Appendix C

GEOTECHNICAL ENGINEERING REPORT

PROPOSED PORTER ARROYO
STORMWATER DETENTION FACILITY
NORTH OF PINON HILLS BOULEVARD AND
EAST OF COLLEGE BOULEVARD
FARMINGTON, NEW MEXICO

Terracon Project No. 69085034
October 30, 2008

Prepared for:

LARKIN GROUP NM. INC.
8500 Menual Boulevard NE, Suite A-440
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Attn: Mr. Joseph J. Casares, P.E.

Prepared by:

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October 30, 2008

Larkin Group NM Inc.
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Albuquerque, New Mexico 87112

Attention: Mr. Joseph J. Casares, P.E.

Regarding: Geotechnical Engineering Report
Proposed Porter Arroyo Stormwater Detention Facility
North of Pinon Hills Boulevard and East of College Boulevard
Farmington, New Mexico
Terracon Project No. 66035601

Ladies and Gentlemen:

Terracon Consultants, Inc. (Terracon) has completed a geotechnical engineering evaluation for proposed Porter Arroyo Stormwater Detention Facility located north of Pinon Hills Boulevard and east of College Boulevard in Farmington, New Mexico.

This study was performed in general accordance with our proposal number G08-507 dated March 9, 2008. The results of our engineering evaluation including the Area Location Map, Boring and Test Pit Location Plan, Logs of Borings and Test Pits, laboratory test results, slope stability analyses results and the geological and geotechnical recommendations to aid in the design and construction of the stormwater detention facility and other geotechnically-related phases of this project, are attached. This evaluation was completed in general accordance with the Office of the State Engineer (OSE), Dam Safety Bureau Rules and Regulations Governing Dam Design, Construction, and Dam Safety published in March 2005. In addition, the report includes recommendations for geotechnically-related earthwork, drainage and site grading.

It should be noted that the recommendations presented herein for the earth embankment dam are provided with the understanding that the purpose of this facility is for the temporary detention of storm water and this facility will be empty of any storm water within 48 hours of the storm event. This facility is not designed for the long-term storage of water and any long-term water storage of water in this facility could result in the failure of this embankment structure.

We appreciate being of service to you in the geotechnical engineering phase of this project, and are prepared to assist you during the construction phases as well. If you have any

questions concerning this report or any of our testing, inspection, design and consulting services, please do not hesitate to contact us.

Sincerely,
TERRACON CONSULTANTS, INC.

Heather M. Dawson
Staff Geologist

Kim M. Preston, P.E.
Four Corners Area Manager

Mary E. Wells, P.E.
Principal

Copies to: Addressee (3)

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GEOTECHNICAL ENGINEERING REPORT

PROPOSED PORTER ARROYO
STORMWATER DETENTION FACILITY
NORTH OF PINON HILLS BOULEVARD AND
EAST OF COLLEGE BOULEVARD
FARMINGTON, NEW MEXICO

Terracon Project No. 69085034
October 30, 2008

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INTRODUCTION

This report contains the results of our geotechnical engineering exploration for proposed Porter Arroyo Stormwater Detention Facility to be located north of Pinon Hills Boulevard and east of College Boulevard in Farmington, New Mexico.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Engineering properties of on-site and borrow source material;
- Dam embankment construction;
- Seismic conditions;
- Dam embankment slope stability.

The services were performed in general accordance with the Office of the State Engineer, Dam Safety Bureau Rules and Regulations Governing Dam Design, Construction and Dam Safety (Dam Design Regulations) published in March 2005. The recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, experience with similar soil conditions and structures and our understanding of the proposed project.

PROJECT INFORMATION

It is our understanding that the project will consist of construction of an earthen dam across Porter Arroyo, which will detain storm water and regulate the downstream flow. Based on a review of project drawings provided by the client, the dam will be 23 feet high, 700 feet across the axis and will have a crest width of 20 feet. The upstream embankment face will have a slope of 2.5:1 (horizontal to vertical) and the downstream embankment face will have a slope of 2:1 (horizontal to vertical). It is understood that the detention pond will empty within 48 hours of the storm event. Terracon previously prepared a draft report, dated February 24, 2003, that was submitted to the Larkin Group NM., Inc. for inclusion with

Larkin's report to the State Engineers Office (OSE), Dam Safety Bureau. That report was prepared under the requirements of the New Mexico Dam Safety Criteria Manual dated 1997. The OSE revised the document "Dam Safety Design and Operation Criteria" in 2003. The current OSE document "Rules and Regulations Governing Dam Design, Construction and Dam Safety", dated March 31, 2005 contains the current criteria for dam design in the State of New Mexico. Additional field and laboratory services as well as additional analyses have been performed in order to meet the new regulations for submittal of a proposed dam structure.

Information from the Terracon report dated February 24, 2003 was used in the preparation of this report. Terracon performed additional subsurface exploration and analyses to augment the information obtained in 2003 in order to prepare this report in accordance with the current OSE rules and regulations.

It should be noted that the recommendations presented herein for the earth embankment dam are provided with the understanding that the purpose of this facility is for the temporary detention of storm water and this facility will be empty of any storm water within 48 hours of the storm event. This facility is not designed for the long-term storage of water and any long-term water storage of water in this facility could result in the failure of this embankment structure.

GEOLOGIC ASSESSMENT

A geological reconnaissance was performed at the site by Terracon personnel. Additionally, a geological and seismic review of the project area was performed. The geological assessment is included in Appendix A of this report.

SITE EXPLORATION

The scope of the services performed for this project included site reconnaissance by a staff geologist, a subsurface exploration program, laboratory testing and engineering analyses.

Field Exploration: A total of two exploratory borings and four test pits were advanced on August 25 and September 8, 2008, respectively, at the approximate locations shown on the Boring and Test Pit Location Plan in Appendix B. Boring B-1 (08) was advanced to a depth of about 31½ feet below existing ground surface and Boring B-2 (08) was advanced to approximately 19 feet below existing ground surface where equipment refusal occurred on sandstone. Borings were advanced with a CME-75 truck-mounted drilling rig, utilizing 7¾-inch, hollow stem augers. Shovel test pits were advanced to a depth of approximately one foot into the subsurface soils at each of the two borrow sources as indicated on the Boring and Test Pit Location Plan in Appendix B.

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Previous field work for the 2003 report included a total of four exploratory borings that were drilled on January 23, 2003. The borings were drilled to depths ranging from about 5 feet to 38 feet below the existing ground surface at the locations shown on the Boring and Test Pit Location Plan in Appendix B.

The borings and test pits were located in the field by Terracon personnel. Ground surface elevations at each location were obtained by interpolation from contours indicated on the site plan. The accuracy of boring and test locations and elevations should only be assumed to the level implied by the methods used to determine each.

A lithologic log of each boring and test pit was recorded by the field geologist during the excavation operations. At selected intervals, samples of the subsurface materials in the project area were taken by driving split-spoon or ring-barrel samplers. Additionally, bulk samples of subsurface materials were obtained from each boring and test pit.

Penetration resistance measurements were obtained in each boring by driving the split-spoon and ring-barrel samplers into the subsurface materials with a 140-pound hammer falling 30 inches. The penetration resistance value is a useful index in estimating the consistency, relative density or hardness of the materials encountered. No groundwater was encountered at the time of subsurface exploration.

Laboratory Testing: Samples retrieved during the field exploration were taken to the laboratory for observation by the project geotechnical engineer and were classified in general accordance with the Unified Soil Classification System described in Appendix C. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Logs of Borings and Test Pits were prepared and are presented in Appendix B.

Laboratory tests were conducted on selected soil samples and are presented in Appendix C and on the Logs of Borings and Test Pits. The test results were used for the geotechnical engineering analyses and the development of recommendations regarding the geological and geotechnical aspects of the design of the earthen dam. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil samples were tested for the following engineering properties:

- Water Content
- Dry Density
- Standard Proctor
- Grain Size Distribution
- Plasticity Index
- Remolded Direct Shear

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In addition, during the 2003 evaluation, Terracon previously tested selected soil samples for the following engineering properties:

- Water Content
- Dry Density
- Compression/Swell
- Standard Proctor
- Grain Size Distribution
- Remolded Permeability
- Plasticity Index
- Remolded Direct Shear

SITE CONDITIONS

The project site is southwest of the Piedra Vista High School located north of Pinon Hills Boulevard and East of College Boulevard in Farmington, New Mexico. The site area is currently undeveloped and can be described as a dry arroyo with formational sandstone outcrops on both sides up to 30 feet in height relative to the elevation in the center of the arroyo. A natural gas pipeline is located underground orthogonal to the proposed orientation of the earthen dam. This pipeline bisects the proposed earthen dam along the southwest portion of the dam axis. The project site vegetation consists of bushes, Pinon trees and weeds common to the area.

SUBSURFACE CONDITIONS

Soil Conditions: As presented on the Logs of Borings and Test Pits, the materials underlying the surface soils and extending to the maximum depth of exploration consisted of moist clayey sands and poorly graded silty sands which were underlain by moderately weathered formational sandstone. The weathering of the sandstone decreased with depth.

Groundwater Conditions: Groundwater was not encountered during the subsurface exploration operations. These observations represent groundwater conditions at the time of the field exploration, and may not be indicative of other times, or at other locations. Groundwater levels can be expected to fluctuate with varying seasonal weather conditions, irrigation water and other factors.

Zones of perched and/or trapped groundwater may also occur at times in the subsurface soils overlying bedrock, on top of the bedrock surface or within permeable fractures in the bedrock materials. The location and amount of perched water is dependent upon several factors, including hydrologic conditions, type of site development, irrigation, fluctuations in water features, seasonal and weather conditions.

Field and Laboratory Test Results: Laboratory tests consisting of Atterberg limits, gradations, moisture density relationships and remolded direct shear tests were performed on representative samples obtained from the on-site sand soil and proposed clay/shale

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borrow source and their results are included in Appendix C. Results from the gradation and Atterberg tests indicate that the proposed, blended embankment soils will to consist of clayey sand materials. The Atterberg limit tests indicate the soils have a low plasticity.

ENGINEERING ANALYSES

Proposed Dam Configuration: Terracon understands, based on conversations with the project civil engineer and a review of preliminary plans, that the material below the dam footprint will be removed to the surface of the underlying sandstone but in no case less than eight (8) feet below the bottom of the dam embankment elevation. The removal should be sloped upward from the upstream and downstream toes of the embankment at an angle of 2:1 (horizontal to vertical). A six (6) foot square reinforced concrete inlet structure will be constructed in the southwest interior portion of the dam impoundment. A 36-inch diameter reinforced concrete pipe (RCP) will be attached to the inlet structure and extended through the dam embankment to allow the storm water to exit the facility. The portion of the conduit that will be within the dam embankment structure should be encased in reinforced concrete as recommended in Section 4.1.6 of the FEMA Technical Manual: Conduits Through Embankment Dams (FEMA Technical Manual), published in September 2005, to facilitate compaction of the embankment soil. The new dam structure can then be constructed around the protected conduit.

The planned dam configuration includes a compacted, blended soil embankment. Based on a review of project drawings provided by the client, the dam will be 23 feet high, 700 feet across the axis and a crest width of 20 feet. The upstream embankment face will have a slope of 2.5:1 (horizontal to vertical) and the downstream embankment face will have a slope of 2:1 (horizontal to vertical). A fifty-foot wide emergency spillway, as designed by the project civil engineer, will be constructed in the sandstone southwest of the dam impoundment area.

Soil Analysis Parameters: The geotechnical parameters utilized for analysis by Terracon include material unit weight, cohesion and shear strengths of the embankment materials to be used to construct the dam. The general descriptions of the materials encountered during our subsurface explorations, laboratory test results, data obtained from project plans and experience with similar materials were utilized to determine the actual parameters used in the computer analyses. The geotechnical parameters used for the sandstone were based on the field classification of the materials encountered during drilling, which was compared with data from technical publications (Hoek & Bray, 1981; Dutton, Shirley P. and Willis, Brian J., 1998, Fetter, C.W. Jr., 1980, and Freeze, R. Allan and Cherry, John A., 1979) to derived applicable values for the dam site. The parameters used are included in the following table.

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Zone	Friction angle (degrees)	Cohesion (psf)	Unit Weight (pcf)
Compacted Embankment Soil	30	50	120
Native Sandstone Foundation	5	200	130

Dam Embankment Stability Analysis: Static analysis of the existing dam cross section was performed by Terracon using the computer program SLIDE. This program is based on a two-dimensional limiting equilibrium method. The factor of safety (FOS) is calculated using a conventional method of slices approach with the Morgenstern and Price method of analysis. The safety factors for the Morgenstern and Price method are presented in this report. The particular procedure employed generates circular-shaped slip surfaces between specified coordinate limits.

The analyses were completed in accordance with generally accepted procedures. Each design condition was considered for the proposed dam configuration.

The owner should be aware that the proposed slopes are unsafe for any recreational activity and injury may occur as a result of recreational activities and/or trespass on the finished slopes.

Seismic Considerations: We have provided seismic design parameters according to the 2006 International Building Code (IBC) for design and construction of the proposed structures. Selected site ground motion parameters for the project have been determined in general accordance with the IBC. The values provided are based on the subsurface exploration presented herein and the USGS software for use in interpolating values.

CONTERMINOUS 48 STATES-2003 NEHRP SEISMIC DESIGN PROVISIONS LATITUDE: 36.77805, LONGITUDE: -108.16400	
Spectral Response Accelerations SMs and SM1 SMs = FaSs and SM1 = FvS1 Site Class C - Fa = 1.2, Fv = 1.7	
Period (sec)	**Sa (g)**
0.2	0.203 (SMs, Site Class C)
1.0	0.090 (SM1, Site Class C)
SDs = 2/3 x SMs and SD1 = 2/3 x SM1 Site Class D - Fa = 1.2 ,Fv = 1.7	
Period (sec)	**Sa (g)**
0.2	0.136 (SDs, Site Class C)
1.0	0.060 (SD1, Site Class C)

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Liquefaction Analysis: Liquefaction analysis was performed using a method (Seed and Idriss, 1971 in Day, 1999) that compares the Seismic Shear Stress ratio (SSR) caused by an earthquake to that which will cause liquefaction of the soil, based on SPT values tested in the field.

CONCLUSIONS

Size Classification: The dam will be 23 feet high, 700 feet across the axis and a crest width of 20 feet and temporarily detain 34 acre feet of storm water at the emergency spillway elevation of 5645.5 feet.. This dam will have a size classification of small in accordance with the "Rules and Regulations Governing Dam Design, Construction and Dam Safety".

Hazard Potential Classification: The proposed dam structure is to be constructed in a wash north of Pinon Hills Boulevard. Downstream from the proposed dam there are residential subdivisions, utility installations and major roadways that could be impacted by a breach in the structure during maximum capacity. Therefore, this structure will be classified as a high hazard potential dam.

Slope Stability Analysis Results: Calculated safety factors are listed in the following table and analysis results are included in Appendix D. The calculated safety factors for the cases analyzed are larger than the minimum required values of 1.5 or 1.1 including seismic.

Design Condition	Slope	Minimum Safety Factor	
		Without Seismic	With Seismic
End of construction (Dry)	Upstream	1.875	1.520
End of construction (Dry)	Downstream	1.574	1.319
Full Steady State	Upstream	1.792	1.336
Full Steady State	Downstream	1.459	1.205

Liquefaction Analysis Results: The typical subsurface condition that is susceptible to liquefaction is a loose or very loose non-plastic sand that has been newly deposited or placed, with a groundwater table near the surface and considerable earth shaking (Day, 1999). Based on the soil types encountered during the subsurface exploration, the in-situ densities, and low seismic potential, the dam embankment is not susceptible to liquefaction. The dam embankment will consist of blended low plastic clayey sand material. The liquefaction analysis indicates the SSR caused by the design earthquake is less than the

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SSR that will cause liquefaction in the embankment. This result confirms our evaluation that liquefaction potential is negligible for the project.

The proposed blend of site soils and the available shale/clay will result in a material not susceptible to liquefaction, provided that the resulting blended materials have more than 30 percent fines and the materials are compacted as recommended in the Earthwork Section of this report.

RECOMMENDATIONS

Embankment Fill: Based on the results of our subsurface exploration, laboratory testing, and engineering evaluation, it is our opinion that the geotechnical conditions at the dam site are suitable for the proposed construction, provided that the recommendations presented in this report are included in the project design and good engineering design and construction practices are applied to the project. The provisions included in this report regarding excavation and construction of the embankments and providing proper drainage around the area, should be included as an integral part of the design of this project.

The material below the dam footprint should be removed to the surface of the underlying sandstone. The removal should be sloped upward from the upstream and downstream toes of the embankment at an angle of 2:1 (horizontal to vertical) to the finished grade elevation as shown on the project plans.

The surface of the sandstone should be leveled and benched as necessary to provide level surfaces for placement of the embankment fill. The embankment fill should be placed and compacted as recommended herein. The embankment fill soil should be overbuilt and cut back to final grade to provide compacted and tested fill soil to the edge of the embankment.

Based on the results of this evaluation, the materials encountered on the site and in the proposed clay/shale borrow area located northeast of the dam site, may be blended as recommended herein and used to construct the embankment provided the materials are moisture conditioned and blended to a relatively homogeneous consistency and particles greater than 3 inches in minimum dimension are removed. The blended materials should meet the recommendations for engineered fill as presented in this report.

Our recommendations are based on the assumption that the subsurface conditions across site are similar to those disclosed by the borings and test pits excavated for this project. If variations are noted during construction or if changes are made in location, size or configuration of the proposed dam, we should be notified so that we can supplement our recommendations, as applicable.

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Embankment Slopes

In general accordance with "Rules and Regulations Governing Dam Design, Construction and Dam Safety", the earth embankment slopes were designed to meet the minimum requirements for the embankment dams. The upstream constructed slope will be 2.5:1 (horizontal to vertical) and downstream constructed slopes will be 2:1. In addition, the crest width will be 20 feet.

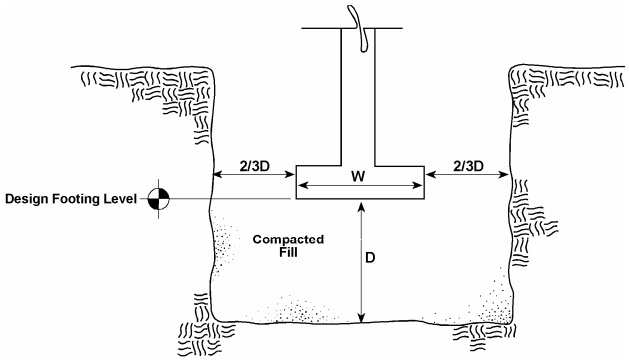
The owner should be aware that the proposed slopes are unsafe for any recreational activity and injury may occur as a result of recreational activities and/or trespass on the finished slopes.

Emergency Spillway: The emergency spillway should be designed by the project civil engineer based on the required site hydrology and required storm parameters. The spillway should be constructed using sound, quality construction incorporating the geotechnically-related recommendations presented in this report.

Intake Structure

Conventional Mat Foundations: The proposed intake structure will be constructed to allow access to the outlet pipe. It is our opinion that the proposed inlet structure can be supported on conventional mat foundation system. The conventional mat foundation system should bear on a minimum of five (5) feet of non-expansive engineered fill placed on a minimum of eight (8) inches of scarified, moisture conditioned and compacted native soils in accordance with the project drawings. Non-expansive engineered fill, which will support mat foundations, should be placed and constructed as recommended in the Earthwork section of this report.

The mat foundations bearing on a minimum of five (5) feet of non-expansive engineered fill, may be designed for a maximum bearing pressure of 2,000 psf. The design bearing pressure applies to dead loads plus design live load conditions. The design bearing pressure may be increased by one-third when considering total loads that include wind or seismic conditions.



Non-expansive engineered fill material should extend below proposed mat foundation elevation a minimum of five (5) feet. The subgrade soils below the mat foundations should be removed to at least a minimum depth of five (5) feet and a minimum of three (3) feet

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horizontally beyond the edge of foundations. The soils should be replaced with non-expansive engineered fill, conditioned to the recommended moisture content and compacted.

Areas of soft or disturbed soils may be encountered at foundation bearing depth after excavation is completed. When such conditions exist beneath planned footing areas, the subgrade soils should be moisture conditioned and compacted prior to placement of the foundation system. If sufficient compaction can not be achieved in-place, the soft or disturbed soils should be removed and replaced with non-expansive engineered fill.

Foundations should be proportioned to reduce differential foundation movement. Proportioning on the basis of equal total settlement is recommended; however, proportioning to relative constant dead-load pressure will also reduce differential settlement between adjacent footings. Total vertical movement resulting from the assumed structural loads is estimated to be on the order of about 1 inch. Differential vertical movement should be on the order of ½ to ¾ of the estimated total vertical movement. Additional foundation movements could occur if water from any source infiltrates the foundation soils; therefore, proper drainage should be provided in the final design and during construction.

Foundations should be reinforced as necessary to reduce the potential for distress caused by differential foundation movement.

Foundation excavations and engineered fill placement should be observed by a representative of Terracon prior to placement of reinforcing steel. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

Below Water Structure: The tower could be under water up to 23 feet deep. The below water structure should be designed to be water tight from outside sources and designed for the potential effects of buoyancy.

General Considerations: The following recommendations are provided for use in the design and construction of this facility.

Conduit Fill Materials: In accordance with the FEMA Technical Manual, the following material specifications should be used adjacent to the conduit in the embankment fill:

Gradation	**Percent finer by weight (ASTM C136)**
1-½ "	100
No. 200 Sieve	50 (min)
Plasticity Index	10 to 30 percent

Flowable fill (also known as controlled low strength materials) is not recommended for backfilling around the conduit in high hazard embankment dams. Flowable fill does not bond to either the conduit material or the adjacent foundation in which it is contact. In addition, flowable fill may develop interior cracks due to shrinkage. Additional design considerations are provided in the FEMA Technical Manual Section 5.3.

Embankment Fill Materials: Clean on-site soils should be blended with available clay/shale in approximate proportions of seven parts on-site sand soils with three part clay/shale (30 percent clay/shale) to form a homogeneous blended material. During the blending phase, the blended material should be moisture conditioned to a moisture content ranging from 1 percent below to 3 percent above optimum moisture content as evaluated by ASTM D698 (Standard Proctor). Prior to placement of the embankment fill, the base area of the embankment should be excavated to the surface of competent sandstone as previously discussed. The competent sandstone surface should be approved in the field by the project geotechnical engineer. The surface of the sandstone should be moistened and proof-rolled prior to fill placement.

Proof-rolling should be performed after a suitable period of relatively dry weather to avoid degrading an otherwise acceptable subgrade. Proof-rolling should be performed with a heavily loaded dump truck or with similar approved construction equipment. The proof-rolling equipment should make at least four passes over each section, with the last two passes perpendicular to the first two. A pass is defined herein as a complete round trip.

Frozen soils should not be used as in the embankment. Blended engineered embankment fill soils should conform to the following:

Gradation	**Percent finer by weight (ASTM C136)**
3"	100
No. 4 Sieve	50-100
No. 200 Sieve	45 (max)
Liquid Limit	30 (max)
Plasticity Index	12 (max)
Maximum expansive potential (%)*	0.5

*Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at about 2 percent below optimum water content. The sample is confined under a 100 psf surcharge and submerged.

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Placement and Compaction: Embankment and engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. Fill lifts should not exceed eight inches loose thickness. Place and compact fill in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. No fill should be placed over frozen ground.

Materials should be compacted to the following:

Material	Minimum Percent (ASTM D698)
Subgrade soils beneath fill areas	95
On-site and imported fill soil blend placed in the dam embankment	95

On-site and engineered fill soils should be compacted at a moisture content ranging from 1 percent below to 3 percent above optimum moisture content as evaluated using ASTM D698.

Earthwork on the project should be observed and tested by Terracon. These services should include observation and testing of engineered fill, subgrade preparation and other geotechnical conditions exposed during the construction of the project.

Excavation and Trench Construction: Excavations into the on-site soils will encounter a variety of conditions. However, caving soils may be encountered on the site, especially in the area of the existing deeper channel in the vicinity of Boring B-3. The individual contractor(s) should be responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local, and federal regulations, including current OSHA excavation and trench safety standards.

As a safety measure, it is recommended that all vehicles and soil piles be kept to a minimum lateral distance from the crest of the slope equal to no less than the slope height. The exposed slope face should be protected against the elements.

The contractor should retain a geotechnical engineer to monitor the soils exposed in all excavations and provide engineering services for slopes. This will provide an opportunity to monitor the soil types encountered and to modify the excavation slopes as necessary. It also offers an opportunity to verify the stability of the excavation slopes during construction.

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Additional Design and Construction Considerations:

Surface Drainage: Positive drainage should be provided during construction and maintained throughout the life of the proposed project. Infiltration of water into the subgrade soils and utility excavations must be prevented during construction. Backfill in utility trenches should be well compacted and free of all construction debris to reduce the possibility of moisture infiltration.

Compliance: To assess compliance, the owner should retain the Terracon to perform full time observation and testing during construction.

GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide testing and observation during excavation, grading and construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

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DRAFT

GEOLOGICAL ASSESSMENT

PROPOSED PORTER ARROYO STORMWATER DETENTION FACILITY NORTH OF PINON HILLS BOULEVARD AND EAST OF COLLEGE BOULEVARD FARMINGTON, NEW MEXICO

Terracon Project No. 69085034
October 30, 2008

LARKIN GROUP NM, INC.
8500 Menual Boulevard NE, Suite A-440
Albuquerque, New Mexico 87112

Attention: Mr. Joseph J. Casares, P.E.

Prepared by:

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DRAFT

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DRAFT

GEOLOGICAL ASSESSMENT

PROPOSED PORTER ARROYO
STORMWATER DETENTION FACILITY
NORTH OF PINON PILLS BOULEVARD AND
EAST OF COLLEGE BOULEVARD
FARMINGTON, NEW MEXICO

Terracon Project No. 69085034
October 30, 2008

INTRODUCTION

This report contains the results of our geological assessment for the Construction of Porter Arroyo Stormwater Detention Facility to be located in Farmington, New Mexico. The site is further described as being located in Southwest ¼ of Section 25, Township 30 North, Range 13 West, New Mexico Prime Meridian (NMPM) in San Juan County, New Mexico.

The purpose of these services is to provide geologic information relative to:

- Regional geologic setting;
- Local and site geology;
- Geologic conditions of detention facility areas;
- Geologic hazards; and
- Seismic history and potential.

The information contained in this report is based upon a site reconnaissance conducted on August 25, 2008 by a staff geologist and available literature. This report is in fulfillment of the "Rules and Regulation Governing Dam Design, construction and Dam Safety" by the Office of the State Engineer Dam Safety Bureau dated March 2005.

PROJECT DESCRIPTION

It is our understanding that the project will consist of construction of an earthen dam across Porter Arroyo, which will detain storm water and regulate the downstream flow. Based on a review of project drawings provided by the client, the dam will be 23 feet high, 700 feet across the axis and will have a crest width of 20 feet. The upstream embankment face will have a slope of 2.5:1 (horizontal to vertical) and the downstream embankment face will have a slope of 2:1 (horizontal to vertical). It is understood that the detention pond will empty within 48 hours of the storm event.

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SITE DESCRIPTION

The project site is southwest of the Piedra Vista High School located north of Pinon Hills Boulevard and East of College Boulevard in Farmington, New Mexico. The site area is currently undeveloped and can be described as a dry arroyo with formational sandstone outcrops on both sides up to 30 feet in height as relative to the elevation in the center of the arroyo. A natural gas pipeline is located underground orthogonal to the proposed orientation of the earthen dam. This pipeline bisects the proposed earthen dam foundation along the southwest portion of the dam axis. The project site vegetation consists of bushes, Pinon trees and weeds common to the area.

REGIONAL GEOLOGIC SETTING

The stormwater detention facility located within the San Juan Basin of the Colorado Plateau physiographic province. The Colorado Plateau of Utah, Colorado, Arizona and New Mexico, is a broad area of uplift that has experienced relatively little deformation allowing the rocks to maintain their "layer cake" appearance. The San Juan Basin, formed during the Laramide Orogeny of Tertiary time, is a structurally complex feature characterized by a broad, gently downwarping interior, which is flanked by numerous uplifts and platforms. It is rimmed by older Cretaceous rock that gradually proceeds to younger Tertiary rock towards the center of the basin.

LOCAL AND SITE GEOLOGY

Sandstone outcrops exposed in the boundaries of the arroyo are comprised of the Ojo Alamo Formation overlain by the Nacimiento Formation. Both Tertiary formations are of Paleocene age. The sandstones exhibit crossbedding and gradational bedding. According to Ward, the Ojo Alamo Formation consists of fine- to coarse-grained conglomeratic sandstone with a thickness of as much as 22 meters.[1] Also according to Ward, the Nacimiento Formation consists of grey and brown shale and tan, medium-grained conglomeratic sandstone with a thickness of as much as 240 meters. Due to the crossbedded nature of the sandstones, no strike and dip measurements were obtained during the assessment.

The material observed in the streambed consists of Quaternary age alluvium. Medium- to coarse-grained sands with gravels are found in the more active washes and arroyos. Less active portions are dominated by fine- to medium-grained clayey sands and support the larger share of vegetation found on the site.

[1] Ward, A.W., 1990, Geologic map emphasizing the surficial deposits of the Farmington 30' X 60' quadrangle, New Mexico and Colorado: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1978, scale 1:100000.

DRAFT

GEOLOGIC HAZARDS

Seismic History and Potential: According the USGS, since 1973 have been two recorded earthquakes within a 100 kilometer radius of the site varying in magnitude from 2.5 to 4.2 and five earthquakes have been recorded within a 150 kilometer radius of the site varying in magnitude from 2.7 to 4.6 (~104 kilometers from the site). This data is presented in Figure A-2. These seven earthquakes were not recorded within 30 kilometers of the site.

The interpolated Probabilistic ground motion values, listed as a percentage of g for the site are provided in the following table. The data is generated from the USGS National Seismic Hazard Mapping Project website (http://earthquake.usgs.gov/research/hazmaps/index.php), and is based on 2002 data.

	10 Percent Probability of Exceedance in 50 Years (% of g)	2 Percent Probability of Exceedance in 50 Years (% of g)
Peak Ground Acceleration	3.3	7.8
0.2 Seconds Spectral Acceleration	7.3	17.0
1.0 Seconds Spectral Acceleration	2.2	5.3

Based on the Dam Design Regulations a dam classified as a “High Hazard Potential” shall be designed for a 2 percent chance of occurrence in 50 years (approximately 2500 year return frequency). Based on a review of data published by the USGS Earthquake hazards web site, the peak acceleration (percent g with 2 percent probability of exceedance in 50 years) is 7.8 percent, or 0.078 g. Seismic design and liquefaction analysis for the site are included within the geotechnical engineering evaluation.

Other Geologic Hazards: Evidence of rock falls was not observed on site. Landslide potential is considered very low at the site. At the time of our field assessment, no evidence of current mass wasting was observed in the area of the dam, diversion or surrounding site topography.

CONCLUSIONS

Based on a review of the preliminary dam drawings, the geotechnical exploration borings, and a field geological assessment, it is our opinion the sandstone and alluvial cover is a good foundation for the dam. There is not a significant potential for geologic hazards or severe erosion.

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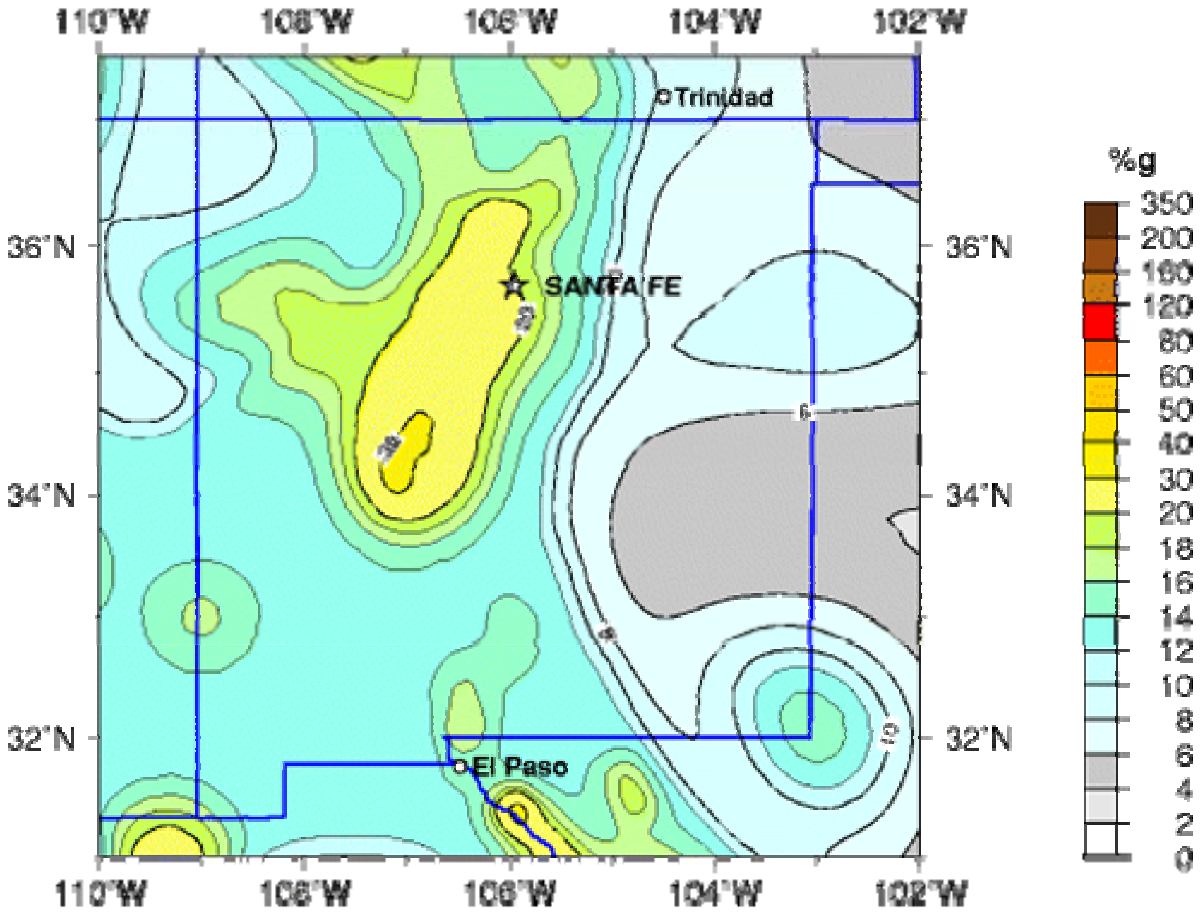
GENERAL COMMENTS

The analysis and recommendations presented in this report are based upon the data obtained from the borings and test pits performed at the indicated locations and from other information discussed in this report. This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made.

DRAFT



Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
site: NEHRP B-C boundary
National Seismic Hazard Mapping Project

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(505) 334-2900 Fax (505) 334-9703

New Mexico Seismic Hazard Map
Construction of Porter Arroyo
Stormwater Detention Facility
Farmington, New Mexico
http://neic.usgs.gov/neis/states/newmexico/hazards.html

Project No. 69085034
Date: October 30, 2008

Not to Scale

FIGURE A-1

U. S. G E O L O G I C A L S U R V E Y

E A R T H Q U A K E D A T A B A S E

FILE CREATED: Wed Oct 29 22:28:58 2008
Circle Search Earthquakes= 7
Circle Center Point Latitude: 36.778N Longitude: 108.162W
Radius: 150.000 km
Catalog Used: PDE
Data Selection: Historical & Preliminary Data

CAT	YEAR	MO	DA	ORIG TIME	LAT	LONG	DEP	MAGNITUDE	IEM NFO TF	DTSVNWG	DIST km
PDE	1976	01	05	062332.90	35.84	-108.34	25	4.6 MLGS	6D.	.....	104
PDE	1977	03	05	030054.70	35.92	-108.29	22	4.2 MLGS	6D.	.....	96
PDE	1987	09	09	094409.28	37.63	-108.12	5	2.5 MLGS	...	.....	95
PDE	1989	11	19	032113.61	38.06	-107.77	5	3.0 MLGS	.F.	.....	145
PDE	1989	11	22	224712.58	37.98	-107.73	5	2.7 MLGS	.F.	.....	138
PDE	2002	06	18	110447.78	37.59	-107.24	5	2.9 MLGS	...	.....	121
PDE-W	2008	06	06	200959	37.36	-109.47	9	3.7 MLSLC	3F.	.....	132

Seismic Data Search Results

Construction of Porter Arroyo
Stormwater Detention Facility
Farmington, New Mexico

Project Mngr: KMP	Terracon	Project No.: 69085034
Designed By: HMD		Scale:
Approved By: KMP	#4A C.R. 3499	Date: 10/30/2008
Checked By: KMP	Flora Vista, NM 87415	Drawn By: HMD
File Name: 69085034-SeismicData.ppt		Figure No.: A2

Figure A-3. View north from approximate middle of structure.

Figure A-4. View east from approximate middle of structure.

Figure A-5. View south from approximate middle of structure.

Figure A-6. View west from approximate middle of structure.

Figure A-7. Looking east from proposed western end of structure.

Figure A-8. Shale and clay stockpile can be seen in middle-left portion of photo.

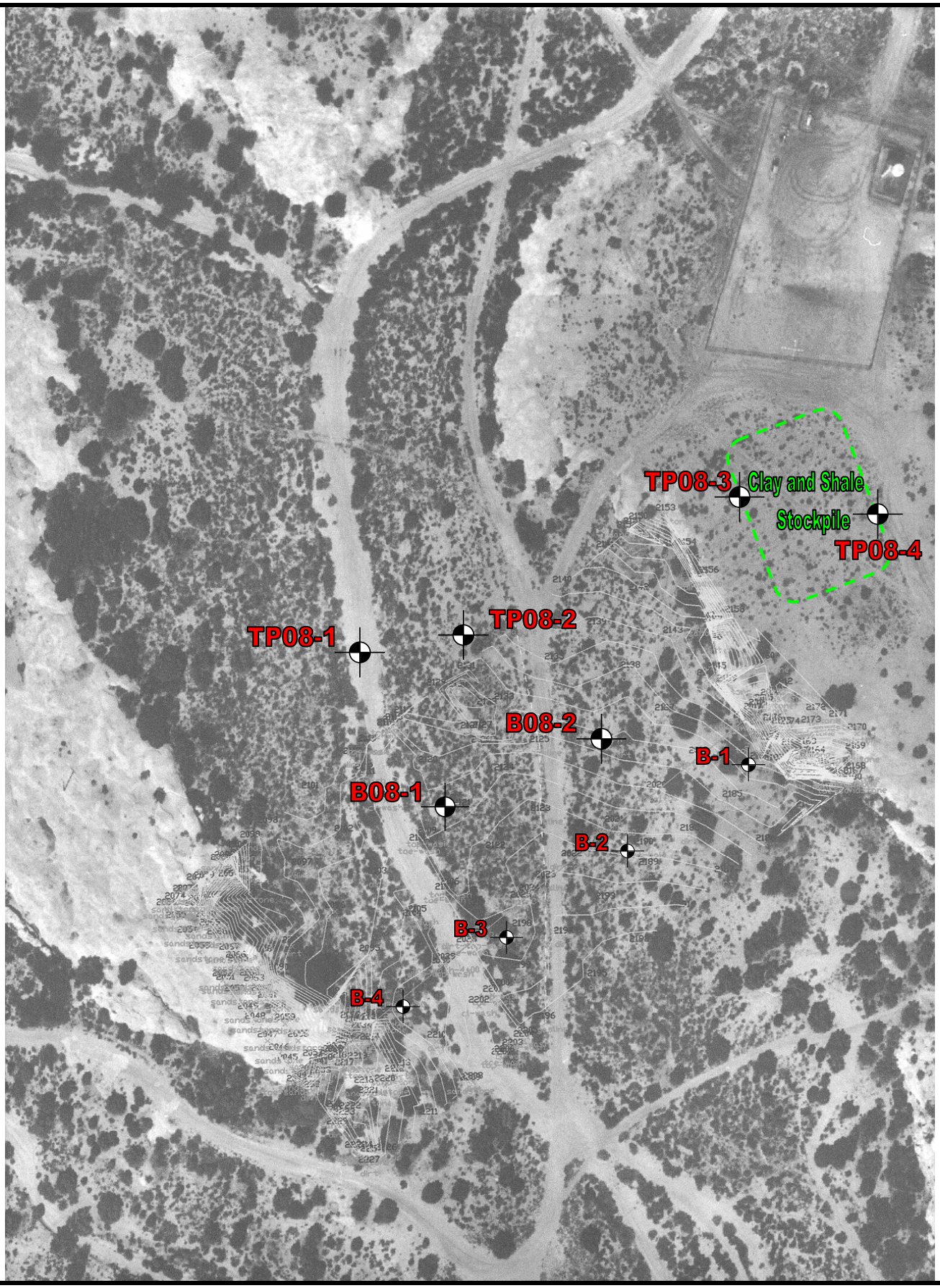
MAP

1927 North American Datum; UTM grid zone 12
Generated by BigTopo7 (www.igage.com)
Map compiled from USGS Quads: Farmington North; NM
Flora Vista; NM Farmington South; NM

0 ¼ ½ 1 Mile
0 1000 2000 3000 5000 Feet
0 0.5 1 Kilometer

BigTopo Map

Project Mngr: KMP	Project No. 68085034	Terracon Consulting Engineers & Scientists #4A CR 3499 Flora Vista, New Mexico 505.334.2900 Fax: 505.334.9703	Site Location Map	FIG No.
Drawn By: HMD	Scale ~ 1:24,000		Porter Arroyo Stormwater Detention Facility Farmington, New Mexico	1
Checked By: KMP	File No. Site Map.doc			
Approved By: KMP	Date: 10/27/08			



Project Mngr: KMP	**Project No.** 68085034	Terracon Consulting Engineers & Scientists #4A CR 3499 Flora Vista, New Mexico 505.334.2900 Fax: 505.334.9703	Boring Location Map	FIG No.
Drawn By: HMD	**Scale** ~ 1:24,000		Porter Arroyo Stormwater Detention Facility Farmington, New Mexico	1
Checked By: KMP	**File No.** Boring.doc			
Approved By: KMP	**Date:** 10/27/08			

LOG OF BORING NO. B1

CLIENT
Larkin Group of New Mexico, Inc.

SITE North of Pinon Hills & East of College Blvd
Farmington, New Mexico

PROJECT
Porter Arroyo Stormwater Detention Dam

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT - N BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psf
	CLAYEY SAND, brown, slightly damp		SC	AUGER				6.0		
	2.5 **SANDSTONE WITH CLAY**, moderately weathered, brown, very dense, slightly damp, medium to fine grained	5			SS		50/5"	4.3		
	9 Bottom of excavation on sandstone at 9 feet Note: No groundwater encountered									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▽	▽
WL	Backfilled at completion	

Terracon

BORING STARTED			
BORING COMPLETED		1-23-03	
RIG	CME 75	FOREMAN	
LOGGED	CLV	JOB #	66035601

LOG OF BORING NO. B2

CLIENT
Larkin Group of New Mexico, Inc.

SITE North of Pinon Hills & East of College Blvd
Farmington, New Mexico

PROJECT
Porter Arroyo Stormwater Detention Dam

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf
	CLAYEY SAND, light brown, slightly damp, caliche, medium to fine grained		SC	AUGER				3.3		
	5	5								
	SANDSTONE, moderately weathered, light brown, very dense, slightly damp, medium to fine grained **		SC SM		MC		50/4"	2.0		
								2.4		
		10			SS		50/3"	2.4		
	12									
	Bottom of excavation on sandstone at 12 feet Note: No groundwater encountered ** Field observations identify a sandstone at 5 feet. Laboratory testing of this material indicates that it breaks down to a silty sand to clayey sand.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▽	▽
WL	Backfilled at completion	

Terracon

BORING STARTED			
BORING COMPLETED		1-23-03	
RIG	CME 75	FOREMAN	
LOGGED	CLV	JOB #	66035601

LOG OF BORING NO. B3

CLIENT
Larkin Group of New Mexico, Inc.

SITE North of Pinon Hills & East of College Blvd
Farmington, New Mexico

PROJECT
Porter Arroyo Stormwater Detention Dam

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	TYPE	RECOVERY, in.	SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf
	SAND, brown, slightly damp, medium grained		SP SM	AUGER				2.5		
	Medium dense	5	SP SM		MC		30	1.0	101	
	Medium dense	10			MC		19	6.7	102	
14	**CLAYEY SAND**, brown, dense, slightly damp, caliche stringers, medium grained	15	SC		MC		30	6.7	102	
	Medium dense	20			MC		31	3.6	102	
25	**SANDSTONE WITH GREY CLAY**, moderately weathered, brown with orange staining, slightly damp, caliche stringers, friable	25			MC		10/0	3.0		
		30			SS		40	6.3		

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▽	▼
WL	Backfilled at completion	

Terracon

BORING STARTED	
BORING COMPLETED	1-23-03
RIG CME 75	FOREMAN
LOGGED CLV	JOB # 66035601

LOG OF BORING NO. B3

CLIENT
Larkin Group of New Mexico, Inc.

SITE North of Pinon Hills & East of College Blvd
Farmington, New Mexico

PROJECT
Porter Arroyo Stormwater Detention Dam

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT - N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf
	SANDSTONE WITH GREY CLAY, moderately weathered, brown with orange staining, slightly damp, caliche stringers, friable	35			SS		10/0	6.8		
	38									
	Bottom of excavation at 38 feet Note: No groundwater encountered									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▽	▼
WL	Backfilled at completion	

Terracon

BORING STARTED			
BORING COMPLETED		1-23-03	
RIG	CME 75	FOREMAN	
LOGGED	CLV	JOB #	66035601

LOG OF BORING NO. B4

CLIENT
Larkin Group of New Mexico, Inc.

SITE North of Pinon Hills & East of College Blvd
Farmington, New Mexico

PROJECT
Porter Arroyo Stormwater Detention Dam

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT - N BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psf
	1 **SILTY SAND**, brown, slightly damp		SM	AUGER				4.9		
	SANDSTONE WITH CLAY, slightly weathered, brown, slightly damp **		SC							
	5	5								

Refusal on sandstone at 5 feet
Note: No groundwater encountered

** Field observations identify a sandstone at 1 foot. Laboratory testing of this material indicates that it breaks down to a silty sand to clayey sand.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▽	▼
WL	Backfilled at completion	

Terracon

BORING STARTED			
BORING COMPLETED		1-23-03	
RIG	CME 75	FOREMAN	
LOGGED	CLV	JOB #	66035601

LOG OF BORING NO. B08-1

CLIENT
Larkin Group

SITE
Farmington, New Mexico

PROJECT
Porter Arroyo

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: CORE SIZE	SAMPLES: TYPE	SAMPLES: RECOVERY	SAMPLES: BLOW COUNTS, n	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psi
	SILTY SAND; tan, dry to moist, medium dense, lightly cemented, trace gravel.		SM		GRAB			2.0		
			SM		RS	12	10	3.0		
		5	SM		RS	12	15	2.0		
		10	SM		RS	4	12	2.0		
	15.5	15	CL		RS	12	19	8.0		
	LEAN CLAY WITH SAND; brown, moist, very stiff. 17.5									
	POORLY GRADED SAND WITH CLAY; tan and orange, moist to dry, medium dense to very dense, well cemented lenses.	20	SP SC		RS	12	15	2.0		
		25	SP SC		RS	11	40/11"	2.0		
	31.5	30	SP SC		RS	12	36	2.0		
	Exploration terminated at approximately 31.5 feet below existing ground surface. No groundwater encountered.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▼	▼
WL		

Terracon

BORING STARTED	8-25-08		
BORING COMPLETED	8-25-08		
RIG	CME-75	FOREMAN	HMD
APPROVED	KMP	JOB #	69085034

LOG OF BORING NO. B08-2

CLIENT
Larkin Group

SITE
Farmington, New Mexico

PROJECT
Porter Arroyo

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: CORE SIZE	SAMPLES: TYPE	SAMPLES: RECOVERY	SAMPLES: BLOW COUNTS, n	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psi
	CLAYEY SAND; brown, dry, medium dense, few pinholes.		SC		GRAB			2.0		
			SC		RS	12	13	4.0		
		5	SC		RS	12	13	5.0		
		10	SC		RS	12	36	4.0		
	15	15			RS	2	25/2"	4.0		
	SANDSTONE; orange and tan, dry, clayey, soft to very hard, complete to fresh weathering.									
	19									
	Exploration terminated at approximately 19 feet below existing ground surface due to auger refusal on sandstone. No groundwater encountered.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▼	▼
WL		

Terracon

BORING STARTED	8-25-08		
BORING COMPLETED	8-25-08		
RIG	CME-75	FOREMAN	HMD
APPROVED	KMP	JOB #	69085034

LOG OF TEST PIT NO. TP08-1

CLIENT **Larkin Group**

SITE **Farmington, New Mexico**

PROJECT **Porter Arroyo**

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: CORE SIZE	SAMPLES: TYPE	SAMPLES: RECOVERY	SAMPLES: BLOW COUNTS, n	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psi
	SHALE AND SANDY LEAN CLAY; gray to light tan, dry, pieces of shale.		CL		GRAB					
	1									
	Exploration terminated at approximately 1 foot below existing ground surface. No groundwater encountered.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▼	▽
WL		

Terracon

TEST PIT STARTED			9-8-08
TEST PIT COMPLETED			9-8-08
RIG		FOREMAN	HMD
APPROVED	KMP	JOB #	69085034

LOG OF TEST PIT NO. TP08-2

CLIENT
Larkin Group

SITE
Farmington, New Mexico

PROJECT
Porter Arroyo

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: CORE SIZE	SAMPLES: TYPE	SAMPLES: RECOVERY	SAMPLES: BLOW COUNTS, n	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psi	
	SHALE AND SANDY LEAN CLAY; gray to light tan, dry, pieces of shale.		CL		GRAB						
	1										
	Exploration terminated at approximately 1 foot below existing ground surface. No groundwater encountered.										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▼	▽
WL		

Terracon

TEST PIT STARTED			9-8-08
TEST PIT COMPLETED			9-8-08
RIG		FOREMAN	HMD
APPROVED	KMP	JOB #	69085034

LOG OF TEST PIT NO. TP08-3

CLIENT **Larkin Group**

SITE **Farmington, New Mexico**

PROJECT **Porter Arroyo**

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: CORE SIZE	SAMPLES: TYPE	SAMPLES: RECOVERY	SAMPLES: BLOW COUNTS, n	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psi
	SILTY SAND; tan, dry.		SM		GRAB					
1	Exploration terminated at approximately 1 foot below existing ground surface. No groundwater encountered.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▼	▼
WL		

Terracon

TEST PIT STARTED			9-8-08
TEST PIT COMPLETED			9-8-08
RIG		FOREMAN	HMD
APPROVED	KMP	JOB #	69085034

LOG OF TEST PIT NO. TP08-4

CLIENT
Larkin Group

SITE
Farmington, New Mexico

PROJECT
Porter Arroyo

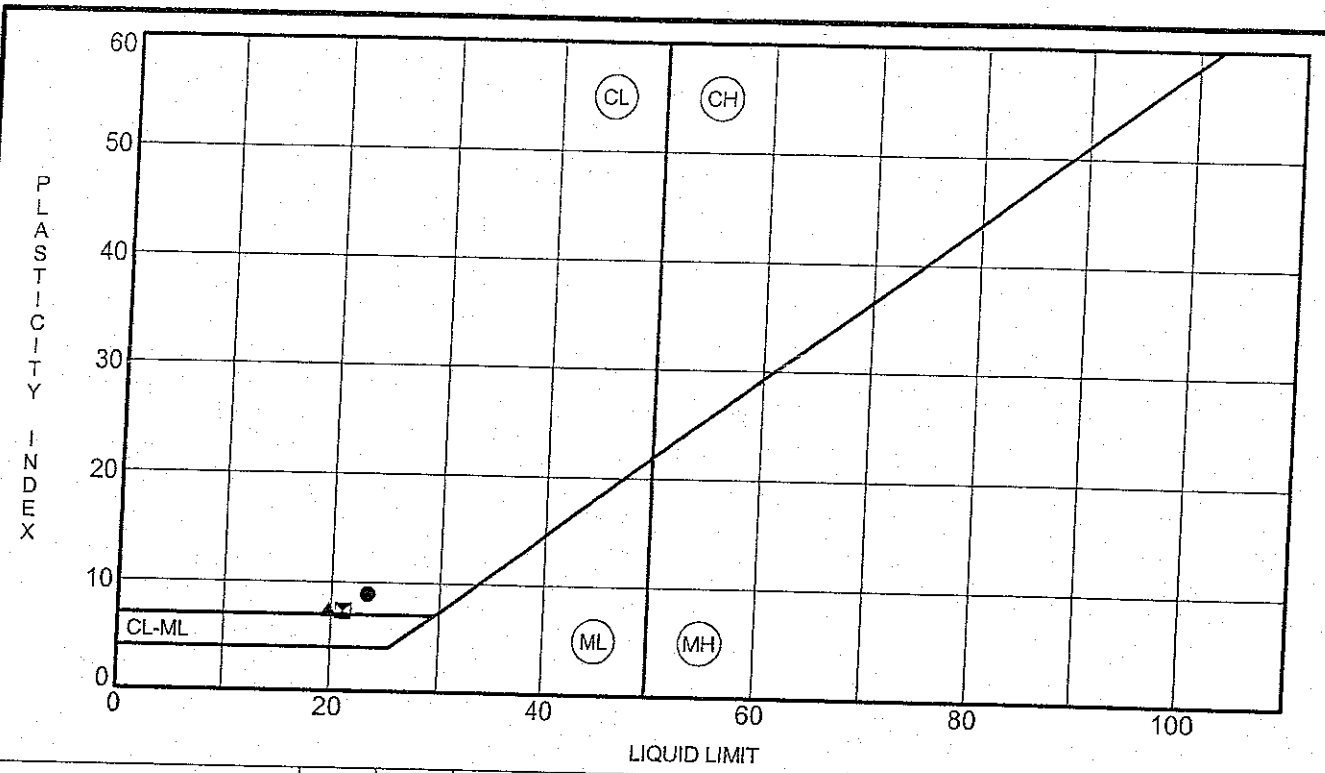
GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: CORE SIZE	SAMPLES: TYPE	SAMPLES: RECOVERY	SAMPLES: BLOW COUNTS, n	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psi	
	SILTY SAND; tan, dry.		SM		GRAB						
1											
	Exploration terminated at approximately 1 foot below existing ground surface. No groundwater encountered.										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽	▼
WL	▼	▼
WL		

Terracon

TEST PIT STARTED			9-8-08
TEST PIT COMPLETED			9-8-08
RIG		FOREMAN	HMD
APPROVED	KMP	JOB #	69085034



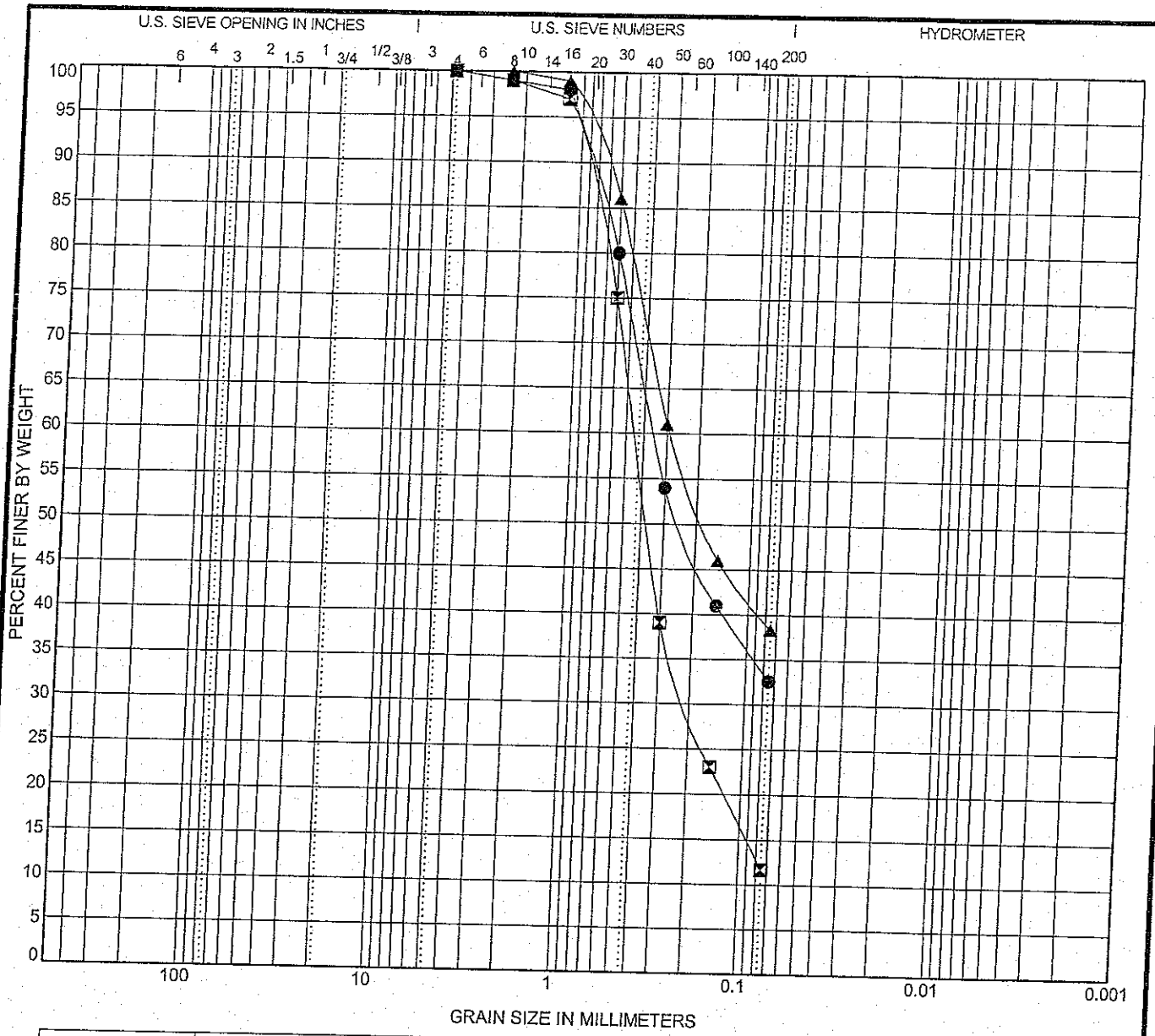
	Specimen Identification		LL	PL	PI	%Fines	Classification
●	B2	0.0ft	23	14	9	33	CLAYEY SAND(SC)
⊠	B2	5.0ft	21	14	7	12	WELL-GRADED SAND with SILTY CLAY(SW-SC)
▲	B4	0.0ft	20	12	8	38	CLAYEY SAND(SC)

Terracon

ATTERBERG LIMITS RESULTS

Project: Porter Arroyo Stormwater Detention Dam
Site: North of Pinon Hills & East of College Blvd Farmington, New Mexico
Job #: 66035601
Date: 8-1-03

TC ATTERBERG LIMITS 66035601.GPJ TERRACON.GDT 8/1/03



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B2	0.0ft	CLAYEY SAND(SC)	23	14	9		
⊠	B2	5.0ft	WELL-GRADED SAND with SILTY CLAY(SW-SC)	21	14	7	1.36	6.65
▲	B4	0.0ft	CLAYEY SAND(SC)	20	12	8		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B2	0.0ft	4.75	0.352			0.0	67.4	32.6	
⊠	B2	5.0ft	4.75	0.449	0.203		0.0	88.3	11.7	
▲	B4	0.0ft	2.36	0.286			0.0	61.7	38.3	

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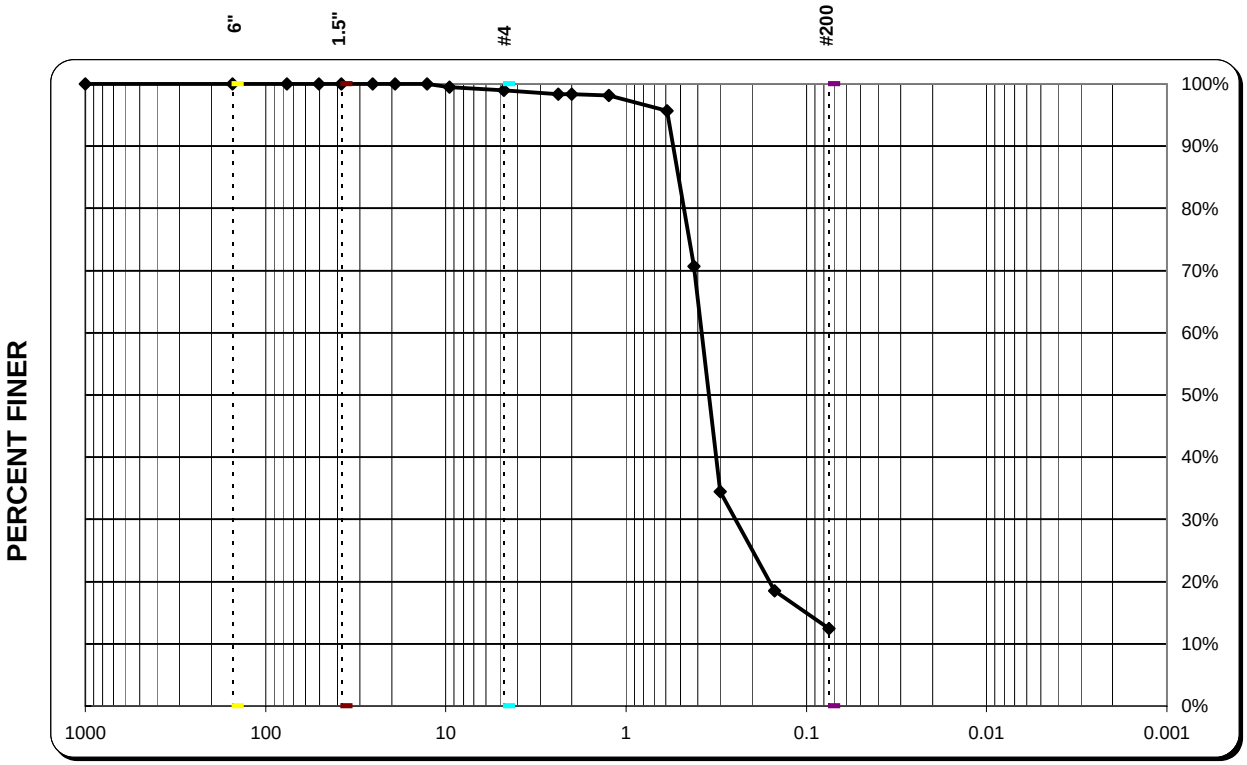
GRAIN SIZE DISTRIBUTION

Project: Porter Arroyo Stormwater Detention Dam
Site: North of Pinon Hills & East of College Blvd Farmington, New Mexico
Job #: 66035601
Date: 8-1-03

TC_GRAIN_SIZE_66035601.GPJ TERRACON.GDT 8/1/03

GRAIN SIZE DISTRIBUTION GRAPH



GRAIN SIZE - mm

TEST SUMMARY

Sieve Size	1 1/2"	3/4"	3/8"	#4	#10	#40	#100	#200
% Passing (Cumulative)	100	100	100	99	98	71	19	12.4
Specification								

% GRAVEL =	1.0	**D_{85} =** 0.5	**D_{15} =** 0.1
% SAND =	86.6	**D_{60} =** 0.4	**D_{10} =**
% SILT & CLAY =	12.4	**D_{50} =** 0.3	**C_U =**
		D_{30} = 0.2	**C_C =**

Sample Date: 8/28/2008

Project No.: 69085034

Project Name: Porter Arroyo

Report Date: 11/3/2008

Sample Location: B08-1 @ 0-5'

Liquid Limit: None

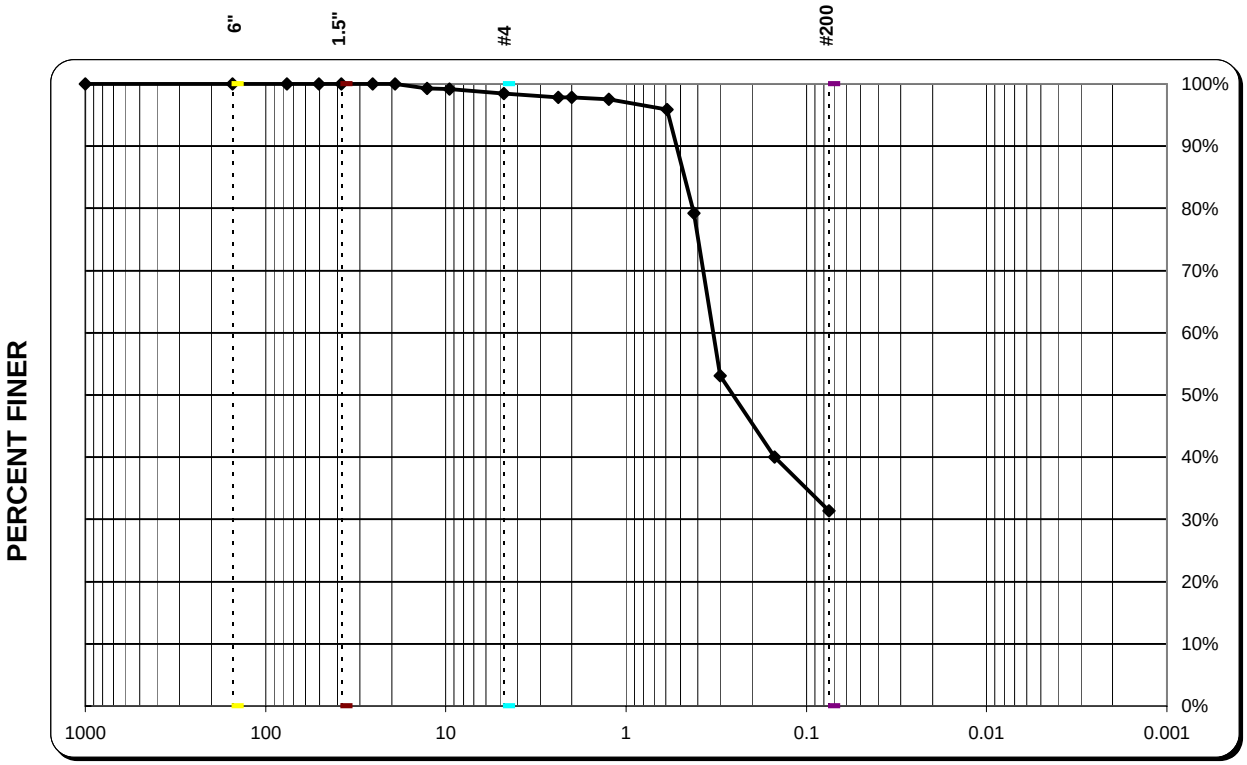
Plasticity Index: NP

USCS Classification: SM

Material Description: Silty Sand

Terracon

GRAIN SIZE DISTRIBUTION GRAPH



GRAIN SIZE - mm

TEST SUMMARY

Sieve Size	1 1/2"	3/4"	3/8"	#4	#10	#40	#100	#200
% Passing (Cumulative)	100	100	99	98	98	79	40	31.4
Specification								

% GRAVEL =	1.5	**D_{85} =** 0.5	**D_{15} =**
% SAND =	67.1	**D_{60} =** 0.3	**D_{10} =**
% SILT & CLAY =	31.4	**D_{50} =** 0.3	**C_U =**
		D_{30} =	**C_C =**

Sample Date: 8/28/2008

Project No.: 69085034

Project Name: Porter Arroyo

Report Date: 11/3/2008

Sample Location: B08-2 @ 0-5'

Liquid Limit: 23

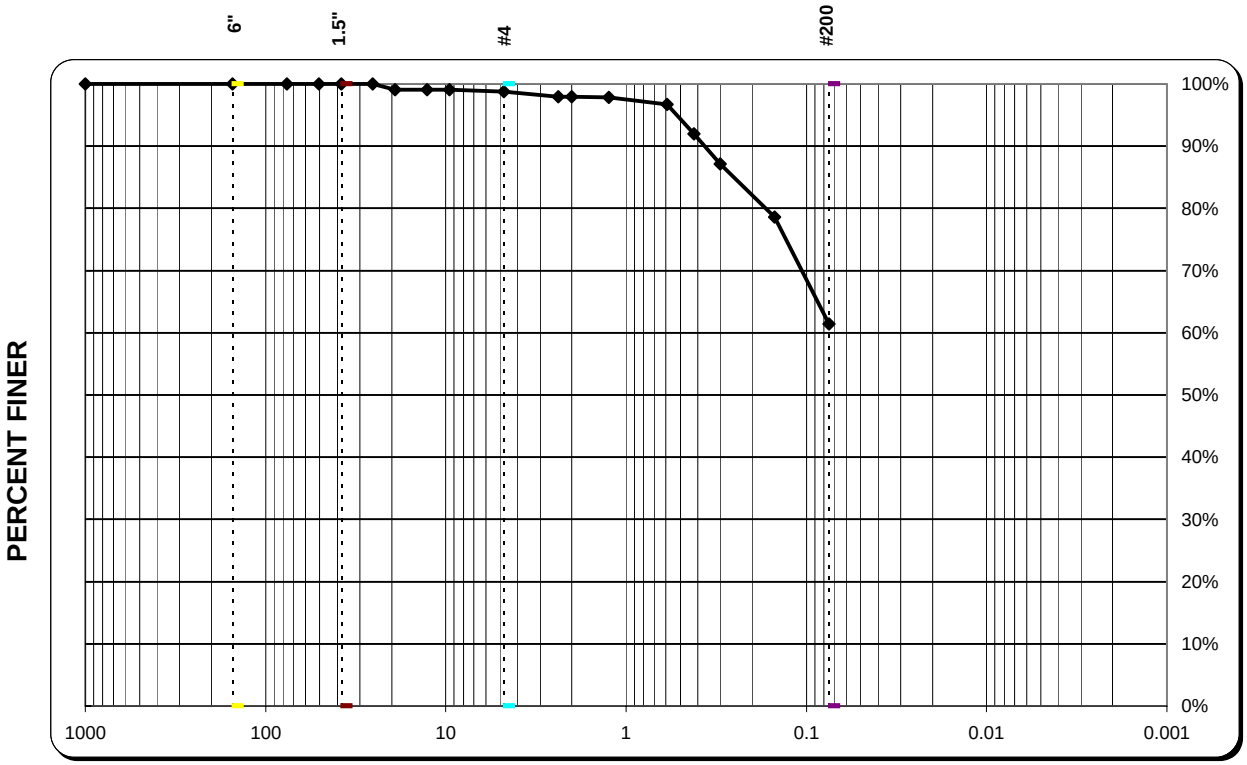
Plasticity Index: 8

USCS Classification: SC

Material Description: Clayey Sand

Terracon

GRAIN SIZE DISTRIBUTION GRAPH



GRAIN SIZE - mm

TEST SUMMARY

Sieve Size	1 1/2"	3/4"	3/8"	#4	#10	#40	#100	#200
% Passing (Cumulative)	100	99	99	99	98	92	79	61.4
Specification								

% GRAVEL =	1.3	**D_{85} =** 0.3	**D_{15} =**
% SAND =	37.3	**D_{60} =**	**D_{10} =**
% SILT & CLAY =	61.4	**D_{50} =**	**C_U =**
		D_{30} =	**C_C =**

Sample Date: 9/8/08

Project No.: 69085034

Project Name: Porter Arroyo

Report Date: 11/3/2008

Sample Location: Blend: TP08-1 @ 0-1' & TP08-2 @ 0-1'

Liquid Limit: 31

Plasticity Index: 16

USCS Classification: CL

Material Description: Sandy Lean Clay

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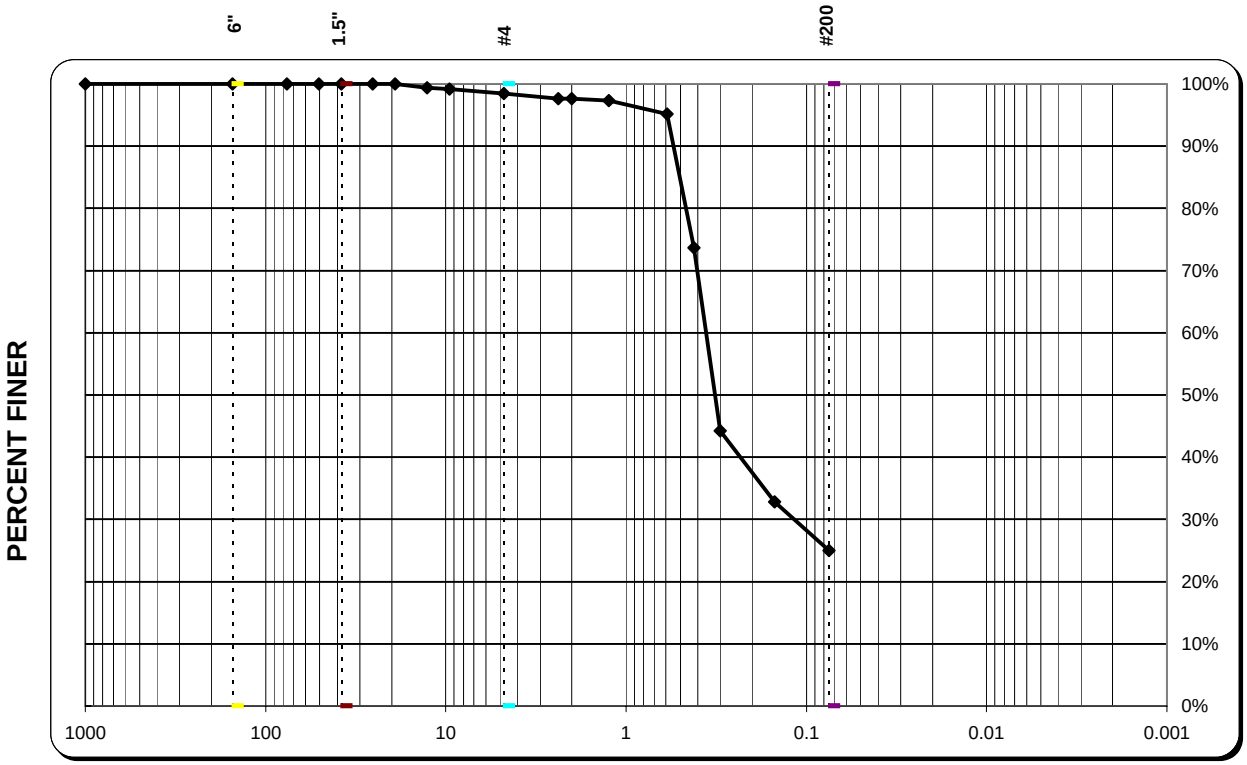
GRAIN SIZE DISTRIBUTION GRAPH



GRAIN SIZE - mm

TEST SUMMARY

Sieve Size	1 1/2"	3/4"	3/8"	#4	#10	#40	#100	#200
% Passing (Cumulative)	100	100	99	98	98	74	33	25.0
Specification								

% GRAVEL =	1.5	**D_{85} =** 0.5	**D_{15} =**
% SAND =	73.5	**D_{60} =** 0.4	**D_{10} =**
% SILT & CLAY =	25.0	**D_{50} =** 0.3	**C_U =**
		D_{30} = 0.1	**C_C =**

Sample Date: 9/8/08

Project No.: 69085034

Project Name: Porter Arroyo

Report Date: 11/3/2008

Sample Location: Blend: TP08-3 @ 0-1' & TP08-4 @ 0-1'

Liquid Limit: 18

Plasticity Index: 2

USCS Classification: SM

Material Description: Silty Sand

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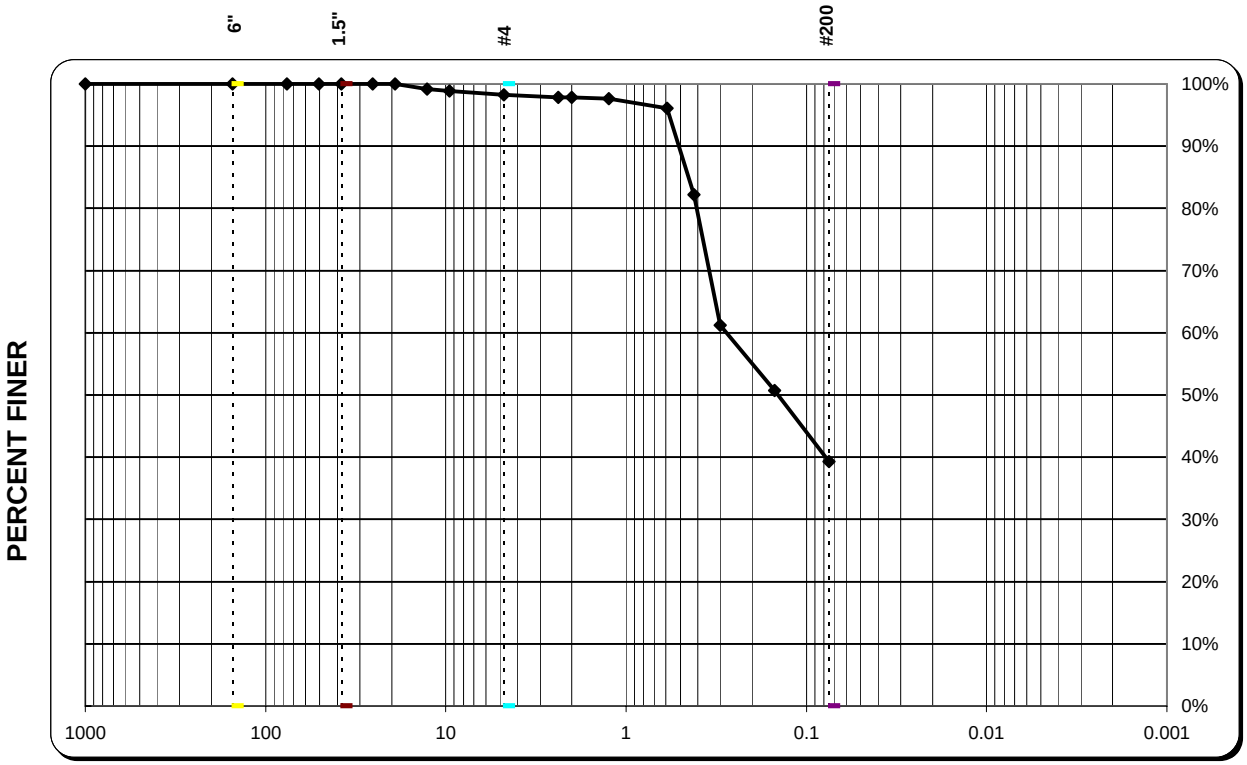
GRAIN SIZE DISTRIBUTION GRAPH



GRAIN SIZE - mm

TEST SUMMARY

Sieve Size	1 1/2"	3/4"	3/8"	#4	#10	#40	#100	#200
% Passing (Cumulative)	100	100	99	98	98	82	51	39.3
Specification								

% GRAVEL =	1.7	**D_{85} =** 0.5	**D_{15} =**
% SAND =	59.0	**D_{60} =** 0.3	**D_{10} =**
% SILT & CLAY =	39.3	**D_{50} =** 0.1	**C_U =**
		D_{30} =	**C_C =**

Sample Date: 9/8/08

Project No.: 69085034

Project Name: Porter Arroyo

Report Date: 11/3/2008

Sample Location: 30%-70% Blend

Liquid Limit: 23

Plasticity Index: 7

USCS Classification: SC-SM

Material Description: Clayey Silty Sand

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Terracon
#4A County Road 3499
Flora Vista, NM 87415
(505) 334-2900 Fax (505) 334-9703

SUMMARY OF LABORATORY TEST RESULTS

Larkin Group of New Mexico
8500 Menual Blvd, NE Suite A-440
Albuquerque, New Mexico 87112
ATTENTION: David Owsley

Report Date: 2/24/03

JOB NO.: 66035601

Sample No.: 66A- 0153

PROJECT: Porter Arroyo Detention Structure

INTENDED USE: General Fill

Physical Properties			
Laboratory Testing	Results	Spec's.	Pass/Fail
Liquid Limit, ASTM D4318	32		
Plastic Limit, ASTM D4318	15		
Plasticity Index, ASTM D4318	17		

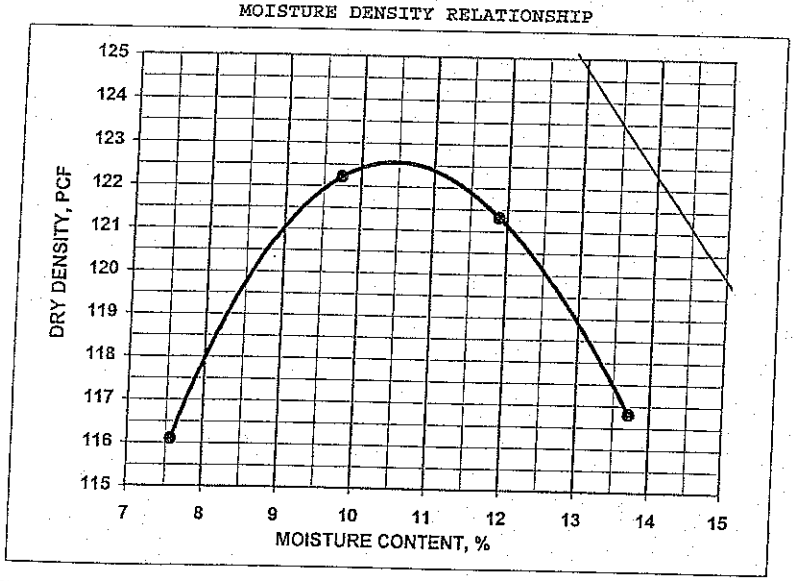
MATERIAL SOURCE: On site blend

SAMPLE LOCATION: B1 @ 5', B2 @ 5', B2 @ 10' & B3 @ 5'

MATERIAL DESCRIPTION/CONDITION:

SAMPLED BY: Christie Vliss Date: 1/23/03

MOISTURE DENSITY RELATIONSHIP



Sieve Analysis

ASTM C117, C136

Sieve Size	% Passing	Specifications minimum	Specifications maximum	Pass/Fail
6-inch				
3-inch				
2-inch				
1 1/2-inch				
1-inch				
3/4-inch				
1/2-inch				
3/8-inch				
No. 4	100			
No. 8	99			
No. 16	96			
No. 30	82			
No. 50	62			
No. 100	51			
No. 200	39.0			

TEST METHOD: ASTM D698 TEST PROCEDURE: A

Specific Gravity Used For Zero Air Voids Curve: 2.70

Oversized Particles, %: 0.0

Bulk Specific Gravity of Oversized Particles: N/A

Absorption of Oversized Particles, %: N/A

MAXIMUM DRY DENSITY: 123.7 lb/ft³ at 95% ⇒ 117.5

OPTIMUM MOISTURE: 10.5 % → in at 8.5 × 117.5 ⇒ 127.5 lb/ft³

emarks:

sandstone 45% 5×10⁻⁷

Terracon

4A County Road 3499
Flaor Vista, New Mexico 87415
Phone - 505.334.2900
Fax - 505.334.9703

LABORATORY COMPACTION CHARACTERISTICS OF SOIL

CLIENT NAME:	Larkin Group	CURVE NO.: 1	DATE: 11/03/08
PROJECT NAME:	Porter Arroyo		
PROJECT LOCATION:	Farmington, New Mexico		
PROJECT NUMBER:	69085034		
MATERIAL SOURCE:	30% 70% Blend		
SAMPLE DESCRIPTION:	Clayey Silty Sand		
MATERIAL CLASSIFICATION:	SC-SM		
TEST PROCEDURE:	ASTM D698, Method A		
COMPACTION RAMMER:	Manual		
DATE PERFORMED:	September 15, 2008		
LABORATORY TECHNICIAN:	SC/KB		

TEST RESULTS

MAXIMUM DRY DENSITY, pcf
123.1

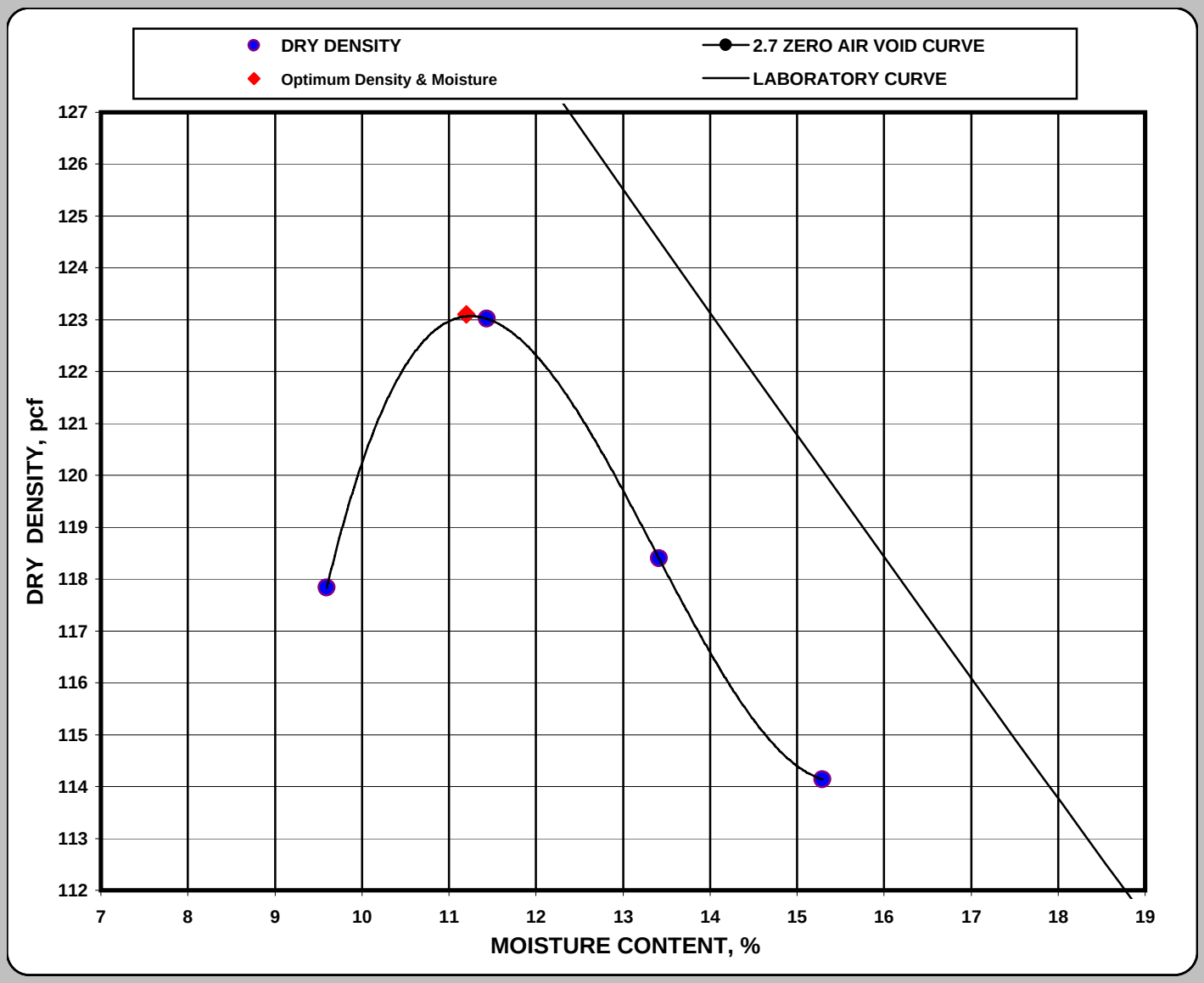
OPTIMUM MOISTURE, %
11.2

Placement Range: 9.2 - 13.2

ATTERBERG LIMITS

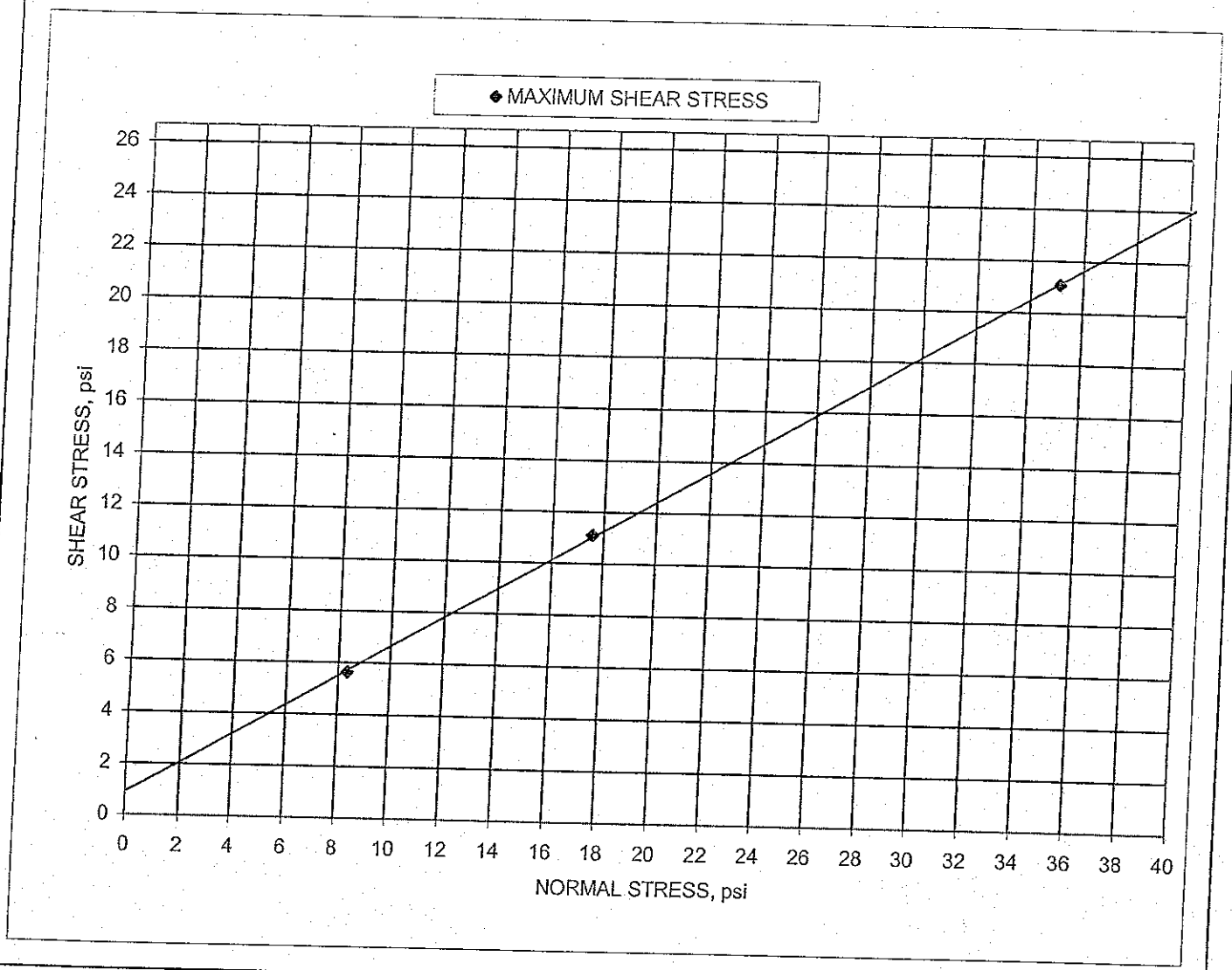
LIQUID LIMIT:	23
PLASTICITY INDEX:	7
% PASSING #200:	39

Reviewed By: KMP



**NP Denotes test procedure not performed*

DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS
ASTM D3080



			FRICTION ANGLE	COHESION	NORMAL STRESS, psi	NORMAL STRESS, psi	NORMAL STRESS, psi
		AT MAXIMUM SHEAR STRESS	29.9 deg	0.9 psi	8.34	17.57	35.13
INITIAL AREA, mm2	2938.1	INITIAL MOISTURE, %			10.6	10.2	10.1
INITIAL LENGTH, mm	25.40	INITIAL DRY DENSITY, pcf			115.6	117.2	116.5
SPECIFIC GRAVITY	2.70	INITIAL SATURATION, %			63	63	61
SG TESTED		INITIAL VOID RATIO			0.46	0.44	0.45
SG ASSUMED	X	FINAL MOISTURE, %			NA	NA	NA
LIQUID LIMIT		FINAL SATURATION, %			NA	NA	NA
PLASTIC LIMIT		FINAL VOID RATIO			NA	NA	NA
PLASTICITY INDEX		MAXIMUM SHEAR STRESS, psi			5.64	11.11	21.09
SAMPLE TYPE	REMOLDED	0.482" HORIZONTAL DEF. SHEAR STRESS, psi			NA	NA	NA
SAMPLE DESCRIPTION	SANDY CLAY						

PROJECT NAME: PORTER ARROYO

LOCATION: FARMINGTON, NM

JOB NO.: 66035601

DATE: 2/20/03

BORING NO. B1-05, B2-05, B2-5-10, & B3-05

SAMPLE NO. BLEND

DEPTH, feet REMOLD B

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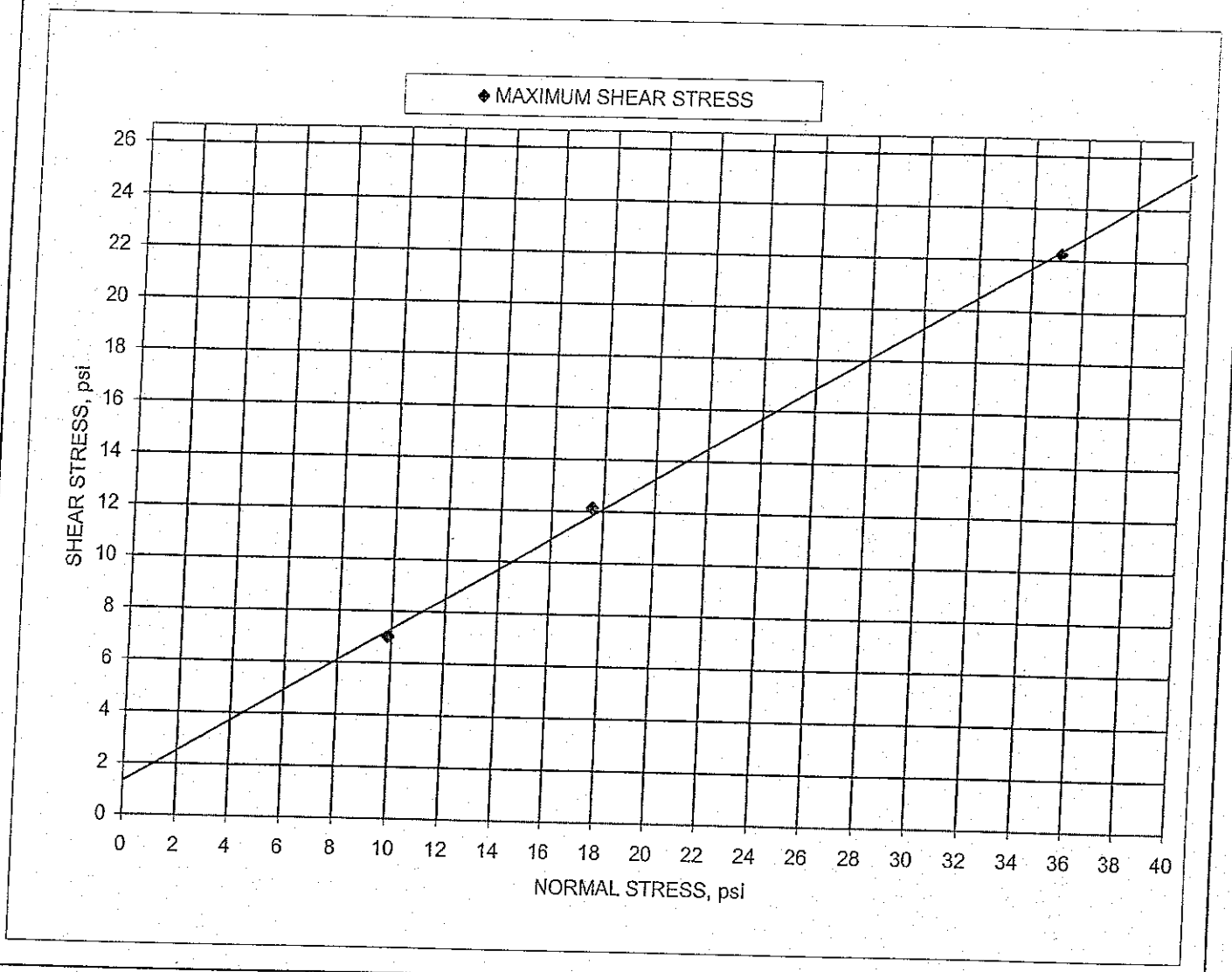
DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS
ASTM D3080



AT MAXIMUM SHEAR STRESS		FRICTION ANGLE 30.9 deg	COHESION 1.3 psi	NORMAL STRESS, psi 9.88	NORMAL STRESS, psi 17.57	NORMAL STRESS, psi 35.13
INITIAL AREA, mm2	2938.1	INITIAL MOISTURE, %		10.0	9.7	9.8
INITIAL LENGTH, mm	25.40	INITIAL DRY DENSITY, pcf		118.9	120.1	117.9
SPECIFIC GRAVITY	2.70	INITIAL SATURATION, %		65	65	62
SG TESTED		INITIAL VOID RATIO		0.42	0.40	0.43
SG ASSUMED	X	FINAL MOISTURE, %		NA	NA	NA
LIQUID LIMIT		FINAL SATURATION, %		NA	NA	NA
PLASTIC LIMIT		FINAL VOID RATIO		NA	NA	NA
PLASTICITY INDEX		MAXIMUM SHEAR STRESS, psi		7.01	12.14	22.25
SAMPLE TYPE	REMOLDED	0.482" HORIZONTAL DEF. SHEAR STRESS, psi		NA	NA	NA
SAMPLE DESCRIPTION	SANDY CLAY					

PROJECT NAME: PORTER ARROYO

LOCATION: FARMINGTON, NM

JOB NO.: 66035601

DATE: 2/20/03

BORING NO. B1-05, B2-05, B2-5-10, & B3-05

SAMPLE NO. BLEND

DEPTH, feet REMOLD A

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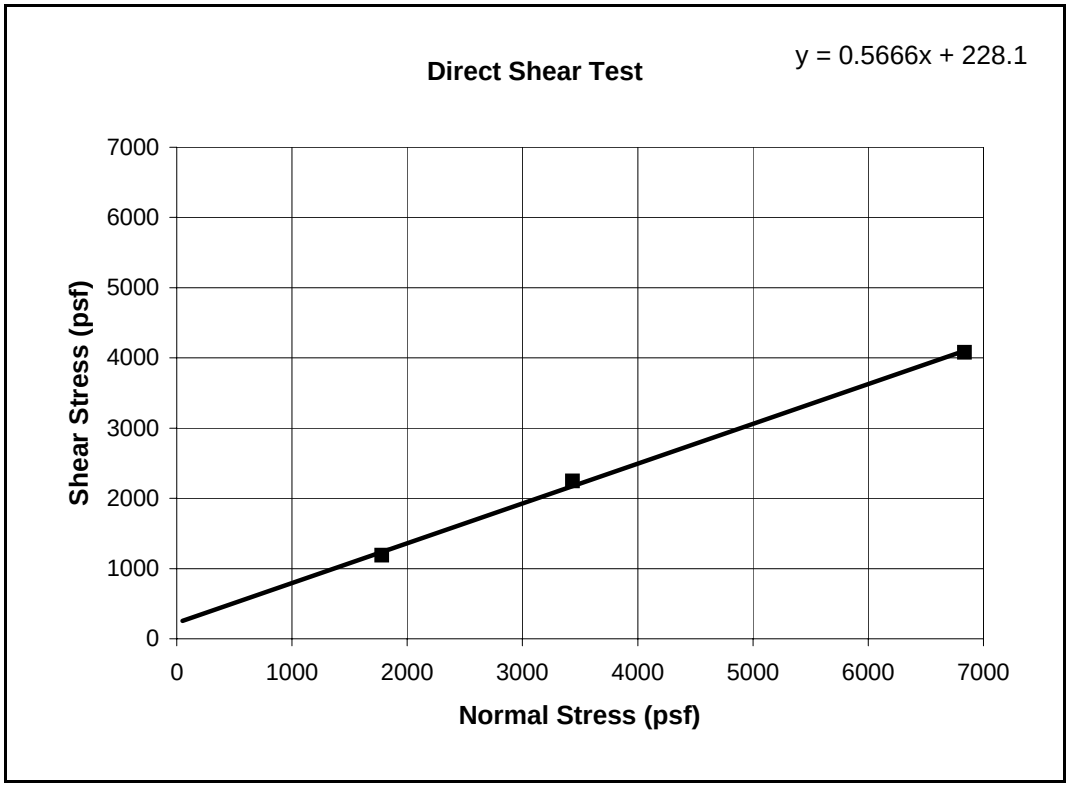
Terracon
4172 Center Park Drive
Colorado Springs, Colorado 80917
Ph (719) 597-2116 Fax (719) 597-2117

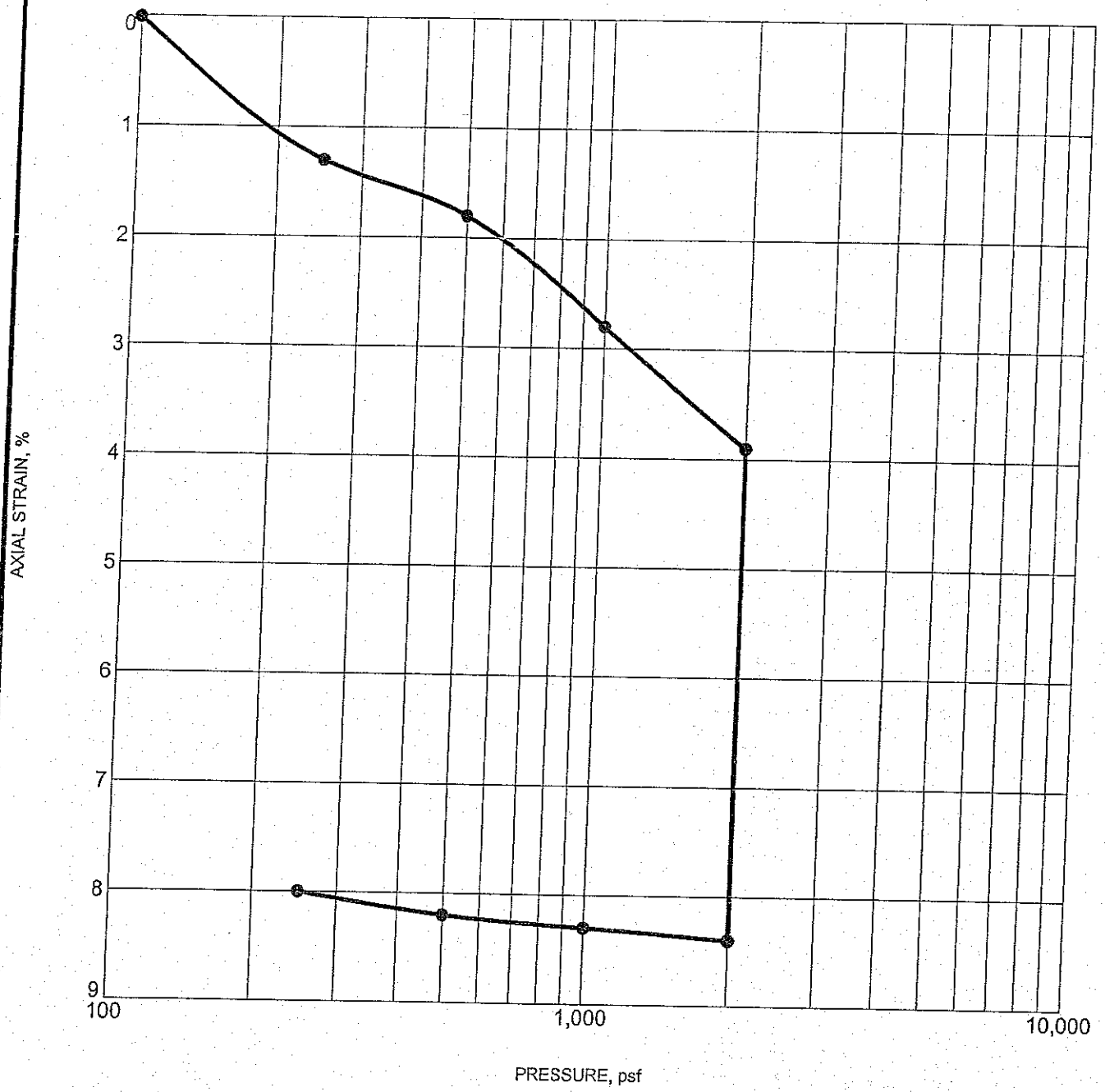
DIRECT SHEAR
ASTM D 3080

CLIENT:	Larkin Group	**DATE OF TEST:**	9/25/08
PROJECT:	Porter Arroyo		
LOCATION:	30% 70% Blend		
TERRACON NO.	69085034	**CLASSIFICATION:**	SC-SM

SAMPLE DATA TEST RESULTS

TEST SPECIMEN NO.	1	2	3
NORMAL PRESSURE (psf)	1780	3435	6836
SHEAR STRESS (psf)	1188	2247	4078
ULTIMATE FRICTION ANGLE	29		
EFFECTIVE COHESION (psf)	200		





Specimen Identification		Classification	γ_d, pcf	WC,%
● B3	5.0ft	POORLY GRADED SAND WITH SILT (SP-SM)	101	1

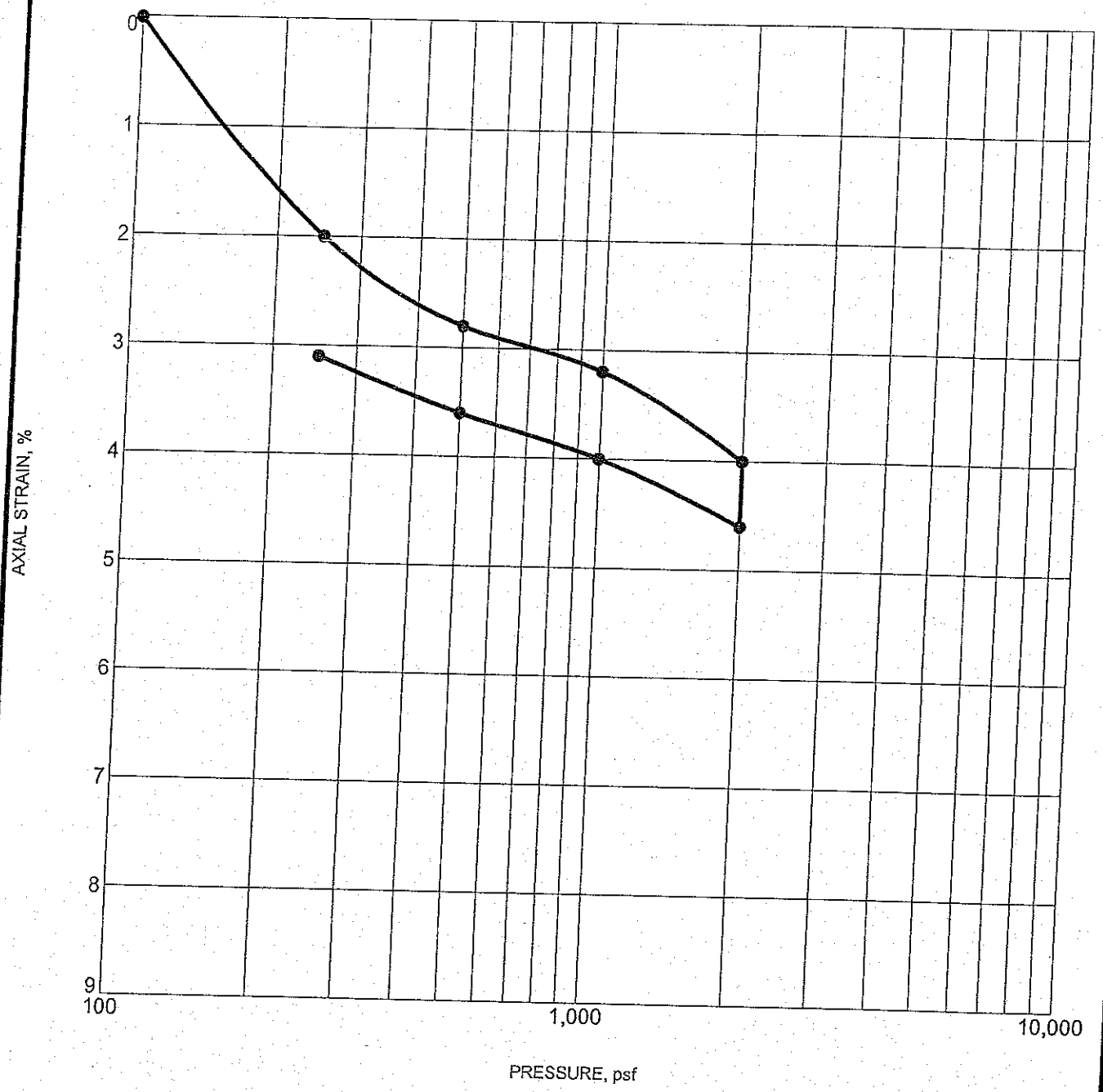
Notes: Saturated at 2000 psf

TC CONSOL STRAIN 66035601.GPJ TERRACON.GDT 8/1/03

Terracon

CONSOLIDATION TEST

Project: Porter Arroyo Stormwater Detention Dam
Site: North of Pinon Hills & East of College Blvd Farmington, New Mexico
Job #: 66035601
Date: 8-1-03



Specimen Identification		Classification	γ_d, pcf	WC,%
● B3	15.0ft	CLAYEY SAND	102	7

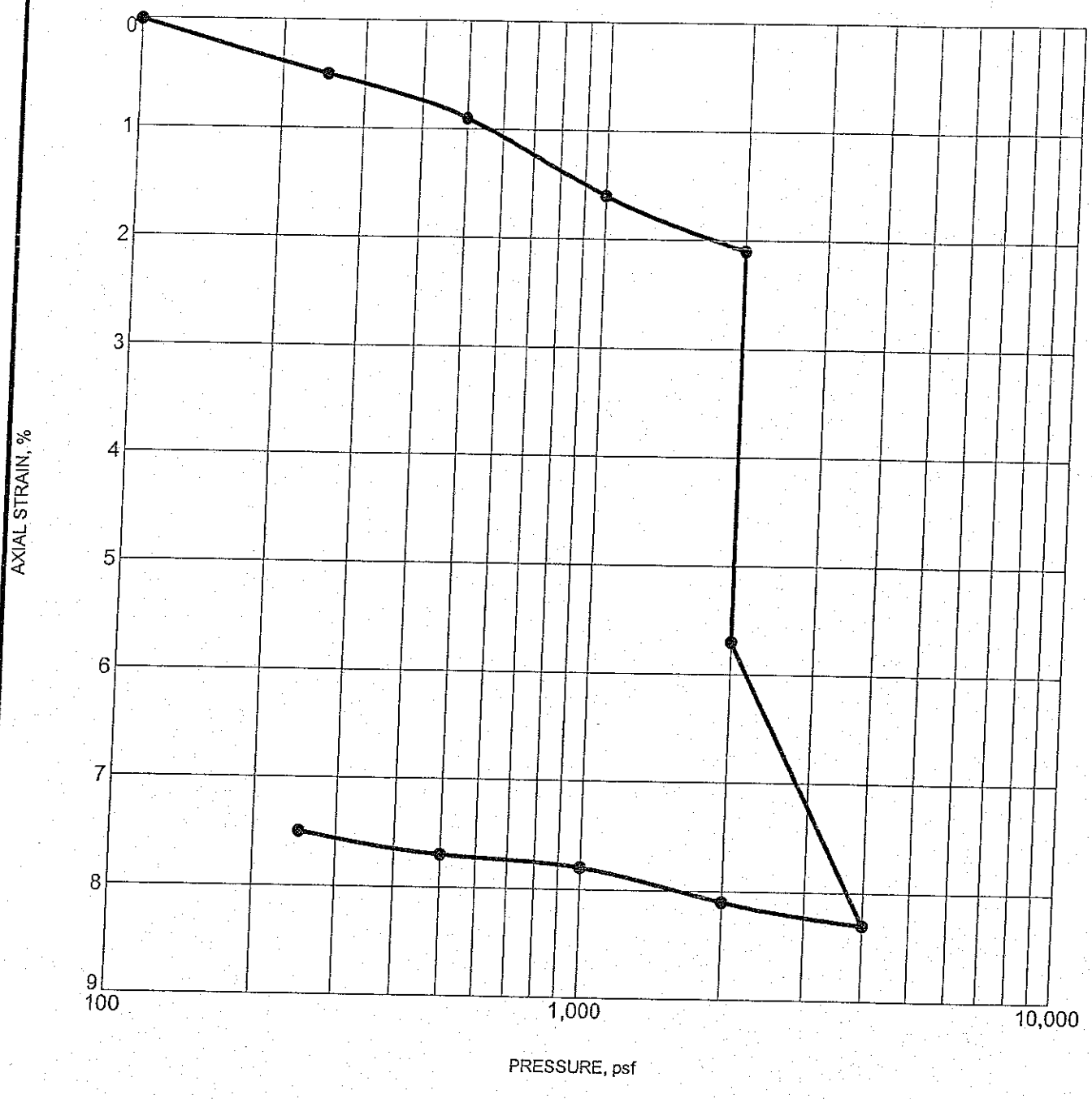
Notes: Saturated at 2000 psf

Terracon

CONSOLIDATION TEST

Project: Porter Arroyo Stormwater Detention Dam
Site: North of Pinon Hills & East of College Blvd Farmington, New Mexico
Job #: 66035601
Date: 8-1-03

TC CONSOL STRAIN 66035601.GPJ TERRACON.GDT 8/1/03



Specimen Identification		Classification	γ_d, pcf	WC,%
● B3	20.0ft	CLAYEY SAND	102	4

Notes:

Terracon

CONSOLIDATION TEST

Project: Porter Arroyo Stormwater Detention Dam
Site: North of Pinon Hills & East of College Blvd Farmington, New Mexico
Job #: 66035601
Date: 8-1-03

TC CONSOL STRAIN 66035601.GPJ TERRACON.GDT 8/1/03

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 90 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N CaSO4

PROJECT:	PORTER ARROYO	TERRACON JOB #:	66035601
SAMPLE	FARMINGTON, NM	DATE:	2/20/03
ID:	B1-05, B2-05, B2-5-10, & B3-05; REMOLD B		
DESCR.:	SANDY CLAY		

Durham Perm Cell
BURETTE Area 0.317 cm^2

INITIAL					
MOISTURE%		DENSITY			
W & T, g	86.68	WET WT, g	216.1		
D & T, g	80.44	DIA, in	2.00	5.08	cm
T, g	20.77	HT, in	2.02	5.14	cm
		AREA		20.27	cm^2
MOIST-		DENSITY:	129.6	PCF WET	
URE, %	10.5	DENSITY:	117.3	PCF DRY	

SPEC GRAV:	2.700	REMOLD (Y/N):	YES
POROSITY, %:	30.4	PROCTOR:	123.7
SATURATION, %:	64.6	OPTIMUM:	10.5
VOID RATIO:	0.44	COMPACTION, %:	94.8
		OVER OPTIMUM, %:	0.0

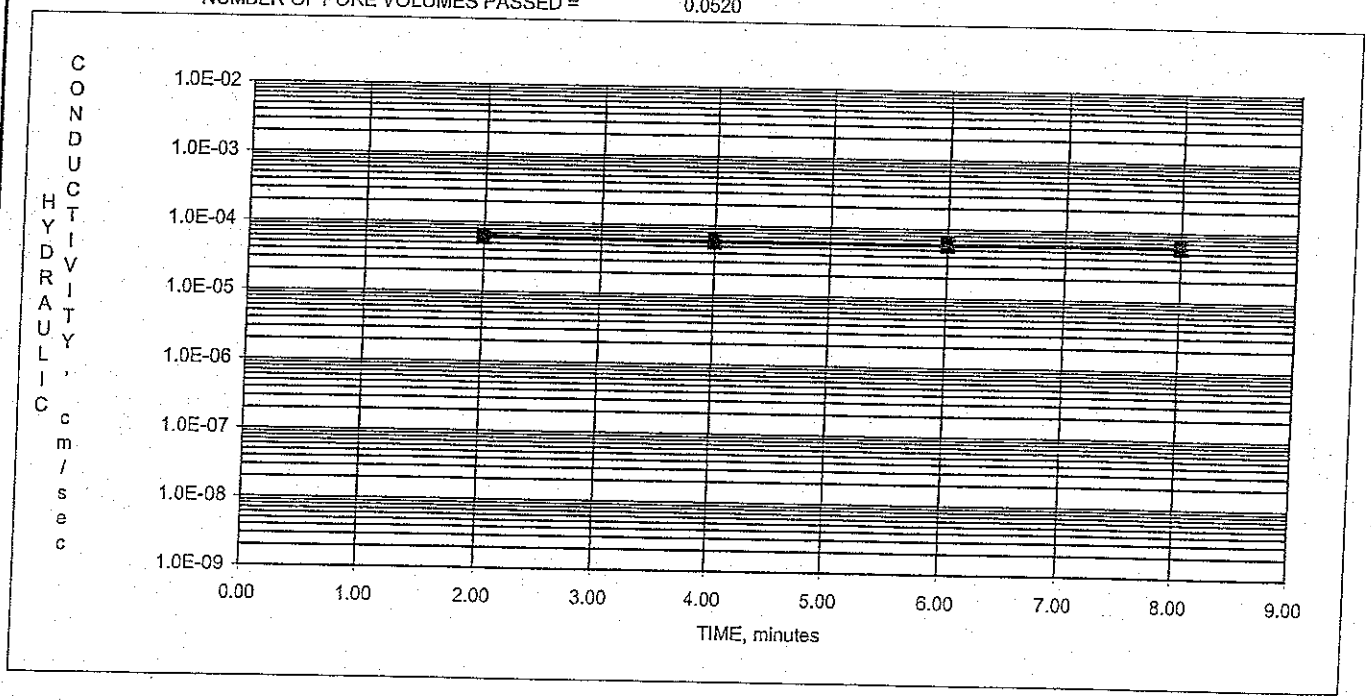
SATURATION:	LATERAL PRESS.:	105.0 psi	BACK PRESSURE (=UPPER=LOWER):	100.0 psi	
TEST:	LATERAL PRESS.:	105.0 psi	UPPER: 100.0 psi	LOWER:	100.0 psi
			BIAS PRESSURE (=LOWER-UPPER)	0.0 psi	

Upper cm^3	Lower cm^3	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
23.0	42.9	0.00	19.9									
24.7	41.1	2.00	16.4	0.193438	6.19E-05	1.7	1.8	0.94	3.2	3	22	0.956
26.1	39.8	4.00	13.7	0.183542	5.87E-05	1.4	1.4	1.04	2.7	2	22	0.956
27.3	38.6	6.00	11.4	0.184522	5.90E-05	1.2	1.2	1.00	2.2	2	22	0.956
28.2	37.6	8.00	9.4	0.188508	6.03E-05	0.9	1.0	0.95	1.8	1	22	0.956

HYDRAULIC CONDUCTIVITY (k) = AVERAGE **6.0E-05** cm/sec

MAXIMUM HYDRAULIC GRADIENT	1.0E-03 TO 1.0E-04	2	0.75< RATIO <1.25	% < 25 AT > 1.0E-8 OR % < 50 AT < 1.0E-8
	1.0E-04 TO 1.0E-05	5		
	1.0E-05 TO 1.0E-06	10		
	1.0E-06 TO 1.0E-07	20		
	1.0E-07 TO 1.0E-10	30		

NUMBER OF PORE VOLUMES PASSED = 0.0520



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MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 90 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N CaSO4

PROJECT:	PORTER ARROYO	TERRACON JOB #:	66035601
SAMPLE	FARMINGTON, NM	DATE:	2/20/03
ID:	B1-05, B2-05, B2-5-10, & B3-05; REMOLD A		
DESCR.:	SANDY CLAY		

Durham Perm Cell
BURETTE Area 0.317 cm^2

INITIAL					
MOISTURE%		DENSITY			
W & T, g	87.01	WET WT, g	216.3		
D & T, g	80.73	DIA, in	2.00	5.07	cm
T, g	20.83	HT, in	2.02	5.14	cm
		AREA		20.21	cm^2
MOIST-		DENSITY:	130.1	PCF WET	
URE, %	10.5	DENSITY:	117.7	PCF DRY	

SPEC GRAV:	2.700	REMOLD (Y/N):	YES
POROSITY, %:	30.2	PROCTOR:	123.7
SATURATION, %:	65.6	OPTIMUM:	10.5
VOID RATIO:	0.43	COMPACTION, %:	95.2
		OVER OPTIMUM, %:	0.0

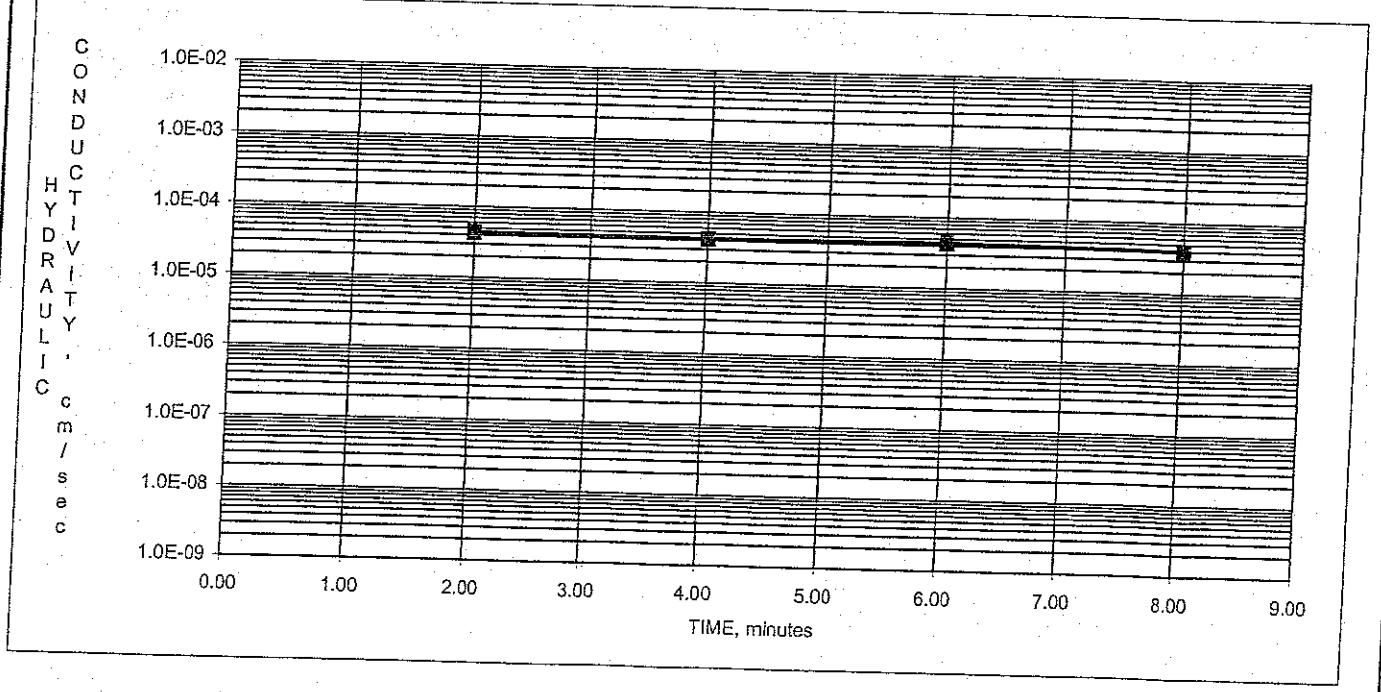
SATURATION:	LATERAL PRESS.:	105.0 psi	BACK PRESSURE (=UPPER=LOWER):	100.0 psi
TEST:	LATERAL PRESS.:	105.0 psi	UPPER: 100.0 psi	LOWER: 100.0 psi
			BIAS PRESSURE (=LOWER-UPPER)	0.0 psi

Upper cm^3	Lower cm^3	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
24.6	45.1	0.00	20.5									
25.9	43.8	2.00	17.9	0.135624	4.35E-05	1.3	1.3	1.00	3.5	3	22	0.956
27.0	42.7	4.00	15.7	0.131140	4.21E-05	1.1	1.1	1.00	3.1	1	22	0.956
28.0	41.7	6.00	13.7	0.136265	4.37E-05	1.0	1.0	1.00	2.7	3	22	0.956
28.8	40.9	8.00	12.1	0.124190	3.98E-05	0.8	0.8	1.00	2.4	6	22	0.956

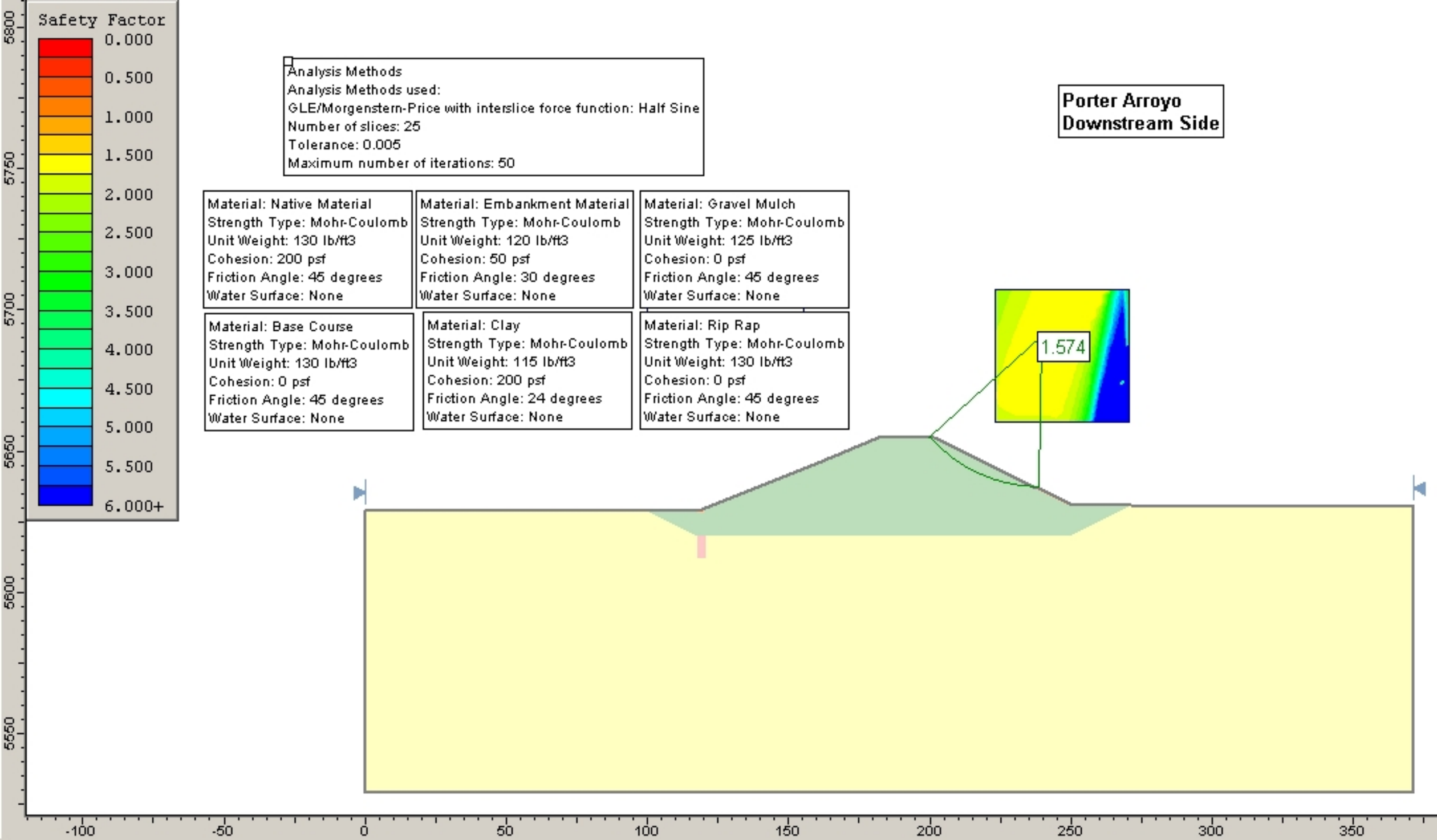
HYDRAULIC CONDUCTIVITY (k) = AVERAGE 4.2E-05 cm/sec

MAXIMUM HYDRAULIC GRADIENT				
	1.0E-03 TO 1.0E-04	2	0.75< RATIO <1.25	% < 25 AT > 1.0E-8 OR % < 50 AT < 1.0E-8
	1.0E-04 TO 1.0E-05	5		
	1.0E-05 TO 1.0E-06	10		
	1.0E-06 TO 1.0E-07	20		
	1.0E-07 TO 1.0E-10	30		

NUMBER OF PORE VOLUMES PASSED = 0.0425



Terracon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4.000
4.500
5.000
5.500
6.000+
Analysis Methods
Analysis Methods used:
GLE/Morgenstern-Price with interslice force function: Half Sine
Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Porter Arroyo
Downstream Side
Material: Native Material
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 200 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Embankment Material
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 50 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Gravel Mulch
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Base Course
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Clay
Strength Type: Mohr-Coulomb
Unit Weight: 115 lb/ft3
Cohesion: 200 psf
Friction Angle: 24 degrees
Water Surface: None
Material: Rip Rap
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
1.574
5800
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5700
5650
5600
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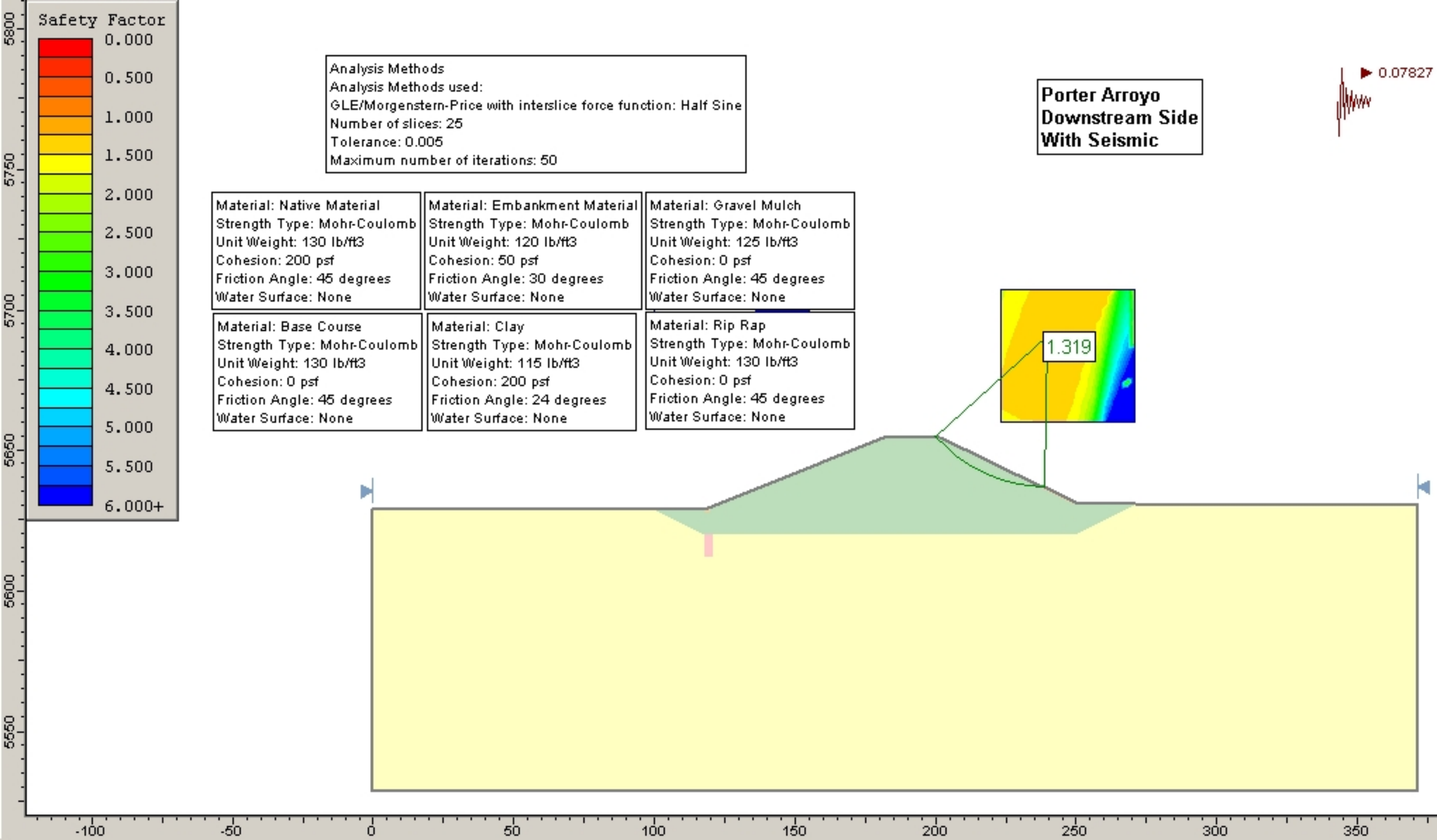
-100
-50
0
50
100
150
200
250
300
350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5.500
6.000+
Analysis Methods
Analysis Methods used:
GLE/Morgenstern-Price with interslice force function: Half Sine
Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Porter Arroyo
Downstream Side
With Seismic
0.07827
Material: Native Material
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 200 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Embankment Material
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 50 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Gravel Mulch
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Base Course
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Clay
Strength Type: Mohr-Coulomb
Unit Weight: 115 lb/ft3
Cohesion: 200 psf
Friction Angle: 24 degrees
Water Surface: None
Material: Rip Rap
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
1.319
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-50
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200
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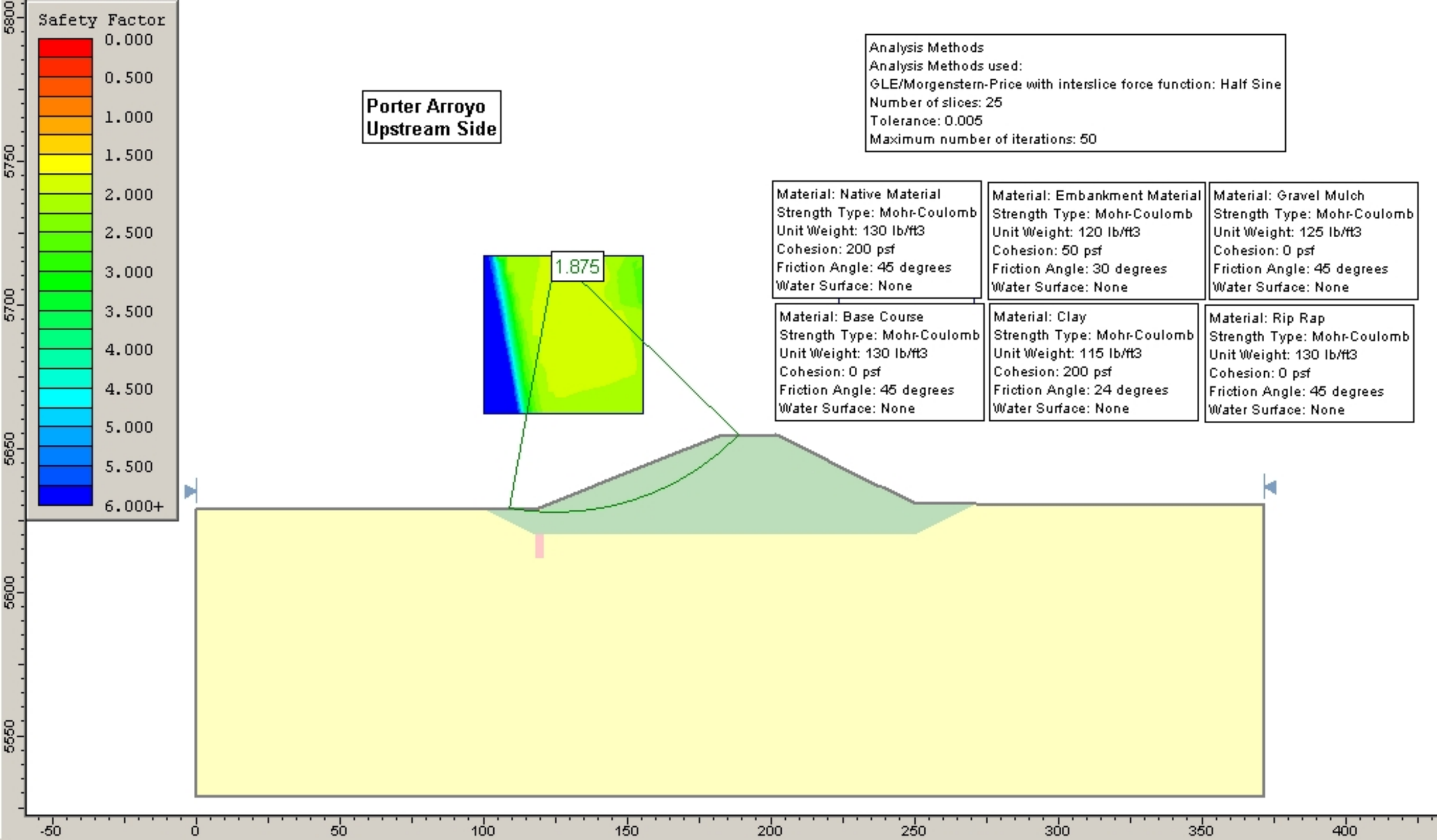
300
350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3.000
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4.000
4.500
5.000
5.500
6.000+
Porter Arroyo
Upstream Side
Analysis Methods
Analysis Methods used:
GLE/Morgenstern-Price with interslice force function: Half Sine
Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Material: Native Material
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 200 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Embankment Material
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 50 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Gravel Mulch
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Base Course
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Clay
Strength Type: Mohr-Coulomb
Unit Weight: 115 lb/ft3
Cohesion: 200 psf
Friction Angle: 24 degrees
Water Surface: None
Material: Rip Rap
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
1.875
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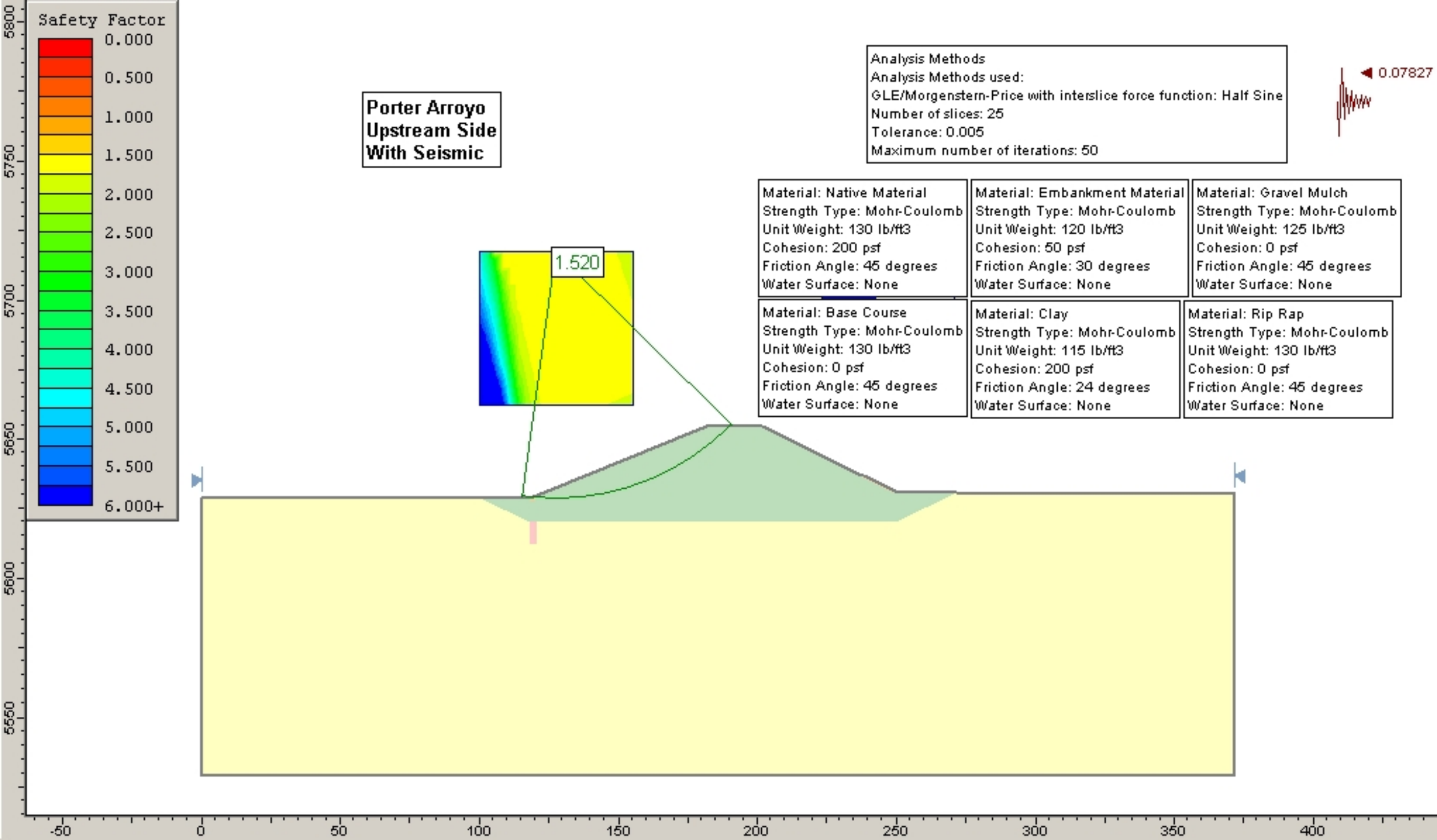
300
350
400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1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
Porter Arroyo
Upstream Side
With Seismic
Analysis Methods
Analysis Methods used:
GLE/Morgenstern-Price with interslice force function: Half Sine
Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
0.07827
1.520
Material: Native Material
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 200 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Embankment Material
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 50 psf
Friction Angle: 30 degrees
Water Surface: None
Material: Gravel Mulch
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Base Course
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
Material: Clay
Strength Type: Mohr-Coulomb
Unit Weight: 115 lb/ft3
Cohesion: 200 psf
Friction Angle: 24 degrees
Water Surface: None
Material: Rip Rap
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: None
5800
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5700
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5600
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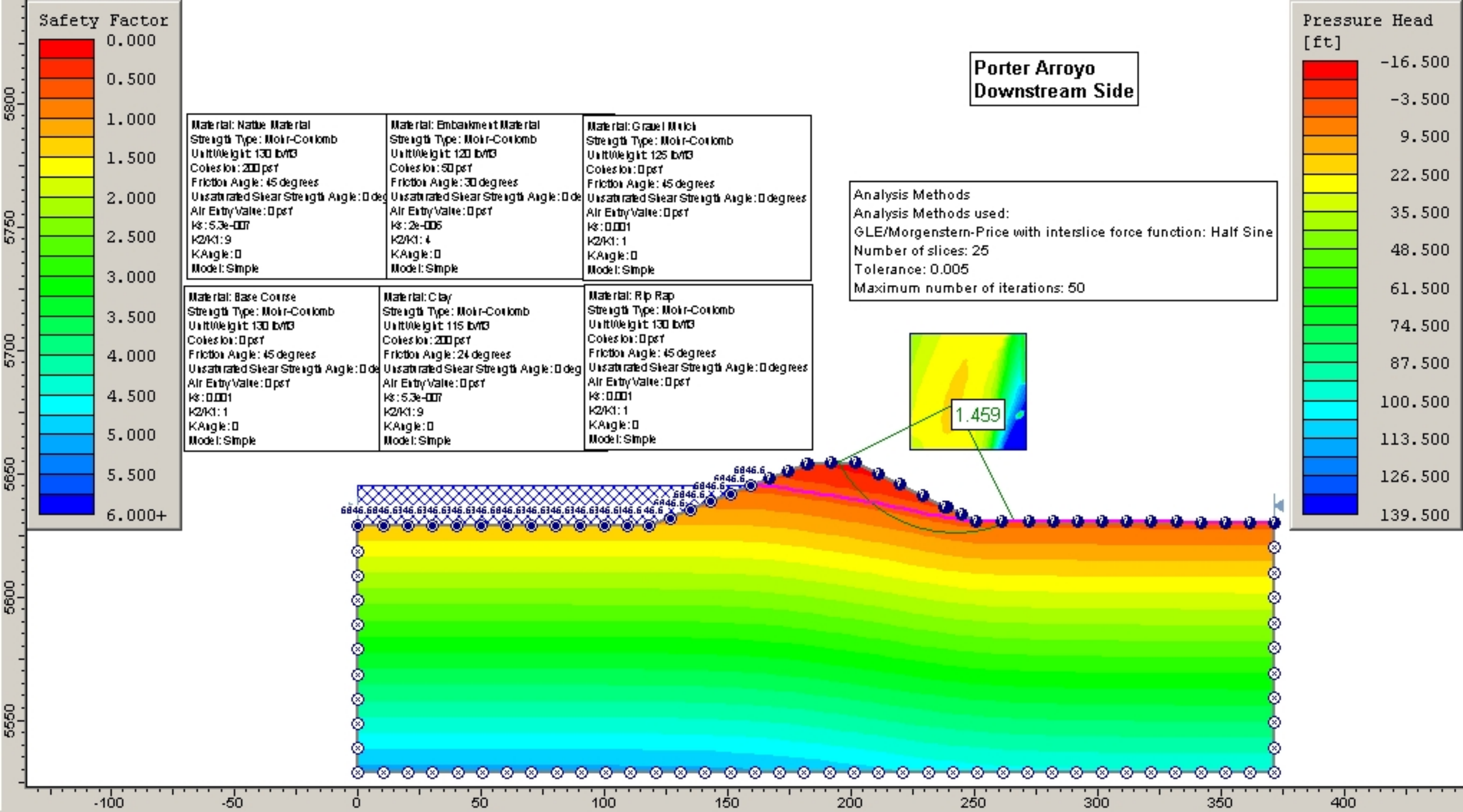
-50
0
50
100
150
200
250
300
350
400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0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
Pressure Head [ft]
-16.500
-3.500
9.500
22.500
35.500
48.500
61.500
74.500
87.500
100.500
113.500
126.500
139.500
Porter Arroyo
Downstream Side
Material: Native Material
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 200 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 deg
Air Entry Value: 0 psf
Ks: 5.3e-007
K2/K1: 9
KAngle: 0
Model: Simple
Material: Embankment Material
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 50 psf
Friction Angle: 30 degrees
Unsaturated Shear Strength Angle: 0 de
Air Entry Value: 0 psf
Ks: 2e-006
K2/K1: 4
KAngle: 0
Model: Simple
Material: Gravel Mulch
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Material: Base Course
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 de
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Material: Clay
Strength Type: Mohr-Coulomb
Unit Weight: 115 lb/ft3
Cohesion: 200 psf
Friction Angle: 24 degrees
Unsaturated Shear Strength Angle: 0 deg
Air Entry Value: 0 psf
Ks: 5.3e-007
K2/K1: 9
KAngle: 0
Model: Simple
Material: Rip Rap
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Analysis Methods
Analysis Methods used:
GLE/Morgenstern-Price with interslice force function: Half Sine
Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
1.459
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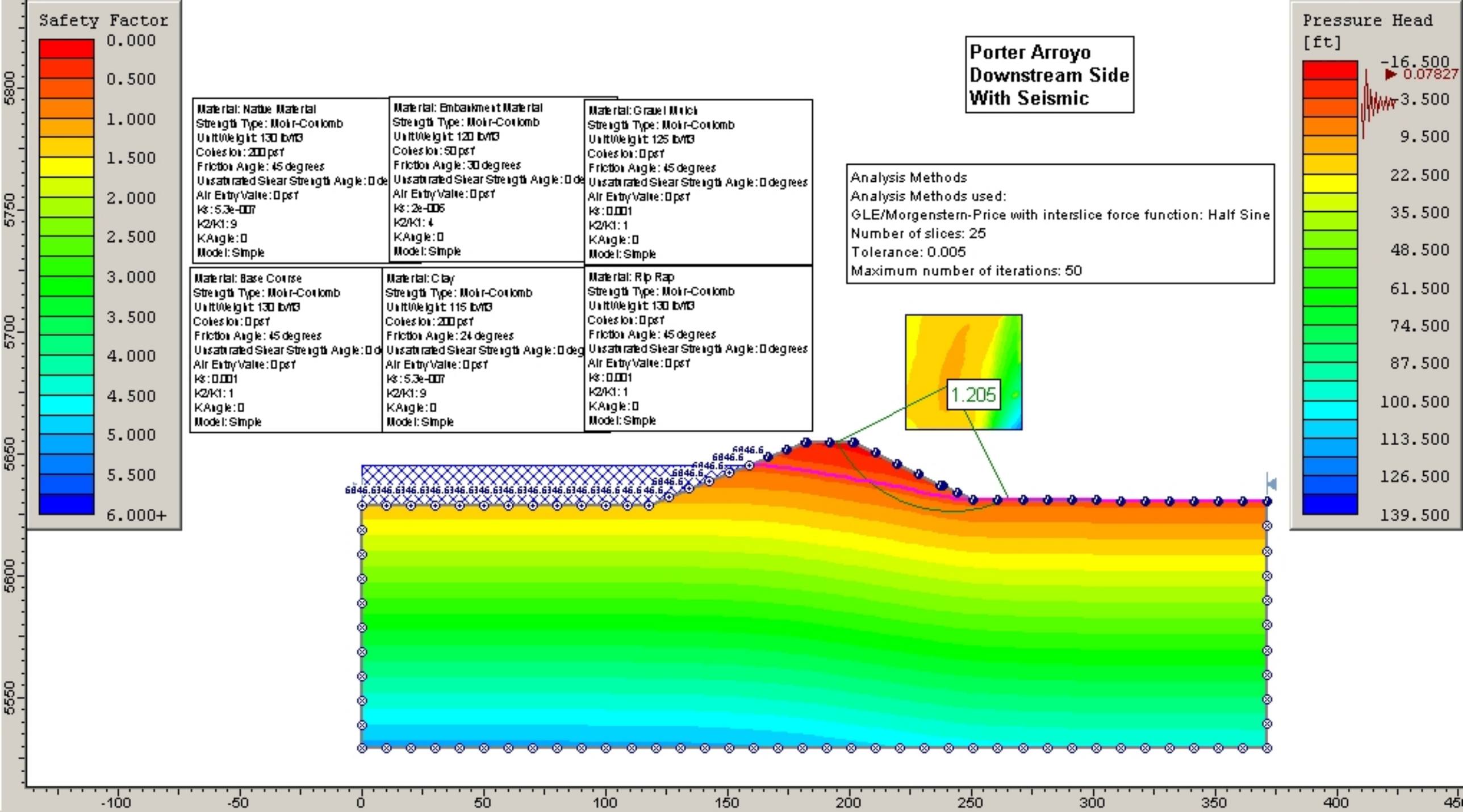
Porter Arroyo
Downstream Side
With Seismic
Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
Pressure Head
[ft]
-16.500
0.07827
3.500
9.500
22.500
35.500
48.500
61.500
74.500
87.500
100.500
113.500
126.500
139.500
Material: Native Material
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 200 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 de
Air Entry Value: 0 psf
Ks: 5.3e-007
K2/K1: 9
KAngle: 0
Model: Simple
Material: Embankment Material
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 50 psf
Friction Angle: 30 degrees
Unsaturated Shear Strength Angle: 0 de
Air Entry Value: 0 psf
Ks: 2e-006
K2/K1: 4
KAngle: 0
Model: Simple
Material: Gravel Mulch
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Material: Base Course
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 d
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Material: Clay
Strength Type: Mohr-Coulomb
Unit Weight: 115 lb/ft3
Cohesion: 200 psf
Friction Angle: 24 degrees
Unsaturated Shear Strength Angle: 0 deg
Air Entry Value: 0 psf
Ks: 5.3e-007
K2/K1: 9
KAngle: 0
Model: Simple
Material: Rip Rap
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Analysis Methods
Analysis Methods used:
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Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
1.205
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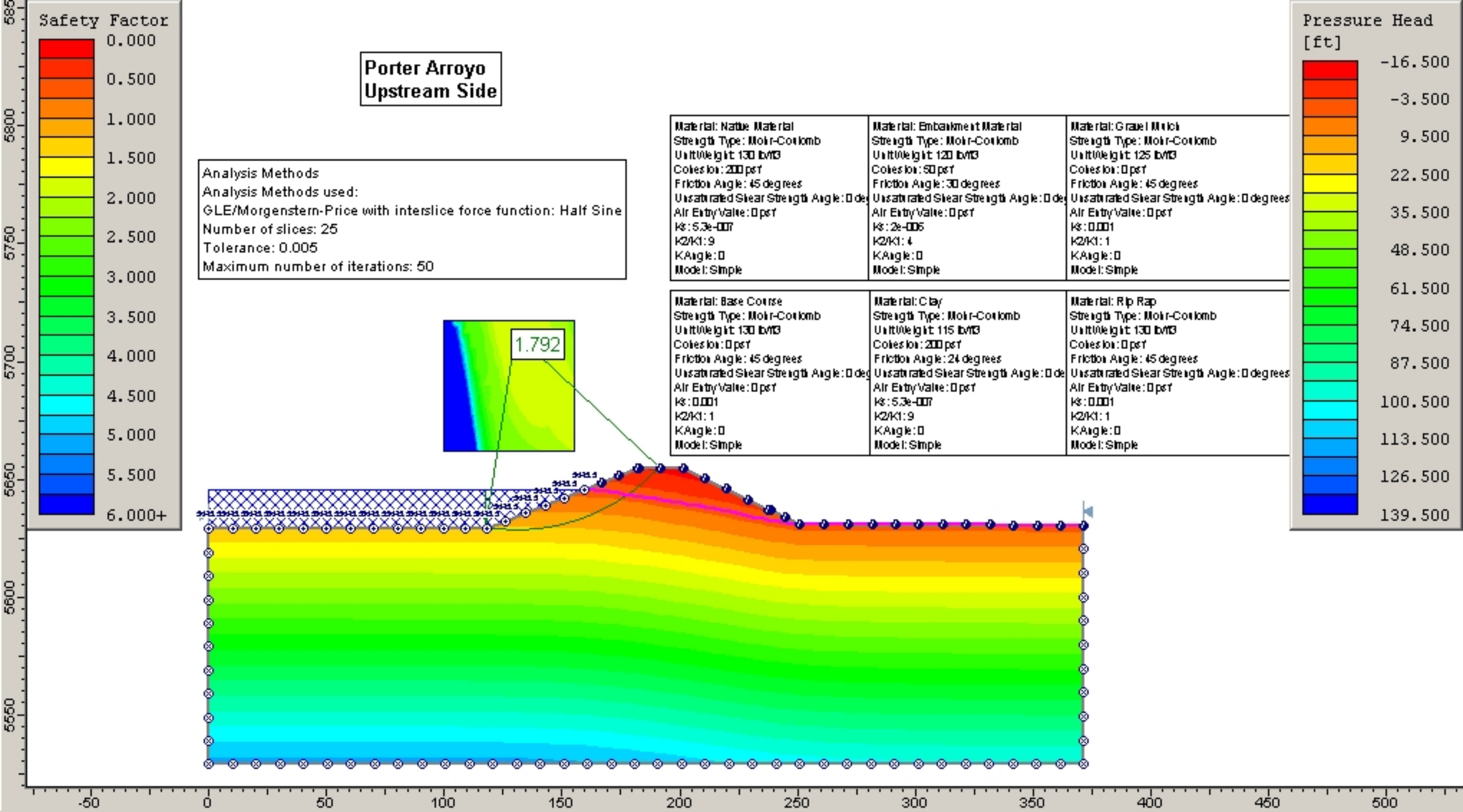
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1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
Porter Arroyo
Upstream Side
Analysis Methods
Analysis Methods used:
GLE/Morgenstern-Price with interslice force function: Half Sine
Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Material: Native Material
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 200 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 5.3e-007
K2/K1: 9
KAngle: 0
Model: Simple
Material: Embankment Material
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 50 psf
Friction Angle: 30 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 2e-005
K2/K1: 4
KAngle: 0
Model: Simple
Material: Gravel Mulch
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Material: Base Course
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Material: Clay
Strength Type: Mohr-Coulomb
Unit Weight: 115 lb/ft3
Cohesion: 200 psf
Friction Angle: 24 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 5.3e-007
K2/K1: 9
KAngle: 0
Model: Simple
Material: Rip Rap
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degrees
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
1.792
Pressure Head
[ft]
-16.500
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9.500
22.500
35.500
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74.500
87.500
100.500
113.500
126.500
139.500
5850
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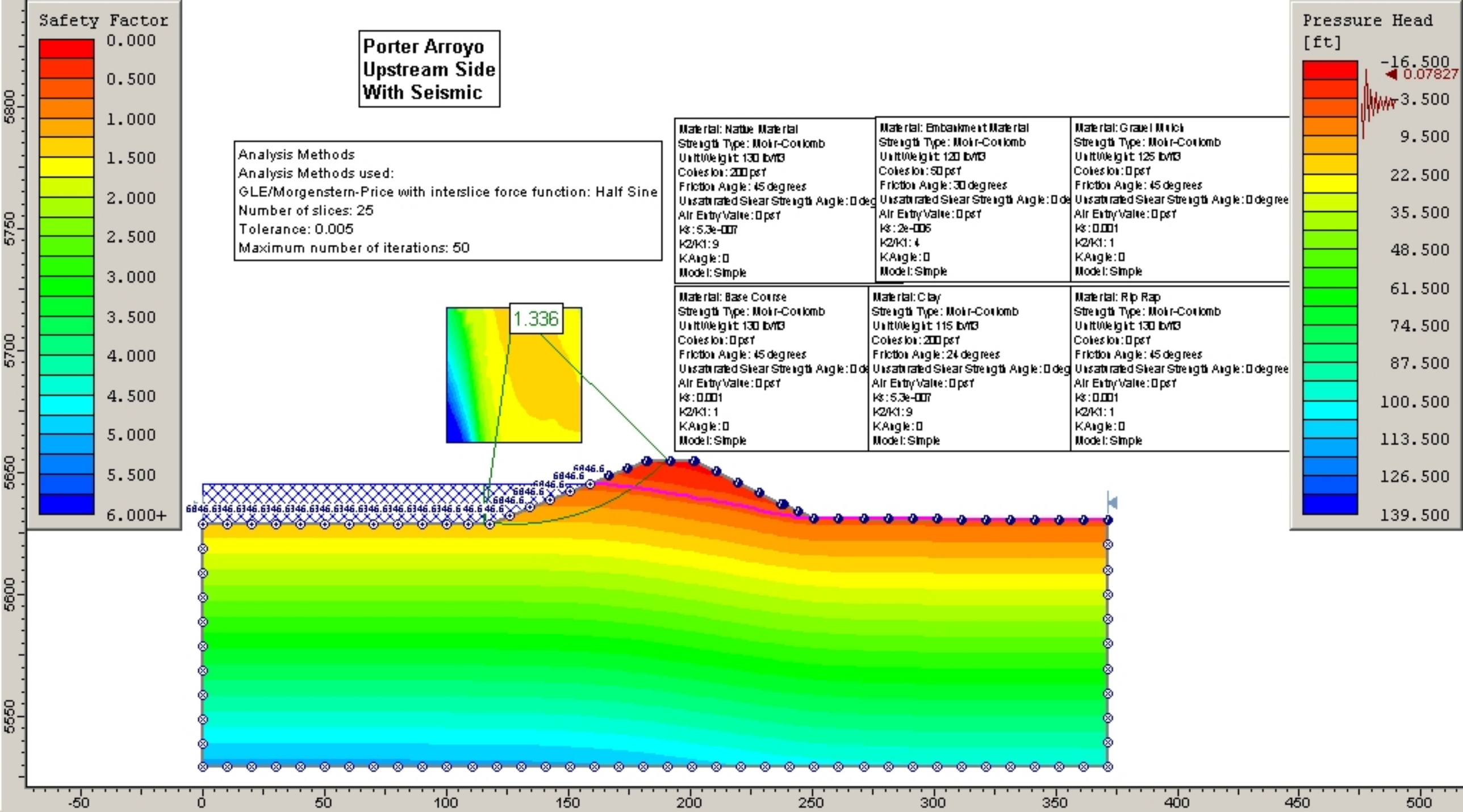
Porter Arroyo
Upstream Side
With Seismic
Safety Factor
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0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
Pressure Head
[ft]
-16.500
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3.500
9.500
22.500
35.500
48.500
61.500
74.500
87.500
100.500
113.500
126.500
139.500
Analysis Methods
Analysis Methods used:
GLE/Morgenstern-Price with interslice force function: Half Sine
Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Material: Native Material
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 200 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 deg
Air Entry Value: 0 psf
Ks: 5.3e-007
K2/K1: 9
KAngle: 0
Model: Simple
Material: Embankment Material
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 50 psf
Friction Angle: 30 degrees
Unsaturated Shear Strength Angle: 0 de
Air Entry Value: 0 psf
Ks: 2e-006
K2/K1: 4
KAngle: 0
Model: Simple
Material: Gravel Mulch
Strength Type: Mohr-Coulomb
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degree
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Material: Base Course
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 de
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
Material: Clay
Strength Type: Mohr-Coulomb
Unit Weight: 115 lb/ft3
Cohesion: 200 psf
Friction Angle: 24 degrees
Unsaturated Shear Strength Angle: 0 deg
Air Entry Value: 0 psf
Ks: 5.3e-007
K2/K1: 9
KAngle: 0
Model: Simple
Material: Rip Rap
Strength Type: Mohr-Coulomb
Unit Weight: 130 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Unsaturated Shear Strength Angle: 0 degree
Air Entry Value: 0 psf
Ks: 0.001
K2/K1: 1
KAngle: 0
Model: Simple
1.336
5800
5750
5700
5650
5600
5550
-50
0
50
100
150
200
250
300
350
400
450
500

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1-3/8" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value". For 3" O.D. ring samplers (RS) the penetration value is reported as the number of blows required to advance the sampler 12 inches using a 140-pound hammer falling 30 inches, reported as "blows per foot," and is not considered equivalent to the "Standard Penetration"or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 - 1	Very Soft
500 – 1,000	2 - 4	Soft
1,000 – 2,000	4 - 8	Medium Stiff
2,000 – 4,000	8 -15	Stiff
4,000 – 8,000	15 - 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Ring Sampler (RS) Blows/Ft.	Relative Density
0 – 3	0-6	Very Loose
4 – 9	7-18	Loose
10 – 29	19-58	Medium Dense
30 – 49	59-98	Dense
> 50	> 99	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	> 30

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GENERAL NOTES
Description of Rock Properties

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding and Foliation Spacing in Rock[a]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

Rock Quality Designator (RQD)[b]		Joint Openness Descriptors	
RQD, as a percentage	Diagnostic description	Openness	Descriptor
Exceeding 90	Excellent	No Visible Separation	Tight
90 – 75	Good	Less than 1/32 in.	Slightly Open
75 – 50	Fair	1/32 to 1/8 in.	Moderately Open
50 – 25	Poor	1/8 to 3/8 in.	Open
Less than 25	Very poor	3/8 in. to 0.1 ft.	Moderately Wide
		Greater than 0.1 ft.	Wide

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.
b. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976.
U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	$PI > 7$ and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
			$PI < 4$ or plots below "A" line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI lots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

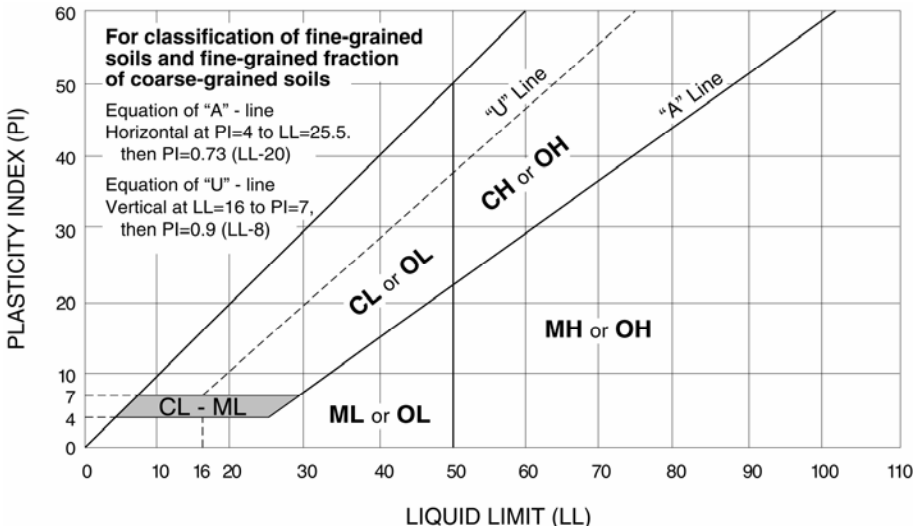
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] $PI \geq 4$ and plots on or above "A" line.

[O] $PI < 4$ or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



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