AP___111____

Evaporation Pond Repairs

(2 of 2)

2017

AXIS GROUP INC.
1101 West Mineral Avenue
Suite 102
Littleton, CO 80120
Tel: (303) 332-5757
www.axisgroupinc.com

REVISED SUMMARY REPORT
EVAPORATION POND REPAIRS

Prepared for:

Western Refining Southwest, Inc.
Gallup Refinery
92 Giant Crossing Road
Gallup, NM 87301
Original Date: December 17, 2015
Revision 1 Date: February 15, 2017

TABLE OF CONTENTS

LIST OF TABLES, FIGURES and APPENDICES

TABLES

FIGURES

APPENDICES

ABBREVIATIONS AND ACRONYMS

Axis	Axis Group Inc.
cm/sec	Centimeters per Second
Facility	Western Refining Southwest, Inc. Gallup Refinery
FOS	Factor of Safety
gpm	Gallons per Minute
NMED	New Mexico Environment Department
OCD	Oil Conservation Division of the Energy, Minerals and Natural Resources Department
Ponds	Evaporation Ponds
RCRA	Resource Conservation and Recovery Act
Refinery	Western Refining Southwest, Inc., Gallup Refinery
RO	Reverse Osmosis (a treatment and filter method)
Site	Western Refining Southwest, Inc. Gallup Refinery
STP-1	Sewage Treatment Pond 1
Western	Western Refining Southwest Inc.
WWTP	Waste Water Treatment Plant

EXECUTIVE SUMMARY

Western Refining Southwest Inc. (Western) Gallup Refinery (Site) performed a significant amount of work on the evaporation pond earth berms in 2014, 2015, and 2016, and is planning additional work in 2017. Western's Summary Report, Evaporation Pond Repairs (December 17, 2015) was reviewed and comments were provided by the NMED Hazardous Waste Bureau (letter dated August 22, 2016). This report is revised to address the comments provided by the NMED and to include additional improvement work conducted in 2016 and potential future work.

Work related to the Site evaporation pond earth berms includes the following:

1. 2014 Geotechnical investigation of borrow soil;
2. 2014 Improvements to Ponds 3, 4, 5, 6, 7, 8, 9, 11, 12A, and 12B;
3. 2015 Improvements to Ponds 4, 5, 6, 7, and 8;
4. 2016 Improvements to Ponds 7 and 8, 9, 11, 12A, and 12B;
5. 2016 Improvements to the stormwater channel area proximate to Pond 6 and 9;
6. 2014, 2015, 2016 land surveying for updated topography on all pond berms;
7. 2015 Soil boring investigation in Pond 7 and Pond 8 west berm;
8. 2015 Drive point piezometers installed in Ponds 6, 7, 8, and 9;
9. 2015 Updated numerical slope stability analysis on Pond 6, 7, 8, and 9;
10. 2014 to Present: Ongoing improvements to reduce water usage;
11. 2014 to Present: Ongoing improvements to increase evaporation;
12. Ongoing improvements to Pond berms as required.

Previously in 2002, the containment earth berms were numerically evaluated for slope stability and the slopes were determined to be stable with sufficient Factors of Safety. Western updated the numerical slope stability analysis using the 2002 soil strength parameters, recent investigation data, and new berm geometry after the construction improvements in 2015. The results of the updated slope stability evaluation were included in the December 2015 Summary Report and indicated that the containment earth berms remain stable with appropriate Factors of Safety.

Western continued to improve the earth berms addressed in the 2015 numerical slope stability work that were the subject of comments by the NMED. Accordingly, revising the numerical slope stability work to address the NMED comments is not appropriate until additional work is conducted as described in Section 4 of this report. The planned additional slope stability work includes collecting updated geotechnical values, evaluating the numerical slope stability after additional soil strength parameters are obtained, and providing an updated numerical slope stability analysis in a future addendum to this revised report.

1.0 INTRODUCTION

Axis Group Inc. (Axis) prepared this revised report to summarize the repair and upgrade work conducted on the evaporation pond containment earth berms at the Western Refining Southwest, Inc. (Western) refinery in Gallup, New Mexico (Site). This report has been revised from the Summary Report submitted to the New Mexico Environment Department Hazardous Waste Bureau (NMED HWB) in December 2015. The revisions address the comments from NMED in their letter dated August 22, 2016 and include a summary of the additional improvement work conducted at the ponds during 2016.

Figure 1 illustrates the location of the Site and Figure 2 is a location map showing each of the evaporation ponds. As shown on Figure 2, the evaporation ponds lie west of the Site process areas and tank farms. In total, the evaporation ponds are approximately 110 acres in aerial extent and are numbered 2, 3, 4, 5, 6, 7, 8, 9, 11, 12A, and 12B. In this report Ponds 7 and 8 are identified as Pond 7/8.

In summary, the ponds are operated as follows:

1. Water from the Waste Water Treatment Plant (WWTP) and the nearby Pilot Travel Center enters the Sewage Treatment Pond 1 (STP 1);
2. Water is pumped from STP 1 to Pond 2;
3. A portion of the Reverse Osmosis (RO) reject water from the process units flows directly to Pond 2 with the remaining RO water being recycled to the facility cooling towers;
4. As needed, WWTP operators move water from one pond to another using siphons or temporary diesel-powered pumps;
5. Water flows in a cascade fashion from Pond 2 through Ponds 3, 4, 5, then 6;
6. Water is also pumped from Pond 2 to Pond 12B and then flows in a cascade fashion into Ponds 12A, 11, and 7/8.

2.0 WORK COMPLETED IN 2014 AND 2015

This section of the report describes the evaporation pond improvement work completed by Western during 2014 and 2015. Photographs of the work are included in Appendix A.

2.1 Summary of 2014 Berm Repair and Upgrades

During January through April 2014 and November through December 2014, Western conducted repairs and upgrades to the containment berms surrounding Ponds 3, 4, 5, 6, 7, 8, 9, 11, 12A, and 12B. These repairs and upgrades included the following:

1. Adding additional new fill material to the outside slopes and crests of the containment berms;
2. Shaping the berm slopes; and
3. Building up the berm crest height and width;

The west berm of Pond 7/8 was shaped such that the crest was widened and aligned further to the east so that the overall outer slope would be flatter and more stable.

Western's earth work contractor used on-site borrow areas for fill material (borrow locations shown on Figure 2). Fill material was excavated from the borrow areas using a track hoe and front-end loader, brought to the containment berms via off-road haul trucks, and placed using a Caterpillar D-6 dozer. The dozer was used to place, shape, and compact the fill material. Soil fill material consisted of a silty to sandy clay, similar in character to the soil that was used to construct the original earth berms.

Figures 3a, 3b, and 3c illustrate the pond limits and crest heights prior to the improvements made in 2014. Figures 4a, 4b, and 4c illustrate the pond limits and crest heights after 2014 upgrades and repairs were complete. Figure 7b provides cross sections illustrating the limits where additional fill material was placed on the pond containment berms during 2014. Photographs of the 2014 berm upgrade activities are included in Appendix A (Photos #1 through #6).

2.2 Summary of 2015 Berm Repair and Upgrades

During March through October 2015, Western continued conducting repairs and upgrades to the containment berms surrounding Ponds 4, 5, 6, and 7/8. These repairs and upgrades included the following:

1. Adding additional new fill material to the outside slopes of the containment berms;
2. Shaping the berm slopes; and
3. Building out the berm crest width;

The fill material was taken from an on-site borrow area (see Figure 2) via scraper to the berm area under construction, placed in horizontal lifts, and compacted using the scraper and a sheep-foot vibratory roller. Each soil lift was placed on a horizontal flat surface at a maximum depth of 8-inches, keyed into the existing berm slope, and compacted to a minimum of 95-percent (95%) of a standard Proctor. A motor grader shaped the slopes as they were being constructed.

Figures 5a, 5b, and 5c illustrate the pond limits and crest heights after the 2015 upgrades and repairs were complete. Figure 7b provides cross sections illustrating the limits where additional fill material was placed on the pond containment berms during 2015. Photographs of the 2015 berm upgrade activities are included in Appendix A (Photos #7 through #14).

2.3 Geotechnical Work in 2015

The following section describes the 2015 field investigation Western conducted at the Site to collect soil geotechnical material properties and determine the phreatic surface (i.e. water table surface) within the berms. To accomplish this investigation, Western drilled four soil borings along the crest of Pond 7/8 and installed 11 drive points at various locations in the Pond 6 and Pond 7/8 berms. Figure 7a illustrates the locations where soil borings and drive-point piezometers were installed.

2.3.1 Soil Geotechnical Properties

In 2015 a soil sample was collected from the on-site borrow area and analyzed for geotechnical parameters which included the following:

1. Proctor values (i.e. laboratory maximum compaction and optimum water content);
2. Classification;
3. Sieve analysis (i.e. particle size gradation);
4. Field density and moisture content tests;
5. Permeability via flex-wall permeameter;

The on-site borrow soil that was used to repair and improve the earth berms is classified as a silty to sandy clay. Based on a flex-wall permeameter test, soil permeability for the borrow material is 1.9 X 10^{-7} cm/sec. Appendix B contains the laboratory results of the geotechnical tests conducted on the soil borrow material.

2.3.2 Pond 7/8 West Berm Soil Borings

Western installed four soil borings along the west berm of Pond 7/8 as shown on Figure 7a and the boring logs in Appendix D. The borings were conducted to visually examine the berm soil at various depths, collect soil samples for potential geotechnical analysis, and to locate the phreatic surface within the earth berm (if present).

Characterization soil samples collected from the soil borings indicated a relatively uniform soil material (i.e. no significant changes in soil type) within each boring from the crest down to the final boring depth. The berm fill soil was characterized as moist red silt and clay. The native material was encountered around 12 feet deep and was characterized as lenses of gray fine sand overlaying a stiff wet red clay. Boring logs for these four soil borings are included in Appendix D.

Western evaluated and compared some historical borings advanced in December 2000 to the borings advanced 2015. During the December 2000 boring program (Appendix C), 3 borings were installed on the Pond 7/8 west berm. The borings showed moist soil at depths ranging from 1 to 5 feet to final depth. None of the borings advanced in Pond 7/8 during 2000 indicated wet soil or water.

During the October 2015 boring program, the four borings indicated moist soil (indicative of the phreatic surface) at depths between 4 to 5 feet below the crest. Wet soil was observed at the berm fill/ native soil interface in three of the four borings. Appendix D contains the logs for each boring in Pond 7/8.

Soil classifications in the December 2000 Pond 7/8 boring logs correspond to classifications in the October 2015 boring logs. The sandy layer encountered and described on the 2015 boring logs SB-8N and SB-8S, is at a depth of 11.5 to 12 feet below the current crest elevation. This depth is consistent with the interface transition from berm fill material to native soil.

2.3.3 Temporary Drive Point Piezometers

In order to determine the phreatic surface within the Pond 6 and Pond 7/8 berms in 2015, Western installed 11 temporary drive-point piezometers at locations shown on Figure 7a.

Water levels (if present) were measured in the drive-point piezometers on three separate occasions since their installation. The water level data is shown on the piezometer logs in Appendix E. The drive-point piezometer logs also illustrate the phreatic surface. The depth to moist soil in the October 2015 borings is similar to the depth of water in the nearest piezometer (4-feet to moist soil in the boring versus 6.33-feet to water in the piezometer). The water level collected from the piezometer reading was used to model the phreatic surface during the slope stability modeling, as the water elevation in the pond was deeper than the elevation where the moist soil was encountered.

Note that piezometers installed at the toe of the berm slopes had screens that were close to the ground surface and therefore influenced by precipitation infiltration. Where precipitation infiltration was noted, the water level in that piezometer was not used for berm evaluation work.

The temporary drive-point piezometers installed in the Pond 7/8 berms were abandoned during the ongoing berm improvement activities which continued into 2016. Western will install new piezometers with casings that preclude surface water infiltration into the piezometers. A proposed piezometer installation and monitoring schedule is provided in Section 4.3 of this report. Piezometer water level data will be collected monthly for three months and the data will be provided in the annual Facility-Wide Groundwater Report.

3.0 WORK COMPLETED IN 2016

This section of the report describes the evaporation pond improvement work completed by Western during 2016. Figures 6a, 6b, and 6c illustrate the pond limits and crest heights after the 2016 upgrades and repairs were complete. Photographs of the work are included in Appendix A. The 2016 repairs and upgrades included the following:

1. Reworked and repaired the outer berms surrounding Ponds 11, 12A, and 12B;
2. Improved the Pond 9 north berm;
3. Regraded the stormwater drainage channel between Pond 6 and Pond 9;
4. Added fill material to buttress the Pond 7/8 west berm;

3.1 Ponds 11, 12A, and 12B Outer Berms

In 2016, Western reworked and repaired the soil material of the outer containment berms around Ponds 11, 12A, and 12B. During routine pond inspections, Western noted that soils in the upper two to three feet of the Pond 11, 12A, and 12B outer berms needed to be repaired. Figure 6a illustrates the 2016 repair work limits for Pond 11, 12A and 12B berms. Photographs of this work are included in Appendix A.

The 2016 repair work of the Pond 11, 12A, and 12B berms began by stripping vegetation from the upper three-feet of the berms. From stations 36+00 to 28+00 and 20+00 to 0+00, the upper 3 feet of soil was scraped from the berms and stockpiled at the toe of the slope where it was reworked and cleaned of any large pieces of wood or rocks. This reworked soil was then replaced on the outer slopes of the berms to flatten the outer slope. From stations 28+00 to 20+00, the upper 3 feet of soil was removed and placed in the nearby borrow area for future use. The removed soil could not be cast to the outer slope in this area as the berm is too close to the existing Land Treatment Unit.

Clay soil from the on-site borrow area was then used to rebuild the upper three feet of the berms to their original crest elevations. Prior to placing the first lift, the berm soil was scarified as appropriate, wetted, and then the borrow soil was placed in horizontal layers up to 8-inches thick. Each lift was moisture conditioned and compacted to a minimum of 95-percent (95%) of a standard Proctor as outlined in the specifications. The outer slopes were then graded meet the final design grades resulting in compacted and flatter outer slopes.

3.2 Pond 7/8 Berms

In 2016, Western improved the Pond 7/8 berms from Station 68+95 to Station 41+00 by adding fill material to buttress the outer slopes of the south and west berms. Figure 6a illustrates the 2016 repair work limits for Pond 7/8 berms. Photographs of this work are included in Appendix A.

Prior to beginning the improvement work, the west property line fence was temporarily removed and relocated to allow for construction vehicle access along the base of Pond 7/8 west berm. The construction area along the base of the Pond 7/8 outer slope was graded flat, scarified, and compacted.

Geotextile fabric was then placed onto the prepared surface as outlined in the design documents. Clay borrow soil was then placed in a horizontal layer on the geotextile fabric and compacted. These soils were placed in maximum of 8-inch lifts which were keyed into the existing berm slope and compacted as outlined in the project specifications.

Soil placement in uniform lifts continued until the outer slope was over-built and then graded back to the design grades. When completed, the toe of the outer slope was located adjacent to the west property boundary line. Once the berm improvement work was complete, the fence was relocated back to the property line and the disturbed area was restored by with seed and mulch.

3.3 Pond 9 North Berm

In 2016, the Pond 9 north berm was improved between Station 15+00 and Station 36+00. Figure 6c illustrates the work limits for Pond 9 completed in 2016. Photographs of this work are included in Appendix A.

Prior to beginning the improvement work, the existing power lines were removed from the toe of the Pond 9 outer north berm. Once the power lines were removed, the power poles were cut off at the base and removed. The power poles were not dug out to avoid disturbing the soil at the toe of the berm.

Once the area was cleared for improvements, soil deemed unacceptable to use as a base material was excavated and removed from the toe of the Pond 9 north berm outer slope. This material was placed on the inside slope of Pond 9 north berm and compacted. Once the soil was removed from the toe of the outer slope, the area was graded flat and geotextile fabric was placed on the prepared surface as outlined in the design documents.

Clay borrow soil was then placed in a horizontal layer on the geotextile fabric and compacted. These soils were placed in a maximum of 8-inch lifts which were keyed into the existing berm slope and compacted as outlined in the project specifications.

Soil was placed in uniform lifts and continued until the outer slope was graded to meet the original design grades.

3.4 Stormwater Channel Improvements

Non-contact stormwater is directed from the Site areas westward to the drainage channel between Pond 6 and Pond 9. From here, the non-contact stormwater collects at retention ponds located west of Pond 6 and south of Pond 7/8.

The stormwater channel between Pond 6 and Pond 9 was improved during the Pond 9 north berm work described in the previous section and shown on Figures 6b and 6c. Non-contact stormwater flow is directed into the improved channel which is sloped to drain to the west side of Pond 6.

During slope improvement work on the Pond 7/8 south berm, soil was placed between about Station 46+00 to about Station 49+00 south of the toe of the south berm. This strip of soil will act as a buffer and deter erosion between the existing stormwater detention basin and the toe of Pond 7/8 south berm.

4.0 SLOPE STABILITY ANALYSIS

The following sections describe the previous and planned numerical slope stability work for the evaporation pond berms. Based on the uniform soil and earth berm construction, the previous numerical slope stability analysis used an arc slip-type slope stability evaluation (versus block or other type of failure analysis). The resulting calculated Factor of Safety values were all greater than 1.0 in every analysis, indicating that the evaluated slopes are stable.

4.1 2002 Geotechnical and Slope Stability Analysis

In 2002, Precision Engineering, Inc. completed a geotechnical investigation as part of a slope stability analysis for the evaporation pond berms. The investigation included 10 soil borings and 7 Dutch Cone soundings. Soil samples and Shelby Tube samples were also collected from various strata throughout the investigation. Soil geotechnical properties derived from those samples (e.g. triaxial shear strength, cohesion, internal angle of friction, and unit weights) were used for the slope stability analysis.

A total of 13 cross-sections were evaluated for the 2002 slope stability analysis resulting in a Factor of Safety ranging from 2.5 to 10. A summary of the 2002 soil geotechnical properties are included in Table 1. Table 2 summarizes the results from the 2002 slope stability analysis. A copy of the Precision Engineering Inc. report is included in Appendix C.

The soil strength parameters used in the numerical analysis included the total stress parameters for cohesion (c) and the angle of internal friction, phi (Ø). It is recognized that total stress strength parameters are appropriate for numerical slope stability analysis for end-of-construction analysis and for partially saturated soil. Based on historical and current soil borings, the soil in the berms is best categorized as partially saturated and therefore, the analysis method is considered appropriate.

4.2 Planned Slope Stability Investigation

In the original Summary Report, Evaporation Pond Repairs (December 2015), Western updated the 2002 numerical slope stability analysis. For completeness, the slope stability work is now provided in Appendix F of this Revised Summary Report, Evaporation Pond Repairs. Since the slopes on several evaporation ponds have already been changed, no adjustments to the 2015 updated numerical slope stability analysis have been made. Changes to the numerical slope stability analysis will be made after additional soil properties have been obtained as described below.

As described in Section 3 of this report, Western continued improving the earth berms in 2016 for evaporation ponds 7/8, 9, 11, 12A, 12B, and the stormwater channel between Pond 6 and Pond 9. During this work, the temporary drive-point piezometers installed to provide initial phreatic surface water levels in the earth berms, were abandoned. Additionally, the outer slopes of the evaporation ponds identified above have been significantly improved. Accordingly, the numerical slope stability work provided in 2015 will be updated with the current topography and updated phreatic water surface.

The NMED comments on the 2015 updated slope stability analysis indicated that effective stress strength parameters should be used to evaluate the effects of additional fill material on the outer slopes. NMED also indicated that more permanent piezometers should be installed in the outer downstream slopes of the berms.

Western intends to install new piezometers in the outer slopes of the earth berms along cross-sections that will be used in an updated numerical slope stability analysis. The new piezometers will be installed in borings with casings and bentonite seals above the screen interval to prevent surface water intrusion and interference. Piezometers will be installed in borings at selected cross-sections in the following earth berms:

- Pond 7/8 west berm
- Pond 6 west berm
- Pond 9 north berm

The water levels will be recorded monthly and when stable (likely 3 months), the water levels will be incorporated into the updated numerical slope stability analysis. Afterward, the water levels in the piezometers will be measured as appropriate and the water level data reported in the Facility Wide Groundwater Report.

Due to access constraints on the outer slopes, the borings for the piezometers will likely be hand-augured at each location. Soil samples will be collected using a hand-drive sampler as needed in the hand-auger borings.

The hand-auger will be used to advance a 4-inch diameter hole to depths required to install the new piezometer and collect the soil samples. The hand-drive sampler has a barrel that holds brass sleeves for the soil samples. The barrel is driven into the soil and then retrieved.

The brass liners are extracted from the barrel, sealed using Teflon™ patches, plastic caps, and tape. Each sleeve will be sealed in the field, labeled as required, and provided to a geotechnical laboratory for analysis. Soil analysis is expected to include:

- Soil characterization and classification
- West and dry unit weights with moisture content
- Atterberg Limits
- Sieve analysis
- Effective stress strength parameters (c’ and Ø’) from a triaxial sheer test

The soil data collected from this investigation will be used to update the numerical slope stability analysis. The cross-sections used in the 2002 and 2015 slope stability work will be used in the updated slope stability evaluation, with minor adjustments to the locations to evaluate the critical cross section. The following will be incorporated into the updated slope stability evaluation:

- Morgenstern Price limit-equilibrium analysis via GeoStudio 2012;
- Updated berm topography at slope stability cross-sections;
- Updated phreatic surface based on newly installed piezometers;
- Soil properties confirmed during the new geotechnical investigation; and
- Effective stress soil strength parameters cohesion (c) and angle of internal friction, phi (Ø).

The results will be prepared and submitted as an addendum to this report. The results will include the following:

- Description of the updated geotechnical parameters;
- Figure identifying the location of the geotechnical samples;
- Description of the slope stability work;
- Discussion of the phreatic surface and its potential affect on slope stability;
- Graphical output from the slope stability program; and
- Tabulated factor of safety for each critical cross-section.

4.3 Proposed Work Schedule

Western intends to install the new piezometers in the appropriate locations by the end of Q4 2017. Once the geotechnical report is available with the updated soil data described above, Western will prepare a revised numerical slope stability analysis. Western expects this work to be complete by the end of Q2 2018 and an addendum report prepared and submitted by the end of Q3 2018.

5.0 ONGOING IMPROVEMENT WORK

5.1 Water Use Reduction

Western is continually improving operations at the evaporation ponds. For example, Western has implemented several water saving measures at the process units to minimize the amount of water being routed to the evaporation ponds. As of November 2015, the flow rate of water to the evaporation ponds is approximately 150 gpm, down from the previous average of 340 gpm.

Part of the work included minimizing the reverse osmosis (RO) reject water flow to Pond 2. The majority of RO water is now directed to the cooling towers with the net effect of minimizing RO reject water to Pond 2.

5.2 Additional Evaporation

In 2014, Western added two additional evaporation blowers to improve evaporation rates at the ponds. As shown on Figure 2, two blower units are located on the west berm of Pond 2 and the two newer blower units are located on the west berm of Pond 3.

The evaporation blowers operate continuously during the peak evaporation season (about April through October) except when they are shut down for maintenance purposes or when the temperature makes evaporation inefficient. Western is internally evaluating additional improvements to enhance evaporation at the ponds.

TABLES

Table 1: Summary of Triaxial Shear Results 2002 Investigation

Sample #	Boring	Depth	phi (degrees)	Cohesion (psi)	Unit Weight (pcf)	Description
Shallow Sample Results						
38631	2	5-7	10	5	137.3	Pond 7 West berm
38640	8	5-7	2	6	140.1	Pond 9 Southwest berm
38645	9	5-7	8	5	137.4	Pond 6 South berm
38650	10	5-7	7	5.5	139.5	Pond 6 West berm
Native Ground Sample Results						
38641	8	10-12	0	8	141.3	Pond 9 Southwest berm
38647	9	15-16	0	7	138.9	Pond 6 South berm
38648	9	16-17	2	2	139.9	Pond 6 South berm
38652	10	15-17	0	4	141.4	Pond 6 West berm

Notes:
Results from Precision Engineering investigation 2002.

Table 2: Previous Slope Stability Summary

Section	Location	Height	Width	Freeboard	Factor of Safety FOS
1	9-SW	5	11	2.5	5.5
2	9-W	4	8	2.2	10.0
3	6-SW	7.6	10	2.2	3.0
4	6-W	7.6	10	2.2	3.0
5	*N/A**	4.2	10	0.9	6.2
6	9-N	5.5	7	1	10.0
7	8-W	7.3	16	1	6.0
8	7-W	7.3	12	2.7	4.9
9	7-W	5.5	12	2.6	7.0
10	11-E	3.9	12	3	10.0
11	12A-S	5	10	2	9.4
12	8-S	8.6	9	3	2.5
13	3-N	4	6	1	5.4

Notes:

Summary of Results from Precision Engineering 2002 report.

* Section not shown on figure in Precision Engineering 2002 report. Location unknown.

Table 3: Summary of 2015 Slope Stability Analysis

Berm	FOS before repair work	FOS after repair work	Factor of Safety remodeled cross section
Pond 6 North	4.3	4.6	
Pond 6 West	4.2	4.5	
Pond 7 West	4	N/A[1]	
Pond 8 North	4.1	4.6	
Pond 9 North	6.8	7.1	9.3 [2]

Notes:

1. No change in berm conditions.
2. Used inputs from Precision 2002 stability analysis of the same section in the current modeling software.

FIGURES

LOCATION MAP
N.T.S.

INDEX OF DRAWINGS:

Figure No.	Title
1	SITE LOCATION COVER SHEET
2	POND LOCATION MAP
3a	PRE-2014 TOPOGRAPHY (NORTH PONDS)
3b	PRE-2014 TOPOGRAPHY (SOUTH PONDS)
3c	PRE-2014 TOPOGRAPHY (POND 9)
4a	2014 POND UPGRADES AND REPAIRS (NORTH PONDS)
4b	2014 POND UPGRADES AND REPAIRS (SOUTH PONDS)
4c	2014 POND UPGRADES AND REPAIRS (POND 9)
5a	2015 POND UPGRADES AND REPAIRS (NORTH PONDS)
5b	2015 POND UPGRADES AND REPAIRS (SOUTH PONDS)
6a	PIEZOMETER AND SLOPE STABILITY SECTION LOCATIONS
6b	POND BERM CROSS SECTIONS
7	ONGOING REPAIR (POND 9)
8	ONGOING REPAIR (PONDS 11, 12a, 12b)

VICINITY MAP
1" = 600'

WESTERN REFINING SOUTHWEST INC.
EVAPORATION POND UPGRADES
GALLUP REFINERY, NEW MEXICO

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.
1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

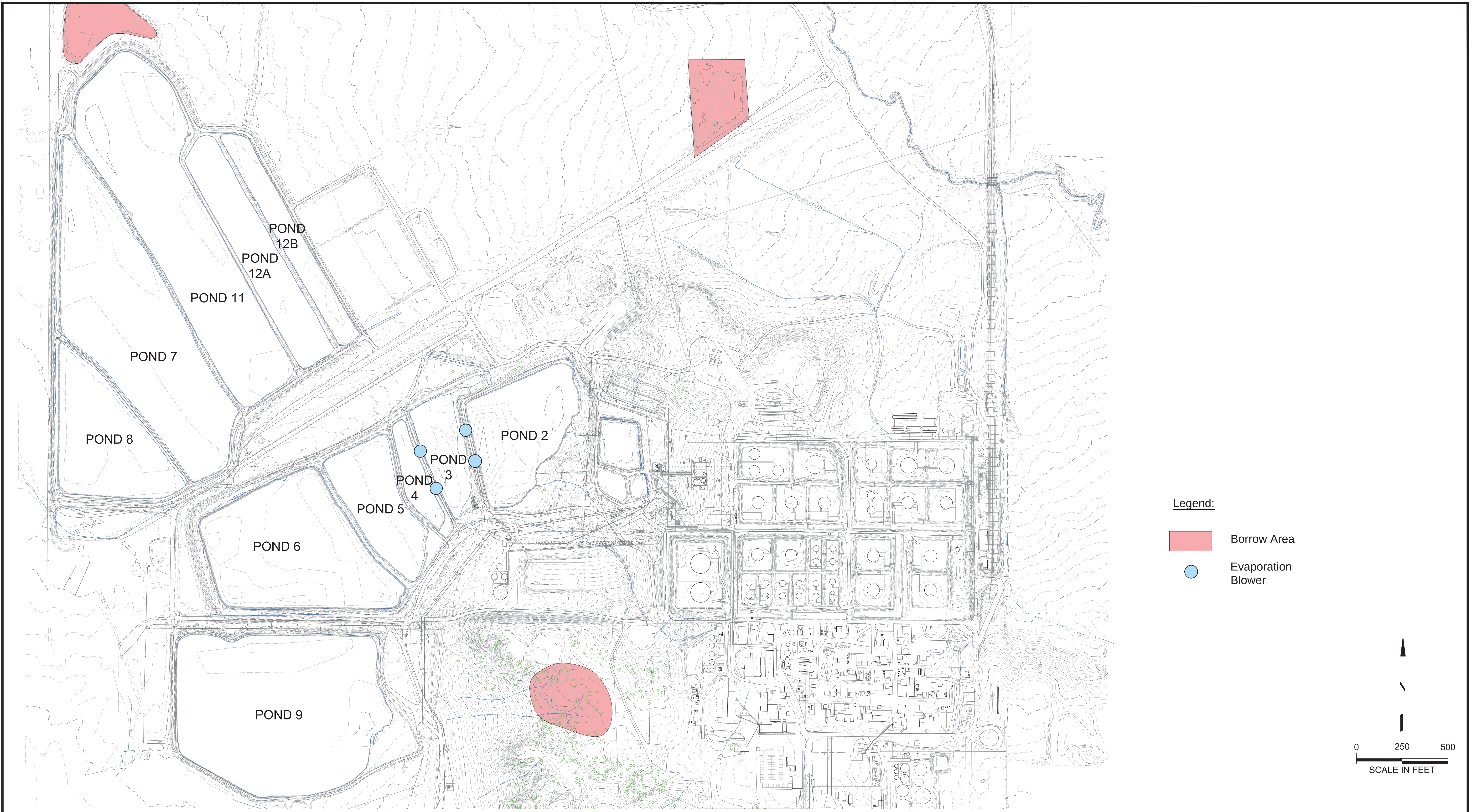
PROJ. NO.: 15-112 | DATE: 11-06-2015 | DRAWN BY: JAY | CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

EVAPORATION PONDS UPGRADE
SITE LOCATION COVER SHEET

DRAWING NO.:
1

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 1 - Cover Sheet.dwg ELundborg Plotted: Dec 17, 2015 - 9:02am



Legend:	
🟥	Borrow Area
○	Evaporation Blower

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 2 - Pond Location Map.dwg ELundborg Plotted: Dec 17, 2015 - 9:08am

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.
1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

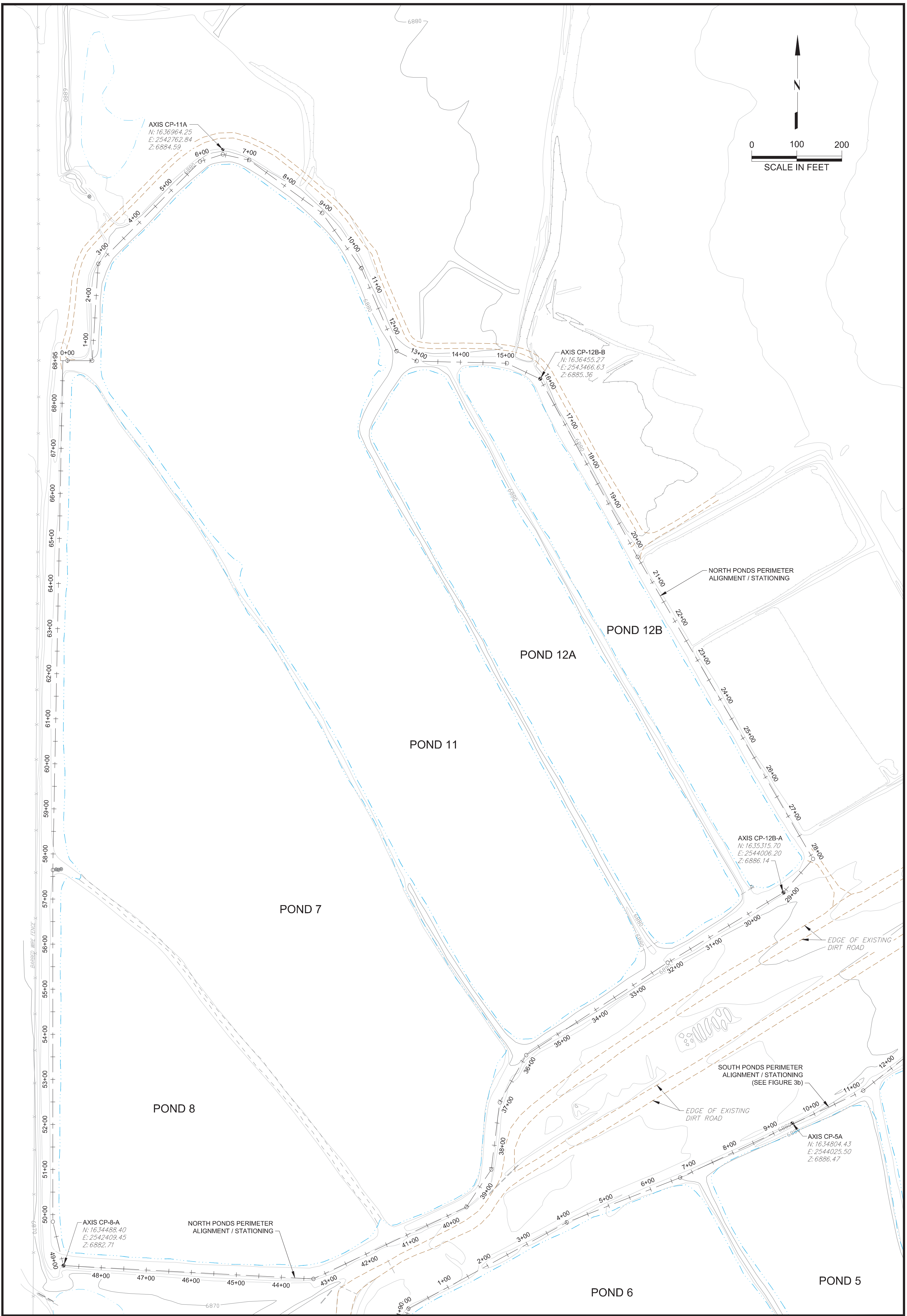
PROJ. NO.: 15-112
DATE: 11-06-2015
DRAWN BY: JAY
CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

POND LOCATION MAP

DRAWING NO.:

2



SEE FIGURE 3b

THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

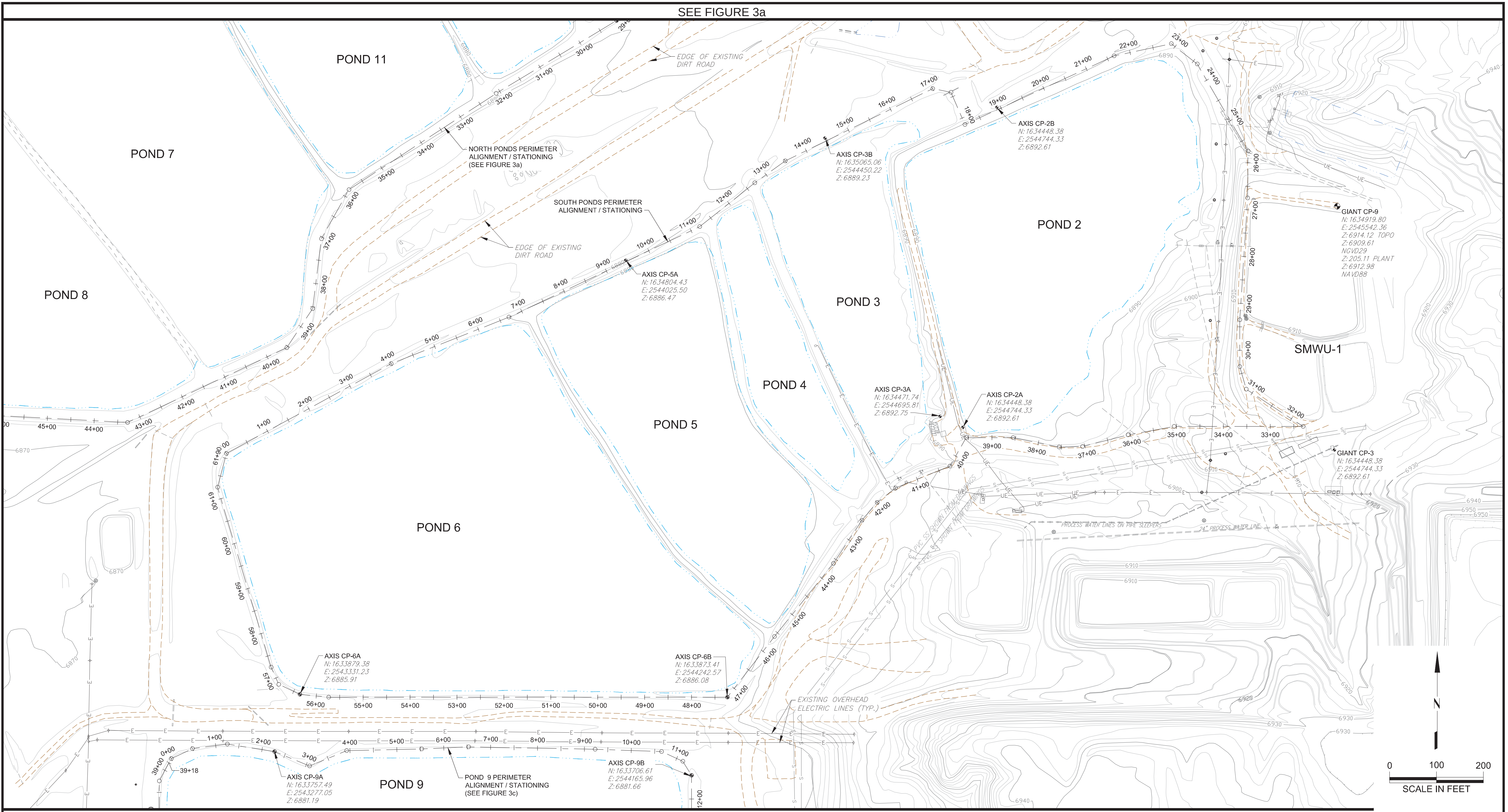
PRE-2014 TOPOGRAPHY
NORTH PONDS

DRAWING NO.: 3a

PROJ. NO.: 15-112
DATE: 11-20-2015
DRAWN BY: JAY
CHECKED BY: JWB

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 3a - 2010 Existing Berms.dwg ELundborg Plotted: Dec 17, 2015 - 9:21am

SEE FIGURE 3a



SEE FIGURE 3c

THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.
1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

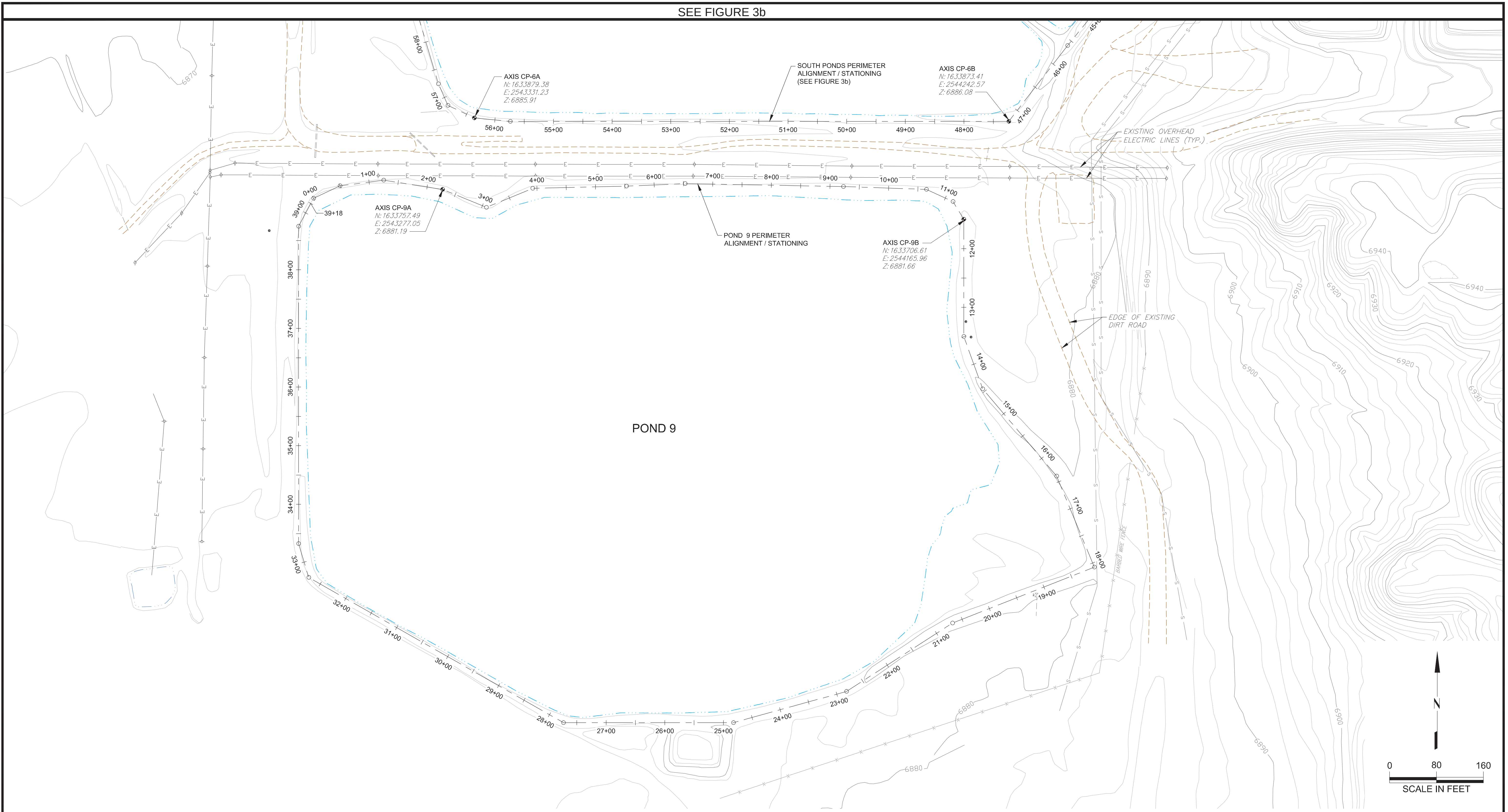
PROJ. NO.: 15-112 | DATE: 11-06-2015 | DRAWN BY: JAY | CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

PRE-2014 TOPOGRAPHY
SOUTH PONDS

DRAWING NO.:
3b

X:\15-112 – WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 3b-3c – 2010 Existing Berms.dwg ELundborg Plotted: Dec 17, 2015 – 9:29am



THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

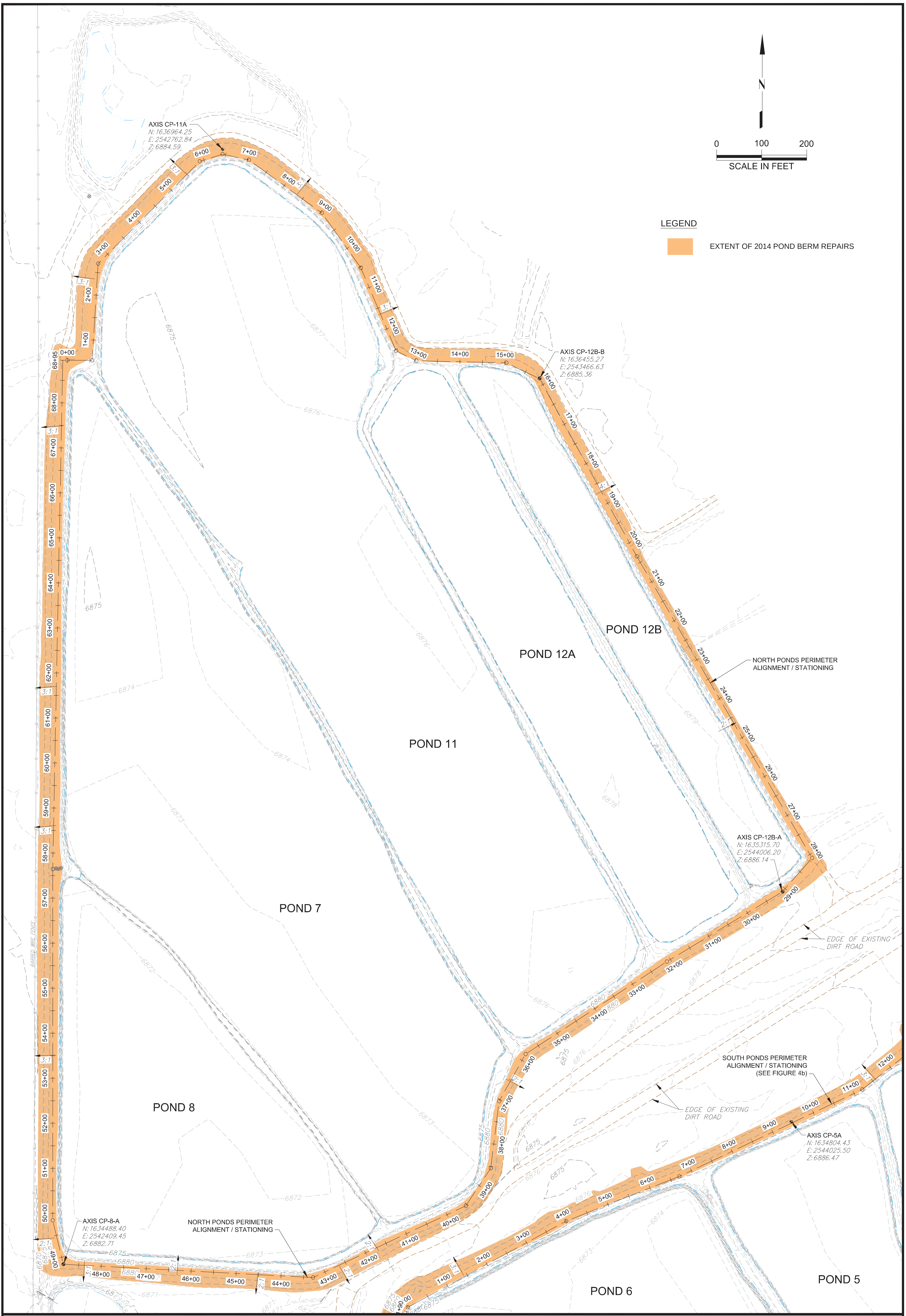
PROJ. NO.: 15-112
DATE: 11-06-2015
DRAWN BY: JAY
CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

PRE-2014 TOPOGRAPHY
POND 9

DRAWING NO.: 3c

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 3b-3c - 2010 Existing Berms.dwg ELundborg Plotted: Dec 17, 2015 - 9:28am



SEE FIGURE 4b

THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

PROJ. NO.: 15-112	DATE: 11-06-2015	DRAWN BY: JAY	CHECKED BY: JWB

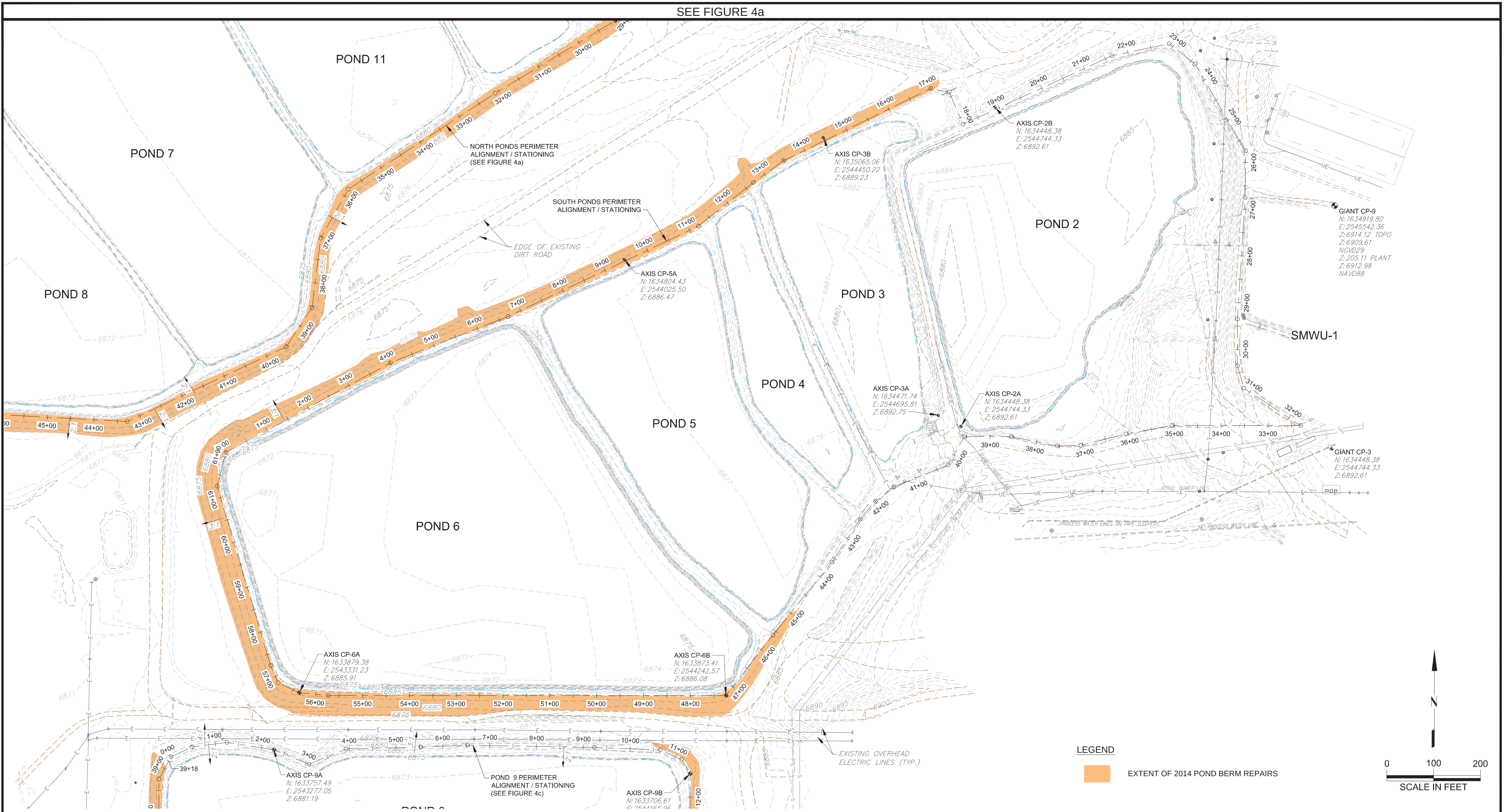
WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2014 POND UPGRADES AND REPAIRS
NORTH PONDS

DRAWING NO.:
4a

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 4a - 2013 Berm Repairs.dwg ELundborg Plotted: Dec 17, 2015 - 9:31am

SEE FIGURE 4a



SEE FIGURE 4c

THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

PROJ. NO.: 15-112
DATE: 11-06-2015
DRAWN BY: JAY
CHECKED BY: JWB

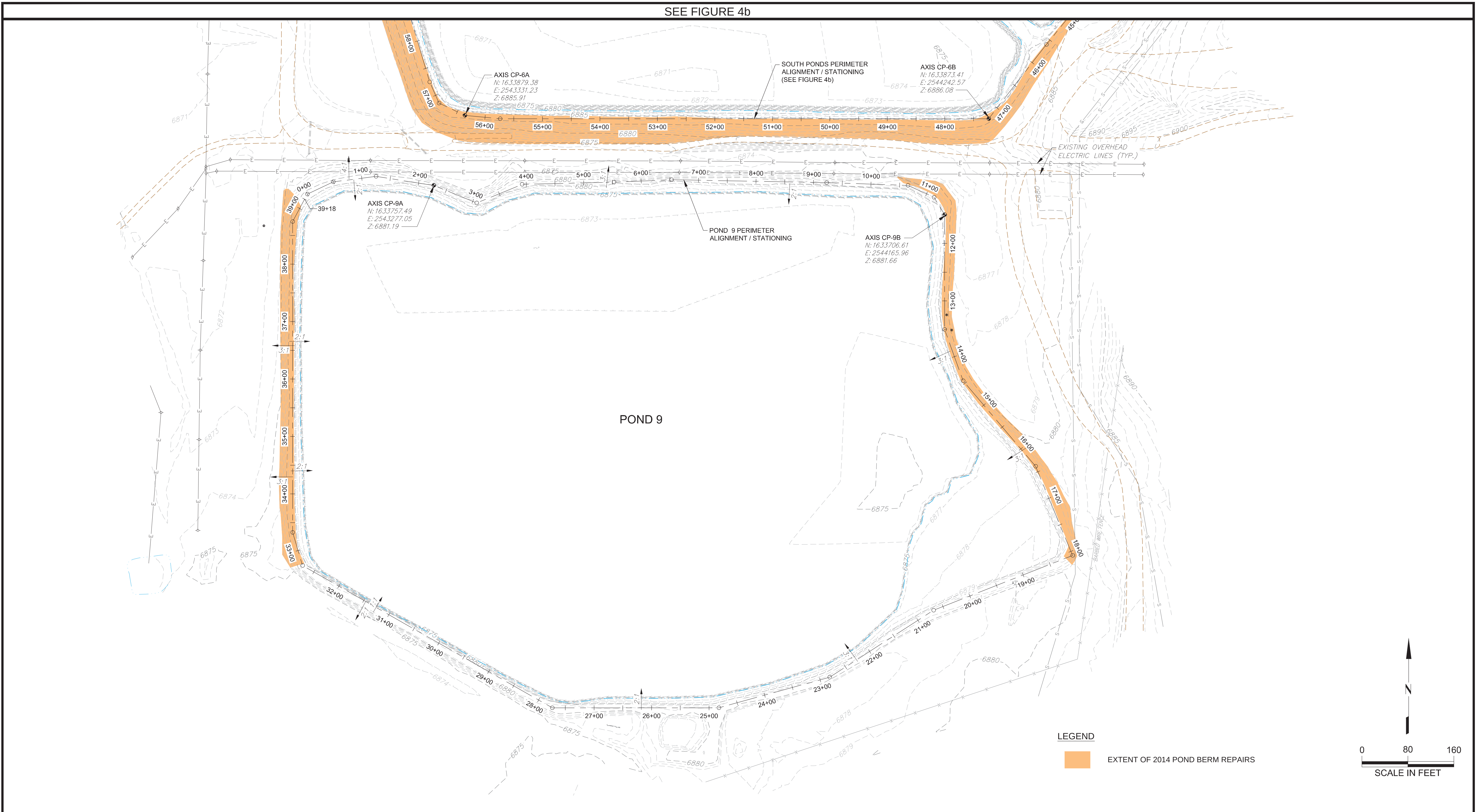
WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2014 POND UPGRADES & REPAIRS
SOUTH PONDS

DRAWING NO.:
4b

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 4b-4c - 2013 Berm Repairs.dwg ELundborg Plotted: Dec 17, 2015 - 9:33am

SEE FIGURE 4b



NO.	BY	DATE:	REVISION

AXIS GROUP Inc.

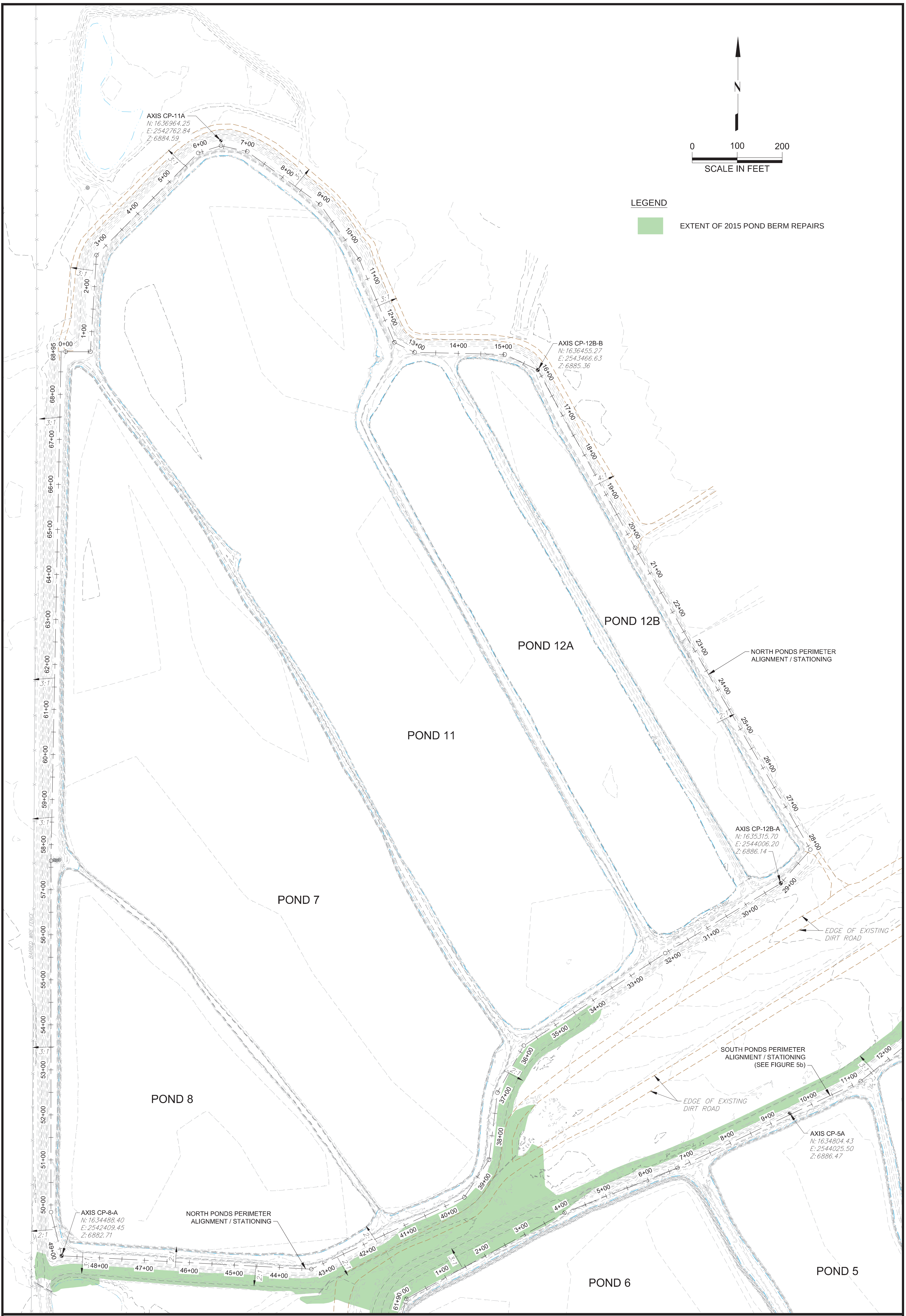
1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

PROJ. NO.: 15-112 | DATE: 11-06-2015 | DRAWN BY: JAY | CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2014 POND UPGRADES & REPAIRS
POND 9

DRAWING NO.:
4c



SEE FIGURE 5b

THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

PROJ. NO.: 15-112	DATE: 11-06-2015	DRAWN BY: JAY	CHECKED BY: JWB

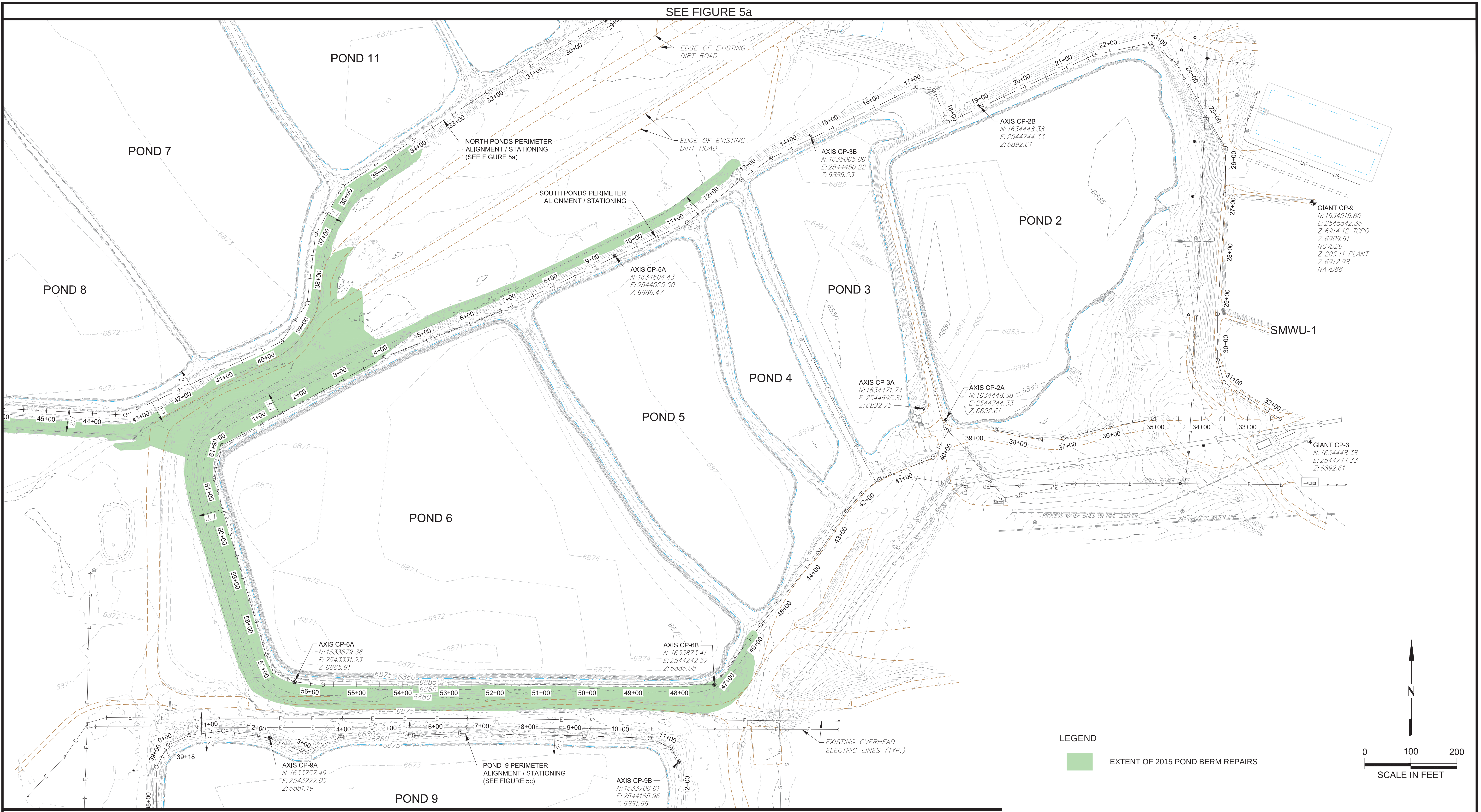
WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2015 POND UPGRADES & REPAIRS
NORTH PONDS

DRAWING NO.:
5a

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 5a - 2015 Berm Repairs.dwg ELundborg Plotted: Dec 17, 2015 - 9:36am

SEE FIGURE 5a



SEE FIGURE 5c

THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

PROJ. NO.: 15-112
DATE: 11-06-2015
DRAWN BY: JAY
CHECKED BY: JWB

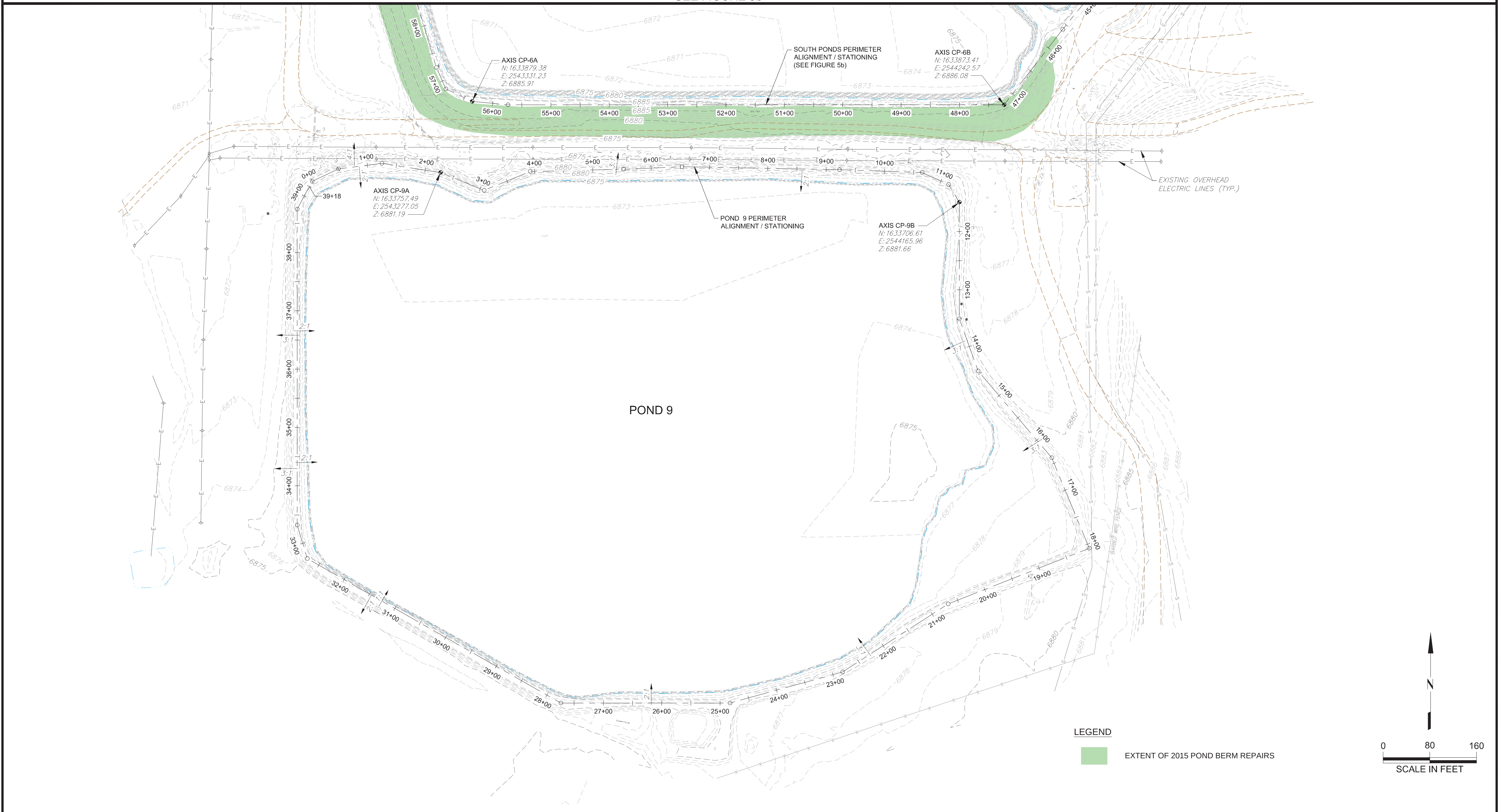
WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2015 POND UPGRADES & REPAIRS
SOUTH PONDS

DRAWING NO.: 5b

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 5b-5c - 2015 Berm Repairs.dwg ELundborg Plotted: Dec 17, 2015 - 9:39am

SEE FIGURE 5b



LEGEND

🟩 EXTENT OF 2015 POND BERM REPAIRS

THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.
1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

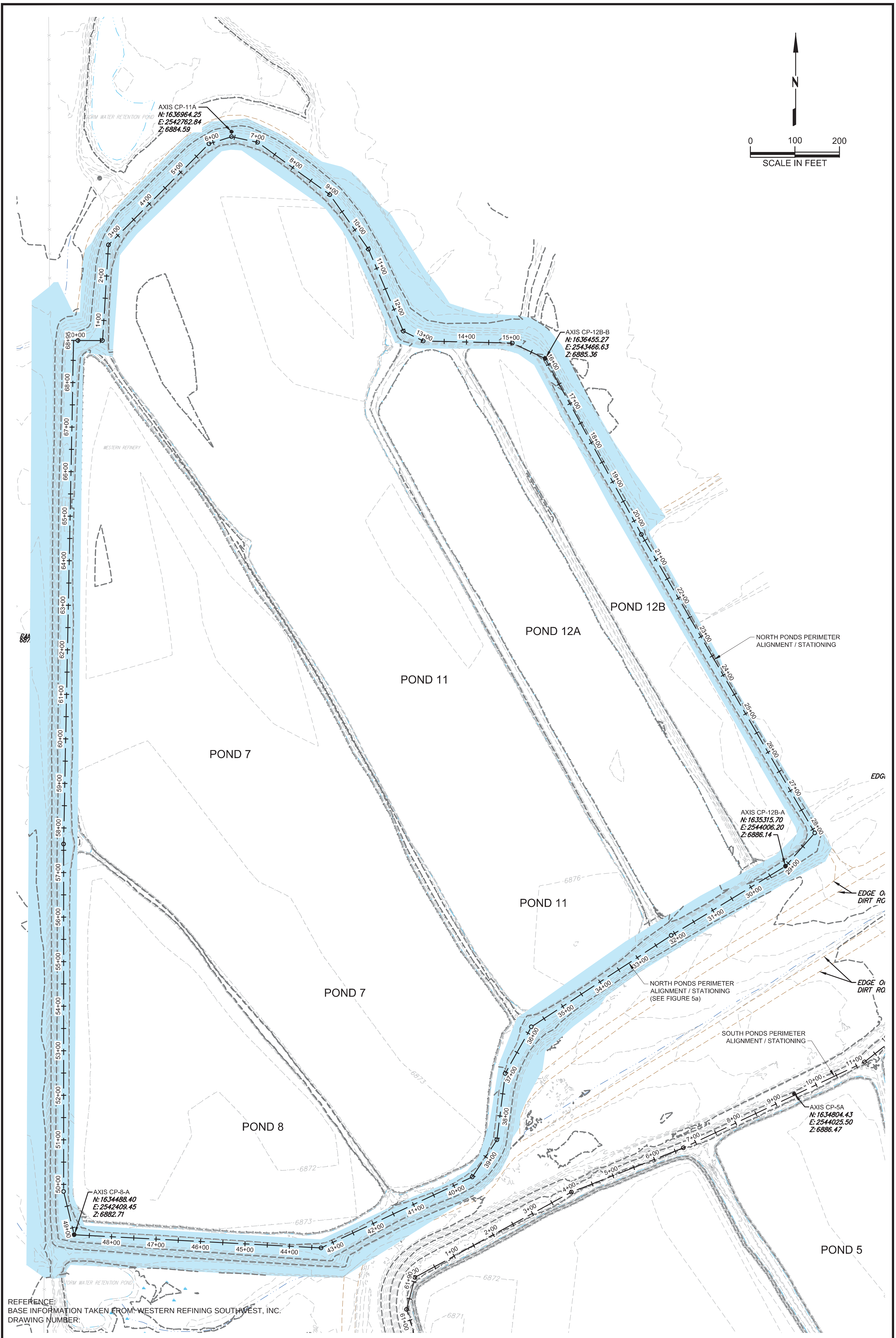
PROJ. NO.: 15-112
DATE: 11-06-2015
DRAWN BY: JAY
CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2015 POND UPGRADES & REPAIRS
POND 9

DRAWING NO.:
5c

X:\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 5b-5c - 2015 Berm Repairs.dwg ELundborg Plotted: Dec 17, 2015 - 9:39am



REFERENCE:
BASE INFORMATION TAKEN FROM: WESTERN REFINING SOUTHWEST, INC.
DRAWING NUMBER:

\\dov.syncedtool.com@SSL\DavWWWRoot\Drawings\15-112 – WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 5b–5c – 2016 Berm Repairs.dwg ELundborg Plotted: Feb 15, 2017 – 7:18pm

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

PROJ. NO.: 15-112	DATE: 11-06-2015	DRAWN BY: JAY	CHECKED BY: JWB

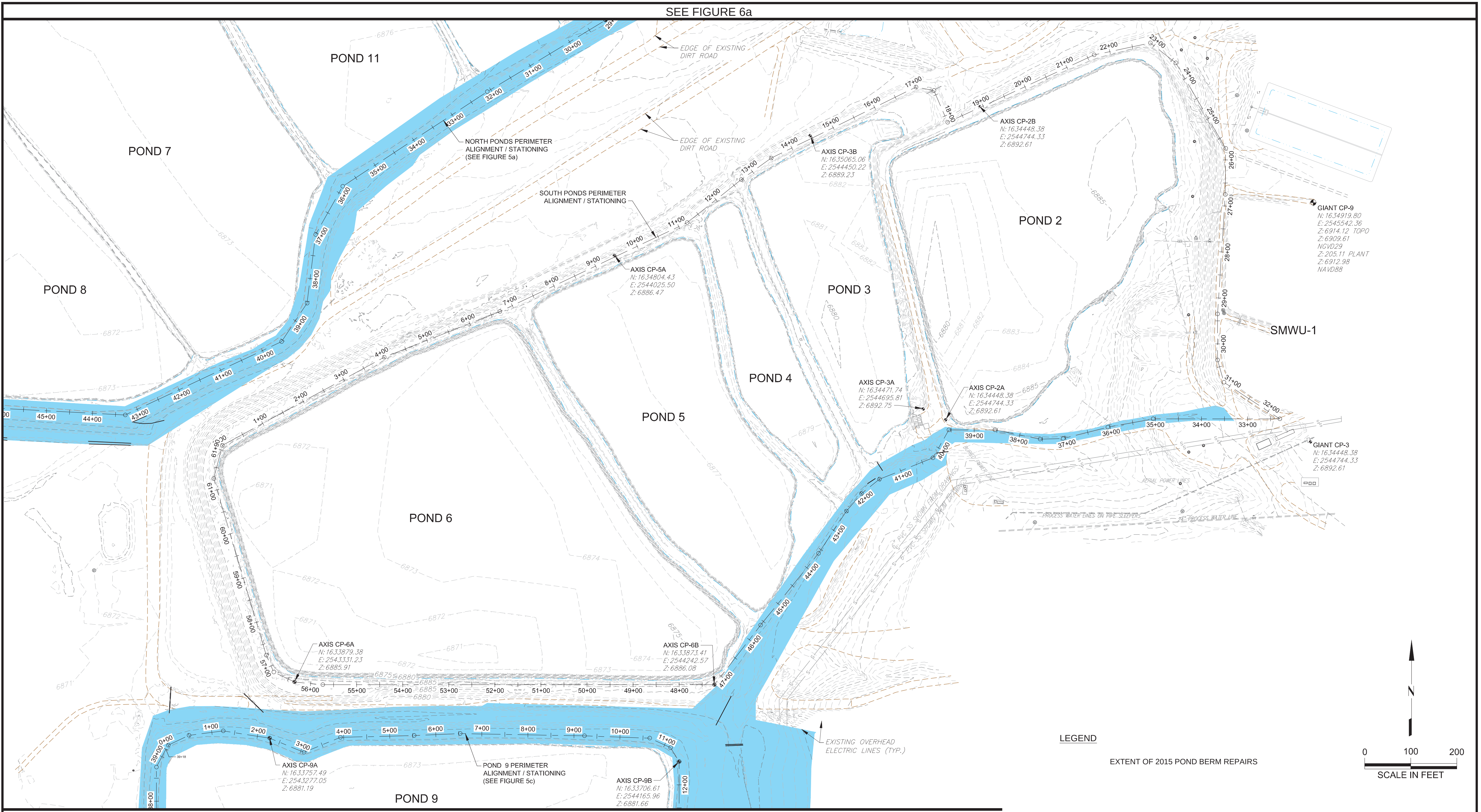
WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2016 POND UPGRADES & REPAIRS
NORTH PONDS

DRAWING NO.:

6a

SEE FIGURE 6a



SEE FIGURE 6c

\\dav.syncedtool.com@SSL\DavWWWRoot\Drawings\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 5b-5c - 2016 Berm Repairs.dwg ELundborg Plotted: Feb 15, 2017 - 7:15pm

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.
1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

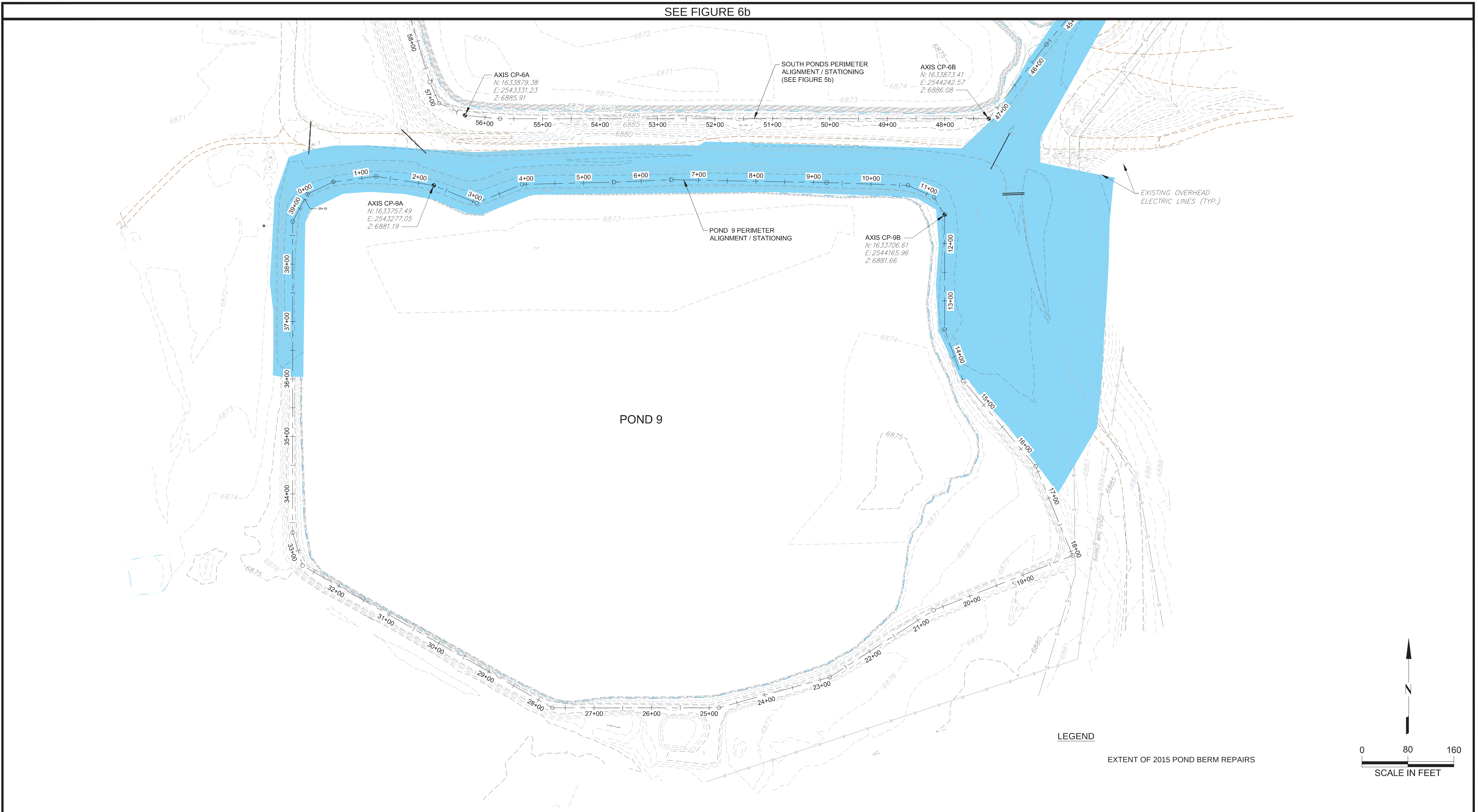
PROJ. NO.: 15-112
DATE: 2-7-2017
DRAWN BY: JAY
CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2016 POND UPGRADES & REPAIRS
SOUTH PONDS

DRAWING NO.:
6b

SEE FIGURE 6b



THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

\\dav.syncedtool.com@SSL\DavWWWRoot\Drawings\15-112 – WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 5b-5c – 2016 Berm Repairs.dwg ELundborg Plotted: Feb 15, 2017 – 7:13pm

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

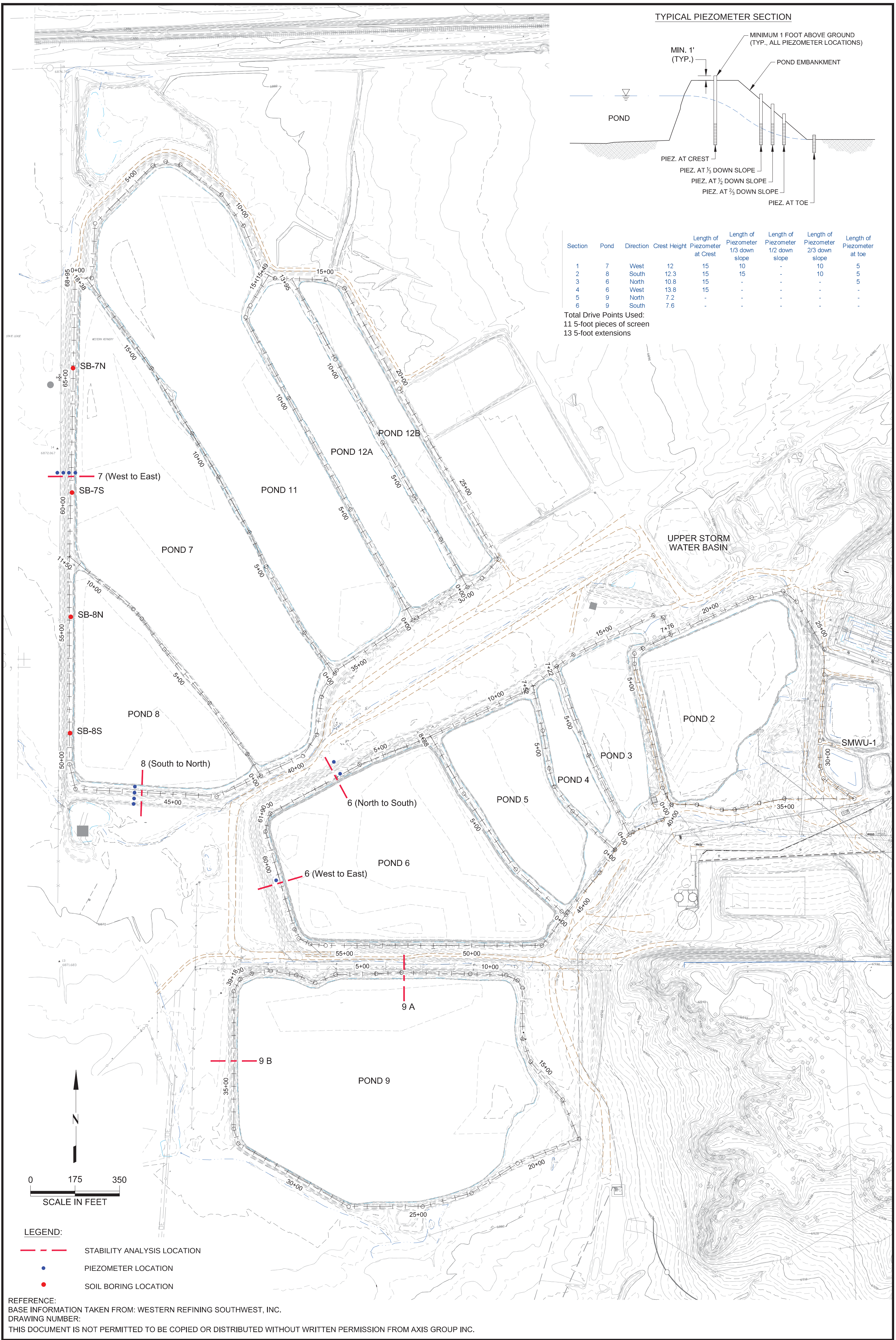
PROJ. NO.: 15-112
DATE: 2-7-2017
DRAWN BY: JAY
CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

2016 POND UPGRADES & REPAIRS
POND 9

DRAWING NO.:

6c



Section	Pond	Direction	Crest Height	Length of Piezometer at Crest	Length of Piezometer 1/3 down slope	Length of Piezometer 1/2 down slope	Length of Piezometer 2/3 down slope	Length of Piezometer at toe
1	7	West	12	15	10	-	10	5
2	8	South	12.3	15	15	-	10	5
3	6	North	10.8	15	-	-	-	5
4	6	West	13.8	15	-	-	-	-
5	9	North	7.2	-	-	-	-	-
6	9	South	7.6	-	-	-	-	-

Total Drive Points Used:
11 5-foot pieces of screen
13 5-foot extensions

LEGEND:

— · —	STABILITY ANALYSIS LOCATION
●	PIEZOMETER LOCATION
●	SOIL BORING LOCATION

REFERENCE:
BASE INFORMATION TAKEN FROM: WESTERN REFINING SOUTHWEST, INC.
DRAWING NUMBER:
THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

AXIS GROUP Inc.
1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

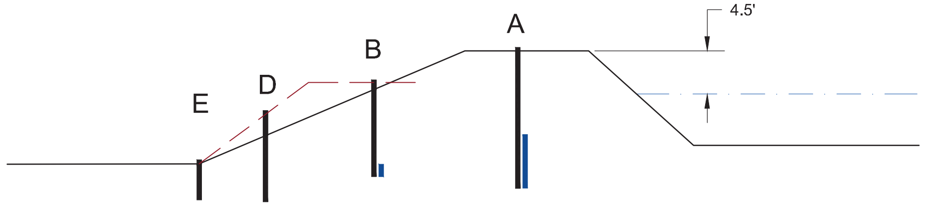
WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

POND 7&8 BORING LOCATIONS
DRIVE POINT PIEZOMETER LOCATIONS
NUMERICAL SLOPE STABILITY SECTION LOCATIONS

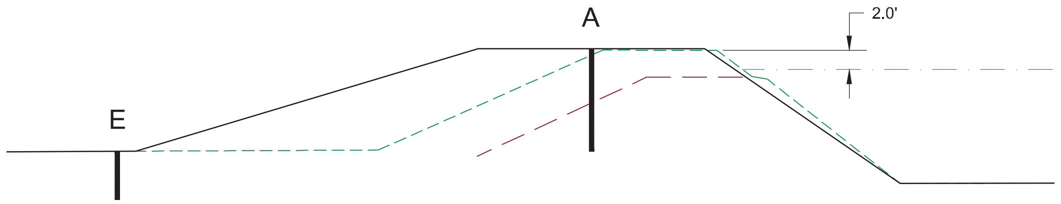
DRAWING NO.: 7a

PROJ. NO.: 15-010-04 | DATE: 2-7-2017 | DRAWN BY: JAY | CHECKED BY: JWB

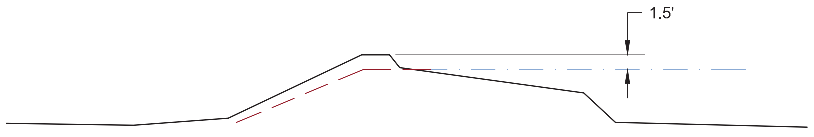
\\dav.syncedtool.com@SSL\DavWWWRoot\Drawings\15-112 - WNR Technical Memorandum\Drawings\Technical Memorandum Figs\FIGURE 6a-6b - X-Sections and Piezometer Locs.dwg ELundborg Plotted: Feb 15, 2017 - 8:16pm



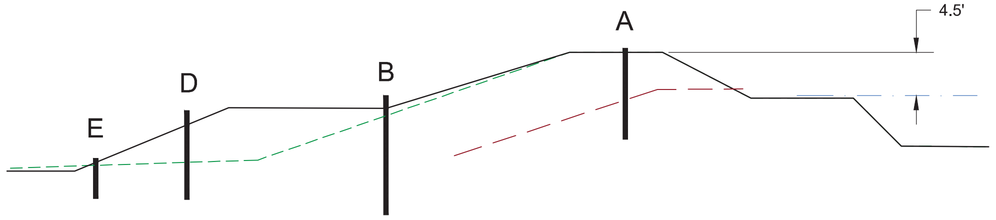
Pond 7 Cross Section (West to East)



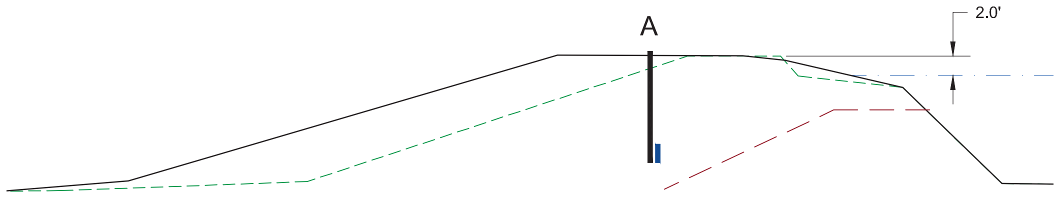
Pond 6 Cross Section (North to South)



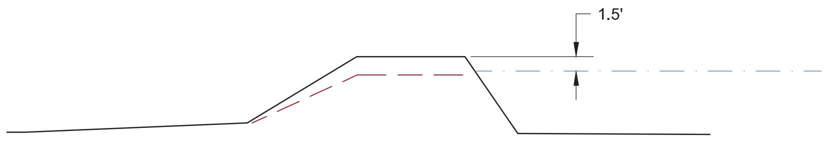
Pond 9 A Cross Section (North to South)



Pond 8 Cross Section (South to North)



Pond 6 Cross Section (West to East)



Pond 9 B Cross Section (East to West)

LEGEND

—— 2015 GRADED SURFACE AFTER BERM REPAIRS

- - - - 2014 GRADED SURFACE AFTER REPAIR WORK

— — — PRE 2014 GRADED SURFACE

— · — · WATER SURFACE

E

PIEZOMETER, I.D. LABEL AND
DETECTED WATER LEVEL

SCALE IN FEET

THIS DOCUMENT IS NOT PERMITTED TO BE COPIED OR DISTRIBUTED WITHOUT WRITTEN PERMISSION FROM AXIS GROUP INC.

NO.	BY	DATE:	REVISION

AXIS GROUP Inc.

1101 WEST MINERAL AVENUE
SUITE 102
LITTLETON, COLORADO. 80120
(303) 332-5757

PROJ. NO.: 15-112
DATE: 2-7-2017
DRAWN BY: JAY
CHECKED BY: JWB

WESTERN REFINING SOUTHWEST, INC. - GALLUP REFINERY, NEW MEXICO

EVAPORATION POND UPGRADES
POND BERM CROSS SECTIONS

DRAWING NO.: 7b

APPENDICES

APPENDIX A

Photographs

Photo #1: Pond 6 Northwest Corner After Fill Placement - Looking South

Photo #2: Pond 6 Northwest Corner After Fill Placement - Looking North

Photo #3: Pond 7/8 West Berm Under Construction - Looking North
(Note how the new crest alignment is shifted to the east)

Photo #4: Pond 11 South Berm Construction Complete - Looking North


04/01/2014

Photo #5: Pond 12A South Berm Construction Complete - Looking West

Photo #6: Borrow area north of Pond 11 – Looking West

Photo #7: Pond 5 North Berm Under Construction, Nearly Complete - Looking East

Photo #8: Pond 6 West Berm Under Construction - Looking South

Photo #9: Pond 6 West Berm Under Construction, Nearly Complete - Looking North

Photo #10: Pond 7/8 and Pond 11 South Berms Under Construction - Looking Northeast

Photo #11: Pond 7/8 and Pond 11 South Berms Under Construction, Nearly Complete - Looking Northeast

Photo #12: Pond 7/8 and Pond 11 South Berms Under Construction, Nearly Complete - Looking Northeast

Photo #13: Density Testing Pond 7/8 with repaired Pond 6 in the background

Photo #14: Moisture conditioning soil in the borrow area.

Photo #15: Pond 7/8 West Berm Fill Over Geotextile

Photo #14: Pond 7/8 West Berm Completed Fill.

Photo #17: Pond 11-12 Berm Being Removed and Reworked

Photo #18: Pond 11-12 Berm Fill Repair Completed.

Photo #19: Pond 9 Start of Fill Placement on North Berm

Photo #20: Pond 9 East End Completed.

Photo #21: Pond 9 Start of Fill Placement on North Berm
Removing Base Material and Placing it on the Interior

Photo #22: Pond 9 North Berm Completed.

APPENDIX B

Geotechnical Data

amec

Client: Bonaguidi Construction
3100 East Aztec Ave.
Suite 5
Gallup, NM 87301-

Attn: Dan Bonaguidi

Project Name: Pond 6 Dock Repair w/Engineer Firm

Gallup, NM

Project Manager: Lee Lommler

Report Date: February 03, 2015

Project #: 14-519-00435.4

Work Order #: 1

Lab #: G5692

Sampled By: Client

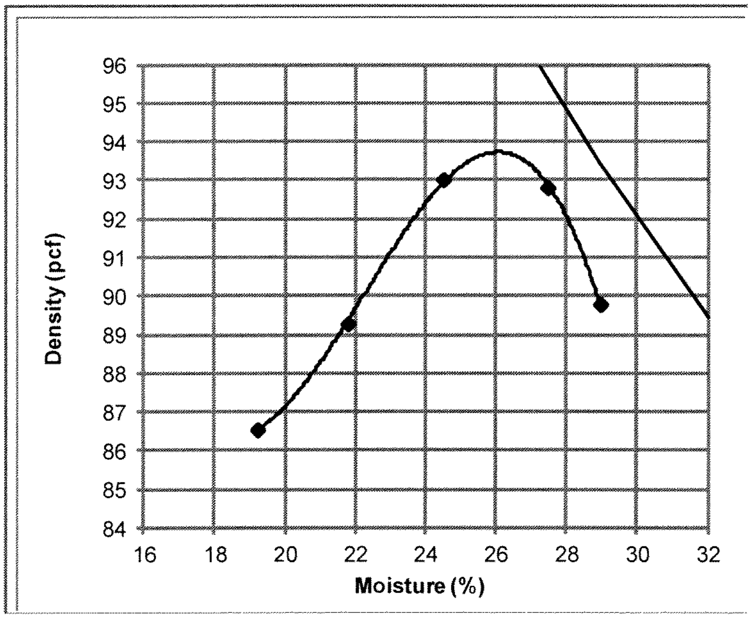
Date Sampled: 1/26/2015

Visual Description of Material: Medium Dark Reddish Brown Clay

Sample Source: TP-1 -2.0' to 3.0'

SOILS / AGGREGATES

No Project Specification was Provided.



Sieve Analysis (ASTM C117-04/C136-06)

200 Wash Procedure: A

Sieve Size	Passing
3/4in.	100%
1/2in.	98%
3/8in.	95%
#4	80%
#10	73%
#40	67%
#50	66%
#100	63%
#200	61%

Moisture Density Relationship: (ASTM D698-07) **Method:** A

Preparation Method: Dry **Rammer Type:** Mechanical

Specific Gravity: 2.651 **Assumed**

Maximum Density: 93.7

Optimum Moisture: 26.1

(ASTM D2216-10)

Moisture Content (%): 12.5%

Plasticity Index (ASTM D4318-10)

Liquid Limit: 65

Plastic Limit: 25

Plasticity Index: 40

Preparation Method: Dry **Liquid Limit Method:** A

PI Air Dried.

Soil Classification (ASTM D2487-10) CH

Reviewed By: ______________________
Jan

Distribution: **Client** ☑ **File:** ☑ **Supplier:** ☑ **Email:** ☐ **Other:** Addressee ()
Dan Bonaguidi (email) (1)

AMEC Environment & Infrastructure, Inc.
8519 Jefferson NE
Albuquerque, NM 87113
Tel 5058211801
Fax 5058217371

www.amec.com

Client: Bonaguidi Construction
3100 East Aztec Ave.
Suite 5
Gallup, NM 87301-

Attn: Dan Bonaguidi

Project Name: Pond 6 Dock Repair w/Engineer Firm

Gallup, NM

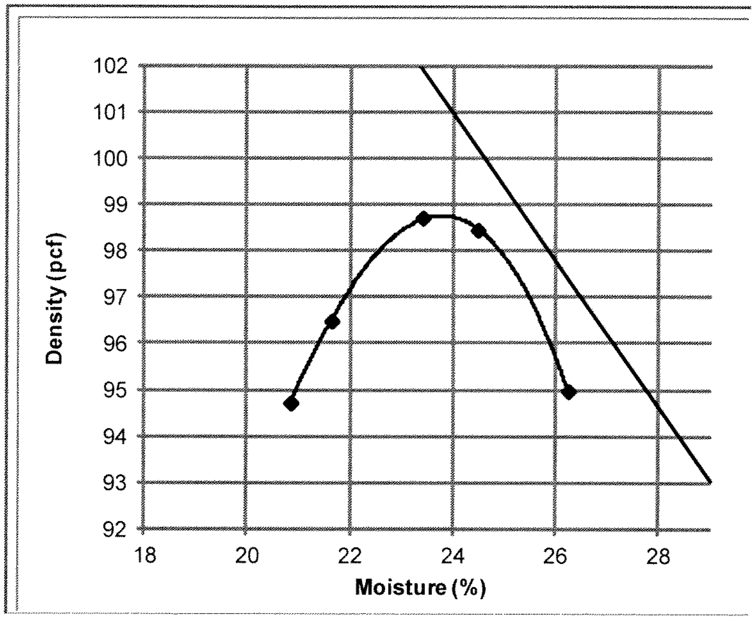
Project Manager: Lee Lommler

Report Date: February 03, 2015

Project #: 14-519-00435.4
Work Order #: 1
Lab #: G5693
Sampled By: Client
Date Sampled: 1/26/2015
Visual Description of Material: Medium to Dark Reddish Brown Clay
Sample Source: TP-2 P-6 SW Corner

SOILS / AGGREGATES

No Project Specification was Provided.



Sieve Analysis (ASTM C117-04/C136-06)

200 Wash Procedure: A

Sieve Size	Passing
#4	100%
#10	96%
#40	88%
#50	84%
#100	78%
#200	74%

Moisture Density Relationship: (ASTM D698-07) **Method:** A
Preparation Method: Dry **Rammer Type:** Mechanical
Specific Gravity: 2.651 **Assumed**
Maximum Density: 98.8
Optimum Moisture: 23.8

(ASTM D2216-10)
Moisture Content (%): 26.9%

Plasticity Index (ASTM D4318-10)

Liquid Limit: 55
Plastic Limit: 23
Plasticity Index: 32

Preparation Method: Dry **Liquid Limit Method:** A
PI Air Dried.

Soil Classification (ASTM D2487-10) CH

Reviewed By:
Jan

Distribution: **Client** ☑ **File:** ☑ **Supplier:** ☑ **Email:** ☐ **Other:** Addressee ()
Dan Bonaguidi (email) (1)

Client:	Bonaguidi Construction 3100 East Aztec Ave. Suite 5 Gallup, NM 87301-	**Report Date:**	February 03, 2015
		Project #:	14-519-00435.4
		Work Order #:	1
Attn:	Dan Bonaguidi	**Lab #:**	G5694
Project Name:	Pond 6 Dock Repair w/Engineer Firm Gallup, NM	**Sampled By:**	Client
		Date Sampled:	1/26/2015
		Visual Description of Material:	Medium Reddish Brown Silty Clay
		Sample Source:	TP-3
Project Manager:	Lee Lommler		

SOILS / AGGREGATES

No Project Specification was Provided.

Sieve Analysis (ASTM C117-04/C136-06)

200 Wash Procedure: A

Sieve Size	Passing
1 1/2in.	100%
1in.	97%
1/2in.	95%
3/8in.	94%
#4	91%
#10	89%
#40	81%
#50	75%
#100	61%
#200	50%

(ASTM D2216-10)

Moisture Content (%): 8.1%

Reviewed By: ______________________
Jan

Distribution: **Client** ☑ **File:** ☑ **Supplier:** ☑ **Email:** ☐ **Other:** Addressee ()
Dan Bonaguidi (email) (1)

ATTERBERG LIMITS
ASTM D 4318

Atterberg Limits Test
ASTM D 4318

Client: Axis Group Inc
Job Number: 2905-3
Project: Western Refinery
Location: --
Project Number: 14-107

Boring Number: Gallup Borrow
Depth: --
Sample Number: --
Test Date: 10/13/2015
Technician: BDF
Sampled Date: 6/22/2015
Sampled By: --
Method: Method A

Test Configuration

Liquid Limits Device: 1080
Material Size of Fines: -#40

Plastic Limits

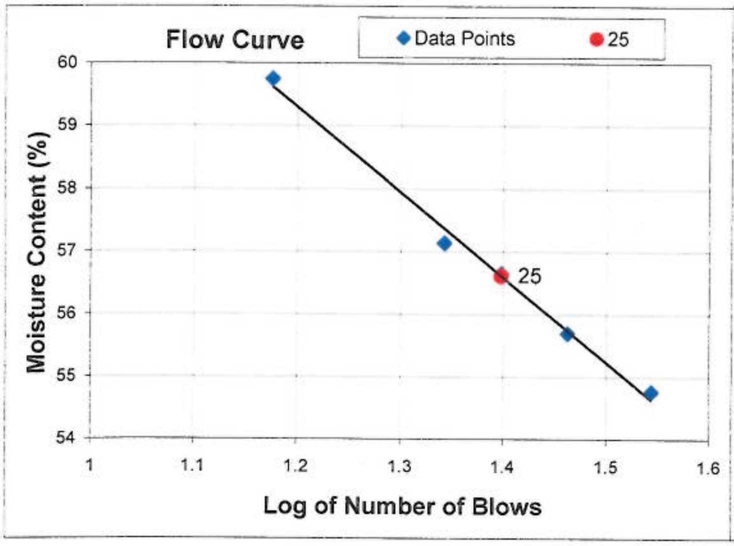
	Sample 1	Sample 2	Sample 3
Weight of Wet Soil & Pan (g):	6.387	6.404	6.414
Weight of Dry Soil & Pan (g):	5.660	5.666	5.689
Weight of Water (g):	0.727	0.738	0.725
Weight of Pan (g):	1.106	1.132	1.128
Moisture Content (%):	16.0	16.3	15.9

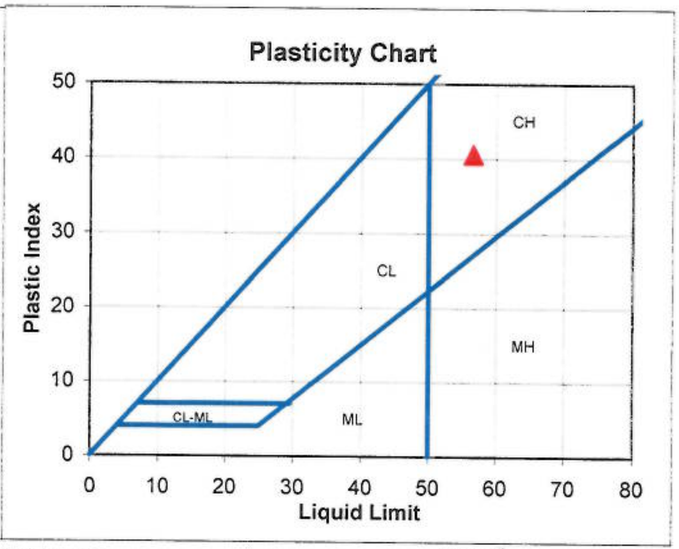
Average: 16.0%
Standard Deviation: 0.2%

Liquid Limits

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Number of Blows:	22	15	29	35	25
Weight of Wet Soil & Pan (g):	9.208	8.627	9.778	8.674	8.770
Weight of Dry Soil & Pan (g):	6.273	5.822	6.688	6.003	5.974
Weight of Water (g):	2.935	2.805	3.090	2.671	2.796
Weight of Pan (g):	1.136	1.127	1.140	1.125	1.038
Moisture Content (%):	57.1	59.7	55.7	54.8	56.6

Plastic Limit: 16
Liquid Limit: 57
Plastic Index: 41
Atterberg Classification CH





Data Entered By: NN
Date: 10/14/2015
File Name: 2905_3_atterberg-ASTMD-4318-R8_0.xls

Data Checked By: CKP
Date: 10/15/15

ATT
ADVANCED TERRA TESTING

MECHANICAL ANALYSIS

ASTM D 6913

Particle Size Distribution (Gradation) of Soil Using Sieve Analysis
ASTM D 6913

Client: Axis Group Inc
Job Number: 2905-3
Project: Western Refinery
Location: --
Project Number: 14-107

Boring Number: Gallup Borrow
Depth: --
Sample Number: --
Sampled Date: --
(+) Wash Date: --
(-) Wash Date: 10/14/15

Sampled By: --
Technician: --
Technician: BDF

Grain Size Data

Hygroscopic Moisture of Fines
Weight of Wet Soil & Pan (g): 1026.36
Weight of Dry Soil & Pan (g): 1013.48
Weight of Water (g): 12.88
Weight of Pan (g): 814.67
Weight of Dry Soil (g): 198.81
Moisture (%): 6.5

Total Wet Weight of Sample (g): 211.69
Total Dry Weight of Sample (g): 198.81
Calculated Weight Plus #200 (g): 2.21
Moisture of Total Sample (%): 6.5
Percent Retained #200 Sieve (%): 1.1

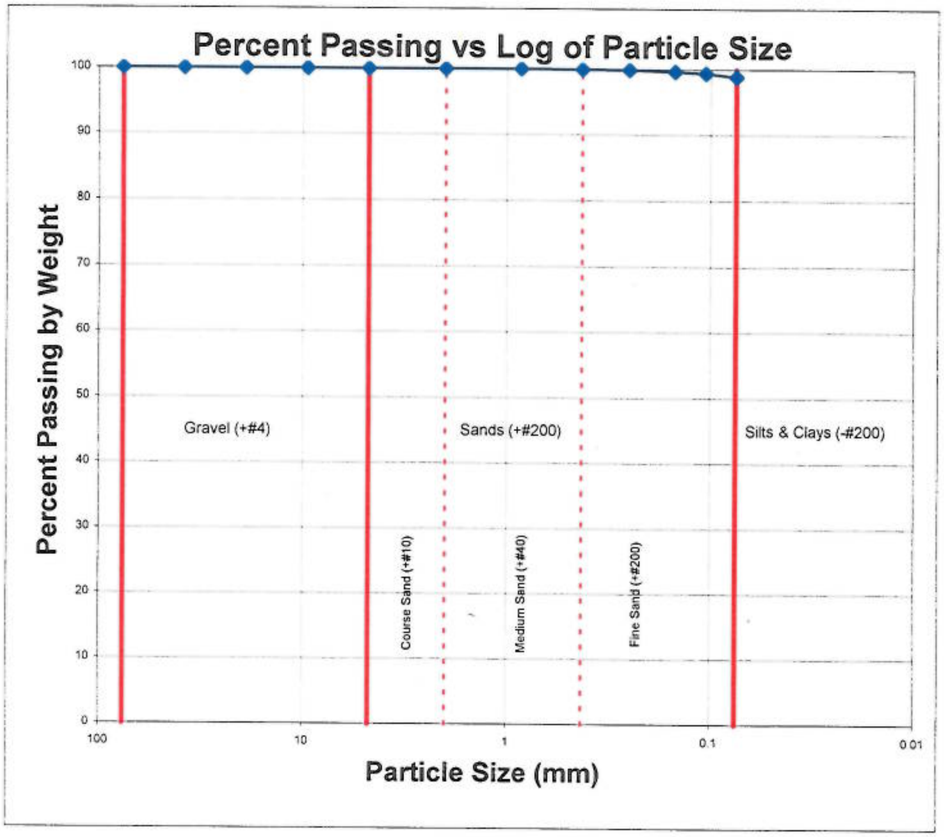
Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
3"	**76.2**	0.00	0.00	0.00	0.00	100.0
1.5"	**38.10**	0.00	0.00	0.00	0.00	100.0
3/4"	**19.05**	0.00	0.00	0.00	0.00	100.0
3/8"	**9.525**	0.00	0.00	0.00	0.00	100.0
#4	**4.750**	0.00	0.00	0.00	0.00	100.0
#10	**2.000**	0.00	0.00	0.00	0.00	100.0
#20	**0.850**	3.14	3.13	0.01	0.01	100.0
#40	**0.425**	3.15	3.11	0.04	0.04	100.0
#60	**0.250**	3.37	3.20	0.17	0.17	99.9
#100	**0.150**	3.63	3.20	0.43	0.43	99.7
#140	**0.106**	3.72	3.19	0.53	0.53	99.4
#200	**0.075**	4.22	3.20	1.03	1.03	98.9

Wet Weight of Soil (g): 211.69
Dry Weight of Soil (g): 198.81

USCS Classification ASTM D 2487
Atterberg Classification: CH
Group Symbol: CH

Course-Grained Soils
Percent Gravels (%): 0.00
Percent Sands (%): 1.11
Percent Fines (%): 98.89

USCS Classification
Fat Clay



Data Entered By: NN
Date: 10/15/2015
File Name: 2905_3_grainSize-ASTM-C33-D1140-D6319-D2487-R6_0.xls

Checked By: CKP
Date: 10/15/15

ATT
ADVANCED TERRA TESTING

STANDARD PROCTOR COMPACTION

Method A, B or C

ASTM D 698

ADVANCED TERRA TESTING

Compaction Test
ASTM D 698 - A

Client:	Axis Group Inc	Job number:	2905-3
Project Number:	14-107		
Project:	Western Refinery	Boring:	Gallup Borrow
Sampled by:	--	Depth:	--
Tested by:	BDF	Sample Id:	--
Location:	--	Test date:	10/13/2015

Initial conditions

Wet Wt. Pan and Soil (g):	303.57	Pf (% fines)	100.00%
Dry Wt. Pan and Soil (g):	283.49	Pc (% course)	0.00%
Wt. Water (g):	20.08	Use Correction?	No
Dish Weight:	6.54	Layers	3
Wet Wt. of Total Fines (lb):	32.19	Blows/Layer	25
Dry Wt. of total fines (lb):	30.01		
Mdc (mass dry coarse) (lb):	0		

Wt of Moisture added (ml)	360	400	320	280	440
Wt. of soil & dish (g)	368.32	262.99	392.63	373.06	351.71
Dry wt. soil & dish (g)	298.54	210.45	323.45	311.36	277.16
Net loss of moisture (g)	69.78	52.54	69.18	61.70	74.55
Wt. of dish (g)	6.97	7.02	6.98	6.98	7.01
Net wt. of dry soil (g)	291.57	203.43	316.47	304.38	270.15
Moisture Content	23.9%	25.8%	21.9%	20.3%	27.6%
Corrected Moisture Content					
Wt of soil & mold (lb)	13.84	13.79	13.74	13.66	13.73
Wt. of mold (lb)	9.78	9.78	9.78	9.78	9.78
Net wt. of wet soil (lb)	4.06	4.01	3.96	3.88	3.95
Net wt of dry soil (lb)	3.28	3.19	3.25	3.23	3.10
Dry Density, (pcf)	98.3	95.6	97.5	96.8	92.9
Corrected Dry Density (pcf)					

Data entry by:	NN	Date:	10/15/15
Data checked by:	SKP	Date:	10/15/15

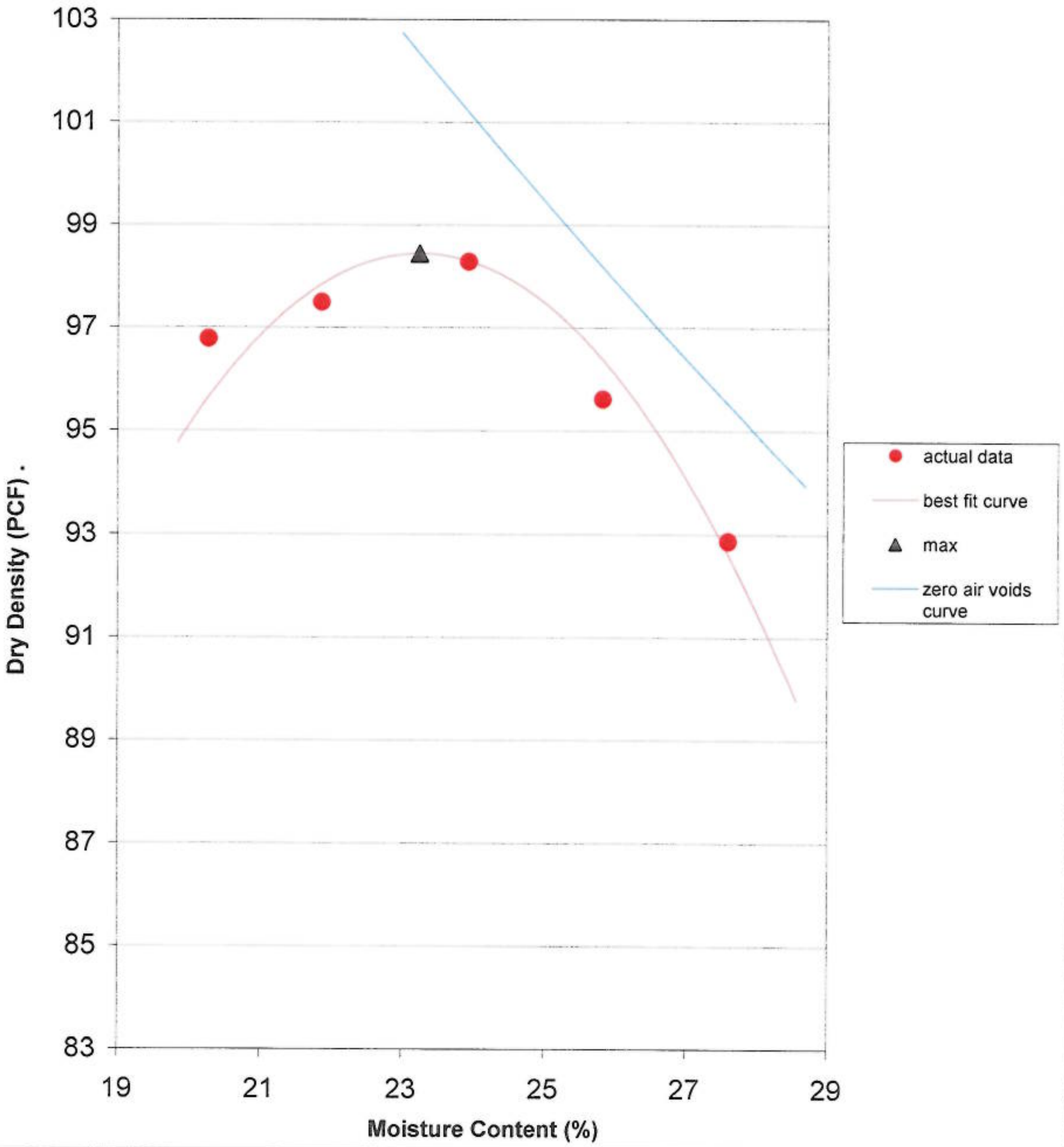
Filename 2905_3_Proctor_ASTMD1557_ASTMD698_R2_1.xls

ATT
ADVANCED TERRA TESTING

Proctor Compaction Test

ASTM D 698 - A

Client:	Axis Group Inc	Job number:	2905-3
Project Number:	14-107		
Project:	Western Refinery	Boring:	Gallup Borrow
Sampled by:	--	Depth:	--
Tested by:	BDF	Sample Id:	--
Location:	--	Test date:	10/13/2015



Optimum Moisture content: 23.2 Maximum dry density: 98.4

Zero air voids curve @ SG = 2.65

Data entry by:	NN	Date:	10/15/15
Data checked by:	CKP	Date:	10/15/15
Filename	2905_3_Proctor_ASTMD1557_ASTMD698_R2_1.xls		

PERMEABILITY TRIAXIAL
Flow Pump
ASTM 5084

PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD

ASTM D 5084

CLIENT	Axis Group Inc	JOB NO.	2905-3
		Sampled By	--
BORING NO.	Gallup Borrow	Date Sampled	--
DEPTH	--	Tested By	CAL
SAMPLE NO.	--	Date Started	10/16/2015
LOCATION	--	Date Finished	10/29/2015
PROJECT	Western Refinery	CELL NUMBER	5P
PROJECT NO.	14-107	PERMEANT	Tap Water
SOIL DESCR.	Remolded -(#4)	CONFINING PRESS. (psf)	720

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	420.36	448.87
Wt. Wet Soil & Pan (g)	426.94	455.45
Wt. Dry Soil & Pan (g)	347.70	347.70
Wt. Lost Moisture (g)	79.24	107.75
Wt. of Pan Only (g)	6.58	6.58
Wt. of Dry Soil (g)	341.12	341.12
Moisture Content %	23.2	31.6
Wet Density PCF	116.7	124.2
Dry Density PCF	94.7	94.4

Init. Diameter (in)	2.408	(cm)	6.116
Init. Area (sq in)	4.554	(sq cm)	29.383
Init. Height (in)	3.012	(cm)	7.650
Vol. Bef. Consol. (cu ft)	0.00794		
Vol. After Consol. (cu ft)	0.00797		
Porosity %	47.74		

FLOW PUMP CALCULATIONS

Pump Setting	99
Velocity CM/Sec	6.53E-04
Q (cc/s)	2.09E-05
Height	3.009
Diameter	2.414
Pressure (psi)	0.402
Area after consol. (cm*cm)	29.524
Gradient	3.698
Permeability k (cm/s)	1.9E-07
Permeability k (m/s)	1.9E-09
Back Pressure (psi)	78.0
Cell Pressure (psi)	83.0
Ave. Effective Stress (psi)	4.799
Average temperature degree C:	22.5

Data entry by: NN Date: 10/30/2015

Checked by:________ Date: 11/5/15

FileName: 2905_3_OrganonFlowPumpPerm-ASTMD-5084-R3_0.xls

PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD
ASTM D 5084

CLIENT	Axis Group Inc	JOB NO.	2905-3
		Sampled By	--
BORING NO.	Gallup Borrow	Date Sampled	--
DEPTH	--	Tested By	CAL
SAMPLE NO.	--	Date Started	10/16/2015
LOCATION	--	Date Finished	10/29/2015
PROJECT	Western Refinery	CELL NUMBER	5P
PROJECT NO.	14-107	PERMEANT	Tap Water
SOIL DESCR.	Remolded -(#4)	CONFINING PRESS. (psf)	720

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)			
		Close	Open	Close	Open	Change	B
40.0	38.0	2.5	13.1				
50.0	48.0	8.0	10.3	38.2	46.1	7.9	0.79
60.0	58.0	10.0	10.9	48.1	56.8	8.7	0.87
70.0	68.0	10.9	11.8	58.1	67.1	9.0	0.90
80.0	78.0	11.7	12.5	68.1	77.4	9.3	0.93
90.0		12.5	12.6	77.9	87.4	9.5	0.95

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT Time (Min)	Burette Reading (CC)	Volume Defl. (cc)
0.00	0.00	12.50	0.00
0.25	0.50	13.00	-0.50
0.5	0.71	13.10	-0.60
1	1.00	13.20	-0.70
2	1.41	13.30	-0.80
4	2.00	13.40	-0.90
9	3.00	13.50	-1.00
16	4.00	13.55	-1.05
30	5.48	13.60	-1.10
60	7.75	13.65	-1.15
120	10.95	13.70	-1.20
240	15.49	13.70	-1.20
360	18.97	13.70	-1.20

Initial Height (in)	3.012	Init. Vol. (CC)	224.82
Height Change (in)	0.003	Vol. Change (CC)	11.70
Ht. After Cons. (in)	3.009	Cell Exp. (CC)	12.57
Initial Area (sq in)	4.554	Net Change (CC)	-0.87
Area After Cons. (sq in)	4.576	Cons. Vol. (CC)	225.69

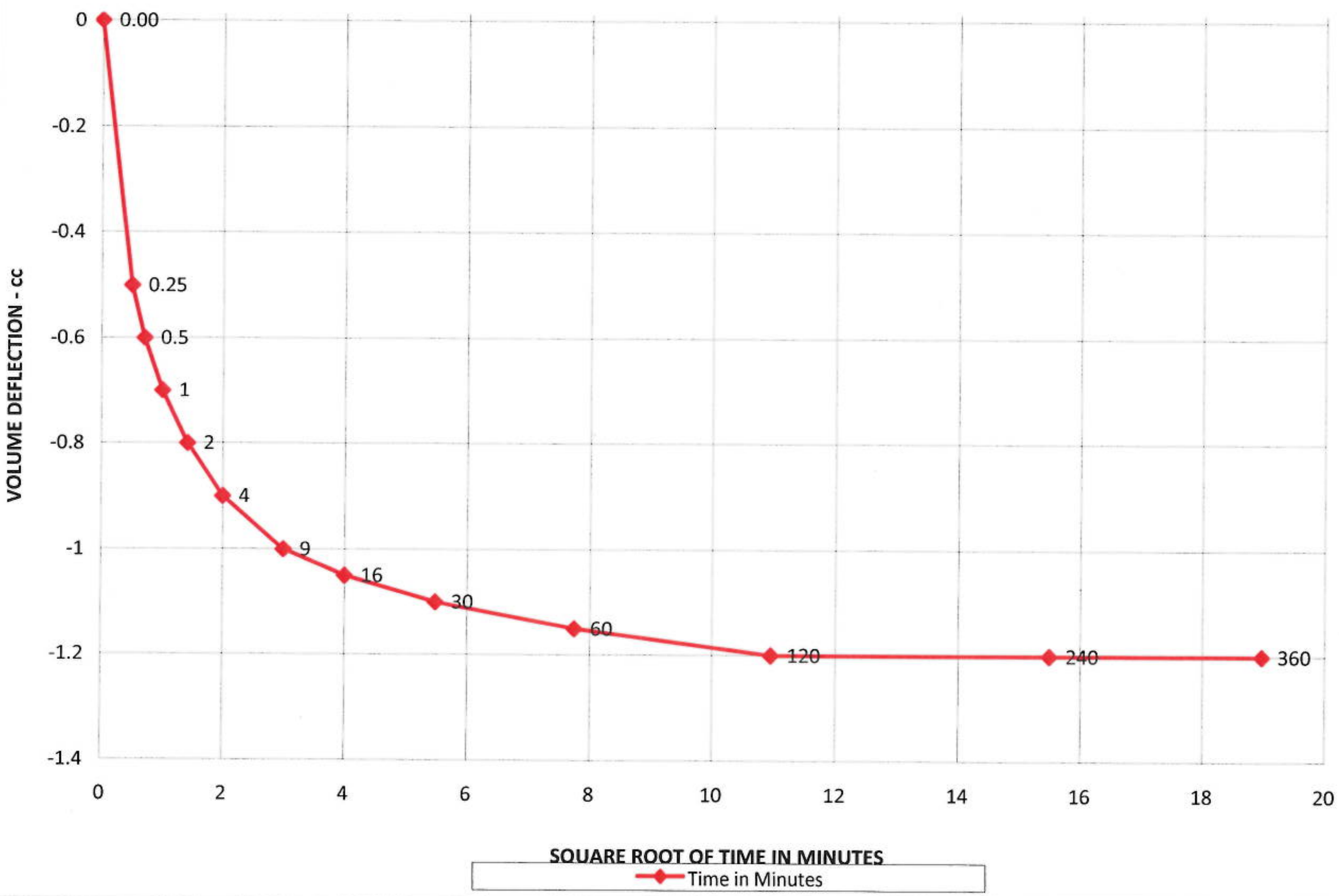
Data entry by: NN Date: 10/30/2015

Checked by: Ca Date: 11/5/15

FileName: 2905_3_OrganonFlowPumpPerm-ASTMD-5084-R3_0.xls

CONSOLIDATION DATA

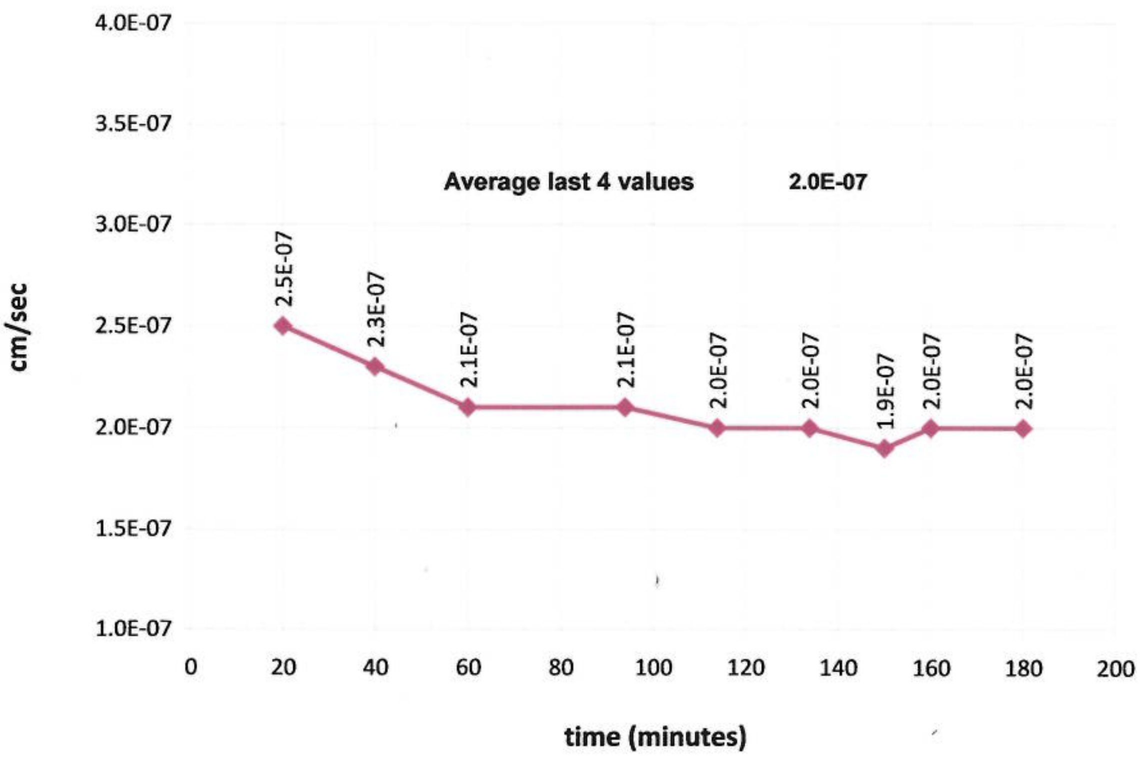
Gallup Borrow,--,--



ATT

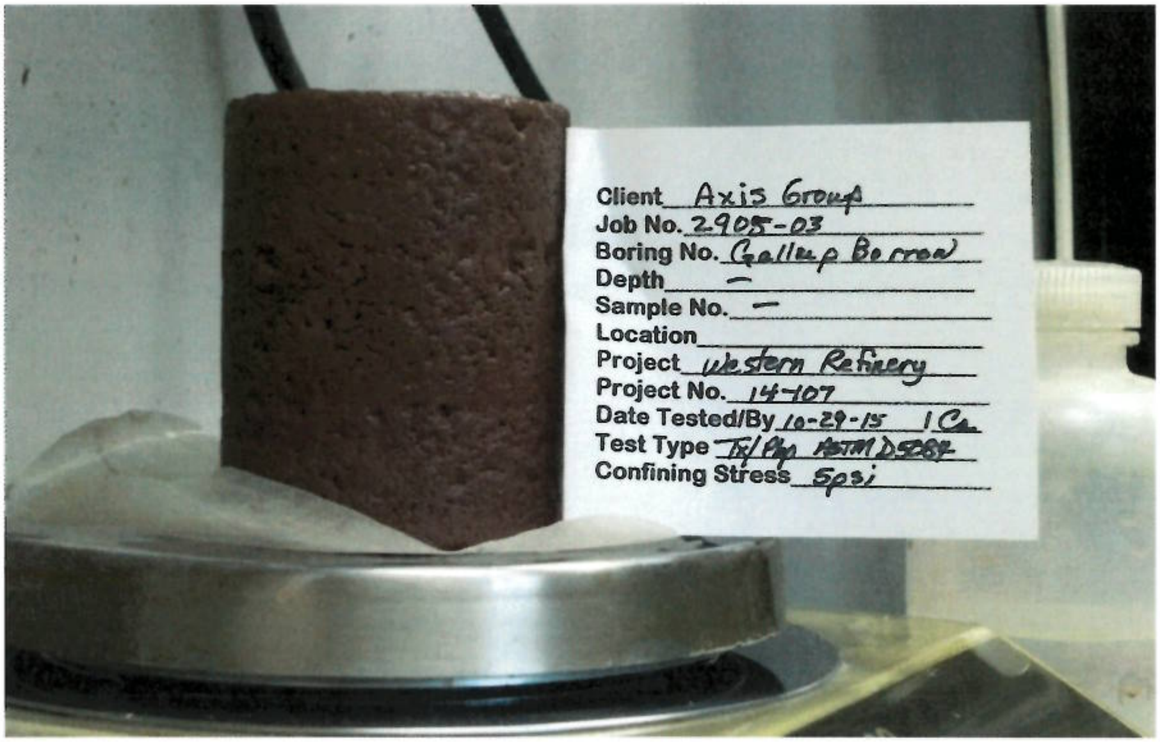
Preliminary Flow Pump Test Data
ASTM D5084 Method D

Client:	Axis Group Inc	Boring Number:	Gallup Borrow		
Job Number:	2905-3	Depth:	--		
Project:	Western Refinery	Sample Number:	--		
Location:	--	Sampled Date:	--	Sampled By:	--
Project Number:	14-107	Test Date:	10/29/2015	Technician:	CAL



Data Entered By: CAL
Date: 10/29/2015
File Name: 2905_3_PrelimPerm_ASTMD-5084-methodD-R1_0.xls

Checked By: NN
Date: 10/30/15



Client Axis Group
Job No. 2905-03
Boring No. Gallup Borrow
Depth —
Sample No. —
Location
Project Western Refinery
Project No. 14-107
Date Tested/By 10-29-15 1 Ca
Test Type Tx/Pm ASTM D5084
Confining Stress 5psi

Q:\Client Data File\2905\3\PICTURE\DSCF6055

amec

Client:	Bonaguidi Construction 3100 East Aztec Ave. Suite 5 Gallup, NM 87301-	**Report Date:**	March 24, 2015
		Project #:	14-519-00435.4
		Report #:	40326
		Tested By:	Michael Martinez
Attn:	Dan Bonaguidi	**Date Tested:**	3/12/2015
Project Name:	Pond 6 Dock Repair w/Engineer Firm Gallup, NM	**Type of Material:**	Pond Berm Subgrade
		Sand Cone Apparatus #:	1733
Project Manager:	Lee Lommler	**Sand Cone Appartus Calibrated Volume:**	0.039

SAND CONE DENSITY TEST (ASTM D1556-07)

Moisture Density Curves Used

AMEC Lab #	Maximum Density	Optimum Moisture	Test Type / Method	Description
G5692	93.7	26.1	ASTM D698-07 / A	Medium Dark Reddish Brown Clay
G5693	98.8	23.8	ASTM D698-07 / A	Medium to Dark Reddish Brown Clay

Test #	Location	Elevation	** Reference	Density of Sand Used (pcf)	Test Hole Vol. ft³	*** % Moisture	Wet Density (pcf)	Dry Density (pcf)	Maximum Density (pcf)	% Com-paction	% Com-paction Required Min	Max
01	Sta. 60+50		01	93.3	0.0930	14.1	114.7	100.5	93.7	100+		

** References the Oringinal Test Number for the Nuclear Density Test Performed

*** Moisture determined by oven-dry method (ASTM D2216).

Reviewed By
jdc

Distribution: Client ☑ File: ☑ Supplier: ☑ Email: ☐ Other: Addressee ()
Dan Bonaguidi (email) (1)

Client:	Bonaguidi Construction 3100 East Aztec Ave. Suite 5 Gallup, NM 87301-	**Report Date:**	March 24, 2015
		Project #:	14-519-00435.4
		Report #:	40326
Attn:	Dan Bonaguidi	**Tested By:**	Michael Martinez
Project Name:	Pond 6 Dock Repair w/Engineer Firm Gallup, NM	**Date Tested:**	3/12/2015
		General Location of Testing:	Pond Berm Subgrade
Project Manager:	Lee Lommler		

FIELD DENSITY TEST USING NUCLEAR DENSITY GAUGE (ASTM D6938-10)

Moisture Density Curves Used

AMEC Lab #	Maximum Density	Optimum Moisture	Test Type / Method	Description
G5692	93.7	26.1	ASTM D698-07 / A	Medium Dark Reddish Brown Clay
G5693	98.8	23.8	ASTM D698-07 / A	Medium to Dark Reddish Brown Clay

Nuclear Density Gauge

Make: Troxler
Model #: 3440-A
Serial #: 37066

Test #	Location	Elevation	Test Mode	Probe Depth (in)	% Moisture Actual	% Moisture Required (-)	% Moisture Required (+)	Wet Density (pcf)	Dry Density (pcf)	Maximum Density (pcf)	% Compaction	% Compaction Required Min	% Compaction Required Max
01	Sta. 60+50	FSG -6'	D	6	13.3			108.2	95.5	93.7	100+	95	
02	Sta. 60+58	FSG -6'	D	6	19.6			109.4	91.4	93.7	98	95	
03	Sta. 60+59	FSG -6'	D	6	14.0			113.4	99.5	98.8	100+	95	

Reviewed By:______________________
jdc

Distribution: Client ☑ File: ☑ Supplier: ☑ Email: ☐ Other: Addressee ()
Dan Bonaguidi (email) (1)

BTSB=Below Top of Subbase, BTOF= Below Top of Fill, FSG = Finished Subgrade, FBC = Finished Base Course, BOP = Bottom of Pipe, BOB = Bottom of Base, BOF = Bottom of Footing, OGP = Original Ground Prep
Test Mode = D for Direct Transmission and B for Backscatter Modes

amec
foster
wheeler

Client: Bonaguidi Construction
3100 East Aztec Ave.
Suite 5
Gallup, NM 87301-

Attn: Dan Bonaguidi

Project Name: Pond 6 Dock Repair w/Engineer Firm

Gallup, NM

Project Manager: Lee Lommler

Report Date: June 11, 2015

Project #: 14-519-00435.4

Work Order #: 2

Lab #: G5746

Sampled By: Derek Martinez

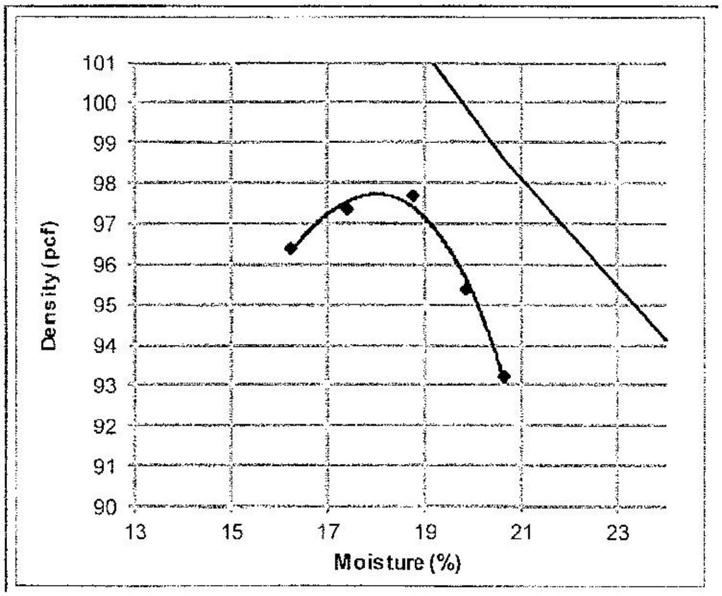
Date Sampled: 6/3/2015

Visual Description of Material: Reddish Clay

Sample Source: Side of Pond 7 & 8

SOILS / AGGREGATES

No Project Specification was Provided.



Sieve Analysis (ASTM C117-04/C136-06)

200 Wash Procedure: A

Sieve Size	Passing

Moisture Density Relationship: (ASTM D1557-09) **Method:** A

Preparation Method: Dry **Rammer Type:** Manual

Specific Gravity: 2.35 **Assumed**

Maximum Density: 97.5

Optimum Moisture: 18.0

Reviewed By:__________________________________

jdc

Distribution: Client ☑ File: ☑ Supplier: ☑ Email: ☐ Other: Addressee ()

Dan Bonaguidi (email) (1)

Field Density Soils Results

amec
foster
wheeler

Report Date: June 22, 2015

Client		**Project**	
Name:	Bonaguidi Construction	**Name:**	(14-519-00435.5) Pond 7 & 8 Dock Repair w/Engineer Firm
Address:	3100 East Aztec Ave Gallup, NM 87301	**Address:**	Gallup, NM
Attention:	Dan Bonaguidi	**Phase:**	**Task:**
PO Number:		**Manager:**	Abe Sandoval
Date Tested:	6/17/2015 by Kevin Olson	**Reference #:**	NS20975
General Description (Material/Location):	Pond 7 & 8		

FIELD DENSITY TEST USING NUCLEAR DENSITY GAUGE (ASTM D6938-10)

Moisture Density Curves Used

Lab/Ref. #	Maximum Density	Optimum Moisture	Test Type/ Method	Description	Source
G5746	97.5	18.0		Reddish Clay	Side of Pond 7 & 8

Nuclear Density Gauge		**Standard Count**		
			Calibration	**Field**
Make:				
Model #:		**Density:**		2443
Serial #:	37041	**Moisture:**		738

					% Moisture						% Compaction		
						Required						Required	
Test #	Location	Elevation	Test Mode	Probe Depth (in.)	Actual	(-)	(+)	Wet Density (lbs/ft^3)	Dry Density (lbs/ft^3)	Maximum Density (lbs/ft^3)	Actual	Min	Max
01	Sta. 43+75	FSG -1'	D	6	20.2	3	3	111.4	92.7	97.5	95	95	
02	Sta. 45+65	FSG -1.5'	D	6	20.7	3	3	114.8	95.1	97.5	98	95	

BTSB=Below Top of Subbase, BTOF= Below Top of Fill, FBC= Final Base Course, FSG = Finished Subgrade, FBC = Finished Base Course, BOP = Bottom of Pipe, BOB = Bottom of Base, BOF = Bottom of Footing, OGP = Original Ground Prep
Test Mode = D for Direct Transmission and B for Backscatter Modes

Distribution: Dan Bonaguidi

Reviewed By: Abe Sandoval

Amec Foster Wheeler Environment & Infrastructure, Inc. - 8519 Jefferson NE - Albuquerque, NM 87113
phone: (505) 821-1801 fax: (505) 821-7371

Field Density Soils Results

Report Date: June 26, 2015

Client

Name: Bonaguidi Construction
Address: 3100 East Aztec Ave Gallup, NM 87301
Attention: Dan Bonaguidi
PO Number:
Date Tested: 6/23/2015 by Kevin Olson
General Description (Material/Location): Dike on Pond #5

Project

Name: (14-519-00435.5) Pond 7 & 8 Dock Repair w/Engineer Firm
Address: Gallup, NM
Phase: **Task:**
Manager: Abe Sandoval
Reference #: NS21609

FIELD DENSITY TEST USING NUCLEAR DENSITY GAUGE (ASTM D6938-10)

Moisture Density Curves Used

Lab/Ref. #	Maximum Density	Optimum Moisture	Test Type/ Method	Description	Source
G5746	97.5	18.0	ASTM D1557/A	Reddish Clay	Side of Pond 7 & 8

Nuclear Density Gauge

Make: Troxler
Model #: 3430
Serial #: 37041

Standard Count

	Calibration	Field
Density:		2418
Moisture:		727

Test #	Location	Elevation	Test Mode	Probe Depth (in.)	% Moisture			Wet Density (lbs/ft^3)	Dry Density (lbs/ft^3)	Maximum Density (lbs/ft^3)	% Compaction		
					Actual	Required (-)	Required (+)				Actual	Required Min	Required Max
01	Pond #5, E End, 220' W of Sign	FSG -1'	D	6	17.3	2	2	108.9	92.8	97.5	95	95	
02	Pond #5 @ Sign	FSG -1.5'	D	6	19.3	2	2	116.0	97.2	97.5	100	95	

BTSB=Below Top of Subbase, BTOF= Below Top of Fill, FBC= Final Base Course, FSG = Finished Subgrade, FBC = Finished Base Course, BOP = Bottom of Pipe, BOB = Bottom of Base, BOF = Bottom of Footing, OGP = Original Ground Prep
Test Mode = D for Direct Transmission and B for Backscatter Modes

Distribution: Dan Bonaguidi
Reviewed By: Abe Sandoval

APPENDIX C

2002 Slope Stability Analysis

February 12, 2002

PRECISION ENGINEERING INC.

GEOTECHNICAL EVALUATION OF EVAPORATION PONDING CONTAINMENT BERMS

GIANT REFINING COMPANY
CINIZA REFINERY
FILE NO. 00-141

Submitted To:

Ms. Dorinda Mancini
Giant Refining Company
Route 3, Box 7
Gallup, New Mexico
87301

GEOTECHNICAL EVALUATION OF EVAPORATION PONDING CONTAINMENT BERMS

GIANT REFINING COMPANY
CINIZA REFINRY
GALLUP, NEW MEXICO

FILE NO: 00-141

PREPARED BY
PRECISION ENGINEERING, INC.
P.O. BOX 422
LAS CRUCES, NEW MEXICO

APPROVED BY

WILLIAM H. KINGSLEY, PE
PE NO. 8313
FEBRUARY 12, 2002

Index

Appendix Contents

1.0 General

An evaluation of the structural integrity of the evaporation lagoon berms located at the Giant Refining Company's Ciniza Refinery has been performed. There are a total of twelve (12) lagoons located in three (3) impoundment areas. Within the major impoundment areas individual lagoons are separated by interior dikes. The structural analysis of the exterior containment berms was performed using a conventional method of slices as well as finite element analyses of the berm sections. A total of thirteen (13) sections were evaluated for stability at the lagoons. Critical section locations were established based on visual inspection of the lagoons as well as a survey of the lagoon berms.

Soil profiles were established based on information obtained from ten subsurface investigation locations. Representative samples were obtained from borings through the berms. The boring depths range from fifteen (15) to twenty (20) feet. The borings were advanced using a truck-mounted CME 75 drill equipped with eight and five-eighths (8-$\frac{5}{8}$) inch outside diameter, continuous flight, hollow-stemmed auger. The borings were completed in accordance with ASTM D-1452: Standard Method for Soil Investigation and Sampling by Auger Methods.

As the auger was advanced, continuous visual inspection of cutting returns was maintained. Samples were taken at five (5) foot intervals throughout the boring and at major soil changes. Standard penetration resistance determinations were accomplished in accordance with ASTM D-1586: Standard Method for Penetration Test and Split-Barrel Sampling of Soils. Relatively undisturbed samples were obtained using Shelby tubes in accordance with ASTM D-1587: Thin-Walled Tube Sampling of Soils for Geotechnical Purposes. Following field classification, the samples were identified and transported to the laboratory for further study.

In addition to borings Dutch Cone soundings were used to evaluate the insitu soil properties and stratigraphy of the embankments and founding soils. Soundings were advanced in accordance with ASTM D-3441: Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil. Soundings were taken at one (1) foot intervals from the surface through the total depth of the sounding. The soundings were advanced using the hydraulic push capabilities of the CME 75D drill unit.

The logs for the auger borings, and the boring location plan are provided in the appendix of this report. The locations of the sections used for the analysis of the berm embankments are also shown on the boring plan.

2.0 Laboratory Investigation

Representative soil samples obtained from the field investigation were examined and classified based on the Unified Classification System (ASTM D-2487) and the AASHTO Classification System (AASHTO M-145). Particle size analyses were conducted on representative samples. Moisture content determinations were made on all samples to establish moisture content profiles. Atterberg Limits were established on representative samples that exhibited a cohesive nature. All of the above indicator tests were used to aid in defining soil stratification and general insitu soil conditions. The mechanical grain size analyses and soil classification summaries are provided in the appendix of this report.

Unit weight and triaxial shear testing was performed on representative samples to determine strength properties for structural analysis of the soils in the embankments. Test results are shown in the appendix of this report. All testing was conducted in accordance with procedures outlined in the ASTM Standard Methods.

3.0 General Site and Soil Conditions

The evaporation lagoons are located at the southern edge of a broad valley formed as the result of the weathering of relatively soft shales (mudstones and siltstones) of the Petrified Forest Member of the Chinle Formation. These siltstones and mudstones of the Chinle have a high montmorillonite clay content. As a result the soils that have developed at the site are comprised of clays of moderate to high plasticity. All boring and soundings indicate the embankments have been constructed of clay taken from the valley floor. The embankments are founded on the native clays of the valley floor.

The Chinle Formation serves as the bedrock formation at this site. Generally, the formation dips to the north-northwest at approximately three (3) degrees. At the southerly edge of the lagoons the formation was encountered at approximately fifteen (15) feet below the natural ground elevation. At the northerly side of the lagoon site the formation has been encountered in past studies at a depth on the order of sixty (60) feet.

Groundwater was not encountered in any of the embankments. The only groundwater that was encountered during the investigation was a boring eight (8). This location is at the extreme southerly edge of the valley floor. During the drilling the groundwater was encountered at a depth of eighteen

(18) feet below the top of the berm. After twenty-four hours the water level had risen to slightly greater than six (6) feet below the boring elevation (top of the containment berm). At that location the berm height is approximately five (5) feet in height, making the water level approximately one (1) foot below the toe of the embankment. It should be noted that no free water was encountered during the drilling of boring eight (8) until the eighteen (18) foot depth. At that depth a water bearing sandy layer approximately two (2) feet in thickness was encountered. This sandy zone immediately overlies the Chinle Formation. The mudstone of the Chinle Formation is not water bearing. The sandy zone is a confined water bearing zone that is artesian. Nearly every boring that has been drilled to the undisturbed Chinle Formation at the Ciniza site has penetrated this overlying sand zone. The zone serves as an excellent marker for the top of the Chinle. There is no evidence of water migration at this location, or the other investigation locations, which can be attributed to leakage from the ponds.

4.0 Analysis

Thirteen (13) sections through the exterior embankments have been analyzed for stability. Both interior as well as exterior stability of the embankments has been checked. Because the interior height of the embankments are low, factors of safety for the interior slopes are very high. The controlling failure mechanism is associated with the geometry of the exterior slope (the slope that defines the outside or nonwetted face of the lagoon group).

The analyses demonstrate that the berms are structurally stable. Factors of safety against failure for the sections analyzed range from a high of 10.0 to a low of 2.5. Typical minimum desirable factors of safety for this type of structure are in the range of 1.3 to 1.5. As mentioned previously the embankments were evaluated using the method of slices (Bishop's Modified Method) as well as finite element evaluation. A computer program developed by the New York State Highway Department named SLOPES was used to evaluate the berms with Bishop's Modified Method. A program developed at the Colorado School of Mines, Geomechanics Research Center by D. V. Griffiths was used to perform the finite element evaluation. The program, named SLOPE1 is well documented in the book "Programming the Finite Element Method" by I. M. Smith and D. V. Griffiths. Plots of the finite element (FE) mesh, deflection data, and vector traces of the deflected mesh were made using a separate plotting program and are presented in the appendix of this report. The deflected mesh graphically shows the result of the FE analysis at the most critical factor of safety identified. There was excellent correlation between the two analysis types where a circular failure provided the critical factor of safety.

The program SLOPES forces a circular failure where the FE program evaluates translation of nodes of the finite element mesh. The finite element program in this respect provides a more critical evaluation of the failure mode. It may be seen with the FE program that although the higher embankments show the critical failure mode to be a circular failure, the lower embankments tended to identify settlement as a more likely failure mode. The observation is somewhat academic, however, since the associated factors of safety against failure are 2.5 at the worst. Structurally, the berms are sound.

The soils comprising the embankments were tested to evaluate their propensity for being dispersive. Pinhole dispersion testing was performed on the materials in the constructed embankments. The soils were found to be in the category of nondispersive. Piping failure is unlikely to occur in the exterior containment embankments.

5.0 Observations and Recommendations

5.1 Wave Damage

A visual examination of the ponds was performed as a portion of the field investigation. Notes made during the field observation indicated there is no obvious structural failure that is occurring on the embankments. It was noted, however, that although the lagoon depth tended to not exceed two to three feet in total depth substantial wave erosion is occurring on the interior portion of the exterior containment embankments. Similarly, wave erosion is occurring along the interior pond separation dikes. Some, generally minor, erosion is occurring on the exterior faces of the perimeter containment berms.

A conscientious effort of embankment maintenance will easily control the exterior erosion of the containment berms. Although continual maintenance of the interior wave damage on the outside containment berms could also be made, over time significant pond volume loss would be realized as material is continually added to the interior of the lagoons at wave damage locations. It is recommended that a more permanent interior wave energy dissipation system be considered.

Wave damage may be reduced by plating the active wave areas with nonerosive material such as rock, grout blankets, or similar materials. If rock is selected at this site it should be placed on a geogrid material such as Tensar®, in Maccaferri® Reno Mattresses, or similar geotextile materials. These materials will prevent the rock from sinking into the soft soils or sliding off the slope where it will be ineffective against wave damage. It is recommended that wave protection be placed such that it extends from the top of the embankment to a minimum of twenty-four (24) inches below the lowest water level.

Where twenty four (24) inches extends below the bottom of the interior slope elevation, the slope protection material should key into the bottom of the lagoon impoundment a minimum of eight (8) inches. Because the lagoons are used as evaporation ponds the slope protection will likely be required on the entire interior face of the outside containment lagoons. Because of the lack of high quality aggregates in the Gallup area, rip-rap type energy dissipation, although permanently effective, will be costly to install.

An alternate wave protection system involves dissipation of the wave energy prior to reaching the embankment berms. Such systems involve the use of geogrids, fabrics, or liner materials constructed as a fence approximately three (3) to five (5) feet away from the wave impact area of the containment berms. It is the intent that these materials reflect or dissipate the majority of the wave energy prior to reaching the embankment material. Floating systems have also been used to reduce minor wave action. Materials such as partially submerged plastic drums have been successfully used to reduce the effects of wave action. These systems should be used to protect interior pond separation dikes as well as the exterior containment berms.

Should Giant Refining Company require assistance in design of these systems or require design review, Precision Engineering, Inc. can assist as required.

5.2 Berm Height

It was noted during the visual inspection that at some locations the impounded water level was within one (1) foot of the containment berm crest elevation. Should an interior dike be breached or high winds cause large waves the exterior containment dike could easily be overtopped. It is strongly recommended that the elevation of the water or the elevation of the exterior berms be adjusted such that the high water mark is a minimum of two (2) feet below the exterior containment berm elevation. It is further recommended that the two (2) feet of freeboard be extended to include the interior pond separation dikes as well. Should the interior dikes be breached the most westerly exterior containment dikes could be overtopped.

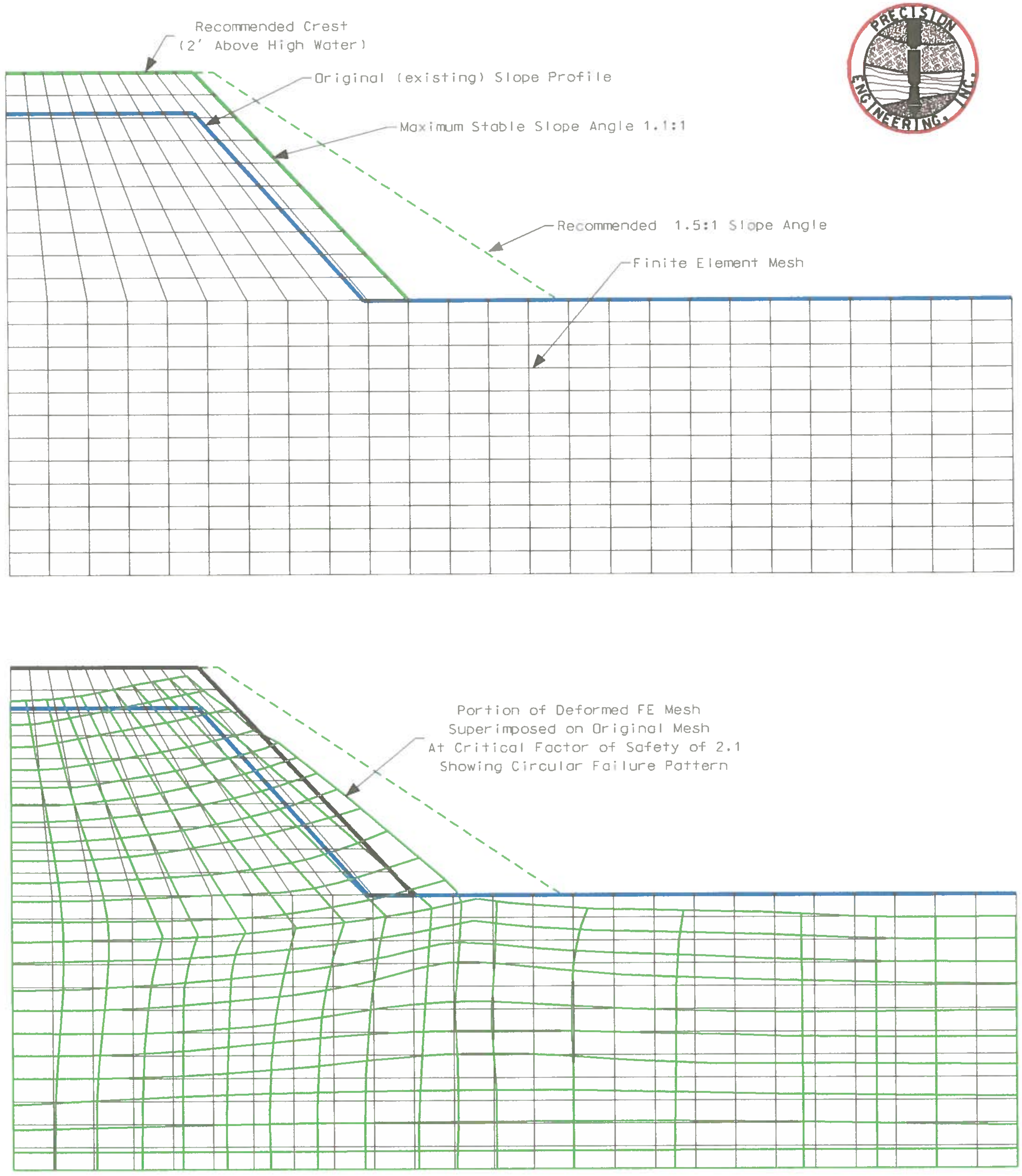
Analysis indicates that when the elevation of the top of the outside containment berms are elevated approximately two (2) feet the minimum factor of safety against failure is 2.1. This minimum critical section is represented by Section 12 on the west side of the ponds (see boring plan). The failure mechanism and associated factor of safety is illustrated in Figure 2.

It is recommended that the berm elevations be adjusted to be two (2) feet above the maximum anticipated water level elevation. It is recommended that the minimum width of the top of the containment berms be ten (10) feet. For structural stability, the side slopes of the berms should not exceed their present slope angle after the addition of material to raise the crest elevation. It is recommended, however, that the slope angles not exceed an angle having a horizontal to vertical ratio of 1.5:1. This typically flatter slope angle will resist the development of erosion channels on the exterior face of the berms.

Soils placed to adjust the elevation of the berm crests were analyzed assuming that the material would be taken from the valley floor near the ponds. Based on material properties evaluated on other projects at the site, the soils may be taken from essentially any location on the Ciniza Refinery property. Soils imported to the site should be evaluated for stability. Soils taken from the Ciniza property may be

Figure 2 - Section 12

Critical Section and Failure Mechanism After Elevating and Reshaping Containment Berms



taken from the "Rattlesnake" pit area or the pit used by the NMSH&TD located east of pond 9. It is recommended that material not be taken from an area within twenty feet of the final berm toe points. It is recommended that the proposed borrow material be tested for strength properties by unconsolidated, undrained triaxial shear before being approved as fill material for the containment berms.

Soil placed on the berms should be keyed into the berms to provide the maximum strength. The side slopes of the existing embankments should be benched to create a horizontal surface for fill construction. This will provide structural interlock with the existing material. All new fill should be placed and compacted in lifts on the benched surfaces. Keys should be cut in the excavated slope to form horizontal benches as nearly level as is reasonable. Each bench should not exceed thirty-six (36) inches in elevation change to avoid stress concentrations within the fill. Bench cut faces may be sloped steeply to facilitate compaction adjacent to the cut face.

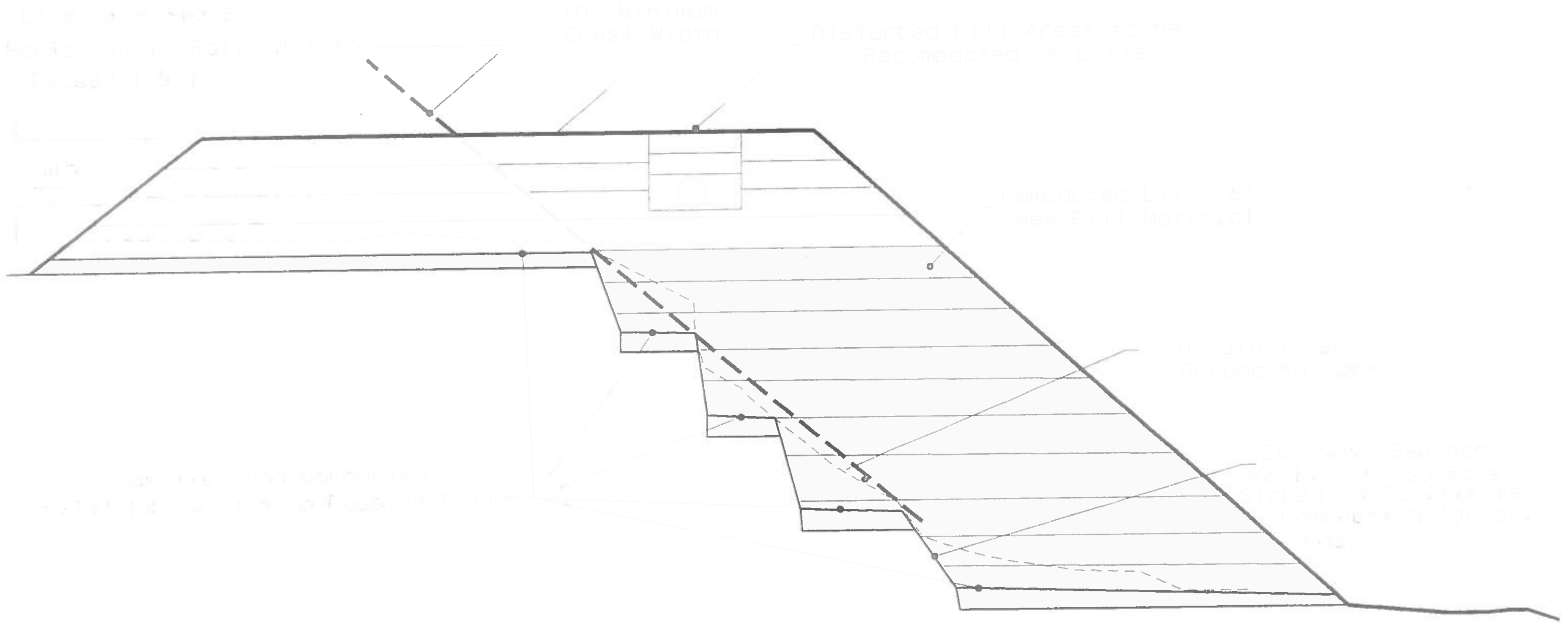
Fill should be placed and compacted beginning at the slope toe and progress to the top of the berm to allow for a more homogeneous new fill section. The berm will be more stable if the new slope section is constructed prior to adding height to the berms. The intent of this recommendation is illustrated in Figure 1.

New fill should be placed on existing material that has been properly prepared to receive material. The existing surface should be cleared and grubbed to remove any organic debris and oversized material. Oversized material consists of rocks or soil lumps that exceed six (6) inches in maximum dimension. The standard proctor test (ASTM D-698) should be used as the reference unit weight because the test results provide a more flexible structure that resists cracking during any potential deformation. The prepared surface should be scarified eight (8) inches and compacted to a minimum of 95% of Standard Proctor unit weight.

Figure 1

General Fill Placement on Existing Slopes

nts



New fill soils should be processed to bring them to a moisture content approximately two (2) percent above optimum moisture content. Compaction at this moisture content will minimize the hydraulic conductivity of the lift after compaction. Under no conditions shall fill material contain vegetative or other organic debris. The fill soils should be placed and compacted in uniform lifts not to exceed eight (8) inches in compacted thickness. The soils should be compacted using pad wheeled or sheepsfoot type equipment to provide better lift interlock and minimize the potential for providing a hydraulic conduit between lifts. The new fill soils should be compacted to a minimum of 100% of Standard Proctor (ASTM D-698) unit weight.

6.0 Summary

Analysis as and visual inspection of the exterior containment berms and interior lagoon separation dikes has provided the following conclusions and recommendations:

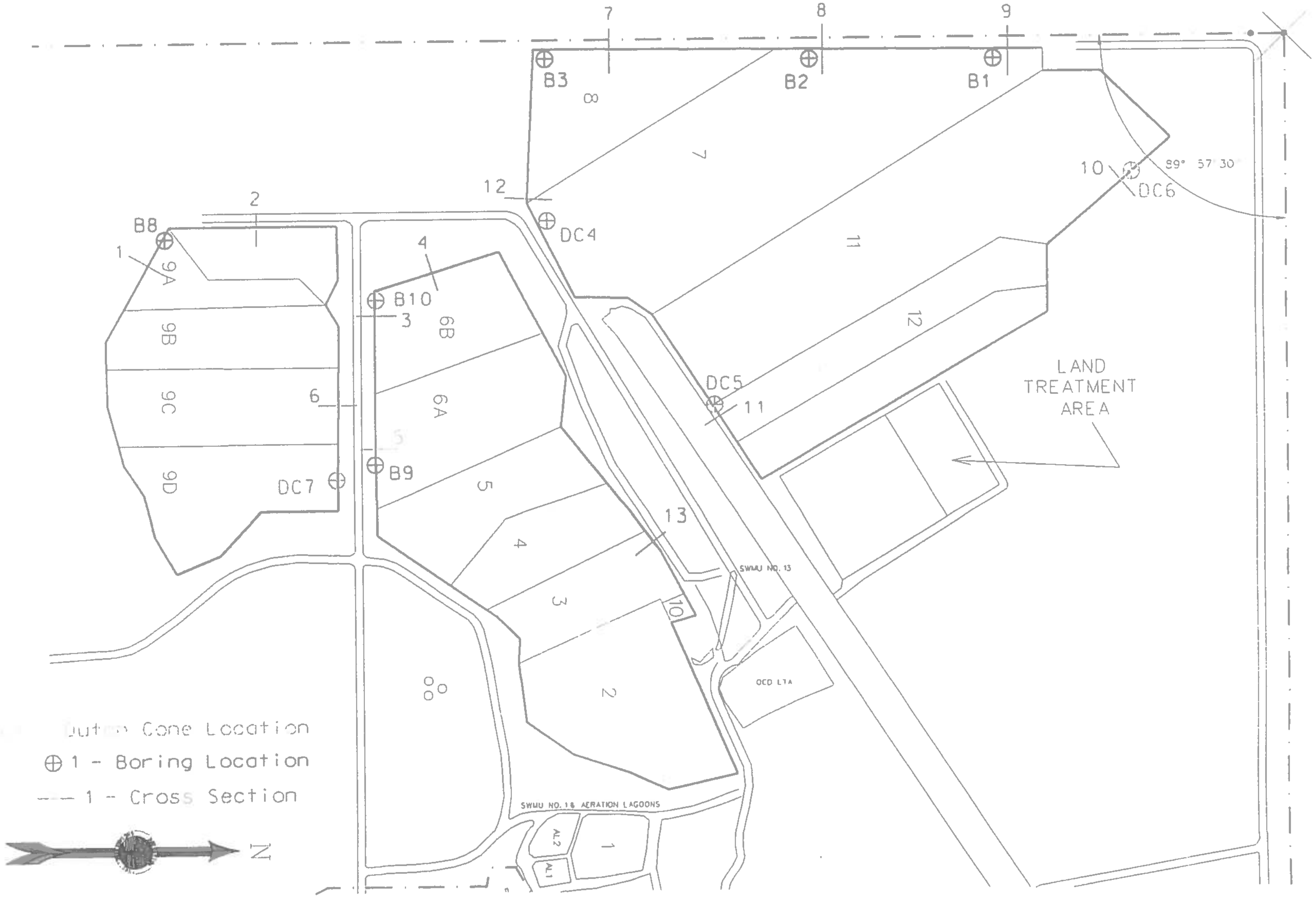
- The containment berms are structurally stable.
- There is little potential for a piping type failure through the lagoon containment berms.
- No water was detected leaking through or below the containment berms that could cause a stability or surface contamination problem.
- The interior slopes of the containment berms and lagoon separation dikes are susceptible to wave erosion. It is recommended that positive wave energy abatement systems be placed or that a continuous interior lagoon maintenance program be established. The maintenance program will likely cause substantial loss of lagoon life and wave abatement is recommended.
- The containment berms are susceptible to overtopping because of a lack of free board. It has been recommended that the berm heights be adjusted to allow for a minimum of two (2) feet of

free board above the maximum anticipated water level. Recommendations for fill placement have been provided. The freeboard area should be protected from erosion degradation.

APPENDIX

PRECISION ENGINEERING, INC.

Giant Refining Company
Ciniza Refinery Evaporation Ponds
Boring Plan



Sheet: 1 OF 10

PRECISION ENGINEERING, INC.

File #: 00-141

Bore Point: SEE SITE PLAN

LOG OF TEST BORINGS

Site: CINIZA

Water Elev: NOT ENCOUNTERED

Elevation: EXISTING

Boring No.: ONE

Date: DECEMBER 06, 2000

LAB #	DEPTH	BLOW COUNT	PLOT	SCALE	SAMPLES	MATERIAL CHARACTERISTICS (MOISTURE, CONDITION, COLOR, GRAINSIZE, ETC.)	%M	L	PI	CLASS.
38625	0.0 - 1.5	4-5-6	//////		SSSS	**CLAY**, REDDISH BROWN, WET, FIRM	25.5		NP	SM/A-2-4
			//////	2.5						
			//////	5.0						
38626	5.0 - 6.5	6-6-6	//////		SSS	STIFF	21.7	47	25	CH/A-7-6
			//////	7.5						
			//////	10						
38627	10.0-11.5	4-5-6	//////		SSS	FIRM	22.5			
	14.5		//////							
38628	15.0-16.5	12-16-23	//-///	15	SSS	**CLAY**, SLIGHTLY SILTY, REDDISH BROWN, MOIST, HARD	13.2	53	33	CH/A-7-6
			//-///	20						
38629	20.0-21.5	7-15-19	//-///		SSS	SOME SILT LAMANAE	12.0			
	21.5 TOTAL DEPTH									

Size & Type of Boring: 8-1/4" ID Hollow Stemmed Auger

Logged By: WHK

Sheet: 2 OF 10

PRECISION ENGINEERING, INC.

File #: 00-141

LOG OF TEST BORINGS

Bore Point: SEE SITE PLAN
WEST DYKE CENTER

Water Elev: NOT ENCOUNTERED

Boring No.: TWO

Site: CINIZA

Elevation: EXISTING

Date: DECEMBER 06, 2000

LAB #	DEPTH	BLOW COUNT	PLOT	SCALE	SAMPLES	MATERIAL CHARACTERISTICS (MOISTURE, CONDITION, COLOR, GRAINSIZE, ETC.)	%M	L	PI	CLASS.
38630	0.0 - 1.5	3-3-3	/*/*/*		S	**CLAY**, VERY SANDY, REDDISH BROWN, WET, SOFT	26.3	30	10	CL/A-4
			/*/*/*		S					
			/*/*/*		S					
			/*/*/*							
			/*/*/*	2.5						
			/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*	5.0						
38631	5.0 - 7.0	SHELBY	/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*							
38632	7.0 -10.0	SHELBY	/*/*/*	7.5						
			//////			NO SAND	33.0			
			//////							
			//////							
			//////							
			//////	10						
			//////							
			//////							
			//////							
			//////							
			//////							
	13.0		//////							
			//*///			**CLAY**, SLIGHTLY SANDY, REDDISH BROWN, MOIST,				
			//*///			HARD				
			//*///							
			//*///	15						
38633	15.0-16.8	SHELBY	//*///							
			//*///							
	16.8		//*///							
	TOTAL DEPTH									
				20						

Size & Type of Boring: 8-1/4" ID Hollow Stemmed Auger

Logged By: WHK

Sheet: 3 OF 10

PRECISION ENGINEERING, INC.

File #: 00-141

LOG OF TEST BORINGS

Bore Point: SOUTHWEST CORNER OF POND 8

Water Elev: NOT ENCOUNTERED

Boring No.: THREE

Site: CINIZA

Elevation: EXISTING

Date: DECEMBER 06, 2000

LAB #	DEPTH	BLOW COUNT	PLOT	SCALE	SAMPLE	MATERIAL CHARACTERISTICS (MOISTURE, CONDITION, COLOR, GRAINSIZE, ETC.)	%M	L	PI	CLASS.
38634	0.0 - 1.5	3-3-5	//*///		S	**CLAY**, SLIGHTLY SANDY(FINE), REDDISH BROWN,	15.8	50	36	CH/A-7-6
			//*///		S	MOIST, FIRM				
			//*///		S					
			//*///							
			//*///	2.5						
			//*///							
			//*///							
			//*///							
			//*///							
			//*///	5.0						
38635	5.0 - 6.5	3-4-3	//////		S	LITTLE TO NO SAND, WET	30.2			
			//////		S					
			//////		S					
			//////							
			//////	7.5						
			//////							
			//////							
			//////							
			//////							
			//////	10						
38636	10.0-11.5	4-4-6	//////		S		31.1	79	41	CH/A-7-5
			//////		S					
			//////		S					
			//////							
			//////							
			//////							
			//////							
			//////							
			//////							
			//////	15						
38637	15.0-16.5	4-6-9	//////		S		28.4			
			//////		S					
			//////		S					
			//////							
			//////							
			//////							
			//////							
			//////							
			//////							
			//////	20						
38638	20.0-21.5	7-15-21	//*///		S	SLIGHTLY SANDY, HARD	30.8	60	34	CH/A-7-6
			//*///		S					
			//*///		S					
	TOTAL DEPTH									

Size & Type of Boring: 8-1/4" ID Hollow Stemmed Auger

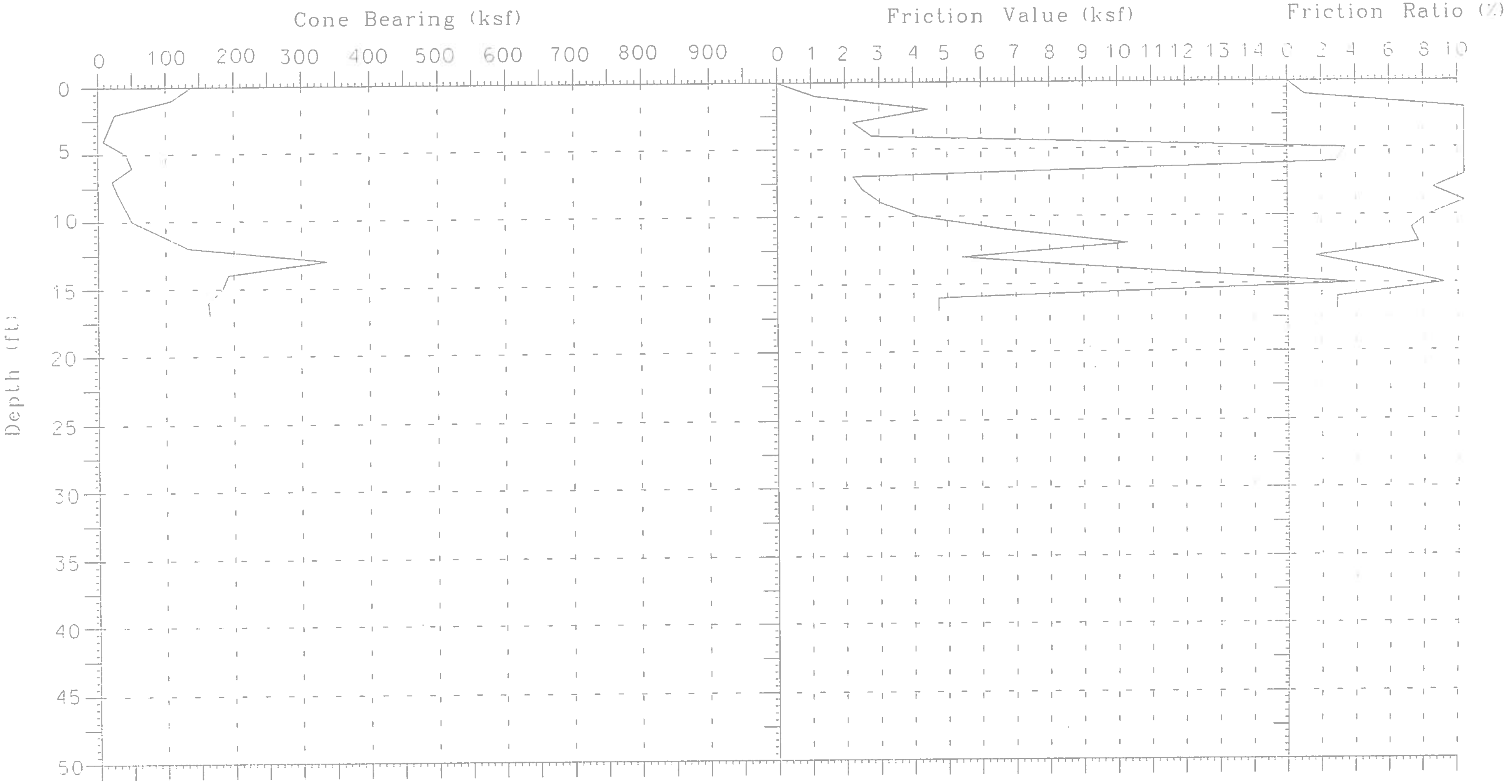
Logged By: WHK

Quasi-Static Penetration Sounding Log

ASTM D-3441

Project Location: CINIZA EVAPORATION PONDS
Sounding Date: December 6, 2000
Project Number: 00-141

Sounding Number: 4
Sounding Location: see plan

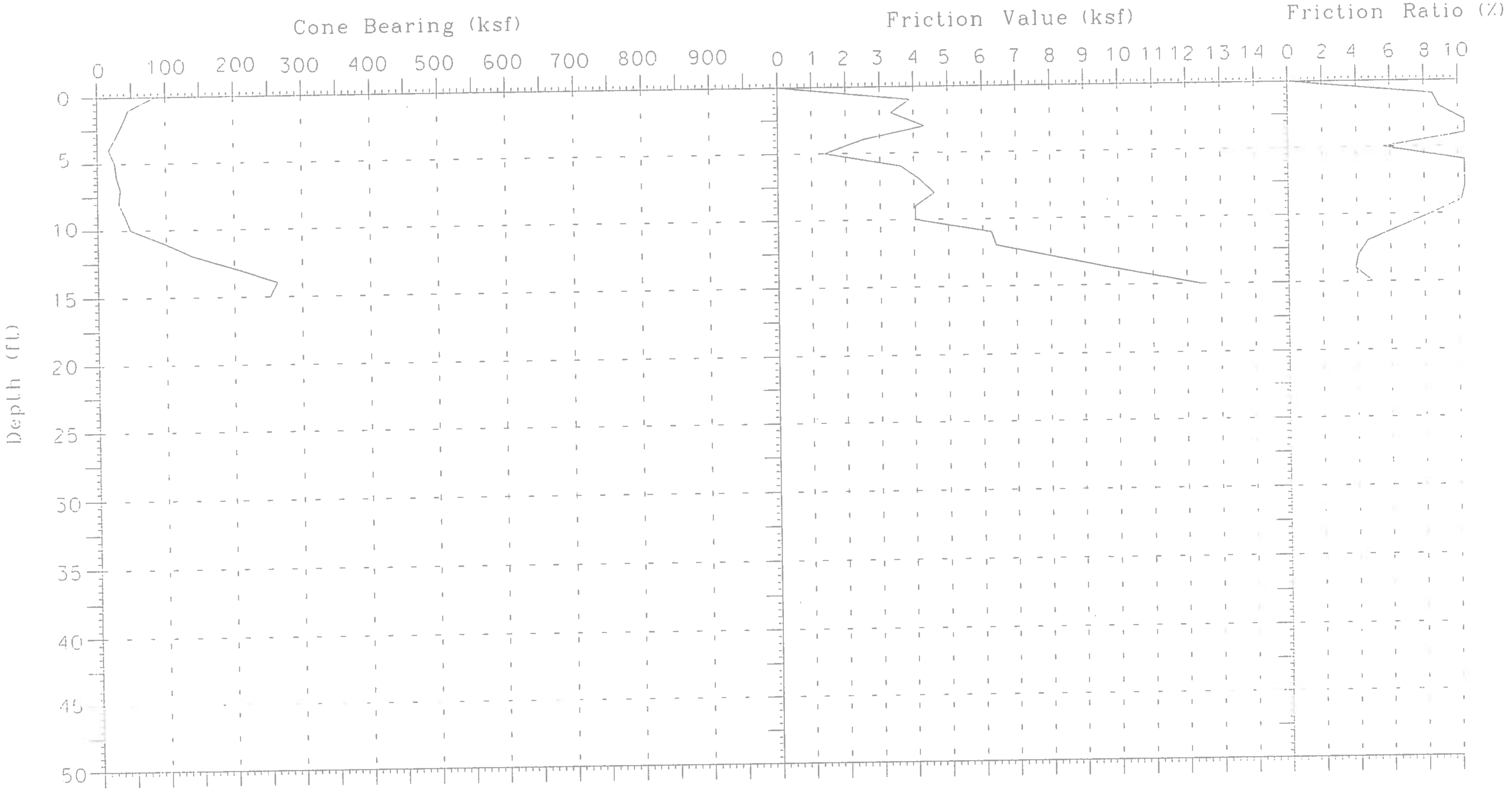


Quasi-Static Penetration Sounding Log

ASTM D-3441

Project Location: CINIZA EVAPORATION PONDS
Sounding Date: December 7, 2000
Project Number: 00-141

Sounding Number: 5
Sounding Location: see plan

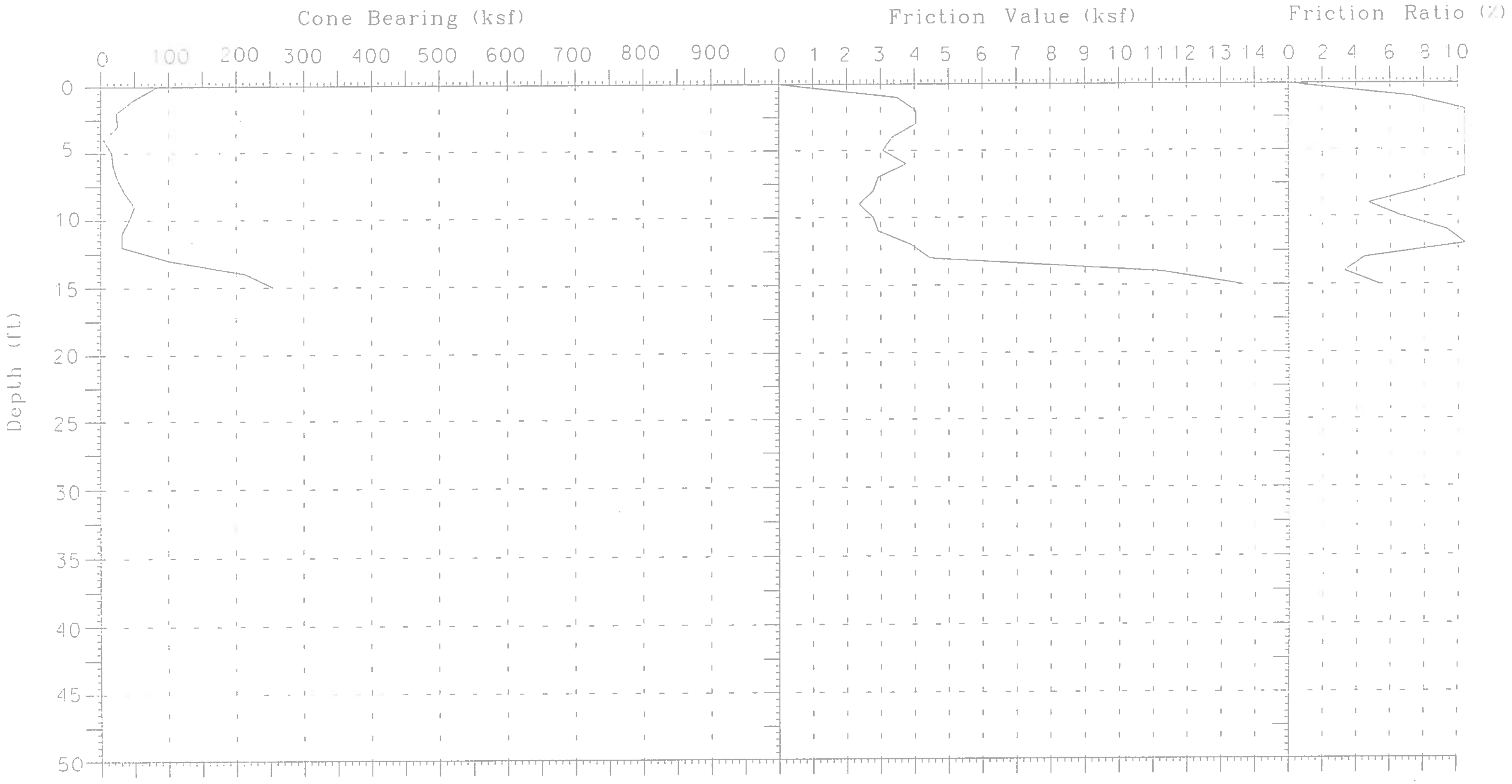


Quasi-Static Penetration Sounding Log

ASTM D-3441

Project Location: CINIZA EVAPORATION PONDS
Sounding Date: December 7, 2000
Project Number: 00-141

Sounding Number: 6
Sounding Location: see plan

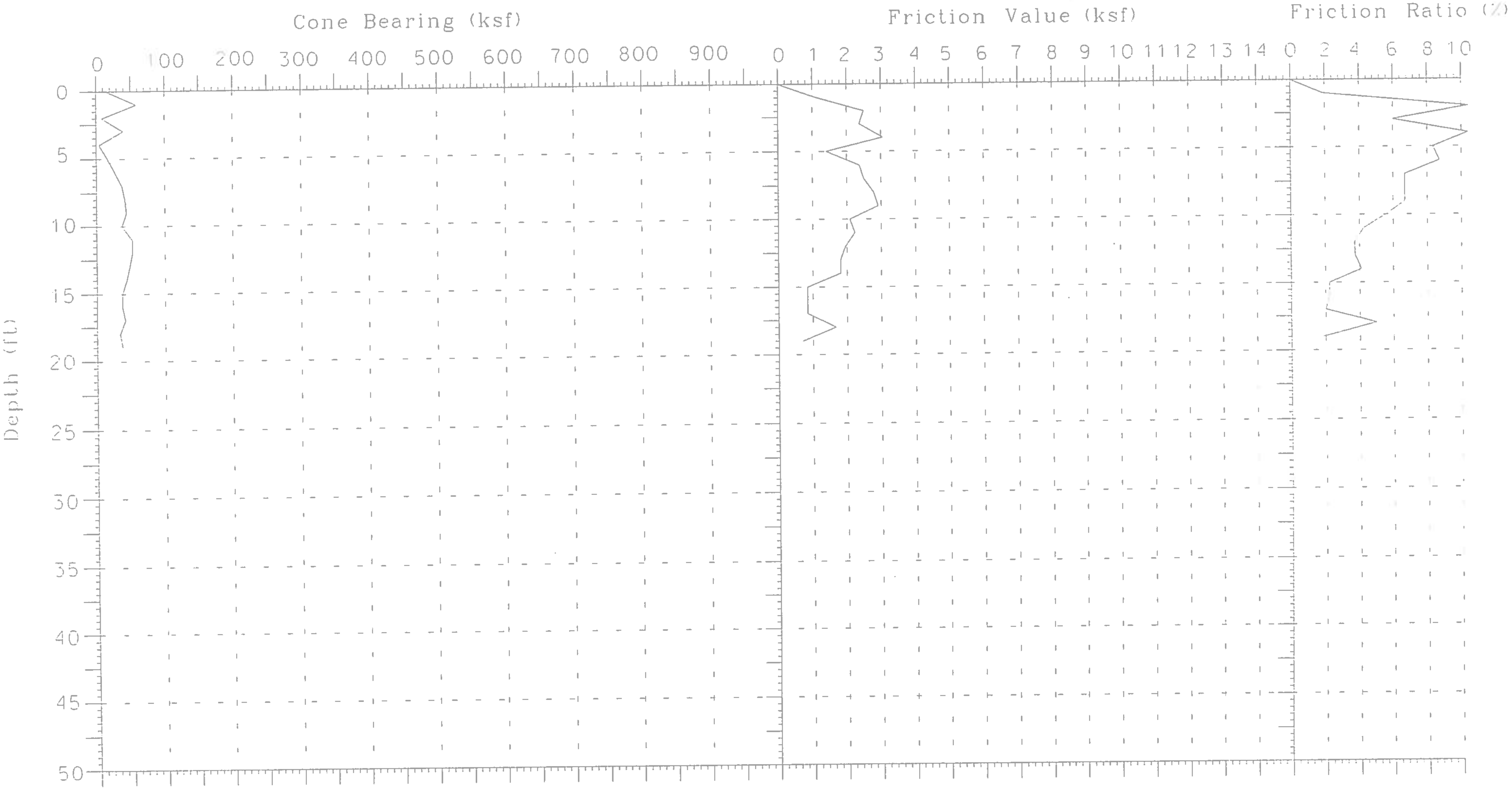


Quasi-Static Penetration Sounding Log

ASTM D-3441

Project Location: CINIZA EVAPORATION PONDS
Sounding Date: December 7, 2000
Project Number: 00-141

Sounding Number: 7
Sounding Location: see plan



Sheet: 8 OF 10

PRECISION ENGINEERING, INC.

File #: 00-141

LOG OF TEST BORINGS

Bore Point: SOUTHWEST CORNER OF POND 9A

Site: CINIZA

Water Elev: 18'

Elevation: EXISTING

Boring No.: EIGHT

Date: DECEMBER 07, 2000

LAB #	DEPTH	BLOW COUNT	PLOT	SCALE	SAMPLE	MATERIAL CHARACTERISTICS (MOISTURE, CONDITION, COLOR, GRAINSIZE, ETC.)	%M	L	PI	CLASS.
38639	0.0 - 1.5	4-4-10	/*/*/*		S	**CLAY**, VERY SANDY(FINE), REDDISH BROWN, WET,	23.1	50	36	CH/A-7-6
			/*/*/*		S	STIFF				
			/*/*/*		S					
			/*/*/*							
			/*/*/*	2.5						
			/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*	5.0						
38640	5.0 - 7.0	SHELBY	//////			LITTLE TO NO SAND SAND, FIRM				
			//////							
			//////							
			//////							
			//////	7.5						
			//////							
			//////							
			//////							
			//////							
			//////	10						
38641	10.0-11.5	3-5-6	//*///		S	SLIGHTLY SANDY	32.2	79	41	CH/A-7-5
			//*///		S					
			//*///		S					
			//*///							
			//*///							
			//*///							
			//*///							
			//*///							
			//*///							
			//*///	15						
38642	15.0-16.5	3-5-5	/*/*/*		S	VERY SANDY	20.1			CH/A-7-6
			/*/*/*		S					
			/*/*/*		S					
			/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*			WATER BEARING AT 18', WATER RISES TO 6'2"				
			/*/*/*			AFTER 24-HOURS AND STABILIZES				
			/*/*/*							
			/*/*/*	20						
38643	20.0-21.2	0-	/*//*/		S	SANDY	24.7	60	34	
		0-	/*//*/		S					
	21.2-21.5	6	/*//*/		S	**MUDSTONE**, REDDISH BROWN W/SOME GREEN MOTTLING,				
	TOTAL DEPTH					DRY, HARD				

Size & Type of Boring: 8-1/4" ID Hollow Stemmed Auger

Logged By: WHK

Sheet: 9 OF 10

PRECISION ENGINEERING, INC.

File #: 00-141

Bore Point: CENTER OF SOUTH SIDE
OF POND 6A

LOG OF TEST BORINGS

Site: CINIZA

Water Elev: NOT ENCOUNTERED

Elevation: EXISTING

Boring No.: NINE

Date: DECEMBER 07, 2000

LAB #	DEPTH	BLOW COUNT	PLOT	SCALE	SAMPLE	MATERIAL CHARACTERISTICS (MOISTURE,CONDITION,COLOR,GRAINSIZE,ETC.)	%M	L	PI	CLASS.
38644	0.0 - 3.0	GRAB	/*/*/*		G	**CLAY**, VERY SANDY, REDDISH BROWN, MOIST, FIRM	14.0	41	25	CL/A-4
			/*/*/*		G					
			/*/*/*		G					
			/*/*/*		G					
			/*/*/*	2.5	G					
			/*/*/*		G					
			/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*	5.0						
38645	5.0 - 7.0	SHELBY	/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*							
			/*/*/*	7.5						
			//////							
			//////							
			//////							
			//////							
			//////	10						
			//////							
			//////							
			//////							
			//////							
38646	12.0-14.0	GRAB	//////		G	WET	27.4			
			//////		G					
			//*///		G					
			//*///		G					
			//*///							
			//*///	15						
38647	15.0-16.0	SHELBY	//*///							
			//*///							
38648	16.0-17.0	SHELBY	//*///			SOFT				
	17.0									
	TOTAL DEPTH									
				20						

Size & Type of Boring: 8-1/4" ID Hollow Stemmed Auger

Logged By: WHK

Sheet: 10 OF 10

PRECISION ENGINEERING, INC.

File #: 00-141

Bore Point: SOUTHWEST CORNER OF
POND 6B

LOG OF TEST BORINGS

Site: CINIZA

Water Elev:

Elevation: EXISTING

Boring No.: TEN

Date: DECEMBER 07, 2000

LAB #	DEPTH	BLOW COUNT	PLOT	SCALE	SAMPLE	MATERIAL CHARACTERISTICS (MOISTURE,CONDITION,COLOR,GRAINSIZE,ETC.)	%M	L	PI	CLASS.
38649	0.0 - 3.0	GRAB	/*//*/		G	**CLAY**, SANDY, REDDISH BROWN, MOIST, FIRM	18.2	52	32	CH/A-7-6
			/*//*/		G					
			/*//*/		G					
			/*//*/		G					
			/*//*/	2.5	G					
			/*//*/		G					
			/*//*/							
			/*//*/							
			/*//*/							
			/*//*/	5.0						
38650	5.0 - 7.0	SHELBY	/*//*/			WET				
			/*//*/							
			/*//*/							
			/*//*/							
38651	7.0 - 10.0	GRAB	//////	7.5	G	LITTLE TO NO SAND, SOFTER AND REDDER 7' TO 10'	37.9	82	40	CH/A-7-5
			//////		G					
			//////		G					
			//////		G					
			//////		G					
			//////	10	G					
	10.0-13.0	GRAB	//////		G					
			//////		G					
			//////		G					
			//////		G					
			//////		G	WET				
			//////		G					
			//////		G					
			//////							
			//////							
			//////	15						
38652	15.0-17.0	SHELBY	//////			**CLAY**, REDDISH BROWN, WET, FIRM, SOME 1/2" ROOT				
			//////			MATTER				
			//////							
	17.0		//////							
	TOTAL DEPTH									
				20						

Size & Type of Boring: 8-1/4" ID Hollow Stemmed Auger

Logged By: WHK

PRECISION ENGINEERING, INC.
P. O. BOX 422,
LAS CRUCES, NEW MEXICO 88004
(505)523-7674

MECHANICAL GRAIN SIZE ANALYSIS SUMMARY

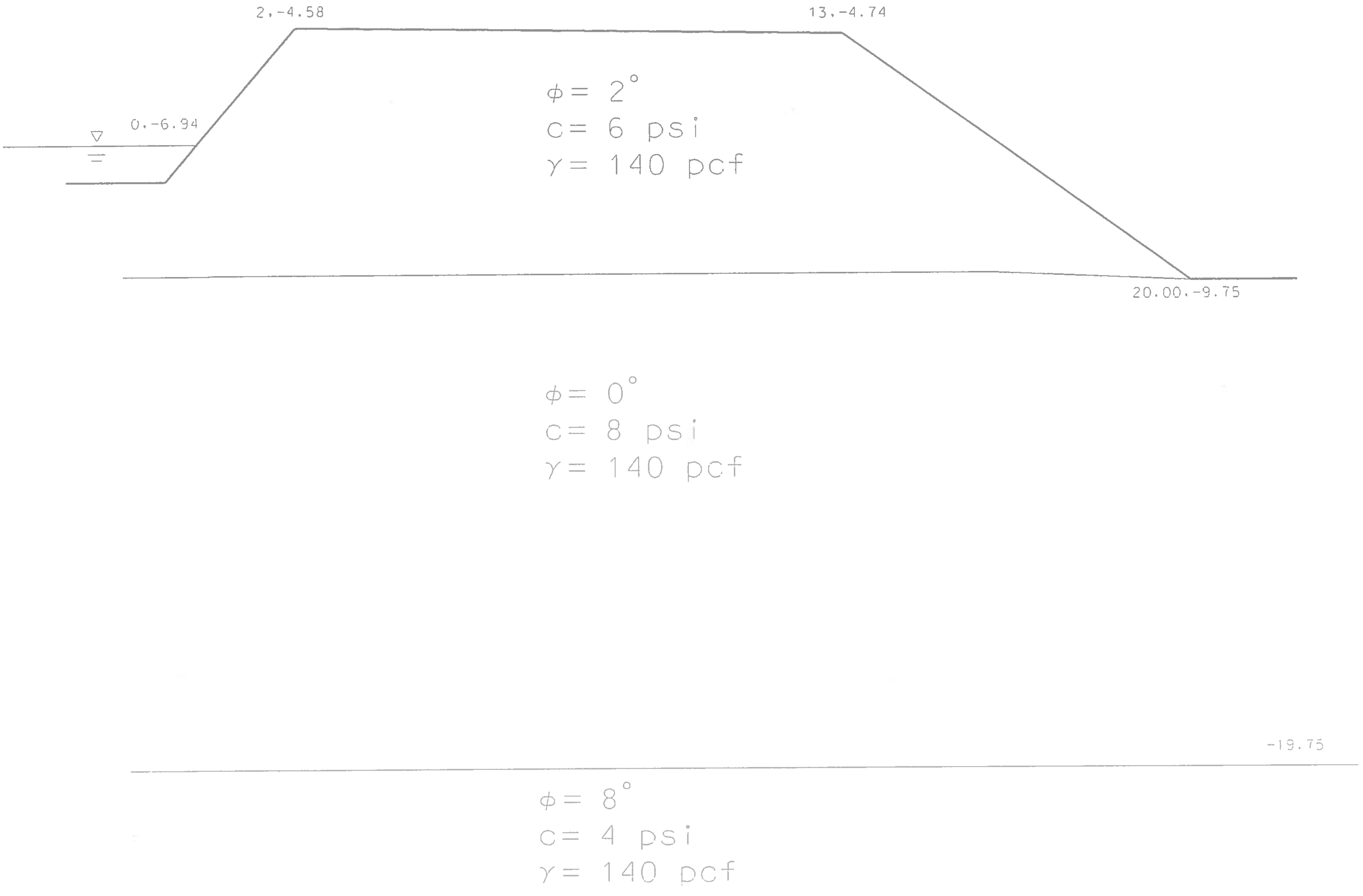
PROJECT: GIANT REFINING
CINIZA EVAPORATION PONDS
FILE NO: 00-141

LOCATION: CINIZA, NM
DATE: DECEMBER 06, 2000

BORING NO.	LAB NO.	DEPTH FEET		SIEVE ANALYSIS % PASSING												ATTERBERG LIMITS		MOIST. CONTENT	USCS CLASS.	AASHTO CLASS.
				1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	LL	PI			
1	38625	0.0- 1.5																25.5		
1	38626	5.0- 6.5													92.4	47	25	21.7	CL	A-7-6
1	38627	10.0-11.5																22.5		
1	38628	15.0-16.5													86.6	53	33	13.2	CH	A-7-6
1	38629	20.0-21.5																12.0		
2	38630	0.0- 1.5													59.3	30	10	26.3	CL	A-4
2	38631	5.0- 7.0																		
2	38632	7.0-10.0																33.0		
2	38633	15.0-16.8																		
3	38634	0.0- 1.5													83.2	50	36	15.8	CH	A-7-6
3	38635	5.0- 6.5																30.2		
3	38636	10.0-11.5													97.4	79	41	31.1	CH	A-7-5
3	38637	15.0-16.5																28.4		
3	38638	20.0-21.5													88.1	60	34	30.8	CH	A-7-6
8	38639	0.0- 1.5																23.1		
8	38640	5.0- 7.0																		
8	38641	10.0-11.5													85.2	72	42	32.2	CH	A-7-6
8	38642	15.0-16.5													61.6	42	19	20.1	CL	A-7-6
8	38643	20.0-21.2																24.7		
9	38644	0.0- 3.0													64.0	41	25	14.0	CL	A-7-6
9	38645	5.0- 7.0																		
9	38646	12.0-14.0																27.4		
9	38647	15.0-16.0																		
9	38648	16.0-17.0																		
10	38649	0.0- 1.5													64.7	52	32	18.2	CH	A-7-6
10	38650	2.5- 4.0																		
10	38651	5.0- 6.0													93.7	82	40	37.9	CH	A-7-5
10	38652	6.0- 6.5																		

Section 1

Factor Of Safety = 5.5

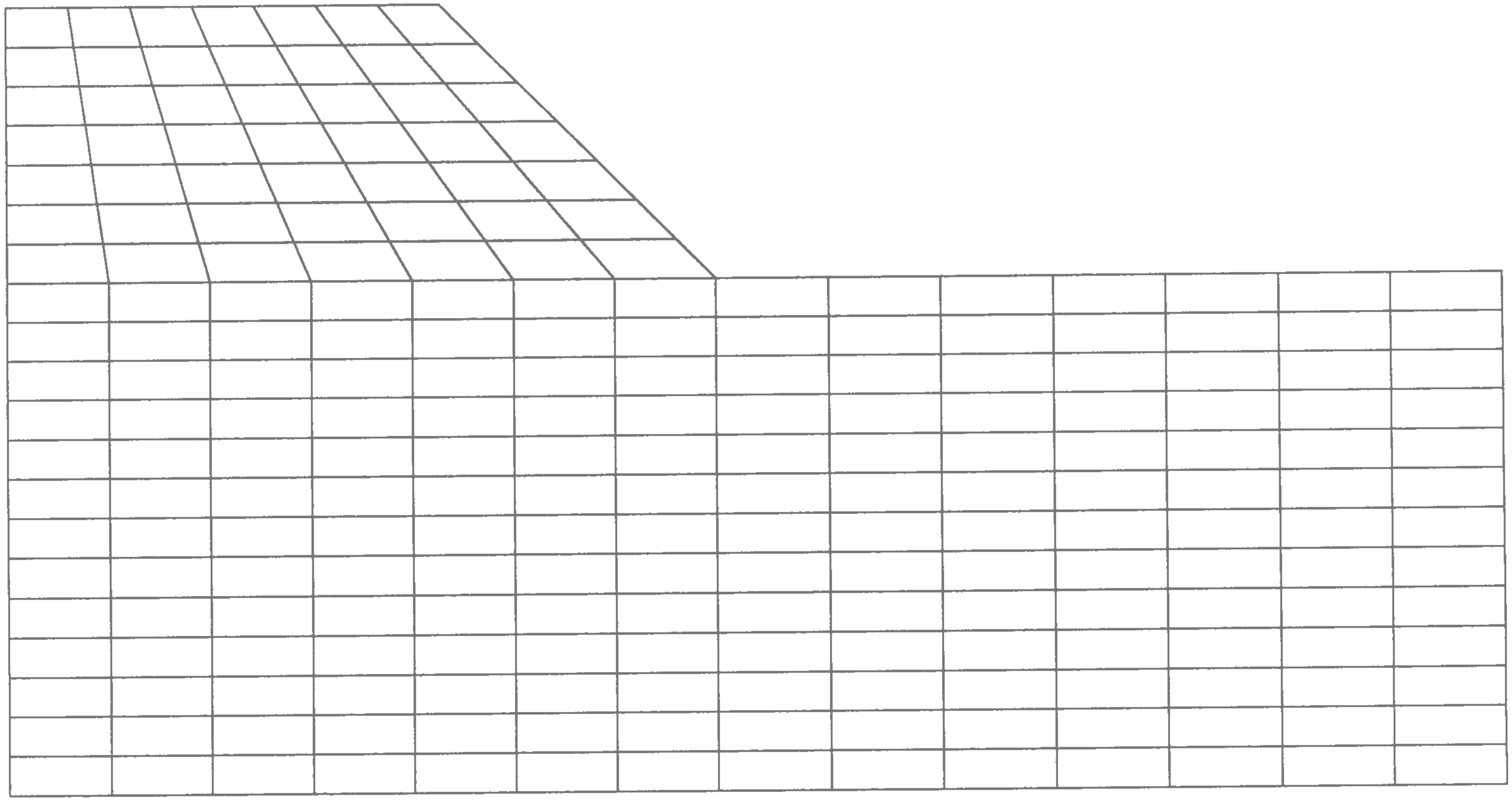


```
Section 1 Profile

w1=   11.00
s1=    7.00
w2=   20.00
h1=    7.00
h2=   13.00

nx1=    7
nx2=    7
ny1=    7
ny2=   13

Group  phi      c      psi   gamma      e          v
  1    2.00  864.00    0.00  140.00  0.1000E+06   0.30
  2    0.00 1152.00    0.00  145.00  0.1000E+06   0.30
  3    8.00  576.00    0.00  135.00  0.1000E+06   0.30

Property group assigned to each element
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   2   2   2   2   2   2   2
   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3

 tol=  0.000100
 limit= 1000

       trial factor    max displacement    iterations
       0.4500E+01      0.4536E+00              51
       0.5000E+01      0.4976E+00              74
       0.5250E+01      0.5456E+00             162
       0.5500E+01      0.2521E+01            1000
```

PRECISION ENGINEERING, INC.

Section 1

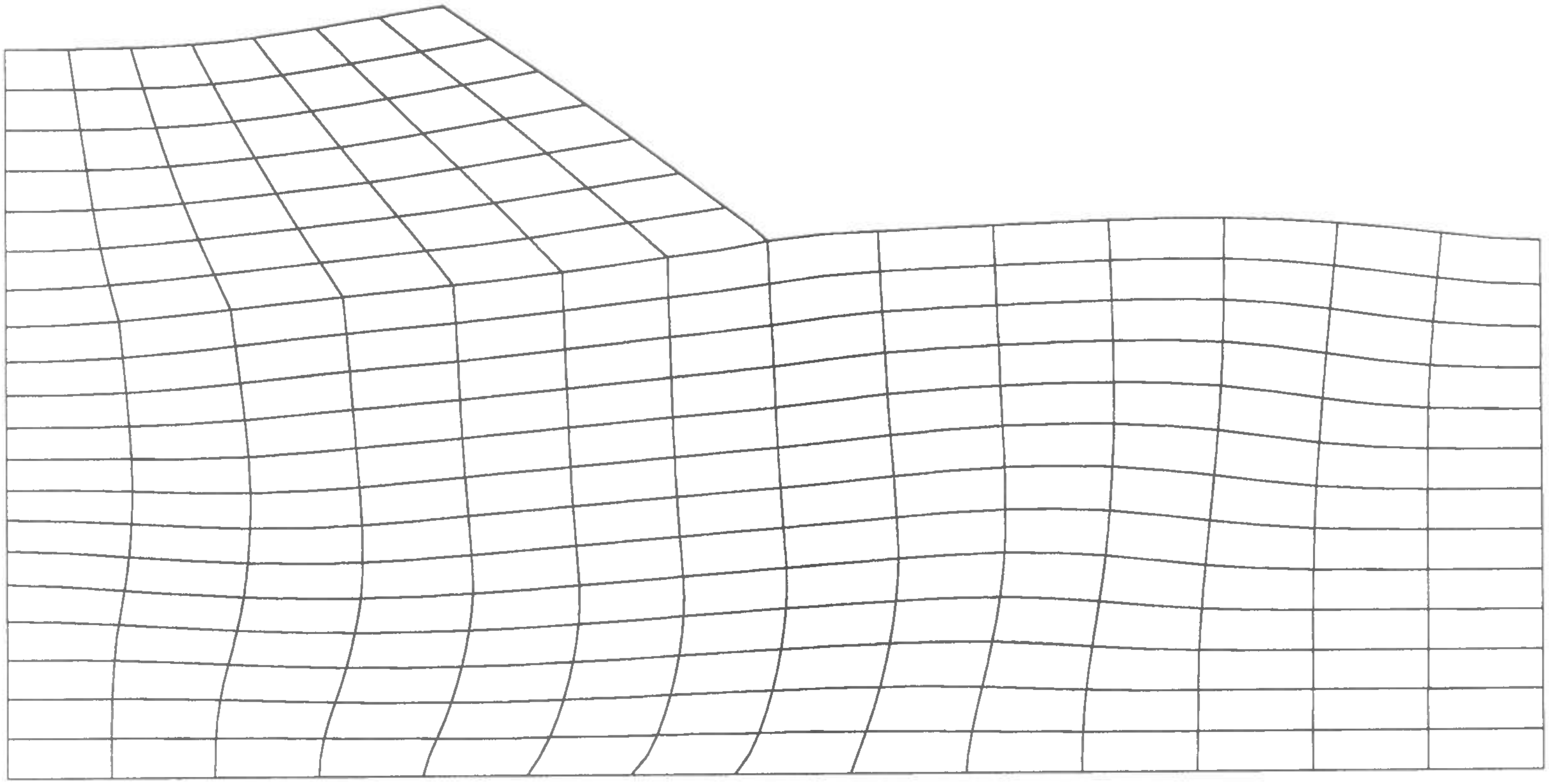
Mesh



PRECISION ENGINEERING, INC.

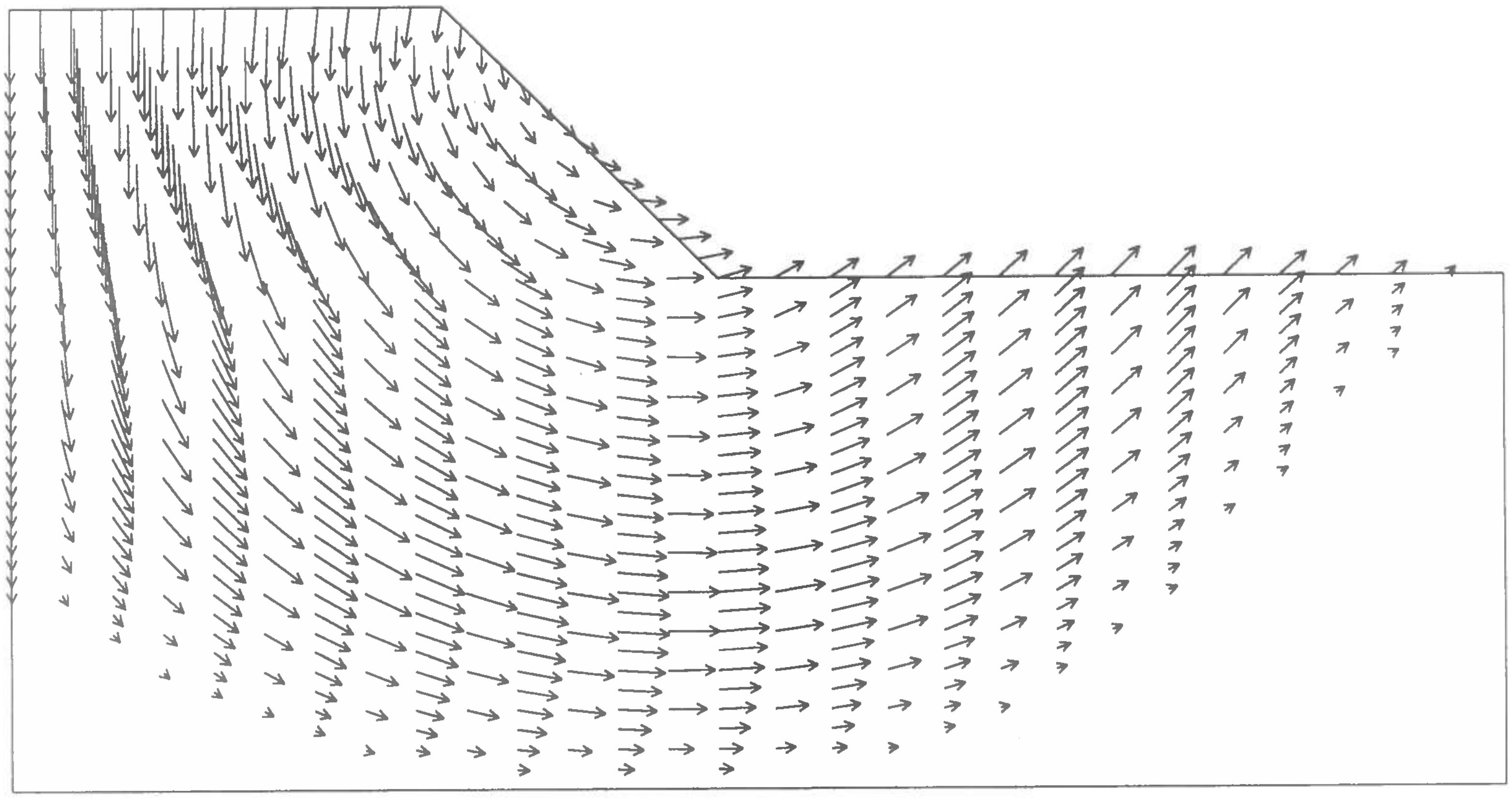
Section 1

Deformed Mesh



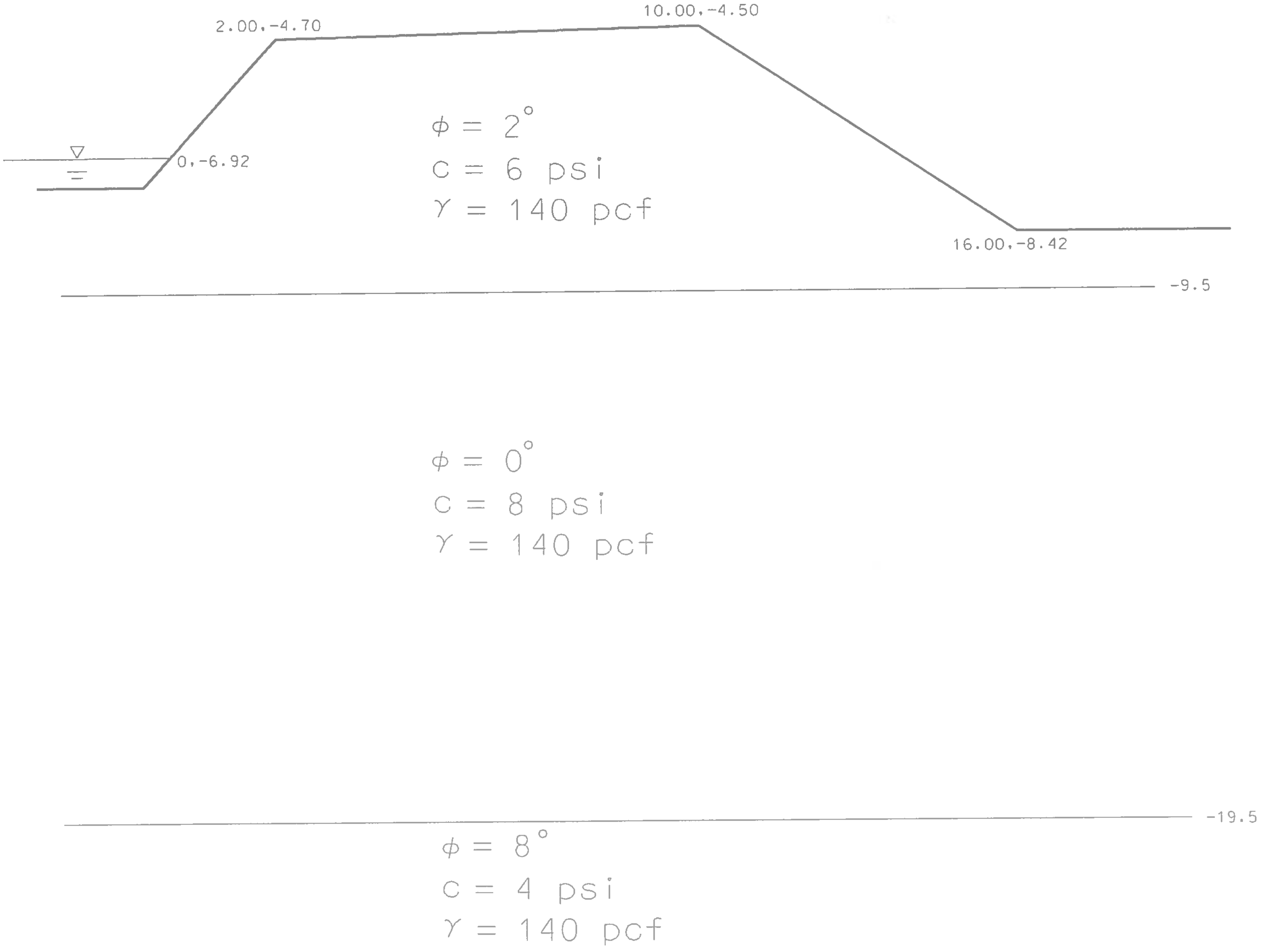
Section 1

Vector Trace



Section 2

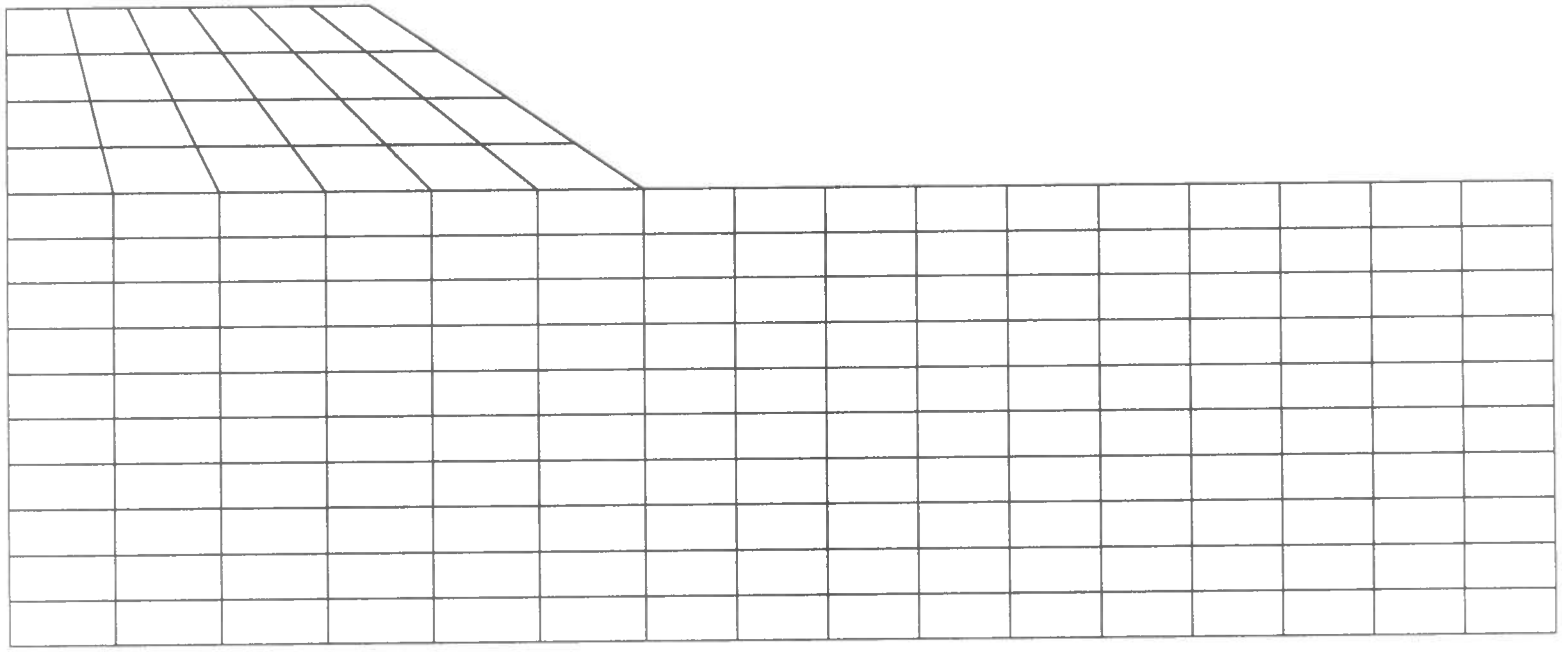
Factor Of Safety = 10.0



```
Section 2 Profile

w1=    8.00
s1=    6.00
w2=   20.00
h1=    4.10
h2=   10.00

nx1=    6
nx2=   10
ny1=    4
ny2=   10

Group  phi      c      psi    gamma      e          v
  1    2.00  864.00    0.00  140.00  0.1000E+06    0.30
  2    0.00 1152.00    0.00  145.00  0.1000E+06    0.30
  3    8.00  576.00    0.00  135.00  0.1000E+06    0.30

Property group assigned to each element
   1   1   1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2

tol=  0.000100
limit= 1000

      trial factor    max displacement   iterations
      0.9000E+01      0.2518E+00            83
      0.9500E+01      0.2638E+00           182
      0.1000E+02      0.3798E+00          1000
```

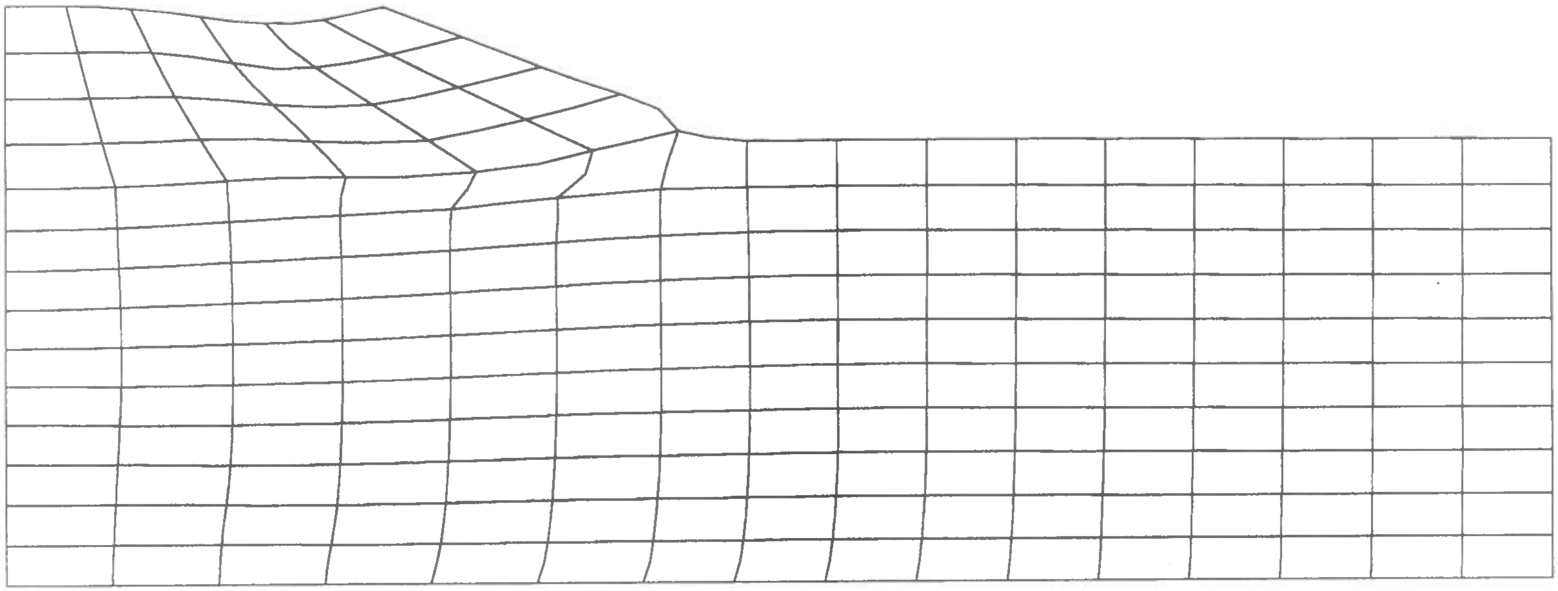
Section 2

Mesh



PRECISION ENGINEERING, INC.

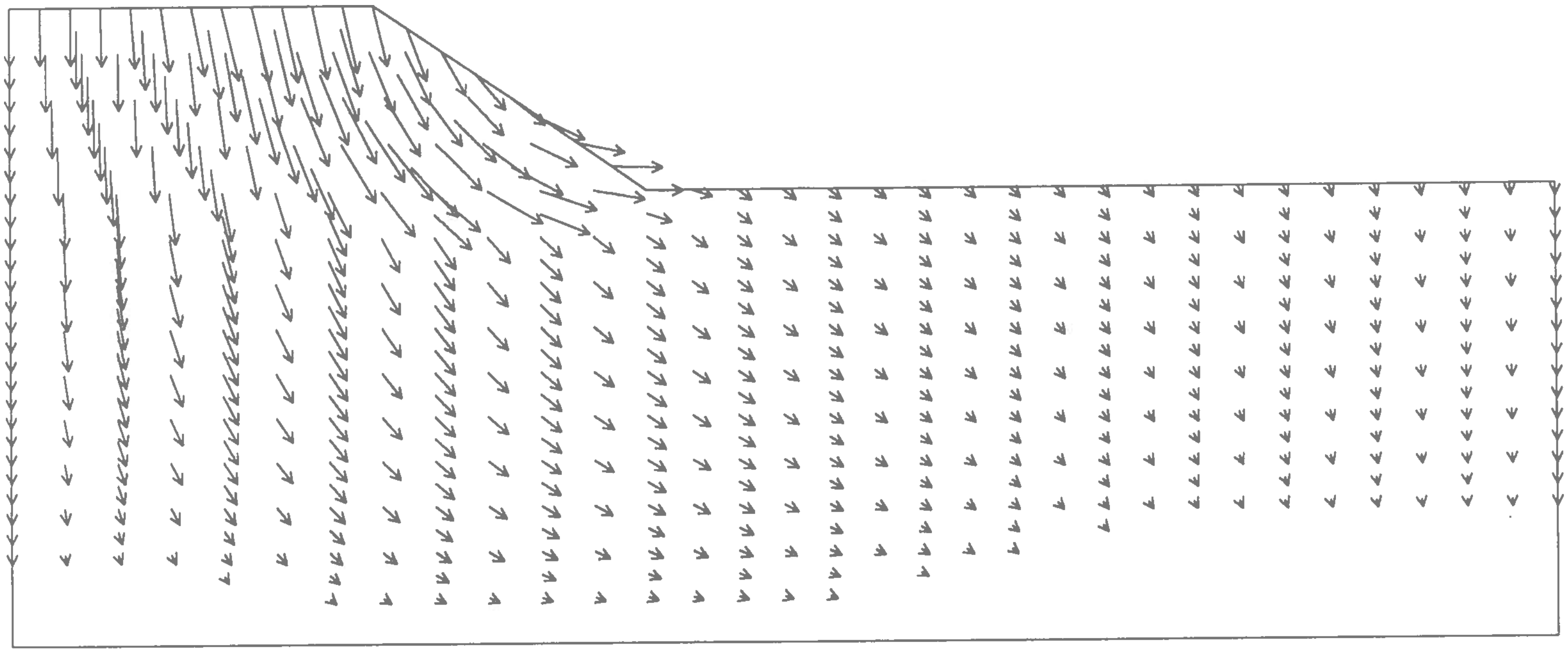
Section 2
Deformed Mesh



PRECISION ENGINEERING, INC.

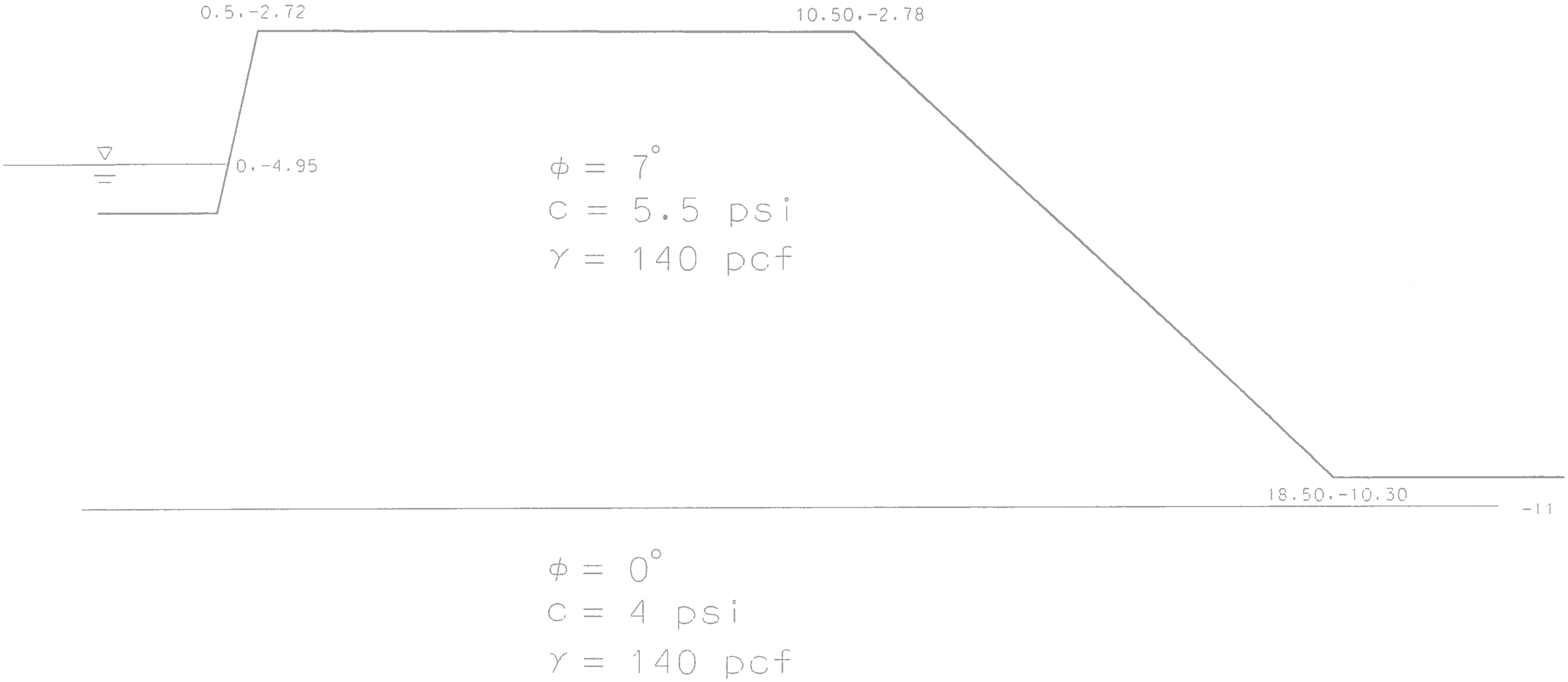
Section 2

Vector Trace



Section 3

Factor Of Safety = 3.0

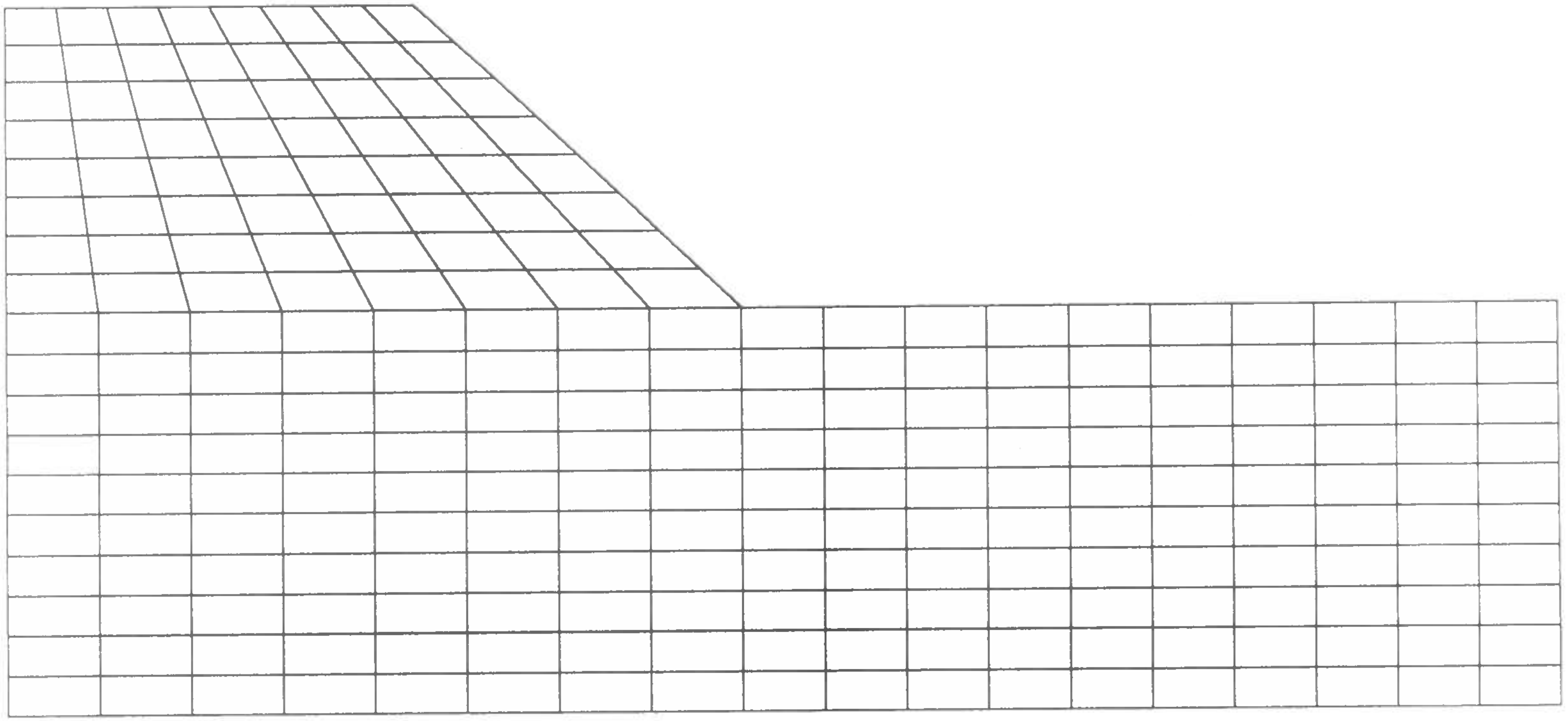


```
Section 3 Profile

w1=   10.00
s1=    8.00
w2=   20.00
h1=    7.50
h2=   10.00

nx1=    8
nx2=   10
ny1=    8
ny2=   10

Group   phi      c       psi    gamma       e           v
  1    7.00  792.00     0.00  140.00  0.1000E+06     0.30
  2    0.00  576.00     0.00  130.00  0.1000E+06     0.30

Property group assigned to each element
     1    1    1    1    1    1    1    1
     1    1    1    1    1    1    1    1
     1    1    1    1    1    1    1    1
     1    1    1    1    1    1    1    1
     1    1    1    1    1    1    1    1
     1    1    1    1    1    1    1    1
     1    1    1    1    1    1    1    1
     1    1    1    1    1    1    1    1
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2
     2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
   2    2

tol=  0.000100
```

```
limit= 1000

      trial factor    max displacement   iterations
      0.2000E+01      0.2554E+00             40
      0.2500E+01      0.3177E+00             62
      0.2750E+01      0.3490E+00             70
      0.3000E+01      0.8735E+00           1000
```

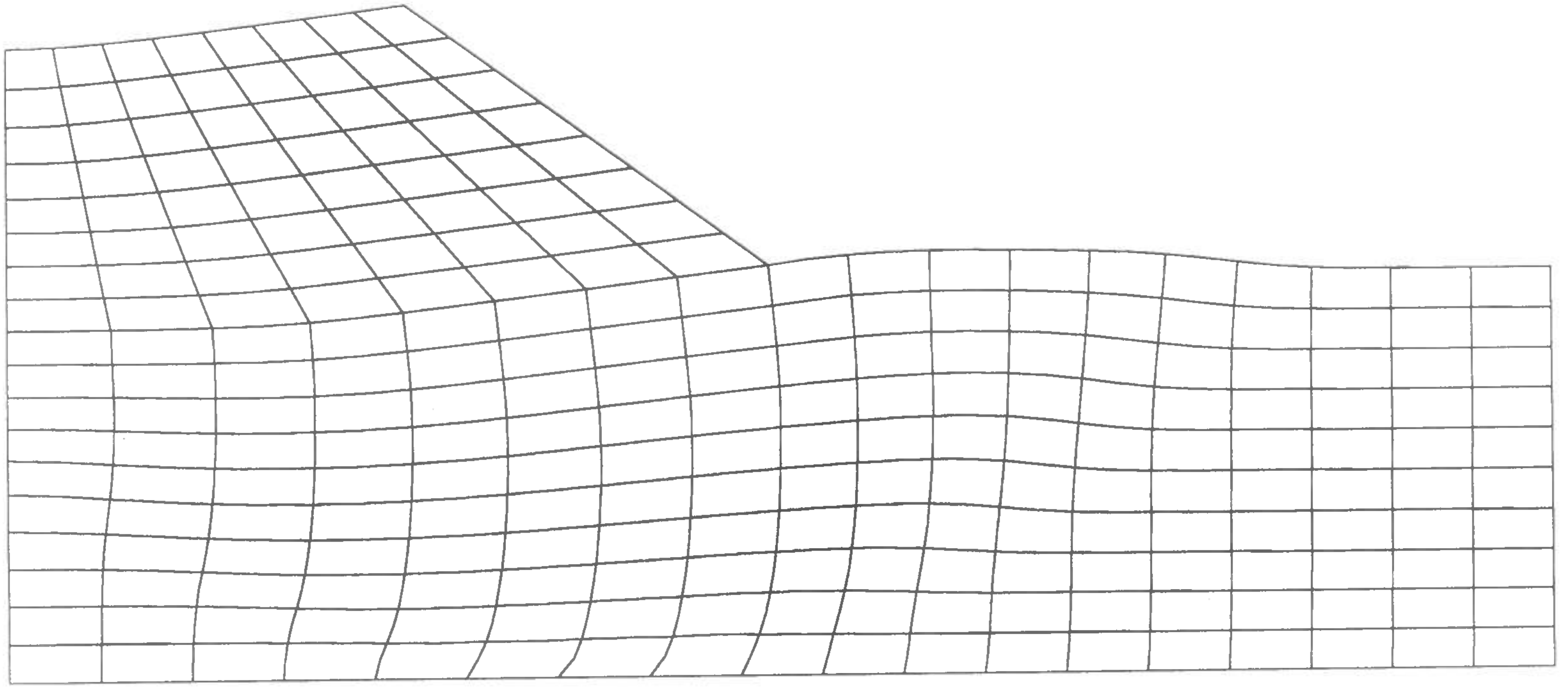
PRECISION ENGINEERING, INC.

Section 3
Mesh



PRECISION ENGINEERING, INC.

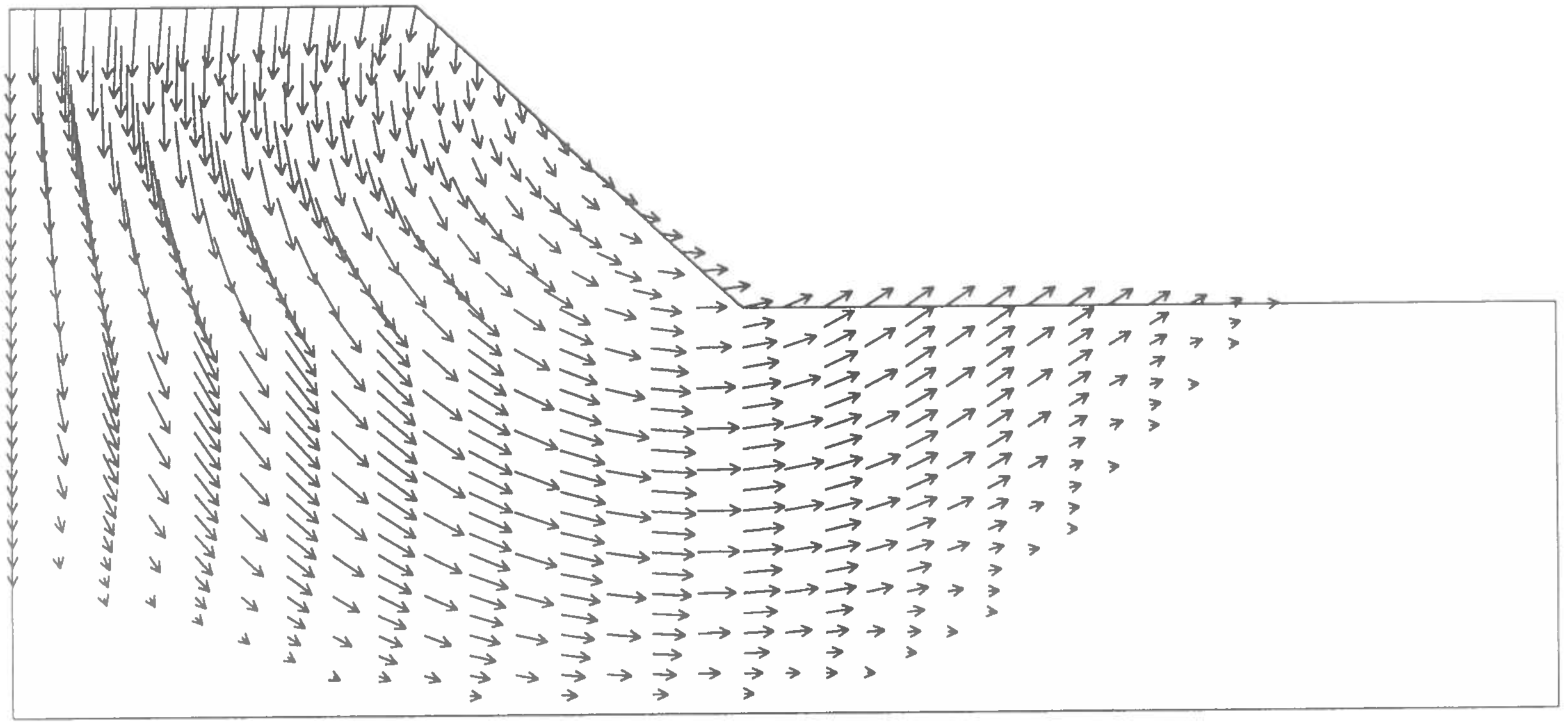
Section 3
Deformed Mesh



PRECISION ENGINEERING, INC.

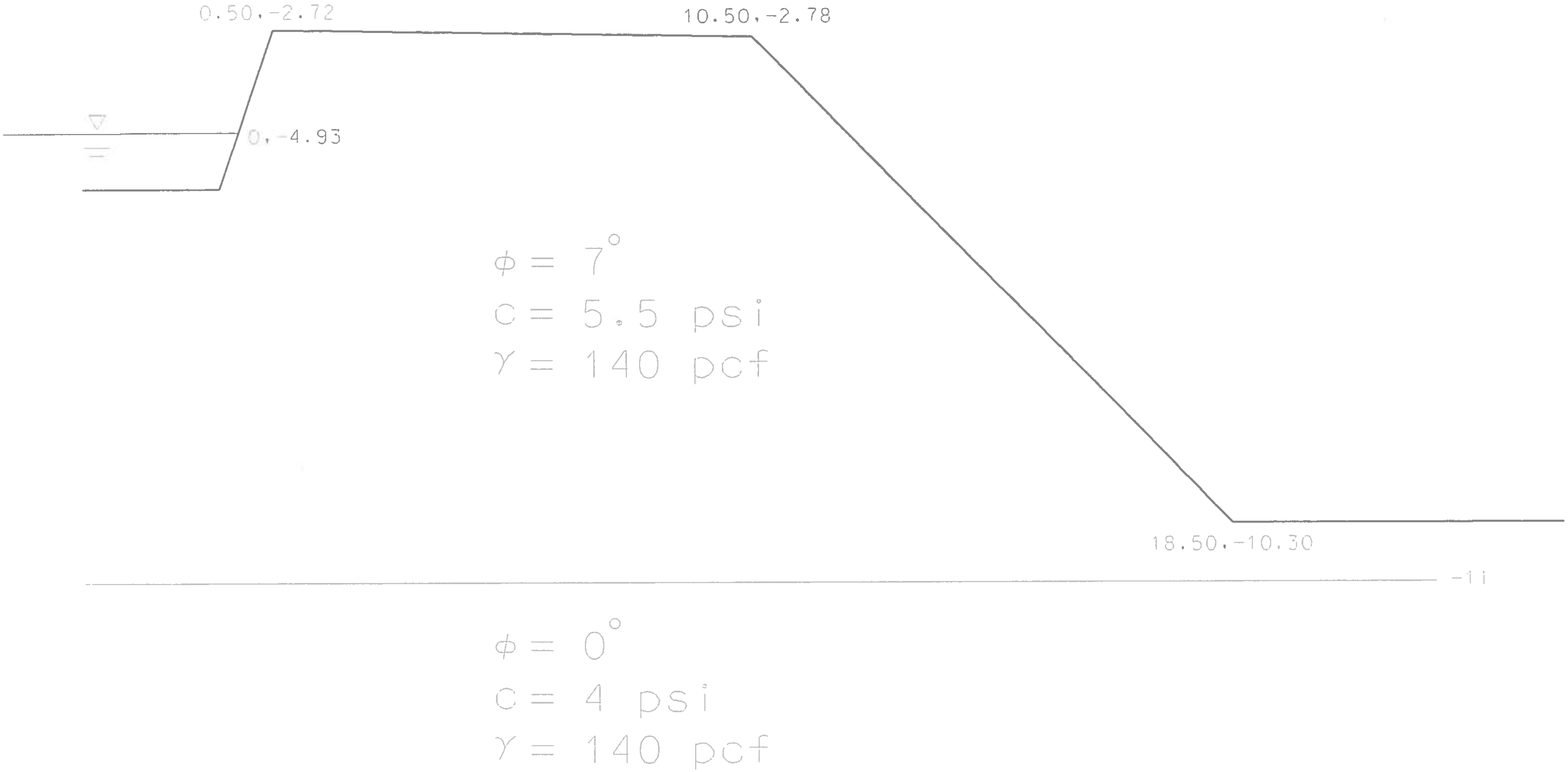
Section 3

Vector Trace



Section 4

Factor Of Safety = 3.0

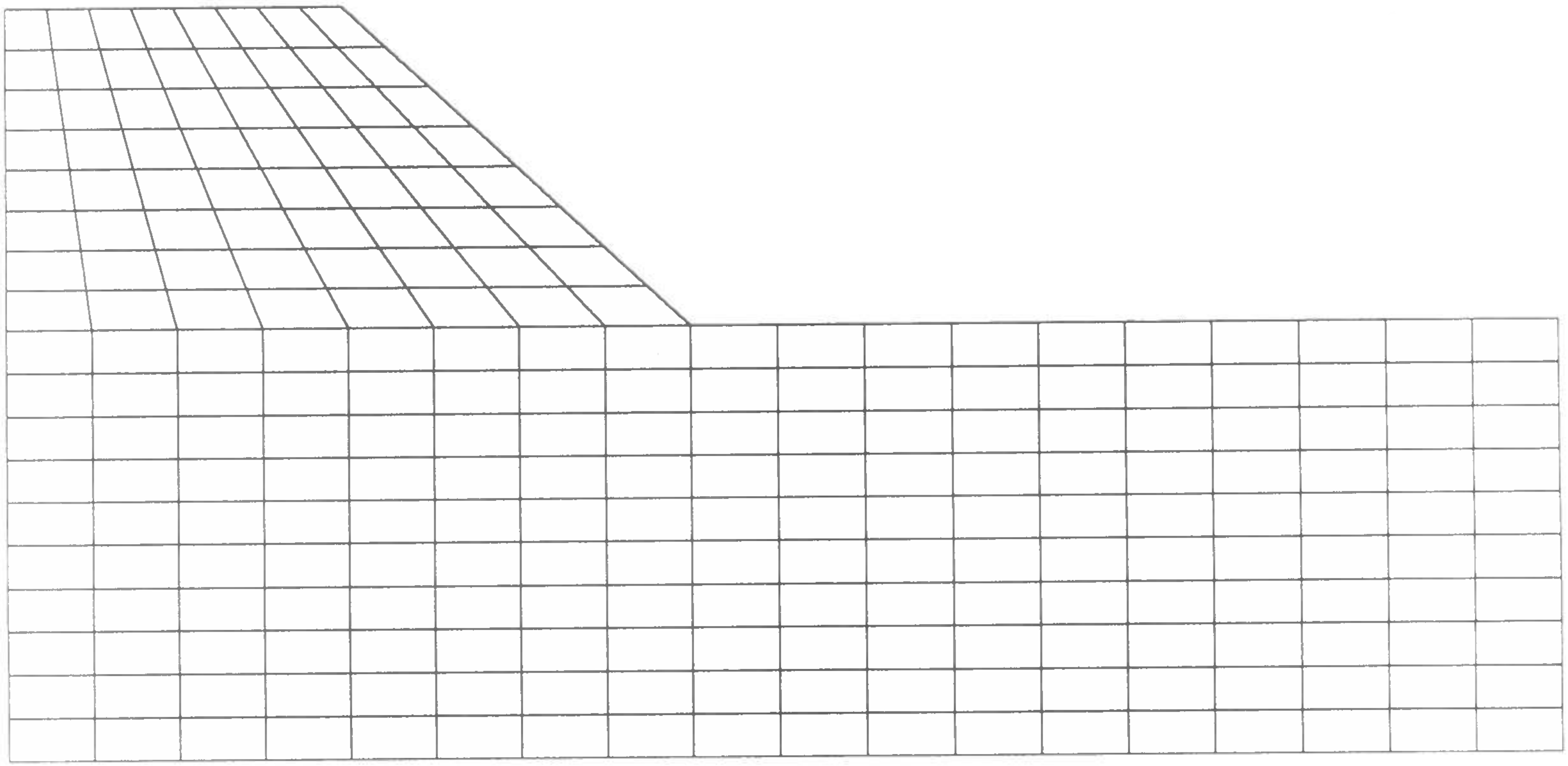


```
Section 4 Profile

w1=    7.75
s1=    8.00
w2=   20.00
h1=    7.50
h2=   10.00

nx1=    8
nx2=   10
ny1=    8
ny2=   10

Group  phi       c       psi    gamma       e          v
  1    7.00  792.00     0.00  140.00  0.1000E+06    0.30
  2    0.00  576.00     0.00  130.00  0.1000E+06    0.30

Property group assigned to each element
    1    1    1    1    1    1    1    1
    1    1    1    1    1    1    1    1
    1    1    1    1    1    1    1    1
    1    1    1    1    1    1    1    1
    1    1    1    1    1    1    1    1
    1    1    1    1    1    1    1    1
    1    1    1    1    1    1    1    1
    2    2    2    2    2    2    2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
  2    2

 tol=  0.000100
```

```
limit= 1000

      trial factor     max displacement   iterations
      0.2000E+01       0.2529E+00             37
      0.2500E+01       0.3136E+00             56
      0.2750E+01       0.3458E+00             65
      0.3000E+01       0.6995E+00           1000
```

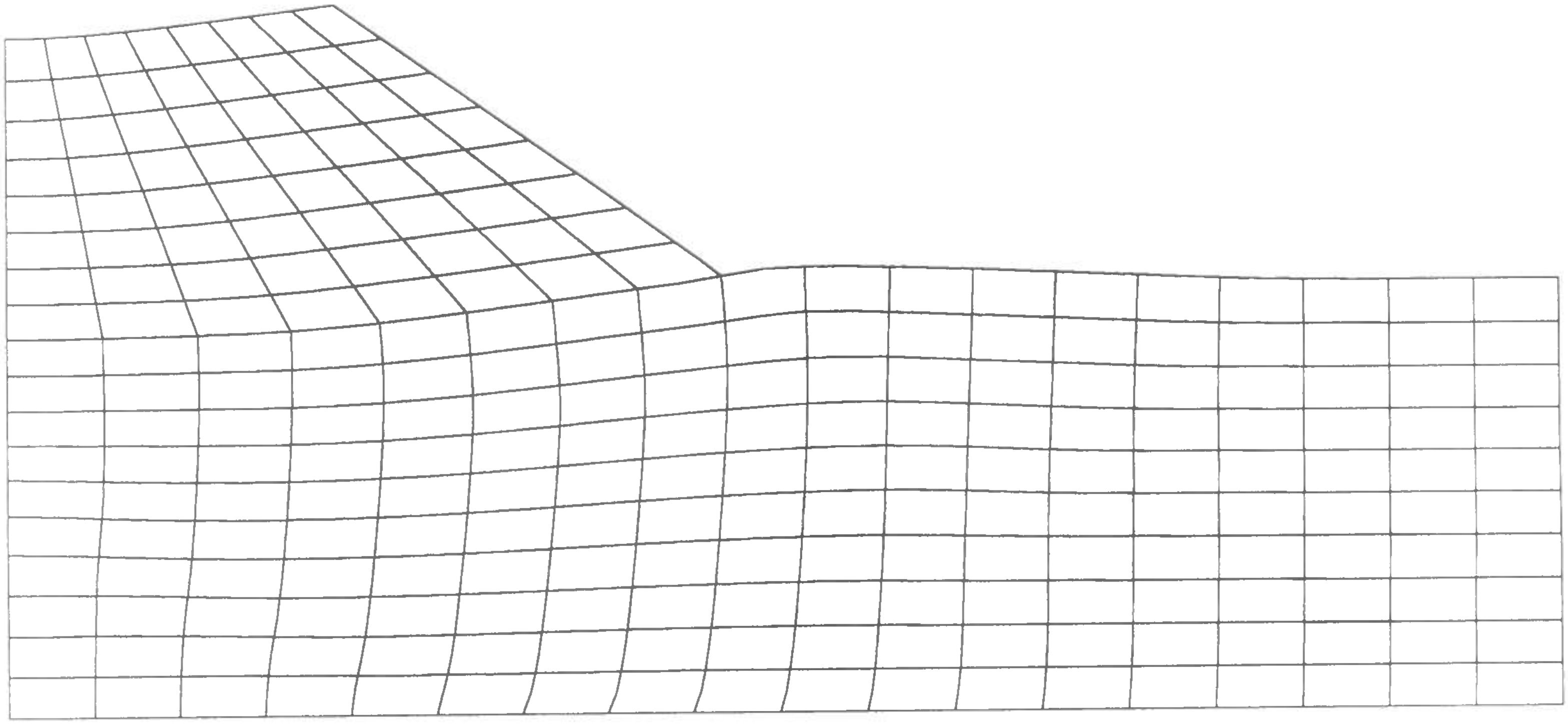
Section 4

Mesh



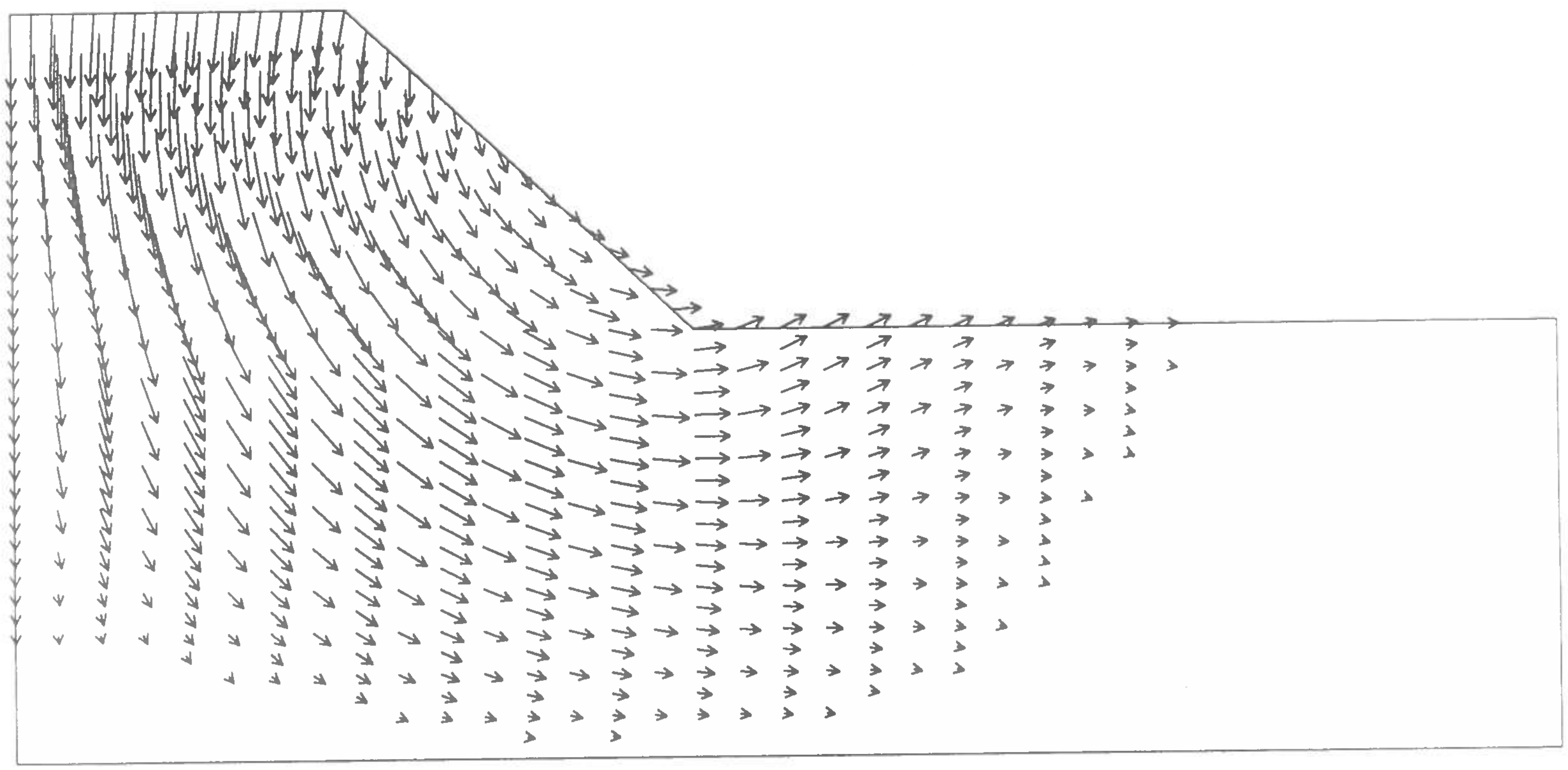
Section 4

Deformed Mesh



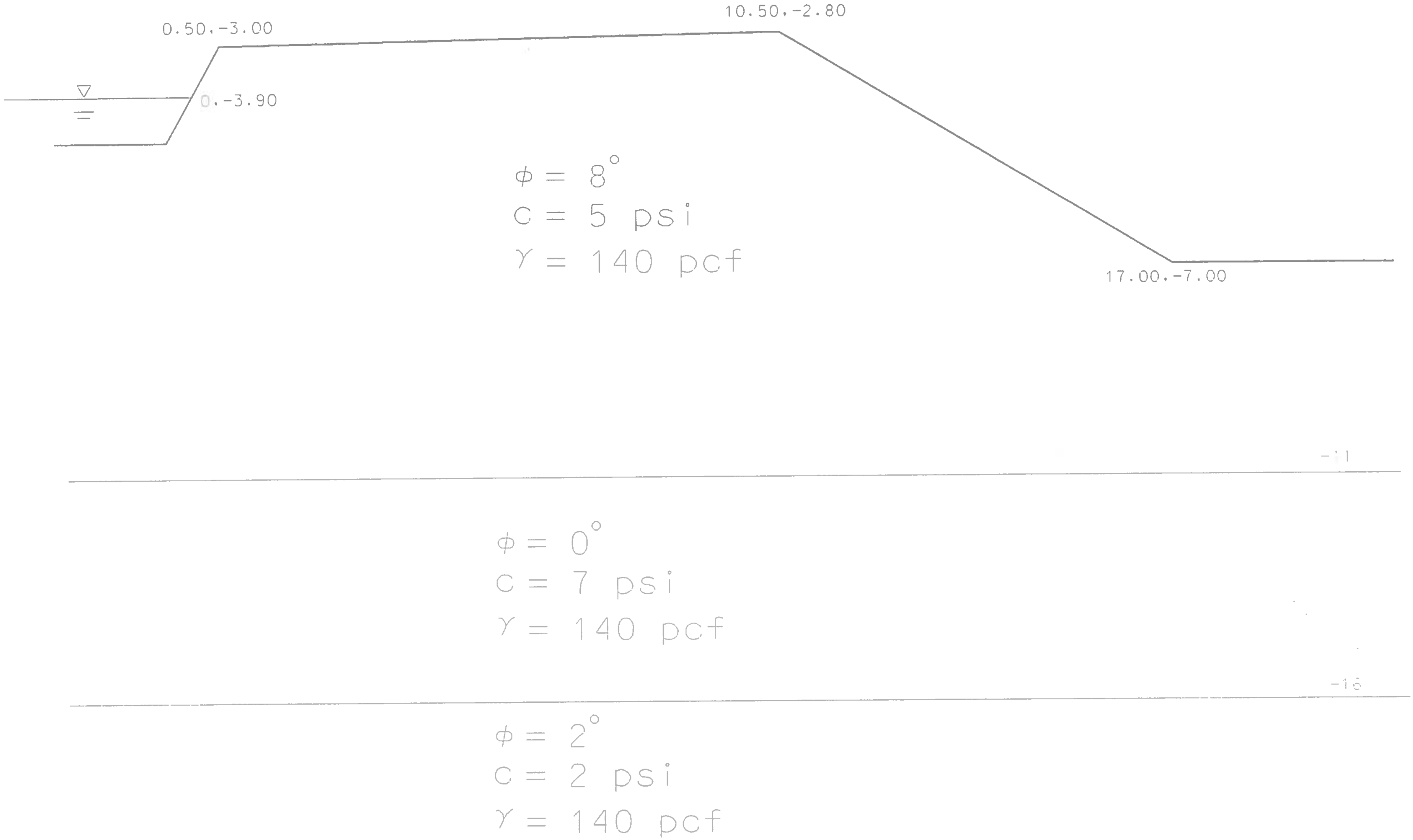
Section 4

Vector Trace



Section 5

Factor Of Safety = 6.2

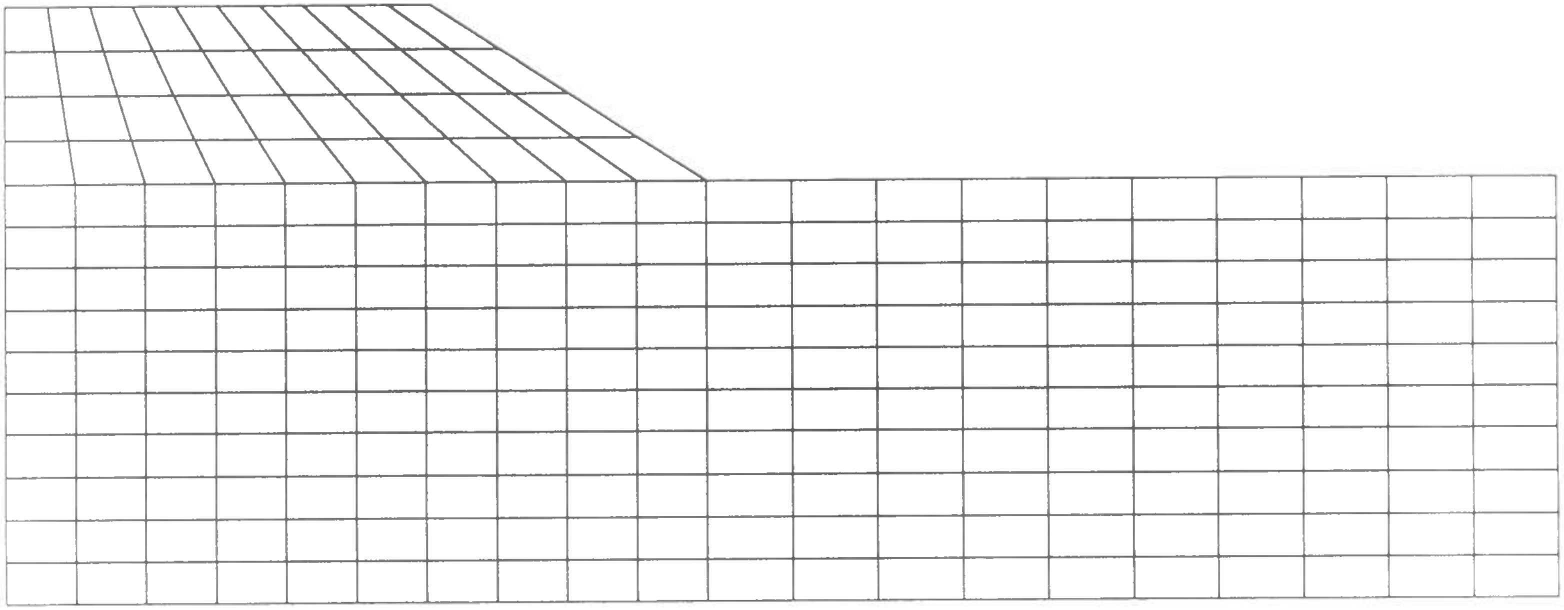


```
Section 5 Profile

w1=   10.00
s1=    6.50
w2=   20.00
h1=    4.20
h2=   10.00

nx1=   10
nx2=   10
ny1=    4
ny2=   10

Group  phi      c      psi    gamma      e          v
  1    8.00  720.00    0.00  140.00  0.1000E+06    0.30
  2    0.00 1008.00    0.00  140.00  0.1000E+06    0.30
  3    2.00  288.00    0.00  140.00  0.1000E+06    0.30

Property group assigned to each element
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3

tol=  0.000100
limit= 1000

      trial factor    max displacement   iterations
```

```
  0.5800E+01      0.2946E+00             127
  0.6000E+01      0.3065E+00             168
  0.6100E+01      0.3191E+00             252
  0.6200E+01      0.3918E+00            1000
```

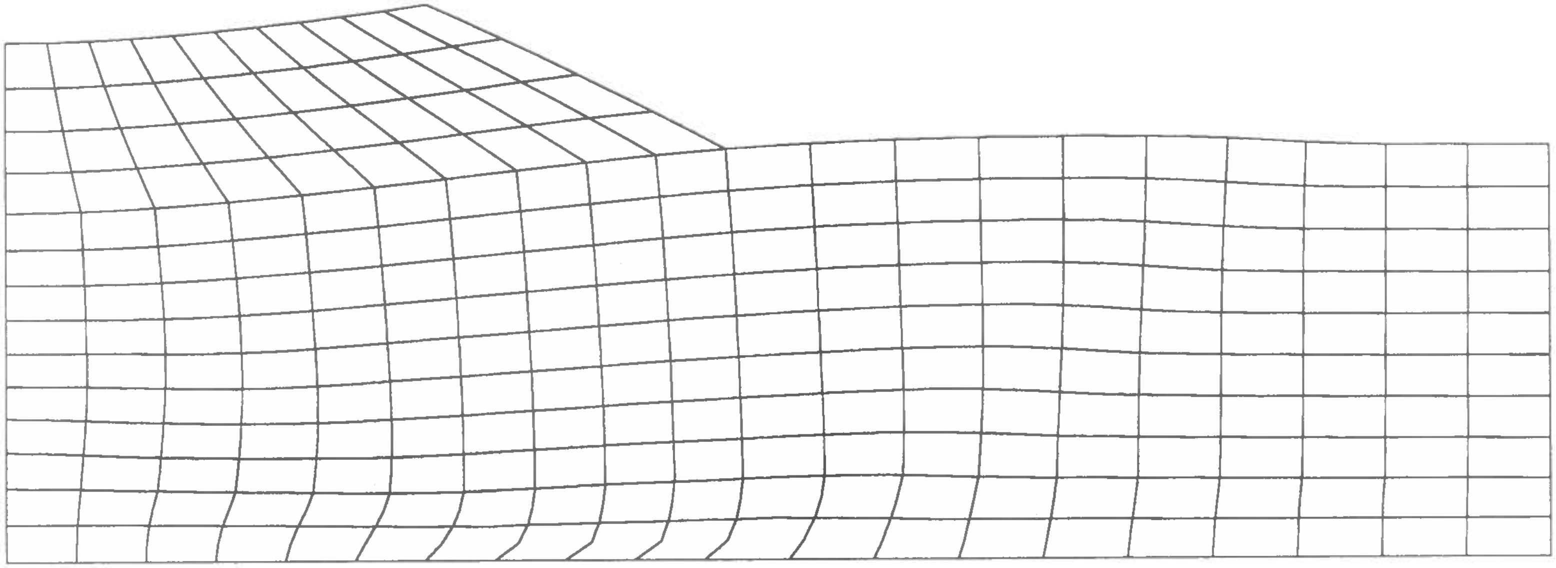
Section 5

Mesh



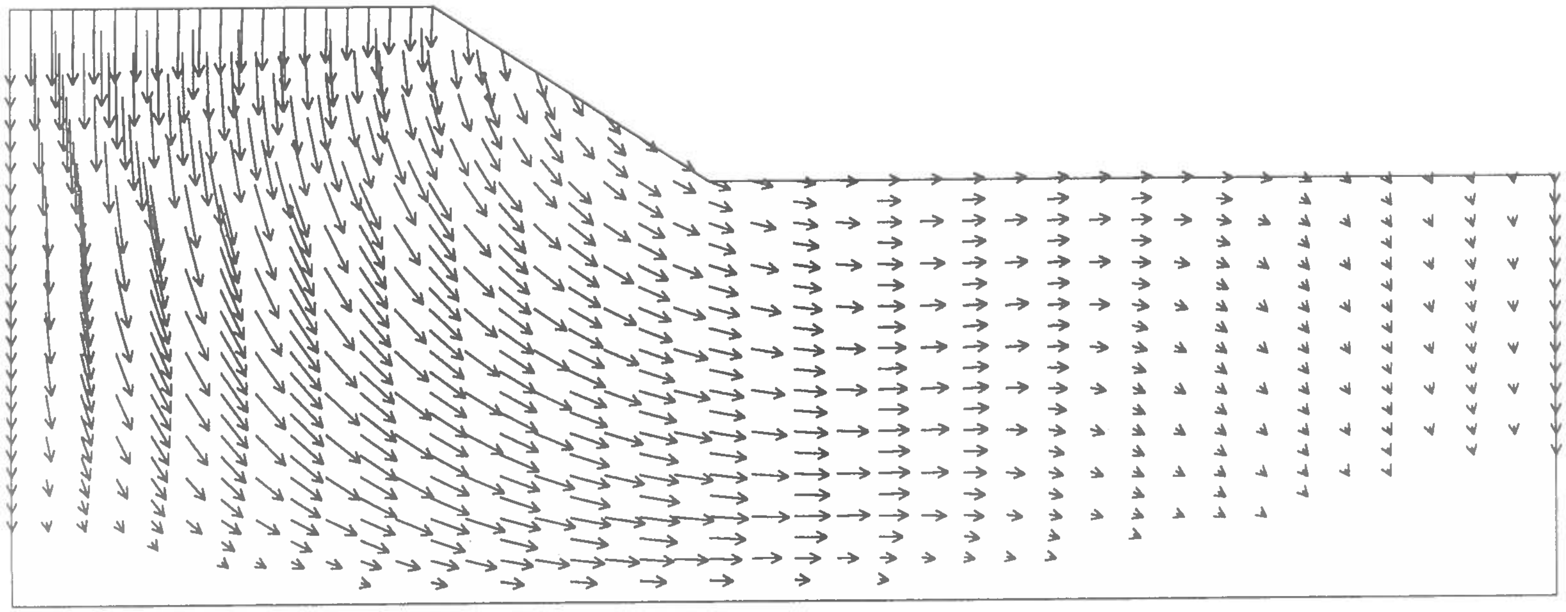
PRECISION ENGINEERING, INC.

Section 5
Deformed Mesh



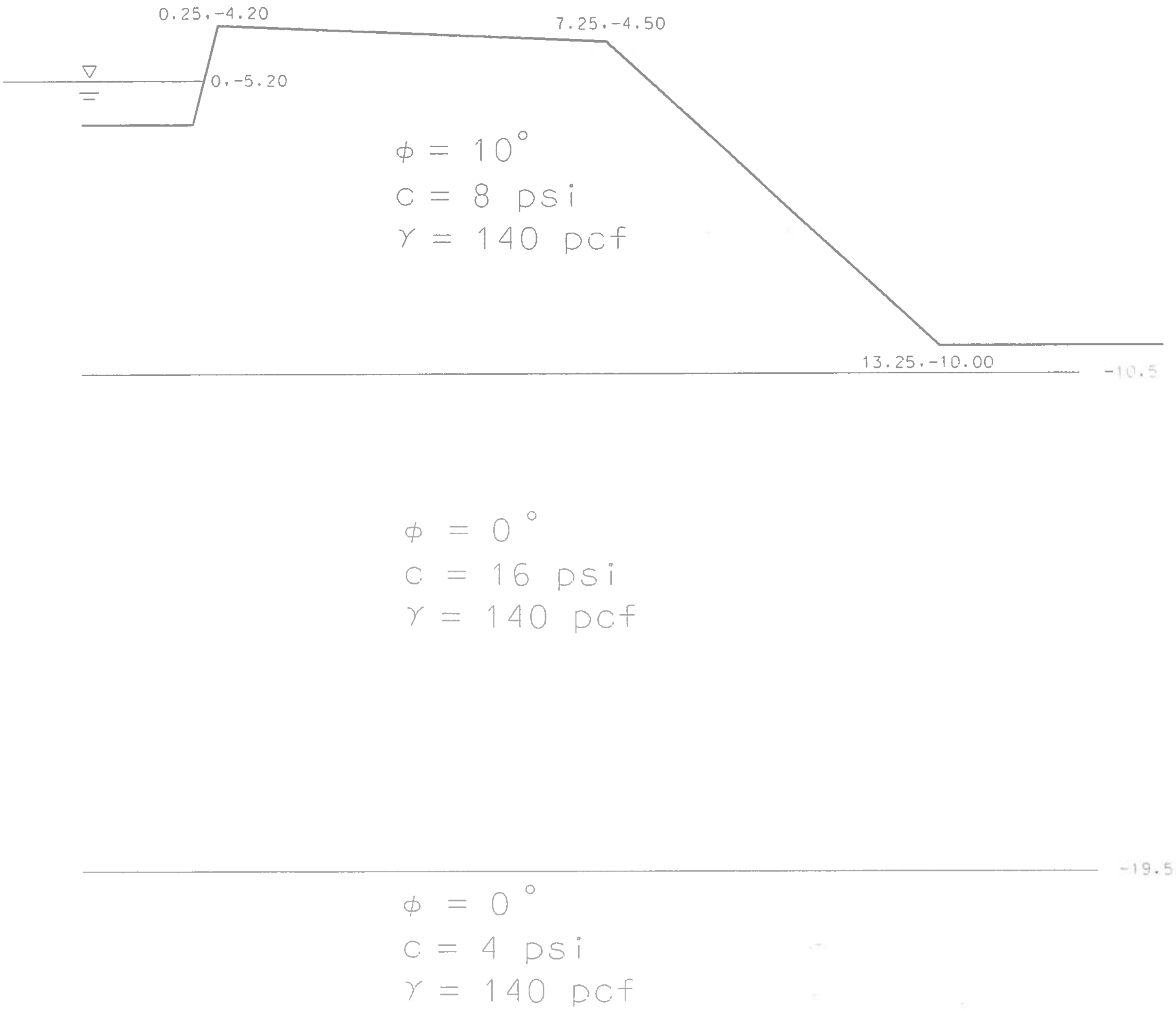
Section 5

Vector Trace



Section 6

Factor Of Safety = 10.0



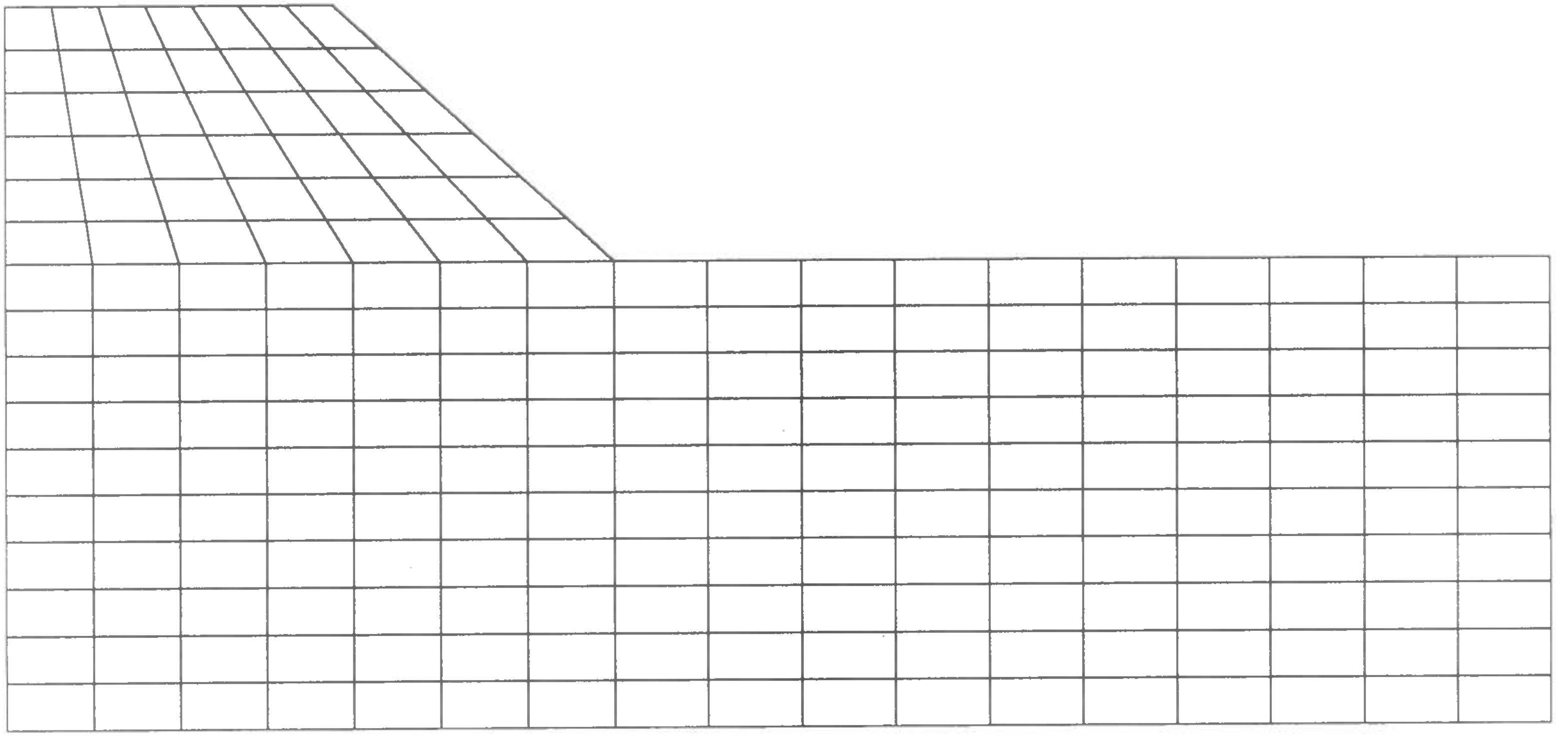
```
Section 6 Profile

w1=    7.00
s1=    6.00
w2=   20.00
h1=    5.50
h2=   10.00

nx1=    7
nx2=   10
ny1=    6
ny2=   10

Group  phi        c      psi    gamma      e          v
  1   10.00 1152.00    0.00  140.00  0.1000E+06     0.30
  2    0.00 2304.00    0.00  140.00  0.1000E+06     0.30
  3    0.00  576.00    0.00  140.00  0.1000E+06     0.30

Property group assigned to each element
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   1   1   1   1   1   1   1
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
  3

 tol=  0.000100
 limit= 1000
```

```
trial factor    max displacement   iterations
0.9000E+01      0.3093E+00             149
0.1000E+02      0.3472E+00             324
0.1010E+02      0.3636E+00             584
0.1020E+02      0.4050E+00            1000
```

PRECISION ENGINEERING, INC.

Section 6

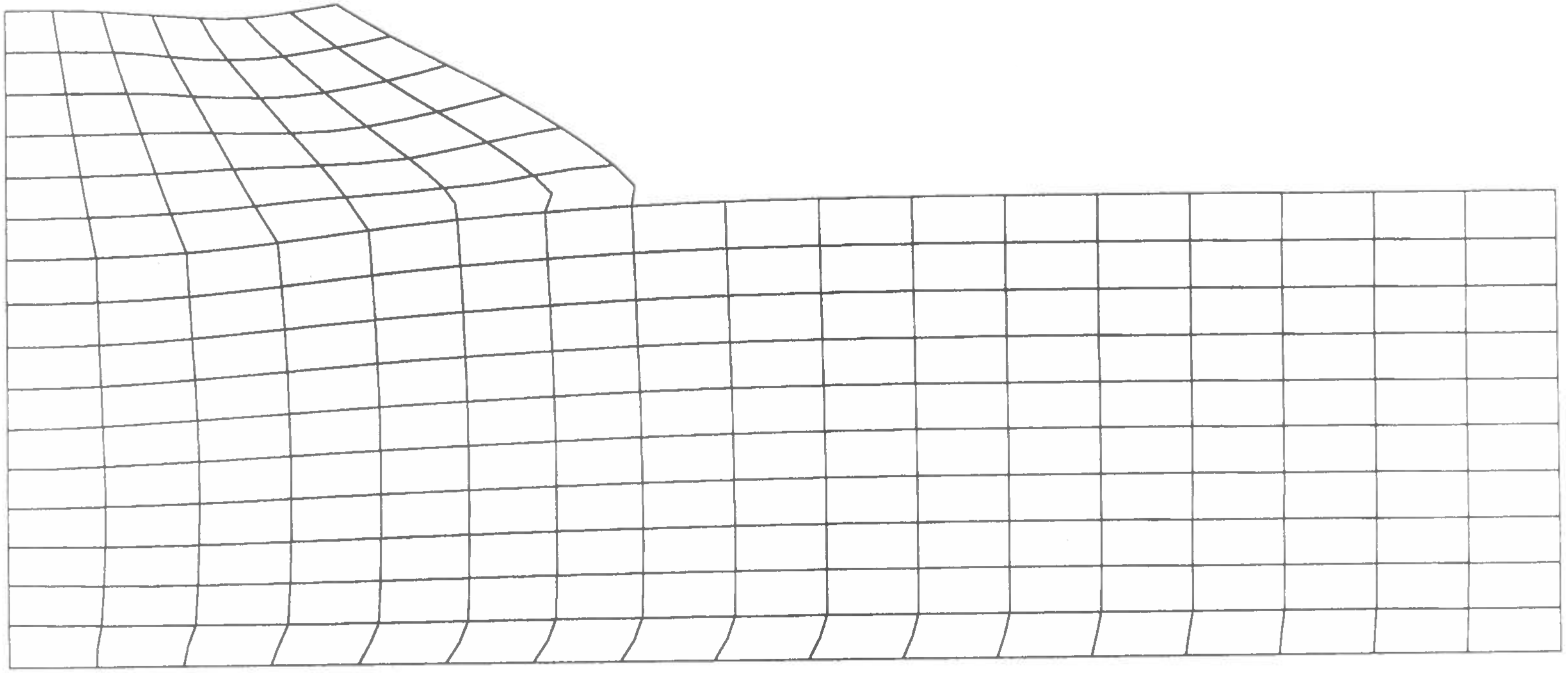
Mesh



PRECISION ENGINEERING, INC.

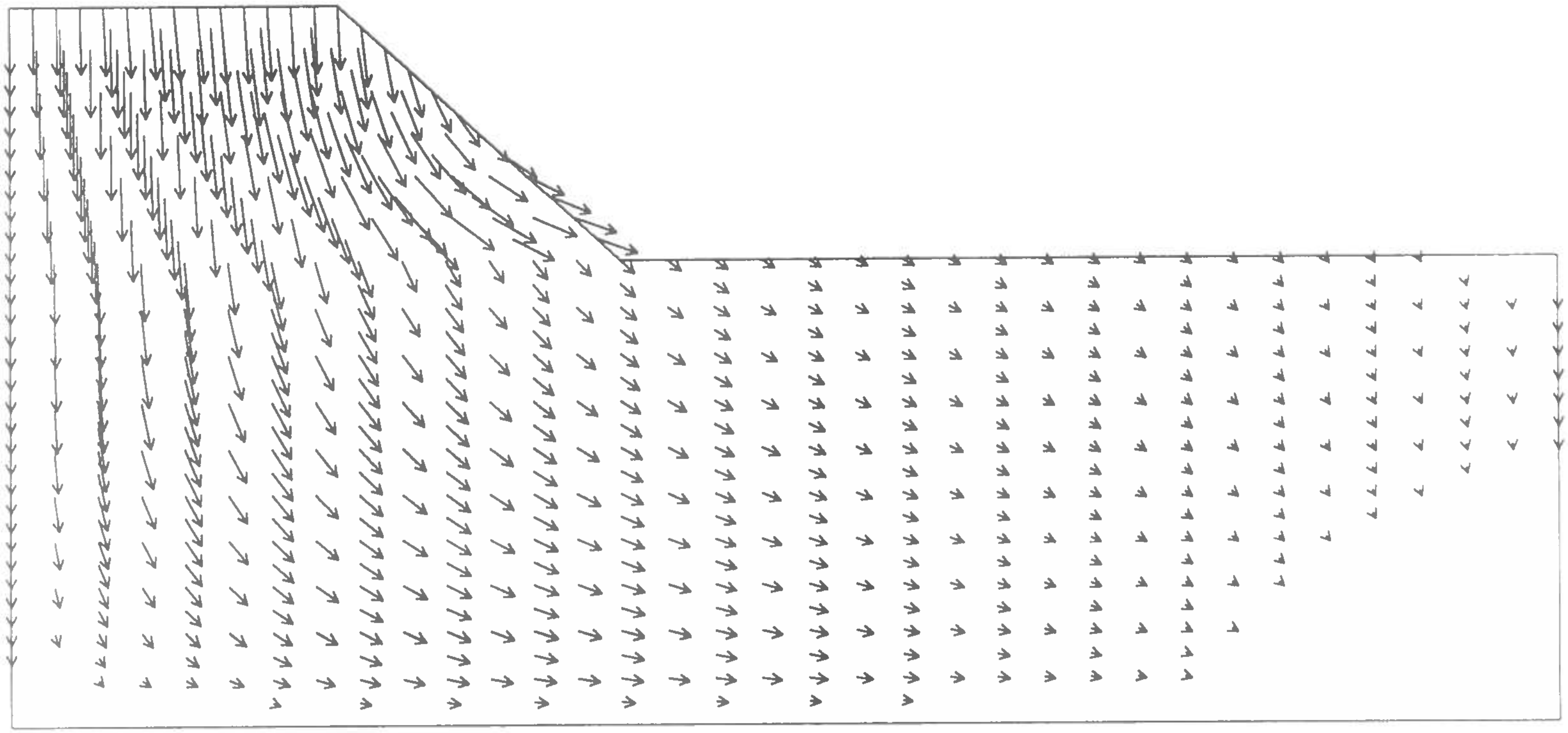
Section 6

Deformed Mesh



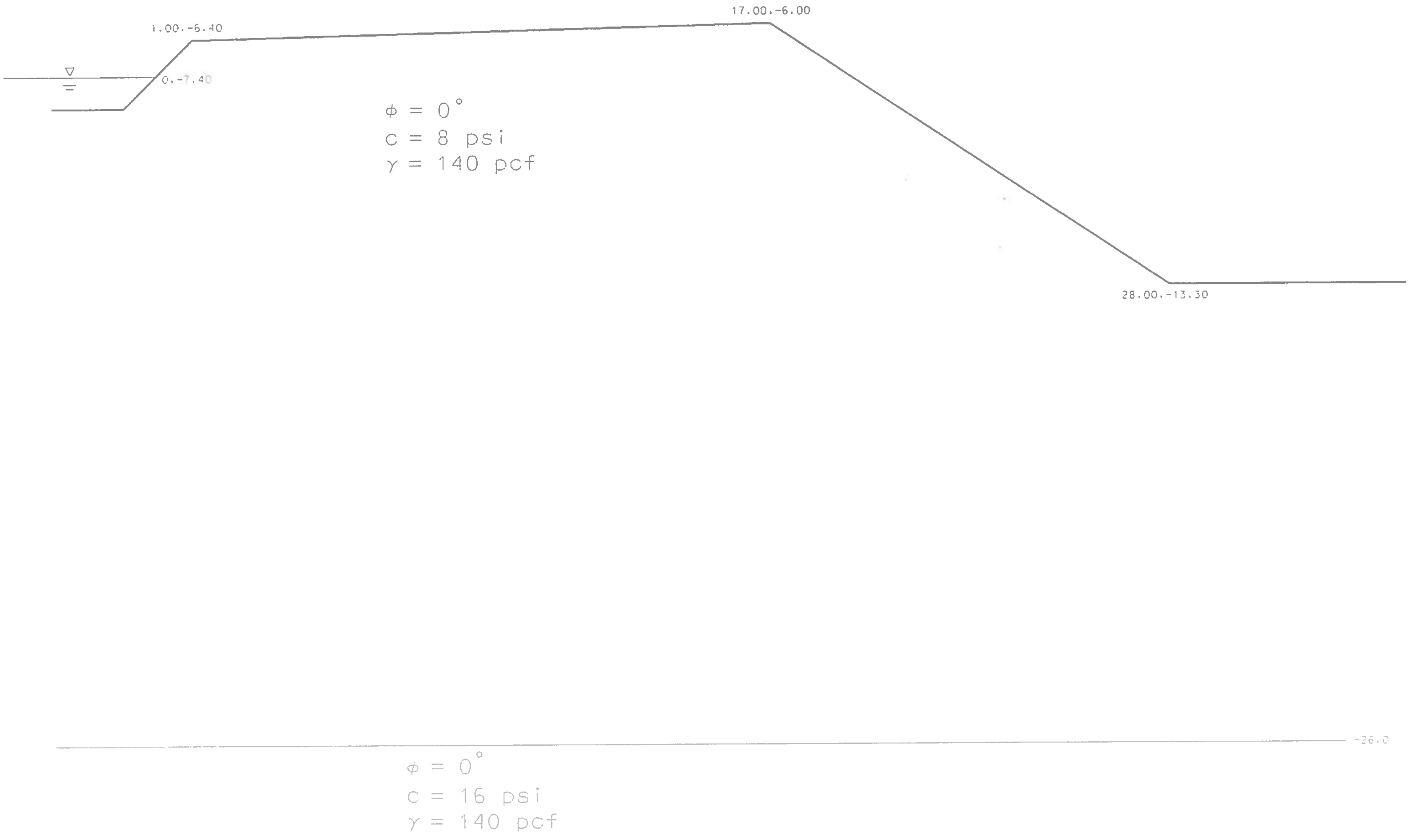
PRECISION ENGINEERING, INC.

Section 6
Vector Trace



Section 7

Factor Of Safety = 6.0

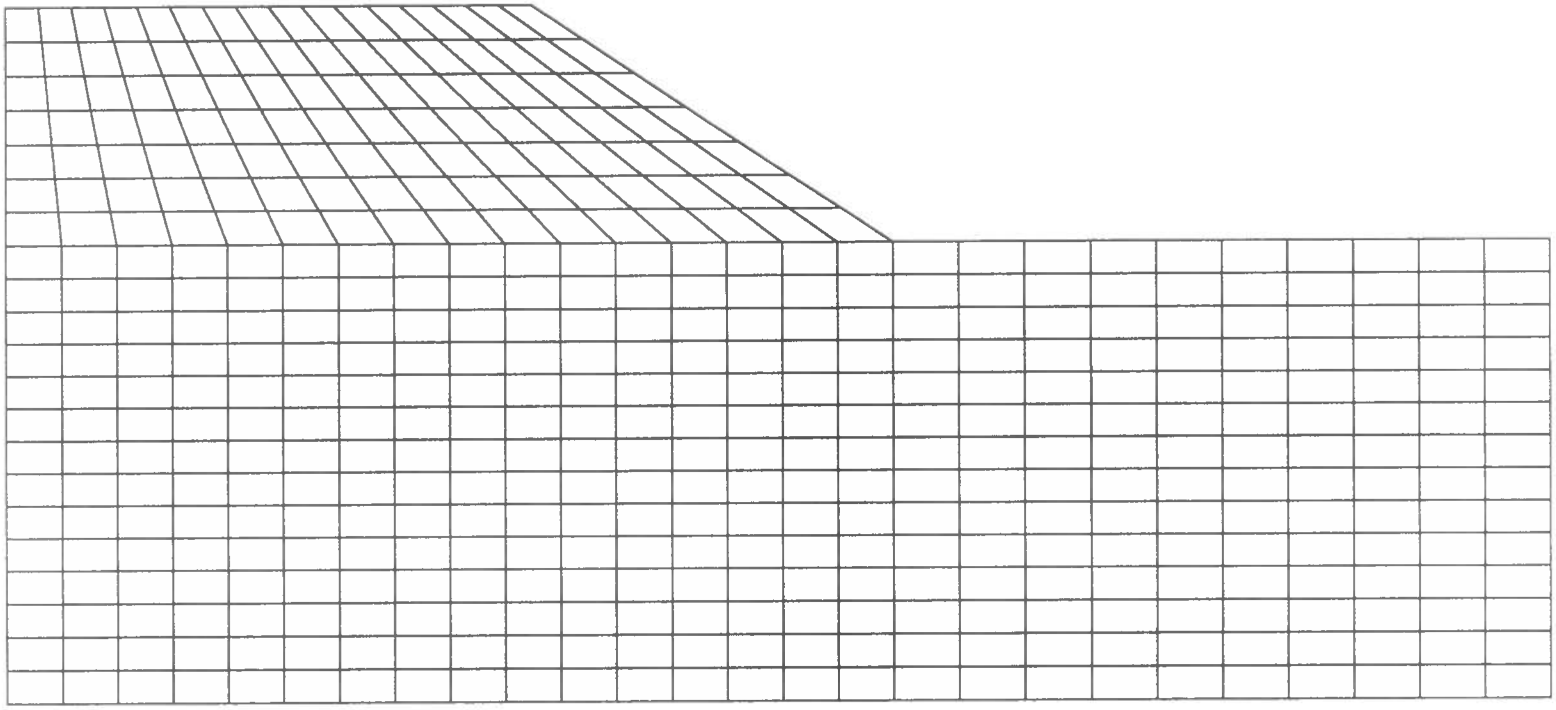


```
Section 7 Profile

w1=   16.00
s1=   11.00
w2=   20.00
h1=    7.30
h2=   14.00

nx1=   16
nx2=   10
ny1=    7
ny2=   14

Group  phi      c      psi    gamma      e         v
  1    0.00 1152.00    0.00  140.00  0.1000E+06    0.30

Property group assigned to each element
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
```

```
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1   1

tol=  0.000100
limit= 1000

      trial factor    max displacement   iterations
      0.5500E+01      0.5128E+00              74
      0.5700E+01      0.5294E+00              83
      0.5800E+01      0.5405E+00              93
      0.5900E+01      0.5552E+00             110
      0.6000E+01      0.6942E+00            1000
```

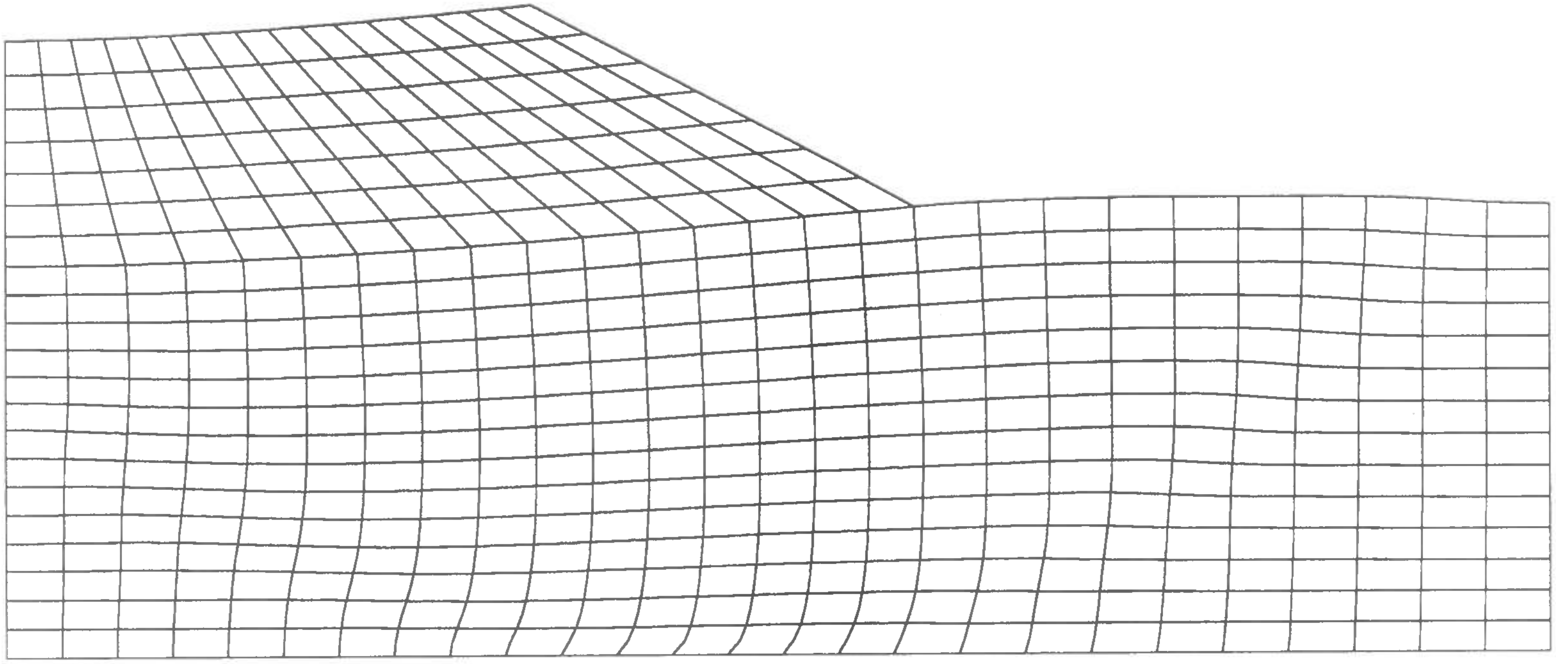
Section 7

Mesh



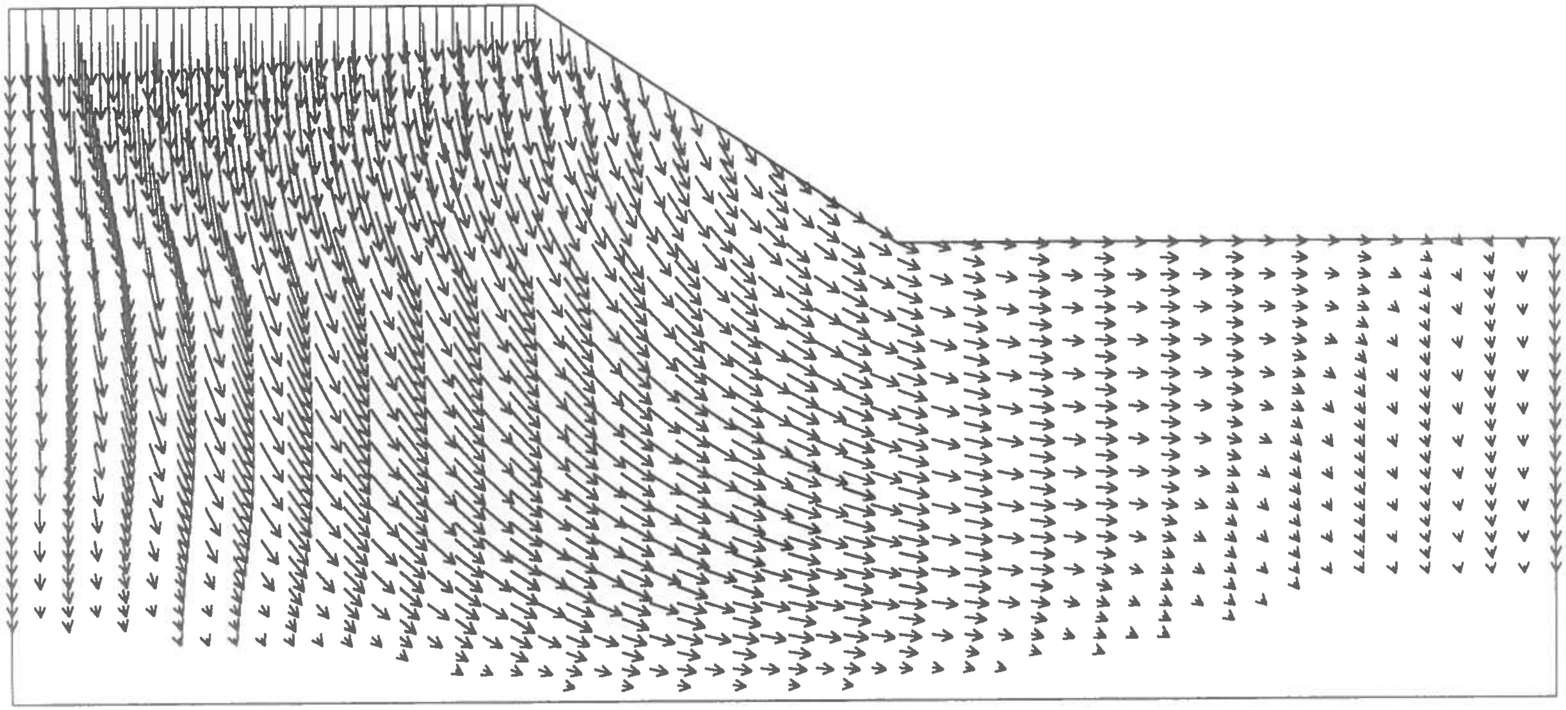
Section 7

Deformed Mesh



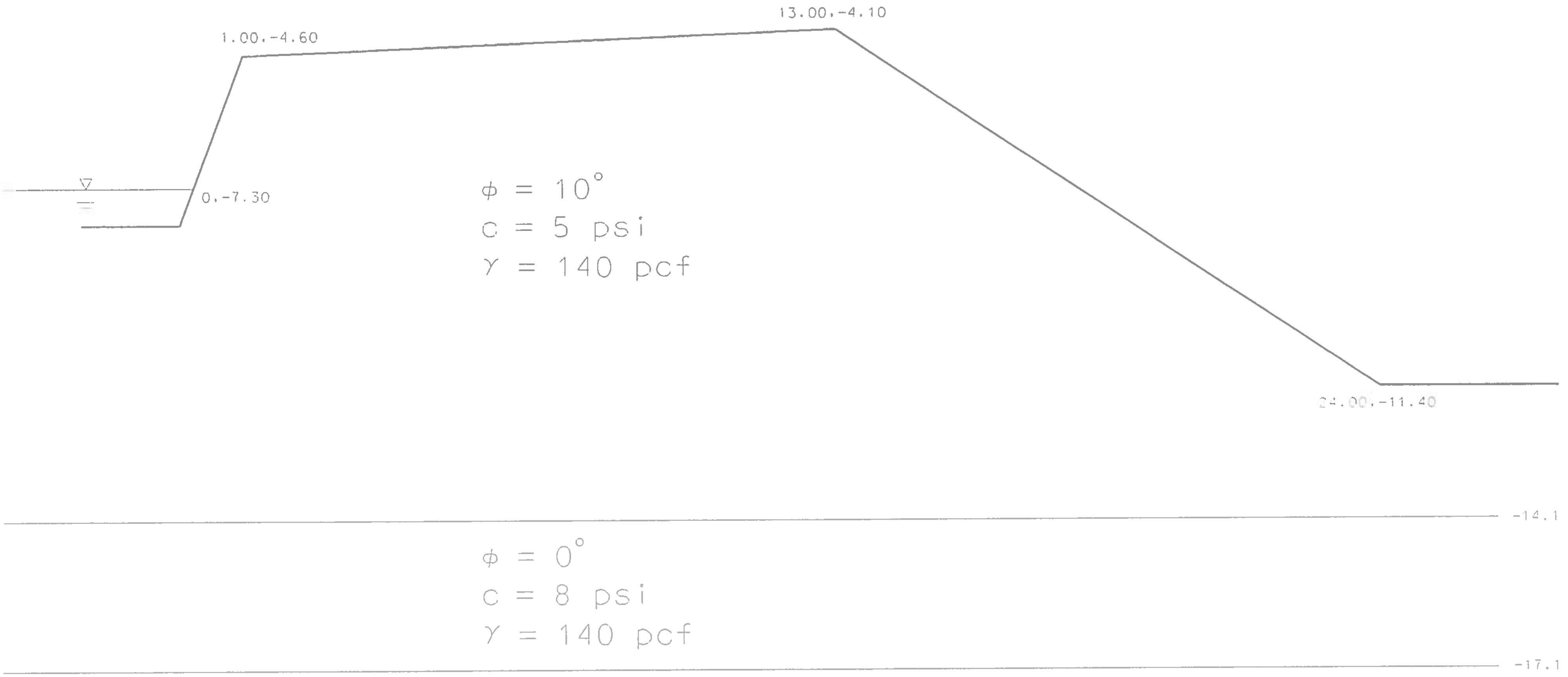
PRECISION ENGINEERING, INC.

Section 7
Vector Trace



Section 8

Factor Of Safety = 4.9

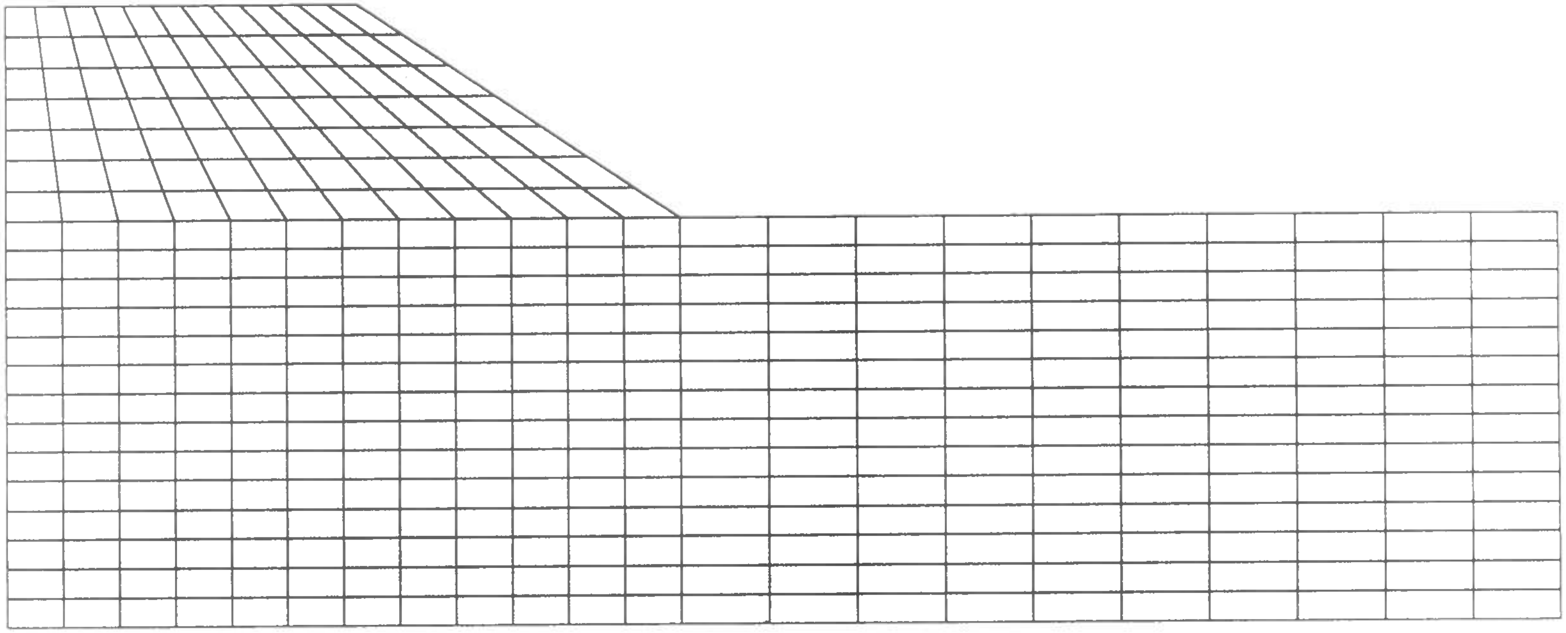


```
Section 8 Profile

w1=   12.00
s1=   11.00
w2=   30.00
h1=    7.30
h2=   14.00

nx1=   12
nx2=   10
ny1=    7
ny2=   14

Group  phi       c     psi    gamma      e          v
  1   10.00  720.00     0.00  140.00  0.1000E+06     0.30
  2    0.00 1152.00     0.00  140.00  0.1000E+06     0.30
  3    0.00 2304.00     0.00  140.00  0.1000E+06     0.30

Property group assigned to each element
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   2   2
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3
   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
```

```
 3   3   3   3
   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3
   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3
   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3
   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3
   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3
   3   3
   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
 3   3   3   3
   3   3

tol=  0.000100
limit= 1000

      trial factor    max displacement   iterations
      0.4600E+01      0.3695E+00              55
      0.4700E+01      0.3768E+00              89
      0.4800E+01      0.3859E+00             151
      0.4900E+01      0.4922E+00            1000
```

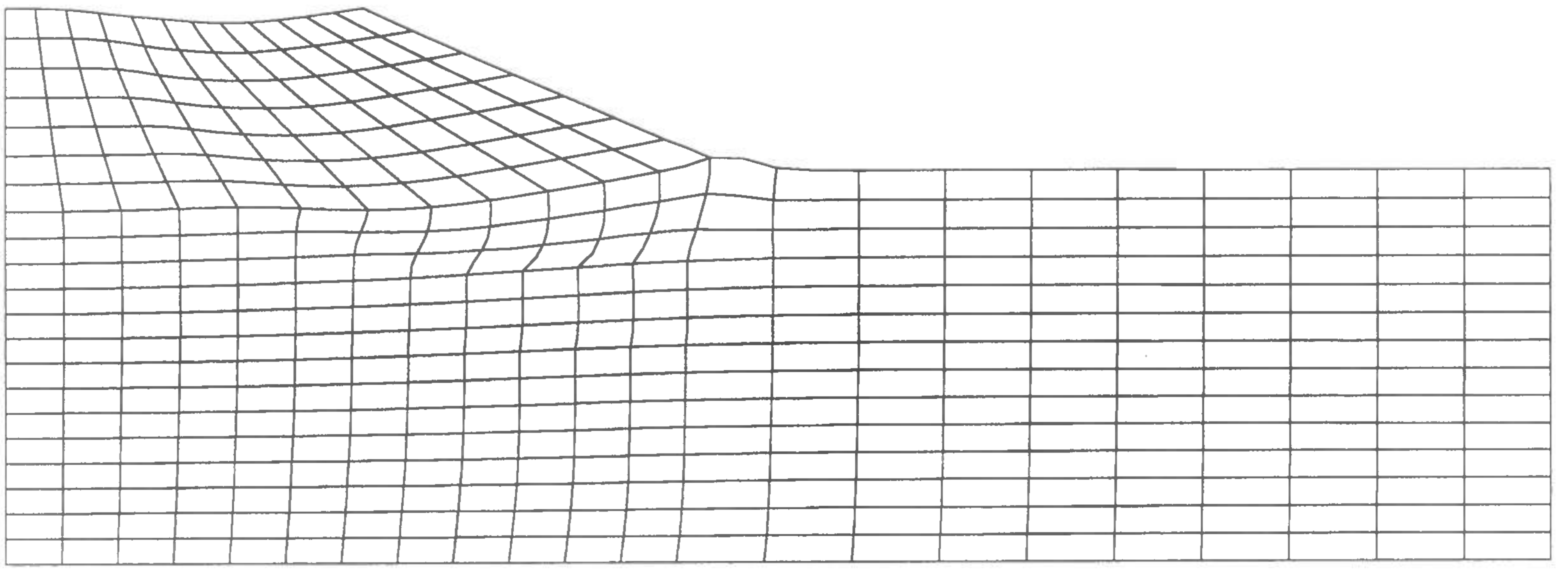
Section 8

Mesh



Section 8

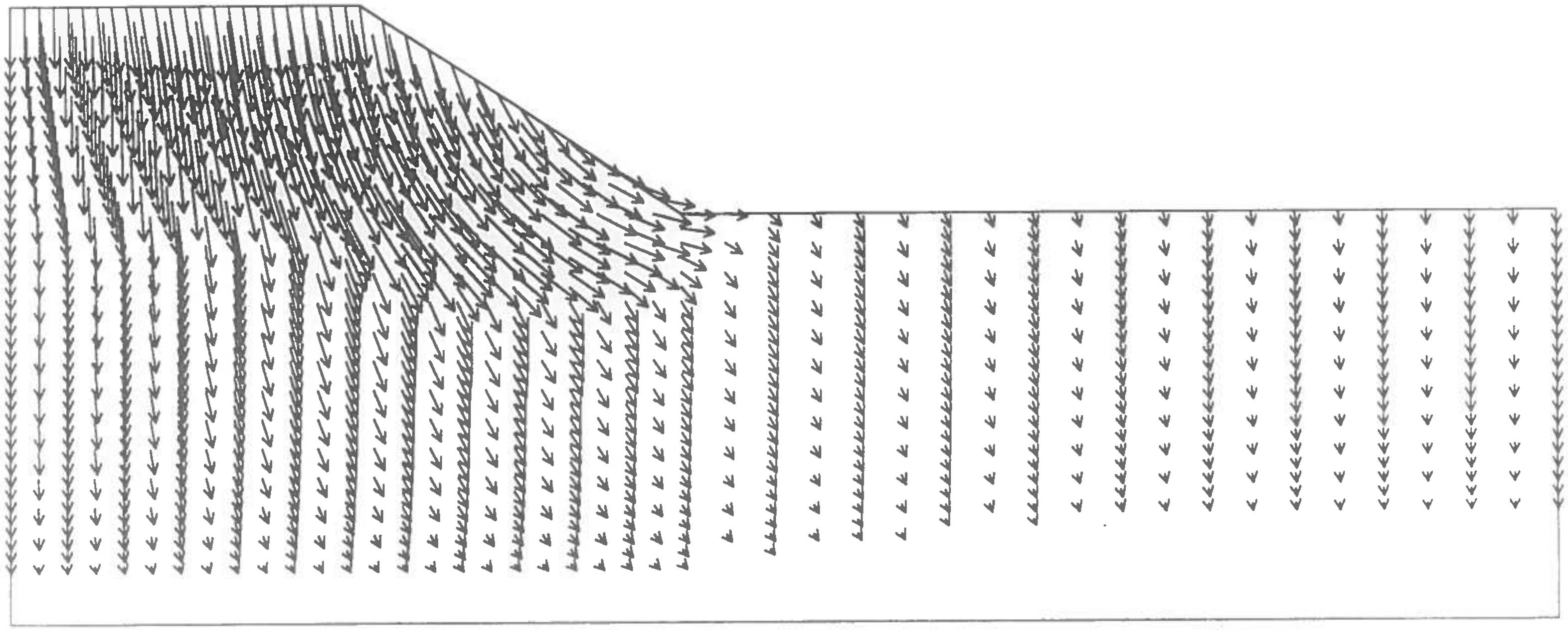
Deformed Mesh



PRECISION ENGINEERING, INC.

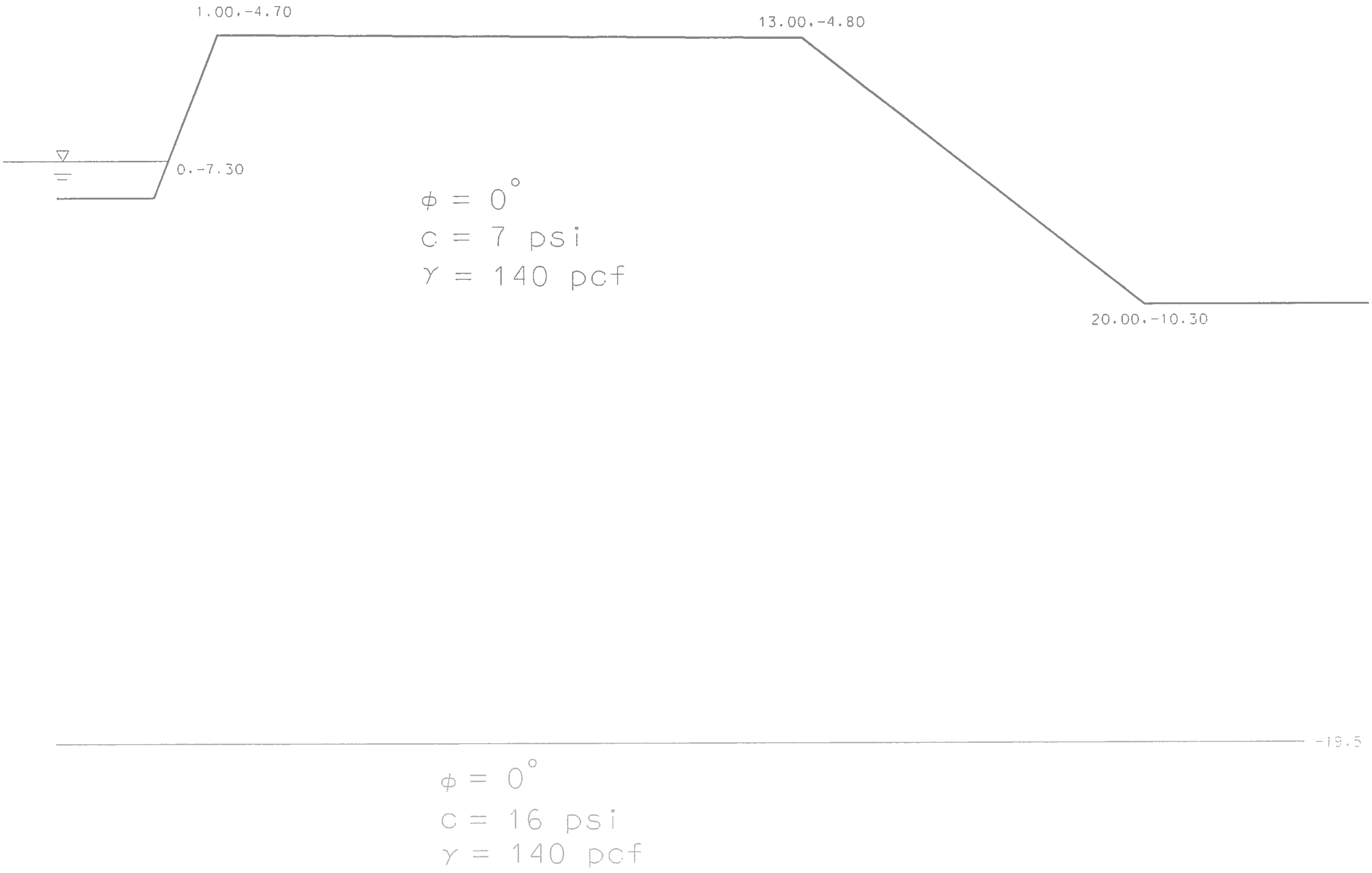
Section 8

Vector Trace



Section 9

Factor Of Safety = 7.0



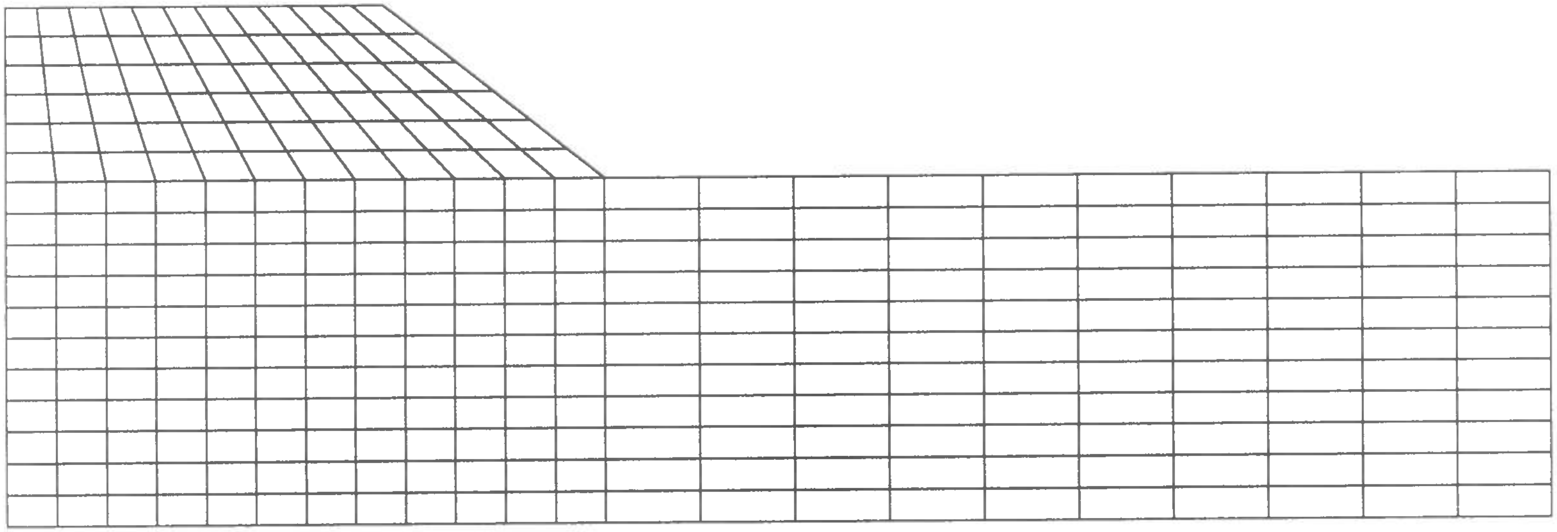
```
Section 9 Profile

w1=   12.00
s1=    7.00
w2=   30.00
h1=    5.50
h2=   11.00

nx1=   12
nx2=   10
ny1=    6
ny2=   11

Group  phi      c      psi    gamma      e           v
  1    0.00 1008.00    0.00  140.00  0.1000E+06    0.30
  2    0.00 2304.00    0.00  140.00  0.1000E+06    0.30

Property group assigned to each element
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1
```

```
    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
 1    1    1    1
    1    1
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
 2    2    2    2
    2    2
    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2
 2    2    2    2
    2    2

tol=  0.000100
limit= 1000

        trial factor     max displacement   iterations
        0.6500E+01       0.3177E+00             100
        0.6600E+01       0.3227E+00             104
        0.6700E+01       0.3283E+00             111
        0.6800E+01       0.3352E+00             122
        0.6900E+01       0.3451E+00             149
        0.7000E+01       0.4483E+00            1000
```

PRECISION ENGINEERING, INC.

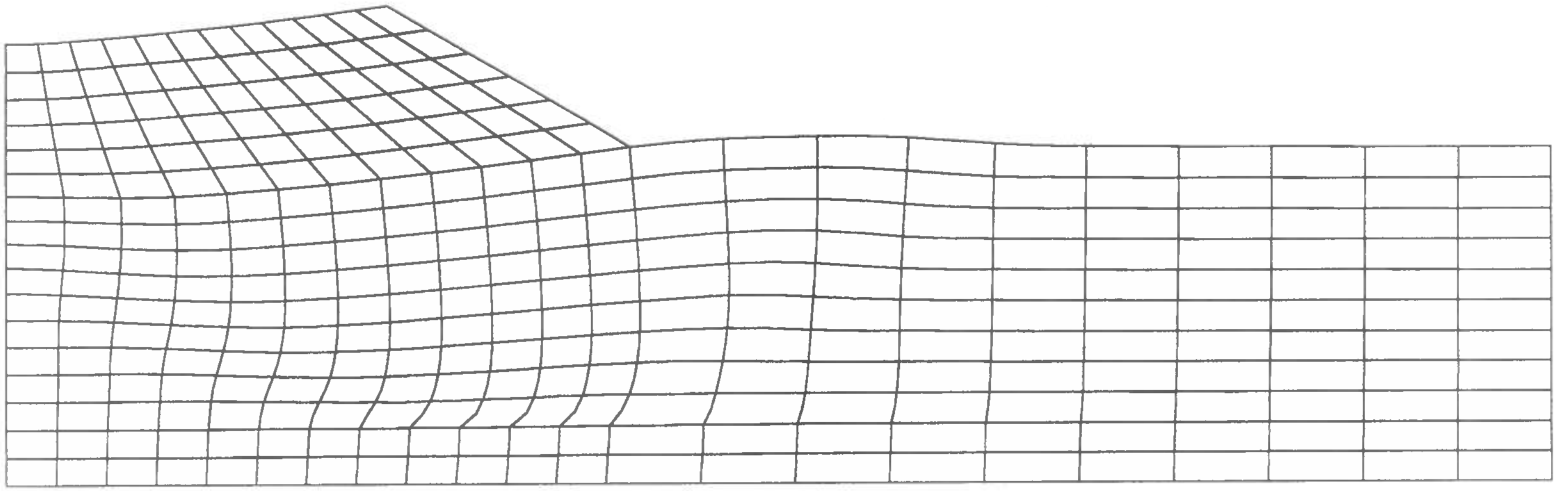
Section 9

Mesh



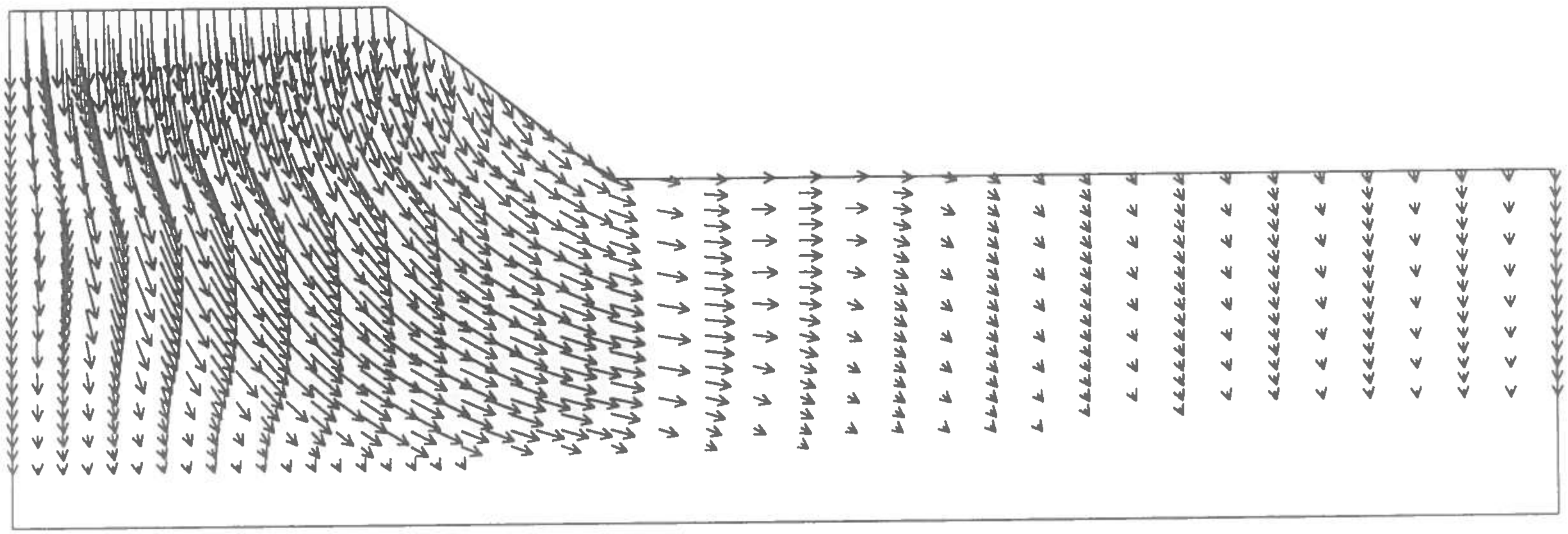
PRECISION ENGINEERING, INC.

Section 9
Deformed Mesh



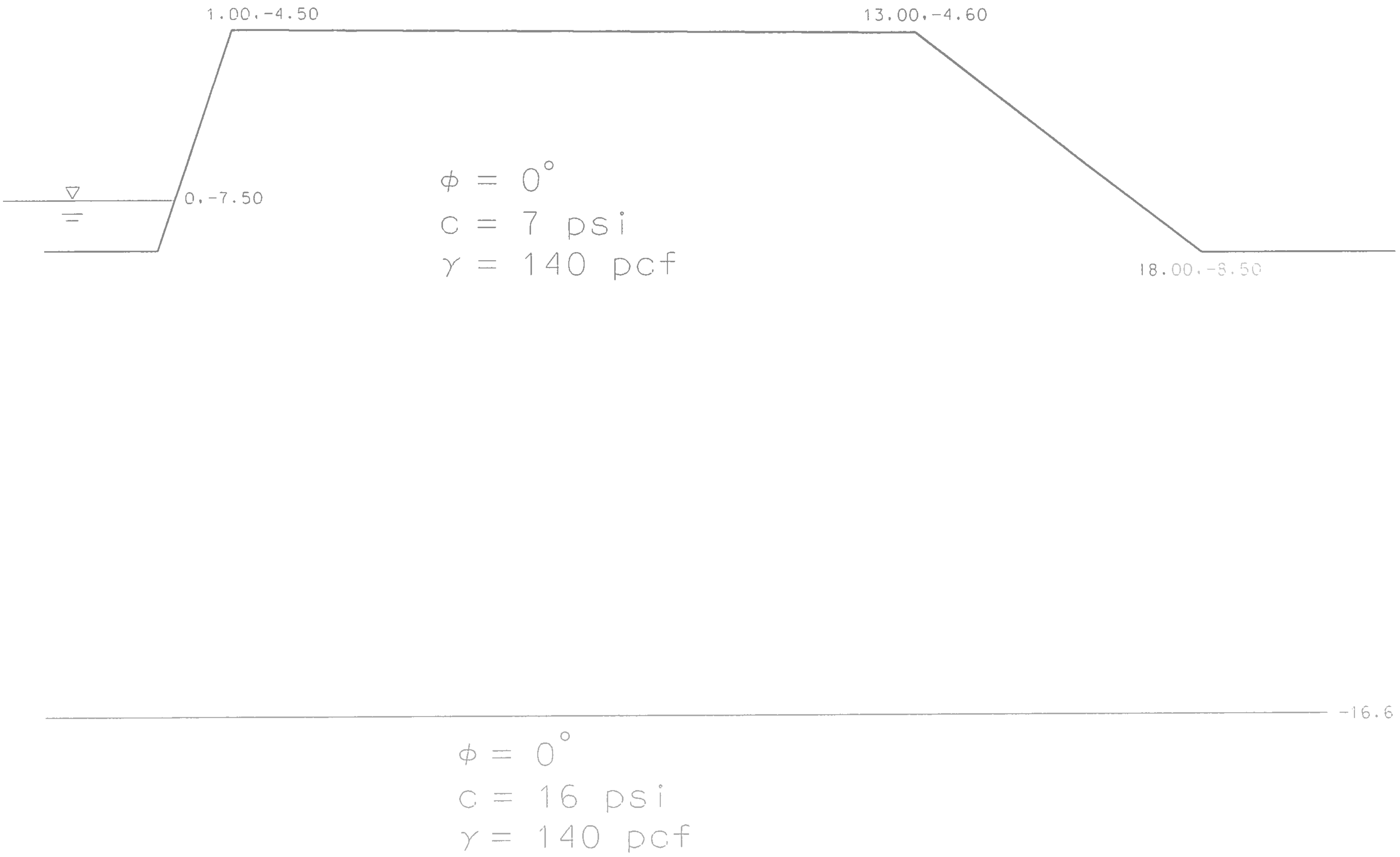
PRECISION ENGINEERING, INC.

Section 9
Vector Trace



Section 10

Factor Of Safety = 10.0

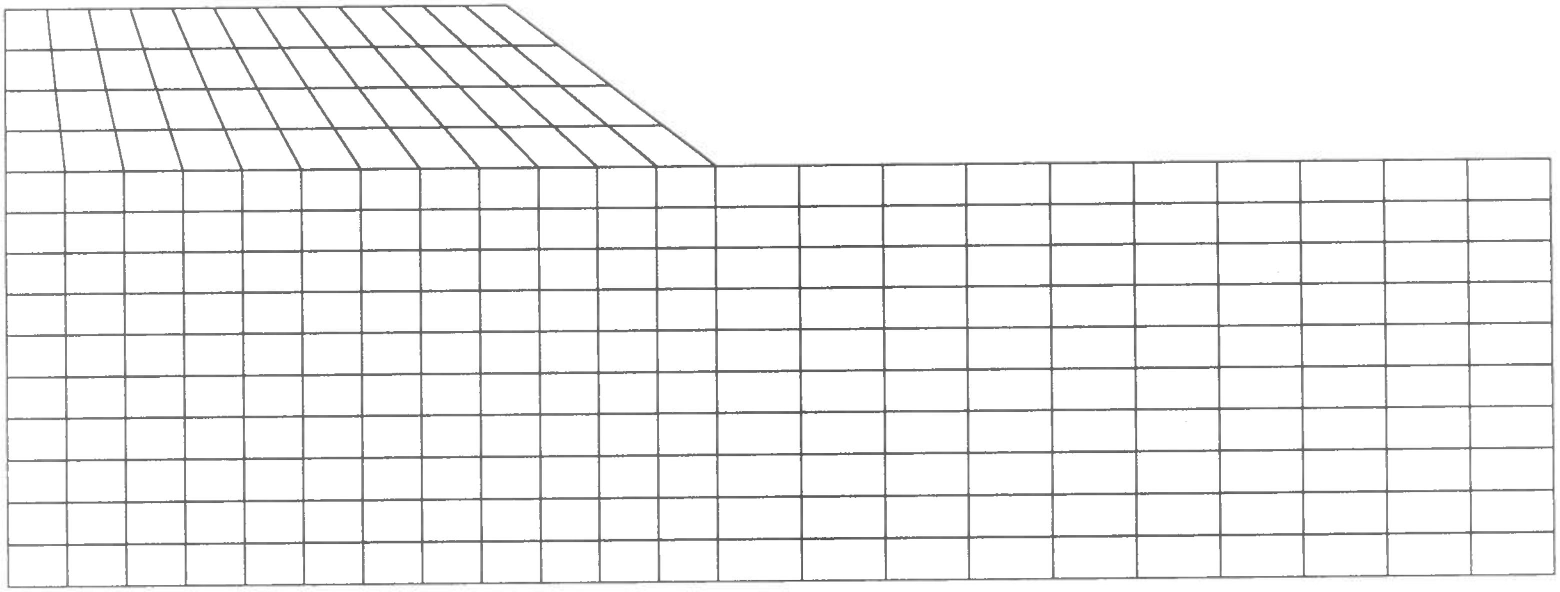


```
Section 10 Profile

w1=   12.00
s1=    5.00
w2=   20.00
h1=    3.90
h2=   10.00

nx1=   12
nx2=   10
ny1=    4
ny2=   10

Group  phi       c       psi    gamma       e           v
  1    0.00 1008.00     0.00  140.00  0.1000E+06     0.30
  2    0.00 2304.00     0.00  140.00  0.1000E+06     0.30

Property group assigned to each element
    1   1   1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2   2   2   2
```

```
   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   2   2

tol=  0.000100
limit= 1000

      trial factor    max displacement   iterations
      0.9500E+01      0.2121E+00             101
      0.9600E+01      0.2150E+00             110
      0.9700E+01      0.2184E+00             121
      0.9800E+01      0.2229E+00             144
      0.9900E+01      0.2381E+00             417
      0.1000E+02      0.3642E+00            1000
```

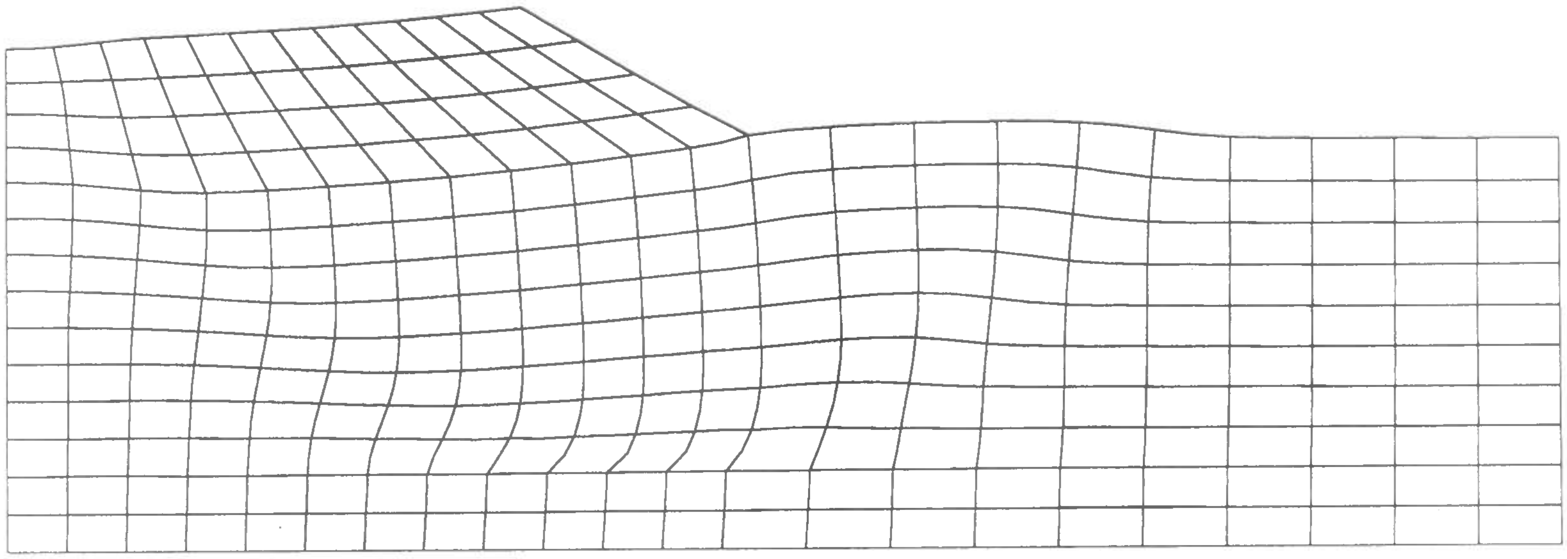
Section 10

Mesh



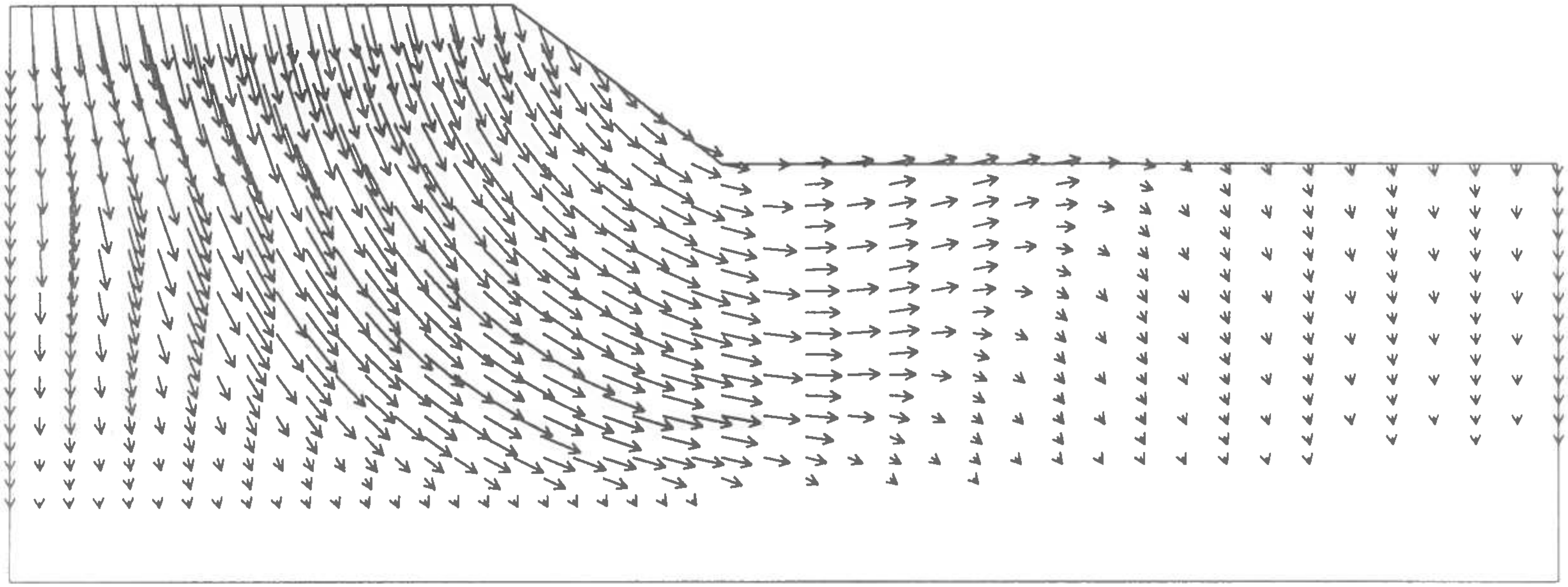
Section 10

Deformed Mesh



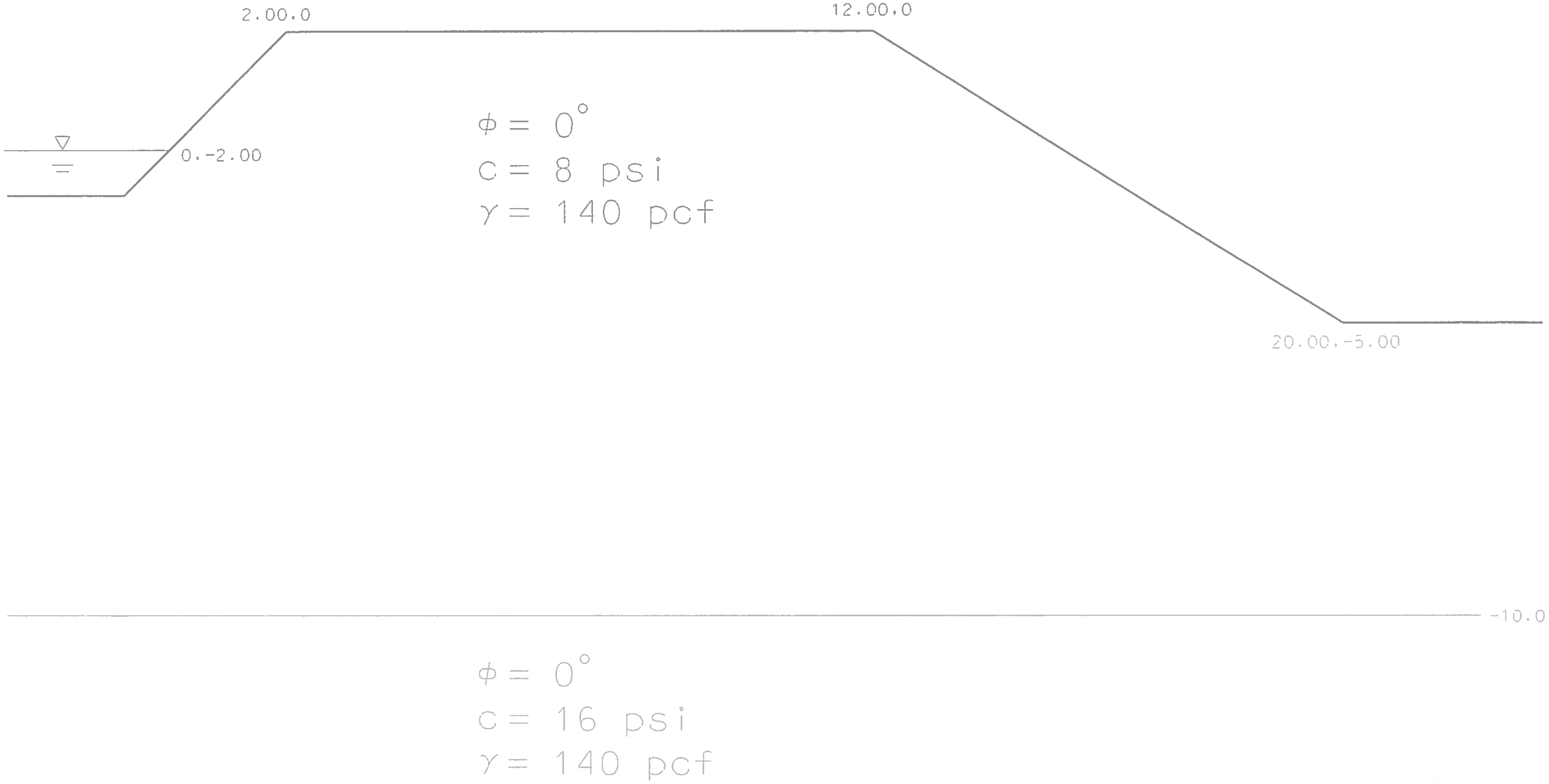
Section 10

Vector Trace



Section 11

Factor Of Safety = 9.4

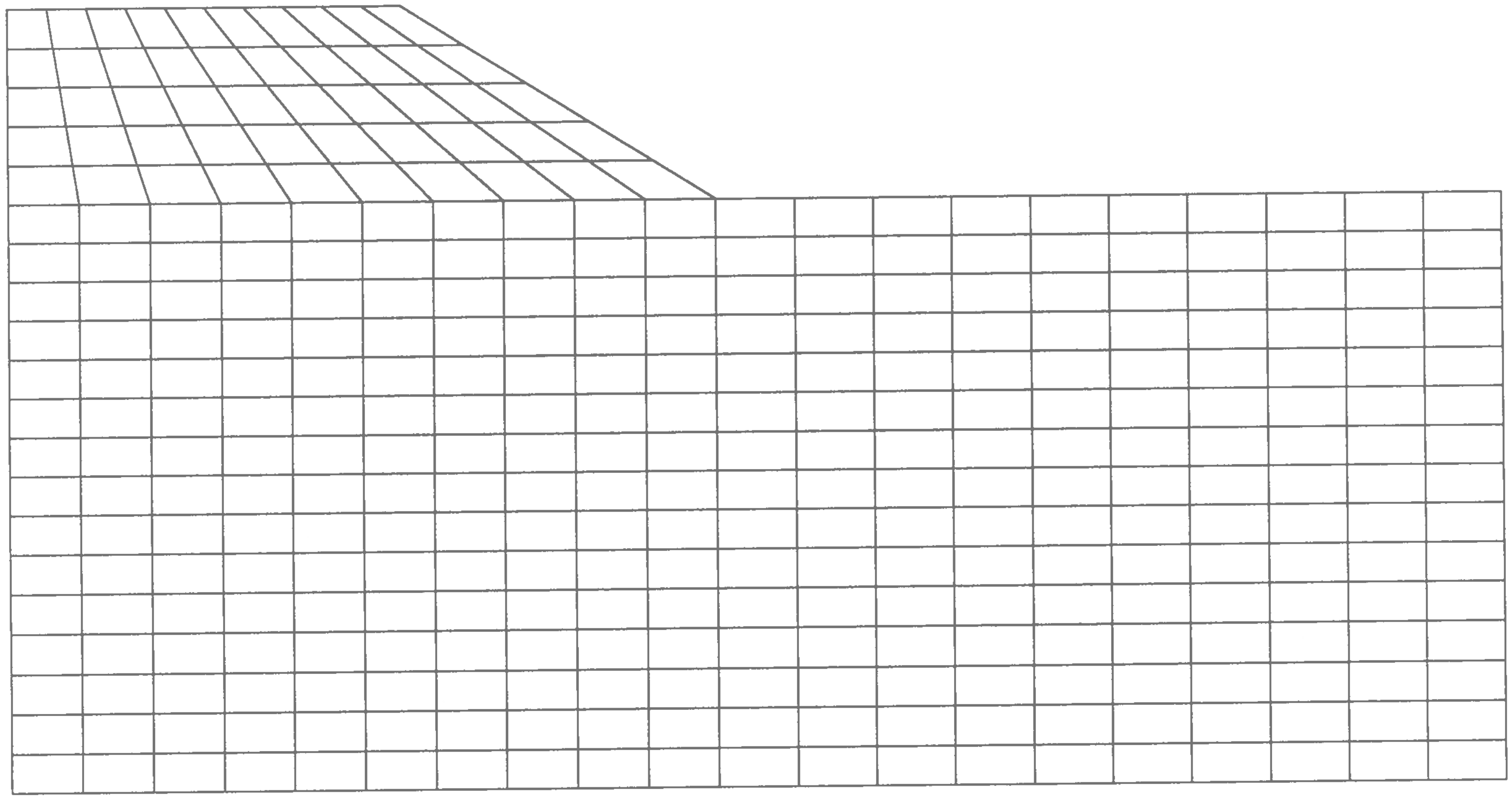


```
Section 11 Profile

w1=   10.00
s1=    8.00
w2=   20.00
h1=    5.00
h2=   15.00

nx1=   10
nx2=   10
ny1=    5
ny2=   15

Group  phi      c      psi    gamma      e          v
  1    0.00 1152.00    0.00   140.00  0.1000E+06    0.30
  2    0.00 2304.00    0.00   140.00  0.1000E+06    0.30

Property group assigned to each element
    1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
  1   1   1   1
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2   2   2   2
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2   2   2   2
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2   2   2   2
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2   2   2   2
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2   2   2   2
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2   2   2   2
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
  2   2   2   2
    2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
```

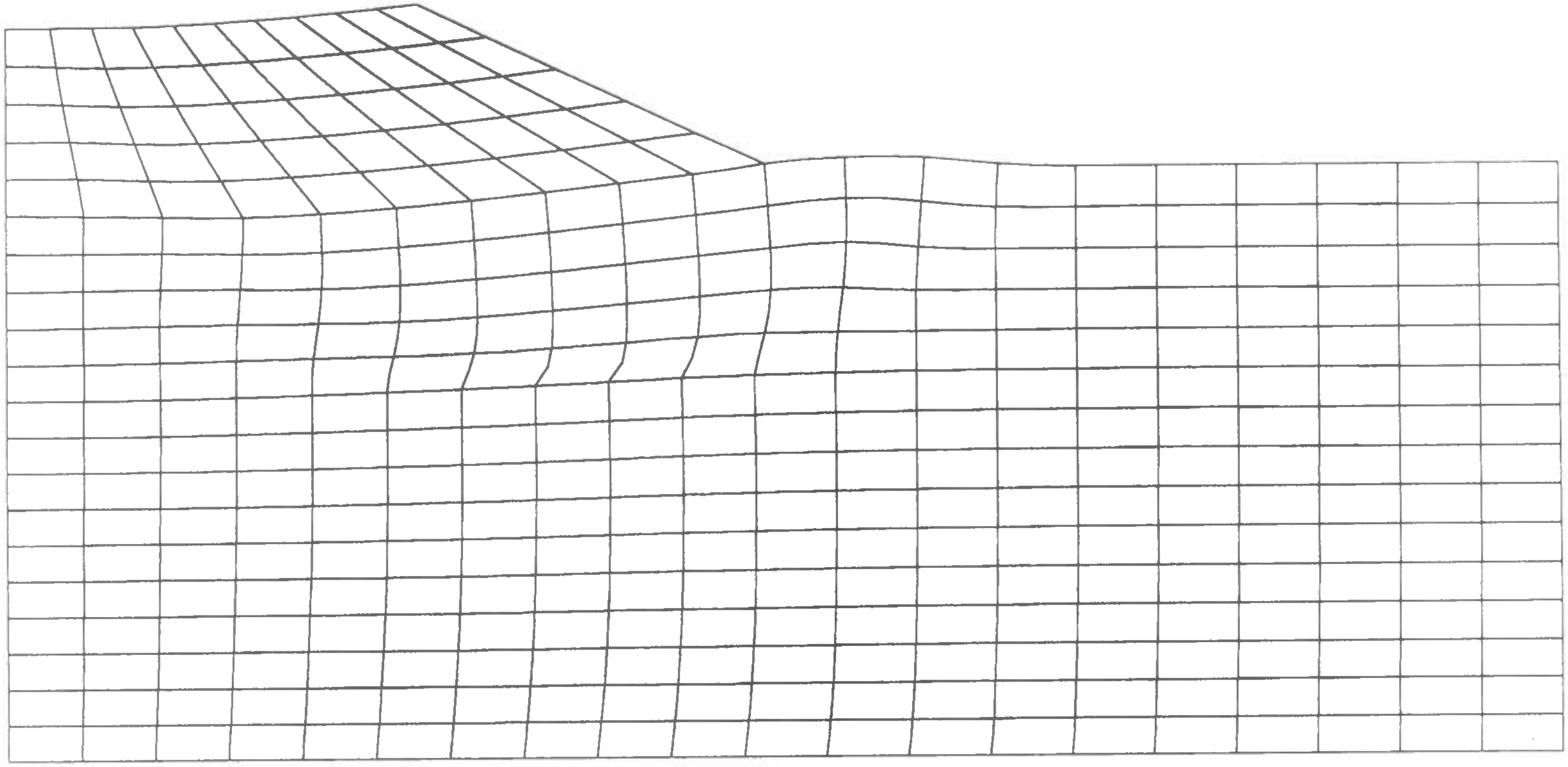
```
 2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2
   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2   2
 2   2   2   2

tol=  0.000100
limit= 1000

      trial factor    max displacement   iterations
      0.9000E+01      0.4058E+00              83
      0.9100E+01      0.4124E+00             110
      0.9200E+01      0.4204E+00             148
      0.9300E+01      0.4331E+00             231
      0.9400E+01      0.5048E+00            1000
```

Section 11

Mesh

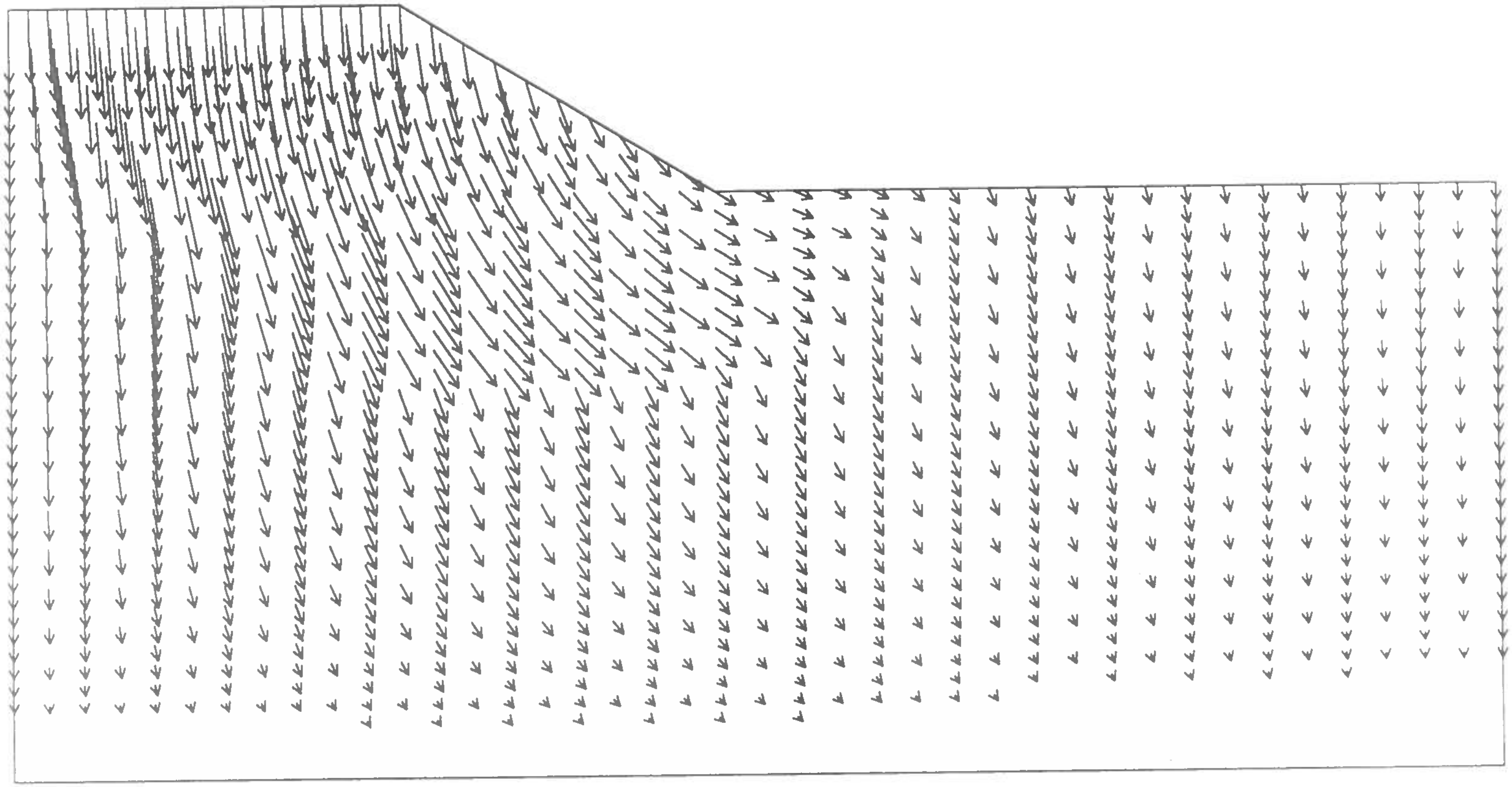


Section 11
Deformed Mesh



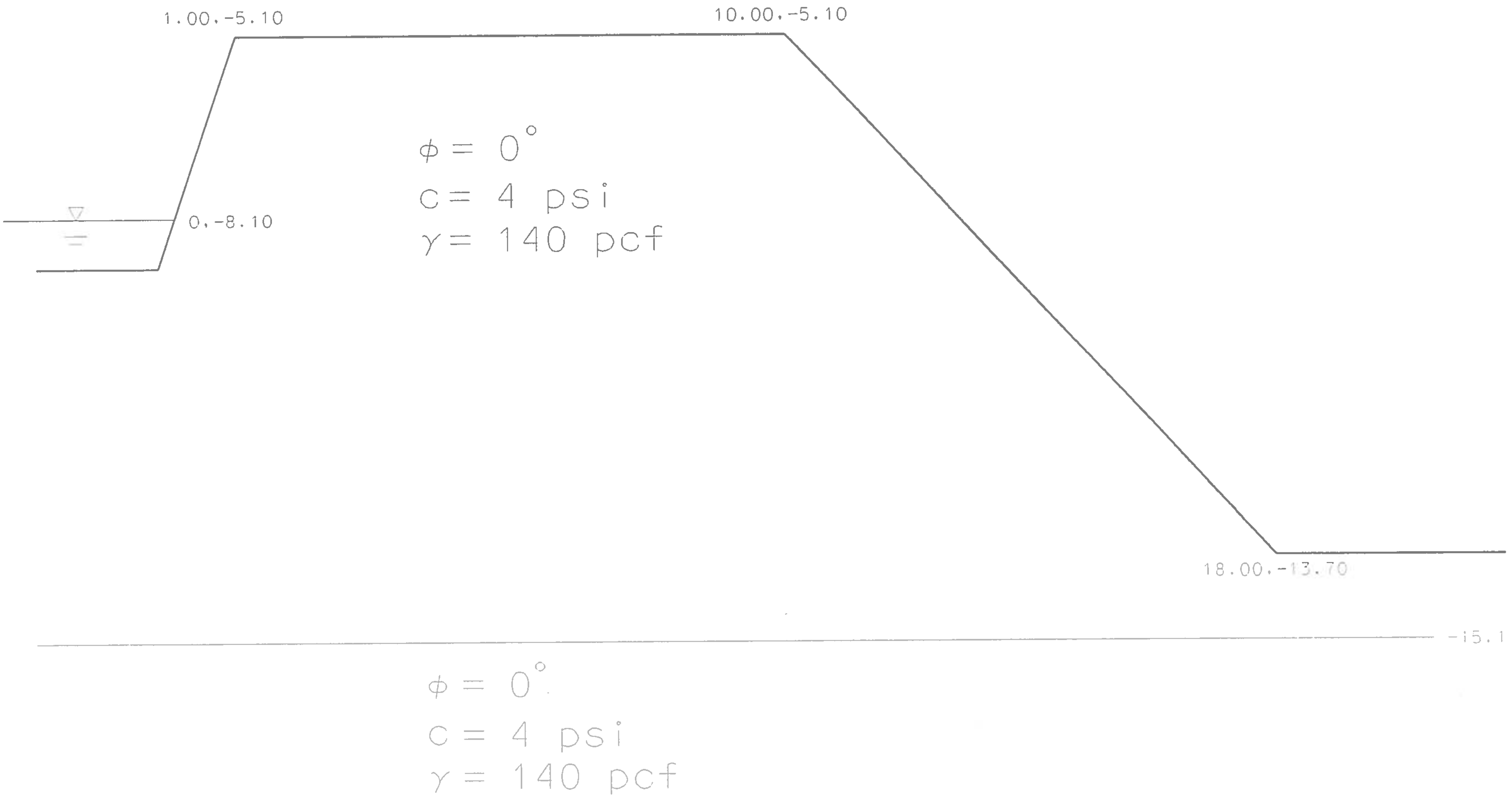
Section 11

Vector Trace



Section 12

Factor Of Safety = 2.5



```
Section 12 Profile

w1=    9.00
s1=    8.00
w2=   30.00
h1=    8.60
h2=   20.00

nx1=   10
nx2=   15
ny1=    9
ny2=   20

Group  phi      c      psi    gamma      e         v
  1    0.00  576.00    0.00  140.00  0.1000E+06    0.30

Property group assigned to each element
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
```

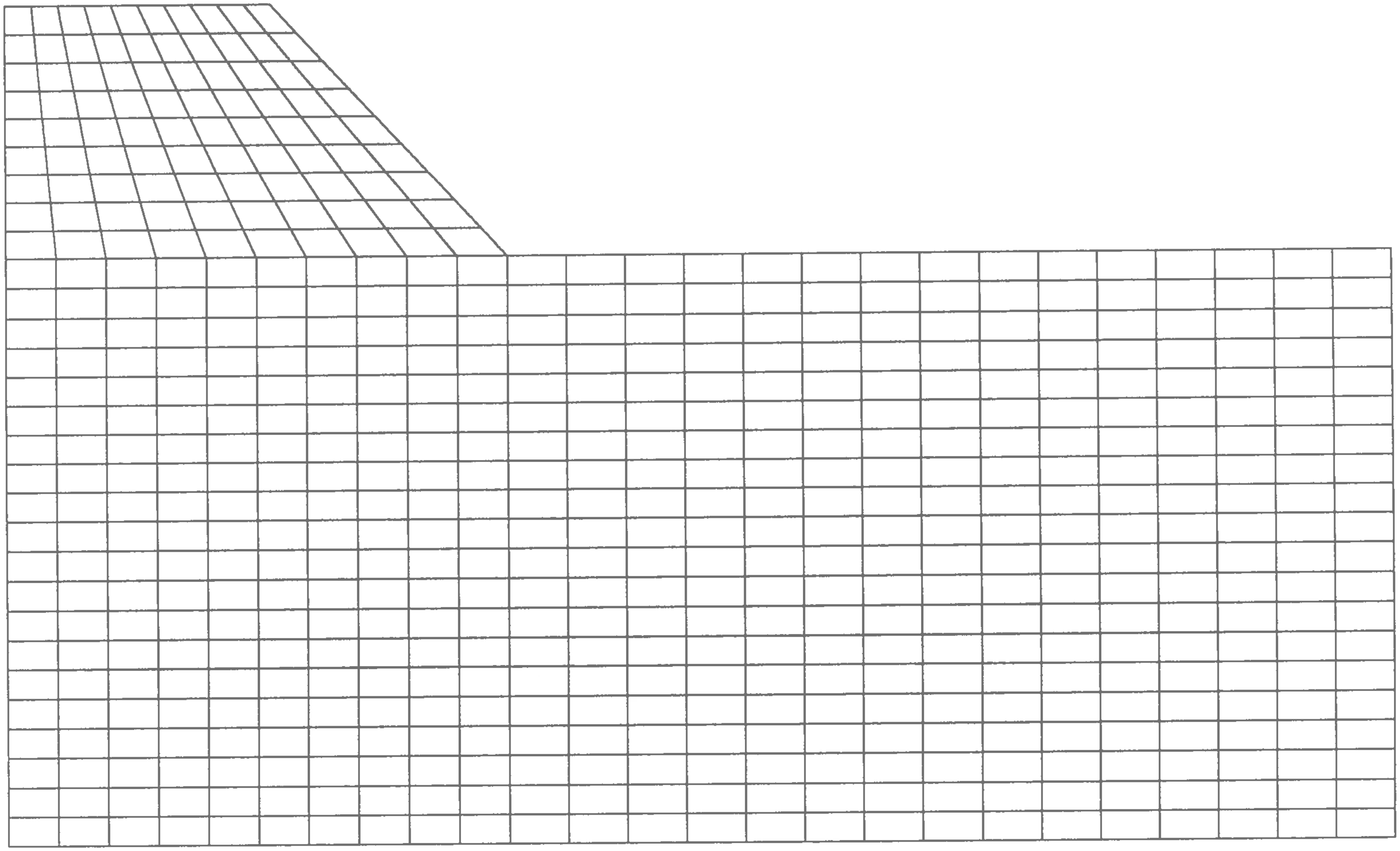
```
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 1   1   1   1
   1   1   1   1   1

tol=  0.000100
limit= 1000

      trial factor    max displacement    iterations
      0.2000E+01      0.8471E+00               53
      0.2100E+01      0.8825E+00               60
      0.2200E+01      0.9211E+00               68
      0.2300E+01      0.9667E+00               76
      0.2400E+01      0.1049E+01              115
```

```
    0.2500E+01      0.2617E+01          1000
```

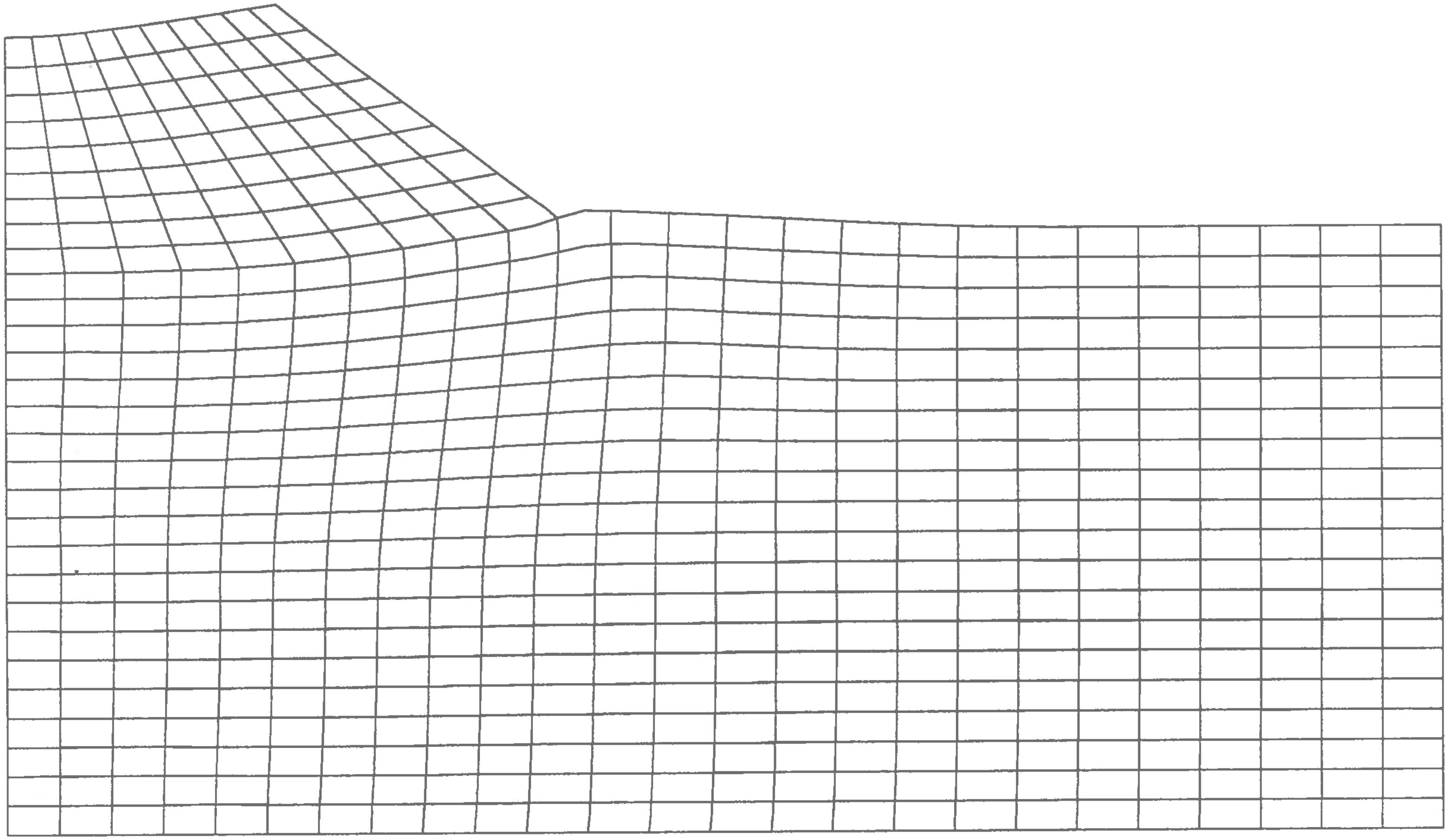
PRECISION ENGINEERING, INC.

Section 12

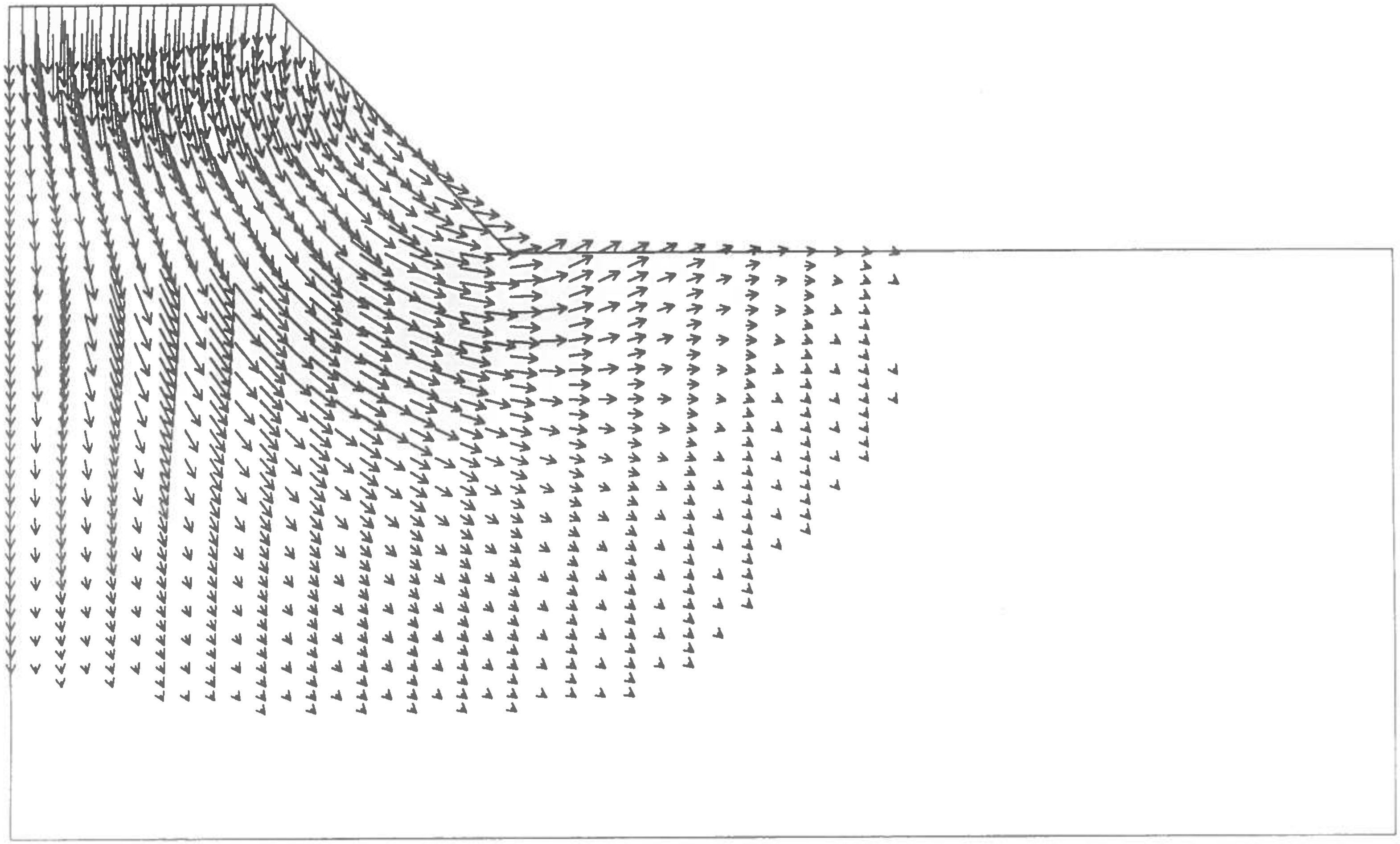
Mesh



Section 12
Deformed Mesh

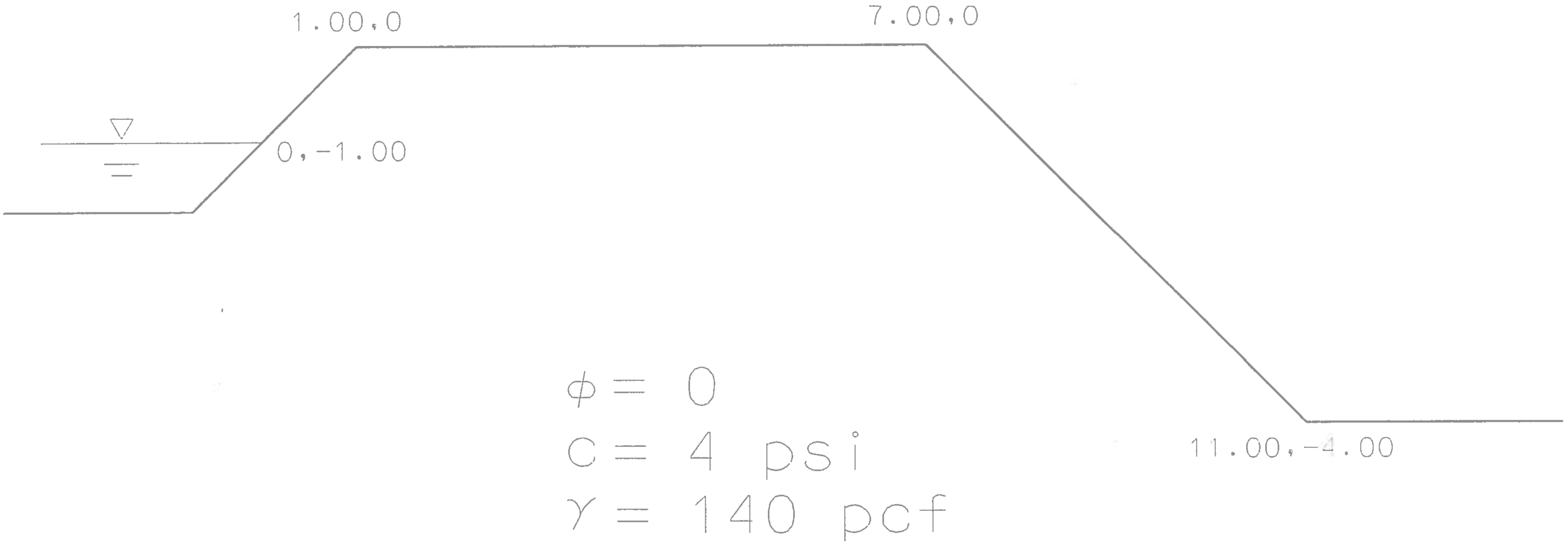


Section 12
Vector Trace



Section 13

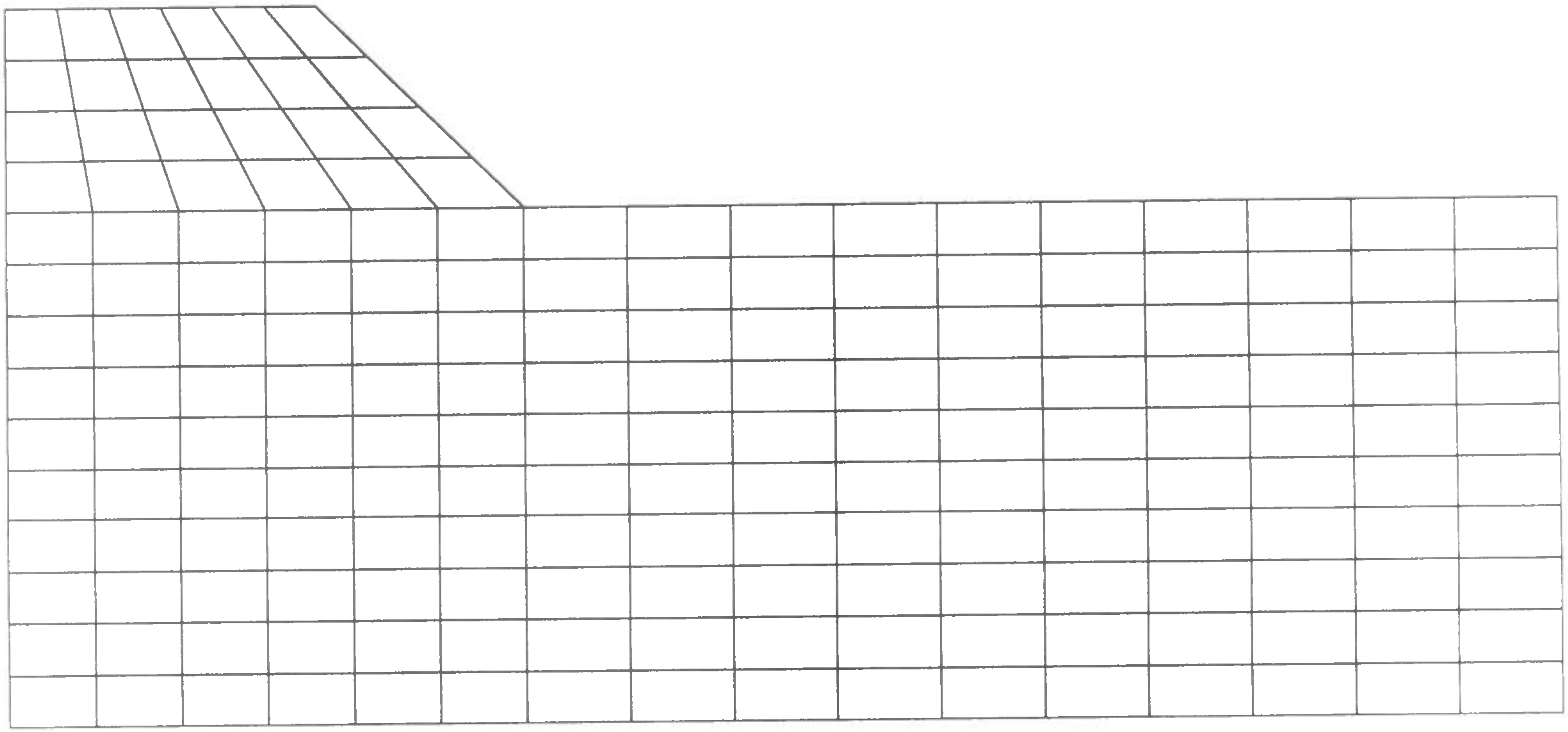
Factor Of Safety = 5.4



```
Section 13 Profile

w1=    6.00
s1=    4.00
w2=   20.00
h1=    4.00
h2=   10.00

nx1=    6
nx2=   10
ny1=    4
ny2=   10

Group  phi      c      psi    gamma      e          v
  1    0.00  576.00    0.00  140.00  0.1000E+06    0.30

Property group assigned to each element
   1   1   1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1

tol=  0.000100
limit= 1000

      trial factor    max displacement   iterations
      0.5000E+01      0.2583E+00              75
      0.5100E+01      0.2652E+00              82
      0.5200E+01      0.2768E+00             105
      0.5300E+01      0.3485E+00             570
      0.5400E+01      0.8591E+00            1000
```

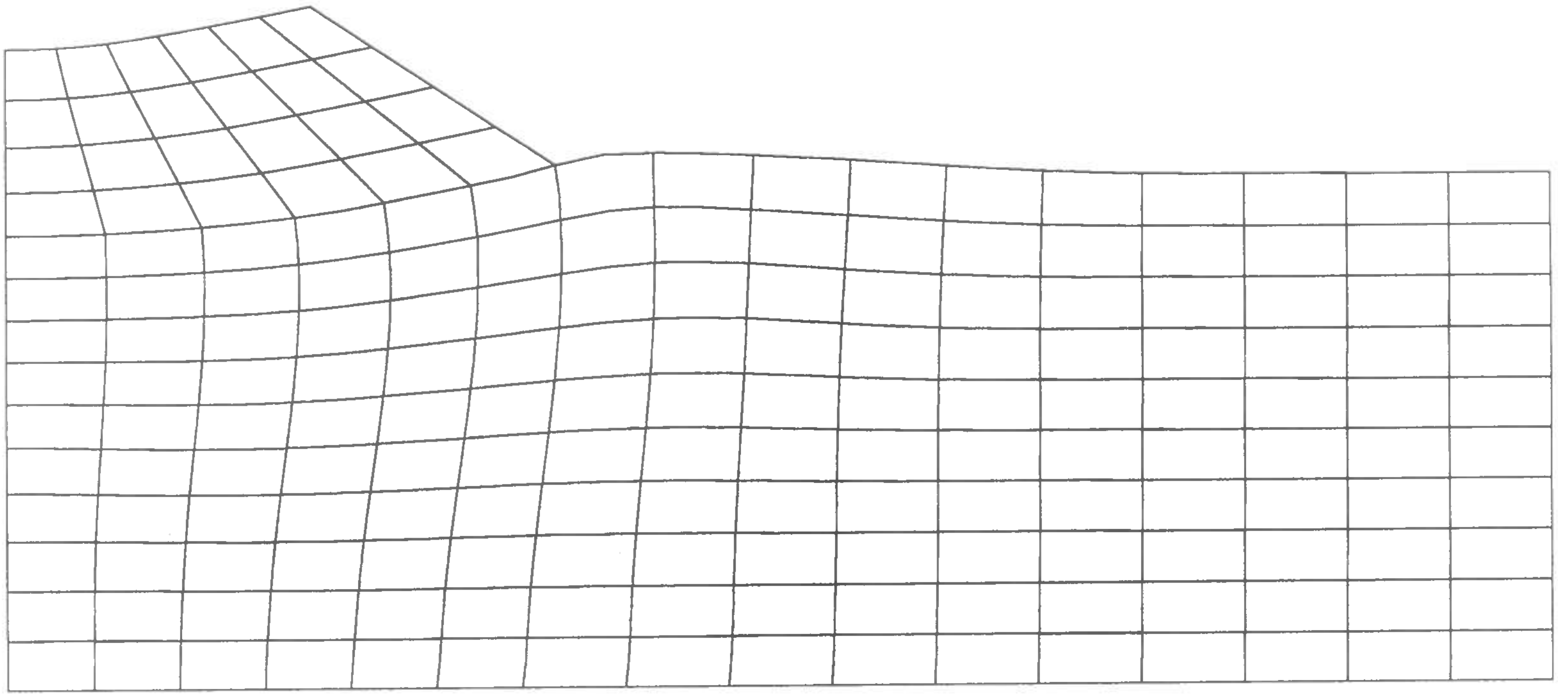
Section 13

Mesh



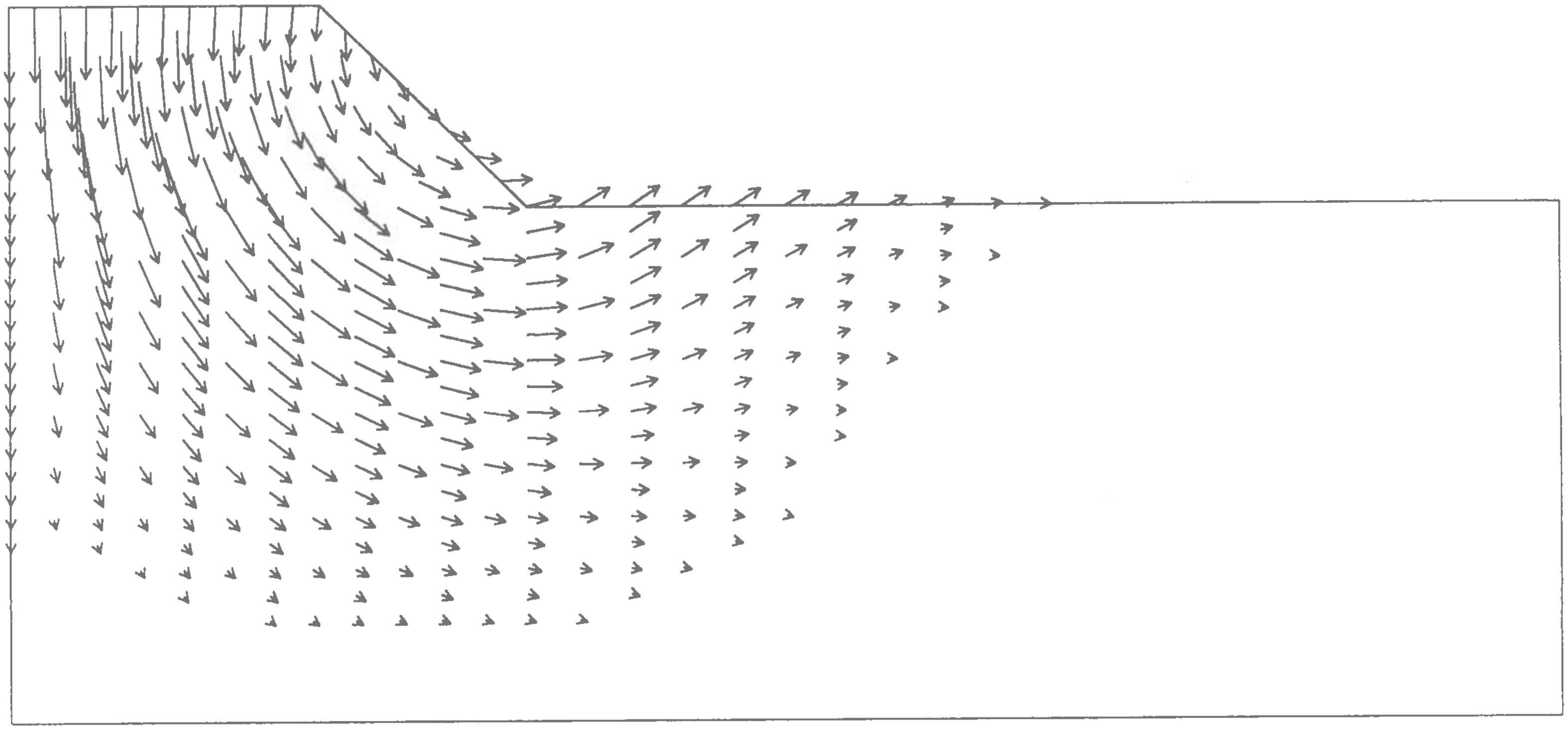
Section 13

Deformed Mesh



Section 13

Vector Trace



Triaxial Shear Results

Project: Ciniza Evaporation Lagoons

Project Number: 00-141

Sample #: 38631

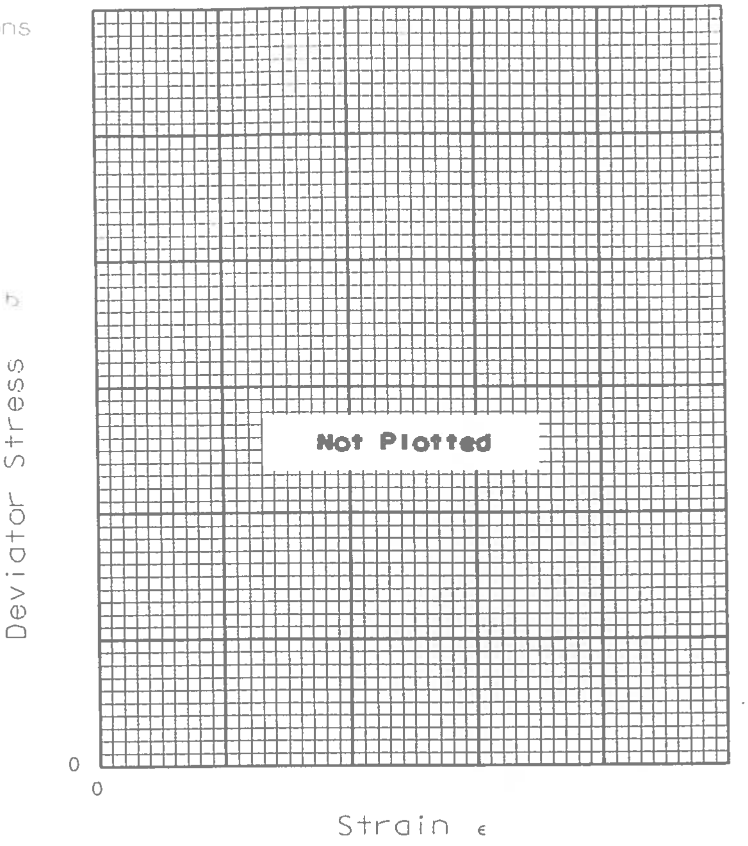
Unit Weight (pcf): 137.3 wet

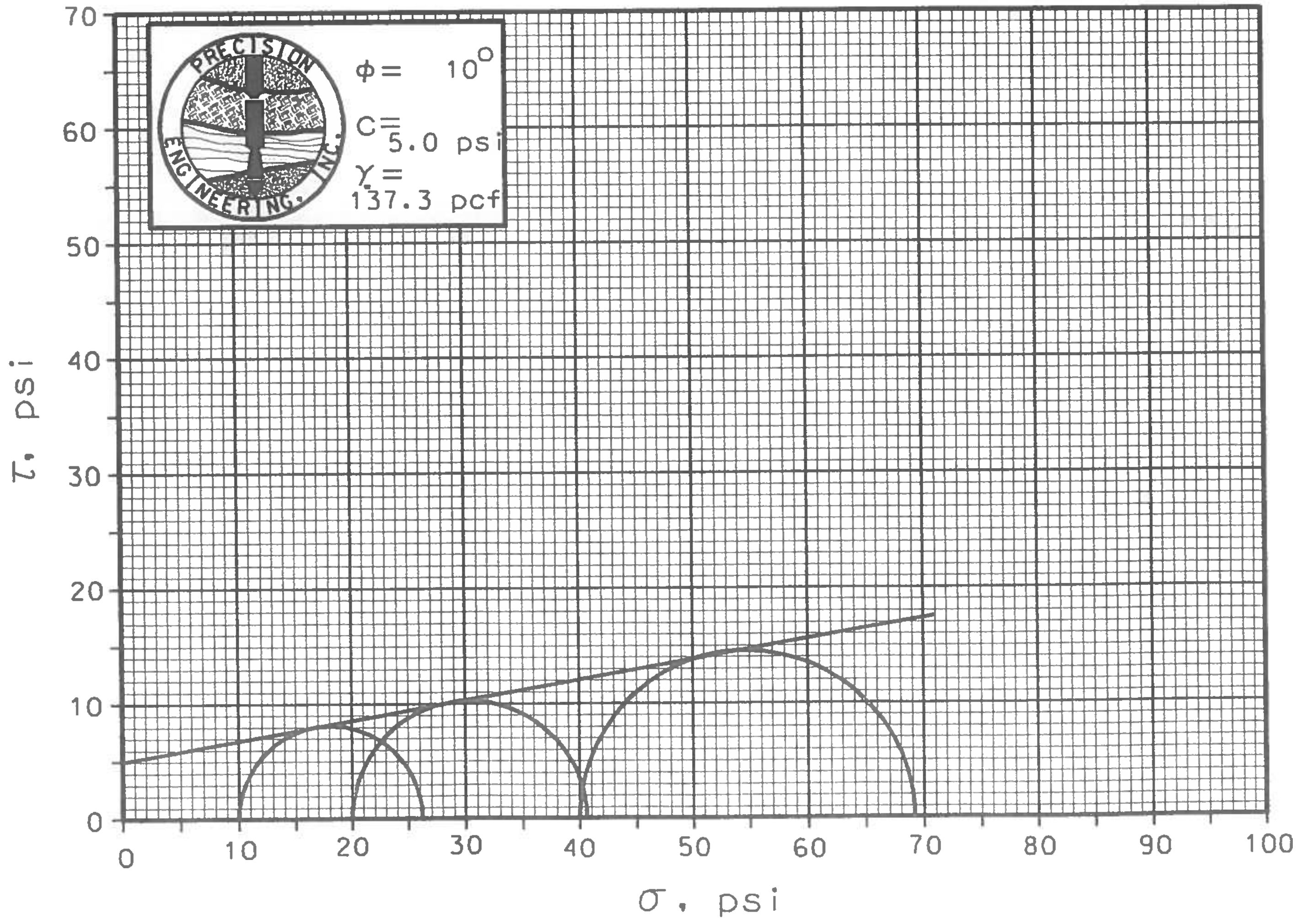
Lateral Pressure = σ_3

Max. Deviator Stress = σ

Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	16.2	26.2
2	20	20.8	40.8
3	40	29.1	69.1





Triaxial Shear Results

Project: Ciniza Evaporation Lagoons

Project Number: 00-141

Sample #: 38640

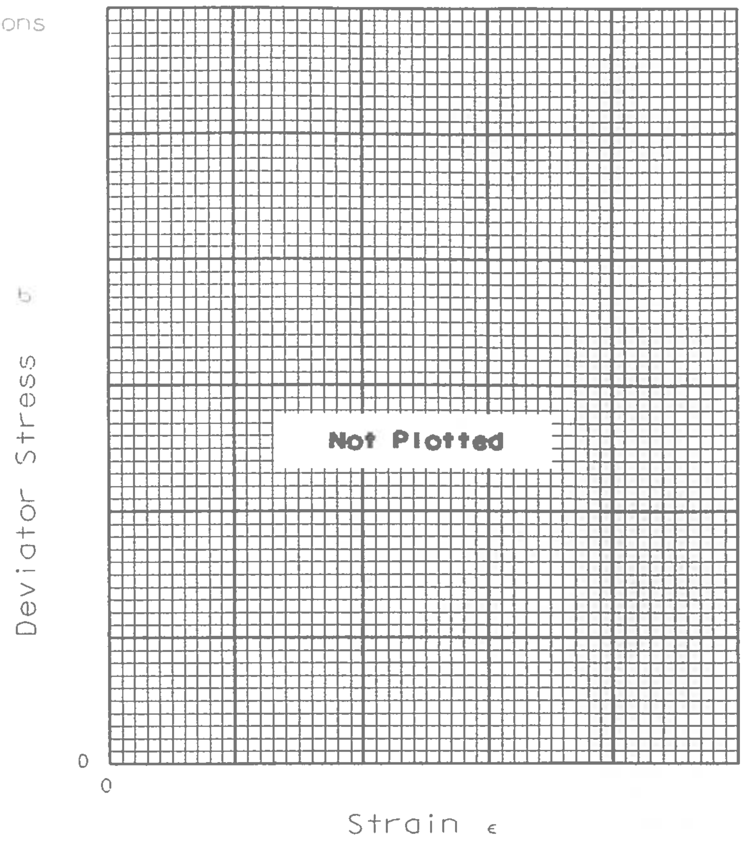
Unit Weight (pcf): 140.1 wet

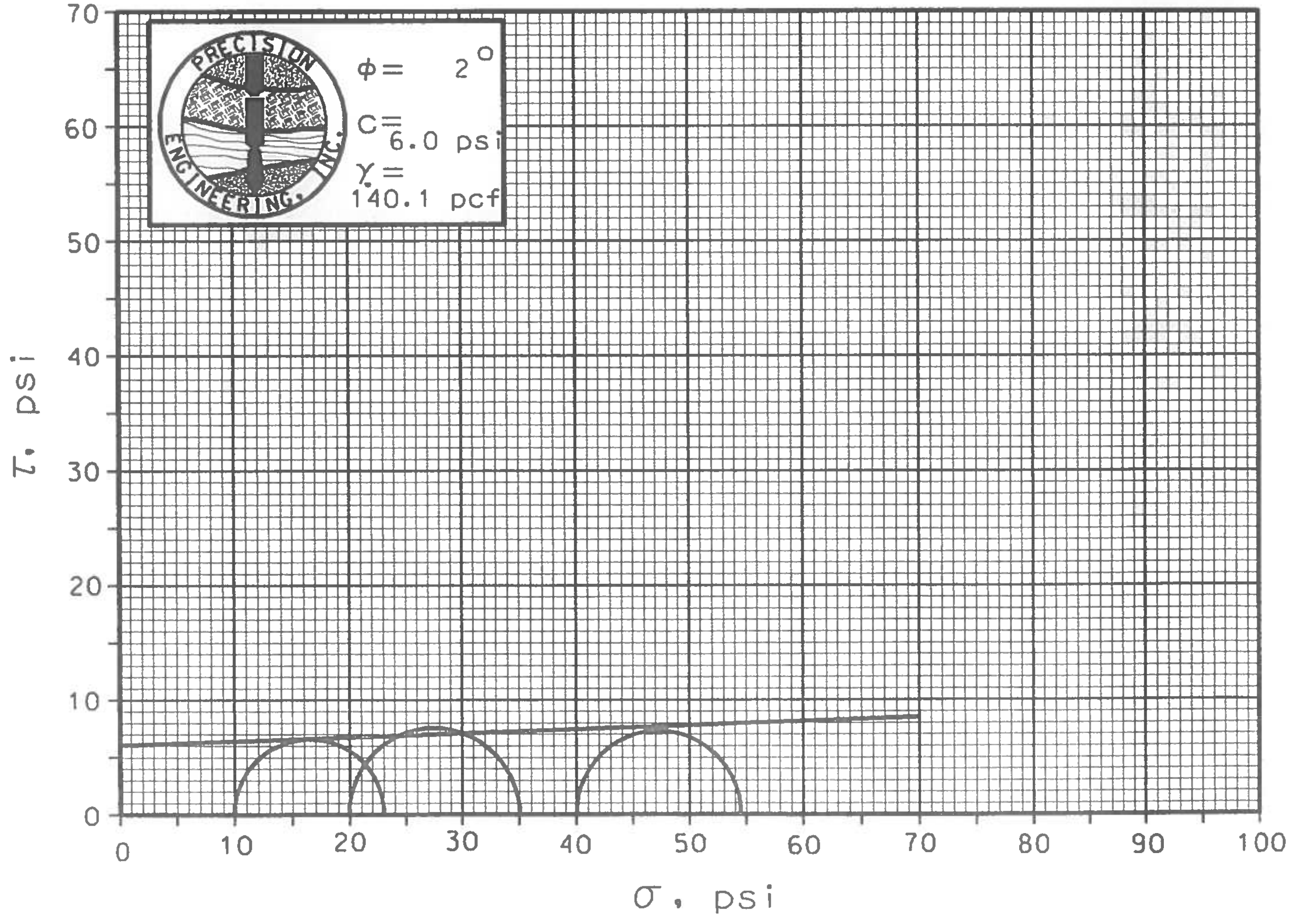
Lateral Pressure = σ_3

Max. Deviator Stress = σ

Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	24.0	23.0
2	20	29.9	35.0
3	40	24.1	54.5





Triaxial Shear Results

Project: Ciniza Evaporation Lagoons

Project Number: 00-141

Sample #: 38641

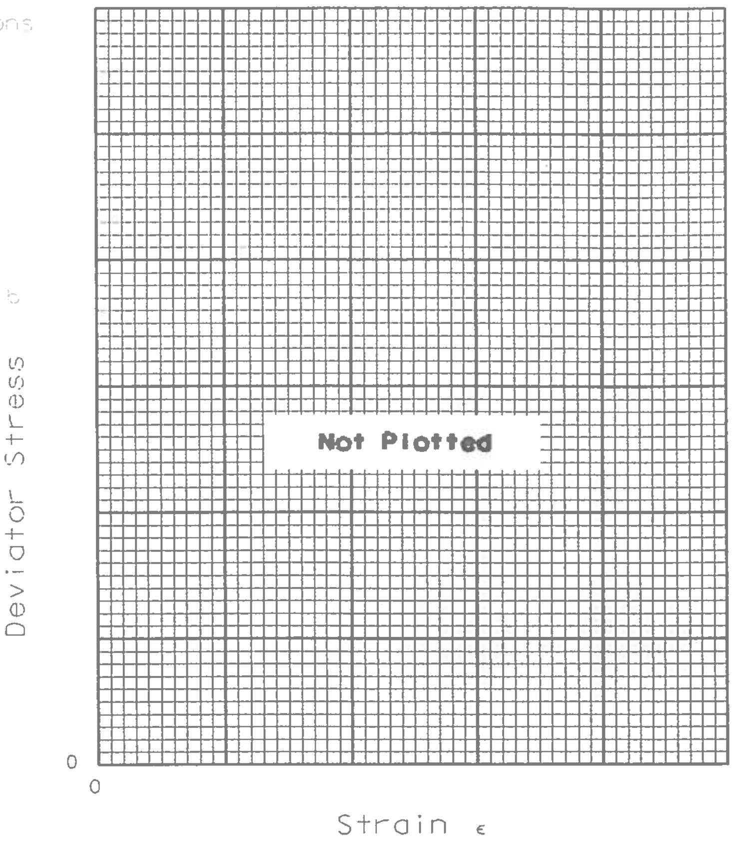
Unit Weight (pcf): 141.3 wet

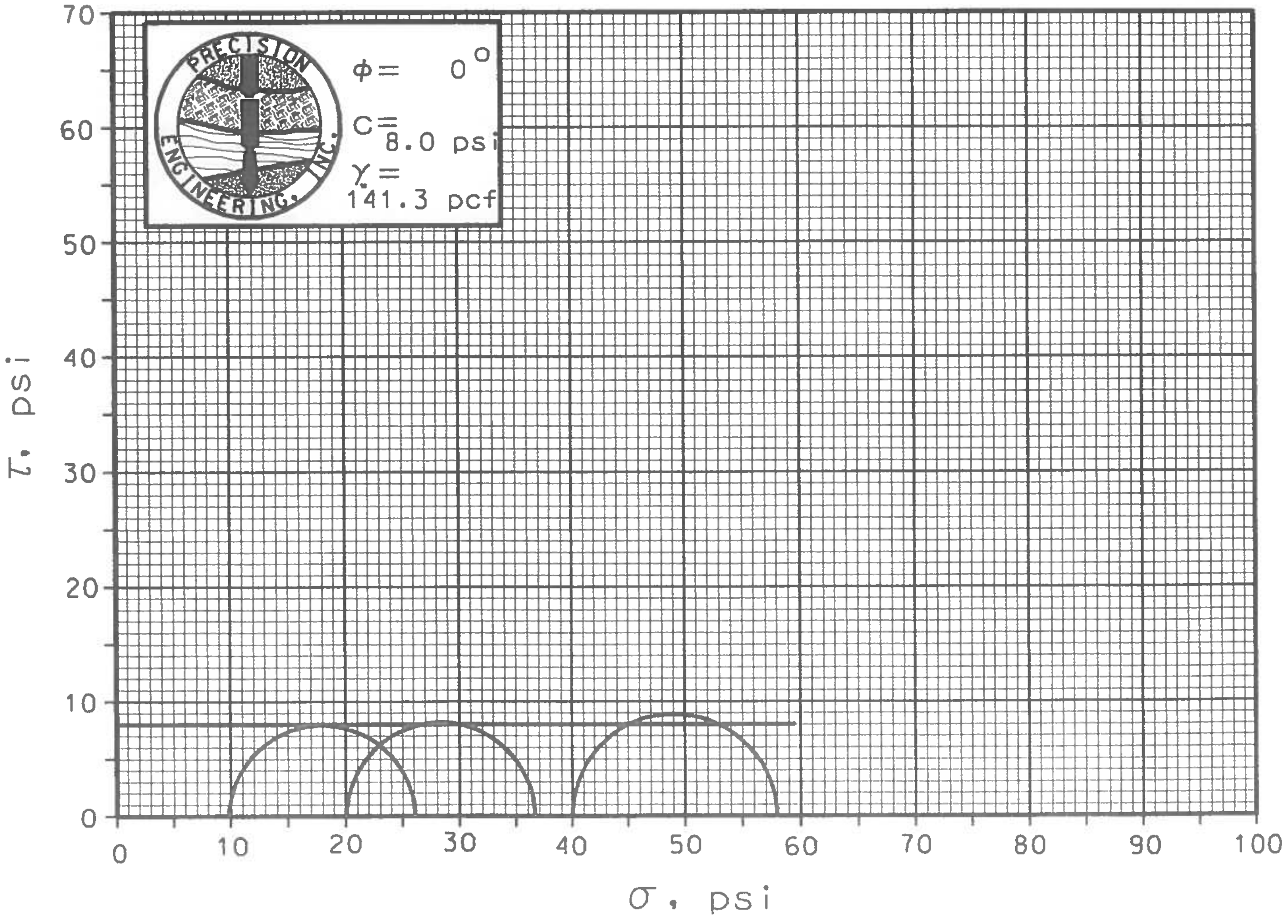
Lateral Pressure = σ_3

Max. Deviator Stress = σ

Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	16.1	26.1
2	20	16.7	36.7
3	40	18.0	58.0

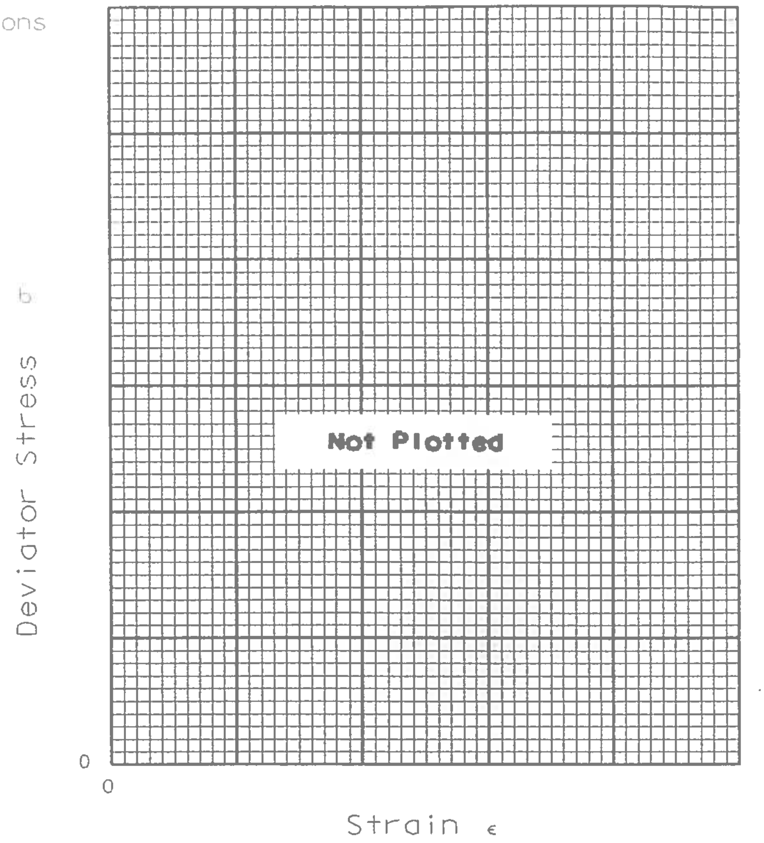


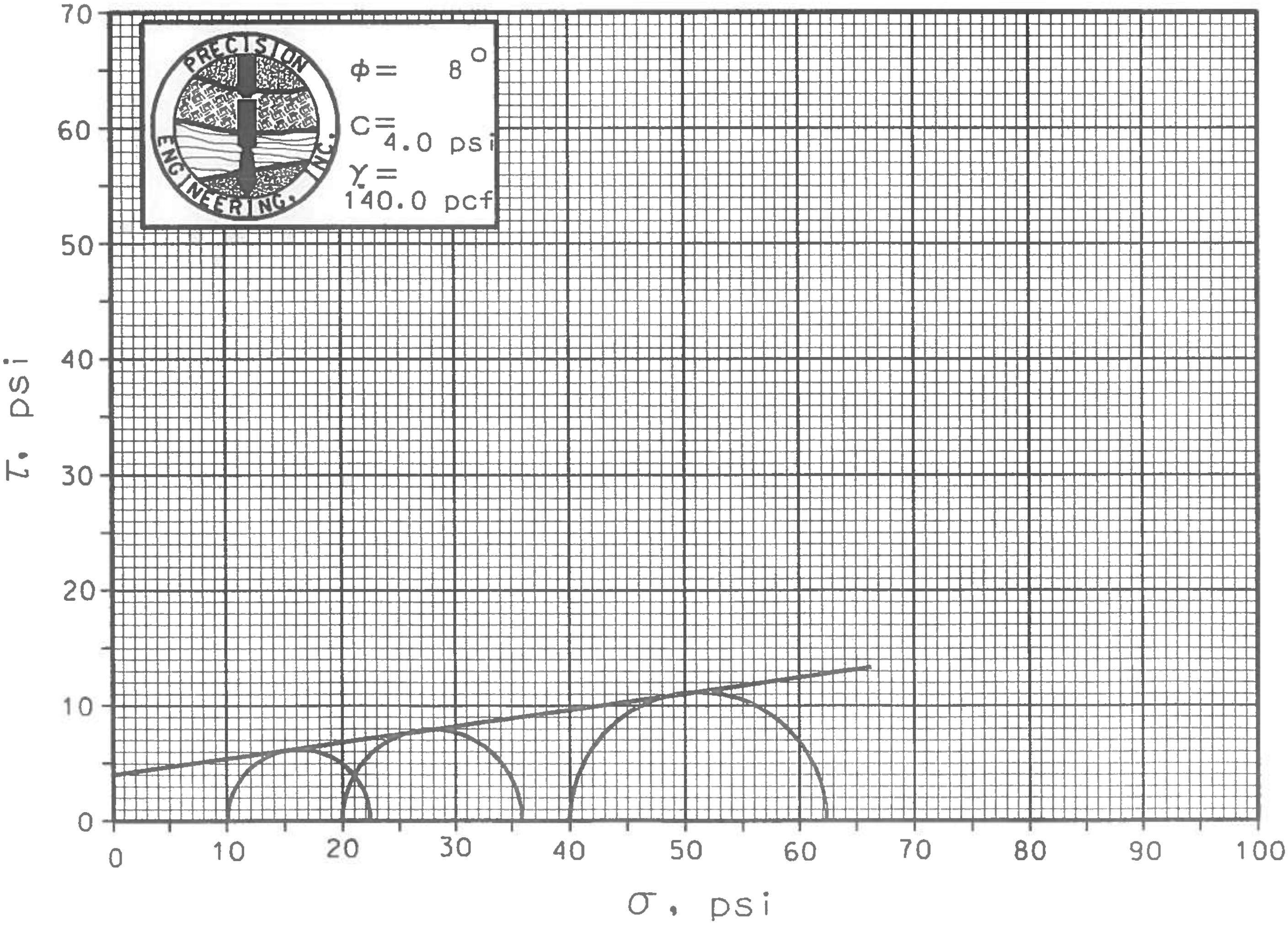


Triaxial Shear Results

Project: Ciniza Evaporation Lagoons
Project Number: 00-141
Sample #: 3864
Unit Weight (pcf): 140.0 wet
Lateral Pressure = σ_3
Max. Deviator Stress = σ_b
Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	12.3	22.3
2	20	15.9	35.9
3	40	22.4	62.4





Triaxial Shear Results

Project: Ciniza Evaporation Lagoons

Project Number: 00-141

Sample #: 38645

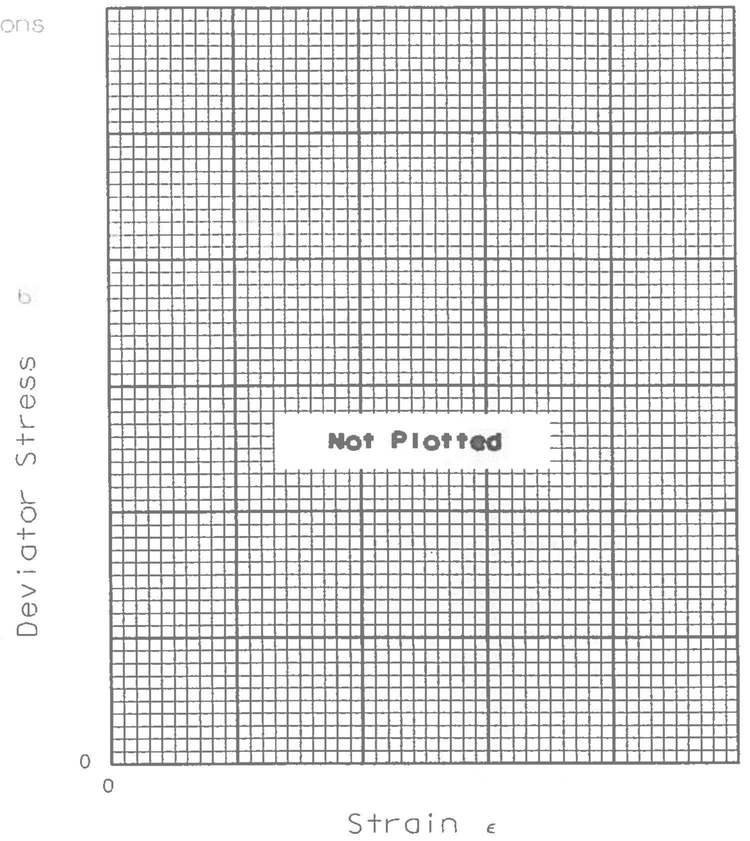
Unit Weight (pcf): 137.4 wet

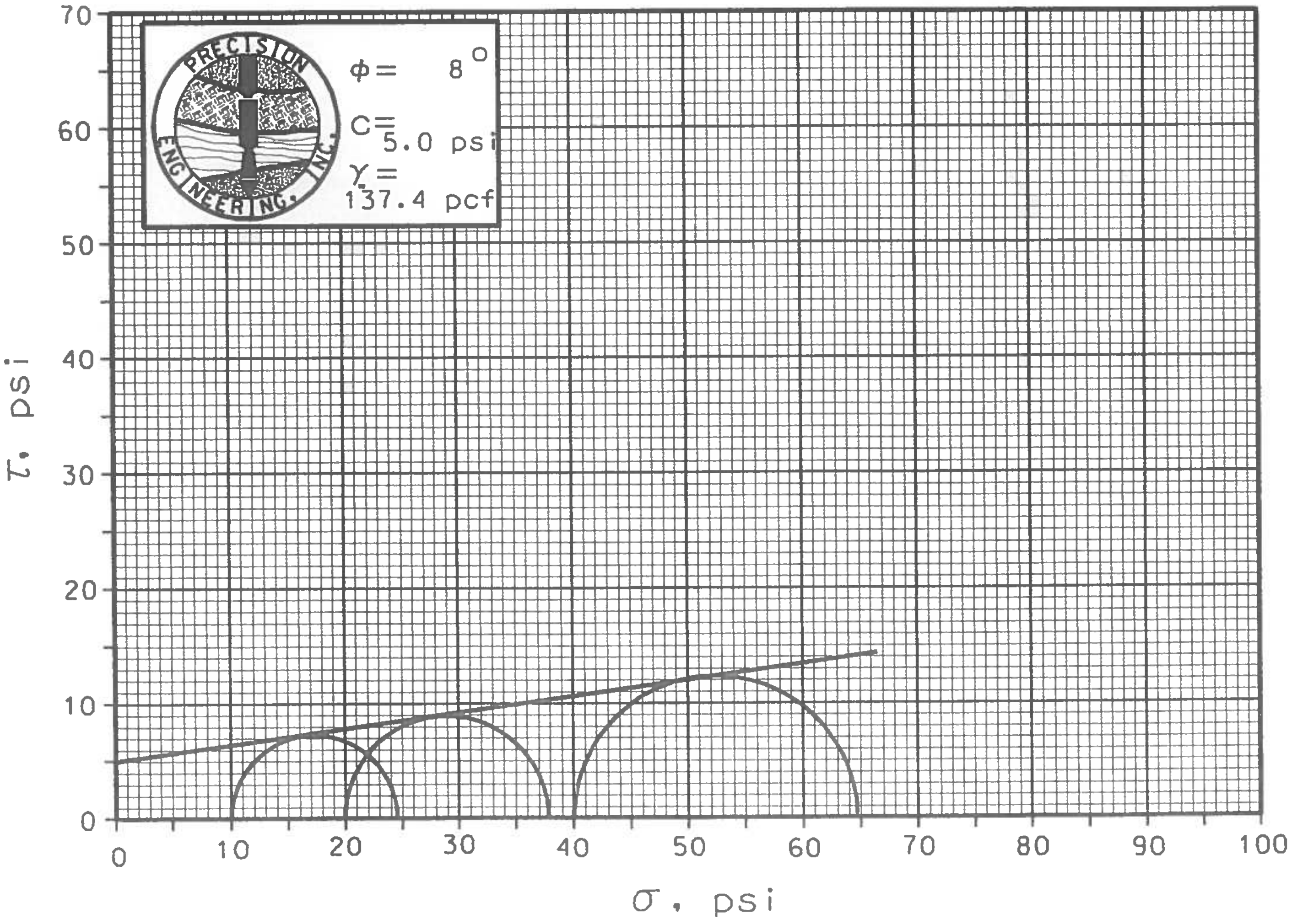
Lateral Pressure = σ_3

Max. Deviator Stress = σ

Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	14.5	24.5
2	20	17.9	37.9
3	40	24.8	64.8

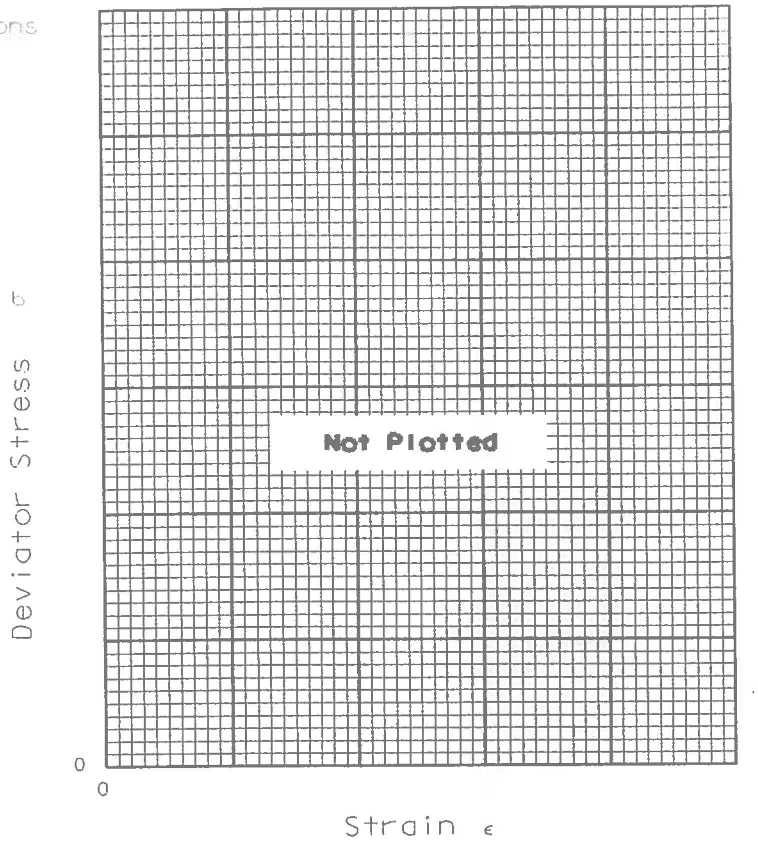


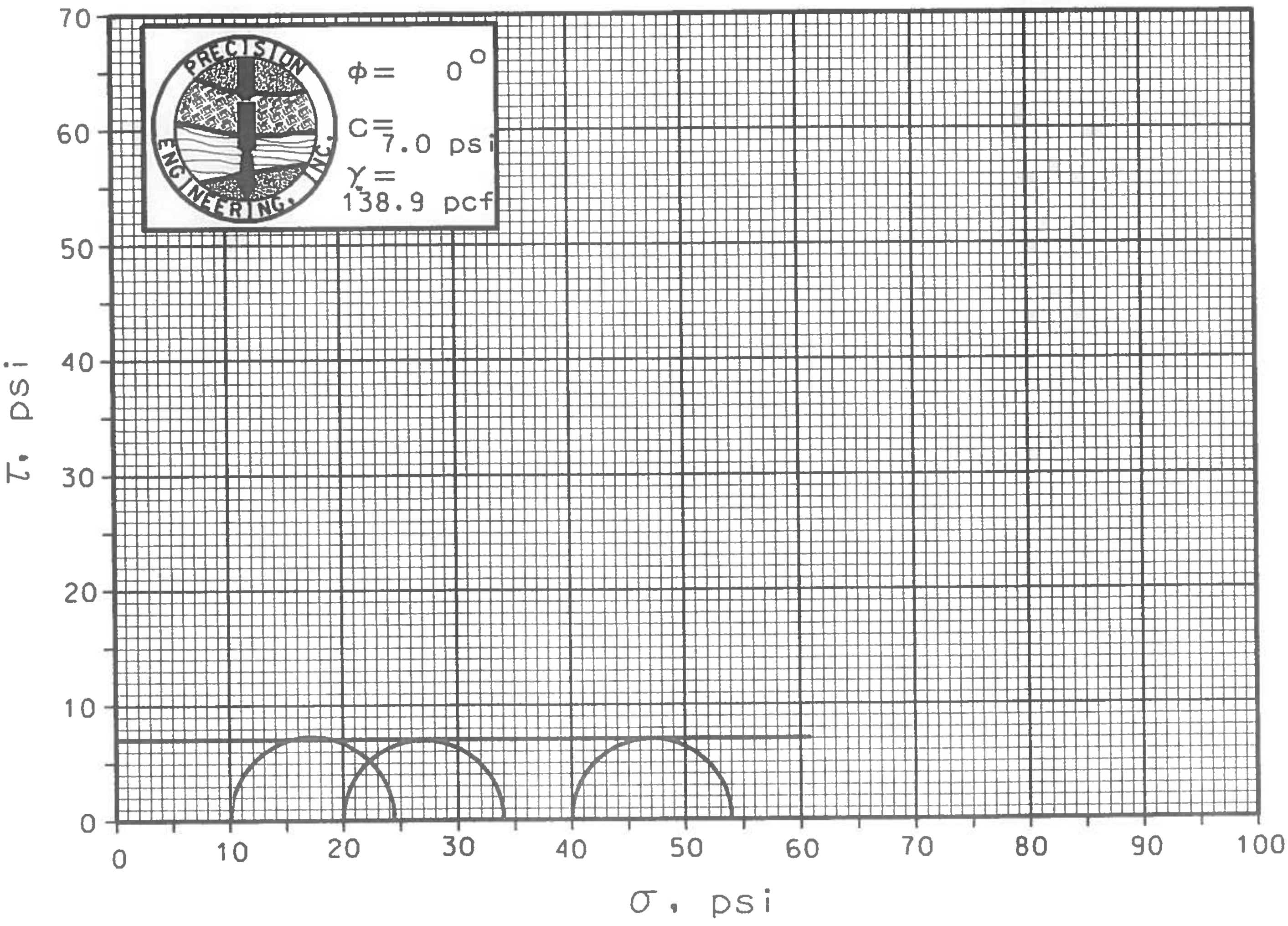


Triaxial Shear Results

Project: Ciniza Evaporation Lagoons
Project Number: 00-141
Sample #: 38647
Unit Weight (pcf): 138.9 wet
Lateral Pressure = σ_3
Max. Deviator Stress = σ
Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	14.4	24.4
2	20	14.0	34.0
3	40	14.0	54.0

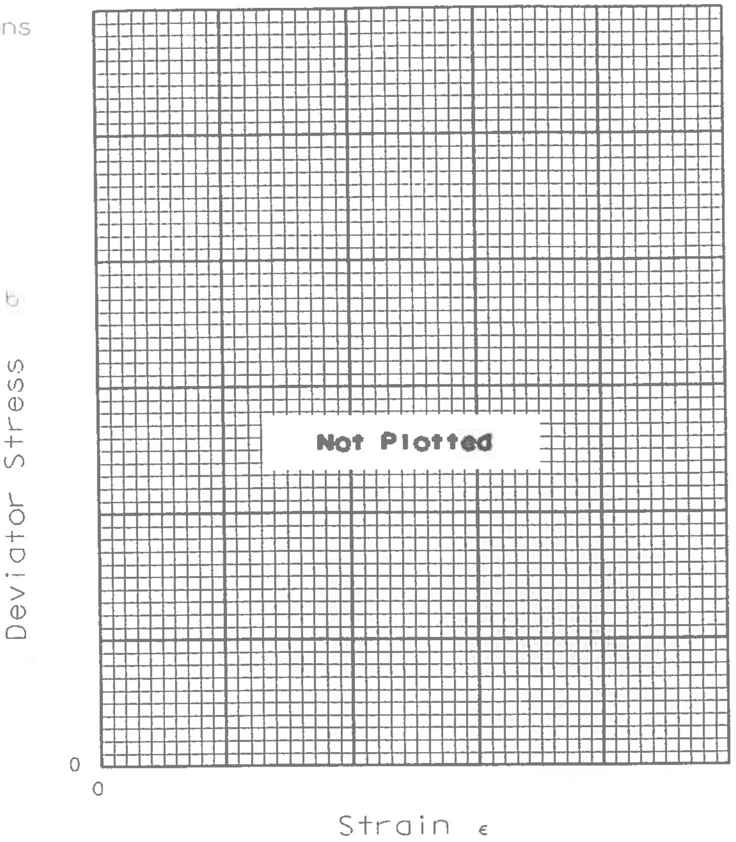


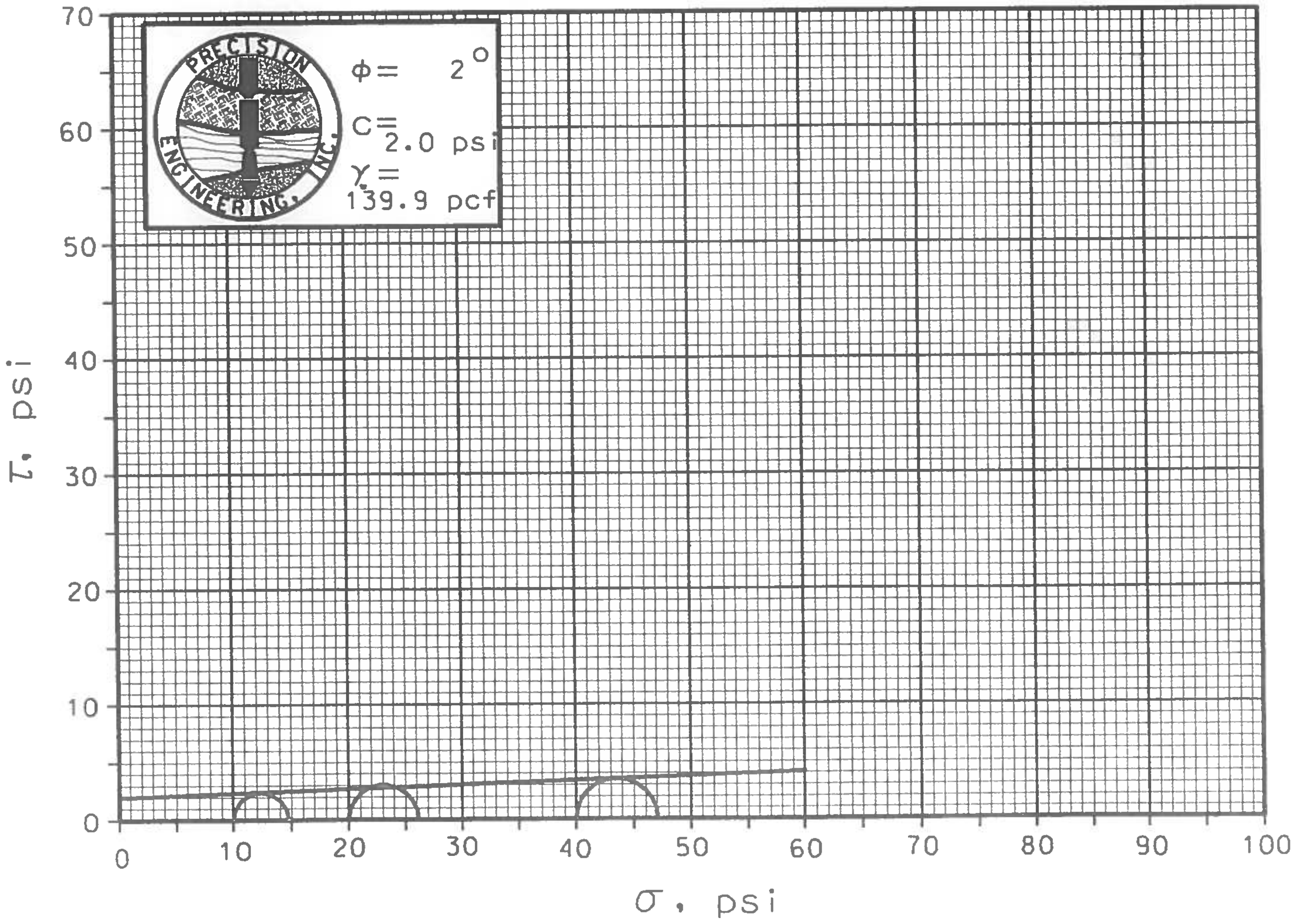


Triaxial Shear Results

Project: Ciniza Evaporation Lagoons
Project Number: 00-141
Sample #: 38648
Unit Weight (pcf): 139.9 wet
Lateral Pressure = σ_3
Max. Deviator Stress = σ
Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	4.9	14.9
2	20	6.1	26.1
3	40	7.1	47.1





Triaxial Shear Results

Project: Ciniza Evaporation Lagoons

Project Number: 00-141

Sample #: 38650

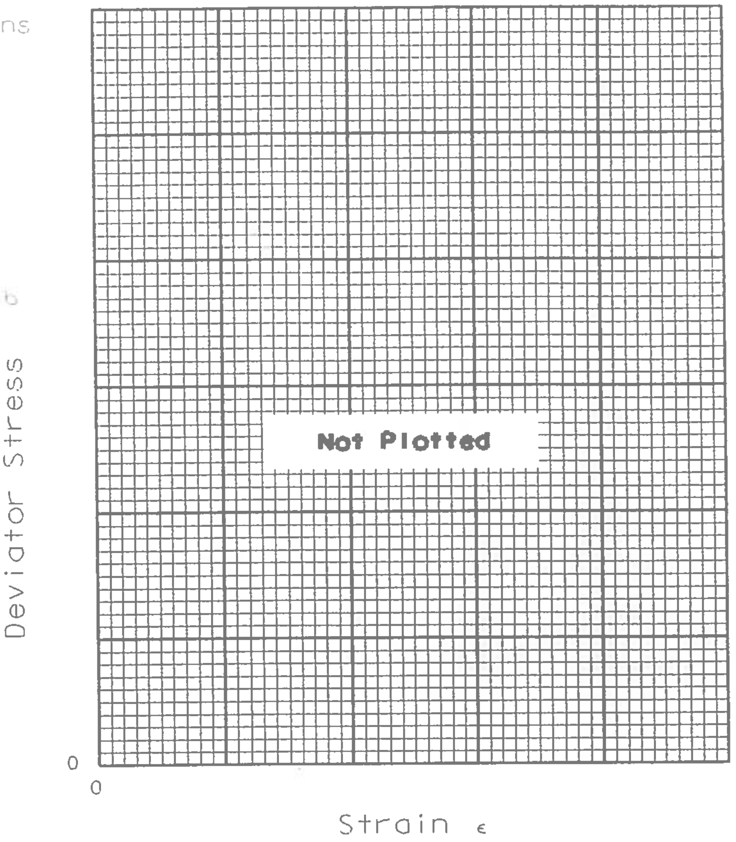
Unit Weight (pcf): 139.5 wet

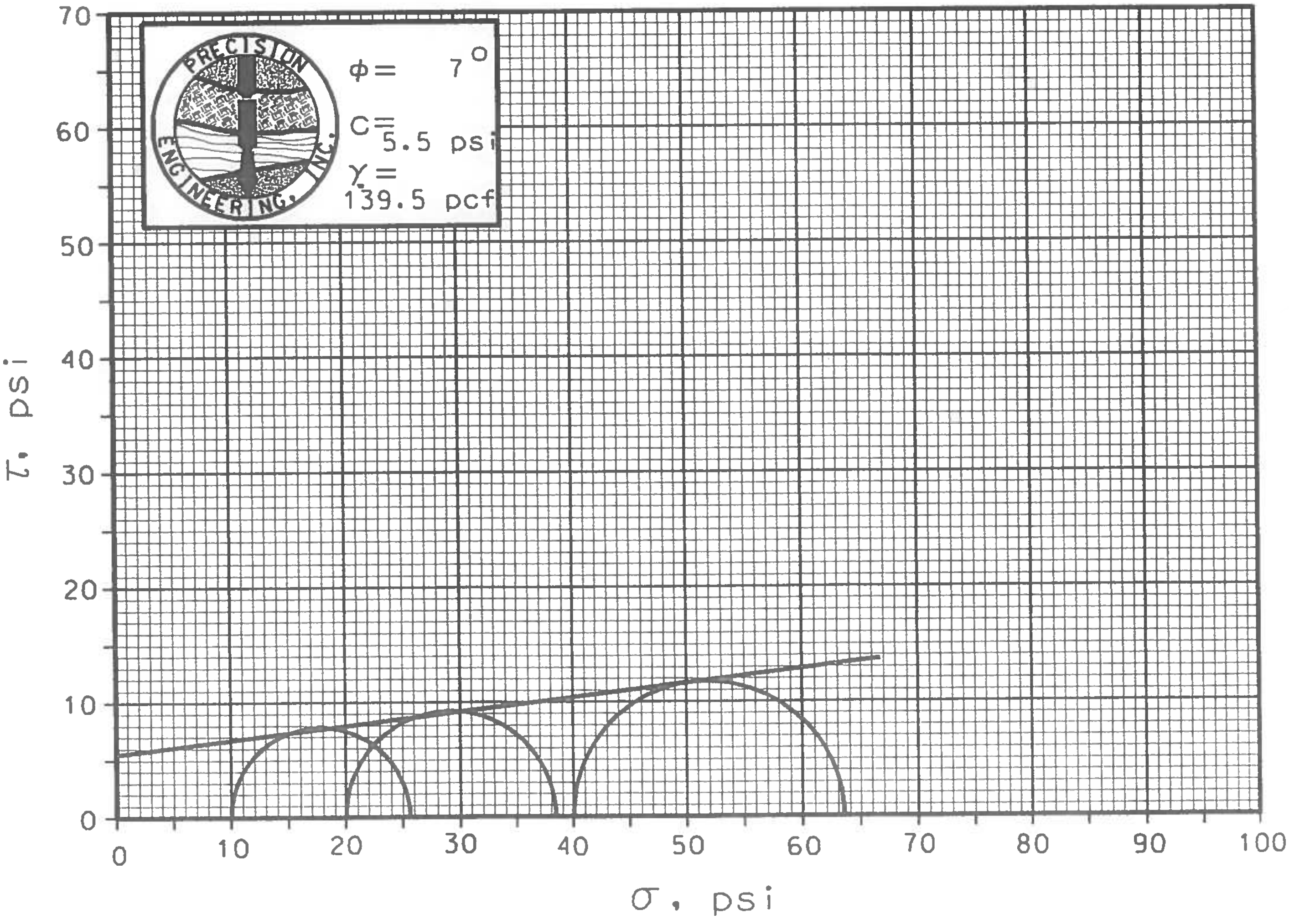
Lateral Pressure = σ_3

Max. Deviator Stress = σ

Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	15.7	25.7
2	20	18.3	38.3
3	40	23.4	63.4





Triaxial Shear Results

Project: Ciniza Evaporation Lagoons

Project Number: 00 141

Sample #: 38652

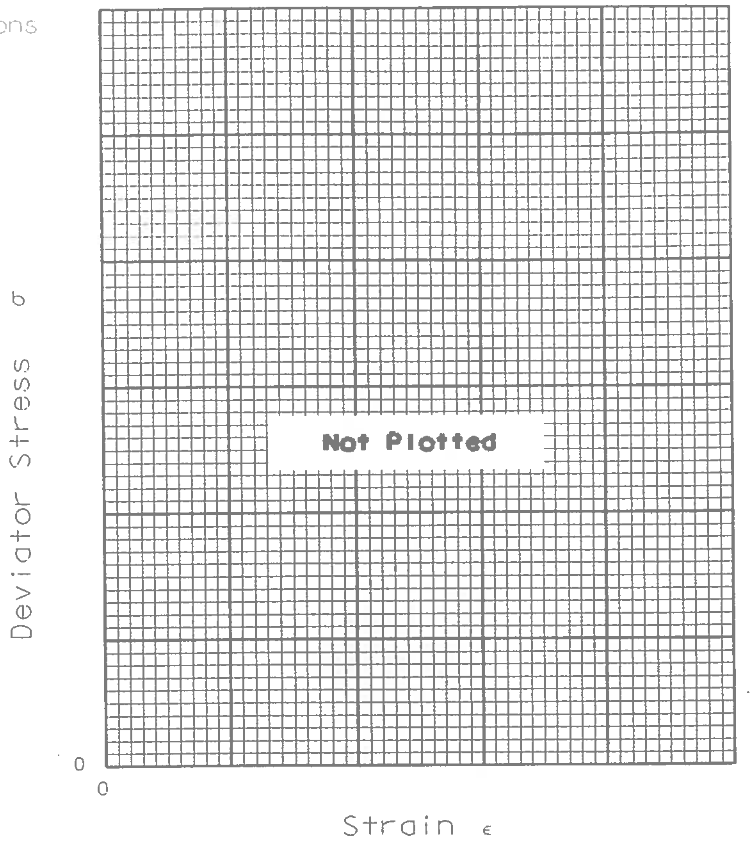
Unit Weight (pcf): 141.4 wet

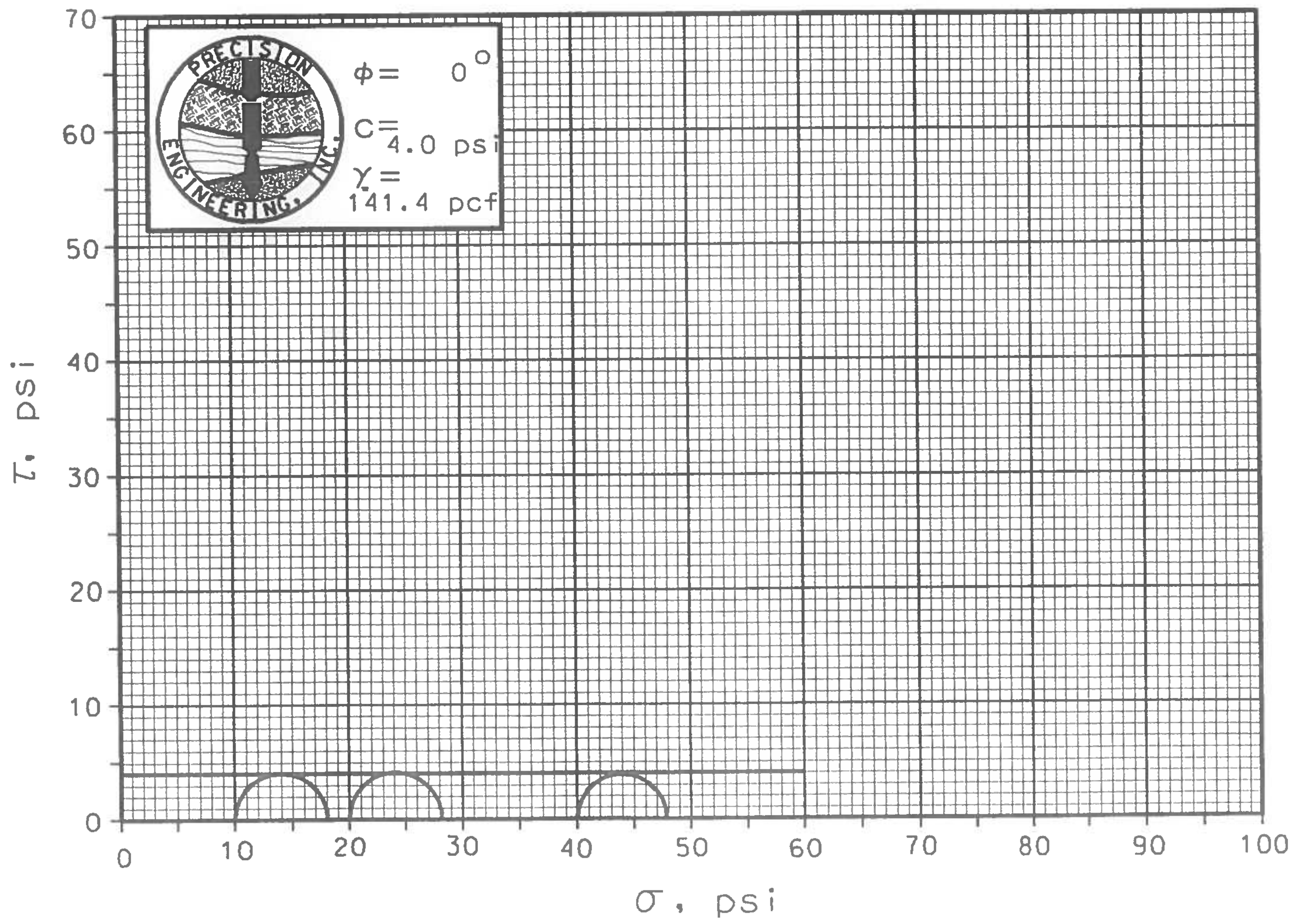
Lateral Pressure = σ_3

Max. Deviator Stress = σ

Max. Vertical Stress = σ_1

Sample	σ_3	σ	σ_1
1	10	8.0	18.0
2	20	8.2	28.2
3	40	7.9	47.9





PRECISION ENGINEERING INC.
GEOTECHNICAL & MATERIALS ENGINEERS
TESTING LABORATORY
(505) 523-7674 • P.O. BOX 422 • LAS CRUCES, NM 88004

KEY TO SOIL CLASSIFICATION AND SYMBOLS

```
       SOIL TYPE                                     SAMPLE TYPE

GRAVEL   SAND   SILT   CLAY

 _____   _____  _____  _____   _____      _____   _____  _____   _____
 ¦O O¦   ¦* *¦  ¦- -¦  ¦/ /¦   ¦+ +¦      ¦ U ¦   ¦ R ¦  ¦ S ¦   ¦ G ¦
 ¦O O¦   ¦* *¦  ¦- -¦  ¦/ /¦   ¦+ +¦      ¦ U ¦   ¦ R ¦  ¦ S ¦   ¦ G ¦
 ¦---¦   ¦---¦  ¦---¦  ¦---¦   ¦+ +¦      ¦ U ¦   ¦ R ¦  ¦ S ¦   ¦ G ¦
 ¦ O ¦   ¦ * ¦  ¦ - ¦  ¦ / ¦   ¦+ +¦      ¦ U ¦   ¦ R ¦  ¦ S ¦   ¦ G ¦
 ¦_O_¦   ¦_*_¦  ¦_-_¦  ¦_/_¦   ¦+_+¦      ¦_U_¦   ¦_R_¦  ¦_S_¦   ¦_G_¦
GRAVELLY SANDY  SILTY CLAYEY CALCAREOUS  UNDIS-   ROCK  SPLIT   GRAB
                             INDURATION  TURBED   CORE  SPOON   AUGER
```

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOIL

(major portion retained on #200 sieve)

Includes (1) clean gravels and sands described as fine, medium, or coarse,depending on grain size distribution and (2) silty or clayey gravels or sands.

Penetration Resistance**	Descriptive Term
0 - 5	Very Loose
6 - 10	Loose
11 - 15	Moderately Dense
16 - 30	Medium Dense
31 - 50	Dense
over 50	Very Dense

FINE GRAINED SOILS

(major portion passing a #200 sieve)

Includes (1) inorganic and inorganic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency rated according to shear strength.

Penetration Resistance**	Descriptive Term
1 - 3	Very Soft
4 - 6	Soft
7 - 11	Firm
12 - 19	Stiff
20 - 30	Very Stiff
over 30	Hard

Descriptive Term (in terms of % moisture)

Dry 0-4%, Damp 4-8%, Moist 8-20%, Wet >20%, Water Bearing is below water table

** Measured in blows/foot by a 140# hammer falling 30".

PRECISION ENGINEERING INC.

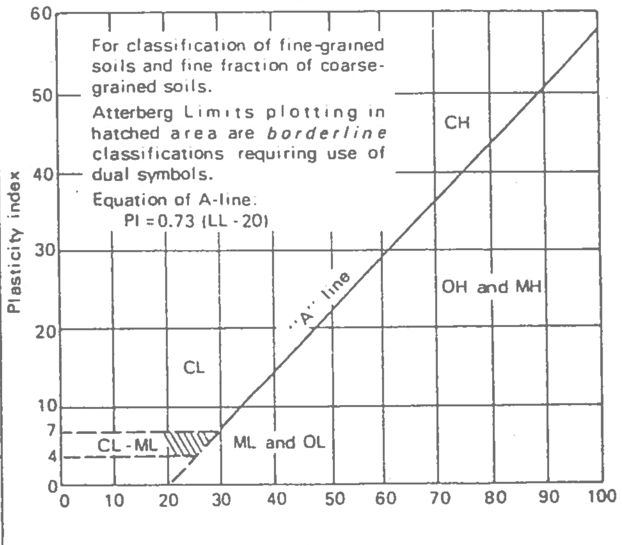
GEOTECHNICAL • MATERIALS • TESTING LABORATORY

Ph: (505) 523-7674 • FAX: (505) 523-7248

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 69 AND D 2488 – 69

(Unified Soil Classification System)

Major divisions			Group symbols	Typical names	Classification criteria		
Coarse-grained soils More than 50% retained on No. 200 sieve*	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% pass No. 200 sieve . . . . . . GW, GP, SW, SP More than 12% pass No. 200 sieve . . . . . . GM, GC, SM, SC 5 to 12% pass No. 200 sieve . . . . *Borderline* classifications requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well-graded sands and gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		Sands with fines	SM	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils 50% or more passes No. 200 sieve*	Silts and clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	Plasticity Chart  For classification of fine-grained soils and fine fraction of coarse-grained soils. Atterberg Limits plotting in hatched area are *borderline* classifications requiring use of dual symbols. Equation of A-line: PI = 0.73 (LL - 20)		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and clays Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity			
	Highly organic soils		Pt	Peat, muck and other highly organic soils	*Based on the material passing the 3 in. (76 mm) sieve.		

APPENDIX D

Boring logs

Boring/Well Log

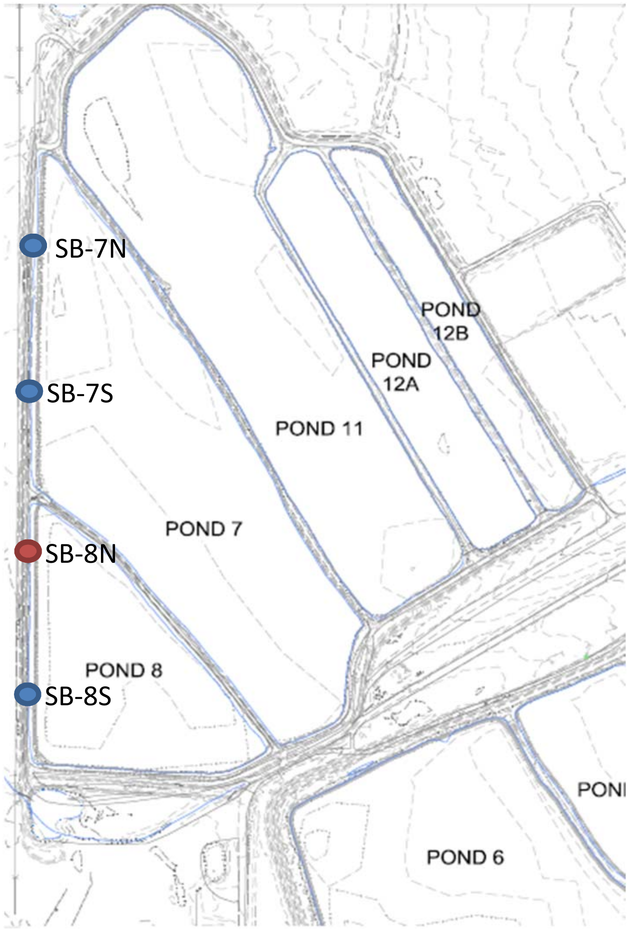
Well/Boring ID: **SB-8N**

Sheet: **1** of **2**

Project:	**Gallup, NM Berm Upgrades**	Drilling Contractor:	**Envirodrill**	Ground Elevation:	
Project #:	**15-110**	Drilling Method:	**Hollow Stem Auger**	TOC Elevation:	**NA**
Customer:	**Western Refining**	Sampling Method:	**Split Spoon**	Filter Pack:	**NA**
Study Area:	**Pond 7/8**	Boring Diameter:	**6.25 inch**	Bentonite Seal:	**NA**
Start Date/Time:	**Mon 10/12/15 1400**	Well Diameter:	**NA**	Grout:	**NA**
End Date/Time:	**Mon 10/12/15 1445**	Well Material:	**NA**	Casing:	**NA**
Logged By:	**Deborah Coakley**	Total Depth (ft)	**14**	Screen:	**NA**

Blow Counts *(6 inches)*	**Recovery** *(inches)*	**PID** *(ppm)*	**Well Diagram**	**Depth** *(feet)*	**Soil Log**	**Soil and Rock Description USCS/ASTM Classification**
2 , 2	18"			1		Red SILT, little Clay, dry (Berm Fill)
2 , 2				2		
1 , 1	0"			3		Red SILT, little Clay, moist (Berm Fill)
1 , 1				4		
1 , 1	18"			5		Red Silty CLAY, moist (Berm Fill)
1 , 1				6		
1 , 1	3"			7		Red Silty CLAY, trace Gravel, moist (Berm Fill)
1 , 2				8		
1 , 1	24"			9		Red SILT, some Clay, moist (Berm Fill)
1 , 1				10		Red SILT, some Clay, little fine Sand, moist (Berm Fill)
1 , 1	8"			11		Red SILT, some fine Sand, wet (Berm Fill)
1 , 1				12		Gray fine SAND, wet, organic odor (Berm Fill)
1 , 3	8"			13		
4 , 5				14		Red Silty CLAY, hard, wet (Native Soil)
				15		

Well/Boring Location Map



Boring/Well Log

Well/Boring ID: SB-8N

Sheet: 2 of 2

Set Up on Soil Boring SB-8N - Looking North

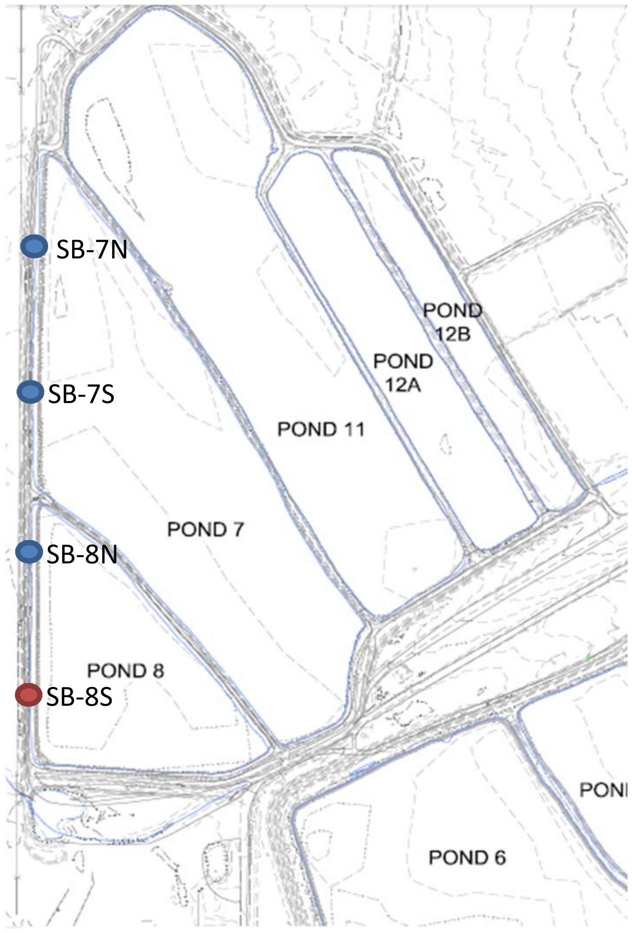
Bottom of Split Spoon Sample from 10 to 12 Feet Deep

Boring/Well Log

Well/Boring ID: SB-8S

Sheet: 1 of 2

Project:	**Gallup, NM Berm Upgrades**	Drilling Contractor:	**Envirodrill**	Ground Elevation:	
Project #:	**15-110**	Drilling Method:	**Hollow Stem Auger**	TOC Elevation:	**NA**
Customer:	**Western Refining**	Sampling Method:	**Split Spoon**	Filter Pack:	**NA**
Study Area:	**Pond 7/8**	Boring Diameter:	**6.25 inch**	Bentonite Seal:	**NA**
Start Date/Time:	**Mon 10/12/15 1500**	Well Diameter:	**NA**	Grout:	**NA**
End Date/Time:	**Mon 10/12/15 1550**	Well Material:	**NA**	Casing:	**NA**
Logged By:	**Deborah Coakley**	Total Depth (ft)	**14**	Screen:	**NA**

Blow Counts (6 inches)	**Recovery** (inches)	**PID** (ppm)	**Well Diagram**	**Depth** (feet)	**Soil Log**	***Soil and Rock Description USCS/ASTM Classification***	***Well/Boring Location Map***
2 , 2	6"			1		Red SILT, little Clay, dry (Berm Fill)	
1 , 2				2			
1 , 1	6"			3		Red SILT, little Clay, dry, wood fragments (Berm Fill)	
1 , 1				4			
1 , 1	8"			5		Red CLAY and Silt, moist (Berm Fill)	
2 , 1				6			
1 , 2	6"			7		Red CLAY and Silt, trace Gravel, moist (Berm Fill)	
1 , 2				8			
1 , 2	12"			9		Red CLAY and Silt, moist (Berm Fill)	
3 , 2				10			
1 , 2	8"			11		Red CLAY and Silt, moist (Berm Fill)	
3 , 4				12			
3 , 7	6"			13		Dk Gray Fine Sand, wet, odor Red CLAY, little Silt, hard, moist (Native Soil)	
10 , 12				14			
				15			

Bottom of Split Spoon Sample from 0 to 2 Feet Deep

Bottom of Split Spoon Sample from 4 to 6 Feet Deep

Boring/Well Log

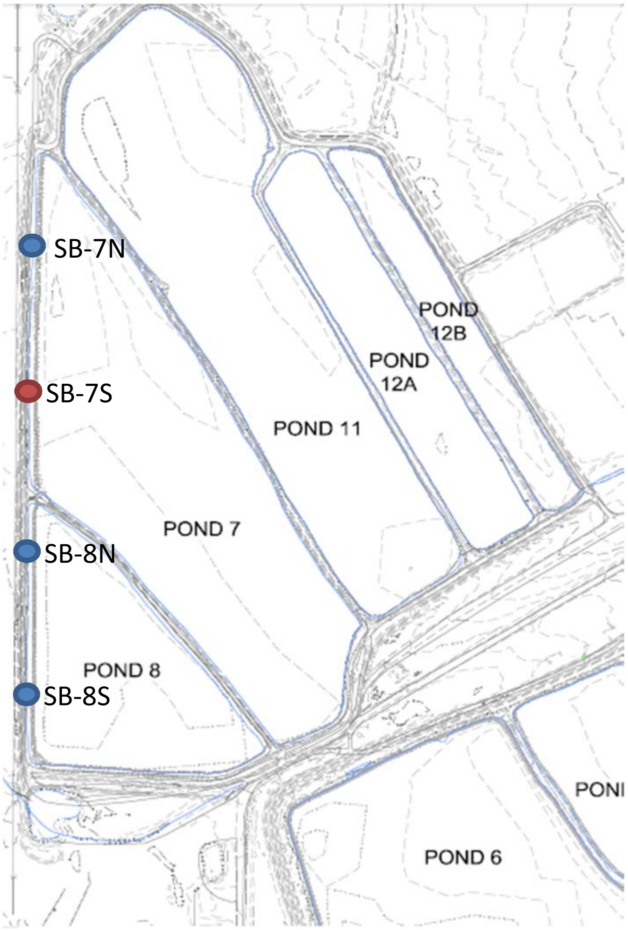
Well/Boring ID: **SB-7S**

Sheet: **1** *of* **2**

Project:	**Gallup, NM Berm Upgrades**	Drilling Contractor:	**Envirodrill**	Ground Elevation:	
Project #:	**15-110**	Drilling Method:	**Hollow Stem Auger**	TOC Elevation:	**NA**
Customer:	**Western Refining**	Sampling Method:	**Split Spoon**	Filter Pack:	**NA**
Study Area:	**Pond 7/8**	Boring Diameter:	**6.25 inch**	Bentonite Seal:	**NA**
Start Date/Time:	**Mon 10/13/15 0800**	Well Diameter:	**NA**	Grout:	**NA**
End Date/Time:	**Mon 10/13/15 0900**	Well Material:	**NA**	Casing:	**NA**
Logged By:	**Deborah Coakley**	Total Depth (ft)	**14**	Screen:	**NA**

Blow Counts (6 inches)	**Recovery** (inches)	**PID** (ppm)	**Well Diagram**	**Depth** (feet)	**Soil Log**	***Soil and Rock Description USCS/ASTM Classification***
2 , 2	6"			1	▨	Red SILT, little Clay, dry (Berm Fill)
2 , 3				2	▨	
3 , 4	18"			3	▤	Red CLAY and Silt, hard, moist at 4', (Berm Fill)
5 , 7				4	▤	
2 , 3	18"			5	▤	Red CLAY and Silt, moist (Berm Fill)
3 , 3				6	▤	
1 , 2	0"			7	▤	
2 , 3				8	▤	
2 , 2	20"			9	▤	Red CLAY and Silt, moist (Berm Fill)
3 , 3				10	▨	Red-Brown SILT, some fine Sand, little Clay
2 , 3	24"			11	▨	Red SILT, some Clay, little fine Sand, wet, odor, blk staining at 11.5' (Berm Fill)
2 , 2				12	▨	
3 , 5	20"			13	▤	Red CLAY and Silt, moist, hard at 13', (Native Soil)
7 , 10				14	▤	
				15		

Well/Boring Location Map



Boring/Well Log

Well/Boring ID: SB-7S

Sheet: 2 of 2

Bottom of Split Spoon Sample from 2 to 4 Feet Deep

Bottom of Split Spoon Sample from 8 to 10 Feet Deep

Boring/Well Log

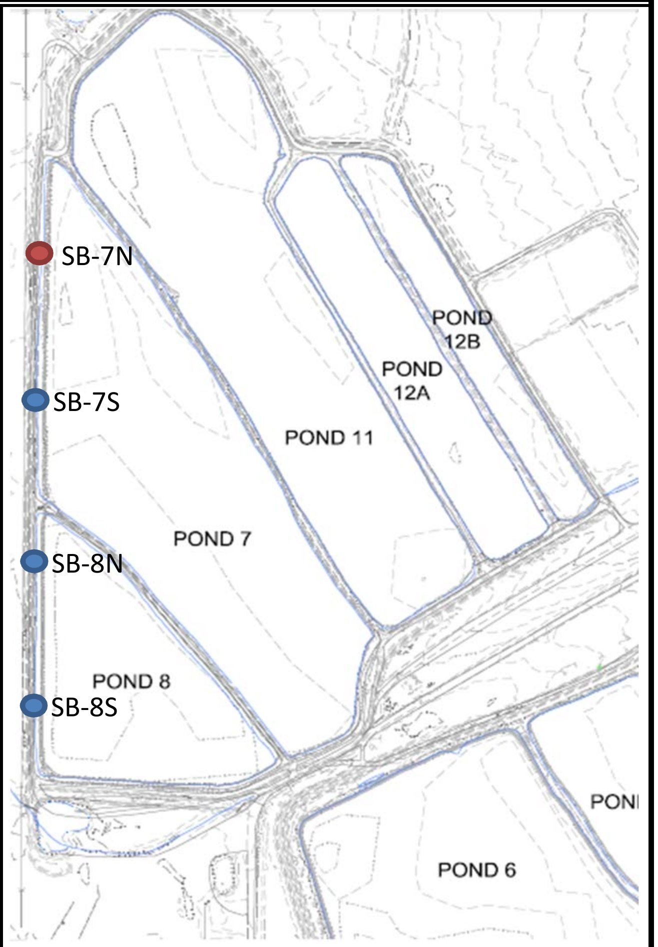
Well/Boring ID: **SB-7N**

Sheet: **1** of **2**

Project:	**Gallup, NM Berm Upgrades**	Drilling Contractor:	**Envirodrill**	Ground Elevation:	
Project #:	**15-110**	Drilling Method:	**Hollow Stem Auger**	TOC Elevation:	**NA**
Customer:	**Western Refining**	Sampling Method:	**Split Spoon**	Filter Pack:	**NA**
Study Area:	**Pond 7/8**	Boring Diameter:	**6.25 inch**	Bentonite Seal:	**NA**
Start Date/Time:	**Mon 10/13/15 0910**	Well Diameter:	**NA**	Grout:	**NA**
End Date/Time:	**Mon 10/13/15 1000**	Well Material:	**NA**	Casing:	**NA**
Logged By:	**Deborah Coakley**	Total Depth (ft)	**14**	Screen:	**NA**

Blow Counts (6 inches)	**Recovery** (inches)	**PID** (ppm)	**Well Diagram**	**Depth** (feet)	**Soil Log**	**Soil and Rock Description USCS/ASTM Classification**
2 , 2	6"			1	▨	Red SILT, some Clay, dry (Berm Fill)
2 , 3				2	▨	
3 , 4	18"			3	▨	Red SILT, some Clay, dry, hard (Berm Fill)
5 , 7				4	▨	
2 , 3	18"			5	▤	Red CLAY and Silt, moist (Berm Fill)
3 , 3				6	▤	
1 , 2	0"			7	▤	Red CLAY and Silt, trace white gravel fill, moist (Berm Fill)
2 , 3				8	▤	
2 , 2	20"			9	▤	Red CLAY and Silt, trace white gravel fill, moist (Berm Fill)
3 , 3				10	▤	
2 , 3	24"			11	▤	Red CLAY and Silt, moist (Native Soil)
2 , 2				12	▤	
3 , 5	20"			13	▤	Red CLAY and Silt, moist (Native Soil)
7 , 10				14	▤	
				15		

Well/Boring Location Map



Bottom of Split Spoon Sample from 8 to 10 Feet Deep

Bottom of Split Spoon Sample from 12 to 14 Feet Deep

APPENDIX E

Piezometer log forms

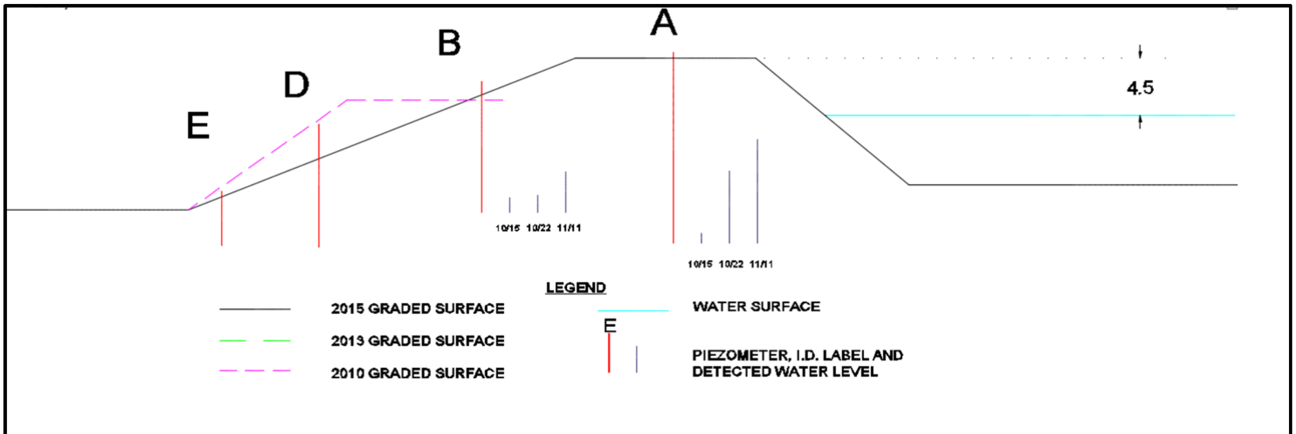
WELL/PIEZOMETER SAMPLING SHEET

PAGE 1 OF 1

PROJECT NAME GALLUP PHREATIC SURFACE **PROJECT NUMBER** 15-112 **CROSS SECTION** POND 7

POND WATER LEVEL (FROM STAFF GAUGE)

CROSS SECTION



Pond 7 Cross Section (West to East)

PIEZOMETER READINGS

	PIEZOMETER DEPTH TO WATER (FROM TOP OF CASING)				
DATE	A	B	C	D	E
10/15/2015	14'	9'		DRY	DRY
10/22/2015	9.15'	8.8'		DRY	DRY
11/11/2015	6.7'	7.0'		DRY	DRY

PIEZOMETER DESCRIPTIONS

PIEZOMETER NAME 7A **LOCATION:** **NORTHING** **EASTING** **ELEVATION** 6883.56
CASING TYPE STEEL **CASING HEIGHT** 4.5" **TOTAL DEPTH** 14.75'
CASING CONDITION

PIEZOMETER NAME 7B **LOCATION:** **NORTHING** **EASTING** **ELEVATION** 6881.36
CASING TYPE STEEL **CASING HEIGHT** 12" **TOTAL DEPTH** 10.1'
CASING CONDITION

PIEZOMETER NAME 7D **LOCATION:** **NORTHING** **EASTING** **ELEVATION** 6878.05
CASING TYPE STEEL **CASING HEIGHT** 31.25" **TOTAL DEPTH** 9.5'
CASING CONDITION

PIEZOMETER NAME 7E **LOCATION:** **NORTHING** **EASTING** **ELEVATION** 6872.45
CASING TYPE STEEL **CASING HEIGHT** 5" **TOTAL DEPTH** 4.2'
CASING CONDITION

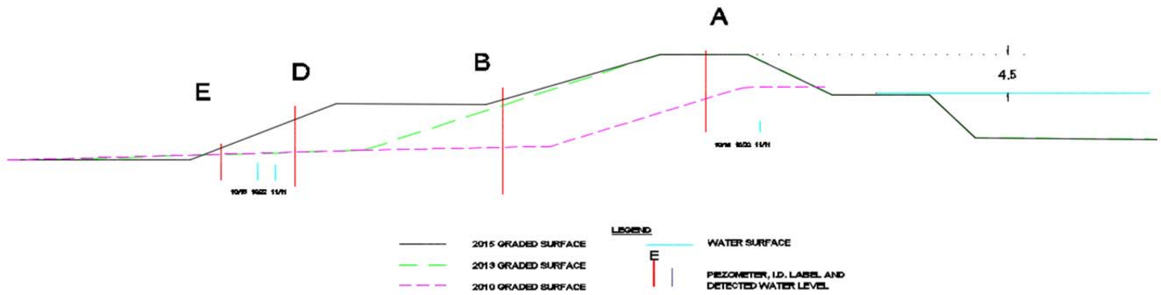
WELL/PIEZOMETER SAMPLING SHEET

PAGE 1 OF 1

PROJECT NAME GALLUP PHREATIC SURFACE **PROJECT NUMBER** 15-112 **CROSS SECTION** POND 8

POND WATER LEVEL (FROM STAFF GAUGE) ______

CROSS SECTION



Pond 8 Cross Section (South to North)

PIEZOMETER READINGS

	PIEZOMETER DEPTH TO WATER (FROM TOP OF CASING)				
DATE	A	B	C	D	E
10/15/2015	DRY	DRY		DRY	DRY
10/22/2015	DRY	DRY		DRY	2.2' **
11/11/2015	8.3	DRY		DRY	2.45

PIEZOMETER DESCRIPTIONS

PIEZOMETER NAME 8A **LOCATION:** **NORTHING** ______ **EASTING** ______ **ELEVATION** 6882.58

CASING TYPE STEEL **CASING HEIGHT** 5" **TOTAL DEPTH** 9.5'

CASING CONDITION ______

PIEZOMETER NAME 8B **LOCATION:** **NORTHING** ______ **EASTING** ______ **ELEVATION** 6878.12

CASING TYPE STEEL **CASING HEIGHT** 16" **TOTAL DEPTH** 12.42'

CASING CONDITION ______

PIEZOMETER NAME 8D **LOCATION:** **NORTHING** ______ **EASTING** ______ **ELEVATION** 6875.88

CASING TYPE STEEL **CASING HEIGHT** 18" **TOTAL DEPTH** 9.25'

CASING CONDITION ______

PIEZOMETER NAME 8E **LOCATION:** **NORTHING** ______ **EASTING** ______ **ELEVATION** 6871.76

CASING TYPE STEEL **CASING HEIGHT** 10" **TOTAL DEPTH** 6.33'

CASING CONDITION **Surface water entering casing.

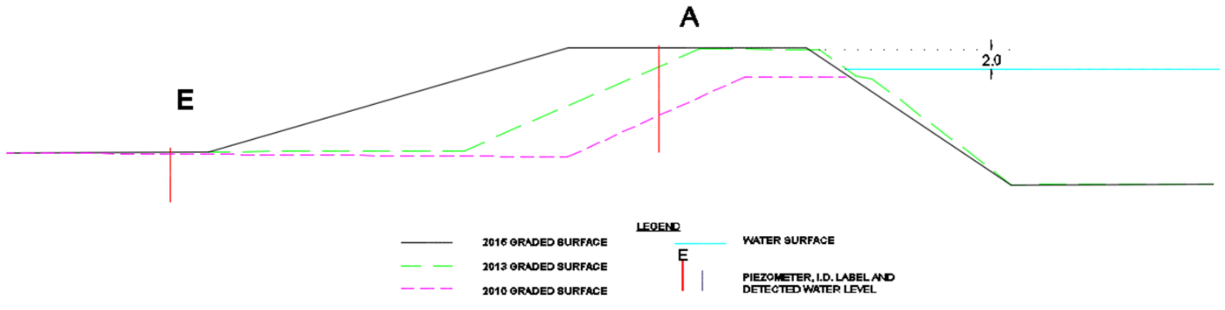
WELL/PIEZOMETER SAMPLING SHEET

PAGE 1 OF 1

PROJECT NAME GALLUP PHREATIC SURFACE **PROJECT NUMBER** 15-112 **CROSS SECTION** POND 6N

POND WATER LEVEL (FROM STAFF GAUGE)

CROSS SECTION



Pond 6 Cross Section (North to South)

PIEZOMETER READINGS

	PIEZOMETER DEPTH TO WATER (FROM TOP OF CASING)				
DATE	A	B	C	D	E
10/15/2015	14'				DRY
10/22/2015	DRY				0.65' **
11/11/2015	DRY				1"

PIEZOMETER DESCRIPTIONS

PIEZOMETER NAME 6N-A **LOCATION:** **NORTHING** **EASTING** **ELEVATION** 6886.56
CASING TYPE STEEL **CASING HEIGHT** 3" **TOTAL DEPTH** 10.45
CASING CONDITION

PIEZOMETER NAME 6N-E **LOCATION:** **NORTHING** **EASTING** **ELEVATION** 6875.06
CASING TYPE STEEL **CASING HEIGHT** 4.8" **TOTAL DEPTH** 4.7
CASING CONDITION **Water entering casing at surface (10/22/15).

PIEZOMETER NAME **LOCATION:** **NORTHING** **EASTING** **ELEVATION**
CASING TYPE **CASING HEIGHT** **TOTAL DEPTH**
CASING CONDITION

PIEZOMETER NAME **LOCATION:** **NORTHING** **EASTING** **ELEVATION**
CASING TYPE **CASING HEIGHT** **TOTAL DEPTH**
CASING CONDITION

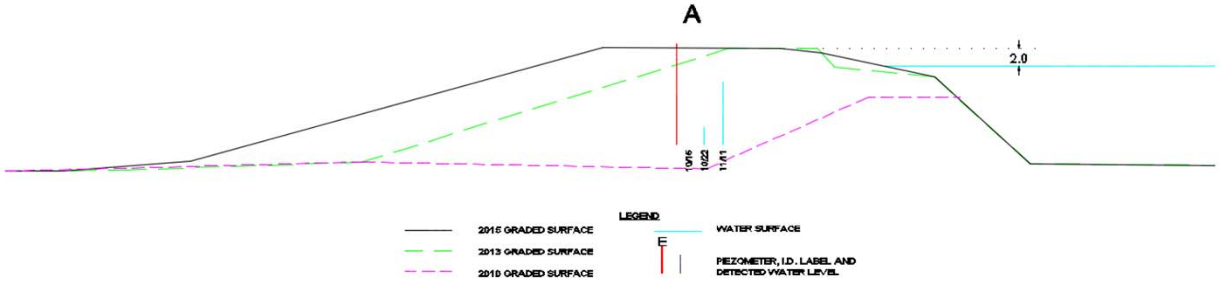
WELL/PIEZOMETER SAMPLING SHEET

PAGE 1 OF 1

PROJECT NAME GALLUP PHREATIC SURFACE **PROJECT NUMBER** 15-112 **CROSS SECTION** POND 6W

POND WATER LEVEL (FROM STAFF GAUGE)

CROSS SECTION



Pond 6 Cross Section (West to East)

PIEZOMETER READINGS

PIEZOMETER DEPTH TO WATER (FROM TOP OF CASING)					
DATE	A	B	C	D	E
10/15/2015	Dry				
10/22/2015	9.65'				
11/11/2015	4.45				

PIEZOMETER DESCRIPTIONS

PIEZOMETER NAME 6W-A **LOCATION:** **NORTHING** **EASTING** **ELEVATION** 6886.23

CASING TYPE STEEL **CASING HEIGHT** 5" **TOTAL DEPTH** 11.58'

CASING CONDITION

PIEZOMETER NAME **LOCATION:** **NORTHING** **EASTING** **ELEVATION**

CASING TYPE **CASING HEIGHT** **TOTAL DEPTH**

CASING CONDITION

PIEZOMETER NAME **LOCATION:** **NORTHING** **EASTING** **ELEVATION**

CASING TYPE **CASING HEIGHT** **TOTAL DEPTH**

CASING CONDITION

PIEZOMETER NAME **LOCATION:** **NORTHING** **EASTING** **ELEVATION**

CASING TYPE **CASING HEIGHT** **TOTAL DEPTH**

CASING CONDITION

APPENDIX F

2015 Slope Stability Analysis
Updating the 2002 Slope Stability Analysis

F-1 Updates to the 2002 Slope Stability Analysis

In the original Summary Report, Evaporation Pond Repairs (December 2015), Western updated the 2002 numerical slope stability analysis using the following:

- Morgenstern Price limit-equilibrium analysis via GeoStudio 2012
- Updated berm topography at slope stability cross-sections
- Updated phreatic surface based on temporary drive-point piezometers
- Existing soil properties confirmed during 2015 geotechnical investigation
- Existing total stress soil strength parameters cohesion (c) and angle of internal friction, phi (Ø)

Based on the updated slope stability modeling, the earth berms remain stable against a circular slip-type failure with Factor of Safety values ranging from 4.7 to 7.1.

The soil strength parameters used in the numerical analysis included the total stress parameters for cohesion (c) and the angle of internal friction, phi (Ø). It is recognized that total stress strength parameters are appropriate for numerical slope stability analysis for end-of-construction analysis and for partially saturated soil. Based on historical and current soil borings, the soil in the berms is best categorized as partially saturated and therefore, the analysis method is considered appropriate.

Because significant berm improvement work was conducted since 2002, the configurations of the berms (i.e. berm crest widths and outer slopes) were different in many locations. Additionally the pond water elevations have increased since 2002.

Accordingly, Western (via Hammon Enterprises Inc.) conducted an updated topographic land survey of the earth berms. The updated topography was used to track the changes to the earth berms and create the cross-section geometry required for the updated slope stability analysis described in this section. Figure 7b provides cross-sections that illustrate changes in the geometry of the earth berms with time and shows the current surface at the end of 2015.

Prior to performing the updated slope stability analysis, Western conducted a field investigation to collect current soil geotechnical material properties and determine the phreatic surface (i.e. water table surface) within the berms. The methods and results of this field investigation are described in Section 2.3 of this report.

The model used to conduct the slope stability analysis was GeoStudio 2012 produced by Geo-slope International. Western used the limit-equilibrium analysis, Morgenstern-Price Method of Slices to analyze the numerical Factor of Safety for stability of the slopes.

The soil material used in constructing and upgrading the earth berms is a uniform material. Accordingly, Western numerically analyzed the slopes using an arc-type or circular slip-type of failure. Based on the updated slope stability modeling, the earth berms remain stable against an arc-type failure with Factor of Safety values ranging from 4.7 to 7.1. The sections below provide a discussion of the methods and soil values used in the updated slope stability modeling work.

F-2 Soil Characterization Properties

Soil characterization properties from the previous investigation (Precision, 2002) were compared to the soil characterization properties from the 2014 and 2015 borrow and berm soil investigations. The 2002 soil investigation results are consistent with the current geotechnical characterization data. Accordingly, the previous soil investigation data were used in the 2015 slope stability analysis.

Slope stability modeling data input includes soil type, unit weight, angle of internal friction (phi angle), shear strength, and cohesion values. The 2002 data included triaxial sheer strength values and were classified into two categories:

1. Berm material ranging from a depth of 5-7 feet; and
2. Subgrade material ranging from 10-17 feet.

This resulted in two sets of soil properties for the berm slope stability analysis:

1. Berm material (unit weight 140 pcf, cohesion 720 psf, phi 8 degrees); and
2. Native soil (unit weight 140 pcf, cohesion 1152 psf, phi 0 degrees).

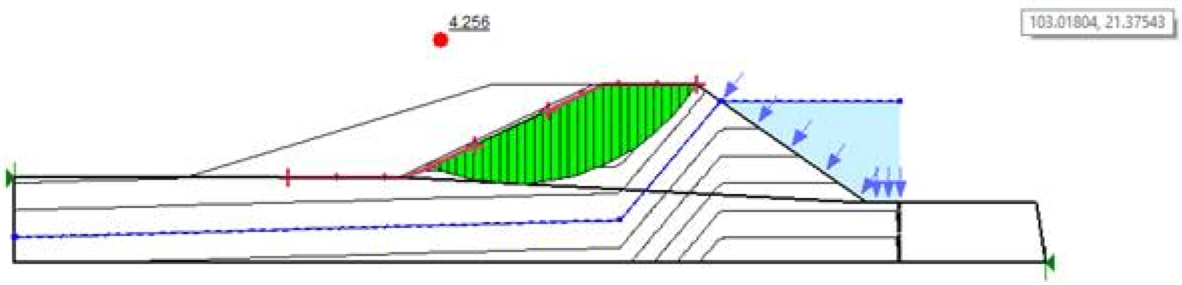
The phreatic surface used for the analysis was derived from current water level data measured in the drive-point piezometers installed along the cross sections of the berms.

F-3 2015 Slope Stability Results

A Factor of Safety greater than 1.0 indicates that the slope is numerically stable from a typical arc-type slope failure. Factors of Safety against a deep slip surface failure in the berms before and after repair work are shown on Table 3.

Based on the slope stability modeling, the berms are stable against an arc-type failure with Factor of Safety values ranging from 4.5 to 7.1. Note that the Factor of Safety from the previous investigation ranged from 2.5 to 10. The change in the Factor of Safety values is largely the result of changes in the berm geometry and the elevation of the water within the ponds. Detailed results from the numerical slope stability modeling are included below.

Slope Stability



File Information

File Version: 8.14

Created By: Eric Lundborg

Last Edited By: Eric Lundborg

Revision Number: 4

Date: 11/3/2015

Time: 3:03:45 PM

Tool Version: 8.14.1.10087

File Name: Pond 6 North old.gsz

Directory: C:\Users\ELundborg\Desktop\Gallup\ponds\

Last Solved Date: 11/3/2015

Last Solved Time: 3:03:47 PM

Project Settings

Length(L) Units: Feet

Time(t) Units: Seconds

Force(F) Units: Pounds

Pressure(p) Units: psf

Strength Units: psf

Unit Weight of Water: 62.4 pcf

View: 2D

Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W

Method: Morgenstern-Price

Settings

Side Function
    Interslice force function option: Half-Sine
PWP Conditions Source: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No

Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °
    Optimize Critical Slip Surface Location: No
    Tension Crack
        Tension Crack Option: (none)

F of S Distribution
    F of S Calculation Option: Constant

Advanced
    Number of Slices: 30
    F of S Tolerance: 0.001
    Minimum Slip Surface Depth: 0.1 ft
    Search Method: Root Finder
    Tolerable difference between starting and converged F of S: 3
    Maximum iterations to calculate converged lambda: 20
    Max Absolute Lambda: 2

Materials

2013 berm material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 8 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Native

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 1,152 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range

Left-Zone Left Coordinate: (32.08628, 0) ft

Left-Zone Right Coordinate: (54, 3.82609) ft

Left-Zone Increment: 4

Right Projection: Range

Right-Zone Left Coordinate: (62.56701, 7.92335) ft

Right-Zone Right Coordinate: (80, 11) ft

Right-Zone Increment: 4

Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft

Right Coordinate: (121, -10) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-7
Coordinate 2	71	-5
Coordinate 3	82.85714	9
Coordinate 4	104	9

Points

	X (ft)	Y (ft)
Point 1	20	0
Point 2	46	0
Point 3	69	11
Point 4	80	11
Point 5	100	-3
Point 6	0	0
Point 7	0	-10
Point 8	121	-10
Point 9	120	-3

Regions

	Material	Points	Area (ft²)
Region 1	2013 berm material	3,4,5,2	408.5
Region 2	Native	6,7,8,9,5,2,1	1,062.5

Current Slip Surface

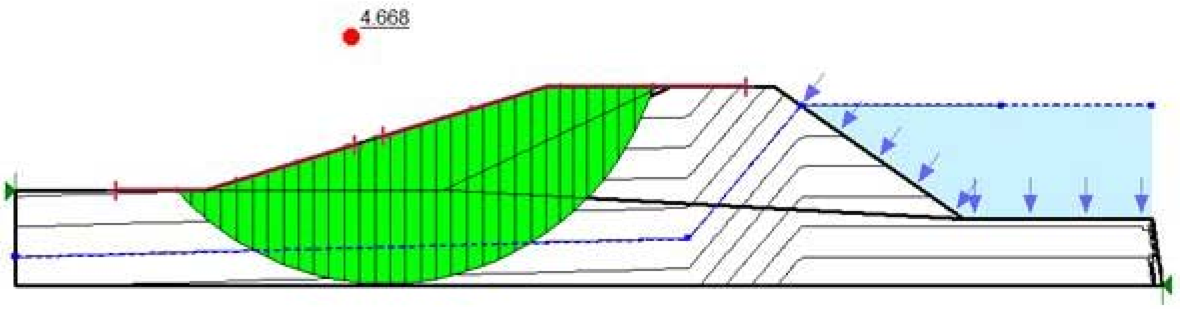
Slip Surface: 98
F of S: 4.256
Volume: 186.85492 ft³
Weight: 26,159.689 lbs
Resisting Moment: 733,232.93 lbs-ft
Activating Moment: 172,277.76 lbs-ft
Resisting Force: 25,838.676 lbs
Activating Force: 6,071.1629 lbs
F of S Rank: 1
Exit: (48.86199, 1.3687779) ft
Entry: (80, 11) ft
Radius: 25.103668 ft
Center: (58.788583, 24.426464) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	49.362812	1.1658329	-422.78067	136.38963	19.168312	720
Slice 2	50.364454	0.78443531	-397.22082	259.31661	36.444572	720
Slice 3	51.366097	0.45093538	-374.64979	376.67057	52.937596	720
Slice 4	52.36774	0.16335379	-354.94407	487.6084	68.528891	720
Slice 5	53.369382	-0.079929263	-338.00257	591.35892	83.110076	720
Slice 6	54.371025	-0.28022487	-323.74349	687.26253	96.588449	720
Slice 7	55.372668	-0.43857373	-312.10189	774.80172	108.89128	720
Slice 8	56.374311	-0.55577484	-303.0279	853.62083	119.96858	720
Slice 9	57.396383	-0.6331324	-296.40425	924.79978	129.97213	720
Slice 10	58.421378	-0.66946161	-292.33562	986.97834	138.71076	720
Slice 11	59.428866	-0.66397737	-290.90693	1,039.0783	146.03293	720
Slice 12	60.436354	-0.61797906	-292.00632	1,082.5774	152.14634	720
Slice 13	61.443842	-0.53124232	-295.64778	1,117.8649	157.10566	720
Slice 14	62.45133	-0.40333951	-301.85801	1,145.407	160.97646	720
Slice 15	63.458817	-0.23362901	-310.67704	1,165.7154	163.83061	720
Slice 16	64.466305	-0.021238609	-322.15929	1,179.3138	165.74175	720

Slice 17	65.473793	0.23495788	-336.37504	1,186.7072	166.78083	720
Slice 18	66.481281	0.53637253	-353.41241	1,188.352	167.01198	720
Slice 19	67.488768	0.88474581	-373.37999	1,184.6275	166.48854	720
Slice 20	68.496256	1.282203	-396.41041	1,175.809	165.24918	720
Slice 21	69.5	1.7294597	-422.55491	1,131.1423	158.97168	720
Slice 22	70.5	2.2292286	-451.98274	1,050.9474	147.70102	720
Slice 23	71.5	2.7867377	-449.05387	965.66162	135.71489	720
Slice 24	72.5	3.406597	-414.05597	874.38546	122.88686	720
Slice 25	73.5	4.0945319	-383.30597	775.85148	109.03881	720
Slice 26	74.5	4.8577553	-357.25399	668.321	93.926391	720
Slice 27	75.5	5.7055272	-336.47783	549.42079	77.216056	720
Slice 28	76.5	6.650028	-321.73756	415.87352	58.447212	720
Slice 29	77.5	7.7077957	-314.06513	263.02715	36.966055	720
Slice 30	78.5	8.9022527	-314.92212	83.969198	11.801101	720
Slice 31	79.5	10.268557	-326.50236	-132.3188	-18.596195	720

Slope Stability



File Information

File Version: 8.14
Created By: Eric Lundborg
Last Edited By: Eric Lundborg
Revision Number: 6
Date: 11/3/2015
Time: 3:05:31 PM
Tool Version: 8.14.1.10087
File Name: Pond 6 North.gsz
Directory: C:\Users\ELundborg\Desktop\Gallup\ponds\
Last Solved Date: 11/3/2015
Last Solved Time: 3:05:33 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W
Method: Morgenstern-Price
Settings

- Side Function
    - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack
    - Tension Crack Option: (none)

F of S Distribution
- F of S Calculation Option: Constant

Advanced
- Number of Slices: 30
- F of S Tolerance: 0.001
- Minimum Slip Surface Depth: 0.1 ft
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

2013 berm material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
    - Piezometric Line: 1

2015 berm material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
    - Piezometric Line: 1

Native

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 1,152 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (10.56397, 0) ft
Left-Zone Right Coordinate: (35.81772, 4.83319) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (38.8435, 5.75774) ft
Right-Zone Right Coordinate: (77, 11) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft
Right Coordinate: (121, -10) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-7
Coordinate 2	71	-5
Coordinate 3	82.85714	9
Coordinate 4	104	9
Coordinate 5	120	9

Points

	X (ft)	Y (ft)
Point 1	20	0
Point 2	46	0
Point 3	69	11
Point 4	80	11
Point 5	100	-3
Point 6	0	0

Point 7	0	-10
Point 8	121	-10
Point 9	120	-3
Point 10	56	11

Regions

	Material	Points	Area (ft²)
Region 1	2013 berm material	3,4,5,2	408.5
Region 2	Native	6,7,8,9,5,2,1	1,062.5
Region 3	2015 berm material	1,2,3,10	214.5

Current Slip Surface

Slip Surface: 44

F of S: 4.668

Volume: 592.03017 ft³

Weight: 82,884.224 lbs

Resisting Moment: 1,973,474.5 lbs-ft

Activating Moment: 422,744.94 lbs-ft

Resisting Force: 55,461.219 lbs

Activating Force: 11,880.392 lbs

F of S Rank: 1

Exit: (17.05789, 0) ft

Entry: (67.265117, 11) ft

Radius: 29.522783 ft

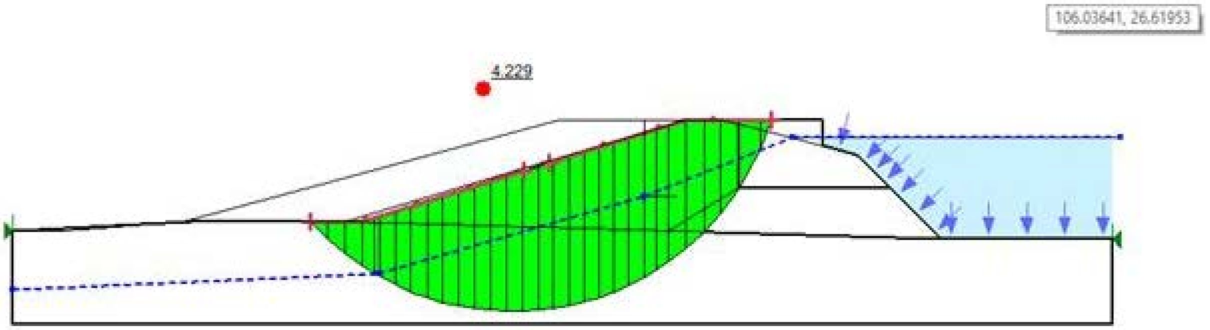
Center: (39.051617, 19.694432) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	17.793417	-0.76427093	-357.83318	370.98069	0	1,152
Slice 2	19.264472	-2.1934748	-266.06511	555.52999	0	1,152
Slice 3	20.840921	-3.5181267	-180.63584	769.79816	0	1,152
Slice 4	22.522764	-4.7465409	-101.02654	1,012.5134	0	1,152
Slice 5	24.204607	-5.8048642	-32.030913	1,233.3735	0	1,152
Slice 6	25.85147	-6.6975891	26.56989	1,428.3156	0	1,152
Slice 7	27.463352	-7.4448172	76.030202	1,598.122	0	1,152
Slice 8	29.075235	-8.0784529	118.40235	1,747.4076	0	1,152
Slice 9	30.687117	-8.6061609	154.16461	1,876.4342	0	1,152
Slice 10	32.298999	-9.033802	183.6827	1,985.6852	0	1,152
Slice 11	33.910882	-9.3658102	207.23329	2,075.8471	0	1,152

Slice 12	35.522764	-9.6054475	225.01994	2,147.7783	0	1,152
Slice 13	37.134647	-9.7549761	237.1838	2,202.4661	0	1,152
Slice 14	38.746529	-9.8157699	243.81062	2,240.9759	0	1,152
Slice 15	40.358412	-9.7883796	244.93474	2,264.3984	0	1,152
Slice 16	41.970294	-9.6725576	240.54073	2,273.7942	0	1,152
Slice 17	43.582176	-9.467247	230.56263	2,270.1388	0	1,152
Slice 18	45.194059	-9.1705323	214.88092	2,254.2677	0	1,152
Slice 19	46.84985	-8.766169	192.5591	2,225.7376	0	1,152
Slice 20	48.54955	-8.2443988	162.98829	2,184.3521	0	1,152
Slice 21	50.24925	-7.606923	126.19744	2,130.5729	0	1,152
Slice 22	51.94895	-6.8453627	81.663717	2,063.9358	0	1,152
Slice 23	53.64865	-5.9485994	28.693329	1,983.3083	0	1,152
Slice 24	55.24925	-4.9718351	-29.443317	1,893.3778	0	1,152
Slice 25	56.717809	-3.9423469	-91.102025	1,766.7551	0	1,152
Slice 26	58.153427	-2.7962032	-160.09794	1,596.0535	0	1,152
Slice 27	59.589044	-1.4906885	-239.03861	1,403.5068	0	1,152
Slice 28	61.136365	0.14212642	-338.20646	1,219.384	171.37324	720
Slice 29	62.795389	2.205245	-464.02891	931.37602	130.89636	720
Slice 30	64.454414	4.7405382	-619.31507	565.94114	79.53784	720
Slice 31	66.113438	8.0829289	-824.9641	49.416237	6.9449992	720
Slice 32	67.104033	10.508097	-974.55335	-365.23379	-51.330262	720

Slope Stability



File Information

File Version: 8.14
Created By: Eric Lundborg
Last Edited By: Eric Lundborg
Revision Number: 16
Date: 11/5/2015
Time: 12:13:05 PM
Tool Version: 8.14.1.10087
File Name: Pond 6 West old.gsz
Directory: P:\15-110 - Western Gallup Berm Upgrades\Slope Stability\
Last Solved Date: 11/5/2015
Last Solved Time: 12:13:08 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W
Method: Morgenstern-Price

- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001
  - Minimum Slip Surface Depth: 0.1 ft
  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3
  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

old berm material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

2013 berm material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

Native

Model: Mohr-Coulomb

Unit Weight: 140 pcf

Cohesion': 1,152 psf

Phi': 0 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range

Left-Zone Left Coordinate: (35, 1) ft

Left-Zone Right Coordinate: (60, 7) ft

Left-Zone Increment: 4

Right Projection: Range

Right-Zone Left Coordinate: (63, 7.94737) ft

Right-Zone Right Coordinate: (89, 13) ft

Right-Zone Increment: 4

Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft

Right Coordinate: (129, -1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-7
Coordinate 2	43	-5
Coordinate 3	74	4
Coordinate 4	91.5	11
Coordinate 5	130	11

Points

	X (ft)	Y (ft)
Point 1	21	1
Point 2	41	1
Point 3	79	13
Point 4	95	13
Point 5	99	9

Point 6	103	5
Point 7	85	5
Point 8	77	0
Point 9	109	-1
Point 10	129	-1
Point 11	129	-11
Point 12	0	-11
Point 13	0	0
Point 14	95	10

Regions

	Material	Points	Area (ft²)
Region 1	2013 berm material	3,4,14,5,6,7,8,2	412
Region 2	old berm material	6,7,8,9	138
Region 3	Native	9,10,11,12,13,1,2,8	1,431.5

Current Slip Surface

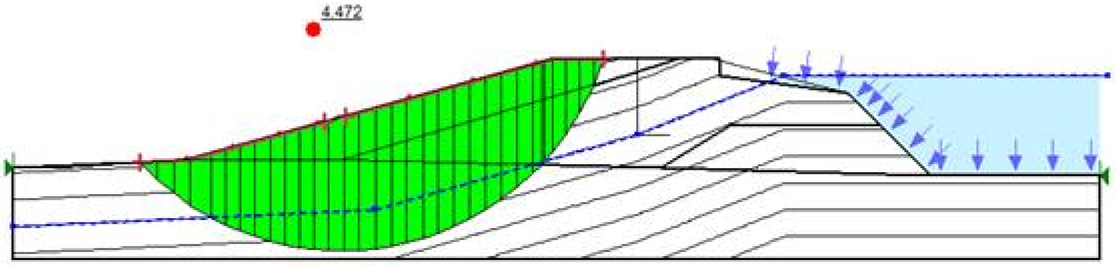
Slip Surface: 24
F of S: 4.229
Volume: 654.34485 ft³
Weight: 91,608.279 lbs
Resisting Moment: 2,272,298.8 lbs-ft
Activating Moment: 537,282.33 lbs-ft
Resisting Force: 59,369.947 lbs
Activating Force: 14,037.723 lbs
F of S Rank: 1
Exit: (35, 1) ft
Entry: (89, 13) ft
Radius: 31.821878 ft
Center: (58.586312, 22.361596) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	36	-0.009615077	-331.7163	427.57961	0	1,152
Slice 2	38	-1.8688358	-209.89627	670.81895	0	1,152
Slice 3	40	-3.4388293	-106.12403	884.04509	0	1,152
Slice 4	41.693554	-4.5938618	-29.134752	1,074.9566	0	1,152
Slice 5	42.693554	-5.2051781	11.913709	1,205.0971	0	1,152
Slice 6	43.934366	-5.8668318	71.0174	1,352.4218	0	1,152
Slice 7	45.803099	-6.7619359	160.7261	1,557.2495	0	1,152
Slice 8	47.671831	-7.5134176	241.47275	1,736.6316	0	1,152

Slice 9	49.540563	-8.1319519	313.92349	1,890.7274	0	1,152
Slice 10	51.409296	-8.6255378	378.57745	2,020.0564	0	1,152
Slice 11	53.278028	-9.0000999	435.80432	2,125.4694	0	1,152
Slice 12	55.146761	-9.2598843	485.86906	2,208.0941	0	1,152
Slice 13	57.015493	-9.407717	528.94802	2,269.2609	0	1,152
Slice 14	58.884225	-9.4451647	565.13896	2,310.4189	0	1,152
Slice 15	60.752958	-9.3726195	594.46633	2,333.0449	0	1,152
Slice 16	62.566801	-9.1979005	616.42368	2,338.8463	0	1,152
Slice 17	64.325755	-8.9256408	631.30011	2,329.9498	0	1,152
Slice 18	66.084708	-8.5509736	639.78631	2,307.8469	0	1,152
Slice 19	67.843662	-8.0701031	641.64542	2,273.1491	0	1,152
Slice 20	69.602616	-7.4778753	636.55584	2,226.1387	0	1,152
Slice 21	71.361569	-6.7674692	624.09193	2,166.6825	0	1,152
Slice 22	73.120523	-5.9299396	603.69552	2,094.1171	0	1,152
Slice 23	74.75	-5.0356447	582.54423	2,014.6932	0	1,152
Slice 24	76.25	-4.0923779	561.12438	1,928.5751	0	1,152
Slice 25	78	-2.8206654	525.44952	1,808.2831	0	1,152
Slice 26	80.049765	-1.0889243	468.55102	1,593.1691	0	1,152
Slice 27	82.074648	0.9411427	392.41591	1,363.0531	136.41416	720
Slice 28	84.024883	3.3125948	293.11515	1,033.0983	103.99786	720
Slice 29	85.127387	4.807397	227.35801	820.68321	83.386419	720
Slice 30	86.467884	7.2361986	109.25958	458.84591	49.131155	720
Slice 31	88.340496	11.236199	-93.6	-184.99057	-25.998729	720

Slope Stability



File Information

File Version: 8.14

Created By: Eric Lundborg

Last Edited By: Eric Lundborg

Revision Number: 10

Date: 11/5/2015

Time: 12:09:05 PM

Tool Version: 8.14.1.10087

File Name: Pond 6 West.gsz

Directory: P:\15-110 - Western Gallup Berm Upgrades\Slope Stability\

Last Solved Date: 11/5/2015

Last Solved Time: 12:09:07 PM

Project Settings

Length(L) Units: Feet

Time(t) Units: Seconds

Force(F) Units: Pounds

Pressure(p) Units: psf

Strength Units: psf

Unit Weight of Water: 62.4 pcf

View: 2D

Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W

Method: Morgenstern-Price

Settings

- Side Function
    - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack
    - Tension Crack Option: (none)

F of S Distribution
- F of S Calculation Option: Constant

Advanced
- Number of Slices: 30
- F of S Tolerance: 0.001
- Minimum Slip Surface Depth: 0.1 ft
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

old berm material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
    - Piezometric Line: 1

2013 berm material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
    - Piezometric Line: 1

2015 berm material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 8 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Native

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 1,152 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (15, 0.71429) ft
Left-Zone Right Coordinate: (37, 5.46512) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (39.43733, 6.1453) ft
Right-Zone Right Coordinate: (70, 13) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft
Right Coordinate: (129, -1) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-7
Coordinate 2	43	-5
Coordinate 3	74	4
Coordinate 4	91.5	11
Coordinate 5	130	11

Points

	X (ft)	Y (ft)
Point 1	21	1
Point 2	41	1
Point 3	79	13
Point 4	64	13
Point 5	84	13
Point 6	99	9
Point 7	103	5
Point 8	85	5
Point 9	77	0
Point 10	109	-1
Point 11	129	-1
Point 12	128	-40
Point 13	0	-38
Point 14	0	0
Point 15	84	11

Regions

	Material	Points	Area (ft^2)
Region 1	2015 berm material	1,2,3,4	210
Region 2	2013 berm material	3,5,15,6,7,8,9,2	381
Region 3	old berm material	7,8,9,10	138
Region 4	Native	10,11,12,13,14,1,2,9	5,025

Current Slip Surface

Slip Surface: 24
F of S: 4.472
Volume: 660.70349 ft^3
Weight: 92,498.489 lbs
Resisting Moment: 2,381,313.2 lbs-ft
Activating Moment: 532,444.45 lbs-ft
Resisting Force: 60,902.035 lbs
Activating Force: 13,616.869 lbs
F of S Rank: 1
Exit: (15, 0.71428572) ft
Entry: (70, 13) ft
Radius: 32.437199 ft
Center: (38.997068, 22.538873) ft

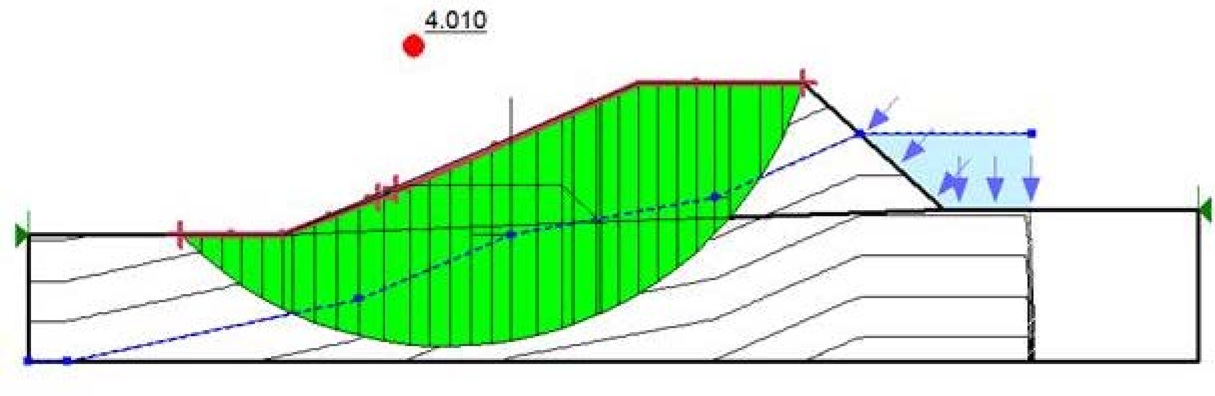
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	16	-0.29295165	-372.08261	418.07102	0	1,152

Slice 2	18	-2.150634	-250.35858	677.68574	0	1,152
Slice 3	20	-3.7244107	-146.35026	908.01202	0	1,152
Slice 4	22.2078	-5.1793224	-49.156016	1,167.3849	0	1,152
Slice 5	24.29482	-6.3582313	30.465109	1,415.9922	0	1,152
Slice 6	26.05326	-7.1883891	87.370524	1,599.1047	0	1,152
Slice 7	27.8117	-7.8943647	136.52697	1,759.8412	0	1,152
Slice 8	29.57014	-8.4846744	178.46586	1,898.3918	0	1,152
Slice 9	31.32858	-8.9658462	213.59454	2,015.2162	0	1,152
Slice 10	33.08702	-9.3428398	242.22251	2,111.0244	0	1,152
Slice 11	34.84546	-9.6193314	264.57915	2,186.7375	0	1,152
Slice 12	36.6039	-9.7979073	280.82585	2,243.4385	0	1,152
Slice 13	38.36234	-9.8801904	291.06388	2,282.3132	0	1,152
Slice 14	40.12078	-9.8669164	295.33915	2,304.5882	0	1,152
Slice 15	42	-9.7434073	293.08629	2,310.9027	0	1,152
Slice 16	43.934366	-9.5064262	298.12809	2,301.2638	0	1,152
Slice 17	45.803099	-9.1618611	310.48143	2,276.5363	0	1,152
Slice 18	47.671831	-8.7018058	315.62817	2,237.7934	0	1,152
Slice 19	49.540563	-8.1210406	313.24262	2,185.5257	0	1,152
Slice 20	51.409296	-7.4125127	302.88468	2,119.7605	0	1,152
Slice 21	53.278028	-6.5668453	283.96923	2,039.9357	0	1,152
Slice 22	55.146761	-5.5715897	255.71948	1,944.7263	0	1,152
Slice 23	57.015493	-4.4100586	217.09414	1,831.7784	0	1,152
Slice 24	58.884225	-3.0594254	166.66882	1,697.273	0	1,152
Slice 25	60.752958	-1.4874515	102.43185	1,535.1464	0	1,152
Slice 26	62.194589	-0.12210508	43.351012	1,389.1829	0	1,152
Slice 27	62.903503	0.61707514	10.068943	1,360.3513	189.76981	720
Slice 28	63.552576	1.3556313	-24.258277	1,282.5053	180.24437	720
Slice 29	64.803689	2.9321063	-99.964992	1,081.925	152.05465	720
Slice			-			

30	66.411067	5.2654325	216.44508	754.25379	106.00346	720
Slice 31	68.018444	8.1634361	-368.16105	326.83844	45.934147	720
Slice 32	69.411067	11.392968	-544.45494	-191.43689	-26.904701	720

Slope Stability



File Information

File Version: 8.14

Created By: Eric Lundborg

Last Edited By: Eric Lundborg

Revision Number: 15

Date: 11/3/2015

Time: 3:26:49 PM

Tool Version: 8.14.1.10087

File Name: Pond 7 West Berm.gsz

Directory: C:\Users\ELundborg\Desktop\Gallup\ponds\

Last Solved Date: 11/3/2015

Last Solved Time: 3:26:52 PM

Project Settings

Length(L) Units: Feet

Time(t) Units: Seconds

Force(F) Units: Pounds

Pressure(p) Units: psf

Strength Units: psf

Unit Weight of Water: 62.4 pcf

View: 2D

Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
- F of S Calculation Option: Constant

Advanced
- Number of Slices: 30
- F of S Tolerance: 0.001
- Minimum Slip Surface Depth: 0.1 ft
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

old berm material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 8 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

2013 berm material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 8 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

Native

Model: Mohr-Coulomb

Unit Weight: 140 pcf

Cohesion': 1,152 psf

Phi': 0 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range

Left-Zone Left Coordinate: (12, 0) ft

Left-Zone Right Coordinate: (27.5, 3) ft

Left-Zone Increment: 4

Right Projection: Range

Right-Zone Left Coordinate: (29, 3.6) ft

Right-Zone Right Coordinate: (61, 12) ft

Right-Zone Increment: 4

Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft

Right Coordinate: (92, 2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-10
Coordinate 2	3	-10
Coordinate 3	26	-5
Coordinate 4	38	0
Coordinate 5	54	3
Coordinate 6	65.4	8
Coordinate 7	79	8

Points

	X (ft)	Y (ft)
Point 1	0	0

Point 2	20	0
Point 3	45	1
Point 4	72	2
Point 5	92	2
Point 6	92	-10
Point 7	0	-10
Point 8	30	4
Point 9	42	4
Point 10	48	12
Point 11	61	12

Regions

	Material	Points	Area (ft^2)
Region 1	Native	1,2,3,4,5,6,7	1,013
Region 2	old berm material	2,8,9,3	63
Region 3	2013 berm material	8,10,11,4,3,9	281

Current Slip Surface

Slip Surface: 24

F of S: 4.010

Volume: 537.44787 ft^3

Weight: 75,242.702 lbs

Resisting Moment: 1,913,922.1 lbs-ft

Activating Moment: 477,246.29 lbs-ft

Resisting Force: 54,288.645 lbs

Activating Force: 13,537.043 lbs

F of S Rank: 1

Exit: (12, 0) ft

Entry: (61, 12) ft

Radius: 29.344763 ft

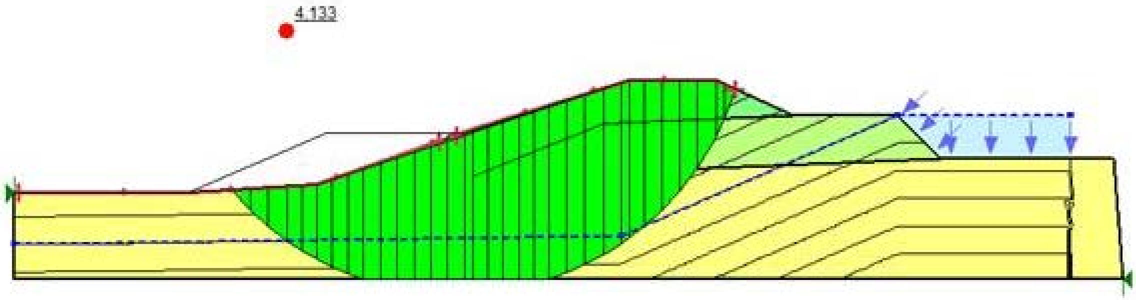
Center: (32.933039, 20.565092) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	12.8	-0.75544219	-443.92128	386.32275	0	1,152
Slice 2	14.4	-2.1632176	-334.37174	567.58737	0	1,152
Slice 3	16	-3.3812502	-236.66216	729.79407	0	1,152
Slice 4	17.6	-4.4375548	-149.0444	872.6481	0	1,152
Slice 5	19.2	-5.3520658	-70.27457	995.97981	0	1,152
Slice 6	20.382549	-5.956997	-16.48534	1,098.4587	0	1,152
Slice 7	21.637581	-6.5021199	34.555116	1,241.1545	0	1,152
Slice 8	23.382549	-7.1666902	99.695172	1,422.6953	0	1,152

Slice 9	25.127516	-7.7080346	157.14593	1,581.1225	0	1,152
Slice 10	27	-8.1554842	222.90221	1,724.9382	0	1,152
Slice 11	29	-8.4973926	296.2373	1,850.926	0	1,152
Slice 12	30.8	-8.6910503	355.12154	1,946.3411	0	1,152
Slice 13	32.4	-8.7639171	401.26843	2,017.7682	0	1,152
Slice 14	34	-8.749339	441.95875	2,073.1591	0	1,152
Slice 15	35.6	-8.6471846	477.18432	2,113.5461	0	1,152
Slice 16	37.2	-8.4565262	506.88724	2,139.9419	0	1,152
Slice 17	39	-8.1274574	518.85334	2,153.1862	0	1,152
Slice 18	41	-7.6298968	511.20556	2,150.7796	0	1,152
Slice 19	42.440678	-7.1928426	500.78931	2,139.8435	0	1,152
Slice 20	43.809099	-6.6714364	484.26409	2,117.2162	0	1,152
Slice 21	44.868421	-6.2423887	469.88558	2,097.5687	0	1,152
Slice 22	45.75	-5.8194752	453.81025	2,073.7885	0	1,152
Slice 23	47.25	-5.035715	422.45361	2,027.1315	0	1,152
Slice 24	48.75	-4.1360358	383.86363	1,924.2743	0	1,152
Slice 25	50.25	-3.1071376	337.21039	1,763.0766	0	1,152
Slice 26	51.75	-1.9311529	281.37894	1,583.7101	0	1,152
Slice 27	53.25	-0.58330182	214.82303	1,380.5706	0	1,152
Slice 28	54.566832	0.75626672	155.52227	1,177.9168	0	1,152
Slice 29	56.325645	2.9590693	66.203297	932.12996	121.69806	720
Slice 30	58.388218	6.0718877	-71.587193	473.45171	66.539299	720
Slice 31	60.129406	9.8004789	-256.59772	-126.74339	-17.812621	720

Slope Stability



File Information

File Version: 8.14
Created By: Eric Lundborg
Last Edited By: Eric Lundborg
Revision Number: 9
Date: 11/3/2015
Time: 3:28:24 PM
Tool Version: 8.14.1.10087
File Name: Pond 8 north old.gsz
Directory: C:\Users\ELundborg\Desktop\Gallup\ponds\
Last Solved Date: 11/3/2015
Last Solved Time: 3:28:26 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W
Method: Morgenstern-Price
Settings

- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °
- Driving Side Maximum Convex Angle: 5 °
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

F of S Distribution
- F of S Calculation Option: Constant

Advanced
- Number of Slices: 30
- F of S Tolerance: 0.001
- Minimum Slip Surface Depth: 0.1 ft
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

Native

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 1,152 psf
- Phi': 0 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

Original Berm Material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

2013 berm Material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (0.44805, 0) ft
Left-Zone Right Coordinate: (49, 5.94118) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (51.1184, 6.68885) ft
Right-Zone Right Coordinate: (83.25, 12) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft
Right Coordinate: (128, -10) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-6
Coordinate 2	70	-5
Coordinate 3	102	9
Coordinate 4	122	9

Points

	X (ft)	Y (ft)
Point 1	20	0
Point 2	52	7
Point 3	35	1
Point 4	0	0
Point 5	107	4
Point 6	127	4
Point 7	128	-10

Point 8	0	-10
Point 9	71	13
Point 10	81	13
Point 11	90	9
Point 12	68	8
Point 13	53	1.75
Point 14	102	9

Regions

	Material	Points	Area (ft²)
Region 1	Native	4,1,3,13,5,6,7,8	1,544.5
Region 2	2013 berm Material	9,10,11,12,13,3,2	202.13
Region 3	Original Berm Material	5,14,11,12,13	245.38

Current Slip Surface

Slip Surface: 74

F of S: 4.133

Volume: 780.2475 ft³

Weight: 109,234.65 lbs

Resisting Moment: 2,622,602.8 lbs-ft

Activating Moment: 634,597.48 lbs-ft

Resisting Force: 65,296.576 lbs

Activating Force: 15,799.871 lbs

F of S Rank: 1

Exit: (25.15243, 0.34349536) ft

Entry: (83.25, 12) ft

Radius: 33.738921 ft

Center: (51.026123, 21.996828) ft

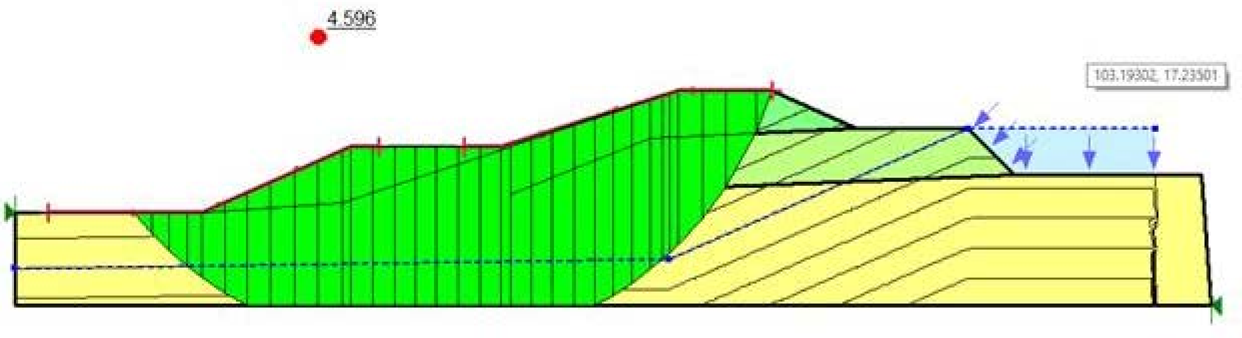
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	26.217824	-0.81513356	-300.16435	487.15934	0	1,152
Slice 2	28.348611	-2.9425312	-165.51529	783.95164	0	1,152
Slice 3	30.479397	-4.7303301	-52.057198	1,046.5475	0	1,152
Slice 4	32.408593	-6.1212996	36.459039	1,256.7849	0	1,152
Slice 5	34.136198	-7.1930546	104.87659	1,420.76	0	1,152
Slice 6	35.887471	-8.1386932	165.44557	1,602.0689	0	1,152
Slice 7	37.662412	-8.9675341	218.74748	1,800.5516	0	1,152
Slice 8	39.437354	-9.675276	264.4928	1,977.3297	0	1,152
Slice 9	41.297756	-10	286.414	1,948.48	0	1,152
Slice 10	43.243618	-10	288.1486	2,039.8	0	1,152

Slice 11	45.189481	-10	289.88319	2,129.4451	0	1,152
Slice 12	47.135343	-10	291.61779	2,217.4449	0	1,152
Slice 13	49.081206	-10	293.35239	2,303.8547	0	1,152
Slice 14	51.027069	-10	295.08699	2,388.7553	0	1,152
Slice 15	52.5	-10	296.4	2,449.5212	0	1,152
Slice 16	53.872742	-10	297.6237	2,500.6942	0	1,152
Slice 17	55.618227	-10	299.17968	2,564.94	0	1,152
Slice 18	57.363711	-10	300.73565	2,628.3327	0	1,152
Slice 19	59.109196	-10	302.29163	2,691.002	0	1,152
Slice 20	60.85468	-10	303.8476	2,753.0903	0	1,152
Slice 21	62.772852	-9.6114826	281.31403	2,557.5895	0	1,152
Slice 22	64.863711	-8.7525088	229.57791	2,486.6004	0	1,152
Slice 23	66.95457	-7.7217267	167.12096	2,397.9729	0	1,152
Slice 24	69	-6.5313618	94.665547	2,292.2948	0	1,152
Slice 25	70.5	-5.5478261	47.834351	2,203.0926	0	1,152
Slice 26	71.900619	-4.4843942	19.713085	2,064.6911	0	1,152
Slice 27	73.799077	-2.8602834	-29.803514	1,825.2012	0	1,152
Slice 28	75.794756	-0.86504518	-99.824335	1,531.7315	0	1,152
Slice 29	77.790436	1.5202646	-194.18562	1,173.7354	0	1,152
Slice 30	79.894138	4.6666153	-333.08684	799.03698	112.29732	720
Slice 31	81.503554	7.5727029	-470.48964	334.20221	46.969058	720
Slice 32	82.628554	10.318343	-611.1051	-191.41524	-0	720

Slope Stability

Report generated using GeoStudio 2012.



File Information

File Version: 8.14

Created By: Eric Lundborg

Last Edited By: Eric Lundborg

Revision Number: 8

Date: 11/3/2015

Time: 3:29:59 PM

Tool Version: 8.14.1.10087

File Name: Pond 8 north.gsz

Directory: C:\Users\ELundborg\Desktop\Gallup\ponds\

Last Solved Date: 11/3/2015

Last Solved Time: 3:30:02 PM

Project Settings

Length(L) Units: Feet

Time(t) Units: Seconds

Force(F) Units: Pounds

Pressure(p) Units: psf

Strength Units: psf

Unit Weight of Water: 62.4 pcf

View: 2D

Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W

Method: Morgenstern-Price

- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001
  - Minimum Slip Surface Depth: 0.1 ft
  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3
  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

Native

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 1,152 psf
- Phi': 0 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

Original Berm Material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

2013 berm Material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 8 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

2015 Berm Material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 7 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (3.51928, 0) ft
Left-Zone Right Coordinate: (39, 7) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (48, 7) ft
Right-Zone Right Coordinate: (81, 13) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft
Right Coordinate: (128, -10) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	-6
Coordinate 2	70	-5
Coordinate 3	102	9
Coordinate 4	122	9

Points

	X (ft)	Y (ft)
Point 1	20	0
Point 2	36	7
Point 3	52	7
Point 4	35	1
Point 5	0	0
Point 6	107	4
Point 7	127	4
Point 8	128	-10
Point 9	0	-10
Point 10	71	13
Point 11	81	13
Point 12	90	9
Point 13	68	8
Point 14	53	1.75
Point 15	102	9

Regions

	Material	Points	Area (ft²)
Region 1	2015 Berm Material	1,2,3,4	92.5
Region 2	Native	5,1,4,14,6,7,8,9	1,544.5
Region 3	2013 berm Material	10,11,12,13,14,4,3	202.13
Region 4	Original Berm Material	6,15,12,13,14	245.38

Current Slip Surface

Slip Surface: 49

F of S: 4.596

Volume: 957.24499 ft³

Weight: 134,014.3 lbs

Resisting Moment: 3,414,988.8 lbs-ft

Activating Moment: 743,046.74 lbs-ft

Resisting Force: 76,776.681 lbs

Activating Force: 16,708.051 lbs

F of S Rank: 1

Exit: (12.755522, 0) ft

Entry: (81, 13) ft

Radius: 39.369411 ft

Center: (43.41024, 24.703012) ft

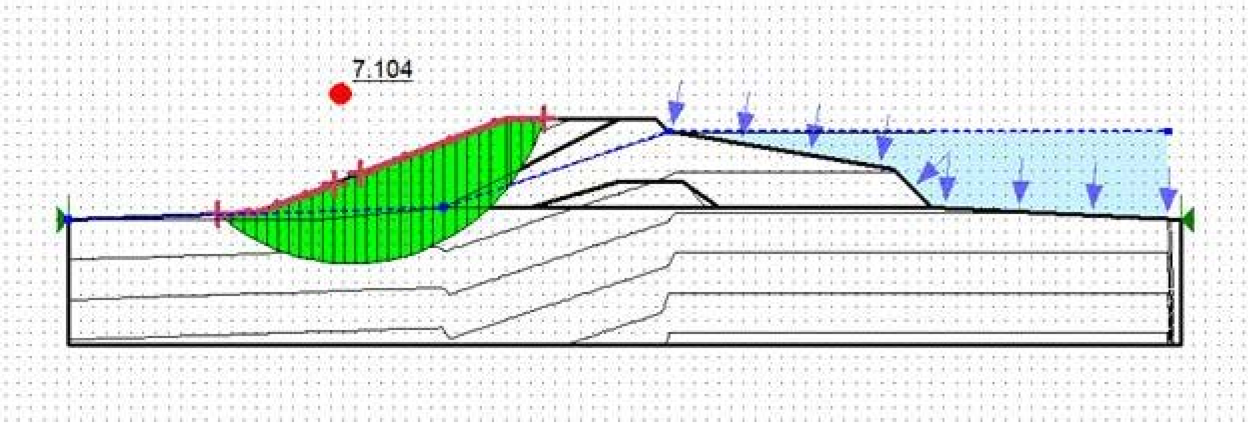
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	13.703364	-1.0916003	-294.06857	450.63349	0	1,152

Slice 2	15.599046	-3.1302891	-165.16452	720.72695	0	1,152
Slice 3	17.494729	-4.9069562	-52.610633	965.16289	0	1,152
Slice 4	19.221285	-6.3432517	38.55331	1,167.2935	0	1,152
Slice 5	21.204634	-7.7736262	129.57669	1,447.7712	0	1,152
Slice 6	23.613901	-9.2986418	226.88535	1,819.0952	0	1,152
Slice 7	26.091218	-10	272.85846	1,862.6203	0	1,152
Slice 8	28.636584	-10	275.12747	2,018.384	0	1,152
Slice 9	31.181951	-10	277.39648	2,172.2976	0	1,152
Slice 10	33.727317	-10	279.66549	2,324.3114	0	1,152
Slice 11	35.5	-10	281.24571	2,429.1151	0	1,152
Slice 12	37.142857	-10	282.7102	2,455.3044	0	1,152
Slice 13	39.428571	-10	284.74776	2,447.9079	0	1,152
Slice 14	41.714286	-10	286.78531	2,439.0499	0	1,152
Slice 15	44	-10	288.82286	2,428.8058	0	1,152
Slice 16	46.285714	-10	290.86041	2,417.2742	0	1,152
Slice 17	48.571429	-10	292.89796	2,404.5764	0	1,152
Slice 18	50.857143	-10	294.93551	2,390.8548	0	1,152
Slice 19	52.5	-10	296.4	2,402.5801	0	1,152
Slice 20	54.125243	-10	297.84879	2,463.7421	0	1,152
Slice 21	56.375729	-10	299.85494	2,547.9806	0	1,152
Slice 22	58.626216	-10	301.86108	2,631.8299	0	1,152
Slice 23	60.876702	-10	303.86723	2,715.4932	0	1,152
Slice 24	63.001621	-9.4261497	269.95319	2,435.9985	0	1,152
Slice 25	65.000973	-8.1962441	194.98936	2,332.2245	0	1,152
Slice 26	67.000324	-6.7914074	109.10982	2,209.3232	0	1,152
Slice 27	68.618623	-5.5267612	31.638501	2,095.2866	0	1,152
Slice 28	69.618623	-4.6706155	-20.893562	2,015.623	0	1,152
Slice		-	-			

29	70.5	3.8560586	57.731942	1,937.5838	0	1,152
Slice 30	72.266134	-2.0143018	-124.44212	1,698.782	0	1,152
Slice 31	74.798401	1.0321007	-245.40674	1,261.2944	0	1,152
Slice 32	77.680701	5.6122581	-452.52177	687.02169	96.554602	720
Slice 33	80.148434	10.756747	-706.16877	-87.47698	-12.294088	720

Slope Stability



File Information

File Version: 8.14
Created By: Eric Lundborg
Last Edited By: Eric Lundborg
Revision Number: 11
Date: 11/5/2015
Time: 12:44:13 PM
Tool Version: 8.14.1.10087
File Name: Pond 9 north rebuild.gsz
Directory: P:\15-110 - Western Gallup Berm Upgrades\Slope Stability\
Last Solved Date: 11/5/2015
Last Solved Time: 12:44:16 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W
Method: Morgenstern-Price

- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: Yes
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001
  - Minimum Slip Surface Depth: 0.1 ft
  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3
  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

old berm material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

2013 berm material

- Model: Mohr-Coulomb
- Unit Weight: 140 pcf
- Cohesion': 720 psf
- Phi': 8 °
- Phi-B: 0 °
- Pore Water Pressure
  - Piezometric Line: 1

2015 berm material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 8 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Native

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 1,152 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (12, 0.4) ft
Left-Zone Right Coordinate: (21.24658, 2.84247) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (23.32877, 3.62329) ft
Right-Zone Right Coordinate: (38, 8) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft
Right Coordinate: (89, 0) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	0
Coordinate 2	30	1
Coordinate 3	48	7
Coordinate 4	88	7

Points

	X (ft)	Y (ft)
Point 1	30	1
Point 2	44	8
Point 3	47	8
Point 4	48	7
Point 5	66	4
Point 6	69	1
Point 7	52	1
Point 8	49	3
Point 9	44	3
Point 10	37	1
Point 11	0	0
Point 12	0	-10
Point 13	89	-10
Point 14	89	0
Point 15	35	8
Point 16	15	0.5

Regions

	Material	Points	Area (ft²)
Region 1	2013 berm material	1,2,3,4,5,6,7,8,9,10	142
Region 2	Native	11,12,13,14,6,7,10,1,16	954
Region 3	old berm material	10,9,8,7	20
Region 4	2015 berm material	2,15,16,1	82.75

Current Slip Surface

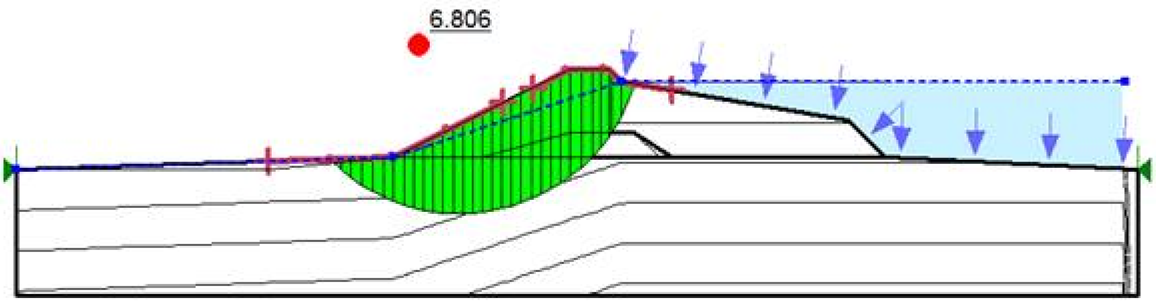
Slip Surface: 24
F of S: 7.104
Volume: 141.31869 ft³
Weight: 19,784.616 lbs
Resisting Moment: 544,677.92 lbs-ft
Activating Moment: 76,671.884 lbs-ft
Resisting Force: 28,318.099 lbs
Activating Force: 3,986.1217 lbs
F of S Rank: 1
Exit: (12, 0.4) ft
Entry: (38, 8) ft
Radius: 16.141931 ft
Center: (22.536086, 12.62918) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	12.5	0.0025815736	25.83891	194.08599	0	1,152

Slice 2	13.5	-0.73295957	73.816677	298.90084	0	1,152
Slice 3	14.5	-1.3583414	114.9205	391.86631	0	1,152
Slice 4	15.441176	-1.8616072	148.11736	489.94597	0	1,152
Slice 5	16.323529	-2.2616754	174.88717	594.25104	0	1,152
Slice 6	17.205882	-2.6001469	197.81761	687.69252	0	1,152
Slice 7	18.088235	-2.8810724	217.16116	769.72191	0	1,152
Slice 8	18.970588	-3.107546	233.11068	840.08487	0	1,152
Slice 9	19.852941	-3.2819014	245.81164	898.81066	0	1,152
Slice 10	20.735294	-3.4058443	255.37035	946.18297	0	1,152
Slice 11	21.617647	-3.4805422	261.85958	982.69612	0	1,152
Slice 12	22.5	-3.5066809	265.32209	1,009.0017	0	1,152
Slice 13	23.382353	-3.4844976	265.77264	1,025.8507	0	1,152
Slice 14	24.264706	-3.4137912	263.19871	1,034.0352	0	1,152
Slice 15	25.147059	-3.2939132	257.55989	1,034.3324	0	1,152
Slice 16	26.029412	-3.1237376	248.78597	1,027.4528	0	1,152
Slice 17	26.911765	-2.9016054	236.77357	1,013.992	0	1,152
Slice 18	27.794118	-2.6252386	221.38068	994.38411	0	1,152
Slice 19	28.676471	-2.2916116	202.41871	968.85372	0	1,152
Slice 20	29.558824	-1.8967614	179.64066	937.36041	0	1,152
Slice 21	30.466364	-1.4202273	144.6503	898.21362	0	1,152
Slice 22	31.399092	-0.8503433	130.10628	850.14582	0	1,152
Slice 23	32.33182	-0.18725464	110.32788	792.26585	0	1,152
Slice 24	33.264548	0.58459607	84.441414	721.63078	0	1,152
Slice 25	34.365456	1.6859257	43.199746	658.23977	86.438237	720
Slice 26	35.159889	2.5725552	8.2784149	568.09953	78.677728	720
Slice 27	35.789363	3.4513666	-29.291877	446.06861	62.690854	720
Slice 28	36.694211	4.9298716	-95.385959	229.37079	32.235962	720
Slice 29	37.564737	6.8651346	-187.77408	-93.70203	-13.168962	720

Slope Stability



File Information

File Version: 8.14

Created By: Eric Lundborg

Last Edited By: Eric Lundborg

Revision Number: 4

Date: 11/5/2015

Time: 12:16:15 PM

Tool Version: 8.14.1.10087

File Name: Pond 9 north.gsz

Directory: P:\15-110 - Western Gallup Berm Upgrades\Slope Stability\

Last Solved Date: 11/5/2015

Last Solved Time: 12:16:18 PM

Project Settings

Length(L) Units: Feet

Time(t) Units: Seconds

Force(F) Units: Pounds

Pressure(p) Units: psf

Strength Units: psf

Unit Weight of Water: 62.4 pcf

View: 2D

Element Thickness: 1

Analysis Settings

Slope Stability

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
  Side Function
    Interslice force function option: Half-Sine
  PWP Conditions Source: Piezometric Line
  Apply Phreatic Correction: No
  Use Staged Rapid Drawdown: No
Slip Surface
  Direction of movement: Right to Left
  Use Passive Mode: No
  Slip Surface Option: Entry and Exit
  Critical slip surfaces saved: 1
  Resisting Side Maximum Convex Angle: 1 °
  Driving Side Maximum Convex Angle: 5 °
  Optimize Critical Slip Surface Location: No
  Tension Crack
    Tension Crack Option: (none)
F of S Distribution
  F of S Calculation Option: Constant
Advanced
  Number of Slices: 30
  F of S Tolerance: 0.001
  Minimum Slip Surface Depth: 0.1 ft
  Search Method: Root Finder
  Tolerable difference between starting and converged F of S: 3
  Maximum iterations to calculate converged lambda: 20
  Max Absolute Lambda: 2

Materials

old berm material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 8 °
Phi-B: 0 °
Pore Water Pressure
  Piezometric Line: 1

2013 berm material

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 720 psf
Phi': 8 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

Native

Model: Mohr-Coulomb

Unit Weight: 140 pcf

Cohesion': 1,152 psf

Phi': 0 °

Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range

Left-Zone Left Coordinate: (20, 0.66667) ft

Left-Zone Right Coordinate: (38.64226, 5.32113) ft

Left-Zone Increment: 4

Right Projection: Range

Right-Zone Left Coordinate: (41, 6.5) ft

Right-Zone Right Coordinate: (52, 6.33333) ft

Right-Zone Increment: 4

Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 0) ft

Right Coordinate: (89, 0) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	0
Coordinate 2	30	1
Coordinate 3	48	7
Coordinate 4	88	7

Points

	X (ft)	Y (ft)
Point 1	30	1
Point 2	44	8
Point 3	47	8
Point 4	48	7

Point 5	66	4
Point 6	69	1
Point 7	52	1
Point 8	49	3
Point 9	44	3
Point 10	37	1
Point 11	0	0
Point 12	0	-10
Point 13	89	-10
Point 14	89	0

Regions

	Material	Points	Area (ft²)
Region 1	2013 berm material	1,2,3,4,5,6,7,8,9,10	142
Region 2	Native	11,12,13,14,6,7,10,1	954
Region 3	old berm material	10,9,8,7	20

Current Slip Surface

Slip Surface: 44

F of S: 6.806

Volume: 138.41056 ft³

Weight: 19,377.479 lbs

Resisting Moment: 458,653.94 lbs-ft

Activating Moment: 67,392.201 lbs-ft

Resisting Force: 26,445.114 lbs

Activating Force: 3,885.647 lbs

F of S Rank: 1

Exit: (24.914244, 0.83047481) ft

Entry: (49.084346, 6.8192757) ft

Radius: 14.505246 ft

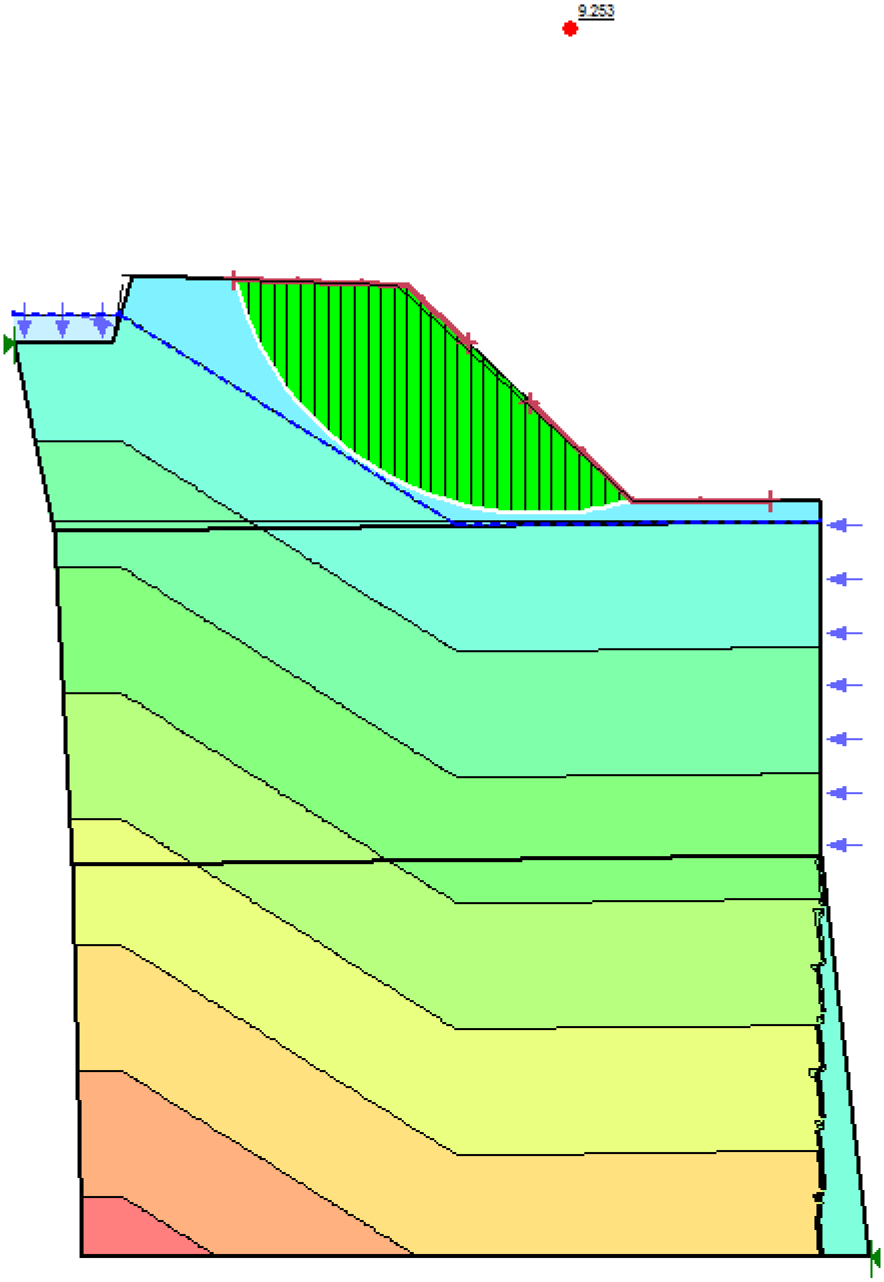
Center: (35.209397, 11.048694) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	25.338057	0.43625788	25.480667	221.1464	0	1,152
Slice 2	26.185683	-0.29509226	72.879978	319.26588	0	1,152
Slice 3	27.033309	-0.92170066	113.7434	407.20522	0	1,152
Slice 4	27.880935	-1.4594852	149.06422	484.35491	0	1,152
Slice 5	28.728561	-1.9195929	179.538	550.29718	0	1,152
Slice 6	29.576187	-2.310107	205.66914	604.80083	0	1,152
Slice 7	30.388889	-2.625912	234.3458	672.89016	0	1,152
Slice 8	31.166667	-2.8759074	266.12329	755.47936	0	1,152
Slice 9	31.944444	-3.0786889	294.95463	828.31586	0	1,152

Slice 10	32.722222	-3.2362743	320.96574	891.47369	0	1,152
Slice 11	33.5	-3.3501522	344.2495	945.18958	0	1,152
Slice 12	34.277778	-3.4213579	364.87051	989.83561	0	1,152
Slice 13	35.055556	-3.4505218	382.86811	1,025.8867	0	1,152
Slice 14	35.833333	-3.4378986	398.25821	1,053.8852	0	1,152
Slice 15	36.611111	-3.3833784	411.03392	1,074.4052	0	1,152
Slice 16	37.388889	-3.2864817	421.16535	1,088.0164	0	1,152
Slice 17	38.166667	-3.1463381	428.59816	1,095.2499	0	1,152
Slice 18	38.944444	-2.9616456	433.25113	1,096.564	0	1,152
Slice 19	39.722222	-2.7306068	435.01209	1,092.3112	0	1,152
Slice 20	40.5	-2.4508332	433.73199	1,082.7007	0	1,152
Slice 21	41.277778	-2.1192056	429.21621	1,067.7572	0	1,152
Slice 22	42.055556	-1.7316683	421.21166	1,047.2653	0	1,152
Slice 23	42.833333	-1.2829212	409.38762	1,020.6927	0	1,152
Slice 24	43.611111	-0.76594372	393.306	987.07155	0	1,152
Slice 25	44.41752	-0.14596426	371.3926	915.46695	0	1,152
Slice 26	45.252561	0.5987328	342.29235	801.62473	0	1,152
Slice 27	46.002561	1.3707939	309.71574	738.01576	60.193642	720
Slice 28	46.66752	2.1706924	273.63322	626.19694	49.549599	720
Slice 29	47.138369	2.7998985	244.1644	518.37236	38.537415	720
Slice 30	47.638369	3.6037238	204.40571	333.03405	18.077535	720
Slice 31	48.542173	5.5133616	92.766234	-42.431396	-19.000787	720

Slope Stability



File Information

File Version: 8.14

Created By: Eric Lundborg

Last Edited By: Eric Lundborg

Revision Number: 6

Date: 11/3/2015

Time: 3:35:03 PM

Tool Version: 8.14.1.10087

File Name: Section 6 old report.gsz
Directory: C:\Users\ELundborg\Desktop\Gallup\ponds\
Last Solved Date: 11/3/2015
Last Solved Time: 3:35:05 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Slope Stability

- Kind: SLOPE/W
- Method: Bishop
- Settings
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.001
  - Minimum Slip Surface Depth: 0.1 ft

Materials

berm

Model: Mohr-Coulomb

Unit Weight: 140 pcf
Cohesion': 1,152 psf
Phi': 10 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

subgrade

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 2,304 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

base

Model: Mohr-Coulomb
Unit Weight: 140 pcf
Cohesion': 576 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (3.104592, -4.343021) ft
Left-Zone Right Coordinate: (9.068182, -6) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (10.66042, -7.52301) ft
Right-Zone Right Coordinate: (16.75, -10) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-2.5, -6) ft
Right Coordinate: (19.25, -29.25) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-2.5	-5.25
Coordinate 2	0.214286	-5.25
Coordinate 3	8.75	-10.61859
Coordinate 4	18	-10.5

Points

	X (ft)	Y (ft)
Point 1	-2.5	-6
Point 2	-1.5	-10.75
Point 3	18	-10.5
Point 4	18	-10
Point 5	13.25	-10
Point 6	7.5	-4.5
Point 7	0.5	-4.25
Point 8	0	-6
Point 9	-1	-19.25
Point 10	18	-19
Point 11	-0.75	-29.25
Point 12	19.25	-29.25

Regions

	Material	Points	Area (ft²)
Region 1	berm	1,2,3,4,5,6,7,8	78.188
Region 2	subgrade	2,9,10,3	163.69
Region 3	base	9,11,12,10	197.53

Current Slip Surface

Slip Surface: 14

F of S: 9.253

Volume: 31.251063 ft³

Weight: 4,375.1488 lbs

Resisting Moment: 124,944.11 lbs-ft

Activating Moment: 13,502.726 lbs-ft

F of S Rank: 1

Exit: (13.219833, -9.9711447) ft

Entry: (3.104592, -4.3430211) ft

Radius: 8.0223547 ft

Center: (10.863166, -2.3027491) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	3.2736461	-	-145.2013	-285.36011	-50.316686	1,152

		4.8472595				
Slice 2	3.6117545	-5.7111613	-104.56352	-72.901045	-12.854421	1,152
Slice 3	3.9498628	-6.3589565	-77.410789	63.750572	11.240946	1,152
Slice 4	4.2879711	-6.8894342	-57.578674	167.53817	29.5415	1,152
Slice 5	4.6260794	-7.3410577	-42.667062	252.05744	44.444527	1,152
Slice 6	4.9641877	-7.7339497	-31.420289	323.52057	57.045406	1,152
Slice 7	5.302296	-8.0802787	-23.079053	385.3354	67.945028	1,152
Slice 8	5.6404043	-8.3880846	-17.141657	439.5937	77.512231	1,152
Slice 9	5.9785126	-8.6630088	-13.256076	487.68137	85.991384	1,152
Slice 10	6.3166209	-8.9091846	-11.164395	530.56871	93.553579	1,152
Slice 11	6.6547292	-9.1297395	-10.671463	568.96378	100.32367	1,152
Slice 12	6.9928375	-9.3270981	-11.625976	603.40005	106.39571	1,152
Slice 13	7.3309458	-9.5031755	-13.908437	634.28961	111.84237	1,152
Slice 14	7.65625	-9.6542664	-17.247535	641.03772	113.03225	1,152
Slice 15	7.96875	-9.782887	-21.486256	624.05871	110.03839	1,152
Slice 16	8.28125	-9.8964734	-26.663106	604.64075	106.61448	1,152
Slice 17	8.59375	-9.9956931	-32.736442	582.92735	102.78582	1,152
Slice 18	8.9219167	-10.084673	-33.178918	557.73416	98.343581	1,152
Slice 19	9.26575	-10.162499	-28.047508	528.94232	93.266803	1,152
Slice 20	9.6095833	-10.224643	-23.894598	497.7483	87.766455	1,152
Slice 21	9.9534166	-10.271475	-20.697251	464.23929	81.857912	1,152
Slice 22	10.29725	-10.303262	-18.438652	428.48488	75.553446	1,152
Slice 23	10.641083	-10.320185	-17.107615	390.53926	68.862608	1,152
Slice 24	10.984917	-10.322337	-16.698257	350.44278	61.792517	1,152
Slice 25	11.32875	-10.30973	-17.209834	308.22318	54.348062	1,152
Slice 26	11.672583	-10.282295	-18.646718	263.89629	46.532036	1,152
Slice	12.016417	-	-	217.46653	38.345217	1,152

27		10.239877	21.018523			
Slice 28	12.36025	-10.182235	-24.340377	168.92704	29.786394	1,152
Slice 29	12.704083	-10.109028	-28.633368	118.25948	20.852336	1,152
Slice 30	13.047916	-10.019815	-33.925191	65.433656	11.537719	1,152

AXIS GROUP INC.
1101 West Mineral Avenue
Suite 102
Littleton, CO 80120
Tel: (303) 332-5757
www.axisgroupinc.com

Style Definition: Heading 1: Font: 12 pt, Left, Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 0 + Alignment: Left + Aligned at: 0.25" + Indent at: 0.5"

Style Definition: Heading 2: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0" + Indent at: 0.25"

Style Definition: Heading 3: Space After: 12 pt, No bullets or numbering, Tab stops: 0.75", Left

Style Definition: Heading 4: Font: (Default) Arial Black, 14 pt, Not Italic, Font color: Auto, Centered, Indent: Left: 0.75", No bullets or numbering

Style Definition: TOC 1: Font: 14 pt, Indent: Left: 0", Hanging: 0.31", Right: 0", Space After: 12 pt

Style Definition: Appedix Title: Font: Arial Black, 12 pt, Bold

Style Definition: Style1: Font: 14 pt, Bold, Italic, Centered, Indent: Left: 0.75", No bullets or numbering

REVISED SUMMARY REPORT
EVAPORATION POND REPAIRS

Prepared for:

Western Refining Southwest, Inc.
Gallup Refinery
92 Giant Crossing Road
Gallup, NM 87301

Original Date: December 17, 2015

Formatted: Font: Not Bold

Revision 1 Date: February 15, 2017

TABLE OF CONTENTS

LIST OF TABLES, FIGURES and APPENDICES

TABLES

FIGURES

Formatted: Space Before: 0 pt, Line spacing: Multiple 0.9 li

Formatted: Line spacing: Multiple 0.9 li

Formatted: Space After: 0 pt, Line spacing: Multiple 0.9 li

Formatted: Font: Bold, Underline

Formatted: Indent: Left: 0", First line: 0"

Formatted: Indent: Hanging: 1.2", Line spacing: Multiple 0.9 li

Formatted: Indent: Hanging: 1.2", Line spacing: Multiple 0.9 li

Formatted: Indent: Hanging: 1.2", Line spacing: Multiple 0.9 li

APPENDICES

Formatted: Font: Bold, Underline

Formatted: Space Before: 6 pt, After: 6 pt, Line spacing: 1.5 lines

Formatted: Indent: Left: 0", Hanging: 1.2", Line spacing: Multiple 0.9 li

Formatted: Font: Bold

ABBREVIATIONS AND ACRONYMS

Axis	Axis Group Inc.
cm/sec	Centimeters per Second
Facility	Western Refining Southwest, Inc. Gallup Refinery
FOS	Factor of Safety
gpm	Gallons per Minute
~~GSF~~	~~Guida Slavich & Flores, P.C.~~
NMED	New Mexico Environment Department
OCD	Oil Conservation Division of the Energy, Minerals and Natural Resources Department
Ponds	Evaporation Ponds
RCRA	Resource Conservation and Recovery Act
Refinery	Western Refining Southwest, Inc., Gallup Refinery
RO	Reverse Osmosis (a treatment and filter method)
Site	Western Refining Southwest, Inc. Gallup Refinery
~~Sp.G.~~	~~Specific Gravity~~
STP-1	Sewage Treatment Pond 1
Western	Western Refining Southwest Inc.
WWTP	Waste Water Treatment Plant

~~EXECUTIVE SUMMARY~~

EXECUTIVE SUMMARY

Western Refining Southwest Inc. (Western) Gallup Refinery (~~Refinery~~Site) performed a significant amount of work on the evaporation pond earth berms in 2014 ~~and~~, 2015, and 2016, and is planning additional work in ~~2016.~~ 2017. Western's Summary Report, Evaporation Pond Repairs (December 17, 2015) was reviewed and comments were provided by the NMED Hazardous Waste Bureau (letter dated August 22, 2016). This report is revised to address the comments provided by the NMED and to include additional improvement work conducted in 2016 and potential future work.

Work related to the ~~Refinery~~Site evaporation pond earth berms includes the following:

1. 2014 Geotechnical investigation of borrow soil;
2. 2014 Improvements to Ponds 3, 4, 5, 6, 7, 8, 9, 11, 12A, and 12B ~~in 2014~~;
3. 2015 Improvements to Ponds 4, 5, 6, 7, and 8 ~~in 2015~~;
4. ~~Land~~2016 Improvements to Ponds 7 and 8, 9, 11, 12A, and 12B;
5. 2016 Improvements to the stormwater channel area proximate to Pond 6 and 9;

~~4.~~6. 2014, 2015, 2016 land surveying for updated topography on all pond berms ~~in 2014 and 2015~~;

~~5.~~7. 2015 Soil boring investigation in Pond 7 and Pond 8 west berm;

~~6.~~8. 2015 Drive point piezometers installed in Ponds 6, 7, 8, and 9;

~~7.~~9. 2015 Updated numerical slope stability analysis on Pond 6, 7, 8, and 9 ~~in 2015~~;

~~8.~~10. ~~Improvements to~~ 2014 to Present: Ongoing improvements to reduce water usage ~~and subsequent storage~~;

~~9.~~11. ~~Improvements to~~ 2014 to Present: Ongoing improvements to increase evaporation;

~~10. Planned~~Ongoing improvements to ~~Ponds 9, 11, 12A, and 12B; and~~

~~11.~~12. ~~Planned improvements to the stormwater channel between~~ Pond ~~6 and Pond 9~~berms as required.

Previously in 2002, the containment earth berms were numerically evaluated for slope stability and the slopes were determined to be stable with sufficient Factors of Safety. Western updated the numerical slope stability analysis using the 2002 soil strength parameters, recent investigation data, and ~~current~~new berm geometry after the construction improvements~~.~~

Formatted: Font: 6 pt

Formatted: Indent: Left: -0.19", Right: -0.19", Space Before: 12 pt, After: 12 pt

Formatted: Indent: Left: -0.19", First line: 0", Right: -0.19", Space Before: 4 pt, After: 4 pt, Tab stops: 0.25", Left

Formatted: Indent: Left: -0.19", First line: 0", Right: -0.19", Space Before: 4 pt, After: 4 pt, Tab stops: 0.25", Left

Formatted: Indent: Left: -0.19", First line: 0", Right: -0.19", Space Before: 4 pt, After: 4 pt, Tab stops: 0.25", Left in 2015. The results of the updated slope stability evaluation were included in the December 2015 Summary Report and indicated that the containment earth berms remain stable with appropriate Factors of Safety. ~~The following report provides additional detail on the work conducted to date and the planned work for 2016.~~

Formatted: Indent: Left: -0.19", Right: -0.19", Space Before: 12 pt, After: 12 pt

Western continued to improve the earth berms addressed in the 2015 numerical slope stability work that were the subject of comments by the NMED. Accordingly, revising the numerical slope stability work to address the NMED comments is not appropriate until additional work is conducted as described in Section 4 of this report. The planned additional slope stability work includes collecting updated geotechnical values, evaluating the numerical slope stability after additional soil strength parameters are obtained, and providing an updated numerical slope stability analysis in a future addendum to this revised report.

~~1.0~~1.0 INTRODUCTION

Formatted: Heading 1

Formatted: Bullets and Numbering

Axis Group Inc. (Axis) prepared this ~~letter~~revised report to summarize the repair and upgrade work conducted on the evaporation pond containment earth berms at the Western Refining Southwest, Inc. (Western) refinery in Gallup, New Mexico (Site). ~~This report covers work conducted as part of the berm upgrade and repair construction activities that have been ongoing at the Site since January 2014~~This report has been revised from the Summary Report submitted to the New Mexico Environment Department Hazardous Waste Bureau (NMED HWB) in December 2015. The revisions address the comments from NMED in their letter dated August 22, 2016 and include a summary of the additional improvement work conducted at the ponds during 2016.

Figure 1 illustrates the location of the Site and Figure 2 is a ~~pond~~ location map showing each of the evaporation ponds. As shown on Figure 2, the evaporation ponds lie west of the ~~Refinery~~Site process areas and tank ~~fields~~farms. In total, the evaporation ponds are approximately 110 acres in aerial extent and are numbered 2, 3, 4, 5, 6, 7, 8, 9, 11, 12A, and 12B. In this report Ponds 7 and 8 are ~~often~~ identified as Pond 7/8.

In summary, the ponds are operated as follows:

1. Water from the Waste Water Treatment Plant (WWTP) and the nearby Pilot Travel Center enters the Sewage Treatment Pond 1 (STP 1);
2. Water is pumped from STP 1 to Pond 2;
3. A portion of the Reverse Osmosis (RO) reject water from the process units flows directly to Pond 2 with the remaining RO water being recycled to the facility cooling towers;
4. As needed, WWTP operators move water from one pond to another using siphons or temporary diesel-powered pumps;
5. Water flows in a cascade fashion from Pond 2 through Ponds 3, 4, 5, then 6;
6. Water is also pumped from Pond 2 to Pond 12B and then flows in a cascade fashion into Ponds 12A, 11, and 7/8.

~~2.0~~2.0 WORK COMPLETED IN 2014 AND 2015

Formatted: Heading 1, Indent: Left: 0", Hanging: 0.5"

Formatted: Bullets and Numbering

This section of the report describes the evaporation pond improvement work completed by Western during 2014 and 2015. ~~—~~Photographs of the work are included in Appendix A.

~~2.1~~2.1 Summary of 2014 ~~Phase 1~~ Berm Repair and Upgrades

Formatted: Heading 2

Formatted: Bullets and Numbering

During January through April 2014 and November through December 2014, Western conducted repairs and upgrades to the containment berms surrounding Ponds 3, 4, 5, 6, 7, 8, 9, 11, 12A, and 12B. These repairs and upgrades included the following:

1. Adding additional new fill material to the outside slopes and crests of the containment berms;
2. Shaping the berm slopes; and
3. Building up the berm crest height and width;

The west ~~berms~~berm of Pond 7~~ and Pond ~~/8 ~~were~~was shaped such that the crest was widened and aligned further to the east so that the overall outer slope would be flatter and more stable.

Western's earth work contractor used on-site borrow areas for fill material (borrow locations shown on Figure 2). Fill material was excavated from the borrow areas using a track hoe and front-end loader, brought to the containment berms via off-road haul trucks, and placed using a Caterpillar D-6 dozer. The dozer was used to place, shape, and compact the fill material. Soil fill material consisted of a silty to sandy clay, similar in character to the soil that was used to construct the original earth berms.

Figures 3a, 3b, and 3c illustrate the pond limits and crest heights prior to the improvements made in 2014. Figures 4a, 4b, and 4c illustrate the pond limits and crest heights after ~~Phase 1~~2014 upgrades and repairs were complete. Figure ~~6b~~7b provides cross sections illustrating the limits where additional fill material was placed on the pond containment berms during 2014. ~~—~~Photographs of the 2014 berm upgrade activities are included in Appendix A (Photos #1 through #6).

~~2.2~~2.2 Summary of 2015 ~~Phase 2~~ Berm Repair and Upgrades

During March through October 2015, Western continued conducting repairs and upgrades to the containment berms surrounding Ponds 4, 5, 6, ~~7,~~ and 7/8. These repairs and upgrades included the following:

Formatted: Heading 2

Formatted: Bullets and Numbering

1. Adding additional new fill material to the outside slopes of the containment berms;
2. Shaping the berm slopes; and
3. Building out the berm crest width;

The fill material was taken from an on-site borrow area (see Figure 2) via scraper to the berm area under construction, placed in horizontal lifts, and compacted using the scraper and a sheep-foot vibratory roller. Each soil lift was placed on a horizontal flat surface at a maximum depth of 8-inches ~~loose~~, keyed into the existing berm slope, and compacted to a minimum of 95-percent (95%) of a standard Proctor. A motor grader shaped the slopes as they were being constructed.

Figures 5a, 5b, and ~~5b~~5c illustrate the pond limits and crest heights after the ~~Phase 2~~2015 upgrades and repairs were complete. Figure ~~6b~~7b provides cross sections illustrating the limits where additional fill material was placed on the pond containment berms during 2015. ~~-~~Photographs of the 2015 berm upgrade activities are included in Appendix A (Photos #7 through #14).

2.3 Geotechnical Work in 2015

The following section describes the 2015 field investigation Western conducted at the Site to collect soil geotechnical material properties and determine the phreatic surface (i.e. water table surface) within the berms. To accomplish this investigation, Western drilled four soil borings along the crest of Pond 7/8 and installed 11 drive points at various locations in the Pond 6 and Pond 7/8 berms. Figure 7a illustrates the locations where soil borings and drive-point piezometers were installed.

~~2.3~~2.3.1 Soil Geotechnical Properties

Formatted: Bullets and Numbering

~~Geotechnical properties of~~In 2015 a soil sample was collected from the on-site borrow ~~material used include~~area and analyzed for geotechnical parameters which included the following:

1. Proctor values (i.e. laboratory maximum compaction and optimum water content);
2. Classification;
3. Sieve analysis (i.e. particle size gradation);
4. Field density and moisture content tests;
5. Permeability via flex-wall permeameter;

The on-site borrow soil that was used to repair and improve the earth berms is classified as a silty to sandy clay. Based on a flex-wall permeameter test, soil permeability for the borrow material is 1.~~9X~~9 X 10^{-7} cm/sec. Appendix B contains the laboratory results of the geotechnical tests conducted on the soil ~~fill and~~ borrow material.

2.3.2 Pond 7/8 West Berm Soil Borings

Western installed four soil borings along the west berm of Pond 7/8 as shown on Figure 7a and the boring logs in Appendix D. The borings were conducted to visually examine the berm soil at various depths, collect soil samples for potential geotechnical analysis, and to locate the phreatic surface within the earth berm (if present).

Formatted: Space Before: 12 pt, After: 12 pt

Characterization soil samples collected from the soil borings indicated a relatively uniform soil material (i.e. no significant changes in soil type) within each boring from the crest down to the final boring depth. The berm fill soil was characterized as moist red silt and clay. The native material was encountered around 12 feet deep and was characterized as lenses of gray fine sand overlaying a stiff wet red clay. Boring logs for these four soil borings are included in Appendix D.

Western evaluated and compared some historical borings advanced in December 2000 to the borings advanced 2015. During the December 2000 boring program (Appendix C), 3 borings were installed on the Pond 7/8 west berm. The borings showed moist soil at depths ranging from 1 to 5 feet to final depth. None of the borings advanced in Pond 7/8 during 2000 indicated wet soil or water.

During the October 2015 boring program, the four borings indicated moist soil (indicative of the phreatic surface) at depths between 4 to 5 feet below the crest. Wet soil was observed at the berm fill/ native soil interface in three of the four borings. Appendix D contains the logs for each boring in Pond 7/8.

Soil classifications in the December 2000 Pond 7/8 boring logs correspond to classifications in the October 2015 boring logs. The sandy layer encountered and described on the 2015 boring logs SB-8N and SB-8S, is at a depth of 11.5 to 12 feet below the current crest elevation. This depth is consistent with the interface transition from berm fill material to native soil.

2.3.3 Temporary Drive Point Piezometers

In order to determine the phreatic surface within the Pond 6 and Pond 7/8 berms in 2015, Western installed 11 temporary drive-point piezometers at locations shown on Figure 7a.

Water levels (if present) were measured in the drive-point piezometers on three separate occasions since their installation. The water level data is shown on the piezometer logs in Appendix E. The drive-point piezometer logs also illustrate the phreatic surface. The depth to moist soil in the October 2015 borings is similar to the depth of water in the nearest piezometer (4-feet to moist soil in the boring versus 6.33-feet to water in the piezometer). The water level collected from the piezometer reading was used to model the phreatic surface during the slope stability modeling, as the water elevation in the pond was deeper than the elevation where the moist soil was encountered.

Note that piezometers installed at the toe of the berm slopes had screens that were close to the ground surface and therefore influenced by precipitation infiltration. Where precipitation infiltration was noted, the water level in that piezometer was not used for berm evaluation work.

The temporary drive-point piezometers installed in the Pond 7/8 berms were abandoned during the ongoing berm improvement activities which continued into 2016. Western will install new piezometers with casings that preclude surface water infiltration into the piezometers. A proposed piezometer installation and monitoring schedule is provided in Section 4.3 of this report. Piezometer water level data will be collected monthly for three months and the data will be provided in the annual Facility-Wide Groundwater Report.

3.0 WORK COMPLETED IN 2016

This section of the report describes the evaporation pond improvement work completed by Western during 2016. Figures 6a, 6b, and 6c illustrate the pond limits and crest heights after the 2016 upgrades and repairs were complete. Photographs of the work are included in Appendix A. The 2016 repairs and upgrades included the following:

1. Reworked and repaired the outer berms surrounding Ponds 11, 12A, and 12B;
2. Improved the Pond 9 north berm;
3. Regraded the stormwater drainage channel between Pond 6 and Pond 9;
4. Added fill material to buttress the Pond 7/8 west berm;

3.1 Ponds 11, 12A, and 12B Outer Berms

In 2016, Western reworked and repaired the soil material of the outer containment berms around Ponds 11, 12A, and 12B. During routine pond inspections, Western noted that soils in the upper two to three feet of the Pond 11, 12A, and 12B outer berms needed to be repaired. Figure 6a illustrates the 2016 repair work limits for Pond 11, 12A and 12B berms. Photographs of this work are included in Appendix A.

The 2016 repair work of the Pond 11, 12A, and 12B berms began by stripping vegetation from the upper three-feet of the berms. From stations 36+00 to 28+00 and 20+00 to 0+00, the upper 3 feet of soil was scraped from the berms and stockpiled at the toe of the slope where it was reworked and cleaned of any large pieces of wood or rocks. This reworked soil was then replaced on the outer slopes of the berms to flatten the outer slope. From stations 28+00 to 20+00, the upper 3 feet of soil was removed and placed in the nearby borrow area for future use. The removed soil could not be cast to the outer slope in this area as the berm is too close to the existing Land Treatment Unit.

Clay soil from the on-site borrow area was then used to rebuild the upper three feet of the berms to their original crest elevations. Prior to placing the first lift, the berm soil was scarified as appropriate, wetted, and then the borrow soil was placed in horizontal layers up to 8-inches thick. Each lift was moisture conditioned and compacted to a minimum of 95-percent (95%) of a standard Proctor as outlined in the specifications. The outer slopes were then graded meet the final design grades resulting in compacted and flatter outer slopes.

3.2 Pond 7/8 Berms

In 2016, Western improved the Pond 7/8 berms from Station 68+95 to Station 41+00 by adding fill material to buttress the outer slopes of the south and west berms. Figure 6a illustrates the 2016 repair work limits for Pond 7/8 berms. Photographs of this work are included in Appendix A.

Prior to beginning the improvement work, the west property line fence was temporarily removed and relocated to allow for construction vehicle access along the base of Pond 7/8 west berm. The construction area along the base of the Pond 7/8 outer slope was graded flat, scarified, and compacted.

Geotextile fabric was then placed onto the prepared surface as outlined in the design documents. Clay borrow soil was then placed in a horizontal layer on the geotextile fabric and compacted. These soils were placed in maximum of 8-inch lifts which were keyed into the existing berm slope and compacted as outlined in the project specifications.

Soil placement in uniform lifts continued until the outer slope was over-built and then graded back to the design grades. When completed, the toe of the outer slope was located adjacent to the west property boundary line. Once the berm improvement work was complete, the fence was relocated back to the property line and the disturbed area was restored by with seed and mulch.

3.3 Pond 9 North Berm

In 2016, the Pond 9 north berm was improved between Station 15+00 and Station 36+00. Figure 6c illustrates the work limits for Pond 9 completed in 2016. Photographs of this work are included in Appendix A.

Prior to beginning the improvement work, the existing power lines were removed from the toe of the Pond 9 outer north berm. Once the power lines were removed, the power poles were cut off at the base and removed. The power poles were not dug out to avoid disturbing the soil at the toe of the berm.

Once the area was cleared for improvements, soil deemed unacceptable to use as a base material was excavated and removed from the toe of the Pond 9 north berm outer slope. This material was placed on the inside slope of Pond 9 north berm and compacted. Once the soil was removed from the toe of the outer slope, the area was graded flat and geotextile fabric was placed on the prepared surface as outlined in the design documents.

Clay borrow soil was then placed in a horizontal layer on the geotextile fabric and compacted. These soils were placed in a maximum of 8-inch lifts which were keyed into the existing berm slope and compacted as outlined in the project specifications.

Soil was placed in uniform lifts and continued until the outer slope was graded to meet the original design grades.

3.4 Stormwater Channel Improvements

Non-contact stormwater is directed from the Site areas westward to the drainage channel between Pond 6 and Pond 9. From here, the non-contact stormwater collects at retention ponds located west of Pond 6 and south of Pond 7/8.

The stormwater channel between Pond 6 and Pond 9 was improved during the Pond 9 north berm work described in the previous section and shown on Figures 6b and 6c. Non-contact stormwater flow is directed into the improved channel which is sloped to drain to the west side of Pond 6.

During slope improvement work on the Pond 7/8 south berm, soil was placed between about Station 46+00 to about Station 49+00 south of the toe of the south berm. This strip of soil will act as a buffer and deter erosion between the existing stormwater detention basin and the toe of Pond 7/8 south berm.

4.0 SLOPE STABILITY ANALYSIS

The following sections describe the previous and planned numerical slope stability work for the evaporation pond berms. Based on the uniform soil and earth berm construction, the previous numerical slope stability analysis used an arc slip-type slope stability evaluation (versus block or other type of failure analysis). The resulting calculated Factor of Safety values were all greater than 1.0 in every analysis, indicating that the evaluated slopes are stable.

~~2.4~~4.1 2002 Geotechnical and Slope Stability Analysis

Formatted: Heading 2

Formatted: Bullets and Numbering

In 2002, Precision Engineering, Inc. completed a geotechnical investigation as part of a slope stability analysis for the evaporation pond berms. The investigation included 10 soil borings and 7 Dutch Cone soundings. Soil samples and Shelby Tube samples were also collected from various strata throughout the investigation. Soil geotechnical properties derived from those samples (e.g. ~~Western elected~~triaxial shear strength, cohesion, internal angle of friction, and unit weights) were used for the slope stability analysis.

A total of 13 cross-sections were evaluated for the 2002 slope stability analysis resulting in a Factor of Safety ranging from 2.5 to 10. A summary of the 2002 soil geotechnical properties are included in Table 1. Table 2 summarizes the results from the 2002 slope stability analysis. A copy of the Precision Engineering Inc. report is included in Appendix C.

The soil strength parameters used in the numerical analysis included the total stress parameters for cohesion (c) and the angle of internal friction, phi (Ø). It is recognized that total stress strength parameters are appropriate for numerical slope stability analysis for end-of-construction analysis and for partially saturated soil. Based on historical and current soil borings, the soil in the berms is best categorized as partially saturated and therefore, the analysis method is considered appropriate.

4.2 Planned Slope Stability Investigation

In the original Summary Report, Evaporation Pond Repairs (December 2015), Western updated the 2002 numerical slope stability analysis. For completeness, the slope stability work is now provided in Appendix F of this Revised Summary Report, Evaporation Pond Repairs. Since the slopes on several evaporation ponds have already been changed, no adjustments to the 2015 updated numerical slope stability analysis have been made. Changes to the numerical slope stability analysis will be made after additional soil properties have been obtained as described below.

As described in Section 3 of this report, Western continued improving the earth berms in 2016 for evaporation ponds 7/8, 9, 11, 12A, 12B, and the stormwater channel between Pond 6 and Pond 9. During this work, the temporary drive-point piezometers installed to provide initial phreatic surface water levels in the earth berms, were abandoned. Additionally, the outer slopes of the evaporation ponds identified above have been significantly improved. Accordingly, the numerical slope stability work provided in 2015 will be updated with the current topography and updated phreatic water surface.

The NMED comments on the 2015 updated slope stability analysis indicated that effective stress strength parameters should be used to evaluate the effects of additional fill material on the outer slopes. NMED also indicated that more permanent piezometers should be installed in the outer downstream slopes of the berms.

Western intends to install new piezometers in the outer slopes of the earth berms along cross-sections that will be used in an updated numerical slope stability analysis. The new piezometers will be installed in borings with casings and bentonite seals above the screen interval to prevent surface water intrusion and interference. Piezometers will be installed in borings at selected cross-sections in the following earth berms:

- Pond 7/8 west berm
- Pond 6 west berm
- Pond 9 north berm

The water levels will be recorded monthly and when stable (likely 3 months), the water levels will be incorporated into the updated numerical slope stability analysis. Afterward, the water levels in the piezometers will be measured as appropriate and the water level data reported in the Facility Wide Groundwater Report.

Due to access constraints on the outer slopes, the borings for the piezometers will likely be hand-augured at each location. Soil samples will be collected using a hand-drive sampler as needed in the hand-auger borings.

The hand-auger will be used to advance a 4-inch diameter hole to depths required to install the new piezometer and collect the soil samples. The hand-drive sampler has a barrel that holds brass sleeves for the soil samples. The barrel is driven into the soil and then retrieved.

The brass liners are extracted from the barrel, sealed using Teflon™ patches, plastic caps, and tape. Each sleeve will be sealed in the field, labeled as required, and provided to a geotechnical laboratory for analysis. Soil analysis is expected to include:

- Soil characterization and classification
- West and dry unit weights with moisture content
- Atterberg Limits
- Sieve analysis
- Effective stress strength parameters (c’ and Ø’) from a triaxial sheer test

The soil data collected from this investigation will be used to update the numerical slope stability analysis. The cross-sections used in the 2002 and 2015 slope stability work will be used in the updated slope stability evaluation, with minor adjustments to the locations to evaluate the critical cross section. The following will be incorporated into the updated slope stability evaluation:

- Morgenstern Price limit-equilibrium analysis via GeoStudio 2012;
- Updated berm topography at slope stability cross-sections;
- Updated phreatic surface based on newly installed piezometers;
- Soil properties confirmed during the new geotechnical investigation; and
- Effective stress soil strength parameters cohesion (c) and angle of internal friction, phi (Ø).

The results will be prepared and submitted as an addendum to this report. The results will include the following:

- Description of the updated geotechnical parameters;
- Figure identifying the location of the geotechnical samples;
- Description of the slope stability work;
- Discussion of the phreatic surface and its potential affect on slope stability;
- Graphical output from the slope stability program; and
- Tabulated factor of safety for each critical cross-section.

4.3 Proposed Work Schedule

Western intends to install the new piezometers in the appropriate locations by the end of Q4 2017. Once the geotechnical report is available with the updated soil data described above, Western will prepare a revised numerical slope stability analysis. Western expects this work to be complete by the end of Q2 2018 and an addendum report prepared and submitted by the end of Q3 2018.

5.0 ONGOING IMPROVEMENT WORK

5.1 Water Use Reduction

Formatted: Heading 2

Formatted: Bullets and Numbering

Western is continually improving operations at the evaporation ponds. For example, Western has implemented several water saving measures at the process units to minimize the amount of water being routed to the evaporation ponds. As of November 2015, the flow rate of water to the evaporation ponds is approximately 150 gpm, down from the previous average of 340 gpm.

Part of the work included minimizing the reverse osmosis (RO) reject water flow to Pond 2. The majority of RO water is now directed to the cooling towers with the net effect of minimizing RO reject water to Pond 2.

5.2 Additional Evaporation

Formatted: Heading 2

Formatted: Bullets and Numbering

In 2014, Western added two additional evaporation blowers to improve evaporation rates at the ponds. As shown on Figure 2, two blower units are located on the west berm of Pond 2 and the two newer blower units are located on the west berm of Pond 3.

The evaporation blowers operate continuously during the peak evaporation season (about April through October) except when they are shut down for maintenance purposes or when the temperature makes evaporation inefficient. Western is internally evaluating additional improvements to enhance evaporation at the ponds.

TABLES

FIGURES

Formatted: Font: Arial, 12 pt

APPENDICES

APPENDIX A

Photographs

Formatted: Font: 12 pt

Formatted: Normal

Formatted: Normal, Centered

Formatted: Normal

APPENDIX B

Geotechnical Data

APPENDIX C

2002 Slope Stability Analysis

Formatted: Normal

Formatted: Font: 12 pt

Formatted: Normal

APPENDIX D

Boring logs

Formatted: Normal

Formatted: Font: 12 pt

APPENDIX E

Piezometer log forms

Formatted: Normal

Formatted: Font: 12 pt

Formatted: Normal

APPENDIX F

~~as the containment earth berm crests have been raised, widened, additional fill material was placed on the outer slopes, and the~~ 2015 Slope Stability Analysis

Updating the 2002 Slope Stability Analysis

Formatted: Normal

Formatted: Font: 12 pt

F-1 Updates to the 2002 Slope Stability Analysis

In the original Summary Report, Evaporation Pond Repairs (December 2015), Western updated the 2002 numerical slope stability analysis using the following:

- Morgenstern Price limit-equilibrium analysis via GeoStudio 2012
- Updated berm topography at slope stability cross-sections
- Updated phreatic surface based on temporary drive-point piezometers
- Existing soil properties confirmed during 2015 geotechnical investigation
- Existing total stress soil strength parameters cohesion (c) and angle of internal friction, phi (Ø)

Based on the updated slope stability modeling, the earth berms remain stable against a circular slip-type failure with Factor of Safety values ranging from 4.7 to 7.1.

The soil strength parameters used in the numerical analysis included the total stress parameters for cohesion (c) and the angle of internal friction, phi (Ø). It is recognized that total stress strength parameters are appropriate for numerical slope stability analysis for end-of-construction analysis and for partially saturated soil. Based on historical and current soil borings, the soil in the berms is best categorized as partially saturated and therefore, the analysis method is considered appropriate.

Because significant berm improvement work was conducted since 2002, the configurations of the berms (i.e. berm crest widths and outer slopes) were different in many locations. Additionally the pond water elevations have increased since 2002.

Accordingly, Western (via Hammon Enterprises Inc.) ~~.~~ conducted an updated topographic land survey of the earth berms. The updated topography was used to track the changes to the earth berms and create the cross-section geometry required for the updated slope stability analysis described in this section. Figure 7b provides cross-sections that illustrate changes in the geometry of the earth berms with time and shows the current surface at the end of 2015.

Prior to performing the updated slope stability analysis, Western conducted a field investigation to collect current soil geotechnical material properties and determine the phreatic surface (i.e. water table surface) within the berms. The methods and results of this field investigation are described in Section 2.3 of this report.

The model used to conduct the slope stability analysis was GeoStudio 2012 produced by Geo-slope International. Western used the limit-equilibrium analysis, Morgenstern-Price Method of Slices to analyze the numerical Factor of Safety for stability of the slopes.

The soil material used in constructing and upgrading the earth berms is a uniform material. Accordingly, Western numerically analyzed the slopes using an arc-type or circular slip-type of failure. ~~The output from the slope stability analysis provides a numerical Factor of Safety against a slope stability failure. A Factor of Safety greater than 1.0 indicates that the slope is stable from a typical arc-type slope failure. Based on previous slope stability work, the earth berms at the Site were stable against an arc- or circular slip-type failure with Factor of Safety values ranging from 2.5 to 10.~~

~~The analysis was conducted using the program GeoStudio 2012 produced by Geo-slope International. The program uses limit-equilibrium analysis based on the Method of Slices to analyze the Factor of Safety for stability of the slopes.~~

Based on the updated slope stability modeling, the earth berms remain stable against an arc-type failure with Factor of Safety values ranging from 4.7 to 7.1. The sections below provide a discussion of the methods and soil values used in the updated slope stability modeling work.

Formatted: Space Before: 12 pt, After: 12 pt

~~1.2.4.12002 Geotechnical and Slope Stability Work~~

~~Precision Engineering, Inc. conducted a geotechnical analysis in 2002 which is included in Appendix C. The site investigation conducted as part of that analysis included 10 soil borings and 7 Dutch Cone soundings. Soil samples and Shelby Tube samples were collected from various strata throughout the investigation. Soil geotechnical properties derived from those samples (e.g. triaxial shear strength, cohesion, and unit weights) were used in the slope stability analysis. A summary of the soil geotechnical properties are included in Table 1. A total of 13 cross-sections were evaluated for slope stability and the resulting Factor of Safety ranged from 2.5 to 10. Table 2 summarizes the results from the Precision Engineering Inc. report.~~

~~1.2.4.22015 Geotechnical and Slope Stability Investigation~~

~~The 2002 Precision Engineering, Inc. slope stability analysis was conducted prior to the recent repair work on the pond containment berms. As shown on Figure 6b, the configurations of the berms (i.e. berm crest widths and outer slopes) were different in many locations in 2014 and 2015 due to the repair work, resulting in new slope cross-sections. The new cross sections as well as higher water levels in the ponds were factored into the updated earth berm slope stability analysis.~~

~~Prior to performing the updated slope stability analysis, Western conducted a field investigation to evaluate current soil geotechnical material properties and to locate the phreatic surface (i.e. water table surface) within the berms. To accomplish this work, Western drilled four soil borings along the crest of Pond 7/8 and installed 11 drive points at various locations in Pond 6 and 7/8 berms. Figure 6a illustrates the locations where soil borings and drive-point piezometers were installed. The text below provides more detail on the boring and drive-point programs.~~

~~*1.2.4.3Pond 7/8 West Berm Soil Borings*~~

~~Western installed soil borings at four locations along the Pond 7/8 west berm at locations that correspond to cross-sections used in the slope stability analysis. The borings were conducted to visually examine the berm soil at various depths, collect soil samples for potential geotechnical analysis, and to locate the phreatic surface within the earth berm (if present).~~

Formatted: Space Before: 12 pt, After: 12 pt

~~Samples collected from the soil borings indicated a relatively uniform soil material (i.e. no significant changes in soil type) within each boring from the crest down to the final boring depth. The berm fill soil was characterized as a red, silt to clay moist soil, until the native material was encountered around 12 feet deep. Native material was characterized as gray fine sand overlaying a stiff wet red clay. Boring logs for these four soil borings are included in Appendix D.~~

Formatted: Space Before: 12 pt, After: 12 pt

~~*1.2.4.4Drive Point Piezometers*~~

~~Western installed 11 drive-point piezometers at locations in the Pond 6 north and west berms, Pond 7 west berm, and Pond 8 south berm at locations that correspond to cross-sections used in the slope stability analysis. The drive-point piezometers were installed to measure the phreatic surface (if present) within the earth berms.~~

~~Water levels (if present) have been measured in the drive-point piezometers three times since installation (as of November 11, 2015) and that data is contained in the piezometer logs in Appendix E. Due to the low permeability clay soil in the berms, as of December 2015, the water levels in the piezometers have not yet completely stabilized. Western will continue to monitor the water levels in the piezometers as needed. The drive-point piezometer logs also visually illustrate the location of the phreatic surface.~~

~~*1.2.4.5Slope Stability Modeling*~~

~~As discussed above, the geometry of the earth berms changed as a result of the earth berm repairs in 2014 and 2015.~~ **F-2 Soil Characterization Properties**

Soil characterization~~Accordingly, Western (via Hammon Enterprises Inc.) conducted an updated land survey of the earth berms. The updated topography was used to track the changes to the earth berms and create the cross-section geometry required for the current slope stability analysis described in this report. Historic survey topography and the cross-sections used in the previous stability analysis were used to establish the historic cross-sections of the earth berms. Figure 6b provides cross-sections that illustrate changes in the geometry of the earth berms with time and shows the current surface at the end of 2015.~~

~~Soil~~ properties from the previous investigation (Precision, 2002) were compared to the soil characterization properties from the 2014 and 2015 borrow and berm soil investigations. The 2002 soil investigation results are consistent with the current geotechnical characterization data. Accordingly, the previous soil investigation data were used in the ~~current~~2015 slope stability analysis.

Slope stability modeling data input includes soil type, unit weight, angle of internal friction (phi angle), shear strength, and cohesion values. The 2002 data included triaxial sheer strength values and were classified into two categories:

1. Berm material ranging from a depth of 5-7 feet; and
2. Subgrade material ranging from 10-17 feet.

This resulted in two sets of soil properties for the berm slope stability analysis:

1. Berm material (unit weight 140 pcf, cohesion 720 psf, phi 8 degrees); and
2. Native soil (unit weight 140 pcf, cohesion 1152 psf, phi 0 degrees).

The phreatic surface used for the analysis was derived from current water level data measured in the drive-point piezometers installed along the cross sections of the berms.

F-3 2015 Slope Stability Results

~~2.4.6~~

A Factor of Safety greater than 1.0 indicates that the slope is numerically stable from a typical arc-type slope failure. Factors of Safety against a deep slip surface failure in the berms before and after repair work are shown on Table 3.

Based on the slope stability modeling, the berms are stable against an arc-type failure with Factor of Safety values ranging from 4.5 to 7.1. Note that the Factor of Safety from the previous investigation ranged from 2.5 to 10. The change in the Factor of Safety values is largely the result of changes in the berm geometry and the

Formatted: Space Before: 12 pt, After: 12 pt

Formatted: Space Before: 12 pt, After: 12 pt

Formatted: Justified

Formatted: Font: Bold

Formatted: Normal, Justified

Formatted: Bullets and Numbering

Formatted: Left

elevation of the water within the ponds. Detailed results from the numerical slope stability modeling are included ~~in Appendix F~~below.

~~1.3 2016 PHASE 3 POND REPAIR AND UPGRADES~~

~~Western plans to continue the ongoing repairs and upgrades to the evaporation ponds during 2016. Planned work includes:~~

1. ~~Rework and repair the berm material on Ponds 11, 12A, and 12B as required;~~
2. ~~Improve the Pond 9 north berm;~~
3. ~~Regrade the stormwater drainage channel between Pond 6 and Pond 9;~~
4. ~~Improve the west berm along Pond 7 and Pond 8;~~

~~1.3.1 Ponds 11, 12A, and 12B~~

~~Western plans to rework and repair the material along the containment berms of Ponds 11, 12A, and 12B. Figure 8 illustrates the design work limits for Ponds 11, 12A, and 12B. Western intends to complete this work in 2016.~~

~~1.3.2 Pond 9 North Berm~~

~~The Pond 9 north berm will also be reconstructed to improve integrity and involves adding fill material to the outer slopes of the Pond 9 north berm. Figure 7a illustrates the design work limits for Pond 9 intended to be completed in 2016.~~

~~1.3.3 Stormwater Channel Improvements~~

~~Currently, non-contact stormwater is directed from the Refinery areas westward toward the drainage channel between Pond 6 and Pond 9 and exits at the west side of Ponds 6 and 9. The portion of the stormwater channel between Pond 6 and Pond 9 will be improved during the construction of the Pond 9 north berm. Non-contact stormwater flow will be directed in an engineered channel sloped to drain and exit at the west side of Pond 6 and Pond 9. From there, non-contact stormwater will flow toward the small retention pond located south of the south west corner of Pond 8. Figure 7b illustrates the design for this work.~~

~~1.3.4 Ponds 7 and 8 West Berm~~

~~Western is evaluating potential improvements to the Pond 7/8 west berm. Potential improvement work may include adding fill material to the outer slope of the west berm. Western intends to complete this evaluation in 2016.~~

~~1.4 ONGOING IMPROVEMENT WORK~~

~~4.1Water Use Reduction~~

Formatted: Heading 2

Formatted: Bullets and Numbering

~~Western is continually improving operations at the evaporation ponds. For example, Western has implemented several water saving measures at the process units to minimize water to the evaporation ponds. As of November 2015, the flow rate of water to the evaporation ponds is about 150 gpm, down from a previous average of 340 gpm.~~

~~Part of the work included minimizing the reverse osmosis (RO) reject water flows to Pond 2. The majority of RO water is now directed to the cooling towers with the net effect of minimizing RO reject water to Pond 2.~~

~~4.2Additional Evaporation~~

Formatted: Heading 2

Formatted: Bullets and Numbering

~~In 2014, Western added two additional evaporation blowers to improve evaporation rates at the ponds. As shown on Figure 2, two blower units are located on the west berm of Pond 2 and the two newer blower units are located on the west berm of Pond 3. Western is internally evaluating additional improvements to enhance evaporation at the ponds.~~

~~TABLES~~

Formatted: Font: Arial, 12 pt

~~FIGURES~~

~~APPENDICES~~

~~APPENDIX A~~

~~Photographs~~

Formatted: Font: 12 pt

Formatted: Normal

Formatted: Normal, Centered

~~APPENDIX B~~

~~Geotechnical Data~~

Formatted: Normal

~~APPENDIX C~~

~~2002 Slope Stability Analysis~~

Formatted: Normal

Formatted: Font: 12 pt

Formatted: Normal

Formatted: Normal

Formatted: Font: 12 pt

~~APPENDIX D~~

~~Boring logs~~

Formatted: Normal

Formatted: Font: 12 pt

~~APPENDIX E~~

~~Piezometer log forms~~

Formatted: Normal

~~APPENDIX F~~

~~Slope Stability Analysis~~

Formatted: Normal

Formatted: Font: 12 pt

Formatted: Normal