Appendix 5-J

WILD HORSE RIDGE

BLIND CANYON SEAM PAD

AND CONVEYOR ACCESS ROADS

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Introduction

This Appendix discusses the construction of the Wild Horse Ridge conveyor belt access roads and the Blind Canyon Seam (Bear Canyon No. 3 Mine) portal pad. Cut and Fill volumes have been determined for the roads and pad and are summarized in Table 5J-1. Also included is an operational slope stability analysis and a reclaimed slope stability analysis. Pre-mining, Operational and Post-mining cross-sections are detailed in Attachment B of this Appendix.

Construction Description

Construction will begin with the Lower Conveyor Access Road and the topsoil storage area. Drainage control structures will be established prior to any work beginning. This will include the stream bypass culvert and Catch Basin "1". Initially, the topsoil storage area will be cleared of any trees and graded to generate a stable base for the pile. Starting at the bottom of the road, shown on Plate 5-2F, topsoil will be removed from all areas where fill is to be placed, and will be stockpiled. Topsoil will be removed from the projected cut areas (Attachment B, segments B and C, Dames & Moore Report, pp. 3-4) and placed in the stockpile. Then material will be removed from the road cut (Segment A) and compacted onto the lower fill areas of the road (Segments B and C). As the cut progresses up the road, topsoil will be removed prior to the road cut being made and placed in the storage pile. Cuts will be made using the sequence shown in Figures 5G-1 and 5G-2, shown for the constructed Tank Seam Access Road.

Table 5J-1

Summary of Cut and Fill Volumes

Area	Cut Vol. (Cu Yds)	Topsoil (Cu Yds)	Fill Vol. (Cu Yds)	Excess (Cu Yds)	Avg haul dist.
Lower Conveyor Access Road	3,324	~1,669	1,336	319 fill	250 ft
Upper Conveyor Access Road	4,933	~2,171	2,766	4 cut	160 ft
Blind Canyon Seam Portal Pad	15,750	~4,860	10,556	51 cut	220 ft

During the initial road cut, care will be taken to prevent disturbed material from migrating down slope 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 5-G1. When the berm is in place, the road cuts will be started as shown in Figures 5-G1 and 5-G2 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 5-E, 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 down slope into the undisturbed area.

Cut slopes, fill slopes, and fill placement will follow the recommendations given in the Slope Stability analysis and report, included on pages 5J-17 through 5J-47. Large boulders will also be placed according to the report. Where possible, care will be taken to avoid disturbing large trees of commercial value and any canyon sweetvetch plants located in the area (see chapter 3).

Final crowning of the road and installation of permanent ditches will be completed following the initial road contouring. The approximate proposed road contours are shown on Plate 5-2F. The 319 excess yards of material from the cut will be used as fill across the Bear Creek culverted crossing.

The Upper Conveyor Access Road, shown on Plate 5-2G, will be constructed using the same method. Initially, Catch Basin "2" will be constructed. Topsoil will be hauled below to the storage pile as it is recovered. Drainage crossings will be installed in the ephemeral stream as each crossing is reached so undisturbed and disturbed drainage will be continually segregated. This will prevent sediment loading in the event a rainstorm occurs during construction, and will protect the catch basin from undisturbed drainage. A small riparian area exists adjacent to this road. Care will be taken to prevent any material from migrating down slope from the road cut into this riparian area. Construction of this road will require the removal of several large trees having commercial value. Where possible, these trees will be harvested and sent to a sawmill to provide valuable commercial use. The Division will be notified when any blasting will take place above spring SBC-14, and when Culvert C-34U is to be installed above the spring, in time to allow a Division hydrologist to make a field visit during the blasting

Excess cut material from the two conveyor access roads will be used to construct the Bear Creek culverted crossing, which will replace the bridge, which currently provides access across the creek. During installation of this culvert, care will be taken to avoid excessive material from impacting Bear Creek. This will be accomplished by placing the culvert in the creek bed. Large rocks and debris will be removed from the creek channel to insure a firm, level surface to place the culvert on. After all of the water has been channeled into the culvert, fill material will be placed on each side of the culvert simultaneously using a track hoe. This will prevent the culvert from shifting or moving during installation. Once the culvert has been filled across, remaining fill will be placed to complete the construction of the road. All activities will be completed in accordance with the approved Stream Alteration Permit, which will be obtained from the State Division of Water Rights.

After the access roads are in place, construction will begin on the Blind Canyon Seam Portal Pad. Temporary and permanent 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. All temporary silt fences will remain in place and be maintained until construction of the sediment pond is completed and all runoff has been directed to the sediment pond.

Topsoil recovery will then begin along the access road approaching the pad. A pilot road will be constructed through the fill area during topsoil recovery activities, providing access into the drainage where the fill is to be placed. Topsoil will be hauled to the storage area shown on Plate 5-2F.

After topsoil recovery activities have been complete and all trees removed from the area, the culvert will be installed for the undisturbed drainage to pass the disturbed area. A dozer will be used to cut the material from the access areas and push it into the fill area. Fill material will be placed in lifts not to exceed 36", as described in the slope stability report. The conveyor belt tunnel will be constructed in the fill in conjunction with filling activities to avoid re-disturbing the compacted fill. As the fill nears the elevation of the coal seam, the coal seam and highwalls at the portal locations will be faced up, exposing the seam. Since the majority of the coal outcrop is already exposed, little coal waste material is expected from the face-up operations. Any material with significant amounts of coal in it will be hauled to the Coal Storage Pad area and processed in accordance with R645-301-511.200.

The out slope of the fill area will be constructed at a slope of 2H:1V, as described in the slope stability analysis report. As soon as possible after the slope has been constructed, erosion control matting will be placed as described in Appendix 7-K to control erosion. The slope will be seeded using the interim seed mix described in Chapter 3.

Following the initial road and pad contouring, the sediment pond will be constructed. Then the final crowning of the road and pad and the installation of permanent ditches and culverts will be completed.

The remaining portions of the access road existed prior to mining activities. Minimal upgrading will be required on this road. If any areas of the road require widening, the material generated from this will be incorporated into the pad fill. All required ditches and culverts will be constructed as soon as practical to insure protection of the hydrologic balance.

Cut and Fill Calculations

The cut and fill volumes shown in Table 5J-1 represent the maximum volumes which will be encountered. Final contours and pad dimensions may vary somewhat to account for any variation in cut and fill volumes. As-built contours and cut and fill volumes will be submitted to the Division following construction.

Volume measurements were made using the "Quicksurf" 3-D modeling software with AutoCad. They are based on the contours shown on Plates 5-7F and 5-7G for pre-mining configuration, Plates 5-2F and 5-2G for operational configuration, and Plates 5-6F and 5-6G for post-mining configuration. Cross-sections for each configuration are included in Attachment B.

Figure 5J-1 shows the locations of cross-sections for the Lower Conveyor Access road. It is proposed to reclaim this area as close as possible to the pre-mining configuration, so the proposed post-mining cross-sections have been represented by the pre-mining cross-sections. The representative volumes for each cross-section are shown in Table 5J-2. The excess 319 yards of material will be used as fill for the Bear Creek culvert crossing.

Table 5J-2

Lower Conveyor Access Road
Cut and Fill Volumes

	Const. Vol. (Cu yds)		Cum.Vol.	**Reclaimed Vol. (cu yds)**		Cum. Vol.
Station	Fill (-)	Cut (+)	(cu yds)	Fill (-)	Cut (+)	(cu yds)
-1+00	0	0	0	0	0	0
0+00	101	13	-88	13	101	88
1+00	94	26	-156	26	94	156
2+00	411	132	-435	13	411	435
3+00	730	266	-899	550	730	615
4+00	0	1,070	171	821	0	-206
5+00	0	1,143	1,314	731	0	-937
6+00	0	674	1,988	674	0	-1,611
Topsoil	**1,669**	----	**319**	---	**1,669**	**58**
Total	**1,336**	**3,324**	**319**	**2,947**	**1,336**	**58**

There is an estimated topsoil volume of 1,669 cu yds which will be salvaged during construction of this road. This topsoil will be stored in the storage area adjacent to the road, as shown on Plate 5-2F.

Figure 5J-2 shows the locations of cross-sections for the Upper Conveyor Access Road. The cut and fill material for this area has been balanced to avoid hauling material to other areas. This area will also be reclaimed as close as possible to the pre-mining configuration, so the proposed post-mining cross-sections have been represented by the pre-mining cross-sections. The representative volumes for each cross-section are shown in Table 5J-3. An estimated topsoil volume of 2,171 cu yds will be salvaged during construction of the road. The topsoil will be hauled to the storage area shown on Plate 5-2F.

Figure 5J-1 Lower Conveyor Access Road Cross-Section Stations

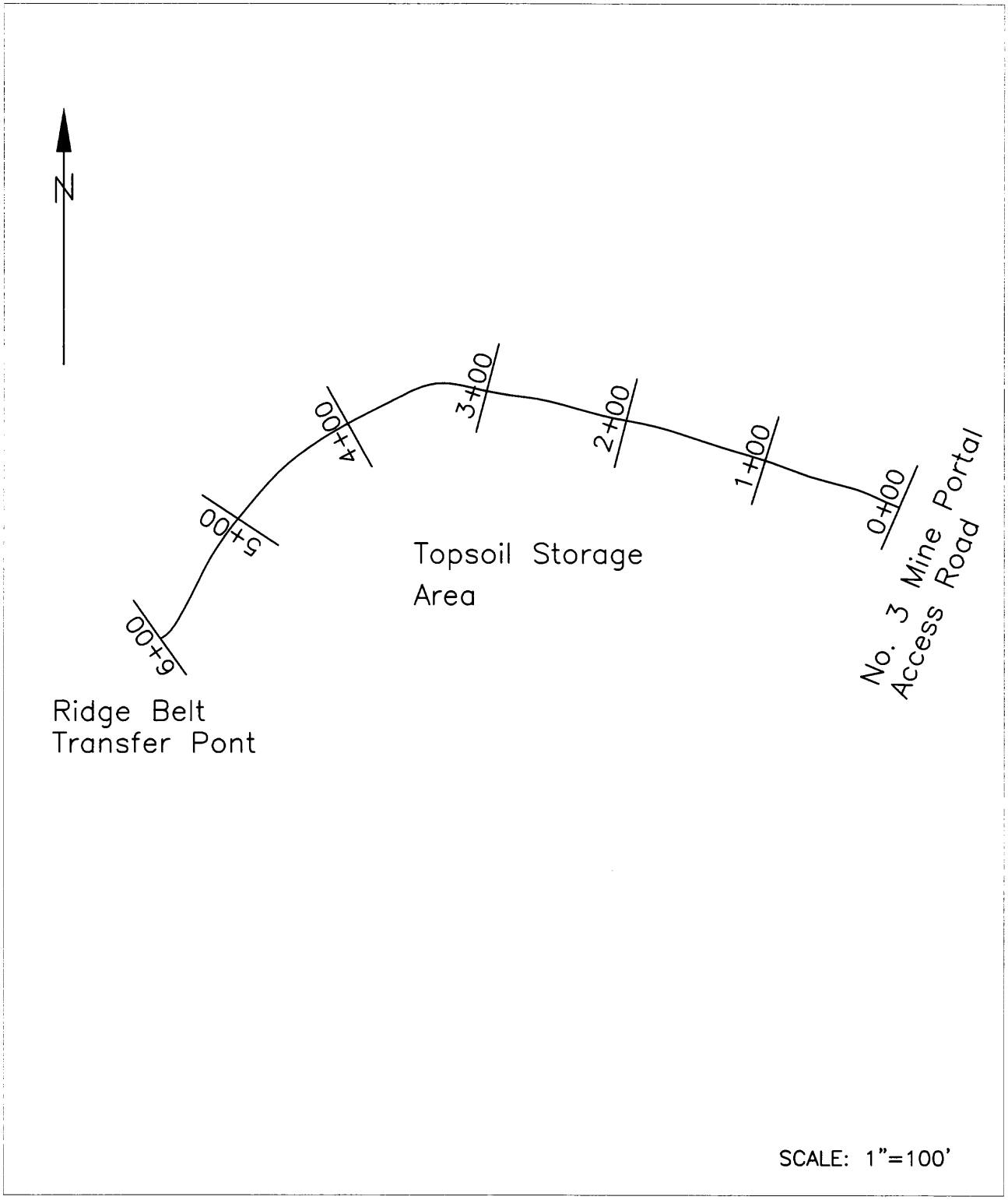

Table 5J-3
Upper Conveyor Access Road
Cut and Fill Volumes

	Const. Vol. (Cu yds)		Cum. Vol.	**Reclaimed Vol. (cu yds)**		Cum. Vol.
Station	Fill (-)	Cut (+)	(cu yds)	Fill (-)	Cut (+)	(cu yds)
-1+00	0	0	0	0	0	0
0+00	754	22	-732	22	190	168
1+00	1,097	355	-1,474	355	1,097	910
2+00	32	1,652	146	672	32	270
3+00	472	156	-170	156	472	652
4+00	218	984	596	1,182	28	-502
5+00	100	1,536	2,032	1,536	0	-2,038
6+00	93	228	2,167	228	93	-2,173
Topsoil	**2,171**	—	-4	---	**2,171**	-2
Total	**2,766**	**4,933**	**-4**	**4,085**	**1,912**	**-2**

Figure 5J-2 Upper Conveyor Access Road Cross-Sections

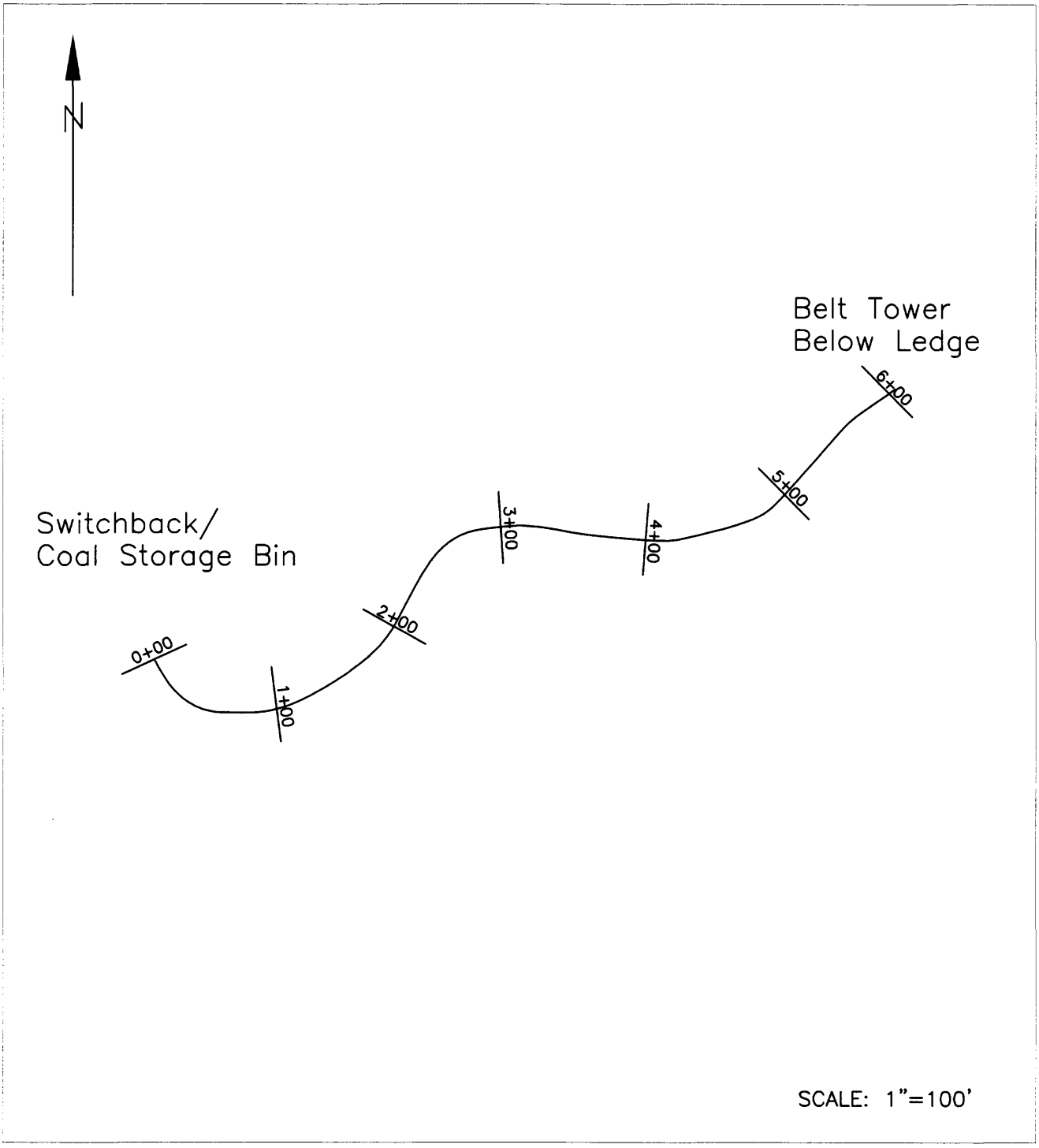

Figure 5J-3 shows the locations of cross-sections for the No. 3 Mine Portal Pad area. The construction sequence will start with the recovery of the topsoil located on the existing cut bench above the proposed pad area. Initial topsoil on the slopes will be recovered using a track hoe to reach approximately 15' below the bench. A pilot road cut will then be made using the track hoe, and the material will be pulled back onto the bench. As the pilot cut proceeds into the bottom of the canyon, the topsoil will be removed from the lower slopes wherever the track hoe can reach. This process will continue until the pilot cut reaches the drainage area where the pad fill is to be placed.

Once access into the drainage has been constructed, the crews will proceed to recover all of the topsoil, which will be hauled to the topsoil storage area shown on Plate 5-2F. An estimated volume of 5,143 cu yds of topsoil material will be recovered. After the topsoil has been removed, the fill will be placed as described in this Appendix. Table 5J-4 shows the calculated cut and fill volumes. The contours of the pad out slope may vary slightly to account for the shortage in cut volumes shown in the Table.

During construction 1,000 yds^3 of material was excavated and moved from TS-15 to TS-11 to allow for construction of the tunnel. Once construction was completed 1,000 yds^3 of material was hauled from TS-17 to backfill the tunnel in TS-15 and the material in TS-11 was left there for reclamation.

During reclamation, the cut and fill process will be reversed. The reclaimed slopes will be reconstructed to approximate original contour, with the exception that localized ridges between drainages will be varied slightly from the original contours. In addition, a portion of the cut slope, shown on Plate 5-6G, will remain in place due to slope stability requirements. This will provide additional material, which will be used to eliminate to the extent possible the bench cut which existed prior to mining. This variation is shown in portal area cross-sections 1+00, 2+00, and 3+00.

Figure 5J-3 No. 3 Mine Portal Area Cross-Section Stations

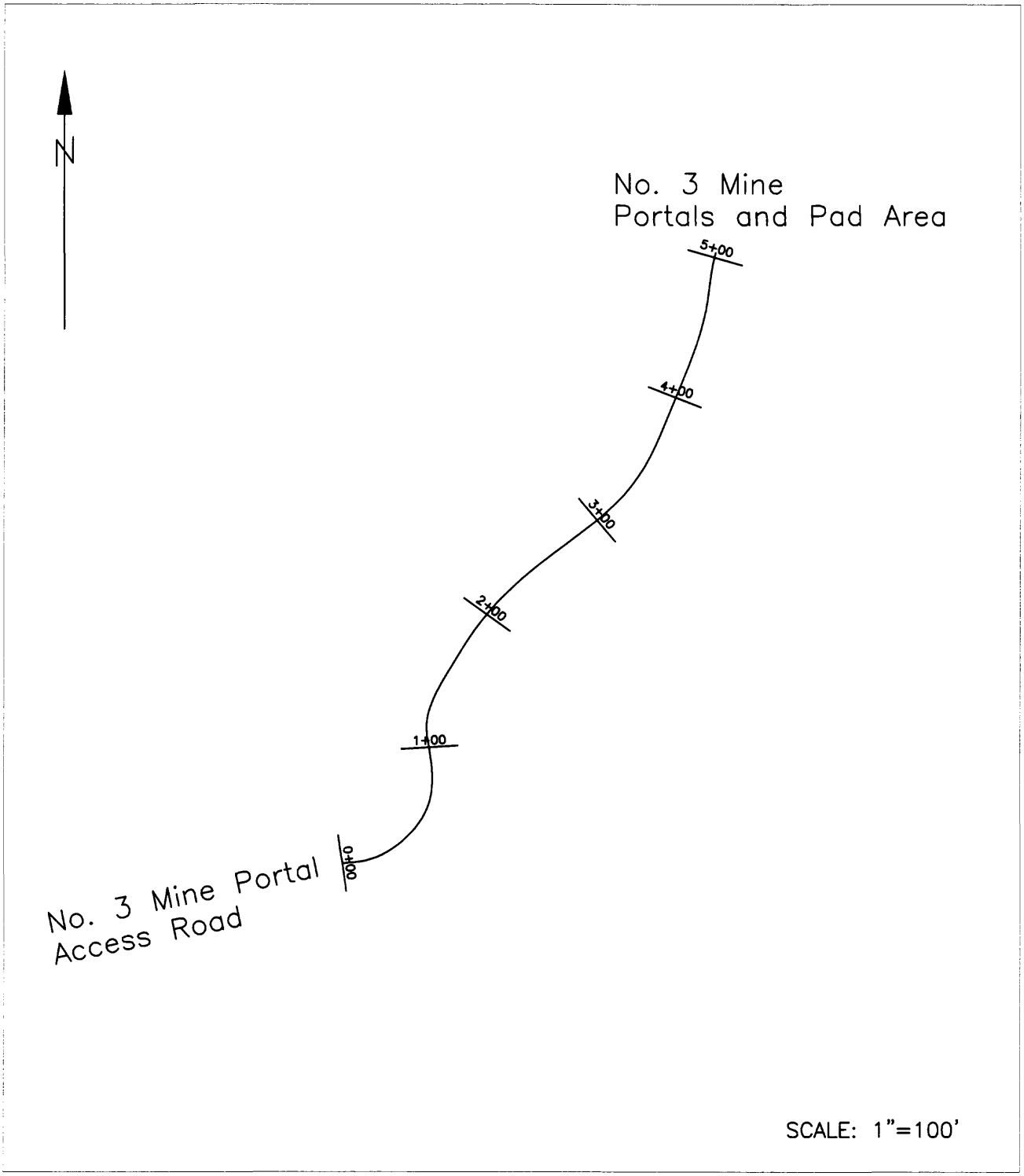

Table 5J-4
No. 3 Mine Portal Area
Cut and Fill Volumes

	Const. Vol. (Cu yds)		Cum. Vol.	**Reclaimed Vol. (cu yds)**		Cum. Vol.
Station	Fill (-)	Cut (+)	(cu yds)	Fill (-)	Cut (+)	(cu yds)
-1+00	0	0	0	0	0	0
0+00	0	153	153	591	0	-591
1+00	0	960	1,113	1,363	0	-1,954
2+00	0	2,865	3,978	2,950	260	-4,644
3+00	1,299	4,174	6,853	6,990	369	-11,265
4+00	6,254	6,126	6,725	2,464	6,254	-7,475
5+00	3,405	1,572	4,892	786	3,405	-4,856
Topsoil	**4,860**	—	-51	---	**4,860**	4
Total	**15,818**	**15,850**	**32**	**15,144**	**15,148**	**4**

Attachment A contains a slope stability analysis the operational cross-sections for the stations shown in Figures 5J-1, 5J-2 and 5J-3. Attachment B contains the A slope stability analysis of the reclaimed cross-sections. Appendix A of Attachment B illustrates the cross-sections, showing the pre-mining configuration, the proposed operational configuration, and the proposed post-mining configuration.

Attachment A

Slope Stability Analysis
Operational Phase

REPORT
SLOPE STABILITY EVALUATION
WILD HORSE RIDGE, BEAR CANYON NO.
CONVEYOR SYSTEM ACCESS ROAD
HUNTINGTON CANYON

For

CO-OP MINING COMPANY

JOB No. 27437-005-162

OCTOBER 7, 1996

DAMES & MOORE

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October 7, 1996

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Attention: Mr. Charles Reynolds
Mining Engineer

Report
Slope Stability Evaluation
Wild Horse Ridge, Bear Canyon No. 3
Conveyor System Access Road
Huntington Canyon
Job No. 27437-005-162

INTRODUCTION

This report presents the results of our slope stability evaluation for the proposed conveyor system access road and staging area at Wild Horse Ridge, Bear Canyon No. 3 near Huntington Canyon, Utah. The approximate road alignment with respect to major topographic features and existing facilities is presented on Plate 1, Vicinity Map. Plates 2A and 2B show the anticipated alignments of the lower and upper sections of the access road, respectively.

SCOPE OF STUDY

The scope of work for this investigation was outlined in our proposal, dated August 19, 1996. Authorization to perform the work was provided by signature on August 26, 1996. In general, the purpose of the investigation was to aid in the feasibility and permitting process of the access road by performing stability analyses at representative sections. In accordance with that purpose, the following services were performed:

1) Completing an engineering geology reconnaissance of the proposed access road alignment and proposed portal staging area. The reconnaissance included estimating depths of surficial deposits, completing field descriptions of surficial and bedrock deposits, obtaining bulk samples for laboratory testing, and identifying representative areas for subsequent stability analyses.

2) Performing laboratory tests to aid in the determination of strength parameters.

3) Performing slope stability analyses for selected sections of the access road and providing recommendations to improve slope stability. Additionally, recommendations for access road cuts and placement of fill at the proposed staging were provided.

PROPOSED CONSTRUCTION

CO-OP mine is anticipating mining new coal seams in the Wild Horse Ridge area. The portal location can generally be accessed by an existing road, however, the canyon below the portal area will be filled to allow for portal access and construction staging. Coal from the mine will be transported to the current processing facility via a new conveyor system.

An access road will be constructed in order to build the conveyor system and to allow for conveyor maintenance. The access road will consist generally of a lower and upper section, as indicated on Plates 2A and 2B. It is our understanding that material excavated during construction of the Lower Access Road will be used in adjacent segments to fill low areas, particularly at drainage crossings. Excavated material from the Upper Access Road will be used primarily to improve the main access road or fill in low areas of adjacent segments.

FIELD RECONNAISSANCE AND LABORATORY TESTING

FIELD RECONNAISSANCE

A field reconnaissance was completed along the lower and upper sections of the proposed conveyor access road and at the proposed portal area. Descriptions were completed for segments along each section where engineering properties differ from adjacent segments. Additionally, representative samples were obtained from surficial deposits for laboratory testing. Soil and rock descriptions for each segment identified are subsequently presented. The segments described are delineated on Plates 2A and 2B.

LOWER SECTION

Lower Section, Segment A

This segment generally consists of 3 to 5 feet of colluvial soils overlying sandstone bedrock. The colluvial soils are predominantly gravel with cobbles and boulder in a silty sand matrix. The percentage of material is estimated as follows:

gravel -	40%
fine to coarse sand -	20%
silty fines -	15%
cobbles and boulders -	25% (angular boulders routinely exceed 3 feet in width.)

The slopes are stable at approximately 35 to 45 degrees with the majority of the slopes comprised of sandstone ledges with shallow surficial deposits. Vegetation consists of cedar, pinion pine and engleman spruce. It is estimated that one-third to one-half of the road will encountered bedrock where blasting will be required. Cuts on the order of 8 feet in height are anticipated in the bedrock.

Lower Section, Segment B

This segment is located at the base of the steeper slope comprising segment A and is above the flood plain of the drainage, as indicated on Plate 2A. Surficial deposits are estimated to be 7 to 10 feet in depth and consist of sandy gravel with cobbles and boulders. Estimated composition is as follows:

20% cobbles and boulders to 5 feet in width
40% fine to coarse sandstone gravel
25% fine to coarse sand
15% silty fines

In this segment excavated material from Segment A will be used to fill in two small drainages and to fill low areas. The majority of this segment will be at grade or on several feet of fill. Vegetation is the same as in segment A, however, sparse grass and sage brush and occasional large pine trees are present.

Lower Section, Segment C

This segment consists of colluvial and stream deposits. The estimated percentage of material is as follows:

30% gravel
30% sand
20% fines
20% cobbles and boulders to 5 feet in width.

This segment will be at grade or on fill, particularly where the drainage is crossed. This segment is more heavily vegetated than the upper segments. Vegetation consists of sagebrush, occasional cottonwood trees and juniper trees. A culvert will be required at the drainage crossing. A bulk sample was obtained in this segment.

UPPER SECTION

Upper Section, Segment A

The conveyor access road in this area will branch from the main access road. The drainage northwest of the road alignment contains abundant vegetation and a small amount of water flows in the drainage. In order to preserve the vegetated area, the road alignment will be shifted to the southeast to avoid the drainage. Excavated material from this segment will be used to reduce the grade of the main access road as it approaches this section and to widen out the switchback on the main access road.

The road in this area will be cut into colluvial deposits and weathered bedrock. Due to the alignment, it is anticipated that one-half of the road will be in colluvial deposits and one-half in weathered bedrock. Uphill cuts in excess of 10 feet high may be required. The colluvial deposits are currently at a slope of 40 to 45 degrees and are expected to exceed 7 feet in depth. The colluvial deposits are composed largely of weathered shaley siltstone with silty and clayey fines comprising over 50 percent of the total material. A bulk sample was obtained in this segment.

Bedrock consists on laminated to thinly bedded shaley siltstone with up to 6-inch thick sandstone beds. The siltstone is moderately soft, moderately to intensely weathered (tends to air slake), and moderately jointed. Joints are closely spaced and closed to 1/8-inch separation. The bedrock stands vertically where previously cut, however, raveling of the slope has occurred. Several minor seeps were noted in the bedrock above the alignment causing damp areas.

Upper Section, Segment B

This segment has approximately 3 to 5 feet of colluvial soils overlying sandstone bedrock. The majority of the cut in this section will be in bedrock. Cuts of 8 to 10 feet in height are anticipated on the uphill side of the road.

Bedrock consists of moderately soft to moderate hard sandstone. The sandstone is thinly to moderately bedded and moderately jointed with joint spacing at approximately 6 inches. The trend of the major joint sets is parallel to the road alignment. The joints are open, dry, contain no filling and are moderate to intensely weathered.

Colluvium consists of sandy gravel with cobbles and boulders with the following estimated percentages:

40% cobbles and boulder (boulders tend to be slabs to 6 ft.)
30% gravel
20% sand
10% fines

The slopes in this area are 55 to 60 degrees with vertical sandstone ledges.

Upper Section, Segment C

The road in this section will be largely on colluvial soils or stream deposits. The general soil composition is as follows:

20% cobbles and boulders to 6 feet in width
20% subrounded to angular sandstone gravel
40% fine to coarse sand
20% silty fines

The surficial deposits throughout this segment are expected to range from 8-10 feet in depth. The upper foot of surficial deposits contains abundant organics and is classified as topsoil. Excavated material from Segment B will be placed in low areas to stabilize the roadway. A culvert will be installed in the drainage and excavated material from Segment B will also be used as backfill against the culvert. The majority of this segment will be on fill. Abundant large pine trees are present throughout the alignment.

Upper Section, Segment D

This section crosses through material that was side-cast during construction of the main access road. The upper end of this section will encountered massive sandstone ledges. A major sandstone ledge is located above the alignment and it is expected that the surficial material between the road alignment and the ledge will have to be removed to prevent excessive raveling. The older trees are "knee-bent" and have accumulations of previous side-cast material on the uphill side. Although the side cast material is generally less than 3 feet deep, it may have to be removed to minimize excessive raveling. The maximum estimated depth of surficial deposits is 7 feet.

The surficial material is largely coarse grained material with the following percentages:

5% boulders to 6 to 8 feet in width
20% cobbles
20% gravel
30% fines
25% sand

Grasses are abundant and may indicate areas of seepage during spring months. The area was dry during our reconnaissance of 9/10/96. Uphill cut slopes on the order of 10 feet in height are anticipated in this segment.

The upper part of this segment will be cut predominantly into sandstone bedrock. The bedrock is moderately hard sandstone with the major joint set at N 10° E with a vertical dip. A N 70° E at 70-90°NW joint set was also noted. Joints are spaced six inches to one foot apart. Joints are open ¼ to 1 inch with rough sidewalls and no infilling. Bedding thickness varies from thinly bedded to massive. Bedding is slightly crossbedded at an orientation of S30°E and a dip of approximately 5 degrees. Overall the rock mass tends to part on bedding planes. A 4 to 5 foot thick coal seam is located near the bottom of the bedrock in this section.

LABORATORY TESTING

Two bulk samples were obtained from the alignment for laboratory testing. Bulk sample 1 (TP-1) is representative of the majority of colluvial/stream deposits overlying sandstone bedrock while bulk sample 2 (TP-2) is representative of the material below or adjacent to the shaley siltstone ledge in segment A of the upper section.

Mechanical gradation analyses were completed on both samples. The coarser material (greater than 3 inches) was not included in the gradation from bulk sample 1. The gradations are presented in the following table.

Bulk Sample	Percent Gravel (>No. 4 Sieve)	Percent Sand (<No.4 >No. 200 Sieve)	Percent Fines (< No. 200 Sieve)	USCS Classification
TP-1	57	26	17	GM
TP-2	11	18	71	ML

The gradation curves are presented in the Appendix.

Direct shear tests (consolidated undrained) were also completed on each sample. The results are indicated in the following table.

Bulk Sample	Friction Angle (total stress)	Cohesion (psf)
TP-1	31	0
TP-2	34	0

The friction angle for TP-1 is indicative only of the material finer than the no. 4 sieve. Thus, the contribution from the coarser material is not included. Therefore, a more realistic friction angle of 34 degrees was used for subsequent analyses.

SLOPE STABILITY ANALYSES

ROCK PROPERTIES

In order to develop bedrock strength parameters for use in the stability analyses, the bedrock was classified according to the Rock Mass Rating (RMR) System (Bieniawski, 1988). The RMR classification system evaluates five parameters from which an overall rating is determined. The parameters include:

Strength of intact rock (from point load or uniaxial compression tests)
Rock Quality Designation (RQD)
Spacing of Discontinuities
Condition of Discontinuities
Groundwater Effects

The strength of the intact rock was estimated from point load tests and correlations with rock fracturing during hammer blows. The RQD was estimated from in-situ bedding plane partings. The spacing and condition of discontinuities were measured in the field as well as an assessment of groundwater in the outcrops. Based on the criteria, an overall rating of 53 (fair rock) was assigned to the sandstone and a rating of 41 (poor to fair rock) was assigned to the shaley siltstone.

With the RMR rating, unit weights, and uniaxial compressive strengths, procedures recommended by Hoek and Brown (1980) were used to derive instantaneous values of cohesion and friction angle for slope stability analyses. The instantaneous cohesion and friction values are dependent on the normal stress and are plotted in Plates 3 and 4 for sandstone and shaley siltstone, respectively. For subsequent stability analyses a friction angle of 47 degrees and a cohesion value of 3600 psf (25 psi) was used for sandstone bedrock. A friction angle of 27 degrees and a cohesion value of 1700 psf (12 psi) was used for the shaley siltstone.

The properties used in the analysis are presented in the following table.

Bedrock Type	Total Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (pcf)	Friction Angle
Sandstone	130	135	3600	43
Siltstone	125	130	1700	27

SOIL PROPERTIES

Soil properties used in the stability analyses were generally derived from laboratory testing results. The friction angle determined for the gravelly colluvium was performed only on material finer than the No. 4 sieve. The coarser gravel, cobble, and boulder fraction is not represented, therefore, the friction angle used in the analysis was conservatively raised from 31 to 34 degrees. The friction angle of 34 degrees obtained for the silty colluvium is thought to be fairly representative of actual soil conditions. No cohesion value was used in the analysis for surficial deposits.

ANALYSES

Slope stability analyses were performed with PCSTBL6, a two dimensional, limit equilibrium slope stability program. The analysis included both circular and irregular failure surfaces to determine the factor of safety against failure. A search routine was used that equally spaced twenty initiation points along a specified

interval. From each of the initiation points generally twenty potential failure surfaces were evaluated and the failure surfaces with the minimum factors of safety identified.

Overall, six cross-sections were chosen for stability analyses. The cross-sections that were representative of steeper slopes were included. The cross-section locations are included in Plates 2A and 2B. Plates 5 through 10 include plots of the sections analyzed. Both circular and random failure surfaces were evaluated for each section. The items indicated below are included on the plots in Plates 5 through 10.

1. soil/bedrock properties used in the analysis
2. the profile modeled
3. delineation of soil and rock units
4. the configuration and location of the failure surfaces with the minimum safety factors.
5. computation of the minimum safety factors
6. search limits.

The following table summarizes the stability analysis results.

Section Designation	Minimum Safety Factor (circular)	Minimum Safety Factor (random)
A-A'	1.46	1.66
B-B'	5.43	5.3
C-C'	5.33	3.96
D-D'	1.72	3.69
E-E'	1.46	1.67
F-F'	7.73	9.59

RECOMMENDATIONS

Based on our site reconnaissance, a large majority of the conveyor access road will be cut into bedrock ledges with intervening colluvium covered slopes. It is anticipated that portions of the road may require blasting where massive sandstone ledges are encountered. Since side-casting will not be allowed on steep slopes, the majority of the steeper portions of the road will be established in bedrock. Side-casting may be allowed near the bottom of drainages for road stabilization.

Where shallow deposits of colluvial material exist above the road, raveling of the colluvial deposits should be anticipated until the next ledge is encountered. However, raveling will generally be confined to material between the road and the ledge immediately above the road. A maintenance program should be anticipated since some ravel immediately above the road is expected. The material that ravels onto the road from the uphill slope should be used in the safety berm or for road stabilization.

Cuts in bedrock will generally be dependent on the joint pattern within the rock, however, vertical cuts should pose minimal stability problems. Cuts in colluvial material will be dependent on the grade of the uphill slope. Where gentle uphill slopes are encountered, cuts of two horizontal to one vertical (2H:1V) are recommended. For steeper slopes the uphill cut will depend on the overall slope. Raveling of shallow colluvial deposits between the top of the cut and the ledge immediately above the road should be anticipated where cuts exceed 2H:1V.

We anticipate that the material placed for the staging pad and portal access area will range from fine grained to boulder sized material. Due to the anticipated abundance of cobble and boulder sized fragments, monitoring of compaction will be very difficult, if possible. We recommend that compaction of the material be performed with earth-moving equipment and the following procedures be used:

1) Slopes of two horizontal to one vertical (2H:1V) be maintained in material used to construct the staging area.

2) The maximum rock size should generally be limited to 24 inches in any dimension. Larger fragments may be incorporated into the fill, provided they are isolated and assimilated into finer grained portions of fill. Alternatively, the larger fragments

may be incorporated into the upper surface of the fill or placed as a safety berm near the edges of the staging area.

3) Materials should be placed and worked to minimize void space between coarser fragments.

4) Maximum lift thicknesses for placement should be limited to 36 inches

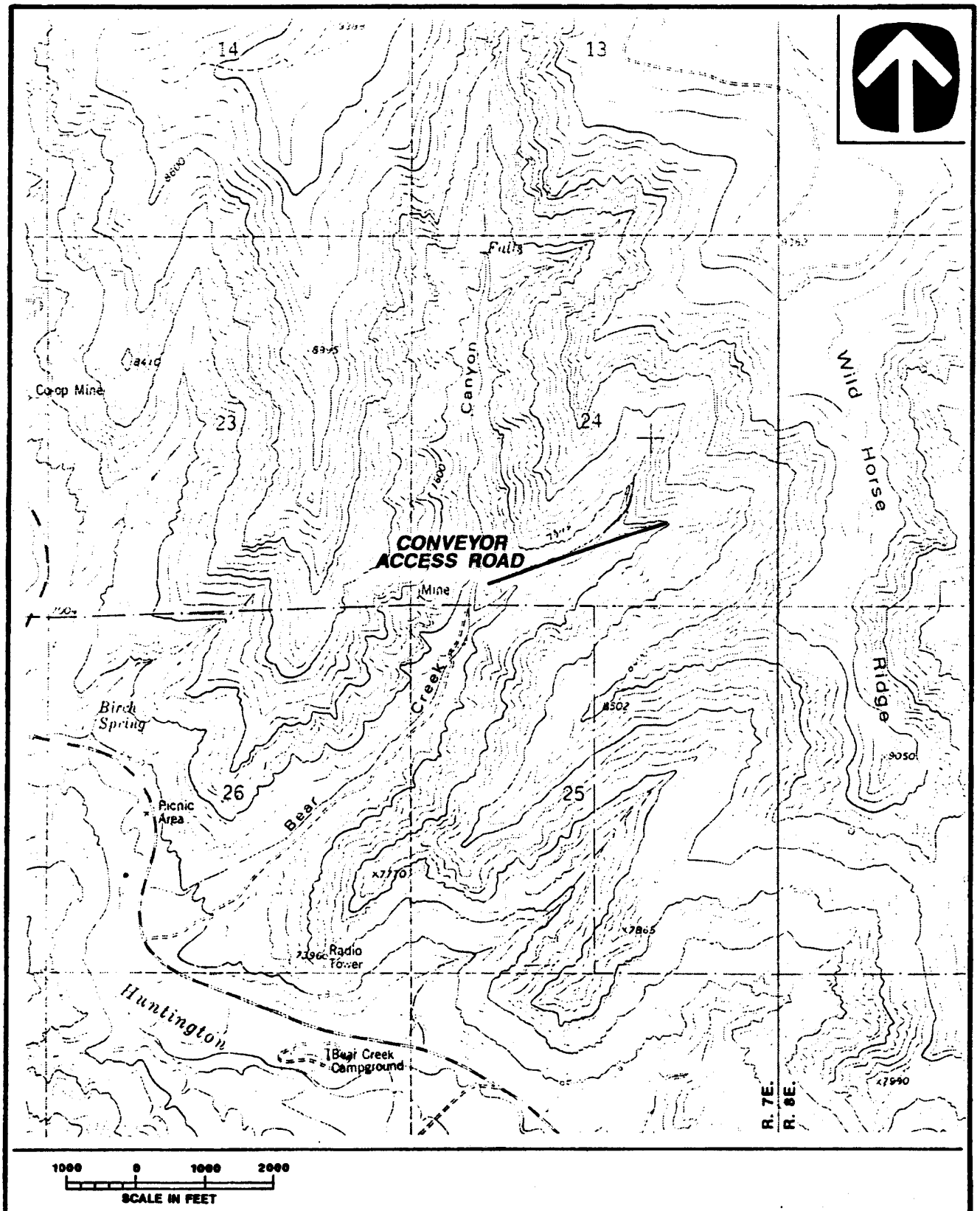
5) Adequate grubbing of vegetation should be accomplished prior to fill placement.

6) A properly sized culvert should be placed below the fill to allow for continued flow within the drainage.

CONCLUSIONS

The majority of road cuts will be in bedrock or in bedrock overlain by shallow colluvial deposits. Vertical cuts in bedrock are expected to be stable, however, blasting should be anticipated.. Cuts in surficial deposits should be maintained at 2H:1V where gentle slopes above the road allow. Where steeper slopes are encountered, the colluvial deposits above the uphill cut should be removed as far as practical, however, raveling of this material between the road cut and first ledge above the road cut should be anticipated. A maintenance program will be required. Accumulations of material on the road due to raveling should be incorporated into a safety berm on the downhill side of the road. Adequately sized culverts will be required in the drainage to maintain flows.

oOo



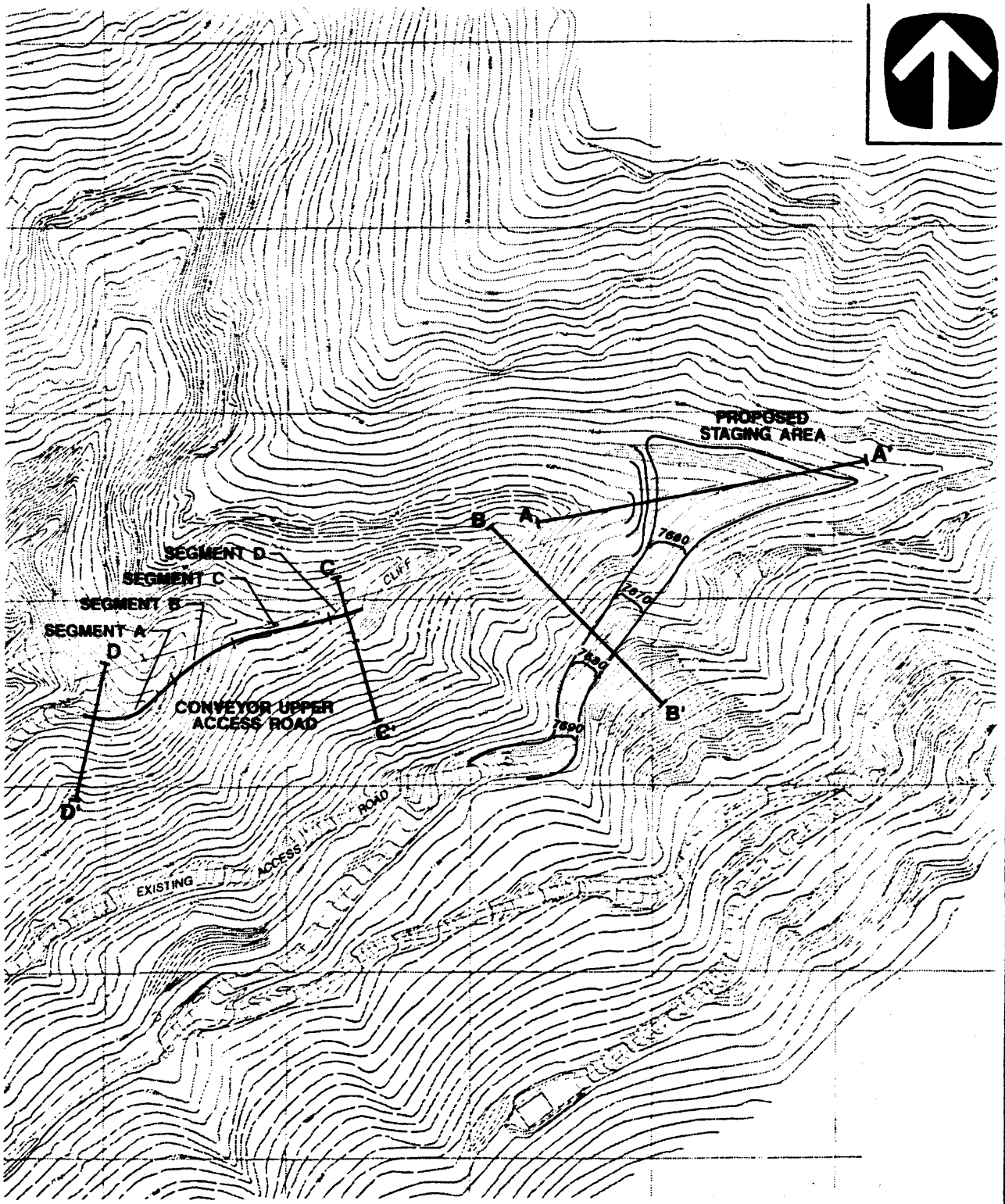
1000 0 1000 2000
SCALE IN FEET

VICINITY MAP

REFERENCE-
ADAPTED FROM U.S.G.S. TOPO MAP,
"HIAWATHA, UTAH," 1978.

Dames & Moore

PLATE 1



75 0 75 150

SCALE IN FEET

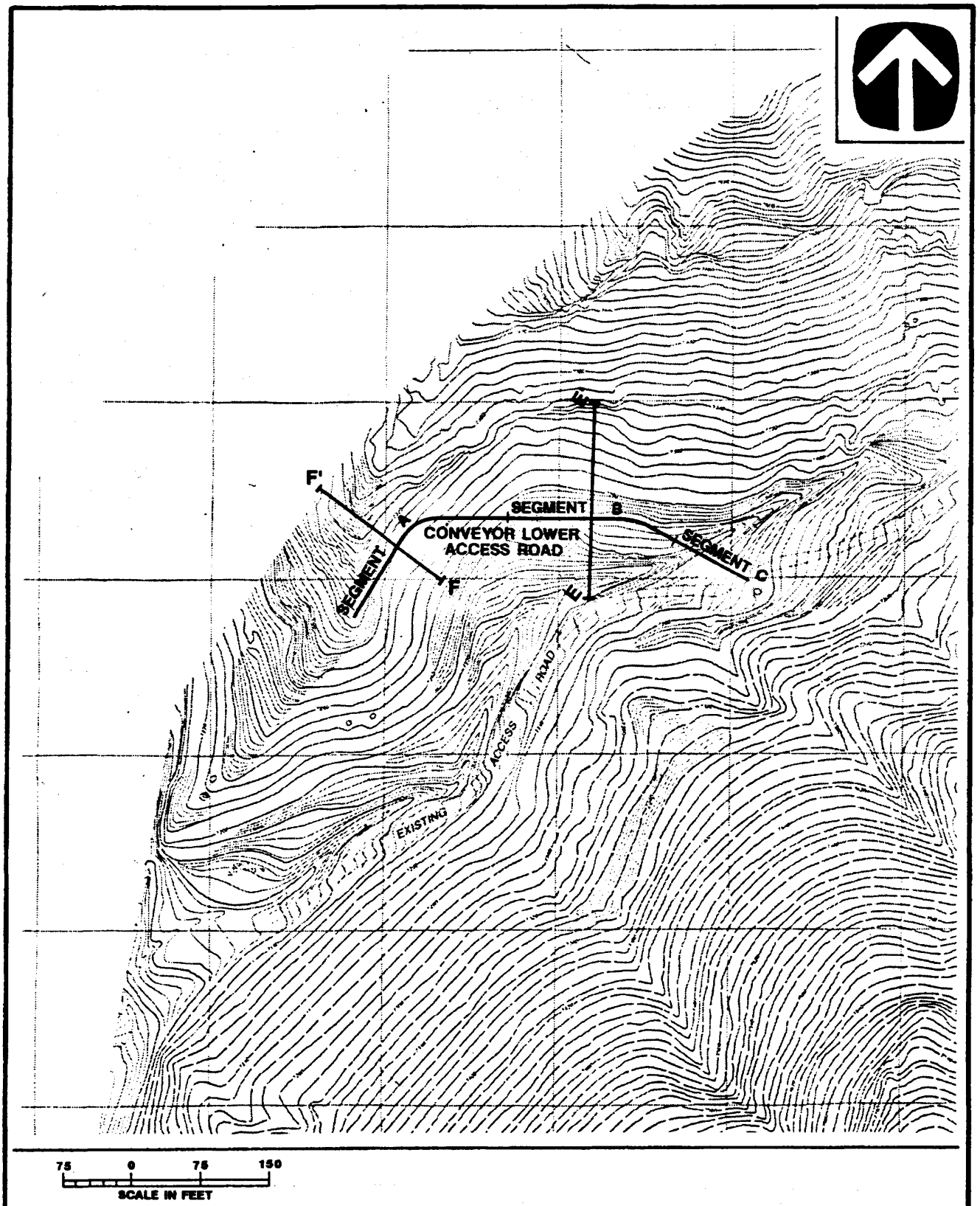
SITE PLAN

CONVEYOR UPPER ACCESS ROAD AND STAGING AREA

REFERENCE-
ADAPTED FROM UNTITLED DRAWING
PROVIDED BY CLIENT.

Dames & Moore

PLATE 2A



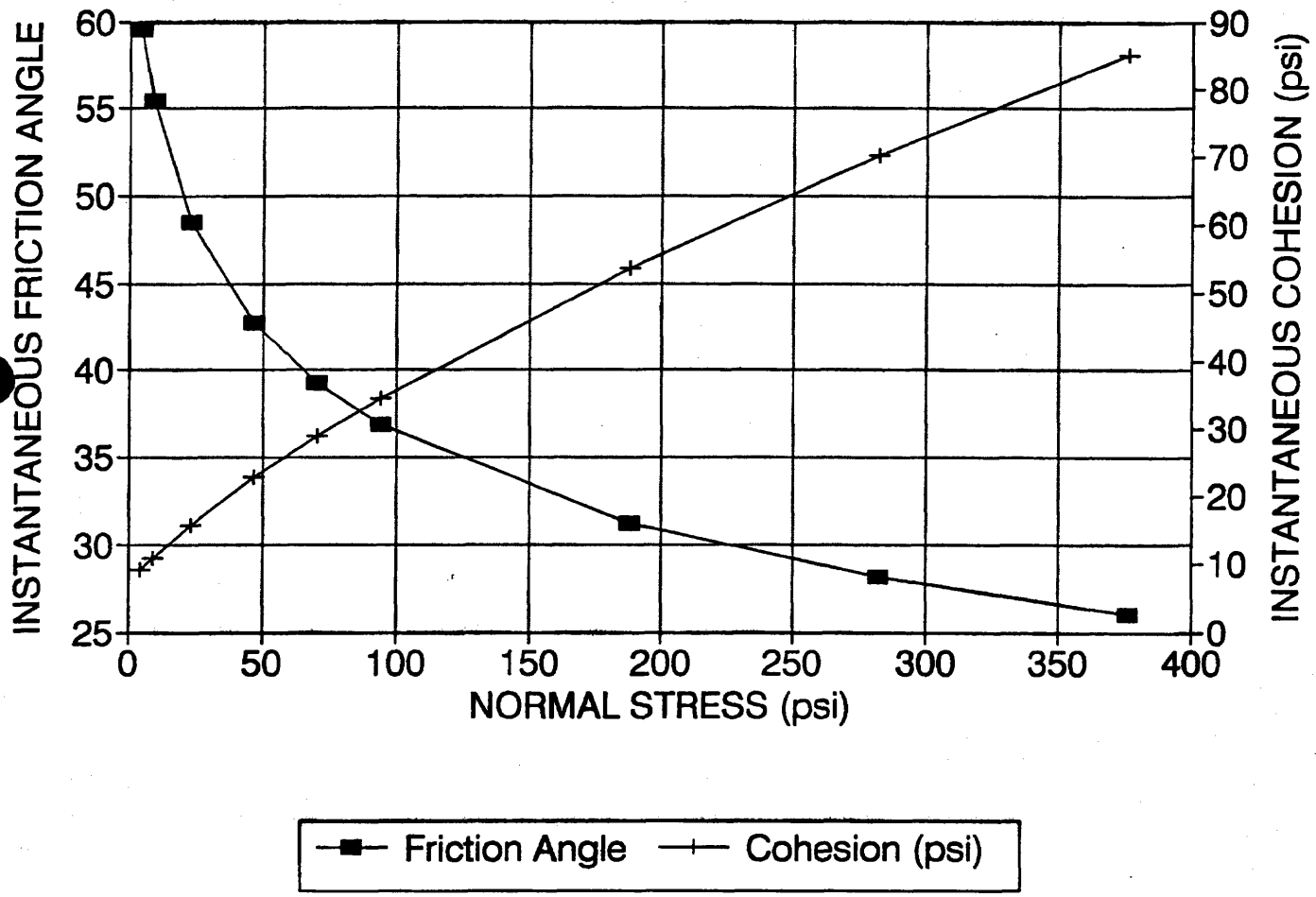
SITE PLAN
CONVEYOR LOWER ACCESS ROAD

REFERENCE-
ADAPTED FROM UNTITLED DRAWING
PROVIDED BY CLIENT.

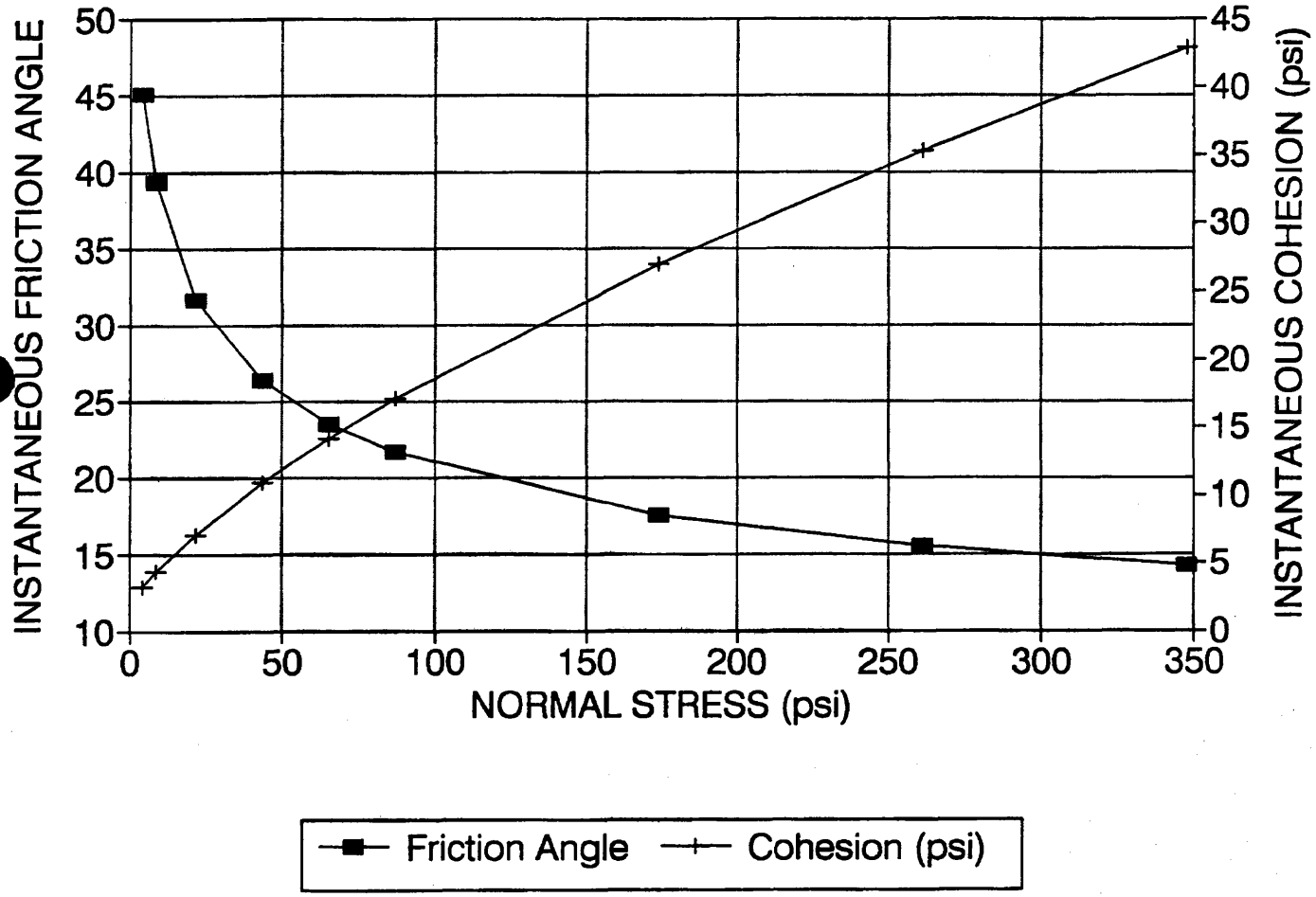
Dames & Moore

PLATE 2B

PHI AND COHESION WITH NORMAL STRESS
SANDSTONE (AVERAGE OF VALUES)

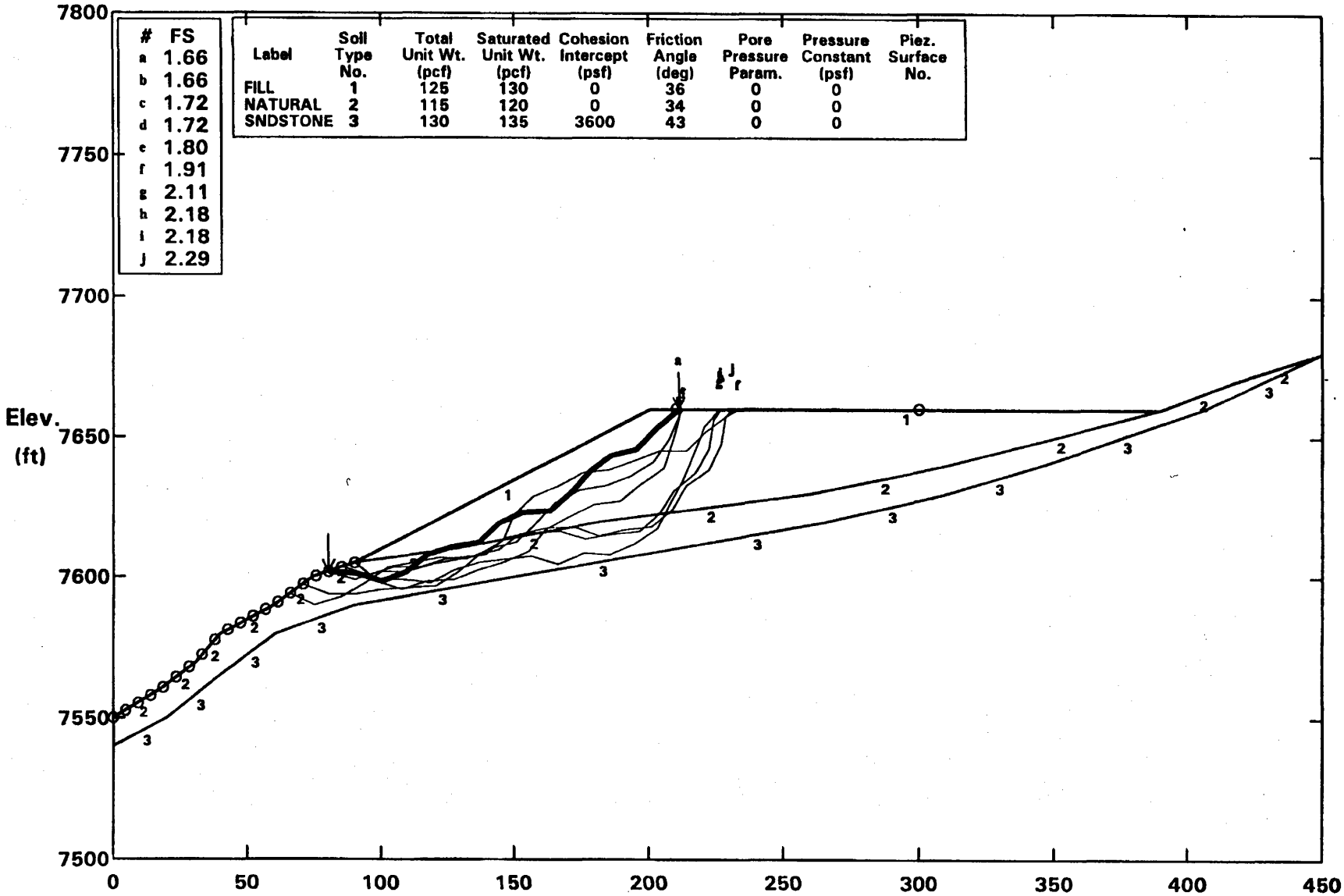


PHI AND COHESION WITH NORMAL STRESS
SHALEY SILTSTONE (AVERAGE OF VALUES)



PORTAL STAGING AREA, 2H:1V SLOPES Section A-A'

Ten Most Critical. C:AARAN.PLT By: DAMES & MOORE 9/27/96



#	FS
a	1.66
b	1.66
c	1.72
d	1.72
e	1.80
f	1.91
g	2.11
h	2.18
i	2.18
j	2.29

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
FILL	1	125	130	0	36	0	0	
NATURAL	2	115	120	0	34	0	0	
SNDSTONE	3	130	135	3600	43	0	0	

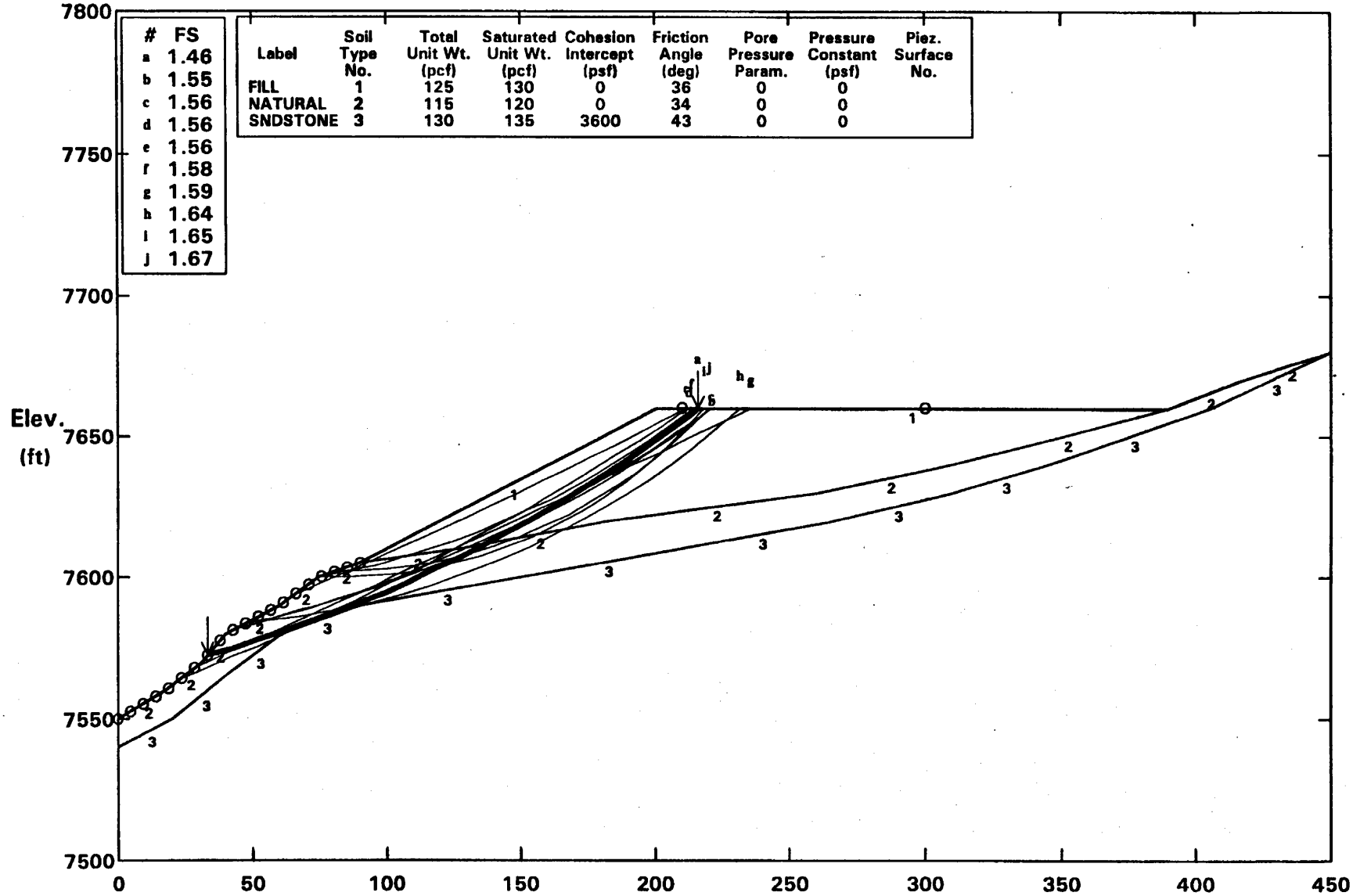
STABL6H FSmin = 1.66 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

PLATE 5A

PORTAL STAGING AREA, 2H:1V SLOPES Section A-A'

Ten Most Critical. C:AA.PLT By: Dames & Moore 09-27-96 3:25pm



#	FS
a	1.46
b	1.55
c	1.56
d	1.56
e	1.56
f	1.58
g	1.59
h	1.64
i	1.65
j	1.67

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
FILL	1	125	130	0	36	0	0	
NATURAL	2	115	120	0	34	0	0	
SNDSTONE	3	130	135	3600	43	0	0	

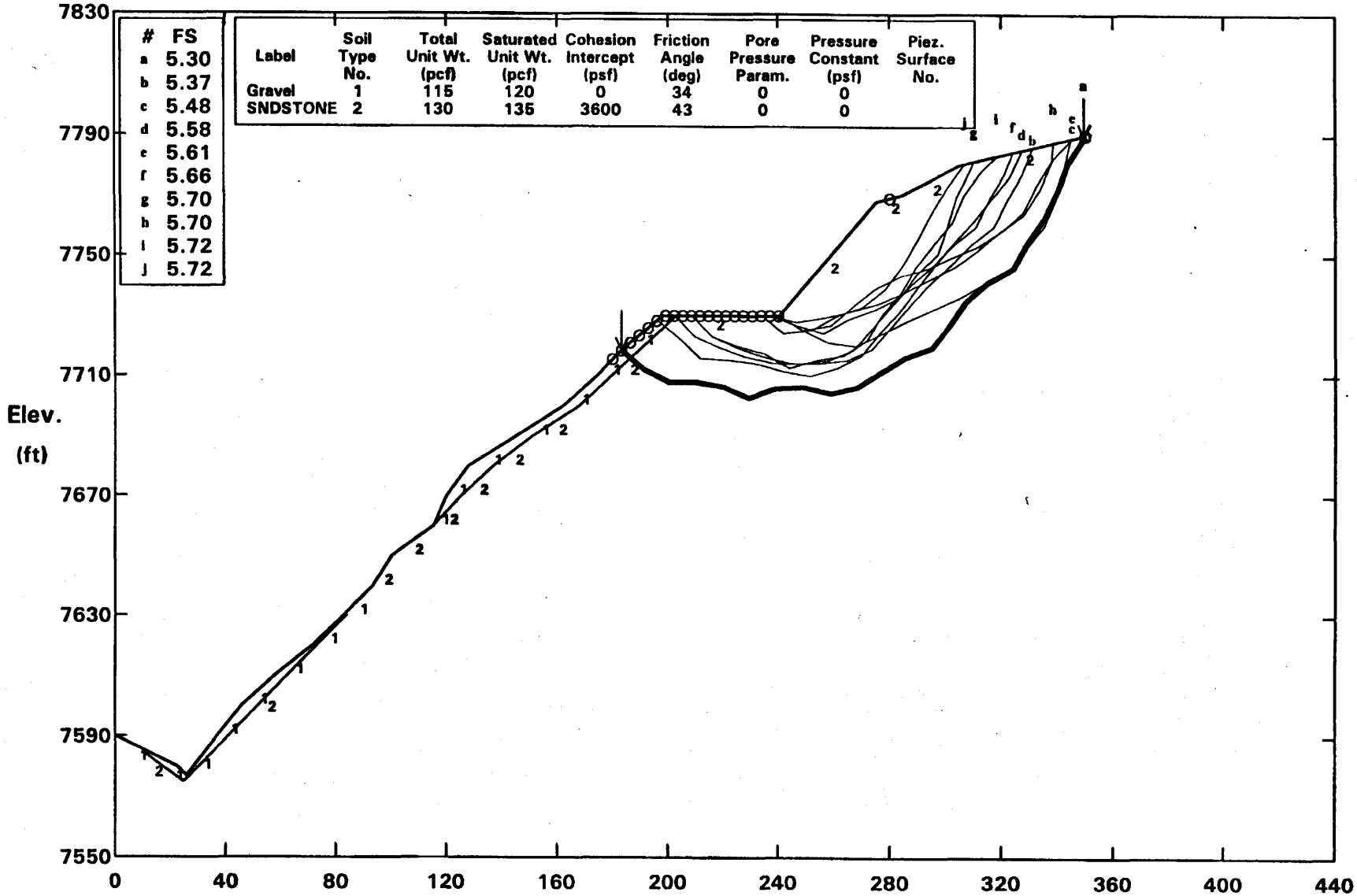
STABL6H FSmin = 1.46 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

PLATE 5B

Portal Staging Area Access Section B-B'

Ten Most Critical. C:BBRAN.PLT By: DAMES & MOORE 9/27/96



#	FS
a	5.30
b	5.37
c	5.48
d	5.58
e	5.61
f	5.66
g	5.70
h	5.70
i	5.72
j	5.72

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Gravel	1	115	120	0	34	0	0	
SNDSTONE	2	130	135	3600	43	0	0	

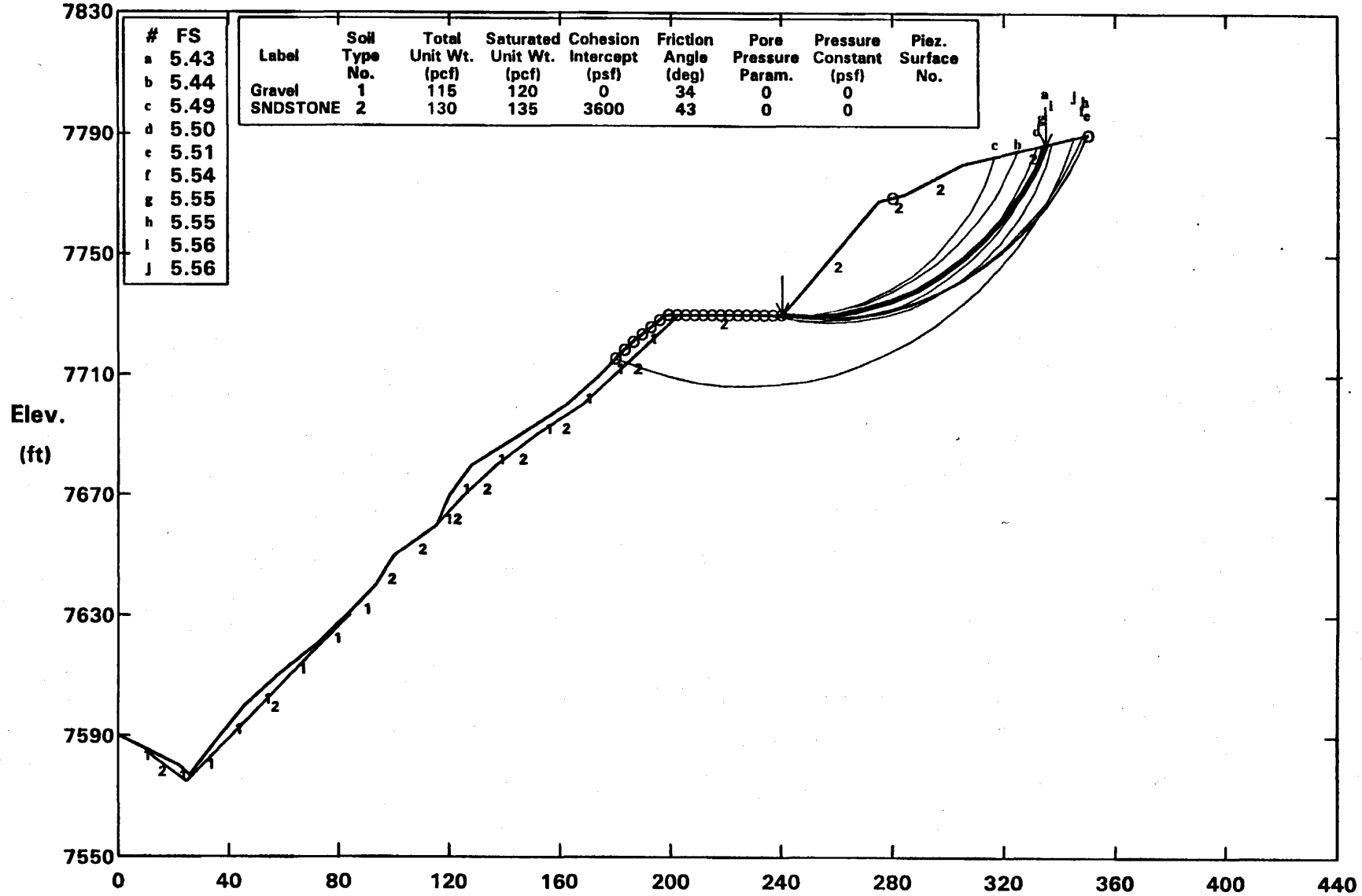
STABL6H FSmin = 5.30 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

PLATE 6A

Portal Staging Area Access Section B-B'

Ten Most Critical. C:BB.PLT By: Dames & Moore 09-27-96 3:35pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Gravel	1	115	120	0	34	0	0	
SNDSTONE	2	130	135	3600	43	0	0	

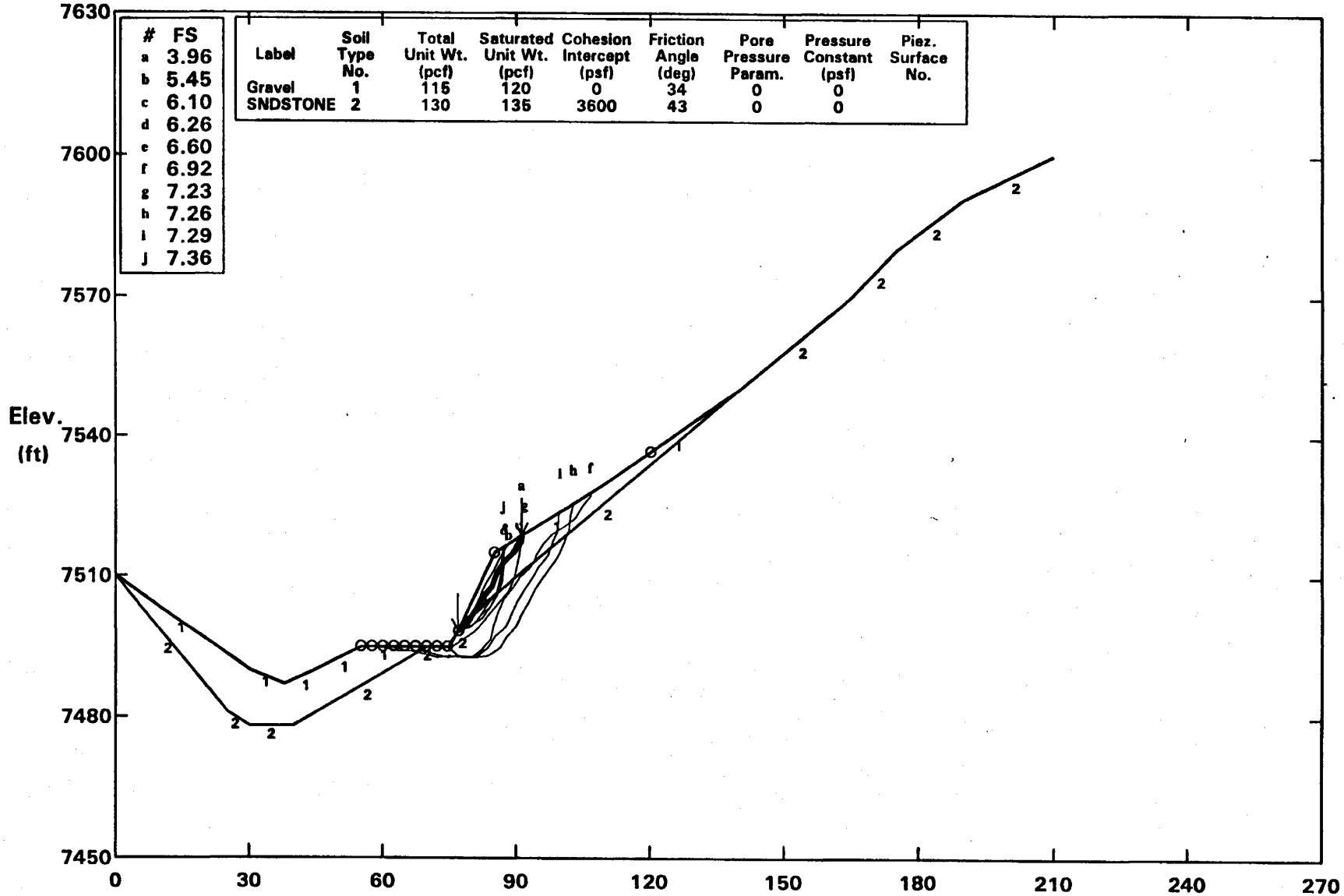
STABL6H FSmin = 5.43 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

PLATE 6B

CONVEYOR UPPER ACCESS ROAD Section C-C'

Ten Most Critical. C:CCRAN.PLT By: Dames & Moore 09-27-96 4:24pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Gravel	1	115	120	0	34	0	0	
SNDSTONE	2	130	135	3600	43	0	0	

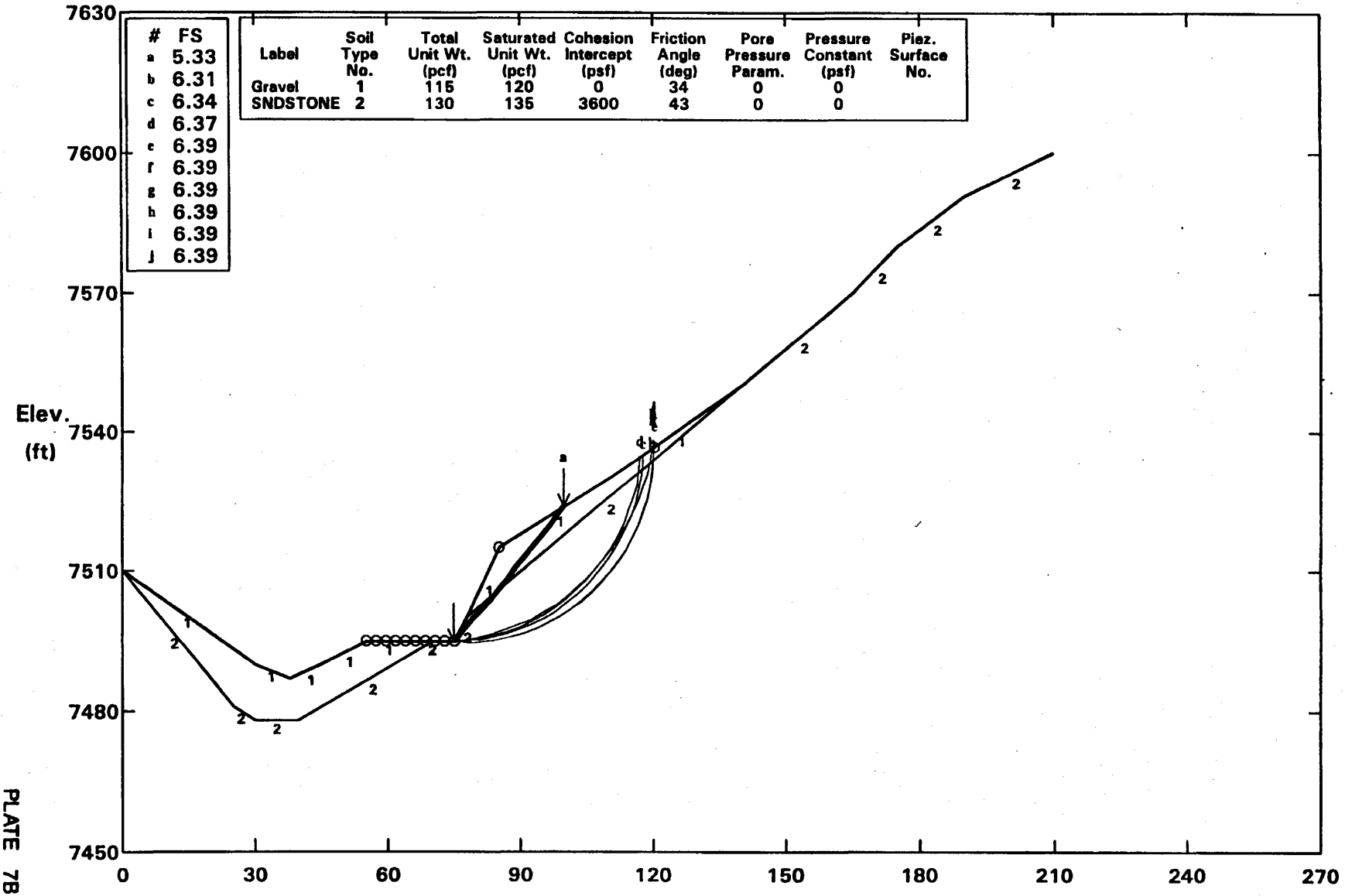
STABL6H FSmin = 3.96 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

PLATE 7A

CONVEYOR UPPER ACCESS ROAD Section C-C'

Ten Most Critical. C:CC.PLT By: Dames & Moore 09-27-96 4:19pm



#	FS
a	5.33
b	6.31
c	6.34
d	6.37
e	6.39
f	6.39
g	6.39
h	6.39
i	6.39
j	6.39

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Gravel	1	115	120	0	34	0	0	
SNDSTONE	2	130	135	3600	43	0	0	

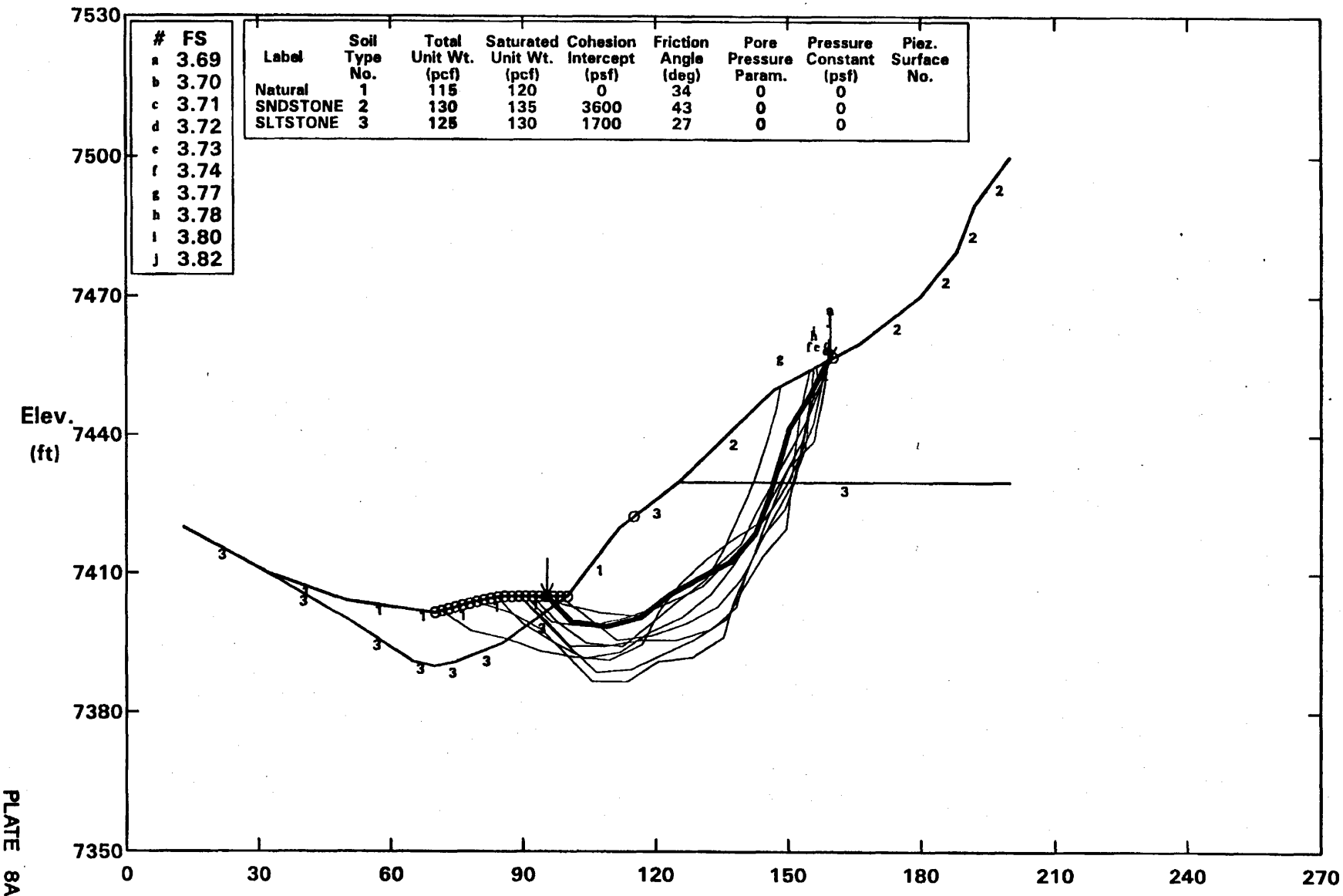
STABL6H FSmin = 5.33 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

PLATE 7B

CONVEYOR UPPER ACCESS ROAD Section D-D'

Ten Most Critical. C:DDRAN.PLT By: Dames & Moore 09-27-96 4:42pm



#	FS
a	3.69
b	3.70
c	3.71
d	3.72
e	3.73
f	3.74
g	3.77
h	3.78
i	3.80
j	3.82

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Natural	1	115	120	0	34	0	0	
SNDSTONE	2	130	135	3600	43	0	0	
SLTSTONE	3	125	130	1700	27	0	0	

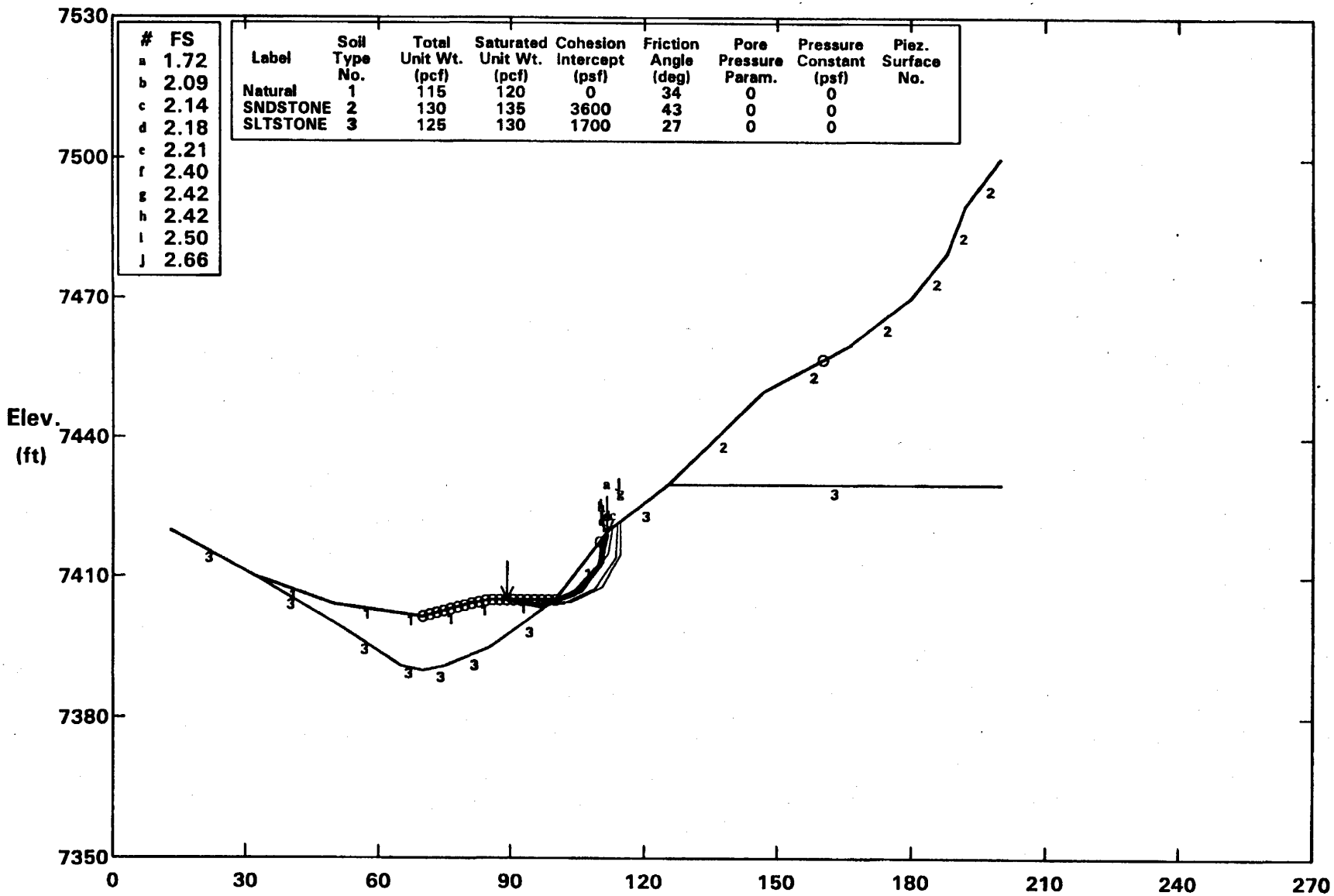
STABL6H FSmin = 3.69 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

PLATE 8A

CONVEYOR UPPER ACCESS ROAD Section D-D'

Ten Most Critical. C:DD.PLT By: Dames & Moore 09-27-96 4:40pm



#	FS
a	1.72
b	2.09
c	2.14
d	2.18
e	2.21
f	2.40
g	2.42
h	2.42
i	2.50
j	2.66

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Natural	1	115	120	0	34	0	0	
SNDSTONE	2	130	135	3600	43	0	0	
SLTSTONE	3	125	130	1700	27	0	0	

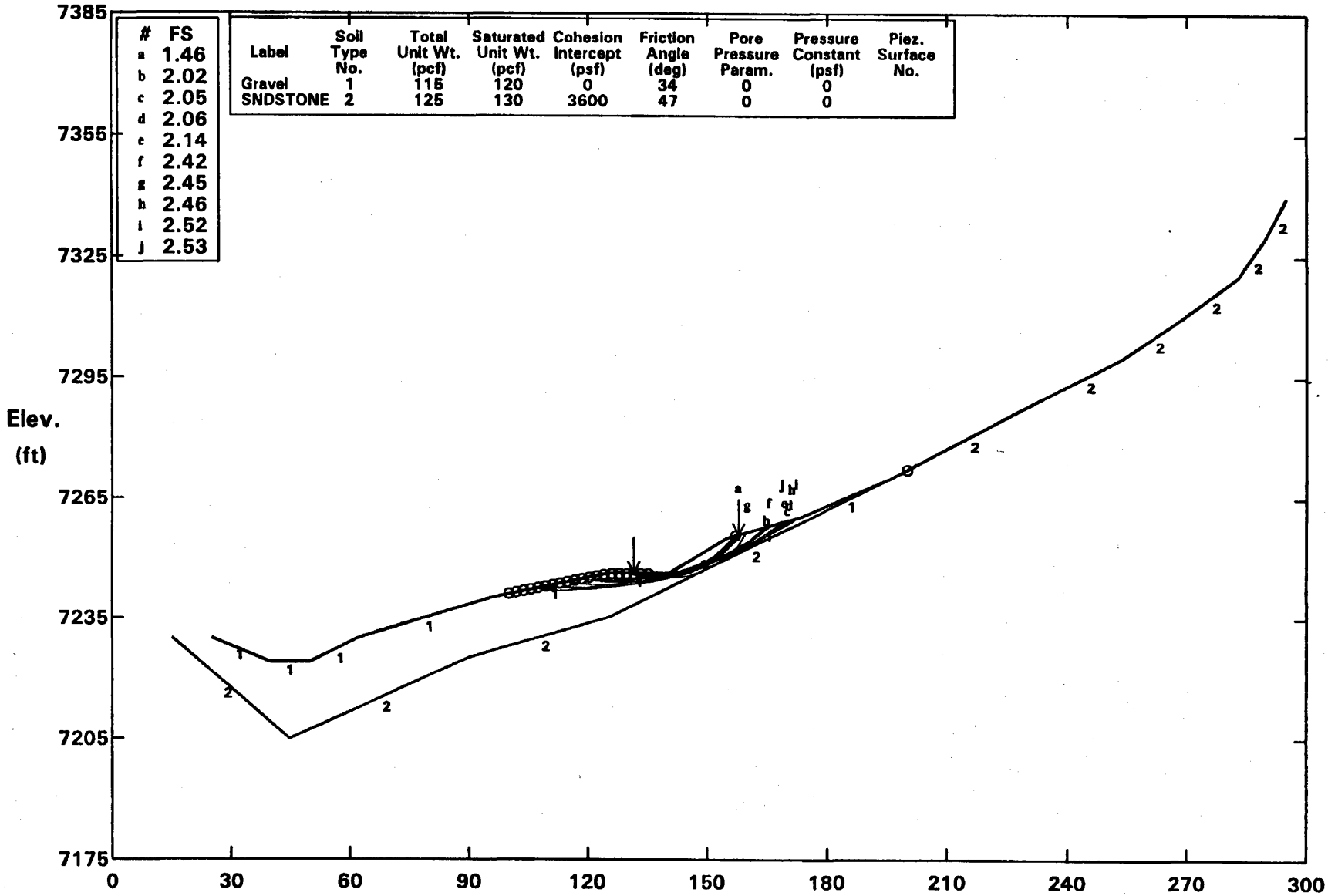
STABL6H FSmin = 1.72 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

PLATE 8B

CONVEYOR LOWER ACCESS ROAD Section E-E'

Ten Most Critical. C:EE.PLT By: Dames & Moore 09-27-96 4:48pm



#	FS
a	1.46
b	2.02
c	2.05
d	2.06
e	2.14
f	2.42
g	2.45
h	2.46
i	2.52
j	2.53

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Gravel	1	115	120	0	34	0	0	
SNDSTONE	2	125	130	3600	47	0	0	

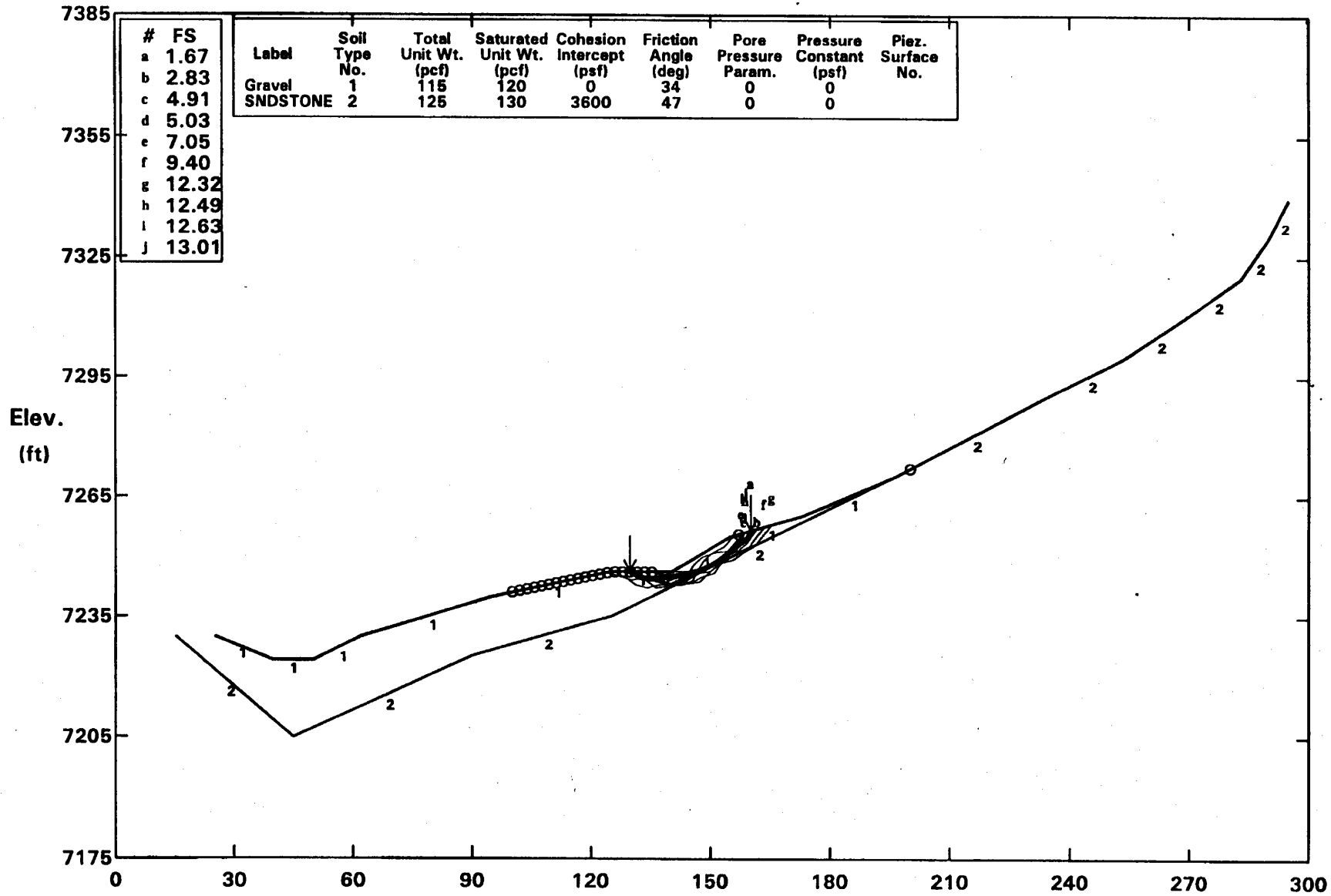
STABL6H FSmin = 1.46 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

PLATE 9A

CONVEYOR LOWER ACCESS ROAD Section E-E'

Ten Most Critical. C:EERAN.PLT By: Dames & Moore 09-27-96 4:48pm



#	FS
a	1.67
b	2.83
c	4.91
d	5.03
e	7.05
f	9.40
g	12.32
h	12.49
i	12.63
j	13.01

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Gravel	1	115	120	0	34	0	0	
SNDSTONE	2	125	130	3600	47	0	0	

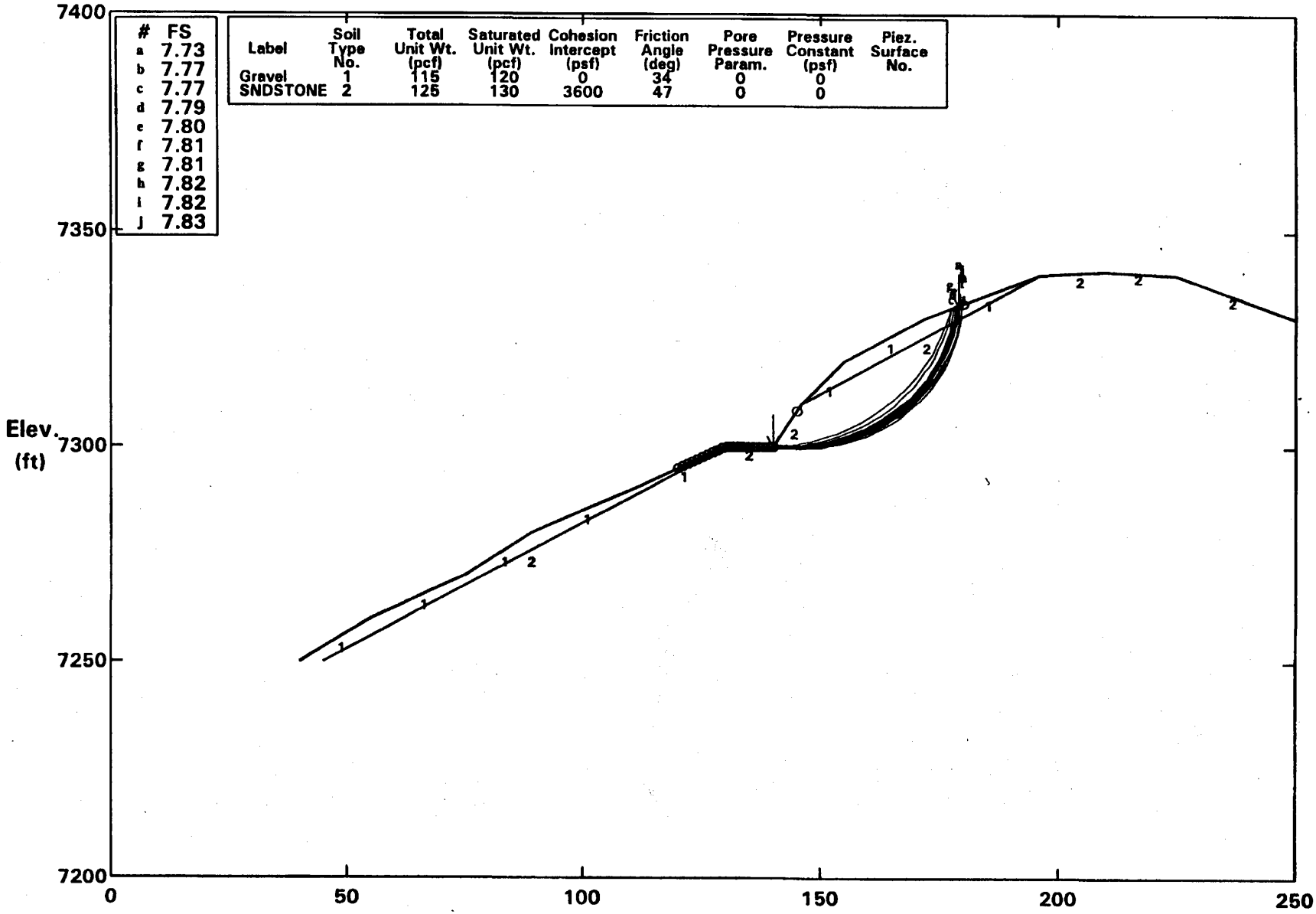
STABL6H FSmin = 1.67 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

PLATE 9B

CONVEYOR LOWER ACCESS ROAD Section F-F'

Ten Most Critical. C:FF.PLT By: Dames & Moore 09-27-96 4:55pm



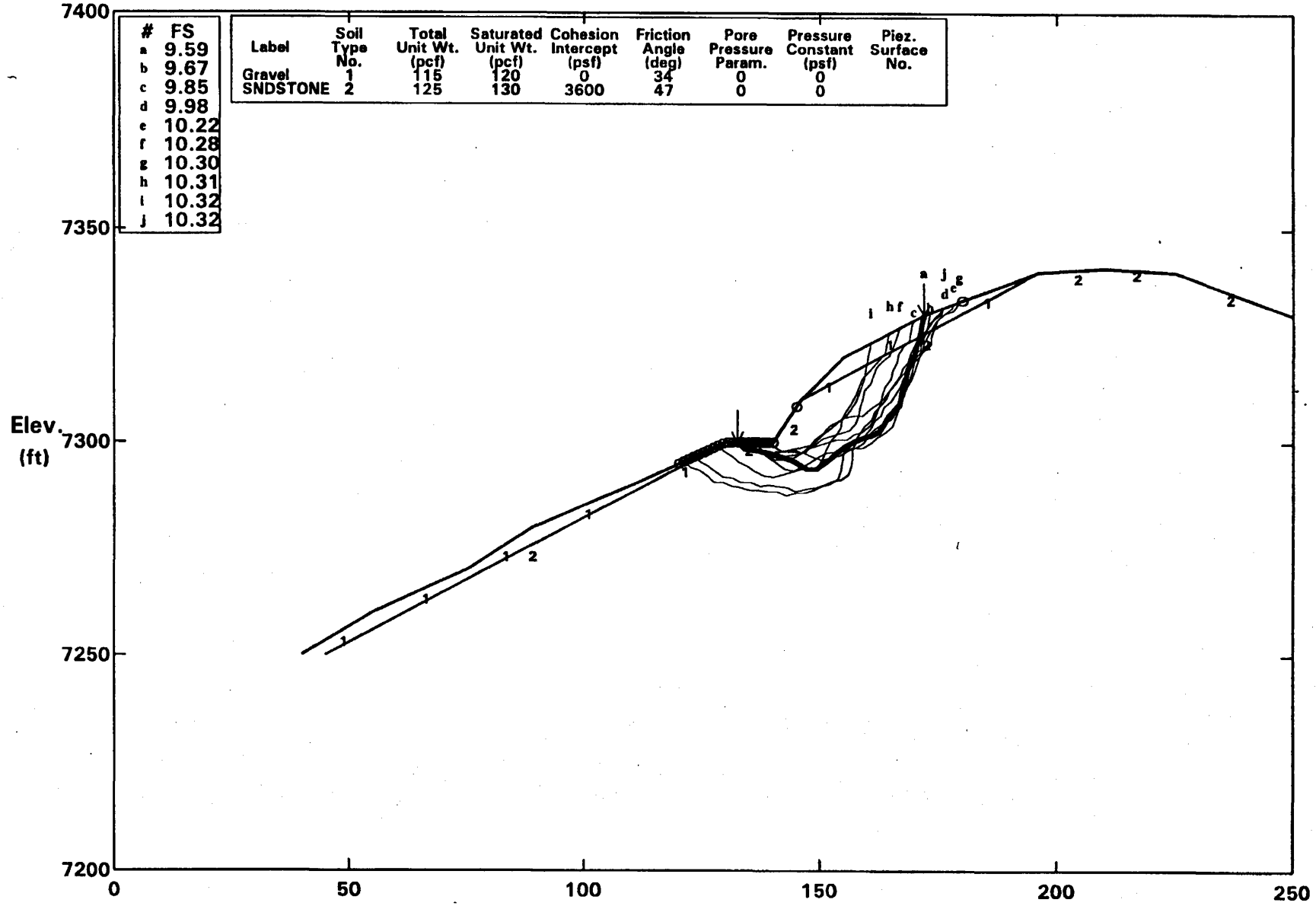
STABL6H FSmin = 7.73 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

PLATE 10A

CONVEYOR LOWER ACCESS ROAD Section F-F'

Ten Most Critical. C:FFRAN.PLT By: Dames & Moore 09-27-96 4:55pm



STABL6H FSmin = 9.59 X-Axis (ft)

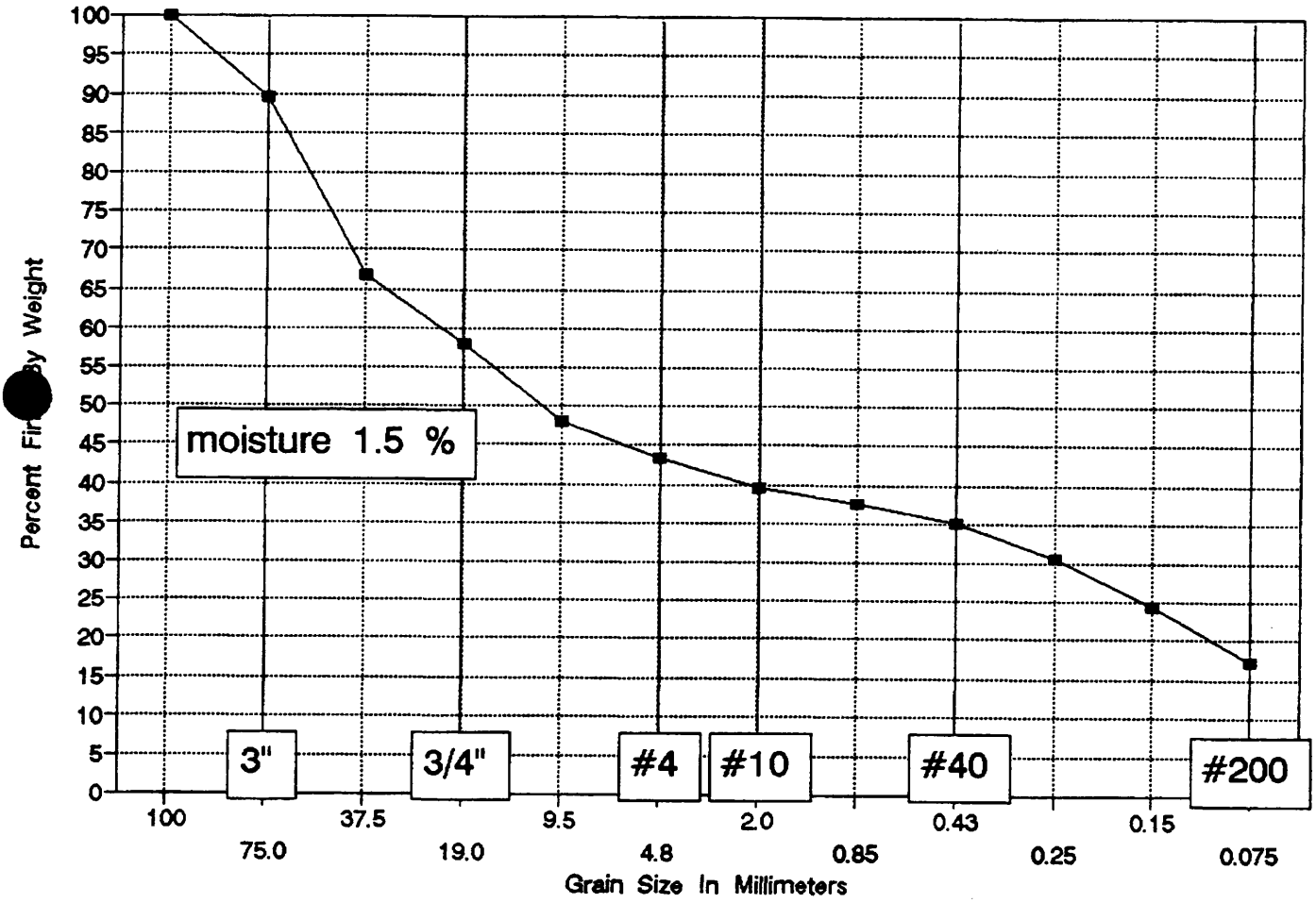
Factors Of Safety Calculated By The Modified Janbu Method

PLATE 10B

Appendix

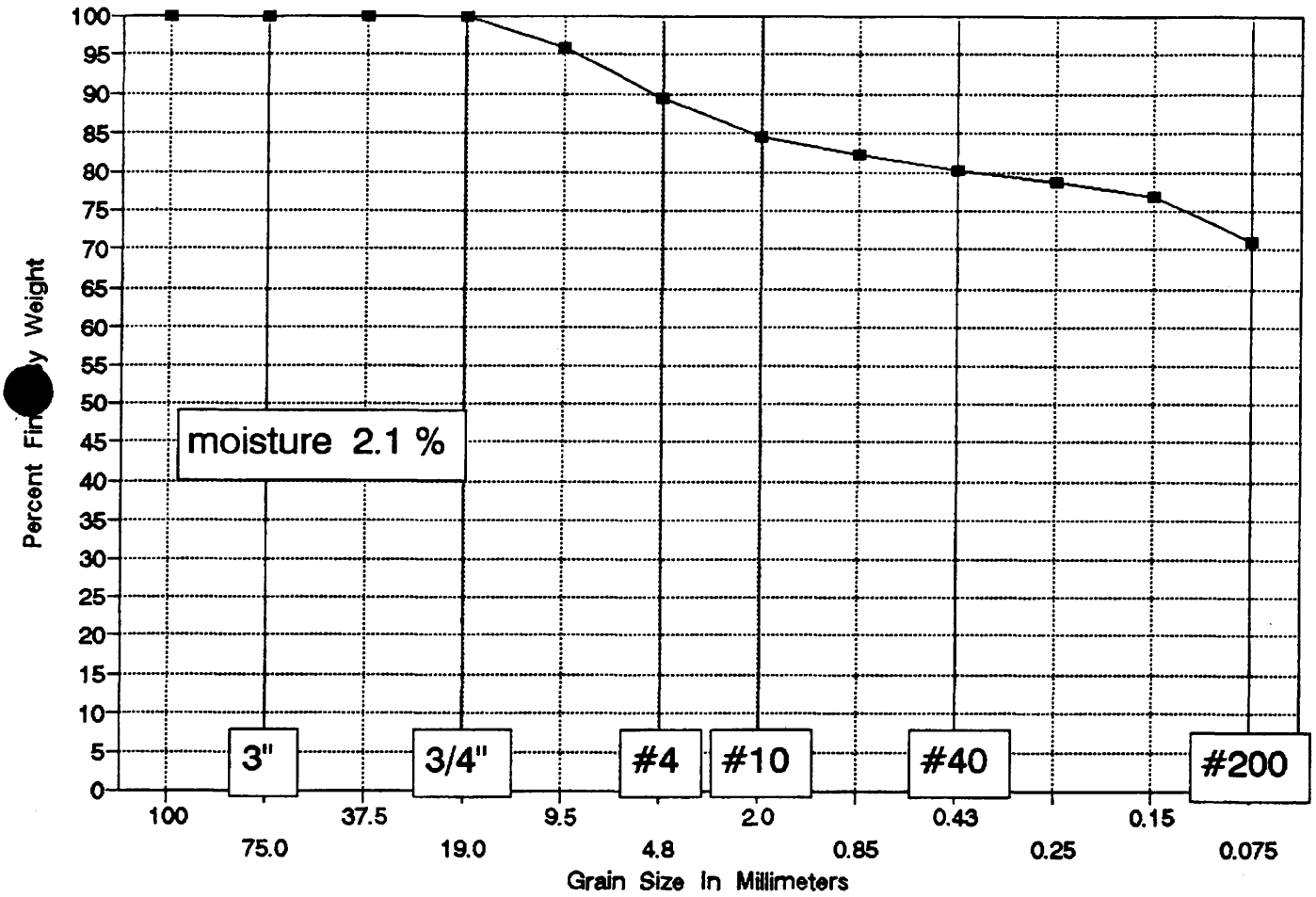
GRADATION CURVE

CO-OP Mine, Bulk Sample TP-1



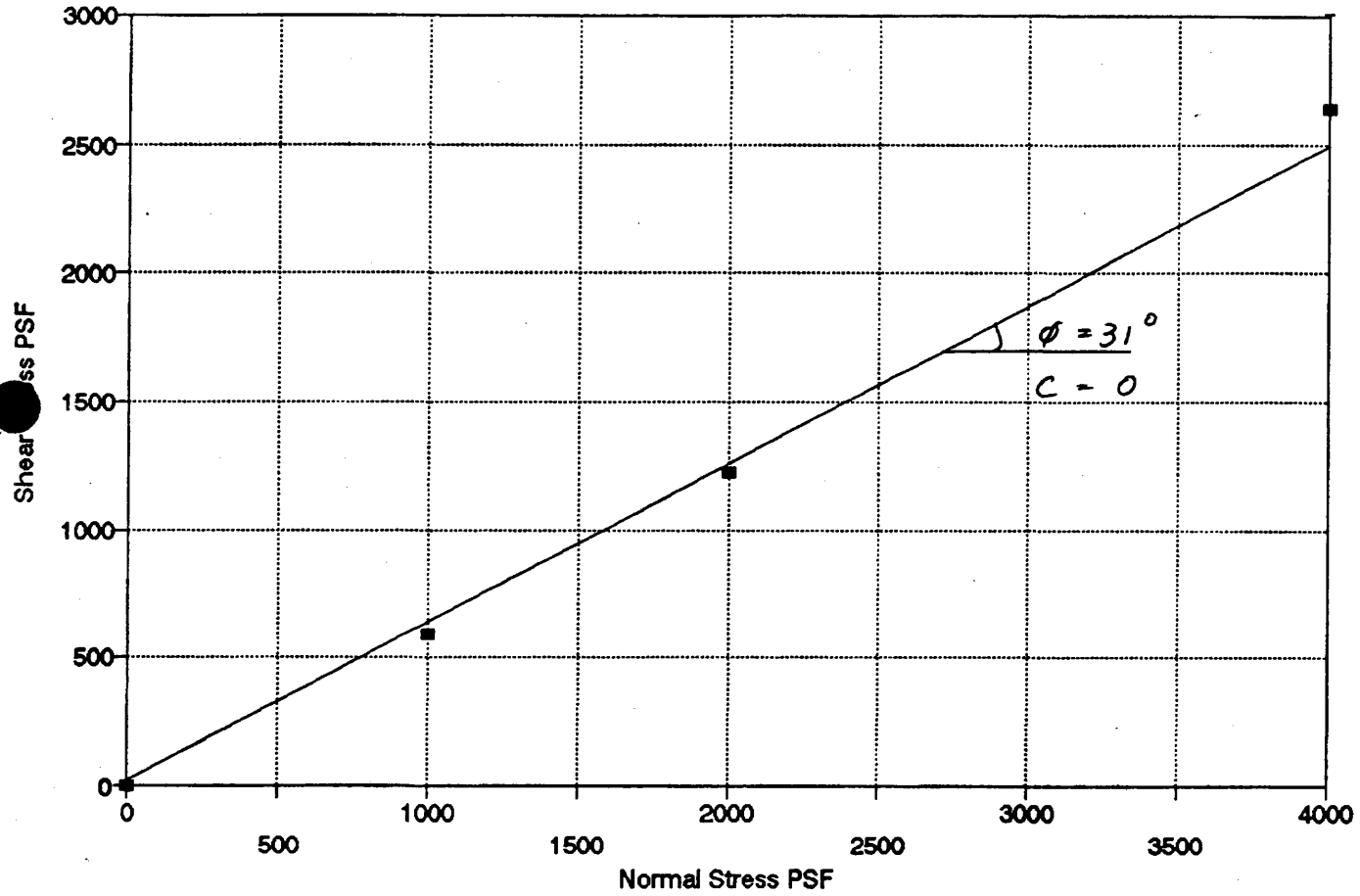
GRADATION CURVE

CO-OP Mine, Bulk Sample TP-2



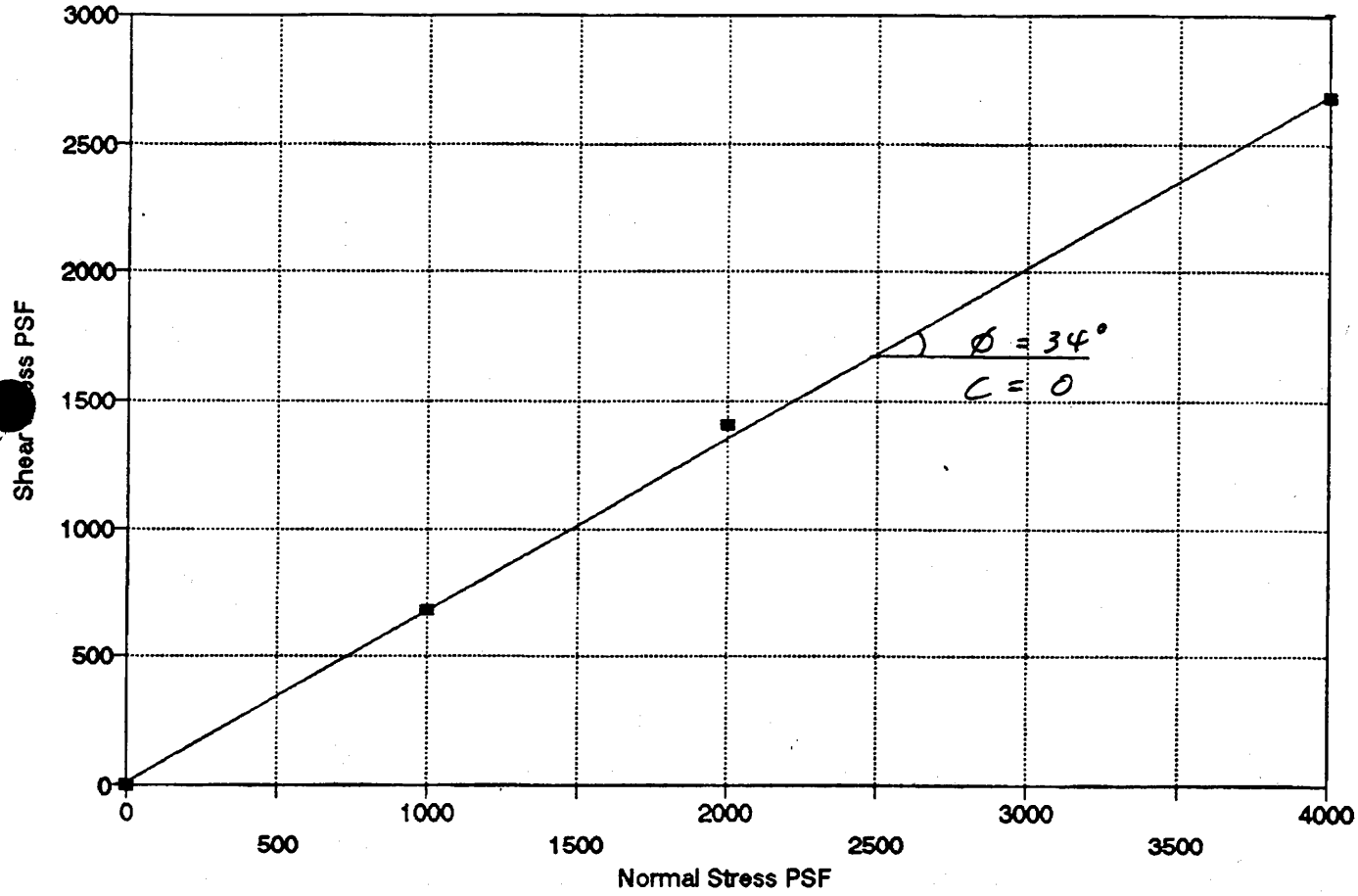
DIRECT SHEAR - Consolidated Undrained

CO-OP Mine, Remold sample TP-1



DIRECT SHEAR - Consolidated Undrained

CO-OP Mine, Remold sample TP-2



DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

127 South 500 East, Suite 300
Salt Lake City, Utah 84102-1959
801 521 9255 Tel
801 521 0380 Fax
800 432 6375 Tel

July 23, 1999

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

Attention: Mr. Charles Reynolds

RE: Slope Stability Evaluation
Portal Staging Area
Wild Horse Ridge, Bear Canyon No. 3
Huntington Canyon

Dear Mr. Reynolds:

This letter presents the results of a reevaluation of the stability of the fill slope at the Portal Staging Area, with the addition of a 7-foot deep sedimentation pond. It is understood that the pond will be located near the easternmost edge of the structural fill comprising the Portal Staging Area. The pond geometry used in the analyses was based on a sketch provided by your office on July 8, 1999. The analyses were performed in accordance with our proposal dated July 13, 1999.

The soil and rock parameters used in the stability analyses are based on those selected as part of our original geotechnical evaluation of the Portal Staging Area (see Slope Stability Evaluation Report, dated October 7, 1996). The properties used in the analyses to model the soil and rock are presented in the following table.

Soil/Bedrock Type	Total Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (psf)	Angle of Internal Friction (degrees)
Compacted Structural Fill	125	130	0	36
Native Granular Colluvium	115	120	0	34
Native Sandstone	130	135	3,600	43

To model the effects of the proposed sedimentation pond on the stability of the staging area slopes, 1) a full pond condition was assumed, and 2) two distinct steady-state seepage conditions were assumed. The first seepage condition is based on a straight-line phreatic surface within the structural fill and native materials resulting from infiltration of the impounded water. The second seepage condition is based on a phreatic surface that follows the interface between the native sandstone and the overlying granular colluvium.

The slope stability analyses were performed with PCSTABL6, which uses two-dimensional, limit equilibrium as a computational basis. The analyses included circular failure surfaces to determine the factor of safety against slope failure. A search routine was used that equally spaced 30 initiation points along a specified slope length. From each of the initiation points 30 trail failure surfaces were generated. A factor of safety was computed for each trail failure surface to aid identification of the minimum factor of safety. The results of the slope stability analyses are attached.

As shown on the attached results, factors of safety against slope failure ranging from 1.44 to greater than 2 were computed for static conditions, a full sedimentation pond, and the two steady-state seepage conditions. The analyses resulted in computed factors of safety greater than about 1.1 for a pseudo-static/earthquake loading of 0.20g (peak horizontal acceleration), and failure conditions constrained to relatively deep slope failure surfaces. By way of comparison, a minimum factor of safety of approximately 0.90 was computed for shallow slope failures (generally characterized by surface slumps and sloughing) and a pseudo-static/earthquake loading of 0.20g.

To account for localized variations and uncertainties associated with the type and strength of the structural fill and native earth materials, factors of safety ranging from 1.3 to 1.5 or greater are considered adequate to represent safe conditions for static loads and steady-state seepage conditions. A factor of safety of 1.1 or greater is commonly used to represent safe conditions for earthquake loads.

In general, the conditions analyzed and the attached results demonstrate computed factors of safety equal to or greater than those considered adequate for safe long-term performance. The primary exception to this conclusion is the condition of shallow slope failures resulting from strong ground motion. It is noted that the presence of the sedimentation pond (or seepage from the pond) does not effect the relatively low computed factors of safety for this condition. In addition, adequate factors of safety were computed against slope failure for relatively deep failure surfaces.

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Based on the results of our analyses for seepage and earthquake (pseudo-static) loading conditions, it appears unlikely that the pond would be in jeopardy as result of strong ground motion. However, shallow surface slides and sloughing of the exposed structural fill and native soil slopes should be expected as a result of strong ground motion.

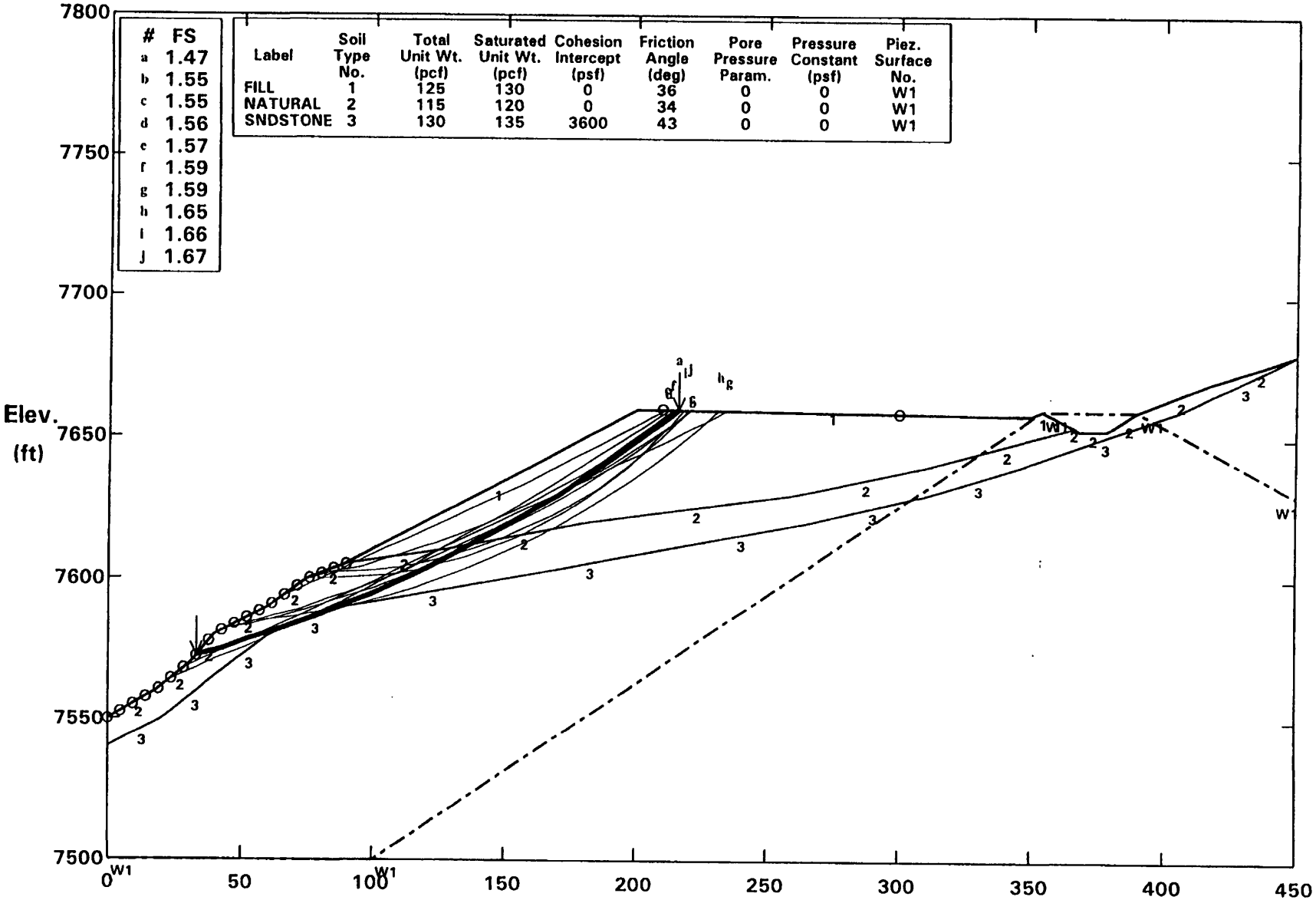
We appreciate the opportunity to provide this service for you. Please call if you have any questions or comments regarding the analytical results presented with this letter, please call.

Respectfully Submitted,
DAMES & MOORE

G. Alexander Rush, P.E.
Senior Geotechnical Engineer
Professional Engineer No. 372768
State of Utah

PORTAL STAGING AREA, 2H:1V SLOPES Section A-A', July 1999 Study

Ten Most Critical. P:AA99.PLT By: Doug Giffin 07-14-99 2:08pm



#	FS
a	1.47
b	1.55
c	1.55
d	1.56
e	1.57
f	1.59
g	1.59
h	1.65
i	1.66
j	1.67

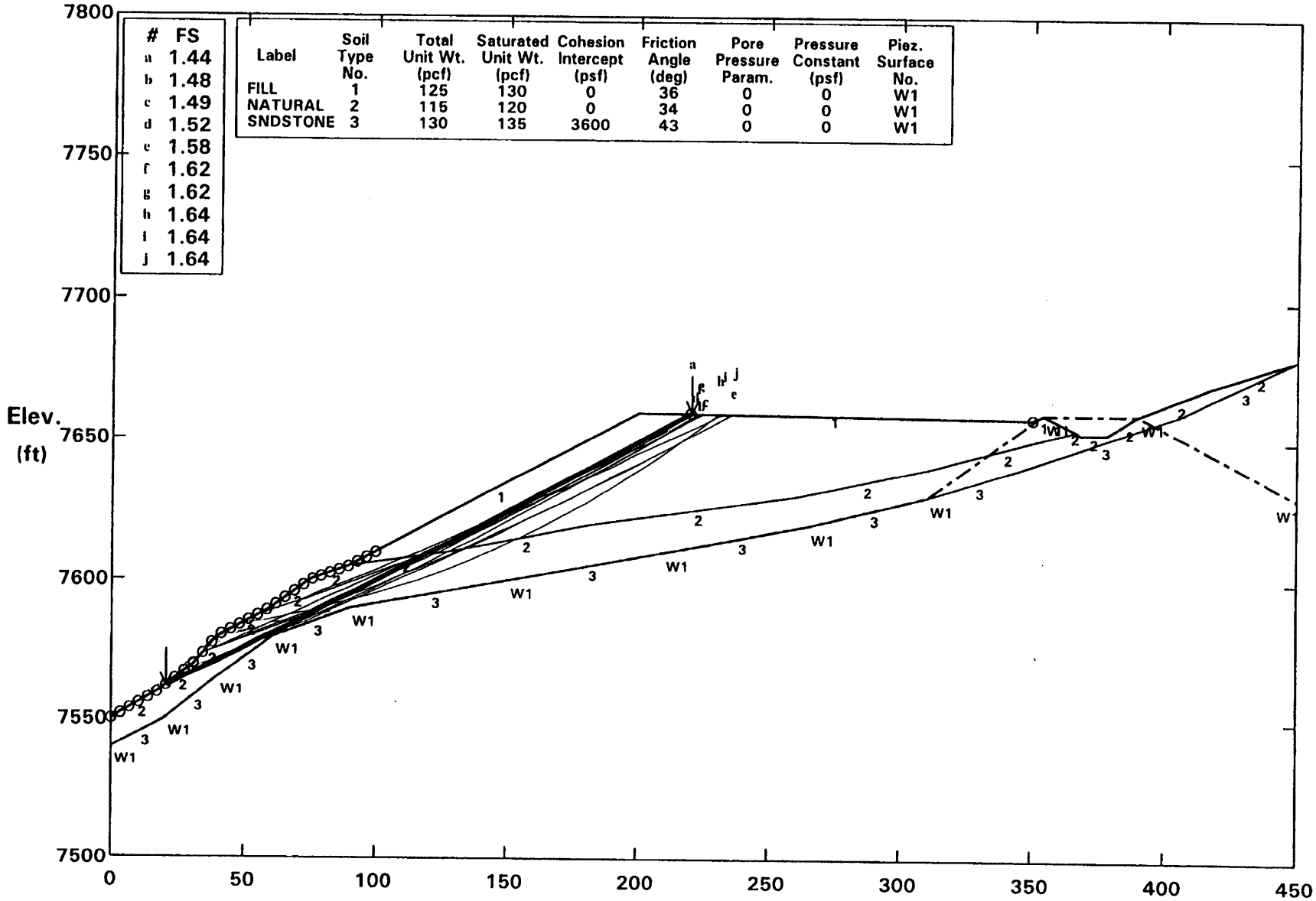
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
FILL	1	125	130	0	36	0	0	W1
NATURAL	2	115	120	0	34	0	0	W1
SNDSTONE	3	130	135	3600	43	0	0	W1

STABL6H FSmin = 1.47 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

PORTAL STAGING AREA, 2H:1V SLOPES Section A-A', July 1999 Study

Ten Most Critical. P:AA99W.PLT By: Doug Giffin 07-16-99 1:14pm



#	FS
a	1.44
b	1.48
c	1.49
d	1.52
e	1.58
f	1.62
g	1.62
h	1.64
i	1.64
j	1.64

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
FILL	1	125	130	0	36	0	0	W1
NATURAL	2	115	120	0	34	0	0	W1
SNDSTONE	3	130	135	3600	43	0	0	W1

STABL6H FSmin = 1.44 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

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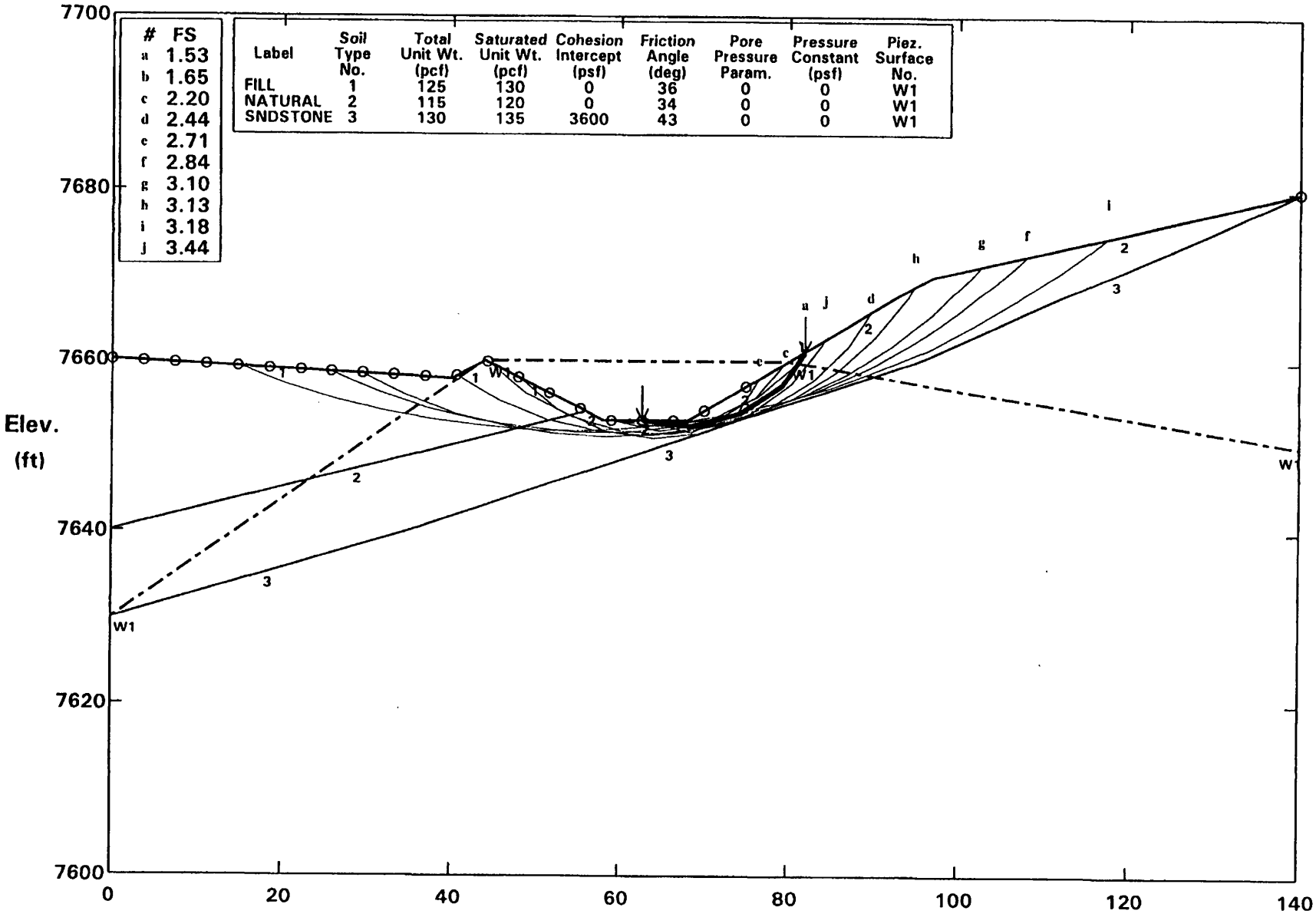

#	FS
a	1.53
b	1.65
c	2.20
d	2.44
e	2.71
f	2.84
g	3.10
h	3.13
i	3.18
j	3.44

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
FILL	1	125	130	0	36	0	0	W1
NATURAL	2	115	120	0	34	0	0	W1
SNDSTONE	3	130	135	3600	43	0	0	W1

STABL6H FSmin = 1.53 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

PORTAL STAGING AREA, 2H:1V SLOPES Section A-A', July 1999 Study

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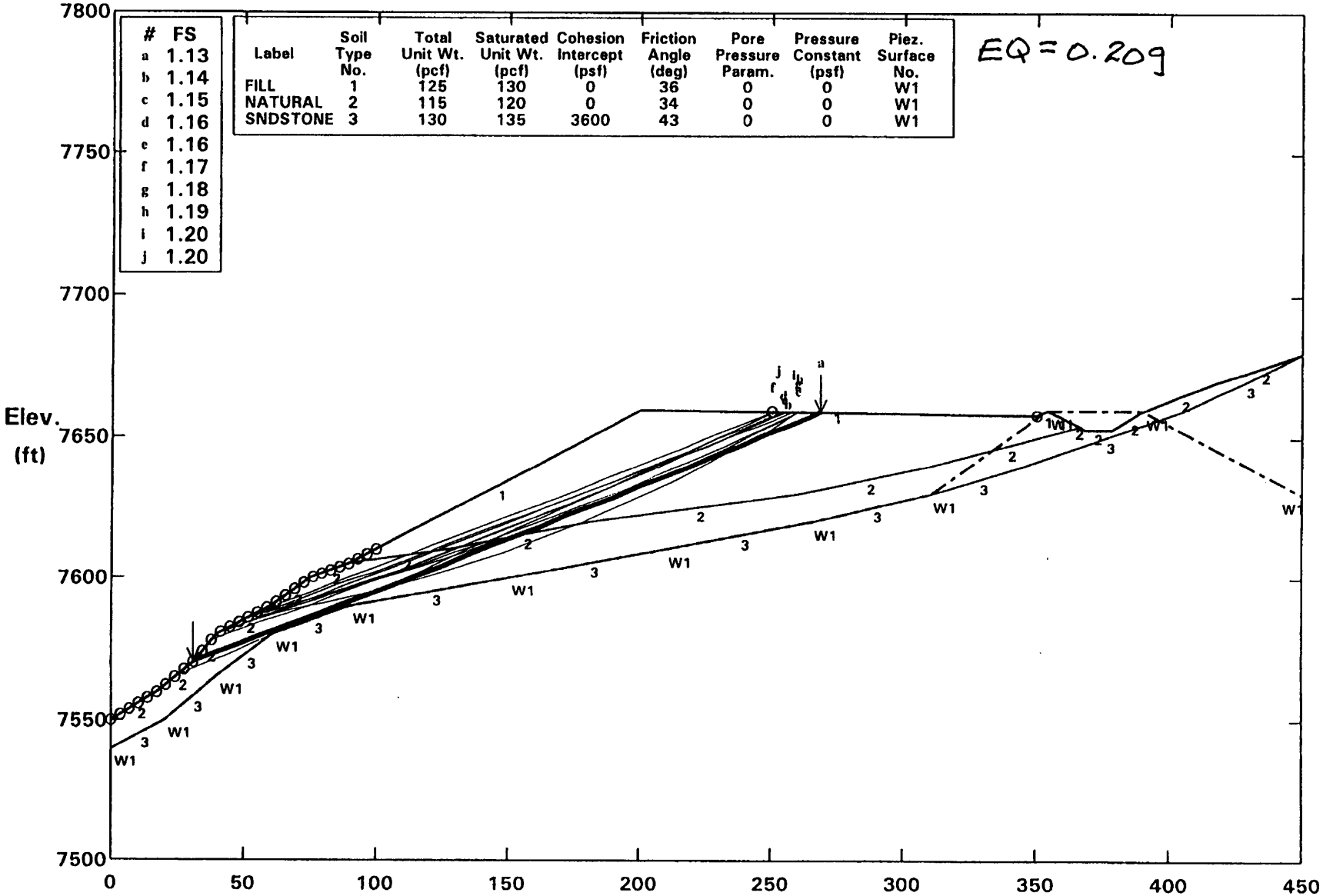


Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
FILL	1	125	130	0	36	0	0	W1
NATURAL	2	115	120	0	34	0	0	W1
SNDSTONE	3	130	135	3600	43	0	0	W1

STABL6H FSmin = 1.13 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

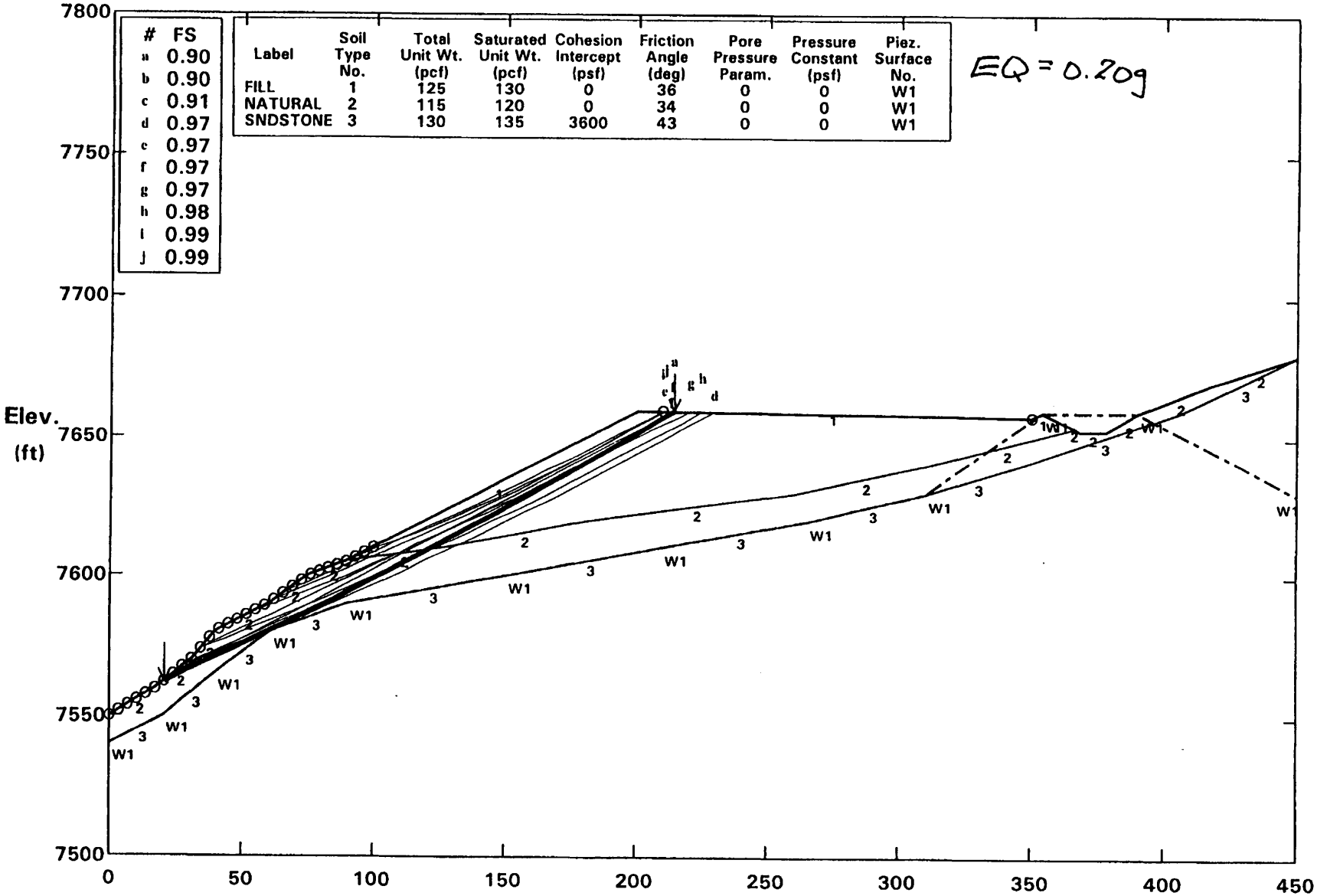
PORTAL STAGING AREA, 2H:1V SLOPES Section A-A', July 1999 Study

Ten Most Critical. P:AA99WEQ.PLT By: Doug Giffin 07-16-99 1:13pm

#	FS
a	0.90
b	0.90
c	0.91
d	0.97
e	0.97
f	0.97
g	0.97
h	0.98
i	0.99
j	0.99

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
FILL	1	125	130	0	36	0	0	W1
NATURAL	2	115	120	0	34	0	0	W1
SNDSTONE	3	130	135	3600	43	0	0	W1

EQ = 0.20g



STABL6H FSmin = 0.90 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Attachment B

Slope Stability Analysis
Post-Mining Slopes

URS

February 28, 2001

Mr. Charles Reynolds
C. W. Mining Company
P.O. Box 1245
Huntington, Utah 84528

REPORT – Slope Stability Evaluation For Reclaimed Slopes along Upper and Lower Conveyor Access Roads and in Portal Area
C. W. Mining Company
Wild Horse Ridge, Bear Canyon No. 3
Huntington, Utah
Job No. H5-00001696.00

INTRODUCTION

This report presents the results of our slope stability evaluation for the proposed reclaimed slopes along the proposed upper and lower conveyor access roads and in the portal area at Wild Horse Ridge, Bear Canyon No. 3 near Huntington, Utah. URS (then Dames & Moore) has preformed previous work in this area for C. W. Mining (then CO-OP Mining Company). This previous work involved slope stability evaluations of cut and fill slopes for these features (see report number 27437-005-162, dated October 7, 1996, and letter report dated July 23, 1999).

SCOPE OF WORK

The scope of work for this evaluation was outlined in our proposal, dated January 30, 2001. Written authorization to perform the work was provided by signature on January 31, 2001. The evaluation of the proposed reclaimed slopes was based on plans and cross sections at 100-foot stations provided by C. W. Mining. Per your request, a geotechnical investigation was not included as part of this scope of work. Subsurface conditions and strength parameters used in our evaluation are based on the results of the previously performed work identified above.

PROPOSED CONSTRUCTION

C. W. Mining is anticipating mining new coal seams in the Wild Horse Ridge area. The portal location can generally be accessed by an existing route; however, the canyon below the portal area will be filled to allow for portal access and construction staging. Coal from the mine will be transported to the current processing facility via a new conveyor system.

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www.urscorp.com

An access road will be constructed in order to build, and later maintain, the conveyor system. The road will basically consist of two segments: upper and lower. It is our understanding that material excavated during construction of the access road will be used as fill and/or stockpiled until the mining operation is complete, at which time the material will be used to reclaim the cut slopes.

SITE CONDITIONS

The majority of the proposed road cuts are in bedrock or in bedrock overlain by shallow colluvial soils. The bedrock consists principally of sandstone and siltstone. The colluvial soils consist of primarily silty gravel and silty sand. Cobbles and boulders make up an estimated 20 to 40 percent of the colluvium. A more detailed description of site conditions is contained in previously prepared reports.

Based on previous field observations and laboratory testing of two bulk samples, the colluvium was assigned a friction angle of 34 degrees with no cohesion. Excavated bedrock materials are expected to possess at least similar strength properties.

RESULTS OF SLOPE STABILITY EVALUATION

We understand from C. W. Mining that a factor of safety of 1.3 is required for the reclaimed slopes. For the strength properties stated above, the maximum slope that can be used while maintaining the required factor of safety is basically 2(H):1(V), or 27 degrees from horizontal. Since some of the proposed cuts are in areas where, due to bedrock, the natural slope is significantly steeper than 2:1, some of the cuts would remain partially exposed. Table 1 presents, by station, the areas in which the proposed reclamation grading satisfies the factor of safety criterion. For those areas not satisfying the factor of safety criterion, Table 1 also presents how much estimated cut would remain exposed if the proposed grading is reduced to a maximum slope of 2:1. Figure 1 illustrates this relationship between grading and the vertical height of the exposed cut.

An asterisk has be used in Table 1 to indicate locations where grading could likely be adjusted without great difficulty from that shown on the cross sections, thus reducing the vertical height of the exposed cut. Such an adjustment in proposed grading is illustrated in Figure 2. The cross sections used in our evaluation are contained in Appendix A.

DISCUSSION AND RECOMMENDATIONS

Some of the 2:1 reclamation grading, especially along the Upper Conveyor Access Road, is not quite steep enough to completely cover the face of the proposed cut slope. One possible method of mitigation would be to locate the road further out away from the slope, lessening the height of the required cut. Another consideration might be to accept a small amount of exposed cut, but

dressing the face so that it blends better into the natural environment. In some areas with a significant amount of exposed cut (such as Station 2+00 along the Upper Conveyor Access Road), the visual impact of the cut will be lessened by naturally occurring steep ledges immediately above the cut.

With respect to reclamation earthwork, a suitable degree of compaction should be obtained by achieving either 95% maximum density with respect to the standard Proctor test (ASTM D-698) or 70% relative density (ASTM D-4254). The later standard is preferable because of the nature of the materials being used. The maximum soil particle size should be limited to 1/2 the lift thickness, and materials should be placed and worked as to minimize void spaces between soil particles. Lift thickness is a function of the compaction method and equipment, but it generally should be no greater than 24 inches unless testing shows adequate compaction of the entire lift can be obtained using thicker lifts.

To help control erosion and improve stability, reclaimed slopes can be revegetated. Vegetation should be preferably native and not require irrigation. Oversized materials can also be used at the fill's surface to provide additional erosion protection. Drainage should be established such that it is directed away from reclaimed slopes.

oOo

TABLE 1

No. 3 Mine Portal Area

Section Station	Approximate Height of Cut Slope (ft)	C-W Proposed Reclamation Avg. Slope (deg)	Satisfies F.S =1.3 Criteria (y/n)?	Estimated Height of Exposed Cut with F.S =1.3 (ft)
0+00	11	6 to 31	yes *	none *
1+00	14	13 to 33	yes *	none *
2+00	36	27	yes	none
3+00	38	27	yes	none
4+00	48	22 to 39	no	20
5+00	30	42	no	16

* Possible if grading is adjusted from that shown on the cross section with slopes no steeper than 2H:1V (27 deg) from toe of cut

Lower Conveyor Access Road

Section Station	Approximate Height of Cut Slope (ft)	C-W Proposed Reclamation Avg. Slope (deg)	Satisfies F.S =1.3 Criteria (y/n)?	Estimated Height of Exposed Cut with F.S =1.3 (ft)
0+00	none (remove fill)	0 to 7	yes	none
1+00	none (remove fill)	11	yes	none
2+00	none (remove fill)	19	yes	none
3+00	none (remove fill)	10 to 17	yes	none
4+00	29	29	no	2
5+00	30	33	no	9
6+00	11	22 to 0	yes	none

Upper Conveyor Access Road

Section Station	Approximate Height of Cut Slope (ft)	C-W Proposed Reclamation Avg. Slope (deg)	Satisfies F.S =1.3 Criteria (y/n)?	Estimated Height of Exposed Cut with F.S =1.3 (ft)
0+00	none (remove fill)	0 to 12	yes	none
1+00	8	36	no	3
2+00	38	42	no	21
3+00	8	33	no	3
4+00	17	35	no	6
5+00	29	39 to 29	no	2 *
6+00	15	38 to 51	no	5 **

* Possible if grading is adjusted from that shown on the cross section
** Smaller height possible (approx. 3 feet) if road is moved outward to opposing slope and cut slope height is reduced

UPPER CONVEYOR ACCESS ROAD

STATION 4+00

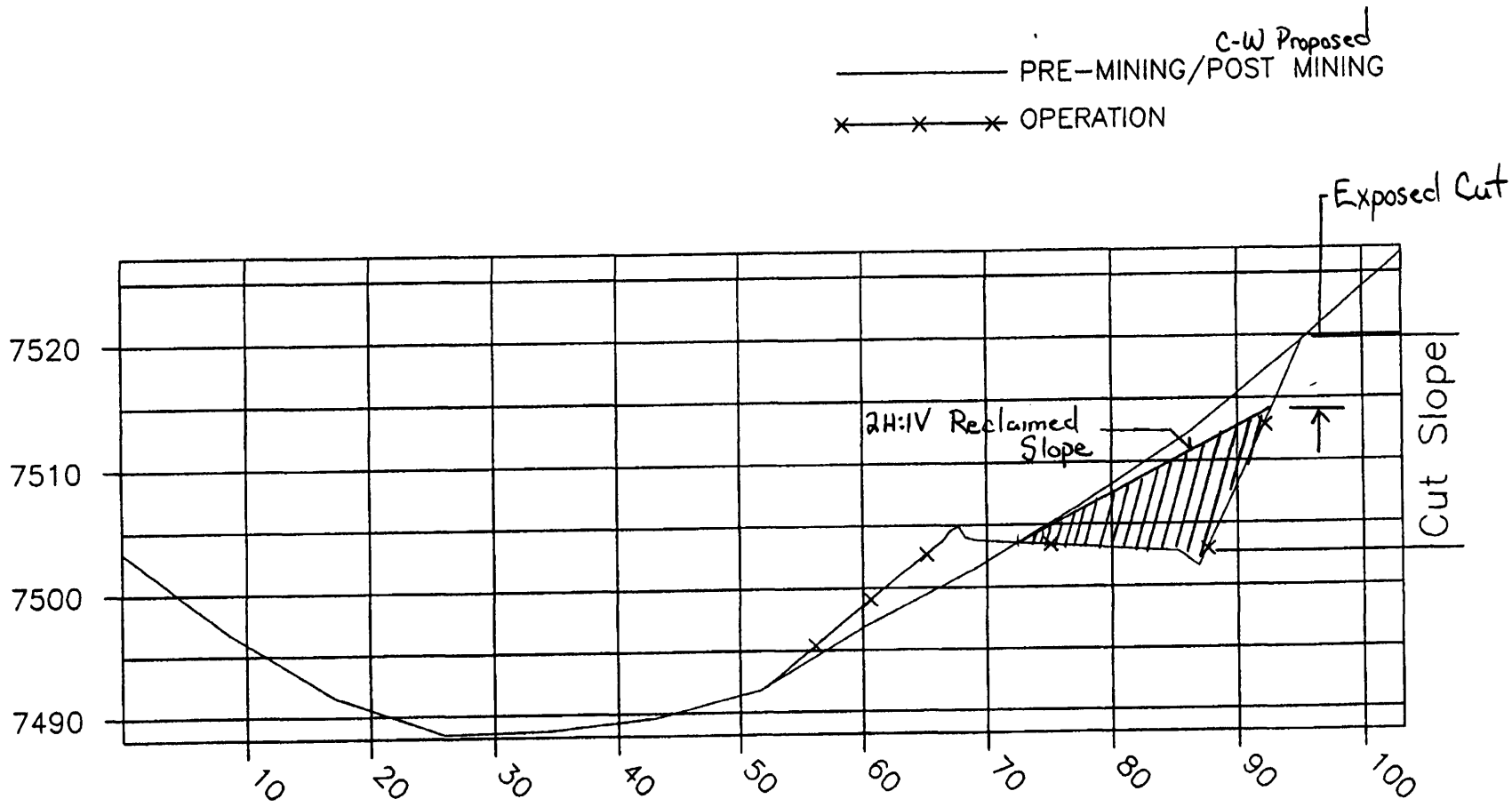


FIGURE 1

UPPER CONVEYOR ACCESS ROAD

STATION 5+00

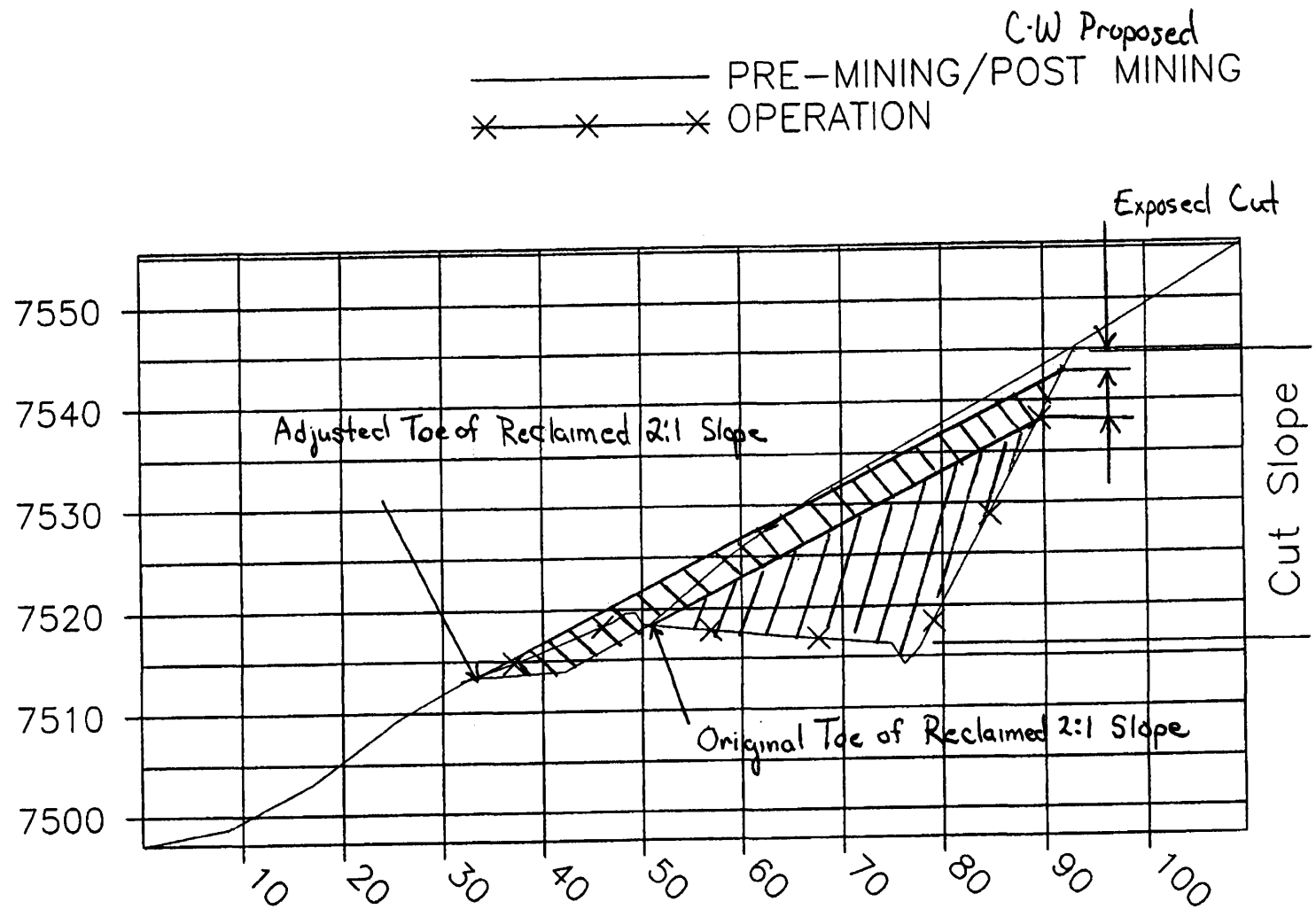


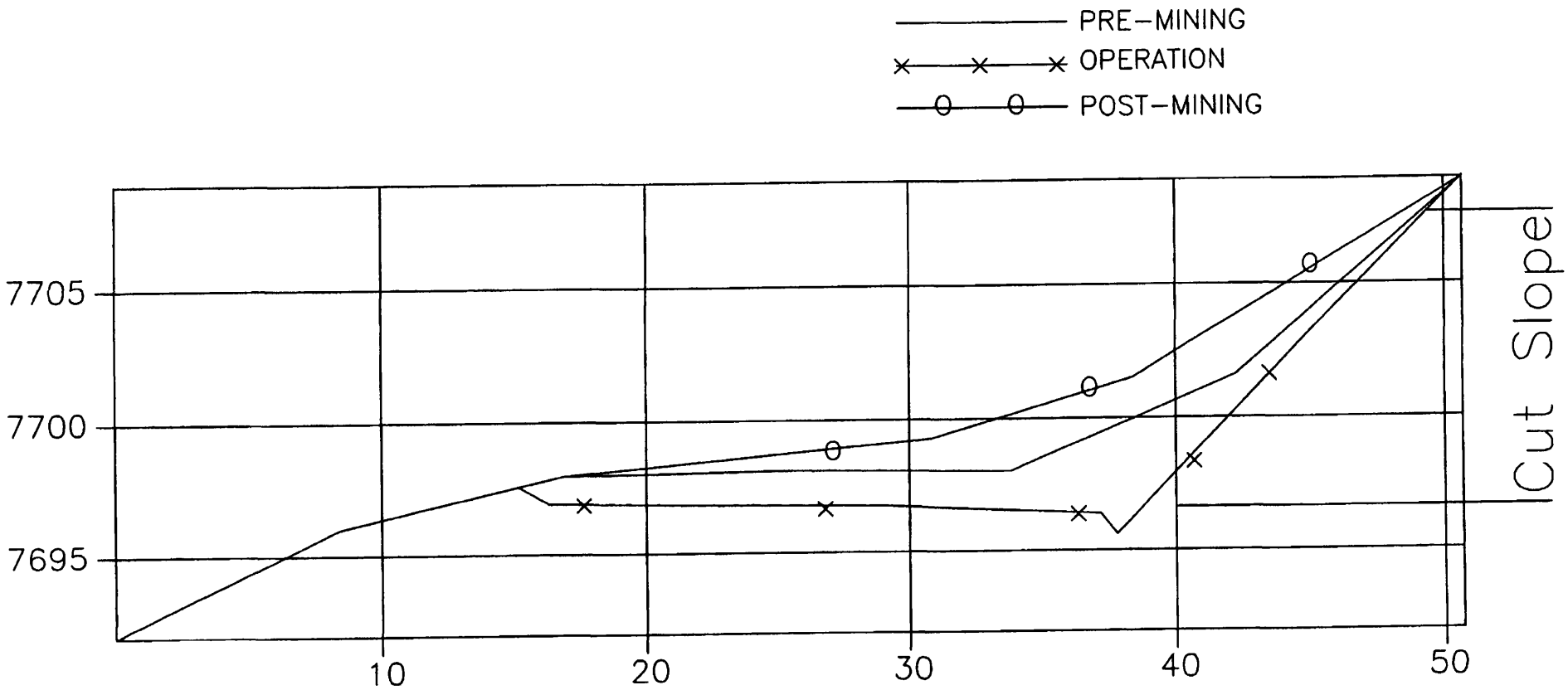
FIGURE 2

APPENDIX A

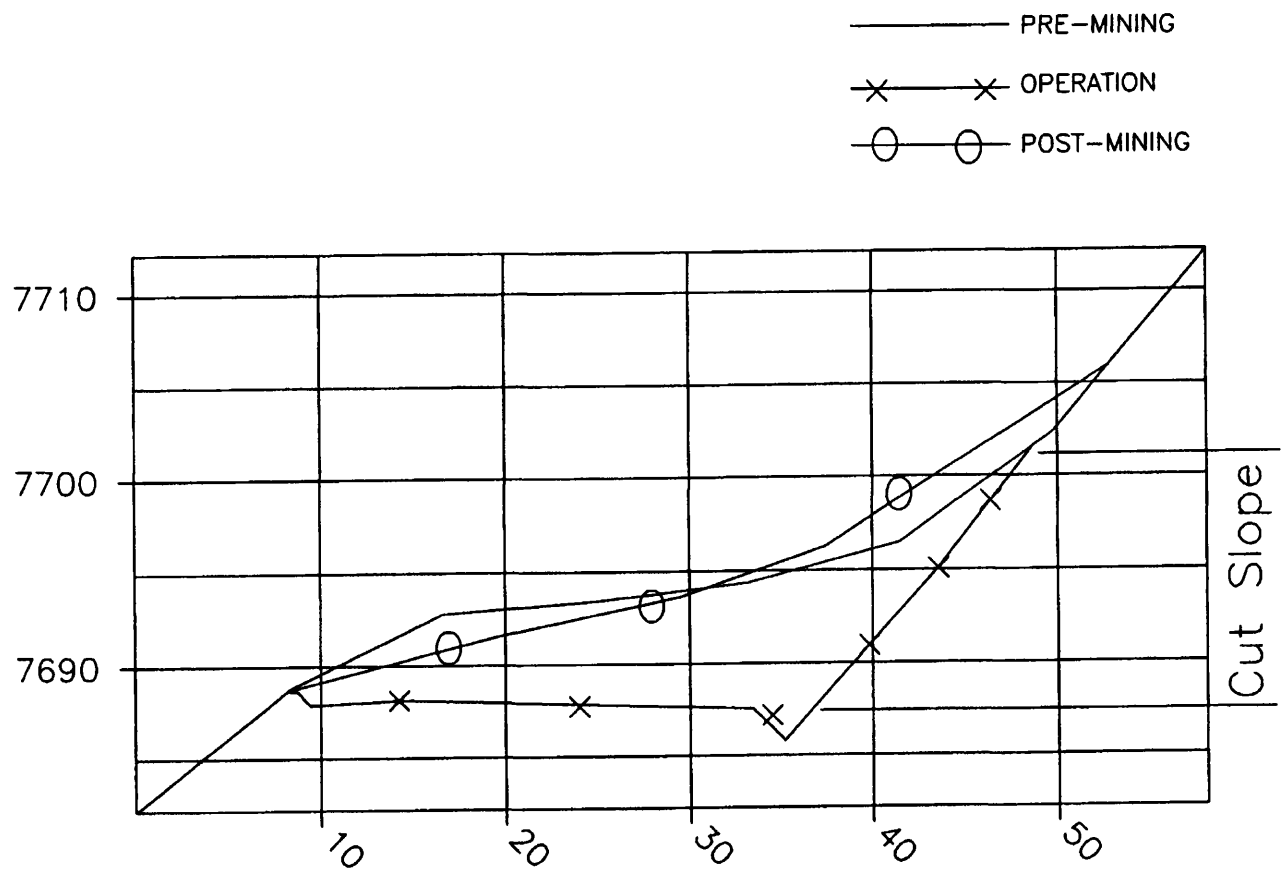
CROSS SECTIONS
USED IN SLOPE STABILITY EVALUATION

NO. 3 MINE PORTAL AREA

STATION 0+00

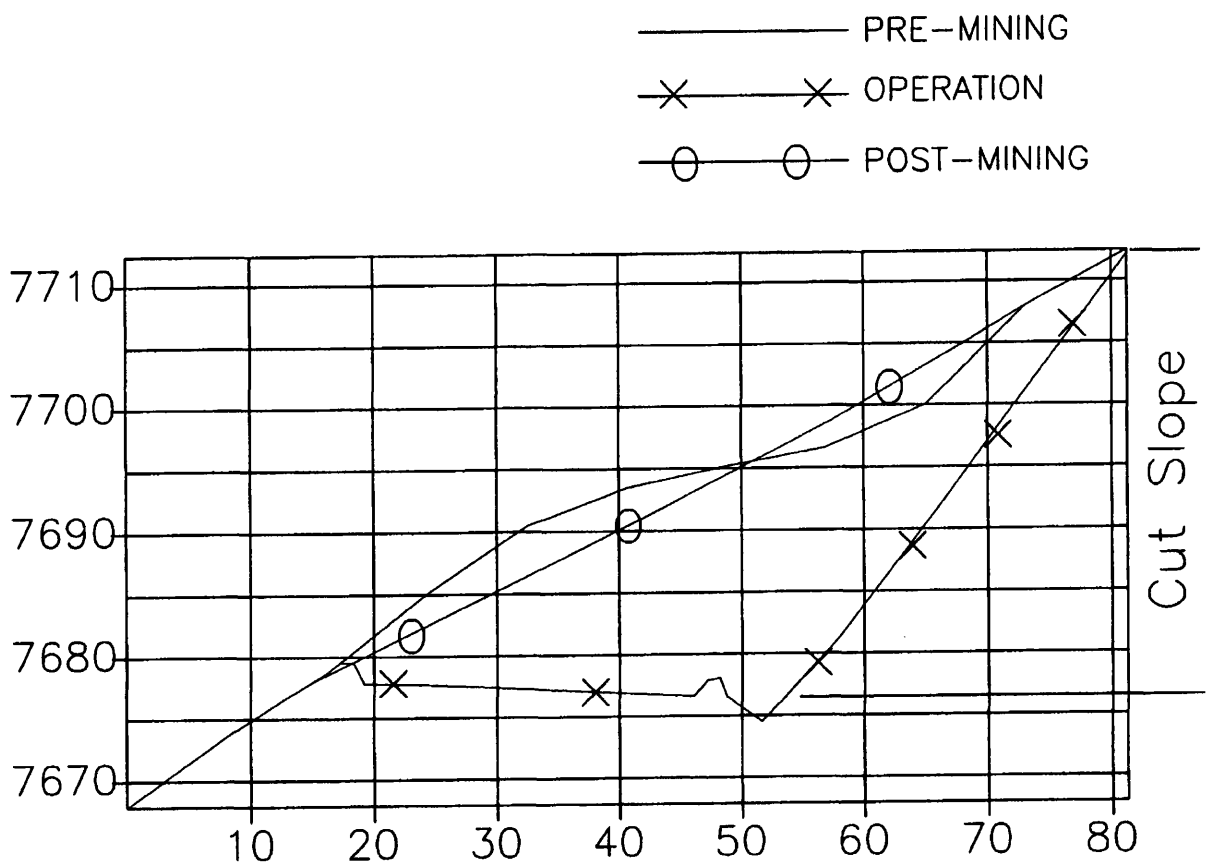


NO. 3 MINE PORTAL AREA
STATION 1+00



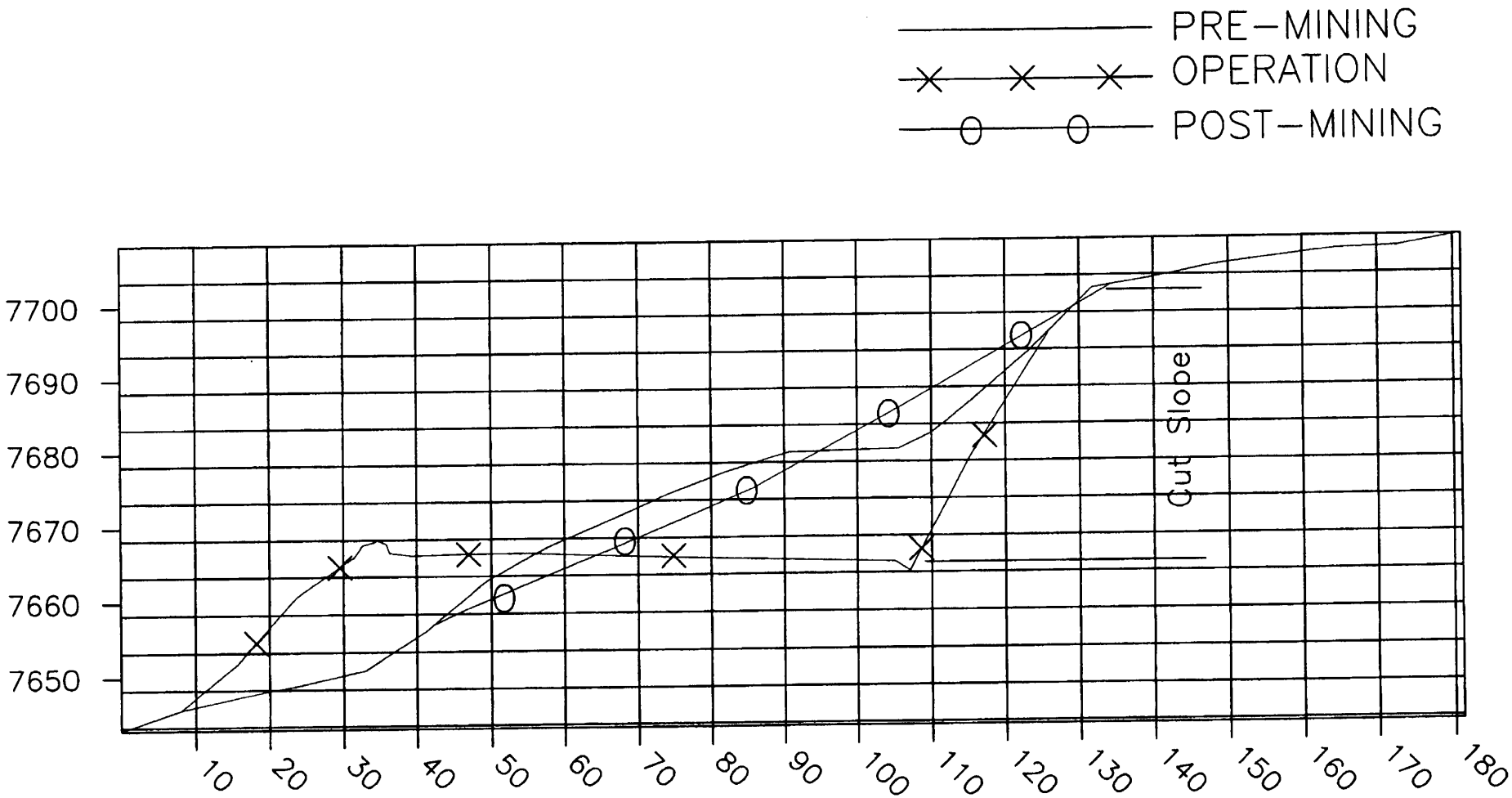
NO. 3 MINE PORTAL AREA

STATION 2+00



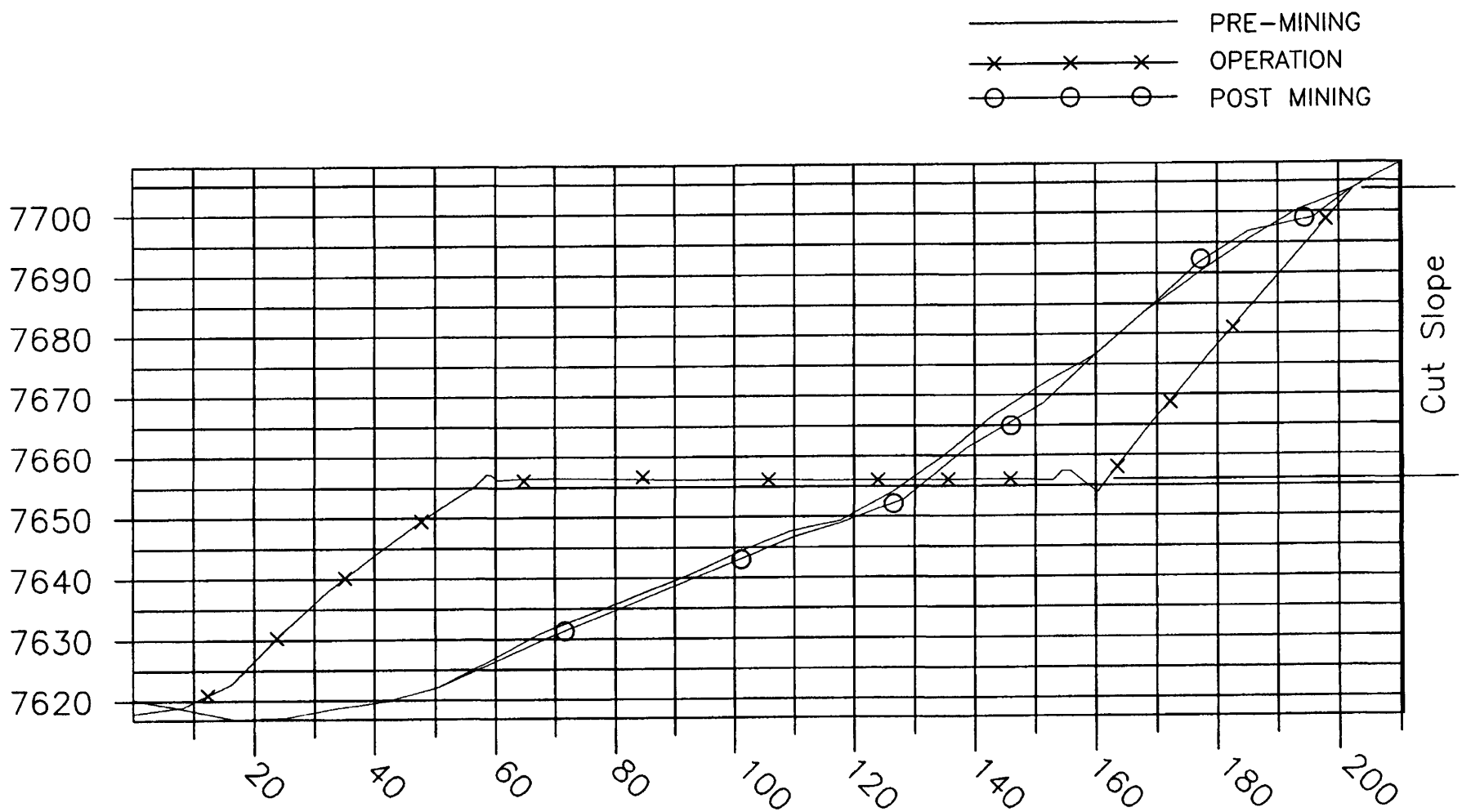
NO. 3 MINE PORTAL AREA

STATION 3+00



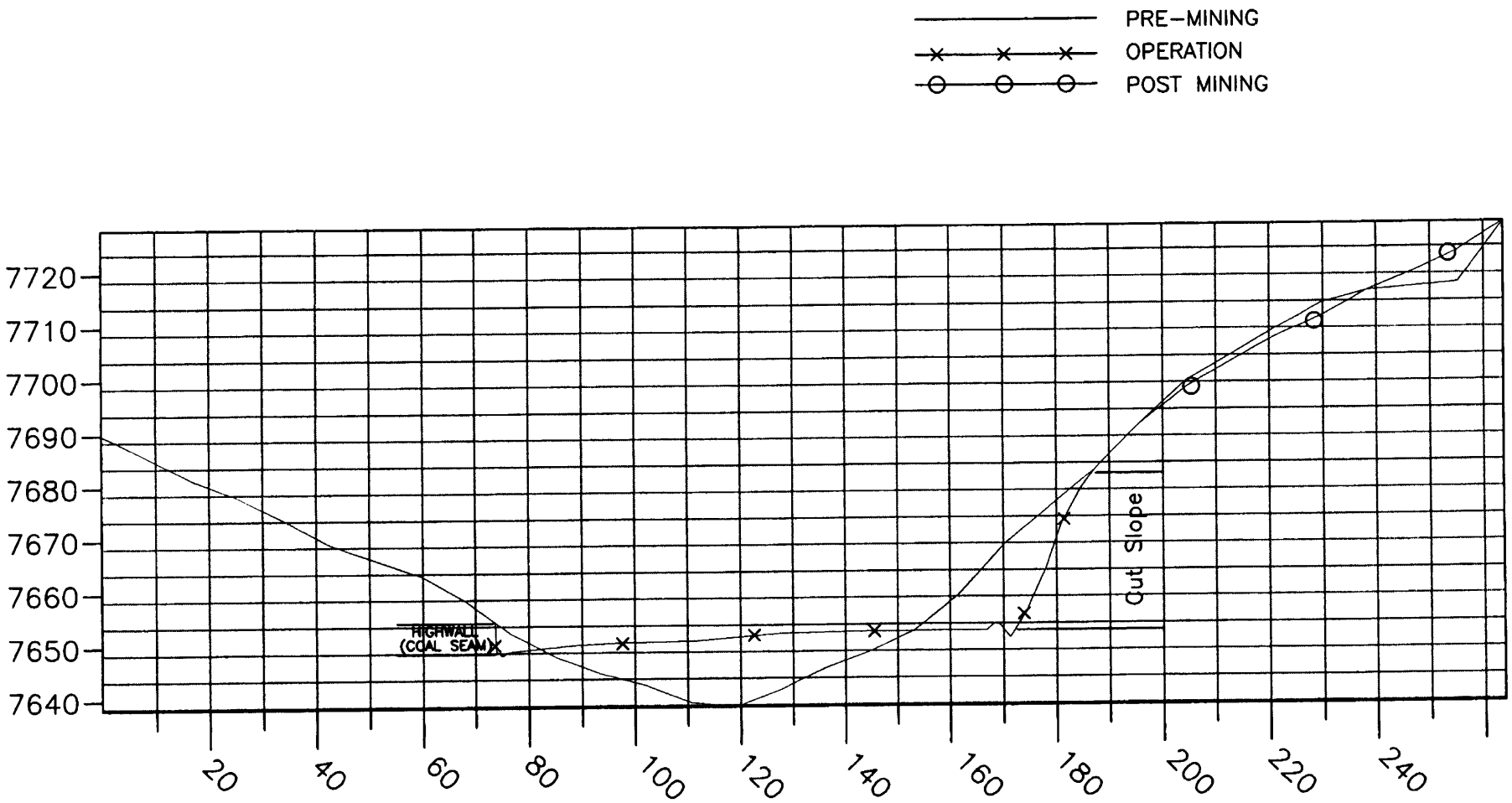
NO. 3 MINE PORTAL AREA

STATION 4+00



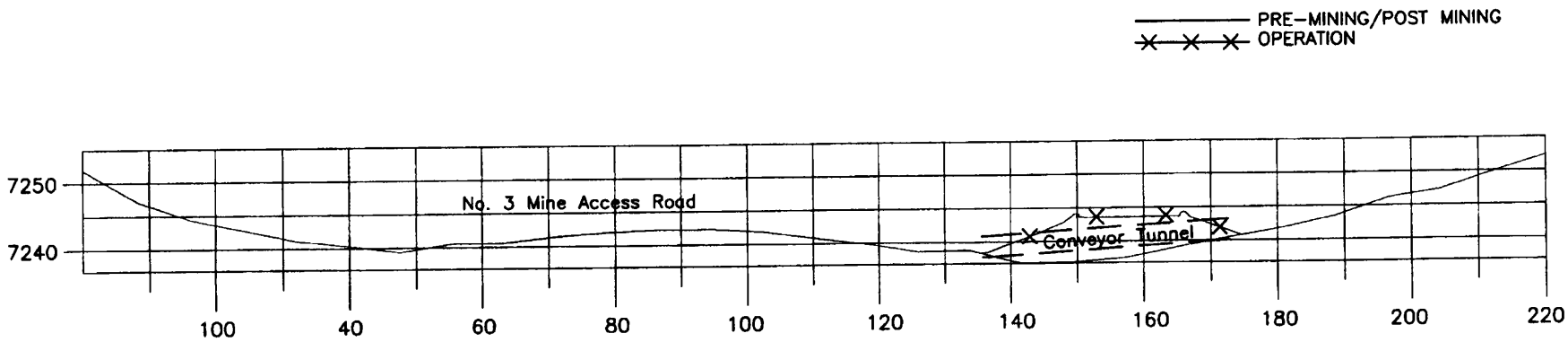
NO. 3 MINE PORTAL AREA

STATION 5+00



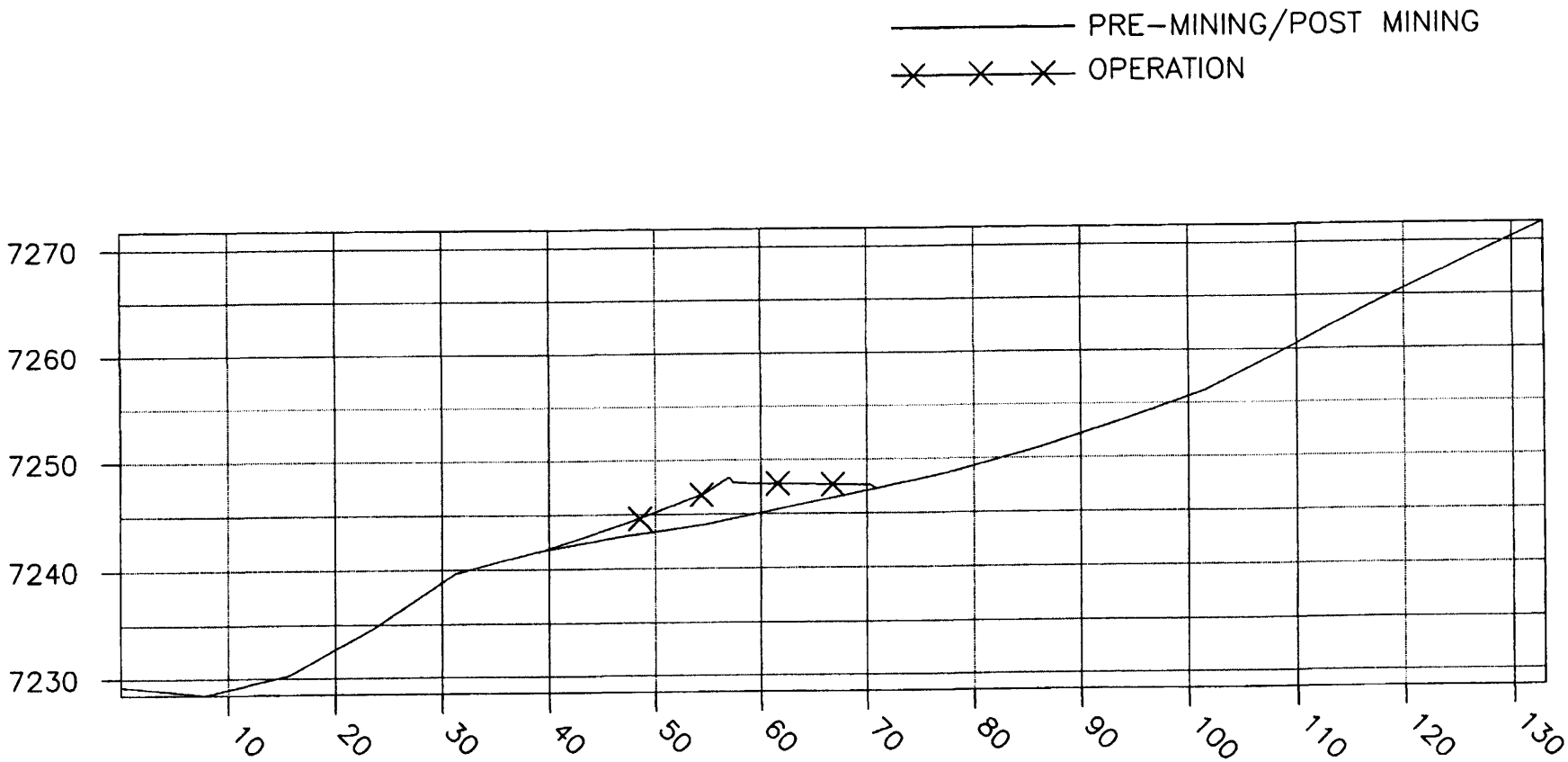
LOWER CONVEYOR ACCESS ROAD

STATION 0+00



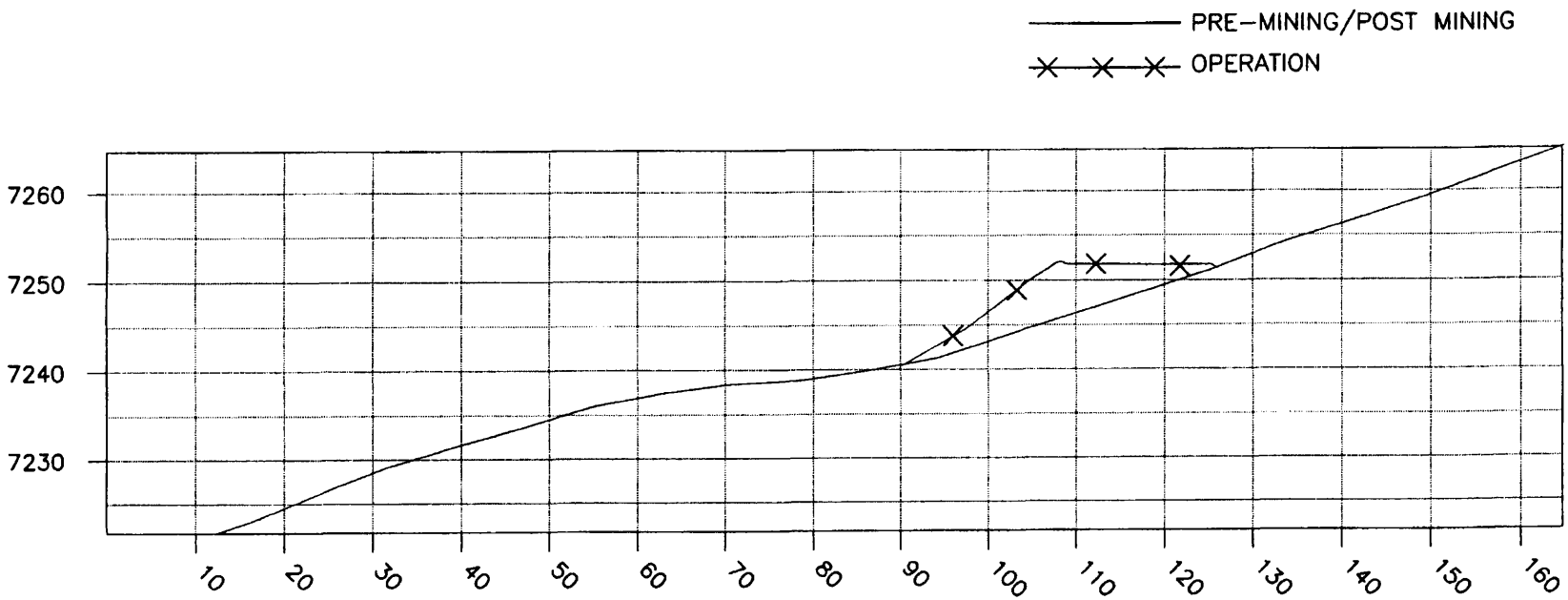
LOWER CONVEYOR ACCESS ROAD

STATION 1+00



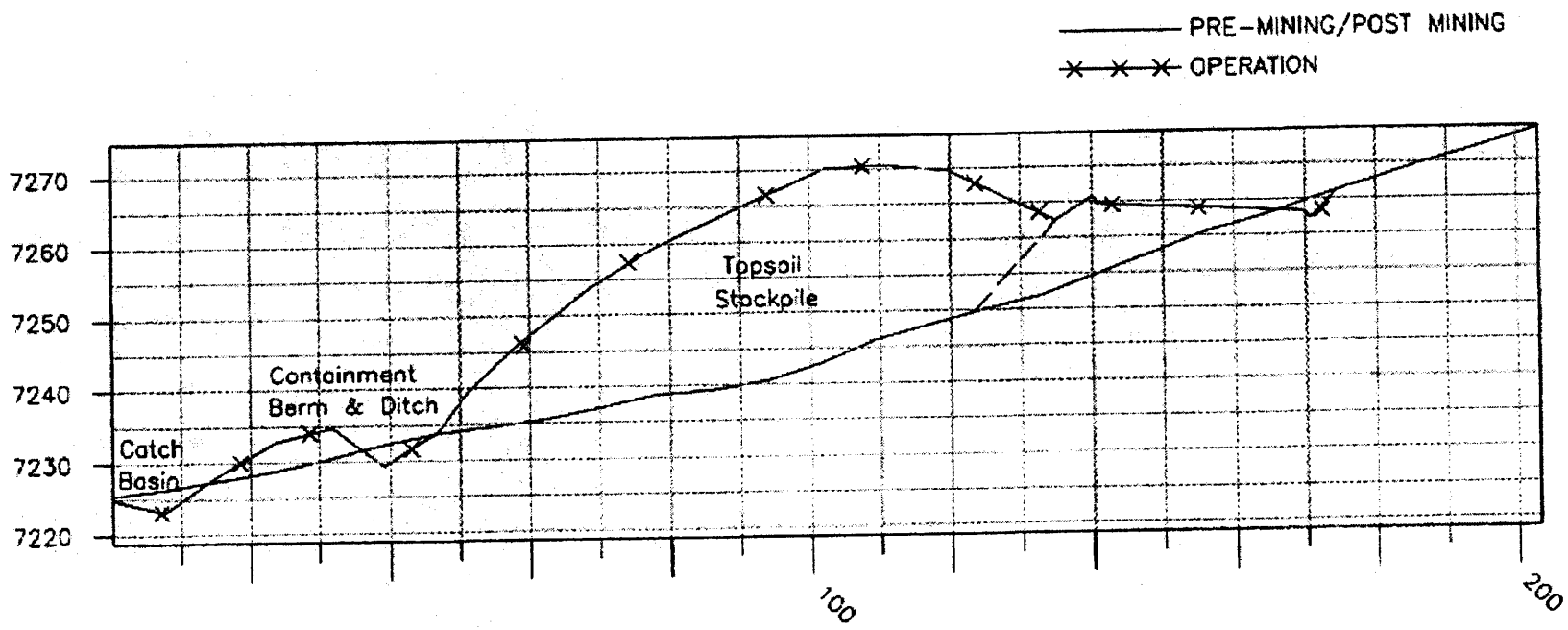
LOWER CONVEYOR ACCESS ROAD

STATION 2+00



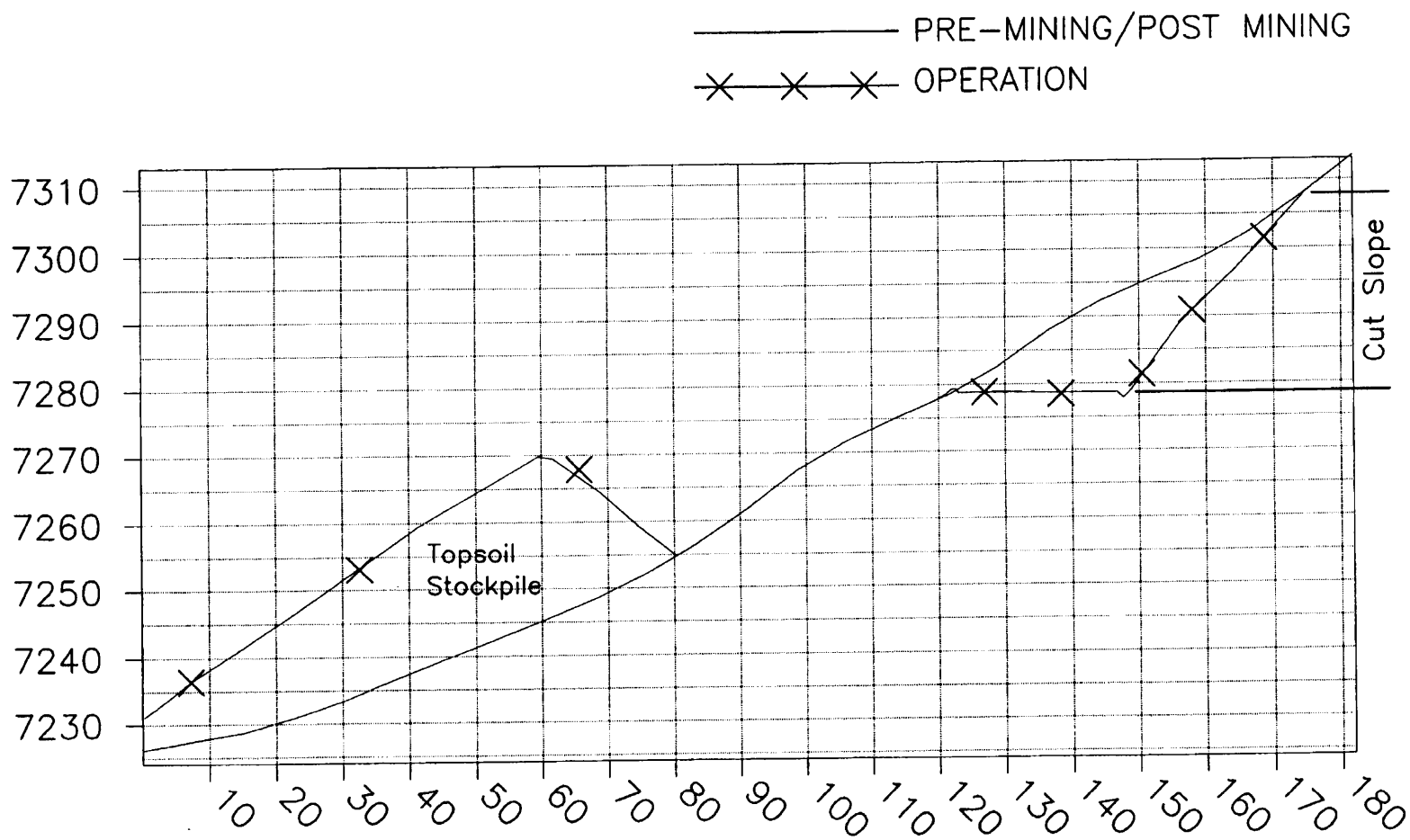
LOWER CONVEYOR ACCESS ROAD

STATION 03+00



LOWER CONVEYOR ACCESS ROAD

STATION 4+00



LOWER CONVEYOR ACCESS ROAD

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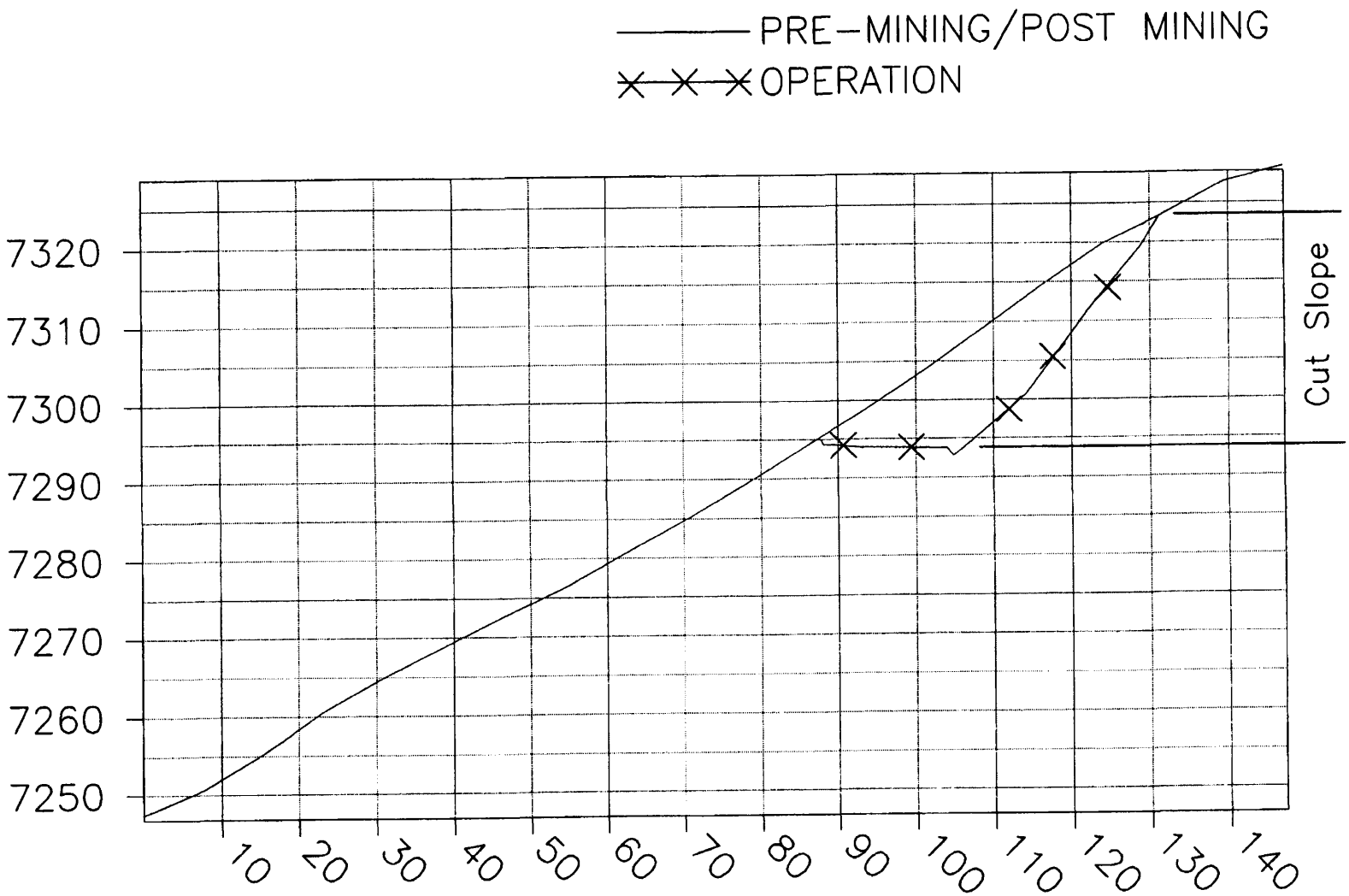
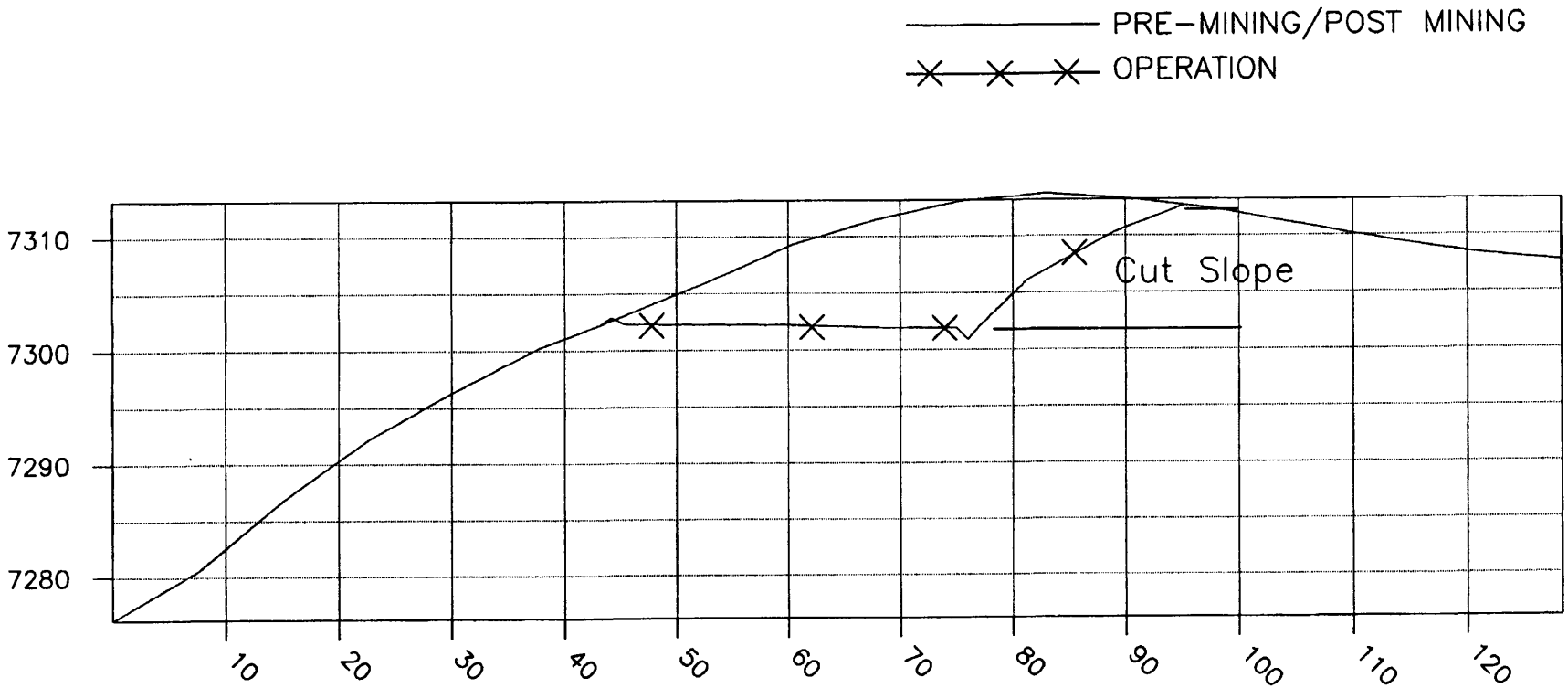


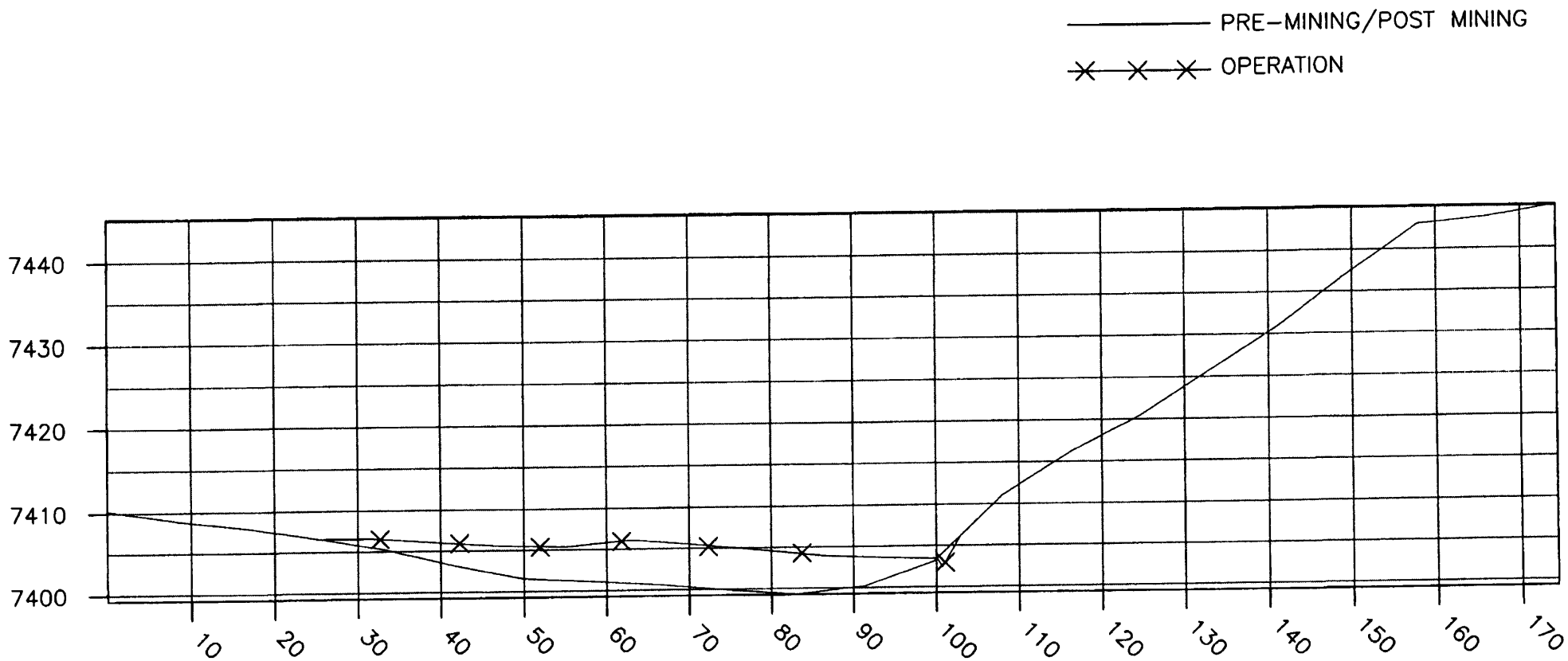
LOWER CONVEYOR ACCESS ROAD

STATION 6+00



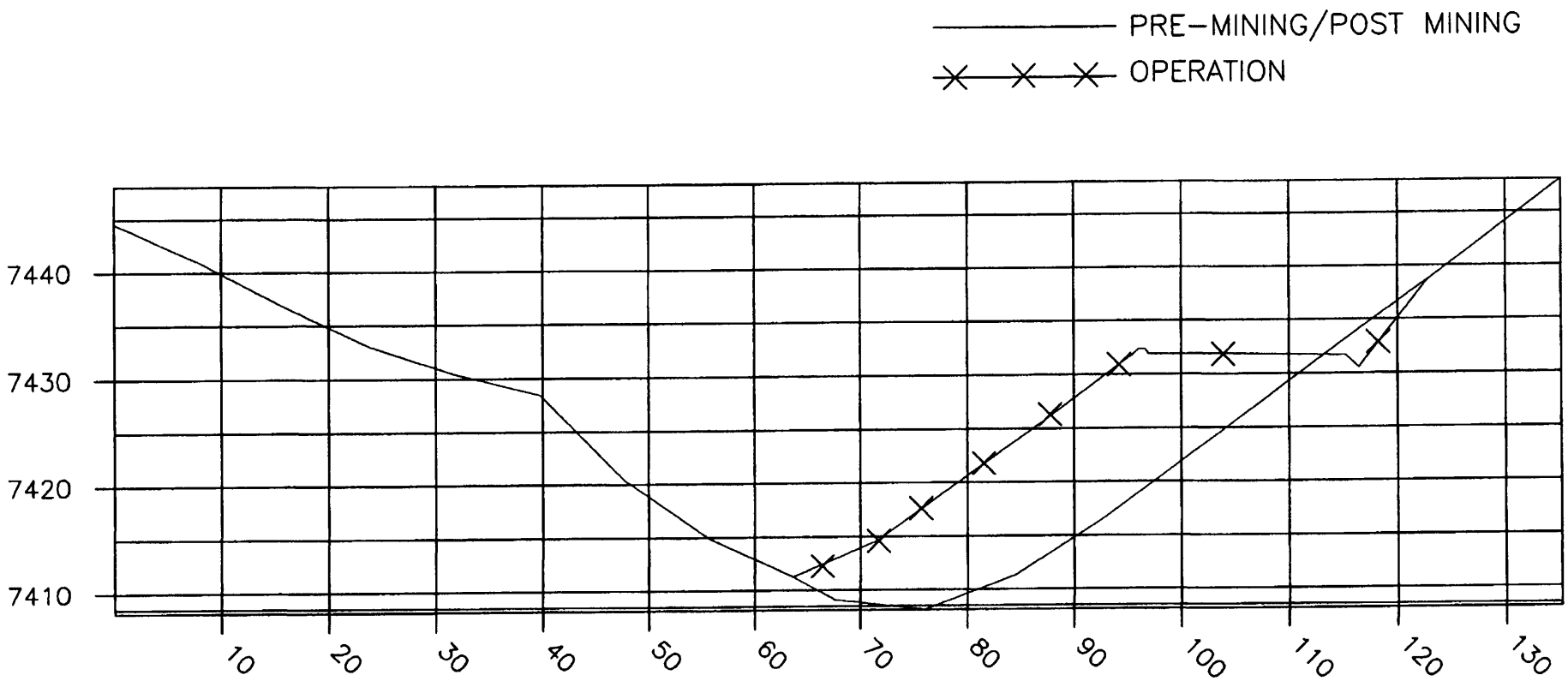
UPPER CONVEYOR ACCESS ROAD

STATION 0+00



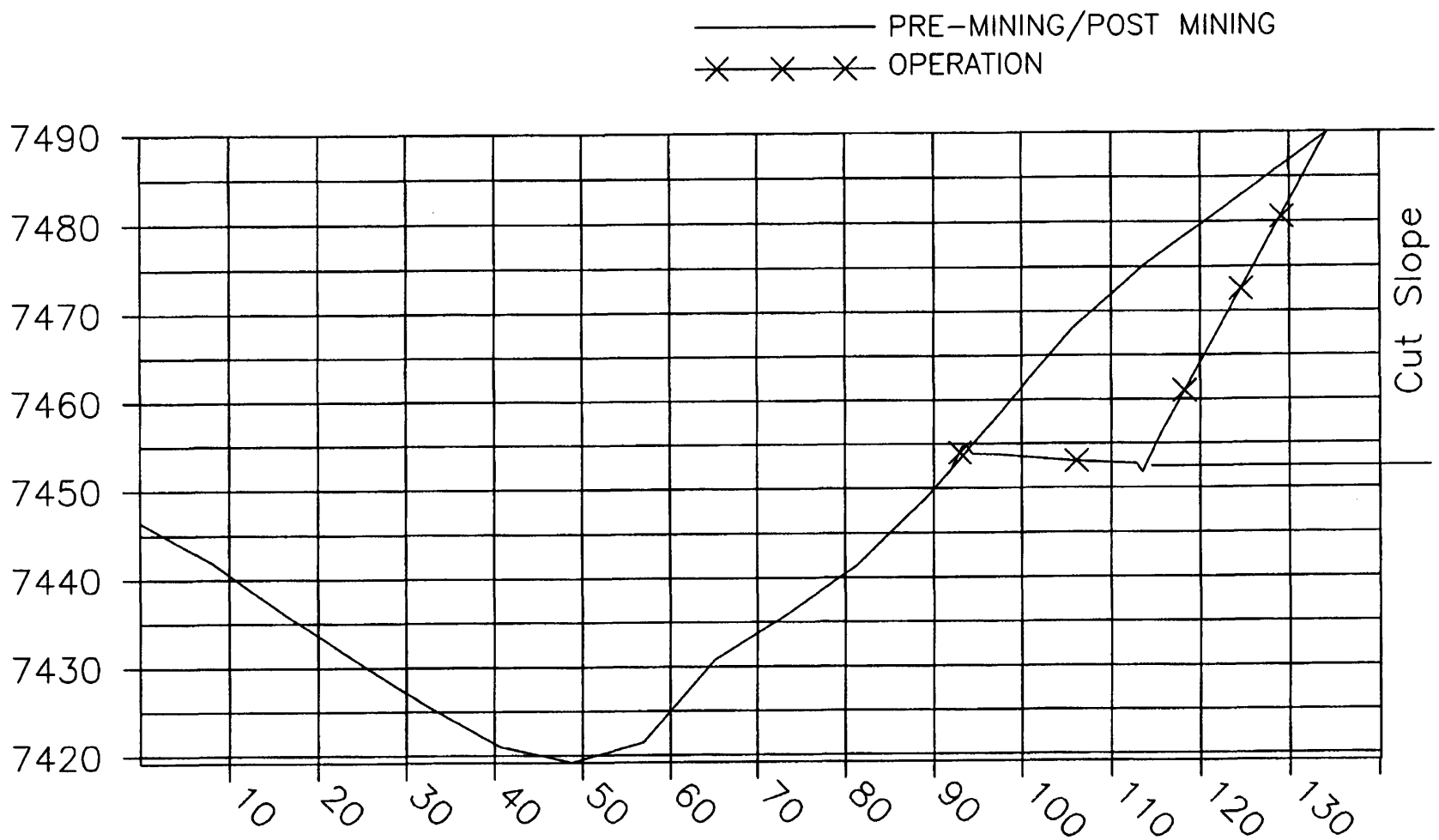
UPPER CONVEYOR ACCESS ROAD

STATION 1+00



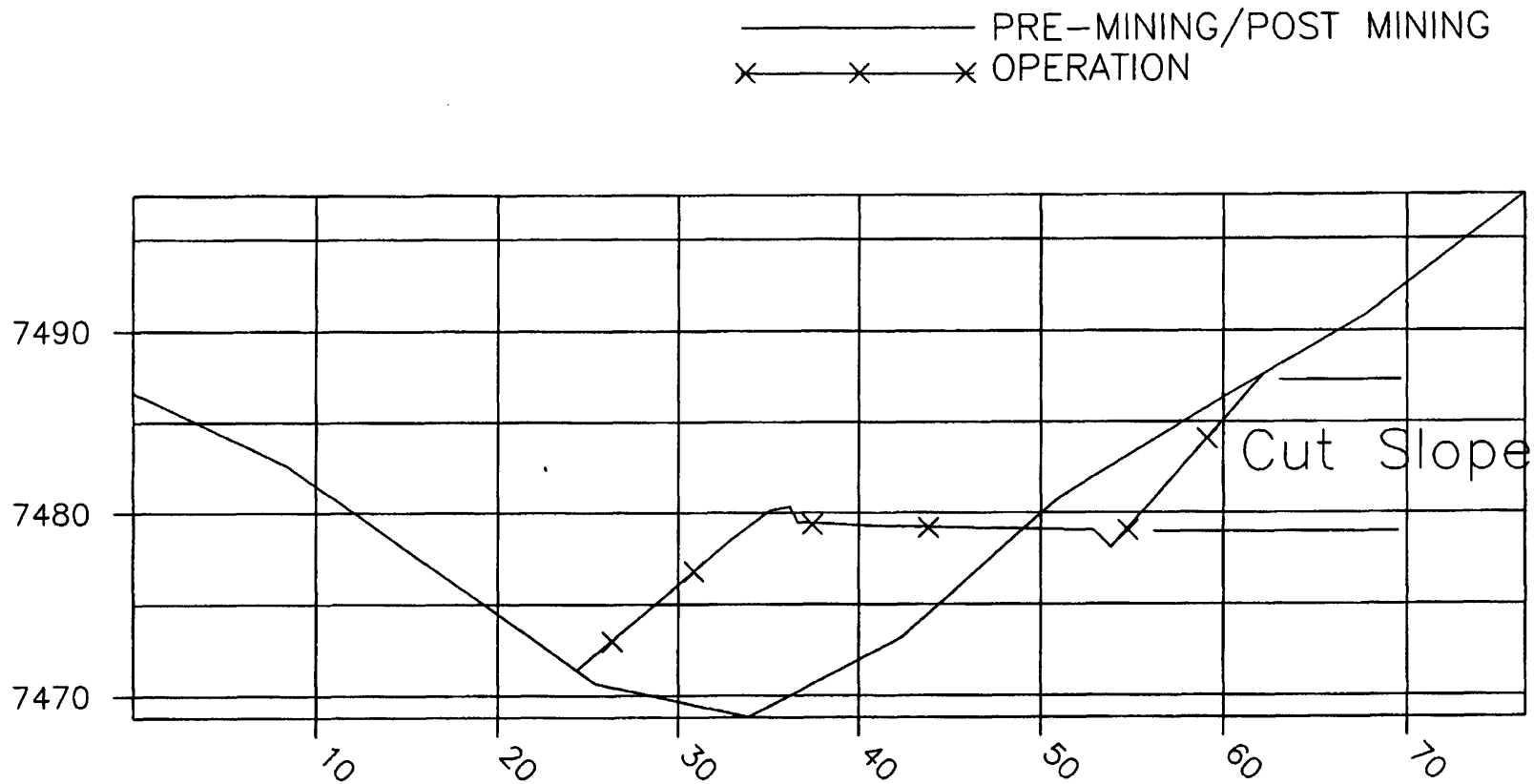
UPPER CONVEYOR ACCESS ROAD

STATION 2+00



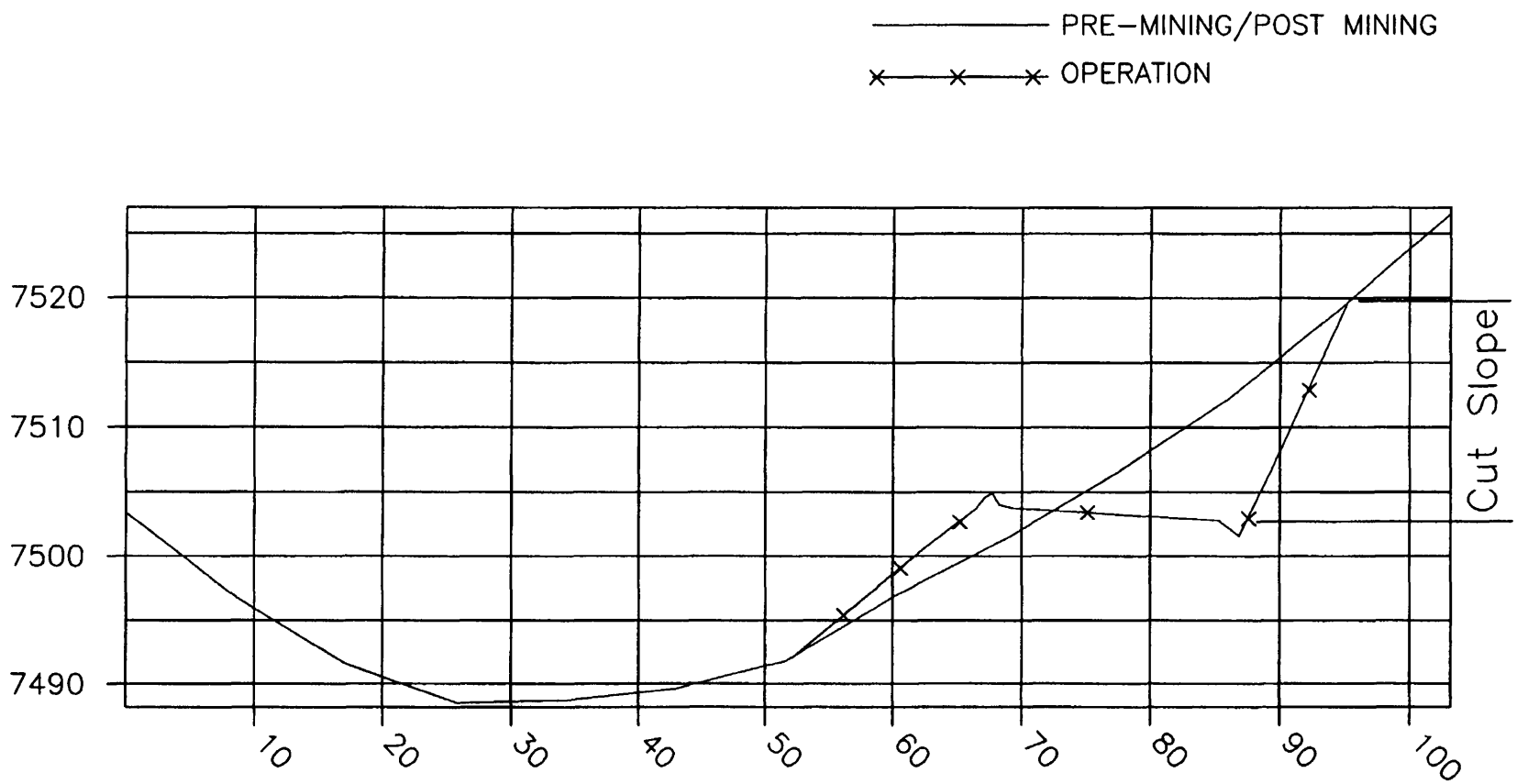
UPPER CONVEYOR ACCESS ROAD

STATION 3+00



UPPER CONVEYOR ACCESS ROAD

STATION 4+00



UPPER CONVEYOR ACCESS ROAD

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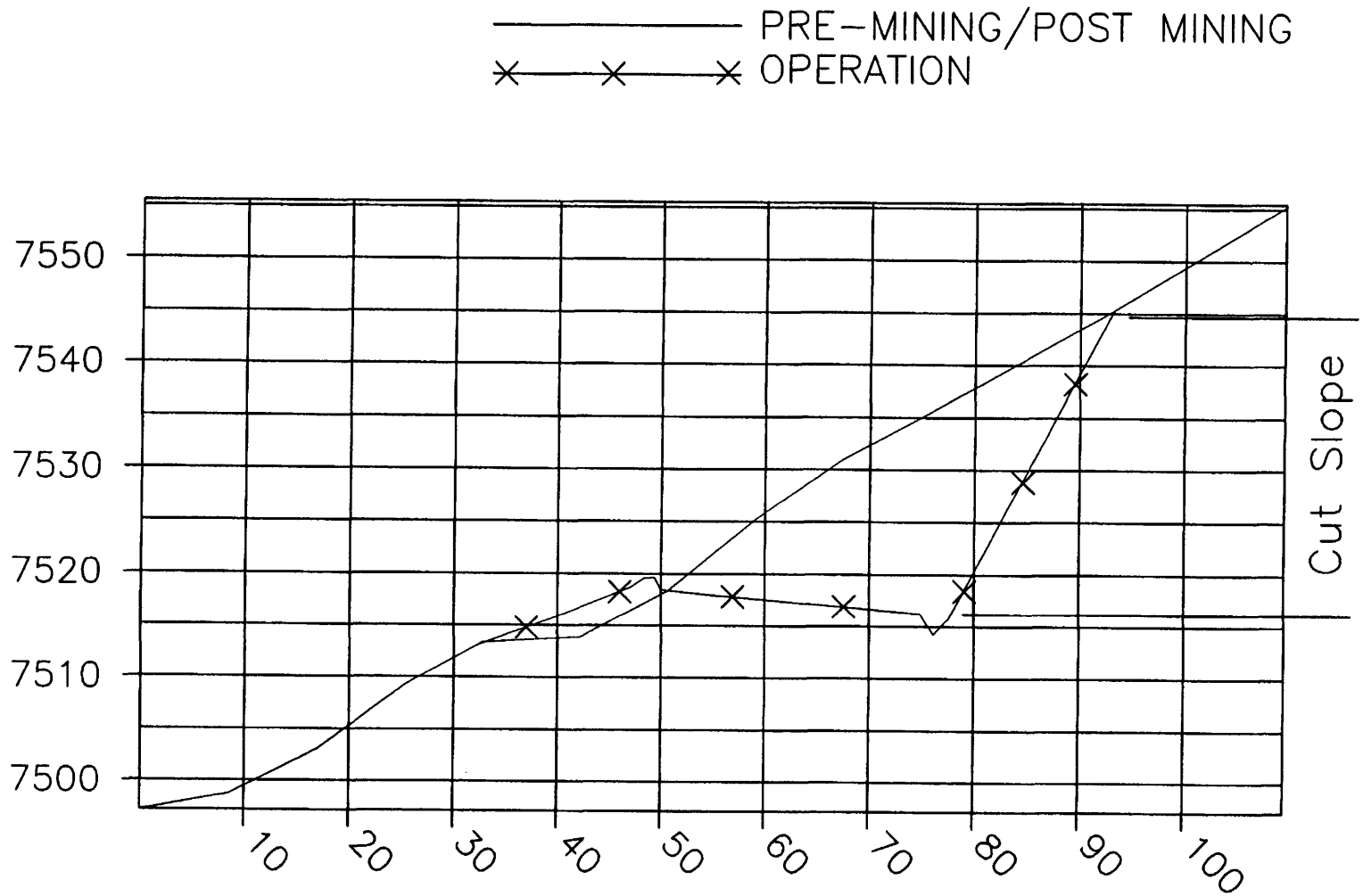
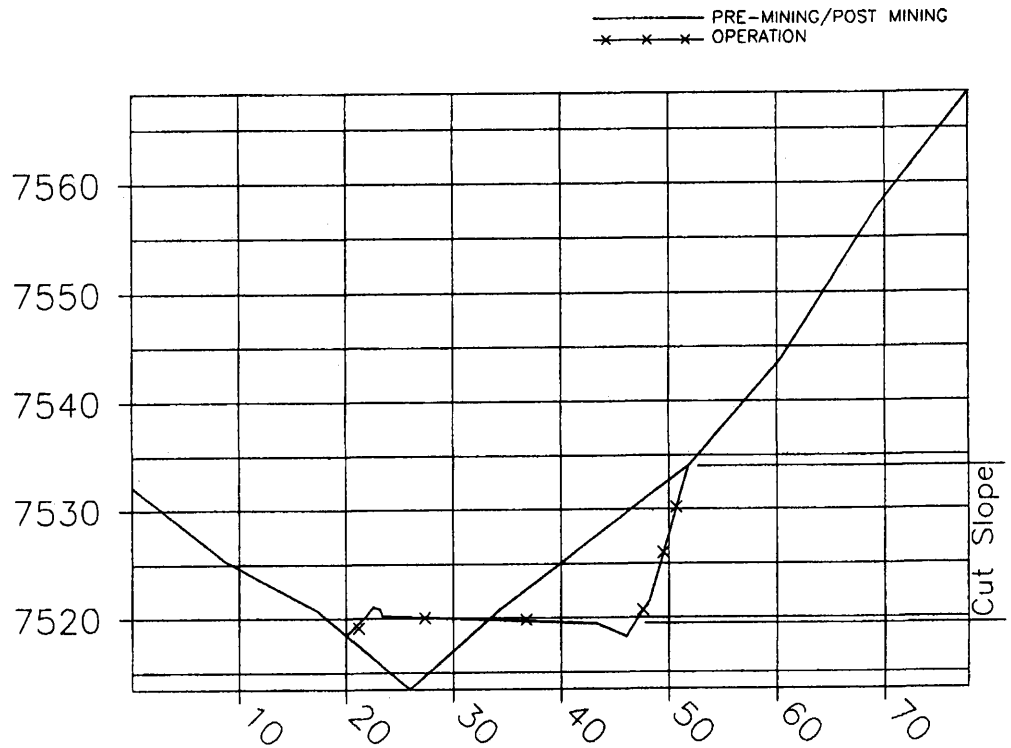


UPPER CONVEYOR ACCESS ROAD

STATION 6+00



Appendix 5-K

Wild Horse Ridge

Tank Seam Pad
And Access Road

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TS-17 Construction Description 5K-4

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Attachment B Slope Stability Analysis 5K-22

Appendix A Cross-Sections of Static Analysis 5K-26

Introduction

This Appendix discusses the construction of the Wild Horse Ridge Tank Seam access road and portal pad. (Areas TS-16 and TS-17 on Plate 2-3G) Cut and Fill volumes have been determined for the road and pad and are summarized in Tables 5K-1 and 5K-2. Also included is an operational slope stability analysis and a reclaimed slope stability analysis. Pre-mining, Operational and Post-mining cross-sections are detailed in Attachment B of this Appendix.

TS-16 Constructions Description

Construction in this area will include the widening of the switchback and adding two passing areas in the road. Construction will begin at the switchback and the material cut out of the side of the mountain to widen the turn will be used just below the switchback and in the area around cross-section 4 to widen the road in these areas. Topsoil will be recovered to a depth of 6-10 inches from the areas where the road will widened generating approximately 124 cu. yd. of material.

The area included in TS-16 will not be reclaimed but will be used for post mining access to the hunting cabin as described on page 4-7. During construction silt fences will be used below all cut and fill areas. Upon completion of construction all disturbed slopes will be covered will erosion control matting and reseeded (See Appendix 7-K). Cut slopes, fill slopes, and fill placement will follow the recommendations given in the Slope Stability analysis and report, included in Attachment B. A summary of the cut and fill volumes is shown Table 5K-1. Cross-Sections are shown in Attachment A.

Table 5K-1

TS-16 Summary of Cut and Fill

Cross Section	Cut Vo. (Cu Yds.)	Topsoil (Cu Yds.)	Fill Vol. (Cu Yds.)	Excess (Cu Yds.)	Amount Hauled	Avg Haul Dist. (Ft)	Cum. Vol. (Cu Yds.)
1	830	~36	139	655 cut	161	450	-655
2	431	~28	550	147 Fill	-0-	-0-	-508
3	52	~30	319	297 fill	-0-	-0-	-211
4	35	~30	161	156 fill	-0-	-0-	-55
Totals	1,348	~124	1,169		161	450	

TS-17 Construction Descriptions

Construction will begin ant the hunting cabin turn off, 300 ft from the pad site. Topsoil will be removed form the project cut areas (Table 5K-2) and placed in the WHR Tank Seam Topsoil Stockpile located inside the bend of the corner. Material will then be removed form the road cuts and compacted around the outside of the two switchbacks located inside the area in order to allow them to be widened. As the cut progresses up the road, topsoil will be removed prior to the road cut being made and placed in the storage pile. Cuts will be made starting at the lower end of the access road and proceed up to and through the Tank Seam Portal Pad. Most of the material will be hauled approximately 300 ft. and placed at the turn intersected by the hunting cabin road. The rest of the material will be hauled no more then 700 ft. to the turn above the Blind Canyon Seam Pad. A retaining wall (shown on plate 5-2G) will be built bellow the turn intersected by the hunting cabin road in order to maintain the maximum allowed slope on the soil below the turn. Cross-sections are shown in attachment A.

Table 5K-2

TS-17 Summary of Cut and Fill Volumes

Area	Cut Vo. (Cu Yds.)	Topsoil (Cu Yds.)	Fill Vol. (Cu Yds.)	Excess (Cu Yds.)	Amount Hauled	Avg Haul Dist. (Ft)	Cum. Vol. (Cu Yds.)
0+00	138	~138	1,357	1,219 fill	1,219	700	-1,219
0+50	80	~80	1,430	1,350 fill	1,350	700	-2,569
1+00	279	~101	624	345 fill	532	50	-2,914
1+50	686	~107	144	543 cut	-0-	-0-	-2,371
2+00	2,033	~135	121	1,912 cut	-0-	-0-	-459
2+50	4,648	~326	841	3,807 cut	3,807	300	3,348
3+00	2,852	~281	3,876	1,024 fill	1,024	300	2,324
3+50	313	~149	2,696	2,383 fill	2,141	300	-59
Totals	11,029	~1,317	11,089		10,173	388	

Topsoil depths vary from 6-10 inches along the access road and are 8 inches at the pad site, but may be as deep as 20 inches along the northeast edge of the pad (Appendix 2-G). Assuming a topsoil depth of 8 inches approximately 1,400 cu. yds. of topsoil will be recovered from the construction area. The topsoil stockpile can hold a maximum of 1,800 cu yds. of material. This will allow us to go deeper then the 8 inches in any areas that are required and still store the material depending on the actual depth of topsoil encountered during construction. If the amount on topsoil material recovered from areas TS-16 and TS-17 exceed the capacity of the topsoil stockpile the additional material will be hauled to the WHR topsoil stockpile. If both the capacity of both the WHR topsoil stockpile and the WHR Tank Seam topsoil stockpile are exceeded the material will be placed in the area labeled Potential Additional Topsoil Storage shown on plates 5-2 and 2-3G.

Silt fences will be placed below the disturbed area before both construction and reclamation begin. During the initial road cut, care will be taken to prevent disturbed material from migrating downslope in the following manner. The initial removal will be made using 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 5G-1. When the berm is in place, the road cuts will be started as shown in Figure 5G-1 and 5G-2 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 during the road cutting to be contained within the berm. In the event blasting is required, which is described in Appendix 5-E, the blasts will be designed to drop the material into the cut area behind the berm. This will prevent material generated by the blast form migrating into the undisturbed area.

Cut slopes, fill slopes, and fill placement will follow the recommendations given in the Slope Stability analysis and report, included in Attachment B. Large boulders will also be placed according to the report. Where possible, care will be taken to avoid disturbing large trees of commercial value and any canyon sweetvetch plants located in the area (see chapter 3). Exposed slopes will be covered with erosion control matting as described in Appendix 7-K.

This procedure will be followed for the construction of the Tank Seam portal pad as well. A road will be cut across the entire length of the pad and berm established. The backhoe will then turn into the mountain and start widening the pad, first recovering the topsoil.

Final crowning of the road, laying of road base and installation of permanent ditches will be completed following the initial road contouring. The approximate road contours are shown on Plate 5-2G.

During reclamation, the cut and fill process described above will be reserved. The reclaimed slopes will be reconstructed to approximate original contour. Subsoil material will be compacted in a minimum of 12 inch lifts. A minimum 8" of topsoil will be placed un-compacted over the regarded area. Topsoil material will be pocked to aid in water retention and runoff control during vegetation establishment (See Appendix 7-K). The 1,000 cu. yds. used in TS-15 and any material used in TS-7 and TS-8 will be replaced by material from TS-5 during reclamation. All material moved will be sampled for toxicity according to table 5O-1

Most areas of the road will remain in place for post-mining access to a hunting cabin. These areas are shown on Plate 2-3G and are labeled "area not requiring recontouring or topsoil within the disturbed boundary". The remaining areas of the road will be completely removed and used for fill material during the cut and fill process and the pre-mining road will be restored as shown on the cross-sections in Attachment A. A more detailed description of the hunting cabin can be found on page 4-4 of the MRP. No culverts will be removed since they are needed for access to the hunting cabin.

During construction 1,000 cu. yds. Of material was hauled to TS-15 as described on page 5J-13. Any additional material generated due to miner variations will be hauled to TS-7 and TS-8 for reclamation in those areas.

Attachment A

Cut and Fill Calculations

The cut and fill volumes shown in Table 5k-1 and 5k-2 represent the maximum volumes that will be encountered. Final contours and pad dimensions may vary somewhat to account for any variation in cut and fill volumes. As-built contours and cut and fill volumes will be submitted to the Division following construction.

Volume measurements were made using "Quicksurf" 3D modeling software with AutoCad. They are based on the contours shown on Plate 5-7G for pre-mining configuration, Plate 5-2G for operational configuration, and Plate 5-6G for post-mining configuration. Cross-sections for each configurations are shown on the following pages. The locations of the cross-sections are shown on Plates 5-6G and 2-3G.

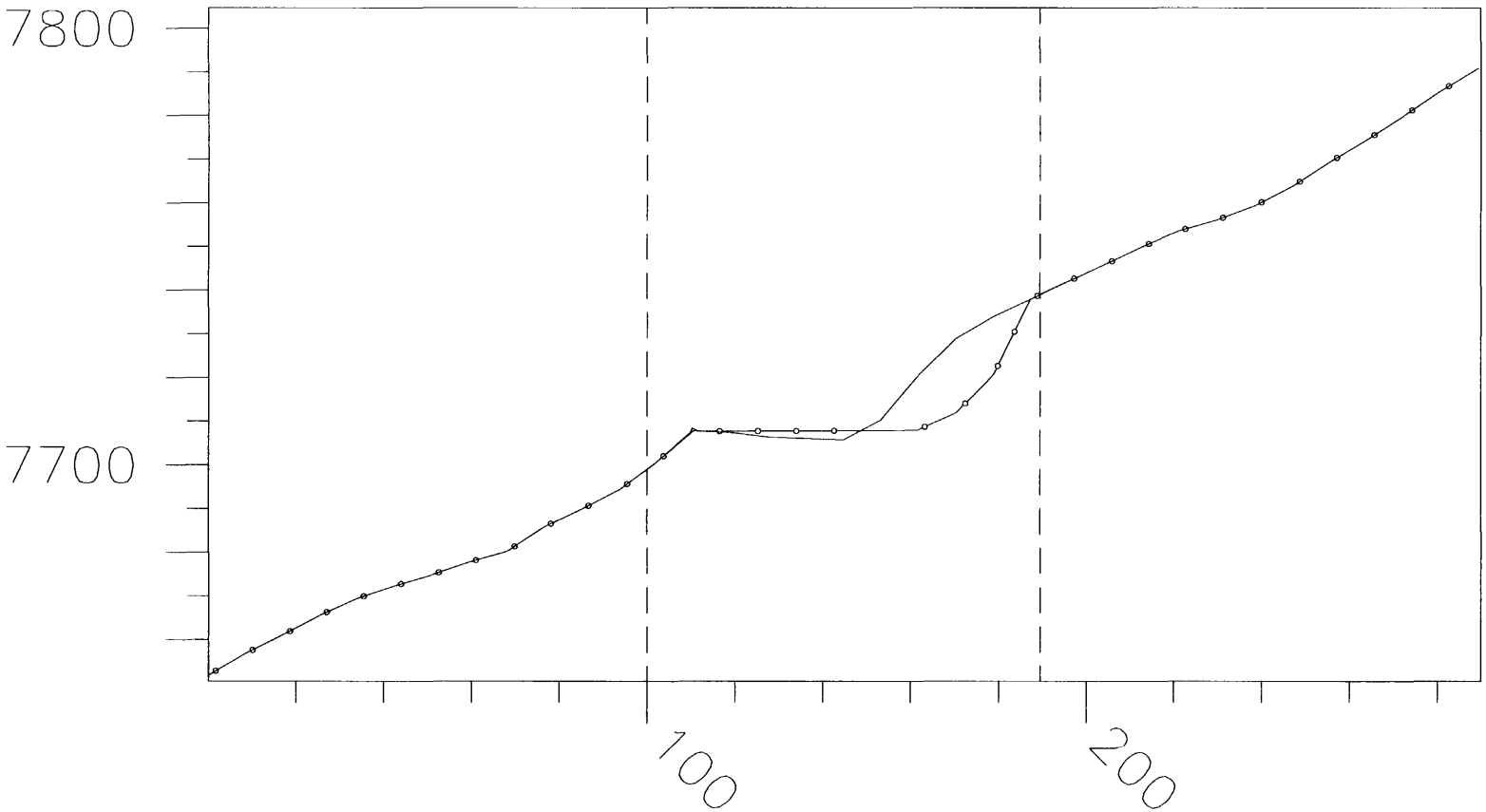
1" = 10'	M. Reynolds	5/13/02
BEAR CANYON	WHR Tank Seam Lower Access Road	

Pre-Mining

Post-Mining/Operation

Dst. Boundary

TS-16 Section 1



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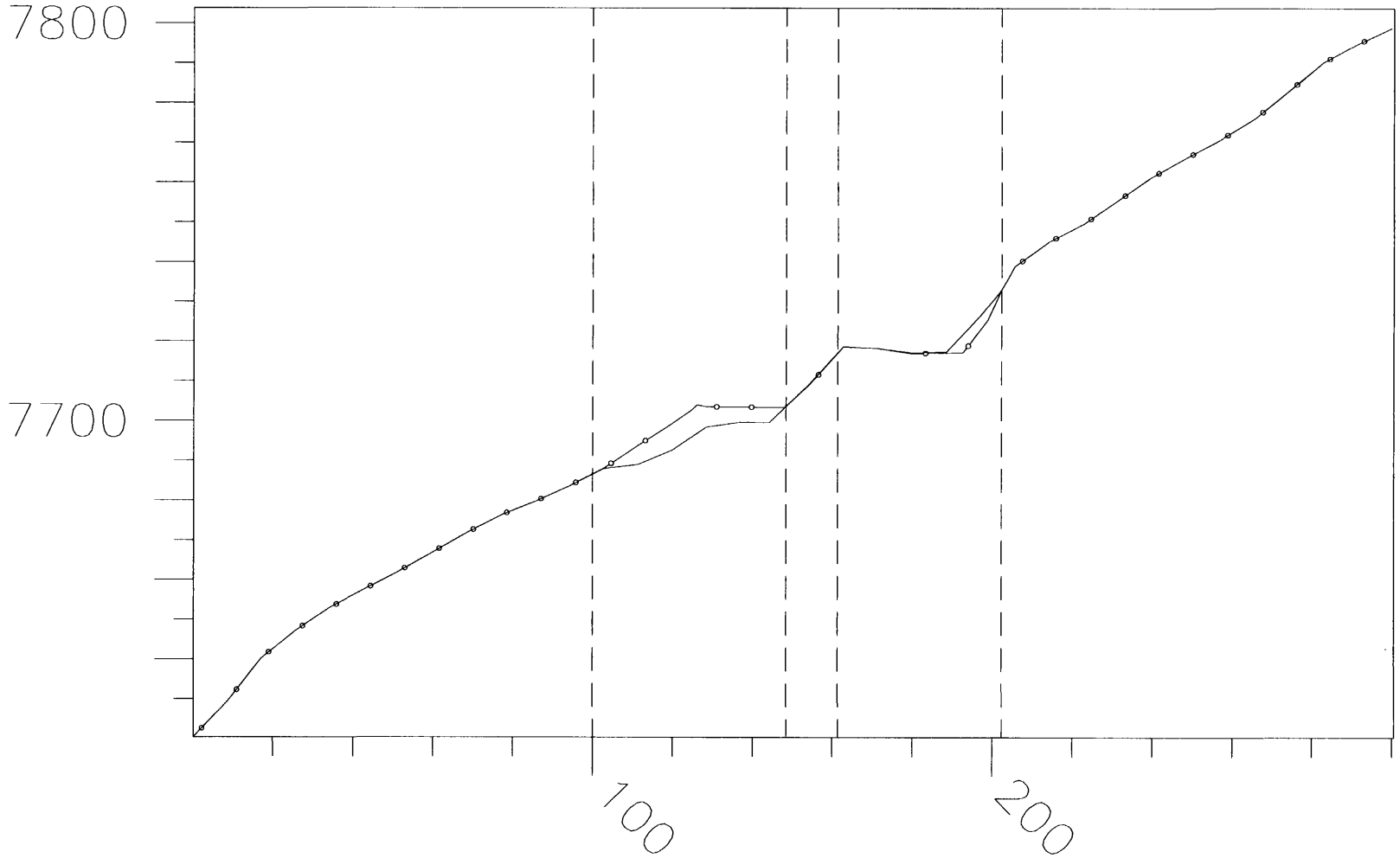
[illegible] FACILITIES		
1" = 40'	M. Reynolds	5/13/02
BEAR CANYON	WHR Tank Seam Lower Access Road	

Pre-Mining

Post-Mining/Operation

Dst. Boundary

TS-16 Section 2



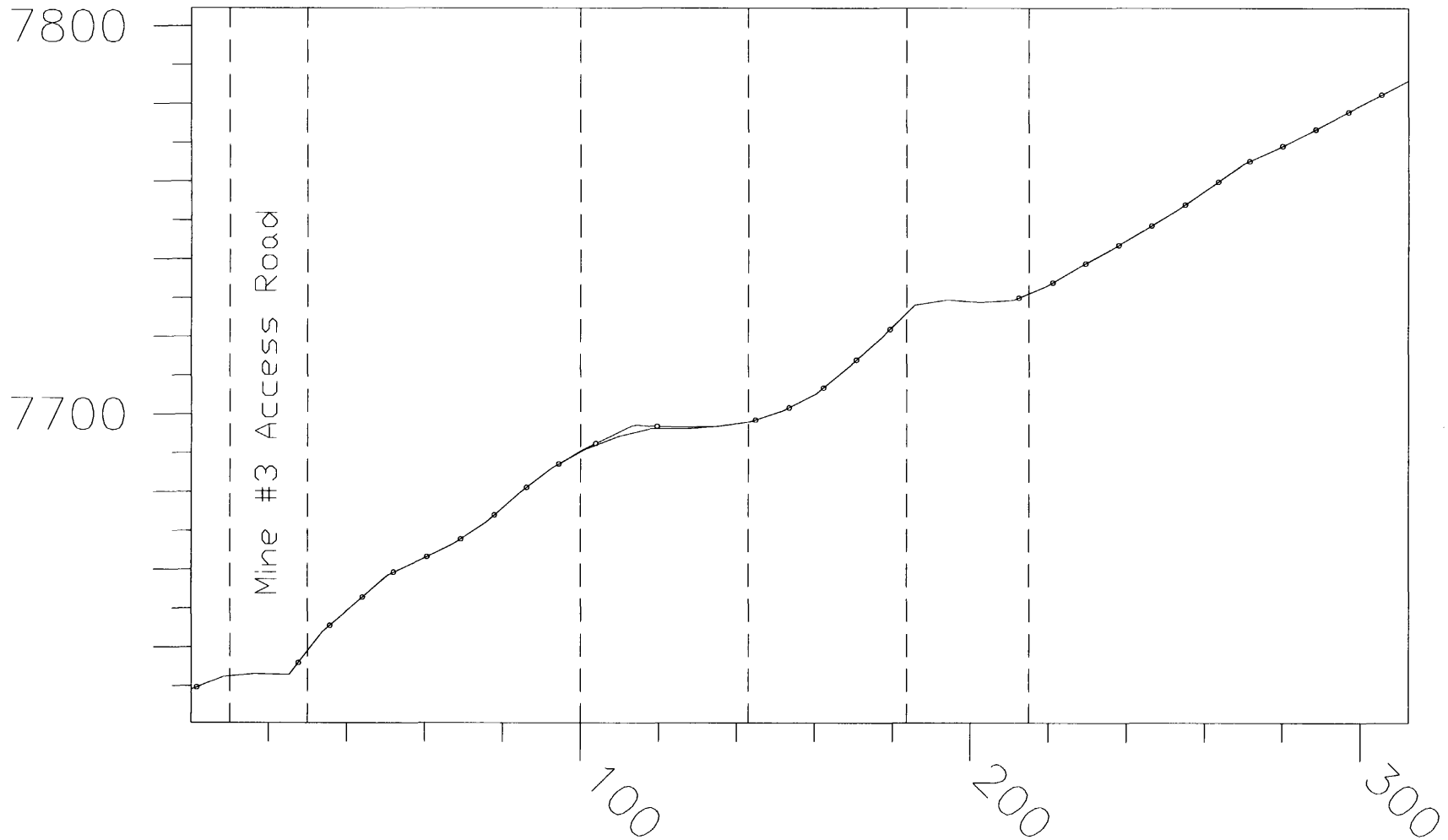
1" = 40'	M. Reynolds	5/13/02
BEAR CANYON	WHR Tank Seam Lower Access Road	

Pre-Mining

Post-Mining/Operation

Dst. Boundary

TS-16 Section 3



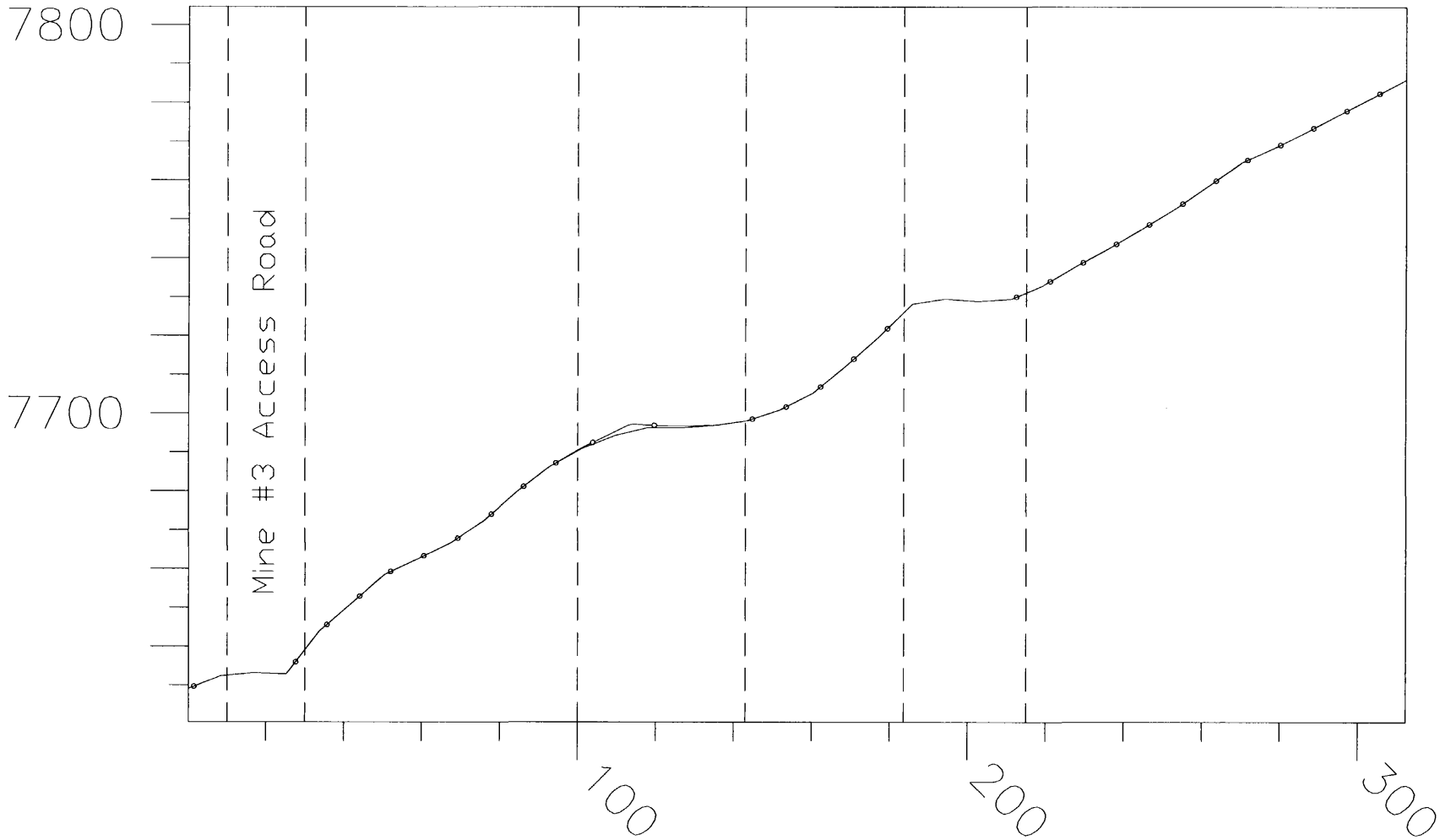
[illegible] MINING [illegible]		
SURFACE FACILITIES		
1" = 40'	M. Reynolds	5/13/02
BEAR CANYON	WHR Tank Seam Lower Access Road	

Pre-Mining

Post-Mining/Operation

Dst. Boundary

TS-16 Section 3



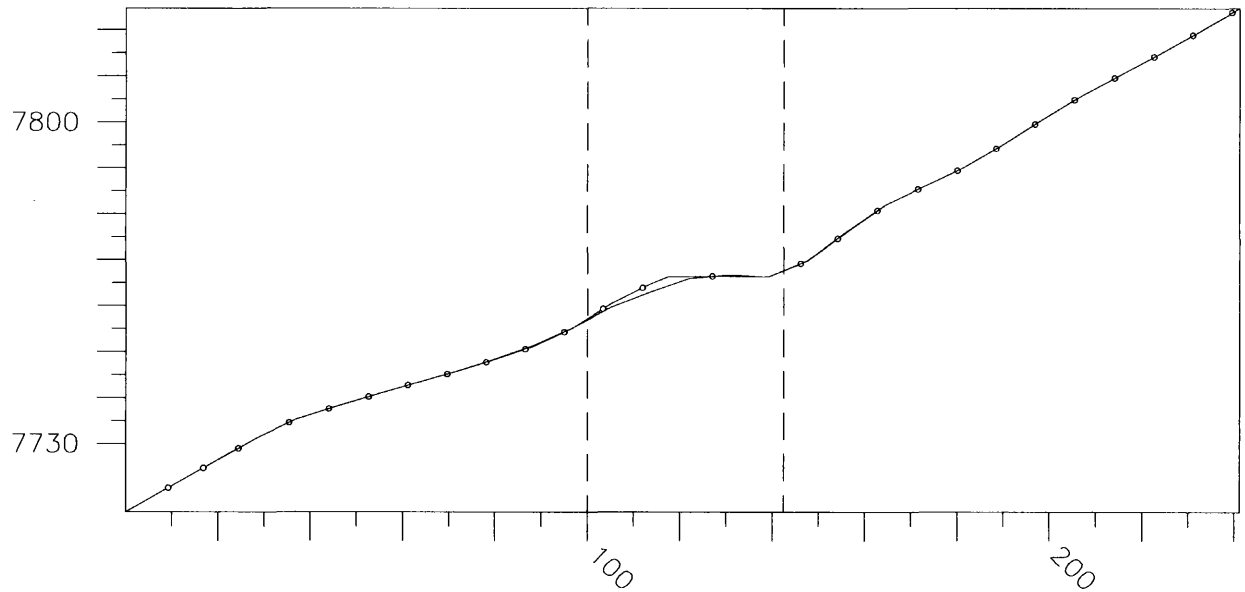
SURFACE FACILITIES		
1" = 40'	M. Reynolds	5/13/02
BEAR CANYON	WHR Tank Seam Lower Access Road	

Pre-Mining

Post-Mining/Operation

Dst. Boundary

TS-16 Section 4



CO-OP MINING CO		
SURFACE FACILITIES		
Scale 1" = 10'	Drawn by M. Reynolds	Date 8/09/01
BEAR CANYON	WHR Tank Seam Access Road	

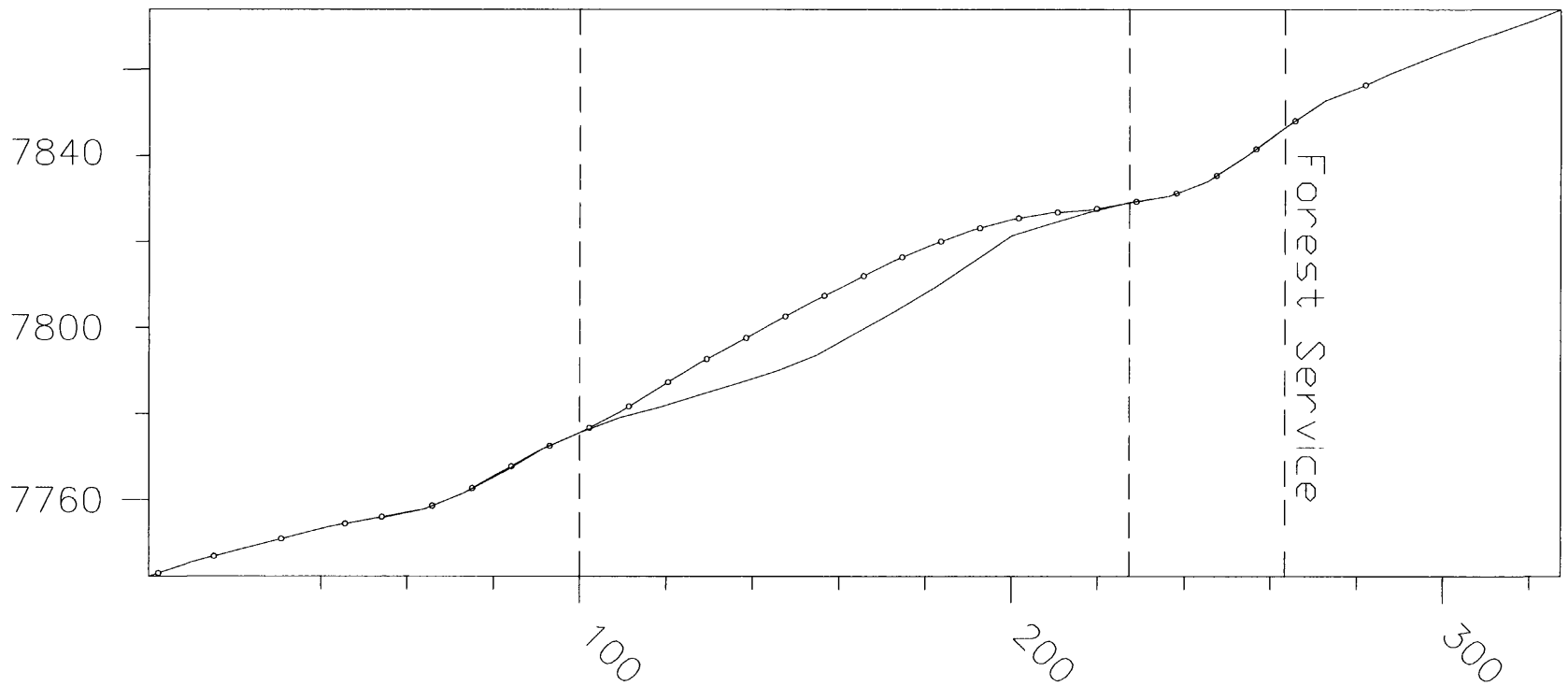
Pre/Post Mining

Operation

Dst. Boundary

Forest Service

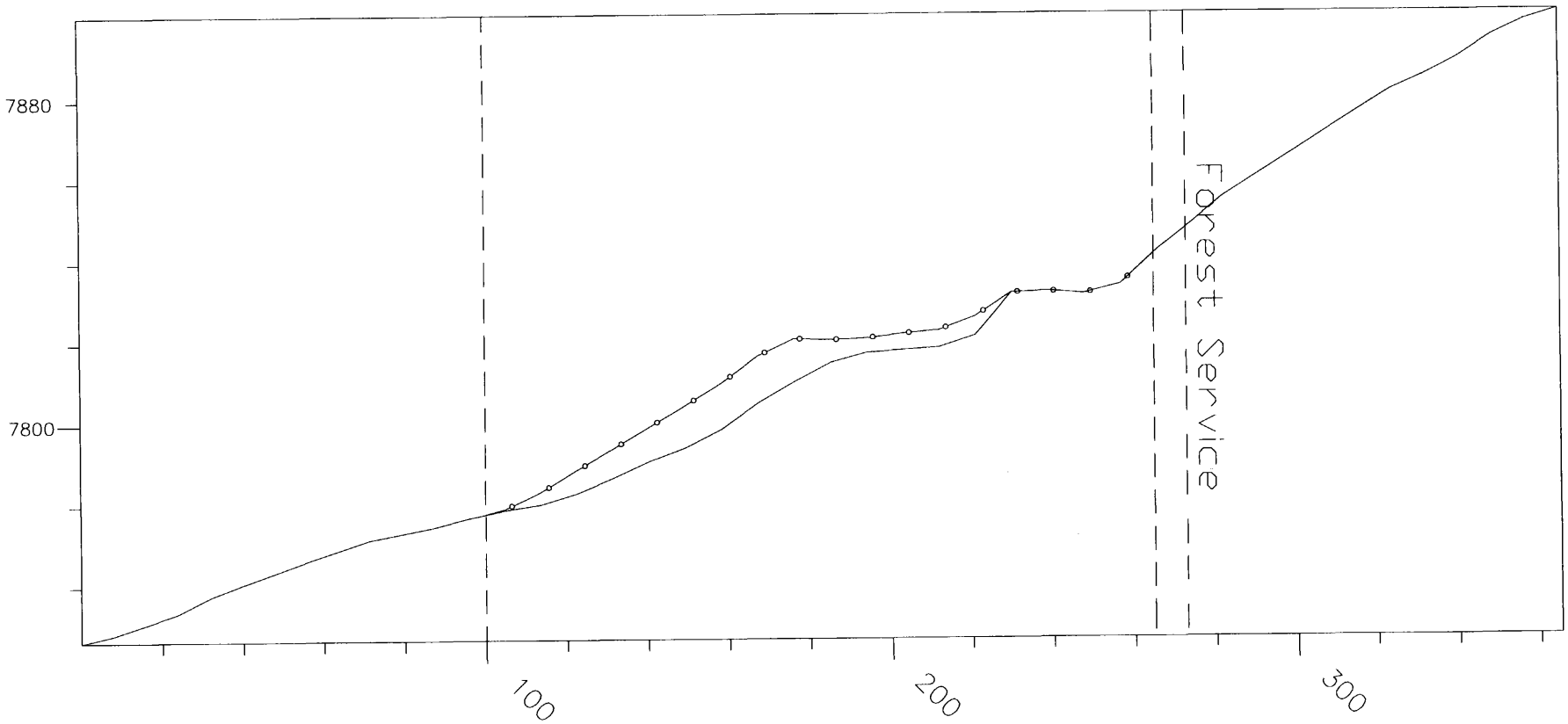
TS-17 Section 0+00



[illegible]		
SURFACE FACILITIES		
1" = 10'	M. Reynolds	8/09/01
BEAR CANYON	WHR Tank Seam Access Road	

Pre/Post Mining
Operation
Dst. Boundary
Forest Service

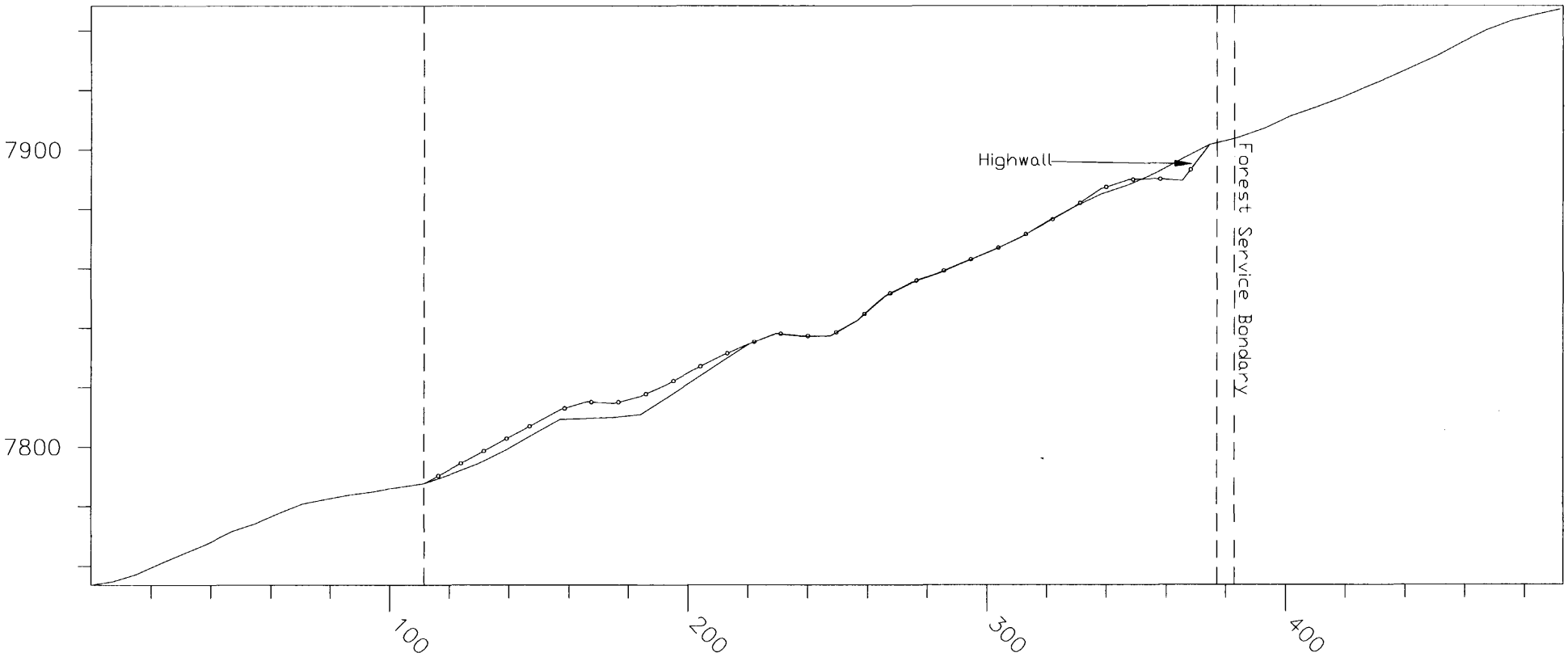
TS-17 Section 0+50



SURFACE FACILITIES		
SCALE 1" = 50'	DRAWN BY M. Reynolds	DATE 8/09/01
BEAR CANYON	WHR Tank Seam Access Road	

Pre/Post Mining
Operation
Dst. Boundary
Forest Service

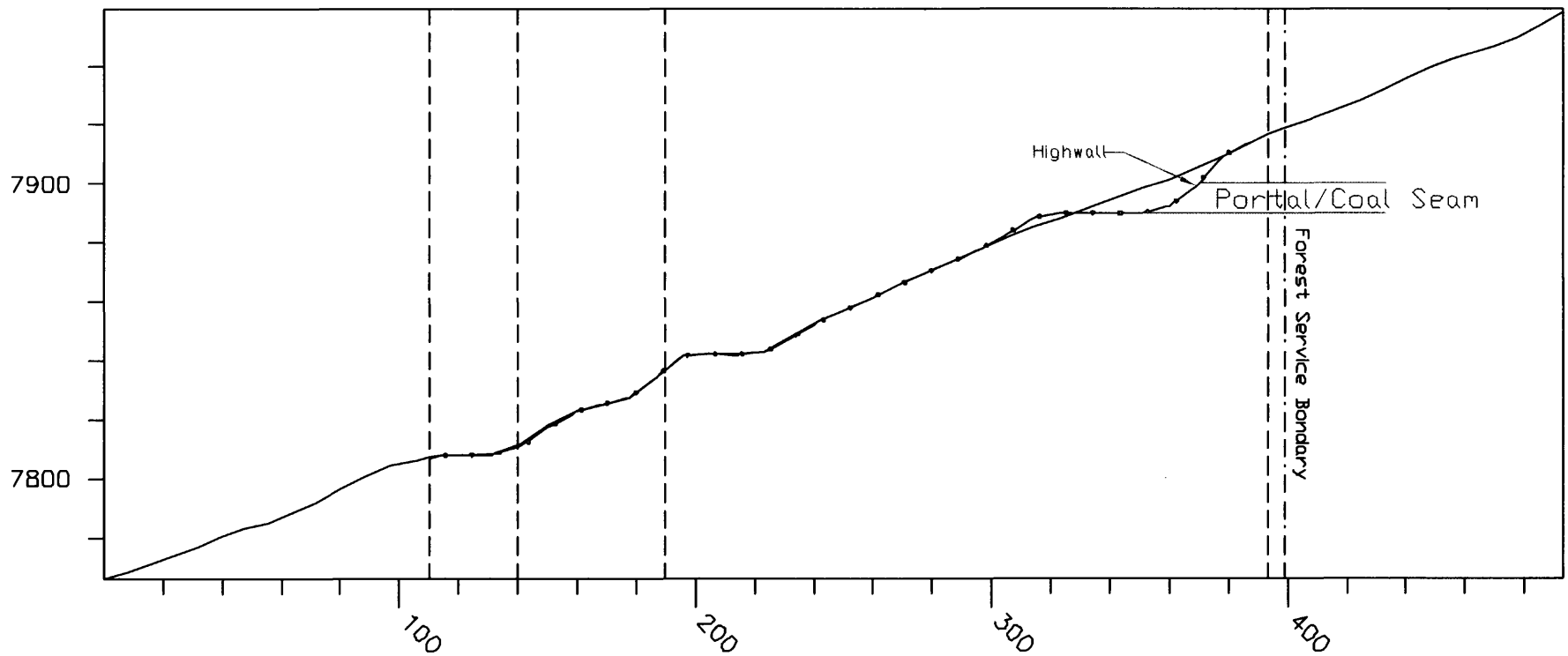
TS-17 Section 1+00



CO-OP MINING CO. HUNTINGTON, UTAH		
SURFACE FACILITIES		
SCALE: 1" = 55'	DRAWN BY: M. Reynolds	DATE: 8/09/01
BEAR CANYON	WHR Tank Seam Access Road	

Pre/Post Mining
Operation
Dst. Boundary
Forest Service

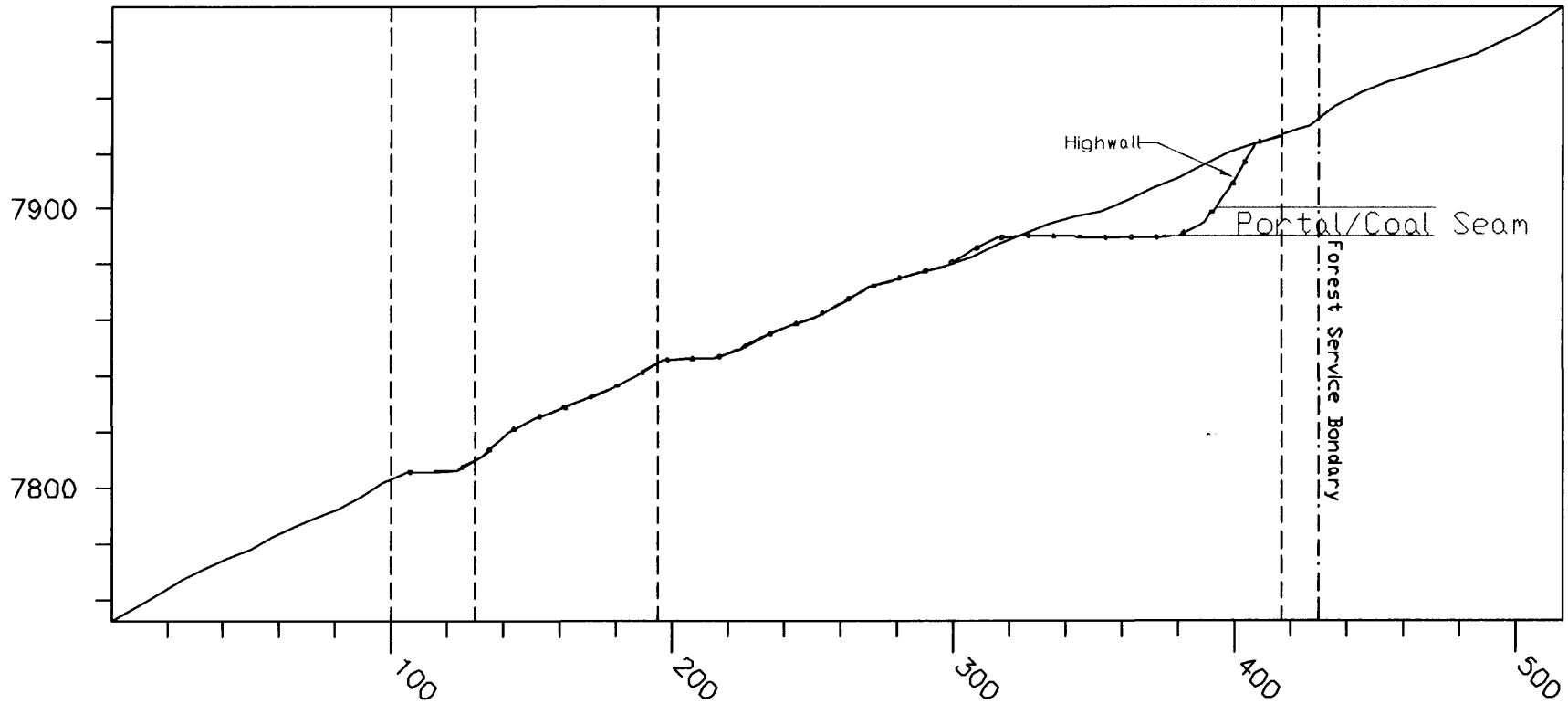
TS-17 Section 1+50



CO-OP MINING CO. HUNTINGTON, UTAH		
SURFACE FACILITIES		
SCALE: 1" = 60'	DRAWN BY: M. Reynolds	DATE: 8/09/01
BEAR CANYON	WHR Tank Seam Access Road	

Pre/Post Mining
Operation
Dst. Boundary
Forest Service

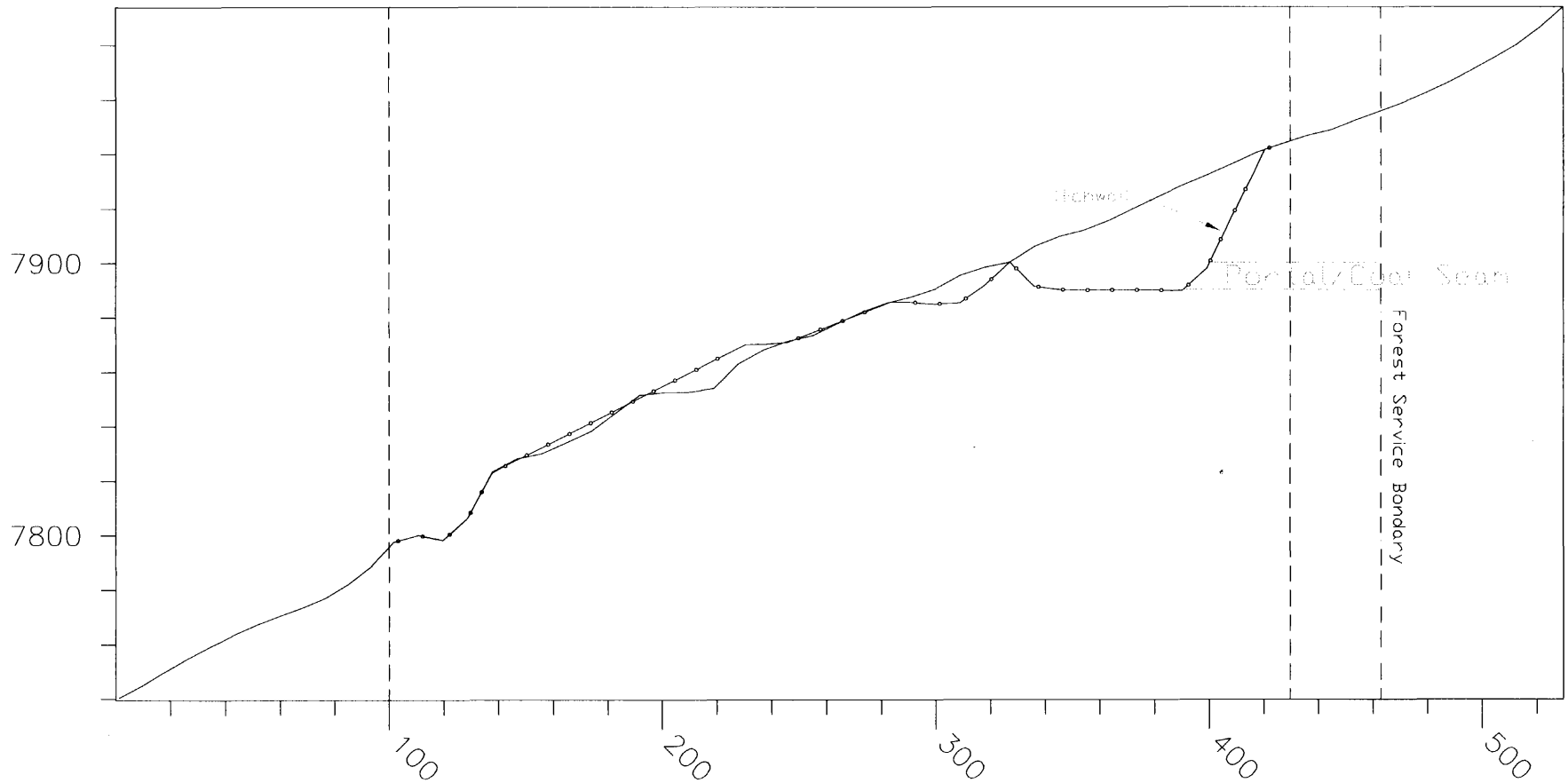
TS 17 Section 2+00



CO-OP MINING CO.		
SURFACE FACILITIES		
SCALE 1" = 60'	DRAWN BY M. Reynolds	DATE 8/09/01
BEAR CANYON	WHR Tank Seam Access Road	

Pre/Post Mining
Operation
Dst. Boundary
Forest Service

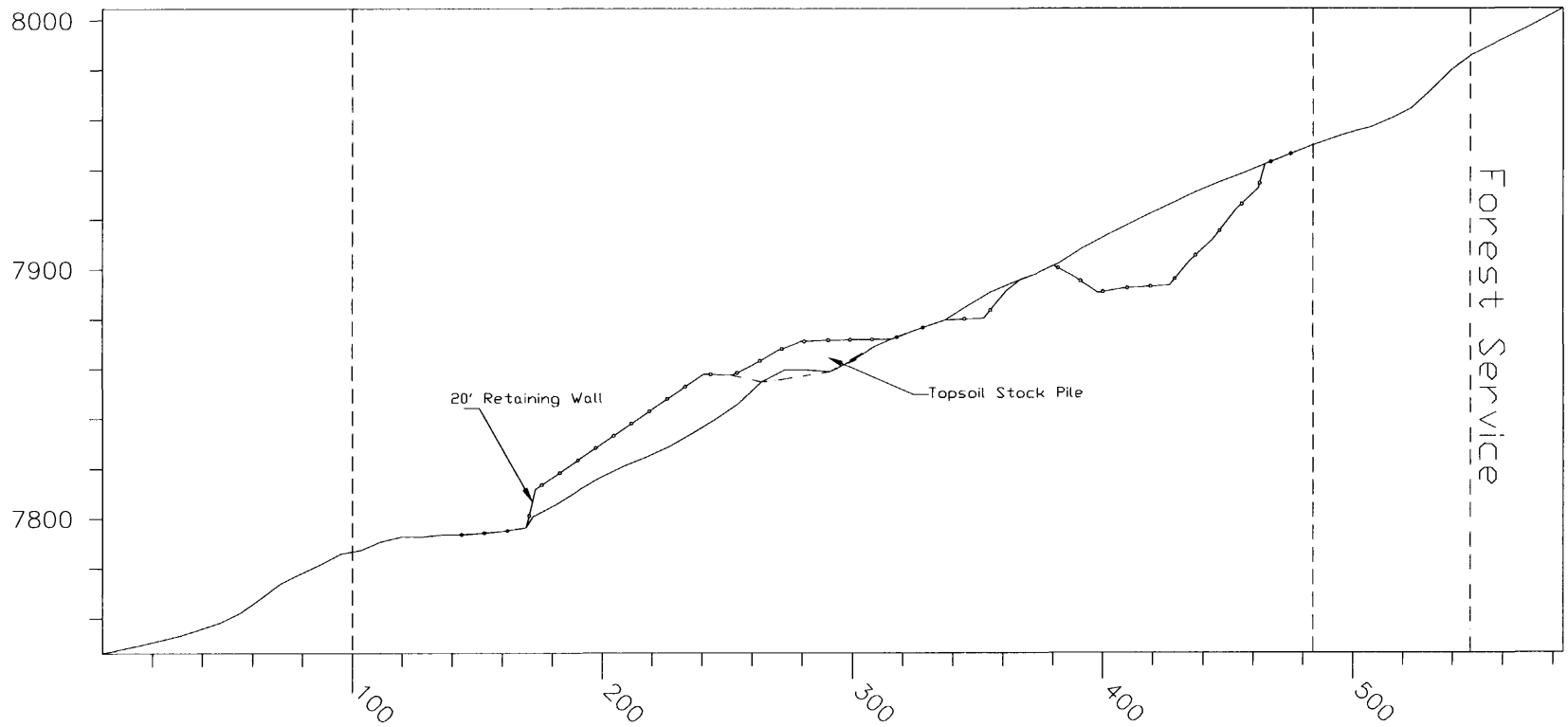
TS-17 Section 2+50



CO OP MINING CO		
SURFACE FACILITIES		
1" = 70'	M. Reynolds	8/09/01
BEAR CANYON	WHR Tank Seam Access Road	

Pre/Post Mining
Operation
Dst. Boundary
Forest Service
Topsoil

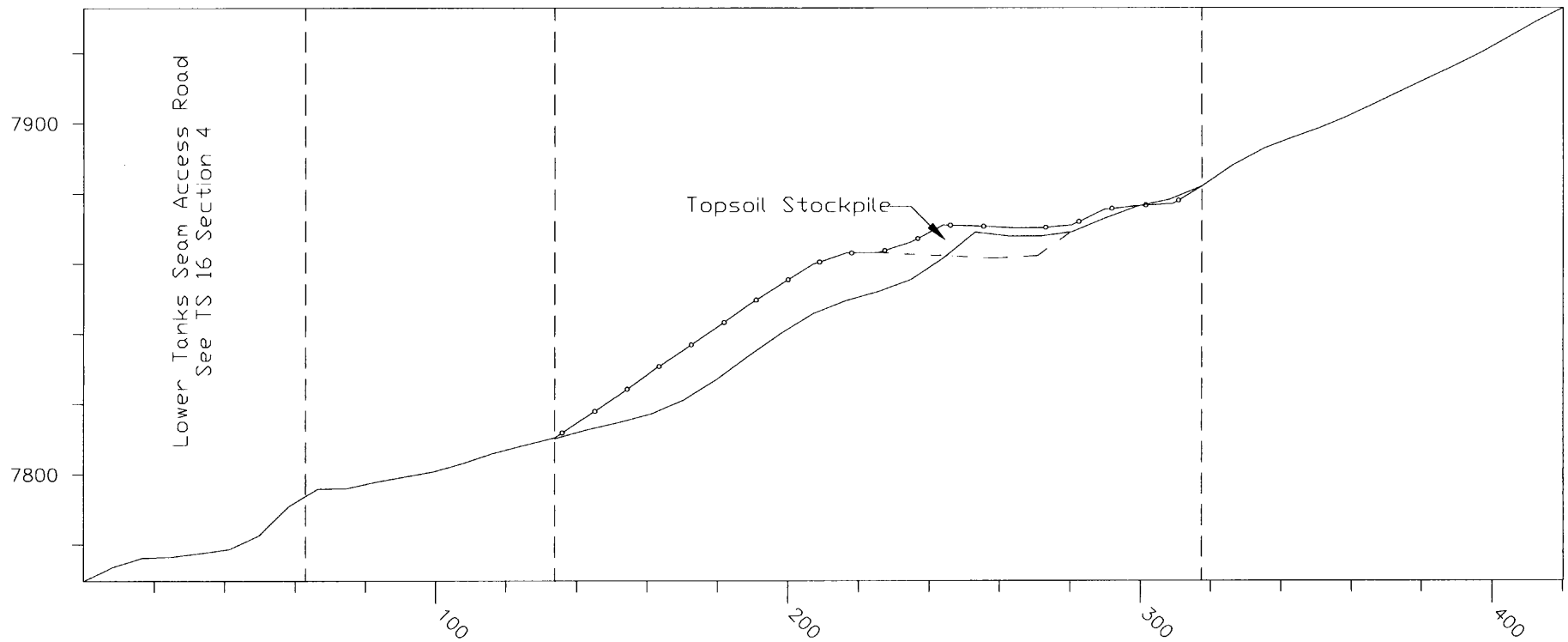
TS-17 Section 3+00



SURFACE FACILITIES		
Scale: 1" = 15'	Drawn By: M. Reynolds	Date: 8/09/01
BEAR CANYON	WHR Tank Seam Access Road	

Pre/Post Mining
Operation
Dst. Boundary
Topsoil

TS 17 Section 3+50



Attachment B

Slope Stability Analysis for the Wild Horse Ridge Tank Seam Portal Site

URS

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

Attention: Mr. Charles Reynolds

RE: Slope Stability Evaluation
Tank Seam Access Road
Bear Canyon

Dear Mr. Reynolds:

INTRODUCTION

This letter presents the results of the slope stability analyses conducted for the proposed access road for the WHR Tank Seam Portal Site. The site work includes a cut into the bedrock, fill over existing native granular colluvium, and topsoil stockpiling. The analyses were conducted on five of the sections given to URS by CO-OP Mining Company. The analyses included both static and dynamic slope stability analysis of the site.

ASSUMPTIONS

The soil properties in the area were given in an earlier report dated October 7, 1996. The properties used in the analyses to model the soil and rock are presented in the following table:

Soil/Bedrock Type	Total Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (psf)	Angle of Internal Friction (degrees)
Compacted Fill	125	130	0	36
Native Granular Colluvium	115	120	0	34
Topsoil*	105	110	0	25
Native Sandstone	130	135	3,600	43

* Topsoil values assumed for the analyses.

URS Corporation
756 East Winchester Street
Suite 400
Salt Lake City, Utah 84107
Tel: 801.904.4000
Fax: 801.904.4100
www.urscorp.com

It was assumed that 10 feet of colluvium covers the native Sandstone. This assumption was based upon the report mentioned above. The dynamic stability used a 0.10g factor for the seismic loading. This is a probabilistic peak acceleration with a 10% chance of being exceeded in 50 years.

ANALYSIS

The five selected sections for analysis are 0+00, 0+50, 2+50, 3+00, and 3+50. The slope stability analyses were preformed using GEO-SLOPE, Version 4.21. The analyses included circular failure surfaces to determine the factor of safety against slope failure. The method used for the analyses was the Spencer method in addition to Bishop, Ordinary and Janbu methods. The analyses used 30 cross sections for each section studied. Different portions of two of the selected sections, sections 2+50 and 3+00, were analyzed for stability. The resulting sections and failure slopes of the analyses are attached at the end of this report.

RESULTS

The minimum factor of safety for the static loads of any slope is 1.3 for compacted fill or cut slopes. The minimum factor of safety for excess spoil used on site is 1.5 for static loads. The minimum factor of safety for dynamic loads is 1.1. The resulting minimum factor of safety for any of the analyses was 1.30 for non-spoil static loads and 1.09 for the dynamic loads. The resulting minimum factors of safety for each of the analyses are given in the following table:

SECTION	TYPE ANALYZED	STATIC	DYNAMIC
0+00	FILL	1.41	1.14
0+50	FILL	1.33	1.09
2+50	EXISTING 2:1 SLOPE	1.30	1.09
2+50 A	UPPER CUT	1.45	1.16
2+50 B	LOWER CUT	1.80	1.38
2+50 C	FILL	1.97	1.50
3+00	FILL	1.39	1.13
3+00 A	UPPER CUT	1.35	1.10
3+00 B	LOWER CUT	1.60	1.25
3+00 C	TOP SOIL	2.68	1.84
3+50	FILL	1.59	1.29

The resulting minimum factors of safety for the sections of the analyses showing the reclaimed areas are given in the following table:

SECTION	TYPE ANALYZED	STATIC	DYNAMIC
2+50	UPPER CUT RECLAIMED	2.18	1.74
2+50	LOWER CUT RECLAIMED	2.41	1.83
3+00	UPPER CUT RECLAIMED	2.24	1.97
3+00	LOWER CUT RECLAIMED	1.51	1.22

CONCLUSION

As can be seen by the table, the resulting factors of safety are at or above the minimum guideline factors of safety. The only section that is at the minimum in both factors of safety is Section 2+50 in the existing 2:1 slope at the lower end of the section. Stabilization of the slope would add to the factor of safety in that area. All other sections showed that the WHR Tank Seam Access Road could be safely built in the area designated.

We appreciate the opportunity we have had to provide this service for you. If you have any questions, comments, or concerns with the analysis done, please feel free to call us.

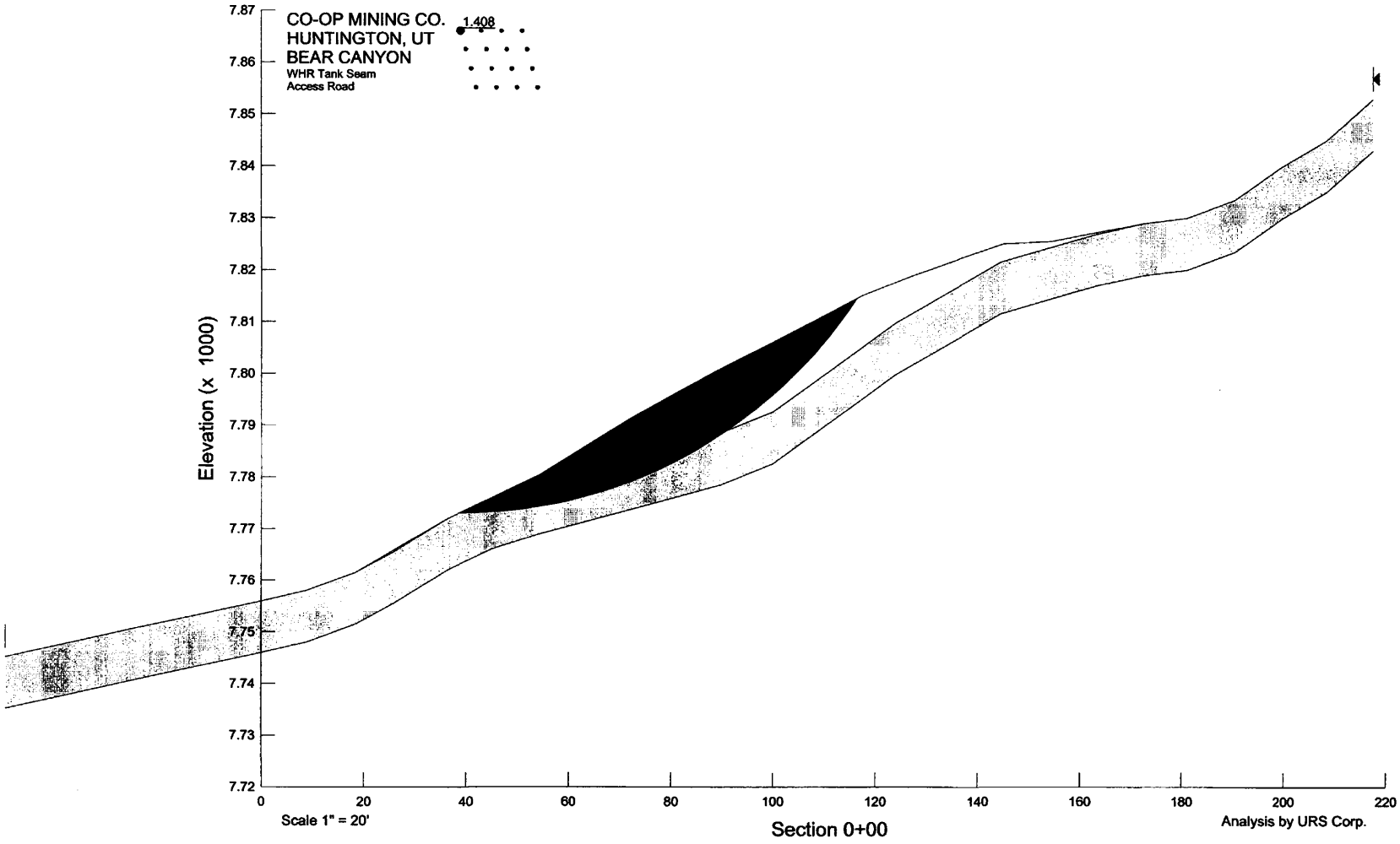
Respectfully Submitted,
URS Corp.

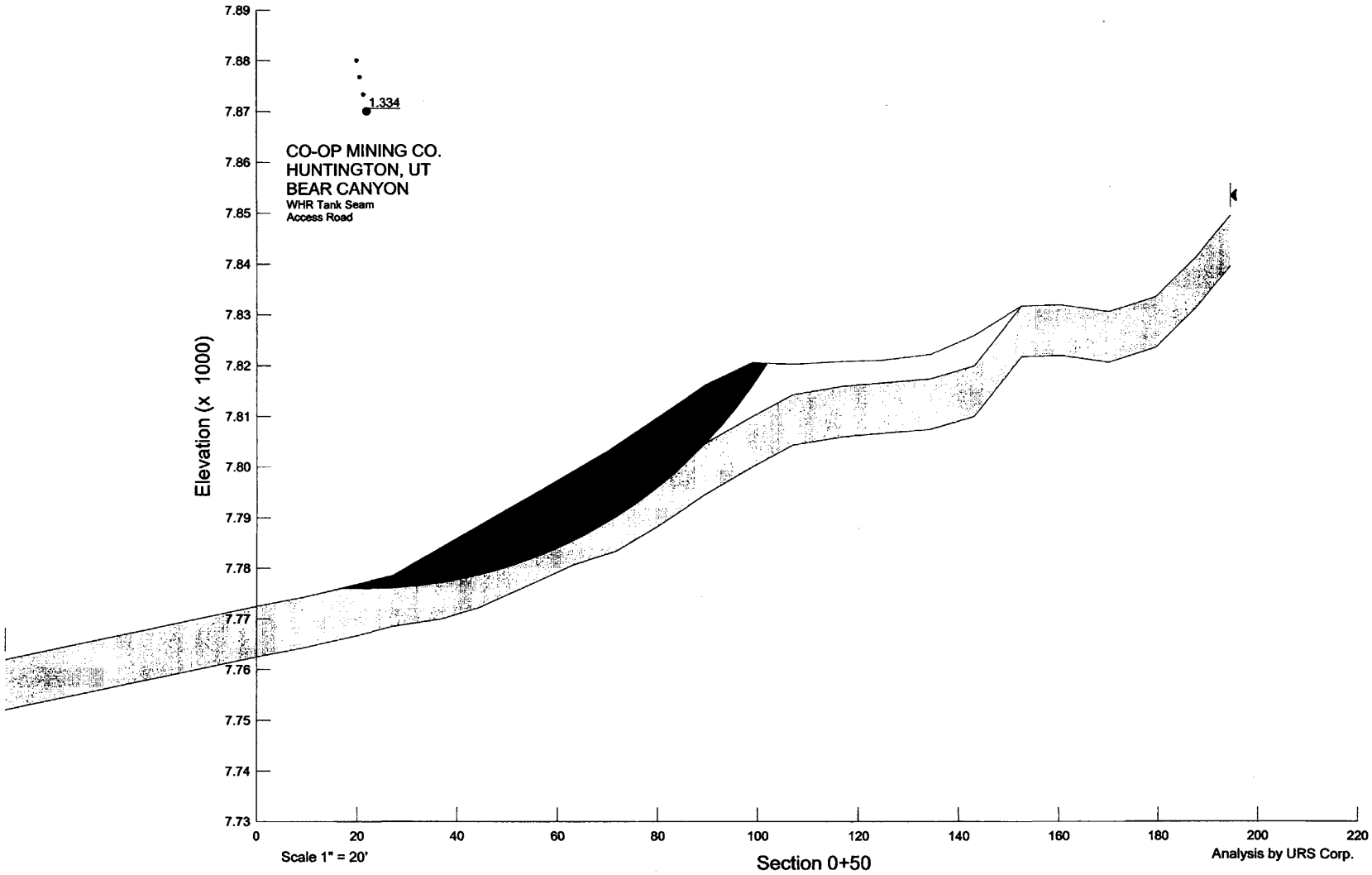
Paul R. Vidmar, P.E.
Project Engineer

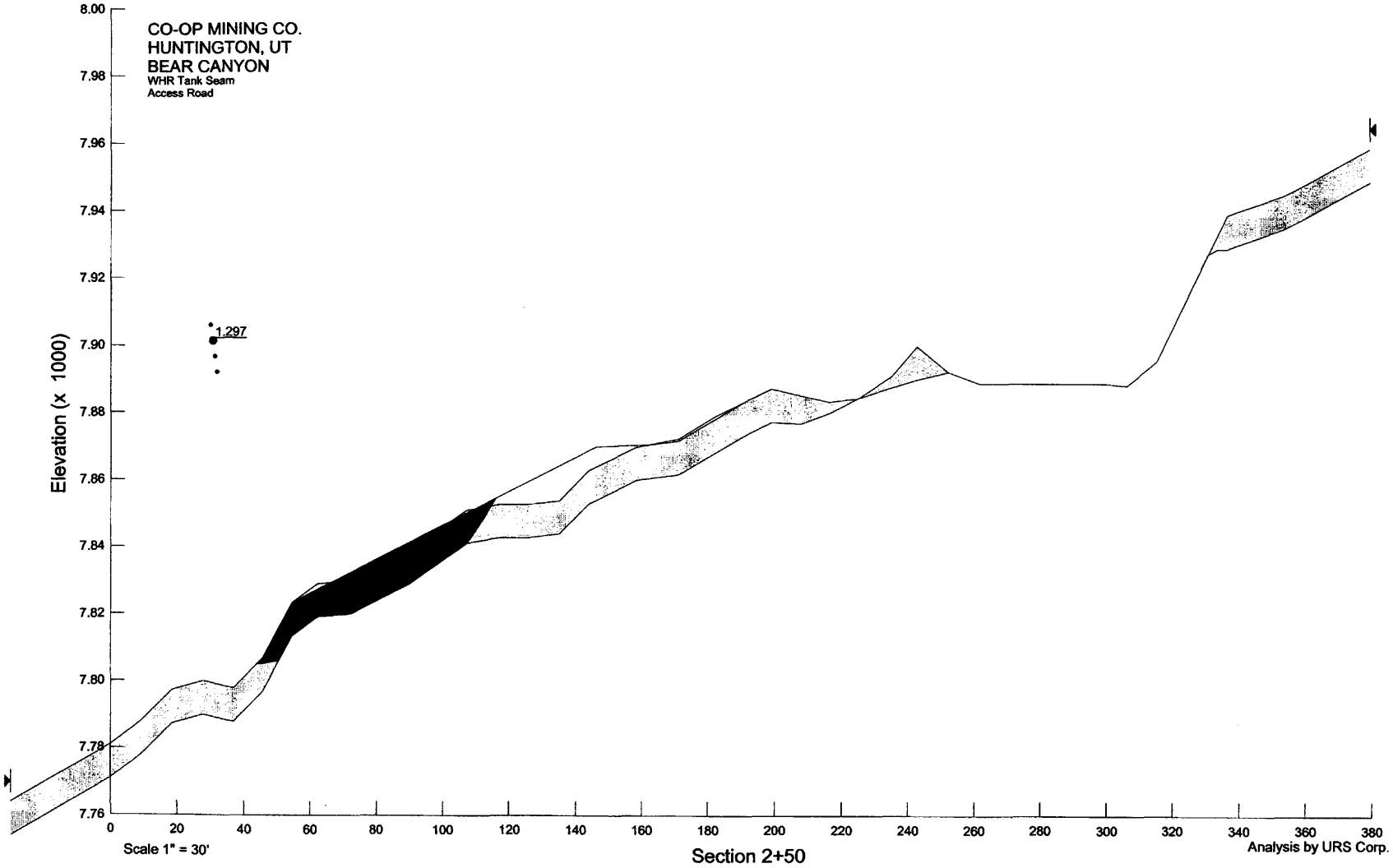
Charles C. Rehn, P.E.
Project Manager

APPENDIX A

CROSS SECTIONS OF STATIC ANALYSES


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.408
Elevation (x 1000)
7.87
7.86
7.85
7.84
7.83
7.82
7.81
7.80
7.79
7.78
7.77
7.76
7.75
7.74
7.73
7.72
0
20
40
60
80
100
120
140
160
180
200
220
Scale 1" = 20'
Section 0+00
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.334
Elevation (x 1000)
7.89
7.88
7.87
7.86
7.85
7.84
7.83
7.82
7.81
7.80
7.79
7.78
7.77
7.76
7.75
7.74
7.73
0
20
40
60
80
100
120
140
160
180
200
220
Scale 1" = 20'
Section 0+50
Analysis by URS Corp.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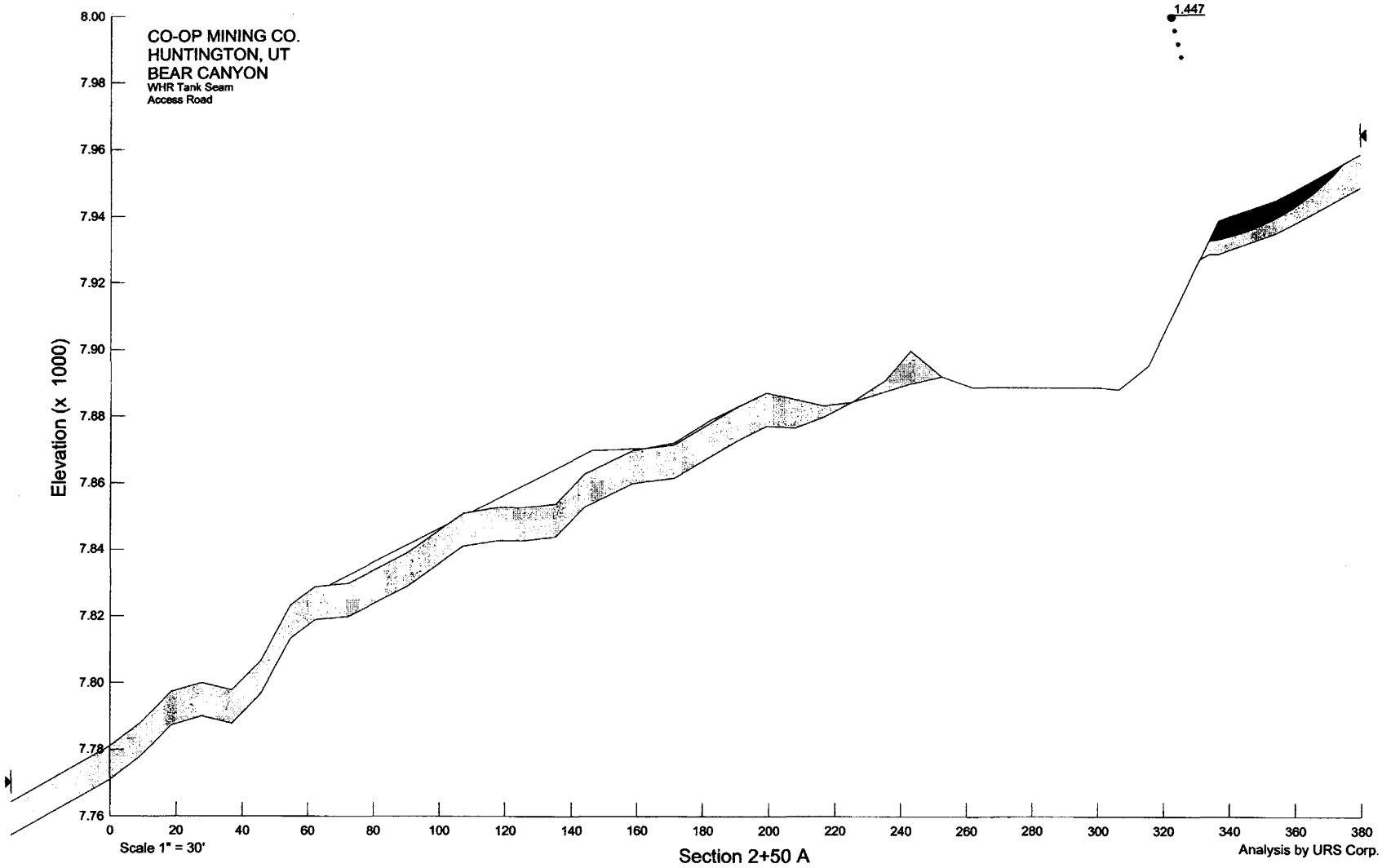
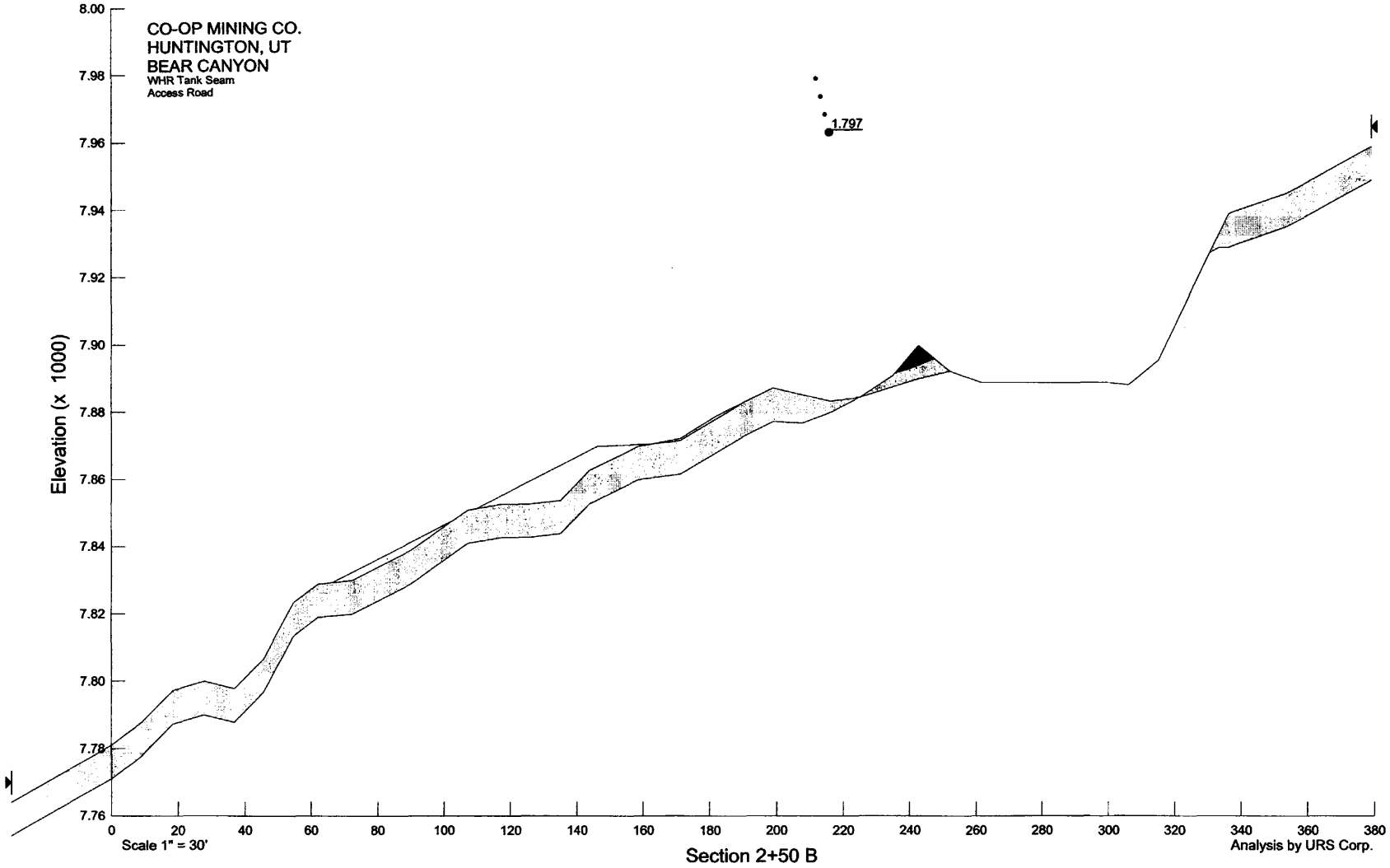
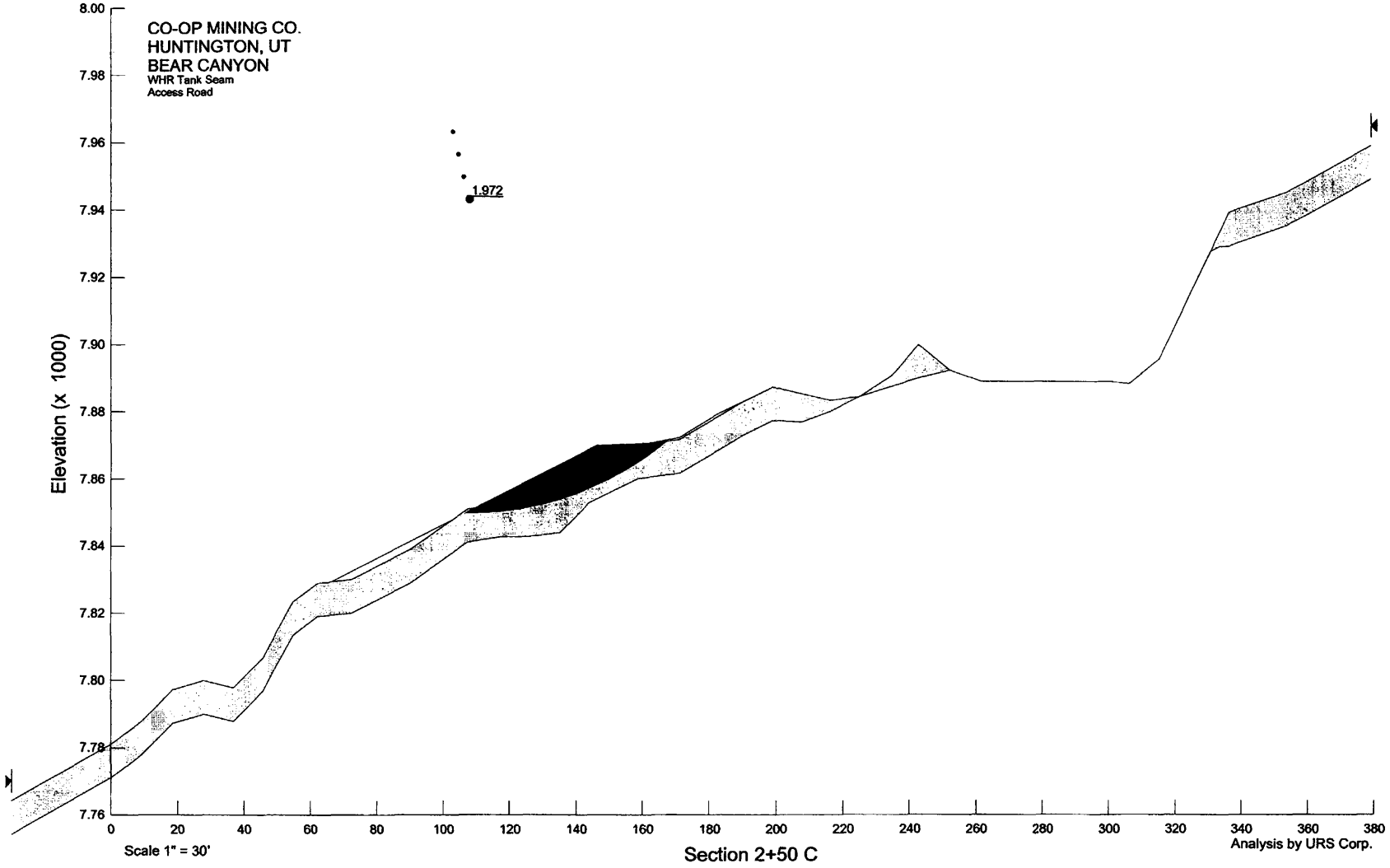
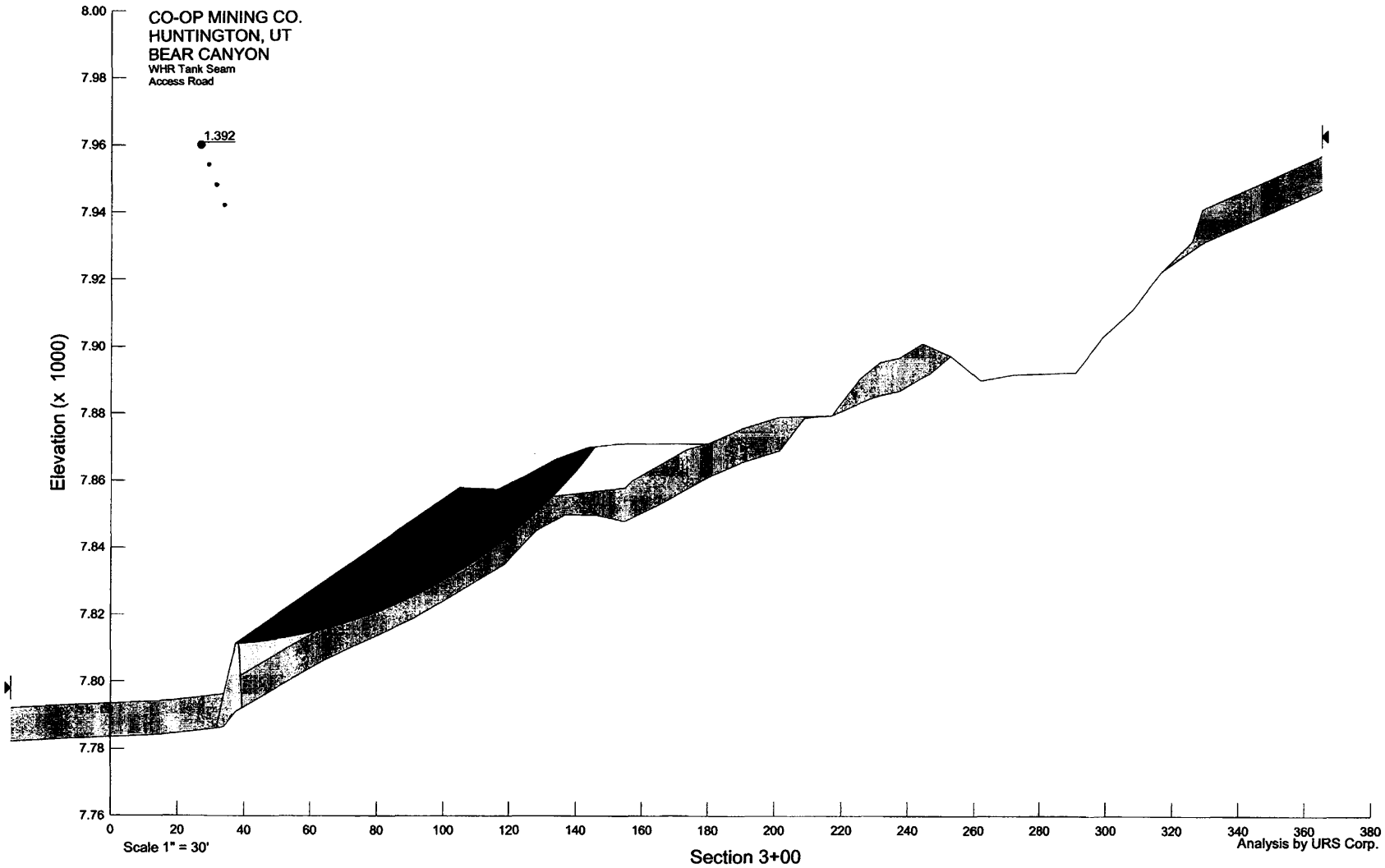
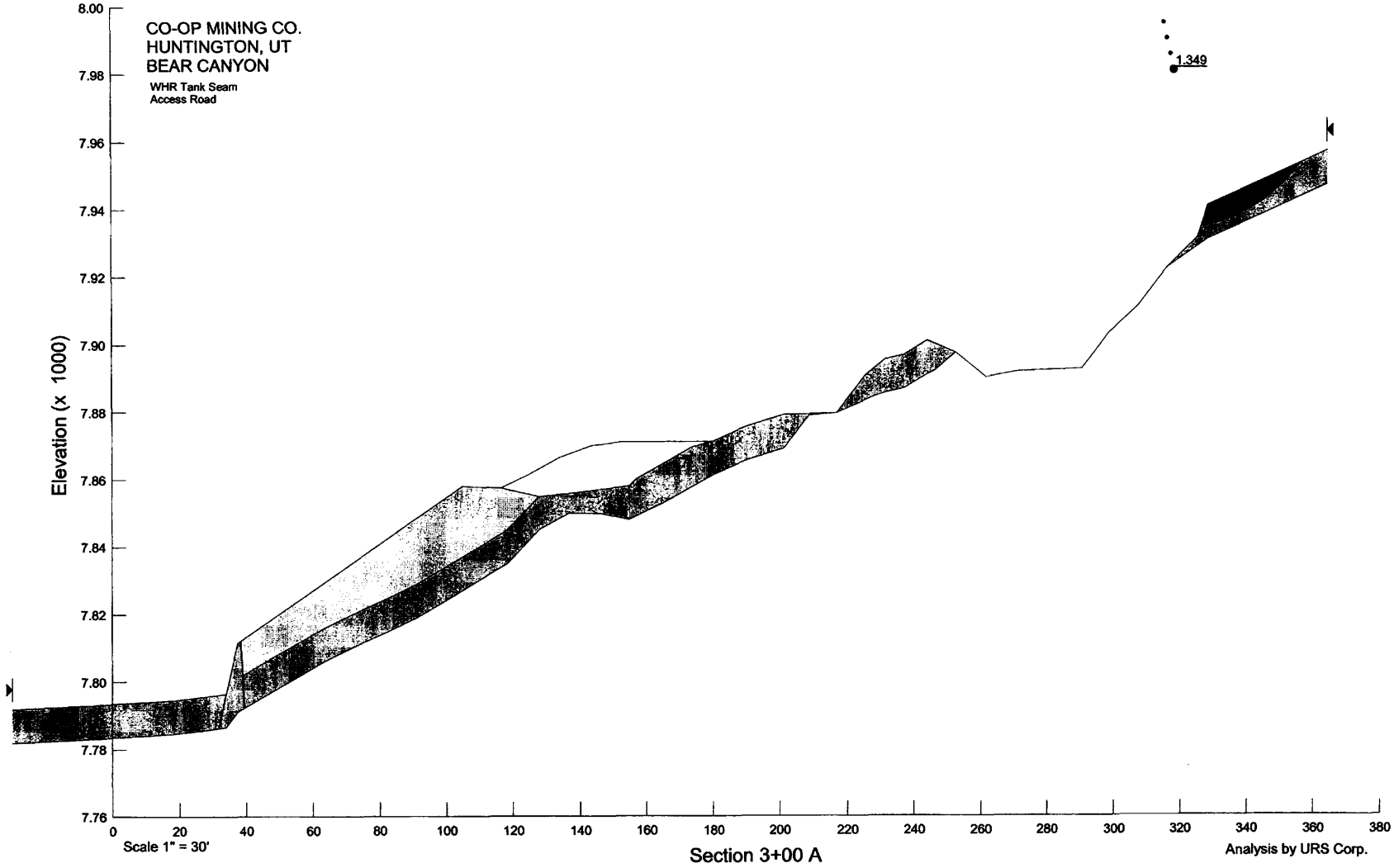
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.297
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 2+50
Analysis by URS Corp.

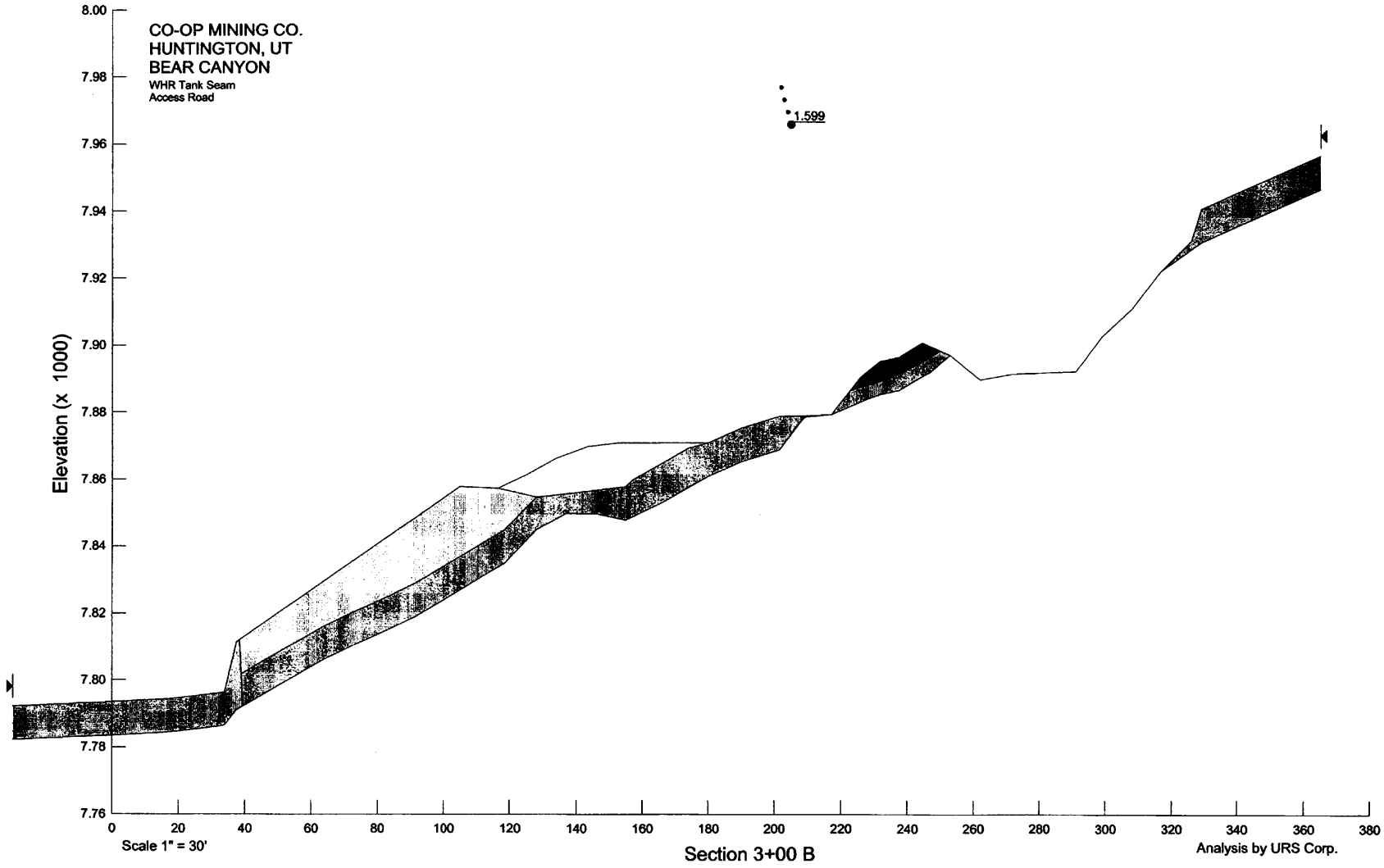

CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.447
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 2+50 A
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.797
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 2+50 B
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.972
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 2+50 C
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.392
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 3+00
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.349
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 3+00 A
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.599
Elevation (x 1000)
8.00
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7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
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300
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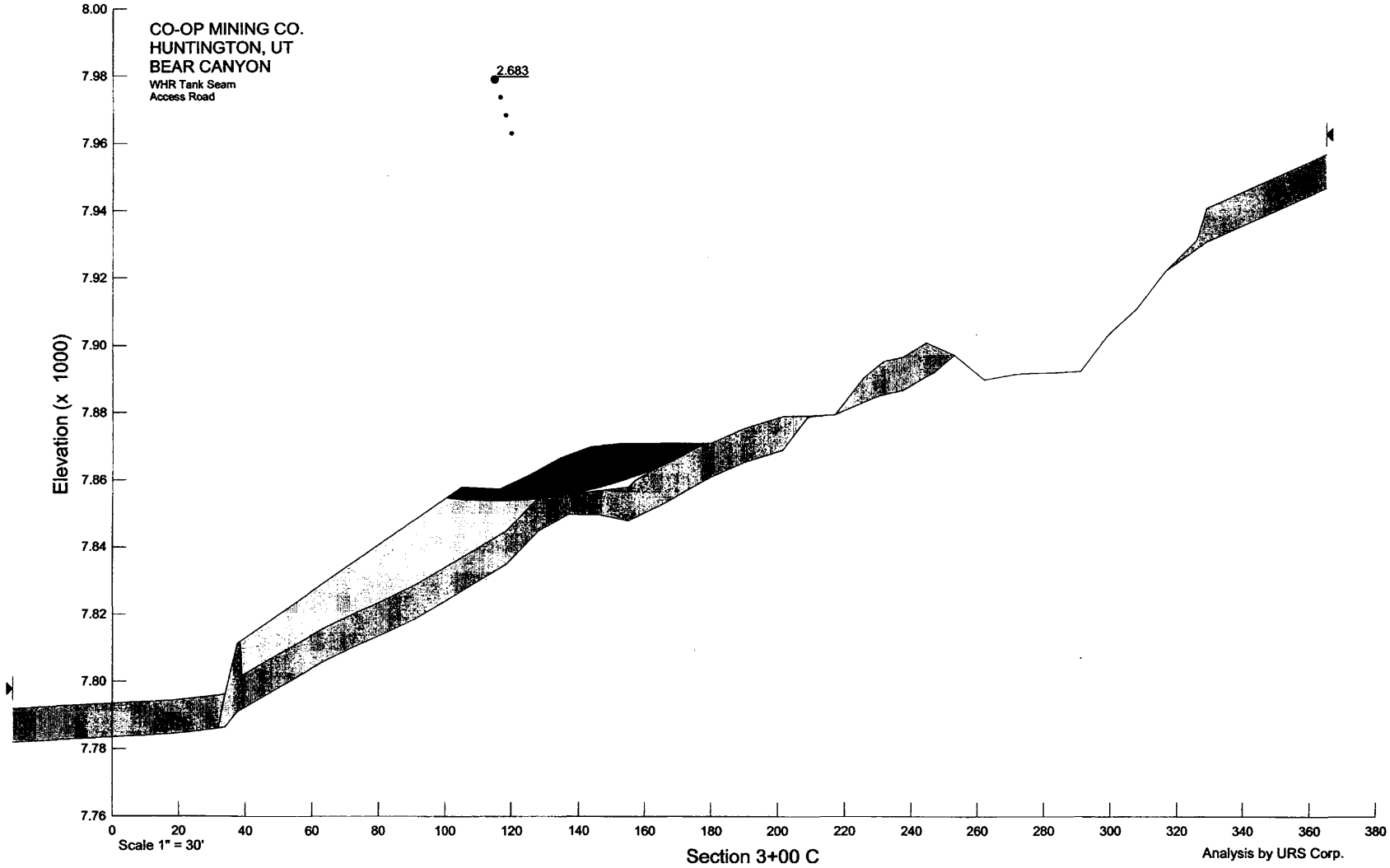
360
380
Scale 1" = 30'
Section 3+00 B
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
2.683
Elevation (x 1000)
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7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
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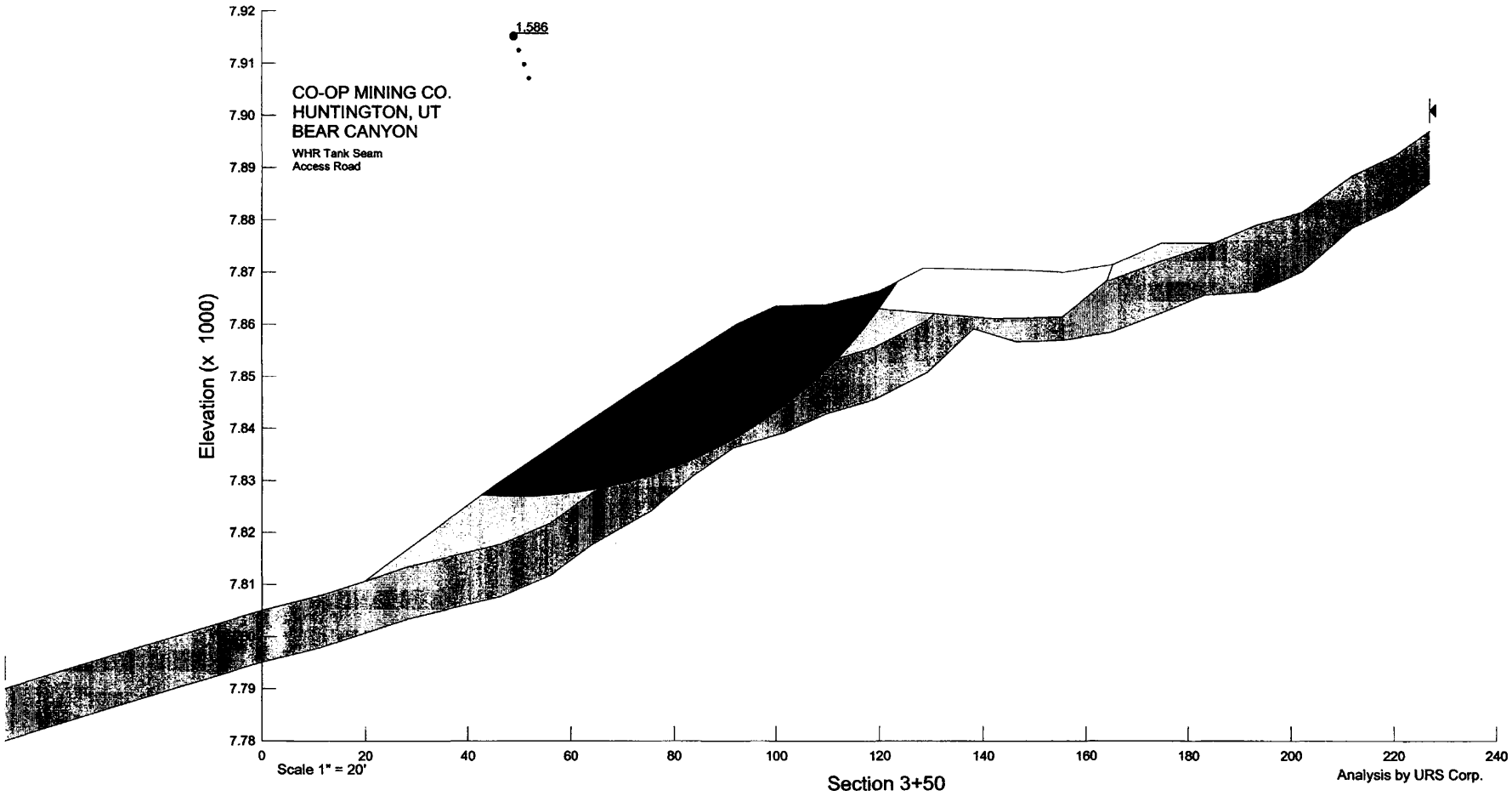
380
Scale 1" = 30'
Section 3+00 C
Analysis by URS Corp.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HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.586
Elevation (x 1000)
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7.91
7.90
7.89
7.88
7.87
7.86
7.85
7.84
7.83
7.82
7.81
7.79
7.78
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120
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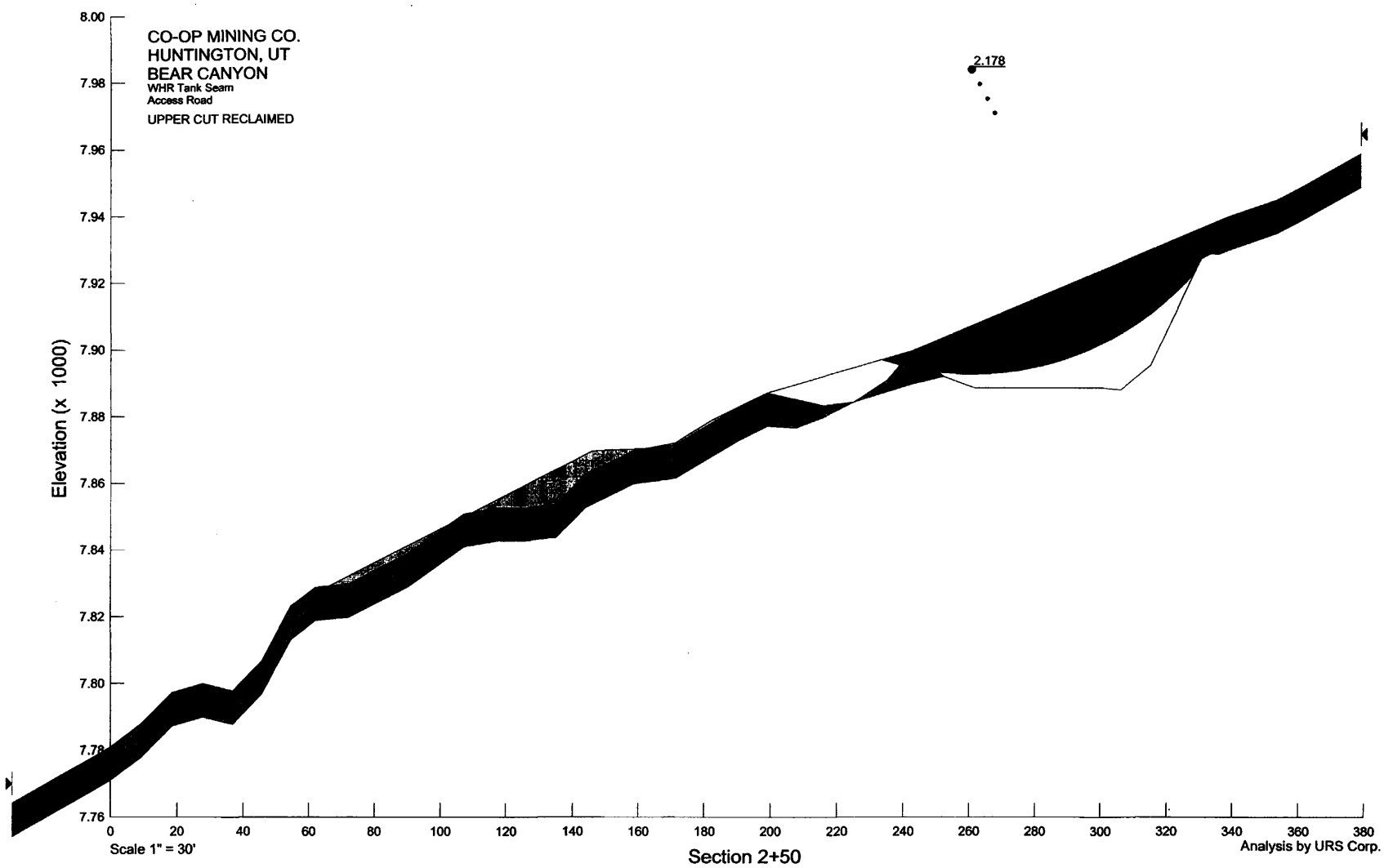
160
180
200
220
240
Scale 1" = 20'
Section 3+50
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
UPPER CUT RECLAIMED
2.178
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
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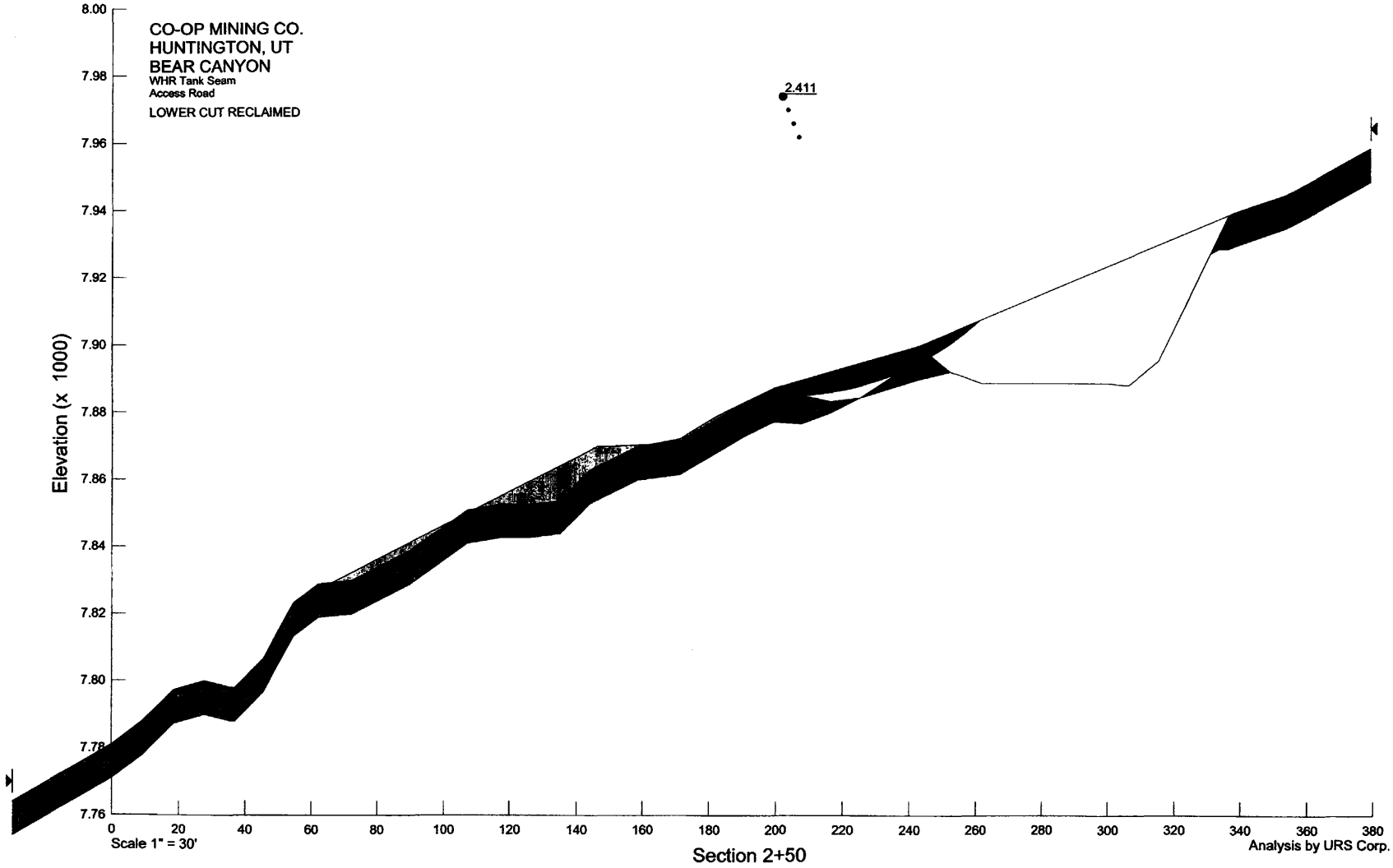
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 2+50
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
LOWER CUT RECLAIMED
2.411
Elevation (x 1000)
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7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
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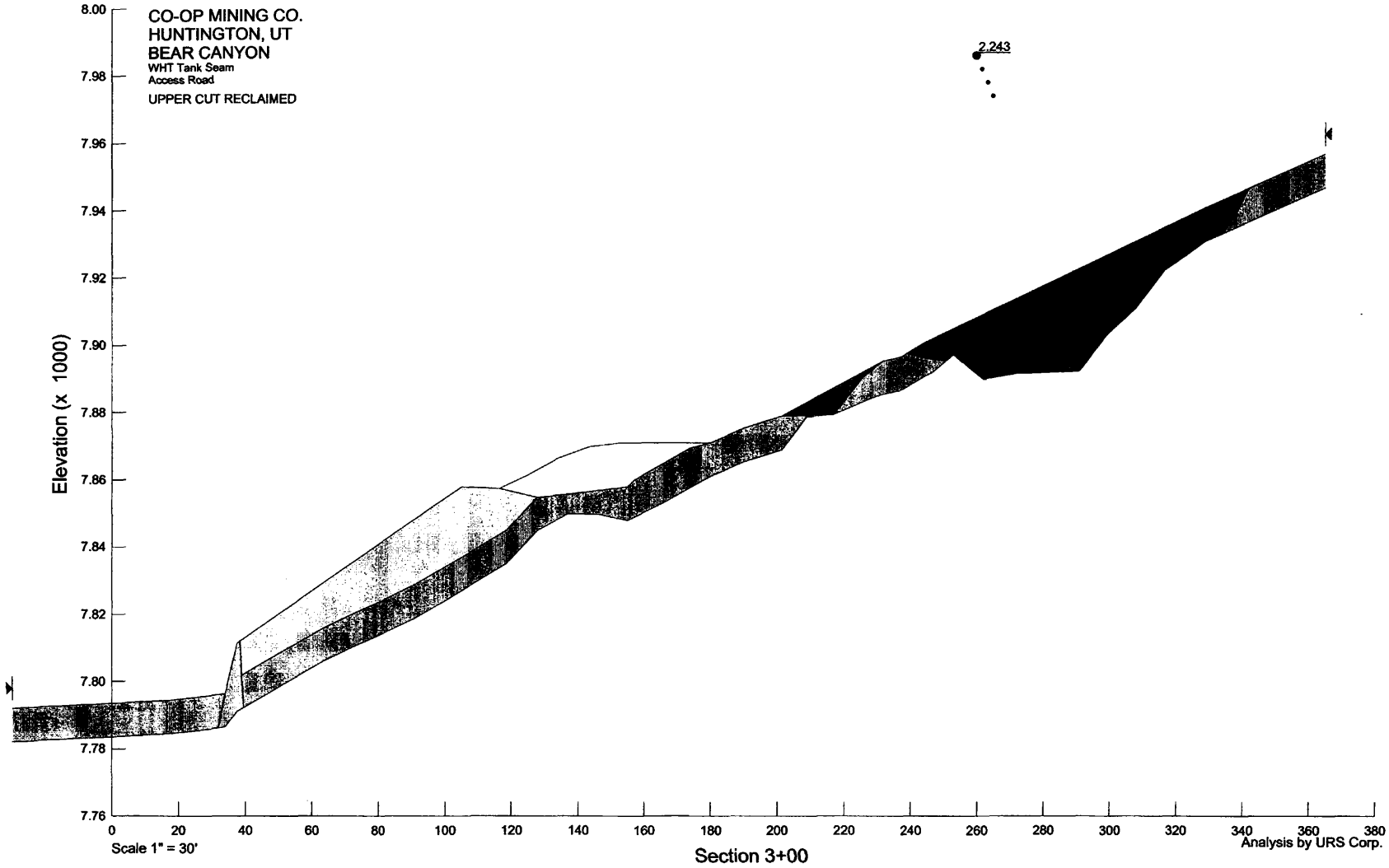
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 2+50
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHT Tank Seam
Access Road
UPPER CUT RECLAIMED
2.243
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
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260
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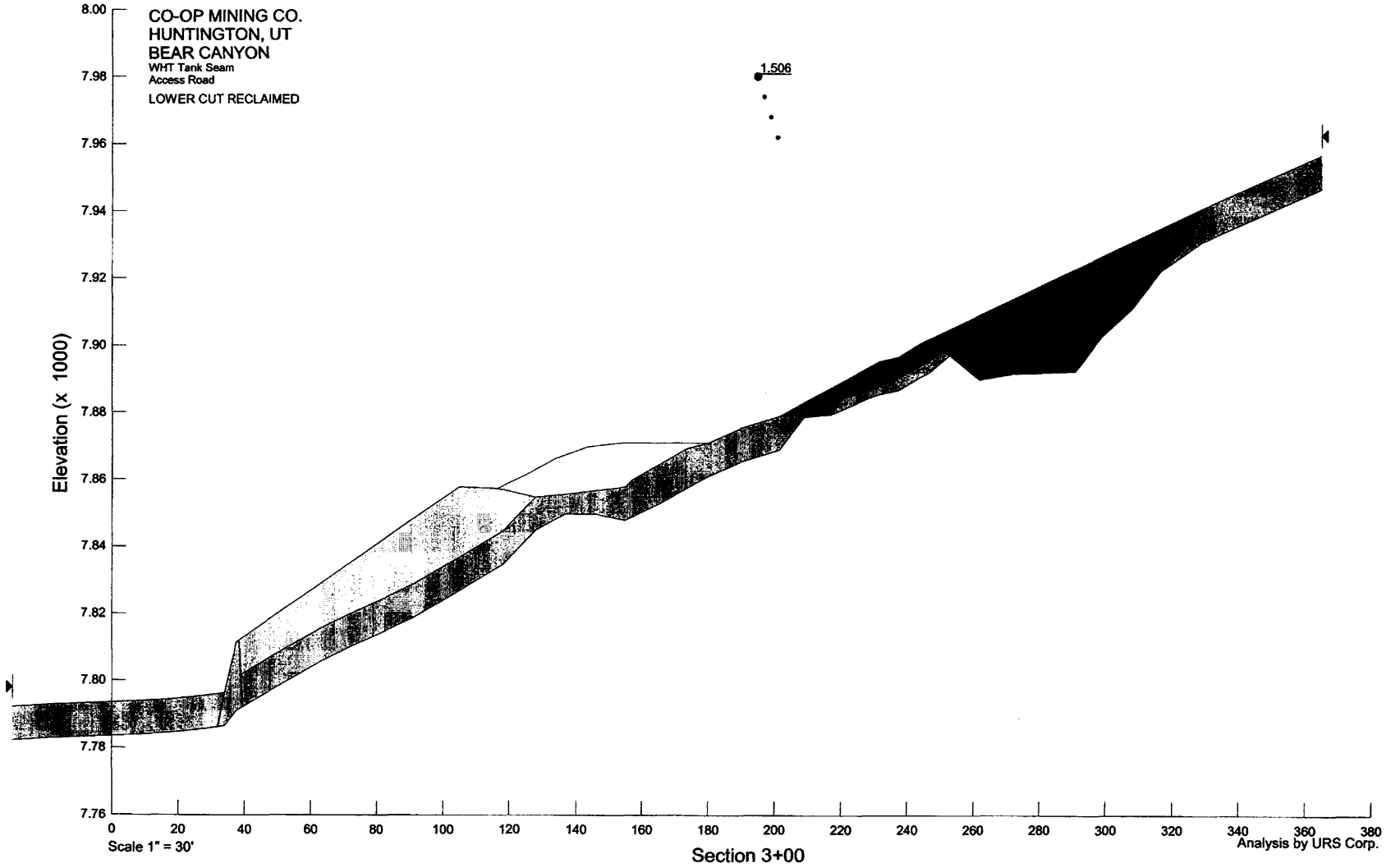
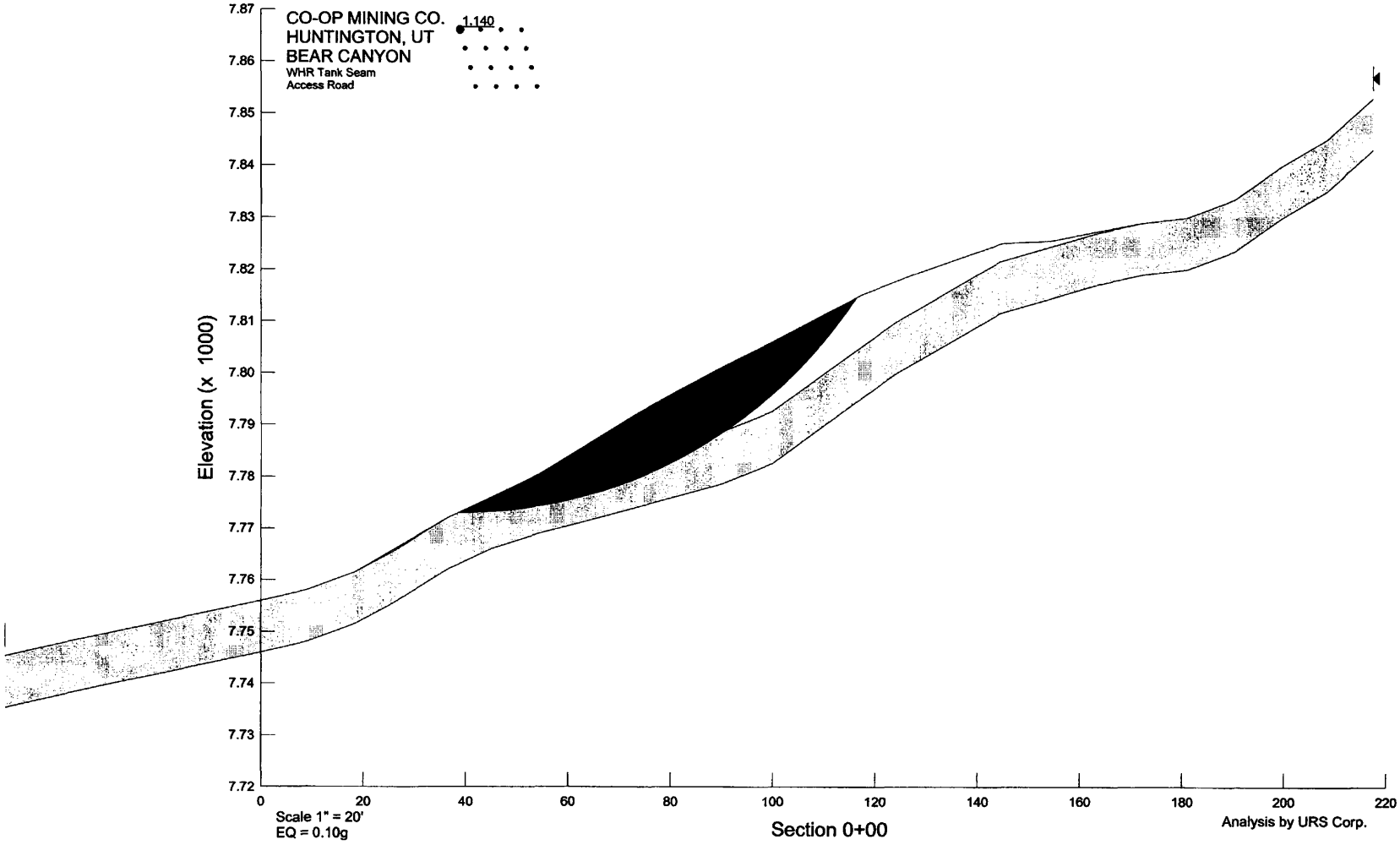
340
360
380
Scale 1" = 30'
Section 3+00
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHT Tank Seam
Access Road
LOWER CUT RECLAIMED
1.506
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
Section 3+00
Analysis by URS Corp.

APPENDIX B

CROSS SECTIONS OF DYNAMIC ANALYSES


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.140
Elevation (x 1000)
7.87
7.86
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7.83
7.82
7.81
7.80
7.79
7.78
7.77
7.76
7.75
7.74
7.73
7.72
0
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200
220
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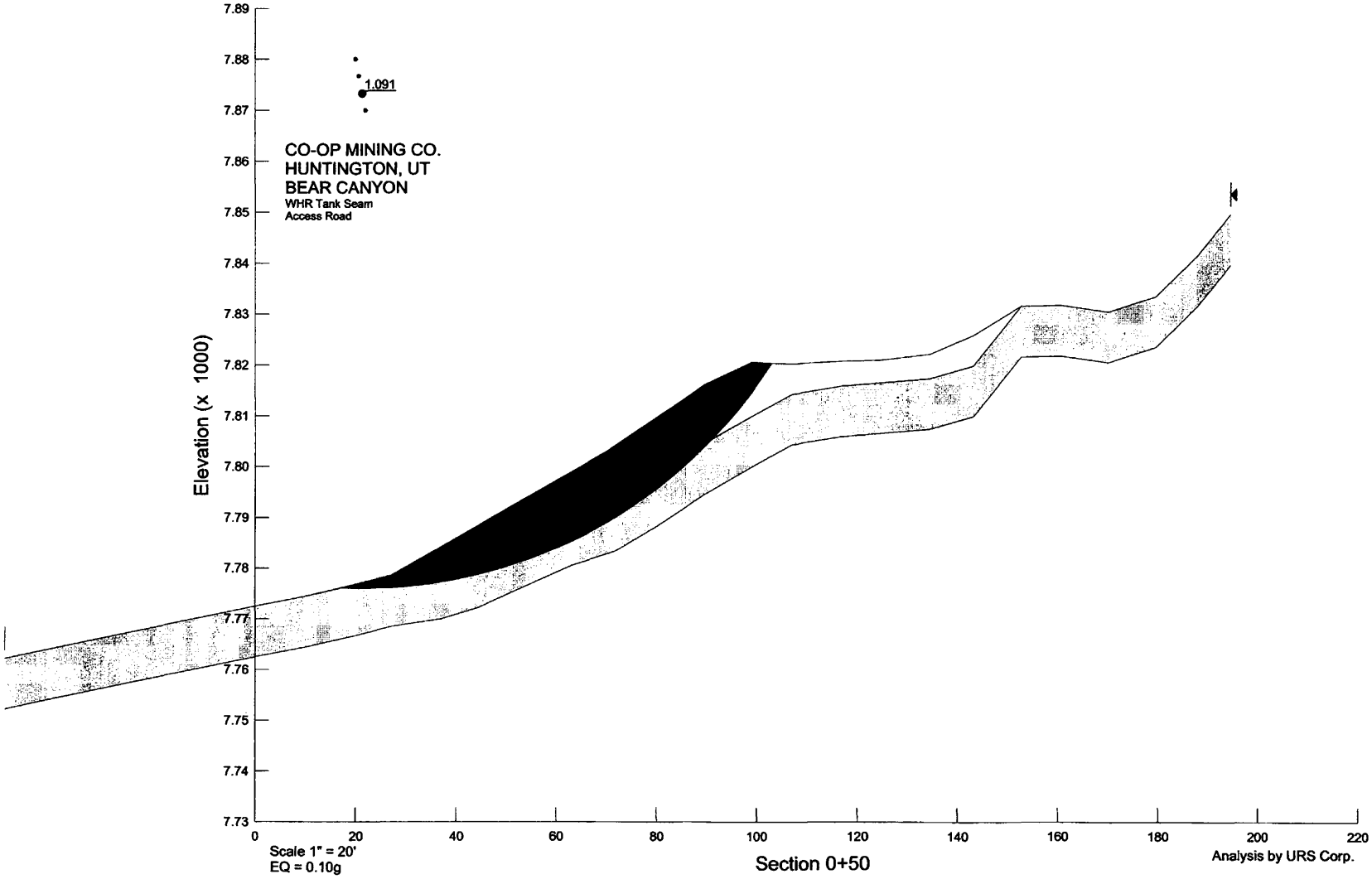
Section 0+00
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.091
Elevation (x 1000)
7.89
7.88
7.87
7.86
7.85
7.84
7.83
7.82
7.81
7.80
7.79
7.78
7.77
7.76
7.75
7.74
7.73
0
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40
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80
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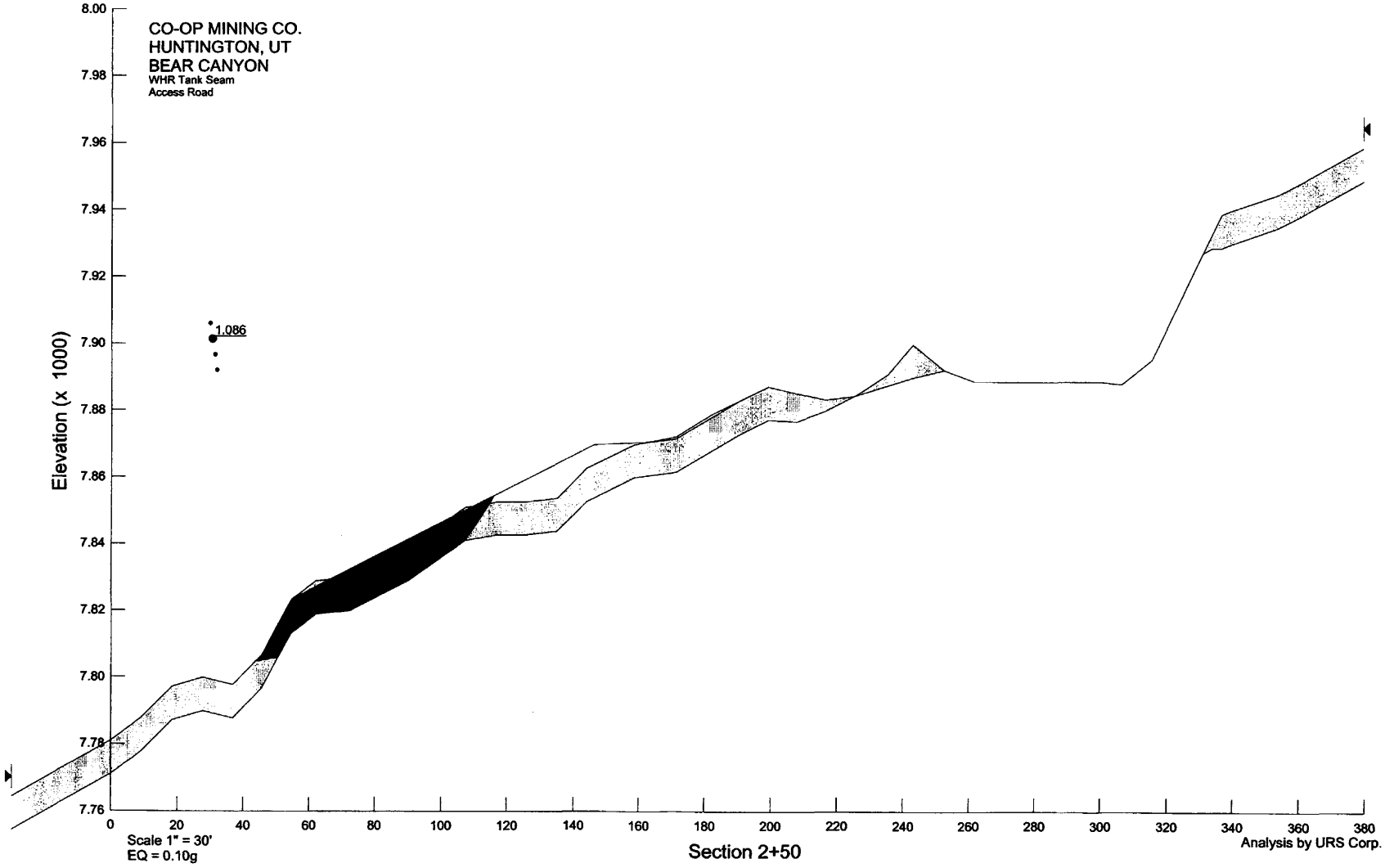
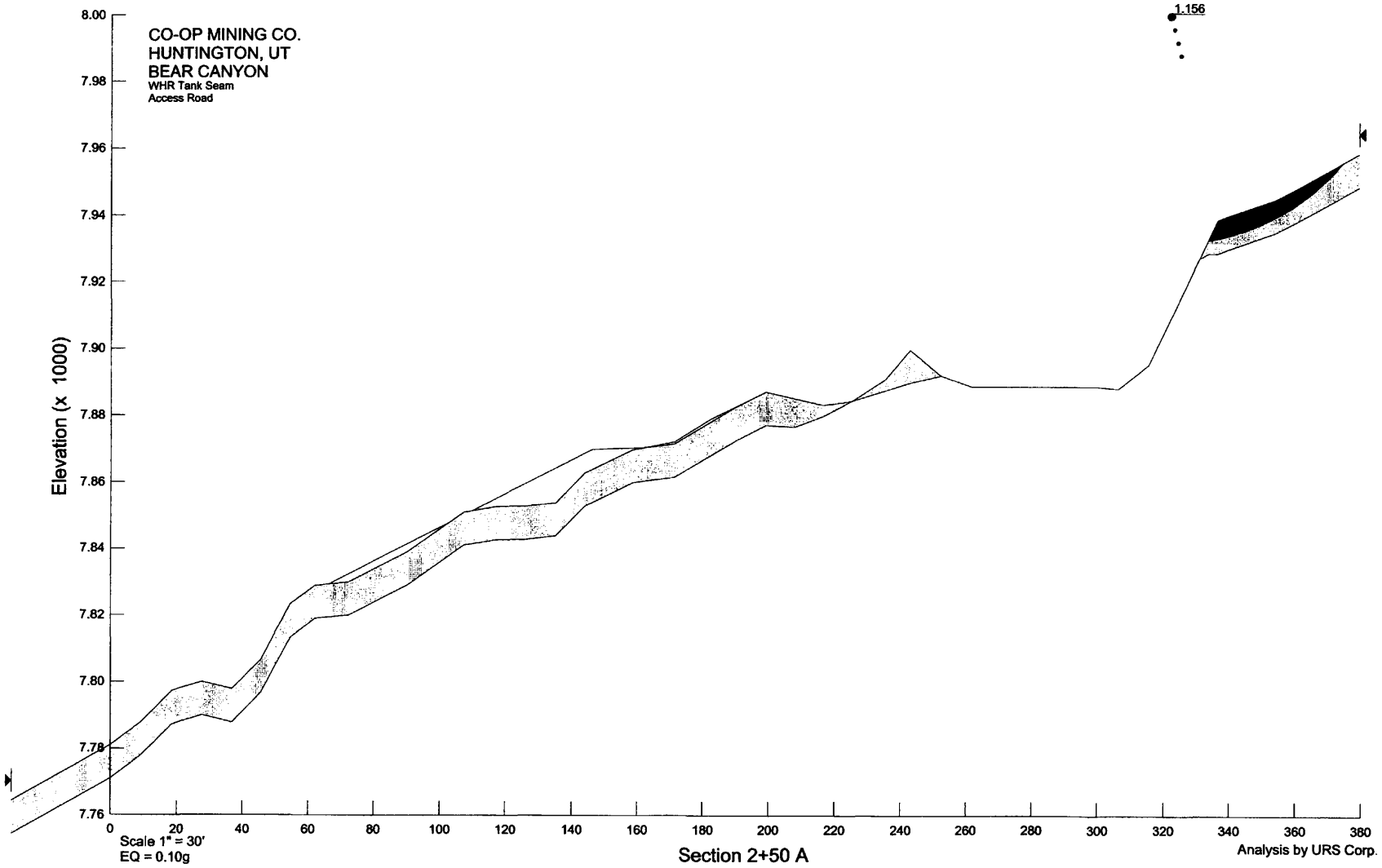
120
140
160
180
200
220
Scale 1" = 20'
EQ = 0.10g
Section 0+50
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.086
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 2+50
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.156
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
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280
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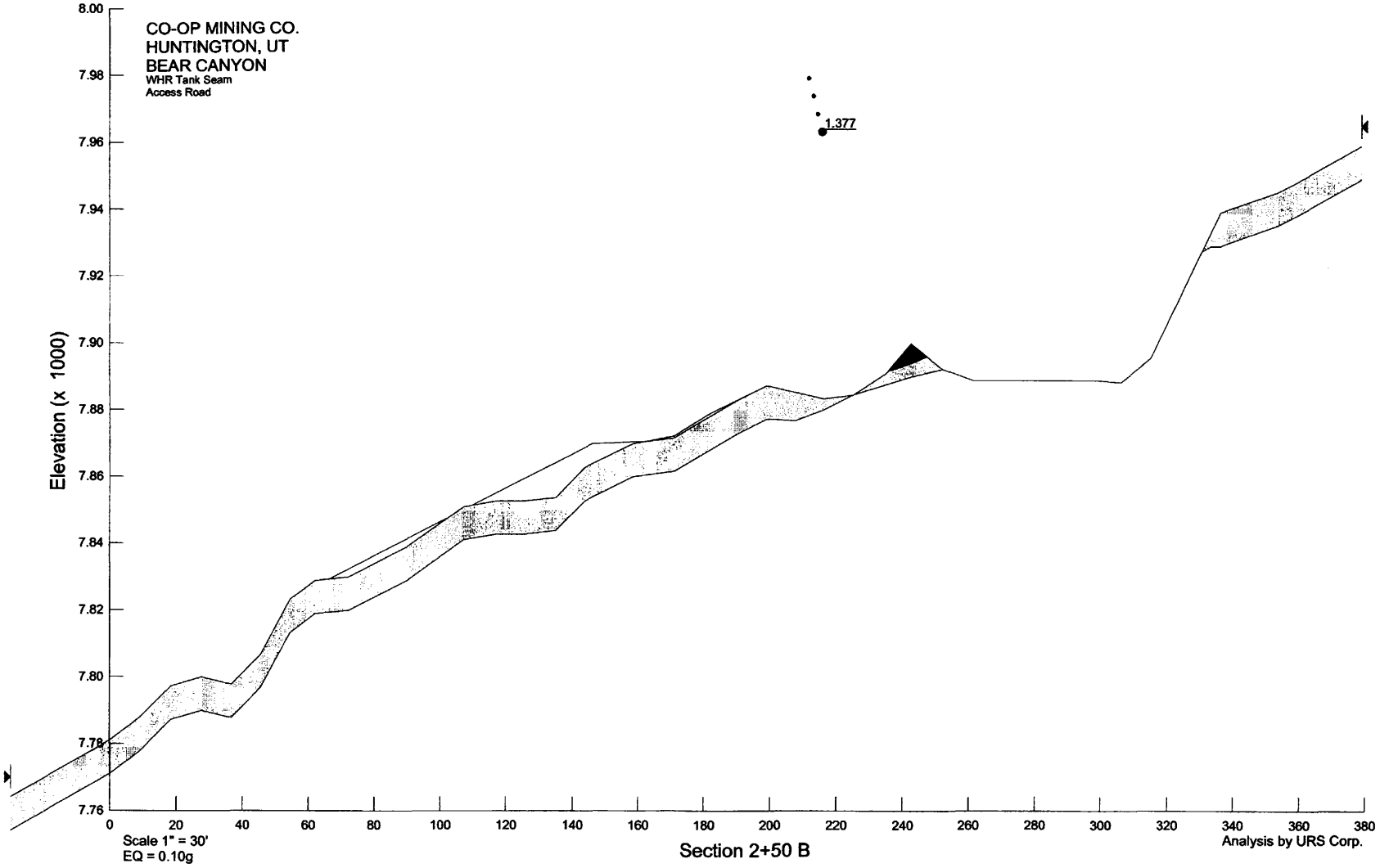
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 2+50 A
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.377
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
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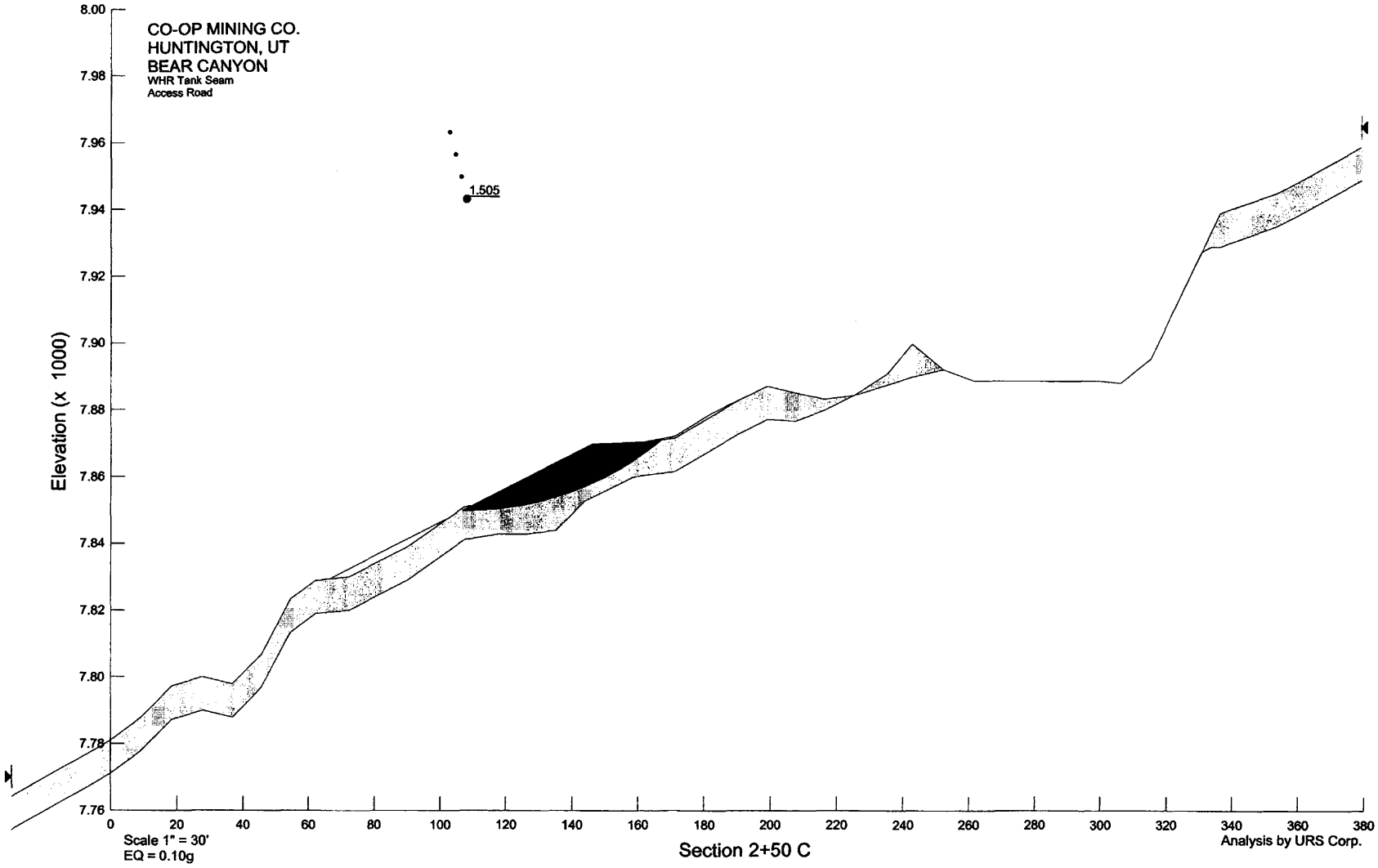
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 2+50 B
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.505
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
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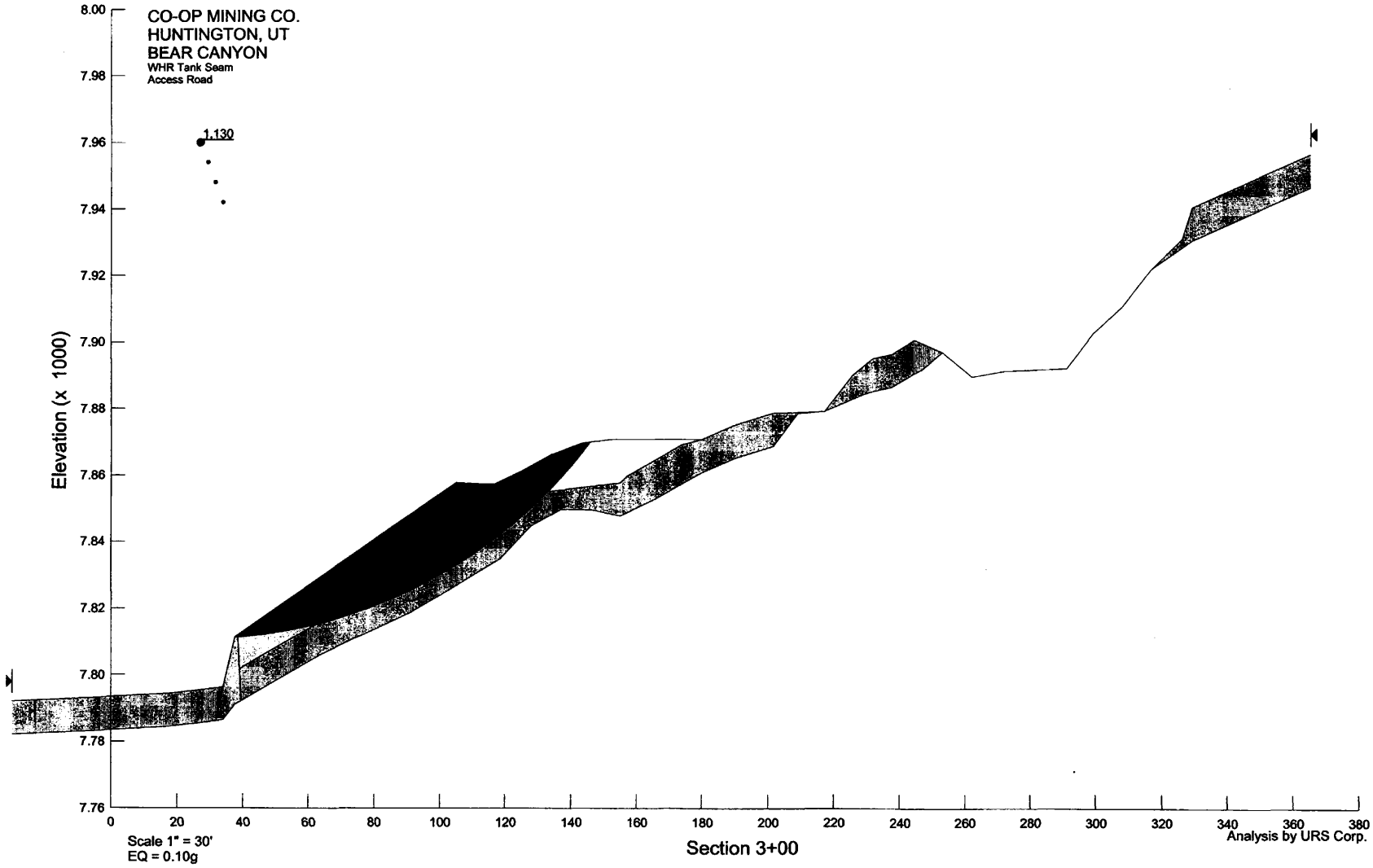
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 2+50 C
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.130
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
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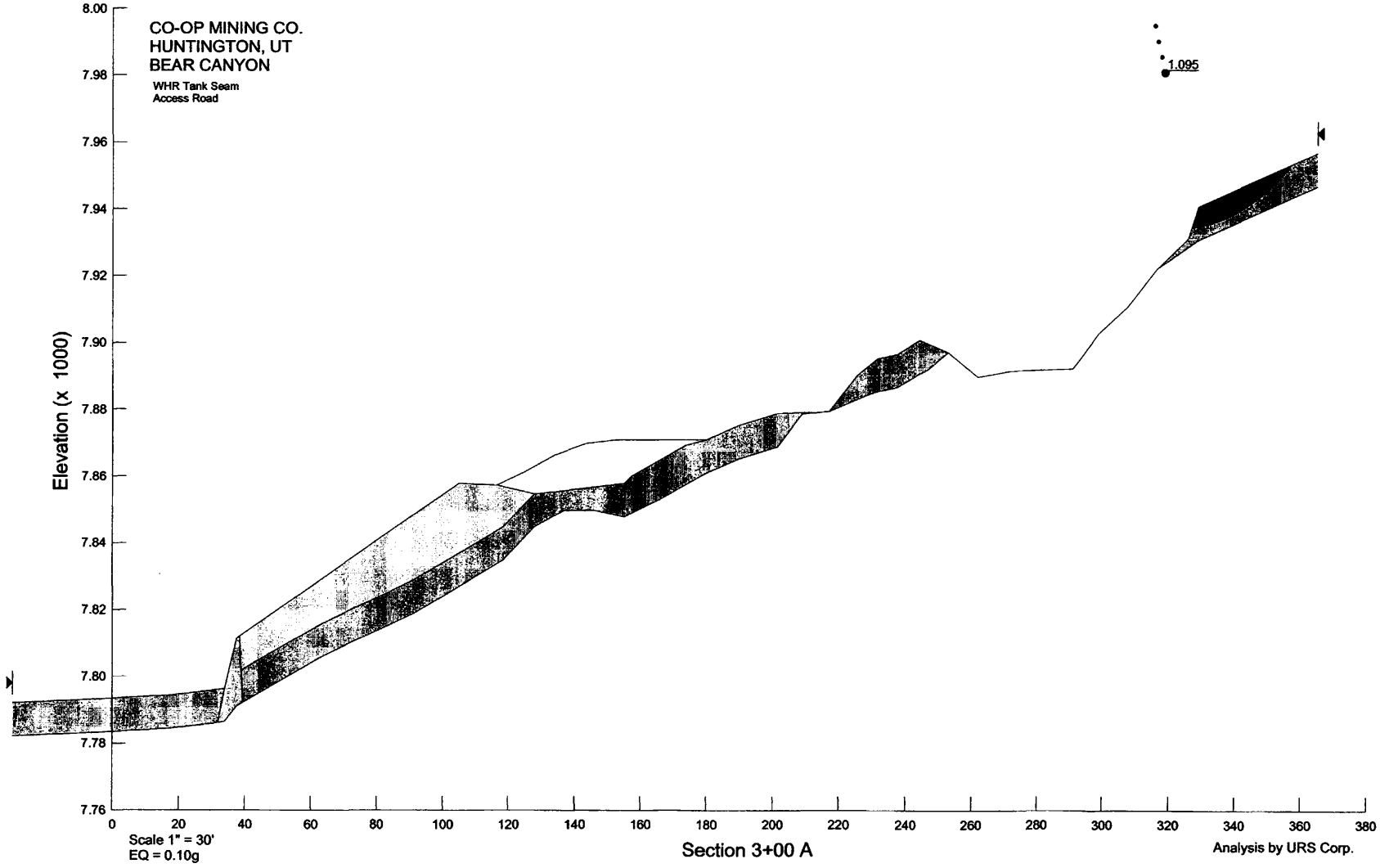
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 3+00
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.095
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
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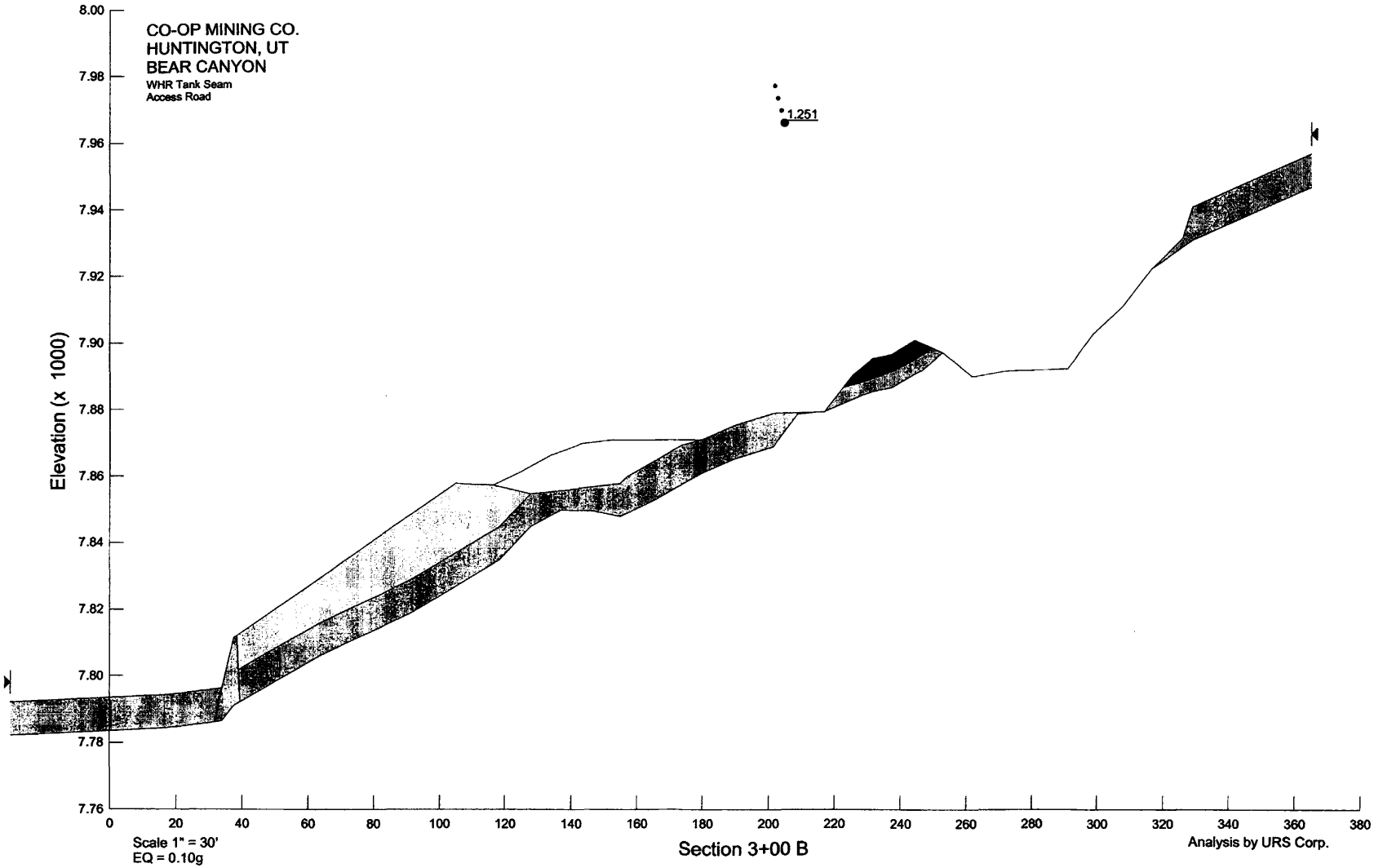
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 3+00 A
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.251
Elevation (x 1000)
8.00
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7.96
7.94
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7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
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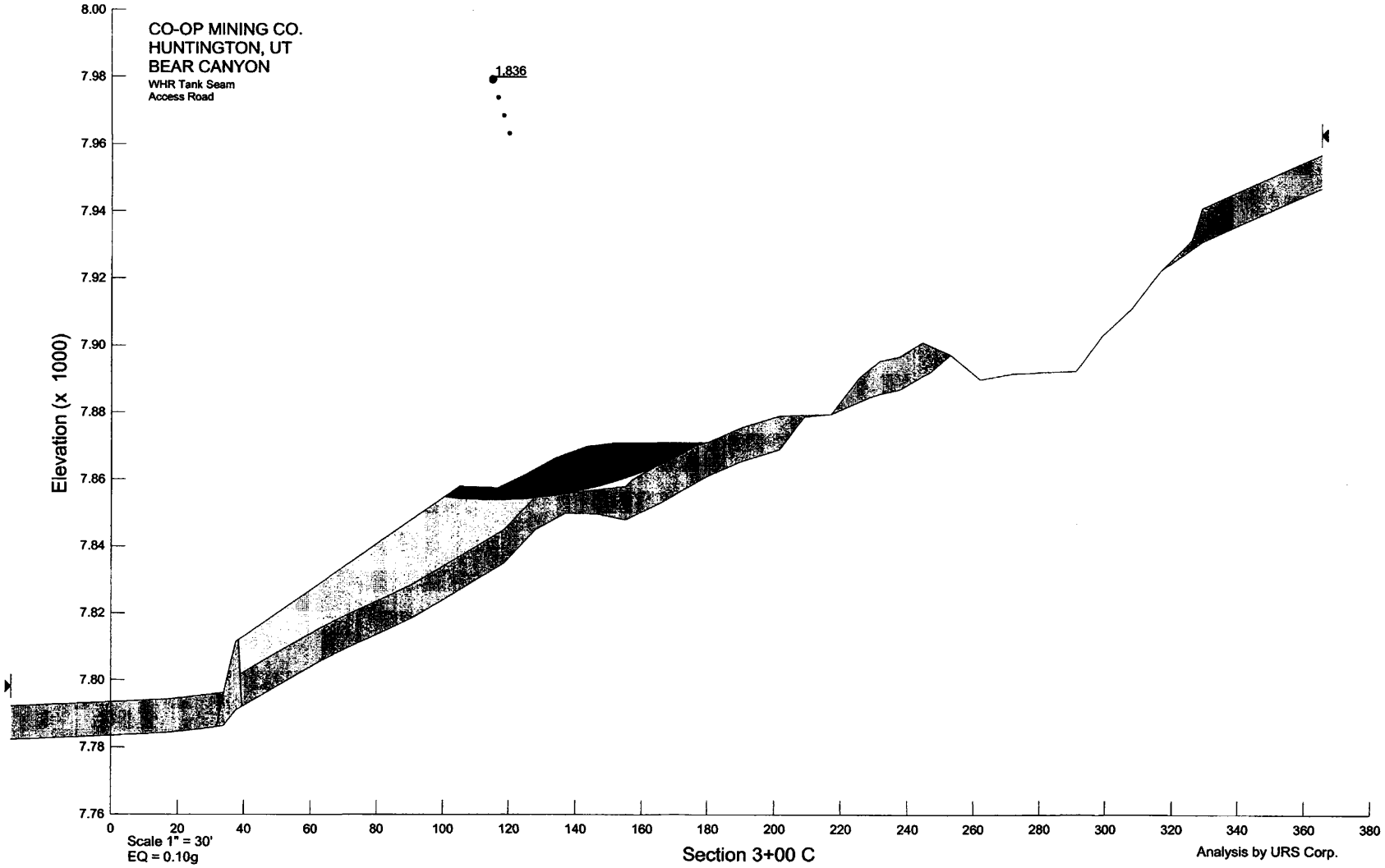
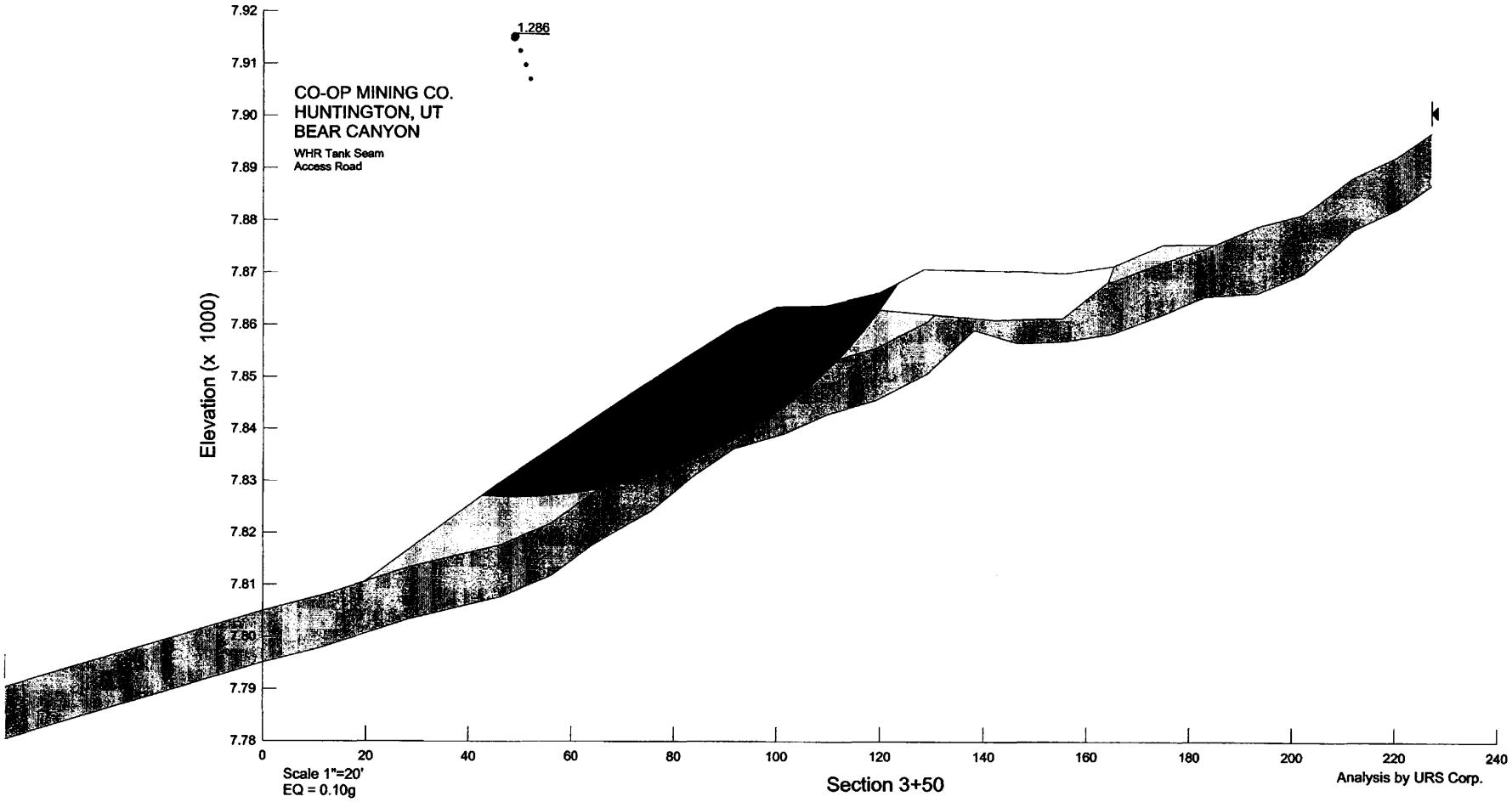
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 3+00 B
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.836
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 3+00 C
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
1.286
Elevation (x 1000)
7.92
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7.89
7.88
7.87
7.86
7.85
7.84
7.83
7.82
7.81
7.80
7.79
7.78
0
20
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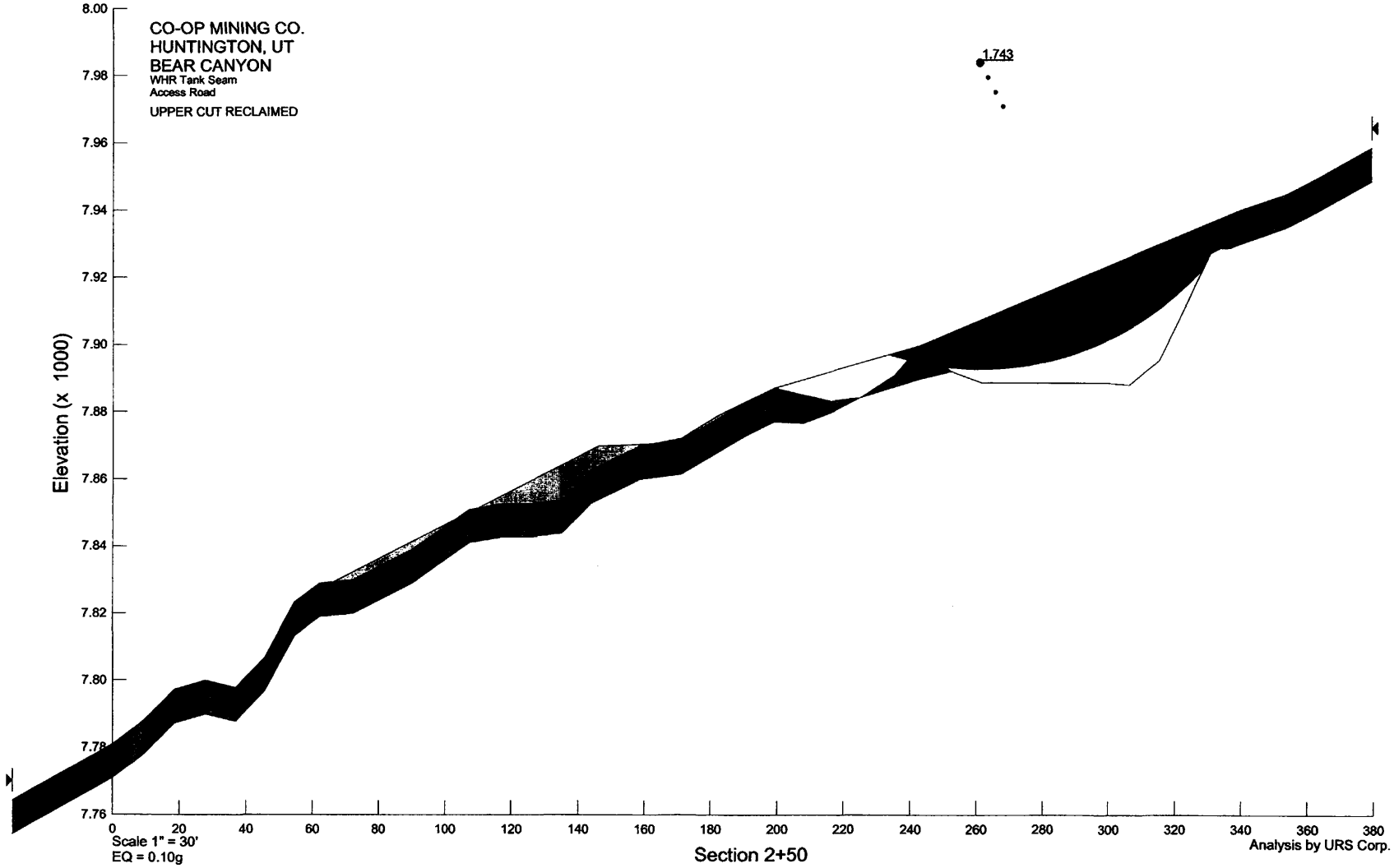
140
160
180
200
220
240
Scale 1"=20'
EQ = 0.10g
Section 3+50
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
UPPER CUT RECLAIMED
1.743
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
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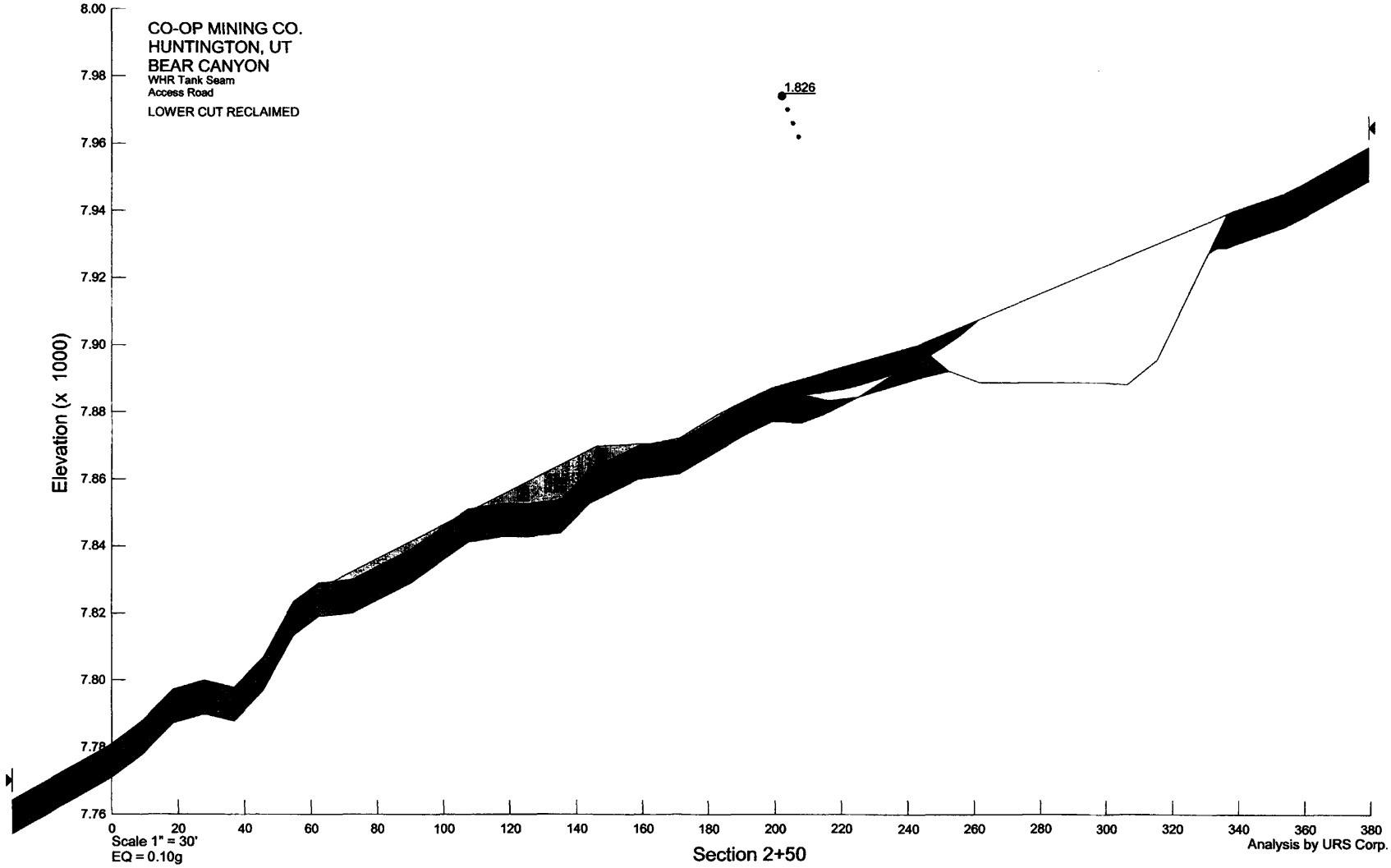
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 2+50
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHR Tank Seam
Access Road
LOWER CUT RECLAIMED
1.826
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
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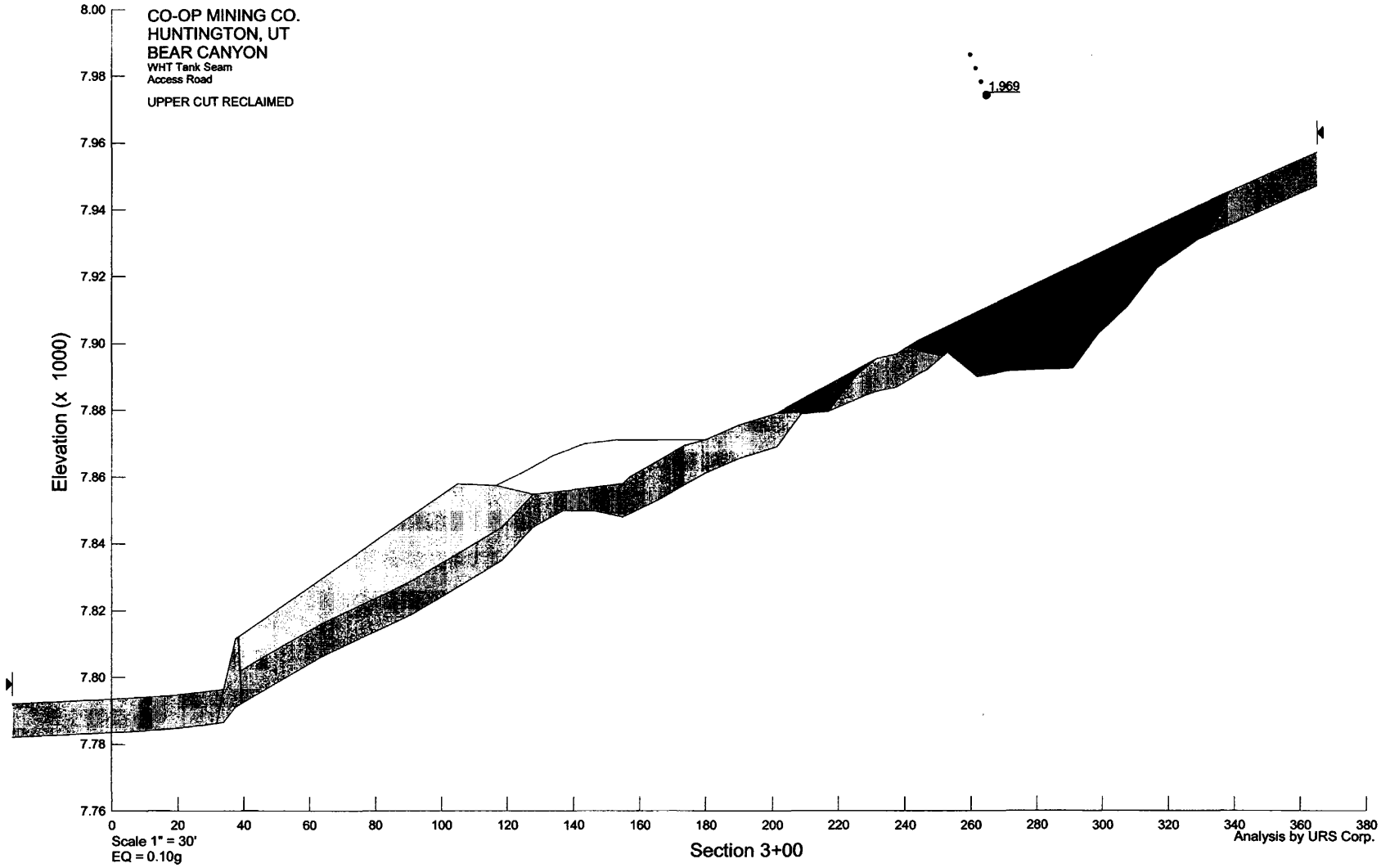
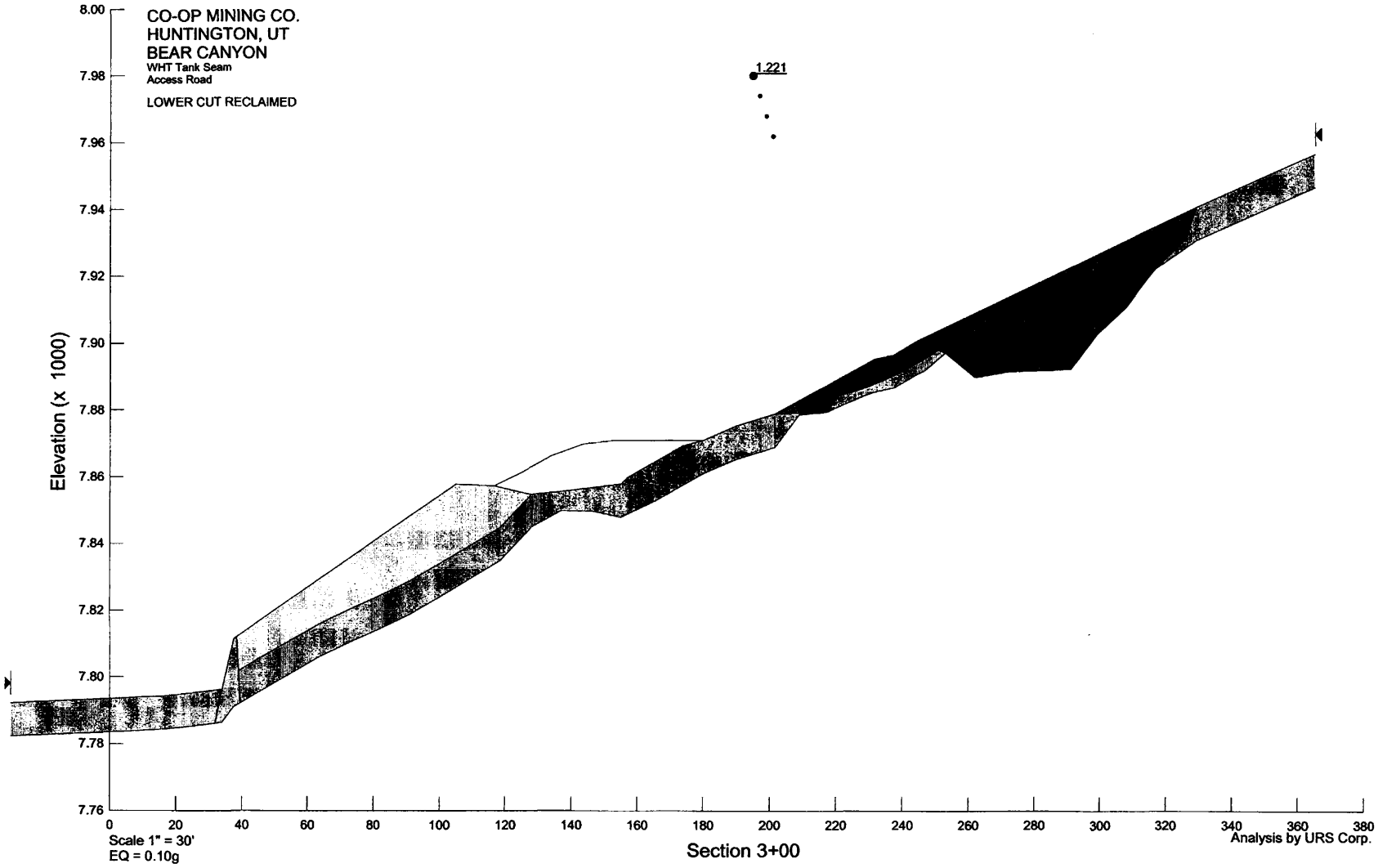
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 2+50
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHT Tank Seam
Access Road
UPPER CUT RECLAIMED
1.969
Elevation (x 1000)
8.00
7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 3+00
Analysis by URS Corp.


CO-OP MINING CO.
HUNTINGTON, UT
BEAR CANYON
WHT Tank Seam
Access Road
LOWER CUT RECLAIMED
1.221
Elevation (x 1000)
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7.98
7.96
7.94
7.92
7.90
7.88
7.86
7.84
7.82
7.80
7.78
7.76
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
Scale 1" = 30'
EQ = 0.10g
Section 3+00
Analysis by URS Corp.

APPENDIX 5-M

BLIND CANYON INTAKE PORTAL

BLIND CANYON INTAKE AND FAN PORTALS

In order to facilitate adequate ventilation across the working face as mining advances from the existing intake portals and to provide an alternative escape way, Co-op Mining requested approval for the blind Canyon Ventilation Portal as shown on Plate 5-1A. In addition to the main fan portal, a small breakthrough exists 80 ft to the north. This opening will be used as an intake portal. Three accidental breakouts have also been observed in the Bear Canyon Seam, two South of the main fan portal and one North of the intake portal.

Because of the proximity of the portals, the surface configuration and operations involved in their creation are similar. The portals are implemented form within the mine by utilization of standard mining methodology and implementation of a continuous miner. The portals simply extended to an exposed coal outcrop in the head of Blind Canyon. The outcrop originally had a 4 ft overhang made up of an overlying sandstone seam approx 12 ft thick. The coal being of a more erosive nature then the sandstone is incised into the slope. The toe of the coal outcrop is composed of broken ledge rock and lies on approximately a 70 pct slope. The nature and location of the outcrop precludes surface access by any means other than foot. Due to this, they are suitable for an escapeway in the event of a catastrophic closure of the existing portal area and is strongly supported by Co-op's safety personnel as well as M.S.H.A

The three accidental breakouts are the result of outcrop material caving into the entries adjacent to the portals.

The portals are supported by roof bolts, which extend into the sandstone rock above the coal. Where necessary, bolted matting will be used to minimize sluffing of rock. The intake portal will be closed with a cement stopping for later use. The intake portal will be closed with a cement stopping for later use. The stopping will prevent access of people as well as large animals, which could theoretically utilize the portal for denning. The fan portal will contain an escapeway door on the fan motor housing, which will only allow access from within the mine. A "No Trespassing" sign will be posted outside the portal. Accidental breakouts large enough to allow entrance into the mine will be fenced and stoppings built to prevent access into the mine.

Surface disturbance is minimal due to the nature of a continuous mining machine pulling the material into the mine. To meet MSHA requirements, a small pad, approximately 30 ft. by 60 ft., will be used in font of the portal for the fan structure. This will require the movement of approximately 240 cu. yds. Of material, which will be placed in a dry area inside the mine. Upon reclamation, the material pulled into the mine will be replaced (see Figure 5M-1). Bonding includes reclamation of the portal. No vegetation exists on the coal outcrop, which will be impacted. Coal debris, which crumbled and fell down the slope during portal construction had been retrieved by hand to whatever degree is reasonable. It is important to note that due to the exposed nature of the coal seam, there is eroded coal presently on the slope.

The drainage form above the portal is minimal due to the size of the impacted area next to the portal. Any water falling on the pad will be contained with a berm. This area of the mine is dry, and no water will be discharged from the portals.

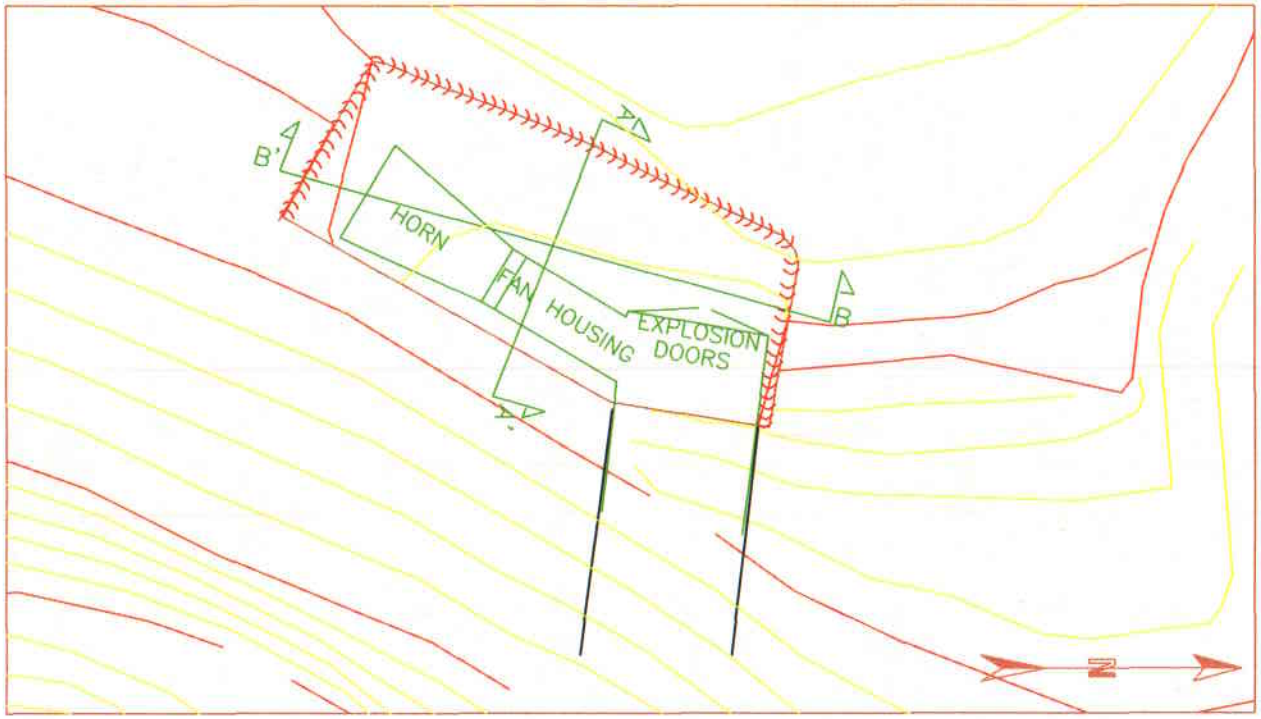
RECLAMATION

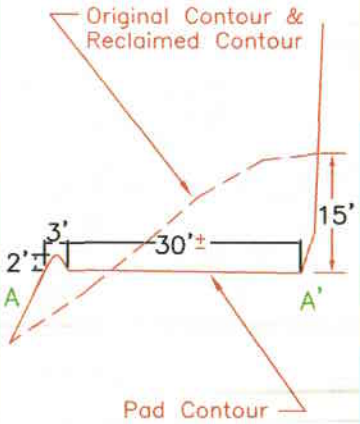
It is anticipated that the reclamation can be accomplished form within the mine by removing all support structures. An LHD will be used to replace the pad material. A D-2 Class Crawler dozer will be utilized to push non-combustible fill into the portals for a minimum distance of 25 ft. A seal will be installed as pictured in Chapter 5, Figure 5-3. The natural appearance of the canyon will be re-established with only the sealing of the portal due to the total lack of vegetation on an exposed seam.

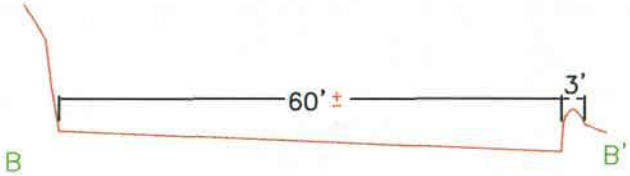
Minimal adverse impacts are anticipated to the surrounding environment. Surface water will not enter the mine due to the overhanging ledge and dip of the coal seam at this point. Also, this is a dry area of the mine, so no mine water is anticipated to be discharged from the portal. If water were to be encountered, Co-op would take whatever action was necessary to contain this water within the mine.

There are no raptor nests present within a half mile of the portal as noted on Co-op's most recent raptor survey.

When the fan is installed there will be an increase in noise anticipated in the area, but due to the constant nature of the fan related noise the impact should be minimal. In order to reduce disturbance during periods of construction, work will not be accomplished during elk calving period or deer fawning periods. Vegetation and forage loss is not anticipated due to the absence of vegetation on an exposed coal seam.







CO-OP MINING CO.		
FAN PORTAL PAD BLIND CANYON		
SCALE: 1" = 25'	DRAWN BY: C. Reynolds	DATE: 10-26-92
BEAR CANYON	FIGURE 5M-1	

APPENDIX 5-N

SHOWER HOUSE WASTE DISPOSAL SYSTEM

SHOWER HOUSE WASTE DISPOSAL SYSTEM

The shower house facilities are designed for a capacity of 120 persons. It is estimated that the flow rate will be approximately 25 gallons per day per person (Uniform Plumbing Code, Appendix 1). This gives the total flow rate of 3,000 gpd.

The waste disposal system will consist of a sewage line, which will drain into a septic tank, and a disposal field for the wastewater. The size of the septic tank shall be at least 3,375 gallons in capacity as required in R317-5-2.2 (R317-5, Utah Administrative Code).

The disposal field will consist of three absorption trenches. The dimension of the trenches will be 3 ft wide by 100 ft long by approx 11 ft deep. Each trench will be constructed in the following manner: 6 ft min of large rock for disposal area (3"-12" md), 8 inches min of ½"-2 1/2 " md gravel contained the disposal field inlet pipe, a straw barrier above the gravel and minimum of 3 ft fill above the disposal field. This will allow a minimum area of 4,600 sq ft for percolation. This area provides an adsorption capacity of 10,120 gallons per day, with a safety factor of 1.84, nearly twice the required capacity. An estimated percolation rate of 2.2 gal per sq ft was used in calculations (R317-5-3.2 (A)). Upon excavation, actual percolation tests will be performed.

The disposal field will be located a minimum of 100 ft form Bear Creek, as shown on Plates 5-2B and 7-1B. Due to the restricted amount of area, the disposal field will be located beneath the parking area. Adequate fill will be placed above the disposal field to prevent any impact on the parking area (settling, etc).

Prior to construction, necessary permits will be obtained form the Utah Pollution Control Committee. The wastewater disposal system will be constructed in accordance with all applicable state federal regulations.

APPENDIX 5-O

SEDIMENT POND MATERIAL

SEDIMENT MATERIAL

Over the life of the mine, sediment from the disturbed area will accumulate in sediment ponds "A", "B" and "C". In order to comply with requirements for available runoff storage, sediment materials will be removed from the ponds and taken to the sediment pond waste storage area shown on Plate 5-2C. Because the Trail Canyon Mine site (ACT/015/021) is a reclaimed site, sediment material removed from the Trial Canyon sediment pond will also be taken to the sediment pond waste storage area shown on Plate 5-2C.

The following items apply to placement of the sediment (fill) material:

a. The sediment pond storage area lies within the disturbed area and all runoff passing through the area will pass through required sediment control structures (Plate 7-1).

b. The disposal area is only moderately sloping and very stable with an overall slope of approximately 1x: 6h. This slope will be maintained.

c. The sediment pond fill material will be taken form the pond and placed in horizontal lifts not to exceed 24 in. The material will be compacted to reduce erosion. During the life of the mine the total depth of the material will not exceed 4 ft in any one location.

d. Due to the nature of the site the material will be covered with coal storage for most of the calendar year. This will help improve and maintain stability and increase compaction.

e. The fill shall be inspected by a qualified professional or registered professional engineer during placement and compaction of fill materials. A certified report will be provided to UDOGM within two weeks after each inspection. A copy of the report will be retained at the mine site.

f. As the pond is being cleaned, temporary sediment material storage will be in the area shown on Plate 5-2C along the road and truck loading area.

g. While located in the temporary storage area two composite random samples will be taken and tested following the laboratory methodologies, and constitutions analyzed as listed in Table 5O-1.

Parameters	Reported As	Suggested Methods
pH		ASA Mono. No. 9, Part 2, (2 ed), 1982. Method 10-3.2, page 171. Perform pH on saturated paste.
Electrical Conductivity (ECe)	mmhos/cm 25°C	ASA Mono. No. 9, Part 2 (2 ed), 1982. Method 10-3.3, pages 172-173.
Saturation Percentage	%	SP = 100(total wt of water)/ (wt of oven-dry soil). Wts of water and soil known when making a saturated paste.
Particle Size Analysis (texture)	% sand, silt, clay	Hydrometer method. Black et al. 1965. Methods of soil analysis. ASA Mono No. 9, Part 1, method 43-5, pages 562-566.
Soluble Ca, Mg and Na	me1/l	ASA Mono. No. 9, Part 2, (2 ed), 1982. Method 10-3.4. pages 173-174.
Sodium Adsorption Ratio	SAR calculated from soluble Ca, Mg & Na	$\frac{[Na^+]}{([Ca^{2+} + Mg^{2+}]/2)^{0.5}}$
Selenium	mg/Kg	Extraction by ASA Mono. No. 9, Part 2 (1 ed), 1965. Method 80-3.2, page 1122. Analyze by Hydride generation for AA or ICP. ASA Mono. No. 9, Part 2 (2 ed), 1982. Method 3-5.5, pages 59-61.

Table 50-1 Analytical Parameters for Overburden

Parameters	Reported As	Suggested Methods
Total N	%	ASA Mono. No. 9, Part 2 (2 ed), 1982. Method 31-3, pages 610-616.
Nitrate-N	mg/Kg	ASA Mono No. 9, Part 2 (2 ed), 1982. Methods 33-4.1, pages 643-645; 33-8.3, pages 679-682 or Sims J. R., and G. D. Jackson. 1977. Soil Sci. Soc. Am. Proc. 35:603-607.
Boron	mg/Kg	ASA Mono No. 9, Part 2 (2 ed), 1982. Method 25-9.1, page 443 for extraction and Method 25-5, pages 443-446 for analysis.
Maximum Acid Potential	%	US EPA. 1978. EPA - 600/2-78-054. Method 3.2.4, Page 51.
Neutralization Potential	%	US EPA. 1978. EPA - 600/2-28-054. Method 3.2.3, page 47.
Organic Carbon	%	ASA Mono No. 9, Part 2 (2 ed), 1982. Method 29-3.5.3, pages 571-573.
Exchangeable Sodium*		ASA Mono No. 9, Part 2 (2 ed), 1982. Method 13-4.4, pages 238-241. Using Flame Emission and using extractates in method 8-3, page 152.
Available Water Capacity	in/in	USDA SCS Soil Survey Investigation Report No. 1, Method 4C1, page 24.

Table 50-1 Analytical Parameters for Overburden (Cont)

Parameters	Reported As	Suggested Methods
Rock Fragments	% Volume	USDA SCS Soil Survey Investigation Report No. 1, Method 3B, Page 18.

Acid/Base Account AB = Total Neutralizing Potential minus Total Acid Potential.

*If samples have a SAR greater than 12 for clay textured soils or greater than 15 for sandy textured soils, then exchangeable sodium % should be analyzed.

1146R01-22

Table 50-1 Analytical Parameters for Overburden (Cont)

Appendix 5-P

#4 MINE AUXILIARY PORTAL

#4 Mine Auxiliary Portal

This portal is located in the left fork of the right fork of Bear Canyon. It will primarily be used for water monitoring access to seeps and springs located in the area that are normally inaccessible during winter months. If needed in the future this portal could also be used for intake ventilation to facilitate adequate ventilation across the working faces. Although this is not one of the MSHA required escapeways, in the extremely unlikely event that miners are unable to use either the primary or secondary escapeway, they could be evacuated through this portal. Although C. W. Mining does not anticipate this occurring if it did miners would be transported from the portal opening by helicopter. Access to this portal from the outside is similar to access to the Blind Canyon Portal described in Appendix 3-I and this portal is also strongly supported by C. W. Mining safety personnel as well as M.S.H.A.

Construction

The construction and reclamation of this portal will be similar to the Blind Canyon portal just the the uses are similar. The portal will extend to a coal outcrop that is covered by soil ranging from 0 to 3 inches in depth. The portals will be 6 to 8 feet tall, 9 to 18 feet wide and will be supported by roof bolts which extend into the sandstone rock above the coal Where necessary additional support will be used and may include matting, screens, cribs, timber, and metal canopies. The portal will be closed with a stopping which will prevent unauthorized access of people as well as large animals which could theoretically utilize the portal for denning. A "No Trespassing" sign will also be posted outside the portal.

The topsoil will be removed from the area by hand and placed in a pile next to the anticipated opening. It will then be transported to a dry location underground once the portal is established. Surface disturbance will be minimal due to the nature of a continuous mining machine pulling the material into the mine. Any soil material that is pulled into the mine will be placed in a dry area inside the mine and will be stored for reclamation. Any coal or waste material which might crumble and fall down the slope will be retrieved by hand to whatever degree is reasonable.

The drainage from above the portal is minimal due to the size of the impacted area and the fact that the portal opening will be on a natural crest causing the water to flow away from the portal. In the event that any water does flow down in to the portal a berm will be constructed by hand above the portal opening to facility the flow of water around the portal opening.

Reclamation

Reclamation will be accomplished from within the mine similar to the Blind Canyon Portal. The topsoil material being stored in mine will be placed outside next to the portal opening. Fill material will then be hauled through the mine and backed filled to a depth of 25 feet using underground equipment such as skid loaders and scoops. A permanent cement seal will then be built in the portal. The topsoil will be spread with underground equipment as much as possible before the hole is completely sealed. After the portal is sealed the remaining topsoil work will be done by hand. For revegetation seeds and erosion control matting will be hauled in by hand and placed over the disturbed area.

Chapter 6

R645-301-600 Geology

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R645-301-600 Geology

R645-301-610 Introduction

This chapter describes the general geological conditions of the permit and adjacent areas and identifies whether the conditions are acceptable for recovery of the coal by underground methods.

R645-301-611 General Requirements

Descriptions of the geology within and adjacent to the permit area is given under R645-301-620 through 627.

R645-301-612 Cross-Sections Maps and Plans

All cross-sections, maps, and plans as required by R645-301-622 have been prepared and certified as described under R645-301-512.100

R645-301-620 Environmental Description

Regional and Structural Geology

The mining site lies at the base of an erosional escarpment that forms the eastern face of the Wasatch Plateau, a subdivision of the Colorado Plateau physiographic province. East of the Wasatch Plateau is Castle Valley, a relatively flat area over 80 mi long and 10 mi wide trending northeast-southwest. East of Castle Valley lies the San Rafael Swell, a great upfold marked by rings of hogback hills and intervening valleys.

The Wasatch Plateau is a high, broad, flat area dissected by numerous streams. The high plateaus of Utah, which include the Wasatch Plateau, are thought to be a transition zone containing geologic structures common to both the Colorado Plateau Province and the Basin and Range Province to the west.

The C.W. mining site is located near the east central edge of what is known as the Wasatch Plateau coalfield. The plateau edge is a steep cliff with a maximum relief of about 1,000 ft, coal outcrops appear in the canyon walls and along the cliffs. Rock types at the site are late Cretaceous in age and are generally composed of gray sandstone of fine to medium grain, interbedded with subordinate gray and dark gray carbonaceous shale and coal present with continental and/or transitional sediments. Marine sediments occur below the sequence and are exposed to the east of the escarpment in the Castle Valley.

Table 6-1 gives the generalized stratigraphic sequence and unit description of the Wasatch Plateau. The oldest rocks are of the early upper Cretaceous age. The major commercial coal seams occur in the Black hawk formation and are of Campanian age.

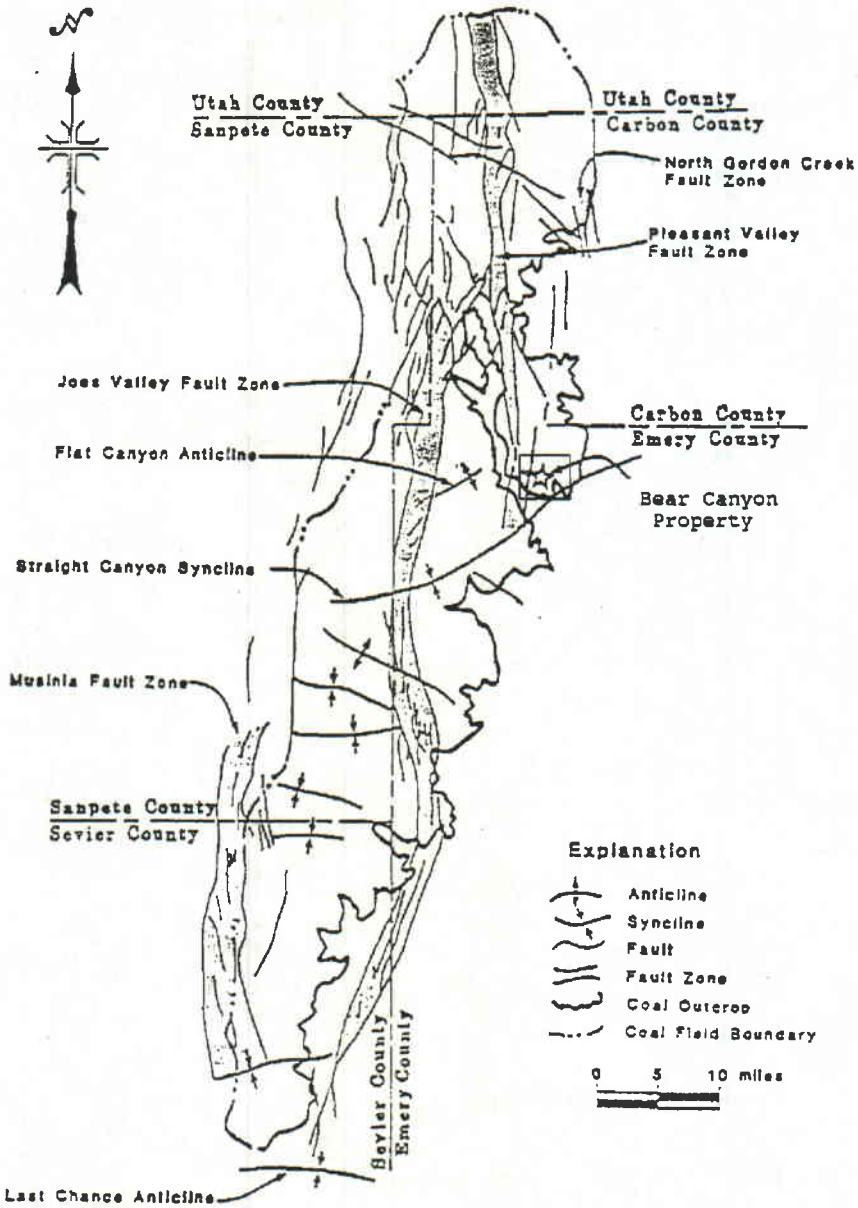
Structurally, strata in the Eastern Wasatch Plateau generally dip southerly (sometimes slightly southeast of southwest) at low angles of 1 to 3 deg. Locally, near faults, the dip increases to about 20 deg. Three major north-south trending fault zones have been defined in the Wasatch Plateau Coal Field (Figure 6-1). Each zone is the product of a high angle block fault with extensive minor fracturing within the graben. The Joes Valley Fault is the largest zone. As shown in Figure 6-1, the zone lies several miles west of the Co-Op permit area. The Pleasant Valley Fault Zone is vertical with between a few ft to 100 ft displacement (Doelling, 1972), although greater displacement occurs locally. The Bear Canyon #1, #2, #3, and #4 Mines operate within this fault zone. The North Gordon Fault Zone, which occurs near the eastern boundary of the Wasatch Plateau field, is the least extensive of the zones. The trends of the faults have a complex pattern. Displacement is generally less than 800 ft (see Plate 6-1 for a larger scale view of faults within the permit area).

TABLE 6-1 Generalized Section of Rock Formations, Wasatch Plateau Coal Field[1]

System	Series	Stratigraphic Unit		Thickness (feet)	Description
TERTIARY	Eocene	Green River Formation		–	Chiefly greenish lacustrine shale and siltstone.
		Wasatch Group	Colton Formation	300-1,500	Varicolored shale with sandstone and limestone lenses, thickest to the north.
	Paleocene		Flagstaff Limestone	200-1,500	Dark yellow-gray to cream limestone, evenly bedded with minor amounts of sandstone, shale and volcanic ash, ledge former.
			North Horn Formation (Lower Wasatch)	500-2,500	Variegated shales with subordinate sandstone, conglomerate and freshwater limestone, thickens to north, slope former.
CRETACEOUS	?				
	Maestrichthian	Mesaverde Group	Price River Formation	600-1,000	Gray to white gritty sandstone interbedded with subordinate shale and conglomerate, ledge and slope former.
	Campanian		Castlegate Sandstone	150- 500	White to gray, coarse-grained often conglomeratic sandstone, cliff former, weathers to shades of brown.
			Blackhawk Formation *MAJOR COAL SEAMS*	700-1,000	Yellow to gray, fine- to medium-grained sandstone, interbedded with subordinate gray and carbonaceous shale, several thick *coal* seams.
			Star Point Sandstone	90-1,000	Yellow-gray massive cliff-forming sandstone, often in several tongues separated by Masuk Shale, thickens westward.
	Santonian	Mancos Shale	Masuk Shale	300-1,300	Yellow to blue-gray sandy shale, slope former, thick in north and central plateau area, thins southward.
			Emery Sandstone *COAL (?)*	50- 800	Yellow-gray friable sandstone tongue or tongues, cliff former, may contain *coal* (?) in south part of plateau if mapping is correct, thickens to west and south. *Coal* may be present in subsurface to west.
	Coniacian		Blue Gate Member	1,500-2,400	Pale blue-gray, nodular and irregularly bedded marine mudstone and siltstone with several arenaceous beds, weathers into low rolling hills and badlands, thickens northerly.
	Turonian		Ferron Sandstone Member *MAJOR COAL SEAMS*	50- 950	Alternating yellow-gray sandstone, sandy shale and gray shale with important *coal* beds of Emery coal field, resistant cliff former, thickens to the south.
	Cenomanian		Tununk Shale Member	400- 650	Blue-gray to black sandy marine slope forming mudstone.
	Albian	Dakota Sandstone *MINOR COAL*		0- 60	Variable assemblages of yellow-gray sandstone, conglomerate shale and *coal*. Beds lenticular and discontinuous.

1(Doelling, 1972, pg. 68)

Figure 6-1 Principle Structural Features in the Wasatch Plateau



Reference: Doelling H.H 1972. Central Utah Coal Fields Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery. Utah Geological and Mineralogical Survey, Salt Lake City.

Cordova

Earth fax Engineering

Stokes

Plate 5-3 shows the topography of the area. The permit area is generally rugged, with elevations varying from 7,000 to about 10,000 ft above sea level. Slopes in the vicinity of the permit area vary from more than 210 pct (65 deg) east of Star Point to less than 4 pct (2 deg) on Gentry Ridge.

Stratigraphy

All of the geologic formations exposed on or adjacent to the permit area are Cretaceous members of the Mesaverde group, with the exception of the North Horn Formation, which is Tertiary (Table 6-1 & Figure 6-1). The minable coal seams are located in the Upper Cretaceous Black hawk Formation.

Mancos Shale

The Mancos Shale, which underlies the Mesa Verde group (Table 6-1), consists of interbedded shale and sandstone members. The uppermost member of the Mancos Shale, directly underlying the Star Point Sandstone, is the Masuk Shale (Doelling, 1972). The Masuk is a dark gray marine shale with thin, discontinuous layers of gray limestone and sandstone (Stokes, 1964).

The Masuk is a soft unit in its exposures but usually forms part of the cliffs rising to the top of the Wasatch Plateau. To the West, it changes faces and joins with the Emery and Star Point sandstones (Doelling, 1972).

Star Point Sandstone

The Star Point Sandstone, the basal formation of the Mesaverde group (Doelling, 1972), is light-colored, fairly well sorted marine sandstone of medium to fine grain (Spieker, 1931). North of the Wattis Canyon area the Star Point Sandstone divides into three tongues.

To the South, the tongues are essentially fused into one massive cliff-forming unit. The Star Point becomes thicker to the southeast, ranging from 400 to 460 ft near the eastern edge of the lease area to 600 ft or more near the central part of Huntington Canyon (Spieker, 1931).

Descriptive core logging of the Star Point Sandstone was conducted in three in-mine drill holes installed in 1992 as part of a hydrogeologic evaluation (EarthFax Engineering, 1992). During the investigation, it was revealed that the Star Point Sandstone beneath the permit area is comprised of three separate sandstone units (in descending order: the Spring Canyon, Storrs, and Panther Tongues) interbedded with two mudstone units (inferred to be tongues of the Blue Gate member of the Mancos Shale). The core logs from the in-mine drill holes are shown in Appendix A.

Black hawk Formation

Overlying the Star Point Sandstone is the coal bearing Black hawk consisting of alternating sandstone, shale, and coal beds, with thin beds of argillaceous freshwater limestone occurring occasionally. The sequence represents deposition alternations between littoral and lagoonal sediments. The formation is approximately 1,000 ft thick, with the valuable coal seams located within the lower 400 ft (Doelling, 1972). The sandstone beds are fine to medium-grained

(Spieker, 1931). The sands of the Black hawk are generally cemented by calcium carbonate or silica, with the exception of a few localized areas in which the cement is almost entirely clay. Iron is also present in the cement of all but the pure white sandstone (Spieker, 1931).

An exception to above mentioned sandstone is the Aberdeen Sandstone, a coarse-grained, white sand that is traceable from the northern part of the Wasatch Plateau coal field southward to the northwest slopes of Gentry Mountain (Spieker, 1931). The generally discontinuous nature of the Black hawk and apparent low specific water yield (Cordova, 1964) indicates that the water yielding capabilities of the Black hawk is only of local importance.

Three general types of shale, all continental in origin, have been identified in the Black hawk formation (Spieker, 1931): ordinary clay shale, carbonaceous shale, and smoke-gray shale. The ordinary clay shell is gray or green, granular, and normally soft at the outcrop; the carbonaceous shell is brown to black, massive, and laminated; and the smoke-gray shell is tough and leathery, and in its unweathered state is hard and homogeneous (Spieker, 1931). Shale acts as an effective barrier to the vertical movement of water within the Black hawk Formation. Therefore, a significant portion of the water that reaches the Black hawk probably percolates downward until it reaches a shale layer, which causes horizontal movement to the surface or another "drain" (i.e. sandstone finger) within the formation.

Castlegate Sandstone

The Castlegate Sandstone, generally considered the basal member of the Price River Formation (Spieker, 1931) consists of massive, highly resistant medium to coarse-grained sandstone beds containing, in places, conglomerate with a matrix of grit (Doelling, 1972). It is thought to be of marine origin (Paul Wier Company, 1977). Although the Castlegate overlies the Black hawk Formation, it appears barren of coal in the plateau lease area.

Price River Formation

The lithologic characteristics of the Price River Formation and the underlying Castlegate Sandstone are similar; however, the castlegate member is differentiated from the Price River Formation in that it consists of medium to coarse-grained sandstone beds with occasional lenses of shale. Although the unit has a high porosity, its apparent low permeability (Cordova, 1964) reduces its water yielding capabilities except through fractures.

North Horn Formation

The youngest geologic formation within the permit area is the North Horn Formation, which caps Price River Formation on Gentry Mountain (Doelling, 1972). The North Horn, the lowest member of the Wasatch Group, consists of variegated shale's, irregular beds of gray, brown, or cream colored sandstone of various textures, and thin beds of steel-gray and cream colored limestone (Spieker, 1931).

Geology of Coal and Adjacent Units

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

Small rider seams also exist interbedded in the black hawk formation. The majority of these seams occur between the Bear Canyon and Tank Seam, which are often referred to as the "Upper beds."

None of the coal lies at depths of more than 1,800 ft. 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	220-250
BLIND CANYON BEDS	0-14
Interval	40-110
HIAWATHA	5-8
Interval	5-8
STAR POINT SANDSTONE	

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 Black hawk 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. The Hiawatha seam was also measured in Left Fork of Fish Creek Canyon Doelling states that "extensive mining under Gentry Mountain (a short distance due north of Bear Canyon) reveals that the Hiawatha is continuous in the anticipated thickness". Where identified and measured, the Hiawatha seam achieved minable thickness in all but one instance (3.3 ft-measurement M-2). However, recent drilling has demonstrated that the Hiawatha seam is not continuous through this area. Mining and drilling in the Hiawatha seam has identified several large sandstone channels and scours which have rendered much of the Hiawatha seam unminable in the vicinity of Bear Creek and

Fish Creek Canyons. Specific work accomplished is shown on the Hiawatha seam Isopach map (Plate 6-15).

Structure

Structurally the strata in the Wasatch Plateau generally dip southerly (slightly southeast or southwest) at angles of 1 to 3 deg. Three major north-south trending fault zones have been defined in the Wasatch Coal Field. Each zone is the product of a high block fault with extensive minor fracturing within the graben. The Bear Canyon Mine is located in the Pleasant Valley Fault Zone. The vertical displacement varies between a few ft and 200 ft plus. A major fault separates the Bear Canyon Mine from the Trail Canyon Mine. (Note: Geotechnical sections are located in Appendix 2-A and the mine is mapped on Plates 5-1A, 5-1B, and 5-1C). Displacement on this particular fault is estimated to be 220 ft. During the mining of the Blind Canyon Seam several minor faults were discovered in the Trail Canyon Mine. These faults may affect the mining of other seams.

R645-301-621 General Requirements

All of the geological formation exposed on or adjacent to the permit area are Cretaceous members of the Mesa Verde group, with the exception of the North Horn Formation, which is Tertiary. The minable coal seams are located in the upper Cretaceous Black hawk Formation.

General Stratigraphy

The exposed geologic column, in ascending order, consists of the Mancos Shale, the Star Point Sandstone, coal-bearing Black hawk Formation and the Castlegate Sandstone Member of the Price River Formation. All of these Geologic units are Cretaceous in age. The Star Point Sandstone through the Price River Formation composes the Mesa Verde Group in this locality.

The Mancos Shale forms the initial steep slopes rising from the washes which in turn are overlain by the initial cliff-forming Star Point Sandstone described in R645-301-620.

The Black hawk Formation is composed of alternating sandstones, shales, mudstones and coal representing marine, transitional and terrestrial varieties of sedimentation. Depositional environments of the Black hawk Formation include littoral, lagoonal, estuarine and swamp type environments. The Black hawk outcrops to form a step and slope topography slightly less resistant than the Star Point below and the Castlegate above. Multiple coal seams are found within the lower 350 ft of the Black hawk.

The Castlegate Member of the Price River Formation makes up a massive, resistant cliff-forming unit above the Black hawk.

Structure

The Bear Canyon Fault, which is part of the north-south trending Pleasant Valley Fault Zone, marks the eastern boundary of the permit area. Displacement on this particular fault is estimated by C.W. Mining to be 200 ft+ in the vicinity of Bear Creek Campground on the north side of State Highway 31. The west side of the fault is down relative to the east side. Strata immediately bordering the fault are disturbed and inconsistent in spatial attitude with equivalent strata in the study area east of the Bear Canyon fault. This will no doubt have a limiting effect on the extent to which coal can be mined in the immediate vicinity of the fault. Strata east of the fault are nearly horizontal in attitude providing excellent mining conditions.

The Blind Canyon Fault, also part of the Pleasant Valley Fault Zone, marks the western boundary of the mine area. Displacement on this normal fault is estimated to be 220 feet, west side down.

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 C. W. Mining. 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 are discussed in Appendix 7-N, Section 2.4.3.

R645-301-622 Cross Sections Maps and Plans

622.100 Elevations and Locations of Core Samples

The elevations and locations of test borings and core samplings are given in Appendix 6-A. Additional drill hole logs can be founding in Appendix 7-A.

622.200 Nature Depth and Thickness of Seam to be Mined

This is shown on Plate 6-3 (Tank Seam), Plate 6-7 (Bear Canyon Seam), Plate 6-11 (Blind Canyon Seam), and Plate 6-15 (Hiawatha Seam).

622.300 Coal Crop Lines and Strike and Dip of Coal Seam

This is shown on Plate 6-4 (Tank Seam), Plate 6-8 (Bear Canyon Seam), Plate 6-12 (Blind Canyon Seam), and Plate 6-16 (Hiawatha Seam).

622.400 Location of Gas and Oil Wells

There are no gas or oil wells within the permit area.

R645-301-623 Geologic Information

623.100 Acid or Toxic Forming Strata

Copies of test results from coal samples taken within the permit area are included in Appendix 6-C. The coal quality is shown on page 6C-2. Analyses for acid- or toxic-forming materials in the coal, roof, and floor rock are shown on pages 6C-7 through 6C-21. Table 2-4a. lists the parameters to be tested for in roof, floor and mid-seam analyses. Coal and rock sample locations are shown on Plates 5-1. Engineering and material properties of the coal and surrounding rock are discussed on page 6C-22.

623.200 Geologic Information to Determine Reclamation

Geologic information to assist in determining whether reclamation can be accomplished is discussed in R645-301-724.

623.300 Geologic Information Pertaining to Subsidence

Geologic Information to assist in preparing the subsidence control plan is given under R645-301-332 (Anticipated Impacts of Subsidence), 645-301-525 (Subsidence Control Plan).

R645-301-624 Additional Geological Information

624.100 Geology in Permit and Adjacent Areas

This information is given in R645-301-620, R645-301-621, and R645-301-724.

624.110 Cross Sections and Maps and Plans

This is addressed under R645-301-622

624.130 Literature and References

Geologic Literature and references are given in R645-301-620.

624.200 Removal of Strata

Does not apply.

624.300 Test Boring

In 1992, C. W. Mining Company drilled 3 in-mine test holes through the Star Point Sandstone to the top of the Masuk Shale. These holes are shown on Plate 7-4 as DH-1A, DH-2, and DH-3, and were later completed as monitor wells. The test holes, shown in Appendix 6-A, revealed the Star Point Sandstone beneath the permit area to be comprised of three separate sandstone tongues interbedded with two mudstone units inferred to be tongues of the Bule Gate member of the Mancos Shale, referred to as Mancos No. 1 and Mancos No. 2. In 1993, DH-3 was abandoned due to pillaring activities, and was sealed in accordance with R645-301-631. It was replaced by DH-4, shown on Plate 7-4.

Spring Canyon Tongue. The Spring Canyon Tongue of the Star Point Sandstone, the uppermost unit, is 88 feet thick at DH-1, 103 feet thick at DH-2, and 98 feet thick at DH-3. It is generally light gray with minor dark minerals, but varies from dark gray to white. The grains range in size from fine to medium, and are moderately well sorted, subangular to subround, and well cemented with calcium carbonate. The unit is generally moderately- to well indurated. Bedding is variable through the unit, from massive to laminated, with muddy zones and partings and locally dense bioturbation. The contact with the overlying Hiawatha coal seam of the Black hawk Formation is abrupt; the lower contact with the Mancos No. 1 mudstone tongue is gradational.

Storrs Tongue. The Storrs tongue is 96 feet thick at DH-1A, 105 feet thick at DH-2, and 120 feet thick at DH-3. It is generally light gray to dark gray, with minor dark minerals. The grains range in size from very fine-to-fine, and are moderately well sorted, sub angular to sub round, and well cemented with calcium carbonate. The unit is generally well indurated. Bedding is variable through the unit, from massive to laminated, with muddy zones and partings and locally dense bioturbation, particularly in the lower portion of the unit. The contacts with the overlying Mancos No. 1 and underlying Mancos No. 2 mudstones are gradational. The Storrs Tongue Sandstone is generally finer grained, denser, more highly indurated, and less permeable than the other two Star Point Sandstone tongues.

Panther Tongue. The Panther Tongue is 105 feet thick at DH-1A, 88 feet thick at DH-2, and 97 feet thick at DH-3. It is generally light gray with minor dark minerals, but, like the Spring

Canyon and Storrs tongues, varies from dark gray to white. The grains range in size from fine to coarse, and are poorly to moderately well sorted, round to sub round, and poorly cemented with calcium carbonate. The unit is generally poorly to moderately-well indurated, and locally friable. Bedding is variable through the unit, from massive to laminated, with muddy partings and local bioturbation. The contact with the overlying Mancos No. 2 mudstone is gradational; the lower contact with the Mancos Shale is abrupt. The Panther Tongue sandstone is less dense, coarser-grained, less well cemented, less indurated, and more permeable than the Spring Canyon and Storrs tongues.

Additional drill hole information is given in Appendix 6-A and Appendix 7-A. A chemical analysis of the coal seam is found in Appendix 6-C.

624.340 Properties of Clay

No significant amount of clay was detected in the samples analyzed. (See Appendix 6-C)

R645-301-630 Operation Plan

R645-301-631 Casing and Sealing of Exploration Holes

Drillholes DH-1A, DH-2, and DH-3, were completed as monitor wells in 1992. The completion of these wells are shown and described in Appendix 7-N. DH-3 was abandoned in 1993 due to pillaring in the location of DH-3. It was replaced by DH-4, shown on Plate 3-4A. DH-4 was drilled into the Spring Canyon Member of the Starpoint Sandstone in January of 1994 and was also completed as a monitor well. The drillhole logs and well completion diagrams for these four wells are included in Appendix 7N-G. All exploratory boreholes drilled by C.W. Mining will be sealed as described in R645-301-529. Holes will be closed and sealed in compliance with all applicable state and federal regulations.

R645-301-632 Subsidence Monitoring

A Subsidence Monitoring Plan along with a map showing the location of monitoring points (Plate 5-3) is given in Chapter 5 under R645-301-525.

Reference:

Cordova 1964. Hydrogeologic reconnaissance of part of the headwaters area of the Cordova, Utah Geological and Mineralogical Survey, Salt Lake City.

Doelling H.H 1972. Central Utah Coal Fields Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery. Utah Geological and Mineralogical Survey, Salt Lake City.

Doelling, H.H., Davis, F.D. 1977. Coal drilling at Trail Mountain, North Horn Mountain, and Johns Peak areas, Wasatch Plateau, Utah, Utah Geological and Mineral Survey, Salt Lake City.

Earth fax Engineering 1993. Revised Hydrogeologic Evaluation of the Bear Canyon Mine Permit and Proposed Expansion Areas.(See Appendix 7-N.)

Stokes, William Lee, 1964. Geologic map of Southeastern Utah, Washington D.C., Williams and Heintz Map Corp.

Spieker,Edmund M., 1931 The Wasatch Plateau Coal Field, Utah, U.S. Geological Survey,

Bulletin 819.

Appendix 6-A

Underground Test Hole Core Logs

KEY TO SYMBOLS

SANDSTONE

MUDSTONE

MUDDY SANDSTONE

SANDY MUDSTONE

SHALE

COAL

CEMENT

BENTONITE

20-40 MESH SILICA SAND

CORE SAMPLE

EARTHFAX ENGINEERING, INC. HYDROGEOLOGIC LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-1A Boring/Well Location: 395059.18 N 2112761.51 E
Project Number: UC-192-06	Reference Elevation: 7535.71 Reference Point: MINE FLOOR
Date Drilled: 06 AUG 1991 Logged by: JDG	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 114.0' Static W.L.: 114.0' Dates Measured: 06 AUG 91 21 APR 92	Boring Depth (Ft): 535' Well Depth (Ft): 171' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC.	WELL COMPLETION DETAILS
0		COAL: Bottom coal. Good core.		Slip Cap with Cover
		MUDSTONE: Gray. Hard. Good core. Carbonaceous banding.		
10		SANDSTONE: Very Fine grained. Sub-rounded grains. Finely laminated. Gray to light gray color. Occasional carbonaceous stringers.		
20		Medium cross-bed sets.		Cement
30		Carbonaceous stringers.		
40		Carbonaceous stringers.		
50		Gray-white color with dark gray carbonaceous stringers on cross-beds.		
		SANDY MUDSTONE: Fine laminations. Varying proportions of sand and silt.		
60		SANDSTONE: Clean, with carbonaceous stringers on cross-beds between intervals of clean sand.		
70		Carbonaceous stringers and low angle cross-beds.		Bentonite Grout
80				
90		COAL: Hiawatha Coal seam.		
100				

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-1A Boring/Well Location: 395059.18 N 2112761.51 E
Project Number: UC-192-06	Reference Elevation: 7535.71 Reference Point: MINE FLOOR
Date Drilled: 06 AUG 1991 Logged by: JDG	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 114.0' Static W.L.: 114.0' Dates Measured: 06 AUG 91 21 APR 92	Boring Depth (ft): 535' Well Depth (ft): 171' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC.	WELL COMPLETION DETAILS
100		SANDSTONE: Light gray-white colored. Spring Canyon Tongue of the Star Point Sandstone.		
		Fine-medium, rounded grains. Laminated.		
110		Fewer carbonaceous stringers. Low angle cross-beds.		
120				1.5" PVC Casing
		Carbonaceous stringers increase.		
130		Horizontal laminations. Massive bedded.		
140				20-40 Mesh Silica Sand
150		Massive bedded. Fine-medium grained. Low angle cross-beds. Dark minerals.		
160				1.5" PVC Slot Screen
		Locally dense carbonaceous stringers.		
170		Fining to fine-very fine grained.		Threaded End Plug
		Coarsening to fine-medium grained.		
180		MUDDY SANDSTONE: Dark gray colored.		Cement Plug
190		MUDSTONE: Sandy. Dark brown-gray colored. Mancos No. 1.		
		SANDY MUDSTONE: Marbled.		
200				

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-1A Boring/Well Location: 395059.18 N 2112761.51 E
Project Number: UC-192-06	Reference Elevation: 7535.71 Reference Point: MINE FLOOR
Date Drilled: 06 AUG 1991 Logged by: JDG	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 114.0' Static W.L.: 114.0' Dates Measured: 06 AUG 91 21 APR 92	Boring Depth (ft): 535' Well Depth (ft): 171' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC.	WELL COMPLETION DETAILS
200		SANDY MUDSTONE: Alternating marbled and laminated muddy inter-beds.		
210				
220		MUDSTONE: Gray-brown colored. Marbled. Laminated.		
230		SANDY MUDSTONE: Marbled. Laminated. Laminations increasing. Sand decreasing. Sandy.		
240				
250		SANDSTONE: Fine-very fine grained. Clean. Low angle cross-beds. Storrs Tongue of the Star Point Sandstone.		
		MUDDY SANDSTONE: Laminated. Marbled. Bioturbated. Sand and mud proportions vary locally.		
260				
270				
280				
290		SANDSTONE: Clean. Low angle cross-beds. occasional carbonaceous stringers.		
300				

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-1A Boring/Well Location: 395059.18 N 2112761.51 E
Project Number: UC-192-06	Reference Elevation: 7535.71 Reference Point: MINE FLOOR
Date Drilled: 06 AUG 1991 Logged by: JDG	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 114.0' Static W.L.: 114.0' Dates Measured: 06 AUG 91 21 APR 92	Boring Depth (ft): 535' Well Depth (ft): 171' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC.	WELL COMPLETION DETAILS
300		SANDSTONE: Occasional carbonaceous partings. Pyritized fracture.		
310		MUDDY SANDSTONE: Mud increasing downward. Laminated. Bioturbated.		
320				
330				
340		MUDSTONE: Occasionally sandy. Marbled. Laminated. Dark gray colored. Locally bioturbated. Mancos No. 2.		
350				
360				
370				
380		SANDY MUDSTONE: Marbled. Bioturbated. Varies to mudstone locally.		
390				
400				

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-1A Boring/Well Location: 395059.18 N 2112761.51 E
Project Number: UC-192-06	Reference Elevation: 7535.71 Reference Point: MINE FLOOR
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First occurrence of G.W.: 114.0' Static W.L.: 114.0' Dates Measured: 06 AUG 91 21 APR 92	Boring Depth (ft): 535' Well Depth (ft): 171' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC.	WELL COMPLETION DETAILS
400		SANDY MUDSTONE		
		SANDSTONE: Low angle cross-beds. Fine-coarse grained. Dark minerals. Occasional muddy partings. Thin-medium bedding. Moderate-poor sorting. Appears to be more pourous than upper units. Panther Tongue of the Star Point Sandstone.		
410				
420				
430		Circulation loss.		
440				
450				
460		Mud-lined fracture.		
470				
480		Losing circulation.		
490		Muddy bands in white sandstone increasing.		
500				

EARTHFAX ENGINEERING, INC. HYDROGEOLOGIC LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-1A Boring/Well Location: 395059.18 N 2112761.51 E
Project Number: UC-192-06	Reference Elevation: 7535.71 Reference Point: MINE FLOOR
Date Drilled: 06 AUG 1991 Logged by: JDG	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 114.0' Static W.L.: 114.0' Dates Measured: 06 AUG 91 21 APR 92	Boring Depth (ft): 535' Well Depth (ft): 171' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC.	WELL COMPLETION DETAILS
500		SANDSTONE:		
		SANDY MUDSTONE: White colored, fine to medium grained sandstone grading to dark gray-brown mudstone. Heavily bioturbated.		Cement Plug
510		SHALE: Moncos Shale.		
520				
530				
540				
550				
560				
570				
580				
590				
600				

EARTHFAX ENGINEERING, INC.

DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-2 Boring/Well Location: 397775.88 N 2112519.39 E
Project Number: UC-192-06	Reference Elevation: 7557.18' Reference Point: MINE FLOOR
Date Drilled: 16 DEC 1991 Logged by: JDG & AM	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 22.98 Static W.L.: 22.98 Dates Measured: 16 DEC 91 21 APR 92	Boring Depth (ft): 530' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC	WELL COMPLETION DETAILS
0		SANDSTONE Light gray sandstone		Slip Cap with Cover
10				
20				
30				
40		Light gray sandstone		Cement
50		Muddy (dark brown cuttings)		1.5" PVC Casing
60		Light gray sandstone resumes		
70				
80				
90		Clean light gray sandstone		
		COAL Hiawatha Coal seam		Bentonite Grout
100				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-2 Boring/Well Location: 397775.88 N 2112519.39 E
Project Number: UC-192-06	Reference Elevation: 7557.18 Reference Point: MINE FLOOR
Date Drilled: 16 DEC 1991 Logged by: JDG & AM	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 22.98' Static W.L.: 22.98 Dates Measured: 16 DEC 91 21 APR 92	Boring Depth (ft): 530' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOG	WELL COMPLETION DETAILS
100		COAL Hiawatha Coal seam SANDSTONE Clean light gray sandstone Spring Canyon Tongue of the Star Point Sandstone		
110		Carbonaceous stringers		
		Light gray Clean		Bentonite Grout
120				1 5" PVC Casing
130				
140				
150				20-40 Mesh Silica Sand
160				
170				
180				1 5" PVC Slot Screen
190		MUDDY SANDSTONE Muddy sandstone/sandy mudstone, gradational Bioturbated Clean interbeds at 198'		Threaded End Plug Bentonite Plug
200				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-2 Boring/Well Location: 397775.88 N 2112519.39 E
Project Number: UC-192-06	Reference Elevation: 7557.18 Reference Point: MINE FLOOR
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First occurrence of G.W.: 22.98' Static W.L.: 22.98' Dates Measured: 16 DEC 91 21 APR 92	Boring Depth (ft): 530' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOG	WELL COMPLETION DETAILS
200		MUDDY SANDSTONE Carbonaceous stringers.		
		SANDY MUDSTONE Grades to mudstone Bioturbated Top of Mancos No 1		
210				
220		Gradational muddy sandstone/sandy mudstone		Bentonite Plug
230				
240		SANDSTONE White-light gray colored Occasional mud in cuttings Storrs Tongue of the Star Point Sandstone		
250				
260				
270				
280				
290				
300				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-2 Boring/Well Location: 397775.88 N 2112519.39 E
Project Number: UC-192-06	Reference Elevation: 7557.18 Reference Point: MINE FLOOR
Date Drilled: 16 DEC 1991 Logged by: JDG & AM	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 22.98' Static W.L.: 22.98' Dates Measured: 16 DEC 91 21 APR 92	Boring Depth (ft): 530' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC	WELL COMPLETION DETAILS
300		SANDSTONE Light gray Clean		
310				
320				Bentonite Plug
330				
		MUDDY SANDSTONE Muddy sandstone/sandy mudstone, gradational Carbonaceous laminations		
340				
		MUDSTONE Top of Mancos No 2		
350				
360				
370				
380				
390		SANDY MUDSTONE Bioturbated		
400				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-2 Boring/Well Location: 397775.88 N 2112519.39 E
Project Number: UC-192-06	Reference Elevation: 7557.18 Reference Point: MINE FLOOR
Date Drilled: 16 DEC 1991 Logged by: JDG & AM	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 22.98' Static W.L.: 22.98' Dates Measured: 16 DEC 91 21 APR 92	Boring Depth (ft): 530' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOG	WELL COMPLETION DETAILS
400		SANDY MUDSTONE Bioturbated		
410				
420		SANDSTONE Sandstone Light gray colored Fine to coarse grained Dark minerals Occasional muddy parting Panther Tongue of the Star Point Sandstone		Bentonite Plug
430				
440				
450				
460				
470				
480				
490				
500				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-2 Boring/Well Location: 397775.88 N 2112519.39 E
Project Number: UC-192-06	Reference Elevation: 7557.18 Reference Point: MINE FLOOR
Date Drilled: 16 DEC 1991 Logged by: JDG & AM	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 22.98' Static W.L.: 22.98' Dates Measured: 16 DEC 91 21 APR 92	Boring Depth (ft): 530' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOG	WELL COMPLETION DETAILS
500		SANDSTONE — Light gray colored Fine-coarse grained Dark minerals Occasional muddy parting Bioturbated Increasing appearance of mud		
510		SHALE — Moncos Shale		
520				Bentonite Grout
530				
540				
550				
560				
570				
580				
590				
600				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-3 Boring/Well Location: 394514.78 N 2113242.89 E
Project Number: UC-192-06	Reference Elevation: 7520.94 Reference Point: MINE FLOOR
Date Drilled: 29 JAN 1992 Logged by: JRP	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 125.28' Static W.L.: 125.28' Dates Measured: 29 JAN 92 21 APR 92	Boring Depth (ft): 545' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOG	WELL COMPLETION DETAILS
0		COAL Floor of mine		Slip Cap with Cover
		MUDSTONE Brown colored drilling fluid return		
10				
		SANDSTONE Gray colored drilling fluid return		
20				
30				
40				Cement
50				1 5" PVC Casing
		Loss of drilling fluids		
60				
70				
80				
90		COAL Hiawatha Coal seam		Bentonite Grout
		SANDSTONE Spring Canyon Tongue of the Star Point Sandstone		
100				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-3 Boring/Well Location: 394514.78 N 2113242.89 E
Project Number: UC-192-06	Reference Elevation: 7520.94 Reference Point: MINE FLOOR
Date Drilled: 29 JAN 1992 Logged by: JRP	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 125.28' Static W.L.: 125.28' Dates Measured: 29 JAN 92 21 APR 92	Boring Depth (ft): 545' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC	WELL COMPLETION DETAILS
100		SANDSTONE — Drilled blind No sample		
110				
120				1.5" PVC Casing
130				
140				20-40 Mesh Silica Sand
150				
160				
170				
180		MUDDY SANDSTONE — Muddy sandstone/sandy mudstone Fine-very fine grained Gray colored Massive-laminated bedding Bioturbated Well cemented Very hard Reacts with HCl		1.5" PVC Slot Screen
190		Top of Moncos No 1		Threaded End Plug Bentonite Plug
200				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-3 Boring/Well Location: 394514.78 N 2113242.89 E
Project Number: UC-192-06	Reference Elevation: 7520.94 Reference Point: MINE FLOOR
Date Drilled: 29 JAN 1992 Logged by: JRP	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 125.28' Static W.L.: 125.28' Dates Measured: 29 JAN 92 21 APR 92	Boring Depth (ft): 545' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC	WELL COMPLETION DETAILS
200		SANDY MUDSTONE — Sandy mudstone/muddy sandstone Gradational contacts Medium-very fine grained Dull luster Gritty-smooth feel Unweathered Sandy units are gray (5Y6/1) Muddy units are gray-brown (5Y4/1) Hard Predominantly quartz with minor dark minerals Mica along muddy partings Laminated Low angle cross-beds Bioturbated Non-fractured Cores are in excellent condition		
210				
220				Bentonite Plug
230		SANDSTONE — Sandstone/muddy sandstone Gray colored Fine grained Storrs Tongue of the Star Point Sandstone		
240		Muddy and bioturbated		
250		Laminated and bioturbated		
260		Sand increasing		
270				
280				
290		Sand and muddy sand		
300				

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-3 Boring/Well Location: 394514.78 N 2113242.89 E
Project Number: UC-192-06	Reference Elevation: 7520.94 Reference Point: MINE FLOOR
Date Drilled: 29 JAN 1992 Logged by: JRP	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 125.28' Static W.L.: 125.28' Dates Measured: 29 JAN 92 21 APR 92	Boring Depth (ft): 545' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC	WELL COMPLETION DETAILS
300		SANDSTONE		
		Clean Sand		
310				
		Muddier and bioturbated		
320				Bentonite Plug
330				
		Grading to muddy sand		
340		SANDY MUDSTONE Muddy sandstone/sandy mudstone Gradational contacts Dark gray-brown colored		
350		Top of Mancos No. 2		
360				
370		Sandy mudstone/mudstone		
380				
390		Sandy mudstone/muddy sandstone		
400				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-3 Boring/Well Location: 394514.78 N 2113242.89 E
Project Number: UC-192-06	Reference Elevation: 7520.94 Reference Point: MINE FLOOR
Date Drilled: 29 JAN 1992 Logged by: JRP	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 125.28' Static W.L.: 125.28' Dates Measured: 29 JAN 92 21 APR 92	Boring Depth (ft): 545' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC	WELL COMPLETION DETAILS
400		SANDY MUDSTONE		
410				
420				
		SANDSTONE — Medium-fine grained Sub-angular to sub-rounded grain texture Moderate sorting Little or no weathering Gray colored with dark minerals Hard Predominantly quartz, with muscovite along muddy partings Calcite cement Massive bedded with laminations locally Bioturbated Few fractures Core is in excellent condition Panther Tongue of the Star Point Sandstone		Bentonite Grout
430				
440				
450				
460				
470				
480				
490				
500				

EARTHFAX ENGINEERING, INC. DRILLING LOG

Project Name: GROUND WATER INVESTIGATION Owner/Client: CO-OP MINING COMPANY	Boring/Well Number: DH-3 Boring/Well Location: 394514.78 N 2113242.89 E
Project Number: UC-192-06	Reference Elevation: 7520.94 Reference Point: MINE FLOOR
Date Drilled: 29 JAN 1992 Logged by: JRP	Drilling Contractor: CO-OP MINE PERSONNEL Drilling Method: HYDRAULIC ROTARY Rig Type: DIAMEC 251
First occurrence of G.W.: 125.28' Static W.L.: 125.28' Dates Measured: 29 JAN 92 21 APR 92	Boring Depth (ft): 545' Well Depth (ft): 190' Boring Diameter (in): 2.9"

DEPTH (FT)	GRAPHICAL LOG	LITHOLOGIC DESCRIPTION AND OBSERVATIONS	SAMPLE LOC.	WELL COMPLETION DETAILS
500		SANDSTONE		
510				
520		SHALE Mancos Shale		Bentonite Plug
530				
540				
550				
560				
570				
580				
590				
600				

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

C. W. MINING COMPANY

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 & Grey Sandstone	
40			
20			
		2' Coal Shale Coal	Plug Drilled Roof Coal (Black Canyon Seam)

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-2 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: TG-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			Plug 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
280			
		9' Coal (Tank Seam)	
260			
		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 (Blind Canyon Seam)

C. W. MINING COMPANY

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	

C. W. MINING COMPANY

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	

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-14 DIRECTION: Up DRILLING ANGLE: _____

180
90
0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
150			
125		12' Mudstone / Shale	
		4' Sandstone	
100		15' Shale / Mudstone	
		20' Sandstone	
75		3' Shale	
		2' Coal	
		Sandstone	
		2' Coal	
		4' Shale	
		1' Coal	
50			
		Sandstone	
25			

C. W. MINING COMPANY

DRILL HOLE LOG

PROJECT No: _____ HOLE No: TS-14 DIRECTION: Up DRILLING ANGLE: _____

180
90
0

DRILLHOLE LOCATION: _____

DRILLER: _____ START DATE: _____ END DATE: _____

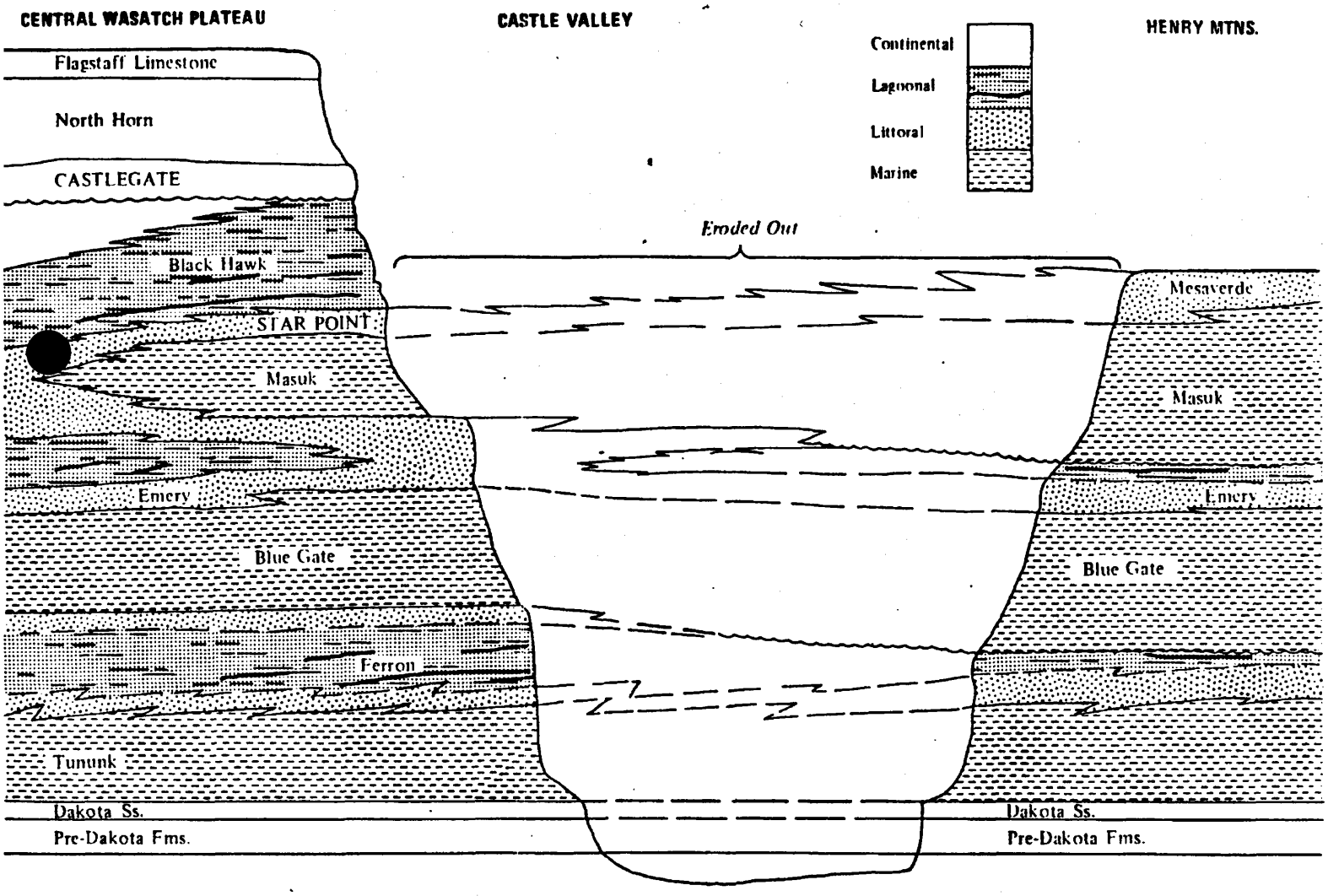
ASSISTANT: _____ START TIME: _____ END TIME: _____

Depth	Graphic Log	Geologic Description	Comments
300			
275			
250			
		1' Sandstone	
		9' Coal	
		7' Sandstone	
		3' Shale/mudstone	
225		2' Coal	
		8' Shale/mudstone	
		12' Sandstone	
		3' Coal	
200			
		10' Sandstone	
		16' Shale/mudstone	
175			
		Sandstone	

Appendix 6-B

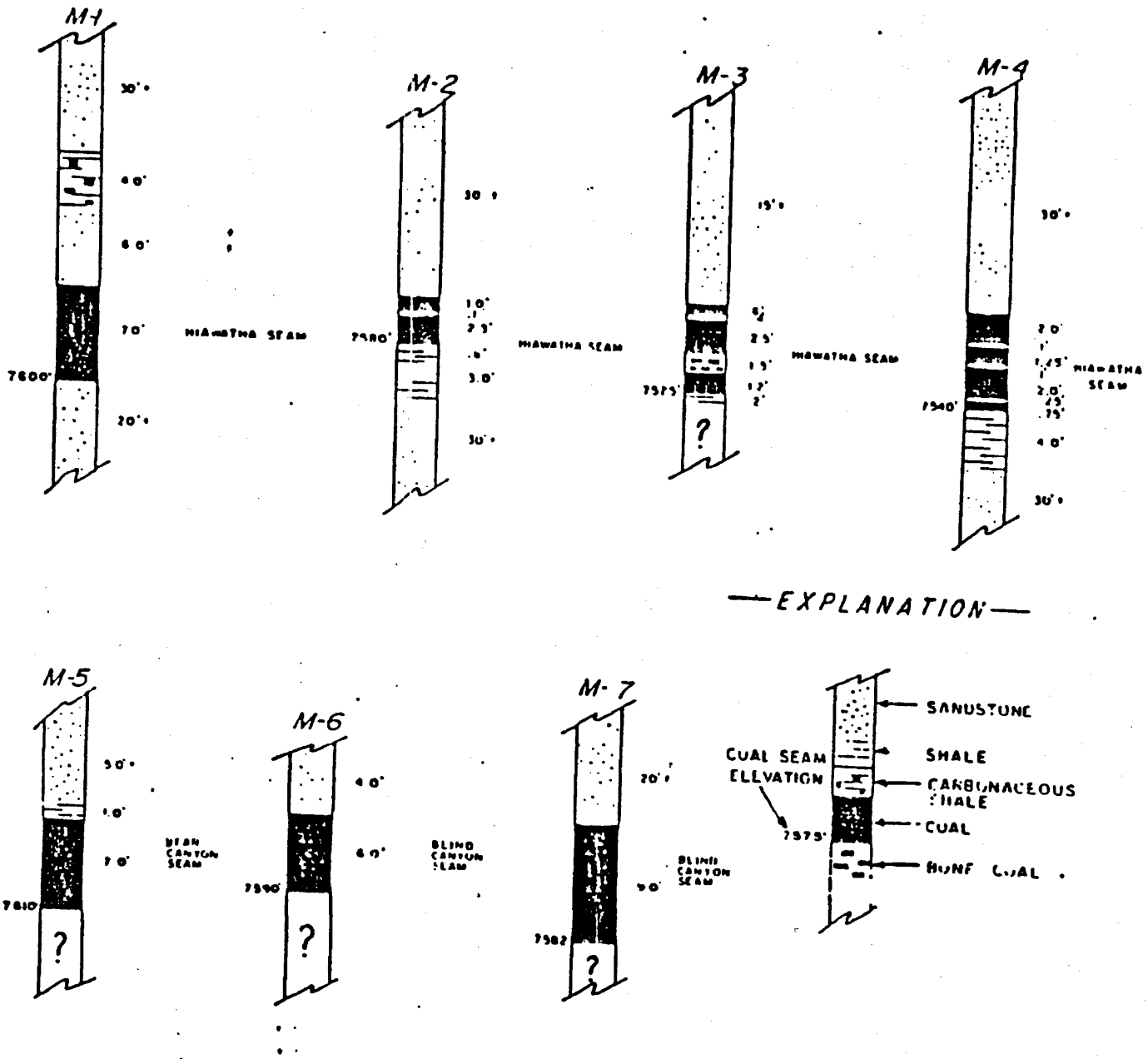
Columnar Outcrop Sections

Figure 6B-1 Stratigraphic Correlation Diagram from Central Wasatch Plateau to the Henry Mountains



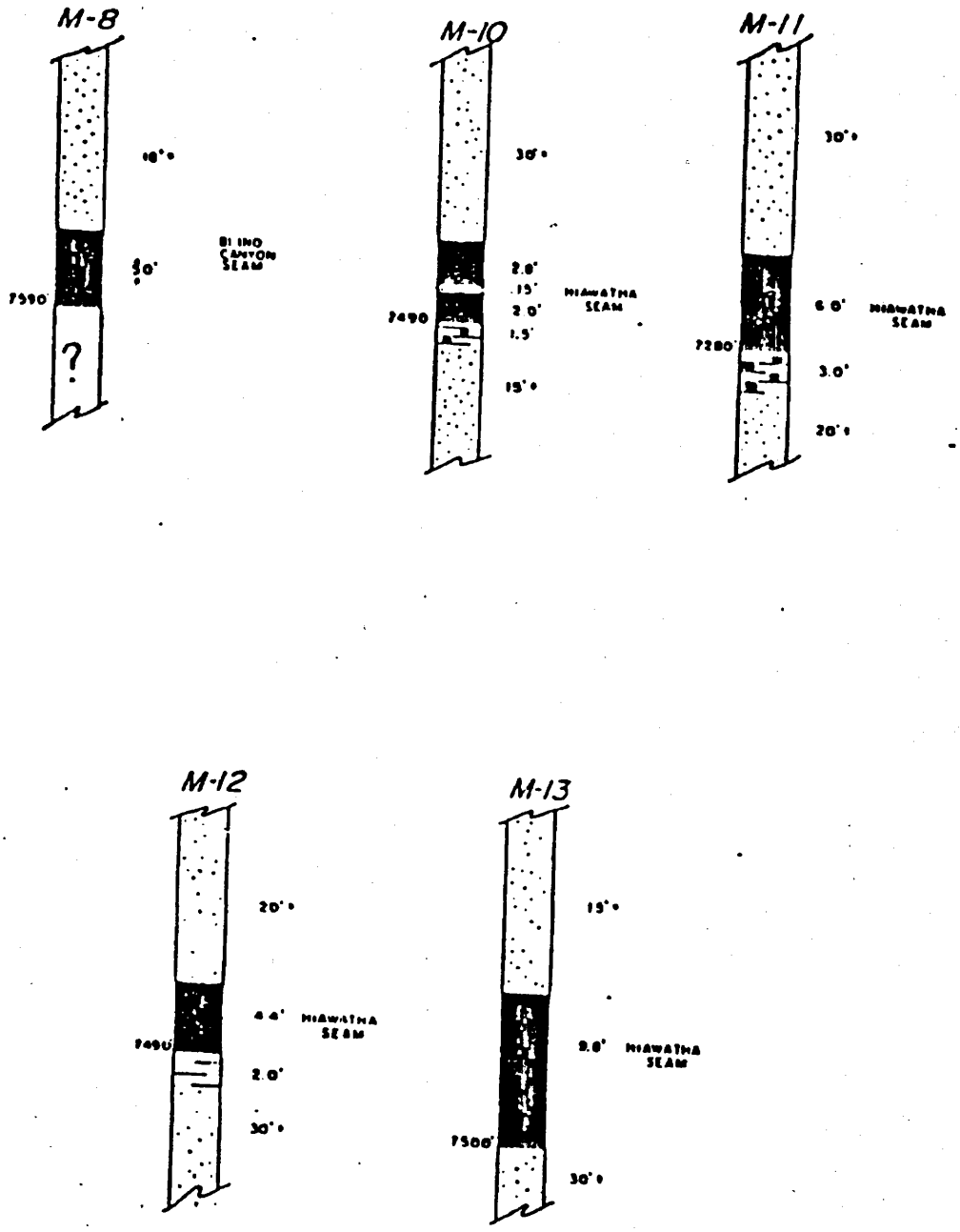
Reference: Doelling, 1972.

Figure 6B-2 Columnar Outcrop Sections, Lower Huntington Canyon, Emery County, Utah



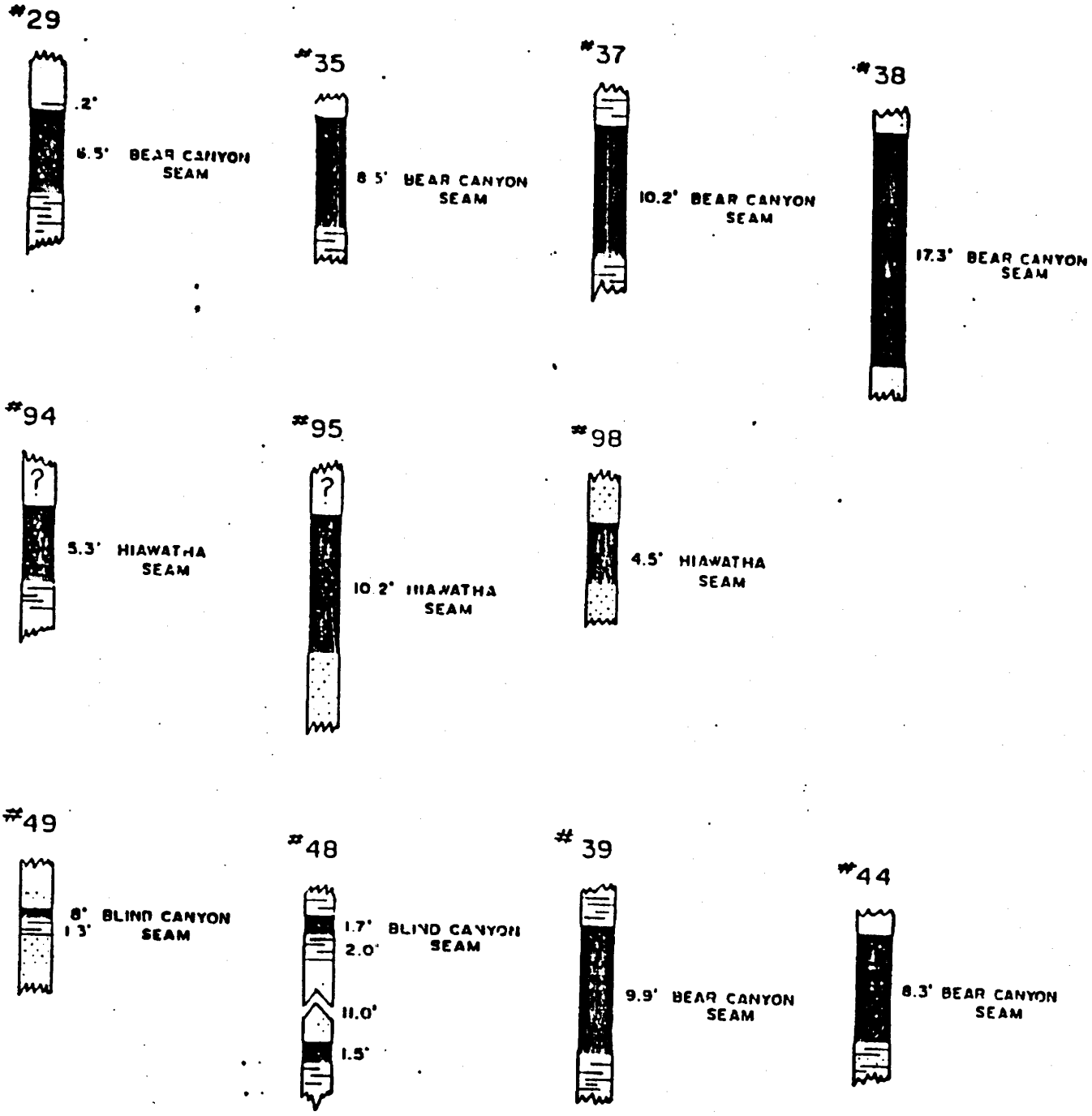
Reference: Sanders Exploration, LTD., Coal Resource Evaluation, Bear Creek Canyon Area, June, 1980.

Figure 6B-2 Columnar Outcrop Sections, Lower Huntington Canyon, Emery County, Utah (cont)



Reference: Sanders Exploration, Limited., Coal Resource Evaluation, Bear Creek Canyon Area, June, 1980.

Figure 6B-2 Columnar Outcrop Sections, Lower Huntington Canyon, Emery County, Utah (cont)



Reference: Adapted from Doelling, 1972.

Figure 6B-3 Description of Blackhawk Formation

Blackhawk Formation

The Blackhawk in the Mesaverde Group of the Wasatch Plateau contains important coal seams in the lower half of the formation. The 700- to 1,000-foot unit, less resistant than the units that contain it, consists of alternating slope- and cliff-forming units (figure 6). The cliff-forming sandstones are generally yellow-gray or white-gray on fresh surfaces and weather to shades of tan, yellow or brown. In places they are reddened by the natural burning of nearby coal seams. Sands are fine- to medium-grained and cemented by either calcite or silica. In a few places they are argillaceous. Iron colors the cement. Occasionally the iron has been leached by organic acids from covering swamps and the sandstone is white.

Slopes of the formation are made of various types of shale and coal. The shales, continental in origin, consist of three kinds: clay shale- soft, granular, gray to green in color and the most common; carbonaceous shale in various shades of brown and black; and smoke gray shale usually associated with the coal.

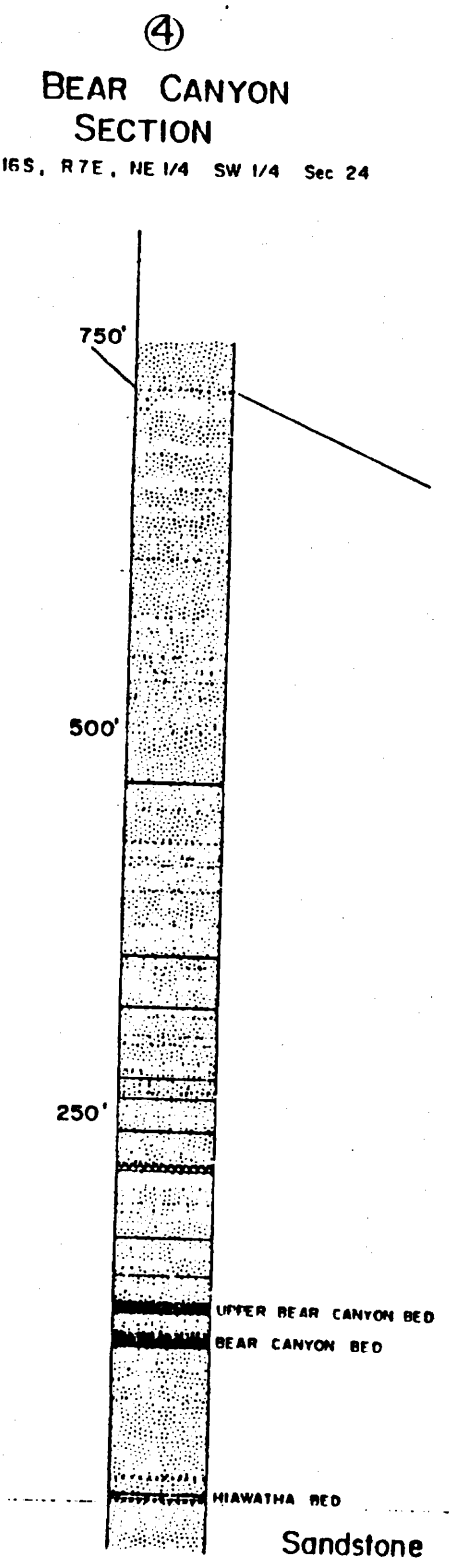
Other strata include friable shaley sandstones, usually thin and platy, that are cemented loosely by calcium carbonate. In some places the rock grades into an impure limestone.

The proportion of shale to sandstone is greater in the north part of the field as compared to the south, but total change in character of the formation is slight. In a section measured by Spicker (1931, p. 30-33) the unit consists of one-third shale and two-thirds sandstone. Key beds are local in extent and each area has its own grouping. An exception is the Aberdeen Sandstone Member. It underlies the Castlegate "A" coal bed and can be traced from the Gordon Creek area southward to Gentry Ridge near Wattis.

The lower contact of the Blackhawk was defined by Spicker (1931, p. 35) as "the clear-cut upper surface of the Star Point Sandstone," but Young (1955, p. 183) redefined the base as the bottom of the Spring Canyon Tongue. Young's work concentrated on the Book Cliffs coal field to the east, but his reports add to the understanding of the Blackhawk in the Wasatch Plateau field. Excerpts from his report follow:

> The redefined Blackhawk formation consists of some prominent littoral marine sandstone tongues and many lesser ones, all projecting eastward into the Mancos, where they lose their identity by grading into shale. Above each of them and below the next succeeding littoral marine sandstone, lagoonal deposits of sandstone, shale and coal were developed behind barrier bars, and where these deposits occur the underlying sandstone is almost everywhere white-capped. . .Division (of six members) is possible only where the basal littoral marine sandstones are developed at the extreme western end of the Book Cliffs at Storrs, Utah (simultaneously the northern end of the Wasatch Plateau field); only the basal sandstones of the Spring Canyon and Aberdeen members are present and between them is about 60 feet of coal-bearing rocks of the Spring Canyon Member. Above the basal sandstone of the Aberdeen Member are about 800 feet of undifferentiated coal measures of the Blackhawk, which are largely lagoonal but may include some inland floodplain deposits in the upper portion.

The commercial coal beds lie in the lower 250 to 350 feet of the formation; some thin units are in the upper part. Two of the more important coal beds are the Hiawatha and Castlegate "A" bed.



Reference: Adapted from Doelling, 1972.

Appendix 6-C

Coal and Rock Characteristics

AVERAGE COAL ANALYSES, HIAWATHA NE QUADRANGLE

	No. Analyses	As-received (percent)	
		Average	Range
BEAR CANYON BED			
Moisture	6	6.8	4.5-10.9
Volatile matter	6	43.8	37.4-46.0
Fixed carbon	6	45.7	44.9-46.0
Ash	6	4.5	3.8- 5.8
Sulfur	6	0.53	0.5- 0.6
Btu/lb	6	13,014	10,840-13,530
BLIND CANYON BED			
Moisture	10	4.8	3.8- 5.3
Volatile matter	9	41.7	40.2-44.7
Fixed carbon	9	44.3	39.2-48.3
Ash	10	8.9	5.8-12.4
Sulfur	8	0.58	0.5- 0.6
Btu/lb	9	12,492	11,700-13,080
HIAWATHA BED			
Moisture	370	5.6	0.7 -11.0
Volatile matter	357	42.3	36.3 -46.4
Fixed carbon	357	45.7	38.3 -52.7
Ash	359	6.2	3.3 -11.2
Sulfur	330	0.61	0.29- 1.1
Btu/lb	365	12,719	11,521-13,600

(After Doelling, 1972)

Sample No. WP-8-75 U.S.G.S. Serial No. D174679

Location Co-op Mine Face channel Sample

Sec. 22, T. 16 S., R. 7 E.

Seam Bear Canyon Seam Formation Blackhawk

Thickness Sampled 7' Date Sampled May 8, 1975

Proximate Analysis

	AD	AR	Dry	MAF
M	4.4	6.1		
VM	45.6	44.8	47.7	50.8
FC	44.1	43.3	46.2	49.2
Ash	5.9	5.8	6.1	
Btu/lb.	13140	12910	13740	14640

Ultimate Analysis

	AD	AR	Dry	MAF
H	5.9	5.9	5.6	6.0
C	72.6	71.4	76.0	80.9
N	1.3	1.3	1.4	1.5
O	13.8	15.1	10.4	11.1
S	0.5	0.5	0.5	0.5

FORMS OF SULFUR:	Sulfate	Pyritic	Organic
As-received	0.02	0.16	0.30
Moist.-free	0.02	0.17	0.32
M. and ash-free	0.02	0.18	0.35

Free-swelling index No. 2 1/2

TRACE ELEMENTS BY VARIOUS DETERMINATIONS (Coal as received)

As (ppm) 1 F (ppm) <20 Hg (ppm) 0.03 Sb (ppm) 0.1 Se (ppm) 1.3

TRACE ELEMENTS, MOSTLly ATOMIC ABSORPTION ON ASH

MgO % 2.33 Cu (ppm) 97 Zn (ppm) 19

K2O % 2.96 Li (ppm) 84 Mn (ppm) 200

Ag (ppm) <1 Pb (ppm) 25

DELAYED NEUTRON DETERMINATION OF URANIUM AND THORIUM

ppm Th 5.0247 ppm U

SEMIQUANTITATIVE 6-STEP SPECTROGRAPHIC ANALYSIS OF THE ASH

G=Greater than 10%; N=Not detected; L=Detected, but below limit of determination

Fe %	5.0	Be (ppm)	N	Pb (ppm)	30	W (ppm)	N	Ba	N
Mg %	1.5	Bi	N	Pd	N	Y	30	La	N
Ca %	G	Cd	N	Pt	N	Zn	N	Sm	N
Ti %	0.3	Co	10	Sb	N	Zr	200	Th	N
Si %	---	Cr	70	Sc	15	Ce	N	Nb	3
Mn (ppm)	150	Cu	70	Sn	N	Ga	20	Ge	N

As (ppm)	N	La (ppm)	N	Sr (ppm)	500	Ga (ppm)	20	Al %	7.0
Au	N	Mo	15	Te	N	Hf	N	Na %	---
B	1500	Nb	L20	U	N	In	N	K %	N
Ba	1500	Ni	20	V	70	Li	N	P %	N

LOOKED FOR ONLY WHEN La OR Ce FOUND:

Pr		Fusibility of ash temp. °F.
Nd		Initial Deform. ------2190
Sm		Softening ----------2250
Eu	N	Fliud ----------2300

Ash Composition

AL2O3 --------	11.0%	
SO3 ---------	~~1.9%~~	8.4%
CL ---------	<0.10%	
CAO ---------	24.0%	
SIO2 --------	~~25.0%~~	24.0%
P2O5 --------	0.74%	
TIO2 --------	0.71%	
MnO --------	<0.020%	
FE2O3 -------	7.6%	
K2O ---------	0.17%	

% Ash determined gravimetrically ashed at 525° C. -6.8%

F-464

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 · AREA CODE 312 726-8434

WESTERN DIVISION MANAGER
LLOYD W. TAYLOR, JR.

SINCE 1908

PLEASE ADDRESS ALL CORRESPONDENCE TO:
10775 EAST 51st AVE., DENVER, COLO. 80239
OFFICE TEL. (303) 373-4772

CO-OP MINING COMPANY
Box No. 300
Huntington, Utah 84528

June 25, 1979

Sample identification by

Kind of sample reported to us	Floor Rock	CO-OP Mining Co.
Sample taken at	xxxxx	Sample No. 57-2162 (CT&E Helper) CO-OP Mine No. 2 Huntington Canyon
Sample taken by	CO-OP Mining Co.	
Date sampled	xxxxx	
Date received	5-24-79	

Analysis report no. 72-82660

SOIL ANALYSIS

pH	8.4
Sodium	5.4
Calcium	.61
Mangesium	4.4
Sodium Adsorption Ratio	6.4
Pyrite (as S-$CaCO_3$ eq t/1000T	0.0
Sand %	65
Silt %	26
Clay %	9

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Gail D. Palmer
G. D. PALMER, Manager, Denver Laboratory

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Charter Member

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OFFICE TEL. (303) 373-4772

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CO-OP MINING COMPANY
Box No. 300
Huntington, Utah

June 25, 1979

		Sample identification by
Kind of sample reported to us	Roof Rock	CO-OP Mining Co.
Sample taken at	xxxxx	Sample No. 57-2163 (CT&E Helper) CO-OP Mine No. 2 Huntington Canyon
Sample taken by	CO-OP Mining Co.	
Date sampled	xxxxx	
Date received	5-24-79	

Analysis report no. 72-82661

SOIL ANALYSIS

pH	8.7
Sodium	12.5
Calcium	.34
Magnesium	.76
Sodium Adsorption Ratio	16.9
Pyrite (as S-$CaCO_3$ eq t/1000T)	0.0
Sand %	
Silt %	
Clay %	

Respectfully submitted,
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Gail D. Palmer

G. D. PALMER, Manager, Denver Laboratory

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ESTERN DIVISION MANAGER
- GAIL D. PALMER

PLEASE ADDRESS ALL CORRESPONDENCE TO
224 South Carbon Avenue
Price, Utah 8450
Phone: (801) 637-7540

March 2, 1982

CO-OP MINING CO
P.O. Box 300
Huntington, Utah 84528

Co-op Mining Co.
#2

Kind of sample reported to us	Coal
Sample taken at	xxxx
Sample taken by	Co-op Mining Co.
Date sampled	xxxx
Date received	2-26-82

Analysis report no. 57-2990

SHORT PROXIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	4.70	xxxxx
% Ash	7.49	7.86
Btu/lb	12937	13575
% Sulfur	0.41	0.43

% Air Dry Loss = 3.07
Moisture, Ash-free Btu = 14733
Pounds of SO2 per 10^6 Btu = 0.63
Moist, Mineral matter free Btu * = 14088
(Based on as rec'd moisture)*
Pounds of Sulfur per 10^6 Btu = 0.32

JB/dt

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

JACK B. BLAIR, Manager, Price Laboratory

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JAVE SELOON
MANAGER
SOUTHWEST DIVISION

PLEASE ADDRESS ALL CORRESPONDENCE TO:
224 S. CARBON AVE., PRICE, UT 84501
OFFICE TEL. (801) 637-7540

CO-OP MINING COMPANY
P.O.Box 300
Huntington, Utah 84528

November 10, 1983

Sample identification by
CO-OP Mining

Bear Canyon
Hiawatha Seam

Kind of sample reported to us	Coal
Sample taken at	Bear Canyon
Sample taken by	Co-op Mining Co.
Date sampled	xxxx
Date received	11-4-83

Analysis report no.57-14270

SHORT PROXIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	7.95	xxxxx
% Ash	9.55	10.37
Btu/lb	11641	12646
% Sulfur	0.50	0.54

% Air Dry Loss =	5.03
Moisture, Ash-free Btu =	14109
Pounds of SO2 per 10^6 Btu =	0.85
Moist, Mineral matter free Btu * =	12992
(Based on as rec'd moisture)*	
Pounds of Sulfur per 10^6 Btu =	0.43
% Residual moisture =	3.07

JB/cj

Respectfully submitted,
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Manager, Price Laboratory

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TELEPHONE: (801) 653-2311

CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 26, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North Bottom
Sample taken by	Co-op	1 bag
Date sampled		13.25 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-2B

Analysis report no. 59-100972

SOIL ANALYSIS

pH	7.5	units	
Electrical conductivity	2700	umhos/cm	(2.7 mmhos/cm)
Saturation percent	47.2		
Soluble calcium	10.62	meq/l	
Soluble magnesium	3.06	meq/l	
Soluble sodium	0.83	meq/l	
Sodium adsorption ratio	0.31		
Exchangeable sodium percent	<0.01		
Total nitrogen	1.28	%	
Nitrate-nitrogen	0.42	mg/kg	
Organic carbon	67.48	%	
Boron	<0.01	mg/kg	
Selenium, total available	<0.1	ppm	
Available water capacity	4.94	%	

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 26, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op North Bottom 1 bag 13.25 lbs. (amended results)
Sample taken at	Co-op	
Sample taken by	Co-op	
Date sampled		
Date received	May 3, 1989	Sample: CS-2B

Analysis report no. 59-100972

SOIL ANALYSIS

Max. acid potential	21.6 tons $CaCO_3$/1000 tons
Neutralization potential	36.2 tons $CaCO_3$/1000 tons

(acid potential based on total sulfur of 0.69%; pyritic sulfur of .14% would yield an acid potential of 4.4)

Coarse fragments	69.6 %
Particle size analysis:	
Sand	88.4 %
Silt	7.6 %
Clay	4.0 %

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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 31, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op North-west Top
Sample taken at	Co-op	1 bag
Sample taken by	Co-op	12.0 lbs. (amended results)
Date sampled		
Date received	May 3, 1989	Sample: CS-1T

Analysis report no. 59-100973

SOIL ANALYSIS

pH	7.5 units	
Electrical conductivity	1200 umhos/cm	(1.2 mmhos/cm)
Saturation percent	46.4	
Soluble calcium	2.32 meq/l	
Soluble magnesium	0.81 meq/l	
Soluble sodium	1.08 meq/l	
Sodium adsorption ratio	0.86	
Exchangeable sodium percent	0.01	
Total nitrogen	1.35 %	
Nitrate-nitrogen	0.28 mg/kg	
Organic carbon	75.44 %	
Boron	0.19 mg/kg	
Selenium, total available	<0.1 ppm	
Available water capacity	4.32 %	

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

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TELEPHONE: (801) 653-2311

CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 31, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North-west Top
Sample taken by	Co-op	1 bag
Date sampled		12.0 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-1T

Analysis report no. 59-100973

SOIL ANALYSIS

pH	7.5	units
Electrical conductivity	1200	umhos/cm (1.2 mmhos/cm)
Saturation percent	46.4	
Soluble calcium	2.32	meq/l
Soluble magnesium	0.81	meq/l
Soluble sodium	1.08	meq/l
Sodium adsorption ratio	0.86	
Exchangeable sodium percent	0.01	
Total nitrogen	1.35	%
Nitrate-nitrogen	0.28	mg/kg
Organic carbon	75.44	%
Boron	0.19	mg/kg
Selenium, total available	<0.1	ppm
Available water capacity	4.32	%

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Manager, Huntington Laboratory

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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 31, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op North-west Top 1 bag 12.0 lbs. (amended results)
Sample taken at	Co-op	
Sample taken by	Co-op	
Date sampled		
Date received	May 3, 1989	Sample: CS-1T

Analysis report no. 59-100973

SOIL ANALYSIS

Max. acid potential	17.2 tons $CaCO_3$/1000 tons
Neutralization potential	13.8 tons $CaCO_3$/1000 tons

(acid potential based on total sulfur of 0.55%; pyritic sulfur of .10% would yield an acid potential of 3.1)

Coarse fragments	97.7 %

Particle size analysis:

Sand	90.4 %
Silt	3.6 %
Clay	6.0 %

Respectfully submitted,
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TELEPHONE: (801) 653-2311

CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 31, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North-west Middle
Sample taken by	Co-op	1 bag
Date sampled	---------	13.75 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-1M

Analysis report no. 59-100974

SOIL ANALYSIS

pH	7.6	units
Electrical conductivity	900	umhos/cm (0.9 mmhos/cm)
Saturation percent	48.9	
Soluble calcium	1.90	meq/l
Soluble magnesium	0.97	meq/l
Soluble sodium	1.10	meq/l
Sodium adsorption ratio	0.92	
Exchangeable sodium percent	0.09	
Total nitrogen	1.26	%
Nitrate-nitrogen	0.24	mg/kg
Organic carbon	72.58	%
Boron	0.11	mg/kg
Selenium, total available	<0.1	ppm
Available water capacity	4.7	%

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 31, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North-west Middle
Sample taken by	Co-op	1 bag
Date sampled	---------	13.75 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-1M

Analysis report no. 59-100974

SOIL ANALYSIS

pH	7.6	units
Electrical conductivity	900	umhos/cm (0.9 mmhos/cm)
Saturation percent	48.9	
Soluble calcium	1.90	meq/l
Soluble magnesium	0.97	meq/l
Soluble sodium	1.10	meq/l
Sodium adsorption ratio	0.92	
Exchangeable sodium percent	0.09	
Total nitrogen	1.26	%
Nitrate-nitrogen	0.24	mg/kg
Organic carbon	72.58	%
Boron	0.11	mg/kg
Selenium, total available	<0.1	ppm
Available water capacity	4.7	%

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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 31, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North-west Middle
Sample taken by	Co-op	1 bag
Date sampled		13.75 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-1M

Analysis report no. 59-100974

SOIL ANALYSIS

Max. acid potential	22.2 tons CaCO3/1000 tons
Neutralization potential	13.8 tons CaCO3/1000 tons

(acid potential based on total sulfur of 0.71; pyritic sulfur of .21 would yield an acid potential of 6.6)

Coarse fragments	94.5 %

Particle size analysis:

Sand	89.5 %
Silt	8.5 %
Clay	2.0 %

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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 31, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North-west Bottom
Sample taken by	Co-op	1 bag
Date sampled	---------	15.25 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-1B

Analysis report no. 59-100975

SOIL ANALYSIS

pH	7.4	units
Electrical conductivity	2600	umhos/cm (2.6 mmhos/cm)
Saturation percent	48.3	
Soluble calcium	9.54	meq/l
Soluble magnesium	3.20	meq/l
Soluble sodium	1.08	meq/l
Sodium adsorption ratio	0.43	
Exchangeable sodium percent	<0.01	
Total nitrogen	1.23	%
Nitrate-nitrogen	0.16	mg/kg
Organic carbon	67.73	%
Boron	0.18	mg/kg
Selenium, total available	<0.1	ppm
Available water capacity	5.49	%

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 31, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North-west Bottom
Sample taken by	Co-op	1 bag
Date sampled		15.25 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-1B

Analysis report no. 59-100975

SOIL ANALYSIS

Max. acid potential	23.1 tons CaCO3/1000 tons
Neutralization potential	30.0 tons CaCO3/1000 tons

(acid potential based on total sulfur of .74%; pyritic sulfur of .23% would yield an acid potential of 7.2)

Coarse fragments	77.4 %

Particle size analysis:

Sand	91.3 %
Silt	2.7 %
Clay	6.0 %

Respectfully submitted,
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TELEPHONE: (801) 653-2311

CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 26, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North Top
Sample taken by	Co-op	1 bag
Date sampled		16.0 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-2T

Analysis report no. 59-100970

SOIL ANALYSIS

pH	8.0	units
Electrical conductivity	600	umhos/cm (0.6 mmhos/cm)
Saturation percent	48.0	
Soluble calcium	0.65	meq/l
Soluble magnesium	0.61	meq/l
Soluble sodium	1.70	meq/l
Sodium adsorption ratio	2.14	
Exchangeable sodium percent	1.86	
Total nitrogen	1.42	%
Nitrate-nitrogen	0.17	mg/kg
Organic carbon	73.57	%
Boron	0.07	mg/kg
Selenium, total available	<0.1	ppm
Available water capacity	4.65	%

Respectfully submitted,
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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 26, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North Top
Sample taken by	Co-op	1 bag
Date sampled		16.0 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-2T

Analysis report no. 59-100970

SOIL ANALYSIS

Max. acid potential	19.1 tons $CaCO_3$/1000 tons
Neutralization potential	5.0 tons $CaCO_3$/1000 tons

(Acid potential based on total sulfur of 0.61% - pyritic sulfur would yield an acid potential of 2.2)

Coarse fragments	98.4 %

Particle size analysis:

Sand	97.1 %
Silt	1.9 %
Clay	1.0 %

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CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 26, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op
Sample taken at	Co-op	North Middle
Sample taken by	Co-op	1 bag
Date sampled		12.5 lbs.
Date received	May 3, 1989	(amended results)

Sample: CS-2M

Analysis report no. 59-100971

SOIL ANALYSIS

pH	7.8	units
Electrical conductivity	580	umhos/cm (0.58 mmhos/cm)
Saturation percent	47.8	
Soluble calcium	0.60	meq/l
Soluble magnesium	0.36	meq/l
Soluble sodium	0.72	meq/l
Sodium adsorption ratio	1.04	
Exchangeable sodium percent	0.26	
Total nitrogen	1.36	%
Nitrate-nitrogen	0.06	mg/kg
Organic carbon	71.88	%
Boron	0.11	mg/kg
Selenium, total available	<0.1	ppm
Available water capacity	4.67	%

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

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OVER 40 BRANCH LABORATORIES STRATEGICALLY LOCATED IN PRINCIPAL COAL MINING AREAS, TIDEWATER AND GREAT LAKES PORTS, AND RIVER LOADING FACILITIES

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

CO-OP MINE
P.O. Box 300
Huntington, UT 84528

July 26, 1989

Sample identification by Co-op

Kind of sample reported to us	COAL	Co-op North Middle 1 bag 12.5 lbs. (amended results)
Sample taken at	Co-op	
Sample taken by	Co-op	
Date sampled		
Date received	May 3, 1989	**Sample: CS-2M**

Analysis report no. 59-100971

SOIL ANALYSIS

Max. acid potential	20.6 tons CaCO3/1000 tons
Neutralization potential	11.2 tons CaCO3/1000 tons

(acid potential based on total sulfur of 0.66%; pyritic sulfur of .11% would yield an acid potential of 3.4)

Coarse fragments	94.1 %
Particle size analysis:	
Sand	90.4 %
Silt	7.6 %
Clay	2.0 %

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Huntington Laboratory

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Inter-Mountain Laboratories, Inc.
2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CO-OP MINING COMPANY
HUNNINGTON, UTAH
Mine: BEAR CANYON MINE

June 8, 1988

Lab No.	Location	Depths	pH	EC mmhos/cm @ 25C	Saturation %	Calcium meq/l	Magnesium meq/l	Sodium meq/l	SAR	Sand %	Silt %	Clay %	Texture
2231	COAL SAMPLE	0.0-0.0	7.5	1.03	63.8	4.94	3.36	1.15	0.56	94.5	3.7	1.8	SAND
2232	ROOF ROCK	0.0-0.0	8.1	0.84	25.1	2.80	3.67	1.95	1.08	90.4	9.4	0.2	SAND
2233	FLOOR ROCK	0.0-0.0	7.8	0.72	24.5	3.44	2.28	1.24	0.73	84.5	14.0	1.5	LOAMY SAND

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio; CEC= Cation Exchange Capacity; ESP= Exchangeable Sodium Percentage; Exch= Exchangeable; Avail= Available

Inter-Mountain Laboratories, Inc.
2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CO-OP MINING COMPANY
HUNNINGTON, UTAH
Mine: BEAR CANYON MINE

June 8, 1988

Lab No.	Location	Depths	Carbonate %	Total Sulfur %	T.S. AB t/1000t	Neut. Pot. t/1000t	T.S. ABP t/1000t	Pyritic Sulfur %	Organic Sulfur %	Nitrate-Nitrogen ppm	Boron ppm	Selenium ppm
[illegible]	CORE SAMPLE	0.0-0.0	1.2	0.90	25.0	11.7	-13.3	<0.01	0.80	1.42	0.31	0.06
2232	ROOF ROCK	0.0-0.0	< 0.1	0.04	1.25	504.	503.	<0.01	0.04	1.51	0.44	0.02
2233	FLOOR ROCK	0.0-0.0	0.5	0.16	5.00	8.41	3.41	0.07	0.09	1.37	0.31	<0.02

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, PyrOrg= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential

iml

Inter-Mountain Laboratories, Inc.

2506 West Main Street

Farmington, New Mexico 87401

Tel. (505) 326-4737

CO-OP MINING COMPANY
HUNNINGTON, UTAH
Mine: BEAR CANYON MINE

June 5, 1988

Lab No.	Location	Depths	Avail Na meq/100g	Exch Na meq/100g	Total Kjeldahl Nitrogen %	Pot Acidity t/1000t	1/3 bar	1 bar	15 bar	Organic Carbon (%)
2231	COAL SAMPLE	0.0-0.0	78.0	77.9	0.78	-0.01	13.4		8.9	Coal
2232	ROOF ROCK	0.0-0.0	87.0	87.0	0.07	-0.01	4.9		3.5	7.67
2233	FLOOR ROCK	0.0-0.0	59.0	59.0	0.35	2.19	7.2		4.2	6.44

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio; CEC= Cation Exchange Capacity; ESP= Exchangeable Sodium Percentage; Exch= Exchangeable; Avail= Available

MATERIAL PROPERTIES

Rock mass, or the overburden at Bear Canyon Mine site consists predominantly of sandstone with intermittent layers of shale and siltstone. Material properties obtained from laboratory tests on cores obtained from holes (East-B, 3-West, and North-Main) drilled into the mine roof are given in Table 1. These material properties are well within the range of properties typically obtained and reported for the corresponding general class of rocks.

Table 1: Mechanical Properties from Core Testing.

Rock Type	Compressive Strength (psi)	Young's Modulus (psi)	Poisson's Ratio
Coal	2,000 to 3,000	$4x10^5$ to $4.5x10^5$	.3 to .4
Shale	15,000 to 17,000	$3x10^6$ to $4x10^6$	.2 to .4
Sandstone	7,000 to 12,000	$3x10^6$ to $4x10^6$	.3 to .4

It is well established that, for realistic analysis of stresses and deformations in coal mines, rock mass, coal, and the gob material properties must be properly adjusted to account for the non-linear behavior caused by phenomena such as weakening due to immediate roof caving, pillar yielding, and gob compaction (Kripakov et al., 1988).

Based on a composite stratigraphy, compressive strength of individual layers given above, drill core quality, and water infusion; the overall rock mass was assigned a Rock Mass Rating (RMR) of 52 corresponding to the classification "Fair" (Bieniawski; 1974). Table 2 shows the geo-mechanics classification of rock mass based on RMR. A visual inspection of the mine suggests that the rock mass quality in general is good and the classification as fair may be treated on the conservative side.

Table 2: Geomechanics Classification of Rock Masses.

Class	Description of Rock Mass	RMR - Cumulative Rating Increments
I	Very good rock	81-100
II	Good rock	61-80
III	Fair rock	41-60
IV	Poor rock	21-40
V	Very poor rock	0-20

Reference: Sinha, Krishna P., Ph.D., TerraTek, Inc., Mathematical Simulations to Evaluate Mining and Roof Control Plan at the Bear Canyon Mine, TR93-09, August, 1992.

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2506 West Main Street Farmington, New Mexico 87401 Tel. (505) 326-4737

CO-OP MINING CO.
Huntington, Utah

DATE SAMPLED: September 7, 1995
DATE REPORTED: October 17, 1995

LOCATION: Bear Canyon #2 Mine

Lab No.	Location	Depths	pH	EC mmhos/cm @ 25°C	Saturation %	Calcium meq/l	Magnesium meq/l	Sodium meq/l	SAR	Coarse Fragments %	Sand %	Silt %	Clay %	Texture
42314	RFM 4:Roof		7.5	1.10	25.0	5.40	4.49	1.26	0.57	66.4	73.8	20.0	6.2	SANDY LOAM
42315	RFM 4:Coal		7.3	1.60	74.2	13.4	4.14	0.96	0.32	79.8	81.2	16.3	2.5	LOAMY SAND
42316	RFM 4:Floor		7.8	0.97	27.2	5.01	4.28	0.87	0.40	78.9	46.2	38.8	15.0	LOAM

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage, Exch= Exchangeable, Avail= Available

SB

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2506 West Main Street Farmington, New Mexico 87401 Tel. (505) 326-4737

CO-OP MINING CO.
Huntington, Utah

DATE SAMPLED: September 7, 1995
DATE REPORTED: October 17, 1995

LOCATION: Bear Canyon #2 Mine

Lab No.	Location	Depths	Organic Matter %	Total Sulfur %	T.S. AB t/1000t	Neut. Pot. t/1000t	T.S. ABP t/1000t	Sulfate Sulfur %	Pyritic Sulfur %	Organic Sulfur %	PyrS AB t/1000t	PyrS ABP t/1000t
42314	RFM 4:Roof		11.6	0.02	0.70	423.	422.	<0.01	0.03	0.03	0.98	422.
42315	RFM 4:Coal		24.6	0.72	22.4	9.03	-13.3	0.03	0.11	0.58	3.50	5.53
42316	RFM 4:Floor		23.1	0.05	1.56	363.	362.	<0.01	0.10	0.06	3.21	360.

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential

JB

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CO-OP MINING CO.
Huntington, Utah

DATE SAMPLED: September 7, 1995
DATE REPORTED: October 17, 1995

LOCATION: Bear Canyon #2 Mine

Lab No.	Location	Depths	Nitrate-Nitrogen ppm	Boron ppm	Bulk Density	Total Kjeldahl Nitrogen %	1/3 bar	15 bar	H2O Sol Selenium ppm
42314	RFM 4:Roof		<0.01	0.04		0.03	11.1	1.5	<0.02
42315	RFM 4:Coal		<0.01	0.13		1.31	11.5	6.2	<0.02
42316	RFM 4:Floor		<0.01	0.12		0.13	9.2	3.2	<0.02

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble,ABPTA= Ammonium Bicarbonate-DPTA, AAO= Acid Ammonium Oxalate

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Inter-Mountain Laboratories, Inc.

1633 Terra Avenue
Sheridan, WY 82801

Soil Analysis Report

C.W. Mining Company
Bear Canyon Mine
P.O. Box 1245
Huntington, UT 84528

Client Project ID: Bear Canyon Mine
Date Received: 09/30/02

Set #0103S00365
Report Date: 01/14/03

Lab Id	Sample Id	pH	Saturation	EC @ 25°C	Calcium	Magnesium	Sodium	Potassium	SAR
		s u.	%	mmhos/cm	meq/L	meq/L	meq/L	meq/L	
0103S00365	RFM-1 Floor	8.3	28.6	1.64	3.36	10.4	4.01	0.57	1.53
0103S00366	RFM-1 Coal	3.7	73.1	1.27	1.47	3.67	4.61	0.31	3.00
0103S00367	RFM-1 Ceiling	8.2	27.4	2.39	4.55	17.8	6.29	0.89	1.88
0103S00368	Sed Pond A	8.3	39.0	3.15	14.9	14.9	6.71	0.52	1.74

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

Inter-Mountain Laboratories, Inc.

1633 Terra Avenue
Sheridan, WY 82801

Soil Analysis Report

C.W. Mining Company
Bear Canyon Mine
P.O. Box 1245
Huntington, UT 84528

Client Project ID: Bear Canyon Mine
Date Received: 09/30/02

Set #0103S00365
Report Date: 01/14/03

Lab Id	Sample Id	Very Fine Sand %	Sand %	Silt %	Clay %	Texture	CO3 %	Organic Matter %	Alkalinity PE meq/L
0103S00365	RFM-1 Floor	18.9	74.0	18.0	8.0	SANDY LOAM	45.8	0.2	2.20
0103S00366	RFM-1 Coal	<0.1	92.0	6.0	2.0	SAND	<0.5	32.3	8.56
0103S00367	RFM-1 Ceiling	8.0	54.0	32.0	14.0	SANDY LOAM	66.9	0.2	1.40
0103S00368	Sed Pond A	13.2	76.0	14.0	10.0	SANDY LOAM	12.8	1.1	0.80

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

Inter-Mountain Laboratories, Inc.

1633 Terra Avenue
Sheridan, WY 82801

Soil Analysis Report

C.W. Mining Company
Bear Canyon Mine
P.O. Box 1245
Huntington, UT 84528

Client Project ID: Bear Canyon Mine
Date Received: 09/30/02

Set #0103S00365
Report Date: 01/14/03

Lab Id	Sample Id	TOC %	Total Sulfur %	Neutral. Pot. t/1000t	Boron PE ppm	Nitrogen Nitrate meq/L	Phosphorus mg/Kg	Selenium ppm
0103S00365	RFM-1 Floor	0.1	<0.01	470	0.17	0.66	2.00	<0.02
0103S00366	RFM-1 Coal	18.8	0.44	-2.55	10.6	12.3	4.90	<0.02
0103S00367	RFM-1 Ceiling	0.1	<0.01	691	0.52	0.92	1.70	<0.02
0103S00368	Sed Pond A	0.6	0.29	127	0.86	0.69	3.60	<0.02

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

Chapter 7

R645-301-700 Hydrology

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R645-301-700 Hydrology

R645-301-710 Introduction

This chapter discusses existing hydrologic resources and potential impacts resulting from existing and proposed mining and reclamation operations. Hydrologic performance standards, design criteria, plans along with methods and calculations and reclamations are discussed.

Cross sections, maps and plans required to be certified under these regulations have been prepared by or under the direction of a qualified, registered, professional engineer whose stamp and signature can be found on the individual document in question.

R645-301-720 Environmental Description

R645-301-721 General Requirements

Existing, premining hydrologic resources within the permit and adjacent areas that may be affected or impacted by proposed coal mining and reclamation operations are defined and discussed in the following outline.

R645-301-722 Cross-Sections and Maps

722.100 Subsurface Water

Plate 7-4A shows the potentiometric surface for Spring Canyon. Plates 7-10A and 7-10B show the mine water surveys for the Blind Canyon Seam and the Hiawatha Seam respectively.

722.200 Surface Water

Plate 7-5 shows the affected watersheds. Plates 7-1 show the surface hydrology.

722.300 Water Monitoring Stations

Plate 7-4 shows the location of all water monitoring stations.

722.500 Slope Measurements or Contour Maps

Plates 7-1 show the existing land surface configuration.

R645-301-723 Sampling and Analysis

All water quality analyses performed to meet the requirements of this chapter will be conducted according to the methodology in the current edition of *Standard Methods for the Examination of Water and Wastewater* or the methodology in 40 CFR Parts 136 and 434. All samples will be analyzed by certified labs.

R645-301-724 Baseline Information

724.100 Groundwater Information

The scope of this study consisted of an investigation of the groundwater hydrology of the Co-Op Mining Company (Co-Op) permit area (Plate 2-1), based on the Utah Division of Oil, Gas and Mining (DOGM) permit application guidelines. Information on regional and site groundwater hydrology and groundwater resources was compiled from:

1. Literature Review. Published and unpublished information on the geology and hydrology of the Bear Creek area, including U.S. Geological Survey investigative reports and personal communications, data from prior mining and engineering investigations in the general area and groundwater and engineering data obtained by Co-Op, were reviewed.

2. Site investigations. Water quality and quantity data was collected from springs, surface seeps, mine roof seeps and sumps and groundwater discharge into drill holes in the mine area, supplemented by published regional data. Stratigraphic sections, aquifer characteristics and the affect of geologic structure on the groundwater regime in the permit area were made on the basis of drill hole logs, drilled for this study, detailed interpretation of geophysical well logs, conducted for this study, and on geologic field mapping.

An outline for the groundwater-monitoring program for the Mine Plan area was then made based on the results of our study, by assessing the impact of mining on the local and regional groundwater hydrology. See Appendix 7-L for further information.

Regional Groundwater Hydrology

The occurrence, availability and movement of groundwater in the Mine Plan and surrounding areas are controlled by structural, stratigraphic and topographic factors, with snow-melt the source for most, if not all, of the groundwater in the Cottonwood-Huntington area (Danielson, et. al., U.S.G.S., 1981). According to this report, available data for the study area, which includes the permit area, indicate that the Star Point sandstone and the lower part of the Blackhawk formation, are an extensive aquifer, with many of the large springs in the Cottonwood-Huntington area, including Bear Springs, issuing from fault displacements of this aquifer. Our studies indicate, however, that within the areas of in-mine wells DH-1A, DH-2 and DH-3, separate and distinct aquifers exist in the Spring Canyon, Storrs, and Panther tongues of

the Star Point Sandstone (See Appendix 7-N), rather than one single aquifer within the Star Point sandstone and Blackhawk formation.

A detailed hydrogeologic evaluation of the Star Point aquifers is included in Appendix 7-N. General observations concerning the groundwater hydrology and geology of the permit area and surrounding areas are presented in Appendix 7-J.

Existing Groundwater Resources

Groundwater occurs under both unconfined and confined conditions in the permit area. The unconfined conditions occur as local perched zones within bedrock and as saturated zones in shallow alluvial deposits along the main drainage bottoms and in the surficial soil mantle, and are expressed as local seeps. Confined conditions occur at depth and are either fault controlled, with the faults serving as channels and/or barriers to groundwater flow, or controlled by an aquifer being overlain by an impermeable layer.

Data obtained from our investigations encountered perched water within the lower portion of the Blackhawk formation. Mine roof seeps, however, do not exhibit seasonal variation or response to precipitation and consist of persistent, relatively unvarying seeps or infiltrations. The source of these seeps is apparently from larger, overlying perched zones, exposed sufficiently by mining activities to allow slow drainage or possibly areas of joint systems, sufficiently interconnected to provide a larger source area.

Drillhole data also indicated that three separate aquifers exist within the Star Point sandstone tongues. The investigation of these aquifers is presented in Appendix 7-N.

Fracture-enhanced permeability allows water to pass vertically through strata, which would normally impede flow. Depending on the extent to which the fractures are interconnected, vertical groundwater flow can be limited to a short distance, or it can extend to the regional water table. Joint systems at the surface exhibit enlargement by weathering but, based on observations within the mine, are expected to be generally closed or possibly non-existent with depth. Only minor, localized diversion of flow within the mine is expected to take place through the joint or fracture systems with no significant affect on regional flow patterns. The degree of rock fracturing in the Bear Canyon seam and overlying mine roof rock is relatively low, based on visual observations of the rock quality within the mine and general lack of mine roof over-break. Outcrop examinations indicate the joint systems are not extensively interconnected.

Springs in the area, specifically Big Bear Springs, located next to the southeast corner of the permit area, are the most significant water resource for the area. Mining activities have not affected the volume or quality of the flow of these springs for the reasons discussed in the following paragraph (See Appendix 7-J and Appendix 7-N).

Flows for the two major springs adjacent to the permit area, Big Bear Spring and Birch Spring, as well as flows for two additional springs, Little Bear Spring and Tie Fork Spring, have been included in Appendix 7N-D. Annual plots of the flows are shown in Appendix 7N-E. Plots of the flow from Big Bear Spring show that peak flows during the period of 1980 through 1986

occurred about one month later than peak flows at the Huntington gauging station. In the 1987-1988 water year, the lag period between peaks in the stream and spring discharge is approximately two months. This increase in lag time is attributed to a combination of lower precipitation accumulations and shorter snowmelt period (See Appendix 7-N, section 2.7.3). Because the period of record flows for Birch Spring is limited (Appendix 7-N, section 2.7.4), a comparison of flows to Huntington Creek prior to 1990 cannot be made.

Aquifer Characteristics

Appendix 7-J, Section 4.0 discusses the groundwater aquifer characteristics in detail. Plate 7-4 identifies the locations of springs and water monitoring points within and adjacent to the Permit Area. A generalized stratigraphic section of the geologic units is shown in Appendix 7-J, Figure 5. Plate 7J-1 and 7J-2 show hyrologic cross-sections, which illustrate the projected potentiometric surfaces within the permit areas.

Field measurements and drill hole data indicate the regional strike, dip and bedding thicknesses are quite uniform within the mine permit area. Four drillholes were drilled immediately North of the permit area and investigated by Savage Energy Services Corporation (T-1, 2, 4, 5). Three additional drill holes were drilled by Co-Op in the same area (SDH-1, 2, 3). Three holes were also drilled north of Wild Horse Ridge by Cyprus/Plateau (MW-114,116,117). Lithology and water level information for all of these holes except MW-114 is shown on Plate 7-9. Projections of bed elevations obtained from this drill hole data were in close agreement with the equivalent bed elevations at the site, at a regional dip of approximately two degrees south.

Evidence of low displacement (5 to 10 ft) faulting was observed within the mine in several locations, as well as in many locations on the surface. Some of these low displacement faults exist in the area around Birch Springs. Large displacement faulting (over 150 ft) is evident by the Bear Creek fault or fault zone at the east margin of the Mine Plan area (Plate 7-4), and the Blind Canyon fault, which bounds the western edge of the mine. The faults can significantly alter the groundwater flow pattern of the area. A well developed, near vertical joint system is evident in outcrops. Regional and site bedding dips are essentially south (1 to 2 degrees), with an easterly component in the permit area.

The stratigraphic section is summarized below, beginning with the Star Point Sandstone at the base, up through the North Horn formation, the uppermost unit exposed in the Mine Plan area:

1. Star Point Sandstone. Thickness ≈ 350 ft; Consists of three tongues of sandstone interbedded with two tongues of the Mancos Shale. Contacts with the shale tongues and with the underlying Mancos shale is gradational. A detailed geologic and hydrologic description of each sandstone bed is described in Appendix 7-N, Section 2.5.

2. Blackhawk formation. Thickness ≈ 825 ft; cyclicly interbedded, 65 pct sandstones, 20 pct siltstones and 15pct mudstones (volume percentages determined by geophysical well log analysis for this study). Sandstones are of low to moderate porosity and generally laterally discontinuous. The lower 100 ft. contains the commercial coal seams. Star Point-Black hawk contact is conformable.

3. Castle Gate Sandstone (lower member of Price River formation). Thickness ≈ 175 ft; fine to medium grained, thick bedded fluvial sandstone with moderate porosity (.22 calculated from geophysical well log data of drill hole T-5) and common solution cavities. Castle Gate-Black hawk contact is conformable.

4. Price River (upper member). Thickness ≈ 650 ft; thick bedded to massive, fine to medium grained sandstone with low to locally moderate porosity, 40-50% mudstone-siltstone interbeds. Price River-Castle Gate contact is conformable.

5. North Horn formation. Thickness ≈ 1500 ft; predominantly shales with common lenses and irregular beds of fine to occasional coarse sandstone, occasional erratic conglomerate lenses and minor thin limestones. North Horn-Price River contact is poorly defined (conformable).

Of the entire section above, the Castlegate sandstone, with few local exceptions, is the most porous, with a porosity of .22, calculated from geophysical density logs conducted for our study. From personal communications (W. Hull, Northwest Energy), zones of voids or open fractures were common within the formation on drilling holes T-1, 2, 4 and 5 and SDH holes 1,2 and 3 and extensive to total drill fluid loss characterizes the formation in the general area. Depths to the drill fluid levels in the above holes ranged from 125 ft (in a bridged hole) to 400 ft below the Castlegate base within a short period after drilling. These occurrences indicate that no significant water was encountered in the formation and that secondary permeability due to void and joints or fractures may occur in a near vertical direction.

Porosity of the remainder of the section, with local exceptions of clean, fine to medium grained sandstones, ranges from generally low for the fine silty sandstones predominant in the section to very low or impermeable for the remaining siltstone-shale sequence.

Aquifer Storage

Quantitative data or published estimates are not available on the amount of water stored in the rock units in the permit area. The Castlegate Sandstone does not appear to serve as even a partially saturated aquifer, apparent from the lack of springs flowing from the formation within the permit area. The Star Point sandstone contains three separate aquifers, as indicated by our in-mine drillholes. All three of these aquifers are only partially saturated in the southern portion of the permit area, and appear to be fully saturated in the northern portion of the permit area. Aquifer piezometric surfaces are shown in Appendix 7-N, Figure 2-2. The Blackhawk formation consists of approximately 30 pct of generally discontinuous sandstone layers, with some of these occurring as perched, saturated to partially saturated zones. About one-third of the Blackhawk has been removed by drainage development in the permit area, leaving approximately 625 acres of this formation, in plan view, within the permit boundaries.

Assuming dry to increasing saturation with depth of these sandstone lenses and an average 825 ft thickness for the Blackhawk and, assuming relatively impervious, remaining, intervening silt to mudstone layers, a storage coefficient of 0.10 is assumed for the Blackhawk. This results in a storage of roughly 55,000 acre-ft within the Blackhawk formation in the permit

area. The initial interception of groundwater, expressed as roof seeps, by the mine workings was approximately 3-½ acre ft/yr.

In 1989, a significant amount of water was encountered in the 1st North Section of the #1 Mine Blind Canyon Seam, expressed as roof drips and flowing from roof fractures. Mining eventually encountered the apparent source of this water, a significant channel sandstone, which traverses East-West along the North end of the #1 Mine. The exact dimensions and configuration of this channel is unknown. Isotopic dating of the water in this aquifer has indicated the water to be approximately 1,000 years old. It is anticipated that Co-Op will eventually dewater this aquifer. Surface and groundwater monitoring has indicated no hydraulic connection between this aquifer and any springs in the permit area. To date, no impacts as a result of this dewatering have been observed in any of the springs within the permit area. Additional discussion on this channel is given in Appendix 7-J.

Isotopic dating of Big Bear Springs, as well as chemical analysis, has indicated that the spring is not hydrologically to the mine water or the channel aquifer. Monitoring of Big Bear Springs, as well as Birch Spring and the other springs within the permit area will continue in order to ensure that no impacts due to mining occur. A description of the isotopic and chemical data of the mine water and springs is shown in Appendix 7-J. In 1998, surface wells SDH-2 and SDH-3 were sampled for baseline parameters and for isotopic dating. This information is discussed in Appendix 7-J.

Hydrologic information from monitor wells MW-114, 116, and 117 indicate that the uppermost tongue of the star point sandstone is unsaturated under Wild Horse Ridge. A detailed discussion of this aquifer is given in Appendix 7-J.

Aquifer Recharge

Snow at the higher elevations provides the greatest source of groundwater recharge. Deuterium analyses of groundwater in the region indicate that most, if not all, groundwater is derived from snowmelt (Danielson et. al., 1981). The percentage of water derived from snowmelt, which recharges the groundwater system versus that which runs off to stream flow is controlled by the surface relief, the permeability of exposed strata, the depth of snow pack, and the rate of snowmelt. Published precipitation contours for the area indicate annual precipitation of 17 to 18 in./yr for the permit area.

Evapo-transpiration is estimated to be on the order of three to four inches annually (Danielson, et. al., 1981). Surface runoff, based on a mean site elevation of 8200 ft and on the generally deeply incised nature of much of the permit area and the predominance of south, east and west-facing slopes, is estimated to be 11 to 12 in./yr. These values correspond to estimates by others for the general area (Intermountain Consultants, 1977).

Up to three inches average annual precipitation is thus available for recharge for the 1140-acre permit area, resulting in an equivalent 285-acre ft/yr. The large proportion of outcrop versus total surface area of most of the permit area makes outcrop areas and drainage channel

alluvium the principal recharge sources, with the soil mantle becoming increasingly important in the north part of the area.

Additional discussion on groundwater recharge is given in Appendix 7-J and 7-N, section 2.4.2.

Aquifer Water Quality

Results of baseline water sample analyses for the Bear Canyon fee area are presented in Tables 7.1, 7.2 and 7.3. The chemical characteristics of the ground and surface water in the permit area are quite uniform with the exception of higher suspended solids content in the surface water. It is noted that sulfate contents are lower in the Bear Springs samples while surface water (Bear Creek), in contact with an appreciable section of the Star Point Sandstone in its lower reaches, is relatively high in sulfate. Previous studies (Danielsen, et. al., 1981) indicate water derived from the Star Point aquifer is higher in sulfate than the overlying units. This is additional indication that the Bear Springs supply is not the Star Point-Blackhawk aquifer.

Baseline water quality data for the springs in and around Wild Horse Ridge and Federal Lease U-024316 are presented in Appendix 7-M. The majority of the springs identified flow from faults and joints in the North Horn and Price River formation. The chemical characteristics of these springs are similar to the other springs within the permit areas. Spring WHR-6 (SBC-14), which issues from the Star Point Sandstone (Spring Canyon Tongue), displays sample

results for TDS consistently over 1500 mg/l. This is similar to the quality observed in Well SBC-3, and is typical of water quality from the Star Point Sandstone.

Appendix 7-M includes some water quality information for the McCadden Hollow springs around Lease U-024316 for 1991 and 1992 and information form springs in the Mohrland Area. All water quality information is also summarized in Appendix 7J-A, the PHC document.

Table 7-1 Water Quality and Flow Data, 1984, 1985

Sample/Date	TDS	TSS	Carbonate (as $CaCO_3$)	Alkalinity (as $CaCO_3$)	Ca	Mg	Fe (dis.)	Na	K	HCO_3	SO_4	Cl	Nitrate	pH	Flow (gpm)
Sump Su-3 (10/84)	300	5	0	285.5	36	36.0	0.19	29.2	4.43	234	55	8.0	0.06	7.3	---
Su-3 Roof Drip (10/84)	380	17	0	383.1	60	38.4	0.12	19.2	3.65	314	40	2.0	0.03	7.3	3-5
SBC-1 Drips (2/85)	235	1	0	---	46	35.0	0.03	3.0	1.4	216	66	4.0	0.06	8.1	3-5
SBC-1 (10/84)	362	11	0	309.8	80	21.6	0.33	26.0	0.97	254	27	50.0	0.24	7.4	---
SBC-1 (11/84)	175	54	5	---	15	36.0	0.06	4.0	1.5	141	43	3.0	0.22	8.4	---
SBC-1 (12/84)	285	4	7	---	45	38.0	0.09	6.0	1.6	220	56	4.0	N/D	8.4	---
SBC-1 (1/85)	320	16	0	---	43	36.0	0.02	7.0	1.6	209	60	4.0	N/D	7.9	---
BC-1 (11/84)	415	1,620	0	---	43	57.0	4.8	8.0	3.5	200	161	4.0	0.47	8.1	26.0
BC-1 (12/84)	405	862	0	---	63	59.0	7.4	8.0	5.8	209	158	5.0	0.86	8.2	18.0
BC-1 (2/85)	485	1,170	0	---	56	60.0	5.13	10.0	4.1	221	191	5.0	0.48	8.0	9.6
BC-2 (10/84)	375	1,345	0	244.0	50	50.4	19.8	7.1	5.77	200	116	20.0	0.47	8.1	---
BC-2 (11/84)	160	2,190	0	---	22	25.0	4.14	4.0	2.3	95	64	N/D	3.41	8.3	26.8
BC-2 (12/84)	405	1,080	0	---	47	56.0	8.95	8.0	3.6	207	163	5.0	0.33	8.2	18.0
BC-2 (2/85)	505	154	0	---	56	62.0	0.92	11.0	4.3	223	202	5.0	0.46	8.3	18.7
Hole WM-C (2/85)	320	46	0	269	68	29.0	0.09	5.0	1.2	---	27	3.0	0.21	8.2	---
Bear Spring (10/84)	362	11	0	254	80	21.6	0.33	26.0	0.97	309.8	27	50.0	0.24	7.4	---
Birch Spring (10/84)	440	6	0	310	64	58.8	0.12	12.2	1.97	378.2	80	30.0	0.04	7.9	---

N/D = Not Detected
See Table 7.1-8 for description of water monitoring points.

Table 7-2 Water Quality and Flow Data, 1986 and 1987

Station: BC-1 (Lower Bear Creek)

Date	Flow gpm	Temp °C	pH	TDS	TSS	Tot. Alk.	Tot. Hard.	Ca	Mg	Fe (Tot.)	Na	K	HCO_3	SO_4	Cl	Nit.
1/15/86	F															
2/17/86	8	2	8.3													
3/20/86	30	2	8.2	540	1,736					23.3				222	5.0	0.44
4/23/86	27	2	8.3	468	5,100	212	375	51	60	13.6	10.0	4.5	253	181	7.3	0.48
5/13/86	49	3	8.2	304	4,540	217	274	52	35	60.0	8.9	2.2	265	74	4.8	0.20
6/15/86	61	4	8.0	438	504	194	265	56	31	9.1	9.0	3.0	237	86	4.0	0.24
7/23/86	62	4	8.1	320	512	184	282	37	46	1.55	7.7	2.9	224	107	4.3	0.26
8/12/86	58	8	8.0													
9/24/86	87	3	8.2													
10/01/86	55	3	8.2	420	110	207	324	70	36	3.91	2.0	0.0	253	122	2.0	0.25
11/22/86	F															
12/10/86	F															
1/05/87	F															
2/06/87	F															
3/26/87	30															
4/07/87	47	1	8.1	536	780	230	441	51	76	12.8	13.0	5.0	280	233	6.0	0.62
5/15/87	54															
6/17/87	59															
7/15/87	39															
8/26/87	42	12	8.4	420	193	200	346	40	60	3.37	9.0	4.0	241	149	2.0	0.67
9/24/87	36															
10/05/87	47	9	8.1	396	2.4	----	332	44	54	0.3	8.0	4.0	248	137	5.0	----
11/05/87	33															
12/04/87	F															

Station: BC-2 (Lower Bear Creek)

Date	Flow gpm	Temp °C	pH	TDS	TSS	Tot. Alk.	Tot. Hard.	Ca	Mg	Fe (Tot.)	Na	K	HCO_3	SO_4	Cl	Nit.
1/15/86	F															
2/17/86	26.2	2	7.9													
3/20/86	39.8	2	8.2	548	1,788					25.5				222	5.0	0.44
4/23/86	40	2	8.2	450	7,370	209	365	57	55	8.68	11.0	4.5	253	181	7.3	0.48
5/13/86	60	4	8.0	328	4,370	224	298	47	44	32.6	9.0	2.5	265	74	4.8	0.20
6/15/86	64	4	8.1	426	584	203	270	57	31	6.50	9.0	3.0	237	86	4.0	0.24
7/23/86	69	7	8.0	328	578	184	279	36	46	7.18	7.8	3.0	224	107	4.3	0.26
8/12/86	47	8	8.1	400	294	210	326	70	37	4.38	11.0	4.0	256	123	6.0	0.29
9/24/86	90	4	8.1													
10/01/86	62	3	8.2													
11/22/86	15	2	8.1													
12/10/86	F															
1/05/87	F															
2/06/87	F															
3/26/87	42.5															
4/07/87	52	1	8.1	560	980	227	455	49	81	18.1	14.0	5.0	276	255	7.0	0.75
5/15/87	67															
6/17/87	58															
7/15/87	47															
8/26/87	49	15	8.1	388	214	191	338	51	61	4.90	9.0	4.0	220	140	6.0	0.63
9/24/87	43															
10/05/87	51	10	8.0	404	54	----	336	53	50	0.34	8.0	4.0	251	139	5.0	----
11/05/87	43															
12/04/87	11.6															

F = frozen N/D = Not Detected units in mg/l unless noted otherwise

Table 7-2 Water Quality and Flow Data, 1986 and 1987 (cont)

Station: BC-3 (Right Fork Bear Creek)

Date	Flow gpm	Date	Flow Gpm
1/15/86	D	7/23/86	D
2/17/86	D	8/12/86	D
3/20/86	D	9/24/86	D
4/23/86	D	10/01/86	D
5/13/86	D	11/22/86	D
6/15/86	D	12/10/86	D

Station: SBC-1* (Mine Water)

Date	Flow gpm	Temp °C	pH	TDS Alk.	TSS Hard.	Tot.	Tot. (Tot.)	Ca	Mg	Fe	Na	K	HCO_3	SO_4	Cl	Nit.
1/15/86	UK	4	8.0													
2/17/86	UK	6	8.1	280	2.0	232	292	51	40	0.04	4.0	3.0	232	49	3.0	0.09
3/20/86	UK	4	8.0	272	6.0	222	282	52	37	0.27	5.0	2.0	222	52	2.0	0.02
4/23/86	UK	3	8.3	266	21	203	244	45	32	0.05	5.3	1.7	241	48	3.3	0.12
5/13/86	UK	3	8.1	272	28	200	256	46	34	0.11	4.6	1.8	244	50	7.7	0.19
6/15/86	UK	8	6.0	382	2.0	254	280	42	43	0.05	5.0	1.0	310	30	4.0	0.39
7/23/86	UK	9	8.0	380	2.0	194	309	63	37	0.14	5.5	2.0	236	117	5.1	0.27
10/01/86	UK	4	8.0	364	----	215	296	62	35	0.05	6.0	2.0	262	85	6.0	0.09
1/05/87	UK	6	8.2	290	6.0	271	301	67	33	0.05	4.0	1.0	330	32	4.0	0.23
4/07/87	UK	3	8.0	306	1.0	275	305	42	44	0.3	5.0	1.0	335	28	4.0	1.21
8/26/87	UK	11	7.9	416	2.8	269	394	91	42	0.14	5.0	4.0	328	127	4.0	0.46

Station: SBC-2 (Portal Well)

Date	Flow gpm	Date	Flow Gpm
1/05/87	D	7/15/87	D
2/06/87	D	8/26/87	D
3/26/87		9/24/87	D
4/07/87	D	10/05/87	D
5/15/87	D	11/05/87	D
6/17/87	D	12/04/87	D

Station: SBC-3 (Right Fork Creek Well)

Date	Flow gpm	Date	Flow Gpm
1/05/87	D	7/15/87	D
2/06/87	D	8/26/87	D
3/26/87		9/24/87	D
4/07/87	D	10/05/87	D
5/15/87	D	11/05/87	D
6/17/87	D	12/04/87	D

D = dry UK = unknown units in mg/l unless noted otherwise
F = frozen N/D = Not detected *SBC-1 is the same monitoring point as SBC-7

Table 7-2 Water Quality and Flow Data, 1986 and 1987 (cont)

Station: SBC-4 (Big Bear Springs Well)

Date	Flow gpm	Temp °C	pH	TDS	TSS	Tot. Alk.	Tot. Hard.	Ca	Mg	Fe (Tot.)	Na	K	HCO_3	SO_4	Cl	Nit.
3/20/86	UK	3	8.0	268	22	244	251	53	29	0.07	4.0	1.0	----	33	2.0	0.20
4/23/86	UK	2	7.9	320	3,840	276	295	55	38	0.07	9.5	1.5	337	40	5.0	0.36
5/13/86	UK	2	7.5	400	1,590	277	336	74	37	10.0	17	1.4	338	79	6.0	0.51
6/15/86	UK	3	8.0	380	3.0	268	288	70	28	0.08	4.0	1.0	327	19	4.0	0.31
7/23/86	UK	3	8.0	288	----	270	292	72	27	0.05[1]	4.2	0.8	329	21	3.0	0.58
9/24/86	UK	6	8.2	300	----	264	293	58	36	0.06[1]	5.0	1.0	323	25	5.0	0.24
10/01/86		UK	5	8.0	262	----	258	287	53	38	0.05[1]	4.0	1.0	315	27	4.00.18
1/05/87	UK	4	8.1	294	18	256	285	58	34	0.25	4.0	1.0	312	30	4.0	0.24
4/07/87	4[2]	2	8.1	272	19	262	286	35	48	0.15	5.0	1.0	319	33	4.0	0.24
8/26/87	UK	12	8.0	264	11	276	303	72	30	0.18	4.0	1.0	337	26	4.0	0.58
9/24/87	D															
10/05/87		UK	9	8.0	296	----	----	304	67	33	0.1	4.0	1.0	338	30	4.0----

Station: SBC-5 (Birch Spring)

Date	Flow gpm	Temp °C	pH	TDS Alk.	TSS Hard.	Tot.	Tot. (Tot.)	Ca	Mg	Fe	Na	K	HCO_3	SO_4	Cl	Nit.
4/07/87	18[2]	4	7.8	412	2.0	322	412	87	48	0.05	7.0	2.0	392	102	7.0	0.09
7/15/87	D[2]															
8/26/87	D[2]															
9/24/87	D[2]															
10/05/87		D[2]														
11/05/87		D[2]														
12/04/87		D[2]														

Station: SBC-6 (COP Development Spring)

Date	Flow gpm	Temp °C	pH	TDS Alk.	TSS Hard.	Tot.	Tot. (Dis.)	Ca	Mg	Fe	Na	K	HCO_3	SO_4	Cl	Nit.
3/20/86	D															
4/23/86	D															
7/23/86	D															
8/12/86	D															
9/24/86	12	9	8.0	458	----	291	331	83	30	0.5	5.0	1.0	355	1.0	6.0	0.05
10/01/86	2.4	6	7.3	362	----	271	302	71	30	0.06	4.0	1.0	331	15.0	6.0	0.03
1/05/87	D															
2/06/87	D															
3/26/87	D															
4/07/87	D															
5/15/87	D															
6/17/87	D															
7/15/87	D															
8/26/87	D															
9/24/87	D															
10/05/87		D														
11/05/87		D														
12/04/87		D														

[1] dissolved Fe
[2] Flows measured at Big Bear and Birch Springs overflows

D = dry units in mg/l unless noted otherwise
UK = unknown

Table 7-3 Baseline Water Quality Data - Annual Averages

Param.	BC-1 1988	BC-1 1995	BC-2 1988	BC-2 1995	BC-3 1988	BC-3 1995
Flow	37	56	33.5	174	Dry	Dry
Temp.	4.7	10.8	4.3	12.3		
pH.	8.0	8.6	7.9	8.5		
Cond.	480	757	503	643		
DO	N/R	5.4	N/R	5.6		
Settleable	10.7	17	5.1	2.5		
TSS	2,765	3,618	1,926	1,198		
TDS	399	468	418	338		
Hardness	345	372	346	288		
Carbonate	0.0	16.8	0.0	7.8		
Bicarbonate	254	1,019	260	606		
Ca	52	53	53	51		
Cl	6.3	6.8	6.0	6.5		
Fe total	N/R	26.4	23	9.5		
Fe Diss.	N/D	N/D	0.09	N/D		
Mg	53	58	52	38		
Mn total	N/R	0.7	0.46	0.23		
Mn diss.	<0.02	N/D	<0.02	N/D		
K	3.3	4.3	3.4	2.5		
Na	8.8	9.8	8.4	5.8		
Lab Cond.	N/R	710	785	556		
Sulfate	150	148	150	73		
O&G	N/D	N/D	N/D	N/D		
Al	<0.1	N/D	0.1	N/D		
As	N/D	N/D	N/D	N/D		
B	0.11	0.20	0.10	0.15		
Cd	N/D	N/D	N/D	N/D		
Cu	0.03	N/D	N/R	N/D		
Pb	N/D	N/D	N/D	N/D		
Mo	N/D	N/D	N/D	N/D		
Nitrogen	0.03	<0.5	0.04	<0.5		
Nitrate	0.25	0.4	0.27	0.13		
Nitrite	N/D	0.04	N/D	0.04		
Phosphate	N/D	0.30	<0.01	0.19		
Se	N/D	N/D	N/D	N/D		
Zn	N/D	N/D	N/D	N/D		

N/D = Not Detected
N/R = Not Reported
<## = Average value is below the detection limit.

Table 7-3 Baseline Water Quality Data - Annual Averages (Cont)

Param.	SBC-3 1988	SBC-3 1995	SBC-6 1988	SBC-6 1995	SBC-9[1] 1988	SBC-9 1995	SBC-10[1]	SBC-10
Flow	Dry	28.2'	Dry	Dry	114	151	237	23
Temp.		9.4			5.8	10.8	8.8	9.6
pH.		7.3			7.9	7.8	7.5	7.9
Cond.		3,987			484	484	638	664
TDS		2,230			360	330	359	355
Hardness		1,508			325	317	336	325
Carbonate		3.3			0	4	0	7.5
Bicarbonate		462			335	342	338	315
Ca		574			77	74	85	72
Cl		34			4.4	5.3	12.5	7.0
Fe total		2.9			0.17	<0.1	0.13	N/D
Fe Diss.		N/D			N/R	N/D	N/R	N/D
Mg		250			32	32	30	35
Mn total		0.13			N/D	N/D	0.02	N/D
Mn diss.		<0.1			N/R	N/D	N/R	N/D
K		12.3			1.7	1.5	N/D	2.5
Na		55			4.2	4.3	2.5	4.0
Lab Cond.		2,496			610	580	655	581
Sulfate		1,308			56.9	32.8	59.5	48.5
O&G								
Al		N/D			<0.1	N/D	N/D	N/D
As		<0.01			N/D	N/D	<0.002	N/D
B		0.6			0.07	0.13	0.05	0.1
Cd		N/D			N/D	N/D	N/D	N/D
Cu		N/D			0.03	N/D	<0.01	N/D
Pb		N/D			N/D	N/D	N/D	N/D
Mo		N/D			N/D	N/D	N/D	N/D
Nitrogen		N/D			0.11	N/D	0.23	N/D
Nitrate		0.33			0.07	N/D	0.12	<0.1
Nitrite		0.01			N/D	<0.01	<0.01	N/D
Phosphate		0.06			0.18	0.01	<0.01	0.015
Se		N/D			N/D	N/D	N/D	N/D
Zn		0.02			0.19	N/D	<0.01	0.01

N/D = Not Detected
N/R = Not Reported
<## = Average value is below the detection limit.
[1]Trace metals analyzed in total form.

Table 7-3 Baseline Water Quality Data - Annual Averages (Cont)

Param.	SBC-4[1] 1988	SBC-4[2] 1991	SBC-4[2] 1992	SBC-4[2] 1993	SBC-4 1994	SBC-4 1995	SBC-5[2] 1991	SBC-5[2] 1992	SBC-5[2] 1993	SBC-5 1994	SBC-5 1995
Flow	6.3	119	116	118	120	107	31.4	28.4	25.7	22.8	20.9
Temp.	6.7	8.1	10.4	13.4	14.3	12.0	8.0	11.6	14.0	14.1	12.2
pH.	7.9	7.7	7.1	7.4	7.4	7.0	7.5	7.3	7.1	6.9	7.1
Cond.	300	483	568	554	404	418	63	672	719	533	385
TDS	292	381	331	335	312	393	323	470	465	438	482
Hardness	294	347	367	316	292	317	440	431	409	385	392
Carbonate	0.0	1.3	0.0	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Bicarbonate	319	352	338	327	323	332	382	353	331	371	380
Ca	60	84	93	80	70	73	102	103	92	86	85
Cl	4.7	7.8	13.6	34.8	5.5	6.3	12.1	14.5	12.0	7.0	7.8
Fe total	N/R	0.15	0.03	0.09	N/D	N/D	0.06	0.04	0.12	N/D	N/D
Fe Diss.	N/D	N/R	N/R	N/R	N/D	N/D	N/R	N/R	N/R	N/D	N/D
Mg	35	34	33	28	29	33	45	42	43	42	43
Mn total	N/R	<0.01	<0.01	0.01	N/D	N/D	<0.01	<0.01	0.01	N/D	N/D
Mn diss.	N/D	N/R	N/R	N/R	N/D	N/D	N/R	N/R	N/R	N/D	N/D
K	1.0	4.3	0.3	0.6	N/D	1.5	2.4	1.1	1.2	N/D	2.3
Na	4.0	4.9	3.6	3.5	3.3	5.0	6.5	5.7	4.3	3.3	7.0
Lab Cond.	N/R	550	636	554	562	618	735	730	719	744	766
Sulfate	27	65	48	40	49	62	126	141	114	103	96
O&G	N/D	<5	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Al	N/D	<0.5	<0.5	N/D	N/D	N/D	<0.5	<0.5	<0.5	N/D	N/D
As	N/D	N/D	<0.002	0.007	N/D	N/D	N/D	<0.002	N/D	N/D	N/D
B	0.43	0.03	0.07	0.11	<0.1	0.15	0.08	0.14	0.12	0.10	0.51
Cd	N/D	<0.005	<0.005	N/D	N/D	<0.01	N/D	<0.005	N/D	N/D	N/D
Cu	N/R	<0.01	<0.01	2.5	N/D	N/D	<0.01	<0.01	N/D	N/D	N/D
Pb	N/D	N/D	0.002	N/D	N/D	N/D	N/D	0.002	N/D	N/D	N/D
Mo	N/D	<0.2	N/D	<0.2	N/D	N/D	N/D	N/D	<0.2	N/D	N/D
Nitrogen	0.09	0.19	0.07	0.05	N/D	N/D	0.18	0.01	0.02	N/D	N/D
Nitrate	0.26	0.16	0.19	0.24	0.32	0.15	N/D	0.13	37.8	0.18	0.10
Nitrite	N/D	N/D	0.05	0.05	N/D	N/D	<0.01	0.01	<0.01	<0.01	N/D
Phosphate	N/D	0.04	<0.01	0.01	0.07	0.09	0.01	0.03	0.02	0.06	0.10
Se	N/D	N/D	N/D	0.003	N/D	N/D	N/D	N/D	<0.002	N/D	N/D
Zn	<0.01	0.04	0.13	<0.01	0.02	N/D	0.01	0.04	0.01	<0.03	<0.01

N/D = Not Detected
N/R = Not Reported
<## = Average value is below the detection limit.
[1]Sample taken from spring overflow.
[2]Trace metals analyzed in total form.

Groundwater Movement

The movement of groundwater in the permit area is discussed in Appendix 7-N, section 2.4.3 and Appendix 7-J, section 6.0. Groundwater movement is strongly controlled by faults and the dip of strata. A stratigraphic cross-section showing the piezometric surfaces for the three Star Point aquifers is shown in Appendix 7-N, Figure 2-2. Plates 7N-3, 7N-4, and 7N-5 show the piezometric surface contours and top-of-unit contours for each aquifer. Table 7.1-4 summarizes the initial water levels from the four in-mine wells (DH-1A, DH-2, DH-3 and DH-4) and surface well SDH-1, shown on Plate 7-4. All three aquifers exhibit movement to the South, with an Easterly component, which varies for each aquifer. Essentially, the groundwater movement follows the regional and local dip of the beds.

Drill holes MW-114, MW-116 and MW-117 are located East of the Bear Canyon Fault. Plate 7J-2 shows the relationship of the potentriometric surfaces on each side of the fault. Plate 7-4A shows the piezometric surface contours for the uppermost aquifer within the Wild Horse Ridge area. No hydrology information is available for the WHR drill holes.

Exploration holes were also drilled upwards to evaluate potential perched aquifers in the area of the Tank Seam. Table 7-5 summarizes the results of this drilling. With the exception of TS-13, all of the drill holes were essentially dry. TS-13 initially flowed approximately 0.5 gpm and decreased to approximately 0.1 gpm by 1997.

Table 7-4 In-Mine and Surface Drillhole Water Level Measurements

Site	Elev. (ft)	Spring Canyon Water Elev. (ft)	Storrs Water Elev. (ft)	Panther Water Elev. (ft)
DH-1A	7,536'	7,433'	7,320'	7,099'
DH-2	7,557'	7,526'	7,402'	7,237'
DH-3	7,521'	7,396'	7,258'	7,070'
DH-4	7,610'	7,549'	-------	-------
SDH-1	9,387'	7,591'	-------	-------
SDH-2	9,486'	7,964'	-------	-------
SDH-3	9,110'	7,600'	-------	-------
MW-114	9,322'	7,650'	-------	-------
MW-116	9,342'	7,744'	-------	-------
MW-117	9,522	7,746'	-------	-------

Table 7-5 Additional DrillholeWater Level Measurements

Site	Elev. (ft)	Water Level Elev. (ft.)	Discharge (gpm)	Drill Hole Depth (ft)	Comments
lu	7509	None	____	200	Drilled vertical into mine roof
ld	7497	None	____	170	
2u	7492	None	____	200	Drilled vertical into mine roof
6d	7460	None	____	100	
7d	7460	None	____	100	
9d	7474	None	____	100	
10d	7509	None	----	200	
11d	7494	None	____	100	
12d	7516	None	----	100	
13d	7505	None	----	100	
14d	7508	None	----	100	
WM_A	7486	None	____	25	Drilled 45 deg up from horiz into working face
WM_B	7493	None	____	60	
WM_C	7130	None	____	50	
WM_D	7220	None	____	46	
WM_E	7430	None	____	400	
TS-6	7,553'	None	<0.1	297'	Drilled vertical into mine roof
TS-7	7,557'	None	Dry	300'	Drilled vertical into mine roof
TS-8	7,535'	None	Dry	270'	Drilled vertical into mine roof
TS-9	7,495'	None	Dry	260'	Drilled vertical into mine roof
TS-10	7,505'	None	Dry	240'	Drilled vertical into mine roof
TS-12	7,500'	None	Dry	250'	Drilled vertical into mine roof
TS-13	7,615'	None	0.5	270'	Drilled vertical into mine roof
TS-14	7,525'	None	Dry	250'	Drilled vertical into mine roof

Note: See Plate 6-11 for locations of drillholes TS-6 through TS-14. See Appendix 6-A for drillhole logs of TS-6 through TS-10 and TS-14. No logs are available for holes TS-12 and TS-13. Locations of additional in-mine drillholes are not known, but drillhole logs can be found in Appendix 7-A.

Three general groundwater flow conditions are hypothesized to exist at the site;

1. Flows exist which follow vertical joints near the surface and move laterally when impermeable beds of shale or mudstone are encountered. These flows are generally expressed as surface seeps, which occur close to the original recharge source, and only occur immediately after periods of recharge.

2. Flows exist which move downward through permeable strata and/or faults and joints in the interior of the mountain until impermeable beds of shale or mudstone are encountered. These flows then move laterally, generally following the dip of the strata, or following faults or fractures, which laterally conduct the water. Lateral movement continues until other vertically permeable lithology or zones of fracturing are encountered, in which vertical movement may continue, or until the land surface is reached, in which the flow discharges as springs or seeps. These flows generally occur year-round. When aquifers of this nature are encountered by mining, flows may be high initially, and then eventually drop to some continuous base flow.

3. Flows occur which are derived from local perched aquifers (sandstone lenses or localized fractures) and are encountered in-mine. These flows are expressed as roof drips and seeps, and will generally flow for a short period of time until the sandstone lenses or fractures are dewatered, and then cease flowing, indicating no apparent recharge.

Permeability of the first condition is secondary and may be up to several hundred ft/yr. Permeability of the second condition is mostly primary and low, on the order of 10 to 20 ft/yr. For the three Star Point sandstone aquifers, slug tests were performed in the in-mine drillholes to determine the permeability of the sandstones. The results of these tests are shown in Appendix 7-N, Table 4-1.

Groundwater Development

No development of groundwater through existing or future wells is planned within the permit expansion area. Use of groundwater in the area consists of the Big Bear Springs flow, which is entirely diverted for culinary use by the Huntington City community, and in-mine flows, which are collected in sumps and used for mining, dust control, and culinary water for Bear Canyon.

Wells and Users

Wells in and adjacent to the permit area (Appendix 7-A and Appendix 7-N) are monitoring wells installed by C. W. Mining.

Mine Dewatering

Dewatering of the mine was not required prior to 1991 due to the low water volumes encountered. Seepage into the mine has been controlled by pumping excess water to sump locations within the mine where it is allowed to settle, and then it is pumped out of the mine and discharged into Bear Creek, as governed by the mine discharge permit (Appendix 7-B).

A discharge line was installed in 1991 to the approved discharge point located above the scale house (Plate 7-1C). A totalizing flow meter is installed to monitor flows. Flows are logged and reported to the Utah Division of Water Quality with the monthly Discharge Monitoring Reports (DMR). Copies of these reports will be included in the quarterly Water Monitoring Reports.

On March 30, 1989, the State of Utah, Department of Health, stated that "a permit is not required" for overflow from the Bear Canyon culinary system (Appendix 7-B). The culinary overflow is piped into culvert C-8U (Plate 7-1C).

Expected mine water is further discussed in the Probable Hydrologic Consequence Determination (PHC), Appendix 7-J. Currently, no water is discharged from the Tank Seam due to the lack of mine water inflow. Similar conditions are expected in both Seams within Wild Horse Ridge.

Ground Water Site Selection

C. W. Mining has selected sites that have been developed for beneficial use, are the primary source of surface water systems, or contain large flows, for monitoring. The parameters tested for and the schedule followed are the ones determined to be adequate based on the study found in Appendix 7J. Three years of baseline data will be collected which exceeds the minimum required by law. The Division recommended list for baseline parameters will be followed which exceeds the minimum required by law. Additionally every five years baseline parameters will be collected. The rest of the time filed readings will be collected which includes flow data and enough parameters to determine an impact. These sites are listed in Table 7-14.

724.200 Surface Water Information

Scope

The purpose of this section is to provide background information on the surface hydrology characteristics of the Co-Op Bear Canyon Mine permit area and the surrounding regional area~~.~~; also, to present a plan of action for complying with the requirements of the Office of Surface Mining (OSM) and the Utah Division of Oil, Gas and Mining (DOGM). In particular, this section includes an evaluation of the geological and hydrological setting of the mine, its relation to the regional ground water and surface water hydrology and its probable impact on the groundwater and surface water systems. Appendix 7-J (PHC), Section 7.0 also contains information pertaining to the surface water hydrology.

Information from field reconnaissance and a review of data from various sources was used in compiling this surface water hydrology section. The data sources included information from Co-Op, reports by the U.S. Geological Survey, Utah Geological and Mineral Survey, U.S. Forest Service and mine application permits on file with OSM (specifically those in the Huntington Canyon area). References used are listed at the end

Surface Water in Regional and Adjacent Areas

The San Rafael River Basin of the Upper Colorado River Region is generally classified as an arid basin. The upper drainages along the Wasatch Plateau receive enough snow precipitation to be classified as semi-arid to sub-humid due to the amount of precipitation increase with altitude.

There are eight major reservoirs in the basin. Seven are mainly for irrigation with a total capacity of 85,000 acre-ft and one, with a capacity of 30,530 acre-ft, is used as the water supply for a power plant. Diversions during irrigation season, April to November, from Huntington, Cottonwood, and Ferron Creeks nearly deplete flows downstream from these diversions. Flows downstream during this period are mainly irrigation return flows along with some groundwater seepage.

At points of major diversions on the Huntington, Cottonwood, and Ferron Creeks the water quality is excellent for irrigation, with dissolved-solids concentrations of less than 500 mg/l. But water at the mouths of these creeks has markedly larger dissolved-solids concentrations. This is mainly due to two factors:

a. In the area between major diversions and the mouths of the creeks, the creeks cross a belt of exposed Mancos Shale 10 to 15 miles wide.

b. This area is also where practically all the intensive irrigation in the San Rafael River Basin is practiced. (Mundoff, '82).

The upper drainage of Huntington Creek encompasses about 200 sq mi of mountainous country in the Wasatch Plateau. About 90 pct of the area is higher than 8,000 ft. The average channel gradient along the stream in the area is about 100 ft/mile. In the lower reaches the stream is in deep, narrow canyons, and surface relief between the stream channel and the top of adjacent canyon walls is typically 2,000 ft or more. (Danielson, '81).

Quantity and Quality of Surface Water

According to Danielson, "...about 65 pct of the annual discharge at the Huntington Creek station (0931800) occurs during the snowmelt period (April-July). Because most of the stream flow is derived from snowmelt, annual discharge to the gaging station correlates well with the April 1 snow pack water content." Approx 80 pct of the discharge from these streams is during the snowmelt from April to July.

As part of the Danielson study, chemical analyses were performed on selected surface water samples from the area. It should be noted that none of the analyzed chemical constituents were found in concentrations that exceeded the drinking water standards of the U.S. Environmental Protection Agency (1976). Danielson also noted that, "The predominant dissolved chemical constituents in water in Huntington Creek upstream from gauging station 0931800 were calcium and bicarbonate. The predominant dissolved chemical constituents in water in tributaries to Huntington Creek were usually calcium, magnesium, and bicarbonate. However, during periods of base flow the concentrations of sulfate in water at the mouths (of the tributaries) were significantly higher than sulfate concentrations in water in Huntington Creek. Water from the Star Point commonly contains slightly higher concentrations of both dissolved solids and sulfate than water from younger rocks in the area."

Water Uses

Most of the surface water from the drainage is diverted for use as crop irrigation. The only other major use is supply water to the Huntington Power plant. The reservoirs in the area have been built to supplement this use. Some water in the area, particularly springs, is issued for livestock watering or as culinary water.

Water rights have been obtained by Co-Op in sufficient quantities for all of the mine's needs. Table 7-6 contains a listing of water rights in the area and Plate ~~7-4~~ 7-12 indicates their various locations. Information on the water rights can be accessed on the Utah Division of Water Rights website at http://nrwrt1.nr.state.ut.us/wrinfo/query.asp. Additional information about the water rights owned by the Co-Op man can be found in Appendix 7-C. Appendix 7-D contains a copy of an agreement between Co-Op and Huntington City with regards to protection of Huntington City's Big Bear Creek Spring (Huntington Spring) water source.

Table 7-6 Area Water Rights

Water Right	Owner	Priority Date	Place of Use	Point of Diversion	Nature Of Use
91-251	ANR	0/0/1900	(1) S 215 ft W 120 ft from NE cor, Sec 12, T 20S, R 6E, SLBM	Surface	Irrigation/ Domestic
91-316	ANR	0/0/1875	spring located in SW4NE4 Sec 10, T18S, R5E, SLBM	Spring	Stockwater
93-116	U.S.F.S	0/0/1875	From a point in NE4SE4 Sec 08, T15S, R7E, SLBM, to a point in SE4SE4 Sec 09, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-129	Nevada Electric	0/0/1875	From a point in NW4NW4 Sec 15, T16S, R7E, SLBM, to a point in NW4NW4 Sec 15, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-130	U.S.F.S	0/0/1875	from a point in SW4NW4 Sec 15, T16S, R7E, SLBM, to a point in SE4NW4 Sec 22, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-131	C.O.P Coal	0/0/1875	from a point in NW4SE4 Sec 22, T16S, R7E, SLBM, to a point in SW4SE4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-138	C.O.P Coal	0/0/1875	from a point in NE4NE4 Sec 15, T16S, R7E, SLBM, to a point in NE4SE4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-139	U.S.F.S	0/0/1875	from a point in NW4NW4 Sec 11, T16S, R7E, SLBM, to a point in SE4SE4 Sec 10, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-140	Utah Trust Land	0/0/1875	from a point in NE4SW4 Sec 02, T16S, R7E, SLBM, to a point in SW4SW4 Sec 02, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-141	C.O.P Coal	0/0/1875	from a point in NW4NW4 Sec 14, T16S, R7E, SLBM, to a point in SE4NE4 Sec 15, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-142	Utah Trust Land	0/0/1875	from a point in NW4NW4 Sec 01, T16S, R7E, SLBM, to a point in NE4NW4 Sec 14, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-143	Nevada Electric	0/0/1875	Spring located in NW4SW4 Sec 26, T16S, R7E, SLBM	Spring	Stockwater
93-144	U.S.F.S	0/0/1875	from a point in SE4SE4 Sec 22, T16S, R7E, SLBM, to a point in SE4SE4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-146	Nevada Electric	0/0/1875	from a point in SE4NE4 Sec 27, T16S, R7E, SLBM, to a point in SE4NE4 Sec 27, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-147	BLM	0/0/1860	from a point in NW4NW4 Sec 35, T16S, R7E, SLBM, to a point in NE4NW4 Sec 35, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-148	BLM	0/0/1902	from a point in SE4SW4 Sec 26, T16S, R7E, SLBM, to a point in SE4SW4 Sec 26, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-149	Nevada Electric	0/0/1875	from a point in SW4SW4 Sec 26, T16S, R7E, SLBM, to a point in SW4SW4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-150	Nevada Electric	0/0/1875	from a point in NE4NW4 Sec 24, T16S, R7E, SLBM, to a point in NE4SE4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-151	U.S.F.S	0/0/1875	from a point in NE4NW4 Sec 13, T16S, R7E, SLBM, to a point in SW4SW4 Sec 13, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-155	Utah Trust Lands	0/0/1902	from a point in NE4NW4 Sec 29, T16S, R8E, SLBM, to a point in SW4SW4 Sec 29, T16S, R8E, SLBM.	Point 2 Point	Stockwater
93-156	A.U. Mines INC.	0/0/1902	from a point in NW4NE4 Sec 29, T16S, R8E, SLBM, to a point in NW4NE4 Sec 29, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-157	A.U. Mines INC.	0/0/1902	from a point in NW4SE4 Sec 20, T16S, R8E, SLBM, to a point in SW4SE4 Sec 20, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-158	C.O.P Coal	0/0/1902	from a point in NE4NW4 Sec 20, T16S, R8E, SLBM, to a point in SE4NW4 Sec 20, T16S, R8E, SLBM.	Point 2 Point	Stockwater
93-160	C.O.P Coal	0/0/1902	from a point in SW4NW4 Sec 07, T16S, R8E, SLBM, to a point in SE4SW4 Sec 17, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-161	C.O.P Coal	0/0/1902	spring located in NW4SE4 Sec 07, T16S, R8E, SLBM	Spring	Stockwater
93-163	C.O.P Coal	0/0/1902	from a point in Lot 4 Sec 06, T16S, R8E, SLBM, to a point in NE4NE4 Sec 15, T16S, R8E, SLBM.	Point 2 Point	Stockwater
93-165	Trust Lands	0/0/1902	from a point in SW4SW4 Sec 29, T16S, R8E, SLBM, to a point in SW4SW4 Sec 29, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-166	U.S.F.S	0/0/1875	from a point in NE4NE4 Sec 19, T16S, R8E, SLBM, to a point in SE4NE4 Sec 30, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-167	C.O.P Coal	0/0/1902	from a point in SW4NW4 Sec 18, T16S, R8E, SLBM, to a point in SW4SE4 Sec 18, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-188	U.S.F.S	0/0/1875	from a point in SE4NW4 Sec 05, T16S, R7E, SLBM, to a point in SE4NW4 Sec 04, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-190	U.S.F.S	0/0/1875	from a point at 0 ft., to a point in NE4SE4 Sec 06, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-192	U.S.F.S	0/0/1875	from a point in NW4SE4 Sec 09, T16S, R7E, SLBM, to a point in NE4SE4 Sec 09, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-193	U.S.F.S	0/0/1875	from a point in SW4SE4 Sec 08, T16S, R7E, SLBM, to a point in NW4SE4 Sec 09, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-195	U.S.F.S	0/0/1875	from a point in NE4NE4 Sec 20, T16S, R7E, SLBM, to a point in NE4NW4 Sec 22, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-196	Hiatt, Marena Madden, et Al	0/0/1902	from a point in SW4SE4 Sec 17, T16S, R7E, SLBM, to a point in SW4SE4 Sec 17, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-199	UP&L	0/0/1902	from a point in NW4NW4 Sec 27, T16S, R7E, SLBM,to a point in SE4SW4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-202	BLM	0/0/1902	from a point in SE4NE4 Sec 35, T16S, R7E, SLBM, to a point in SE4NE4 Sec 35, T16S, R7E, SLBM.	Point 2 Point	Stockwater

93-203	Zions Bank& Frank A	0/0/1902	from a point in NW4NW4 Sec 02, T17S, R7E, SLBM, to a point in NE4SE4 Sec 35, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-210	Zionsl Bank & Frank A	0/0/1902	from a point in NW4SW4 Sec 35, T16S, R7E, SLBM, to a point in SE4SW4 Sec 35, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-214	Utah Power And Light	0/0/1902	from a point in SW4NW4 Sec 36, T16S, R7E, SLBM, to a point in SE4SE4 Sec 06, T17S, R8E, SLBM.	Point 2 Point	Stockwater
93-217	Utah Power And Light	0/0/1902	from a point in NW4SW4 Sec 01, T17S, R7E, SLBM, to a point in SW4SE4 Sec 36, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-219	HCIC	0/0/1875	(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM, (2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM	Surface	Irrigation/Power/Industrial/Domestic/Minicipal/Stock Water
93-220	HCIC	0/0/1875	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM	Surface	Irrigation/Power/Industrial/Domestic/Minicipal/Stock Water
93-253	HCIC	0/0/1875	(1) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Stock Water/ Irrigation/ Domestic/ Municipal
93-254	HCIC	0/0/1875	(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM	Surface	Stock Water/ Irrigation/ Domestic/ Municipal
93-259	HCIC	0/0/1875	spring located in NW4SW4 Sec 17, T16S, R7E, SLBM	Spring	Stockwater
93-260	HCIC	0/0/1902	spring located in SW4SE4 Sec 17, T16S, R7E, SLBM	Spring	Stockwater
93-303	HCIC	0/0/1875	(1) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Stock Water/ Irrigation/ Domestic/ Minicpal
93-304	HCIC	0/0/1875	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Domestic
93-309	HCIC	0/0/1875	(1) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Domestic/ Municipal/Stock Water
93-310	HCIC	0/0/1875	(1) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/Domestic/Municipal/ Stock Water
93-317	U.S.F.S	0/0/1875	spring located in SE4NW4 Sec 10, T18S, R5E, SLBM	Spring	Stockwater
93-390	Nevada Electric	0/0/1875	from a point in SW4SE4 Sec 22, T16S, R7E, SLBM, to a point in SW4SE4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-508	ANR	0/0/1902	spring located in Lot 2 Sec 06, T16S, R8E, SLBM	Spring	Stockwater
93-509	C.O.P Coal	0/0/1875	spring located in SE4NW4 Sec 06, T16S, R8E, SLBM	Spring	Stockwater
93-510	C.O.P Coal	0/0/1902	spring from a point at 0 ft., to a point in NE4NE4 Sec 15, T16S, R8E, SLBM	Spring	Stockwater
93-511	IPA	0/0/1902	spring located in Lot 7 Sec 06, T16S, R8E, SLBM	Spring	Stockwater
93-512	ANR	0/0/1902	from a point in SE4NE4 Sec 05, T16S, R8E, SLBM, to a point in SE4NE4 Sec 09, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-513	Utah Trust Lands	0/0/1902	from a point in SW4NW4 Sec 10, T16S, R8E, SLBM, to a point in NW4SW4 Sec 10, T16S, R8E, SLBM.	Point 2 Point	Stockwater
93-514	C.O.P Coal	0/0/1902	from a point in SW4SW4 Sec 10, T16S, R8E, SLBM, to a point in SW4SW4 Sec 10, T16S, R8E, SLBM	Point 2 Point	Stockwater
93-522	IPA	0/0/1902	(1) N 950 ft W 1430 ft from SE cor, Sec 06, T 16S, R 8E, SLBM	Surface	Mining/ Stock Water
93-565	Utah Trust Land	0/0/1902	from a point in NE4NW4 Sec 28, T16S, R8E, SLBM, to a point in NE4SE4 Sec 10, T17S, R8E, SLBM.	Point 2 Point	Stockwater
93-928	HCIC	0/0/1902	(1) N 1240 ft E 270 ft from SW cor, Sec 21, T 14S, R 6E, SLBM	Surface	Irrigation/ Power/ Industrial/ Fish Culture/ Stock Water/ Domestic
93-955	Utah Water Recources	8/8/1922	(1) N 1240 ft E 270 ft from SW cor, Sec 21, T 14S, R 6E, SLBM	Surface	Irrigation/ Stock Water
93-964	U.S. Fuel	8/17/1929	(1) S 1450 ft E 1400 ft from NW cor, Sec 05, T 16S, R 8E, SLBM	Surface	Industrial
93-970	ANR	4/10/1930	(1) N 1831 ft W 1012 ft from SE cor, Sec 08, T 16S, R 8E, SLBM	Surface	Industrial
93-1063	Utah Water Recources	3/30/1961	(1) N 1641 ft E 938 ft from SW cor, Sec 21, T 14S, R 6E, SLBM, (2) S 2220 ft W 2200 ft from NE cor, Sec 33, T 14S, R 6E, SLBM,(3) S 3272 ft W 282 ft from NE cor, Sec 33, T 14S, R 6E, SLBM, (4) N 165 ft W 750 ft from S4 cor, Sec 05, T 17S, R 8E, SLBM	Surface	Irrigation/ StockWater/ Domestic
93-1067	C.O.P Coal	1/20/1964	(1) N 79 ft E 75 ft from SW cor, Sec 24, T 16S, R 7E, SLBM	Surface	Irrigation/ Domestic/ Mining
93-1089	ANR	7/0/1910	(1) N 1500 ft W 85 ft from SE cor, Sec 08, T 16S, R 8E, SLBM	Under ground	Irrigation
93-1115	Utah Power And Light	12/10/1968	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM , (2) N 2350 ft W 500 ft from SE cor, Sec 10, T 17S, R 7E, SLBM	Surface	Irrigation/ Power/ Industrial
93-1129	Utah Trust Lands	0/0/1875	spring located at N3000 ft. E350 ft. from SW corner, Sec 10, T16S, R8E, SLBM	Spring	Stockwater
93-1139	HCIC	0/0/1890	(1) S 940 ft W 550 ft from N4 cor, Sec 28, T 14S, R 6E, SLBM	Surface	Irrigation/Power/Fish Culture/Industrial/Industrial /StockWater/Municipal/ Domestic
93-1182	Peabody Coal Co.	0/0/1902	from a point in NW4SE4 Sec 26, T16S, R7E, SLBM, to a point in SW4SE4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-1183	Pacificorp UP&L	0/0/1902	from a point in NE4SW4 Sec 22, T16S, R7E, SLBM, to a point in NE4SW4 Sec 22, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-1187	U.S.F.S	0/0/1875	from a point in NE4SW4 Sec 20, T16S, R8E, SLBM, to a point in NE4SW4 Sec 20, T16S, R8E, SLBM.	Point 2 Point	Stockwater

93-1408	U.S.F.S	0/0/1875	spring located in NW4NE4 Sec 06, T16S, R7E, SLBM	Spring	Stockwater
93-1411	U.S.F.S	0/0/1875	spring located in NE4SW4 Sec 09, T16S, R7E, SLBM	Spring	Stockwater
93-1425	U.S.F.S	0/0/1875	spring located in SE4SW4 Sec 21, T16S, R8E, SLBM	Spring	Stockwater
93-1426	U.S.F.S	0/0/1875	spring located in SW4NW4 Sec 21, T16S, R8E, SLBM	Spring	Stockwater
93-1427	U.S.F.S	0/0/1875	spring located in NE4NE4 Sec 20, T16S, R8E, SLBM	Spring	Stockwater
93-1428	U.S.F.S	0/0/1875	spring located in NE4NE4 Sec 19, T16S, R8E, SLBM	Spring	Stockwater
93-1429	U.S.F.S	0/0/1875	spring located in NE4SE4 Sec 13, T16S, R7E, SLBM	Spring	Stockwater
93-1430	U.S.F.S	0/0/1875	spring located in SE4SE4 Sec 12, T16S, R7E, SLBM	Spring	Stockwater
93-1431	U.S.F.S	0/0/1875	spring located in NE4SE4 Sec 12, T16S, R7E, SLBM	Spring	Stockwater
93-1432	U.S.F.S	0/0/1875	spring located in SE4NE4 Sec 12, T16S, R7E, SLBM	Spring	Stockwater
93-1433	U.S.F.S	0/0/1875	spring located in NW4SE4 Sec 12, T16S, R7E, SLBM	Spring	Stockwater
93-1434	U.S.F.S	0/0/1875	spring located in NW4SW4 Sec 11, T16S, R7E, SLBM	Spring	Stockwater
93-1435	U.S.F.S	0/0/1875	spring located in NE4SE4 Sec 10, T16S, R7E, SLBM	Spring	Stockwater
93-1436	U.S.F.S	0/0/1875	spring located in NW4NW4 Sec 11, T16S, R7E, SLBM	Spring	Stockwater
93-1437	U.S.F.S	0/0/1875	spring located in NE4NW4 Sec 01, T16S, R7E, SLBM	Spring	Stockwater
93-1438	U.S.F.S	0/0/1875	spring located in NE4NW4 Sec 01, T16S, R7E, SLBM	Spring	Stockwater
93-2193	HCIC	0/0/1879	(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM	Surface	Irrigation/ Domestic/ Municipal/ StockWater
93-2194	HCIC	0/0/1884	(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater
93-2195	HCIC	0/0/1888	(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM	Surface	Irrigation/ StockWater
93-2196	HCIC	0/0/1879	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2197	HCIC	0/0/1884	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2198	HCIC	0/0/1888	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2199	HCIC	0/0/1879	(1) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2200	HCIC	0/0/1884	(1) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2201	HCIC	0/0/1888	(1) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2202	HCIC	0/0/1879	(1) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2203	HCIC	0/0/1884	(1) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2204	HCIC	0/0/1888	(1) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Stockwater
93-2205	HCIC	0/0/1879	(1) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2206	HCIC	0/0/1884	(1) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Stockwater
93-2207	HCIC	0/0/1888	(1) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2208	HCIC	0/0/1879	(1) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2209	HCIC	0/0/1884	(1) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2210	HCIC	0/0/1888	(1) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2220	HCIC	0/0/1879	(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM (2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2221	HCIC	0/0/1884	(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM (2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2222	HCIC	0/0/1888	(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM (2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic
93-2223	HCIC	0/0/1879	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic/ Power/ Industrial
93-2224	HCIC	0/0/1884	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic/ Power/ Industrial
93-2225	HCIC	0/0/1888	(1) S 1535 ft E 785 ft from NW cor, Sec 36, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic/ Power/ Industrial

93-3033	HCIC	0/0/1875	from a point in NW4SW4 Sec 26, T16S, R7E, SLBM, to a point in NW4SW4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-3033	North West Carbon Corp	0/0/1875	from a point in NW4SW4 Sec 26, T16S, R7E, SLBM, to a point in NW4SW4 Sec 26, T16S, R7E, SLBM.	Point 2 Point	Stockwater
93-3047	Utah Trust Lands	0/0/1860	spring located in SW4NE4 Sec 28, T16S, R8E, SLBM.	Spring	Stockwater
93-3171	North West Carbon Corp	0/0/1875	from a point in NW4SW4 Sec 26, T16S, R7E, SLBM, to a point in SW4SW4 Sec 26, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-3195	HCIC	2/28/1980	(1) S 940 ft W 550 ft from N4 cor, Sec 28, T 14S, R 6E, SLBM	Surface	Irrigation/ Industrial/ Power/ Fish Culture/ Stock Water/ Domestic/ Municipal
93-3207	BLM	0/0/1860	from a point in NE4NE4 Sec 27, T16S, R7E, SLBM, to a point in NE4NE4 Sec 27, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-3208	BLM	0/0/1860	from a point in SW4NW4 Sec 26, T16S, R7E, SLBM,to a point in SW4NW4 Sec 26, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-3209	BLM	0/0/1860	from a point in NE4SW4 Sec 26, T16S, R7E, SLBM, to a point in NE4SW4 Sec 26, T16S, R7E, SLBM	Point 2 Point	Stockwater
93-3524	ANR	4/10/1930	(1) N 1831 ft W 1012 ft from SW cor, Sec 09, T 16S, R 8E, SLBM	Surface	Industrial/ Municipal
93-3657	J. O Kingston	0/0/1875	(1) S 1725 ft W 1280 ft from NE cor, Sec 22, T 16S, R 7E, SLBM, (2) N 79 ft E 75 ft from SW cor, Sec 24, T 16S, R 7E, SLBM	Surface	Irrigation/ Stockwater
93-3725	HCIC	0/0/1875	(1) N 1060 ft E 685 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM, (2) N 2030 ft E 60 ft from SW cor, Sec 26, T 16S, R 7E, SLBM, (3) S 1770 ft W 980 ft from NE cor, Sec 27, T 16S, R 7E, SLBM, (4) S 2040 ft W 530 ft from NE cor, Sec 27, T 16S, R 7E, SLBM	Surface	Irrigation/ Municipal/ StockWater/ Domestic/ Power/ Industrial
93-3739	ANR	7/00/1910	(1) N 1500 ft W 85 ft from SE cor, Sec 08, T 16S, R 8E, SLBM	Under ground	Irrigation
93-3745	IPA	4/10/1930	(1) N 1831 ft W 1012 ft from SE cor, Sec 08, T 16S, R 8E, SLBM	Surface	Industrial/ Municipal
93-3746	IPA	4/10/1930	(1) N 1831 ft W 1012 ft from SW cor, Sec 09, T 16S, R 8E, SLBM	Surface	Industrial/ Municipal

Note: This table includes water rights on file with the Utah Division of Water Rights in or near the permit area.

Mine Plan Area Surface Water

The channel of Bear Creek is straddled by the mine plan area. Bear Creek is a perennial stream with flows often frozen during the winter. An ephemeral tributary flows into Bear Creek from the east in the mine plan area. Some of the higher portions of this drainage contain intermittent flows, but this flow is adsorbed by the ground before it reaches Bear Creek.

Measurements at the mouth of Bear Creek made during the Danielson study indicate a significant impact to stream flow from snowmelt, between 18 and 153 gpm (Table 7-7). The headwater springs of Bear Creek issue from the North Horn Formation, a locally recharged water zone. These springs flow over steep, often unstable slopes to the creek bed, which results in high concentrations of suspended solids measurements taken during the Danielson study, which illustrates the high concentrations in Bear Creek.

Concerning the unusually high sediment loads in Bear Creek, Danielson stated the following:

> "Bear Creek transported large quantities of suspended sediment during 1978 and 1979. Springs emerging from the North Horn Formation in the headwaters of Bear Creek continuously erode the shale and mudstone and permit sloughing of large amounts of fine-grained material from the escarpments."

Table 7-7 Stream Flow Measurements (1977-79)

	Date	Discharge (cfs)	(gpm)
Bear Creek (site no. 81)	08-10-78	0.09	40.4
	10-25-78	0.08	35.9
	11-08-78	0.06	26.9
	12-13-78	0.04	18.0
	06-27-79	0.34	152.3
	07-16-79	0.21	94.3
	10-30-79	0.05	22.4

Measurement of suspended sediments were collected during the Danielson study. Below are the results from selected tributaries of Huntington Creek.

Table 7-8 Suspended Sediments, Huntington Creek Tributaries

Stream	Site No.	Date	Concentration	Tons/day
Huntington Creek (gauging station 0931800)	88	08-13-78	104	27
		11-17-78	72	2.5
		06-13-79	114	6
		08-07-79	44	15
Crandall Canyon (gauging station 09317919)	51	08-12-78	49	0.14
		11-18-78	60	0.08
		06-14-79	15	0.41
		08-06-79	56	0.15
Tie Fork Canyon (gauging station 09317920)	67	08-13-78	12	0.03
		11-18-78	57	0.12
		06-14-79	38	0.68
		08-06-79	66	0.17
Bear Creek	81	10-25-78	8,860	1.9
		06-14-79	2,140	4.0
Deer Creek	87	06-14-79	609	3.1

* Stream flow measurements are taken from Danielson, 1981, see references

Effects of Mining on Surface Water

The operation of Bear Canyon Mine by C. W. Mining is expected to have only a very minimal effect on surface water on the area. The quality of Bear Creek before passing through the mine plan area is poor. Generally, as the excess mine water is discharged into Bear Creek; the surface water quality is improved significantly after passing through the mine site. The potential impacts to surface waters are discussed in Appendix 7-J, section 9.1.2. The greatest potential impact of mining operations is probably an increase in sediment loading to Bear Creek. Controls and diversion structures have been constructed to prevent sediment-laden water from disturbed area from mixing with local surface water, to minimize the mining impacts on the receiving stream waters.

Surface Water Site Selection

All perennial streams inside the permit area start within the permit area. Because of this the major groundwater sources feeding them are monitored. Surface monitoring sites have been selected at all major confluences and at other points of interest. Additionally sites were selected in all perennial streams as close as possible, based on accessibility, to the edge of the permit boundary to detect any of site impacts. The parameters tested for and the schedule followed are the ones determined to be adequate based on the study found in Appendix 7J. Three years of baseline data will be collected which exceeds the minimum required by law. The Division recommended list for baseline parameters will be followed which exceeds the minimum required by law. Additionally every five years baseline parameters will be collected. The rest of the time field readings will be collected which includes flow data and enough parameters to determine an impact. These sites are listed in Table 7-14.

724.300 Geologic Information

Geologic information for use in determining the probable hydrologic consequence of mining operations upon the quality and quantity of surface and ground water, whether reclamation can be accomplished, and whether the proposed operations have been designed to prevent material damage to the hydrologic balance outside the permit area is discussed in detail in Chapter 6 Geology (R645-301-624) and under numerous headings in this chapter.

724.400 Climatological Information

The climate of the Bear Canyon Mine area is typical of subalpine areas in the central region of Utah. In general, the summer season is short with maximum temperature readings (°F) in the 80's and minimum readings in the 40's. Fall and spring seasons are erratic in nature, with snow precipitation occurring as early as September and as late as the first part of June. Winters in this subalpine area are often severe, with recorded temperatures of -20°F or below at times. Major snowfalls can occur in the months of December, January, and February. Snow frequently remains on the ground from November until April in depths varying up to 6 ft. Winds are generally light to moderate, with average speeds below 21 m.p.h. The prevailing wind direction within the area of the mine site is from the southwest. Winds are generally parallel to the canyon, except during storm periods. Wind speed varies from canyon to canyon.

The estimated annual background total suspended particulate (TSP) in rural, central Utah is approximately 20 $\mu g/m^3$ (AeroVironment, 1977). Because of the proximity to existing mines, background TSP could be higher than the average background total for typical rural areas.

724.411 Precipitation

Precipitation varies greatly in the vicinity of the permit area due to the Manti-Lasal Mountain Range. Local factors affecting precipitation in the area are altitude, topography, and geographic location relative to the west-to-east storm track. The normal annual precipitation at the center of the permit area is approximately 8 to 10 inches greater than it is near the office area.

The nearest weather monitoring station is at Hiawatha, located about 5 miles Northeast of the center of the permit area. The annual precipitation recorded at the Hiawatha station is 13.18 inches Table 7-9 shows the precipitations recorded from 1916 to 1975. An isohyetal map from the Hydrologic Atlas of Utah shows an annual precipitation of 22 inches at the center of the permit area. (This is the source of the discrepancy referenced in the OSM completeness determination.) Approximately 16 inches, or 73%, of this precipitation occurs as snow from October to April. The other 6 inches, or 27%, occurs from May to September as rainfall. Snow accumulation averages 4.5 ft. A maximum snow depth of 6 ft is to be expected.

In mid-1991, a precipitation gauge was installed at the Bear Canyon Mine, located at the Scale house. Table 7-10 shows the average monthly precipitation from 1992 through 1995. Additional precipitation data for the surrounding area is shown in Appendix 7-N, *Hydrogeologic Evaluation.*

724.412 Wind Direction and Velocity

In general, winds are light to moderate, with average speeds below 20 mph[1]. Wind speed varies from canyon to canyon. At the Bear Canyon Portal area, the average wind speed is estimated at 10 mph, directed from west-southwest. Tornadoes are very rare, but strong winds may occur, particularly in these mountain passes and canyons. The highest gust in the vicinity of the mine site is expected to be more than 100 mph. The gust would occur under extremely unstable conditions with active fronts. See Appendix 7-P.

[1]Arlo Richardson, Utah State Climatologist, Utah State University.

724.413 Temperature

Temperature is seasonally variable and highly influenced by elevation. January temperatures vary from a mean minimum of 13°F to a mean maximum of 30°F. July temperatures vary from a mean minimum of 54°F to a mean maximum of 82°F (Jeppson et al., 1968). Similar temperature ranges are recorded at the Hiawatha Station. Table 7-11 shows the temperatures recorded between 1922 and 1975. The average annual temperature is 45°F. July is the warmest month (an average of 69°F) and January is the coldest (an average of 23°F). Wide daily temperature ranges are caused by relatively strong daytime warming and rapid nighttime cooling.

724.420 Evaporation and Relative Humidity

The potential evaporation is about 40 inches/yr. Transpiration is less than 18 inches/yr. The relative humidity ranges from a summer average of 45% to a winter average of 85%.

Table 7-9 Precipitation Totals - Hiawatha Station (inches)

Month	Mean	Greatest Daily	Year	Snow		
				Mean	Maximum Monthly	Year
January	0.87	0.92	1944	21.3	59.0	1969
February	0.98	1.29	1923	12.8	47.0	1969
March	0.99	1.20	1935	9.7	39.5	1952
April	0.91	1.33	1944	4.0	22.0	1965
May	1.05	2.00	1922	2.0	25.0	1964
June	1.04	2.14	1941	0.2	1.0	1925
July	1.22	1.20	1973	0.0	0.0	-
August	1.92	2.05	1946	0.0	0.0	-
September	1.26	1.73	1961	4.2	11.0	1965
October	1.20	1.54	1941	1.3	14.0	1961
November	0.73	1.35	1943	6.6	30.5	1951
December	1.01	1.53	1916	13.0	50.5	1951
Annual	13.18	2.14	June 1941	74.5	59.0	January 1969

Station: Hiawatha
Elevation: 7,220 ft
Period of Record: 1916 – 1975

Longitude: 110° 01'
Latitude: 39° 29'

Table 7-10 Precipitation Totals - Bear Canyon Station (inches)

Month	Mean	Greatest Daily	Year
January	0.51	0.43	1993
February	0.53	0.31	1994
March	1.00	1.22	1993
April	1.11	0.59	1995
May	1.42	0.67	1992
June	0.39	0.33	1995
July	0.62	0.69	1992
August	2.00	1.01	1995
September	0.78	0.52	1994
October	0.99	0.47	1992
November	0.35	0.26	1994
December	0.34	0.30	1995
Annual	10.04	1.22	March 1993

Station:	Bear Canyon Mine	Longitude:	111° 05' 40"
Elevation:	7,092 ft.	Latitude:	39° 24' 30"
Period of Record:	1992 – 1995		

Table 7-11 Temperatures (°F)

Month	Means			Extremes			
	Daily Maximum	Daily Minimum	Monthly	Record Highest	Year	Record Lowest	Year
January	32.2	13.5	22.9	59	1971	-16	1971
February	36.2	17.4	26.8	59	1971	-18	1933
March	43.9	22.7	33.9	68	1966	-10	1964
April	54.5	31.1	42.9	80	1928	7	1975
May	64.8	39.9	52.3	86	1936	18	1965
June	74.4	48.9	61.7	93	1961	26	1943
July	82.0	56.2	69.1	95	1931	35	1968
August	79.0	54.5	65.4	93	1940	33	1968
September	71.3	46.6	59.0	92	1934	19	1965
October	59.0	36.6	47.8	78	1933	10	1972
November	43.5	24.1	33.8	63	1975	-2	1931
December	34.4	16.1	25.0	58	1959	-12	1924
Annual	56.3	34.0	45.1	95	July 1931	-18	Feb 1933

Station: Hiawatha
Elevation: 7,220 ft.
Period of Record: 1922 – 1975

Longitude: 110° 01'
Latitude: 39° 29'

724.500 Supplemental Information

Rule R645-301-728 discusses the probable hydrologic consequences of existing and proposed mining operations.

724.700 Alluvial Valley Floor

This does not apply.

R645-301-725 Baseline Cumulative Impact Area Information

A copy of the Cumulative Hydrologic Impact prepared by the Division can be found in Appendix 7-L.

R645-301-726 Modeling

Some modeling, interpolation and statistical techniques are utilized in this chapter; however, actual surface and ground water information is predominately provided.

R645-301-727 Alternate Water Source Information

No alternate water source is needed since we do not expect to impact any current water sources as explained in R645-301-724.100 and R645-301-724.200.

R645-301-728 Probable Hydrologic Consequence Determination

See Appendix 7J.

728.200 Baseline Information

This is discussed in Appendix 7J in sections 3 through 7 of the first Mayo report, and Appendix 7M and 7N.

728.310 Adverse Impacts to the Hydrologic Balance

See section 1 of the second Mayo report in Appendix 7J.

728.320 Acid/Toxic Forming Material

See section 2 of the second Mayo report in Appendix 7J.

728.330 Impacts of Proposed on:

728.331	Sediment Yield;	See section 3 of the second Mayo report in Appendix 7J.
728.332	Water Quality;	See section 4 of the second Mayo report in Appendix 7J.
728.333	Stream Flow Alteration;	See section 5 of the second Mayo report in Appendix 7J.
728.334	Water Availiabity;	See section 6 of the second Mayo report in Appendix 7J.

728.340-350 Affects on Water Resources and Water Rights

See section 7 of the second Mayo report in Appendix 7J.

R645-301-729 Cumulative Hydrologic Impact Assessment

See Appendix 7-L.

R645-301-730 Operation Plan

R645-301-731 General Requirements

731.100 Hydrologic Balance Protection

Affects of Mining on Groundwater Balance

Mining operations in the permit area will be confined to the coal bearing strata within the basal part of the Blackhawk formation. The coal strata are generally dry throughout most of the permit area, with the Tank Seam being dry throughout the entire property, and are part of an undeveloped aquifer system, which consists of a series of generally discontinuous perched water zones within the Blackhawk formation. Overlying formations are not uniformly saturated. The Star Point Sandstone is unsaturated in the Southern and Eastern parts of the permit area, and saturated in all three tongues on the Northwestern end of the permit area. The potential groundwater impacts are discussed in detail in Appendix 7-J, section 9.0. The potential impacts can be categorized into two basic sections: 1.) Potential impacts to groundwater quantity and 2.) Potential impacts to groundwater quality.

Quantity

Mining affects on water quantities consist of interceptions of local perched zones, and the interception of a larger perched aquifer at the North end of the Blind Canyon Seam workings. Investigations have shown that this aquifer is not hydraulically connected to Big Bear or Birch Spring (Appendix 7-N), so dewatering of this aquifer will have no impact on the quantity of these springs. These waters are collected in sumps within the mine and either diverted for culinary water and dust control or it is discharged into Bear Creek. Groundwater surveys are conducted and submitted annually to the Division. Groundwater is also removed as moisture within the coal itself, as evaporation in the mine ventilation air discharge, and in dust suppression.~~.~~ ~~As discussed in the PHC, the estimated volume of water removed in this manner is 22 acre-feet per year.~~ A calculation of maximum yearly water loss anticipated is included below.

Water Consumed During Production

Continuous Miner

Inherent Coal Moisture = 6% Mine Run Moisture = 7% Max Yearly Production = 400,000 tons

water loss = ((0.07-0.06)*400,000 Tons)*(2,000 lbs/1 TON)*(1 gal/8.33 lbs)*(1acre-ft/325,850 gal)

water loss = 2.95 acre-ft/year

Longwall

Inherent Coal Moisture = 6% Mine Run Moisture = 12% Max Yearly Production = 2,100,000 tons

water loss = ((0.12-0.06)*2,100,000 Tons)*(2,000 lbs/1 TON)*(1 gal/8.33 lbs)*(1acre-ft/325,850 gal)

water loss = 92.84 acre-ft/year

Surface Dust Suppression

Average water used for road watering = 600,000 gallons Average water used for stockpiles = 2 gallons/Ton

water loss = 600,000+(2 gal/Ton*2,500,000 Tons) = 6,043,371 gal/yr = 18.55 acre-ft/year

Ventilation Loss

p_b = barometric pressure = 29.88 in. HG t_d = dry bulb temperature = 40°F ,45°F

t_w = wet bulb temperature = 38°F , 43°F Q = Ventilation quantity = 160,250 inlet, 191,540 outlet

p_s'=sat. vapor press., wet bulb (in. Hg) = 0.18079*e^((17.27*t_w - 552.64) / (t_w +395.14)) = 0.023, 0.279

p_v= actual vapor pressure (in. Hg) = p_s'-[((p_b - p_s')*(t_d - t_w)) / (2800-1.3*t_w))] = 0.208, 0.257

W = specific humidity (lb/lb dry air) = 0.622*(p_v / (p_b-p_v)) W_I =0.0043 W_E =0.0054

p_a =partial pressure of air (in. Hg) = p_b – p = 29.67 inlet, 29.62 oulet

v = specific volme (ft^3/lb) = (0.754 * (t_d +460)) / p_a = 12.71 inlet, 12.85 oulet

G = weight flow-rate (lb/h) = 60 * Q / v = 756,756 inlet, 894,071 outlet Average = 825,414

water loss =G (lb/h)*(W_E – W_I)* .016018 (ft^3/lb)*8766 (h/yr) / 43560(ft^3/acre-ft) = 2.77 acre-ft/year

Water Produced – Antiquity water produced in the Bear Canyon #1 Mine

Average Flow = 30 gpm

Yearly water generated = (30gpm) * (60 min/1 hour) * (24 hour/ 1 day) *(365 day/ 1 year) = 15,768,000 gallons/year

water gain = 15,768,000 gallons/year * (1acre-ft/325,850 gal) = 48.39 acre-ft/year

Total Maximum Water Loss = 2.95 + 92.84 + 18.55+ +2.77-48.39 = 69 acre-ft/year

The affects of subsidence in the permit area, on regional or local groundwater flow, are expected to be minor and of short duration. Localized diversions or interceptions of short duration only are expected due to the plastic flow of shaley units and to both development and tightening of existing fractures which occur due to unbalanced compressive-tensile forces associated with subsidence. The reclamation plan proposes to control post-mining subsidence which is expected to be a maximum of ~~5.5~~10 feet assuming all three seams are mined, with no subsidence to occur in a varying 100 to 200 ft wide corridor from outcrop areas and permit boundary areas~~, as well as under escarpments~~.

In the portion of Federal Lease U-024316 to be permitted, mining will take place in the ~~Tank~~Blind Seam only, ~~which will limit any subsidence to a maximum of 1.9 feet.~~ In the event mining reaches far enough ~~North~~ to mine at an elevation below Bear Creek, an adequate barrier will be left to completely prevent any impact on Bear Creek. This barrier is shown on Plate 5-3 and described in Appendix 5-C.

Quality

The potential impacts to water quality include contamination of water due to rock dust usage, abandoned equipment, the usage of hydrocarbons, and contamination from road salting. These potential water quality impacts are discussed in detail in Appendix 7-J, Section 9.0 (PHC) and Appendix 7-P.

Rock dust which is used for the suppression of coal dust may potentially impact the groundwater flowing through the mine by the dissolution of the rock dust constituents into the water. This could result in increase concentrations of TDS or sulfates. Gypsum rock dust has been known to result in high TDS concentrations; therefore Co-Op has implemented the use of

Rock dust which is used for the suppression of coal dust may potentially impact the groundwater flowing through the mine by the dissolution of the rock dust constituents into the water. This could result in increase concentrations of TDS or sulfates. Gypsum rock dust has been known to result in high TDS concentrations; therefore Co-Op has implemented the use of limestone rock dust. Mine water discharged into Bear Creek is monitored for TDS, as well as the in-mine water monitoring wells, to ensure increased concentrations do not result for the mining activities.

Hydrocarbons (in the form of fuels, greases, and oils) are stored and used on-site for the mining equipment. Spillage of these materials could potentially contaminate the groundwater in the permit area. Section 9.0 of the PHC (Appendix 7-J) discusses in detail the program, which C. W. Mining has implemented to prevent contamination of the groundwater from these sources. Road salting is also discussed. Abandoned equipment is discussed in Appendix 7-Q.

Mitigation and Control Plans

No treatment of groundwater occurrence or other control measures in the present mine have been required. Interference of the groundwater regime has consisted of interception of local perched zones within the Blackhawk formation, with the significant portion of the flow coming from a sandstone channel located at the North end of the Blind Canyon Seam workings.

No treatment of groundwater occurrence or other control measures have been required or are expected to be required for the permit area. See the discussion on potential impacts in Appendix 7-J.

As discussed in Appendix 7-J, section 9-1, hydrocarbons in the form of oil and fuel are stored at the mine site. A spill prevention control and counter measures plan is maintained onsite-outlining controls to prevent and mitigate any hydrocarbon spills. Within six months of the implementation of the Wild Horse Ridge facilities construction, this plan will be updated to reflect the controls for the new facilities. If any state appropriated water rights are impacted in the future C. W. Mining will meet with the water right holder and the Division and develop a site specific water replacement plan.

Water Monitoring

Groundwater Monitoring Plan

Monitoring activities are designed to determine water levels, discharge and water quality fluctuations in relevant aquifers or groundwater occurrences in the mine area. Data is collected from mine sumps, from monitoring wells within the mine, observation wells on the surface, and springs. The objectives are to identify potential impacts during and after mining and, provide continuing data on the areas aquifer characteristics and groundwater occurrences. A recommended water-monitoring program is included in Appendix 7-J, section 10.0. The current approved water monitoring program is shown in Table 7-14.

Springs below the mine will be sampled to determine discharge and water quality parameters and their possible variation with time. These springs include SBC-14, Big Bear Springs, COP Development Springs, and Birch Springs (Plate 7-4). Periodic checks will be made of the mine area to determine any impact not currently expressed at the surface. This data

will be used to estimate seasonal fluctuations, aquifer recharge and consistent long-term changes and to ensure that no impacts occur. Springs above the mine will be monitored for field parameters, since the potential for impact to these springs is quantity rather than quality. SBC-9A and SBC-4 will be monitored for lead quality.

Groundwater monitoring will follow the ground water sampling guidelines as shown in Table 7-12 using the water quality parameter list in Table 7-13. These tables follow the recommendations presented in Appendix 7-J. New significant occurrences within the present permit area will be promptly included in the sampling program, as specified by state requirements. Operational ground water monitoring will continue through reclamation to Bond Release.

The sampling matrix for each of the existing monitoring stations during the operational phase of mining is included in Table 7-14. ~~No baseline data is available for SBC-17, but will be collected in 2000 and 2001, prior to mining occurring within the vicinity of this spring.~~ Baseline samples were collected for SBC-14, SBC-15, SBC-16, SBC-17, MW-114 and MW-117 in 2001. Three years of baseline will be collected on all additional sites added after 2001.

Temporary Drill Hole Seals. Within 30 days of completion, drill holes utilized for groundwater monitoring will be sealed in a nonpermanent fashion by installing PVC surface casing with a threaded cap for access.

Temporary Drill Hole Seals. Within 30 days of completion, drill holes utilized for groundwater monitoring will be sealed in a nonpermanent fashion by installing PVC surface casing with a threaded cap for access.

Annual Report. An Annual Report evaluating all data collected for the year will be submitted to DOGM as required.

Quarterly Data Submission. All water monitoring data will be submitted to DOGM on a quarterly basis within 90 days or less of quarterly sampling collection.

DH-1A, DH-2, DH-3. Three observation wells, DH-1A, DH-2, DH-3, were installed in 1992 (Plate 7-4). These wells are for the collection of piezometric surface and water quality data from the Spring Canyon tongue of the Star Point Sandstone, and are located such as to determine the extent or occurrence of groundwater within the depths of potential impact of the mining activities on the groundwater regime. Construction and Development of these wells are discussed in Appendix 7-N. In 1993 DH-3 was abandoned and was replaced by DH-4, shown on Plate 7-4.

Groundwater encountered in these wells will be sampled as specified above along with the other locations and used to correlate with the water quality data from Bear Springs, COP Development Springs, Huntington Spring, and Birch Springs to provide a check on estimates of groundwater contamination. These springs were selected since their flow is the sole use of groundwater to be possibly affected by mining activities in the permit area. Discussion of initial data gathered in 1992 from the wells is found in Appendix 7-J (PHC) and Appendix 7-N.

Table 7-12 Ground Water Sampling

	Baseline Monitoring	Operational Monitoring	Post-mining Monitoring
Type of Sampling site	Springs, In-Mine Flows, Boreholes, Observation Wells.	Springs, In-Mine Flows, Boreholes, Observation Wells.	Springs, Observation Wells, Mine discharge points.
Field Measurements and Parameters (Table 7.1-7)	Water levels and/or flow and water quality	Water levels and/or flow and water quality	Water levels and/or flow and water quality
Sample Frequency Each site	Quarterly Adequate to describe seasonal variation. Monthly recommended for more accurate description of seasonal variation.	Quarterly samples springs and wells; In-mine flows at initial interception, quarterly after 1st 30 days until diminished. From sumps and/or mine discharge points quarterly or as required by UPDES.	Quarterly based on potential impact; or once per annum (spring sampling at low flow).
Sampling Duration	Three ~~Two~~ years (~~one complete year of data before submission of PAP~~Prior to mining in the area).	Every year until two years after surface reclamation activities have ceased. Sites will be monitored 4 times a year.	Until termination of bonding.
Type of Data Collected and Reported	Wells and Boreholes: Water quality, water level of flow logs, collar elevation; ground elevations; screened interval; formation where completed; depth. Springs: Water quality, location, and flow.	Wells and boreholes: Water quality, water level or flow. Springs: Flow and water quality with one sample taken at low flow.	Wells and Boreholes: Water quality, water level or flow. Springs: Flow, water quality with one sample taken at low flow. Phase I: Whether pollution of surface and subsurface water is occurring, the probability of future occurrence, and estimated cost of abatement. Phase II: After revegetation has been established and contributing suspended solids to streamflow or runoff outside the premit area is not excess of the requirements set by UCA 40-10-17(j) of the Act and by R645-301-751. Phase III: Until reclamation requirements of the Act and the permit are fully met.
Comments	Springs and seeps should be measured from source at high and low flow periods.	During the year preceding re-permitting. Springs, one water quality sample at low flow for baseline parameters. Other sites, one sample for baseline parameter.	

Table 7-13 Ground Water Quality Parameter List

Field Measurements:

*	-	Water Levels or Flow
*	-	pH
*	-	Specific Conductivity (umhos/cm)
*	-	Temperature (C)

Laboratory Measurements: (mg/l) (Major, minor ions and trace elements are to be analyzed in dissolved form only.)

*	-	Total Dissolved Solids	
*	-	Total Hardness (as $CaCO_3$)	
	-	Aluminum (Al)	
	-	Arsenic (As)	
*	-	Carbonate (CO_3^{-2})	
*	-	Cation-anion balance	
	-	Boron (B)	
*	-	Bicarbonate (HCO_3^-)	
	-	Cadmium (Cd)	
*	-	Calcium (Ca)	
*	-	Chloride (Cl^-)	
	-	Copper (Cu)	
*	-	Iron (Fe)	(Total and Dissolved)
†	-	Lead (Pb)	
*	-	Magnesium (Mg)	
*	-	Manganese (Mn)	(Total and Dissolved)
	-	Molybdenum (Mo)	
	-	Nitrogen: Ammonia (NH_3)	
	-	Nitrite (NO_2)	
	-	Nitrate (NO_3^-)	
*	-	Potassium (K)	
	-	Phosphate (PO_4^{-3})	
	-	Selenium (Se)	
*	-	Sodium (Na)	
*	-	Specific Conductivity (umhos/cm)	
*	-	Sulfate (SO_4^{-2})	
	-	Zinc (Zn)	

Sampling Period:

- Baseline

*Operational, Post-mining

†Quarterly for site SBC-9A and SBC-4

Table 7-14 Water Monitoring Matrix: Operational Phase of Mining

Location	Jan	Feb	Mar	Apr	May	June	July	Aug[3]	Sept	Oct	Nov	Dec
Streams												
BC-1 (Upper Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-2 (Lower Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-3 (Lower Rt Fork Bear Creek)		oper			oper	field	field	oper.	field	oper		
BC-4 (Upper Rt Fk. Bear Creek)		oper			oper.	field	field	oper.	field	oper		
CK-1 (Upper Cedar Creek)		oper			oper.	field	field	oper.	field	oper		
CK-2 (Lower Cedar Creek)		oper			oper.	field	field	oper.	field	oper		
MH-1 (Lower McCadden Hollow Creek)					field [5]		field	field		field		
MH-2 (Upper McCadden Hollow Creek)					field [5]		field	field		field		
FC-1 (Lower Left Fork Fish Creek)[7]					field [5]		field	field		field		
FC-2 (Lower Right Fork Fish Creek)[7]					field [5]		field	field		field		
FC-3 (Right Fork Fish Creek Property Line)[7]					field [5]		field	field		field		
FC-4 (Upper Right Fork Fish Creek)[7]					field [5]		field	field		field		
FC-5 (Mud Spring)[7]					field [5]		field	field		field		
FC-6 (Upper Left Fork Fish Creek)[7]					field [5]		field	field		field		
FC-7 (Water Right Upper LF FC)					field [5]		field	field		field		
FC-8 (Water Right Upper LF FC)					field [5]		field	field		field		
Springs												
SBC-3 (Creek Well)		oper			oper			oper.		oper		
SBC-4 (Big Bear Springs) [4]		oper			oper			oper.		oper		
SBC-5 (Birch Spring) [4]		oper			oper.			oper.		oper		
SBC-9A (Hiawatha Seam)		oper			oper			oper		oper		
SBC-12 (16-7-13-1)					field. [5]		field	field		field		
SBC-14 (WHR-6)		oper			oper.			oper.		oper		
SBC-15 (WHR-5)					field[5]		field	field		field		
✓SBC-16 (WHR-4)[6,7]					field[5]		field	field		field		
✓SBC-16A [7]					field[5]		field	field		field		
✓SBC-16B [7]					field[5]		field	field		field		
SBC-17 (16-7-24-4)		oper			oper.			oper.		oper		
SBC-18 (WHR-2) [7]					field[5]		field	field		field		
✓SBC-20 (16-8-16-4)[7]					field[5]		field	field		field		
✓SBC-21 (16-8-18-1)[7]					field[5]		field	field		field		
SBC-22 (Stockwater Trough)					field[5]		field	field		field		
SBC-23 ((FBC-12)					field[5]		field	field		field		
SCC-1 (16-8-20-1					field[5]		field	field		field		
✓SCC-2 (16-8-15-5)[7]					field[5]		field	field		field		
SCC-3 (Mohrland Portal)					field[5]		field	field		field		
SCC-5 (16-8-7-3)					field[5]		field	field		field		
SMH-1 (FBC-6)					field. [5]		field	field		field		
SMH-2 (FBC-5)					field [5]		field	field		field		
SMH-3 (FBC-13)					field. [5]		field	field		field		
SMH-4 (FBC-4)					field [5]		field	field		field		
SMH-5 (Stockwater Trough)					field [5]		field	field		field		
Wells												
SDH-2 (Well, Sec. 11, T16S, R7E)					level [5]		level	level	level	level		
SDH-3 (Well, Sec. 10, T16S, R7E)					level [5]		level	level	level	level		
MW-114 (Well, Sec 18, T16S, R8E)					level [5]		level	level	level	level		
MW-117 (Well, Sec 12, T16S, R8E)					level [5]		level	level	level	level		

Notes:
1. See Tables 7-13 and 7-17 for listing of water quality monitoring parameters.
2. oper. = operational base. = baseline
3. Baseline parameters taken in August of year 5 prior to each permit renewal.
4. SBC-4 and SBC-5 shall also be tested for oil and grease.
5. First sample to be taken in May or June, when Gentry Mountain is accessible.
6. A comment will be made regarding the level of the pond feeding the spring
7. Weekly monitoring to begin one month prior to mining in area and continue until one month after. Monthly monitoring will then be done for an additional six months.

Table 7-14A Surface Water Monitoring Matrix: Baseline Collection

Site Name	Site Description	Baseline Monitoring Start Date
BC-1	Upper Bear Creek	September 2, 1980
BC-2	Lower Bear Creek	September 2, 1980
BC-3	Lower Right Fork Bear Creek	January 5, 1987
BC-4	Upper Right Fork Bear Creek	February 29, 2000
CK-1	Upper Cedar Creek	June 9, 1994
CK-2	Lower Cedar Creek	June 9, 1994
MH-1	Lower McCadden Hallow Creek	July 31, 1991
MH-2	Upper McCadden Hallow Creek	May, 2007
FC-1	Lower Left Fork Fish Creek	June 9, 1994
FC-2	Lower Right Fork fish Creek	July 31, 1991
FC-3	Right Fork Fish Creek Property	May, 2007
FC-4	Upper Right Fork Fish Creek	May, 2007
FC-5	Right Fork Fish Creek Below Mud	May, 2007
FC-6	Upper Left Fork Fish Creek	May, 2007
FC-7	Water Right Upper LF Fish Creek	May, 2007
FC-8	Water Right Upper LF Fish Creek	May, 2007

Notes:
1. See Tables 7-13 and 7-17 for listing of water quality monitoring parameters.
2. See Table 7-14 for specific months that the sites will be monitored in.

Table 7-14B Ground Water Monitoring Matrix: Baseline Collection

Site Name	Site Description	Baseline Monitoring Start Date
SBC-3	Bear Creek Well	January 5, 1987
SBC-4	Big Bear Spring	January 5, 1987
SBC-5	Birch Spring	July 24, 1986
SBC-9A	Bear Canyon #1 Mine Portal	September 25, 2002
SBC-12	16-7-16-1	June 8, 1994
SBC-14	WHR-6	October 26, 1993
SBC-15	WHR-5	October 27, 1992
SBC-16	WHR-4	March 22, 1993
SBC-16A		May, 2007
SBC-16B		May, 2007
SBC-17	16-7-24-4	May 22, 2000
SBC-18	WHR-2	March 22, 1993
SBC-20	16-8-16-4	June 8, 1994
SBC-21	16-8-18-1	June 8, 1994
SBC-22	Stock Watering Trough	May, 2007
SBC-23	FBC-12	March 22, 1993
SCC-1	16-8-20-1	June 8, 1994
SCC-1	16-8-15-5	June 8, 1994
SCC-3	Mohrland Portal	January 19, 1979
SCC-5	16-8-7-3	June 8, 1994
SMH-1	FBC-6	October 13, 1992
SMH-2	FBC-5	October 13, 1992
SMH-3	FBC-13	August 29, 1993
SMH-4	FBC-4	October 13, 1992
SMH-5	Stock Watering Trough	May, 2007

Notes:
1. See Tables 7-13 and 7-17 for listing of water quality monitoring parameters.
2. See Table 7-14 for specific months that the sites will be monitored in.

Table 7-15 Past ~~and existing~~ monitoring sites

Site ID	Description	Status
Springs		
SBC-1	Under Ground Seep[1]	Dried up early 1988, and monitoring was discontinued.
SBC-2	Portal Well[2]	Dry from 1987. Caved in, lost (2) quarters and relocated in 1991.
~~SBC-3~~	~~Creek Well~~	~~Active~~
~~SBC-4~~	~~Huntington Spring~~	~~Active~~
~~SBC-5~~	~~Birch Spring~~	~~Active~~
SBC-6	COP Development Spring[3]	Dried up in 1987, with no flow through 2000. Monitoring discontinued in 2000.
~~SBC-12~~	~~Bear Creek Source (16-7-13-1)~~	~~Active~~
~~SBC-14~~	~~Right Fork Spring WHR-6~~	~~Active~~
~~SBC-15~~	~~Right Fork Spring WHR-5~~	~~Active~~
~~SBC-16~~	~~Fish Creek Spring WHR-4~~	~~Active~~
~~SBC-17~~	~~Upper Bear Spring 16-7-24-4~~	~~Active~~
~~SMH-1~~	~~MH Left Fork Spring (FBC-6)~~	~~Active~~
~~SMH-2~~	~~MH Water Trough (FBC-5~~	~~Active~~
~~SMH-3~~	~~MH/Trail Ridge Spring (FBC-13)~~	~~Active~~
~~SMH-4~~	~~MH Right Fork Spring (FBC-4)~~	~~Active~~
In-Mine Sources		
SBC-7	Sump #1	Dried up and discontinued in 2000.
SBC-8	Sump #2	Dried up and discontinued in 2000.
SBC-9	Sump #3[4 6]	Abandoned in 1999 due to retreat mining and replaced by SBC-13.
~~SBC-9A~~	~~Hiawatha Seam 1st North~~	~~Activated in Oct. 2002 when a borehole was drilled up to the old SBC9 site.~~
SBC-10	Sump #4	Flow first measured Dec. 1991. Monitoring initiated Jan. 1992. In July, 1995, retreat mining progressed passed this sump, making it inaccessible. Monitoring was discontinued in August 1995. Flows from this area have subsequently flowed through the pillared area and out of the 1st East pillared section.
SBC-11	Hiawatha Seam 1st North	Abandoned in January 2003
SBC-13	1st East Pillared Section[5]	Abandoned in April 2002 due to retreat mining and replaced by SBC-9A
Wells		
DH-1A	2nd W. Monitor Well	Abandoned in 2001 due to retreat mining.
DH-2	3rd W. Monitor Well6	Abandoned in 1999 due to retreat mining.
DH-3	1st E. Monitor Well6	Abandoned in 1993 due to retreat mining and was replaced by DH-4.
DH-4	3rd W. Bleeder Monitor Well6	Abandoned in 1999 due to retreat mining.
~~SDH-2~~	~~Well, Sec. 11, T16S, R7E~~	~~Active~~
~~SDH-3~~	~~Well, Sec. 10, T16S, R7E~~	~~Active~~
~~MW-114~~	~~Wild Horse Ridge Monitor Well~~	~~Active~~
~~MW-117~~	~~Gentry Mtn. Monitor Well~~	~~Active~~
MW-116	Gentry Mtn. Monitor Well	The side caved in and the well was lost

SDH-1, SDH-2, SDH-3. These three monitoring wells were installed in 1995 from the surface (Plate 7-4). These wells are completed in the Spring Canyon tongue of the Star Point Sandstone, with SDH-1 and SDH-2 located to monitor the potentiometric surface in conjunction with the DH wells discussed previously. SDH-3 was installed West of the Blind Canyon fault (western boundary of the permit area) in order to observe the relationship of the Spring Canyon aquifer on each side of the fault. Completion diagrams of these wells are included in Appendix 7-A. The initial baseline data is included in Appendix 7J-A. Based on these baseline levels, a potentiometric surface for the Spring Canyon aquifer was developed. This is shown in Appendix 7-J, Figure 13b, and on Plate 7J-2.

In 1996, SDH-1 well plugged and was lost while attempting to unplug the well. SDH-2 and SDH-3 are monitored for water levels as shown in Table 7-14.

MW-114, ~~MW-116,~~ MW-117. These ~~three~~Two wells were drilled in 1991 by Cyprus/Plateau, and are located North of the Wild Horse Ridge expansion area. Both~~All three~~ wells are located East of the Bear Canyon fault. MW-114 is located immediately North of and adjacent to the permit area. These wells were also completed in the Spring Canyon member of the Starpoint Sandstone. Baseline water levels for these wells are included in Appendix 7J-A, and well completion diagrams are included in Appendix 7-A. Water age dating and chemical information will be collected from these wells to verify that the hydrologic patterns in the Wild Horse Ridge area are consistent with the patterns discussed in the PHC which have been found in the existing permit area. This information will also be collected from any new wells installed within or adjacent to the Wild Horse Ridge area.

Additional Monitor Wells. A minimum of one additional drillhole will be installed in the northern portion of the Wild Horse Ridge area, shown as DH-5 on Plate 5-1C. If necessary, additional wells may be installed following the installation and evaluation of DH-5 in order to adequately characterize the groundwater aquifers of the lower Blackhawk and upper Star point formations. DH-5 and any additional drillholes will be tested using the same methodology, which was used in the previous in-mine wells, described in Appendix 7-N. The holes will then be completed as monitor wells in the same manner as described in Appendix 7-N.

Springs above the mine have also been selected based on the conclusion of Appendix 7J and 2006 field investigations that included regulating agencies and interested parties. Because these springs are above the coal seam water quality impacts are not a major concern, however flow quantity impacts are. Sites were selected because they were either major contributors to surface water systems, or they were springs that have been developed for beneficial use or have water rights on them. The major contributors to surface water systems are SMH-3, SMH-4, SBC-12, SBC-18, SBC-20, SBC-21, SCC-1, SCC-3, and SCC-5. Perennial portions of the streams feed by sites SCC-5, SCC-2, SBC-16, SBC-16A, SBC-16B, SBC-20, and SBC-21 will be undermined. Because of this these sites will be monitored for flow weekly starting one month prior to undermining and continuing until one month after undermining at which time they will be monitored monthly for six months before returning back to their normal monitoring schedule. The actual start time will be determined based on continual underground surveying that is required by MSHA. During the monitoring weekly reports will be sent to the Division via email. The ground water sites selected because they were developed or had water rights are SMH-1, SMH-2, SMH-5, SBC-15, SBC-16, SBC-16A, SBC-16B, and SBC-22.

Measuring the flow from springs and seeps is almost always difficult because flows tend to be dispersed and rarely concentrate into well-defined channels amenable to discharge measurement.
The most accurate method of measuring small discharges, and the method that will be used, is by observing the time required to fill a container of known capacity, or the time required to partly fill a calibrated container. The basic equipment is a stopwatch and a calibrated container.

Purchased pre-calibrated containers may be used or containers will be calibrated by either adding known volumes of water by increments and measuring the depth of water in the container, or by weighing the container with varying amounts of water in it, noting the depth in the container, and using the formula: $V = (W2-W1)/w$; where: V = volume of water in the container, $W2$ = weight of container with water, $W1$ = weight of empty container, and w = unit weight of water.

The basic field procedure will consists of interrupting the flow and collecting the water. Temporary earth dams may be constructed to divert the water through a small diameter pipe for capture. Or it may be possible to place a trough or half of a stove pipe against the spring or seep to carry the water to the calibrated container. Cloths, clay, or other materials will be used to temporarily seal cracks and force the water to go into the calibrated container. Where flows come out of the ground in a number of distinct sources or if they are scattered over a broad area, the results of several different measurements will be added together.

731.220 Surface Water Monitoring

In the past, C. W. Mining has monitored three stations on Bear Creek, one above (north) the mine plan area, one at the right-hand tributary (center) and one below the mine area (southwest). The monitoring location above the mining area is approx 3000 ft upstream from where the mine road crosses Bear Creek in the mine plan area. The monitoring location at the right-hand tributary of Bear Creek is located just above its confluence with the main Bear Creek. Two additional monitoring locations will be added to this tributary for mining in Wild Horse Ridge, one above the disturbed area (northeast), as well as a spring located in the drainage (SBC-14, see section 7.1). The monitoring location downstream is near the Ballpark topsoil storage pile. Monitoring stations are shown on Plate 7_4 and listed below. Monitoring points have also been added to the Fish Creek and McCadden Hollow drainages to monitor for water quantity impacts.

Streams

1. Upper Bear Creek - BC-1
2. Lower Bear Creek - BC-2
3. Lower Right Fork Bear Creek - BC-3
4. Upper Right Fork Bear Creek - BC-4
5. Lower McCadden Hollow Creek - MH-1
6. Fish Creek Left Fork - FC-1
7. Fish Creek Right Fork - FC-2 1
8. Fish Creek RF Property Line - FC-3 2
9. Upper Fish Creek Right Fork - FC-4 3
10. Fish Creek Past Mud Spring - FC-5 4
11. Upper Fish Creek Left Fork - FC-6 5
12. Upper Fish Creek LF Water Right- FC-7 6
13. Upper Fish Creek LF Water Right- FC-8 7
14. Upper Cedar Creek - ~~CK-1~~ 8
15. Lower Cedar Creek - ~~CK-2~~ 9
16. Upper McCadden Hollow Creek - MH-2 10

Surface monitoring will follow the surface water sampling guidelines as shown in Table 7-16, using the water quality parameter list in Table -16. Monthly sampling matrix for each of the existing monitoring stations are included in Table 7-14. Operational surface water monitoring will continue through reclamation to bond release. Three years of baseline will be collected on all new sites.

Table 7-16 Surface Water Sampling

	Baseline Monitoring	Operational Monitoring	Post-mining Monitoring
Type of Sampling Site	Surface Water Bodies.	Surface Water Bodies.	Surface Water Bodies.
Field Measurements and Parameters (Table 7.1-7)	Performed during water level/flow measurements.	Performed during water level/flow measurements.	Performed during water level/flow measurements.
Sample Frequency	Quarterly for lakes, reservoirs and impoundments (water level and quality); monthly flow measurements and quarterly water quality measurements (one sample at low flow and high flow each) for perennial streams. Monthly flow and water quality measurements during period of flow for intermittent streams. Sampling for ephemeral streams determined at pre-design conference.	Quarterly for lakes, reservoirs and impoundments (water level and quality); monthly flow measurements and quarterly water quality measurements (one sample at low flow and high flow each) for perennial streams. Monthly flow and water quality measurements during period of flow for intermittent streams. Sampling for ephemeral streams determined at pre-design conference.	Two per annum for perennial streams (high & low flow); two per annum during snowmelt and rainfall for intermittent streams.
Sampling Duration	~~Two~~ Three years (~~one complete year of data before submission of PAP~~Prior to mining in the area).	Every year until two years after surface reclamation activities have ceased. Sites will be monitored 4 times a year.	Every year until termination of bonding.
Type of Data Collected and Reported	Flow and/or water levels and water quality.	Flow and/or water levels and water quality.	Flow and/or water levels and water quality per operational parameters.
Comments	All field measurements should be performed concurrently with water level/flow measurements.	All field measurements should be performed concurrently with water level/flow measurements.	All field measurements should be performed concurrently with water level/flow measurements.
Additional Comments		For every fifth year preceding re-permitting, one sample at low flow and high flow each should be taken for baseline water quality parameters. The construction monitoring program will be conducted on a site-specific basis in addition to the operational monitoring.	

Table 7-17 Surface Water Quality Parameter List

Field Measurements:

*	-	Water Levels or Flow
*	-	pH
*	-	Specific Conductivity (umhos/cm)
*	-	Temperature (C□)
*	-	Dissolved Oxygen (ppm) (perennial streams only)

Laboratory Measurements: (mg/l) (Major, minor ions and trace elements are to be analyzed in dissolved form only.)

#	*	-	Total Settleable Solids	
#	*	-	Total Suspended Solids	
	*	-	Total Dissolved Solids	
	*	-	Total Hardness (as $CaCO_3$)	
		-	Aluminum (Al)	
		-	Arsenic (As)	
		-	Boron (B)	
	*	-	Carbonate (CO_3^{-2})	
	*	-	Bicarbonate (HCO_3^-)	
		-	Cadmium (Cd)	
	*	-	Calcium (Ca)	
	*	-	Chloride (Cl^-)	
		-	Copper (Cu)	
	*	-	Iron (Fe)	(Total and Dissolved)
		-	Lead (Pb)	
	*	-	Magnesium (Mg)	
	*	-	Manganese (Mn)	(Total and Dissolved)
		-	Molybdenum (Mo)	
		-	Nitrogen: Ammonia (NH_3)	
		-	Nitrite (NO_2)	
		-	Nitrate (NO_3^-)	
	*	-	Potassium (K)	
		-	Phosphate (PO_4^{-3})	
		-	Selenium (Se)	
	*	-	Sodium (Na)	
	*	-	Specific Conductivity (umhos/cm)	
	*	-	Sulfate (SO_4^{-2})	
		-	Zinc (Zn)	
	*	-	Oil and Grease	
	*	-	Cation-Anion Balance	

Sampling Period:

-Baseline

*Operational, Postmining

#Construction

Flows will be determined by direct measurement (depth times width times 2/3 velocity), by use of portable or stationary weirs or flumes, or, whenever feasible, by timed filling of a unit volume container. Measurements will be taken by qualified personnel following standard procedures with calibrated instruments.

Stream monitoring sites were selected based on the conclusion of Appendix 7J and 2006 field investigations that included regulating agencies and interested parties.

Annual Report. An Annual Report evaluating all data collected for the year will be submitted to DOGM as required.

Quarterly Data Submission. All water monitoring data will be submitted to DOGM on a quarterly basis within 30 days following the end of the quarter.

Discharge Permit and Reporting. All discharge report forms filed to meet Government requirements will be submitted to DOGM in the quarterly Water Monitoring Report. A copy of the mine discharge permit is included in Appendix 7-B.

Post-Mining Portal Discharge. No gravity discharges are expected from the Bear Canyon No. 3 or No. 4 mines during or following reclamation. Any post-mining portal discharge that occurs will be monitored quarterly for operational parameters shown on Table 7-16. No water will be discharged into the mine during or following reclamation.

Undermining of Perennial Streams. There are two areas where perennial streams will be undermined. They are the upper reaches of the right fork and left fork of Fish Creek.

The left fork is fed by one watershed and several springs. FC-7 and FC-6 are surface monitoring sites in this watershed, however flow has only been observed at these points during major storm events and spring run-off. Most of the year the streams are dry above the confluence of the major springs feeding it. These springs are SBC-18, SBC-20, and SBC-21, with SBC-21 being the largest. The confluence of these springs with the main stream channel is inaccessible.

The right fork of Fish creek has two splits and is fed by three watersheds. The left split of the stream channel has base flow fed by SCC-5. This point also marks the start of the perennial section. The center split base flow is fed by SCC-2 which also marks the start of the perennial section for the center split. The right split is dry except during spring run-off or large storm events. However during wet years water may flow from site FC-5 (Mudd Spring). Because of this FC-5 was selected as the start of the perennial section of the right split. Monitoring site FC-4 was selected because it is the confluence of the three splits. Site FC-3 marks the property line between private and federal property, and site FC-2 was selected to monitoring off site impacts.

In these areas C. W. Mining will increase the monitoring of these sites to a weekly basis one month prior to mining in the area. This weekly monitoring will continue until one month after mining has left the area. Monitoring will then be reduced to once a month for an additional 6 months at which time it will resume its normal schedule. This increased monitoring will include the sites FC-2, FC-3, FC-4, FC-5, and SCC-2 for the right fork of Fish Creek, and FC-1, FC-6, SBC-16, SBC-16A, SBC-16B, SBC-18, SBC-20, and SBC-21 for the left fork of Fish Creek. The actual start time will be determined based on continual underground surveying that is required by MSHA. During the monitoring weekly reports will be sent to the Division via email.

731.300 Acid and Toxic Forming Materials

All provisions of R645-301-731.300 will be followed when dealing with acid or toxic forming material

.

731.400 Transfer of Wells

This was addressed in R645-301-731.210

731.500 Discharges

C. W. Mining's discharge permit is located in Appendix 7-B.

731.530 Water Rights and Replacement

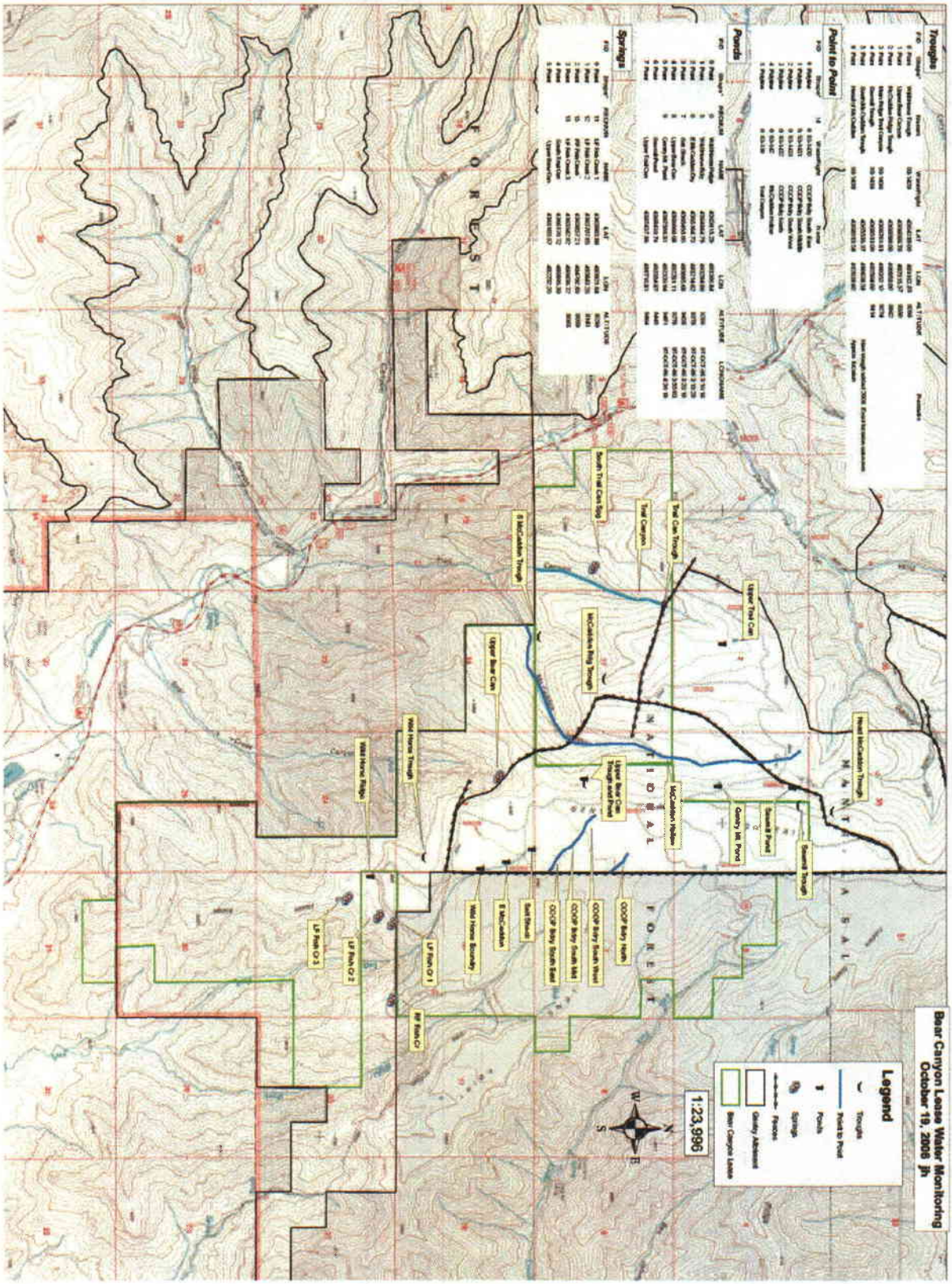
If a state appropriated water supply is impacted by mining and/or mining related activities, C. W. Mining will replace it as required under R645-301-731.530 of the Utah State Code. Also in accordance with federal lease stipulation 21, if any water resource that has been identified for protection is impacted, C. W. Mining will replace the water resource.

Lease stipulation 21 requires the replacement of all water sources identified for protection. Figure 7-0 shows all water sources identified for protection. In accordance with the lease stipulation all sources identified will be replaced if impacted. Several of the sources identified are within the subsidence area and have been selected as water monitoring points as

shown on Plate 7-4. The relationship between the water monitoring points and the names identified on figure 7-0 is outlined below.

F. S. Name	Monitoring Name	Location
LF Fish Cr 3	SBC-16	Inside subsidence zone
LF Fish Cr 2	SBC-16A	Inside subsidence zone
LF Fish Cr 1	SBC-16B	Inside subsidence zone
RF Fish Cr	SBC-18	Inside subsidence zone
Wild Horse Ridge	SBC-22	Inside subsidence zone
Wild Horse Boundary	none (Inspected with FC-6)	Outside subsidence zone
E McCadden	none (Inspected with FC-6)	Outside subsidence zone
Salt Shack	none (Inspected with FC-6)	Outside subsidence zone
S McCadden Trough	SMH-3	Outside subsidence zone
McCadden Rdg Trough	SMH-2	Inside subsidence zone
Upper Bear Can Trough	SMH-5	Outside subsidence zone
COOP Bdry South East	none (Inspected with FC-7)	Outside subsidence zone
COOP Bdry South Mid	none (Inspected with FC-7)	Outside subsidence zone
COOP Bdry South West	none (Inspected with FC-7)	Outside subsidence zone
COOP Bdry North	none (Inspected with FC-8)	Inside subsidence zone
McCadden Hollow	none (Inspected with SMH-4)	Inside subsidence zone
Gentry Mt Pond	none	Outside permit area
Sawmill Pond	none	Outside permit area
Sawmill Trough	none	Outside permit area
Head McCadden Trough	none	Outside permit area
Upper Trail Can	none	Outside permit area
Trail Can Trough	FBC-1	Outside subsidence zone
Trail Canyon	none	Outside subsidence zone
South Trail Can Spg	FBC-8	Outside subsidence zone

Figure 7-0 Forest Service Protected Water Resources



State appropriated water rights with points of diversions within the permit area are shown on Plate 7-12. All water resources identified for protection by the U. S. Forest Service are shown on Figure 5C-3. All water resources identified for monitoring are shown on Plate 7-4. These sites were identified in 2006 during several field surveys that included representatives from the following agencies at one or more of the surveys.

C. W. Mining Company
Utah Division of Oil Gas and Mining
State of Utah Water Rights Division
United States Forest Service
United States Department of the Interior - Bureau of Land Management
United States Department of the Interior - Office of Surface Mining
C. O. P. Coal Development Company
ANR Inc.
Huntington Cleveland Irrigation Company
Huntington Cattle Association

The primary water rights owners that may be impacted are C. O. P Coal Development, ANR Inc., United States Forest Service, and Huntington Cleveland Irrigation Company. Following is a discussion of the water usage of the entities and probable water replacement methods.

C. O. P. Coal Development

C.O.P Coal Development is the land owner and federal lease holder of all land being mined by C. W. Mining Company. They are a controlling entity of C. W. Mining in is much as they can dictate mining areas and methods through their lease requirements. Their water rights include stock watering, residential, and industrial. Stock water rights are associated with springs located above the mine within the subsidence area. These lands and water are leased to cattlemen who use the water for stock watering. The springs they use for residential use are located outside of the permit area near the old Trail Canyon Mine and inside the Bear Canyon #1 Mine. No impact is expected to these springs based on the investigation included in appendix 7J. These springs also provide the industrial water

used for the mining operations conducted by C. W. Mining Company.

C. W. Mining has agreed to work with C. O. P Development on the replacement of any water rights.

ANR Inc.

ANR is affiliated with C. W. Mining in that they are both controlling entities of Hiawatha Coal Company. ANR Inc. is the private land owner and the federal lease holder for all lands mined by Hiawatha Coal. C. W. Mining is the LMU holder for all federal leases held by ANR Inc. Their water rights include stock watering, municipal, industrial, irrigation and residential. The only water rights located within the affected area are the ones used for stock watering. They also lease land and water to cattlemen.

C. W. Mining has agreed to work with ANR Inc. on the replacement of any water rights.

United States Forest Service

The U. S. Forest Service owns stock watering rights within the subsidence area. These water rights are used by wildlife and cattlemen who are leasing the land and water from the Forest Service.

Because of the nature of their use if these water rights were impacted the Forest Service would need the water to be restored to the original location. If the impact was a cracked stream or pond C. W. Mining would use pond liners, grouting, or other technologies available to repair the cracks. If the impact was a displaced spring C. W. Mining would install guzzlers, wells or other available technology to restore the water. Based on the experiences of other mines these methods have been acceptable.

Huntington Cleveland Irrigation Company

Huntington Cleveland Irrigation Company (HCIC) has water rights for stock watering, irrigation, and municipal uses. HCIC's points of diversion for their state appropriated water rights are located downstream of the subsidence area. Because of this, the stock-watering and irrigation uses for HCIC may not require replacement right at the source. They do require that the same quantity of water flows downstream to their points of diversion. For municipal use they have two springs of concern located outside, but near the permit area. These are Birch spring and Big Bear Spring. These springs are discussed in depth in Appendix 7J on pages 116 through 126. If these springs were impacted HCIC would require the same quantity of flow at a quality that meets drinking water standards.

If stock watering or irrigation water were impacted C. W. Mining would transfer or retire enough of their shares in HCIC to cover the lost water, or any course of action agreed upon between C. W. Mining and HCIC. Based on the study included in Appendix 7J showing that the springs are recharged locally, no impact to Birch Spring and Big Bear Spring is expected. However members of HCIC have expressed concern that the faults C. W. Mining will mine up against maybe recharge areas for these springs. In the extremely unlikely event that one of these springs is impacted, C. W. Mining would replace the lost flow with equivalent flow from existing springs which it currently holds water rights on. The replacement of either of the springs would most likely be development of new sources that meet the required standards, or the transfer of water from a source, that meets the standards, owned by C. W. Mining to the culinary water system impacted. Details regarding the replacement would be negotiated with HCIC and the municipalities impacted.

The requirement to replace water would be contingent upon the finding from Utah Division of Oil Gas and Mining that a state appropriated water supply or protected water resource was contaminated, diminished, or interrupted by underground coal mining and reclamation activities conducted after October 24, 1991.

731.600 Stream Buffer Zones

Anywhere that mining and reclamation activities are conducted within 100 feet of a perennial stream runoff and sediment control structures exist to protect water quality. These areas are designated as "Stream Buffer Zone do not Disturb".

731.700 Cross Sections and Maps

Plate 7-4 shows the water monitoring locations. Plates 7-1 show the hydrology of the disturbed area and water systems. Plate 7-10 shows in mine water surveys.

R645-301-732 Sediment Control Measures

All disturbed areas associated with mining and reclamation operations are protected by sediment control structures. Most of the larger areas are served by sediment ponds. Other disturbed areas, classified as Alternate Sediment Control Areas (ASCA's), utilize alternative methods of sediment control such as catch basins, silt fences, and interim revegetation. R645-301-742 and Appendix 7-K contain a detailed description of these methods.

732.100 Siltation Structures

Silt fences are used through the mine site. Their location and use is described in R645-301-742.100 and Appendix 7-K.

732.200 Sediment Ponds

This is addressed in R645-301-742.220

732.300 Diversions

This is addressed in R645-301-742.300

732.400 Road Drainages

All roads will be constructed, maintained and reconstructed to comply with R645-301-742.400

R645-301-733 Impoundments

Four sediment ponds are currently maintained within the permit area. All are temporary impoundments. No permanent impoundments are proposed. These are discussed in R645-301-742.220.

Plans and cross sections for sediment ponds A, B, C, and D can be found on Plates 7-2, 7-3, 7-6, and 7-11 respectably.

Appendix 7-E contains the slope stability analysis for sediment pond A. Appendix 7-I contains the sedimentation pond certification.

R645-301-734 Discharge Structures

C. W. Mining has five discharge points. One is in the Bear River above the scale house. The discharge structure consists of a pipe running from the storage tank to the river. The others are below the sediment ponds. These structures are detailed along with the sediment ponds.

R645-301-735 Disposal of Excess Spoil

C. W. Mining currently anticipates no excess spoil

R645-301-736 Coal Mine Waste

See R645-301-528.330 for a discussion of generation, storage, and disposal of coal mine waste.

R645-301-737 Non Coal Mine Waste

See R645-301-528.330 for a discussion of generation, storage, and disposal of non-coalmine waste.

R645-301-738 Temporary Casing of Wells

See Appendix 7-A and 7-N.

R645-301-740 Design Criteria and Plans

R645-301-741 General Requirements

The purpose of this section is to present the methodology used during hydrologic calculations for the Co-op Mine complex. The hydrologic calculations performed include runoff volumes and peak discharges, sediment storage calculations, existing sedimentation pond capacity, and existing diversion structure adequacy. The hydraulic design of permanent diversion structures, and adequacy of riprap is also addressed.

Runoff Calculations

Undisturbed watershed boundaries used to determine runoff conditions at the site are shown on Plates 7-5 and 7-5A. The disturbed area boundaries and the smaller undisturbed area boundaries are also shown in greater detail on Plates 7-1. Drainage areas are labeled according to whether or not it contributes to the sedimentation ponds (disturbed), or is diverted around the ponds (undisturbed). For example, AU-5 represents watershed 5 (U for undisturbed area).

Data obtained from these watersheds were input to a computer code called "Peak." to generate runoff hydrographs which were used for the design of drainage diversions. Inflow hydrographs and outflow hydrographs from the sedimentation ponds were developed using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980), or equivalent program. Both of these codes model runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972).

The design calculations for diversion structures were based on the 10-yr, 6-hr storm event. Similarly, the design calculations for the sedimentation ponds inflow and outflow hydrographs were performed using the 25-yr, 6-hr storm event.

According to the U.S. Soil Conservation Service (1972), the algebraic and hydrologic relations between storm rainfall, soil moisture storage, and runoff can be expressed by the equations,

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

and

$$S = \frac{1000}{CN} - 10 \tag{2}$$

where Q = direct runoff volume (inches)
S = watershed storage factor (inches)
P = rainfall depth (inches)
CN = runoff curve number (dimensionless)

It should be noted that (a) Equation (1) is valid only for $P \geq 0.2S$ (otherwise Q=0), (b) Equation (2), as stated, is in inches, with the values of 1000 and 10 carrying the dimensions of inches, although metric conversions are possible, and (c) CN is only a convenient transformation of S to establish a scale of 0 to 100 and has no intrinsic meaning.

The average curve number for undisturbed areas was chosen from professional judgement and tabulated values presented in Figure 7-1 using approximate cover densities as reported in R645-301-321. A curve number of 76 was used for the undisturbed areas, assuming a hydrologic soil group of C.

The curve number for disturbed areas was chosen from professional judgment and tabulated values presented by the U.S. Soil Conservation Service (1972). Accordingly, a value of 90 was used for the pad and road areas, and a value of 100 was used for the pond area.

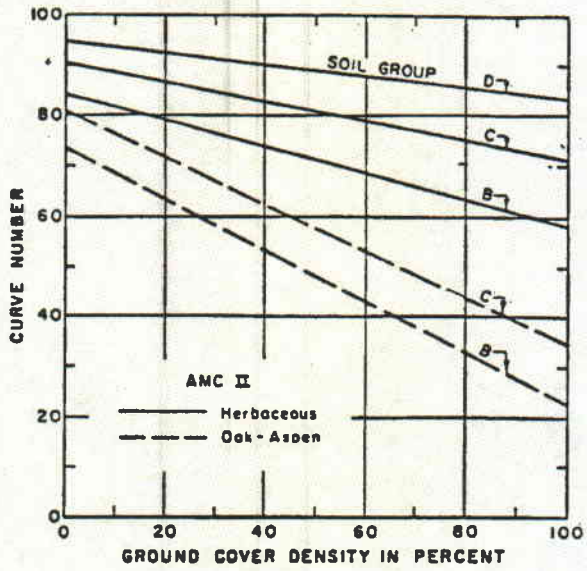
The translation of the runoff depth to an outflow hydrograph is accomplished in the codes using the triangular unit hydrograph of the U.S. Soil Conservation Service (1972). This unit hydrograph is shown in Figure 7-2 along with a typical curvilinear hydrograph. It is characterized by its time to peak (T_p), recession time (T_r), time of base (T_b), and the relations between these parameters (i.e., T_r=1.67T_p; T_b=2.67T_p). Thus, from the geometry of a triangle, the incremental runoff (Q) can be defined by the equation,

$$Q = \frac{(2.67T_p)(q_p)}{2} \tag{3}$$

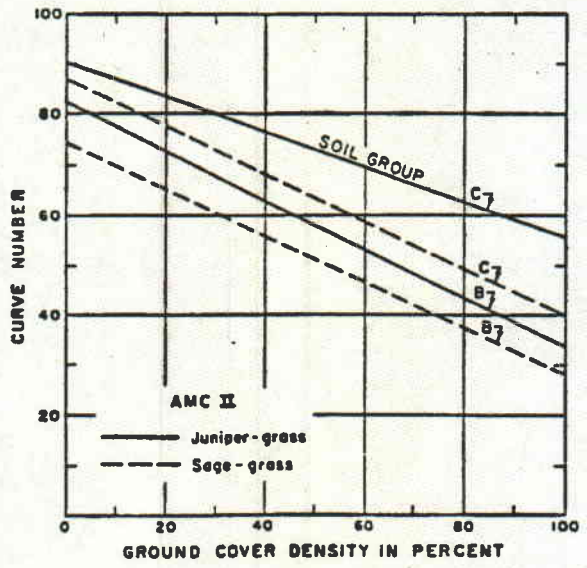
or

$$q_p = \frac{0.75(Q)}{T_p} \tag{4}$$

where q_p = peak flow rate (dimensioned according to Q and T)



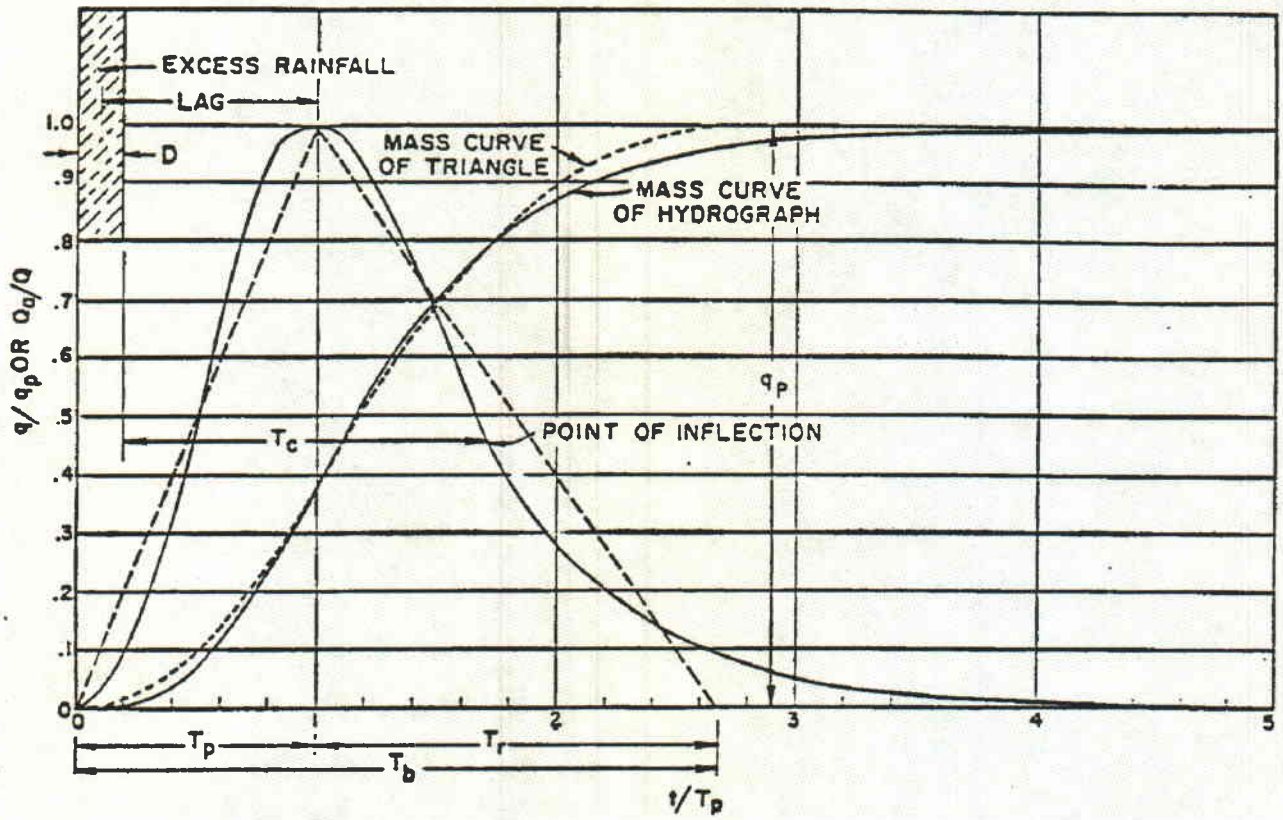
Graph for estimating runoff curve numbers of forest-range complexes in western United States: herbaceous and oak-aspen complexes.



Graphs for estimating runoff curve numbers of forest-range complexes in western United States: Juniper-grass and sage-grass complexes.

Figure 7-1 Curve Number Graphs

Figure 7-2 Curvilinear and Triangular Unit Hydrographs



When Q is expressed in inches and T_p in hours, q_p will be in inches per hour. The flow at any time $0<t<T_r$ may be determined by simple linear proportioning of the triangular unit hydrograph. The time to peak is related to the familiar expression time of concentration (T_c) by the equation,

$$T_c + t = 1.7T_p \tag{5}$$

in which the factor 1.7 is an empirical finding cited by the U.S. Soil Conservation Service (1972).

The time of concentration may be estimated by several formulas. For this report, T_c was determined from the following equations (U.S. Soil Conservation Service, 1972):

$$L = \frac{l^{0.8}(S+1)^{0.7}}{1900Y^{0.5}} \tag{6}$$

and

$$T_c = 1.67L \tag{7}$$

where L = watershed lag (hours)
l = hydraulic length of the watershed, or distance along the main channel to the watershed divide (feet)
S = watershed storage factor defined in Equation (2-2)
Y = average watershed slope (percent)
T_c = time of concentration (hours)

The precipitation values for the design storm events were obtained from precipitation - frequency maps for the state of Utah prepared by Miller et al., (1973). The precipitation data are presented in Table 7-18.

TABLE 7-18 Precipitation Data for the Co-Op Mine Complex

Frequency (years)	Duration (hours)	Precipitation (inches)
2	6	1.0
10	6	1.5
10	24	2.1
25	6	1.8

Reference: Miller et al., 1973

Sedimentation Ponds

POND CAPACITY

The capacity of each pond is designed based on runoff and sediment storage volumes. The ponds are designed to completely contain the 10-year, 24-hour storm at the required sediment storage capacity. As required by the Utah Division of Oil, Gas & Mining (1990), R645-301-742.221.31 and 742.221.36, adequate sediment control must be provided and maintained by periodic sediment removal.

Runoff Volume. The runoff calculations for those watersheds contributing to each pond were performed as described above. Each analysis was conducted for the 10-year, 24-hour storm event presented in Table 7-18.

Sediment Storage. The annual sediment volumes entering the ponds were calculated using a modified version of the universal soil loss equation (Israelson et al., 1984). The modified universal soil loss equation is:

$$A = R \times K \times LS \times VM \tag{8}$$

where, A = computed amount of soil loss per unit area for the time interval represented by factor R (tons per acre per year).

R = rainfall factor. R values for Utah presented by Israelson, et al. (1984).

K= soil erodibility factor. K values for Utah presented by Israelson et al. (1984). (tons per acre per year per unit of R).

LS = topographic factor based on length and steepness of slope. (dimensionless).

VM = erosion control factor based on vegetative, chemical, or mechanical measures. (dimensionless).

The maximum sediment storage volume and the 60 pct clean-out level is calculated for each pond.

SPILLWAY ANALYSIS

All sedimentation ponds are constructed with spillways that are designed to pass the peak runoff from the 25-year, 6-hour storm event (DOGM, 1990) presented in Table 7-18. The pond spillways are constructed as a riprapped open channel.

The discharge capacity of the riprapped overflow spillways was determined using a method developed by the U.S. Soil conservation Service (1968) and expanded by Barfield et al. (1981) for broad-crested weirs. According to this methodology, the critical specific energy head (H_{ec}) is determined for selected values of the energy head of water in the pond (H_p) from Figure 7-3. The discharge capacity of the spillway is then calculated for the standard 100-foot wide rectangular section from the equation,

$$q_r = (0.544)(g^{0.5})(H_{ec}^{1.5})(100) \qquad (12)$$

where, q_r = discharge for standard 100-foot rectangular section (cubic feet per second)

and all other parameters have been previously defined. The flow is then corrected for a trapezoidal section using the equation,

$$q = [(1.5b + zH_{ec})/150](q_r) \qquad (13)$$

where, q = corrected discharge (cubic feet per second)
b = bottom width of channel (feet)
z = channel side slope (run over rise - dimensionless)

Spillway design calculations are performed using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al, 1980). It should be noted that the sedimentology option of SEDIMOT II was used during design only to permit routing of the hydrograph through the pond. However, since sediment contributions from the 25-year, 6-hour event are not of concern in design of the pond (only sediment yield from the 10-year, 24-hour and smaller storms is of regulatory concern), the sediment inputs to the model were suppressed.

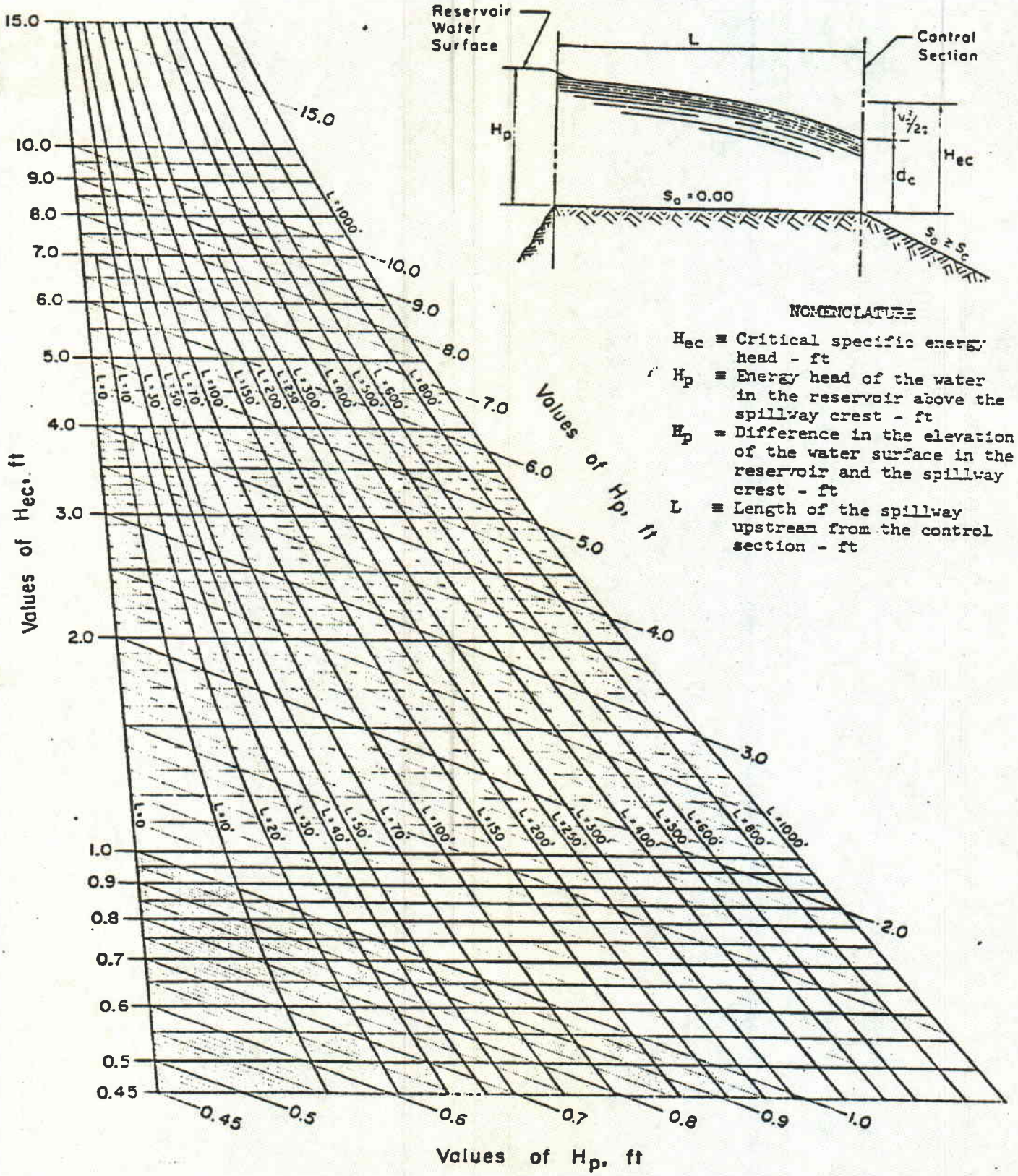


Figure 7-3 Head Relationship for Selected Broad-crest Weirs

Thus, the output from the program indicates sediment concentrations of 0 milligrams per liter. Therefore, sediment yield outputs provided by SEDIMOT II are meaningless.

It should also be noted that, although detention times shown on the SEDIMOT II output are relatively low (less than one hour), these times have no regulatory meaning for a 25-year event (i.e., regulatory concerns address the detention time only for the 10-year and smaller events). Again, the program was used primarily for its spillway design capabilities and not for dealing with the specifics of sediment yield and detention times from the 25-year, 6-hour design event.

The model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980) assumes that the pond is initially full of water to the elevation of the primary spillway when the storm event occurs. This is a conservative assumption since, the pond is typically empty of water to the top of the decant level.

POND CONSTRUCTION AND MAINTENANCE

Pond embankments were constructed in maximum lifts of 18 inches and compacted to 95 pct of T-99 compaction test capabilities at optimum moisture. Dikes are designed to have an 8-foot minimum top width or have a top width not less than (H + 35)/5, whichever is greater. The upstream and downstream slopes were designed not to exceed 1V:1.5H, except in areas where size is restricted. In such cases, steeper slopes were used if a 1.5 safety factor could be demonstrated with the designated soil materials. Where soil moisture was critical to stability, ponds were lined with bentonite clay to prevent seepage. Embankments were keyed into the

natural ground surface and unsuitable materials were excluded from the fill. Pond embankments were seeded to reduce erosion, as described in R645-301-331. These methods will provide stability protection from erosion as well as from sudden draw down.

Ponds and basins are regularly inspected and repaired, if necessary. Riprap at major inflow points is replaced if needed. Ponds and basins will be cleaned out when 60% of the design sediment storage capacity has accumulated.

Diversion Structures

BERMS

Earthen berms with a minimum height of 1.5 feet are constructed around the perimeter of all disturbed areas. The location of the berms are presented on Plates 7-1. The berms are used to prevent random discharge from disturbed areas and protect natural drainages or diversions. These berms are routinely maintained.

DRAINAGE DITCHES

The location of diversion ditches are presented on Plates 7-1. The ditches are labeled based on the type of drainage it is diverting (disturbed or undisturbed).

Diversions were designed to convey runoff from a disturbed or undisturbed drainage area. Grades on the diversion ditches are constructed, where possible, at approximately 5 pct. Some critical sections are riprapped with rock to reduce erosion. Ditches are routinely maintained by removing sediment and replacing riprap when necessary.

The ditch capacity and flow velocity was calculated using the Manning and continuity equations (Chow, 1959):

$$V = \frac{1.486}{n} R^{0.67} S^{0.50} \tag{14}$$

and

$$Q = AV \tag{15}$$

where, V = velocity (feet per second)
R = hydraulic radius (feet)
S = hydraulic slope (feet per foot)
n = roughness coefficient
Q = discharge (cubic feet per second)
A = flow area (square feet)

Peak discharges for the undisturbed drainage areas were calculated as described above. Values of the roughness coefficient required for the solution of Equation (14) were obtained by comparing local conditions with tabulated values provided by Chow (1959). An average roughness coefficient of 0.035 was representative of most ditches.

The diversion ditch geometries were measured in the field and approximated with trapezoidal or triangular ditch cross sections. The hydraulic slope of each ditch was either measured in the field or approximated from the topographic base maps (scale: 1"=50'). The capacity of each ditch was verified using a minimum slope value in Equation (14) and solving for the depth of flow. The maximum flow velocity for each ditch was calculated using Equation (14) and the maximum ditch slope measured from the topographic base maps. Flow velocities of 5 feet per second or less were considered acceptable for unlined ditches without erosion protection. Where velocities were greater than 5 feet per second, the adequacy of the existing riprap was determined using the methods defined below.

Calculations with Equations (14) and (15) were performed using an interactive computer code entitled FLOWMASTER I as obtained from Haestad Methods, Inc. (1990). This code was used to determine flow conditions in the diversion channel at the design flow rate.

CULVERTS

The location of diversion culverts are presented on Plates 7-1. The culverts are labeled based on the drainage area diverted (disturbed or undisturbed). The location, size, and slope of each culvert were verified in the field.

Peak discharges for the 10-year, 6-hour storm event were calculated as described above. The adequacy of each culvert was determined using nomographs prepared by the U.S. Department of Transportation (1977). These nomographs for circular culverts with inlet control are presented in Figure 7-4. Based on the known culvert size, entrance type, and peak discharge,

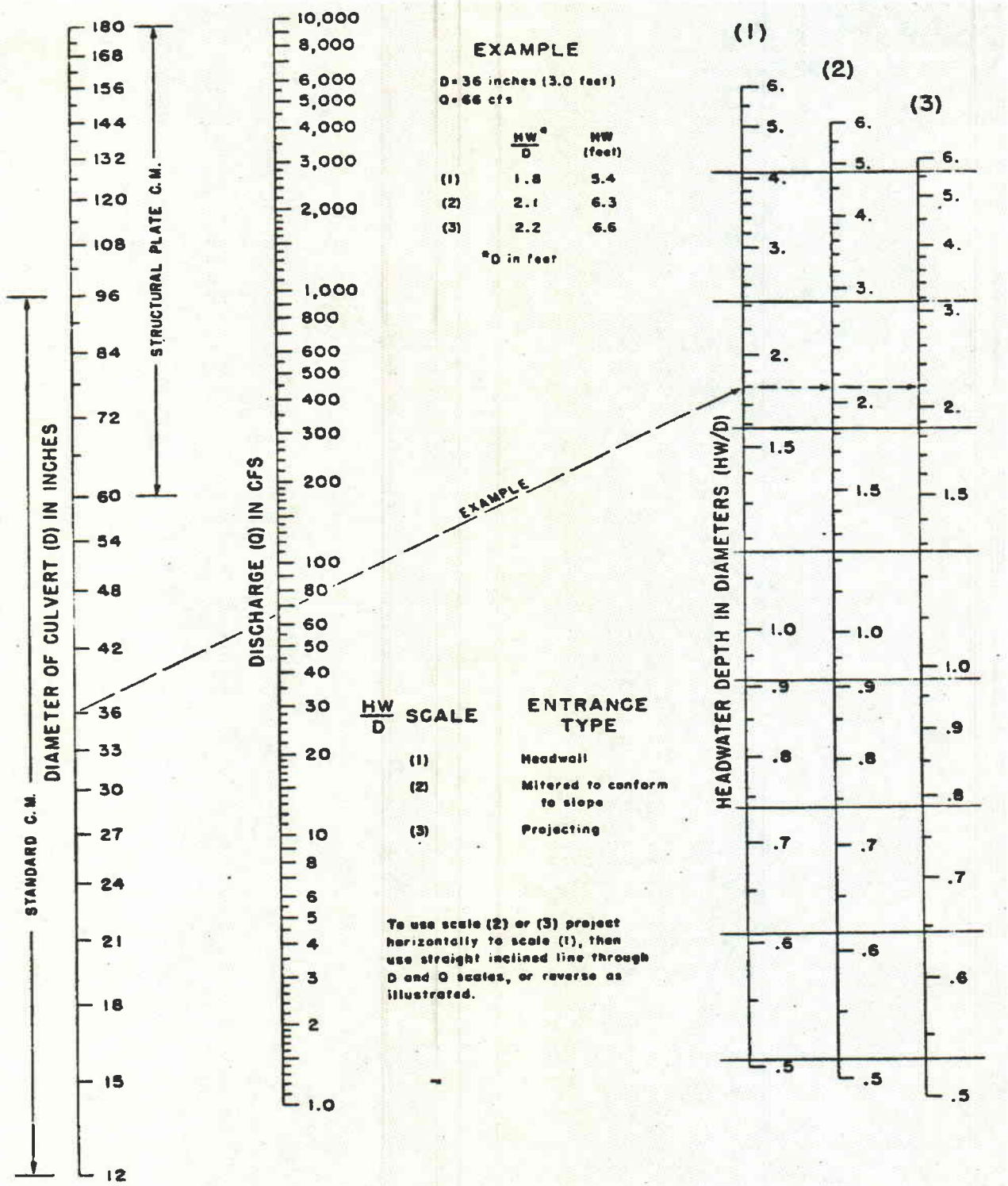


Figure 7-4 Headwater Depths for C.M. Pipe Culverts with Inlet Control

the headwater depth/diameter ratio was determined from the nomograph. If this value was 1.0 or less, the culvert was considered adequate to pass the design discharge rate. If the ratio was greater than 1.0, a closer inspection of the culvert geometry and entrance was necessary.

Exit velocities from each circular culvert were calculated based on equations 14 and 15. Roughness coefficients of 0.024 and 0.011 were used for the calculations, which can be considered typical for corrugated metal pipe and concrete culverts, respectively (Chow, 1959).

Riprap Protection

The use of riprap to line drainage ditches, culvert outlets, channel diversions or spillways is required when flow velocities exceed approximately 5 feet per second. Calculations to determine the adequacy of existing riprap sections are based on a method defined by the U.S. Department of Transportation (1978).

The size of stone needed to protect a diversion channel or spillway from erosion by a current moving parallel to the channel is determined by the use of Figures 7-5 and 7-6. The size of stone (k) is determined by a trial-and-error method which consists of first estimating a stone size.

The mean velocity (V_m) of the water must be converted to the velocity against the stone by the use of Figure 7-5. With the velocity against the stone (V_s), enter Figure 7-5 and read the stone size for the channel side slope (not the hydraulic slope, unless it is steeper than the side slope of the ditch). The stone size from Figure 7-6 is the 50 percent (median) size, by weight, of a well-graded mass of stone with a unit weight of 165 pounds per cubic foot. If the stone size from Figure 7-6 agrees with the assumed stone size, it is correct. If not, the procedure is repeated until agreement is achieved.

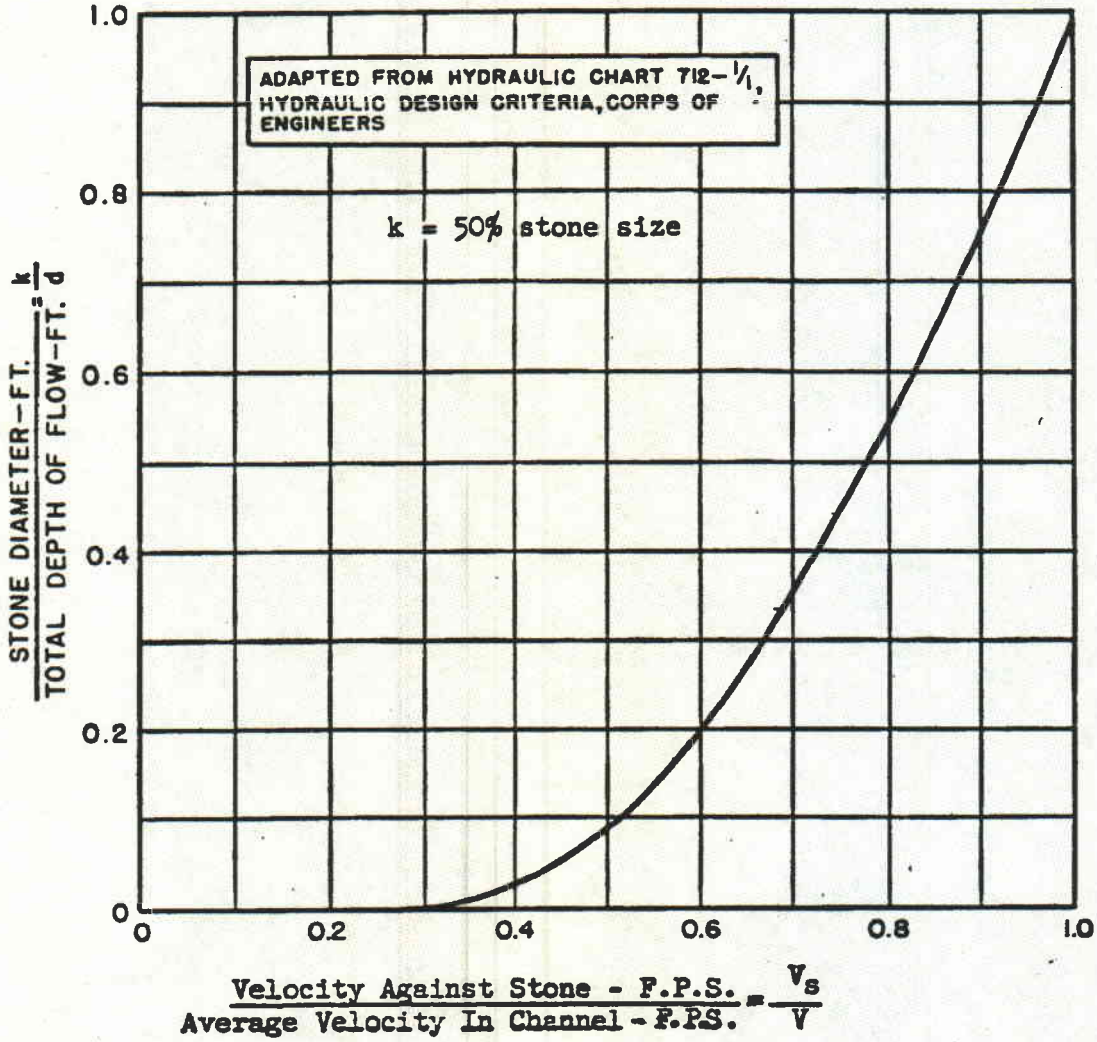


Figure 7-5 Velocity Against Stone on Channel Bottom

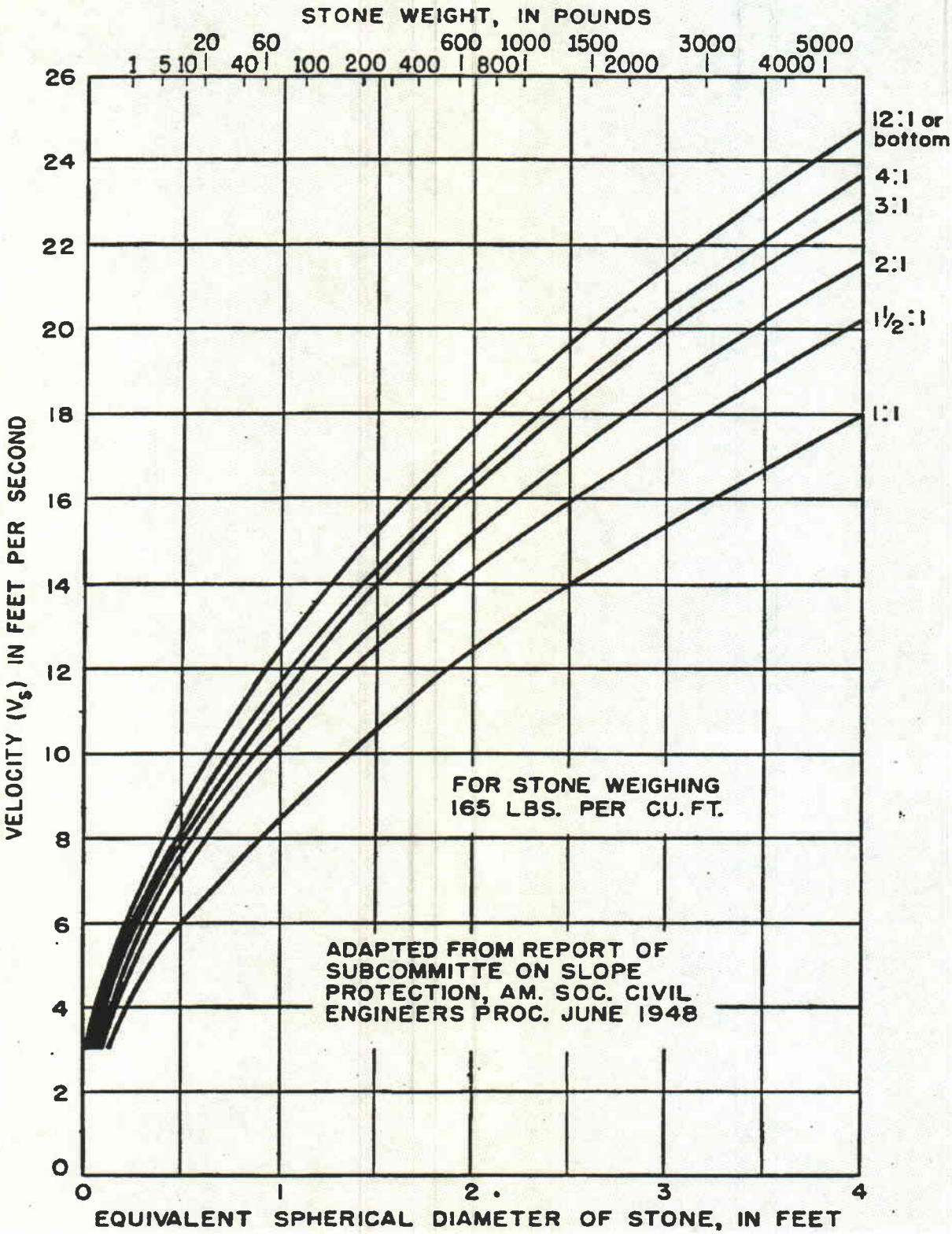


Figure 7-6 Size of Stone that will Resist Displacement for Various Velocities and Side Slopes

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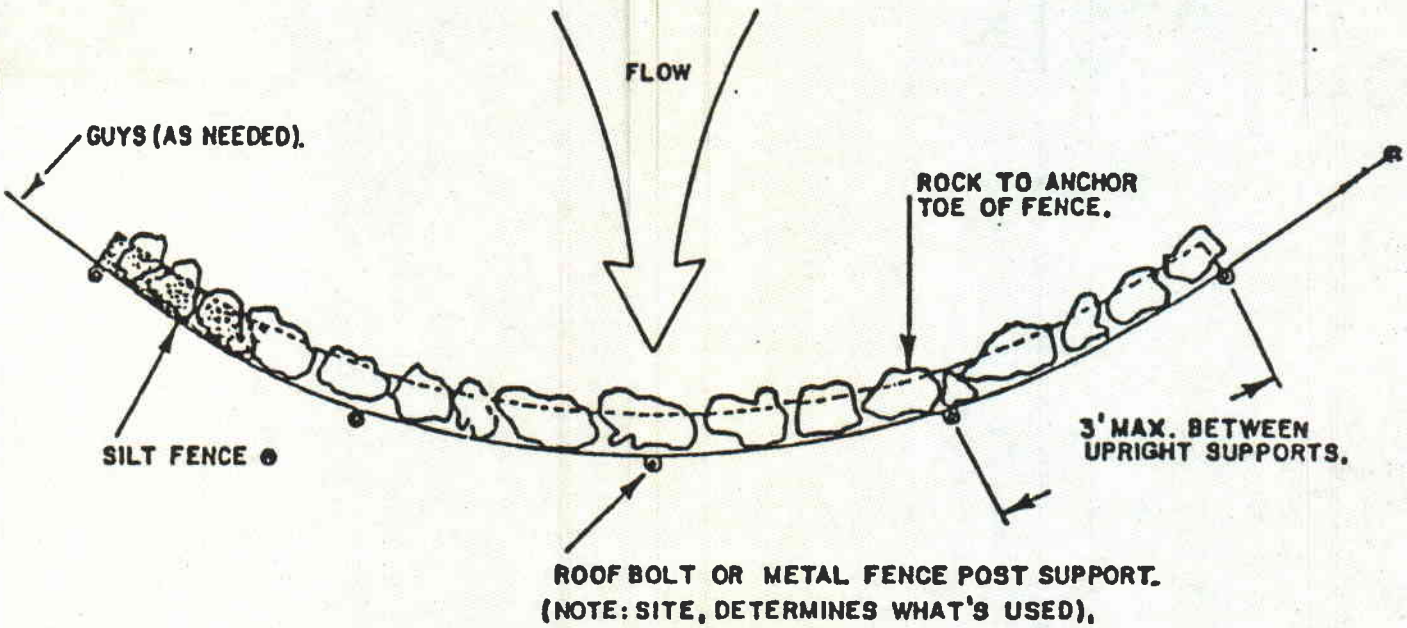
R645-301-742 Sediment Control Measures

742.200 Siltation Structures

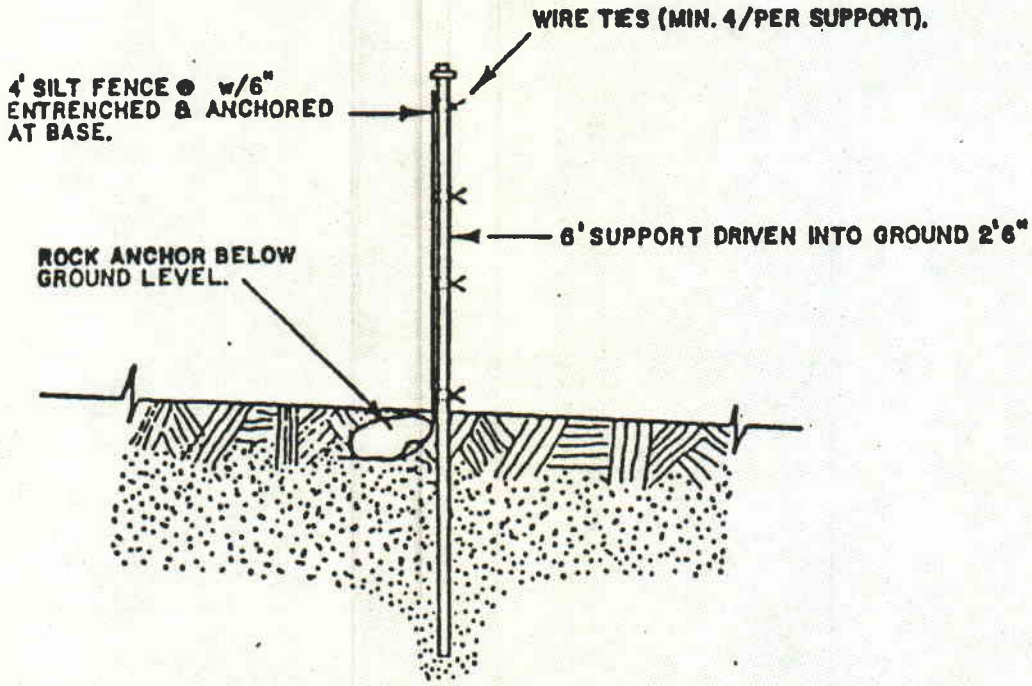
In order to reduce potential impacts from sediment, silt fences shall be installed as shown in Figure 7-7. Silt fence locations are noted on Plates 7-1. A more detailed description of sediment control using silt fences can be found in R645-301-742.300 and Appendix 7-K.



PLAN

TYPICAL SITE

NOTE: GALVANIZED TIE WIRE TO BE USED IN STRUCTURE CONST..



END VIEW (TYPICAL)

Figure 7-7 Typical Silt Fence

742.220 Sediment Ponds

Four sedimentation ponds, A, B, C, and D have been constructed to hold run-off from the disturbed area of the Mine Plan to facilitate settling and filtering of contaminated surface water from the mine site.

Surveys of A, B, and C sedimentation ponds were conducted in November 1990, and October, 1995, by Olympus Aerial Surveys, Inc. Additional pond surveys were conducted by EarthFax Engineering, Inc. in May, 1991. As-built surveys were completed for ponds A and B in July, 1991, and the topography and cross sections are contained on Plates 7-2 and 7-3, respectively. As-built surveys for Pond C was completed in August, 1993, and the topography and cross-sections are shown on Plate 7-6.

A fourth sediment pond is proposed in 2002 to be built in conjunction with the Bear Canyon No. 3 mine Portal Area. All of the runoff from the portal pad will report to sediment pond D.

Discharge. Discharge from the sediment ponds is to Bear Creek or the Right Fork ephemeral drainage. Each pond is constructed with both an open channel spillway and a decant device, 4 in. valved drainpipe with down turned inlet located above the 60 pct sediment cleanout elevation. The decant device allows for separation of oil, grease and other floatables. Discharge to surface waters is governed by the State of Utah Division of Water Quality. See Appendix 7-B, Discharge Permit.

Sediment Pond A

Calculations were performed on pond A in 1990 to determine whether the existing structure would fully contain the design sediment volume and runoff volume from the 10-yr, 24-hr storm. Also to see if the flow-line of the existing decant device was located at the required elevation of 2-ft above the 60 pct sediment clean out level.

To meet these requirements it was recommended that the pond be deepened 3 to 4 ft. In 1991 the pond was deepened 5 ft or 2 ft deeper than planned to a depth of 7,082 ft. This provides for additional storage and a greater margin of safety.

The stage-capacity curve for pond A is presented in Appendix 7-F. Calculations in Appendix 7-F were updated in Oct 1991 using the as-built dimensions. A summary of the revised data is contained in Table 7-19.

The storm runoff volume from the 10-yr 24-hr storm event is 64,951 cu ft (1.49 acre-ft). The computation of the runoff volume assumed a curve number of 90 for the disturbed areas, 100 for the pond area, and 76 or 83 for the undisturbed drainage contributing to the pond. Assuming the pond fully contains this runoff volume, the decant elevation is 7088 ft. The sediment clean out level is at an elevation of 7086 ft, 2 ft below the decant elevation.

Table 7-19 Sed Pond A Stage-Capacity Data

ELEVATION (FT)	AREA (FT)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
7,082	4826		0
		10,618	
7,084	5,792		10,618
		13,084	
7.086	7,292		23,702
		16,144	
7,088	8,852		39,846
		19,366	
7,090	10,514		59,212
		22,247	
7,092	11,733		81,459
		24,752	
7,094	13,019		106,211
		6,590	
7,094.5 Spillway Flow Line	13,340		112,801
		20,765	
7,096	14,347		133,566
		5,792	
7,096.4 Top of Embankment	14,613		139,336

The maximum sediment storage volume is 39,500 cu ft, located at an elevation of 7087.9 ft. The sediment storage volume at the sediment clean out level elevation of 7086 ft, is 23,702 cu ft. With an estimated annual sediment volume of 3848 cu ft, the enlarged pond will provide over 6 yrs of sediment storage. This scenario will allow for greater sediment storage and less frequent maintenance.

The 25-yr, 6-hr storm was routed through the primary spillway to determine the maximum stage and flow rate. Data obtained from these watersheds were input to a computer code developed by Hawkins and Marshall (1979) to generate runoff hydrographs, which were used for the design of drainage diversions. Inflow hydrographs to and outflow hydrographs from the sedimentation ponds were developed using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980). Both of these codes model runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972).

Although the max allowable sediment elevation is 7086 ft, computations were conducted assuming that the pond contained the max available sediment volume of 32,288 cu ft at an elevation of 7087.9 ft. It was further assumed that the pond was full of water up to the spillway flow line prior to the start of the design runoff event. This results in a conservative estimation of the max stage since, in general, the pond can be assumed to be empty to the decant elevation at the beginning of a storm event.

From the analysis of the 25-yr, 6-hr storm event, the max inflow rate to the proposed pond structure is 18.65 cu ft per sec (cfs) and the max outflow rate is 13.87 cfs. The corresponding high water elevation is 7095.08, 1.32 ft below the assumed min embankment elevation of 7096.4 ft. Thus, pond A will adequately pass the 25-yr, 6-hr peak flow.

The inlet channel to pond A was evaluated to determine the adequacy of the existing riprap and capacity of the channel during the 25-yr, 6-hr storm event. The calculations for the inlet channel is presented in Appendix 7-F. Based on the min channel slope, the channels has adequate capacity. Based on the max channel slope, the flow velocity is 7.1 ft per sec. Material from the pond has been pushed up to the access road and inlet covering any riprap that may be there. Although this flow velocity is considered erosive, the sediment will be contained by the pond. If erosion is extensive, the inlet will be adequately maintained.

The open channel primary spillway was evaluated to determine the suitability of the existing riprap. Using the peak discharge rate of 13.87 cfs during the 25-yr, 6-hr storm, the flow velocity was calculated to be 7.9 ft per sec. The existing median riprap diameter of 4 in. on the channel bottom and 10 in. on the side slopes is marginally adequate for this flow velocity. The flow velocity and riprap sizing calculations are presented in Appendix 7-F.

Sediment Pond B

Calculations were performed on pond B in 1991 to determine whether the existing structure would fully contain the design sediment volume and the runoff volume from the 10-yr, 24-hr storm. In addition, the flow line of the existing decant device must be located at an elevation of 2-ft above the 60 pct sediment clean out level. As recommended in 1991 the pond was deepened approx 2 to 3 ft to accommodate the criteria discussed above. The following calculations are based on the as-built pond geometry as shown in Plate 7-3.

The stage-capacity data for pond B were determined from the pond topography contained in Plate 7-3. A summary of these data is contained in Table 7-20. The stage-capacity curve for pond B is presented in Appendix 7-F.

The storm runoff volume from the 10-yr 24-hr storm event is 9095 cu ft (0.209 acre-ft). The computation of the runoff volume assumed a curve number of 90 for the disturbed areas, 100 for the pond area, and 76 for the undisturbed drainages contributing to the pond. Assuming the pond fully contains this runoff volume, the decant elevation is 7064.9 ft. The 60 pct sediment clean out level is at an elevation of 7062.9 ft, 2 ft below the decant elevation. The sediment storage volume at the 60 pct clean out level is 2200 cu ft. The maximum sediment storage volume is 3670 cu ft, located at an elevation of 7063.4 ft. With an estimated annual sediment volume of 213 cu ft, the proposed pond design will provide many years of sediment storage. This scenario is proposed since it will allow for greater sediment storage and less frequent maintenance.

Table 7-20 Sediment Pond B

Elevation (Ft)	Area (Ft^2)	Incremental Volume (Ft^3)	Cumulative Volume (Ft^3)
7,062	2,350		0
		2,619.5	
7,063	2,869		2,609.5
		3,142.5	
7,064	3,416		5,752.0
		3,711	
7,065	4,006		9,463.0
		4,260.5	
7,066.9	4,515		13,723.5
		4,276.8	
7,066	4,989		18,000.3
		501.6	
7,067	5,042		18,501.9
		5,310	
7,068	5,578		23,811.9

The 25-year, 6-hour storm was routed through the primary spillway to determine the maximum stage and flow rate. Data obtained from these watersheds were input to a computer code developed by Hawkins and Marshall (1979) to generate runoff hydrographs, which were used for the design of drainage diversions. The inflow hydrograph to and outflow hydrograph from the sedimentation pond was developed using the hydrology and sedimentology model SEDIMOT II (Warner et al., 1980; Wilson et al., 1980). Both of these codes model runoff using the rainfall-runoff function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972).

Computations were conducted assuming that the pond contained the maximum sediment volume of 3670 cu ft. It was further assumed that the pond was full of water up to the spillway flow line prior to the start of the design runoff event. This results in a conservative estimation of the maximum stage since, in general, the pond can be assumed to be empty to the decant elevation at the beginning of a storm event.

From the analysis of the 25-year, 6-hour storm event, the maximum inflow rate to the proposed pond structure is 2.98 cfs and the maximum outflow rate is 2.40 cfs. The corresponding high water elevation is 7067.19, 0.81 ft below the minimum embankment elevation of 7068 ft. Thus, pond B will adequately pass the 25-yr, 6-hr peak flow.

The inlet channels to pond B were evaluated to determine the adequacy of the existing riprap and capacity of the channels during the 25-year, 6-hour storm event. The calculations for the inlet channels are presented in Appendix 7-F. Based on the minimum channel slope, both

inlet channels have adequate capacity. The inlet channel adjacent to the road is constructed using grouted riprap and is adequate for the maximum flow velocity of 9.0 ft per second. The flow velocity of 2.2 ft per sec for the northern inlet channel is considered non-erosive and does not require riprap.

The open channel primary spillway was evaluated to determine the suitability of the existing riprap. Using the peak discharge rate of 2.40 cfs during the 25-yr, 6-hr storm, the flow velocity was calculated to be 5.25 ft per sec. The existing median riprap diameter of 6 inches is adequate for this flow velocity. The flow velocity and riprap sizing calculations are presented in Appendix 7-H.

Sediment Pond C

The following calculations are based on the as-built pond geometry shown in Plate 7-6.

The stage-capacity data for pond C are contained in Table 7-21. The stage-capacity curve for pond C is presented in Appendix 7-F.

The storm runoff volume from the 10-yr 24-hr storm event is 7,881 cu ft (0.181 acre-ft). The computation of the runoff volume assumed a curve number of 90 for the disturbed areas, 100 for the pond area. The decant elevation is 7032.3 ft, allowing for a water storage volume of 10,423 cu ft. The 60 pct sediment clean out level is at an elevation of 7030.3 ft, 2 ft below the decant elevation. The sediment storage volume at the 60 pct clean out level is 3,169 cu ft. The

maximum sediment storage volume is 5,282 cu ft, located at an elevation of 7031.4 ft. With an estimated annual sediment volume of 126 cu ft, the sediment level would reach the 60 pct cleanout level in approximately 25 years.

Computations were conducted assuming that the pond contained the maximum sediment volume. It was further assumed that the pond was full of water up to the emergency spillway flow line prior to the start of the design runoff event. This results in a conservative estimation of the maximum stage since, in general, the pond can be assumed to be empty to the decant elevation at the beginning of a storm event. Pond C will adequately pass the 25-yr, 6-hr peak flow.

The inlet channel to pond C was evaluated to determine size and riprap requirements. Using the peak discharge rate of 2.66 cfs during the 25-yr, 6-hr storm, the flow velocity was calculated to be 6.03 ft per sec. The channel will be riprapped with 4 in. M.D. riprap. Calculations for the inlet channels are presented in Appendix 7-F.

The open channel primary spillway was evaluated to determine the suitability of the existing rip-rap. Using the peak discharge rate of 2.09 cfs during the 25-yr, 6-hr storm, the flow velocity was calculated to be 4.71 ft per sec. This flow velocity is considered non-erosive and does not require riprap. The depth of flow is 0.09 ft Flow velocity and riprap-sizing calculations are presented in Appendix 7-F.

Table 7-21 Sed Pond C Stage-Capacity Data

ELEVATION (FT)	AREA (FT)	INCREMENTAL VOLUME (FT^3)	CUMULATIVE VOLUME (FT^3)
7,026	22		0
		120	
7,027	218		120
		399	
7,028	579		519
		815	
7,029	1,051		1,334
		1,315	
7,030	1,578		2,648
		1,736	
7,031	1,894		4,384
		2,070	
7,032	2,245		6,454
		2,411	
7,033	2,576		8,864
		2,745	
7,034	2,914		11609
		3,096	
7,035	3,278		14,705
		1,000	
7,035.3	3,390		15,705

Sediment Pond D

This sediment pond is designed to treat the runoff from the No. 3 Mine portal pad in Wild Horse Ridge. The design is based on the proposed geometry shown on Plate 7-11. The stage-capacity data for pond D is shown in Table 7-22. A stage-capacity curve is presented in Appendix 7-F, along with the design calculations.

The storm runoff volume from the 10-yr 24-hr storm event is 3,855 cu ft (0.088 acre-ft). The computation of the runoff volume assumed a curve number of 90 for the disturbed area and the pond area. The decant elevation is 7648 ft, allowing for a water storage volume of 5,565 cu ft. The 60 pct sediment clean out level is at an elevation of 7646.3 ft, 1.7 ft below the decant elevation. The sediment storage volume at the 60 pct clean out level is 665 cu ft. The maximum sediment storage volume is 1,109 cu ft, located at an elevation of 7647 ft. With an estimated annual sediment volume of 24 cu ft, the sediment level would reach the 60 pct cleanout level in approximately 27 years.

The spillway calculations were made assuming that the pond contained the maximum sediment volume and was full of water up to the emergency spillway flow line prior to the start of the design runoff event, and assuming all of the flow went through the emergency spillway. This results in a conservative estimation of the maximum stage and spillway design since the pond could be assumed to be empty to the decant elevation at the beginning of the storm event. The outlet structures will, therefore, adequately pass the 25-yr, 6-hr peak flow.

The inlet channel to pond D was evaluated to determine size and riprap requirements. Using a peak flow of 1.03 cfs for the 10-yr, 24-hr sorm, the flow velocity was calculated to be 6.62 fps. The channel will be riprapped with 4 in. M.D. riprap. The inlet design calculations are shown in Appendix 7-F.

For the emergency spillway, the flow velocity was determined to be 8.04 fps. To prevent erosion, the spillway will be riprapped with 6" M.D. riprap. The spillway design calculations are also shown in Appendix 7-F. A minimum safety factor of 1.36 was determined for rapid drawdown conditions.

Table 7-22 Sediment Pond D Stage-Capacity Data

Elevation (ft)	Area (ft^2)	Incremental Volume (ft^3)	Cumulative Volume (ft^3)
7,644	42.2		0
		125	
7,645	208.65		125
		338	
7,646	467.98		463
		646	
7,647	825.02		1,109
		1,050	
7,648	1,274.70		2,159
		1,619	
7,649	1,962.65		3,778
		2,417	
7,650	2,871.97		6,195
		1,529	
7,650.5	3,243.73		7,724

Slope Stability Analysis

A computer slope stability analysis for pond "A" is contained in Appendix 7-E. The computer analysis of the sediment pond included the condition under which the most conservative factor of safety would be derived. This is a condition wherein the soil is saturated from the sediment pond being full of water and then the analysis is run with the sediment pond empty. For purposes of analysis the soil was assumed saturated by the water occasionally held in the pond. The cross-sections towards the back of Appendix-E indicate a division between soil No. 2 and soil No. 1. Referring back to the computer printout sheets, soil No. 2 is indicated to be in a saturated condition.

Again, this analysis provides for the most conservative results and is the worst condition; which would only occur after saturation due to the sediment pond being full and then after rapid "draw-down" or dewatering of the sediment pond. This same material was used in the construction of Ponds "B" and "C". A Slope Stability Analysis of the material to be used to construct Sediment Pond "D" is shown in Appendix 5-J.

Pond Maintenance and Monitoring

All embankments of temporary impoundments, surrounding areas, and diversion ditches, disturbed or created by construction shall be graded, fertilized, seeded and mulched to comply with the requirements of R645-302-353 immediately after the embankment is complete. Areas in which the vegetation is not successful, or where rills and gullies develop shall be repaired and revegetated.

In addition, all dams and embankments shall be routinely maintained during the mining operation. Any vegetative growth will be cut where necessary to facilitate inspection and repairs. Ditches and spillways shall be cleaned as needed. Any combustible materials present on the surface shall be removed and all other appropriate maintenance procedures followed.

Sediment ponds will be cleaned out when they reach the 60 pct clean out level. Sediment material from the sedimentation ponds will be placed in the sediment pond waste area (Plate 5-2C) and is discussed in Appendix 5-O.

Quarterly Inspections. Quarterly inspections will be made of all sediment ponds and submitted to DOGM with the quarterly Water Monitoring Report. If any inspection discloses that a potential hazard exists, Co-Op will notify the Division immediately as required by R645-301-515.200.

Annual Inspections. Annual inspections will be made by a qualified registered professional engineer of all sediment ponds and a certified report will be submitted to the Division with the annual report. The report will include discussion of items noted in R645-301-514.312. Copies of the reports will be placed in Appendix 7-I.

Portal Pad Catch Basin

Runoff from the Belt Portal Pad area is collected and totally contained in a catch basin at the base of the road slope (See Plates 5-2 and 5-5). Calculation factors for catch basin sizing are listed below.

Factor	Value
Area	3,765 ft^2
Soil Type	C
Min Infiltration Rate	0.05 to 0.15 in./hr use 0.10 in./hr, see p 7F-7
6 hr-10 yr Storm	1.38 in. (0.23 in./hr)
Rainfall Data Base	Hiawatha Data by E. Arlo Richardson. See App 7-G.

Total Accumulation 245 ft^3

(3,765 ft^2 x (0.23 in./hr - 0.10 in./hr) x 1 ft/12 in. x 6 hr

Catch Basin Size	442 ft^3
Area	354 ft^2
Av Depth	1.25 ft
Berm Height	1.5 ft min
Excess Volume	198 ft^3

Note: The hoist located in the basin is a tubular structure and will not appreciably affect the overall storage capacity of the catch basin and will not jeopardize the structure's effectiveness during the design event.

742.300 Diversions

The majority of the disturbed area of the Bear Canyon Mine is on the west side of Bear Canyon (same side as the No. 1 and 2 mine portals and to the south). Run-off from this west side disturbed area is collected and channeled to Sedimentation Ponds "A" and "C" with exception of runoff from the ASCA areas (Alternate Sediment Control Areas) which are described in Appendix 7-K. The small amount of run-off from the disturbed area east of Bear Creek where the scale house building is located is channeled to Sedimentation Pond "B". The runoff from the Wild Horse Ridge Portal Area is channeled to Sediment Pond "D". Remaining disturbed areas are designated as ASCA's and treated as described in Appendix 7-K. In order to minimize the amount of water crossing the disturbed area, run-off from the undisturbed areas above are diverted around or channeled through the disturbed areas and into Bear Creek. Plates 7-1 show the arrangement of the various sedimentation and diversion structures.

The existing facilities within the Co-Op Mine were constructed in a manner, which minimizes changes to the prevailing hydrologic balance. Contributions of sediment to the stream channel are prevented by diverting drainage from undisturbed areas away from the site. In addition, existing sedimentation ponds collect disturbed area surface runoff, and a system of berms around the disturbed areas prevent drainage to the stream channel.

In addition, Co-Op implemented an extensive interim revegetation program in October 1983 wherein soil tackifiers and mulches were utilized to stabilize the soil for vegetation establishment. Additional interim revegetation has been performed since that time as required.

Storm Runoff Calculations

Peak discharge rates from the undisturbed and disturbed area drainages of the Co-Op Mine were calculated for use in determining the adequacy of the existing diversion ditches and culverts. The storm runoff calculations for the temporary diversion structures were based on the 10-year, 6-hour storm event of 1.5 inches of precipitation (Miller et. al., 1973).

The undisturbed drainage areas for the Co-Op Mine are presented on Plate 7-5. The disturbed drainage areas are presented on Plates 7-5 and 7-1. Each drainage area is labeled according to whether it contributes to the pond (typically, disturbed) or is diverted (undisturbed). For example, AU-6 represents undisturbed watershed number 6.

Curve numbers for the undisturbed drainage areas were estimated from vegetation data presented in R645-301-321, and by field observations. Cover densities were estimated from information presented in R645-301-321. Based on a cover density of 40 pct, a curve number of 76 for the undisturbed areas was estimated using Figure 7-1. Curve number calculations are presented in Appendix 7-G.

The curve number for disturbed areas was chosen from professional judgment and tabulated values presented by the U.S. Soil Conservation Service (1972). Accordingly, a value of 90 was used for the pad and road areas.

Data obtained from the watersheds were input to a computer code called "Peak" to generate runoff hydrographs. This computer code models runoff using the rainfall-runoff

function and triangular unit hydrograph of the U.S. Soil Conservation Service (1972). A summary of the runoff calculations is presented in Table 7-23. All runoff calculations are contained in Appendix 7-G.

Diversion Structures

Diversion structures within the Co-Op Mine area include drainage ditches and culverts to convey storm runoff from disturbed and undisturbed drainage areas, and berms to contain disturbed-area drainage. These diversion structures are located on Plates 7-1. The peak discharge rates are based on the 10-year, 6-hour storm event.

The dimensions of the existing diversion ditches and berms were measured in the field. The measurements approximate either a trapezoidal or triangular shape. Typical sections for each diversion identified on Plates 7-1 are contained in Table 7-24 in tabular form.

The capacity of existing diversion ditches was determined by calculating the normal depth of flow based on a minimum ditch slope. The maximum flow velocity was calculated based on the maximum ditch slope. Ditch slopes were measured in the field and estimated from topographic maps with a scale of 1" = 50'. An average ditch slope was measured for those sections without an apparent change in grade. Maximum and minimum slopes were measured where applicable. A summary of ditch calculations is presented in Table 7-24. All ditch calculations are contained in Appendix 7-G.

Table 7-23 Summary of Storm Runoff Calculations for 10 Year 6 Hour Storm

Watershed	Curve Number CN	Time of Concentration (Hr)	Drainage Area (Acres)	Peak Discharge (CFS)
AU-1	76	0.094	6.46	0.83
AU-1A	83	0.032	1.36	0.51
AU-1B	83	0.026	1.16	0.44
AU-1C	76	0.120	16.40	1.95
AU-2	76	0.075	2.23	0.30
AU-2A	76	0.077	1.64	0.22
AU-2B	76	0.081	3.80	0.51
AU-3	76	0.078	3.87	0.52
AU-3A	76	0.016	0.30	0.05
AU-4	76	0.093	7.97	1.02
AU-4A	83	0.029	0.92	0.35
AU-5	76	0.104	20.14	2.51
AU-6	76	0.059	2.73	0.39
AU-7	76	0.094	13.46	1.72
AU-8	76	0.050	4.95	0.72
AU-9	76	0.100	4.77	0.60
AU-10	76	0.137	35.52	4.05
AU-11	76	0.045	0.62	0.09
AU-12	76	0.050	2.33	0.34
AU-13	76	0.022	0.66	0.10
AU-14	76	0.050	2.43	0.35
AU-15	76	0.058	0.91	0.13
AU-16	76	0.152	44.93	4.92
AU-17	76	0.152	30.10	3.29
AU-18	76	0.152	36.55	4.00
AU-19	76	0.144	36.03	4.03

Table 7-23 Summary of Storm Runoff Calculations for 10 Year 6 Hour Storm (cont)

Watershed	Curve Number CN	Time of Concentration (Hr)	Drainage Area (Acres)	Peak Discharge (CFS)
AU-20	76	0.131	20.55	2.37
AU-21	76	0.110	9.45	1.15
AU-22	76	0.086	12.12	1.59
AU-23	76	0.093	5.25	0.64
AU-23A	76	0.033	0.28	0.04
AU-24	76	0.119	13.89	1.66
AU-25	76	0.087	2.27	0.30
AU-26	76	0.033	0.63	0.10
AU-27	76	0.027	0.2	0.03
AU-28	76	0.039	0.59	0.09
AU-28A	76	0.071	0.99	0.14
AU-29	76	0.025	1.29	0.29
AU-29A	76	0.023	0.55	0.67
AU-30	76	0.029	0.49	0.08
AU-31	76	0.048	2.21	0.32
AU-32	76	0.036	1.84	0.28
AU-33	76	0.040	0.71	0.11
AU-34	76	0.045	1.84	0.27
AU-35	76	0.032	0.2	0.13
AU-36	76	0.031	0.75	0.12
AU-37	76	0.198	139.82	13.64
AU-38	76	0.094	8.97	1.15
AU-39	76	0.048	1.26	0.18
AU-40	76	0.283	197.5	15.96
AU-41	76	0.100	11.59	1.46
AU-42	76	0.002	4.24	0.67
AU-43	76	0.095	13.7	1.75

Table 7-23 Summary of Storm Runoff Calculations for 10 Year 6 Hour Storm (cont)

Watershed	Curve Number CN	Time of Concentration (Hr)	Drainage Area (Acres)	Peak Discharge (CFS)
Bear Creek	76	0.604	1,728	108.18
Bear Creek[1]	76	0.604	1,728	108.18

Table 7-23 Summary of Storm Runoff Calculations for 10 Year 6 Hour Storm (cont)

Watershed	Curve Number CN	Time of Concentration (Hr)	Drainage Area (Acres)	Peak Discharge (CFS)
AD-1A	76	0.090	3.70	0.48
AD-1B	76	0.037	2.12	0.32
AD-2A	76	0.040	0.97	0.15
AD-2B	83	0.025	1.08	0.41
AD-2C	83	0.012	0.25	0.10
AD-3A	76	0.034	1.49	0.23
AD-3B	76	0.034	0.78	0.12
AD-4	83	0.011	0.08	0.03
AD-5	76	0.056	2.13	0.30
AD-6	90	0.220	1.39	0.81
AD-7	90	0.145	2.95	1.83
AD-8 upper	90	0.021	0.70	0.48
AD-8 lower	90	0.247	2.79	1.59
AD-9	90	0.069	0.35	0.23
AD-10 upper	90	0.026	0.30	0.20
AD-10 lower	90	0.078	0.65	0.42
AD-11	95	0.011	0.69	0.65
AD-12 upper	90	0.020	0.22	0.15
AD-12 lower	90	0.076	0.34	0.22
AD-13	91	0.106	1.78	1.23
AD-14	90	0.009	0.08	0.05
AD-15	90	0.069	1.83	1.20
AD-16	90	0.030	0.77	1.24
AD-17	90	0.019	0.24	0.16
AD-18	90	0.170	0.9	0.55
AD-19	90	0.009	0.15	0.10
AD-20	90	0.019	0.47	0.32

[1] Sized for the 100 Yr – 6 hr storm event.

Table 7-24 Summary of Division Ditch Calculations

Ditch	Bottom Width (Ft)	Top Width (Ft)	Depth (Ft)	Type 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	14	0.33	6:1	3 Av.	AD-13	Soil
D-9D	0	2	1	1:1	4 Min 10	AD-15	Soil
D-10D	1	3.33	0.67	1.5:1	7 Min 50	AD-6, AD-3B, (part) AD-2B, AD-2C	D_{50} 4" Bedrock
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 Shed	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	0.06 Av.	AU-4A	Soil
D-15D	0	2.00	1.00	1:1	0.05 Av.	AD-16	Soil
D-16D	0	1.50	1.75	1:1	0.05 Av.	AD-18	Soil
D-17D	0	.96	1	1:1	0.08 Av.	AU-23, AD-20	Soil

Notes: 1. Dimensions given indicate minimum requirements. Actual dimensions may vary. Minimum required cross-sections will be maintained.

2. The use of line drainage ditches is required when flow velocities exceed approximately 5 feet per second. Rip-rap may be installed where not required.

Table 7-24 Summary of Division Ditch Calculations (Cont)

Ditch	Bottom Width (Ft)	Top Width (Ft)	Depth (Ft)	Type Side Slope H:V	Measured Slope %	Contributing Watershed	REQ'D Av. Rip-Rap Size (In.)
D-1U	2	1.33	0.67	1:1	2 Min 8 Max	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 16 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	2 Min 31 Max	AU-1, AU-1[a], AU-1B, AU—1C, AU-2, AU-2[a], AU-2B	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 damage	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 damage	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	2	0.67	1.5:1	5 Min 16 Max	AU-3	Soil
D-16U	0	2	0.67	1.5:1	10 Av.	AU-1B	Soil

Table 7-24 Summary of Division Ditch Calculations (Cont)

Ditch	Bottom Width (Ft)	Top Width (Ft)	Depth (Ft)	Type Side Slope H:V	Measured Slope %	Contributing Watershed	REQ'D Av. Rip-Rap Size (In.)
D-17U	0	2	0.67	1.5:1	13 Av.	AU-1[a]	Bedrock
D-18U	0	2	0.67	1.5:1	5 Min	AU-1	Soil
D-19U	0	2	0.67	1.5:1	6 Av.	AU-2B	Soil
D-20U	0	1.33	0.67	1:1	16 Av.	AU-42	Soil
D-21U	0	2	1.0	1:1	13 Av.	AU-43	D_{50}=3"
D-22U	0	3	1.0	1.5:1	11 Av.	AU-19, AU-25	D_{50}=6"
D-23U	0	1.16	0.58	1:1	19 Av.	AU-36	Soil
D-24U	0	1.16	0.58	1:1	14 Av.	AU-35	Soil
D-25U	0	1	0.5	1:1	16 Av.	AD-17	Soil
D-26U	0	1	0.5	1:1	24 Av.	AU-32	Soil
D-27U	0.50	2	0.5	1.5:1	13 Min, 30 Max	AU-31	Soil
D-28U	0	1	0.5	1:1	14 Av.	AU-33	Soil
D-29U	0	1.33	0.67	1:1	8 Av.	AU-34	Soil
D-30U	0	1.16	0.58	1:1	13 Av.	AU-25	Soil
D-31U	0	3	1.0	1.5:1	12 Av.	AU-20, AU-26	Bedrock
D-32U	0	1	0.5	1:1	17 Av.	AU-30	Soil
D-33U	0	1.16	0.58	1:1	18 Av.	AU-29	Soil
D-34U	1	2.74	0.58	1.5:1	11 Av.	AU-24	Soil
D-35U	0	2.0	1.0	1:1	10 Av.	AU-29	Soil
D-36U	0	1.0	0.5	1:1	8 Av.	AU-27	Soil
D-37U	0	1.4	0.7	1:1	8 Av.	AU-26, AU-21	Soil
D-38U	0	1.33	.0.67	1:1	12 Min, 20 Max	AU-21	D_{50}=3"
D-39U	0	1.0	0.5	1:1	10 Av.	AU-28	Soil

Table 7-24 Summary of Division Ditch Calculations (Cont)

Ditch	Bottom Width (Ft)	Top Width (Ft)	Depth (Ft)	Type Side Slope H:V	Measured Slope %	Contributing Watershed	REQ'D Av. Rip-Rap Size (In.)
D-40U	0	1.5	0.75	1:1	9 Av.	AU-24A, C-39U	D_{50}=3
D-41U	0	2	1	1:1	15 Av.	AU-22, AU-23A, C-40U	D_{50}=4
D-42U	0	0.5	0.25	1:1	36 Min, 63Max	AU-23A	Soil
D-43U	0	2	2	2:1	20 Min, 45 Max	AU-23	D_{50}=5

Notes:

1. Dimensions given indicate minimum requirements. Actual dimensions may vary. Minimum required cross-sections 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.

All calculations for the diversion ditches resulted in a maximum flow velocity of less than the maximum permissible velocity. A flow velocity of less than 5 feet per second was considered non-erosive for those ditch sections with little or no riprap or vegetation. For those ditch sections with an abundance of vegetation or riprap maximum permissible velocities were based on the channel characteristics as presented in Appendix 7-G.

Fifty-three culverts have been or will be installed within the Co-Op Mine area to divert storm runoff from the disturbed and undisturbed drainage areas. These culverts were located in the field and are identified on Plates 7-1.

The adequacy of the culverts to pass the design flow rate was determined. Table 7-25 summarizes the culvert sizing calculations. Because the resulting HW/D (headwater depth divided by the culvert diameter) ratio is less than one for each culvert, these existing culverts will adequately pass the design storm. Culvert calculations are presented in Appendix 7-G.

The slope of each culvert was measured in the field. Calculations were performed to determine the exit velocities at each culvert and the required riprap. A summary of the culvert flow velocity and riprap sizing calculations is presented in Table 7-25. Culvert flow velocity computations are presented in Appendix 7-G.

Where culvert exit velocities were in excess of the maximum permissible velocity, erosion protection measures were designed. These measures are presented in Appendix 7-G.

Table 7-25 Culvert Characteristics

Culvert	Diameter (in.)	Type	Contributing Watersheds	Slope (ft/ft)	Outlet Condition
C-21U	36	CMP	Right Fork Drainage	0.06	Bedrock
C-22U	20	CMP	AU-19, AU-25	0.06	Soil
C-23U	36	CMP	AU-36, AU-35, AU-34, AU-20, AU-26, C-24U	0.06	11" rip-rap
C-24U	32	CMP	AU-40, C-25U	0.06	10" rip-rap
C-25U	30	CMP	AD-17, C-26U	0.06	8" rip-rap
C-26U	30	CMP	AU-39, AU-32, AU-33, C-30U, C-34U	0.06	8" rip-rap
C-27U	15	CMP	AU-22, AU-28, AU29A, AU-31	0.06	4" rip-rap
C-28U	15	CMP	AU-43, C-29U	0.06	4" rip-rap
C-29U	15	CMP	AU-20, AU-25, AU-26	0.06	3" rip-rap
C-30U	15	CMP	AU-21, AU-27, AU-30	0.06	Soil
C-31U	12	CMP	AU-29	0.06	Soil
C-32U	15	CMP	AU-22, AU-28, AU-29A	0.06	3" rip-rap
C-33U	24	CMP	AU-24, AU-28A, AU-37	0.06	8" rip-rap
C-34U	24	CMP	AD-19, AU-31, AU-37, AU-38, C-31U, C-32U	0.06	8" rip-rap
C-35U	84	CMP	Bear Creek	0.06	48" rip-rap
C-36U	15	CMP	AU-27, AU-21	0.11	3" rip-rap
C-37U	15	CMP	Abandoned In Place		
C-38U	15	CMP	AU-28	0.08	Soil
C-39U	15	CMP	AU-22, AU-32A, C-40U	0.18	6" rip-rap
C-40U	12	CMP	AU-23	0.001	Soil

Table 7-25 Culvert Characteristics (Cont)

Culvert	Diameter (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	4.0	10" rip-rap
C-3D	20	slt pipe	AD-3A	0.03	4" rip-rap
C-4D	21	CMP	AD-3A, AD-5, AD-7, AD-14, C-10D	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	Soil
C-11D	12	CMP flexible	AD-4A	0.05 0.25	3" rip-rap
C-12D	8	CMP	AD-18	0.05	Soil
C-13D	12	CMP	AU-23, AD-20	0.07	Soil

Diversion Structures Modifications

Culvert C-8U Extension, 1989

In order to reduce migration of coal fines into undisturbed drainage, culvert C-8U which passes under the storage pad, was extended uphill approximately 60 ft during the summer of 1989. A berm will be built to meet the required headwater and to prevent runoff to the south from entering the drainage. The headwall will be riprapped and the existing trash rack will be resecured to the culvert as presently installed. Extending the culvert will increase the distance between the coal storage and the inlet to the culvert.

A small sediment basin will be constructed and maintained at the inlet of culvert C-8U in the Spring of 1992, and cleaned as needed to reduce potential impacts of suspended solids to surface waters.

Culvert Outlet C-1U 1991

In order to reduce erosion occurring at the outlet of culvert C-1U, a flexible culvert was added to the end of the in-place culvert. The extension extends to a point where the discharge is onto the rock cliff. The only runoff that crosses the slope below the Upper Storage Pad will then be the direct impact precipitation. The flexible culvert is attached to the slope using the method identified in Figure 7-13. Vegetation will be evaluated, stabilized, and supplemented as required.

A splash basin and drainage channel will be established at the immediate impact area in the downcast material at the base of the cliff, to direct drainage to the original drainage path. Due to the inaccessible nature of the location all work will be performed by hand. This limits the size of rip-rap that can be placed so the construction will be reviewed by qualified personnel along with the division. See Figure 7-8 for a profile of the cliff and downfall area. The remaining downcast material in the pile at the base of the cliff will be stabilized with erosion control matting and using interim reclamation procedures defined in R545-301-331.

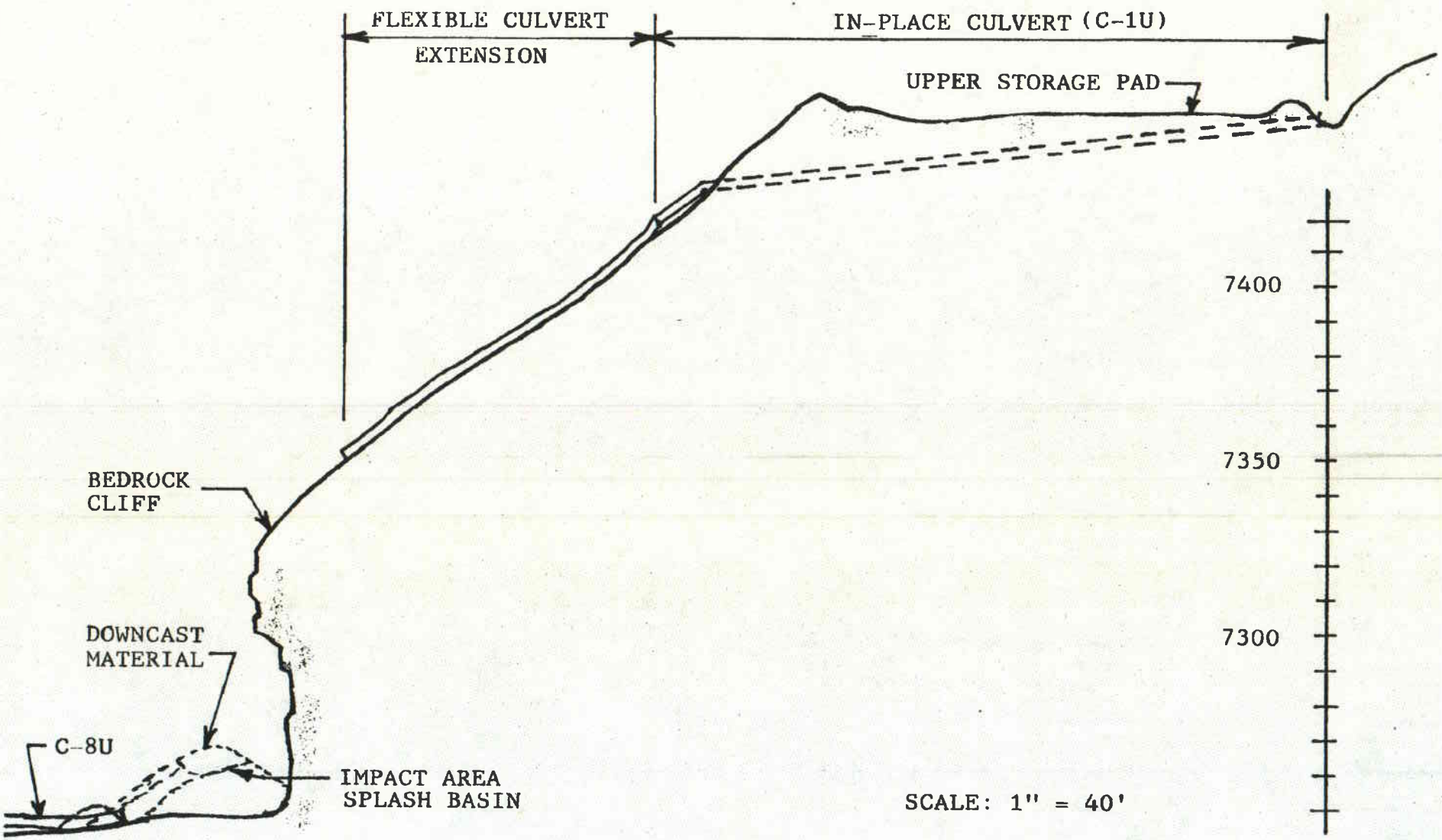


Figure 7-8 Culvert C-1U - Downslope Profile

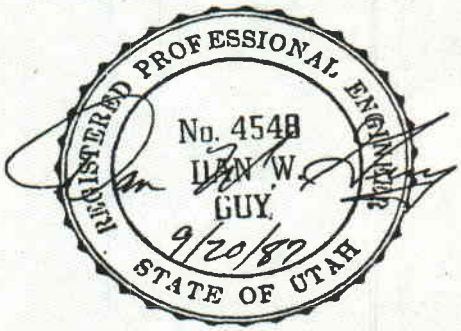
Additional Control for Hiawatha Seam Mining

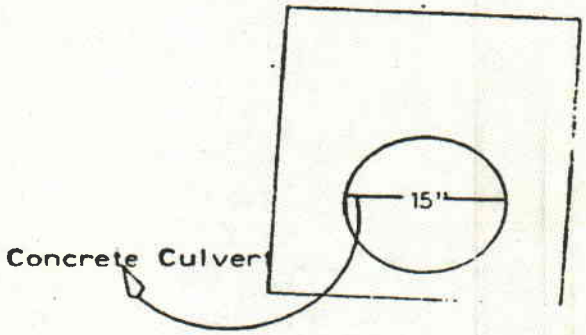
As shown on Plate 7-1C, the out-slope of the proposed Hiawatha Seam portal pad encroaches upon the ephemeral channel between D-1D and D-2D. A 15 in. flexible culvert (C-1D and C-2D) and drainage ditch (D-10D and D-7D), as shown on Plate 7-1C, is installed to convey the drainage from the upper areas of the channel beneath the pad to the coal storage pad below. Installation details are shown in Figures 7-9 (Downspout Structure), 7-10 (Collection Box), 7-11 (Ditch D-10D Cross-Section), 7-12 (Buried Cross Sections), 7-13 (Exposed Section Anchor). Riprap specifications will be adhered to as specified in Table 7-24 and Table 7-5.

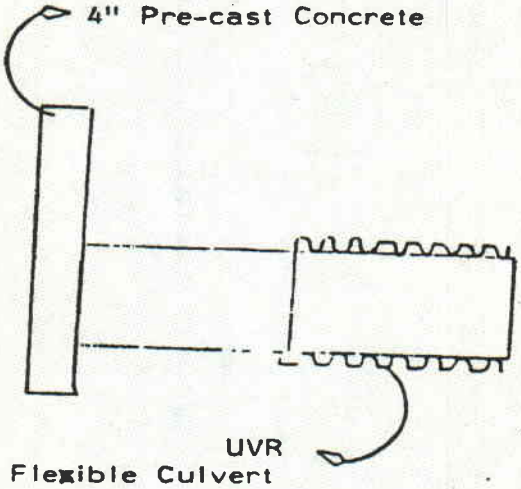
Prior to September 1995, the flexible culvert was used to convey the drainage the entire length of the slope. A storm event which exceeded the design peak flow of the culvert destroyed a section of the flexible culvert from the uppermost belt tower below the coal storage bin to the coal processing pad. To reduce maintenance, this section will be replaced by a drainage channel as shown in Figure 7-11 and on Plate 7-1C.

In 1998, the lower portion of the flexible culvert was ceased to function and has resulted in continued high maintenance. To reduce maintenance, Ditch D-7D will be extended to carry the runoff currently flowing through Culvert C-2D. This portion of the channel will be riprapped in accordance with Table 7-24. Since the channel slope in this area (49%) does not exceed the design slope for ditch D-7D (55%), the existing design for ditch D-7D will be adequate.

DOWNSPOUT STRUCTURE







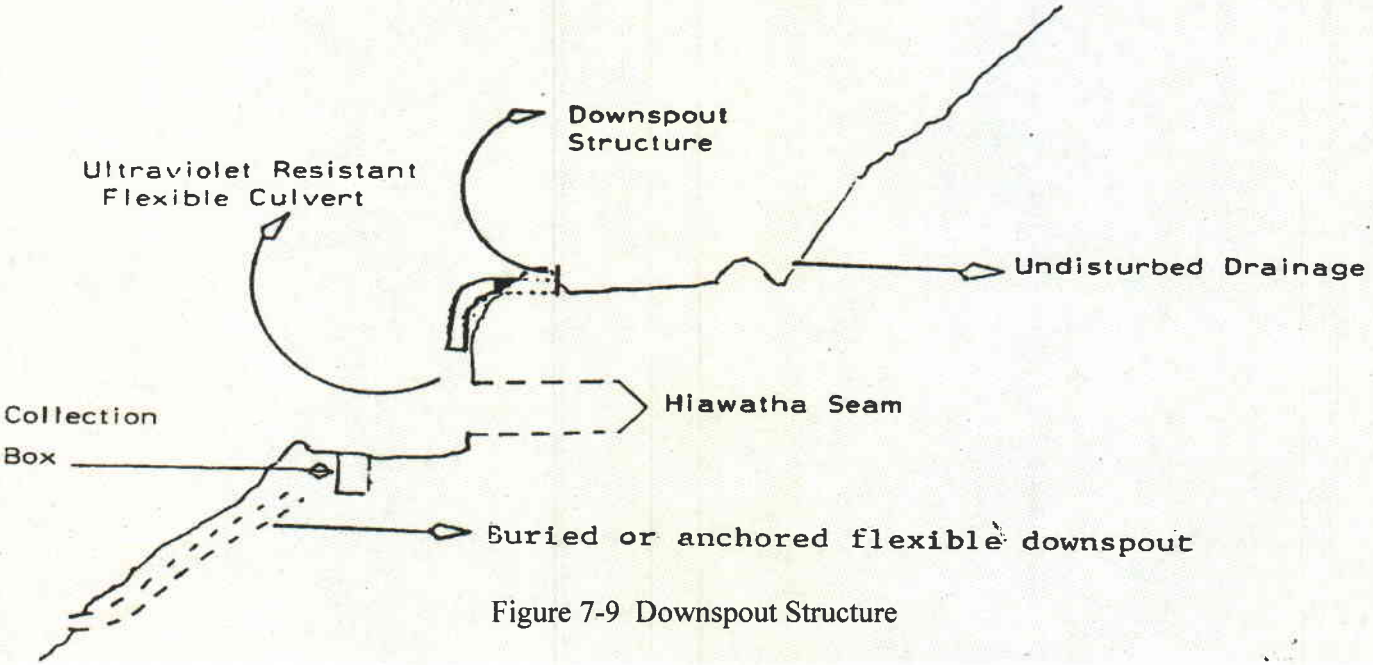
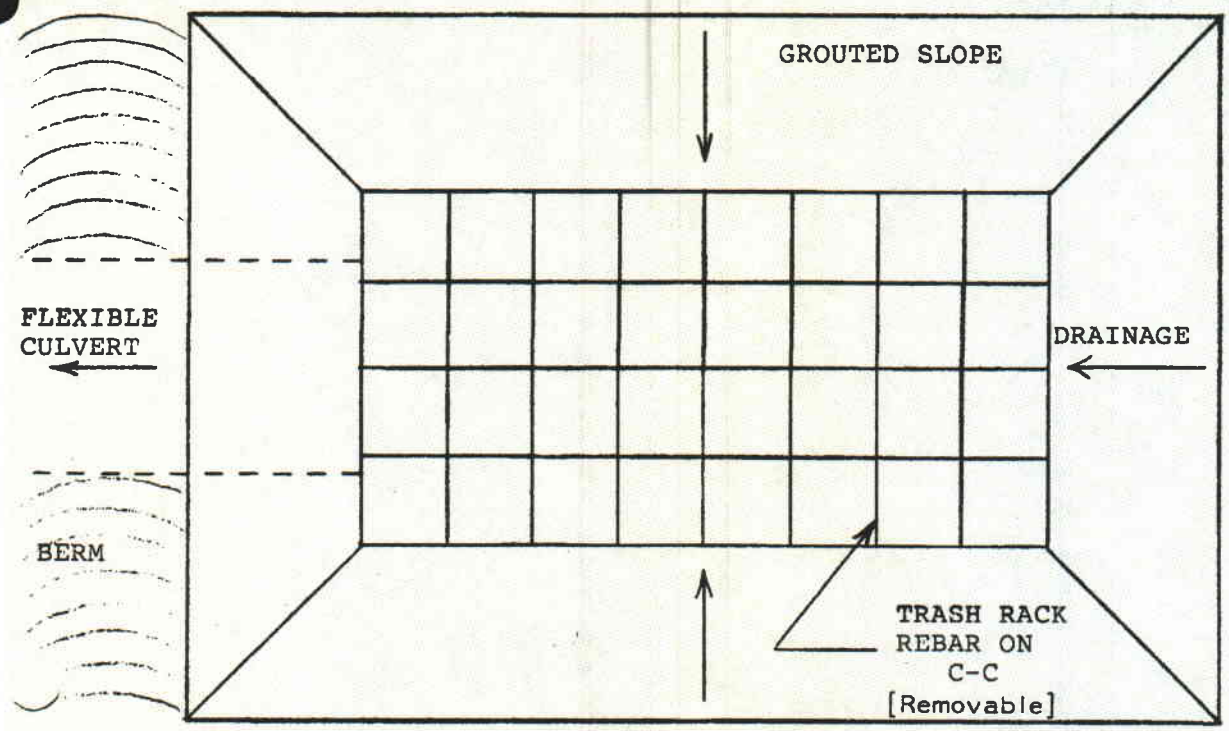
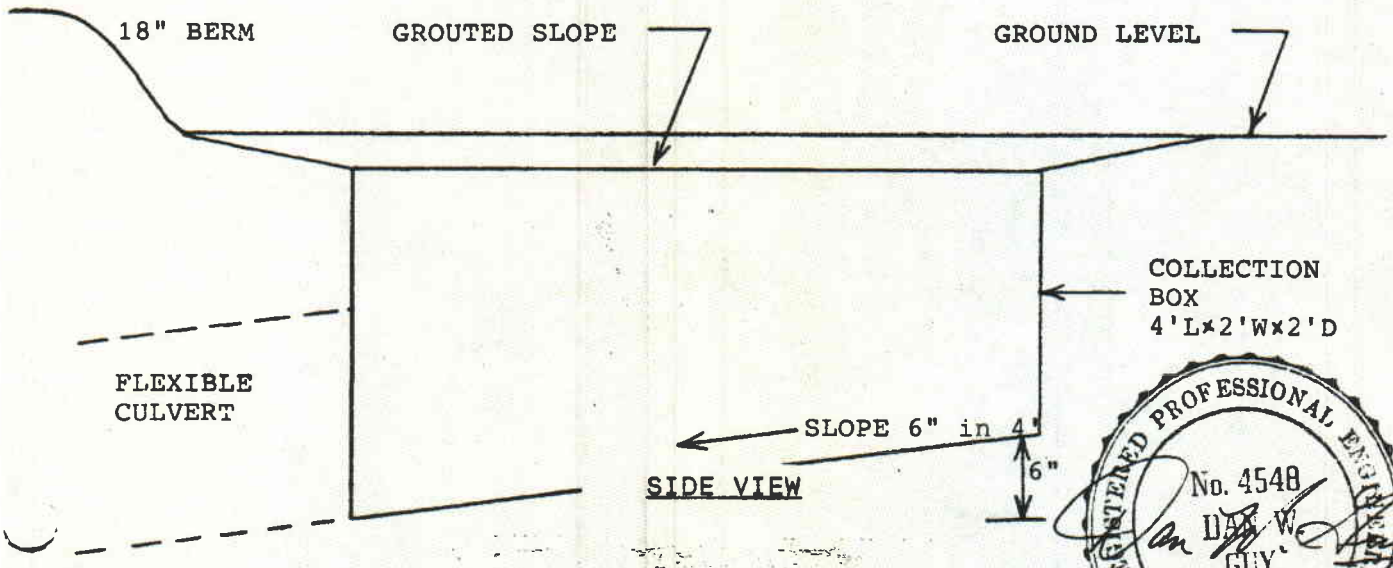


Figure 7-9 Downspout Structure



TOP VIEW

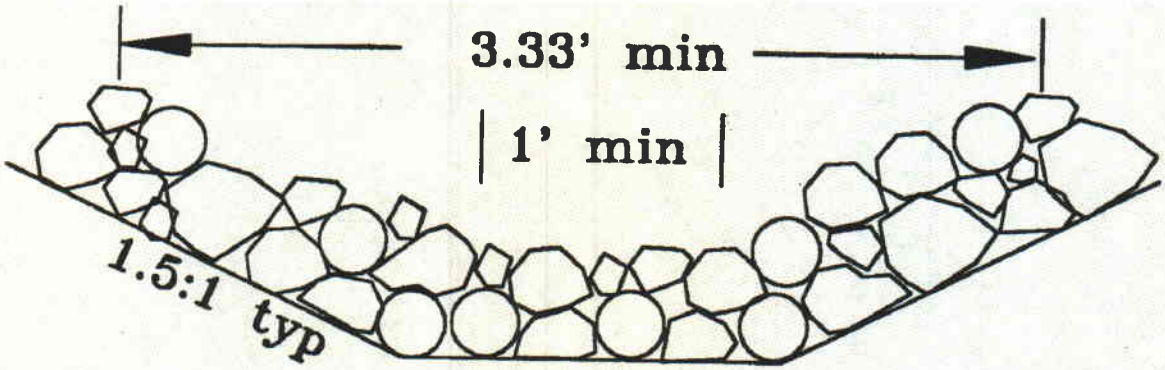


SIDE VIEW

Figure 7-10 Collection Box

Ditch D-10D

Typical Cross-Section



Minimum channel depth = 0.67'

Figure 7-11 Ditch D-10D Cross-Section

Cross-Section of

Buried Flexible Culvert

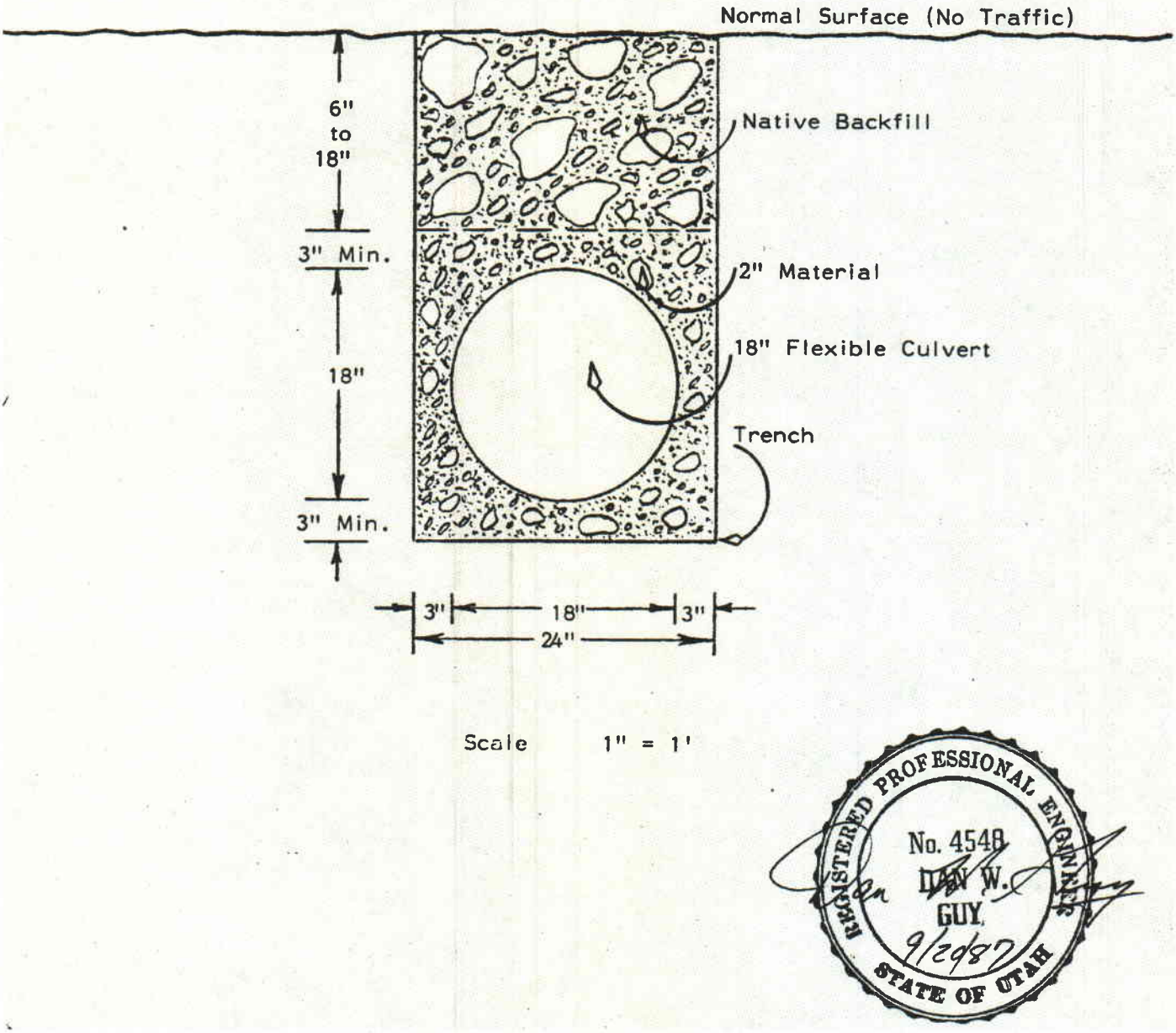


Figure 7-12 Buried Flexible Culvert

Typical Anchor for

Exposed Flexible Culvert

Note: In all areas where the flexible culvert is not buried, it will be anchored per this typical.

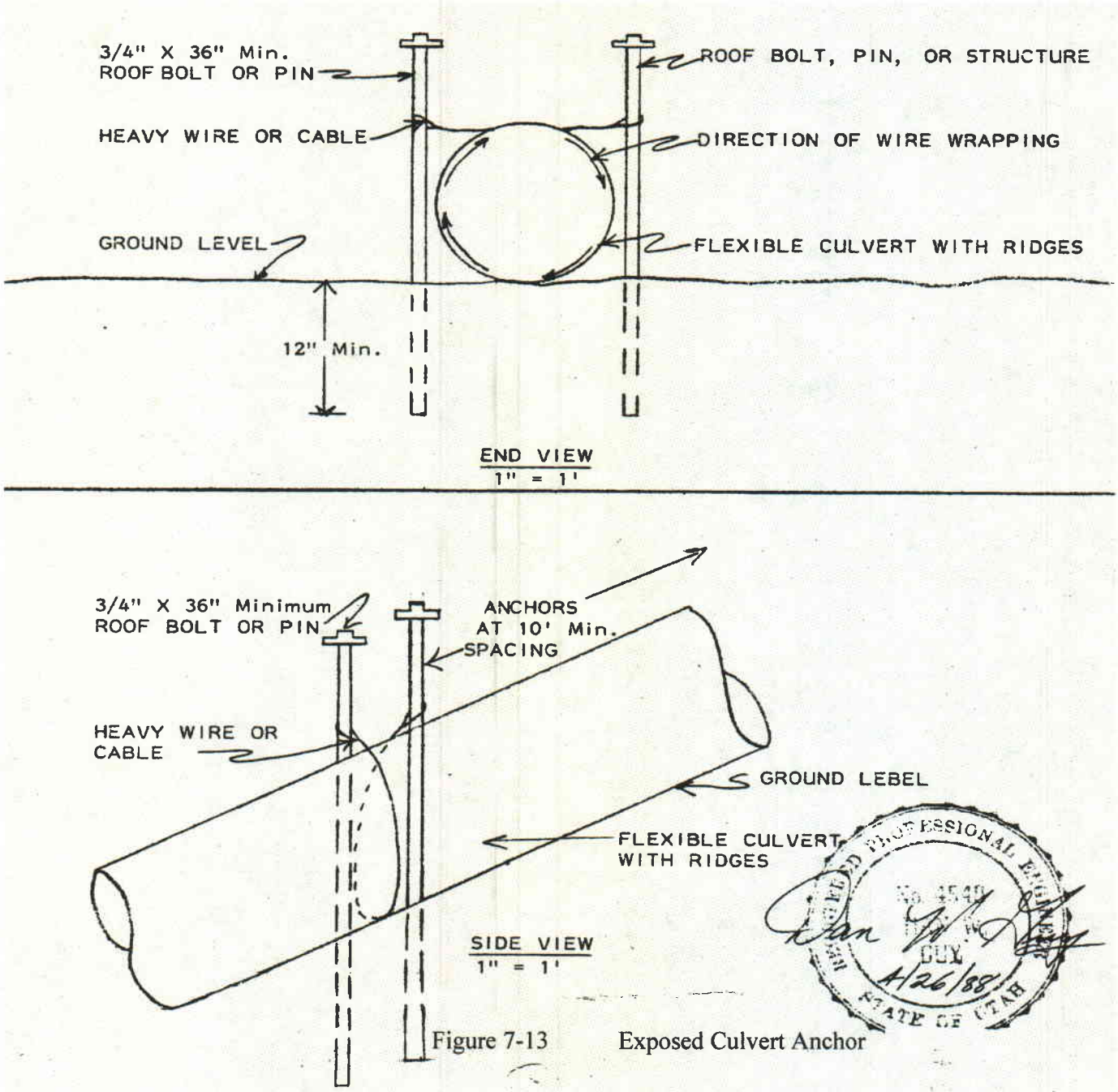
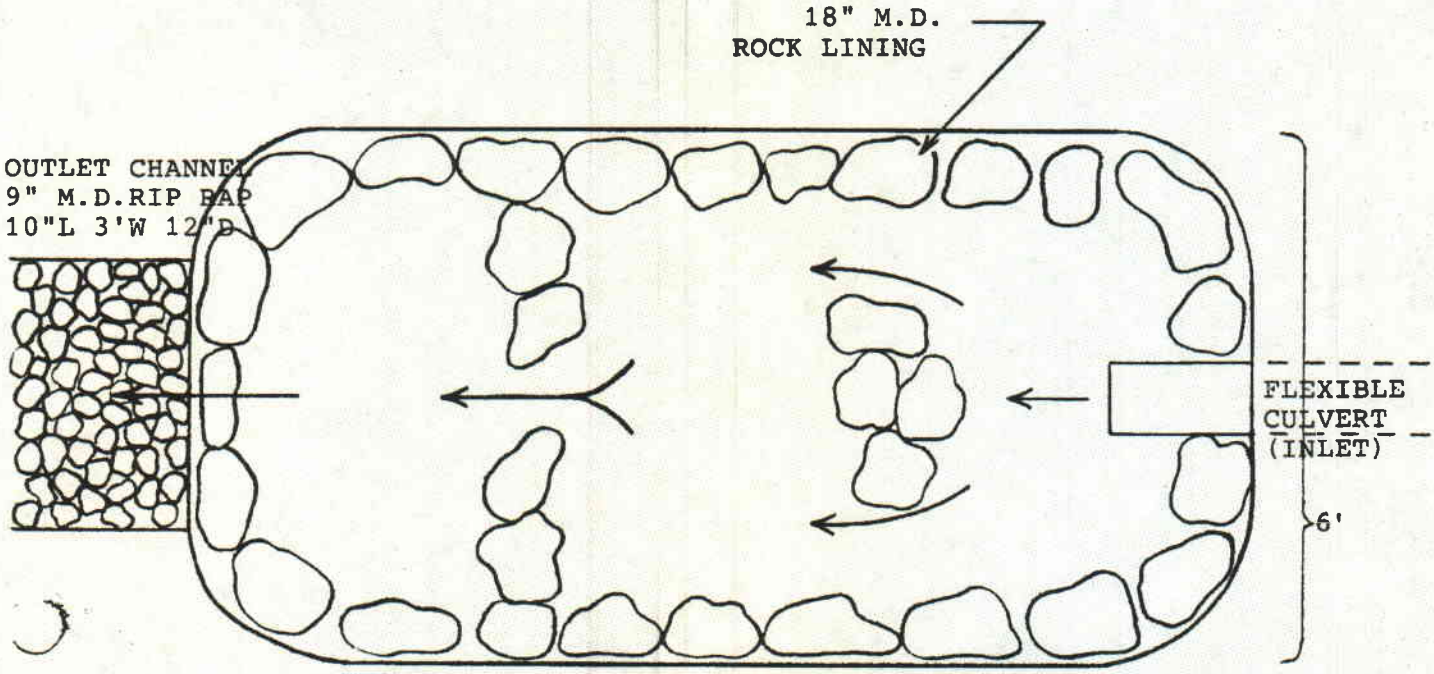
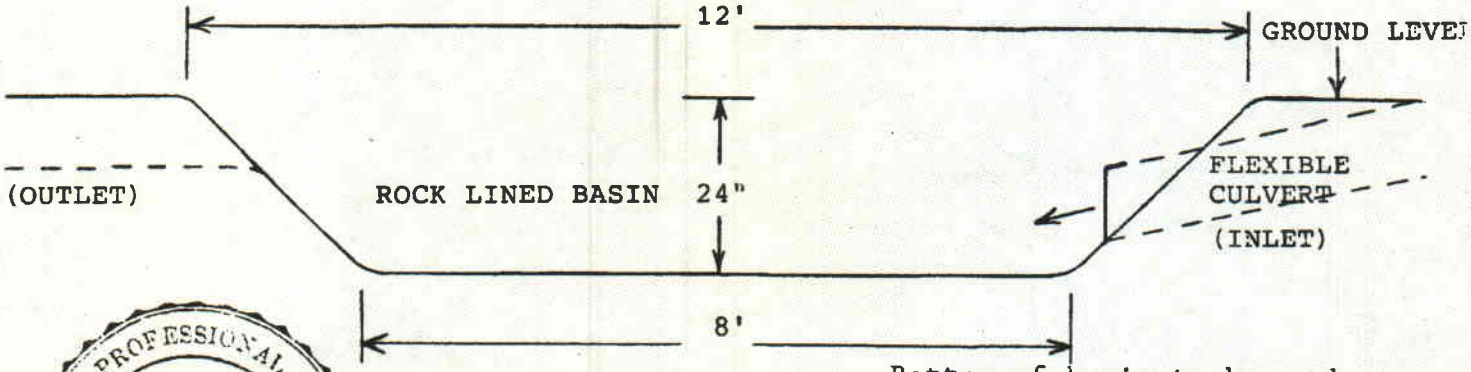


Figure 7-13 Exposed Culvert Anchor



TOP VIEW



SIDE VIEW

Bottom of basin to be rock lined (18 in. M.D.) if bed-rock is not found during installation.

Figure 7-14 Catch Basin

LICENSED PROFESSIONAL ENGINEER
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STATE OF UTAH

The drainage channel is protected by 4 in. M.D. riprap. When the drainage reaches the Coal Processing pad, it will be conveyed into the Ditch D-7D, which will contain 6 in. M.D. riprap (Plate 7-1C). Ditch designs are shown in Appendix 7-G.

The ditch in this area has been measured, and a typical post-mining section is shown in Appendix 7-H as cross-section RC-3. The ditch profile is shown on Plate 7-8A as Profile RC-3.

DRAINAGE CONTROL SYSTEM BEAR CANYON NO. 1 MINE LOWER SEAM PORTAL AREA

a. Upper Pad. Drainage from the disturbed area on the upper pad from the sub-station to culvert C-1D, will continue to flow into culvert C-1D, as approved; the outlet location of the flexible culvert was moved approx 20 ft to the west of the original location to direct runoff onto the rock ledge above the Lower Seam (Hiawatha) portals; water then flows over the rock ledge to the portal pad below;

b. Portal Pad. The northeast corner of the bin is bermed a min of 30 in. high over to the highwall. Runoff water from the upper pad flows into Ditch D-10D. Runoff from under the bin flows into a collection box at the edge of the portal pad area; the pad is sloped to flow to the box;

c. Flexible Culvert. The collection box at the portal pad discharges into a 15 in. flexible culvert, which discharges into Ditch D-10D adjacent to the uppermost conveyor support;

d. Conveyor Support Area and Slope. Ditch D-10D is constructed to weave across this area as shown on Plate 17-1C until it reaches the Coal Processing Pad area, where it drains into the lower flexible culvert.

e. Coal Processing Pad. This pad is also sloped to drain to the culvert; water is then conveyed down to the lower (Lump Coal) pad area;

f. Lump Coal Pad. The flexible culvert parallels the conveyor down to the lump coal bin, passes beneath the bin supports, and empties into a catch basin/energy dissipater just south of the bin; runoff then flows south into ditch D-7D and passes into Sediment Pond "A."

Drainage is shown on Plate 7-1. Detailed drawings of the various drainage controls are shown in the attached typical details.

Ditch D-7D, Catch Basin

In order to reduce sediment loading at the low-sloped portion of ditch D-7D a catch basin will be constructed at the north west corner of the bath house and shop. This basin will catch sediment, which has previously tended to block flow in the ditch behind the bathhouse and shop. The basin will not be designed for full containment but will be installed to provide this additional control. The basin is easily accessed and will be maintained routinely as required. See Plate 7-1C.

Tipple Wash Drainage 1992

Water is directed down the slope under the Tipple during cleaning. To control erosion during this washing, a drainage channel (D-11D) will be riprapped and grouted down the slope as shown on Plate 7-1C. Grouting is required due to the steepness of the slope (see calcs App. 7-G). Drainage will then be directed into an existing culvert (C-10D) that crosses the Coal Storage Pad. This culvert was installed during construction of the pad for possible future use. From the outlet the flow will pass down another ditch, D-12D, and into ditch D-3D.

This controlled source of water is estimated at 50 gpm (0.11 cfs). Culvert and channel designs were made using 0.25 cfs (112 gpm). This will result in a conservative design. Ditch D-3D is designed for a flow of 2.36 cfs (see App. 7-G). The Tipple will not be washed during a hydrologic event, so the design flow and the wash flow will not be combined. No alterations to downstream drainage control structures are required and none are proposed.

Shower House Drainage Control and Stream Protection

Due to the narrow nature of Bear Canyon, disturbance for the shower house structure and parking lot will encroach upon the 100 ft buffer zone of Bear Creek. Co-Op requests authorization from the division for operation within this zone. Bear Creek will be protected from disturbed runoff or sediment loading with berms placed along the lower edge of the disturbed area. Ditch D-9D (Plate 7-1B) will convey all disturbed runoff from the area to sediment pond "C", preventing disturbed runoff from entering Bear Creek. Stream Buffer Zone signs will be placed at the edge of the disturbed area as shown on Plates 5-2 in accordance with R645-301-521.600.

Access to the area will require the crossing of Bear Creek. A 60" culvert (C-14U) will be installed according to the stream alteration permit shown in Appendix 7-O. The only other impact to Bear Creek will be the riprapping of the outlet to sediment pond "C", also included in Appendix 7-O. Temporary sediment control structures will be placed in Bear Creek during the installation of C-14U to trap sediment resulting from the culvert installation. Reclamation of C-14U will be performed in accordance with R645-301-760.

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 a silt fence as shown on Plate 7-1E (BTCA Area "U"). The area, approx. 0.25 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-11D. A silt fence will be located prior to the inlet of C-11D.

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 7-25 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. The 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 pre-mining channel conditions. Pre-mining 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 pre-mining configuration. The majority of the boulders in the pre-mining channels will remain as markers, which can be excavated back to. Photographs of the pre-mining channels are contained in Appendix 7-H, and the profiles on Plate 7-8C reflect the pre-mining profiles and descriptions.

Wild Horse Ridge Access

The portal pad for the Bear Canyon No. 3 Mine will drain into Sediment Pond "D". For the remaining disturbed areas associated with the Wild Horse Ridge access road and conveyor belt, runoff will be controlled using alternate (ASCA) treatments. See Plates 7-1F and 7-1G for division structures and ASCA areas (BTCA Area "V", "W", "X" and "Y").

Runoff control for these ASCA areas are described in Appendix 7-K, and will consist of silt fences, erosion control matting and/or catch basins as described in Appendix 7-K and shown on Plates 7-1F and 7-1G. ASCA areas under the conveyor belt will be protected by a pan structure on the conveyor belt is described in Appendix 7-K.

Designs for the ditches and culverts associated with this area are included in Appendix 7-G and summarized in Tables 7-24 and 7-28.

The reclaimed channel designs for the Wild Horse Ridge Area are described in Appendix 7-H and R645-301-760.

Area AD-8 Drainage, 1993

In 1993, the inlet to culvert C-7D failed, resulting in NOV 93-35-6-1. In order to eliminate the maintenance problems with culvert C-7D, the south end of drainage area AD-8, the coal storage pad, will be regraded to allow the drainage to flow into ditch D-7D below the fans shown on Plate 2-4C. At this point, the storage pad is level with D-7D, allowing drainage to easily flow into the ditch. The berm around the coal storage pad will prevent drainage over the edge of the pad and direct the flow toward ditch D-7D. The point at which the storage pad intersects D-7D is outside of the angle of repose of the coal pile, and the ditch will not be plugged by coal spillage. A catch basin exists just below this point which will trap any coal fines which may be washed into the drainage, protecting ditch D-7D below this point.

Ditch D-8D Water Bar

In 1996, Co-Op observed that erosion problems existed which were associated with the water bar conveying runoff from Ditch D-8D to the inlet of Sediment Pond "B" as a result of water associated with the Water Truck. In order to eliminate these problems, the water bar and associated channel will be grouted using an 8" concrete slab. This will prevent the channel from eroding. Figure 7-15 shows a typical cross-section of the concrete crossing. A steel bridge structure and swell provides vehicle crossing as shown in the figure. The bridge is designed so that the water bar design cross-section is maintained passing under it.

Culvert C-40U

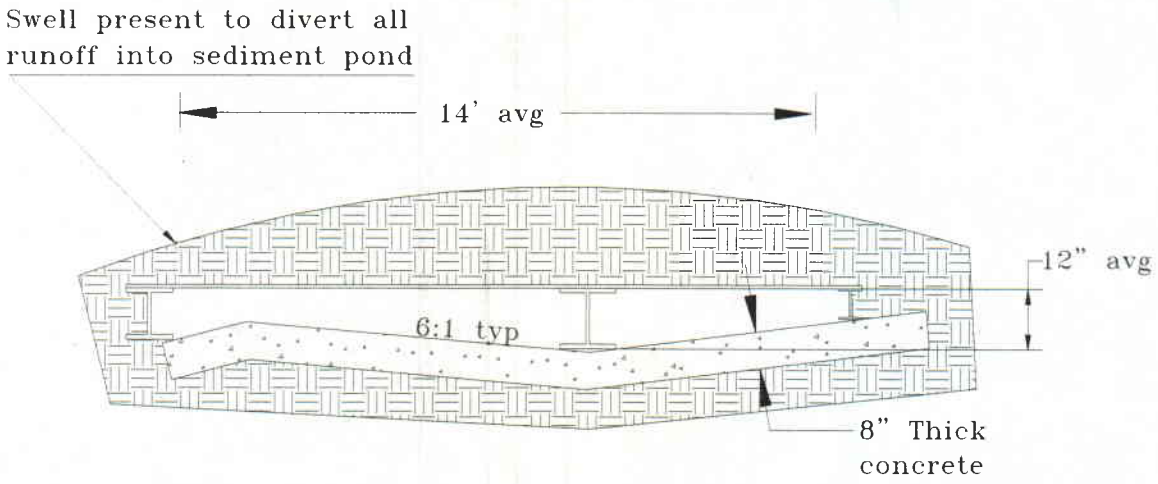
A trash and a debris clean out basin will be placed at the entrance to culvert C-40U. Additionally while constructing the Tank Seam Portal C.W. Mining will investigate other methods that can be incorporated to reduce the possible culvert C-40U becoming plugged by debris.

Additional Sediment Control

In order to reduce potential impacts form sediment, silt fences shall be installed as shown in Figure 7-7. Silt fence locations are noted on Plates 7-1.

Figure 7-15 Ditch D-8D Water Bar Concrete Structure

Typical Cross-Section



Minimum Channel Depth = 0.67'
Minimum Required Depth =0.33'

R645-301-744 Discharge Structures

See R645-301-742.220.

R645-301-760 Reclamation Hydrology

Post-Mining Rehabilitation

Upon completion of mining activities all diversion structures (ditches, culverts, ponds) shall be removed and reclaimed as close to the 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.

The Haul Road and No. 3 Mine Access Road will remain in place to facilitate the recreational Post-Mining Land use described in Ch. 4. All disturbed areas adjacent to these roads will be reclaimed as described in Ch. 3.

Restoration of Natural Channels

There are eighteen channels in addition to Bear Creek whose drainages have been disturbed by mining activities. Reclamation of all but two 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, with the exception of channels RC-TS1 through RC-TS6. Table 7-27 contains a summary of the reclaimed channel parameters. The remaining two channels will be culverted to allow drainage to cross the Haul Road (RCC-2 and RCC-3). Additional culverts will remain in place on Bear Creek and along the No. 3 Mine Access Road. Plates 7-7 show the location of these culverts. The designs are included in Appendix 7-H. Table 7-28 summarizes the designs.

Table 7-26 Characteristics of Proposed Reclaimed Channels

Channel	Bottom Width (ft)	Side Slopes	Depth (ft)	Lining
RC-1	6	1.5:1	1.5	D50 = 6"
RC-2	3	2:1	1.5	D50 = 9"
RC-3	3	2:1	1.5	D50 = 9"
RC-4	4	2:1	1.5	D50 = 6"
RC-5	1.5	2:1	1.5	D50 = 6"
RC-6	2	2:1	1.5	D50 = 6"
RC-7	6	2:1	4	D50 = 24"
RC-8	8	2:1	2.5	D50 = 24"
RC-9	7	2:1	3	D50 = 24"
RC-10	6	1.5:1	6	D50 = 24"
RC-11	2	2:1	1.5	D50 = 6"
RC-12	1	2:1	2	D50 = 6"
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

Table 7-27 Summary of Post-mining Drainage Ditches

Channel	Bottom Width (ft)	Top Width (ft)	Side Slopes	Depth (ft)	Lining
RC-RD1	0.0	6	2:1	1.5	Soil
RC-RD2	0.0	8	2:1	2.0	D50 = 6"
RC-RD3	0.0	6	2:1	1.5	Soil
RC-RD4	0.0	8	2:1	2.0	D50 = 6"
RC-RD5	5.0	14	3:1	1.5	Soil
RC-RD6	0.0	6	2:1	1.5	Soil
RC-RD7	0.0	6	2:1	1.5	Soil
RC-RD8	0.0	7	2:1	1.75	D50 = 6"
RC-RD9	0.0	12	3:1	2.0	D50 = 6"
RC-RD10	0.0	6	2:1	1.5	Soil
RC-RD11	0.0	5	2:1	1.25	Soil
RC-RD12	0.0	6	2:1	1.5	D50 = 3"
RC-RD13	0.0	6	2:1	1.5	D50 = 3"
RC-RD14	0.0	8	2:1	2.0	Bedrock
RC-RD15	0.0	5	2:1	1.25	Soil
RC-RD16	2.0	7	2:1	1.25	Soil
RC-BP1	0	5	3:1, 1:1	1.24	Soil

Note: See Appendix 7-H, pg. 130 for a discussion on channel RC-BP1.

Table 7-28 Summary of Post-mining Culverts

Culvert	Contributing Watershed	Dia. (in)	Culvert Type	Slope (ft/ft)	Outlet Conditions
RCC-1	Road Drainage	15	CMP	0.06	Soil
RCC-2	WS-8	24	CMP	0.04	D_{50} = 6"
RCC-3	WS-9, WS-10	18	CMP	0.10	D_{50} = 12"
RCC-4	Bear Canyon	84	CMP	0.06	D_{50} = 48"
RCC-5	WS-2, WS-3 WS-3A	30	CMP	0.10	D_{50} = 6"
RCC-6	WS-12, WS-13	20	CMP	0.06	D_{50} = 6"
RCC-7	Right Fork Lower	36	CMP	0.06	D_{50} = 36"
RCC-8	WS-14, WS-16	15	CMP	0.06	D_{50} = 6"
RCC-9	WS-16	15	CMP	0.06	D_{50} = 6"
RCC-10	Right Fork Right	30	CMP	0.06	D_{50} = 24"
RCC-11	WS-19, WS-20	15	CMP	0.06	D_{50} = 6"

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 7-27 also represents the observed premining channel parameters.

Bear Creek Channel Reclamation

Upon final abandonment and reclamation the culverted sections of Bear Creek will be reclaimed as follows:

1. Large track mounted excavators will be used in conjunction with a small backhoe and crawler tractor to remove the 60 in diameter culvert and to regrade the opposing banks on approximately a 3 to 1 slope to facilitate revegetation and to enhance the establishment of a riparian zone.

2. The recontoured channel will be riprapped as discussed in Appendix 7-H.

3. Two culverts, identified as RCC-4, shown on Plate 7-7 and Plates 3-2, will remain in place for postmining land use. Designs for these culverts are included in Appendix 7-H.

Sedimentation Ponds Reclamation

Sediment ponds "A", "B" and "C" will be the last structures to be removed. Each pond will be maintained until revegetation is established on all reclaimed lands. When revegetation has been established, drainage ditches conveying water to the Pond will be removed, allowing runoff to drain to Bear Creek. The ponds will then be decanted and allowed to dry. The sediment ponds will then be regraded. Reclamation, redistribution of soils, is discussed in R645-301-242. Revegetation is addressed in R645-301-341. Seed mix is included in R645-301-341. Silt fences will be installed along the creek side of the disturbance on each pond and maintained until vegetation is re-established, at which time the silt fences will be removed. Cross sections of reclamation channels are found in Appendix 7-H. Decant culverts will be salvaged if possible. Otherwise, they will be disposed of in an approved landfill.

Sediment Pond "D", due to its remote location, will be reclaimed during the initial reclamation of the NO. 3 Mine Portal Pad. ASCA treatment will be used for this reclaimed area as described in Appendix 7-K. See Plates 3-2 for designated Post-Mining ASCA areas.

Post-Mining Water Quality Standards

During the reclamation bond liability, water monitoring will be conducted to assess the potential for water pollution. Prior to final bond release, an assessment of the water quality information will be made to assess any impacts to springs or surface water, to demonstrate that disturbance to the hydrologic balance in the permit and adjacent areas have been minimized, and to show that the water quality and quantity are suitable for the post-mining land uses.

Water quality standards and effluent limitations for chemical constituents will be based on a comparison to the background levels measured and demonstrated by the baseline water quality data.

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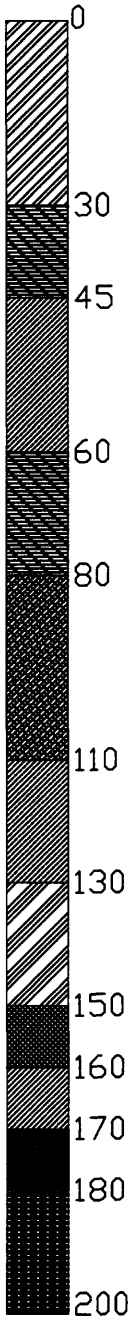
Appendix 7-A

DRILL HOLE LOGS

Hole 1 Up

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-1		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	



Grey Sandy Shale, some carbon and coal

Grey-Brown Shale, some carbon and coal

Grey Siltstone, some carbon and coal

Grey-Brown Silty Shale, no carbon

Dark Grey Shale, no carbon

Grey Siltstone, some carbon and coal

Grey-Tan Siltstone, no carbon

Grey-Tan Silty Shale, no carbon

Yellow-Tan Shale, no carbon

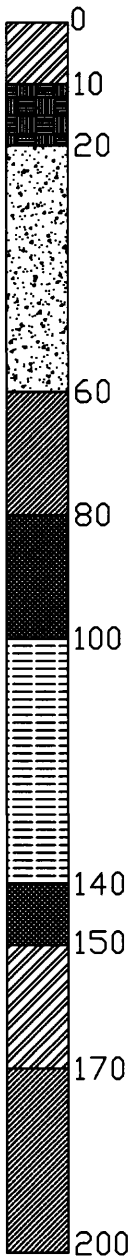
Yellow Clay Shale, no carbon

Yellow-Tan Siltstone, no carbon

Figure 7A-1 Log, Drill Hole 1 up

Hole 2 Up

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-2		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	



Grey-Clayey Shale, some carbon and coal

Grey Clay, some carbon and coal

Yellow-Tan Silty Shale, no carbon

Yellow-Tan Shale, no carbon

Yellow-Tan Clayey Shale, no carbon

Tan Siltstone, no carbon

Tan-Grey Silty Shale, no carbon

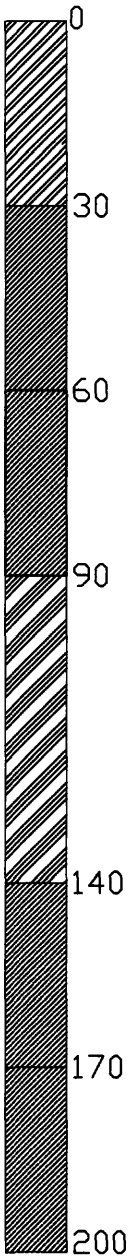
Grey Shale, no carbon

Grey Siltstone, some carbon and coal

Figure 7A-2 Log, Drill Hole 2 up

Hole 1 Down

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-3		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	



Grey Shale, some carbon and coal

Grey Sandy Shale, some carbon and coal

Grey Siltstone, much carbon and coal

Grey-Light Brown Siltstone, some carbon and coal

Grey-Light Brown Siltstone, much carbon

Grey Siltstone, very little carbon

Figure 7A-3 Log, Drill Hole 1 Down

Hole 6 Down

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-4		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	

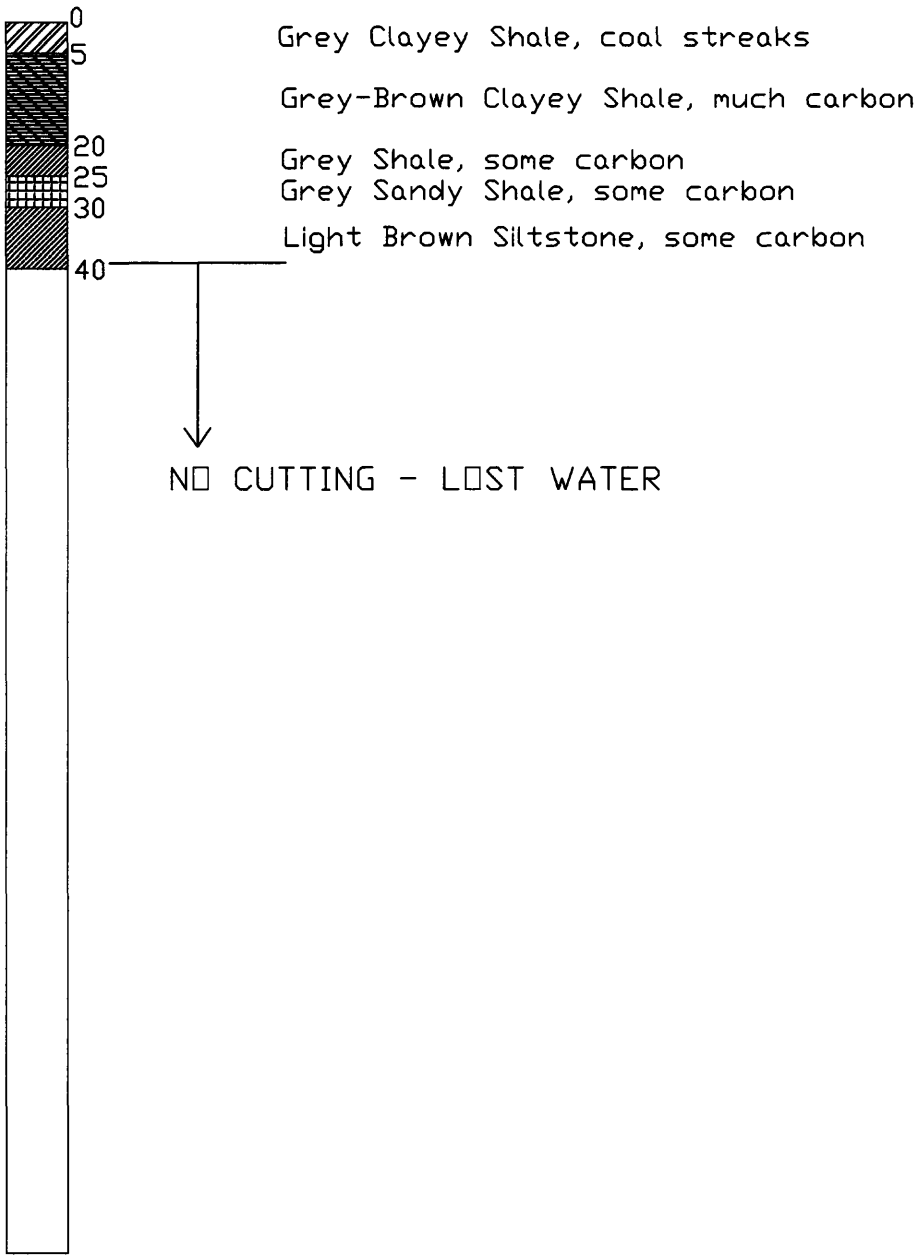
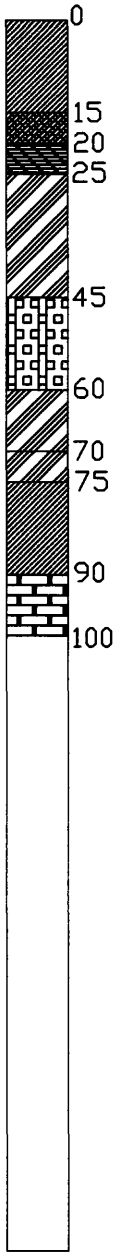


Figure 7A-4 Log, Drill Hole 6 Down

Hole 7 Down

CO-OP MINING CO.		
HUNTINGTON, UTAH		
Figure 7A-5		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	



Grey Brown Siltstone, some carbon

Light Brown Clayey Shale, much carbon
Light Brown-Grey Shale, some carbon

Light Brown Siltstone, some carbon

Light Brown Sandstone, some carbon

Light Brown Siltstone, much carbon and coal
Coal (95%), Light Brown Siltstone (5%)

Brown Siltstone, some carbon

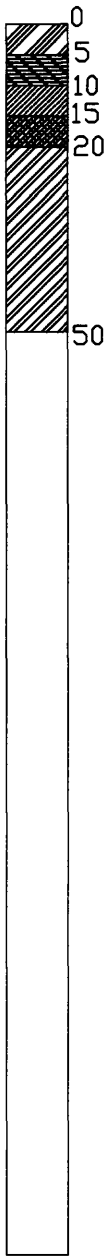
Brown Sandstone, some carbon

NO CUTTING - LOST WATER

Figure 7A-5 Log, Drill Hole 7 Down

Hole 9 Down

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-6		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	



Brown Siltstone, much coal
Grey-Brown Shale, some carbon
Grey Clay Shale, much carbon
Light Brown-Grey Shale, some carbon

Light Brown Siltstone, no carbon

NO CUTTING - LOST WATER

Figure 7A-6 Log, Drill Hole 9 Down

Hole 10 Down

CO-OP MINING CO.		
HUNTINGTON, UTAH		
Figure 7A-7		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	

0-3 Coal
3-13 Grey Shale
13-19 Coal

19-40 Grey Shale

40 (Trace Coal)

40-65 Red Sandstone

65-70 Coal

70-200 White Sandstone

No water encountered

Figure 7A-7 Log, Drill Hole 10 Down

Hole 11 Down

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-8		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	

0-5 Coal

5-25 Grey Shale

25-27 Coal

27-60 Grey Shale

60-70 Black Slate (some coal)

70-80 Soft Brown Shale

80-82.5 Coal

80-100 White Sandstone

(Lost circulation at 80' - regained with drill mud)

No water encountered

Figure 7A-8 Log, Drill Hole 11 Down

Hole 12 Down

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-9		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	

0-5 Coal

5-50 Grey Shale

50-55 Black Slate

55-80 Grey Shale

80 - Lost circulation

(2 additional holes drilled same area - lost circulation on each at approximately 80')

No water encountered

Figure 7A-9 Log, Drill Hole 12 Down

Hole 13 Down

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-10		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	

0-5 Hard White Shale
5-6 Coal

6-20 Hard White Shale

20-20.3 Coal

20-35 Hard White Shale

30-35 Hard White Shale/Mixed Brown Shale
35-40 Brown Shale

40-50 Tan Shale

50-60 Hard White Shale
60-61 (□xidized Coal) Mixed Brown Slate
61-65 Hard White Shale

60-75 Brown Slate mixed Sandstone

75-100 Brown Slate mixed White Shale

No water encountered

Figure 7A-10 Log, Drill Hole 13 Down

Hole 14 Down

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-11		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	

0-5 Coal
5-10 Brown Shale (Some coal)

10-70 Grey Shale

70-76 Soft Brown Shale

76-88'9" Grey Shale

88'9"-95' Coal
95-98 Brown Shale with some coal
98-100 Coal

No water encountered

Figure 7A-11 Log, Drill Hole 14 Down

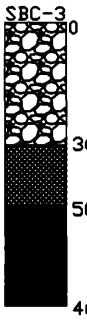
SBC-2, SBC-3 and SBC-4

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-12		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	

Colluvium - Clay and gravel, Very moist, tan.

Small seeps, 30 to 36 feet

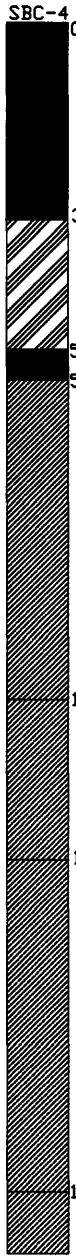
Gray siltstone with interbedded tan, fine sandstone, dry to slightly moist



Alluvium - Clay and gravel

Gray silty claystone

Tan sandstone, fine, moist zone at 42 feet



Tan sandstone, fine, slightly silty, slightly moist, few thin siltstone layers - increase to 30%, 25 to 30 feet

Dark grey shale, carbon., 30 fine sandstone layers at base slightly moist

Coal

Gray fine sandstone with gray shale, trace coal, slightly moist

Shale layers decrease with depth to trace

Few siltstone layers, 70 to 105 feet

Grey fine sandstone, slightly silty, shale, interbedde, dry

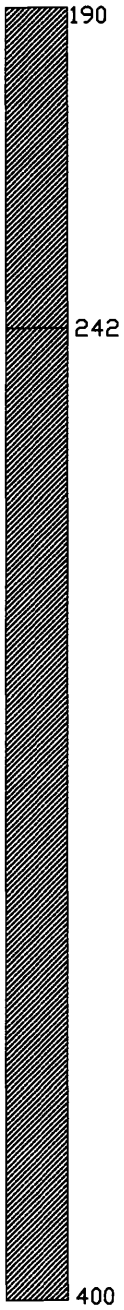
Grey siltstone, trace shale layers, dry

Grey siltstone, with shale and claystone beds, dry

Figure 7A-12 Log, Drill Hole SBC-2, SBC-3 and SBC-4

SBC-2 (cont)

CO-OP MINING CO. HUNTINGTON, UTAH		
Figure 7A-13		
SCALE: 1" = 30'	DRAWN BY: N. Ortega	DATE: 8/06/02
BEAR CANYON	Drill Hole 1up	



Grey siltstone with shale and claystone beds - dry

Grey siltstone, uniform, dry

Few gray shale and claystone interbeds, 280 to 400 feet, dry

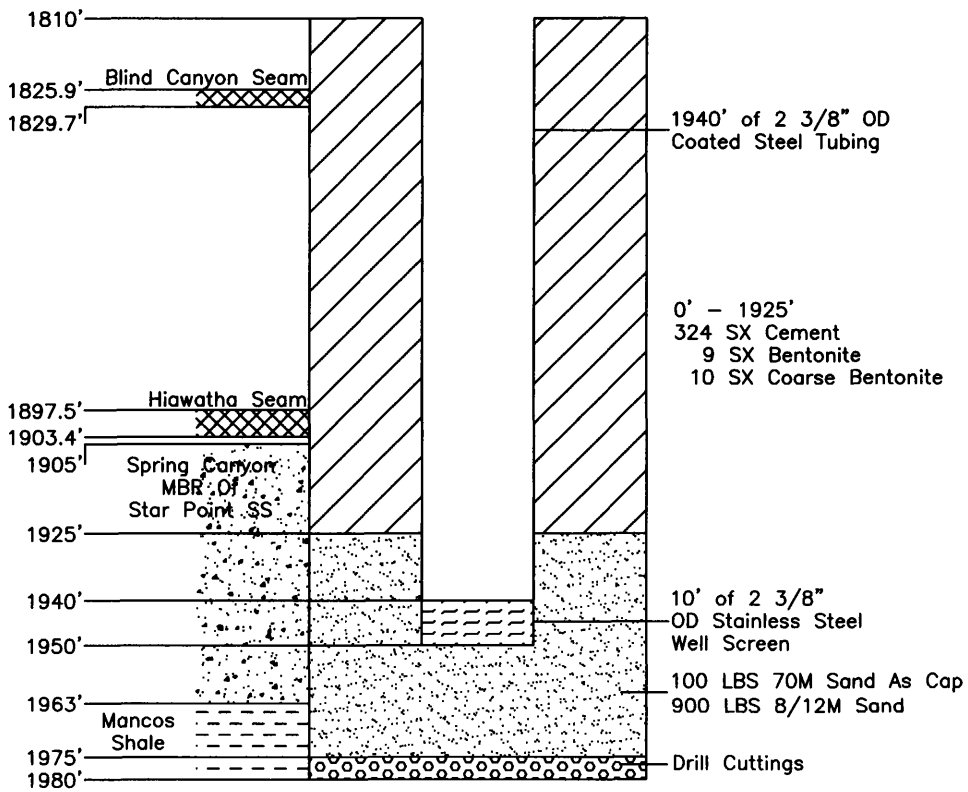
Dry

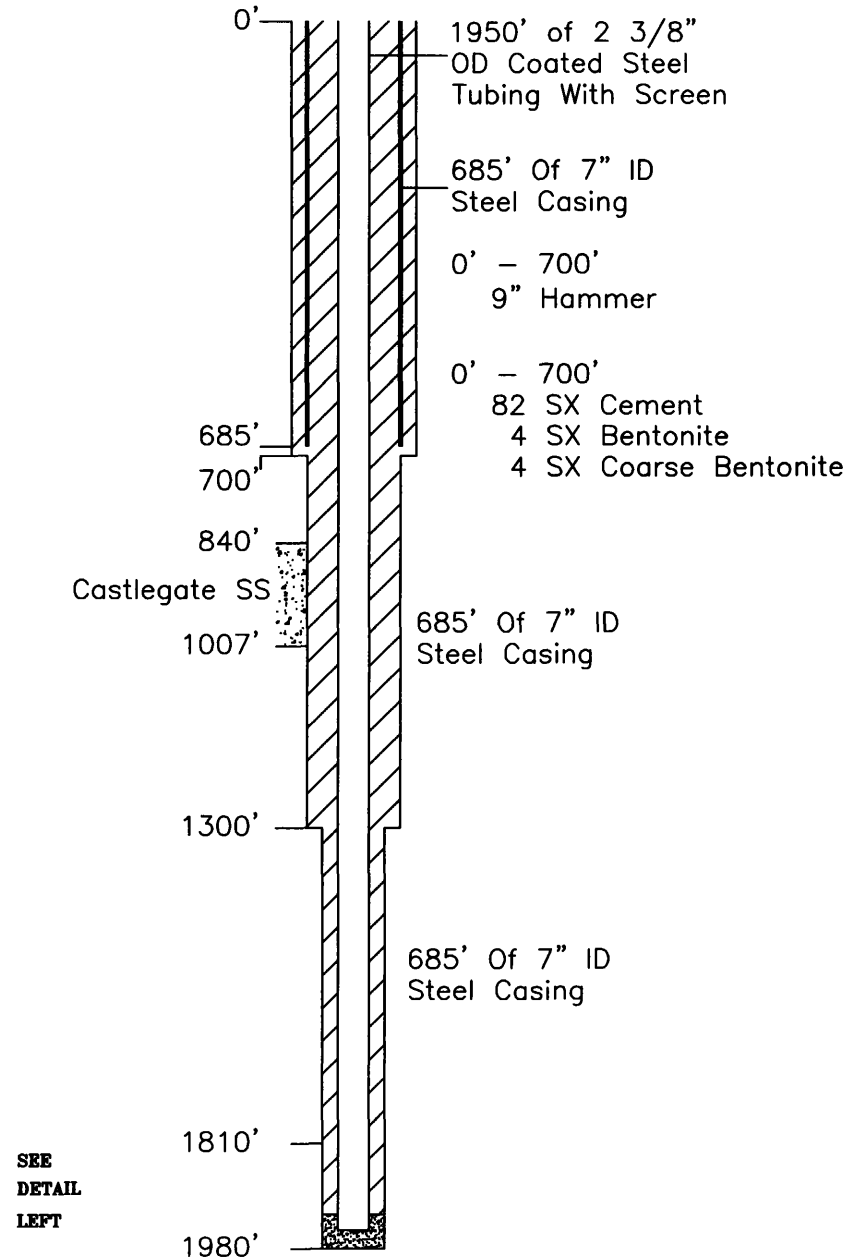
Few moist to very moist zones, 370 to 400 feet

Figure 7A-13 Log, Drill Hole SBC-2 (cont)

CO-OP MINING CO. HUNTINGTON, UTAH		
Well Completion Diagram SDH-1		
SCALE: As shown	DRAWN BY: C. Reynolds	DATE: 6/18/97
BEAR CANYON	FIGURE 7A-14	

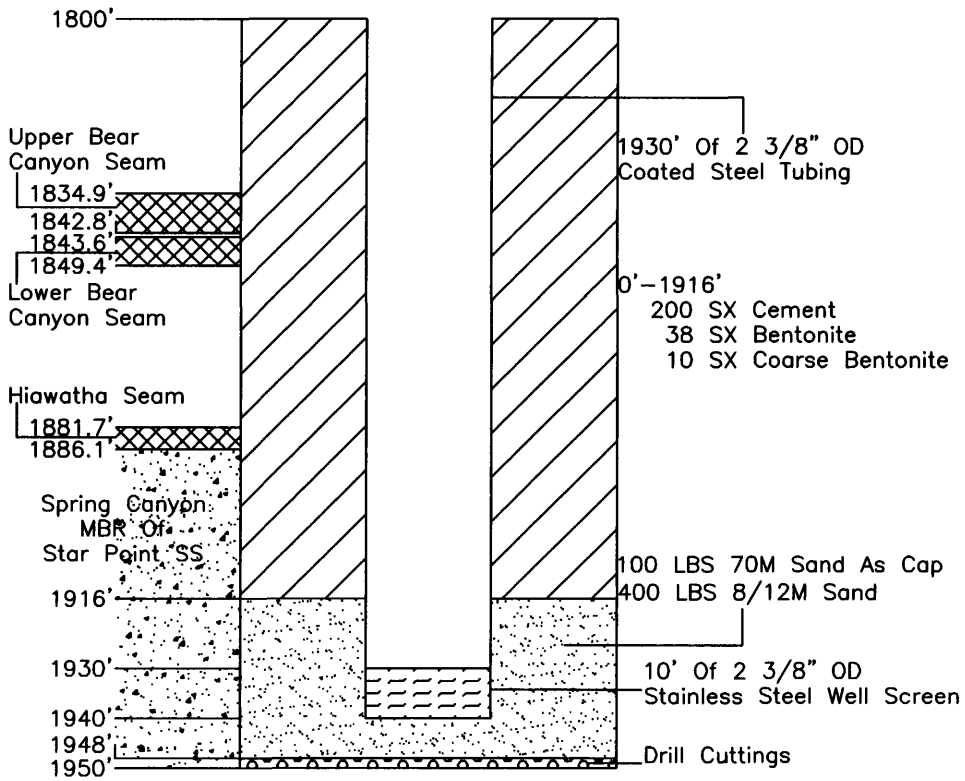
DETAIL

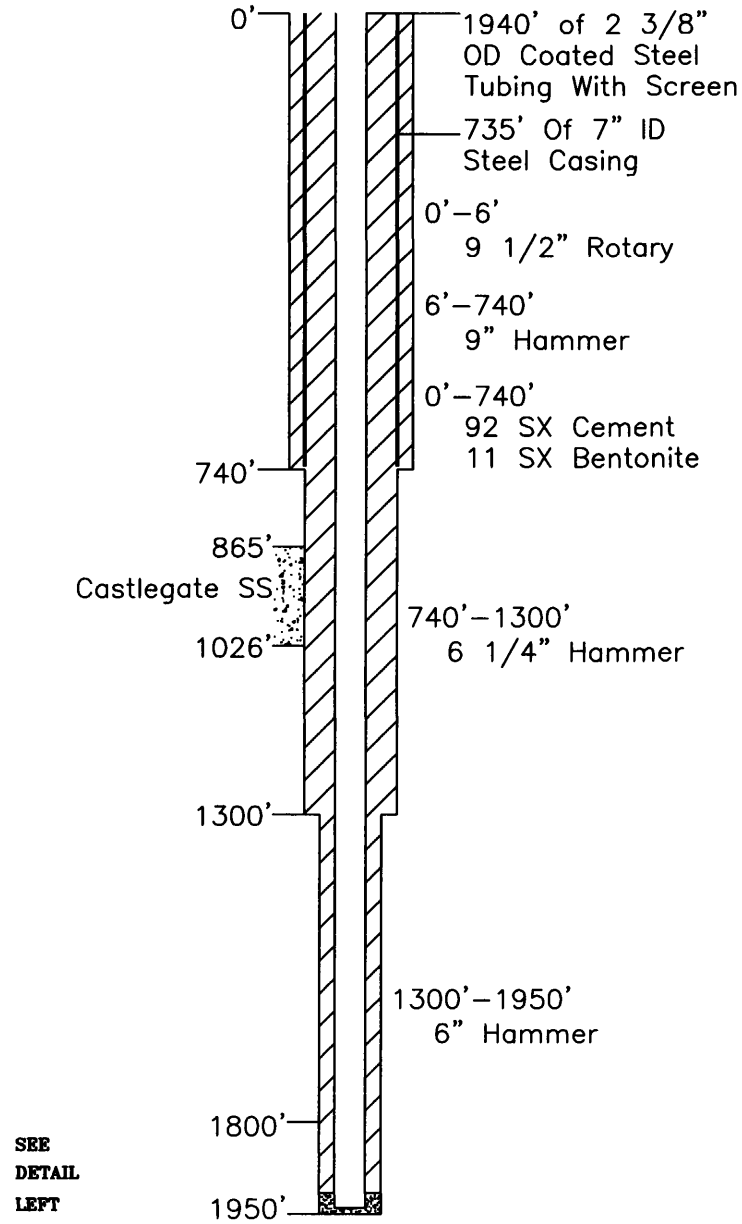




CO-OP MINING CO. HUNTINGTON, UTAH		
Well Completion Diagram SDH-2		
SCALE: As shown	DRAWN BY: C. Reynolds	DATE: 6/18/97
BEAR CANYON	FIGURE 7A-15	

DETAIL

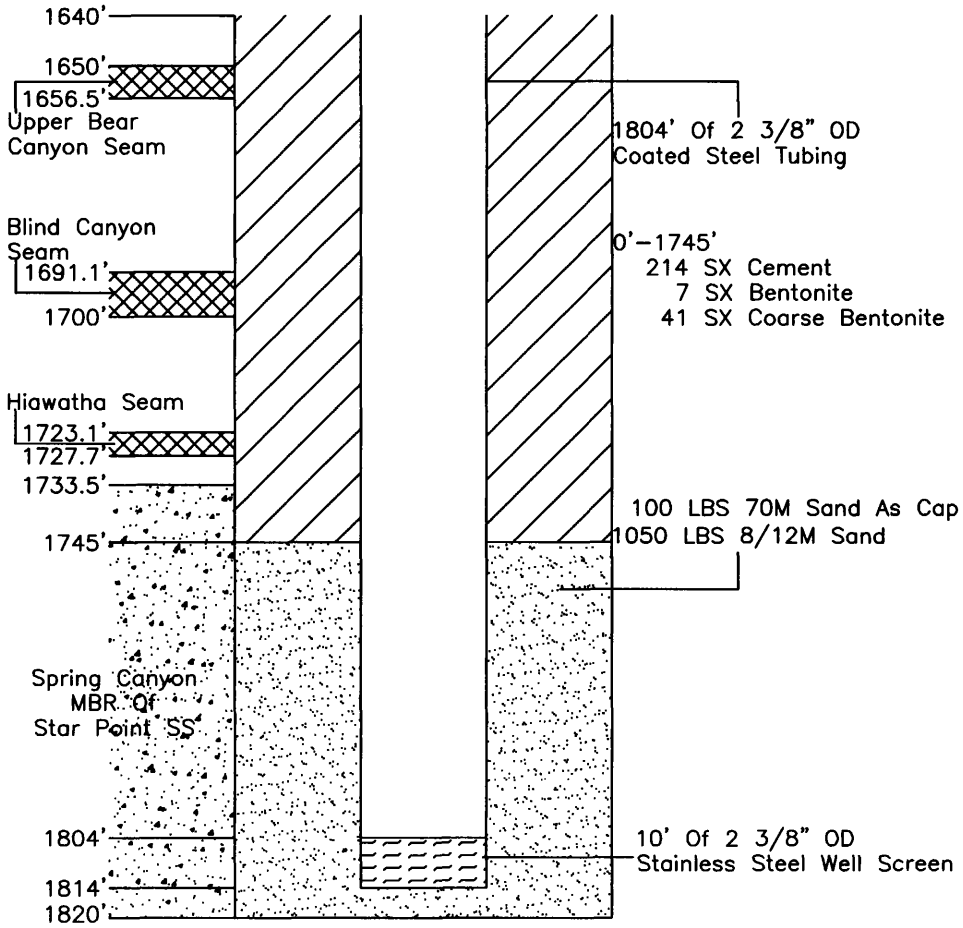


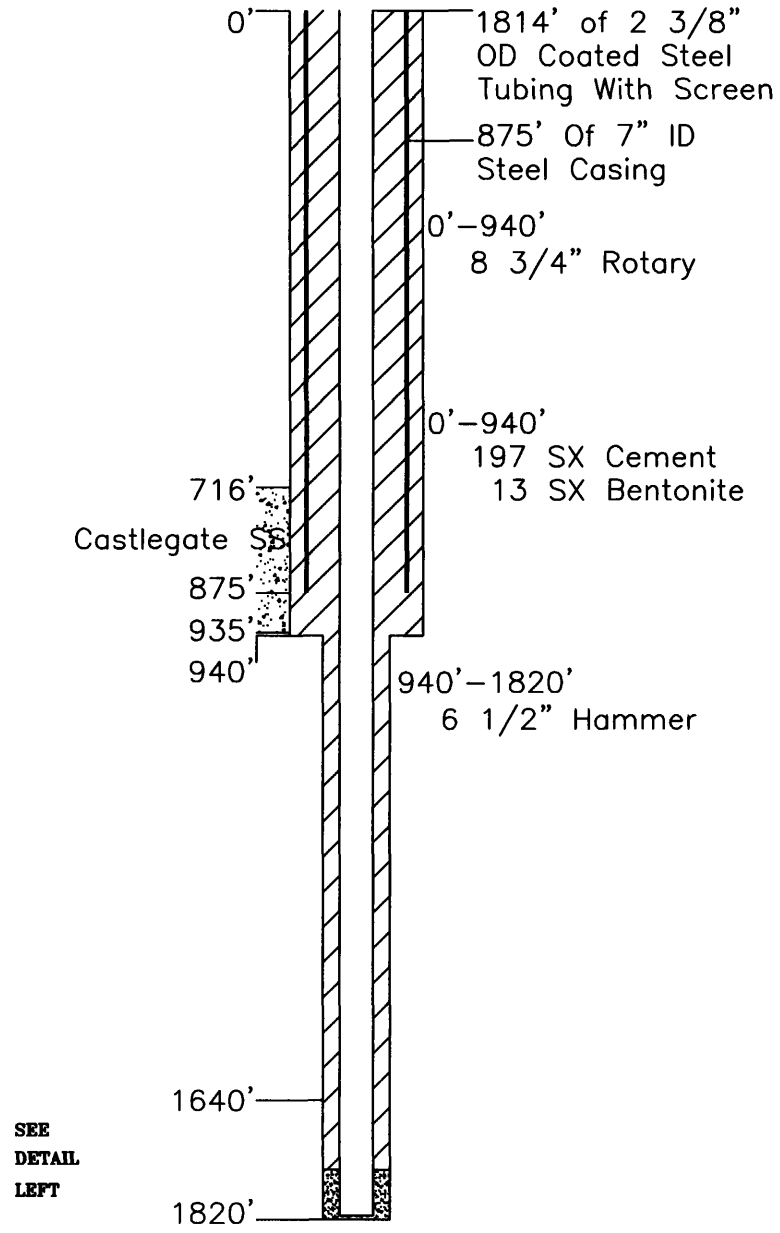


SEE DETAIL LEFT

CO-OP MINING CO. HUNTINGTON, UTAH		
Well Completion Diagram SDH-3		
SCALE: As shown	DRAWN BY: C. Reynolds	DATE: 6/18/97
BEAR CANYON	FIGURE 7A-16	

DETAIL





CO-OP MINING CO.

HUNTINGTON, UTAH

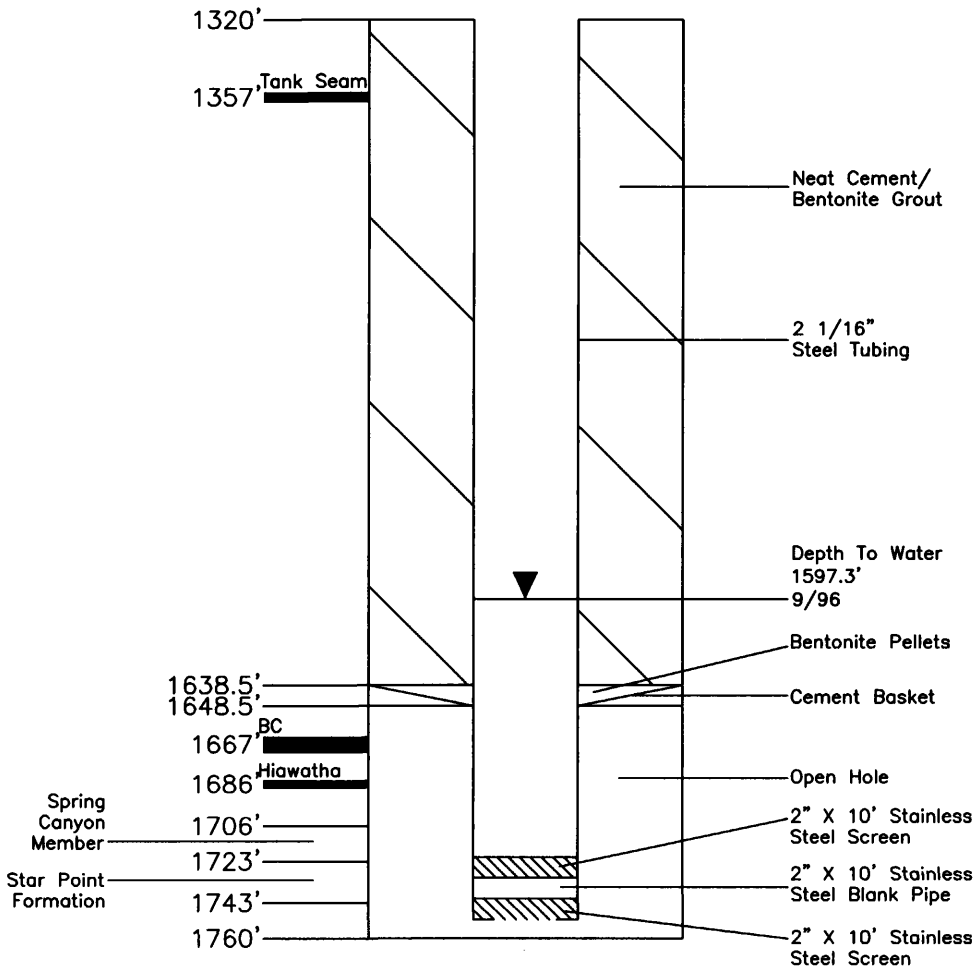
Well Completion Diagram

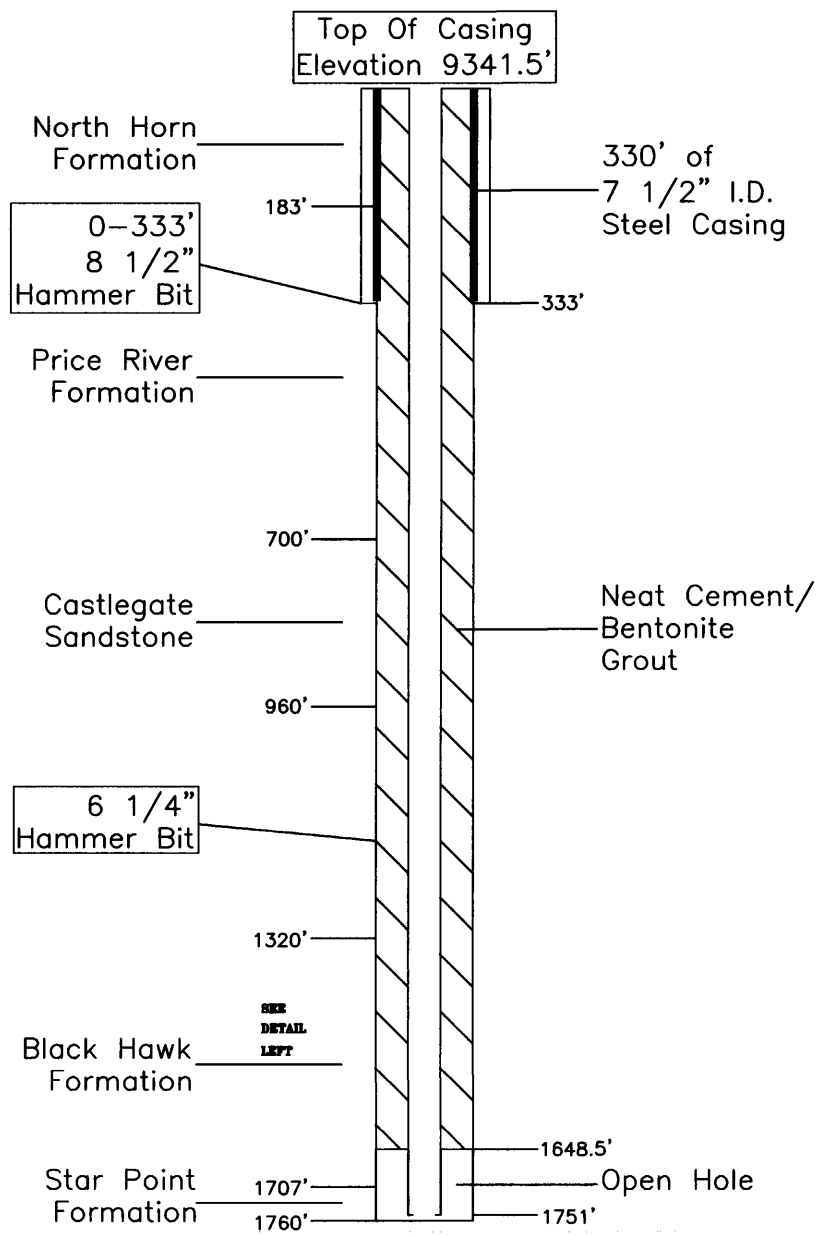
MW-116

SCALE:	DRAWN BY:	DATE:
As shown	C. Reynolds	6/18/97

BEAR CANYON | **FIGURE 7A-17**

DETAIL



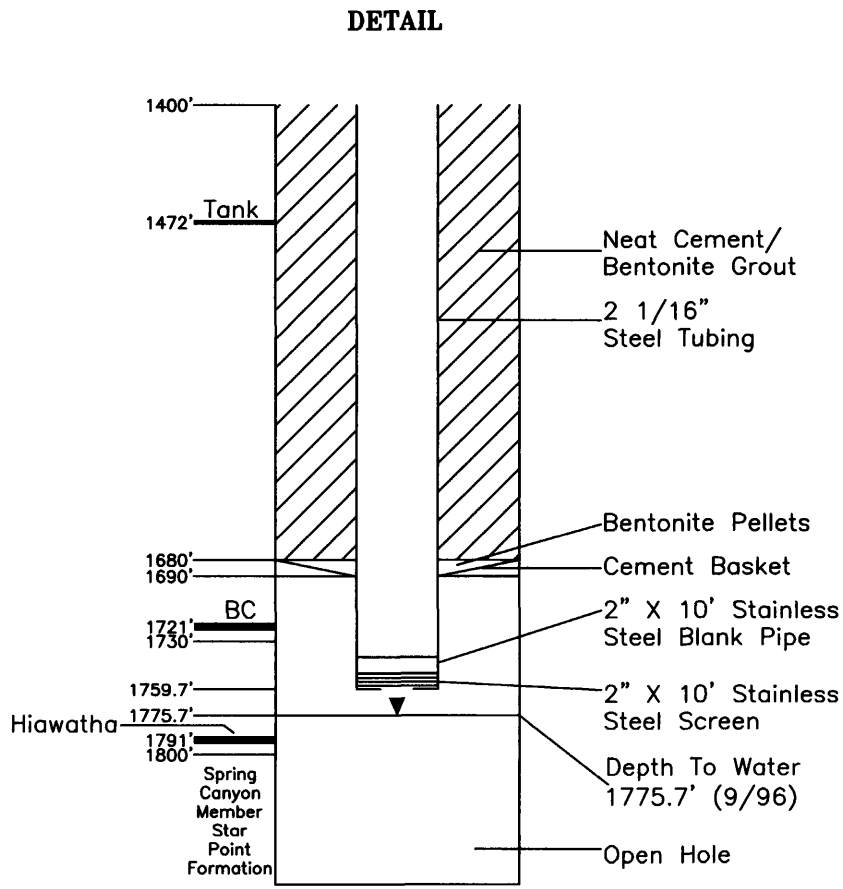


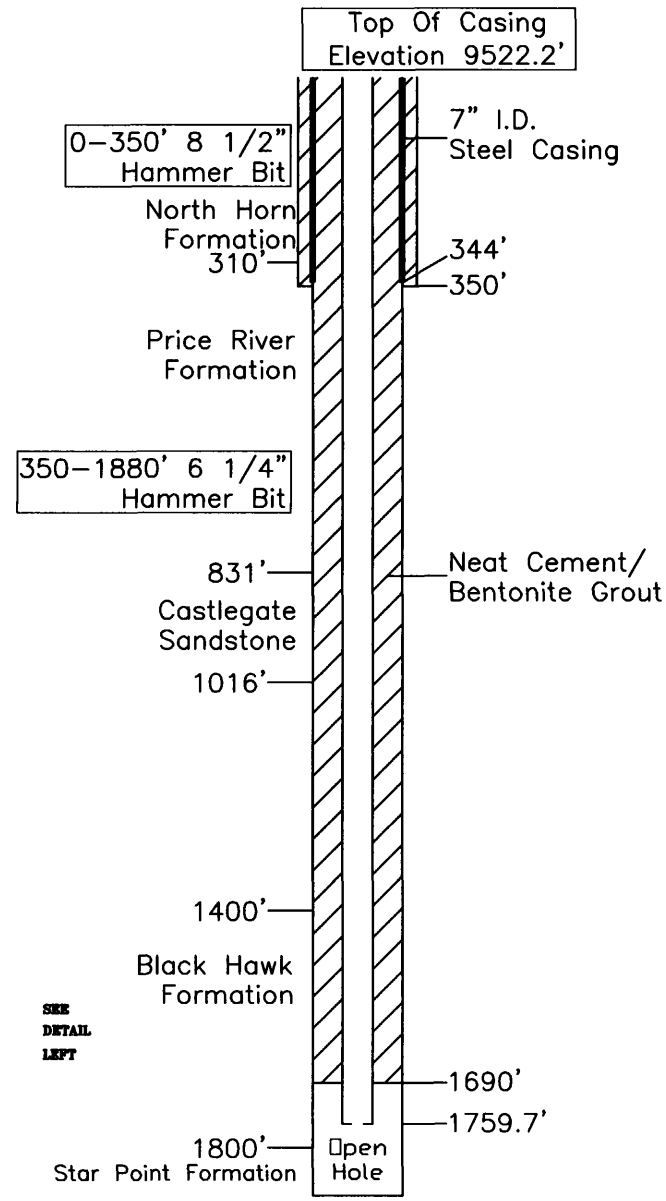
B.C.

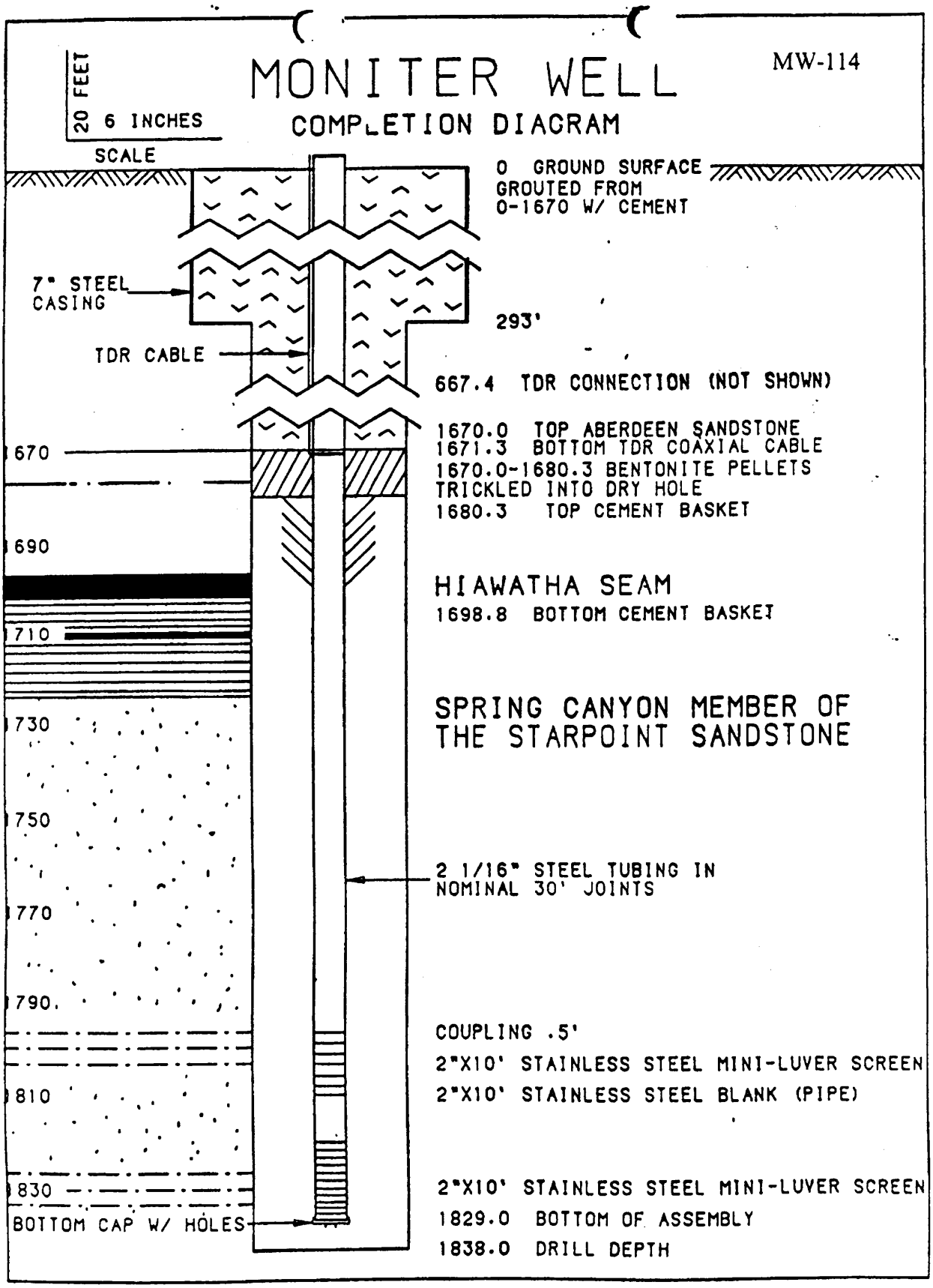
7A-18

8/01/02

CO-OP MINING CO. HUNTINGTON, UTAH		
Well Completion Diagram MW-117		
SCALE: As shown	DRAWN BY: C. Reynolds	DATE: 6/18/97
BEAR CANYON	FIGURE 7A-18	






MONITER WELL
MW-114
COMPLETION DIAGRAM
20 FEET
6 INCHES
SCALE
0 GROUND SURFACE
GROUTED FROM
0-1670 W/ CEMENT
7" STEEL
CASING
293'
TDR CABLE
667.4 TDR CONNECTION (NOT SHOWN)
1670.0 TOP ABERDEEN SANDSTONE
1671.3 BOTTOM TDR COAXIAL CABLE
1670.0-1680.3 BENTONITE PELLETS
TRICKLED INTO DRY HOLE
1680.3 TOP CEMENT BASKET
1670
1690
HIAWATHA SEAM
1698.8 BOTTOM CEMENT BASKET
1710
SPRING CANYON MEMBER OF
THE STARPOINT SANDSTONE
1730
1750
2 1/16" STEEL TUBING IN
NOMINAL 30' JOINTS
1770
1790
COUPLING .5'
2"X10' STAINLESS STEEL MINI-LUVER SCREEN
2"X10' STAINLESS STEEL BLANK (PIPE)
1810
1830
2"X10' STAINLESS STEEL MINI-LUVER SCREEN
BOTTOM CAP W/ HOLES
1829.0 BOTTOM OF ASSEMBLY
1838.0 DRILL DEPTH

Appendix 7-B

Discharge Permit

STATE OF UTAH
DIVISION OF WATER QUALITY
DEPARTMENT OF ENVIRONMENTAL QUALITY
SALT LAKE CITY, UTAH

AUTHORIZATION TO DISCHARGE UNDER THE

UTAH POLLUTANT DISCHARGE ELIMINATION SYSTEM
(UPDES)

GENERAL PERMIT FOR COAL MINING

In compliance with provisions of the Utah *Water Quality Act, Title 19, Chapter 5, Utah Code Annotated ("UCA") 1953, as amended* (the *"Act"*),

C. W. Mining Company - Bear Canyon Mine

as identified in the application No. UTG040006 is authorized to discharge from all outfall(s) to receiving waters named:

Bear Creek

in accordance with discharge point(s), effluent limitations, monitoring requirements and other conditions as set forth herein.

This permit shall become effective on May 1, 2003.

This permit and the authorization to discharge shall expire at midnight, April 30, 2008

Signed this 24th day of April, 2003.

Don A. Ostler
Executive Secretary
Utah Water Quality Board

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I. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

A. Criteria for Inclusion in the General Permit for Coal Mining

This General permit shall apply only to the discharge of treated wastewater from:

Coal mining operations either new or existing in Utah which include or will include in part, or in whole, alkaline mine water drainage, storm water runoff from coal preparation plant associated areas, active mining areas, and post mining areas until the performance bond is released. The total dissolved solids (TDS) is limited to a concentration of 500 mg/L at all discharge points or one ton per day as a sum from all mine water or decant operations.

B. Notice of Intent for a General Permit for Coal Mining)

Any facility which desires coverage under this general permit for coal mining and meets the requirements of Part I.A. can be issued general permit coverage by submitting a notice of intent (NOI) to the Division of Water Quality.

The NOI shall include:

1. A completed Environmental Protection Agency Application (EPA Form 3510-1) oequivalent information.

2. Location and identification number (such as 001, 002, etc.) of each existing discharge and/or proposed discharge point(s). this includes the latitude and longitude to the nearest 15 seconds and the name of the receiving water(s).

3. A description of the source of the wastewater for each discharge point.

4. A description of the treatment given or proposed for the wastewater at each discharge point and if necessary a justification of why no treatment is required.

5. Flow characteristics for each discharge point such as whether flow is or will be continuous or intermittent and indicate projected and/or actual average and maximum flows in gpd.

6. Data for each discharge point for the following parameters:

   a. Biochemical demand (BOD_5).
   b. Chemical oxygen demand (COD).
   c. Total organic carbon (TOC).
   d. Total suspended solids (TSS).
   e. Flow.
   f. Ammonia (as N).
   g. Oil and grease.
   h. Temperature.

n. Date and time of analysis for each parameter.
o. Utah certified laboratory which has completed the analysis for each parameter.

For each discharge point the presence or absence of any toxic and/or priority pollutants as listed Table II, UAC R317-8-3.13.

C. Description of Discharge Point(s).

The authorization to discharge provided under this permit is limited to those outfalls specifically designated below as discharge locations. Discharges at any location not authorized under a UPDES permit is a violation of the *Act* and may be subject to penalties under the *Act*. Knowingly discharging from an unauthorized location or failing to report an unauthorized discharge may be subject to criminal penalties as provided under the *Act*.

Outfall Number	Location of Discharge Point(s)
002	Bear Canyon Mine Sediment Pond "A" Treatment Facility. Latitude 111°5'40", Longitude 39°24'30". Discharge goes to Bear Creek.
003	Bear Canyon Mine Sediment Pond "B" Treatment Facility. Latitude 111°5'40", Longitude 39°24'30". Discharge goes to Bear Creek.
004	Bear Canyon Mine Underground Seepage Water Overflow. Latitude 111°5'30", Longitude 39°24'40".Discharge goes to Bear Creek.
006	Bear Canyon Mine Sediment Pond "C" Treatment Facility. Latitude 111°5'40", Longitude 39°24'27".Discharge goes to Bear Creek.
007	Bear Canyon Mine Sediment Pond "D" Treatment Facility. Latitude 111°5', Longitude 39°23'6".Discharge goes to Bear Creek.

D. Narrative Standard.

It shall be unlawful, and a violation of this permit, for the permittee to discharge or place any waste or other substance in such a way as will be or may become offensive such as unnatural deposits, floating debris, oil, scum or other nuisances such as color, odor or taste, or cause conditions which produce undesirable aquatic life or which produce objectionable tastes in edible aquatic organisms; or result in concentrations or combinations of substances which produce undesirable physiological responses in desirable resident fish, or other desirable aquatic life, or undesirable human health effects, as determined by bioassay or other tests performed in accordance with standard procedures.

E. Specific Limitations and Self-monitoring Requirements.

1. Effective immediately and lasting the duration of this permit, the permittee is authorized to discharge from Outfall(s) 002, 003, 004, 006 and 007. Such discharges shall be limited and monitored by the permittee as specified below:

	Discharge Limitations a/			Monitoring Requirements	
Effluent Characteristics	Average 30-Day	Average 7-Day	Daily Maximum	Measurement Frequency	Sample Type
Flow, MGD	N/A	N/A	NA	Monthly	Measured b/
Oil & Grease, mg/L	N/A	N/A	10c/	Monthly	Grab
Total Iron, mg/L	N/A	N/A	1.0	Monthly	Grab e/
Total Suspended Solids, mg/L	25	35	70	Monthly	Grab e/
Total Dissolved Solids, mg/L	500 d/	N/A	NA	Monthly	Grab e/

The pH shall not be less than 6.5 standard units nor greater than 9.0 standard units in any sample and shall be monitored monthly by a grab sample.

There shall be no visible sheen or floating solids or visible foam in other than trace amounts.

There shall be no discharge of sanitary wastes or process water from coal preparation plants.

N.A. - Not Applicable.

a/ See Definitions, *Part I.A* for definition of terms.

b/ For intermittent discharge, the duration of the discharge shall be reported.

c/ If a visual sheen for oil and grease is observed then a grab sample must be taken immediately and the results shall not exceed 10 mg/L.

d/ If each outfall cannot achieve a 30-day average of 500 mg/L, then the permittee is limited to one ton (2000 lbs) per day as a sum from all outfalls.

e/ These samples may also be a composite sample

2. Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): in the final effluent before mixing with the receiving water.

3. Any discharge or increase in the volume of a discharge caused by precipitation within any 24 hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt of equivalent volume) at outfall(s) 002, 003, 006 and 007 may comply with the following limitations instead of the otherwise applicable limitations for TSS and pH in Part I.E.1:

Effluent Characteristics	Daily Maximum
Settleable Solids	0.5 ml/L
pH	6.5 to 9.0 S.U.

In addition to the monitoring requirements specified under Part I.E.1 all effluent samples collected during storm water discharge events shall also be analyzed for settleable solids. Such analyses shall be conducted monthly by grab samples.

4. Any discharge or increase in the volume of a discharge caused by precipitation within any 24 hour period greater than the 10-year, 24 hour precipitation event (or snowmelt of equivalent volume) at outfall(s) 002, 003, 006 and 007 may comply with the following limitations instead of the otherwise applicable limitations:

The pH shall not be less than 6.5 standard units nor greater than 9.0 standard units. However as stated in Part I.E.3, all effluent samples collected during storm-water discharge events shall be analyzed for settleable solids and parameters identified under Part I.E.1.

5. The operator shall have the burden of proof that the discharge or increase in discharge was caused by the applicable precipitation event described in Parts I.E.3 and 4. The alternate limitations in Parts I.E.3 and 4 shall not apply to treatment systems that treat underground mine water only.

F. Storm Water Requirements. . It has been determined that Bear Canyon Mine has a regulated storm water discharge as per UAC R317-8-3.9., therefore, the following permit conditions governing storm water discharges apply.

1. Coverage of This Section.

   a. Discharges Covered Under This Section. The requirements listed under this section shall apply to storm water discharges from Bear Canyon Mine, subject to effluent limitations listed in Part I.E. of this permit.

      1) Site Coverage. Storm water discharges from the following portions of Bear Canyon Mine may be eligible for this permit: haul roads (nonpublic roads on which coal or coal refuse is conveyed), access roads (nonpublic roads providing light vehicular traffic within the facility property and to public roadways), railroad spurs, sidings, and internal haulage lines (rail lines used for hauling coal within the facility property and to offsite commercial railroad lines or loading areas), conveyor belts, chutes, and aerial tramway haulage areas (areas under and around coal or refuse conveyor areas, including transfer stations), equipment storage and maintenance yards, coal handling buildings and structures, and inactive coal mines and related areas (abandoned and other inactive mines, refuse disposal sites and other mining-related areas on private lands).

2. Prohibition of Non-storm Water Discharges.

   a. The following non-storm water discharges may be authorized by this permit provided the non-storm water component of the discharge is in compliance with this section; fire fighting activities; fire hydrant flushings; potable water sources including waterline flushings; drinking fountain water; irrigation drainage, lawn watering; routine external building washdown water where detergents or other compounds have not been used in the process; pavement washwaters where spills or leaks of toxic or hazardous materials (including oils and fuels) have not occurred (unless all spilled material has been removed) and where detergents are not used; air conditioning condensate; uncontaminated compressor condensate; uncontaminated springs; uncontaminated ground water; and foundation or footing drains where flows are not contaminated with process materials such as solvents.

3. Storm Water Pollution Prevention Plan Requirements. Most of the active coal mining-related areas, described in paragraph 1. above, are subject to sediment and erosion control regulations of the U.S. Office of Surface Mining (OSM) that enforces the Surface Mining Control and Reclamation Act (SMCRA). OSM has granted authority to the Utah Division of Oil Gas and Mining (DOGM) to implement SMCRA through State SMCRA regulations. All SMCRA requirements regarding control of erosion, siltation and other pollutants resulting from storm water runoff, including road dust resulting from erosion, shall be primary requirements of the pollution prevention plan and shall be included in the contents of the plan directly, or by reference. Where determined to be appropriate for protection of water quality, additional sedimentation and erosion controls may be warranted.

   a. Contents of Plan. The plan shall include at a minimum, the following items:

      1) Pollution Prevention Team. Each plan shall identify a specific individual or individuals within the facility organization as members of a storm water Pollution Prevention Team that are responsible for developing the storm water

pollution prevention plan and assisting the facility manager in its implementation, maintenance, and revision. The plan shall clearly identify the responsibilities of each team member. The activities and responsibilities of the team shall address all aspects of the facility's storm water pollution prevention plan.

2) Description of Potential Pollutant Sources. Each plan shall provide a description of potential sources that may reasonably be expected to add significant amounts of pollutants to storm water discharges or that may result in the discharge of pollutants during dry weather from separate storm sewers draining the facility. Each plan shall identify all activities and significant materials that may potentially be significant pollutant sources. Each plan shall include, at a minimum:

a) Deadlines for Plan Preparation and Compliance
Bear Canyon Mine shall prepare and implement a plan in compliance with the provisions of this section within 270 days of the effective date of this permit.

b) Keeping Plans Current

Bear Canyon Mine shall amend the plan whenever there is a change in design, construction, operation, or maintenance, that has a significant effect on the potential for the discharge of pollutants to the waters of the State or if the storm water pollution prevention plan proves to be ineffective in eliminating or significantly minimizing pollutants from sources identified by the plan, or in otherwise achieving the general objectives of controlling pollutants in storm water discharges associated with the activities at the mine.

c) Drainage.

(1) A site map, such as a drainage map required for SMCRA permit applications, that indicate drainage areas and storm water outfalls. These shall include but not be limited to the following:

(a) Drainage direction and discharge points from all applicable mining-related areas described in paragraph 1.a(1). (Site Coverage) above, including culvert and sump discharges from roads and rail beds and also from equipment and maintenance areas subject to storm runoff of fuel, lubricants and other potentially harmful liquids.

(b) Location of each existing erosion and sedimentation control structure or other control measures for reducing pollutants in storm water runoff.

(c) Receiving streams or other surface water bodies.

(d) Locations exposed to precipitation that contain acidic spoil, refuse or unreclaimed disturbed areas.

(e) Locations where major spills or leaks of toxic or

hazardous pollutants have occurred.

(f) Locations where liquid storage tanks containing potential pollutants, such as caustics, hydraulic fluids and lubricants, are exposed to precipitation.

(g) Locations where fueling stations, vehicle and equipment maintenance areas are exposed to precipitation.

(h) Locations of outfalls and the types of discharges contained in the drainage areas of the outfalls.

(2) For each area of the facility that generates storm water discharges associated with the mining-related activity with a reasonable potential for containing significant amounts of pollutants, a prediction of the direction of flow, and an identification of the types of pollutants that are likely to be present in storm water discharges associated with the activity. Factors to consider include the toxicity of the pollutant; quantity of chemicals used, produced or discharged; the likelihood of contact with storm water; and history of significant leaks or spills of toxic or hazardous pollutants. Flows with a significant potential for causing erosion shall be identified.

d) Inventory of Exposed Materials. An inventory of the types of materials handled at the site that potentially may be exposed to precipitation. Such inventory shall include a narrative description of significant materials that have been handled, treated, stored or disposed in a manner to allow exposure to storm water method and location of onsite storage or disposal; materials management practices employed to minimize contact of materials with storm water runoff a description of existing structural and nonstructural control measures to reduce pollutants in storm water runoff; and a description of any treatment the storm water receives.

e) Spills and Leaks. A list of significant spills and leaks of toxic or hazardous pollutants that occurred at areas that are exposed to precipitation or that otherwise drain to a storm water conveyance at the facility beginning 3 years prior to the effective date of this permit. Such list shall be updated as appropriate during the term of the permit.

f) Sampling Data. A summary of any existing discharge sampling data describing pollutants in storm water discharges from the portions of Bear Canyon Mine covered by this permit, including a summary of any sampling data collected during the term of this permit.

g) Risk Identification and Summary of Potential Pollutant Sources. A narrative description of the potential pollutant sources from the following activities: truck traffic on haul roads and resulting generation of sediment subject to runoff and dust generation; fuel or other liquid storage; pressure lines containing slurry, hydraulic fluid or other potential harmful liquids; and loading or temporary storage of acidic refuse or spoil. Specific potential pollutants shall be identified where known.

3) Measures and Controls. Bear Canyon Mine shall develop a description of storm water management controls appropriate for the facility and implement such controls. The appropriateness and priorities of controls in a plan shall reflect identified potential sources of pollutants at Bear Canyon Mine. The description of storm water management controls shall address the following minimum components, including a schedule for implementing such controls.

a) Good Housekeeping. Good housekeeping requires the maintenance of areas that may contribute pollutants to storm water discharges in a clean, orderly manner. These are practices that would minimize the generation of pollutants at the source or before it would be necessary to employ sediment ponds or other control measures at the discharge outlets. Where applicable, such measures or other equivalent measures would include the following: sweepers and covered storage to minimize dust generation and storm runoff; conservation of vegetation where possible to minimize erosion; watering of haul roads to minimize dust generation; collection, removal, and proper disposal of waste oils and other fluids resulting from vehicle and equipment maintenance; or other equivalent measures.

b) Preventive Maintenance. A preventive maintenance program shall involve timely inspection and maintenance of storm water management devices as well as inspecting and testing facility equipment and systems to uncover conditions that could cause breakdowns or failures resulting in discharges of pollutants to surface waters, and ensuring appropriate maintenance of such equipment and systems. Where applicable, such measures would include the following: removal and proper disposal of settled solids in catch basins to allow sufficient retention capacity; periodic replacement of siltation control measures subject to deterioration such as straw bales; inspections of storage tanks and pressure lines for fuels, lubricants, hydraulic fluid or slurry to prevent leaks due to deterioration or faulty connections; or other equivalent measures.

c) Spill Prevention and Response Procedures. Areas where potential spills that can contribute pollutants to storm water discharges can occur, and their accompanying drainage points shall be identified clearly in the storm water pollution prevention plan. Where appropriate, specifying material handling procedures, storage requirements, and use of equipment such as diversion valves in the plan should be considered. Procedures for cleaning up spills shall be identified in the plan and made available to the appropriate personnel. The necessary equipment to implement a clean up shall be available to personnel.

d) Inspections. In addition to or as part of the comprehensive site evaluation required under paragraph 3.a.(4) of this section, qualified facility personnel shall be identified to inspect designated areas of the facility at appropriate intervals specified in the plan. The following shall be included in the plan:

(1) Active Mining-Related Areas and Those Inactive Areas Under SMCRA Bond Authority. The plan shall require quarterly

inspections by the facility personnel for areas of the facility covered by pollution prevention plan requirements. This inspection interval corresponds with the quarterly inspections for the entire facility required to be provided by SMCRA authority inspectors for all mining-related areas under SMCRA authority, including sediment and erosion control measures. Inspections by the facility representative may be done at the same time as the mandatory inspections performed by SMCRA inspectors. Records of inspections of the SMCRA authority facility representative shall be maintained.

(2) Inactive Mining-Related Areas Not Under SMCRA Bond. The plan shall require annual inspections by the facility representative except in situations referred to in paragraph 3.a.(4)(d) below.

(3) Inspection Records. The plan shall require that inspection records of the facility representative and those of the SMCRA authority inspector shall be maintained. A set of tracking or follow-up procedures shall be used to ensure that appropriate actions are taken in response to the inspections.

e) Employee Training. Employee training programs shall inform personnel responsible for implementing activities identified in the storm water pollution prevention plan or otherwise responsible for storm water management at all levels of responsibility of the components and goals of the storm water pollution prevention plan. Training should address topics such as spill response, good housekeeping and material management practices. The pollution prevention plan shall identify periodic dates for such training.

f) Record keeping and Internal Reporting Procedures. A description of incidents (such as spills, or other discharges) along with other information describing the quality and quantity of storm water discharges shall be included in the plan required under this part. Inspections and maintenance activities shall be documented and records of such activities shall be incorporated into the plan.

g) Non-storm Water Discharges.

(1) Certification. The plan shall include a certification that the discharge has been tested or evaluated for the presence of non-storm water discharges such as drainage from underground portions of inactive mines or floor drains from maintenance or coal handling buildings. The certification shall include the identification of potential significant sources of non-storm water discharges at the site, a description of the results of any test and/or evaluation, a description of the evaluation criteria or testing method used, the date of any testing and/or evaluation, and the onsite drainage points that were directly observed during the test. Certifications shall be signed in accordance with Part IV.G.4. of this permit.

(2) Exceptions. Except for flows from fire fighting activities, authorized sources of non-storm water listed in Part I.F.2.a. that are combined with storm water discharges associated with industrial activity must be identified in the plan. The plan shall identify and ensure the implementation of appropriate pollution prevention measures for the non-storm water component(s) of the discharge.

(3) Failure to Certify. If Bear Canyon Mine is unable to provide the certification required (testing or other evaluation for non-storm water discharges), the Executive Secretary must be notified within 180 days after the effective date of this permit. If the failure to certify is caused by the inability to perform adequate tests or evaluations, such notification shall describe: the procedure of any test conducted for the presence of non-storm water discharges; the results of such test or other relevant observations; potential sources of non-storm water to the storm discharge lines; and why adequate tests for such storm discharge lines were not feasible. Non-storm water discharges to waters of the State that are not authorized by a UPDES permit are unlawful, and must be terminated.

h) Sediment and Erosion Control. The plan shall identify areas that, due to topography, activities, or other factors, have a high potential for significant soil erosion, and identify structural, vegetative, and/or stabilization measures to be used to limit erosion and reduce sediment concentrations in storm water discharges. As indicated in paragraph I.F.3. above, SMCRA requirements regarding sediment and erosion control measures are primary requirements of the pollution prevention plan for mining-related areas subject to SMCRA authority. The following sediment and erosion control measures or other equivalent measures, should be included in the plan where reasonable and appropriate for all areas subject to storm water runoff:

(1) Stabilization Measures. Interim and permanent stabilization measures to minimize erosion and lessen amount of structural sediment control measures needed, including: mature vegetation preservation; temporary seeding; permanent seeding and planting; temporary mulching, matting, and netting; sod stabilization; vegetative buffer strips; temporary chemical mulch, soil binders, and soil palliatives; nonacidic road surfacing material; and protective trees.

(2) Structural Measures. Structural measures to lessen erosion and reduce sediment discharges, including: silt fences; earth dikes; straw dikes; gradient terraces; drainage swales; sediment traps; pipe slope drains; porous rock check dams; sedimentation ponds; riprap channel protection; capping of contaminated sources; and physical/chemical treatment of storm water.

i) Management of Flow. The plan shall contain a narrative consideration of the appropriateness of traditional storm water management practices (other than those as sediment and erosion control measures listed above)

used to manage storm water runoff in a manner that reduces pollutants in storm water runoff from the site. The plan shall provide that the measures, which the permittee determines to be reasonable and appropriate, shall be implemented and maintained. Appropriate measures may include: discharge diversions; drainage/storm water conveyances; runoff dispersion; sediment control and collection; vegetation/soil stabilization; capping of contaminated sources; treatment; or other equivalent measures.

4) Comprehensive Site Compliance Evaluation. Qualified personnel shall conduct site compliance evaluations at intervals specified in the plan, but in no case less than once a year. Such evaluations shall provide:

a) Areas contributing to a storm water discharge associated with coal mining-related areas shall be visually inspected for evidence of, or the potential for, pollutants entering the drainage system. These areas include haul and access roads; railroad spurs, sidings, and internal haulage lines; conveyor belts, chutes and aerial tramways; equipment storage and maintenance yards; coal handling buildings and structures; and inactive mines and related areas. Measures to reduce pollutant loadings shall be evaluated to determine whether they are adequate and properly implemented in accordance with the terms of the permit or whether additional control measures are needed. Structural storm water management measures, sediment and erosion control measures, and other structural pollution prevention measures, as indicated in paragraphs 3.a.(3)(h) and 3.a.(3)(i) above and where identified in the plan, shall be observed to ensure that they are operating correctly. A visual evaluation of any equipment needed to implement the plan, such as spill response equipment, shall be made.

b) Based on the results of the evaluation, the description of potential pollutant sources identified in the plan, in accordance with paragraph 3.a.(2) of this section, and pollution prevention measures and controls identified in the plan, in accordance with paragraph 3.a.(3) of this section, shall be revised as appropriate within 2 weeks of such evaluation and shall provide for implementation of any changes to the plan in a timely manner. For inactive mines, such revisions may be extended to a maximum of 12 weeks after the evaluation.

c) A report summarizing the scope of the evaluation, personnel making the evaluation, the date(s) of the evaluation, major observations relating to the implementation of the storm water pollution prevention plan, and actions taken in accordance with paragraph 3.a.(4)(b) above shall be made and retained as part of the storm water pollution prevention plan for at least 3 years after the date of the evaluation. The report shall identify any incidents of noncompliance. Where a report does not identify any incidents of noncompliance, the report shall contain a certification that the facility is in compliance with the storm water pollution prevention plan and this permit. The report shall be signed in accordance with Part IV.G.4. (Signatory Requirements) of this permit.

d) Where compliance evaluation schedules overlap with inspections required under 3.a.(3)(d), the compliance evaluation may be conducted in

place of one such inspection. Where annual site compliance evaluations are shown in the plan to be impractical for inactive mining sites due to the remote location and inaccessibility of the site, site inspections required under this part shall be conducted at appropriate intervals specified in the plan, but, in no case less than once in 3 years.

4. Numeric Effluent Limitations. There are no additional numeric effluent limitations beyond those described in Part I.E. of this permit.

5. Monitoring and Reporting Requirements.

a. Benchmark Analytical Monitoring Requirements. Bear Canyon Mine must monitor their storm water discharges associated with industrial activity at least quarterly (4 times per year) during years 2 and 4 of the permit cycle except as provided in paragraphs 5.a.(3) (Sampling Waiver), 5.a.(4) (Representative Discharge), and 5.a.(5) (Alternative Certification). Bear Canyon Mine is required to monitor their storm water discharges for the pollutants of concern listed in Table E. below. Reports must be made in accordance with 5.b. (Reporting). In addition to the parameters listed in Table E. below, Bear Canyon Mine measurements or estimates (in inches) of the storm event that generated the sampled runoff; the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event; and an estimate of the total volume (in gallons) of the discharge sampled.

The results of benchmark monitoring are primarily for Bear Canyon Mine's use to determine the overall effectiveness of the SWPPP in controlling the discharge of pollutants to receiving waters. Benchmark values are not viewed as permit limitations. An exceedance of a benchmark value does not, in and of itself, constitute a violation of this permit. While exceedance of a benchmark value does not automatically indicate a violation of a water quality standard has occurred, it does signal that modifications to the SWPPP or more specific pollution prevention controls may be necessary.

Table E.
Monitoring Requirements for Coal Mining Facilities

Pollutants of Concern	Cut-Off Concentration
Total Recoverable Aluminum	0.75 mg/L
Total Recoverable Iron	1.0 mg/L
Total Suspended Solids	100 mg/L

1) Monitoring Periods. Bear Canyon Mine shall monitor samples collected during the sampling periods of: January through March, April through June, July through September, and October through December during the second and fourth years of this permit cycle.

2) Sample Type. A minimum of one grab sample shall be taken. All such samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches in magnitude and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. The required 72-hour storm event interval is waived where the preceding measurable storm event did not result in a measurable discharge from the facility. The required 72-hour storm event interval may also be waived where Bear Canyon Mine documents that less than a 72-hour interval is representative for local storm events during the season when sampling is being conducted. The grab sample

shall be taken during the first 30 minutes of the discharge. If the collection of a grab sample during the first 30 minutes is impracticable, a grab sample can be taken during the first hour of the discharge, and the discharger shall submit with the monitoring report a description of why a grab sample during the first 30 minutes was impracticable. If storm water discharges associated with industrial activity commingle with process or nonprocess water, then where practicable permittees must attempt to sample the storm water discharge before it mixes with the non-storm water discharge.

3) Sampling Waiver.

a) Adverse Conditions. If Bear Canyon Mine is unable to collect samples within a specified sampling period due to adverse climatic conditions, thus a substitute sample shall be collected from a separate qualifying event in the next monitoring period and the data submitted along with the data for the routine sample in that period. Adverse weather conditions that may prohibit the collection of samples include weather conditions that create dangerous conditions for personnel (such as local flooding, high winds, hurricanes, tornadoes, electrical storms, etc.) or otherwise make the collection of a sample impracticable (drought, extended frozen conditions, etc.).

b) Low Concentration Waiver. When the average concentration for a pollutant calculated from all monitoring data collected from an outfall during the second year monitoring is less than the corresponding value for that pollutant listed in Table E. under the column Monitoring Cut-Off Concentration, Bear Canyon Mine may waive monitoring and reporting requirements for the fourth year monitoring period. Bear Canyon Mine must submit to the Executive Secretary, in lieu of the monitoring data, a certification that there has not been a significant change in industrial activity or the pollution prevention measures in area of the facility that drains to the outfall for which sampling was waived.

c) Inactive and Unstaffed Site. If Bear Canyon Mine is unable to conduct quarterly chemical storm water sampling at an inactive and unstaffed site, the operator of the facility may exercise a waiver of the monitoring requirements as long as the facility remains inactive and unstaffed. Bear Canyon Mine must submit to the Executive Secretary, in lieu of monitoring data, a certification statement on the Storm Water Discharge Monitoring Report (SWDMR) stating that the site is inactive and unstaffed so that collecting a sample during a qualifying event is not possible.

4) Representative Discharge. If the facility has two or more outfalls that, based on a consideration of industrial activity, significant materials, and management practices and activities within the area drained by the outfall, discharge substantially identical effluents, Bear Canyon Mine may test the effluent of one of such outfalls and report that the quantitative data also applies to the substantially identical outfall(s) provided that Bear Canyon Mine includes in the storm water pollution prevention plan a description of the location of the outfalls and explains in detail why the outfalls are expected to discharge substantially identical effluents. In addition, for each outfall that Bear Canyon Mine believes is representative, an estimate of the size of the drainage area (in square feet) and

an estimate of the runoff coefficient of the drainage area [e.g., low (under 40 percent), medium (40 to 65 percent), or high (above 65 percent)] shall be provided in the plan. Bear Canyon Mine shall include the description of the location of the outfalls, explanation of why outfalls are expected to discharge substantially identical effluents, and estimate of the size of the drainage area and runoff coefficient with the SWDMR.

5) Alternative Certification. Bear Canyon Mine is not subject to the monitoring requirements of this section provided that certification is made for a given outfall or on a pollutant-by-pollutant basis in lieu of monitoring reports required under paragraph b. below, under penalty of law, signed in accordance with Part IV.G.4. (Signatory Requirements). The Certification shall state that material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, industrial machinery or operations, or significant materials from past industrial activity that are located in areas of the facility within the drainage area of the outfall are not presently exposed to storm water and are not expected to be exposed to storm water for the certification period. Such certification must be retained in the storm water pollution prevention plan, and submitted to DWQ in accordance with Part II.D. of this permit. In the case of certifying that a pollutant is not present, Bear Canyon Mine must submit the certification along with the monitoring reports required under paragraph b. below. If Bear Canyon Mine cannot certify for an entire period, they must submit the date exposure was eliminated and any monitoring required up until that date. This certification option is not applicable to compliance monitoring requirements associated with effluent limitations.

b. Reporting. Bear Canyon Mine shall submit monitoring results for each outfall associated with industrial activity [or a certification in accordance with Sections (3), (4), or (5) above] obtained during the second year reporting period, on Storm Water Discharge Monitoring Report (SWDMR) form(s) postmarked no later than the 31st day of the following March. Monitoring results [or a certification in accordance with Sections (3), (4), or (5) above] obtained during the fourth year reporting period shall be submitted on SWDMR form(s) postmarked no later than the 31st day of the following March. For each outfall, one signed SWDMR form must be submitted to the Executive Secretary per storm event sampled. Signed copies of SWDMRs, or said certifications, shall be submitted to the Executive Secretary at the address listed in Part II.D. of the permit.

c. Visual Examination of Storm Water Quality. Bear Canyon Mine shall perform and document a visual examination of a representative storm water discharge at the following frequencies: quarterly for active areas under SMCRA bond located in areas with average annual precipitation over 20 inches; semi-annually for inactive areas under SMCRA bond, and active areas under SMCRA bond located in areas with average annual precipitation of 20 inches or less; visual examinations are not required at inactive areas not under SMCRA bond.

1) Visual Monitoring Periods. Examinations shall be conducted in each of the following periods for the purposes of visually inspecting storm water runoff or snow melt: Quarterly-January through March; April through June; July through September; and October through December. Semi-annually—January through June and July through December.

2) Sample and Data Collection. Examinations shall be made of samples collected within the first 60 minutes (or as soon thereafter as practical, but not to exceed

two hours) of when the runoff or snowmelt begins discharging. The examinations shall document observations of color, odor, clarity, floating solids, settled solids, suspended solids, foam, oil sheen, and other obvious indicators of storm water pollution. The examination must be conducted in a well-lit area. No analytical tests are required to be performed on the samples. All such samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches in magnitude and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. Where practicable, the same individual will carry out the collection and examination of discharges for the life of the permit.

3) Visual Storm Water Discharge Examination Reports. Visual examination reports must be maintained onsite in the pollution prevention plan. The report shall include the examination date and time, examination personnel, the nature of the discharge (i.e., runoff or snow melt), visual quality of the storm water discharge (including observations of color, odor, clarity, floating solids, settled solids, suspended solids, foam, oil sheen, and other obvious indicators of storm water pollution), and probable sources of any observed storm water contamination.

II. MONITORING, RECORDING AND REPORTING REQUIREMENTS

A. Representative Sampling. Samples taken in compliance with the monitoring requirements established under *Part I* shall be collected from the effluent stream prior to discharge into the receiving waters. Samples and measurements shall be representative of the volume and nature of the monitored discharge. Sludge samples shall be collected at a location representative of the quality of sludge immediately prior to the use-disposal practice.

B. Monitoring Procedures. Monitoring must be conducted according to test procedures approved under *Utah Administrative Code ("UAC") R317-2-10*, unless other test procedures have been specified in this permit.

C. Penalties for Tampering. The *Act* provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than six months per violation, or by both.

D. Reporting of Monitoring Results. Monitoring results obtained during the previous month shall be summarized for each month and reported monthly on a Discharge Monitoring Report Form (EPA No. 3320-1), post-marked no later than the 28th day of the month following the completed reporting period. The first report is due on June 28, 2003. If no discharge occurs during the reporting period, "no discharge" shall be reported. Legible copies of these, and all other reports including whole effluent toxicity (WET) test reports required herein, shall be signed and certified in accordance with the requirements of *Signatory Requirements (see Part IV.G)*, and submitted to the Director, Division of Water Quality:

original to: Department of Environmental Quality
Division of Water Quality
288 North 1460 West
PO Box 144870
Salt Lake City, Utah 84114-4870

E. Compliance Schedules. Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any Compliance Schedule of this permit shall be submitted no later than 14 days following each schedule date.

F. Additional Monitoring by the Permittee. If the permittee monitors any parameter more frequently than required by this permit, using test procedures approved under *UAC R317-2-10* or as otherwise specified in this permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR. Such increased frequency shall also be indicated. Only those parameters required by the permit need to be reported.

G. Records Contents. Records of monitoring information shall include:

1. The date, exact place, and time of sampling or measurements:
2. The individual(s) who performed the sampling or measurements;
3. The date(s) and time(s) analyses were performed;
4. The individual(s) who performed the analyses;
5. The analytical techniques or methods used; and,
6. The results of such analyses.

H. Retention of Records. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least three years from the date of the sample, measurement, report or application. This period may be extended by request of the Executive Secretary at any time. A copy of this UPDES permit must be maintained on site during the duration of activity at the permitted location.

I. Twenty-four Hour Notice of Noncompliance Reporting.

1. The permittee shall (orally) report any noncompliance which may seriously endanger health or environment as soon as possible, but no later than twenty-four (24) hours from the time the permittee first became aware of circumstances. The report shall be made to the Division of Water Quality, (801) 538-6146, or 24 hour answering service (801) 536-4123.

2. The following occurrences of noncompliance shall be reported by telephone (801) 536-4123 as soon as possible but no later than 24 hours from the time the permittee becomes aware of the circumstances:

   a. Any noncompliance which may endanger health or the environment;

   b. Any unanticipated bypass which exceeds any effluent limitation in the permit (See *Part III.G, Bypass of Treatment Facilities.)*;

   c. Any upset which exceeds any effluent limitation in the permit (See *Part III.H, Upset Conditions.*); or,

   d. Violation of a maximum daily discharge limitation for any of the pollutants listed in the permit.

3. A written submission shall also be provided within five days of the time that the permittee becomes aware of the circumstances. The written submission shall contain:

   a. A description of the noncompliance and its cause;

   b. The period of noncompliance, including exact dates and times;

   c. The estimated time noncompliance is expected to continue if it has not been corrected; and,

   d. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

   e. Steps taken, if any, to mitigate the adverse impacts on the environment and human health during the noncompliance period.

4. The Executive Secretary may waive the written report on a case-by-case basis if the oral report has been received within 24 hours by the Division of Water Quality, (801) 538-6146.

5. Reports shall be submitted to the addresses in *Part II.D, Reporting of Monitoring Results.*

J. Other Noncompliance Reporting. Instances of noncompliance not required to be reported within 24 hours shall be reported at the time that monitoring reports for *Part II.D* are submitted. The reports shall contain the information listed in *Part II.I.3*.

K. Inspection and Entry. The permittee shall allow the Executive Secretary, or an authorized representative, upon the presentation of credentials and other documents as may be required by law, to:

1. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of the permit;

2. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

3. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and,

4. Sample or monitor at reasonable times, for the purpose of assuring permit compliance or as otherwise authorized by the *Act*, any substances or parameters at any location.

III. COMPLIANCE RESPONSIBILITIES

A. Duty to Comply. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. The permittee shall give advance notice to the Executive Secretary of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

B. Penalties for Violations of Permit Conditions. The *Act* provides that any person who violates a permit condition implementing provisions of the *Act* is subject to a civil penalty not to exceed $10,000 per day of such violation. Any person who willfully or negligently violates permit conditions of the Act is subject to a fine not exceeding $25,000 per day of violation; Any person convicted under *UCA 19-5-115(2)* a second time shall be punished by a fine not exceeding $50,000 per day. Except as provided at *Part III.G, Bypass of Treatment Facilities* and *Part III.H, Upset Conditions*, nothing in this permit shall be construed to relieve the permittee of the civil or criminal penalties for noncompliance.

C. Need to Halt or Reduce Activity not a Defense. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

D. Duty to Mitigate. The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

E. Proper Operation and Maintenance. The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by a permittee only when the operation is necessary to achieve compliance with the conditions of the permit.

F. Removed Substances. Collected screening, grit, solids, sludges, or other pollutants removed in the course of treatment shall be buried or disposed of in such a manner so as to prevent any pollutant from entering any waters of the state or creating a health hazard. Sludge/digester supernatant and filter backwash shall not directly enter either the final effluent or waters of the state by any other direct route.

G. Bypass of Treatment Facilities.

1. Bypass Not Exceeding Limitations. The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to 2. and 3. of this section.

2. Prohibition of Bypass.

a. Bypass is prohibited, and the Executive Secretary may taken enforcement action against a permittee for bypass, unless:

(1) Bypass was unavoidable to prevent loss of human life, personal injury, or severe property damage;

(2) There were no feasible alternatives to bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgement to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance, and

(3) The permittee submitted notices as required under section G.3.

b. The executive Secretary may approve an anticipated bypass, after considering its adverse effects, if the Executive Secretary determines that it will meet the three conditions listed in sections G.2a. (1), (2) and (3).

3. Notice.

a. Anticipated bypass. Except as provided above in section G.2. and below in section G. 3.b, if the permittee knows in advance of the need for a bypass, it shall submit prior notice, at least ninety days before the date of bypass. The prior notice shall include the following unless otherwise waived by the Executive Secretary:

(1) Evaluation of alternative to bypass, including cost-benefit analysis containing an assessment of anticipated resource damages:

(2) A specific bypass plan describing the work to be performed including scheduled dates and times. The permittee must notify the Executive Secretary in advance of any changes to the bypass schedule;

(3) Description of specific measures to be taken to minimize environmental and public health impacts;

(4) A notification plan sufficient to alert all downstream users, the public and others reasonably expected to be impacted by the bypass;

(5) A water quality assessment plan to include sufficient monitoring of the receiving water before, during and following the bypass to enable evaluation of public health risks and environmental impacts; and

(6) Any additional information requested by the Executive Secretary.

b. Emergency Bypass. Where ninety days advance notice is not possible, the permittee must notify the Executive Secretary, and the Director of the Department of Natural Resources, as soon as it becomes aware of the need to bypass and provide to the Executive Secretary the information in section G.3.a.(1) through (6i) to the extent practicable.

c. Unanticipated bypass. The permittee shall submit notice of an unanticipated bypass to the Executive Secretary as required under Part II.I., Twenty Four Hour Reporting. The permittee shall also immediately notify the Director of the Department of Natural Resources, the public and downstream users and shall implement measures to minimize impacts to public health and environment to the extent practicable.

H. Upset Conditions.

1. Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with technology based permit effluent limitations if the requirements of paragraph 2. of this section are met. Executive Secretary's administrative determination regarding a claim of upset cannot be judiciously challenged by the permittee until such time as an action is initiated for noncompliance.

2. Conditions necessary for a demonstration of upset. A permittee who wishes to establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

   a. An upset occurred and that the permittee can identify the cause(s) of the upset;

   b. The permitted facility was at the time being properly operated;

   c. The permittee submitted notice of the upset as required under Part II.I, Twenty-four Hour Notice of Noncompliance Reporting; and,

   d. The permittee complied with any remedial measures required under Part III.D, Duty to Mitigate.

3. Burden of proof. In any enforcement proceeding, the permittee seeking to establish the occurrence of an upset has the burden of proof.

I. Toxic Pollutants. The permittee shall comply with effluent standards or prohibitions established under Section 307(a) of *The Water Quality Act of 1987* for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

J. Changes in Discharge of Toxic Substances. Notification shall be provided to the Executive Secretary as soon as the permittee knows of, or has reason to believe:

1. That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

   a. One hundred micrograms per liter (100 ug/L);

   b. Two hundred micrograms per liter (200 ug/L) for acrolein and acrylonitrile; five hundred micrograms per liter (500 ug/L) for 2,4-dinitrophenol and for 2-methyl-4, 6-dinitrophenol; and one milligram per liter (1 mg/L) for antimony;

   c. Five (5) times the maximum concentration value reported for that pollutant in the permit application in accordance with *UAC R317-8-3.4(7)* or (10); or,

   d. The level established by the Executive Secretary in accordance with *UAC R317-8-4.2(6).*

2. That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

a. Five hundred micrograms per liter (500 ug/L);

b. One milligram per liter (1 mg/L) for antimony:

c. Ten (10) times the maximum concentration value reported for that pollutant in the permit application in accordance with *UAC R317-8-3.4(9)*; or,

d. The level established by the Executive Secretary in accordance with *UAC R317-8-4.2(6)*.

K. Industrial Pretreatment. Any wastewaters discharged to the sanitary sewer, either as a direct discharge or as a hauled waste, are subject to Federal, State and local pretreatment regulations. Pursuant to Section 307 of *The Water Quality Act of 1987*, the permittee shall comply with all applicable federal General Pretreatment Regulations promulgated at *40 CFR 403*, the State Pretreatment Requirements at *UAC R317-8-8*, and any specific local discharge limitations developed by the Publicly Owned Treatment Works (POTW) accepting the wastewaters.

In addition, in accordance with *40 CFR 403.12(p)(1)*, the permittee must notify the POTW, the EPA Regional Waste Management Director, and the State hazardous waste authorities, in writing, if they discharge any substance into a POTW which if otherwise disposed of would be considered a hazardous waste under *40 CFR 261*. This notification must include the name of the hazardous waste, the EPA hazardous waste number, and the type of discharge (continuous or batch).

IV. GENERAL REQUIREMENTS

A. Planned Changes. The permittee shall give notice to the Executive Secretary as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required only when the alteration or addition could significantly change the nature or increase the quantity of pollutants discharged. This notification applies to pollutants which are not subject to effluent limitations in the permit. In addition, if there are any planned substantial changes to the permittee's existing sludge facilities or their manner of operation or to current sludge management practices of storage and disposal, the permittee shall give notice to the Executive Secretary of any planned changes at least 30 days prior to their implementation.

B. Anticipated Noncompliance. The permittee shall give advance notice to the Executive Secretary of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

C. Permit Actions. This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

D. Duty to Reapply. If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee shall apply for and obtain a new permit. The application shall be submitted at least 180 days before the expiration date of this permit.

E. Duty to Provide Information. The permittee shall furnish to the Executive Secretary, within a reasonable time, any information which the Executive Secretary may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the Executive Secretary, upon request, copies of records required to be kept by this permit.

F. Other Information. When the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or any report to the Executive Secretary, it shall promptly submit such facts or information.

G. Signatory Requirements. All applications, reports or information submitted to the Executive Secretary shall be signed and certified.

1. All permit applications shall be signed by either a principal executive officer or ranking elected official

2. All reports required by the permit and other information requested by the Executive Secretary shall be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

   a. The authorization is made in writing by a person described above and submitted to the Executive Secretary, and,

   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility, such as the position of plant manager, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

3. Changes to authorization. If an authorization under paragraph IV.G.2 is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of paragraph IV.G.2 must be submitted to the Executive Secretary prior to or together with any reports, information, or applications to be signed by an authorized representative.

4. Certification. Any person signing a document under this section shall make the following certification:

> "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

H. Penalties for Falsification of Reports. The *Act* provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction be punished by a fine of not more than $10,000.00 per violation, or by imprisonment for not more than six months per violation, or by both.

I. Availability of Reports. Except for data determined to be confidential under *UAC R317-8-3.2*, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the office of Executive Secretary. As required by the *Act*, permit applications, permits and effluent data shall not be considered confidential

J. Oil and Hazardous Substance Liability. Nothing in this permit shall be construed to preclude the permittee of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under the *Act*.

K. Property Rights. The issuance of this permit does not convey any property rights of any sort, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of federal, state or local laws or regulations.

L. Severability. The provisions of this permit are severable, and if any provisions of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

M. Transfers. This permit may be automatically transferred to a new permittee if:

1. The current permittee notifies the Executive Secretary at least 20 days in advance of the proposed transfer date;

2. The notice includes a written agreement between the existing and new permittees containing a specific date for transfer of permit responsibility, coverage, and liability between them; and,

3. The Executive Secretary does not notify the existing permittee and the proposed new permittee of his or her intent to modify, or revoke and reissue the permit. If this notice is not received, the transfer is effective on the date specified in the agreement mentioned in paragraph 2 above.

N. State Laws. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable state law or regulation under authority preserved by *UCA 19-5-117.*

O. Water Quality-Reopener Provision. This permit may be reopened and modified (following proper administrative procedures) to include the appropriate effluent limitations and compliance schedule, if necessary, if one or more of the following events occurs:

1. Water Quality Standards for the receiving water(s) to which the permittee discharges are modified in such a manner as to require different effluent limits than contained in this permit.

2. A final wasteload allocation is developed and approved by the State and/or EPA for incorporation in this permit.

3. A revision to the current Water Quality Management Plan is approved and adopted which calls for different effluent limitations than contained in this permit.

P. Toxicity Limitation-Reopener Provision. This permit may be reopened and modified (following proper administrative procedures) to include whole effluent toxicity (WET) testing, a WET limitation, a compliance schedule, a compliance date, additional or modified numerical limitations, or any other conditions related to the control of toxicants if toxicity is detected during the life of this permit.

V. GLOSSARY OF TERMS

A. Definitions.

1. The "30-day (and monthly) average" is the arithmetic average of all samples collected during a consecutive 30-day period or calendar month, whichever is applicable. The calendar month shall be used for purposes of reporting self-monitoring data on discharge monitoring report forms.

2. The "7-day (and weekly) average" is the arithmetic average of all samples collected during a consecutive 7-day period or calendar week, whichever is applicable. The 7-day and weekly averages are applicable only to those effluent characteristics for which there are 7-day average effluent limitations. The calendar week which begins on Sunday and ends on Saturday, shall be used for purposes of reporting self- monitoring data on discharge monitoring report forms. Weekly averages shall be calculated for all calendar weeks with Saturdays in the month. If a calendar week overlaps two months (i.e., the Sunday is in one month and the Saturday in the following month), the weekly average calculated for that calendar week shall be included in the data for the month that contains the Saturday.

3. "Daily Maximum" ("Daily Max.") is the maximum value allowable in any single sample or instantaneous measurement.

4. "Composite samples" shall be flow proportioned. The composite sample shall, as a minimum, contain at least four (4) samples collected over the composite sample period. Unless otherwise specified, the time between the collection of the first sample and the last sample shall not be less than six (6) hours nor more than 24 hours. Acceptable methods for preparation of composite samples are as follows:

   a. Constant time interval between samples, sample volume proportional to flow rate at time of sampling;

   b. Constant time interval between samples, sample volume proportional to total flow (volume) since last sample. For the first sample, the flow rate at the time the sample was collected may be used;

   c. Constant sample volume, time interval between samples proportional to flow (i.e., sample taken every "X" gallons of flow); and,

   d. Continuous collection of sample, with sample collection rate proportional to flow rate.

5. A "grab" sample, for monitoring requirements, is defined as a single "dip and take" sample collected at a representative point in the discharge stream.

6. An "instantaneous" measurement, for monitoring requirements, is defined as a single reading, observation, or measurement.

7. "Upset" means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

8. "Bypass" means the intentional diversion of waste streams from any portion of a treatment facility.

9. "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

10. "Executive Secretary" means Executive Secretary of the Utah Water Quality Board.

11. "EPA" means the United States Environmental Protection Agency.

12. "Act" means the "*Utah Water Quality Act*".

13. "Best Management Practices" ("*BMPs*") means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State. *BMPs* also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

14. "Coal pile runoff" means the rainfall runoff from or through any coal storage pile.

15. "*CWA*" means *The Federal Water Pollution Control Act*, as amended, by *The Clean Water Act of 1987.*

16. "Point Source" means any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharges. This term does not include return flows from irrigated agriculture or agriculture storm water runoff.

17. "Significant spills" includes, but is not limited to: releases of oil or hazardous substances in excess of reportable quantities under *Section 311* of the *Clean Water Act* (see *40CFR 110.10* and *40 CFR 117.21)* or *Section 102* of the *CERCLA* (see *40 CFR 302.4).*

18. "Storm water" means storm water runoff, snow melt runoff, and surface runoff and drainage.

19. "Waste pile" means any noncontainerized accumulation of solid, nonflowing waste that is used for treatment or storage.

20. "10-year, 24-hour precipitation event" means the maximum 24-hour precipitation event with a probable reoccurrence interval of once in 10 years. This information is available in *Weather Bureau Technical Paper no. 40,* May 1961 and *NOAA Atlas 2,* 1973 for the 11 Western States, and may be obtained from the National Climatic center of the Environmental Data Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

21. The term "coal preparation plant" means a facility where coal is crushed, screened, sized and cleaned, dried, or otherwise prepared and loaded for transit to a consuming facility.

22. The term "coal preparation plant associated areas" means the coal preparation plant yards, immediate access roads, coal refuse piles, and coal storage piles and facilities.

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Appendix 7-C

WATER RIGHTS

All Water Rights can be accessed from the Utah Water Rights web page at www.waterrights.Utah.gov. Included in this Appendix is pertinent information that cannot be accessed from the Water Rights web page.

INCORPORATED UNDER
THE LAWS OF THE STATE OF UTAH

NUMBER

SHARES

Huntington-Cleveland Irrigation Company

Capital $150,000 150,000 Shares

This Certifies That C. W. Kingston is the owner of

*****Three Hundred Thirty Three and 77/100***** Shares of the Capital Stock of

Huntington-Cleveland Irrigation Company

transferable only on the books of the Corporation by the holder hereof in person or by Attorney upon surrender of this Certificate properly endorsed.

IN WITNESS WHEREOF, the said Corporation has caused this Certificate to be signed by its duly authorized officers and its Corporate Seal to be hereunto affixed this 16 day of February A.D. 19 62

Secretary

President

SHARES 333 77/100

August 20, 1985
Salt Lake City, Utah

TO WHOM IT MAY CONCERN:

I, LaVenda Kingston, widow of C. W. Kingston and owner of 333.77 shares of stock in and to the Huntington Cleveland Irrigation Company, hereby grant unto Co-op Mining Company, the right to use the water represented by such shares in its mining operations, or for any other use Co-op Mining Co. deems appropriate.

LaVenda Kingston

LaVenda Kingston

STATE OF UTAH
NATURAL RESOURCES & ENERGY
Water Rights

Scott M. Matheson, Governor
Temple A. Reynolds, Executive Director
Dee C. Hansen, State Engineer

East Main Street • P.O. Box 718 • Price, UT 84501 • 801-637-1303

September 30, 1983

Division of Oil, Gas and Mining
Attn: Joseph C. Helfrich
4241 State Office Building
Salt Lake City, Utah 84114

Dear Mr. Helfrich:

At the request of Mr. Melvin Coonrod, consultant for Co-op Mining Company, please be advised that the above mentioned company has filed Change Application No. a-12921 (93-1067), of which a copy is enclosed, requesting the right to withdraw up to 0.25 sec.-ft. of water from a mine tunnel in Bear Canyon located at a point: N. 79 ft. & E. 75 ft. from the SW Cor. Sec. 26, T16S, R7E, SLB&M. It is proposed to use the water for mining and irrigation purposes within the SE¼, NE¼, T16S, R7E, SLB&M.

The change application was filed with this office on September 2, 1983. Normal processing time for such a request is 90-120 days, provided that there are no protests filed.

I trust that this brief explanation will help clarify their present water rights status. If I can assist further in any way please feel free to call on me.

Sincerely,

Mark P. Page

Mark P. Page
Area Engineer

cc: Melvin Coonrod
Co-op Mining Company

Enclosure

93-1067

Form No. 107 3-66 CHANGE APPLICATION NO. a-12921

Application for Permanent Change of Point of Diversion Place and Nature of Use of Water

STATE OF UTAH

Please clearly and correctly complete the information requested below which defines the right or rights being changed. (Type or clearly print.)

For the purpose of obtaining permission to permanently change: the point of diversion ☒, place ☐, or nature of use ☐, of water rights acquired by Charles W Kingston A-35836 (93-1067)
(Give Number of Application, certificate of appropriation, title and date of Decree or other identification of right.)

If the right described has been amended by a previous approved change application, give the number of such change application. No. a-6330

1. The name of the applicant is Mrs. Charles W. (Lavenda) Kingston
2. The post-office address of the applicant is 862 East Garfield Ave. SLC, Utah 84110
3. The flow of water which has been or was to have been used in second-feet is .25
4. The quantity of water which has been or was to have been used in acre-feet is
5. The water has been or was to have been used for and during periods as follows:

Irrigation (purpose) from April 1 (month) (day) to October 31 (month) (day) incl.

Mining (purpose) from January 1 (month) (day) to December 31 (month) (day) incl.

and stored each year (if stored) from (month) (day) to (month) (day) incl.

6. The direct source of supply is Tunnel (Trail Canyon) in Emery County.
(well, spring, stream, drain, river; if other explain)
7. The point or points of diversion N. 210 ft. & W. 320 ft. from Ek Cor. Sec. 22, T16S, R7E, SLBM Hiawatha Quad. San Rafael R. Hydro Survey Sheet 21

(Must be the same as that of right being changed unless a previous change has been filed and approved. Then use the point or points approved in the previous change.)

8. Diversion works:

If a well give diameter and depth

If a dam and reservoir give height, capacity, and area inundated

If other give type of diversion facility Pump and pipeline

9. The water involved has been or was to have been used for the following purposes in the following described legal subdivisions: (If used for irrigation, state sole or supplemental supply, and describe other supplemental rights.)

Irrigation SEkSEk Sec. 22, NEkNEk Sec. 27; T16S, R7E, SLBM

Total acres to be irrigated .50

Stockwatering (number and kind)

Domestic (number of families and/or persons, etc.)

Other Mining

10. The point at which water has been or was to have been returned to the stream channel is situated as follows: (Please describe method of return.)

Note: Paragraph 10 is to be completed only when all or part of the water is returned to the natural stream or channel.

The Following Changes Are Proposed

11. The flow of water to be changed in cubic feet per second is .25
12. The quantity of water to be changed in acre-feet is

Num
Appl.
Alpha
T & R

13. The water will be used each year for:

Irrigation (purpose) from April 1 (month) (day) to October 31 (month) (day) incl.

Mining (purpose) from January 1 (month) (day) to December 31 (month) (day) incl.

and stored each year (if stored) from ..... (month) (day) to ..... (month) (day) incl.

14. It is now proposed to divert the water from Tunnel (Bear Canyon) (i.e., spring, spring area, stream, river, drain, well, etc.)

at a point(s) as follows: N. 79 ft. & E. 75 ft. from the SW cor. Sec. 24 T16S, R7E, SLBM Hiawatha Quad. San Rafael R. Hydro Survey Sheet 21 (8½ miles NW of Huntington)

NOTE: The "point of diversion," or "point of return," must be located by course and distance or by rectangular distances with reference to some regularly established United States land corner or United States mineral monument if within a distance of six miles of either, or if a greater distance to some prominent and permanent natural object. A spring area must also be described by metes and bounds.

15. The proposed diverting and conveying works will consist of: (if a well, state diameter and depth thereof)

Pump and Pipeline

16. If water is to be stored, give capacity of reservoir in acre-feet..... height of dam.....

area inundated in acres..... legal subdivisions of area inundated .....

17. The water is to be used for the following purposes in the following described legal subdivisions: (if used for irrigation, state sole or supplemental supply, and describe other supplemental rights.)

Irrigation SE¼, NE¼, SEC. 26; T 16S, R7E, SLM

Total acres to be irrigated .50

but limited to the sole irrigation supply of..... acres.

Stockwatering (number and kind).....

Domestic (number of families and/or persons, etc.) .....

Other Mining

18. If paragraphs 11 and 12 designate that only part of the right described in paragraphs 1 to 10 inclusive is to be changed, designate the status of the water so affected by this change as to its being abandoned or used as heretofore.

EXPLANATORY

The following additional facts are set forth in order to define more clearly and completely the full purpose of the proposed change: The change in the point of diversion is due to a change in the location of mining tunnel

The undersigned hereby acknowledges that even though he may have been assisted in the preparation of the above-numbered application through the courtesy of the employees of the State Engineer's Office, all responsibility for the accuracy of the information contained therein, at the time of filing, rests with the applicant.

Lorinda Livingston

Signature of Applicant

Form No. 107 3-66

CHANGE APPLICATION NO. A-12921

Application for Permanent Change of Point of Diversion Place and Nature of Use of Water

STATE OF UTAH

Please clearly and correctly complete the information requested below which defines the right or rights being changed. (Type or clearly print.)

For the purpose of obtaining permission to permanently change: the point of diversion ☒, place ☒, or nature of use ☐, of water rights acquired by Charles W. Kingston A-35836 (93-1067)
(Give Number of Application, certificate of appropriation, title and date of Decree or other identification of right.)

If the right described has been amended by a previous approved change application, give the number of such change application. No. a-6330

1. The name of the applicant is Mrs. Charles W. (Iavenda) Kingston
2. The post-office address of the applicant is 862 East Garfield Ave. SLC, Utah 84110
3. The flow of water which has been or was to have been used in second-feet is .25
4. The quantity of water which has been or was to have been used in acre-feet is
5. The water has been or was to have been used for and during periods as follows:

   Irrigation (purpose) from April 1 (month) (day) to October 31 (month) (day) incl.

   Mining (purpose) from January 1 (month) (day) to December 31 (month) (day) incl.

   and stored each year (if stored) from (month) (day) to (month) (day) incl.
6. The direct source of supply is Tunnel Trail Canyon in Emery County.
   (well, spring, stream, drain, river; if other explain)
7. The point or points of diversion N. 210 ft. & W. 320 ft. from E¼ Cor. Sec. 22, T16S, R7E, SLBM Hiawatha Quad. San Rafael R. Hydro Survey Sheet 21
   (Must be the same as that of right being changed unless a previous change has been filed and approved. Then use the point or points approved in the previous change.)
8. Diversion works:

   If a well give diameter and depth

   If a dam and reservoir give height, capacity, and area inundated

   If other give type of diversion facility Pump and pipeline
9. The water involved has been or was to have been used for the following purposes in the following described legal subdivisions: (If used for irrigation, state sole or supplemental supply, and describe other supplemental rights.)

   Irrigation SE¼SE¼ Sec. 22, NE¼NE¼ Sec. 27; T16S, R7E, SLBM

   Total acres to be irrigated .50

   Stockwatering (number and kind)

   Domestic (number of families and/or persons, etc.)

   Other Mining
10. The point at which water has been or was to have been returned to the stream channel is situated as follows: (Please describe method of return.)

    Note: Paragraph 10 is to be completed only when all or part of the water is returned to the natural stream or channel.

The Following Changes Are Proposed

11. The flow of water to be changed in cubic feet per second is .25
12. The quantity of water to be changed in acre-feet is

(This page not to be filled in by applicant)

STATE ENGINEER'S ENDORSEMENTS

1. Sept 2, 1983 Change Application received over counter / by mail in State Engineer's office by AP
2. _____ Priority of right to make change brought down to, on account of _____
3. _____ Fee for filing Application $_____, received by _____, Receipt No. _____
4. _____ Application microfilmed by _____ Roll No. _____ and indexed by _____
5. _____ Application platted by _____
6. 9-2-83 Application examined by AP
7. _____ Application returned, with letter, to _____ for correction
8. _____ Corrected application resubmitted over counter / by mail to State Engineer's office _____
9. 9-2-83 Application approved for advertisement by AP
10. _____ Notice to water users prepared by _____
11. Dec 21, 1983 Publication began, was completed Dec 28, 1983 Jan 4, 1984 Emery Co. Progress
12. _____ Proof slips checked by _____
13. 1-30-84 Change Application protested by 1) Huntington City
14. _____ Publisher paid MEV No. _____
15. _____ Field Examined by _____
16. 8/20/84 Application designated for approval / rejection by AP
17. _____ Change Application copied _____ proofread by _____
18. 9-27-84 Change Application approved / rejected and returned to applicant _____

This application is approved on the following conditions:

1. Actual construction work necessitated by proposed change shall be diligently prosecuted to completion.
2. Proof of change shall be submitted to the State Engineer's office by _____
3. This change is subject to all conditions imposed on the approval of the original application or right P.D. 1-31-98

_____
State Engineer

19. _____ Time for making proof of change extended to _____
20. _____ Proof of change submitted.
21. _____ Certificate of change No. _____ issued.

I hereby certify that the foregoing is a true copy of the Application by _____ to change the point of diversion, place and nature of use of water as shown, with endorsements thereon, on the records of my office on the date given below.

Salt Lake City, Utah _____, 19____ _____
State Engineer

Change Application No. a-12921

23-1067

13. The water will be used each year for:

Irrigation (purpose) from April 1 (month) (day) to October 31 (month) (day) incl.

Mining & Domestic (purpose) from January 1 (month) (day) to December 31 (month) (day) incl.

and stored each year (if stored) from January 1 (month) (day) to December 31 (month) (day) incl.

14. It is now proposed to divert the water from Tunnel (Bear Canyon) (i.e., spring, spring area, stream, river, drain, well, etc.)

at a point(s) as follows: N. 79 ft. & E. 75 ft. from the SW cor. Sec. 24 T16S, R7E, SLBM Hiawatha Quad. San Rafael R. Hydro Survey Sheet 21 (8½ miles NW of Huntington)

NOTE: The "point of diversion," or "point of return," must be located by course and distance or by rectangular distances with reference to some regularly established United States land corner or United States mineral monument if within a distance of six miles of either, or if a greater distance to some prominent and permanent natural object. A spring area must also be described by metes and bounds.

15. The proposed diverting and conveying works will consist of: (if a well, state diameter and depth thereof)

Pump and pipeline

16. If water is to be stored, give capacity of reservoir in acre-feet NA* height of dam NA

area inundated in acres NA legal subdivisions of area inundated

* 2 - 10,000 ga. tanks

17. The water is to be used for the following purposes in the following described legal subdivisions: (if used for irrigation, state sole or supplemental supply, and describe other supplemental rights.)

Irrigation SE¼, NE¼, Sec. 26; T16S, R7E, SLBM

Total acres to be irrigated .50

but limited to the sole irrigation supply of _____ acres.

Stockwatering (number and kind) _____

Domestic (number of families and/or persons, etc.) 1 family, shower house 25 mine pers.

Other Mining

18. If paragraphs 11 and 12 designate that only part of the right described in paragraphs 1 to 10 inclusive is to be changed, designate the status of the water so affected by this change as to its being abandoned or used as heretofore.

EXPLANATORY

The following additional facts are set forth in order to define more clearly and completely the full purpose of the proposed change: The change in the point of diversion is due to a change in the location of mining tunnel.

The undersigned hereby acknowledges that even though he may have been assisted in the preparation of the above-numbered application through the courtesy of the employees of the State Engineer's Office, all responsibility for the accuracy of the information contained therein, at the time of filing, rests with the applicant.

Lavenda Kingston
Signature of Applicant

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER RIGHTS

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

1636 West North Temple, Suite 220
Salt Lake City, Utah 84116-3156
801-538-7240
801-538-7315 (Fax)

July 2, 1992

Co-Op Mining Company
c/o Joseph O. Kingston
53 West Angelo Avenue
Salt Lake City, UT 84115

Dear Applicant:

RE: APPROVED CHANGE APPLICATION
NUMBER 93-3657 (a15965)

Enclosed is a copy of approved Change Application No. 93-3657 (a15965). This is your authority to proceed with the actual construction work which under Section 73-3-10 and 73-3-12, Utah Code Annotated, 1953, as amended, must be diligently prosecuted to completion. The water must be put to beneficial use and proof of appropriation be made to the State Engineer on or before January 31, 1996, otherwise, the application will be lapsed.

Proof of change is evidence to the State Engineer that the water has been placed to its full intended beneficial use. By law, it must be prepared by a registered engineer or land surveyor, who will certify to the location and the uses for the water. Your proof of change will become the basis for the extent of your water right.

Failure on your part to comply with the requirements of the statutes may result in forfeiture of this application. It is the applicants obligation to maintain a current address with this office. Please notify this office immediately of any address change.

Your contact with this office, should you need it, is with the Regional Engineer, Mark Page. The telephone number is (801)637-1303.

Sincerely,

Robert L. Morgan

Robert L. Morgan, P.E.
State Engineer

RLM:jb
Encl.: Copy of Approved Change Application
Memorandum Decision

BEFORE THE STATE ENGINEER OF THE STATE OF UTAH

IN THE MATTER OF CHANGE APPLICATION	)	
	)	MEMORANDUM DECISION
NUMBER 93-3657 (a15965)	)	

Change Application Number 93-3657 (a15965) was filed January 11, 1991, by Co-Op Mining Company c/o Joseph O. Kingston. Heretofore, 15.0 acre-feet of water has been diverted from Huntington Creek at the Cleveland Canal located at a point North 1740 feet and East 160 feet from the S1/4 Corner of Section 9, T17S, R8E, SLB&M. The water has been used for irrigation and livestock purposes. The water under this change application is represented by Stock Certificate Number 2690, in the amount of 48 shares of Class A stock in the Huntington-Cleveland Irrigation Company. Hereafter, the applicant proposes to divert the same quantity of water from a spring located at a point South 1725 feet and West 1280 feet from the NE Corner of Section 22, T16S, R7E, SLB&M, and from the Bear Canyon Mine portal located at a point North 79 feet and East 75 feet from the SW Corner of Section 24, T16S, R7E, SLB&M. The water is to be used for the domestic supply of 19 families, the supplemental irrigation of 1.39 acre, and for uses associated with coal mining at the Bear Canyon Mine, which includes bathhouse facilities, dust suppression, fire protection and other related uses.

Public notice of the change application was given in The Emery County Progress beginning February 5, 1991, and ending February 19, 1991. Subsequent to the public notice, protests were filed by the North Emery Water Users' Association, Castle Valley Special Service District, and Huntington City.

A hearing was held on Thursday, May 2, 1991, in Castle Dale, Utah to review the application and receive comments from the protestants. The applicant was represented by Attorney Carl E. Kingston. The protestants were represented by their legal counsel, Mr. Jeffrey W. Appel.

In defense of the application, Mr. Kingston indicated that Co-Op Mining Company has been mining coal in Trail and Bear Canyons since 1940. During this time, it has been their understanding that the water used at the mine and for the residences in Trail Canyon has been validated by shares of stock owned in the Huntington-Cleveland Irrigation Company, and by an individual water right referenced as 93-1067. He indicated that all of the mining prior to 1980 took place in Trail Canyon. At that time, because of geologic problems, the mining effort was moved to Bear Canyon where it is still taking place.

The present use of water is reflective of the historic use made at the mine and the residences. The spring referenced in this change application is located in Trail Canyon and is used to provide water for the 19 residences, as well as a portion of the irrigated acreage. The water diverted at the mine portal provides for the mining and support facilities, which includes an office and bathhouse, as well as irrigation of top soil stock piles. The in-mine use involves dust control at the mine face. The individual water right owned by the applicant is also diverted from the Bear Canyon Mine portal and used for domestic, irrigation and mining uses in Bear Canyon. This right is junior in priority to the rights of the Huntington-Cleveland Irrigation Company.

By way of background concerning this change application, Mr. Kingston indicated that in 1990, Co-Op transferred 60 shares of their Irrigation Company stock to a neighboring mine. At that time, his client was contacted by the Irrigation Company requesting that shares of stock be transferred to the mine because Co-Op's private water right is junior to the rights of the Irrigation Company. As a result, the applicant had Stock Certificate #2690 divided from a prior Certificate in the amount of 48 shares. It should be noted that the applicant holds an additional 188.77 shares of stock in the Company.

Mr. Kingston believes that the concerns of the protestants, which deal with claimed interference of the water quality and quantity of their culinary springs in the area has not resulted from the applicant's diversion of water for mining purposes.

Mr. Richard White, a Hydrologist with Earthfax Engineering, was present at the hearing and indicated that he was retained by the applicant to perform a hydrologic study of the area. In his review of Huntington Creek flow data, spring flow data from Big Bear, Little Bear, Tie Fork and Birch Springs, and recent precipitation data from five stations in the area, it appeared to him that the concerns of the protestants rest in the fact that for the past several years, less than normal precipitation has fallen on the watershed. As a result, water has not been available to recharge the springs. He also indicated that the quantity of water flowing in the Bear Canyon Mine has been relatively constant since 1984. Therefore, it is his opinion that the Co-Op Mining operation is not interfering with, nor are they responsible for the reduced flows at the protestants' springs.

Mr. Appel, speaking in behalf of the protestants, indicated that the concerns of his clients centered around two main problems: First, a reduction in the quantity of water available for delivery to the culinary and municipal water systems; Secondly, the degradation of the water quality, particularly in Birch Spring. Collectively, the protestants provide culinary and municipal water to approximately 4000 people in Emery County, and these sources of water are invaluable. Mr. Appel feels that the water that has historically been diverted by the applicant has been done without the benefit of a properly approved water right. He also stated that the applicant's historic water use exceeds the limit of their private water right, which according to his information is limited to the irrigation of 0.50 acre.

His clients believe that the continuing decline in flow at Birch Spring and Big Bear Spring, can be attributed to the applicant's mining activity in Bear Canyon. During a 120 day period in late 1989 and early 1990, the water flow at Birch Spring increased approximately threefold. During this same time period, the other springs in the area continued to experience a slight decrease in flow. Also during this unusual flow event, oil and grease were found in Birch Spring. As a result, the protestants have filed protests against the renewal of the applicant's mining permit with the Division of Oil, Gas & Mining, as well as this water application.

It is the opinion of the protestants that the applicant's mining operation has interfered with the quantity and quality of their culinary springs. As a result, the granting of this change application, and the renewal of the applicant's mine permit should be held in question. Mr. Appel feels that his clients rights have been jeopardized as a result of the applicant's ongoing violations of their current mining permit as it pertains to their underground as well as surface operations, and the approval of this water right will result in continued problems.

Attorney Kingston stated that data obtained from core holes drilled at the Bear Canyon Mine indicated that the regional aquifer which underlies the mining permit area, is below the area being mined. As a result, contamination from in-mine work could not influence the quality of the protestants' water sources. In a similar manner, the re-charge area for the protestants' springs is located up slope from the applicant's surface facilities. Contamination of the springs from this area of the mining operation would be highly unlikely. He further indicated that Co-Op will drill four monitor wells to further define the location of the regional aquifer in relation to their mining activities. Additional sampling will also be scheduled which will include Big Bear and Birch Springs, if the protestants will allow access to these sources.

Mr. Appel asked that he be allowed ten days from the date of the hearing to provide supplemental comments to the hearing record. This request was granted. Mr. Kingston was afforded an opportunity to provide a response to Mr. Appel's comments.

On May 23, 1991, this office received Mr. Appel's additional comments. They centered around the lack of information contained on the applicant's change application. He pointed to deficiencies with respect to the prior points of diversion, places and extent of use. Again, he raised the issue concerning the applicant's private water right. He also questioned the supplemental nature of the change application. He feels that the approval of this application will result in an enlargement of the water right. Attorney Appel also pointed out that his clients' use of the water is statutorily recognized as a higher priority use than that of the applicant. Therefore, interference should not be allowed to continue. Because of the many deficiencies found in the application, and the enlargement and priority issues, Mr. Appel believes that the application should be denied by the State Engineer.

On June 3, 1991, this office received Mr. Kingston's response. He indicated that the issues raised and addressed at the hearing, had not changed. The historic water use by the applicant at Trail and Bear Canyons has not significantly changed. The applicant has maintained a personal water right, as well as shares in the Company to cover their water use. Mr. Kingston pointed out that the information contained on the change application is adequate, and does represent the intent of the applicant. Therefore, he feels that the application should be approved, and allow the applicant to continue the historic use of the water.

The State Engineer has reviewed the written responses from the applicant in defense of the application, as well as the report prepared by Earthfax Engineering. Likewise, all of the information, testimony and reports provided by the protestants, which includes two reports from geologist Bryce Montgomery, have also been reviewed. It appears that there are two issues that need to be resolved. One is the protestants' concerns with the physical mining operation of the applicant, and their purported interference with the underground water flow paths, as well as aquifer contamination. These are matters that are not within the jurisdiction of the State Engineer to resolve, and will not be dealt with in this proceeding. It appears that the applicant and protestants should continue to work with the Division of Oil, Gas & Mining, in an attempt to resolve these concerns.

The second issue which will be addressed in these proceedings is whether or not the proposed change application can be approved in accordance with the provisions of Sections 73-3-3 and 73-3-8. It is believed that the change application as filed with this Division contains all of the relevant information and meets the statutory requirements of the law. It is not vague and misrepresentative of the applicant's intentions. It is noted that the origin of the water rights held by the protestants and the applicant are based on share ownership in the Huntington-Cleveland Irrigation Company. The pertinent rights were decreed in the A.H. Christensen Decree dated January 28, 1915. The relative priorities of the applicant's and protestants' water rights are equal. It is recognized that domestic and municipal uses are superior to other uses with the same priority if water availability becomes a critical issue, and there is insufficient water to provide for all uses. However, it is the opinion of the State Engineer that a critical water shortage does not exist which may require such a declaration.

In reviewing all of the pertinent information, including information from a recent field examination, it is believed that the current water use at the Bear Canyon Mine and the associated uses in Trail Canyon have not significantly changed over the past many years. The applicant is not seeking to divert additional water nor change water sources beyond current practices. It is the opinion of this Division that there has not been definitive information provided by the protestants concerning the applicant's interference with historic flows at the protestants' springs. Each party is encouraged to sample and monitor their water sources for their own protection, and for the mutual benefit of each. It is the opinion of the State Engineer that the approval of this change application will not interfere with the water rights of the protestants or other water users on Huntington Creek.

It is, therefore, **ORDERED** and Change Application Number 93-3657 (a15965) is hereby **APPROVED** subject to all prior rights and the following conditions:

1) The applicant must install totalizing water meters at the spring and the mine portal to measure all water diverted and utilized, and provide additional information concerning the in-mine use. A written report of the annual water use is to be provided to the State appointed River Commissioner. Any costs

associated with the monitoring and regulating this change application shall be borne by the applicant.

2) No changes in the points of diversion can be made without prior authorization from the Division of Water Rights.

3) Continued ownership of the shares of stock must be maintained which provide the basis for this change application.

This Decision is subject to the provisions of Rule R655-6-17 (1992 Utah Administrative Code--formerly R625) of the Division of Water Rights and to Sections 63-46b-13 and 73-3-14 of the Utah Code Annotated, 1953, which provide for filing either a Request for Reconsideration with the State Engineer or an appeal with the appropriate District Court. A Request for Reconsideration must be filed with the State Engineer within 20 days of the date of this Decision. However, a Request for Reconsideration is not a prerequisite to filing a court appeal. A court appeal must be filed within 30 days after the date of this Decision, or if a Request for Reconsideration has been filed, within 30 days after the date the Request for Reconsideration is denied. A Request for Reconsideration is considered denied when no action is taken 20 days after the Request is filed.

Dated this 2nd day of July, 1992.

Robert L. Morgan

Robert L. Morgan, P.E., State Engineer

RLM/MPP/mjk/jb

Mailed a copy of the foregoing Memorandum Decision this 2nd day of July, 1992, to:

Co-Op Mining Company
Attn: Carl E. Kingston, Attorney
53 West Angelo Avenue
Salt Lake City, UT 84115

North Emery Water Users' Association
Castle Valley Special Service District
Huntington City
Attn: Jeffrey W. Appel and Michele Mattsson
c/o Haley & Stolebarger
175 South Main Street, Suite 1000
Salt Lake City, UT 84111

Huntington-Cleveland Irrigation Company
ATTN Varden Wilson
55 North Main
Huntington UT 84528

Oran Varden Wilson
River Commissioner
PO Box 406
Huntington, UT 84528

Judy Barbour

Judy Barbour, Secretary

APPLICATION FOR PERMANENT CHANGE OF WATER

RECEIVED
JAN 17 1991
JAN 11 1991
WATER RIGHTS
PRICE

Rec. by L.K.
Fee Paid $ 30.00
Receipt # 39987
Microfilmed
Roll #

STATE OF UTAH

For the purpose of obtaining permission to make a permanent change of water in the State of Utah, application is hereby made to the State Engineer, based upon the following showing of facts, submitted in accordance with the requirements of Section 73-3-3 Utah Code Annotated 1953, as amended.

***WATER RIGHT NO.** 93 - 3657 ***APPLICATION NO. a** a-15965

Changes are proposed in (check those applicable)

X point of diversion. X place of use. X nature of use. ____ period of use.

1. **OWNER INFORMATION**

Name: Co-Op Mining Company c/o Joseph O. Kingston *Interest: ____%

Address: 53 West Angelo Avenue

City: Salt Lake City State: Utah Zip Code: 84115

2. ***PRIORITY OF CHANGE:** January 11, 1991 ***FILING DATE:** January 11, 1991

*Is this change amendatory? (Yes/No): No

3. **RIGHT EVIDENCED BY:** A.H. Christensen Decree - Huntington Creek 93-228
Huntington-Cleveland Irrigation Company Stock Certificate No. 2690

Prior Approved Change Applications for this right: ____

********************************** **HERETOFORE** **********************************

4. **QUANTITY OF WATER:** ____ cfs and/or 15.0 ac-ft.
5. **SOURCE:** Huntington Creek
6. **COUNTY:** Emery
7. **POINT(S) OF DIVERSION:** See Attached Sheet

Description of Diverting Works: Earth and concrete diversion dams, earthen ditches, pipelines

8. **POINT(S) OF REDIVERSION**

The water has been rediverted from ____ at a point: ____

Description of Diverting Works: ____

9. **POINT(S) OF RETURN**

The amount of water consumed is ____ cfs or 15.0 ac-ft.

The amount of water returned is ____ cfs or ____ ac-ft.

The water has been returned to the natural stream/source at a point(s): ____

***These items are to be completed by the Division of Water Rights.**

10. **NATURE AND PERIOD OF USE**

Irrigation:	From	March 2	to	November 14
Stockwatering:	From	January 1	to	December 31
Domestic:	From	January 1	to	December 31
Municipal:	From		to	
Mining:	From		to	
Power:	From		to	
Other:	From		to	

11. **PURPOSE AND EXTENT OF USE**

Irrigation: 32,673.26 acres. Sole supply of _____ acres.
Stockwatering (number and kind): 6797 Cattle
Domestic: 650 Families and/or _____ Persons.
Municipal (name): _____
Mining: _____ Mining District in the _____ Mine.
Ores mined: _____
Power: Plant name: _____ Type: _____ Capacity: _____
Other (describe): _____

12. **PLACE OF USE**

Legal description of place of use by 40 acre tract(s): Within the boundaries of the Huntington-Cleveland Irrigation Company distribution system

13. **STORAGE**

Reservoir Name: _____ Storage Period: from _____ to _____
Capacity: _____ ac-ft. Inundated Area: _____ acres.
Height of dam: _____ feet.
Legal description of inundated area by 40 tract(s): _____

*********************** **THE FOLLOWING CHANGES ARE PROPOSED** ***********************

14. **QUANTITY OF WATER:** _____ cfs and/or 15.0 ac-ft.
15. **SOURCE:** 1) Spring 2) Mine POrtal
Balance of the water will be abandoned: _____, or will be used as heretofore: _____
16. **COUNTY:** Emery
17. **POINT(S) OF DIVERSION:** 1) S. 1725 ft. & W. 1280 ft. from NE Cor. Sec. 22; 2) N. 79 ft. & E. 75 ft. from SW Cor. Sec. 24, both T16S, R7E, SLB&M.

Description of Diverting Works: Collection boxes, sumps, portable pumps & 10,000 gal. storage ta
*COMMON DESCRIPTION: 11 miles NW of Huntington Hiawatha Quad

18. **POINT(S) OF REDIVERSION**

The water will be rediverted from _____ at a point: _____

Description of Diverting Works: _____

19. **POINT(S) OF RETURN**

The amount of water to be consumed is _____ cfs or 15.0 ac-ft.
The amount of water to be returned is _____ cfs or _____ ac-ft.

20. **NATURE AND PERIOD OF USE**

Irrigation:	From March 2	to November 14
Stockwatering:	From ______	to ______
Domestic:	From January 1	to December 31
Municipal:	From ______	to ______
Mining:	From January 1	to December 31
Power:	From ______	to ______
Other:	From ______	to ______

21. **PURPOSE AND EXTENT OF USE**

Irrigation: 1.39 acres. Sole supply of 1.00 acres.

Stockwatering (number and kind): ______

Domestic: 19 Families and/or ______ Persons.

Municipal (name): ______

Mining: Unnamed Mining District at the Bear Canyon Mine.

Ores mined: Coal

Power: Plant name: ______ Type: ______ Capacity: ______

Other (describe): ______

22. **PLACE OF USE**

Legal description of place of use by 40 acre tract(s): E½NE¼, NE¼SE¼ Sec. 22, SE¼NE¼, N½SE¼ Section 26, both T16S, R7E, SLB&M.

STORAGE

Reservoir Name: ______ Storage Period: from ______ to ______

Capacity: ______ ac-ft. Inundated Area: ______ acres.

Height of dam: ______ feet.

Legal description of inundated area by 40 tract(s): ______

24. **EXPLANATORY**

The following is set forth to define more clearly the full purpose of this application. Include any supplemental water rights used for the same purpose. (Use additional pages of same size if necessary):

This Change Application will be used supplementally with 93-1067 for irrigation purposes only.

****

The undersigned hereby acknowledges that even though he/she/they may have been assisted in the preparation of the above-numbered application through the courtesy of the employees of the Division of Water Rights, all responsibility for the accuracy of the information contained herein, at the time of filing, rests with the applicant(s).

[signature]

Signature of Applicant(s)

Paragraph #7 - Points of Diversion

Howard Ditch
N. 730 ft. & E. 1110 ft. from W¼ Cor. Sec. 36, T16S, R7E, SLB&M

Brinkerhoff Ditch
N. 1030 ft. & W. 370 ft. from SE Cor. Sec. 36, T16S, R7E, SLB&M

Dell Lott Ditch
S. 370 ft. & E. 350 ft. from NW Cor. Sec. 6, T17S, R8E, SLB&M

Elk & Rilda Springs
Elk Spring: N. 2100 ft. & E. 1800 ft. from SW Cor. Sec. 5, T17S, R7E, SLB&M
Rilda Spring: N. 200 ft. & W. 2700 ft. from E¼ Cor, Sec. 29, T16S, R7E, SLB&M

Harrison Ditch
N. 760 ft. from SW Cor. Sec. 5, T17S, R8E, SLB&M

Rowley Ditch
N. 100 ft. & E. 1270 ft. from SW Cor. Sec. 5, T17S, R8E, SLB&M

North Ditch
N. 960 ft. & W. 440 ft. from E¼ Cor. Sec. 15, T17S, R8E, SLB&M

Seely & Collard Ditch
S. 1320 ft. & W. 300 ft. from N¼ Cor. Sec. 8, T17S, R8E, SLB&M

Robins-Truman Ditch
N. 2300 ft. & W. 60 ft. from S¼ Cor. Sec. 9, T17S, R8E, SLB&M

Cleveland Canal
N. 2290 ft. & W. 65 ft. from S¼ Cor. Sec. 9, T17S, R8E, SLB&M
Re-diversion point: N. 750 ft. & E. 1950 ft. from W¼ Cor. Sec. 11, T17S, R10E, SLB&M

Bear Canyon Spring
N. 2045 ft. & E. 185 ft. from S¼ Cor. Sec. 26, T16S, R7E, SLB&M

Little Bear Canyon Spring
N. 1750 ft. & W. 95 ft. from S¼ Cor. Sec. 9, T16S, R7E, SLB&M

Huntington Canal
S. 850 ft. & W. 530 ft. from N¼ Cor. Sec. 15, T17S, R8E, SLB&M

Unnamed Spring
N. 2813 ft. & W. 2716 ft. from S¼ Cor. Sec. 26, T16S, R7E, SLB&M

Birch Spring
N. 2026 ft. & W. 2172 ft. from S¼ Cor. Sec. 26, T16S, R7E, SLB&M

Unnamed Spring
S. 1120 ft. & W. 2020 ft. from N¼ Cor. Sec. 35, T16S, R7E, SLB&M

Ranger Station Spring
S. 928 ft. & E. 147 ft. from N¼ Cor. Sec. 23, T16S, R7E, SLB&M

STATE ENGINEER'S ENDORSEMENT

CHANGE APPLICATION NUMBER: a15965 WATER RIGHT NUMBER: 93 - 3657

1. January 11, 1991 Change Application received by MP.

2. January 11, 1991 Priority of Change Application.

3. January 15, 1991 Application reviewed and approved for advertising by MP.
   February 6, 1991 Publication began in Emery County Progress.
   March 28, 1991 Publication completed and verified by LK.

4. March 22, 1991 End of protest period.
   Application protested: NO

5. March 2, 1992 Application designated for APPROVAL by MP and KLJ.

6. Comments:
   Protested by: North Emery Water Users' Association, Castle Valley Special District and Huntington City 3/22/91

Conditions:
This application is hereby APPROVED by Memorandum Decision, dated July 2, 1992, subject to prior rights and the following conditions:

a. Actual construction work necessitated by proposed change shall be diligently prosecuted to completion.
b. Proof of change shall be submitted to the State Engineer's Office by January 31, 1996.

Robert L. Morgan

Robert L. Morgan, P.E.
State Engineer

Time for making Proof of Change extended to_____

Proof submitted_____

APPENDIX 7-D

AGREEMENT WITH HUNTINGTON CITY

AGREEMENT

THIS AGREEMENT entered into this 27th day of January, 1982, by and between Co-op Mining Company, a Utah partnership, C.O.P., INC., a Utah corporation, hereinafter jointly referred to as "Co-op", and Huntington City, a municipal corporation, hereinafter called "City".

WITNESSETH:

THAT WHEREAS, Co-op is undertaking to develop and put into operation a coal mine in Big Bear Creek Canyon, in Emery County, Utah;

AND WHEREAS, City has received in the past and is now receiving a significant portion of its culinary water supply from a spring in Big Bear Creek Canyon in the general proximity of the proposed mining operation;

AND WHEREAS, the parties to this Agreement wish to cooperate with each other so as to assure that Co-op activities will not in any manner result in a loss or diminution of the water supply available to the City from the Spring, the parties do hereby AGREE and COVENANT between themselves as follows:

1. That, at the option of City, representatives of City and the Co-op will make inspections underground in the old Bear Canyon Mine and any other mine operated in Bear Canyon by Co-op, to check for water.

2. That the City will maintain a flow meter at the Spring site and shall take measurements from the meter on a continuing basis so that any interference with the water supply or diminution in the flow can be readily determined; and the flow figures as measured shall be made available to Co-op.

3. That in the event that the quality of water at the Big Bear Creek Spring site decreases below the standards set by the Utah State Board of Health for culinary water, or in the event that the quantity of water at the Big Bear Spring decreases in flow 25% below the flow for the month immediately preceding, in any 30-day period; or 50 per cent below the average flow for the preceding 180 days in any 180-day period and such decrease cannot reasonably be accounted for as being a result of a lack of precipitation or other causes unrelated to Co-op's mining activities, then Co-op shall in accordance with this Agreement undertake such action as may be necessary to obtain water from some other source, and place said water into the culinary water system of City in such quantity and quality as would replenish the flow and quality that has been lost with the same quantity of water, the quality of which passes the standards of the

Utah State Board of Health for culinary water. Co-op agrees to use all reasonable diligence to take the required action or make the required replacement of a permanent acceptable nature as rapidly as feasible, not to exceed one year, unless a greater time is required by law, and further agrees to maintain such temporary measures until permanent measures are completed, at Co-op's sole expense. In the event that water treatment is required to bring the water obtained by Co-op up to Utah State standards for culinary water, Co-op further agrees to pay the proportionate share of the cost for treatment of said water as long as the interruption continues. In the event it is later determined that such decrease in the flow or quality of water is not a result of Co-op's mining activities, City agrees to reimburse Co-op for its reasonable and necessary expenses incurred pursuant to this paragraph. Co-op further agrees that if said mining operations diminish or interfere with the flow of or quality of water from the above Spring to the extent that mechanical water treatment plant is necessary, said Co-op shall pay a percentage of the plant cost related to said plant, proportional to the water needing treatment as a result of the diminution in quality or quantity of the Big Bear Springs, compared to the total water being treated by the City.

4. The parties further agree that the figures of 25% and 50 per cent relative to a decrease in flow of the Big Bear Creek Spring cited in paragraph 3 above as the trigger for Co-op's obligation to replace said diminution of flow may be altered from time to time by mutual agreement of the parties after a period of three years, after which time the parities will have sufficient spring flow data to more accurately establish that point at which the diminution of flow at the Spring site is likely to have been caused by the Co-op's mining operations.

5. In the event that there is a good faith dispute between the parties hereto whether or not Co-op's mining activities are the cause of a diminished flow or quality in Big Bear Creek Spring, the parties shall cooperate in taking immediate corrective measures reasonably necessary to restore said flow or quality of water. Each party shall bear one-half of the cost thereof, provided that if it can later be shown that said mining activities were not responsible for said diminution in flow or quality, City shall reimburse Co-op within a reasonable time from such showing for Co-op's costs already paid pursuant to this paragraph and Co-op shall not be obligated to pay any additional costs of the corrective measures not yet paid at the time of such showing. Further, if it can be later shown that said mining activities were responsible for said diminution in flow or quality, Co-op shall reimburse City within a reason-

able time for City's costs already paid pursuant to this Agreement.

6. In the event of good faith dispute between the parties as to the cause of any diminution in flow or quality of said Spring, the parties agree to appoint an arbitration committee and to be bound by the decision of said committee. This committee shall consist of five menbers: one Co-op representative, one City representative, and three representatives chosen by the other two members. The arbitration committee shall immediately meet and within 30 days make a preliminary decision as to the cause of any dininution in flow or quality of said Spring which preliminary decision shall bind the parties until the committee has had time to make a full investigation and reach a final decision. Nothing in this Agreement shall be construed as depriving either party of a right of action against any other non-parties including any insurance company issuing insurance pursuant to paragraph 9 hereof.

7. In the event any other mining operation or other activity of any other person or entity is proposed or planned in the area which may affect the flow of the Big Bear Creek Spring, City will require such person or entity to sign an agreement similar to this Agreement, binding such other person or entity to bear responsibility for any adverse effect such other person's or entity's activities may have upon the flow or quality of said Spring. In the event any diminution in the flow or quality of the Spring may be attributable to the activities of any person or entity other than Co-op, Co-op shall have the right to establish the same to City's reasonable satisfaction and thereby shall be entitled to reimbursement by City within a reasonable time from such establishment for reasonable costs incurred by Co-op for corrective action required under this Agreement to the extent it is established that such other person or entity is responsible for the diminished flow or quality. In that event City agrees to look to such other person or entity for such corrective action as it deems necessary.

8. This Agreement shall terminate and Co-op shall have no further obligation hereunder with respect to any diminution of flow of Big Bear Creek Spring, one year after the final termination of Co-op's or its successors in interests' mining activity in Bear Canyon.

9. In order to assure performance on its part of the covenants of this Agreement, Co-op agrees to insure the City in an amount not less than Three Hundred Thousand ($300,000) Dollars with a company acceptable to City which insurance policy may be the same policy as is required by Section 40-10-10(6) Utah Code Annotated.

10. In the event legal action is brought to enforce the terms of this Agreement, the losing party in such action agrees to pay all costs thereof, including the reasonable attorney's fees of the prevailing party.

11. This Agreement shall cover the proposed mining operation on the Six Hundred Eighty (680) acres covered by and described in Cause No. ACT - 015-025, before the Utah Board of Oil, Gas and Mining, Department of Natural Resources.

12. As a condition to entering into the foregoing Agreement, the City agrees that it will withdraw its protest in Cause No. ACT - 015-025 before the Board of Oil, Gas and Mining, Department of Natural Resources of the State of Utah, and also it agrees that it will not protest the proposed mining operation on the the Six Hundred Eighty (680) acres as heretofore filed as a mining plan with the Board of Oil, Gas and Mining, Department of Natural Resources of the State of Utah, or protest the issuance by Emery County of any necessary building permits or approvals for Co-op's mining operations in Bear Canyon.

13. The City hereby specifically reserves its rights to protest any and all other legal remedies on all other mining plans or proposals on land not included in the acreage covered by this Agreement.

14. Co-op agrees that the transfer or assignment of the premises affecting said Spring or this Agreement shall not release Co-op from any obligations in this Agreement unless Huntington City has in writing consented to said release, which consent shall not be unreasonably withheld.

15. The parties shall not assign their obligations or rights under this Agreement without the mutual consent of each other.

16. It is agreed by the parties that this Agreement applies to and binds the heirs, executors, administrators, successors and assigns of the respective parties hereto.

IN WITNESS WHEREOF, the said parties to this Agreement have here unto affixed their signatures, the day and year first above written.

CO-OP MINING COMPANY

By D. J. Peterson

ATTEST:

Luana Kingston
Secretary

C.O.P., INC.

By D. J. Peterson
Its President

ATTEST:

City Recorder

HUNTINGTON CITY

By
Its Mayor

Appendix 7-E

SLOPE STABILITY ANALYSIS

SEDIMENTATION POND "A"

SLOPE STABILITY ANALYSIS
ON
EMBANKMENT OF SEDIMENTATION POND "A"
BEAR CREEK CANYON MINE SITE
CO-OP MINING COMPANY

JULY 1984

Prepared by
Harold Lee Wimmer, P. E.
Utah P.E. No. 3535

HORROCK & CAROLLO ENGINEERS
One West Main
American Fork, Utah 84003
801-756-7628

SECTION 1

In conjunction with the redesign of sedimentation pond "A" of the Bear Creek Canyon Mine site, various in place and laboratory soil tests were performed. Using the parameters obtained from these tests, slope stability analysis were performed to confirm the stability of the 2H:IV interior slope and determine a stable angle for the exterior slope.

SECTION II CONSTRUCTION

On September 29, 1983, I visited the site in conjunction with Wendell Owen of the Co-Op and reviewed in detail the provisions taken at the site during construction. I also reviewed with Mr. Owen the construction procedures which enabled me to determine how the embankment was constructed to its present slope.

SECTION III MATERIAL TESTING

While at the site, using a Troxler 3411B nuclear density gauge, I determined the in-place density of the embankment material. I also obtained moisture density samples and samples of the embankment material, which I returned to the lab for additional testing. The results of these in-place determinations indicate that the average in-place density of the material varied from 89% to 94% of the laboratory obtained T-99 standard proctor.

I submitted a sample of the embankment material to Chen and Associates, a consulting soil and foundation engineering firm, to determine the relationship of the loading to shear stress, and to determine the internal cohesion. These results are included in the Appendix. The material gradation results are also included in the Appendix. The gradation results indicated that the material is free draining confirming the on site tests.

SECTION IV OCCURRENCE OF GROUND WATER

The results of the gradation analysis indicate that the material is free draining. This was further observed at the site through reviewing the existing material in place and performing percolation tests in the embankment. Because of the geology of the mine plan area the embankment is not effected by ground water, but for purposes of analysis the soil was assumed saturated by the water occasionally held in the pond. This assumed extent of saturation provides for conservative results.

SECTION V FACTOR OF SAFETY

A computer model was constructed to analyze the stability of the embankment and the following conditions were assumed.

1. The soil below the maximum water elevation on the interior slope to the toe of the exterior slope (soil #2) was assumed saturated.

2. In-place soil density of 118 pounds per cubic foot.

3 2H:IV angles were used for both interior and exterior slopes.

A computer simulation was then applied to this situation to determine various failure planes. The "Method of Slices" is the basis for the modified Bishop method computer program. Various failure planes were investigated to determine a minimum factor of safety. The results of these computer runs and a copy of the computer listing is attached in the Appendix. The results of these computer simulations indicate that the minimum factor of safety with a .1 g earthquake loading is 3.8 for the interior slope and 2.8 for the exterior slope at the point of maximum length.

SECTION VI CONCLUSIONS

In conclusion the sedimentation pond "A" embankment as now existing is:

1. Free draining.

2. No water was encountered in test holes dug in embankments.

3. No movement of the embankment has been detected.

4. The computer simulation on failure planes indicates that the factor of safety is at least 2.8 with a 0.1 g earthquake loading for 2H:IV slopes for both the interior and exterior of the embankment.

APPENDIX

ENGINEERS

Project Name Cone Mine Date 10/6/8[illegible]

Project No. _____ Station or Pit Location _____

Sample No #2 Requisted by HCW

Native material, Pond dikes

AS RECEIVED GRADATION

Screen Size	Weight (a)	Percent Retained	Percent Passing	SPECS.
3"				
2"	0	0	100%	
1½"	1132.1	14.0	86.0	
3/4"	875.8	10.9	75.1	
1/2"	466.3	5.8	69.3	
3/8"				
#4	1112.1	13.8	55.6	
Wet Wt. #4				
Wt. #4	448[illegible]	55.6		
Total Wt. Dry	[illegible]			

WASHED GRADATION AFTER CRUSHING (2500 GM. DRY SAMPLE)

Screen Size	Weight Retained	Percent Retained	Percent Passing	Total % Passing	SPECS.
#8	141.7	8.9	91.1	19.7	
#10	31.1	2.0	89.1	17.9	
#16	69.5	4.4	84.7	17.5	
#20	40.7	2.6	82.2	16.7	
#30	31.8	2.0	80.1	16.2	
#40	47.9	3.0	77.1	15.8	
#50	91.4	5.9	71.4	15.2	
#100	[illegible]	22.1	49.3	14.0	
[illegible]	146.4	9.2	40.1	9.7	
#200	635.7	40.1	0		
Total Wt.	1586.8				

MOISTURE DETERMINATION	
	-#4
Container & Wet Soil Weight (gm.)	
Container & Dry Soil Weight (gm.)	
H_2O Loss	
% Moisture	

A.A.S.H.O Classification

Wt. before washing _____

Wt. after washing _____

COPIES TO:

Tested by Kirk I. [illegible]

ENGINEERS

Project Name Coco Mine Date 10/6/8.

Project No. _____ Station or Pit Location _____

Sample No #1 (Coal [illegible]) Requisted by [illegible]

~ sediment in Pond

AS RECEIVED GRADATION

Screen Size	Weight (a)	Percent Retained	Percent Passing	SPECS.
3"				
2"				
1"	0	0	100%	
3/4"	63.0	0.8	99.2	
1/2"	94.7	1.2	98.[illegible]	
~~3/8"~~				
#4	31[illegible]	3.9	94.1	
~~Wet Wt. -#4~~				
Wet Wt. #4	7654.4	94.[illegible]		
Total Wt Dry	8131.9			

WASHED GRADATION AFTER CRUSHING (2500 GM. DRY SAMPLE)

Screen Size	Weight Retained	Percent Retained	Percent Passing	Total % Passing	SPECS.
#8	126.3	8.5	91.5	18.3	
#10	37.6	2.5	89.0	16.8	
#16	121.7	8.2	80.8	16.3	
#20	79.7	5.4	75.5	14.8	
#30	60.4	4.1	71.4	13.8	
#40	67.1	4.5	66.9	13.1	
#50	95.5	6.4	60.5	12.3	
#100	328.[illegible]	22.[illegible]	38.4	11.1	
#200	113.[illegible]	7.6	30.[illegible]	7.0	
-#200	457.0	30.8	0		
Total Wt	1489.1				

MOISTURE DETERMINATIO.	
	-#4
Container & Wet Soil Weight (gm.)	
Container & Dry Soil Weight (gm.)	
H_2O Loss	
% Moisture	

A.A.S.H.O Classification

Wt. before washing _____

Wt. after washing _____

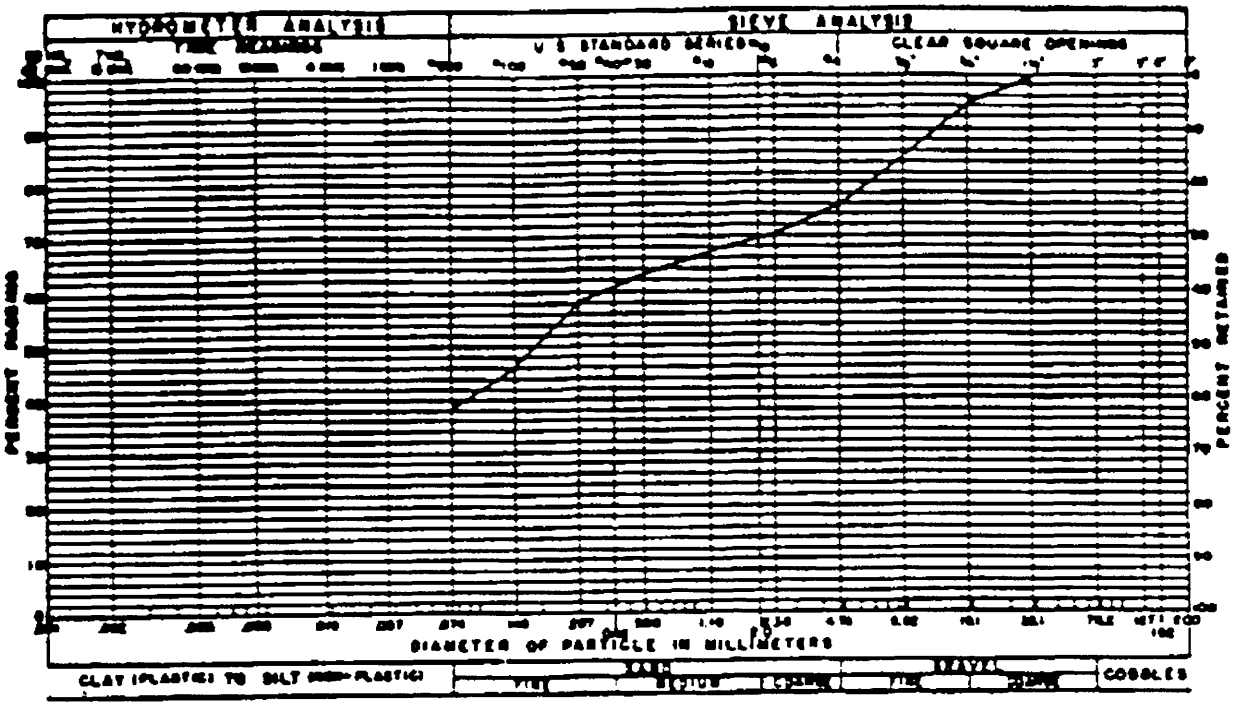
COPIES TO:

[illegible] Kirk [illegible]

CHEN AND ASSOCIATES

Consulting Engineers

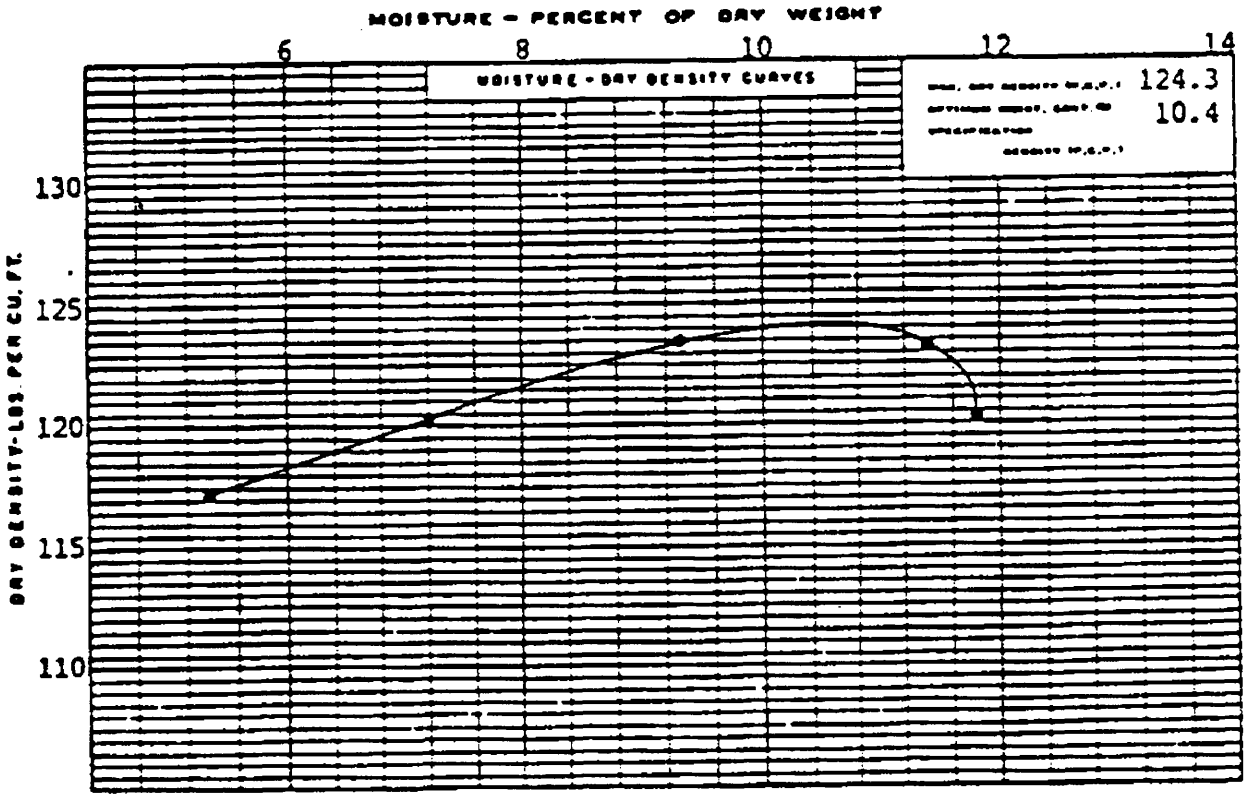
Soil and Foundation Engineering



GRADATION TEST RESULTS

GRAVEL 25 % SAND 37 % SILT AND CLAY 38 %

LIQUID LIMIT % PLASTICITY INDEX %



COMPACTION TEST RESULTS

COMPACTION TEST PROCEDURE ASTM D-698 Method C

SAMPLE OF Clayey Sand and Gravel

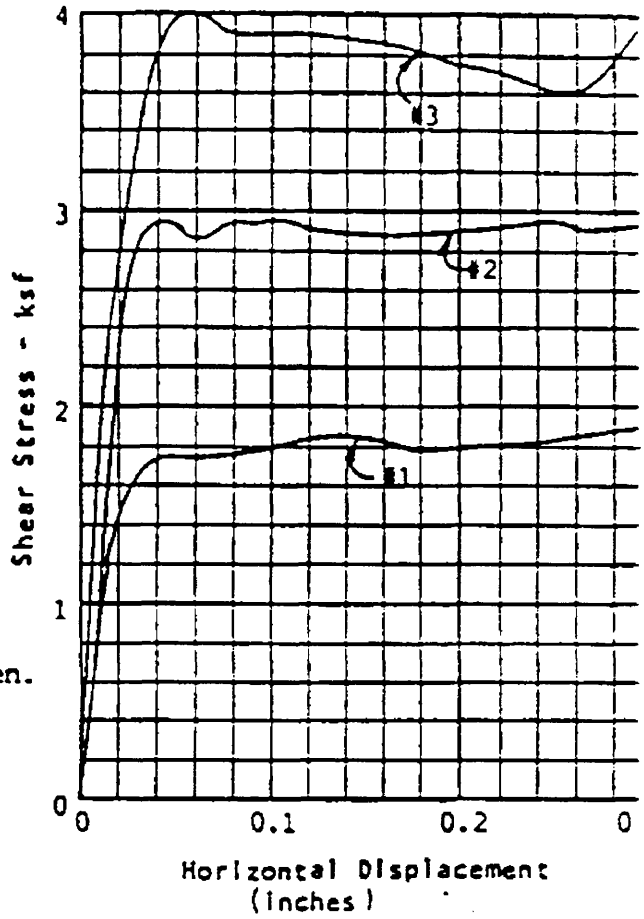
#525284 FROM DEPTH

CA-3

CHEN AND ASSOCIATES

Consulting Soil and Foundation Engineers

TEST NUMBER	1	2	3	4
LOCATION				
HEIGHT-INCH	.75	.75	.75	
DIAMETER-INCH	1.925	1.925	1.925	
WATER CONTENT - %	10.0	10.0	10.0	
DRY DENSITY - pcf	117.8	117.8	117.8	
CONSOL. LOAD - ksf	2.0	4.0	6.0	
NORMAL LOAD - ksf	2.0	4.0	6.0	
SHEAR STRESS - ksf	1.8	3.0	4.0	



TYPE OF SPECIMEN Remolded @ 95% Std.Proctor Den.

SOIL DESCRIPTION Clayey Sand and Gravel

TYPE OF TEST Consolidated-Undrained

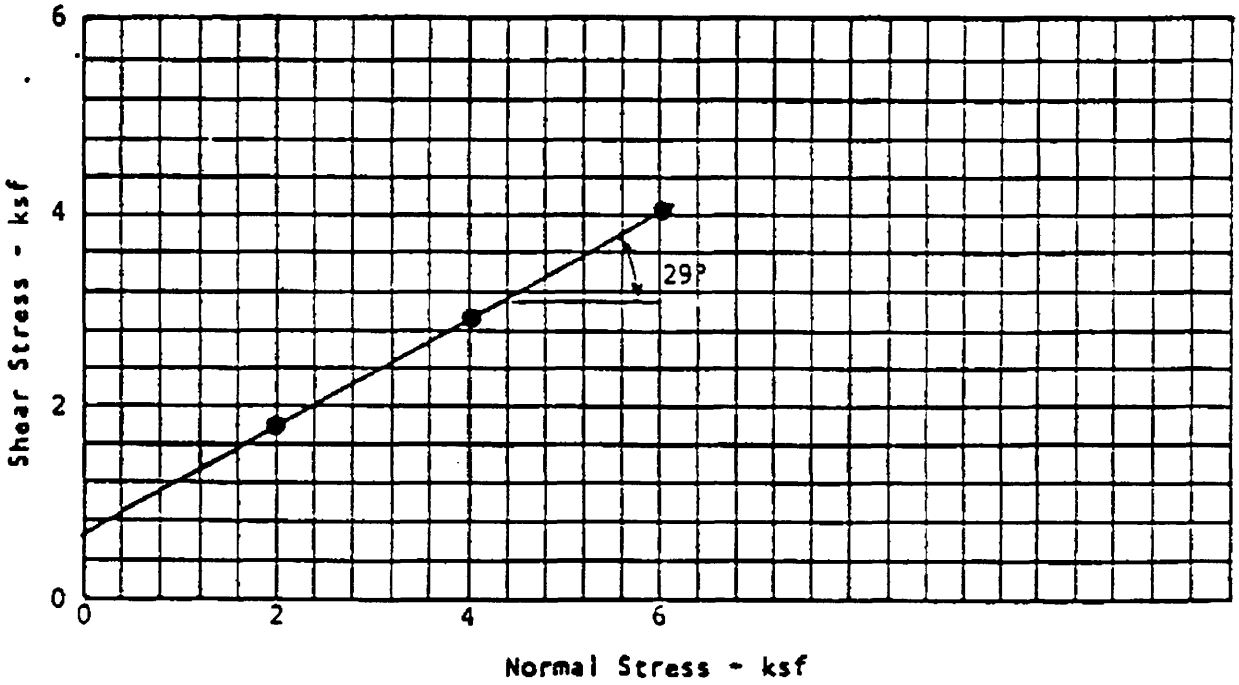
Saturated

Strain Rate 0.02 in/sec

TAN Ø

Ø 29°

COHESION - ksf 0.7



#525284

DIRECT SHEAR TEST RESULTS

HORROCKS ENGINEERS

7/12/83

SLOPE STABILITY ANALYSIS

for

CO-OP MINE - SLOPE STABILITY ** SEDIMENT POND A

DATA FILE: "CPSLOA:T14"

PROJECT NUMBER: 8309-42

by: EGN

WATER UNIT WEIGHT= 62.40

Interior Slope

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	108.0	94.0	10.0	4.57

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	255.8	-41.3	700	1.7	120.3	29	101.4
2	670.6	-29.1	700	1.7	315.4	29	103.2
3	994.6	-18.3	700	1.7	467.8	29	104.9
4	1248.6	-8.2	700	1.7	587.2	29	106.6
5	1441.1	1.7	700	1.7	677.7	29	108.3
6	1573.8	11.6	700	1.7	740.1	29	110.0
7	1642.9	21.9	700	1.7	772.6	29	111.7
8	1636.9	33.1	700	1.7	769.8	29	113.4
9	1527.4	46.0	700	1.7	718.3	29	115.1
10	702.7	58.1	700	.9	352.0	29	116.5
11	555.8	71.0	700	.9	326.0	29	117.4
12	69.9	83.6	700	.2	50.6	29	117.9

ITERATION	INITIAL	CALCULATED
1	1.0000	4.3859
2	4.3859	4.5570
3	4.5570	4.5669
4	4.5669	4.5674

FACTOR OF SAFETY= 4.57 AT X= 108 Y= 94 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	110.0	98.0	10.0	5.71

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	119.8	-26.5	700	1.4	56.3	29	105.5
2	327.1	-17.9	700	1.4	153.8	29	106.9
3	497.2	-9.6	700	1.4	233.8	29	108.3
4	633.8	-1.6	700	1.4	298.1	29	109.7
5	738.4	6.5	700	1.4	347.2	29	111.1
6	810.3	14.6	700	1.4	381.1	29	112.5
7	846.8	23.1	700	1.4	398.2	29	113.9
8	842.0	32.1	700	1.4	396.0	29	115.3
9	571.3	40.6	700	1.0	294.8	29	116.5
10	514.1	48.8	700	1.0	320.2	29	117.5
11	423.2	59.6	700	1.1	331.7	29	118.6
12	94.5	72.3	700	.7	94.5	29	119.5

ITERATION	INITIAL	CALCULATED
1	1.0000	4.9462
2	4.9462	5.6651
3	5.6651	5.7085
4	5.7085	5.7108

FACTOR OF SAFETY= 5.71 AT X= 110 Y= 98 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	104.0	98.0	10.0	10.14

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	35.5	-7.0	700	1.0	16.7	29	102.8
2	98.5	-1.5	700	1.0	46.3	29	103.7
3	150.9	4.1	700	1.0	71.0	29	104.7
4	192.6	9.6	700	1.0	90.6	29	105.7
5	223.2	15.3	700	1.0	105.0	29	106.6
6	242.0	21.1	700	1.0	113.8	29	107.6
7	247.7	27.2	700	1.0	116.5	29	108.6
8	238.3	33.6	700	1.0	112.1	29	109.5
9	210.4	40.6	700	1.0	99.0	29	110.5
10	158.0	48.4	700	1.0	74.3	29	111.5
11	68.2	57.8	700	1.0	32.1	29	112.4

ITERATION	INITIAL	CALCULATED
1	1.0000	8.2214
2	8.2214	10.0653
3	10.0653	10.1340
4	10.1340	10.1361

FACTOR OF SAFETY= 10.14 AT X= 104 Y= 98 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	109.0	98.0	15.0	3.94

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	74.3	-39.9	700	1.2	34.9	29	99.4
2	632.5	-31.7	700	2.3	297.4	29	101.1
3	1249.7	-21.9	700	2.3	587.7	29	103.4
4	1748.2	-12.7	700	2.3	822.2	29	105.7
5	2145.1	-3.8	700	2.3	1008.8	29	108.0
6	2446.9	4.9	700	2.3	1150.8	29	110.3
7	2653.4	13.8	700	2.3	1247.8	29	112.6
8	2756.6	23.1	700	2.3	1296.4	29	114.9
9	2400.4	32.3	700	2.0	1233.4	29	117.0
10	2639.8	43.5	700	2.5	1569.2	29	119.3
11	1738.0	59.6	700	2.5	1277.1	29	121.8
12	209.5	75.7	700	.9	209.5	29	123.4

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6937
2	3.6937	3.9291
3	3.9291	3.9432
4	3.9432	3.9440

FACTOR OF SAFETY= 3.94 AT X= 109 Y= 98 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

Interior Slope

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	94.0	15.0	4.09

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	549.4	-54.2	700	2.4	258.4	29	93.9
2	1283.4	-40.2	700	2.4	603.6	29	96.4
3	1755.6	-28.9	700	2.4	825.7	29	98.8
4	2488.6	-18.2	700	2.7	1170.4	29	101.3
5	3099.3	-7.7	700	2.7	1457.5	29	104.0
6	3555.5	2.6	700	2.7	1672.1	29	106.7
7	3861.2	12.9	700	2.7	1815.9	29	109.3
8	4004.5	23.7	700	2.7	1883.3	29	112.0
9	3950.6	35.5	700	2.7	1857.9	29	114.7
10	2756.1	47.5	700	2.0	1400.7	29	117.0
11	1680.6	58.4	700	1.4	961.8	29	118.7
12	1178.1	73.0	700	1.4	768.7	29	120.1
13	48.8	84.9	700	.1	42.6	29	120.9

ITERATION	INITIAL	CALCULATED
1	1.0000	5.0280
2	5.0280	4.1140
3	4.1140	4.0898
4	4.0898	4.0892

FACTOR OF SAFETY= 4.09 AT X= 106 Y= 94 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	105.0	101.0	15.0	4.90

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	3.3	-20.3	700	.4	1.5	29	99.8
2	182.2	-15.9	700	1.8	85.7	29	100.9
3	450.4	-9.0	700	1.8	211.8	29	102.7
4	672.6	-2.1	700	1.8	316.3	29	104.4
5	850.5	4.7	700	1.8	400.0	29	106.2
6	983.6	11.6	700	1.8	462.6	29	108.0
7	1069.7	18.6	700	1.8	503.0	29	109.8
8	1103.5	26.0	700	1.8	519.0	29	111.6
9	1076.2	33.8	700	1.8	506.1	29	113.3
10	970.8	42.6	700	1.8	456.5	29	115.1
11	457.1	50.1	700	1.0	241.1	29	116.5
12	358.3	56.6	700	1.0	246.9	29	117.5
13	93.8	61.6	700	.4	84.3	29	118.2
14	89.2	66.8	700	.8	89.2	29	118.8

ITERATION	INITIAL	CALCULATED
1	1.0000	4.1830
2	4.1830	4.8519
3	4.8519	4.8964
4	4.8964	4.8990

FACTOR OF SAFETY= 4.90 AT X= 105 Y= 101 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	102.0	15.0	5.22

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	153.5	-14.2	700	1.8	72.2	29	102.3
2	422.0	-7.1	700	1.8	198.5	29	104.2
3	641.7	-.1	700	1.8	301.8	29	106.0
4	813.8	6.9	700	1.8	382.7	29	107.8
5	937.2	14.0	700	1.8	440.8	29	109.6
6	1008.4	21.3	700	1.8	474.2	29	111.4
7	1020.4	29.1	700	1.8	479.9	29	113.3
8	960.7	37.4	700	1.8	451.8	29	115.1
9	466.7	44.5	700	1.0	245.6	29	116.5
10	398.2	50.1	700	1.0	265.7	29	117.5
11	215.7	55.6	700	.7	184.1	29	118.4
12	124.6	62.3	700	1.0	124.6	29	119.2

ITERATION	INITIAL	CALCULATED
1	1.0000	4.4326
2	4.4326	5.1679
3	5.1679	5.2127
4	5.2127	5.2151

FACTOR OF SAFETY= 5.22 AT X= 106 Y= 102 R= 15
EARTHQUAKE= .10

Interior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	109.0	100.0	20.0	3.78

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	591.0	-43.3	700	3.1	277.9	29	95.4
2	1457.2	-32.0	700	3.1	685.3	29	98.5
3	2405.2	-21.8	700	3.2	1131.2	29	101.6
4	3375.3	-12.2	700	3.2	1587.4	29	104.8
5	4137.1	-2.9	700	3.2	1945.6	29	108.0
6	4703.9	6.3	700	3.2	2212.2	29	111.2
7	5072.8	15.7	700	3.2	2385.7	29	114.4
8	3258.4	23.6	700	2.0	1636.9	29	117.0
9	4602.0	31.8	700	3.0	2572.6	29	119.5
10	3801.3	42.7	700	3.0	2385.6	29	122.5
11	2580.8	56.4	700	3.0	2001.1	29	125.5
12	1.2	64.2	700	.0	1.2	29	127.0
13	453.1	70.3	700	1.4	453.1	29	127.7

ITERATION	INITIAL	CALCULATED
1	1.0000	3.7806
2	3.7806	3.7785

FACTOR OF SAFETY= 3.78 AT X= 109 Y= 100 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	106.0	106.0	20.0	4.41

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1.1	-17.8	700	.2	.5	29	99.9
2	261.9	-14.1	700	2.3	123.2	29	101.1
3	686.1	-7.4	700	2.3	322.7	29	103.4
4	1038.0	-.8	700	2.3	488.2	29	105.7
5	1319.3	5.7	700	2.3	620.4	29	108.0
6	1528.9	12.4	700	2.3	719.0	29	110.3
7	1662.7	19.2	700	2.3	782.0	29	112.6
8	1712.6	26.3	700	2.3	805.4	29	114.9
9	1461.5	33.4	700	2.0	791.8	29	117.0
10	1055.6	40.0	700	1.7	701.8	29	118.8
11	742.9	46.7	700	1.7	614.1	29	120.5
12	353.9	55.1	700	2.0	353.9	29	122.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8643
2	3.8643	4.3791
3	4.3791	4.4085
4	4.4085	4.4100

FACTOR OF SAFETY= 4.41 AT X= 106 Y= 106 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	102.0	104.0	20.0	4.95

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	269.2	-27.2	700	2.8	126.6	29	92.9
2	667.8	-18.3	700	2.8	314.1	29	95.7
3	906.6	-9.9	700	2.8	426.4	29	98.6
4	1148.3	-1.9	700	2.7	540.0	29	101.3
5	1539.2	5.8	700	2.7	723.9	29	104.0
6	1816.1	13.5	700	2.7	854.1	29	106.7
7	1970.8	21.6	700	2.7	926.8	29	109.3
8	1985.5	30.1	700	2.7	933.7	29	112.0
9	1825.4	39.5	700	2.7	858.5	29	114.7
10	1114.1	48.8	700	2.0	628.5	29	117.0
11	462.2	56.4	700	1.3	366.0	29	118.6
12	141.8	63.0	700	1.1	141.8	29	119.8

ITERATION	INITIAL	CALCULATED
1	1.0000	4.5173
2	4.5173	4.9325
3	4.9325	4.9501
4	4.9501	4.9508

FACTOR OF SAFETY= 4.95 AT X= 102 Y= 104 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	87.00
2	100.00	87.00
3	116.00	95.00
4	118.00	96.00
5	127.00	96.00
6	156.00	81.50
7	200.00	81.50

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	3	2
3	3	6	2
4	6	7	2
5	3	4	1
6	4	5	1
7	5	6	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	102.0	107.0	20.0	6.40

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	103.9	-2.7	700	1.8	48.8	29	101.0
2	287.4	2.3	700	1.8	135.2	29	102.8
3	438.8	7.4	700	1.8	206.4	29	104.6
4	557.3	12.5	700	1.8	262.1	29	106.3
5	641.2	17.7	700	1.8	301.5	29	108.1
6	687.9	23.1	700	1.8	323.5	29	109.8
7	693.2	28.7	700	1.8	326.0	29	111.6
8	650.7	34.7	700	1.8	306.0	29	113.4
9	550.2	41.1	700	1.8	258.7	29	115.1
10	346.6	47.8	700	1.6	228.6	29	116.8
11	57.2	52.2	700	.4	57.2	29	117.8
12	42.8	54.9	700	.7	42.8	29	118.4

ITERATION	INITIAL	CALCULATED
1	1.0000	5.2973
2	5.2973	6.3473
3	6.3473	6.4019
4	6.4019	6.4043

FACTOR OF SAFETY= 6.40 AT X= 102 Y= 107 R= 20
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	53.0	86.0	10.0	4.67

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	.0	-63.4	700	.0	.0	29	44.1
2	403.4	-54.5	700	1.8	207.0	29	45.0
3	984.1	-39.8	700	1.8	512.6	29	46.7
4	1413.9	-26.7	700	1.8	747.1	29	48.5
5	1747.3	-15.6	700	1.8	936.3	29	50.3
6	2004.4	-5.1	700	1.8	1089.7	29	52.1
7	2192.7	5.2	700	1.8	1210.7	29	53.9
8	2312.3	15.6	700	1.8	1299.3	29	55.7
9	2355.5	26.7	700	1.8	1352.1	29	57.5
10	2302.3	39.1	700	1.8	1359.5	29	59.3
11	2097.9	54.6	700	1.8	1295.8	29	61.1
12	846.5	71.4	700	.9	562.6	29	62.4

ITERATION	INITIAL	CALCULATED
1	1.0000	5.9845
2	5.9845	4.6933
3	4.6933	4.6741
4	4.6741	4.6738

FACTOR OF SAFETY= 4.67 AT X= 53 Y= 86 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	92.0	10.0	7.29

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	15.8	-19.6	700	.6	15.8	29	46.6
2	143.2	-14.2	700	1.3	112.5	29	47.5
3	270.5	-6.9	700	1.3	188.3	29	48.8
4	373.8	.3	700	1.3	252.9	29	50.1
5	453.8	7.6	700	1.3	306.5	29	51.3
6	509.8	14.9	700	1.3	348.8	29	52.6
7	539.8	22.5	700	1.3	378.9	29	53.8
8	540.1	30.6	700	1.3	395.0	29	55.1
9	503.4	39.4	700	1.3	393.7	29	56.3
10	415.0	49.7	700	1.3	368.1	29	57.6
11	162.0	59.2	700	.7	162.0	29	58.6
12	72.6	68.8	700	.7	72.6	29	59.3

ITERATION	INITIAL	CALCULATED
1	1.0000	6.0224
2	6.0224	7.2216
3	7.2216	7.2876
4	7.2876	7.2907

FACTOR OF SAFETY= 7.29 AT X= 50 Y= 92 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	94.0	10.0	9.24

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	36.9	-11.2	700	.9	36.9	29	50.1
2	103.3	-5.8	700	.9	103.3	29	51.0
3	174.9	-.3	700	1.0	163.3	29	52.0
4	228.9	5.5	700	1.0	198.9	29	53.0
5	270.8	11.3	700	1.0	228.9	29	54.0
6	299.9	17.3	700	1.0	252.8	29	55.0
7	315.3	23.5	700	1.0	270.3	29	56.0
8	315.1	29.9	700	1.0	280.5	29	57.0
9	296.4	36.8	700	1.0	281.9	29	58.0
10	232.0	44.1	700	.9	232.0	29	58.9
11	173.4	51.9	700	.9	173.4	29	59.8
12	75.7	61.6	700	.9	75.7	29	60.8

ITERATION	INITIAL	CALCULATED
1	1.0000	7.5257
2	7.5257	9.1670
3	9.1670	9.2357
4	9.2357	9.2381

FACTOR OF SAFETY= 9.24 AT X= 52 Y= 94 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	46.0	92.0	10.0	13.12

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	6.4	-4.0	700	.4	6.4	29	45.3
2	48.3	-.3	700	.9	39.8	29	45.9
3	89.1	4.7	700	.9	66.6	29	46.8
4	122.1	9.7	700	.9	89.7	29	47.7
5	147.1	14.8	700	.9	109.0	29	48.5
6	163.6	20.0	700	.9	124.4	29	49.4
7	171.0	25.3	700	.9	135.5	29	50.3
8	168.0	31.0	700	.9	141.6	29	51.1
9	152.7	37.8	700	.9	142.1	29	52.0
10	101.1	42.8	700	.7	101.1	29	52.8
11	71.7	48.5	700	.7	71.7	29	53.5
12	28.7	54.9	700	.7	28.7	29	54.2

ITERATION	INITIAL	CALCULATED
1	1.0000	10.5338
2	10.5338	13.0454
3	13.0454	13.1176
4	13.1176	13.1192

FACTOR OF SAFETY= 13.12 AT X= 46 Y= 92 R= 10
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

Exterior Slope

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	57.0	90.0	15.0	3.50

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	.2	-56.4	700	.0	.2	29	44.5
2	771.2	-48.6	700	2.7	412.6	29	45.9
3	1918.5	-34.7	700	2.7	1023.9	29	48.5
4	2790.9	-23.0	700	2.7	1505.9	29	51.2
5	3470.9	-12.2	700	2.7	1897.5	29	53.8
6	3991.0	-2.0	700	2.7	2213.8	29	56.5
7	4361.8	8.3	700	2.7	2460.0	29	59.2
8	4578.8	18.8	700	2.7	2633.8	29	61.8
9	4619.4	30.0	700	2.7	2724.6	29	64.5
10	4426.6	42.9	700	2.7	2705.7	29	67.1
11	3832.4	60.1	700	2.7	2498.0	29	69.8
12	894.7	78.3	700	.8	658.1	29	71.5

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6880
2	3.6880	3.5051
3	3.5051	3.4972
4	3.4972	3.4969

FACTOR OF SAFETY= 3.50 AT X= 57 Y= 90 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	98.0	15.0	4.45

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	105.4	-26.1	700	1.3	105.4	29	51.4
2	558.7	-19.0	700	2.1	458.1	29	53.1
3	959.9	-10.7	700	2.1	691.9	29	55.2
4	1282.8	-2.5	700	2.1	889.0	29	57.3
5	1531.3	5.6	700	2.1	1051.0	29	59.5
6	1704.3	13.8	700	2.1	1177.6	29	61.6
7	1796.2	22.3	700	2.1	1266.0	29	63.7
8	1793.9	31.4	700	2.1	1310.1	29	65.8
9	1670.8	41.5	700	2.1	1297.4	29	67.9
10	1365.3	53.8	700	2.1	1198.9	29	70.0
11	624.6	71.3	700	1.8	624.6	29	72.0

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8124
2	3.8124	4.4023
3	4.4023	4.4514
4	4.4514	4.4550

FACTOR OF SAFETY= 4.45 AT X= 58 Y= 98 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	96.0	15.0	4.70

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	7.3	-23.9	700	.4	7.3	29	45.9
2	264.1	-19.3	700	1.9	182.7	29	47.0
3	593.0	-11.8	700	1.9	373.9	29	48.9
4	864.7	-4.5	700	1.9	538.1	29	50.8
5	1082.3	2.8	700	1.9	676.8	29	52.7
6	1246.0	10.1	700	1.9	790.2	29	54.6
7	1353.5	17.6	700	1.9	877.2	29	56.5
8	1398.9	25.4	700	1.9	934.9	29	58.4
9	1371.1	33.8	700	1.9	958.3	29	60.3
10	1248.9	43.1	700	1.9	937.2	29	62.2
11	985.1	54.3	700	1.9	849.5	29	64.1
12	412.6	69.1	700	1.6	412.6	29	65.9

ITERATION	INITIAL	CALCULATED
1	1.0000	3.9771
2	3.9771	4.6404
3	4.6404	4.6925
4	4.6925	4.6961

FACTOR OF SAFETY= 4.70 AT X= 52 Y= 96 R= 15
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	220.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	47.0	97.0	15.0	8.30

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	7.2	-6.0	700	.4	7.2	29	45.4
2	113.9	-2.4	700	1.4	88.1	29	46.4
3	233.3	3.1	700	1.4	165.0	29	47.8
4	329.4	8.6	700	1.4	231.0	29	49.2
5	401.6	14.2	700	1.4	285.8	29	50.7
6	448.4	19.9	700	1.4	328.6	29	52.1
7	467.3	25.9	700	1.4	358.3	29	53.5
8	454.3	32.2	700	1.4	373.0	29	55.0
9	403.0	38.9	700	1.4	369.7	29	56.4
10	302.2	46.4	700	1.4	302.2	29	57.8
11	128.9	55.2	700	1.4	128.9	29	59.3

ITERATION	INITIAL	CALCULATED
1	1.0000	6.7507
2	6.7507	8.2322
3	8.2322	8.2974
4	8.2974	8.2998

FACTOR OF SAFETY= 8.30 AT X= 47 Y= 97 R= 15
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	95.0	20.0	3.00

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	35.8	-46.0	700	.8	16.8	29	43.6
2	1141.1	-38.5	700	3.2	589.3	29	45.6
3	2540.2	-27.4	700	3.2	1352.6	29	48.8
4	3653.0	-17.4	700	3.2	1981.2	29	52.1
5	4537.0	-7.8	700	3.2	2502.2	29	55.3
6	5216.8	1.4	700	3.2	2927.2	29	58.5
7	5698.1	10.8	700	3.2	3258.8	29	61.7
8	5970.8	20.4	700	3.2	3491.9	29	64.9
9	5999.8	30.7	700	3.2	3611.2	29	68.2
10	5713.3	42.3	700	3.2	3581.8	29	71.4
11	3659.4	54.7	700	2.4	2377.4	29	74.2
12	2355.2	72.4	700	2.4	1638.0	29	76.7
13	25.1	85.6	700	.1	25.1	29	77.9

ITERATION	INITIAL	CALCULATED
1	1.0000	2.8932
2	2.8932	2.9918
3	2.9918	2.9982
4	2.9982	2.9986

FACTOR OF SAFETY= 3.00 AT X= 58 Y= 95 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	20.0	4.21

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	58.1	-19.9	700	1.6	27.3	29	43.2
2	468.3	-13.7	700	2.5	252.9	29	45.3
3	981.2	-6.3	700	2.5	559.4	29	47.8
4	1395.7	1.0	700	2.5	819.6	29	50.3
5	1713.5	8.3	700	2.5	1034.4	29	52.9
6	1931.5	15.8	700	2.5	1202.2	29	55.4
7	2040.9	23.5	700	2.5	1319.0	29	58.0
8	2024.6	31.7	700	2.5	1376.5	29	60.5
9	1849.6	40.8	700	2.5	1359.5	29	63.0
10	1446.3	51.5	700	2.5	1235.2	29	65.6
11	603.2	65.0	700	2.3	603.2	29	68.0

ITERATION	INITIAL	CALCULATED
1	1.0000	3.6025
2	3.6025	4.1625
3	4.1625	4.2063
4	4.2063	4.2093

FACTOR OF SAFETY= 4.21 AT X= 50 Y= 100 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	102.0	20.0	4.61

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	21.2	-14.9	700	.7	21.2	29	46.9
2	355.1	-10.6	700	2.3	266.6	29	48.3
3	733.9	-4.0	700	2.3	496.7	29	50.6
4	1043.7	2.5	700	2.3	694.3	29	52.9
5	1284.8	9.0	700	2.3	859.6	29	55.1
6	1454.7	15.7	700	2.3	991.5	29	57.4
7	1547.7	22.6	700	2.3	1087.2	29	59.7
8	1553.5	29.8	700	2.3	1141.9	29	61.9
9	1453.8	37.6	700	2.3	1146.9	29	64.2
10	1214.3	46.5	700	2.3	1086.2	29	66.4
11	581.7	55.0	700	1.5	581.7	29	68.4
12	250.1	64.0	700	1.5	250.1	29	69.9

ITERATION	INITIAL	CALCULATED
1	1.0000	3.8773
2	3.8773	4.5600
3	4.5600	4.6115
4	4.6115	4.6148

FACTOR OF SAFETY= 4.61 AT X= 52 Y= 102 R= 20
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	46.0	102.0	20.0	7.88

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	6.6	-2.1	700	.5	6.6	29	45.3
2	125.4	.9	700	1.6	97.1	29	46.3
3	263.6	5.6	700	1.6	189.0	29	47.9
4	376.1	10.3	700	1.6	268.7	29	49.6
5	461.9	15.1	700	1.6	335.9	29	51.2
6	519.5	20.0	700	1.6	389.8	29	52.8
7	546.5	25.0	700	1.6	429.3	29	54.4
8	539.3	30.3	700	1.6	452.8	29	56.1
9	492.6	35.9	700	1.6	457.6	29	57.7
10	338.0	41.3	700	1.3	338.0	29	59.2
11	239.0	46.7	700	1.3	239.0	29	60.5
12	94.8	52.7	700	1.3	94.8	29	61.9

ITERATION	INITIAL	CALCULATED
1	1.0000	6.4094
2	6.4094	7.8126
3	7.8126	7.8758
4	7.8758	7.8782

FACTOR OF SAFETY= 7.88 AT X= 46 Y= 102 R= 20
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	57.0	99.0	25.0	2.82

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	330.9	-41.8	700	2.4	155.6	29	40.4
2	876.6	-34.7	700	2.4	412.3	29	42.8
3	2938.2	-26.0	700	4.1	1468.8	29	46.1
4	4718.6	-15.8	700	4.1	2480.1	29	50.2
5	6119.1	-6.1	700	4.1	3312.9	29	54.4
6	7176.4	3.5	700	4.1	3984.1	29	58.5
7	7894.5	13.1	700	4.1	4495.8	29	62.6
8	8246.7	23.1	700	4.1	4835.5	29	66.8
9	8162.1	34.1	700	4.1	4969.8	29	70.9
10	7138.5	47.0	700	4.3	4419.6	29	75.1
11	4073.3	66.5	700	4.3	2595.1	29	79.4
12	35.2	81.0	700	.3	35.2	29	81.7

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7148
2	2.7148	2.8136
3	2.8136	2.8196
4	2.8196	2.8200

FACTOR OF SAFETY= 2.82 AT X= 57 Y= 99 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	25.0	3.27

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	633.0	-37.1	700	3.6	297.7	29	35.0
2	1590.7	-27.2	700	3.6	748.1	29	38.6
3	2230.1	-18.2	700	3.6	1048.8	29	42.2
4	3526.1	-9.1	700	4.1	1745.3	29	46.1
5	4688.1	.5	700	4.1	2465.8	29	50.2
6	5512.7	10.1	700	4.1	3027.7	29	54.4
7	5983.5	20.0	700	4.1	3423.1	29	58.5
8	6046.2	30.5	700	4.1	3626.6	29	62.6
9	5573.1	42.5	700	4.1	3578.2	29	66.8
10	4216.0	57.9	700	4.1	3114.0	29	70.9
11	302.4	68.5	700	.5	284.9	29	73.2
12	376.3	75.4	700	1.2	376.3	29	74.1

ITERATION	INITIAL	CALCULATED
1	1.0000	3.0608
2	3.0608	3.2527
3	3.2527	3.2655
4	3.2655	3.2663

FACTOR OF SAFETY= 3.27 AT X= 50 Y= 100 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	48.0	106.0	25.0	4.72

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	10.8	-10.3	700	1.0	5.1	29	43.5
2	283.9	-6.3	700	2.5	164.9	29	45.2
3	692.3	-.6	700	2.5	419.6	29	47.7
4	1028.1	5.1	700	2.5	640.2	29	50.2
5	1290.4	10.9	700	2.5	826.3	29	52.7
6	1475.9	16.7	700	2.5	976.3	29	55.2
7	1578.7	22.8	700	2.5	1087.3	29	57.7
8	1588.6	29.2	700	2.5	1154.6	29	60.2
9	1488.9	36.0	700	2.5	1170.4	29	62.6
10	1251.1	43.4	700	2.5	1121.3	29	65.1
11	687.7	50.9	700	1.9	687.7	29	67.4
12	284.9	58.7	700	1.9	284.9	29	69.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.9636
2	3.9636	4.6680
3	4.6680	4.7174
4	4.7174	4.7203

FACTOR OF SAFETY= 4.72 AT X= 48 Y= 106 R= 25
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	42.0	106.0	25.0	11.03

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	56.9	-8.8	700	2.3	26.7	29	38.2
2	124.8	-3.4	700	2.3	58.7	29	40.5
3	133.1	1.9	700	2.3	62.6	29	42.8
4	210.3	7.0	700	2.1	121.7	29	45.1
5	386.5	12.0	700	2.1	250.1	29	47.2
6	514.6	17.0	700	2.1	355.9	29	49.3
7	591.2	22.2	700	2.1	437.5	29	51.4
8	611.2	27.5	700	2.1	492.5	29	53.5
9	566.4	33.2	700	2.1	517.0	29	55.7
10	477.6	39.5	700	2.3	477.6	29	57.9
11	202.3	46.9	700	2.3	202.3	29	60.2

ITERATION	INITIAL	CALCULATED
1	1.0000	9.4221
2	9.4221	10.9930
3	10.9930	11.0292
4	11.0292	11.0299

FACTOR OF SAFETY= 11.03 AT X= 42 Y= 106 R= 25
EARTHQUAKE= .10

Exterior Slope

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	55.0	102.0	30.0	2.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	763.6	-42.2	700	3.6	359.1	29	34.9
2	1963.7	-33.4	700	3.6	923.5	29	38.5
3	2836.0	-25.4	700	3.6	1333.7	29	42.2
4	5382.9	-16.7	700	4.8	2650.0	29	46.4
5	7339.0	-7.2	700	4.8	3806.8	29	51.3
6	8837.8	2.1	700	4.8	4748.5	29	56.1
7	9889.4	11.4	700	4.8	5480.0	29	60.9
8	10466.6	21.1	700	4.8	5988.3	29	65.8
9	10491.6	31.5	700	4.8	6236.9	29	70.6
10	8552.9	42.7	700	4.5	5132.4	29	75.3
11	5806.7	56.4	700	4.5	3414.4	29	79.8
12	1006.1	69.7	700	2.0	577.7	29	83.0
13	6.3	75.8	700	.2	3.0	29	84.1

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7349
2	2.7349	2.7707
3	2.7707	2.7723

FACTOR OF SAFETY= 2.77 AT X= 55 Y= 102 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	30.0	3.00

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1382.1	-45.9	700	4.4	612.4	29	28.6
2	3222.5	-34.7	700	4.4	1515.5	29	33.0
3	4525.5	-24.9	700	4.4	2128.3	29	37.4
4	5373.3	-15.9	700	4.4	2527.0	29	41.8
5	7113.4	-6.9	700	4.8	3463.8	29	46.4
6	8596.8	2.4	700	4.8	4398.3	29	51.3
7	9632.8	11.7	700	4.8	5122.4	29	56.1
8	10192.6	21.4	700	4.8	5622.5	29	60.9
9	10196.3	31.8	700	4.8	5861.2	29	65.8
10	9460.9	43.7	700	4.8	5752.2	29	70.6
11	4878.3	55.3	700	3.1	3112.1	29	74.6
12	2775.9	68.9	700	3.1	1916.7	29	77.7
13	80.3	79.8	700	.5	80.3	29	79.5

ITERATION	INITIAL	CALCULATED
1	1.0000	3.0347
2	3.0347	2.9976
3	2.9976	2.9960

FACTOR OF SAFETY= 3.00 AT X= 50 Y= 100 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	45.0	105.0	30.0	3.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	827.9	-33.4	700	4.4	389.4	29	28.6
2	2069.8	-23.7	700	4.4	973.4	29	33.0
3	2867.2	-14.8	700	4.4	1348.4	29	37.4
4	3289.0	-6.2	700	4.4	1546.8	29	41.8
5	4095.7	2.5	700	4.6	2031.9	29	46.3
6	5028.9	11.3	700	4.6	2682.2	29	50.8
7	5562.9	20.4	700	4.6	3144.8	29	55.4
8	5638.5	30.1	700	4.6	3391.7	29	60.0
9	5126.7	40.9	700	4.6	3362.5	29	64.5
10	3713.4	54.2	700	4.6	2909.2	29	69.1
11	614.8	65.3	700	1.6	614.8	29	72.2
12	67.7	78.8	700	.6	67.7	29	73.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.5111
2	3.5111	3.7524
3	3.7524	3.7651
4	3.7651	3.7657

FACTOR OF SAFETY= 3.77 AT X= 45 Y= 105 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	116	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	52.0	112.0	30.0	3.84

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	18.1	-10.6	700	.7	18.1	29	46.5
2	481.0	-7.1	700	2.9	352.3	29	48.3
3	1055.4	-1.6	700	2.9	708.2	29	51.2
4	1532.7	4.0	700	2.9	1018.5	29	54.1
5	1912.4	9.6	700	2.9	1282.8	29	57.0
6	2190.9	15.3	700	2.9	1499.7	29	59.9
7	2361.4	21.2	700	2.9	1665.6	29	62.8
8	2412.2	27.3	700	2.9	1775.3	29	65.7
9	2324.4	33.7	700	2.9	1819.9	29	68.6
10	2067.1	40.8	700	2.9	1784.7	29	71.5
11	594.6	45.8	700	1.0	570.9	29	73.5
12	674.7	49.7	700	1.7	674.7	29	74.9
13	247.9	55.0	700	1.7	247.9	29	76.5

ITERATION	INITIAL	CALCULATED
1	1.0000	3.3179
2	3.3179	3.8044
3	3.8044	3.8394
4	3.8394	3.8416

FACTOR OF SAFETY= 3.84 AT X= 52 Y= 112 R= 30
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

Exterior Slope

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	55.0	105.0	35.0	2.77

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1457.3	-42.3	700	5.0	685.4	29	31.6
2	3654.5	-32.0	700	5.0	1718.7	29	36.5
3	5159.2	-22.7	700	5.0	2426.3	29	41.5
4	8198.8	-13.4	700	5.8	4026.3	29	46.9
5	10777.7	-3.8	700	5.8	5580.3	29	52.7
6	12690.9	5.8	700	5.8	6821.2	29	58.5
7	13932.5	15.5	700	5.8	7746.2	29	64.3
8	14433.5	25.7	700	5.8	8322.9	29	70.1
9	10361.9	35.5	700	4.5	5983.1	29	75.3
10	8347.7	45.2	700	4.5	4609.4	29	79.8
11	2709.4	53.2	700	2.0	1378.7	29	83.0
12	2466.0	63.0	700	3.9	1159.7	29	85.9

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7941
2	2.7941	2.7726
3	2.7726	2.7720

FACTOR OF SAFETY= 2.77 AT X= 55 Y= 105 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	58.0	108.0	35.0	2.79

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	919.2	-36.3	700	4.4	432.3	29	37.4
2	2358.1	-27.7	700	4.4	1109.0	29	41.8
3	4404.6	-19.4	700	4.8	2189.9	29	46.4
4	6529.5	-11.1	700	4.8	3426.1	29	51.3
5	8249.6	-3.1	700	4.8	4471.9	29	56.1
6	9586.2	4.8	700	4.8	5337.4	29	60.9
7	10536.8	12.8	700	4.8	6021.3	29	65.8
8	11075.8	21.1	700	4.8	6511.3	29	70.6
9	9782.4	29.6	700	4.5	5710.6	29	75.3
10	8174.9	38.6	700	4.5	4528.1	29	79.8
11	2826.0	45.6	700	2.0	1433.6	29	83.0
12	3608.6	55.7	700	5.3	1697.1	29	86.7

ITERATION	INITIAL	CALCULATED
1	1.0000	2.7363
2	2.7363	2.7910
3	2.7910	2.7928

FACTOR OF SAFETY= 2.79 AT X= 58 Y= 108 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	50.0	100.0	35.0	2.93

SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	2844.9	-50.4	700	5.9	1337.9	29	23.3
2	6727.7	-36.7	700	5.9	3164.0	29	29.2
3	9199.3	-25.3	700	5.9	4326.3	29	35.1
4	10706.7	-14.9	700	5.9	5035.2	29	41.0
5	12170.2	-5.1	700	5.8	5894.0	29	46.9
6	14174.3	4.4	700	5.8	7177.7	29	52.7
7	15511.8	14.1	700	5.8	8147.4	29	58.5
8	16121.3	24.2	700	5.8	8775.6	29	64.3
9	15853.2	35.3	700	5.8	8990.6	29	70.1
10	10727.7	46.4	700	4.5	6155.1	29	75.3
11	7653.3	58.9	700	4.5	4282.8	29	79.8
12	1687.3	71.2	700	2.0	898.1	29	83.0
13	128.2	78.8	700	.6	60.3	29	84.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.2239
2	3.2239	2.9346
3	2.9346	2.9289
4	2.9289	2.9287

FACTOR OF SAFETY= 2.93 AT X= 50 Y= 100 R= 35
EARTHQUAKE= .10

WATER UNIT WEIGHT= 62.40

POINT	X-ORD	Y-ORD
1	0.00	81.50
2	44.00	81.50
3	73.00	96.00
4	82.00	96.00
5	84.00	95.00
6	100.00	87.00
7	200.00	87.00

LINE	LEFT	RIGHT	SOIL
1	1	2	2
2	2	5	2
3	5	6	2
4	6	7	2
5	2	3	1
6	3	4	1
7	4	5	1

SOIL	UNIT WEIGHT	COHESION	ø	SATURATED
1	118	700	29	NO
2	118	700	29	YES

CIRCLE	X-ORD	Y-ORD	RADIUS	FACTOR OF SAFETY
	45.0	105.0	35.0	3.20

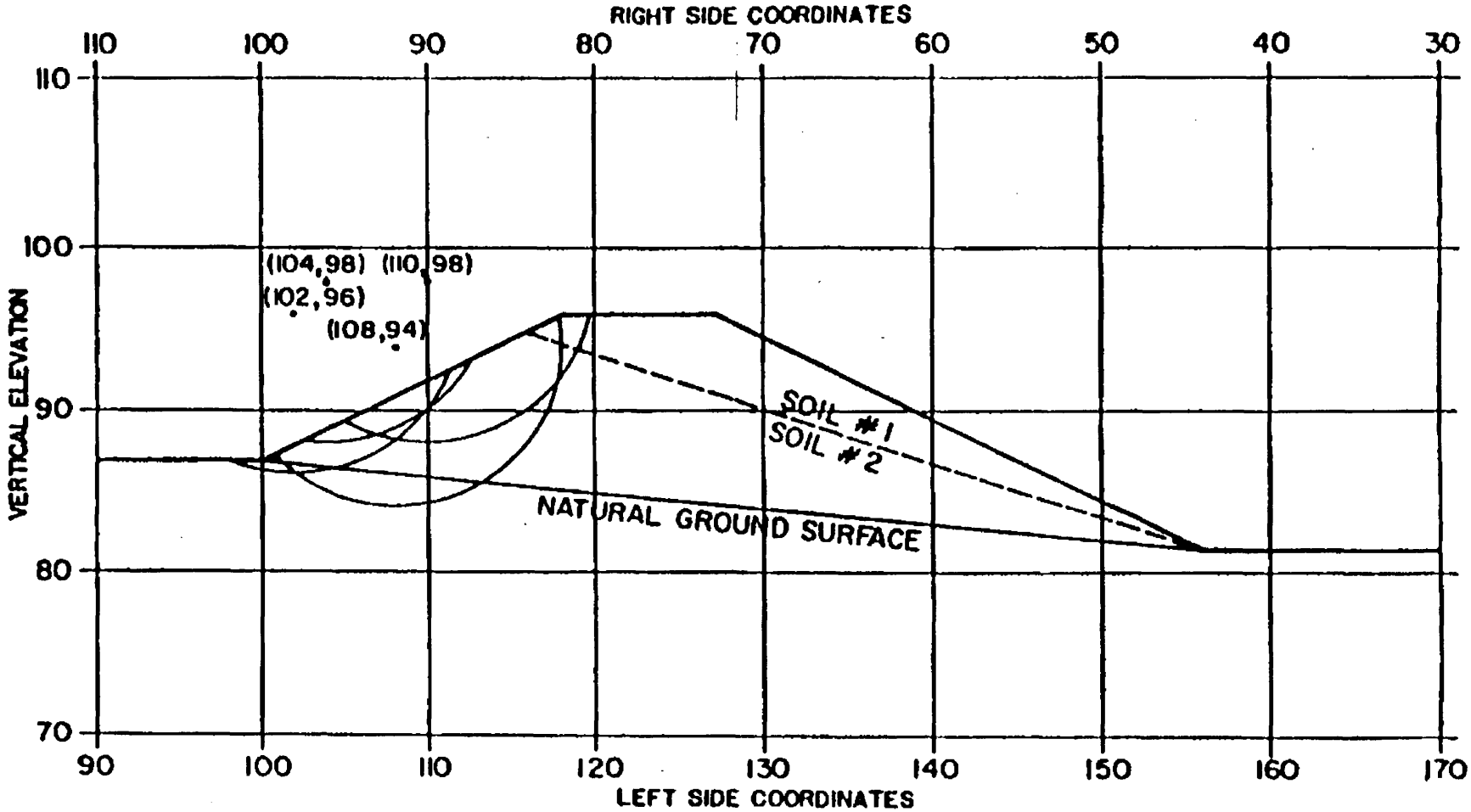
SLICE	WEIGHT	INCLINATION	COHESION	WIDTH	EFF WEIGHT	ø	X
1	1462.0	-42.3	700	5.0	687.5	29	21.6
2	3665.2	-32.0	700	5.0	1723.7	29	26.5
3	5173.8	-22.7	700	5.0	2432.8	29	31.5
4	6143.7	-14.1	700	5.0	2889.3	29	36.5
5	6653.8	-5.7	700	5.0	3129.2	29	41.5
6	8812.7	3.1	700	5.8	4315.1	29	46.9
7	10243.5	12.8	700	5.8	5329.1	29	52.7
8	10960.3	22.8	700	5.8	6007.3	29	58.5
9	10827.8	33.7	700	5.8	6286.1	29	64.3
10	9526.0	46.2	700	5.8	6015.0	29	70.1
11	4743.0	61.5	700	4.9	3409.3	29	75.4
12	190.1	72.5	700	1.0	190.1	29	78.3

ITERATION	INITIAL	CALCULATED
1	1.0000	3.1718
2	3.1718	3.1953
3	3.1953	3.1962

FACTOR OF SAFETY= 3.20 AT X= 45 Y= 105 R= 35
EARTHQUAKE= .10

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 10'

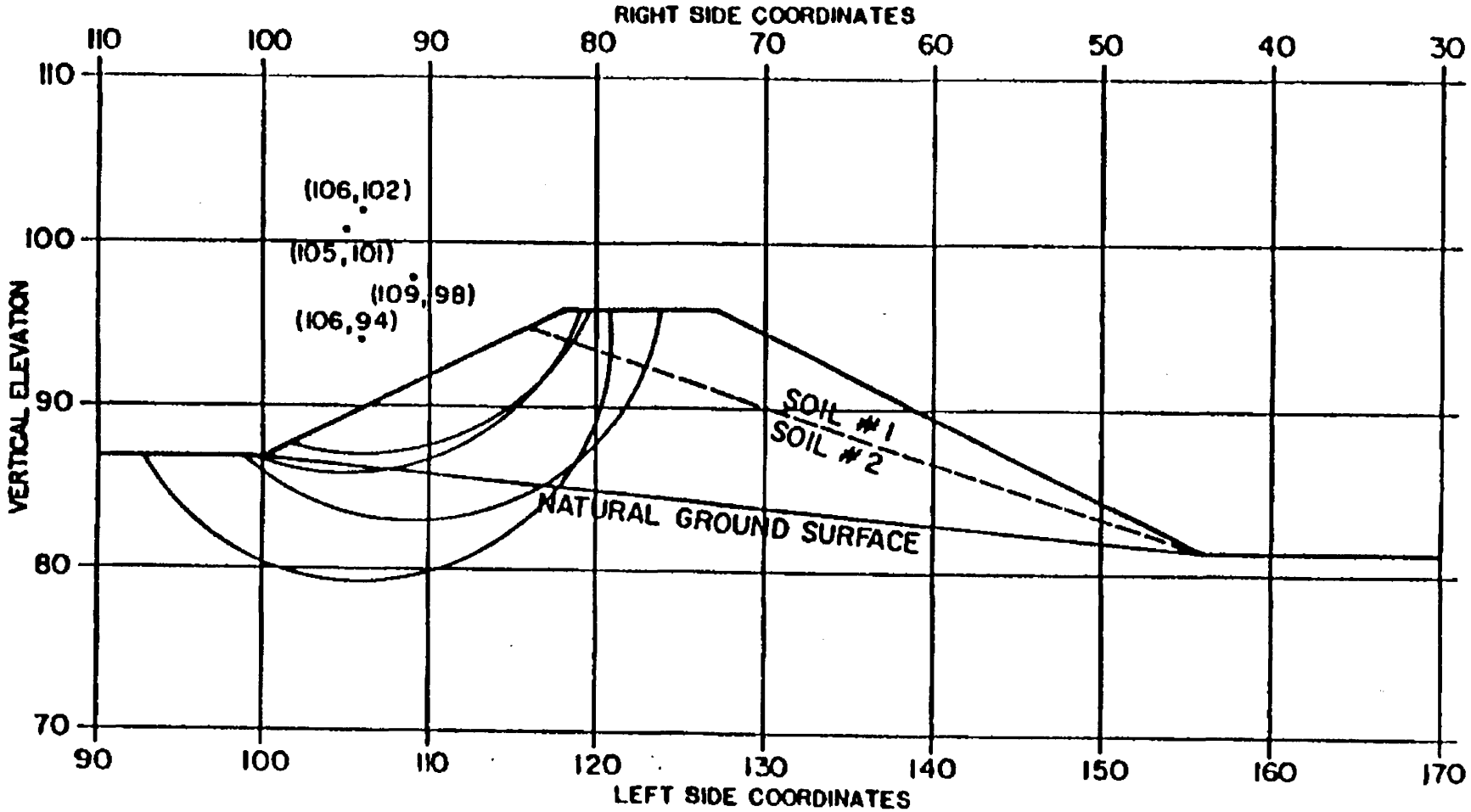
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 15'

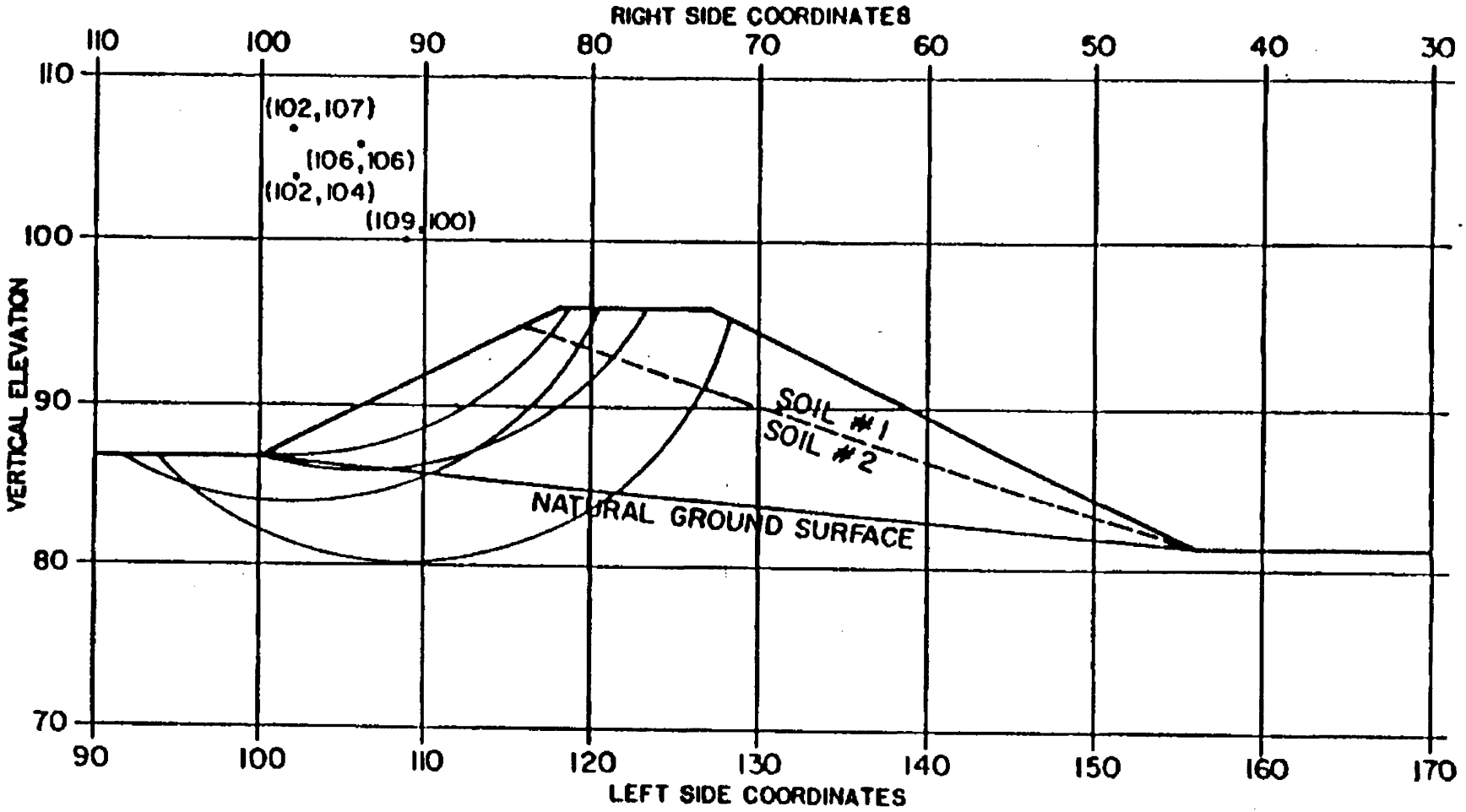
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CARILLO ENGINEERS

BEAR CREEK CANYON MINE - SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 20'

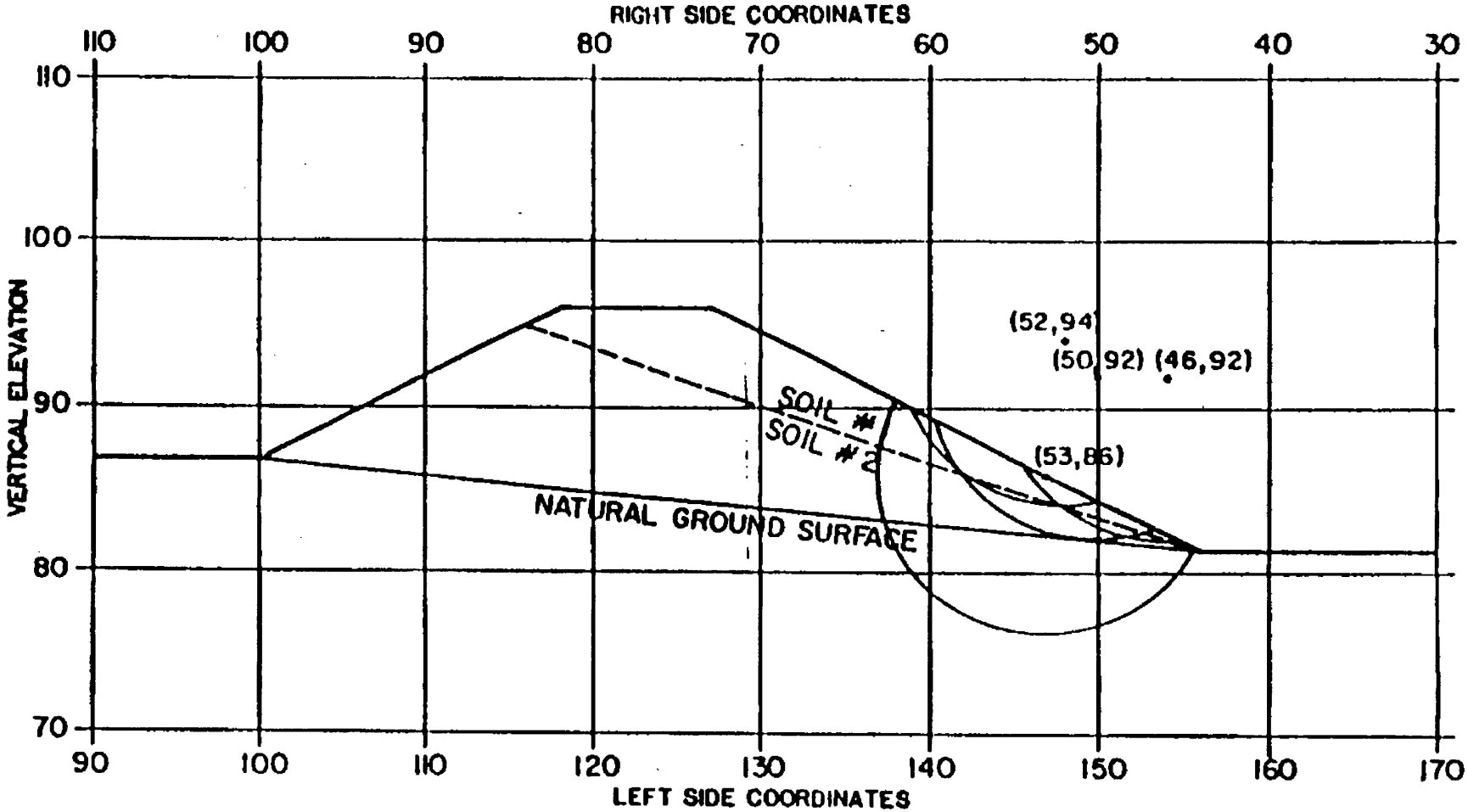
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CARILLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 10'

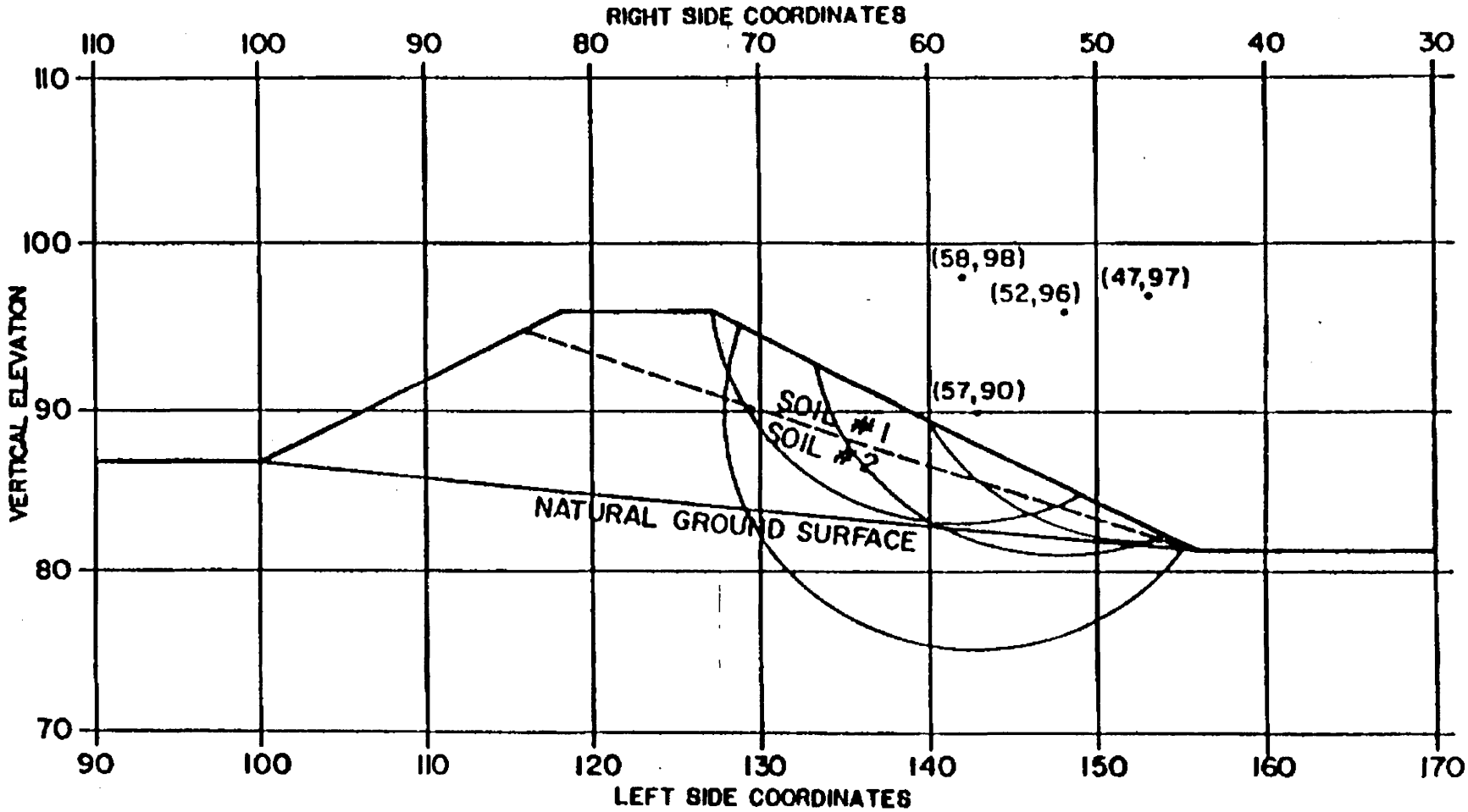
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CARCILO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 15'

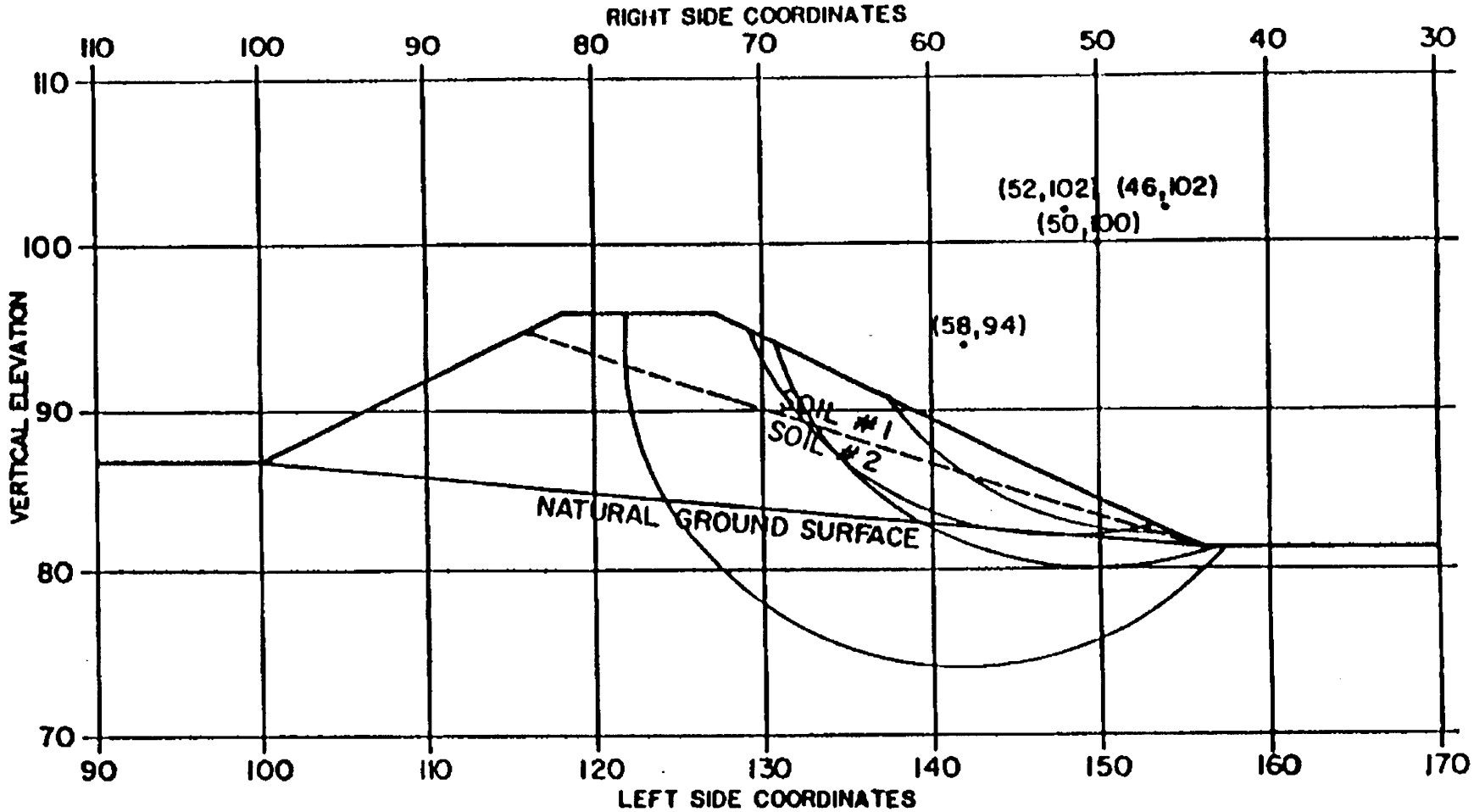
CO-OP MINING COMPANY

SCALE 1" = 10'

KORROCKS CARDILLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



CO-OP MINING COMPANY

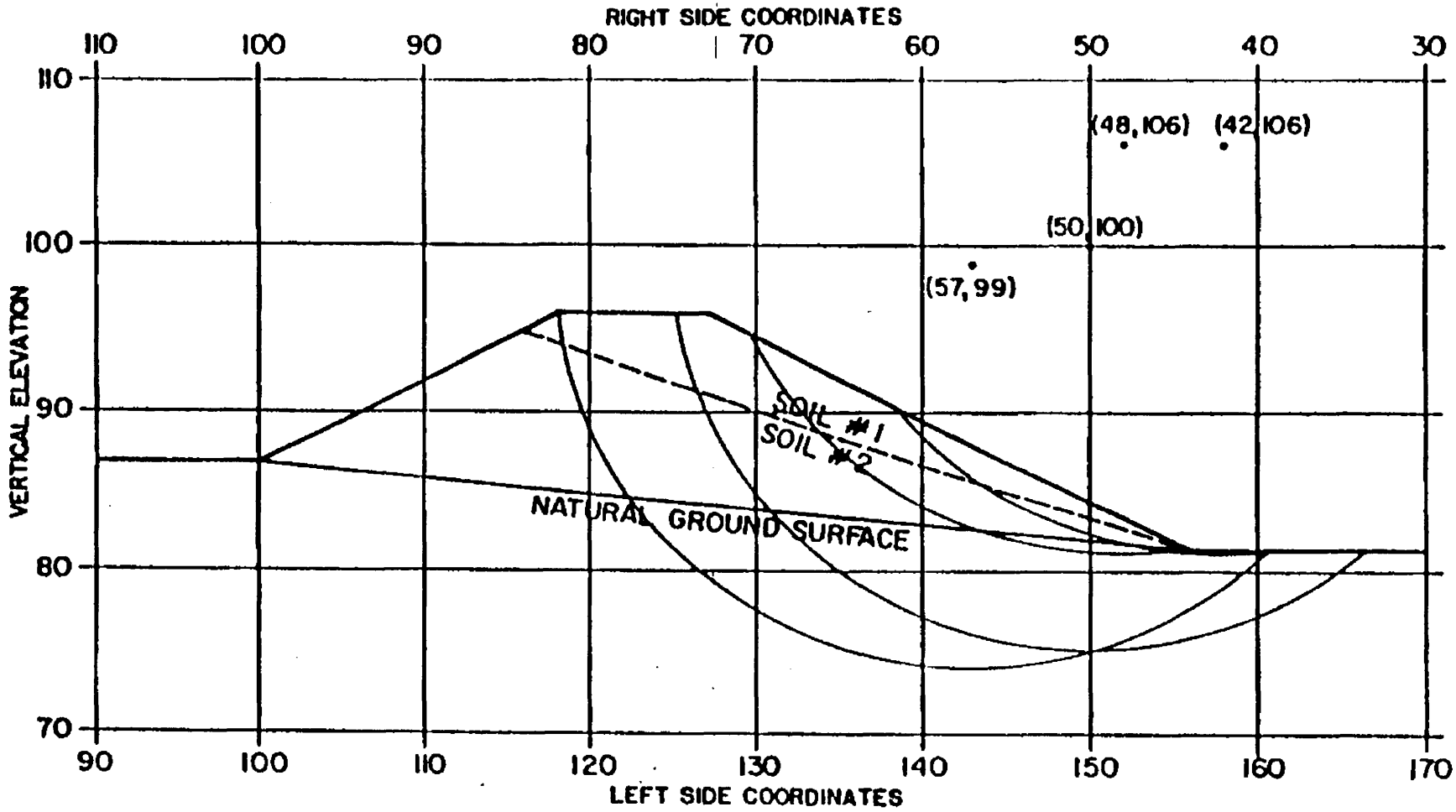
RADIUS = 20'

SCALE 1" = 10'

HORROCKS CARDILLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 25'

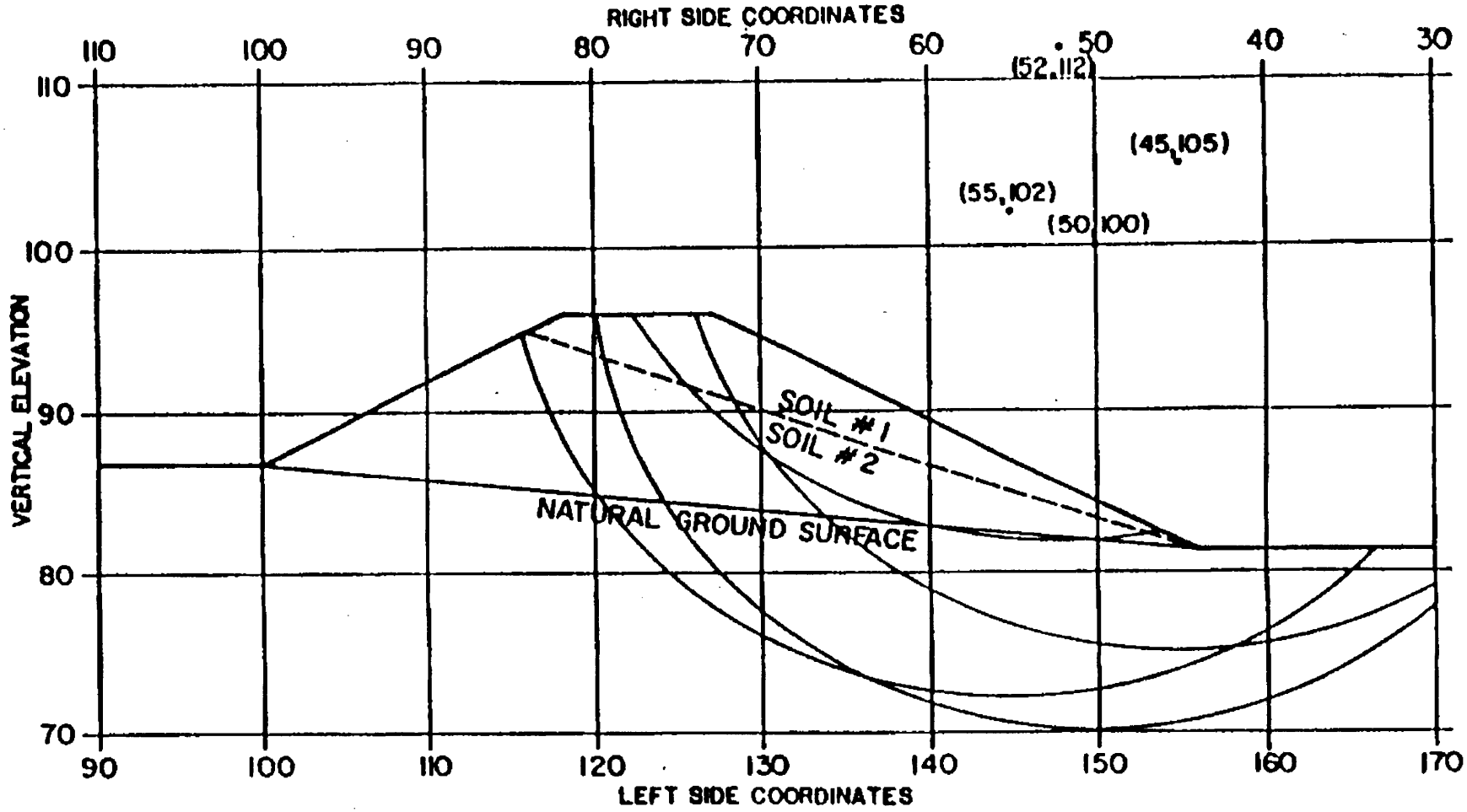
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CARDILLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 30'

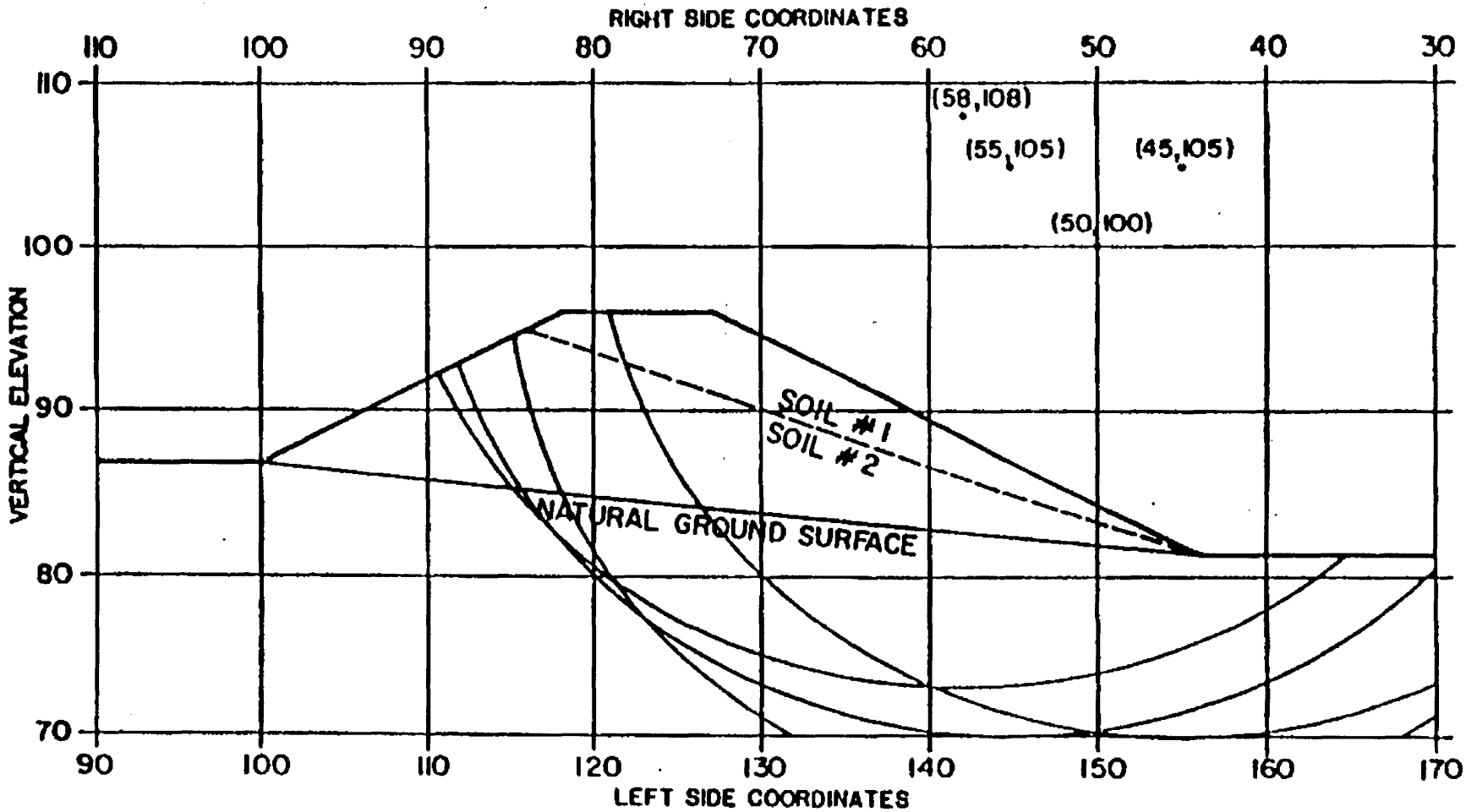
CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CARDILLO ENGINEERS

BEAR CREEK CANYON MINE – SEDIMENTATION POND "A"

CROSS SECTION THROUGH EMBANKMENT



RADIUS = 35'

CO-OP MINING COMPANY

SCALE 1" = 10'

HORROCKS CAROLLO ENGINEERS

"SLOPE"

A slope stability program utilizing the simplified or "modified Bishop" method.

The program was written by John P. Cross, P.E., Processing Manager of STS Consultants, Northbrook, Illinois. This program was printed in the October 1982 issue of "CIVIL ENGINEERING."

This version was copied from "CIVIL ENGINEERING" and edited for the Hewlett-Packard 9845 desk-top computer by Horrocks Engineers in March 1983. The format for the input and the output was changed from the original version, however, the program itself was not changed.

HORROCKS ENGINEERS
ONE WEST MAIN STREET
AMERICAN FORK, UTAH 83003
TELEPHONE (801)756-7628

```
42    OPTION BASE 1
44    OVERLAP
46    PRINTER IS 16
48    PRINT "SLOPE STABILITY ANALYSIS"
50    DIM P(50,2),L(50,3),S2(5,4),A(50),F(50,7),Z(50,4),H$[80],Sbit$(0:1)[3]
52    INTEGER Logo(2)
54    Sbit$(1)=" NO"
56    Sbit$(0)="YES"
58    S9=10
60    J6=0
62    OUTPUT 5;"R"
64    ENTER 5;M,D,Time$
66    Date$=VAL$(M)&"/"&VAL$(D)&"/83"
68    PRINTER IS 0
70    PRINT "",LIN(4),TAB(80-LEN(Date$));Date$,LIN(0);
72    GOSUB Logo    ! PRINT HORROCKS ENGINEERS' LOGO
74    PRINT LIN(5),TAB(28),"SLOPE STABILITY ANALYSIS",LIN(2),TAB(38),"for",LIN(2
);
```

*** INPUT OF PROGRAM VARIABLES ***

```
78    INPUT "ENTER THE DATA FILE NAME",File$
79    INPUT "ENTER THE PROJECT NUMBER",Pn$
82    INPUT "ENTER THE USER'S INITIALS",User$
186   LINK File$,5000
190   READ H$
191   PRINT TAB(40-LEN(H$)/2);H$
195   PRINT LIN(36),TAB(30),"DATA FILE: "&CHR$(34)&File$&CHR$(34),LIN(1)
200   PRINT TAB(25),"PROJECT NUMBER: "&Pn$,LIN(1)
201   PRINT TAB(37),"by: "&User$
203   PRINTER IS 16
210   READ S0
211   IF S0=0 THEN 270
[illegible]   READ S6
[illegible]   READ S7
[illegible]   READ W0
[illegible]   READ E1
310   READ P1
311   PRINTER IS 16
315   PRINT "POINT      X-ORD       Y-ORD"
320   FOR I=1 TO P1
331     PRINT SPA(2) I;
```

```
332     IMAGE 3X,2(7D.3D,2X)
350     READ P(I,1),P(I,2)
371     PRINT USING 332;P(I,1),P(I,2)
380   NEXT I
400   READ L1
401   PRINT LIN(1),"LINE    FROM       TO    SOIL BENEATH"
402   IMAGE 3X,2(4D,3X),2X,2D
410   FOR I=1 TO L1
421     PRINT I;
440     READ L(I,1),L(I,2),L(I,3)
480     PRINT USING 402;L(I,1),L(I,2),L(I,3)
490   NEXT I
510   READ S1
511   PRINT LIN(1),"SOIL   UNIT WEIGHT  COHESION    "&CHR$(210)&"   SATURATION"
512   IMAGE 3X,4D.DD,2X,9D,3X,3D,3X,3A
520   FOR I=1 TO S1
531     PRINT I;
550     READ S2(I,1),S2(I,2),S2(I,3),S2(I,4)
610     PRINT USING 512;S2(I,1),S2(I,2),S2(I,3),Sbit$(S2(I,4))
620   NEXT I
```

*** CIRCLE DEFINITION ***

```
640   F9=0
641   PRINTER IS 16
650   PRINT "CIRCLE DEFINITION"
660   INPUT "ENTER THE X-ORD, Y-ORD, AND RADIUS OF THE FAIL SURFACE  FORMAT X,Y,
R",X,Y,R
```

*** CHECK TO SEE IF CIRCLE EXCEEDS TOP LINE END POINTS ***

```
730   U1=P1
740   FOR I=2 TO P1
750     IF (P(I,1)<P(I-1,1)) AND (U1=P1) THEN 770
760     GOTO 780
770     U1=I-1
780   NEXT I
790   J1=R*R-(P(1,2)-Y)^2
800   J2=R*R-(P(U1,2)-Y)^2
810   IF J1<=0 THEN 830
820   IF (J1>0) AND (P(1,1)>X-SQR(J1)) THEN 860
830   IF J2<=0 THEN 850
840   IF (J2>0) AND (P(U1,1)<X+SQR(J2)) THEN 860
850   GOTO 880
860   DISP "CIRCLE EXCEEDS TOP LINE END POINTS";
870   GOTO 4380
```

*** DEFINE INTERSECTION OF CIRCLE WITH LINES ***

```
890   FOR I=1 TO L1
900     X1=P(L(I,1),1)
910     Y1=P(L(I,1),2)
[illegible]0  X2=P(L(I,2),1)
[illegible]0  Y2=P(L(I,2),2)
[illegible]40  IF X2=X1 THEN 960
950     GOTO 970
960     S=9.99E10
970     IF X2<>X1 THEN 990
980     GOTO 1000
990     S=(Y2-Y1)/(X2-X1)
1000    IF [illegible]
```

```
1010    C1=X1-Y1/S
1020    C2=1/S^2+1
1030    C3=2*C1/S-2*X/S-2*Y
1040    C4=C1^2-2*X*C1+X^2+Y^2-R^2
1050    C5=C3^2-4*C2*C4
1060    IF C5<0 THEN 1080
1070    GOTO 1090
1080    Z(I,1)=0
1090    IF C5<0 THEN 1630
1100    Q1=(-C3+SQR(C5))/(2*C2)
1110    Q2=(-C3-SQR(C5))/(2*C2)
1120    Q3=Q1/S+C1
1130    Q4=Q2/S+C1
1140    GOTO 1240
1150    C5=R^2-(Y-Y1)^2
1160    IF C5<0 THEN 1180
1170    GOTO 1190
1180    Z(I,1)=0
1190    IF C5<0 THEN 1630
1200    Q3=X+SQR(C5)
1210    Q4=X-SQR(C5)
1220    Q1=Y1
1230    Q2=Y1
1240    J1=0
1250    J2=0
1260    IF (ABS(S)<=9.99E9) AND (Q3>=X1) AND (Q3<=X2) THEN 1280
1270    GOTO 1290
1280    J1=1
1290    IF (ABS(S)<=9.99E9) AND (Q4>=X1) AND (Q4<=X2) THEN 1310
1300    GOTO 1320
1310    J2=1
1320    IF (S<-9.99E9) AND (Q1>=Y2) AND (Q1<=Y1) THEN 1340
1330    GOTO 1350
1340    J1=1
1350    IF (S<-9.99E9) AND (Q2>=Y2) AND (Q2<=Y1) THEN 1370
1360    GOTO 1380
1370    J2=1
1380    IF (S>9.99E9) AND (Q1>=Y1) AND (Q1<=Y2) THEN 1400
1390    GOTO 1410
1400    J1=1
1410    IF (S>9.99E9) AND (Q2>=Y1) AND (Q2<=Y2) THEN 1430
1420    GOTO 1440
1430    J2=1
1440    Z(I,1)=J1+J2
1450    IF J1=1 THEN 1470
1460    GOTO 1480
1470    Z(I,2)=Q3
1480    IF J1=1 THEN 1500
1490    GOTO 1510
1500    Z(I,3)=Q1
1510    IF (J1=0) AND (J2=1) THEN 1530
1520    GOTO 1540
1530    Z(I,2)=Q4
1540    IF (J1=0) AND (J2=1) THEN 1560
1550    GOTO 1570
1560    Z(I,3)=Q2
1570    IF (J1=1) AND (J2=1) THEN 1590
1580    GOTO 1600
1590    Z(I,4)=Q4
1600    IF (J1=1) AND (J2=1) THEN 1620
1610    GOTO 1630
1620    Z(I,3)=Q2
1630  NEXT I
1640  X4=0
1650  X5=9.99E20
1660  I1=1
```

```
2270  FOR I=1 TO Q1-1
2280    Q3=A(I+1)-A(I)
2290    Q4=INT(Q3/Q2)+1
2300    C1=Q3/Q4
2310    C2=A(I)
2320    FOR J=1 TO Q4
2330      IF J<Q4 THEN 2350
2340      GOTO 2360
2350      I1=I1+1
2360      IF J<Q4 THEN 2380
2370      GOTO 2390
2380      A(I1)=C2+C1
2390      IF J<Q4 THEN 2410
2400      GOTO 2420
2410      C2=C2+C1
2420    NEXT J
2430  NEXT I
2440  FOR I=1 TO I1
2450    FOR J=1 TO I1-1
2460      IF A(J+1)>A(J) THEN 2500
2470      J1=A(J+1)
2480      A(J+1)=A(J)
2490      A(J)=J1
2500    NEXT J
2510  NEXT I
```

*** DEFINE SOIL PARAMETERS FOR EACH SLICE ***

```
2530  F1=I1-1
2540  FOR I=1 TO F1
2550    F(I,4)=A(I+1)-A(I)
2560    X6=F(I,4)
2570    F(I,7)=(A(I+1)+A(I))/2
2580    X3=F(I,7)
2590    Y1=Y-SQR(R^2-(A(I)-X)^2)
2600    Y2=Y-SQR(R^2-(A(I+1)-X)^2)
2610    A5=ATN(ABS(Y2-Y1)/F(I,4))
2620    IF Y2<Y1 THEN 2640
2630    GOTO 2650
2640    A5=-A5
2650    F(I,2)=A5
2660    IF A5=0 THEN 2680
2670    GOTO 2690
2680    F(I,2)=1.0E-5
2690    Y3=Y-SQR(R^2-(X3-X)^2)
2700    I4=0
2710    FOR J=1 TO L1
2720      L5=L(J,1)
2730      L6=L(J,2)
2740      IF (P(L5,2)<=Y3) AND (P(L6,2)<=Y3) THEN 2840
2750      IF (P(L5,1)<X3) AND (P(L6,1)<X3) THEN 2840
2760      IF (P(L5,1)>X3) AND (P(L6,1)>X3) THEN 2840
2770      Y6=P(L5,2)+(P(L5,2)-P(L6,2))/(P(L5,1)-P(L6,1))*(X3-P(L5,1))
2780      IF Y6<=Y3 THEN 2840
2790      I4=I4+1
2800      Z(I4,1)=Y6
2810      Z(I4,2)=L(J,3)
2820      W=0
2830      E=0
2840    NEXT J
2850    IF I4=1 THEN 2970
2860    FOR J=1 TO I4
2870      FOR J1=1 TO I4-1
2880        IF Z(J1,1)>=Z(J1+1,1) THEN 2950
```

```
2900        L5=Z(J1,1)
2910        Z(J1,1)=Z(J1+1,1)
2920        Z(J1,2)=Z(J1+1,2)
2930        Z(J1+1,1)=L5
2940        Z(J1+1,2)=L6
2950      NEXT J1
2960    NEXT J
2970    I4=I4+1
2980    Z(I4,1)=Y3
2990    FOR J1=1 TO I4-1
3000      IF (I=1) AND (J1=1) AND (X3>=S6) THEN 3020
3010      GOTO 3030
3020      I6=S8-Y1
3030      IF (I=F1) AND (J1=1) AND (X3>=S6) AND (X3<=S7) THEN 3050
3040      GOTO 3060
3050      J6=S8-Y2
3060      W=W+(Z(J1,1)-Z(J1+1,1))*X6*S2(Z(J1,2),1)
3070      IF (Z(J1,1)<S0) AND (X3>=S6) AND (X3<=S7) THEN 3090
3080      GOTO 3100
3090      W=W+(S0-Z(J1,1))*X6*W0
3100      IF S2(Z(J1,2),4)>.95 THEN 3120
3110      GOTO 3130
3120      E4=S2(Z(J1,2),1)
3130      IF S2(Z(J1,2),4)<.95 THEN 3150
3140      GOTO 3160
3150      E4=S2(Z(J1,2),1)-W0
3160      E=E+(Z(J1,1)-Z(J1+1,1))*X6*E4
3170    NEXT J1
3180    F(I,1)=W
3190    F(I,5)=E
3200    F(I,3)=S2(Z(I4-1,2),2)
3210    F(I,6)=2*PI*(S2(Z(I4-1,2),3)/360)
3220  NEXT I
3221  NORMAL
3230  IF F9=0 THEN 3360
3240  PRINT USING 3250;CHR$(210)
3250  IMAGE "SLICE   WEIGHT   INCLINATION   COHESION   WIDTH    EFF WEIGHT    "A
      X"
3280  D=360/(2*PI)
3290  FOR I=1 TO F1
3300    PRINT USING 3320;I,F(I,1),F(I,2)*D,F(I,3),F(I,4),F(I,5),F(I,6)*D,F(I,7)
3320    IMAGE 3D,10D.D,7D.D,12D,9D.D,11D.D,7D,7D.D
3340  NEXT I
3350  PRINT
3360  D=0
3361  PRINTER IS 0
3370  FOR I=1 TO F1
3380    D=D+F(I,1)*SIN(ABS(F(I,2)))*(F(I,2)/ABS(F(I,2)))
3390    D=D+E1+F(I,1)*COS(ABS(F(I,2)))
3400  NEXT I
3410  IF I6>0 THEN 3430
3420  GOTO 3440
3430  I7=W0*I6*I6*(R-I6/3)/(2*R)
3440  IF I6>0 THEN 3460
3450  GOTO 3470
3460  D=D-SGN(B)*I7
3470  IF (I6>0) AND (F9=1) THEN 3490
3480  GOTO 3510
3490  PRINT USING 3500;I7
3500  IMAGE "DRIVING FORCE COUNTER BALANCE OF",10D.2D
3510  IF J6>0 THEN 3530
3520  GOTO 3540
3530  I7=W0*J6*J6*(R-J6/3)/(2*R)
3540  IF J6>0 THEN 3560
3550  GOTO 3570
3560  D=D+SGN(B)*I7
```

```
3580  GOTO 3610
3590  PRINT USING 3600;I7
3600  IMAGE "DRIVING FORCE INCREASE OF",10D.2D
```

*** ITERATIVE SOLUTION FOR FACTOR OF SAFETY ***

```
3620  F0=1
3630  R4=0
3640  I6=0
3650  FOR I=1 TO F1
3660    R1=F(I,3)+F(I,4)+F(I,5)*TAN(F(I,6))
3670    R2=1/COS(ABS(F(I,2)))
3680    R3=1+TAN(F(I,6))*TAN(F(I,2))/F0
3690    R4=R4+R1*(R2/R3)
3700  NEXT I
3710  F2=R4/D
3720  I6=I6+1
3730  IF F9=1 THEN 3750
3740  GOTO 3820
3750  IF I6=1 THEN 3770
3760  GOTO 3880
3770  PRINT
3780  PRINT USING 3790
3790  IMAGE "ITERATION",11X,"INITIAL",10X,"CALCULATED"
3800  PRINT USING 3810;I6,F0,F2
3810  IMAGE 3X,3D,13X,3D.4D,12X,3D.4D
3820  IF I6>10 THEN 3840
3830  GOTO 3850
3840  PRINT "WILL NOT CLOSE"
3850  IF I6>10 THEN 3970
3860  IF ABS(ABS(F0)-ABS(F2))<.005 THEN 3900
3870  F0=ABS(F2)
3880  R4=0
3890  GOTO 3650
3900 !
3901  IF NOT F9 THEN
3902    PRINTER IS 16
3903  ELSE
3904    PRINTER IS 0
3905  END IF
3910  PRINT
3920  PRINT USING 3930;F2,X,Y,R
3930  IMAGE "FACTOR OF SAFETY= ",5D.2D,"  AT X= ",4D," Y= ",4D, " R= ",4D
3940  PRINT USING 3950;E1
3950  IMAGE "EARTHQUAKE= ",2D.2D
3951  IF F9 THEN 4380
3960  PRINT
3961  A$=""
3970  INPUT "DO YOU WISH A FORMAL PRINTOUT (Y/N)",A$
3990  IF UPC$(A$[1,1])="N" THEN 4320
3991  PRINTER IS 0
4030  IMAGE @"WATER UNIT WEIGHT=",3D.2D
4040  PRINT USING 4030;W0
4041  IF S0 THEN
4050    PRINT
4060    IMAGE "SUBMERGENCE AT "3D.2D,"  FROM  ",3D.1D,"  TO  ",3D.1D
 070    PRINT USING 4060;S0,S6,S7
 71   END IF
 080  PRINT
4090  PRINT " POINT   X-ORD     Y-ORD"
4100  IMAGE 4D,7D.2D,7D.2D
4110  FOR I=1 TO P1
4120    PRINT USING 4100;I,P(I,1),P(I,2)
4130  NEXT I
4140  PRINT
```

```
4150  PRINT "      LINE     LEFT    RIGHT     SOIL"
4160  IMAGE 4(8D)
4170  FOR I=1 TO L1
4180    PRINT USING 4160;I,L(I,1),L(I,2),L(I,3)
4190  NEXT I
4200  PRINT
4210  PRINT "SOIL        UNIT WEIGHT        COHESION      "&CHR$(210)&"      SATURAT
ED"
4220  IMAGE 3D,15D,17D,9D,7X,3A
4230  FOR I=1 TO S1
4240    PRINT USING 4220;I,S2(I,1),S2(I,2),S2(I,3),Sbit$(S2(I,4))
4250  NEXT I
4260  PRINT
4270  PRINT "CIRCLE   X-ORD    Y-ORD   RADIUS  FACTOR OF SAFETY"
4280  IMAGE 12D.D,7D.D,7D.D,8D.2D
4290  PRINT USING 4280;X,Y,R,F2
4300  PRINT
4310  PRINT
4311  A$=""
4320  INPUT "DO YOU WISH A DIAGNOSTIC RUN (Y/N)",A$
4340  IF UPC$(A$[1,1])="N" THEN 4370
4360  F9=1
4370  IF UPC$(A$[1,1])<>"N" THEN 720
4371  A$=""
4380  INPUT "DO YOU WANT TO CONTINUE (Y/N)",A$
4400  IF UPC$(A$[1,1])<>"N" THEN 630
4401  DISP " FINISHED "
4410  STOP
4520 Logo:PLOTTER IS 13,"GRAPHICS"
4530  GRAPHICS
4540  SCALE 0,559,0,454
4550  LORG 2
4560  FOR I=0 TO 5
4570    Logo(1)=-2175
4580    Logo(2)=-4352
4590    R=454-I
4600    GLOAD Logo(*),0,R
4610  NEXT I
4620  FOR I=6 TO 14
4630    Logo(1)=-2115
4640    Logo(2)=-4352
4650    R=454-I
4660    GLOAD Logo(*),0,R
4670  NEXT I
4680  FOR I=15 TO 21
4690    Logo(1)=-2175
4700    Logo(2)=-4352
4710    R=454-I
4720    GLOAD Logo(*),0,R
4730  NEXT I
4740  CSIZE 15/4.54,9/15
4750  MOVE 27,450
4760  LABEL "HORROCKS"
4770  MOVE 27,437
4780  CSIZE 15/4.54,8/15
4790  LABEL "ENGINEERS"
4800  DUMP GRAPHICS 430,454
4810  GCLEAR
4820  EXIT GRAPHICS
4830  RETURN
```

Slope stability program

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For natural or man-made slopes, the index of stability with respect to a sudden failure is known as the safety factor of the slope. The safety factor may be defined as the ratio of the potential resisting forces to the drive forces tending to cause movement. A slope on the verge of failure would have a safety factor of 1.0. The analysis of slope stability is, therefore, the analytical procedure of determining the most critical, i.e., the lowest, factor of safety of given or proposed slope.

Manual methods of slope stability analysis were developed prior to the advent of the electronic computer. These approaches resulted in high analysis costs and conservative slope configurations. Repetitive calculations lended themselves to computerized methods and numerous programs exist that have been written for large computer systems to perform slope stability analysis according to a number of theoretical methods.

The simplified or modified Bishop method is reasonably accurate for most purposes where the slope under analysis can be assumed to fail along a circular failure surface. The factor of safety is defined as the ratio of the resisting moments to driving moments around the center of the failure arc. Initially, a cross-section of the slope is drawn detailing soil strata and piezometric surfaces. A center point is then chosen from which an arc is taken through the cross-section. This arc represents the failure surface under evaluation. This failure zone is broken down into a series of slices which can be individually evaluated for their weight and strength characteristics. An illustration of a slope cross-section being defined by a series of slices is shown in Figure 1.

The forces acting on each slice are illustrated in Figure 1, where ΔX is the width of the slice, W is the weight of the slice, T is the force acting along the failure surface at the bottom of the slice, N is the effective force acting normally to the base of the slice and θ is the inclination of the failure surface or slice base. The factor of safety is defined as:

$$F = \frac{\dfrac{\Sigma\,(C\,\Delta X + N \tan \Phi) \sec \theta}{1 + \dfrac{\tan \Phi \tan \theta}{F}}}{\Sigma\, W \sin \theta}$$

Where C is the cohesion, Φ is the friction angle and the summation occurs over each slice of the failure zone. As the factor of safety, F, occurs on both sides of the equation. An interactive solution where F is initially estimated and then back substituted until the calculated F and estimated F close within a specified tolerance.

The equation can be modified to handle two additional conditions by adding additional factors to the term defining the driving force. These two conditions are standing pools, i.e., submergence of a portion of the slope, and earthquake loading. For submergence, the weight of water acting above the slice is added to the weight of the slice itself. The total driving force is increased or decreased by the weight of water above or below the exit of the failure surface from the slope. The second condition of earthquake loading can be handled by increasing the driving force calculated for each slice by $EW\cos\theta$, where E is the earthquake loading factor. Similarly the resisting force is decreased by a decrease in the normal force due to the earthquake loading.

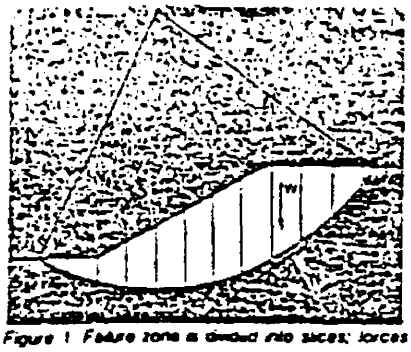

Figure 1. Failure zone is divided into slices; forces acting upon a slice are indicated.

Following the calculation of the safety factor for this arc, the center or radius of the arc is modified to generate a new failure surface. The previously mentioned procedure is again followed with a new factor of safety being deter-

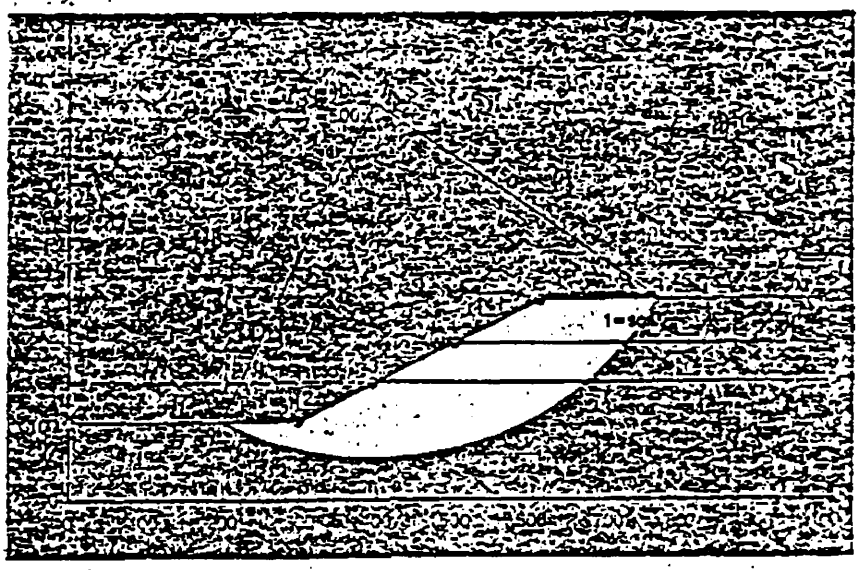

Figure 2. shows a typical cross-section and the input parameters required to define the cross-section for the program.

Table for Figure 2

Point	X	Y	Line	Left	Right	Soil	Soil	Cohesion	Phi	Saturated
1	0	100	1	1	2	3	1	127 2000	20	No
2	300	100	2	2	3	3	2	130 1000	33	No
3	400	150	3	3	4	2	3	130 1000	33	Yes
4	500	200	4	4	5	1				
5	800	250	5	5	6	1				
6	1000	250	6	4	7	2				
7	1000	200	7	3	8	3				
8	1000	150								

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mined. This entire sequence is repeated until the failure surface for the minimum factor of safety is determined.

The program included in this article follows the same general procedure as previously defined. The program can be broken down into nine segments. Lines 100-620 are input routines for the entry of data defining the cross-section, lines 630-710 define the circle that will generate the failure surface, lines 720-860 perform a verification that the failure arc falls fully within the cross-section and lines 880-1840 define the intersection points between the line segments and the failure arc. The slice array is set up between line 1850 and 2220, with slice boundaries defined in lines 2230-2510. Lines 2520-3600 include the definition of the soil parameters for each slice and the actual iterative solution for the factor of safety occurs between lines 3610 and 3950. The remainder of the program is the formal output of the results.

The program includes a diagnostic print-out where all the slice parameters can be displayed for any given failure surface. As currently configured the program can handle models including

```
2050 IF A(I)>A(J) THEN 2090
2060 A1=A(I)
2070 A(I)=A(J)
2080 A(J)=A1
2090 NEXT J
2100 NEXT I
2110 U1=0
2120 FOR I=1 TO N-1
2130 IF A(I)<A(I+1) THEN 2150
2140 GO TO 2160
2150 U1=U1+1
2160 IF A(I)<A(I+1) THEN 2180
2170 GO TO 2190
2180 A(U1)=A(I)
2190 NEXT I
2200 U1=U1+1
2210 A(U1)=A(I)
2220 I1=U1
2230 REM *** DEFINE SLICE BOUNDARIES ***
2240 B1=A(I1)-A(1)
2250 B2=B1/S9
2260 U1=I1
2270 FOR I=1 TO U1-1
2280 B3=A(I+1)-A(I)
2290 B4=INT(B3/B2)
2300 C1=B3/B4
2310 C2=A(1)
2320 FOR J=1 TO B4
2330 IF J<B4 THEN 2350
2340 GO TO 2360
2350 I1=I1+1
2360 IF J<B4 THEN 2380
2370 GO TO 2390
2380 A(I1)=C2+C1
2390 IF J<B4 THEN 2410
2400 GO TO 2420
2410 C2=C2+C1
2420 NEXT J
2430 NEXT I
2440 FOR I=1 TO I1
2450 FOR J=I TO I1-1
2460 IF A(J+1)>A(J) THEN 2500
2470 J1=A(J+1)
2480 A(J+1)=A(J)
2490 A(J)=J1
2500 NEXT J
2510 NEXT I
2520 REM *** DEFINE SOIL PARAMETERS FOR EACH SLICE ***
2530 F1=I1-1
2540 FOR I=1 TO F1
2550 Z(I,4)=A(I+1)-A(I)
2560 Z(I,6)=(A(I)+A(I+1))/2
2570 Z(I,7)=A(I+1)-A(I)
2580 X1=Y-SQR(R^2-(A(I)-X)^2)
2590 X2=Y-SQR(R^2-(A(I+1)-X)^2)
2600 A3=ATN(ABS(X2-X1)/Z(I,4))
2610 IF X2<X1 THEN 2640
2620 GO TO 2630
2630 A3=-A3
2640 Z(I,3)=A3
2650 IF A3<0 THEN 2680
2660 GO TO 2690
2670 Z(I,2)=1.6E-3
2680 X3=Y-SQR(R^2-(A(I)-X)^2)
2690 X4=Y
2700 FOR J=1 TO I1
2710 L3=Z(J,1)
2720 L4=Z(J,2)
2730 IF Z(L3,2)<X3 AND Z(L4,2)>X3 THEN 2840
2740 IF Z(L3,1)<X3 AND Z(L4,1)>X3 THEN 2840
2750 IF Z(L3,1)>X3 AND Z(L4,1)>X3 THEN 2840
2760 T4=(Z(L3,2)*Z(L4,2)-Z(L4,2)*Z(L3,2))/(Z(L3,1)-Z(L3,2))
2770 IF T4<X4 THEN 2840
2780 X4=T4
2790 I0=J
2800 Z(I,4,1)=Z(J,1)
2810 Z(I,4,2)=Z(J,2)
2820 NEXT J
2830 IF I0=0 THEN 2870
2840 Z(I,4)=X4
2850 Z(I,5)=Y-X4
2860 FOR J1=1 TO I1
2870 IF Z(J1,1)>Z(I,4,1) THEN 2930
2880 L5=Z(J1,1)
2890 L6=Z(J1,2)
2900 Z(J1,1)=Z(I,4,1)
2910 Z(J1,2)=Z(I,4,2)
2920 Z(J1,1)=L5
2930 Z(J1,2)=L6
2940 NEXT J1
2950 NEXT I
2960 I4=I4+1
2970 Z(I4,1)=Y3
2980 FOR J1=1 TO I4-1
2990 IF Z(J1)=Y3 AND Z(J1+1)=Y3 THEN 3020
3000 GO TO 3030
3010 I4=I4-1
3020 IF Z(J1)=Y3 AND Z(J1+1)=Y3 THEN 3030
3030 NEXT J1
3040 GO TO 3060
3050 I4=I4-1
3060 U=U+(Z(J1,1)-Z(J1-1,1))*(Z(J1,2)+Z(J1-1,2))/2
3070 IF Z(J1,1)<Z(I,4,1) AND Z(J1,1)>Z(I,4,1) AND Z(J1,2)<Z(I,4,2) THEN 3090
3080 GO TO 3100
3090 U=U+(Z(I,4,1)-Z(J1-1,1))*(Z(I,4,2)+Z(J1-1,2))/2
3100 IF B2(Z(J1,2)*4)>.75 THEN 3120
3110 GO TO 3130
3120 E4=B2(Z(J1,2)*4)
3130 IF B2(Z(J1,2)*4)<0.75 THEN 3150
3140 GO TO 3160
3150 E4=B2(Z(J1,2)*4)
3160 E=E+(Z(J1,1)-Z(J1-1,1))*E4*E4
3170 NEXT J1
3180 F(I,1)=U
3190 F(I,3)=E
3200 F(I,2)=B2(Z(I,4,2)*4)
3210 F(I,6)=2*F(I,2)*B2(Z(I,4,2)*4)/360
3220 NEXT I
3230 IF F1>1 THEN 3250
3240 PRINT 0401 USING 3270
3250 PRINT 0401 USING 3270
3260 IMAGE "SLICE  WEIGHT  INCLINATION "
3270 PRINT 0401 USING 3270
3280 IMAGE " COHESION  WIDTH  CTR WEIGTH  PHI  E"
3290 O=360/(2*PI)
3300 FOR I=1 TO F1
3310 PRINT 0401 USING 3320;I,F(I,1),F(I,2),F(I,3),F(I,4),F(I,5)
3320 IMAGE (3D.DD,1D.DD,2D.1D,1D.DD,2D.1D,2D.DD,1D.DD)
3330 IMAGE  7D.1D  3D.2D
3340 NEXT I
3350 PRINT 0401
3360 B=0
3370 FOR I=1 TO F1
3380 B=B+F(I,1)*SIN(ABS(F(I,2)))*(F(I,3)/ABS(F(I,2)))
3390 B=B+F(I,1)*COS(ABS(F(I,2)))
3400 NEXT I
3410 IF I<0 THEN 3430
3420 GO TO 3440
3430 I7=ABS(I*(R-I*G/3)/(2*R))
3440 IF I<0 THEN 3460
3450 GO TO 3470
3460 B=B-SGN(B)*I7
3470 IF I<0 AND F9=1 THEN 3490
3480 GO TO 3510
3490 PRINT 0401 USING 3500;I7
3500 IMAGE "DRIVING FORCE COUNTER BALANCE OF",DD.DD
3510 IF J<0 THEN 3530
3520 GO TO 3540
3530 I7=ABS(J*(R-J*G/3)/(2*R))
3540 IF J<0 THEN 3560
3550 GO TO 3570
3560 B=B+SGN(B)*I7
3570 IF J<0 AND F9=1 THEN 3590
3580 GO TO 3610
3590 PRINT 0401 USING 3600;I7
3600 IMAGE "DRIVING FORCE INCREASE OF",DD.DD
3610 REM *** ITERATIVE SOLUTION FOR FACTOR OF SAFETY ***
3620 F0=1
3630 R=0
3640 I4=0
3650 FOR I=1 TO F1
3660 B1=F(I,3)*F(I,4)*F(I,5)*TAN(F(I,6))
3670 B2=1/COS(ABS(F(I,2)))
3680 B3=I*TAN(F(I,6))*TAN(F(I,2))/F0
3690 B4=B4+B1*(B2/B3)
3700 NEXT I
3710 F2=B4/B
3720 I4=I4+1
3730 IF F9=1 THEN 3750
3740 GO TO 3820
3750 IF I4=1 THEN 3770
3760 GO TO 3800
3770 PRINT 0401
3780 PRINT 0401 USING 3790;I
3790 IMAGE "ITERATION",DD,"INITIAL",10X,"CALCULATED"
3800 PRINT 0401 USING 3810;F0,F2
3810 IMAGE 2F.3D,1X,3D,4D,12X,3D,4D
3820 IF I4>10 THEN 3840
3830 GO TO 3850
3840 PRINT 0401 "WILL NOT CLOSE"
3850 IF I4>10 THEN 3970
3860 IF ABS(ABS(F0)-ABS(F2))<0.005 THEN 3900
3870 F0=ABS(F2)
3880 B4=0
3890 GO TO 3430
3900 REM *** PRINT OUT ***
3910 PRINT 0401
3920 PRINT 0401 USING 3930;F2,X,Y,R
3930 IMAGE "FACTOR OF SAFETY=",2D.2D,"AT",3D,3D,3D
3940 PRINT 0401 USING 3950;E
3950 IMAGE "EARTHQUAKE=",2D.2D
3960 PRINT 0401
3970 PRINT 0401 "DO YOU WISH A FORMAL PRINTOUT (Y OR N)"
3980 INPUT 0401A$
3990 IF A$="N" THEN 4320
4000 PRINT 0401
4010 PRINT 0401 U0
4020 PRINT 0401 "CW" "CW" "ORD"
4030 IMAGE "WATER UNIT WEIGHT=",3D.2D,"EARTHQUAKE=",2D.2D
4040 PRINT 0401 USING 4050;U0,E
4050 PRINT 0401
4060 IMAGE "SUBMERGENCE AT",3D,2D,"FROM",3D,3D,3D
4070 PRINT 0401 USING 4080;B1,B2
4080 PRINT 0401
4090 PRINT 0401 "POINT" "X-ORD" "Y-ORD"
4100 IMAGE 4D,7D,2D,7D,2D
4110 FOR I=1 TO F1
4120 PRINT 0401 USING 4130;I,F(I,1),F(I,2)
4130 NEXT I
4140 PRINT 0401
4150 PRINT 0401 "SLICE" "LEFT" "RIGHT" "SOIL"
4160 IMAGE 4(4D)
4170 FOR I=1 TO I1
4180 PRINT 0401 USING 4190;I,I7,C(I,1),C(I,2)
4190 NEXT I
4200 PRINT 0401
4210 PRINT 0401 "SOIL" "UNIT WEIGHT" "COHESION" "PHI" "SATURATED"
4220 IMAGE 3D,13D,17D,7D,7D
4230 FOR I=1 TO S1
4240 PRINT 0401 USING 4250;I,B2(I),B3(I),B4(I),B5(I)
4250 NEXT I
4260 PRINT 0401
4270 PRINT 0401 "CIRCLE" "X-ORD" "Y-ORD" "RADIUS" "FACTOR OF SAFETY"
4280 IMAGE 12D,4D,7D,4D,7D,4D,2D
4290 PRINT 0401 USING 4300;X,Y,R,F2
4300 PRINT 0401
4310 PRINT 0401
4320 PRINT 0401 "DO YOU WISH A DIAGNOSTIC RUN (Y OR N)"
4330 INPUT 0401A$
4340 IF A$="Y" THEN 4360
4350 GO TO 4370
4360 F9=1
4370 IF A$="Y" THEN 720
4380 PRINT 0401 "CONTINUE (Y OR N)"
4390 INPUT 0401A$
4400 IF A$="Y" THEN 630
```

up to 20 points, 20 lines, and 5 soil types. The minimum number of slices is set at 10, but can be changed by modifying the value of S9 at line 150 and changing the dimensioning of arrays A, F and Z.

A cross-section is drawn of the slope showing all soil strata and piezometric surfaces. Each intersect point between lines on the cross-section is numbered, with the constraint that all points along the top line must be numbered consecutively from left to right initiating with point 1. Points beneath the top line may be numbered in any order. These points are then defined with X and Y coordinates (the entire cross-section must fall in the first quadrant).

Lines are then specified by assigning line numbers for each line occurring between two end points. These lines are defined by a left point, a right point and the number of the soil type occurring beneath the line. Vertical lines are not allowed and should be modeled by offsetting the X-coordinate of one end point by a small amount, i.e., .01. Piezometric surfaces within the cross-section are treated as any other soil strata interface with saturated soil beneath and unsaturated soil above the line segment. Soil types are defined by specifying a unit weight, cohesion, phi angle and an indication of whether the soil is saturated.

Additional information that must be supplied includes the unit weight of water, the earthquake loading factor and information defining any standing pool of water. This pool is specified by inputting the Y-coordinate of the pool elevation and the left and right X-coordinates defining the extent of the pool. The only remaining input parameters are the center coordinates and radius of the failure arc. The input can be in any consistent set of units.

Figure 2 shows a typical cross-section and the input parameters required to define the cross-section for the program. The sample execution in the box shows the typical input sequence and output formats. This result is not necessarily the minimum factor of safety for this slope, but the factor of safety for the specified failure surface. Additional runs should be made using different centers and radii until the minimum factor of safety is located.

The program presented here is the nucleus from which system specific enhancements should be made. These enhancements are not included in this version for the purpose of minimizing the size of the program presented. Particularly valuable enhancements include the ability to edit interactively, save input on a disc or tape and perform a search for the minimum factor of safety without manually inputting each circle definition. Additional enhancements could include plotting capabilities and more detailed diagnostic features.

A computerized evaluation of slope stability should never take place apart from a complete evaluation of the geophysical conditions involved. Likewise, the results should always be subjected to evaluation and interpretation based on current engineering practice and experience.

Cross received his M.S. degree in civil engineering from Rose-Hulman Institute of Technology, Terre Haute, Indiana in 1972. Currently data processing manager/project engineer, Cross has been with STS (formerly Soil Testing Services) for 10 years. He holds a Master of Divinity from Trinity Evangelical Divinity School and is working on an MBA at the Keller Graduate School of Management.

Appendix 7-F

SEDIMENT POND CALCULATIONS

Pond A - Existing Structure

Stage - Area data

Elev. (ft.)	Area (ft^2)	Δ vol (ft^3)	Cumulative vol. (ft^3)
7082	4826		0
		10,618	
7084	5792		10,618
		13,084	
7086	7292		23,702
		16,144	
7088	8852		39,846
		19,366	
7090	10,514		59,212
		22,247	
7092	11,733		81,459
		24,752	
7094	13,019		106,211
		6590	
7094.5	13,340		112,801
		20,765	
7096	14,347		133,566
		5792	
7096.4	14,613		139,358

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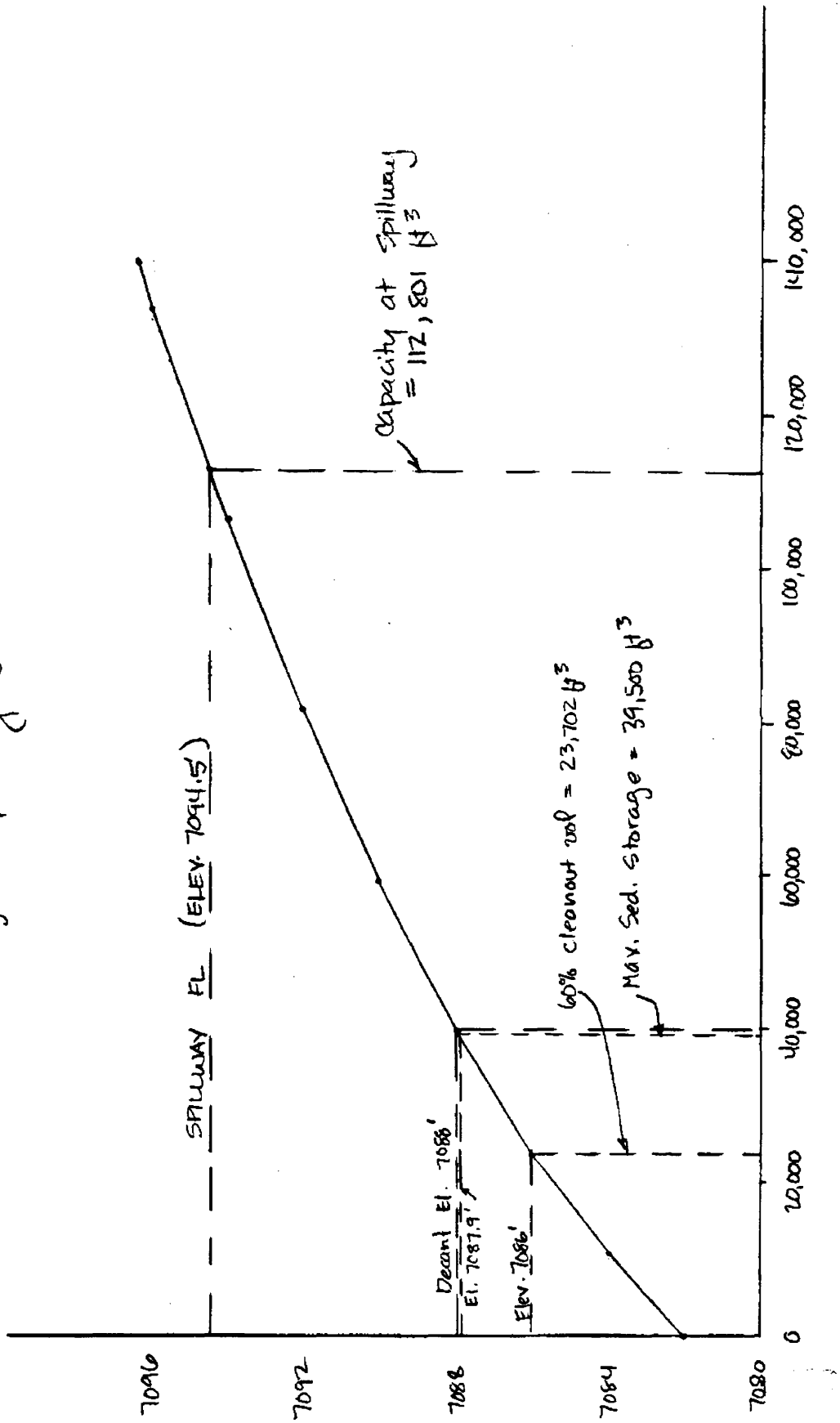
POND A

Stage - Capacity Curve



Soil Erosion to Ponds A + B

Use the Modified Universal Soil Loss Equation:

$$A = R \cdot K \cdot LS \cdot VM$$

Ref: Israelsen, C.E., J.E. Fletcher, F.W. Hawks, E.K. Israelsen. 1984. Erosion and Sedimentation in Utah: A Guide for Control. Utah Water Research Laboratory. Logan, Utah.

A = Amount of Soil Loss per Unit Area

R = Rainfall Factor

K = Soil Erodibility Factor

LS = topographic Factor

VM = erosion control factor = 1.2 for bare, compacted soil
= 0.1 for seedings + mulch

For Both Ponds →

R = 160 tons/Ac/Hr. (Mean Annual R value from Figure 1, (Israelsen et al, 1984))

K = 0.1 tons/Ac/EI (Israelsen et al, 1984)

$$LS = \left(\frac{650 + 450s + 65s^2}{10{,}000 + s^2}\right)\left(\frac{l}{72.6}\right)^m$$

(Ref: Clyde, et al, 1978. Manual of Erosion Control Principles + Practices. Utah Water Research Laboratory - Logan, Utah)

l = Slope length
s = Slope Steepness

$$m = \begin{cases} .2 & \text{for } 0 < s < 1\% \\ .3 & \text{for } 1 < s < 3\% \\ .4 & \text{for } 3 < s < 5\% \\ .5 & \text{for } s > 5\% \end{cases}$$

POND A

Sediment Volumes

Drainage Area	Slope length ℓ (ft.)	Slope S (%)	LS	VM	A (tons/Ac/yr)	Area (Acres)	A [a] (ft^3/year)
AD-1a	800	66	72.49	.1	11.6	3.70	858
AD-1b	150	95	47.6	.1	7.6	2.12	323
AD-2a	290	72	48.7	.1	7.79	0.97	151
AD-2b	320	59	39.47	.65 (brush + soil)	41.05	1.08	887
AD-2c	140	64	29.13	.65 (brush + soil)	30.29	0.25	151
AD-3a	400	70	55.24	.1	8.84	1.49	263
AD-3c	400	71	56.22	.1	9.00	0.78	140
AD-5	250	73	45.99	.1	7.36	2.13	314
AD-6	600	2	0.34	1.2	0.65	1.39	18
AD-7	1140	8	3.31	1.2	6.36	2.95	375
AD-8 upper	140	70	32.68	.35 (brush)	18.3	0.70	256
AD-8 lower	600	1	0.18	.9 (coal)	0.26	2.79	15
AD-9	420	7.2	1.74	1.2	3.34	0.35	23
AD-10 upper	130	34	10.93	.35 (brush)	6.12	0.30	37
AD-10 lower	200	2	0.25	1.2	0.47	0.65	6
AD-11	110	20	4.22	.6 (pond + unstab.)	4.05	0.69	56
AD-12 upper	100	64	24.62	1.2	47.27	0.22	208
AD-12 lower	500	8	2.19	1.2	4.21	0.34	29
AD-14	75	61	20.00	1.2	38.4	0.08	61
							4171 ft^3

(a) assume a soil unit weight of 100 lb/ft^3

Storm Events

2 year - 6 hour P = 1.0

10 year - 6 hour P = 1.5

10 year - 24 hour P = 2.1

25 year - 6 hour P = 1.8

25 year - 24 hour P = 2.7

Curve Numbers

Disturbed area (pad, roads, etc) - CN = 90

Pond Area - CN = 100

Undisturbed areas - CN = 76

Areas w/ primarily brush only, CN = 83

Pond A

10-year, 24-hour runoff volume
Precip. = 2.1 inches

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \qquad S = \frac{1000}{CN} - 10$$

Watershed	CN	S	Q(in)	Area (AC)	runoff vol. (ft³)
AD-1a	76	3.16	0.47	3.70	6313
AD-1b	76	3.16	0.47	2.12	3617
AD-2a	76	3.16	0.47	0.97	1655
AD-2b	83	2.05	0.76	1.08	2980
AD-2c	83	2.05	0.76	0.25	690
AD-3a	76	3.16	0.47	1.49	2542
AD-3b	76	3.16	0.47	0.78	1331
AD-5	76	3.16	0.47	2.13	3634
AD-6	90	1.11	1.18	1.39	5954
AD-7	90	1.11	1.18	2.95	12,636
AD-8	90	1.11	1.18	3.49	14,949
AD-9	90	1.11	1.18	0.35	1,499
AD-10	90	1.11	1.18	0.95	4,069
AD-11	95	0.53	1.58	0.69	3957
AD-12	90	1.11	1.18	0.56	2399
AD-14	90	1.11	1.18	0.08	343

Total = 68,568 ft³

* Determine if Pond A will fully contain the runoff from the 10-year, 24-hour precipitation event ASSUMING the pond is full of water up to the decant elevation.

Decant elevation = 7088 ft
pond capacity @ decant = 39,846 ft³

Pond capacity at Spillway FL = 112,801 ft³
pond capacity at Decant ~ FL = - 39,846 ft³

Available runoff storage = 72,955 ft³

Since the runoff volume from the 10-year, 24-hour storm is 68,568 ft³ there is more than adequate storage in the existing pond structure.

* Decant Elev. is 2' higher than the 60% sediment cleanout elevation. (Dave Alliotti, State Health Dept., Price Utah)

60% cleanout elevation = 7086 ft vol = 23,702 ft³

Maximum Sediment volume = $\frac{23,702}{.6}$ = 39,500 ft³

Elev. of Max. Sediment volume = 7087.9'

Annual Sed. volume = 4,171 ft³

Therefore, Pond A will provide many years of sediment storage before cleanout is required.

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Pond A

Sedimot II Data

	Watershed	CN	Area (Ac.)	Slope Y (%)	Hyd. length ℓ (ft.)	$S = \frac{1000}{CN} - 10$	$L = \frac{\ell^{.8}(S+1)^{.7}}{1900 Y^{.5}}$	$T_c = 1.67L$ Time of Conc. (Hr)
1	AD-1a	76	3.70	66	1300	3.16	.05	.09
20	AD-1b	76	2.12	95	520	3.16	.022	.037
2	AD-2a	76	0.97	72	440	3.16	.02	.04
3	AD-2b	83	1.08	59	320	2.05	.015	.025
4	AD-2c	83	0.25	64	140	2.05	.007	.012
5	AD-3a	76	1.49	70	400	3.16	.021	.034
6	AD-3b	76	0.78	71	400	3.16	.020	.034
7	AD-4	83	0.08	49	100	2.05	.007	.011
8	AD-5	76	2.13	73	760	3.16	.034	.056
9	AD-6	90	1.39	1.7	720	1.11	.131	.220
10	AD-7	90	2.95	8	1130	1.11	.087	.145
11	AD-8 upper	90	0.70	70	400	1.11	.013	.021
12	AD-8 lower	90	2.79	1.0	600	1.11	.148	.247
13	AD-9	90	0.35	7.2	420	1.11	.042	.069
14	AD-10 upper	90	0.30	34	320	1.11	.015	.026
15	AD-10 lower	90	0.65	2	220	1.11	.047	.078
16	AD-11	95	0.69	20	110	0.53	.007	.011
17	AD-12 upper	90	0.22	64	340	1.11	.012	.020
18	B.C. AD-12 lower	90	0.34	8	500	1.11	.045	5/92 .076
19	AD-14	90	0.08	61	120	1.11	.005	.009

Travel Times to Pond A

Watershed	Approx. slope to conveyance ditch	length of travel (ft.)	Velocity (ft/s)	Travel Time (Hr.)
AD-1a	3%	100	3.5	.01
AD-1b	10%	720	6.5	.03
AD-2a	12%	800	7	.03
AD-2b	35%	1060	12	.03
AD-2c	50%	1300	14	.03
AD-3a	S_1=73% S_2=7%	L_1=350 L_2=1360	V_1=17 V_2=5.3	.08
AD-3b	7%	1700	5.3	.09
AD-4 7110 - 7100	50%	1280	14	.03
AD-5	7%	1560	5.3	.08
AD-6	50%	1410	14	.03
AD-7	7%	1570	5.3	.08
AD-8 upper	7%	1300	5.3	.07
AD-8 lower	7%	1300	5.3	.07
AD-9	7.2%	540	5.5	.03
AD-10 upper	3%	350	3.5	.03
AD-10 lower	3%	150	3.5	.01
AD-11	—	0	—	0
AD-12 upper	—	0	—	0
AD-12 lower	—	0	—	0
AD-14	5%	450	4.5	.03

** Travel times based on Flow Velocities estimated from the Graph on following page (use paved area/small upland gullies).

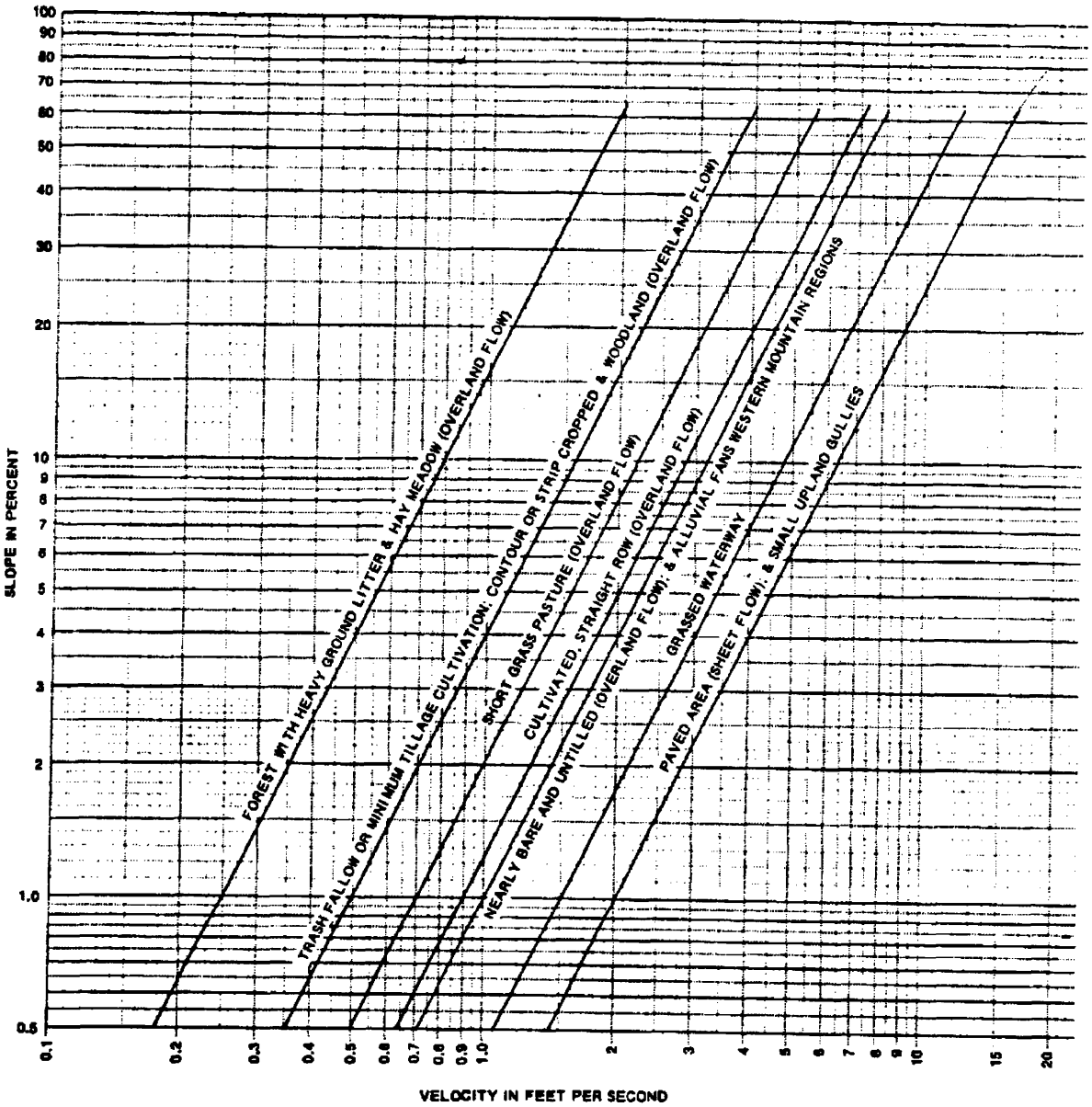


Figure 15.2.—Velocities for upland method of estimating T_c

* Use SCS Type B Distribution.

* Note: In order to route hydrograph through the pond spillway, the Sedimentology option of Sedimot II must be used. Although some approximations for sediment data are required, the output is not required for the 25-year, 6-hour storm. Thus, only the hydrology data is valid. Disregard sedimentology output!!

* 25-year, 6-hour storm = 1.8 inches

* Specific gravity of eroded sediment = 2.5
* Coef. for distributing sed. load = 1.5
* Submerged Bulk Specific gravity = 1.25

Grain Size Distribution:

Size (mm)	% Finer
.25	100
.10	50
.05	35
.01	19
.005	15
.001	6
.0001	0

7 values

* No. of structures = 1 (pond)
* Between structures routing parameters → all ∅
* No. of subwatersheds = 20
* MUSCLE data → all ∅
* % dead space → assume 20% (Not reqd for Hydrology)
* Outflow withdrawal → surface
* Inflow vertical concentration → mixed
* Enter stage data assuming pond empty to decant elevation.
* Enter stage - discharge curve for trap spillway.

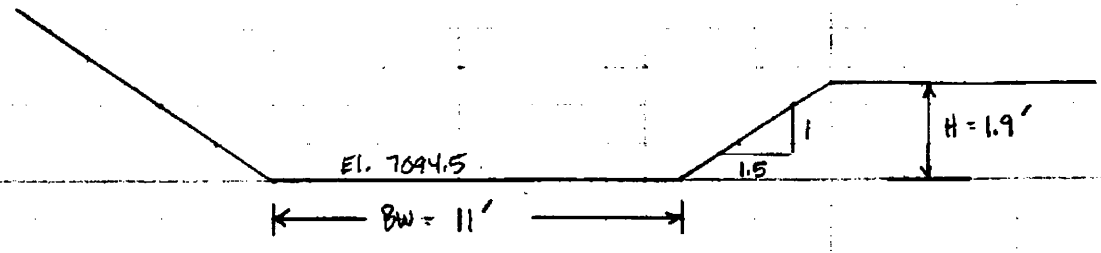
Rainfall Distribution = SCS Type B - 6 hour

P = 1.8 inches

Time (%)	Depth (%)	Time (hrs.)	Depth (in.)	30 min. Intensity
0	0	0	0	
				.06
8.33	3.5	0.5	0.06	
				.08
16.67	8.0	1.0	0.14	
				.10
25.0	13.5	1.5	0.24	
				.17
33.33	23.0	2.0	0.41	
				.67 ← Peak
41.67	60.0	2.5	1.08	
				.18
50.0	70.0	3.0	1.26	
				.14
58.33	78.0	3.5	1.40	
				.10
66.67	83.5	4.0	1.50	
				.09
75.0	88.5	4.5	1.59	
				.08
83.33	92.5	5.0	1.67	
				.07
91.67	96.5	5.5	1.74	
				.06
100.00	100.0	6.0	1.80	

POND A

Spillway Data (Not to Scale)



Average Riprap = 4" on bottom
10" on side slopes

$n = .0395 D_{50}^{1/6} = .036$ (Barfield, et al 1983)

Calculate a stage-discharge curve for the spillway →

Based on a 100-foot wide rectangular section:

$$q_r = (.544) g^{1/2} (H_{ec})^{1.5} (100) = 308.69 H_{ec}^{1.5}$$

Using attached figure: L = 10'

H_p (ft)	H_{ec} (ft)	q_r (ft^3/s)
.5	.40	78.1
.8	.68	173.1
1.2	1.09	351.3
1.6	1.48	555.8
1.9	1.78	733.1

Convert to trapezoidal section by:

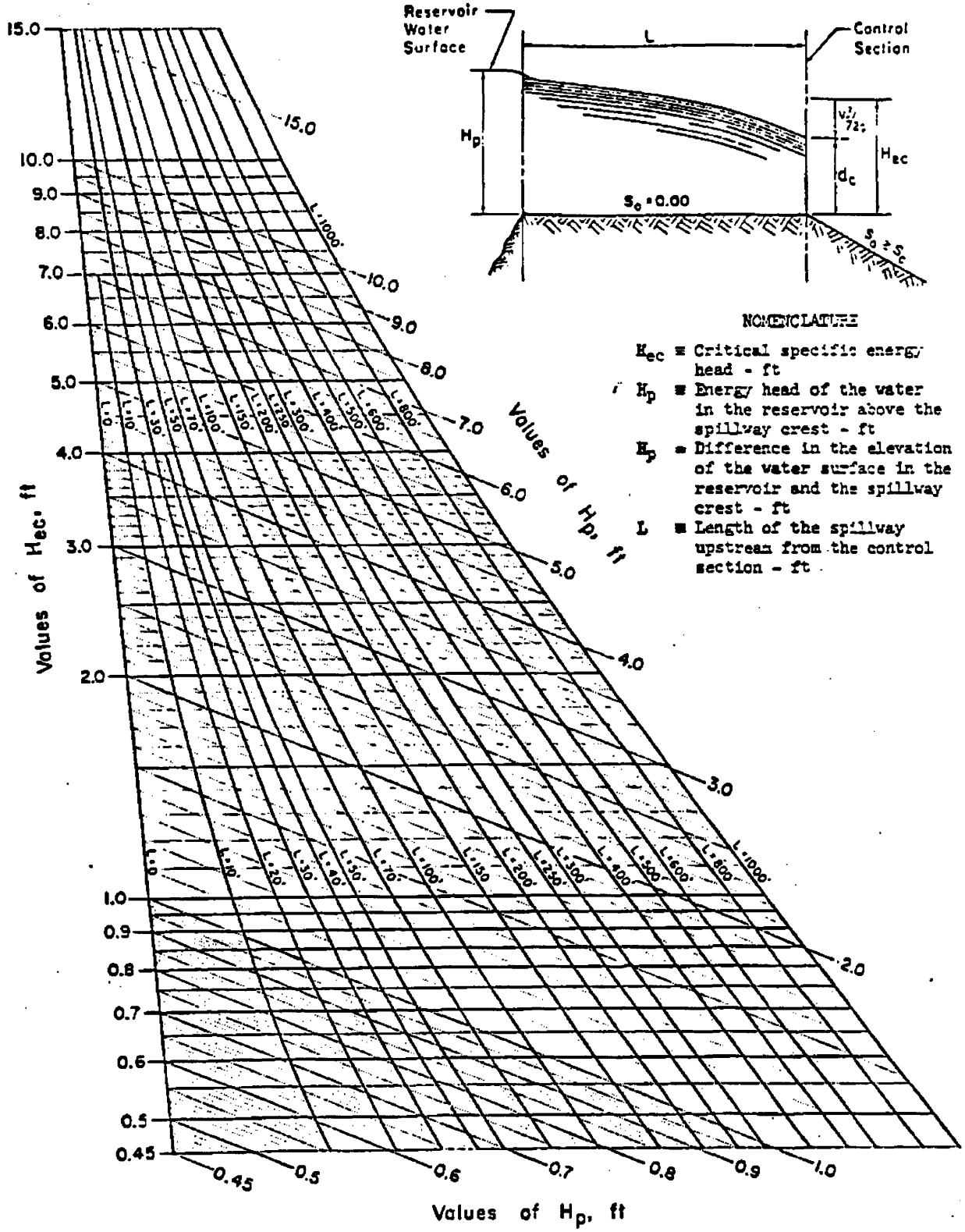
$$q_{trap} = \left[(1.5b + 2H_{ec}) / 150 \right] (q_r)$$

b = bottom width = 11'
z = side slope (run/rise) = $\frac{1.5}{1}$ = 1.5

Elev (ft.)	H_{ec} (ft)	q_r (ft³/s)	q_{trap} (cfs)
7094.5	0	0	0
7094.9	.40	78.1	8.90
7095.3	.68	173.1	20.22
7095.7	1.09	351.3	42.47
7096.1	1.48	555.8	69.36
7096.4	1.78	733.1	93.69

Note: Assume pond is empty of water to the Spillway Flowline when storm occurs.

This is conservative since the pond would likely be drained of water to the decant level.



Head relationships for selected broad-crest weirs (from U.S. Soil Conservation Service, 1968)

Revise stage-capacity data for Sediment II.
Assume pond is full of sediment to the maximum sediment level & full of water up to the spillway flow line when storm event occurs

	Elevation	Stage	Area (ft^2)	Area (Ac)	Discharge (cfs)
Max. Sediment. →	7087.9	0	8774	.201	0
Decant →	7088.0	.1	8852	.203	0
	7090.0	2.1	10,514	.241	0
	7092.0	4.1	11,733	.269	0
	7094.0	6.1	13,019	.299	0
Spillway FL →	7094.5	6.6	13,340	.306	0
	7094.9	7.0	13,609	.312	8.9
	7095.3	7.4	13,877	.319	20.2
	7095.7	7.8	14,146	.325	42.5
	7096.1	8.2	14,414	.331	69.4
Top of Embankment →	7096.4	8.5	14,613	.335	93.7

```
*****************************************************************
                        -- SEDPC --
              SEDIMOT II MODEL FOR THE IBM PC/XT
              CONVERTED BY TECH ENGINEERING INC.
                 VERSION 1.10 NOVEMBER 17,1983
*****************************************************************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*****************************************************************

      UNIVERSITY OF KENTUCKY COMPUTER MODEL
      OF SURFACE MINE HYDROLOGY AND SEDIMENTOLOGY
      FOR MORE INFORMATION CONTACT THE AGRICULTURAL
      ENGINEERING DEPARTMENT

      THE UK MODEL IS A DESIGN MODEL DEVELOPED TO PREDICT
      THE HYDRAULIC AND SEDIMENT RESPONSE FROM SURFACE
      MINED LANDS FOR A SPECIFIED RAINFALL EVENT (SINGLE STORM)

      VERSION DATE 9-23-83

      DISCLAIMER: NEITHER THE UNIVERSITY NOR ANY OF ITS EMPLOYEES
      ACCEPT ANY RESPONSIBILITY OR LEGAL LIABILITY FOR THE
      CONCLUSIONS DRAWN FROM THE RESULTS OF THIS MODEL

*****************************************************************
*****************************************************************


*****************************************************************
*                                                               *
*     THE FOLLOWING VALUES ARE NOW PREDICTED BY SEDIMOT II.     *
*     THEY CAN BE FOUND IN SUMMARY TABLES.                      *
*      1. PERIOD OF SIGNIFICANT CONCENTRATION                   *
*      2. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      3. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PEAK 24 HOUR PERIOD                            *
*      4. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      5. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PEAK 24 HOUR PERIOD                            *
*                                                               *
*     ALL CONCENTRATIONS ARE IN ML/L.                           *
*                                                               *
*****************************************************************
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****

WATERSHED IDENTIFICATION CODE

POND A - 25-YEAR, 6-HOUR STORM
SCS TYPE B STORM DISTRIBUTION
DRAINAGE AREA REVISION
RUN DATE = 7 MAY 1992

****

********** INPUT RAINFALL PATTERN **********

VALUE	DEPTH	TIME
1	.00	.00
2	.06	.50
3	.14	1.00
4	.24	1.50
5	.41	2.00
6	1.08	2.50
7	1.26	3.00
8	1.40	3.50
9	1.50	4.00
10	1.59	4.50
11	1.67	5.00
12	1.74	5.50
13	1.80	6.00

INPUT PARTICLE SIZE-PERCENT FINER DISTRIBUTIONS

SIZE,MM	.250	.100	.050	.010	.005	.001
	.000					
PCT FINER NO. 1	100.000	50.000	35.000	19.000	15.000	6.000
	.000					

**********INPUT VALUES**********

STORM DURATION	=	6.00	HOURS
PRECIPATION DEPTH	=	1.80	INCHES
SPECIFIC GRAVITY	=	2.50	
LOAD RATE EXPONENT FACTOR	=	1.50	
SUBMERGED BULK SPECIFIC GRAVITY	=	1.25	

* *

JUNCTION 1, BRANCH 1, STRUCTURE 1

* *

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	3.70	76.00	.090	.010	.000	.00	.0
2	.97	76.00	.040	.030	.000	.00	.0
3	1.08	83.00	.025	.030	.000	.00	.0
4	.25	83.00	.012	.030	.000	.00	.0
5	1.49	76.00	.034	.080	.000	.00	.0
6	.78	76.00	.034	.090	.000	.00	.0
7	.08	83.00	.011	.030	.000	.00	.0
8	2.13	76.00	.056	.080	.000	.00	.0
9	1.39	90.00	.220	.030	.000	.00	1.0
10	2.95	90.00	.145	.080	.000	.00	1.0
11	.70	90.00	.021	.070	.000	.00	.0
12	2.79	90.00	.247	.070	.000	.00	1.0
13	.35	90.00	.069	.030	.000	.00	.0
14	.30	90.00	.026	.030	.000	.00	.0
15	.65	90.00	.078	.010	.000	.00	.0
16	.69	95.00	.011	.000	.000	.00	.0
17	.22	90.00	.020	.000	.000	.00	.0
18	.34	90.00	.076	.000	.000	.00	.0
19	.08	90.00	.009	.030	.000	.00	.0
20	2.12	76.00	.037	.030	.000	.00	.0

*** SEDIMENT INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	SEG NUM	SOIL K	LENGTH FEET	SLOPE PCT	CP VALUE	PART OPT	SURF COND
1	1	.00	.0	.00	.000	1.0	.0
2	1	.00	.0	.00	.000	1.0	.0
3	1	.00	.0	.00	.000	1.0	.0
4	1	.00	.0	.00	.000	1.0	.0
5	1	.00	.0	.00	.000	1.0	.0
6	1	.00	.0	.00	.000	1.0	.0
7	1	.00	.0	.00	.000	1.0	.0
8	1	.00	.0	.00	.000	1.0	.0
9	1	.00	.0	.00	.000	1.0	.0
10	1	.00	.0	.00	.000	1.0	.0
11	1	.00	.0	.00	.000	1.0	.0
12	1	.00	.0	.00	.000	1.0	.0
13	1	.00	.0	.00	.000	1.0	.0
14	1	.00	.0	.00	.000	1.0	.0
15	1	.00	.0	.00	.000	1.0	.0
16	1	.00	.0	.00	.000	1.0	.0
17	1	.00	.0	.00	.000	1.0	.0
18	1	.00	.0	.00	.000	1.0	.0
19	1	.00	.0	.00	.000	1.0	.0
20	1	.00	.0	.00	.000	1.0	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)	SEDIMENT TONS	DIAM (MM)	DELIVERY RATIO 1	DELIVERY RATIO 2
1	1.02	.32	.00	.100	1.000	1.000
2	.27	.32	.00	.100	1.000	1.000
3	.59	.56	.00	.100	1.000	1.000
4	.14	.56	.00	.100	1.000	1.000
5	.41	.32	.00	.100	1.000	1.000
6	.21	.32	.00	.100	1.000	1.000
7	.04	.56	.00	.100	1.000	1.000
8	.59	.32	.00	.100	1.000	1.000
9	1.06	.93	.00	.081	.910	1.000
10	2.39	.93	.00	.087	.940	1.000
11	.62	.93	.00	.100	1.000	1.000
12	2.08	.93	.00	.079	.898	1.000
13	.31	.93	.00	.100	1.000	1.000
14	.27	.93	.00	.100	1.000	1.000
15	.58	.93	.00	.100	1.000	1.000
16	.81	1.29	.00	.100	1.000	1.000
17	.20	.93	.00	.100	1.000	1.000
18	.30	.93	.00	.100	1.000	1.000
19	.07	.93	.00	.100	1.000	1.000
20	.58	.32	.00	.100	1.000	1.000

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	1.1884	ACRE-FT
PEAK DISCHARGE	=	12.0044	CFS
AREA	=	23.0600	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS
BETA	=	.0100	
RAINFALL EROSITIVITY FACTOR	=	9.59	EI UNIT
PEAK CONCENTRATION	=	.00	MG/L
PEAK SETTLEABLE CONCENTRATION	=	.00	ML/L
PEAK SETTLEABLE CONCENTRATION	=	.00	MG/L
TOTAL SEDIMENT YIELD	=	.0000	TONS
REPRESENTATIVE PARTICLE SIZE	=	.0001	MM
TIME OF PEAK CONCENTRATION	=	.00	HRS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-6.80	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

* *

POND RESULTS

* *

***** CONTROL VARIABLES OPTIONS *****

FLOW	FRACTN	ISDO	NRHP	NSP	NCSTR
3	0	1	500	11	1

***** BASIN GEOMETRY *****

STAGE (FT)	AREA (ACRES)	AVERAGE DEPTH (FT)	DISCHARGE (CFS)	CAPACITY (ACRES-FT)
.00	.201	.00	.00	.00
.10	.203	.10	.00	.02
2.10	.241	2.01	.00	.46
4.10	.269	3.88	.00	.97
6.10	.299	5.70	.00	1.54
6.60	.306	6.14	.00	1.69
7.00	.312	6.50	8.90	1.82
7.40	.319	6.85	20.20	1.94
7.80	.325	7.20	42.50	2.07
8.20	.331	7.55	69.40	2.20
8.50	.335	7.81	93.70	2.30

***** STORM EVENT SUMMARY *****

TURBULENCE FACTOR	=	1.00	
PERMANENT POOL CAPACITY	=	1.693	ACRE-FT
DEAD STORAGE	=	20.00	PERCENT
TIME INCREMENT OUTFLOW	=	.10	HRS
VISCOSITY	=	.009	CM**2/SEC
INFLOW RUNOFF VOLUME	=	1.188	ACRE-FT
OUTFLOW ROUTED VOLUME	=	1.188	ACRE-FT
STORM VOLUME DISCHARGED (PLUG FLOW)	=	1.188	ACRE-FT
POND VOLUME AT PEAK STAGE	=	1.818	ACRE-FT
PEAK STAGE	=	7.002	FT
PEAK INFLOW RATE	=	12.004	CFS
PEAK DISCHARGE RATE	=	8.949	CFS
PEAK INFLOW SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.0000	ML/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.00	MG/L
STORM AVERAGE EFFLUENT CONCENTRATION	=	.00	MG/L
AVERAGE EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
BASIN TRAP EFFICIENCY	=**********		PERCENT
DETENTION TIME OF FLOW WITH SEDIMENT	=	.17	HRS
DETENTION TIME FROM HYDROGRAPH CENTERS	=	.17	HRS
DETENTION TIME INCLUDING STORED FLOW	=	.17	HRS
SEDIMENT LOAD DISCHARGED	=	.00	TONS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-7.70	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

*** RUN COMPLETED ****

Pond A - Summary

25-year, 6-hour storm
P = 1.8 in.

Inflow runoff volume = 1.19 Ac-ft
Outflow routed volume = 1.19 Ac-ft

Peak Stage = 7.00 (Elev. 7094.90')

Peak inflow = 12.0 cfs
Peak Discharge = 8.9 cfs

Freeboard = 1.50 ft.

Check Flow Capacity and Adequacy of Riprap on Inlet + Outlet Structures ⇒

Pond A

Inlet ⇒

Peak inflow = 11.4 cfs

Inlet is the entire access ramp to the pond. A small low-flow channel has been carved, but the whole ramp may be used for high flows. Assume the entire ramp is the inlet channel:

max slope = 2'/10' = .20
Min slope = 2'/10' = .20

resulting Velocity = 5.83 ft/s
resulting Depth = 0.17 ft OKAY ✓

Although the velocity can be considered erosive, the sediment will be contained by the pond, + is considered adequate. The channel will be maintained if excessive erosion occurs.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND A

Comment: INLET WITH REVISED DRAINAGE AREA

Solve For Depth

Given Input Data:

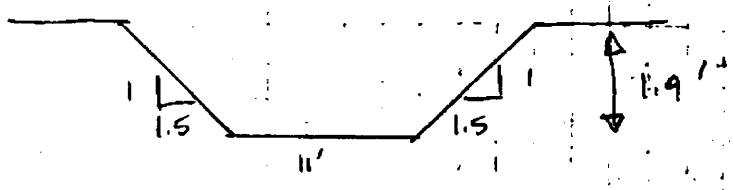
Bottom Width.....	11.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.2000 ft/ft
Discharge.....	12.00 cfs

Computed Results:

Depth.....	0.18 ft
Velocity.....	5.95 fps
Flow Area.....	2.02 sf
Flow Top Width...	11.36 ft
Wetted Perimeter.	11.51 ft
Critical Depth...	0.33 ft
Critical Slope...	0.0269 ft/ft
Froude Number....	2.49 (flow is Supercritical)

Pond A - outlet

Peak Q = 8.9 cfs



D_{50} = 4" bottom
10" side slopes

$n = .0395 (D_{50})^{1/6}$
$= .036$

Max + Min slope = 6'/13' = .46

resulting velocity = 6.68 ft/s
resulting depth = 0.12 ft

OKAY

Check riprap sizing ⇒

use attached figures:

assume K = 6" = .5 depth = d = .12

$\frac{K}{d} > 1$ ∴ $\frac{V_s}{V} = 1$ $V_s = V = 6.68$ ft/s

d_{50} = .4 ft ≐ 5" (for 2:1 slope)

existing riprap size is marginally adequate and will be maintained.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND A

Comment: OUTLET WITH REVISED DRAINAGE AREA

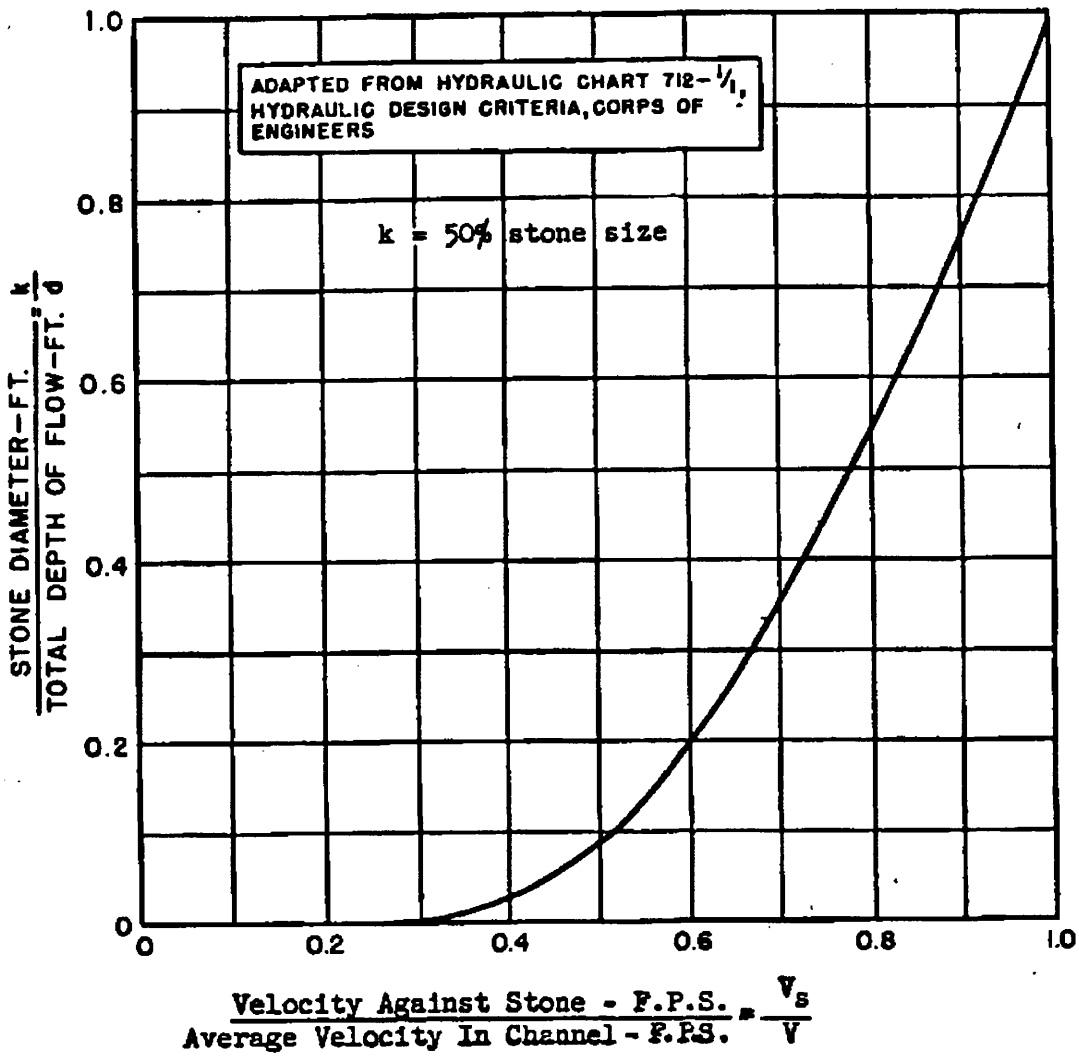
Solve For Depth

Given Input Data:

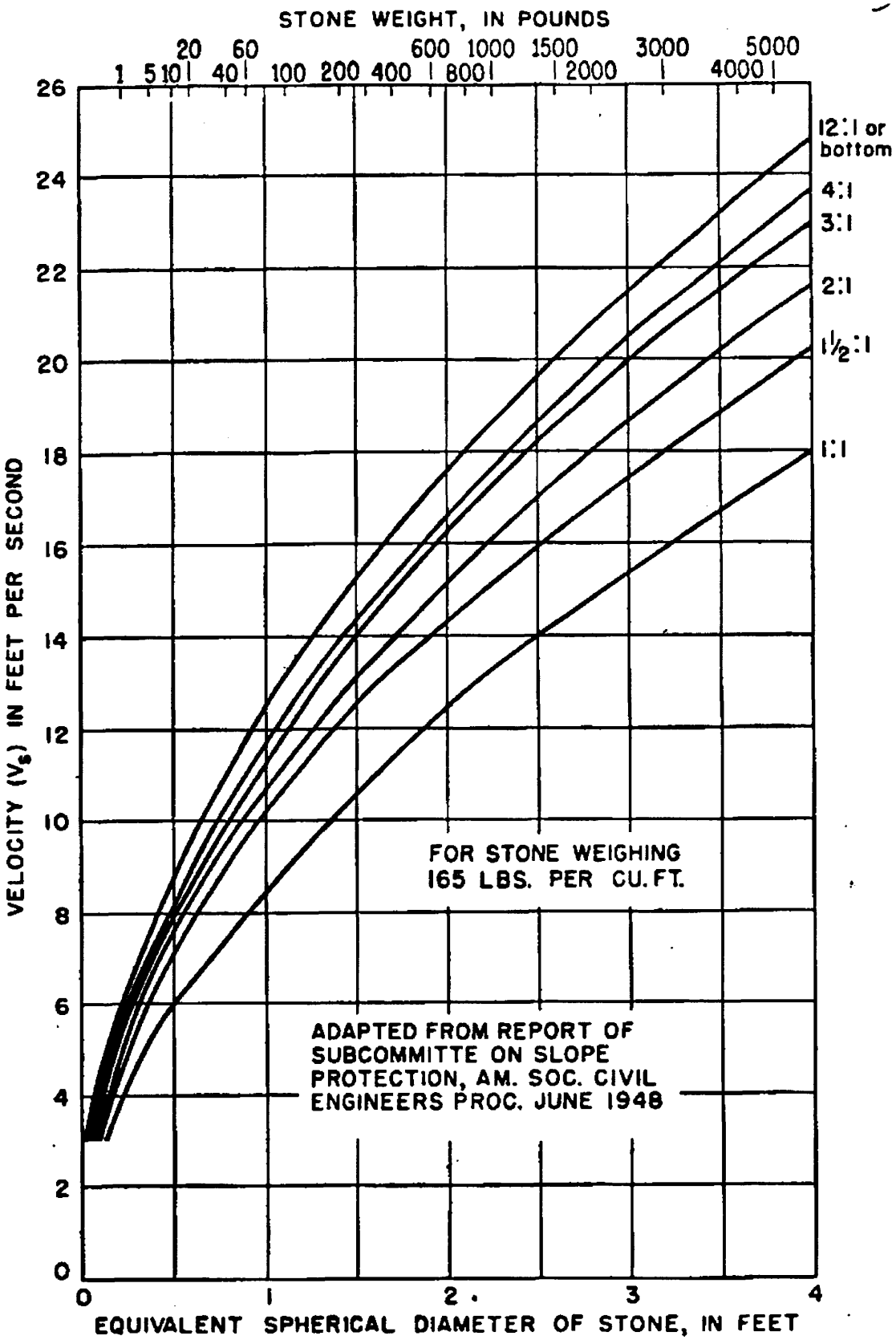
Bottom Width.....	11.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.036
Channel Slope....	0.4600 ft/ft
Discharge.....	8.90 cfs

Computed Results:

Depth.....	0.12 ft
Velocity.....	6.68 fps
Flow Area.....	1.33 sf
Flow Top Width...	11.36 ft
Wetted Perimeter.	11.43 ft
Critical Depth...	0.27 ft
Critical Slope...	0.0301 ft/ft
Froude Number....	3.44 (flow is Supercritical)



Velocity Against Stone on Channel Bottom (U.S. Department of Transportation, 1978).



Size of Stone that will Resist Displacement for Various Velocities and Side Slopes (U.S. Department of Transportation, 1978).

Pond 8

Stage - Capacity Data

Elev. (ft)	Area (ft^2)	Δ vol (ft^3)	cum. vol (ft^3)
7062	2350		0
		2609.5	
7063	2869		2609.5
		3142.5	
7064	3416		5752.0
		3711.0	
7065	4006		9463.0
		4260.5	
7066	4515		13,723.5
		4276.8	
Spillway FL → 7066.9	4989		18,000.3
		501.6	
7067	5042		18,501.9
		5310.0	
Top of Embankment → 7068	5578		23,811.9

Decant elevation = 7064.9'

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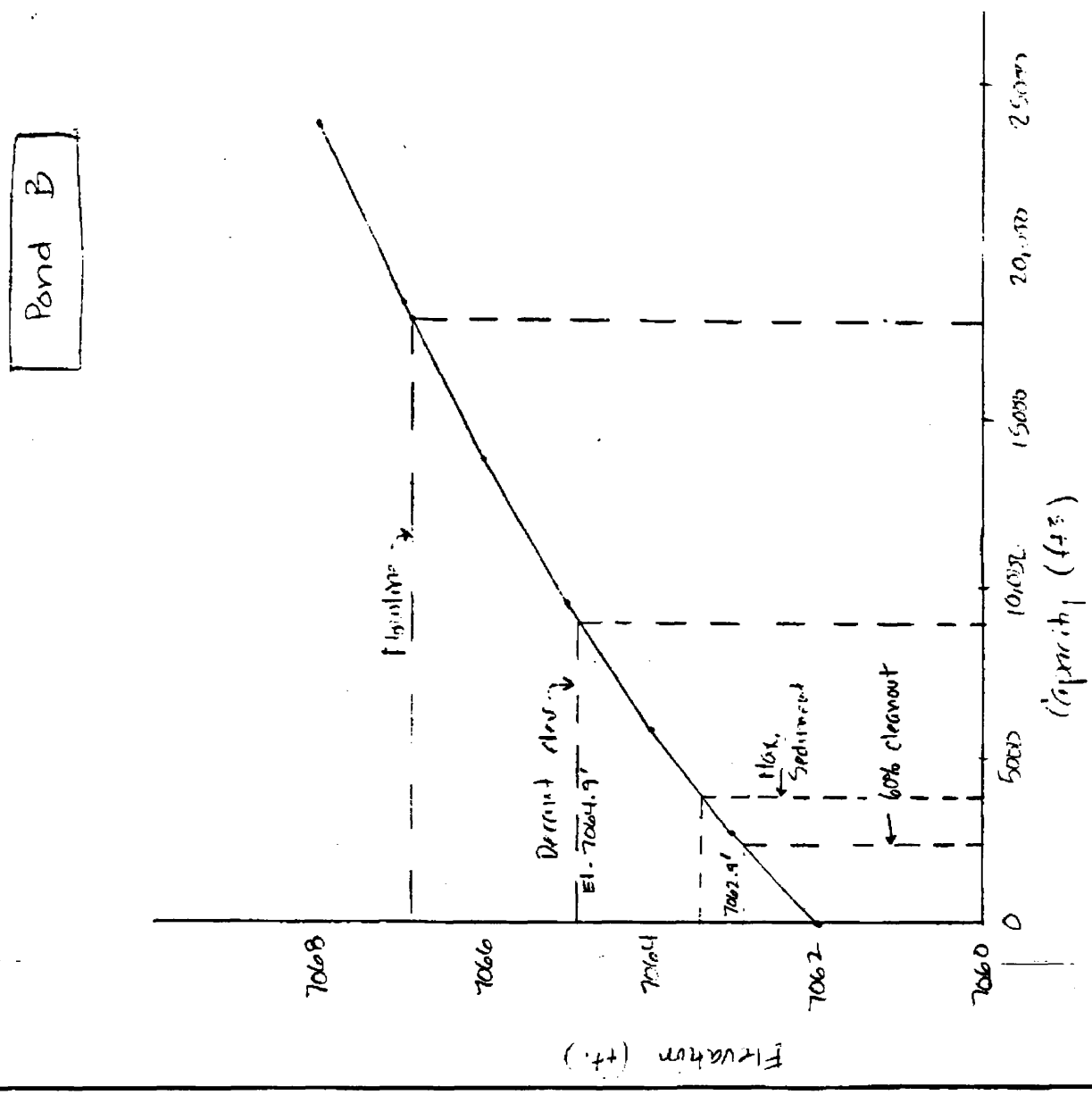
ENGINEERS / SCIENTISTS

PROJECT [illegible] PAGE 32 OF 51
COMPUTED [illegible] DATE 10/91
CHECKED _____ DATE _____



POND B

Disturbed Area AD-13 contributes to pond B.

$\ell = 800'$
$S = 8\%$

$$LS = \left(\frac{650 + 450(8) + 65(8)^2}{10000 + 8^2}\right)\left(\frac{800}{72.6}\right)^{.5} = 2.77$$

$A = 16(.10)(2.77)(1.2) = 5.33$ tons/Ac/year

Area of AD-10 = 1.78 Acres = 77,540 ft^2

Unit wt. of Soil ~ 100 lbs/ft^3

$A = 190$ ft^3/year

Runoff from 10-year, 24-hour storm:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad S = \frac{1000}{CN} - 10$$

CN = 90 for disturbed area
= 100 for pond surface.

$$\text{average } CN = \frac{5578\ ft^2(100) + 71{,}962\ ft^2(90)}{77{,}540\ ft^2} = 91$$

$S = \frac{1000}{91} - 10 = 0.99$ $\qquad P = 2.1$ inches

$$Q = \frac{(2.1 - (.2)(.99))^2}{2.1 + (.8)(.99)} = 1.25 \text{ inches}$$

$$\text{Volume} = 1.25 \text{ in}\left(\frac{1 ft}{12 in}\right)(77{,}540\ ft^2) = 8077\ ft^3$$

Check to see if Pond B will fully contain the 10-year, 24-hour precipitation event ⇒

Capacity at Spillway = 18,000.3 ft^3
Capacity at Decant = - 8,900.0 ft^3

Storage space for runoff = 9,100.3 ft^3

Since the runoff volume from the design storm is 8077 ft^3, the pond will NOT spill.

Decant elevation = 7064.9'

60% cleanout elevation = 7062.9'

60% cleanout volume = 2,200 ft^3

Maximum Sediment volume = $\frac{2200}{.6}$ = 3670 ft^3

Maximum Sediment Elevation = 7063.4'

∴ The existing pond will provide many years of sediment storage with an adequate decant system.

Pond B

Sediment I Data:

Watershed A5-10 contributes to pond.

CN = 91
Area = 1.78 Acres
l = Hyd length = 800'
y = ave slope = 8%

$$S = \frac{1000}{CN} - 10 = 0.99$$

$$L = \frac{l^{.8}(S+1)^{.7}}{1900\,y^{.5}} \qquad L = \frac{800^{.8}(1.99)^{.7}}{1900\sqrt{8}}$$

$$L = 0.063$$

$$T_c = 1.67L = 0.106 \text{ hr.}$$

* Use SCS Type B Distribution (See page 12 of this calc)

* Note: In order to route hydrograph through the pond spillway, the Sedimentology option of Sedimot II must be used. Although some approximations for sediment data are required, the output is not required for the 25-year, 6-hour storm. Thus, only the hydrologic data is valid. Disregard Sedimentology output!!

* 25-year, 6-hour storm = 1.8 inches

* Specific gravity of eroded sediment = 2.5
* Coef. for distributing Sed. Load = 1.5
* Submerged Bulk Specific gravity = 1.25

Grain Size Distribution:

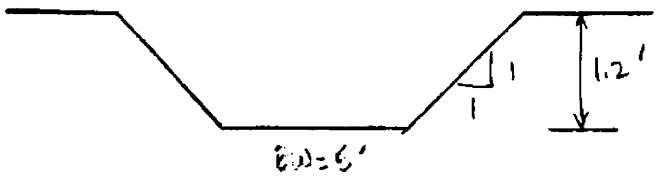
Size (mm)	% Finer
.25	100
.10	50
.05	35
.01	19
.005	15
.001	6
.0001	0

7 values

* No. of Structures = 1 (pond)
* Between Structures routing parameters → all Ø
* No. of Subwatersheds = 1
* MUSCLE data → all Ø
* % dead space → assume 20% (Not req'd for Hydrology)
* Outflow withdrawal → Surface
* Inflow vertical concentration → mixed
* Enter Stage Data Assuming pond empty to Decant elevation.
* Enter Stage - discharge curve for trap. Spillway.

POND E

SPILLWAY DATA (Not to Scale)



riprap D_{50} ~ 6"

calculate a Stage - discharge curve for the Spillway →

Based on a 100-foot wide rectangular section:

$$q_r = (.544)\, g^{1/2} (H_{ec})^{1.5} (100) = 308.69\, H_{ec}^{1.5}$$

Using attached Figure: L = 10'

H_p (ft)	H_{ec} (ft)	q_r (ft^3/s)
.5	.40	78.1
.8	.63	173.1
1.1	0.88	299.5

convert to trapezoidal section:

$$q_{trap} = \left[(1.5b + zH_{ec}) / 150 \right] (q_r)$$

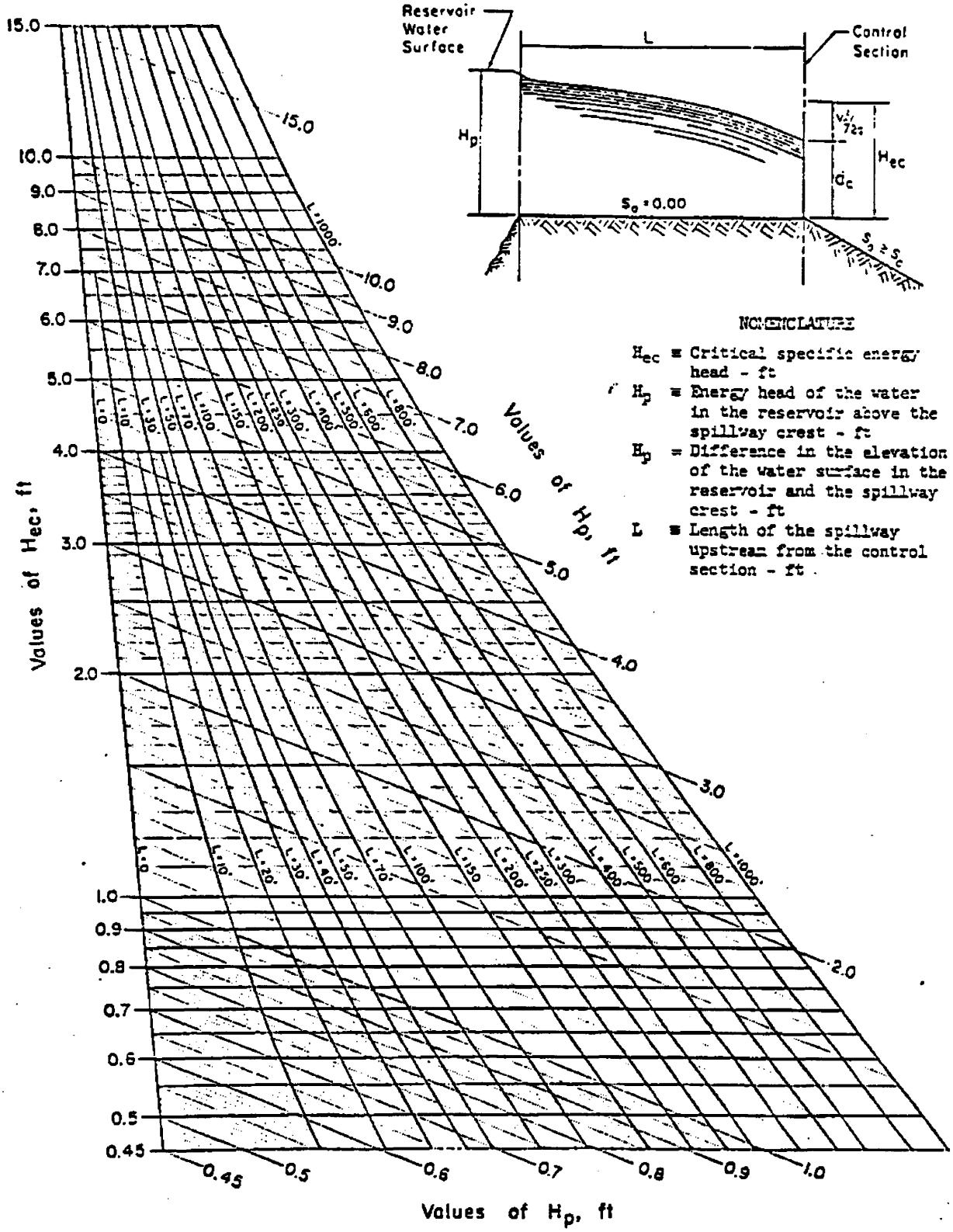
$b = 5'$
$z = 1$

Elev (ft.)	H_{ec} (ft)	q_r (ft^3/s)	q_{trap} (cfs)
7066.9	0	0	0
7067.4	.4	78.1	4.11
7067.7	.68	173.1	9.44
7068.0	.98	299.5	16.93

Assume pond is full of water to spillway [illegible] when 25-year, 24-hour storm occurs.

Revised Stage - Discharge curve ⇒

	Elevation (ft.)	Stage (ft)	Area (ft^2)	Area (Ac.)	Discharge (cfs)
	7066.8	0	4937	.113	0
FL →	7066.9	.1	4989	.115	0
	7067.4	0.6	5256	.121	4.11
	7067.7	0.9	5417	.124	9.44
Top of Embankment →	7068.0	1.2	5578	.128	16.93



Head relationships for selected broad-crest weirs (from U.S. Soil Conservation Service, 1968)

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*****************************************************************
                    -- SEDPC --
          SEDIMOT II MODEL FOR THE IBM PC/XT
          CONVERTED BY TECH ENGINEERING INC.
             VERSION 1.10 NOVEMBER 17,1983
*****************************************************************


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*****************************************************************

      UNIVERSITY OF KENTUCKY COMPUTER MODEL
      OF SURFACE MINE HYDROLOGY AND SEDIMENTOLOGY
      FOR MORE INFORMATION CONTACT THE AGRICULTURAL
      ENGINEERING DEPARTMENT

      THE UK MODEL IS A DESIGN MODEL DEVELOPED TO PREDICT
      THE HYDRAULIC AND SEDIMENT RESPONSE FROM SURFACE
      MINED LANDS FOR A SPECIFIED RAINFALL EVENT (SINGLE STORM)

      VERSION DATE 9-23-83

      DISCLAIMER: NEITHER THE UNIVERSITY NOR ANY OF ITS EMPLOYEES
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      CONCLUSIONS DRAWN FROM THE RESULTS OF THIS MODEL

*****************************************************************
*****************************************************************


*****************************************************************
*                                                               *
*     THE FOLLOWING VALUES ARE NOW PREDICTED BY SEDIMOT II.     *
*     THEY CAN BE FOUND IN SUMMARY TABLES.                      *
*      1. PERIOD OF SIGNIFICANT CONCENTRATION                   *
*      2. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      3. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PEAK 24 HOUR PERIOD                            *
*      4. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      5. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PEAK 24 HOUR PERIOD                            *
*                                                               *
*     ALL CONCENTRATIONS ARE IN ML/L.                           *
*                                                               *
*****************************************************************
```

****

WATERSHED IDENTIFICATION CODE

POND B - 25-YEAR, 6-HOUR STORM
SCS TYPE B DISTRIBUTION

****

********** INPUT RAINFALL PATTERN **********

VALUE	DEPTH	TIME
1	.00	.00
2	.06	.50
3	.14	1.00
4	.24	1.50
5	.41	2.00
6	1.08	2.50
7	1.26	3.00
8	1.40	3.50
9	1.50	4.00
10	1.59	4.50
11	1.67	5.00
12	1.74	5.50
13	1.80	6.00

INPUT PARTICLE SIZE-PERCENT FINER DISTRIBUTIONS

SIZE,MM	.250	.100	.050	.010	.005	.001
	.000					
PCT FINER NO. 1	100.000	50.000	35.000	19.000	15.000	6.000
	.000					

**********INPUT VALUES**********

STORM DURATION	=	6.00	HOURS
PRECIPATION DEPTH	=	1.80	INCHES
SPECIFIC GRAVITY	=	2.50	
LOAD RATE EXPONENT FACTOR	=	1.50	
SUBMERGED BULK SPECIFIC GRAVITY	=	1.25	

* *
JUNCTION 1, BRANCH 1, STRUCTURE 1
* *

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	1.78	91.00	.106	.000	.000	.00	.0

*** SEDIMENT INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	SEG NUM	SOIL K	LENGTH FEET	SLOPE PCT	CP VALUE	PART OPT	SURF COND
1	1	.00	.0	.00	.000	1.0	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)	SEDIMENT TONS	DIAM (MM)	DELIVERY RATIO 1	DELIVERY RATIO 2
1	1.68	.99	.00	.100	1.000	1.000

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.1469	ACRE-FT
PEAK DISCHARGE	=	1.6814	CFS
AREA	=	1.7800	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS
BETA	=	1.0000	
RAINFALL EROSITIVITY FACTOR	=	9.59	EI UNIT
PEAK CONCENTRATION	=	.00	MG/L
PEAK SETTLEABLE CONCENTRATION	=	.00	ML/L
PEAK SETTLEABLE CONCENTRATION	=	.00	MG/L
TOTAL SEDIMENT YIELD	=	.0000	TONS
REPRESENTATIVE PARTICLE SIZE	=	.0001	MM
TIME OF PEAK CONCENTRATION	=	.00	HRS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-6.00	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

* *

POND RESULTS

* *

***** CONTROL VARIABLES OPTIONS *****

FLOW	FRACTN	ISDO	NRHP	NSP	NCSTR
3	0	1	500	5	1

***** BASIN GEOMETRY *****

STAGE (FT)	AREA (ACRES)	AVERAGE DEPTH (FT)	DISCHARGE (CFS)	CAPACITY (ACRES-FT)
.00	.113	.00	.00	.00
.10	.115	.10	.00	.01
.60	.121	.59	4.11	.07
.90	.124	.89	9.44	.11
1.20	.128	1.18	16.93	.14

***** STORM EVENT SUMMARY *****

TURBULENCE FACTOR	=	1.00	
PERMANENT POOL CAPACITY	=	.011	ACRE-FT
DEAD STORAGE	=	20.00	PERCENT
TIME INCREMENT OUTFLOW	=	.10	HRS
VISCOSITY	=	.009	CM**2/SEC
INFLOW RUNOFF VOLUME	=	.147	ACRE-FT
OUTFLOW ROUTED VOLUME	=	.147	ACRE-FT
STORM VOLUME DISCHARGED (PLUG FLOW)	=	.147	ACRE-FT
POND VOLUME AT PEAK STAGE	=	.031	ACRE-FT
PEAK STAGE	=	.268	FT
PEAK INFLOW RATE	=	1.681	CFS
PEAK DISCHARGE RATE	=	1.381	CFS
PEAK INFLOW SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.0000	ML/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.00	MG/L
STORM AVERAGE EFFLUENT CONCENTRATION	=	.00	MG/L
AVERAGE EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
BASIN TRAP EFFICIENCY	=**********		PERCENT
DETENTION TIME OF FLOW WITH SEDIMENT	=	.17	HRS
DETENTION TIME FROM HYDROGRAPH CENTERS	=	.17	HRS
DETENTION TIME INCLUDING STORED FLOW	=	.17	HRS
SEDIMENT LOAD DISCHARGED	=	.00	TONS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-7.00	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

*** RUN COMPLETED ****

Pond B - Summary

Inflow runoff volume = 0.15 Ac-ft
Outflow runoff volume = 0.15 Ac-ft

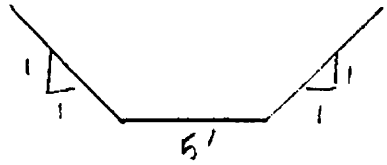
Peak inflow rate = 1.68 cfs
Peak outflow rate = 1.38 cfs

Peak Stage = 0.27' (Elev. 7067.07')

Freeboard = 0.93'

Pond B - outlet

Q peak = 1.38 cfs



$d_{50} = 6''$ $n = .036$

Min slope = max slope = 5'/12' = .42

resulting depth = .06 ft okay ✓
resulting velocity = 4.23 ft/s. ok ✓

Existing riprap is okay ✓

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND B

Comment: POND B OUTLET

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.036
Channel Slope....	0.4200 ft/ft
Discharge.....	1.38 cfs

Computed Results:

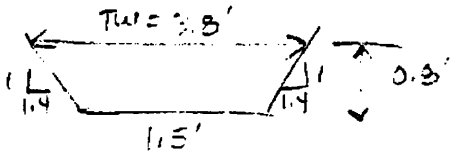
Depth.....	0.06 ft
Velocity.....	4.23 fps
Flow Area.....	0.33 sf
Flow Top Width...	5.13 ft
Wetted Perimeter.	5.18 ft
Critical Depth...	0.13 ft
Critical Slope...	0.0385 ft/ft
Froude Number....	2.96 (flow is Supercritical)

Pond B - Inlets

* Inlet 1 : Adjacent to Road - grouted riprap.

Min Slope = Max Slope = 6'/9' = .67

BW = 1.5'



Q peak = 1.68 cfs to pond. Inlet 2 receives approx. 80% of this. ∴ flow in = 1.34 cfs.

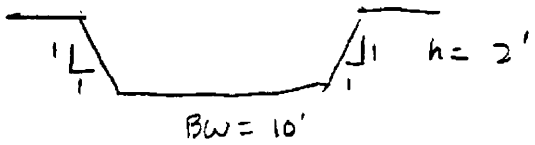
resulting depth = 0.11 ft. OKAY
resulting velocity = 7.34 ft/s OKAY since the inlet is grouted riprap.

---

* Inlet 2 : North End of Pond

min slope = max slope = 4'/13' = .31

Q in = 0.34 cfs



resulting depth = .02 ft OK
resulting velocity = 1.72 ft/s OK

Velocity considered non-erosive.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND B

Comment: POND B INLET #1

Solve For Depth

Given Input Data:

Bottom Width.....	1.50 ft
Left Side Slope..	1.40:1 (H:V)
Right Side Slope.	1.40:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.6700 ft/ft
Discharge.....	1.34 cfs

Computed Results:

Depth.....	0.11 ft
Velocity.....	7.34 fps
Flow Area.....	0.18 sf
Flow Top Width...	1.81 ft
Wetted Perimeter.	1.88 ft
Critical Depth...	0.27 ft
Critical Slope...	0.0325 ft/ft
Froude Number....	4.07 (flow is Supercritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND B

Comment: POND B INLET #2

Solve For Depth

Given Input Data:

Bottom Width.....	10.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.3100 ft/ft
Discharge.....	0.34 cfs

Computed Results:

Depth.....	0.02 ft
Velocity.....	1.72 fps
Flow Area.....	0.20 sf
Flow Top Width...	10.04 ft
Wetted Perimeter.	10.06 ft
Critical Depth...	0.03 ft
Critical Slope...	0.0560 ft/ft
Froude Number....	2.16 (flow is Supercritical)

Sediment Pond "C" Calculations

Soil Erosion to Pond "C"

REGISTERED PROFESSIONAL ENGINEER
No. 7900
KIMLY C. MANGUM
STATE OF UTAH

Use the modified Universal Soil Loss Equation:

$$A = R \cdot K \cdot LS \cdot VM$$

Ref: Israelson, C.E., J.E. Fletcher, F.W. Haws, E.K. Israelson, 1984. Erosion and Sedimentation in Utah: A Guide for Control. Utah Water Research Laboratories, Logan, Utah.

A = Amount of soil loss per unit area
R = Rainfall Factor
K = Soil Erodibility Factor
LS = Topographic Factor
VM = Erosion control factor:
= 1.2 for bare, copmacted soil
= 0.1 for Seedlings, Brush

For Pond "C" ⟶

R = 16 ft-tons/acre/Hr.
(Mean annual R value from Figure 1, (Israelson et al, 1984))

K = 0.1 tons/Ac/EI (Israelson et al, 1984)

$$LS = \left(\frac{650 + 450s + 65s^2}{10{,}000 + s^2}\right) \cdot \left(\frac{l}{72.5}\right)^m$$

l = slope length
s = Slope steepness

m = 0.2 for $0 < s < 1$ %
0.3 for $1 < s < 3$
0.4 for $3 < s < 5$
0.5 for $s > 5$

Drainage Area	Slope Length l (ft.)	Slope s (%)	LS	VM	A	Area (Acres)	A* (ft³/yr)
AD-15	400	7.5	1.79	1.2	3.44	1.84	126

(*)assume 100 lb/ft³ unit soil wt.

Total Sediment Volume = 126 ft³

Design Events

2 Year - 6 Hour	P = 1.0
10 Year - 6 Hour	P = 1.5
10 Year - 24 Hour	P = 2.1
25 Year - 6 Hour	P = 1.8
25 Year - 24 Hour	P = 2.7

For 10 year - 24 hour storm, P = 2.1 in.

Curve Numbers

Disturbed area - CN = 90

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad S = \frac{1000}{CN} - 10$$

Watershed	CN	S	Q (in)	Area (Ac)	Runoff Vol. (ft^3)
AD-15	90	1.11	1.18	1.84	7,881

Total Runoff Volume = 7,881 ft^3

To allow a 5 year factor of safety for sediment storage:

Sediment volume = 630 ft^3

Total Pond Volume = 8,511 ft^3

Quick TR-55 Version: 5.45 S/N: 1315430158

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Pond "C" Peak Discharge

CALCULATED
DISK FILE: POND-C .GPD

Drainage Area	(acres)	1.84	--->	0.0029 sq.mi.
Runoff Curve Number	(CN)	90		
Time of Concentration,Tc	(hrs)	0.09		
Rainfall Distribution	(Type)	II		
Pond and Swamp Areas	(%)	4.46	--->	0.1 acres

	Storm #1	Storm #2	Storm #3
Frequency (years)	10	25	10
Duration (hours)	24	6	6
Rainfall, P, (in)	2.1	1.8	1.5
Initial Abstraction, Ia (in)	0.222	0.222	0.222
Ia/p Ratio	0.106	0.123	0.148
Unit Discharge, * qu (csm/in)	1038	1033	1024
Runoff, Q (in)	1.18	0.93	0.68
Pond & Swamp Adjustment Factor	0.75	0.75	0.75
PEAK DISCHARGE, qp (cfs)	2.66	2.09	1.51

Summary of Computations for qu

Ia/p	#1	0.100	0.100	0.100
C0	#1	2.553	2.553	2.553
C1	#1	-0.615	-0.615	-0.615
C2	#1	-0.164	-0.164	-0.164
qu (csm)	#1	1040.188	1040.188	1040.188
Ia/p	#2	0.300	0.300	0.300
C0	#2	2.465	2.465	2.465
C1	#2	-0.623	-0.623	-0.623
C2	#2	-0.117	-0.117	-0.117
qu (csm)	#2	974.755	974.755	974.755
* qu (csm)		1038	1033	1024

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

$$\log(qu) = C0 + (C1 * \log(Tc)) + (C2 * (\log(Tc))^2)$$

qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)

Pond C - As-built Structure

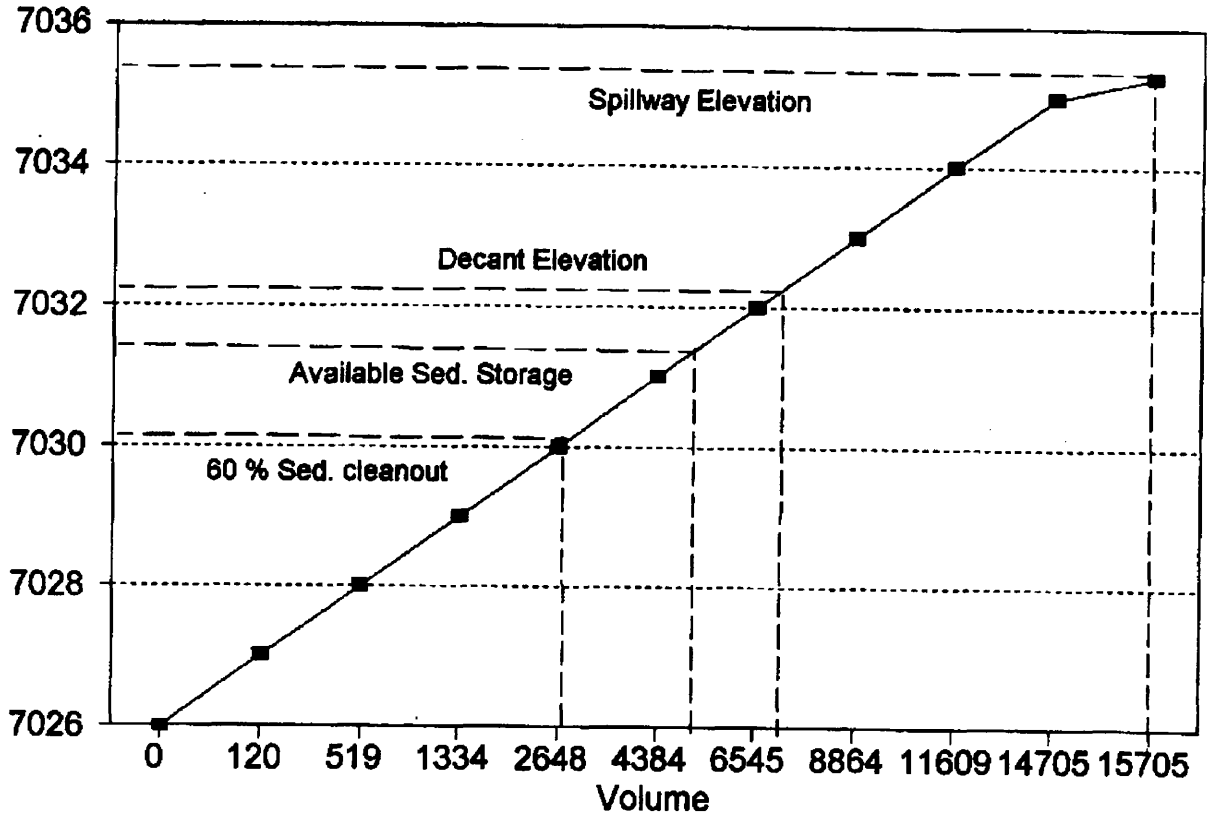
Stage - Area data

Elev. (ft.)	Area (ft^2)	Vol (ft^3)	cumulative Vol. (ft^3)
7026	22	0	0
7027	218	120	120
7028	579	399	519
7029	1,051	815	1,334
7030	1,578	1,315	2,648
7031	1,894	1,736	4,384
7032	2,245	2,070	6,545
7033	2,576	2,411	8,864
7034	2,914	2,745	11,609
7035	3,278	3,096	14,705
7035.3	3,390	1,000	15,705

Maximum volume below the emergency spillway is 15,705 cubic feet. The required volume for the 10 year - 24 hour storm event is 8,511 cubic feet. Therefore, the structure will contain the required storm event.

POND C

Stage - Capacity Curve



Outlet Structures

The proposed outlet structures will consist of a 4" decant and an emergency spillway in the form of a tapezoidal rip-rapped channel. The dimensions of the channel are shown on plate 7-6.

The combined outlets must pass the 25 Year - 6 Hour storm.

Outlet Calculations

Drainage area = 2.1 acres
Runoff CN = 90
Time of Concentration = 0.09 hrs.
Distribution = SCS Type II
Pond area = 0.09 acres
Precipitation, 25 Year - 6 Hour = 1.8 in.

From Table 4-1 (SCS TR-55), I_a = 0.222.

I_a/P = 0.1233

Unit Discharge:

$$\text{Log}(Qu) = C_o + C_1\log(Tc) + C_2[\log(Tc)]^2$$

Where:
Qu = Unit peak discharge (csm/in)
Tc = Time of concentration (hr)

C_o, C_1, C_2 = Coefficients from Table F-1 (SCS TR-55)

Qu = 1032.36 csm/in.

Peak Discharge:

Qp = Qu*A*Q*Fp

Where:
Qp = Peak discharge (cfs)
Qu = Unit discharge (csm/in)
A = Drainage area (qs.mi.)
Fp = Pond and swamp adjustment factor (Table 4-2, SCS TR-55)
Q = Runoff from 25 Year - 6 Hour = 0.93 cfs

Assuming the pond is full at the time of occurrence of the 25 year - 6 hour event, the worst case scenario is that the emergency outlet will receive a total flow of 2.09 cfs (With the decant closed).

FLOWMASTER was used to check the adequacy of the outlet design.

Inlet Design

The adequacy of the inlet design was checked for the 10 Year - 24 Hour event using FLOWMASTER.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND C

Comment: POND C INLET

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....	0.2000 ft/ft
Discharge.....	2.66 cfs

Computed Results:

Depth.....	0.19 ft
Velocity.....	6.03 fps
Flow Area.....	0.44 sf
Flow Top Width...	2.58 ft
Wetted Perimeter.	2.70 ft
Critical Depth...	0.35 ft
Critical Slope...	0.0263 ft/ft
Froude Number....	2.57 (flow is Supercritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND C

Comment: POND C OUTLET

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.033
Channel Slope....	0.3000 ft/ft
Discharge.....	2.09 cfs

Computed Results:

Depth.....	0.09 ft
Velocity.....	4.71 fps
Flow Area.....	0.44 sf
Flow Top Width...	5.26 ft
Wetted Perimeter.	5.31 ft
Critical Depth...	0.17 ft
Critical Slope...	0.0297 ft/ft
Froude Number....	2.86 (flow is Supercritical)

References:

Haestad Methods, Inc. 1991. FlowMaster I - User's Manual. Waterbury, Connecticut.

U.S. Soil Conservation Service, 1986. Urban Hydrology for Small Watersheds, Technical Release 55. United States Department of Agriculture, Washington, D.C.

Haestad Methods, Inc. 1989. Quick TR-55, Hydrology for Small Watersheds. Michael K. Glazner. Waterbury, Connecticut.

SEDIMENT POND "D"

Sediment Pond "D" Calculations

Sediment Pond "D" is designed to contain and treat the runoff for the Wild Horse Ridge Blind Canyon Seam portal pad (Bear Canyon No. 3 Mine). The pond is designed to contain the runoff from the 10-year 24-hour storm event in accordance with R645-301-742.220. The area is shown on Plate 7-5A, designated as area AD-18.

1 Soil Erosion to Pond "D"

Use the modified Universal Soil Loss Equation: A = R x K x LS x VM

Ref: Israelson, C.E., J.E. Fletcher, F.W. Haws, E.K. Israelson, 1984. Erosion and Sedimentation in Utah: A Guide for Control. Utah Water Research Laboratories, Logan, Utah.

A = Amount of soil loss per unit area
R = Rainfall Factor
K = Soil Erodibility Factor
LS = Topographic Factor
VM = Erosion control factor: = 1.2 for bare, compacted soil
= 0.1 for Seedlings, Brush

For Sediment Pond "D"

R= 16 ft-tons/acre/Hr. [Mean annual R value from Figure 1, (Israelson et al, 1984)]
K = 0.1 tons/ Ac/EI (Israelson et al, 1984)

$$LS = \left(\frac{650 + 450s + 65s^2}{10{,}000 + s^2}\right) \cdot \left(\frac{l}{72.6}\right)^m$$

l = slope length
s = slope steepness

m = 0.2 for 0 < s < 1 %
0.3 for 1 < s < 3 %
0.4 for 3 < s < 5 %
0.5 for s > 5

Drainage Area	Hyd. Length	Slope s (%)	LS	VM	A	A[a] (ft^3 / yr)
AD-18	770	3.16	0.70	1.2	1.34	24 ft^3/yr

[(a)] assume 100 lb/ft^3 unit soil wt.

To allow a 5 year factor of safety for sediment storage:

Sediment Volume = 270 ft^3

2 Peak design capacity

The pond is designed to contained the runoff from the 10-year 24-hour storm event. The outlet structures will be designed to pass the volume from a 25-year 6-hour storm event.

For Bear Canyon:

10 Year - 24 Hour	P = 2.1 in.
25 Year - 6 Hour	P = 1.8 in.

Curve Numbers: Disturbed Area - CN = 90

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad S = \frac{1000}{CN} - 10$$

Area	CN	S	Qu (in)	Area (acres)	Runoff Vol. (ft^3)
AD-18	90	1.11	1.18	0.9	3,855

Total Runoff volume = 3,855 ft^3
Total pond volume required for runoff and sediment = 4,125 ft^3

The proposed structure is shown on Plate 7-11. Following is the stage-capacity data for the proposed structure.

3 Stage - Capacity data

The following table presents the stage-volume data for the proposed structure.

Elev (ft)	Area (ft^2)	Vol (ft^3)	Cumulative Volume (ft^3)	
7644	42.20	0	0	
7645	208.65	125	125	
7646	467.98	338	463	
7647	825.02	646	1,109	
7648	1,274.70	1,050	2,159	
7649	1,962.65	1,619	3,778	
7650	2,871.97	2,417	6,195	
7650.5	3,243.73	1,529	7,724	Emergency spillway
7651.5	4,003.10	----	------	

The maximum volume below the emergency spillway is 7,724 cubic feet. The required volume for the 10 year - 24 hour storm event is 3,855 cubic feet, and the design sediment volume is 270 cubic feet, for a total design capacity of 4,125 cubic feet. Therefore, the structure will contain the required storm event. The maximum sediment capacity while still allowing for capacity of the design storm event is 3,869, which occurs near an elevation of 7649. To allow for an additional volume safety factor, the maximum sediment level will be set at 7647, allowing a sediment storage capacity of 1,109 ft^3. The primary spillway (decant) will be installed 1 foot above the maximum sediment level, at an elevation of 7648.

Sediment will be removed from the sediment pond in accordance with the plan presented in Appendix 3-K as soon as practical after it reaches 60% of the max design volume of 1,109 ft^3 .

The 60% Sediment Volume = 665 ft^3
The 60% Sediment cleanout elevation = 7,646.3

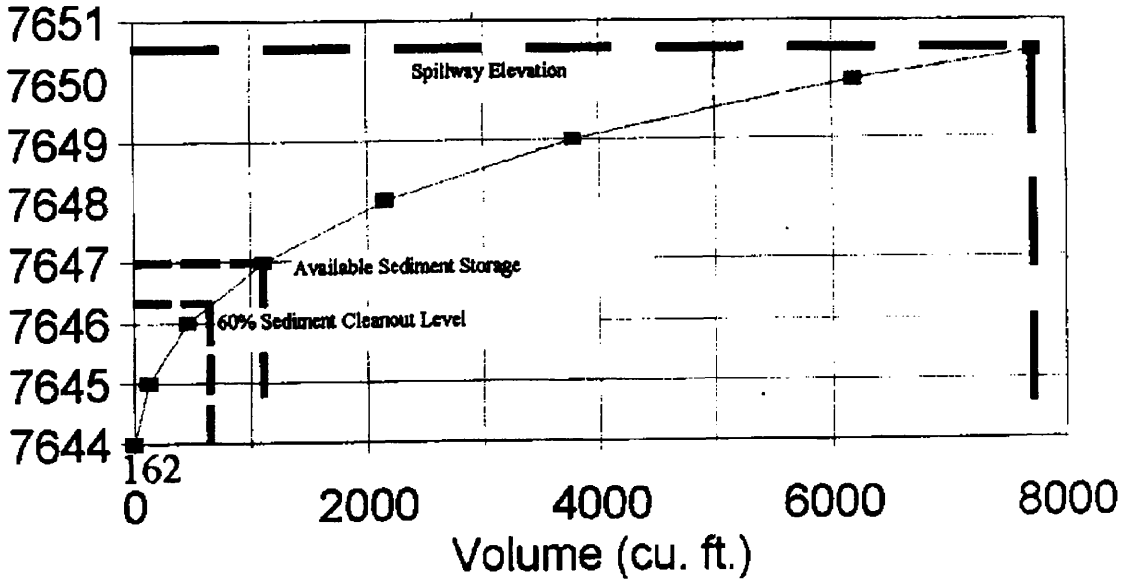
The decant elevation = 7,648

The volume above the decant = 5,565 ft^3.
10 - year 24 - hour storm volume = 3,855 ft^3

This will allow the pond to be decanted if necessary to a level to continue to allow for full containment of the design storm event.

POND D

Stage - Capacity Curve



4 Inlet Design

The adequacy of the inlet design was checked for the 10 Year - 24 Hour event using *Peak and Flowmaster* software programs.

Area	CN	Area (acres)	Slope Y(%)	Hyd length (ft)	Time of Conc.
AD-18	90	0.9	3.2	771	0.170

The following table summarizes the hydrograph and peak flow calculations for the watershed. The *Peak* software program was used to determine the peak flow.

PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AD-18

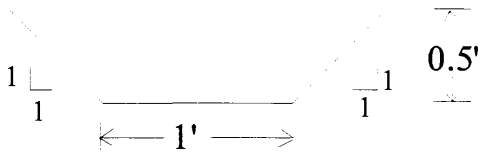
STORM:	WATERSHED:
Distribution = SCS Type 'II'	Curve Number = 90
Precip. Depth = 2.10 in	Time of Conc. = 0.1700 hr
Duration = 24.00 hr	Area = 0.90 ac

OUTPUT SUMMARY

Runoff depth = 1.1769 in
Initial Abstraction = 0.2222 in
Peak Flow = 1.03 cfs (1.1313 iph)
At T = 12.53 hrs

The inlet consists of a riprapped channel from Ditch D-16D (Plate 7-1G) into the sediment pond. Following is a cross-section of the inlet and the ditch calculation output. The inlet design was evaluated using *Flowmaster*.

Pond D Inlet cross-section



The slope of the channel inlet is 1'/3' = 0.33.

With a peak flow of 1.03 cfs, the resulting depth of flow = 0.14 ft.
The resulting velocity = 6.62 fps.

To prevent erosion, a grouted riprap will be used to line the inlet.

Worksheet
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Pond D Inlet
Flow Element	Trapezoidal Channe
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.330000	ft/ft
Left Side Slope	1.00	V : H
Right Side Slope	100.00	V : H
Bottom Width	1.00	ft
Discharge	1.03	cfs

Results		
Depth	0.14	ft
Flow Area	0.2	ft^2
Wetted Perimeter	1.35	ft
Top Width	1.14	ft
Critical Depth	0.30	ft
Critical Slope	0.029640	ft/ft
Velocity	6.70	ft/s
Velocity Head	0.70	ft
Specific Energy	0.84	ft
Froude Number	3.22	
Flow Type	Supercritical	

Notes: Grouted Riprap

5 Outlet Design

The proposed outlet structures will consist of a 4" decant and an emergency spillway in the form of a tapezoidal rip-rapped channel. The dimensions of the channel are shown on Plate 7-11. The combined outlets must past the 25 Year - 6 Hour storm.

Outlet Calculations

Drainage area = 0.9 acres
Runoff CN = 90
Time of Concentration = 0.1700 hrs.
Distribution = SCS Type II
Pond area = included in drainage area
Precipitation, 25 Year - 6 Hour = 1.8 in.

The table below shows the calculated peak flow which must pass through the two outlets:

PEAK
HYDROGRAPH GENERATION PROGRAM

INPUT SUMMARY FOR W.S.: AD-18 Pond Outlet Design

STORM:	WATERSHED:
Distribution = SCS Type 'II'	Curve Number = 90
Precip. Depth = 1.80 in	Time of Conc. = 0.1700 hr
Duration = 6.00 hr	Area = 0.90 ac

OUTPUT SUMMARY

Runoff depth = 0.9258 in
Initial Abstraction = 0.2222 in
Peak Flow = 2.07 cfs (2.2781 iph)
At T = 3.22 hrs

Flowmaster was used to evaluate the emergency spillway. Based on the following calculations, the emergency spillway will pass the entire flow from the 25 year - 6 hour event. Therefore, the outlet designs are adequate.

The resulting flow velocity = 8.04 fps, so 6" m.d. riprap will be used in the outlet.

Worksheet
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Pond D Outlet
Flow Element	Trapezoidal Channe
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.330000	ft/ft
Left Side Slope	0.75	V : H
Right Side Slope	0.75	V : H
Bottom Width	1.00	ft
Discharge	2.07	cfs

Results		
Depth	0.20	ft
Flow Area	0.3	ft^2
Wetted Perimeter	1.67	ft
Top Width	1.54	ft
Critical Depth	0.42	ft
Critical Slope	0.022881	ft/ft
Velocity	8.12	ft/s
Velocity Head	1.03	ft
Specific Energy	1.23	ft
Froude Number	3.52	
Flow Type	Supercritical	

Notes: Riprapped Channel

6 Protection From Rapid Drawdown

In accordance with R645-301-553.300, Sediment Pond D cross-section A-A' (shown on Plate 7-11) was analyzed for rapid drawdown stability. The analysis was conducted using a software program called SBSLOPE, released by the Office of Surface Mining.

The input data for the program was reviewed with Wayne Western, engineer for the Division of Oil, Gas & Mining. The program is not capable of printing the output, so the output results were visually confirmed by Wayne Western. The analysis resulted in a minimum safety factor of 1.36, which is greater than the required factor of 1.3.

References:

Haestad Methods, Inc. 1991. FlowMaster Open Channel Flow Module, Version 3.3. Waterbury, CT.

Israelson, C.E., J.E. Fletcher, F.W. Haws, E.K. Israelson, 1984. Erosion and Sedimentation in Utah: A Guide for Control. Utah Water Reserch Laboratories, Logan, Utah.

U.S. Soil Conservation Service, 1986. Urban hydrology for Small Watersheds, Technical Release 55. United States Department of Agriculture, Washington, D.C.