From: Pam Grubaugh-Littig (PGRUBAUGH-LITTIG)
To: JKelley
Date: Wednesday, February 9, 1994 9:51 am
Subject: Tank Seam

The Dames and Moore report indicated a safety factor 1.4 if certain recommendations were followed, e.g. the separation of cobbles, etc. As you stated yesterday, Co-Op did not include any of the recommendations in their proposal, i.e. the parameters that were used to compute the safety factor. Please have a summary of the safety factor findings laid out and check with Randy about all of this and get his signoff on the "mechanical" stability of the proposal. Thanks.

CC: RHarden

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

Michael O. Leavitt
Governor
Ted Stewart
Executive Director
James W. Carter
Division Director

355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, Utah 84180-1203
801-538-5340
801-359-3940 (Fax)
801-538-5319 (TDD)

TO: File

February 23, 1994

TO: Pamela Grubaugh-Littig, Permit Supervisor

FROM: Henry Sauer, Senior Reclamation Soils Specialist

RE: Tank Seam Proposal, Co-Op Mining Company, Bear Canyon Mine, ACT/015/025, Folder #2, Emery County, Utah

SYNOPSIS

The permittee has responded (received December 3, 1993) to the Division's denial of the initial proposal to construct an access road and portal facility in order to mine the Tank Seam.

The Tank Seam proposal, as submitted, is recommended for denial as provided under R645-300-131.100. The permittee has not adequately demonstrated compliance with the Utah Coal Mining Rules.

The forthcoming analysis attempts to illuminate the primary reasons for this writer's recommendation of denial. Minor issues were noted during the review but were not deemed pertinent at this juncture.

ANALYSIS

R645-301-242. Soil Redistribution & R645-301-244. Soil Stabilization

The permittee has not adequately demonstrate that redistribution and protection of the soils resource on the regraded surfaces is feasible. The geotechnical report by Dames and Moore with regards to the surface stability of the constructed road fills states the following " During thunder storms or other wet periods small localized minor slides and sloughs should be anticipated along the slopes". Topsoil slides, sloughs and surface erosion would likely be similar to that described above and/or of greater magnitude with uncompacted topsoil placed on constructed reclamation fills. The proposed

topsoil redistribution plan does not meet the requirements of these sections of the Utah Coal Mining Rules and R645-301-553.230, R645-301-535 et. seq.

The proposed topsoil stockpile design (Plate 8-6) depicts 1H:1V side slopes. The stockpile design does not meet the requirements of the this section of the Utah Coal Mining Rules.

R645-301-537. Regraded Slopes

According to the soil survey information provided by the permittee (Plate 8-1, Appendix 8-B) the following profile conditions exists within the excavated portion of the proposed access road and the Tank Seam portal pad.

1) Approximately 3 acres of disturbance will be created.

2) Approximately 0.8 acres of the proposed disturbance is within the Travessilla-Rock Outcrop-Strych Complex (TR).
i) Seventy five percent of this map unit is composed of talus, rock outcrop or shallow soils (i.e. Travesilla very bouldery fine sandy loam, 14 inches deep) over bedrock.
ii) Fifteen percent of this map unit is composed of deep soils (i.e. Strych very bouldery loam, 60 inches deep) of which 10 % (by volume) of the profile is composed of particles greater than 3 inches in diameter (i.e. cobble size or greater).

3) Approximately 2.2 acres of the proposed disturbance is within the Podo-Datino-Rock Outcrop Complex (PDR).
i) Fifty five percent of this map unit is composed of rock outcrop or shallow soil (i.e. Podo very stony fine sandy loam, 12 inches deep).
ii) Thirty five percent of this map unit is composed of deep soils (i.e. Datino very stony fine sandy loam, rock outcrop is present below 60 inches) of which 26 % (by volume) of the profile is composed of particles greater than 3 inches in diameter.

The permittee's proposal includes designs to place the majority of the excavated material into constructed fills during operations and at the time of final reclamation. As stated in the conclusion and recommendation section of the geotechnical report (slope stability analysis) by Dames and Moore (September 16, 1993), "The fill material should be compacted in lifts not exceeding 8-inches in depth and all rock fragments cobble size and larger (i.e. 3 inches diameter or greater) should be removed from the fill". The majority of the material excavated during the construction of the road will be greater than three inches in

diameter and will not meet the maximum size criteria for fill material. Therefore, excess spoil will be created, for which there is currently no plan to address the requirements of R645-301-528. 310 Excess Spoil and insufficient quantities of suitable material (i.e. particle size < 3 inches diameter) will exist for the construction of stable fills.

R645-301-553. Backfilling and Grading

The proposed post-mining topography map (Plate 3-2E) depicts topographic feature which currently exist. Numerous portions of the reclaimed surface as depicted on Plate 3-2E would be nearly vertical. Sections of the proposed post mining topography are equal to or steeper than the constructed road fills. The proposed post mining topography does not meet the requirements of this section of the Utah Coal Mining Rules.

RECOMMENDATION

The Tank Seam proposal, as submitted, is recommended for denial as provided under R645-300-131.100. The permittee has not adequately demonstrated compliance with the Utah Coal Mining Rules.

CC: Jesse Kelly, DOGM
Tom Munson, DOGM
Susan White, DOGM

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*                  **  TRANSMIT CONFIRMATION REPORT  **                     *
*                                                                           *
*            Journal No.   :  024                                           *
*            Receiver      :  13815238                                      *
*            Transmitter   :  DIV OIL GAS & MINING                          *
*            Date          :  Feb 25,94 16:52                               *
*            Document      :  03 pages                                      *
*            Time          :  02'08"                                        *
*            Mode          :  G3 NORMAL                                     *
*            Result        :  OK                                            *
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State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

Michael O. Leavitt
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UTAH DIVISION OF OIL, GAS AND MINING
FACSIMILE COVER SHEET

DATE: February 25, 1994

FAX # 381-5238

ATTN: Charles Reynolds

COMPANY: Co-Op Mining Co.

FROM: Tom L

DEPARTMENT: DOGM

NUMBER OF PAGES BEING SENT (INCLUDING THIS ONE): _____

If you do not receive all of the pages, or if they are illegible, please call (801) 538-5340.

We are sending from a Murata facsimile machine. Our telecopier number is (801) 359-3940.

MESSAGES:

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DIVISION OF OIL, GAS AND MINING

Michael O. Leavitt
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February 23, 1994

Mr. Wendell Owen
Co-Op Mining Company
P.O. Box 1245
Huntington, Utah 84528

Re: Denial of Tank Seam Proposal, Co-Op Mining Company, Bear Canyon Mine, ACT/015/025-93B, Folder #3, Emery County, Utah

Dear Mr. Owen:

The proposal to build a road and portal to access the Tank Seam is a significant revision to the current Bear Canyon Mine permit. This proposal includes the construction of an access road, 3000 feet in length, at a 9 to 15 percent grade. The road traverses across outcrops, colluvium, and terrace slopes averaging 35 degrees.

The mining and reclamation plan must provide the basis for determining whether or not the backfilling and grading plan proposed by the applicant will (1) minimize off-site effects, (2) achieve a final surface configuration which closely resembles the general surface configuration of the land prior to mining, and (3) provides a subsurface foundation for a vegetative cover capable of stabilizing the surface from erosion and (4)) supporting the approved postmining land use.

Pursuant to R645-300-133.7I0, the Division must find that the applicant has: "Demonstrated that reclamation as required by the State Program can be accomplished according to information given in the permit application". The Division has reviewed the resubmittal of the Tank Seam proposal and found that the proposal does not demonstrate that the reclamation of the Tank Seam road can be accomplished according to the information given in this application for the permit change.

Conditions for the reclaimed road and portal to be stable **require** compaction of the fill material in eight-inch lifts according to the engineering report prepared by Dames and Moore. If the constructed lifts are eight-inch lifts, it is reasonable to require that the maximum size of the material to be placed in the lifts be limited to eight-inches to afford proper compaction. Outcrop material will be blasted during

the construction and a significant amount of the material may fall into the oversize category and not be suitable for fill. The proposal states, however, that the construction of the operational fills will have material compacted in three-foot lifts, which does not meet the static safety factor for "constructed" compacted fills, as presented in the engineering report. Based on this inconsistency, the plan fails to meet the engineering design and performance standards.

The reclaimed slopes are not found to be suitable for the topsoil adherence and re-establishment of vegetative cover or erosional stability. In accordance with R645-301-242.110 through .130, "topsoil must be redistributed in a manner that achieves an approximately uniform stable, thickness consistent with the approved postmining land use, contours, and surface-water drainage systems as well as prevent excess compaction of the material (for plant root penetration) and protect the material from wind and water erosion before and after seeding and planting". Additionally, surface roughness for water holding and erosion control, which is essential for successful revegetation, is eliminated by the compaction requirement.

The proposal for reclaimed drainages associated with this portal access road does not support a finding that the drainages will be designed, located, constructed and maintained to be stable. The plan presents globally-applied criteria on a watershed by watershed basis and ignores site specific criteria for the Tank Seam. The proposal for riprapping of the reclaimed channel in this steep environment has a strong probability of failure based on the forces which come to bear on the riprap. The design of the riprap for the culverts, taken from the table on page 7G-24A, would require 15-inch to 30-inch riprap, which is well outside the realm of stable engineering design.

Pursuant to R645-311-131.200, "The application for a permit or permit change will have the burden of establishing that their application is in compliance with all the requirements of the State Program". An affirmative finding that reclamation as required by the State Program of the Tank Seam road cannot be concluded with the current proposal and is therefore, denied, pending resolution of the above problems.

Sincerely,

Pamela Grubaugh-Littig
Permit Supervisor

cc: Lowell P. Braxton

Appendix 3-H

TANK SEAM ACCESS ROAD

This Appendix discusses the construction of the Tank Seam Access Road and Tank Seam Portal Pad. In order to clearly complete proper cut and fill calculations for the road, the road has been divided into stations spaced at approx. 100 ft o.c. as shown in Figure 3H-4. A cross section of each station follows Figure 3H-4. Stations 0+00 and 1+00 lie on the Upper storage Pad, Station -1+00 to the North on the existing road and Station 2+00 to the south on the lowest end of the Tank Seam Road. The station numbers increase as you proceed up the road toward the pad.

Construction will begin on the Upper Storage Pad. Construction will consist of removing topsoil for storage, then removing material from the road cut and compacting it onto the Upper Storage Pad. Topsoil removal and storage is discussed in section 8.9.5. Table 3H-1 shows the cut and fill volume calculations. Volumes in the table represent total cut and fill volume of material between stations. The majority of the fill material will be placed in the area of stations 8+00 and 9+00.

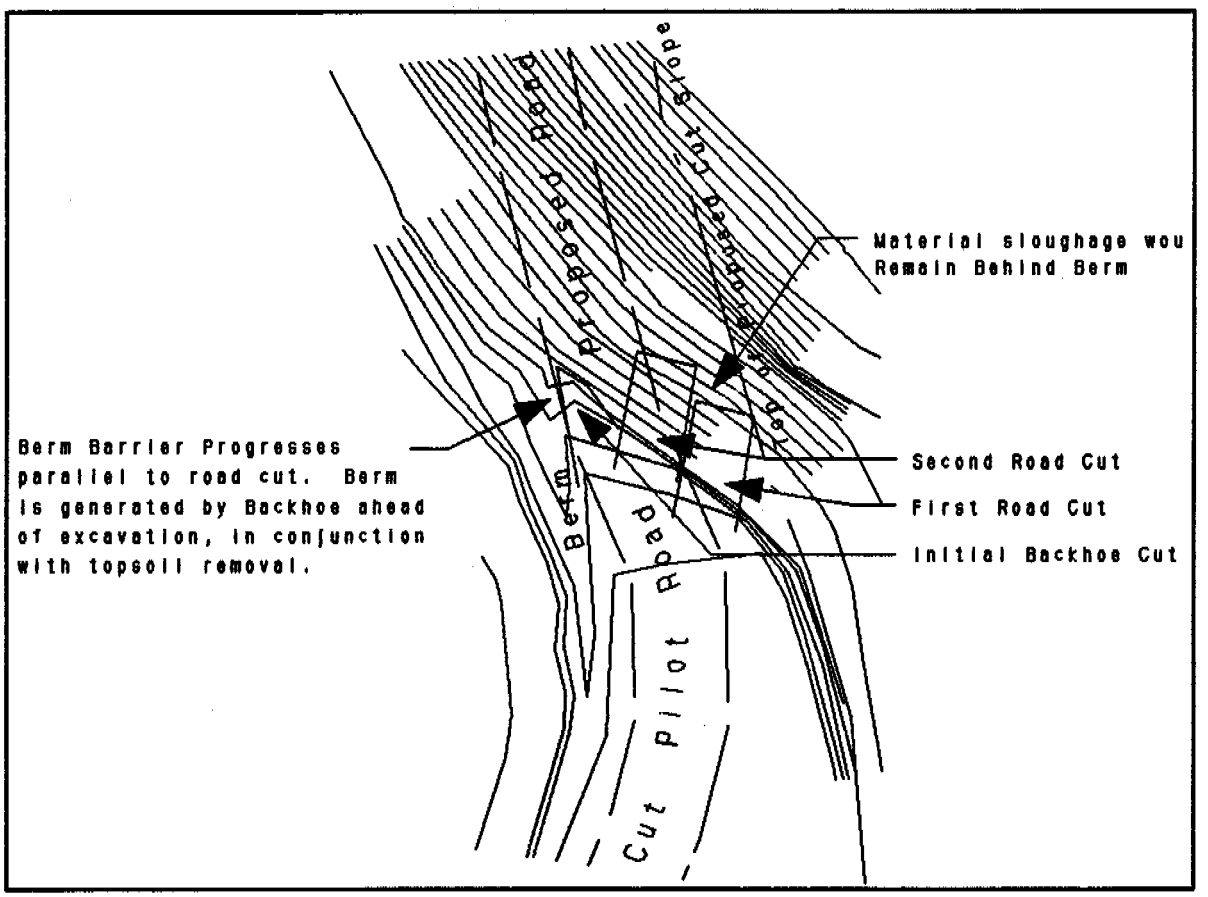
During the initial road cut, care will be taken to prevent disturbed material from migrating downslope in the following manner. The initial topsoil removal will be made using a backhoe. Trees and/or shrubs immediately ahead of the cut will be removed by pulling them back into the previous cut. Using the backhoe, a berm will be created on the downhill side of the cut, as shown in Figure 3H-1. When the berm is in place, the road cuts will be started as shown in Figure 3H-1 using a backhoe and/or front-end loader. The

road cuts will be made into the slope towards the cut face rather than parallel to the slope, which will result in any rocks or sloughage dislodged by the equipment bucket during the road cutting to be contained within the berm. In the event blasting is required, which is described in Appendix 3-M, the blasts will be designed to drop the material into the cut area behind the berm. This will prevent material generated by the blast from migrating downslope into the undisturbed area. This procedure will be used to cut a pilot road until the first large fill area (Stations 8+00 and 9+00) is reached.

When small fill areas are reached (e.g. Station 6+00), a temporary silt fence will be installed at the base of the proposed fill for runoff control, and the same cutting procedure will be used to create an initial berm inside the silt fence with a backhoe after topsoil removal. The area inside the berm will then be prepared to allow the placement of the fill, as shown in Figure 3H-2. Fill material in these areas will be restricted to no more than 10' downslope from the road, allowing a backhoe to easily reach the material during reclamation. Rock fragments larger than 18 inches which are disturbed will be embedded into the surface of the fill as described in the slope stability analysis on page 3H-48. Remaining rock fragments will be temporarily placed in the storage area of the Upper Storage Pad until the large fill area is reached. Fill will be compacted in 18 inch lifts as described on page 3H-48. These areas are included in the disturbed area, and are designated as BTCA areas (See Plate 7-1E and Appendix 7-K). As soon as the fill material is in place, erosion control matting will be placed

So rock fragments which are not disturbed stay in place?

Figure 3H-1. Typical Road Excavation Sequence



NOTE: Road cut sequence may vary. All cuts will be made behind the berm generated by the initial backhoe cut.

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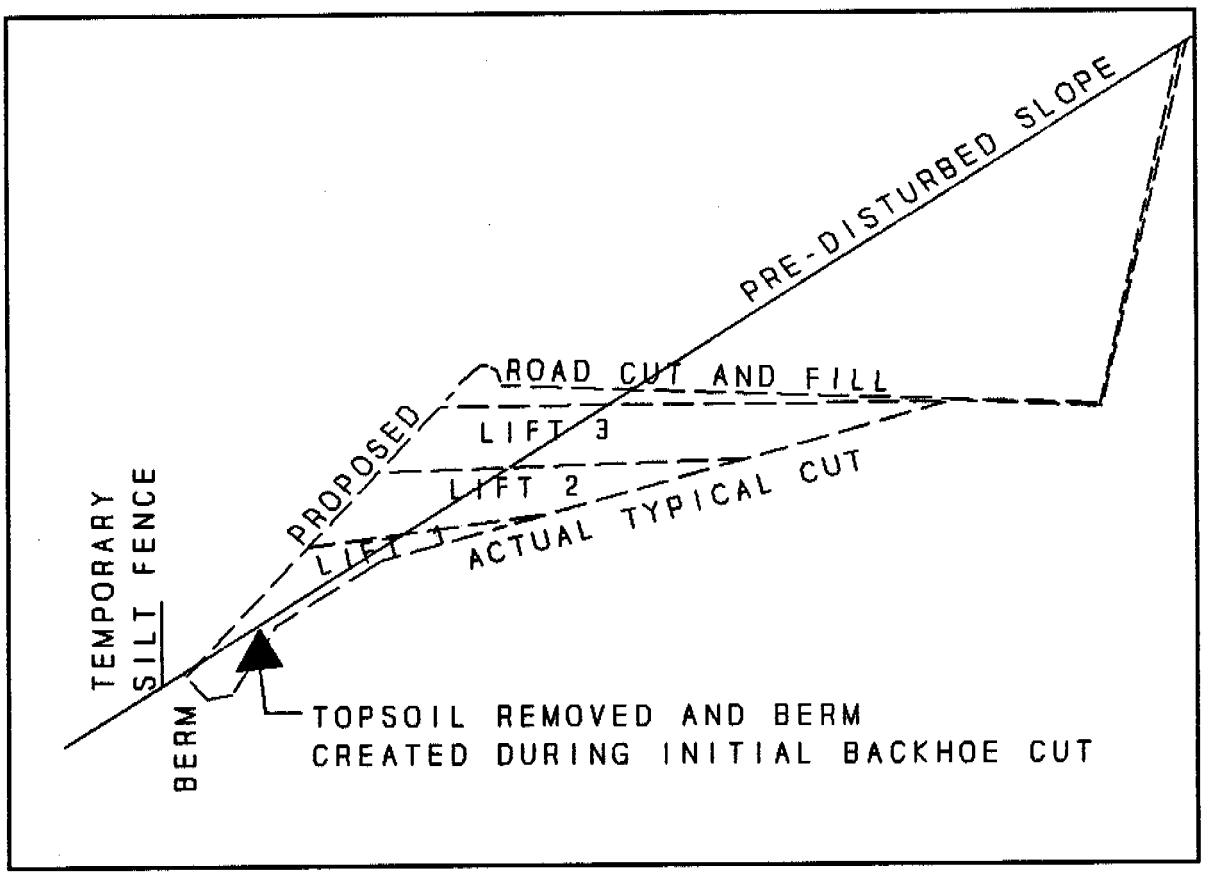
Figure 3H-2. Cut and Fill Diagram for Small Areas



NOTE: This diagram represents a typical sequence for the construction of small fills alongside the cut road. Configurations shown are typical and the actual profile may vary.

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on the disturbed slopes as described in Appendix 7-K. The temporary silt fence at the base of the fill material will remain in place for runoff treatment until installation of the erosion control matting is complete.

When the large fill area is reached, temporary silt fences will be placed below the fill area prior to equipment entering the proposed disturbed area. The silt fences will be placed so as to treat runoff from all disturbed area not contained by a berm during construction. Topsoil recovery will then begin in the fill area. During topsoil removal a ramp will be constructed which will weave back and forth along the face of the fill area to the base.

As the base of the fill area is approached, care similar to the procedures described previously for cut and fill will be taken to prevent rocks and other material from being pushed onto or below the silt fences. The following sequence will then be used starting at the base of the fill area. What

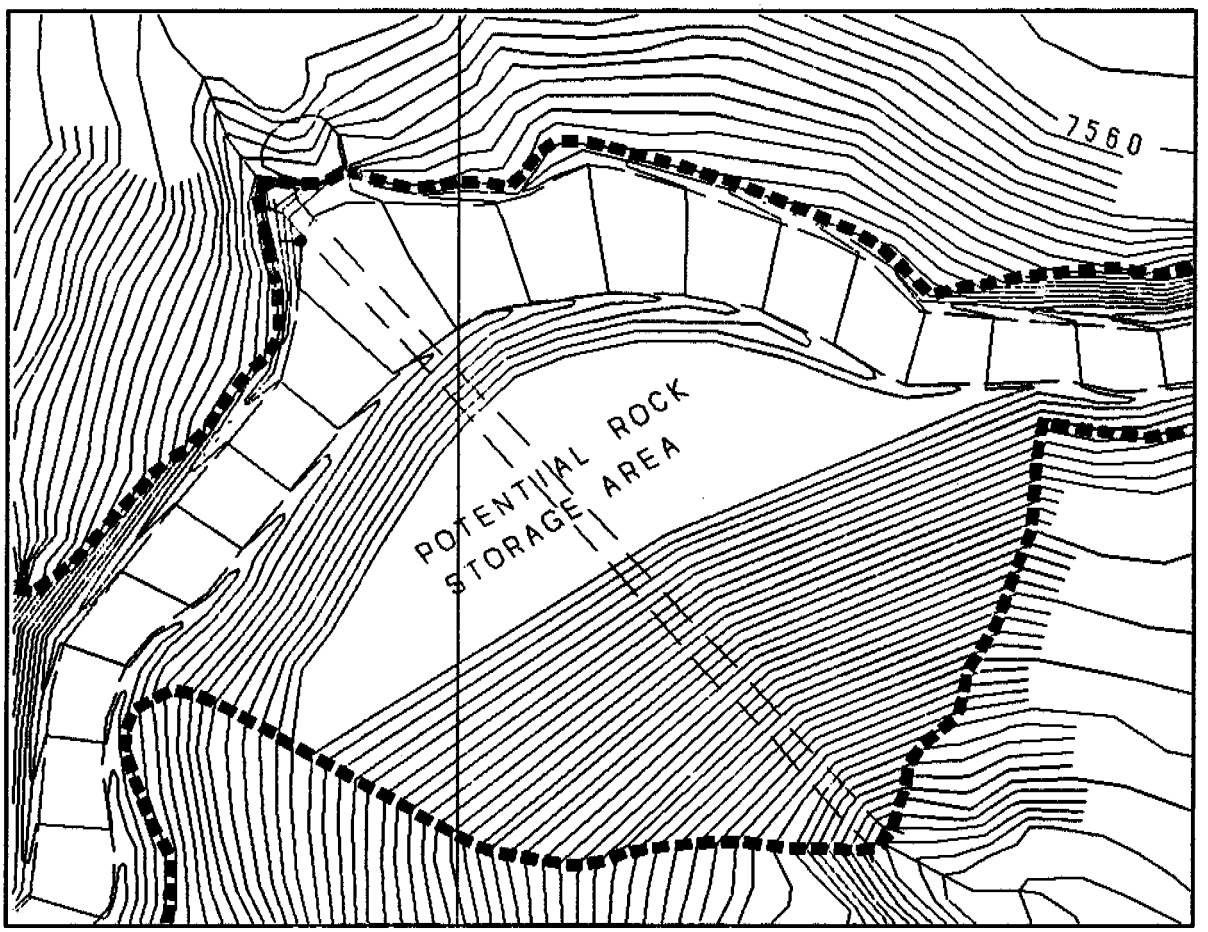
The base of the fill area will be prepared according to the recommendations on Page 3H-48 by removing all vegetation and rock fragments larger than 18 inches which are not embedded into the natural ground and/or stable, and any cobble or boulder sized rocks which are positioned so as to interfere with the compaction activities. Placement of the fill material will then begin and the material will be compacted in lifts not exceeding 18 inches. The initial cut to reach the base of the fill area will act as a series

subjective! How will stability be determined.

of terraces with which the fill material can be keyed into the natural soils, as recommended on page 3H-48. As the fill progresses up the slope, removal of rock fragments and vegetation will continue on the slope above the fill. Rock fragments less than 18 inches will be incorporated into the fill as they are removed. Rock fragments larger than 18 inches will be incorporated into the surface of the fill and will be embedded into the fill material to aid in surface stabilization. In the event the amount of large rocks disturbed exceeds the amount which can be incorporated into the surface, remaining rocks will be temporarily placed on the Upper Storage Pad until construction of the road is complete, and then will be placed as described below according to the discussion on page 3H-48. What?

The cut and fill volumes in Table 3H-1 represent the maximum amount of fill which will be encountered in the road excavation. The possible presence of excessive rock fragments larger than 18 inches may generate a reduced amount of fill and rocks which may need to be stored until reclamation. The extreme width of the road at stations 8+00 and 9+00 account for the maximum amount of fill material which may be encountered. Excessive rock fragments could decrease the available fill. If this scenario is encountered, an alternate configuration for the fill material is shown in Figure 3H-3. This alternate configuration, involving terracing of the fill, would provide a stable surface for which to store the additional rocks encountered during construction. If additional storage area is required, the necessary amount of area will be obtained by redesignating part of the Upper Storage Pad for storage

Figure 3H-3. Alternate Fill Area Configuration



SCALE: 1" = 40'

NOTE: This figure represents an alternate fill configuration to account for the potential lack of fill material due to excessive large rocks (>18" m.d.). The elevation of the terrace may be lower than shown, or the terrace area may consist of more than one terrace, depending on the amount of fill available and amount of rocks encountered. As excavation progresses, the amount of fill will be monitored. Approximately 3900 sq. ft. of terrace area is available for potential rock storage area (0.09 acres).

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of these rocks. These storage areas will be level or near level, so as to meet the requirements of R645-301-535. Rock fragments will be placed in single lifts as described on page 3H-48, in order to guarantee the safety factor requirements of R645-301-535.

As the fill material is placed and compacted, the surface of the slope will be scarified and ripped horizontally to create a rough surface and water-holding pockets for interim vegetation, along with the embedded rocks. Erosion control matting will be installed in junction with the filling and compacting to prevent erosion from occurring on the fresh slopes. The matting will provide erosion and runoff control, and will aid in the establishment of interim vegetation. The matting will be maintained on the slopes as the primary BTCA treatment (Appendix 7-K), and will be maintained until an adequate demonstration that interim vegetation qualifies the slopes for designation as SAE (Small Area Exemption) areas. Division approval will be required before this designation can be made. Temporary silt fences will be removed once the installation of the matting is complete.

Culverts will also be installed on the fill slope as construction progresses up the slope, in order to avoid disturbance of the surface after construction. Culvert outlets will be protected as described in Section 7.2.7.3.

The cut and fill methodologies in the Appendix will be used throughout the construction of the road and the portal pad. As construction of the pilot road progresses, temporary ditches which

meet the design specifications of the permanent ditches will be maintained along the pilot road, with silt fences placed just above the culvert inlets treating any runoff. Approximate silt fence locations are shown on Plates 7-1C and 7-1E. Upon completion of construction, final as-built contours will be submitted to the Division.

Final crowning of the road and installation of permanent ditches will be completed following initial road and pad contouring. The approximate proposed road and pad contours are shown on Plates 2-4C and 2-4E.

A slope stability analysis of the cut slopes and fill areas, as well as some discussion on the construction methodology, is on page 3H-44 following the cross sections.

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Figure 3H-4. Tank Seam Road/Pad Stations Map

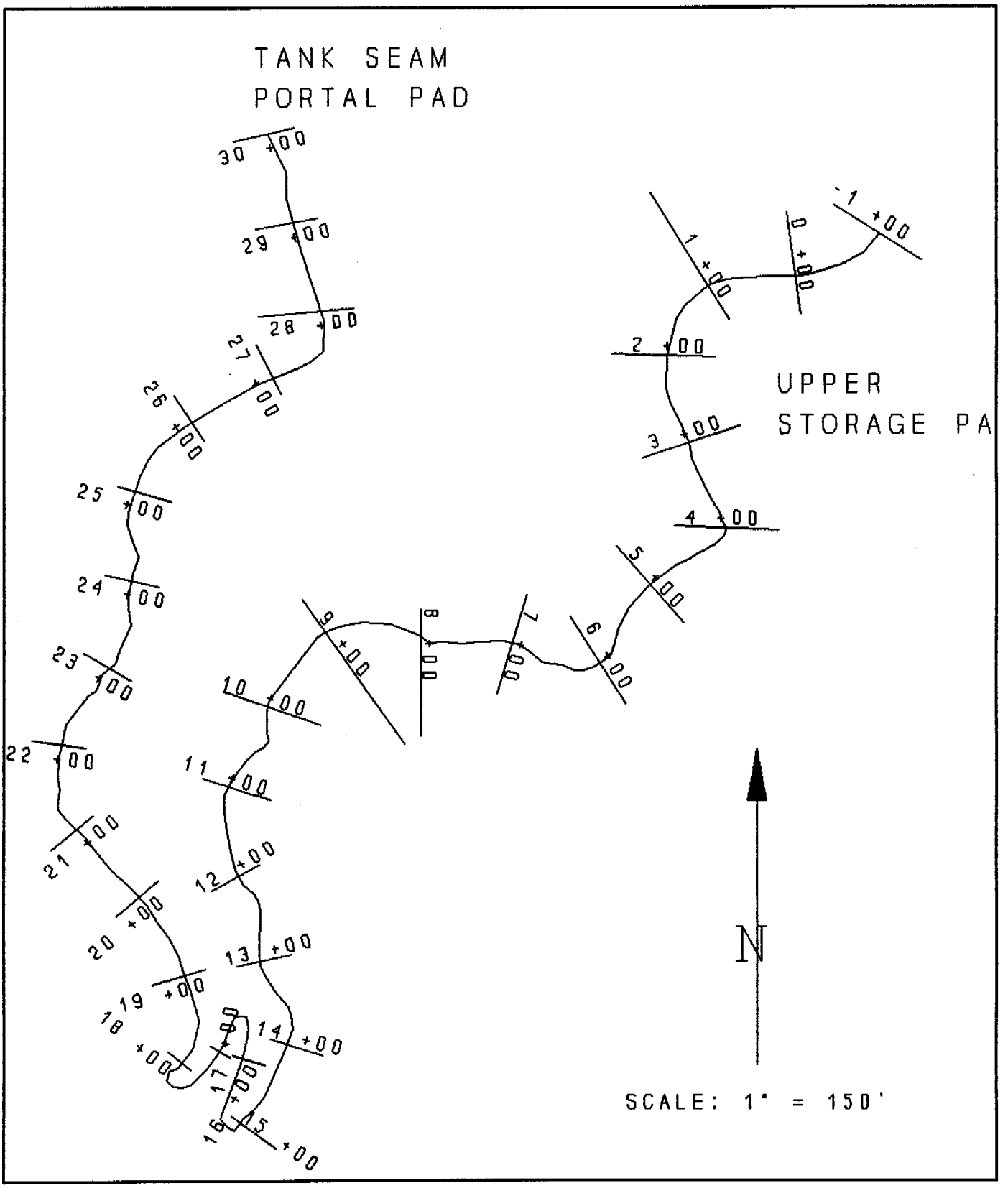

Table 3H-1. Tank Seam Road Cut & Fill Summary

Station	Fill(-) Volume* (cu yd)	Cut(+) Volume* (cu yd)	Volume Cumul. (cu yd)	Station	Fill(-) Volume* (cu yd)	Cut(+) Volume* (cu yd)	Volume Cumul. (cu yd)
-1+00			0	15+00			-12,764
	456	0			300	69	
0+00			- 456	16+00			-12,995
	2,084	0			140	236	
1+00			-2,084	17+00			-12,899
	2,419	0			175	299	
2+00			-4,959	18+00			-12,775
	631	367			0	550	
3+00			-5,223	19+00			-12,225
	68	802			0	871	
4+00			-4,489	20+00			-11,354
	53	669			0	796	
5+00			-3,873	21+00			-10,558
	139	386			0	819	
6+00			-3,626	22+00			-9,739
	68	480			0	642	
7+00			-3,214	23+00			-9,097
	3,025	122			0	713	
8+00			-6,117	24+00			-8,384
	7,145	0			822	83	
9+00			-13,262	25+00			-9,123
	498	526			269	536	
10+00			-13,234	26+00			-8,856
	779	258			0	1,265	
11+00			-13,755	27+00			-7,591
	0	676			0	4,528	
12+00			-13,079	28+00			-3,063
	0	741			0	1,994	
13+00			-12,338	29+00			-1,069
	150	266			0	1,110	
14+00			-12,222	30+00			41
	1,089	547					
15+00			-12,764				

*Cut and fill volumes measured using Quicksurf Version 4.0 3-D modeling software package, copyright 1991, Schreiber Instruments, Inc., based on premining contours from 1991 aerial survey and proposed contours shown on Plate 2-4E.

B.C.

3H-13

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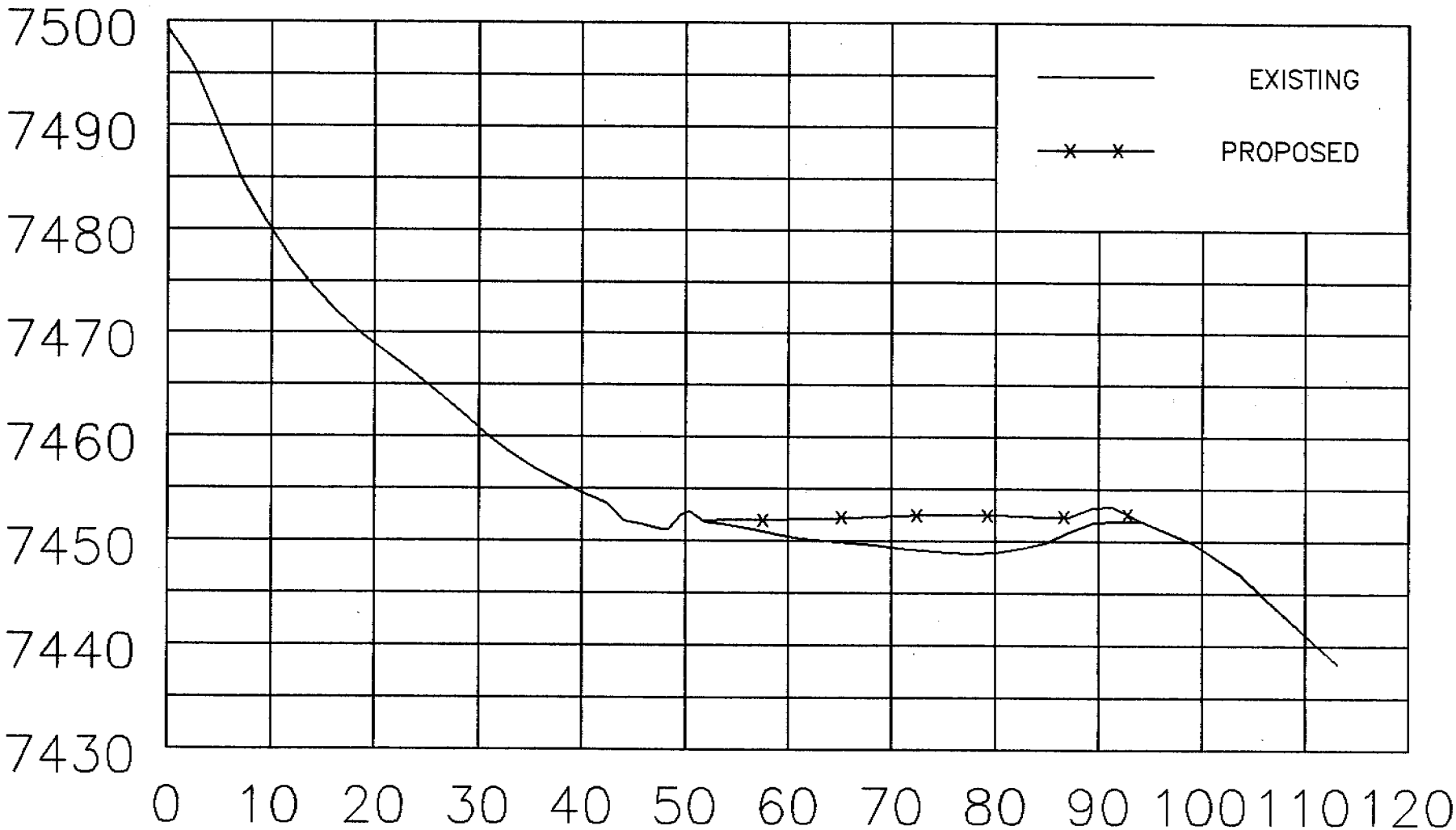
4/20/94

STATION 0+00



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3H-14

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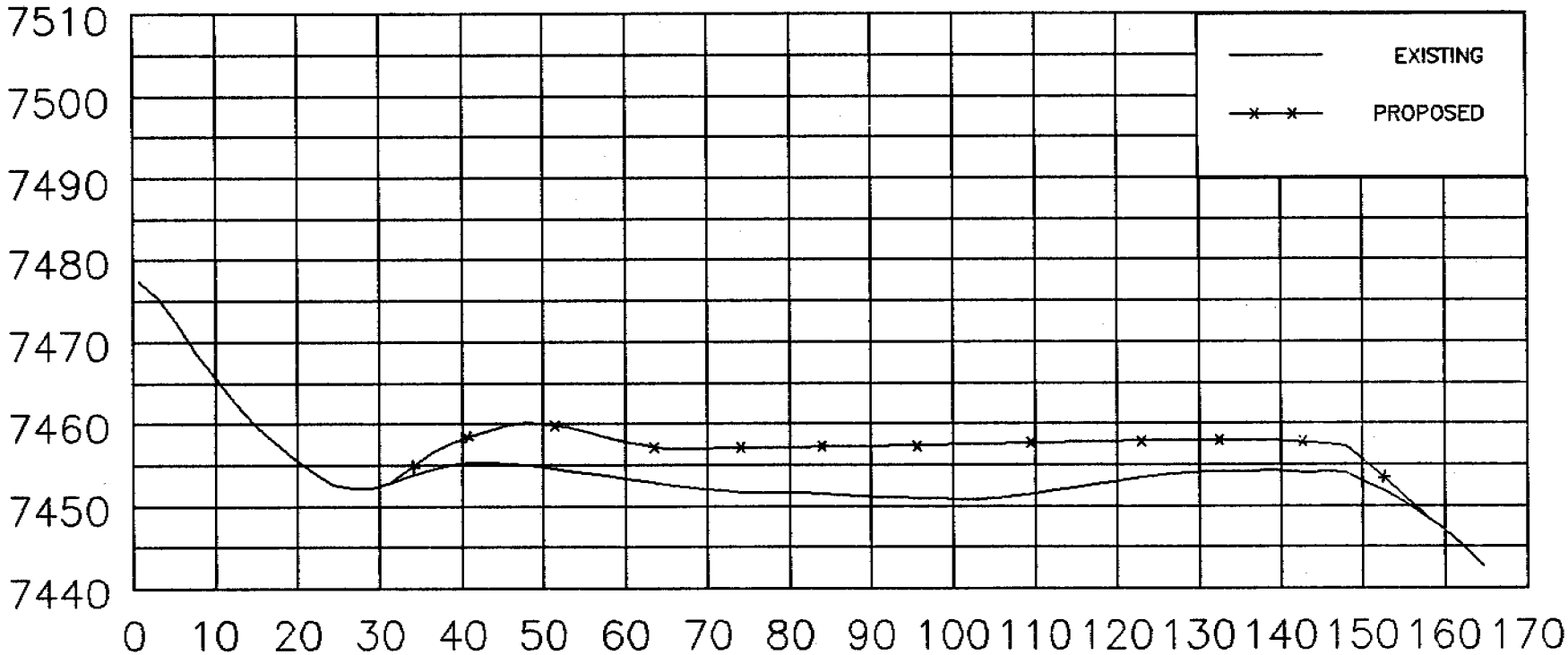
4/20/94

STATION 1+00



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3H-15

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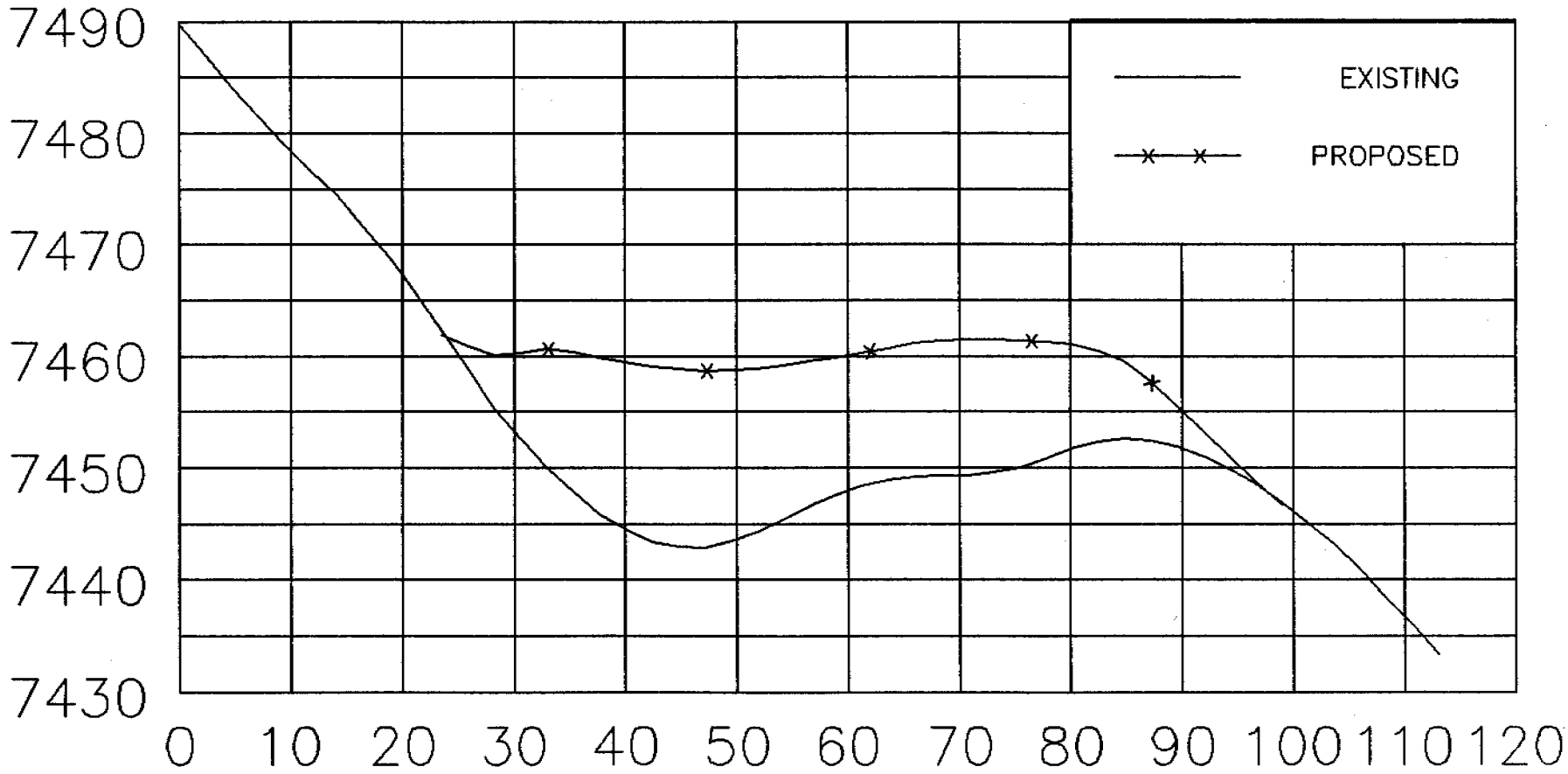
STATION 2+00



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4/20/94

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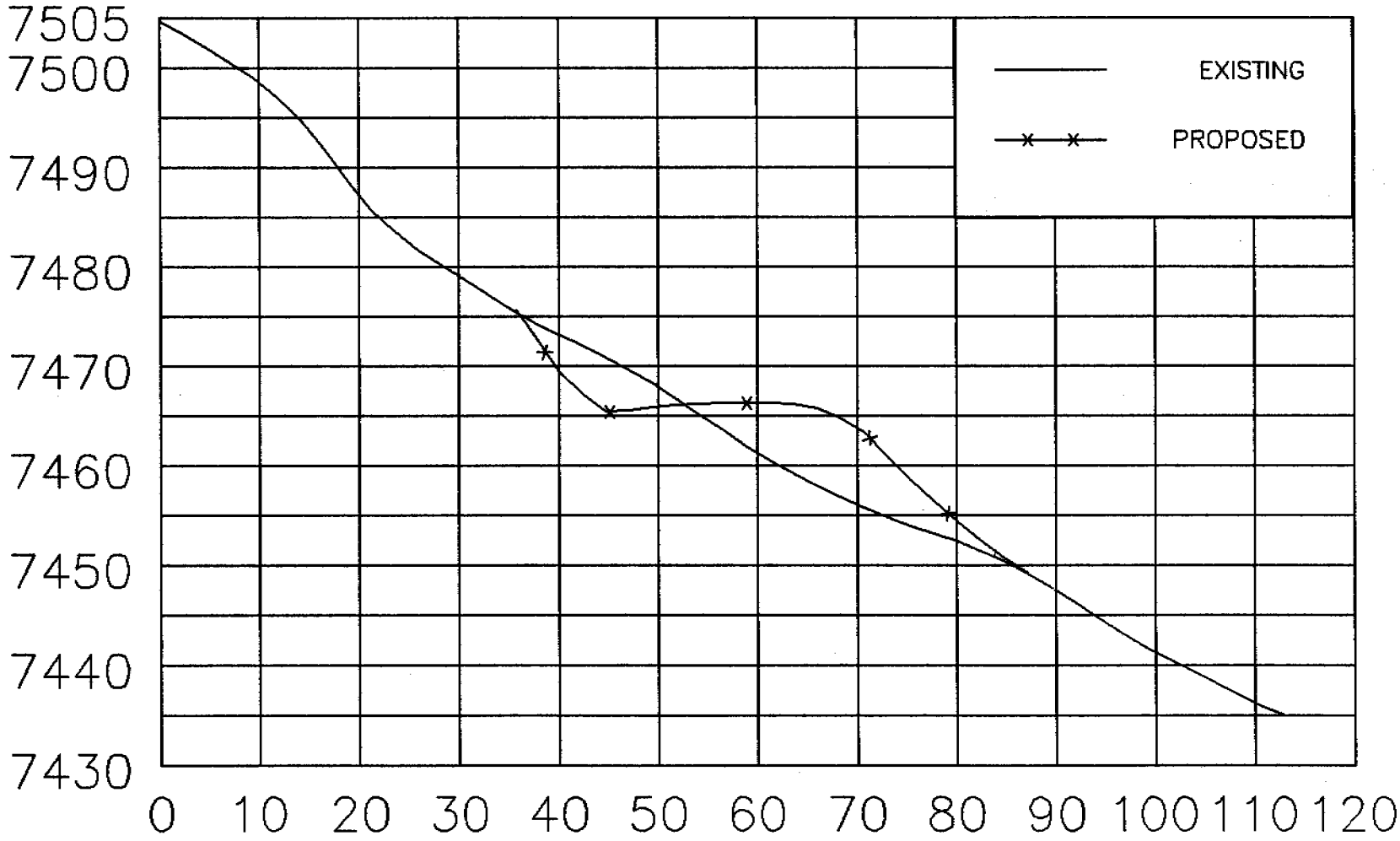
STATION 3+00



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4/20/94

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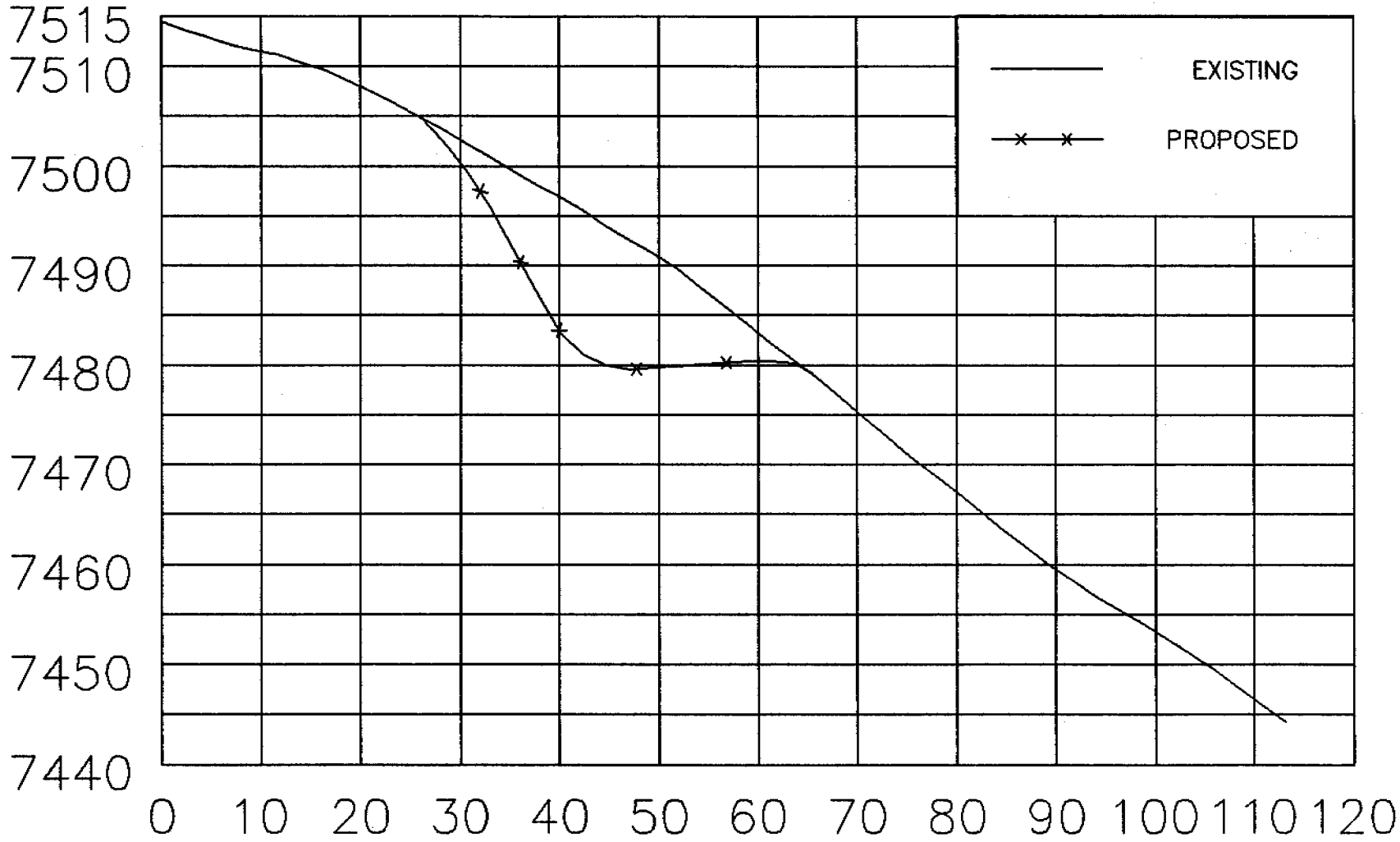
STATION 4+00



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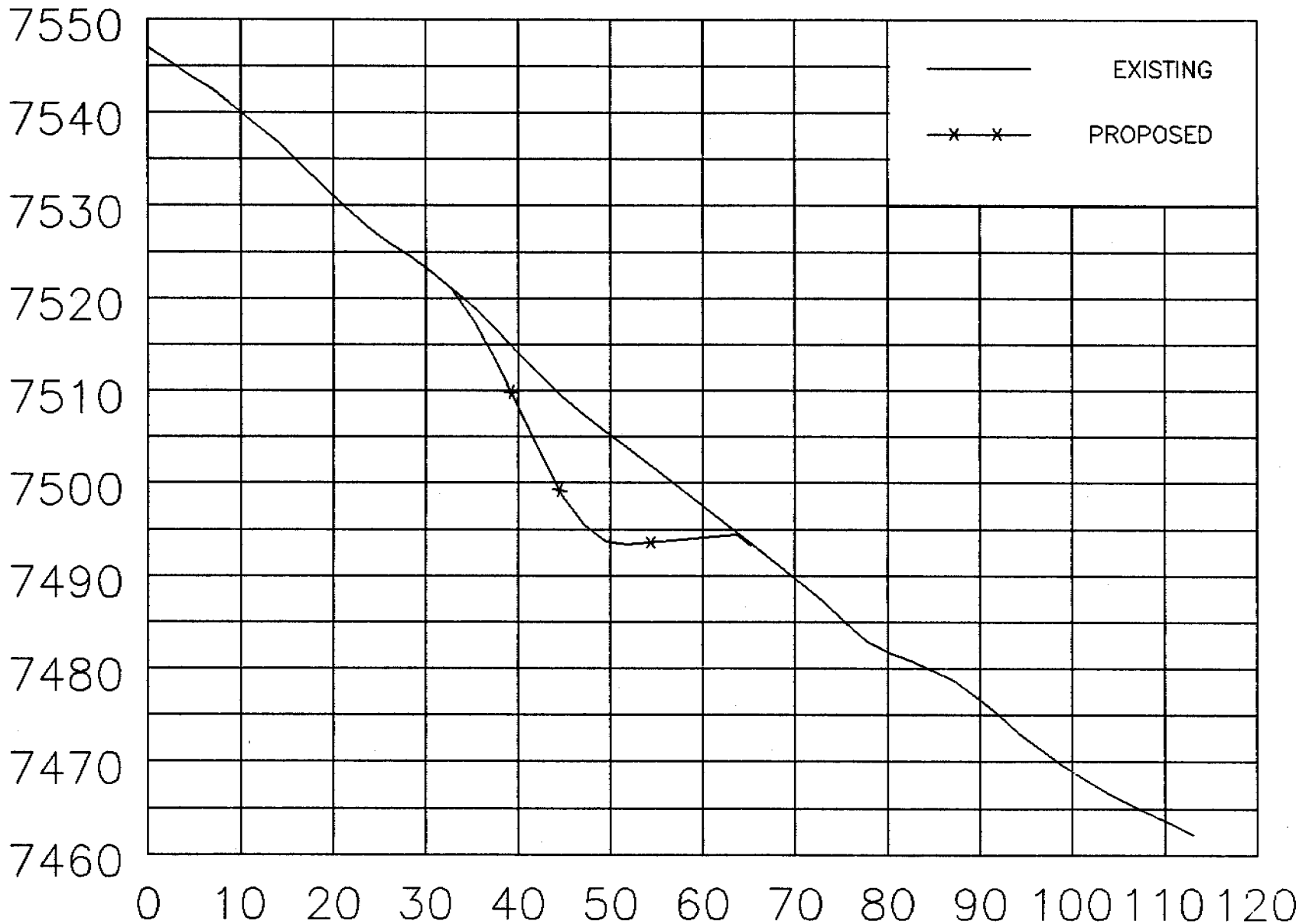

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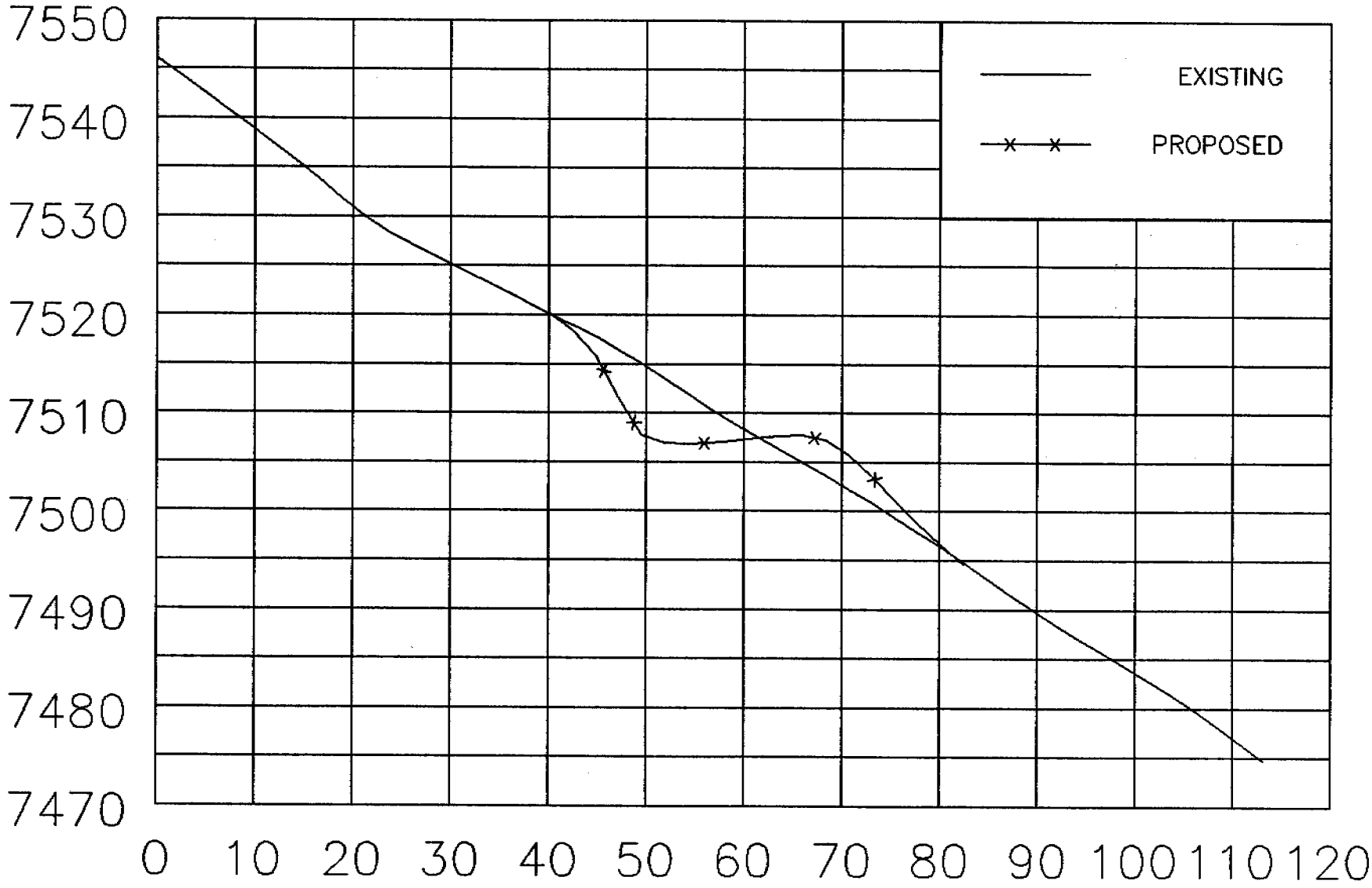
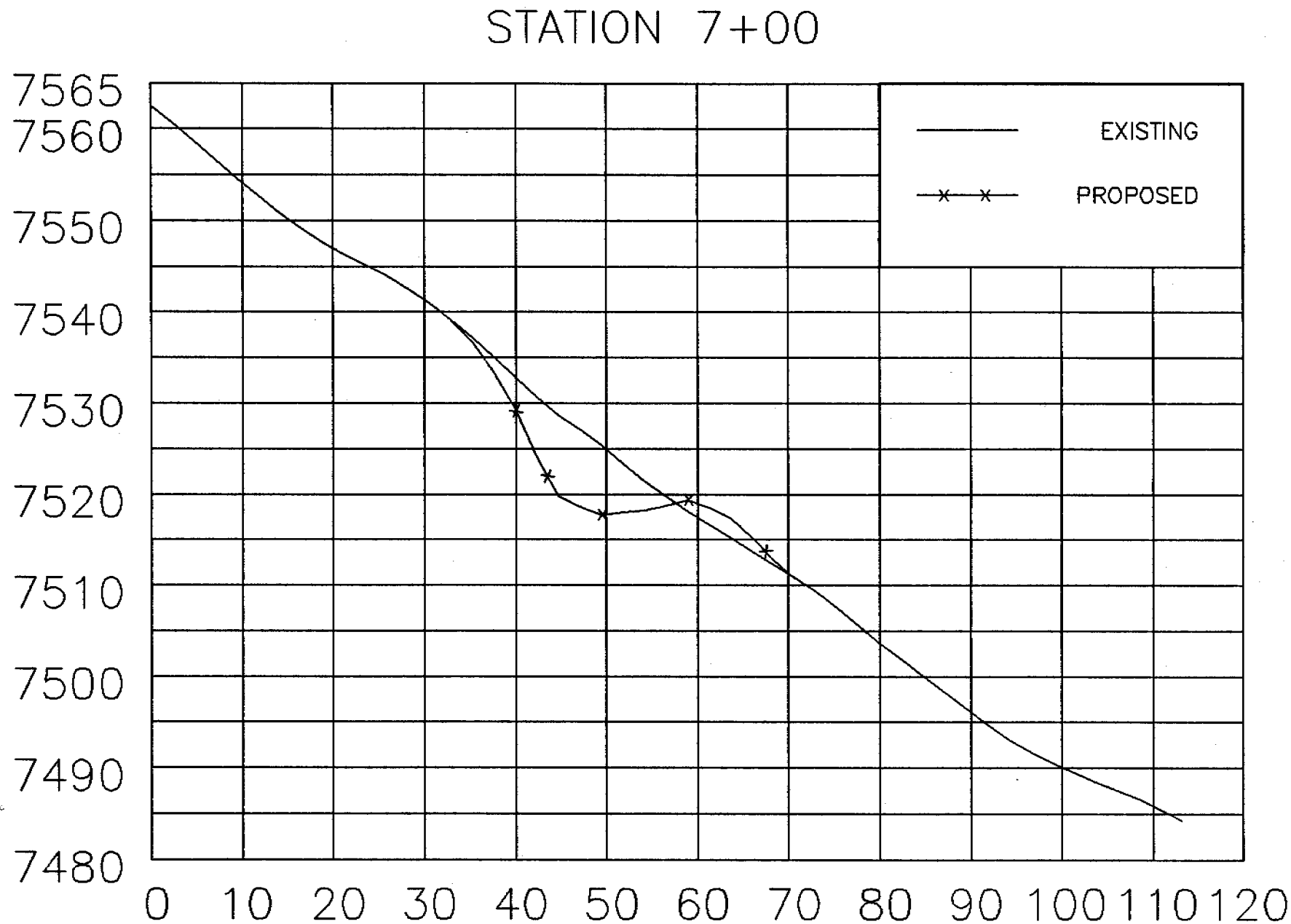
STATION 6+00




STATION 7+00
7565
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7540
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3H-21

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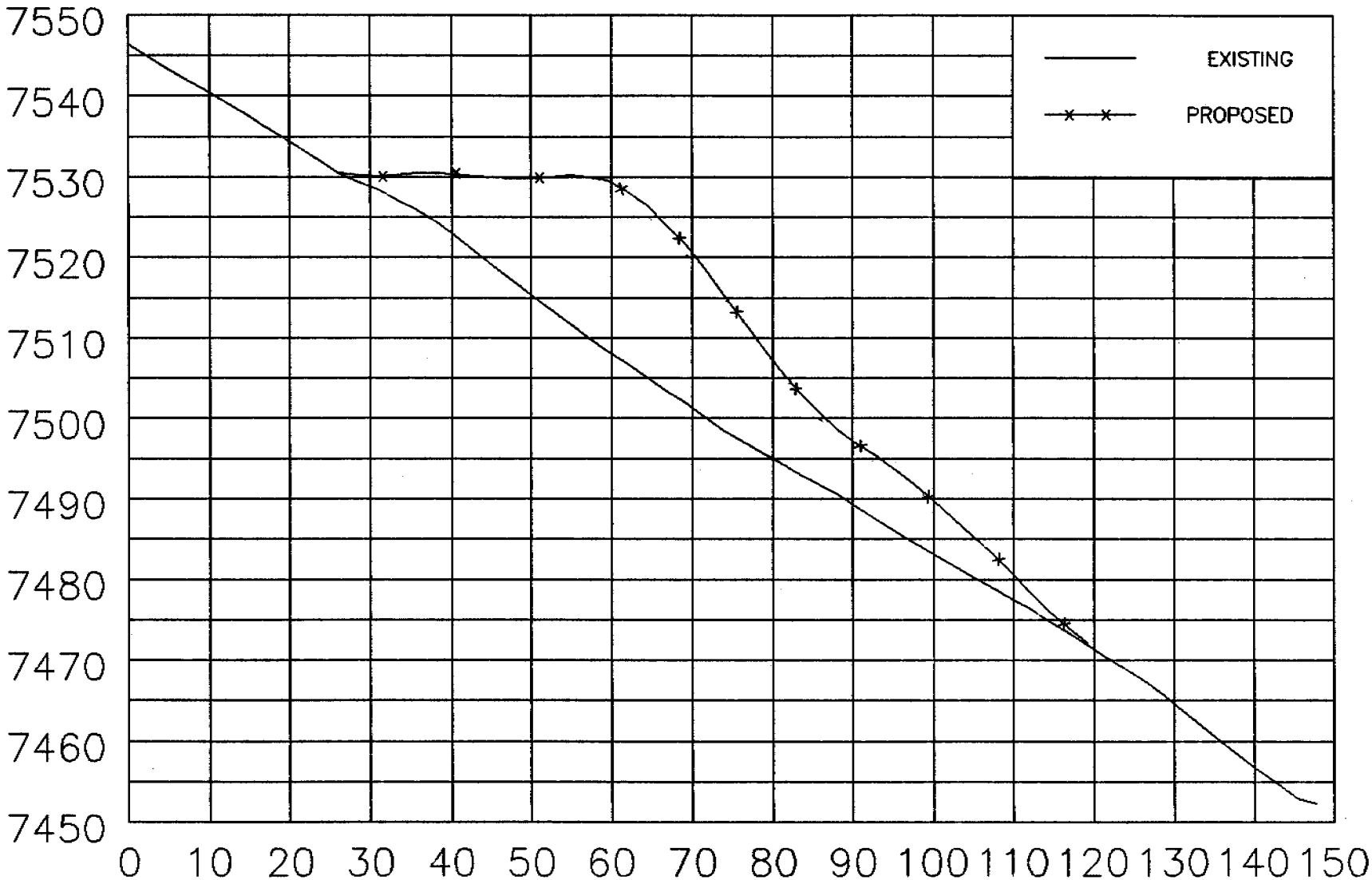
4/20/94

STATION 8+00



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3H-22

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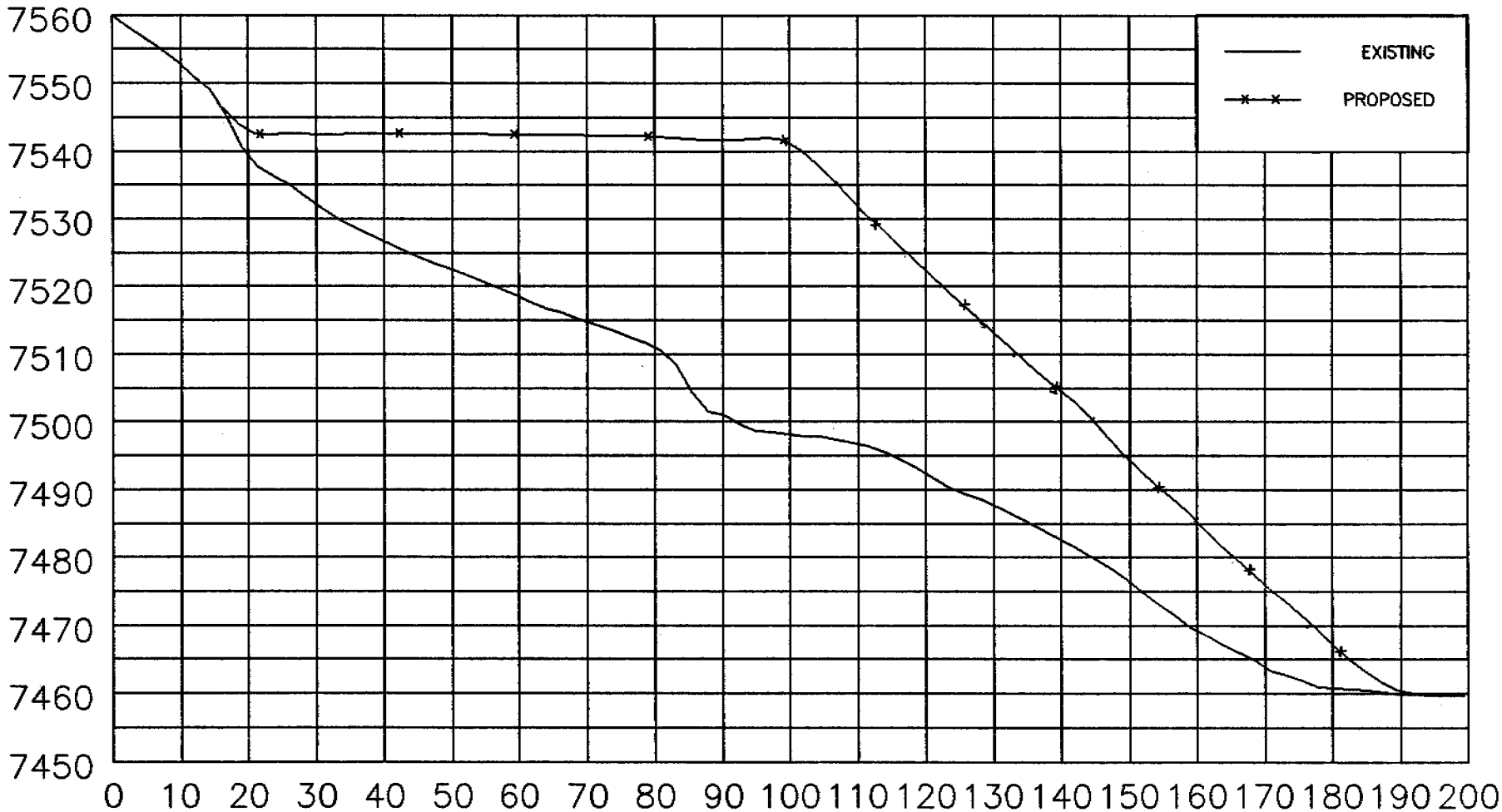
STATION 9+00



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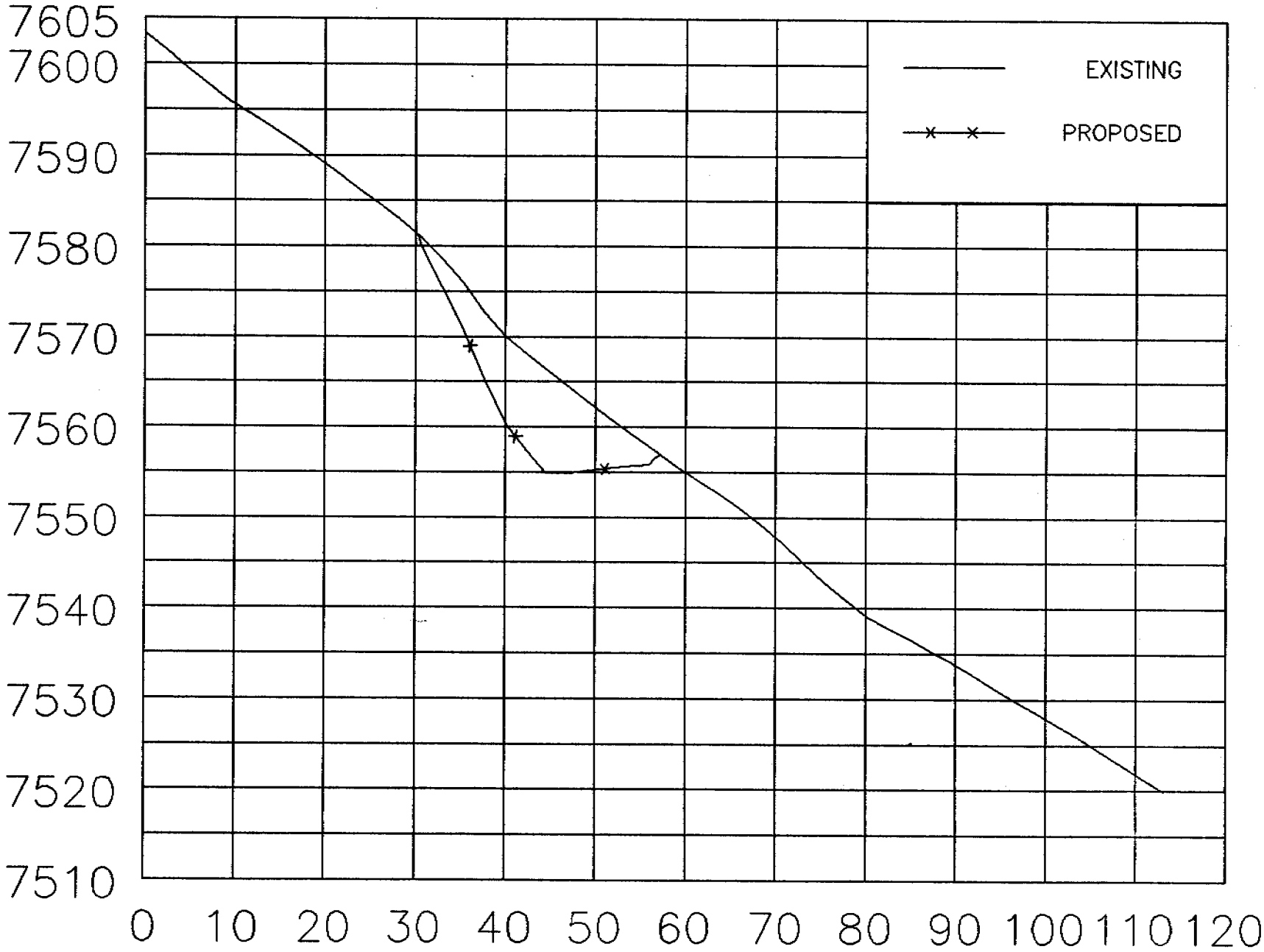

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4/20/94

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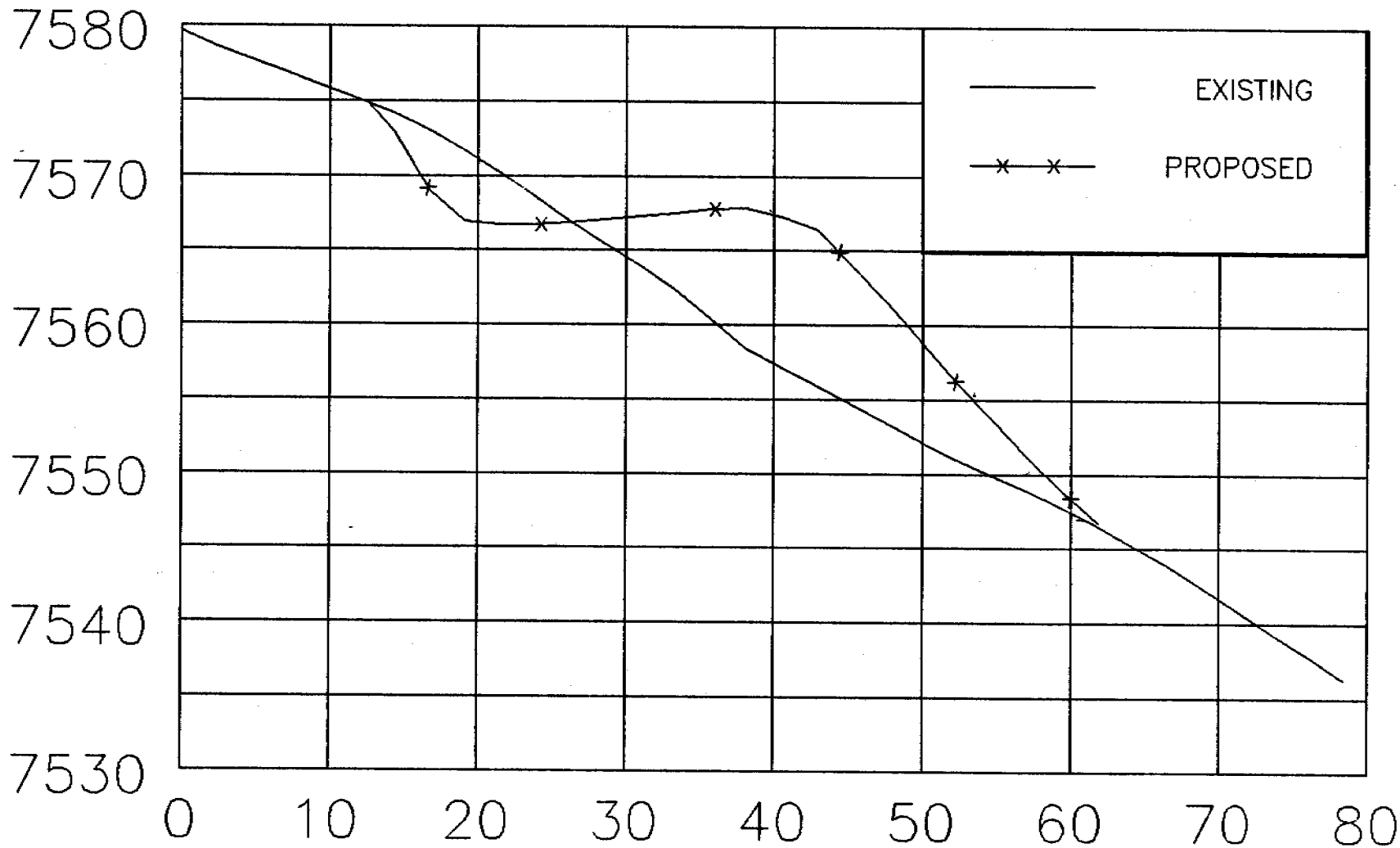

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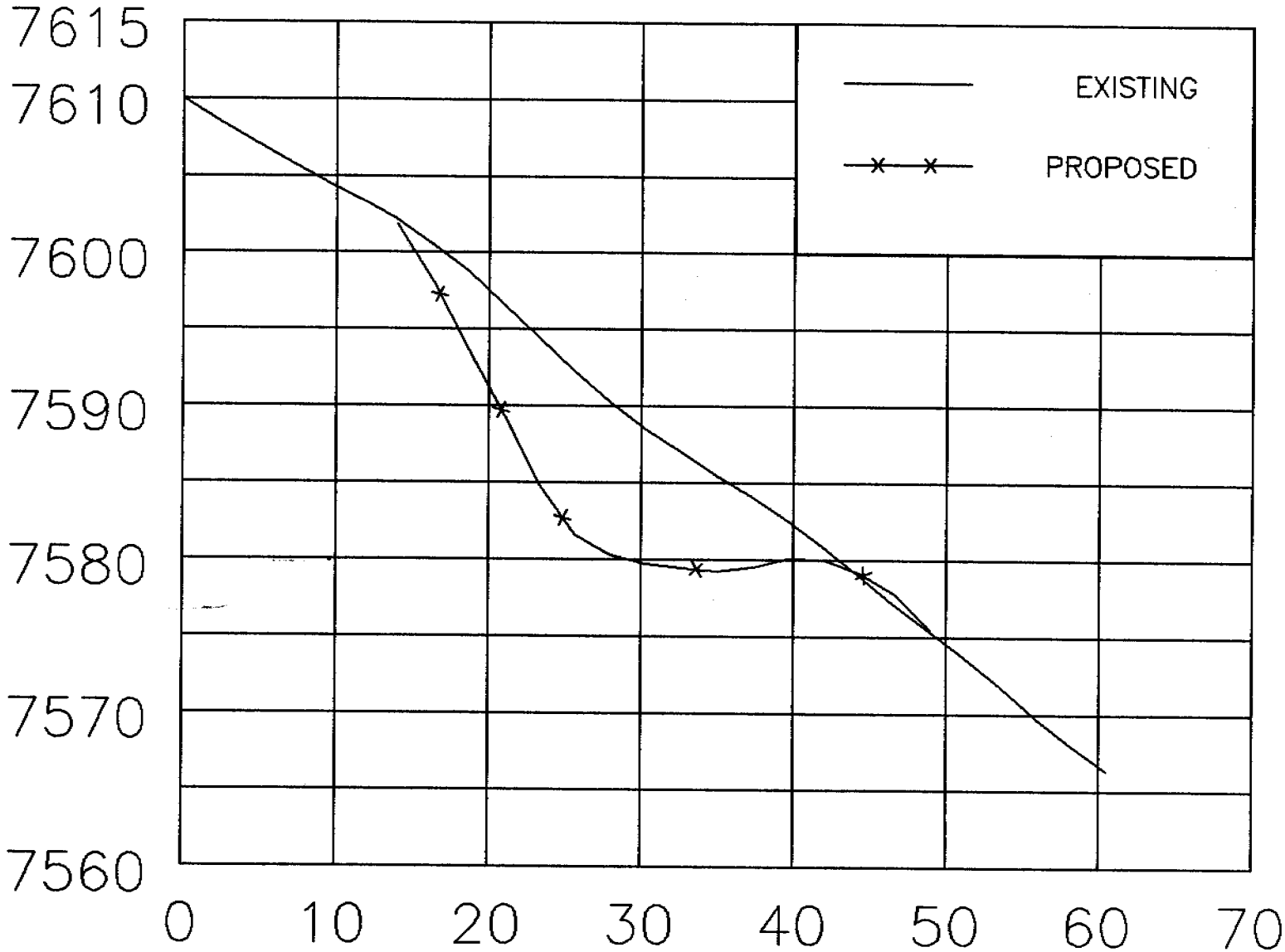

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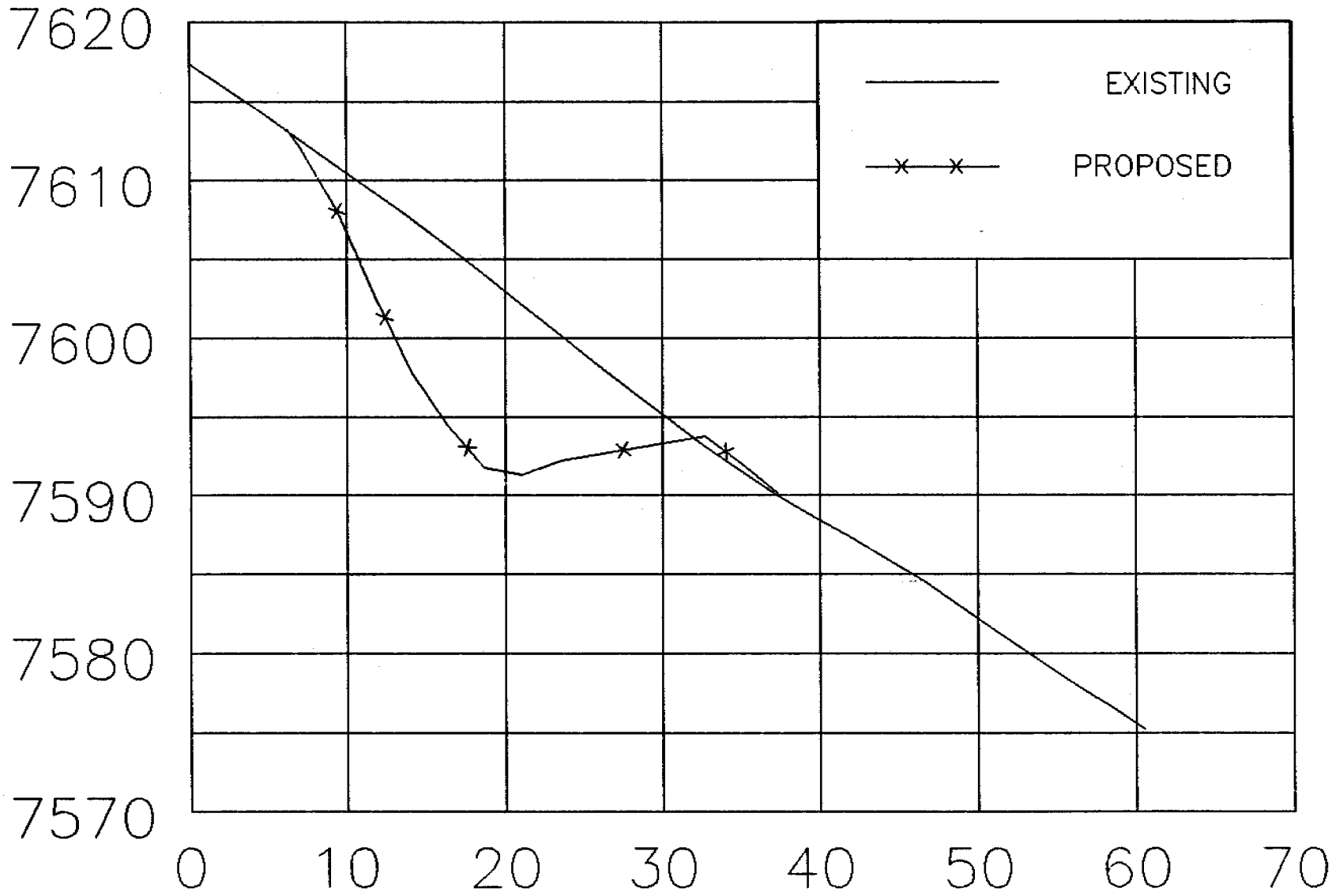

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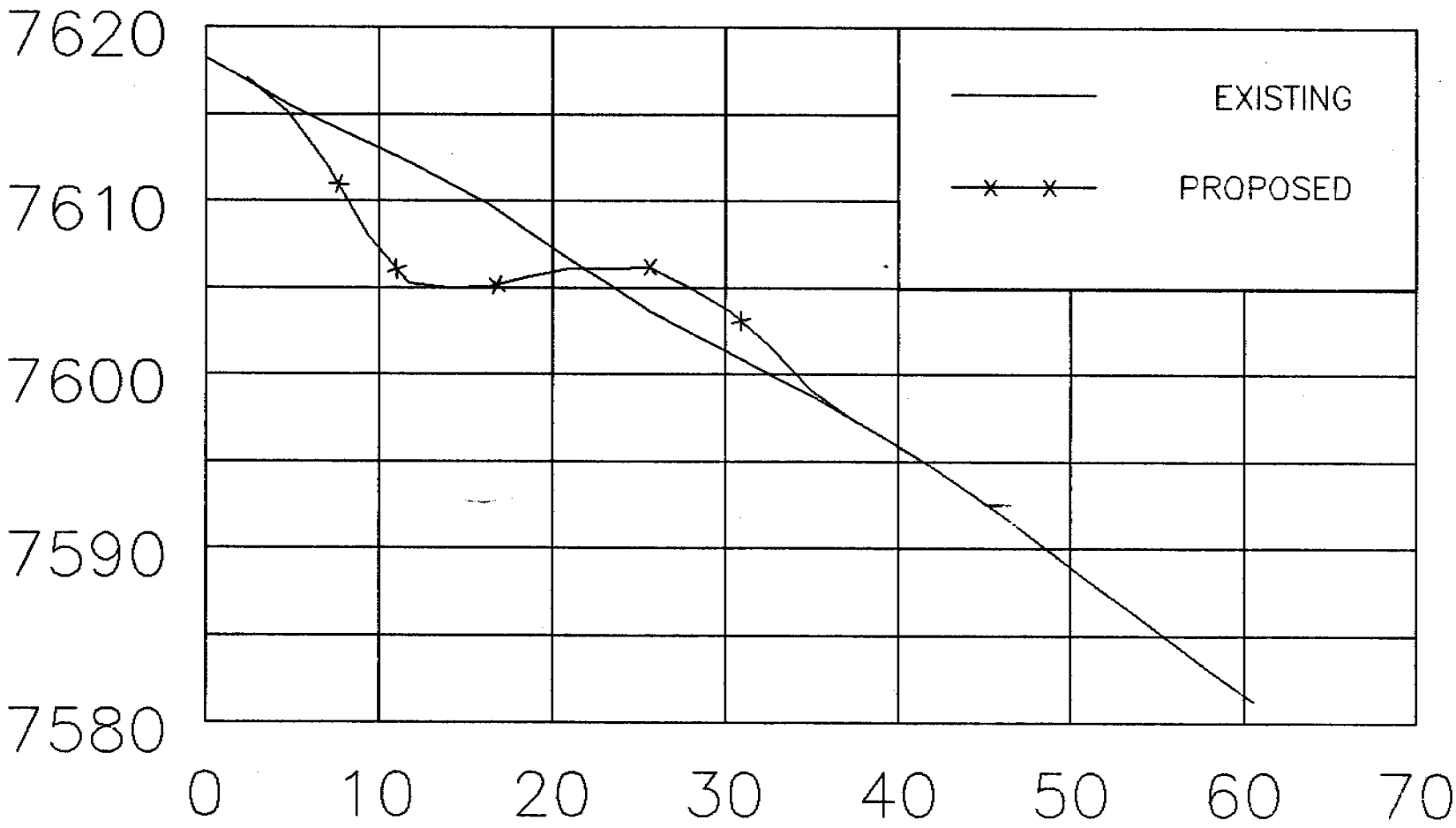

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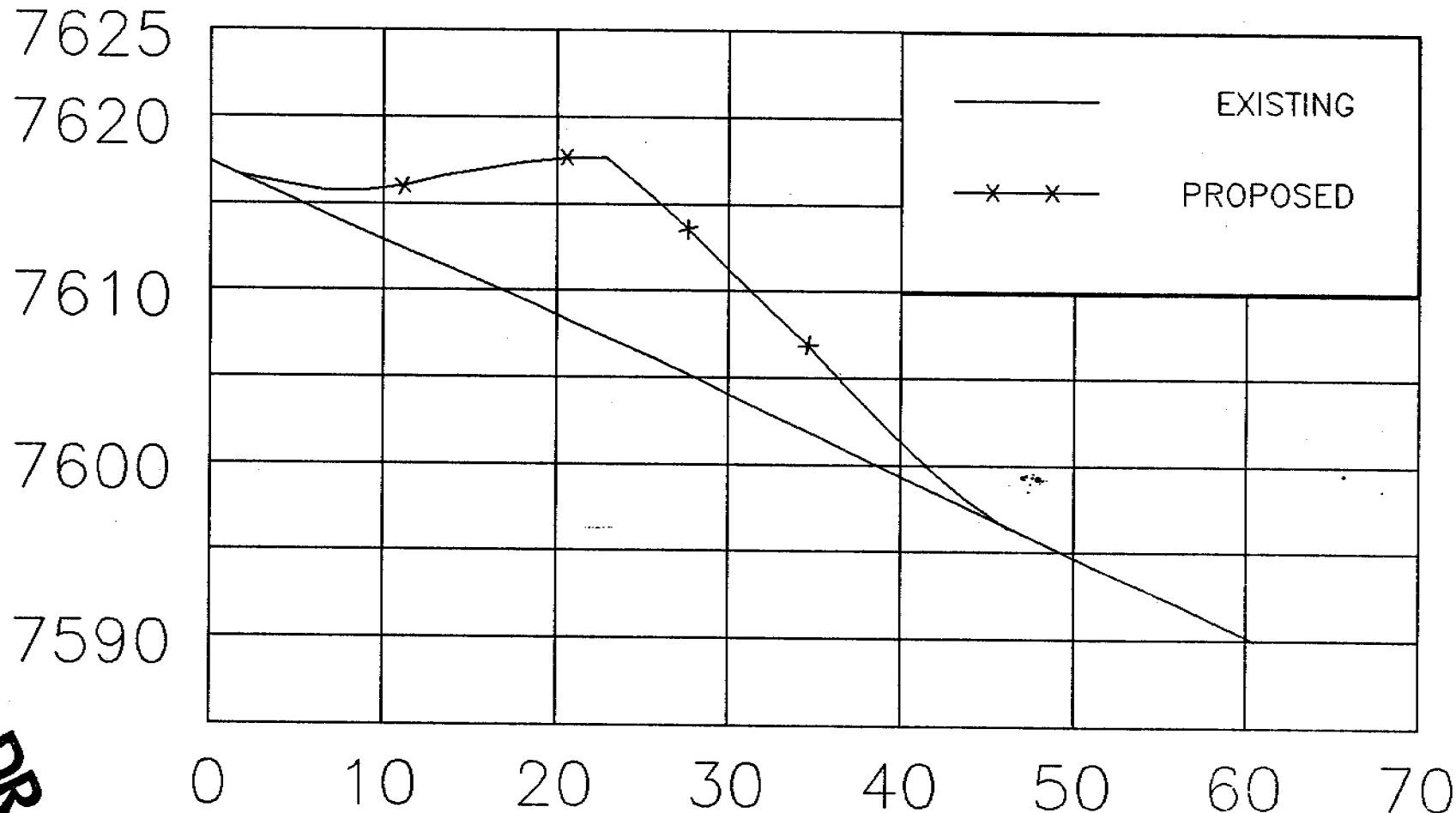

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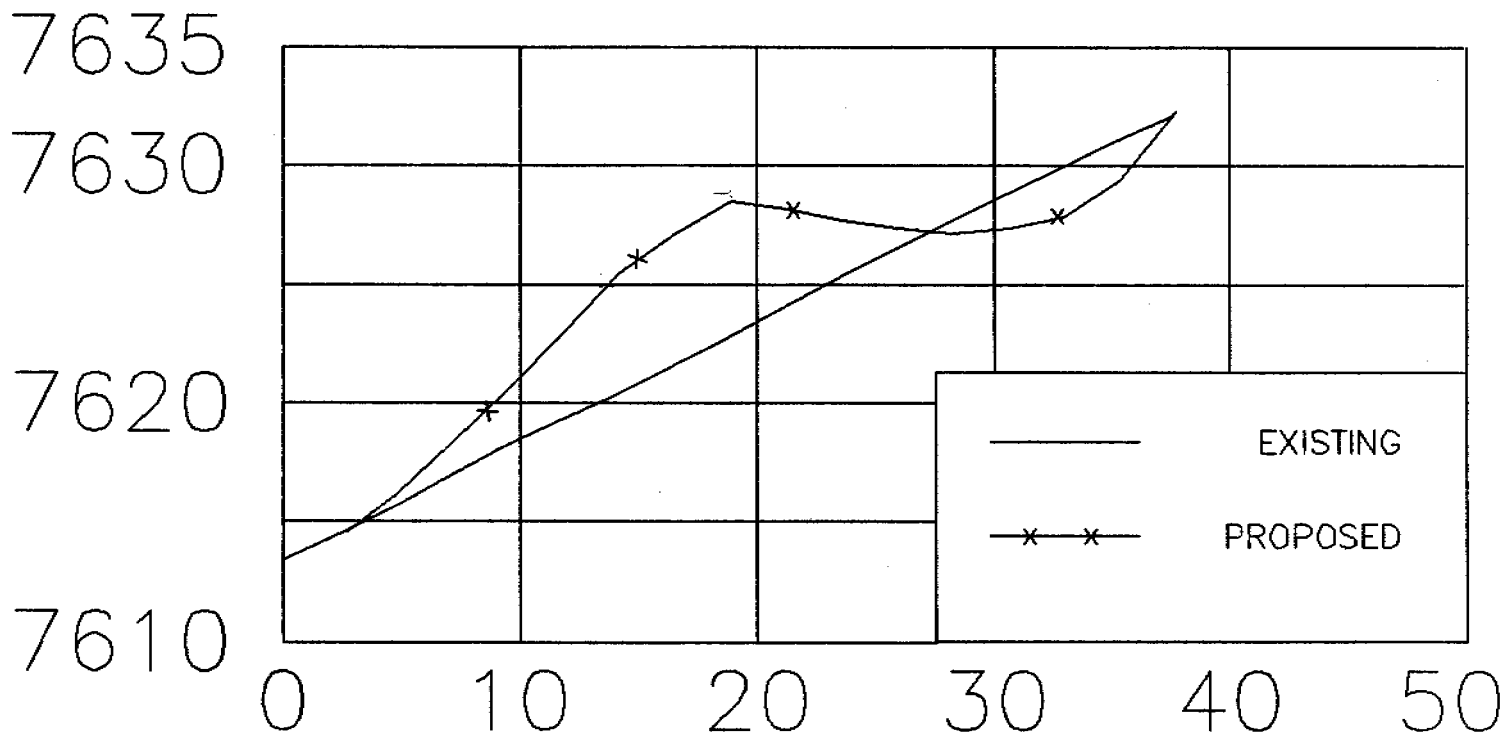

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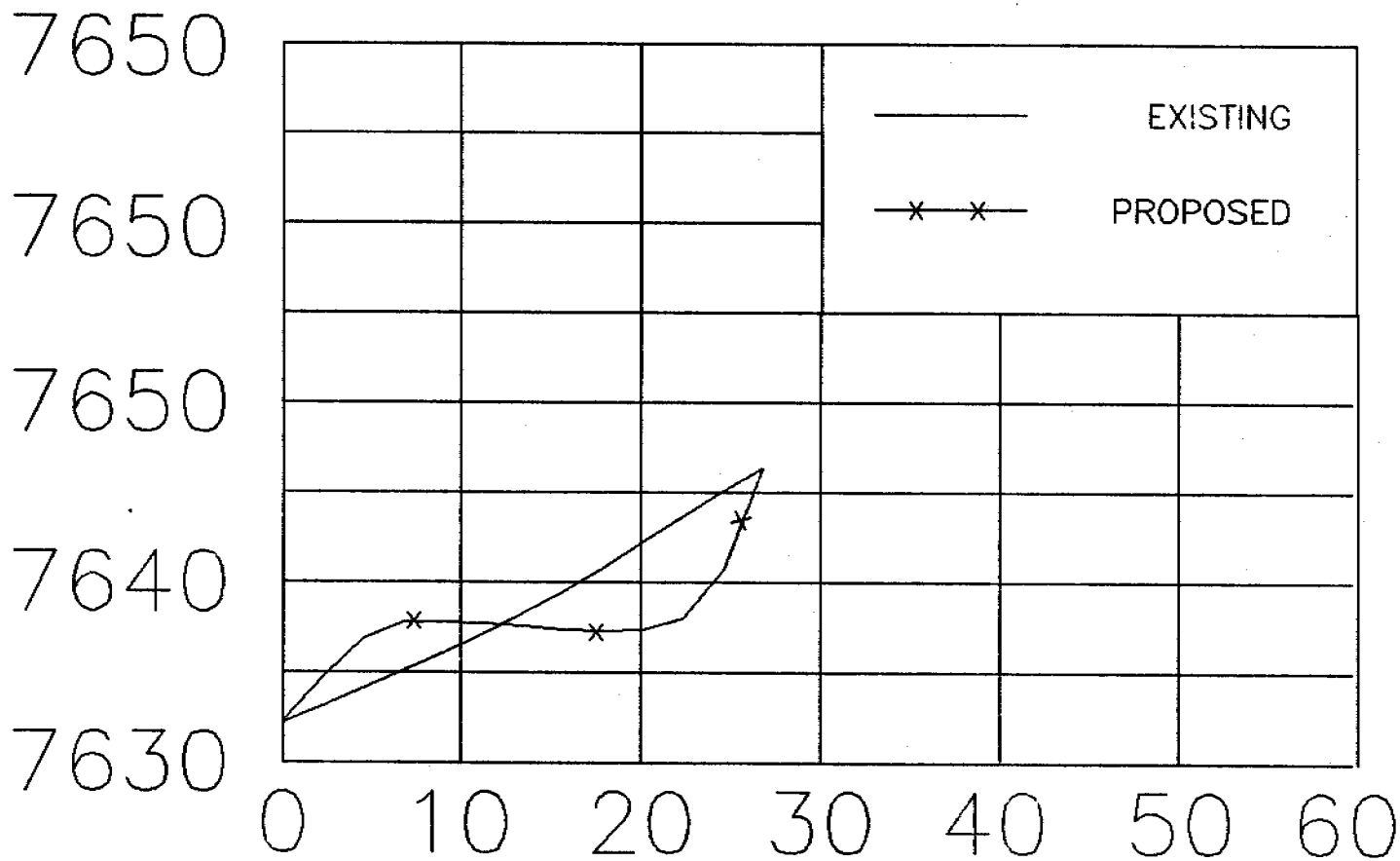

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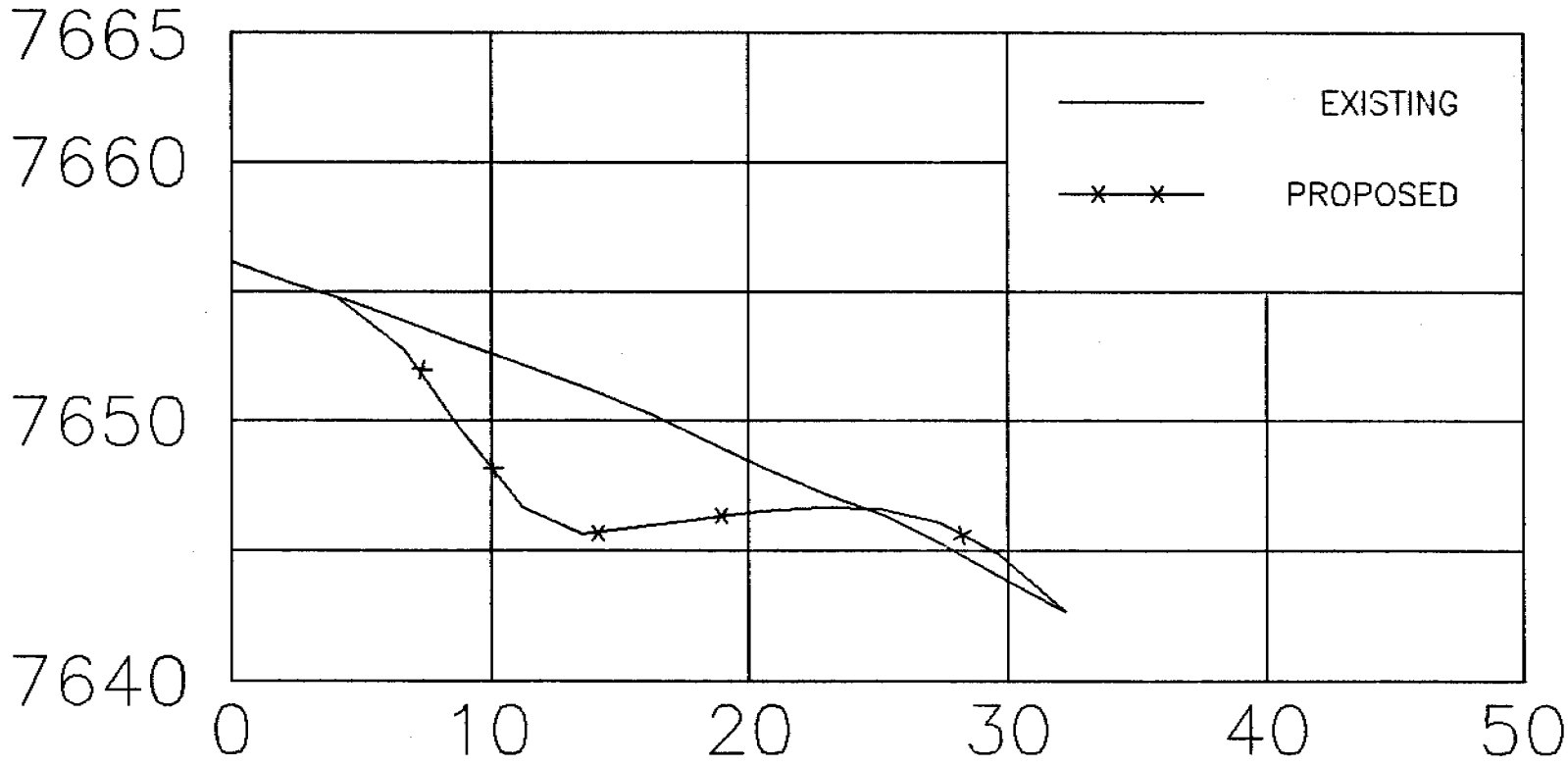

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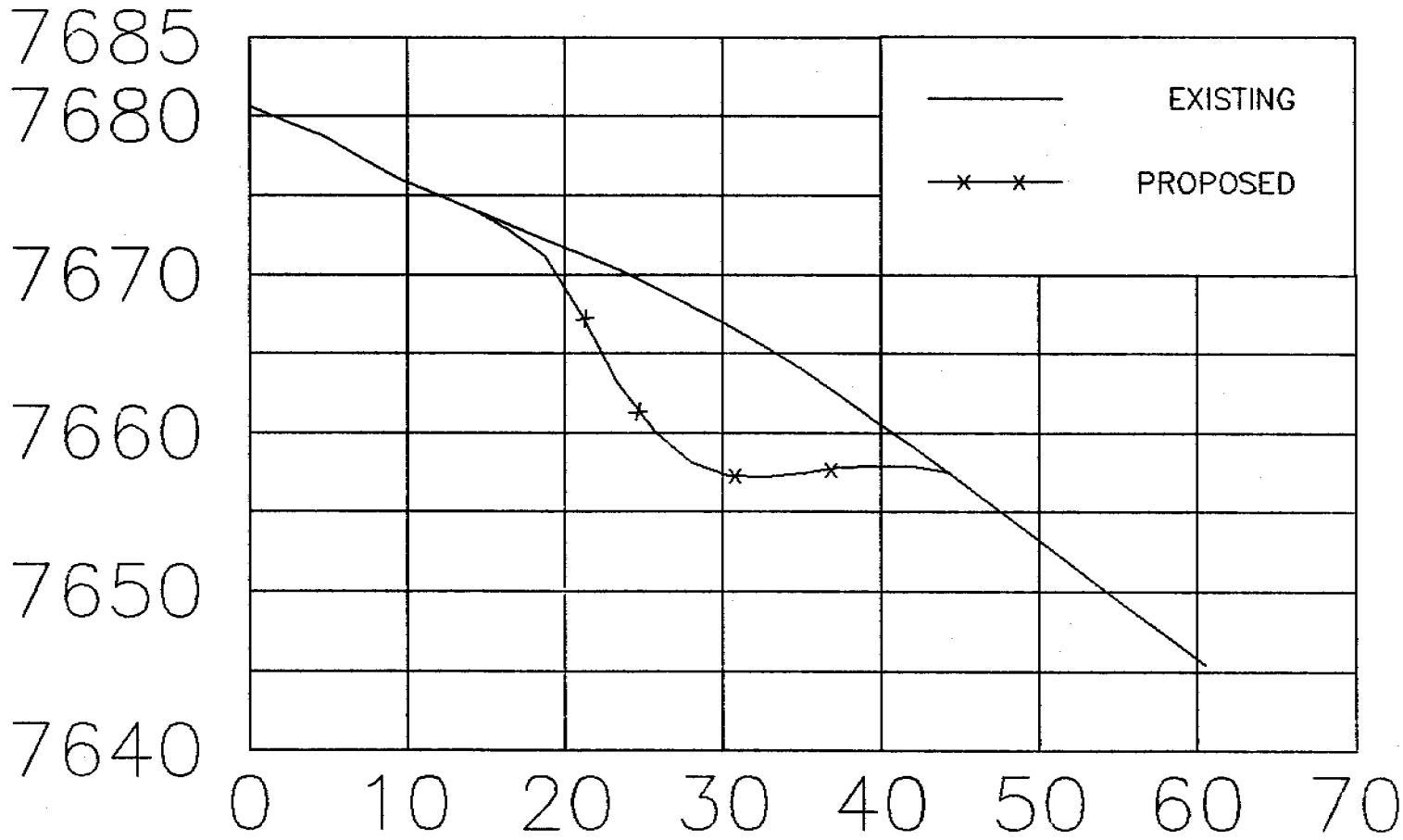

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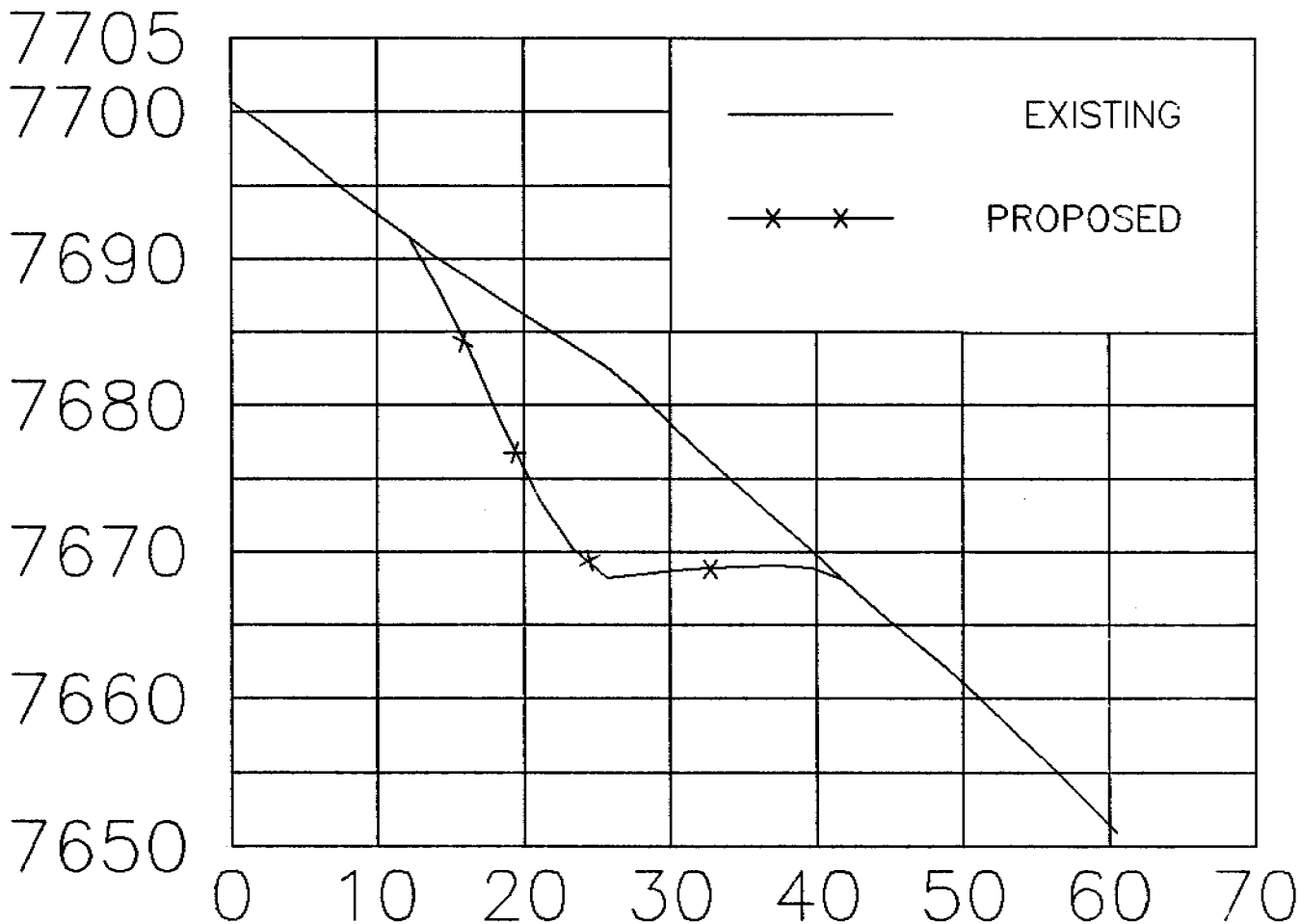

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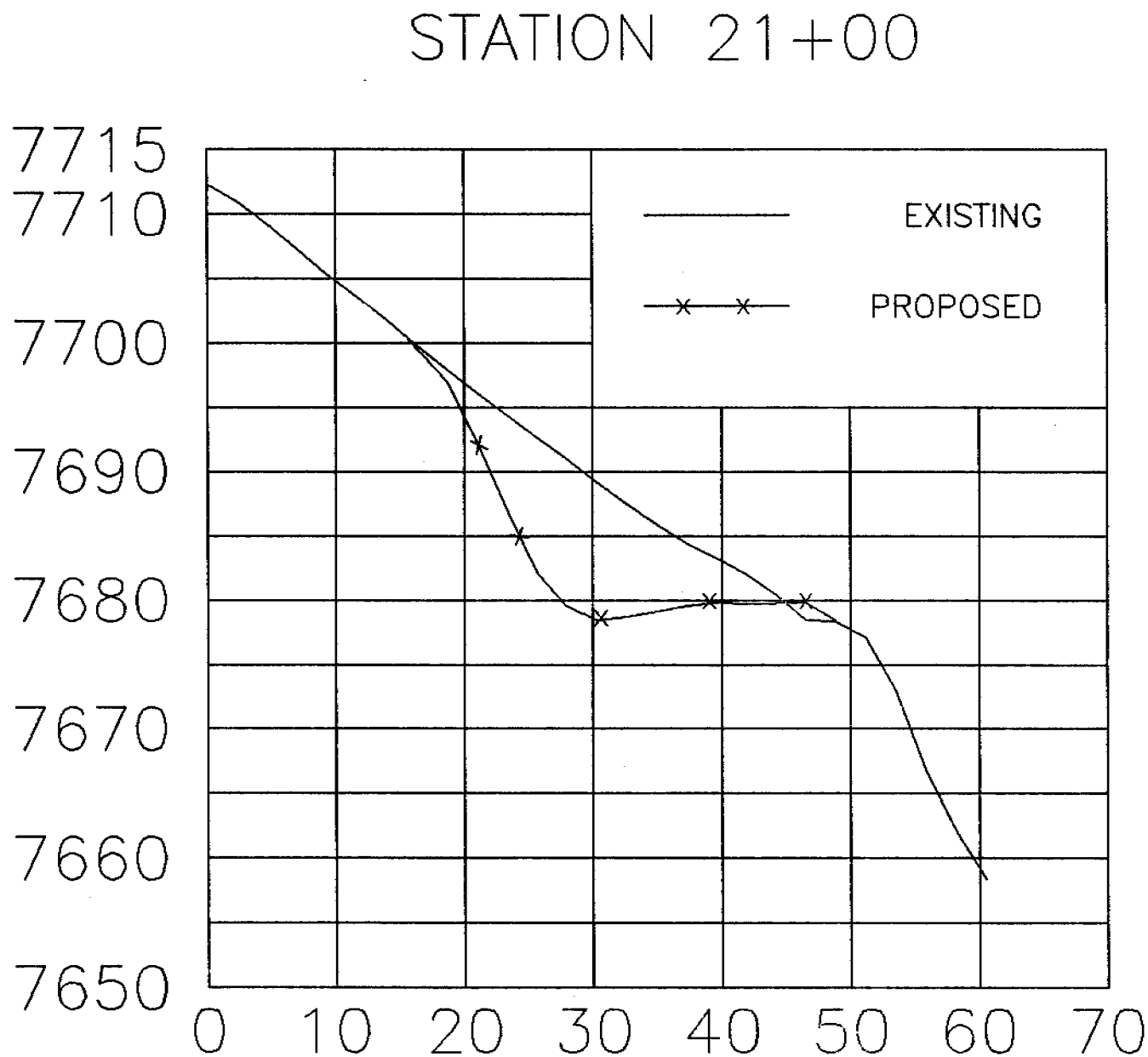
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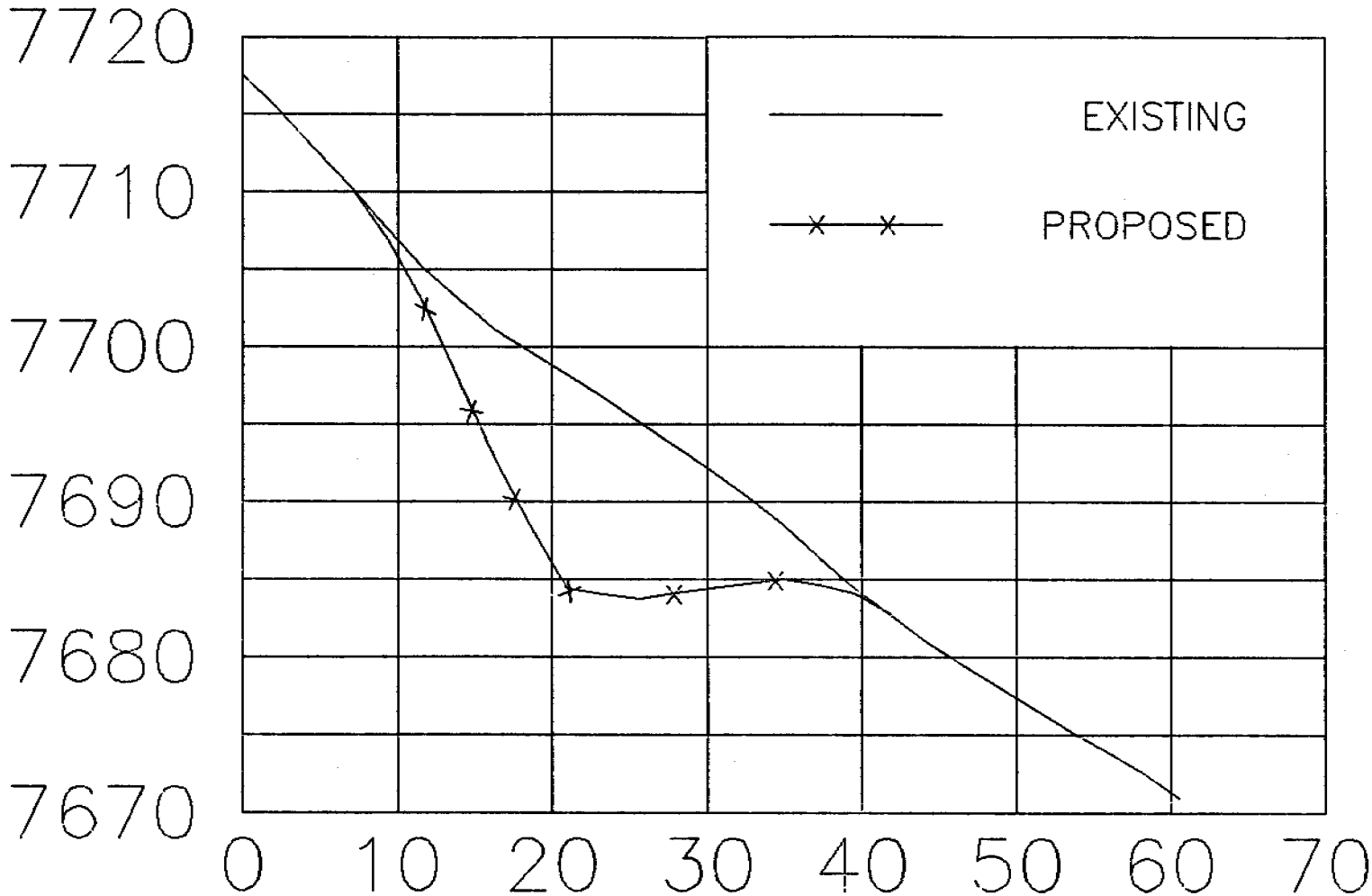

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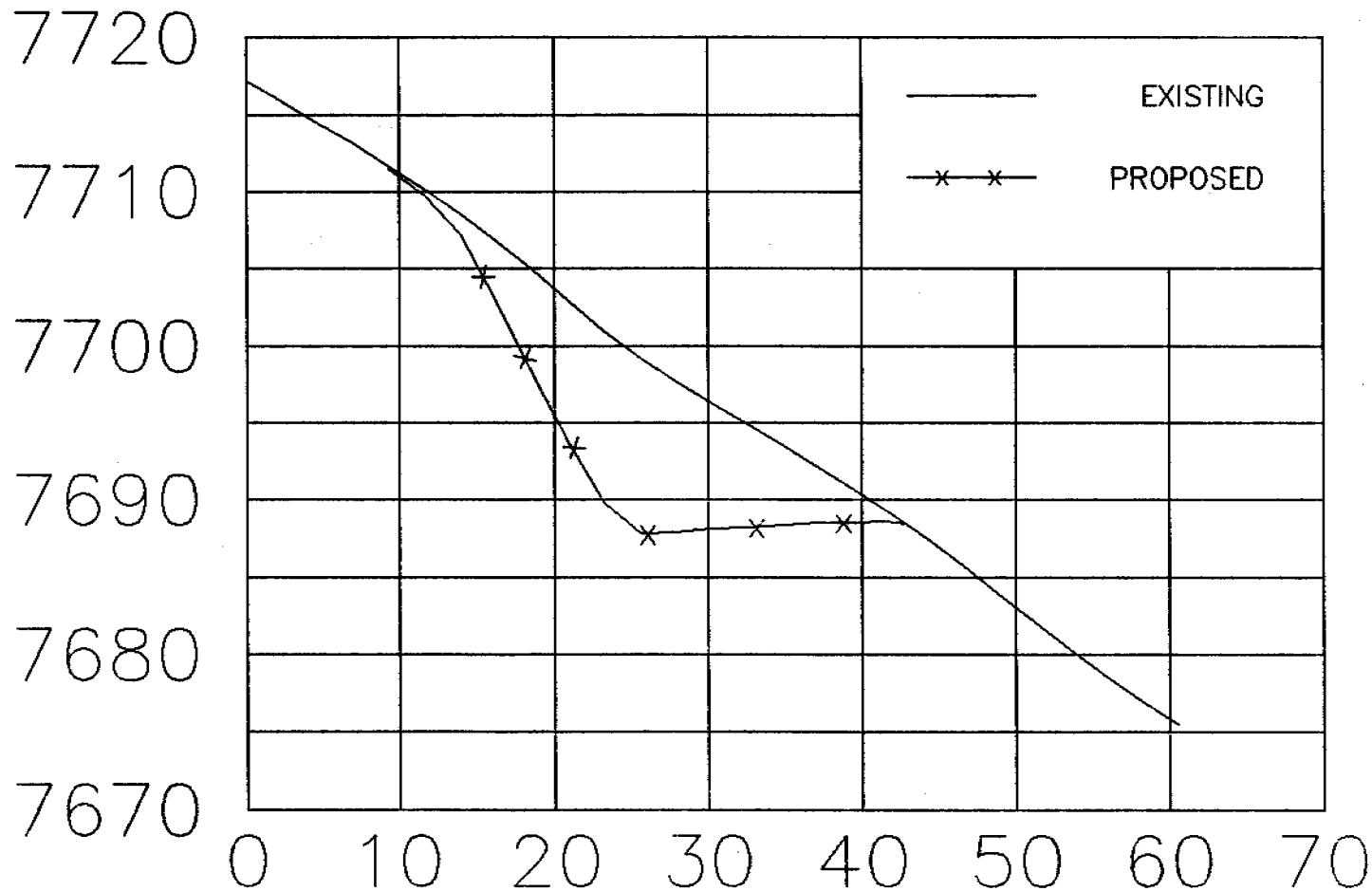

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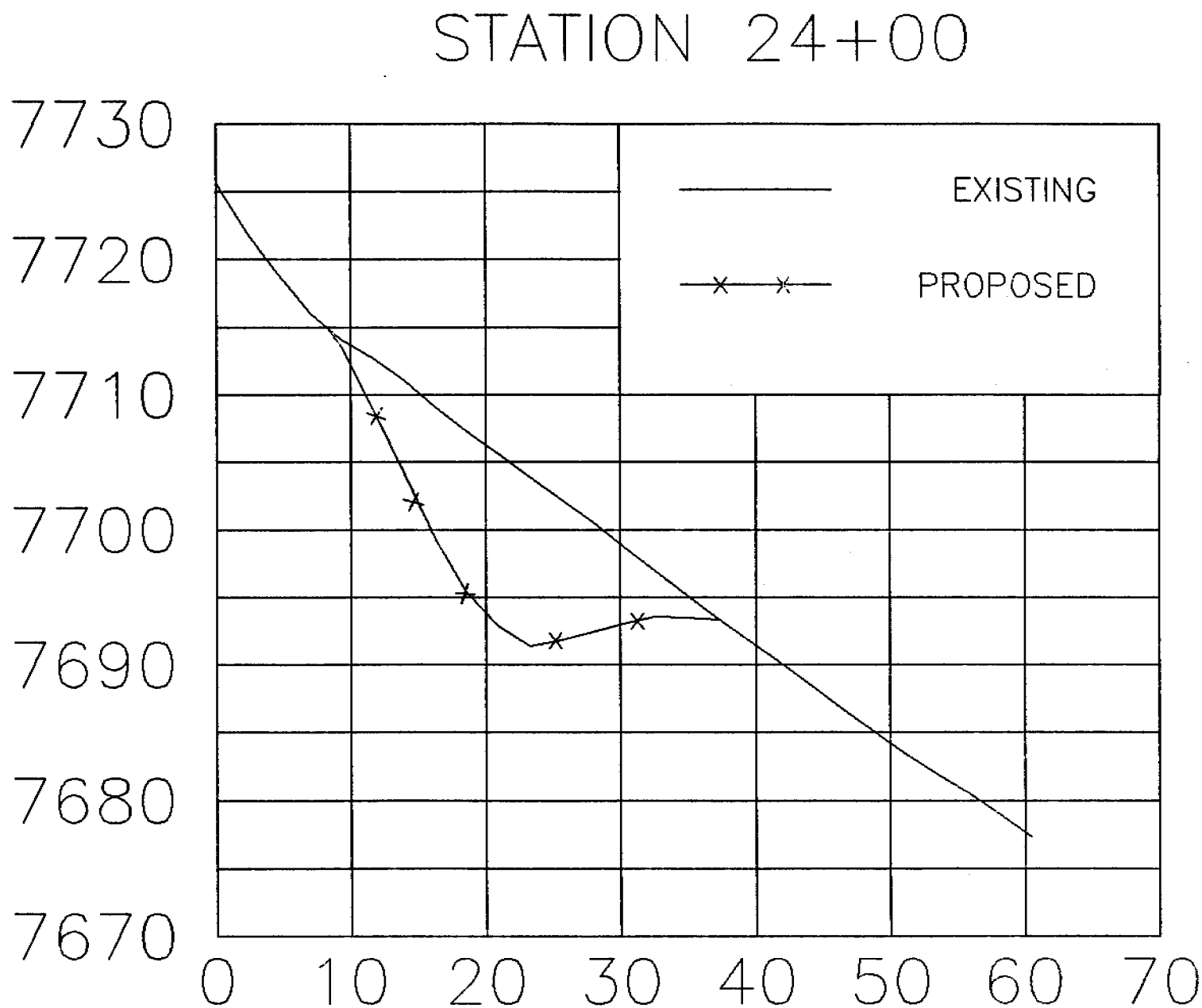
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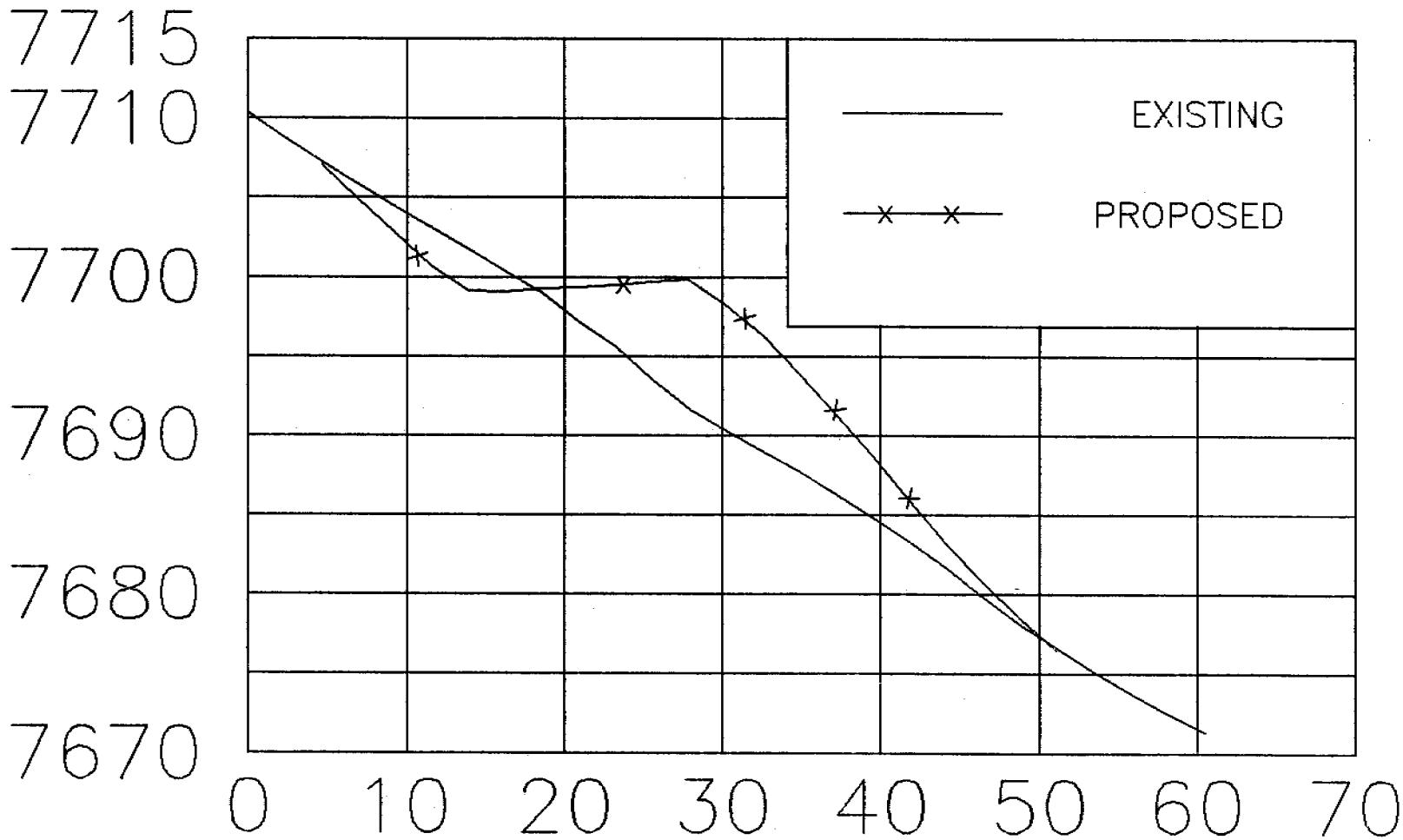

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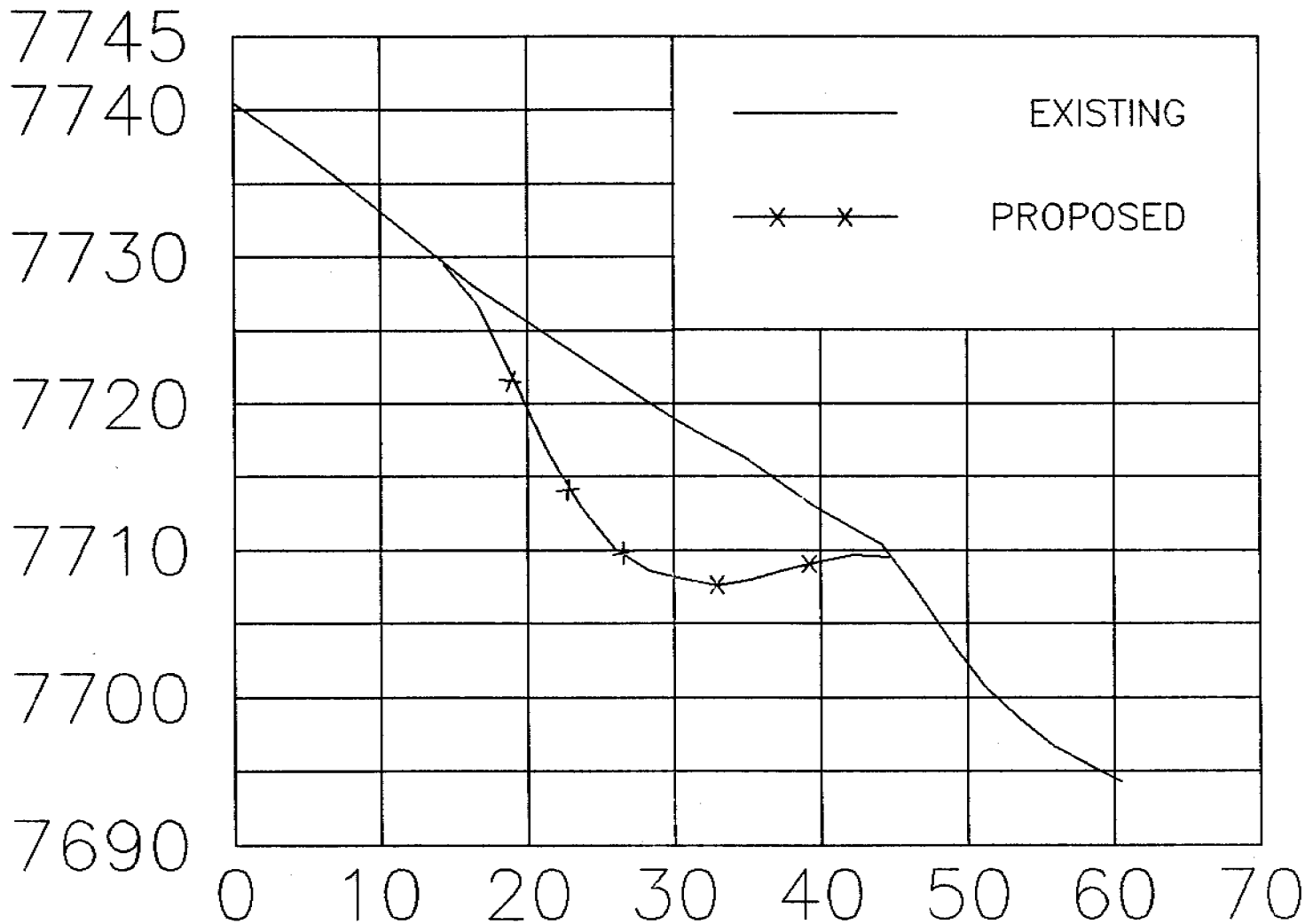

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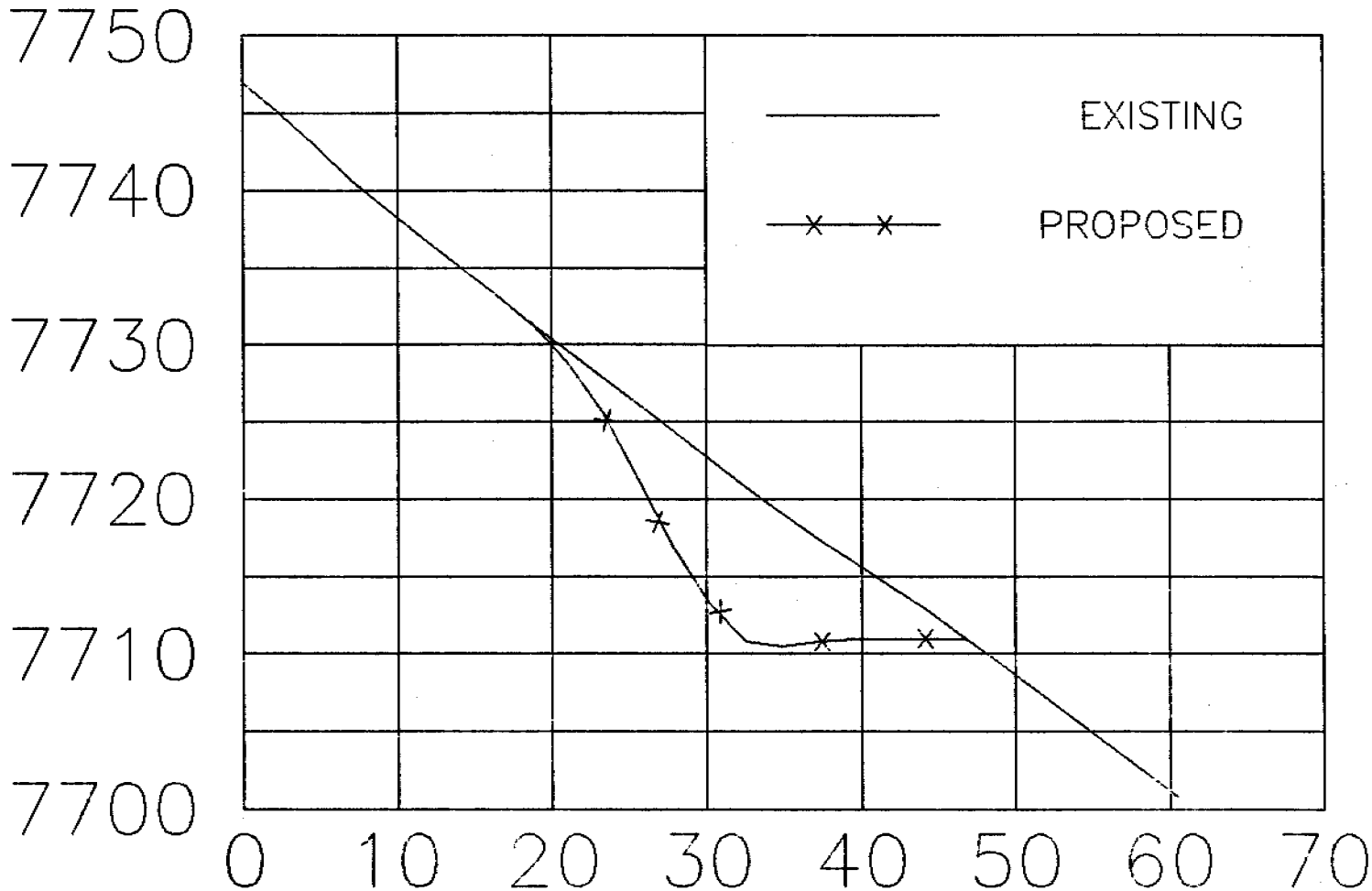

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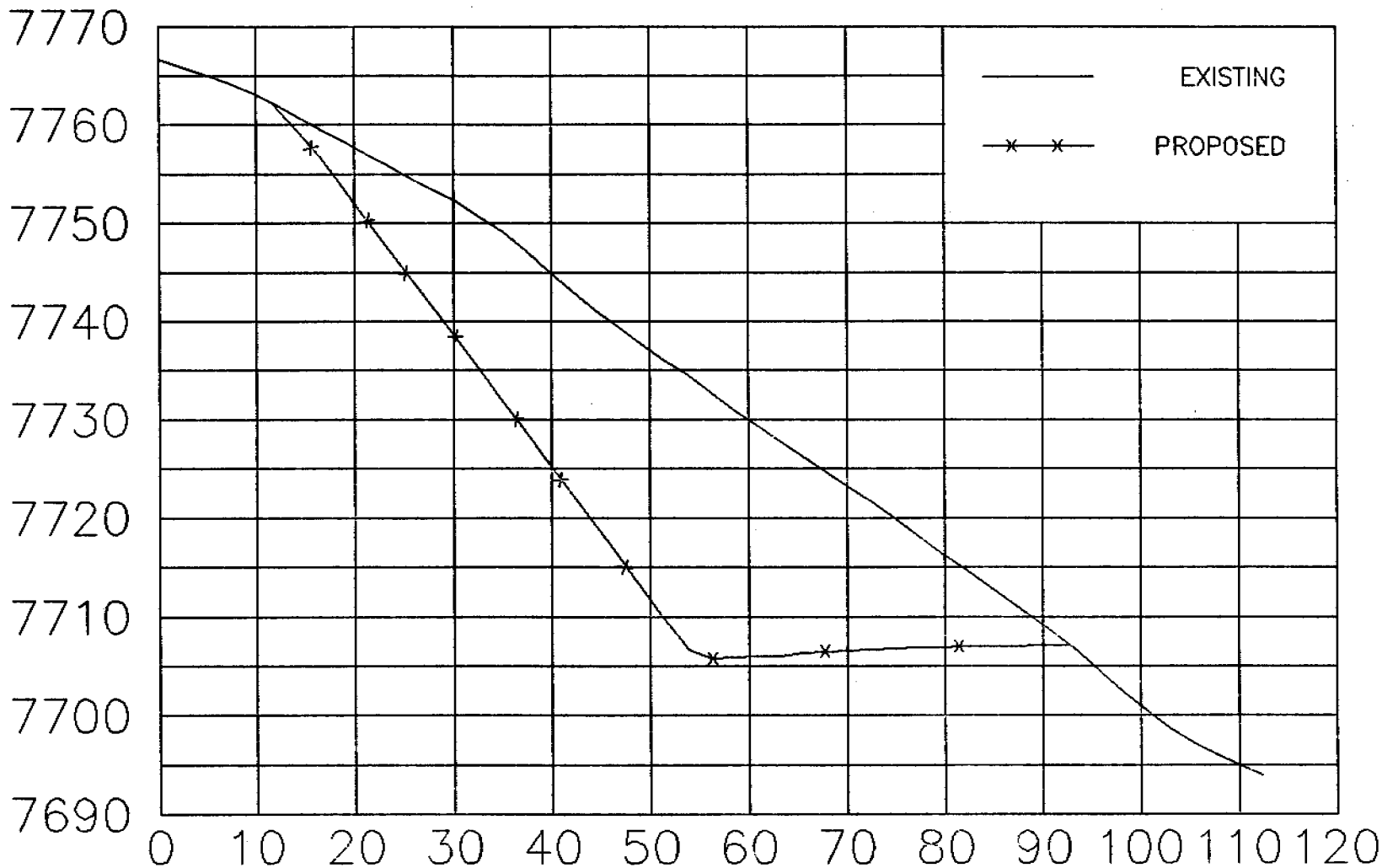

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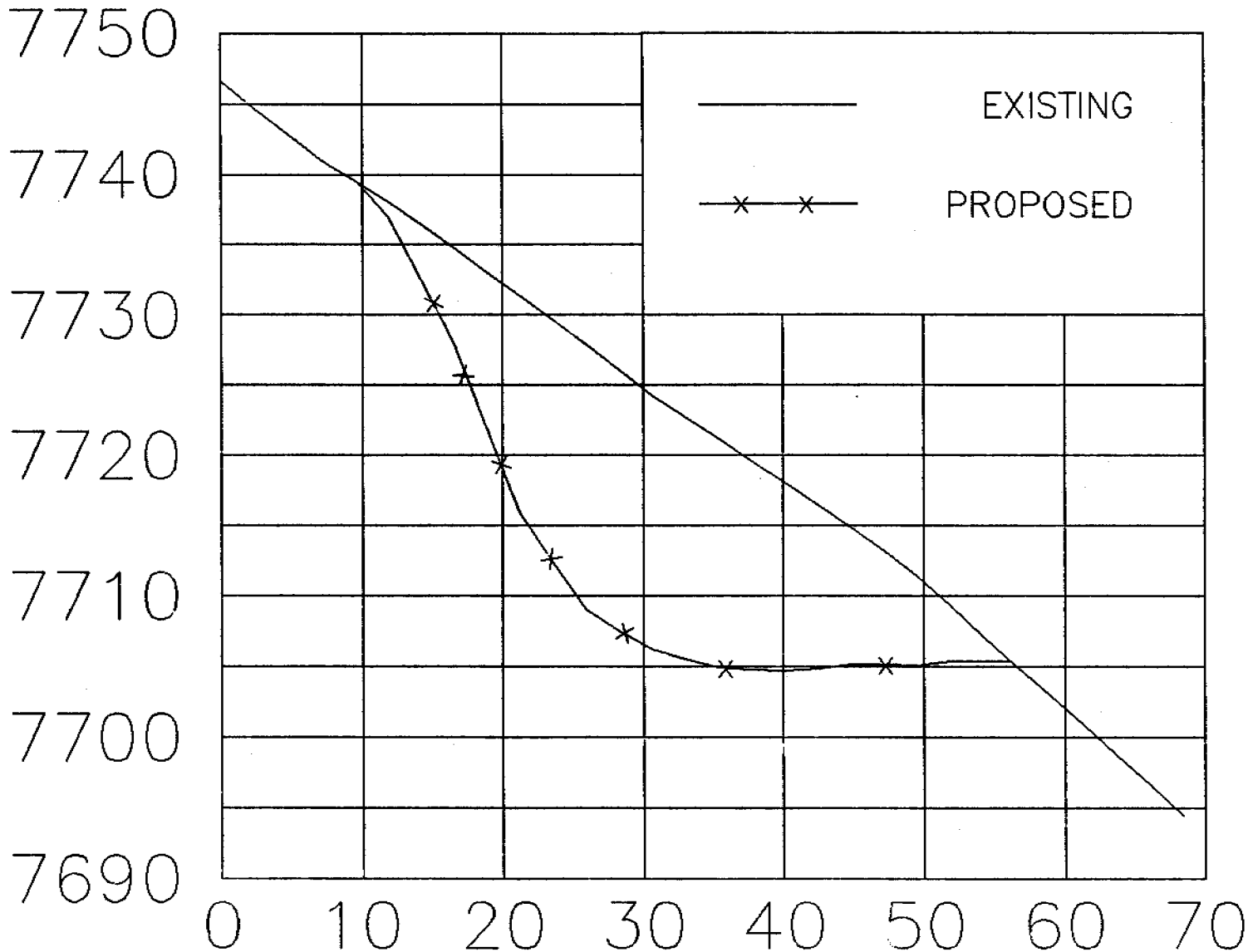

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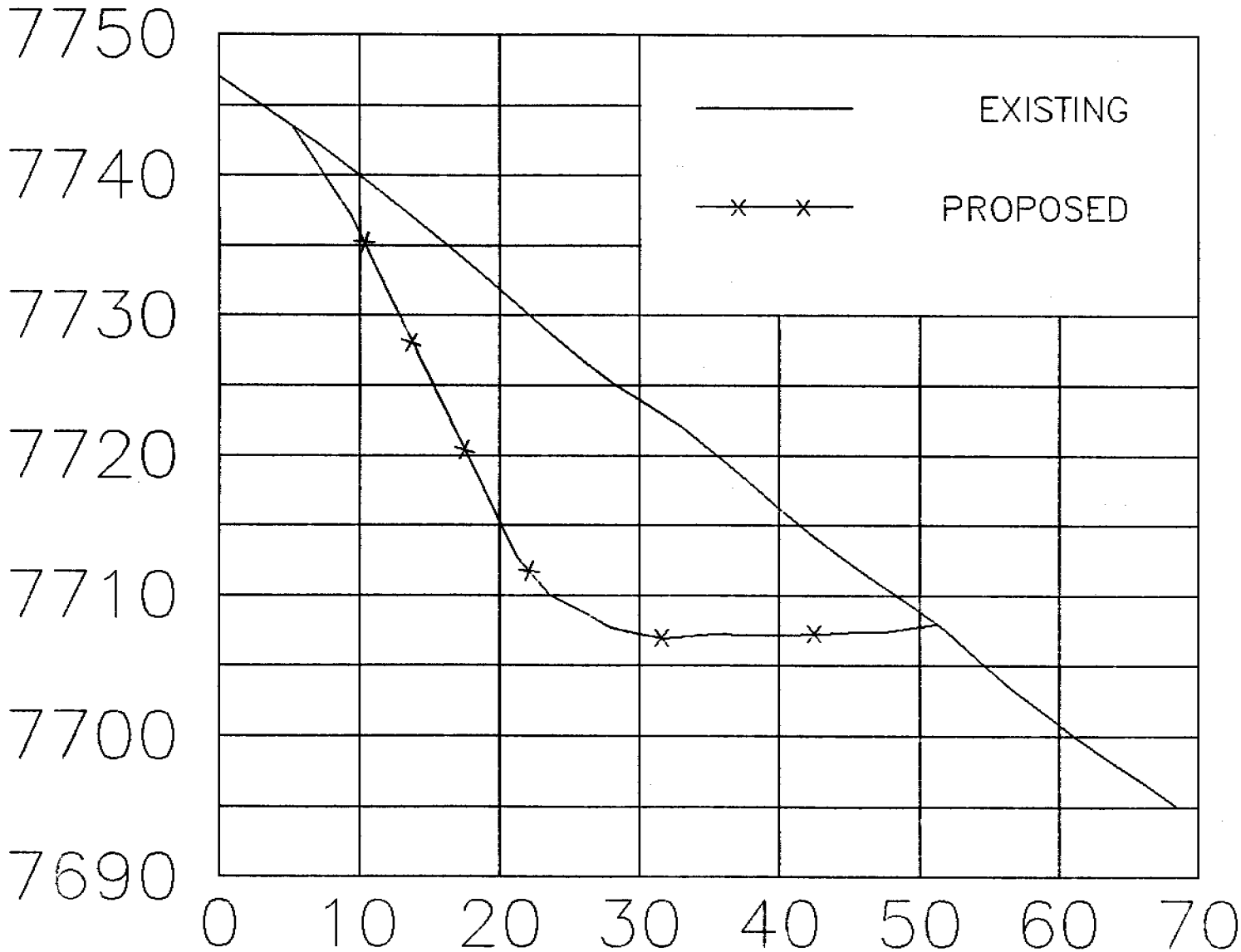

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TANK SEAM ACCESS ROAD

SLOPE STABILITY ANALYSIS

DRAFT

DAMES & MOORE

127 SOUTH 500 EAST, SUITE 300, SALT LAKE CITY, UTAH 84102-1959
(801) 521-9255 FAX: (801) 521-0380

May 6, 1994

CO-OP Mining Company
P.O. Box 1245
Highway 31
Huntington Canyon
Huntington, Utah 84528

Attention: Mr. Charles Reynolds
Mining Engineer

Report
Geotechnical Consultation
Tank Seam Portal Access Road
Job No. 27437-001-162

INTRODUCTION

An initial report addressing the stability of the Tank Seam Portal Access Road, dated September 16, 1993 was previously sent to CO-OP Mining Company. Several initial concepts concerning road construction have been re-evaluated. This report updates the initial report and incorporates latest construction concepts.

CO-OP Mining Company proposes to construct an access road in Bear Creek Canyon to the Tank Coal Seam located at an elevation of approximately 7,720 feet. The general location of the proposed road relative to existing coal facilities is shown on Plate 1, Plot Plan.

On August 30, 1993, Wendell Owen and Charles Reynolds contacted Dames & Moore and requested that the design cut and fill slopes of the proposed extension of the existing access road at the Bear Creek Mine be evaluated. CO-OP Mining Company plans to commence underground mining of the Tank Seam which is above the Bear Creek Seam currently being mined. On September 2, 1993, an engineering geologist from the Salt Lake City office of Dames & Moore made a reconnaissance of the proposed access road alignment accompanied by Charles Reynolds, Project Mining Engineer for CO-OP Mining Company. Observations and recommendations resulting from that reconnaissance and subsequent analyses are presented in this report.

BACKGROUND

CO-OP Mining Company is in the process of expanding its underground coal mining operation and proposes to mine the Tank Coal Seam approximately 300 feet above the Bear Creek Seam currently being mined. To access the Tank Seam, CO-OP Mining Company proposes to extend the existing access road from the Bear Creek Portal, at elevation 7,440 feet, to the Tank Seam portal area, at an elevation of approximately 7,720 feet.

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OFFICES WORLDWIDE

An engineering geologist and a geotechnical engineer from Dames & Moore visited the site in 1980 and performed a reconnaissance survey of the area prior to the construction of the Bear Creek Portal access road. That road was built with cut slopes in rocky slope wash (colluvium) using side-cast construction. The road has been serviceable with little or no maintenance problems since construction was completed. Two letter reports addressing the Bear Creek Portal Access Road cut and fill stability were provided to CO-OP Mining Company, dated December 29, 1980 and February 20, 1981.

EXCEPT an increase in the Disturbed Area From Erosion

The proposed access road to the Tank Seam Portal is expected to be 14 feet wide with a drainage ditch and safety berm. The total width may approach 20 feet. Planned construction is expected to be achieved through cut and fill methods.

SITE CONDITIONS

The general location of the Tank Seam Portal Access Road is shown on Plate 1, Plot Plan. The access road will be constructed by cut and fill methods. The average natural slope angle of the slopes across which the Tank Seam access road must traverse is approximately 35 degrees. The majority of material to be excavated is expected to consist of fine to coarse gravel, cobble, and boulder sized pieces of sandstone in a matrix of sand and clayey silt. This material generally has a slight to medium dry strength due in part to the presence of calcium carbonate cementation. Some natural slopes in this material are standing vertically up to a height of 15 feet.

Bedrock of moderately hard to hard, fine to medium grained, bedded sandstone is present as scattered outcrops throughout the slope. Most of the outcrops form prominent near horizontal ledges on the slopes. Vertical joints form boulder sized blocks in the bedrock which in turn produce angular boulder and cobble sized rock fragments that are scattered across the slope surface. Occasional juniper and pinon pine trees as well as sage brush and other large shrubs comprise the majority of vegetation on the slopes.

SOIL CONDITIONS

During the reconnaissance of the Tank Seam Portal Access Road, two soil samples were obtained to determine the engineering properties of the soil. The approximate locations where the soil samples were taken are shown on Plate 1, Plot Plan. The results of a partial grain size analysis are tabulated below:

SAMPLE NO.	SIEVE NO.	PERCENT FINER BY WEIGHT
1	# 4	91.6
	# 10	74.4
	# 40	62.7
	#200	27.1

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SAMPLE NO.	SIEVE NO.	PERCENT FINER BY WEIGHT
2	# 4	74.0
	# 10	65.8
	# 40	55.3
	#200	37.0

Results of Atterberg limits tests performed on material finer than the number 200 sieve for both samples are tabulated below:

SAMPLE NO.	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
1	24	19	5	CL-ML
2	22	16	6	CL-ML

These tests indicate that the finer fraction of the natural soil in the area is more silty than the soil tested previously during construction of the Bear Creek Portal Access Road.

Consolidated drained direct shear tests were performed on remolded portions of these two samples. The average strength values obtained from the direct shear tests indicate an effective stress friction angle of 32 degrees and a cohesion value of 180 psf. These soil properties were utilized in the subsequent slope stability analyses for both the cut slopes and the major fill slopes.

SLOPE STABILITY ANALYSIS

An analysis of the stability of proposed cut slopes and fill sections was performed utilizing a two dimensional, limit equilibrium stability program called PCSTABL5. For the cut slope evaluation, an automatic search routine was employed to determine the failure surfaces with the lowest factors of safety. Both random and circular failure surfaces were evaluated. For the fill section, a specified failure surface was input to represent the critical failure surface. For both analyses, a natural slope of 35 degrees was modeled considering dry conditions.

The analyses of the cut slope section considered vertical cuts, one horizontal to four vertical (1H:4V) cuts, and one horizontal to two vertical (1H:2V) cuts. Bedrock was conservatively modeled to be present 6 feet vertically below the ground surface and to trend parallel to the natural cut. The depth to bedrock along the Tank Seam Access Road is realistically expected to vary from exposures at the ground surface to depths of 2 to 3 feet. From a constructability standpoint, a 1H:2V cut configuration was determined to be the most stable. Plate 2 presents the configuration modeled, the input material properties, and the ten failure surfaces with the minimum safety factors. A minimum factor of safety of 1.4 was determined

for the input configuration. The "arrows" on Plate 2 indicate the failure surface with the lowest safety factor.

The analyses of the fill section modeled an access road entirely constructed on fill. The fill slope was input with a 1H:1V slope and a specified failure surface was evaluated. Plate 3 presents the slope configuration, input properties, and the minimum safety factor. The natural slope was modeled as a plane surface, however, in reality this surface would be stepped due to occasional bedrock outcrops, and the factor of safety may actually be somewhat higher than portrayed.

CONCLUSIONS AND RECOMMENDATIONS

It is our understanding, from a telephone conversation with Charles Reynolds, that a minimum factor of safety required for cut and fill slopes along the access road is 1.3. The computer analysis for cut slope stability indicates a minimum static factor of safety of 1.4 for a slope of 1H:2V, or a slope angle of approximately 63 degrees. In the stability analysis we conservatively assumed a depth to bedrock of 6 feet. The depth to bedrock along the Tank Seam Access Road alignment will probably vary from exposures at the ground surface to depths of 2 to 3 feet. Only in the larger gullies, where the road will be mostly or entirely on fill, will the depth to bedrock exceed the assumed average of 6 feet. The effect of the calcium carbonate cementation in the soil was not incorporated into the analysis. If it had been, the factor of safety would be significantly higher.

The large fill across the gully where soil sample No. 2 was taken is expected to have a factor of safety of approximately 1.4 if the fill slope is constructed at a slope of 1H:1V. The fill material should be compacted in lifts not exceeding 18 inches in depth and compacted by heavy machinery during placement. All rock fragments in excess of 18 inches should be removed from the fill. Rock fragments incorporated in the fill should be placed in a manner to minimize void space. It is recommended that the natural slope surface be prepared for the fill by removing vegetation and loose cobble and boulder sized rock fragments. Cobble and boulder sized rock fragments securely embedded into existing slopes may be left in-place provided adequate compaction is achieved adjacent to these fragments. We recommend that a series of narrow terraces, approximately 10 feet wide, be constructed to key the fill material into the natural slopes.

This is contrary to 8/10 Report

Stability of the slopes will be influenced by the degree of saturation of existing soils. Therefore, surface drainage must be channeled to prevent or at least minimize runoff over the slopes. Also, snow removed from the access road should be placed at the south end of the switchback to minimize the amount of moisture percolating into the fill slopes or road surface due to melting snow. We understand that erosion control mats will be placed on constructed slopes to minimize minor slides and sluffs.

We understand that boulders obtained from cut areas during construction, that are not incorporated in fill areas, will be placed on terraced portions of fill slopes. Boulders will be placed in a single lift on horizontal terraces to simulate natural conditions.

Based on the slope stability analysis and observations made during the reconnaissance visit, it is our opinion that the cut and fill slopes will perform satisfactory and similar to those located along the Bear Creek Portal Access Road.

We appreciate the opportunity of visiting the site and assisting you with the expansion of the Bear Creek Mine. If you have any questions concerning this report or if we can assist you in any other way please call at your earliest convenience.

Sincerely,

DAMES & MOORE, INC.

C. Charles Payton

C. Charles Payton, C.E.G.
Associate

Russell L. Owens

Russell L. Owens, P.E.
Professional Engineer
State of Utah

Attachments:

Plate 1 - Plot Plan
Plate 2 - Cut Slope Cross-Section
Plate 3 - Fill Slope Cross-Section

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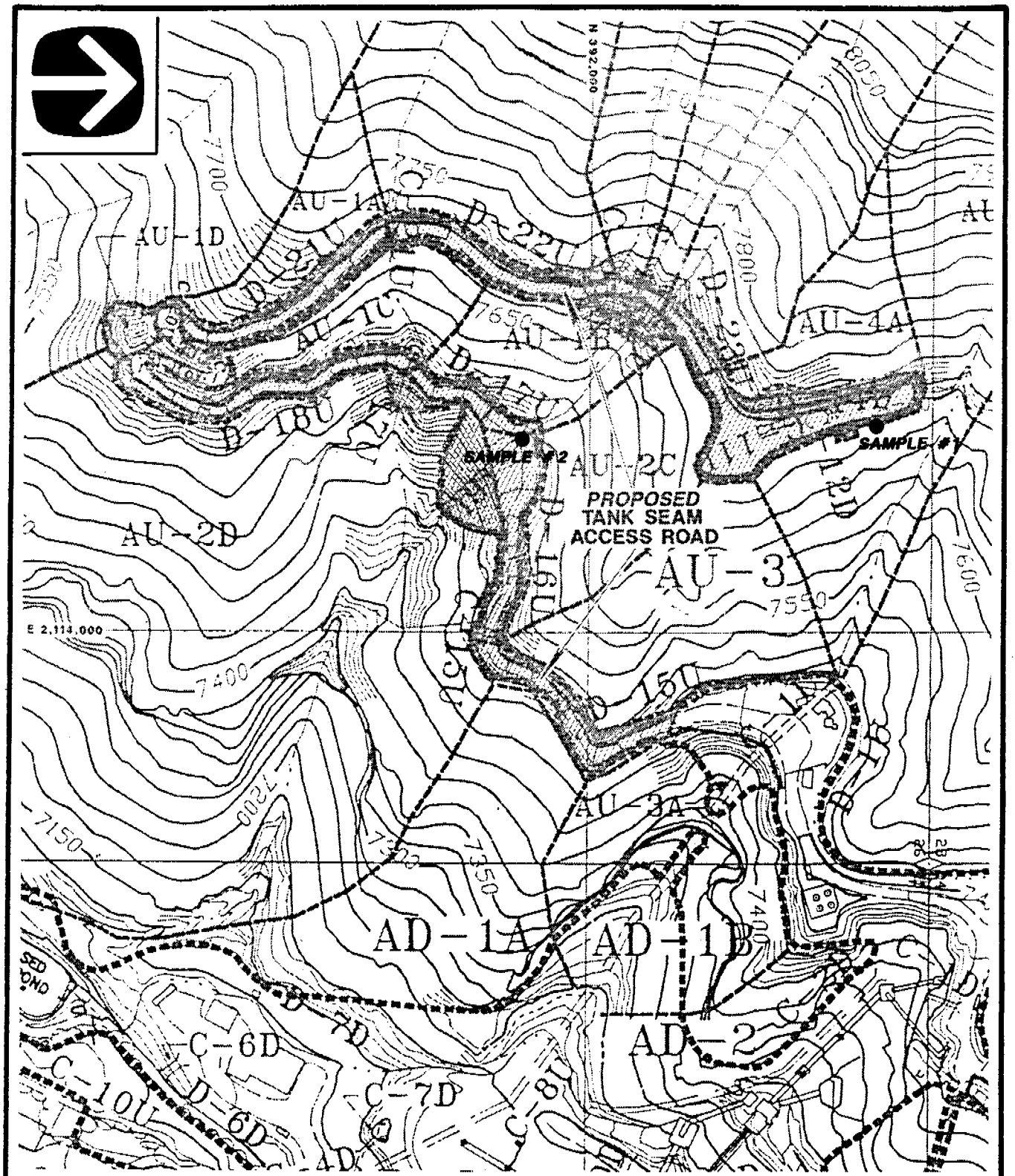

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SCALE IN FEET

AD-1 INDICATES DRAINAGE AREAS THAT ARE DIVERTED THROUGH SEDIMENT PONDS OR ALTERNATE SEDIMENT CONTROL STRUCTURES

AU-1 INDICATES DRAINAGE AREAS THAT ARE DIVERTED BY DITCH AND/OR CULVERT TO OFF-SITE WITH LIMITED OR NO SEDIMENT CONTROL

REFERENCE-
ADAPTED FROM DRAWING ENTITLED, "WATERSHED MAP; BEAR CANYON," BY CO-OP MINING CO., HUNTINGTON, UTAH, PLATE 7-5, DATED 5-6-91.

DRAFT

CO-OP MINING CO.
PLOT PLAN
BEAR CANYON MINE

Dames & Moore

B.C.
3H-50
5/16/94

FILE 27437-002-102 BY _____ DATE _____ CHECKED BY _____ DATE _____

APPENDIXES

A Violation List 2A-1
B Title Insurance Policy 2B-1
C Insurance 2C-1
D Affidavit of Publication 2D-1
E Pole Line Easement 2E-1
F Federal Lease 2F-1
G Waiver Letters 2G-1

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Table 2-2 Apparent Completeness Review - Other Permits and Licenses 12

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Plate 2-1	Permit Area
Plate 2-2	Surface Ownership
Plate 2-3	Sub-Surface Ownership
Plates 2-4A thru 2-4E	Surface Facilities

DRAFT

2.6.4 Horizontal Extent of Underground Working for Each Phase

Section 3.4 tabulates the horizontal extent of underground working.

2.6.5 Vertical Extent for Each Phase

Plates 3-4A, ~~and~~ 3-4B and 3-4C show the mine development plan by seam during each of the next five years, then for each five-year period thereafter for the life of the mine.

Between 1983 and 1986, all production was from the Middle Seam (Section 3.4.1, Mining Plans). In 1983 - 1986 recovery of the Middle Seam occurred on the Co-Op fee land (Plate 3-4A). Production of the Hiawatha Seam began in 1987 (Plate 3-4B). Production in the Tank Seam (Plate 3-4C) is projected to begin in 1994.

2.7 PERSONAL INJURY AND PROPERTY DAMAGE INFORMATION

Co-Op carries public liability and property damage insurance in due force. In response to OSM's completeness statement, this policy has been increased to comply with the requirements of 30 CFR 806.14 and R645-301-117. The policy bears a rider requiring the insurer to notify OSM and DOGM if the policy is cancelled. A copy of the certificate of insurance and rider is supplied to the Utah Division of Oil, Gas, and Mining. (Appendix 2-C).

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2.11 NEWSPAPER ADVERTISEMENT/PROOF OF PUBLICATION

As required with the filing of this application with Division of Oil, Gas, and Mining, the applicant has filed an advertisement with the Emery County Progress and Sun Advocate, local newspapers with circulation in Emery & Carbon countries sufficient to cover the locality of the applicant's operations. This advertisement follows the format required under 30 CFR 786.11 9aO and R614-300-121. A copy of the publication is attached in Appendix 2-D. Proof of publication can be found with a copy of the add, in Appendix 2-D. Proof of Publication for the Tank Seam Permit Amendment is also shown in Appendix 2-D.

DRAFT

STATE OF UTAH)
ss.
County of Emery,)

I, Dan Stockburger, on oath, say that I am the Publisher of the Emery County Progress, a weekly newspaper of general circulation, published at Castle Dale, State and County aforesaid, and that a certain notice, a true copy of which is hereto attached, was published in the full issue of such newspaper for Four (4) consecutive issues, and that the first publication was on the

22nd day of June, 19 93

and that the last publication of such notice was in the issue of such newspaper dated the

13th day of July, 19 93

Subscribed and sworn to before me this

13th day of July, 19 93

Notary Public

My Commission expires January 10, 1995

Residing at Price, Utah

Publication fee, $ 64.00

Notary Public
LINDA THAYN
811 North 10th East
Price, Utah 84501
My Commission Expires
January 10, 1995
State of Utah

DRAFT

B.C.

2D-7

10/22/93

AFFIDAVIT OF PUBLICATION

STATE OF UTAH)
ss.
County of Carbon,)

I, Dan Stockburger, on oath, say that I am the Publisher of the Sun Advocate, a twice-weekly newspaper of general circulation, published at Price, State and County aforesaid, and that a certain notice, a true copy of which is hereto attached, was published in the full issue of such newspaper for Four (4) consecutive issues, and that the first publication was on the

22nd day of June, 19 93

and that the last publication of such notice was in the issue of such newspaper dated the

13th day of July, 19 93

Dan Stockburger

Subscribed and sworn to before me this

13th day of July, 19 93

Linda Thayn
Notary Public

My Commission expires January 10, 1995

Residing at Price, Utah

Publication fee, $ 64.00

Notary Public
LINDA THAYN
811 North 10th East
Price, Utah 84501
My Commission expires
January 10, 1995
State of Utah

NOTICE

Co-Op Mining Company, P.O. Box 1245, Huntington, Utah, hereby announces it's intent to file application to extend mining into the Tank Seam, located above the existing seam within the existing permit area of the Bear Canyon Mine (ACT/015/025) with the Division of Oil, Gas, and Mining under the laws of the State of Utah. This includes an additional surface disturbance of approx. 2.5 acres. A copy of the complete application is available for public inspection at the Division of Oil, Gas, and Mining offices, 355 West, North Temple, Suite 350, Salt Lake City, Utah 84180-1203. Written comments on the application should be submitted to the State of Utah, Division of Oil, Gas & Mining, at the above address. The area to be mined can be found on the USGS Hiawatha quadrangle map. The proposed mining and surface disturbance is within privately owned Fee Land. The coal area is described as follows: T16S, R7E SLBM Fee Land, Sec. 34 SW¼, SE¼; Sec. 23 E½, E½, W½; Sec. 24 All West of N-S Bear Canyon Fault, Sec. 25 All West of N-S Bear Canyon Fault, Sec. 26 NE¼, NE¼, NW¼ NE¼, N½, SW¼, NE¼ and access/haul road and topsoil storage area shown on Plate 2-1 of the Mining and Reclamation Plan.

Published in the Sun Advocate June 22, 29 and July 6 and 13, 1993.

DRAFT

143 SOUTH MAIN ST.
P.O. BOX 45838
SALT LAKE CITY, UTAH 84145
FED. TAX I.D. # 87-0217663

Newspaper Agency Corporation

The Salt Lake Tribune (NA) DESERET NEWS

LEGAL ADVERTISING INVOICE

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CO-OP MINING COMPANY P.O. BOX 1245 HUNTINGTON, UT 84528	LE-3812450	07/06/93

FOR BILLING INFORMATION
CALL (801) 237-2822

AFFIDAVIT OF PUBLICATION

AS NEWSPAPER AGENCY CORPORATION LEGAL BOOKKEEPER, I CERTIFY THAT THE ATTACHED ADVERTISEMENT OF NOTICECO-OP MINING COMPANY, P.O. BOX 1245, H FOR CO-OP MINING COMPANY WAS PUBLISHED BY THE NEWSPAPER AGENCY CORPORATION, AGENT FOR THE SALT LAKE TRIBUNE AND DESERET NEWS, DAILY NEWSPAPERS PRINTED IN THE ENGLISH LANGUAGE WITH GENERAL CIRCURATION IN UTAH, AND PUBLISHED IN SALT LAKE CITY, SALT LAKE COUNTY IN THE STATE OF UTAH.

PUBLISHED ON JUN 29 JUL 06 1993

SIGNATURE

DATE 07/06/93

ACCOUNT NAME				TELEPHONE
G COMPANY				801-381-2450
SCHEDULE				AD NUMBER
06 1993				6P820170
. NO.	CAPTION			MISC. CHARGES
ON	NOTICECO-OP MINING COMPANY, P.O. BOX 1245, H			.00
IZE	TIMES		RATE	AD CHARGE
1 COLUMN	2		1.16	97.44
LE ON RECEIPT OF THIS INVOICE			TOTAL AMOUNT DUE	97.44

THANK YOU FOR USING LEGAL ADVERTISING.

DRAFT

B.C.

10/22/93

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FOR BILLING INFORMATION
CALL (801) 237-2822

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PUBLISHED ON JUL 21 1993

SIGNATURE

DATE 07/21/93

ACCOUNT NAME				TELEPHONE
OMPANY				801-381-2450
SCHEDULE				AD NUMBER
				7K820040
NO.	CAPTION			MISC. CHARGES
	NOTICECO-OP MINING COMPANY, P.O. BOX 1245, H			.00
E	TIMES	RATE		AD CHARGE
1 COLUMN	1	.00		.00
E ON RECEIPT OF THIS INVOICE		TOTAL AMOUNT DUE		.00

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B.C. 2D-10 10/22/93

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3.3.2 Portals

Bear Canyon #1 Mine has seven portals:

Bear Canyon Seam	- Bear Canyon Side	3
	- Blind Canyon Side	2
Hiawatha Seam		2
	TOTAL	7

The Bear Canyon Seam (Plate 3-4A) has two fan, one belt, and two intake portals. The first fan portal is in Bear canyon near the upper storage pad and the second is in Blind Canyon. The belt portal pad is shown on Plate 3-6. One intake portal is located in the main portal area, and one in Blind Canyon (Appendix 3-I).

There are two portals in the Hiawatha Seam (Plate 3-4B): a belt and an intake portal. A new fan portal is planned in the Hiawatha seam when mining conditions warrant.

The Bear Canyon #2 Mine, proposed for the Tank Seam, will have three portals (Plate 3-4C), all located in Bear Canyon. This will create a total of ten portals for the Bear Canyon Mine Permit.

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3.3.3 Surface Buildings and Structures

Surface structures consist of; shops, parts warehouse, bath house; truck scales, weighman office, mine offices; caretaker dwelling, mine run coal receiver bin, crushing and sizing structure, truck load out bins, stockpile towers, and conveyors to carry coal to storage and load out sites, etc.. A complete list of surface buildings and structures is in Appendix 3-A and shown on Plate 2-4.

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3.3.4 Coal Handling, Storage and Loading

Coal carried from the mine by conveyor belt to a receiver bin, conveyed to the sizing and crushing plant, the lump removed and diverted to the lump bin or seasonal storage area, the rest of the oversized crushed, and the coal sized to meet the various requirements of the different customers, then conveyed to the truck load out bins, or the stockpile area.

Coal will be transferred from the Tank Seam through a 4 foot drop tube to the Blind Canyon Seam of the Bear Canyon No. 1 Mine through a borehole. The borehole will be approximately 8 ft diameter, bored from the surface adjacent to the portal. The conveyor from the portal and the drop tube structure will be enclosed. Vibrators will be placed on the outside of the drop tube to prevent the wedging of coal in the tube.

3.3.5 Power System, Transmission Lines and Substations

Surface power systems, transmission lines and substations will be removed and the areas reclaimed, when they are no longer required.

3.3.6 Water Supply System

The system, which carries water from the mine or cistern to the loadout area, wash plant, bathhouses and offices, consists of a 2-inch pipeline and water storage tanks. An extension will be added to carry culinary water to the Shower House, as shown on Plates 7-1B and 2-4B. Copies of the approved culinary water permit plans are attached in Appendix 3-B. A waterline will be installed from the Blind Canyon Seam up through the borehole to supply water to the Tank Seam Mine.

Water rights information for the mine and surrounding area is found in Appendix 7-C.

3.3.9 Storage, Waste and Refuse Areas

Waste disposal plans, removal, handling and storage are discussed in Section 3.5.8. All waste will be disposed of in a manner in line with R645-301-513.300 and MSHA regulations.

3.3.10 Transportation, Roads and Parking Areas

There are ~~six~~ seven primary roads in the permit area: Bear Canyon Haul Road, Portal Access Road, Tank Seam Access Road, Shower House Road, road to Sediment Pond A, Tipple Access Road and the Shop Road. All roads are shown on Plates 2-4. Road profiles and typical cross sections are shown on Plates 3-5. A description of all roads is included in Appendix 3-D, along with maintenance procedures. Construction of the Tank Seam Access Road is discussed in Appendix 3-H.

The mine area is approached on the Bear Canyon Haul Road. The mine portal is reached on the Portal Access Road. The Tank Seam Portal is reached on the Tank Seam Access Road. Four other primary roads provide access; to the Sediment Pond A, the coal preparation facility (tipple), the shop, and to the Shower House.

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3.3.11 Topsoil Storage Piles

Topsoil storage piles are located as shown on Plate~~s~~ 8-~~35~~. Topsoil material will be removed, stored, protected, maintained and redistributed as described in Chapter 8.

3.3.12 Explosives Storage and Handling

Co-Op has an explosives facility within the permit area but does not anticipate the use of explosives in their normal mining operation. However, ~~in the unlikely event~~when the need arises in the underground operation the following procedure will be adhered to:

3.3.12.1 Use of Explosives

~~There will be no surface blasting activities incident to this underground operation. There is a possibility that the need to~~Co-Op occasionally use~~s~~ explosives in the underground operation to advance through faults, dikes, or other rock strata too hard for cutting by the continuous miner. A~~ny~~ll use of explosives in the underground operation will be in compliance with all applicable state and federal laws, and will be conducted by persons trained~~, examined and industrial commission~~and certified. Surface blasting is discussed in section 3.4.5.3. Blasting material will be stored in fire proof bullet proof magazines and clearly designated as an (Explosive Storage Area), as required by state and federal laws.

3.3.14 Total Area for Surface Disturbance During Permit Term

The surface acreage within the disturbed area boundaries of the mine operation are shown on Plates 2-4 and summarized as follows:

Table 3.3-1 Surface Disturbance Summary

DESCRIPTION	Total acres	Pre-1977 acres	New acres
Ball Park Topsoil Pile	1.27	-0-	1.27
Lower Haul Road	1.6	1.6	0.0
Sed Pond B & Scale Office Pad	2.56	1.23	1.33
Sed Pond A	0.75	-0-	0.75
Main Pad Area	12.30	8.86	3.44
~~Lower~~ Portal Access Road	~~1.26~~ 2.62	0.01	~~1.25~~ 2.61
~~Portal Access Road~~Blind Canyon Seam Portal Area	~~3.06~~ 1.70	0.51	~~2.55~~ 1.19
Upper Storage Pad	0.74	-0-	0.74
Shower House Pad	1.84	-0-	1.84
Tank Seam Access Road	2.25	-0-	2.25
Tank Seam Portal Pad	0.46	-0-	0.46
TOTAL	~~25.38~~ 25.09	12.21	~~13.17~~ 15.88

There are approx 17 total acres of Pre-1977 disturbed area in the permit area. Additional information concerning disturbed acreage is found in Section 8.7.

3.3.15 Detailed Construction Schedule

Construction starting and completion dates are listed in Table 3A-1, Appendix 3-A.

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3.4 OPERATION

Co-Op started it's mining operation through an existing mine in the Bear Canyon Seam and later extended into the Hiawatha Seam below. Access to the lower Hiawatha seam was made in the summer of 1986 through two new portals in the outcrop, and through a rock slope tunnel from the Bear Canyon seam. In 1994, Co-Op will extend operations into the Tank Seam, located above the Bear Canyon seam. The following mining plans pertain to the ~~existing~~ operation in these t~~wo~~hr~~ee~~ seams.

3.4.1 Mining Plans

There are ~~three~~four main seams in the Bear Canyon Property, the Tank Seam, the upper (Upper Bear), the middle (Bear or Blind Canyon), and lower (Hiawatha) Seam. There are no plans to mine the upper~~most~~Bear seam due to extensive burning and limited lateral extent of the seam. Mining plan, sequence and projected development for the Bear Canyon ~~and~~, Hiawatha and Tank seams are shown on Plates 3-4A ~~and~~, 3-4B and 3-4C respectively.

3.4.1.1 Advance-Retreat Mining Procedures

Underground coal mining procedures follow two basic approaches to the recovery of involved reserves. These are advancing and retreating. If mining advances along both sides of any set of entries from their starting point to their termination, the system is advancing; if mining is not started until the entries reach their limit and then begins at the termination point on both sides,

3.4.3 Conservation of Coal Resource

Maximum recovery of this reserve has been practiced from the time Co-Op began mining on this property. Mining plans have established mine layouts to reach all areas of the property and, at the same time, by the adoption of pillar recovery techniques in room and pillar work, raise the pct of recovery of reserves in the mining area to the maximum. Whereas room and pillar methods without pillar mining recover approx 50 pct of the coal. Mining methods of this type employed by Co-Op have historically shown an overall recovery of approx 60 pct of in-place reserves.

3.4.3.1 Minable Reserves

The Bear Canyon and Hiawatha Seams will be mined to a min thickness of 5 ft which is the lower limit for operation of the equipment that must also mine to full seam heights of 10 ft or more.

Rider Seams. The "upper seam" in this area is the Upper Bear Canyon Bed, which is probably just a split off the main Bear Canyon seam presently being mined. This seam lies only 15 ft to 20 ft above the Bear Canyon Seam at the mine site, and is evidenced only by a ledge and some burning. Speiker and Doelling have both referred to a probable upper split of the Bear Canyon Seam in this area, likely with a small lateral extent and little, if any, mining potential. ~~An~~ additional seam~~s~~ out-crop~~s~~ about 200 ft above the

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mine portals; however, this is one of the "upper beds" listed on Table 6-~~1~~2, and again is not considered to have any economic potential due to limited lateral extent and extreme burning of seams in this horizon (Doelling p. 6-14). No rider seams of any importance are known to exist in the interval between the Bear Canyon and the Hiawatha Seams.

These seams (or splits) are not considered as minable reserves, due to the burning, questionable lateral extent and inability to trace these upper seams (or splits), and due to the close proximity of the upper Bear Canyon split to the main bed presently being mined. ~~The seams presently being mined are considered the uppermost, minable seams in the area and there are no plans to enter or mine these upper seams.~~ Exploration in 1992 has indicated a mineable seam, the Tank Seam, in the uppermost area of the "upper beds". Mining is expected to extend into this seam in 1994. Mining activities will be completed in this seam prior to completing activities in the two lower seams. This is consistent with mining practices recommended for multiple seam areas.

Additional information on rider seams is presented in Section 6.5.2. Available borehole data is shown in Figures 3.4-3 through 3.4-6, and in Appendixes 6-A and 6-B of this permit. Locations and elevations of all test borings are shown on Plates 6-B and Figure 3.4-1.

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3.4.3.3 Projected Maximum Recovery and Rate

Recoverable Reserves. Table 3.4-1 shows the reserves in each seam determined from our most recent data.

Table 3.4-1 Coal Reserves - Bear Canyon Mine

Reserve Area	Seam	Coal Reserves (tons)	
		In-Place	Recoverable
Federal Lease (U-024318)	Bear Canyon	65,363	12,600
	Hiawatha	48,003	24,002
	SUBTOTAL	113,366	36,602
(U-024316)	Bear Canyon	4,966,000	2,483,000
	Hiawatha	*3,310,500	*1,655,000
	SUBTOTAL	8,276,500	4,138,000
Fee Land	Tank	5,924,160	2,962,080
	Bear Canyon	6,839,142	3,419,571
	Hiawatha	2,499,172	1,249,586
	SUBTOTAL	15,262,474	7,631,237
Total Area	Tank	5,924,160	2,962,080
	Bear Canyon	11,870,505	5,915,171
	Hiawatha	5,857,675	2,928,588
	TOTAL	~~17,728,180~~ 23,652,340	~~8,843,759~~ 11,805,839

NOTES: 1. Reserves based on latest projections (4/10/90) submitted to the B.L.M. in the L.M.U. Application.

* Minable tonnage questionable based on adjacent drilling (See Plate 3-4B).

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The reserves shown reflect minable coal in only Bear Canyon, Tank, and Hiawatha Seams. These reserve estimates are based on numerous outcrop measurements as well as inseam measurements, both in Bear Canyon and Trail Canyon (Chapter 6, Figure 3.4-3 through 3.4-6).

Recovery Rate. The recoverable coal reserves were estimated by multiplying the in-place reserve by a recovery factor of 50 pct.

The operation will produce 200,000 to 400,000 tons of raw coal per year with at least 3 miner sections working 240 days. This is 400+ to 800+ tons per day with 2 production shifts operating. The rate of production (considering a lower rate during the initial buildup years plus the tonnage still to be mined in the area of old workings) will make the projected mine life of approx ~~22~~ 30 years.

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3.4.5.1 Signs

Signs used on the property are constructed of suitable material, employ uniform and standard designs and conform to local ordinances and codes. They will be maintained during the conduct of all activities to which they pertain. The gate at the main entrance is posted with a sign containing the company name, address, telephone number and identification number. Table 3.4-2 lists signs and duration of maintenance and placement. Surface blasting is ~~not planned~~occasionally used at this underground mine. ~~If such blasting becomes necessary for some reason~~When surface blasting is performed, "Blasting Area" signs will be posted on access roads and on public roads within 200 feet. In addition, the blasting area will be conspicuously flagged in the vicinity of charged holes. All other requirements of DOGM mining regulation pertaining to surface blasting will also be satisfied. The blasting plan for the Tank Seam road construction is shown in Appendix 3-M.

~~In the event that surface blasting becomes necessary~~During periods of construction using surface blasting the entrance to the property from the public road will be posted with a sign stating, "Warning! Explosives in Use" and explaining the blast warning and all-clear signals and the marking of blast areas.

Topsoil stockpile areas are marked with "Topsoil" signs.

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Structures. Building and structures are protected against fire by the location of adequate numbers, sizes and types of fire extinguishers in compliance with regulations. Water is available from the surface water distributing systems.

Refuse Piles. Co-Op does not produce processed coal and does not produce coal refuse.

Explosives. ~~This is an underground mine using continuous mining methods which does not necessitate the need for blasting. In the event blasting would be necessary it would be~~All surface and underground blasting will be performed in accordance with existing federal and state laws. ~~All surface work, such as site preparation is completed at this time~~Site preparation work for the Tank Seam road and pad may require the use of surface blasting. ~~No surface blasting is anticipated in the permit term~~A blasting plan for this work is included in Appendix 3-M.

3.4.5.4 Compliance with Regulations

Co-Op will comply with all federal and state regulations pertaining to the operation of this mine within the permit area.

Routine Reports. All routine reports pertaining to the operation will be submitted to the proper governmental agencies, in particular those required under CFR 30 Chapter 75. 1800-1808.

Reporting of Accidents. All accidents will be reported to MSHA in accordance with CFR 30 Chapter 1 Sub-part B par. 80.1080.12; Sub-

3.4.6.2 Operating Schedule

The mine operates 240 days per year, 5 days per week to produce the above tonnages. A total of 30 + miners working 3 shifts per day (2 production and 1 maintenance) and producing from 400+ to 800+ ton per shift per unit.

Table 3.4-3 Scheduled Sequence of Underground Activity*

Year	Acreage
1984	~~11~~30
1985	~~11~~40
1986	~~11~~50
1987	~~11~~60
1988	~~11~~70
1989-1993	~~65~~180
1994-1998	~~65~~140
1999-2003	~~65~~180
2004-2008	125
2009-2014	65

* not Surface Disturbance

3.4.6.3 Employment

Total personnel in 1993 is ~~30~~ 70, ~~5~~ 8 of whom ~~will be~~ are salaried and ~~30~~ 62 are hourly employees. This number may go up or down approx ~~5~~ 10 people depending on market and production needs.

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3.5.5.2 Mitigating Measures to be Employed to Reduce Impacts on Vegetative Resources

All ~~disturbed~~ recontoured areas will be planted and revegetated during the first appropriate season following grading and redistribution of topsoil. This program will include any necessary addition of remedial treatments to the soil. A suitable, permanent and diverse vegetative cover has been selected on the basis of appropriate land management agency requirements and will be established on all reclaimed areas (Chapter 9). The schedule of the program is presented in Section 3.6.6. What follows is an outline of the major aspects of the revegetation plan. The specific measures involved will be addressed on a site specific basis.

Seeding and Planting (817.111). All plants used to revegetate the disturbed areas will be native or compatible species selected specifically for the vegetative community, as detailed in Section 9.3.2. Seed types will include wheatgrass, salina wildrye, sagebrush, pinyon and juniper and are listed in Chapter 9, Section 9.5. Wherever possible, seed will be drilled or disked into the ground. In steep slope areas, where such techniques are difficult or impossible, hydro-seedings or cyclone spreader seeding will be

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b. Solid waste generated in the facilities removal will be collected and disposed of as identified in Section 3.6.3.2. See Appendix 3-E for toxic materials and handling.

Adjacent areas that have been impacted by coal fines or other results of the operation will be examined prior to reclamation. If coal fines are evident in quantities that exceed 50 pct of the exposed ground, then such material will be removed. Methods of removal will consist of either vacuuming (if justified by large quantities), or by washing down the area by high-pressure water hoses. The wash down procedure is particularly effective on rock and rocky slopes. All other extraneous debris from the operations will also be removed from the areas. Disposal of all materials will be as described in Section 3.6.3.2.

It should be noted that the existence of small to moderate amounts of coal fines has not been established as detrimental to either soils or vegetation; therefore, amounts less than the 50 pct figure cited above will not be removed.

c. The Tank Seam portal area and access road will be reclaimed as described in Section 3.6.11.

~~e~~d. A backhoe and dozer will work in conjunction to remove the outer edge of the recontoured operational benches and compact it against the highwall. This will be accomplished by the backhoe reaching over the edge of the bank approx 20 in.

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pulling the material back. The dozer will then push and compact this material from the highwall outward to reach a bench slope of approx 1v:3h for drainage purposes.

~~d~~e. This operation will start on the upper bench and work across the bench to the upper access road.

~~e~~f. The backhoe and dozer will work in the same manner to eliminate the access road, working down to the lower pad. A typical cross-section of the reclaimed road cut is shown in Figure 3.6-2.

~~f~~g. The above procedure will continue on down the canyon reshaping the mine yard and disturbed area to the configuration shown on Plate 3-2, Post-mining topography.

~~g~~h. As backfilling and grading is completed, operational areas will be scarified by ripping to a depth of approx 14 in. with a dozer unless the steepness of the reclaimed slope does not allow for safe access and operation. Accessible steep slopes will be terraced and/or receive ripping to create ledges, crevices, pockets and screes (See Section 3.6.4.3). These areas are shown on the Post mining Topography Plate 3-2 as cat track terraces. This will reduce compaction and prevent topsoil slippage, and improve soil retention and vegetation establishment in the cat tracks. The area will be walked over to create grouser marks which run perpendicular to the slope.

~~h~~j. Distribution and handling of plant growth materials from topsoil piles and from substitute in-place sites, prior to and following grading and ripping is defined in Chapter 8.

~~i~~j. Areas will be reseeded as defined in Chapter 9.

3.6.4.1 Recontouring

The cut slopes will be constructed in a manner to achieve physical stability with a safety factor equal to or greater than 1.3. This design will reduce slides and other related erosional damage. Stability analysis on existing highwalls have confirmed that they have a factor of safety greater than 1.3 as they presently exist (Appendix 3-F).

3.6.4.2 Removal of Highwall

Due to the laws requiring removal of highwalls constructed following 1977, the Division has directed Co-Op to recover all highwalls. Plates 3-2 show existing highwalls (Plates 2-4) are recovered during reclamation. Appendix 3-L includes cut and fill calculations for the mine site, including removal of highwalls.

In Feb 1981, a slope stability analysis (Appendix 3-F) was performed by Dames & Moore on the Bear Canyon Mine access road. The purpose of this study was to analyze the static safety factor of the side-cast cut and fill slopes along

In addition to the vegetative stabilization discussed in Section 3.6.5, Revegetation Plan, physical stabilization of the soil is also planned. The specific methods to be implemented are defined in Chapter 8 and 9.

3.6.4.5 Coil Fine Impacted Areas

Areas identified as impacted by coal fines will have the coal fines cleaned from the surface prior to or during final reclamation activities. Efforts to reduce sources for migrating coal fines are discussed in Section 3.5.7. Coal fines will be removed from the surface by use of vacuumes and/or by washing with water. Washing will only be done in a manner where surface soil materials are not measurably removed, such as on rock outcrops. Collected fines will be disposed of in approved spoil locations identified in other sections of this plan.

3.6.5 Revegetation Plan

All reclaimed disturbed areas will be planted and revegetated during the first appropriate season following grading and topsoil redistribution procedures and will include, the addition of remedial soil treatments. A permanent, diverse vegetative cover, using approved seed mixes listed in Chapter 9, Section 9.5, will be established on all reclaimed areas.

The operator will submit a detailed revegetation plan in the

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3.6.6 Schedule of Reclamation

The general timetable for completing the major steps in reclamation is:

201~~42~~ -	Landfills and solid wastes will be regraded and seeded as they are completed.
201~~42~~ -	Underground mine openings will be closed and sealed as they are abandoned.
201~~42~~ -	Surface facilities will be removed as they become unnecessary.
201~~42~~-201~~53~~ -	The completion of surface reclamation will be in as short a time as possible after operations cease.

The specific timetable for completing each major step or phase in reclamation is not applicable for all. Reclamation will commence upon abandonment (year 201~~42~~).

3.6.8 Reclamation Bonding

BOND

CO-OP MINING COMPANY

BEAR CANYON MINE

ACT/015/025, EMERY COUNTY, UTAH

3.6.8.1 Detailed Timetable for Completion of Major Reclamation Processes

The following schedule of reclamation is proposed to be initiated within 90 days (weather permitting) of final abandonment of the mining operation:

		Accumulated Time
a.	Seal Portals - 1.5 weeks	1.5 weeks
b.	Remove Structures - ~~7.~~8 weeks	~~8.8~~9.5 weeks
c.	Soil Replacement and Ripping - ~~4.~~7 weeks	1~~3~~6.5 weeks
d.	Channel Restoration - 2.2 weeks	1~~5.7~~8.7 weeks
e.	Revegetation - 1 week	~~16.7~~20.2 weeks

The above reclamation tasks can, therefore, be completed within ~~16.7~~20.3 weeks following the start of reclamation activities.

Summary of Reclamation Cost Estimate

a.	Seal Portals and Backfill	$ ~~24,500.00~~35,000.00
b.	Removal of Structures	$ ~~61,316.30~~62,202.90
c.	Soil Placement and Ripping	$ ~~30,016.84~~76,398.32
d.	Channel Restoration	$ ~~50,682.23~~51,045.00
e.	Revegetation	$ ~~32,790.63~~44,119.70
f.	Monitor Well Plugging	$ 114.32
g.	Maintenance and Monitoring of Subsidence, Vegetation and Erosion (10 yr bond liability Period)	$ 39,143.20
h.	Hydrology Monitoring (10 yr bond liability period)	$ 29,630.00
i.	Supervision (~~16.7~~20.2 weeks)	$ ~~11,810.24~~14,285.44
j.	Mobilization and Demobilization	$ 2,500.00
		$~~282,503.76~~354,438.96
	10 pct contingency	$ ~~28,250.38~~35,443.90
	(1990 dollars)	$~~310,754.14~~389,882.86

Escalated Values	Escalation Factor
1991 - $~~316,472~~397,057	1.84% (actual)
1992 - $~~322,295~~404,363	1.84% (est)
1993 - $~~328,225~~411,803	1.84% (est)
1994 - $~~334,265~~419,380	1.84% (est)
1995 - $~~340,415~~427,097	1.84% (est)

Bond will be posted in accordance with R645-301-820.

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Reclamation Costs

a. **Seal and Backfill Portals**

AMR Costs-$3,500/seal including backfill x ~~7~~10 seals $ ~~24,500.00~~35,000.00

b. **Removal Structures**

All estimates with 10 digit numbers are from 1990 Means Site Work cost Data. Utah adjustment factor = 0.923. Most of the steel and equipment will be salvaged for scrap or reuse. M&P Enterprises in Huntington, Utah will pick up and pay $40.00/ton for scrap iron & equipment if placed in 30 cu yd (8ft wide x 20 ft long x 5 ft high) dumpsters or loaded with crane on their trucks.

Sales-Receiving-Scale House Complex

020-604-0700 (Wood Building, includes disposal)
Volume = (40 ft)(80 ft)(20 ft) = 64,000 cu ft
Cost = (0.923)(0.16/cu ft)(64,000 cu ft) = $9,451.52
Time = 64,000 cu ft/(14,800 cu ft) = 4.32 days

Cost Subtotal $9,451.52
Time Subtotal 4.32 days

Shower House

020-604-0700 (Wood Portion, includes disposal)
Volume = (92 ft)(50 ft)(8 ft) = 36,800 cu ft
Cost = (0.923)(0.16/cu ft)(36,800 cu ft) = $5,434.62
Time = 36,800 cu ft/(14,800 cu ft/day) = 2.49 days

020-604-0650 (Masonry Portion, includes disposal)
Volume = (92 ft)(50 ft)(8 ft) = 36,800 cu ft
Cost = (0.923)(0.16/cu ft)(36,800 cu ft) = $5,434.62
Time = 36,800 cu ft/(14,800 cu ft/day) = 2.49 days

Cost Subtotal $10,869.24
Time Subtotal 4.98 days

Shop

020-604-0500 (Steel Building, includes disposal)
Volume = (40 ft)(93 ft)(18 ft) = 66,960 cu ft
Cost = (0.923)(0.16/cu ft)(66,960 cu ft) = $9,888.65
Time = 66,960 cu ft/(14,800 cu ft/day) = 4.52 days

Cost Subtotal $9,888.65
Time Subtotal 4.52 days

Fans

~~2~~3 Fans; below are approx dimensions for ~~both~~11 fans.
Fan enclosure and explosion doors, ⅛ in steel plate welded
Approx dimensions:

(4) 10.5 ft x 10.5 ft plate
(2) 11 ft x 5 ft plate
(1) 7½ ft x 13 ft plate
(1) 4 ft x 9 ft diam. fan
(1) 15 ft long x 10 ft diam., taper to 9 ft diam x ¾ horn (3, 5 ft sections bolted).
(1) 4 ft x 9 ft diam. x ¾ in ring between fan and horn

Torch cut plates, and bolts (assumed jammed)
Approx cut length = (2)(4)(10.5 ft)+(2)(2)(11 ft)+(2)(1)(13 ft) = 154 ft (2 cuts per plate)

020-730-0010 (Torch Cutting, 1 in Plate)
Equivalent length (for 1 in plate) = (⅛)(154 ft) = 19.3 ft
Cutting Cost = (0.923)(2.65/ft)(19.3 ft) = (47.21)(~~2~~3 fans) = ~~$94.41~~ 141.63
Cutting Time = 19.3 ft/(95 ft/day) = 0.2 days(~~2~~3 fans) = 0.~~4~~60 days/2 crews = 0.~~2~~30 days

Horn sections and ring bolted together with ¾ in diam bolts at 1 ft spacing.
Number of Bolts = (3 Seems)[(pi)(10 ft)] = 95 bolts

020-730-0040 (Torch Cutting 1 in diam Bar)
Equivalent bolts (for 1 in diam) = (¾)(95 bolts) = 72 bolts
Cutting Cost = (0.923)(1.20/bolt)(72 bolts)=(79.75)(~~2~~3 fans) = $~~159.49~~ 239.25
Cutting Time = 72 bolts/(210 bolts/day) = 0.34 days(~~2~~3 fans) = ~~0.68~~1.02 days/2 crews = 0.~~34~~51 days

Assume each piece takes 10 min. average to load with crane after cutting.
Number of pieces =~~2~~3 fans[7 plates+1 fan+3 horn sections+1 ring]=~~24~~36 pieces
Time = ~~24~~36(0.17 hr) = ~~4~~6.1 hrs
Labor = (2 men)(~~4~~6.1 hrs)($15.83/hr) $ ~~129.81~~193.13
Crane + operator = (~~4~~6.1 hrs)($78.25/hr) $ ~~320.83~~472.33
$ ~~450.64~~670.46

Time = 0.~~51~~76 days

020-554-5000 (Plain Concrete)
Footing Volume = [2(2ft)(7½ft)(8/12)](~~2~~3 fans) = ~~4~~60 cu ft
Slab Volume = (13ft)(16ft)(8/12)(~~2~~3 fans) = ~~277.3~~416 cu ft
Volume=~~4~~60+~~277.3~~416 = ~~317.3~~476 cu ft/27 = ~~11.75~~17.63 cu yd
Cost = (0.923)(47.80/cu yd)(~~11.75~~17.63 cu yd) = $~~518.40~~ 777.83
Time = ~~11.75~~17.63 cu yd/(45 cu yd/day) = 0.~~26~~39 days

020-554-5550 (Concrete Disposal on Site)
Volume = ~~11.75~~17.63 yd
Cost = (0.923)(4.64/cu yd)(~~11.75~~17.63 cu yd) = $~~50.32~~75.50
Time = ~~11.75~~17.63 cu yd/(232 cu yd/day) = 0.0~~5~~8 days

Cost Subtotal $~~1,273.26~~1,904.67
Time Subtotal ~~1.36~~2.04 days

Cost Subtotal $6,889.60
Time Subtotal 7.03 days

Building Enclosure for Tank Seam Belt Portal

020-604-0500 (Steel Building, includes disposal)
Volume = (12 ft)(12 ft)(12 ft) = 1,728 cu ft
Cost = (0.923)(0.16 cu ft)(1,728 cu ft) = $255.19
Time = 1,728 cu ft/(14,800 cu ft/day) = 0.12 days

Cost Subtotal $255.19
Time Subtotal 0.12 days

Remove Structures Cost Total = $~~61,316.30~~62,202.90
Remove Structures Time Total = 39.26~~40.06~~ days

c. **Soil Placement and Ripping**

Soil Placement Volume Summary:

Tank Saam Access Road & Portal Pad

See Appendix 3-L.

Cut Subtotal	20,561 cu yds
Fill Subtotal	20,551 cu yds

Upper Storage Pad

See Appendix 3-L, Cross Sections C-C, D-D and J-J.

Section C-C	Cut (250 sq ft)x(130 ft)=32,500 cu ft=	1,204 cu yds
	Fill (250 sq ft)x(130 ft)=32,500 cu ft=	1,204 cu yds
Section D-D	Cut (513 sq ft)x(120 ft)=61,560 cu ft=	2,280 cu yds
	Fill (513 sq ft)x(120 ft)=61,560 cu ft=	2,280 cu yds
Section J-J	Cut (250 sq ft)x(320 ft)=80,000 cu ft=	2,963 cu yds
	Fill (388 sq ft)x(320 ft)=124,160 cu ft=	4,599 cu yds
	Cut Subtotal	6,447 cu yds
	Fill subtotal	8,083 cu yds

Portal Pad Area & Road

See Appendix 3-L, Cross Sections E-E and F-F.

Section E-E	Cut (250 sq ft)x(340 ft)=85,000 cu ft=	3,148 cu yds
	Fill (350 sq ft)x(340 ft)=119,000 cu ft=	4,408 cu yds
Section F-F	Cut (450 sq ft)x(210 ft)=94,500 cu ft=	3,500 cu yds
	Fill (450 sq ft)x(210 ft)=94,500 cu ft=	3,500 cu yds
	Cut Subtotal	6,648 cu yds
	Fill subtotal	7,908 cu yds

Portal Access Road

See Appendix 3-L, Cross Section H-H.

Section H-H	Cut(140 sq ft)x(1,500 ft)=210,000 cu ft=	7,778 cu yds
	Fill(165 sq ft)x(1,500 ft)=247,500 cu ft=	9,167 cu yds

Lower Road to Switchback

See Appendix 3-L, Cross Section K-K.

Section K-K	Cut(75 sq ft)x(1,450 ft)=108,750 cu ft=	4,028 cu yds
	Fill(75 sq ft)x(1,450 ft)=108,750 cu ft=	4,028 cu yds

Tipple Access Road

See Appendix 3-L, Cross Section G-G.

Section G-G	Cut(63 sq ft)x(500 ft)=31,500 cu ft=	1,167 cu yds
	Fill(63 sq ft)x(500 ft)=31,500 cu ft=	1,167 cu yds

Coal Storage Pad

See Appendix 3-L, Table 3L-2, Cross Sections 1-1 through 7-7.

Cut Subtotal	23,573 cu yds
Fill Subtital	19,453 cu yds

Scale House

After removal of the scale house, there will be 711 cu yds of fill needed. [(40ft wide x 80ft long x 6ft deep)=19,200 cu ft/27=711 cu yds]

There is adequate material in the area to provide for this and some additional fill if required.

Cut Subtotal	711 cu yds
Fill Subtital	711 cu yds

Sediment Pond "A"

See Appendix 3-L, Cross Section B-B.

Section B-B	Cut(350 sq ft)x(120ft)=42,000 cu ft=	1,556 cu yds
	Fill(350 sq ft)x(120ft)=42,000 cu ft=	1,556 cu yds

Sediment Pond "B"

See Appendix 3-L, Cross Section A-A.

Section A-A	Cut(225 sq ft)x(140ft)=31,500 cu ft=	1,167 cu yds
	Fill(225 sq ft)x(140ft)=31,500 cu ft=	1,167 cu yds

Sediment Pond "C"

See Appendix 3-L, Cross Section L-L.

Section L-L	Cut(175 sq ft)x(50ft)=8,750 cu ft=	324 cu yds
	Fill(175 sq ft)x(50ft)=8,750 cu ft=	324 cu yds

Shower House

See Appendix 3-L, Cross Section M-M.

Section M-M	Cut(500 sq ft)x(185ft)=92,500 cu ft=	3,426 cu yds
	Fill(500 sq ft)x(185ft)=92,500 cu ft=	3,426 cu yds

Cut Total =	~~56,825~~77,376 cu yds
Fill Total =	~~56,990~~77,541 cu yds

SOIL PLACEMENT

Areas	Earth Moved	Cu Yds	Equipment Used	Cost/hr	Time (hrs)	Cost
Tank Seam Access Road & Portal Pad	Cut	20,551	BH-235	$104.45	62.28	$ 6,501.15
	Fill	20,551				
	Hauled	13,288*				
Upper Storage Pad	Cut	6,447	BH-235	$104.45	24.49	$ 2,557.98
	Fill	8,083				
Portal Pad Area & Road	Cut	6,648	BH-235	$104.45	23.96	$ 2,502.62
	Fill	7,908				
Portal Access Road	Cut	7,778	BH-235	$104.45	27.78	$ 2,901.62
	Fill	9,167				
Lower Road to Switchback	Cut	4,028	BH-235	$104.45	12.21	$ 1,275.33
	Fill	4,028				
Tipple Access Road	Cut	1,167	BH-235	$104.45	3.54	$ 369.75
	Fill	1,167				
Coal Storage Pad	Cut	19,453	BH-235	$104.45	58.95	$ 6,157.33
	Fill	19,453				
	Excess Cut	4,120**				
Scale House	Cut	711	D9 Cat	$118.97	1.38	$ 164.18
	Fill	711				
Sediment Pond "A"	Cut	1,556	D9 Cat	$118.97	3.02	$ 359.29
	Fill	1,556				
Sediment Pond "B"	Cut	1,167	D9 Cat	$118.97	2.27	$ 270.05
	Fill	1,167				
Sediment Pond "C"	Cut	324	D9 Cat	$118.97	0.63	$ 74.95
	Fill	324				
Shower House	Cut	3,426	D9 Cat	$118.97	6.65	$ 791.15
	Fill	3,426				
Totals	Cut	~~56,825~~ 77,376			~~164.88~~ 227.16	~~$17,424.26~~ $23,929.41
	Fill	~~56,990~~ 77,541			(~~20.61~~ days) 28.40	

*See Appendix 3-L and the following page.

**Excess Cut will be hauled from the Coal Storage Pad to the Upper Storage Pad, Portal Pad Area & Road, and Portal Access Road, as discussed in Appendix 3-L.

Hauling ~~Excess Cut to Upper Areas~~
Where possible 10 yd dump trucks will be loaded with the 980 loader, otherwise they will be loaded with the BH-235.

Round trip time for 1 truck = ~~(load time) + (dump time) + 2(haul time)~~:
980 Loader load time = 2 cycles/(106 cycles/hr) = 1.13 min. ~~to load~~
~~Average Dist = .7 miles @ average speed of 7 MPH = 6.00 min to haul~~
BH-235 load time = 5 cycles/(165 cycles/hr) = 1.82 min.
Average truck dump time ~~to dump~~ = 4.75 min. ~~to unload~~
~~6.00 min back down~~
~~17.88 min (avg time)~~

Round trip time (with 980 Loader):
= 1.13 + 4.75 + 2(haul time) = 5.88 min. + 2(haul time)
Round trip time (with BH235):
= 1.82 + 4.75 + 2(haul time) = 6.57 min. + 2(haul time)

Tank Seam Access Road & Portal Pad Area

Of the total soil to be moved (20,551 cu yd) 13,288 cu yd will need to be hauled from one part of this area to another as needed.

Approx. 70% will be loaded with the 980 Loader and 30% with the BH-235.
Avg. Distance = 0.26 miles @ Avg. speed of 7 MPH; haul time = 2.23 min.

Round trip time for 1 truck load (with 980 Loader):
= 5.88 + 2(2.23) = 10.34 min.
Round trip time for 1 truck load (with BH-235):
= 6.57 + 2(2.23) = 11.03 min.

Number of loads = 13,288 cu yd/10 cu yd truck = 1,329 loads
980 Loader time = (10.34 min.)(hr/60 min)(0.7x1,329 loads)/3 trucks = 53.44 hrs
= 6.68 days (concurrent with soil placement)
BH-235 time = (11.03 min)(hr/60 min)(0.3x1,329 loads)/3 trucks = 24.43 hrs
= 3.05 days

980 Loader cost = (102.11/hr)(53.44 hrs) =	5,456.76
BH-235 cost = (104.45/hr)(24.43 hrs) =	2,551.71
Dump Truck cost = (43.30/hr)(53.44 hrs + 24.43 hrs)(3 trucks) =	10,115.31
	$18,123.78

Excess Cut From Coal Storage Pad to Upper Areas:

Avg. Distance = 0.7 miles @ avg. speed of 7 MPH; haul time = 6.00 min.
Round trip time for 1 truck load (980 Loader):
= 5.88 + 2(6.00) = 17.88 min.

~~Soil to be hauled = 4,120 cu yds~~
~~Number of loads using 10 yd dump trucks = 412 loads~~
Number of loads = 4,120 cu yd/10 cu yd truck = 412 loads
Hauling time = (17.88 min.)(hr/60 min)(412 loads)~~=123 hrs~~/3trucks = 4~~1~~0.93 hrs
= 5.12 days (concurrent with soil placement)

980 loader cost = (102.11/hr)(4~~1~~0.93 hrs) =	$ 4,1~~86.51~~79.36
Dump Truck cost = (43.30/hr)(4~~1~~0.93 hrs)(3 trucks)=	$ 5,3~~25.90~~16.81
	$ 9,~~512.41~~496.17

~~Time = 5.13 days (concurrent with soil placement)~~

Cost Subtotal	$27,619.95
Time Subtotal	3.05 days

Hauling Material to Fill Borehole

10,560 cu yd will need to be hauled from the Blind Canyon Seam portal.

Round trip time:
Loader haul time = 0.3 miles @ 7 mph x 2 loads = 5.14 min. to haul
Loader cycle time = 2 cycles/(106 cycles/hr) = 1.13 min. to load
Truck haul time = 1.1 miles @ 7 mph = 9.43 min.
Total cycle time = 15.70 min.

Number of loads = 10,560 cu yd/10 cu yd truck = 1,056 loads

980 Loader time = (15.7 min)(hr/60 min)(1,056 loads)/3 trucks = 92.1 hrs.
= 11.5 days (concurrent with soil placement)

980 Loader cost = (102.11/hr)(92.1 hrs) = 9,404.33
Dump Truck cost = (43.30/hr)(92.1 hrs)(3 trucks) = 11,963.79
$21,368.12

Cost Total	$21,368.12
Time Total	11.5 days

Ripping (Cat - D9)

Rip top 14 in of soil to prepare for revegetation.
Area to be ripped (See table 8.9-1) = 22.34 - 1.27 (ball park) = 21.07 acres
+ 2.7 (new road, etc. for tank seam) = 23.77 acres

Volume = (~~21.07~~23.77 acres)(43,560 sq ft/acre)(14/12)(cu yd/27 cu ft) = ~~39,658~~ cu yd
44,740
Time = ~~39,658~~ cu yd/(1,610 cu yd/hr) = ~~24.6~~27.8 hrs = 3.~~08~~47 days
Cost = (~~24.6~~27.8 hrs)($125.21/hr) = $~~3,080.17~~3,480.84

Soil Placement Cost Subtotal =	$ ~~17,424.26~~23,929.41
Hauling Excess Cut Cost Subtotal =	$ ~~9,512.41~~27,619.95
Filling Borehole Cost Subtotal =	$ 21,368.12
Ripping Cost Subtotal =	$ ~~3,080.17~~ 3,480.84
Cost Total	$ ~~30,016.84~~76,398.32
Time Total	~~23.69~~34.92 days

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d. Channel Restoration

EXCAVATION OF RECLAIMED CHANNELS

Channel	Channel Length[1] (ft)	Channel Area[2] (sq ft)	Channel Volume (cu yd)	Culvert Diam. (in)	Culvert Length (ft)	Culvert Area (sq ft)	Culvert Volume (cu yd)	Excavated Volume (cu yd)
RC1	~~As built - adequate for reclamation.~~							
	~~320~~	~~56.4~~	~~668~~	~~16.5~~	~~140~~	~~1.49~~	~~8~~	~~660~~
RC2	640	64.5	1,529	24	300	3.14	35	1,494
RC3	1,030	64.5	2,461	16.5	530	1.49	29	2,432
RC4	160	48	284	12	170	0.79	5	279
RC5	165	40	244	12	170	0.79	5	239
RC6	25	48	44	--	--	--	--	44
RC7	30	27	30	24	30	3.14	3	27
RC8	120	27	120	18	120	1.77	8	112
RC9	190	44	310	--	--	--	--	310
RC10	190	255	1,794	60	140	19.63	102	1,692
Totals			~~6,816~~ ~~7,494~~				~~187~~ ~~195~~	~~6,629~~ ~~7,289~~

Notes:
1 See plates 7-8A, 7-8B.
2 See appendix 7-H.

Excavation BH (235)

Volume = ~~6,816~~ ~~7,494~~ cu yds - ~~187~~ ~~195~~ cu yds = ~~6,629~~ ~~7,289~~ cu yds
Time = ~~6,629~~ cu yds/(330 cu yd/hr) = 2~~0~~2.09 hrs = 2.~~51~~76 days
Cost = (2~~0~~2.09 hrs)($104.45/hr) = $~~2,098.40~~ ~~2,307.30~~

Pulling of Culverts

CMP Culverts:
Assume it takes an average of 10 min/20 ft length to load culverts w/crane.
Number of section = ~~1,320~~ ~~1,460~~ ft/20 ft = ~~66~~ ~~73~~
Crane time = ~~66~~ ~~73~~(0.17) = ~~11~~ ~~12.4~~ hrs
Labor = (2 men)(~~11~~ ~~12.4~~ hrs)($15.83/hr) = $ ~~348.26~~ ~~392.58~~
Crane + operator = (~~11~~ ~~12.4~~ hrs)($78.25/hr) = $ ~~860.75~~ ~~970.30~~
~~$1,209.01~~ ~~1,362.88~~

Time = ~~1.30~~ ~~1.55~~ days

Placing & Shaping of Rip Rap

Assume an additional 40 sec/cycle is added to the Backhoe(235) cycle time for the shaping of the rip rap.
New cycle time = 40 + 20 = 60 sec = 1 min

Production = (2 cu yd/cycle)(60 cycles/hr) = 120 cu yd/hr (60 cycles/hr)

Efficiency - 55 min/hr

Production = (120 cu yd/cycle)(55 min/60 min) = 110 cu yd/hr (55 cycles/hr)

Volume = 4,958 cu yd
Time = 4,958 cu yd/(110 cu yd/hr) = 45.1 hrs = 5.64 days
Cost = (45.1 hrs)($104.45/hr) = $4,710.70

Rip Rap Material Cost

From 1990 Means Site Work Cost Data, with Utah site work material adjustment factor = 0.846.

Cost = (0.846)(9.63/cu yd)(4,958 cu yd) = $40,392.73

Excavation of Channels Cost Subtotal =	$ ~~2,098.40~~ 2,307.30
Pulling Culverts Cost Subtotal =	$ ~~3,480.40~~ 3,634.27
Rip Rap Cost Subtotal =	$45,103.43
Cost Total	$~~50,682.23~~51,045.00
Time Total	~~10.74~~11.16 days

e. Revegetation

Drill Seeding (Section 9.5) 16 acres x $891.00/acre		$14,256.00
Hydroseeding (Section 9.5) 7 acres x $1,667.00/acre		~~$11,669.00~~ 16,169.90
Riparian Area Planting (Section 9.5) 1 acre x $2,210.00/acre		$2,210.00
Install Matting (Section 9.5) 1.5 acres x $3,103.75/acre	$11,483.88	~~$4,655.63~~
Cost Total		~~$32,790.63~~ 44,119.78

f. Monitor Well Plugging

Approx. 4 in diam x 40 ft deep	
1 yds cement @ $51.00/yd	$ 51.00
4 hrs labor @ $15.83/hr	$ 63.32
Cost Total	$ 114.32

g. Maintenance and/or Monitoring for Vegetation, Erosion, and Subsidence

(Bond for 10-year bond liability period)

Vegetation - field survey, sampling, analysis and report writing @ $1,000.000/day + $80.00/day vehicle expense (Mt. Nebo Scientific), 3 days/yr	$3,240.00/yr
Erosion - 1 day to field survey @ $141.44/day	141.44/yr
Subsidence 2 day field survey @ $141.44/day 1 day certified surveyor @ $250/day	532.88/yr
Subtotal	$3,914.32/yr
Cost Total 10 yrs x $3,914.32 =	$39,143.20

h. Hydrology Monitoring, Quarterly

Labor - 4 days annually @ $126.64/day	$ 506.56/yr
Laboratory work - per Commercial Testing and Engineering Co. Huntington, Utah ($87.73/sample)(7 samples) - $614.11/quarter x 4	2,456.44/yr
Subtotal	$2,963.00/yr
Cost Total 10 yrs x $2,963.00 =	$29,630.00

i. Supervision - ~~16.7~~ 20.2 weeks @ $707.20/week	~~$11,810.24~~ 14,285.44
j. Mobilization and Demobilization of 5 pieces of equipment @ $500 each	$ 2,500.00

The above listed costs include reclamation costs added between 1985 and the latest modification.

Each mine entry which is temporarily inactive, but has a further projected useful service under the approved permit application, shall be protected by barricades or other covering devices, fenced, and posted with signs, to prevent access into the entry and to identify the hazardous nature of the opening, These devices shall be periodically inspected and maintained in good operation condition by the person who conducts the underground coal mining activities.

Co-Op is committed to sealing all portals in the prescribed manner which are temporarily inactive in course of normal mining activities.

3.6.11 Tank Seam Access Road Reclamation

This section provides a detailed description of the backfilling and grading plans for the Tank Seam Access Road and Portal Area. Reclamation will be scheduled to allow revegetating of the area in conjunction with backfilling and grading.

As soon as the Tank Seam portals are sealed and all facilities removed, the borehole will be filled using the cuttings from initial construction of the borehole. This cuttings will be stored underground in the Blind Canyon Seam during operation. Backfilling will begin at the Tank Seam Portal Area. Backfilled material shall be placed by heavy equipment such as a front-end loader and track backhoe in lifts not exceeding 18 inches and compacted as described on page 3F-27. Lifts will be placed parallel to the slope of the

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road until the final lifts are reached which are wide enough for the equipment to drive on. final lifts will be placed by a backhoe and compacted in a sloping manner as shown in Figure 3.6-3.

In areas where fill material is located on the outslope, fill material will be pulled back using a backhoe and the material incorporated into the lifts placed on the cut bench. Where large fill areas exist, the fill will be excavated in a reverse sequence from the placement described in Appendix 3-H. This will allow the fill to be removed and then reclamation to proceed from the bottom of the slopes toward the top, as the "pilot cut" is reclaimed.

Fill material will be excavated from around the large boulders which were left in place during construction using a backhoe, and the approximate original contour of the slope will be restored. Channels will be restored in the large fill areas by duplicating the configuration shown in Appendix 7-H.

As the lifts are placed and fill material retrieved, topsoil will be redistributed on the outslope and upper lifts and spread using a backoe. Any boulder sized rock fragments will be embedded into the surface in the upper lifts as described on page 3F-27.

Using the bucket of the backhoe, the surface will then be ripped and scarified, creating horizontal pockets to aid in water retention for revegetation. The bucket will also spread the topsoil at the top of the cut in a manner to blend the reclaimed slope with the natural slope above.

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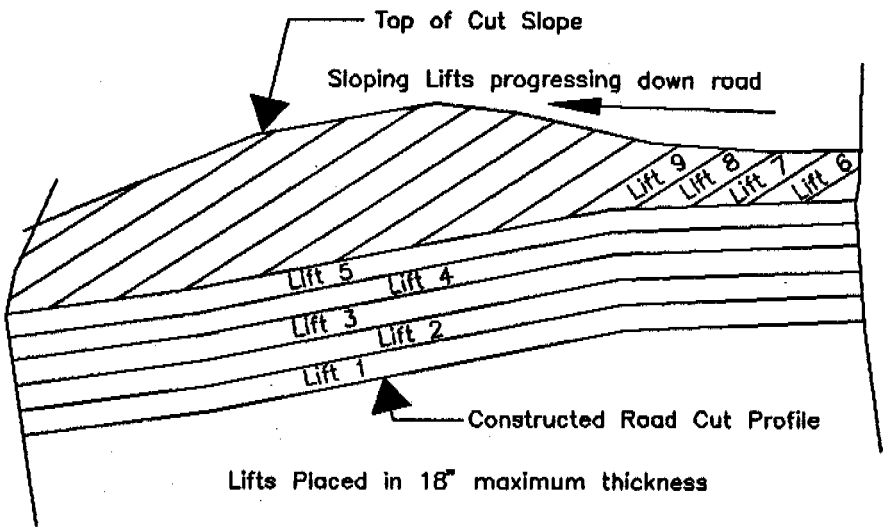
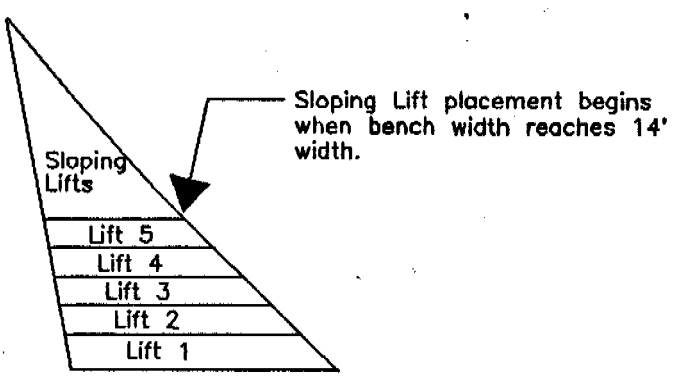


TANK SEAM ACCESS ROAD PROFILE



CROSS-SECTION OF TYPICAL LIFT SEQUENCE

Figure 3.6-3. Typical compaction lift sequence

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As backfilling progresses down the road, seed and mulch will be placed on the completed slopes behind backfilling in accordance with Section 3.6.5.1. following mulching, erosion control matting similar to Excelsior S-2 or equivalent will be placed on the slopes by hand, and stapled to the reclaimed surfaces.

Reclamation will progress in this manner to the bottom of the Tank Seam Access Road.

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EXISTING STRUCTURES

Table 3A-1 lists each structure and construction dates. Reclamation is expected in 2012.

Table 3A-1 Existing Structures

Existing Structure	Construction Dates Starting	Completion	Photo #
Fuel Tanks	10/83	6/84	2
Truck Loading Facility	9/82	4/83	3
Shop - Bathhouse - Warehouse	10/83	9/84	4
Added Machine Shop	11/89	12/89	5
Oil Slack Loading Facility	4/83	7/83	3
Storage & Stacking Facility	6/80	4/84	3
Coal Processing Facility	4/80	12/85	6
Non-Coal Storage Yard	3/80	9/84	7
Transformer Sub-Station	4/80	6/80	8
Conveyor Structures	3/80	6/80	3
Cross Conveyor	7/89	9/89	9
Sales Receiving-Scale Office	6/84	10/87 (Phase I) 10/92 (Phase II)	Fig 3A-1
Lamp House	10/83	4/84	10
Coal Storage Bins	4/85	10/85	11
Powder Magazine	9/82	containerized	7
Lump Coal Facility	10/83	12/85	6
Electric Service Depot	Mobile Trailer		12
Water Tanks & System	8/82	11/82	13
Mine Fan	9/82	11/82	14
Lump Coal Storage Pad	8/92	10/92	15
Equipment Wash Pad	8/92	10/92	16
Shower House	under construction		17
Tank Seam Fan	proposed		18
Tank Seam Borehole Structure	proposed		19

The location of each of the listed structures is shown on Plates 2-4, Surface Facilities. Co-Op has sought interim approval for each structure in the course of construction, the hydrologic safeguards have been implemented, topsoil removed and stored, interim revegetation completed where earthwork is at final grade, and health and safety standards implemented as per MSHA standards.

All of the structures are to be reclaimed during reclamation (year 2012) and are detailed in Section 3.6.6 and 3.6.7. In order to consolidate all previous plan submittals, current photographs were taken 5/90 and are attached herein. A brief description of each facility follows under "Facility Description".

FACILITY DESCRIPTIONS

1. Sales - Receiving - Scales Office. Containing parts warehouse, parts receiving, scale office, mine offices, and security guard quarters. See Figure 3A-1, and Photo #1.

2. Fuel Tanks. There are three - 10,000 gal. fuel storage tanks installed at the downslope of the shop area. These tanks are contained within a natural berm of the slope with the only access by way of the disturbed drainage ditch leading directly to the sediment pond. The pond is designed to contain any spillage which could foreseeably occur. The area will be posted " No Smoking " and fire extinguishers are in place, all MSHA safety standards will be adhered to. See Photo #2.

3. Truck Loading Facility. The truck loadout is a conveyor system designed to load tractor-trailer trucks from any of the storage areas. It is electrically manipulated so as to minimize spillage. As each unit is loaded, the area is cleaned of spilled coal on a daily basis, and all runoff is contained. See Photo #3.

4. Shop - Bathhouse - Warehouse. The shop building with attached bathhouse is for servicing of both underground and surface equipment. Major and minor repairs are implemented and it is used to inventory parts to be utilized on a continual roll over basis. The buildings are heated with a coal furnace and are equipped with standard heavy equipment handling implements such as wenches, welders, etc. See Photo #4. A new machine shop (30 ft by 40 ft) was added in 1989 to better facilitate mine related repairs. See Photo #5.

5. Oil Slack Loading Facility. The oil slack loadout is designed to handle oiled stoker coal, primarily for non-commercial clients, it maintains a 20,000 ton storage bin with an electrical controlled auger to load small tonnages. The bin is fed via of a hopper and conveyor which is loaded by way of an end loader. See photo #3.

6. Coal Storage Area and Stacking Facility. The coal storage yard (Phase 1) is equipped with a system of conveyors wherein coal can be segregation according to size and is of a short

term nature where the piles are constantly being consumed and replenished. The area also contains two 6,000 gal oil storage tanks which are used to store oil for stoker coal. All run-off is controlled, and passes through the primary sediment pond. See Photo #3. A seasonal coal storage area (approx .5 acres) is located east of the Sales Office. See Photo #15. Run-off flows to sediment pond "B".

7. Coal Processing Facility. This facility is primarily a coal segregation site where the various sizes of coal can be separated and then stacked in the designed locations. This area is controlled run-off and is passed through the sediment pond. See Photo #6.

8. Non-Coal Storage Yard. This area is utilized for all material which is in storage on the property with projected use and or salvage value. Historically, the site has been utilized for this purpose and is designed with hydrologic safeguards to protect for this purpose and is designed with hydrologic safeguards to protect the watershed. See Photo #7.

9. Transformer Substation. This facility is the concern of the mine's power supplier, Utah Power & Light. However, Co-Op does maintain the fence, and enforces health and environmental safeguards. The structure is pictured on Photo #8.

10. Conveyor Structures. These conveyors are the route by which the coal exits the mine to the storage piles and loadouts. Photo #3 pictures the conveyors and load out facilities from below.

Cross Conveyor. In order to reduce problems encountered with the use of the Coal Recovery bin (i.e. fires and coal fine movement) a cross-over belt from the Blind Canyon Seam conveyor to the Hiawatha Seam conveyor was installed in 1989, bypassing the bin. See Photo #9.

11. Lamp House. Located near the mine portal to charge cap lamps, and to store safety equipment & supplies. See Photo #10.

12. Caretakers Residence. There is not a caretakers Residence in the Permit area at the Present time.

13. Coal Recovery Bin. As the name implies, is approx 50 ft X 100 ft bin where coal fall from the conveyor chute prior to traveling to the crusher is pictured in Photo #11. **- To be removed -**

14. Powder Magazine. Consists of a storage shed. See Photo #7.

15. Lump Coal Facility. Consists of storage bin & loading conveyor. See Photo #6.

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16. Electric Service Depot. Storage for electric supplies - located in non-coal storage yard. See Photo #12.

17. Water Tanks. Surge tanks - part of bathhouse water supply system. See Photo #13.

18. Mine Fan. Mine Ventilation fan - MSHA approved has safety guards in place. See Photo #14.

19. Lump Coal Storage Pad. Consists of a concrete pad and misc. concrete retaining walls. See Photo #15

20. Equipment Wash Pad. Consists of a concrete pad with a grease and oil trap.

21. Shower House. Consists of a two story masonry block structure that houses employee showers, training classrooms and offices. See Photo #16. The waste disposal system is discussed in Appendix 3-J.

22. Tank Seam Fan. Tank Seam Ventilation Fan - MSHA approved, has safety guards in place. See photo #18.

23. Tank Seam Borehole Structure. Metal structure fully enclosing borehole and conveyor - conveys coal from Tank Seam mine to the Blind Canyon Seam Mine. See photo #19.

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UNDER CONSTRUCTION

Photo #17 Shower House

PROPOSED

Photo #18 Tank Seam Fan

DRAFT

PROPOSED

Photo #19 Tank Seam Borehole Structure

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If ~~both the upper and lower~~ three seams are extracted, maximum subsidence has been estimated from Figure 3C-1 as follows;

	Fee and Fed Lease U024318	Fed Lease U024316
HIAWATHA		
Panel Width	600 ft	600 ft
Average Depth	860 ft	1810 ft
Width/Depth Ratio	0.75	0.33
Seam Thickness	5 ft	5 ft
Max Calculated Subsidence	3.2 ft	1 ft
TANK SEAM		
Panel Width	600 ft	NOT MINEABLE
Average Depth	560 ft	
Width/Depth Ratio	1.07	
Seam Thickness	8 ft	
Max Calculated Subsidence	5.5 ft	1 ft
Total Calc. Subsidence	**14.1 ft**	**2.8 ft**

Again, past experience in this area shows no indication that subsidence would be this drastic. No actual subsidence has been noted from areas pillared as much as 40 years ago, and the subsidence monitoring network initiated in 1987, has shown only minor (0.47 ft max 1992) variations in elevation. Based on this, little, if any, detectable subsidence is expected to become apparent when mining under these depths. Some minor fracturing and an escarpment rock fall have been noted in the adjacent Trail Canyon Mine area, and although these are assumed to be mine-related, they occurred in areas of relatively low cover and unknown outcrop protection. No such occurrences have been noted in relation to the Bear Canyon Mine. (See Plate 3-3).

Reclamation

All roads shall be removed upon completion of the mining operation. The timing and procedure of removal and reclamation is discussed in detail under the Backfilling and Grading Plan in Sec. 3.6.4. See Section 3-6, and Chapters 7, 8 and 9 for full reclamation procedures.

During reclamation road surfacing material will be removed and salvaged or buried as fill material in the reclamation of highwalls, see Appendix 3-L. Reclamation will then be accomplished by ripping up the remaining base, and ensuring that suitable plant growth material is in place prior to planting the area with the approved seed mix. During this time, all culverts shall be removed and either salvaged or disposed of in an approved landfill, and the natural drainage patterns shall be restored.

PRIMARY ROADS

There are ~~67~~ Primary roads within the Permit Area. Each road is described below. Construction of the Tank Seam Access road is described in Appendix 3-H.

Primary Haul Road

The Bear Canyon Haul Road is approx 3690 ft long from the gate to the base of the Portal Access Road and Tipple Access Road. See

Tipple Access Road

This road is 600 ft long, and was constructed to provide access to the Coal Preparation Facility. The road has an overall slope of approx 12 pct, and does not exceed 25 pct at any point.

Shop Road

This road is 160 ft long, and provides access to the Shop Pad. The road has an overall slope of approx 1 pct, and does not exceed 5 pct at any point.

Tank Seam Access Road

This road is approx 3,000 ft long, and provides access to the Bear Canyon #2 Mine, located in the Tank Seam. The road has an overall slope of approx 9 pct, and does not exceed 16 pct at any point. Construction of this road is discussed in Appendix 3-H.

The Tank Seam Access Road will be maintained in accordance with the requirements of this Appendix. During snow storms, snow will be plowed to and stored against the cut slope of the road along the ditches, in order to prevent saturation of fill outslopes along the road due to snow melt.

ANCILLARY ROADS

The only Ancillary Road on the permit area is a jeep trail that was constructed pre-law, probably as a cattle trail. This road is shown on Plate 2-4C. The road is blocked off, is not within the disturbed area, and is not used; therefore, no maintenance or reclamation plan is proposed for this trail.

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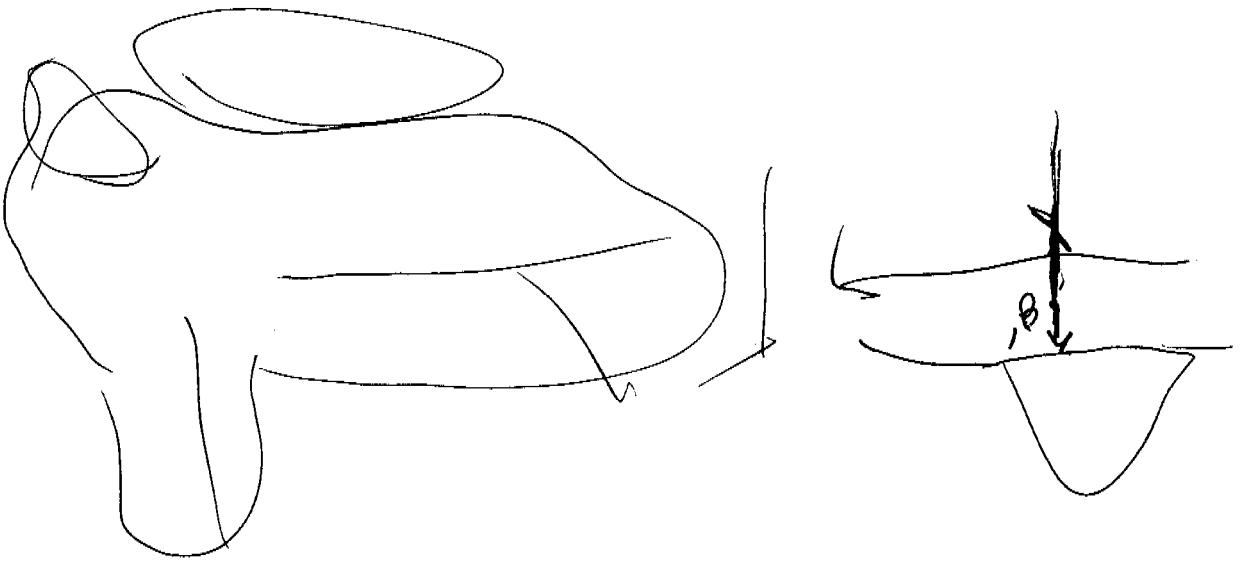
RECLAIMED TANK SEAM PORTAL ACCESS ROAD

SLOPE STABILITY ANALYSIS



DAMES & MOORE

127 SOUTH 500 EAST, SUITE 300, SALT LAKE CITY, UTAH 84102-1959
(801) 521-9255 FAX: (801) 521-0380

May 10, 1994

CO-OP Mining Company
P.O. Box 1245
Highway 31
Huntington Canyon
Huntington, Utah 84528

Attention: Mr. Charles Reynolds
Mining Engineer

Report
Stability Analysis for Reclaimed
Tank Seam Portal Access Road
Job No. 27437-001-162

INTRODUCTION

Dames & Moore performed stability analyses for construction and reclamation of the Tank Seam Portal Access Road in 1993. Minor revisions were incorporated into that report, dated September 16, 1993 for access road construction, and an updated report has been issued. This report incorporates updated reclamation concepts and replaces the original stability analysis for the reclaimed Tank Seam Portal Access Road, dated September 22, 1993.

STABILITY ANALYSIS

This report presents stability analyses for the anticipated configuration of the Reclaimed Tank Seam Portal Access Road. The general location of the proposed access road is presented on Plate 1. It is assumed that the access road excavation will be reclaimed to approximately the same slope as the topography adjacent to the access road alignment. Backfill materials will be derived from the fill sections of the road and from adjacent slopes during the reshaping. Materials to be used during reclamation of the access road will be native soils and no additional materials from offsite borrow sources are anticipated. Boulders obtained during initial road construction that are not incorporated into reclamation fill and that cannot be broken down into smaller fragments will be placed on stable flat areas of the mine site.

A stability analysis of the proposed reclaimed slope was performed utilizing a two dimensional, limit equilibrium stability program called PCSTABL5. An automatic search routine was employed to determine the failure surfaces with the lowest factors of safety. Only circular failure surfaces were evaluated. A natural slope of 35 degrees was modeled considering dry conditions.

The analysis of the cut slope section considered one horizontal to two vertical (1H:2V) cuts. Bedrock was modeled to be present 6 feet vertically below the ground surface and to trend parallel to the natural cut. The roadway section cut was backfilled to conform to the natural existing slopes above and below the access road excavation. The small fill section, which includes the safety berm, was left in place in the stability analysis model. However, it could be removed during reclamation activities. Removal of the berm would not decrease the stability of the slope. Plate 2 presents the configuration modeled, the

input material properties, and the ten failure surfaces with the minimum safety factors. A minimum factor of safety of 1.8 was determined for the input configuration. The "arrows" on Plate 2 indicate the failure surface with the lowest safety factor.

The fill material placed in the road cuts should be compacted in lifts not exceeding 18 inches in depth and compacted by heavy machinery during placement. All rock fragments in excess of 18 inches should be removed from the initial lifts of the fill. Rock fragments obtained during road construction and incorporated in the fill should be placed in a manner to minimize void space. During placement of the fill, boulder sized rock fragments in excess of 18 inches could be incorporated into upper lifts of the fill provided the majority of the fragments are well embedded in the fill and the material adjacent to these rock fragments is properly compacted. The surface of the reclaimed ground that is devoid of protruding rock fragments should be scarified to a minimum depth of 12 inches to reduce surface compaction and to aid in the re-establishment of vegetation.

All of the existing gullies for slope drainage should be re-established to their natural configuration. Since the stability of the reclaimed slopes will be influenced by the degree of saturation of the existing soils, surface drainage must be channeled to prevent or at least minimize runoff over the reclaimed slopes.

Questions have been raised concerning the stability of the scarified surface of the reclaimed slopes, particularly if topsoil comprises the majority of the scarified material. To evaluate this scenario, a reclaimed slope of 35 degrees with simulated 18 inch lifts was modelled. The friction angle of the outer 12 inches of the slope was reduced to 30 degrees to mimic scarified conditions. We understand that an erosion control/revegetation blanket similar to Excelsior S-2 or equivalent will be placed over the scarified slope surface and stapled into scarified material to minimize erosion potential and to enhance slope stability. This blanket was also incorporated into the model and a minimal tensile strength utilized. The modelled configuration, input properties, and the ten failure surfaces with the minimum factors of safety are presented on Plate 3.

The analysis indicates that the scarified material will achieve minimum factors of safety provided proper construction techniques are utilized and the erosion control/revegetation blanket is properly placed and adequately attached to underlying soils. Scarification and placement of the blanket should be coordinated such that vegetation can begin to develop prior to spring runoff.

Based on our slope stability analysis and observations made during our reconnaissance visit, it is our opinion that the reclaimed fill slopes, if properly constructed, will perform similar to or better than the natural existing slopes in the area of the proposed Tank Seam Portal Access Road.

Again, we are pleased to be able to assist you with the expansion of the Bear Creek Mine. If you have any questions concerning this report, our previous reports, or if we can assist you in any other way please call at your earliest convenience.

oOo

DRAFT

The following Plates are attached and complete this report:

Plate 1 - Plot Plan
Plate 2 - Reclaimed Slope Cross-Section
Plate 3 - Reclaimed Slope Scarified Section

LICENSED PROFESSIONAL ENGINEER
93-180048-2202
RUSSELL L. OWENS
STATE OF UTAH

Sincerely,

DAMES & MOORE, INC.

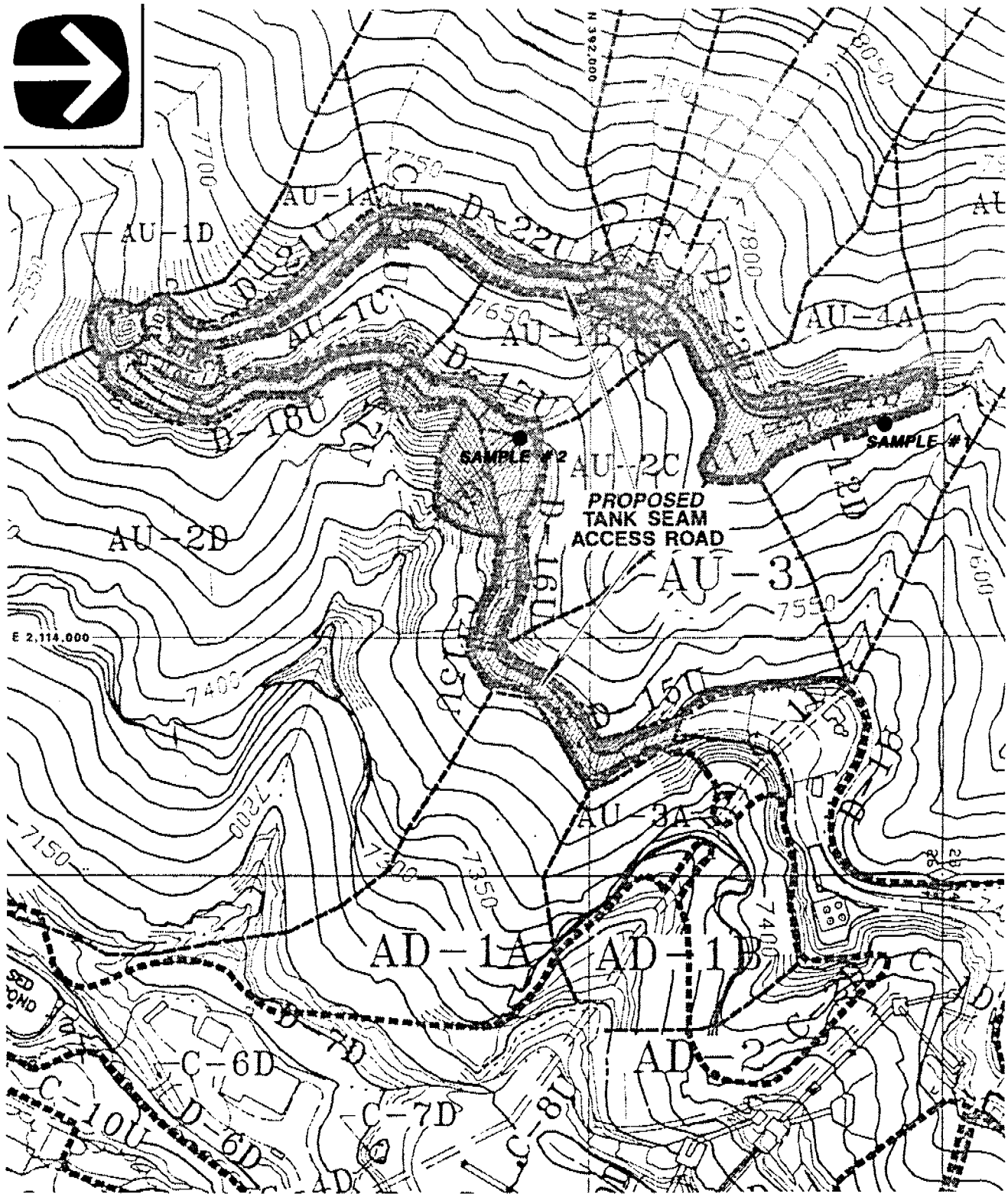
C. Charles Payton

C. Charles Payton, C.E.G.
Associate

Russell L. Owens

Russell L. Owens, P.E.
Professional Engineer
State of Utah

DRAFT



100 0 100 200

SCALE IN FEET

AD-1 INDICATES DRAINAGE AREAS THAT ARE DIVERTED THROUGH SEDIMENT PONDS OR ALTERNATE SEDIMENT CONTROL STRUCTURES

AU-1 INDICATES DRAINAGE AREAS THAT ARE DIVERTED BY DITCH AND/OR CULVERT TO OFF-SITE WITH LIMITED OR NO SEDIMENT CONTROL

DRAFT

REFERENCE-
ADAPTED FROM DRAWING ENTITLED, "WATERSHED MAP; BEAR CANYON," BY CO-OP MINING CO., HUNTINGTON, UTAH, PLATE 7-5, DATED 5-6-91.

CO-OP MINING CO.
PLOT PLAN
BEAR CANYON MINE

Dames & Moore

FILE 27437-002-162 BY _____ DATE _____ CHECKED BY _____ DATE _____

B.C.
3F-29
5/16/94

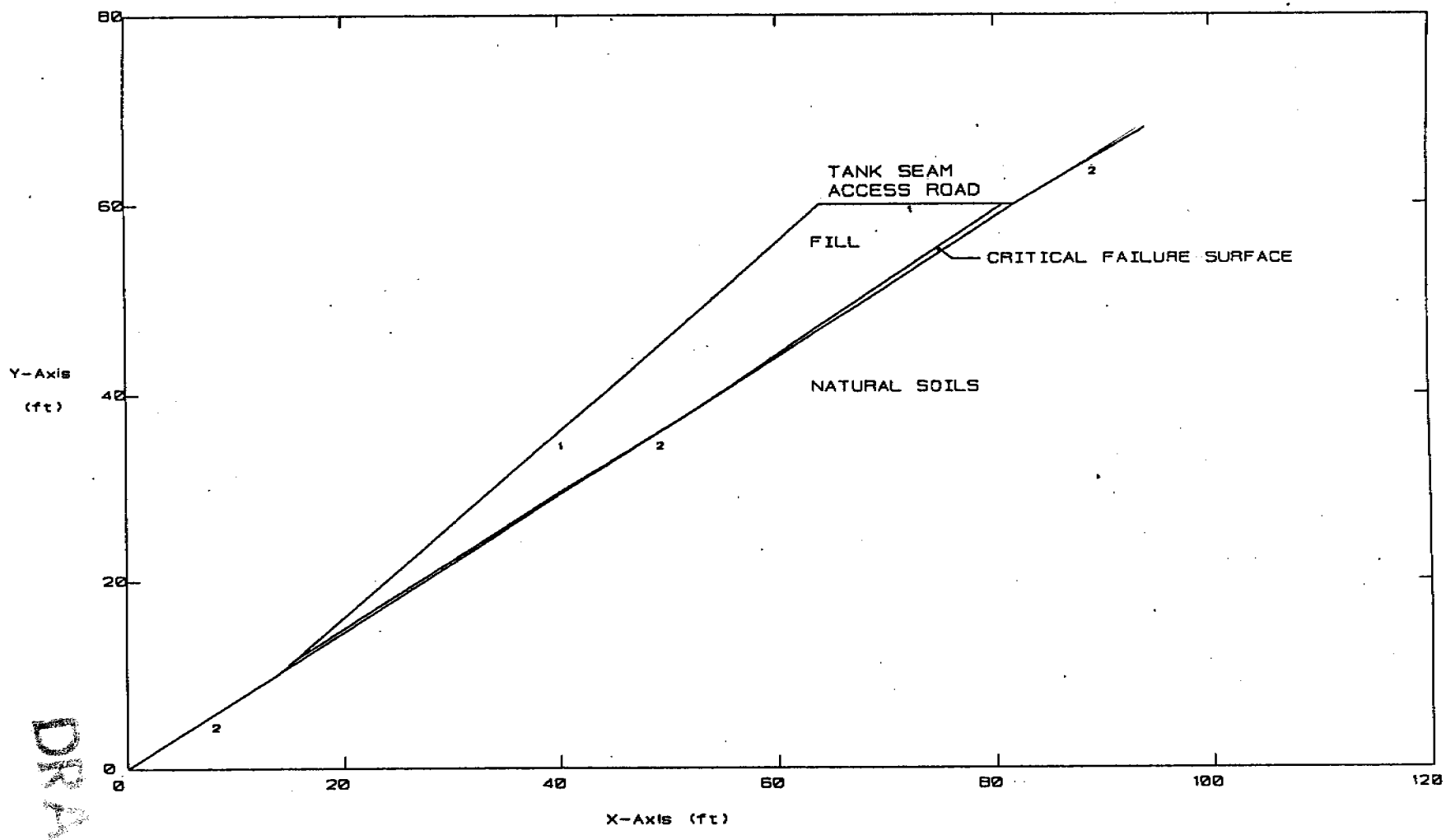
PLATE 1

FILE _____ BY _____ DATE _____ CHECKED BY _____ DATE _____

B.C.
3H-52
5/16/94

CO-OP FIII 1:1 FILL SLOPE

Specified Critical Failure Surface, Minimum FS=1.44



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)
1	125	130	180	36
2	120	125	180	32

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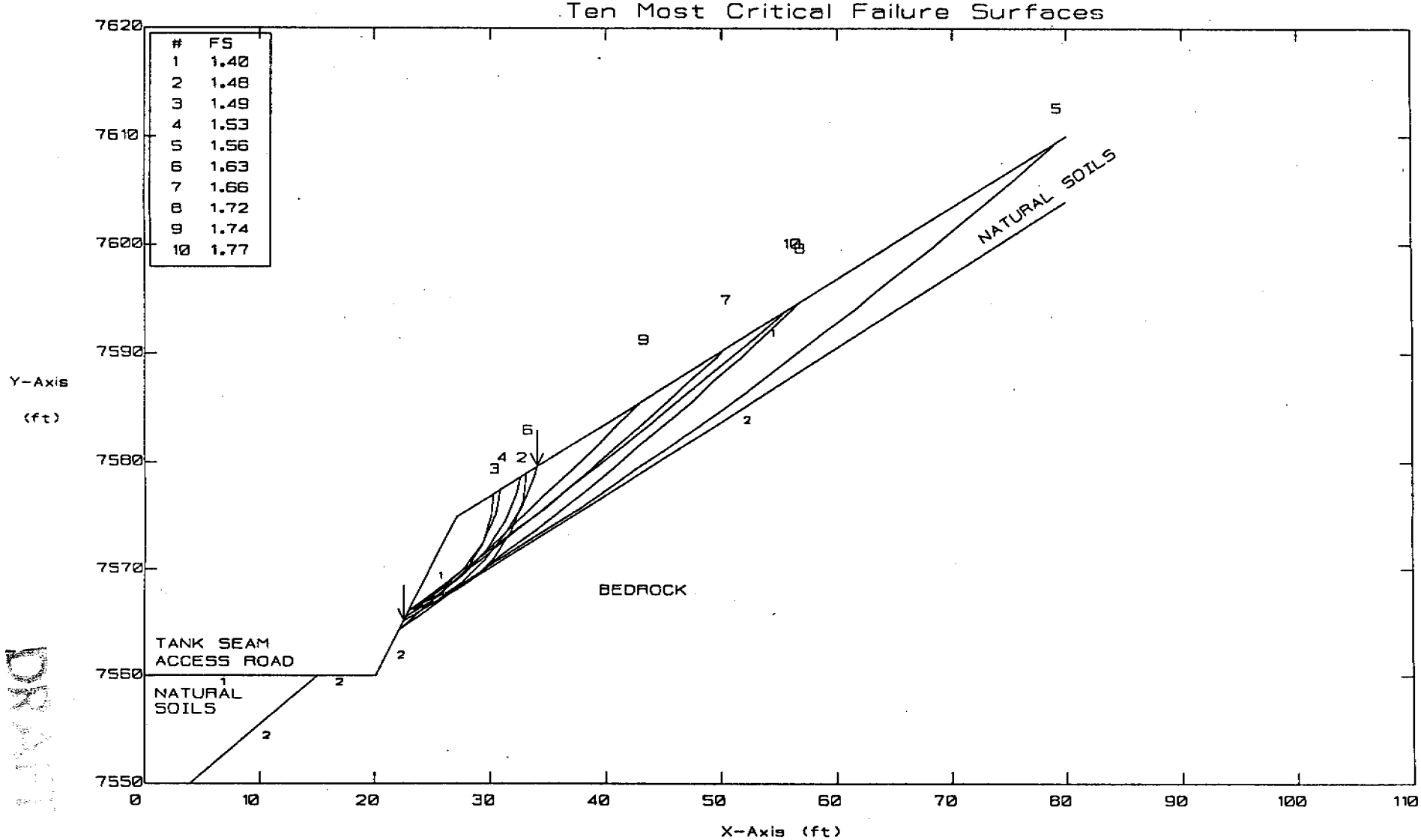
PLATE 3

FILE _____ BY _____ DATE _____ CHECKED BY _____ DATE _____

B.C.
3H-51
5/16/94

CO-OP Mine 1H:2V Cut slope

Ten Most Critical Failure Surfaces



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)
1	120	125	180	32
2	130	140	500	38

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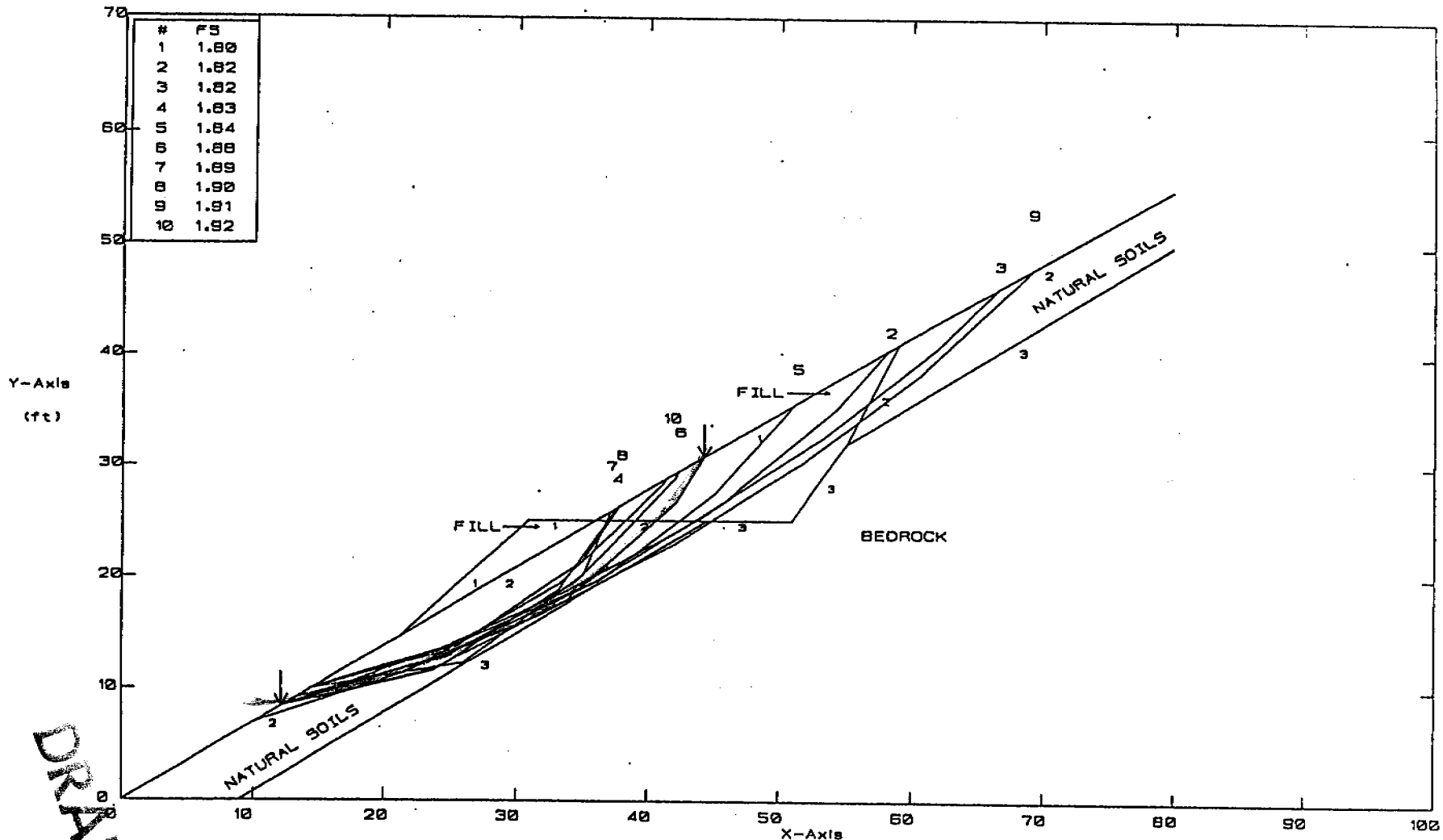
PLATE 2

B.C.
3F-30
5/16/94

FILE _____ BY _____ DATE _____ CHECKED BY _____ DATE _____

CO-OP Mine 1H:2V Cut slope, Reclaimed

Ten Most Critical Failure Surfaces



#	FS
1	1.80
2	1.82
3	1.82
4	1.83
5	1.84
6	1.88
7	1.89
8	1.90
9	1.91
10	1.92

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)
1	125	130	180	36 Compacted Fill
2	120	125	180	32 Natural Soils
3	130	140	500	38 Bedrock

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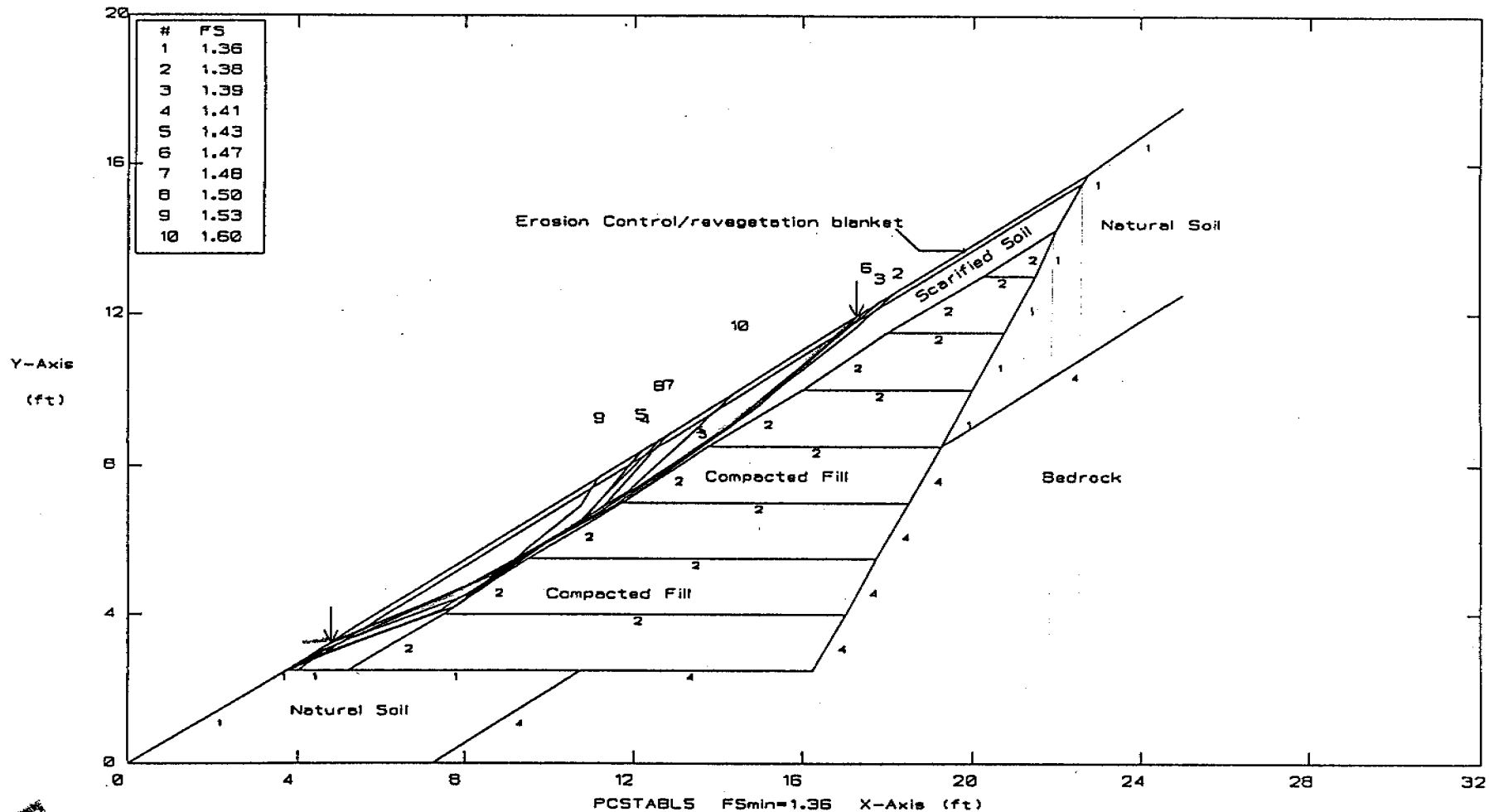
PLATE 2

B.C.
3F-31
5/16/94

FILE _____ BY _____ DATE _____ CHECKED BY _____ DATE _____

CO-OP Mine 1H:2V Cut slope, Scarified Reclaimed Slope

Ten Most Critical Failure Surfaces



#	FS
1	1.36
2	1.38
3	1.39
4	1.41
5	1.43
6	1.47
7	1.48
8	1.50
9	1.53
10	1.60

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Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Material Type
1	120	125	180	32	Natural Soil
2	125	130	180	38	Compacted Fill
3	110	115	0	30	Scarified Soil
4	130	140	500	38	Bedrock
5	1	1	100	0	Erosion Control/Revegetation Blanket

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PLATE 3

DISCUSSION OF REPRESENTATIVE CROSS SECTIONS

Sediment Ponds "A" and "B"

Sediment pond sections show adequate volume of material available for recovery. See Section A-A for sediment pond "B" and Section B-B for sediment pond "A".

Upper Storage Pad

Sections C-C, D-D, and J-J (upper storage pad area) indicate enough material to recover approx. twenty ft. of highwall. The cut and fill areas of sections C-C and D-D are basically balanced. As seen in section J-J some additional material will need to be hauled from below for complete highwall recovery.

Additional material required from below:
(388 sq ft - 250 sq ft) x (320 ft) = 44,160 cu ft = 1636 cu yd

Construction of the Tank Seam Access Road will result in placement of additional material on the storage pad (section 0+00, 1+00, 2+00 and 3+00, Appendix 3-H). This material will be used for reclamation of the Tank Seam Access Road, and will not influence the upper storage pad reclamation.

Portal Pad Area and Road

Sections E-E and F-F (portal pad area & road) show enough material for approx. twenty five ft. of recovery. Section F-F is basically balanced. As seen in section E-E some additional material will need to be hauled from below for complete highwall recovery.

Additional material required from below:
(350 sq ft - 250 sq ft) x (340 ft) = 34,000 cu ft = 1260 cu yd

Portal Access and Tipple Access Roads

Sections G-G and H-H (typical road profiles) show enough material to recover approximately ten ft. of highwall. Section G-G is basically balanced. In the area of section H-H the highwall varies from 0 to 35 ft with an average of 16 ft as shown on page 3L-23. Section H-H shows typical recovery of a 16 ft (average) highwall.

Additional material required from below:
(165 sq ft - 140 sq ft) x (1500 ft) = 37,500 cu ft = 1389 cu yd

Total volume required from below:

1636 + 1260 + 1389 = 4285 cu yd

Mass balance calculations of sections 1-1 through 7-7 show excess material available from below equal to 4,120 cu yd (see table 3L-2 page 3L-5) which is approx. equal to that required above. The cut and fill angles can be varied slightly to provide the required material for highwall recovery above.

Tank Seam Access Road and Portal Pad

Appendix 3-H presents cross sections 0+00 through 30+00 for the construction of the Tank Seam Access Road and portal pad. Reclamation will involve restoring the road and pad area approximately to the premining cross section (designated as "existing" in Appendix 3-H). The total volume of fill material to be replaced in the road and pad area si 20,551 cu yd. This volume was determined using Quicksurf v. 4.0, a 3-D modeling software program. 13,288 cu yd will be hauled from the fill area at section 8+00 and 9+00 and the upper storage pad to reclaim the upper section of the road and the portal area.

Appendix 3-M

SURFACE BLASTING PLAN

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GENERAL

This blasting plan is designed to meet the requirements of R645-301-524. Occasionally during surface site preparation, surface blasting may be required to break rocks too large to move with equipment. The following sections describe the procedures and limitations which will be adhered to in these blasts.

Blaster Certification

Co-Op Mining company currently employs a certified blaster who has been trained and certified by the Utah Division of Oil, Gas & Mining in accordance with R645-105. A copy of the blaster certificate is maintained on file at the minesite.

The certified blaster will be present during all surface blasting activities, and will ensure that all state and federal regulations are adhered to during blasting. The blaster and at least one other person will be present at the firing of a blast.

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Blast Design

The following blast design pertains to blasting within 1,000 feet of any building used as a dwelling, public building, school, church, or community or institutional building outside the permit area, or within 500 feet of an active or abandoned underground mine. Approval will be obtained from MSHA prior to conducting blasting within 500 feet of an active underground mine. This design describes the use of blasting to break large rocks encountered during construction. This design will be used in the construction of the Tank Seam road in the event rocks are encountered which are too large for the equipment to move, or cutting into bedrock is required. No buildings exist outside the permit area within 1,000 feet of the proposed Tank Seam Road.

Holes to be used will be 1¼" diameter, 4′ deep and will be spaced 4′ apart. The explosive to be used is Irecoal D 378 permissible explosive. Ireco electric 25 ms delay detonators will be used. The weight of explosives for each blast will be less than 5 pounds. 0.6 pounds of explosive per each hole will be used. The following standards will be maintained for all blasts.

<u>Airblast Limits and Ground Vibration (R645-301-524.600).</u> Airblast and ground vibration limits at the location of any building structure outside the permit area will not exceed those outline in R645-301-524.621 and R645-301-524.642. No buildings exist outside the permit area within one-half mile of the anticipated blasting area for the Tank Seam road.

Pre-Blast Survey

Since each blast will not exceed 5 pounds of explosive weight, the requirements of a pre-blast survey are not applicable to the blasting plan.

Blasting Schedule

Since each blast will not exceed 5 pounds of explosive weight, a blasting schedule and public notification will not be required.

Warning Signs and Signals

During periods of construction involving blasting, warning signs will be posted as described in Section 3.4.5.1.

Warning and all-clear signals of different patterns, audible within a range of one-half mile from the point of the blast, will be given to inform anyone in the area of the status of blasting activities. The signals and their patterns and meanings will be described in the "Warning" sign at the entrance to the property. Each person within the permit area, or anyone who resides or regularly works within one-half mile of the permit area will be notified of the meaning of the signals.

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Access to the area will be controlled to prevent livestock or unauthorized persons from entering the area by individuals monitoring the perimeter of the blasting area until the all-clear signal is given.

Blasting Record

A blasting record will be maintained onsite of each blast performed, and will be made available to the Division and the public upon request. The record will include the following:

Name of the operator conducting the blast

Location, date and time of the blast

Name, signature and certification number of the blaster

Identification, direction and distance from the nearest blast hole to the nearest building outside the permit area

Weather conditions

A record of the blast, as required in R645-301-524.740

DRAFT

APPENDIXES

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Plate 6-4	Structure Contour Map Bear Canyon Seam
Plate 6-5	Interburden Isopach Map Bear Cyn.-Hiawatha Seam
Plate 6-6	Overburden Map Hiawatha Seam
Plate 6-7	Isopach Map Hiawatha Seam
Plate 6-8	Structure Contour Map Hiawatha Seam
Plate 6-9	Interburden Isopach Map Tank-Bear Cyn. Seam
Plate 6-10	Overburden Map Tank Seam
Plate 6-11	Isopach Map Tank Seam
Plate 6-12	Structure Contour Map Tank Seam

Coal outcrops slightly lower in elevation in the southern portion of the area than in the northern portion.

Small faults noted in the field along outcrops were interpreted to be largely of non-tectonic origin (e.g. landslide and slump) by Co-Op. Other faults observed did not express displacement of sufficient magnitude to prohibit mining.

No geologic conditions exist within the permit area which will obstruct or inhibit reclamation activities. The affects of the geologic structures on groundwater movement is discussed in Appendix 7-N, Section 2.4.3.

6.5.2.3 Coal

Multiple coal seams are found in the lower 350 ft of the Blackhawk Formation as was previously mentioned. In ascending order the seams are as follows: Hiawatha, Blind Canyon, Bear Canyon, ~~and the~~ upper beds, and the Tank Seam (Table 6-2).

None of the coal lies at depths of more than 1,800 in the study area. Depth should not be a limiting factor in mining.

It was noted in the field that strata situated at elevations consistent with the upper beds structural horizon were badly burned and not of economic importance, with the exception of the Tank Seam, which has an average thickness of 7 feet in the permit area, but disappears to the North.

Table 6-2 Coal Beds, Lower Huntington Canyon

LAYER	FT
TANK SEAM	0-8
Interval	240
UPPER BEDS	0-6
Interval	200
BEAR CANYON BEDS	0-10
Interval	40-60
HIAWATHA	5-8
STAR POINT SANDSTONE	

After Doelling, 1972
Authors note: Hiawatha to Blind Canyon interval can be as great as 110 feet

---

The Tank seam outcrops locally in the Southern portions of the study area. Drilling in the Bear Canyon Mine indicates minable thickness within the permit area. Drillhole logs are found in Appendix 6-A. The seam, a member of the upper beds of the Blackhawk formation, achieves minable thickness only in the Southern portions of Bear Canyon and Fish Creek Canyon. Drillholes North of the study area have shown the Tank Seam to be nonexistent to the North.

The Blind Canyon and Bear Canyon seams were measured and observed at various points in the study area by the author. However, these seams were traceable only locally in Bear Canyon. Limited traceability of these two seams is attributed to the lenticular nature of the seams, the extent of slope debris acting as a cover and/or depositional irregularities. H. H. Doelling indicates the Bear Canyon seam is present in Left Fork of Fish Creek Canyon (east of Bear Creek Canyon) with a thickness of 6.5 ft. However, this measurement was not verified in the field, possibly because this particular exposure has since been covered by

slope debris.

A small adit approximately 50 ft in length and interpreted as penetrating the Bear Canyon seam (measurement M-5), and a longer adit approximately 300 ft in length and interpreted as penetrating the Blind Canyon seam (measurement M-7), were discovered in Bear Creek Canyon, Section 24, Township 16 South, Range 7 East. The full extent and history of these workings is not known. The fact that these two seams are not traceable for any significant area beyond these old workings indicates the subordinate nature of the Bear and Blind Canyon seams.

The Bear Canyon Mine is located in the SW 1/4 of Section 24, Township 16 South, Range 7 East. Two seams were worked there, the upper of which was the Bear Canyon seam (elevation 7,340 ft). This interpretation is based on the seams stratigraphic position above the Star Point Sandstone. The Blind Canyon seam apparently has pinched out or has been replaced in this locality. The mine lies on the west side of the Bear Canyon fault. The presence of the Hiawatha and Bear Canyon seams at the mine lend credence to the author's opinion that these seams are probably present across canyon to the east where they were not traceable nor measurable due to slope cover.

The Hiawatha seam was identified throughout the majority of the study area based on its stratigraphic relationship with the underlying Star Point Sandstone. The Star Point Sandstone is continuous and conspicuous within the area covered by this report. While the Hiawatha seam was not measured in Left Fork of Fish Creek Canyon by this author or previous investigators (i.e. E.M. Spieker, H.H. Doelling), the presence of the Reichert Mine (Hiawatha Seam-After Doelling) in Section 20, Township 16 South, Range 8 East suggests the interstitial presence of the Hiawatha seam in Left Fork. Where identified and measured, the Hiawatha seam achieved

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-6 DIRECTION: Up DRILLING ANLE: _____

(180) 90 0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
300			
275		8" Coal	
250		5' Coal	
		8' Coal (Tank Seam) (5' Core)	
225		Unknown (not logged)	
25		Sandstone	
		Roof Coal	Blind Canyon Seam

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DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-7 DIRECTION: UP DRILLING ANLE: 180

DRILLHOLE LOCATION: 56 North, Between 1 and 2 Right

180 / 90 / 0

DRILLER: _____ START DATE: 10/31/91 END DATE: 11/4/91

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
120			
		Shale	
100		Sandstone	
80		3' Coal	
60		Bedded Brown, white & Green Sandstone	
40			
20			
		2' Coal Shale Coal	Plug Drilling Knight Coal (Black Canyon Seam)

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-7 DIRECTION: _____ DRILLING ANLE: _____

180
90
0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
240			
		1' Coal	
220			Core Drilled
		2' Coal	Plug Drilled
200			
		Bedded Sandstone	
180			
		Shale	
		2' Coal	
160			
		Bedded Sandstone	
140		1' Coal	
		Sandstone	

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-7 DIRECTION: _____ DRILLING ANLE: _____

180
90
0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
300		Shale	
280		Bedded Sandstone	
260			Pkg Drilled Core Drilled
		8' Coal	

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-8 DIRECTION: UP DRILLING ANLE: _____

180 / 90 / 0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
120		Shale	
		2' Coal	
		Shale	
100			
		1' Coal	
80			
60			
40			
20		4' Coal (Split)	
		Shale	
		3' Coal	Roof Coal Blind Canyon Seam

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-8 DIRECTION: _____ DRILLING ANLE: _____

180
90
0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
240			
		Bedded Sandstone	
220		2' Coal	
		1' Coal	
		Bedded Sandstone	
200			
180			
160			
140		Sandstone	
		Shale	

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-8 DIRECTION: _____ DRILLING ANLE: _____

180
90
0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
28			
		9' Coal (Tank Seam)	
26			
		1' Coal	

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS9 DIRECTION: UP DRILLING ANLE: _____

180
90
0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
150			
		1' Coal	
125		5' Shale	
		Bedded Sandstone	
100			
		3' Coal	
75			
		Bedded	
50			
		Sandstone	
25			
		5' Coal	Roof Coal (Bad Camera Scan)

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DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-9 DIRECTION: _____ DRILLING ANLE: _____

180 / 90 / 0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
275			
		8' Coal (Tank Seam)	
250		2' Coal, 5' Shale	
		4' Shale	
		Bedded Sandstone	
225			
		2' Coal, 3' Shale	
		Shale	
200			
		10' Sandstone	
		5' Shale	
175		1' Coal, 4' Sandstone	
		Shale	

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DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-10 DIRECTION: UP DRILLING ANLE: _____

180 / 90 / 0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
150			
		7' Shale	
		2' Coal	
125			
		3' Shale	
		5' Shale	
		Bedded Sandstone	
100			
		5' Shale	
		1' Coal	
75		12' Shale	
		2' Coal	
		Sandstone	
		2' Shale	
		Sandstone	
50		1' Coal	
25			
		2' Shale	
		6' Coal	Roof Coal, Blind Canyon Seam

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-10 DIRECTION: _____ DRILLING ANLE: _____

180 / 90 / 0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
275			
250			
		8' Coal	
225		2' Coal, 3' Shale	
		Shale	
200		3' Coal	
		Bedded Sandstone	
175		2' Coal	
		5' Shale	
		5' Shale	

LIST OF PLATES

Plate 7-1A thru 7-1DE	Hydrology Map
Plate 7-2	Sedimentation Pond "A"
Plate 7-3	Sedimentation Pond "B"
Plate 7-4	Water Monitoring
Plate 7-5	Watershed Map
Plate 7-6	Sedimentation Pond "C"
Plate 7-7	Post-Mining Watershed
Plates 7-8	Cross Sections & Profiles
Plate 7-9	- DELETED -
Plate 7-10A	Mine Water Survey, Blind Canyon Seam
Plate 7-10B	Mine Water Survey, Hiawatha Seam

Appendix 7-L

Figure 4. Major Hydrologic Relationship and Location of Coal Processing Waste and Underground Development Waste.

Figure 5. Surface Water Drainage Area Map.

Figure 6. Potential Recharge Area Above Coal Resource.

Appendix 7-N

Plate 1	Geology and Structure Map
Plate 2	Water Sampling Locations
Plate 3	Spring Canyon Tongue Piezometric Surface and Top-of-Unit Contours
Plate 4	Storrs Tongue Piezometric Surface and Top-of-Unit Contours
Plate 5	Panther Tongue Piezometric Surface and Top-of-Unit Contours

Table 7.2-10 Summary of Diversion Ditch Calculations

DITCH	BOTTOM WIDTH (FT)	TOP WIDTH (FT)	DEPTH (FT)	TYP SIDE SLOPE H:V	MEASURED SLOPE %	CONTRIBUTING WATERSHED	REQ'D AV. RIP-RAP SIZE (IN.)
D-1D	0	1.33	0.67	1:1	2 Min 11 Max	AD-3A	Soil
D-2D	0	1.33	0.67	1:1	6 Min 20 Max	AD-3A, AD-5	Bedrock
D-3D	0	2	1	1:1	2 Min 6 Av. 18 Max	AD-3A, AD-5 AD-7	Soil Soil Grouted
D-4D	0	2	1	1:1	2 Min 6 Av. 17 Max	AD-14	Soil Soil D_{50} 6"
D-5D	0	1.33	0.67	1:1	4 Min 10 Max	AD-9	Soil
D-6D	0	3	1.5	1:1	2 Min 4 Max	AD-3A,AD-5,AD-7, AD-9, AD-10, AD-12, AD-14	Soil
D-7D	2	3.5	0.75	1.5:1	2 Min 6 Av. 55 Max	AD-1A,AD-1B,AD-2A,AD-2B,AD-2C, AD-3B,AD-4,AD-6, AD-8	Soil Soil D_{50} 6"
D-8D	0	2	1	1:1	2 Min 7 Max	AD-13	Soil
D-8D Water Bar	0	2.67	0.67	2:1	3 Av.	AD-13	Soil
D-9D	0	2	1	1:1	4 Min 10 Max	AD-15	Soil
D-10D	1	3.33	0.67	1.5:1	7 Min 50 Max	AD-6,AD-3B,(part) AD-2B, AD-2C	D_{50}4" Bedrock
D-10aD	0	2	1	1:1	7 Av.	AD-6,AD-3B,(part) AD-2B, AD-2C	Soil
D-11D	0	1	0.5	1:1	41 Min Near Vert	TIPPLE WASH HOSE	Grouted Rip-rap
D-12D	0	1	0.5	1:1	81 Av.	TIPPLE WASH HOSE	Soil
D-13D Water Bar	0	6	0.5	10:1 2:1	0.5 Av.	AD-6 Partial	Soil
D-14D	0	1.33	0.67	1.5:1	0.05 Av	AU-4A	Soil

Notes:

1. Dimensions given indicate minimum requirements. Actual dimensions may vary. Minimum required cross section will be maintained.
2. The use of riprap to line drainage ditches is required when flow velocities exceed approximately 5 feet per second. Rip-rap may be installed where not required.

Table 7.2-10 Summary of Diversion Ditch Calculations (cont)

DITCH	BOTTOM WIDTH (FT)	TOP WIDTH (FT)	DEPTH (FT)	TYP SIDE SLOPE H:V	AV. MEASURED SLOPE %	CONTRIBUTING WATERSHED	REQ'D AV. RIP-RAP SIZE (IN.)
D-1U	2	3.33	0.67	1:1	2 Min 8 Max	AU-3, AU-5	Soil
D-2U	0	1.33	0.67	1:1	7 Min 10 Max	AU-6, AU-11	Soil
D-3U	1	2	0.5	1:1	4 Min 18 Max	AU-8	Soil
D-4U	1	4	1	1.5:1	1 Min 10 Av. 18 Max	AU-10	Soil Soil D_{50} 6"
D-5U	0	1	0.5	1:1	4 Min 13 Max	AU-15	Soil
D-6U	0	1.33	0.67	1:1	3 Min 6 Max	AU-14	Soil
D-7U	0	1.33	0.67	1:1	1 Min 16 Max	AU-12	Soil
D-8U	2	4	0.67	1:1	6 Av.	AU-1	Soil
D-9U	3	5	1	1:1	1 Min 6 Max	AU-16	Soil D_{50} 4"
D-10U	3	4	0.5	1:1	3 Min 10 Max	AU-17	Soil
D-11U	0	2	1	1:1	3 Min 8 Max	misc. road drainage	Soil
D-12U	0	3	1	1.5:1	3 Min 9 Max	AU-18	Soil D_{50} 4"
D-13U	0	2	1	1:1	2 Min 23 Max	misc. road drainage	Soil
D-14U	4	5.5	0.5	1.5:1	6 Min 66 Max	Sed Pond A Outlet	D_{50} 4" D_{50} 10"
D-15U	0	3	1	1.5:1	13 Av	AU-3	Soil
D-16U	0	3	1	1.5:1	12 Av	AU-2C	Soil
D-17U	0	3	1	1.5:1	10 Av	AU-1B	Soil
D-18U	0	3	1	1.5:1	13 Av	AU-1A, AU-1C	Soil
D-19U	0	3	0.5	1.5:1	12 Av	AU-1A, AU-1C part	Soil
D-20U	0	3	0.5	1.5:1	11 Av	AU-1A, AU-1C part	Soil
D-21U	0	3	1	1.5:1	10 Av	AU-1A	Soil
D-22U	0	3	1	1.5:1	4 Av	AU-1	Soil
D-23U	0	3	1	1.5:1	6 Av	AU-2B	Soil

Notes:

1. Dimensions given indicate minimum requirements. Actual dimensions may vary. Minimum required cross section will be maintained.
2. The use of riprap to line drainage ditches is required when flow velocities exceed approximately 5 feet per second. Riprap may be installed where not required.

Table 7.2-11 Culvert Charateristics

Culvert	Dia (in.)	Type	Contributing Watersheds	Slope (ft/ft)	Outlet Condition
C-1U	30 ~~15~~	CMP flexible	AU-3, AU-4, AU-4A, AU-5	0.12 0.73	Bedrock
C-2U	12	stl pipe	AU-11	0.08	Soil
C-3U	12	CMP	AU-6, AU-7, AU-11	0.05	4" rip-rap
C-4U	12	CMP	AU-8, AU-9	0.05	4" rip-rap
C-5U	12	CMP	AU-8, AU-9, AU-15	0.05	4" rip-rap
C-6U	12	CMP	AU-6, AU-7, AU-11, AU-13, AU-14	0.05	4" rip-rap
C-7U	12	CMP	AU-12	0.05	6" rip-rap
C-8U	18	Flexible CMP, RCP	AU-2, AU-3 AU-4, AU-5	0.13	12" rip-rap
C-9U	60	stl pipe	Bear Creek[b]	0.06	48" rip-rap
C-10U	60	RCP	Bear Creek[b]	0.06	48" rip-rap
C-11U	18	CMP	AU-16	0.10	6" rip-rap
C-12U	24	CMP	AU-17	0.04	6" rip-rap
C-13U C-13aU	15 ~~16~~	CMP	misc. road drainage	0.06	3" rip-rap
C-14U	60	CMP	Bear Creek	0.06	48" rip-rap
C-15U	12	CMP	AU-2C	0.20	Bedrock
C-16U	18	CMP flexible	AU-1B, AU-2 AU-2A, AU-2B	0.05 1.00	36" m.d. Rocks in Channel
C-17U	15	CMP flexible	AU-1, AU-1A AU-1C	0.05 1.00	Bedrock
C-18U	12	CMP	AU-1A, AU-1C partial	0.24	3" rip-rap
C-19U	12	CMP	AU-1A, AU-1C partial	0.24	3" rip-rap
C-20U	12	CMP	AU-1A	0.24	3" rip-rap
C-21U	12	CMP	AU-1	0.06	42" m.d. Boulders
C-22U	15	CMP flexible	AU-2	0.05 1.00	96" m.d. Boulder in Channel
C-23U	15	CMP flexible	AU-2A	0.05 1.00	18" m.d. Rocks in Channel
C-24U	15	CMP flexible	AU-2B	0.05 1.00	18" m.d. Rocks in Channel

Table 7.2-11 CULVERT CHARACTERISTICS (con't)

Culvert	Dia (in.)	Type	Contributing Watersheds	Slope (ft/ft)	Outlet Condition
C-1D	15	CMP, flexible	AD-6, AD-3B	1.00	24" rip-rap
C-2D	15	CMP, RCP, flexible	AD-2B, AD-2C, AD-3B, AD-4, AD-6	0.40	10" rip-rap
C-3D	20	stl pipe	AD-3A	0.03	4" rip-rap
C-4D	21	CMP	AD-3A, AD-5 AD-7	0.18	9" rip-rap
C-5D	18	CMP	AD-9	0.08	soil
C-6D	12	CMP	AD-10	0.48	9" rip-rap
C-7D	18	CMP	Abandoned In Place		
C-8D	18	CMP	AD-3A, AD-5 AD-7	0.05	3" rip-rap
C-9D	18	CMP	See C-8D	0.05	3" rip-rap
C-10D	18	CMP	TIPPLE WASH HOSE	0.03	3" rip-rap
C-11D	12	stl pipe	AD-4A part	0.01	Soil
C-12D	12	CMP flexible	AD-4A	0.05 0.72	Grouted

Tank Seam Portal Pad & Access Road

Due to the remote location of the Tank Seam Portal Pad with respect to the sedimentation ponds, drainage from the portal area will be controlled using silt fences as shown on Plate 7-1E (BTCA Area "U"). The area, approx. 0.43 acres, will be used only for mine access and portal structures, and will not be used for storage. Ditch D-14D will convey the drainage from AU-4A, which includes the portal pad, to culvert C-12D. Two silt fences will be located prior to the inlet of C-12D. A third silt fence will be located at the base of the disturbed borehole area on each side of culvert C-12D above the outlet and will treat the area containing the enclosed belt and borehole structure.

Runoff will be conveyed past the Tank Seam Access Road via ditches and culverts (See Plates 7-1C and 7-1E). Runoff from the disturbed slopes and cut faces along the access road, designated as BTCA areas "H" through "T", will be treated with silt fences and/or erosion control matting as described in Appendix 7-K.

Culvert outlets will be located in places where the outlet conditions meet or exceed the minimum requirements, which are shown in Appendix 7-G. Table 7.2-11 shows the actual outlet conditions which will exist for each culvert. These conditions reflect existing conditions within the premining channels at the points where the culvert outlets will be located, with the exception of culverts C-18U, C-19U and C-20U. Riprap will be placed at these three outlets as shown in Table 7.2-11. The other culverts along

the road will not require any disturbance at the outlets, but will use the premining conditions which exist.

The reclaimed channel designs for the Tank Seam Access Road are described in Appendix 7-H, and reflect the premining channel conditions. Premining channels consisted of eroded channels passing over large boulders embedded into the soil and/or bedrock. Reclamation activities for the channels will involve excavating the channel back to the premining configuration. The majority of the boulders in the premining channels will remain as markers which can be excavated back to. Photographs of the premining channels are contained in Appendix 7-H, and the profiles on Plate 7-8C reflect the premining profiles and descriptions.

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7.3 RECLAMATION HYDROLOGY

7.3.1 Post-Mining Rehabilitation

Upon completion of mining activities all diversion structures (ditches, culverts, ponds) shall be removed and reclaimed as close to as original configurations as possible. Sequencing of this reclamation shall be from the highest points in elevation to the lowest ones. In addition, the lower disturbed area collection ditches and the sedimentation ponds shall not be removed until the reclaimed areas have stabilized.

7.3.2 Restoration of Natural Channels

There are ~~nine~~fifteen channels in addition to Bear Creek whose drainages have been disturbed by mining activities. Reclamation of these channels shall include placement of naturally configured channels. Design of these channels is provided in Appendix 7-H. Plates 7-7 and 7-8 show the locations, typical cross-sections and profiles of these channels upon reclamation. Table 7.3-1 contains a summary of the reclaimed channel parameters.

Channels RC-TS1 through RC-TS6 refer to the channels disturbed by the Tank Seam Access Road. Appendix 7-H and Plate 7-8C provide documentation of the premining channels. This documentation will be used to restore the postmining channels to the premining conditions. Information in Table 7.3-1 also represents the observed premining channel parameters.

Table 7.3-1 Characteristics of Proposed ~~of~~ Reclaimed Channels

Channel	Bottom Width (ft)	Side Slopes	Depth (ft)	Lining
RC-1	10	1.5:1	2.5	D50 = 6"
RC-2	3	2:1	2	D50 = 9"
RC-3	3	2:1	2	D50 = 9"
RC-4	4	2:1	2	D50 = 6"
RC-5	2	2:1	2	D50 = 6"
RC-6	4	2:1	2	D50 = 6"
RC-7	3	2:1	2	D50 = 3"
RC-8	3	2:1	2	D50 = 3"
RC-9	3	2:1	2	D50 = 6"
RC-10	6	1.5:1	6	D50 = 24"
RC-TS1	10'-12' Avg.	1:1 Typ	8'-9' Avg.	12"-72" Rock
RC-TS2	12' Avg.	1.5:1 Typ	4' Avg.	Bedrock 12"-72" Rock
RC-TS3	6' Avg.	1.5:1 Typ	4' Avg.	12"-60" Rock
RC-TS4	15' Avg.	1:1 Typ	4' Avg.	8"-36" Rock
RC-TS5	4'-6' Avg.	1.5:1 Typ	2'-6' Avg.	18"-48" Rock
RC-TS6	20' Avg.	1:1 Typ	2'-5' Avg.	Bedrock 18"-48" Rock

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WATERSHED CHARACTERISTICS

Undisturbed Areas
and BTCA Areas Not Reporting To Sediment Pond

P=1.5"

Watershed	CN	Area (Ac.)	Slope y(%)	Hyd. length l(ft.)	$S=\frac{1000}{CN}-10$	$L=\frac{l^{.8}(s+1)^{.7}}{1900Y^{.5}}$	$T_c=1.67L$ Time of Conc.(Hr)
~~AU-1~~	~~76~~	~~34.92~~	~~75.0~~	~~3,000~~	~~3.16~~	~~0.100~~	~~0.167~~
~~AU-2~~	~~76~~	~~0.22~~	~~95.5~~	~~120~~	~~3.16~~	~~0.007~~	~~0.011~~
~~AU-3~~	~~76~~	~~1.43~~	~~49.3~~	~~560~~	~~3.16~~	~~0.032~~	~~0.053~~
~~AU-4~~	~~76~~	~~8.86~~	~~84.1~~	~~1,380~~	~~3.16~~	~~0.051~~	~~0.085~~
AU-1	76	5.49	60	1,090	3.16	0.050	0.084
AU-1A	76	1.02	41	575	3.16	0.036	0.060
AU-1B	83	1.14	59	330	2.05	0.016	0.027
AU-1C	83	1.37	67	680	2.05	0.021	0.035
AU-1D	90	0.07	63	115	1.11	0.010	0.017
AU-2	76	2.23	62	975	3.16	0.045	0.075
AU-2A	76	1.64	63	1,025	3.16	0.046	0.077
AU-2B	76	3.67	63	1,100	3.16	0.024	0.040
AU-2C	76	1.70	64	575	3.16	0.029	0.048
AU-2D	76	16.14	72	1,950	3.16	0.072	0.120
AU-3	76	2.17	66	400	3.16	0.021	0.035
AU-3A	76	0.27	59	125	3.16	0.009	0.015
AU-4	76	7.52	63	1,300	3.16	0.056	0.093
AU-4A	83	1.46	45	620	2.05	0.022	0.044
AU-5	76	20.14	77.3	1,700	3.16	0.104	0.104
AU-6	76	2.73	70.0	780	3.16	0.058	0.058
AU-7	76	13.46	69.4	1,400	3.16	0.094	0.094
AU-8	76	4.95	85.7	720	3.16	0.050	0.050
AU-9	76	4.77	64.8	1,440	3.16	0.100	0.100
AU-10	76	35.52	76.1	2,380	3.16	0.137	0.137
AU-11	76	0.62	73.0	570	3.16	0.045	0.045
AU-12	76	2.33	44.1	480	3.16	0.050	0.050
AU-13	76	0.66	77.5	240	3.16	0.022	0.022
AU-14	76	2.43	66.7	620	3.16	0.050	0.050
AU-15	76	0.91	15.6	300	3.16	0.058	0.058
AU-16	76	44.93	71.0	2,580	3.16	0.152	0.152
AU-17	76	30.10	71.0	2,580	3.16	0.152	0.152
AU-18	76	36.55	71.0	2,580	3.16	0.152	0.152
BEAR CREEK	76	1,728	58.1	12,800	3.16	0.360	0.600

DRAFT

Summary of Peak Flows for
10-year, 6-hour storm P=1.5"
(SCS type B distribution)

Watershed	Peak Q (cfs)
AD-1A	0.48
AD-1B	0.29
AD-2A	0.15
AD-2B	0.41
AD-2C	0.10
AD-3A	0.23
AD-3B	0.12
AD-4	0.03
AD-5	0.30
AD-6	0.81
AD-7	1.83
AD-8	2.07
AD-9	0.23
AD-10	0.62
AD-11	0.65
AD-12	0.35
AD-13	1.23
AD-14	0.05
AU-1	~~3.68~~0.72
AU-1A	0.14
AU-1B	0.43
AU-1C	0.51
AU-1D	0.05
AU-2	~~0.03~~0.30
AU-2A	0.22
AU-2B	0.55
AU-2C	0.25
AU-2D	1.92
AU-3	~~0.21~~0.33
AU-3A	0.04
AU-4	~~1.16~~0.97
AU-4A	0.54
AU-5	2.51
AU-6	0.39
AU-7	1.72
AU-8	0.72
AU-9	0.60
AU-10	4.05
AU-11	0.09
AU-12	0.34
AU-13	0.10
AU-14	0.35
AU-15	0.13
AU-16	4.92
AU-17	3.29
AU-18	4.00
BEAR CREEK	108.53

DRAFT

PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AU-1

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0840 hr
Duration = 6.00 hr	Area = 5.49 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 0.72 cfs (0.1305 iph)
At T = 2.53 hrs

INPUT SUMMARY FOR W.S.: AU-1A

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0600 hr
Duration = 6.00 hr	Area = 1.02 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 0.14 cfs (0.1398 iph)
At T = 2.51 hrs

DRAFT

PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AU-1B

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 83
Precip. Depth = 1.50 in	Time of Conc. = 0.0270 hr
Duration = 6.00 hr	Area = 1.14 ac

OUTPUT SUMMARY

Runoff depth = 0.3788 in
Initial Abstraction = 0.4096 in
Peak Flow = 0.43 cfs (0.3741 iph)
At T = 2.50 hrs

INPUT SUMMARY FOR W.S.: AU-1C

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 83
Precip. Depth = 1.50 in	Time of Conc. = 0.0350 hr
Duration = 6.00 hr	Area = 1.37 ac

OUTPUT SUMMARY

Runoff depth = 0.3788 in
Initial Abstraction = 0.4096 in
Peak Flow = 0.51 cfs (0.3696 iph)
At T = 2.51 hrs

DRAFT

PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AU-1D

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 90
Precip. Depth = 1.50 in	Time of Conc. = 0.0170 hr
Duration = 6.00 hr	Area = 0.07 ac

OUTPUT SUMMARY

Runoff depth = 0.6835 in
Initial Abstraction = 0.2222 in
Peak Flow = 0.05 cfs (0.6755 iph)
At T = 2.50 hrs

INPUT SUMMARY FOR W.S.: AU-2

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0750 hr
Duration = 6.00 hr	Area = 2.23 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow =0.30 cfs (0.1345 iph)
At T = 2.52 hrs

PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AU-2A

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0770 hr
Duration = 6.00 hr	Area = 1.64 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 0.22 cfs (0.1332 iph)
At T = 2.53 hrs

INPUT SUMMARY FOR W.S.: AU-2B

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0400 hr
Duration = 6.00 hr	Area = 3.67 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 0.14 cfs (0.1487 iph)
At T = 2.51 hrs

PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AU-2C

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0480 hr
Duration = 6.00 hr	Area = 1.70 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 0.25 cfs (0.1451 iph)
At T = 2.51 hrs

INPUT SUMMARY FOR W.S.: AU-2D

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.1200 hr
Duration = 6.00 hr	Area = 16.14 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 1.92 cfs (0.1180 iph)
At T = 2.54 hrs

PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AU-3

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0350 hr
Duration = 6.00 hr	Area = 2.17 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 0.33 cfs (0.1509 iph)
At T = 2.51 hrs

INPUT SUMMARY FOR W.S.: AU-3A

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0150 hr
Duration = 6.00 hr	Area = 0.27 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 0.04 cfs (0.1605 iph)
At T = 2.50 hrs

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PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AU-4

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 76
Precip. Depth = 1.50 in	Time of Conc. = 0.0930 hr
Duration = 6.00 hr	Area = 7.52 ac

OUTPUT SUMMARY

Runoff depth = 0.1873 in
Initial Abstraction = 0.6316 in
Peak Flow = 0.97 cfs (0.1273 iph)
At T = 2.53 hrs

INPUT SUMMARY FOR W.S.: AU-4A

STORM:	WATERSHED:
Distribution = SCS Type 'B'	Curve Number = 83
Precip. Depth = 1.50 in	Time of Conc. = 0.0440 hr
Duration = 6.00 hr	Area = 1.46 ac

OUTPUT SUMMARY

Runoff depth = 0.3788 in
Initial Abstraction = 0.4096 in
Peak Flow = 0.54 cfs (0.3662 iph)
At T = 2.51 hrs

DRAFT

CULVERT CHARACTERISTICS

Culvert	Dia (in.)	Type	Contributing Watersheds	Peak Q(cfs)	Slope (ft/ft)	Outlet Condition
C-1U	~~15~~ 30	CMP ~~flexible~~	AU-3, AU-4, AU-4A, AU-5	~~3.97~~ 3.81	0.12 0.73	Bedrock
C-2U	12	CMP	AU-11	0.09	0.08	Soil
C-3U	12	CMP	AU-6, AU-7, AU-11	2.20	0.05	4" rip-rap
C-4U	12	CMP	AU-8, AU-9	1.32	0.05	4" rip-rap
C-5U	12	CMP	AU-8, AU-9, AU-15	1.45	0.05	4" rip-rap
C-6U	12	CMP	AU-6, AU-7, AU-11, AU-13, AU-14	2.65	0.05	4" rip-rap
C-7U	12	CMP	AU-12	0.34	0.05	6" rip-rap
C-8U	18	Flexible CMP, RCP	AU-2, AU-3 AU-4, AU-5	4.00	0.13	12" rip-rap
C-9U	60	stl pipe	Bear Creek[b]	108.53	0.06	48" rip-rap
C-10U	60	RCP	Bear Creek[b]	108.53	0.06	48" rip-rap
C-11U	18	CMP	AU-16	4.92	0.10	6" rip-rap
C-12U	24	CMP	AU-17	3.29	0.04	6" rip-rap
C-13U C-13aU	15	CMP	misc. road drainage	1.00	0.06	3" rip-rap
C-14U	60	CMP	Bear Creek	108.53	0.06	48" rip-rap
C-15U	12	CMP	AU-2C	0.25	0.20	Bedrock
C-16U	18	CMP flexible	AU-1B, AU-2 AU-2A, AU-2B	1.50	0.05 1.00	36" m.d. Rock in Channel
C-17U	15	CMP flexible	AU-1, AU-1A AU-1C	1.37	0.05 1.00	Bedrock
C-18U	12	CMP	AU-1A, AU-1C partial	0.20	0.24	3" rip-rap
C-19U	12	CMP	AU-1A, AU-1C partial	0.17	0.24	3" rip-rap
C-20U	12	CMP	AU-1A	0.14	0.24	3" rip-rap
C-21U	12	CMP	AU-1	0.72	0.06	42" m.d. Rock
C-22U	15	CMP flexible	AU-2	0.30	0.05 1.00	96" m.d. Rock in Channel
C-23U	15	CMP flexible	AU-2A	0.22	0.05 1.00	18" m.d. Rock in Channel
C-24U	15	CMP flexible	AU-2B	0.55	0.05 1.00	18" m.d. Rock in Channel

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CULVERT CHARACTERISTICS (con't)

Culvert	Dia (in.)	Type	Contributing Watersheds	Peak Q(cfs)	Slope (ft/ft)	Outlet Condition
C-1D	15	CMP, flexible	AD-6, AD-3B	0.93	1.00	24" rip-rap
C-2D	15	CMP, RCP, flexible	AD-2B, AD-2C, AD-3B, AD-4, AD-6	1.47	0.40	10" rip-rap
C-3D	20	stl pipe	AD-3A	0.23	0.03	4" rip-rap
C-4D	21	CMP	AD-3A, AD-5 AD-7	4.43	0.18	9" rip-rap
C-5D	18	CMP	AD-9	0.23	0.08	soil
C-6D	12	CMP	AD-10	0.62	0.48	9" rip-rap
C-7D	18	CMP	Abandoned In Place			
C-8D	18	CMP	AD-3A, AD-5 AD-7	2.36	0.05	3" rip-rap
C-9D	18	CMP	See C-8D	2.36	0.05	3" rip-rap
C-10D	18	CMP	TIPPLE WASH HOSE	0.25	0.03	3" rip-rap
C-11D	12	stl pipe	AU-4A part	0.54	0.01	soil
C-12D	12	CMP flexible	AU-4A	0.54	0.05 0.72	Grouted

DRAFT

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-1U

Solve For Actual Depth

Given Input Data:

Diameter.....	2.50 ft
Slope.....	0.7300 ft/ft
Manning's n.....	0.024
Discharge.....	3.81 cfs

Computed Results:

Depth.....	0.25 ft
Velocity.....	15.33 fps
Flow Area.....	0.25 sf
Critical Depth....	0.64 ft
Critical Slope....	0.0142 ft/ft
Percent Full.....	9.81 %
Full Capacity.....	189.83 cfs
QMAX @.94D.....	204.20 cfs
Froude Number.....	6.61 (flow is Supercritical)

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-15U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.2000 ft/ft
Manning's n.....	0.024
Discharge.....	0.25 cfs

Computed Results:

Depth.....	0.12 ft
Velocity.....	4.86 fps
Flow Area.....	0.05 sf
Critical Depth....	0.21 ft
Critical Slope....	0.0196 ft/ft
Percent Full.....	11.69 %
Full Capacity.....	8.63 cfs
QMAX @.94D.....	9.28 cfs
Froude Number.....	3.03 (flow is Supercritical)

Minimum Required riprap conditions = 3" m.d. riprap at outlet

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-16U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.50 ft
Slope.....	1.0000 ft/ft
Manning's n.....	0.024
Discharge.....	1.50 cfs

Computed Results:

Depth.....	0.17 ft
Velocity.....	13.86 fps
Flow Area.....	0.11 sf
Critical Depth....	0.46 ft
Critical Slope....	0.0167 ft/ft
Percent Full.....	11.18 %
Full Capacity.....	56.90 cfs
QMAX @.94D.....	61.21 cfs
Froude Number.....	7.22 (flow is Supercritical)

Minimum required riprap conditions = 30" m.d. riprap at outlet

NOTE: At slope = 0.05 ft/ft, Flow depth = **0.35** ft.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-17U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.25 ft
Slope.....	1.0000 ft/ft
Manning's n.....	0.024
Discharge.....	1.37 cfs

Computed Results:

Depth.....	0.17 ft
Velocity.....	13.81 fps
Flow Area.....	0.10 sf
Critical Depth....	0.46 ft
Critical Slope....	0.0180 ft/ft
Percent Full.....	13.51 %
Full Capacity.....	34.99 cfs
QMAX @.94D.....	37.64 cfs
Froude Number.....	7.15 (flow is Supercritical)

Minimum required riprap conditions = 30" m.d. riprap at outlet

NOTE: At slope = 0.05 ft/ft, Flow depth = **0.35** ft.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-18U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.2400 ft/ft
Manning's n.....	0.024
Discharge.....	0.20 cfs

Computed Results:

Depth.....	0.10 ft
Velocity.....	4.85 fps
Flow Area.....	0.04 sf
Critical Depth....	0.18 ft
Critical Slope....	0.0199 ft/ft
Percent Full.....	10.06 %
Full Capacity.....	9.45 cfs
QMAX @.94D.....	10.17 cfs
Froude Number.....	3.26 (flow is Supercritical)

Minimum required riprap conditions = 3" m.d. riprap at outlet

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-19U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.2400 ft/ft
Manning's n.....	0.024
Discharge.....	0.17 cfs

Computed Results:

Depth.....	0.09 ft
Velocity.....	4.62 fps
Flow Area.....	0.04 sf
Critical Depth....	0.17 ft
Critical Slope....	0.0202 ft/ft
Percent Full.....	9.31 %
Full Capacity.....	9.45 cfs
QMAX @.94D.....	10.17 cfs
Froude Number.....	3.23 (flow is Supercritical)

Minimum required riprap conditions = 3" m.d. riprap at outlet

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-20U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.2400 ft/ft
Manning's n.....	0.024
Discharge.....	0.14 cfs

Computed Results:

Depth.....	0.08 ft
Velocity.....	4.35 fps
Flow Area.....	0.03 sf
Critical Depth....	0.15 ft
Critical Slope....	0.0206 ft/ft
Percent Full.....	8.50 %
Full Capacity.....	9.45 cfs
QMAX @.94D.....	10.17 cfs
Froude Number.....	3.19 (flow is Supercritical)

Minimum required riprap conditions = 3" m.d. riprap at outlet

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-21U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.0600 ft/ft
Manning's n.....	0.024
Discharge.....	0.72 cfs

Computed Results:

Depth.....	0.26 ft
Velocity.....	4.35 fps
Flow Area.....	0.17 sf
Critical Depth....	0.35 ft
Critical Slope....	0.0193 ft/ft
Percent Full.....	26.38 %
Full Capacity.....	4.73 cfs
QMAX @.94D.....	5.09 cfs
Froude Number.....	1.77 (flow is Supercritical)

Minimum required riprap conditions = 3" m.d. riprap at outlet

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-22U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.25 ft
Slope.....	1.0000 ft/ft
Manning's n.....	0.024
Discharge.....	0.30 cfs

Computed Results:

Depth.....	0.08 ft
Velocity.....	8.74 fps
Flow Area.....	0.03 sf
Critical Depth....	0.21 ft
Critical Slope....	0.0187 ft/ft
Percent Full.....	6.56 %
Full Capacity.....	34.99 cfs
QMAX @.94D.....	37.64 cfs
Froude Number.....	6.54 (flow is Supercritical)

Minimum required riprap conditions = 15" m.d. riprap at outlet

NOTE: At slope = 0.05 ft/ft, Flow depth = **0.17** ft.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-23U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.25 ft
Slope.....	1.0000 ft/ft
Manning's n.....	0.024
Discharge.....	0.22 cfs

Computed Results:

Depth.....	0.07 ft
Velocity.....	7.95 fps
Flow Area.....	0.03 sf
Critical Depth....	0.18 ft
Critical Slope....	0.0193 ft/ft
Percent Full.....	5.67 %
Full Capacity.....	34.99 cfs
QMAX @.94D.....	37.64 cfs
Froude Number.....	6.41 (flow is Supercritical)

Minimum required riprap conditions = 15" m.d. riprap at outlet

NOTE: At slope = 0.05 ft/ft, Flow depth = **0.14** ft.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-24U

Solve For Actual Depth

Given Input Data:

Diameter.....	1.25 ft
Slope.....	1.0000 ft/ft
Manning's n.....	0.024
Discharge.....	0.55 cfs

Computed Results:

Depth.....	0.11 ft
Velocity.....	10.50 fps
Flow Area.....	0.05 sf
Critical Depth....	0.29 ft
Critical Slope....	0.0180 ft/ft
Percent Full.....	8.74 %
Full Capacity.....	34.99 cfs
QMAX @.94D.....	37.64 cfs
Froude Number.....	6.79 (flow is Supercritical)

Minimum required riprap conditions = 18" m.d. riprap at outlet

NOTE: At slope = 0.05 ft/ft, Flow depth = **0.22** ft.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-11D

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.0100 ft/ft
Manning's n.....	0.015
Discharge.....	0.54 cfs

Computed Results:

Depth.....	0.28 ft
Velocity.....	2.95 fps
Flow Area.....	0.18 sf
Critical Depth....	0.31 ft
Critical Slope....	0.0075 ft/ft
Percent Full.....	28.30 %
Full Capacity.....	3.09 cfs
QMAX @.94D.....	3.32 cfs
Froude Number.....	1.16 (flow is Supercritical)

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CULVERT ADEQUACY

Comment: CULVERT C-12D

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.7200 ft/ft
Manning's n.....	0.024
Discharge.....	0.54 cfs

Computed Results:

Depth.....	0.12 ft
Velocity.....	9.60 fps
Flow Area.....	0.06 sf
Critical Depth....	0.31 ft
Critical Slope....	0.0191 ft/ft
Percent Full.....	12.44 %
Full Capacity.....	16.38 cfs
QMAX @.94D.....	17.62 cfs
Froude Number.....	5.79 (flow is Supercritical)

Minimum required riprap conditions = 12" m.d. riprap at outlet

NOTE: At slope = 0.05 ft/ft, Flow depth = **0.24** ft.

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DITCH CHARACTERISTICS

DITCH	CHANNEL SLOPE %	CONTRIBUTING WATERSHED	PEAK Q(cfs)	BANK AND BOTTOM DESC.	MANNING'S η (a)
D-1D	2 Min, 11 Max	AD-3A	0.23	Rocky Soil	0.03
D-2D	6 Min, 20 Max	AD-3A, AD-5	0.53	Rocky Soil, Bedrock	0.03
D-3D	2 Min, 6 Av, 14 Max	AD-3A, AD-5, AD-7	2.36	Soil, grouted half round culvert	0.03
D-4D	2 Min, 7 Av, 17 Max	AD-14	0.05	Soil	0.03
D-5D	4 Min, 10 Max	AD-9	0.23	Soil	0.03
D-6D	2 Min, 4 Max	AD-3A, AD-5, AD-7,AD-9,AD-10 AD-12, AD-14	3.61	Rocky Soil	0.03
D-7D	2 Min, 6 Av, 55 Max	AD-1A, AD-1B, AD-2A, AD-2B, AD-2C, AD-3B, AD-4,AD-6,AD-8	4.46	Soil, D_{50}≈3"	0.03, 0.033
D-8D	2 Min, 7 Max	AD-13	1.23	Soil	0.03
D-8D Water Bar	3 Av.	AD-13	1.23	Soil	0.03
D-9D	4 Min, 10 Max	AD-15	1.25	Soil	0.03
D-10D	7 Min, 50 Max	AD-6, AD-3B, AD-2C	0.93	D_{50}≈4"	0.033
D-10aD	7 Av.	AD-6, AD-3B, AD-2C(part)	0.93	D_{50}≈4"	0.033
D-11D	41 Min, Near Vertical Max	TIPPLE WASH HOSE	0.25	Grouted rip-rap	0.035
D-12D	81 Av.	TIPPLE WASH HOSE	0.25	Grouted	0.03
D-13D Water Bar	0.5 Av.	AD-6 Partial	0.23	Soil	0.03
D-14D	0.05 Av.	AD-4A	0.54	Soil	0.03

DITCH CHARACTERISTICS (cont)

DITCH	CHANNEL SLOPE %	CONTRIBUTING WATERSHED	PEAK Q(cfs)	BANK AND BOTTOM DESC.	MANNING'S η (a)
D-1U	2 Min, 8 Max	AU-3, AU-5	~~2.72~~ 2.51	D_{50}≈2", D_{max}≈4"	0.03
D-2U	7 Min, 10 Max	AU-6, AU-11	0.48	Rocky Soil	0.03
D-3U	4 Min, 18 Max	AU-8	0.72	Rocky Soil	0.03
D-4U	1 Min, 10 Av, 18 Max	AU-10	4.05	Rocky Soil	0.03
D-5U	4 Min, 13 Max	AU-15	0.13	Rocky Soil	0.03
D-6U	3 Min, 6 Max	AU-14	0.35	Rocky Soil	0.03
D-7U	1 Min, 16 Max	AU-12	0.34	Rocky Soil	0.03
D-8U	2 Min, 6 Av 31 Max	AU-1	~~3.68~~ 5.04	Soil D_{50}≈6"	0.033
D-9U	1 Min, 6 Max	AU-16	4.92	D_{50}≈4"	0.03
D-10U	3 Min, 10 Max	AU-17	3.29	D_{50}≈4"	0.03
D-11U	3 Min, 8 Max	misc. road drainage	1.0(b)	Soil	0.03
D-12U	3 Min 9 Max	AU-18	4.0	Soil D_{50}≈4"	0.03
D-13U	2 Min, 6 Av, 23 Max	misc. road drainage	1.0(b)	Soil	0.03
D-14U	6 Min, 66 Max	Outlet of Sed Pond A AD-3A, AD-5, AD-7, AD-8, AD-9, AD-10, AD-11,AD-12, AD-14	8.6	D_{50}≈4" D_{Max}≈10"	0.033
D-15U	13 Av	AU-3	0.33	Soil	0.03
D-16U	12 Av	AU-2C	0.25	Soil	0.03
D-17U	10 Av	AU-1B	0.43	Soil	0.03
D-18U	13 Av	AU-1A, AU-1C	0.65	Soil	0.03
D-19U	12 Av	AU-1A, AU-1C partial	0.20	Soil	0.03
D-20U	11 Av	AU-1A, AU-1C partial	0.17	Soil	0.03
D-21U	10 Av	AU-1A	0.14	Soil	0.03
D-22U	4 Av	AU-1	0.72	Soil	0.03
D-23U	6 Av	AU-2B	0.55	Soil	0.03

(a) BASED ON TABLES FROM BARFIELD ET AL(1981) AND THE EQUATION $\eta = .0395(D_{50})^{1/6}$;(D in ft)

(b) PEAK Q FOR MISC ROAD DRAINAGE ASSUMED TO BE 1.0 cfs BASED ON SIMILAR DISTURBED AREAS

(c) SEE TABLE 7.2-10 FOR SUMMARY OF DIVERSION DITCH CALCULATIONS.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-11D

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.4100 ft/ft
Discharge.....	0.25 cfs

Computed Results:

Depth.....	0.22 ft
Velocity.....	5.01 fps
Flow Area.....	0.05 sf
Flow Top Width...	0.45 ft
Wetted Perimeter.	0.63 ft
Critical Depth...	0.33 ft
Critical Slope...	0.0517 ft/ft
Froude Number....	2.64 (flow is Supercritical)

Use Min. Depth = 6 inches	=>	Min Freeboard = 0.28 ft
Velocity ≈ 5 fps	=>	No rip-rap required typ
At near vertical slope	=>	Use grouted rip-rap

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-11D

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	9.9990 ft/ft
Discharge.....	0.25 cfs

Computed Results:

Depth.....	0.12 ft
Velocity.....	16.58 fps
Flow Area.....	0.02 sf
Flow Top Width...	0.25 ft
Wetted Perimeter.	0.35 ft
Critical Depth...	0.33 ft
Critical Slope...	0.0517 ft/ft
Froude Number....	11.79 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-12D

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.033
Channel Slope....	0.8100 ft/ft
Discharge.....	0.25 cfs

Computed Results:

Depth.....	0.05 ft
Velocity.....	5.03 fps
Flow Area.....	0.05 sf
Flow Top Width...	1.09 ft
Wetted Perimeter.	1.13 ft
Critical Depth...	0.12 ft
Critical Slope...	0.0369 ft/ft
Froude Number....	4.17 (flow is Supercritical)

Use Minimum Depth = 6 inches	=>	Min Freeboard = 0.45 ft
Velocity ≈ 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-13D

Comment: WATER BAR

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	10.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0050 ft/ft
Discharge.....	0.23 cfs

Computed Results:

Depth.....	0.22 ft
Velocity.....	0.79 fps
Flow Area.....	0.29 sf
Flow Top Width...	2.64 ft
Wetted Perimeter.	2.70 ft
Critical Depth...	0.16 ft
Critical Slope...	0.0317 ft/ft
Froude Number....	0.42 (flow is Subcritical)

Use Minimum Depth = 0.5 ft	=>	Min Freeboard = 0.34 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-14D

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0500 ft/ft
Discharge.....	0.54 cfs

Computed Results:

Depth.....	0.34 ft
Velocity.....	3.03 fps
Flow Area.....	0.18 sf
Flow Top Width...	1.03 ft
Wetted Perimeter.	1.24 ft
Critical Depth...	0.38 ft
Critical Slope...	0.0291 ft/ft
Froude Number....	1.29 (flow is Supercritical)

Use Min. Depth = 0.67 ft => Min Freeboard = 0.33 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-1U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0200 ft/ft
Discharge.....	2.51 cfs

Computed Results:

Depth.....	0.36 ft
Velocity.....	2.99 fps
Flow Area.....	0.84 sf
Flow Top Width...	2.71 ft
Wetted Perimeter.	3.01 ft
Critical Depth...	0.34 ft
Critical Slope...	0.0224 ft/ft
Froude Number....	0.95 (flow is Subcritical)

Use Min. Depth = 0.67 ft	=>	Min Freeboard = 0.3~~0~~1 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-1U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0800 ft/ft
Discharge.....	2.51 cfs

Computed Results:

Depth.....	0.24 ft
Velocity.....	4.76 fps
Flow Area.....	0.53 sf
Flow Top Width...	2.47 ft
Wetted Perimeter.	2.67 ft
Critical Depth...	0.34 ft
Critical Slope...	0.0224 ft/ft
Froude Number....	1.81 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-2U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0700 ft/ft
Discharge.....	0.48 cfs

Computed Results:

Depth.....	0.38 ft
Velocity.....	3.41 fps
Flow Area.....	0.14 sf
Flow Top Width...	0.75 ft
Wetted Perimeter.	1.06 ft
Critical Depth...	0.43 ft
Critical Slope...	0.0348 ft/ft
Froude Number....	1.39 (flow is Supercritical)

Use Min. Depth = 0.67 ft	=>	Min Freeboard = 0.29 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-2U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1000 ft/ft
Discharge.....	0.48 cfs

Computed Results:

Depth.....	0.35 ft
Velocity.....	3.90 fps
Flow Area.....	0.12 sf
Flow Top Width...	0.70 ft
Wetted Perimeter.	0.99 ft
Critical Depth...	0.43 ft
Critical Slope...	0.0348 ft/ft
Froude Number....	1.64 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-3U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0400 ft/ft
Discharge.....	0.72 cfs

Computed Results:

Depth.....	0.21 ft
Velocity.....	2.89 fps
Flow Area.....	0.25 sf
Flow Top Width...	1.41 ft
Wetted Perimeter.	1.58 ft
Critical Depth...	0.23 ft
Critical Slope...	0.0267 ft/ft
Froude Number....	1.21 (flow is Supercritical)

Use Min. Depth = 0.5 ft	=>	Min Freeboard = 0.29 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-3U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1800 ft/ft
Discharge.....	0.72 cfs

Computed Results:

Depth.....	0.13 ft
Velocity.....	4.80 fps
Flow Area.....	0.15 sf
Flow Top Width...	1.26 ft
Wetted Perimeter.	1.37 ft
Critical Depth...	0.23 ft
Critical Slope...	0.0267 ft/ft
Froude Number....	2.46 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-4U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0100 ft/ft
Discharge.....	4.05 cfs

Computed Results:

Depth.....	0.71 ft
Velocity.....	2.75 fps
Flow Area.....	1.47 sf
Flow Top Width...	3.14 ft
Wetted Perimeter.	3.57 ft
Critical Depth...	0.59 ft
Critical Slope...	0.0209 ft/ft
Froude Number....	0.71 (flow is Subcritical)

Use Minimum Depth = 1 ft	=>	Min Freeboard = 0.29 ft
Velocity < 5 fps	=>	No rip-rap required typ
At steep slope 18%	=>	Use D_{50}= 6"

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-4U

Comment: AV. SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1000 ft/ft
Discharge.....	4.05 cfs

Computed Results:

Depth.....	0.40 ft
Velocity.....	6.39 fps
Flow Area.....	0.63 sf
Flow Top Width...	2.19 ft
Wetted Perimeter.	2.43 ft
Critical Depth...	0.59 ft
Critical Slope...	0.0209 ft/ft
Froude Number....	2.09 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-4U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.033
Channel Slope....	0.1800 ft/ft
Discharge.....	4.05 cfs

Computed Results:

Depth.....	0.36 ft
Velocity.....	7.38 fps
Flow Area.....	0.55 sf
Flow Top Width...	2.07 ft
Wetted Perimeter.	2.29 ft
Critical Depth...	0.59 ft
Critical Slope...	0.0253 ft/ft
Froude Number....	2.53 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-5U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0400 ft/ft
Discharge.....	0.13 cfs

Computed Results:

Depth.....	0.26 ft
Velocity.....	1.99 fps
Flow Area.....	0.07 sf
Flow Top Width...	0.51 ft
Wetted Perimeter.	0.72 ft
Critical Depth...	0.25 ft
Critical Slope...	0.0415 ft/ft
Froude Number....	0.98 (flow is Subcritical)

Use Minimum Depth =0.5 ft	=>	Min Freeboard = 0.24 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-5U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1300 ft/ft
Discharge.....	0.13 cfs

Computed Results:

Depth.....	0.20 ft
Velocity.....	3.10 fps
Flow Area.....	0.04 sf
Flow Top Width...	0.41 ft
Wetted Perimeter.	0.58 ft
Critical Depth...	0.25 ft
Critical Slope...	0.0415 ft/ft
Froude Number....	1.71 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-6U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0300 ft/ft
Discharge.....	0.35 cfs

Computed Results:

Depth.....	0.39 ft
Velocity.....	2.29 fps
Flow Area.....	0.15 sf
Flow Top Width...	0.78 ft
Wetted Perimeter.	1.11 ft
Critical Depth...	0.38 ft
Critical Slope...	0.0363 ft/ft
Froude Number....	0.91 (flow is Subcritical)

Use Minimum Depth = 8 in.	=>	Min Freeboard = 0.28 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-6U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0600 ft/ft
Discharge.....	0.35 cfs

Computed Results:

Depth.....	0.34 ft
Velocity.....	2.97 fps
Flow Area.....	0.12 sf
Flow Top Width...	0.69 ft
Wetted Perimeter.	0.97 ft
Critical Depth...	0.38 ft
Critical Slope...	0.0363 ft/ft
Froude Number....	1.27 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-7U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0100 ft/ft
Discharge.....	0.34 cfs

Computed Results:

Depth.....	0.47 ft
Velocity.....	1.51 fps
Flow Area.....	0.23 sf
Flow Top Width...	0.95 ft
Wetted Perimeter.	1.34 ft
Critical Depth...	0.37 ft
Critical Slope...	0.0365 ft/ft
Froude Number....	0.55 (flow is Subcritical)

Use Minimum Depth = 8 in.	=>	Min Freeboard = 0.20 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-7U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1900 ft/ft
Discharge.....	0.34 cfs

Computed Results:

Depth.....	0.27 ft
Velocity.....	4.55 fps
Flow Area.....	0.07 sf
Flow Top Width...	0.55 ft
Wetted Perimeter.	0.77 ft
Critical Depth...	0.37 ft
Critical Slope...	0.0365 ft/ft
Froude Number....	2.17 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-8U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.033
Channel Slope....	0.0200 ft/ft
Discharge.....	5.04 cfs

Computed Results:

Depth.....	0.54 ft
Velocity.....	3.35 fps
Flow Area.....	1.50 sf
Flow Top Width...	3.61 ft
Wetted Perimeter.	3.93 ft
Critical Depth...	0.51 ft
Critical Slope...	0.0241 ft/ft
Froude Number....	0.92 (flow is Subcritical)

Use Min. Depth = 0.67 ft	=>	Min Freeboard = 0.~~21~~13 ft
Velocity < 5 fps	=>	No rip-rap required typ
At steep slope 31%	=>	Use D_{50}= 6"

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-8U

Comment: AV. SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.033
Channel Slope....	0.0600 ft/ft
Discharge.....	5.04 cfs

Computed Results:

Depth.....	0.39 ft
Velocity.....	4.93 fps
Flow Area.....	1.02 sf
Flow Top Width...	3.18 ft
Wetted Perimeter.	3.42 ft
Critical Depth...	0.51 ft
Critical Slope...	0.0241 ft/ft
Froude Number....	1.53 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-8U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.033
Channel Slope....	0.3100 ft/ft
Discharge.....	5.04 cfs

Computed Results:

Depth.....	0.25 ft
Velocity.....	8.63 fps
Flow Area.....	0.58 sf
Flow Top Width...	2.74 ft
Wetted Perimeter.	2.89 ft
Critical Depth...	0.51 ft
Critical Slope...	0.0241 ft/ft
Froude Number....	3.30 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-9U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0100 ft/ft
Discharge.....	4.92 cfs

Computed Results:

Depth.....	0.52 ft
Velocity.....	2.72 fps
Flow Area.....	1.81 sf
Flow Top Width...	4.03 ft
Wetted Perimeter.	4.46 ft
Critical Depth...	0.42 ft
Critical Slope...	0.0205 ft/ft
Froude Number....	0.71 (flow is Subcritical)

Use Minimum Depth =1 ft	=>	Min Freeboard = 0.48 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-9U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0600 ft/ft
Discharge.....	4.92 cfs

Computed Results:

Depth.....	0.30 ft
Velocity.....	4.93 fps
Flow Area.....	1.00 sf
Flow Top Width...	3.60 ft
Wetted Perimeter.	3.85 ft
Critical Depth...	0.42 ft
Critical Slope...	0.0205 ft/ft
Froude Number....	1.65 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-10U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0300 ft/ft
Discharge.....	3.29 cfs

Computed Results:

Depth.....	0.29 ft
Velocity.....	3.42 fps
Flow Area.....	0.96 sf
Flow Top Width...	3.58 ft
Wetted Perimeter.	3.83 ft
Critical Depth...	0.32 ft
Critical Slope...	0.0217 ft/ft
Froude Number....	1.16 (flow is Supercritical)

Use Minimum Depth = 0.5 ft	=>	Min Freeboard = 0.31 ft
Velocity ≈ 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-10U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1000 ft/ft
Discharge.....	3.29 cfs

Computed Results:

Depth.....	0.20 ft
Velocity.....	5.04 fps
Flow Area.....	0.65 sf
Flow Top Width...	3.41 ft
Wetted Perimeter.	3.58 ft
Critical Depth...	0.32 ft
Critical Slope...	0.0217 ft/ft
Froude Number....	2.03 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-11U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0300 ft/ft
Discharge.....	1.00 cfs

Computed Results:

Depth.....	0.58 ft
Velocity.....	2.98 fps
Flow Area.....	0.34 sf
Flow Top Width...	1.16 ft
Wetted Perimeter.	1.64 ft
Critical Depth...	0.57 ft
Critical Slope...	0.0316 ft/ft
Froude Number....	0.98 (flow is Subcritical)

Use Minimum Depth = 1 ft	=>	Min Freeboard = 0.42 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-11U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0800 ft/ft
Discharge.....	1.00 cfs

Computed Results:

Depth.....	0.48 ft
Velocity.....	4.31 fps
Flow Area.....	0.23 sf
Flow Top Width...	0.96 ft
Wetted Perimeter.	1.36 ft
Critical Depth...	0.57 ft
Critical Slope...	0.0316 ft/ft
Froude Number....	1.55 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-12U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0300 ft/ft
Discharge.....	4.00 cfs

Computed Results:

Depth.....	0.80 ft
Velocity.....	4.13 fps
Flow Area.....	0.97 sf
Flow Top Width...	2.41 ft
Wetted Perimeter.	2.90 ft
Critical Depth...	0.85 ft
Critical Slope...	0.0223 ft/ft
Froude Number....	1.15 (flow is Supercritical)

Use Min. Depth = 1 ft	=>	Min Freeboard = 0.20 ft
Velocity < 5 fps	=>	No rip-rap required typ
At steep slope 9%	=>	Use D_{50}= 4

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-12U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0900 ft/ft
Discharge.....	4.00 cfs

Computed Results:

Depth.....	0.65 ft
Velocity.....	6.24 fps
Flow Area.....	0.64 sf
Flow Top Width...	1.96 ft
Wetted Perimeter.	2.36 ft
Critical Depth...	0.85 ft
Critical Slope...	0.0223 ft/ft
Froude Number....	1.92 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-13U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0200 ft/ft
Discharge.....	1.00 cfs

Computed Results:

Depth.....	0.62 ft
Velocity.....	2.56 fps
Flow Area.....	0.39 sf
Flow Top Width...	1.25 ft
Wetted Perimeter.	1.77 ft
Critical Depth...	0.57 ft
Critical Slope...	0.0316 ft/ft
Froude Number....	0.81 (flow is Subcritical)

Use Minimum Depth = 1 ft	=>	Min Freeboard = 0.38 ft
Velocity < 5 fps	=>	No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-13U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0900 ft/ft
Discharge.....	1.00 cfs

Computed Results:

Depth.....	0.47 ft
Velocity.....	4.50 fps
Flow Area.....	0.22 sf
Flow Top Width...	0.94 ft
Wetted Perimeter.	1.33 ft
Critical Depth...	0.57 ft
Critical Slope...	0.0316 ft/ft
Froude Number....	1.63 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-14U

Comment: MIN SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	4.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.033
Channel Slope....	0.0600 ft/ft
Discharge.....	8.60 cfs

Computed Results:

Depth.....	0.37 ft
Velocity.....	5.11 fps
Flow Area.....	1.68 sf
Flow Top Width...	5.11 ft
Wetted Perimeter.	5.33 ft
Critical Depth...	0.49 ft
Critical Slope...	0.0227 ft/ft
Froude Number....	1.57 (flow is Supercritical)

Use Min. Depth = 0.5 ft	=>	Min Freeboard = 0.13 ft
Velocity > 5 fps	=>	Use D_{50}= 4"
At max slope 66%	=>	Use D_{50}= 10"

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-14U

Comment: MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	4.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.033
Channel Slope....	0.6600 ft/ft
Discharge.....	8.60 cfs

Computed Results:

Depth.....	0.18 ft
Velocity.....	11.08 fps
Flow Area.....	0.78 sf
Flow Top Width...	4.54 ft
Wetted Perimeter.	4.65 ft
Critical Depth...	0.49 ft
Critical Slope...	0.0227 ft/ft
Froude Number....	4.73 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-15U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1300 ft/ft
Discharge.....	0.33 cfs

Computed Results:

Depth.....	0.24 ft
Velocity.....	3.84 fps
Flow Area.....	0.09 sf
Flow Top Width...	0.72 ft
Wetted Perimeter.	0.86 ft
Critical Depth...	0.31 ft
Critical Slope...	0.0311 ft/ft
Froude Number....	1.95 (flow is Supercritical)

Use Minimum Depth = 1 ft => Min Freeboard = 0.76 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-16U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1200 ft/ft
Discharge.....	0.25 cfs

Computed Results:

Depth.....	0.22 ft
Velocity.....	3.47 fps
Flow Area.....	0.07 sf
Flow Top Width...	0.66 ft
Wetted Perimeter.	0.79 ft
Critical Depth...	0.28 ft
Critical Slope...	0.0323 ft/ft
Froude Number....	1.85 (flow is Supercritical)

Use Minimum Depth = 1 ft => Min Freeboard = 0.78 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-17U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1000 ft/ft
Discharge.....	0.43 cfs

Computed Results:

Depth.....	0.28 ft
Velocity.....	3.72 fps
Flow Area.....	0.12 sf
Flow Top Width...	0.83 ft
Wetted Perimeter.	1.00 ft
Critical Depth...	0.35 ft
Critical Slope...	0.0300 ft/ft
Froude Number....	1.76 (flow is Supercritical)

Use Minimum Depth = 1 ft => Min Freeboard = 0.72 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-18U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1300 ft/ft
Discharge.....	0.65 cfs

Computed Results:

Depth.....	0.31 ft
Velocity.....	4.55 fps
Flow Area.....	0.14 sf
Flow Top Width...	0.93 ft
Wetted Perimeter.	1.11 ft
Critical Depth...	0.41 ft
Critical Slope...	0.0284 ft/ft
Froude Number....	2.04 (flow is Supercritical)

Use Minimum Depth = 1 ft => Min Freeboard = 0.69 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-19U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1200 ft/ft
Discharge.....	0.20 cfs

Computed Results:

Depth.....	0.20 ft
Velocity.....	3.29 fps
Flow Area.....	0.06 sf
Flow Top Width...	0.60 ft
Wetted Perimeter.	0.73 ft
Critical Depth...	0.26 ft
Critical Slope...	0.0333 ft/ft
Froude Number....	1.82 (flow is Supercritical)

Use Min. Depth = 0.5 ft => Min Freeboard = 0.30 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-20U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1100 ft/ft
Discharge.....	0.17 cfs

Computed Results:

Depth.....	0.19 ft
Velocity.....	3.05 fps
Flow Area.....	0.06 sf
Flow Top Width...	0.58 ft
Wetted Perimeter.	0.69 ft
Critical Depth...	0.24 ft
Critical Slope...	0.0340 ft/ft
Froude Number....	1.73 (flow is Supercritical)

Use Min. Depth = 0.5 ft => Min Freeboard = 0.31 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-21U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1000 ft/ft
Discharge.....	0.14 cfs

Computed Results:

Depth.....	0.22 ft
Velocity.....	2.86 fps
Flow Area.....	0.05 sf
Flow Top Width...	0.44 ft
Wetted Perimeter.	0.63 ft
Critical Depth...	0.26 ft
Critical Slope...	0.0411 ft/ft
Froude Number....	1.52 (flow is Supercritical)

Use Minimum Depth = 1 ft => Min Freeboard = 0.78 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-22U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0400 ft/ft
Discharge.....	0.72 cfs

Computed Results:

Depth.....	0.49 ft
Velocity.....	3.06 fps
Flow Area.....	0.24 sf
Flow Top Width...	0.97 ft
Wetted Perimeter.	1.37 ft
Critical Depth...	0.50 ft
Critical Slope...	0.0330 ft/ft
Froude Number....	1.09 (flow is Supercritical)

Use Minimum Depth = 1 ft => Min Freeboard = 0.51 ft
Velocity < 5 fps => No rip-rap required

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DITCH D-23U

Comment: MIN AND MAX SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	0.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0600 ft/ft
Discharge.....	0.55 cfs

Computed Results:

Depth.....	0.34 ft
Velocity.....	3.26 fps
Flow Area.....	0.17 sf
Flow Top Width...	1.01 ft
Wetted Perimeter.	1.21 ft
Critical Depth...	0.38 ft
Critical Slope...	0.0291 ft/ft
Froude Number....	1.40 (flow is Supercritical)

Use Minimum Depth = 1 ft => Min Freeboard = 0.66 ft
Velocity < 5 fps => No rip-rap required

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Channel Design

Channel slopes (from post-mining topography map):

Channel	Watershed	Minimum Slope (ft/ft)	Maximum Slope (ft/ft)
RC-1	WS-1	0.13	0.31
RC-2	WS-2	0.09	0.29
RC-3	WS-3	0.08	0.67
RC-4	WS-4	0.05	0.40
RC-5	WS-5	0.05	0.50
RC-6	WS-6	0.10	0.10
RC-7	WS-7	0.05	0.05
RC-8	WS-8	0.07	0.07
RC-9	WS-9	0.08	0.08
RC-10	Bear Canyon	0.06	0.06
RC-TS1	WS-1 partial	0.03	0.40
RC-TS2	WS-1 partial	0.20	0.75
RC-TS3	WS-1 partial	0.30	0.50
RC-TS4	WS-1 partial	0.35	0.70
RC-TS5	WS-1 partial	0.30	0.60
RC-TS6	WS-1 partial	0.16	0.65

NOTE: See pages 7H-52 thru 7H-77 for RC-TS channel designs. Plate 7-8C shows the profiles for these channels.

Minimum slope used to calculate channel depth. Maximum slope used to determine riprap requirements.

Riprap sizing based on the curves provided on pg 16 of this calc. and on the equation:

$$n = 0.0395(d_{50})^{1/6}$$ (Barfield et al., 1981)

where n = Manning's roughness coefficient
d_{50} = median diameter (ft)

Results of FlowMaster calculations ----> see pg 17-36 of this calc.

Maximum permissible velocities (based on 2:1 side slope limitations):

d_{50} = 3" ==> V_{max} = 5.6 ft/s d_{50} = 9" ==> V_{max} = 8.9 ft/s
d_{50} = 6" ==> V_{max} = 7.2 ft/s d_{50} = 24" ==> V_{max} = 15.2 ft/s

Reclaimed Tank Seam Access Road Channel Designs

Construction of the Tank Seam Access Road will require the disturbance of six channels, shown on Plate 7-7 as RC-TS1 through RC-TS6. All six channels exist as naturally eroding channels. Due to the steep maximum slopes, as shown on page 7H-15, riprap designs will not be proposed for these channels. This sections characterizes and documents the premining channels which exist prior to disturbance. Reclamation will consist of restoring these channels to this configuration and mimmicking the premining conditions, in order to obtain a naturally stable drainage and restore the approximate original configuration to the channels.

Disturbance of the channels will consist primarily of placing fill in the channels to provide access across the channels for the road. This will allow the channels to essential remain intact beneath the fill. Upon reclamation, the fill material will be excavated from the channels and fill areas, and the channels will be restored, with many of the large boulders shown in the photographs of each channel remaining in place for the post-mining channel. Profiles of the pre-mining, and subsequently the proposed post-mining, channels are shown on Plate 7-8C. A description of each channel follows. As the channels are reclaimed, the reclaimed channel will be blended in with the natural channels above and below the reclaimed channel by attempting to duplicate the appearance of the natural channels as they appear in the following photographs.

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RC-TS1

RC-TS1 is located between station 9+00 and 10+00 (See page 3H-11). The channel has an average bottom width of 11′ and an average depth of 8′. The slope of the channel varies from 3% to 40%, with an average slope of 20%. The channel consists primarily of large boulders embedded into the soil. The rock size generally varies from 12"-72" m.d., with some boulders exceeding 72". These boulders (Photos TS1-1 and TS1-2) create near vertical drops in the channel, but also act naturally as energy dissipators in the channel. Photo TS1-1 shows the top portion of the channel which will be disturbed, and photo TS1-3 shows the bottom of the channel, where the outlet of C-16U will be located during operation.

Photo TS1-1: Top portion of Pre-mining channel RC-TS1. Top of channel located below large boulders shown in top center of photo.

Photo TS1-2: An 11′ vertical drop caused by large boulders (120-144" m.d.) embedded into the bottom of RC-TS1.

Photo TS1-3: Lower portion of RC-TS1, where the reclaimed channel will merge into the natural channel (Adjacent to leaning tree, top center). Slope at this location is approximately 3%.

RC-TS2

RC-TS2 is located between station 10+00 and 11+00 (See page 3H-11). The channel has an average bottom width of 12′ and an average depth of 4′, varying from 2 to 8 ft. The slope of the channel varies from 20% to 75%. The channel, as shown on Plate 7-8C, consists of a steep profile directly on bedrock with 20% to 30% grade "terraces" containing large boulders embedded into the surface. The rock size varies from 12"-72" m.d., with some boulders exceeding 72". These boulders primarily project from the side slope of the channel. The North side slope and the bottom of the channel consists primarily of bedrock outcrop, as shown in Photo TS2-3.

Photo TS2-1: Top portion of RC-TS2, where the reclaimed channel will join to the natural channel. Bedrock outcrop can be seen as red color in sides of channel.

Photo TS2-2: Lower portion of channel, where the reclaimed channel will join the natural channel (center of photo).

Photo TS2-3: A horizontal view of the channel showing the outcropping of bedrock in the channel.

RC-TS3

RC-TS3 is located between station 21+00 and 22+00 (See page 3H-11). The channel has an average bottom width of 6′ and an average depth of 4′, varying from 2 to 7 ft. The slope of the channel varies from 30% to 50%, with the majority of the slope around 35%. This channel will see a minimal amount of disturbance (about 40 ft). The channel consists of boulders 18" to 60" embedded into the soil, with some larger boulders projecting out of the side slope of the channel. Photos TS3-1 through TS3-3 show the natural channel configuration.

Photo TS3-1: Upper portion of the channel shown, where natural channel will join the reclaimed channel.

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Photo TS3-2: Typical channel configuration for RC-TS3.

Photo TS3-3: Bottom of channel RC-TS3, where reclaimed channel will join natural channel (adjacent to large boulder shown in top right corner).

RC-TS4

RC-TS4 is located between station 24+00 and 25+00 (See page 3H-11). The channel has an average bottom width of 15′ and an average depth of 4′, with runoff coming into the channel as sheet flow. The slope of the channel varies from 35% to 70%. The dominant presence of vegetation in the channel indicates minimal flows through the channel, primarily as sheet flow. The top portion of the channel is dominated by rock averaging 8"-36" m.d. The lower portion of the channel (Photo TS3-3) contains a great deal of "litter" scattered through the vegetative cover in the channel.

Photo TS4-1: Upper portion of RC-TS4 where the natural channel will join the reclaimed channel (lower center of photo).

Photo TS4-2: Profile of channel RC-TS4, showing the South side slope and the channel bottom configuration.

Photo TS4-3: Lower portion of RC-TS4. Reclaimed channel joins natural channel at the location of the large boulder shown just left of center in the photo.

RC-TS5

RC-TS5 is located at station 25+00 (See page 3H-11), adjacent to RC-TS4. The channel has a bottom width of 4′ to 6′ and a depth of 2′ to 6′. The slope of the channel is 60%, with some portions varying down to 30%. The channel is the same configuration as RC-TS4, except much narrower and with a greater presence of 18" to 48" m.d. rocks. At the location of photo TS5-3, RC-TS5 terminates and runoff enters channel RC-TS6.

Photo TS5-1: Upper portion of channel RC-TS5, where the natural channel joins the reclaimed channel (center of photo).

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Photo TS5-2: Profile of channel RC-TS5 showing North side slope and vegetative and rock cover in bottom of channel.

Photo TS5-3: Outlet of channel RC-TS5 where it drains into channel RC-TS6. Location of culvert C-23U outlet.

RC-TS6

RC-TS6 is located at station 25+00 (See page 3H-11) adjacent to RC-TS5. The channel has an average bottom width of 20′ and a depth of 2 to 5 ft. Runoff through the channel occurs primarily as sheet flow, with the channel originating immediately above the disturbed area. The slope of the channel varies from 16% to 65%, with a 7′ vertical drop occurring due to a ledge outcrop of bedrock. The channel is dominated by rock fragments 18" to 48" m.d. with some larger rocks present. The channel contains a series of terraces where bedrock is present at or near the surface.

Photo TS6-1: Upper portion of channel RC-TS6, where the natural channel joins the reclaimed channel (center of photo).

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Photo TS6-2: Typical cross section of channel RC-TS6, showing a dominating presence of rock fragments with some outcropping bedrock.

Photo TS6-3: Lower portion of Channel RC-TS6, where reclaimed channel drains into natural channel (also location of culvert C-24U outlet).

Tank Seam Access Road Channel Characteristics

Channel	Peak Flow* (cfs)	Maximum Velocity** (ft/s)	Maximum Flow Depth** (ft)
RC-TS1	4.53	5.01	0.18
RC-TS2	2.42	4.56	0.07
RC-TS3	2.18	5.06	0.08
RC-TS4	0.43	2.06	0.02
RC-TS5	0.31	2.90	0.03
RC-TS6	0.60	2.05	0.02

* Peak flows based on 10-Year, 24-Hour event using SCS Type II distribution.

** Maximum velocities and flow depths determined using FlowMaster Open Channel Flow Module, Version 3.3, Haestad Methods, Inc.

Flow depths in channels RC-TS4, RC-TS5 and RC-TS6 indicate the presence of sheet flow. Natural channel conditions in all channels provide a stable channel for the maximum velocities. The FlowMaster calculations are included, and are based on minimum and maximum channel slopes.

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS1

Comment: DESIGN BASED ON MINIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	11.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.0300 ft/ft
Discharge.....	4.53 cfs

Computed Results:

Depth.....	0.18 ft
Velocity.....	2.28 fps
Flow Area.....	1.99 sf
Flow Top Width...	11.36 ft
Wetted Perimeter.	11.50 ft
Critical Depth...	0.17 ft
Critical Slope...	0.0328 ft/ft
Froude Number....	0.96 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS1

Comment: DESIGN BASED ON MAXIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	11.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.4000 ft/ft
Discharge.....	4.53 cfs

Computed Results:

Depth.....	0.08 ft
Velocity.....	5.01 fps
Flow Area.....	0.90 sf
Flow Top Width...	11.16 ft
Wetted Perimeter.	11.23 ft
Critical Depth...	0.17 ft
Critical Slope...	0.0328 ft/ft
Froude Number....	3.10 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS2

Comment: DESIGN BASED ON MINIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	12.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.2000 ft/ft
Discharge.....	2.42 cfs

Computed Results:

Depth.....	0.07 ft
Velocity.....	3.06 fps
Flow Area.....	0.79 sf
Flow Top Width...	12.13 ft
Wetted Perimeter.	12.19 ft
Critical Depth...	0.11 ft
Critical Slope...	0.0380 ft/ft
Froude Number....	2.12 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS2

Comment: DESIGN BASED ON MAXIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	12.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.7500 ft/ft
Discharge.....	2.42 cfs

Computed Results:

Depth.....	0.04 ft
Velocity.....	4.56 fps
Flow Area.....	0.53 sf
Flow Top Width...	12.09 ft
Wetted Perimeter.	12.12 ft
Critical Depth...	0.11 ft
Critical Slope...	0.0380 ft/ft
Froude Number....	3.84 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS3

Comment: DESIGN BASED ON MINIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	6.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.3000 ft/ft
Discharge.....	2.18 cfs

Computed Results:

Depth.....	0.08 ft
Velocity.....	4.33 fps
Flow Area.....	0.50 sf
Flow Top Width...	6.21 ft
Wetted Perimeter.	6.27 ft
Critical Depth...	0.16 ft
Critical Slope...	0.0342 ft/ft
Froude Number....	2.68 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS3

Comment: DESIGN BASED ON MAXIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	6.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.5000 ft/ft
Discharge.....	2.18 cfs

Computed Results:

Depth.....	0.07 ft
Velocity.....	5.06 fps
Flow Area.....	0.43 sf
Flow Top Width...	6.18 ft
Wetted Perimeter.	6.23 ft
Critical Depth...	0.16 ft
Critical Slope...	0.0342 ft/ft
Froude Number....	3.38 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS4

Comment: DESIGN BASED ON MINIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	15.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	0.50:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.3500 ft/ft
Discharge.....	0.43 cfs

Computed Results:

Depth.....	0.02 ft
Velocity.....	1.67 fps
Flow Area.....	0.26 sf
Flow Top Width...	15.03 ft
Wetted Perimeter.	15.04 ft
Critical Depth...	0.03 ft
Critical Slope...	0.0580 ft/ft
Froude Number....	2.25 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS4

Comment: DESIGN BASED ON MAXIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	15.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	0.50:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.7000 ft/ft
Discharge.....	0.43 cfs

Computed Results:

Depth.....	0.01 ft
Velocity.....	2.06 fps
Flow Area.....	0.21 sf
Flow Top Width...	15.02 ft
Wetted Perimeter.	15.04 ft
Critical Depth...	0.03 ft
Critical Slope...	0.0580 ft/ft
Froude Number....	3.07 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS5

Comment: DESIGN BASED ON MINIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	4.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.3000 ft/ft
Discharge.....	0.31 cfs

Computed Results:

Depth.....	0.03 ft
Velocity.....	2.35 fps
Flow Area.....	0.13 sf
Flow Top Width...	4.07 ft
Wetted Perimeter.	4.09 ft
Critical Depth...	0.06 ft
Critical Slope...	0.0474 ft/ft
Froude Number....	2.30 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS5

Comment: DESIGN BASED ON MAXIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	4.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.6000 ft/ft
Discharge.....	0.31 cfs

Computed Results:

Depth.....	0.03 ft
Velocity.....	2.90 fps
Flow Area.....	0.11 sf
Flow Top Width...	4.05 ft
Wetted Perimeter.	4.08 ft
Critical Depth...	0.06 ft
Critical Slope...	0.0474 ft/ft
Froude Number....	3.15 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS6

Comment: DESIGN BASED ON MINIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	20.00 ft
Left Side Slope..	0.50:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.1600 ft/ft
Discharge.....	0.60 cfs

Computed Results:

Depth.....	0.02 ft
Velocity.....	1.34 fps
Flow Area.....	0.45 sf
Flow Top Width...	20.03 ft
Wetted Perimeter.	20.06 ft
Critical Depth...	0.03 ft
Critical Slope...	0.0574 ft/ft
Froude Number....	1.59 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: RC-TS6

Comment: DESIGN BASED ON MAXIMUM SLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	20.00 ft
Left Side Slope..	0.50:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.6500 ft/ft
Discharge.....	0.60 cfs

Computed Results:

Depth.....	0.01 ft
Velocity.....	2.05 fps
Flow Area.....	0.29 sf
Flow Top Width...	20.02 ft
Wetted Perimeter.	20.04 ft
Critical Depth...	0.03 ft
Critical Slope...	0.0574 ft/ft
Froude Number....	2.98 (flow is Supercritical)

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