1B equals 5.84 minutes.

Peak flows from Area 1C were determined based on assuming 100% of the rainfall went directly to the pond. The peak flows for the ditches occurred at 2.52 hours when the rainfall intensity was 0.22 inches in 30 minutes or 0.0073 inches/minute. This resulted in a peak flow of:

$$1.6\ acres\ x\ \frac{0.0073\ inches}{minute}\ x\ \frac{43{,}560\ ft2}{acres}\ x\ \frac{1\ minute}{60\ second}\ x\ \frac{1\ foot}{12\ inches}\ x\ 0.71\ cubic\ feet/second$$

Table 4-2.1: Diversion Peak Flow Rates

	Acres	**Curve No.**	**Time of Concentrtation**	**Peak Flow**
1A	26.3	82.6	0.162 hrs	18.9 cfs
1B	3.4	82	0.0973	2.52
1C	1.6	-		0.71
1D	0.9	-		
Total	**32.2 acres**			**22.13 cfs**

(Peak flows based on 100 year, 6 hour storm event of 2.2 inches)

Each ditch was designed to keep the velocity below 5 feet per second in order to prevent erosion. Ditch DA will be a V-ditch for the entire length until it approaches the pond where the slope increases from 2 to 18%. At that point, a wide trapezoidal ditch will be used with a rip-rap lining. Ditch DB will be a narrow trapezoidal ditch for its entire length. Both ditches will be monitored throughout the life of the facility for erosion and formation of gullies. If erosion does occur with the ditches, the applicant will repair any gullies and install velocity controls (i.e. rip-rap, gabions, etc.) as needed to correct the problem.

Rip-rap sizing for the steep section of ditch DA was taken from Utah State Department of Transportation Manual of Instruction, Part 4, Roadway Drainage, Section 4-610.30, Stable Channel Design. Using a stone diameter of 0.5 feet, Manning's n = 0.0305 from fig. 3-28, Utah DOT MOl Part 4 (Exhibit VII), the calculated depth of the flow is less than the stone diameter so use velocity against stone equal to the average velocity. (Exhibit VIII) Then entering the calculated velocity of 7.58 fps in fig. 3-30 (Exhibit IX) the required stone size for 2.5: 1 side slope is confirmed at the assumed size, i.e. 0.5 feet diameter for D_{50}.

Ditch DA

- V-ditch, 2.5:1 side slopes, 2% channel slope, Manning’s n = 0.035, peak flow 18.9 cfs, depth 1.32 feet, velocity 4.34 feet/second.
- Trapezoidal, 10 foot bottom width, 2.5:1 side slopes, 18% channel slope, Manning’s n = 0.0305, peak flow 18.9 cfs, depth 0.235 feet, velocity 7.58 feet/second, rip-rap D50 size = 0.5 feet.

Ditch DB

- Trapezoidal, 2 foot bottom width, 2.:1 side slopes, 12% channel slope, Manninng’s n = 0.035, peak flow 2.52 cfs, depth 0.217 feet, velocity 4.59 fps.

Combined Ditch A and B (after final reclamation and removal of sediment pond)

- Trapezoidal, 10 foot bottom width, 3:1 side slopes, 2.1% channel slope, Manning's n = 0.35, peak flow 22.1 cfs, depth of flow 0.52 feet, depth of ditch 1.0 feet, velocity 3.61 feet/second.

CURVE NUMBER DETERMINATION FOR DIVERSION PEAK FLOW CALCULATION

Area 1A

15.3 Acres Undisturbed

Sage Grass, 10% Cover, Soil Type C

CN = 83 SCS NEH-4 fig 9.6 (Exhibit VI)

11.0 Acres Disturbed

Waste rock pile consisting of soils with moderate infiltration rate, deep and well drained with moderate fine to moderate coarse texture use Soil Type B, NO Cover, Dirt Roads

CN = 82 NEH-4 Table 9.1

Weighted Average CN =

(15.3 (83) + 11.0 (82)) / (15.3 + 11.0) = 82.6

Area 1B

Use CN = 82 as above for disturbed area with No Cover.

Access Road Drainage

The access road will cross several natural ephemeral drainage channels and will require culverts to convey the runoff underneath the road surface. The drainage areas for each culvert have been marked on Map 4-2 and numbered 2 through 5. (Area 1 is the waste rock storage site and the undisturbed area which naturally drains through the site.) Peak flows were determined in the same manner as was used for the diversions in the previous section. Table 4-3 gives the parameters used to determine peak flows and culvert sizing. See Exhibit 10, Tables 2 through 5 for hydrograph results. Refer to Exhibit XIX for culvert outlet protection and trash racks.

Application to Alter a Natural Stream Channel

See following page.

STATE OF UTAH
NATURAL RESOURCES
Water Rights

Norman H. Bangerter, Governor
Dee C. Hansen, Executive Director
Robert L. Morgan, State Engineer

Southeastern Area • 453 S. Carbon Avenue • P.O. Box 718 • Price, UT 84501-0718 • 801-637-1303

April 3, 1990

UP&L Mining Division
Attn: Val Payne, Senior Environmental Engineer
P.O. Box 310
Huntington, Utah 84528

Dear Val:

Pursuant to the requirements set forth in Section 73-3-29 (Natural Stream Channel Alteration) Utah Code Annotated, 1953, a field examination of the proposed Wilberg Waste Rock Site was completed on March 30, 1990. Upon review of the designed channel crossings, it was concluded that the existing channels are, at best, ephemeral in nature and are not supportive of a riparian type habitat. Further, installation of the drainage controls (culverts) and ancillary site construction should not adversely impact the immediate drainage areas. Therefore, application to alter a natural stream channel is hereby waived.

In regards to construction of monitor wells, applications should be submitted to this office prior to drilling. I have enclosed several application forms for your use, which should incorporate any existing as well as proposed monitor wells. Please be advised that all wells must be constructed by a licensed well driller of the State of Utah.

In addition, I have included Administrative Rules for Well Drillers and Stream Channel Alterations as requested. If I can be of any further assistance, please feel free to contact me at your convenience.

Sincerely,

William A. Warmack

William A. Warmack
Assistant Area Engineer

Enclosures
WAW/mjk

Table 4.3: Access Road Culvert Sizing

Area #	Acres	Hydrologic Length	Slope (%)	Curve Number	Time of Conc. (hrs)	Peak Flow (cfs)	Culvert Diameter (in)	Culvert Capacity (cfs)	Minimum Culvert Slope (%)
2	2.21	420	37.4	80	0.0433	0.589	12	2.3	0.5
3	25.14	2630	34.6	80	0.195	5.08	24	13	0.5
4	4.18	915	8.6	73	0.207	0.186	12	2.3	0.5
5	33.97	3260	29.3	80	0.252	6.21	24	13	0.5

Earth Dam Design

The earth dam is analyzed for stability using a computer program, Rotational Equilibrium Analysis of Multilayered Embankments, by Yang H. Huang. (Exhibit XII) Both the simplified Bishop method and the normal method of slices are used to determine a factor of safety based on a cylindrical failure surface. The method allows a variety of conditions to be analyzed including both static and seismic loading and seepage through the earth dam. A piezometric surface is specified along with the geometry of the dam as input for the program. Soil data includes density, angle of internal friction, cohesion, depth and thickness of each layer.

The factors of safety are determined for a number of points forming a grid pattern above the slope. A routine within the program automatically searches for the minimum factor of safety between the grid points and displays the location of the center and gives the radius and the most critical factor of safety.

The analysis of stability is based on the method of slices which assumes the failure surface is cylindrical and the earth mass rotates about some center point located above the slope. The sliding mass is divided into separate slices, each slice being acted upon by a set of forces. The weight of the soil in the slice acts to cause the soil to move. This is the driving force of the slope failure. The resisting force is the sum of the shear and cohesion acting along the failure surface. The factor of safety is the ratio of resisting forces to the driving force.

$$SF = \frac{\sum_{i=1}^{n}(c\,Li + Ni\tan\emptyset)}{\sum_{i=1}^{n}(Wi\sin\theta i)}$$

Where:

SF	=	Factor of Safety
n	=	Number of slices
c	=	Effective cohesion
Li	=	Length of *ith* slice at the failure surface
Ni	=	Effective normal force at the failure surface
Ø	=	Angle of internal friction of the soil
Ni Tan	=	Shear strength of the soil
Wi	=	Weight of *ith* slice
θ	=	Angle of inclination of the *ith* slice

Equation 2.7, Yang H. Huang, STABILITY ANALYSIS OF EARTH SLOPES, Van Nostrand Reinhold Co., 1983.

The normal method of slices assumes the resultant of all forces on the vertical sides of the slice is zero in the direction normal to the failure arc for that slice. This method is usually conservative in comparison to other stability methods. The simplified Bishop method assumes the resultant of the forces on the sides of the slice is zero in the vertical direction. This produces an equation for the safety factor as follows:

$$SF = \frac{\sum_{i=1}^{n} c\,Li + Wi - UiLi \quad tan\theta \;[\frac{1}{Mi \;\; \theta}]}{\sum_{i=1}^{n} Wi \sin\theta i}$$

Where *Ui* = Pore pressure = depth from phreatic surface x density of water

$$Mi \quad \theta \quad = Cos\,\theta i\,[1 + \frac{\tan \emptyset}{SF}]$$

All other parameters described above.

Equation 24.12, T.W. Lambe and Robert V. Whitman, SOIL MECHANICS, John Wiley and Sons, 1969.

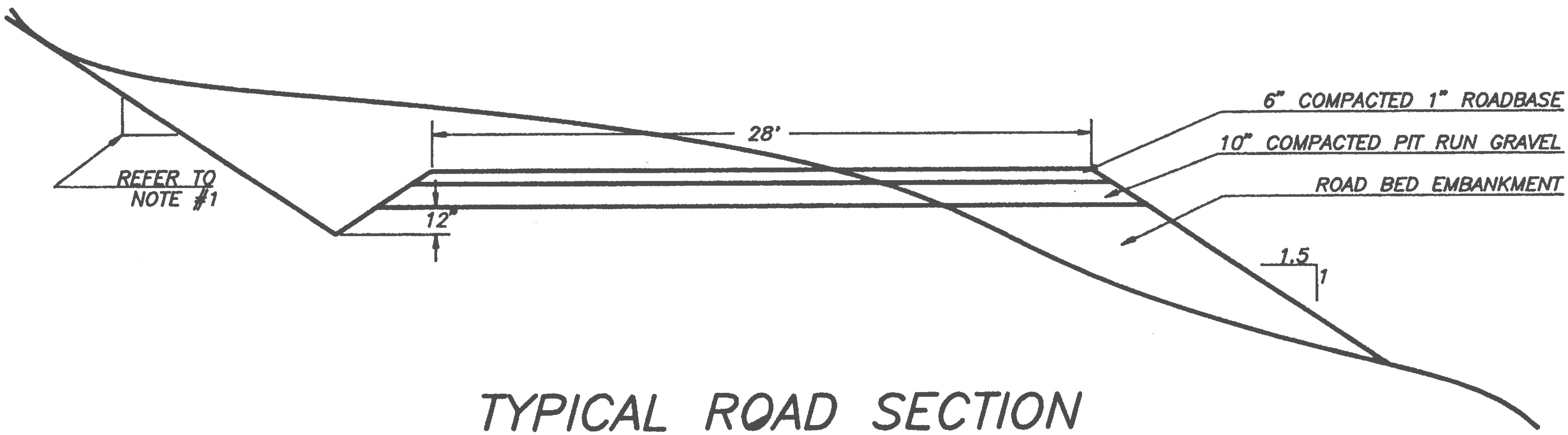
Because the equation contains the expression for safety factor on both sides, the solution is a trial and error procedure.

The earth dam is analyzed under three conditions of loading: (1) full reservoir and steady - state seepage, (2) full reservoir with seismic loading, and (3) rapid draw down. Soil layer strength parameters are obtained from the geotechnical investigation performed by Rollins, Brown and Gunnell, Inc. dated 7 September, 1989 (See Geotechnical Report R645-301-500 Engineering, Appendix A). Strength parameters for the dam embankment were determined by the same firm and dated 29 September, 1989 (refer to this report within the Geotechnical Report page number 4-62). The location of the phreatic surface was determined from Figure 4.3, Huang, a chart for determining the point of exit of the phreatic surface from the earth slope. (Exhibit XIII) The seismic coefficient of 1.13 was taken from Table 2.2, Huang, for Zone 2 which includes Central and Eastern Utah. (Exhibit XIV).

The results of the analysis are:

Condition	Safety Factor	Exhibit
Full reservoir with steady state seepage	1.9	XV
Full reservoir with seismic loading	1.3	XVI
Rapid draw down	2.4	XVII

Refer to Exhibit XVIII for the diagram of the input data for the program and the location of critical failure surfaces.



TYPICAL ROAD SECTION

NOTE:
1— CUT SLOPE 1 V TO 1.5 H IN UNCONSOLIDATED MATERIAL
CUT SLOPE 1 V TO 0.5 H IN ROCK MATERIAL.

EXHIBIT I

UNTREATED ROAD BASE SPECIFICATION

1 INCH GRADATION

Sieve Size	Ideal Gradation (percent passing)	Ideal Gradation Tolerance
1 inch	100	0
1/2 inch	85	±6
No. 4	55	±6
NO. 16	31	±4
No. 200	9	±2

3/4 INCH GRADATION

Sieve Size	Ideal Gradation (percent passing)	Ideal Gradation Tolerance
3/4 inch	100	0
3/8 inch	85	±7
No. 4	61	±6
No. 16	33	±5
No. 200	9	±2

Note:

1. That portion of the material passing the No. 40 sieve shall be non-plastic when tested by AASHTO Designation T-90
2. The above gradation specifications are to be done by AASHTO Designation T-27
3. The aggregate shall be of uniform density and quality and shall have a rodded weight of not less than 75 pounds per cubic foot according to AASHTO Designation T-19

Exhibit II

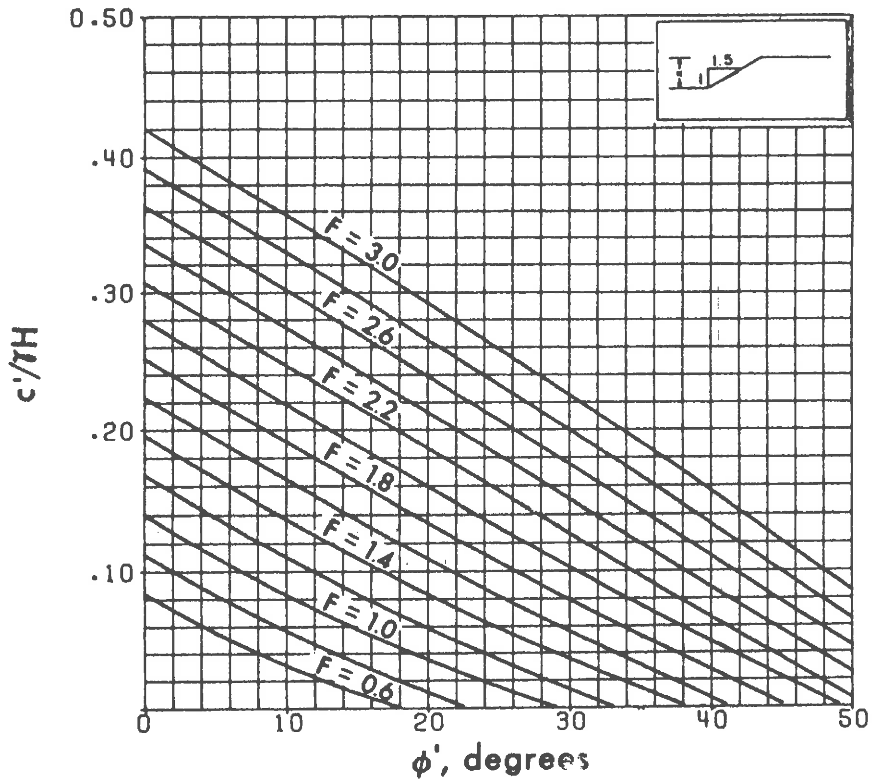


FIGURE A-3. - Factors of safety—1.5:1 slope, no phreatic surface, D = 1.00.

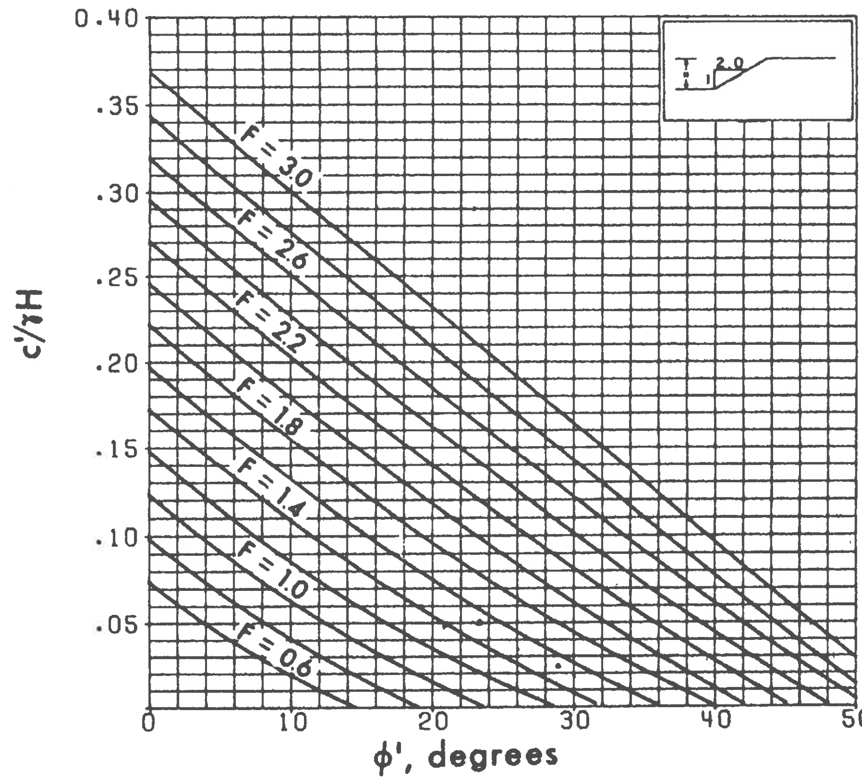


FIGURE A-4. - Factors of safety—2.0:1 slope, no phreatic surface, D = 1.00.

EXHIBIT III

FROM: D.R. Tesarik and P.C. Williams, Factor of Safety Charts for Estimating the Stability of Saturated and Unsaturated Tailings Pond Embankments, Bureau of Mines Report of Investigations 8564, US Department of the Interior

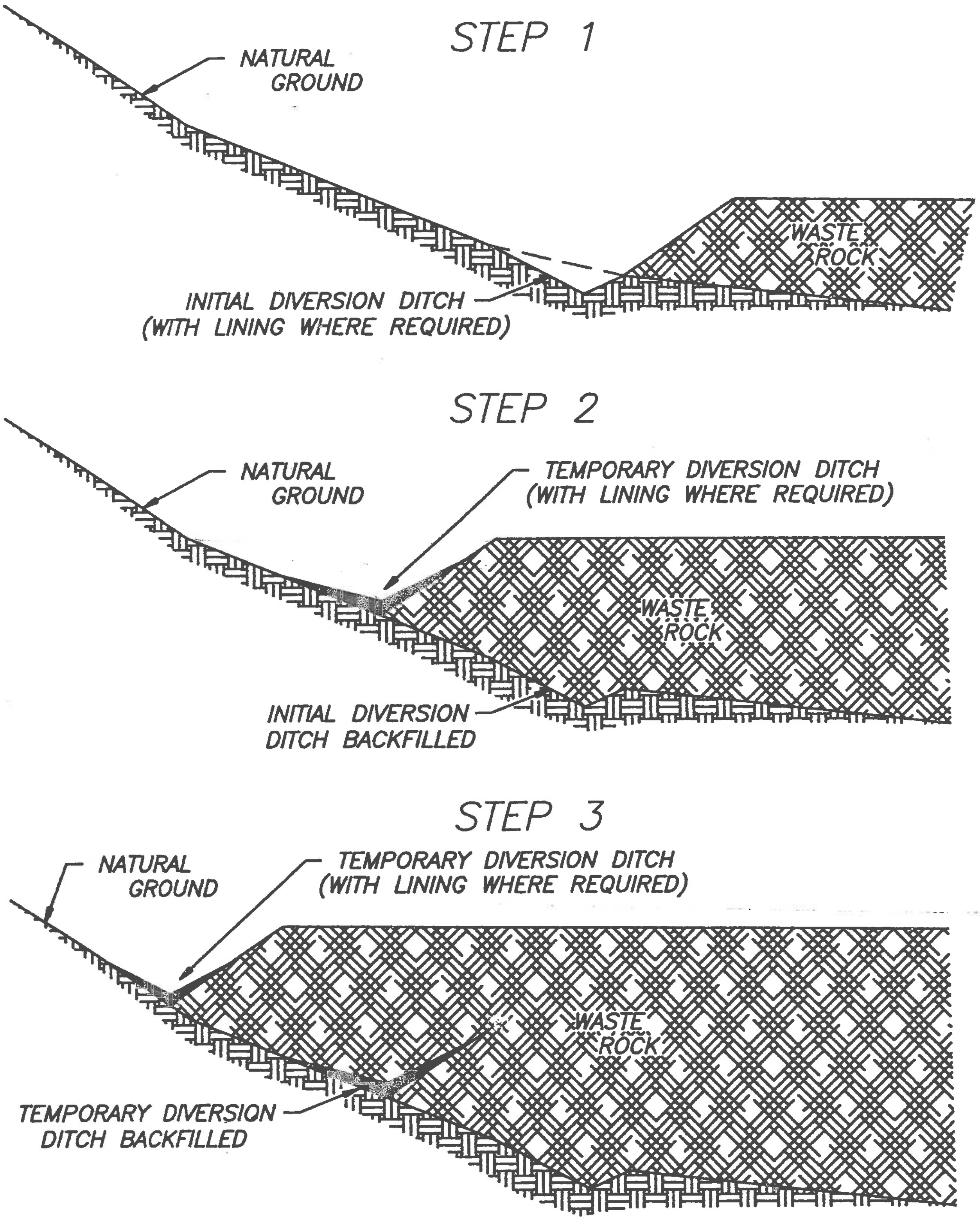


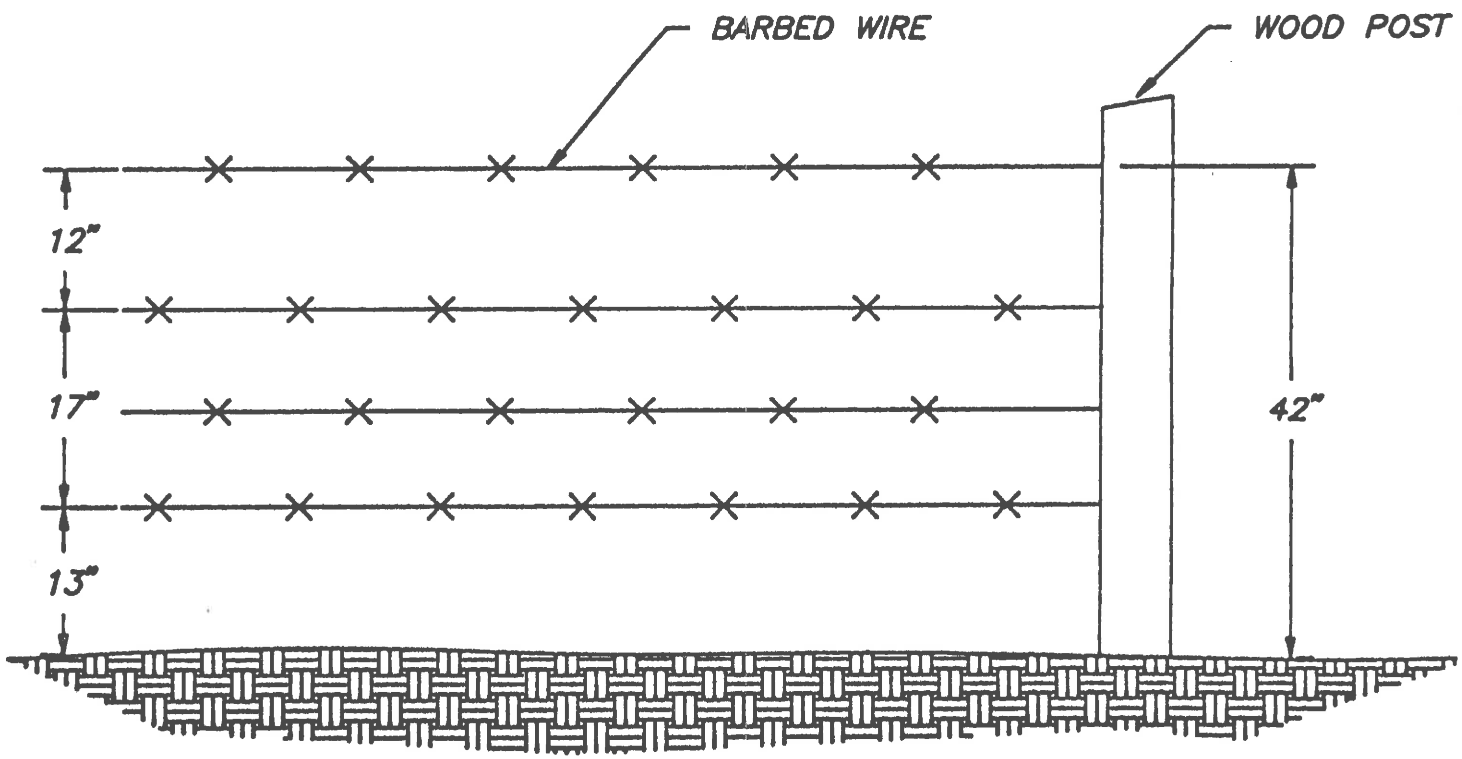
EXHIBIT IV

CAD FILE NAME/DISK#: CWRSFDDS/1.

UTAH POWER & LIGHT
MINING DIVISION

COTTONWOOD MINE
WASTE ROCK STORAGE FACILITY
DIVERSION DITCH SEQUENCE

DRAWN BY: J. GARRETT	KS1152A
SCALE: NONE	DRAWING #:
DATE: AUG. 8, 1989	SHEET 1 OF 1 — REV.



WASTE ROCK STORAGE FACILITY
FENCE DETAIL

EXHIBIT V

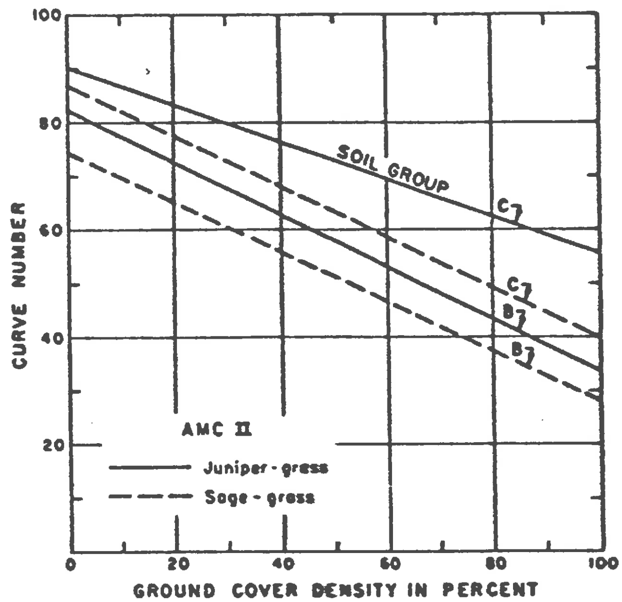


Figure 9.6.--Graph for estimating runoff curve numbers of forest-range complexes in western United States: juniper-grass and sage-grass complexes.

National Engineering Handbook, Section 4, Hydrology, Soil Conservation Service, U.S. Department of Agriculture.

EXHIBIT VI

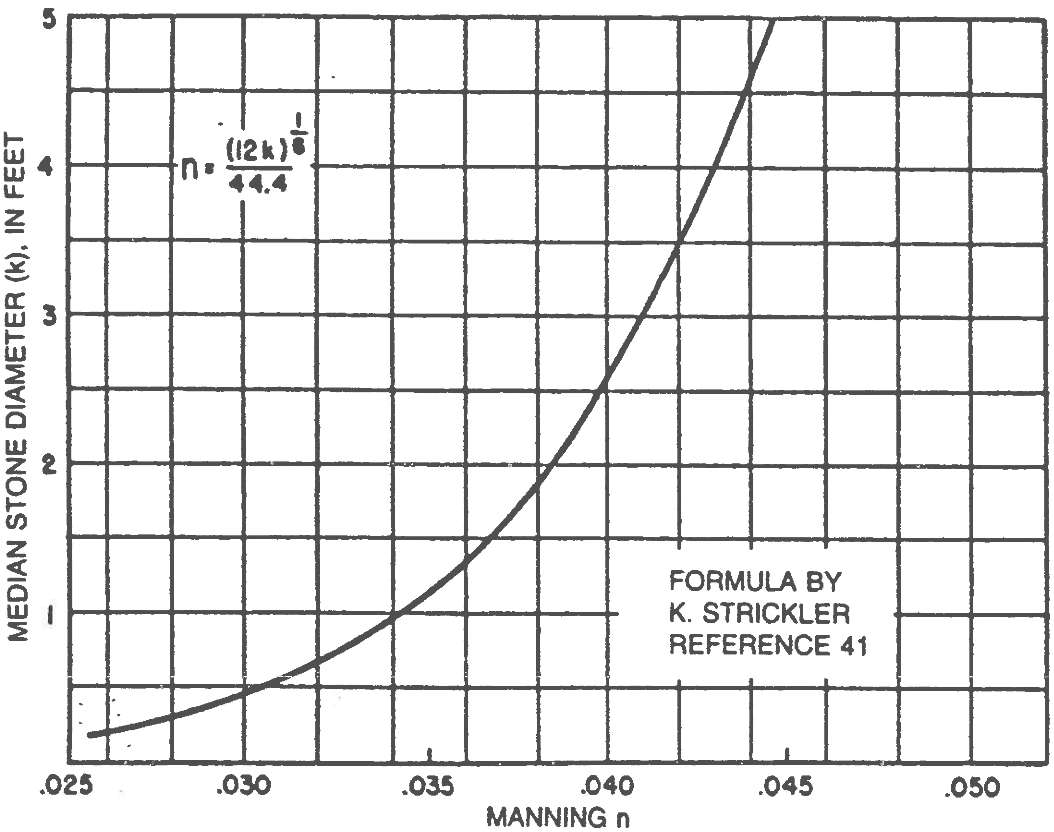


Figure 3-28: MANNING'S n VS. STONE SIZE

UTAH STATE DEPARTMENT OF TRANSPORTATION
MANUAL OF INSTRUCTION, PART 4
ROADWAY DRAINAGE

EXHIBIT VII

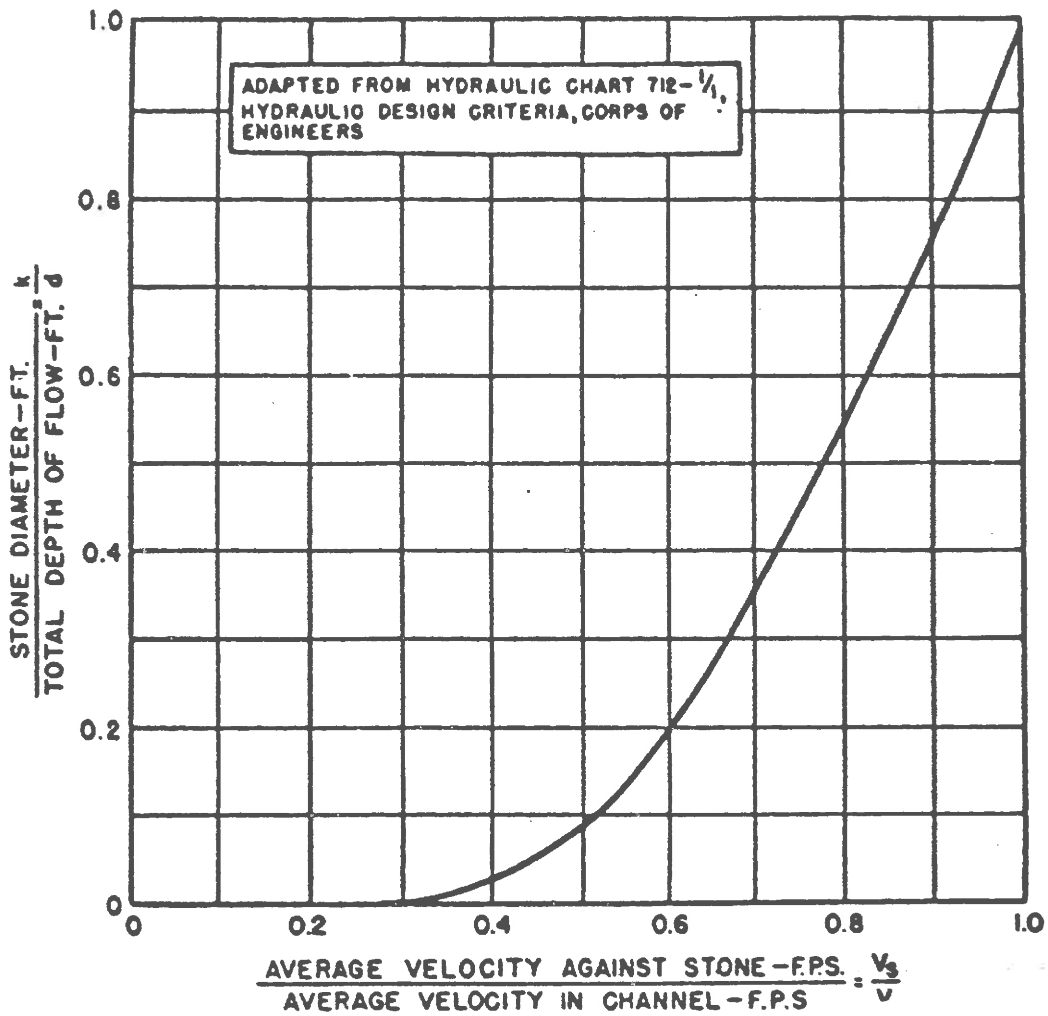


Figure 3-29: AVERAGE VELOCITY AGAINST STONE ON CHANNEL BOTTOM

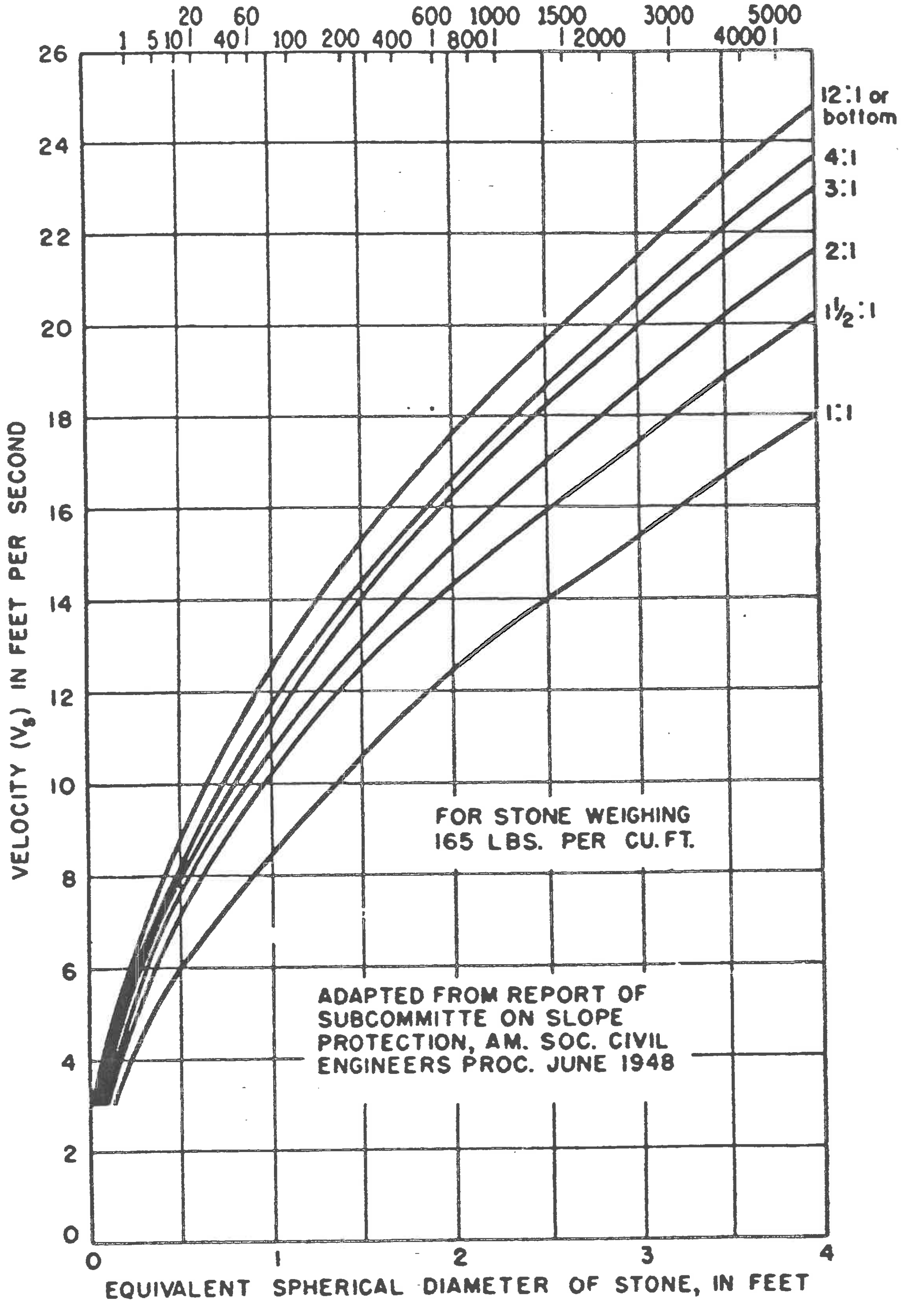


Figure 3-30: SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

UTAH STATE DEPARTMENT OF TRANSPORTATION
MANUAL OF INSTRUCTION, PART 4
ROADWAY DRAINAGE

EXHIBIT IX

TABLE 1-A

STORM RUNOFF DETERMINATION
FOR
CWRSF 1-A

INPUT SUMMARY:

DISTRIBUTION = SCS 6 HOUR	RUNOFF AREA = .0411 SQ. MILES
RAINFALL DEPTH = 2.2 INCHES	RUNOFF CURVE NO. = 82.6
STORM DURATION = 6 HOURS	TIME OF CONCENTRATION = .162 HRS.

HYDROGRAPH ORDINATES:

TIME (HR)	PPT (IN)	CUM. FLOW (IN)	DEL. FLOW (IN)	FLOW RATE (IN/HR)	FLOW RATE (CFS)
0.00	0.00	0.0000	0.0000	0.0000	0.00
2.35	1.08	0.1581	0.0151	0.5308	14.08
2.38	1.12	0.1732	0.0156	0.5604	14.86
2.40	1.15	0.1888	0.0160	0.5889	15.62
2.42	1.19	0.2048	0.0165	0.6162	16.34
2.44	1.22	0.2213	0.0169	0.6425	17.04
2.46	1.26	0.2382	0.0174	0.6677	17.71
2.48	1.29	0.2556	0.0144	0.6920	18.35
2.51	1.32	0.2700	0.0049	0.7107	18.85
2.53	1.33	0.2749	0.0049	0.7100	18.83
2.55	1.34	0.2797	0.0049	0.6895	18.29
2.57	1.35	0.2847	0.0049	0.6487	17.20
2.59	1.36	0.2896	0.0050	0.5872	15.57
2.61	1.37	0.2946	0.0050	0.5121	13.58
2.64	1.38	0.2996	0.0050	0.4451	11.81

OUTPUT SUMMARY:

TOTAL RUNOFF DEPTH = .814 IN.	TIME TO PEAK = 2.516 HOURS
INITIAL ABSTRACTION = .421 IN.	RUNOFF VOLUME CHECK = .816 IN.
PEAK FLOW = 18.905 CFS	

EXHIBIT 10
TABLE 1-A

TABLE 1-B

STORM RUNOFF DETERMINATION
FOR
CWRSF 1-B

INPUT SUMMARY:

DISTRIBUTION = SCS 6 HOUR
RAINFALL DEPTH = 2.2 INCHES
STORM DURATION = 6 HOURS
RUNOFF AREA = .00531 SQ. MILES
RUNOFF CURVE NO. = 82
TIME OF CONCENTRATION = .0915 HRS.

HYDROGRAPH ORDINATES:

TIME (HR)	PPT (IN)	CUM. FLOW (IN)	DEL. FLOW (IN)	FLOW RATE (IN/HR)	FLOW RATE (CFS)
0.00	0.00	0.0000	0.0000	0.0000	0.00
2.35	1.08	0.1462	0.0081	0.5735	1.97
2.37	1.10	0.1543	0.0082	0.5887	2.02
2.38	1.12	0.1625	0.0084	0.6036	2.07
2.39	1.14	0.1709	0.0086	0.6182	2.12
2.40	1.16	0.1794	0.0087	0.6325	2.17
2.42	1.18	0.1881	0.0089	0.6465	2.22
2.43	1.20	0.1970	0.0090	0.6602	2.26
2.44	1.22	0.2060	0.0091	0.6737	2.31
2.45	1.24	0.2151	0.0093	0.6868	2.35
2.46	1.26	0.2244	0.0094	0.6997	2.40
2.48	1.28	0.2338	0.0096	0.7123	2.44
2.49	1.30	0.2434	0.0091	0.7247	2.48
2.50	1.32	0.2525	0.0026	0.7354	2.52
2.51	1.33	0.2552	0.0026	0.7282	2.50
2.53	1.33	0.2578	0.0027	0.7028	2.41
2.54	1.34	0.2605	0.0027	0.6589	2.26
2.55	1.34	0.2631	0.0027	0.5963	2.04
2.56	1.35	0.2658	0.0027	0.5170	1.77
2.57	1.35	0.2685	0.0027	0.4466	1.53
2.59	1.36	0.2712	0.0027	0.3855	1.32
2.60	1.36	0.2739	0.0027	0.3337	1.14

OUTPUT SUMMARY:

TOTAL RUNOFF DEPTH = .784 IN.
INITIAL ABSTRACTION = .439 IN.
PEAK FLOW = 2.52 CFS
TIME TO PEAK = 2.502 HOURS
RUNOFF VOLUME CHECK = .785 IN.

EXHIBIT 10
TABLE 1-B

TABLE 2

STORM RUNOFF DETERMINATION
FOR
CWRSF AREA 2

INPUT SUMMARY:

DISTRIBUTION = SCS 6 HOUR
RAINFALL DEPTH = 1.5 INCHES
STORM DURATION = 6 HOURS

RUNOFF AREA = .00345 SQ. MILES
RUNOFF CURVE NO. = 80
TIME OF CONCENTRATION = .0433 HRS.

HYDROGRAPH ORDINATES:

TIME (HR)	PPT (IN)	CUM. FLOW (IN)	DEL. FLOW (IN)	FLOW RATE (IN/HR)	FLOW RATE (CFS)
2.43	0.82	0.0369	0.0014	0.2171	0.48
2.44	0.83	0.0383	0.0014	0.2212	0.49
2.44	0.84	0.0397	0.0014	0.2252	0.50
2.45	0.84	0.0412	0.0015	0.2293	0.51
2.45	0.85	0.0426	0.0015	0.2333	0.52
2.46	0.85	0.0441	0.0015	0.2373	0.53
2.47	0.86	0.0456	0.0015	0.2413	0.54
2.47	0.87	0.0472	0.0015	0.2452	0.55
2.48	0.87	0.0487	0.0016	0.2491	0.55
2.48	0.88	0.0503	0.0016	0.2530	0.56
2.49	0.89	0.0519	0.0016	0.2568	0.57
2.49	0.89	0.0535	0.0016	0.2607	0.58
2.50	0.90	0.0551	0.0005	0.2645	0.59
2.51	0.90	0.0556	0.0004	0.2622	0.58
2.51	0.90	0.0561	0.0004	0.2534	0.56
2.52	0.91	0.0565	0.0005	0.2382	0.53
2.52	0.91	0.0570	0.0005	0.2163	0.48
2.53	0.91	0.0574	0.0005	0.1878	0.42
2.53	0.91	0.0579	0.0005	0.1622	0.36
2.54	0.91	0.0583	0.0005	0.1398	0.31
2.55	0.91	0.0588	0.0005	0.1209	0.27
2.55	0.92	0.0592	0.0005	0.1054	0.23
2.56	0.92	0.0597	0.0005	0.0935	0.21
2.56	0.92	0.0601	0.0005	0.0851	0.19
2.57	0.92	0.0606	0.0005	0.0803	0.18
2.57	0.92	0.0611	0.0005	0.0792	0.18
2.58	0.92	0.0615	0.0005	0.0794	0.18
2.59	0.93	0.0620	0.0005	0.0797	0.18
2.59	0.93	0.0625	0.0005	0.0799	0.18
2.60	0.93	0.0629	0.0005	0.0802	0.18

OUTPUT SUMMARY:

TOTAL RUNOFF DEPTH = .286 IN.
INITIAL ABSTRACTION = .5 IN.
PEAK FLOW = .589 CFS

TIME TO PEAK = 2.501 HOURS
RUNOFF VOLUME CHECK = .286 IN.

TABLE 3

STORM RUNOFF DETERMINATION
FOR
CWRSF AREA 3

INPUT SUMMARY:

DISTRIBUTION = SCS 6 HOUR
RAINFALL DEPTH = 1.5 INCHES
STORM DURATION = 6 HOURS
RUNOFF AREA = .0393 SQ. MILES
RUNOFF CURVE NO. = 80
TIME OF CONCENTRATION = .195 HRS.

HYDROGRAPH ORDINATES:

TIME (HR)	PPT (IN)	CUM. FLOW (IN)	DEL. FLOW (IN)	FLOW RATE (IN/HR)	FLOW RATE (CFS)
0.00	0.00	0.0000	0.0000	0.0000	0.00
2.21	0.58	0.0024	0.0020	0.0040	0.10
2.24	0.61	0.0044	0.0026	0.0091	0.23
2.26	0.64	0.0070	0.0032	0.0172	0.44
2.29	0.66	0.0102	0.0037	0.0286	0.73
2.31	0.69	0.0139	0.0043	0.0429	1.09
2.34	0.72	0.0182	0.0048	0.0595	1.51
2.37	0.75	0.0229	0.0053	0.0779	1.97
2.39	0.78	0.0282	0.0058	0.0975	2.47
2.42	0.81	0.0340	0.0062	0.1179	2.99
2.44	0.84	0.0402	0.0067	0.1386	3.52
2.47	0.87	0.0469	0.0071	0.1592	4.04
2.50	0.90	0.0540	0.0028	0.1793	4.55
2.52	0.91	0.0569	0.0020	0.1933	4.90
2.55	0.91	0.0589	0.0021	0.1999	5.07
2.57	0.92	0.0610	0.0021	0.1986	5.04
2.60	0.93	0.0631	0.0021	0.1890	4.79
2.63	0.94	0.0652	0.0022	0.1709	4.33
2.65	0.95	0.0674	0.0022	0.1524	3.87
2.68	0.95	0.0696	0.0022	0.1355	3.44

OUTPUT SUMMARY:

TOTAL RUNOFF DEPTH = .286 IN.
INITIAL ABSTRACTION = .5 IN.
PEAK FLOW = 5.08 CFS
TIME TO PEAK = 2.557 HOURS
RUNOFF VOLUME CHECK = .286 IN.

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EXHIBIT 10
TABLE 3

TABLE 4

STORM RUNOFF DETERMINATION
FOR
CWRSF AREA 4

INPUT SUMMARY:

DISTRIBUTION = SCS 6 HOUR
RAINFALL DEPTH = 1.5 INCHES
STORM DURATION = 6 HOURS
RUNOFF AREA = .00653 SQ. MILES
RUNOFF CURVE NO. = 73
TIME OF CONCENTRATION = .207 HRS.

HYDROGRAPH ORDINATES:

TIME (HR)	PPT (IN)	CUM. FLOW (IN)	DEL. FLOW (IN)	FLOW RATE (IN/HR)	FLOW RATE (CFS)
0.00	0.00	0.0000	0.0000	0.0000	0.00
3.20	1.10	0.0317	0.0011	0.0392	0.17
3.23	1.11	0.0328	0.0011	0.0391	0.16
3.26	1.11	0.0340	0.0012	0.0392	0.17
3.28	1.12	0.0351	0.0012	0.0394	0.17
3.31	1.12	0.0363	0.0012	0.0398	0.17
3.34	1.13	0.0375	0.0012	0.0403	0.17
3.37	1.14	0.0387	0.0012	0.0409	0.17
3.39	1.14	0.0400	0.0013	0.0415	0.17
3.42	1.15	0.0412	0.0013	0.0422	0.18
3.45	1.16	0.0425	0.0013	0.0428	0.18
3.48	1.16	0.0438	0.0012	0.0435	0.18
3.51	1.17	0.0450	0.0009	0.0440	0.19
3.53	1.18	0.0459	0.0009	0.0441	0.19
3.56	1.18	0.0468	0.0009	0.0437	0.18
3.59	1.18	0.0477	0.0009	0.0429	0.18
3.62	1.19	0.0487	0.0009	0.0416	0.18
3.64	1.19	0.0496	0.0009	0.0399	0.17
3.67	1.20	0.0506	0.0010	0.0384	0.16
3.70	1.20	0.0515	0.0010	0.0372	0.16

OUTPUT SUMMARY:

TOTAL RUNOFF DEPTH = .13 IN.
INITIAL ABSTRACTION = .74 IN.
PEAK FLOW = .186 CFS
TIME TO PEAK = 3.525 HOURS
RUNOFF VOLUME CHECK = .13 IN.

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EXHIBIT 10
TABLE 4

TABLE 5

STORM RUNOFF DETERMINATION
FOR
CWRSF AREA 5

INPUT SUMMARY:

DISTRIBUTION = SCS 6 HOUR
RAINFALL DEPTH = 1.5 INCHES
STORM DURATION = 6 HOURS
RUNOFF AREA = .0531 SQ. MILES
RUNOFF CURVE NO. = 80
TIME OF CONCENTRATION = .252 HRS.

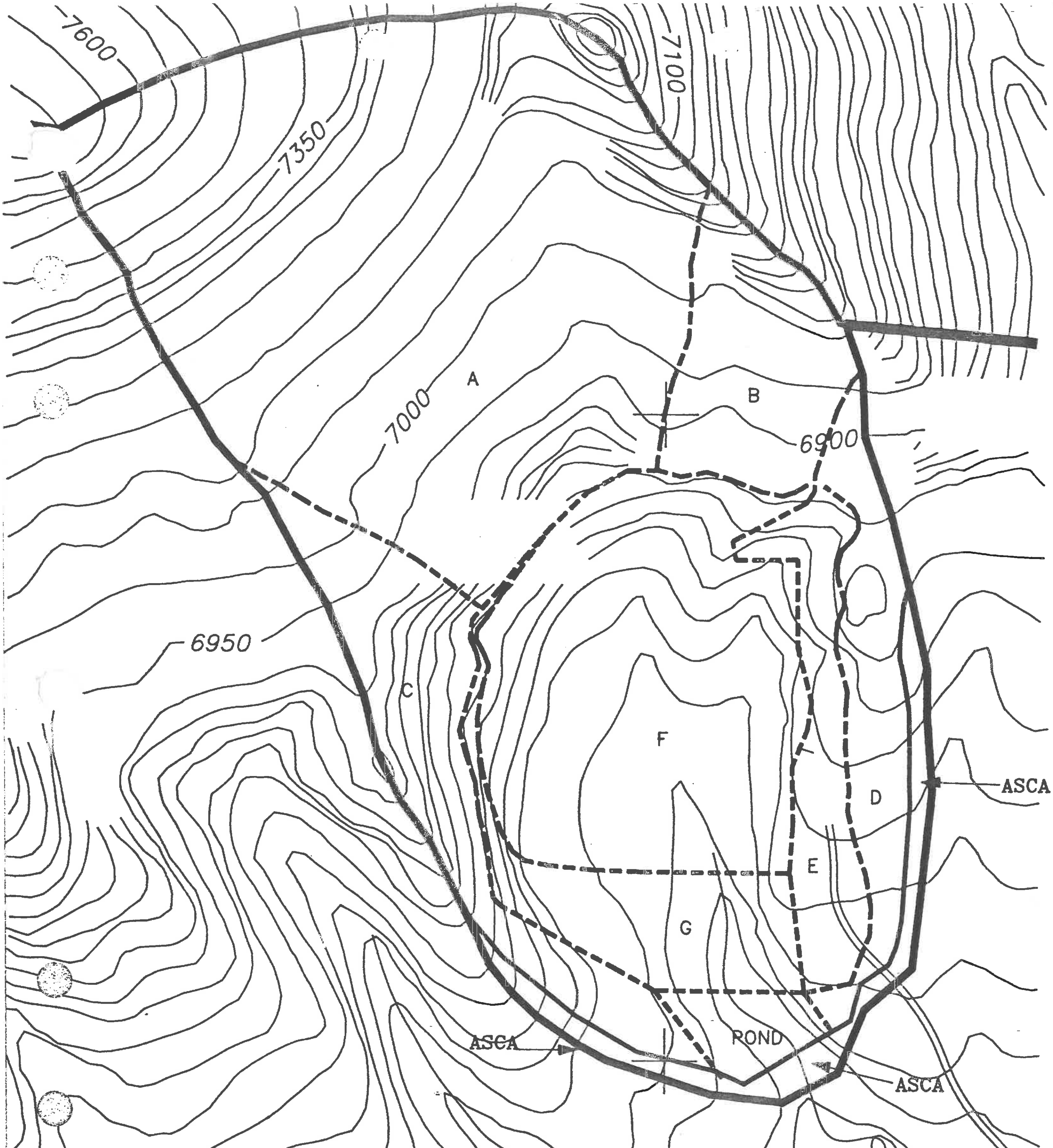
HYDROGRAPH ORDINATES:

TIME (HR)	PPT (IN)	CUM. FLOW (IN)	DEL. FLOW (IN)	FLOW RATE (IN/HR)	FLOW RATE (CFS)
0.00	0.00	0.0000	0.0000	0.0000	0.00
2.52	0.91	0.0567	0.0026	0.1598	5.48
2.55	0.92	0.0594	0.0027	0.1744	5.98
2.59	0.93	0.0621	0.0027	0.1809	6.20
2.62	0.94	0.0648	0.0028	0.1785	6.12
2.65	0.95	0.0676	0.0028	0.1667	5.71
2.69	0.96	0.0705	0.0029	0.1512	5.18
2.72	0.97	0.0734	0.0029	0.1364	4.68
2.76	0.98	0.0763	0.0030	0.1228	4.21
2.79	0.99	0.0793	0.0030	0.1109	3.80
2.82	1.00	0.0823	0.0031	0.1011	3.46
2.86	1.01	0.0854	0.0031	0.0937	3.21
2.89	1.02	0.0886	0.0032	0.0893	3.06
2.92	1.03	0.0917	0.0032	0.0881	3.02
2.96	1.04	0.0950	0.0033	0.0890	3.05
2.99	1.05	0.0982	0.0028	0.0905	3.10

OUTPUT SUMMARY:

TOTAL RUNOFF DEPTH = .286 IN.
INITIAL ABSTRACTION = .5 IN.
PEAK FLOW = 6.208 CFS
TIME TO PEAK = 2.595 HOURS
RUNOFF VOLUME CHECK = .286 IN.

EXHIBIT 10
TABLE 5



SOIL–EROSION MAP
EXHIBIT XI

SCALE 1"=200'

```
   DO 880 N=2,50                                                    XYPL0249
   LINE(N)=PLUS                                                     XYPL0250
   IF (MOD(N,10)-1) 880,870,880                                     XYPL0251
70 LINE(N)=EXXE                                                     XYPL0252
30 CONTINUE                                                         XYPL0253
   LOAD LINE                                                        XYPL0254
90 DO 950 J=1,M                                                     XYPL0255
00 IF (JA(J)-IXSN(J)) 910,910,950                                   XYPL0256
10 JJ=JA(J)                                                         XYPL0257
   IF (IY(JJ,J)-I) 950,920,950                                      XYPL0258
20 JB=IX(JJ,J)                                                      XYPL0259
   IF (LINE(JB).NE.BLANK.AND.LINE(JB).NE.PLUS) GO TO 930            XYPL0260
   JK=J                                                             XYPL0261
   IF(J .EQ. M) JK=22                                               XYPL0262
   IF(NSPG .EQ. 1 .AND. J .EQ. M-1) JK=21                           XYPL0263
   LINE(JB)=POINT(JK)                                               XYPL0264
   GO TO 940                                                        XYPL0265
30 IF(NSPG .EQ. 1 .AND. J .GE. M-1 .OR. NSPG .NE. 1 .AND. J .EQ. M) XYPL0266
  * GO TO 940                                                       XYPL0267
   IF (LINE(JB).NE.POINT(J)) LINE(JB)=EXXE                          XYPL0268
40 JA(J)=JA(J)+1                                                    XYPL0269
   GO TO 900                                                        XYPL0270
50 CONTINUE                                                         XYPL0271
RINT A LINE OF THE GRAPH.                                           XYPL0272
   IF (MOD(I,5)-1) 970,960,970                                      XYPL0273
60 K=((.2)*I+1.)                                                    XYPL0274
   WRITE(6,20) YLABEL(K),(LINE(N),N=1,51)                           XYPL0275
   GO TO 980                                                        XYPL0276
70 WRITE(6,30) (LINE(N),N=1,51)                                     XYPL0277
80 CONTINUE                                                         XYPL0278
   WRITE(6,40) (XLABEL(N),N=1,6)                                    XYPL0279
   RETURN                                                           XYPL0280
   END                                                              XYPL0281
```

EXHIBIT XII

Appendix VI

List of REAME in BASIC

```
5 REM REAME(ROTATIONAL EQUILIBRIUM ANALYSIS OF MULTILAYED EMBANKMENTS)
10 REM INTERACTIVE OR BATCH MODE
15 DIM C(19),E8(80),F2(90),G(19),L2(9,11),L4(9,11),N0(10),L3(9,11)
20 DIM N6(20),P2(19),R4(11),R5(90),S4(49,20),T1(19),T6(10),T7(10)
25 DIM T8(11),T$(72),X(3),X1(50,20),X3(50),Y(3),Y8(50,20)
30 DIM A0(5),B9(5),F8(5),F9(5),S5(5),Y7(50),Y9(49,20)
35 PRINT "TITLE -";
40 MAT INPUT T$
45 PRINT
50 PRINT "FILE NAME";
55 INPUT F$
60 FILE #1,F$
65 PRINT "READ FROM FILE?(ENTER 1 WHEN READ FROM FILE & 0 WHEN NOT)";
70 INPUT B0
75 PRINT
80 IF B0=1 THEN 95
85 SCRATCH #1
90 GO TO 100
95 RESTORE #1
100 PRINT "NO. OF STATIC AND SEISMIC CASES-";
105 INPUT P6
110 FOR P5=1 TO P6
115 PRINT
120 PRINT "CASE NO.";P5,"SEISMIC COEFFICIENT=";
125 INPUT S5(P5)
130 PRINT
135 IF P5<>1 THEN 1195
140 IF B0=1 THEN 165
145 PRINT "NUMBER OF BOUNDARY LINES -";
150 INPUT N5
155 WRITE #1,N5
160 GO TO 175
165 READ #1,N5
170 PRINT "NO. OF BOUNDARY LINES=";N5
175 PRINT
180 FOR J=1 TO N5
185 IF B0=1 THEN 210
190 PRINT "NO. OF POINTS ON BOUNDARY LINE";J;"=";
195 INPUT N6(J)
200 WRITE #1,N6(J)
```

Yang H. Huang
STABILITY ANALYSIS
OF EARTH SLOPES,
Van Nostrand Reinhold
Co., 1983

```
20 [illegible]TO 220
210 [illegible]D #1,N6(J)
215 PRINT "NO. OF POINTS ON BOUNDARY LINE";J;"=";N6(J)
220 PRINT
225 PRINT "BOUNDARY LINE -";J
230 FOR I=1 TO N6(J)
235 IF BO=1 THEN 270
240 PRINT I;"X-COORDINATE=";
245 INPUT X1(I,J)
250 PRINT TAB(3);"Y-COORDINATE=";
255 INPUT Y8(I,J)
260 WRITE #1,X1(I,J),Y8(I,J)
265 GO TO 280
270 READ #1,X1(I,J),Y8(I,J)
275 PRINT I;"X COORD.=";X1(I,J),"Y COORD.=";Y8(I,J)
280 NEXT I
285 PRINT
290 NEXT J
295 PRINT
300 PRINT"LINE NO. AND SLOPE OF EACH SEGMENT ARE:"
305 FOR J=1 TO N5
310 N1=N6(J)-1
315 PRINT J,
320 FOR I=1 TO N1
325 IF X1(I+1,J)=X1(I,J) THEN 340
330 S4(I,J)=(Y8(I+1,J)-Y8(I,J))/(X1(I+1,J)-X1(I,J))
335 GO TO 345
340 S4(I,J)=99999
345 Y9(I,J)=Y8(I,J)-S4(I,J)*X1(I,J)
350 PRINT S4(I,J);
355 NEXT I
360 PRINT
365 NEXT J
370 PRINT
375 IF BO=1 THEN 415
380 PRINT "MIN. DEPTH OF TALLEST SLICE=";
385 INPUT D4
390 PRINT
395 PRINT "NO. OF RADIUS CONTROL ZONES=";
400 INPUT F6
405 WRITE #1,D4,F6
410 GO TO 430
415 READ #1,D4,F6
420 PRINT "MIN. DEPTH OF TALLEST SLICE=";D4
425 PRINT "NO. OF RADIUS CONTROL ZONES=";F6
430 FOR I=1 TO F6
435 PRINT
440 IF BO=1 THEN 510
445 PRINT "RADIUS DECREMENT FOR ZONE";I;"=";
450 INPUT T6(I)
455 PRINT
460 PRINT "NO. OF CIRCLE FOR ZONE";I;"=";
465 INPUT NO(I)
470 PRINT
475 PRINT "ID NO. FOR FIRST CIRCLE FOR ZONE";I;"=";
480 INPUT T7(I)
485 PRINT
490 PRINT "NO. OF BOTTOM LINES FOR ZONE";I;"=";
495 INPUT T8(I)
500 WRITE #1,T6(I),NO(I),T7(I),T8(I)
505 GO TO 535
510 READ #1,T6(I),NO(I),T7(I),T8(I)
515 PRINT "RADIUS DECREMENT FOR ZONE";I;"=";T6(I)
520 PRINT "NO. OF CIRCLES FOR ZONE";I;"=";NO(I)
```



```
525 PRINT "ID NO. FOR FIRST CIRCLE FOR ZONE";I;"=[illegible]
530 PRINT "NO. OF BOTTOM LINES FOR ZONE";I;"=";T8(I)
535 PRINT
540 IF BO=1 THEN 555
545 PRINT "INPUT LINE NO.,BEGIN PT. NO.,AND END PT. NO. FOR ZONE";I
550 PRINT "EACH LINE ON ONE LINE & EACH ENTRY SEPARATED BY COMMA"
555 FOR J=1 TO T8(I)
560 IF BO=1 THEN 580
565 INPUT L2(J,I),L3(J,I),L4(J,I)
570 WRITE #1,L2(J,I),L3(J,I),L4(J,I)
575 GO TO 595
580 READ #1,L2(J,I),L3(J,I),L4(J,I)
585 PRINT "FOR ZONE";I,"LINE SEQUENCE";J
590 PRINT "LINE NO.=";L2(J,I),"BEG. NO.=";L3(J,I),"END NO.=";L4(J,I)
595 NEXT J
600 NEXT I
605 E7=X1(L3(1,1),L2(1,1))
610 G8=X1(L4(1,1),L2(1,1))
615 IF T8(1)=1 THEN 650
620 FOR I=2 TO T8(1)
625 IF X1(L3(I,1),L2(I,1))>=E7 THEN 635
630 E7=X1(L3(I,1),L2(I,1))
635 IF X1(L4(I,1),L2(I,1))<=G8 THEN 645
640 G8=X1(L4(I,1),L2(I,1))
645 NEXT I
650 IF E7<>X1(1,N5) THEN 665
655 IF G8<>X1(N6(N5),N5) THEN 665
660 GO TO 680
665 PRINT
670 PRINT "ROCK LINE IS TOO SHORT OR EXTENDS BEYOND GROUND LINE"
675 STOP
680 L2(1,F6+1)=N5
685 L3(1,F6+1)=1
690 L4(1,F6+1)=N6(N5)
695 T8(F6+1)=1
700 T9=N5-1
705 PRINT
710 IF BO=1 THEN 725
715 PRINT"INPUT COHESION, FRIC. ANGLE, UNIT WT. OF SOIL"
720 PRINT "EACH SOIL ON ONE LINE & EACH ENTRY SEPARATED BY COMMA"
725 FOR I=1 TO T9
730 IF BO=1 THEN 750
735 INPUT C(I),P2(I),G(I)
740 WRITE #1,C(I),P2(I),G(I)
745 GO TO 755
750 READ #1,C(I),P2(I),G(I)
755 NEXT I
760 IF BO<>1 THEN 785
765 PRINT "SOIL NO.","COHESION","FRIC. ANGLE","UNIT WEIGHT"
770 FOR I=1 TO T9
775 PRINT I,C(I),P2(I),G(I)
780 NEXT I
785 FOR I=1 TO T9
790 T1(I)=TAN(P2(I)*3.141593/180)
795 NEXT I
800 PRINT
805 IF BO=1 THEN 835
810 PRINT "ANY SEEPAGE? (ENTER 0 WITHOUT SEEPAGE, 1 WITH PHREATIC"
815 PRINT "SURFACE, AND 2 WITH PORE PRESSURE RATIO)";
820 INPUT N3
825 WRITE #1,N3
830 GO TO 875
835 READ #1,N3
840 IF N3=0 THEN 860
```

```
845 IF N3=[illegible] THEN 870
850 PRINT "[illegible] PORE PRESSURE RATIO"
855 GO TO 875
860 PRINT "NO SEEPAGE"
865 GO TO 875
870 PRINT "USE PHREATIC SURFACE"
875 IF B0=1 THEN 960
880 IF N3<>1 THEN 905
885 PRINT
890 PRINT "UNIT WEIGHT OF WATER=";
895 INPUT G5
900 WRITE #1,G5
905 PRINT
910 PRINT "ANY SEARCH?(ENTER 0 WITH GRID AND 1 WITH SEARCH)";
915 INPUT Z0
920 PRINT
925 PRINT "NO. OF SLICES=";
930 INPUT P4
935 PRINT
940 PRINT "NO. OF ADD. RADII=";
945 INPUT N7
950 WRITE #1,Z0,P4,N7
955 GO TO 1005
960 IF N3<>1 THEN 975
965 READ #1,G5
970 PRINT "UNIT WEIGHT OF WATER=";G5
975 READ #1,Z0,P4,N7
980 IF Z0=0 THEN 995
985 PRINT "USE SEARCH"
990 GO TO 1000
995 PRINT "USE GRID"
1000 PRINT "NO. OF SLICES=";P4,"NO. OF ADD. RADII=";N7
1005 P7=Z0
1010 IF N3=0 THEN 1195
1015 IF N3=2 THEN 1155
1020 PRINT
1025 IF B0=1 THEN 1055
1030 PRINT "NO. OF POINTS ON WATER TABLE =";
1035 INPUT N4
1040 PRINT
1045 WRITE #1,N4
1050 GO TO 1065
1055 READ #1,N4
1060 PRINT "NO. OF POINTS ON WATER TABLE=";N4
1065 FOR I=1 TO N4
1070 IF B0=1 THEN 1110
1075 PRINT I;"X-COORDINATE=";
1080 INPUT X3(I)
1085 PRINT TAB(3);"Y-COORDINATE=";
1090 INPUT Y7(I)
1095 PRINT
1100 WRITE #1,X3(I),Y7(I)
1105 GO TO 1120
1110 READ #1,X3(I),Y7(I)
1115 PRINT I;"X COORD.=";X3(I),"Y COORD.=";Y7(I)
1120 NEXT I
1125 IF X3(1)<=X1(1,N5) THEN 1135
1130 GO TO 1140
1135 IF X3(N4)>=X1(N6(N5),N5) THEN 1195
1140 PRINT
1145 PRINT"PIEZOMETRIC LINE IS NOT EXTENDED AS FAR OUT AS GROUND LINE"
1150 STOP
1155 PRINT
1160 IF B0=1 THEN 1185
```



```
1165 PRINT "PORE PRESSURE RATIO=";
1170 INPUT R8
1175 WRITE #1,R8
1180 GO TO 1195
1185 READ #1,R8
1190 PRINT "PORE PRESSURE RATIO=";R8
1195 IF P5=1 THEN 1215
1200 Z=F4
1205 Z3=F5
1210 Z0=P7
1215 IF Z0<>0 THEN 1510
1220 IF P5<>1 THEN 1415
1225 PRINT
1230 PRINT "INPUT COORD. OF GRID POINTS 1,2,AND 3"
1235 PRINT
1240 FOR I=1 TO 3
1245 IF B0=1 THEN 1285
1250 PRINT "POINT";I;"X-COORDINATE =";
1255 INPUT X(I)
1260 PRINT TAB(8);"Y-COORDINATE =";
1265 INPUT Y(I)
1270 PRINT
1275 WRITE #1,X(I),Y(I)
1280 GO TO 1295
1285 READ #1,X(I),Y(I)
1290 PRINT "POINT";I;"X COORD.=";X(I);"Y COORD.=";Y(I)
1295 NEXT I
1300 IF B0=1 THEN 1385
1305 PRINT "X INCREMENT=";
1310 INPUT Z1
1315 PRINT
1320 PRINT "Y INCREMENT=";
1325 INPUT Z2
1330 PRINT
1335 PRINT "NO. OF DIVISIONS BETWEEN POINTS 1 AND 2=";
1340 INPUT Z
1345 PRINT
1350 PRINT "NO. OF DIVISIONS BETWEEN POINTS 2 AND 3=";
1355 INPUT Z3
1360 WRITE #1,Z1,Z2,Z,Z3
1365 PRINT "CONTINUE?(ENTER 1 FOR CONTINUING AND 0 FOR STOP";
1370 INPUT G7
1375 IF G7=0 THEN 6260
1380 GO TO 1405
1385 READ #1,Z1,Z2,Z,Z3
1390 PRINT "X INCREMENT=";Z1,"Y INCREMENT=";Z2
1395 PRINT "NO. OF DIVISIONS BETWEEN POINTS 1 AND 2=";Z
1400 PRINT "NO. OF DIVISIONS BETWEEN POINTS 2 AND 3=";Z3
1405 F5=Z3
1410 F4=Z
1415 IF Z1<>0 THEN 1430
1420 IF Z2<>0 THEN 1430
1425 GO TO 1440
1430 PRINT
1435 PRINT "AUTOMATIC SEARCH WILL FOLLOW AFTER GRID"
1440 Z4=Z5=0
1445 IF Z3<>0 THEN 1460
1450 Z6=Z7=0
1455 GO TO 1470
1460 Z6=(X(3)-X(2))/Z3
1465 Z7=(Y(3)-Y(2))/Z3
1470 IF Z<>0 THEN 1485
1475 Z8=Z9=0
1480 GO TO 1495
```

```
1485 Z8=[illegible]-X(1))/Z
1490 Z9=[illegible]-Y(1))/Z
1495 A1=A3=X(1)
1500 A2=A4=Y(1)
1505 GO TO 1810
1510 IF P5<>1 THEN 1685
1515 PRINT
1520 IF B0=1 THEN 1545
1525 PRINT"NO. OF CENTERS TO BE ANALYZED =";
1530 INPUT Z5
1535 WRITE #1,Z5
1540 GO TO 1555
1545 READ #1,Z5
1550 PRINT "NO. OF CENTERS TO BE ANLYZED=";Z5
1555 D3=Z5
1560 IF P5<>1 THEN 1690
1565 PRINT
1570 IF B0=1 THEN 1645
1575 PRINT "X COORDINATE OF TRIAL CENTER=";
1580 INPUT A1
1585 PRINT "Y COORDINATE OF TRIAL CENTER=";
1590 INPUT A2
1595 PRINT
1600 PRINT "X INCREMENT=";
1605 INPUT Z1
1610 PRINT "Y INCREMENT=";
1615 INPUT Z2
1620 WRITE #1,A1,A2,Z1,Z2
1625 PRINT "CONTINUE?(ENTER 1 FOR CONTINUING AND 0 FOR STOP)";
1630 INPUT G7
1635 IF G7=0 THEN 6260
1640 GO TO 1660
1645 READ #1,A1,A2,Z1,Z2
1650 PRINT "X COORD.=";A1,"Y COORD.=";A2
1655 PRINT "X INCREMENT=";Z1,"Y INCREMENT=";Z2
1660 A0(Z5)=A1
1665 B9(Z5)=A2
1670 F8(Z5)=Z1
1675 F9(Z5)=Z2
1680 GO TO 1725
1685 Z5=D3
1690 A1=A0(Z5)
1695 A2=B9(Z5)
1700 Z1=F8(Z5)
1705 Z2=F9(Z5)
1710 GO TO 1725
1715 A1=A7
1720 A2=A8
1725 R=0
1730 PRINT
1735 PRINT
1740 A5=A1
1745 IF D3=0 THEN 1755
1750 PRINT "SEARCH STARTED AT CENTER NO.";D3-Z5+1
1755 A6=A2
1760 Z4=R
1765 Z5=Z5-1
1770 Z3=Z=0
1775 IF Z0=1 THEN 1790
1780 Z8=Z9=0
1785 GO TO 1810
1790 Z8=Z1
1795 Z9=Z2
1800 A9=B2=B3=G6=B5=0
```



```
1805 B4=2
1810 Z3=Z3+1
1815 Z=Z+1
1820 B6=M0=0
1825 FOR E6=1 TO Z3
1830 FOR K0=1 TO Z
1835 K2=0
1840 IF Z0=1 THEN 1850
1845 GO TO 1885
1850 IF B6<>2 THEN 1885
1855 M0=A9=B2=B3=G6=B5=0
1860 B4=2
1865 A1=A5
1870 A2=A6
1875 Z8=Z1
1880 Z9=Z2
1885 X0=A1
1890 Y0=A2
1895 R=Z4
1900 IF Z0<>1 THEN 1940
1905 IF ABS(X0-A5)<20*Z1 THEN 1940
1910 IF ABS(Y0-A6)<20*Z2 THEN 1940
1915 PRINT
1920 PRINT "THE INCREMENTS USED FOR SEARCH ARE TOO SMALL,  OR EQUAL"
1925 PRINT "TO ZERO, SO THE MINIMUM FACTOR OF SAFETY CANNOT BE FOUND"
1930 IF Z5<>0 THEN 2815
1935 STOP
1940 J2=SQR((X0-X1(1,N5))**2+(Y0-Y8(1,N5))**2)
1945 J3=SQR((X0-X1(N6(N5),N5))**2+(Y0-Y8(N6(N5),N5))**2)
1950 IF J3>=J2 THEN 1960
1955 J2=J3
1960 FOR I=1 TO (F6+1)
1965 J4=99999
1970 FOR J=1 TO T8(I)
1975 FOR K=L3(J,I) TO (L4(J,I)-1)
1980 IF X1(K,L2(J,I))=X1(K+1,L2(J,I)) THEN 2035
1985 J8=(X0+S4(K,L2(J,I))*(Y0-Y9(K,L2(J,I)))))/(S4(K,L2(J,I))**2+1)
1990 IF J8<X1(K,L2(J,I)) THEN 2000
1995 GO TO 2010
2000 J9=SQR((X0-X1(K,L2(J,I)))**2+(Y0-Y8(K,L2(J,I)))**2)
2005 GO TO 2050
2010 IF J8>X1(K+1,L2(J,I)) THEN 2025
2015 J9=SQR((X0-J8)**2+(Y0-S4(K,L2(J,I))*J8-Y9(K,L2(J,I)))**2)
2020 GO TO 2050
2025 J9=SQR((X0-X1(K+1,L2(J,I)))**2+(Y0-Y8(K+1,L2(J,I)))**2)
2030 GO TO 2050
2035 IF Y0<Y8(K,L2(J,I)) THEN 2000
2040 IF Y0>Y8(K+1,L2(J,I)) THEN 2025
2045 J9=ABS(X0-X1(K,L2(I,J)))
2050 IF J9>=J4 THEN 2060
2055 J4=J9
2060 NEXT K
2065 NEXT J
2070 IF J4<=J2 THEN  2095
2075 PRINT
2080 PRINT"****  WARNING AT NEXT CENTER  ****"
2085 PRINT "MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE"
2090 J4=J2
2095 R4(I)=J4
2100 NEXT I
2105 R3=R4(F6+1)
2110 FOR L0=1 TO F6
2115 IF N0(L0)=0 THEN 2230
2120 R=R4(L0)
```

```
2125 IF [illegible])=0 THEN 2135
2130 GO [illegible]5
2135 H0=([illegible]0)-R4(L0+1))/N0(L0)
2140 GO TO 2150
2145 H0=T6(L0)
2150 R=R-(T7(L0)-1)*H0
2155 FOR J0=1 TO N0(L0)
2160 IF R>=R4(L0+1) THEN 2200
2165 K2=K2+1
2170 F2(K2)=1E6
2175 R5(K2)=R
2180 IF K2<>1 THEN 2195
2185 F1=1E6
2190 R2=R
2195 GO TO 2235
2200 GOSUB 2925
2205 GOSUB 4480
2210 IF F2(K2)>100 THEN 2235
2215 IF H0<=0 THEN 2230
2220 R=R-H0
2225 NEXT J0
2230 NEXT L0
2235 M0=M0+1
2240 IF Z0<>1 THEN 2255
2245 IF B6-1>0 THEN 2255
2250 GO TO 2260
2255 B6=1
2260 PRINT
2265 PRINT
2270 PRINT
2275 PRINT "AT POINT (";X0;Y0;")";"THE RADIUS AND FACTOR OF SAFETY ARE:"
2280 FOR H4=1 TO K2
2285 PRINT R5(H4),F2(H4)
2290 NEXT H4
2295 PRINT "LOWEST FACTOR OF SAFETY =";F1;"AND OCCURS AT RADIUS =";R2
2300 PRINT
2305 IF Z0-1<0 THEN 2315
2310 GO TO 2360
2315 IF M0=1 THEN 2325
2320 IF F1>=H1 THEN 2345
2325 H1=F1
2330 H2=R2
2335 A7=X0
2340 A8=Y0
2345 A1=A1+Z8
2350 A2=A2+Z9
2355 GO TO 2820
2360 IF M0=1 THEN 2410
2365 A9=A9+1
2370 IF F1-H1<0 THEN 2410
2375 IF G6=1 THEN 2445
2380 IF B3<>0 THEN 2610
2385 IF A9<>1 THEN 2580
2390 A9=0
2395 A1=A1-B4*Z8
2400 B3=1
2405 GO TO 2625
2410 H1=F1
2415 H2=R2
2420 A7=X0
2425 A8=Y0
2430 G1=G3
2435 G2=G4
2440 GO TO 2525
```



```
2445 IF B3<>0 THEN 2475
2450 IF A9<>1 THEN 2495
2455 B3=1
2460 A2=A2-B4*Z9
2465 A9=0
2470 GO TO 2625
2475 IF A9<>1 THEN 2495
2480 IF B2<>1 THEN 2495
2485 B2=2
2490 GO TO 2625
2495 A9=B3=G6=0
2500 B2=M0=1
2505 B4=2
2510 A1=A7+Z8
2515 A2=A8
2520 GO TO 2625
2525 IF G6=1 THEN 2555
2530 IF B3=0 THEN 2545
2535 A1=A1-Z8
2540 GO TO 2625
2545 A1=A1+Z8
2550 GO TO 2625
2555 IF B3=0 THEN 2570
2560 A2=A2-Z9
2565 GO TO 2625
2570 A2=A2+Z9
2575 GO TO 2625
2580 M0=B2=G6=1
2585 A9=B3=0
2590 B4=2
2595 A1=A7
2600 A2=A8+Z9
2605 GO TO 2625
2610 IF A9<>1 THEN 2580
2615 IF B2<>1 THEN 2580
2620 B2=2
2625 R=0
2630 IF B2<>2 THEN 1835
2635 B5=B5+1
2640 IF B5<>1 THEN 2705
2645 IF H1<100 THEN 2660
2650 PRINT "IMPROPER CENTER IS USED FOR SEARCH"
2655 GO TO 2815
2660 Z8=Z1/4
2665 Z9=Z2/4
2670 B2=A9=B3=G6=0
2675 B4=2
2680 M0=1
2685 B5=B5+1
2690 A1=A7+Z8
2695 A2=A8
2700 GO TO 1835
2705 PRINT
2710 PRINT "AT POINT (";A7;A8;")";"RADIUS";H2
2715 PRINT
2720 PRINT
2725 PRINT "THE MINIMUM FACTOR OF SAFETY IS";H1
2730 PRINT
2735 PRINT
2740 PRINT "ANY PLOT?(ENTER 0 FOR NO PLOT AND 1 FOR PLOT)";
2745 INPUT P8
2750 IF P8=0 THEN 2795
2755 PRINT
2760 PRINT "YOU MAY LIKE TO ADVANCE PAPER TO THE TOP OF NEXT PAGE"
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```
2765 PRINT [illegible] ENTIRE PLOT WILL FIT IN ONE SINGLE PAGE."
2770 PRINT "FO[illegible] PROGRAM TO PROCEED, HIT THE RETURN KEY."
2775 PRINT "AFT[illegible] PLOT, YOU MAY LIKE TO ADVANCE PAPER TO NEXT PAGE"
2780 PRINT "AND HIT THE RETURN KEY AGAIN"
2785 INPUT C$
2790 GOSUB 4725
2795 IF Z0=1 THEN 2875
2800 A1=A7
2805 A2=A8
2810 B6=2
2815 IF Z5<>0 THEN 1560
2820 NEXT K0
2825 A3=A3+Z6
2830 A4=A4+Z7
2835 A1=A3
2840 A2=A4
2845 NEXT E6
2850 PRINT
2855 PRINT "AT POINT (";A7;A8;")";"RADIUS";H2
2860 PRINT
2865 PRINT
2870 PRINT "THE MINIMUM FACTOR OF SAFETY IS";H1
2875 IF Z5<>0 THEN 1560
2880 IF Z0=0 THEN 2890
2885 GO TO 2915
2890 IF Z1<>0 THEN 2905
2895 IF Z2<>0 THEN 2905
2900 GO TO 2915
2905 Z0=Z5=1
2910 GO TO 1715
2915 NEXT P5
2920 GO TO 6260
2925 REM SUBROUTINE FSAFTY
2930 DIM B1(80),C8(80),D6(80),L1(80),S(80),S8(80),T4(80)
2935 DIM W(80),W1(80),X2(80),X4(20),X5(20),Y4(80,20),Y5(80)
2940 IF R>R3 THEN 2955
2945 F7=1E6
2950 GO TO 4475
2955 S7=0
2960 FOR J=1 TO N5
2965 X4(J)=-99999.0
2970 X5(J)=99999.0
2975 N1=N6(J)-1
2980 FOR I=1 TO N1
2985 IF S4(I,J)=99999 THEN 3105
2990 A=1+S4(I,J)**2
2995 B=S4(I,J)*(Y9(I,J)-Y0)-X0
3000 D=(Y9(I,J)-Y0)**2+X0**2-R**2
3005 T2=B**2-A*D
3010 IF ABS(T2)<1 THEN 3110
3015 IF T2>0 THEN 3025
3020 GO TO 3105
3025 X6=(-B-SQR(T2))/A
3030 X7=(-B+SQR(T2))/A
3035 IF X6>=(X1(I,J)-0.01) THEN 3045
3040 GO TO 3070
3045 IF X6<=(X1(I+1,J)+0.01) THEN 3055
3050 GO TO 3070
3055 X4(J)=X6
3060 IF J<>N5 THEN 3070
3065 Y6=S4(I,J)*X4(J)+Y9(I,J)
3070 IF X7>=(X1(I,J)-0.01) THEN 3080
3075 GO TO 3105
3080 IF X7<=(X1(I+1,J)+0.01) THEN 3090
```



```
3085 GO TO 3105
3090 X5(J)=X7
3095 IF J<>N5 THEN 3105
3100 Y1=S4(I,J)*X5(J)+Y9(I,J)
3105 NEXT I
3110 NEXT J
3115 IF X4(N5)=-99999.0 THEN 2945
3120 IF X5(N5)=99999.0 THEN 2945
3125 IF Y0<Y6 THEN 3135
3130 GO TO 3140
3135 IF Y0<Y1 THEN 2945
3140 R1=0
3145 IF Y0>Y6 THEN 3270
3150 X4(N5)=X0-R
3155 X8=X4(N5)
3160 FOR K=1 TO N5
3165 K1=N5+1-K
3170 N1=N6(K1)-1
3175 Y4(1,K1)=-9999.0
3180 FOR I=1 TO N1
3185 IF X1(I,K1)=X1(I+1,K1) THEN 3210
3190 M=I
3195 IF X8>X1(I,K1) THEN 3205
3200 GO TO 3210
3205 IF X8<=X1(I+1,K1) THEN 3220
3210 NEXT I
3215 GO TO 3230
3220 Y4(1,K1)=S4(M,K1)*X8+Y9(M,K1)
3225 IF K=1 THEN 3260
3230 IF (Y4(1,K1)+9999.0)=0 THEN 3265
3235 IF (Y0-Y4(1,K1))>0 THEN 3250
3240 R1=R1+(Y3-Y4(1,K1))*C(K1)
3245 GO TO 3260
3250 R1=R1+(Y3-Y0)*C(K1)
3255 GO TO 3290
3260 Y3=Y4(1,K1)
3265 NEXT K
3270 IF Y0>Y1 THEN 3290
3275 X5(N5)=X0+R
3280 X8=X5(N5)
3285 GO TO 3160
3290 J6=N5-1
3295 N1=N6(N5)-1
3300 R7=(X5(N5)-X4(N5))/P4
3305 P9=0
3310 D7=X4(N5)
3315 FOR I=1 TO P4
3320 D8=0
3325 FOR J=2 TO N1
3330 IF X1(J,N5)<=(D7+0.01) THEN 3350
3335 IF X1(J,N5)>=(D7+R7-0.01) THEN 3350
3340 D8=D8+1
3345 D6(D8)=X1(J,N5)
3350 NEXT J
3355 FOR J=2 TO J6
3360 IF X4(J)<=(D7+0.01) THEN 3385
3365 IF X4(J)>=(D7+R7-0.01) THEN 3385
3370 D8=D8+1
3375 D6(D8)=X4(J)
3380 GO TO 3405
3385 IF X5(J)<=(D7+0.01) THEN 3405
3390 IF X5(J)>=(D7+R7-0.01) THEN 3405
3395 D8=D8+1
3400 D6(D8)=X5(J)
```

```
3405 NEXT J
3410 IF D8<1 THEN 3540
3415 IF D8=1 THEN 3525
3420 E5=D8-1
3425 D9=0
3430 FOR L=1 TO E5
3435 D9=D9+1
3440 E0=D6(D9)
3445 E2=D9+1
3450 E3=D9
3455 FOR K=E2 TO D8
3460 IF D6(K)>=E0 THEN 3475
3465 E0=D6(K)
3470 E3=K
3475 NEXT K
3480 D6(E3)=D6(D9)
3485 D6(D9)=E0
3490 NEXT L
3495 B1(P9+1)=D6(1)-D7
3500 FOR L=2 TO D8
3505 B1(P9+L)=D6(L)-D6(L-1)
3510 NEXT L
3515 B1(P9+D8+1)=D7+R7-D6(D8)
3520 GO TO 3545
3525 B1(P9+1)=D6(1)-D7
3530 B1(P9+2)=D7+R7-D6(1)
3535 GO TO 3545
3540 B1(P9+1)=R7
3545 P9=P9+D8+1
3550 D7=D7+R7
3555 NEXT I
3560 E4=0
3565 FOR J=1 TO P9
3570 IF J>(P9-E4) THEN 3595
3575 IF B1(J)<>0 THEN 3585
3580 E4=E4+1
3585 B1(J)=B1(J+E4)
3590 NEXT J
3595 P9=P9-E4
3600 IF P9<=40 THEN 3605
3605 X2(1)=X4(N5)+B1(1)/2
3610 FOR J=2 TO P9
3615 X2(J)=X2(J-1)+(B1(J)+B1(J-1))/2
3620 NEXT J
3625 FOR J=1 TO P9
3630 Y5(J)=Y0-SQR(R**2-(X2(J)-X0)**2)
3635 S(J)=(X0-X2(J))/R
3640 IF Y1<=Y6 THEN 3650
3645 S(J)=-S(J)
3650 C8(J)=(Y0-Y5(J))/R
3655 NEXT J
3660 FOR J=1 TO P9
3665 I7=0
3670 FOR K=1 TO N5
3675 Y4(J,K)=-9999.0
3680 N1=N6(K)-1
3685 FOR I=1 TO N1
3690 IF X1(I,K)=X1(I+1,K) THEN 3715
3695 M=I
3700 IF X2(J)>X1(I,K) THEN 3710
3705 GO TO 3715
3710 IF X2(J)<=X1(I+1,K) THEN 3725
3715 NEXT I
3720 GO TO 3770
```



```
3725 Y4(J,K)=S4(M,K)*X2(J)+Y9(M,K)
3730 IF I7=0 THEN 3760
3735 IF K=1 THEN 3760
3740 IF Y4(J,K)>(Y3-0.1) THEN 3760
3745 PRINT "BOUNDARY LINE NO.";K;"IS OUT OF PLACE, PLEASE"
3750 PRINT "CHANGE THE INPUT DATA AND RUN THE PROGRAM AGAIN"
3755 STOP
3760 Y3=Y4(J,K)
3765 I7=1
3770 NEXT K
3775 S8(J)=Y4(J,N5)-Y5(J)
3780 IF S8(J)>S7 THEN 3790
3785 GO TO 3795
3790 S7=S8(J)
3795 NEXT J
3800 IF S7<D4 THEN 2945
3805 I6=0
3810 FOR J=1 TO P9
3815 E1=0
3820 W(J)=0
3825 W1(J)=0
3830  FOR K=1 TO N5
3835 IF (Y4(J,K)+9999.0)=0 THEN 3845
3840 GO TO 3855
3845 I6=I6+1
3850 GO TO 4165
3855 S1=Y4(J,N5)-Y4(J,K)
3860 IF S1>=(S8(J)-0.01) THEN 4090
3865 IF E1=1 THEN 3890
3870 PRINT
3875 PRINT "AT POINT (";X0;Y0;")";"WITH RADIUS OF";R
3880 PRINT "THE CIRCLE CUTS INTO ROCK SURFACE"
3885 STOP
3890 IF N9<0 THEN 4080
3895 IF N9=0 THEN 3905
3900 GO TO 4080
3905 Y2=Y5(J)
3910 L1(J)=K-I6
3915 N9=1
3920 IF C(L1(J))=0 THEN 3950
3925 IF J=1 THEN 4105
3930 IF C(L1(J-1))=0 THEN 3940
3935 GO TO 4105
3940 IF T1(L1(J-1))=0 THEN 3960
3945 GO TO 4105
3950 IF T1(L1(J))=0 THEN 3995
3955 GO TO 3925
3960 O2=L1(J-1)
3965 O3=Y4(J-1,N5)
3970 IF Y1<Y6 THEN 3985
3975 O4=-1
3980 GO TO 4045
3985 O4=1
3990 GO TO 4045
3995 IF J=1 THEN 4160
4000 IF C(L1(J-1))<>0 THEN 4015
4005 IF T1(L1(J-1))<>0 THEN 4015
4010 GO TO 4160
4015 O2=L1(J)
4020 O3=Y4(J,N5)
4025 IF Y1<Y6 THEN 4040
4030 O4=1
4035 GO TO 4045
4040 O4=-1
```

```
4045 05=Y0 [illegible] R**2-(X2(J)-B1(J)/2-X0)**2)
4050 06=03 [illegible]
4055 W1(J)=04*0.5*06**2*G(02)*(Y0-05-06/3)/R
4060 IF C(L1(J-1))=0 THEN 4070
4065 GO TO 4160
4070 IF T1(L1(J-1))=0 THEN 4105
4075 GO TO 4160
4080 Y2=Y4(J,K-I6)
4085 GO TO 4105
4090 N9=0
4095 E1=1
4100 GO TO 4160
4105 W4=B1(J)*(Y4(J,K)-Y2)*G(K-I6)
4110 W(J)=W(J)+W4
4115 W1(J)=W1(J)+W4*S(J)
4120 IF S5(P5)=0 THEN 4160
4125 IF C(K-I6)<>0 THEN 4155
4130 IF T1(K-I6)<>0 THEN 4155
4135 IF Y6>=Y1 THEN 4150
4140 IF X2(J)<X1(2,N5) THEN 4160
4145 GO TO 4155
4150 IF X2(J)>X1(2,N5) THEN 4160
4155 W1(J)=W1(J)+W4*S5(P5)*(Y0-0.5*(Y4(J,K)+Y2))/R
4160 I6=1
4165 NEXT K
4170 NEXT J
4175 IF N3=1 THEN 4205
4180 IF N3=0 THEN 4300
4185 FOR J=1 TO P9
4190 E8(J)=W(J)*(1-R8)
4195 NEXT J
4200 GO TO 4315
4205 N2=N4-1
4210 FOR J=1 TO P9
4215 FOR I=1 TO N2
4220 M=I
4225 IF X2(J)>=X3(I) THEN 4235
4230 GO TO 4240
4235 IF X2(J)<=X3(I+1) THEN 4250
4240 NEXT I
4245 GO TO 4255
4250 T4(J)=((Y7(M+1)-Y7(M))/(X3(M+1)-X3(M)))*(X2(J)-X3(M))+Y7(M)
4255 NEXT J
4260 FOR J=1 TO P9
4265 IF T4(J)-Y5(J)>0 THEN 4275
4270 GO TO 4285
4275 E8(J)=W(J)-(T4(J)-Y5(J))*G5*B1(J)
4280 GO TO 4290
4285 E8(J)=W(J)
4290 NEXT J
4295 GO TO 4315
4300 FOR J=1 TO P9
4305 E8(J)=W(J)
4310 NEXT J
4315 R0=R1
4320 01=0
4325 FOR J=1 TO P9
4330 R0=R0+C(L1(J))*B1(J)/C8(J)+E8(J)*T1(L1(J))*C8(J)
4335 01=01+W1(J)
4340 NEXT J
4345 IF R0=0 THEN 2945
4350 IF 01<1 THEN 2945
4355 F7=R0/01
4360 IF F7<0 THEN 4455
```



```
4365 IF F7>100 THEN 4475
4370 IF F7>1 THEN 4380
4375 F7=2
4380 I9=0
4385 I9=I9+1
4390 P1=F7
4395 M2=M3=0
4400 FOR J=1 TO P9
4405 M4=C(L1(J))*B1(J)+E8(J)*T1(L1(J))
4410 M5=P1*C8(J)+T1(L1(J))*S(J)
4415 M2=M2+M4/M5
4420 M3=M3+M4*T1(L1(J))*S(J)/M5**2
4425 NEXT J
4430 F7=P1*(1+(R1/P1+M2-01)/(01-M3))
4435 IF ABS(F7-P1)/P1>0.0001 THEN 4445
4440 GO TO 4475
4445 IF I9<10 THEN 4385
4450 IF F7>0 THEN 4475
4455 PRINT
4460 PRINT "AT POINT (";X0;Y0;")";"WITH RADIUS OF";R
4465 PRINT "THE FACTOR OF SAFETY IS NEGATIVE"
4470 STOP
4475 RETURN
4480 REM SUBROUTINE SAVE
4485 K2=K2+1
4490 R5(K2)=R
4495 F2(K2)=F7
4500 IF K2<>1 THEN 4530
4505 F1=F2(K2)
4510 R2=R5(K2)
4515 G3=X4(N5)
4520 G4=X5(N5)
4525 GO TO 4720
4530 IF F2(K2)>=F1 THEN 4555
4535 F1=F2(K2)
4540 R2=R5(K2)
4545 G3=X4(N5)
4550 G4=X5(N5)
4555 IF F2(K2)<>1E6 THEN 4570
4560 I3=I8=2
4565 GO TO 4640
4570 IF F6<>1 THEN 4600
4575 IF K2<>N0(1) THEN 4600
4580 IF F2(K2)>F2(K2-1) THEN 4600
4585 I3=I8=3
4590 R5(K2+1)=R3
4595 GO TO 4640
4600 IF K2<3 THEN 4720
4605 IF N7=0 THEN 4720
4610 IF F2(K2)>F2(K2-1) THEN 4620
4615 GO TO 4720
4620 IF F2(K2-1)<F2(K2-2) THEN 4630
4625 GO TO 4720
4630 I3=1
4635 I8=2
4640 D0=R
4645 FOR I0=I3 TO I8
4650 R6=R5(K2-3+I0)
4655 D1=(R5(K2-2+I0)-R5(K2-3+I0))/(N7+1)
4660 FOR N=1 TO N7
4665 R6=R6+D1
4670 R=R6
4675 GOSUB 2925
4680 IF F7>=F1 THEN 4705
```

```
4685 F1=
4690 R2=
4695 G3=X4(N5)
4700 G4=X5(N5)
4705 NEXT N
4710 NEXT I0
4715 R=D0
4720 RETURN
4725 REM SUBROUTINE XYPLOT
4730 DIM B7(50,22),B8(11),I1(51,22),I2(51,22),I5(22),J1(22)
4735 DIM L5(22),L$(51),P$(22),S0(50,22),X9(6)
4740 IF A$="+" THEN 4870
4745 B$=" "
4750 A$="+"
4755 E$="X"
4760 P$(1)="1"
4765 P$(2)="2"
4770 P$(3)="3"
4775 P$(4)="4"
4780 P$(5)="5"
4785 P$(6)="6"
4790 P$(7)="7"
4795 P$(8)="8"
4800 P$(9)="9"
4805 P$(10)="0"
4810 P$(11)="A"
4815 P$(12)="B"
4820 P$(13)="C"
4825 P$(14)="D"
4830 P$(15)="E"
4835 P$(16)="F"
4840 P$(17)="G"
4845 P$(18)="J"
4850 P$(19)="K"
4855 P$(20)="L"
4860 P$(21)="P"
4865 P$(22)="*"
4870 M1=N5
4875 FOR J=1 TO M1
4880 L5(J)=N6(J)
4885 L8=L5(J)
4890 FOR I=1 TO L8
4895 S0(I,J)=X1(I,J)
4900 B7(I,J)=Y8(I,J)
4905 NEXT I
4910 NEXT J
4915 IF N3<>1 THEN 4955
4920 M1=M1+1
4925 L5(M1)=N4
4930 N8=N4
4935 FOR I=1 TO N8
4940 S0(I,M1)=X3(I)
4945 B7(I,M1)=Y7(I)
4950 NEXT I
4955 C1=C2=S0(1,1)
4960 C3=C4=B7(1,1)
4965 FOR J=1 TO M1
4970 L8=L5(J)
4975 FOR I=1 TO L8
4980 IF C2<=S0(I,J) THEN 4990
4985 C2=S0(I,J)
4990 IF C1>=S0(I,J) THEN 5000
4995 C1=S0(I,J)
5000 IF C4<=B7(I,J) THEN 5010
```



```
5005 C4=B7(I,J)
5010 IF C3>=B7(I,J) THEN 5020
5015 C3=B7(I,J)
5020 NEXT I
5025 J1(J)=1
5030 NEXT J
5035 D2=C1-C2
5040 N8=0
5045 IF D2<>0 THEN 5075
5050 D2=0.2*C2
5055 IF C2 <> 0 THEN 5065
5060 D2=0.2
5065 C2=C2-0.5*D2
5070 C1=C1+0.45*D2
5075 FOR I=1 TO 75
5080 IF D2>10 THEN 5105
5085 IF D2>1 THEN 5120
5090 D2=D2*10
5095 N8=-I
5100 GO TO 5115
5105 D2=D2/10
5110 N8=I
5115 NEXT I
5120 IF D2<8 THEN 5135
5125 K7=10
5130 GO TO 5185
5135 IF D2<5 THEN 5150
5140 K7=8
5145 GO TO 5185
5150 IF D2<4 THEN 5165
5155 K7=5
5160 GO TO 5185
5165 IF D2<2 THEN 5180
5170 K7=4
5175 GO TO 5185
5180 K7=2
5185 IF N8>0 THEN 5205
5190 C5=K7
5195 C5=C5/10**(1-N8)
5200 GO TO 5210
5205 C5=K7*10**(N8-1)
5210 C6=0
5215 IF C2>=0 THEN 5235
5220 C6=C6-C5
5225 IF C6>C2 THEN 5220
5230 GO TO 5250
5235 C6=C6+C5
5240 IF C6>C2 THEN 5220
5245 IF C6<C2 THEN 5235
5250 C7=C5*10+C6
5255 IF C7>=C1 THEN 5270
5260 C2=C6-0.001*C5
5265 GO TO 5035
5270 I=INT((C7-C1)/(2*C5))
5275 C6=C6-I*C5
5280 C7=C6+10*C5
5285 D2=C3-C4
5290 N8=0
5295 IF D2<>0 THEN 5325
5300 D2=0.2*C4
5305 IF C4<>0 THEN 5315
5310 C2=0.2
5315 C4=C4-0.5*D2
5320 C3=C3+0.45*D2
```

```
5325 [illegible]I=1 TO 75
5330 [illegible]>10 THEN 5355
5335 I[illegible]D2>1 THEN 5370
5340 D2=D2*10
5345 N8=-I
5350 GO TO 5365
5355 D2=D2/10
5360 N8=I
5365 NEXT I
5370 IF D2<8 THEN 5385
5375 K7=10
5380 GO TO 5435
5385 IF D2<5 THEN 5400
5390 K7=8
5395 GO TO 5435
5400 IF D2<4 THEN 5415
5405 K7=5
5410 GO TO 5435
5415 IF D2<2 THEN 5430
5420 K7=4
5425 GO TO 5435
5430 K7=2
5435 IF N8>0 THEN 5455
5440 C0=K7
5445 C0=C0/10**(1-N8)
5450 GO TO 5460
5455 C0=K7*10**(N8-1)
5460 C9=0
5465 IF C4>=0 THEN 5485
5470 C9=C9-C0
5475 IF C9>C4 THEN 5470
5480 GO TO 5500
5485 C9=C9+C0
5490 IF C9>C4 THEN 5470
5495 GO TO 5485
5500 D5=C0*10+C9
5505 IF D5>=C3 THEN 5520
5510 C4=C9-0.001*C0
5515 GO TO 5285
5520 I=INT((D5-C3)/(2*C0))
5525 C9=C9-I*C0
5530 D5=C9+10*C0
5535 M1=M1+1
5540 J1(M1)=1
5545 S0(1,M1)=G1
5550 S0(2,M1)=G2
5555 L5(M1)=2
5560 FOR J=1 TO M1
5565 L8=L5(J)
5570 FOR I=1 TO L8
5575 I1(I,J)=INT((((S0(I,J)-C6)/(C7-C6))*50)+1.5)
5580 IF J=M1 THEN 5590
5585 I2(I,J)=INT(51.5-(((B7(I,J)-C9)/(D5-C9))*50))
5590 NEXT I
5595 NEXT J
5600 K8=1
5605 J0=51
5610 FOR I=1 TO 10
5615 IF I>5 THEN 5645
5620 IF (C6+C5*(I-1)*2)=0 THEN 5640
5625 IF (C6+C5*(I-1)*2)>0 THEN 5645
5630 K8=10*(I-1)+6
5635 GO TO 5645
5640 K8=10*(I-1)+1
```



```
5645 IF (C9+C0*(I-1)*1.05)>=0 THEN 5655
5650 J0=51-5*I
5655 NEXT I
5660 FOR I=1 TO 11
5665 IF I>6 THEN 5675
5670 X9(I)=C6+C5*(I-1)*2
5675 B8(I)=INT(C9+C0*(11-I))
5680 NEXT I
5685 FOR N8=1 TO M1
5690 IF N8=M1 THEN 5765
5695 N1=L5(N8)-1
5700 H5=L5(N8)
5705 FOR H7=1 TO N1
5710 H3=I1(H7+1,N8)-I1(H7,N8)
5715 H4=I2(H7+1,N8)-I2(H7,N8)
5720 IF H3<2 THEN 5755
5725 H6=H3-1
5730 FOR H8=1 TO H6
5735 I1(H5+H8,N8)=I1(H7,N8)+H8
5740 I2(H5+H8,N8)=I2(H7,N8)+INT(H8*H4/H3)
5745 NEXT H8
5750 H5=H5+H6
5755 NEXT H7
5760 GO TO 5805
5765 H5=I1(2,N8)-I1(1,N8)-1
5770 H9=I1(1,N8)
5775 FOR I=1 TO H5
5780 I1(I,N8)=H9+I
5785 J8=(I1(I,N8)-1.5)*(C7-C6)/50+C6
5790 W2=A8-SQR(H2**2-(J8-A7)**2)
5795 I2(I,N8)=INT(51.5-(W2-C9)/(D5-C9)*50)
5800 NEXT I
5805 FOR I=1 TO H5
5810 FOR J=I TO H5
5815 IF I2(I,N8)<=I2(J,N8) THEN 5850
5820 K=I2(I,N8)
5825 I2(I,N8)=I2(J,N8)
5830 I2(J,N8)=K
5835 K=I1(I,N8)
5840 I1(I,N8)=I1(J,N8)
5845 I1(J,N8)=K
5850 NEXT J
5855 NEXT I
5860 I5(N8)=H5
5865 NEXT N8
5870 PRINT TAB(8);
5875 FOR I=1 TO 72
5880 PRINT T$(I);
5885 NEXT I
5890 PRINT
5895 PRINT "        FOR SEISMIC COEFFICIENT OF";S5(P5)
5900 PRINT "        AT POINT (";A7;A8;")";"RADIUS";H2
5905 PRINT "        THE MINIMUM FACTOR OF SAFETY IS";H1
5910 PRINT
5915 FOR I=1 TO 51
5920 FOR N8=1 TO 51
5925 L$(N8)=B$
5930 NEXT N8
5935 L$(1)=L$(K8)=L$(51)=A$
5940 IF(I-INT(I/5)*5)<>1 THEN 5970
5945 FOR N8=1 TO 51
5950 IF (N8-INT(N8/10)*10)<>1 THEN 5960
5955 L$(N8)=A$
5960 NEXT N8
```

```
5965 L$(1)=L      L$(51)=E$
5970 IF I=1 T     5990
5975 IF I=J0 THEN 5990
5980 IF I=51 THEN 5990
5985 GO TO 6015
5990 FOR N8=2 TO 50
5995 L$(N8)=A$
6000 IF(N8-INT(N8/10)*10)<>1 THEN 6010
6005 L$(N8)=E$
6010 NEXT N8
6015 FOR J=1 TO M1
6020 IF J1(J)>I5(J) THEN 6145
6025 F3=J1(J)
6030 IF I2(F3,J)<>I THEN 6145
6035 K9=I1(F3,J)
6040 IF L$(K9)=B$ THEN 6055
6045 IF L$(K9)=A$ THEN 6055
6050 GO TO 6095
6055 L7=J
6060 IF J<>M1 THEN 6070
6065 L7=22
6070 IF N3<>1 THEN 6085
6075 IF J<>M1-1 THEN 6085
6080 L7=21
6085 L$(K9)=P$(L7)
6090 GO TO 6135
6095 IF N3=1 THEN 6105
6100 GO TO 6110
6105 IF J>=M1-1 THEN 6135
6110 IF N3<>1 THEN 6120
6115 GO TO 6125
6120 IF J=M1 THEN 6135
6125 IF L$(K9)=P$(J) THEN 6135
6130 L$(K9)=E$
6135 J1(J)=J1(J)+1
6140 GO TO 6020
6145 NEXT J
6150 IF(I-INT(I/5)*5)<>1 THEN 6195
6155 K=INT(0.2*I+1)
6160 PRINT TAB(8);B8(K);TAB(14);
6165 FOR N8=1 TO 51
6170 PRINT L$(N8);
6175 IF N8<>51 THEN 6185
6180 PRINT
6185 NEXT N8
6190 GO TO 6225
6195 PRINT TAB(14);
6200 FOR N8=1 TO 51
6205 PRINT L$(N8);
6210 IF N8<>51 THEN 6220
6215 PRINT
6220 NEXT N8
6225 NEXT I
6230 PRINT USING 6235,X9(1),X9(2),X9(3),X9(4),X9(5),X9(6)
6235 :        #######  #######  #######  #######  #######  #######
6240 PRINT
6245 PRINT
6250 INPUT C$
6255 RETURN
6260 END
```

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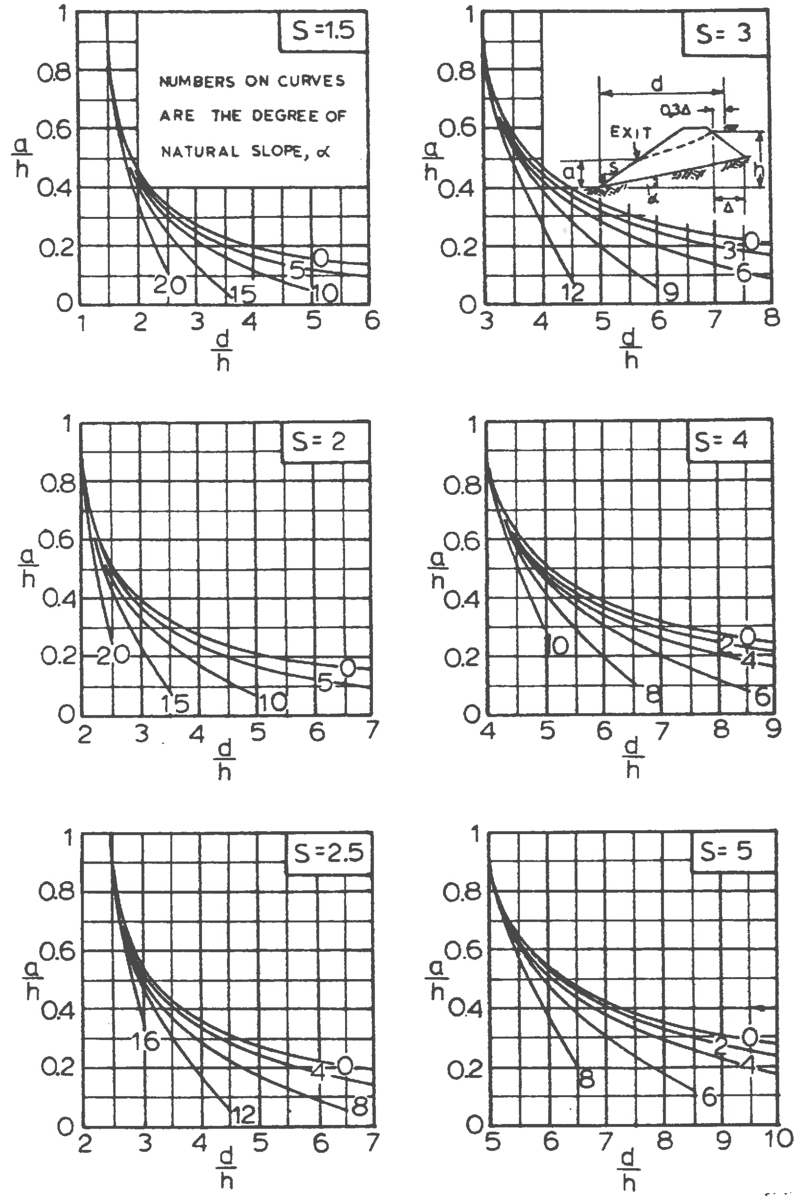

FIGURE 4.3. Chart for determining point of exit.

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EXHIBIT XIII

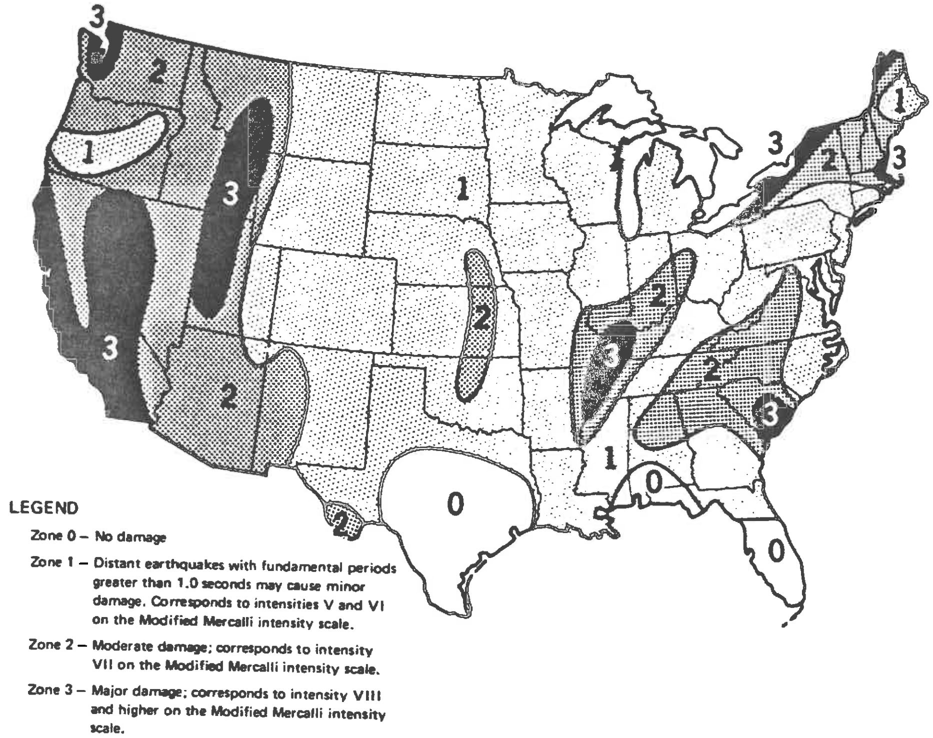

FIGURE 2.9. Seismic zone map of continental United States (After Algermissen, 1969)

Table 2.2 Seismic Coefficients Corresponding to Each Zone.

ZONE	INTENSITY OF MODIFIED MERCALLI SCALE	AVERAGE SEISMIC COEFFICIENT	REMARK
0	—	0	No damage
1	V and VI	0.03 to 0.07	Minor damage
2	VII	0.13	Moderate damage
3	VII and higher	0.27	Major damage

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EXHIBIT XIV

```
Rotational Equilibruim Analysis of Multilayered Embankments

PROJECT TITLE -? COTTONWOOD W[illegible]RSF

FILE NAME? DAM1

READ FROM FILE? (Enter 1 when read from file & Ø when not)? 1

NO. OF STATIC AND SEISMIC CASES=? 1

CASE NO. 1     SEISMIC COEFFICIENT=? Ø

NO. OF BOUNDARY LINES= 8

NO. OF POINTS ON BOUNDARY LINE 1 = 2

BOUNDARY LINE - 1
  COORDINATE # 1  = ( Ø , Ø )
  COORDINATE # 2  = ( 25Ø , Ø )

NO. OF POINTS ON BOUNDARY LINE 2 = 2

BOUNDARY LINE - 2
  COORDINATE # 1  = ( Ø , 11 )
  COORDINATE # 2  = ( 25Ø , 11 )

NO. OF POINTS ON BOUNDARY LINE 3 = 2

BOUNDARY LINE - 3
  COORDINATE # 1  = ( Ø , 15 )
  COORDINATE # 2  = ( 25Ø , 15 )

NO. OF POINTS ON BOUNDARY LINE 4 = 2

BOUNDARY LINE - 4
  COORDINATE # 1  = ( Ø , 19 )
  COORDINATE # 2  = ( 25Ø , 19 )

NO. OF POINTS ON BOUNDARY LINE 5 = 2

BOUNDARY LINE - 5
  COORDINATE # 1  = ( Ø , 25 )
  COORDINATE # 2  = ( 25Ø , 25 )

NO. OF POINTS ON BOUNDARY LINE 6 = 2

BOUNDARY LINE - 6
  COORDINATE # 1  = ( 4Ø , 33 )
  COORDINATE # 2  = ( 146 , 3Ø )

NO. OF POINTS ON BOUNDARY LINE 7 = 3

BOUNDARY LINE - 7
  COORDINATE # 1  = ( Ø , 33 )
  COORDINATE # 2  = ( 4Ø , 33 )
  COORDINATE # 3  = ( 86.5 , 48.5 )

NO. OF POINTS ON BOUNDARY LINE 8 = 7

BOUNDARY LINE - 8
  COORDINATE # 1  = ( Ø , 48.5 )
  COORDINATE # 2  = ( 86.5 , 48.5 )
```

EXHIBIT XV

COORDINATE # 4 = ([illegible] , [illegible])
COORDINATE # 5 = (137 , 34.5)
COORDINATE # 6 = (146 , 3Ø)
COORDINATE # 7 = (25Ø , 3Ø)

L[illegible] NO. AND SLOPE OF EACH SEGMENT ARE:

1	Ø
2	Ø
3	Ø
4	Ø
5	Ø
6	-2.83Ø189E-Ø2
7	Ø .3333334
8	Ø .3333334 Ø -.5 -.5 Ø

MIN DEPTH OF TALLEST SLICE= 3
NO. OF RADIUS CONTROL ZONES= 1

RADIUS DECREMENT FOR ZONE 1 = Ø
NO. OF CIRCLES FOR ZONE 1 = 5
ID NO.FOR FIRST CIRCLE FOR ZONE 1 = 1
NO. OF BOTTOM LINES FOR ZONE 1 = 1

FOR ZONE 1 LINE SEQUENCE 1
LINE NO.= 1 BEG. NO.= 1 END NO.= 2

SOIL NO.	COHESION	FRIC. ANGLE	UNIT WEIGHT
1	Ø	3Ø	12Ø
2	Ø	34	13Ø
3	Ø	34	13Ø
4	15Ø	27	13Ø
5	Ø	34	13Ø
6	1ØØ8	32.7	123.8
7	Ø	Ø	62.4

USE PHREATIC SURFACE
UNIT WEIGHT OF WATER= 62.4
USE GRID
NO. OF SLICES= 1Ø NO. OF ADD. RADII= 3

NO. OF POINTS ON WATER TABLE= 5
COORDINATE # 1 = (Ø , 48.5)
COORDINATE # 2 = (86.5 , 48.5)
COORDINATE # 3 = (137 , 34.5)
COORDINATE # 4 = (146 , 3Ø)
COORDINATE # 5 = (25Ø , 3Ø)

INPUT COORD. OF GRID POINTS 1,2,AND 3

POINT 1 X COORD.= 111 Y COORD.= 6Ø
POINT 2 X COORD.= 151 Y COORD.= 5Ø
POINT 3 X COORD.= 176 Y COORD.= 1ØØ

X INCREMENT= 4 Y INCREMENT= 4

NO. OF DIVISIONS BETWEEN POINTS 1 AND 2= 4
N[illegible] OF DIVISIONS BETWEEN POINTS 2 AND 3= 5

[illegible]UTOMATIC SEARCH WILL FOLLOW AFTER GRID

AT POINT (111 6Ø)THE RADIUS AND FACTOR OF SAFETY ARE:
6Ø 3.544193

```
 40.47214          3.057313
 30.70821          4.400839
 20.94428          9.61191
LOWEST FACTOR OF SAFETY = 3.057313 AND OCCURS AT RADIUS = 40.47214



AT POINT ( 121  57.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 57.5             2.859315
 48.68328         2.46288
 39.86656         2.165707
 31.04984         3.022677
 22.23313         6.190835
LOWEST FACTOR OF SAFETY = 2.146885 AND OCCURS AT RADIUS = 37.66239



AT POINT ( 131  55 )THE RADIUS AND FACTOR OF SAFETY ARE:
 55               2.593468
 47.1305          2.287888
 39.261           2.079407
 31.39149         2.055751
 23.52199         5.757919
LOWEST FACTOR OF SAFETY = 1.968248 AND OCCURS AT RADIUS = 35.32624



AT POINT ( 141  52.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 52.5             2.738529
 [illegible].57771        2.491286
 38.65542         2.383912
 31.73313         2.299669
 24.81084         3.221789
LOWEST FACTOR OF SAFETY = 2.254928 AND OCCURS AT RADIUS = 35.19428



AT POINT ( 151  50 )THE RADIUS AND FACTOR OF SAFETY ARE:
 50               3.260975
 44               3.23008
 38               3.387799
 32               3.478361
 26               4.628189
LOWEST FACTOR OF SAFETY = 3.23008 AND OCCURS AT RADIUS = 44



AT POINT ( 116  70 )THE RADIUS AND FACTOR OF SAFETY ARE:
 70               3.226276
 60.47214         2.787477
 50.94428         2.364968
 41.41641         3.352857
 [illegible]88855         7.912275
LOWEST FACTOR OF SAFETY = 2.364968 AND OCCURS AT RADIUS = 50.94428



AT POINT ( 126  67.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 67.5             2.7537
```

```
 50.[illegible]         1.[illegible]
 41.75605          2.41743
 33.1774           5.712003
LOWEST FACTOR OF SAFETY = 1.913985 AND OCCURS AT RADIUS = 48.19354



AT POINT ( 136  65 )THE RADIUS AND FACTOR OF SAFETY ARE:
 65               2.560599
 57.36656         2.221772
 49.73313         2.143275
 42.09969         2.097306
 34.46625         5.327466
LOWEST FACTOR OF SAFETY = 2.028898 AND OCCURS AT RADIUS = 45.91641



AT POINT ( 146  62.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 62.5             2.703031
 55.81378         2.534073
 49.12756         2.455843
 42.44134         2.536948
 35.75511         3.464938
LOWEST FACTOR OF SAFETY = 2.445503 AND OCCURS AT RADIUS = 45.78445



AT POINT ( 156  60 )THE RADIUS AND FACTOR OF SAFETY ARE:
 [illegible]      3.259335
 [illegible]      3.298867
 48               3.488634
 42               3.974185
 36               6.227028
LOWEST FACTOR OF SAFETY = 3.259335 AND OCCURS AT RADIUS = 60



AT POINT ( 121  80 )THE RADIUS AND FACTOR OF SAFETY ARE:
 80               3.081869
 70.70821         2.633557
 61.41641         2.226766
 52.12462         2.827497
 42.83283         7.195063
LOWEST FACTOR OF SAFETY = 2.163766 AND OCCURS AT RADIUS = 59.09347



AT POINT ( 131  77.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 77.5             2.733912
 69.15542         2.326391
 60.81084         1.979112
 5[illegible].46626         2.245595
 [illegible].12168         5.536005
LOWEST FACTOR OF SAFETY = 1.916596 AND OCCURS AT RADIUS = 58.7247



AT POINT ( 141  75 )THE RADIUS AND FACTOR OF SAFETY ARE:
 75               2.598493
```

```
 [illegible]         [illegible]
 52.22769            2.23[illegible]38
 45.4[illegible]52   3.952[illegible]
LOWEST FACTOR OF SAFETY = 2.153055 AND OCCURS AT RADIUS = 56.50658



AT POINT ( 151  72.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 72.5               2.710229
 66.04985           2.654971
 59.59969           2.60792
 53.14953           2.759505
 46.69937           3.835899
LOWEST FACTOR OF SAFETY = 2.60792 AND OCCURS AT RADIUS = 59.59969



AT POINT ( 161  70 )THE RADIUS AND FACTOR OF SAFETY ARE:
 70                 3.332017
 64                 3.394558
 58                 3.748289
 52                 4.603681
 46                 8.980051
LOWEST FACTOR OF SAFETY = 3.332017 AND OCCURS AT RADIUS = 70



AT POINT ( 126  90 )THE RADIUS AND FACTOR OF SAFETY ARE:
 [illegible]        3.041515
 [illegible].94428  2.5789
 71.88855           2.195744
 62.83282           2.436629
 53.77709           6.813785
LOWEST FACTOR OF SAFETY = 2.105234 AND OCCURS AT RADIUS = 69.62462



AT POINT ( 136  87.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 87.5               2.766999
 79.39149           2.362091
 71.28298           2.035705
 63.17446           2.268292
 55.06595           5.477588
LOWEST FACTOR OF SAFETY = 1.984229 AND OCCURS AT RADIUS = 69.25585



AT POINT ( 146  85 )THE RADIUS AND FACTOR OF SAFETY ARE:
 85                 2.666601
 77.8387            2.342608
 70.6774            2.324941
 63.5161            2.418824
 [illegible].3548   3.84908
LOWEST FACTOR OF SAFETY = 2.306292 AND OCCURS AT RADIUS = 76.04837
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AT POINT ( 156  82.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 82.5               2.783508
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70.07123          [illegible]
63.85774          3.007469
57.64365          4.359215
LOWEST FACTOR OF SAFETY = 2.783508 AND OCCURS AT RADIUS = 82.5



AT POINT ( 166  80 )THE RADIUS AND FACTOR OF SAFETY ARE:
 80               3.460093
 74               3.565962
 68               4.07712
 62               5.415854
 56               14.79745
LOWEST FACTOR OF SAFETY = 3.460093 AND OCCURS AT RADIUS = 80



AT POINT ( 131  100 )THE RADIUS AND FACTOR OF SAFETY ARE:
 100              3.04081
 91.18034         2.594735
 82.36069         2.203512
 73.54103         2.305713
 64.72138         6.583996
LOWEST FACTOR OF SAFETY = 2.12083 AND OCCURS AT RADIUS = 80.15578



AT POINT ( 141  97.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 97.5             2.830522
 89.62755         2.436576
 81.7551          2.123475
 73.88265         2.347678
 66.0102          5.473756
LOWEST FACTOR OF SAFETY = 2.072628 AND OCCURS AT RADIUS = 79.78699



AT POINT ( 151  95 )THE RADIUS AND FACTOR OF SAFETY ARE:
 95               2.760116
 88.07477         2.447414
 81.14954         2.448535
 74.22431         2.633861
 67.29908         3.944263
LOWEST FACTOR OF SAFETY = 2.411715 AND OCCURS AT RADIUS = 84.61215



AT POINT ( 161  92.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 92.5             2.892463
 86.5             2.966379
 80.5             3.04569
 74.5             3.30924
 68.5             5.059313
LOWEST FACTOR OF SAFETY = 2.892463 AND OCCURS AT RADIUS = 92.5



AT POINT ( 171  90 )THE RADIUS AND FACTOR OF SAFETY ARE:
 90               3.63745
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 78              4.47[illegible]
 72              6.525649
 66              34.27849
LOWEST FACTOR OF SAFETY = 3.63745 AND OCCURS AT RADIUS = 90



AT POINT ( 136  110 )THE RADIUS AND FACTOR OF SAFETY ARE:
 110             3.077027
 101.4164        2.63026
 92.83281        2.253409
 84.24921        2.291141
 75.66562        6.442675
LOWEST FACTOR OF SAFETY = 2.177216 AND OCCURS AT RADIUS = 88.54102



AT POINT ( 146  107.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 107.5           2.907893
 99.86362        2.52755
 92.22725        2.242378
 84.59088        2.470216
 76.9545         5.503069
LOWEST FACTOR OF SAFETY = 2.195842 AND OCCURS AT RADIUS = 90.31816



AT POINT ( 156  105 )THE RADIUS AND FACTOR OF SAFETY ARE:
 [illegible]5    2.870354
 [illegible].31084  2.571913
 91.62168        2.608025
 84.93251        2.874833
 78.24335        4.153072
LOWEST FACTOR OF SAFETY = 2.542379 AND OCCURS AT RADIUS = 96.63855



AT POINT ( 166  102.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 102.5           3.02651
 96.5            3.129835
 90.5            3.312849
 84.5            3.749648
 78.5            6.560286
LOWEST FACTOR OF SAFETY = 3.02651 AND OCCURS AT RADIUS = 102.5



AT POINT ( 176  100 )THE RADIUS AND FACTOR OF SAFETY ARE:
 100             3.851414
 94              4.092094
 88              5.028397
 [illegible]     8.104567
                 1000000
LOWEST FACTOR OF SAFETY = 3.851414 AND OCCURS AT RADIUS = 100


AT POINT ( 126  67.5 )RADIUS 48.19354


THE MINIMUM FACTOR OF SAFETY IS 1.[illegible]
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4

AT POINT (126 67.5)THE RADIUS AND FACTOR OF SAFETY ARE:

67.5	2.7537
[illegible]91935	2.332679
[illegible]3387	1.991727
41.75805	2.417483
33.1774	5.712003

LOWEST FACTOR OF SAFETY = 1.913985 AND OCCURS AT RADIUS = 48.19354

AT POINT (130 67.5)THE RADIUS AND FACTOR OF SAFETY ARE:

67.5	2.655757
59.27712	2.260258
51.05425	1.993058
42.83137	2.172066
34.60849	5.386652

LOWEST FACTOR OF SAFETY = 1.983175 AND OCCURS AT RADIUS = 48.99853

AT POINT (122 67.5)THE RADIUS AND FACTOR OF SAFETY ARE:

67.5	2.87992
58.56158	2.466768
49.62316	2.096653
40.68473	2.839975
[illegible] 74631	6.255259

[illegible]ST FACTOR OF SAFETY = 1.986216 AND OCCURS AT RADIUS = 47.38855

AT POINT (126 71.5)THE RADIUS AND FACTOR OF SAFETY ARE:

71.5	2.794992
62.83489	2.365706
54.16979	2.009868
45.50468	2.446572
36.83957	5.843439

LOWEST FACTOR OF SAFETY = 1.903152 AND OCCURS AT RADIUS = 52.00351

AT POINT (126 75.5)THE RADIUS AND FACTOR OF SAFETY ARE:

75.5	2.840454
66.75044	2.404181
58.00087	2.044182
49.2513	2.361216
40.50173	6.008069

LOWEST FACTOR OF SAFETY = 1.93131 AND OCCURS AT RADIUS = 55.81348

AT POINT (130 71.5)THE RADIUS AND FACTOR OF SAFETY ARE:

71.5	2.691607
63.19267	2.288913
54.88533	1.973464
46.578	2.214105
38.27066	5.446256

[illegible]

AT POINT (122 71.5)THE RADIUS AND FACTOR OF SAFETY ARE:

71.5	2.723805
[illegible]47712	2.49922
[illegible]45424	2.120849
44.43136	2.707928
35.40848	6.449379

LOWEST FACTOR OF SAFETY = 2.023755 AND OCCURS AT RADIUS = 51.19852

AT POINT (127 71.5)THE RADIUS AND FACTOR OF SAFETY ARE:

71.5	2.76666
62.92434	2.342452
54.34867	1.990251
45.77301	2.350387
37.19734	5.727583

LOWEST FACTOR OF SAFETY = 1.897779 AND OCCURS AT RADIUS = 52.20476

AT POINT (128 71.5)THE RADIUS AND FACTOR OF SAFETY ARE:

71.5	2.740086
63.01378	2.322023
54.52756	1.978053
46.04134	2.296522
[illegible].55512	5.623163

[illegible]EST FACTOR OF SAFETY = 1.898079 AND OCCURS AT RADIUS = 52.406

AT POINT (127 72.5)THE RADIUS AND FACTOR OF SAFETY ARE:

72.5	2.777634
63.90322	2.351591
55.30644	1.998775
46.70965	2.360716
38.11287	5.762839

LOWEST FACTOR OF SAFETY = 1.897505 AND OCCURS AT RADIUS = 53.15724

AT POINT (127 73.5)THE RADIUS AND FACTOR OF SAFETY ARE:

73.5	2.788877
64.8821	2.360991
56.26421	2.007466
47.64631	2.366404
39.02841	5.80003

LOWEST FACTOR OF SAFETY = 1.898358 AND OCCURS AT RADIUS = 54.10974

AT POINT (128 72.5)THE RADIUS AND FACTOR OF SAFETY ARE:

72.5	2.751042
63.99266	2.331235
55.48532	1.979878
46.97798	2.305367
38.47064	5.655391

```
AT POINT ( 129  72.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 72.5            2.726097
 [illegible].08211       2.312241
 [illegible]66421        1.973625
 4[illegible].24632      2.262482
 [illegible]3.82842      5.558596
LOWEST FACTOR OF SAFETY = 1.907056 AND OCCURS AT RADIUS = 53.55974



AT POINT ( 128  73.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 73.5            2.762265
 64.97155        2.340695
 56.4431         1.987866
 47.91465        2.316104
 39.3862         5.689541
LOWEST FACTOR OF SAFETY = 1.896828 AND OCCURS AT RADIUS = 54.31099



AT POINT ( 128  71.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 71.5            2.740086
 63.01378        2.322023
 54.52756        1.978053
 46.04134        2.296522
 37.55512        5.623163
[illegible]ST FACTOR OF SAFETY = 1.898079 AND OCCURS AT RADIUS = 52.406

AT POINT ( 128  72.5 )RADIUS 53.35849
**************************************************
THE MINIMUM FACTOR OF SAFETY IS 1.896735
**************************************************

ANY PLOT? (enter 0 for no plot, and 1 for plot)? 1

YOU MAY LIKE TO ADVANCE PAPER TO THE TOP OF NEXT PAGE
SO THE ENTIRE PLOT WILL FIT IN ONE SINGLE PAGE.
FOR THE PROGRAM TO PROCEED, HIT THE RETURN KEY.
AFTER PLOT, YOU MAY LIKE TO ADVANCE PAPER TO NEXT PAGE
AND HIT THE RETURN KEY AGAIN
?
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RUN
Rotational Equilibruim Analysis of Multilayered Embankments

PROJECT TITLE -? COTTONWOOD WRSF SEISMIC

FILE NAME? IAM8

READ FROM FILE? (Enter 1 when read from file & Ø when not)? 1

NO. OF STATIC AND SEISMIC CASES=? 1

CASE NO. 1     SEISMIC COEFFICIENT=? .13

NO. OF BOUNDARY LINES= 8

NO. OF POINTS ON BOUNDARY LINE 1 = 2

BOUNDARY LINE - 1
  COORDINATE # 1  = ( Ø , Ø )
  COORDINATE # 2  = ( 25Ø , Ø )

NO. OF POINTS ON BOUNDARY LINE 2 = 2

BOUNDARY LINE - 2
  COORDINATE # 1  = ( Ø , 11 )
  COORDINATE # 2  = ( 25Ø , 11 )

NO. OF POINTS ON BOUNDARY LINE 3 = 2

BOUNDARY LINE - 3
  COORDINATE # 1  = ( Ø , 15 )
  COORDINATE # 2  = ( 25Ø , 15 )

NO. OF POINTS ON BOUNDARY LINE 4 = 2

BOUNDARY LINE - 4
  COORDINATE # 1  = ( Ø , 19 )
  COORDINATE # 2  = ( 25Ø , 19 )

NO. OF POINTS ON BOUNDARY LINE 5 = 2

BOUNDARY LINE - 5
  COORDINATE # 1  = ( Ø , 25 )
  COORDINATE # 2  = ( 25Ø , 25 )

NO. OF POINTS ON BOUNDARY LINE 6 = 2

BOUNDARY LINE - 6
  COORDINATE # 1  = ( 4Ø , 33 )
  COORDINATE # 2  = ( 146 , 3Ø )

NO. OF POINTS ON BOUNDARY LINE 7 = 3

BOUNDARY LINE - 7
  COORDINATE # 1  = ( Ø , 33 )
  COORDINATE # 2  = ( 4Ø , 33 )
  COORDINATE # 3  = ( 86.5 , 48.5 )

NO. OF POINTS ON BOUNDARY LINE 8 = 7

BOUNDARY LINE - 8
  COORDINATE # 1  = ( Ø , 48.5 )
  COORDINATE # 2  = ( 86.5 , 48.5 )
```

EXHIBIT XVI
4-9

```
  COORDINATE # 4  = ( [illegible] , [illegible] )
  COORDINATE # 5  = ( 137 , 34.5 )
  COORDINATE # 6  = ( 146 , 30 )
  COORDINATE # 7  = ( 250 , 30 )


 [illegible]T NO. AND SLOPE OF EACH SEGMENT ARE:
                 0
 2               0
 3               0
 4               0
 5               0
 6             -2.830189E-02
 7               0  .3333334
 8               0  .3333334  0 -.5 -.5  0

MIN DEPTH OF TALLEST SLICE= 3
NO. OF RADIUS CONTROL ZONES= 1

RADIUS DECREMENT FOR ZONE 1 = 0
NO. OF CIRCLES FOR ZONE 1 = 5
ID NO.FOR FIRST CIRCLE FOR ZONE 1 = 1
NO. OF BOTTOM LINES FOR ZONE 1 = 1

FOR ZONE 1     LINE SEQUENCE 1
LINE NO.= 1    BEG. NO.= 1    END NO.= 2

SOIL NO.        COHESION        FRIC. ANGLE    UNIT WEIGHT
     1           0               30             120
     2           0               34             130
     3           0               34             130
     4           150             27             130
     5           0               34             130
     6           1008            32.7           123.8
     7           0               0              62.4

USE PHREATIC SURFACE
UNIT WEIGHT OF WATER= 62.4
USE GRID
NO. OF SLICES= 10               NO. OF ADD. RADII= 3

NO. OF POINTS ON WATER TABLE= 5
  COORDINATE # 1  = ( 0 , 48.5 )
  COORDINATE # 2  = ( 86.5 , 48.5 )
  COORDINATE # 3  = ( 137 , 34.5 )
  COORDINATE # 4  = ( 146 , 30 )
  COORDINATE # 5  = ( 250 , 30 )

INPUT COORD. OF GRID POINTS 1,2,AND 3

POINT 1 X COORD.= 111 Y COORD.= 60
POINT 2 X COORD.= 151 Y COORD.= 50
POINT 3 X COORD.= 176 Y COORD.= 100

X INCREMENT= 4                 Y INCREMENT=   4

NO. OF DIVISIONS BETWEEN POINTS 1 AND 2= 4
[illegible] OF DIVISIONS BETWEEN POINTS 2 AND 3= 5

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID


AT POINT ( 111  60 )THE RADIUS AND FACTOR OF SAFETY ARE:
 60             2.01649
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 40.47214           1.970622
 30.70621           3.05155
 20.94428           6.54903
LOWEST FACTOR OF SAFETY = 1.929481 AND OCCURS AT RADIUS = 52.67705



AT POINT ( 121   57.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 57.5               1.802972
 48.68328           1.65576
 39.86656           1.531434
 31.04984           2.191351
 22.23313           4.739994
LOWEST FACTOR OF SAFETY = 1.513928 AND OCCURS AT RADIUS = 37.66239



AT POINT ( 131   55 )THE RADIUS AND FACTOR OF SAFETY ARE:
 55                 1.703243
 47.1305            1.587459
 39.261             1.494403
 31.39149           1.51528
 23.52199           4.502667
LOWEST FACTOR OF SAFETY = 1.430584 AND OCCURS AT RADIUS = 35.32624



AT POINT ( 141   52.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 52.5               1.77199
 [illegible].57771  1.685619
 38.65542           1.649461
 31.73313           1.623854
 24.81084           2.411011
LOWEST FACTOR OF SAFETY = 1.580499 AND OCCURS AT RADIUS = 35.19428



AT POINT ( 151   50 )THE RADIUS AND FACTOR OF SAFETY ARE:
 50                 1.960636
 44                 1.98549
 38                 2.072558
 32                 2.104106
 26                 2.766088
LOWEST FACTOR OF SAFETY = 1.960636 AND OCCURS AT RADIUS = 50



AT POINT ( 116   70 )THE RADIUS AND FACTOR OF SAFETY ARE:
 70                 1.809147
 60.47214           1.687234
 50.94428           1.519598
 41.41641           2.329818
 [illegible].88855  5.507259
LOWEST FACTOR OF SAFETY = 1.519598 AND OCCURS AT RADIUS = 50.94428



AT POINT ( 126   67.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 67.5               1.676047
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50.3357 1.[illegible]463
41.75805 1.711029
33.1774 4.327925
LOWEST FACTOR OF SAFETY = 1.335976 AND OCCURS AT RADIUS = 48.1[illegible]

AT POINT (136 65)THE RADIUS AND FACTOR OF SAFETY ARE:
65 1.623845
57.36656 1.488162
49.73313 1.468353
42.09969 1.505421
34.46625 4.154773
LOWEST FACTOR OF SAFETY = 1.42117 AND OCCURS AT RADIUS = 45.91641

AT POINT (146 62.5)THE RADIUS AND FACTOR OF SAFETY ARE:
62.5 1.697918
55.81378 1.634046
49.12756 1.625154
42.44134 1.716904
35.75511 2.504432
LOWEST FACTOR OF SAFETY = 1.62354 AND OCCURS AT RADIUS = 54.14233

AT POINT (156 60)THE RADIUS AND FACTOR OF SAFETY ARE:
1.91279
1.928139
48 2.034135
42 2.235571
36 3.327371
LOWEST FACTOR OF SAFETY = 1.91279 AND OCCURS AT RADIUS = 60

AT POINT (121 80)THE RADIUS AND FACTOR OF SAFETY ARE:
80 1.696237
70.70821 1.570245
61.41641 1.432381
52.12462 1.953488
42.83283 5.073921
LOWEST FACTOR OF SAFETY = 1.410261 AND OCCURS AT RADIUS = 59.[illegible]347

AT POINT (131 77.5)THE RADIUS AND FACTOR OF SAFETY ARE:
77.5 1.60873
69.15542 1.469144
60.81084 1.341091
52.46626 1.570739
[illegible].12168 4.177697
LOWEST FACTOR OF SAFETY = 1.313514 AND OCCURS AT RADIUS = 58.7347

AT POINT (141 75)THE RADIUS AND FACTOR OF SAFETY ARE:
75 1.582255

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 60.2[illegible]526       1.474[illegible]
 52.8[illegible]789       1.559819
 45.4[illegible]52        3.03956
LOWEST FACTOR OF SAFETY = 1.451125 AND OCCURS AT RADIUS = 65.75329



AT POINT ( 151  72.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 72.5            1.643366
 66.04985        1.628203
 59.59969        1.650836
 53.14953        1.789975
 46.69937        2.641985
LOWEST FACTOR OF SAFETY = 1.618818 AND OCCURS AT RADIUS = 64.4373



AT POINT ( 161  70 )THE RADIUS AND FACTOR OF SAFETY ARE:
 70              1.867603
 64              1.895766
 58              2.074799
 52              2.408469
 46              4.04728
LOWEST FACTOR OF SAFETY = 1.867603 AND OCCURS AT RADIUS = 70



AT POINT ( 126  90 )THE RADIUS AND FACTOR OF SAFETY ARE:
 [illegible]     1.635705
 [illegible].94428        1.511875
 71.88855        1.397985
 62.83282        1.674166
 53.77709        4.851444
LOWEST FACTOR OF SAFETY = 1.364657 AND OCCURS AT RADIUS = 69.62462



AT POINT ( 136  87.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 87.5            1.575513
 79.39149        1.44914
 71.28298        1.344737
 63.17446        1.566456
 55.06595        4.126736
LOWEST FACTOR OF SAFETY = 1.328937 AND OCCURS AT RADIUS = 69.25585



AT POINT ( 146  85 )THE RADIUS AND FACTOR OF SAFETY ARE:
 85              1.563909
 77.8387         1.458461
 70.6774         1.488166
 63.5161         1.635882
 [illegible].3548         2.912951
LOWEST FACTOR OF SAFETY = 1.451629 AND OCCURS AT RADIUS = 76.04837



AT POINT ( 156  82.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 82.5            1.624983
```

```
 70.07183          1.701971
 63.85774          1.865056
 57.64365          2.837572
LOWEST FACTOR OF SAFETY = 1.624983 AND OCCURS AT RADIUS = [illegible].5



AT POINT ( 166  80 )THE RADIUS AND FACTOR OF SAFETY ARE:
 80               1.851737
 74               1.899283
 68               2.134538
 62               2.607295
 56               4.94205
LOWEST FACTOR OF SAFETY = 1.851737 AND OCCURS AT RADIUS = 80



AT POINT ( 131  100 )THE RADIUS AND FACTOR OF SAFETY ARE:
 100              1.599601
 91.18034         1.490207
 82.36069         1.38527
 73.54103         1.582665
 64.72138         4.72374
LOWEST FACTOR OF SAFETY = 1.360489 AND OCCURS AT RADIUS = 80.15578



AT POINT ( 141  97.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 97.5             1.561595
 89.62755         1.451296
 81.7551          1.368218
 73.88265         1.596515
 66.0102          4.122639
LOWEST FACTOR OF SAFETY = 1.356723 AND OCCURS AT RADIUS = 79.78699



AT POINT ( 151  95 )THE RADIUS AND FACTOR OF SAFETY ARE:
 95               1.561721
 88.07477         1.47047
 81.14954         1.520857
 74.22431         1.721814
 67.29908         2.898039
LOWEST FACTOR OF SAFETY = 1.468915 AND OCCURS AT RADIUS = 86.34346



AT POINT ( 161  92.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 92.5             1.625874
 86.5             1.66282
 80.5             1.763262
 74.5             1.957185
 68.5             3.087495
LOWEST FACTOR OF SAFETY = 1.625874 AND OCCURS AT RADIUS = 92.5



AT POINT ( 171  90 )THE RADIUS AND FACTOR OF SAFETY ARE:
 90               1.856553
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 78              2.21694-2
 72              2.834898
 66              5.86634
LOWEST FACTOR OF SAFETY = 1.856552 AND OCCURS AT RADIUS = 90



AT POINT ( 136  110 )THE RADIUS AND FACTOR OF SAFETY ARE:
 110             1.581748
 101.4164        1.481484
 92.83281        1.393724
 84.24921        1.563674
 75.66562        4.651863
LOWEST FACTOR OF SAFETY = 1.378527 AND OCCURS AT RADIUS = 90.68691



AT POINT ( 146  107.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 107.5           1.558004
 99.86362        1.463614
 92.22725        1.407095
 84.59088        1.646941
 76.9545         4.146478
LOWEST FACTOR OF SAFETY = 1.401212 AND OCCURS AT RADIUS = 90.31816



AT POINT ( 156  105 )THE RADIUS AND FACTOR OF SAFETY ARE:
 105             1.569494
 [illegible].31084      1.496174
 91.62168        1.568147
 84.93251        1.810999
 78.24335        2.928159
LOWEST FACTOR OF SAFETY = 1.496174 AND OCCURS AT RADIUS = 98.31084



AT POINT ( 166  102.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 102.5           1.638506
 96.5            1.689401
 90.5            1.836109
 84.5            2.111443
 78.5            3.68458
LOWEST FACTOR OF SAFETY = 1.638506 AND OCCURS AT RADIUS = 102.5



AT POINT ( 176  100 )THE RADIUS AND FACTOR OF SAFETY ARE:
 100             1.873812
 94              1.968293
 88              2.318879
 82              3.088333
 [illegible]            3.435985
LOWEST FACTOR OF SAFETY = 1.873812 AND OCCURS AT RADIUS = 100


AT POINT ( 131  77.5 )RADIUS 58.7247


THE MINIMUM FACTOR OF SAFETY IS 1.313514
```

AT POINT (131 77.5)THE RADIUS AND FACTOR OF SAFETY ARE:

[illegible]7.5	1.60[illegible]73
[illegible]15542	1.469144
[illegible]81084	1.341091
[illegible]2.46626	1.570739
[illegible]4.12168	4.177697

LOWEST FACTOR OF SAFETY = 1.313514 AND OCCURS AT RADIUS = 58.7247

AT POINT (135 77.5)THE RADIUS AND FACTOR OF SAFETY ARE:

77.5	1.588542
69.5132	1.451284
61.52638	1.358743
53.53958	1.540035
45.55277	4.036378

LOWEST FACTOR OF SAFETY = 1.350813 AND OCCURS AT RADIUS = 59.52968

AT POINT (127 77.5)THE RADIUS AND FACTOR OF SAFETY ARE:

77.5	1.639468
68.79765	1.496786
60.09529	1.369287
51.39294	1.601361
[illegible].69058	4.418625

L[illegible]ST FACTOR OF SAFETY = 1.312946 AND OCCURS AT RADIUS = 5[illegible].9197

AT POINT (123 77.5)THE RADIUS AND FACTOR OF SAFETY ARE:

77.5	1.676841
68.43988	1.541291
59.37976	1.407905
50.31964	1.800449
41.25951	4.772162

LOWEST FACTOR OF SAFETY = 1.367521 AND OCCURS AT RADIUS = 57.11473

AT POINT (127 81.5)THE RADIUS AND FACTOR OF SAFETY ARE:

81.5	1.633362
72.71319	1.497253
63.92638	1.373658
55.13957	1.585509
46.35276	4.515703

LOWEST FACTOR OF SAFETY = 1.324585 AND OCCURS AT RADIUS = 61.72968

AT POINT (127 73.5)THE RADIUS AND FACTOR OF SAFETY ARE:

73.5	1.647979
64.8821	1.499754
56.26421	1.366148
47.64631	1.651432
39.02841	4.341705

AT POINT (127 69.5)THE RADIUS AND FACTOR OF SAFETY ARE:

69.5	1.659342
[illegible].96657	1.505898
[illegible].43313	1.369993
43.8997	1.643372
35.36626	4.286059

LOWEST FACTOR OF SAFETY = 1.323118 AND OCCURS AT RADIUS = 50.29977

AT POINT (131 73.5)THE RADIUS AND FACTOR OF SAFETY ARE:

73.5	1.616476
65.23988	1.472547
56.97975	1.351276
48.71963	1.557057
40.4595	4.126545

LOWEST FACTOR OF SAFETY = 1.332266 AND OCCURS AT RADIUS = 54.91472

AT POINT (123 73.5)THE RADIUS AND FACTOR OF SAFETY ARE:

73.5	1.686053
64.52434	1.545464
55.54868	1.407309
46.57302	1.826137
[illegible].59735	4.664006

[illegible]EST FACTOR OF SAFETY = 1.358755 AND OCCURS AT RADIUS = 53.30476

AT POINT (128 73.5)THE RADIUS AND FACTOR OF SAFETY ARE:

73.5	1.639535
64.97155	1.491839
56.4431	1.357197
47.91465	1.622328
39.3862	4.279207

LOWEST FACTOR OF SAFETY = 1.308074 AND OCCURS AT RADIUS = 54.31099

AT POINT (129 73.5)THE RADIUS AND FACTOR OF SAFETY ARE:

73.5	1.631561
65.06099	1.484388
56.62198	1.35133
48.18297	1.596608
39.74396	4.22275

LOWEST FACTOR OF SAFETY = 1.311055 AND OCCURS AT RADIUS = 54.51223

AT POINT (128 74.5)THE RADIUS AND FACTOR OF SAFETY ARE:

74.5	1.637299
65.95043	1.490945
57.40087	1.357845
48.8513	1.626116
40.30173	4.295122

```
AT POINT ( 128  75.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 75.5            1.635225
 [illegible]92938      1.490221
 [illegible].35864      1.358612
 49.78796        1.616221
 41.21727        4.312266
LOWEST FACTOR OF SAFETY = 1.303726 AND OCCURS AT RADIUS = 56.21597



AT POINT ( 128  76.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 76.5            1.633303
 67.90821        1.489658
 59.31641        1.359488
 5Ø.72461        1.6Ø2822
 42.13282        4.33Ø6
LOWEST FACTOR OF SAFETY = 1.3Ø2694 AND OCCURS AT RADIUS = 57.16846



AT POINT ( 128  77.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 77.5            1.631527
 68.8871         1.489243
 6Ø.27419        1.36Ø463
 51.66128        1.591912
 [illegible].Ø4837       4.35ØØ3
[illegible]EST FACTOR OF SAFETY = 1.3Ø5246 AND OCCURS AT RADIUS = 58.12Ø96



AT POINT ( 129  76.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 76.5            1.62568
 67.99765        1.482428
 59.49529        1.351639
 5Ø.99293        1.6Ø36Ø5
 42.49Ø57        4.26956
LOWEST FACTOR OF SAFETY = 1.3Ø2697 AND OCCURS AT RADIUS = 57.3697



AT POINT ( 127  76.5 )THE RADIUS AND FACTOR OF SAFETY ARE:
 76.5            1.641365
 67.81876        1.497193
 59.13753        1.368336
 5Ø.45629        1.6Ø9574
 41.77506        4.397661
LOWEST FACTOR OF SAFETY = 1.31Ø383 AND OCCURS AT RADIUS = 56.96722


[illegible]POINT ( 128  76.5 )RADIUS 57.16846
*************************************************
THE MINIMUM FACTOR OF SAFETY IS 1.3Ø2694
*************************************************

ANY PLOT? (enter Ø for no plot, and 1 for plot)? Ø
Ok
```

Rotational Equilibruim Analysis of Multilayered Embankments

PROJECT TITLE -? COTTONWOOD WRSF RAPID DRAWDOWN

LE NAME? DAMS

READ FROM FILE? (Enter 1 when read from file & 0 when not)? 1

NO. OF STATIC AND SEISMIC CASES=? 1

CASE NO. 1   SEISMIC COEFFICIENT=? Ø

NO. OF BOUNDARY LINES= 7

NO. OF POINTS ON BOUNDARY LINE 1 = 2

BOUNDARY LINE - 1
  COORDINATE # 1 = (Ø , Ø)
  COORDINATE # 2 = (25Ø , Ø)

NO. OF POINTS ON BOUNDARY LINE 2 = 2

BOUNDARY LINE - 2
  COORDINATE # 1 = (Ø , 11)
  COORDINATE # 2 = (25Ø , 11)

NO. OF POINTS ON BOUNDARY LINE 3 = 2

BOUNDARY LINE - 3
  COORDINATE # 1 = (Ø , 15)
  COORDINATE # 2 = (25Ø , 15)

NO. OF POINTS ON BOUNDARY LINE 4 = 2

BOUNDARY LINE - 4
  COORDINATE # 1 = (Ø , 19)
  COORDINATE # 2 = (25Ø , 19)

NO. OF POINTS ON BOUNDARY LINE 5 = 2

BOUNDARY LINE - 5
  COORDINATE # 1 = (Ø , 25)
  COORDINATE # 2 = (25Ø , 25)

NO. OF POINTS ON BOUNDARY LINE 6 = 2

BOUNDARY LINE - 6
  COORDINATE # 1 = (4Ø , 33)
  COORDINATE # 2 = (146 , 3Ø)

NO. OF POINTS ON BOUNDARY LINE 7 = 8

BOUNDARY LINE - 7
  COORDINATE # 1 = (Ø , 33)
  COORDINATE # 2 = (4Ø , 33)
  COORDINATE # 3 = (86.5 , 48.5)
  COORDINATE # 4 = (91 , 5Ø)
  COORDINATE # 5 = (1Ø6 , 5Ø)
  COORDINATE # 6 = (137 , 34.5)
  COORDINATE # 7 = (146 , 3Ø)
  COORDINATE # 8 = (25Ø , 3Ø)

EXHIBIT XVII

```
LINE NO. AND SLOPE OF EACH SEGMENT LINE
 1              0
 2              0
 3              0
 4              0
 5              0
               -2.830189E-02
                0  .333334  .333334  0 -.5 -.5  0

MIN DEPTH OF TALLEST SLICE= 3
NO. OF RADIUS CONTROL ZONES= 1

RADIUS DECREMENT FOR ZONE 1 = 0
NO. OF CIRCLES FOR ZONE 1 = 5
ID NO.FOR FIRST CIRCLE FOR ZONE 1 = 1
NO. OF BOTTOM LINES FOR ZONE 1 = 1

FOR ZONE 1      LINE SEQUENCE 1
LINE NO.= 1     BEG. NO.= 1    END NO.= 2

SOIL NO.        COHESION       FRIC. ANGLE    UNIT WEIGHT
    1            0              30             120
    2            0              34             130
    3            0              34             130
    4            150            27             130
    5            0              34             130
    6            1008           32.7           123.8

USE PHREATIC SURFACE
UNIT WEIGHT OF WATER= 62.4
USE GRID
NO. OF SLICES= 10              NO. OF ADD. RADII= 3

NO. OF POINTS ON WATER TABLE= 6
  COORDINATE # 1  = ( 0 , 33 )
  COORDINATE # 2  = ( 40 , 33 )
  COORDINATE # 3  = ( 86.5 , 48.5 )
  COORDINATE # 4  = ( 137 , 34.5 )
  COORDINATE # 5  = ( 146 , 30 )
  COORDINATE # 6  = ( 250 , 30 )

INPUT COORD. OF GRID POINTS 1,2,AND 3

POINT 1 X COORD.= 35 Y COORD.= 40
POINT 2 X COORD.= 105 Y COORD.= 60
POINT 3 X COORD.= 105 Y COORD.= 90

X INCREMENT= 8                 Y INCREMENT=   8

NO. OF DIVISIONS BETWEEN POINTS 1 AND 2= 3
NO. OF DIVISIONS BETWEEN POINTS 2 AND 3= 3

AUTOMATIC SEARCH WILL FOLLOW AFTER GRID

**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 35  40 )THE RADIUS AND FACTOR OF SAFETY ARE:
 35.69314       6.739603
 29.95451       7.155602
 24.21588       7.639589
 18.47725       8.75721
 12.73863       12.63302
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AT POINT ( 58.33334  46.66667 )THE RADIUS AND FACTOR OF SAFETY ARE:
 46.66667         3.528333
 [illegible].7667          3.193475
 [illegible].86713         2.994491
 32.96736         2.724675
 15.96759         6.544636
LOWEST FACTOR OF SAFETY = 2.663461 AND OCCURS AT RADIUS = 24.94231



AT POINT ( 81.66667  53.33334 )THE RADIUS AND FACTOR OF SAFETY ARE:
 53.33334         6.787232
 43.88942         5.60588
 34.4455          4.869568
 25.00158         5.989396
 15.55766         9.974754
LOWEST FACTOR OF SAFETY = 4.869568 AND OCCURS AT RADIUS = 34.4455



AT POINT ( 105  60.00001 )THE RADIUS AND FACTOR OF SAFETY ARE:
 60.00001         6.089161
 50.00001         5.74837
 40.00001         5.990893
 30.00001         9.811441
 [illegible]              15.83161
[illegible]EST FACTOR OF SAFETY = 5.618844 AND OCCURS AT RADIUS = 52.50001


**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 35  50 )THE RADIUS AND FACTOR OF SAFETY ARE:
 38.91015         5.223855
 34.52812         5.325674
 30.14609         5.410542
 25.76406         6.022244
 21.38203         8.918515
LOWEST FACTOR OF SAFETY = 5.223855 AND OCCURS AT RADIUS = 38.91015



AT POINT ( 58.33334  56.66667 )THE RADIUS AND FACTOR OF SAFETY ARE:
 56.66667         3.420709
 48.66427         2.958459
 40.66187         2.600232
 32.65946         2.484243
 24.65706         5.941665
[illegible]EST FACTOR OF SAFETY = 2.453164 AND OCCURS AT RADIUS = 34.66006



AT POINT ( 81.66667  63.33334 )THE RADIUS AND FACTOR OF SAFETY ARE:
 63.33334         7.761678
 53.78678         5.767468
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 34.6752            5.78254
 35.14718           9.596755
LOWEST FACTOR OF SAFETY = 4.830188 AND OCCURS AT RADIUS = 44.24023


AT POINT ( 105   70 )THE RADIUS AND FACTOR OF SAFETY ARE:
 70                 6.402729
 60                 5.652396
 50                 5.767771
 40                 9.836742
 30                 16.62873
LOWEST FACTOR OF SAFETY = 5.652396 AND OCCURS AT RADIUS = 60


**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 35   60 )THE RADIUS AND FACTOR OF SAFETY ARE:
 44.20407           4.285009
 40.76326           4.384427
 37.32244           4.778785
 33.88163           5.419759
 30.44081           8.851052
LOWEST FACTOR OF SAFETY = 4.285009 AND OCCURS AT RADIUS = 44.20407


AT POINT ( 58.33334   66.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 66.66666           3.579324
 58.56163           2.99455
 50.4566            2.62732
 42.35157           2.441682
 34.24653           6.325668
LOWEST FACTOR OF SAFETY = 2.404449 AND OCCURS AT RADIUS = 44.37782


AT POINT ( 81.66667   73.33333 )THE RADIUS AND FACTOR OF SAFETY ARE:
 73.33333           1000000
LOWEST FACTOR OF SAFETY = 1000000 AND OCCURS AT RADIUS = 73.33333


AT POINT ( 105   80 )THE RADIUS AND FACTOR OF SAFETY ARE:
 80                 6.917097
 70                 5.827034
 59.99999           5.72434
 49.99999           10.27125
 39.99999           18.1946
LOWEST FACTOR OF SAFETY = 5.72434 AND OCCURS AT RADIUS = 59.99999


**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 35   70 )THE RADIUS AND FACTOR OF SAFETY ARE:
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 48.08155         4.169716
 45.23177         4.540398
 42.38199         5.573303
 39.5322          1000000
LOWEST FACTOR OF SAFETY = 3.904194 AND OCCURS AT RADIUS = 50.93133


* * WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE



AT POINT ( 58.33334  76.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 72.8667          3.478548
 65.41902         3.04644
 57.97135         2.55063
 50.52368         2.603717
 43.076           6.999839
LOWEST FACTOR OF SAFETY = 2.496367 AND OCCURS AT RADIUS = 56.10943



AT POINT ( 81.66667  83.33333 )THE RADIUS AND FACTOR OF SAFETY ARE:
 83.33333         1000000
LOWEST FACTOR OF SAFETY = 1000000 AND OCCURS AT RADIUS = 83.33333



AT POINT ( 105  89.99999 )THE RADIUS AND FACTOR OF SAFETY ARE:
 [illegible].99999         7.619468
 [illegible]               6.134912
 70               5.767331
 59.99999         10.77295
 49.99999         20.09167
LOWEST FACTOR OF SAFETY = 5.767331 AND OCCURS AT RADIUS = 70


AT POINT ( 58.33334  66.66666 )RADIUS 44.37782


THE MINIMUM FACTOR OF SAFETY IS 2.404449




AT POINT ( 58.33334  66.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 66.66666         3.579324
 58.56163         2.99455
 50.45666         2.62732
 42.35157         2.441682
 34.24653         6.325668
LOWEST FACTOR OF SAFETY = 2.404449 AND OCCURS AT RADIUS = 44.37782



AT POINT ( 66.33334  66.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 66.66666         4.089378
 58.05567         3.280184
 49.44467         2.764726
 40.83367         2.849908
 32.22267         6.836557
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**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 50.33334  66.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 60.55484        3.068747
 54.17814        2.869317
 47.80143        2.612848
 41.42473        2.692136
 35.04802        5.034355
LOWEST FACTOR OF SAFETY = 2.588557 AND OCCURS AT RADIUS = 46.20726


**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 58.33334  74.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 71.68605        3.501799
 64.09503        2.996709
 56.50401        2.568019
 48.91299        2.560401
 41.32197        6.956368
LOWEST FACTOR OF SAFETY = 2.482871 AND OCCURS AT RADIUS = 52.7085


AT POINT ( 58.33334  58.66667 )THE RADIUS AND FACTOR OF SAFETY ARE:
 58.66667        3.43863
 50.64374        2.970074
 42.62081        2.597154
 34.59789        2.461787
 26.57496        5.943261
LOWEST FACTOR OF SAFETY = 2.427096 AND OCCURS AT RADIUS = 38.60935


AT POINT ( 60.33334  66.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 66.66666        3.674947
 58.43514        3.021702
 50.20362        2.635236
 41.97209        2.471201
 33.74056        6.870487
LOWEST FACTOR OF SAFETY = 2.429103 AND OCCURS AT RADIUS = 44.02997


**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 56.33334  66.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 65.6269         3.419702
 57.85631        2.95482
 50.08572        2.595966
 42.31513        2.470448
 34.54454        5.601561
LOWEST FACTOR OF SAFETY = 2.417525 AND OCCURS AT RADIUS = 46.20043
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**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 58.33334  68.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 [illegible]37316        3.600377
 [illegible].3063        3.000184
 52.23944       2.627412
 44.17258       2.457391
 36.10572       6.855815
LOWEST FACTOR OF SAFETY = 2.420134 AND OCCURS AT RADIUS = 46.1893


AT POINT ( 58.33334  64.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 64.66666       3.536054
 56.58216       2.983017
 48.49765       2.615768
 40.41314       2.450719
 32.32864       6.130396
LOWEST FACTOR OF SAFETY = 2.392439 AND OCCURS AT RADIUS = 42.43428


AT POINT ( 58.33334  62.66667 )THE RADIUS AND FACTOR OF SAFETY ARE:
 62.66667       3.497487
 54.60269       2.976369
 46.53871       2.606422
 [illegible].47473       2.462836
 [illegible].41074       6.036296
LOWEST FACTOR OF SAFETY = 2.398912 AND OCCURS AT RADIUS = 42.50672


AT POINT ( 60.33334  64.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 64.66666       3.624181
 56.45567       2.99718
 48.24467       2.622976
 40.03367       2.458164
 31.82267       6.969959
LOWEST FACTOR OF SAFETY = 2.414668 AND OCCURS AT RADIUS = 42.08642

**** WARNING AT NEXT CENTER ****
MAXIMUM RADIUS IS LIMITED BY END POINT OF GROUND LINE


AT POINT ( 56.33334  64.66666 )THE RADIUS AND FACTOR OF SAFETY ARE:
 64.6237        3.465327
 56.67428       2.979157
 48.72486       2.621456
 40.77543       2.457069
 [illegible].82601       5.200487
LOWEST FACTOR OF SAFETY = 2.414468 AND OCCURS AT RADIUS = 44.75014

AT POINT ( 58.33334  64.66666 )RADIUS 42.43428
*****************************************************
THE MINIMUM FACTOR OF SAFETY IS 2.392439
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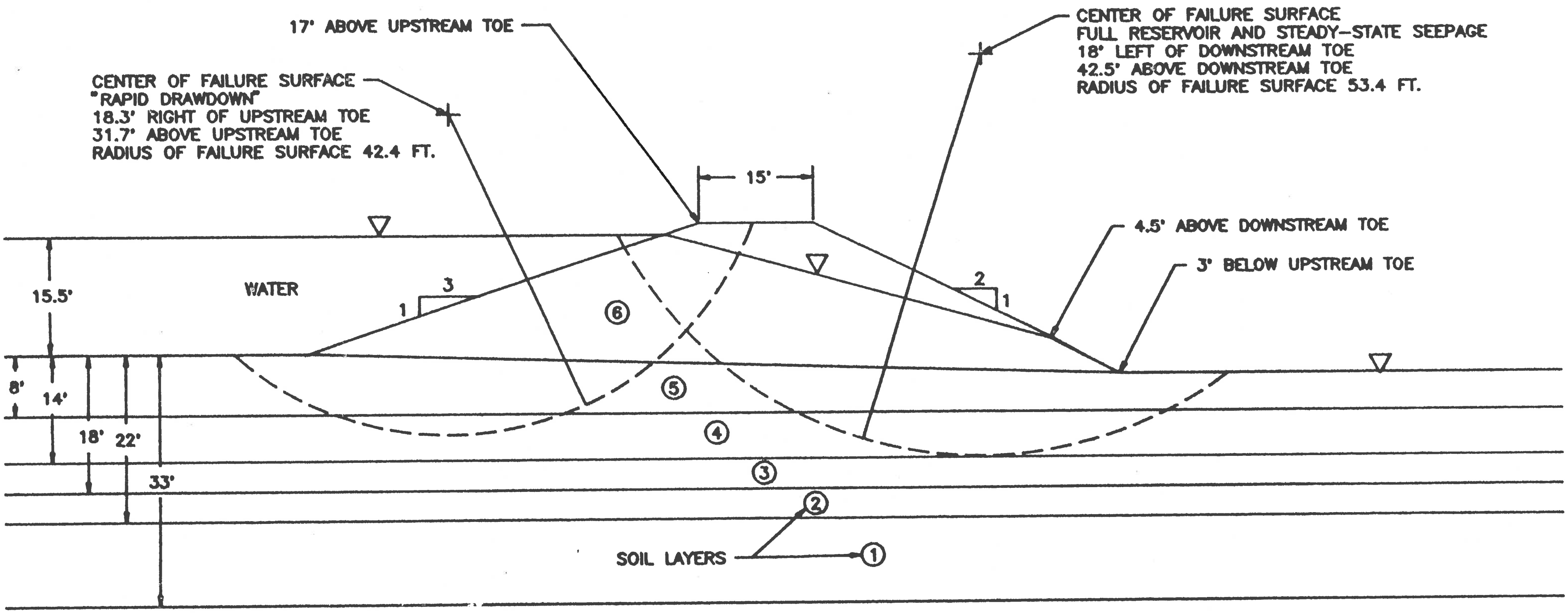
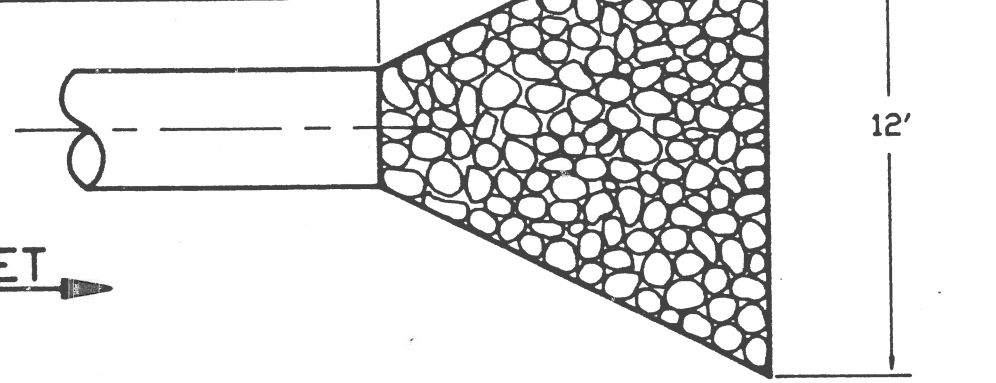
SOIL	DESCRIPTION	COHESION	ANGLE OF INT. FRICTION	DENSITY
1	BROWN SANDY GRAVELLY CLAY	0 psf	30 Degrees	120 pcf
2	BROWN SILTY SAND	0 psf	34 Degrees	130 pcf
3	BROWN SILTY CLAYEY SAND	0 psf	34 Degrees	130 pcf
4	BROWN SILTY SANDY CLAY	150 psf	27 Degrees	130 pcf
5	BROWN SILTY SANDY GRAVEL	0 psf	34 Degrees	130 pcf
6	SANDY SILT	1008 psf	32.7 Degrees	123.8 pcf



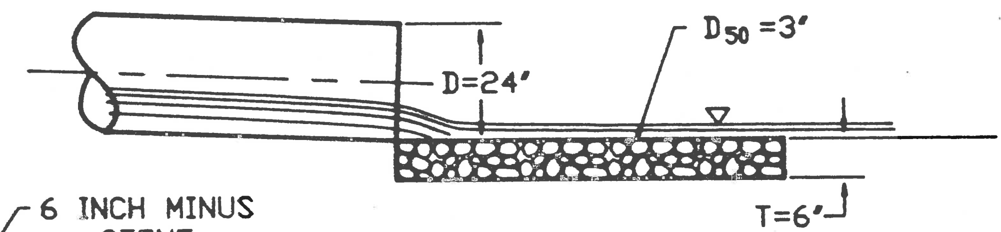
STABILITY ANALYSIS DIAGRAM - EARTH DAM

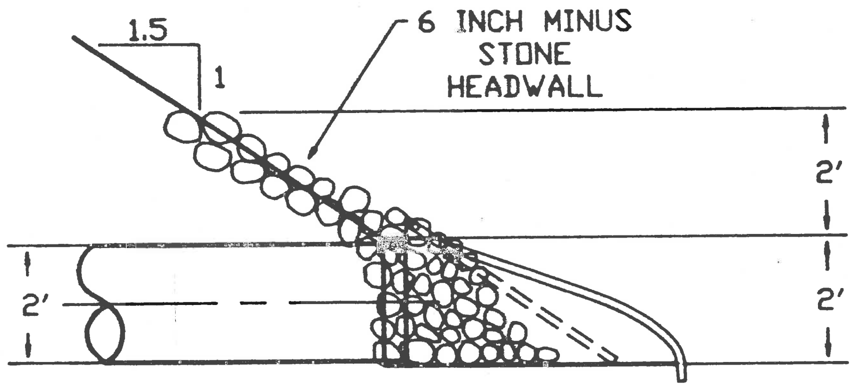
EXHIBIT XVIII

CULVERT LOCATION	DISCHARGE cfs	SLOPE %	VELOCITY fps
STA 0+36	6.21	2.8	5.7
STA 8+02	5.08	3.8	6.25

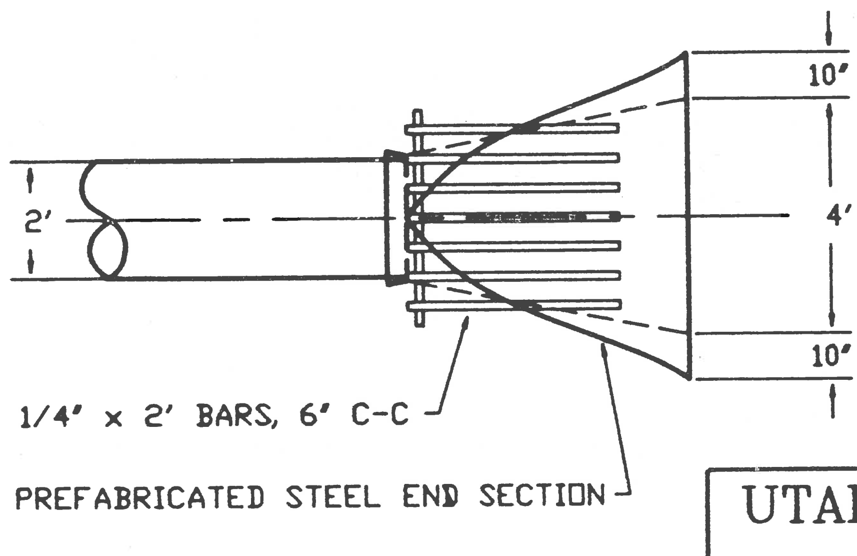


CULVERT OUTLET





CULVERT INLET



NOTE:

ROCK HEADWALLS ON INLETS WILL BE CONSTRUCTED WITH 6 INCH MINUS STONES.

CAD FILE NAME/DISK#: [illegible]

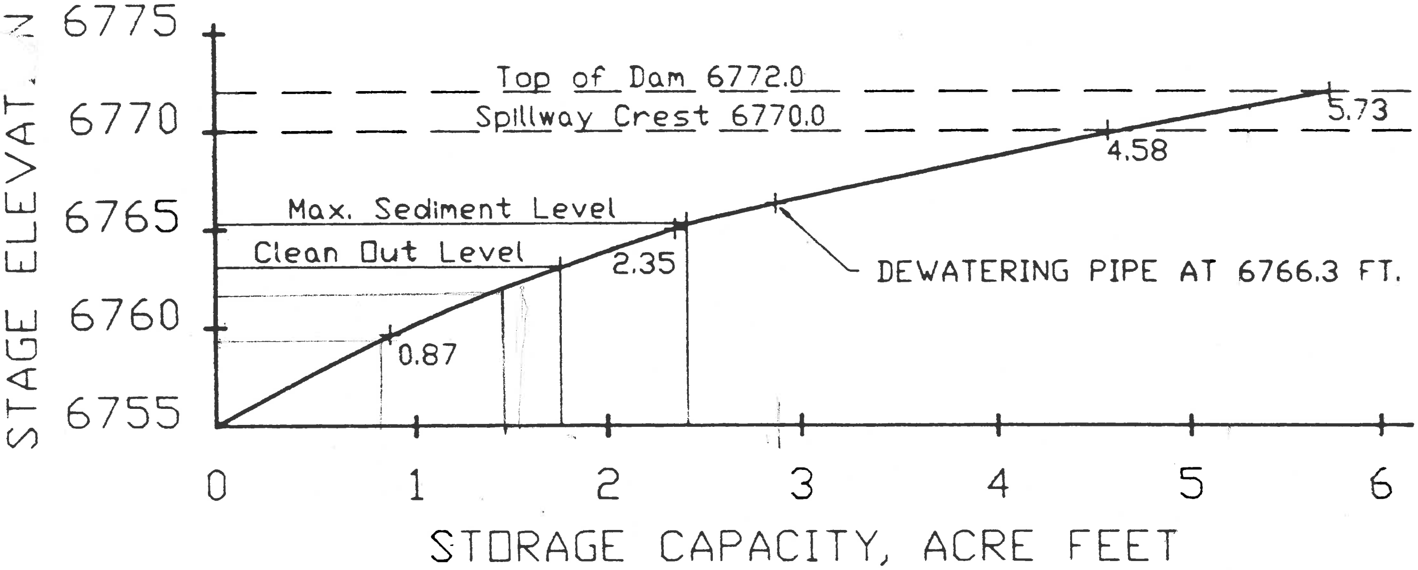
UTAH POWER & LIGHT
MINING DIVISION

[illegible]

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY-ACCESS ROAD
CULVERT OUTLET PROTECTION & INLET TRASH RACK

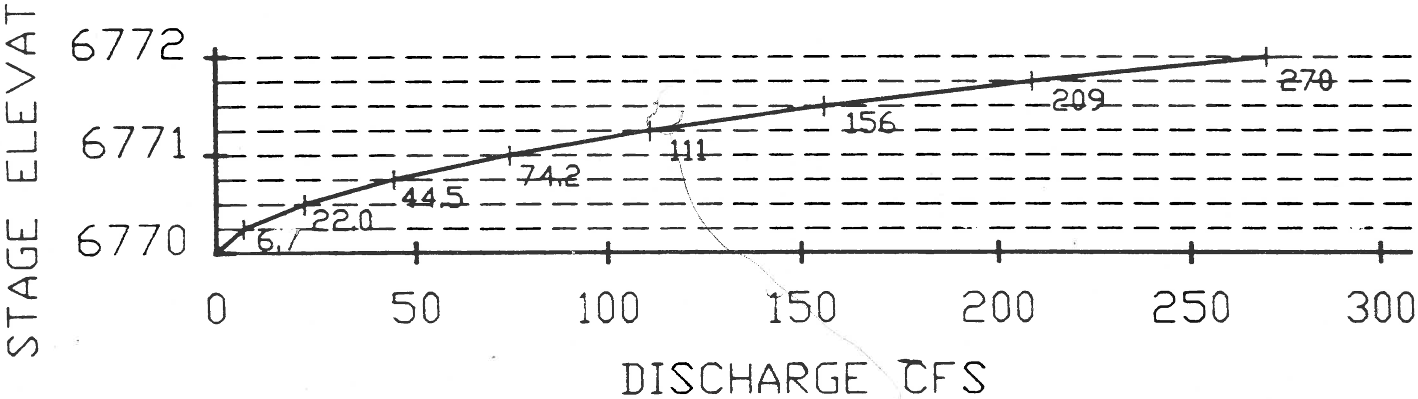
DRAWN BY:	K. LARSEN	EXHIBIT XIX
SCALE:	NONE	DRAWING #:
DATE:	5-4-90	SHEET 1 OF 1 REV. ___

STAGE - CAPACITY CURVE



MAXIMUM SEDIMENT VOLUME 2.41 AC.FT. AT 6765.3 FT.
CLEAN OUT OF POND REQUIRED AT 1.75 AC.FT. AT 6763.1 FT.
DEWATERING PIPE ELEVATION 1.0 FT. ABOVE MAX. SEDIMENT LEVEL

STAGE - DISCHARGE CURVE

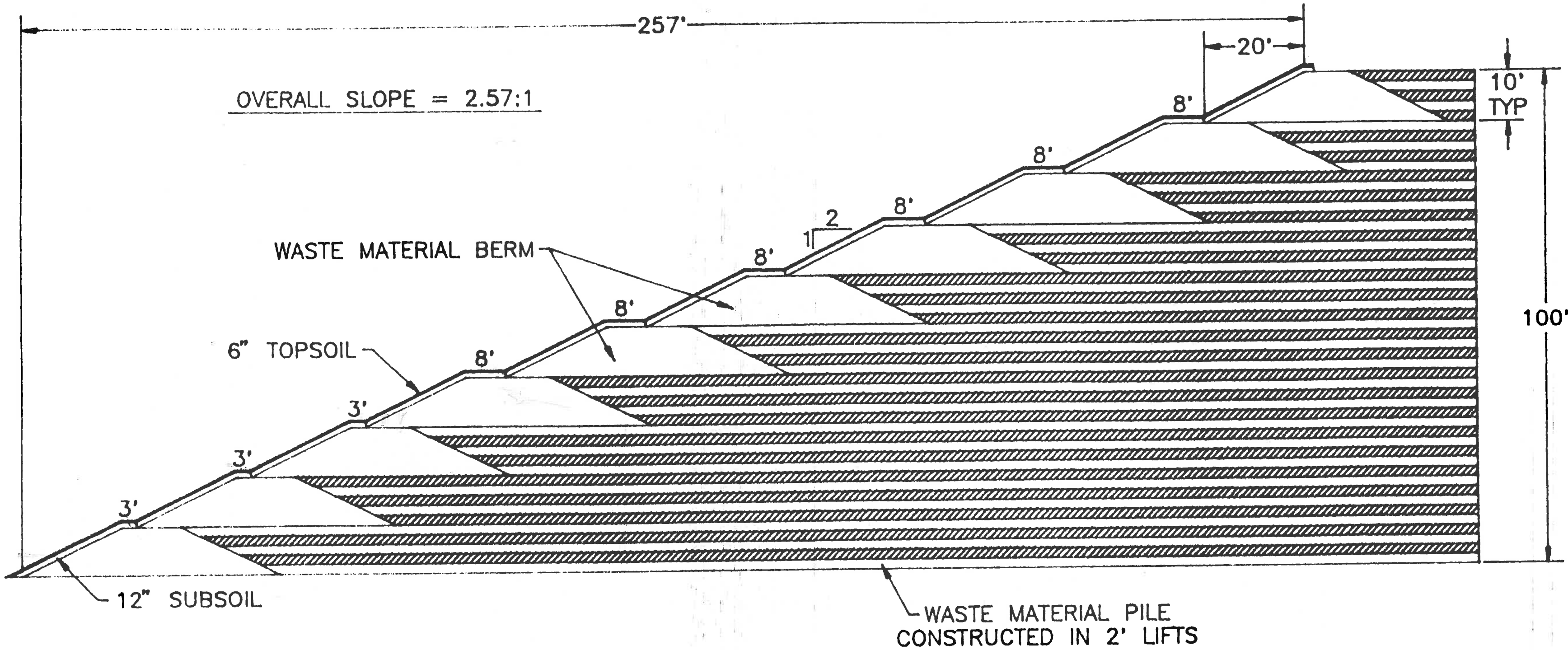


CAD FILE NAME/DISK#: CWWRSDC KL4

UTAH POWER & LIGHT
MINING DIVISION

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY - SEDIMENT POND
STAGE CAPACITY AND STAGE DISCHARGE CURVES

DRAWN BY: K. LARSEN	EXHIBIT XX	
SCALE: NONE	DRAWING #:	
DATE: 5-4-90	SHEET 1 OF 1	REV. ___



SEQUENCE

1. CONSTRUCT BERM WITH WASTE ROCK PILE MATERIAL FROM MINING OPERATION.
2. COVER OUTSIDE SLOPE OF BERM WITH 12" OF SUBSOIL AND 6" OF TOPSOIL.
3. REVEGETATE OUTSIDE SLOPE.
4. PLACE WASTE MATERIAL INSIDE OF BERM AND COMPACT IN 2' LIFTS.
5. WHEN WASTE MATERIAL LEVEL REACHES TOP OF THIRD BERM CONSTRUCT THE NEXT BERM WITH 8' OFFSET AT TOE OF NEW BERM.

CAD FILE NAME/DISK#: EX-XXI

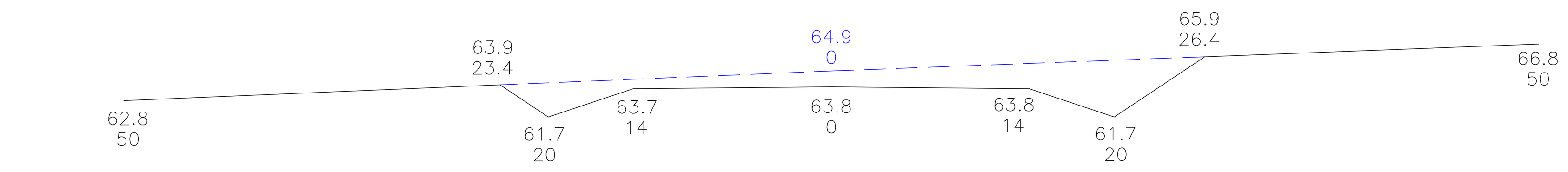
PACIFICORP
FUEL RESOURCES DEPARTMENT
201 SO. MAIN ONE UTAH CENTER SUITE 2000 SALT LAKE CITY, UTAH 84140-0020

COTTONWOOD/WILBERG MINE
WASTE MATERIAL PILE
CONSTRUCTION SEQUENCE

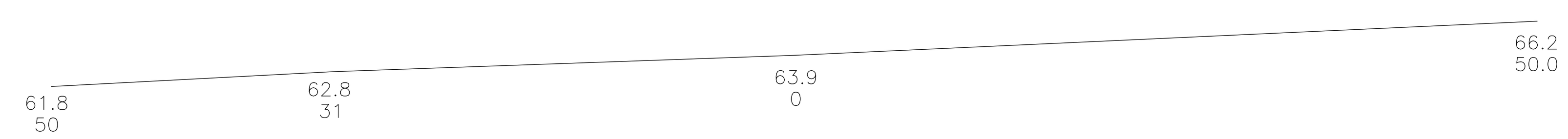
DRAWN BY: K. LARSEN	EXHIBIT XXI	
SCALE: NONE	DRAWING #:	
DATE: JANUARY 6, 1993	SHEET 1 OF 1	REV.

R645-301-800: Bonding

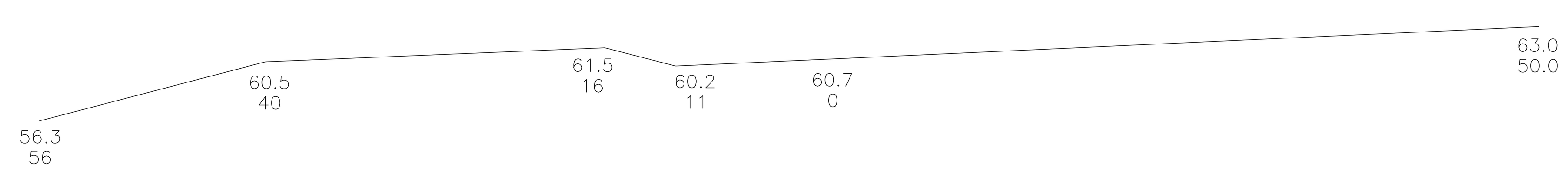
A detailed bond estimate is provided for in Volume 2, Part 4 of the Cottonwood/Wilberg Mining and Reclamation Plan.



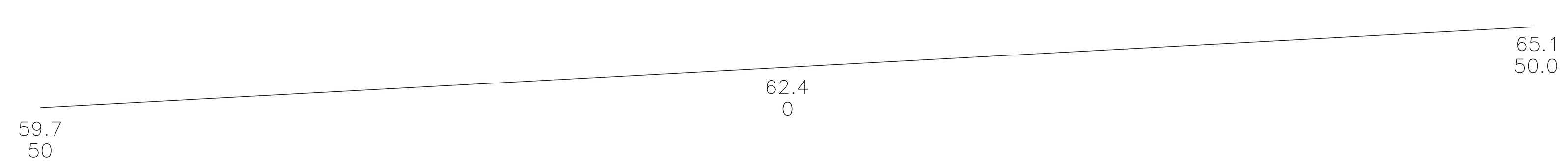
STA. 1+13.7



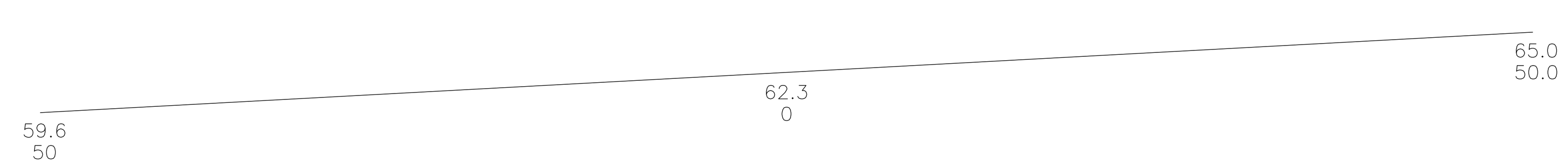
STA. 0+66



STA. 0+36



STA. 0+17

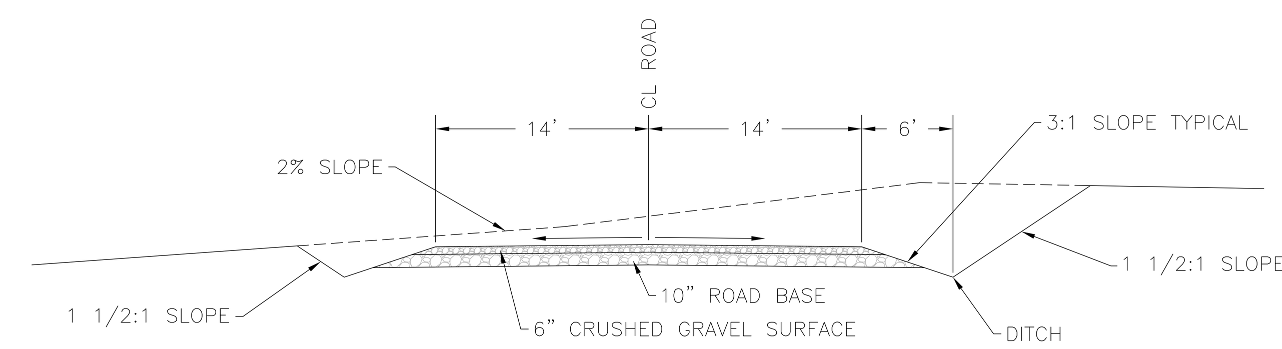


STA. 0+00

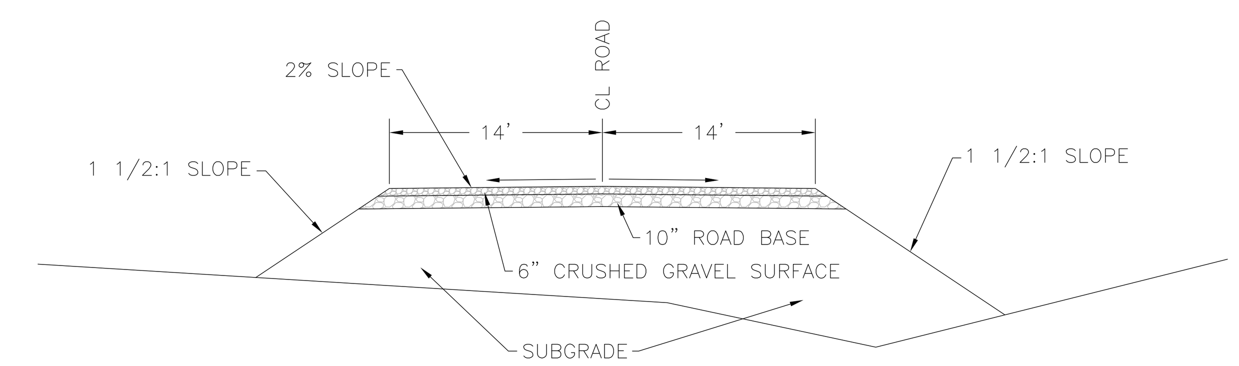
LEGEND

PRE-EXISTING GRADE LINE

EXISTING GRADE LINE



TYPICAL CUT SLOPE – CROSS SECTION



TYPICAL FILL SLOPE – CROSS SECTION

REGISTERED PROFESSIONAL ENGINEER NO. 7059 THOMAS J. FAUCHEUX STATE OF UTAH 3/26-90

REGISTERED PROFESSIONAL ENGINEER J. BLAKE WEBSTER No. 7728 STATE OF UTAH 4/2/91

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 165651 STATE OF UTAH

DATE	REVISION	BY	CHK.
1-9-02	REVISED TEXT HEIGHTS AND LINE TYPES FOR CLARITY	KJL	
3/21/90	GENERAL REVISIONS	TJF	

CAD FILE NAME/DISK#: 10810

4-8

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

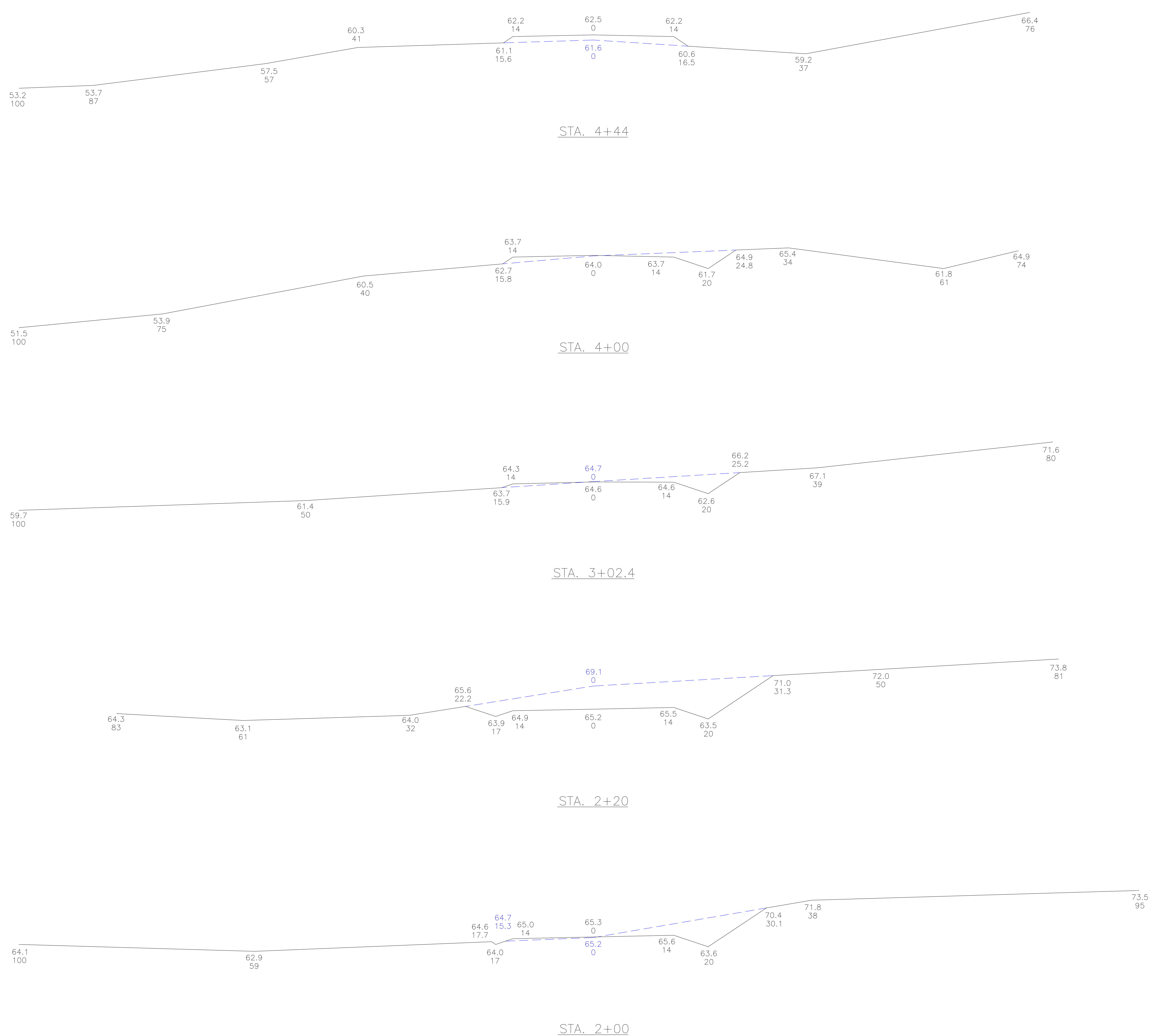
COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
ACCESS ROAD CROSS SECTIONS

DRAWN BY: K. LARSEN
SCALE: 1"=10'
DATE: MAY 5, 1989
DRAWING #: CM-10810-WB
SHEET 1 OF 6
REV.

LEGEND

PRE–EXISTING GRADE LINE

EXISTING GRADE LINE



DATE	REVISION	BY	CHK.
1–9–02	REVISED TEXT HEIGHTS AND LINE TYPES FOR CLARITY	KJL	
3/21/90	GENERAL REVISIONS	TJF	

4-8

CAD FILE NAME/DISK#: 10810

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

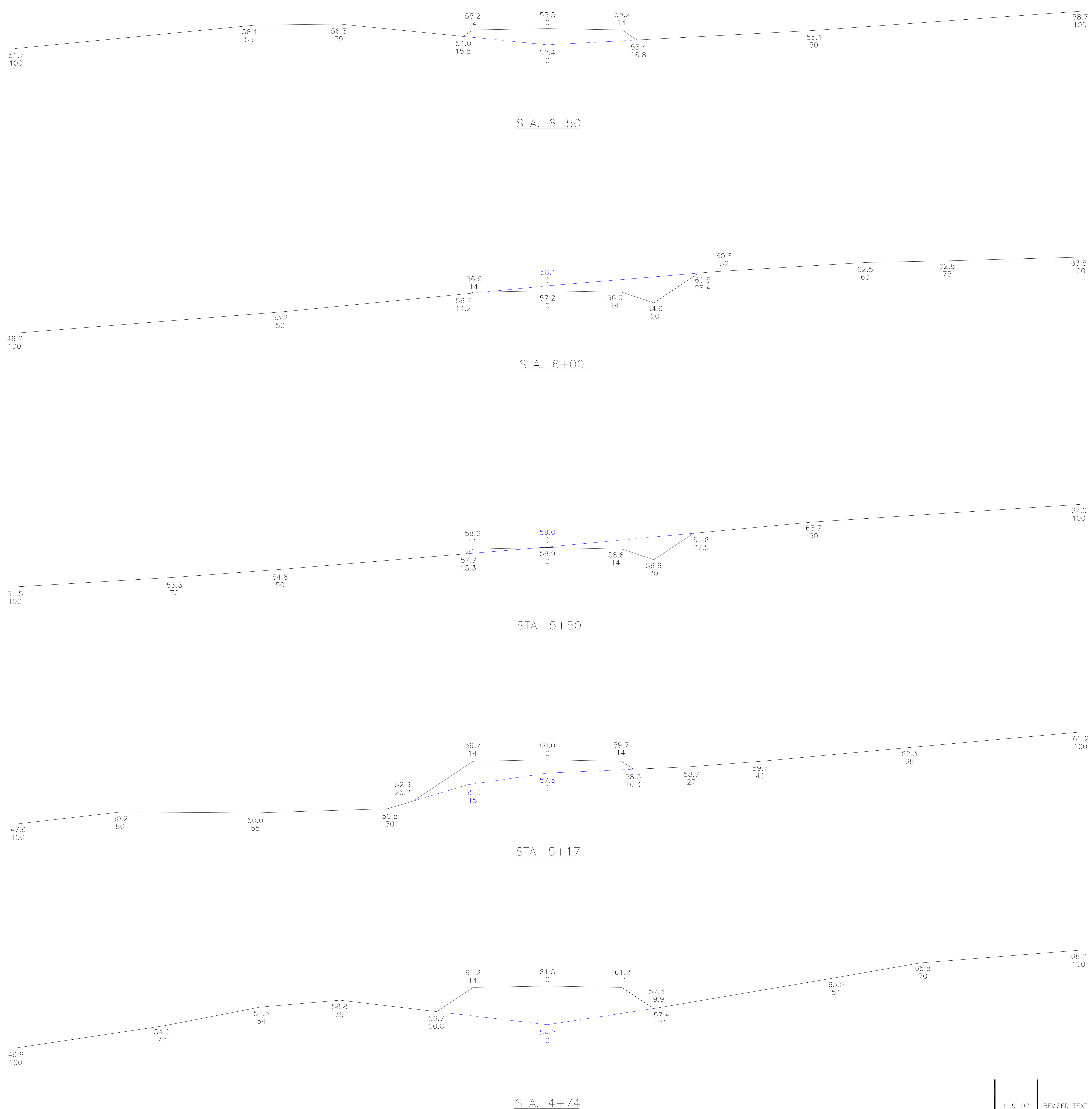
COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
ACCESS ROAD CROSS SECTIONS

DRAWN BY:	K. LARSEN	CM–10810–WB	
SCALE:	1" = 10'	DRAWING #:	
DATE:	MAY 5, 1989	SHEET 2 OF 6	REV.

REGISTERED PROFESSIONAL ENGINEER NO. 7059 THOMAS J. FAUCHEUX STATE OF UTAH 3/26/90

REGISTERED PROFESSIONAL ENGINEER J. BLAIR WEBSTER No. 7728 STATE OF UTAH 4/2/91

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 165651 STATE OF UTAH



LEGEND

PRE-EXISTING GRADE LINE

EXISTING GRADE LINE

REGISTERED PROFESSIONAL ENGINEER NO. 7059 THOMAS J. FAUCHEUX STATE OF UTAH 3/26-90

REGISTERED PROFESSIONAL ENGINEER J. BLAKE WEBSTER No. 7728 STATE OF UTAH 4/2/91

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 165651 STATE OF UTAH

4-8

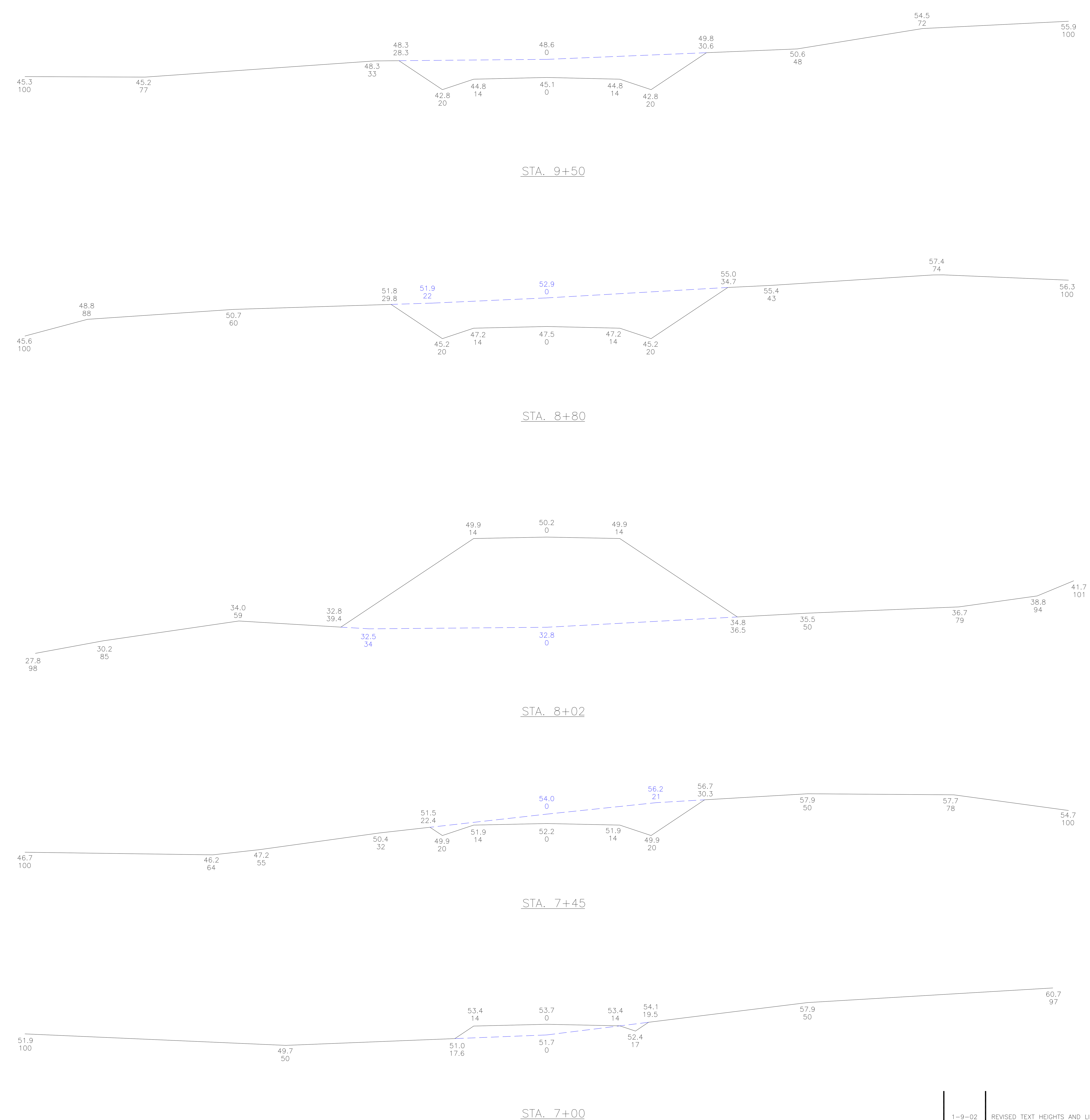
CAD FILE NAME/DISK#: 10810

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
ACCESS ROAD CROSS SECTIONS

DATE	REVISION	BY	CHK.
1-9-02	REVISED TEXT HEIGHTS AND LINE TYPES FOR CLARITY	KJL	
3/21/90	GENERAL REVISIONS	TJF	

DRAWN BY: K. LARSEN	CM-10810-WB
SCALE: 1" = 10'	DRAWING #:
DATE: MAY 5, 1989	SHEET 3 OF 6 REV.



LEGEND

PRE-EXISTING GRADE LINE

EXISTING GRADE LINE

REGISTERED PROFESSIONAL ENGINEER NO. 7059 THOMAS J. FAUCHEUX STATE OF UTAH 3/26/90

REGISTERED PROFESSIONAL ENGINEER J. BLAKE WEBSTER No. 7728 STATE OF UTAH 4/2/91

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 165651 STATE OF UTAH

4-8

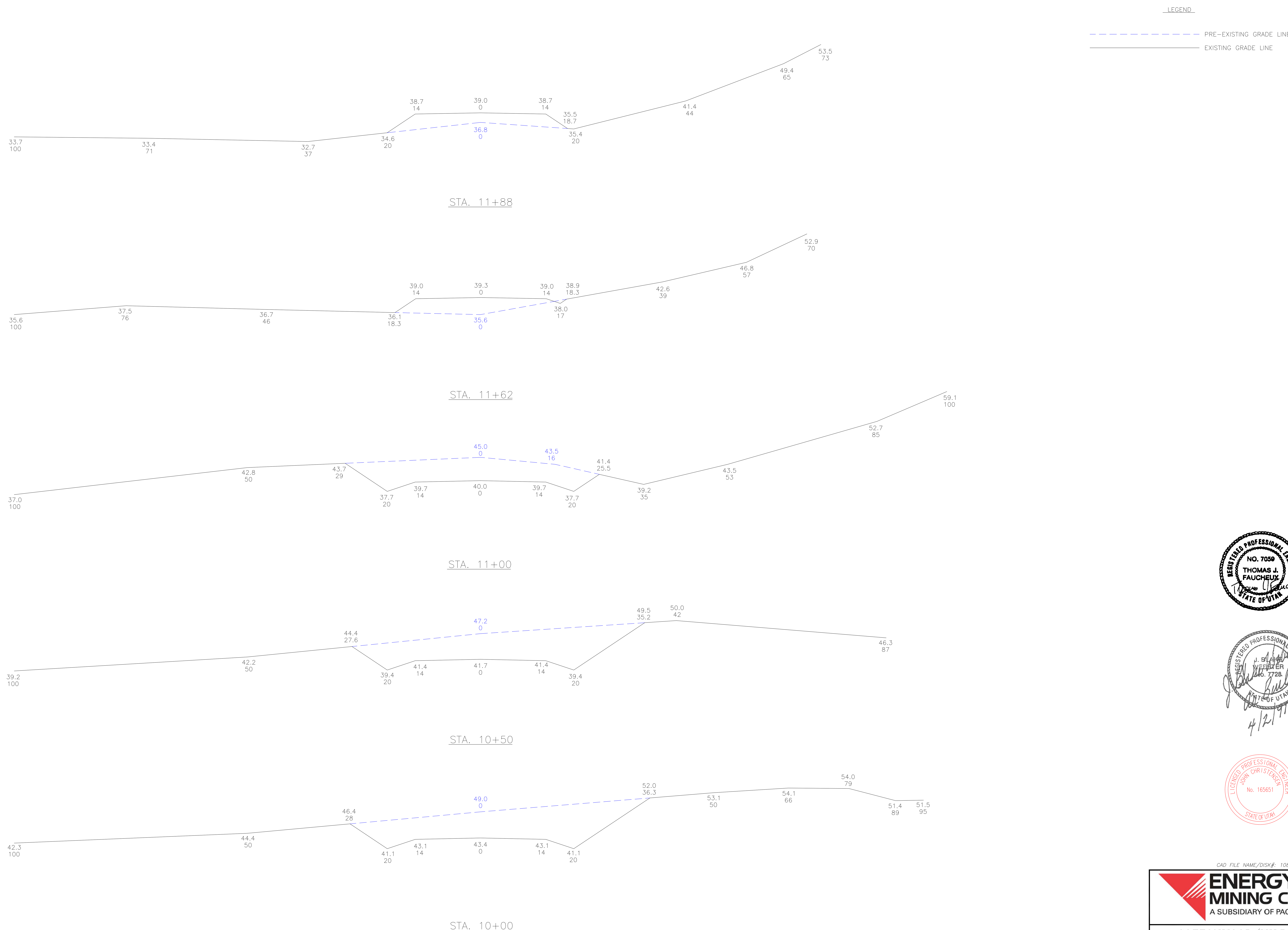
CAD FILE NAME/DISK#: 10810

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
ACCESS ROAD CROSS SECTIONS

DATE	REVISION	BY	CHK.
1-9-02	REVISED TEXT HEIGHTS AND LINE TYPES FOR CLARITY	KJL	
3/21/90	GENERAL REVISIONS	TJF	

DRAWN BY:	K. LARSEN	DRAWING #:	CM-10810-WB
SCALE:	1" = 10'		
DATE:	MAY 5, 1989	SHEET 4 OF 6	REV.



4-8

CAD FILE NAME/DISK#: 10810

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
ACCESS ROAD CROSS SECTIONS

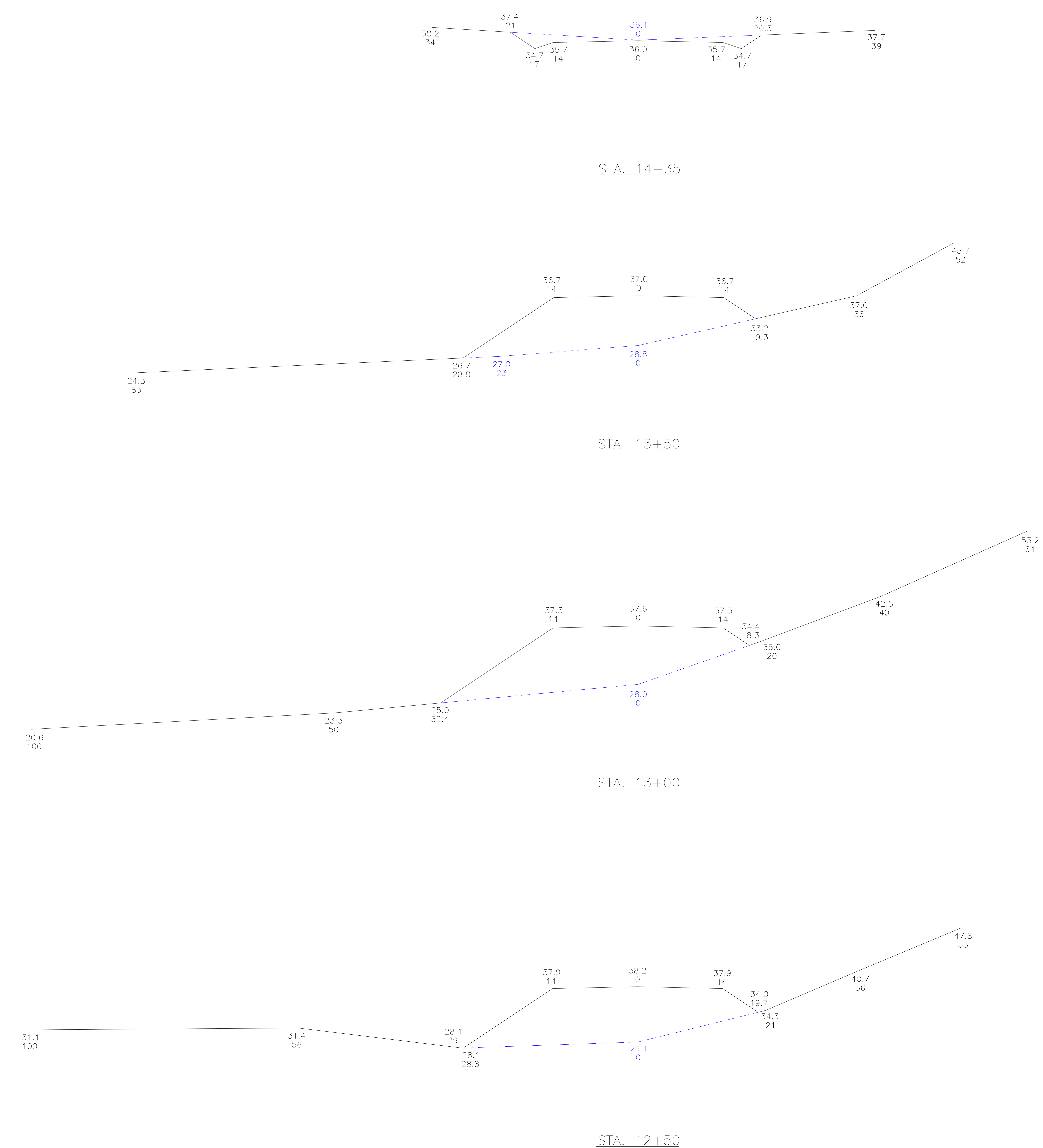
DRAWN BY:	K. LARSEN	DRAWING #:	CM-10810-WB
SCALE:	1"=10'		
DATE:	MAY 5, 1989	SHEET 5 OF 6	REV.

DATE	REVISION	BY	CHK.
1-9-02	REVISED TEXT HEIGHTS AND LINE TYPES FOR CLARITY	KJL	
3/21/90	GENERAL REVISIONS	TJF	

REGISTERED PROFESSIONAL ENGINEER NO. 7059 THOMAS J. FAUCHEUX STATE OF UTAH 3/26/90

REGISTERED PROFESSIONAL ENGINEER J. BLAIR WEBSTER No. 7728 STATE OF UTAH 4/2/91

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 165651 STATE OF UTAH



LEGEND

PRE–EXISTING GRADE LINE
EXISTING GRADE LINE

DATE	REVISION	BY	CHK.
1–9–02	REVISED TEXT HEIGHTS AND LINE TYPES FOR CLARITY	KJL	
3/21/90	GENERAL REVISIONS	TJF	

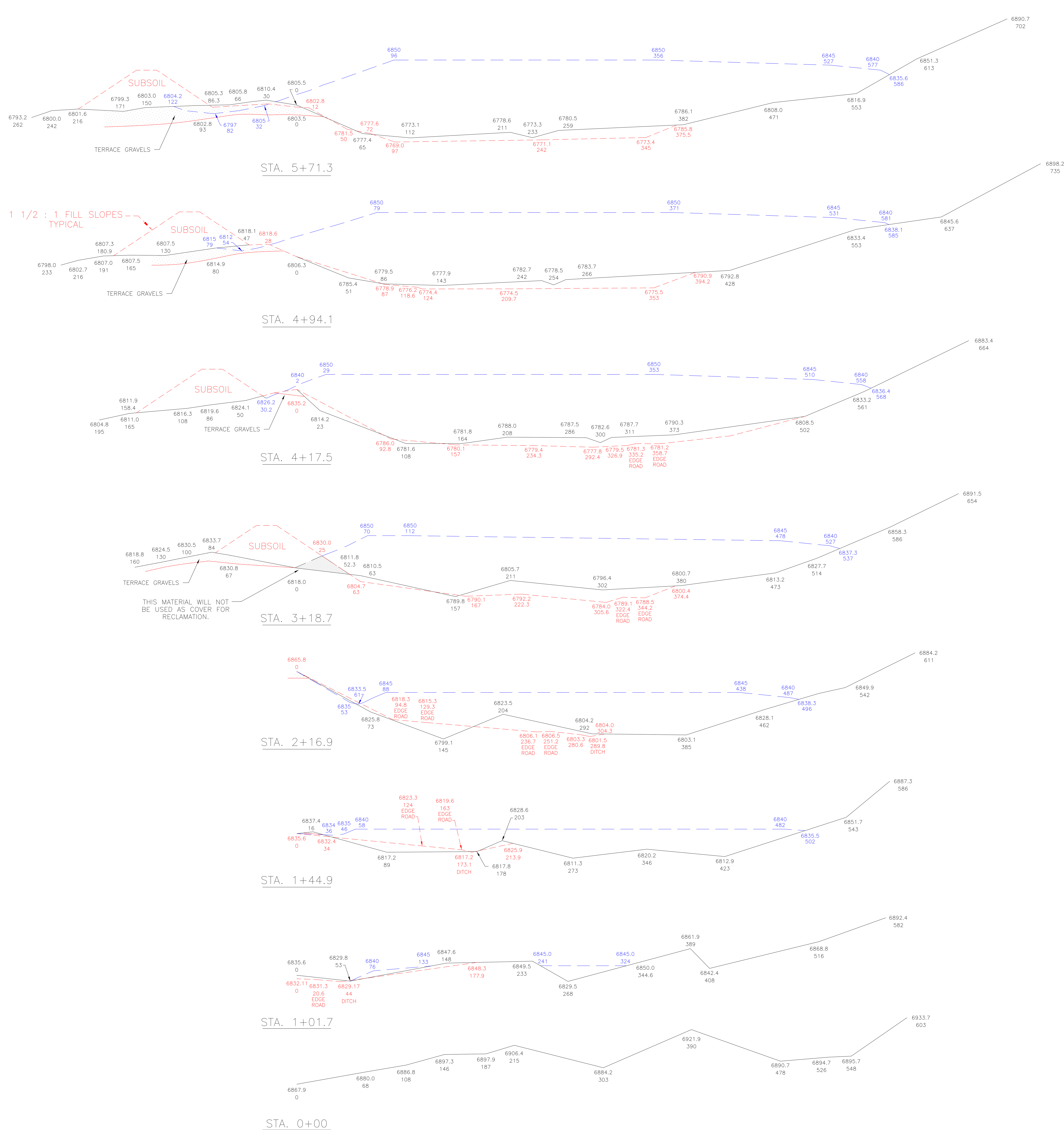
4-8

CAD FILE NAME/DISK#: 10810

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
ACCESS ROAD CROSS SECTIONS

DRAWN BY: K. LARSEN
SCALE: 1"=10'
DATE: MAY 5, 1989
DRAWING #: CM–10810–WB
SHEET 6 OF 6
REV.



REGISTERED PROFESSIONAL ENGINEER NO. 7889 STEVEN E. KOCHEVAR STATE OF UTAH

STEVEN E. KOCHEVAR NO. 7889 — 1/7/93 DATE

LEGEND

ORIGINAL GROUND LINE

EXCAVATION LINE (AS-BUILT)

COMPLETED CONSTRUCTION LINE

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 165651 STATE OF UTAH

4-10

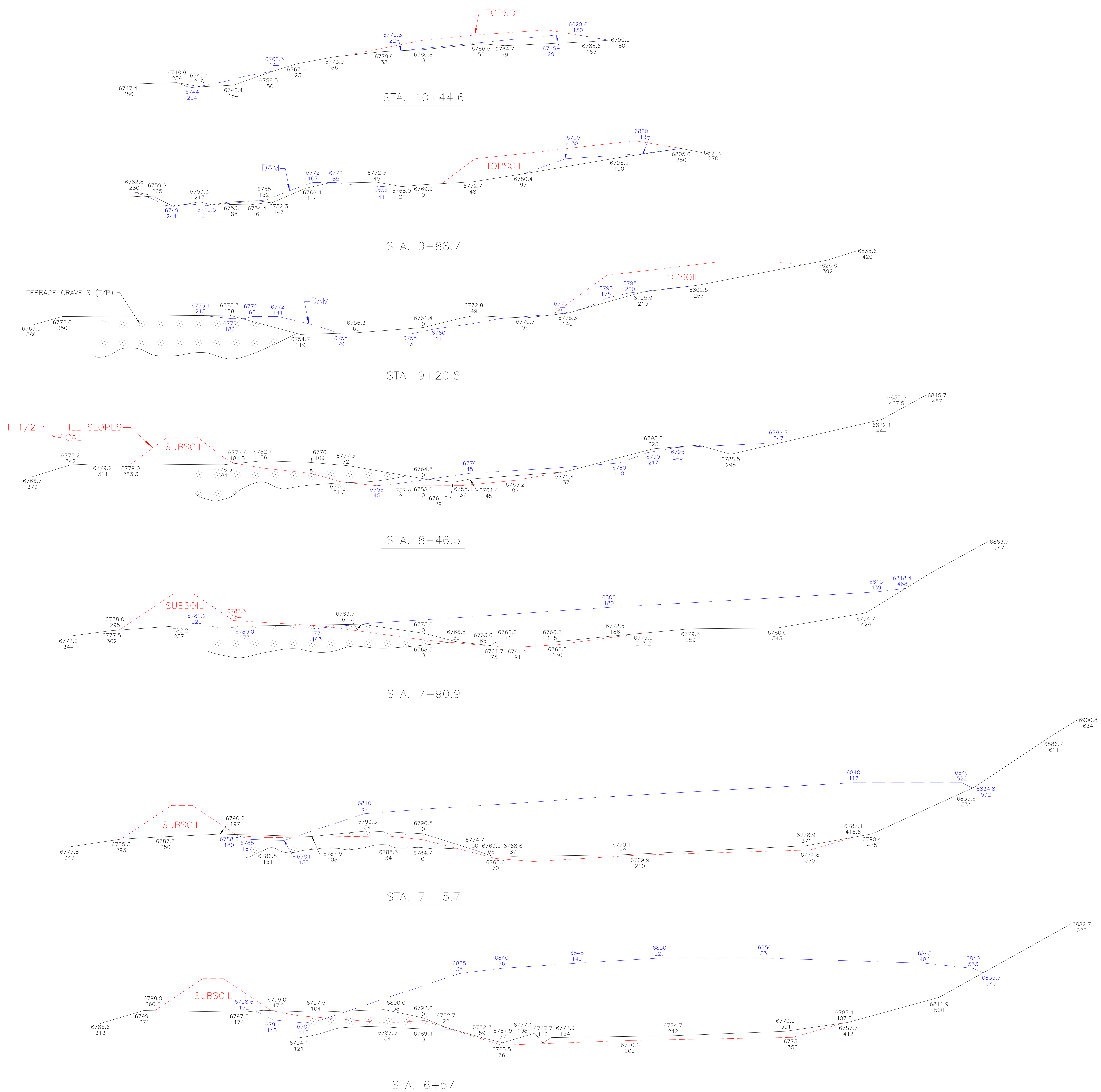
CAD FILE NAME/DISK#: 10811

DATE	REVISIONS	BY	CHK
1-9-02	CHANGED NOTATIONS ED RD TO EDGE ROAD	KJL	
1-5-93	REVISED WASTE ROCK STORAGE PILE ELEVATIONS	KJL	
3-27-91	REMOVED TOPSOIL AND SUBSOIL ELEVATIONS	KJL	
7-20-90	ADDED TERRACE GRAVELS AREAS TO CROSS SECTIONS	KJL	
5-7-90	ADDED NOTE ON STA. 3+18.7	KJL	
9-19-89	REVISED TOP OF WASTE ROCK STORAGE PILE	KJL	

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
CROSS SECTIONS

DRAWN BY: K. LARSEN
SCALE: 1" =50'
DATE: JANUARY 5, 1993
DRAWING #: CM-10811-WB
SHEET 1 OF 2
REV.



REGISTERED PROFESSIONAL ENGINEER NO. 7889 STEVEN E. KOCHEVAR STATE OF UTAH

STEVEN E. KOCHEVAR NO. 7889 — 1/7/93 DATE

LEGEND

- ORIGINAL GROUND LINE
- EXCAVATION LINE (AS-BUILT)
- COMPLETED CONSTRUCTION LINE

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 160651 STATE OF UTAH

4-10

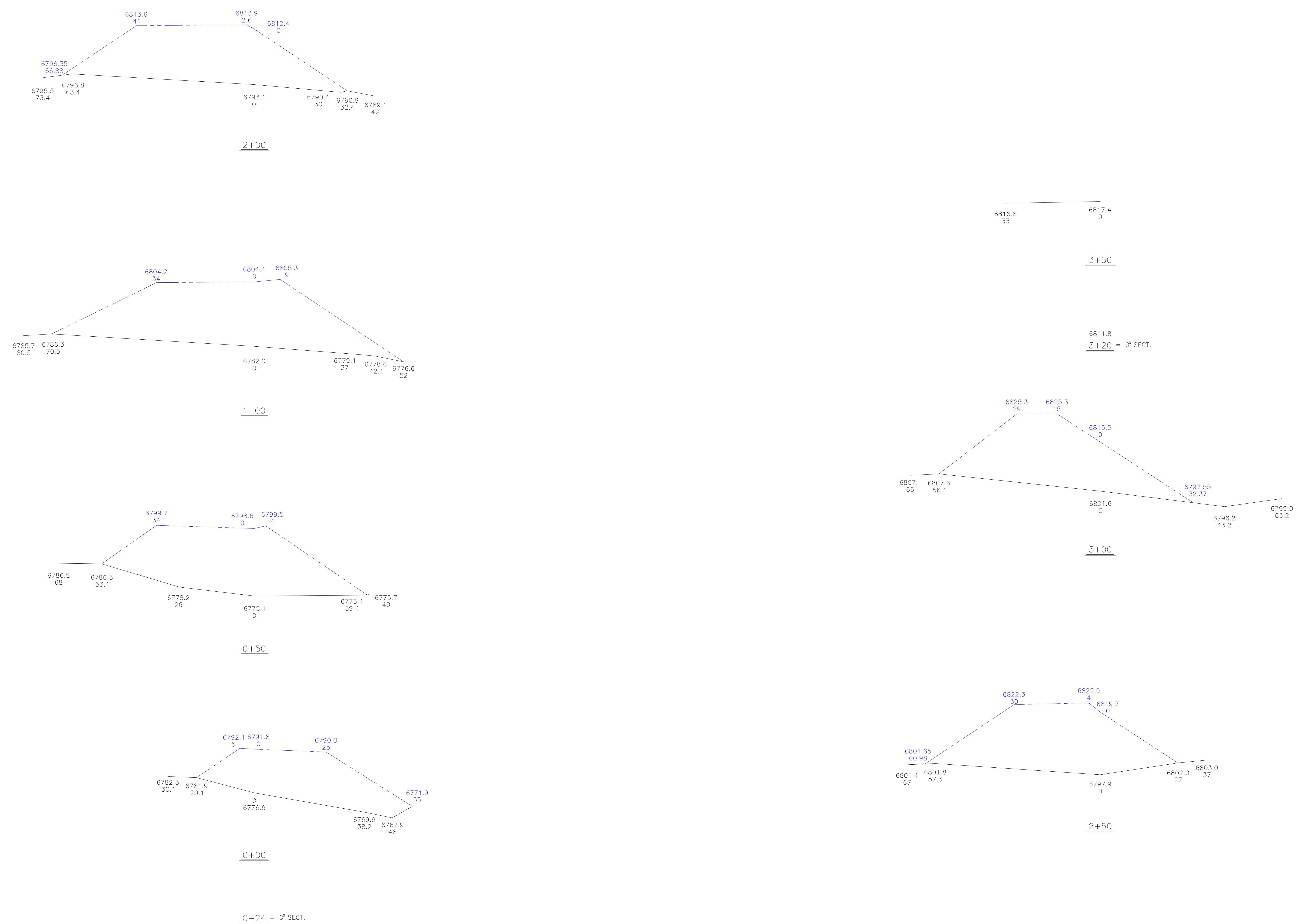
CAD FILE NAME/DISK#: 10811

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
CROSS SECTIONS

DATE	REVISIONS	BY	CHK
1-9-02	CHANGED NOTATIONS ED RD TO EDGE ROAD	KJL	
1-5-93	REVISED WASTE ROCK STORAGE PILE ELEVATIONS	KJL	
3-27-91	REMOVED TOPSOIL AND SUBSOIL ELEVATIONS	KJL	
7-20-90	ADDED TERRACE GRAVELS AREAS TO CROSS SECTIONS	KJL	
9-19-89	REVISED TOP OF WASTE ROCK STORAGE PILE	KJL	

DRAWN BY: K. LARSEN	DRAWING #: CM-10811-WB
SCALE: 1" = 50'	
DATE: JANUARY 5, 1993	SHEET 2 OF 2 REV.



REGISTERED PROFESSIONAL ENGINEER J. BLAKE WEBSTER No. 7728 STATE OF UTAH

4/2/91

PRE-EXISTING NATURAL GROUND

COMPLETED TOPSOIL PILE

CAD FILE NAME/DISK#: CM10815

4-11A

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
TOPSOIL CROSS SECTIONS

DATE	REVISIONS	BY
3/28/91	REPRESENTS THE AS BUILT CONDITIONS AS OF 8/1/90	KJL

DRAWN BY: K. LARSEN		CM-10815-WB
SCALE: 1" = 20'		DRAWING #:
DATE: AUGUST 6, 1990	SHEET 1 OF 1	REV. ___

LICENSED PROFESSIONAL ENGINEER No. 165651 STATE OF UTAH

CAD FILE NAME/DISK#: CM10817

8-1

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
VEGETATION MAP

DATE	REVISION	BY	CHK.
7/26/02	REVISED RIGHT-OF-WAY PERMIT BOUNDARY	KJL	
3/15/02	GPS BLACK SAGEBRUSH REFERENCE AREA	KJL	
1/9/02	REVISED DATE OF PHOTO, PERMIT BOUNDARY	KJL	
7/20/00	CONVERTED TO AUTOCAD AND REVISED TO DATE	KJL	

DRAWN BY: K. LARSEN
SCALE: 1"=200'
DATE: AUGUST 10, 1989
DRAWING #: CM-10817-WB
SHEET 1 OF 1
REV.

Date of Photography July 2005

Note
- •1 Soil Pedon Excavation Site
- ■ Composite Sample Sites

DATE	REVISION	BY	CHK.
7/26/02	REVISED RIGHT-OF-WAY PERMIT BOUNDARY	KJL	
1/9-02	REVISED DATE OF PHOTO	KJL	
9/22/89	REVISED SOILS BOUNDARIES	JRG	

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 165651 STATE OF UTAH

7-1

CAD FILE NAME/DISK#: CM10818

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
SOILS MAP

DRAWN BY: K. LARSEN
SCALE: 1" = 200'
DATE: AUGUST 10, 1989
DRAWING #: CM-10818-WB
SHEET 1 OF 1
REV.

9-1

CAD FILE NAME/DISK#: CM10819WB

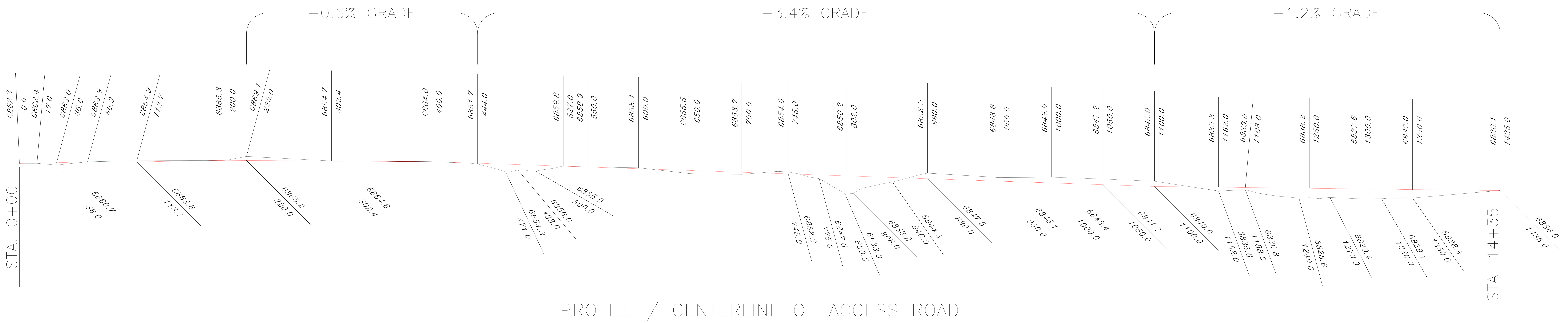
D.W.R. RAPTOR RECONNAISSANCE SURVEY
MAY 18, 2001

DATE	REVISIONS	BY	CHK.
12-13-01	NESTS SHOWN ARE BASED ON THE 2001 RAPTOR SURVEY	KJL	
9-20-00	CONVERTED DRAWING TO AUTOCAD USING USGS 7.5 MINUTE QUAD MAPS – NESTS SHOWN REPRESENT THE 2000 RAPTOR SURVEY	KJL	
7-7-90	REVISED CRITICAL VALUE AND LIMITED VALUE NOTATIONS AND ADDED WILDLIFE HABITAT MITIGATION AREAS	KJL	

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

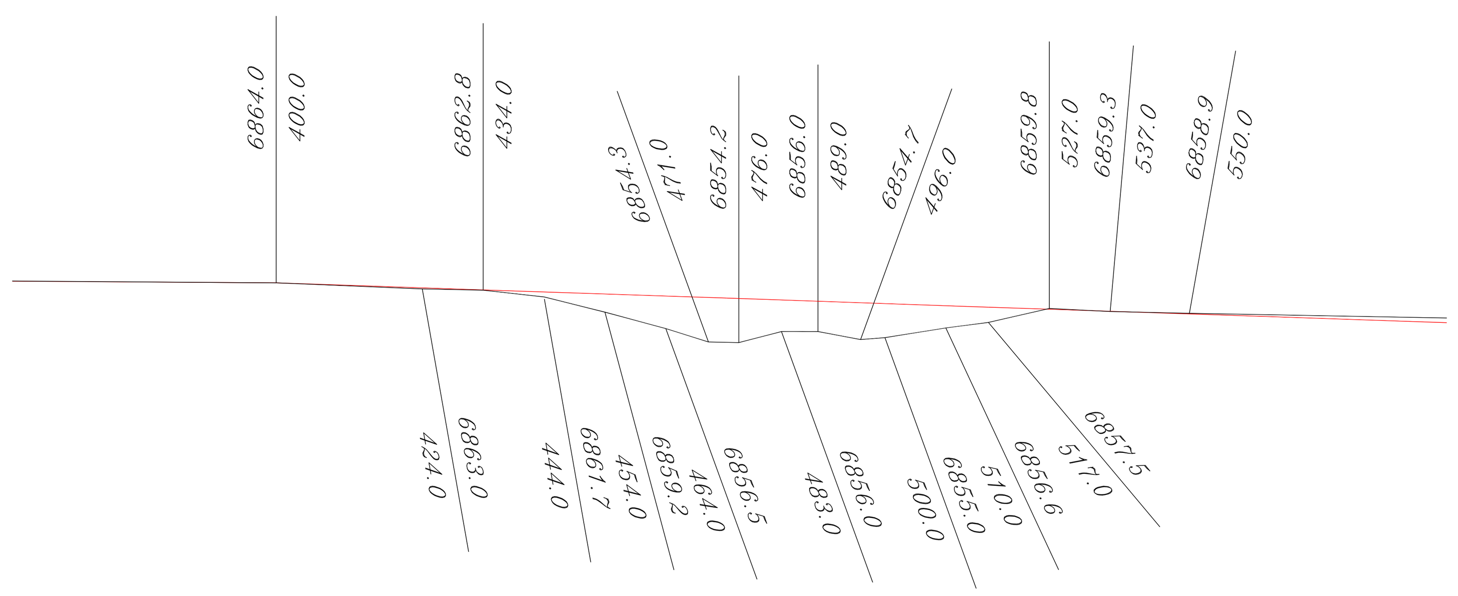
COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
WILDLIFE HABITAT MAP

DRAWN BY: K. LARSEN
SCALE: 1" =500'
DATE: SEPTEMBER 19, 2000
DRAWING #: CM-10819-WB
SHEET 1 OF 1
REV. ___



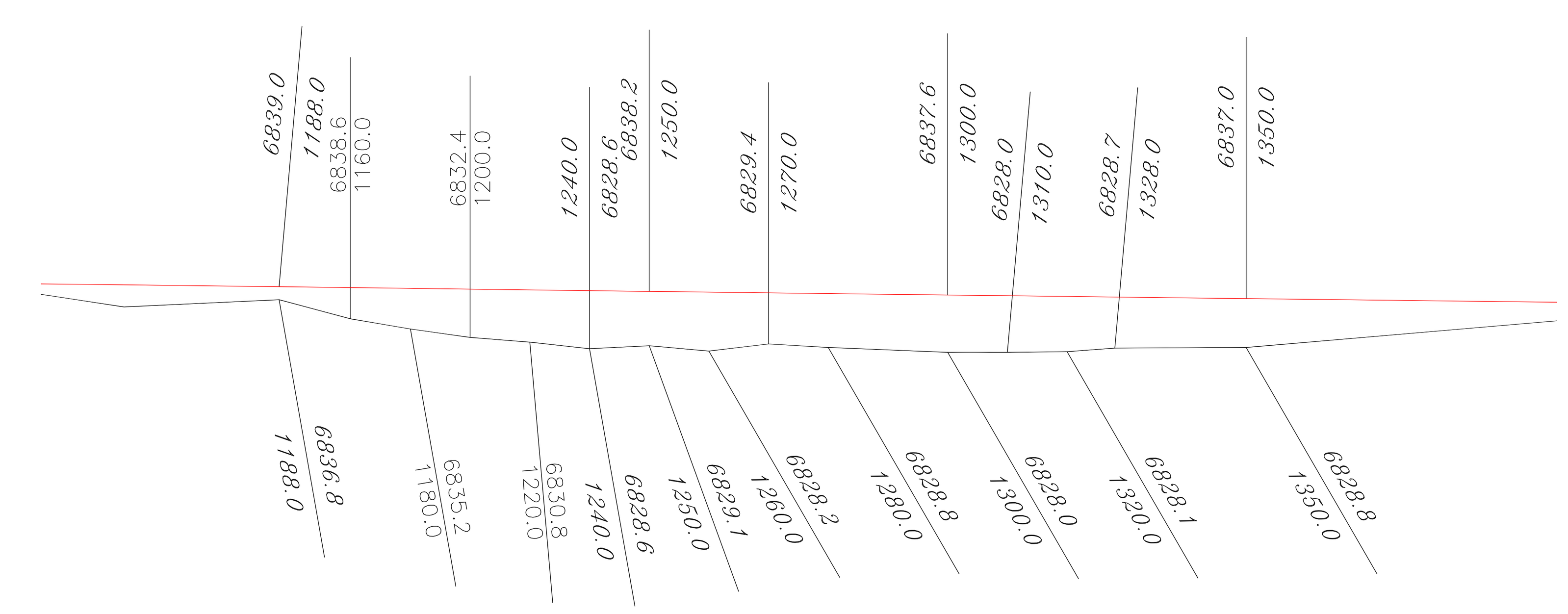
PROFILE / CENTERLINE OF ACCESS ROAD

SCALE: 1"=50'



STREAM FLOW AT 4+74

STREAM FLOW AT 8+02



STREAM FLOW AT 13+00

NOTE:
FINAL RECLAMATION WILL RETURN THE ROADWAY TO THE PRE-EXISTING GRADE

Existing Natural Ground

Proposed Road Grade

CULVERTS

Peak Flow	Diameter	Station	Thickness	Length	Cover Depth	Min. Culvert Slope
6.2 cfs	24" dia	0+36	0.064	40'	min 12"	0.5%
.186 cfs	12" dia	4+74	0.064	60'	~6.5'	0.5%
5.08 cfs	24" dia	8+02	0.064	80'	~17'	0.5%
.589 cfs	12" dia	13+00	0.064	60'	~8'	0.5%

REGISTERED PROFESSIONAL ENGINEER NO. 7059 THOMAS J. FAUCHEUX STATE OF UTAH

22 Sep '89

LICENSED PROFESSIONAL ENGINEER JOHN CHRISTENSEN No. 165651 STATE OF UTAH

CAD FILE NAME/DISK#: 10820

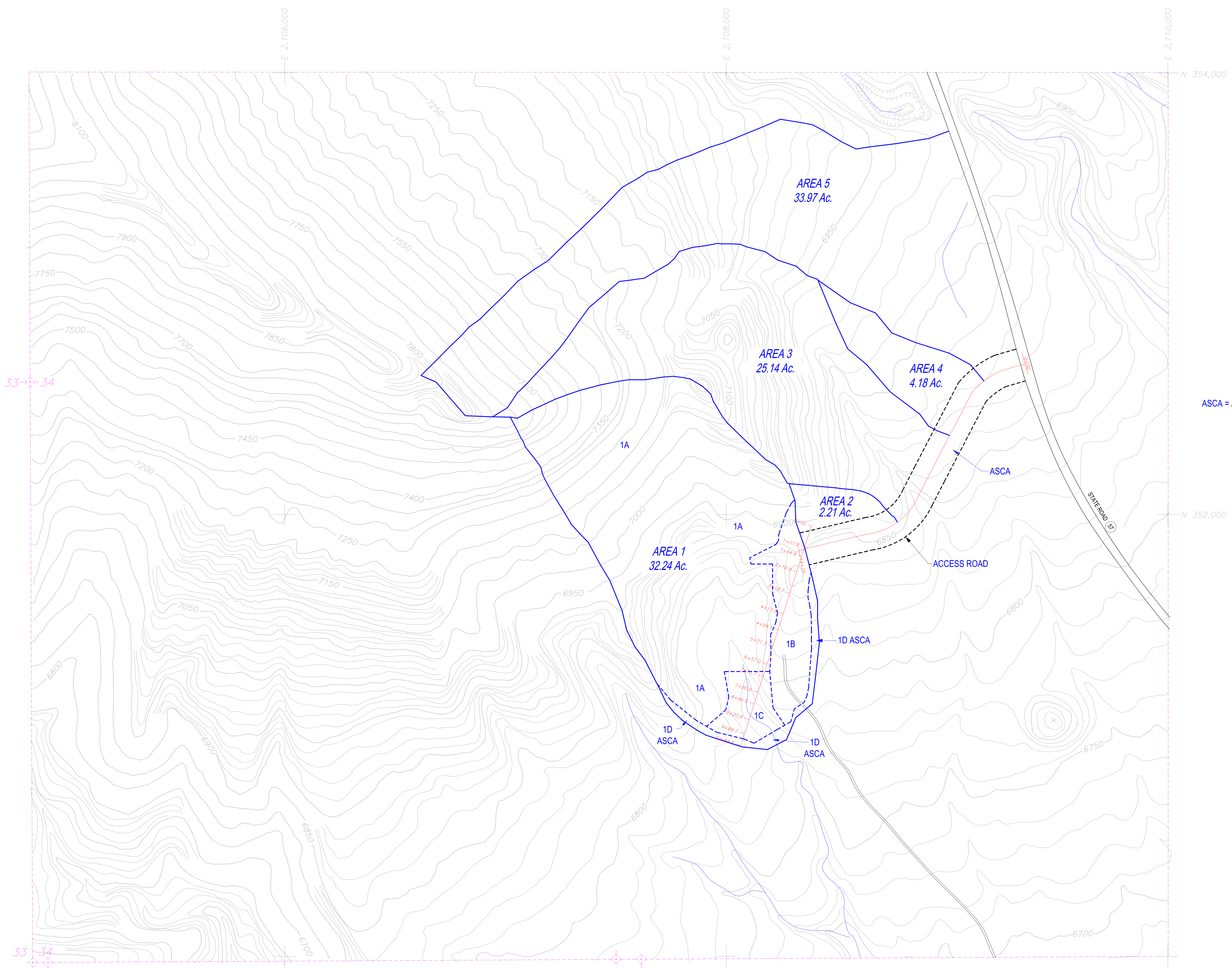
4-9

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
PROFILE/CENTERLINE OF ACCESS ROAD

DATE	REVISION	BY
1-9-02	CHANGED COLOR OF PROPOSED ROAD LINES TO RED FOR CLARIFICATION	KJL
9/18/89	ADDED STREAM FLOW CROSS SECTIONS	KJL

DRAWN BY: K. LARSEN
SCALE: 1"=50'
DATE: AUGUST 11, 1989
DRAWING #: CM-10820-WB
SHEET 1 OF 1
REV.



ASCA = ALTERNATE SEDIMENT CONTROL AREA

DATE	REVISION	BY
9/22/89	REVISED HYDROLOGICAL AREA LINES	JRG

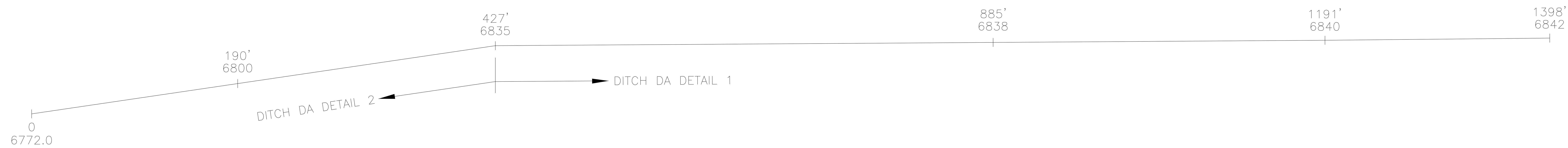
CAD FILE NAME/DISK#: CM10821

4-2

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

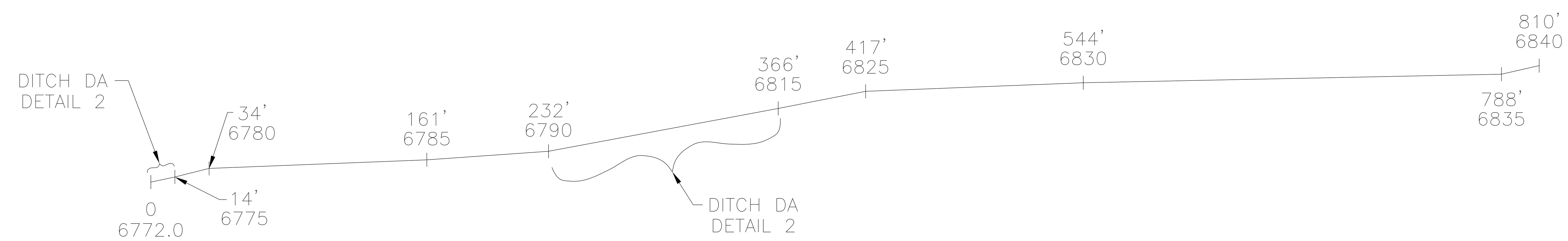
COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
HYDROLOGICAL AREA MAP

DRAWN BY: J. GARRETT
SCALE: 1" = 200'
DATE: JULY 20, 1989
DRAWING #: CM-10821-WB
SHEET 1 OF 1
REV.



FINAL RECLAMATION PROFILE OF DIVERSION DITCH DA

SCALE: 1"=50'

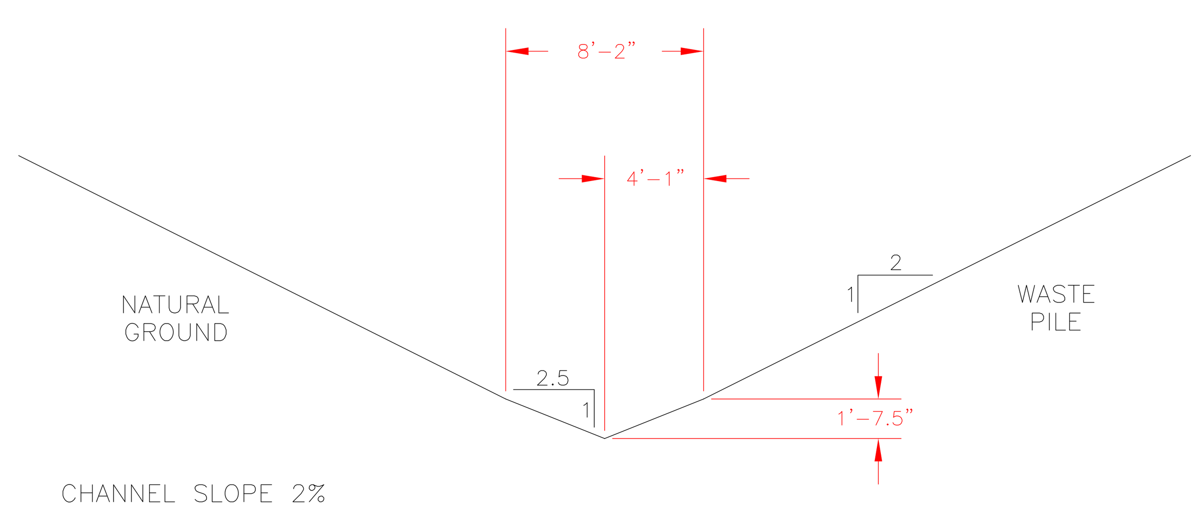


FINAL RECLAMATION PROFILE OF DIVERSION DITCH DB

SCALE: 1"=50'

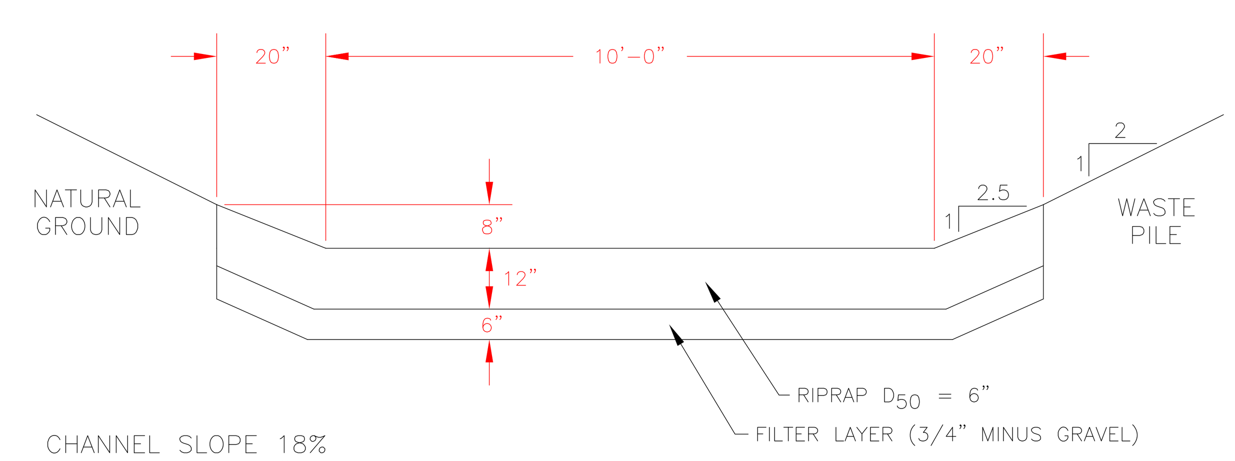
STEVEN E. KOCHEVAR NO. 7889 1/7/93 DATE

I CERTIFY THAT I AM A REGISTERED PROFESSIONAL ENGINEER IN THE STATE OF UTAH AND DO ALSO CERTIFY THAT THIS DRAWING/PLAN IS ACCURATE IN DEPICTING THE DIVERSION DITCH PROFILES AND CROSS SECTIONS TO THE BEST OF MY KNOWLEDGE AND BELIEF.



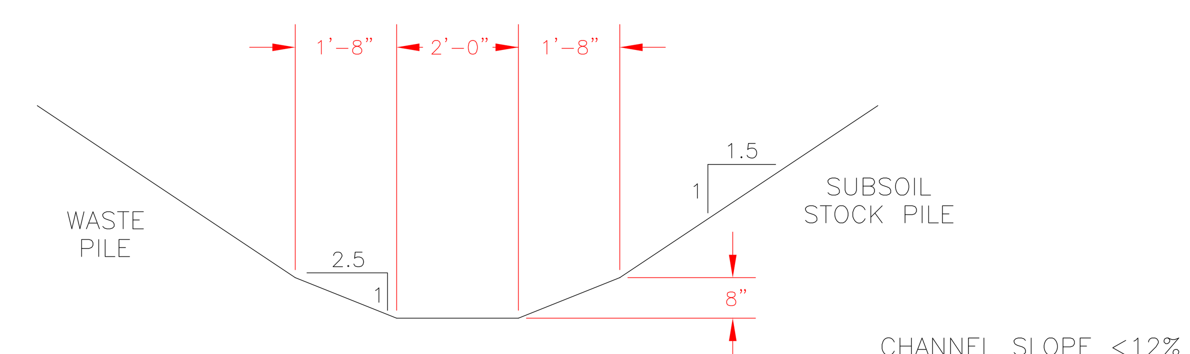
CHANNEL SLOPE 2%
FLOW DEPTH 16"
FLOW 18.9 cfs
VELOCITY 4.34 fps

DITCH DA
DETAIL 1



CHANNEL SLOPE 18%
FLOW DEPTH 3"
FLOW 18.9 cfs
VELOCITY 7.58 fps

DITCH DA
DETAIL 2



DITCH DB

CHANNEL SLOPE <12%
FLOW DEPTH 3"
FLOW 2.52 cfs
VELOCITY 4.59 fps

DATE	REVISIONS	BY	CHK
1-4-93	REVISED DIVERSION DITCH DA AND DB PROFILES TO REFLECT FINAL RECLAMATION	KJL	

CAD FILE NAME/DISK#: 10830

4-12

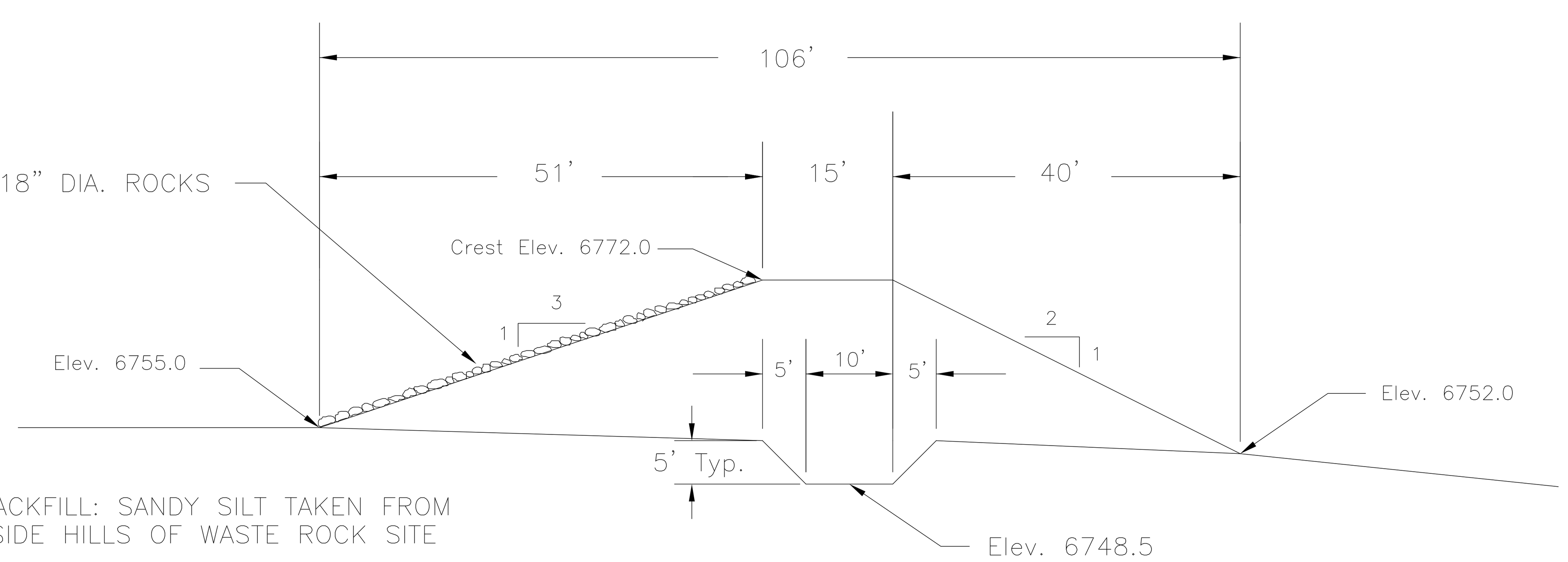
ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
DIVERSION DITCH PROFILES & CROSS SECTIONS

DRAWN BY: K. LARSEN
SCALE: AS NOTED
DATE: JANUARY 4, 1992
DRAWING #: CM-10830-WB
SHEET 1 OF 1
REV.

PLAN VIEW OF SEDIMENTATION POND

SCALE: 1"=30'

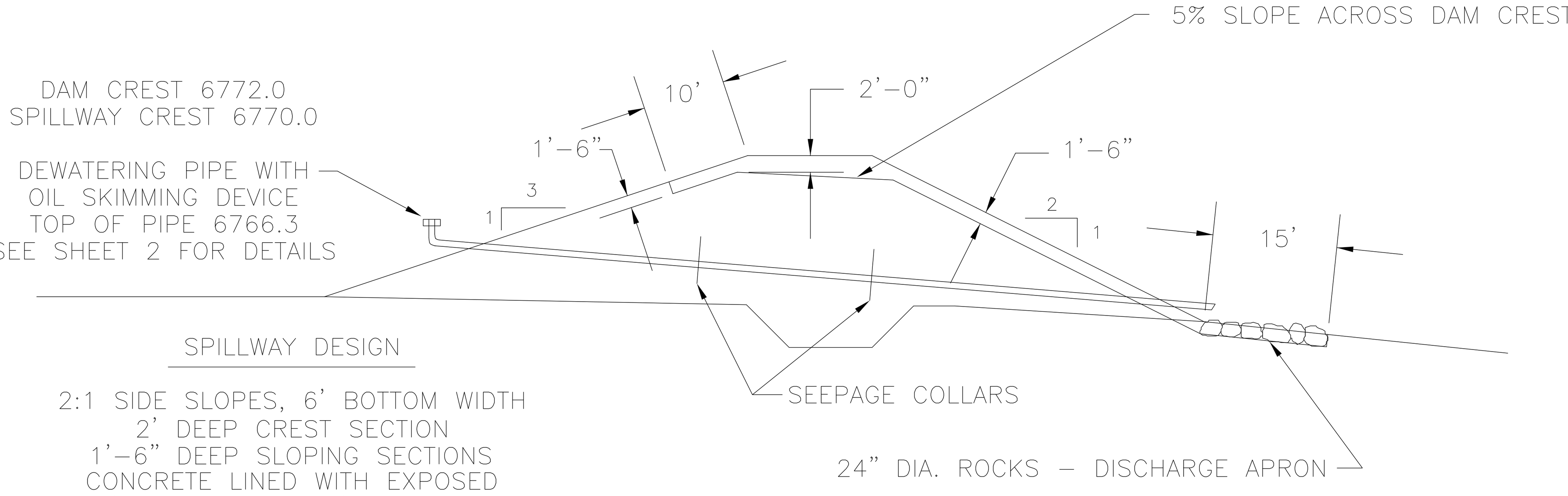


BACKFILL: SANDY SILT TAKEN FROM SIDE HILLS OF WASTE ROCK SITE

COMPACTION: 95% OF STD. PROCTOR

OPTIMUM MOISTURE CONTENT: ±1.5%

TYPICAL DAM CROSS SECTION



SPILLWAY DESIGN

2:1 SIDE SLOPES, 6' BOTTOM WIDTH
2' DEEP CREST SECTION
1'-6" DEEP SLOPING SECTIONS
CONCRETE LINED WITH EXPOSED
12" DIA. ROCKS, 24" DIA. ROCKS
IN DISCHARGE APRON.

TYPICAL SPILLWAY CROSS SECTION

REGISTERED PROFESSIONAL ENGINEER NO. 7059 THOMAS J. FAUCHEUX STATE OF UTAH
5-7-90

DATE	REVISIONS	BY	CHK.
4/30/91	REVISED TO REFLECT THE AS-BUILT CONDITIONS OF THE WASTE ROCK POND AND DAM	KJL	
5/7/90	CHANGED DEWATERING PIPE ELEV. TO 6766.3	KJL	
3/24/90	REVISED CONTOUR LINES AT DAM; ADDED DECANT	TJF	

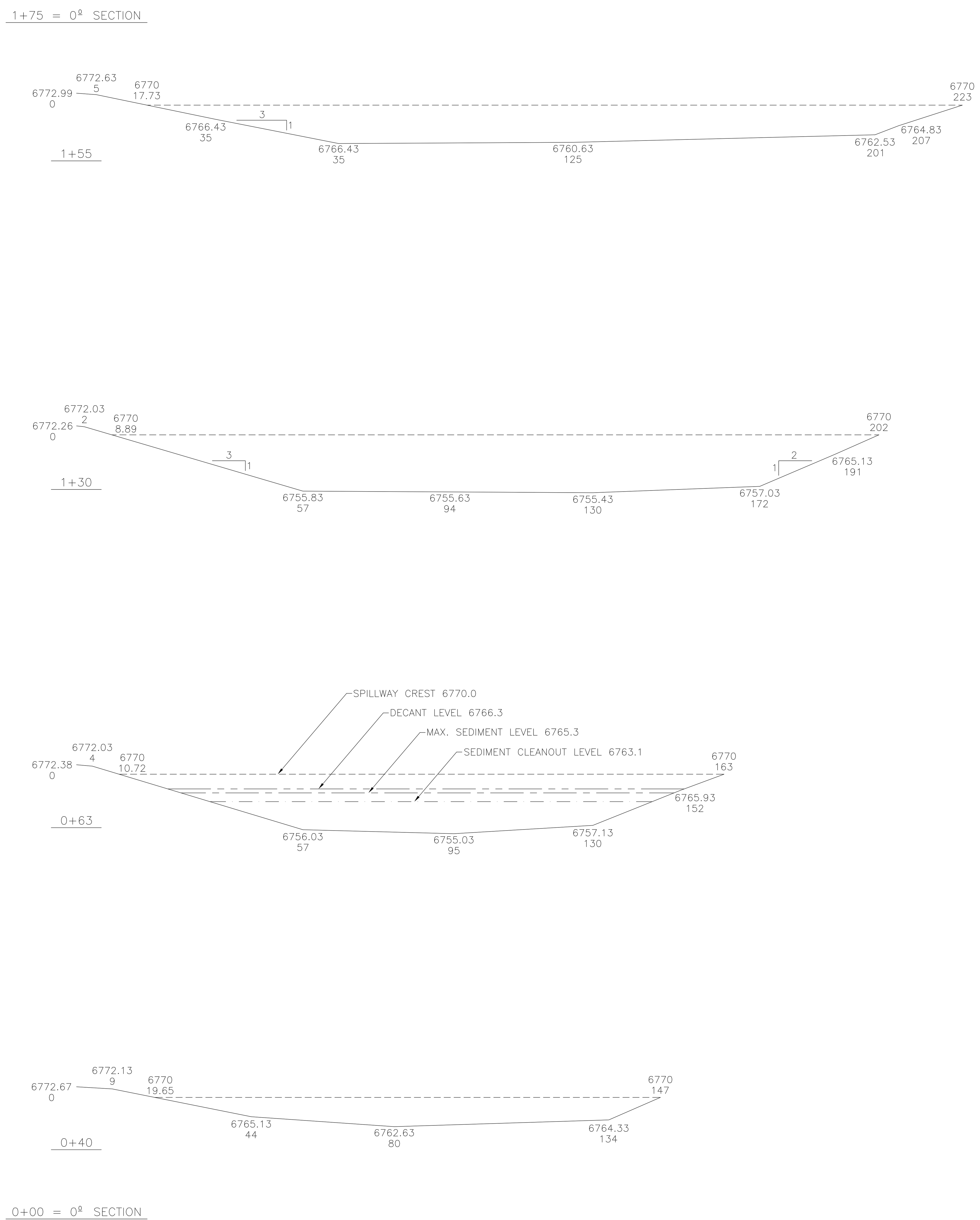
CAD FILE NAME/DISK#: 10837

4-13

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

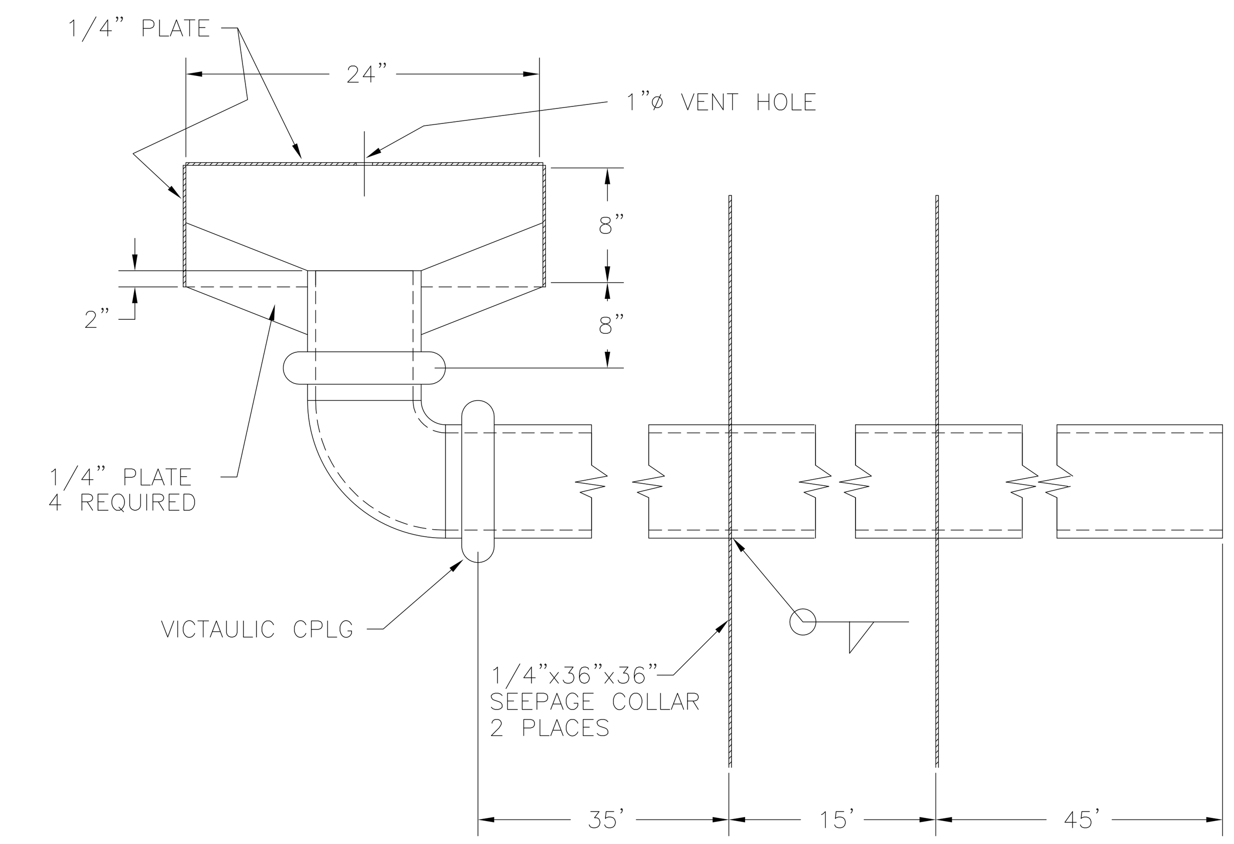
COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
DAM CROSS SECTIONS

DRAWN BY:	K. LARSEN	DRAWING #:	CM-10837-WB
SCALE:	AS NOTED		
DATE:	JANUARY 17, 1990	SHEET 1 OF 2	REV.

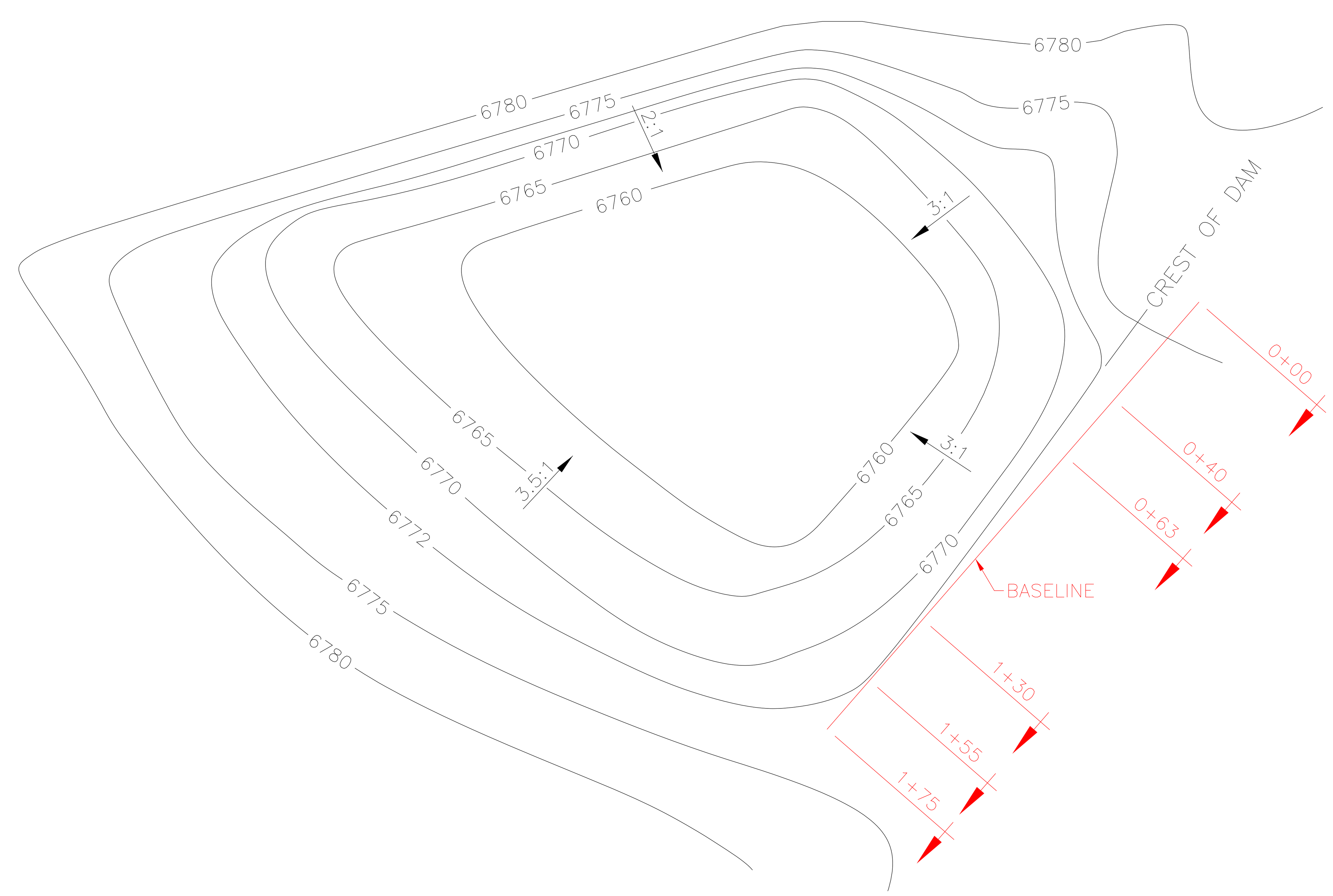


SEDIMENTATION POND – CROSS SECTIONS

SCALE: 1"=20'



6" DEWATERING PIPE AND OIL SKIMMER



PLAN VIEW – SEDIMENTATION POND

SCALE: 1"=30'

REGISTERED PROFESSIONAL ENGINEER NO. 7059 THOMAS J. FAUCHEUX STATE OF UTAH

5-7-90

CAD FILE NAME/DISK#: 10837

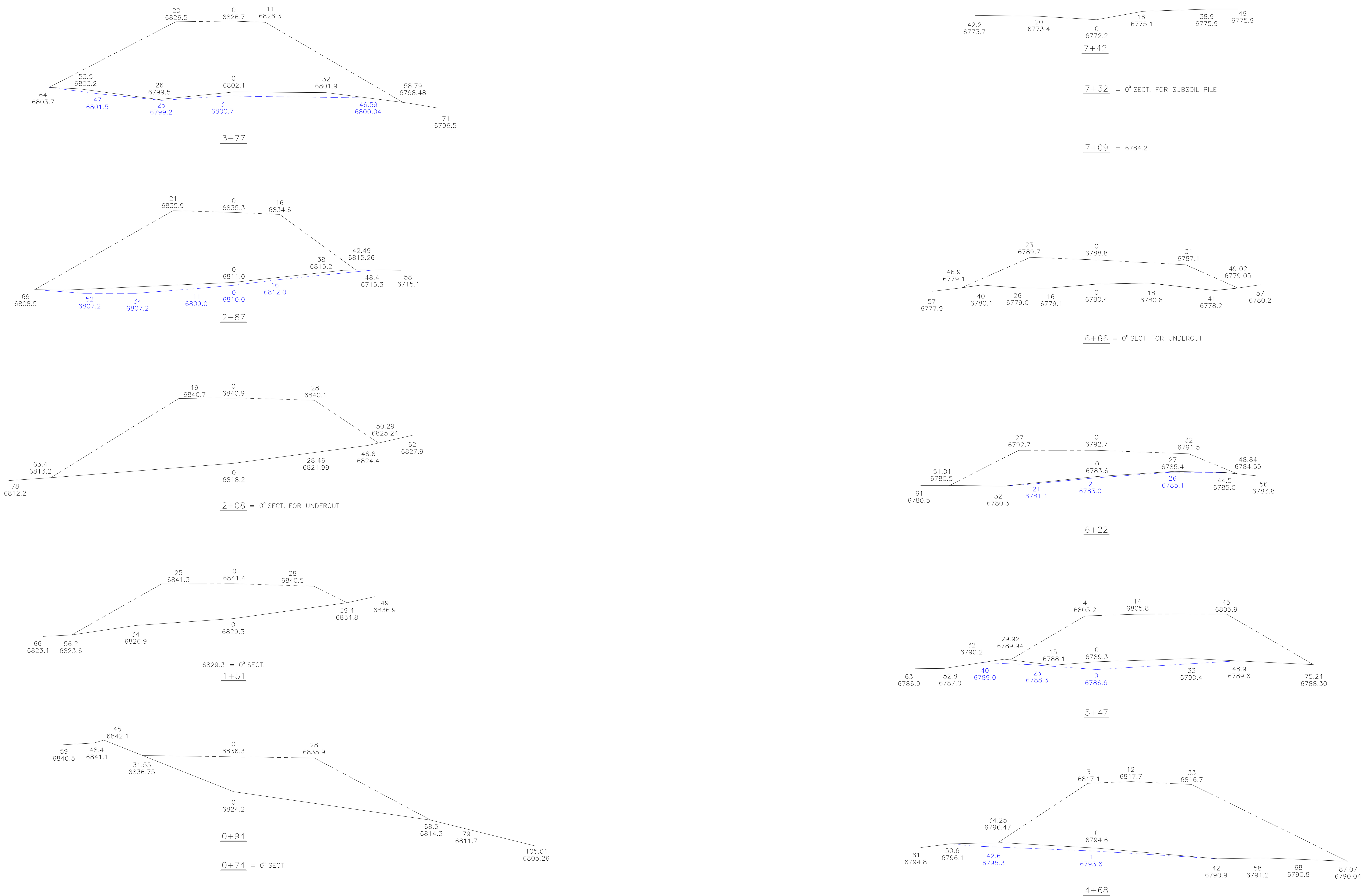
4-13

DATE	REVISIONS	BY	CHK.
5/1/91	REVISED TO REFLECT THE CURRENT CONDITIONS OF THE WASTE ROCK POND AND DAM	KJL	
5/7/90	ADDED SEDIMENT AND DECANT LEVEL NOTES	KJL	
5/7/90	GENERAL REVISIONS: ADDED DEWATERING PIPE	TJF	

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
DAM CROSS SECTIONS

DRAWN BY: K. LARSEN
SCALE: AS NOTED
DATE: JANUARY 17, 1990
DRAWING #: CM-10837-WB
SHEET 2 OF 2
REV.



PRE-EXISTING NATURAL GROUND

EXCAVATED UNDERCUT

COMPLETED SUBSOIL PILE

J. BLAKE WEBSTER No. 7728 REGISTERED PROFESSIONAL ENGINEER STATE OF UTAH

4/2/91

4-11B

CAD FILE NAME/DISK#: CM10846

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

COTTONWOOD/WILBERG MINE
WASTE ROCK STORAGE FACILITY
SUBSOIL CROSS SECTIONS

DATE	REVISIONS	BY
3/28/91	REPRESENTS THE AS BUILT CONDITIONS AS OF 8/1/90	KJL

DRAWN BY: K. LARSEN	DRAWING #: CM-10846-WB
SCALE: 1" =20'	
DATE: AUGUST 6, 1990	SHEET 1 OF 1 REV.