Lowe Railroad MSHA Impoundment

Background

The Lowe Railroad MSHA Impoundment (MSHA ID No. 1211-NM-09-00097-01) is located immediately north of the Lowe Coal Stockpile in Area III, see Exhibit 11-13E. The impoundment was constructed in 1981 when the railroad was extended further south to facilitate mining operations. The impoundment's embankment has a maximum height of approximately 50 feet with side slopes of 1.5 horizontal to 1.0 vertical. The top width of the embankment is 35 feet. The maximum capacity of the impoundment is approximately 100 acre-feet.

Within the Lowe Railroad MSHA Impoundment watershed there are two smaller impoundments (Lowe Railroad Impoundments #1 and #2) and a topsoil stockpile (LWR1_TS_W), see Exhibit 11-67 and 11-67A, respectively. Both Lowe Railroad Impoundments #1 and #2 were designed as total containment structures, 100 year-6 hour storm event, therefore no spillway were required (30 CFR 816.49(a)(9)(ii)(B)) and will retain surface runoff and sediment generated from the areas disturbed by mining activities. In addition, the impoundments will keep the 100 year-6 hour flood from impacting the topsoil stockpile.

Hazard Classification

In the event of a failure of the MSHA Impoundment Embankment, the potential for loss of life or significant property damage downstream is very low. There are no dwellings, public buildings, commercial buildings, or public transportation/utilities downstream of the MSHA Impoundment. Additionally, it will not constitute a hazard to mine employees and equipment since it is downstream of the active pit and reclamation activities. Lowe Railroad Impoundment would be classified as a low hazard dam.

Lowe Railroad Impoundments #1 and #2 were designed to safely retain the 100 year – 6 hour runoff of 6.87 and 6.55 acre-feet, respectively. The capacity of Impoundment #1 is 19.20 acre-feet and Impoundment #2 has a capacity of 18.37 acre-feet. Both structures will retain surface water runoff and sediment storage. Water and/or sediment level will be kept below the maximum permissible level, see NM-0003E Chapter 11 Sediment Ponds 11.5.4.2 for additional information on the maximum permissible level.

Watershed Area

Lowe Railroad Impoundment #1 has a watershed of 105.73 acres. The watershed drainage is from the Lowe Coal Stockpile, overburden material adjacent to the Lowe bypass road, and part of the topsoil stockpile material. Impoundment #2 has a watershed of 133.27 acres. The drainage extends north to the mid point of the Neck Road, see Exhibit 11-13E for the watershed boundaries.

Design Criteria

The design criteria and key assumptions made for the hydrology analysis for Lowe Railroad Impoundments #1 and #2, are as follows:

Lowe Railroad MSHA Impoundment

1. The design storm event for both impoundments is 100 year-6 hour, see Appendix 11-AA for SedCad Modeling analysis.

2. The capacity to store runoff from a 100 year – 6 hour storm will be maintained at all times. Water and/or sediment will not be higher than the maximum permissible level see tables 11-5Q and 11-5R. This is the elevation at which the impoundment can no longer contain the designed storm event. If the water and/or sediment exceed the permissible level then it will either be pumped and/or cleaned to an acceptable elevation.

3. Since the railroad embankment has the potential to impound 100 acre-feet of water and is about 50 feet high the MSHA impoundment criteria is applicable as required by 30 CFR 77.216.

Stability Analysis

The slope stability analysis for Lowe MSHA Impoundment was performed by Western Technologies, Incorporated located in Farmington, New Mexico. For more information, refer to the analysis report titled "Lowe Railroad Impoundment #1 – Stability Analysis", can be found in this appendix. Note: Lowe Railroad MSHA Impoundment is referred to as Lowe Railroad Embankment #1 in the stability analysis report.

The static factors of safety for the upstream and downstream slopes of the railroad embankment are 3.1 and 3.7, respectively. This indicates that the railroad embankment is stable and meets the minimum safety factor of 1.5. Modifications to Impoundments #1 and #2 have not affected the stability of the Railroad embankment; therefore; the report is still valid.

Summary

Lowe Railroad Impoundments #1 and #2 will safely retain the 100 year -6 hour storm event. If a storm exceeds the designed storm event, the railroad embankment has the potential to 100 acre-feet of water. Therefore, it is considered a MSHA Impoundment. The Railroad embankment meets the minimum static safety factor if such an event were to happen.

Lowe Railroad MSHA Impoundment

Modifications

April 2008 Impoundments #1 and #2 were both modified due to an OSM Notice of Violation, the berm breached on the topsoil stockpile and the 100 year-6 hour storm floodplain had the potential to impact the topsoil stockpile. The impoundments were redesigned to contain the 100 year- 6 hour storm event. The north embankment on Impoundment #1 was raised and the spillway on Impoundment #2 was closed. The western topsoil berm is now the railroad embankment. This will reduce the loss of topsoil in the event of a 100 year- 6 hour storm.

In 1995, Impoundment #2 was modified based on a September and October, 1994 OSM/AFO inspection. The inspection was an observance of seepage on the western boundary of the impoundment. BHP installed a 3 ½'spoil clay liner. The permeability of the spoil material was tested by AGRA Earth & Environment. Clay liner is shown on the as-built design, Exhibit 11-67A. For additional information see Lowe Railroad Embankment #2 Modification on the following page, this includes the permeability results.

NAVAJO MINE

LOWE RAILROAD EMBANKMENT #2 MODIFICATION

BHP Minerals International Inc. is proposing to modify the Lowe Railroad Embankment #2 impoundment. This embankment is located along the railroad just north of Lowe Stockpile (also see EXHIBIT 11-13E, "Area III Impoundments and Pond Location/Watershed Areas", for location). The embankment occasionally contains surface water runoff to the east of the railroad. In addition, EXHIBIT's 11-67 and 11-67a shows the location of the embankment and the drainage area. This modification addresses the seepage of water from the western face of the Lowe Railroad Embankment #2. This situation was observed by OSM/AFO during a September and October, 1994 inspection.

BHP proposes that we level the area and backfill the pond with approximately 28,600 cyds of existing spoil material. The clay material from the existing North Lowe Pit spoil pile will be used. Once the area has been completely leveled from elevations 5325' down to 5310', the area will be covered with 3 1/2' of clay liner material. The spoil clay material was tested for permeability by AGRA Earth & Environmental. A copy of the AGRA laboratory results are provided within the appendix. A portion of railroad embankment will also be lined with the clay material. The proposed work modification is shown on EXHIBIT 11-67 as cross-sections C-C and D-D.

Currently the basin capacity is 18.18 acre-feet at 5320' elevation. It was determined the highest point of elevation was 5325' before it drops back down in elevation. After the spoil clay material has been brought in and compacted and backfilled against the railroad embankment, the basin capacity is calculated to be 16.39 acre-feet at elevation 5325' which is substantially greater than the required

(12/08/95;12/26/95)

capacity of 12.32 acre-feet for a 100-yr., 6-hr. storm.

Lowe Railroad Embankment #2 watersheds are approximately 105.1 acres of mostly disturbed land. The SEDCAD+ analysis provided in APPENDIX 11-AA is valid for the embankment modification proposal. The modification will compile with Federal regulation 30 CFR 816.46, which requires that a sedimentation pond without a spillway contain runoff generated from a 100-yr., 6-hr event. Runoff quantities were determined using the SEDCAD+ computer model.

(12/08/95;12/26/95)

AGRA
Earth & Environmental

AGRA Earth &
Environmental, Inc.
2060 Afton Place
Farmington, New Mexico 87401
Tel (505) 327-7928
Fax (505) 326-5721

LABORATORY REPORT

Client: BHP Minerals - Navajo Mine Area III
P.O. Box 155
Fruitland, NM 87416

AGRA Project No.: C95-9506

February 2, 1995
Page (1 of 1)

Project Lowe Pond #2 Liner
Location Navajo Mine Area III

Type of Material Clay
Source of Material Lowe Stockpile Northeast
Requested By E. Tsosie Date 1/10/95 Sampled By L. Waresback/AGRA Date1/10/95
Submitted By L. Waresback/AGRA Date 1/10/95

Reviewed By L. Waresback

Sieve Analysis, ASTM

Sieve Size	Accumulative Percent Passing	Specification
3"		
2 1/2"		
2"		
1 1/2"		
1"		
3/4"		
1/2"	100	
3/8"	98	
1/4"	--	
No. 4	96	
No. 8	93	
No. 10	92	
No. 16	91	
No. 30	88	
No. 40	87	
No. 50	86	
No. 100	83	
No. 200	78	

Moisture-Density Relationship, Test Method ASTM D698A

Maximum Dry Density: 98.1 pcf Optimum Moisture Content: 20.5 percent

Plasticity Index, ASTM D4318

	Results	Specification
Liquid Limit (LL)	63	
Plastic Limit (PL)	21	
Plasticity Index (PI=LL-PL)	42	

Other

Permeability 8.4 x 10^{-9}cm/sec. Spec. 1.0 x 10^{-7} cm/sec. minimum
Remolded to 95% of ASTM D698 at Optimum Moisture Content.

Distribution:Client, Billimg /mir

Engineering & Environmental Services

AGRA
Earth & Environmental

AGRA Earth &
Environmental, Inc.
2060 Afton Place
Farmington, New Mexico 87401
Tel (505) 327-7928
Fax (505) 326-5721

LABORATORY REPORT

Client: BHP Minerals - Navajo Mine Area III
P.O. Box 155
Fruitland, NM 87416

AGRA Project No.: C95-9506

February 2, 1995
Page (1 of 1)

Project Lowe Pond #2 Liner
Location Navajo Mine Area III

Type of Material Clay
Source of Material Lowe Pit West
Requested By E. Tsosie
Submitted By L. Waresback/AGRA

Date 1/10/95
Date 1/10/95

Sampled By L. Waresback/AGRA Date1/10/95

Reviewed By L. Waresback

Sieve Analysis, ASTM

Sieve Size	Accumulative Percent Passing	Specification
3"		
2 1/2"		
2"		
1 1/2"		
1"		
3/4"	100	
1/2"	98	
3/8"	97	
1/4"	--	
No. 4	92	
No. 8	89	
No. 10	88	
No. 16	85	
No. 30	83	
No. 40	82	
No. 50	81	
No. 100	79	
No. 200	76	

Moisture-Density Relationship, Test Method ASTM D698A

Maximum Dry Density: 102.9pcf Optimum Moisture Content: 18.0 percent

Plasticity Index, ASTM D4318

	Results	Specification
Liquid Limit (LL)	49	
Plastic Limit (PL)	25	
Plasticity Index (PI = LL-PL)	24	

Other

Permeability 1.3 x 10^{-8}cm/sec. Spec. 1.0 x 10^{-7} cm/sec. minimum
Remolded to 95% of ASTM D698 at Optimum Moisture Content.

Distribution:Client, Billimg /mir

Engineering & Environmental Services

Lowe Railroad Embankment #2 As-Built/ Modification

Reclamation on the eastern edge of Lowe Railroad Embankment #2 Pond has changed the topography so that the current pond can retain over 20 acre-feet. Therefore, the pond must be modified or permitted by MSHA. To eliminate this problem, a spillway has been added to the western end of the pond along the 5324' elevation. The crest of the spillway extends 426' southwards at elevation 5324'. When topography starts to break, the spillway slopes 434' downward at -7.3% towards Lowe Railroad Embankment #1. The pond will contain 11.11 acre-feet at the 5324' elevation. The pond must hold 8.07 acre-feet to contain the 10 year, 24-hour storm event. The spillway is designed for the 25 year, 6-hour storm event, and the peak stage is at 5325.09' elevation. This allows for one foot of free board in the spillway.

The spillway outflow channel will show signs of scouring during an overflow event from the spillway. In the past, overflow through the spillways have been very infrequent; especially, since the average annual rainfall for the area is only 7.0 inches. The outflow channel will be inspected and maintained. Any sediment generated will be retained in Lowe Railroad Embankment #1, immediately downstream, and it will not leave the permit area.

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Due to text updates

LOWE RAILROAD IMPOUNDMENT #1

STABILITY ANALYSIS

GEOTECHNICAL EVALUATION

LOWE RAILROAD EMBANKMENT I
AREA III - NAVAJO MINE
FRUITLAND, NEW MEXICO
JOB NO. 3127JC127

Prepared for:

BHP - NAVAJO MINE

August 8, 1997

Lawrence E. Cyhova, P.E.
Geotechnical Engineer

Jon C. Schwindt, P.E.
Vice President

August 8, 1997

BHP - Navajo Mine
P.O. Box 1717
Fruitland, New Mexico 87416

Attn: Mr. Leonard Raymond

Re: Geotechnical Evaluation
Lowe Railroad Embankment I
Area III - Navajo Mine
Fruitland, New Mexico

Job No. 3127JC127

Western Technologies Inc. has completed the geotechnical evaluation for the existing Lowe Railroad Embankment I at Navajo Mine, south of Fruitland, New Mexico. This study was performed in general accordance with our verbal/telephone quote and BHP purchase order AG9559 on July 24, 1997. The original study for this project was conducted in January of 1988. This report is to cover additional depth of water behind the railroad embankment. The results of our evaluation, including the field observations, borings logs and the geotechnical recommendations are attached.

We appreciate being of service to you in the geotechnical engineering phase of this project. If conditions change, or if you have any questions concerning this report and consulting services, please do not hesitate to contact us. We look forward to working with you on future projects.

Sincerely,
WESTERN TECHNOLOGIES INC.
Geotechnical Engineering Services

Lawrence E. Cynova, P.E.
Geotechnical Engineer

Copies to: Addressee (4)

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GEOTECHNICAL EVALUATION
LOWE RAILROAD EMBANKMENT I
FRUITLAND, NEW MEXICO
JOB NO. 3127JC127

1.0 PURPOSE

This report contains the results of our geotechnical evaluation of the existing railroad slope located at the Lowe Railroad Embankment I, Area III of the Navajo Mine, south of Fruitland, New Mexico. The purpose of these services is to determine the depth of fill, material types and stability of the existing slopes.

2.0 PROJECT DESCRIPTION

Project information supplied by Mr. Leonard Raymond, indicates that the railroad embankment was constructed in about 1981. The embankment has a railroad and service road and is about 35 feet in width. The railroad fill is several thousand feet in length. Our work was primarily concerned with the deep fill which is approximately 600 feet in length. It is understood that this empoundment area has a small drainage area and the maximum water behind the embankment will be at elevation 5308. The embankment is approximately 50 feet in height at its highest point. The area behind the embankment is dry about 70 percent of the time. After a precipitation event and if significant water is present behind embankment, the water will be pumped/hauled away.

3.0 SCOPE OF SERVICES

3.1 Field Exploration

Two borings were drilled to depths ranging from 41 to 42 feet below existing site grades on the existing railroad embankment area. A field log was prepared for each boring. The final logs describe the materials encountered; their thicknesses, and locations where samples were obtained. The Unified Soil Classification System was used to classify soils. The soil classification symbols appear on the boring logs and are briefly described in Appendix A.

3.2 Labortory Analyses

Laboratory analyses were performed on representative soil samples to aid in material classification and to estimate pertinent engineering properties of the on-site soils for preparation of this report. Testing was performed in general accordance with applicable ASTM specifications. The following tests were performed and the results are presented in Appendix B.

- Water content
- Dry density
- Shear strength-direct shear

3.3 Analyses and Report

Analyses was performed and this report was prepared for the exclusive purpose of providing geotechnical engineering information and recommendations. The scope of services for this project does not include, either specifically or by implication, any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken. We are available to discuss the scope of such studies with you.

4.0 SITE CONDITIONS

4.1 Surface

The Lowe Railroad Embankment I is located just north of Lowe Stockpile loading area. The general site drainage is to the west down a wash. Spoils piles and a top dressing stockpiles are located east and northeast of the Railroad Embankment. The site contained a sparse to moderate growth of weeds, grass, and brush. Rock outcrops at many locations surrounding this site.

4.2 Geologic History

The material located at the Lowe Railroad Embankment appears to have been cut from the surrounding hills and mesas and placed as fill. This material probably originated as flood plain and valley alluvium deposits derived from the cretaceous sedimentary beds of the Fruitland Formation.

This formation consists of gray to brown shale and claystone interbedded with tan to yellow sandstone and coal. It was deposited as coastal swamp and floodplain deposits which accumulated behind and above the near shore sands of the Pictured Cliff Sandstone, also of cretaceous age. The Fruitland Formation remains one of the most important coal horizons in the San Juan Basin.

5.0 ANALYSIS PROCEDURES

5.1 General

The slope stability analysis was conducted on the highest section of the embankment where water is stored after precipitation runoff. A fully loaded coal train was assumed to be on the railroad embankment during this analysis.

5.2 Material Properties

The sandy clay materials encountered in the embankment areas have moderate to high cohesion and moderate to moderately high angles of internal friction. The direct shear tests were conducted at or slightly above existing moisture contents for embankment materials and in the saturated condition for ponds materials. The large particle size of the embankment materials caused difficulty in trimming soils samples and therefore soil samples were remolded to near in-place densities. The claystone or shale under the soils at the embankments was assumed to have high cohesion and low to moderately high angles of internal friction. Based upon our observations and our experience with similar materials, the following material properties were assigned to the existing slope materials:

Sandy Clay - Native Area
Dry unit weight - 107 (pcf) pounds per cubic foot
Angle of internal friction - 20°
Cohesion - 300 (pcf) pounds per cubic foot

Sandy Clay - Saturated Zone
Dry unit weight - 95 (pcf) pounds per cubic foot
Angle of internal friction - 20°
Cohesion - 300 (pcf) pounds per cubic foot

Sandy Clay - Embankment Area
Dry unit weight - 107 (pcf) pounds per cubic foot
Angle of internal friction - 32°
Cohesion - 1400 (pcf) pounds per cubic foot

Claystone
Dry unit weight - 110 (pcf) pounds per cubic foot
Angle of internal friction - 0°
Cohesion - 10,000 (psf) pounds per cubic foot

5.3 Slope Stability Analysis

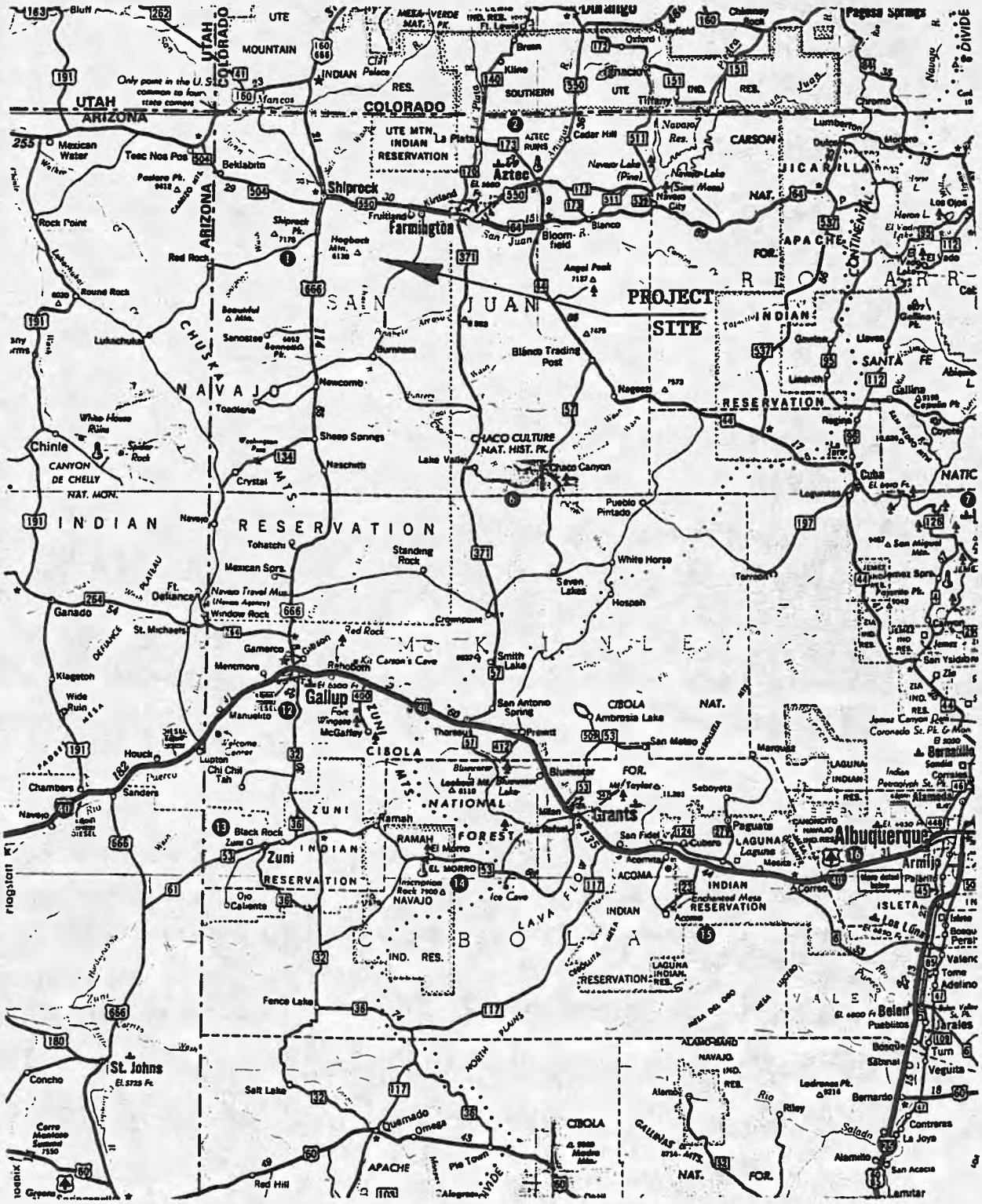
The static stability of the existing slope was analyzed using strength parameters from test results and estimates from observations and past experience with similar materials. The analysis was conducted on the slope configuration (Plate 3) as measured in the field by BHP personel. A computer program (SB Slope developed by Von Guten Engineering Software) using simplified Bishop's Analysis was performed for the existing slope configurations.

The following table presents the results of the analysis:

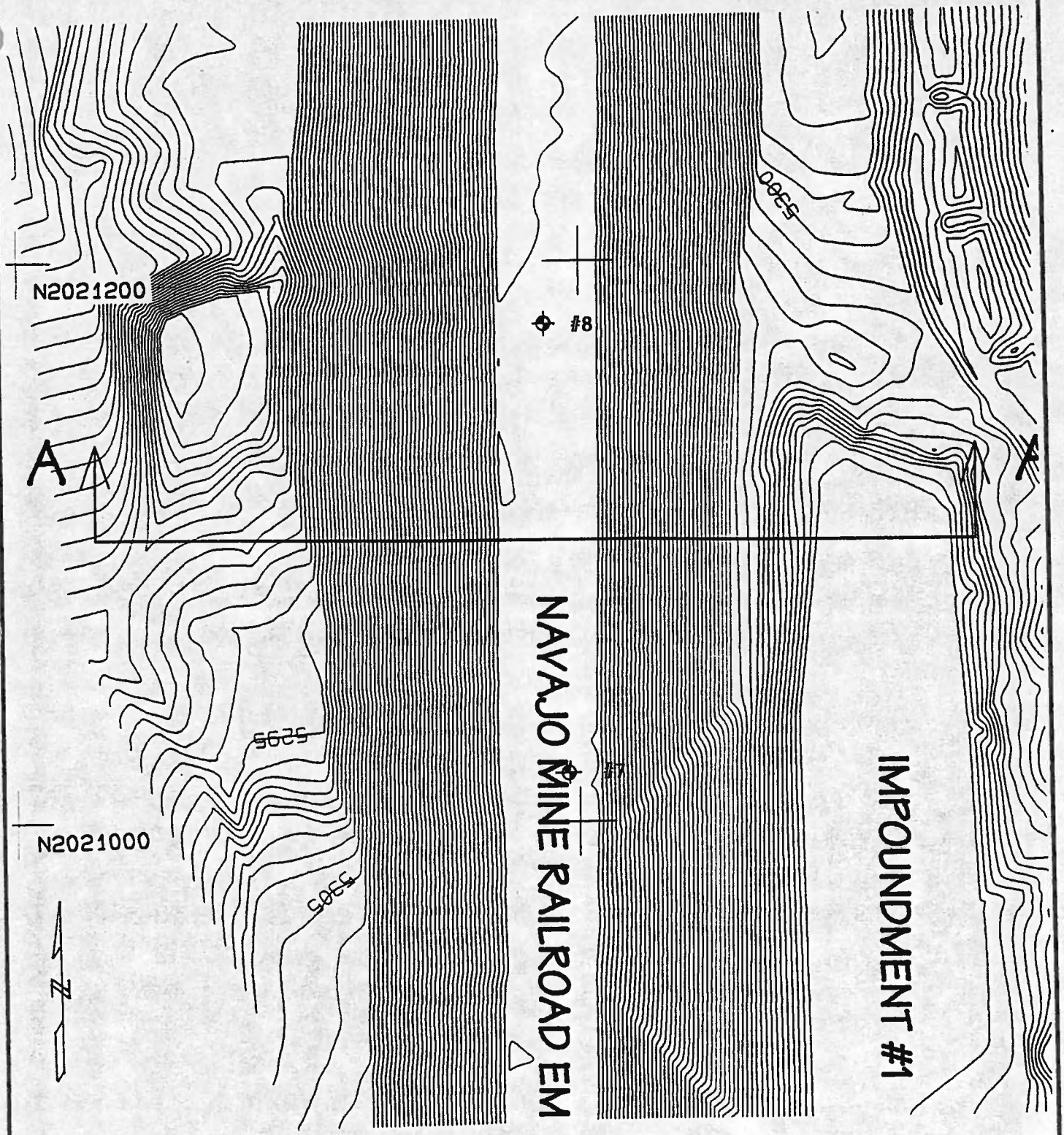
Section	Analysis	Factor of Safety
Downstream	Circle 1	3.7
Upstream	Circle 2	3.1

A minimum static factor of safety of 1.5 is required for embankments by the Mine Safety & Health Administration.

Based upon laboratory test results, estimates of soil parameters and our computer analysis, the upstream and downstream slope of the railroad embankment meets the static factor of safety.



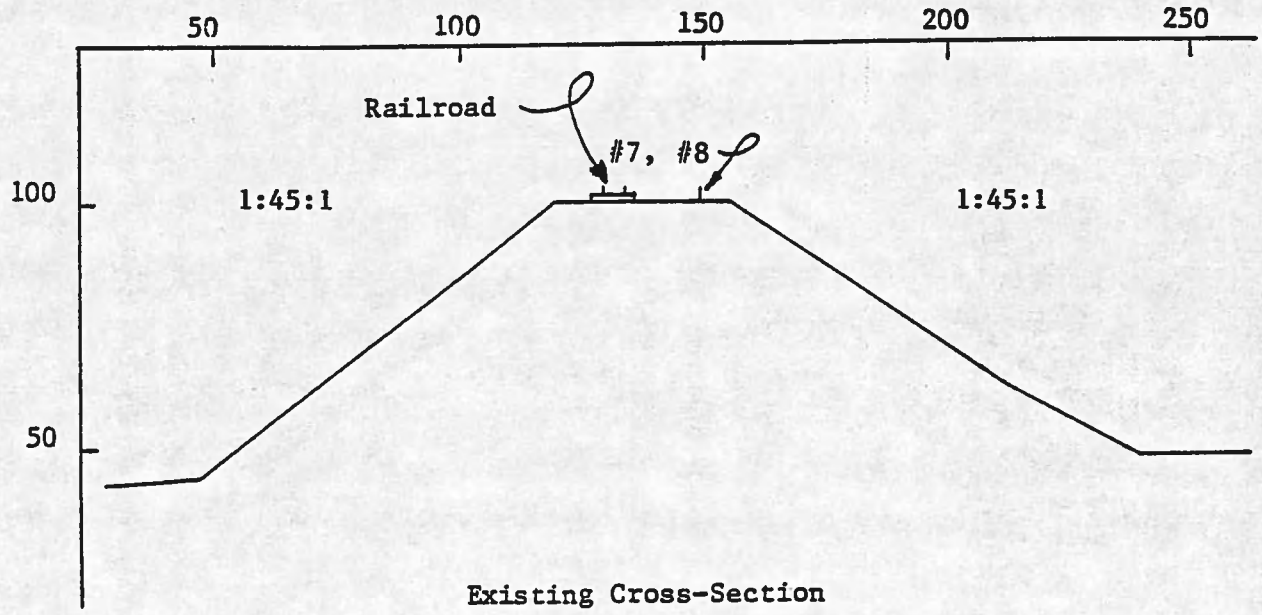
LOWE RAILROAD EMBANKMENT I	
Vicinity Map	
Western Technologies Inc.	
Job No.: 3127JC127	Plate: 1



LEGEND

BORING

LOWE RAILROAD EMBANKMENT I	
Boring Location Diagram	
Western Technologies Inc.	
Job No.: 3127JC127	Plate: 2



Existing Cross-Section

Slopes are shown as horizontal to vertical

LOWE RAILROAD EMBANKMENT I	
Slope Profile	
Western Technologies Inc.	
Job No.: 3127JC127	Plate: 3

Allowable Soil Bearing Capacity	The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.
Backfill	A specified material placed and compacted in a confined area.
Base Course	A layer of specified material placed on a subgrade or subbase.
Base Course Grade	Top of base course.
Bench	A horizontal surface in a sloped deposit.
Caisson	A concrete foundation element cast in a circular excavation which may have an enlarged base. Sometimes referred to as a cast-in-place pier.
Concrete Slabs-on-Grade	A concrete surface layer cast directly upon a base, subbase or subgrade.
Crushed Rock Base Course	A base course composed of crushed rock of a specified gradation.
Differential Settlement	Unequal settlement between or within foundation elements of a structure.
Engineered Fill	Specified material placed and compacted to specified density and/or moisture conditions under observations of a representative of a soil engineer.
Existing Fill	Materials deposited through the action of man prior to exploration of the site.
Existing Grade	The ground surface at the time of field exploration.
Expansive Potential	The potential of a soil to expand (increase in volume) due to absorption of moisture.
Fill	Materials deposited by the actions of man.
Finished Grade	The final grade created as a part of the project.
Gravel Base Course	A base course composed of naturally occurring gravel with a specified gradation.
Heave	Upward movement
Native Grade	The naturally occurring ground surface.
Native Soil	Naturally occurring on-site soil.
Rock	A natural aggregate of mineral grains connected by strong and permanent cohesive forces. Usually requires drilling, wedging, blasting or other methods of extraordinary force for excavation.
Sand & Gravel Base	A base course of sand and gravel of a specified gradation.
Sand Base Course	A base course composed primarily of sand of a specified gradation.
Scarify	To mechanically loosen soil or break down existing soil structure.
Settlement	Downward movement.
Soil	Any unconsolidated material composed of discrete solid particles, derived from the physical and/or chemical disintegration of vegetable or mineral matter, which can be separated by gentle mechanical means such as agitation in water.
Strip	To remove from present location.
Subbase	A layer of specified material placed to form a layer between the subgrade and base course.
Subbase Grade	Top of subbase.
Subgrade	Prepared native soil surface.

LOWE RAILROAD EMBANKMENT I		
Definition of Terminology		
Western Technologies Inc.		
11-Q-40	Job No.: 3127JC127	Plate: A-1

COARSE-GRAINED SOILS
LESS THAN 50% FINES*

GROUP SYMBOLS	DESCRIPTION	MAJOR DIVISIONS
GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LESS THAN 5% FINES	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size
GP	POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES LESS THAN 5% FINES	
GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES, MORE THAN 12% FINES	
GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES, MORE THAN 12% FINES	
SW	WELL-GRADED SANDS OR GRAVELLY SANDS, LESS THAN 5% FINES	SANDS More than half of coarse fraction is smaller than No. 4 sieve size
SP	POORLY-GRADED SANDS OR GRAVELLY SANDS, LESS THAN 5% FINES	
SM	SILTY SANDS, SAND-SILT MIXTURES, MORE THAN 12% FINES	
SC	CLAYEY SANDS, SAND-CLAY MIXTURES, MORE THAN 12% FINES	

NOTE: Coarse-grained soils receive dual symbols if they contain 5 to 12% fines (e.g. SW-SM, GP-GC, etc.)

FINE-GRAINED SOILS
MORE THAN 50% FINES

GROUP SYMBOLS	DESCRIPTION	MAJOR DIVISIONS
ML	INORGANIC SILTS, VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS	SILTS AND CLAYS Liquid limits less than 50
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
OL	ORGANIC SILTS OR ORGANIC SILT-CLAYS OF LOW PLASTICITY	
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDS OR SILTS, ELASTIC SILTS	SILTS AND CLAYS Liquid limit more than 50
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY	
PT	PEAT, MUCK, AND OTHER HIGHLY ORGANIC SOILS	HIGHLY ORGANIC SOILS

NOTE: Fine-grained soils may receive dual classification based upon plasticity charactenstics

SOIL SIZES

COMPONENT	SIZE RANGE
BOULDERS	ABOVE 12 in.
COBBLES	3 in. to 12 in.
GRAVEL	No. 4 to 3 in.
Coarse	3/4 in. to 3 in.
Fine	No. 4 to 3/4 in.
SAND	No. 200 to No. 4
Coarse	No. 10 to No. 4
Medium	No. 40 to No. 10
Fine	No. 200 to No.40
*Fines (Silt or Clay)	BELOW No. 200

NOTE: Only sizes smaller than three inches are used to classify soils

CONSISTENCY

CLAYS & SILTS	BLOWS/FOOT*
VERY SOFT	0-2
SOFT	2-4
FIRM	4-8
STIFF	8-16
VERY STIFF	16-32
HARD	Over 32

RELATIVE DENSITY

SANDS & GRAVELS	BLOWS/FOOT*
VERY LOOSE	0-4
LOOSE	4-10
MEDIUM DENSE	10-30
DENSE	30-50
VERY DENSE	Over 50

*Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1 3/8" ID) split spoon (ASTM D1586)

PLASTICITY OF FINE GRAINED SOILS

PLASTICITY INDEX	TERM
0	Non-Plastic
1 - 7	Low
8 - 25	Medium
Over 25	High

DEFINITION OF MOISTURE CONTENT

DRY
SLIGHTLY DAMP
DAMP
MOIST
WET
SATURATED

LOWE RAILROAD EMBANKMENT I

Method of Soil Classification

Western Technologies Inc.

11-Q-41

Job No.: 3127JC127 | Plate: A-2

The number shown in "BORING NO." refers to the approximate location of the same number indicated on the "Boring Location Diagram" as positioned in the field by measurements from existing features.

"ELEVATION" refers to ground surface elevation at the boring location established by the client.

"TYPE SIZE BORING" refers to the exploratory equipment used in the boring wherein HSA = hollow stem auger.

"N" in Blows/Foot" refers to the number of blows of a 140-pound weight, dropped 30 inches, required to advance a two-inch-outside-diameter split-barrel sampler a distance of 1 foot, Standard Penetration Test (ASTM D1586). Refusal to penetration is defined as more than 100 blows per foot.

"R" in Blows/Foot" refers to the number of blows of a 140-pound weight, dropped 30 inches, required to advance a 2.42-inch-inside-diameter ring sampler a distance of 1 foot. Refusal to penetration is considered more than 50 blows per foot.

"Sample Type" refers to the form of sample recovery, in which N = Split-barrel sample, R = Ring sample, G = Grab Sample.

"Dry Density, pcf" refers to the laboratory-determined dry density in pounds per cubic foot. The symbol "NR" indicates that no sample was recovered.

"Water Content, %" refers to the laboratory-determined moisture content in percent (ASTM D2216).

"Unified Classification" refers to the soil type as defined by "Method of Soil Classification". The soils were classified visually in the field and, where appropriate, classifications were modified by visual examination of samples in the laboratory and/or by appropriate tests.

These notes and boring logs are intended for use in conjunction with the purposes of our services defined in the text. Boring log data should not be construed as part of the construction plans nor as defining construction conditions.

Boring logs depict our interpretations of subsurface conditions at the locations and on the date(s) noted. Variations in subsurface conditions and soil characteristics may occur between borings. Groundwater levels may fluctuate due to seasonal variations and other factors.

The stratification lines shown on the boring logs represent our interpretation of the approximate boundary between soil types based upon visual field classification. The transition between materials is approximate and may be far more or less gradual than indicated.

LOWE RAILROAD EMBANKMENT I		
Boring Log Notes		
Western Technologies Inc.		
11-Q-42	Job No.: 3127JC127	Plate: A-3

DATE DRILLED: 11-25-1987

DRILL RIG TYPE: CME-55

BORING TYPE/SIZE: HSA/7"

BORING NO. 7

LOCATION: See Boring Location Diagram

ELEVATION: 5338 Feet

FIELD ENGR: S. Wood

WATER CONTENT (%)	DRY DENSITY (LBS/CU.FT)	SAMPLE TYPE	SAMPLE	BLOWS/FT. R or N	BLOWS/FT. C	DEPTH	USCS	GRAPHIC	SOIL DESCRIPTION
		G							FILL 0 TO 34.5 FEET SANDY CLAY; tan, damp to slightly damp, stiff to very stiff, some lumps of weather shale, some scattered pieces of sandstone, some gravel top 3 inches of surface, sandstone boulder 15 to 16.5 feet, brown carbonaceous shale below 29 feet.
12.8	101	R N		50/11" 49		5			
		N		54		10			
7.5	110	R N		50/8" 50/5.5"		15			
		N		50		20			
	NR	R N		50/8" 51		25			
		N		49		30			
		N		74		35			SHALE; brown to orange, slightly damp, claystone, weathered.
		N		50/4"		40			SHALE; tan, slightly damp, fine sand and claystone, moderate cementation.
						45			Auger Refusal 42 Feet
						50			
						55			
						60			

GROUNDWATER ENCOUNTERED NO: X YES:____ DEPTH:____ DATE: 11-25-1987

NOTES

LOWE RAILROAD EMBANKMENT I

Boring Log

Western Technologies Inc.

Job No.: 3127JC127 | Plate: A-4

11-Q-43

SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A IFICATION.

DATE DRILLED: 11-25-1987

DRILL RIG TYPE: CME-55

BORING TYPE/SIZE: HSA/7"

BORING NO. 8

LOCATION: See Boring Location Diagram

ELEVATION: 5338 Feet

FIELD ENGR: S. Wood

WATER CONTENT (%)	DRY DENSITY (LBS/CU.FT)	SAMPLE TYPE	SAMPLE	BLOWS/FT. R or N	BLOWS/FT. C	DEPTH	USCS	GRAPHIC	SOIL DESCRIPTION
		G							FILL 0 TO 34.5 FEET SANDY CLAY; tan, very stiff, damp to slightly damp, some pieces of weathered shale and sandstone, sandstone boulder from 7.5 to 8 feet, some gravel on surface.
10.3	111	R N		50/6" 50		5			
11.5	109	R		50/9"		10			
10.5	103	R		50/8"					
11.0	106	R N		50/6" 49		15			
		N		46		20			
		N		66		25			
6.7	107	R N		50/8" 44		30			
		N		81		35			SHALE; brown, black to orange, stiff to hard, slightly damp to damp, carbonaceous, some coal, some claystone.
		N		57		40			Auger Refusal At 41 Feet
						45			
						50			
						55			
						60			

GROUNDWATER ENCOUNTERED NO: X YES:____ DEPTH:____ DATE: 11-25-1987

NOTES

LOWE RAILROAD EMBANKMENT I

Boring Log

Western Technologies Inc.

Job No.: 3127JC127 | Plate: A-5

11-Q-44

SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A VERIFICATION.

SOIL PROPERTIES

Boring No.	Depth (ft)	Soil Class.	Soil Property		Shear Strength		Perm.	Specific Gravity	Water Soluble Matter (ppm)		Remarks
			Initial Dry Density (pcf)	Initial Water Content (%)	C (ksf)	ϕ (Deg)	K (Cm/Sec)		Salts	Sulfates	
7	9-14.5	CL	107	11.0	0.3	20					DS
8	0-20	CL	107	10.8	1.4	37					DS
8	29-31.5	CL	107	11.0	1.5	32					DS

NOTE: Initial Dry Density and Initial Water Content are in-situ values unless otherwise noted.

LEGEND
Shear Strength Test Method

DS Direct Shear
DS Direct Shear (Saturated)
UC Unconfined Compression
UU Unconsolidated Undrained
CU Consolidated Undrained w/pore pressure
CU Consolidated Undrained
CD Consolidated Drained

REMARKS
1. Compacted density (approximately 95% of ASTM D698 at moisture value slightly below optimum)
2. Visual Classification
3. Constant head
4. Falling head

LOWE RAILROAD EMBANKMENT I

Soil Properties

Western Technologies Inc.

Job No.: 3127JC127 | Plate: B-1

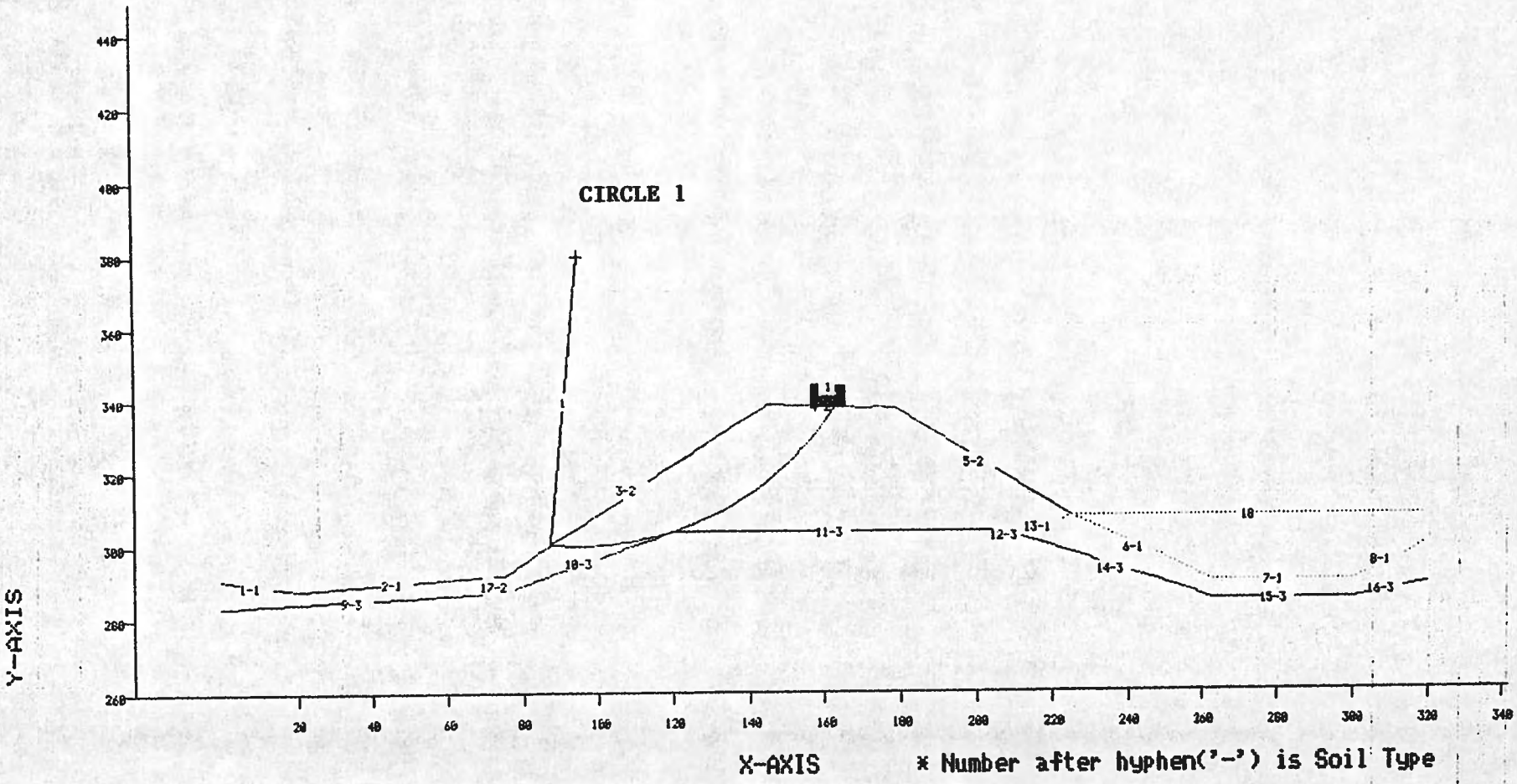
S SLOPE

Simplified Bishop Slope Stability Analysis

PROJECT: Lowe Railroad embankment I
LOCATION: Fruitland, NM
FILE: LOWEIII
COMPLETE SLOPE CROSS SECTION

SOIL*	DENSITY	COHESION	PHI
1	95.0	300.0	20.0
2	107.0	1400.0	32.0
3	110.0	10000.0	0.0

CIRCLE	X	Y	RADIUS	FS
1	95.0	380.0	80.0	3.75



* Number after hyphen('-') is Soil Type

Western Technologies Inc. - Phoenix, AZ

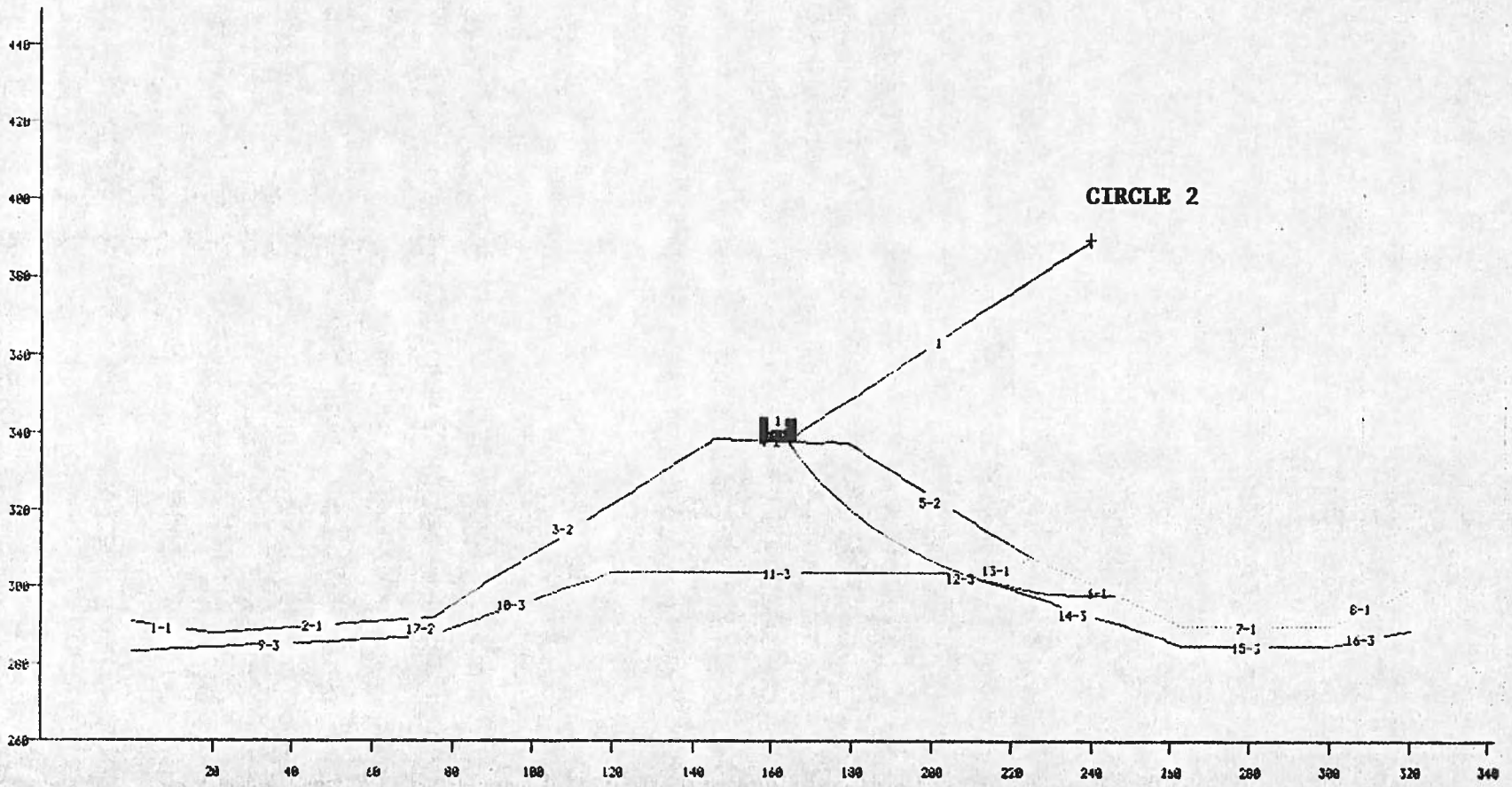
SB SLOPE

Simplified Bishop Slope Stability Analysis

PROJECT:
LOCATION: Fruitland, NM
FILE: LOWEIV
COMPLETE SLOPE CROSS SECTION

CIRCLE	X	Y	RADIUS	FS
1	240.0	390.0	92.0	3.13

SOIL*	DENSITY	COHESION	PHI
1	95.0	300.0	20.0
2	107.0	1400.0	32.0
3	110.0	10000.0	0.0



* Number after hyphen('-') is Soil Type

Western Technologies Inc. - Phoenix, AZ