DESIGN REPORT:

CRANDALL CANYON MINE ACCESS
AND COAL HAUL ROAD

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Prepared for Mr. Bill Wollen
Vice President, Western Operations
Genwal Coal Company, Inc.

Boyle Engineering Corporation
18 South Carbon Avenue
Price, Utah 84501
(801) 637-6121

March 13, 1981

File in:
C/ 0150032, 1981, Incoming
Refer to:
❑ Confidential
❑ Shelf
❑ Expandable
Date 9/11/81 For additional information

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SUMMARY

The purpose of this report is to substantiate the design of a road to serve a coal mine in Crandall Canyon.

Design of the road must satisfy those requirements established by the governing regulatory agencies and integrate with the environment.

The proposed alignment extends from State Highway 31 in Huntington Canyon approximately 1½ miles up Crandall Canyon to the mine site. A 24 foot wide, 60 foot span bridge will cross Huntington Creek. Crandall Creek will be diverted back into the original channel. The archaeological site will be bypassed by the proposed and alternate alignments.

Safety, environmental impact, cost, and timely completion were held paramount in selection of alignment. The proposed alignment best satisfies all of these parameters.

The proposed alignment as detailed on the design drawings should be constructed to serve as access to the mine site.

INTRODUCTION

PURPOSE

This report provides a written narrative substantiating design drawings for an access/haul road extending from State Highway 31 in Huntington Canyon 1½ miles up Crandall Canyon. The road will serve the proposed mine to be operated by Genwal Coal Company.

PROBLEM

An improved road is an absolute necessity for operation of the mine facility. Design of the road must satisfy the requirements established by the governing regulatory agencies. Local geology makes this task difficult, particularly as relating to integration with existing environment.

SCOPE

In designing the road, four alignments were considered. The routes differ only in the lower reaches of the road. However, since the four alternate alignments are variations of two distinctively different alignments, only the two alignments will be discussed in this report.

Selection of the proposed alignment as most appropriate was based upon safety, environmental, cost and time considerations.

The proposed alignment is described and selection as most appropriate substantiated in Section I. Section II addresses the alternate alignment. Justification which manifests the alternate alignment to be less appropriate is given. A brief discussion of cost followed by

conclusions and recommendations complete the report.

SECTION I: PROPOSED ALIGNMENT

The proposed alignment as described on the design drawings best satisfies the selection parameters of safety, impact on environment, cost, and timely completion. Each of the major design and construction obstacles are discussed under separate headings which follow.

HUNTINGTON CREEK

A 60 foot single span bridge as approved for final design by the Forest Service will cross Huntington Creek. Total bridge width is 24 feet providing two 11 foot traffic lanes. The bridge deck will be precast, prestressed concrete sections. Bridge abutments, wingwalls, and foundation will be constructed of in-place reinforced concrete. Reinforced concrete approach slabs are provided to accommodate any differential settlement between bridge and roadway embankment. The foundation is a spread footing designed according to soil characteristics as identified in the foundation report prepared by R & M Consultants[1]. Tapered wingwalls are provided for roadway embankment restraint and channelization.

Hydraulic information for design is based upon a report prepared for Genwal Coal Company by Valley Engineering, Inc.[2] This report recommended

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[1] Genwal Huntington Creek Bridge Foundation Report, Project No. 161005, R & M Consultants (Murray, Utah, 1981).

[2] Genwal Coal Company Crandall Canyon Bridge Concept Plan, Valley Engineering, Inc. (Richfield, Utah, 1980).

construction of a 60 foot span bridge. The increased span affords a considerably greater flow capacity.

CRANDALL CREEK

Environmental impact and safety were the governing parameters in selecting the proposed roadway alignment along the lower reaches of Crandall Creek. Diversion of Crandall Creek into the original channel will be necessary. A 9'-6" x 6'-5" corrugated metal pipe arch culvert will be placed in the original channel to carry Crandall Creek under the roadway. Grading of portions of the original channel near the proposed confluence with Huntington Creek will be necessary to provide a smooth transitional slope. Channel grading is designed such that existing discharge velocities will not be exceeded.

In order to provide a more natural channel bottom through the culvert, the design requires the invert of the culvert be placed one foot below invert of flow profile. Native material will then be placed throughout the bottom of the culvert.

Diversion of Crandall Creek into the original channel allows the road alignment to follow a reasonably gentle curve directly following the bridge.

The existing alignment of Crandall Creek and the proposed road embankment conflict in three areas above the mouth of Crandall Canyon. It will be necessary to construct retaining walls to prevent the roadway embankment from encroaching upon and altering the alignment of Crandall Creek

in these areas.

Erosion protection of the roadway embankment will be necessary in several locations where abrupt changes in the alignment of Crandall Creek exist.

ARCHAEOLOGICAL SITE

An archaeological site has been identified near the mouth of Crandall Canyon. Protection of the site and timely completion of the road were decisive in selection of the proposed alignment. The proposed alignment averts the archaeological site and provides a buffer between the road and site.

LOCAL GEOLOGY AND ENVIRONMENT

Considerable difficulty was encountered in designing a road which satisfies specific requirements and mitigates environmental impact. Local geologic features constrained alignment selection. The proposed alignment and alternate alignment are, therefore, identical above the archaeological site. Outcrops of the Star Point Sandstone Formation are encountered with no reasonable possibility of circumvention in two conspicuous regions. Drilling and blasting will be necessary for construction of the road in these regions.

SECTION II: ALTERNATE ALIGNMENT

The alternate alignment differs both horizontally and vertically in

the lower portion of the road. The major difference being the alternate alignment averts Crandall Creek at the canyon mouth. This allows Crandall Creek to maintain existing alignment.

HUNTINGTON CREEK

Bridge span, width and location are identical for both alignments. However, the bridge will be in a 33.3 percent grade in the alternate alignment. The west bridge abutment will be raised two feet resulting in a considerable increase in construction cost. The exposed concrete surface of the west abutment will be increased by 33%.

CRANDALL CREEK

In order to circumvent Crandall Creek an extreme curve is necessary beginning at the west bridge abutment. The alternate alignment then parallels Crandall Creek for approximately 300 feet with roadway embankment falling in the existing Crandall Creek channel. Grade constraints on approaches to State Highway 31 and the bridge dictate vertical alignment of the roadway. This vertical alignment is below the existing Crandall Creek channel immediately following the bridge. Channel excavation or berming will be necessary to pass design flows.

ARCHAEOLOGICAL SITE

Both the proposed and alternate alignments avert the archaeological

site. Refer to the subject heading of the same title in Section I for discussion.

LOCAL GEOLOGY AND ENVIRONMENT

Both the proposed and alternate alignments are identical beyond the archaeological site. Refer to the subject heading of the same title in Section I for discussion.

COSTS

Preliminary cost estimates for the proposed and alternate alignments are approximately equal. The major differences which account for the approximately equal costs for construction are summarized below.

Proposed Alignment

1. Additional channel excavation.
2. 9'-6" x 6'-5" x 65' corrugated metal pipe arch culvert.
3. 75' x 15' high retaining wall at archaeological site.

Alternate Alignment

1. Increased west bridge abutment height.
2. Fewer earthwork balance points forces excessive overhaul.

3. Excess excavation to be disposed of.

4. Special treatment of Crandall Creek channel at canyon mouth.

CONCLUSIONS

In design of the road, numerous field trips were conducted to verify the most appropriate solutions to obstacles encountered. The following conclusions were derived from these field reviews and investigations for design:

1. The proposed alignment provides excellent earthwork balance.

2. Both alignments provide acceptable vertical grades.

3. The proposed alignment affords a greater degree of traffic safety.

4. The proposed alignment provides numerous earthwork balance points which minimizes overhaul and lessens construction impact.

5. A disposal area for excess excavation is necessary for the alternate alignment.

6. Both alignments impact Crandall Creek.

7. Due to the proximity of Crandall Creek to the alternate alignment at the canyon mouth, future impact upon Crandall Creek can be anticipated.

8. A more aesthetically pleasing bridge crossing at Huntington Creek can be provided with the proposed alignment. This is possible due to less exposed concrete and a bridge profile which is concurrent with the water profile.

RECOMMENDATIONS

Design investigation as summarized in this report manifest the following recommendations:

1. Construction of a road in Crandall Canyon should follow the proposed alignment.

2. The bridge crossing at Huntington Creek should provide two traffic lanes.

3. The bridge span at Crandall Creek should be 60 feet.

4. Solid rock slopes encountered in construction should have a ¼ horizontal to 1 vertical slope.

5. Fractured rock slopes encountered in construction should have a ½ horizontal to 1 vertical slope.

6. A natural earth bottom should be provided in the culvert on Crandall Creek by oversizing the culvert and installing accordingly.

7. Temporary ponds for sediment removal should be constructed of straw bales along Crandall Creek prior to construction.

8. Isolation of the bridge foundation construction area on Huntington Creek should be provided by temporary diking.

9. Bridge construction should be coordinated with water users and accomplished during low flow (early spring).

PROPOSED

B O Y L E E N G I N E E R I N G - H O R I Z O N T A L A L I G N M E N T

GENWAL COAL CORP. MINE ACCESS ROAD ALT NO. 4; CRANDALL CANYON

********** HORIZONTAL GEOMETRY **********

	20	101200.6191	107370.5920		1011.1431	S 88-29-13.2 W
PC	21	101195.4704	107175.6600		1206.1431	0- 0- .0 R S 88-29-13.2 W
CC	22	101396.7765	107170.3429	RAD=	201.3763	59-40-57.8 R
		DEGREE= 28-27- 7.5		L=	209.7656	
PI		101192.4202	107060.1779	TAN=	115.5224	EXT= 30.7828
PT	23	101290.5697	106999.2508		1415.9087	N 31-49-49.0 W 0- 0- .0 L N 31-49-49.0 W
PC	31	101497.4300	106870.8405		1659.3844	0- 0- .0 L N 31-49-49.0 W
CC	32	101372.0177	106668.8097	RAD=	237.7914	94- 0- .0 L
		DEGREE= 24- 5-41.9		L=	390.1228	
PI		101714.0816	106736.3523	TAN=	255.0000	EXT= 110.8772
PT	33	101564.8081	106529.6099		2049.5071	S 54-10-11.0 W 155-43-28.9 L N 78-26-42.1 E
PC	47	101564.8081	106529.6099		2049.5071	155-43-28.9 R S 54-10-11.0 W
CC	48	101950.5141	106251.1200	RAD=	475.7370	35- 0- .5 R
		DEGREE= 12- 2-36.9		L=	290.6125	
PI		101477.0002	106407.9967	TAN=	150.0000	EXT= 23.0873
PT	49	101474.8270	106258.0124		2340.1196	S 89-10-11.6 W 0- 0- .0 L S 89-10-11.6 W
PC	57	101468.5839	105827.1380		2771.0393	0- 0- .0 L S 89-10-11.6 W
CC	58	99890.3135	105850.1511	RAD=	1588.4371	7-12-16.6 L
		DEGREE= 3-36-25.4		L=	199.7364	
PI		101467.1351	105727.1485	TAN=	100.0000	EXT= 3.1446
PT	59	101453.1578	105628.1301		2970.7757	S 81-57-55.0 W 0- 0- .6 L S 81-57-54.4 W
PC	61	101414.5257	105354.4578		3247.1613	0- 0- 1.1 R S 81-57-55.5 W

CC	62	105644.2737	104757.4026	RAD=	4271.6792	8- 2- 4.5 R
		DEGREE=	1-20-28.7	L=	599.0165	
PI		101372.5945	105057.4026	TAN=	300.0000	EXT= 10.5215
						S 90- 0- .0 W
PT	63	101372.5945	104757.4026		3846.1777	0- 0- .0 L
						S 90- 0- .0 W
PC	71	101372.5945	104677.4065		3926.1738	0- 0- .0 L
						S 90- 0- .0 W
CC	72	100267.7515	104677.4065	RAD=	1104.8430	25-29-59.8 L
		DEGREE=	5-11- 9.2	L=	491.7194	
PI		101372.5945	104427.4065	TAN=	250.0000	EXT= 27.9315
						S 64-30- .2 W
PT	73	101264.9669	104201.7601		4417.8933	0- 0- .0 R
						S 64-30- .2 W
PC	81	100498.6569	102595.1545		6197.8968	0- 0- .0 R
						S 64-30- .2 W
CC	82	101385.8616	102171.9804	RAD=	982.9591	23- 0- 5.9 R
		DEGREE=	5-49-44.1	L=	394.6133	
PI		100412.5548	102414.6374	TAN=	200.0000	EXT= 20.1404
						S 87-30- 6.1 W
PT	83	100403.8369	102214.8275		6592.5101	0- 0- .0 L
						S 87-30- 6.1 W
PC	91	100385.5445	101795.5829		7012.1536	0- 0- .0 R
						S 87-30- 6.1 W
CC	92	99859.0790	101818.5533	RAD=	526.9664	25-39-25.6 L
		DEGREE=	10-52-21.9	L=	235.9760	
PI		100380.3137	101675.6969	TAN=	120.0000	EXT= 13.4904
						S 61-50-40.5 W
PT	93	100323.6899	101569.8964		7248.1296	0- 0- .0 R
						S 61-50-40.5 W
PC	101	100173.4623	101289.1989		7566.4996	0- 0- .0 R
						S 61-50-40.5 W
CC	102	100341.7262	101199.1450	RAD=	190.8466	44-49-56.8 R
		DEGREE=	30- 1-18.8	L=	149.3324	
PI		100136.3150	101219.7898	TAN=	78.7245	EXT= 15.5994
						N 73-19-22.7 W

PT	103	100158.9071	101144.3766		7715.8321	180- 0- .0 L
						S 73-19-22.7 E
PC	111	100158.9071	101144.3766		7715.8321	180- 0- .0 R
						N 73-19-22.7 W
CC	112	99943.3895	101079.8124	RAD=	224.9808	41-24-34.3 L
		DEGREE= 25-28- 1.1		L=	162.6009	
PI		100183.3100	101062.9188	TAN=	85.0345	EXT= 15.5337
						S 65-16- 3.0 W
PT	113	100147.7330	100985.6845		7878.4330	0- 0- .0 R
						S 65-16- 3.0 W
PC	121	100018.0490	100704.1518		8188.3985	0- 0- .0 R
						S 65-16- 3.0 W
CC	122	100208.0041	100616.6516	RAD=	209.1393	61-43-57.0 R
		DEGREE= 27-23-45.6		L=	225.3340	
PI		99965.7512	100590.6179	TAN=	125.0000	EXT= 34.5085
						N 53- 0- .0 W
PT	123	100040.9781	100490.7885		8413.7325	180- 0- .0 R
						S 53- 0- .0 E
PC	131	100040.9781	100490.7885		8413.7325	180- 0- .0 L
						N 53- 0- .0 W
CC	132	99951.0520	100423.0243	RAD=	112.5996	67-20- .0 L
		DEGREE= 50-53- 4.3		L=	132.3253	
PI		100086.1142	100430.8908	TAN=	75.0000	EXT= 22.6915
						S 59-40- .0 W
PT	133	100048.2370	100366.1582		8546.0582	16-17-49.5 R
						S 75-57-49.5 W
PC	141	100048.2370	100366.1582		8546.0582	16-17-49.5 L
						S 59-40- .0 W
CC	142	100375.0173	100174.9480	RAD=	378.6116	30-20- .0 R
		DEGREE= 15- 7-59.3		L=	200.4432	
PI		99996.4057	100277.5780	TAN=	102.6300	EXT= 13.6634
						S 90- 0- .0 W
PT	143	99996.4057	100174.9480		8746.5015	0- 0- .0 L
						S 90- 0- .0 W
	15	99996.4057	100074.5780		8846.8715	

B O Y L E E N G I N E E R I N G - E A R T H W O R K C A L C U L A T I O N S

GENWALL COAL CORP. MINE ACCESS ROAD ALT. NO. 4; CRANDELL CANYON

********** V E R T I C A L G E O M E T R Y **********

GRADE	BEGINNING OF CURVE STATION	BEGINNING OF CURVE ELEVATION	CURVE P.I. STATION	CURVE P.I. ELEVATION	END OF CURVE STATION	END OF CURVE ELEVATION	CURVE LENGTH
			1085.00	338.00			
.000000							
	1200.00	338.00	1300.00	338.00	1400.00	346.63	200.00
.086338							
	2683.71	457.47	2783.71	466.10	2883.71	472.63	200.00
.065333							
	2883.71	472.63	3083.71	485.70	3283.71	501.70	400.00
.079994							
	3500.00	519.00	3600.00	527.00	3700.00	535.22	200.00
.082229							
	4533.70	603.78	4633.70	612.00	4733.70	614.25	200.00
.022500							
	4733.70	614.25	4833.70	616.50	4933.70	623.86	200.00
.073600							
	5358.70	655.14	5458.70	662.50	5558.70	666.90	200.00
.044000							
	5983.70	685.60	6083.70	690.00	6183.70	698.46	200.00
.084615							
	6763.70	747.54	6863.70	756.00	6963.70	764.00	200.00
.080000							
	7363.70	796.00	7463.70	804.00	7563.70	807.67	200.00
.036667							
	7963.70	822.33	8063.70	826.00	8163.70	834.00	200.00
.080000							
	8563.70	866.00	8663.70	874.00	8763.70	882.34	200.00
.083355							

********** E A R T H W O R K V O L U M E S **********

BASELINE STATION	CENTERLINE STATION	X-SECTION AREA CUT	X-SECTION AREA FILL	INCRENTAL VOL CUT	INCRENTAL VOL FILL	ACCUMULATED VOL CUT	ACCUMULATED VOL FILL	MASS HAUL
1200.00	1200.00	.0	-259.2	0	0	0	0	0
1250.00	1250.00	.0	-81.7	0	-316	0	-363	-363
1300.00	1300.00	41.2	-1.0	38	-77	38	-451	-413
1400.00	1400.00	155.1	-2.5	363	-7	402	-458	-57
1500.00	1500.00	.0	-148.9	287	-280	689	-781	-92
1600.00	1600.00	50.3	-.0	93	-276	782	-1098	-316
1700.00	1700.00	.0	-142.4	93	-264	875	-1401	-526
1800.00	1800.00	99.5	-19.5	184	-300	1060	-1746	-686
1900.00	1900.00	105.9	-.0	380	-36	1440	-1787	-347
2000.00	2000.00	230.5	-.0	623	0	2063	-1787	276
2100.00	2100.00	52.7	-30.1	525	-56	2588	-1851	736
2200.00	2200.00	.0	-561.3	98	-1095	2685	-3111	-426
2300.00	2300.00	53.2	-311.1	99	-1616	2784	-4969	-2185
2400.00	2400.00	.0	-792.1	99	-2043	2882	-7318	-4436
2500.00	2500.00	.0	-584.9	0	-2550	2882	-10251	-7369
2550.00	2550.00	.0	-852.7	0	-1331	2882	-11782	-8899
2600.00	2600.00	.0	-317.4	0	-1083	2882	-13028	-10145
2700.00	2700.00	31.3	-240.1	58	-1032	2940	-14215	-11275
2800.00	2800.00	16.0	-206.7	88	-827	3028	-15167	-12138
2900.00	2900.00	34.5	-132.8	94	-629	3122	-15889	-12768
2950.00	2950.00	98.3	-129.7	123	-243	3245	-16169	-12924
3000.00	3000.00	321.1	-152.0	388	-261	3633	-16469	-12836
3100.00	3100.00	19.2	-169.0	630	-595	4263	-17153	-12889
3200.00	3200.00	.0	-484.3	36	-1210	4299	-18544	-14245
3300.00	3300.00	226.1	-155.9	419	-1186	4717	-19907	-15190
3400.00	3400.00	160.3	-272.3	716	-793	5433	-20819	-15386
3500.00	3500.00	509.4	-950.1	1240	-2264	6673	-23422	-16749
3600.00	3600.00	168.0	-348.4	1254	-2405	7928	-26188	-18260
3700.00	3700.00	155.5	-292.7	599	-1187	8527	-27553	-19027
3800.00	3800.00	658.4	-860.8	1507	-2136	10034	-30010	-19976
3900.00	3900.00	271.2	-699.5	1721	-2889	11755	-33332	-21577
4000.00	4000.00	917.8	-.0	2202	-1295	13957	-34822	-20865
4100.00	4100.00	433.3	-2.8	2502	-5	16459	-34828	-18369
4200.00	4200.00	303.4	-37.8	1364	-75	17823	-34915	-17091
4300.00	4300.00	667.7	-3.6	1798	-77	19622	-35003	-15381
4400.00	4400.00	529.5	-.0	2217	-7	21839	-35010	-13172
4500.00	4500.00	1268.1	-.0	3329	0	25167	-35010	-9843
4600.00	4600.00	773.6	-.0	3781	0	28948	-35010	-6062
4700.00	4700.00	160.9	-63.6	1731	-118	30679	-35146	-4467
4800.00	4800.00	.0	-443.0	298	-938	30977	-36225	-5248
4900.00	4900.00	172.0	-236.0	319	-1257	31295	-37671	-6375
5000.00	5000.00	247.6	-6.8	777	-450	32072	-38188	-6115
5100.00	5100.00	438.6	.0	1271	-13	33343	-38202	-4859
5200.00	5200.00	226.3	-75.8	1231	-140	34575	-38364	-3789
5300.00	5300.00	643.6	-.0	1611	-140	36185	-38525	-2340
5400.00	5400.00	424.7	-107.0	1978	-198	38164	-38753	-589
5500.00	5500.00	437.7	-57.4	1597	-304	39761	-39103	658
5600.00	5600.00	67.5	-98.9	936	-289	40696	-39436	1260
5700.00	5700.00	34.9	-418.1	190	-957	40886	-40537	349
5800.00	5800.00	.0	-302.3	65	-1334	40951	-42071	-1120
5900.00	5900.00	.0	-452.6	0	-1398	40951	-43679	-2728
6000.00	6000.00	.0	-183.5	0	-1178	40951	-45033	-4083
6100.00	6100.00	.0	-342.3	0	-974	40951	-46153	-5202
6200.00	6200.00	.0	-425.2	0	-1421	40951	-47787	-6837
6300.00	6300.00	.0	-1087.3	0	-2801	40951	-51009	-10058
6400.00	6400.00	.0	-1098.0	0	-4047	40951	-55663	-14712
6500.00	6500.00	.0	-770.4	0	-3460	40951	-59642	-18691
6600.00	6600.00	.0	-316.0	0	-2012	40951	-61956	-21005

********** E A R T H W O R K V O L U M E S **********

BASELINE STATION	CENTERLINE STATION	X-SECTION AREA CUT	X-SECTION AREA FILL	INCREMENTAL VOL CUT	INCREMENTAL VOL FILL	ACCUMULATED VOL CUT	ACCUMULATED VOL FILL	MASS HAUL
6700.00	6700.00	.0	-318.5	0	-1175	40951	-63307	-22356
6800.00	6800.00	32.7	-111.7	61	-797	41011	-64223	-23212
6900.00	6900.00	66.8	-83.8	184	-362	41196	-64639	-23444
7000.00	7000.00	191.1	-9.0	478	-172	41673	-64837	-23164
7100.00	7100.00	266.7	-34.2	848	-80	42521	-64929	-22408
7200.00	7200.00	117.3	-643.0	711	-1254	43232	-66371	-23139
7300.00	7300.00	199.7	-588.9	587	-2281	43819	-68995	-25176
7400.00	7400.00	246.1	-570.1	826	-2146	44645	-71463	-26818
7500.00	7500.00	210.0	-592.9	845	-2154	45489	-73940	-28451
7600.00	7600.00	.0	-511.5	389	-2045	45878	-76292	-30414
7700.00	7700.00	3206.1	-422.1	5937	-1729	51815	-78280	-26465
7800.00	7800.00	1912.9	-297.3	9480	-1332	61295	-79812	-18517
7900.00	7900.00	1471.3	-785.8	6267	-2006	67562	-82119	-14557
8000.00	8000.00	151.9	-13.3	3006	-1480	70568	-83820	-13252
8100.00	8100.00	106.5	-296.4	479	-573	71047	-84480	-13433
8200.00	8200.00	.0	-625.6	197	-1707	71244	-86443	-15200
8300.00	8300.00	.0	-123.5	0	-1387	71244	-88039	-16795
8400.00	8400.00	2488.1	-.0	4608	-229	75851	-88302	-12450
8500.00	8500.00	4813.9	-.0	13522	0	89374	-88302	1072
8600.00	8600.00	783.0	-.0	10365	0	99738	-88302	11437
8700.00	8700.00	.0	-288.4	1450	-534	101188	-88916	12272
8800.00	8800.00	.0	-271.6	0	-1037	101188	-90108	11080

********** S L O P E S T A K E D A T A **********

BASELINE STATION	CENTERLINE STATION	PROFILE GRADE ELEV	---- LEFT ----- SLOPE	CATCH PT	CENTERLINE OFFSET	---- RIGHT ---- CATCH PT	SLOPE
1200.00	1200.00	338.000	1.5	-24.47	.00	23.99	1.5
1250.00	1250.00	338.540	2.0	-19.48	.00	19.47	2.0
1300.00	1300.00	340.158	1.5	-19.72	.00	22.73	1.5
1400.00	1400.00	346.634	1.0	-38.00	.00	15.66	2.0
1500.00	1500.00	355.268	2.0	-17.53	.00	16.93	2.0
1600.00	1600.00	363.901	2.0	-18.42	.00	19.25	1.5
1700.00	1700.00	372.535	2.0	-20.30	.00	25.31	1.5
1800.00	1800.00	381.169	2.0	-24.40	.00	23.44	1.0
1900.00	1900.00	389.803	1.5	-22.50	.00	23.03	1.5
2000.00	2000.00	398.436	1.5	-23.94	.00	26.09	1.0
2100.00	2100.00	407.070	1.5	-27.99	.00	25.52	1.0
2200.00	2200.00	415.704	1.5	-41.20	.00	19.63	2.0
2300.00	2300.00	424.338	1.5	-39.74	.00	28.96	1.0
2400.00	2400.00	432.971	1.5	-45.81	.00	23.17	2.0
2500.00	2500.00	441.605	1.5	-55.29	.00	21.53	2.0
2550.00	2550.00	445.922	1.5	-73.38	.00	17.91	2.0
2600.00	2600.00	450.239	1.5	-36.34	.00	15.38	2.0
2700.00	2700.00	458.859	1.5	-33.18	.00	26.30	1.0
2800.00	2800.00	466.796	1.5	-36.55	.00	25.32	1.5
2900.00	2900.00	473.702	1.5	-30.81	.00	23.97	1.0
2950.00	2950.00	477.045	1.5	-32.79	.00	30.43	1.0
3000.00	3000.00	480.479	1.5	-35.34	.00	55.87	1.0
3100.00	3100.00	487.622	1.5	-30.85	.00	23.53	1.0
3200.00	3200.00	495.131	1.5	-70.80	.00	15.61	2.0
3300.00	3300.00	503.002	1.5	-40.21	.00	34.52	.3
3400.00	3400.00	511.001	1.5	-51.53	.00	24.59	.3
3500.00	3500.00	519.001	1.5	-81.80	.00	25.30	.3
3600.00	3600.00	527.056	1.5	-80.79	.00	21.81	.3
3700.00	3700.00	535.223	1.5	-57.25	.00	22.08	.3
3800.00	3800.00	543.446	1.5	-94.99	.00	60.27	1.0
3900.00	3900.00	551.669	1.5	-101.07	.00	45.41	1.0
4000.00	4000.00	559.892	1.5	-18.48	.00	68.62	1.0
4100.00	4100.00	568.114	1.5	-33.14	.00	43.66	1.0
4200.00	4200.00	576.337	1.5	-33.79	.00	40.12	1.0
4300.00	4300.00	584.560	1.5	-35.72	.00	60.87	1.0
4400.00	4400.00	592.783	1.5	-23.44	.00	38.15	1.0
4500.00	4500.00	601.006	1.5	-23.67	.00	71.53	1.0
4600.00	4600.00	608.573	1.5	-20.43	.00	40.29	1.0
4700.00	4700.00	613.322	1.5	-30.91	.00	31.75	1.0
4800.00	4800.00	616.303	1.5	-48.38	.00	16.05	2.0
4900.00	4900.00	621.525	1.5	-49.59	.00	29.06	1.0
5000.00	5000.00	628.740	2.0	-22.72	.00	34.54	1.0
5100.00	5100.00	636.100	1.0	-23.48	.00	36.40	1.0
5200.00	5200.00	643.460	1.5	-32.26	.00	39.33	1.0
5300.00	5300.00	650.820	1.5	-19.67	.00	51.26	1.0
5400.00	5400.00	658.053	1.5	-36.99	.00	56.66	1.0
5500.00	5500.00	664.062	1.5	-40.33	.00	56.84	1.0
5600.00	5600.00	668.717	1.5	-30.44	.00	29.40	1.0
5700.00	5700.00	673.117	1.5	-55.25	.00	29.28	1.0
5800.00	5800.00	677.517	1.5	-42.31	.00	15.66	2.0
5900.00	5900.00	681.917	1.5	-42.03	.00	18.56	2.0
6000.00	6000.00	686.344	1.5	-32.51	.00	15.68	2.0
6100.00	6100.00	692.091	1.5	-39.96	.00	20.17	2.0
6200.00	6200.00	699.841	1.5	-44.14	.00	20.42	2.0
6300.00	6300.00	708.302	1.5	-84.35	.00	29.79	1.5
6400.00	6400.00	716.764	1.5	-87.83	.00	26.35	1.5
6500.00	6500.00	725.225	1.5	-54.28	.00	22.91	2.0
6600.00	6600.00	733.687	1.5	-37.51	.00	20.26	2.0

********** S L O P E S T A K E D A T A **********

BASELINE STATION	CENTERLINE STATION	PROFILE GRADE ELEV	---- LEFT ----- SLOPE	CATCH PT	CENTERLINE OFFSET	---- RIGHT ---- CATCH PT	SLOPE
6700.00	6700.00	742.148	1.5	-33.47	.00	21.94	2.0
6800.00	6800.00	750.595	1.5	-28.93	.00	23.32	1.0
6900.00	6900.00	758.857	1.5	-29.79	.00	26.46	1.0
7000.00	7000.00	766.904	2.0	-21.82	.00	33.33	1.0
7100.00	7100.00	774.904	1.5	-27.75	.00	39.68	1.0
7200.00	7200.00	782.904	.3	-60.52	.00	25.70	.5
7300.00	7300.00	790.904	.3	-58.57	.00	29.78	.5
7400.00	7400.00	798.761	.3	-58.37	.00	30.51	.5
7500.00	7500.00	804.891	1.5	-59.51	.00	52.00	1.0
7600.00	7600.00	808.998	1.5	-47.07	.00	18.69	2.0
7700.00	7700.00	812.664	1.5	-41.79	.00	179.23	.5
7800.00	7800.00	816.331	1.5	-28.49	.00	168.58	.5
7900.00	7900.00	819.998	1.5	-37.02	.00	160.69	.5
8000.00	8000.00	823.807	1.5	-22.60	.00	30.49	1.0
8100.00	8100.00	829.344	1.5	-66.06	.00	30.41	1.0
8200.00	8200.00	836.904	1.5	-63.90	.00	27.11	1.5
8300.00	8300.00	844.904	1.5	-22.57	.00	16.85	2.0
8400.00	8400.00	852.904	1.5	-160.69	.00	33.33	.5
8500.00	8500.00	860.904	1.0	-184.00	.00	38.89	.5
8600.00	8600.00	868.915	1.0	-26.99	.00	40.58	1.0
8700.00	8700.00	877.060	1.5	-29.88	.00	20.91	2.0
8800.00	8800.00	885.361	1.5	-36.24	.00	16.67	2.0

ALTERNATE

B O Y L E E N G I N E E R I N G - H O R I Z O N T A L A L I G N M E N T

GENWAL COAL CORP. MINE ACCESS ROAD ALT NO. 3; CRANDALL CANYON

**********HORIZONTAL GEOMETRY**********

	20	101200.6191	107370.5920		1010.0909	S 88-29-13.0 W
PC	27	101195.4702	107175.6600		1205.0909	0- 0- .0 R S 88-29-13.0 W
CC	28	101280.6414	107173.4103	RAD=	85.2009	55-40-58.0 R
		DEGREE= 67-14-52.4		L=	82.8023	
PI		101194.2820	107130.6757	TAN=	45.0000	EXT= 11.1536
PT	29	101230.7660	107104.3333		1287.8932	N 35-49-49.0 W 0- 0- .0 L N 35-49-49.0 W
PC	37	101503.8649	106907.1487		1624.7385	0- 0- .0 L N 35-49-49.0 W
CC	38	101345.5671	106687.9077	RAD=	270.4160	90- 0- .0 L
		DEGREE= 21-11-16.8		L=	424.7685	
PI		101723.1059	106748.8509	TAN=	270.4160	EXT= 112.0100
PT	39	101564.8081	106529.6099		2049.5070	S 54-10-11.0 W 180- 0- .0 L N 54-10-11.0 E
PC	47	101564.8081	106529.6099		2049.5070	180- 0- .0 R S 54-10-11.0 W
CC	48	101950.5141	106251.1200	RAD=	475.7370	35- 0- .5 R
		DEGREE= 12- 2-36.9		L=	290.6125	
PI		101477.0002	106407.9967	TAN=	150.0000	EXT= 23.0873
PT	49	101474.8270	106258.0124		2340.1195	S 89-10-11.6 W 0- 0- .0 L S 89-10-11.6 W
PC	57	101468.5839	105827.1380		2771.0392	0- 0- .0 L S 89-10-11.6 W
CC	58	99880.3135	105850.1511	RAD=	1588.4371	7-12-16.6 L
		DEGREE= 3-36-25.4		L=	199.7364	
PI		101467.1351	105727.1485	TAN=	100.0000	EXT= 3.1446
PT	59	101453.1578	105628.1301		2970.7756	S 81-57-55.0 W 0- 0- .6 L S 81-57-54.4 W
PC	61	101414.5257	105354.4578		3247.1612	0- 0- 1.1 R S 81-57-55.5 W
CC	62	105644.2737	104757.4026	RAD=	4271.6792	8- 2- 4.5 R

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                    DEGREE=  1-20-28.7        L=  599.0165

PI          101372.5945    105057.4026   TAN=  300.0000   EXT=  10.5215

                                                          S 90- 0-  .0 W
PT   63     101372.5945    104757.4026        3846.1776     0- 0-  .0 L
                                                          S 90- 0-  .0 W

PC   71     101372.5945    104677.4065        3926.1737     0- 0-  .0 L
                                                          S 90- 0-  .0 W
CC   72     100267.7515    104677.4065   RAD= 1104.8430   25-29-59.8 L

                    DEGREE=  5-11- 9.2        L=  491.7194

PI          101372.5945    104427.4065   TAN=  250.0000   EXT=  27.9315

                                                          S 64-30-  .2 W
PT   73     101264.9669    104201.7601        4417.8932     0- 0-  .0 R
                                                          S 64-30-  .2 W

PC   81     100498.6569    102395.1545        6197.8967     0- 0-  .0 R
                                                          S 64-30-  .2 W
CC   82     101385.8616    102171.9804   RAD=  982.9591   23- 0- 5.9 R

                    DEGREE=  5-49-44.1        L=  394.6133

PI          100412.5548    102414.6374   TAN=  200.0000   EXT=  20.1404

                                                          S 87-30- 6.1 W
PT   83     100403.8368    102214.8275        6592.5100     0- 0-  .0 L
                                                          S 87-30- 6.1 W

PC   91     100385.5445    101795.5829        7012.1535     0- 0-  .0 R
                                                          S 87-30- 6.1 W
CC   92      99859.0790    101818.5533   RAD=  526.9664   25-39-25.6 L

                    DEGREE= 10-52-21.9        L=  235.9760

PI          100380.3137    101675.6969   TAN=  120.0000   EXT=  13.4904

                                                          S 61-50-40.5 W
PT   93     100323.6899    101569.8964        7248.1295     0- 0-  .0 R
                                                          S 61-50-40.5 W

PC  101     100173.4623    101289.1989        7566.4995     0- 0-  .0 R
                                                          S 61-50-40.5 W
CC  102     100341.7262    101199.1450   RAD=  190.8466   44-49-56.8 R

                    DEGREE= 30- 1-18.8        L=  149.3324

PI          100136.3150    101219.7898   TAN=   78.7245   EXT=  15.5994

                                                          N 73-19-22.7 W
PT  103     100158.9071    101144.3766        7715.8319   180- 0-  .0 L
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						S 73-19-22.7 E
PC	111	100158.9071	101144.3766		7715.8320	180- 0- .0 R
						N 73-19-22.7 W
CC	112	99943.3895	101079.8124	RAD=	224.9808	41-24-34.3 L
		DEGREE= 25-28- 1.1		L=	162.6009	
PI		100183.3100	101062.9188	TAN=	85.0345	EXT= 15.5337
						S 65-16- 3.0 W
PT	113	100147.7330	100985.6845		7878.4328	0- 0- .0 R
						S 65-16- 3.0 W
PC	121	100018.0490	100704.1518		8188.3983	0- 0- .0 R
						S 65-16- 3.0 W
CC	122	100208.0041	100616.6516	RAD=	209.1393	61-43-57.0 R
		DEGREE= 27-23-45.6		L=	225.3340	
PI		99965.7512	100590.6179	TAN=	125.0000	EXT= 34.5085
						N 53- 0- .0 W
PT	123	100040.9781	100490.7885		8413.7324	180- 0- .0 R
						S 53- 0- .0 E
PC	131	100040.9781	100490.7885		8413.7324	180- 0- .0 L
						N 53- 0- .0 W
CC	132	99951.0520	100423.0243	RAD=	112.5996	67-20- .0 L
		DEGREE= 50-53- 4.3		L=	132.3258	
PI		100086.1142	100430.8908	TAN=	75.0000	EXT= 22.6915
						S 59-40- .0 W
PT	133	100048.2370	100366.1582		8546.0581	16-17-49.5 R
						S 75-57-49.5 W
PC	141	100048.2370	100366.1582		8546.0581	16-17-49.5 L
						S 59-40- .0 W
CC	142	100375.0173	100174.9480	RAD=	378.6116	30-20- .0 R
		DEGREE= 15- 7-59.3		L=	200.4432	
PI		99996.4057	100277.5780	TAN=	102.6300	EXT= 13.6634
						S 90- 0- .0 W
PT	143	99996.4057	100174.9480		8746.5014	0- 0- .0 L
						S 90- 0- .0 W
	15	99996.4057	100074.5780		8846.8714	

B O I L E E N G I N E E R I N G - E A R T H W O R K C A L C U L A T I O N S

GENWALL COAL CORP. MINE ACCESS ROAD ALT. 3; CRANDELL CANYON

********** V E R T I C A L G E O M E T R Y **********

GRADE	BEGINNING OF CURVE STATION	BEGINNING OF CURVE ELEVATION	CURVE P.I. STATION	CURVE P.I. ELEVATION	END OF CURVE STATION	END OF CURVE ELEVATION	CURVE LENGTH
			1085.00	338.00			
.020000							
	1200.00	340.30	1300.00	342.30	1400.00	350.31	200.00
.080070							
	2683.71	453.09	2783.71	461.10	2883.71	468.97	200.00
.078667							
	2883.71	468.97	3083.71	484.70	3283.71	500.70	400.00
.079994							
	3500.00	518.00	3600.00	526.00	3700.00	534.32	200.00
.083196							
	4533.70	603.68	4633.70	612.00	4733.70	614.25	200.00
.022500							
	4733.70	614.25	4833.70	616.50	4933.70	623.86	200.00
.073600							
	5358.70	655.14	5458.70	662.50	5558.70	666.58	200.00
.040800							
	5983.70	683.92	6083.70	688.00	6183.70	696.46	200.00
.084615							
	6763.70	745.54	6863.70	754.00	6963.70	762.33	200.00
.083333							
	7363.70	795.67	7463.70	804.00	7563.70	807.67	200.00
.036667							
	7963.70	822.33	8063.70	826.00	8163.70	834.00	200.00
.080000							
	8563.70	866.00	8663.70	874.00	8763.70	882.34	200.00
.083355							

********** E A R T H W O R K V O L U M E S **********

BASELINE STATION	CENTERLINE STATION	X-SECTION AREA CUT	X-SECTION AREA FILL	INCRENTAL VOL CUT	INCRENTAL VOL FILL	ACCUMULATED VOL CUT	ACCUMULATED VOL FILL	MASS HAUL
1200.00	1200.00	.0	-378.3	0	0	0	0	0
1250.00	1250.00	.0	-216.6	0	-551	0	-633	-633
1300.00	1300.00	9.0	-86.2	8	-280	8	-956	-948
1400.00	1400.00	.0	-122.2	17	-386	25	-1400	-1375
1500.00	1500.00	.0	-20.0	0	-263	25	-1702	-1677
1600.00	1600.00	.0	-266.7	0	-531	25	-2313	-2288
1700.00	1700.00	.0	-391.9	0	-1220	25	-3715	-3690
1800.00	1800.00	143.6	-.0	266	-726	291	-4550	-4259
1900.00	1900.00	82.4	-.0	418	0	709	-4550	-3841
2000.00	2000.00	240.1	.0	597	0	1307	-4550	-3243
2100.00	2100.00	69.2	-39.3	573	-73	1879	-4634	-2754
2200.00	2200.00	.0	-482.0	128	-965	2007	-5744	-3736
2300.00	2300.00	100.4	-222.3	186	-1304	2193	-7244	-5050
2400.00	2400.00	.0	-621.3	186	-1562	2379	-9040	-6661
2500.00	2500.00	.0	-361.0	0	-1819	2379	-11132	-8753
2550.00	2550.00	15.4	-543.5	14	-838	2393	-12095	-9702
2600.00	2600.00	54.7	-148.5	65	-641	2458	-12832	-10374
2700.00	2700.00	141.0	-82.7	362	-428	2821	-13325	-10504
2800.00	2800.00	96.9	-44.9	441	-236	3261	-13597	-10335
2900.00	2900.00	125.2	-36.8	411	-151	3672	-13770	-10098
2950.00	2950.00	195.0	-46.9	296	-77	3969	-13859	-9891
3000.00	3000.00	464.8	-78.0	611	-116	4580	-13992	-9413
3100.00	3100.00	44.8	-109.7	944	-348	5524	-14392	-8869
3200.00	3200.00	15.1	-390.1	111	-926	5635	-15457	-9822
3300.00	3300.00	255.4	-116.8	501	-939	6135	-16537	-10401
3400.00	3400.00	179.8	-216.4	806	-617	6941	-17246	-10305
3500.00	3500.00	537.5	-871.4	1328	-2014	8270	-19563	-11293
3600.00	3600.00	195.6	-277.7	1358	-2128	9628	-22010	-12382
3700.00	3700.00	178.5	-244.7	693	-967	10320	-23122	-12802
3800.00	3800.00	717.1	-793.9	1659	-1923	11979	-25334	-13355
3900.00	3900.00	308.1	-631.8	1899	-2640	13877	-28370	-14493
4000.00	4000.00	971.8	.0	2370	-1170	16248	-29716	-13468
4100.00	4100.00	459.3	-2.0	2650	-4	18898	-29720	-10822
4200.00	4200.00	325.1	-28.8	1452	-57	20350	-29786	-9435
4300.00	4300.00	693.9	-1.3	1887	-56	22237	-29850	-7612
4400.00	4400.00	543.5	-.0	2291	-2	24529	-29853	-5324
4500.00	4500.00	1280.4	-.0	3378	0	27906	-29853	-1946
4600.00	4600.00	905.1	-.0	4047	0	31954	-29853	2101
4700.00	4700.00	161.0	-63.5	1974	-118	33928	-29988	3940
4800.00	4800.00	.0	-443.0	298	-938	34226	-31066	3160
4900.00	4900.00	172.0	-236.0	319	-1257	34545	-32512	2032
5000.00	5000.00	247.6	-6.8	777	-450	35322	-33029	2292
5100.00	5100.00	438.6	.0	1271	-13	36593	-33044	3549
5200.00	5200.00	226.3	-75.8	1231	-140	37824	-33205	4618
5300.00	5300.00	643.6	-.0	1611	-140	39435	-33367	6068
5400.00	5400.00	425.5	-106.5	1980	-197	41415	-33594	7821
5500.00	5500.00	448.5	-52.7	1618	-295	43033	-33933	9100
5600.00	5600.00	79.0	-83.4	977	-252	44010	-34223	9787
5700.00	5700.00	49.0	-366.8	237	-834	44247	-35182	9065
5800.00	5800.00	9.9	-243.7	109	-1130	44356	-36482	7874
5900.00	5900.00	.0	-370.3	18	-1137	44374	-37789	6585
6000.00	6000.00	18.9	-107.9	35	-886	44409	-38809	5602
6100.00	6100.00	.0	-231.6	35	-629	44444	-39531	4913
6200.00	6200.00	.0	-302.6	0	-989	44444	-40669	3776
6300.00	6300.00	.0	-863.1	0	-2159	44444	-43151	1293
6400.00	6400.00	.0	-873.5	0	-3216	44444	-46850	-2405
6500.00	6500.00	.0	-621.8	0	-2769	44444	-50034	-5590
6600.00	6600.00	.0	-210.7	0	-1542	44444	-51807	-7363

********** E A R T H W O R K V O L U M E S **********

BASELINE STATION	CENTERLINE STATION	X-SECTION AREA CUT	X-SECTION AREA FILL	INCREMTAL VOL CUT	INCREMTAL VOL FILL	ACCUMULATED VOL CUT	ACCUMULATED VOL FILL	MASS HAUL
6700.00	6700.00	.0	-214.5	0	-787	44444	-52713	-8268
6800.00	6800.00	78.2	-54.3	145	-498	44589	-53285	-8696
6900.00	6900.00	119.2	-34.8	366	-165	44955	-53475	-8520
7000.00	7000.00	264.2	-.0	710	-64	45665	-53549	-7884
7100.00	7100.00	326.1	-13.5	1093	-25	46758	-53578	-6820
7200.00	7200.00	263.3	-588.2	1091	-1114	47849	-54859	-7010
7300.00	7300.00	626.6	-556.6	1648	-2120	49497	-57297	-7800
7400.00	7400.00	639.6	-557.5	2345	-2063	51842	-59670	-7827
7500.00	7500.00	211.5	-590.7	1576	-2126	53418	-62115	-8696
7600.00	7600.00	.0	-511.5	392	-2041	53810	-64462	-10652
7700.00	7700.00	3206.1	-422.1	5937	-1729	59747	-66450	-6703
7800.00	7800.00	1912.9	-297.3	9480	-1332	69227	-67982	1245
7900.00	7900.00	1471.3	-785.8	6267	-2006	75494	-70289	5205
8000.00	8000.00	151.9	-13.3	3006	-1480	78500	-71991	6510
8100.00	8100.00	106.5	-296.4	479	-573	78979	-72650	6329
8200.00	8200.00	.0	-625.6	197	-1707	79176	-74613	4562
8300.00	8300.00	.0	-123.5	0	-1387	79176	-76209	2967
8400.00	8400.00	2488.1	-.0	4608	-229	83783	-76472	7312
8500.00	8500.00	4813.9	-.0	13522	0	97306	-76472	20834
8600.00	8600.00	783.0	-.0	10365	0	107670	-76472	31199
8700.00	8700.00	.0	-288.4	1450	-534	109120	-77086	32034
8800.00	8800.00	.0	-271.6	0	-1037	109120	-78278	30842

********** S L O P E S T A K E D A T A **********

BASELINE STATION	CENTERLINE STATION	PROFILE GRADE ELEV	---- LEFT ----- SLOPE	CATCH PT	CENTERLINE OFFSET	---- RIGHT ---- CATCH PT	SLOPE
1200.00	1200.00	340.300	1.5	-27.84	.00	27.30	1.5
1250.00	1250.00	341.675	2.0	-21.95	.00	25.38	1.5
1300.00	1300.00	343.802	1.5	-19.54	.00	24.78	1.5
1400.00	1400.00	350.307	1.5	-27.23	.00	17.22	2.0
1500.00	1500.00	358.314	2.0	-15.01	.00	17.46	2.0
1600.00	1600.00	366.321	2.0	-22.70	.00	24.02	1.5
1700.00	1700.00	374.328	1.5	-25.88	.00	30.78	1.5
1800.00	1800.00	382.335	1.5	-25.45	.00	21.65	1.5
1900.00	1900.00	390.342	1.5	-22.44	.00	22.41	1.5
2000.00	2000.00	398.349	1.5	-24.41	.00	26.82	1.0
2100.00	2100.00	406.356	2.0	-24.48	.00	26.56	1.0
2200.00	2200.00	414.363	1.5	-38.99	.00	18.48	2.0
2300.00	2300.00	422.370	1.5	-36.59	.00	32.83	1.0
2400.00	2400.00	430.377	1.5	-41.53	.00	21.12	2.0
2500.00	2500.00	438.383	1.5	-44.67	.00	17.52	2.0
2550.00	2550.00	442.387	1.5	-70.97	.00	27.03	1.0
2600.00	2600.00	446.390	1.5	-29.22	.00	27.23	1.0
2700.00	2700.00	454.396	1.5	-25.43	.00	34.82	1.0
2800.00	2800.00	462.357	1.5	-24.90	.00	28.12	1.0
2900.00	2900.00	470.249	1.5	-24.66	.00	28.70	1.0
2950.00	2950.00	474.189	1.5	-27.33	.00	35.19	1.0
3000.00	3000.00	478.137	1.5	-30.94	.00	63.49	1.0
3100.00	3100.00	486.059	1.5	-28.07	.00	26.17	1.0
3200.00	3200.00	494.014	1.5	-68.96	.00	25.16	1.5
3300.00	3300.00	502.002	1.5	-31.64	.00	34.81	.3
3400.00	3400.00	510.001	1.5	-49.69	.00	24.97	.3
3500.00	3500.00	518.001	1.5	-81.06	.00	25.57	.3
3600.00	3600.00	526.080	1.5	-76.93	.00	22.09	.3
3700.00	3700.00	534.320	1.5	-55.58	.00	22.34	.3
3800.00	3800.00	542.639	1.5	-94.45	.00	61.81	1.0
3900.00	3900.00	550.959	1.5	-100.56	.00	47.64	1.0
4000.00	4000.00	559.279	1.5	-18.96	.00	70.06	1.0
4100.00	4100.00	567.598	2.0	-24.75	.00	44.38	1.0
4200.00	4200.00	575.918	1.5	-31.65	.00	41.04	1.0
4300.00	4300.00	584.237	1.5	-32.21	.00	61.48	1.0
4400.00	4400.00	592.557	1.5	-23.66	.00	38.43	1.0
4500.00	4500.00	600.877	1.5	-23.79	.00	71.98	1.0
4600.00	4600.00	608.529	1.5	-20.47	.00	64.23	1.0
4700.00	4700.00	613.319	1.5	-30.90	.00	31.75	1.0
4800.00	4800.00	616.303	1.5	-48.38	.00	16.05	2.0
4900.00	4900.00	621.525	1.5	-49.59	.00	29.06	1.0
5000.00	5000.00	628.740	2.0	-22.72	.00	34.54	1.0
5100.00	5100.00	636.100	1.0	-23.48	.00	36.40	1.0
5200.00	5200.00	643.460	1.5	-32.26	.00	39.33	1.0
5300.00	5300.00	650.820	1.5	-19.67	.00	51.26	1.0
5400.00	5400.00	658.040	1.5	-36.94	.00	56.69	1.0
5500.00	5500.00	663.902	1.5	-39.78	.00	57.11	1.0
5600.00	5600.00	668.265	1.5	-29.03	.00	30.23	1.0
5700.00	5700.00	672.345	1.5	-53.37	.00	31.28	1.0
5800.00	5800.00	676.425	1.5	-38.58	.00	25.63	1.0
5900.00	5900.00	680.505	1.5	-39.13	.00	16.94	2.0
6000.00	6000.00	684.614	1.5	-28.35	.00	24.54	1.5
6100.00	6100.00	690.147	1.5	-36.25	.00	17.43	2.0
6200.00	6200.00	697.841	1.5	-40.39	.00	17.63	2.0
6300.00	6300.00	706.302	1.5	-82.69	.00	27.43	1.5
6400.00	6400.00	714.764	1.5	-86.11	.00	24.21	1.5
6500.00	6500.00	723.225	1.5	-50.93	.00	20.51	2.0
6600.00	6600.00	731.697	1.5	-31.28	.00	17.53	2.0

********** S L O P E S T A K E D A T A **********

BASELINE STATION	CENTERLINE STATION	PROFILE GRADE ELEV	---- LEFT ----- SLOPE	CATCH PT	CENTERLINE OFFSET	---- RIGHT ---- CATCH PT	SLOPE
6700.00	6700.00	740.148	1.5	-29.70	.00	18.92	2.0
6800.00	6800.00	748.606	1.5	-25.26	.00	25.90	1.0
6900.00	6900.00	757.012	1.5	-24.53	.00	29.07	1.0
7000.00	7000.00	765.358	1.5	-18.24	.00	35.90	1.0
7100.00	7100.00	773.692	1.5	-23.00	.00	41.76	1.0
7200.00	7200.00	782.025	.3	-60.21	.00	47.94	1.0
7300.00	7300.00	790.358	.3	-58.41	.00	85.24	1.0
7400.00	7400.00	798.538	.3	-58.30	.00	78.90	1.0
7500.00	7500.00	804.858	1.5	-59.43	.00	52.12	1.0
7600.00	7600.00	808.998	1.5	-47.07	.00	18.69	2.0
7700.00	7700.00	812.664	1.5	-41.79	.00	179.23	.5
7800.00	7800.00	816.331	1.5	-28.49	.00	168.53	.5
7900.00	7900.00	819.998	1.5	-37.02	.00	160.69	.5
8000.00	8000.00	823.807	1.5	-22.60	.00	30.49	1.0
8100.00	8100.00	829.344	1.5	-66.06	.00	30.41	1.0
8200.00	8200.00	836.904	1.5	-63.90	.00	27.11	1.5
8300.00	8300.00	844.904	1.5	-22.57	.00	16.85	2.0
8400.00	8400.00	852.904	1.5	-160.69	.00	33.33	.5
8500.00	8500.00	860.904	1.0	-184.00	.00	38.89	.5
8600.00	8600.00	868.915	1.0	-26.99	.00	40.58	1.0
8700.00	8700.00	877.060	1.5	-29.88	.00	20.91	2.0
8800.00	8800.00	885.361	1.5	-36.24	.00	16.67	2.0

GENWAL HUNTINGTON CREEK BRIDGE FOUNDATION REPORT

R&M Project #161005

Prepared by

R&M Consultants, Inc.
5280 South 320 West, Suite E-160
Murray, Utah 84107
(801) 263-3419

February 1981

GENWAL HUNTINGTON CREEK BRIDGE FOUNDATION REPORT

I. PURPOSE AND SCOPE

The purpose of this report is to present the results of investigations to determine criteria for foundation design for a 60-foot pre-stressed concrete bridge across Huntington Creek approximately 11 miles above the Huntington Canyon Power Plant, just off Utah Highway 31. The bridge will accommodate heavy truck loading for the Genwal coal mine to be located approximately 1 mile up Crandall Canyon from the proposed bridge.

II. INVESTIGATION APPROACH

A CME-55 drill rig, utilizing an 8" hollow stem auger was used to drill one hole at each abutment location at the bridge site. Blow counts and penetration samples were taken using a 340-lb hammer with 30" free fall and a split spoon California sampler device. Drilling was accomplished February 5-6, respectively for borings #1 & 2. Laboratory testing of samples was then accomplished to determine classification, density, moisture, and other criteria to be used for bearing and settlement considerations. Prior to drilling, the site was inspected by a soils engineer and geologist, and available hydrology reports were reviewed along with aerial photography and other published geologic data for the specific bridge location.

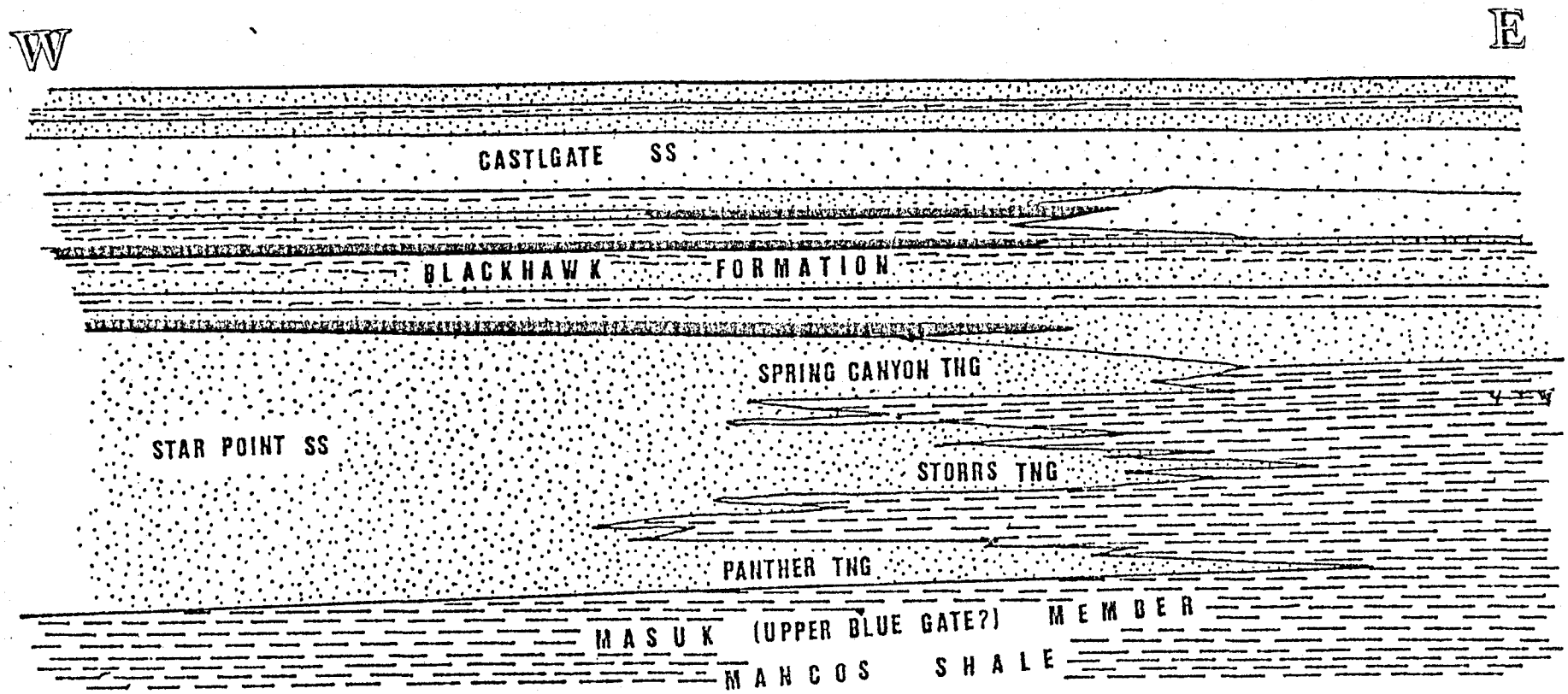
III. GEOLOGY

Rocks exposed in the area of the proposed bridge crossing of Huntington Creek are assigned to two units: the Mancos Shale and the overlying Star Point Sandstone.

The Mancos Shale is exposed in the immediate vicinity of the confluence of Huntington Creek and Crandall Creek as well as along the entire length of Huntington Canyon. Strata at the proposed bridge crossing belong to the Masuk Member of the Mancos Shale and consist of medium gray, slope-forming, mudstone and siltstone with subordinate silty sandstone. The Mancos Shale is generally non-resistant and weathers to form moderate slopes which are usually covered by a colluvial veneer of sandstone boulders and cobbles derived from the overlying Star Point sandstone. The Huntington Creek channel is filled with alluvial material derived from upstream outcrops of sandstones and siltstones.

Approximately 40 feet above the level of Huntington Creek, the Mancos Shale passes into the Star Point Sandstone across a sharp, but conformable, contact. This contact is expressed as change from the even slopes Mancos to the alternating benches, cliffs, and ledges of the Star Point. The Star Point sandstone consists of a series of relatively thick (40-80 feet) cliff-forming sandstone units separated by thinner partings of slope-forming shale and very fine-grained sandstone with an aggregate thickness of over 450 feet. The Star Point Sandstone has been divided into three prominent tongues of which only the lowermost Panther Tongue (fig. 1) is exposed near the proposed bridge crossing. This sandstone consists of buff to tan colored, medium and fine-grained sandstone which is dominantly massive to thick-bedded.

All strata exposed in the vicinity of the proposed bridge crossing strike in a roughly east-west direction and dip very gently (2-5°) to the north and northwest. Both the Mancos Shale and the Panther Tongue of the Star Point Sandstone appear to be massive units lacking any well developed fracture of joint systems. We have observed fractures in the Panther Tongue at certain isolated outcrops but these are not pervasive, lack any systematic orientation, and are probably a weathering phenomena not related to any internal properties of the rock.



STRATIGRAPHIC FRAMEWORK OF CRANDALL CANYON

Figure 1

IV. DESIGN CONSIDERATIONS

In conversations with Boyle Engineering Corp. structural design engineers, the following items were discussed:

A. Abutment loading was estimated to be 300 kips for each abutment. Anticipated width of the footing is approximately 9 feet.

B. Scour depth information was unavailable for the specific bridge location, however a review of boring logs and AASHTO specifications dictated a minimum of bottom of footing at least 4 foot below the deepest point in the stream.

C. Wing walls and back walls are to be designed with 14 feet of fill compacted on the outer edge and 7 feet of sloping fill and riprap on the water side.

V. CONSTRUCTION CONSIDERATIONS

In considering practical methods of construction, it was generally agreed that piling should be avoided if possible since high mobilization costs and possible boulder encounters during driving would render piling usage both uneconomical and impractical. Spread footings may be used, but must be placed at a depth wherein the bottom of the footing is at least 4 feet below the permanent stream bed. Therefore, during construction, some water can be expected in the footing excavations from the existing water table which was 5 feet below grade at the date of boring. If water is encountered it may be displaced using lean concrete to provide a working surface for the foundation.

The entire area around the abutment should be cleared and grubbed and fill materials must be used which are free of organic material. Fill should be compacted in 6" lifts to 95% maximum density as designated in AASHTO T-180. Both sides of the back wall should be filled simultaneously.

VI. DESIGN RECOMMENDATIONS

The following design criteria shall be used for footing and backwall design:

A. Allowable bearing pressure. Allowable bearing pressures are presented in figure 2 and are dependent on the depth and width of footing. These allowable bearing pressures provide for a factor of safety of 2 against bearing failure while limiting total settlement to 1" or less. Note that depth of footing has a much greater influence on allowable bearing than does width of footing. The designer is cautioned not to exceed values shown on figure 2.

B. Backwall design. For backwall design the following parameters shall be used: cohesion (c=0), angle of internal friction ($\phi=30^{\circ}$), dry density (γ_d= 110.0 p.c.f.).

C. Frost depth = 5 feet below grade minimum.

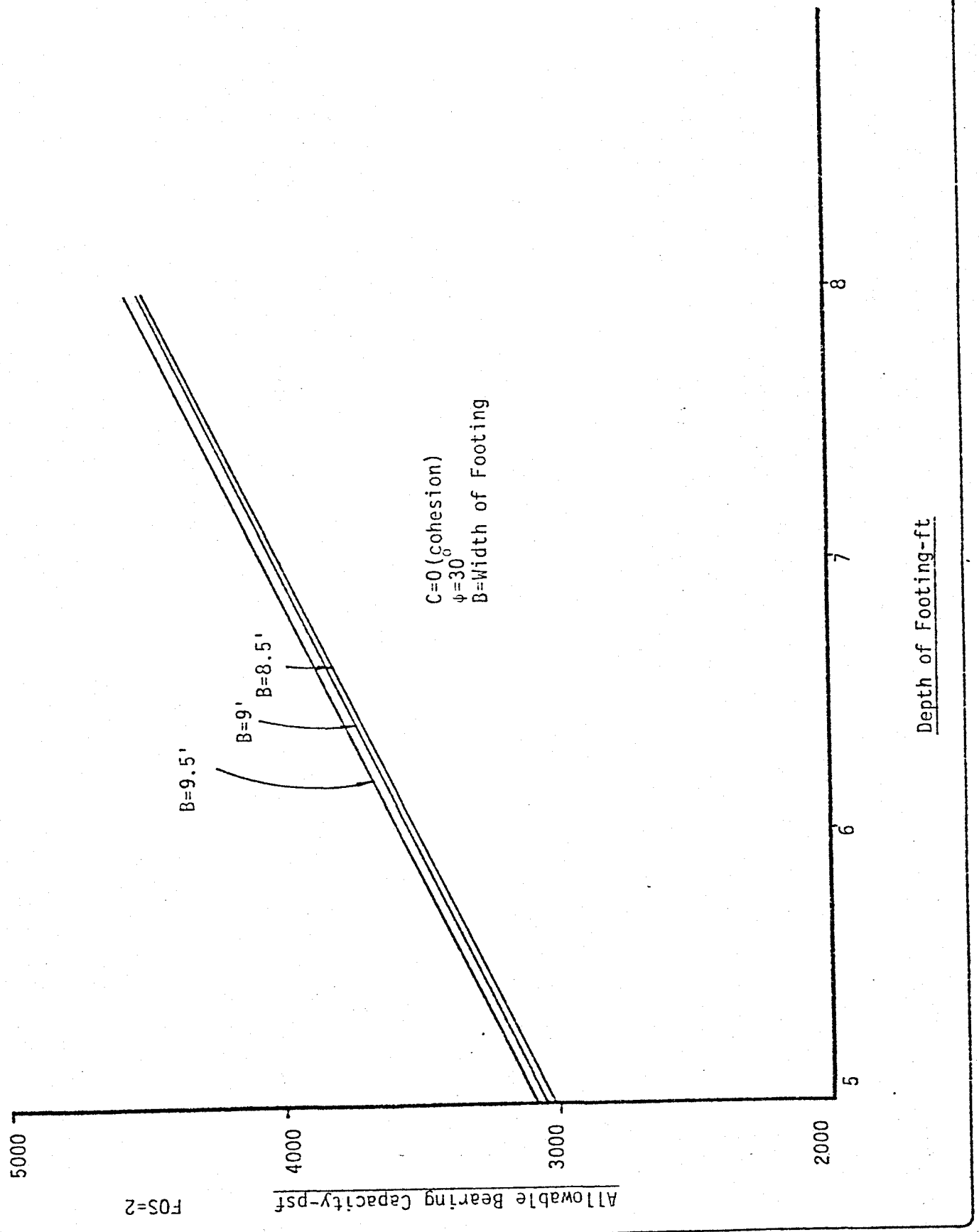
D. Scour = 4 feet depth. Bottom of footings must be at this elevation or lower.

E. Water table varies with season and control of upstream dams - high water table above bottom of footing should be anticipated.

VII. CLOSURE

Soil conditions may vary greatly for areas in the vicinity of the proposed bridge, however we believe the preceding discussion and recommendations to be valid for the present proposed location.

During construction, if soil conditions are found to be radically different from those addressed in this report, R&M Consultants, Inc. should be contacted immediately.



DRN.	JKH
CHK.	LDM
DATE.	FEB 1981
SCALE	NONE

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

Allowable Bearing Capacity
Genwal Crandall Canyon Bridge

FB.	
GRID.	
PROJ.NO.	161005
DWG.NO.	2

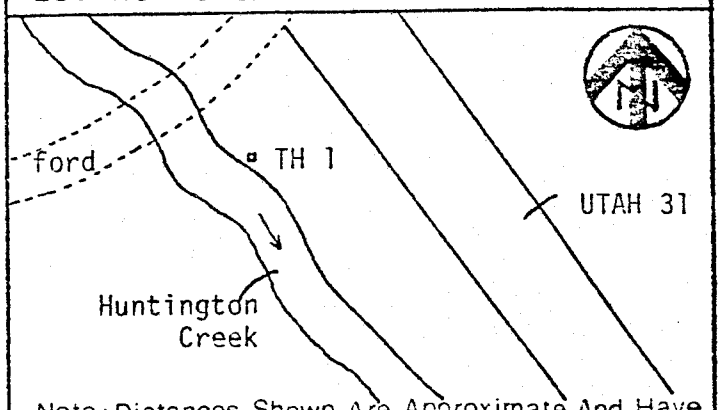
APPENDIX A

Bore Logs

BORING NUMBER 1 Date Completed: 2-5-81

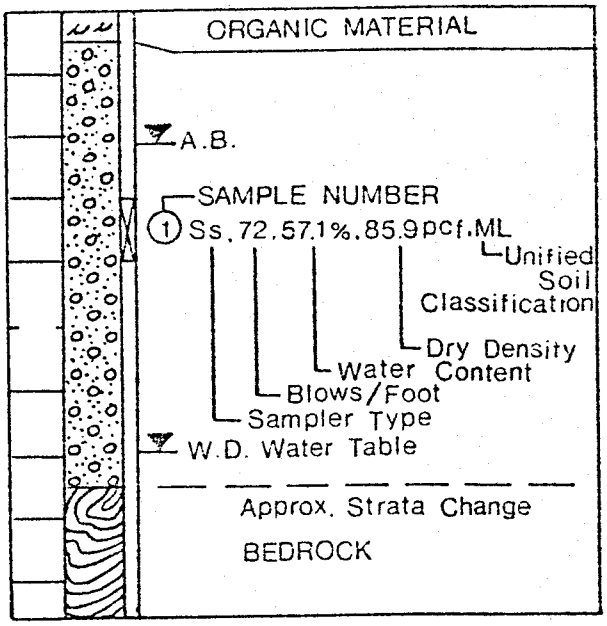
Depth (ft.)	Soil Graph	Location Sampled	SOIL DESCRIPTION
		① A	SILTY SAND Trace boulders 0-1.5'
			A.B.
5		②	Sh, 8, SM
			W.D.
10		③	Sh, 8, SM-SW
15		④	Sh, 19, 20.2%, 99.9pcf, GM-GW
			GRAVELLY SAND Dark brown, moist, very dense
20		⑤	Sh, 10, 50/5"
			Boulder, .5' diameter
25		⑥	Sh, 28, SM SAND, CLEAN TO SILTY, GRAVELLY Dark brown, slightly moist, very dense
30		⑦	Sh, 36, 50/2"
35		⑧	Sh, 53, 50/3"
		⑨	SILTSTONE Dark gray to black, bioturbated
40 TD			Total Depth 40'

LOCATION SKETCH No Scale



Note: Distances Shown Are Approximate And Have Not Been Measured by Surveying Methods.

EXPLANATION



W.D.–While Drilling
A.B.– After Boring

TYPICAL SOIL LOG

Ss 1.4" Split Spoon With 140 lb. Hammer (30" F.F.)
Sz 1.4" Split Spoon With 340 lb. Hammer (12" F.F.)
Sh 2.5" Split Spoon With 340 lb. Hammer (30" F.F.)
Sp 2.5" Split Spoon, Pushed
A Auger Sample
Ts Shelby Tube
Tm Modified Shelby Tube
Bs Bulk Sample

SAMPLE TYPE SYMBOLS

Organic Material
Clay
Silt
Sand
Gravel
Cobbles & Boulders
Bedrock

SOIL SYMBOLS

RCL
PCL
2-18-81
NONE

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

SOIL LOG

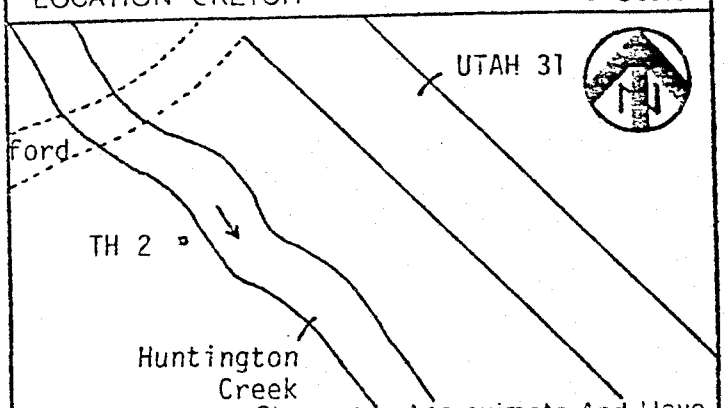
Genwal Coal
East Bridge Abutment

F.B.
GRID
PROJ.NO. 161005
DWG.NO. A-1

BORING NUMBER 2 Date Completed: 2-6-81

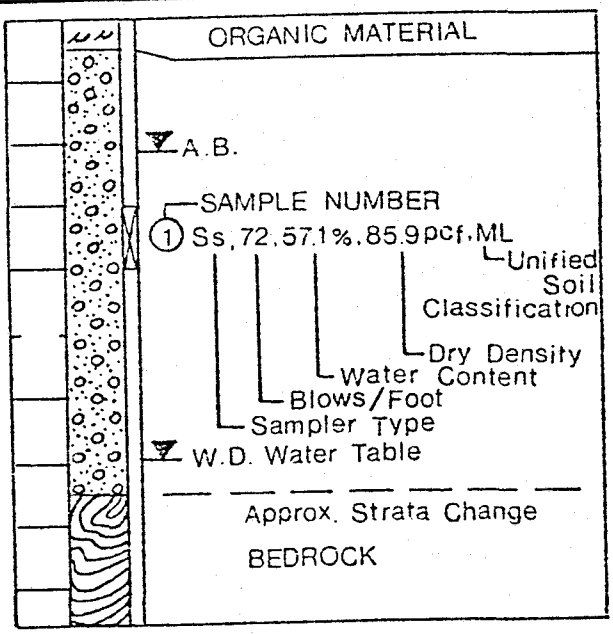
Depth	Soil Graph	Location Sampled	SOIL DESCRIPTION
		①	A, Sandy gravel. Brown, dry. Boulders at 0'
			A.B.
5		②	Sh, 26, SM
			W.D.
10		③	Sh, 52, GM-GW
			Boulder 1.5' diameter
15		④	Sh, 46, 16.9%, 110.3pcf, SM
20		⑤	Sh, 22, GM
			GRAVELLY SAND. Trace boulders. Brown, very moist, medium dense.
25		⑥	Sh, 35, SM-SW
			Boulder. 4.5' diameter
30		⑦	Sh, 50/1", Refusal
			SANDY GRAVEL
35		⑧	Sh, 100+, Refusal
		⑨ A-C	Boulder. 1.5' diameter
			SANDY GRAVEL
		⑨ D-G	SILTSTONE Dark gray, bioturbated
40 TD			Total depth 40'

LOCATION SKETCH No Scale



Note: Distances Shown Are Approximate And Have Not Been Measured by Surveying Methods.

EXPLANATION



W.D.–While Drilling
A.B.–After Boring

TYPICAL SOIL LOG

Ss 1.4" Split Spoon With 140 lb. Hammer (30" F.F.)
Sz 1.4" Split Spoon With 340 lb. Hammer (12" F.F.)
Sh 2.5" Split Spoon With 340 lb. Hammer (30" F.F.)
Sp 2.5" Split Spoon, Pushed
A Auger Sample
Ts Shelby Tube
Tm Modified Shelby Tube
Bs Bulk Sample

SAMPLE TYPE SYMBOLS

Organic Material
Gravel
Clay
Cobbles & Boulders
Silt
Bedrock
Sand

SOIL SYMBOLS

DWN.	RCL
CKD.	RCL
DATE	2-18-81
SCALE	NONE

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

SOIL LOG

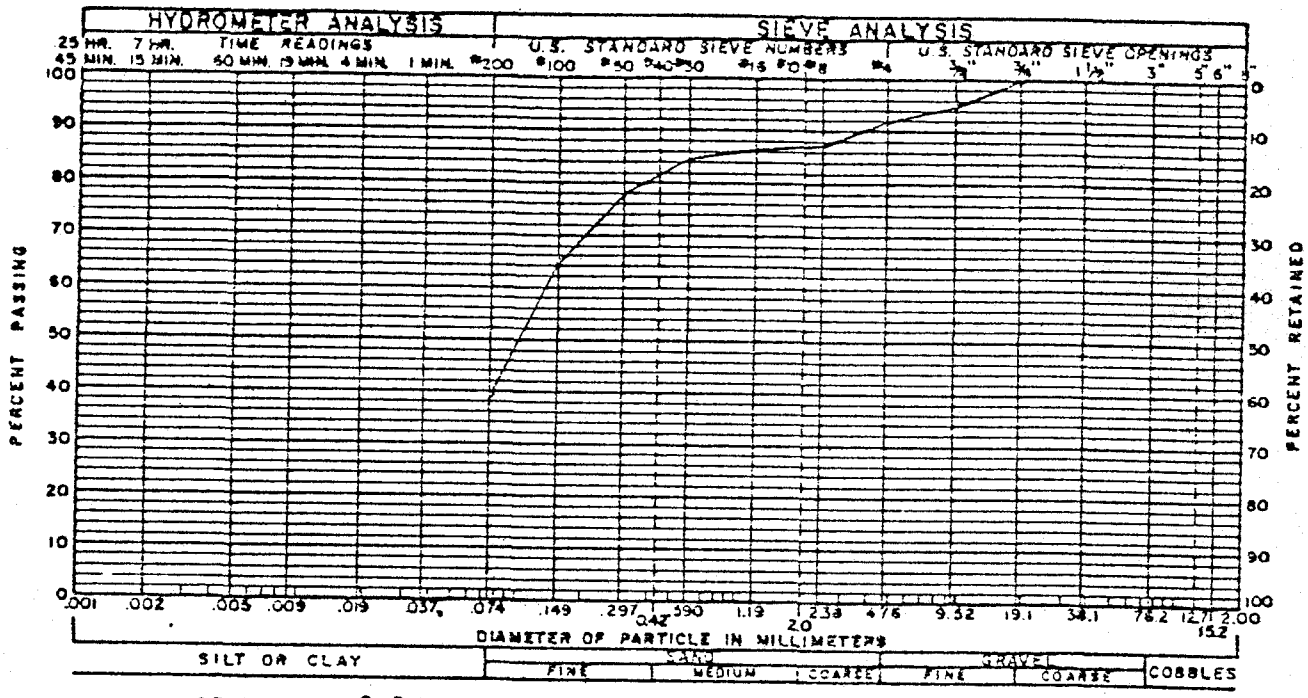
Genwal Coal
West Bridge Abutment

F.B.	
GRID	
PROJ.NO.	161005
DWG.NO.	A-2

APPENDIX B

Test Results

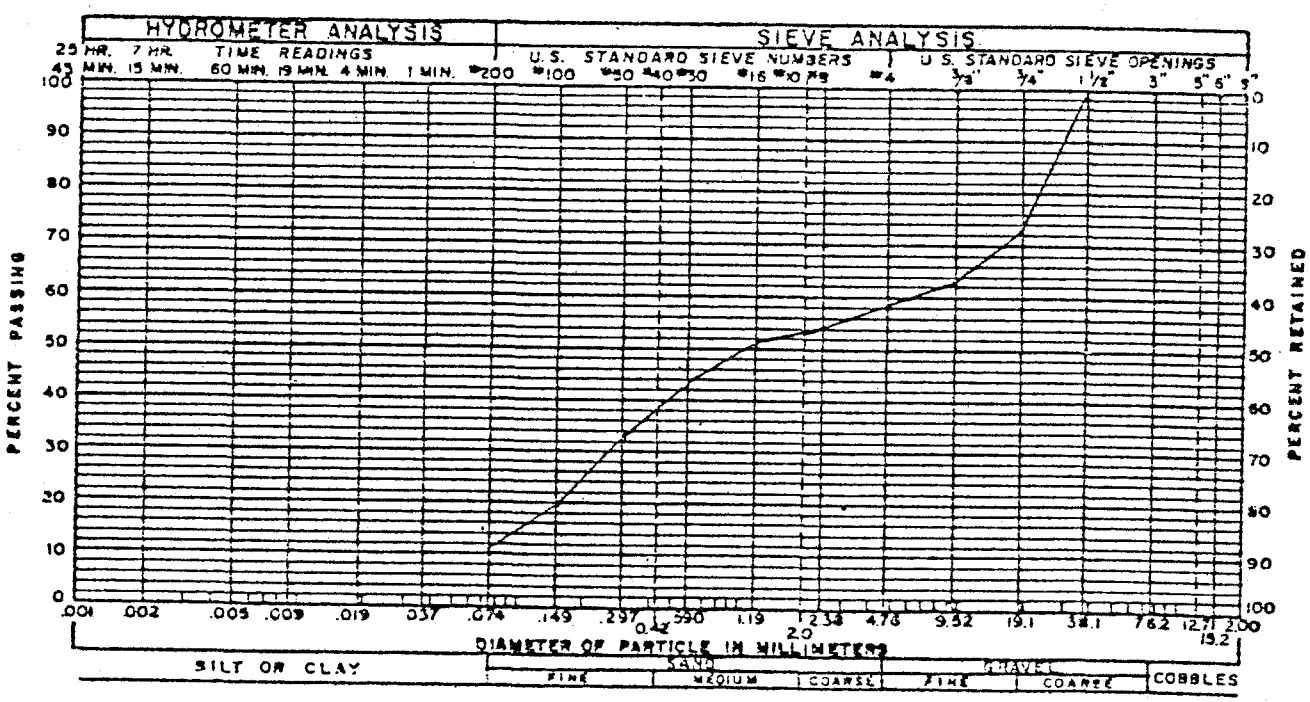
Delta



GRAVEL 9.0 % SAND 53.0% SILT AND CLAY 38.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand, silty, gravelly FROM Test Hole 1-2 @ 5.0'-6.5'



GRAVEL 42.0% SAND 48.0 % SILT AND CLAY 10.0 %

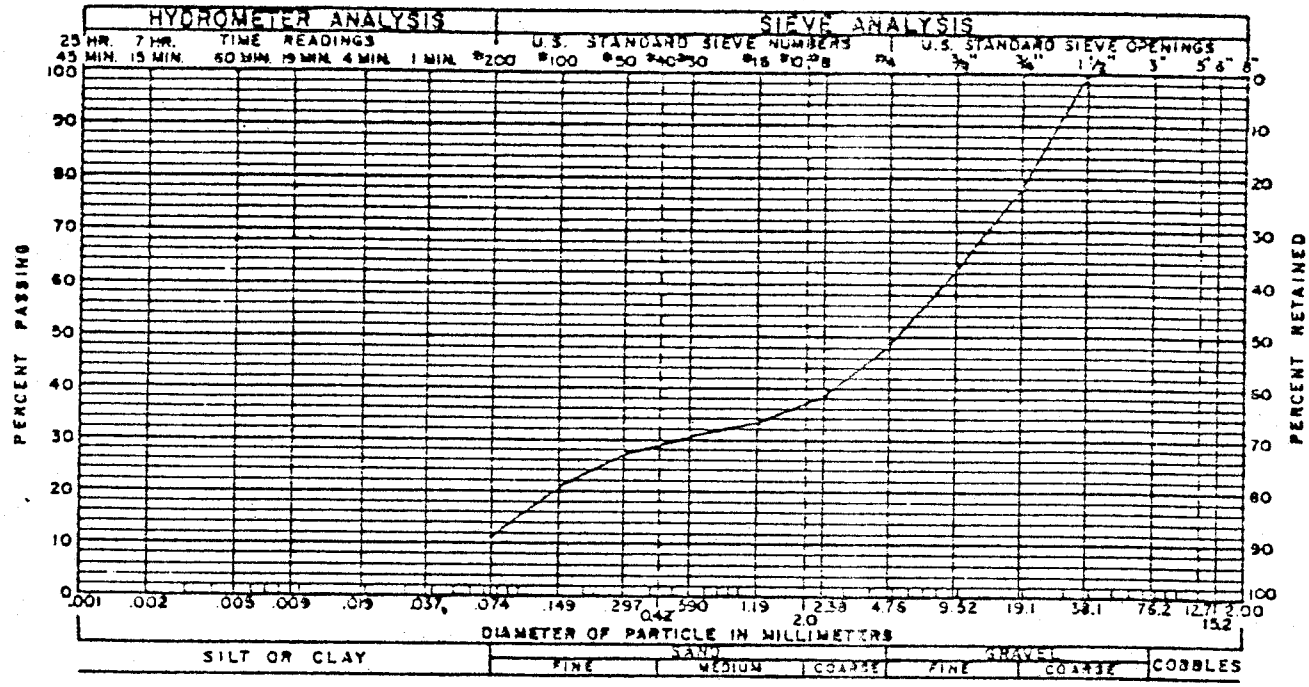
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand, clean to silty, gravelly FROM Test Hole 1-3 @ 10.0'-11.5'

GRADATION TEST RESULTS

Figure 1

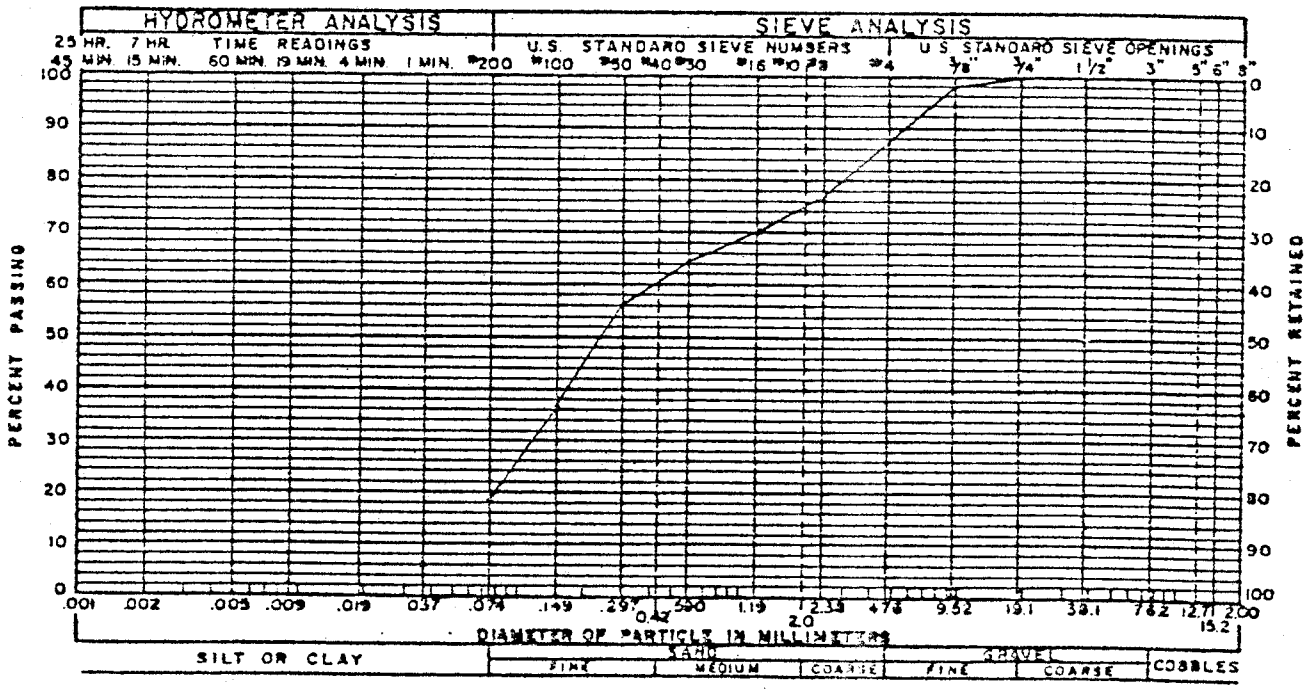
Delta



GRAVEL 51.0 % SAND 38.0% SILT AND CLAY 11.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Gravel, sandy, clean to silty FROM Test Hole 1-4 @ 15.0'-16.5'



GRAVEL 13.0% SAND 69.0 % SILT AND CLAY 18.0 %

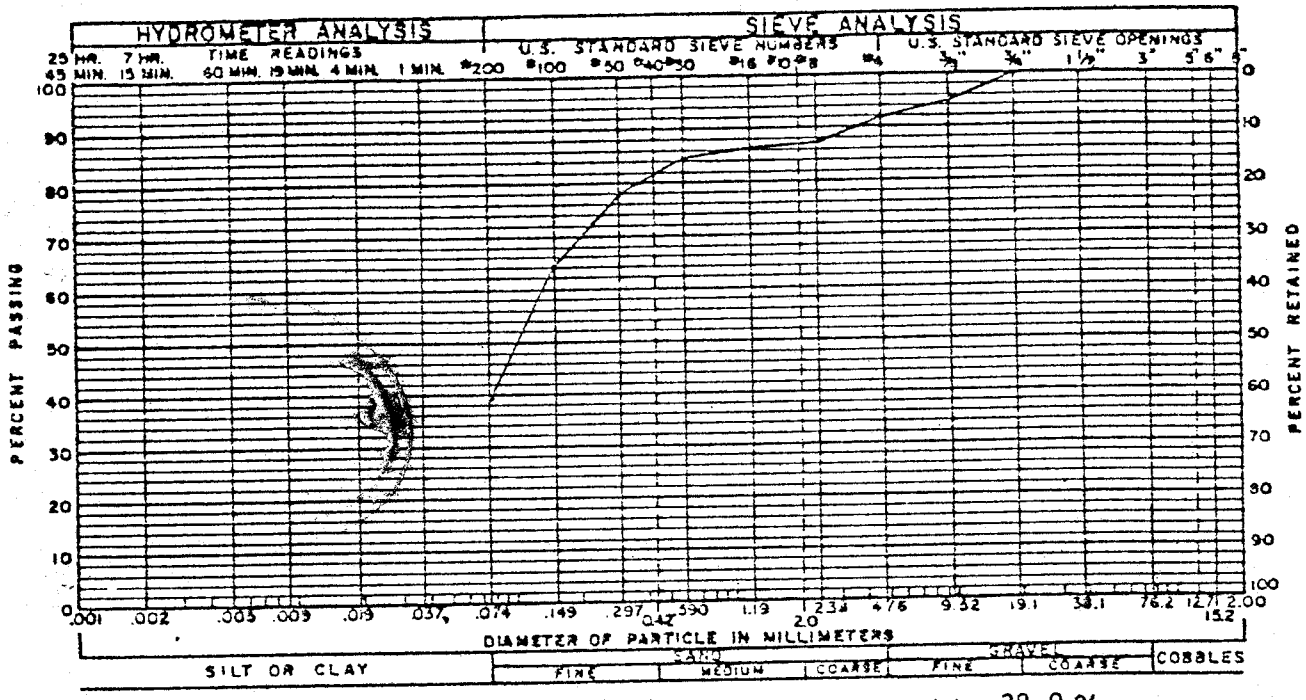
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand, silty, gravelly FROM Test Hole 1-6 @ 25.0'-26.5'

GRADATION TEST RESULTS

Figure 2

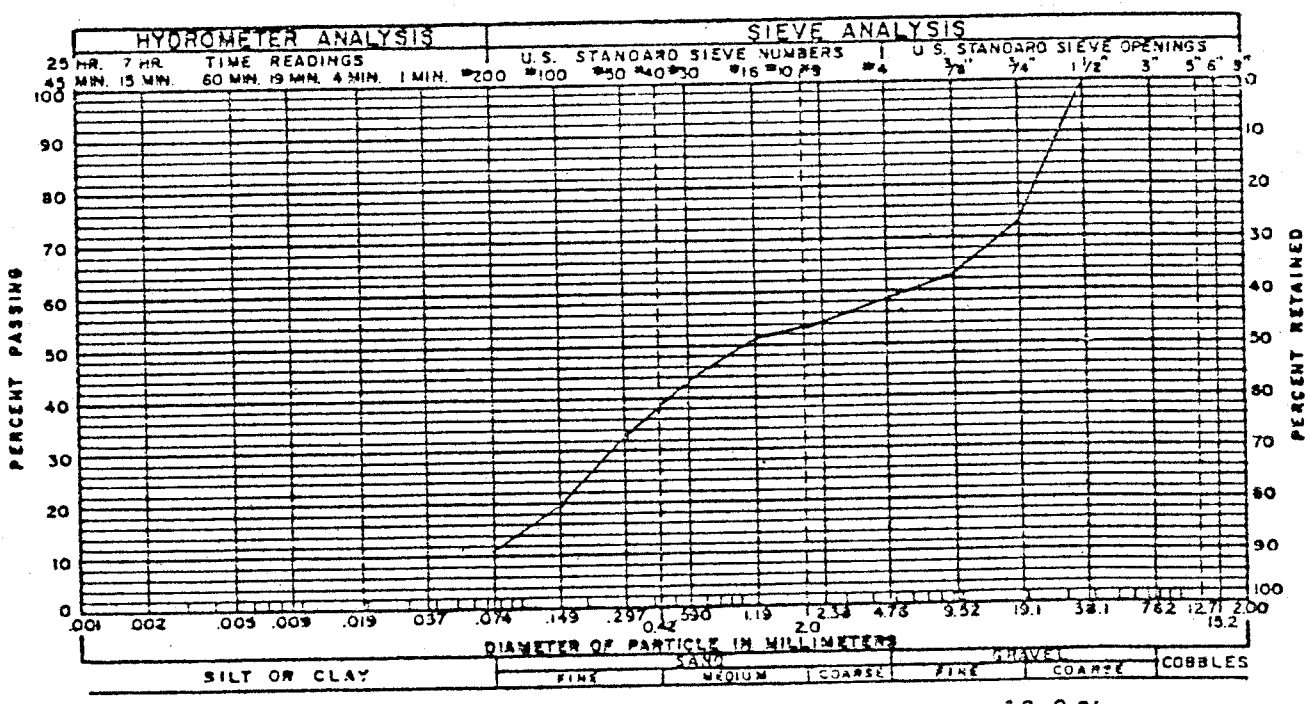
Delta



GRAVEL 9.0 % SAND 53.0% SILT AND CLAY 38.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand, silty, gravelly FROM Test Hole 1-2 @ 5.0'-6.5'



GRAVEL 42.0% SAND 48.0 % SILT AND CLAY 10.0 %

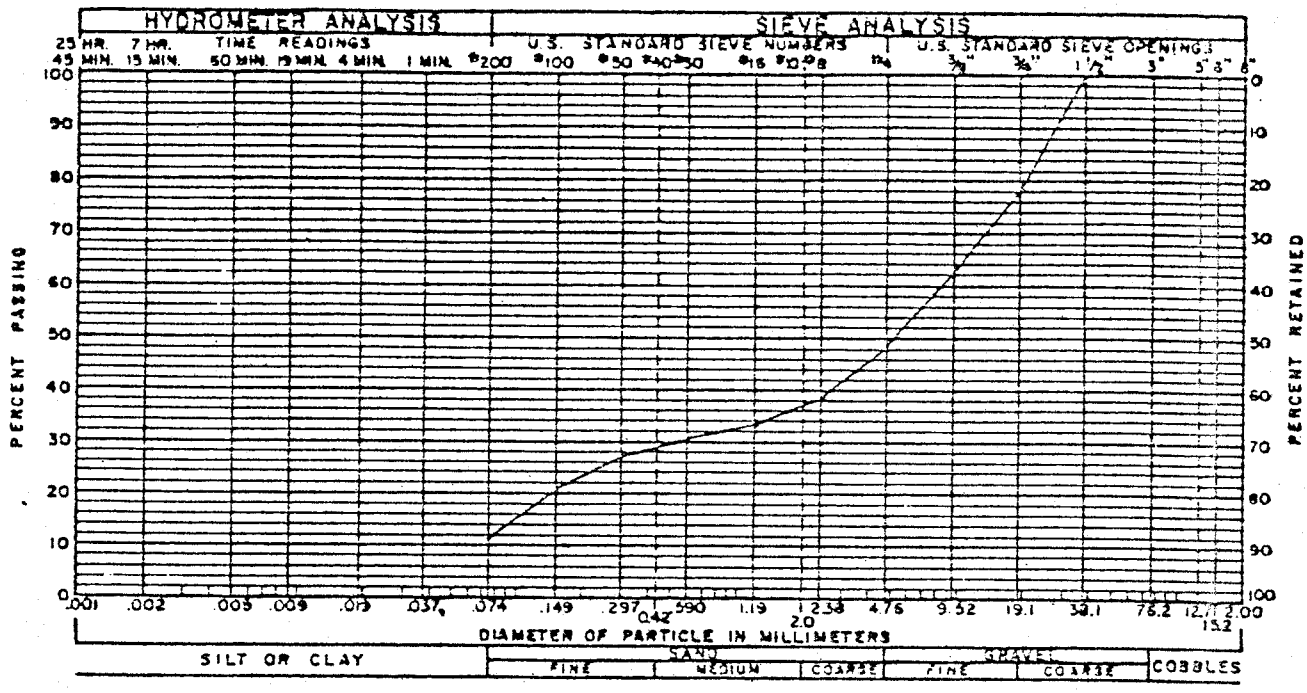
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand, clean to silty, gravelly FROM Test Hole 1-3 @ 10.0'-11.5'

GRADATION TEST RESULTS

Figure 1

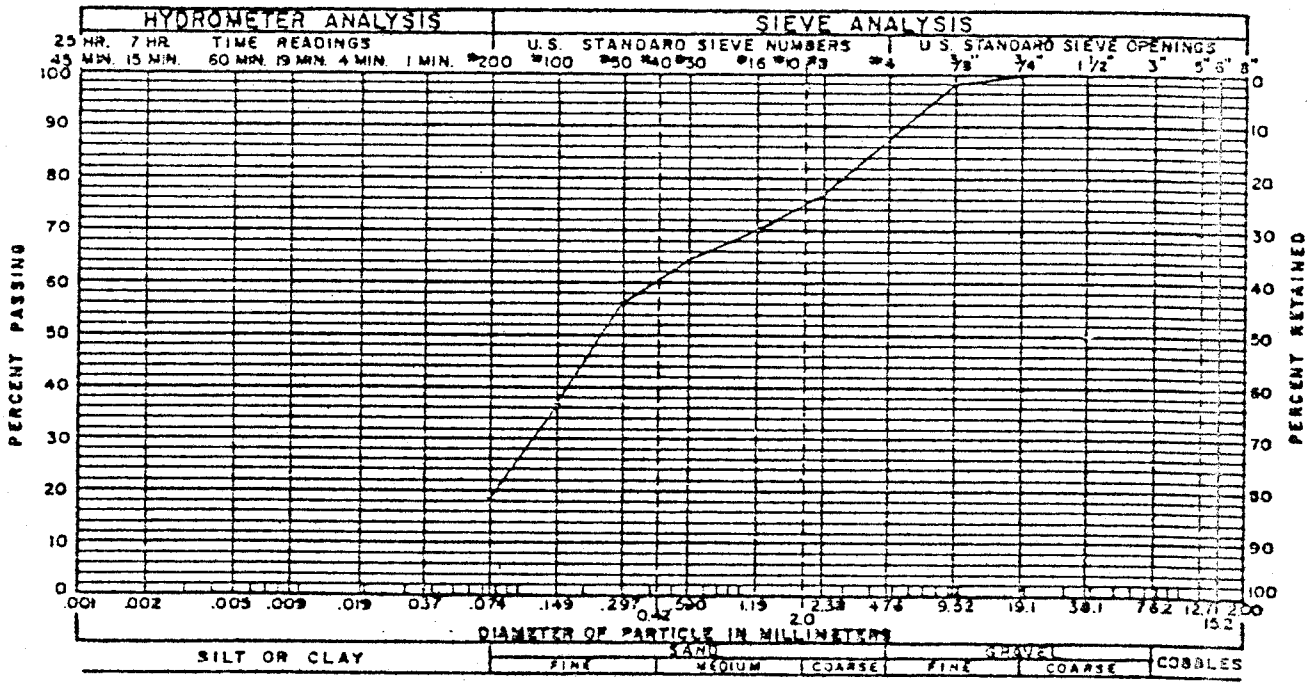
Delta



GRAVEL 51.0 % SAND 38.0% SILT AND CLAY 11.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Gravel, sandy, clean to silty FROM Test Hole 1-4 @ 15.0'-16.5'



GRAVEL 13.0% SAND 69.0 % SILT AND CLAY 18.0 %

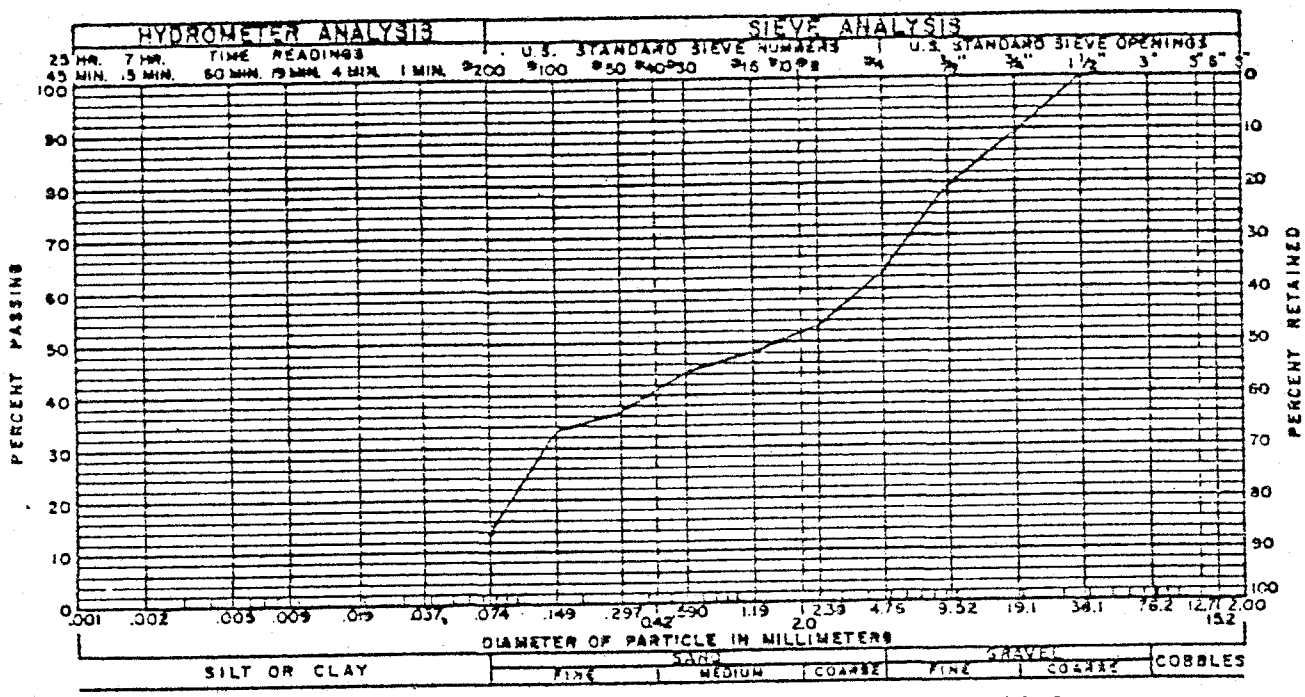
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand, silty, gravelly FROM Test Hole 1-6 @ 25.0'-26.5'

GRADATION TEST RESULTS

Figure 2

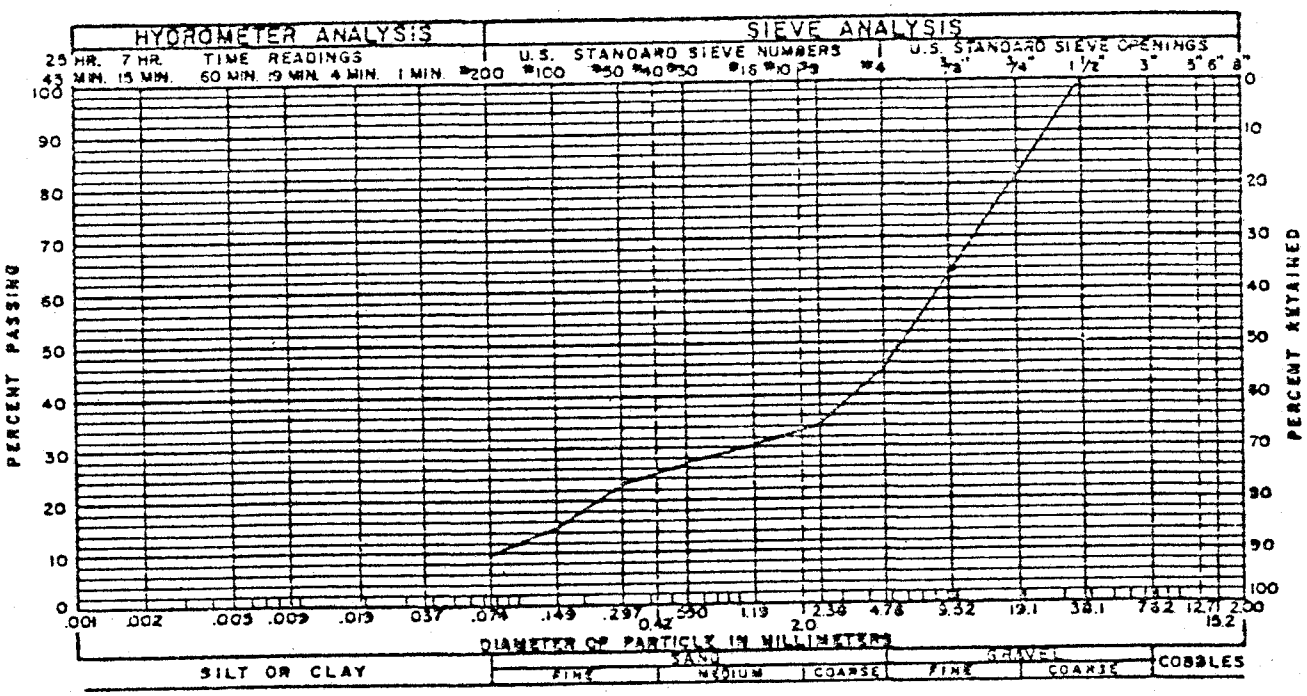
Delta



GRAVEL 36.0% SAND 50.0 % SILT AND CLAY 14.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand, gravelly, silty FROM Test Hole 2-2 @ 5.0'-6.5'



GRAVEL 55.0 % SAND 35.0 % SILT AND CLAY 10.0 %

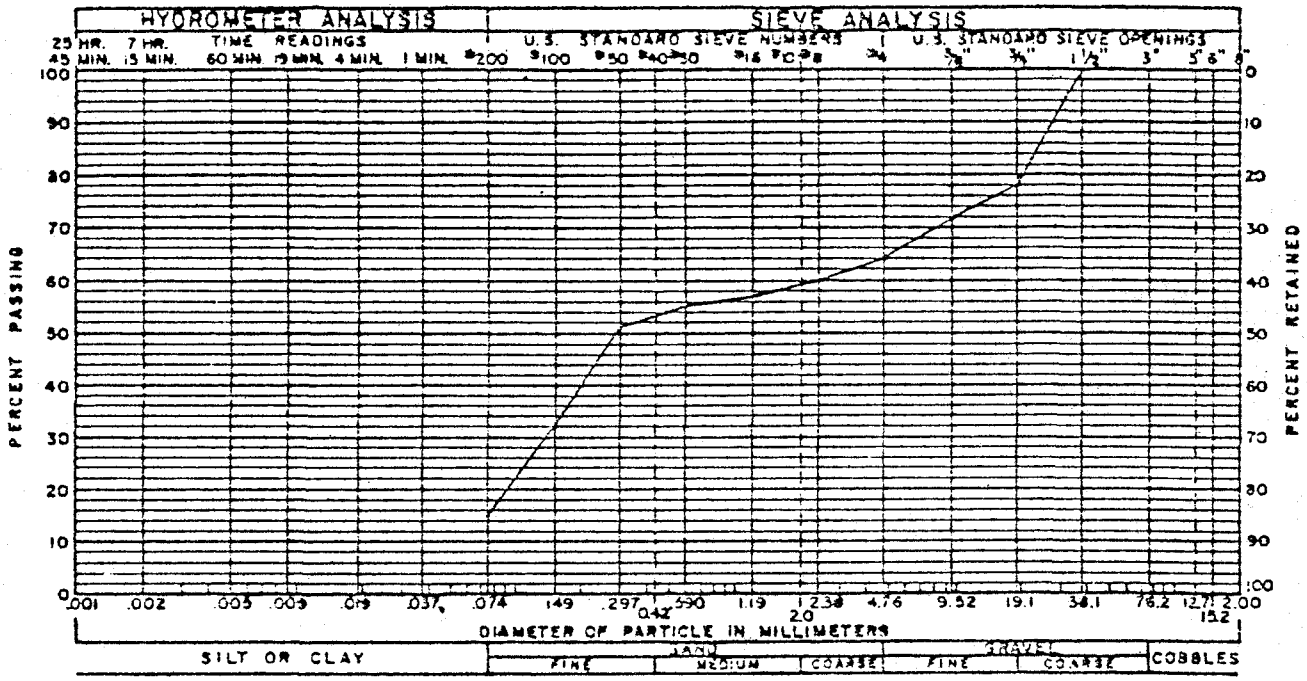
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Gravel, sandy, clean to silty FROM Test Hole 2-3 @ 10.0'-11.5'

GRADATION TEST RESULTS

Figure 3

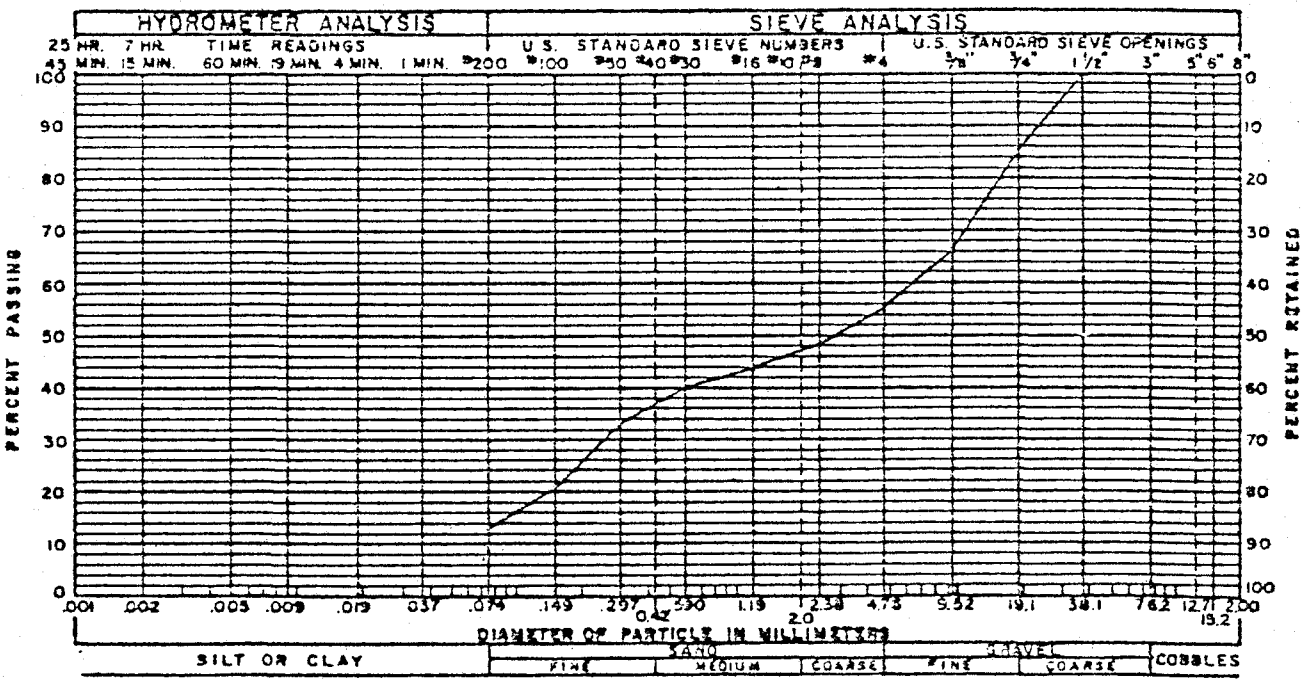
Delta



GRAVEL 36.0% SAND 49.0 % SILT AND CLAY 15.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sandy, gravelly, silty FROM Test Hole 2-4 @ 15.0'-16.5'



GRAVEL 45.0% SAND 42.0 % SILT AND CLAY 13.0 %

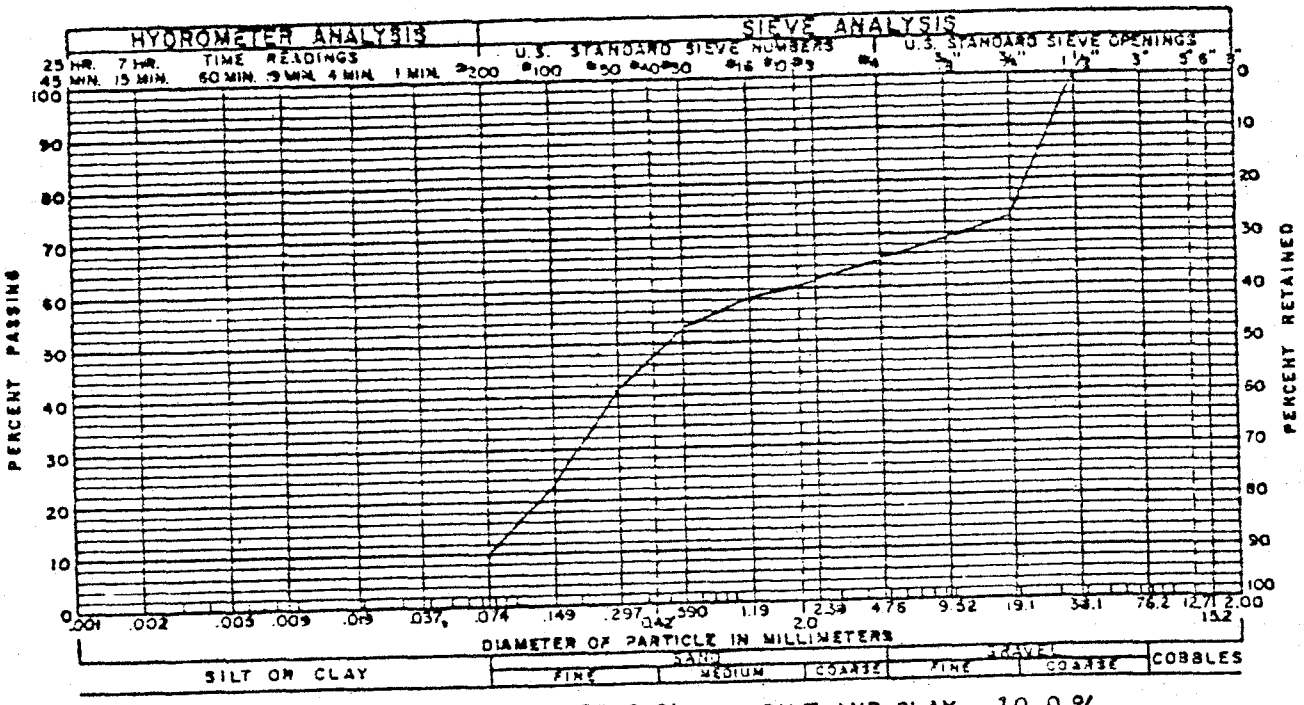
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Gravel, sandy, silty FROM Test Hole 2-5 @ 20.0'-21.0'

GRADATION TEST RESULTS

Figure 4

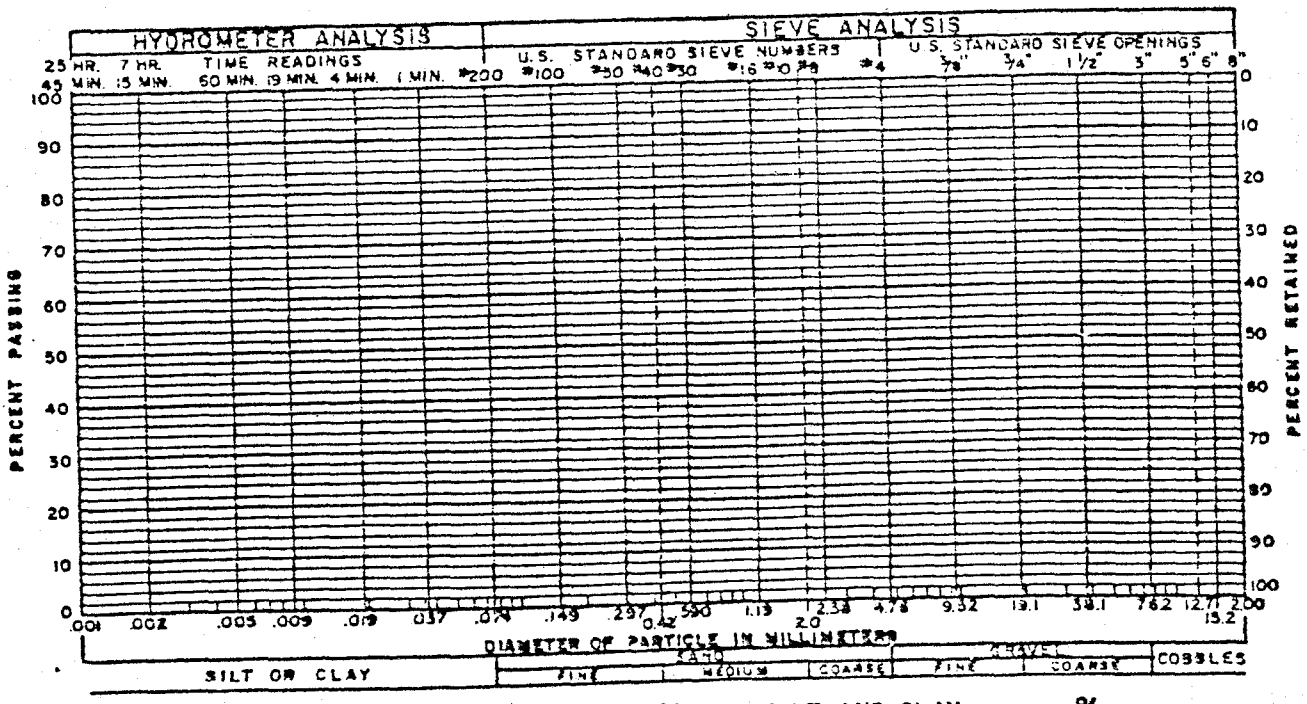
Delta



GRAVEL 35.0 % SAND 55.0 % SILT AND CLAY 10.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand, gravelly, clean to silty FROM Test Hole 2-6 @ 25.0'-26.5'



GRAVEL % SAND % SILT AND CLAY %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM

GRADATION TEST RESULTS

Figure 5

SLOPE STABILITY STUDIES

GENWAL COAL MINE ACCESS ROAD

R&M Project No. 161005

Prepared for

Boyle Engineering Corp.
Salt Lake City, Utah

Prepared by

R&M Consultants, Inc.
5280 South 320 West, Suite E-160
Murray, Utah 84107
(801) 263-3419

March 1981

R&M

I. INTRODUCTION

Presented in this report are the results of our analysis concerning the stability of a 1½-mile all-weather Class I access road proposed by Genwal Coal Company, Inc. near Huntington Canyon, Utah. This road, connecting to Utah Highway 10, would provide access to the coal leases acquired by Genwal approximately 1½ miles up Crandall Canyon, a small canyon off Huntington Canyon.

This proposed access road would generally run along the Crandall Creek on its north bank some 30-50 feet above the creek bed, and span over Huntington Creek with a bridge crossing immediately before joining Utah Highway 10.

The configurations of the slope and roadway used for the stability analysis are based on the alignment and cross sections prepared and furnished by Boyle Engineering Corporation of Salt Lake City, Utah. Due to the limitation of time and budget, only those cross sections considered as critical were analyzed.

Recommendations regarding the retaining structures for the roadbed and the preparation of subgrade are also presented.

II. SUBSURFACE CONDITIONS

Method of Investigation

The proposed access road is to be located along the north slope of Crandall Canyon with varying steepness. Because of the rugged terrain along the selected route of the road, it was not possible to bore holes for determining the subsurface conditions. Instead, test pits were dug with a backhoe to expose the subsoil and allow visual examination and soil sampling for laboratory testing.

A total of 4 test pits were dug at locations where slope stability of the proposed road appeared critical. Test Pit (TP) No. 1 was located approximately 12 feet left of ℄ Station 25+60, TP No. 2 at 25 feet left of ℄ Station 47+75, TP No. 3 at 45 feet left of ℄ Station 71+00, TP No. 4 at 20 feet left of ℄ Station 81+45.

Subsurface Conditions

Generally, a layer of up to 15-ft thick alluvial overburden covers the ground on the slope along the selected route of the road. Underlying this alluvial overburden is the Star Point Sandstone, Blackhawk Formation (?), which frequently outcrops in Crandall Creek and on top of the slope, north of the proposed road, forming cliffs.

The Star Point Sandstone consists of cross-laminated, medium- to fine-grained sandstone and siltstone. Generally, the upper cliff-forming Star Point Sandstone is massive and resistant; while the lower Star Point Sandstone varies from massive to thin-bedded and is mostly non-resistant. The rock is weathered to form platy fissile plates toward its surface. All strata exposed along the selected route strike roughly in an east-west direction and dip very gently (3-7°) to the north. A more detailed geological description of the Star Point Sandstone is presented in "Genwal Huntington Creek Bridge Foundation Report" dated February, 1981, prepared by R&M Consultants, Inc.

The alluvial overburden is the material weathered and decomposed from the underlying and outcropping Star Point Sandstone. It consists of silty sand with gravels and boulders up to 3 ft in size. Scattered vegetation covers the area of the proposed road with organic substances found in the top 1 ft of soil.

Laboratory Testing

Selected soil samples obtained from the test pits were analyzed and tested in the laboratory. Eleven grain size distribution analyses and two moisture-density compaction tests (modified Proctor) have been conducted. The results of these tests are included in Appendix A.

The alluvial overburden material is, as indicated by the grain size distribution results, classified mainly as SM material according to the Unified Soil Classification system and is generally varying from fair to well graded. The percentage passing No. 200 sieve varies from 20% to 40%. This material is judged to be very low to non-plastic and should be fair to good material for road construction.

The two moisture-density compaction tests show that the alluvial overburden material has an average maximum dry density of 120 pcf with an optimum water content of 11.5%.

Soil Parameters

Based on laboratory test results and field observation, the soil parameters used for the slope stability analysis were as follows:

Material	Angle of Internal Friction, ϕ	Cohesion, C	Unit Wt., pcf
Alluvial Overburden	35°	0	105
Embankment Fill	40°	0	120

The bedrock was considered to have a much higher shear strength, therefore the failure circle would not cut into the rock.

III. STABILITY ANALYSIS

The analysis of stability of the proposed access road was accomplished by using the SLOPE-II Computer Program developed by Geo-Slope Programming Ltd. and marketed by Boeing Computer Services Company.

A total of 4 cross sections of the slope and roadway were analyzed: Station 25+50, Station 47+00, Station 48+00 and Station 73+00. These locations were selected because they were judged to be of high slope failure potential. Station 25+50 was designated to be analyzed by the Forest Service because of archeological finds requiring preservation.

Surcharge due to traffic load was considered in the stability analysis by assuming AASHTO HS20-44 trucks occupying both traffic lanes. Four line loads of 320 pounds per lineal foot spaced at 6-ft centers on the traffic lanes were used to represent such surcharge loads.

Bishop's Simplified Method was chosen as the theoretical basis for analyzing the slope stability problem. The outcome of the analysis from the computer program indicated block failure of a soil mass sliding on the surface of bedrock to be the general probable failure mode of all cross sections analyzed. Sketches showing the most critical slip surface of each cross section are included in Appendix B. The minimum factors of safety of these cross sections against slope failure are tabulated as follows:

Station	Minimum Factor of Safety
25+50	1.658
47+00	2.243
48+00	2.159
73+00	1.357

As shown above, the most critical cross section has a minimum factor of safety of 1.36. This cross section is representative from Station 71+50 to Station 74+00 where a retaining structure is required downslope of the proposed road to avoid a high embankment that would fill up the creek. The most critical factor of safety for the proposed road against slope instability exceeded the minimum of 1.25 required by CFR[1].

The proposed road is therefore considered stable. However, construction of the road and the retaining structure must conform to the requirements discussed in the next section to ensure that parameters used for the analysis were valid. R&M Consultants, Inc. should be contacted before any deviation from such requirements and change of road alignment is made since additional analysis of the road stability may be required.

IV. SUBGRADE PREPARATION AND PAVEMENT DESIGN

The alluvial overburden material consists mainly of silty sand (SM material) with some gravels and boulders up to 3 ft in size. This material is considered as fair to well graded, very low to non-plastic.

According to the results of the grain size distribution analyses performed on samples obtained from the test pits, the CBR value of the alluvial overburden material should range from 15 to 25. For the purpose of pavement design of the proposed road, a CBR value of no greater than 20 should be used.

Vegetation, including grass, bushes and trees, within limits of the proposed road should be cleared and grubbed. The top 1 ft of soil should be removed to eliminate most of the organic material in the subgrade. The alluvial overburden material may be used for the construction of roadway embankment. Cobbles and boulders

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[1] "Code of Federal Regulations, Volume 30 - Mineral Resources" revised as of July 1, 1979, published by the Office of Federal Register, Chapter VII - Office of Surface Mining, etc.

larger than 6 inches in size in the alluvial overburden should be broken into smaller pieces when used as embankment fill material.

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The most probable slope failure mode of the proposed access road is block failure; a soil mass sliding over the surface of bedrock. The proposed road is considered stable with a minimum factor of safety against slope failure exceeding the required 1.25. The stretch of road from Station 71+50 to Station 74+00 has the highest failure potential with a critical minimum safety factor of approximately 1.36.

Generally, there is a higher risk of slope failure of the road where retaining structure is required to contain the roadway embankment. Special consideration has to be given to the design of these retaining structures.

The alluvial overburden material along the route of the proposed road is generally suitable for borrow material for road construction. However, boulders 6 inches or larger in size should be broken up to be used as borrow material. To ensure the validity of the soil parameters used in the slope stability analysis, the construction and compaction requirement recommended below should be followed.

Recommendations

The vegetation within the road construction limits should be cleared and grubbed. The top 12 inches of soil should be stripped and discarded. A CBR value no greater than 20 is recommended for the pavement design of the proposed road.

The alluvial overburden material, free of cobbles and boulders larger than 6 inches, may be used for the roadway embankment. This material should be compacted in 8-inch loose lifts to at least 96% of the maximum density determined by ASTM 1557-70 (modified Proctor Method).

Because of higher slope failure potential, the roadway embankment retaining structures should be founded on bedrock wherever practical. The retaining structures should be analyzed individually for stability against overturning. The safety factors against overturning and sliding are recommended to be at least 2.0 and 1.5, respectively.

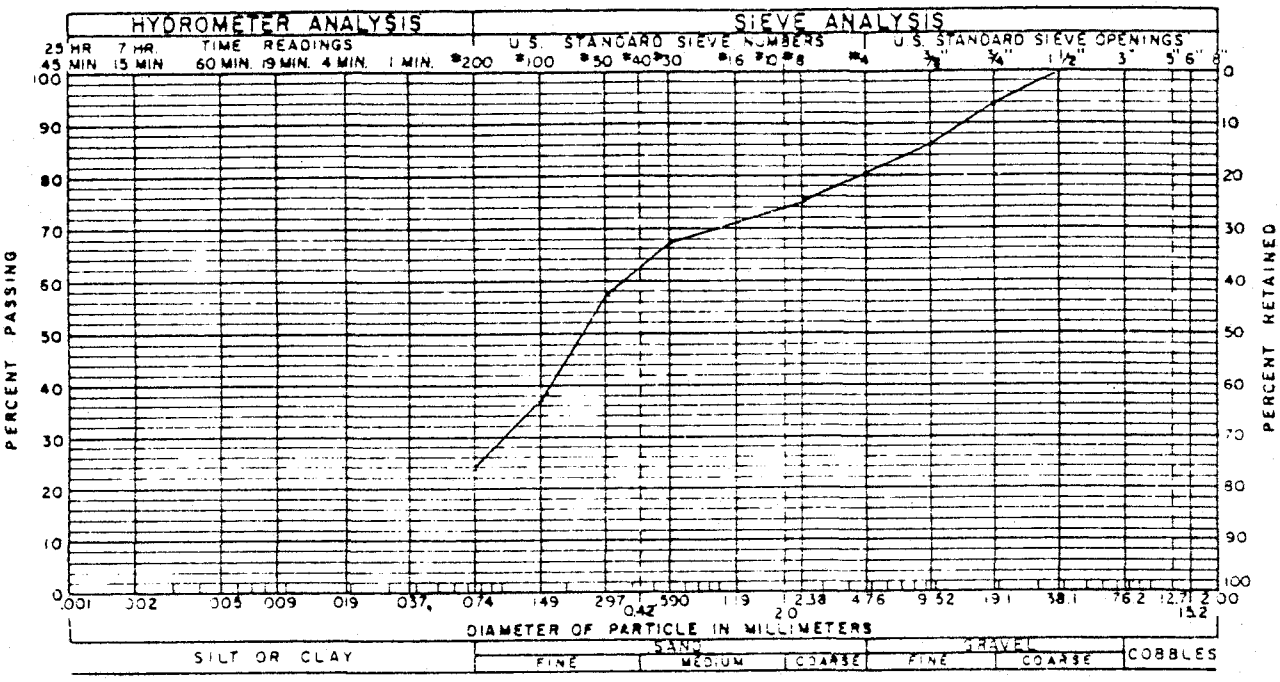
Ditch should be provided on the inside shoulder of the proposed road and should be designed to safely pass the peak runoff from a 10-year, 24-hour or greater precipitation event. The rock strata along the proposed road generally dip 3-7° to the north and should be advantageous in minimizing runoff infiltration into the roadbed. Sediment controls should also be provided to minimize surface erosion. Revegetation is recommended on cut surface in the soil overburden upslope of the road; and either rock riprap or vegetation is recommended on fill surface downslope of the road.

J. S. Liu, P.E., Ph.D.
Senior Geotechnical Engineer

Larry Migliaccio, P.E.
Director

APPENDIX A - LABORATORY TEST RESULTS

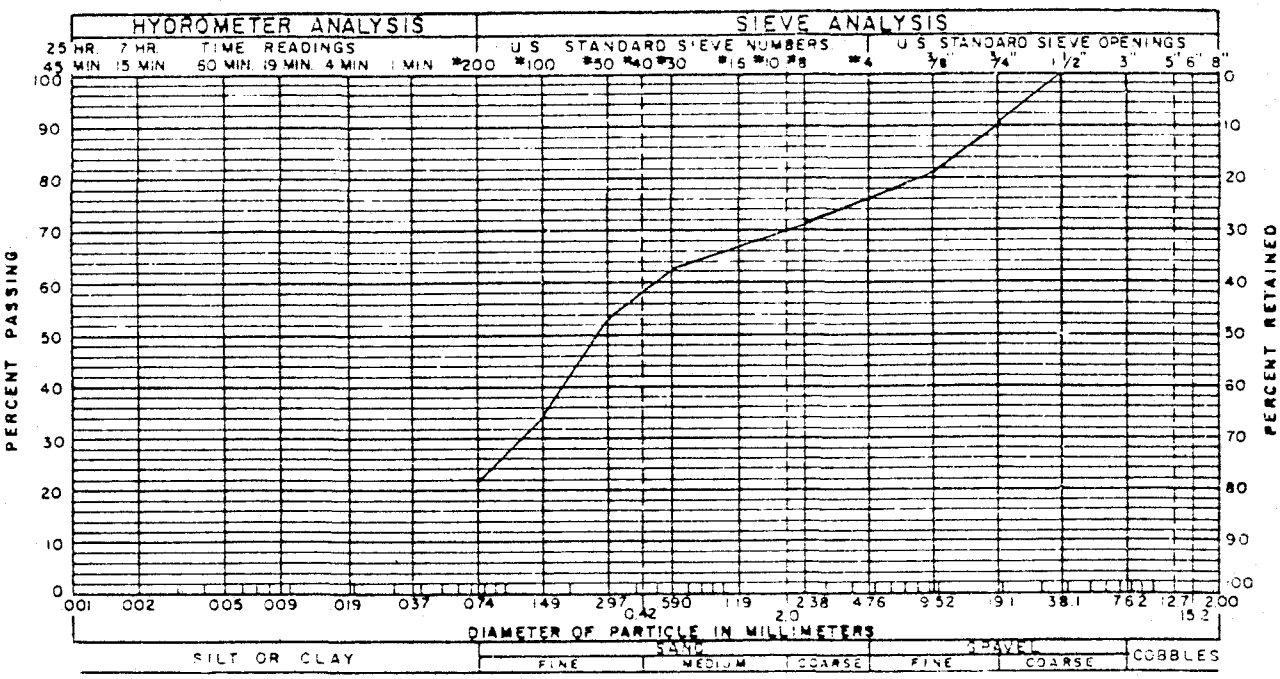
Delta



GRAVEL 25.0 % SAND 51.0% SILT AND CLAY 24.0%

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand - gravelly, silty FROM Test Pit 1-1 @ 5-6'
SM



GRAVEL 24.0 % SAND 54.0% SILT AND CLAY 22.0%

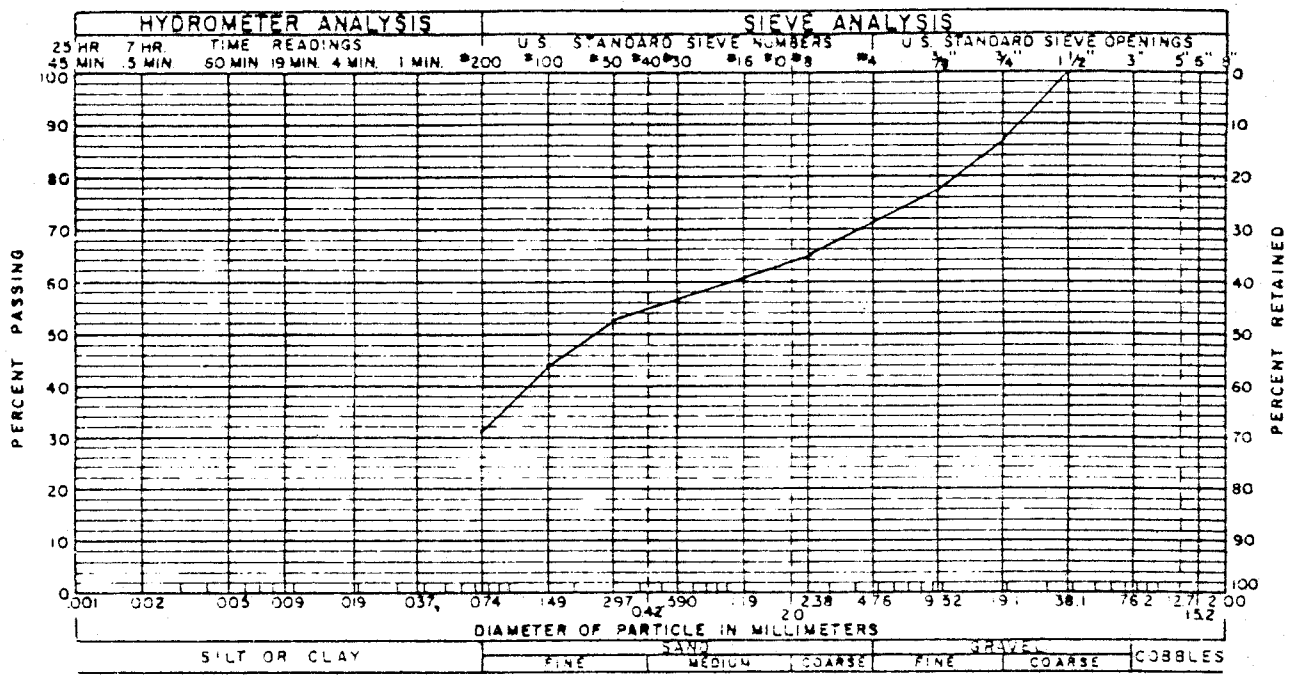
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand - gravelly, silty FROM Test Pit 1-2 @ 10-11'
SM

GRADATION TEST RESULTS

Figure A-1

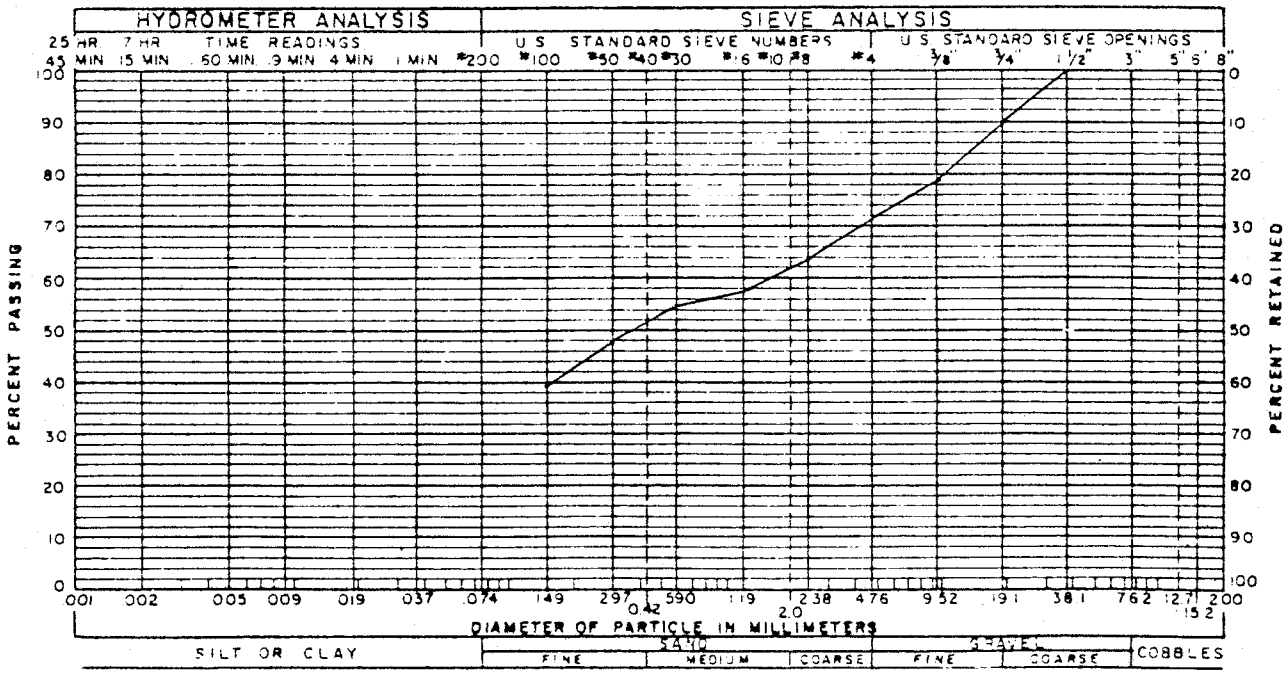
Delta



GRAVEL 29.0 % SAND 39.0% SILT AND CLAY 32.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand - silty, gravelly FROM Test Pit 2-1 @ 5-6'
SM



GRAVEL 29.0 % SAND 43.0 % SILT AND CLAY 28.0 %

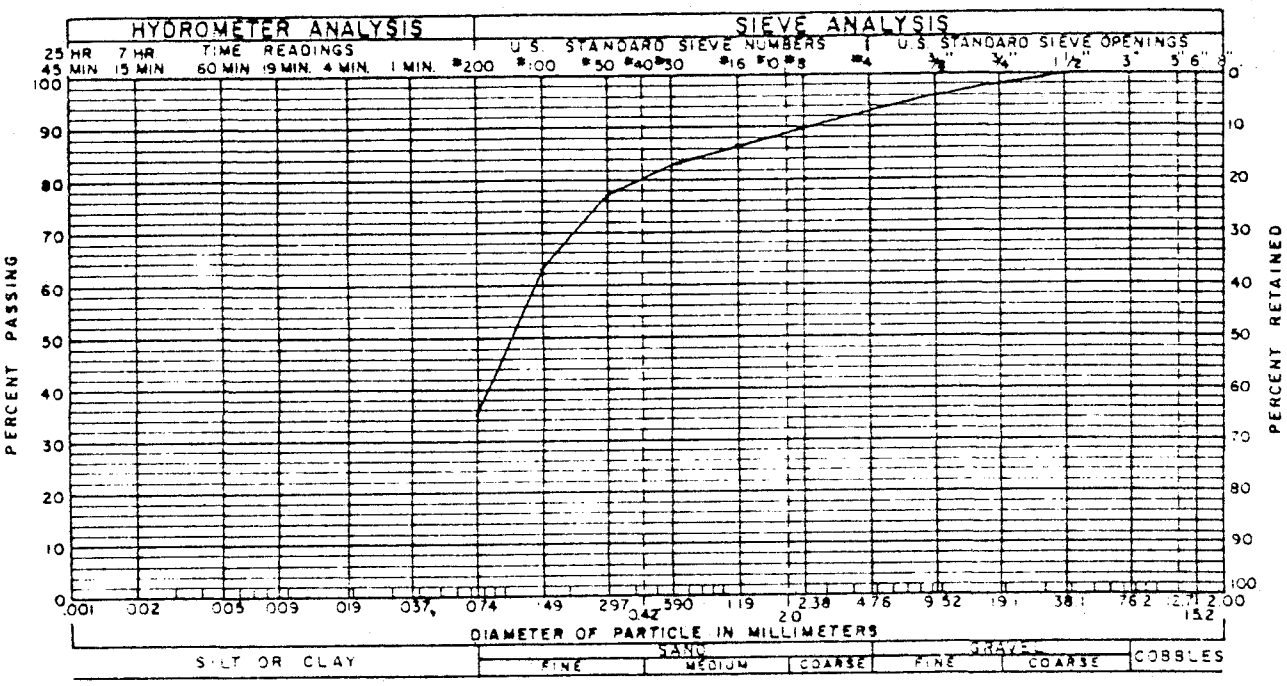
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand - gravelly, silty FROM Test Pit 2-2 @ 10-11'
SM

GRADATION TEST RESULTS

Figure A-2

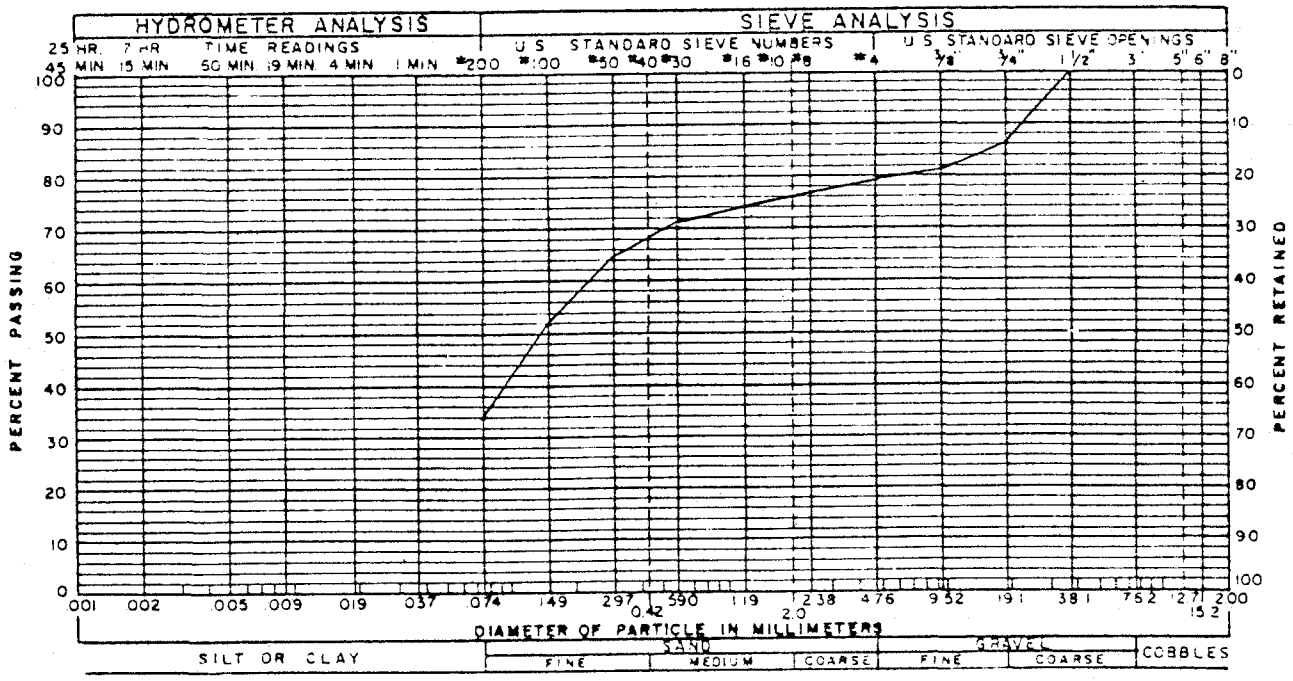
Delta



GRAVEL 7.0 % SAND 58.0% SILT AND CLAY 36.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand - silty, gravelly FROM Test Pit 3-1 @ 5-6'
SM



GRAVEL 21.0 % SAND 45.0% SILT AND CLAY 34.0%

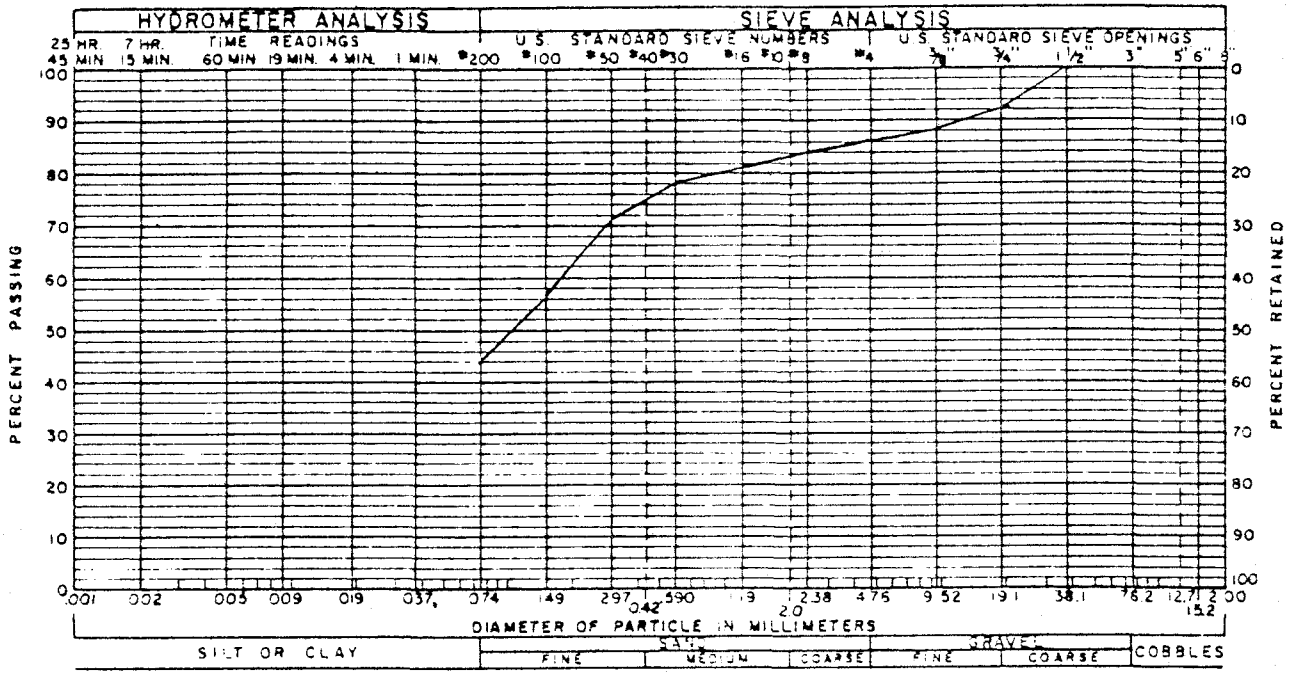
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand - silty, gravelly FROM Test Pit 3-2 @ 10-11'
SM

GRADATION TEST RESULTS

Figure A-3

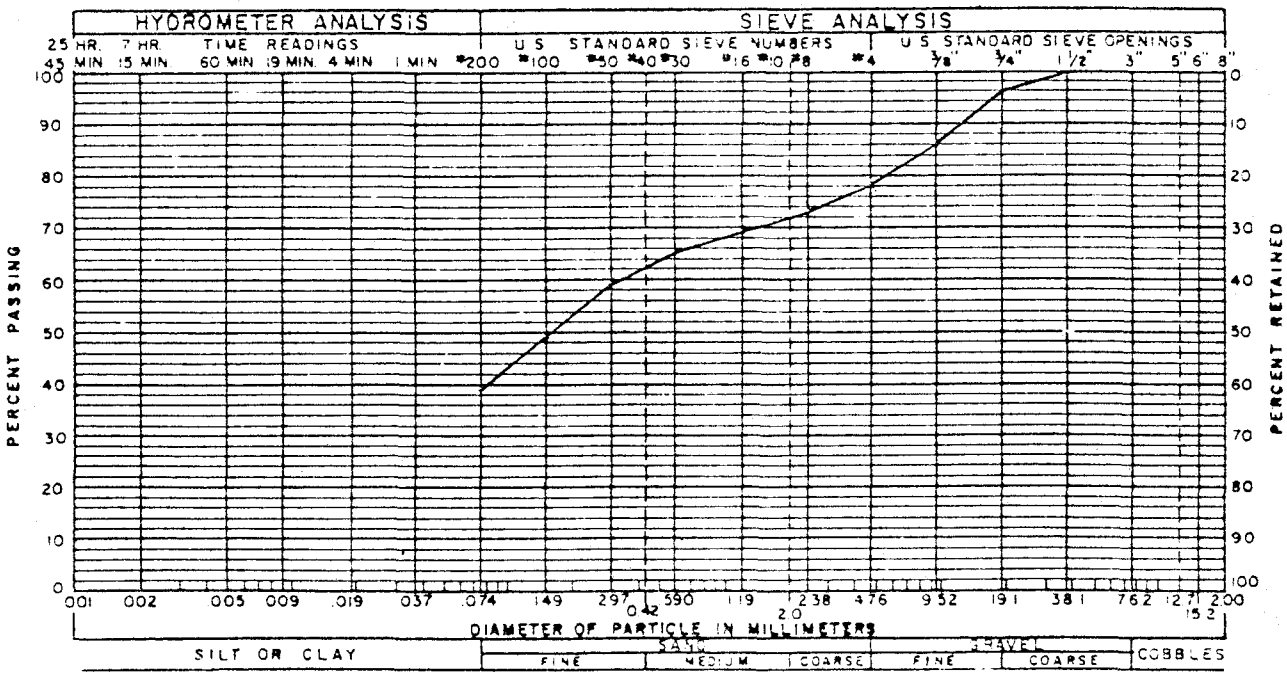
Delta



GRAVEL 14.0% SAND 42.0% SILT AND CLAY 44.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Silt and Sand, gravelly FROM Test Pit 4-1 @ 5-6'
ML-SM



GRAVEL 22.0 % SAND 39.0% SILT AND CLAY 39.0%

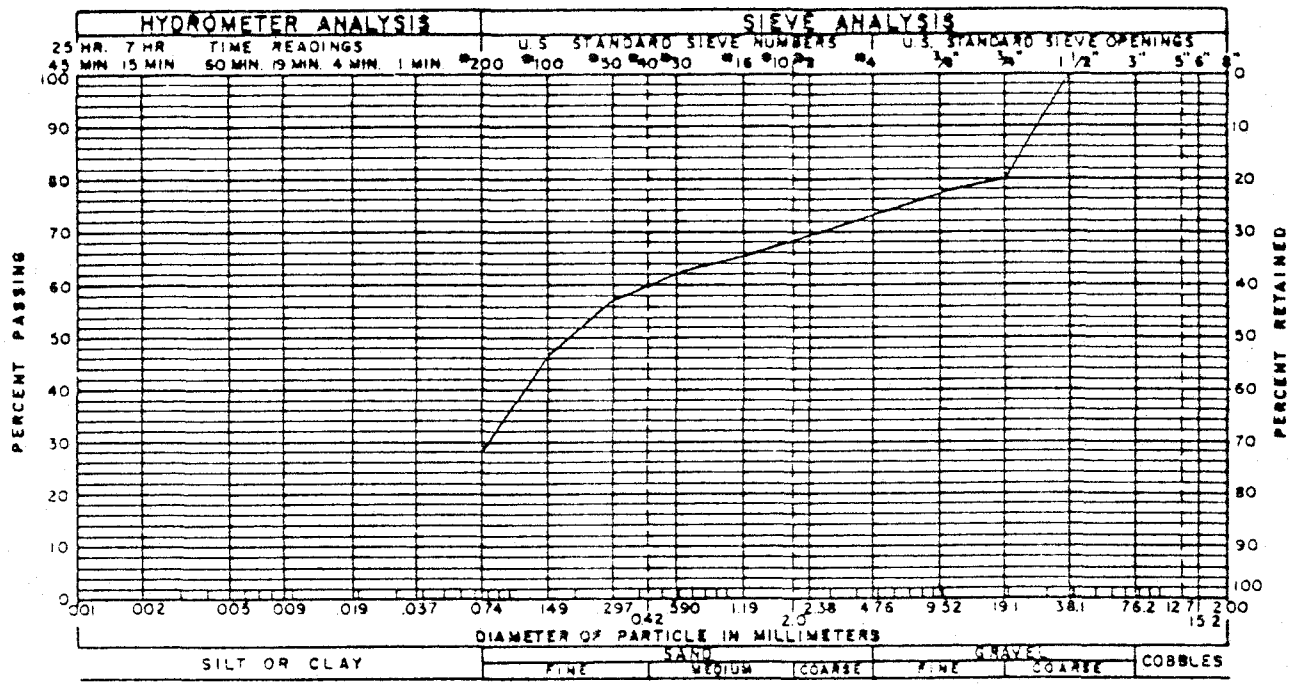
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Silt and Sand, gravelly FROM Test Pit 4-2 @ 10-11'
ML-SM

GRADATION TEST RESULTS

Figure A-4

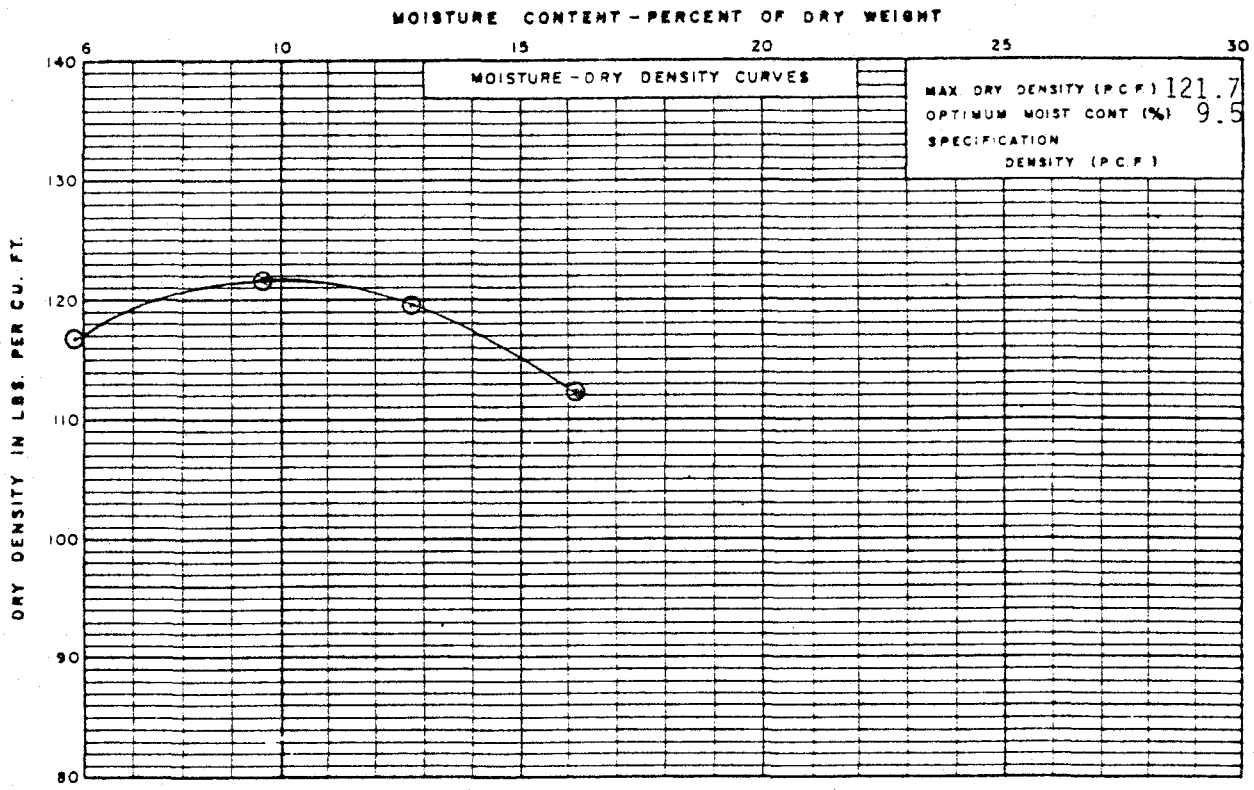
Delta



GRADATION TEST RESULTS

GRAVEL 27.0 % SAND 45.0 % SILT AND CLAY 28.0 %

LIQUID LIMIT % PLASTICITY INDEX NP %



COMPACTION TEST RESULTS

COMPACTION TEST PROCEDURE ASTM D 1557-70, Method C

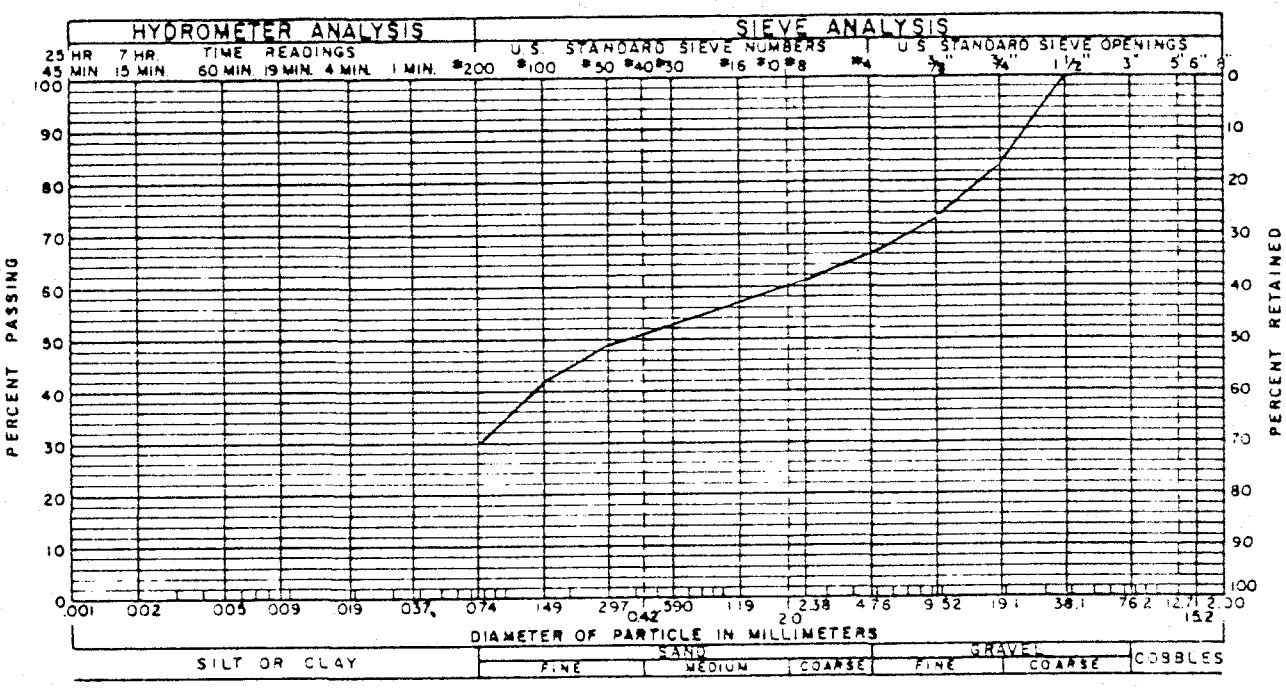
SAMPLE OF Sand - silty, gravelly SM

FROM Bag #1 (both #1's mixed) DEPTH

Test Pit 1

Figure A-5

Delta

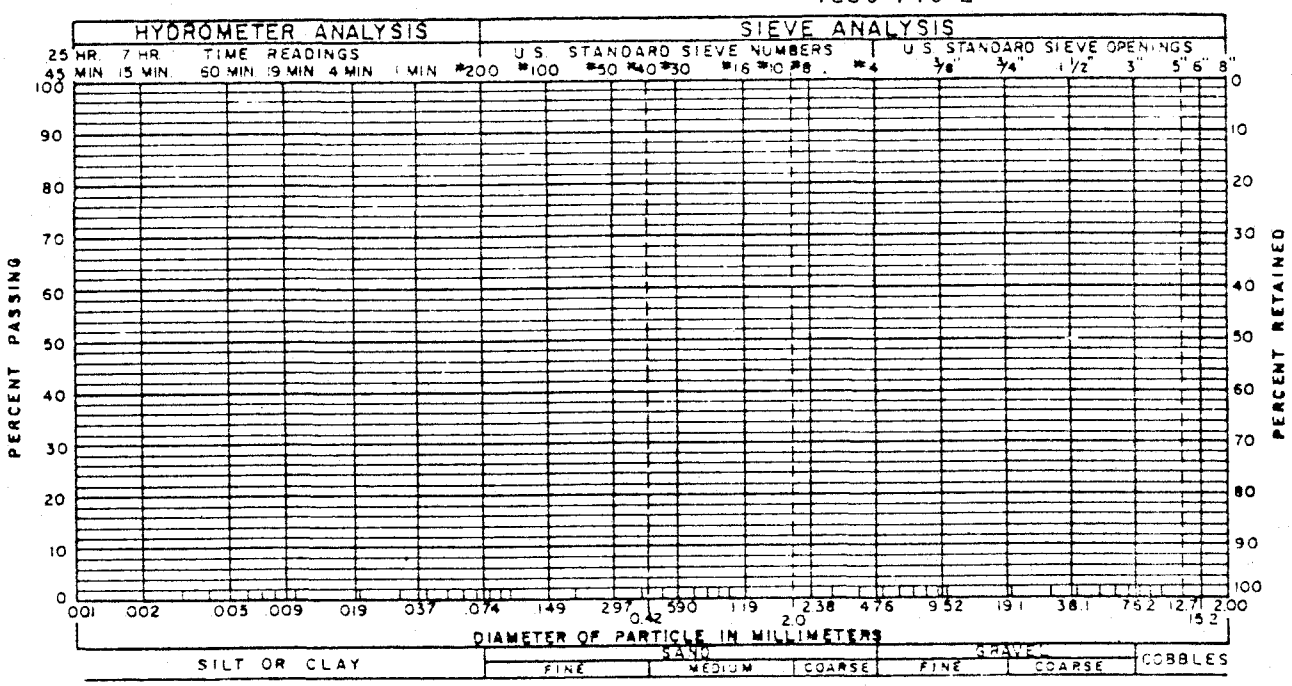


GRAVEL 34.0 % SAND 36.0% SILT AND CLAY 30.0 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Sand and Gravel, silty FROM Bag #2
SM-GM

Test Pit 2



GRAVEL % SAND % SILT AND CLAY %

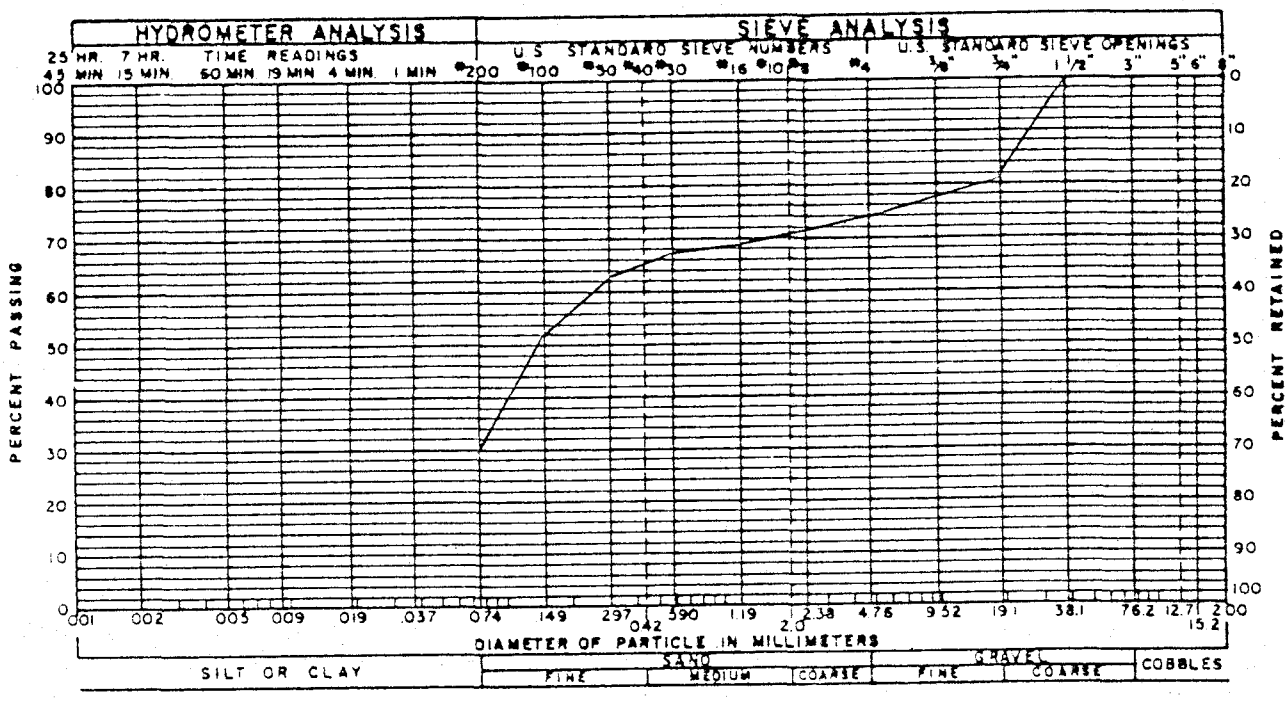
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM

GRADATION TEST RESULTS

Figure A-6

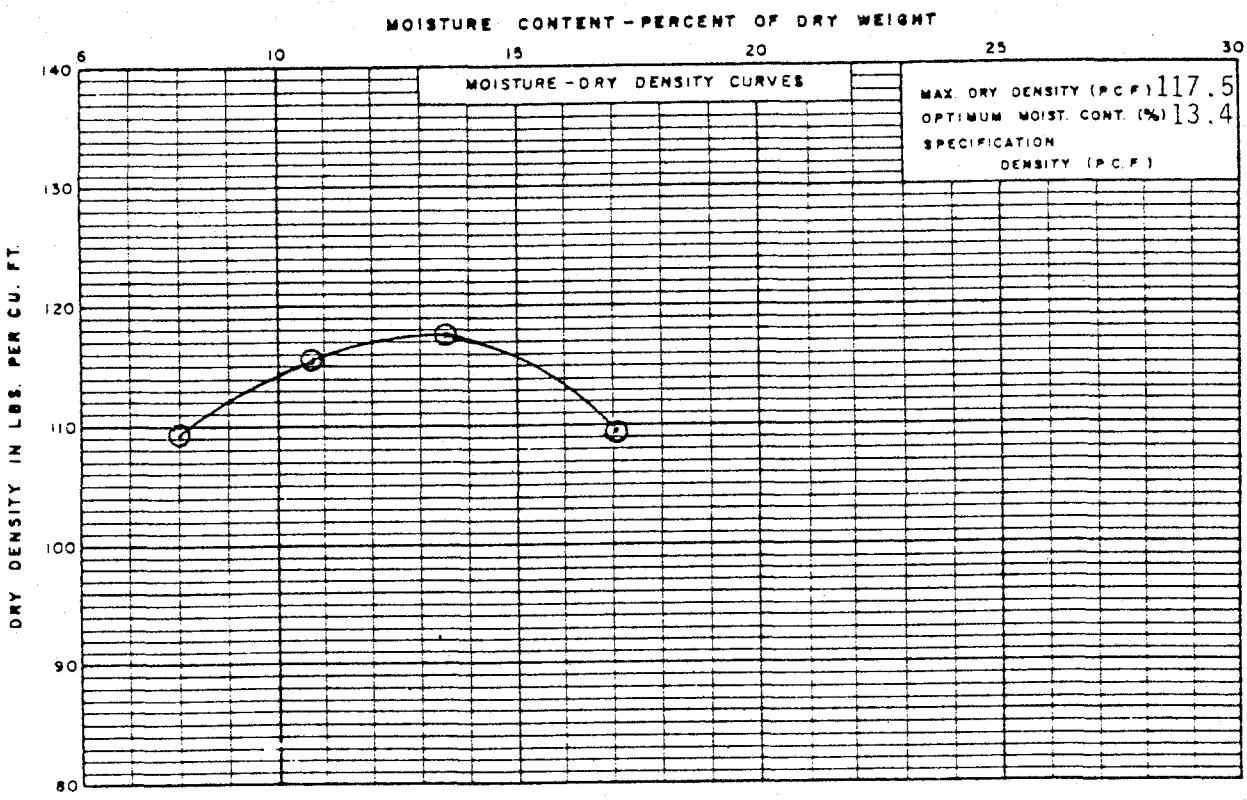
Delta



GRADATION TEST RESULTS

GRAVEL 26.0 % SAND 44.0% SILT AND CLAY 30.0%

LIQUID LIMIT % PLASTICITY INDEX NP %



COMPACTION TEST RESULTS

COMPACTION TEST PROCEDURE ASTM D 1557-70, Method C

SAMPLE OF Sand - silty, gravelly SM

FROM Bag #3 (both #3's mixed) DEPTH

Test Pit 3

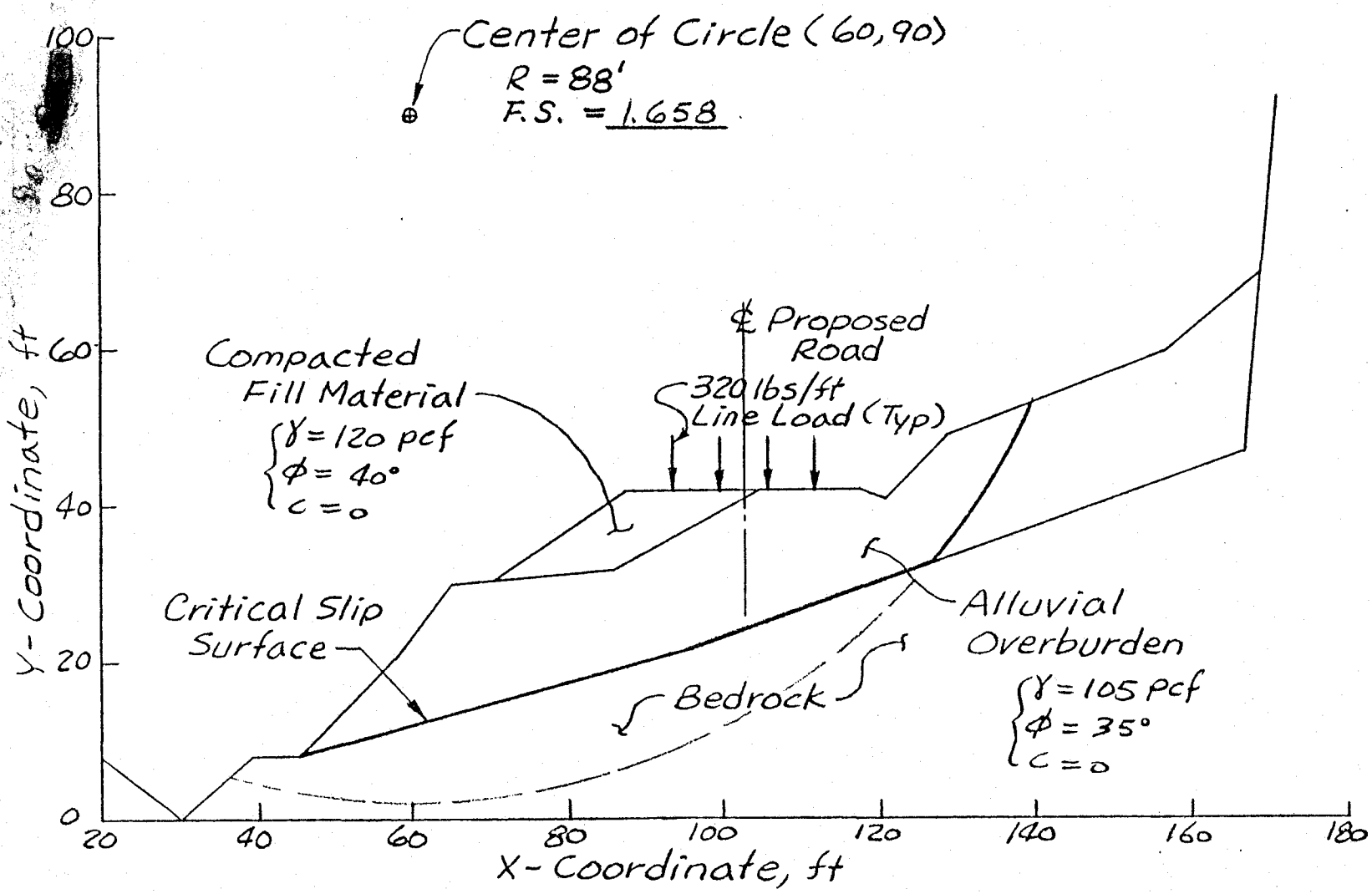
Figure A-7

TABLE A-1

SUMMARY OF LABORATORY TEST RESULTS

TEST PIT	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	SHEAR STRENGTH				SPECIFIC GRAVITY	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)		DIRECT SHEAR		TRIAXIAL			
							ø°	c, psf	ø°	c, psf		
1	5-6	4.1									2.765	Sand, gravelly, silty
2	5-6	9.2										Sand, silty, gravelly
3	5-6	8.2										Sand, silty, gravelly
4	5-6	14.3										Silt & Sand gravelly
Bag #1					NP							Sand, silty, gravelly
Bag #3					NP							Sand, silty, gravelly

APPENDIX B - CRITICAL SLIP CIRCLES



STATION 25+50

Note: ℄ of proposed road is shifted 8' to the right to avoid constructing embankment in creek for stability analysis purpose.

DWN. JSL
CKD. JSL
DATE. 3-25-81
SCALE 1" = 20'

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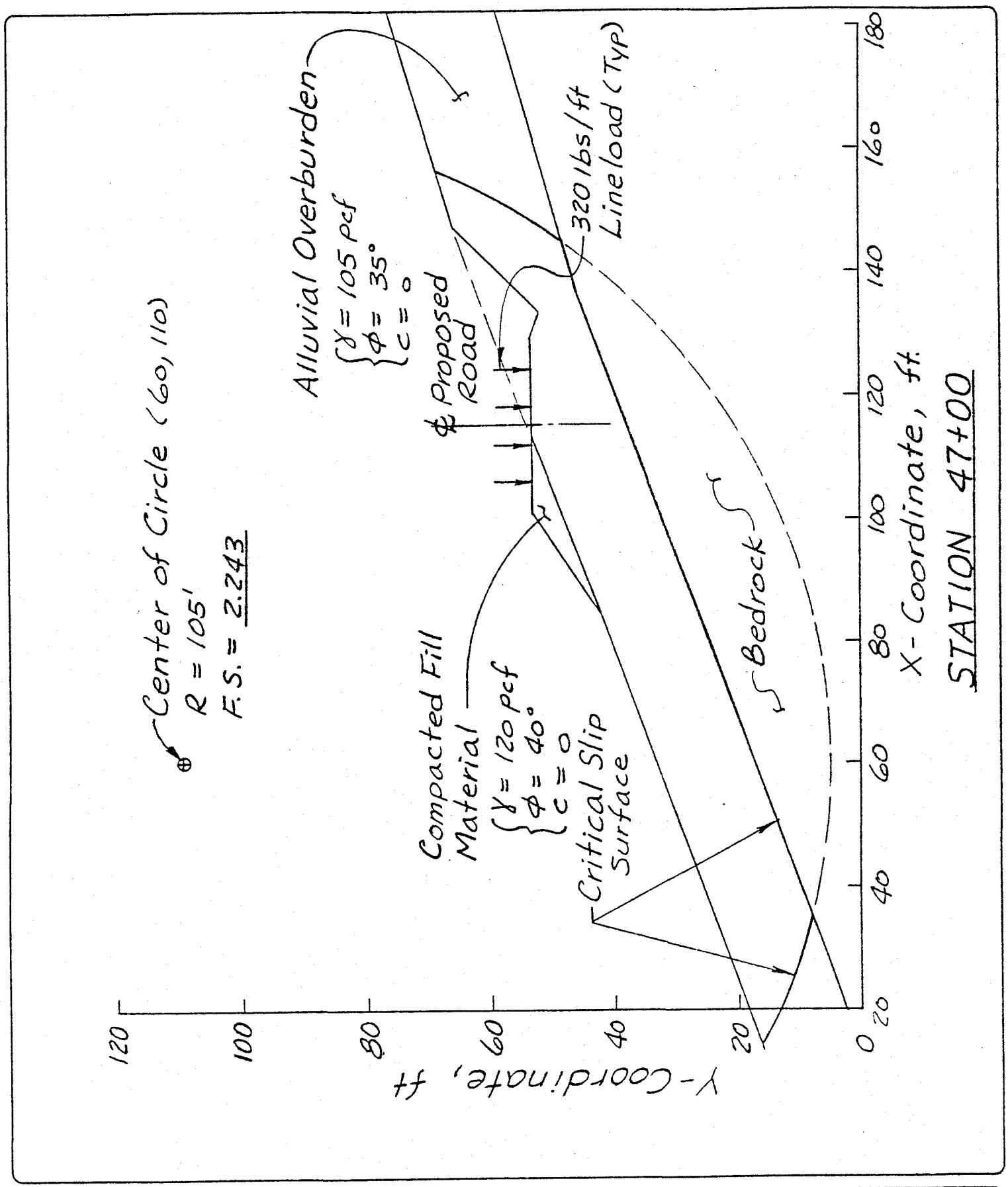
GENWAL COAL
TANDALL CANYON ROAD
STABILITY STUDY

F.B.
GRID.
PROJ.NO. 161005
DWG.NO. B-1



DWN.	JSL
CKD.	JSL
DATE.	3-25-81
SCALE.	1" = 20'

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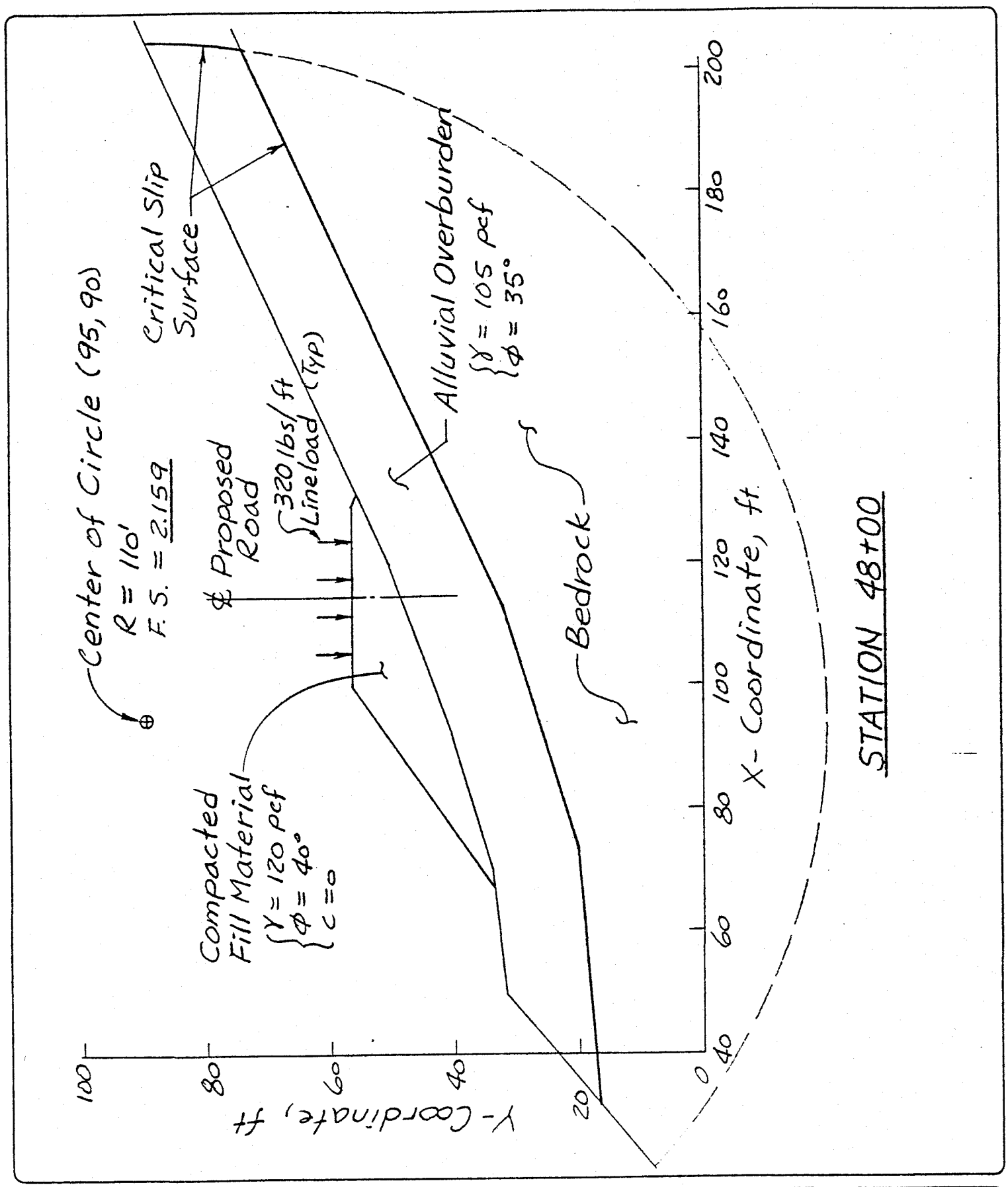
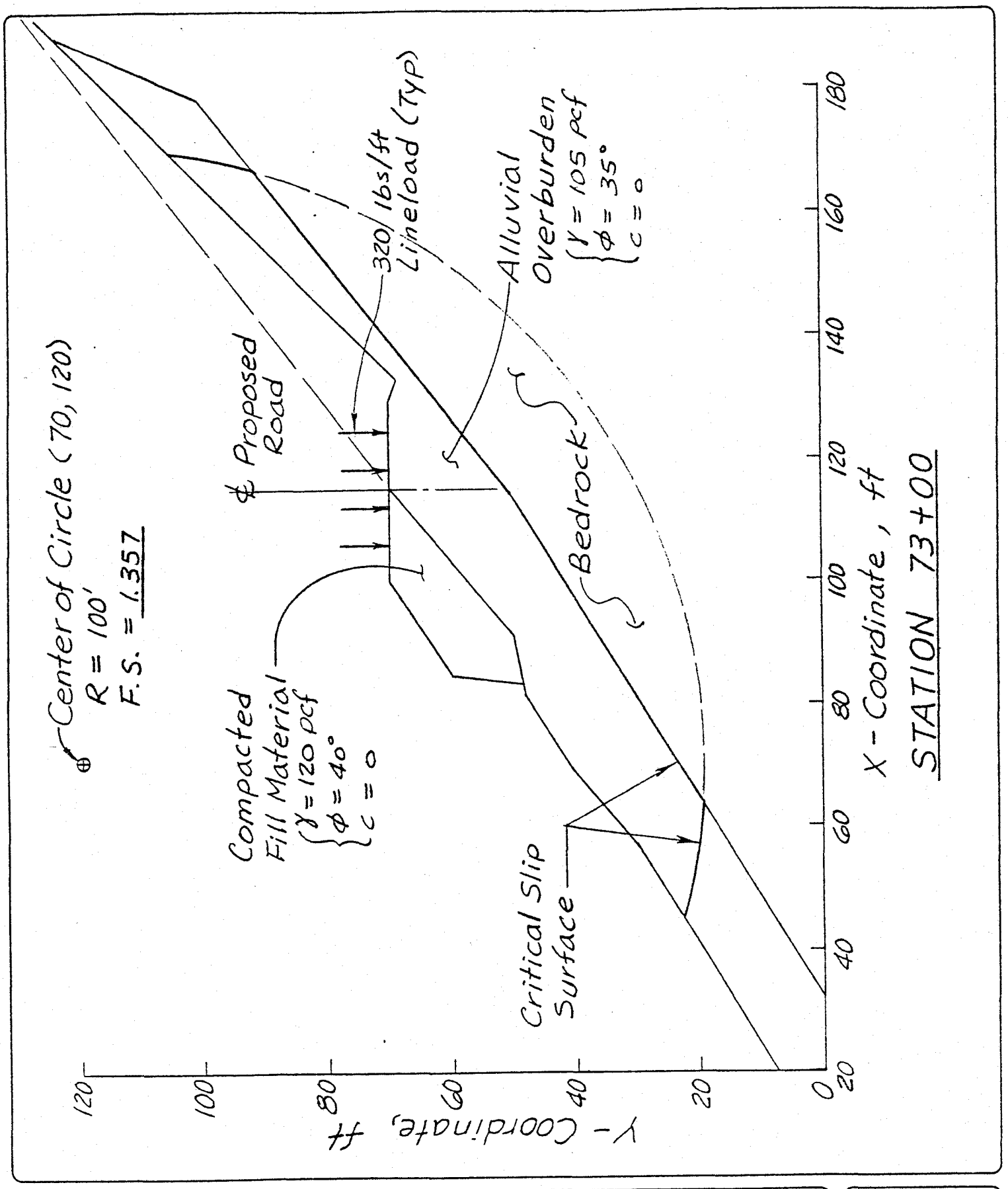
GRID.	
PROJ. NO.	161005
DWG. NO.	B-2



DWN. JSL	R&M CONSULTANTS, INC. ENGINEERS GEOLOGISTS PLANNERS SURVEYORS	GENWAL COAL CRANDALL CANYON ROAD STABILITY STUDY	F.B.
CKD. JSL			GRID.
DATE. 3-25-81			PROJ. NO. 161005
SCALE. 1" = 20'			DWG. NO. B-3



DWN.	JSL
CKD.	JSL
DATE.	3-25-81
SCALE.	1" = 20'

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DWG.NO.	B-4