DEL MAR BLUFFS STABILIZATION
PROJECT 2 – PRESERVING TRACKBED SUPPORT

SUPPLEMENTAL GEOTECHNICAL EVALUATION

AND

DETERMINATION OF SITE SPECIFIC CONCEPTUAL REPAIR ALTERNATIVES

Prepared for:

North County Transit District
810 Mission Avenue
Oceanside, California 92054

Project No. 040151-009

June 2, 2003
(Revised November 5, 2003)

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Project No. 040151-009

To: North County Transit District
810 Mission Avenue
Oceanside, California 92054

Attention: Ms. Leslie Blanda

Subject: Del Mar Bluffs Stabilization Project 2 – Preserving Trackbed Support, Supplemental Geotechnical Evaluation and Determination of Site Specific Conceptual Repair Alternatives

In accordance with your request, Leighton and Associates in conjunction with Simon Wong Engineering is pleased to present the results of our supplemental geotechnical evaluation of the coastal bluff stability between Milepost 244.1 and Milepost 245.7 in the City of Del Mar, California. This report is a follow-up to the previous Del Mar Bluffs Geotechnical Study, Parts 1 and 2. The purpose of this additional evaluation was to further analyze the stability of the 50- to 70-foot high coastal bluffs that provide support for the North San Diego County Transit District (NCTD) Rail Alignment, within the previously established high-priority areas, and to develop recommendations for repair measures. The following report provides our conclusions and recommendation with regard to preserving trackbed support of the North County Transit District, rail alignment for at least 20 years.

If you have any questions regarding our report, please contact this office. We appreciate this opportunity to be of service

Respectfully submitted,

LEIGHTON AND ASSOCIATES, INC.

REGISTERED PROFESSIONAL ENGINEER
WILLIAM D. OLSON
No. 45283
Exp. 9/30/06
CIVIL
STATE OF CALIFORNIA

REGISTERED GEOLOGIST
MICHAEL R. STEWART
NO. 1349
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

William D. Olson, RCE 45283
Senior Project Engineer

Michael R. Stewart, CEG 1349
Principal Geologist/Vice President

Distribution: (3) Addressee
(1) Simon Wong Engineering, Attention: Mr. Jim Frost
(1) Ashford Engineering, Attention: Mr. Scott Ashford
(1) City of Del Mar, Attention: Mr. Bob Scott
(1) City of Del Mar, Attention: Mr. David Scherer
(1) Terra Costa, Attention: Mr. Walt Crampton

3934 Murphy Canyon Road, Suite B205 ▪ San Diego, CA 92123-4425
858.292.8030 ▪ Fax 858.292.0771 ▪ www.leightongeo.com

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1.0 INTRODUCTION

1.1 Project Location

The Del Mar Bluffs Stabilization Project 2 - Preserving Trackbed Support (Project 2) is situated along 1.6 miles of North County Transit District (NCTD) railroad right-of-way on the western edge of the City of Del Mar, as shown on Figure 1, Site Location Map. The project area extends from rail Milepost (MP) 244.1 near Coast Boulevard south to MP 245.7 at about Torrey Pines State Beach. Within this reach, the NCTD rail alignment runs atop the 50- to 70-foot high coastal bluffs. Railroad right-of-way varies between approximately 100 feet and 235 feet in width and, in some places, extends onto the beach below.

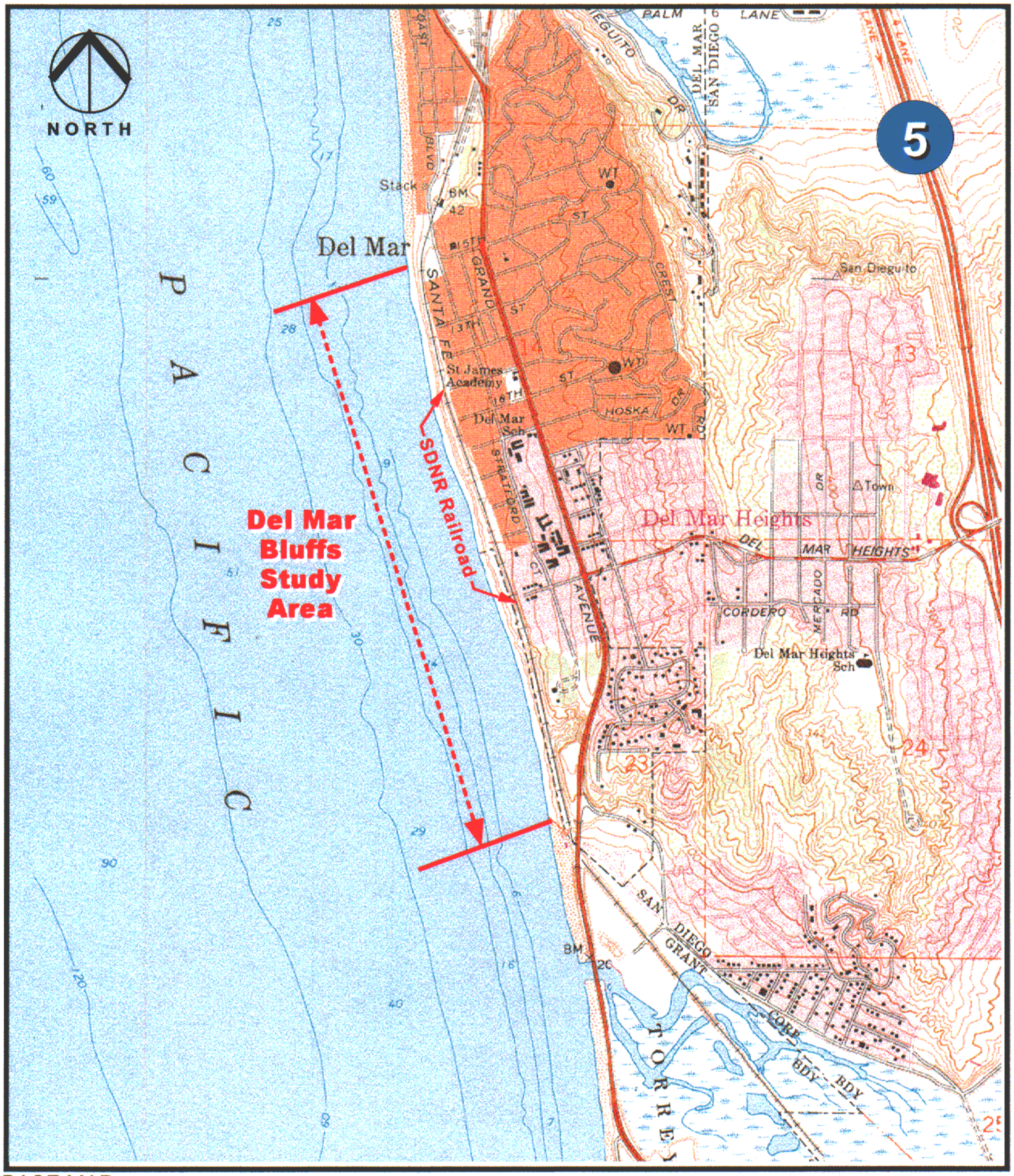
1.2 Project Description

The coastal bluffs supporting the rail alignment in the project area have a history of landslides and surficial failures. In addition, the bluffs are subject to ongoing erosion and failures that could threaten the viability of rail service. Project 2 includes the design and installation of stabilization measures intended to preserve trackbed support in high-priority areas and maintain the viability of rail operations for at least 20 years.

1.3 Project Background

The NCTD railroad right-of-way is an integral part of the 128-mile Los Angeles to San Diego (LOSSAN) Rail Corridor. The corridor provides a vital link for passenger and freight movements within San Diego County as well as between San Diego, Los Angeles and points further north. Approximately 44 passenger trains per day traverse the section of track within the project area, including NCTD Coaster commuter rail service and Amtrak inter-city rail service. In terms of ridership, the LOSSAN corridor is Amtrak's second busiest inter-city rail corridor in the nation. It is also Amtrak's fastest growing rail corridor; increasing over 26 percent in the last year. Overall, in FY 2003, more than 6.6 million passengers traveled the LOSSAN corridor.

In addition to passenger rail, four to eight freight trains, operated by the Burlington Northern Santa Fe Railway (BNSF), travel this section of track daily. Last year, BNSF carried nearly 6 million gross tons of freight over this section



BASE MAP: TOPO! Interactive Map, San Diego County

0 1000 2000 4000

1"=2,000'

Scale in Feet

Del Mar Bluffs Del Mar, California	SITE LOCATION MAP	Project No. 040151-009 Date November 2003 Figure No. 1

The LOSSAN rail corridor is considered a critical facility due to the dependence on the facility by passengers and by freight movements as mentioned above and due to the fact that it is the *only* rail line connecting San Diego to points north. Therefore, as part of maintaining its portion of the LOSSAN Rail Corridor, NCTD has adopted a four-phased approach to preserve the track structure, ensure the viability of rail service and protect its investment in the railroad right-of-way located along the bluffs tops. The first phase of this approach included construction of approximately $1.8 million in drainage improvements along the right-of-way which were completed in 1998.

The second phase, which was completed in January 2001, included conducting a geotechnical study of the bluffs. The results of the geotechnical study (herein referenced to as the "Geotechnical Study"), was entitled the "Del Mar Bluffs Geotechnical Study, Part 1: Geotechnical Evaluation and Part 2: Conceptual Repair Alternatives" and was prepared by Leighton and Associates. The Geotechnical Study characterized the nature and causes of bluff erosion, identified and prioritized areas in need of stabilization, and presented a range of conceptual stabilization options. The Geotechnical Study concluded that the bluffs are subject to failure due to inadequate lateral support, storm wave action, and significant seismic activity. In addition, groundwater seepage and inadequate surface drainage were identified as factors that contributed to the ongoing degradation of the coastal bluff.

The information provided in the Geotechnical Study now serves as the basis for phase three of the Del Mar Bluffs trackbed preservation program and defines overall project priorities. Phase three (the current phase) consists of two separate Del Mar Bluffs stabilization projects to design and construct stabilization measures within "high-priority" areas.

- The first project entitled "Del Mar Bluffs Stabilization Project 1 – Drainage Improvements and Landslide Warning System" (Project 1) is currently under construction and includes the installation of surface and subsurface drainage improvements along the NCTD railroad right-of-way and within the defined high-priority areas. Project 1 also includes the installation of a landslide warning system within portions of the high-priority areas to provide early warning of slope failure along the railroad right-of-way.

- The second project entitled "Del Mar Bluffs Stabilization Project 2 – Preserving Trackbed Support" (Project 2) is currently under design and is the subject of this document. Project 2 involves the installation of additional stabilization measures to provide additional lateral support for the railroad right-of-way within high-priority areas that are marginally stable. It should be noted that there may not be sufficient funding to mitigate all of the high-priority areas at this time. Therefore, the work will be prioritized based on geotechnical analysis and some work may be performed in the future when additional funding becomes available.

The fourth phase of the approach includes identification of an alternative railroad alignment through the City of Del Mar as a long-term solution to bluff erosion and slope stability concerns. The California High-Speed Rail Authority (CHSRA) in association with the California Department of Transportation (Caltrans) is currently evaluating this alternative as part of its study of conventional rail improvements between Los Angeles and San Diego.

1.4 Purpose and Scope

The Geotechnical Study previously identified the high-priority areas in need of bluff stabilization and presented a range of stabilization measures; however, the stabilization measures (or repair alternatives) were conceptual in nature and not site specific. Therefore, the purpose of this report is to identify the site specific repair measures for the high-priority areas needing mitigation.

The first part of this report provides supplemental geotechnical data based on the results of the additional geotechnical investigation performed since the completion of the Geotechnical Study. In addition, supplemental geotechnical analysis (including slope stability analysis) of representative geologic cross sections prepared at selected locations along the bluffs was also performed. The results of the analysis along with topographic and geological features along the right-of-way, were used to divide the high-priority areas into smaller "stabilization areas" with similar stabilization requirements. These stabilization areas are assigned a priority number based on the factors of safety and the degree to which additional lateral support/mitigative measures are recommended to mitigate the potential for deep-seated instability of the trackbed foundation materials.

Next, the potential stabilization measures originally presented in the Geotechnical Study are revisited to briefly discuss the characteristics of the various conceptual repair alternatives and whether or not they meet the objectives of the project. The project objectives are: preserve trackbed support along the railroad alignment for at least a 20-year period; provide minimum recommended factors of safety; maintain uninterrupted rail operations; and preserve natural bluff areas as much as possible. Those conceptual stabilization measures that do not meet the objectives for stabilization are dismissed from further consideration.

Finally, the report provides recommended conceptual repair alternatives and/or mitigative measures for each of the stabilization areas on a site specific basis using data developed during this and earlier phases of work.

2.0 SITE CONDITIONS, SUBSEQUENT INVESTIGATIONS AND RELATED CONCLUSIONS

2.1 Site Geology

The geologic conditions of the project site have been described in the Geotechnical Study. Additional studies recommended in that report have been achieved by: 1) the drilling of additional borings as part of the Project 1 design; 2) the logging of borings drilled as part of the Eighth Street Emergency Repair; 3) additional field mapping; 4) observations of backhoe test pits and trenches, hydro-augers and other exposures related to Project 1 construction; and 5) additional slope stability analyses.

To summarize the geologic conditions, the site is underlain by sandy permeable materials of the Quaternary-aged Bay Point Formation (i.e. Terrace Deposits) which overlie the generally dense sandstones and relatively impermeable siltstones and claystones of the Eocene-aged Delmar Formation. This unit also includes localized permeable zones related to sandy lenses and sandy paleo channel infill deposits, and dense resistant layers. The extent and elevations of these dense layers have been better defined by observations during construction activities of Project 1 near the base of the bluff. The Eocene-aged Torrey Sandstone can be observed just east of the tracks in the southern portion of the site and within Anderson Canyon. This unit is shown on the geologic maps and cross sections but does not underlie the rail alignment.

Within both formations that underlie the right-of-way there are fracture zones that roughly parallel the bluff face. Recent observations related to Project 1 construction and the logging of the borings drilled since the Geotechnical Study have also confirmed the presence of near horizontal layers of highly fractured claystone within the Delmar Formation that were identified in some of the earlier borings. Shears within these zones are highly polished and randomly oriented. In addition to these horizontal claystone beds, steeply dipping fractures and joints are also present. Near-vertical fractures and joints are closely spaced near the bluff face, but steeply dipping fractures and joints can also be observed at wider spacing throughout the entire right of way. As an example, closely spaced vertical fractures and joints can be observed at the outlet excavation at 8th Street (Project 1). More steeply dipping fractures and joints were observed in borings LB- 2 through LB-6 and also in several of the Project 1 excavations, which were located near the tracks. The highly fractured zones near the bluff face can in part be attributed to weathering. East of the bluff face, the formation of these highly fractured claystone beds and the presence of steeply dipping fractures and joints within what is a typically brittle formational unit, are believed to be related to tectonic and/or depositional processes. These joints and fracture zones consist of breaks in the bedrock and provide weak zones on which failures can occur and also conduits for ground water migration within the bluff.

The approximate areal extent of each of the geologic units and the interpretation of the subsurface geologic conditions are indicated on the provided Geotechnical Map and Sections (Plates 2 through 8).

2.2 Field Explorations

In order to evaluate the site's pertinent soil and geologic conditions and develop the site geologic maps and cross sections used for slope stability analysis, several phases of field investigations, extensive geologic mapping and numerous exploratory borings have been performed. The result of this work is presented on the Geotechnical Map and Sections (Plates 2 through 8). For ease of review, copies of all of the boring logs are presented in Appendix B.

In total, 32 borings have been drilled to depths ranging from 60 to 70 feet below the existing ground surface (bgs). These included 22 small diameter borings drilled by a hollow-stem auger drill rig and 10 large-diameter borings. The large-diameter borings were downhole logged by geologists to better evaluate the subsurface conditions. The borings have been used to characterize the subsurface conditions and develop the geologic cross sections utilized in the slope stability analysis. These cross sections and the geologic maps have been refined with the results of the additional data obtained since the completion of the Geotechnical Study.

The 32 borings, discussed above, include 4 small-diameter borings drilled by Leighton in 1978, 16 small-diameter borings drilled by others as part of the first phase of the Geotechnical Study, 6 large-diameter borings drilled by Leighton for the Geotechnical Study, 3 large-diameter borings and 2 small-diameter borings drilled by Leighton as part of Project 1, and 1 additional large-diameter boring drilled and downhole logged at the Eight Street Emergency Repair (Leighton, 2001b).

In addition to the field investigations and subsurface explorations, geologists have observed the installation of 70 hydro-augers and numerous construction excavations as part of Project 1. The results of this additional work with some refinement have confirmed the findings presented in the Geotechnical Study.

2.3 Laboratory Testing

Laboratory testing was performed on representative soil samples obtained during the various phases of site exploration and the results utilized in the slope stability analysis. The laboratory tests included moisture/density determinations, soluble sulfate content, pH and resistivity, chloride content, and direct shear tests. A discussion of the tests performed and a summary of the results are presented in Appendix C. The moisture/density determinations of the "undisturbed" ring samples obtained from the borings are shown on the boring logs (Appendix B). A discussion of the strength parameters utilized in the slope stability analysis is presented in Section 3.3.

2.4 Bluff Retreat

As discussed in the Geotechnical Study, average bluff retreat rates in the study area are estimated at a maximum of 0.4 to 0.6 feet per year. This corresponds to a retreat of approximately 10 feet in the project's 20-year design life, assuming that the bluff will retreat at an average rate of 0.5 feet per year for the next 20 years. Bluff retreat is typically episodic with no retreat for some time and then several feet or more occurring in one event.

2.5 Ground Water

As described in the Geotechnical Study, ground water is a major factor influencing slope stability as it accelerates the degradation of the bluff and bluff face erosion. Based on observations during the various phases of field investigation, hydro-auger installation and construction excavations, the majority of the ground water is located in a perched horizon at the base of the Bay Point Formation with additional localized zones of ground water within near-vertical fractures and joints and sandy channel infills of the Delmar Formation. As discussed previously, geologic observations indicate that the near-vertical fractures and joints within the Delmar Formation are more prevalent near the bluff face, but do extend landward with lesser frequency and typically wider spacing through the entire right-of-way as observed in numerous borings and trenches. These near-vertical fractures and joints create potential pathways for migration of ground water throughout the bluff and the right-of-way.

Ground water can also be observed as numerous localized seeps in the exposed bluff face with additional seepage zones likely masked by dense vegetation or loose surficial soils. Fluctuation in ground water levels within the near-surface soils and weathered and fractured material near the bluff face is also anticipated after periods of heavy rainfall resulting in additional seepage zones and a temporary increase in seepage.

Since construction of the rail alignment in the early 1900's, there have been many efforts to reduce the amount of water in the bluff. Historically these efforts have included construction of a storm drain system, surface drainage improvements and the installation of subdrains. In 1998, the District completed construction of $1.8 million of additional surface and subsurface drainage improvements. Additionally, Project 1, which also consists of both surface and subsurface drainage improvements, has been recently completed.

While these past projects have collected a large amount of subsurface water, not all ground water is intercepted by these improvements as evidenced by lingering seepage in the exposed bluff face in improved areas. Considering that the Project 1 improvements, which include interceptor trench drains and hydro-augers, will further help to reduce the amount of ground water within the bluffs, the amount of ground water is reduced in the current stability analysis compared to the initial analysis in the Geotechnical Study. Additional discussion of the ground water levels utilized in the slope stability analysis is presented in Section 3.1.

3.0 SLOPE STABILITY

The Geotechnical Study characterized the overall bluff stability, established the high-priority areas and provided conceptual repair alternatives to improve the slope stability. Actual repair recommendations were to be made based on site specific analysis. The Geotechnical Study also noted that additional site investigation and design would be required to implement the selected alternatives. This recommended additional site investigation and design is the basis for this study.

Since the completion of the Geotechnical Study, additional investigation of the site has been accomplished for the Eighth Street Emergency Repair and the Project 1 improvements. The results of the additional borings and field and laboratory testing are included in this report. This section presents the results of additional site specific slope stability analysis performed in the high-priority areas. In addition, this analysis is to be utilized in the selection and further development of stabilization measures.

3.1 Stability Analysis

In the Geotechnical Study, 17 cross sections were prepared and 11 of those cross sections were analyzed. The results of this previous analysis were then utilized in part to develop the high-priority areas. For this study, all of the 17 original cross sections have been reviewed and updated where appropriate. In addition, 12 new cross sections were developed as part of this study. Consequently, a total of 25 geological cross sections (i.e., 13 of the original cross sections and 12 new cross sections) have been analyzed to evaluate the current site specific conditions. To simplify the current discussion of the bluff stability, the original 13 cross sections (previously identified by letters in the Geotechnical Study) have been relabeled and are now identified as numbered cross sections from north to south. The geological cross sections, Sections 1-1' through 25-25' (Plates 2 through 8), start at MP 244.2 and end at MP 245.4.

The locations of the 12 new geologic cross sections were selected based on: 1.)the results of the previous slope stability analyses presented in the Geotechnical Study; 2.) the site specific geologic conditions; and 3.) recent field observations that include determining the lateral distance between the track and top edge of the bluff. Additionally, the new cross sections are located within high-priority areas with the exception of Section 20-20', which was prepared to evaluate an area of additional concern related to an existing retaining wall identified during Project 1.

The stability analysis performed for this study utilized the computer program Slope/W (Geo-Slope, 2002) with Spencer's and Bishop's methods for block and circular failure modes, respectively. Analyzed scenarios included: 1) static conditions; 2) static conditions with a train surcharge loading; and 3) pseudo-static (seismic) conditions.

While near-vertical fractures and joints can be observed throughout the right of way, they are most concentrated near the bluff face. For the purposes of slope stability analysis, the analyzed static and surcharged scenarios in the northern areas (north of MP 245.21 or Station 1491+20) considered a shallow profile of ground water parallel to the bluff face (a 5-foot hydrostatic head within a 10-foot fractured bluff face zone). This ground water profile is considered to be a valid representation of the current site conditions based on observations during the construction activities of Project 1. For analyses in the southern portions of the project (south of MP 245.21 or Station 1491+20), substantially less ground water seepage is observed on the bluff face. The reduction in the ground water to the south is due to the partial removal of the permeable terrace deposits on the bluff top, existing drainage improvements that extend through the terrace deposits and the distance from the upslope developments. As a result, the ground water profile model was changed to incorporate a 2-foot hydrostatic head within a 5-foot fracture zone. Figures 2 and 3 present generalized cross sections that illustrate the ground water profiles utilized in the slope stability analysis.

In addition to the conditions described above, two alternative or hypothetical ground water conditions were analyzed to determine how sensitive the slope stability analysis would be to ground water. The first condition consisted of an increased ground water profile with a 10-foot hydrostatic head within a 10-foot fractured bluff face zone applied to five representative cross sections, Sections 1-1', 2-2' 3-3', 5-5' and 10-10'. The second condition analyzed a complete removal of ground water in selected cross sections with calculated factors of safety less than 1.5. The results indicate a reduction in the factors of safety with an increase in ground water, but only a slight increase in the factors of safety with the elimination of ground water. Results of the analyses are presented and further discussed in Section 3.4.

It should also be noted that the slope stability analysis contained herein does not include the effects of additional bluff retreat. While additional bluff retreat is likely to occur over the life span of the project, it was not considered in our stability analysis. According to NCTD, there are limited funds available for stabilization of the bluffs at this time. Therefore, the goal of Project 2 is to identify the areas currently in need of stabilization, prioritize the areas by greatest need, and stabilize the areas in order of priority as funding allows. Additional bluff retreat will, as identified in the Geotechnical Study, expand the high-priority areas in the future and, as additional funds become available, further stabilization will be considered where appropriate.

3.2 Factor of Safety

For this study calculated factors of safety, generated by the slope stability analysis program for each cross section, were used to assess the stability of the bluff as it exists today. In order to generate these calculated factors of safety, the model required selection of a constant evaluation point at which the potential failure surface intersects the existing ground surface. As there are no specific criteria published to aid in the selection of such a point, the distance was established using engineering judgment that was primarily based on the State of California Department of Transportation (Caltrans) Trenching and Shoring Manual, Section 7 "Railroads".

In the Caltrans manual, shoring requirements are determined based on the relationship of excavations to "railroad reference lines", below which any excavation requires shoring. In view of this, a point 10 feet from the railroad centerline (approximately 6 feet beyond the end of a typical railroad tie) was selected as it is just inside the limits of the aforementioned reference lines and thus would require shoring according to the Caltrans manual. In addition, NCTD has indicated that a failure within 10 feet of the track would be a serious concern and would likely "shut down" the rail line. It should be noted that a greater distance could be chosen if it was required to have maintenance or emergency vehicle access on the west side of the track. Also, as the evaluation point moves toward the edge of the bluff, the calculated factor of safety for all cross sections would decrease and subsequently, the areas with low factors of safety requiring stabilization would increase.

The calculated factors of safety generated, as discussed above, are compared to minimum factors of safety in order to assess the potential for failure within the established 10-foot distance from the railroad centerline. The following minimum factors of safety (FS) were considered reasonable or acceptable parameters:

- Static Analysis: FS = 1.5
- Pseudo-Static (Seismic) Analysis with a seismic coefficient of 0.15: FS = 1.15
- Pseudo-Static (Seismic) Analysis with a seismic coefficient of 0.28: FS = 1.00

The selection of the factor of safety for a static condition is based on various published guidelines, including:

- National Research Council's Transportation Research Board's Special Report 247, "Landslides: Investigation and Mitigation", which states:

  "The choice of appropriate safety factor for a given slope depends on a number of considerations, such as the quality of the data used in the analysis, which in turn depends on the quality of the subsurface investigations; laboratory and field testing; interpretation of field and laboratory data; quality of construction control; and in some cases, degree of completeness of information about the design problem. The engineer must also consider the probable consequences of failure. In most transportation situations, slope designs generally require safety factors in the range of 1.25 to 1.50. Higher factors may be required if slope movements have the potential for causing loss of human life or great economic loss or if there is considerable uncertainty regarding

the pertinent design parameters, construction quality control, potential for seismic activity and so forth. Likewise, lower safety factors may be used if the engineer is confident of the accuracy of the input data and if good construction control may be relied upon."

- American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, Section 1.2.3.2e (AREMA, 2000), which states:

  "Generally a factor of safety of 1.5 is considered adequate, although, lower safety factors may be considered acceptable if the engineer performing the stability analysis has sufficient design data available for analysis. Higher safety factors are required when limited test and field data are available for use in the performance of the slope stability analysis."

- Naval Facilities Engineering Command (NAVFAC), Soil Mechanics, Design Manual 7.01, which requires that slopes have a safety factor of no less than 1.5 for reasonable assurance of stability in permanent or sustained loading conditions.

In summary, the aforementioned guidelines recommend selecting a factor of safety between 1.25 and 1.50 or higher depending on various factors. The value determined for this study was primarily influenced by two characteristics of the rail line.

First, as indicated in Section 1.3, the rail line is a critical facility and the only rail line connecting San Diego to points north. Consequently, its loss of use would have a severe impact on NCTD's, Amtrak's, and BNSF's ability to provide service. Second, the rail line can be considered a "lifeline facility". In the event of a natural or manmade disaster, the rail line may be one of the few alternatives to quickly get people and rescue, relief, and/or recovery supplies between Los Angeles and San Diego. These two reasons alone justify a higher factor of safety than a typical project.

Therefore, considering the rail line is a critical, lifeline facility and the associated consequences of failure, a 1.5 factor of safety is established as the appropriate value to evaluate slope stability. A factor of safety higher than 1.5 was considered to be conservative as some of the unknowns which would call for increasing the FS are accounted for in other inputs to the analysis, such as soil strengths.

Discussions supporting the selection of the minimum factors of safety for the pseudo-static (seismic) analyses and the seismic coefficients are presented in Section 3.5.

3.3 Soil Properties

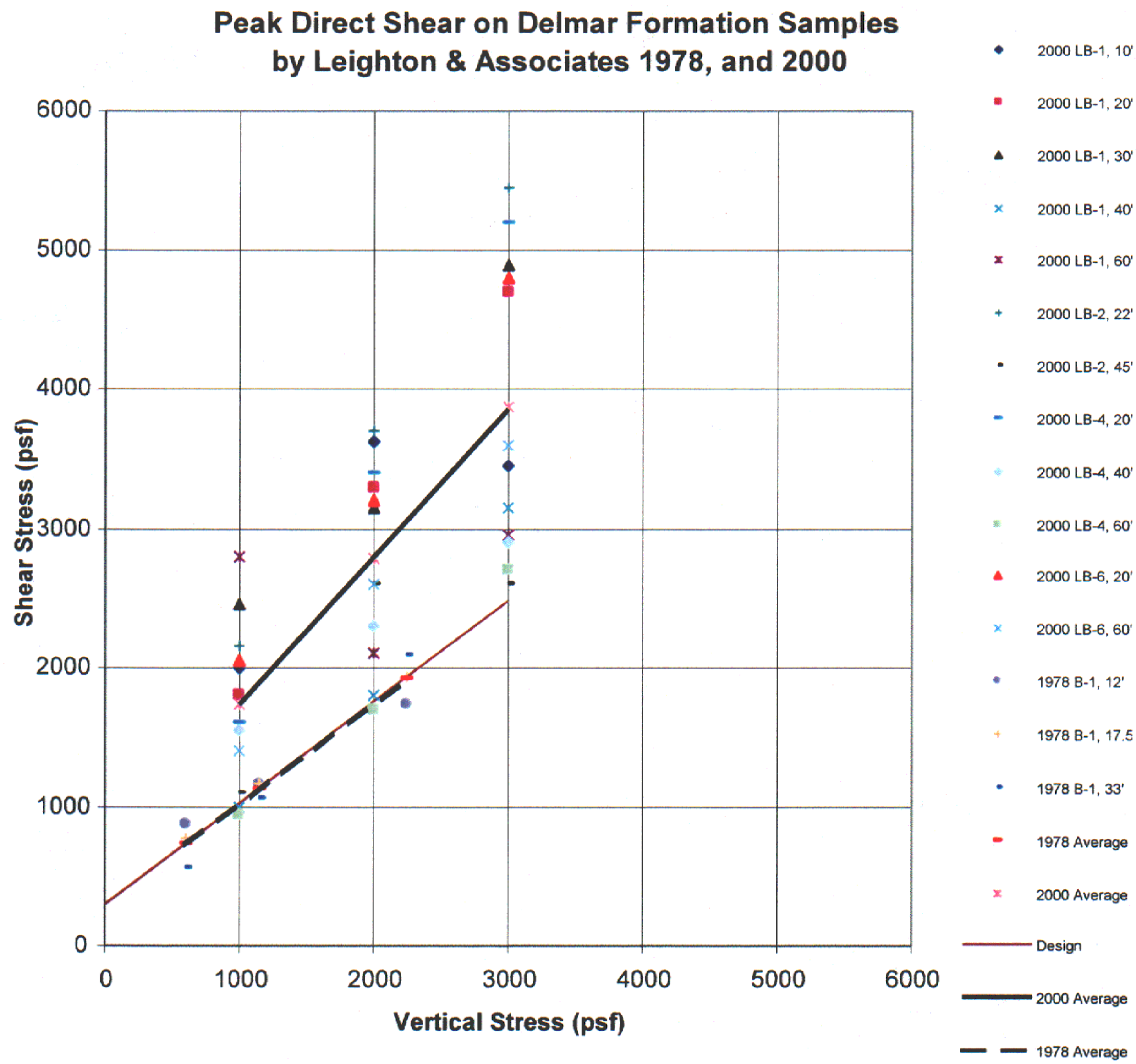
The soil properties used in the analysis consisted of soil strength parameters and unit weights that are based on laboratory testing from the Geotechnical Study, laboratory testing from the recent site investigation, field observations during the Eighth Street Emergency Repair and Project 1 construction activities, and engineering judgment. In general, the soil properties used in the analysis were consistent with the Geotechnical Study with the exception of the landsliding material strength parameters. Recent field observations during Project 1 indicated that the landsliding material generally consists of loose and disturbed material. As a result, the strength parameters for the landslide material were reduced for the current study.

A summary of the assigned soil strength parameters for each geologic unit used in the slope stability analysis is provided in Table 1, below. Based on laboratory test data, the average moist unit weight used in the analyses for the fill soils, beach deposits, Bay Point and Delmar Formations was 125 pounds per cubic foot (pcf), while 110 pcf was used for the landslide materials.

Table 1
Soil Strength Parameters for Slope Stability Analysis

Material	Unit Weight (pcf)	Friction Angle, (degrees)	Cohesion, (psf)
Fill Soils	125	32	100
Bay Point Formation	125	36	200
Delmar Formation	125	36	300
(within +/- 5° horizontal)	125	25	150
Landslide Materials	110	18	50
Beach Deposits	125	30	0

The overall stability of the slope is significantly affected by the strength of the Delmar Formation. While testing an intact block of the Delmar Formation would yield relatively higher strength parameters, the use of such a strength in the slope stability analysis would show no failures occurring on the bluff. As a majority of the bluff has experienced numerous failures, the use of intact strength values is not appropriate. As presented on Figures 4 through 7, a comparison of the average peak and residual strength data indicates that the Delmar Formation experiences significant strength loss once the cementation between the soil grains is broken. Similarly, when joints and fractures develop within the unit from both weathering and tectonic influences, the loss of contact can greatly reduce or eliminate the strength across the break . In addition, the geometry or steepness of the bluff induces a state of tension behind the crest and at times in the middle of the slope face. When the tensile strength of the materials is exceeded, cracks form. These zones of tension tend to expand during earthquakes, leading to additional areas where reduced strengths and higher water pressures are appropriate for use in the analyses. For these reasons, lower bound strength parameters were assigned to the Delmar Formation (i.e., the strength parameters presented on Figure 4, friction angle of 36 degrees and cohesion of 300 pounds per square foot, psf). To account for the presence of sheared siltstone and claystone beds, strength parameters similar to the average residual values of fine-grained Delmar Formation samples (i.e., friction angle of 25 degrees and cohesion of 150 psf) were assigned to this material within 5 degrees of horizontal (see Figures 5, 6, and 7).



Average Strength Values

2000 Test Data		1978 Test Data	
Friction Angle, ϕ (degrees)	**47**	Friction Angle, ϕ (degrees)	**36**
Cohesion, c (psf)	**650**	Cohesion, c (psf)	**300**

SUMMARY OF PEAK DIRECT SHEAR TESTS - DEL MAR FORMATION 1978 AND 2000

Project No.	**040151-009**
Scale	**Not to scale**
Engr./Geol.	**SAC/MRS**
Drafted By	**KAM/HMR**
Date	**November 2003**

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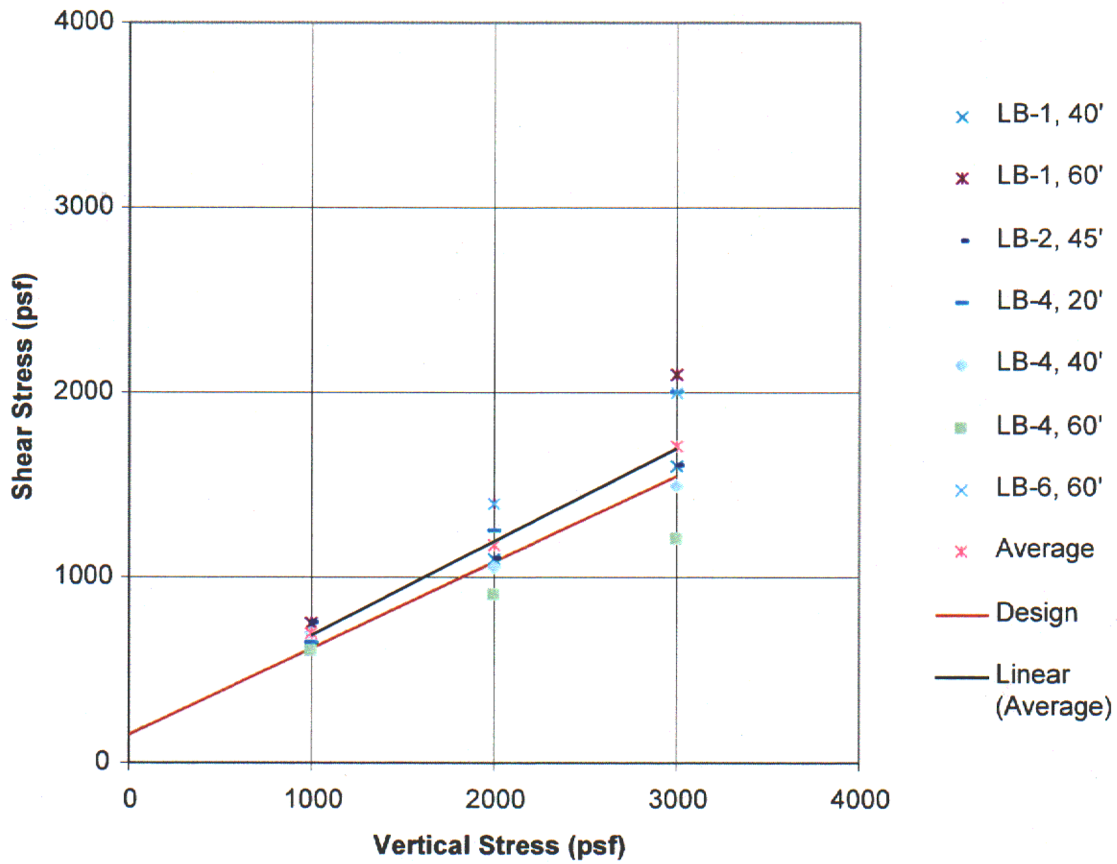
Figure No. 4

Composite of Residual Direct Shear on Fine-Grained Samples of Delmar Formation by Leighton & Associates 2000



Average Strength Values

Friction Angle, ϕ (degrees)	**27**
Cohesion, c (psf)	**170**

SUMMARY OF RESIDUAL DIRECT SHEAR TESTS - DEL MAR FORMATION, 2000

Project No.	**040151-009**
Scale	**Not to scale**
Engr./Geol.	**SAC/MRS**
Drafted By	**KAM/HMR**
Date	**November 2003**

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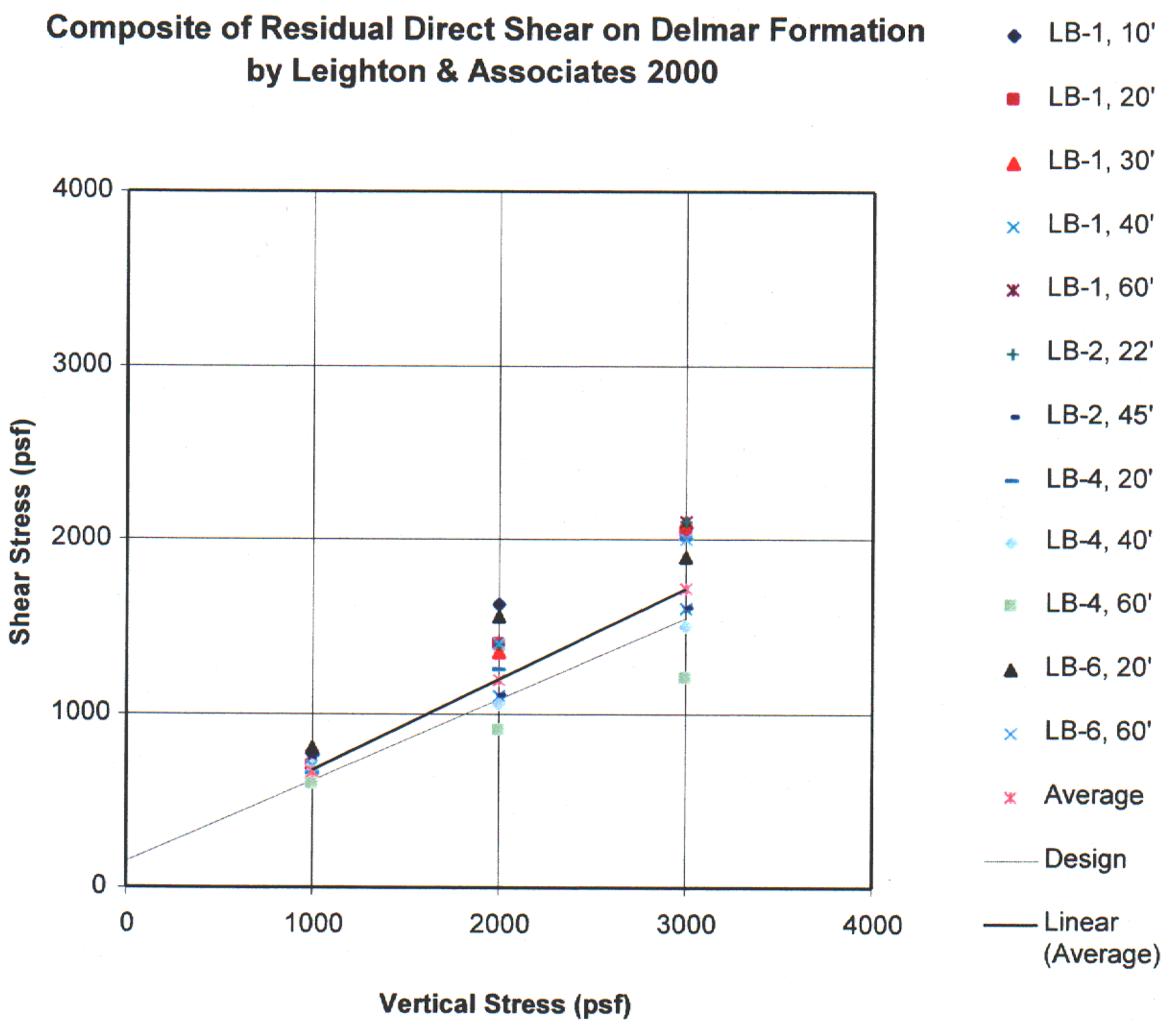
Figure No. 5



Average Strength Values

Friction Angle, ϕ (degrees)	29
Cohesion, c (psf)	150

SUMMARY OF RESIDUAL DIRECT SHEAR TESTS - DEL MAR FORMATION, 2000

Project No.	040151-009
Scale	Not to scale
Engr./Geol.	SAC/MRS
Drafted By	KAM
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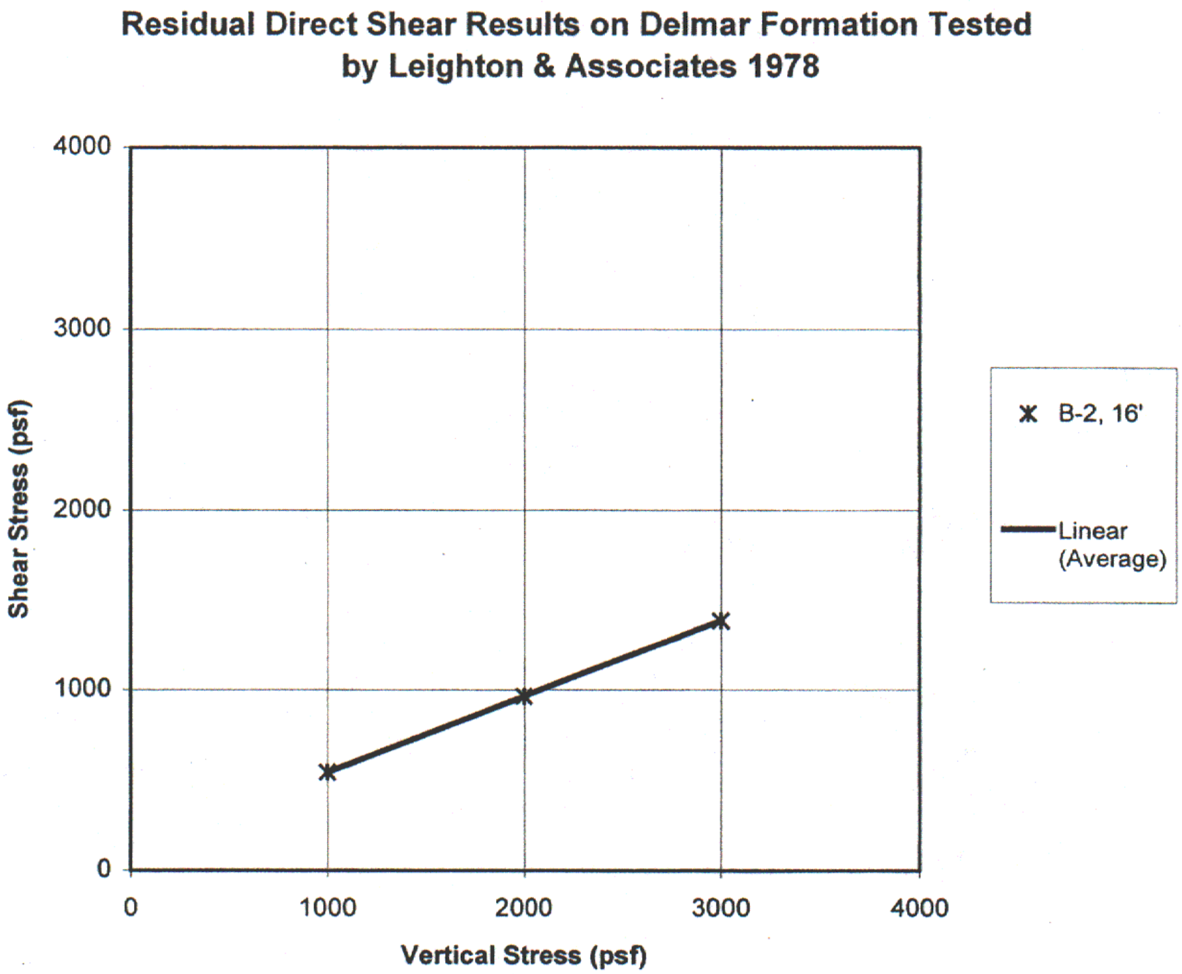
Figure No. 6



Average Strength Values

Friction Angle, ϕ (degrees)	23
Cohesion, c (psf)	125

SUMMARY OF RESIDUAL DIRECT SHEAR TESTS - DEL MAR FORMATION, 1978

Project No.	040151-009
Scale	Not to scale
Engr./Geol.	SAC/MRS
Drafted By	KAM
Date	November 2003

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Figure No. 7

As verification of the soil properties used in the analyses, two existing landslides on the bluff were modeled and analyzed to back calculate the strength parameters prior to failure (determining what strength parameters generated a factor of safety of approximately 1.0, which corresponds to the moment of failure). The failures analyzed included a block fall at MP 244.47 (Station 1529+60), and a wedge failure at MP 245.27 (Station 1488+85) as shown on Plates 3 and 7, respectively). The results of the back calculation analysis, as presented in Appendix D, Slope Stability Calculations, indicate that the selected soil strength parameters for the Delmar Formation appropriately model bluff failures.

3.4 Results of Analysis for Static Conditions

Circular and block failure surfaces were considered in the analysis for static conditions with and without a train surcharge loading. Typically, block or wedge surfaces represent the probable failure for a natural bluff condition while a circular surface represent the probable failure for a fill slope condition. In modeling the train surcharge, a uniform strip load of 3,000 pounds per square foot (psf) was applied across a width of 5 feet. This is considered equivalent to typical stresses under a 50,000 pound train axle load (Section 4.3.3, AREMA, 2003), which is considered to be the appropriate loading for this section of the LOSSAN corridor.

Table 2, below, presents a summary of the results for the stability analysis of the existing conditions under both static scenarios (static and static with a train surcharge load). The results of this analysis indicate that 18 of the 25 sections analyzed have a factor of safety less than 1.5 for a static condition with a train surcharge load and a modeled ground water profile as discussed in Section 3.1. The condition determined to be the most appropriate for analysis is static with surcharge and 2 to 5 feet of hydrostatic head. The computer program Slope/W calculation plots for the analyses are presented in Appendix D, Slope Stability Analyses.

In addition to the analyses performed with the conditions noted above, two additional hypothetical ground water analyses, as mentioned in Section 3.1, were performed on the five selected cross sections. One analysis assumed an increased water level and the other assumed a complete elimination of ground water. Even though these conditions are unlikely to occur, the hypothetical analyses are worthwhile to aid in understanding the sensitivity of the bluff to water.

The hypothetical analysis of Sections 1-1', 2-2', 3-3', 5-5' and 10-10' for a static condition (no surcharge) with an increased ground water profile (a 10-foot of hydrostatic head within a 10-foot fractured bluff face zone) indicated a reduction in the calculated factors of safety. The reductions ranged from approximately 4 percent in Section 2-2' to approximately 24 percent in Section 3-3'. For the hypothetical analysis of selected cross sections with no ground water, the results, as shown on Table 2, indicate a slight to moderate increase in the calculated factors of safety. However, only four cross sections,

Sections 3-3', 4-4', 5-5' and 22-22' yielded factors of safety greater than 1.5 assuming no ground water and a static condition with no surcharge loading.

In summary, the conditions assumed in the analysis, which include the train surcharge loading and a 2 to 5 foot hydrostatic head, represent a reasonable interpretation of the site conditions that can be expected.

Table 2
Summary of Results for Static Scenarios

Section	Station Location	Factor of Safety (FS)		
		With ground water	Without ground water*	With Train Surcharge
1-1'	1544+07	1.26	1.47	1.26
2-2'	1543+00	1.42	1.45	1.42
3-3'	1540+57	1.31	1.51	1.31
4-4'	1540+30	1.50	1.54	1.47
5-5'	1539+56	1.44	1.50	1.44
6-6'	1538+92	1.43	1.47	1.43
7-7'	1537+82	1.24	1.24	1.24
8-8'	1537+15	1.34	1.34	1.34
9-9'	1536+69	1.02	1.08	1.02
10-10'	1535+69	1.25	1.34	1.25
11-11'	1533+24	1.17	1.23	1.17
12-12'	1532+25	1.23	1.27	1.23
13-13'	1530+31	1.37	1.37	1.35
14-14'	1529+60	1.36	1.44	1.35
15-15'	1520+95	2.10	--	1.90
16-16'	1518+47	2.07	--	2.07
17-17'	1516+05	1.33	1.33	1.29
18-18'	1512+55	1.98	--	1.98
19-19'	1499+61	1.60	--	1.60
20-20'	1493+77	1.65	--	1.65
21-21'	1491+02	1.42	1.44	1.41
22-22'	1488+03	1.46	1.51	1.45
23-23'	1484+37	1.34	1.36	1.34
24-24'	1483+00	1.58	--	1.52
25-25'	1482+81	1.74	--	1.25

* Selected sections analyzed without ground water.

-- No analysis performed for sections with a static FS (with ground water) equal to or greater than 1.50

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3.5 Results of Analysis for Pseudo-Static (Seismic) Conditions

In order to evaluate the bluff stability in the event of a major earthquake on a regional active fault, a seismic slope stability or pseudo-static analysis, as defined by California Division of Mines and Geology in Special Publication 117, was performed. For this analysis, two values of the ground motion parameters or seismic coefficients (0.15 and 0.28) were considered.

The seismic coefficient (k_H) of 0.15 was selected based on the range presented by Seed as indicated in California Division of Mines and Geology Special Publication 117 – Guidelines for Evaluating and Mitigating Seismic Hazards in California (CDMG, 1997). According to Seed, a seismic coefficient range of 0.10 to 0.15 corresponds to maximum earthquake magnitudes of M6.5 to M8.25. Although the maximum moment magnitude of the Rose Canyon Fault Zone is considered to be M7.0 by the California Department of Transportation (Caltrans), the upper bound of the seismic coefficient range, k_H = 0.15, was elected for the analysis based on the location of the site relative to the Rose Canyon Fault and the standard of practice in Southern California. It should be noted that for the seismic coefficient of 0.15, the minimum acceptable pseudo-static factor of safety of 1.15, as recommended by Seed (CDMG, 1997), was used to assess bluff stability. This analysis is most appropriate for conditions that may occur during a minor to moderate seismic event.

The higher seismic coefficient, 0.28, is equal to one-half the deterministic peak horizontal ground motion. The peak horizontal ground motion assigned to the site using Caltrans maps is 0.55g. Accordingly, the seismic coefficient was calculated to be 0.28. For the higher seismic coefficient, k_H = 0.28, the minimum acceptable pseudo-static factor of safety of 1.0, as specified by Caltrans (Caltrans, 1999), was used to assess bluff stability. It should be noted that use of a higher seismic coefficient, 0.28, is in general agreement with the recently published recommendations for evaluating steep slopes during major seismic events (Ashford and Sitar, 2002).

Table 3 presents a summary of the results for the pseudo-static stability analysis. Results of the slope stability analysis for pseudo static (seismic) conditions indicate that 14 of the 25 cross sections analyzed have a factor of safety less than the minimum acceptable parameter for a seismic coefficient of 0.15 (i.e., FS=1.15), and 19 of the 25 cross sections analyzed were less than the minimum acceptable parameter for a seismic coefficient of 0.28 (i.e., FS=1.00). For the purposes of prioritizing areas to stabilize, the Caltrans (1999) methodology, traditionally used for transportation facilities, using the higher seismic coefficient of 0.28 was selected. This decision was based on the slightly higher conservatism of this method, and the fact that an M7.0 earthquake on the Rose Canyon would be a major seismic event.

Table 3
Summary of Results for Pseudo-Static Analysis

		Factor of Safety	
Section	Station Location	$k_H = 0.15$*	$k_H = 0.28$**
1-1’	1544+07	1.12	0.95
2-2’	1543+00	1.18	0.98
3-3’	1540+57	1.11	0.90
4-4’	1540+30	1.19	0.93
5-5’	1539+56	1.21	1.01
6-6’	1538+92	1.19	0.99
7-7’	1537+82	0.98	0.78
8-8’	1537+15	1.03	0.84
9-9’	1536+69	0.94	0.79
10-10’	1535+69	0.89	0.69
11-11’	1533+24	0.90	0.77
12-12’	1532+25	0.97	0.79
13-13’	1530+31	1.01	0.81
14-14’	1529+60	1.13	0.90
15-15’	1520+95	1.30	1.00
16-16’	1518+47	1.40	1.11
17-17’	1516+05	1.07	0.92
18-18’	1512+55	1.46	1.18
19-19’	1499+61	1.25	1.03
20-20’	1493+77	1.21	0.95
21-21’	1491+02	1.10	0.92
22-22’	1488+03	1.17	0.97
23-23’	1484+37	1.11	0.92
24-24’	1483+00	1.14	0.90
25-25’	1482+81	1.31	1.08

* minimum acceptable parameter, factor of safety: 1.15

** minimum acceptable parameter, factor of safety: 1.0

3.6 Slope Stability Summary

As previously noted, the factor of safety for static slope stability (with surcharge) is considered to be the primary design criteria. The factor of safety for pseudo static (seismic) condition (k_H=0.28) is the secondary design criteria.

Table 4 presents a summary of the cross sections that have one or more factors of safety less than the minimum acceptable parameters defined previously. Therefore, these are the areas that should be considered the first priority for stabilization. As previously noted, the impacts of additional bluff retreat were not included in the slope stability analysis. The locations of the cross sections with factors of safety less than the minimum acceptable parameters are also illustrated on Plates 2 through 8.

Table 4
Summary of Sections with Factors of Safety Below Acceptable Parameters

Section	Station Location	Factor of Safety (FS)	
		Static with Surcharge	Pseudo-Static $k_H = 0.28$
1-1'	1544+07	1.26	0.95
2-2'	1543+00	1.42	0.98
3-3'	1540+57	1.31	0.90
4-4'	1540+30	1.47	0.93
5-5'	1539+56	1.44	1.01
6-6'	1538+92	1.43	0.99
7-7'	1537+82	1.24	0.78
8-8'	1537+15	1.34	0.84
9-9'	1536+69	1.02	0.79
10-10'	1535+69	1.25	0.69
11-11'	1533+24	1.17	0.77
12-12'	1532+25	1.23	0.79
13-13'	1530+31	1.35	0.81
14-14'	1529+60	1.35	0.90
17-17'	1516+05	1.29	0.92
20-20'	1493+77	1.65	0.95
21-21'	1491+02	1.41	0.92
22-22'	1488+03	1.45	0.97
23-23'	1484+37	1.34	0.92
24-24'	1483+00	1.52	0.90
25-25'	1482+81	1.25	1.08

4.0 STABILIZATION AREAS

Based on the slope stability analyses presented in Section 3, ten unique and discontinuous "Stabilization Areas" have been established. In general, the limits of the individual stabilization areas were determined based on the slope stability analysis (areas having less than the minimum acceptable parameters or factor of safety) and similar geotechnical and topographic conditions. It should be noted that there are portions of these areas that have existing stabilization improvements that were not taken into account during the current slope stability analysis; thus the entire area does not require a new stabilization measure. The Stabilization Areas are numbered from 1 to 10 in order from north to south. In addition, each area is assigned a priority number that indicates the need for repair based on the factor of safety. It should be noted that the primary and secondary considerations utilized to rank the areas recommended for stabilization were the static (with surcharge) and seismic slope stability (k_H=0.28) factors of safety, respectively.

The Stabilization Areas, identified as SA-1 through SA-10, are summarized below and illustrated on Plates 2 through 8.

4.1 Stabilization Area 1 (SA-1)

Priority Ranking: 5
Location: Station 1544+70 to 1540+66
Section 1-1', Factor of Safety = 1.26 (0.95 seismic)
Section 2-2', Factor of Safety = 1.42 (0.98 seismic)

4.2 Stabilization Area 2 (SA-2)

Priority Ranking: 7
Location: Station 1540+66 to 1539+40
Section 3-3', Factor of Safety = 1.31 (0.90 seismic)
Section 4-4', Factor of Safety = 1.47 (0.93 seismic)
Section 5-5', Factor of Safety = 1.44 (1.01 seismic)

4.3 Stabilization Area 3 (SA-3)

Priority Ranking: 11
Location: Station 1539+40 to1538+85
Section 6-6', Factor of Safety = 1.43 (0.99 seismic)

4.4 Stabilization Area 4 (SA-4)

Priority Ranking: 3
Location: Station 1538+85 to 1536+90
Section 7-7', Factor of Safety = 1.24 (0.78 seismic)
Section 8-8', Factor of Safety = 1.34 (0.84 seismic)

4.5 Stabilization Area 5 (SA-5)

Priority Ranking: 1
Location: Station 1536+90 to 1532+50
Section 9-9', Factor of Safety = 1.02 (0.79 seismic)
Section 10-10', Factor of Safety = 1.25 (0.69 seismic)
Section 11-11', Factor of Safety = 1.17 (0.77 seismic)

4.6 Stabilization Area 6 (SA-6A and SA-6B)

Priority Ranking: 2 for SA-6A and 9 for SA-6B
Location: Station 1532+50 to 1531+65 and 1530+25 to 1529+10
Section 12-12', Factor of Safety = 1.23 (0.79 seismic)
Section 13-13', Factor of Safety = 1.35 (0.81 seismic)
Section 14-14', Factor of Safety = 1.35 (0.90 seismic)

4.7 Stabilization Area 7 (SA-7)

Priority Ranking: 6
Location: Station 1516+57 to 1515+50
Section 17-17', Factor of Safety = 1.29 (0.92 seismic)

4.8 Stabilization Area 8 (SA-8A and SA-8B)

Priority Ranking: 10
Location: Station 1494+05 to 1493+33 and 1491+15 to 1490+80
Section 20-20', Factor of Safety = 1.65 (0.95 seismic)
Section 21-21', Factor of Safety = 1.41 (0.92 seismic)

4.9 Stabilization Area 9 (SA-9A and SA-9B)

Priority Ranking: 12 for SA-9A and 8 for SA-9B
Location: Station 1490+80 to 1484+80 and 1484+80 to 1483+55
Section 22-22', Factor of Safety = 1.45 (0.97 seismic)
Section 23-23', Factor of Safety = 1.34 (0.92 seismic)

4.10 Stabilization Area 10 (SA-10)

Priority Ranking: 4
Location: Station 1483+55 to 1482+10
Section 24-24' (West), Factor of Safety = 1.52 (0.90 seismic)
Section 25-25 (East), Factor of Safety = 1.25 (1.08 seismic)

4.11 Priority of Stabilization Areas

Based on the priority ranking identified above, Table 5 presents the stabilization areas in order of improvement or repair priority:

Table 5
Stabilization Area Priority

Priority	Stabilization Area
1	SA-5
2	SA-6A
3	SA-4
4	SA-10
5	SA-1
6	SA-7
7	SA-2
8	SA-9B
9	SA-6B
10	SA-8
11	SA-3
12	SA-9A

5.0 REVIEW AND ANALYSIS OF CONCEPTUAL REPAIR ALTERNATIVES

As a first step in determining the site specific stabilization alternatives for the high-priority areas, a review of the conceptual repair alternatives (i.e. stabilization measures) presented in the Geotechnical Study was performed.

The conceptual repair alternatives as presented in the Geotechnical Study included: 1) maintenance and repair of existing facilities; 2) stabilization at the bluff toe; 3) stabilization of the bluff face; 4) stabilization of the bluff top; 5) drainage improvements; and/or 6) groundwater reduction. The figures which correspond to the conceptual alternatives included in the Geotechnical Study are provided in Appendix E. Selection of the appropriate mitigation alternative is highly dependent upon the site specific stabilization problem at each of the Stabilization Areas and will likely include a combination of the methods.

Factors that were considered during the evaluation of the conceptual repair alternatives included the need to: 1) preserve track bed support for +/- 20 years; 2) provide for a minimum factor of safety; 3) maintain uninterrupted rail service; and 4) preservation of natural bluff areas.

As a result of this review, it has been determined that several of the conceptual repair measures do not adequately meet the needs of the project as they do not provide the minimum recommended factor of safety or they will not be effective over the entire 20-year design life. Therefore, alternatives that do not meet the goals of the project have been dismissed from further consideration.

5.1 Repair of Existing Facilities

The Geotechnical Study identified a number of existing facilities at the site that are in need of repair and/or ongoing maintenance, including storm drain outlets and existing sea walls. Repair of some of the drainage facilities was conducted as part of Project 1. Repair of sea walls will be considered where they can be utilized in conjunction with other stabilization methods or where they can be utilized to meet the project goals. Monitoring of all existing improvements will also be performed as part of on-going maintenance. It should be noted that the repair of the existing facilities alone does not improve bluff stability to acceptable levels.

5.2 Stabilization at Bluff Toe

Stabilization at the bluff toe should be considered in areas where slope stability analysis indicates low factors of safety at the base of the bluff and where improvements at the bluff toe will increase the factor of safety. Methods for stabilization include: 1) wooden or concrete sea walls; 2) steel piles and wood lagging walls; 3) soil cement buttress; 4) rock revetments; and 5) beach replenishment. Temporary toe protection, such as beach replenishment, were not taken into consideration as an effective measure that meets the project goals and therefore, were not recommended as part of any stabilization alternative. The other bluff toe stabilization options were considered where appropriate. In general, however, toe protection alone does not meet the goals of the project based on the slope stability analysis, but may help to reduce the expected bluff retreat.

5.3 Stabilization of Bluff Face

Stabilization of the bluff face can be considered where factors of safety indicate adequate lateral support is not present or where additional erosion or failures will move the bluff face landward. Stabilization can be accomplished through slope grading or the use of pipe and board retaining walls.

Slope grading can be used to stabilize the bluff face and re-establish eroded and failed areas. Slope grading would generally consist of the placement of compacted fill soils on the face of the slope to provide additional lateral support and/or flatten localized over-steepened areas. Removal of existing slope failures material could also be performed as part of slope grading. In areas where a conventional 2:1 horizontal to vertical slope cannot be constructed because of space limitations, the slope grading can incorporate steeper gradients through the use of geogrid reinforcement, or soil cement.

Slope grading alternatives can be designed to meet the project goals. With the goal to minimize disturbance of natural bluffs, the use of slope grading should be limited to areas of existing manufactured slopes. Slope grading would also likely include removals of existing compressible or disturbed material to provide a width of fill soils that is sufficient to achieve the desired factor of safety. These removals may encroach on the trackbed support and require the use of temporary shoring or the disruption of rail service.

Pipe and board retaining walls are generally considered a surficial repair and do not meet the goals of the project to improve overall gross stability of the slope. This option may, however, be applicable for repair of shallow surficial slope failures, repair of localized erosional areas or the retention of plantable soil on a steeper than 2:1 (horizontal to vertical) slope or on a soil cement slope.

5.4 Bluff Top Stabilization

Where the top of the bluff within 10 feet of the tracks has an inadequate factor of safety, additional bluff top stabilization is recommended. In general bluff top stabilization can be accomplished through the installation of a soldier pile wall system within the right-of-way or, in localized areas, it can be accomplished by a system of soil nails installed through the bluff face.

Soldier piles can incorporate, as needed, tiebacks and grade beams. In addition, if the tops of the soldier piles become exposed over time, lagging can be added to modify the system through the recommended lifetime. Exposed areas can be "rock scaped" as desired to match the surroundings. This option would involve little, if any, disruption of rail operation.

Soil nails can also be considered for stabilization of the bluff top. However, in areas mantled by surficial or disturbed soil deposits, soil nail installation would require disturbance of the natural bluff face and would likely increase erosion and/or require the use of a hard facing to be placed on the bluff face. In these types of areas, the use of soil nails is not being considered because it does not meet the project objectives. However, in localized areas of dense bedrock, the amount of disturbance caused or the extent of hard facing required would be substantially reduced and soil nails may provide an effective solution.

5.5 Drainage Improvements

Drainage improvements were recommended in the Geotechnical Study to reduce erosion of the bluff face and infiltration of water into the subsurface soils. Project 1 incorporated both surface and subsurface drainage improvements. Therefore, additional drainage improvements are not being considered as part of Project 2 except for back drains or surface drainage (i.e., area drains or drainage swales) within future graded areas.

6.0 RECOMMENDED STABILIZATION ALTERNATIVES

The following describes each of the stabilization areas, discusses the existing site specific conditions in each stabilization area and recommends stabilization alternatives.

6.1 Stabilization Area 1 (SA-1)

Priority Area No. 5
Location: Station 1544+70 to 1540+66
Section 1-1', Factor of Safety = 1.26 (0.95 seismic)
Section 2-2', Factor of Safety = 1.42 (0.98 seismic)
Total Length: 404 feet
Length Recommended for Stabilization: 404 feet

In this area, the edge of the bluff is roughly 25 feet west of the track centerline at Station 1544+07 (Section 1-1'), and 20 feet west of the track centerline at Station 1543+00 (Section 2-2') with an elevation of roughly 45 feet above mean sea level (msl). The bluff face is a natural bluff with a series of failures (block falls and landslides) along the toe resulting in an oversteepened condition. Because of the close proximity of the tracks to the top of the bluff and the oversteepened conditions, the calculated factors of safety in this area are below the minimum acceptable parameters and stabilization is recommended for the upper portion of the bluff. To the north of this area, the track is set back a greater distance from the bluff top and is not a high-priority area.

In order to achieve the factor of safety criterion for SA-1, stabilization is recommended. One option that will provide the necessary stabilization would be the construction of a soldier pile wall system. This alternative could be easily constructed on the bluff top within the right-of-way without disruption of rail operations. The soldier piles wall system could be buried.

Because of the somewhat lower bluff height in this area, a second option may be the construction of a large (15'+) sea wall along the bluff toe or a shorter wall with grading of the natural bluff behind the wall. This option would require substantial disturbance of the natural bluff in this area. This option likely raises a wealth of issues that may not be reviewed favorably from a number of perspectives.

6.2 Stabilization Area 2 (SA-2)

Priority Area No. 7
Location: Station 1540+66 to 1539+40
Section 3-3', Factor of Safety = 1.31 (0.90 seismic)
Section 4-4', Factor of Safety = 1.47 (0.93 seismic)
Section 5-5', Factor of Safety = 1.44 (1.01 seismic)
Total Length: 126 feet
Length Recommended for Stabilization: 81 feet

SA-2 includes a former drainage channel that has been partially infilled with fill soils. In 1998, the central portion of this area required emergency stabilization of the trackbed. The emergency stabilization measures consisted of constructing a 45-foot long soldier pile retaining wall (a 2-foot diameter drilled shaft foundation with a 40 foot long steel "H" pile, HP14 x 89, and wood lagging) located approximately 15 feet west of the track centerline and placement of additional fill. In this section of the bluff, slope stability calculations indicate a low factor of safety in the upper portion of the bluff both north and south of the previous repair.

In order to improve the factor of safety, additional stabilization is recommended on either side of the previous repair. One option that provides adequate stability is the continuation of the existing soldier pile system to the north and south of the existing repair. This could be done within the right-of-way and without disruption to rail service.

A second alternative would be to regrade the existing fill area and use a soil cement type of buttress to achieve adequate stability. This alternative would require removal of the existing fill, probable disturbance of the margins of the area, and, possibly, temporary excavations adjacent to the track. It should be noted that if temporary excavations were performed, they would require temporary shoring or the disruption of rail operations during construction.

6.3 Stabilization Area 3 (SA-3)

Priority Area No. 11
Location: Station 1539+40 to 1538+85
Section 6-6', Factor of Safety = 1.43 (0.99 seismic)
Total Length: 55 feet
Length Recommended for Stabilization: 55 feet

In this relatively limited area, the bluff is characterized by an oversteepened natural bluff. This area has been the site of very recent failures within the upper portion of the bluff. Calculated factors of safety for static, train surcharge and pseudo-static loading conditions are slightly below acceptable parameters. The area with a factor of safety below the criteria is predominately limited to the upper portion of the bluff.

Stabilization of SA-3 could be accomplished by the installation of a soldier pile wall system along the bluff top. This stabilization method could be installed with little disruption to rail operations. The repair would be entirely within the right-of-way.

A second option is the extension of the sea wall located just to the south of this area along with the construction of a soil cement or geogrid reinforced slope (buttress) to stabilize the bluff. This option would require disturbance of a natural bluff and grading beyond and west of the right-of-way. In addition, temporary excavations would likely be recommended adjacent to the track. These temporary excavations would require a disruption in rail operations or a need for temporary shoring such as a shallow soldier pile system.

6.4 Stabilization Area 4 (SA-4)

Priority Area No. 3
Location: Station 1538+85 to 1536+90
Section 7-7', Factor of Safety = 1.24 (0.78 seismic)
Section 8-8', Factor of Safety = 1.34 (0.84 seismic)
Total Length: 195 feet
Length Recommended for Stabilization: 195 feet

Previous slope failures within SA-4 have resulted in the placement of stabilization measures consisting of a large embankment fill and a relatively high wooden sea wall along the toe of slope. Portions of the slope face are now eroded and much of the slope is in an oversteepened condition. Slope stability calculations indicate that this entire section of the bluff has factors of safety less than the minimum acceptable parameters.

In order to increase the factor of safety, stabilization measures are recommended. Stabilization can be accomplished by the installation of a soldier pile wall system. This option can be accomplished from the bluff top within the right-of-way with little or no disruption to rail operations. No disturbance of the bluff face is required.

A second option to stabilize the slope is to regrade the bluff face and construct a soil cement or reinforced buttress. Based on the assumption that the existing sea wall at the toe of the bluff is structurally sound, stabilization measures consisting of either a soil cement or reinforced buttress constructed behind the existing sea wall could be implemented. If it is determined that the existing wall is structurally insufficient, a replacement sea wall with a fill slope placed behind the wall, with or without geogrid reinforcement, could be considered. Geogrid reinforcement will allow an increase in the inclination of the slope, however, embedment lengths of the reinforcement layers could be restricted by the existing track alignment and will be dependent on the height of the new wall and the soil strength parameters of the backfill soil.

It should be noted that the grading alternatives will require temporary excavations adjacent to the track. These temporary excavations would require a disruption in rail operations or temporary shoring. Based on the depth of fill, temporary shoring for this area would likely be some type of a soldier pile system. The soldier pile shoring would be similar to the first alternative but at a shallower depth as it is only needed for the temporary condition. Also, slope grading in this area would include grading outside of the right-of-way and extensive disturbance of the existing bluff face.

6.5 Stabilization Area 5 (SA-5)

Priority Area No. 1
Location: Station 1536+90 to 1532+50
Section 9-9', Factor of Safety = 1.02 (0.79 seismic)
Section 10-10', Factor of Safety = 1.25 (0.69 seismic)
Section 11-11', Factor of Safety = 1.17 (0.77 seismic)
Total Length: 440 feet
Length Recommended for Stabilization: 350 feet

SA-5 consists of a predominately natural bluff with the track in close proximity to the edge of the bluff. A localized area of fill soils is present adjacent to a storm drain structure (BR 244.4). The bluff is oversteepened due to past failures and the lower half of the bluff is mantled by slope creep deposits and landslide debris. This loose material is easily eroded during storms and periods of heavy surf with the exception of the southern 350 feet where a low wooden sea wall is present. Because of previous landsliding in this area, soldier piles have been installed at the top of the bluff roughly between Station 1536+50 and 1535+60. Recent bluff failures have also occurred just north of the existing soldier piles.

Because of the close proximity to the bluff edge, the abundance of failures and the oversteepened condition in this area, the upper bluff requires stabilization except at the location of the existing soldier piles.

The option that appears best suited for this area would be an extension of the soldier pile wall system to span the entire length. This option could be constructed within the right-of-way with only minimal disruption. Because of the close proximity of the tracks to the bluff edge some of this work may be required to be performed at night or may require breaks in rail operations.

As another option in this area, the slope could be reconstructed as a soil cement buttress. This option would require removal of a portion of the existing fill soils and necessitate temporary excavations along the track. Temporary excavations would require the use of shoring or a disruption of rail operations. Note that a similar condition was previously repaired just to the south of SA-5 at BR244.45. Soil removals during the replacement of the storm drain at this location proved to be much more extensive than anticipated and resulted in a break in rail service. Slope grading of this area will likely have some impacts to the adjacent areas of natural bluff.

6.6 Stabilization Area 6 (SA-6A and SA-6B)

Priority Area No. 2 for SA-6A and Priority Area No. 9 for SA-6B
Location: Station 1532+50 to 1531+65, and Station 1530+25 to 1529+10
Section 12-12', Factor of Safety = 1.23 (0.79 seismic)
Section 13-13', Factor of Safety = 1.35 (0.81 seismic)
Section 14-14', Factor of Safety = 1.35 (0.90 seismic)
Total Length: 200 feet
Length Recommended for Stabilization: 85 feet for SA-6A and 115 feet for SA-6B

As pictured on the cover of the Geotechnical Study, the track in this area is in very close proximity to the bluff edge. Previous landsliding has occurred in this area and the bluff has been reconstructed as a manufactured fill slope. The existing slope is currently constructed at gradients that are generally considered unstable with near vertical portions in some areas. A retaining wall is present at the bluff top in the northern portion of SA-6 and a low sea wall is present at the toe of the bluff for a majority of the length of SA-6. Slope stability calculations indicate the area has an inadequate factor of safety. In between SA-6A and SA-6B an existing soil cement repair was constructed in the late 1990's roughly between Station 1531+65 and 1530+25. Because of the previous repair, this portion of the slope is considered a medium priority area. The repair was initiated as a storm drain replacement project but removals of unsuitable material were much more extensive than anticipated and expanded the repair area to a much larger area that required breaks in rail operations. At the southern end of SA-6B, the fill soils at the top of the bluff overlie an area of natural bluff. The southerly end of this area is the site of a recent bluff failure and the exposed bluff face consists of a near vertical face of dense bedrock with fill above (see Appendix D, Section 14-14').

A fill slope is present on the bluff face roughly between Station 1532+50 and 1531+65. In addition, a small sea wall built in 1965 continues from SA-5 and extends to Station 1530+30. The slope stability analyses for the remaining unimproved portion of the bluff indicate that the calculated factors of safety for static, train surcharge and pseudo-static analysis condition fall below the acceptable criterion.

Given the existing sea wall and existing manufactured fill slope, stabilization measures between Station 1532+50 and 1531+65 (SA-6A) consist of either a soldier pile retaining system or a soil cement buttress. Considering the natural topography of the bluff and the dense exposed bluff face, stabilization measures between Station 1530+35 and 1529+10 (SA-6B) consist of a soldier pile retaining system or an embedded soil nail on the bluff face or soil nails with a facing.

The soldier pile wall system can be constructed within the right-of-way with minimal or no disruption to rail operations. Slope grading would require work to be performed outside the right-of-way and possibly, as with the previous repair, may include large excavations. Temporary excavations next to the track would require the use of shoring (such as a shallow soldier pile system) or a disruption of the rail operations. At the southern end of this section where the use of soil nails can be considered, the installation can be done without impacts to rail operations. However, it would require work outside the right-of-way and on the beach. In addition, the work is likely to cause additional disturbance of the natural bluff areas. Slope disturbance would probably result in some increased erosion, but this could be reduced by use of a bluff facing in conjunction with soil nail system.

6.7 Stabilization Area 7 (SA-7)

Priority Area No. 6
Location: Station 1516+57 to 1515+50
Section 17-17', Factor of Safety = 1.29 (0.92 seismic)
Total Length: 107 feet
Length Recommended for Stabilization: 107 feet

Notably, SA-7 is located north of the 8th Street Emergency Repair site where a soldier pile wall system was constructed in 2001. The slope stability analyses for this portion of the bluff indicate that the calculated factors of safety are below the acceptable criterion.

Given the existing steep bluff face, stabilization measures consist of either a continuation of the soldier pile retaining system (installed as part of the previous emergency repair) or possibly an embedded soil nail repair. The soldier pile wall system can be constructed within the right-of-way with minimal or no disruption to rail operations. The grade beam can be constructed below grade.

With regard to soil nails, the installation can be done without impacts to rail operations, but would likely require work outside the right-of-way and on the beach. Also, soil nail installation will likely result in additional disturbance of the natural bluff area, an increase in slope erosion, and/or the use of a facing on the slope.

6.8 Stabilization Area 8 (SA-8A and SA-8B)

Priority Area No. 10
Location: Station 1494+05 to 1493+33 and 1491+15 to 1490+80
Section 20-20', Factor of Safety = 1.65 (0.95 seismic)
Section 21-21', Factor of Safety = 1.41 (0.92 seismic)
Total Length: 107 feet
Length Recommended for Stabilization: 107 feet

In SA-8A and SA-8B, removal of storm drains resulted in the construction of a retaining wall in each area. In section SA-8A, this wall is located on the beach and retains fill soils extending up to the bluff top. In section SA-8B, the wall is located near the bluff top. Within both areas, the track is in relatively close proximity to the edge of the bluff. The bluff is locally oversteepened from past erosion with the limits of this section confined to a localized condition.

Slope stability calculations for these areas indicate factors of safety below the design criterion for seismic slope stability at both locations and also for static slope stability at section SA-8B.

In order to provide an acceptable factor of safety for these areas, stabilization is recommended. One option that will provide the necessary stabilization would be the construction of a soldier pile wall system across these two limited areas. This alternative could be easily constructed on the bluff top within the right-of-way without disruption of rail operations. The soldier piles could be buried or above grade. Another possible conceptual repair alternative given the limited length and locally oversteepened erosional areas is a soil cement buttress.

6.9 Stabilization Area 9 (SA-9A and SA-9B)

Priority Area No. 12 for SA-9A and Priority Area No. 8 for SA-9B
Location: Station 1490+80 to 1484+80 and 1484+80 to 1483+55
Section 22-22', Factor of Safety = 1.45 (0.97 seismic)
Section 23-23', Factor of Safety = 1.34 (0.92 seismic)
Total Length: 725 feet
Length Recommended for Stabilization: 600 feet for SA-9A and 125 feet for SA-9B

Stabilization Area 9, located north of Anderson Canyon, is prone to blockfalls, landslides and is locally oversteepened. What appear to be minimal fill soils are present at the top of bluff, possibly the result of a previous erosional repair. The bluff face in this area is generally very steep and composed of relatively dense materials with limited zones of loose surficial soils.

The slope stability analyses for this portion of the bluff indicate that the calculated factors of safety are below the acceptable criterion locally for static slope stability and throughout for seismic conditions; therefore, stabilization is recommended.

Given the existing steep bluff face, the appropriate stabilization measures consist of either a soldier pile retaining system or a soil nail reinforcement alternative. The soldier pile wall system can be constructed within the right-of-way with minimal or no disruption to rail operations. Soil nails, if utilized, can be installed without impact to rail operations, but would likely require work on the beach within the right-of-way. Soil nail installation would likely result in disturbance of the natural bluff areas, an increase in slope erosion, and/or the use of a facing on the slope.

6.10 Stabilization Area 10 (SA-10)

Priority Area No. 4
Location: Station 1483+55 to 1482+10
Section 24-24', (West Side) Factor of Safety = 1.52 (0.90 seismic)
Section 25-25', (East Side) Factor of Safety = 1.25 (1.08 seismic)
Total Length: 145 feet (East Side)
Length Recommended for Stabilization: 145 feet (East Side)

SA-10 is located at Anderson Canyon where a large fill slope has been constructed across a major drainage channel with fill slopes located both east and west of the tracks. These slopes are supported by a sea wall on the west side with a slope gradient that is steeper than currently considered acceptable for an unreinforced fill slope. A detention basin and storm drain inlet is present on the east side. Some areas of surficial sloughing and slumping can be observed on both sides and locally oversteepened areas also exist on both sides of the track. The tracks are roughly 20 feet from the top of slope on the west side but only 5 feet from the top of slope on the east where a near vertical section of slope is present.

Slope stability analyses for this portion of the bluff indicate that the calculated factors of safety for static and for train surcharge conditions are generally above the acceptable criterion for gross stability on the west side. However, the analysis indicates that the calculated factors of safety for surcharge conditions are below the acceptable criterion on the east side. As a result of this and given that it is a fill slope with oversteepened areas, stabilization measures are warranted for the east side in this area.

Stabilization measures consist of either a soldier pile retaining system or a soil cement replacement fill. Note that in this area, mitigation of the slope stability issues should be considered only on the east side of the tracks.

A soldier pile wall system can be constructed within the right-of-way with minimal or no disruption to rail operations. Construction of a graded slope such as a soil cement or geogrid reinforced slope can also be considered. Conventionally graded and somewhat flatter slopes are likely not an alternative because of space limitations. The soil cement or geogrid slope can be constructed but will likely require disruption of rail operations or extensive shoring. It may be possible to construct a soil cement stabilization on the east side of the track in conjunction with a retaining wall to reduce impacts.

6.11 Summary of Stabilization Areas

Table 6 provides a summary of the currently recommended lengths for the stabilization areas.

Table 6
Recommended Stabilization Lengths

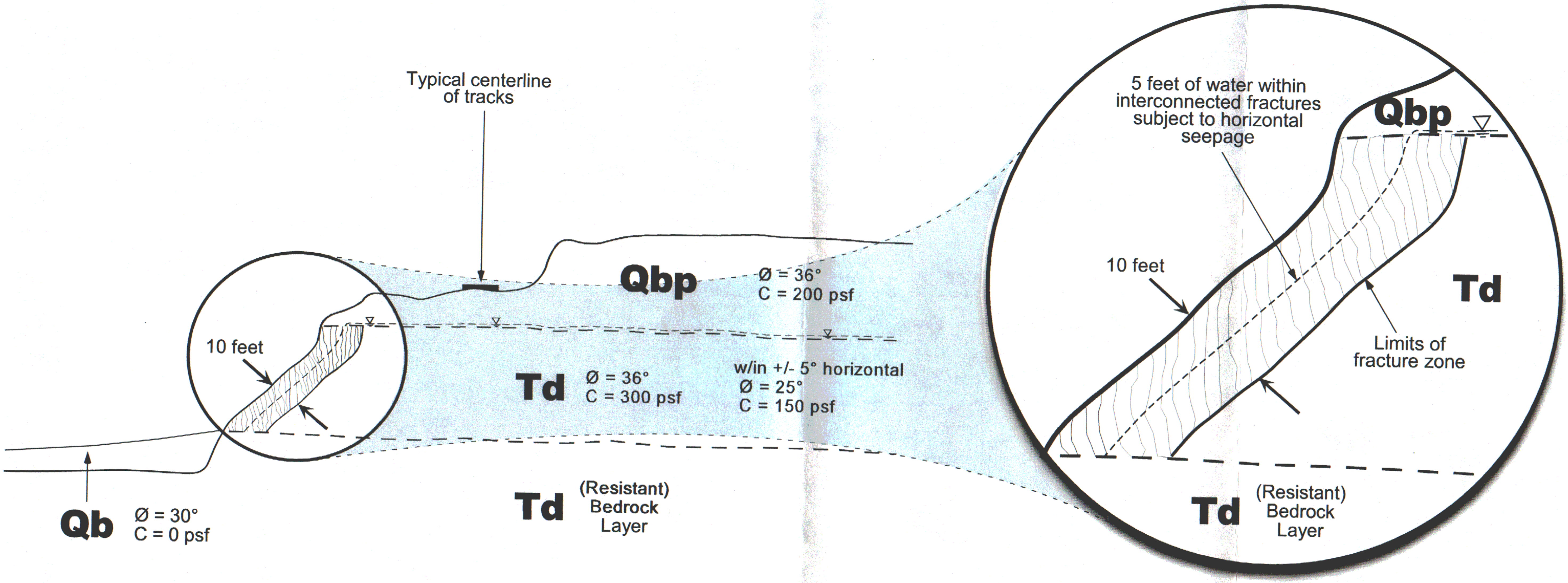
Area	Length of Stabilization (feet)
SA-1	404
SA-2	81
SA-3	55
SA-4	195
SA-5	350
SA-6A	85
SA-6B	115
SA-7	107
SA-8	107
SA-9A	600
SA-9B	125
SA-10	145
TOTAL	2,369

As presented in the table above, the current total recommended length of stabilization is 2,369 feet, or roughly 28 percent of the entire bluff length. The total length of the study area is 1.6 miles (8,450 feet).

7.0 CONCLUSIONS

In conclusion, the slope stability analysis included within this report demonstrates which areas of this critical link of the LOSSAN corridor do not currently meet the project criteria for factor of safety and where stabilization is warranted. The conceptual repair alternatives presented in Part 2 of the Geotechnical Study have been further evaluated to define which alternatives meet the project needs and objectives. Those alternatives that meet the project needs have been considered in the stabilization alternatives present as Section 6 of this report.

Through a substantial amount of additional slope stability analysis, areas have now been grouped into Stabilization Areas of like soil and geologic conditions which have then been prioritized based on the factor of safety. This additional analysis has reaffirmed the need for stabilization within the high-priority areas defined by the Geotechnical Study. The analysis also provides for the selection of improvements to the areas with the greatest need at this time. Options for the repair/stabilization of the high-priority areas that meet the goals of this project have been reviewed and suggested on a site specific basis.



LEGEND

Qb Beach Deposit

Qbp Bay Point Formation

Td Delmar Formation

⊻ Perched groundwater profile

SIMPLIFIED
SLOPE STABILITY MODEL
NORTH OF MP 245.21

Del Mar Bluffs Project
Del Mar, California

Project No.	040151-009
Scale	Not to scale
Engr./Geol.	WDO/MRS
Drafted By	KAM
Date	November 2003

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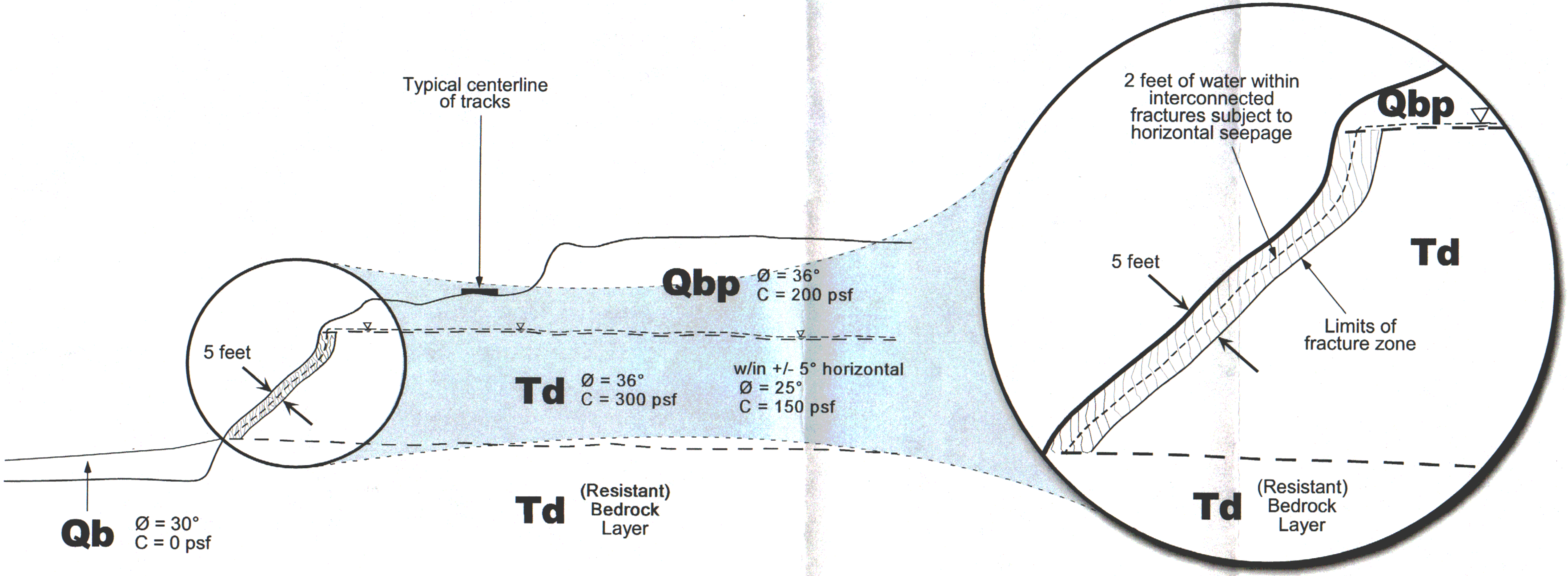
Figure No. 2



LEGEND

- **Qb** Beach Deposit
- **Qbp** Bay Point Formation
- **Td** Delmar Formation
- ⊽ Perched groundwater profile

SIMPLIFIED SLOPE STABILITY MODEL SOUTH OF MP 245.21

Del Mar Bluffs Project
Del Mar, California

Project No.	040151-009
Scale	Not to scale
Engr./Geol.	WDO/MRS
Drafted By	KAM
Date	November 2003

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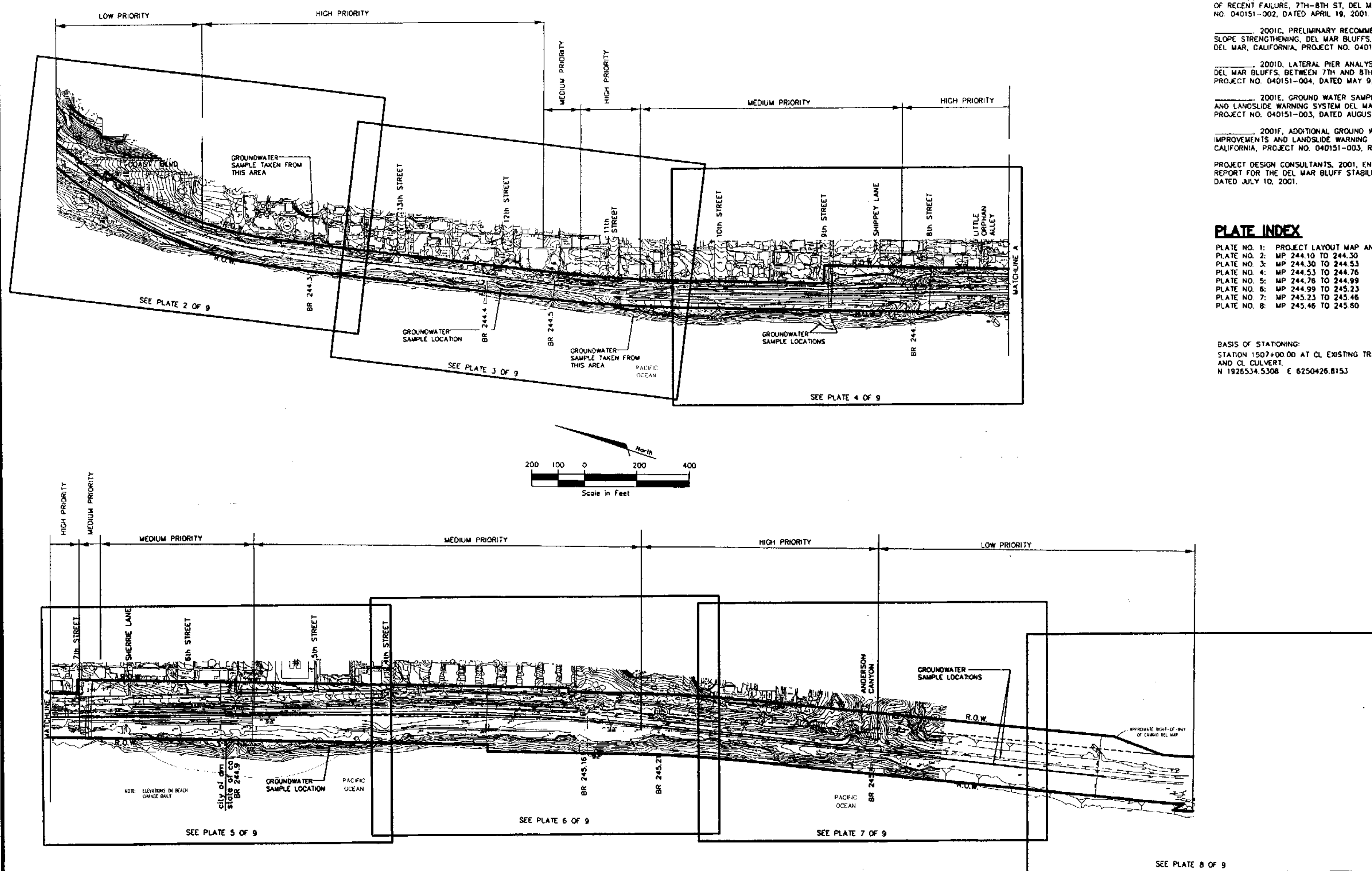
Figure No. 3



KEY MAP
DEL MAR BLUFFS
1" = 200'

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PLATE NO. 6: MP 244.99 TO 245.23
PLATE NO. 7: MP 245.23 TO 245.46
PLATE NO. 8: MP 245.46 TO 245.60

BASIS OF STATIONING:
STATION 1507+00.00 AT CL EXISTING TRACK AND CL CULVERT.
N 1926534.5308 E 6250426.8153

LEGEND

GEOLOGIC UNITS

- Af ARTIFICIAL FILL
- Qls LANDSLIDE DEPOSIT
- Qb BEACH DEPOSIT
- Qbp BAY POINT FORMATION
- Td DELMAR FORMATION

MAP SYMBOLS

- APPROX. LOCATION OF GEOLOGIC CONTACT
- SEEPAGE
- SOIL CREEP
- APPROX. NCTD RIGHT-OF-WAY
- CLEAN AND REHAB EXISTING 8" CMP SUBDRAIN
- C.O. CLEANOUT

NOTES:

SUBDRAINS SHOWN ON MAP BASED ON REVIEW OF AT&SF DOCUMENTS (AT&SF, 1978); NOT ALL SUBDRAINS OBSERVED DURING FIELD MAPPING.

REFERENCED BORING LOGS CONTAINED WITHIN PART I, VOLUME II OF GEOTECHNICAL EVALUATION BY LEIGHTON AND ASSOCIATES, PROJECT NUMBER 040151-001, DATED JANUARY 31, 2001.

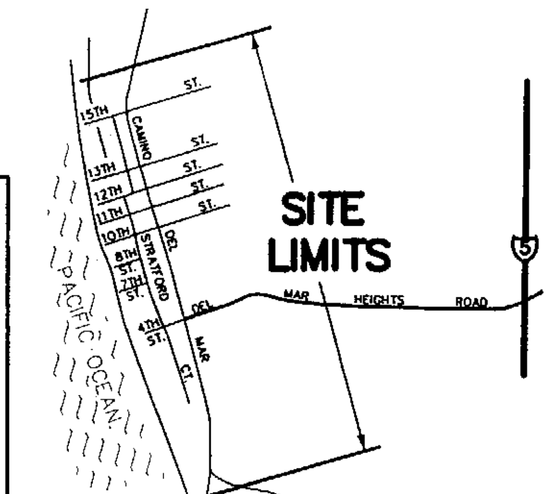
EASTERLY R.R. RIGHT-OF-WAY BETWEEN 7TH STREET AND 8TH STREET PLOTTED PER A.T. & S.F. RY. CO. RIGHT-OF-WAY SURVEY PLAT DATED 7-10-72 CECL DWG. NO. 20-31295 SHEET 4 OF 6 SHEETS. (PLOTTED PER EXISTING MANHOLES PER SURVEY PLAT)

THE RAILROAD RIGHT-OF-WAY IS PLOTTED PER RECORD INFORMATION PROVIDED BY BRUCE SMITH OF N.C.T.D. ON MAY 15, 2001.

ORIGINAL EXISTING CONTOURS ARE BASED ON 5-1995 AERIAL PHOTOGRAPHY BY AERO TECH WITH SUPPLEMENTARY SURVEYS ON 3-1995 BY ASSOCIATED ENGINEERS, INC.

SUPPLEMENTAL FIELD TOPOGRAPHIC SURVEY PROVIDED BETWEEN 4-30-01 AND 6-15-01, BY MLSI.

SEE (LEIGHTON, 2001E AND F) FOR GROUNDWATER SAMPLING RESULTS.



TORREY PINES STATE RESERVE

VICINITY MAP
NTS
TB 1187-F6

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San Diego, CA 92123

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GEOTECHNICAL MAP AND SECTIONS
DEL MAR BLUFFS PROJECT II
DEL MAR, CALIFORNIA

PROJECT LAYOUT MAP AND NOTES

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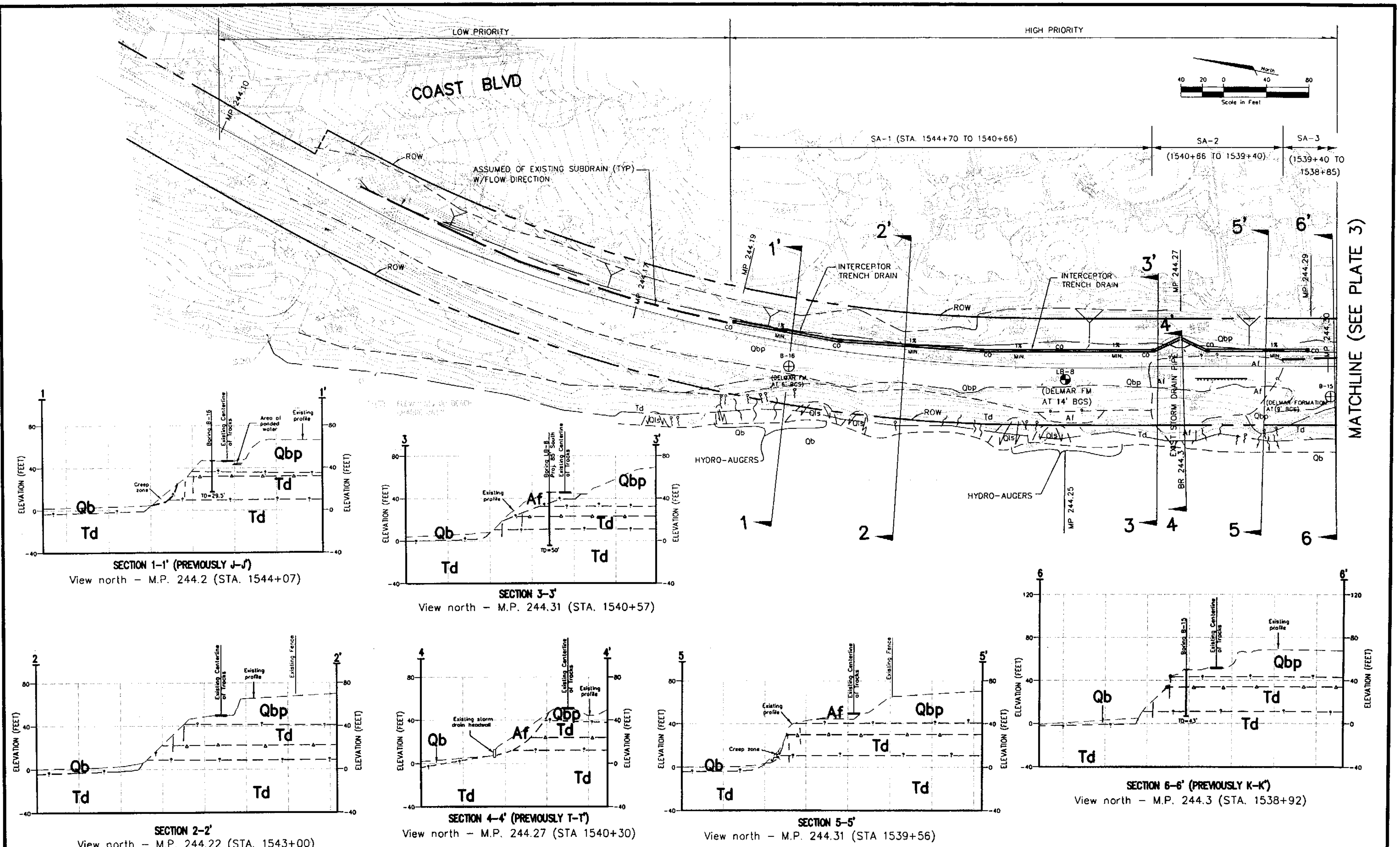

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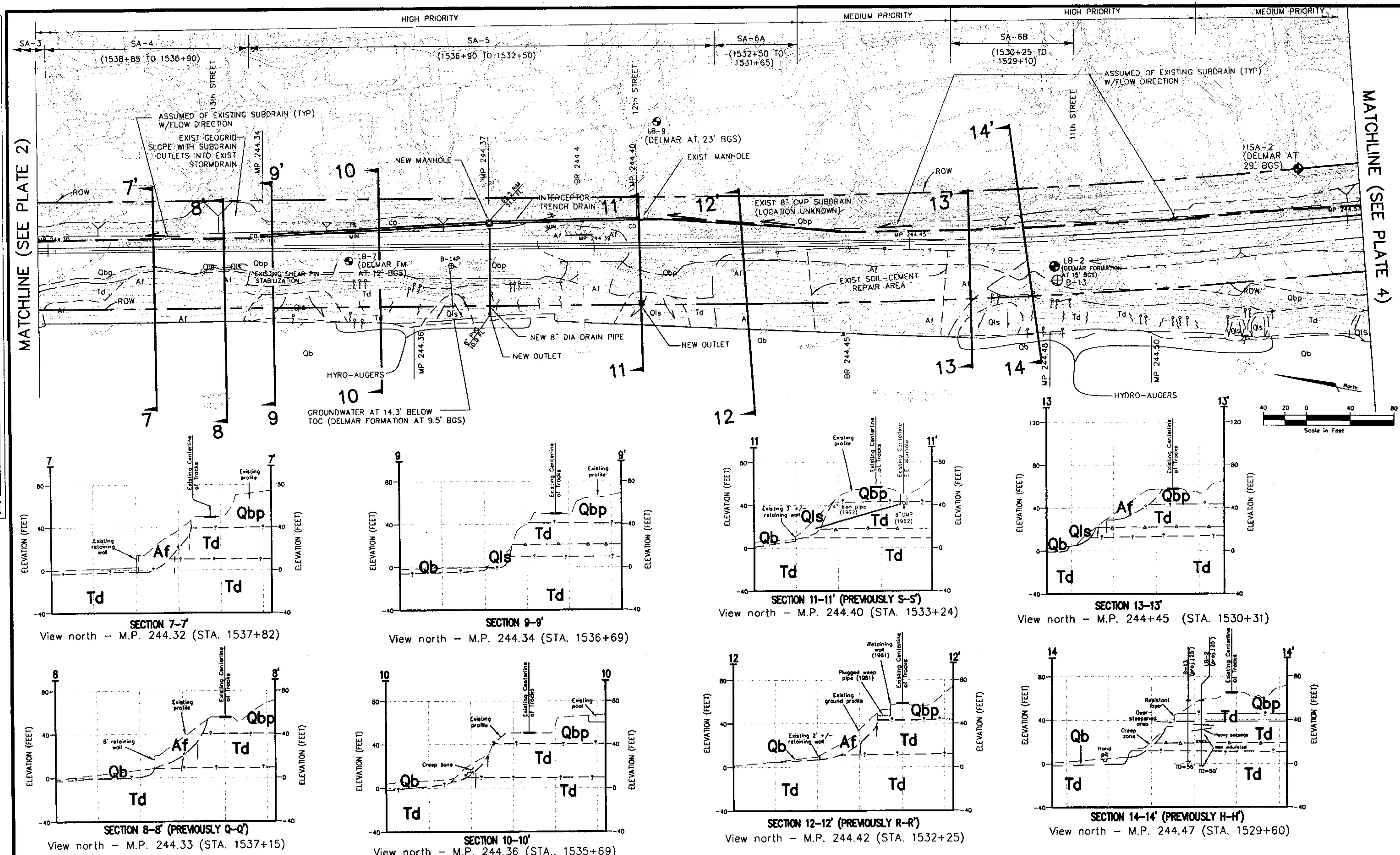

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GEOTECHNICAL MAP AND SECTIONS DEL MAR BLUFFS PROJECT II DEL MAR, CALIFORNIA

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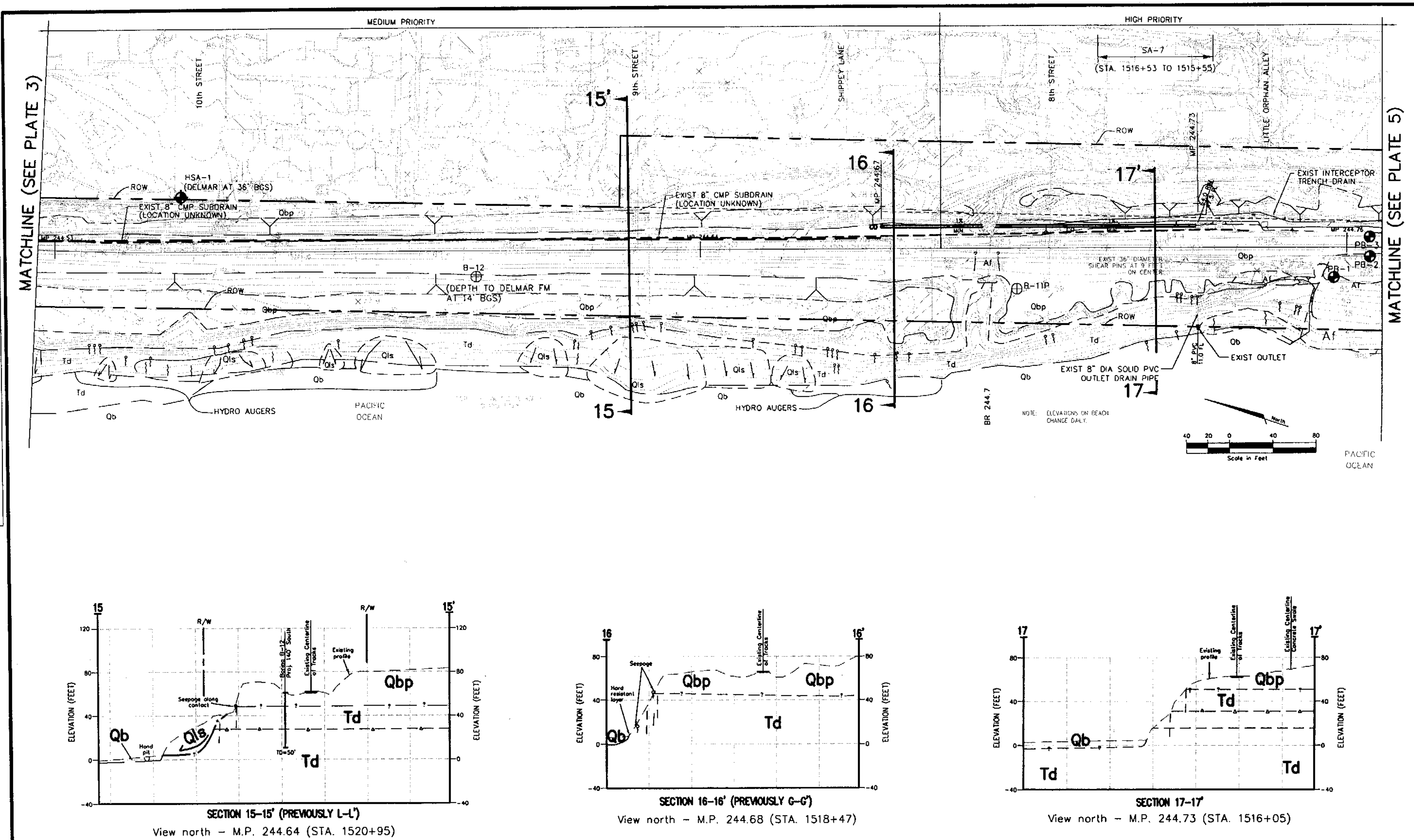

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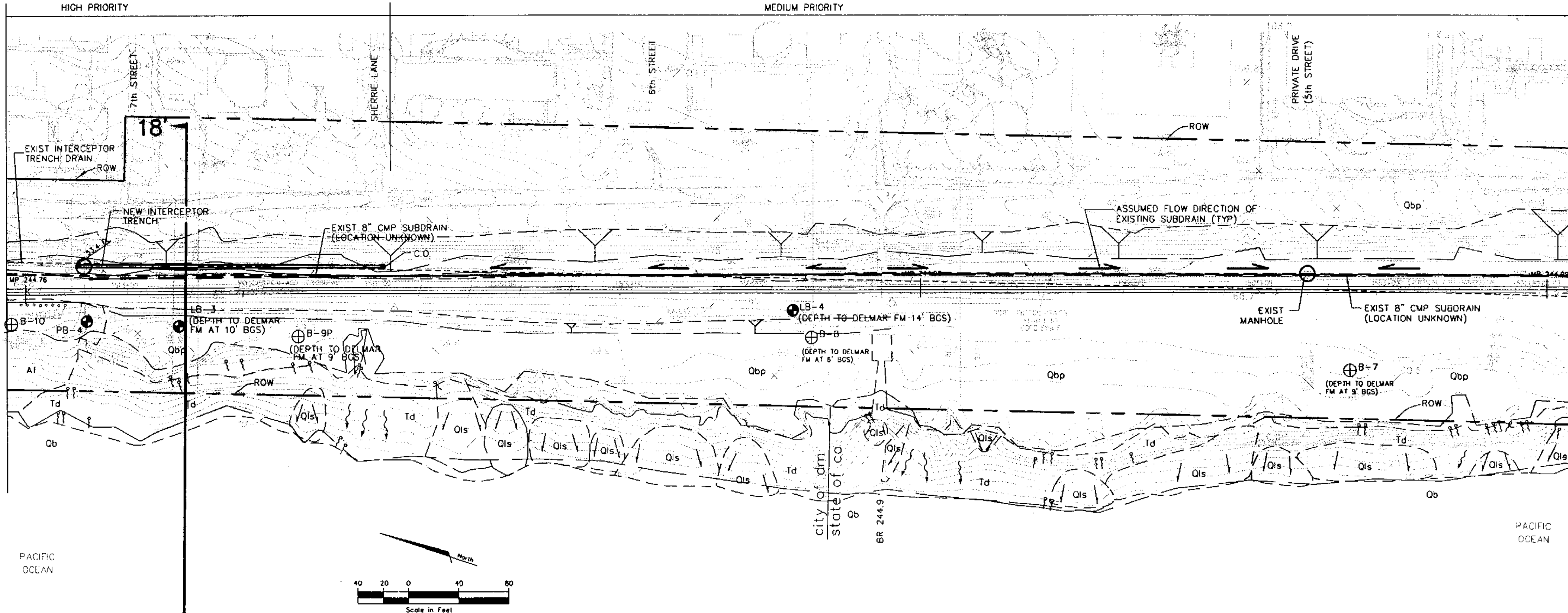

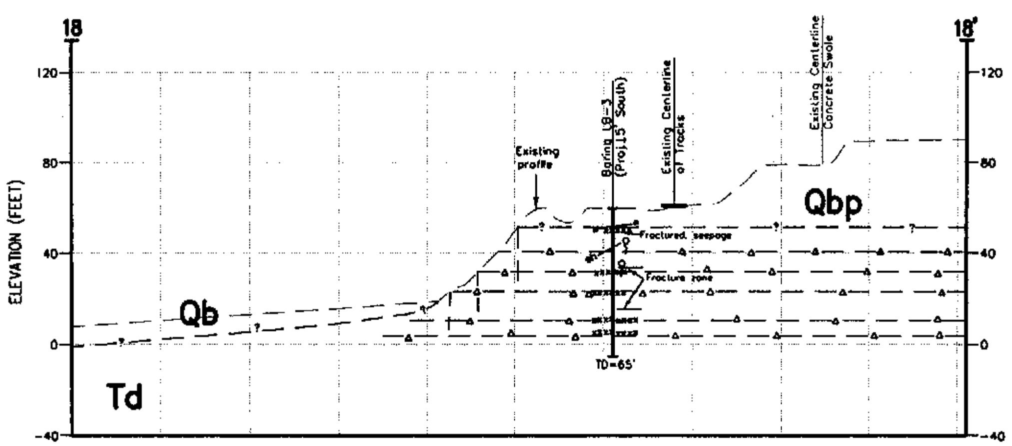

SECTION 18-18' (PREVIOUSLY M-M')

View north – M.P. 244.79 (STA. 1512+55)

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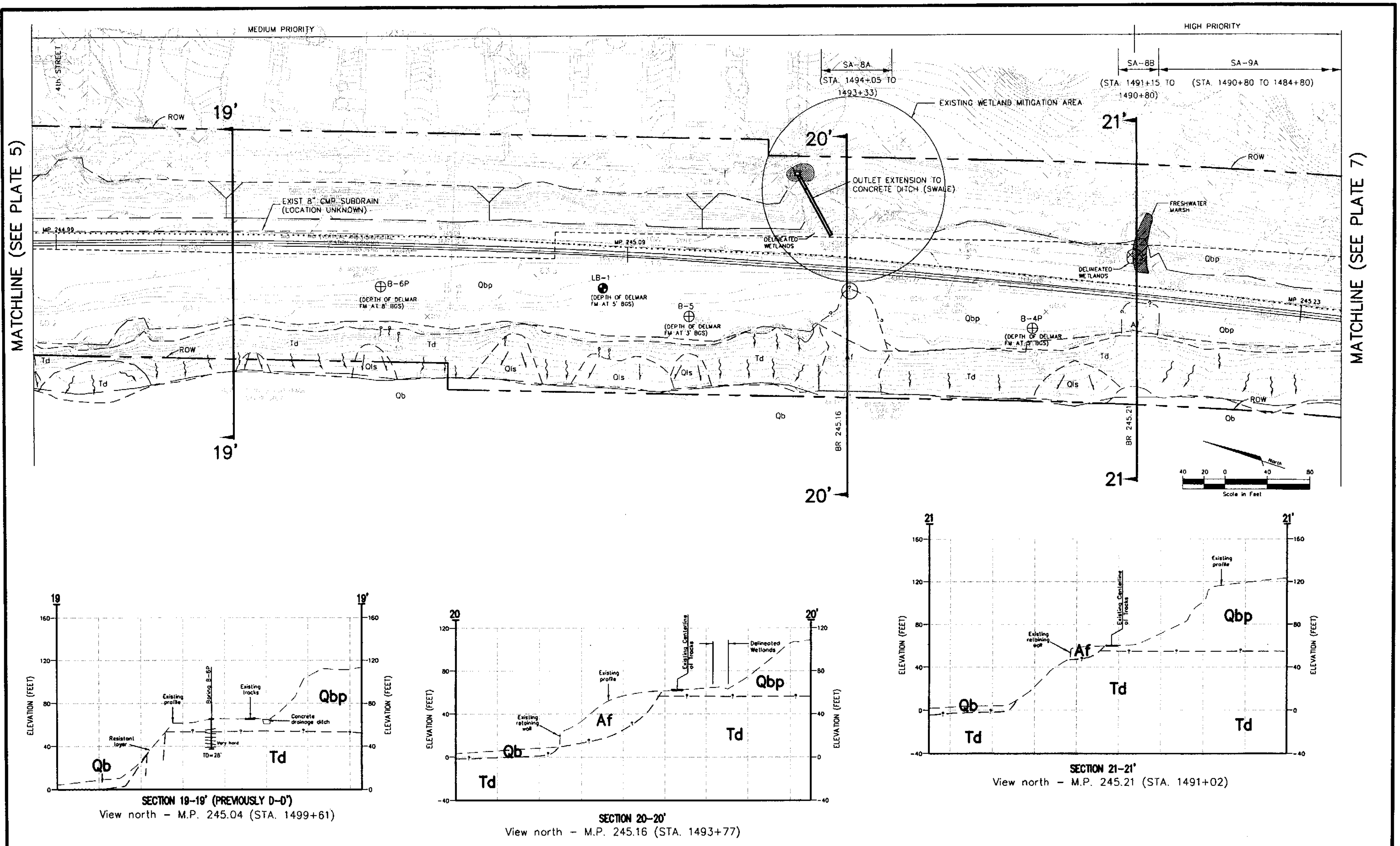

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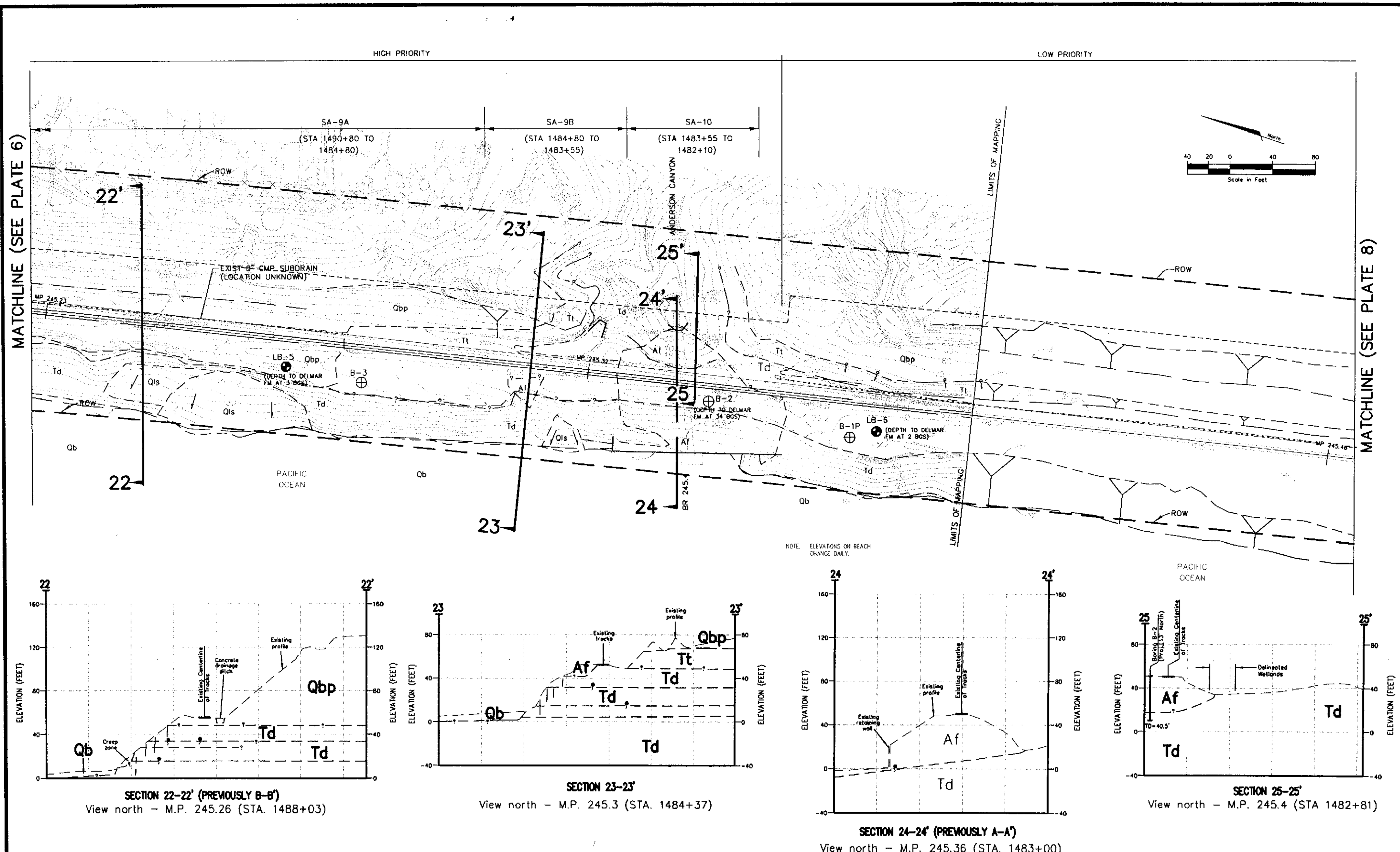
PLATE NO. 6 OF 8

DATED OCTOBER 2003



REV.	DATE	DESCRIPTION	BY / APP

INFORMATION CONFIDENTIAL: All plans, drawings, specifications, and or information furnished herewith shall remain the property of the North San Diego County Transit Development Board; shall be held confidential; and shall not be used for any purpose not provided for in agreements with the North San Diego County Transit Development Board.

DESIGNED BY
DRAWN BY KRD
CHECKED BY WDO
APPROVED BY MRS
DATE

LEIGHTON AND ASSOCIATES, INC.
3934 Murphy Canyon Road
Suite B-205
San Diego, CA 92123

NCTD NORTH SAN DIEGO COUNTY TRANSIT DEVELOPMENT BOARD

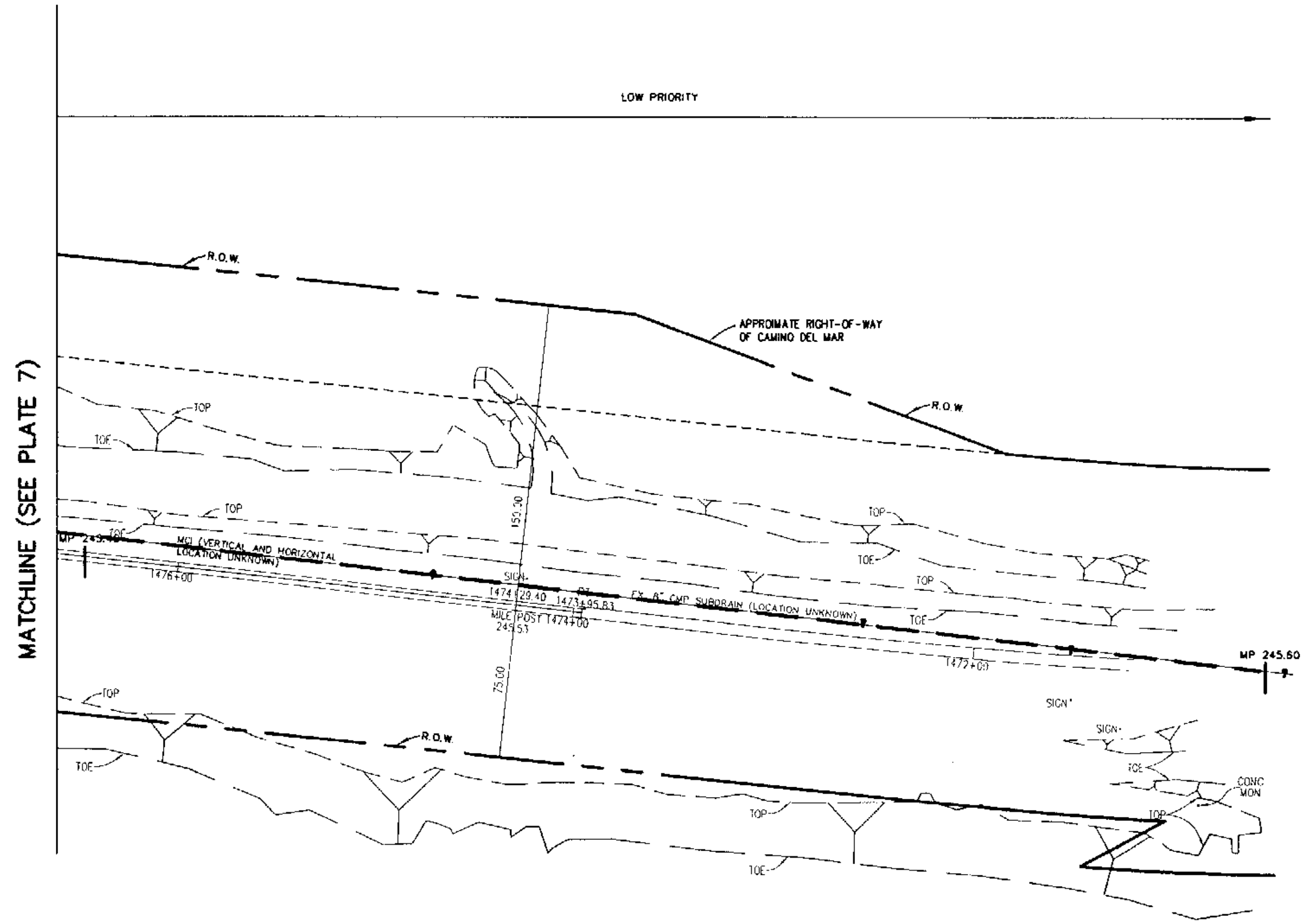
SUBMITTED: APPROVED:

GEOTECHNICAL MAP AND SECTIONS
DEL MAR BLUFFS PROJECT II
DEL MAR, CALIFORNIA

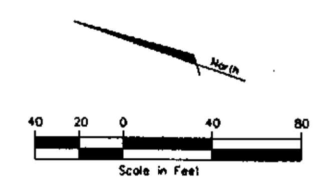
MILE POST 245.23 TO 245.46

SCALE AS REFERENCED
CONTRACT NO.
DRAWING NO.
REV. PLATE NO. 7 OF 8
DATED OCTOBER 2003

CHECKING PRINT NO. DATE: CHECKED BY: DATE: CORRECTED BY: DATE: B'CHECKED BY: DATE: SIGNED BY: DATE:



NOTE: ELEVATIONS ON BEACH
CHANGE DAILY.



REV.	DATE	DESCRIPTION	BY	APP

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DESIGNED BY
DRAWN BY KRD
CHECKED BY WDO
APPROVED BY MRS
DATE

LEIGHTON AND ASSOCIATES, INC.
3934 Murphy Canyon Road
Suite B-205
San Diego, CA 92123

NORTH SAN DIEGO COUNTY TRANSIT DEVELOPMENT BOARD
N C T D

SIMON WONG ENGINEERING
STRUCTURAL AND BRIDGE ENGINEERS
9968 Hibert Street, Suite 202
San Diego, CA 92131
(858) 566-3113

Job No. 518-109

SUBMITTED: ______ APPROVED: ______

GEOTECHNICAL MAP AND SECTIONS DEL MAR BLUFFS PROJECT II DEL MAR, CALIFORNIA

MILE POST 245.46 TO 245.60

SCALE AS REFERENCED
CONTRACT NO.
DRAWING NO.
REV.
PLATE NO. 8 OF 8

DATED OCTOBER 2003

CHECKING PRINT NO. ______ DATE: ______
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CORRECTED BY: ______ DATE: ______
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SIGNED BY: ______ DATE: ______

APPENDIX A

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Aerial Photographs

Agency	Date	Flight No.	Photo Nos.
USDA	1953	AXN-8M	82 and 84
GTI	November 26, 1969	16	37a BU, 37b BU
GTI	July 29, 1990		41-44, 49-51, 54-60 (oblique photos)
GTI	January 28, 1999		86-95 (oblique photos)

GEOTECHNICAL BORING LOG KEY

Date ______________ Sheet 1 of 1

Project KEY TO BORING LOG GRAPHICS Project No. ______________

Drilling Co. ______________ Type of Rig ______________

Hole Diameter ______________ Drive Weight ______________ Drop ____ in.

Elevation Top of Hole +/-______ ft. Ref. or Datum ______________

Elevation (feet)	Depth (feet)	Graphic Log	Notes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By ______________ Sampled By ______________

Depth scale: 0, 5, 10, 15, 20, 25, 30

SPT SAMPLE

CAL SAMPLE

GROUND WATER TABLE AT TIME OF DRILLING

Soil Class. (U.S.C.S.)	Geotechnical Description
CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
CH	Inorganic clay or high plasticity; fat clay
OL-OH	Organic clay, silt or silty clay-clayey silt mixtures
ML	Inorganic silt; very fine sand; silty or clayey fine sand; clayey silt with low plasticity
MH	Inorganic silt; diatomaceous fine sandy or silty soils; elastic silt
CL-ML	Low plasticity clay to silt mixture
ML-SM	Sandy silt to silty sand mixture
CL-SC	Sandy clay to clayey sand mixture
SC-SM	Clayey sand to silty sand mixture
SW	Well graded sand; gravelly sand, little or no fines
SP	Poorly graded sand; gravelly sand, little or no fines
SM	Silty sand; poorly graded sand-silt mixture
SC	Clayey sand; poorly graded sand; clay mixture
GW	Well graded gravel; gravel-sand mixture, little or no fines
GP	Poorly graded gravel; gravel-sand mixture, little or no fines
GM	Silty gravel; gravel-sand-silt mixture
GC	Clayey gravel; gravel-sand-clay mixture
	Sandstone
	Siltstone
	Claystone
	Breccia (angular gravel and cobbles or matrix-support conglomerate)
	Conglomerate (rounded gravel and cobble clast-supported)
	Igneous granitic or granitic type rock
	Metavolcanic or metamorphic rock
	Artificial or man-made fill
	Asphaltic concrete
	Portland cement concrete

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Boring Logs - Geotechnical Investigation, 10th Street Retaining Wall (April 30, 2002)

GEOTECHNICAL BORING LOG HSA-1

Date 4-11-02   Sheet 1 of 3

Project Del Mar Bluffs   Project No. 040151-007

Drilling Co. Cal Pac Drilling   Type of Rig Hollow-Stem Auger

Hole Diameter 8 in.   Drive Weight 140 pounds   Drop 30 in.

Elevation Top of Hole +/- 80 ft.   Ref. or Datum Mean Sea Level

Logged By GJM

Sampled By GJM

Elevation (feet)	Depth (feet)	Graphic Log	Notes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
80	0			Bag-1 @0'-5'				SM	QUATERNARY BAY POINT FORMATION (Qbp) @ 0': Silty fine to medium SAND: Red-brown, damp to moist, loose
75	5			2	13	106.0	5.2		@ 6': Silty fine to medium SAND: Red-brown, damp to moist, loose
70	10			3	18	111.4	6.3		@ 11': Silty fine to medium SAND: Red-brown, damp to moist, loose
65	15			4	35	113.5	8.9		@ 16': Silty fine to medium SAND: Orange-gray, damp to moist, medium dense
60	20			5	36	109.4	9.4		@ 21': Silty fine to medium SAND: Orange-brown, damp to moist, medium dense
55	25			6	75	119.9	12.0		@ 26': Silty fine to medium SAND: Dark orange-brown with some black grains, damp to moist, dense
50	30								

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GEOTECHNICAL BORING LOG HSA-1

Date 4-11-02 | Sheet 2 of 3

Project Del Mar Bluffs | Project No. 040151-007

Drilling Co. Cal Pac Drilling | Type of Rig Hollow-Stem Auger

Hole Diameter 8 in. | Drive Weight 140 pounds | Drop 30 in.

Elevation Top of Hole +/- 80 ft. | Ref. or Datum Mean Sea Level

GEOTECHNICAL DESCRIPTION

Logged By GJM

Sampled By GJM

Elevation (feet)	Depth (feet)	Graphic Log	Notes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
50	30			7	50/5"	108.7	19.3	SM	@ 31': Medium to SAND: Light orange-brown, damp to moist, wet, dense to very dense
45	35			8	50/4"	112.8	18.4	CL	
								CL	TERTIARY DEL MAR FORMATION (Td) @ 36': Silty CLAYSTONE: Olive gray-green, damp to moist, dense to very dense
40	40			9 Bag-10 @40'-45'	50/5"	114.5	16.0	SM	@ 41': Silty fine SANDSTONE: Green, damp to moist, dense to very dense
35	45			11	60/6"	114.9	12.7		@ 45': Silty fine to medium SANDSTONE: Green-gray green, very dense
30	50			12	55/6"	108.7	15.9	SM/SC	@ 50': Silty fine to medium slightly clayey SANDSTONE: Olive green-gray green, very dense
25	55			13	60/6"	108.0	15.3	CL	@ 55': Silty CLAYSTONE: Gray-green to olive-green, damp to very dense
20	60								

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GEOTECHNICAL BORING LOG HSA-1

Date 4-11-02 Sheet 3 of 3
Project Del Mar Bluffs Project No. 040151-007
Drilling Co. Cal Pac Drilling Type of Rig Hollow-Stem Auger
Hole Diameter 8 in. Drive Weight 140 pounds Drop 30 in.
Elevation Top of Hole +/- 80 ft. Ref. or Datum Mean Sea Level

GEOTECHNICAL DESCRIPTION

Logged By GJM
Sampled By GJM

Elevation (feet)	Depth (feet)	Graphic Log	Notes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
20	60			14	50/5"	101.9	19.2	CL	@ 60': Silty fine to sandy CLAYSTONE: Olive green-gray green, damp to very dense
									Total Depth = 61 Feet Ground water encountered at 29 feet at time of drilling Backfilled with soil cuttings on 4/11/02
15	65								
10	70								
5	75								
0	80								
-5	85								
-10	90								

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GEOTECHNICAL BORING LOG HSA-2

Date 4-11-02 Sheet 1 of 2
Project Del Mar Bluffs Project No. 040151-007
Drilling Co. Cal Pac Drilling Type of Rig Hollow-Stem Auger
Hole Diameter 8 in. Drive Weight 140 pounds Drop 30 in.
Elevation Top of Hole +/- 73 ft. Ref. or Datum Mean Sea Level

Elevation (feet)	Depth (feet)	Graphic Log	Notes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By GJM Sampled By GJM
	0							SM	ARTIFICIAL FILL (Af) @ 0': Silty fine to medium SAND: Brown, red-brown, damp to loose
70								SM	QUATERNARY BAY POINT FORMATION (Qbp)
	5			1	28	112.2	4.3		@ 6': Silty fine to medium SAND: Orange-brown to red-brown, damp to moist, medium dense
65									
	10			2	21	103.3	7.4		@ 11': Silty fine to medium SAND: Orange-brown to red-brown, damp to moist, medium dense
60									
	15			3	42	102.0	3.0		@ 16': Silty fine to medium SAND: Gray to orange-gray, damp to moist, medium dense
55									
	20			4	50/5"	122.3	10.2		@ 21': Silty fine to medium SAND: Dark orange-brown with some black grains, damp to moist, dense to very dense
50									
	25			5	80	107.9	20.0		@ 26': Medium to coarse SAND: Light gray to light orange-gray, wet to saturated, dense
45									
								SM	TERTIARY DEL MAR FORMATION (Td)
	30								

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GEOTECHNICAL BORING LOG HSA-2

Date 4-11-02 Sheet 2 of 2

Project Del Mar Bluffs Project No. 040151-007

Drilling Co. Cal Pac Drilling Type of Rig Hollow-Stem Auger

Hole Diameter 8 in. Drive Weight 140 pounds Drop 30 in.

Elevation Top of Hole +/- 73 ft. Ref. or Datum Mean Sea Level

GEOTECHNICAL DESCRIPTION

Logged By GJM

Sampled By GJM

Elevation (feet)	Depth (feet)	Graphic Log	Notes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
	30			6	60/6"	106.8	15.6	SM	
									@ 31': Silty fine to medium SANDSTONE: Light gray, yellow-gray, damp to moist, medium dense
40									
	35			7	50/5"	104.4	20.5		@ 35': Medium to coarse SANDSTONE: Light gray to light yellow-gray, moist to wet, very dense
35									
	40								
30									
	45			8	50/6"	111.5	14.9	CL	@ 45': CLAYSTONE: Olive-green, damp to very stiff
25									
	50								
20									
	55				50/4"	116.5	15.8		@ 55': CLAYSTONE: Olive-green, damp to very stiff (little sample recovery)
									Total Depth = 56 Feet Ground water encountered at 26 feet at time of drilling Backfilled with soil cuttings on 4/11/02
15									
	60								

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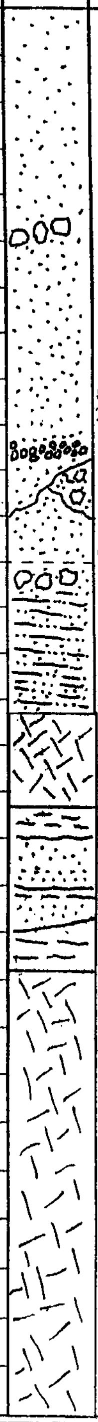
Boring Logs – Supplemental Geotechnical Investigation, Project 1 - Drainage Improvement and Landslide Warning System (October 26, 2001)

GEOTECHNICAL BORING LOG LB-7

Date 8-28-01 | Sheet 1 of 2
Project Del Mar Bluffs | Project No. 040151-001
Drilling Co. San Diego Drilling Company | Type of Rig Bucket Auger
Hole Diameter 30 | Drive Weight | Drop ___ in
Elevation Top of Hole 53 ft. | Ref. or Datum Mean Sea Level

GEOTECHNICAL DESCRIPTION

Logged By GJM/MRS
Sampled By



Depth (feet)	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
0						SM	QUATERNARY TERRACE DEPOSITS (Qbp) @ 0': Reddish brown, fine to medium damp silty SAND (shear pin exposed in east side of boring to a depth of 14 feet)
5						SM/SC	@ 5': Mottled gray and reddish brown, fine to medium, moist, slightly clayey SAND
						SM/SW	@ 7': Gradation change to reddish brown, medium, very moist SAND, no clay; friable, horizontal
	standing water after 24 hours						
10						SW	@ 9.5': Gravel lag with 1/2"-2" pebbles and cobbles
						SM	@ 10': Sharp sloping contact to light and dark gray silty SAND on east side with inclusions and fractures (infilled) with very light gray clayey silt, contact appears erosional
	C:N/S 5W					SM	@ 11.5': 2" thick layer of medium to coarse SAND with moderate to heavy seepage
							TERTIARY DEL MAR FORMATION (Td) @ 12': Gray-green, fine silty SANDSTONE, very dense, unfractured, scattered inclusions of dark gray to black sandstone, orientated out of slope 4-5' west
						SM	@ 13': Yellow-brown, damp, very dense, silty SANDSTONE
15	B:horizontal					SM	@ 15': Becomes gray, slightly coarser SANDSTONE
	B:horizontal						
20						SM/CL	@ 19': Interbedded dark gray CLAYSTONE, very hard, slightly fractured and orange-brown to gray, damp, silty SANDSTONE
	C:horizontal					CL	@ 21': Sharp contact to gray-green CLAYSTONE, fractured, very hard
25						CL	@ 24': Light gray to olive-green CLAYSTONE
30							

GEOTECHNICAL BORING LOG LB-7

Date 8-28-01 | Sheet 2 of 2
Project Del Mar Bluffs | Project No. 040151-001
Drilling Co. San Diego Drilling Company | Type of Rig Bucket Auger
Hole Diameter 30 | Drive Weight | Drop ___ in.
Elevation Top of Hole 53 ft. | Ref. or Datum Mean Sea Level

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By GJM/MRS Sampled By
30								Total Depth = 30 Feet Downhole Logged to 24 Feet - Water at 27 feet 1 hour after drilling Moderate to Heavy Seepage at 11.5 Feet Backfilled with 2-sack cement slurry: 8/29/01 to within +/-5 feet of grade. Top of boring backfilled with soil. Water level after 24 hours was at a depth of 8 to 10 feet below surface.
35								
40								
45								
50								
55								
60								

GEOTECHNICAL BORING LOG LB-8

Date 8-29-01 | Sheet 1 of 2

Project Del Mar Bluffs | Project No. 040151-001

Drilling Co. San Diego Drilling Company | Type of Rig Bucket Auger

Hole Diameter 30 | Drive Weight | Drop in.

Elevation Top of Hole 47 ft. | Ref. or Datum Mean Sea Level

Logged By GJM/MRS

Sampled By

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
0							SM	ARTIFICIAL FILL (Af) @ 0': Brown, dark reddish brown, fine to medium silty SAND, damp to moist, medium dense to dense; some gravels
							SM/SW	QUATERNARY TERRACE DEPOSITS (Qt) @ 2': Sharp contact orange-reddish brown, medium SAND, damp, medium dense; friable, some gravels
5							SM	@ 6': Grades to orange-brown, fine to medium silty clayey SAND, mottled gray and orange-brown, damp, medium dense to dense
							SM	@ 8.5'-9': Yellow-brown, fine silty clayey SAND, damp, medium dense
10							SM	@ 13': Reddish orange-brown, medium SAND, very moist to wet, medium dense, light seepage
		C:N30E 30W					SM	TERTIARY DEL MAR FORMATION (Td) @ 14': Sharp contact, yellow-brown, fine to medium silty SANDSTONE, damp, dense
15							SM	@ 17': Grades to light gray, light yellow, fine to medium silty SANDSTONE, damp, dense
20							SM	@ 20': Grades into light gray, medium to coarse silty SANDSTONE, damp to moist, dense
								@ 21': Slightly coarser
								@ 22': Moderate to heavy seepage
								@ 22.5': Inclusions of claystone to 4"
							SM	@ 23': Grades to orange-brown SANDSTONE, dense
		F:horizontal					CL	@ 24': Irregular erosional contact, gray clayey SAND
25		F:N60W 20N F:N40W 25N					CL	@ 25': Irregular contact, greenish CLAYSTONE, fractured, polished surfaces randomly orientated; several steeply dipping fractures continuous around hole
							SM	@ 28': Gray-green silty SANDSTONE, fractured, becomes less fractured, very hard
30								

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GEOTECHNICAL BORING LOG LB-8

Date 8-29-01 | Sheet 2 of 2
Project Del Mar Bluffs | Project No. 040151-001
Drilling Co. San Diego Drilling Company | Type of Rig Bucket Auger
Hole Diameter 30 | Drive Weight | Drop in.
Elevation Top of Hole 47 ft. | Ref. or Datum Mean Sea Level

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By GJM/MRS Sampled By
30		F:N40W 20N						
							SM	@ 31': Olive-green, dark gray mottled, damp, very dense clay SANDSTONE
35								
40								
45								
50								Total Depth = 50 Feet Downhole Logged to 36 Feet - Standing water at 33 feet, 1 hour after drilling Moderate to Heavy Seepage at 13 and 24 feet Backfilled: 8/29/01
55								
60								

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GEOTECHNICAL BORING LOG LB-9

Date 8-29-01 | Sheet 1 of 2
Project Del Mar Bluffs | Project No. 040151-001
Drilling Co. San Diego Drilling Company | Type of Rig Bucket Auger
Hole Diameter 30 | Drive Weight ______ | Drop ____ in.
Elevation Top of Hole 70 ft. | Ref. or Datum Mean Sea Level

GEOTECHNICAL DESCRIPTION

Logged By GJM
Sampled By ______

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
0								@ 0-3": Asphalt Concrete
								QUATERNARY TERRACE DEPOSITS (Qt)
							SM	@ .5': Orange brown, fine to medium silty SAND, damp, dense
5								
							SM/SC	@ 6': Grades to reddish brown-gray brown, fine to medium clayey SAND, damp, dense, mottled
							SM	@ 8': Orange brown-gray, mottled, fine to medium silty SAND, damp to moist, dense
10								
								@ 11': Same as above
							SM	@ 12': Grades to light gray to gray, fine to medium silty SAND, damp, dense; friable
15							SM	@ 15': Grades to orange-brown, fine to medium silty SAND, damp, dense; mottled, orange-brown to gray-brown
20								
							SM	@ 21': Grades to orange-brown to yellow-brown, thinly laminated SAND, moist, dense; friable
							SM/SW	@ 22': Grades to yellow-brown, medium to coarse SAND, wet to saturated, dense; some gravels, moderate to heavy seepage
								TERTIARY DEL MAR FORMATION (Td)
							SM	@ 23': Sharp wavy erosional contact, yellow-brown, fine to medium silty SANDSTONE, damp to wet, dense, fractured
25								
							CL	@ 26': Irregular contact, greenish CLAYSTONE, hard, fractured
								@ 29': Seepage from fracture
30								

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GEOTECHNICAL BORING LOG LB-9

Date 8-29-01 | Sheet 2 of 2
Project Del Mar Bluffs | Project No. 040151-001
Drilling Co. San Diego Drilling Company | Type of Rig Bucket Auger
Hole Diameter 30 | Drive Weight | Drop ___ in.
Elevation Top of Hole 70 ft. | Ref. or Datum Mean Sea Level

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By GJM Sampled By
30								
35								
40								
45								
50								
55								Total Depth = 55 Feet Downhole Logged to 29 Feet Heavy Seepage at 23 Feet and 29 Feet, Standing water at 30 Feet 1 hour after drilling Backfilled: 8/30/01
60								

505A(11/77)

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GEOTECHNICAL BORING LOG S.PIN#6

Date 6-13-01 | Sheet 1 of 2
Project Del Mar Bluff | Project No. 040151-004
Drilling Co. San Diego Drilling Company | Type of Rig E-120
Hole Diameter 36 | Drive Weight N/A | Drop -- in.
Elevation Top of Hole 62 ft. | Ref. or Datum See Geotechnical Map

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By KBC Sampled By --
0								Steel casing from 0-10'
5								
10		x-bedding sw dipping					SM	TERTIARY DEL MAR FORMATION (Td) @ 10'-15': Silty medium SANDSTONE: Yellow-brown, damp, dense to very dense; cross-bedding common dipping southwesterly Note: heavy seepage emitting from cased area, at approximately 10 feet
15		c: horizontal					CL	@ 15': Sharp, horizontal contact to fine sandy CLAYSTONE: Olive-gray, damp, hard
20								
		c: horizontal					SM	@ 23': Silty fine to medium SANDSTONE: Greenish gray, damp, dense to very dense
25								@ 27.3'-28': White cemented SANDSTONE concretionary layer: very dense @ 28': Silty fine to medium SANDSTONE: Dark gray, damp, dense to very dense; scattered black peat? lenses; few +/-6" diameter concretion nodules
30								

505A(11/77)

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG S.PIN#6

Date 6-13-01 | Sheet 2 of 2
Project Del Mar Bluff | Project No. 040151-004
Drilling Co. San Diego Drilling Company | Type of Rig E-120
Hole Diameter 36 | Drive Weight N/A | Drop -- in.
Elevation Top of Hole 62 ft. | Ref. or Datum See Geotechnical Map

GEOTECHNICAL DESCRIPTION

Logged By KBC
Sampled By --

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
30							CL	TERTIARY DEL MAR FORMATION (Continued) @ 30'-33': Silty sandy CLAYSTONE to clayey SANDSTONE: Olive-green, damp, hard to very dense
		c: horizontal						@ 33'-39': Approximately horizontal contact to fine sandy CLAYSTONE: Olive-green, damp, stiff to very stiff; upper 6" is tectonically sheared
35								
		c: horizontal						@ 39'-42': Approximately horizontal contact to sandy CLAYSTONE: Olive-green, damp, hard
40								
		c: horizontal						@ 42'-47': Approximately horizontal contact to fine sandy CLAYSTONE: Olive-green, damp, hard
45								
		c: horizontal					SC	@ 47'-49': Approximately horizontal contact to clayey SANDSTONE: Gray-green with rose-brown mottles commom, damp, dense
		c: horizontal						@ 49'-52': Approximately horizontal contact to clayey SANDSTONE: Dark gray, damp, dense to very dense
50								
		c: horizontal						@ 52'-54': Clayey SANDSTONE: Olive-green, damp, dense to very dense
		c: horizontal					SM	@ 54': Silty fine to medium SANDSTONE: light gray, damp, medium dense to dense; moderately friable
55								
								Total Depth = 57 Feet Cased from 0-10 feet; downhole logged to 55 feet Ground water seepage encountered at 10 feet at time of drilling Concrete and steel shear pin placed 6/14/01
60								

LEIGHTON & ASSOCIATES

Boring Logs – Del Mar Bluffs Geotechnical Study
(January 31, 2001)

BORING LOGS FROM CURRENT INVESTIGATION

GEOTECHNICAL BORING LOG LB-1

Date 6-13-00 | Sheet 1 of 3

Project HDR/Del Mar | Project No. 040151-001

Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket

Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841#, 60'-90' 2,446# | Drop 12 in.

Elevation Top of Hole 63 ft. | Ref. or Datum See Map

Logged By KTS/RKW

Sampled By KTS

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
0								BAYPOINT FORMATION (Qbp)
								@ 0'-5': Light brown, mottled with reddish brown, moist to wet, medium dense, fine to medium SAND with few cobbles; caving, weakly cemented
			Bag-1 @2'-4'				SM	
5							ML	@ 5': Seepage at base of Baypoint Formation, very active
								DELMAR FORMATION (Td)
								@ 5': Light olive-gray, moist, slightly stiff, SILTSTONE
							SM-ML	@ 7': Blue-gray, very damp, slightly stiff to stiff, fine to medium sandy SILTSTONE
			Bag-2 @8'-10'				SM	@ 8.5': Blue-gray, very damp, stiff, silty CLAYSTONE; fractured; approximately 1/2' thick interbedded with gray medium SANDSTONE with subhorizontal laminations below
10			R-1	Push/8" 5/4"				@ 10': Bluish gray, damp, stiff to very stiff, silty CLAYSTONE
							ML/CL	@ 10.5': Silty CLAYSTONE becomes SILTSTONE
15								
							SM/ML	@ 19': Change in material to dark gray, very damp, dense, silty fine to medium SAND, interbedded with SILTSTONE between 19' and 20'
20			R-2	10			SM	@ 20'-23.5': Light maroon gray, very moist to wet at base, medium dense, medium SANDSTONE; thin clay lenses, subhorizontal laminations
			Bag-3 @21'-23'					@ 20': Light gray, moist, medium dense, silty fine to medium SANDSTONE; grades to slightly coarser sand at tip
								@ 21'-23': Material same as Sample R-2
								@ 23.5'-24.5': Interbed of dark gray, very damp, very stiff to hard, silty CLAYSTONE; 1' thick, subhorizontal contacts
25							ML/CL	@ 24.5'-26.5': Material same as between 20'-23.5' sand coarsens to base of unit, moisture increases to minor seepage at base. Rip-up clasts of blue-gray SILTSTONE within SANDSTONE
								@ 26': Blue-gray, very damp, slightly stiff, silty CLAYSTONE
							ML	@ 29'-33.5': Light blue/green-gray, damp, hard, very fine sandy SILTSTONE grades to coarse sandy SILTSTONE; iron-oxide mottled
30								

GEOTECHNICAL BORING LOG LB-1

Date 6-13-00 | Sheet 2 of 3

Project HDR/Del Mar | Project No. 040151-001

Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket

Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841#, 60'-90' 2,446# | Drop 12 in.

Elevation Top of Hole 63 ft. | Ref. or Datum See Map

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By KTS/RKW Sampled By KTS
30								
			R-3	14			ML-SM	@ 32': Light blue gray, very damp to slightly moist, stiff/dense, fine SANDSTONE
								@ 33.5': Planar subhorizontal contact to blue-gray silty CLAYSTONE, fractured, iron-oxide on surfaces, few waxy surfaces, spalling material, possible minor seepage from fractures
35								
								@ 37': Localized cemented zones
40			R-4	6	110.1	16.6	ML	@ 40': Dark blue-gray, damp, stiff to very stiff, clayey SILTSTONE
								@ 41.5': Increased cementation, mottled yellow and red-brown, oxide staining
								@ 42.5': Blue-gray to dark blue-gray, damp, hard/very dense, very fine sandy SILTSTONE, moderately cemented, reddish oxide staining
45								
								@ 47'-61': Light gray to dark blue gray, damp, very stiff, clayey SILTSTONE; fractured, lacks continuation
50			R-5	9	110.2	17.0	ML-SM	@ 50': Dark blue-gray, damp, stiff to very stiff, clayey SILTSTONE; massive
55								
60								

GEOTECHNICAL BORING LOG LB-1

Date 6-13-00

Sheet 3 of 3

Project HDR/Del Mar

Project No. 040151-001

Drilling Co. San Diego Drilling

Type of Rig E-120 Bucket

Hole Diameter 24 in.

Drive Weight 0'-30' 4,991#, 30'-60' 3,841#, 60'-90' 2,446#

Drop 12 in.

Elevation Top of Hole 63 ft.

Ref. or Datum See Map

Logged By KTS/RKW

Sampled By KTS

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
60			R-6	28			ML-SM	@ 60': Light blue-gray, damp to very damp, stiff to very stiff, fine SANDSTONE
			Bag-4 @61'-63'				SM	@ 61': Light brown, medium SANDSTONE with subhorizontal laminations
								@ 62.5': Blue gray to dark blue-gray, damp, hard/very dense, very fine sandy SILTSTONE; moderately cemented
65							CL	@ 65': Light blue-gray, damp, hard silty CLAYSTONE; a few waxy, polished, fractured, surfaces; randomly oriented (Logged to 65')
							ML	
70			R-7	18	111.7	17.3		@ 70': Light blue gray, slightly damp, very stiff to slightly hard, clayey SILTSTONE; massive
								Total Depth = 70 Feet Backfilled/tamped 6/13/00 Upper 5 Feet slurry cap Active seepage at 5 Feet
75								
80								
85								
90								

GEOTECHNICAL BORING LOG LB-2

Date 6-14-00 | Sheet 1 of 3
Project HDR/Del Mar | Project No. 040151-001
Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841# | Drop 12 in.
Elevation Top of Hole 58 ft. | Ref. or Datum See Map

Logged By KTS/MRS
Sampled By KTS

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
0							SM	BAYPOINT FORMATION (Qbp) @ 0'-1-1/2': Light brown, very dry, loose, SAND @ 1-1/2': Reddish brown and blue-gray, mottled, very damp to moist, loose to slightly dense, silty SAND
			Bag-1 @3'-5'					
5			R-1				SM	@ 5': Reddish brown, very moist to wet, loose to slightly dense, clayey fine to medium SAND, weakly cemented
							SM	@ 9': Grade to light reddish brown, very moist to wet, loose to slightly dense, very fine to medium SAND, with SILT
10								
							SM	@ 14'-15': Contact at base of Baypoint Formation is extremely undulatory, black staining, scoured/rip-ups of Td in Qbp
15								DELMAR FORMATION (Td) @ 14'-28': Yellow, moist to wet at base, stiff, grades to very dense, silty, very fine SANDSTONE; grades to silty coarse SANDSTONE; seepage at base
20			Bag-2 @20'-22'					@ 20'-22': Light yellow, moist, slightly dense to dense, silty fine to medium SANDSTONE
		GB:N85E, 10N	R-2	8				@ 22': Light yellow, wet, dense, silty fine to coarse SANDSTONE; massive @ 23': General bedding attitude on 4" thick lense of dark brown SAND
25								
		GB:N10E, 9N						@ 26': Pebbly sand lense, 2" thick, heavy free-flowing seepage, general bedding attitude on faint subhorizontal laminations
							ML/CL	@ 28': Slightly undulatory, irregular erosional contact with iron-oxide along contact, material below is gray-brown, damp, stiff, silty CLAYSTONE; iron-oxide, joints, moderately fractured
30								

GEOTECHNICAL BORING LOG LB-2

Date 6-14-00 | Sheet 2 of 3
Project HDR/Del Mar | Project No. 040151-001
Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841# | Drop 12 in.
Elevation Top of Hole 58 ft. | Ref. or Datum See Map

Logged By KTS/MRS
Sampled By KTS

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
30							ML	@ 30': Blue-gray, moist, stiff to very stiff, clayey SILTSTONE and siltstone; zones weak of cementation in SILTSTONE material
			Bag-3 @32'-34'					@ 32': Iron-oxide mottling (similar to staining above resistant beds seen in neighboring boreholes)
35								@ 35': Material becomes very hard and competent, cemented
		J:N60W, 33N					SM-ML	@ 39': Material change to blue-gray, very damp, very stiff to hard, clayey SILTSTONE to siltstone; randomly, fractured with waxy polished surfaces, non planar, slightly random, weakly cemented
40								@ 40': Generalized joint/fracture attitudes, decrease in fractures below, more competent
		J:N10E, 20S						
		J:N55W, 42S						
45			R-3	9				@ 45': Blue-gray, damp, stiff to very stiff, SILTSTONE with clay; massive
50								Downhole logged to 50'
						∇		All tailings to T.D. are blue-gray clays and silts with iron-oxide bands, and extremely wet due to seepage above
55								
60								

GEOTECHNICAL BORING LOG LB-2

Date 6-14-00 | Sheet 3 of 3

Project HDR/Del Mar | Project No. 040151-001

Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket

Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841# | Drop 12 in.

Elevation Top of Hole 58 ft. | Ref. or Datum See Map

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By KTS/MRS Sampled By KTS
60								Total Depth = 60 Feet Backfilled and tamped 6/14/00 5 feet slurry cap Water at 27 feet; standing water at 53 feet at time of backfill
65								
70								
75								
80								
85								
90								

GEOTECHNICAL BORING LOG LB-3

Date 6-14-00 | Sheet 1 of 3
Project HDR/Del Mar | Project No. 040151-001
Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841# | Drop 12 in.
Elevation Top of Hole 59 ft. | Ref. or Datum See Map

Logged By KTS/MRS
Sampled By KTS

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
0							SM	BAYPOINT FORMATION (Qbp) @ 0'-10': Reddish brown, damp to wet at base, slightly dense, clayey medium SAND grades to silty medium to coarse sand at base; seepage at base, boring is belling
5			R-1	Push	103.0	12.0	SM-SC	@ 5': Reddish brown, very moist to wet, loose to slightly dense, clayey SAND; lacks cementation
		CS:N50E, 14N						@ 9'-10': Zone of generally undulatory contact, rip-ups of Td within Qbp (8" diameter, dark brown, rip-up 1' above contact), few cobbles, dark brown staining
10							ML	@ 10': Clay seam attitude, paper thin, along contact
		J:N65W, 35S						DELMAR FORMATION (Td) @ 9.5'-10.5': Light yellow, very moist to wet, slightly stiff, SILTSTONE; very weakly cemented, mottled iron-oxide
		J:E-W, vertical						@ 10.5': Material change to green/blue-gray, very damp, soft to slightly stiff, silty CLAYSTONE; randomly oriented fractures, polished, waxy surfaces, iron-oxide on surfaces, seepage between fractures, material spalling, joint attitudes
								@ 13.5': Gradual change to gray, damp, stiff, SILTSTONE
15								
		J:N60W, 14S						
		S:N70E-60W, 25-35N					ML-CL	@ 18': Zone of CLAYSTONE with shears (remolded clay surfaces along similar orientation), iron-oxide on surfaces around portion of hole only, moisture in fractures, purple-brown staining (mottled), shear attitude, joint attitude
20		J:N34E, 38S					ML	@ 20': Blue-gray and yellowish gray, mottled SILTSTONE
		C:horizontal						@ 22': Horizontal contact to reddish brown, silty SAND, lenses of light sand at 25' and 27', 2" and 6" thick, respectively
25			R-2	8	117.4	11.5	ML-SM	@ 25': Blue-gray, damp, stiff to very stiff, SILTSTONE with very fine SAND; massive, weak to moderately cemented
								@ 26': Blue-green gray, damp, very stiff, silty CLAYSTONE; short, random non-planar; waxy fractures
		GB:N30E, 5N					SM	@ 28': General bedding attitude, blue-gray silty fine to medium SANDSTONE; 8" thick with dark green laminations
							ML-CL	@ 29': Blue/green-gray very fine sandy SILTSTONE, grades to silty CLAYSTONE; randomly fractured with waxy, polished surfaces,
30								

GEOTECHNICAL BORING LOG LB-3

Date 6-14-00 | Sheet 2 of 3
Project HDR/Del Mar | Project No. 040151-001
Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841# | Drop 12 in.
Elevation Top of Hole 59 ft. | Ref. or Datum See Map

Logged By KTS/MRS
Sampled By KTS

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
30								iron-oxide, reddish mottled staining to 32.5'
							ML-SM	@ 32.5': Light blue-gray, moist to wet, hard, SILTSTONE; moderately cemented, dark blue streaks and random, discontinuous polished surfaces
35							ML	@ 36': Light blue-gray, moist, very stiff clayey SILTSTONE; iron oxide and waxy polished surfaces, short, randomly oriented fractures
							ML-CL	@ 38'-46': Blue-gray, very damp (to wet in fractures), very stiff to hard, SILTSTONE and silty CLAYSTONE, zones of random, waxy polished surfaces in clayier material, reddish brown mottled staining
40								
							SC	@ 44': Lense of sandy CLAYSTONE
45			R-3	12	124.7	9.8		@ 45': Blue-gray, damp, very stiff, fine SANDSTONE, minor iron-oxide mottling, weakly cemented
							SC-CL	@ 46': Blue-gray, very damp, stiff, CLAYSTONE, fractures with waxy, polished surfaces, iron-oxide
							SM	@ 47.5': Gray grades to blue/green-gray, moist to wet, dense to very dense, fine grades to coarse SANDSTONE; massive, weakly cemented
50								
							CL	@ 52': Dark gray silty CLAYSTONE, 7" thick, weakly cemented
							SM	@ 53': Brown, damp, slightly dense, fine to coarse SANDSTONE; non-planar, subhorizontal contacts
55							ML-CL	@ 54.5': Blue-gray, silty CLAYSTONE; waxy, polished fractures
							ML-SM	@ 56.5'-65': Gray and brown, mottled, damp, very stiff, sandy SILTSTONE; weakly cemented
60								

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG LB-3

Date 6-14-00 | Sheet 3 of 3
Project HDR/Del Mar | Project No. 040151-001
Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841# | Drop 12 in.
Elevation Top of Hole 59 ft. | Ref. or Datum See Map

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By KTS/MRS Sampled By KTS
60								
65			R-4	23	123.4	11.0		@ 65': Dark gray, dry to damp, hard, very fine SANDSTONE, moderately cemented
								Total Depth = 65 Feet Backfilled and Tamped 6/15/00 5 feet slurry cap Ground water encountered at 10, 12, 20, and 52 feet at time of drilling
70								
75								
80								
85								
90								

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG LB-4

Date: 6-14-00 Sheet 1 of 3
Project: HDR/Del Mar Project No. 040151-001
Drilling Co.: San Diego Drilling Type of Rig: E-120 Bucket
Hole Diameter: 24 in. Drive Weight: 0'-30' 4,991#, 30'-60' 3,841#, 60'-90' 2,446# Drop: 12 in.
Elevation Top of Hole: 64 ft. Ref. or Datum: See Map

GEOTECHNICAL DESCRIPTION

Logged By: KTS/MRS
Sampled By: KTS

Depth (feet)	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
0						SM-SC	BAYPOINT FORMATION (Qbp) @ 0'-14': Reddish brown, moist to wet at base, loose to slightly dense, SAND with CLAY; seepage at base
5							
10						SM	
							@ 12'-14': Moderate to active seepage and minor belling
						SC-SM	DELMAR FORMATION (Td) @ 14'-64': Light yellowish gray, wet at top to moist with depth, soft at top grades to stiff, very fine sandy CLAY, grades to clayey, very fine SANDSTONE
15						CL	@ 16': Light greenish gray; moist to wet (from fractures), slightly stiff, silty CLAYSTONE; randomly fractured, iron-oxide
						ML	@ 18': Material becomes cemented, yellowish gray, damp, hard SILTSTONE, mottled iron-oxide, lacks fractures @ 19'-20': Yellow-gray, wet, very dense, silty fine to medium SILTSTONE
20		R-1	6				@ 20': Blue-gray, damp, hard, clayey SILTSTONE; massive, moderately cemented, minor iron-oxide @ 20'-22': Mottled blue-gray CLAYSTONE and yellow-gray SANDSTONE; sheared zone (non-continuous), non-planar features, iron-oxide on surfaces, seepage from fractures
						SM-ML	@ 22'-25': Yellow-gray, moist to wet at base, dense, silty fine to medium SANDSTONE; weakly cemented, lense of dark gray clay, 2" thick, iron-oxide banding
25	J/S:N27W-40W, 32-40S J/S:N45W, 42N					CL	@ 25'-26.5': Greenish gray, very damp to moist, slightly stiff, CLAYSTONE; waxy, polished fractures with iron-oxide joint/shear attitudes on non-continuous features
	GB:N55W, 23S					SM	@ 26.5': Light gray, grades to blue-gray, moist to wet, very dense, very fine sandy SILTSTONE, cemented, general bedding attitude on yellow silt bed, lacks cementation, planar feature
30							

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG LB-4

Date 6-14-00 | Sheet 2 of 3

Project HDR/Del Mar | Project No. 040151-001

Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket

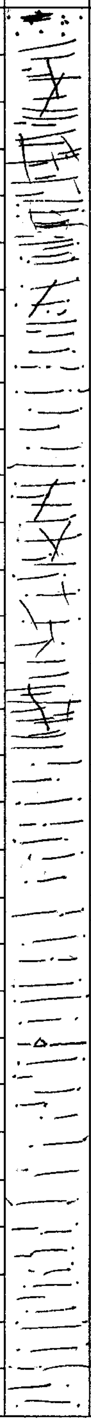
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841#, 60'-90' 2,446# | Drop 12 in.

Elevation Top of Hole 64 ft. | Ref. or Datum See Map

GEOTECHNICAL DESCRIPTION

Logged By KTS/MRS

Sampled By KTS



Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
30							CL-ML	@ 30': Clay lense in above unit, then coarse SAND at base of unit
		J:N45E, 35N						@ 31': Blue-gray CLAYSTONE with polished waxy surfaces, some iron-oxide, joint attitude, lacks visible voids
								@ 34': Mottled zones of increased SILT content and partial cementation
35								
		S:N62E, 31S						@ 36': Shear attitude on non-continuous, polished surface
							ML	@ 37'-40': Blue-gray, wet, very dense, SILTSTONE; weakly cemented
40			R-2	8	110.5	18.0		@ 40': Dark blue-gray and mottled reddish staining, damp, hard, CLAYSTONE and silty claystone; random waxy fracture, moderately cemented
								@ 42': Cemented SILTSTONE bed with reddish staining
							ML-CL	@ 44': Slightly fractured CLAYSTONE with polished non-planar surfaces, very weakly cemented
45								
		J:N20W, 65N J:N20W, 77N						@ 46': Gray, moist to wet, very stiff to hard SILTSTONE; few joints with faint, non-continuous, polished surfaces, attitudes
50								
								@ 51': Color changes to light blue-gray
		S:N70W, 5-35S					CL	@ 52': Shear attitude, continuous around hole but 1/2 steepens, irregular paper-thin CLAY, fainty polished
55								
							ML-SM	@ 57': Blue-gray, moist, dense/hard, very fine sandy SILTSTONE; weakly to moderately cemented
								(Downhole logged to 59 feet)
60								

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG LB-4

Date 6-14-00 | Sheet 3 of 3
Project HDR/Del Mar | Project No. 040151-001
Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841#, 60'-90' 2,446# | Drop 12 in.
Elevation Top of Hole 64 ft. | Ref. or Datum See Map

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By KTS/MRS Sampled By KTS
60			R-3	20	112.7	16.4		@ 60': Blue-gray, damp, very stiff, silty CLAYSTONE
65								Total Depth = 64 Feet Backfilled and tamped 6/15/00 5 feet slurry cap Ground water encountered at 12 and 20 feet at time of drilling
70								
75								
80								
85								
90								

505A(11/77)

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG LB-5

Date 6-16-00 | Sheet 1 of 3

Project HDR/Del Mar | Project No. 040151-001

Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket

Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841# | Drop 12 in.

Elevation Top of Hole 55 ft. | Ref. or Datum See Map

GEOTECHNICAL DESCRIPTION

Logged By KTS/MRS

Sampled By KTS

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
0							SM	BAYPOINT FORMATION (Qbp) @ 0'-3.5': Reddish brown, moist (at base), loose to slightly dense, fine to medium SANDSTONE
		C:N40W, 4N					ML-SM	@ 3.5': Contact attitude, generalized non-planar, undulatory, rip-ups of clay in sandstone, light seepage
5								DELMAR FORMATION (Td) @ 3.5': Yellow-orange, very damp to slightly moist, stiff, silty very fine SANDSTONE (grades to silty medium to coarse sandy SILTSTONE), iron-oxide bands
		C:N7W, 6S						@ 6': Blue gray, damp, stiff to very stiff with depth, very fine sandy CLAYSTONE/SILTSTONE (zones); cementation increases with depth, very short, non-planar fractures, decrease at 10', iron-oxide in upper portions
10								
								@ 14': Light brown, moist to wet, dense, very fine to medium SANDSTONE lense, subhorizontal, grades to material above
15								
								@ 16': Dark blue-gray, very damp, stiff to very stiff, silty CLAYSTONE, few polished fracture surfaces, randomly oriented
		CS:N45E, 1N					ML-CL	@ 17.5': Clay seam attitude, paper thin clay seam, gently undulatory, material below is mottled (rip-ups?), dark gray CLAYSTONE and light gray, fine to medium SILTSTONE; very stiff
								@ 19.5': Interbedded blue-gray, fine to coarse SILTSTONE; wet (light seepage), dense to very dense (slightly cemented at base)
20							CL-ML	@ 20.5': Blue-gray, damp, very stiff to hard, silty CLAYSTONE and claystone; moderately fractured with polished, popouts (non-planar, short), zones of weak cementation
25								
		J/S:N10W, 37S						@ 28': Joint or shear attitude on non-continuous planar, polished surface within CLAYSTONE, black rootlet staining
30								

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG LB-5

Date 6-16-00 | Sheet 2 of 3

Project HDR/Del Mar | Project No. 040151-001

Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket

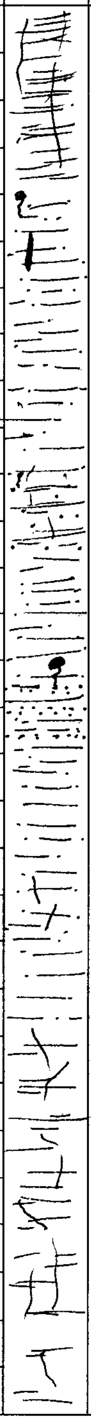
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841# | Drop 12 in.

Elevation Top of Hole 55 ft. | Ref. or Datum See Map

GEOTECHNICAL DESCRIPTION

Logged By KTS/MRS

Sampled By KTS



Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	Geotechnical Description
30								
								@ 34': Moist zone, lacks continuation below, light seepage
35							ML	@ 35': Paleo-root, black charcoal branch, material below is blue-gray, very damp, slightly stiff, sandy SILTSTONE; massive
								@ 39': Dark gray lense of SILTSTONE with charcoal pieces
40								@ 40': 4" sand lense then organic banded interbedded very fine SAND and CLAY, some charcoal pods, subhorizontal, minor seepage
							ML-SM	@ 41.5'-44.5': Blue-gray, moist to wet at base, stiff, SILTSTONE, grades to very fine sandy SILTSTONE; zones of cementation, seepage
							SM	@ 44.5'-45.5': Zone similar to 40'; organized banded lenses of SANDSTONE; slightly moist
45							ML-SM	@ 45.5': Blue/green, slightly damp, stiff, sandy SILTSTONE
								@ 48.5': Blue-gray, damp, slightly stiff CLAYSTONE; iron-oxide fractures, waxy, polished surface, randomly oriented
								@ 49': Blue/green, slightly damp, stiff, SILTSTONE
50								
								@ 51.5': Blue-green gray, damp, stiff to hard, silty CLAYSTONE; few waxy fractures with iron-oxide, cemented
55								
60								

GEOTECHNICAL BORING LOG LB-5

Date	6-16-00
Sheet	3 of 3
Project	HDR/Del Mar
Project No.	040151-001
Drilling Co.	San Diego Drilling
Type of Rig	E-120 Bucket
Hole Diameter	24 in.
Drive Weight	0'-30' 4,991#, 30'-60' 3,841#
Drop	12 in.
Elevation Top of Hole	55 ft.
Ref. or Datum	See Map

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By KTS/MRS Sampled By KTS
60								Total Depth = 60 Feet Backfilled and tamped 6/16/00 5 feet slurry cap Ground water encountered at 20, 34, 44 feet at time of drilling
65								
70								
75								
80								
85								
90								

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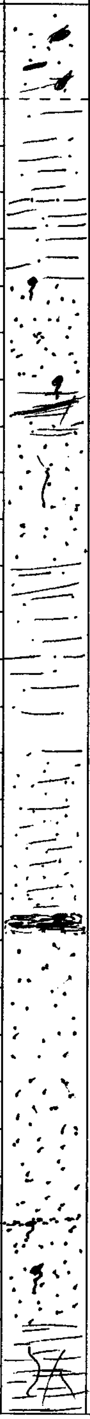
GEOTECHNICAL BORING LOG LB-6

Date 6-19-00 | Sheet 1 of 3
Project HDR/Del Mar | Project No. 040151-001
Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841#, | Drop 12 in.
Elevation Top of Hole 51 ft. | Ref. or Datum See Map

Logged By KTS/MRS
Sampled By KTS



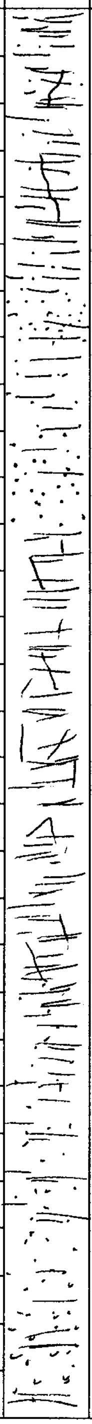
Depth (feet)	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
0						SM-SC	BAYPOINT FORMATION (Qbp) @ 0'-2': Reddish brown, damp, slightly dense, clayey fine to medium SANDSTONE; weakly cemented, non-planar, gradual contact with Td, rip-ups of SILTSTONE, iron-oxide pods, pods of CLAY
						ML	DELMAR FORMATION (Td) @ 2': Mottled gray and light brown in blocky pattern, very damp, slightly stiff, very fine sandy SILTSTONE; increase in cementation with depth
5						SM	
							@ 6': Mottled blue gray and light brown in blocky pattern, wet, dense, fine to medium SANDSTONE; iron-oxide staining in light brown portions, very minor seepage
	J:N10-50W, 36-43S					ML-CL	@ 8': Green/blue-gray, very damp to wet in fractures, slightly stiff CLAYSTONE with SILT; polished waxy fracture surfaces, non-planar, joint attitudes are range of typical fracture planes
10						SM	@ 9.5': Non-horizontal, non-planar contact with light gray and blue-gray, silty fine to medium SANDSTONE; weakly cemented
	S:N73W, 47N					ML-CL	@ 12': Shear contact attitude at base of 55', below is blue-green CLAYSTONE that immediately grades to gray, very damp, soft to slightly stiff SILT/SILTSTONE; grades to incresed cementation of stiffness below
15							@ 15': Reddish mottled staining
							@ 16': Blue-gray, very damp, slightly hard/dense, silty very fine SANDSTONE/very fine SILTSTONE; moderately cemented
20							@ 19.5'-20': Concretion, continuous
		R-1	9	120.3	7.1		@ 20': Yellowish gray, very damp, dense, silty fine to coarse SANDSTONE; massive, cemented
							@ 21': Undulatory contact between blue-gray material and yellowish gray material, weaker cementation at contact, slightly dense to dense, silty fine SANDSTONE, grades to fine to coarse SANDSTONE
25							
	GB:N30E, 16S						@ 26': General bedding attitude on pebble lense, mostly continuous, possibly offset in portion? minor seepage in lense
	S:N55E, 40S						@ 28': Shear attitude, material is blue-green CLAYSTONE with waxy polished fractures, partially discontinuous, random
30							

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG LB-6

Date 6-19-00 | Sheet 2 of 3
Project HDR/Del Mar | Project No. 040151-001
Drilling Co. San Diego Drilling | Type of Rig E-120 Bucket
Hole Diameter 24 in. | Drive Weight 0'-30' 4,991#, 30'-60' 3,841#, | Drop 12 in.
Elevation Top of Hole 51 ft. | Ref. or Datum See Map

Logged By KTS/MRS
Sampled By KTS



Depth (feet)	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
30						ML-CL	@ 30': Blue and gray mottled, silty CLAYSTONE/SILTSTONE, very moist to wet, mottled, stiff and very stiff, iron-oxide, gradual increase in cementation to 35'; some red staining, moderately fractured with few randomly oriented polished surfaces
35							@ 35': Dark blue/green-gray, SILTSTONE; wet, very stiff, reddish staining
						SM-ML	@ 36': Reddish brown, fine SANDSTONE @ 36.5': Same as at 35'
						SM	@ 39': Irregular contact to gray damp, very dense, silty fine to medium SANDSTONE
40		R-2	15	119.7	13.7		@ 40': Blue-gray, very damp, hard/dense, very fine SANDSTONE; massive, weakly to moderately cemented
						CL	@ 41': CLAYSTONE; few random polished surfaces
						CL	@ 44': Mottled red and blue-gray, very hard CLAYSTONE with few random polished surfaces
45							
						SC	@ 49': Very hard in areas, with sand, very few fractures
50							
						SC-SM	@ 51': Increase in sand, very dense, no fractures
55							
60							

LEIGHTON & ASSOCIATES

GEOTECHNICAL BORING LOG LB-6

Date 6-19-00 Sheet 3 of 3

Project HDR/Del Mar Project No. 040151-001

Drilling Co. San Diego Drilling Type of Rig E-120 Bucket

Hole Diameter 24 in. Drive Weight 0'-30' 4,991#, 30'-60' 3,841# Drop 12 in.

Elevation Top of Hole 51 ft. Ref. or Datum See Map

Depth (feet)	Graphic Log	Attitudes	Sample No.	Blows Per Foot	Dry Density (pcf)	Moisture Content (%)	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged By KTS/MRS Sampled By KTS
60			R-3	7/6" 27/12"	124.4	10.1		@ 60': Blue-gray, damp, hard, fine SANDSTONE Total Depth = 60 Feet Backfilled and Tamped 6/19/00 5 feet slurry cap Ground water encountered at 6, 8, 27 feet at time of drilling
65								
70								
75								
80								
85								
90								

PREVIOUS BORING LOGS BY LEIGHTON AND ASSOCIATES

GEOTECHNICAL BORING LOG

Date 1/20/78 Drill Hole No. P1 Sheet 1 of 2 -

Project Santa Fe Railroad Job No. 478008-1

Drilling Co. Pioneer Type of Rig B-53 Flite

Hole Diameter ______ Drive Weight 140 lb. Drop 30 in.

Elevation Top of Hole 63.0 Ref. or Datum

Depth Feet	Graphic Log	Attitudes	Tube Sample No.	Blows Per Foot	Dry Density pcf	Moisture Content, %	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged by WH - DLH Sampled by WH
0							SM-SC	Fill-cinders, silty-clayey sand.
			1	17/6" 29/6"	119.4	11.3	SM	Dark orange, moist, medium dense, silty medium grained sand.
5								Moist-wet. Fill? — — — — ? — —
			2	9/19	111.4	14.1		Loose, medium, dense, natural ground, wet, dark orange mottled with gray 200=15-20%.
10			3	20/35	108.2	14.1	SM	Dark orange, brown, wet-saturated, medium. Terrace Deposit (Qt)
			4	55/6"	102.2	12.7	SC	Pale yellow, moist, wet, dense, clayey coarse to medium sand - (Ted) Del Mar Formation bedrock.
15								
			5	41/6" 60/4"	106.0	21.3	ML	Light gray ground, clayey silt, moist, dense. @ 17.5': Increased density, very dense now light green color. @ 17 - 22': Less dense, moist.
20								
			6	61/6"	110.6	13.8		
25								@ 26': Less density, increased moisture.
			7	60/5"	96.3	20.5		@ 27.5': Clean fine sand in sample.
30								

GEOTECHNICAL BORING LOG

Date 1/20/78 Drill Hole No. P1 Sheet 2 of 2

Project Santa Fe Railroad Job No. 478008-1

Drilling Co. Pioneer Type of Rig B-53 Flite

Hole Diameter ____ Drive Weight 140 lb. Drop 30 in.

Elevation Top of Hole 63.0 Ref. or Datum

Depth Feet	Graphic Log	Attitudes	Tube Sample No.	Blows Per Foot	Dry Density pcf	Moisture Content, %	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged by WH Sampled by WH
30							ML	As above.
			8	60/5"	100.8	14.0		Coarse grained sand in sample tube.
35			①					@ 36': Very dense. @ 36.5': Less dense but still very hard.
			9	42/6" 60/4.5"	105.8	18.8		
40								
			10	63/6"	102.2	13.9		@ 43': Drilling becoming difficult moist material sticks to auger hard to clear cuttings from hole.
45			②					
			11	61/6"	99.3	18.2		
50								
								@ 53': Slight decrease in density.
55								T.D. 54' No water - No Caving
60								

GEOTECHNICAL BORING LOG

Date 1/20/78 Drill Hole No. P2 Sheet 1 of 1-

Project Santa Fe Railroad Job No. 478008-1

Drilling Co. Pioneer Type of Rig B-53 Flite

Hole Diameter ____ Drive Weight 140 lb. Drop 30 in.

Elevation Top of Hole 63.0 Ref. or Datum

Logged by WH

Sampled by WH

Depth Feet	Graphic Log	Attitudes	Tube Sample No.	Blows Per Foot	Dry Density pcf	Moisture Content, %	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
0							SW	Track Bed - Sandy gravel, medium brown, moist
							SM	Fill - Dark orange, silty sand, fine to coarse grained, pebbly, moist, dense.
			12	18/6" 27/6"	117.8	6.7		@ 3': Less pebble, very moist, orange brown, to brown sand, somewhat silty.
5			13	16/6" 27/5"	122.6	7.8		
			14	20/6"	112.8	14.9	SM	@ 5.5': Orange brown, sand, fine-coarse grained (natural) very moist to wet, dense. Terrace Deposit (Qt)
			15	13/6" 34/6"	87.2	14.1		@ 8': Somewhat denser.
10								
			16	60/5"	103.4	13.3		
							SM	@ 12.7': Tan, sand, fine-medium grained, moist, dense, Del Mar Formation (Ted) bedrock.
15								
			17	30/6" 60/6"	105.3	22.4	ML	@ 16': Light gray grained, clayey silt, moist, dense (bedrock).
								T.D. 17' No Water - No Caving
20								
25								

GEOTECHNICAL BORING LOG

Date 1/20/78 Drill Hole No. P 3 Sheet 1 of 1-

Project Santa Fe Railroad Job No. 478008-1

Drilling Co. Pioneer Type of Rig B-53 Flite

Hole Diameter ______ Drive Weight 140 lb. Drop 30 in.

Elevation Top of Hole 63.0 Ref. or Datum

Depth Feet	Graphic Log	Attitudes	Tube Sample No.	Blows Per Foot	Dry Density pcf	Moisture Content, %	Soil Class (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged by WH Sampled by WH
0			18	9/6" 26/6'	107.2	14.0	SM/ SC	Fill-Grayish brown to orange brown, sand, fine-coarse grained, moist, pebbles in upper foot, with gravel.
5			19 20	18/6' 32/6' 23/6' 31/6'	109.5	15.6	SM	@ 2.8': Brown to orange brown sand, fine-coarse grained, moist, dense, terrace deposit (Qt)
10			21	24/6' 42/6'	109.1	16.4		
15							SC	Tan, sand, fine-medium grained, moist, dense. Note: Upper contact approximate Del Mar Formation (Ted) bedrock.
			22	25/6' 60/5'	102.9	21.5	ML	Light gray grained, clayey silt, moist, dense.
20								T.D. 17.5' No Water - No Caving
25								
30								

GEOTECHNICAL BORING LOG

Date 1/20/78 Drill Hole No. P4 Sheet 1 of 1-

Project Santa Fe Railroad Job No. 478008-1

Drilling Co. Pioneer Type of Rig B-53 Flite

Hole Diameter ______ Drive Weight 140 lb. Drop 30 in.

Elevation Top of Hole 63.5 Ref. or Datum

Logged by WH

Sampled by WH

Depth Feet	Tube Sample No.	Blows Per Foot	Dry Density pcf	Moisture Content, %	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION
0					SM/SC	Fill-Brown, silty sand, fine-medium grain, very moist, medium dense.
	23	9/6" 18/6"	112.3	13.6		@ 2-3': Old road bed.
					SM	@ 3': Orange brown, sand, fine-coarse graine (natural) very moist, dense. Terrace Deposit (Qt)
5						
	24	17/6" 24/6"	111.1	13.2		
10	25	11/6" 20/6"	109.0	14.4		
	26	62/6"	104.5	13.6		
					SC	@ 12.7': Tan, sand, fine-coarse, moist, dens Del Mar Formation (Ted) bedrock.
15						
	27	29/6" 51/6"	103.7	11.2		
					ML	@ 16.7': Light gray grained, clayey silt, moist, dense, (bedrock).
20						T.D. 18' No Water - No Caving
25						
30						

PREVIOUS BORING LOGS BY OTHERS

APPENDIX A

Field Mapping and Subsurface Exploration Logs

Geologic Units and Feature Identification

The Site Plan and Geologic Map (in pocket) was prepared based upon information supplied by the client, or others, along with MAHG's field measurements and observations. Site geology including surficial units, bedrock units, measurement of bedrock structure, contacts, areas of notable seepage and springs as well as the approximate locations of exploratory borings and trenches associated with this field investigation are presented on the Geotechnical Map. In addition, ten geologic cross sections were prepared to enable the evaluation of slope stability at selected locations and these sections are presented in Appendix D.

General Field Procedures

The Boring and Trench Logs on the following pages depict or describe the subsurface (soil and water) conditions encountered at the specific exploration locations on the date that the exploration was performed. Subsurface conditions may differ between exploration locations and within areas of the site that were not explored. The subsurface conditions may also change at the exploration locations over the passage of time.

Boring and Test Trench Elevations

The ground surface elevations reported on the field logs were established from interpolation of elevations and contours illustrated on the Site Plan and Geologic Map.

Boring and Test Trench Locations

All subsurface exploration locations were located on-site based on visual observation and measurement from existing improvements. The locations are shown on the Geotechnical Map. Subsurface exploration locations reported for this study should be considered accurate only to the degree implied by the method used in determining them.

Water Level Measurement

The water levels reported on the Boring Logs represent the depth to the piezometric water surface measured at the conclusion of the drilling operation after a short wait, or in monitoring wells that were constructed within selected boreholes. Water levels are expected to show seasonal and long-term fluctuations consistent with historical trends in the area.

Field Sampling and Testing Procedures

Drilling was performed between April 27 and April 30, 1998, utilizing Mobile B-53 and B-61 truck-mounted rigs equipped with 8-inch-diameter, continuous-flight, hollow-stem augers. Trenches were excavated with a rubber tire mounted backhoe provided by the client.

The field operations were conducted in general accordance with the procedures recommended by the American Society for Testing and Materials (ASTM) designation D 420 entitled "Standard Guide for Sampling Soil and Rock" and/or other relevant specifications. Soil samples were preserved and transported to our laboratory in general accordance with the procedures recommended by ASTM designation D 4220 entitled "Standard Practice for Preserving and Transporting Soil Samples". Brief descriptions of the sampling and testing procedures are presented below:

Ring-Lined Barrel Sampling - (ASTM D 3550)

In this procedure, a barrel sampler constructed to receive a stack of 1-inch-high brass rings is used to collect soil samples for classification and laboratory testing. Ring samples were collected from closely spaced intervals in all of the hollow-stem auger borings. Each hollow-stem rig was equipped with a 140-pound wireline downhole hammer, manually operated to fall an approximate distance of 30 inches. An 18-inch or 24-inch-long barrel fitted with 2.5-inch-diameter rings was subsequently driven a distance of 18 inches or to practical refusal (considered to be 50 blows for 6 inches).The method provides relatively undisturbed samples that fit directly into laboratory test instruments without additional handling and disturbance.

Raw blow count data were recorded for each 6-inch increment of the 18-inch drive. The sum of blows required to drive the sampler the final 12 inches, or fraction thereof, is noted on the Field Logs, presented in this Appendix, as an uncorrected N-value. Penetration resistance of the initial 6-inch seating interval is not shown, except in the instance of total penetration of 6 inches or less. The raw blow count values, presented as *N=XX*, do not have exact equivalency with Standard Penetration Test "N-values" as determined by ASTM D 1586. However, it is commonly accepted that general correlations can be applied to obtain approximately equivalent (uncorrected) Standard Penetration Test N-values and their respective consistency and relative density classifications according to the following tables.

Table A-1
Blow Count/Density Relationships for Granular Soils

Ring Sample Blow Count	*SPT Blow Count*	*Description*
0 - 5	0 - 4	Very loose
5 – 13	4 - 10	Loose
13 – 38	10 - 30	Medium dense
38 – 63	30 - 50	Dense
> 63	> 50	Very dense

Table A-2
Blow Count/Consistency Relationships for Fine-Grained Soils

Ring Sample Blow Count	*SPT Blow Count*	*Description*
0 - 3	0 - 2	Very soft
3 - 5	2 - 4	Soft
5 - 10	4 - 8	Firm/Medium stiff
10 - 19	8 - 15	Stiff
19 - 38	15 - 30	Very stiff
>38	>30	Hard

Bulk Sample

A relatively large volume of soil is collected with a shovel or trowel. The sample is transported to the materials laboratory in a sealed plastic bag or bucket.

Classification of Samples

Excavated soils and discrete soil samples were visually-manually classified, based on texture and plasticity, in general accordance with the Unified Soil Classification System (ASTM D 2488-75). The classifications are reported on the field logs. Plasticity noted on the field logs reflects soil conditions at field moisture contents, and may not correlate with achievable plasticity at differing moisture contents.

FIELD LOG OF BORING B - 1P

Medall, Aragon, Higley Geotechnical, Inc.

Project:	*NORTH COUNTY TRANSIT DISTRICT*
Location:	*DEL MAR, CALIFORNIA*
Project No.	*3650-SF*

Dates(s) Drilled:	**4/27/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**51.0 Ft.**
Rig Make/Model:	**Mobile B-61**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**50.4 Ft.**

Comments: Located at south end of project alignment.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
0	50		SC	Clayey Sand: Dense; yellowish brown; moist; fine to coarse grained. [Fill]			
			SM	Silty Sandstone: Very dense; pale yellow (5Y 8/3); moist; fine to medium grained; about 40% fines. [Delmar Fm.]			
			SP-SM	Sandstone: Very dense; gray (N6); moist; fine to medium grained; slightly silty; very weakly cemented.			
5	45	RING 67/6"			101.6	10.6	SHEAR
			ML, CL	Sandy Siltstone and Silty Claystone: Hard; dark gray (N4) with common dusky red (2.5YR 3/2) mottles; moist; trace to some fine to medium-grained sand; crumbly, friable, and non-plastic.			
10	40	RING 80/11"	CL		102.4	16.7	SHEAR
15							

Column headings also include: BULK, DRIVE, LITHOLOGY, WELL COMPLETION.

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 1P

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
15	35	RING 83/6"	SM	Silty Sandstone and Siltstone: Very dense or hard; mostly gray (N6), with few small reddish FeO mottles; fine to medium grained sand; thinly bedded.	98.9	13.1	
			CL	Silty Claystone: Hard; dark gray (N4); moist; crumbly, friable, and non-plastic.			
20	30	RING 60/3"	SP-SM	Sandstone: Very dense; brownish yellow (10YR 6/6); moist; fine to coarse grained; uncemented. Much thinner than in adjacent bluff face.	99.5	9.8	SHEAR
25	25	RING 76/6"	ML, CL / ML	Sandy Siltstone and Silty Claystone: Hard; mostly gray (N5), with some reddish FeO mottles to 1" across; moist; sand proportion mostly fine-grained; faintly plane laminated.	98.3	14.4	
30	20	RING 59/6"	CL	— Silty claystone, as above; dark gray (N4).	101.9	17.5	SHEAR
35							

Continued on next sheet.

FIG. A-2

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 1P

Project: ***NORTH COUNTY TRANSIT DISTRICT***

Location: ***DEL MAR, CALIFORNIA*** Project No. ***3650-SF***

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
35	15	RING 80/6"	ML	Sandy Siltstone and Silty Claystone: Hard; mostly gray (N5), with some reddish FeO mottles to 1" across; moist; sand proportion mostly fine-grained; faintly plane laminated.	101.2	12.7	
			SP-SM	Sandstone: Very dense; dark gray (N4); moist; fine to medium grained; very weakly cemented with trace of clay.			
40	10	RING 80/6"	CL	← Sandy claystone, dark gray (N4), texture of small slickensided granules. Local lens.	108.4	14.3	
			CL	Silty Claystone: Hard; dark gray (N4), abundantly mottled with dusky red (2.5YR 3/2) iron oxides; moist; very silty, with occasional trace of fine-grained sand; massive and non-plastic. Harder drilling.			
45	5	RING 60/6"	CL	← Silty claystone, as above.	N/R	N/R	
50	0	RING 80/6"	CL	← Silty claystone, as above.	102.8	15.3	SHEAR

Bottom of boring at 51.0 feet.
No groundwater encountered.
Piezometer installed as depicted in well completion column..

FIG. A-3

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 2

Project:	NORTH COUNTY TRANSIT DISTRICT
Location:	DEL MAR, CALIFORNIA — Project No. 3650-SF

Dates(s) Drilled:	**4/27/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**40.5 Ft.**
Rig Make/Model:	**Mobile B-61**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**51.4 Ft.**

Comments: Located at Andersen Canyon embankment fill.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
0			SM	Gravelly Sand with Silt: Dense; dark brown (7.5YR 4/2); moist; fine to coarse grained; estimated 20-25% fine to coarse-grained gravel ballast; trace of clay. [Fill]			
	50						
5		RING	SP-SC	Clayey Sand: Dense; dark yellowish brown (10YR 4/4); moist; mostly fine to medium grained, with trace of gravel and silt. [Fill]			
	45	N=47			100.3	7.4	
10		RING		Becomes medium dense; very moist.			
	40	N=14	SP-SC		108.6	13.0	CONS
15							

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 2

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA*

Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
15	35	RING N=13	SP-SC	Clayey Sand: Medium dense; dark yellowish brown (10YR 4/4); very moist; fine to medium grained; trace of silt. [Fill] — Trace FeO mottling.	114.6	12.9	CONS
20	30	RING N=18	SP-SC	Becomes wet; slightly sticky.	115.0	14.5	
25	25	RING N=17	SP-SC	— Contains few yellowish siltstone fragments; moist.	114.1	10.2	CONS
30	20	RING N=23	ML, CL / ML, CL	Clayey Siltstone and Sandy Claystone: Very stiff; mottled pale yellow, dark brown, and dark gray; wet; consists mostly of small intact sedimentary fragments in clayey silt matrix. [Fill] Abrupt contact.	94.6	24.2	
35			SP-SM	Sandstone: Very dense; pale brownish yellow (10YR 6/6); wet; fine to medium grained; massively bedded. [Delmar Fm.]			

Continued on next sheet.

FIG. A-5

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 2

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35				RING 62/6"		SP-SM	Sandstone: Very dense; pale brownish yellow (10YR 6/6); wet; fine to medium grained; massively bedded. [Delmar Fm.]	113.6	17.5		
	15										
						ML	Clayey Silt: Hard; mottled dark gray (N4) and dusky red (2.5YR 2/3); moist; crumbly, friable, and non-plastic.				
40				RING 53/6"		ML		98.9	12.6		

Bottom of boring at 40.5 feet.
Perched groundwater encountered in zone from approximately 33.0 to 38.0 feet.
No groundwater encountered below 38.0 feet.
Boring backfilled with soil cuttings.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 3

Project:	NORTH COUNTY TRANSIT DISTRICT		
Location:	DEL MAR, CALIFORNIA	Project No.	3650-SF

Dates(s) Drilled:	4/27/98	Logged By:	M. Doerschlag
Drilled By:	California-Pacific	Total Depth:	35.5 Ft.
Rig Make/Model:	Mobile B-61	Hammer Type:	Wireline downhole
Drilling Method:	Hollow-stem Auger	Hammer Weight/Drop:	140 Lb./±30 In.
Hole Diameter:	8 In.	Surface Elevation:	54.0 Ft.

Comments: Located north of Andersen Canyon.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0						SP-SC	Clayey Sand: Medium dense; dark yellowish brown (10YR 4/4); moist; fine to medium grained; trace of silt. [Fill]				
	50		■	RING N=23				105.3	7.3		
5						SP	Sand: Medium dense; pale yellow; moist; fine to coarse grained, with trace of silt. [Fill]				
			■	RING N=18							
	45					SP, ML, CL	Clayey Silt and Sand: Medium dense or stiff mottled mixture of yellowish sand and grayish clayey silt; moist; common fragmentary silty claystone. [Fill]	94.7	13.9		
10											
			■	RING N=55		ML, SM	Sandy Siltstone and Silty Sandstone: Hard or very dense; mostly yellowish brown (2.5YR 6/4); moist; sand component predominantly fine-grained; thinly bedded and closely fractured; fine-grained strata are non-plastic. [Delmar Fm.]				
	40							N/R	N/R		
15											

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 3

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK / DRIVE / TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15				ML, SM	Sandy Siltstone and Silty Sandstone: Hard or very dense; yellowish brown abruptly becoming dark gray (N4) at 16 feet; moist; sand mostly fine-grained; thinly bedded; fine-grained strata are non-plastic.				
		RING 55/6"		SM	— Silty sandstone, fine to medium grained, very silty.	108.2	13.2		
	35								
20									
		RING 56/6"		ML	— Clayey siltstone, gray (5Y 6/1), trace of fine-grained sand, friable and non-plastic.	98.6	16.0		
	30				Grades increasingly clayey.				
25									
		RING 65/6"		ML	← Clayey siltstone, dark gray (N4), trace of sand.	105.4	16.1		
	25								
30					Becomes harder drilling.				
		RING 62/6"		ML	— Siltstone, lacks clay. Trace of coal.	98.4	15.1		
	20								
35									

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 3

Sheet 3 of 3

Project: ***NORTH COUNTY TRANSIT DISTRICT***

Location: ***DEL MAR, CALIFORNIA*** Project No. ***3650-SF***

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS BULK	SAMPLE INTERVALS DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35						SP	Sandstone: Very dense; color and moisture undetermined; well-cemented with calcium carbonate. Bluff exposure is erosion-resistant, lenticular ledge about 14" thick. Very hard drilling.				

Refusal encountered at 35.5 feet.
No groundwater encountered.
Boring backfilled with soil cuttings.

FIELD LOG OF BORING B - 4P

Medall, Aragon, Higley Geotechnical, Inc.

Project:	*NORTH COUNTY TRANSIT DISTRICT*
Location:	*DEL MAR, CALIFORNIA* — Project No. *3650-SF*

Dates(s) Drilled:	**4/27/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**55.5 Ft.**
Rig Make/Model:	**Mobile B-61**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**60.5 Ft.**

Comments: Groundwater seepage noted along nearby bluff face.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0	60					SP-SC	Clayey Sand: Dense; dark reddish brown (5YR 3/4); moist; fine to medium grained, with occasional trace of gravel to ~1". [Bay Point Fm.] Sharp contact.				
5	55			RING N=51		ML, SC, CL	Sandy Siltstone: Hard; olive yellow (2.5Y 6/6); moist; fine-grained sand. Includes few thin clayey sand lenses, and occasional olive silty clay rip-up clasts. [Delmar Fm.]	94.0	23.3		
						CL	Silty Claystone: Hard; pale yellow (2.5YR 7/4); moist; slightly plastic.				
10	50			RING 68/12"		SP-SC	Clayey Sandstone: Very dense; mottled pale yellow (2.5Y 8/4) to olive yellow (5Y 6/8); moist; fine to medium grained; massively bedded; very weakly cemented.	107.3	21.3		SHEAR
15											

Continued on next sheet.

FIELD LOG OF BORING B - 4P

Medall, Aragon, Higley Geotechnical, Inc.

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
15	45	RING 80/9"	ML, SP	Sandy Siltstone and Sandstone: Hard or very dense; siltstone light gray (2.5Y 7/2), and sandstone yellow (2.5Y 8/6); moist; fine to medium-grained sand; fine-grained strata contain trace of clay and are non-plastic.	100.5	18.0	SHEAR
				Abrupt contact.			
			CL	Silty Claystone: Hard; very dark gray (5YR 3/1); moist; friable and non-plastic, with granular texture.			
20	40	RING 50/6"			105.8	16.9	SHEAR
				Grades less clay; color lightens.			
25	35	RING 66/6"	ML, SM	Siltstone and Silty Sandstone: Hard or very dense; mostly light gray (2.5Y 8/1) to gray (N6), with local orange mottling; moist; sands fine to medium grained.	102.4	13.1	
30	30	RING 50/3"	SM	Very silty fine to medium-grained sandstone; gray (N5).	110.0	11.5	
			CL, ML	Silty Claystone: Hard; gray (N5); moist; very silty; non-plastic and friable.			
35							

Continued on next sheet.

FIELD LOG OF BORING B - 4P

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35	25	RING 85/6"		CL	Silty Claystone: Hard; gray (N5); moist; very silty; non-plastic; becomes commonly mottled with dusky red iron oxide staining and small hematitic concretions.	92.0	18.6		SHEAR
40	20	RING 56/6"		CL	Silty claystone, as above.	105.2	19.3		
				ML	Sandy Siltstone: Hard; gray (N6); moist; mostly fine-grained sand; generally massive in recovered samples.				
45	15	RING 100/6"		ML	Sandy siltstone, as above.	116.2	10.3		
50	10	RING 50/3"		ML	Sandy siltstone, as above.	107.3	13.7		
55									

Continued on next sheet.

FIELD LOG OF BORING B - 4P

Project: ***NORTH COUNTY TRANSIT DISTRICT***

Location: ***DEL MAR, CALIFORNIA***

Project No. ***3650-SF***

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
55	5			57/6"		CL	Silty Claystone: Hard; dark gray (N4), abundantly mottled with dusky red (2.5YR 3/2) iron oxides; moist; very silty; massive and non-plastic.	102.1	17.5		SHEAR

Bottom of boring at 55.0 feet.
No groundwater encountered.
Piezometer installed as depicted in well completion column..

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 5

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

Dates(s) Drilled:	**4/28/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**51.0 Ft.**
Rig Make/Model:	**Mobile B-61**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**59.5 Ft.**

Comments:

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0						SP-SC	Clayey Sand: Dense; dark reddish brown (5YR 3/2); moist; fine to coarse grained, with trace of gravel to ~2" diameter. [Bay Point Fm.] Sharp contact.				
						ML, CL	Clayey Siltstone and Silty Claystone: Hard; dark to very dark gray (N4-N3), locally becoming black (N2), moist; friable and non-plastic, non-cemented. Bluff outcroppings contain common coal-bearing lenses to ~6" thick. [Delmar Fm.]				
	55										
5				RING 50/6"		ML	← Clayey siltstone, as above.	106.7	14.1		
	50										
10				RING 65/6"		CL	← Silty claystone, black (N2).	104.7	16.1		
						SP-SM	Silty Sandstone: Very dense; dark gray (N5) apparently mottled with shades of yellow; moist to locally very moist; fine to coarse grained. Interval inferred from bluff exposure.				
	45										
15											

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 5

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15			■	RING 70/6"		SP-SM	Silty Sandstone: Very dense; dark gray (N5); moist to locally very moist; fine to coarse grained. Locally contains sandy siltstone drapes and partings.	107.3	14.1		
	40					ML	Sandy Siltstone: Hard; gray (N5); moist; sand component fine to medium grained; apparently massively bedded; non-plastic and mostly lacks clay. Sample @ 20 ft. found to have plane and convolute lamination, with estimated 30-40% sand. Increasingly sandy with depth.				
20			■	RING 55/6"				111.2	12.2		
							Color becomes 10YR 5/1, possibly grading to silty sandstone.				
	35										
25			■	RING 67/6"		ML	Sandy siltstone, mottled with reddish brown (2.5YR 3/4) oxidation color.	101.9	15.0		
						ML	Clayey Siltstone: Hard; mottled gray (10YR 6/1) and yellow (10YR 7/6); moist; trace of fine-grained sand; non-plastic. Harder drilling.				
	30										
30			■	RING 62/6"		ML	Sandy siltstone, as above.	110.7	15.8		
	25										
35											

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 5

Sheet 3 of 3

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK / DRIVE / TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35		RING 58/6"		ML	Clayey Siltstone: Hard; color mostly olive gray (5Y 5/2); moist.	96.6	17.1		
	20								
40		RING 80/6"		ML	Sandy Siltstone: Hard; dark gray (N5); moist; contains estimated 20-30% fine to medium-grained sand. Little or no clay; non-plastic.	117.4	10.6		
	15								
45		RING 55/6"		ML	Siltstone, trace of fine-grained sand.	102.0	17.2		
	10								
50		RING 112/12"		ML	Siltstone, as above.	108.8	18.6		

Bottom of boring at 51.0 feet.
Groundwater seepage reported by driller somewhere in upper 20 feet of boring; interpreted to be from basal portion of sandstone interval located from 13 to 19 feet.
Boring backfilled with soil cuttings.

FIG. A-16

FIELD LOG OF BORING B - 6P

Medall, Aragon, Higley Geotechnical, Inc.

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

Dates(s) Drilled:	**4/28/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**28.0 Ft.**
Rig Make/Model:	**Mobile B-61**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**64.3 Ft.**

Comments: Groundwater seepage apparent from nearby bluff.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0				SP	Sand: Dense; dark yellowish brown (10YR 4/4); moist; fine to medium grained, with occasional trace of gravel; trace of clay and Fe-oxide binding agents. [Bay Point Fm.]				
	60	RING N=36				114.3	6.9		
5					Becomes wet.				
					Becomes medium to coarse grained, some fine gravel.				
		RING N=54		CL	Silty Claystone: Hard; pale olive (5Y 6/3); moist; very silty; slightly plastic to non-plastic. [Delmar Fm.]	102.0	18.8		
10	55								
		RING 70/12"		SC-SP, SP	Clayey Sandstone and Sandstone: Very dense; pale olive(5Y 6/4) becoming olive yellow (5Y 6/8); moist; fine to medium grained.	114.6	11.3		
15	50								

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 6P

Sheet 2 of 2

Project: ***NORTH COUNTY TRANSIT DISTRICT***

Location: ***DEL MAR, CALIFORNIA*** | Project No. ***3650-SF***

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15						SP	Clayey Sandstone and Sandstone: As before; grades primarily SP classification.				
						ML	Sandy Siltstone: Hard; mostly gray (5Y 5/1); moist; fine to medium grained sand, and trace of clay; apparently massively bedded.				
				RING 50/6"		ML		110.7	16.6		
	45										
20							Becomes harder drilling.				
				RING 76/6"		ML, SM	Sandy siltstone with clay, and some thinly bedded silty fine to medium-grained sandstone; color dark gray (N6) with abundant dusky red mottles; slightly sticky when wet.	117.7	14.3		
	40										
25											
				RING 82/6"		ML	Sandy siltstone with clay.	110.9	15.4		

Boring terminated at 28.0 feet due to very slow progress.
Perched groundwater encountered in zone from approximately 6.0 to 8.0 feet (base of Bay Point Fm.).
Piezometer installed as depicted in well completion column..

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 7

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* — Project No. *3650-SF*

Dates(s) Drilled:	**4/28/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**56.0 Ft.**
Rig Make/Model:	**Mobile B-61**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**61.3 Ft.**

Comments:

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
0			SP-SC	Clayey Sand: Dense becoming locally very dense; dark reddish brown (5YR 3/4); moist, becoming very moist by ~2 ft.; fine to medium grained, with trace of gravel to ~2" diameter; very weakly cemented with clay and Fe-oxides. [Bay Point Fm.]			
	60						
5		RING		Becomes very moist to wet. Trace of coarse-grained sand.			
	55	N=70			114.4	10.8	SHEAR
			CL	Silty Claystone: Hard; pale olive (5Y 6/3); moist; up to several percent fine-grained sand; non-plastic and non-cemented; massive appearance. [Delmar Fm.]			
10		RING					
	50	N=52			105.1	17.2	SHEAR
			ML	Clayey Siltstone: Hard; dark gray (N4); moist; trace of fine to medium-grained sand.			
15							

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 7

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15	45	RING 80/12"		ML	Clayey Siltstone: Hard; dark gray (N4); moist; trace of fine to medium-grained sand; texture locally comprises small granules somewhat loosely bound together; non-plastic.	106.5	21.2		
20	40	RING 67/6"		ML	Sandy Siltstone: Hard; gray (N5); moist; sand component fine to medium grained; apparently massively bedded; non-plastic and mostly lacks clay. Increasingly sandy with depth.	108.1	12.8		SHEAR
25	35	RING 50/3"			Unit contains subordinate thin layers of silty, fine to medium-grained sandstone.	111.8	12.9		
30	30	RING 100/6"			Very fine-grained silty sandstone.	105.9	12.1		SHEAR
					6-inch-thick well-cemented layer, hard drilling.				
35				SP	Sandstone: Very dense; very pale brown (10YR 7/4); wet; fine to coarse grained.				

Continued on next sheet.

FIELD LOG OF BORING B - 7

Medall, Aragon, Higley Geotechnical, Inc.

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA*

Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35		RING 100/5"		SP	Sandstone: Very dense; very pale brown (10YR 7/4); wet; fine to coarse grained; massively bedded.	104.7	9.9		SHEAR
	25								
40		RING 90/6"		SP, SP-SM		N/R	N/R		
	20								
		RING 70/6"		SP-SM	— Color gray (N6). Abrupt lower contact.				
				ML	Clayey Siltstone: Hard; gray (N5), with few dusky red mottles to about 1/2" across; moist; trace of fine-grained sand; non-plastic.	102.4	23.2		
45		RING 66/6"				109.7	17.7		SHEAR
	15								
50		RING 90/10"		ML, SC	← Sample with some clayey sandstone layer(s) to 6-8" thick.	106.3	15.1		
	10								
55									

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 7

Project:	NORTH COUNTY TRANSIT DISTRICT
Location:	DEL MAR, CALIFORNIA	Project No. 3650-SF

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS BULK	SAMPLE INTERVALS DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
55				RING 55/6"		ML, CL	Clayey Siltstone: As before; grading to silty claystone.	105.9	19.2		SHEAR

Bottom of boring at 56.0 feet.
Perched groundwater encountered in zone from approximately 6.0 to 9.0 feet (base of Bay Point Fm.); also, sandstone aquifer encountered from 34 to 43 feet.
Boring backfilled with soil cuttings.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 8

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

Dates(s) Drilled:	**4/29/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**61.0 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**60.5 Ft.**

Comments:

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS BULK	SAMPLE INTERVALS DRIVE	SAMPLE INTERVALS TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0	60					SP	Sand: Dense; strong brown (7.5YR 4/6); moist, becoming very moist by ~2 ft.; fine to medium grained; estimated 3-5% clay and Fe-oxide binder. [Bay Point Fm.]				
							Becomes wet.				
5	55			RING 61/12"			Knife-sharp contact.				
						CL	Silty Claystone: Hard; pale olive (5Y 6/4) to yellow (2.5Y 7/6); moist; up to several percent fine-grained sand; non-plastic and non-cemented; granulated appearance. [Delmar Fm.]	106.1	17.0		
						SP-SM, ML	Silty Sandstone and Siltstone: Very dense or hard; mostly yellow (2.5Y 8/6); moist; apparently thinly bedded; siltstone beds with trace of clay; fine to medium-grained sandstone.				
10	50			RING 50/6"				100.3	11.5		
15											

Continued on next sheet.

FIELD LOG OF BORING B - 8

Medall, Aragon, Higley Geotechnical, Inc.

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15	45	RING 55/6"	ML	Clayey Siltstone: Hard; gray (N5); moist; trace of fine-grained sand; non-plastic; massively bedded.	112.7	12.4		
			ML, SM	Sandy Siltstone: Hard; gray (N5); moist; sand component fine to medium grained; apparently massively bedded; non-plastic and mostly lacks clay. Increasingly sandy with depth. Sample @ 15 ft. classified as clayey siltstone with sand.				
20	40	RING 62/6"	ML		102.9	9.5		
25	35	RING 54/3"	ML	← Very sandy siltstone, trace of clay.	110.4	12.0		
			SM	Silty Sandstone: Very dense; dark gray (N4), with some small dusky red mottles; moist; fine to coarse grained. Inferred upper contact from harder drilling performance.				
30	30	RING 62/6"			102.3	9.2		
			ML, CL	Sandy Siltstone and Silty Claystone: Hard; dark gray (N4); moist; typically 5-10% fine to medium-grained sand; spotted with reddish Fe oxides along discontinuities. Mostly crumbly, friable, non-plastic, and often with granulated appearance.				
35								

Continued on next sheet.

FIELD LOG OF BORING B - 8

Medall, Aragon, Higley Geotechnical, Inc.

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA*

Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35	25	RING 50/5"	ML, CL	Sandy Siltstone and Silty Claystone: Hard; dark gray (N4), frequently spotted with reddish Fe oxides along discontinuities; moist; trace of mostly fine-grained sand; non-plastic, granulated appearance.	104.1	15.4		
40	20	RING 80/9"	CL	← Silty claystone, color very dark gray (5Y 3/1), crumbly texture.	102.3	16.2		
45	15	RING 50/6"	CL	← Silty claystone.	104.7	16.9		
50	10	RING 55/6"	CL	Silty Claystone: Hard; gray (5Y 5/1); moist; non-plastic. Near 50-ft. depth, contains some very thin (~1") layers of silty sandstone. Not mottled.	107.1	11.0		
55								

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 8

Sheet 4 of 4

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
55	5		■	RING 85/7"		CL	Silty Claystone: Hard; gray (5Y 5/1); moist; non-plastic. Sample @ 55 ft. intensely fractured, with marble-size granules bounded by random slicks.	114.6	10.2		
60	0		■	RING 62/6"			← Trace of reddish FeO mottling; few traces of carbonized organic matter.	95.8	13.8		

Bottom of boring at 61.0 feet.
Perched groundwater encountered in zone from approximately 4.0 to 5.5 feet (base of Bay Point Fm.).
Boring backfilled with soil cuttings.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 9P

Project: **NORTH COUNTY TRANSIT DISTRICT**

Location: **DEL MAR, CALIFORNIA** | Project No. **3650-SF**

Dates(s) Drilled:	**4/29/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**45.5 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**59.3 Ft.**

Comments: Groundwater seepage and dense arundo cane at nearby bluff.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
0			SP	Sand: Dense; mostly yellowish red (5YR 5/8); moist becoming very moist at 1-2 ft.; fine to medium grained; trace of clay and Fe-oxide binding agents. [Bay Point Fm.]			
	55	RING N=45		Becomes wet.	109.5	10.0	SHEAR
5							
		RING N=35	SP-SC	Becomes medium to coarse grained; some highly weathered black volcanic clasts; slightly increased clay. Gravel lag deposit at base of formation; sharp contact.	113.4	14.3	SHEAR
	50		CL	Silty Claystone: Hard; pale olive (5Y 6/3); moist; very silty; non-plastic; apparently massively bedded. [Delmar Fm.]			
10							
		RING 70/12"		Silty claystone, with trace of fine to coarse-grained sand.	107.3	19.7	SHEAR
	45						
15							

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 9P

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA*

Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
15			CL	Silty Claystone: Hard; pale olive (5Y 6/3); moist; very silty; non-plastic. Trace of fine to coarse-grained sand.			
		RING 73/12"	ML, CL	Clayey Siltstone and Silty Claystone: Hard; pale yellow (5Y 7/4) and olive (5Y 6/3), with yellow (5Y 7/8) mottles and laminae; moist; non-plastic.	115.2	11.9	SHEAR
	40						
20							
		RING 75/12"	ML	Clayey siltstone, with 1" wide, vertical clay-filled fracture (?) in sample. Abruptly becomes dark gray (N5 to 5Y 5/1).	117.4	10.4	
	35						
25							
		RING 50/6"	SM	Silty Sandstone: Very dense; dark gray (N4); moist; fine to medium grained, with trace of clay; uncemented.	114.5	7.6	SHEAR
	30						
30							
		RING N=45	ML	Clayey Siltstone: Hard; dark gray (10YR 4/1); moist; non-plastic; texture of loosely bound granules. Hard drilling.	108.0	12.9	SHEAR
	25						
35							

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 9P

Project: ***NORTH COUNTY TRANSIT DISTRICT***

Location: ***DEL MAR, CALIFORNIA*** | Project No. ***3650-SF***

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35						ML	Clayey Siltstone: Hard; dark gray (10YR 4/1); moist; non-plastic. Approximate lower contact.				
				RING 72/6"		SM	Silty Sandstone: Very dense; gray (N5); moist; fine to coarse grained; appears massively bedded. Very weakly cemented, but hard drilling.	105.8	8.4		SHEAR
40	20										
				RING 55/6"			← Silty sandstone with trace of clay.	116.5	8.2		
45	15			RING 65/6"		CL	Silty Claystone: Hard; dark gray (N4), with abundant dusky red mottles; moist; texture of small, hard granules; non-plastic.	110.8	12.1		SHEAR

Boring terminated at 45.5 feet due to slow drilling progress and overheating equipment.
Perched groundwater encountered in zone from approximately 4.0 to 9.0 feet (base of Bay Point Fm.).
Piezometer installed as depicted in well completion column..

FIG. A-29

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 10

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

Dates(s) Drilled:	**4/29/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**56.0 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**62.0 Ft.**

Comments: Groundwater seepage from nearby bluff exposures.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0						SP-SC	Clayey Sand with Gravel: Medium dense; brown (7.5YR 4/4); moist; fine to medium grained, with gravel and cobble-size rocks to ~4" diameter. [Fill]				
	60										
			■	RING 13/12"			Approximate contact.	106.5	6.6		
5						SP	Sand: Dense; yellowish red (5YR 5/8); moist becoming very moist near 8 ft.; fine to medium grained; trace of clay and Fe-oxide binding agents. [Bay Point Fm.]				
	55						Sharp contact.				
10			■	RING 43/6"		SP	Sandstone: Very dense; yellow (5Y 7/8); very moist; fine to medium grained; uncemented; apparently massively bedded. [Delmar Fm.]	104.9	14.4		SHEAR
	50										
						ML, CL	Clayey Siltstone and Silty Claystone: Hard; olive brown (2.5Y 4/4); moist; generally trace of fine-grained sand.				
15											

Continued on next sheet.

FIG. A-30

FIELD LOG OF BORING B - 10

Medall, Aragon, Higley Geotechnical, Inc.

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15			ML, CL	Clayey Siltstone and Silty Claystone: Hard; pale olive (5Y 6/3); moist; non-plastic. Trace of fine-grained sand.				
	45			— Cuttings dusky red (2.5YR 3/2) from about 17-18 ft.				
			SP-SM	Silty Sandstone: Very dense; dark reddish brown (5YR 2.5/2); wet; fine-grained. Thinly bedded in bluff exposures.			▼	
20		RING 73/6"			105.8	19.2		
	40							
25			ML	Siltstone and Silty Sandstone: Hard or very dense; dark gray (N4); moist; fine to medium grained sand; siltstones commonly with trace of clay; uncemented.				
	35							
30		RING 60/6"	SM	← Fine-grained, very silty sandstone.	107.6	11.9		
	30							
35								

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 10

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35						ML	Clayey Siltstone: Hard; mostly gray (5Y 5/1), occasionally mottled with dusky red Fe-oxide staining; moist; non-plastic.				
	25										
40				RING 40/6"		ML	Sandy siltstone, gray (5Y 5/1), slight granulated texture, some Fe-oxide mottling.	111.0	12.9		
	20										
45											
	15										
50				RING 65/6"		ML	Clayey siltstone with trace of sand, slight granulated texture, non-plastic.	103.1	15.5		
	10										
55											

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 10

Project: **NORTH COUNTY TRANSIT DISTRICT**

Location: **DEL MAR, CALIFORNIA** | Project No. **3650-SF**

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS BULK	SAMPLE INTERVALS DRIVE	SAMPLE INTERVALS TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
55				RING 52/6"		ML	Sandy Siltstone: Hard; gray (N5); moist; fine-grained sand.	111.8	15.5		SHEAR

Bottom of boring at 56.0 feet.
Perched groundwater encountered in sandstone member from approximately 19.0 to 25.0 feet.
Boring backfilled with soil cuttings.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 11P

Project:	*NORTH COUNTY TRANSIT DISTRICT*
Location:	*DEL MAR, CALIFORNIA*
Project No.	*3650-SF*

Dates(s) Drilled:	**4/29/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**51.0 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**60.2 Ft.**

Comments: Surface water in adjacent drainage.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0	60		SP	Sand: Mostly dense; mostly strong brown (7.5YR 4/6); moist; fine to medium grained, with trace of gravel; trace of clay and Fe-oxide binding agents. [Bay Point Fm.]				
		RING N=34	SP		117.1	7.4		
5	55							
		RING N=40	SP	← Color 10YR 5/6; includes some coarse-grained sand.	109.3	4.4		
10	50							
				Sharp contact.				
		RING 67/12"	SP	Sandstone: Very dense; yellow (5Y 7/8); very moist becoming wet; fine to medium grained, with trace of silt; uncemented; massively bedded. [Delmar Fm.]	106.8	10.0		
15								

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 11P

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15	45					SP	Sandstone: Very dense; yellow (5Y 7/8); wet; fine to medium grained, with trace of silt; uncemented; massively bedded.				
				RING 72/6"		SP	— Sandstone, little or no fines.	103.3	21.4		
20	40						— Slightly cemented from 20-21 ft.; harder drilling.				
						ML	Sandy Siltstone: Hard; very dark gray (N3); moist; fine to medium-grained sand; massive and non-plastic.				
				RING 55/6"				110.9	15.6		
25	35										
				RING 50/6"		ML	← Siltstone, as above.	113.1	14.0		
30	30										
35											

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 11P

Sheet 3 of 3

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35	25	RING 53/6"	ML, SM	Sandy Siltstone: As before; some very silty sandstone.	103.5	13.5		
			SP-SM	Silty Sandstone: Very dense; gray (N5); moist; fine to coarse grained; apparently massively bedded. Slightly cemented from 36 to 37 ft., and hard drilling. Becomes siltier with depth.				
			SM	Becomes easier drilling; interpreted silty sandstone.				
40	20							
				Approximate contact.				
			ML	Clayey Siltstone: Hard; olive gray (5Y 4/2); moist; trace of sand; non-plastic, with some granulated textures.				
45	15	RING 56/6"		← Clayey siltstone, as above.	107.4	15.8		
50	10	RING 58/6"	ML, SM	← Mixed clayey siltstone and thin silty sandstone, with common dusky red mottles	109.0	10.9		

Bottom of boring at 51.0 feet.
Perched groundwater encountered in zone from approximately 14.0 to 21.0 feet, measured depth of 15.1 feet after well installation. No groundwater encountered below 21.0 feet.
Piezometer installed as depicted in well completion column..

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 12

Project: **NORTH COUNTY TRANSIT DISTRICT**

Location: **DEL MAR, CALIFORNIA** | Project No. **3650-SF**

Dates(s) Drilled:	**4/30/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**50.0 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**60.5 Ft.**

Comments: Boring located in rail cut.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0	60					SP	Sand: Dense; yellowish red (5YR 4/6); moist becoming very moist near 5 ft.; fine to medium grained; trace of clay and Fe-oxide binding agents. [Bay Point Fm.]				
5	55										
10	50			RING 59/12"			Lightens to strong brown (7.5YR 5/6).	98.5	10.7		
							Becomes wet.			▼	
							Sharp contact.				
						CL	Silty Claystone: Hard; light yellowish brown (2.5Y 6/4); moist; trace of fine to medium-grained sand; slightly plastic. [Delmar Fm.]				
15											

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 12

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15	45		CL	Silty Claystone: Hard; light yellowish brown (2.5Y 6/4); moist; trace of fine to medium-grained sand; slightly plastic.				
			SM	Silty Sandstone: Very dense; dark gray (5YR 4/1); moist; fine to medium grained and very silty. Apparently massively bedded.				
20	40	RING 60/6"		← Silty sandstone, as above.	104.7	12.3		
			ML, CL	Clayey Siltstone and Silty Claystone: Hard; dark gray (N4); moist; occasional trace of fine to medium-grained sand; non-plastic. Increasing sand content with depth.				
25	35							
30	30	RING 60/6"	SM	← Local very fine-grained, very silty sandstone; light gray (5YR 6/1).	113.5	8.8		
				Very clayey from about 33 to 35 feet.				
35								

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 12

Project: **NORTH COUNTY TRANSIT DISTRICT**

Location: **DEL MAR, CALIFORNIA** | Project No. **3650-SF**

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35	25					SM, SP-SM	Silty Sandstone: Very dense; gray (N5); moist; fine to medium grained. Inferred from cuttings.				
40	20		■	RING 91/9"		ML	← Sandy siltstone, gray (N5), trace of clay, massive texture. Thin, local layer.	95.3	9.2		
45	15					CL	Silty Claystone: Hard; dark gray (N4) and dusky red (10R 3/3); moist; non-plastic and friable, with pronounced granulated texture. Hard drilling.				
50			■	RING 56/6"		ML	← Grades to clayey siltstone, olive gray, slight granulated texture.	102.3	14.4		

Bottom of boring at 50.0 feet.
Slight groundwater seepage inferred to originate from approximately 13.0 to 14.0 feet (base of Bay Point Fm.).
Boring backfilled with soil cuttings.

FIELD LOG OF BORING B - 13

Medall, Aragon, Higley Geotechnical, Inc.

Project:	*NORTH COUNTY TRANSIT DISTRICT*
Location:	*DEL MAR, CALIFORNIA*
Project No.	*3650-SF*

Dates(s) Drilled:	**4/30/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**56.0 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**57.6 Ft.**

Comments: Groundwater seepage visible at bluff face.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0				SP	Sand: Dense to very dense; red (2.5YR 4/8); slightly moist; fine to medium grained; trace of clay and Fe-oxide binding agents. [Bay Point Fm.]				
	55								
5									
	50				Lightens to strong brown (2.5YR 5/6) and yellowish brown (10YR 5/6).				
10		RING N=60				106.2	4.6		SHEAR
	45				Sharp contact.				
				SP	Sandstone: Very dense; yellow (10YR 7/5) becoming very pale brown (10YR 7/4); moist to very moist; fine to coarse grained; massively bedded and essentially uncemented. [Delmar Fm.]				
15									

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 13

Project: ***NORTH COUNTY TRANSIT DISTRICT***

Location: ***DEL MAR, CALIFORNIA*** | Project No. ***3650-SF***

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
15		RING 55/6"	SP	Sandstone: Very dense; very pale brown (10YR 7/4); moist to very moist; fine to coarse grained; massively bedded.	118.4	11.9	SHEAR
	40						
20		RING 57/6"	SP	← Sandstone, as above.	111.3	11.8	
			ML	Clayey Silt: Hard; very pale brown (10YR 7/4); moist; non-plastic.			
	35						
			SP	Sandstone: Very dense; very pale brown (10YR 7/4); moist; fine to coarse grained; uncemented.			
25		RING 65/6"	SP	← Sandstone, as above.	107.8	19.2	SHEAR
	30						
			CL	Silty Claystone: Hard; dark gray (10YR 4/1); moist; trace of fine-grained sand; non-plastic.			
30		RING 70/6"	CL	← Silty claystone, as above.	111.9	16.9	SHEAR
	25						
35							

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 13

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35		RING 60/6"		ML, CL	Clayey Siltstone and Silty Claystone: Hard; gray (10YR 6/1) at 35 feet becoming mostly dark gray (N4) at greater depths; moist; non-plastic. Variably granulated textures, ranging from massive to intensely fractured.	116.4	12.8		SHEAR
	20								
40		RING 59/9"		ML	← Clayey siltstone, dark gray (N4) with some dusky red Fe oxide mottling, trace of sand, granulated texture.	106.2	15.7		
	15								
45		RING 50/6"		ML	← Clayey siltstone, less clay than above, and only slightly granulated texture.	111.8	17.2		SHEAR
	10								
50		RING 65/6"		ML	← Very clayey siltstone, abundant dusky red mottles, intensely fractured.	107.7	19.9		
	5								
55									

Continued on next sheet.

FIELD LOG OF BORING B - 13

Medall, Aragon, Higley Geotechnical, Inc.

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS BULK	SAMPLE INTERVALS DRIVE	SAMPLE INTERVALS TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
55				RING 56/6"		ML	Clayey Siltstone and Silty Claystone: As before at 50 ft.	112.6	18.1		SHEAR

Bottom of boring at 56.0 feet.
Perched groundwater encountered in sandstone unit from approximately 23.0 to 28.0 feet; no groundwater encountered below 28.0 feet.
Boring backfilled with soil cuttings.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 14P

Project:	*NORTH COUNTY TRANSIT DISTRICT*
Location:	*DEL MAR, CALIFORNIA* — Project No. *3650-SF*

Dates(s) Drilled:	**4/30/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**51.0 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**52.8 Ft.**

Comments:

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
0			SP-SC	Clayey Sand: Dense; red (2.5YR 3/6); moist; fine to medium grained, with rare gravel clasts to 1/2"; trace of Fe-oxide binding agent. [Bay Point Fm.]			
	50						
5		RING 57/12"	SP-SC	← Color locally pale brown (10YR 6/3).	113.1	9.9	
	45						
				Sharp contact.			
10		RING 55/6"	SP	Sandstone: Very dense; yellow (10YR 7/6); moist to very moist; fine to coarse grained, with trace of silt; uncemented; massively bedded. [Delmar Fm.]	115.3	15.5	
	40						
15							

Continued on next sheet.

FIELD LOG OF BORING B - 14P

Medall, Aragon, Higley Geotechnical, Inc.

Project:	*NORTH COUNTY TRANSIT DISTRICT*
Location:	*DEL MAR, CALIFORNIA*
Project No.	*3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK / DRIVE / TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15		RING 56/6"		SP	Sandstone: Very dense; color becoming pale brown (10YR 8/3); becomes wet at 15 feet; mostly medium to coarse grained, with trace of silt; uncemented; massively bedded.	108.3	17.5		
	35								
				SM	Grades silty, fine-grained.				
20		RING 50/6"		ML	Clayey Siltstone: Hard; dark gray (N4); moist; trace of fine to medium-grained sand; massive and non-plastic.	112.4	15.4		SHEAR
	30								
25		RING 43/6"		ML	← Clayey siltstone, as above.	99.3	17.6		
	25								
30		RING 50/6"		ML	← Siltstone, little to no clay, massively bedded.	111.8	15.5		SHEAR
	20								
35									

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 14P

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	OTHER TESTS
35		RING 60/6"	ML, SM	Siltstone and Silty Sandstone: Hard or very dense; dark to very dark gray (N3-N4); slightly moist to moist; sandy layers mostly fine to medium grained. Classified silty sandstone at 35 ft. depth.	99.3	11.6	SHEAR
	15						
40		RING 55/6"	ML	← Sandy siltstone, little to no clay, massive.	106.2	14.8	
	10						
45		RING 72/6"	SM	Silty Sandstone: Very dense; dark gray (N4); moist; fine to medium grained; apparently massively bedded. Exposed at toe of bluffs.	102.5	10.5	SHEAR
	5		ML	Clayey Siltstone: Hard; dark gray (N5) with common dusky red mottles; moist; local trace of sand; non-plastic, locally with some granulated textures.			
50		RING 42/6"		← Clayey siltstone, as above.	107.3	14.9	SHEAR

Bottom of boring at 51.0 feet.
Perched groundwater encountered in zone from approximately 15.0 to 17.0 feet, at base of sandstone member.
No groundwater encountered below 17.0 feet.
Piezometer installed as depicted in well completion column..

FIG. A-46

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 15

Project:	*NORTH COUNTY TRANSIT DISTRICT*		
Location:	*DEL MAR, CALIFORNIA*	Project No.	*3650-SF*

Dates(s) Drilled:	**4/30/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**43.0 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**50.3 Ft.**

Comments:

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0	50					SP-SC	Clayey Sand with Gravel: Dense; dark red (2.5YR 3/6); moist; fine to medium grained. [Fill]				
						SP-SC	Clayey Sand: Dense; dark red (2.5YR 3/6); moist becoming very moist at about 4 ft.; fine to medium grained; very weakly cemented with clay and Fe oxides. [Bay Point Fm.]				
5	45										
							Becomes wet.				
							Sharp contact.				
						CL	Silty Claystone: Hard; yellow (10YR 8/6); moist to very moist; non-plastic. [Delmar Fm.]				
10	40										
						ML	Sandy Siltstone: Hard; yellow (10YR 7/6); moist; fine-grained sand; non-plastic.				
				RING 55/12"				108.8	16.0		
15						SM	Silty Sandstone: Very dense; yellow (10YR 7/6); moist; fine to medium grained. Interval deduced from bluff face exposure.				

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 15

Sheet 2 of 3

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15	35		SM	Silty Sandstone: Very dense; yellow (10YR 7/6); moist; fine to medium grained. Interval deduced from bluff face exposure.				
		RING 74/12"	ML	Clayey Siltstone: Hard; mostly dark gray (N4) with frequent dusky red mottles; moist; small amounts of fine to medium-grained sand; variably massive to intensely fractured or granulated.	104.6	17.7		
20	30							
		RING 74/12"	ML	← Clayey siltstone, as above, granulated texture.	99.7	16.4		
25	25							
		RING N=27	ML	← Clayey siltstone with sand, olive gray (5Y 5/2) with red (10R 3/6) mottles.	97.6	18.8		
30	20			Siltstone: Hard; dark gray (5Y 4/1); moist; non-plastic; trace of clay and fine-grained sand. Mostly massive to lightly granular texture.				
35								

Continued on next sheet.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 15

Sheet 3 of 3

Project:	NORTH COUNTY TRANSIT DISTRICT
Location:	DEL MAR, CALIFORNIA
Project No.	3650-SF

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
35	15						Siltstone: Hard; dark gray (5Y 4/1) and gray (N5); moist; non-plastic; trace of clay; mostly massive and without granular texture.				
				RING 53/6"		ML	← Siltstone, as above.	107.8	16.0		
40	10										
				RING 72/6"		ML	← Very sandy siltstone, gray (N5), massive	103.8	15.8		

Bottom of boring at 43.0 feet.
Perched groundwater encountered in zone from approximately 7.0 to 9.0 feet (base of Bay Point Fm.).
Boring backfilled with soil cuttings.

Medall, Aragon, Higley Geotechnical, Inc.

FIELD LOG OF BORING B - 16

Project:	NORTH COUNTY TRANSIT DISTRICT
Location:	DEL MAR, CALIFORNIA
Project No.	3650-SF

Dates(s) Drilled:	**4/30/98**	Logged By:	**M. Doerschlag**
Drilled By:	**California-Pacific**	Total Depth:	**29.5 Ft.**
Rig Make/Model:	**Mobile B-53**	Hammer Type:	**Wireline downhole**
Drilling Method:	**Hollow-stem Auger**	Hammer Weight/Drop:	**140 Lb./±30 In.**
Hole Diameter:	**8 In.**	Surface Elevation:	**46.5 Ft.**

Comments: Located at north end of project alignment.

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS: BULK	SAMPLE INTERVALS: DRIVE	SAMPLE INTERVALS: TYPE, N (Blows/ft.)	LITHOLOGY	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
0						SP-SC	Clayey Sand with Gravel: Dense; dark red (2.5YR 3/6); moist; fine to coarse grained. [Fill]				
	45										
						SP-SC	Clayey Sand: Dense; yellowish red (5YR 4/6); moist; fine to medium grained; very weakly cemented with clay and Fe oxides. [Bay Point Fm.]				
5							Sharp contact.				
						SP	Sandstone: Very dense; yellow (5Y 8/6); moist; fine to coarse grained; local trace of silt; uncemented; massively bedded. [Delmar Fm.]				
	40										
10											
	35						Becomes yellow (5Y 7/7).				
						CL, ML	Silty Claystone and Clayey Siltstone: Hard; yellow (10YR 8/6) to pale brown (10YR 7/3); moist; trace of fine to medium-grained sand; slightly plastic from 13-16 feet.				
15											

Continued on next sheet.

FIELD LOG OF BORING B - 16

Sheet 2 of 2

Medall, Aragon, Higley Geotechnical, Inc.

Project: *NORTH COUNTY TRANSIT DISTRICT*

Location: *DEL MAR, CALIFORNIA* | Project No. *3650-SF*

DEPTH (Ft.)	ELEVATION (MSL)	SAMPLE INTERVALS TYPE, N (Blows/ft.)	USCS	GEOTECHNICAL DESCRIPTION	DRY DENSITY (Pcf)	MOISTURE CONTENT (%)	WELL COMPLETION	OTHER TESTS
15			ML	Clayey Siltstone: Hard; yellow (10YR 8/6) to pale brown (10YR 7/3); moist; trace of fine to medium-grained sand; non-plastic below about 16 feet.				
	30							
20		RING		Abruptly becomes gray (5Y 5/1).				
		69/12"	ML	Clayey siltstone, non-plastic, slight granulated texture.	109.9	15.0		
	25							
25								
	20							
		RING 48/6"	ML	Clayey siltstone, very pale brown (10YR 7/4) with dusky red mottles, massively bedded.	101.3	20.8		

Bottom of boring at 29.5 feet.
No groundwater encountered.
Boring backfilled with soil cuttings.

EXPLANATION OF GEOTECHNICAL BORING LOG

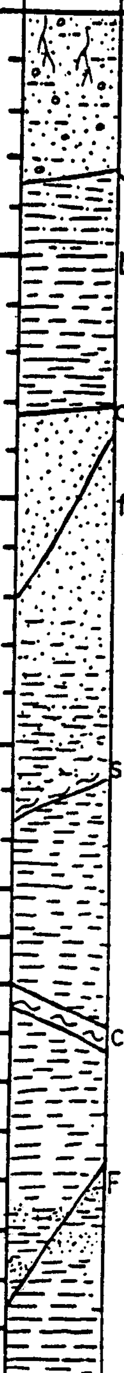
Date ________ Drill Hole No. ________ Sheet __ of -

Project ________ Job No. ________

Drilling Co. ________ Type of Rig ________

Hole Diameter ________ Drive Weight ________ Drop ________ in.

Elevation Top of Hole ________ Ref. or Datum ________

Depth Feet	Graphic Log	Attitudes	Tube Sample No.	Blows Per Foot	Dry Density pcf	Moisture Content, %	Soil Class. (U.S.C.S.)	GEOTECHNICAL DESCRIPTION Logged by ________ Sampled by ________
0								Attitudes: Strike/Dip (b) = Bedding (c) = Contact (j) = Joint (f) = Fracture (F) = Fault (cs) = Clay Seam (s) = Shear
							SM	
		j:N10W/ 20E						
5		b:Horizontal					ML	
			1	14	106.2	14.9	CL	Relatively undisturbed drive sample (Modified California Sampler) - Number to left represents Sample Number
		c:N80W/ 10N	1					Bulk Sample (with sampling interval)
10		f:N-S/ 65W						
			2	15		15.8	SP	Standard Penetration Test (Split-Spoon Sampler)
15			N.R.	18				Sample not recovered
		s:N50E/ 40W						
							CL/ CH	
20		cs:N30W/ 20E						
		F:N10E/ 70W				seep		
25						ground water table		
								Total Depth = 28' (depth of hole)
30								

Graphic Log:

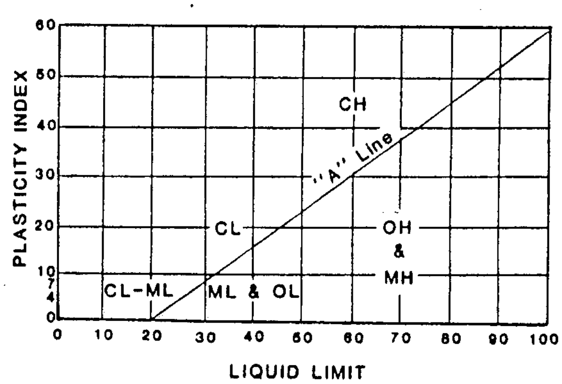
- silt
- sand
- clay
- contact
- fracture
- shear/clay seam
- zone with calcareous cement
- roots
- seep
- ground water table
- clast

MAJOR DIVISIONS		SOIL CLASS.	TYPICAL NAMES
COARSE GRAINED SOILS (More than 1/2 of soil > no. 200 sieve size)	GRAVELS (More than 1/2 of coarse fraction > no. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (More than 1/2 of coarse fraction < no. 4 sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS (More than 1/2 of soil < no. 200 sieve size)	SILTS & CLAYS LL < 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS LL > 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils

CLASSIFICATION CHART
(Unified Soil Classification System)

CLASSIFICATION	RANGE OF GRAIN SIZES	
	U.S. Standard Sieve Size	Grain Size in Millimeters
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76.2
GRAVEL	3" to No. 4	76.2 to 4.76
coarse	3" to 3/4"	76.2 to 19.1
fine	3/4" to No. 4	19.1 to 4.76
SAND	No. 4 to No. 200	4.76 to 0.074
coarse	No. 4 to No. 10	4.76 to 2.00
medium	No. 10 to No. 40	2.00 to 0.420
fine	No. 40 to No.200	0.420 to 0.074
SILT & CLAY	Below No. 200	Below 0.074

GRAIN SIZE CHART



PLASTICITY CHART

METHOD OF SOIL CLASSIFICATION

APPENDIX C

Laboratory Testing Procedures and Test Results

Chloride Content: Chloride content was tested in accordance with Caltrans Test Method CT422. The results are presented below:

Sample Location	Sample Description	Chloride Content (ppm)	Chloride Attack Potential*
B-1 @ 0'-5'	Red-brown silty SAND	300	Threshold
B-1 @ 40'-45'	Dark Olive silty clayey SAND	500	Positive

* per City of San Diego Program Guidelines for Design Consultant, 1992.

Direct Shear Tests: A Direct shear test was performed on a selected relatively undisturbed sample which was soaked for a minimum of 24 hours under a surcharge equal to the applied normal force during testing. After transfer of the sample to the shear box and reloading of the sample, the pore pressures set up in the sample (due to the transfer) were allowed to dissipate for a period of approximately 1 hour prior to application of shearing force. The sample was tested under various normal loads utilizing a motor-driven, strain-controlled, direct-shear testing apparatus at a strain rate of 0.005 inches per minute. After a shear strain of 0.2 inches, the motor was stopped and the sample was allowed to "relax" for approximately 15 minutes. The stress drop during the relaxation period was recorded. It is anticipated that, in a majority of samples tested, the 15 minutes relaxing of the samples is sufficient to allow dissipation of pore pressures that may have set up in the samples due to shearing. The drained peak strength was estimated by deducting the shear force reduction during the relaxation period from the peak shear values. The shear values at the end of shearing are considered to be ultimate values and are shown in parenthesis.

Sample Location	Sample Description	Friction Angle (degrees)	Apparent Cohesion (psf)
B-1, 16 Feet	Dark brown silty SAND	36 (34)	300 (300)

APPENDIX C (Continued)

Maximum Dry Density Tests: The maximum dry density and optimum moisture content of typical materials were determined in accordance with ASTM Test Method D1557. The results of these tests are presented in the table below:

Sample Location	Sample Description	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
B-1 @ 0'-5'	Red-brown silty SAND	128.0	7.5

Minimum Resistivity and pH Tests: Minimum resistivity and pH tests were performed in general accordance with Caltrans Test Method CT643 for Steel or CT532 for concrete and standard geochemical methods. The results are presented in the table below:

Sample Location	Sample Description	pH	Minimum Resistivity (ohms-cm)
B-1 @ 0'-5'	Red-brown silty SAND	8.77	2336

Soluble Sulfates: The soluble sulfate contents of selected samples were determined by standard geochemical methods (Caltrans Test Method CT417). The test results are presented in the table below:

Sample Location	Sample Description	Soluble Sulfate Content (ppm)	Potential Degree of Sulfate Attack*
B-1 @ 0'-5'	Red-brown silty SAND	<150	Negligible
B-1 @ 40'-45'	Dark Olive silty clayey SAND	<150	Negligible

* Based on the 1997 edition of the Uniform Building Code, Table No. 19-A-4, prepared by the International Conference of Building Officials (ICBO, 1997).

Laboratory Testing - Geotechnical Investigation, 10th Street Retaining Wall (April 30,2002)

COMPACTION TEST
ASTM D 1557

Project Name: DEL MAR BLUFFS
Project Number: 040151-007
Boring Number: B-1
Sample Number: 1
Sample Description: SM, BROWN SILTY SAND

Tested By: MDR
Date: 4/18/02
Depth (ft.):

Scalp Fraction (%): +#4: 0.4 +3/8": +3/4":

Preparation Method: [ ] Moist [X] Dry

Compaction Method: [X] Mechanical Ram [ ] Manual Ram

Mold Volume (ft.^{3}): 0.03344 **Ram Weight:** 10 lbs. **Drop:** 18 inches

Water added (ml):	150	200	50	100		
TEST NUMBER:	1	2	3	4	5	6
Weight of Soil and Mold (g)	5523	5480	5361	5455		
Weight of Mold (g)	3432	3432	3432	3432		
Weight of Soil (g)	2091	2048	1929	2023		
Wet Soil and Tare (g)	186.9	213.2	191.6	197.0		
Dry Soil and Tare (g)	174.3	195.3	185.0	186.6		
Weight of Tare (g)	12.0	12.0	11.9	11.9		
Wet Density (pcf)	137.9	135.0	127.2	133.4		
Moisture Content (%)	7.8	9.8	3.8	6.0		
Dry Density (pcf)	127.9	123.0	122.5	125.9		

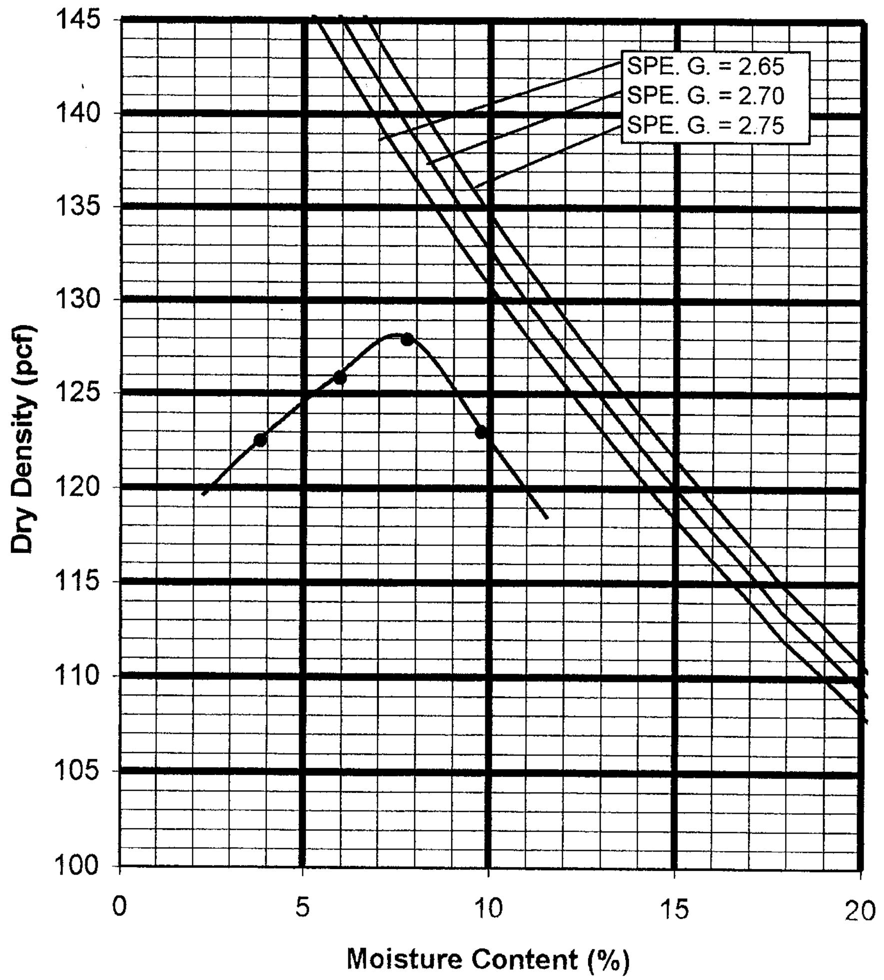
Maximum Dry Density (pcf) 128.0 **Optimum Moisture Content (%)** 7.5

PROCEDURE

[X] **Procedure A**
Soil: Passing No. 4 (4.75mm) Sieve
Mold: 4 in. (101.6 mm) Diameter
Layers: 5 (five)
Blows per Layer: 25 (twenty-five)
May be used if 20% or less by weight of the material is retained on the No. 4 sieve.

[ ] **Procedure B**
Soil: Passing 3/8 in. (9.5 mm) Sieve
Mold: 4 in. (101.6 mm) Diameter
Layers: 5 (five)
Blows per Layer: 25 (twenty-five)
Shall be used if more than 20% by weight of the material is retained on the No. 4 sieve and 20% or less by weight is retained on the 3/8 in. sieve.

[ ] **Procedure C**
Soil: Passing 3/4 in. (19.0 mm) Sieve
Mold: 6 in. (152.4 mm) Diameter
Layers: 5 (five)
Blows per Layer: 56 (fifty-six)
Shall be used if more than 20% by weight of the material is retained on the 3/8 in. sieve and less than 30% by weight is retained on the 3/4 in. sieve.



Rev. 01-02

TERATEST LABS

pH and Resistivity Sulfate Content Chloride Content

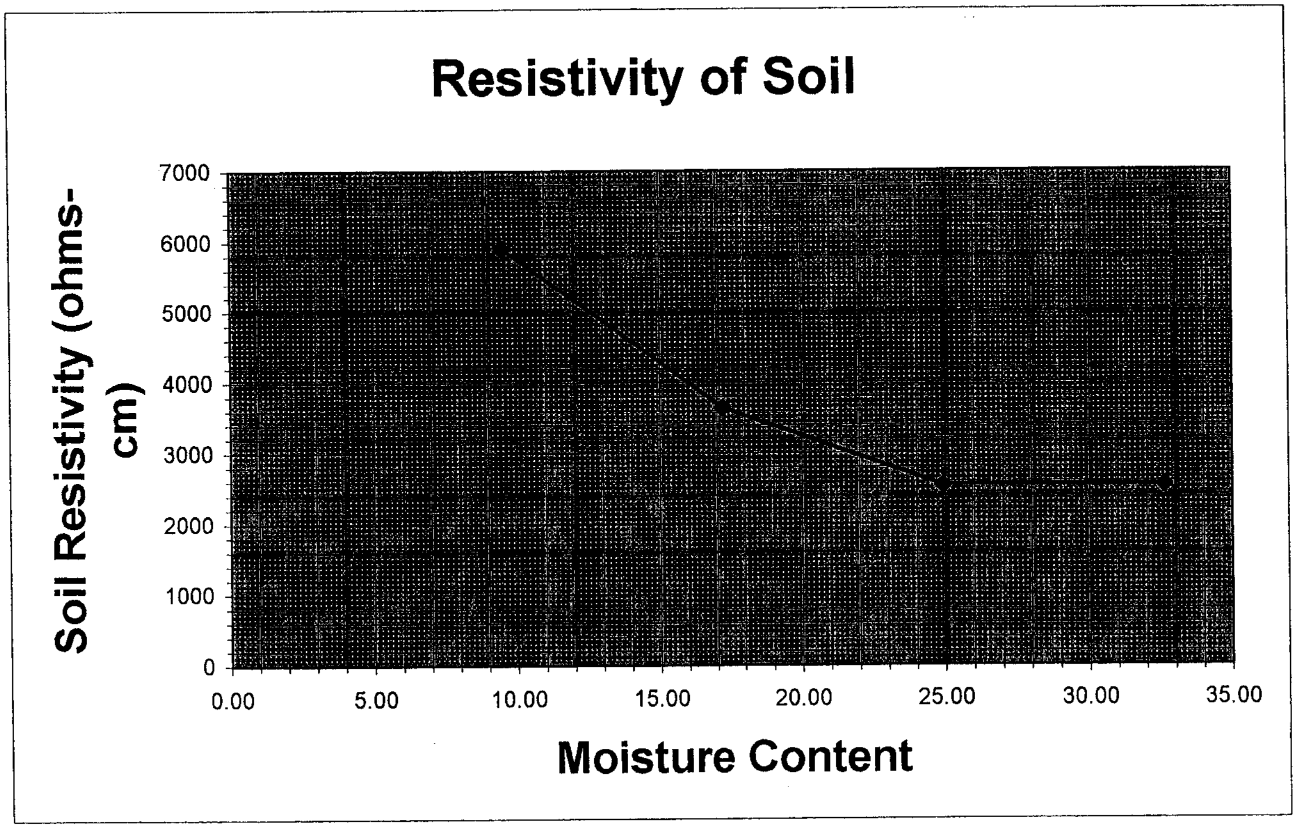
CT 532, CT 417, CT 422

Project Name: DEL MAR BLUFFS
Date: 4/17/02
Project Number: 040151-007
Tested By: MDR
Boring Number: B-1
Checked By:
Sample Number: 1
Depth (ft.): 0.0-5.
Sample Description: SM, REDDISH BROWN SILTY SAND

Initial Moisture Content	
Wet Wt. Soil+Container (g)	196.5
Dry Wt. Soil+Container (g)	193.2
Weight of Container (g)	12.0
Moisture Content (%)	1.8

Initial Sample Weight	1300
Box Constant	6.87
Soil pH	7.21
Sulfate Content (ppm)	<150
Chloride Content(ppm)	303

Water Added (ml)						
Moisture Content	9.51	17.21	24.90	32.59		
Spec. Cond.(uhm/cm)	860	530	370	370		
Resistivity (ohms-cm)	5908	3641	2542	2542		



Rev. 10-01

pH and Resistivity **Sulfate Content** **Chloride Content**

TERATEST LABS

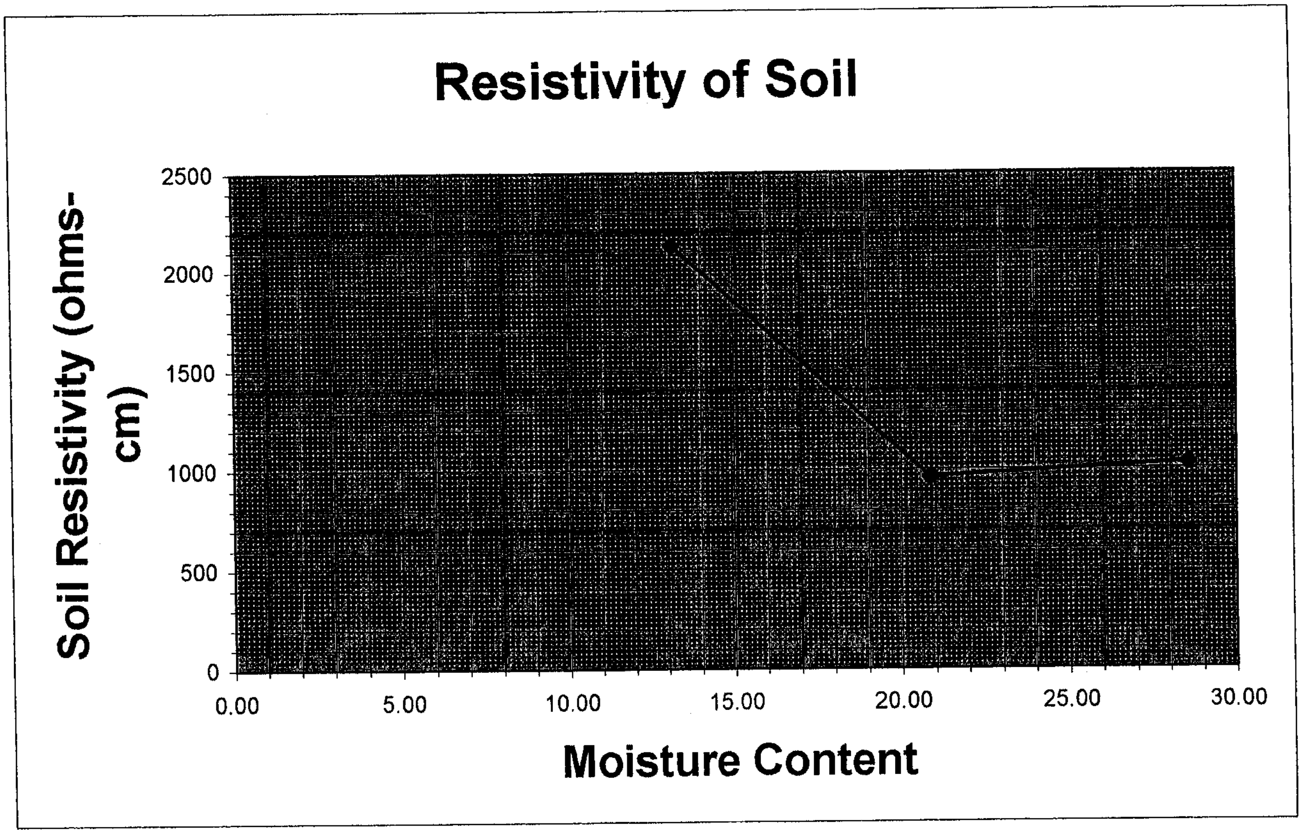
CT 532, CT 417, CT 422

Project Name:	DEL MAR BLUFFS	Date:	4/17/02
Project Number:	040157-007	Tested By:	MDR
Boring Number:	B-1	Checked By:	
Sample Number:	10	Depth (ft.):	40.0-45.0
Sample Description:	SC-SM, DARK OLIVE SILTY, CLAYEY SAND		

Initial Moisture Content	
Wet Wt. Soil+Container (g)	189.5
Dry Wt. Soil+Container (g)	180.3
Weight of Container (g)	12.0
Moisture Content (%)	5.5

Initial Sample Weight	1300
Box Constant	6.87
Soil pH	8.93
Sulfate Content (ppm)	<150
Chloride Content(ppm)	489

Water Added (ml)						
Moisture Content	13.16	20.85	28.54			
Spec. Cond.(uhm/cm)	310	140	150			
Resistivity (ohms-cm)	2130	962	1031			



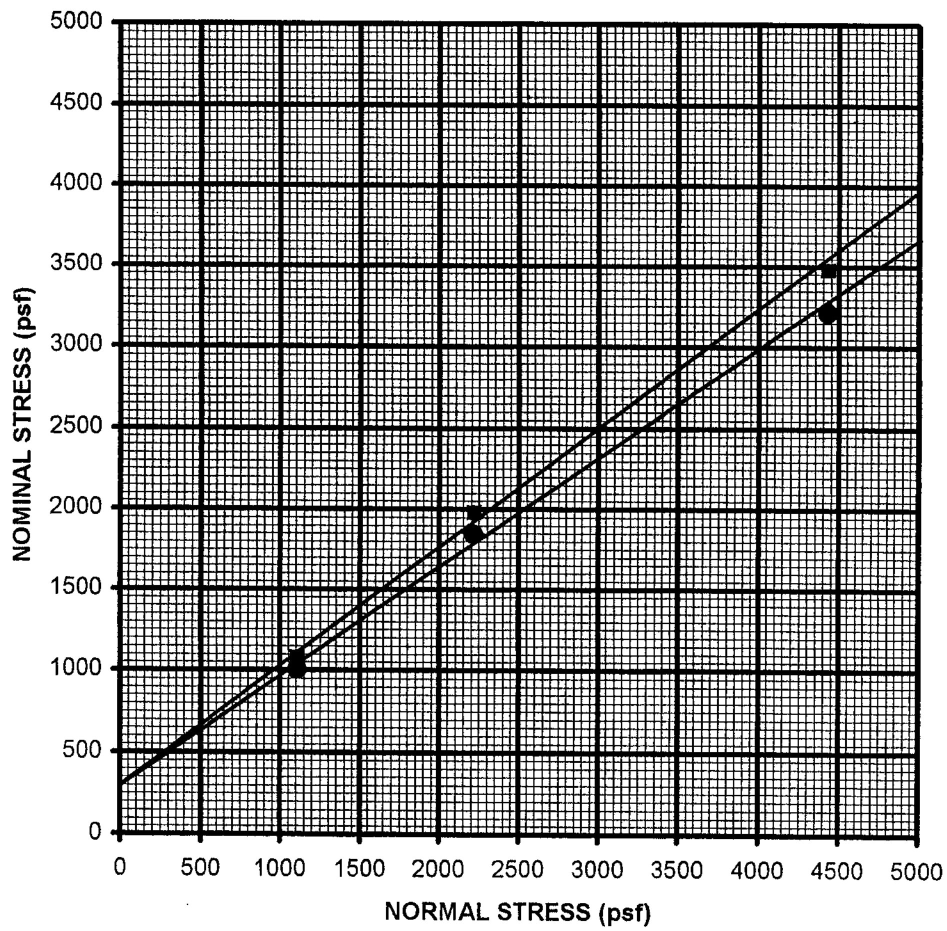
Rev. 10-01

TERATEST LABS

DIRECT SHEAR TEST RESULT
ASTM D 3080

Project Name:	DEL MAR BLUFFS	Date:	4/16/02
Project Number:	040151-007	Tested By:	BCC
Boring Number:	B-1	Checked By:	
Sample Number:	4	Depth (ft.):	16.0
Soil Description:	SM, DARK BROWN SILTY SAND		

VERTICAL STRESS (psf)	PROVING RING DIAL READING		CONVERSION FACTOR	SHEAR STRESS (psf)	RELAXED STRESS (psf)	PEAK	
						COHESION (psf)	300
						FRICTION (deg.)	36
	PEAK ■	RELAXED ●					
1108	72	67	15	1080	1005	RELAXED	
2216	132	123	15	1980	1845	COHESION (psf)	300
4432	232	214	15	3480	3210	FRICTION (deg.)	34



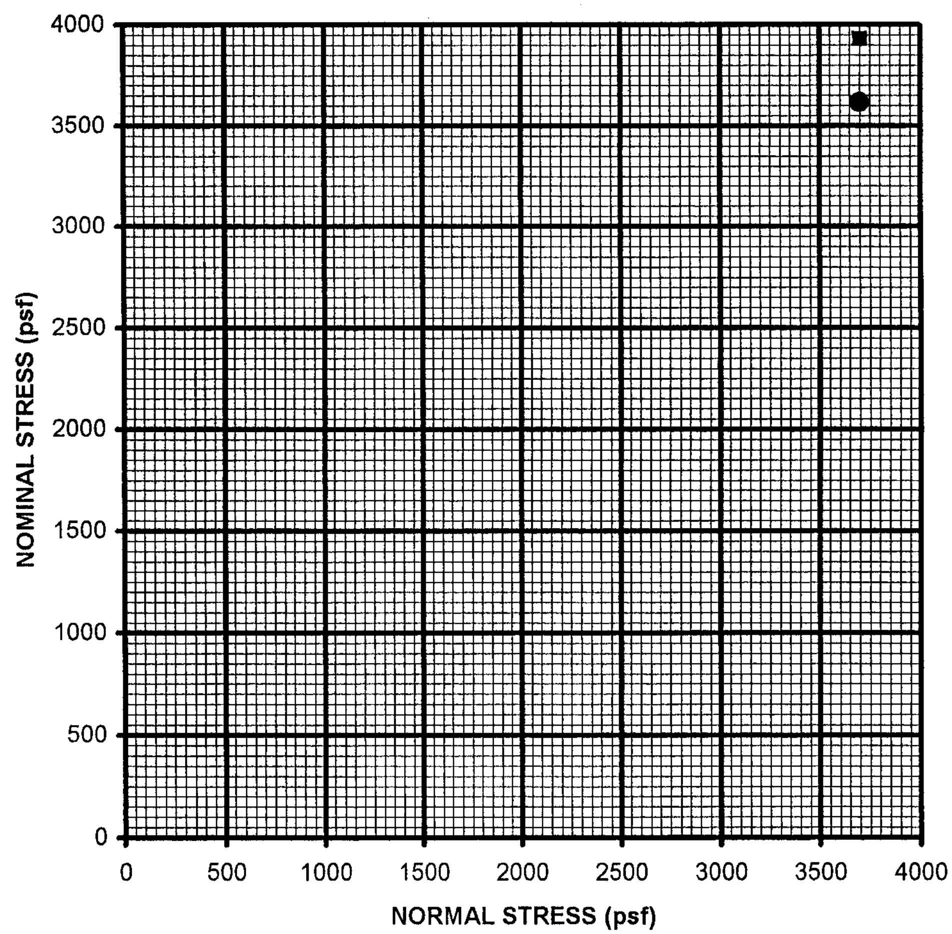
Rev. 02-02

TERATEST LABS

DIRECT SHEAR TEST RESULT
ASTM D 3080

Project Name:	DEL MAR BLUFFS	Date:	4/16/02
Project Number:	040151-007	Tested By:	BCC
Boring Number:	B-1	Checked By:	
Sample Number:	7	Depth (ft.):	31.0
Soil Description:	SC, REDDISH-BROWN CLAYEY SAND		

VERTICAL STRESS (psf)	PROVING RING DIAL READING		CONVERSION FACTOR	SHEAR STRESS (psf)	RELAXED STRESS (psf)	PEAK	
						COHESION (psf)	
						FRICTION (deg.)	
	PEAK ■	RELAXED ●					
3700	262	241	15	3930	3615	RELAXED	
						COHESION (psf)	
						FRICTION (deg.)	



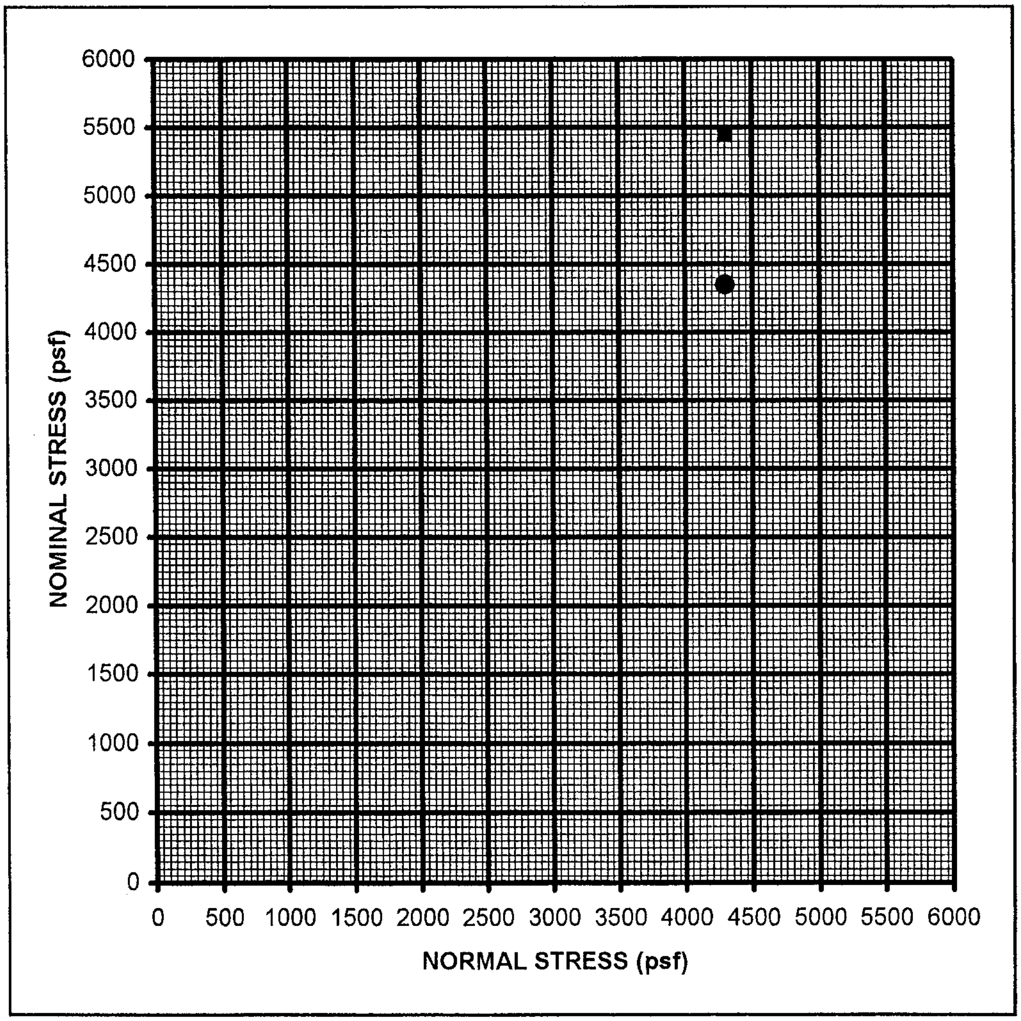
Rev. 02-02

TERATEST LABS

DIRECT SHEAR TEST RESULT
ASTM D 3080

Project Name:	DEL MAR BLUFFS	Date:	4/16/02
Project Number:	040151-007	Tested By:	BCC
Boring Number:	B-1	Checked By:	
Sample Number:	8	Depth (ft.):	36.0
Soil Description:	SC, OLIVE CLAYEY SAND		

VERTICAL STRESS (psf)	PROVING RING DIAL READING		CONVERSION FACTOR	SHEAR STRESS (psf)	RELAXED STRESS (psf)	PEAK	
						COHESION (psf)	
						FRICTION (deg.)	
	PEAK ■	RELAXED ●					
4300	363	290	15	5445	4350	RELAXED	
						COHESION (psf)	
						FRICTION (deg.)	



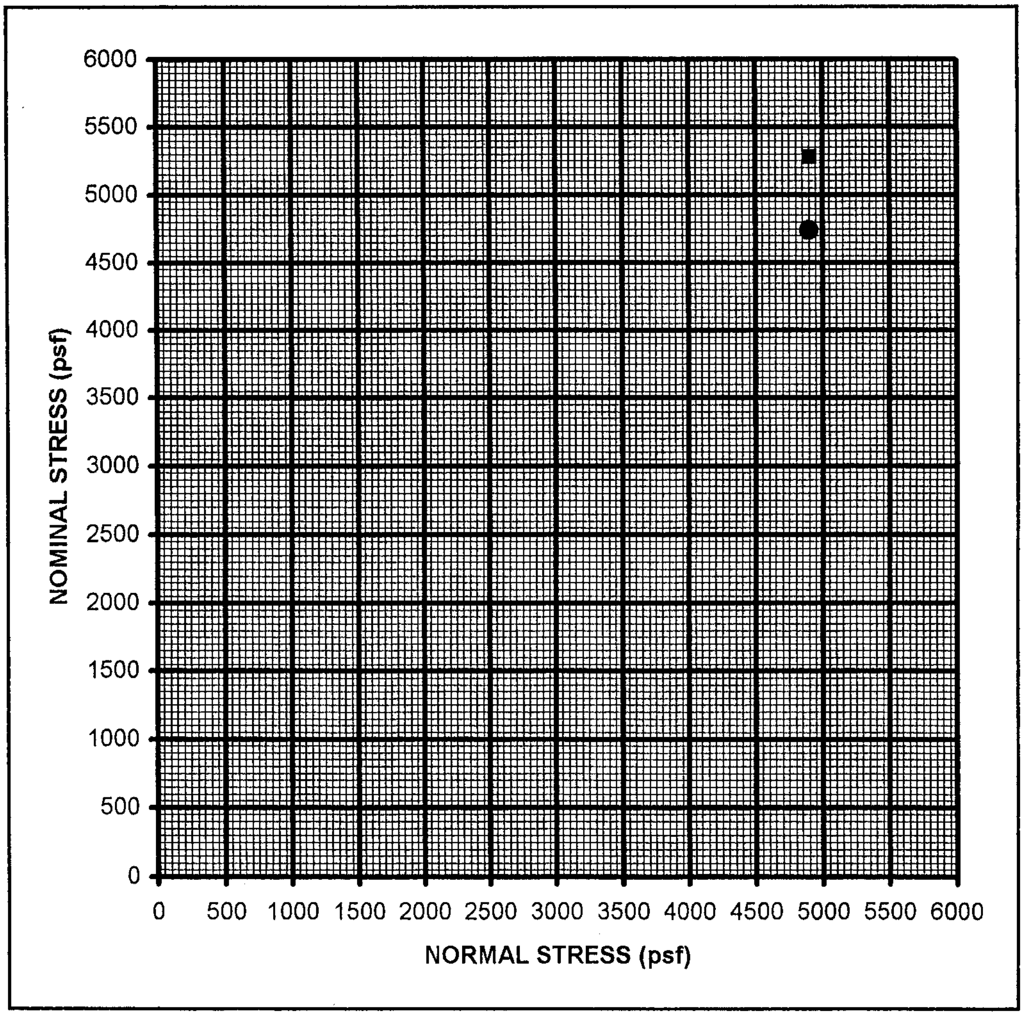
Rev. 02-02

TERATEST LABS

DIRECT SHEAR TEST RESULT
ASTM D 3080

Project Name:	DEL MAR BLUFFS	Date:	4/16/02
Project Number:	040151-007	Tested By:	BCC
Boring Number:	B-1	Checked By:	
Sample Number:	9	Depth (ft.):	41.0
Soil Description:	SC, DARK BLUISH-GRAY CLAYEY SAND		

VERTICAL STRESS (psf)	PROVING RING DIAL READING		CONVERSION FACTOR	SHEAR STRESS (psf)	RELAXED STRESS (psf)	PEAK	
						COHESION (psf)	
						FRICTION (deg.)	
	PEAK ■	RELAXED ●					
4900	352	316	15	5280	4740	RELAXED	
						COHESION (psf)	
						FRICTION (deg.)	



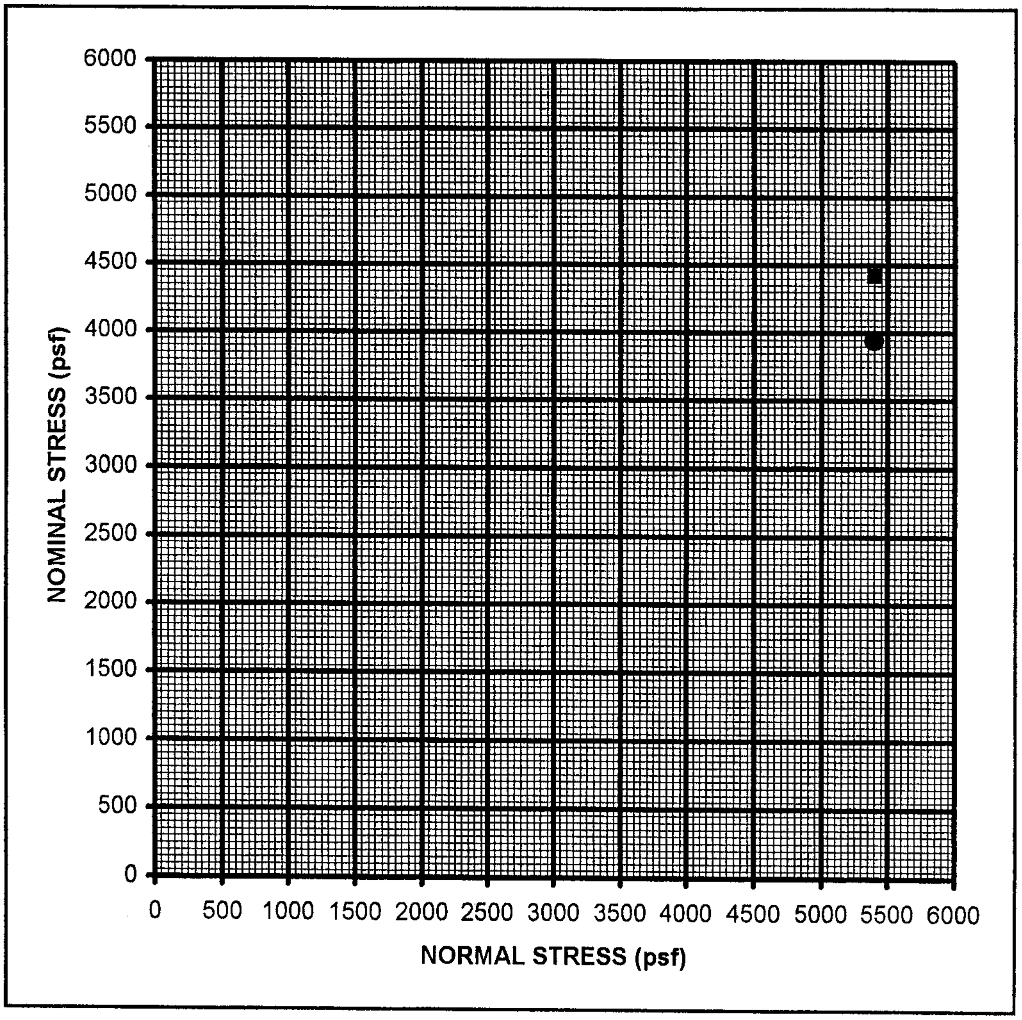
Rev. 02-02

TERATEST LABS

DIRECT SHEAR TEST RESULT
ASTM D 3080

Project Name:	DEL MAR BLUFFS	Date:	4/17/02
Project Number:	040151-007	Tested By:	BCC
Boring Number:	B-1	Checked By:	
Sample Number:	11	Depth (ft.):	45
Soil Description:	SC, DARK BLUISH-GRAY CLAYEY SAND		

VERTICAL STRESS (psf)	PROVING RING DIAL READING		CONVERSION FACTOR	SHEAR STRESS (psf)	RELAXED STRESS (psf)	PEAK	
						COHESION (psf)	
						FRICTION (deg.)	
	PEAK ■	RELAXED ●					
5400	295	263	15	4425	3945	RELAXED	
						COHESION (psf)	
						FRICTION (deg.)	



Rev. 02-02

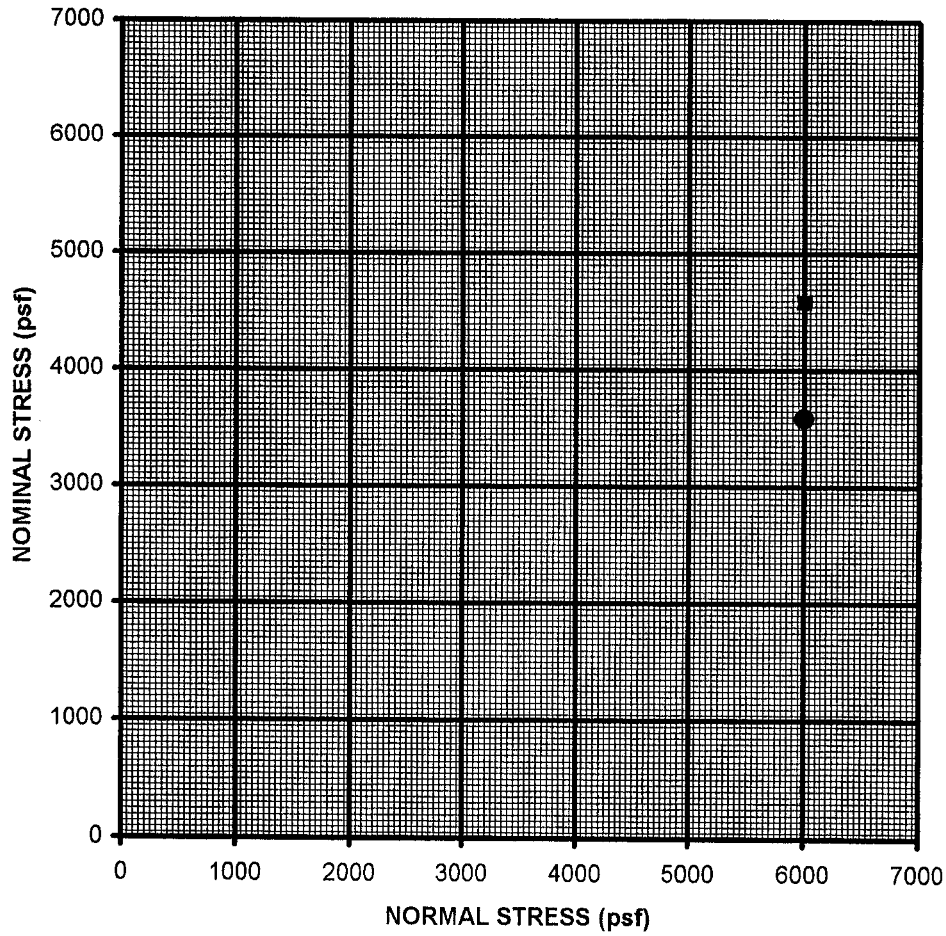
TERATEST LABS

DIRECT SHEAR TEST RESULT

ASTM D 3080

Project Name:	DEL MAR BLUFFS	Date:	4/17/02
Project Number:	040151-007	Tested By:	BCC
Boring Number:	B-1	Checked By:	
Sample Number:	12	Depth (ft.):	50.0
Soil Description:	SC, GRAY CLAYEY SAND		

VERTICAL STRESS (psf)	PROVING RING DIAL READING		CONVERSION FACTOR	SHEAR STRESS (psf)	RELAXED STRESS (psf)	PEAK	
						COHESION (psf)	
						FRICTION (deg.)	
	PEAK ■	RELAXED ●					
6000	306	239	15	4590	3585	RELAXED	
						COHESION (psf)	
						FRICTION (deg.)	



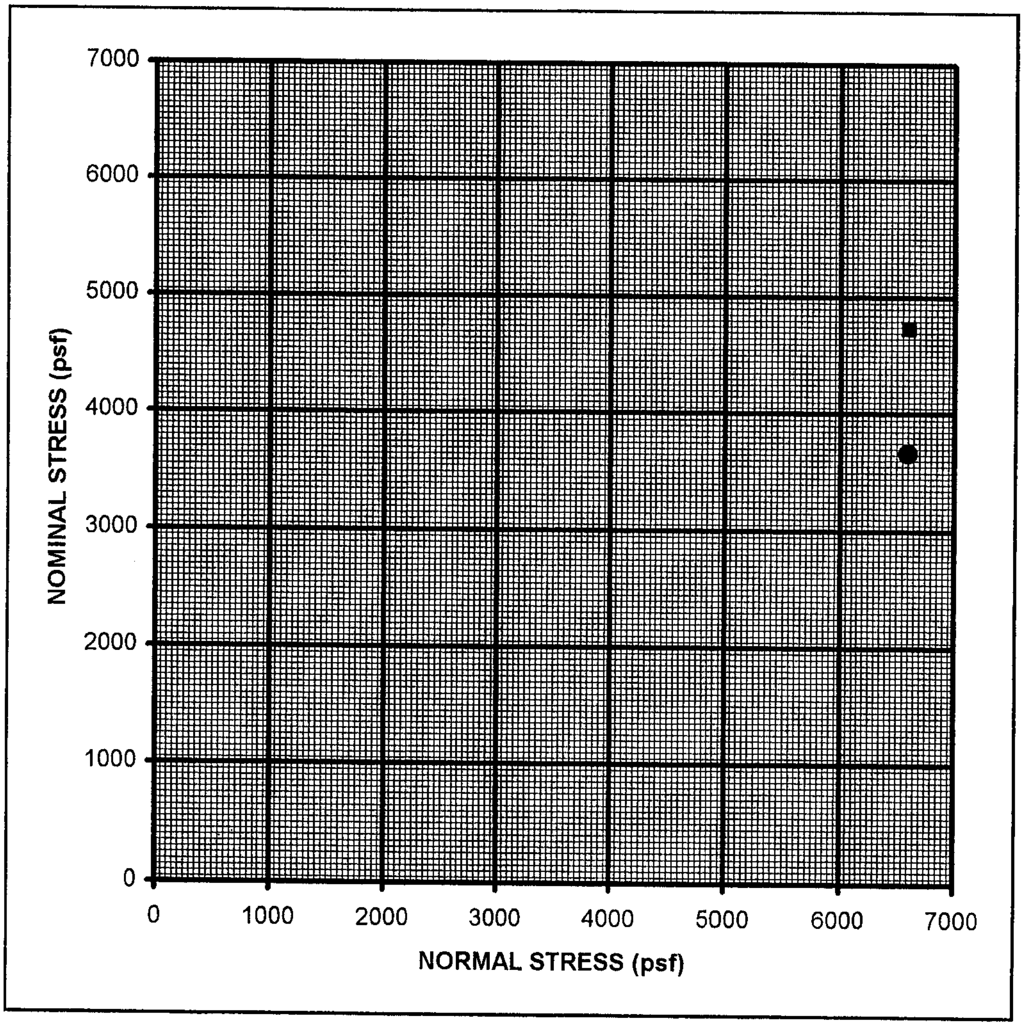
Rev. 02-02

TERATEST LABS

DIRECT SHEAR TEST RESULT
ASTM D 3080

Project Name:	DEL MAR BLUFFS	Date:	4/17/02
Project Number:	040151-007	Tested By:	BCC
Boring Number:	B-1	Checked By:	
Sample Number:	13	Depth (ft.):	55.0
Soil Description:	s(CL), OLIVE GRAY SANDY LEAN CLAY		

VERTICAL STRESS (psf)	PROVING RING DIAL READING		CONVERSION FACTOR	SHEAR STRESS (psf)	RELAXED STRESS (psf)	PEAK	
						COHESION (psf)	
						FRICTION (deg.)	
	PEAK ■	RELAXED ●					
6600	316	244	15	4740	3660	RELAXED	
						COHESION (psf)	
						FRICTION (deg.)	



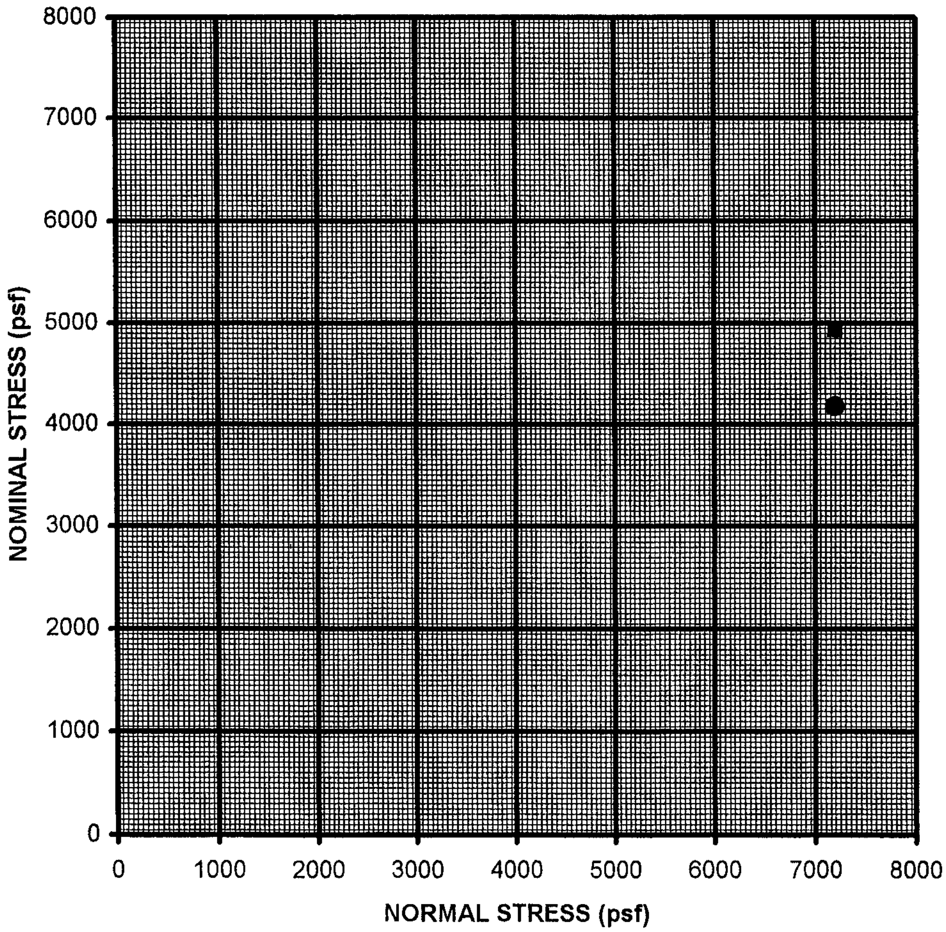
Rev. 02-02

TERATEST LABS

DIRECT SHEAR TEST RESULT
ASTM D 3080

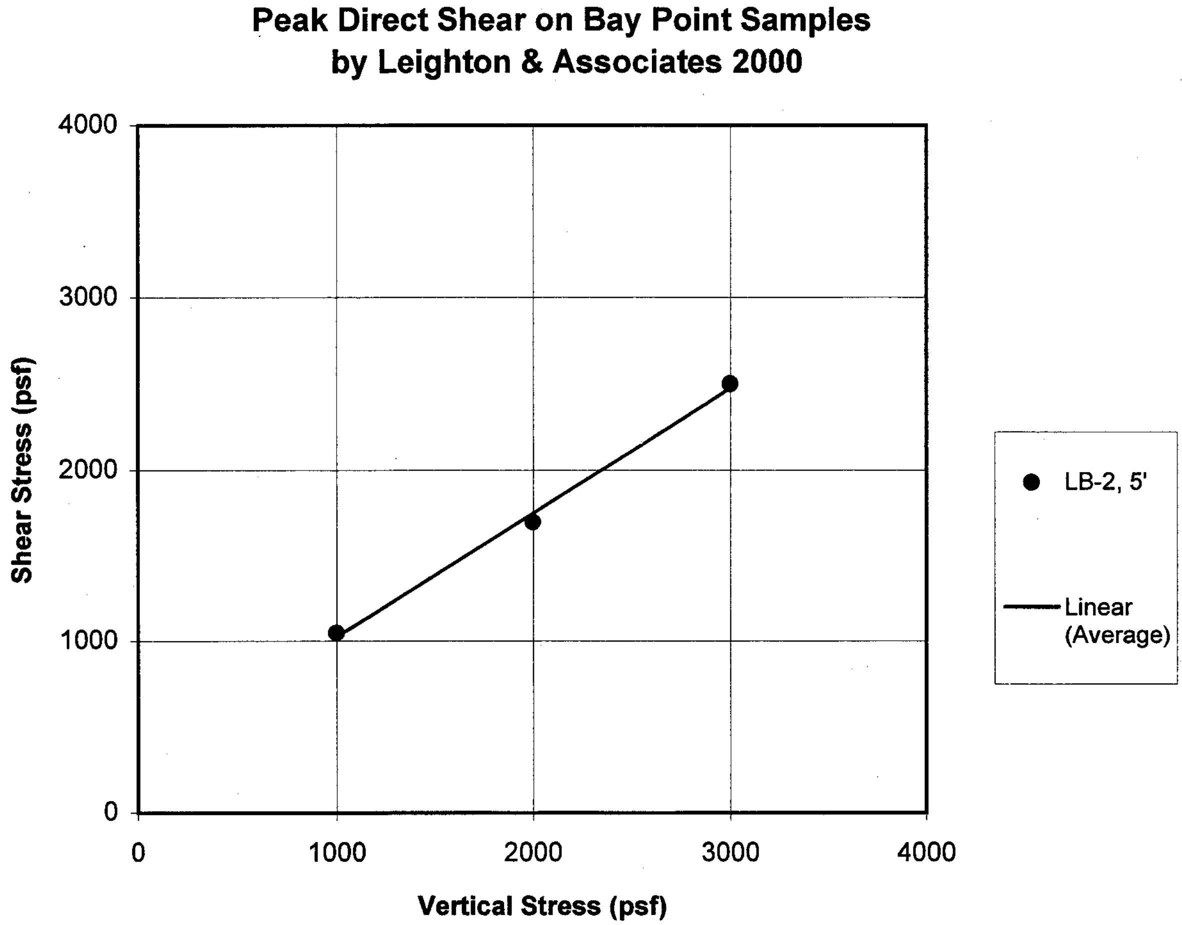
Project Name: DEL MAR BLUFFS Date: 4/18/02
Project Number: 040151-007 Tested By: BCC
Boring Number: B-1 Checked By:
Sample Number: 14 Depth (ft.): 60
Soil Description: CL, OLIVE CLAY

VERTICAL STRESS (psf)	PROVING RING DIAL READING		CONVERSION FACTOR	SHEAR STRESS (psf)	RELAXED STRESS (psf)	PEAK	
						COHESION (psf)	
						FRICTION (deg.)	
	PEAK ■	RELAXED ●					
7200	329	278	15	4935	4170	RELAXED	
						COHESION (psf)	
						FRICTION (deg.)	



Rev. 02-02

Laboratory Testing - Del Mar Bluffs Geotechnical Study
(January 31, 2001)

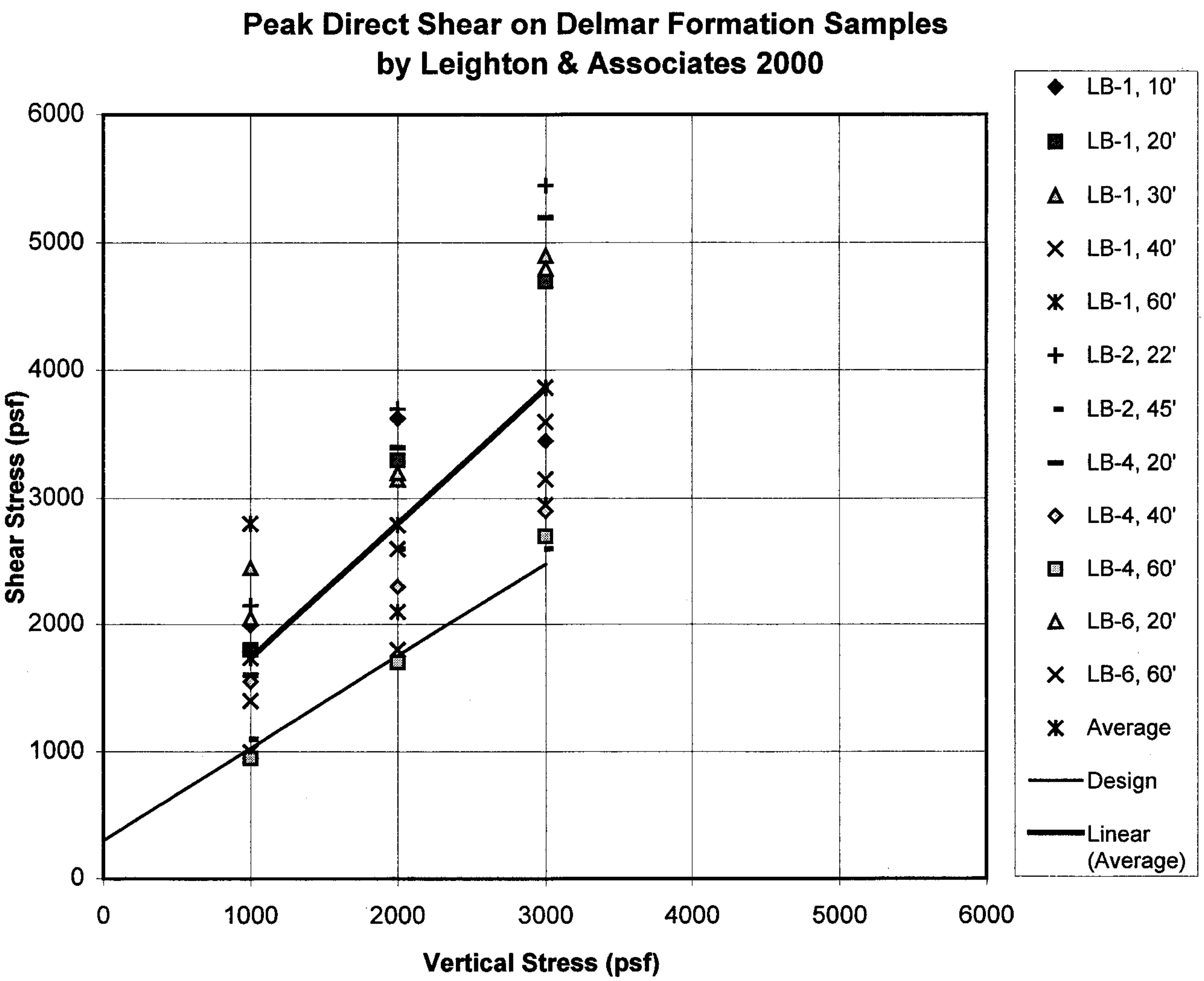


Average Strength Values

Friction Angle, ϕ (degrees)	**36**
Cohesion, c (psf)	**300**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-1**



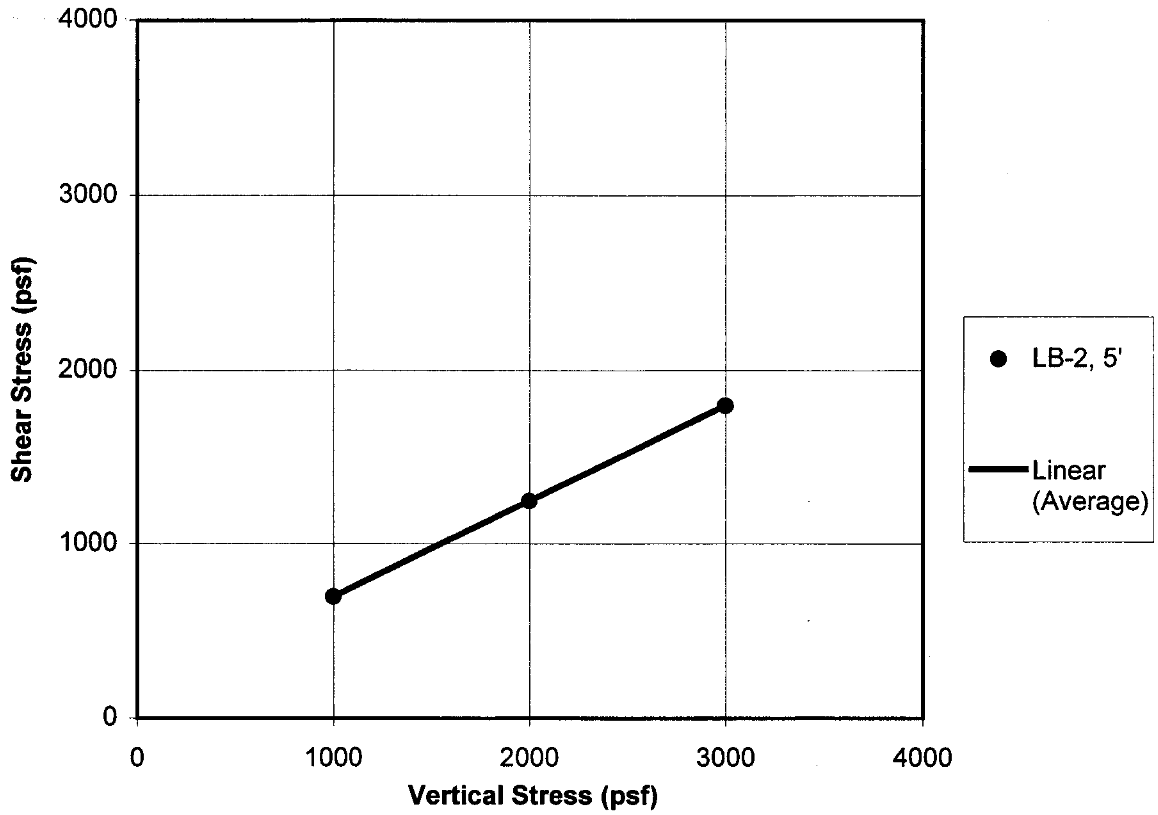
Average Strength Values

Friction Angle, ϕ (degrees)	47
Cohesion, c (psf)	650

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-2**

Ultimate Direct Shear on Bay Point by Leighton & Associates 2000

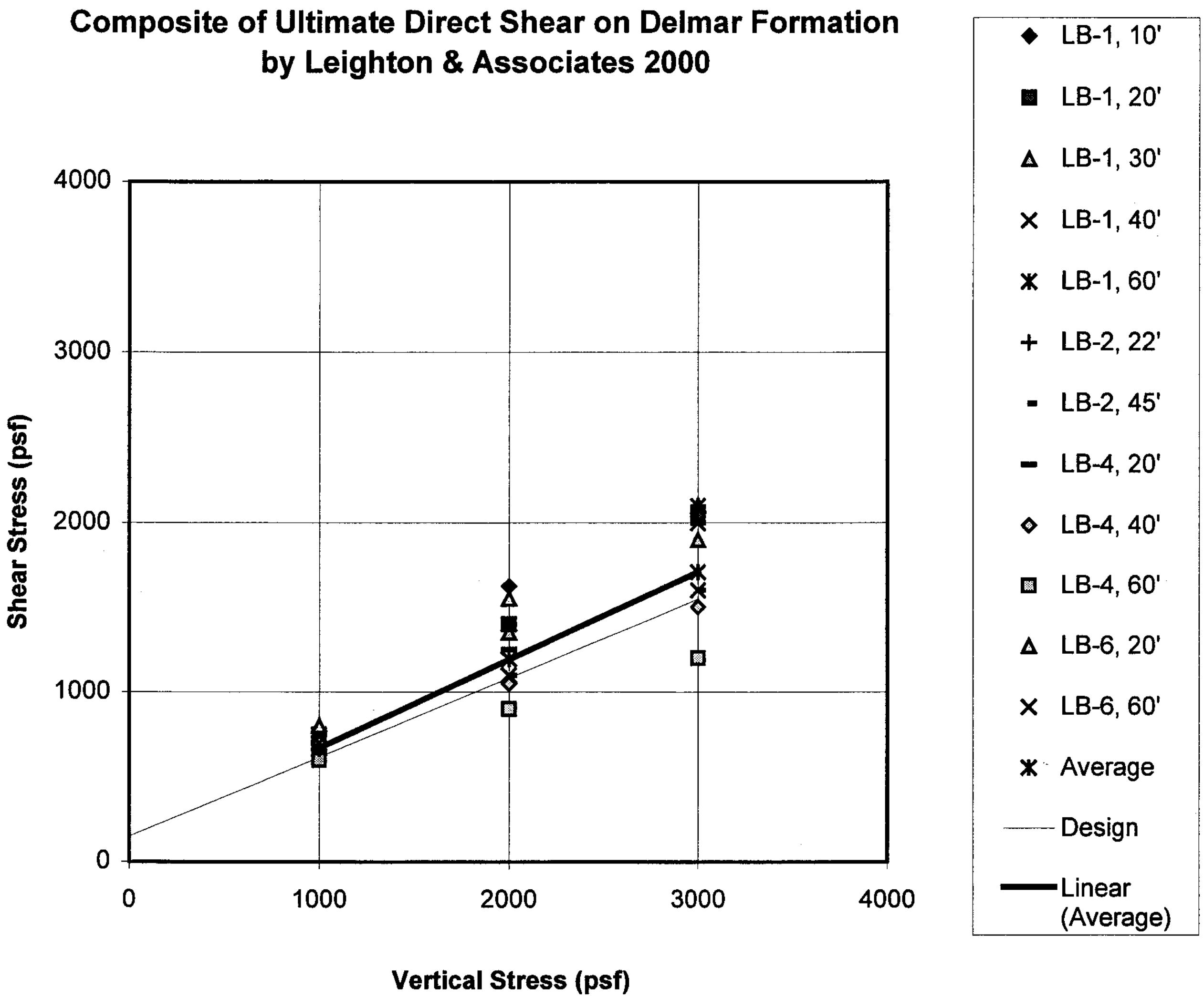


Average Strength Values

Friction Angle, ϕ (degrees)	**29**
Cohesion, c (psf)	**150**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-3**



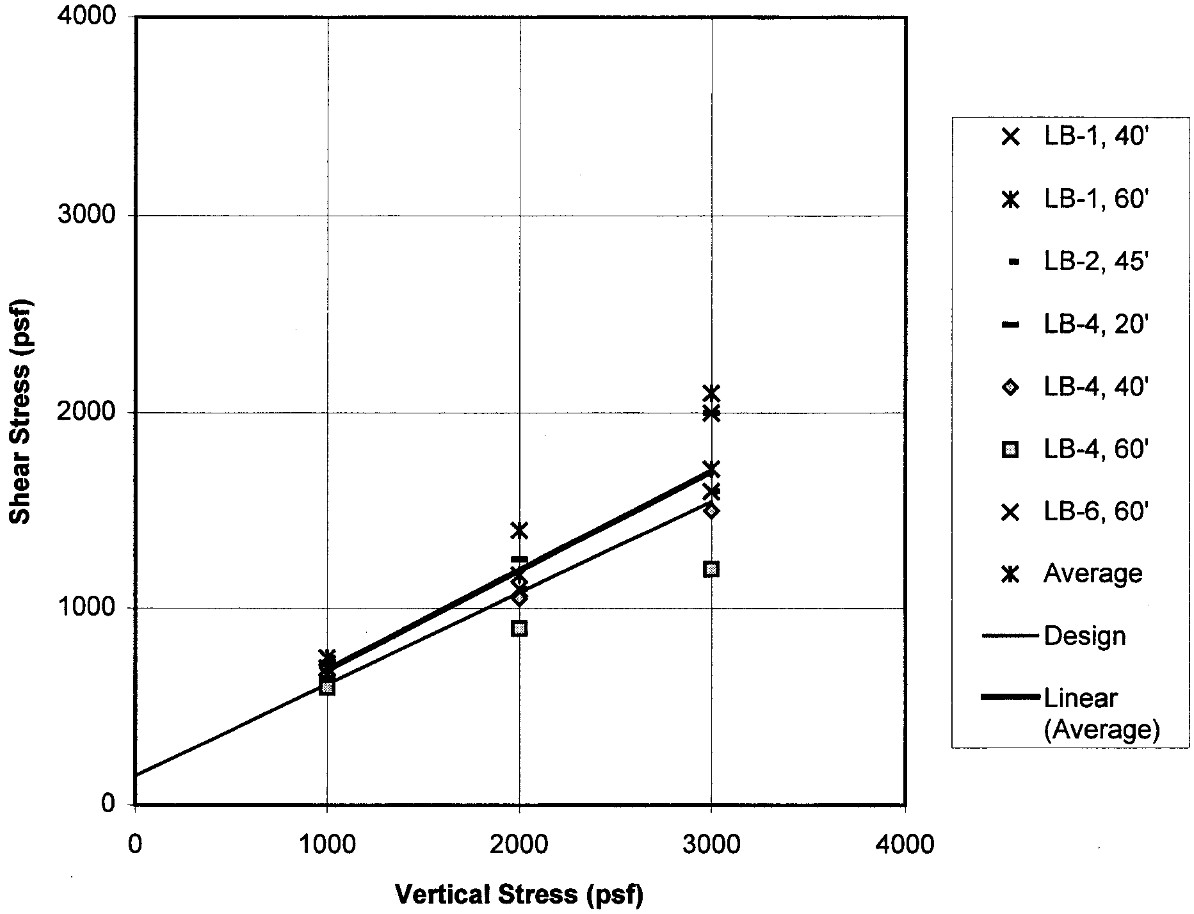
Average Strength Values

Friction Angle, ϕ (degrees)	29
Cohesion, c (psf)	150

DIRECT SHEAR SUMMARY

Project No.	040151-001
Project Name	HDR/Del Mar
Figure No.	G-4

Composite of Ultimate Direct Shear on Fine-Grained Samples of Delmar Formation by Leighton & Associates 2000



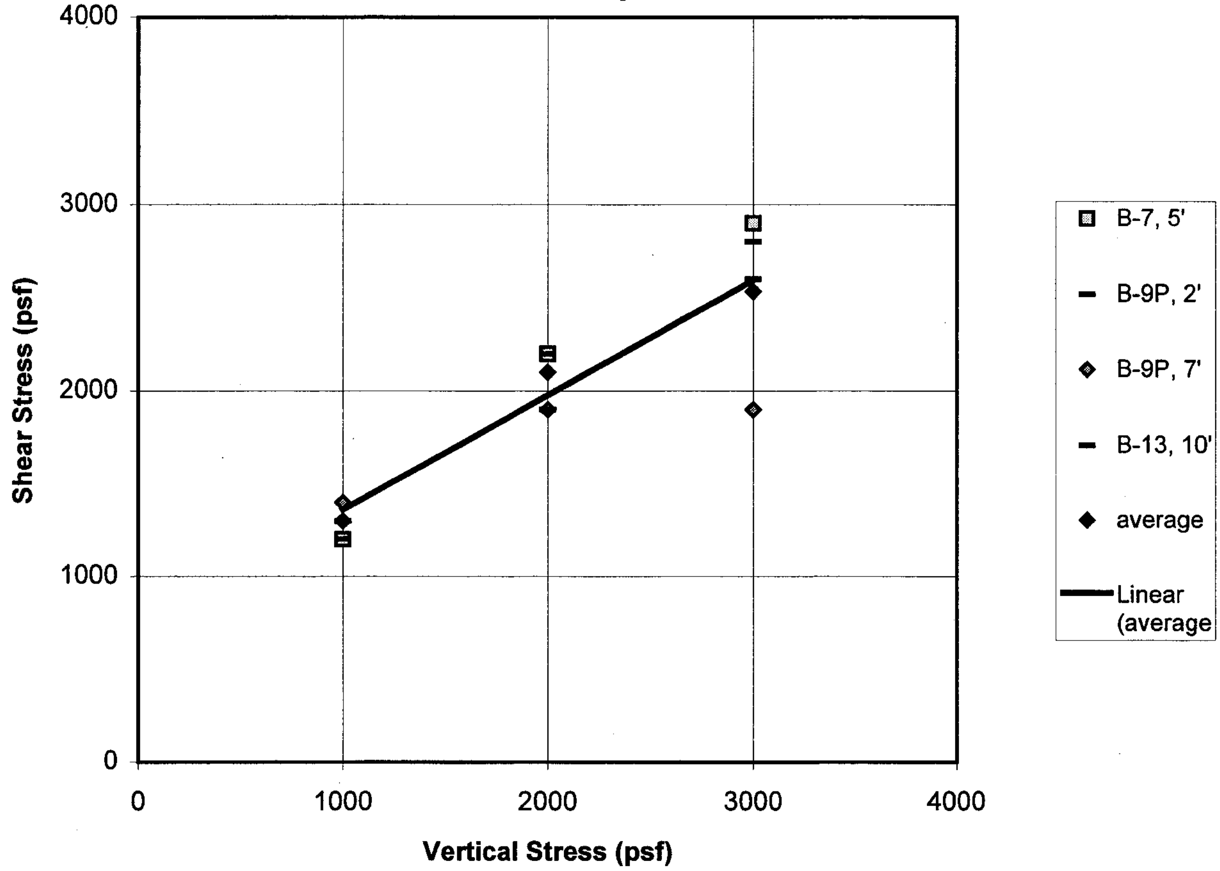
Average Strength Values

Friction Angle, ϕ (degrees)	27
Cohesion, c (psf)	170

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-4a**

Composite of Peak Direct Shear Results Tested on Bay Point Formation at Field Moisture by MAH 1998

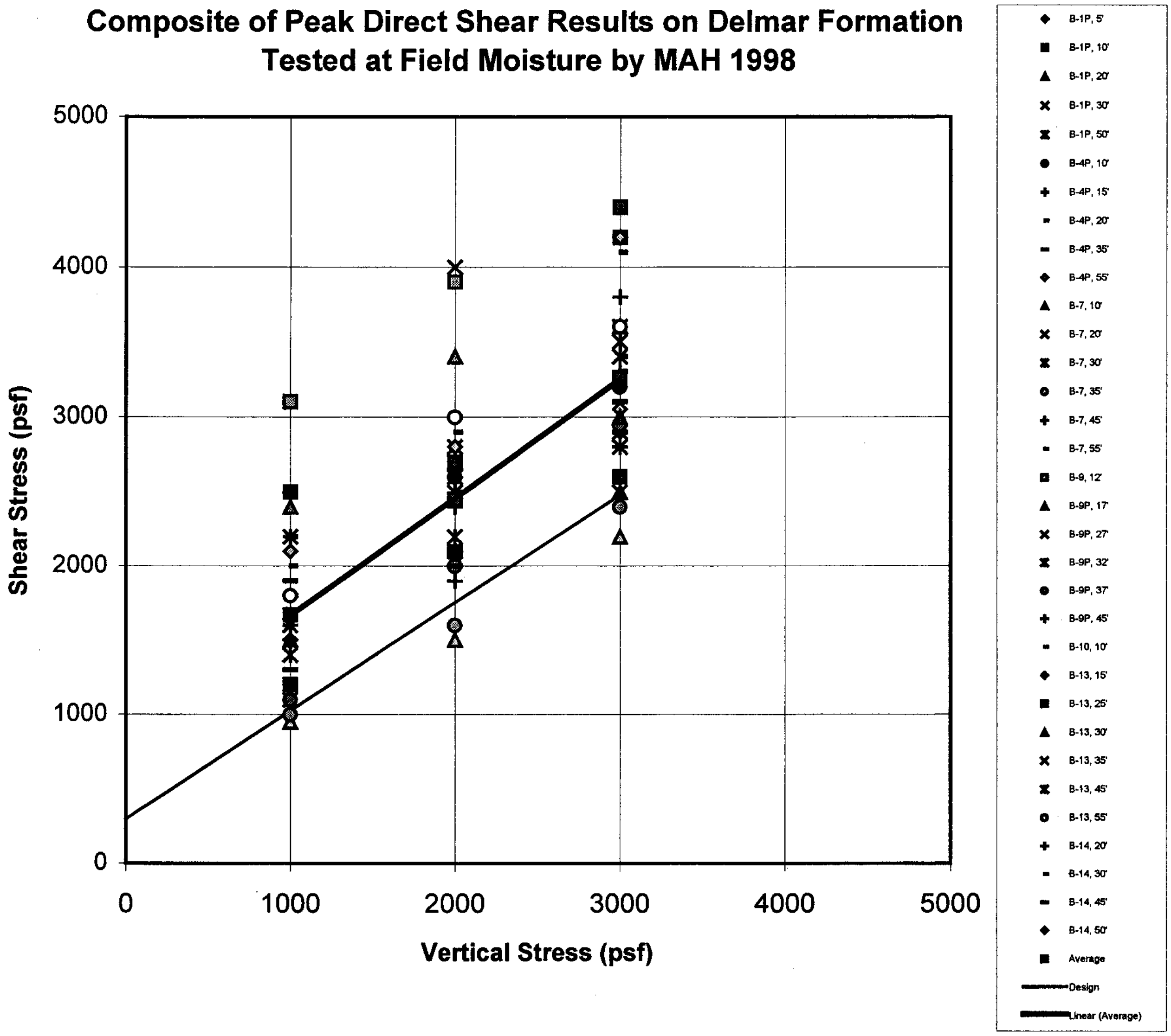


Average Strength Values

Friction Angle, ϕ (degrees)	**32**
Cohesion, c (psf)	**700**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-5**

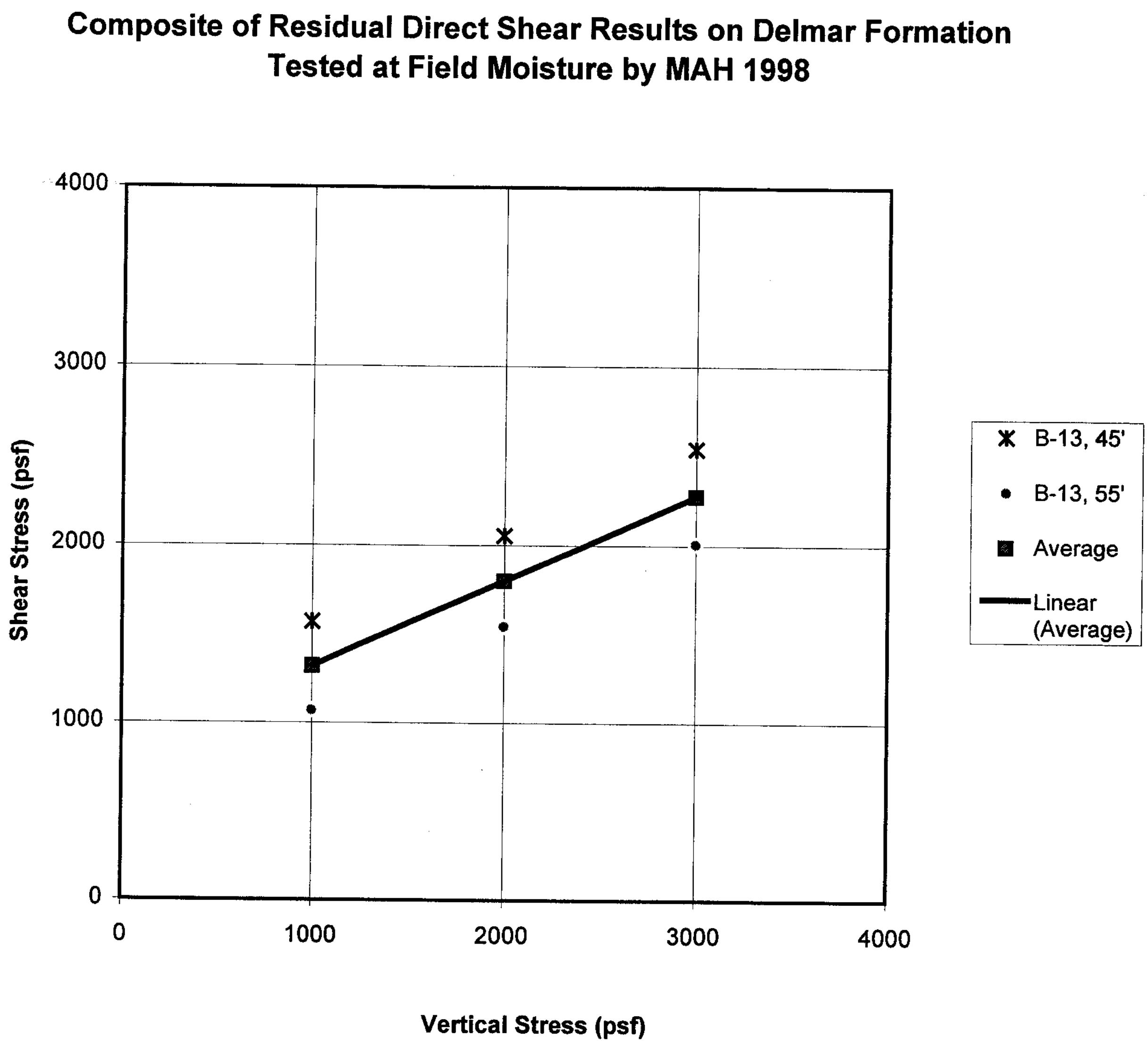


Average Strength Values

Friction Angle, ϕ (degrees)	38
Cohesion, c (psf)	900

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-6**



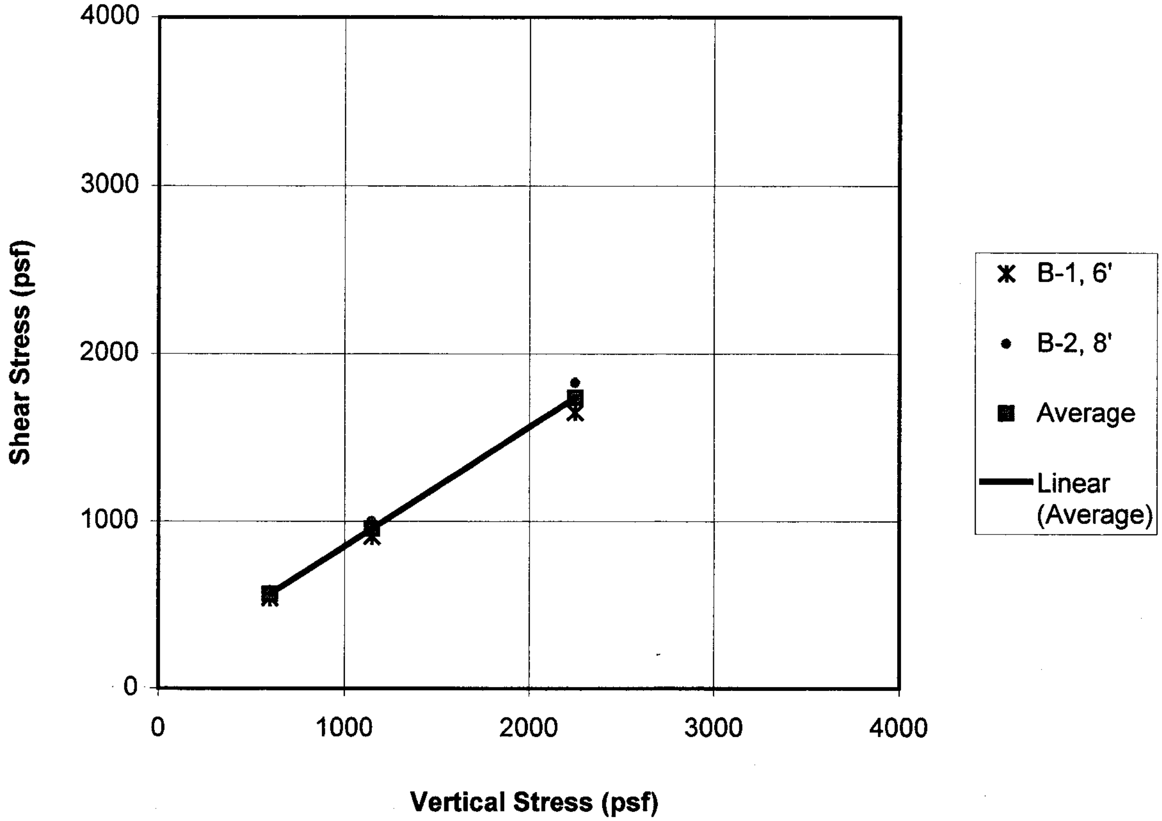
Average Strength Values

Friction Angle, ϕ (degrees)	26
Cohesion, c (psf)	800

DIRECT SHEAR SUMMARY

Project No.	040151-001
Project Name	HDR/Del Mar
Figure No.	G-7

Composite of Peak Direct Shear Results on Bay Point Formation Tested by Leighton & Associates 1978



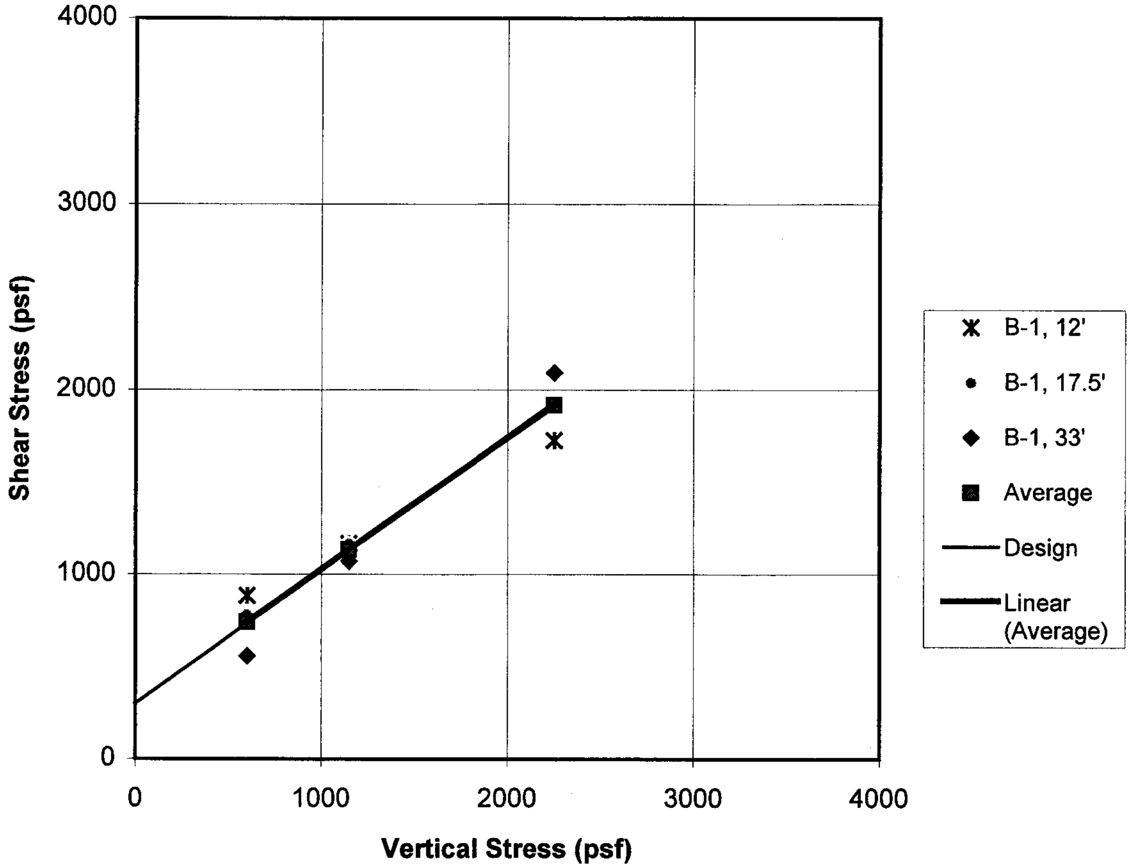
Average Strength Values

Friction Angle, ϕ (degrees)	**35**
Cohesion, c (psf)	**140**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-8**

Composite of Peak Direct Shear Results on Delmar Formation Tested by Leighton & Associates 1978

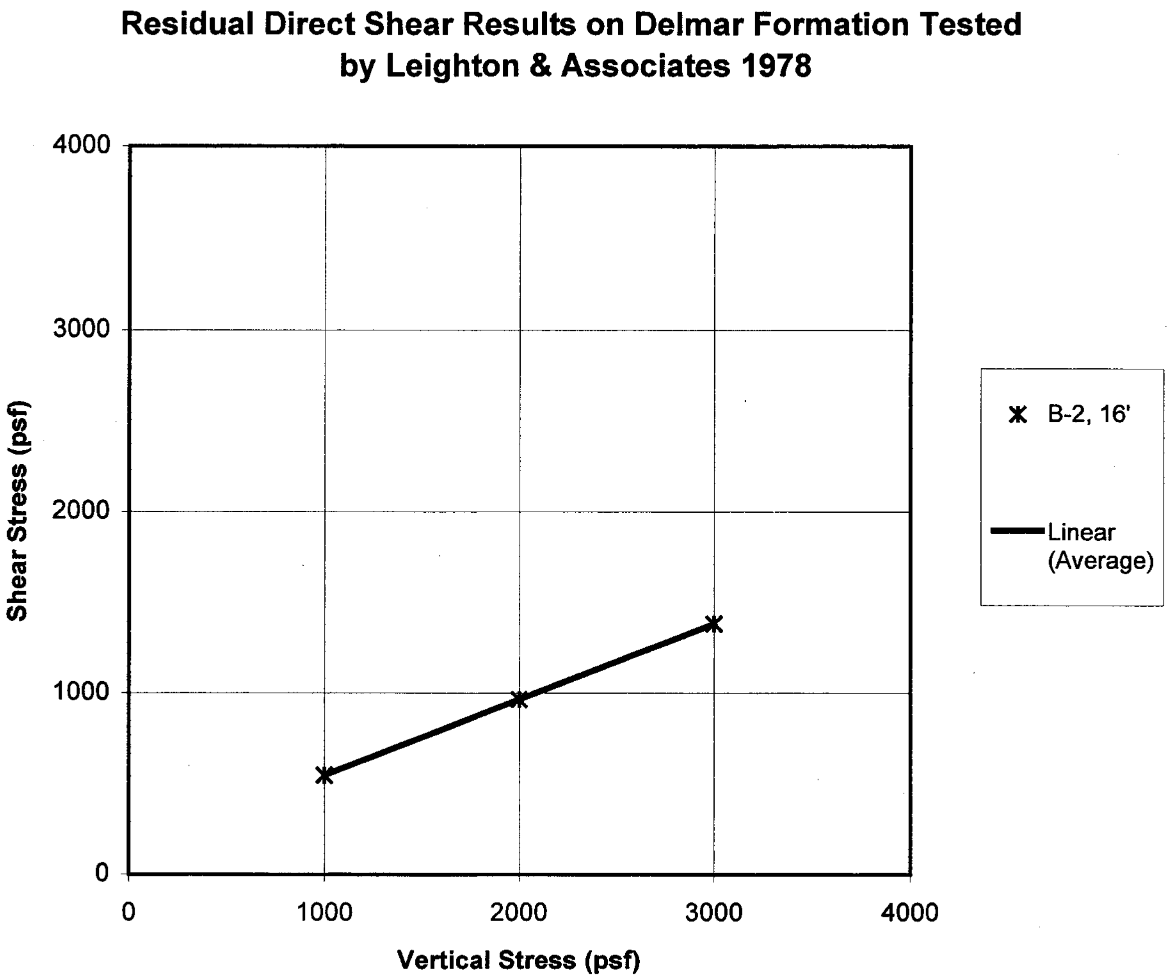


Average Strength Values

Friction Angle, ϕ (degrees)	**36**
Cohesion, c (psf)	**300**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-9**

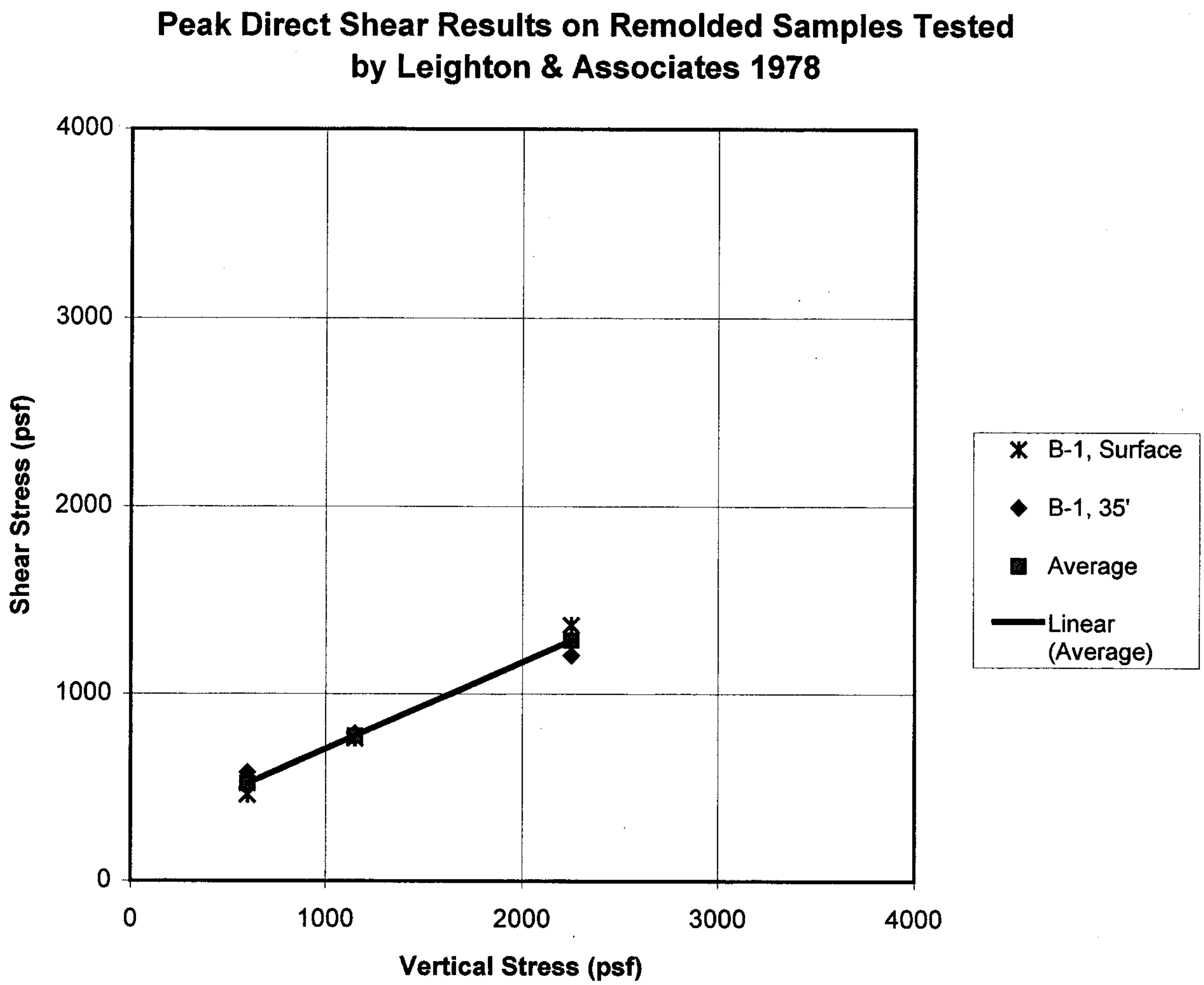


Average Strength Values

Friction Angle, ϕ (degrees)	23
Cohesion, c (psf)	125

DIRECT SHEAR SUMMARY

Project No.	040151-001
Project Name	HDR/Del Mar
Figure No.	G-10

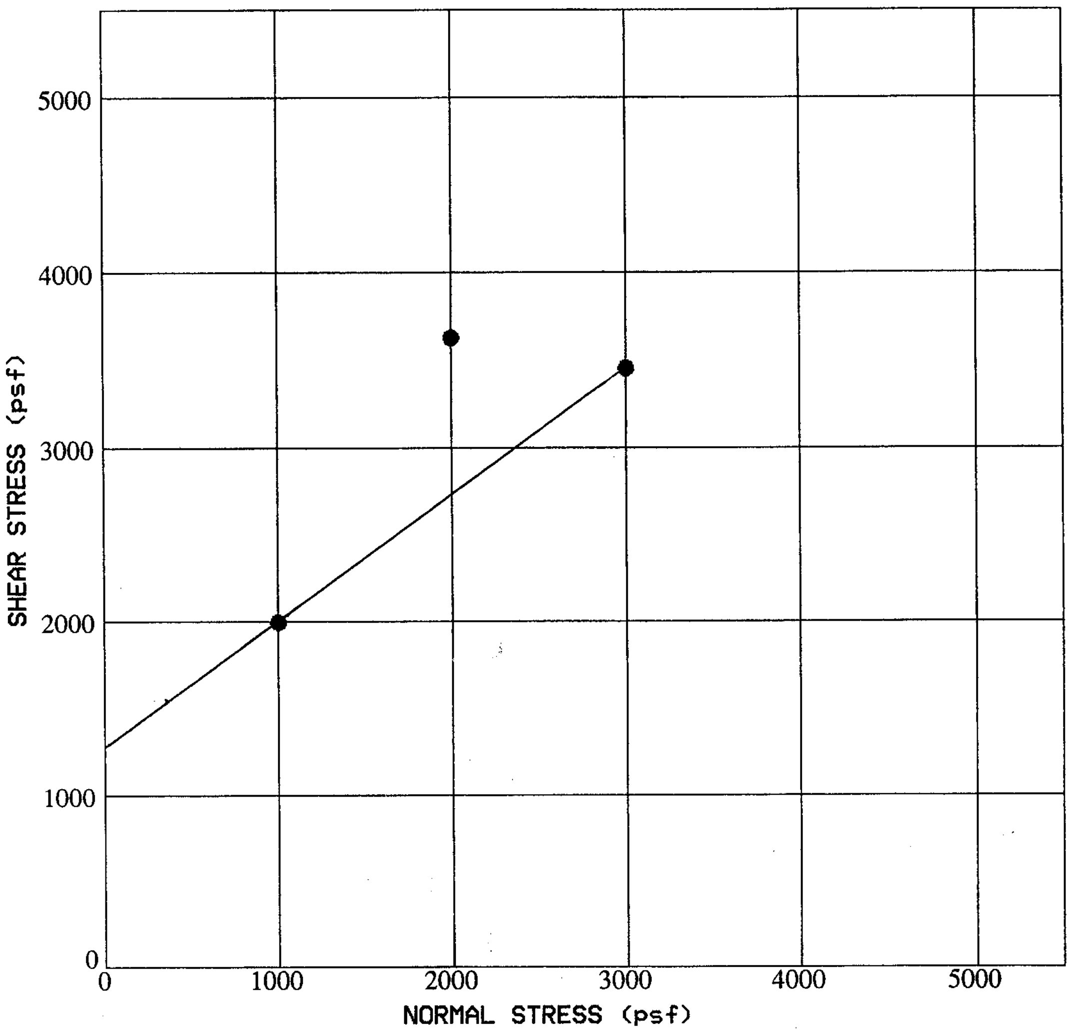


Average Strength Values

Friction Angle, ϕ (degrees)	25
Cohesion, c (psf)	240

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**G-11**



Boring No.	LB-1	Depth (ft)	10.5
Sample No.	R-1	Soil Type	Siltst.
Type of Sample	Ring		

Friction Angle (deg.) 36

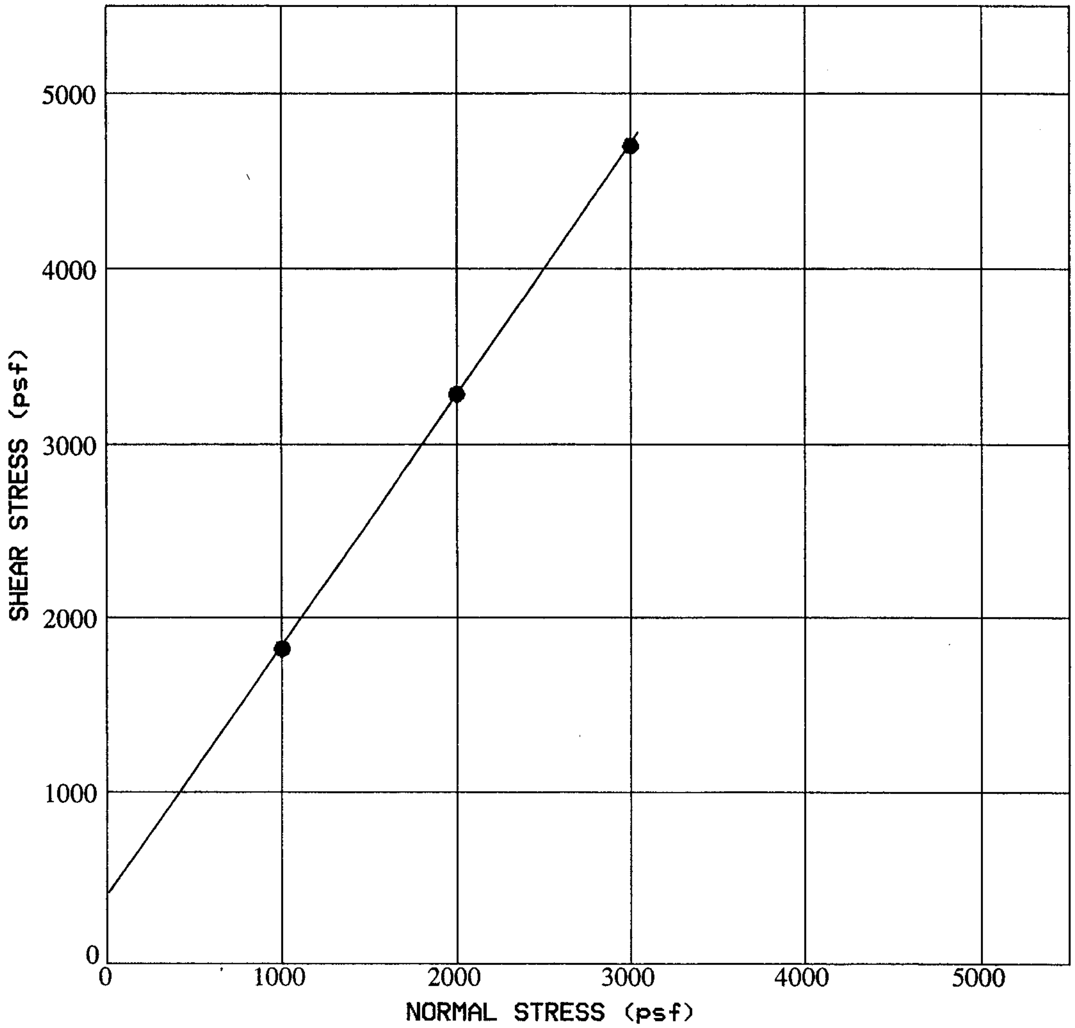
Cohesion (psf) 1250

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 Figure No. D-1



Boring No. LB-1 Depth (ft) 20.5

Sample No. R-2 Soil Type Sandst.

Type of Sample Ring

Friction Angle (deg.) 55.5

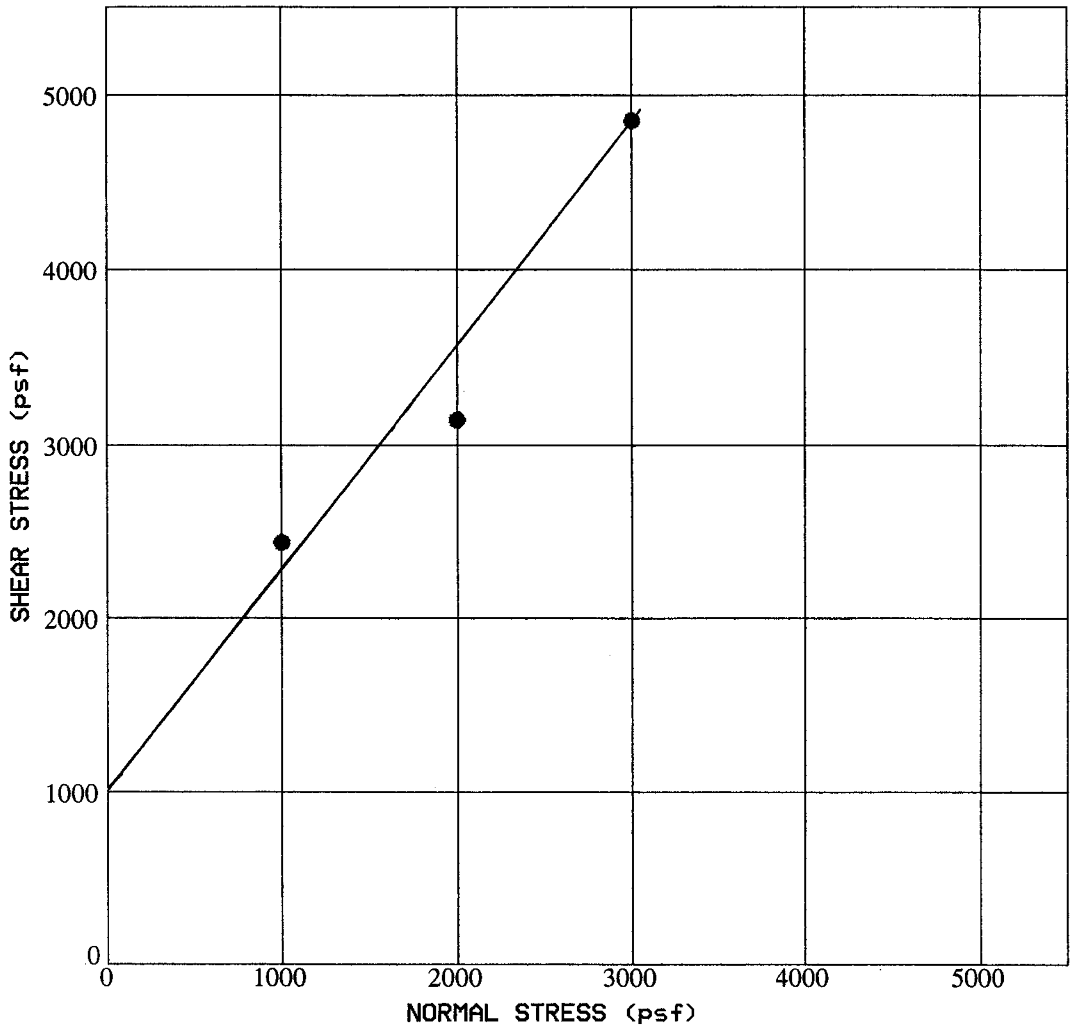
Cohesion (psf) 350

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-2



Boring No. LB-1 Depth (ft) 30.5

Sample No. R-3 Soil Type Sandst.

Type of Sample Ring

Friction Angle (deg.) 51

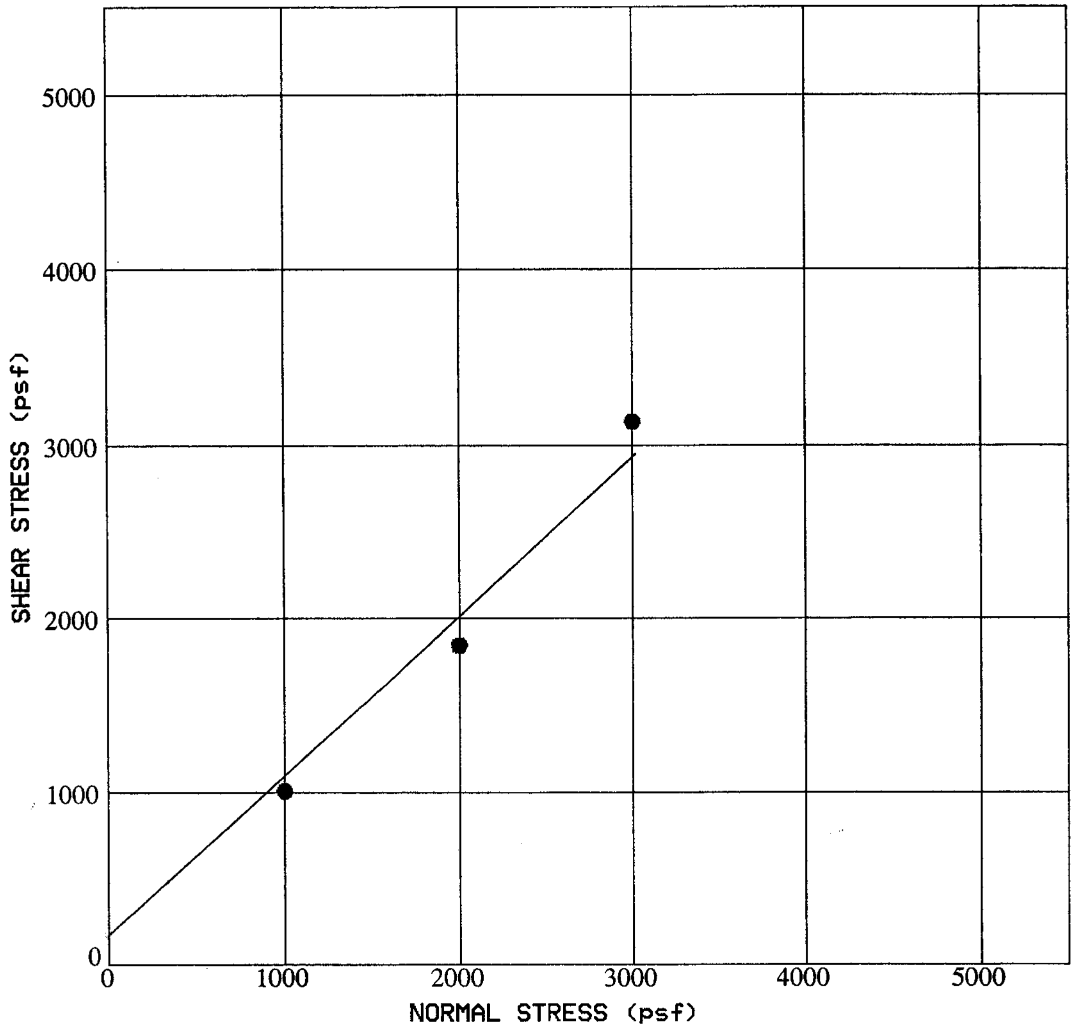
Cohesion (psf) 1000

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-3



Boring No.	LB-1	Depth (ft)	40.5
Sample No.	R-4	Soil Type	Clayst.
Type of Sample	Ring		

Friction Angle (deg.) 42

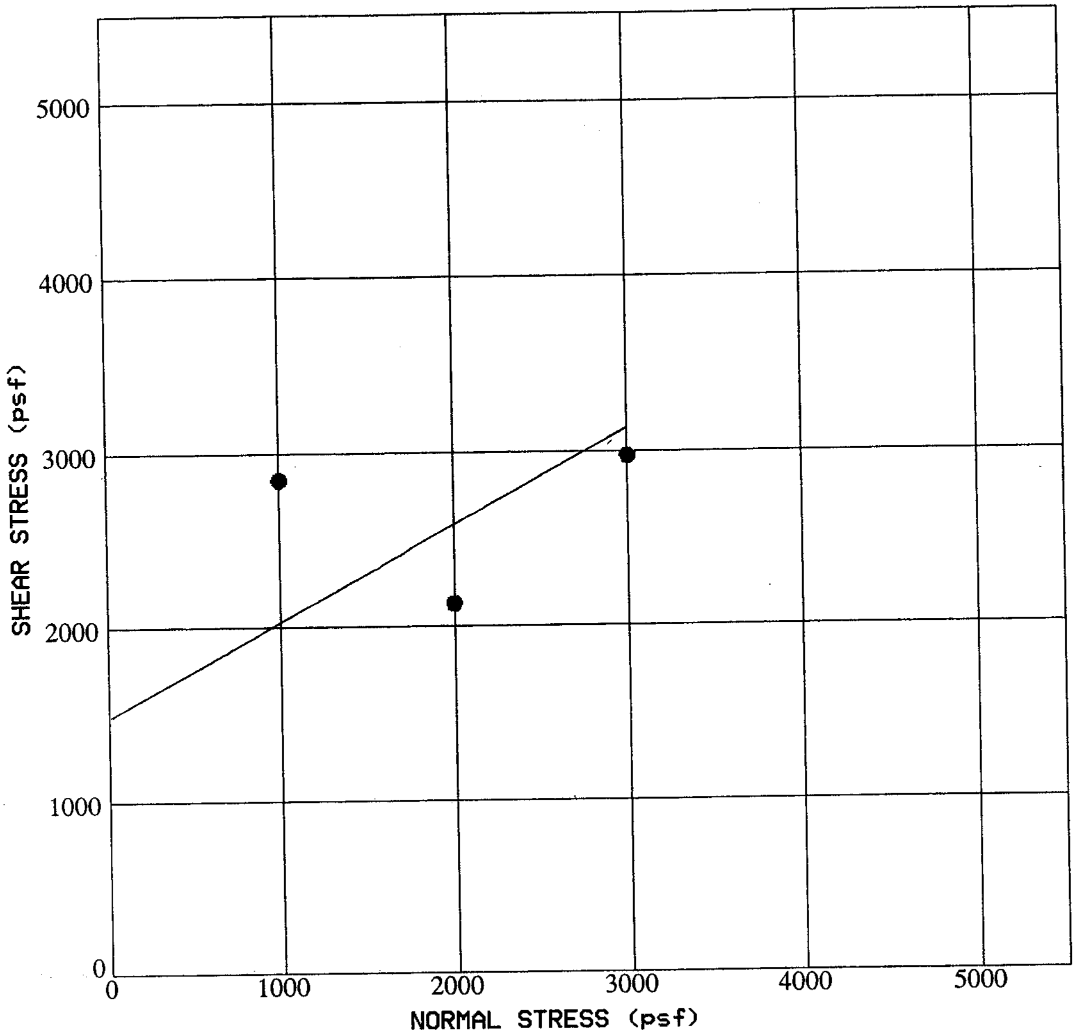
Cohesion (psf) 100

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-4



Boring No.	LB-1	Depth (ft)	60.5
Sample No.	R-6	Soil Type	Sandst.
Type of Sample	Ring		

Friction Angle (deg.) 28

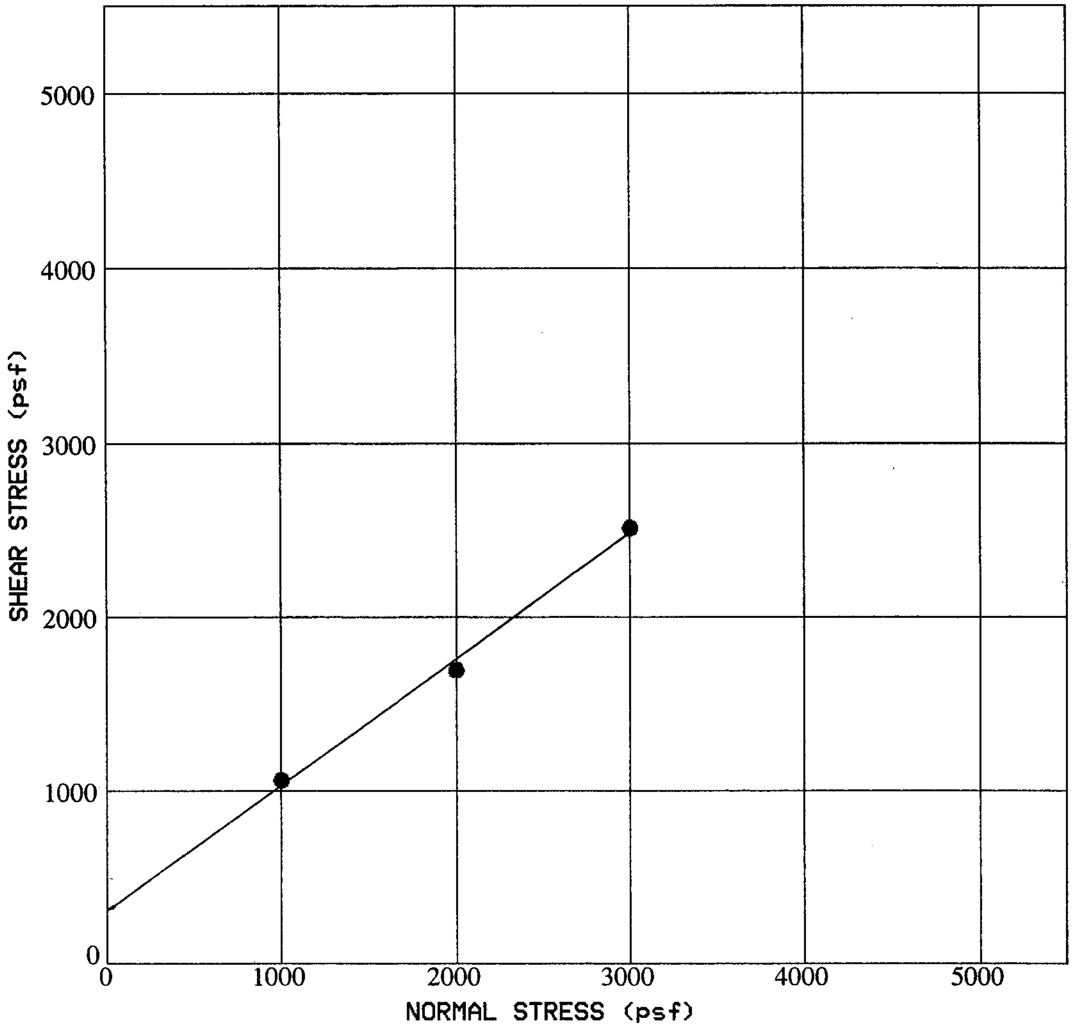
Cohesion (psf) 1500

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-5



Boring No. LB-2 Depth (ft) 5.5

Sample No. R-1 Soil Type SP-SM

Type of Sample Ring

Friction Angle (deg.) 36

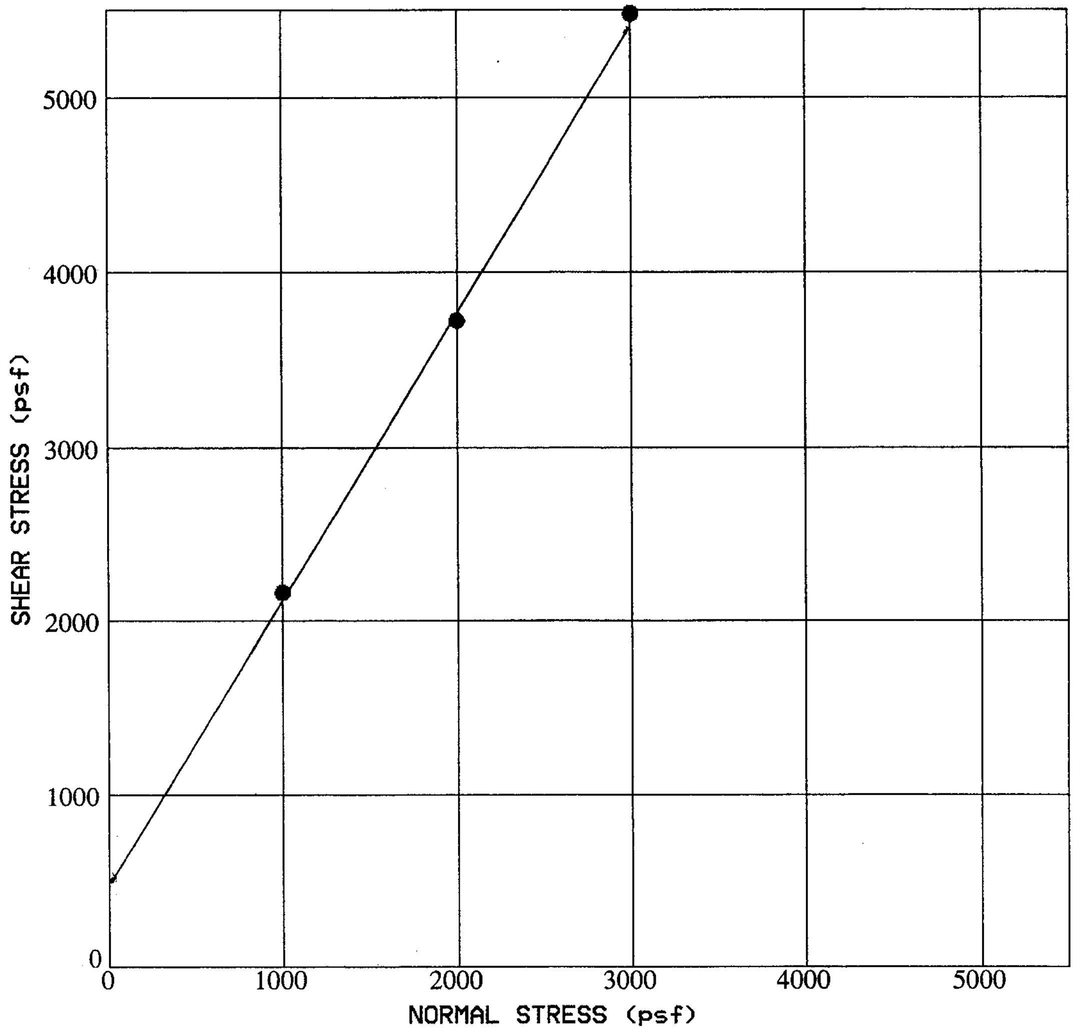
Cohesion (psf) 300

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-6



Boring No.	LB-2	Depth (ft)	22.5
Sample No.	R-2	Soil Type	Sandst.
Type of Sample	Ring		

Friction Angle (deg.) 58.5

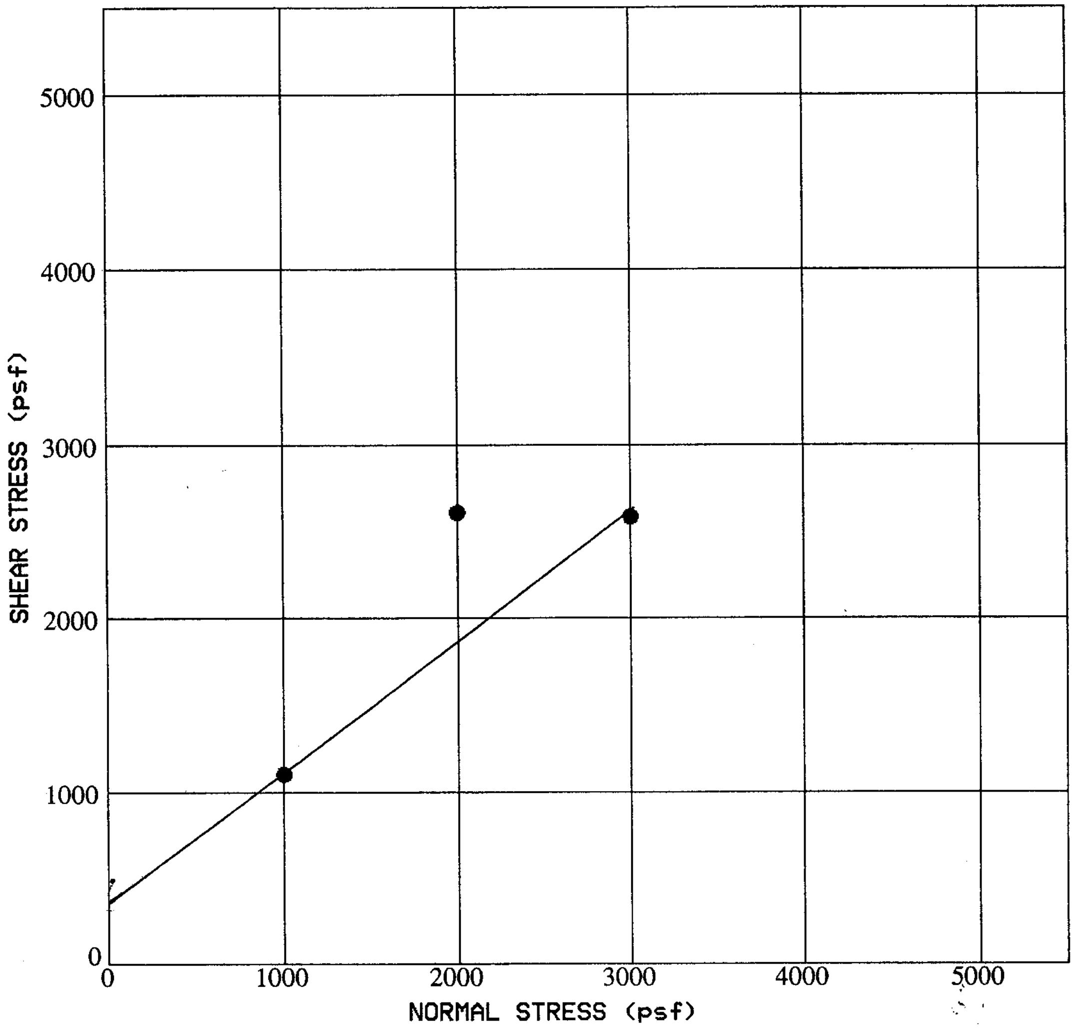
Cohesion (psf) 500

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-7



Boring No.	LB-2	Depth (ft)	45.5
Sample No.	R-3	Soil Type	Siltst.
Type of Sample	Ring		

Friction Angle (deg.) 37.5

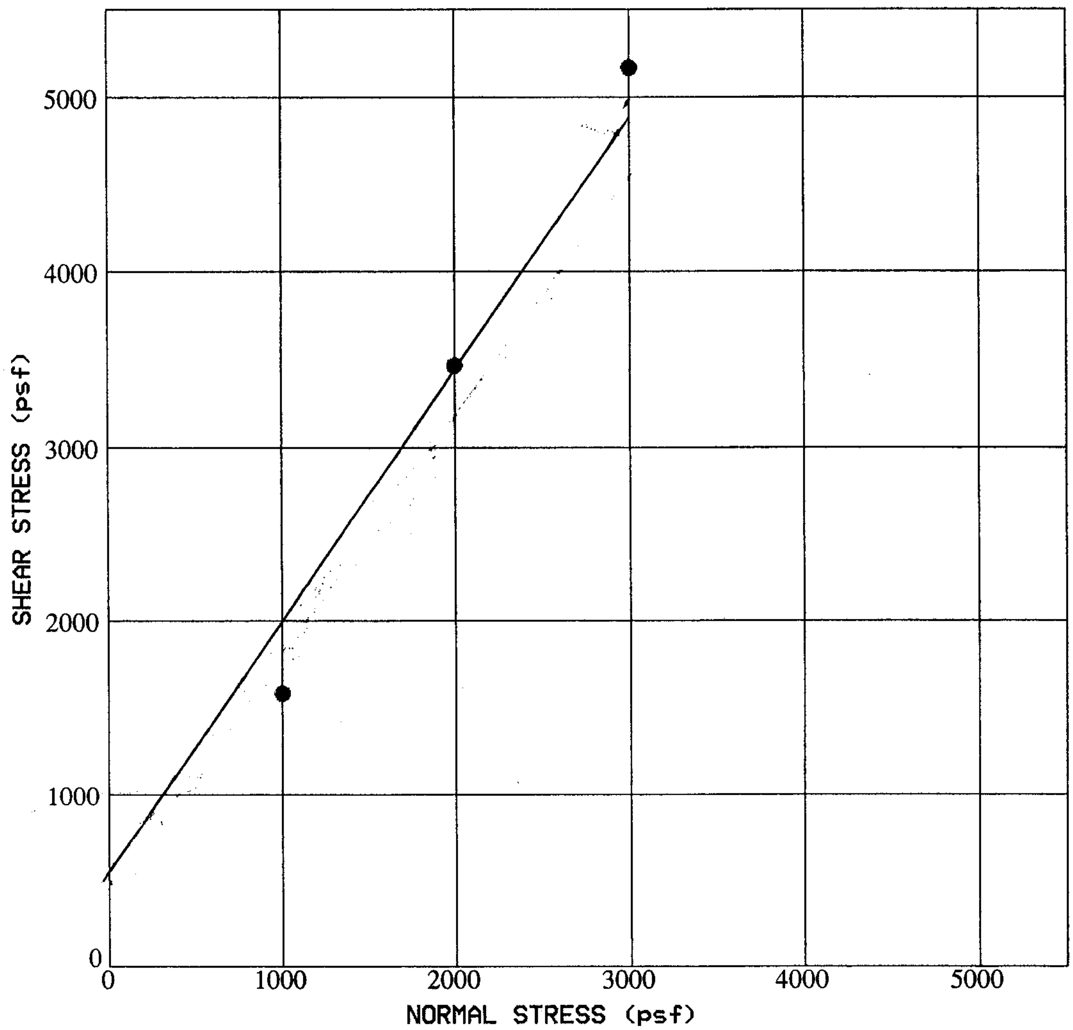
Cohesion (psf) 400

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-8



Boring No.	LB-4	Depth (ft)	20.5
Sample No.	R-1	Soil Type	Sandst.
Type of Sample	Ring		

Friction Angle (deg.) 54

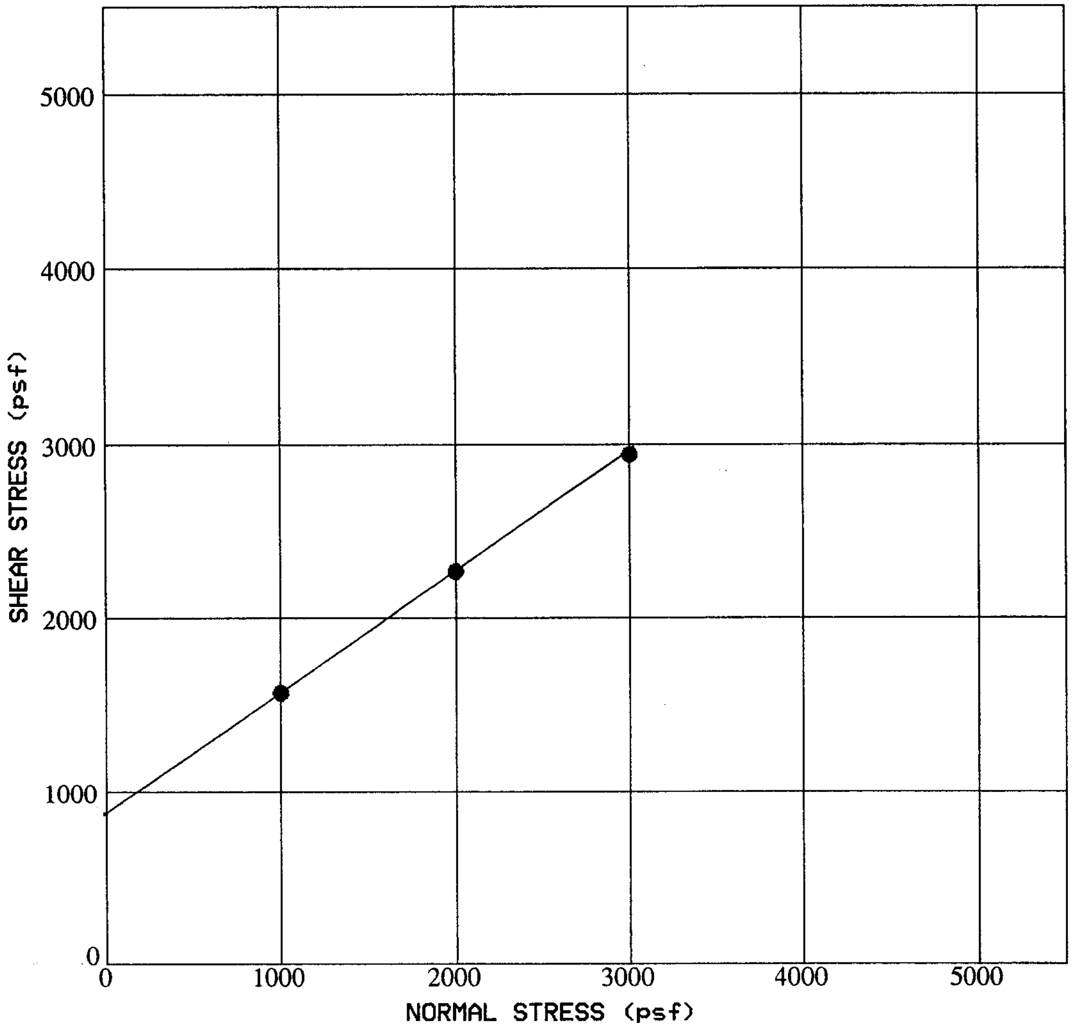
Cohesion (psf) 500

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 Figure No. D-9



Boring No.	LB-4	Depth (ft)	40.5
Sample No.	R-2	Soil Type	Clayst.
Type of Sample	Ring		

Friction Angle (deg.) 34

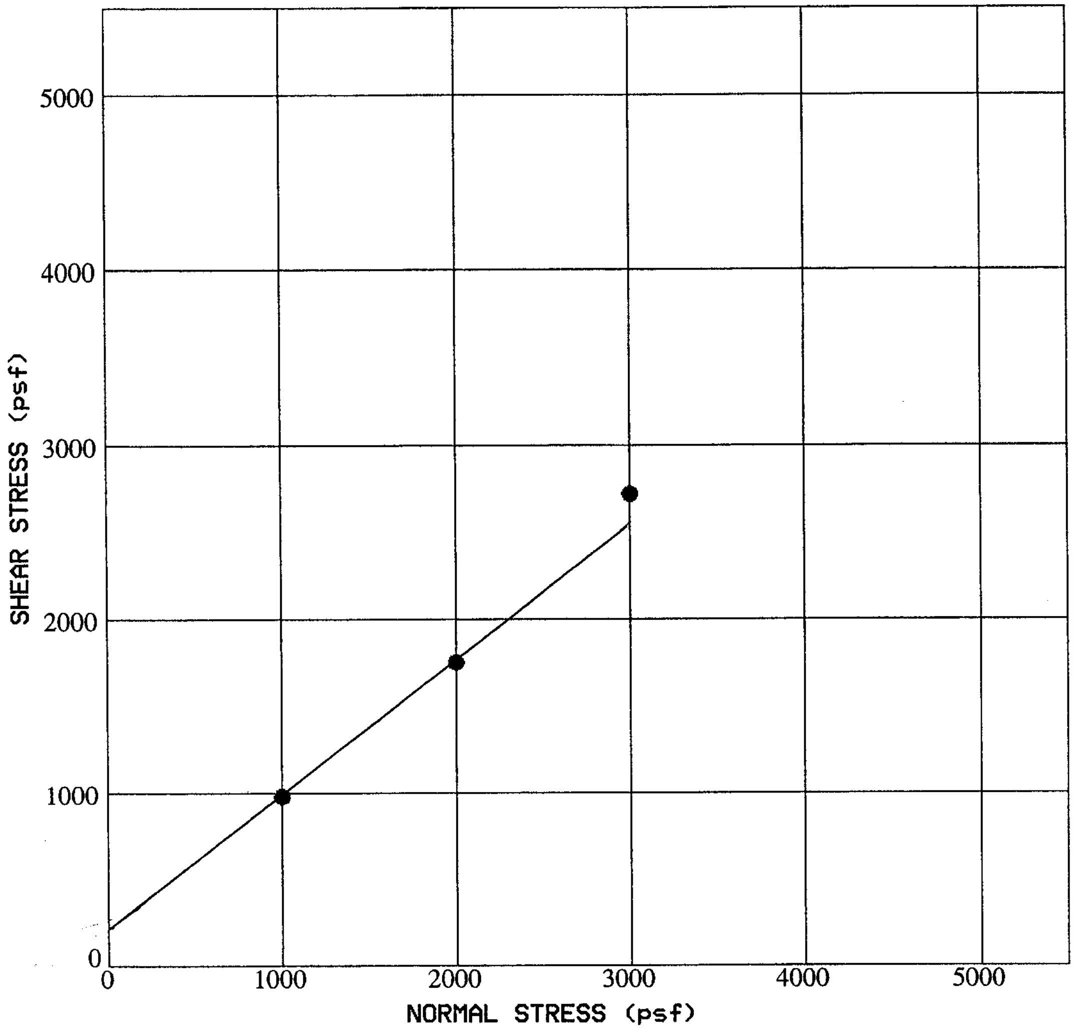
Cohesion (psf) 900

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-10



Boring No.	LB-4	Depth (ft)	60.5
Sample No.	R-3	Soil Type	Clayst.
Type of Sample	Ring		

Friction Angle (deg.) 38

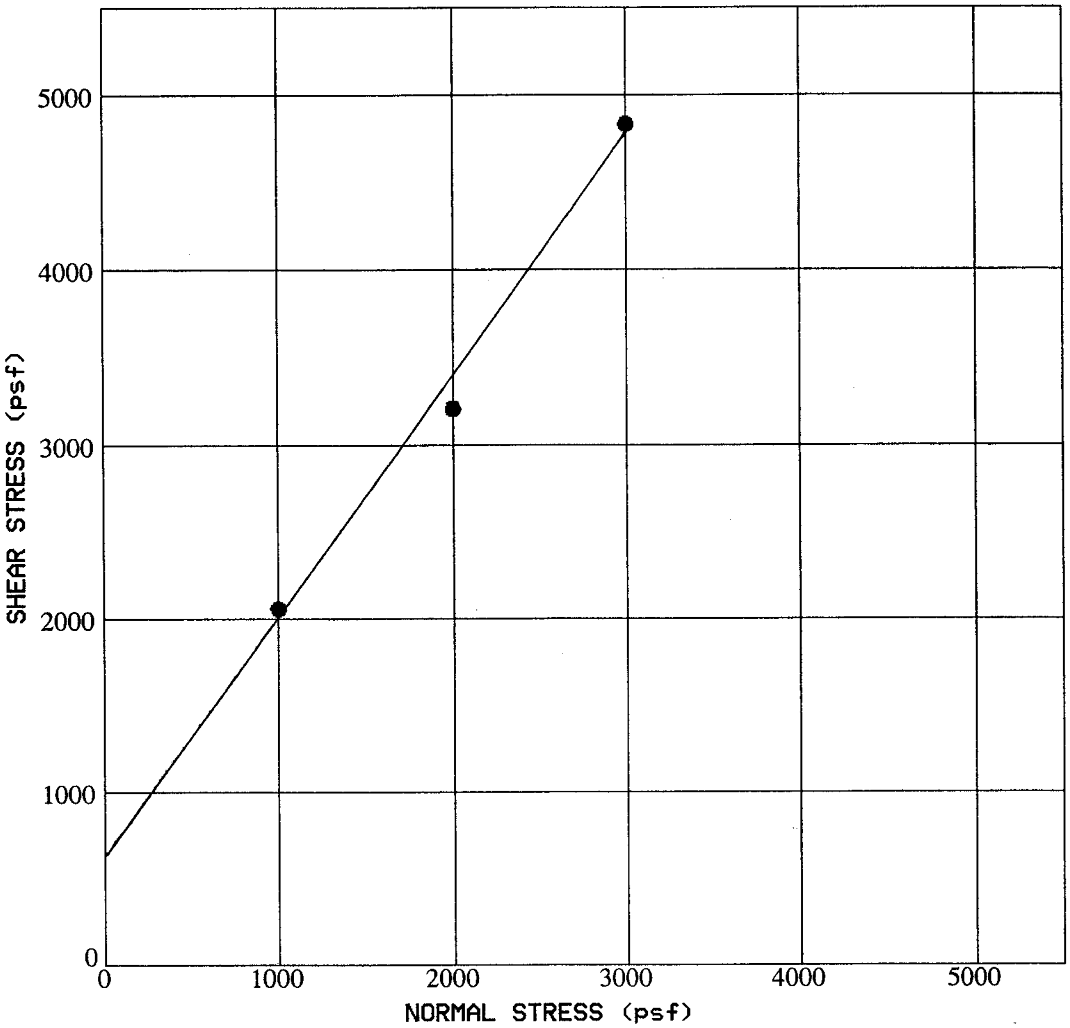
Cohesion (psf) 200

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D-11



Boring No.	LB-6	Depth (ft)	20.5
Sample No.	R-1	Soil Type	Sandst.
Type of Sample	Ring		

Friction Angle (deg.) 54

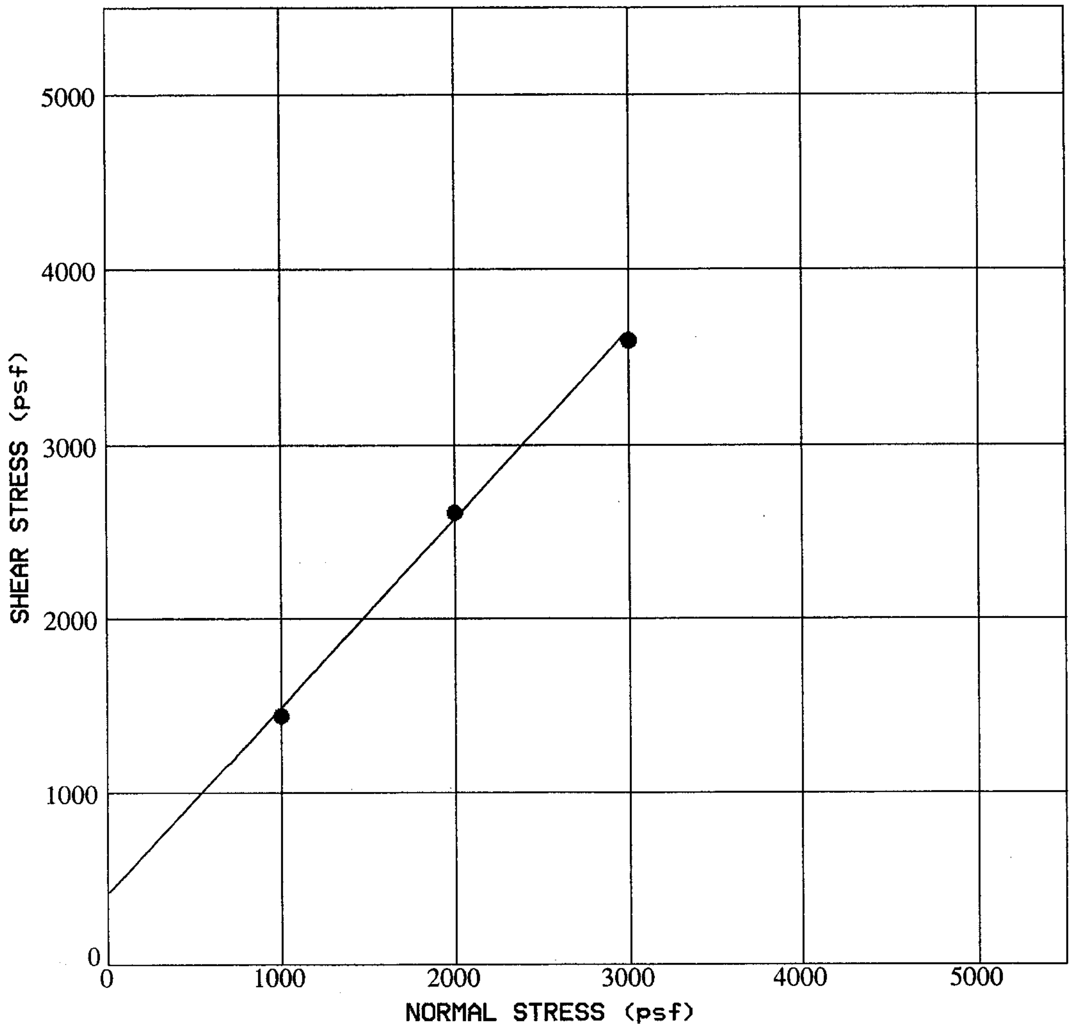
Cohesion (psf) 600

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 **Figure No.** D12



Boring No.	LB-6	Depth (ft)	60.5
Sample No.	R-3	Soil Type	Sandst.
Type of Sample	Ring		

Friction Angle (deg.) 46.5

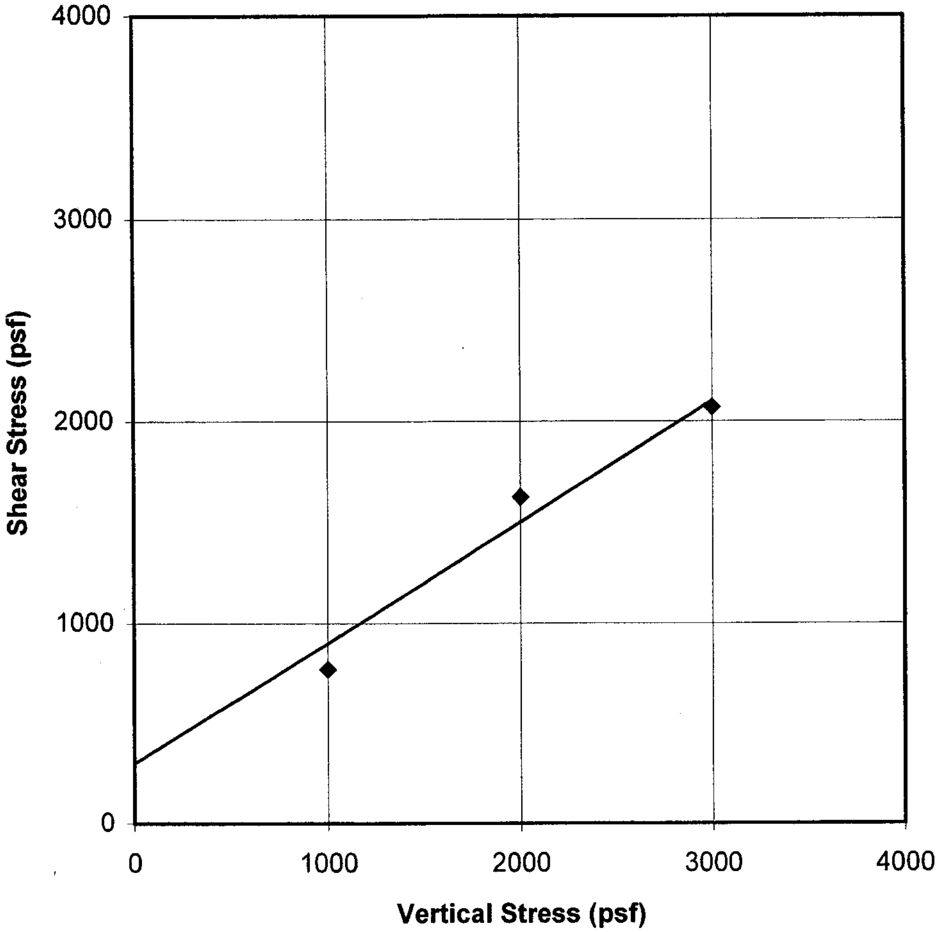
Cohesion (psf) 400

DIRECT SHEAR TEST RESULTS

Project No. 040151-001

Project Name HDR/Del Mar

Date 7/17/00 Figure No. D-13



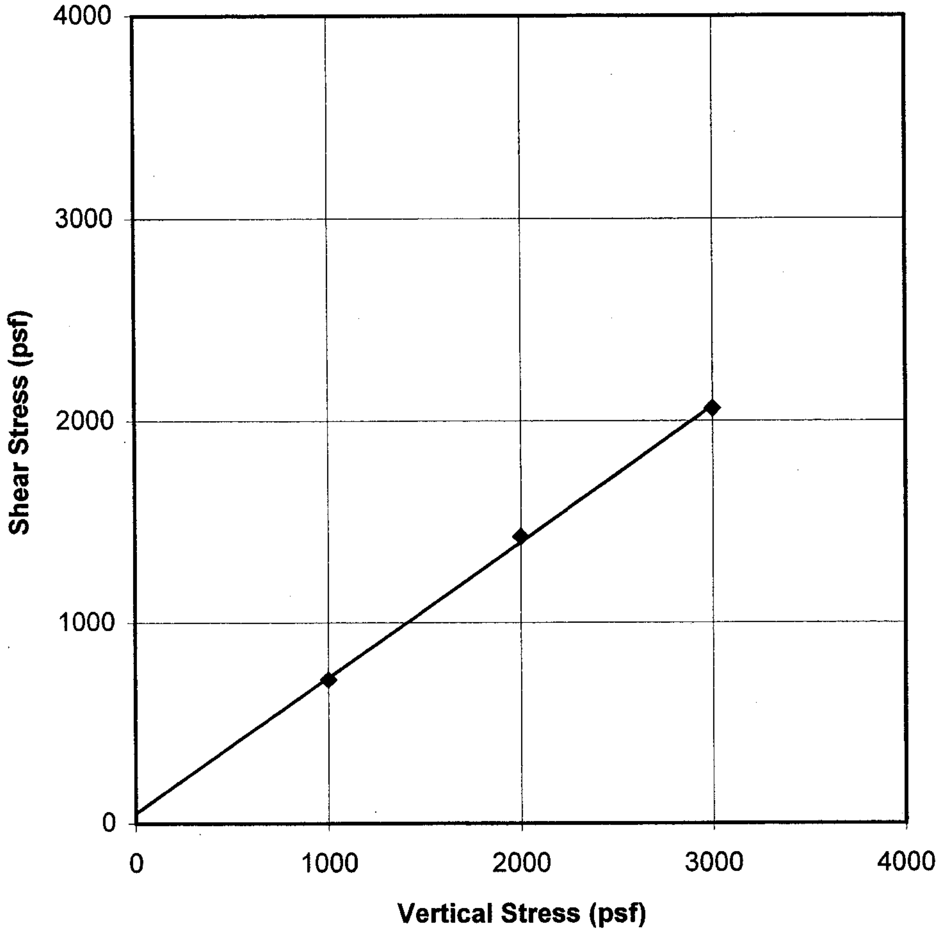
Boring Location	**LB-1**
Sample Depth (feet)	**10**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**31**
Cohesion, c_{ult} (psf)	**300**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-14**



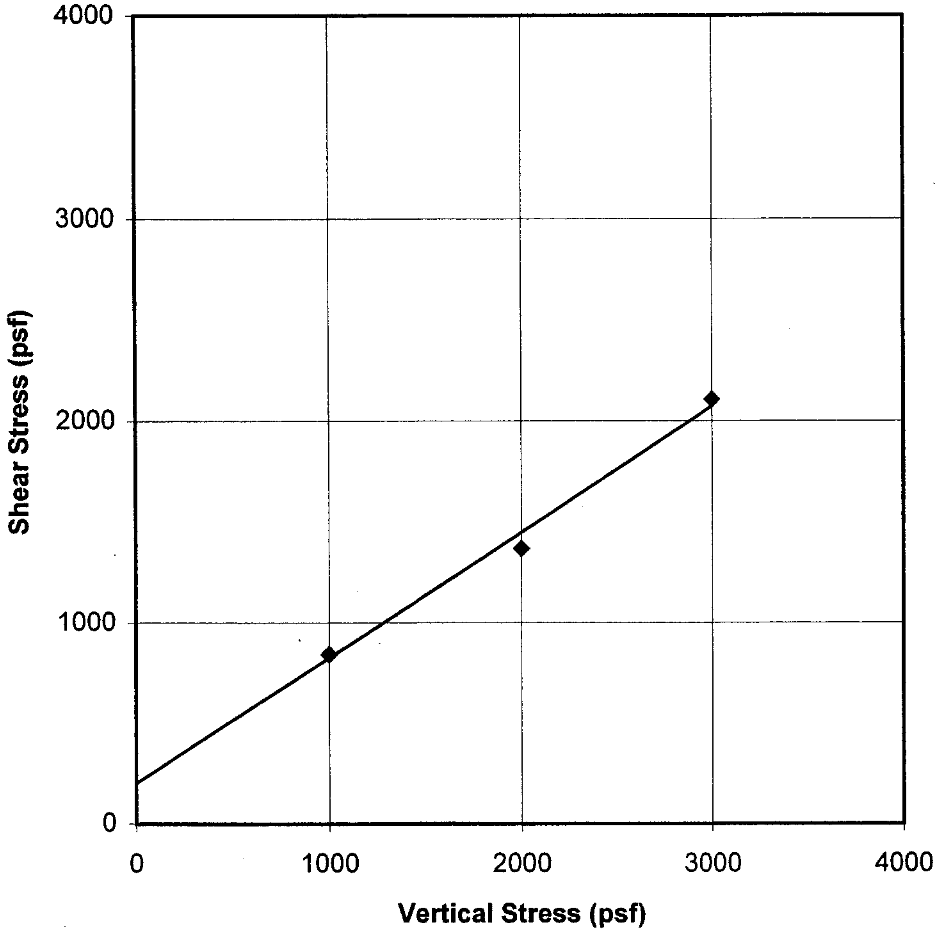
Boring Location	**LB-1**
Sample Depth (feet)	**20**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**34**
Cohesion, c_{ult} (psf)	**50**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-15**



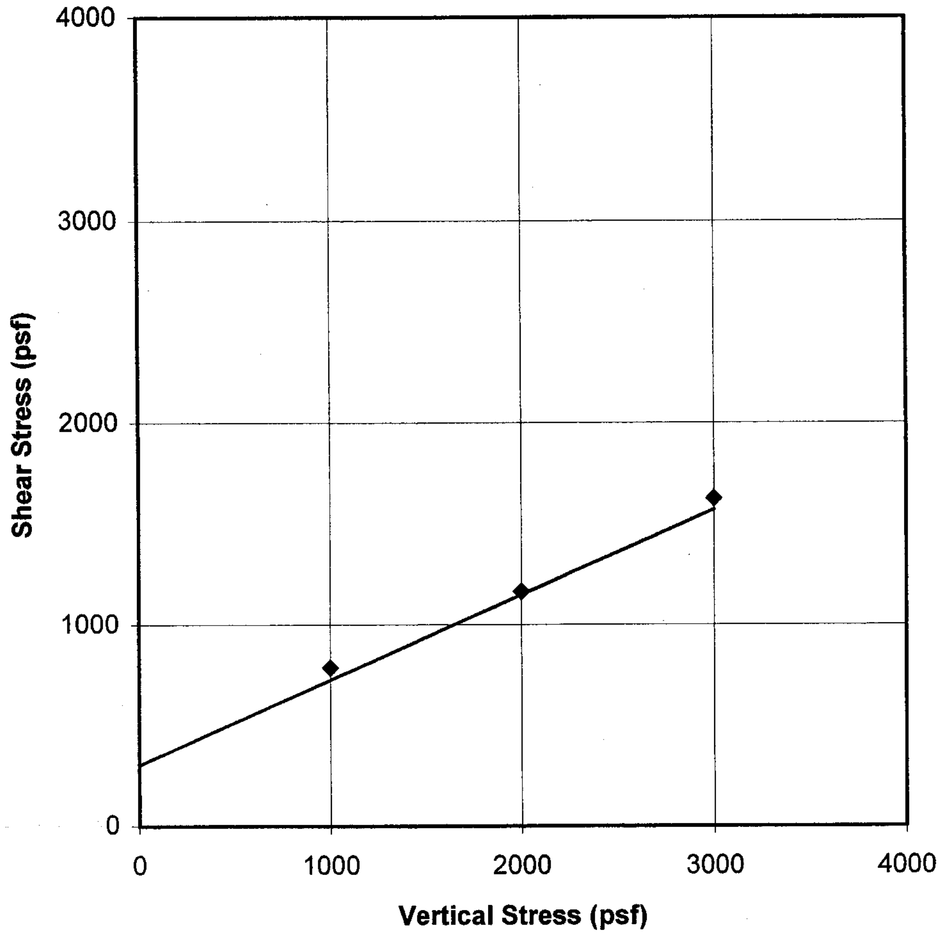
Boring Location	**LB-1**
Sample Depth (feet)	**30**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**32**
Cohesion, c_{ult} (psf)	**200**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-16**



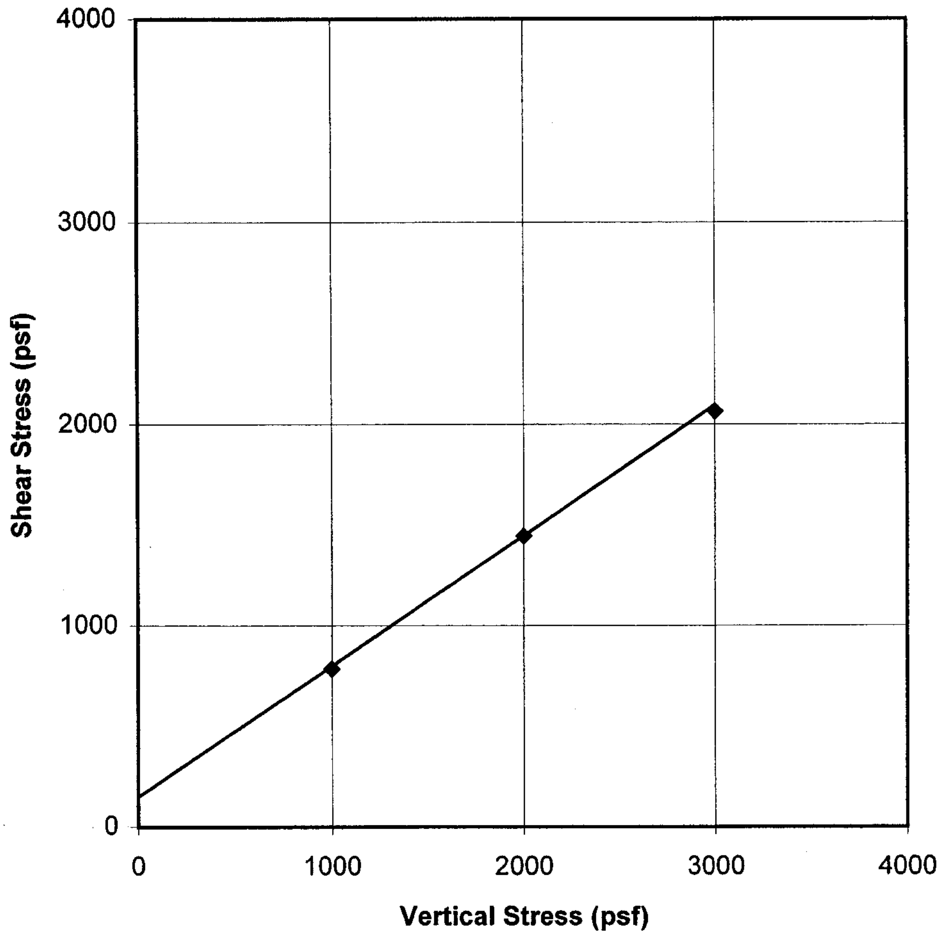
Boring Location	LB-1
Sample Depth (feet)	40

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	23
Cohesion, c_{ult} (psf)	300

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-17**



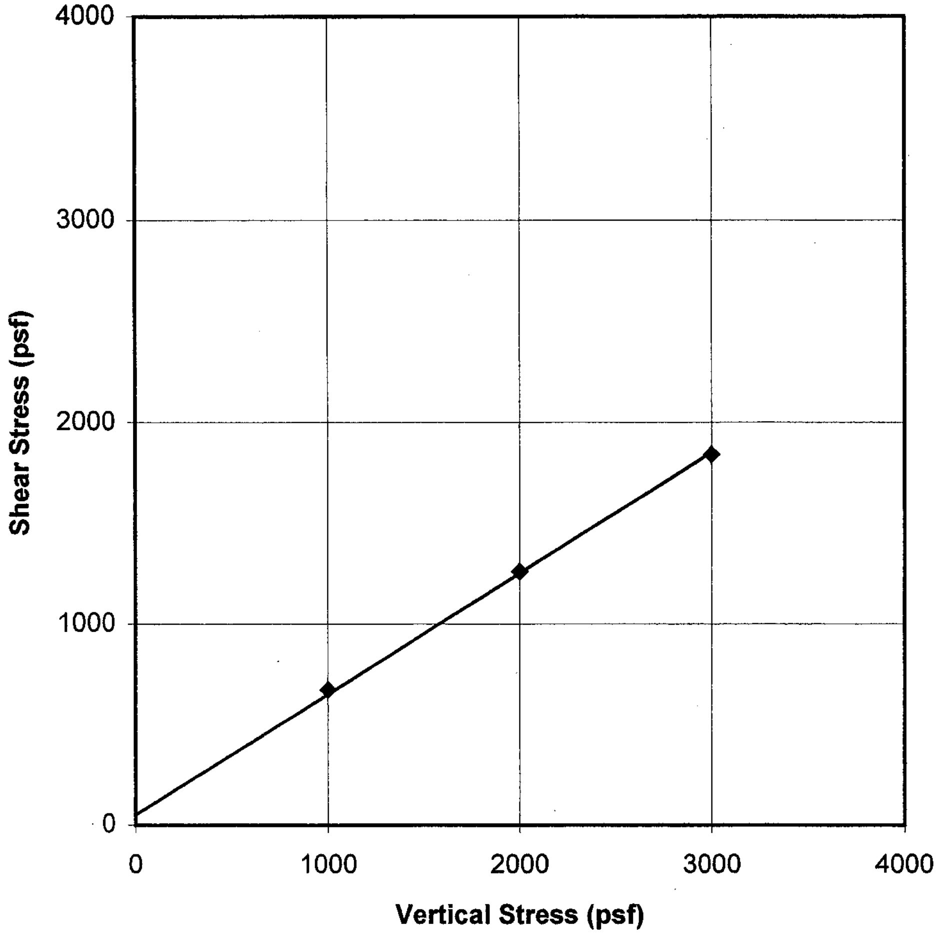
Boring Location	**LB-1**
Sample Depth (feet)	**60**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**33**
Cohesion, c_{ult} (psf)	**150**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	D-18



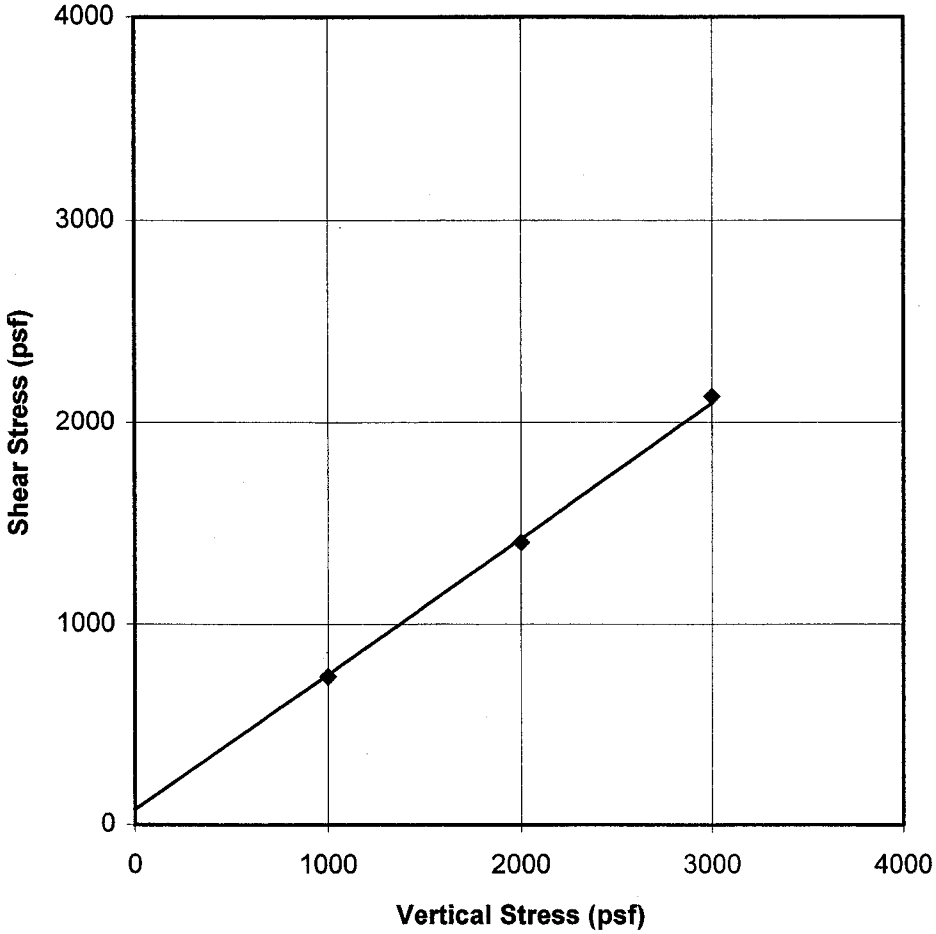
Boring Location	LB-2
Sample Depth (feet)	5

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	31
Cohesion, c_{ult} (psf)	50

DIRECT SHEAR SUMMARY

Project No.	040151-001
Project Name	HDR/Del Mar
Figure No.	D-19



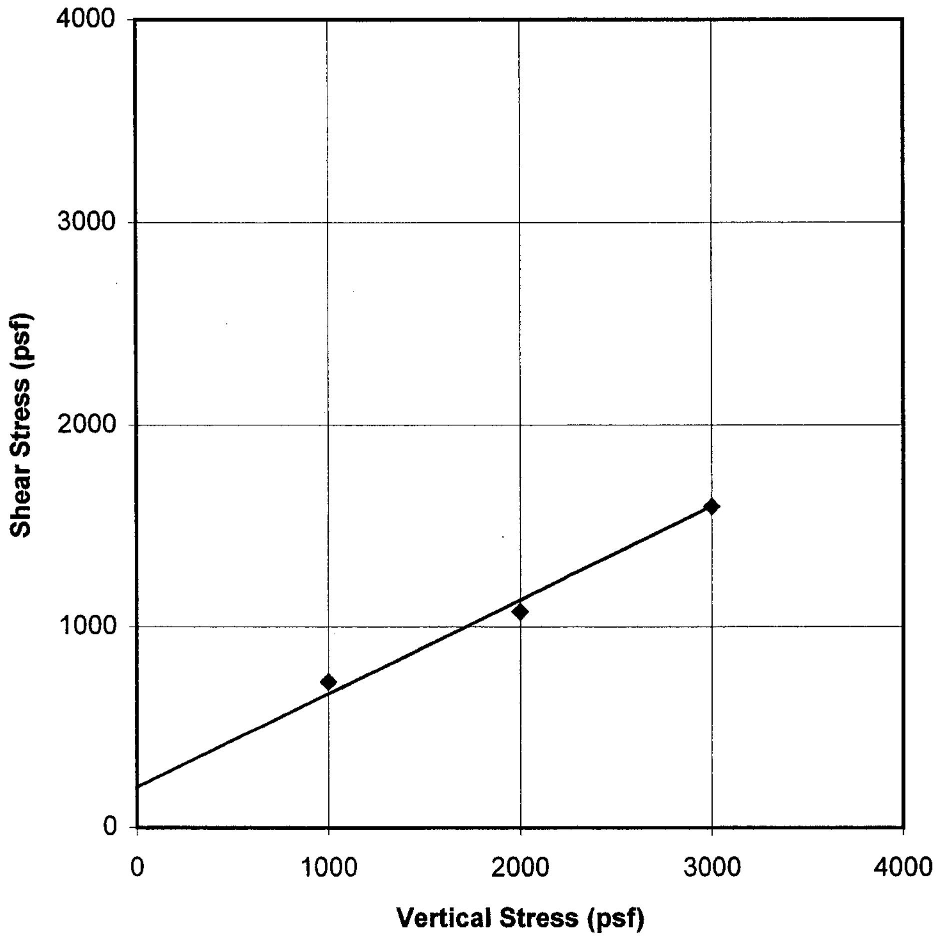
Boring Location	**LB-2**
Sample Depth (feet)	**22**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**34**
Cohesion, c_{ult} (psf)	**75**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-20**



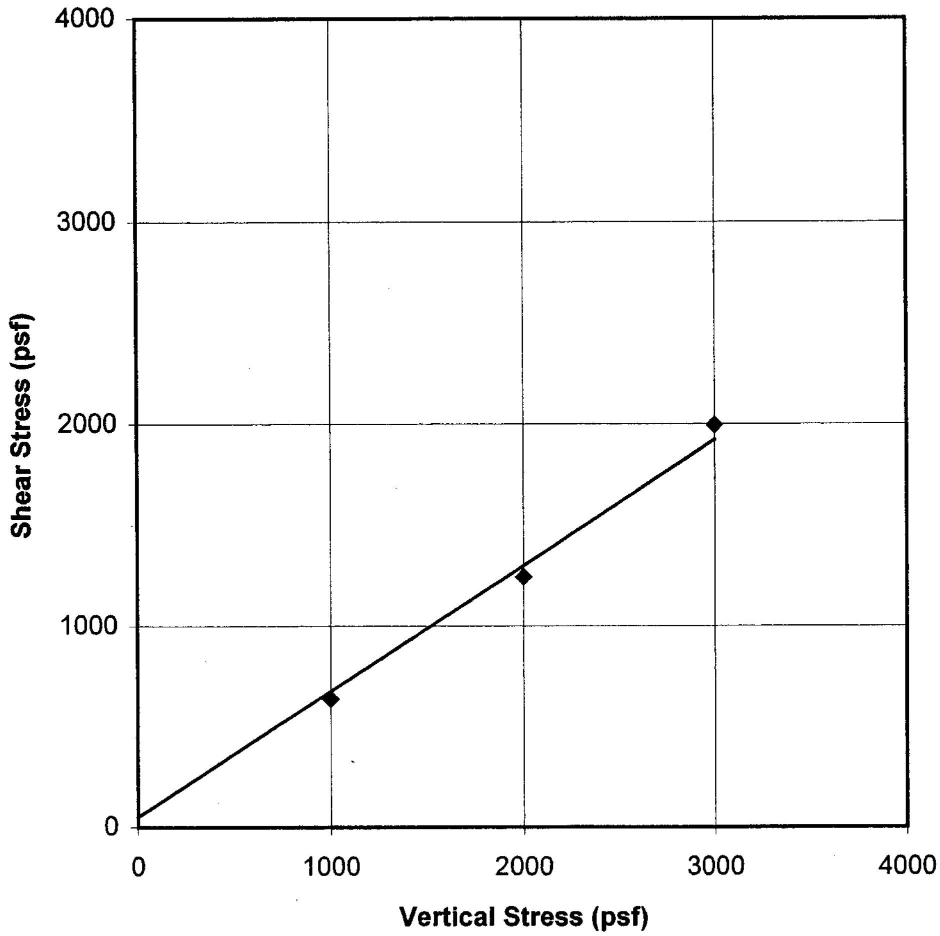
Boring Location	**LB-2**
Sample Depth (feet)	**45**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**25**
Cohesion, c_{ult} (psf)	**200**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-21**



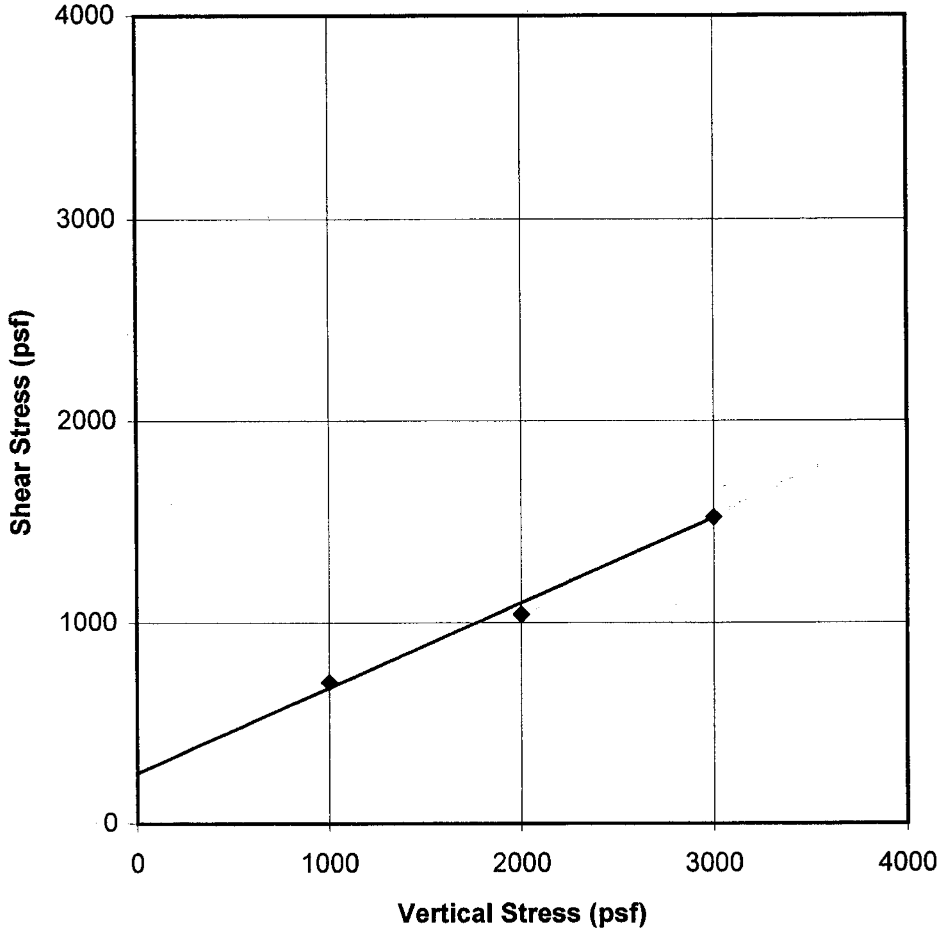
Boring Location	**LB-4**
Sample Depth (feet)	**20**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**32**
Cohesion, c_{ult} (psf)	**50**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-22**



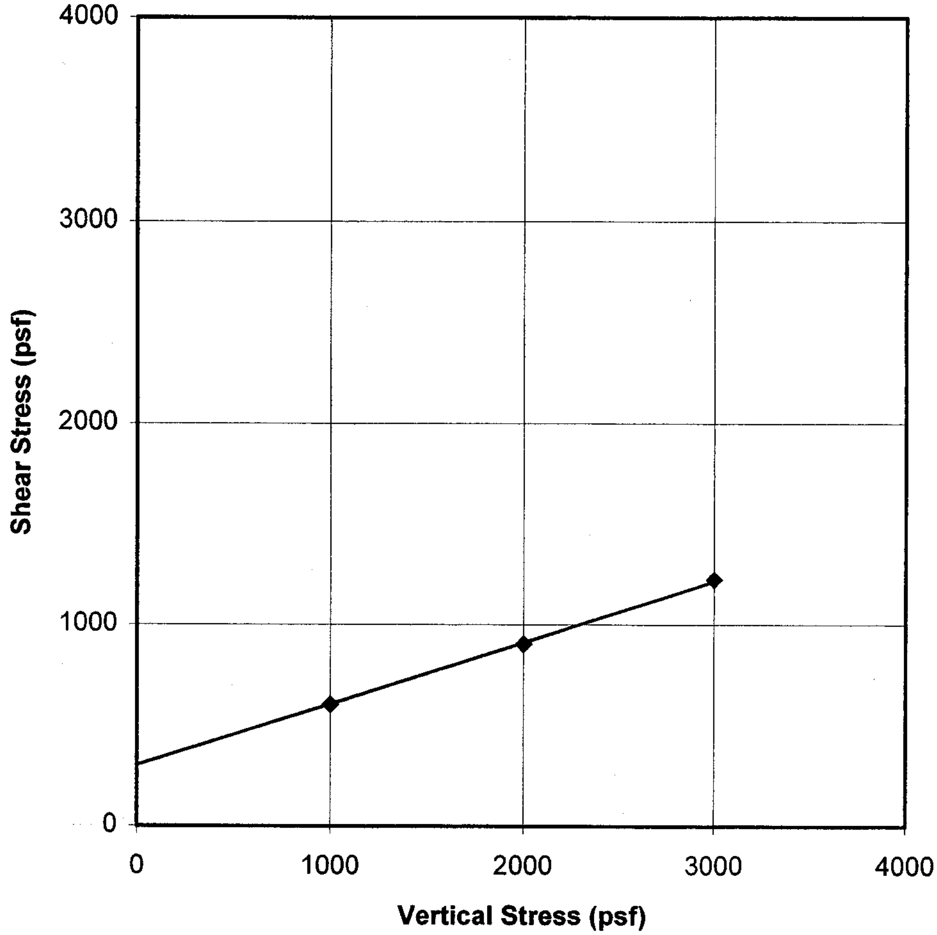
Boring Location	**LB-4**
Sample Depth (feet)	**40**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**23**
Cohesion, c_{ult} (psf)	**250**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-23**



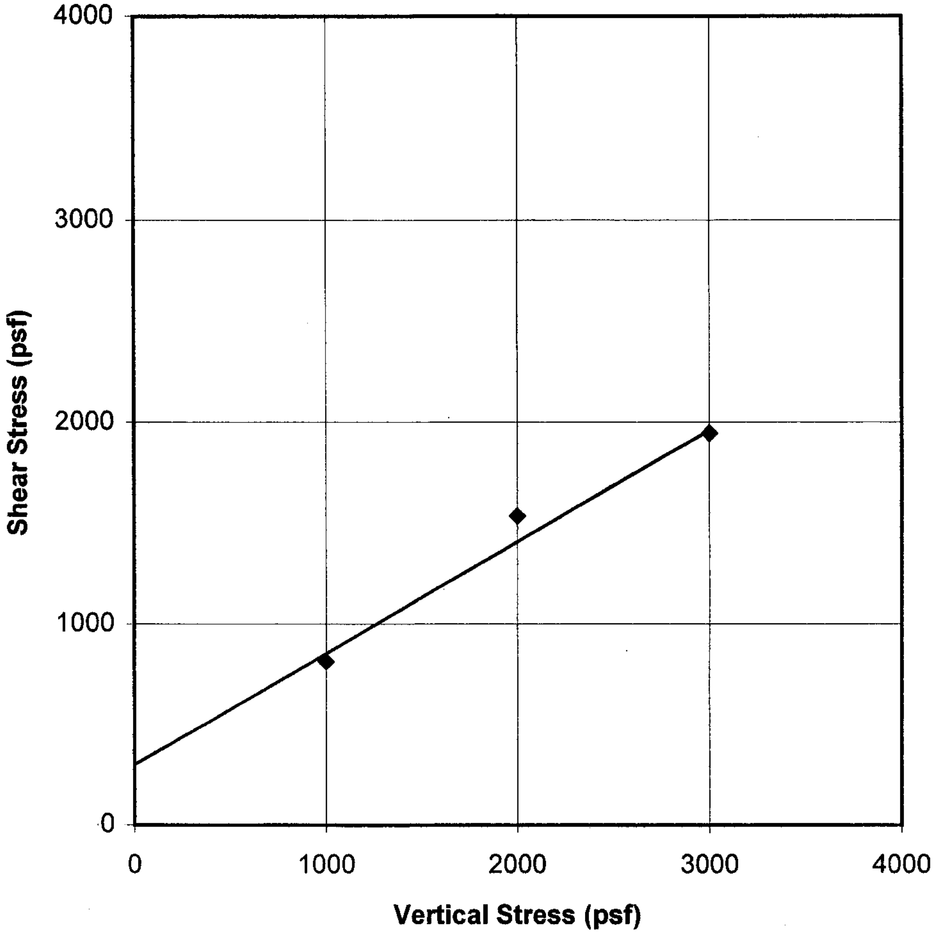
Boring Location	LB-4
Sample Depth (feet)	60

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	17
Cohesion, c_{ult} (psf)	300

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-24**



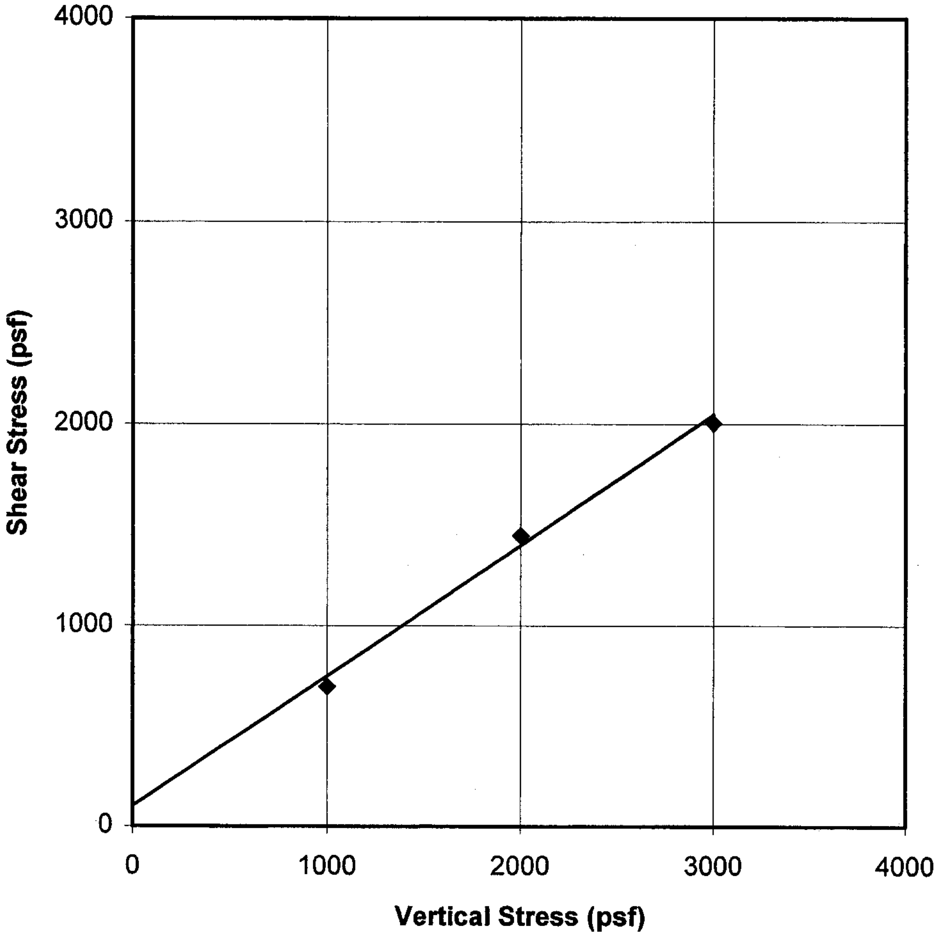
Boring Location	**LB-6**
Sample Depth (feet)	**20**

Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	**29**
Cohesion, c_{ult} (psf)	**300**

DIRECT SHEAR SUMMARY

Project No.	**040151-001**
Project Name	**HDR/Del Mar**
Figure No.	**D-25**



Boring Location	LB-6
Sample Depth (feet)	60

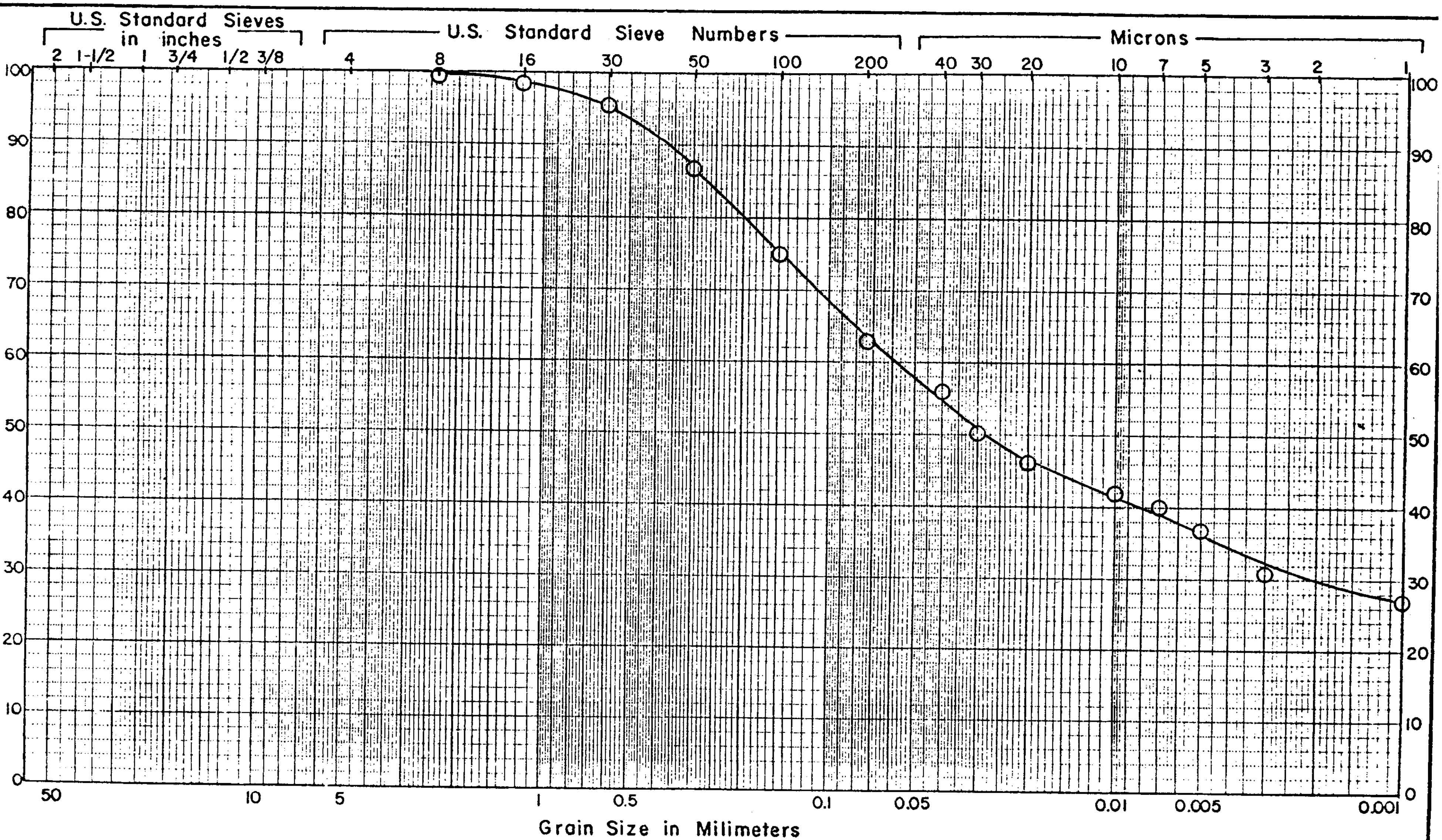
Average Ultimate Strength Values

Friction Angle, ϕ_{ult} (deg)	33
Cohesion, c_{ult} (psf)	100

DIRECT SHEAR SUMMARY

Project No.	040151-001
Project Name	HDR/Del Mar
Figure No.	D-26

PREVIOUS LABORATORY TESTING BY LEIGHTON AND ASSOCIATES

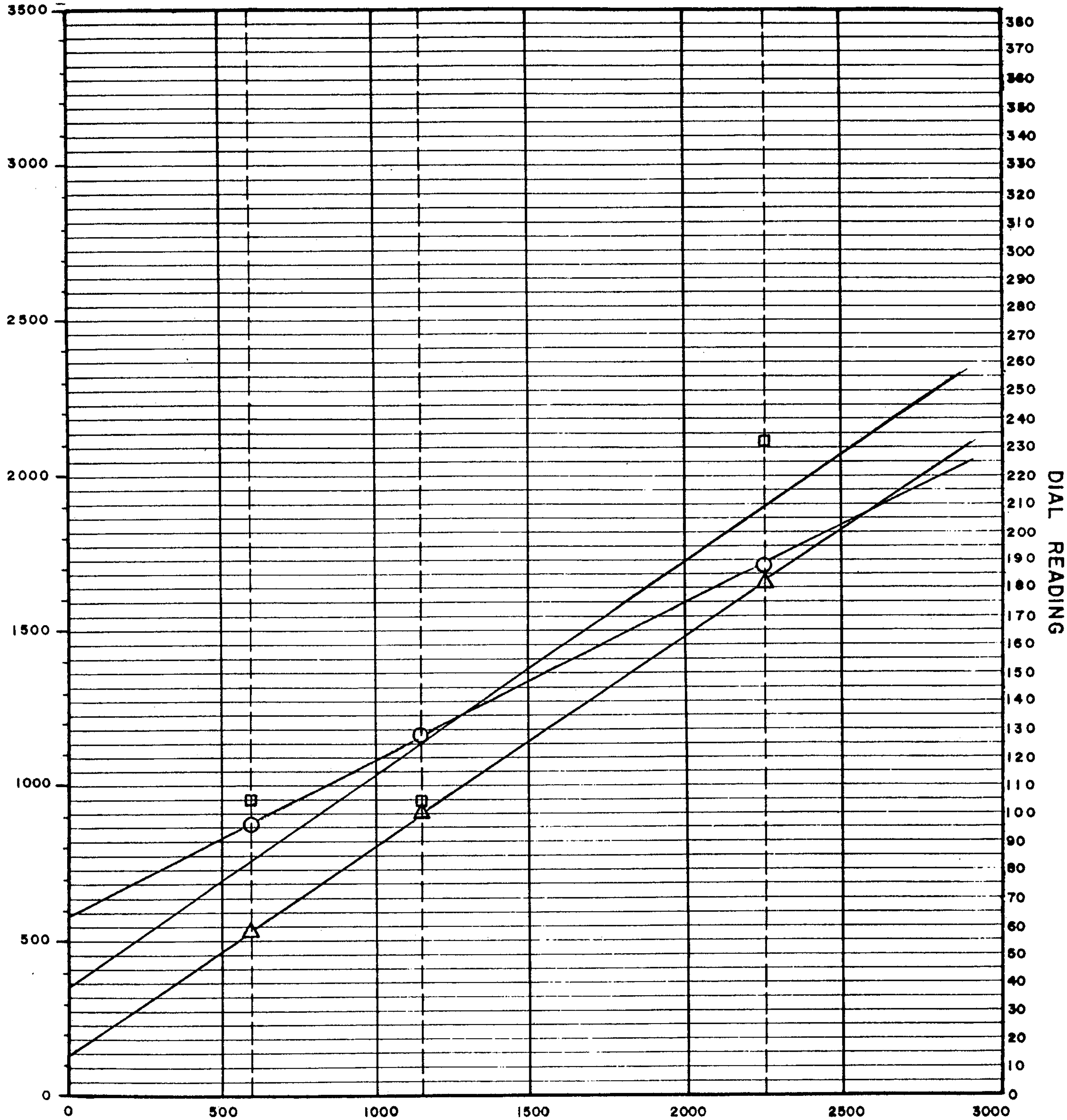


Gravel		Sand			Silt or Clay
Coarse	Fine	Coarse	Medium	Fine	

Symbol	Hole No.	Sample No.	Depth or Elev.	Field Moisture (%)	LL (%)	PI (%)	Activity PI/-2μ	Cu D_{60}/D_{10}	Cc $\frac{(D_{30})^2}{D_{10} \times D_{60}}$	Percent Passing No. 200	Percent Passing 2μ	U.S.C.S.
O	/	/	35'		41	23						CL
	CLAY@ TOE OF SLOPE				47	15						ML

GRADATION TEST RESULTS

DIRECT SHEAR SUMMARY



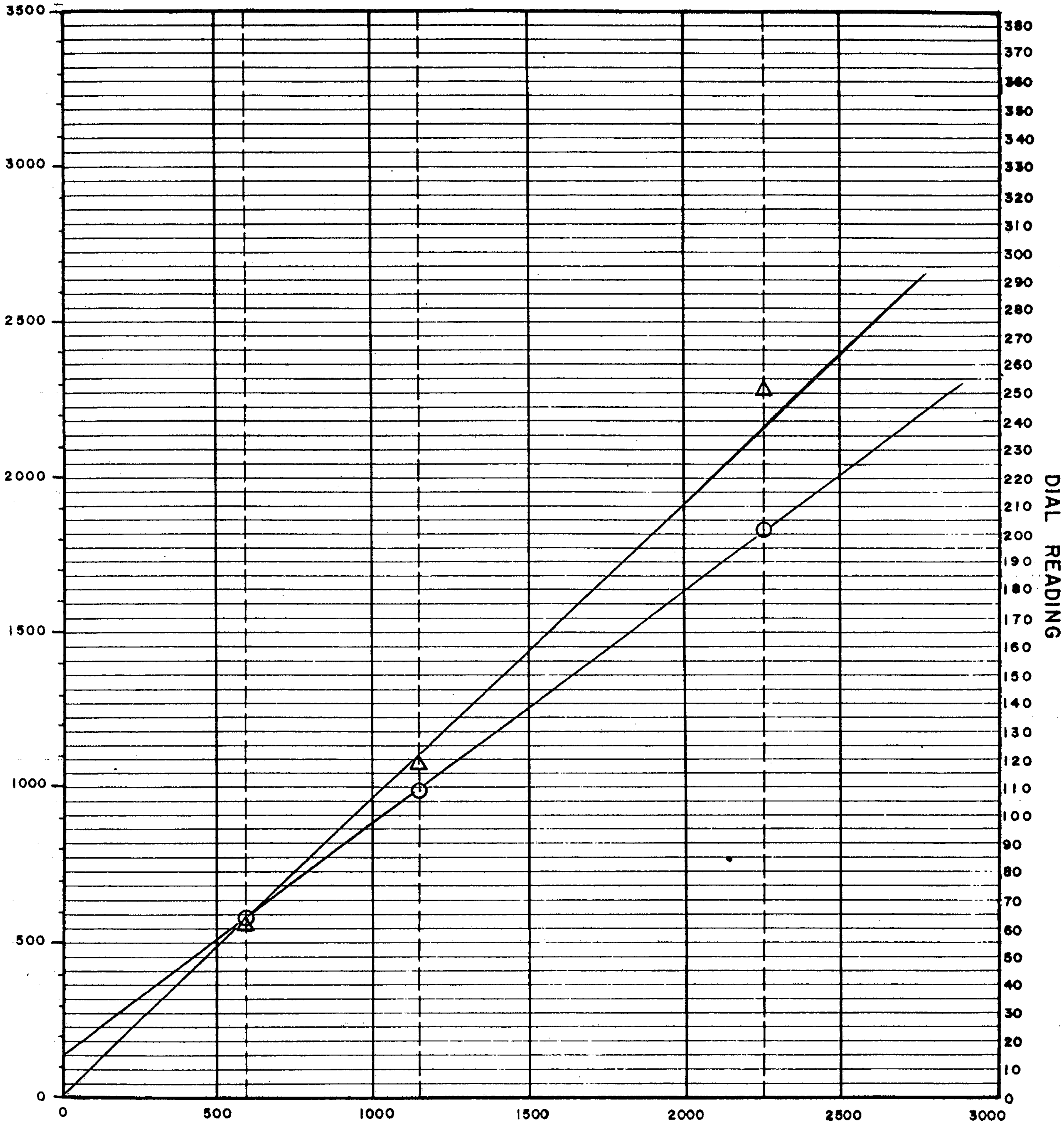
Boring	Depth	Symbol	Friction Angle	Cohesion	Remarks
1	6'	△	34°	140 psf	
1	12'	○	27°	580 psf	
1	17½'	□	35°	360 psf	

Project No.: 478008-1

Leighton & Associates

Plate No.:

DIRECT SHEAR SUMMARY



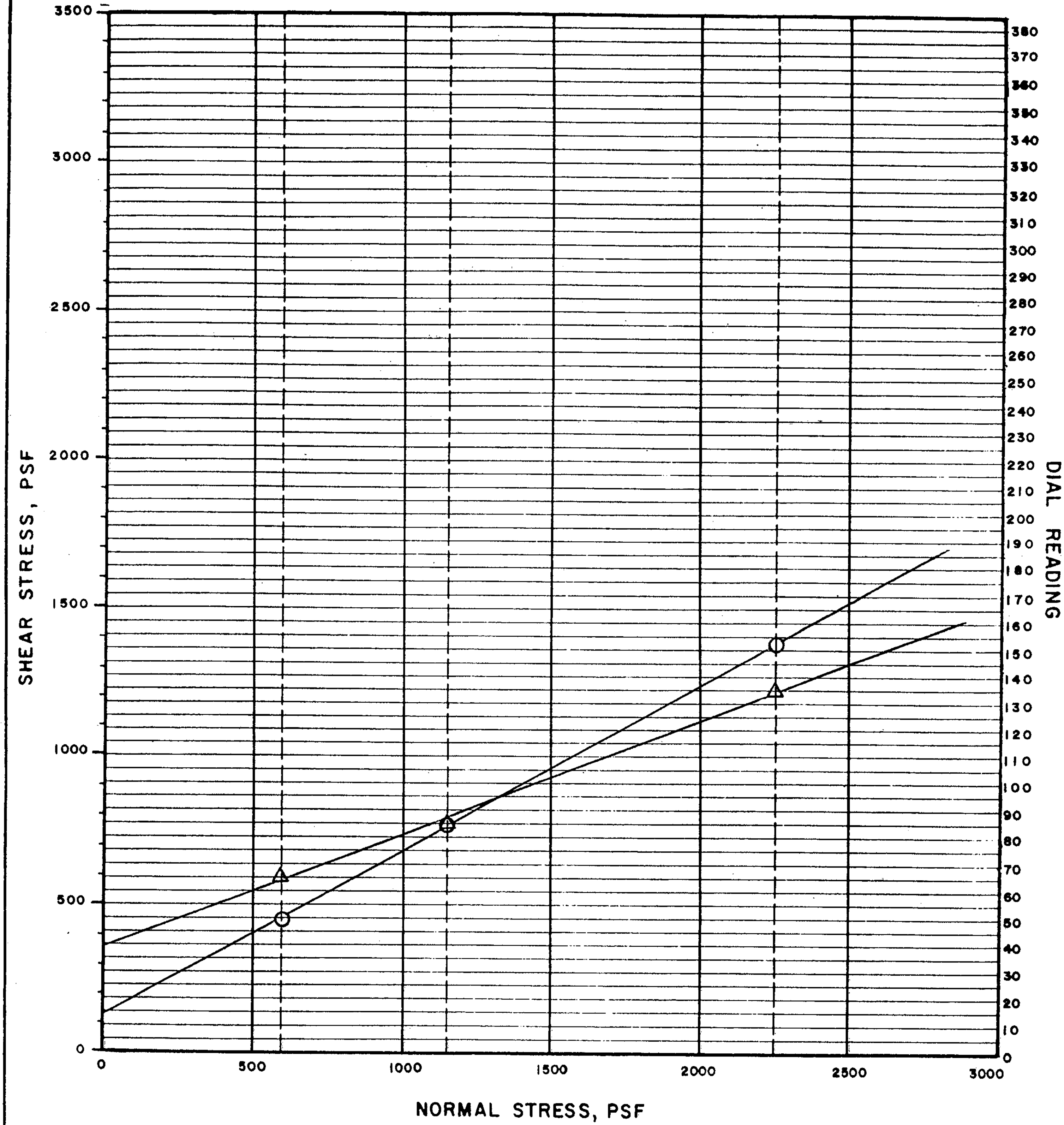
Boring	Depth	Symbol	Friction Angle	Cohesion	Remarks
1	33'	△	43°	0 psf	
2	8'	○	37°	140 psf	

Project No.: 478008-1

Leighton & Associates

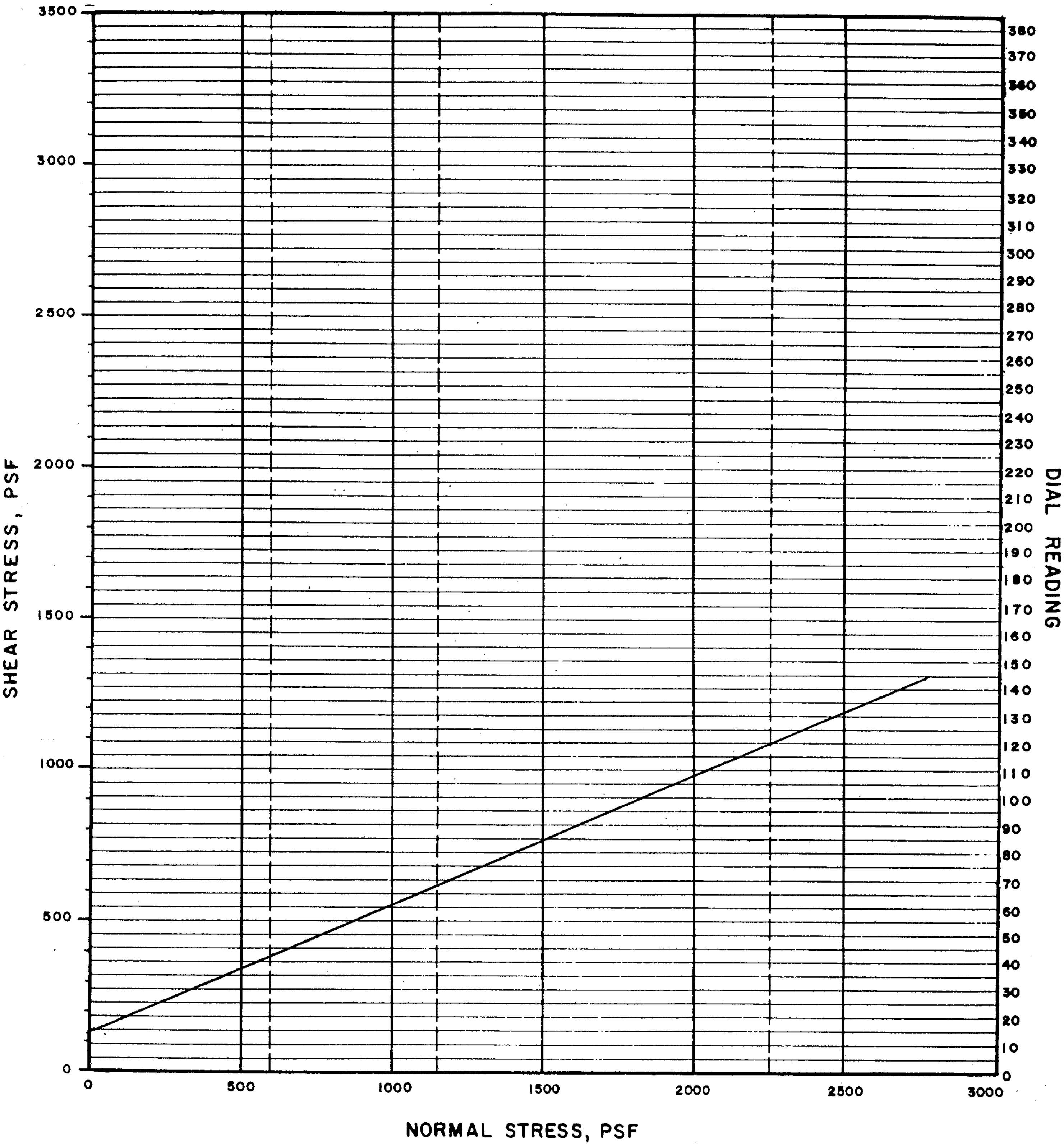
Plate No.:

DIRECT SHEAR SUMMARY



Boring	Depth	Symbol	Friction Angle	Cohesion	Remarks
1	35'	△	21°	350 psf	REMOLDED TO 90%
SURFACE SAMPLE	SURFACE	○	29°	130 psf	REMOLDED TO 90%

DIRECT SHEAR SUMMARY



Boring	Depth	Symbol	Friction Angle	Cohesion	Remarks
2	16°		23°	125 psf	RESIDUAL

PREVIOUS LABORATORY TESTING BY OTHERS

APPENDIX B

Laboratory Testing

Moisture-Density Determinations

The dry unit weight and field moisture content were determined for each of the recovered barrel samples. The moisture-density information provides a gross indication of soil consistency and can assist in delineating local variations. The information can also be used to correlate soils or weakly lithified bedrock found on this site with soils on other sites in the general area. Sample locations and the corresponding test results are illustrated on the Boring Logs in Appendix A.

Compaction Tests

Representative bulk soil samples were tested to determine their maximum dry densities and optimum moisture contents per the ASTM D 1557-91 (Method A) procedure. The test method uses 25 blows of a 10-pound hammer falling 18 inches on each of 5 soil layers in a 1/30 cubic foot cylinder. Soil samples are tested at varying moisture contents to create a curve illustrating achieved dry density as a function of moisture content. The table in the following page presents the test results.

Table B-1
Maximum Density - Optimum Moisture Content Determinations

Soil Classification	*Location*	*Maximum Dry Density (pcf)*	*Optimum Moisture Content (%)*
Sandy Silt (ML)	B - 1P 20-30 ft.	120.5	10.0
Clayey Sand (SP-SC)	B - 2 5-10 ft.	130.0	8.5
Silty Clay (CL)	B - 6P 9-12½ ft.	119.5	13.0
Sandy Silt (ML)	B - 7 20-25 ft.	118.0	16.0
Silty Clay (CL)	B - 9P 12½-17½ ft	112.5	17.0
Sand (SP)	B - 11P	127.0	10.0

Soil Classification	Location	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
Clayey Sand (SP-SC)	0-5 ft. B - 14P 5-10 ft.	123.5	10.0

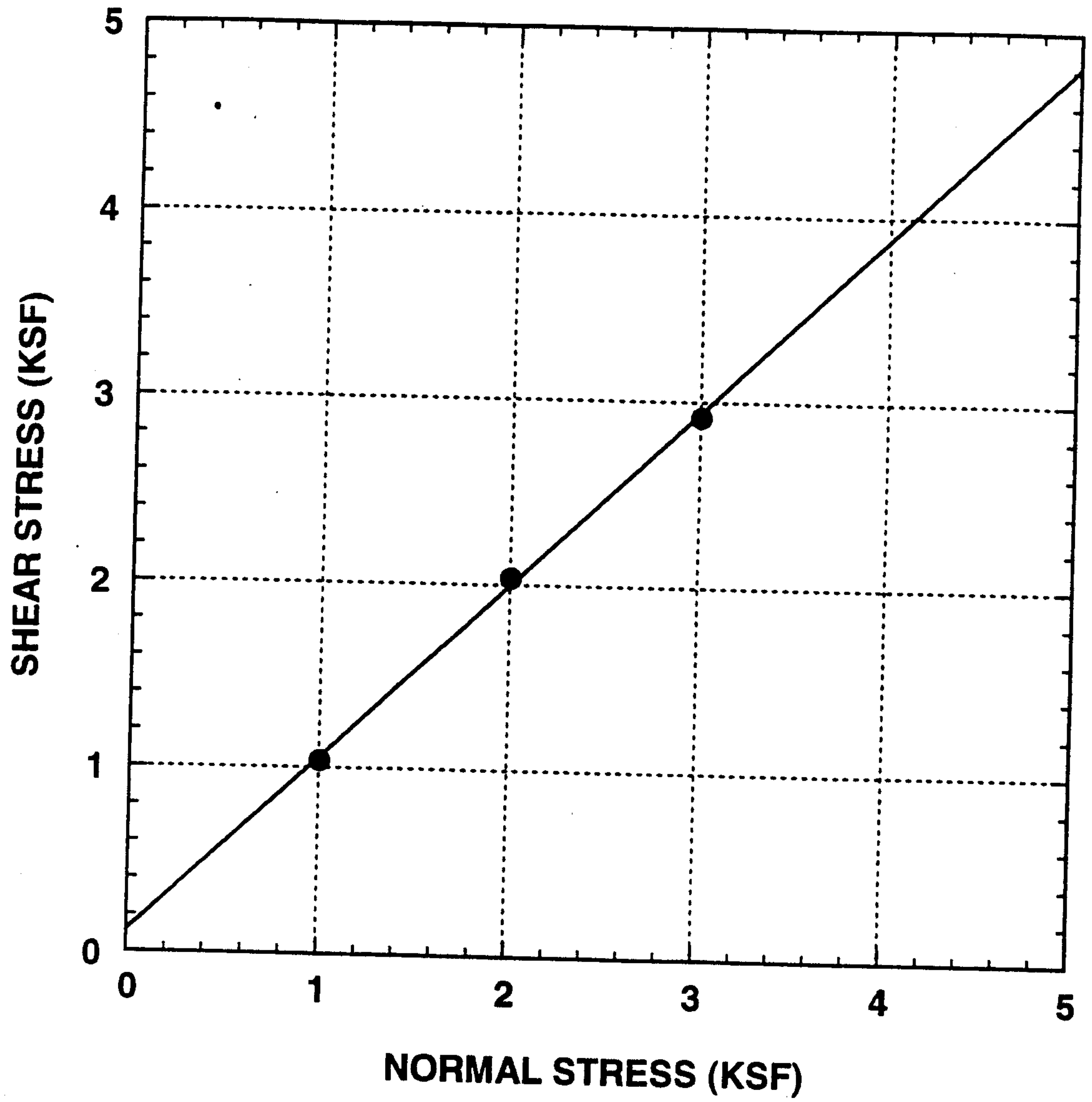
Strength Tests

Direct shear tests were performed on undisturbed samples collected from varying depths within representative Borings. The samples were tested at field moisture contents, and tested in a direct shear machine of the strain control type. Test samples are retained within standard one-inch-high brass rings. Samples were tested at increasing normal loads to determine the Mohr-Coulomb shear strength parameters presented on Figures B-1 through B-39.

Consolidation Tests - (ASTM D 2435)

In this procedure, a series of cumulative vertical loads are applied to a small, laterally confined soil sample. The apparatus is designed to accept a one-inch-high brass ring containing an undisturbed or remolded soil sample. During each load increment, vertical compression (consolidation) of the sample is measured and recorded at selected time intervals. Porous stones are placed in contact with both sides of the specimen to permit the ready addition or release of water. Undisturbed samples were initially at field moisture content, and were subsequently inundated at a load near the existing overburden pressure to determine soil behavior under saturated conditions. The test results are plotted graphically on Figures B-40 through B-42.

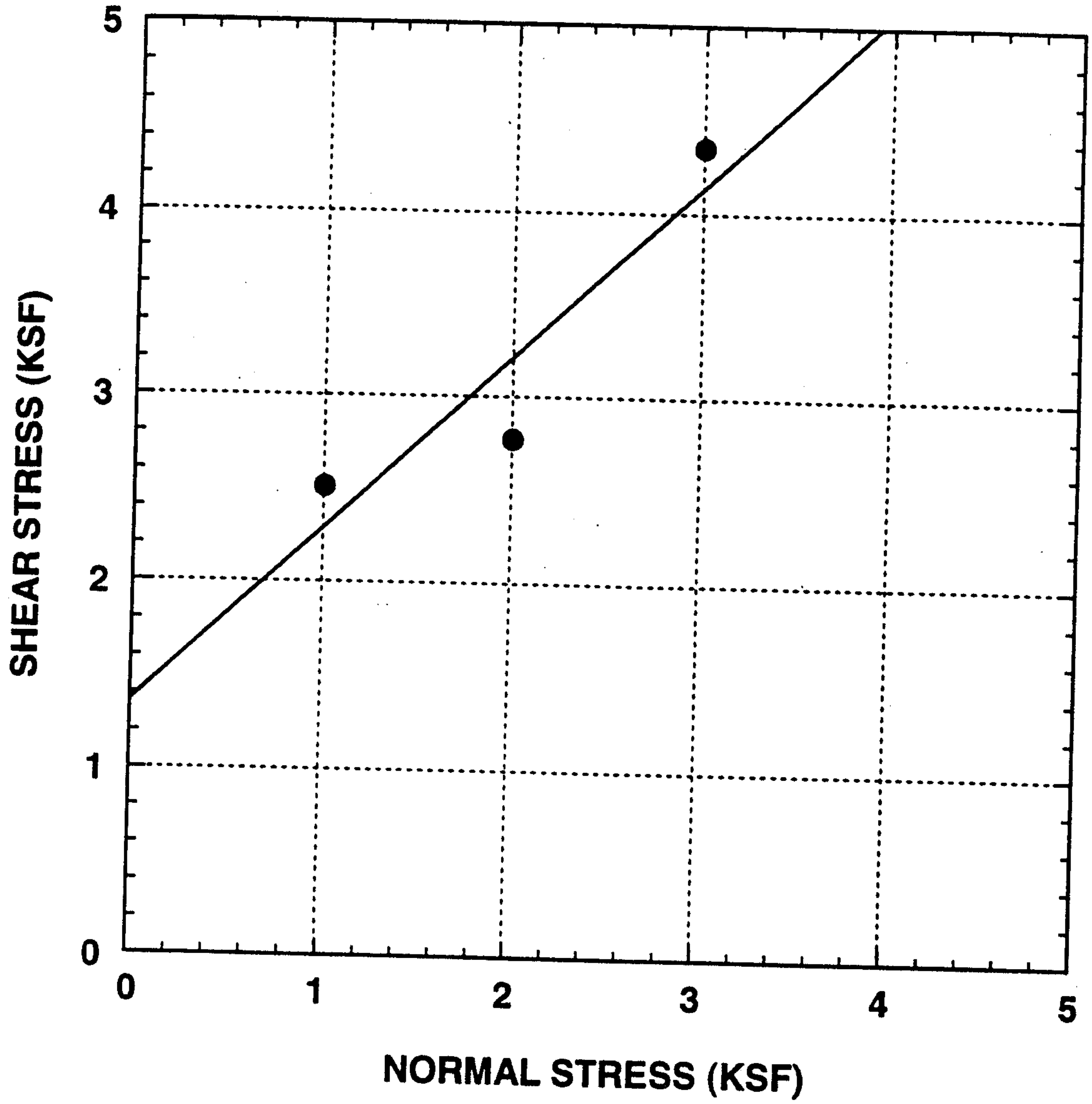
DIRECT SHEAR TEST DIAGRAM



C = 100 psf $\phi = 43°$

Test Condition: Undisturbed at Field Moisture	Location: B - 1P	Depth: 5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 1	

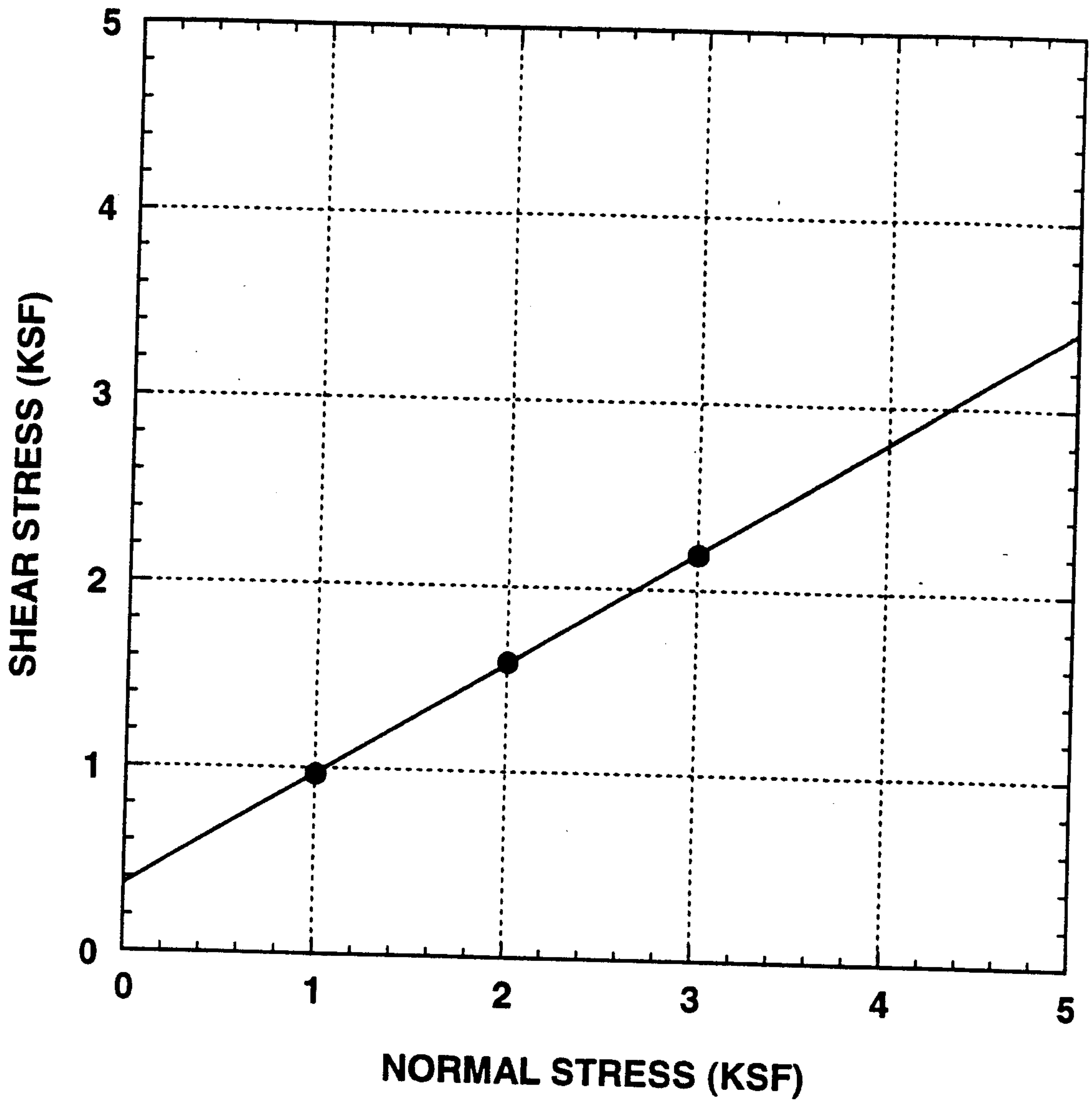
DIRECT SHEAR TEST DIAGRAM



C = 1400 psf $\phi = 42^\circ$

Test Condition: Undisturbed at Field Moisture	Location: B - 1P	Depth: 10'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 2**	

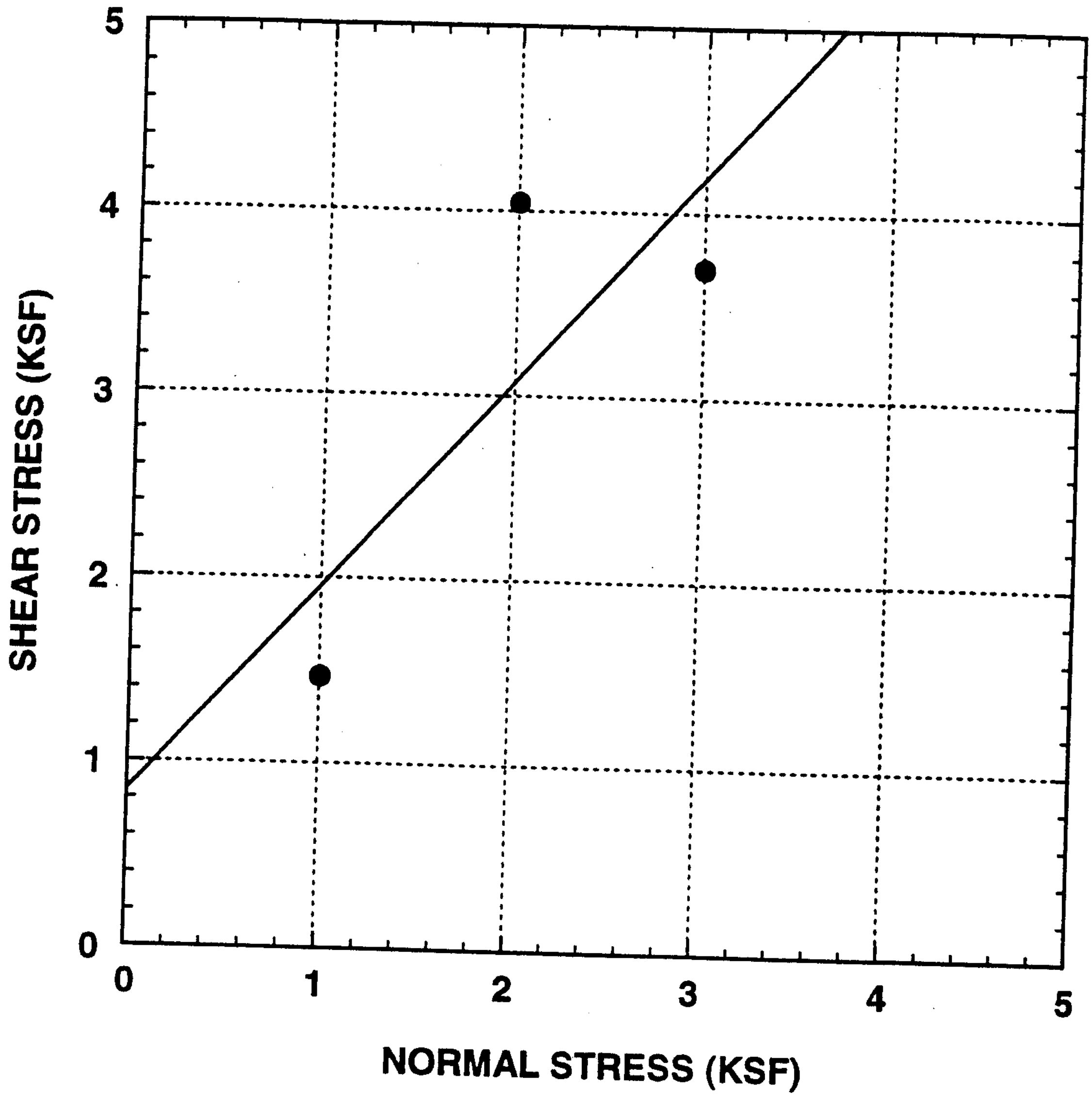
DIRECT SHEAR TEST DIAGRAM



C = 375 psf $\phi = 31°$

Test Condition: Undisturbed at Field Moisture	Location: B - 1P	Depth: 20'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 3**	

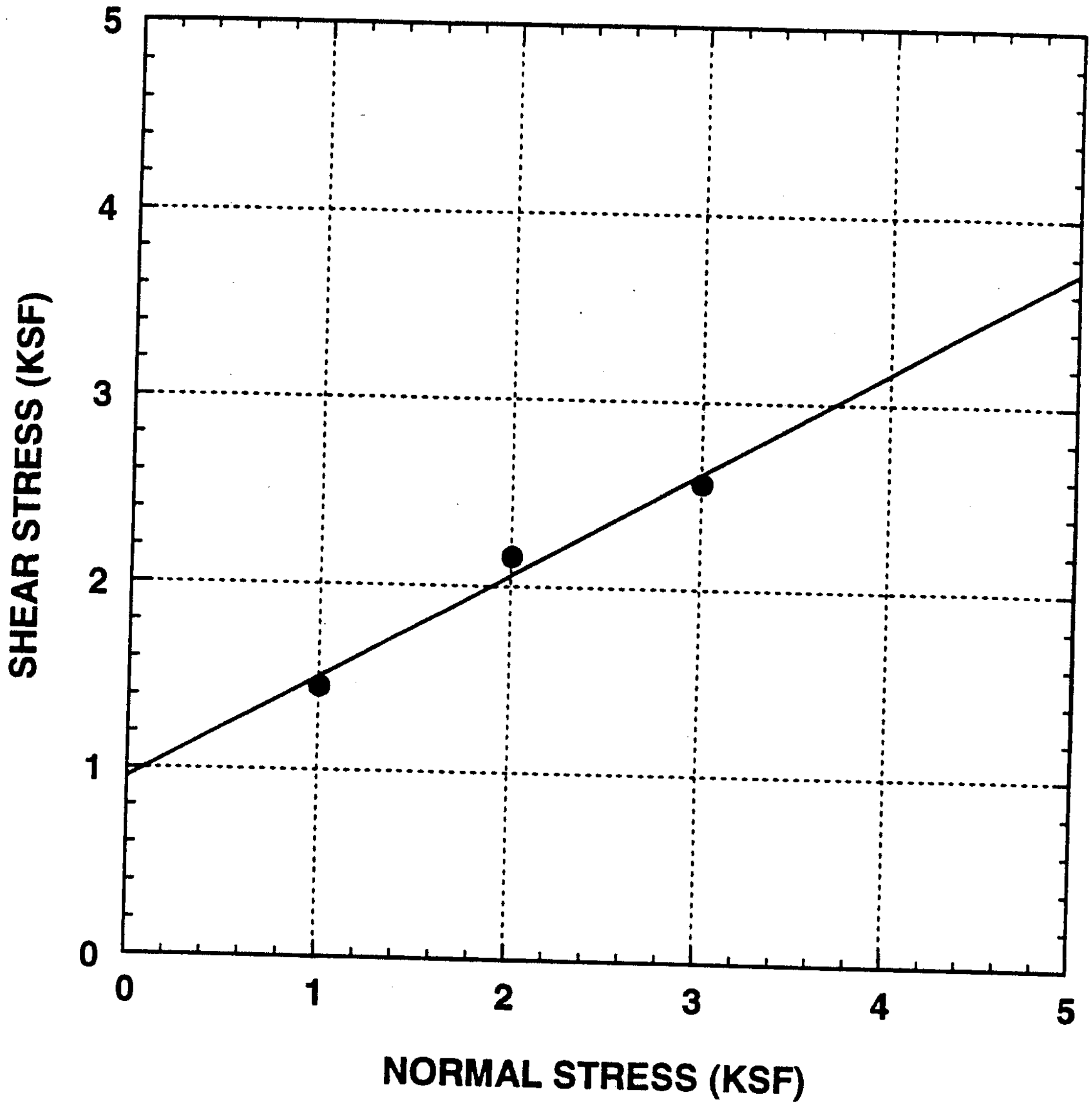
DIRECT SHEAR TEST DIAGRAM



C = 850 psf $\phi = 48°$

Test Condition: Undisturbed at Field Moisture	Location: B - 1P	Depth: 30'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 4**	

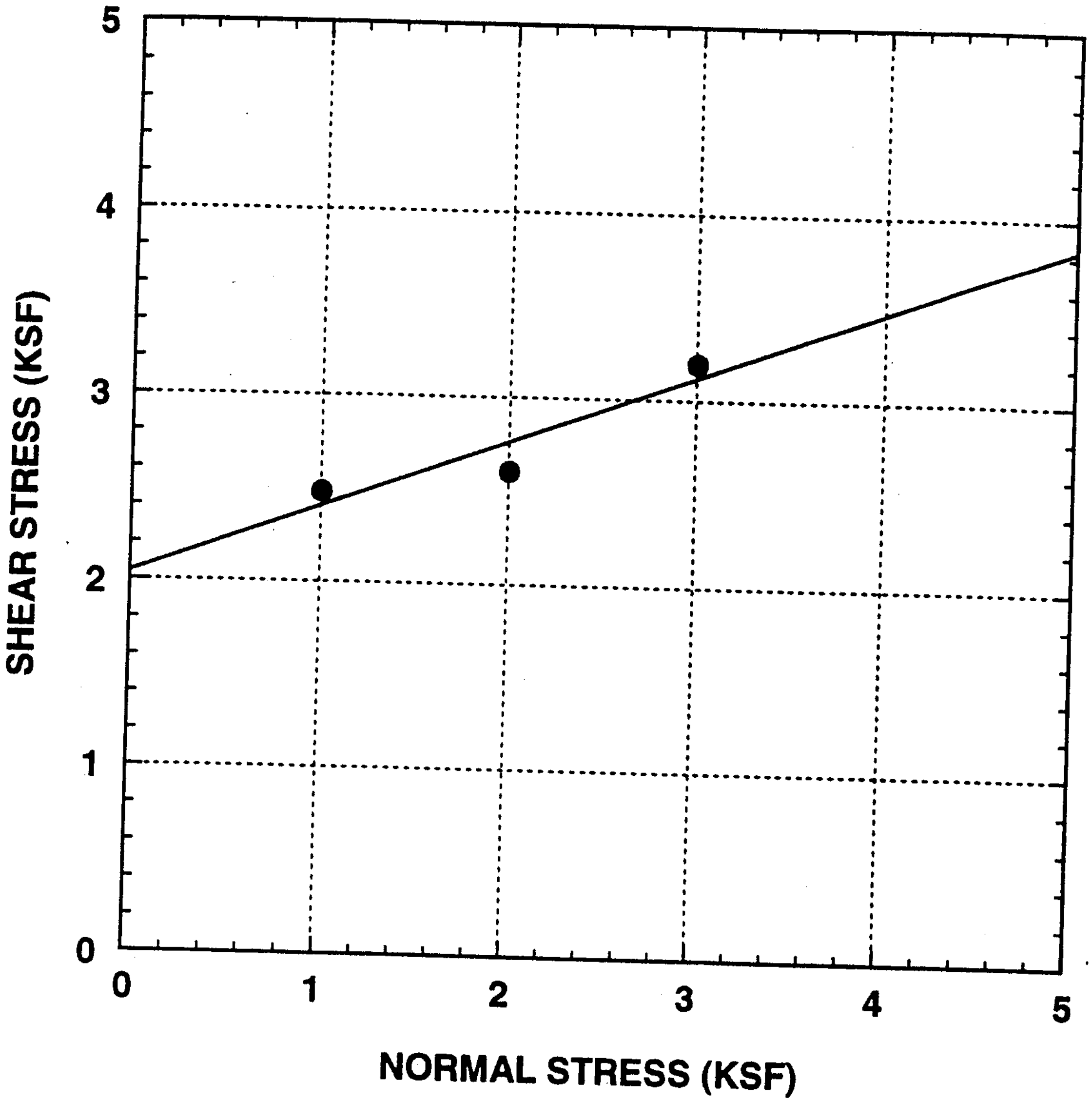
DIRECT SHEAR TEST DIAGRAM



C = 950 psf $\phi = 29°$

Test Condition: Undisturbed at Field Moisture	Location: B - 1P	Depth: 50'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 5**	

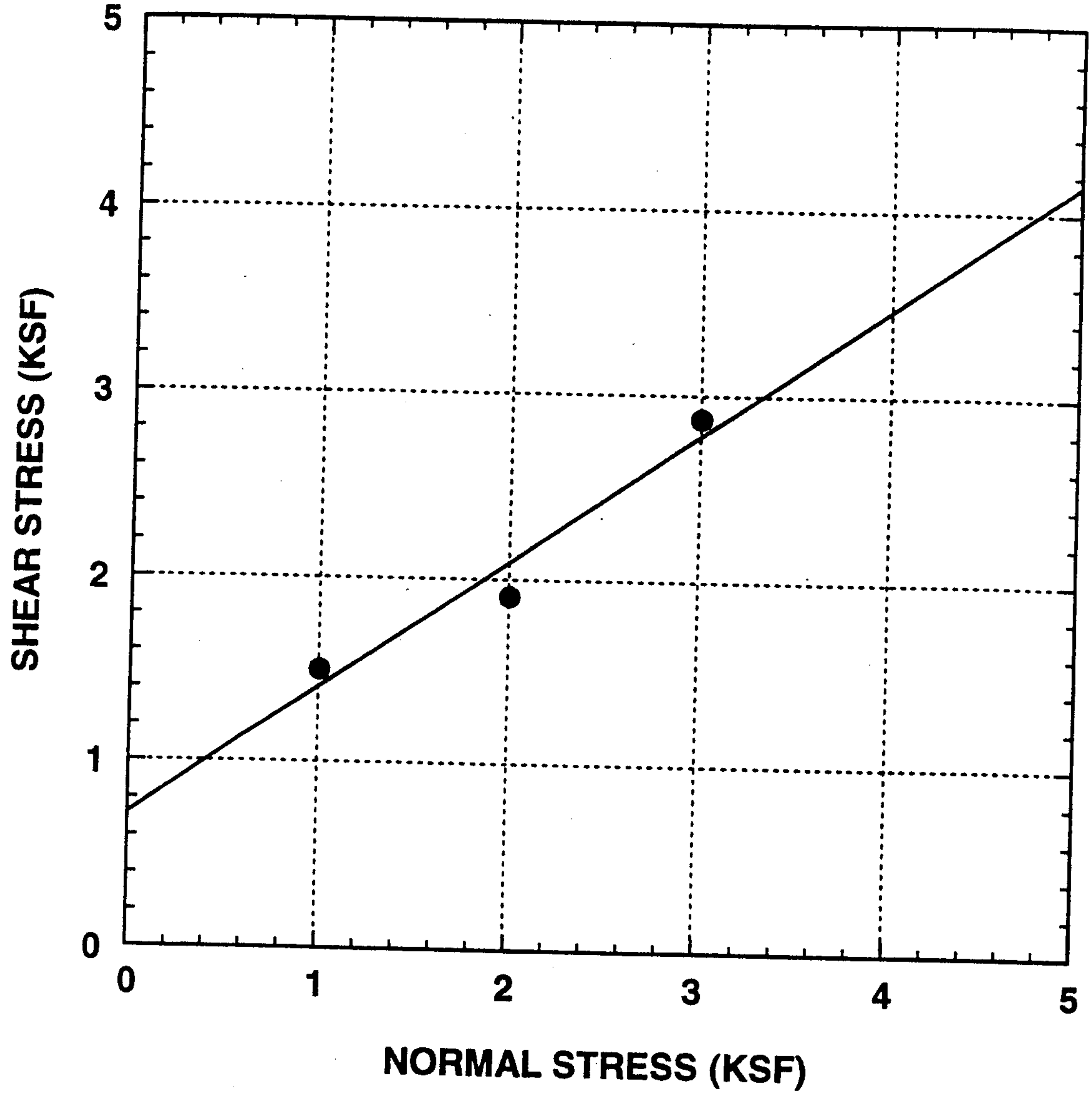
DIRECT SHEAR TEST DIAGRAM



C = 2050 psf $\phi = 20°$

Test Condition: Undisturbed at Field Moisture	Location: B - 4P	Depth: 10'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 6**	

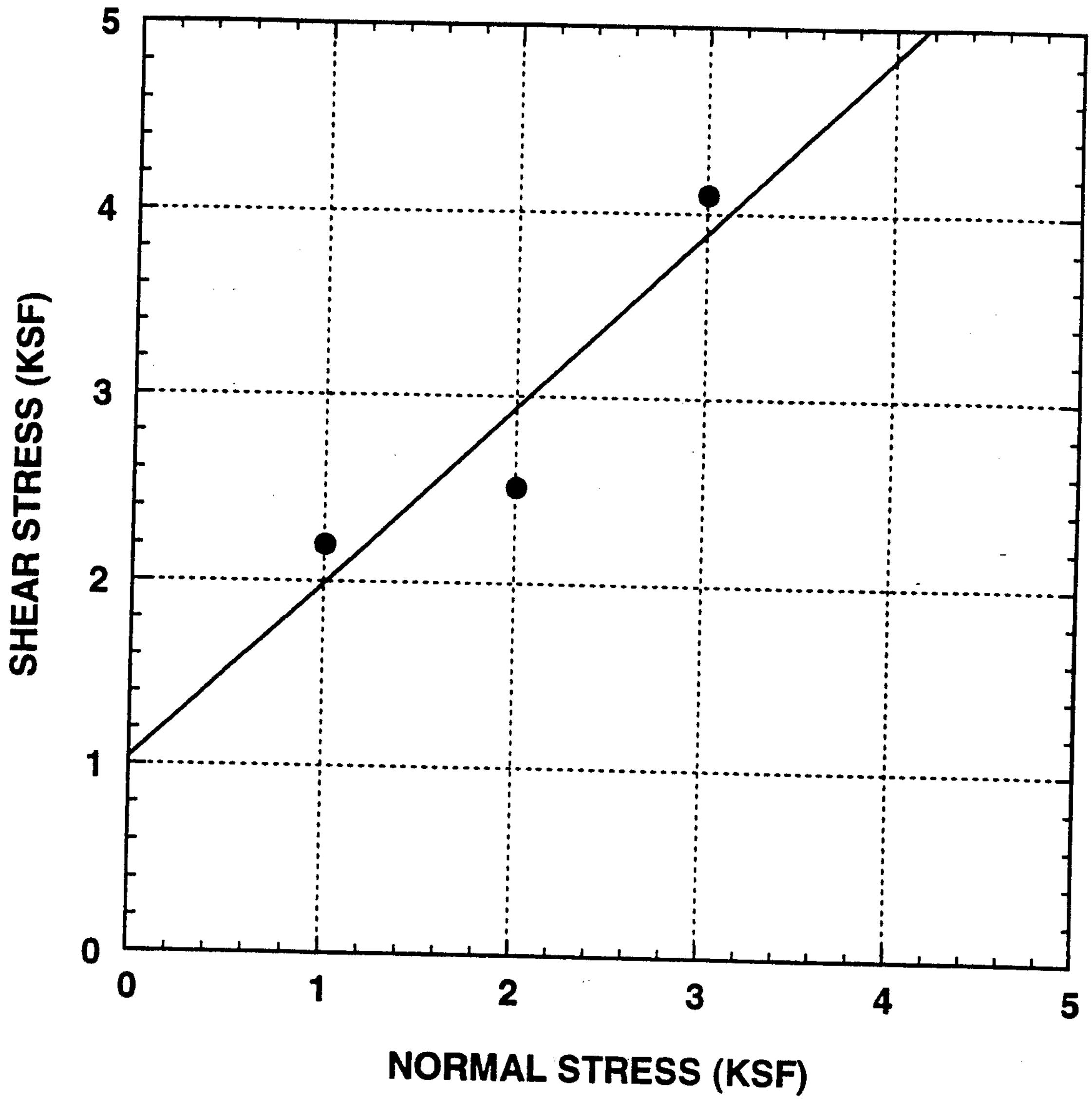
DIRECT SHEAR TEST DIAGRAM



C = 700 psf $\phi = 34°$

Test Condition: Undisturbed at Field Moisture	Location: B - 4P	Depth: 15'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 7	

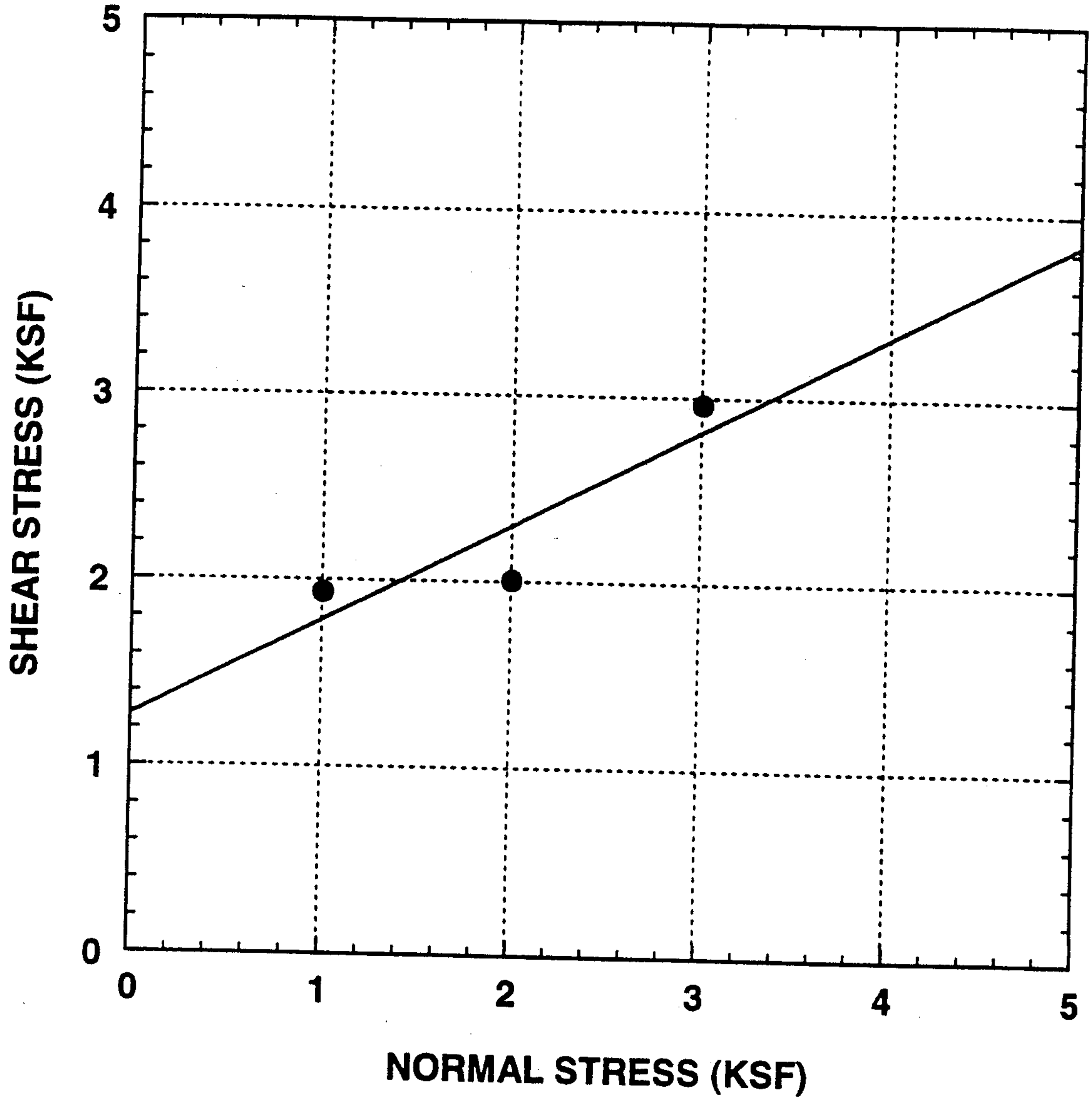
DIRECT SHEAR TEST DIAGRAM



C = 1050 psf $\phi = 43°$

Test Condition: Undisturbed at Field Moisture	Location: B - 4P	Depth: 20'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 8**	

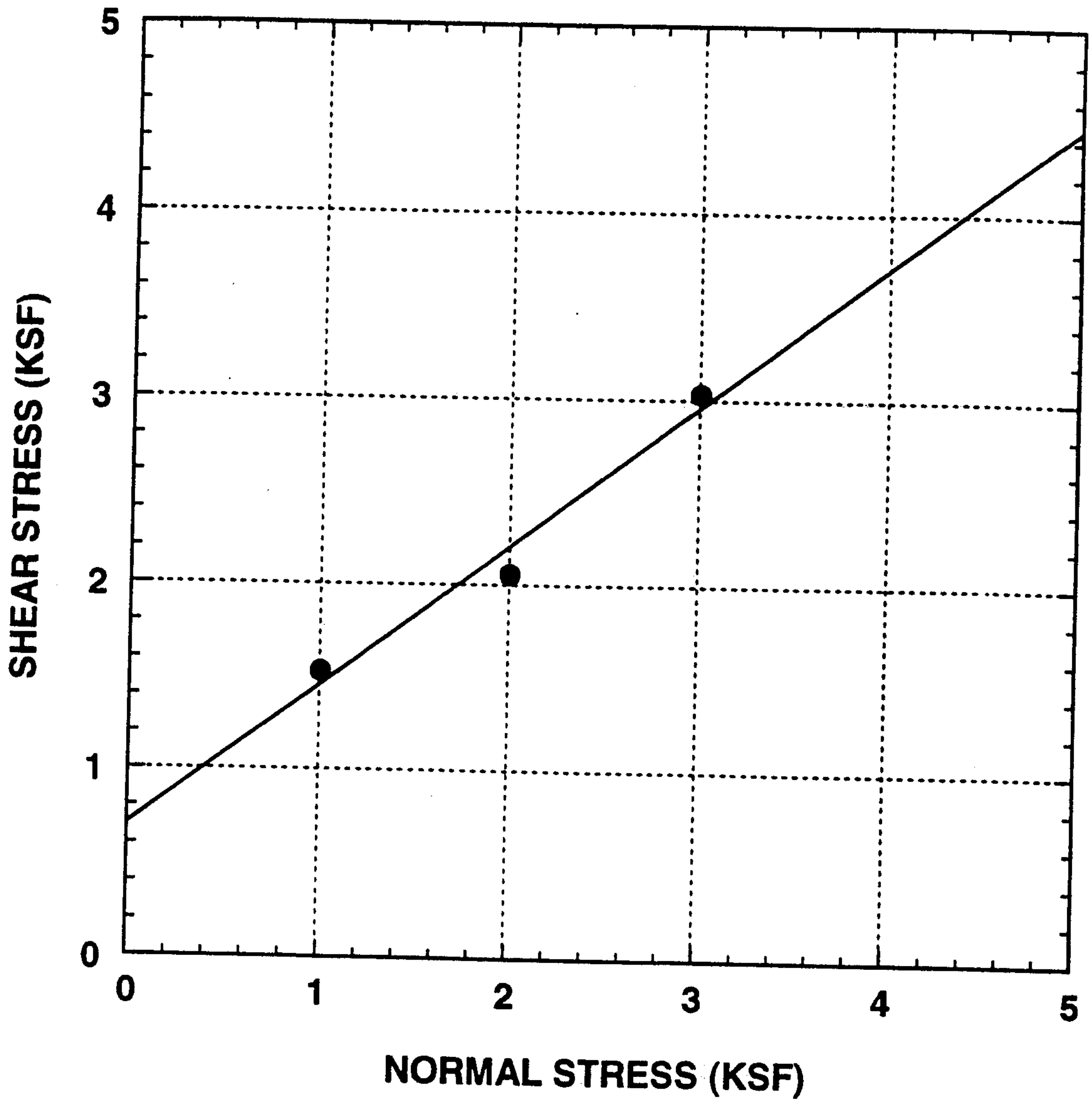
DIRECT SHEAR TEST DIAGRAM



C = 1250 psf $\phi = 27°$

Test Condition: Undisturbed at Field Moisture	Location: B - 4P	Depth: 35'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 9**	

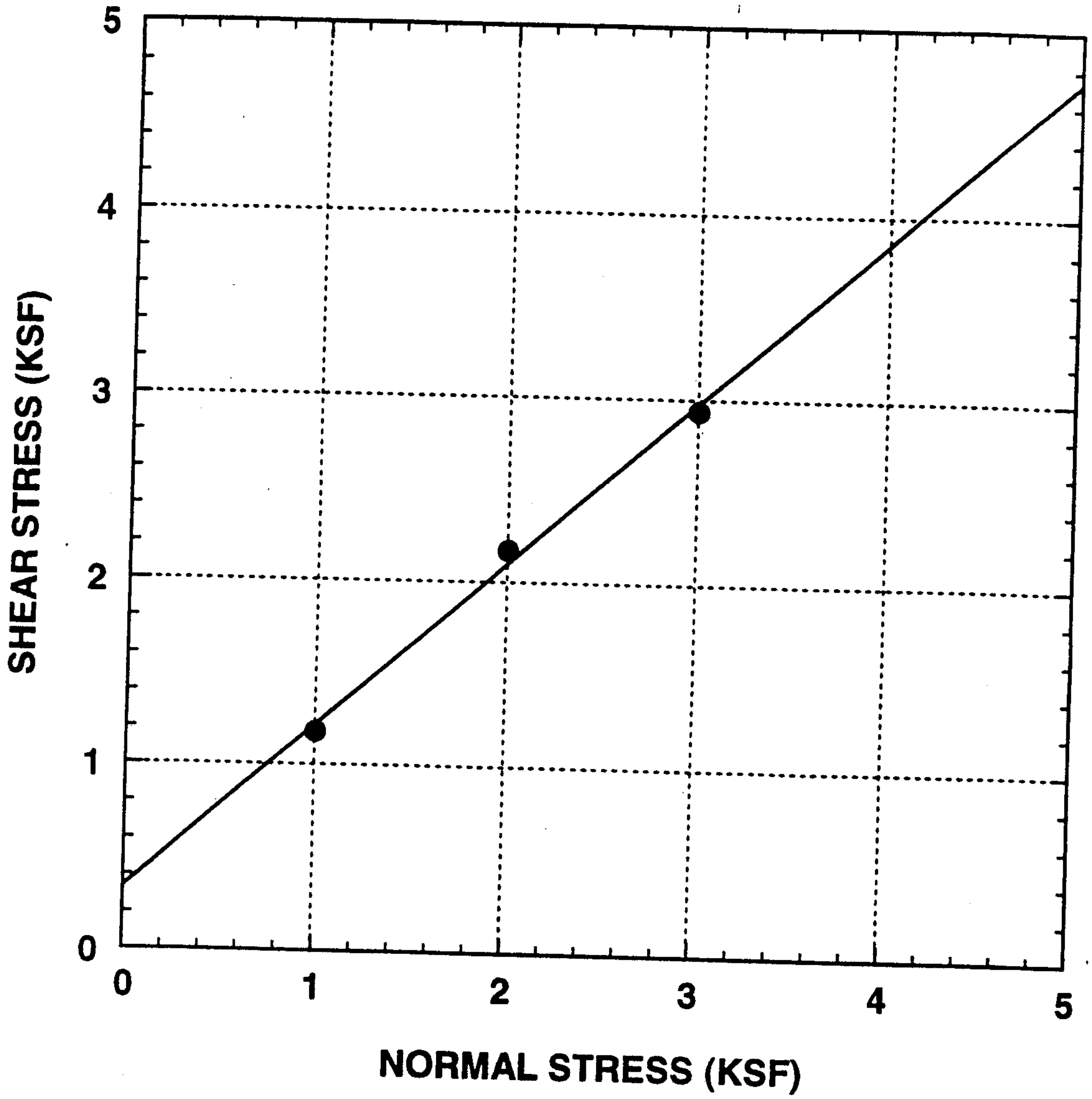
DIRECT SHEAR TEST DIAGRAM



C = 750 psf $\phi = 35^{\circ}$

Test Condition: Undisturbed at Field Moisture	Location: B - 4P	Depth: 55'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 10**	

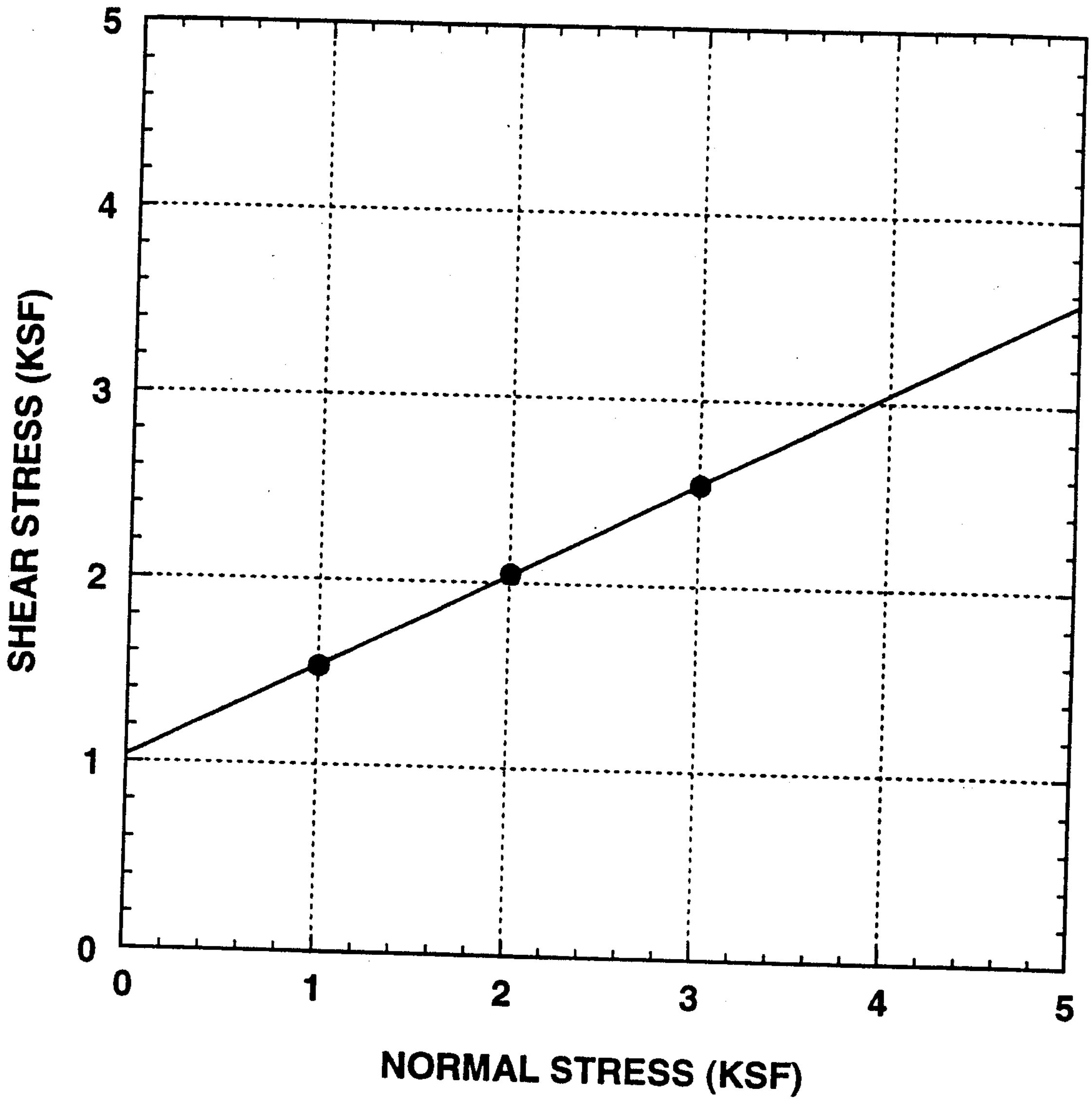
DIRECT SHEAR TEST DIAGRAM



C = 350 psf $\phi = 41^\circ$

Test Condition: Undisturbed at Field Moisture	Location: B - 7	Depth: 5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 11**	

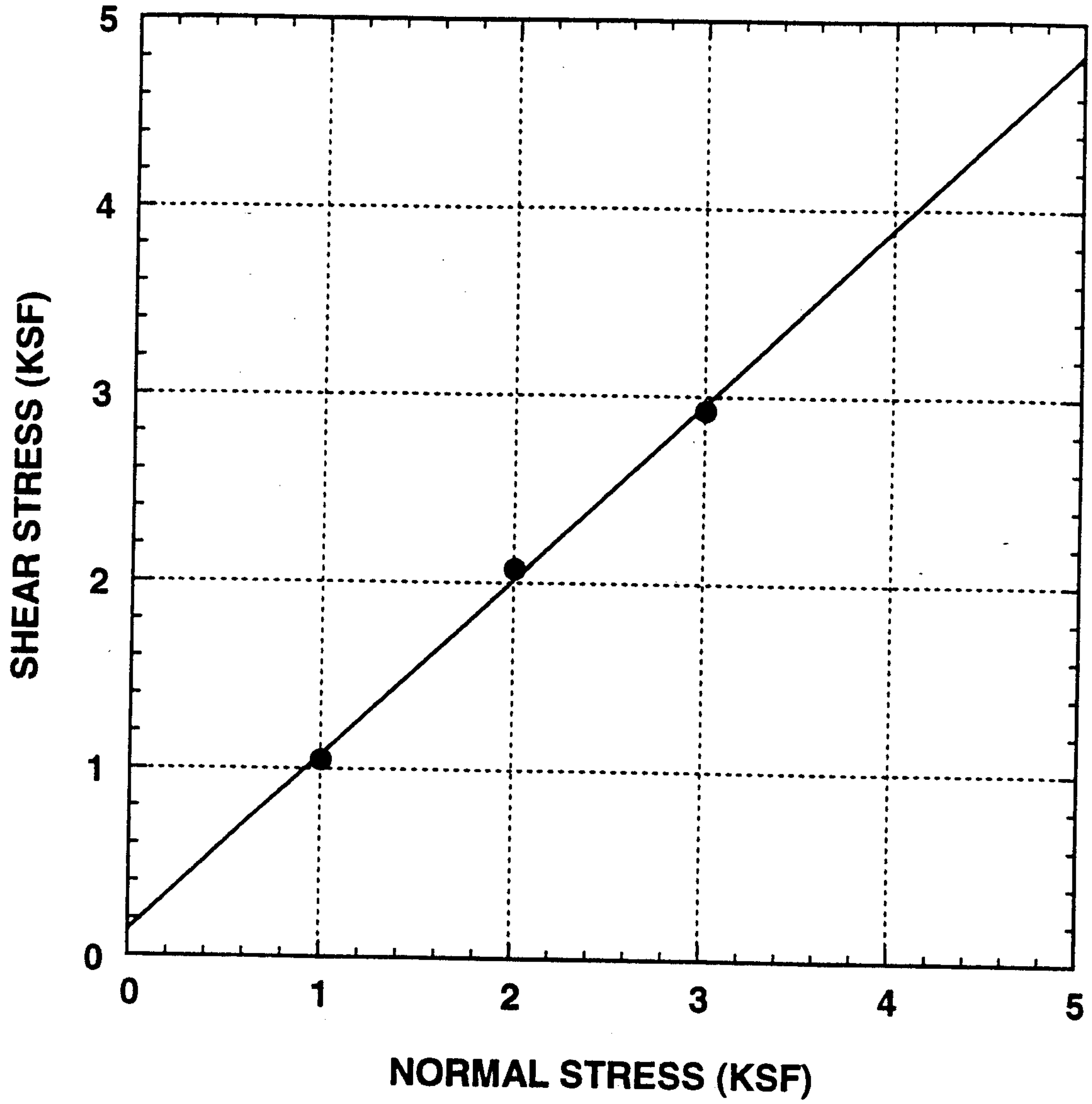
DIRECT SHEAR TEST DIAGRAM



C = 1025 psf $\phi = 27^{\circ}$

Test Condition: Undisturbed at Field Moisture	Location: B - 7	Depth: 10'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 12**	

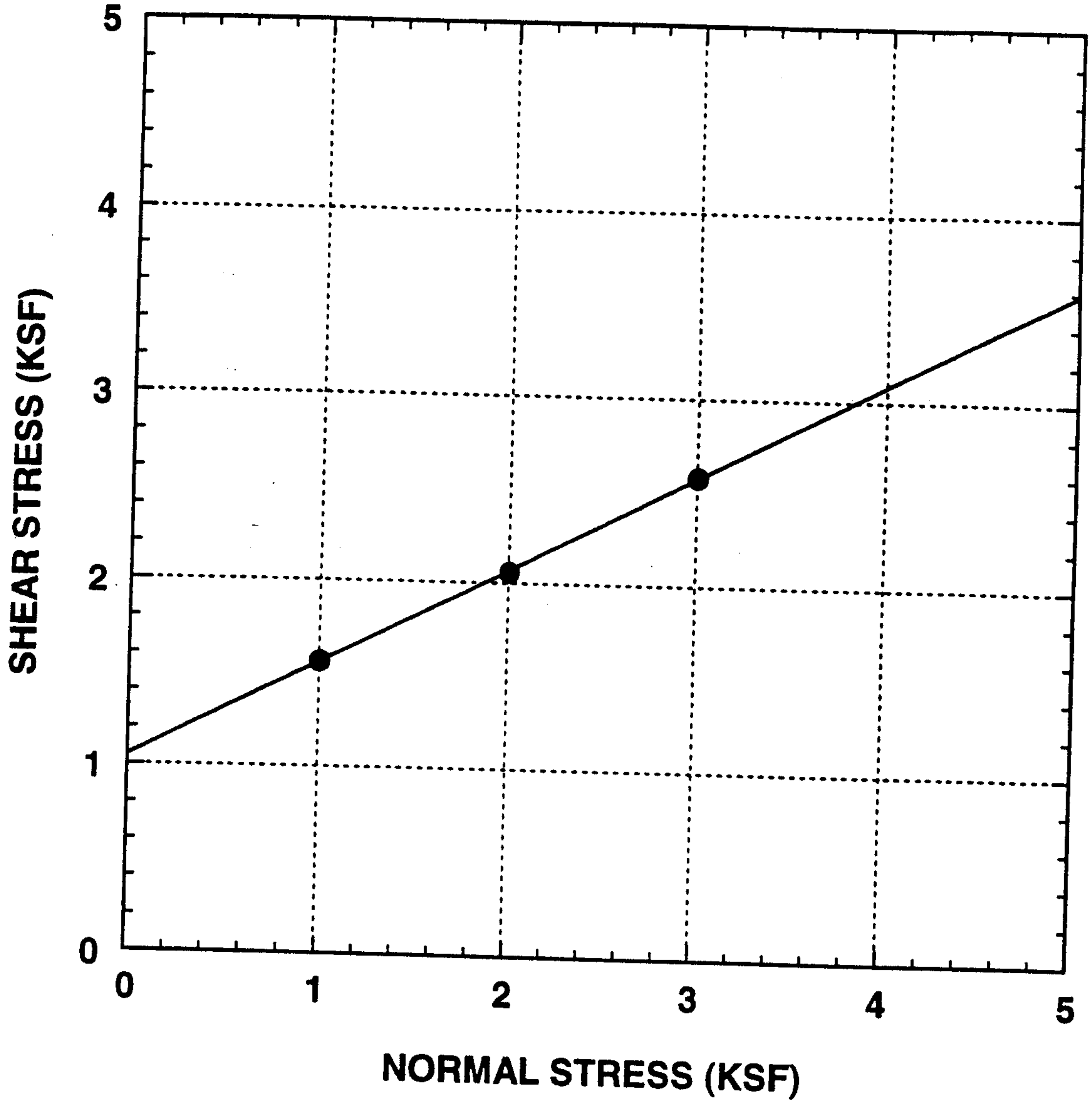
DIRECT SHEAR TEST DIAGRAM



C = 125 psf $\phi = 43^{\circ}$

Test Condition: Undisturbed at Field Moisture	Location: B - 7	Depth: 20'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 13**	

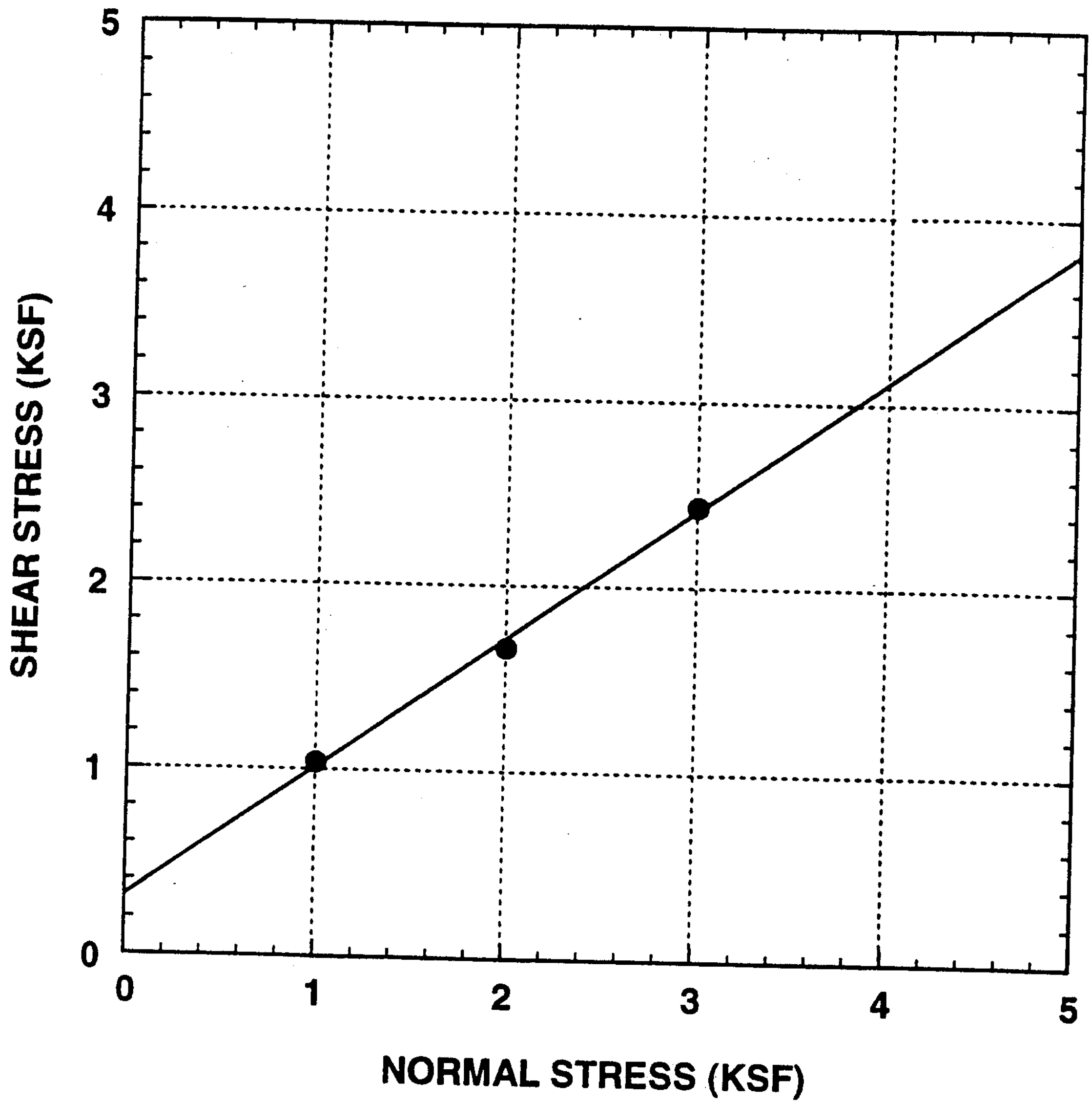
DIRECT SHEAR TEST DIAGRAM



C = 1050 psf $\phi = 27°$

Test Condition: Undisturbed at Field Moisture	Location: B - 7	Depth: 30'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 14**	

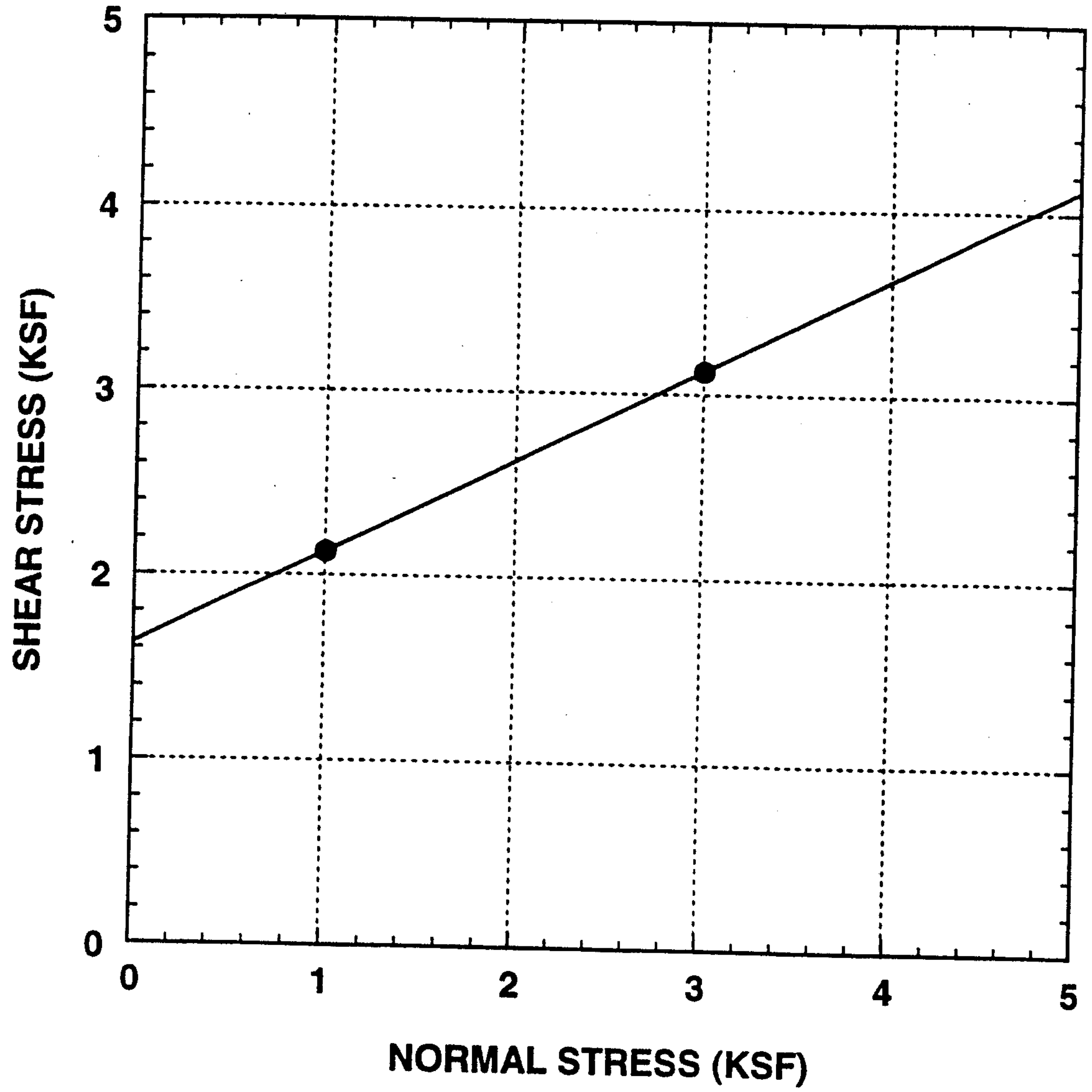
DIRECT SHEAR TEST DIAGRAM



C = 300 psf $\phi = 35^{\circ}$

Test Condition: Undisturbed at Field Moisture	Location: B - 7	Depth: 35'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 15**	

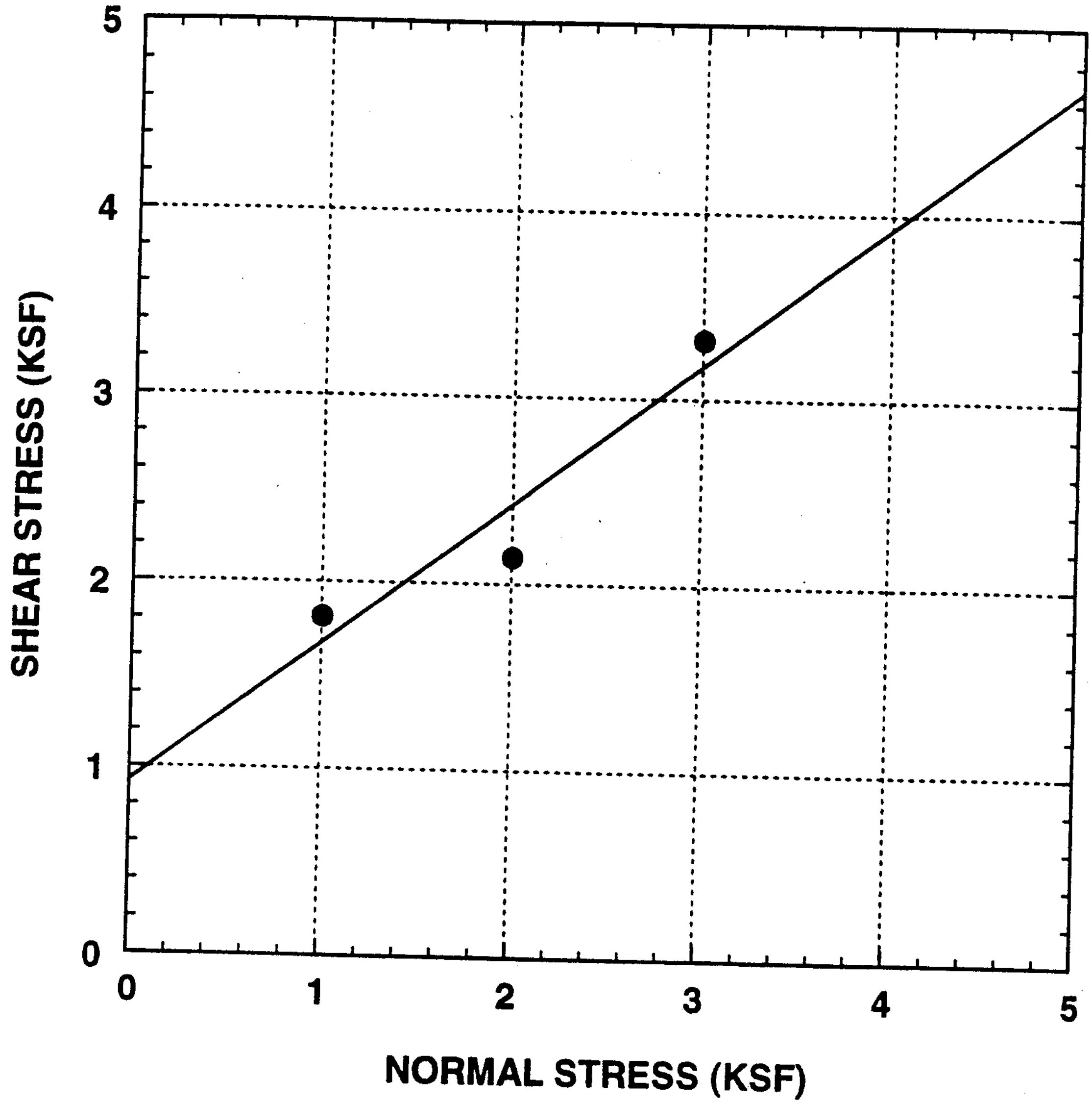
DIRECT SHEAR TEST DIAGRAM



C = 1625 psf $\phi = 26°$

Test Condition: Undisturbed at Field Moisture	Location: B - 7	Depth: 45'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 16**	

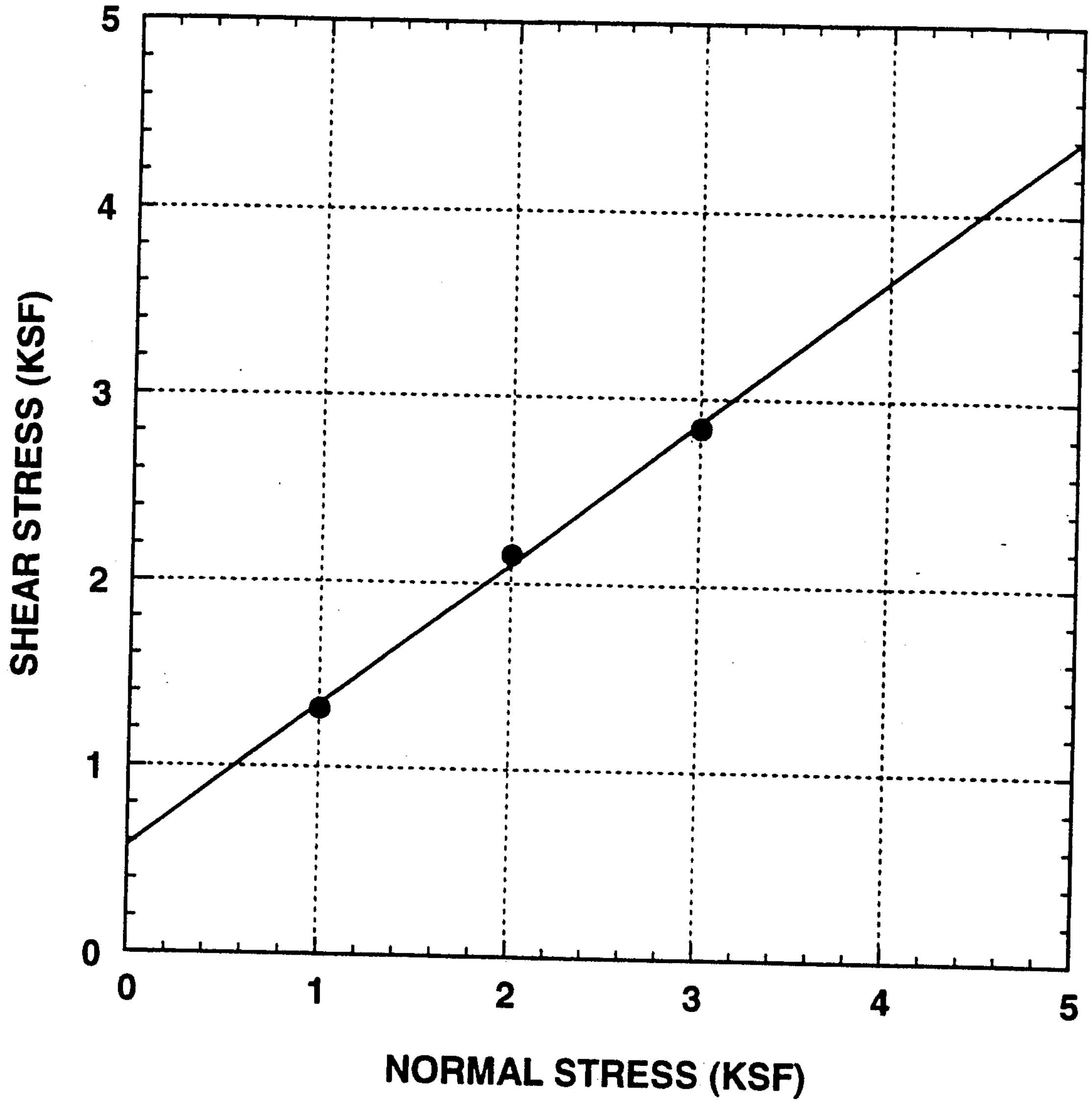
DIRECT SHEAR TEST DIAGRAM



C = 925 psf $\phi = 37°$

Test Condition: Undisturbed at Field Moisture	Location: B - 7	Depth: 55'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 17**	

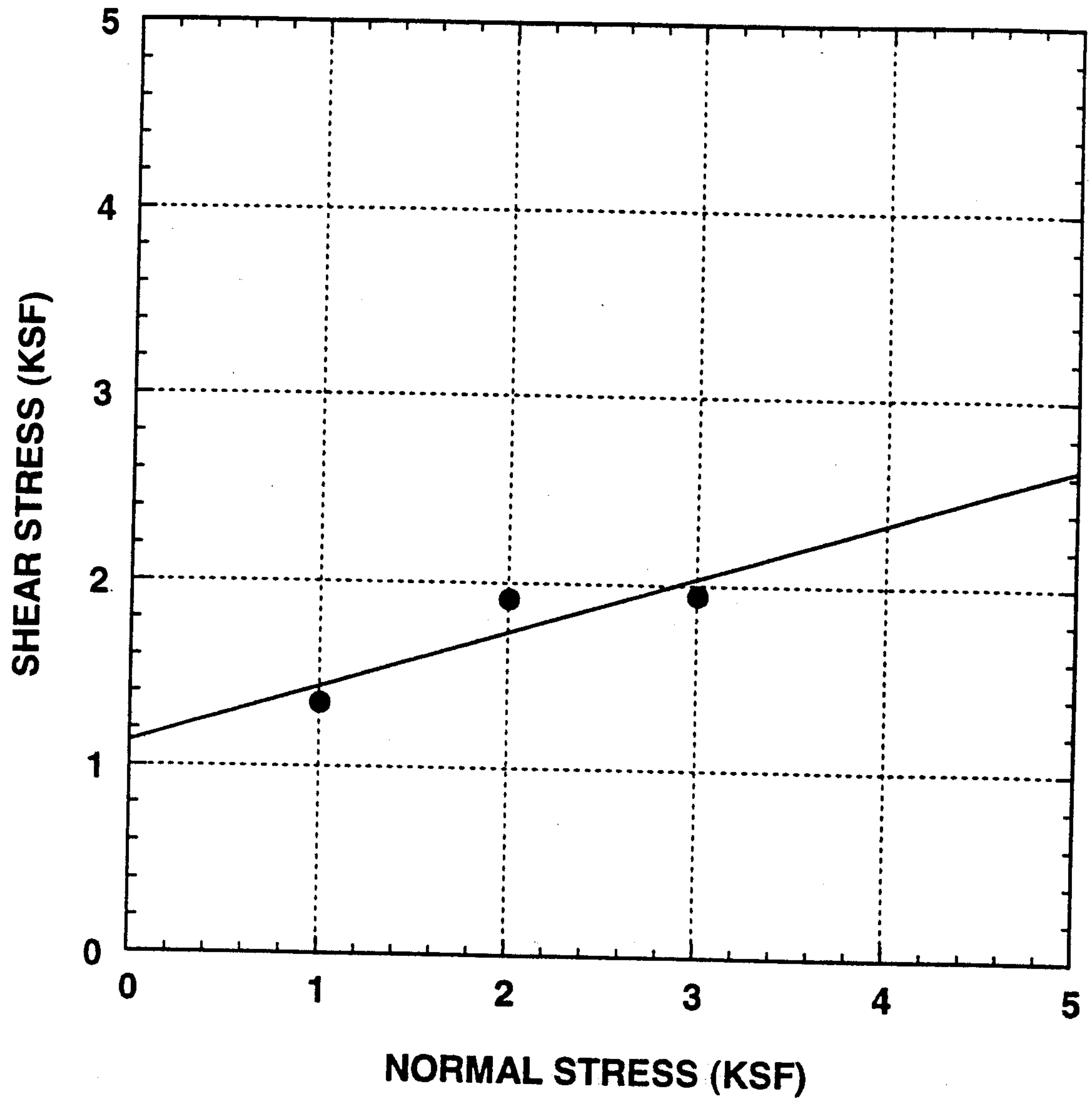
DIRECT SHEAR TEST DIAGRAM



C = 575 psf $\phi = 37°$

Test Condition: Undisturbed at Field Moisture	Location: B - 9P	Depth: 2.5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 13	

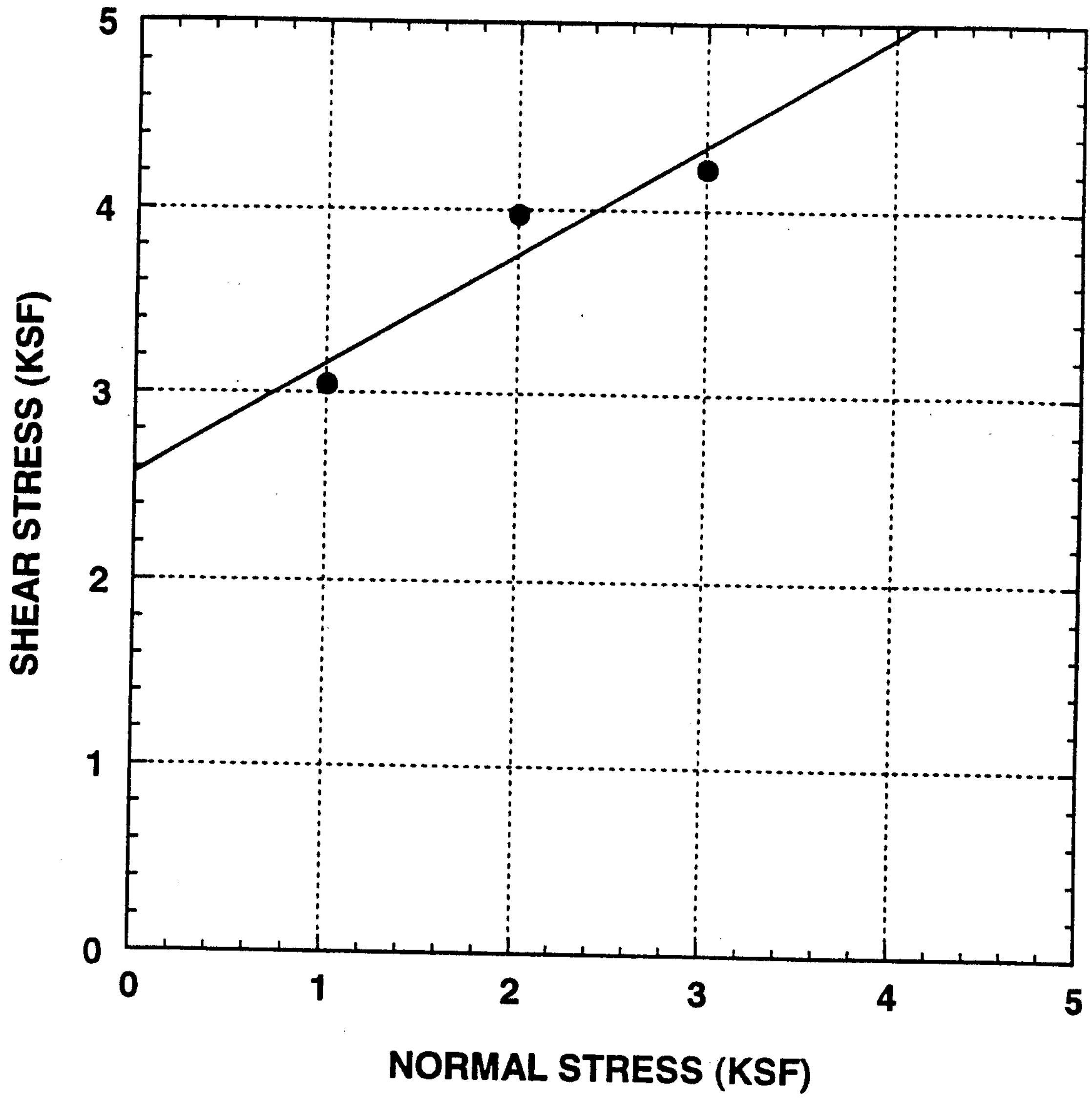
DIRECT SHEAR TEST DIAGRAM



C = 1125 psf $\phi = 17^{o}$

Test Condition: Undisturbed at Field Moisture	Location: B - 9P	Depth: 7.5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 19	

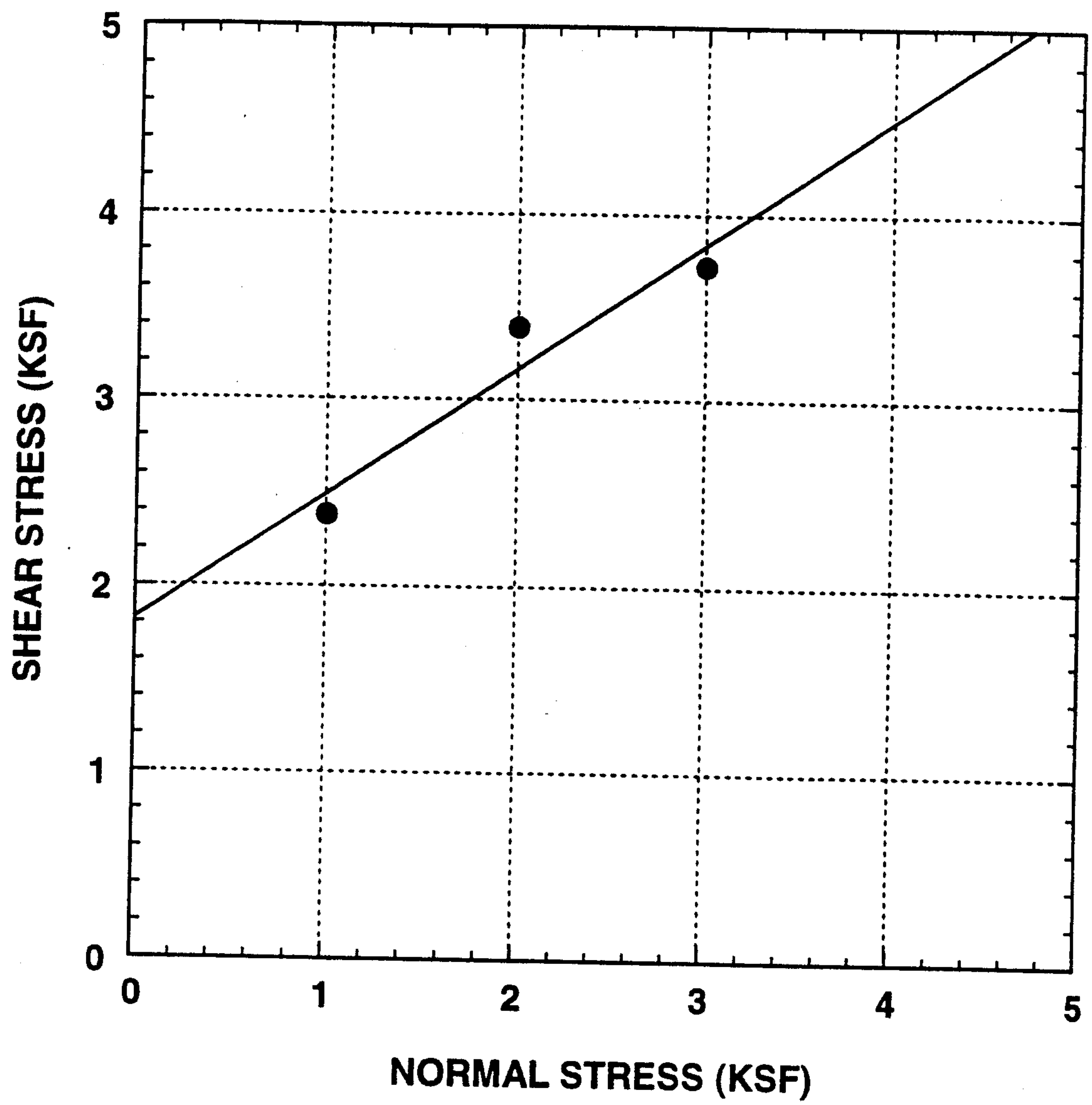
DIRECT SHEAR TEST DIAGRAM



C = 2575 psf $\phi = 30^\circ$

Test Condition: Undisturbed at Field Moisture	Location: B - 9P	Depth: 12.5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 20**	

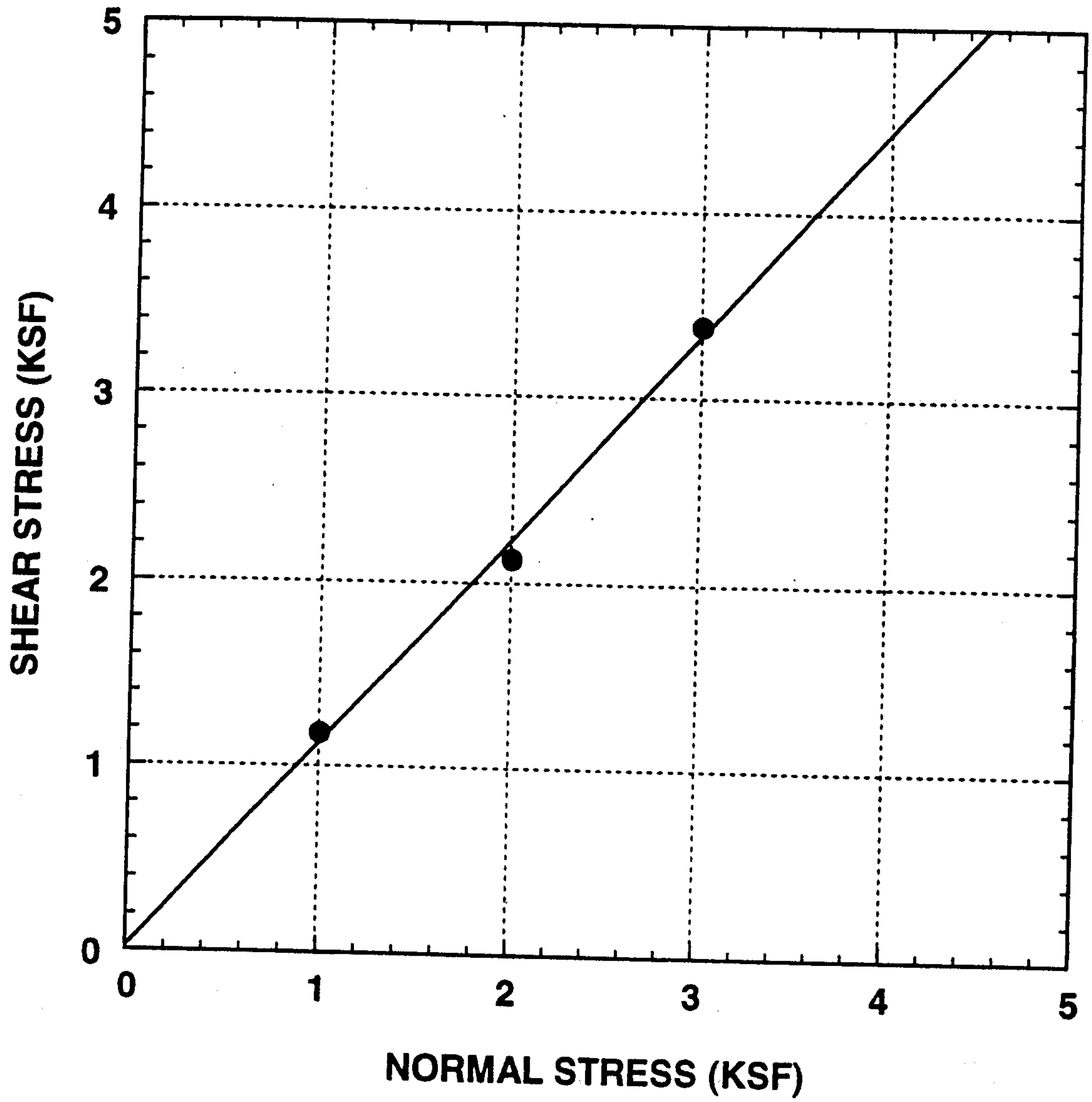
DIRECT SHEAR TEST DIAGRAM



C = 1825 psf   ϕ = 34°

Test Condition: Undisturbed at Field Moisture	Location: B - 9P	Depth: 17.5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 21**	

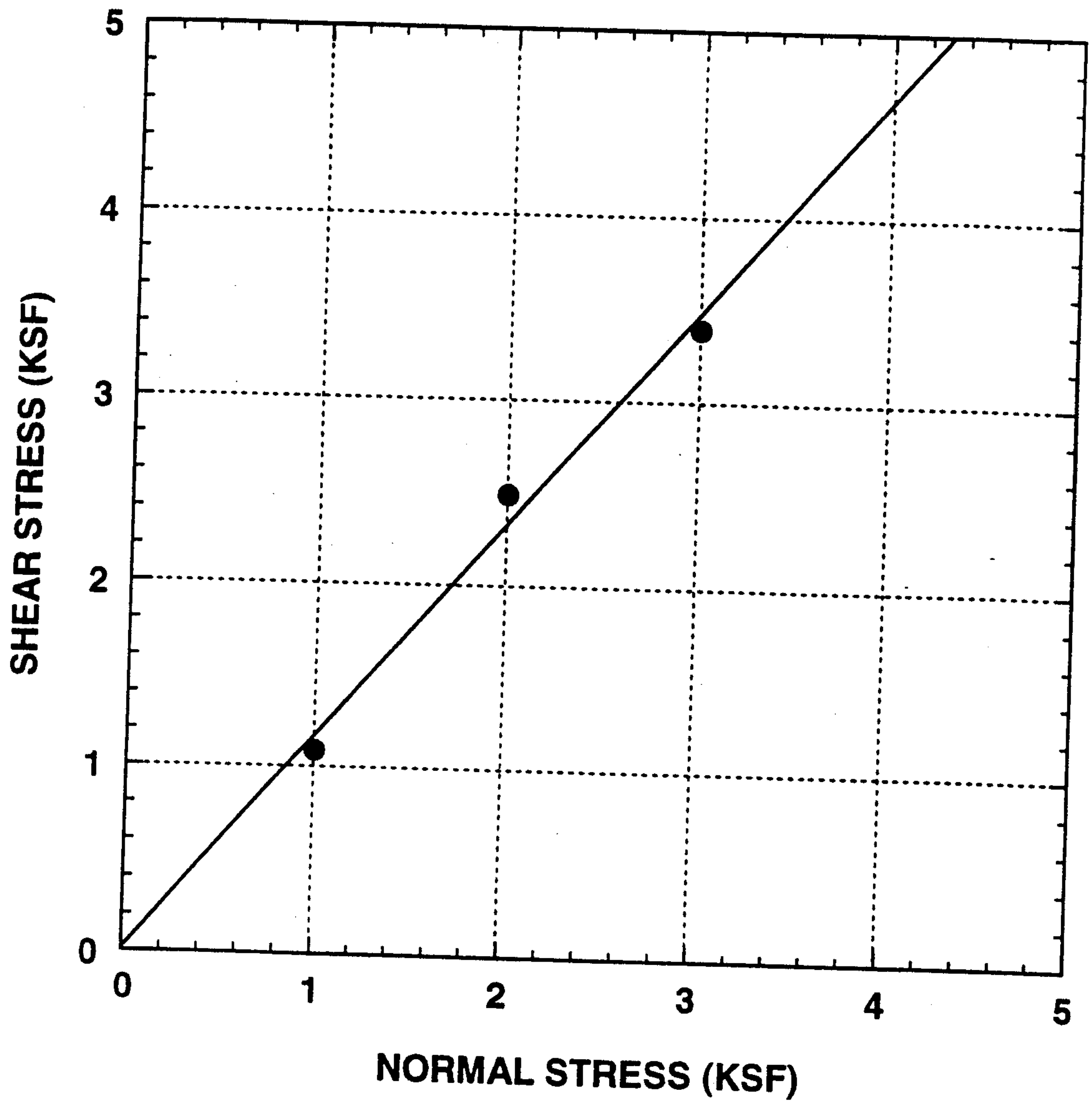
DIRECT SHEAR TEST DIAGRAM



C = 0 psf $\phi = 48°$

Test Condition: Undisturbed at Field Moisture	Location: B - 9P	Depth: 27.5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 22**	

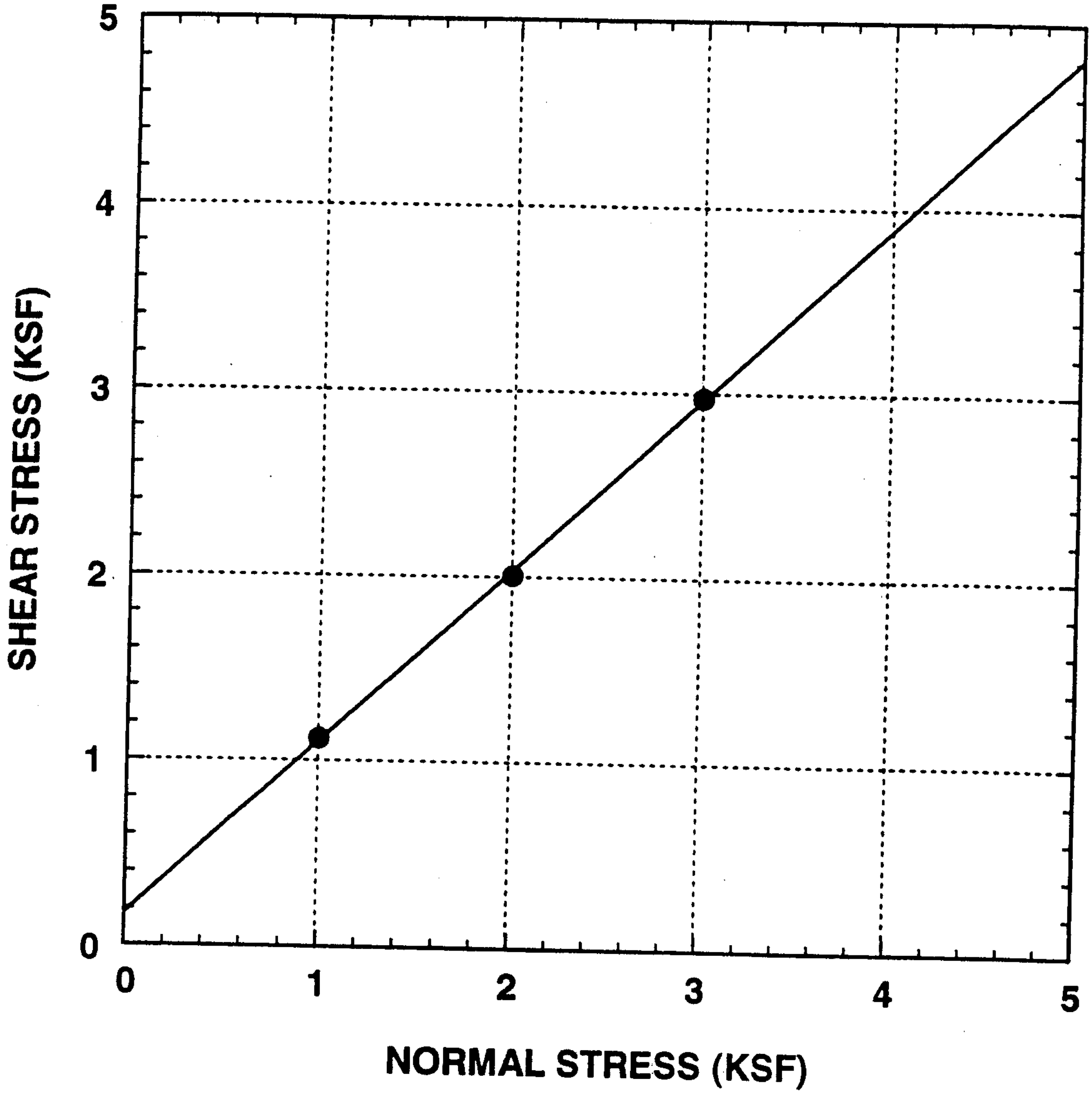
DIRECT SHEAR TEST DIAGRAM



C = 0 psf $\phi = 49°$

Test Condition: Undisturbed at Field Moisture	Location: B - 9P	Depth: 32.5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 23**	

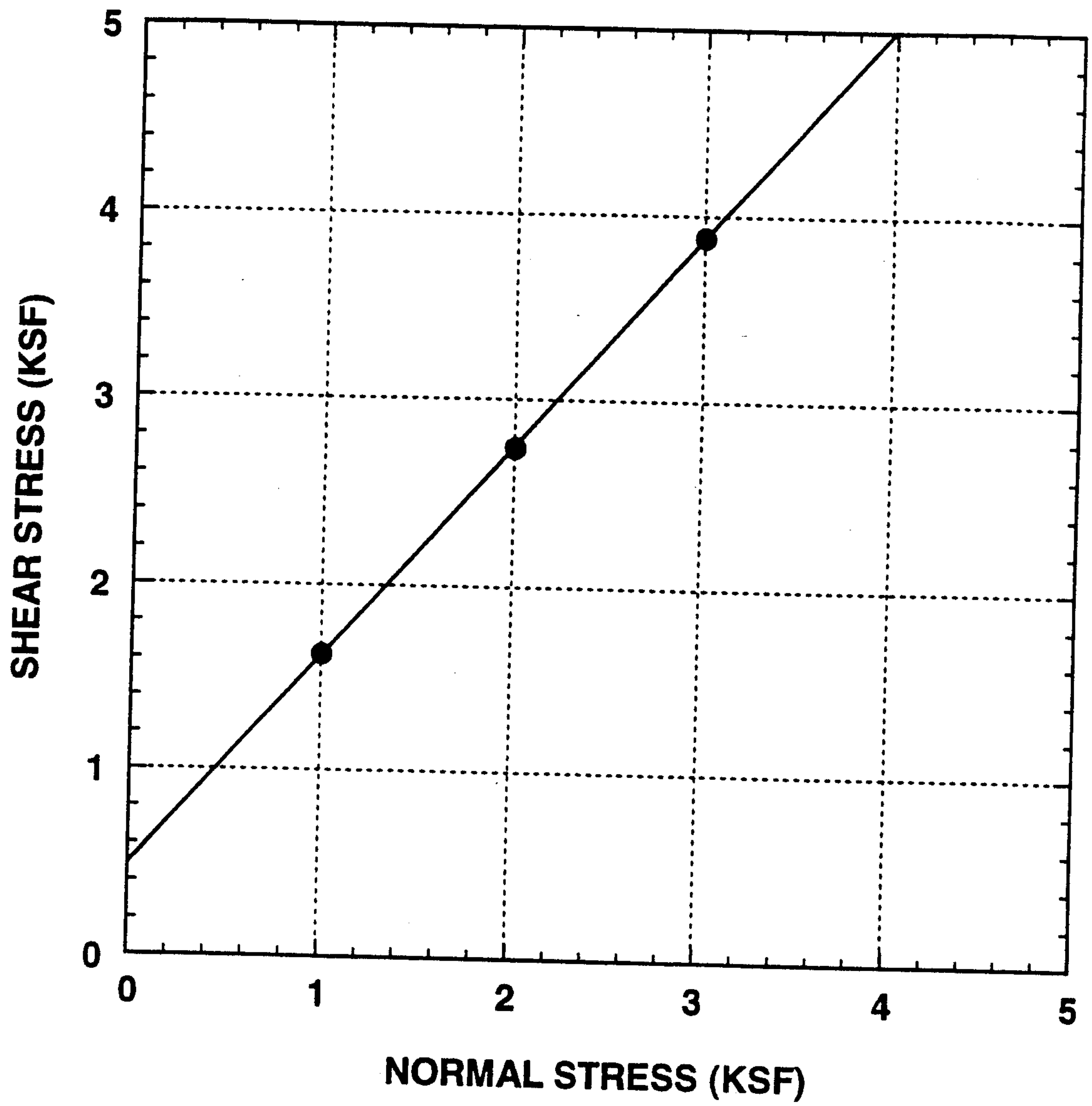
DIRECT SHEAR TEST DIAGRAM



C = 175 psf $\phi = 43°$

Test Condition: Undisturbed at Field Moisture	Location: B - 9P	Depth: 37.5'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 24	

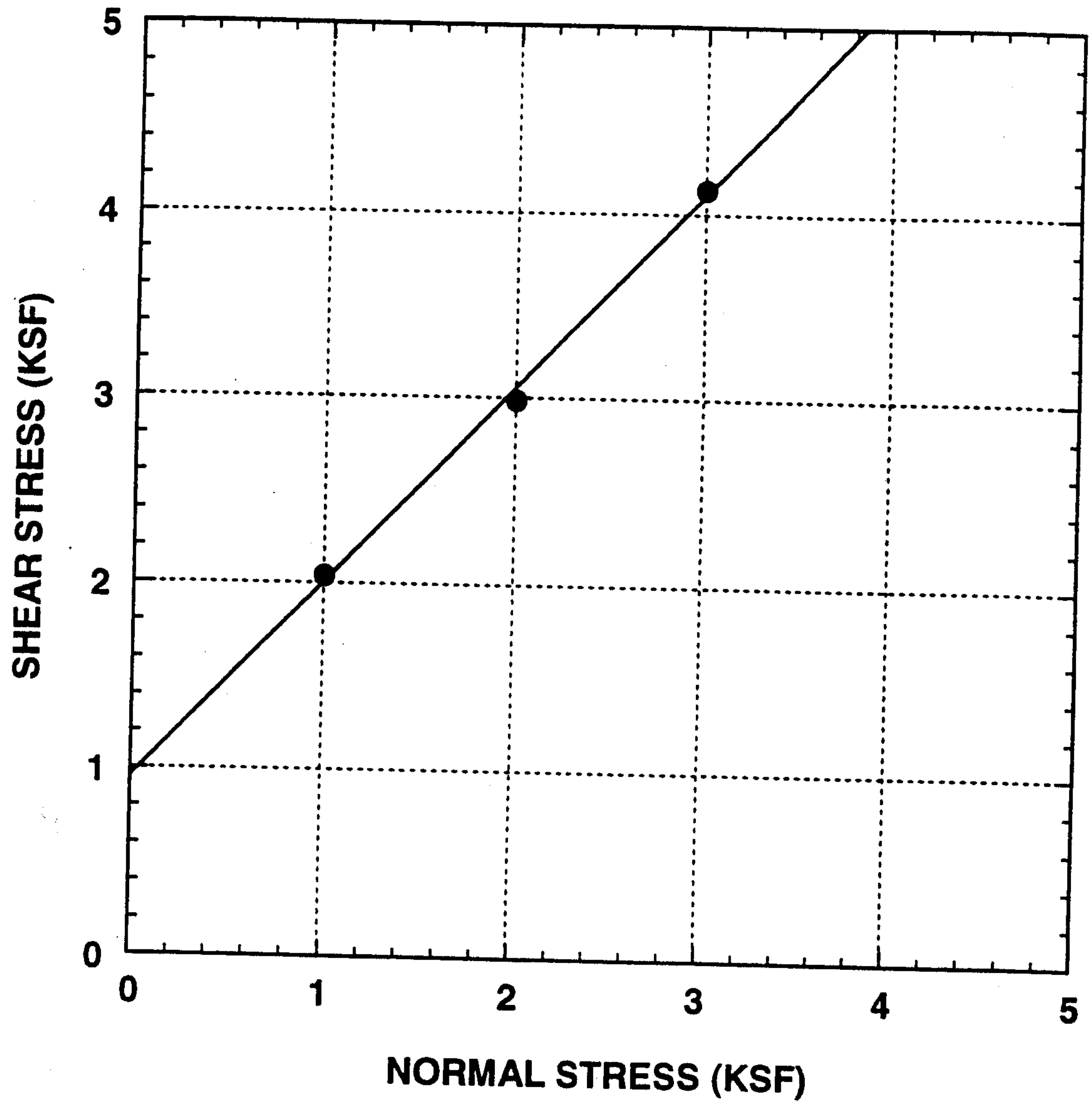
DIRECT SHEAR TEST DIAGRAM



C = 500 psf $\phi = 48°$

Test Condition: Undisturbed at Field Moisture	Location: B - 9P	Depth: 45'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 25**	

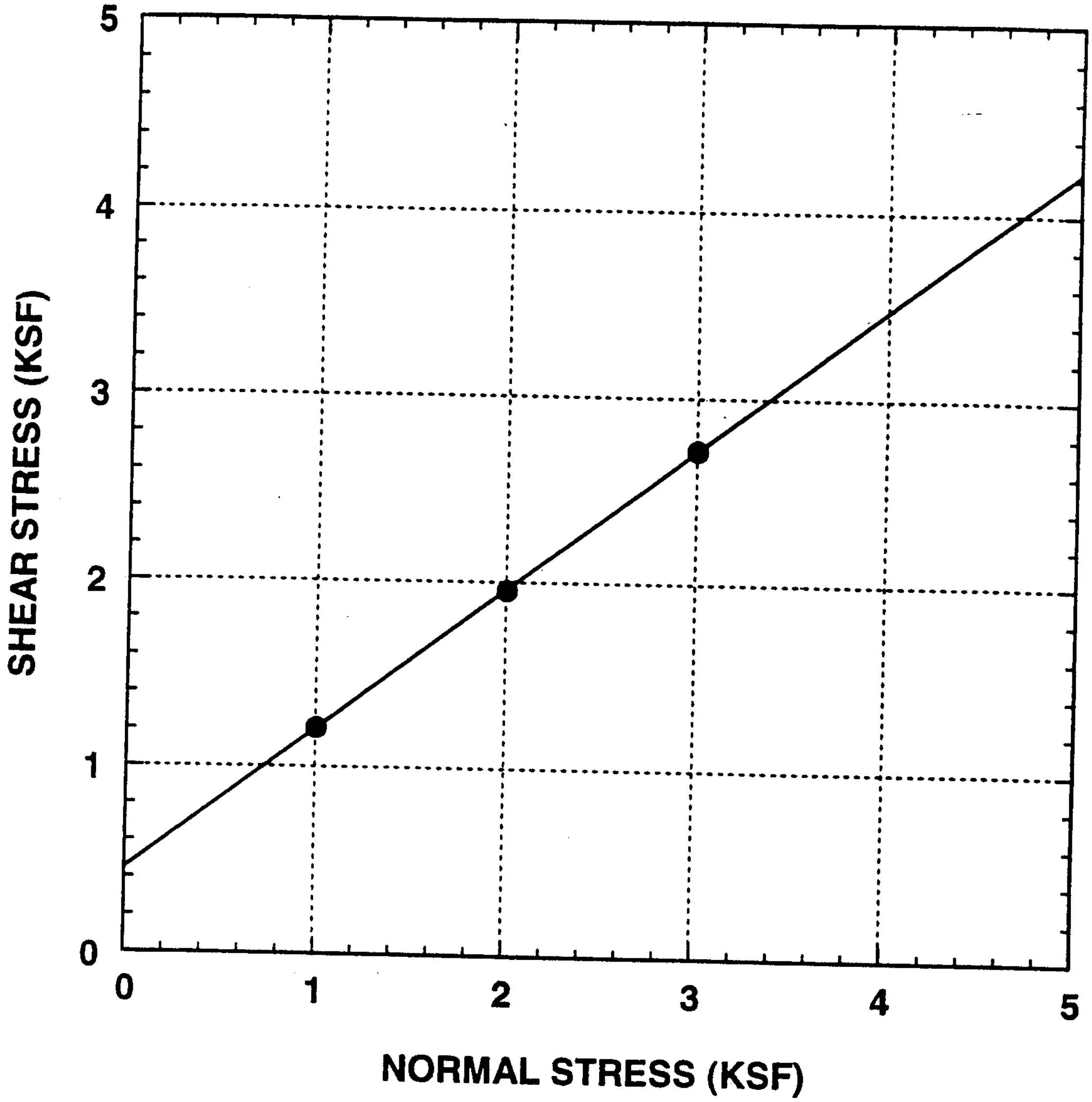
DIRECT SHEAR TEST DIAGRAM



C = 950 psf $\phi = 46^{\circ}$

Test Condition: Undisturbed at Field Moisture	Location: B - 10	Depth: 10'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 26**	

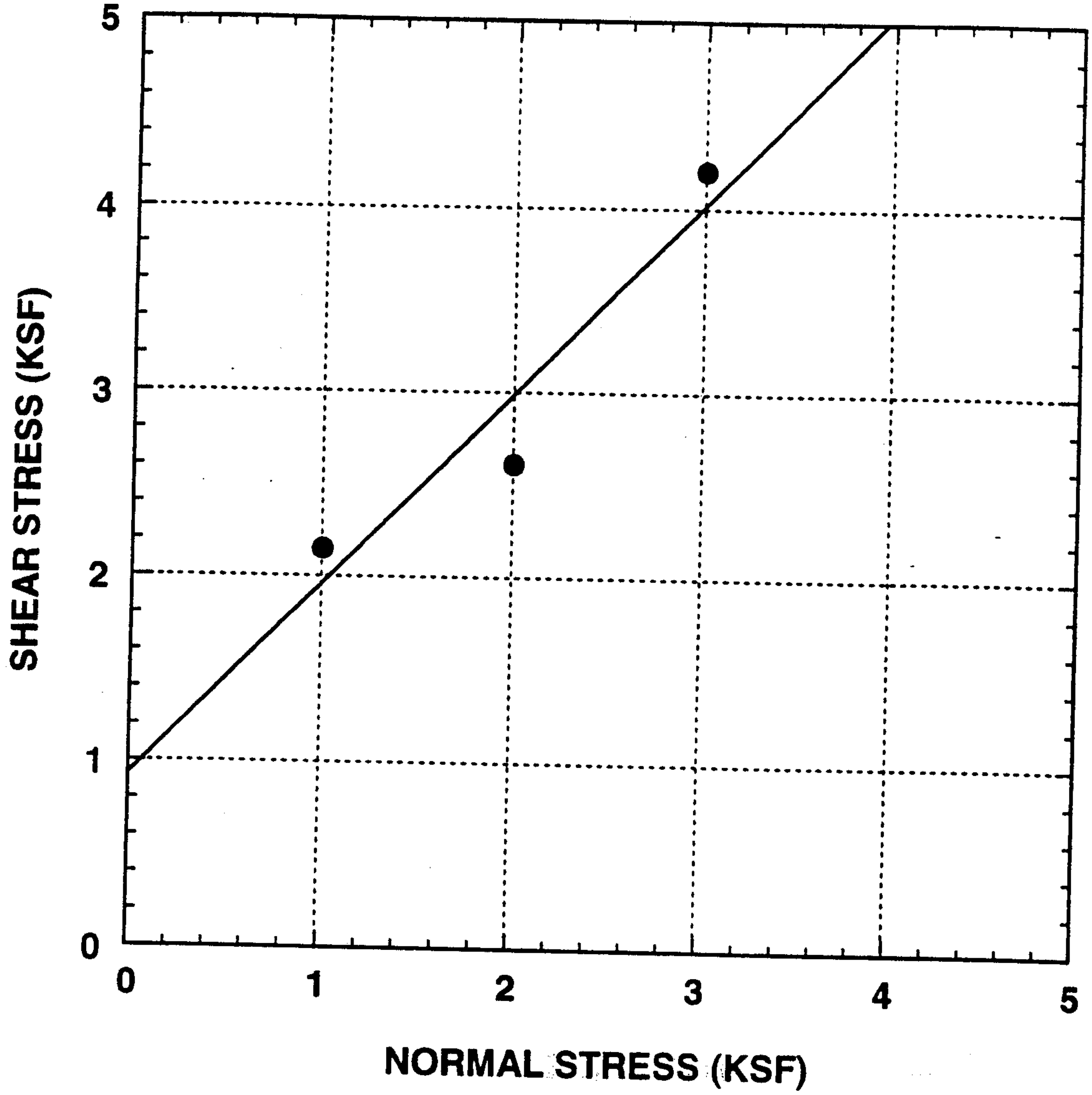
DIRECT SHEAR TEST DIAGRAM



C = 450 psf $\phi = 37^\circ$

Test Condition: Undisturbed at Field Moisture	Location: B - 13	Depth: 10'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 27**	

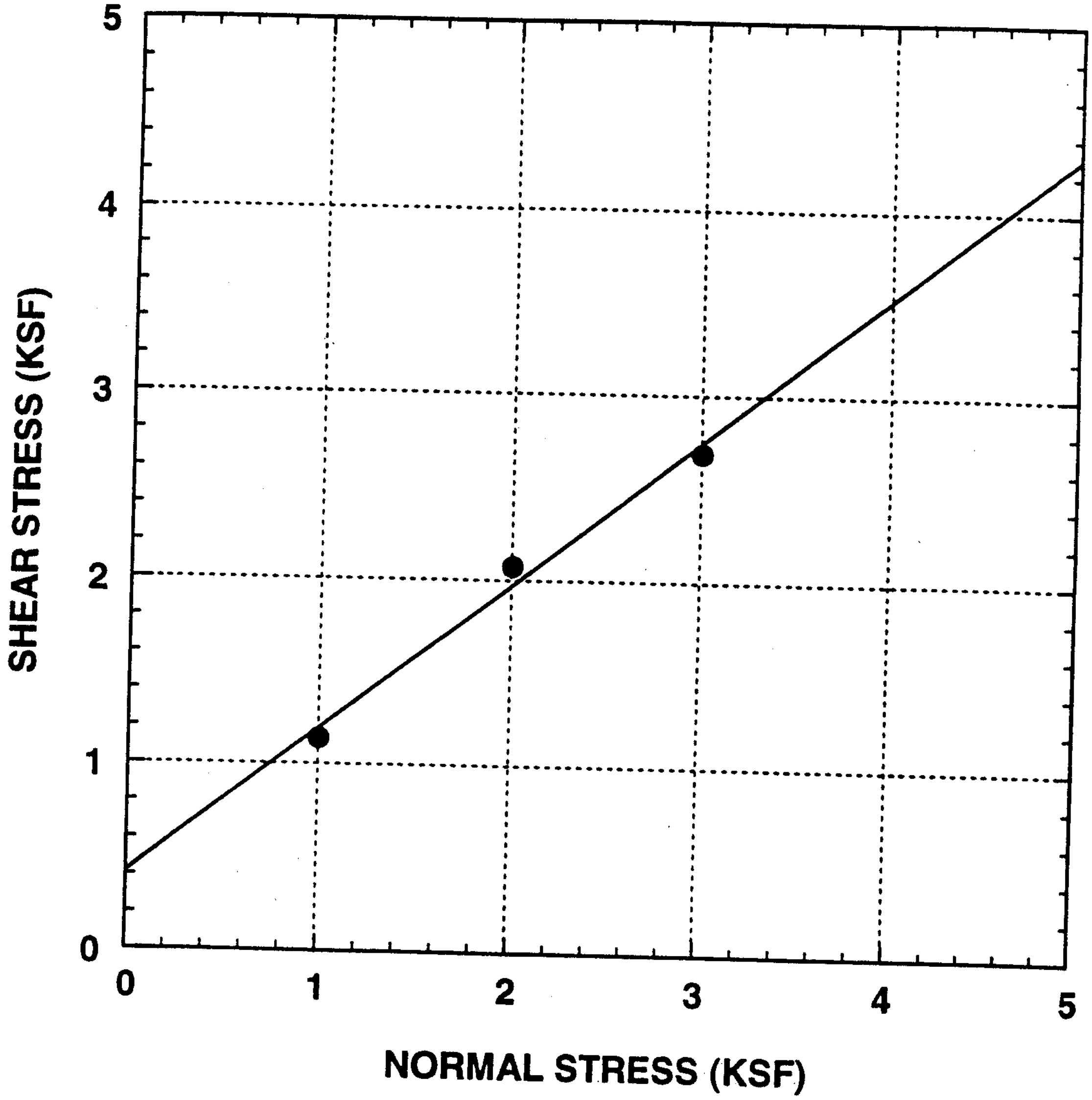
DIRECT SHEAR TEST DIAGRAM



C = 925 psf $\phi = 46^\circ$

Test Condition: Undisturbed at Field Moisture	Location: B - 13	Depth: 15'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 23	

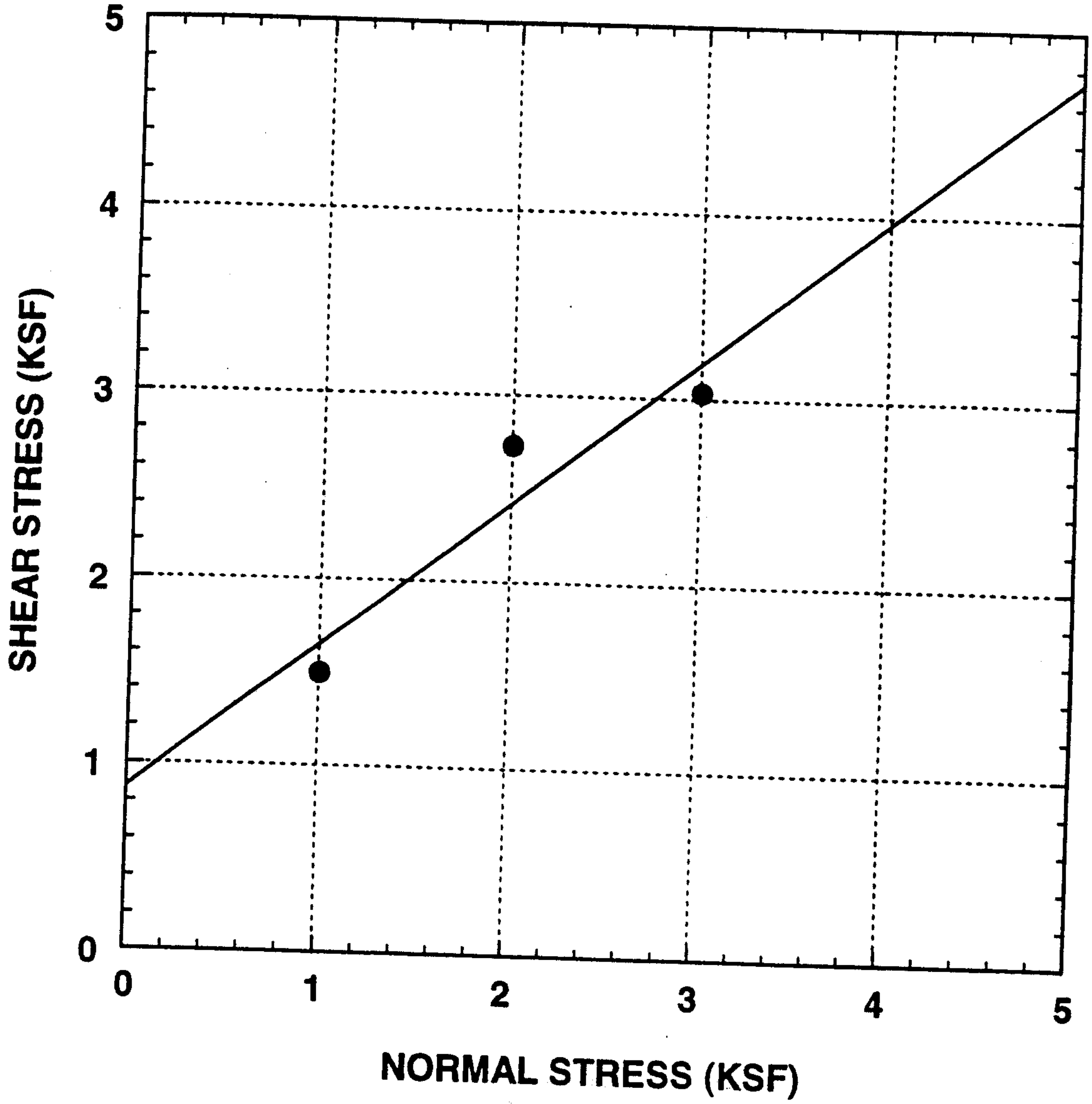
DIRECT SHEAR TEST DIAGRAM



C = 400 psf $\phi = 38°$

Test Condition: Undisturbed at Field Moisture	Location: B - 13	Depth: 25'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 29**	

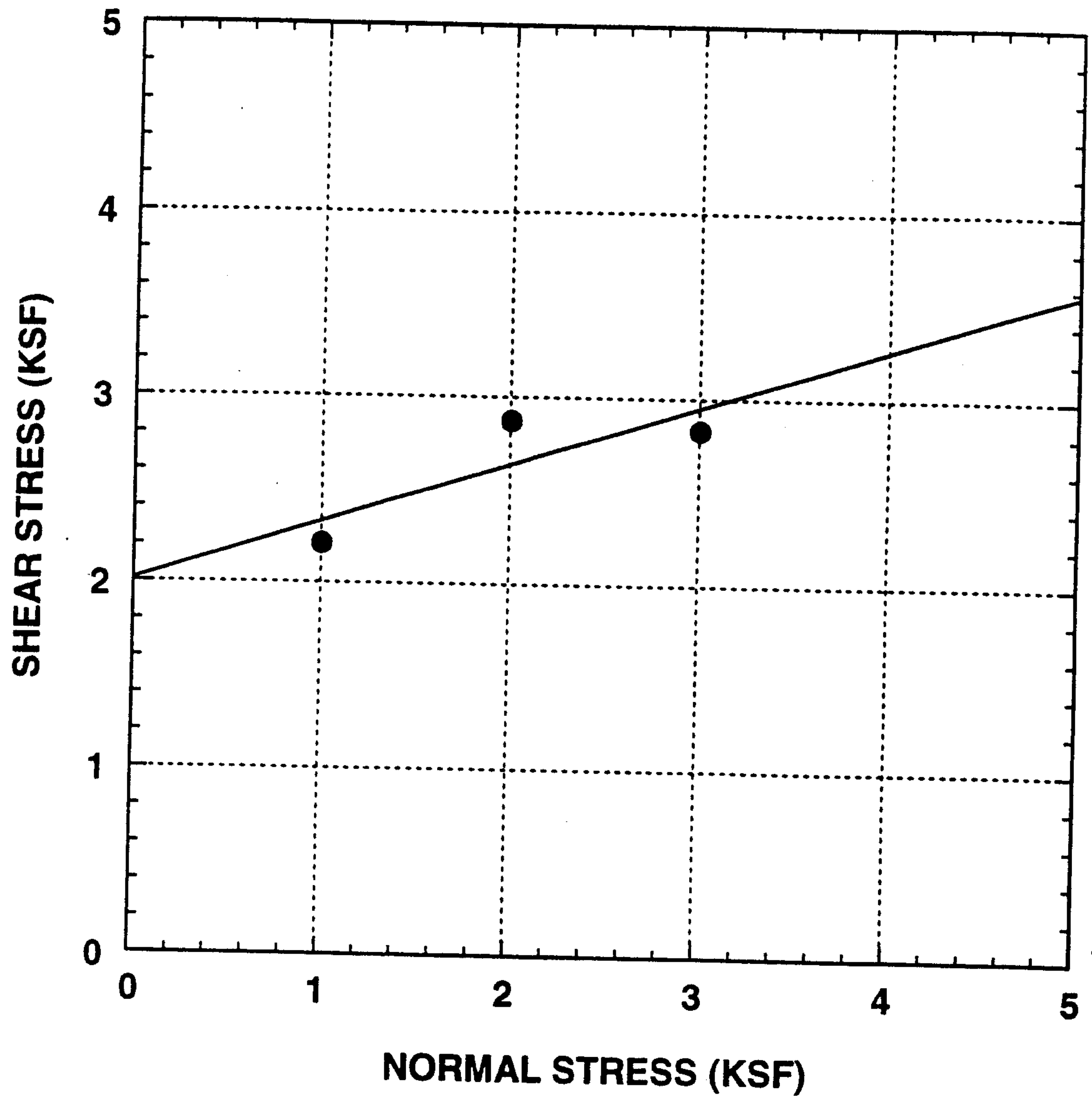
DIRECT SHEAR TEST DIAGRAM



C = 875 psf $\phi = 38°$

Test Condition: Undisturbed at Field Moisture	Location: B - 13	Depth: 30'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 30	

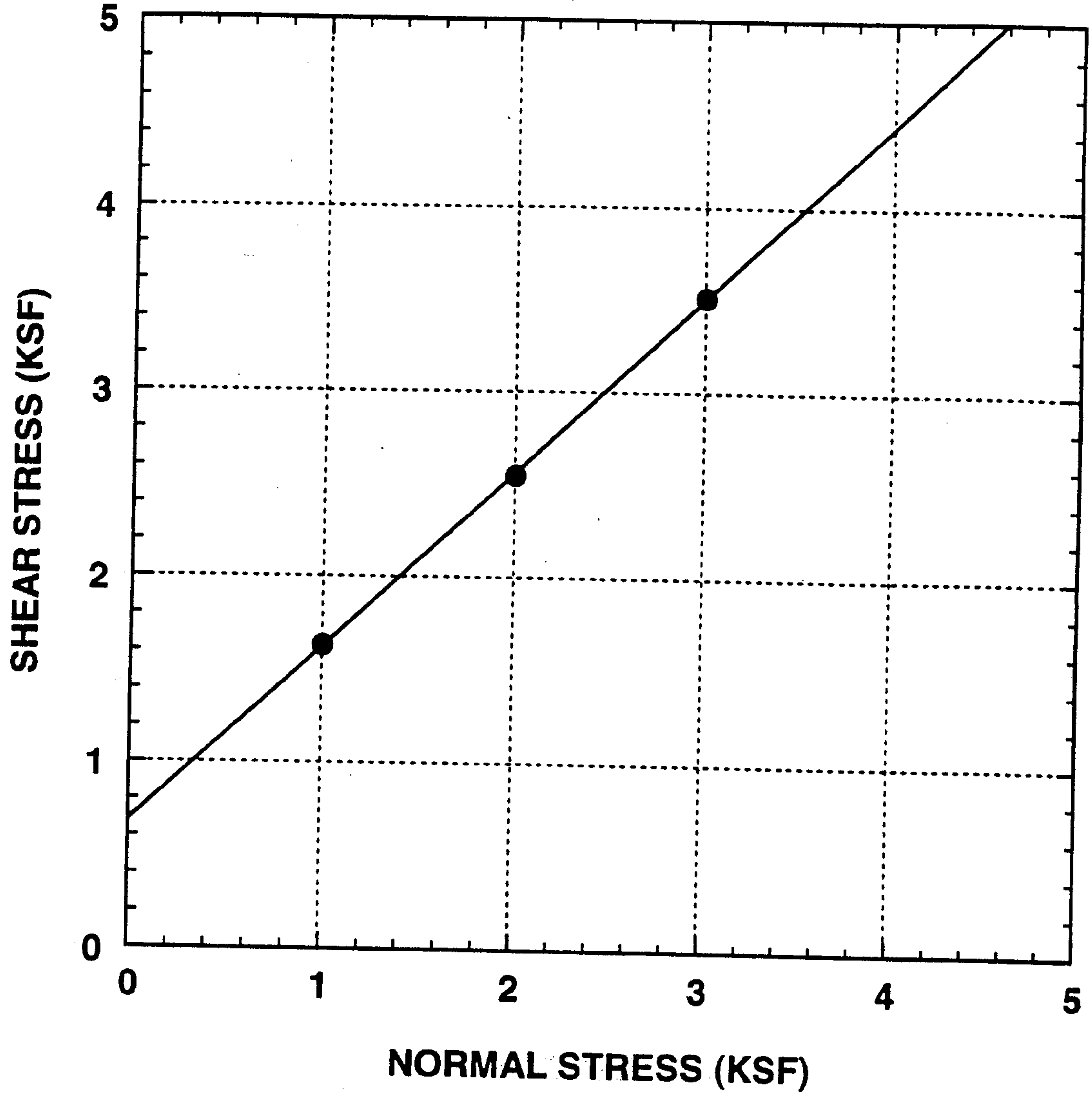
DIRECT SHEAR TEST DIAGRAM



C = 2000 psf $\phi = 17°$

Test Condition: Undisturbed at Field Moisture	Location: B - 13	Depth: 35'
'roject Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 31	

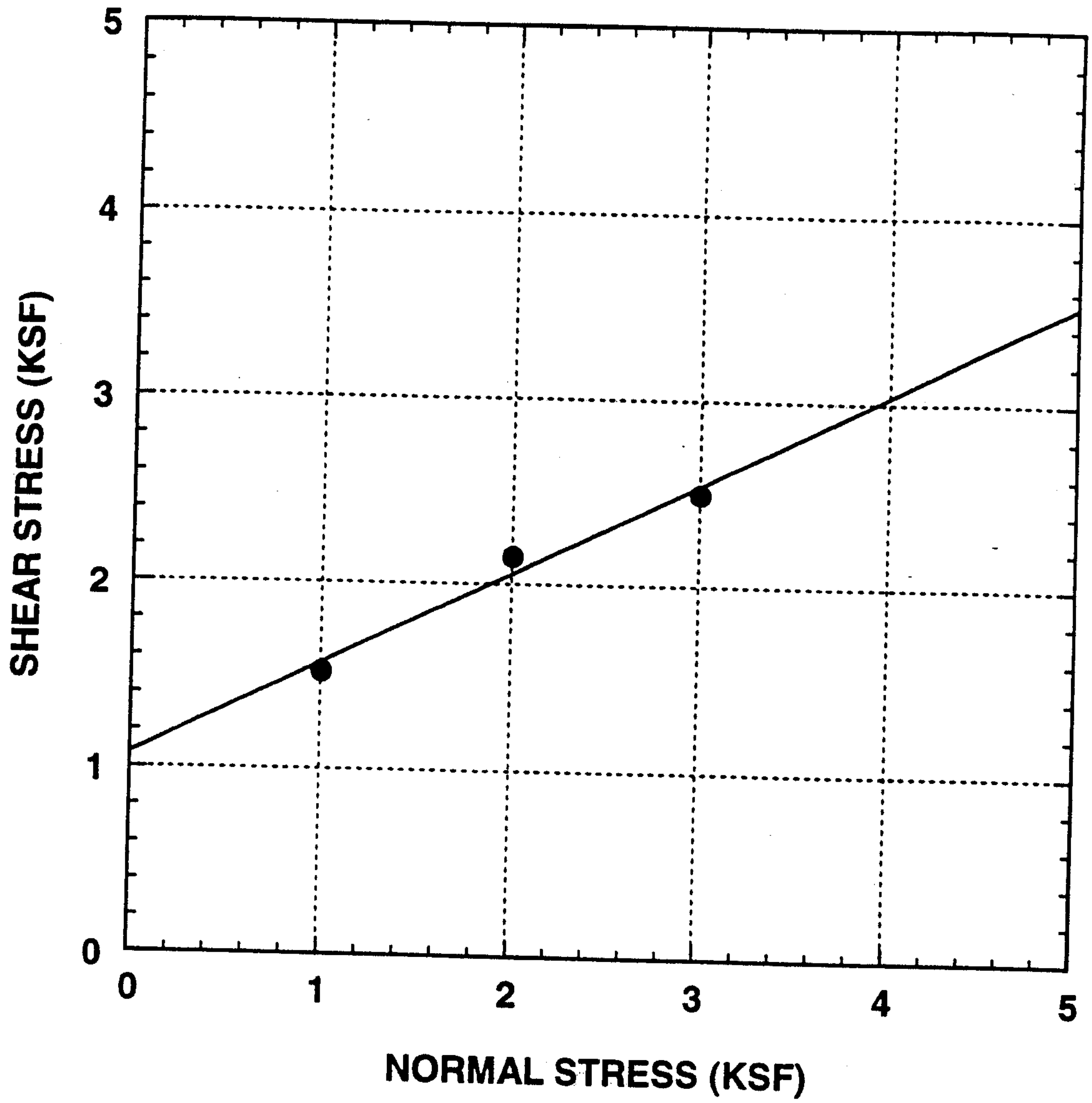
DIRECT SHEAR TEST DIAGRAM



C = 675 psf $\phi = 43^\circ$

Test Condition: Undisturbed at Field Moisture	Location: B - 13	Depth: 45'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 32**	

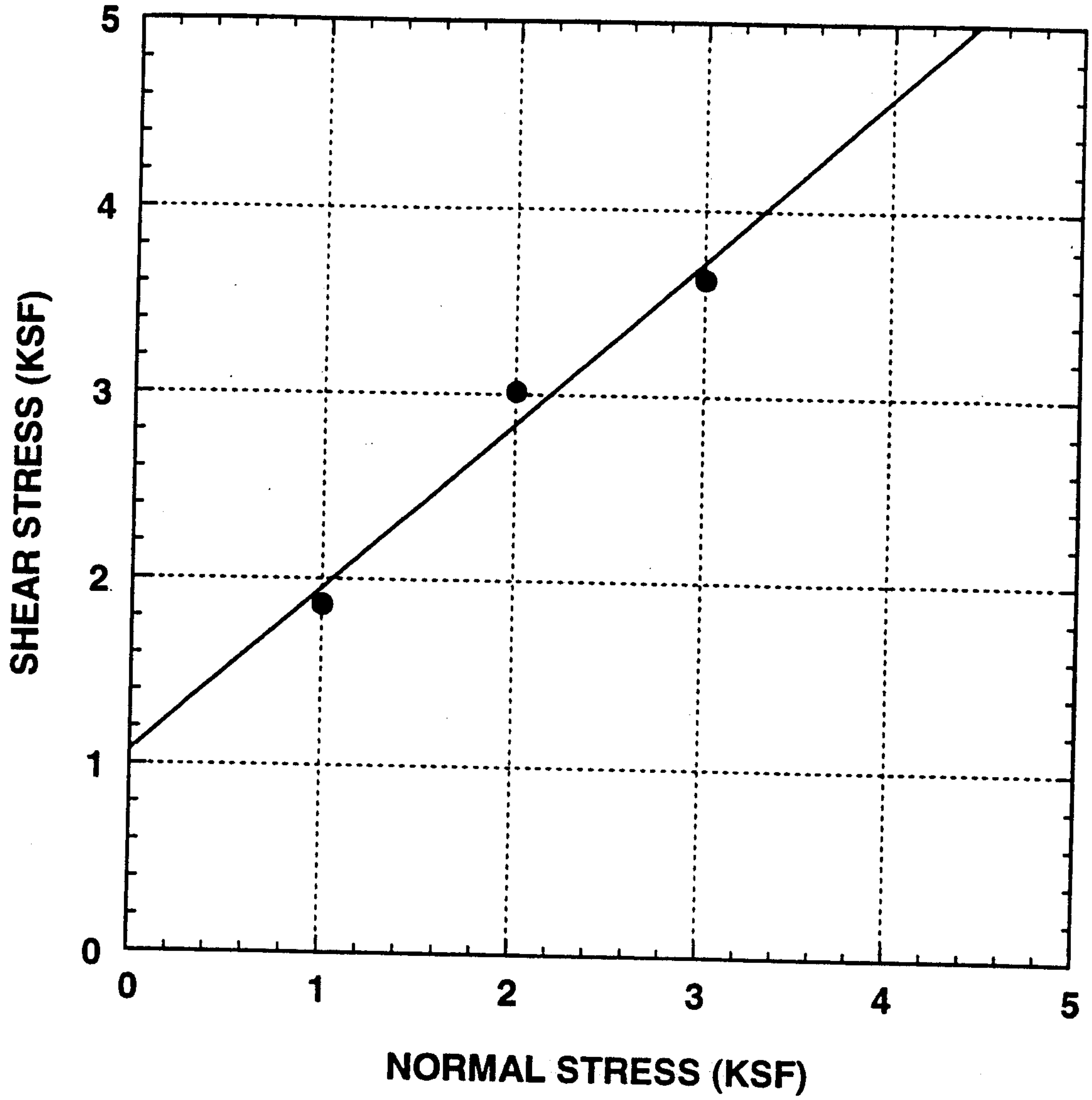
DIRECT SHEAR TEST DIAGRAM



C = 1075 psf $\phi = 26°$

Test Condition: Undisturbed at Field Moisture - Residual	Location: B - 13	Depth: 45'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 33	

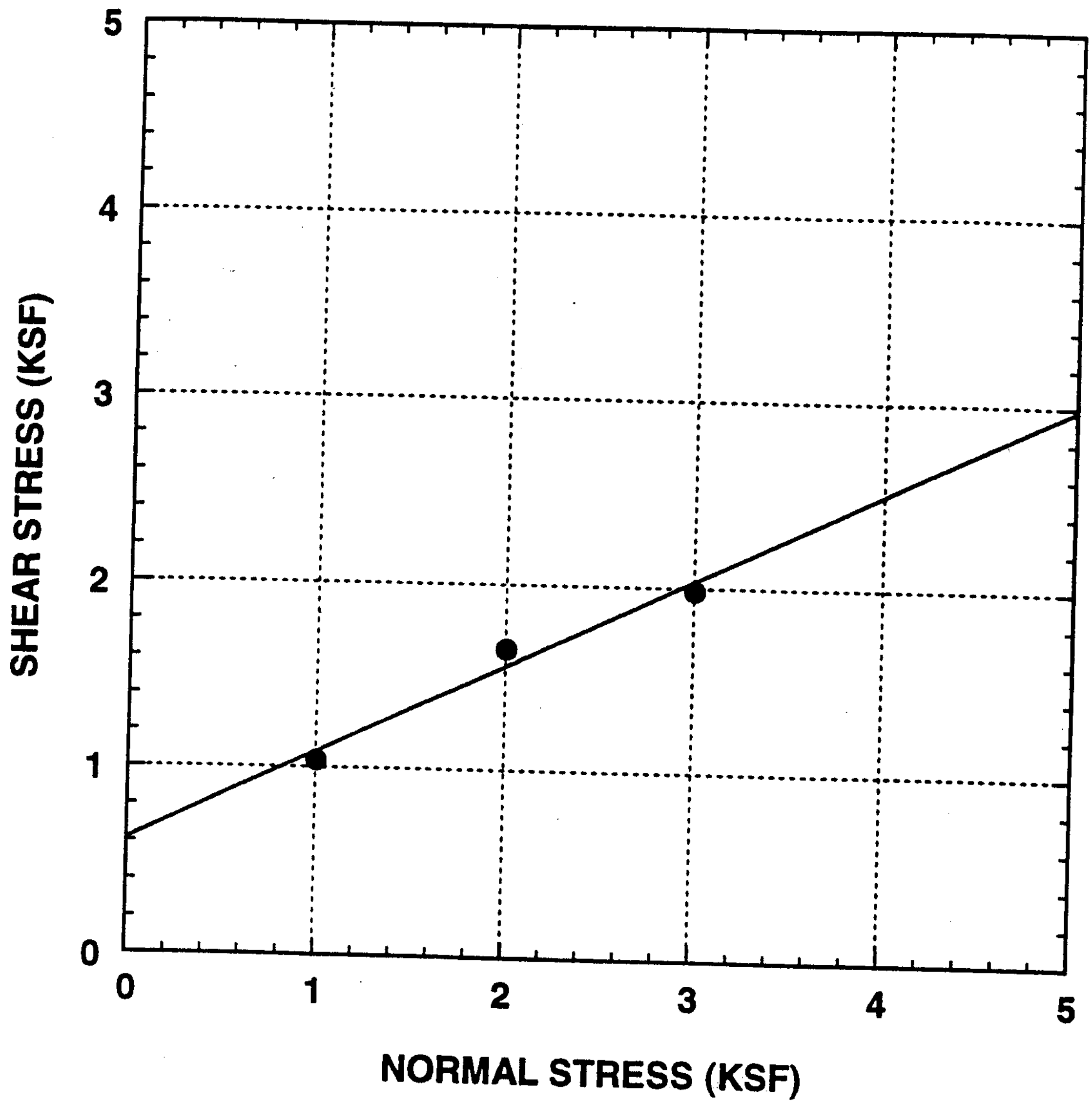
DIRECT SHEAR TEST DIAGRAM



C = 1075 psf $\phi = 41°$

Test Condition: Undisturbed at Field Moisture	Location: B - 13	Depth: 55'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 34**	

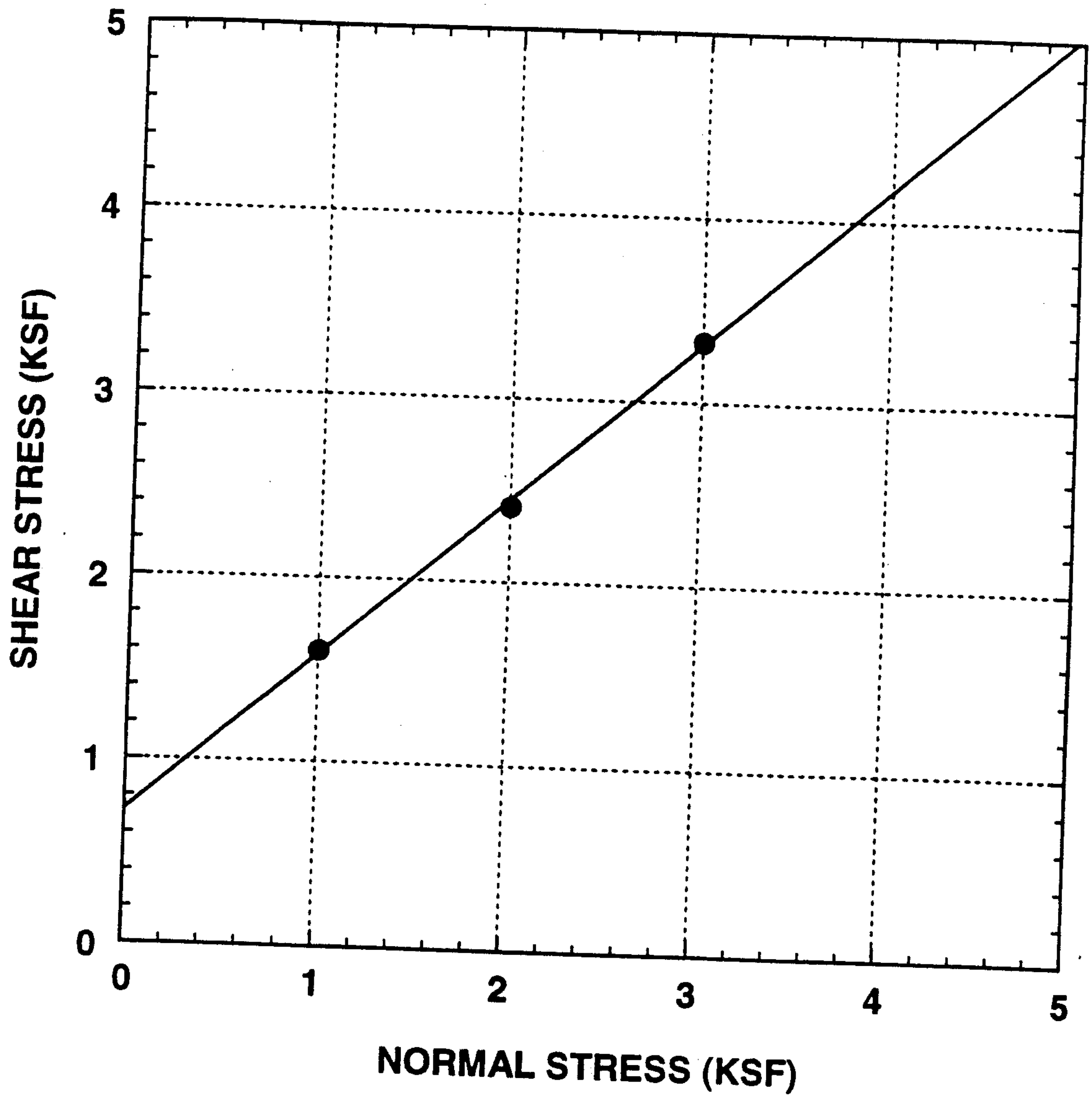
DIRECT SHEAR TEST DIAGRAM



C = 600 psf $\phi = 25^{\circ}$

Test Condition: Undisturbed at Field Moisture - Residual	Location: B - 13	Depth: 55'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 35	

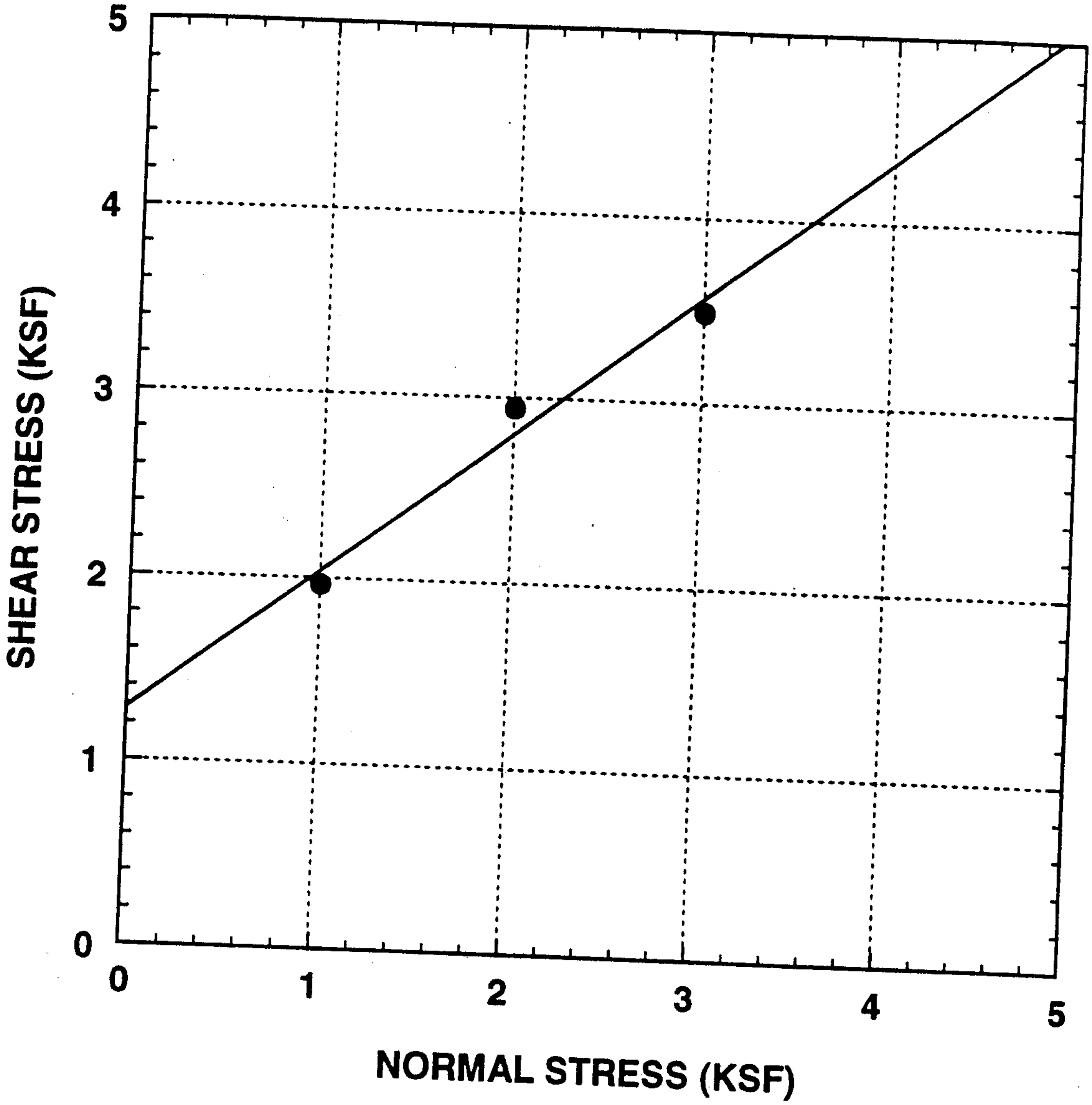
DIRECT SHEAR TEST DIAGRAM



C = 725 psf $\phi = 40^\circ$

Test Condition: Undisturbed at Field Moisture	Location: B - 14	Depth: 20'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 36**	

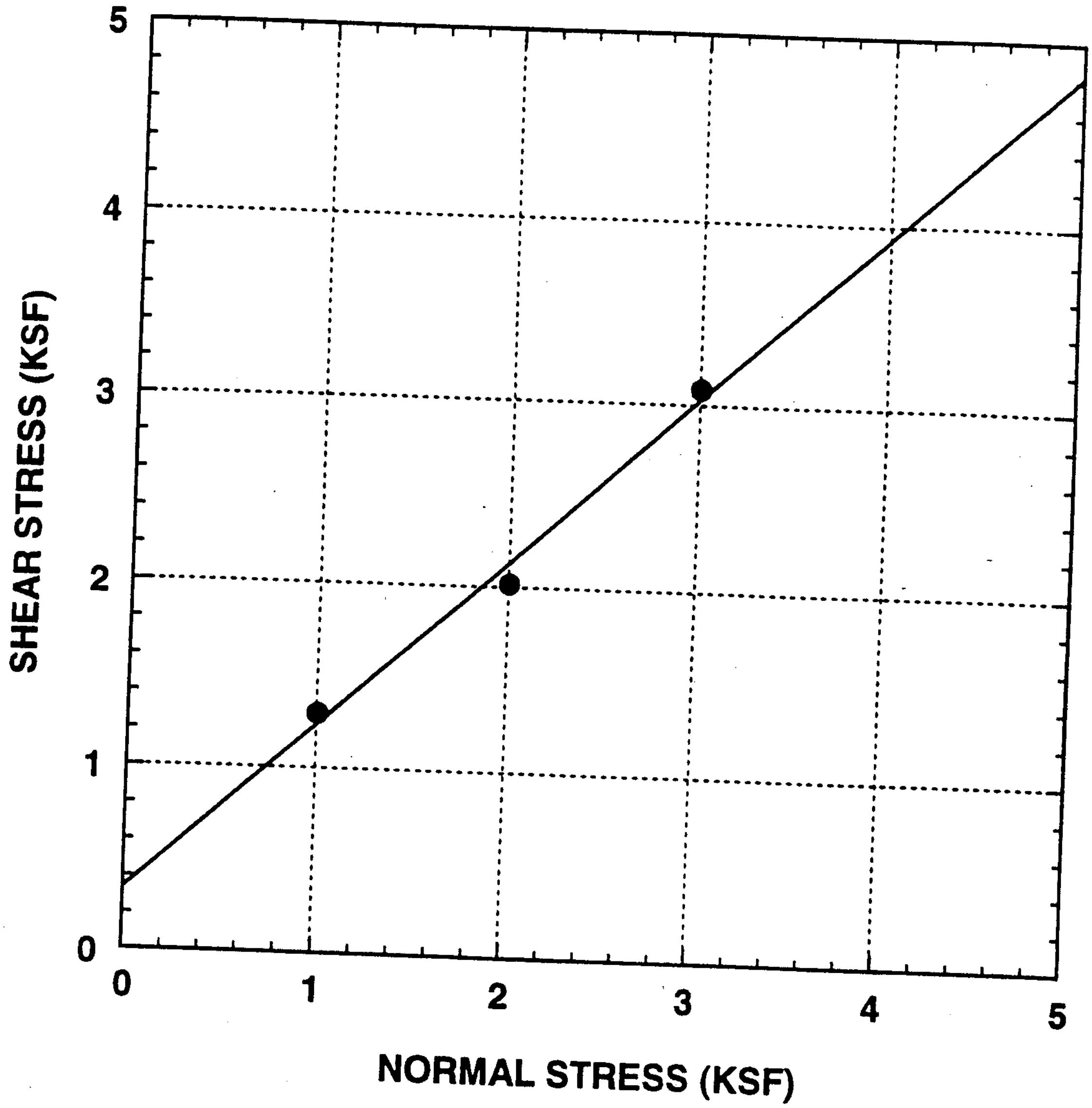
DIRECT SHEAR TEST DIAGRAM



C = 1275 psf $\phi = 37°$

Test Condition: Undisturbed at Field Moisture	Location: B - 14	Depth: 30'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 37**	

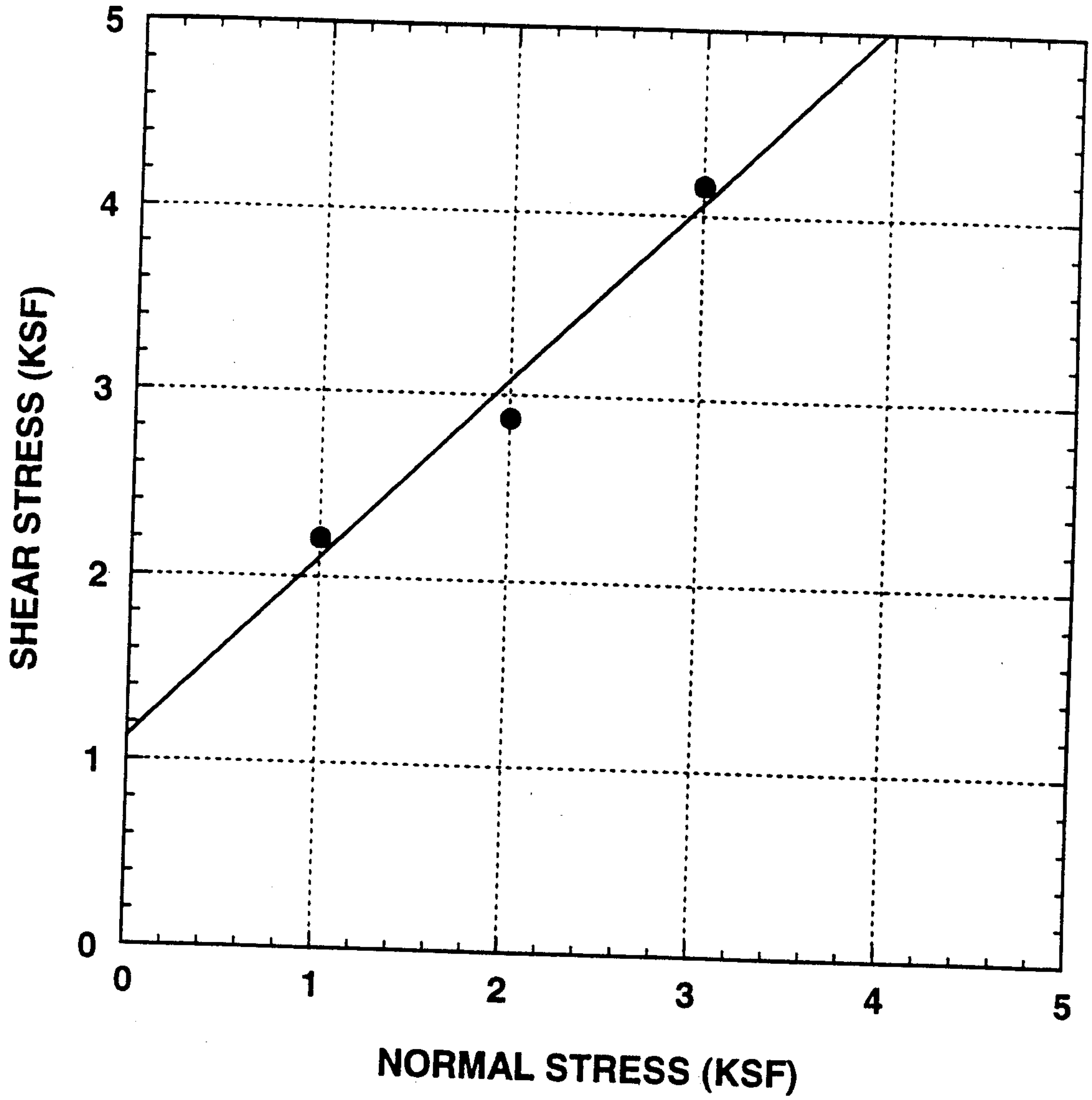
DIRECT SHEAR TEST DIAGRAM



C = 350 psf $\phi = 42°$

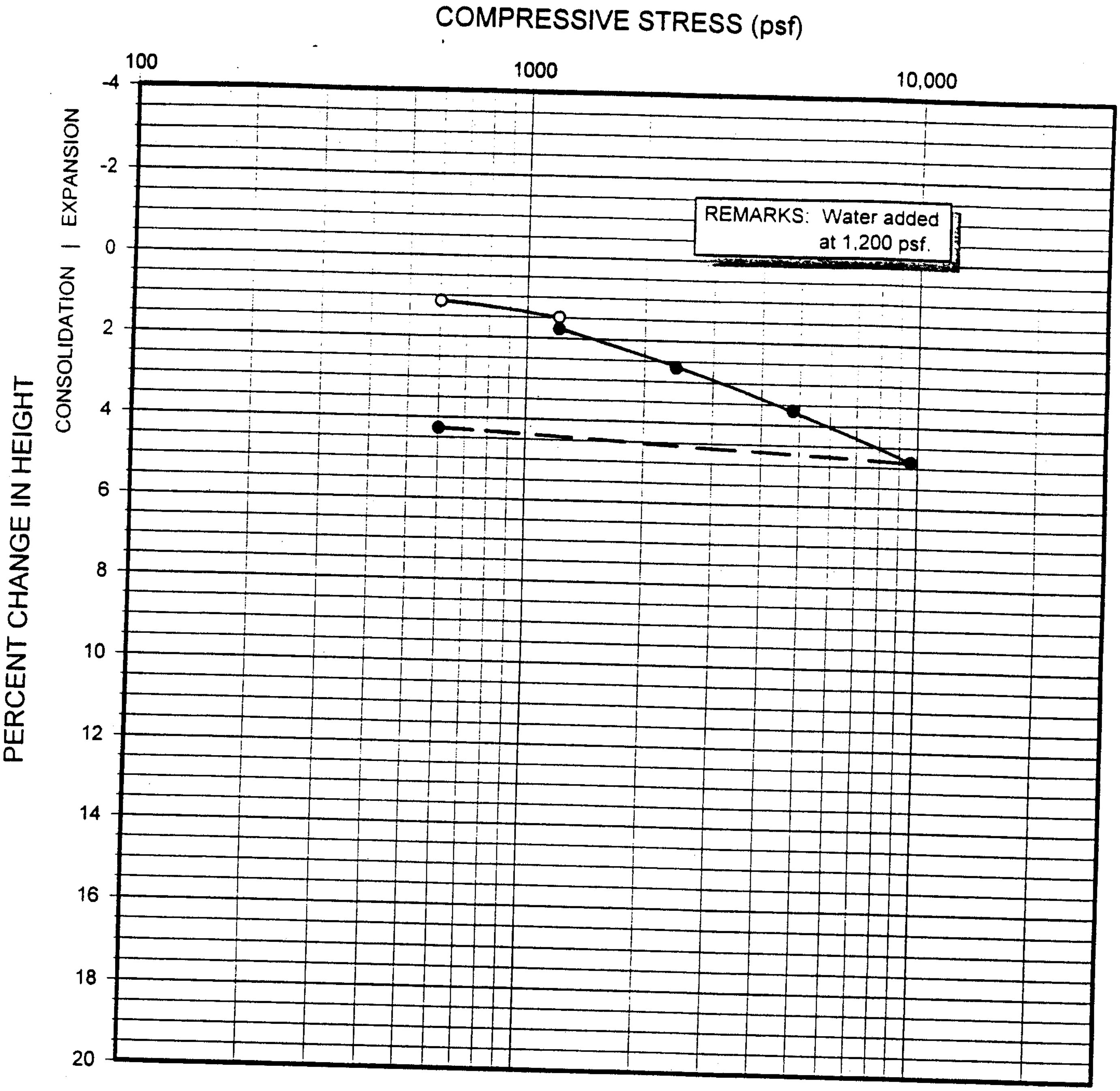
Test Condition: Undisturbed at Field Moisture	Location: B - 14	Depth: 45'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	Figure: B - 38	

DIRECT SHEAR TEST DIAGRAM



C = 1125 psf $\phi = 44°$

Test Condition: Undisturbed at Field Moisture	Location: B - 14	Depth: 50'
Project Name: North County Transit District - Del Mar	Project No.: 3650 - SF	
Medall, Aragón, Higley, Geotechnical, Inc.	**Figure: B - 39**	



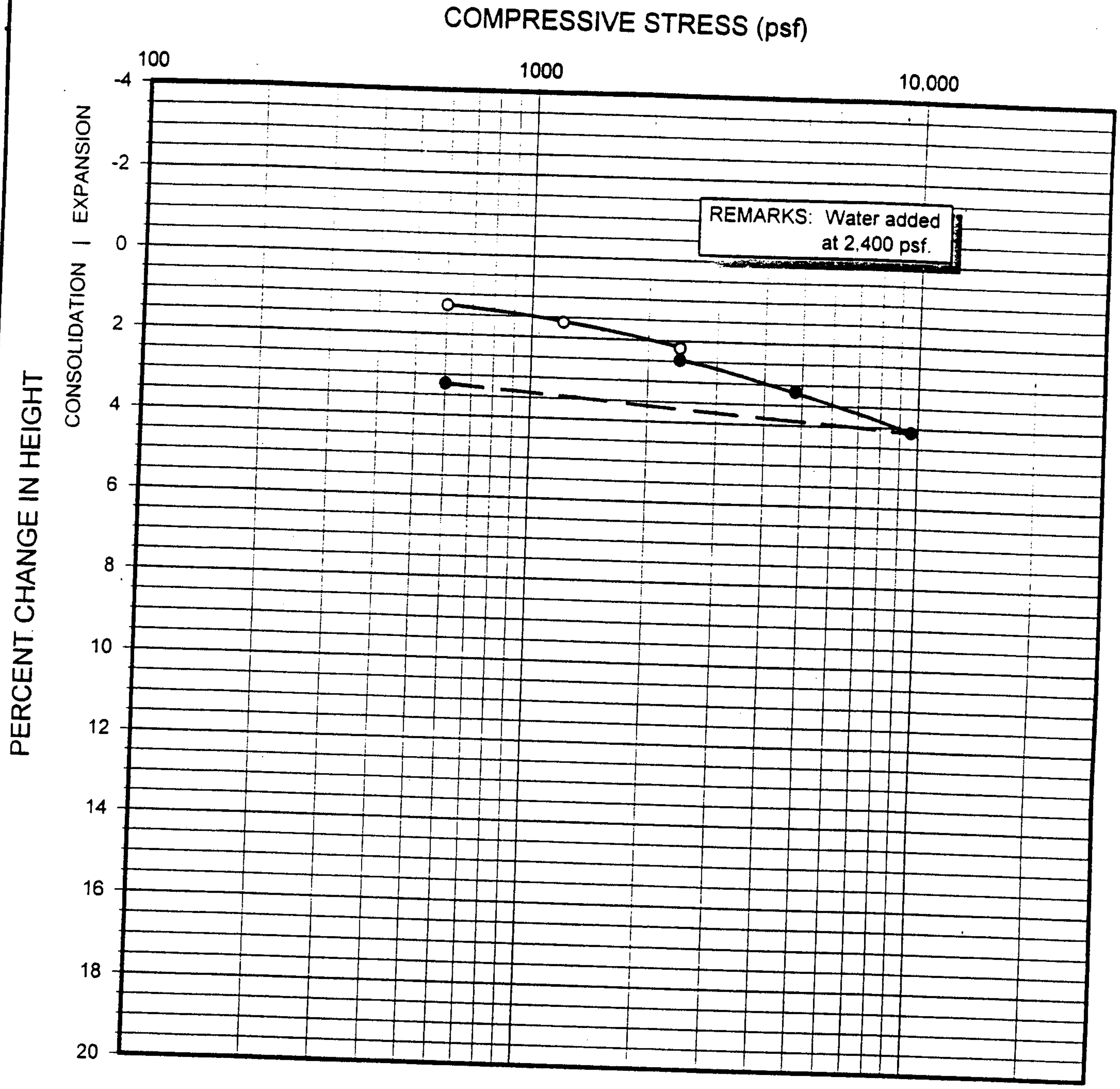
Boring: B - 2	Depth (ft.): 10.0	Dry Density (pcf): 108.6	Moisture (%): 13.0	Saturation (%): 66
Sample Description: Clayey Sand (SP-SC), fine to medium grained. [Fill]				

Medall, Aragon, Higley Geotechnical, Inc.

CONSOLIDATION CURVE

NORTH COUNTY TRANSIT DISTRICT, DEL MAR RAIL LINE

PROJECT NO. 3650-SF	DATE: 6/18/98	**FIG. B-40**



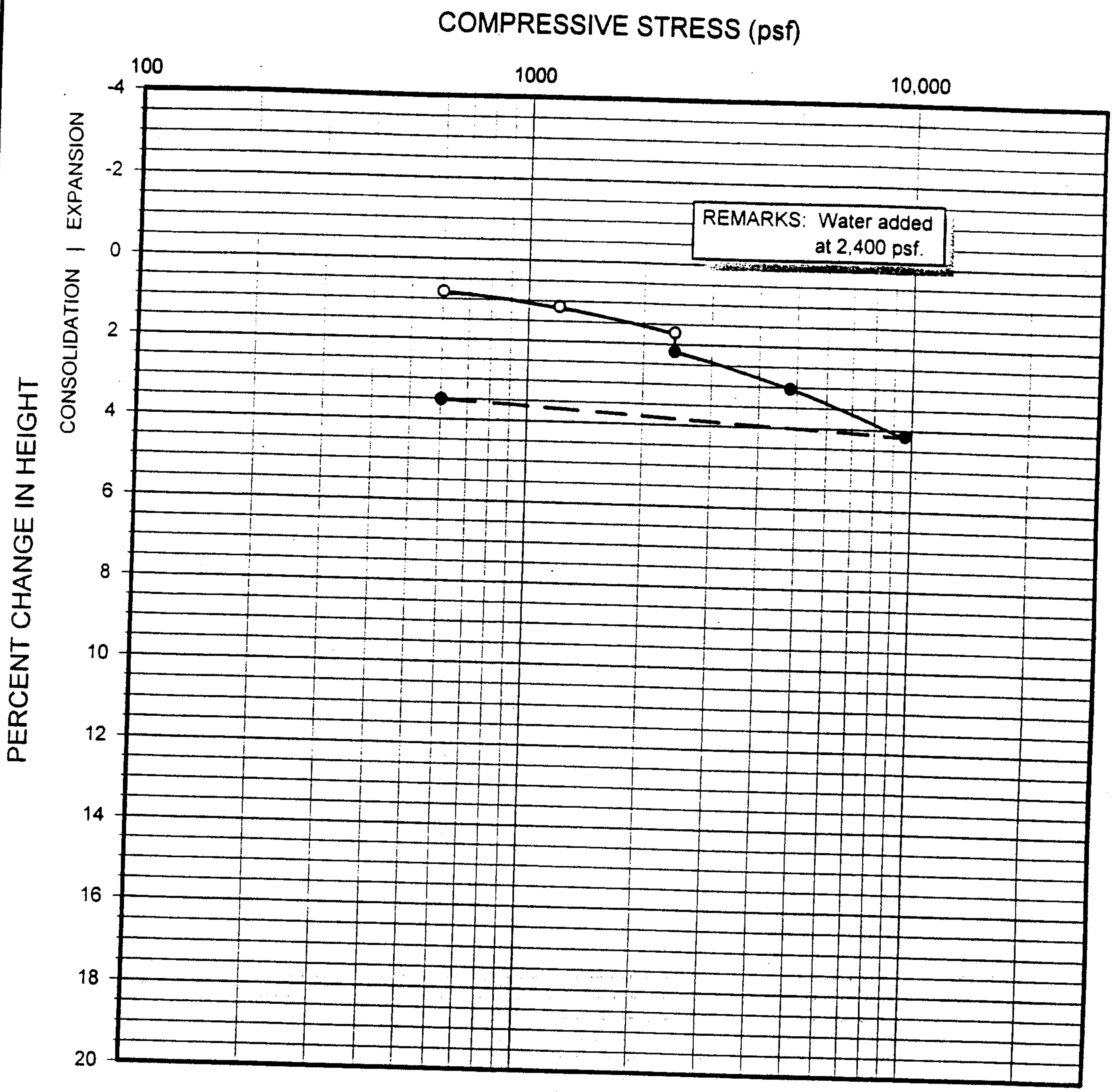
Boring: B - 2	Depth (ft.): 15.0	Dry Density (pcf):114.6	Moisture (%): 12.9	Saturation (%): 77
Sample Description: Clayey Sand (SP-SC), fine to medium grained. [Fill]				

Medall, Aragon, Higley Geotechnical, Inc.

CONSOLIDATION CURVE

NORTH COUNTY TRANSIT DISTRICT, DEL MAR RAIL LINE

PROJECT NO. 3650-SF	DATE: 6/18/98	FIG. B-41



Boring: B - 2	Depth (ft.): 25.0	Dry Density (pcf):114.1	Moisture (%): 10.2	Saturation (%): 60
Sample Description: Clayey Sand (SP-SC), fine to medium grained. [Fill]				

Medall, Aragon, Higley Geotechnical, Inc.

CONSOLIDATION CURVE

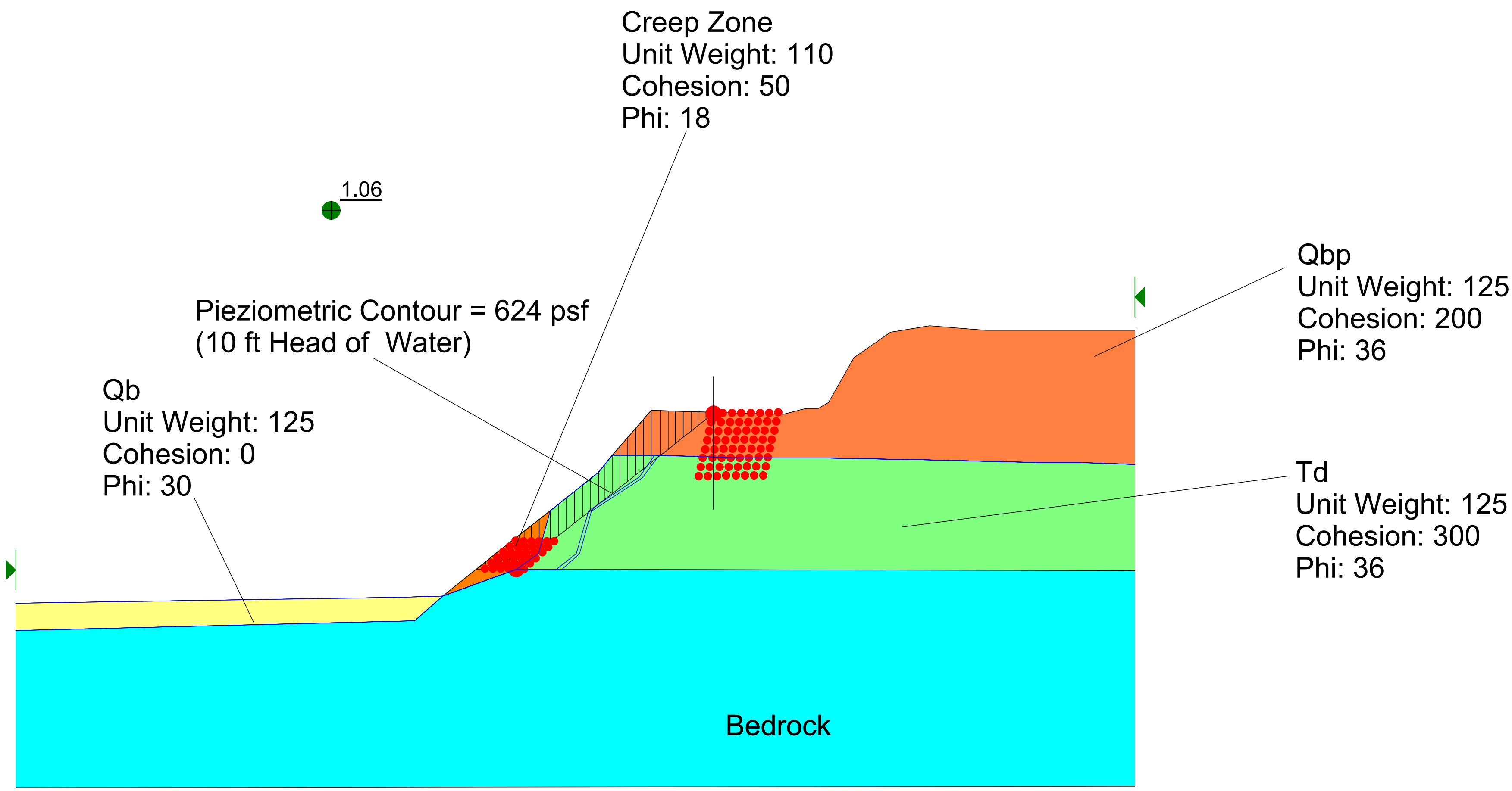
NORTH COUNTY TRANSIT DISTRICT, DEL MAR RAIL LINE

PROJECT NO. 3650-SF	DATE: 6/18/98	**FIG. B-42**

Increased Ground Water Profile Analysis

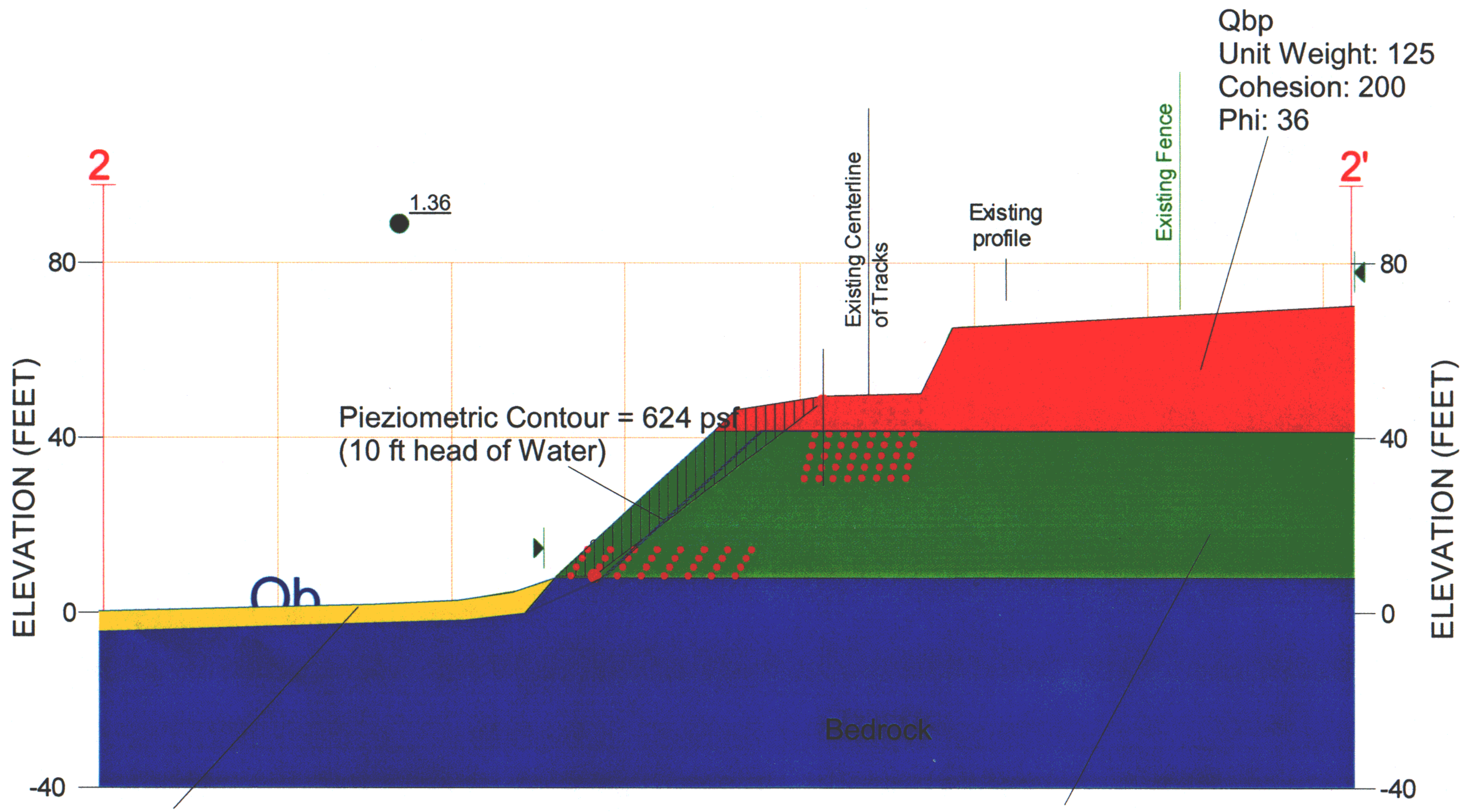
Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Static 1 10ft water.slz
Analysis Method: Spencer

Factor of Safety: 1.06



Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 10ft Water Static 1B.slz
Analysis Method: Spencer

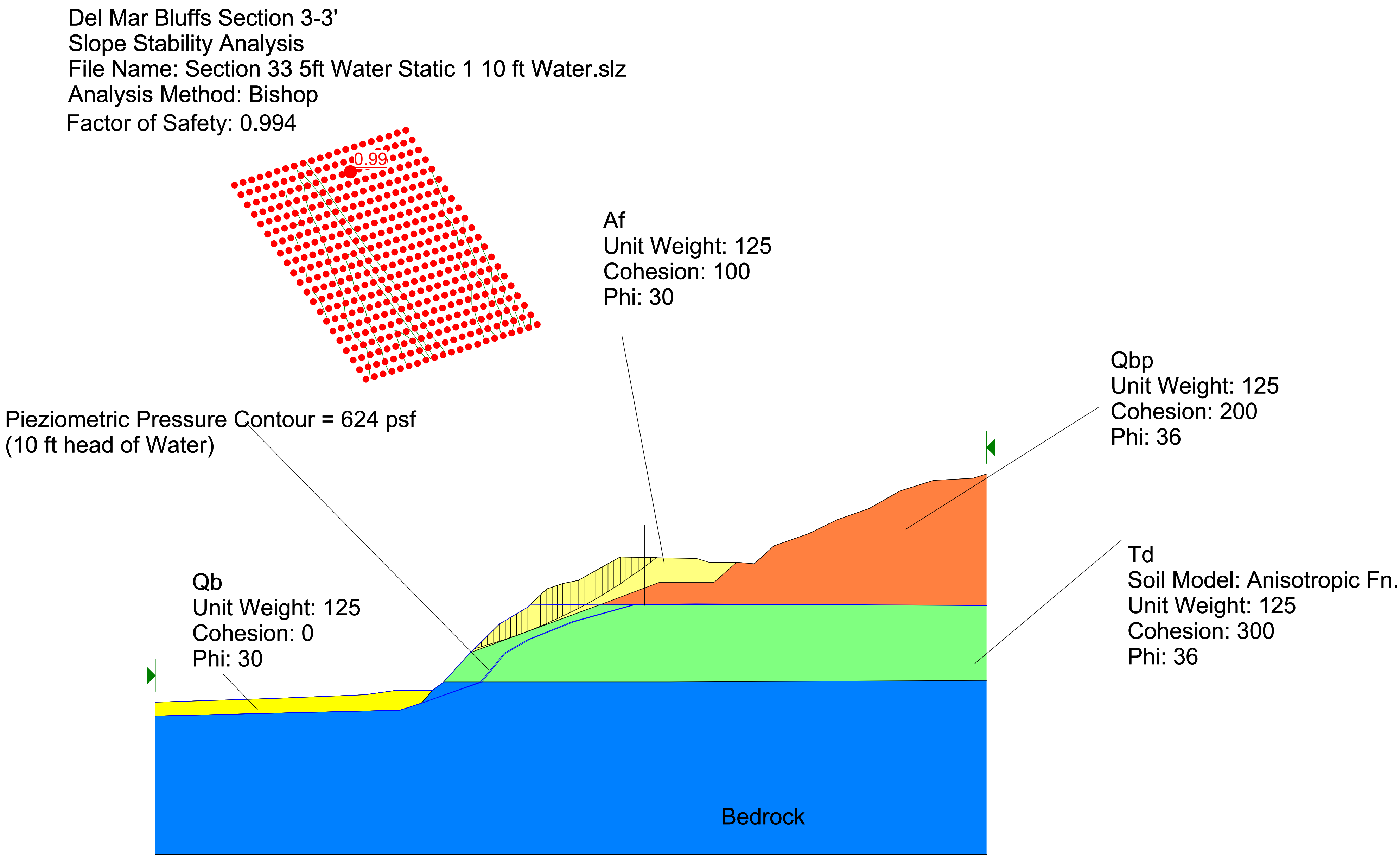
Factor of Safety: 1.36



Qb
Unit Weight: 125
Cohesion: 0
Phi: 30

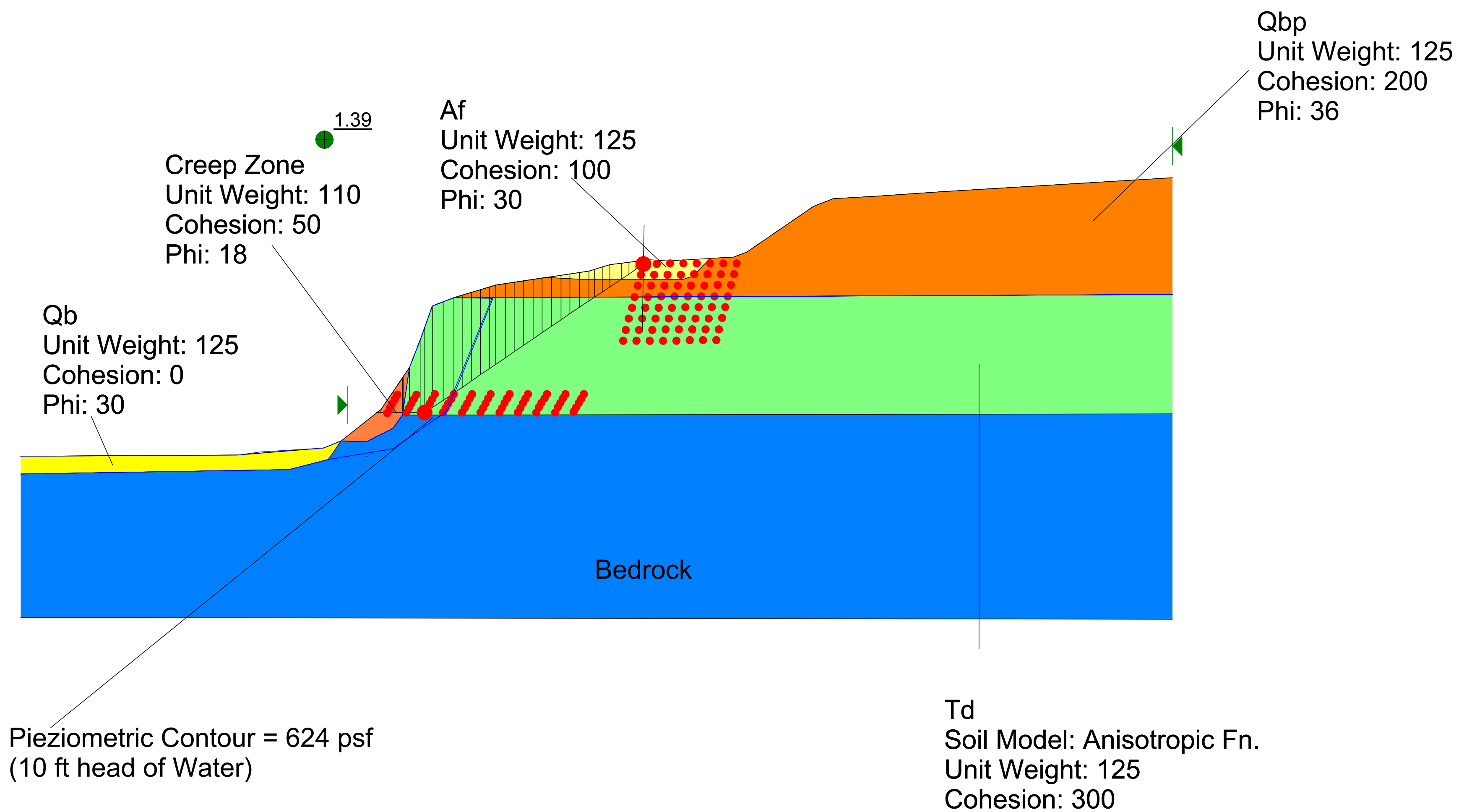
SECTION 2-2'
View north - M.P. 244.22 (STA. 1543+00)

Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36


Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 5ft Water Static 1 10 ft Water.slz
Analysis Method: Bishop
Factor of Safety: 0.994
0.99
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
PiezIometric Pressure Contour = 624 psf
(10 ft head of Water)
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock

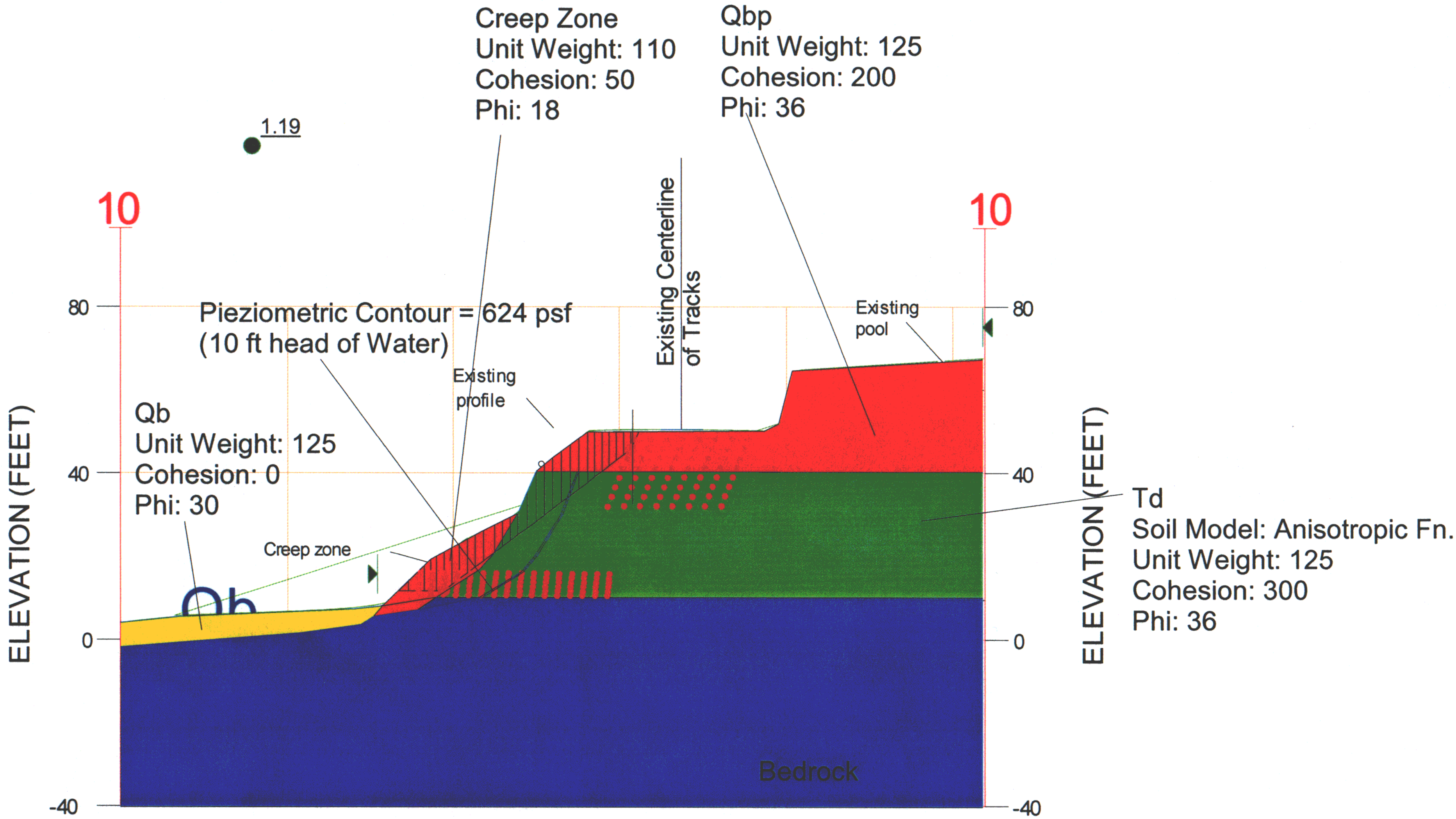
Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 10ft Water Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.39



Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 10 ft Water Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.19



SECTION 10-10'

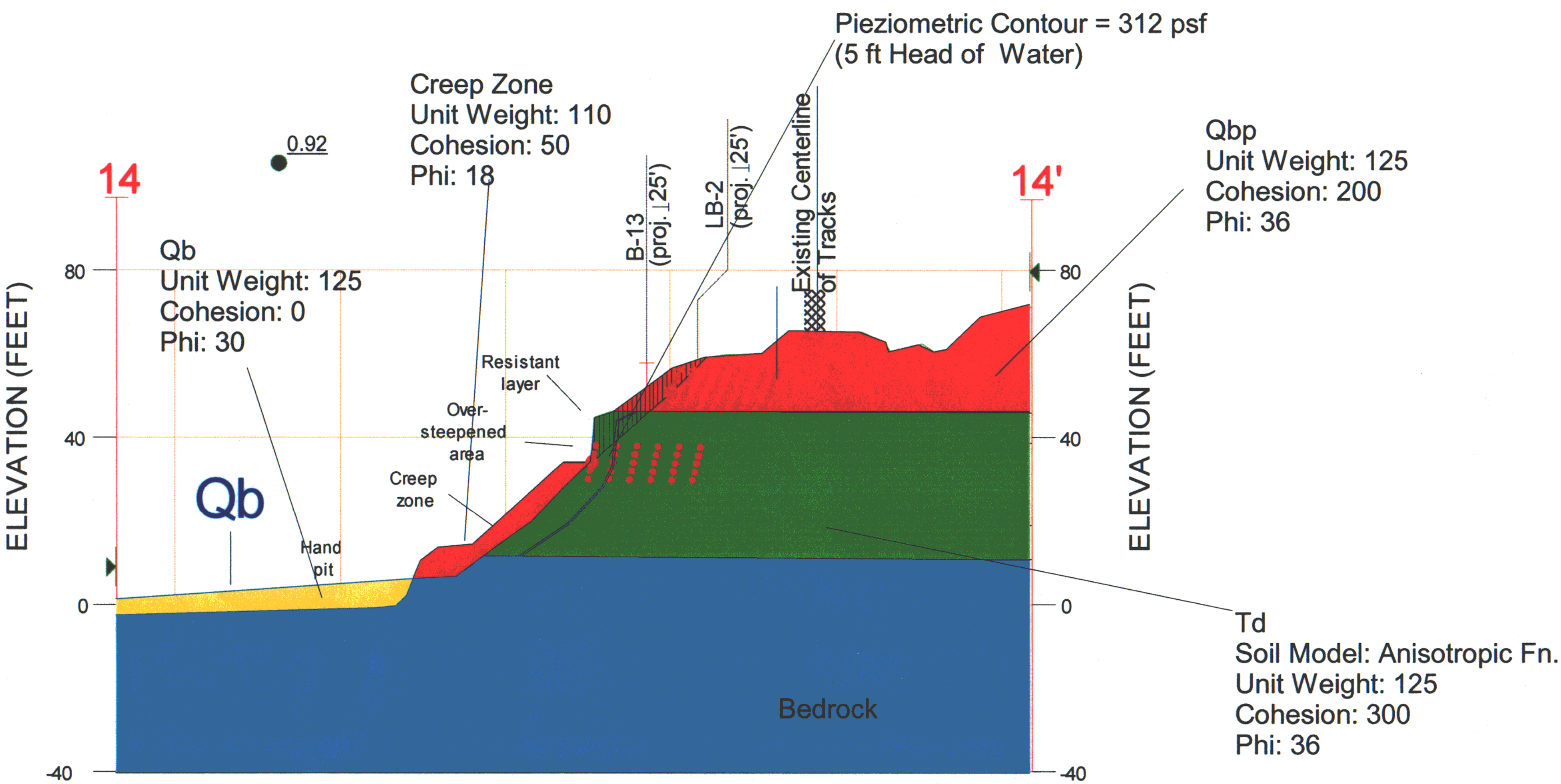
View north - M.P. 244.36 (STA.. 1535+69)

Back Calculation Analysis

Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Failure 1.slz
Analysis Method: Spencer

Factor of Safety: 0.922

Surcharge = 3,000 psf

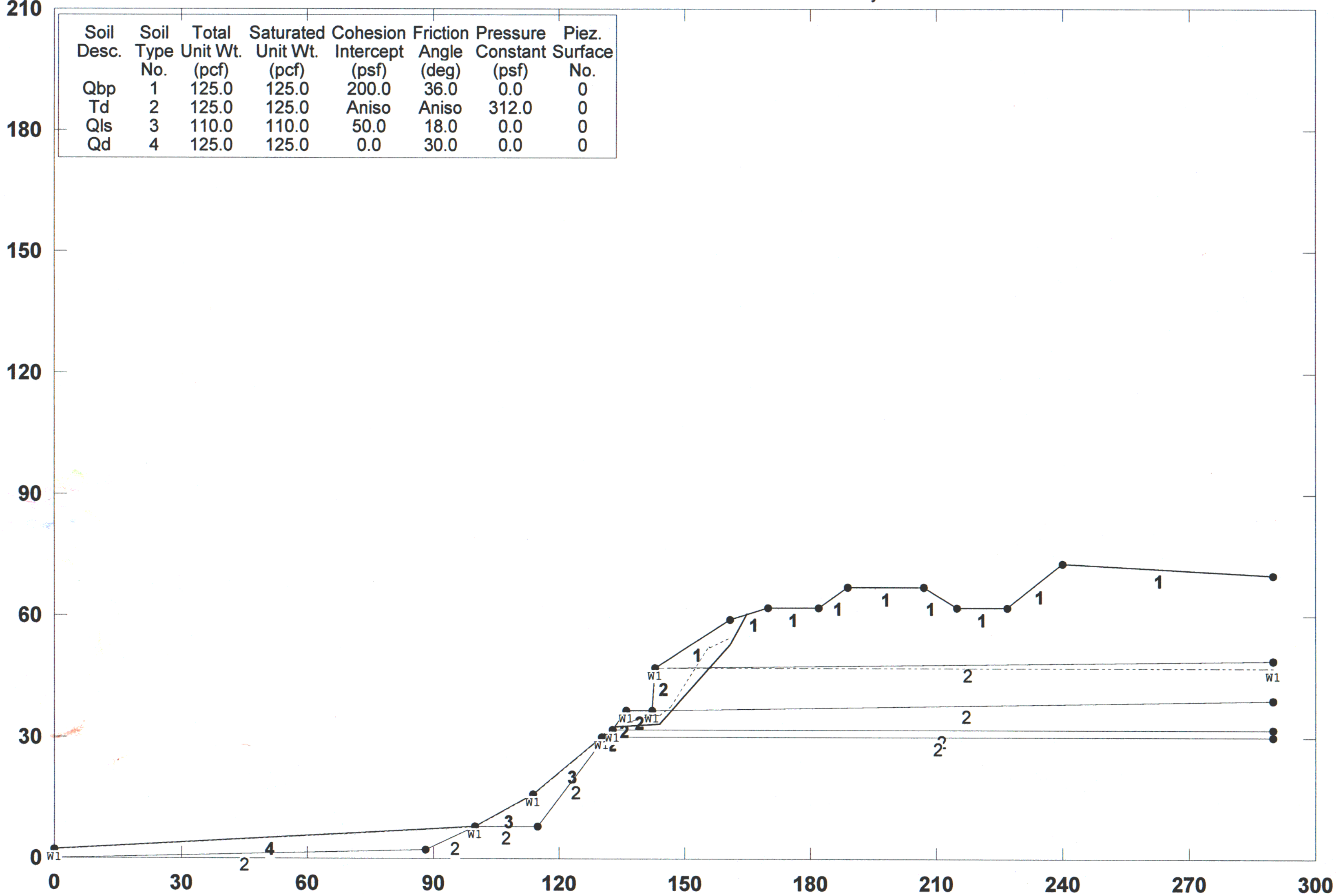


SECTION 14-14' (PREVIOUSLY H-H')
View north - M.P. 244.47 (STA. 1529+60)

Cross Section H-H' with Water Filled Tension Cracks in Cemented Units

P:\LEIGHTON\040000~1\040151.009\ENG\SLOPES~1\DM14BCK6.PLT Run By: Username 9/5/2003 3:43PM

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pressure Constant (psf)	Piez. Surface No.
Qbp	1	125.0	125.0	200.0	36.0	0.0	0
Td	2	125.0	125.0	Aniso	Aniso	312.0	0
Qls	3	110.0	110.0	50.0	18.0	0.0	0
Qd	4	125.0	125.0	0.0	30.0	0.0	0

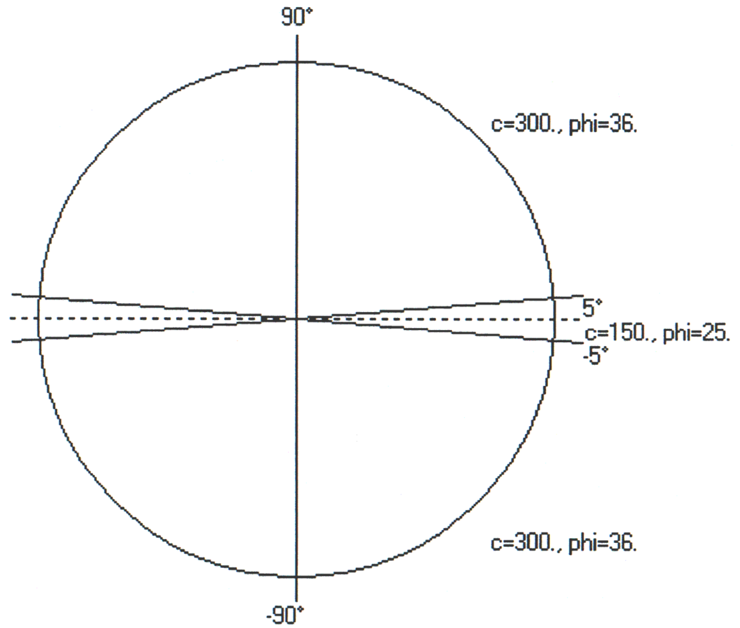


GSTABL7 v.2 FSmin=1.07

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-2)

GSTABL7

Anisotropic Soil Definition

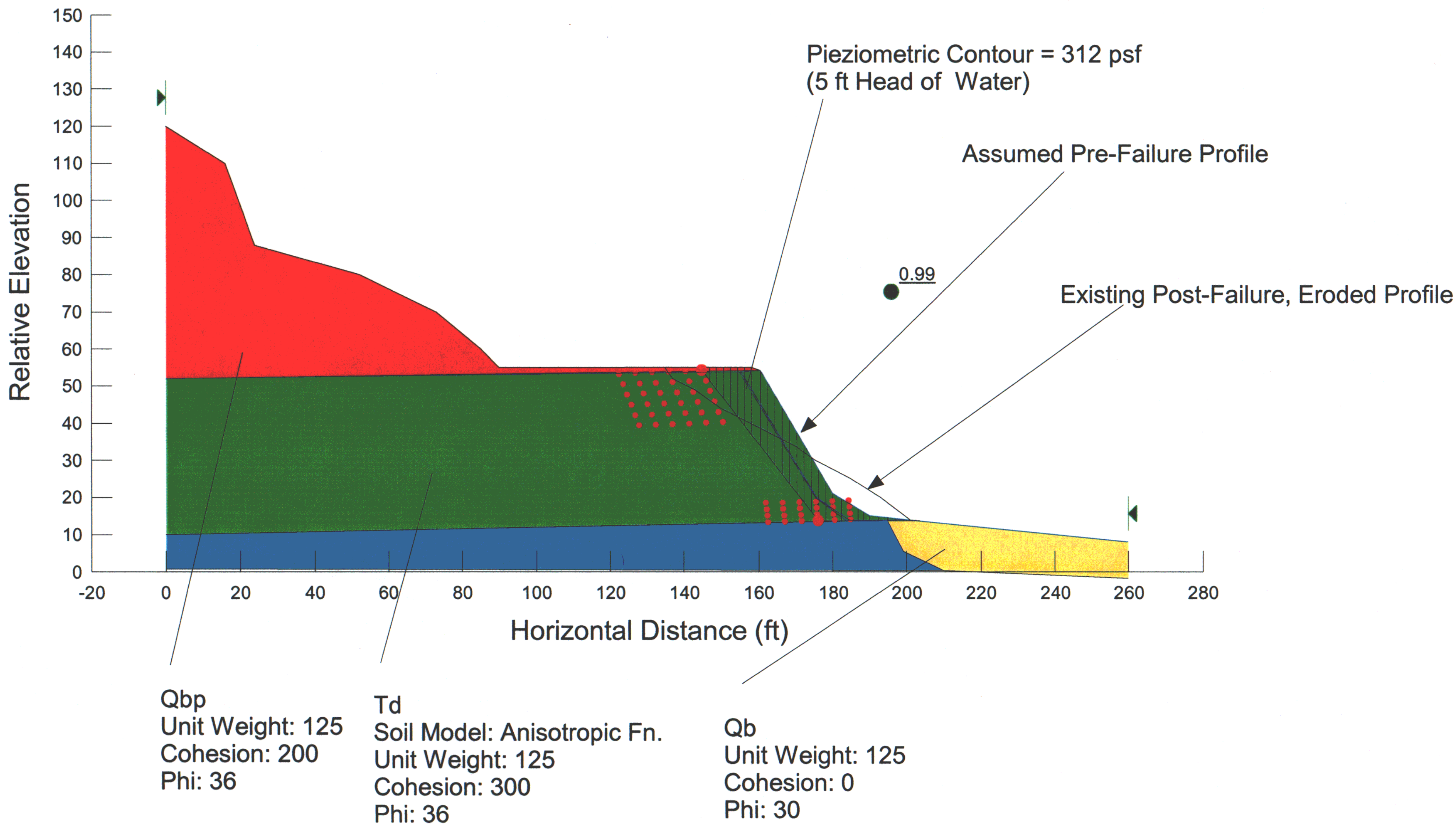


Soil2

Cross Section H-H' with Water Filled

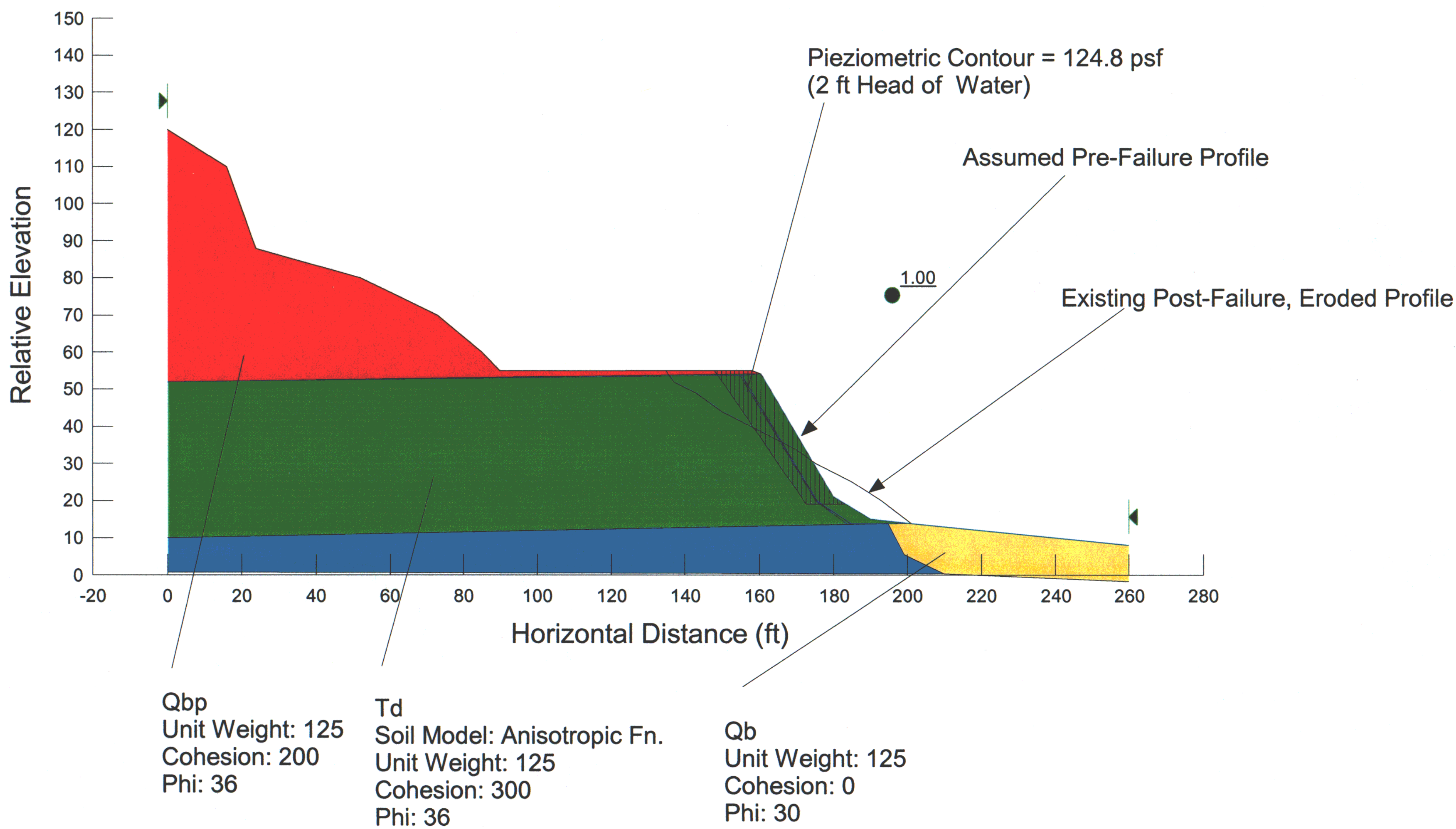
Del Mar Bluffs Cross Section @ STA. 1488+85 (M.P. 245.27)
Back Claclulation, Slope Stability Analysis
File Name: STA. 1488+85 Section Back Calc 1.slz
Analysis Method: Spencer

Factor of Safety: 0.995



Del Mar Bluffs Cross Section @ STA. 1488+85 (M.P. 245.27)
Back Claclulation, Slope Stability Analysis
File Name: STA. 1488+85 Section Back Calc 2.slz
Analysis Method: Spencer

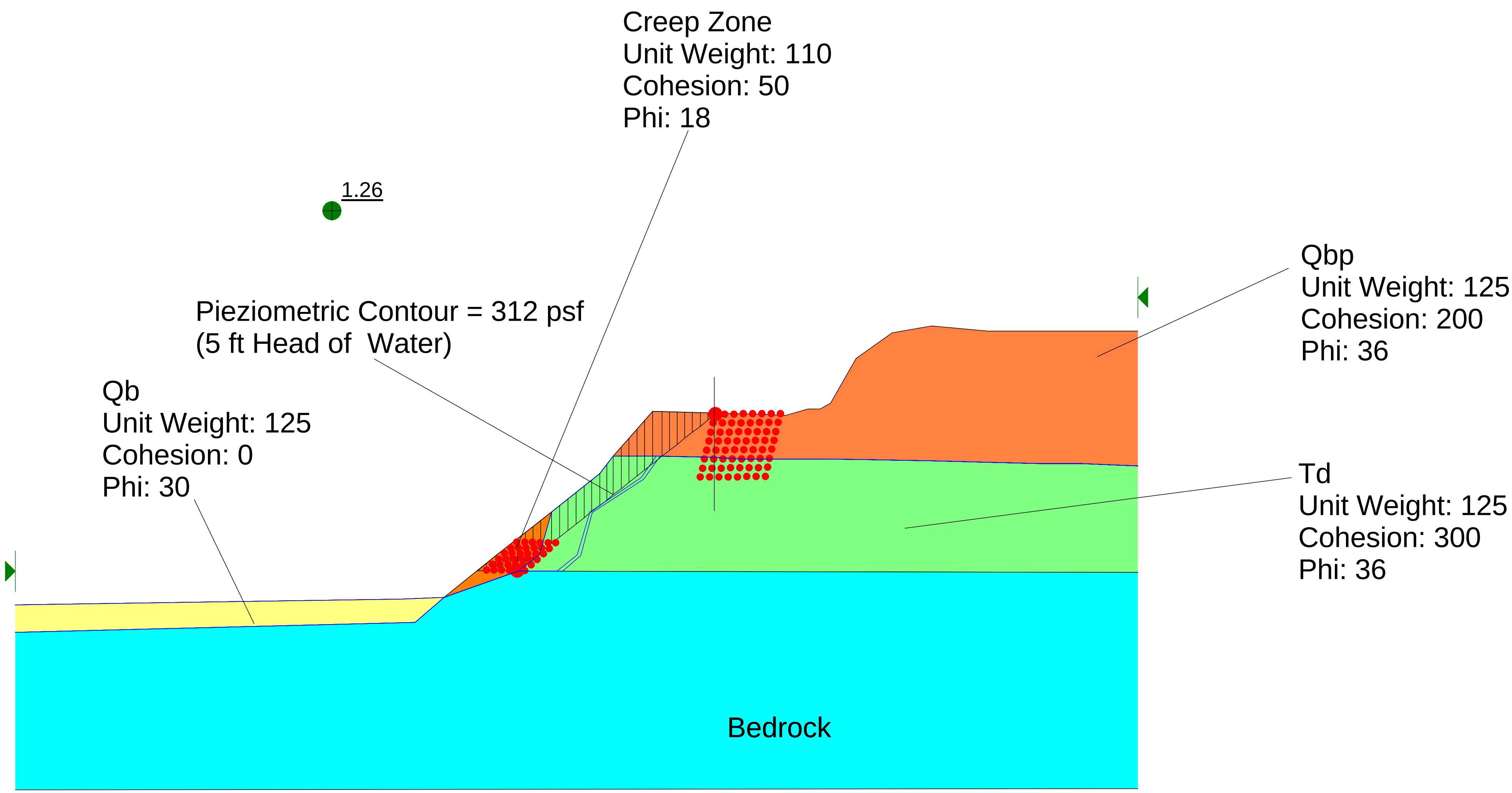
Factor of Safety: 0.997



Cross Section 1-1’

Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Static 1.slz
Analysis Method: Spencer

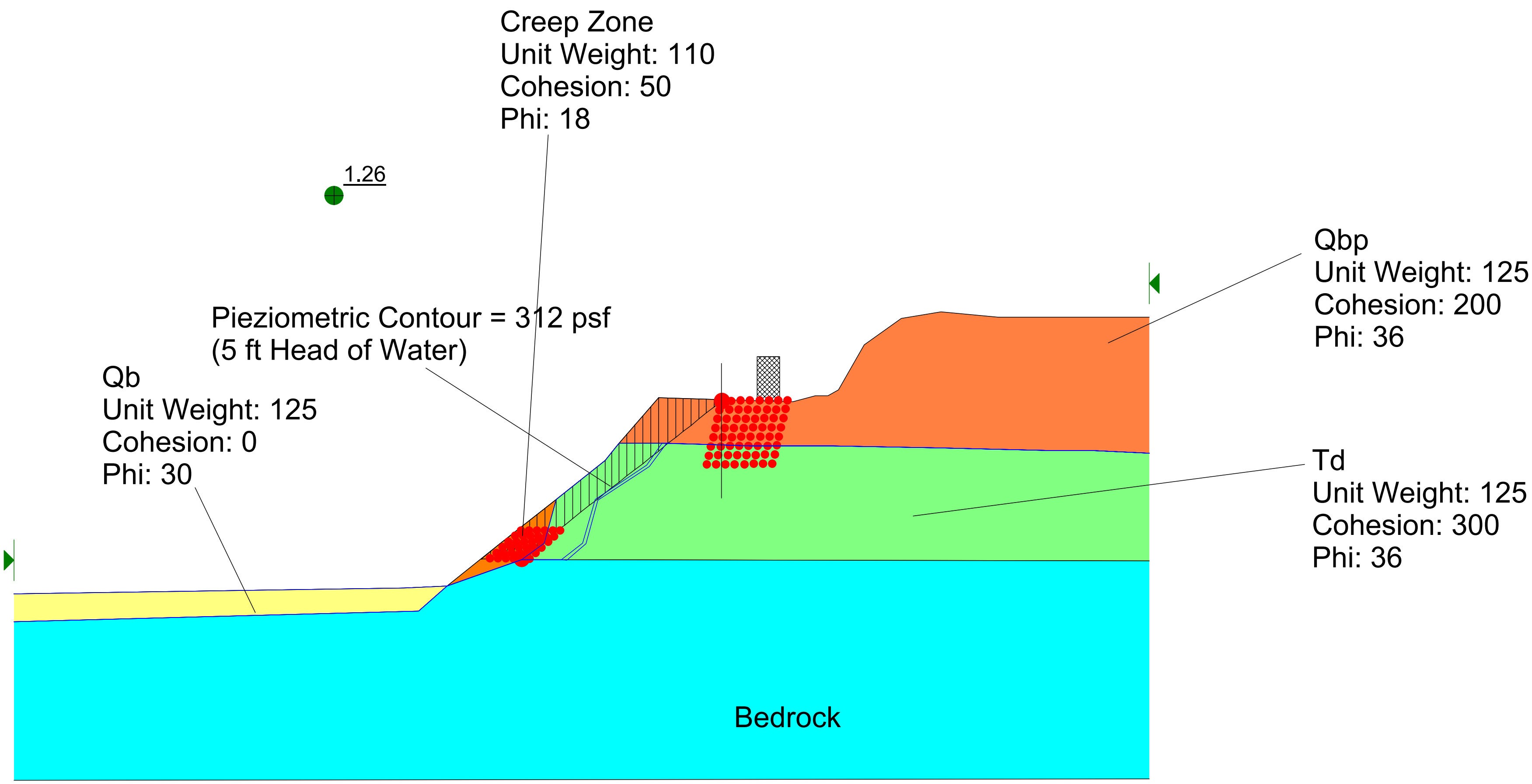
Factor of Safety: 1.26



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Static 2.slz
Analysis Method: Spencer

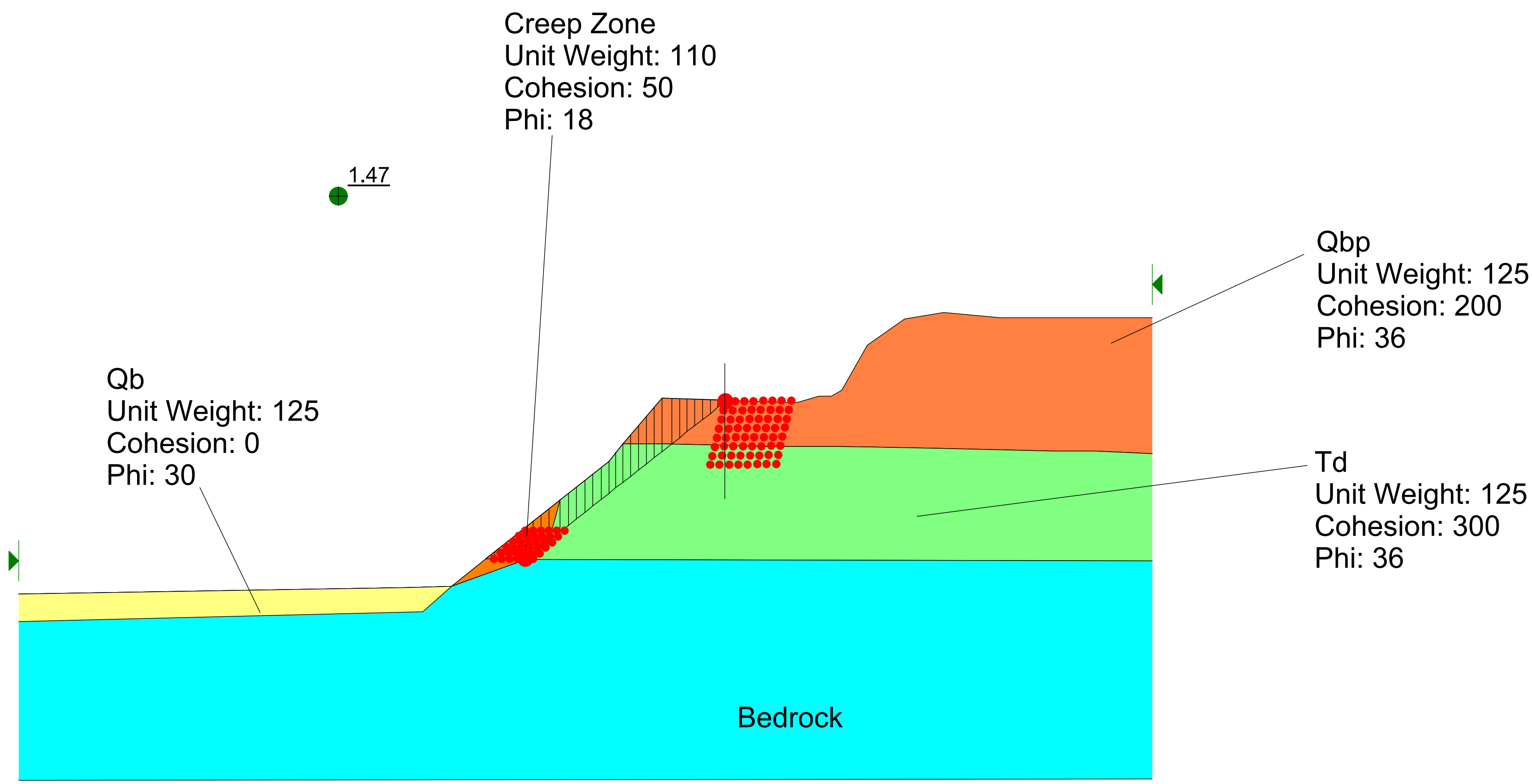
Factor of Safety: 1.26

Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis, No Water
File Name: Section 11 Static 3.slz
Analysis Method: Spencer

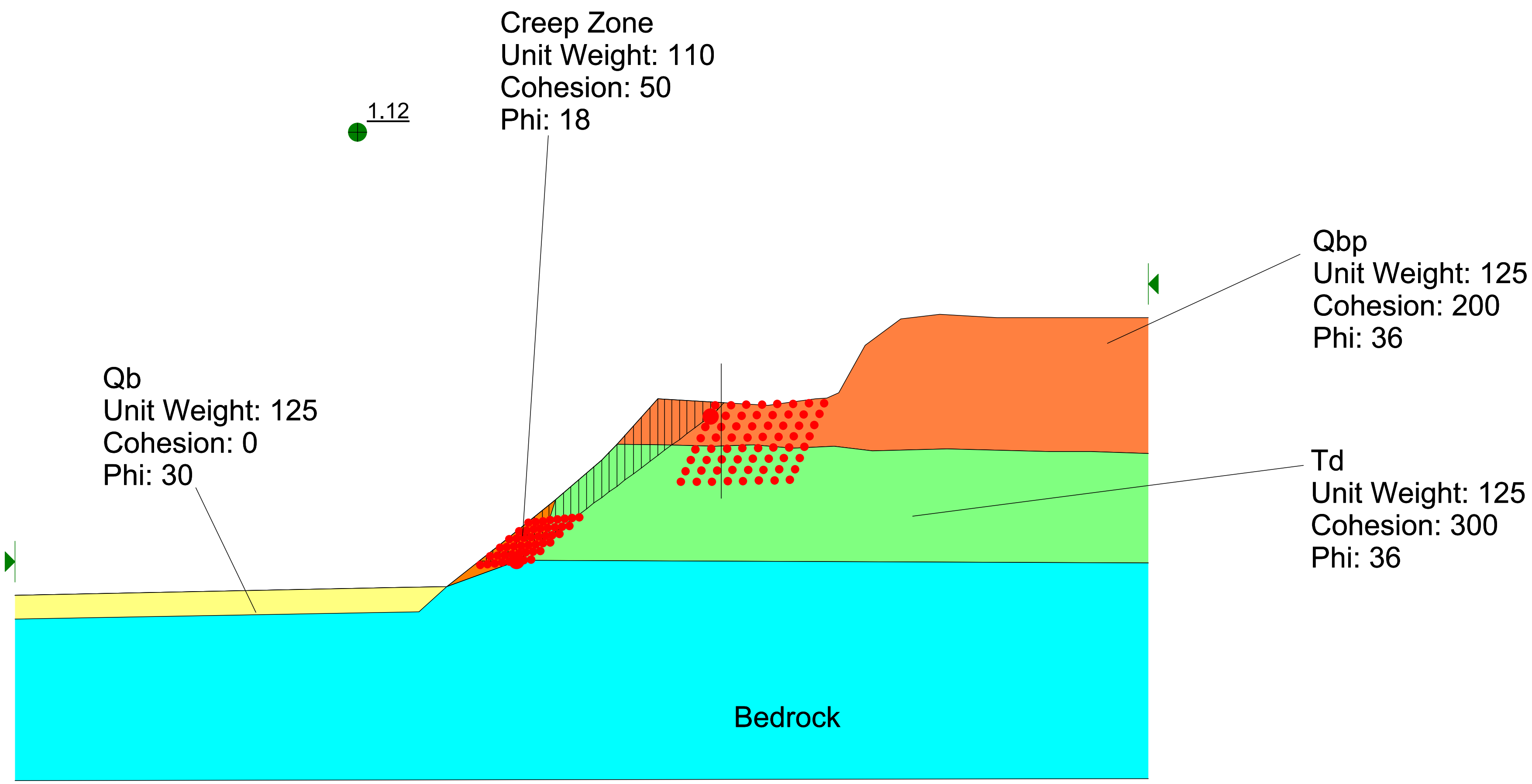
Factor of Safety: 1.47



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Pseudo Static 1.slz
Analysis Method: Spencer

Factor of Safety: 1.12

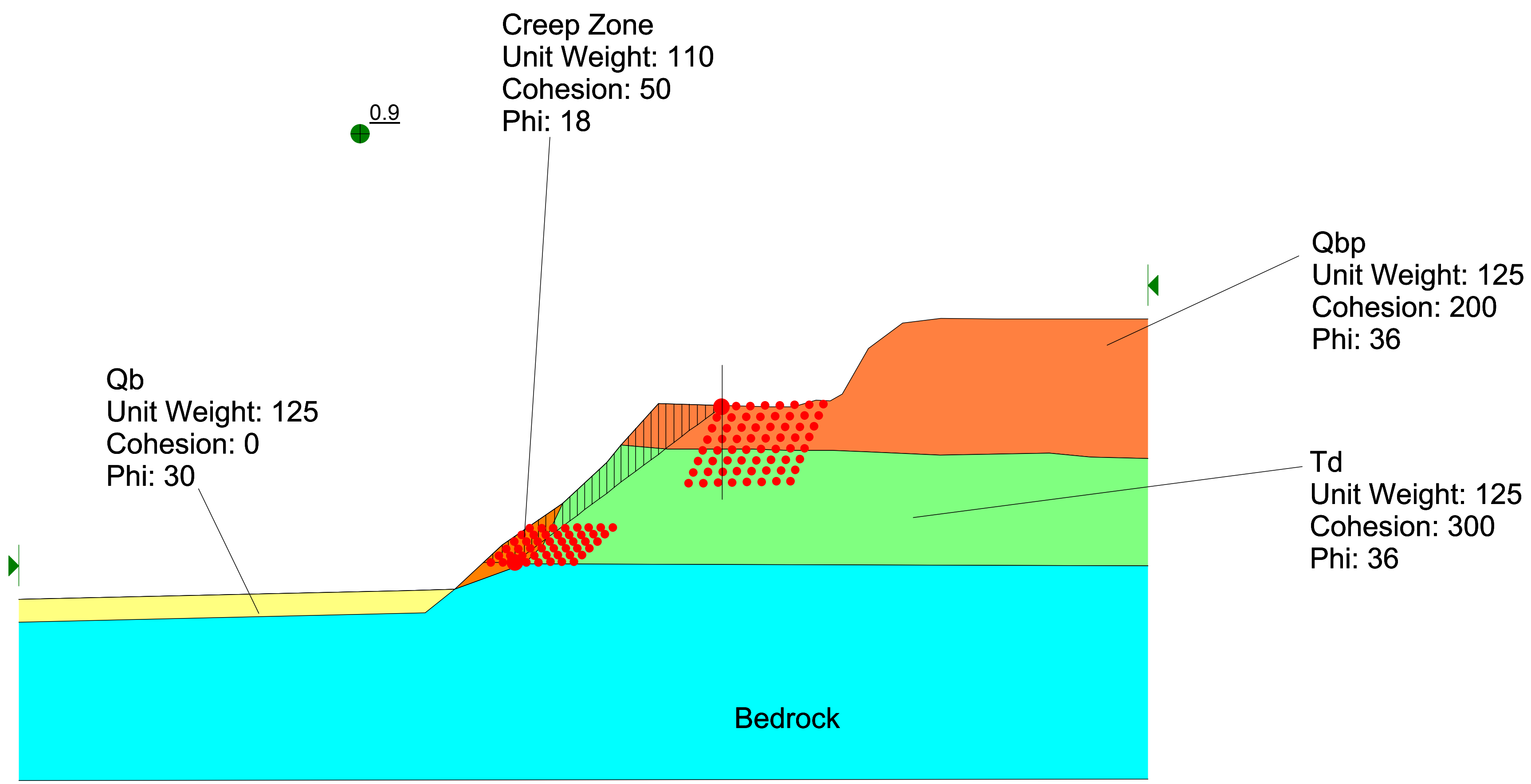
Sesimic Coefficient = 0.15



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Pseudo Static 2.slz
Analysis Method: Spencer

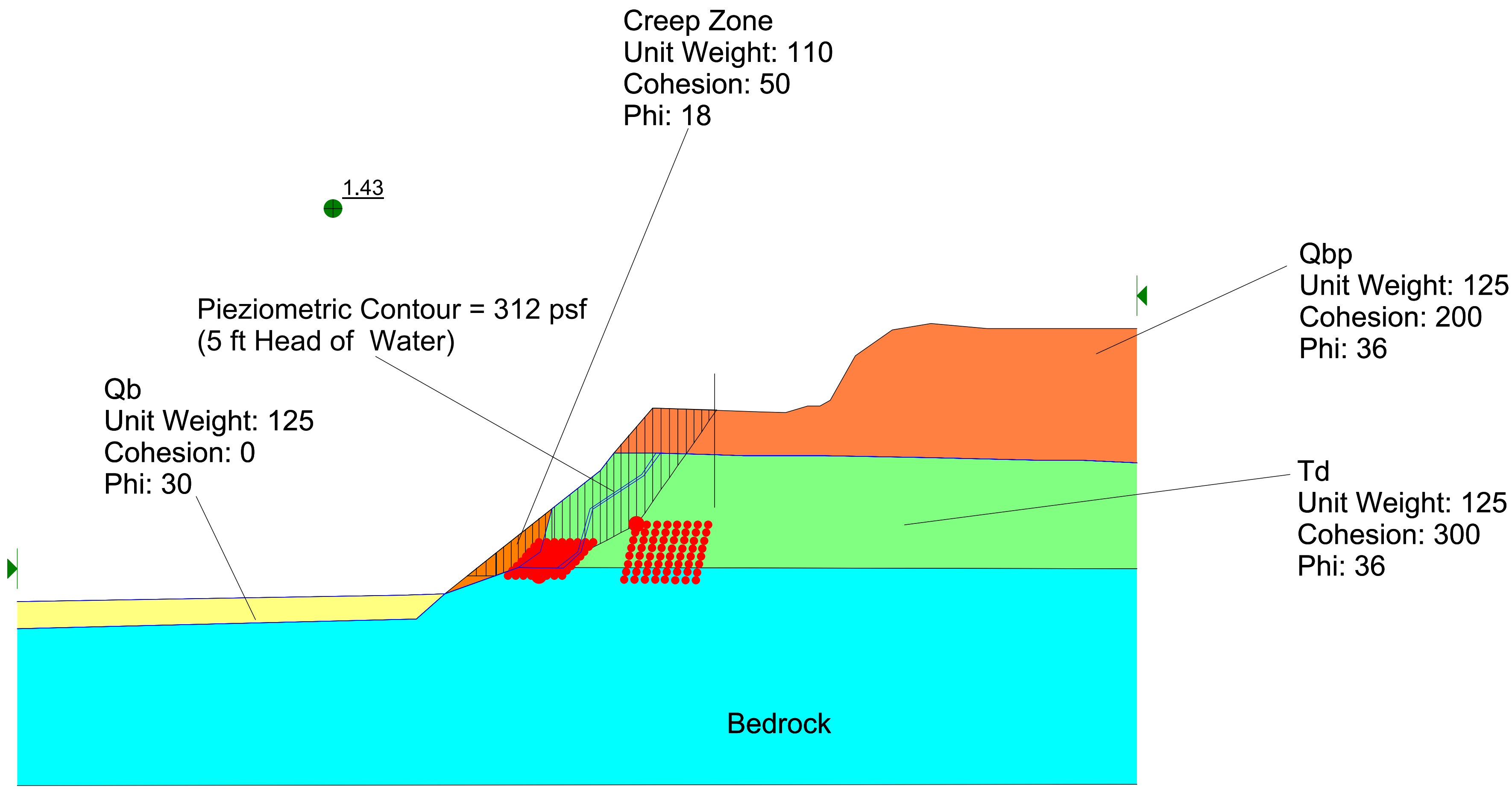
Factor of Safety: 0.95

Seismic Coefficient = 0.28



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Static 1B.slz
Analysis Method: Spencer

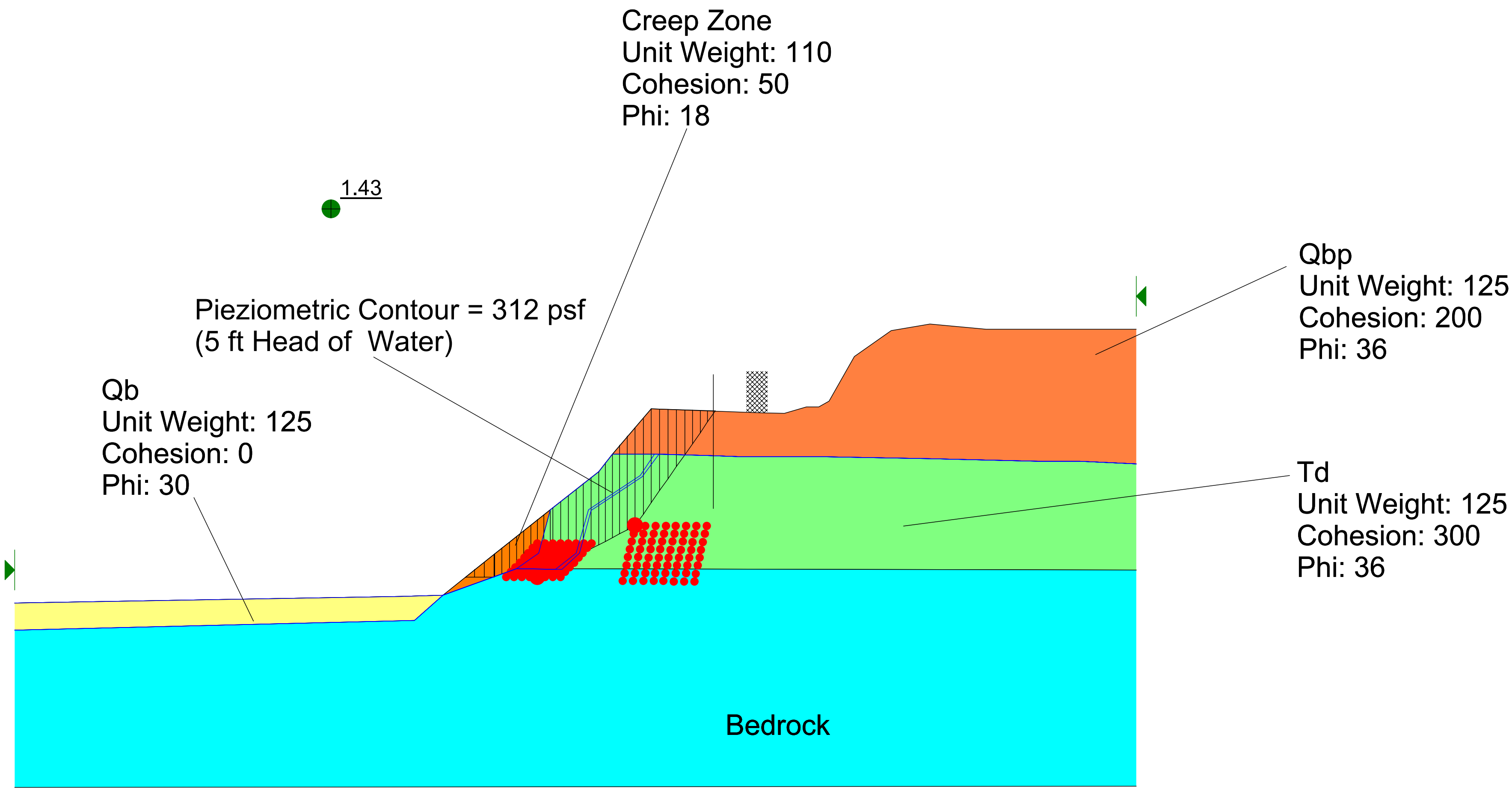
Factor of Safety: 1.43



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Static 2B.slz
Analysis Method: Spencer

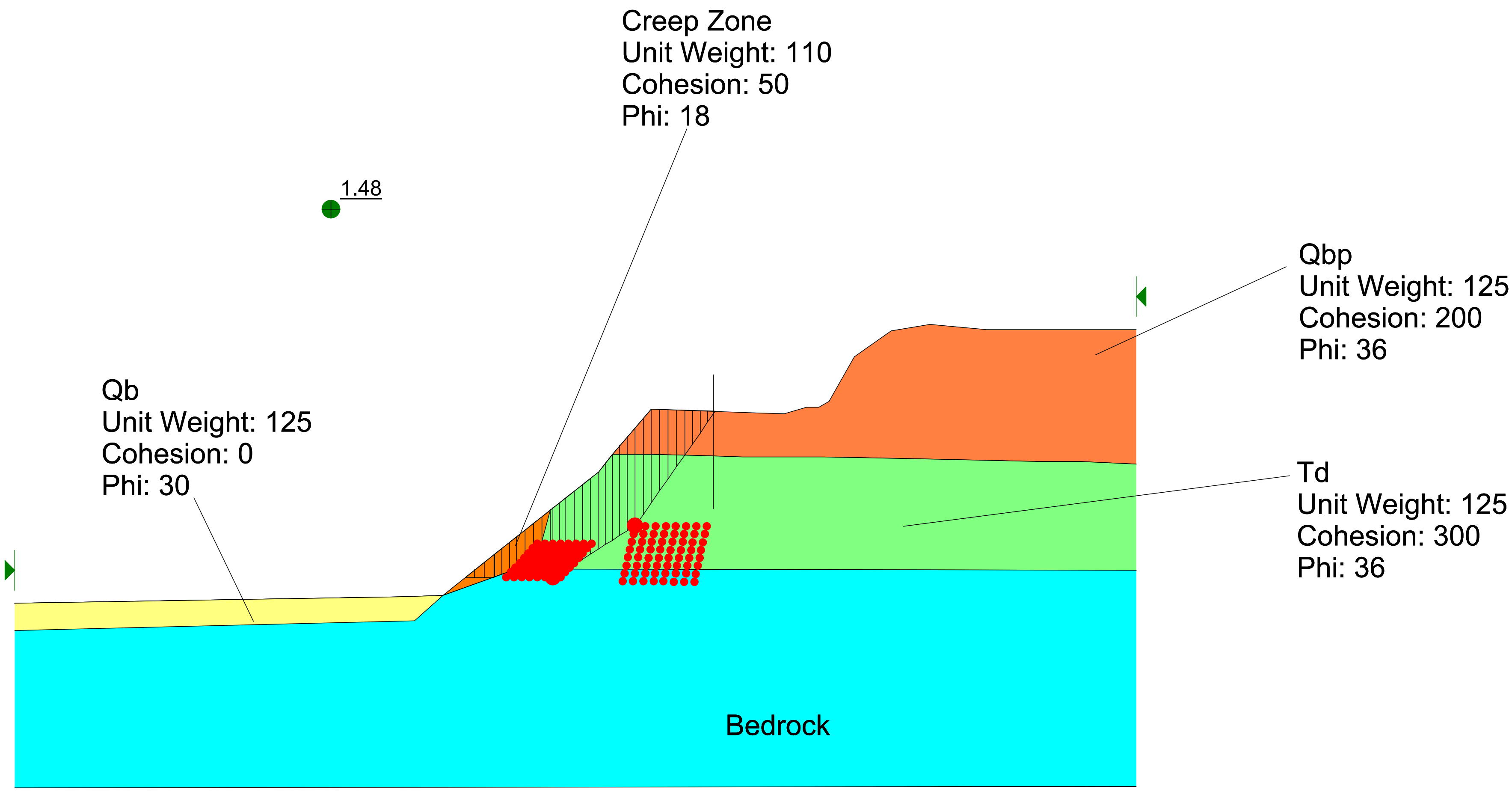
Factor of Safety: 1.43

Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis, No Water
File Name: Section 11 Static 3B.slz
Analysis Method: Spencer

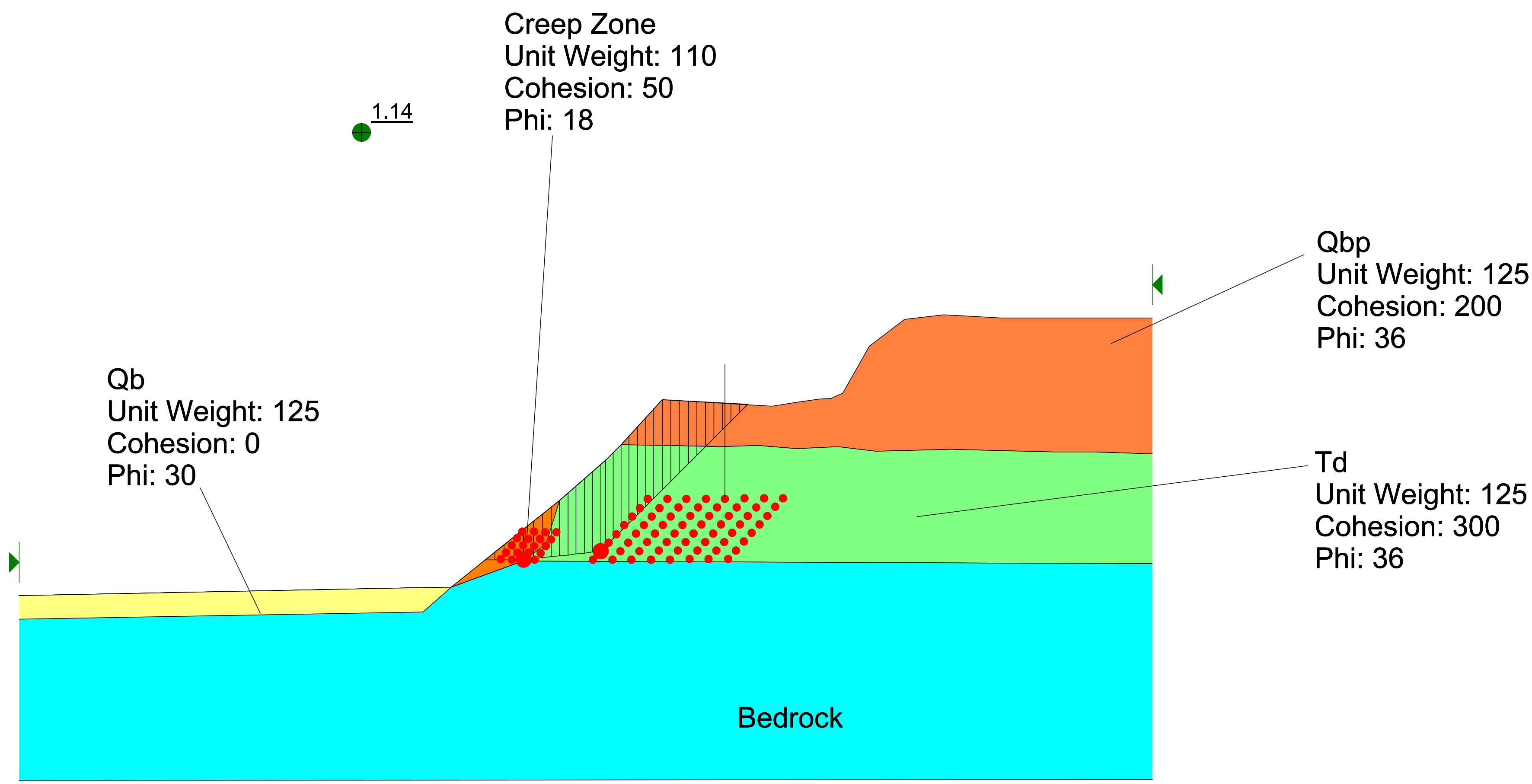
Factor of Safety: 1.48



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Pseudo Static 1B.slz
Analysis Method: Spencer

Factor of Safety: 1.14

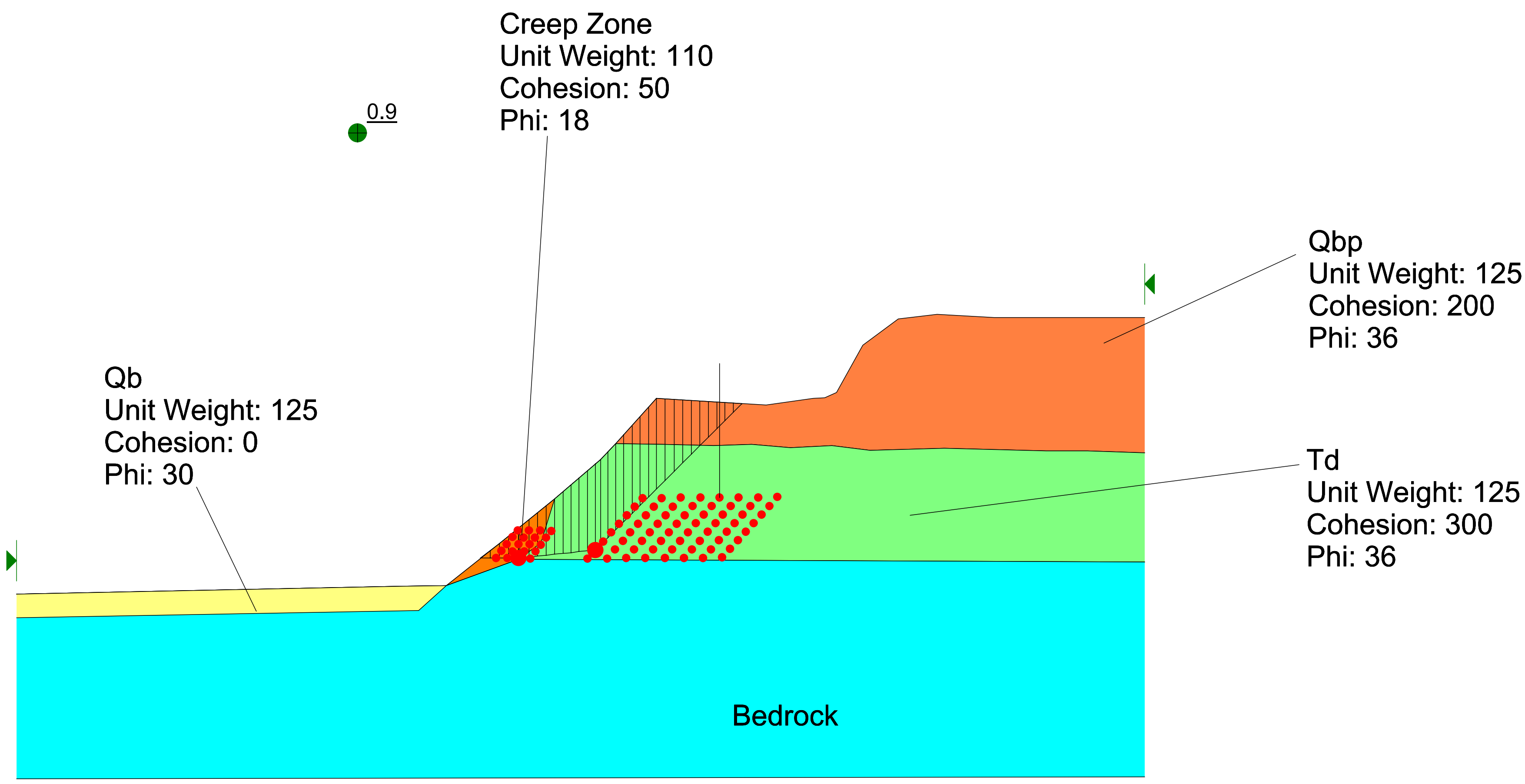
Sesimic Coefficient = 0.15



Del Mar Bluffs Cross Section 1-1'
Slope Stability Analysis
File Name: Section 11 Pseudo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 0.95

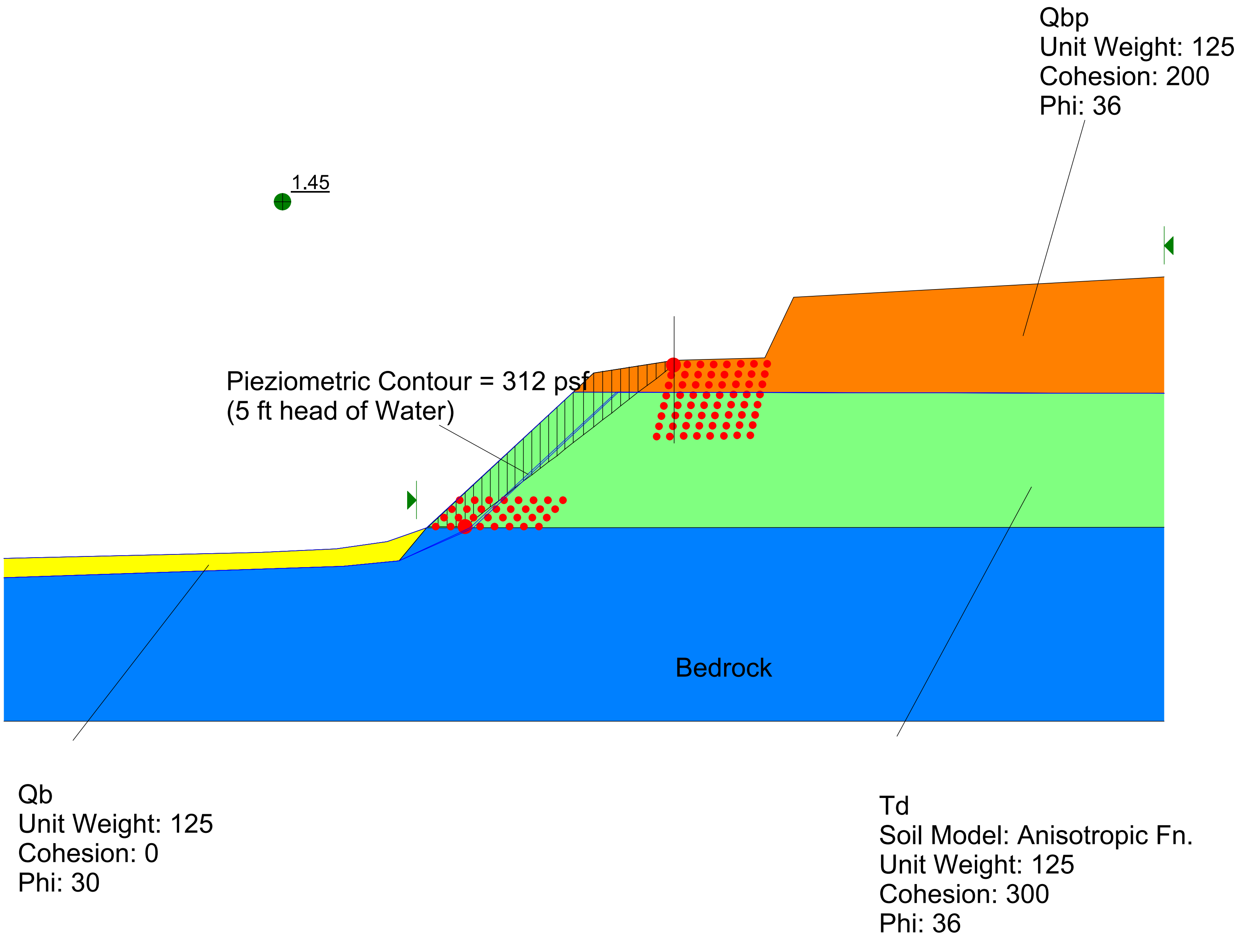
Sesimic Coefficient = 0.28



Cross Section 2-2’

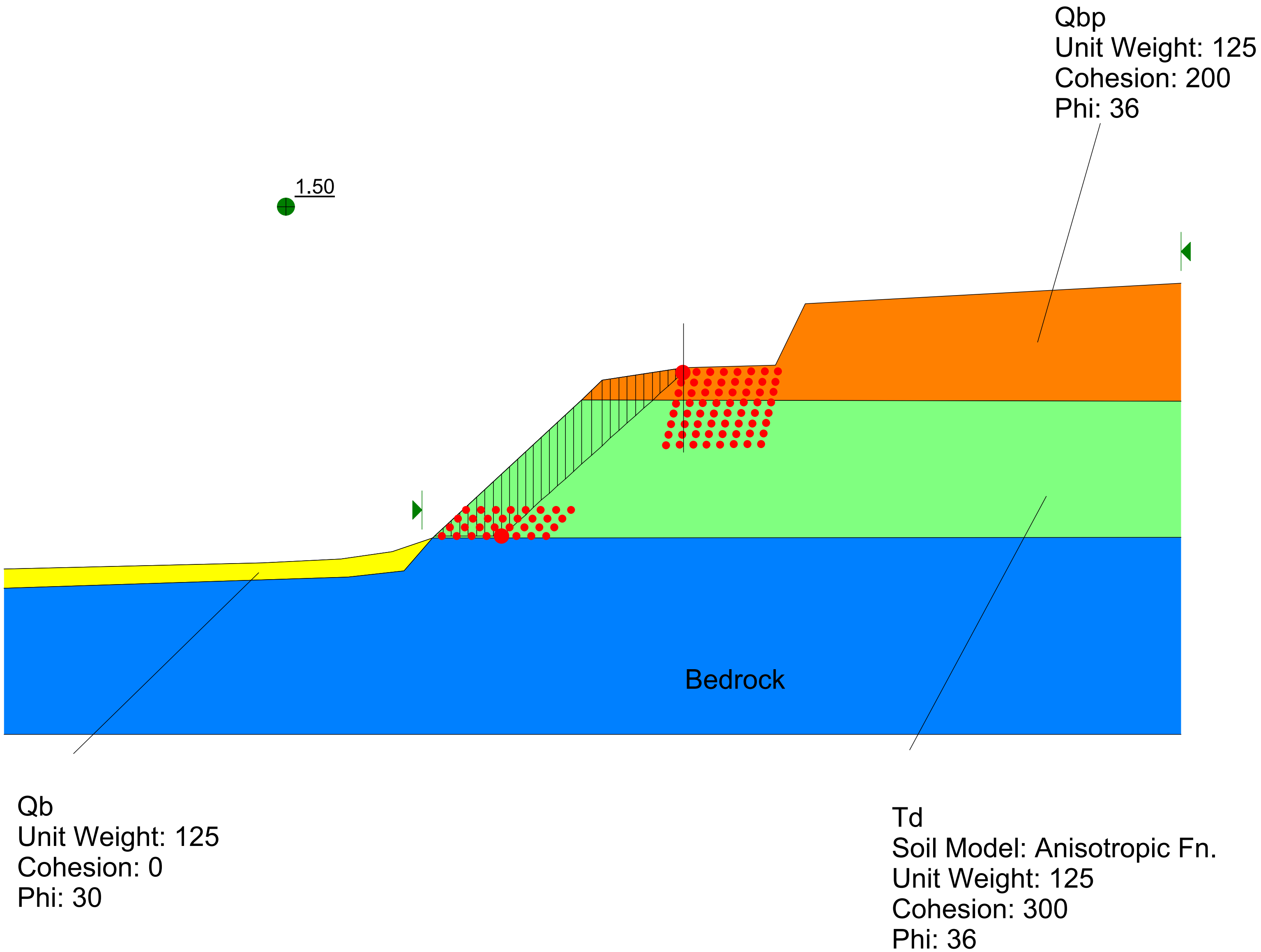
Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 5ft Water Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.45

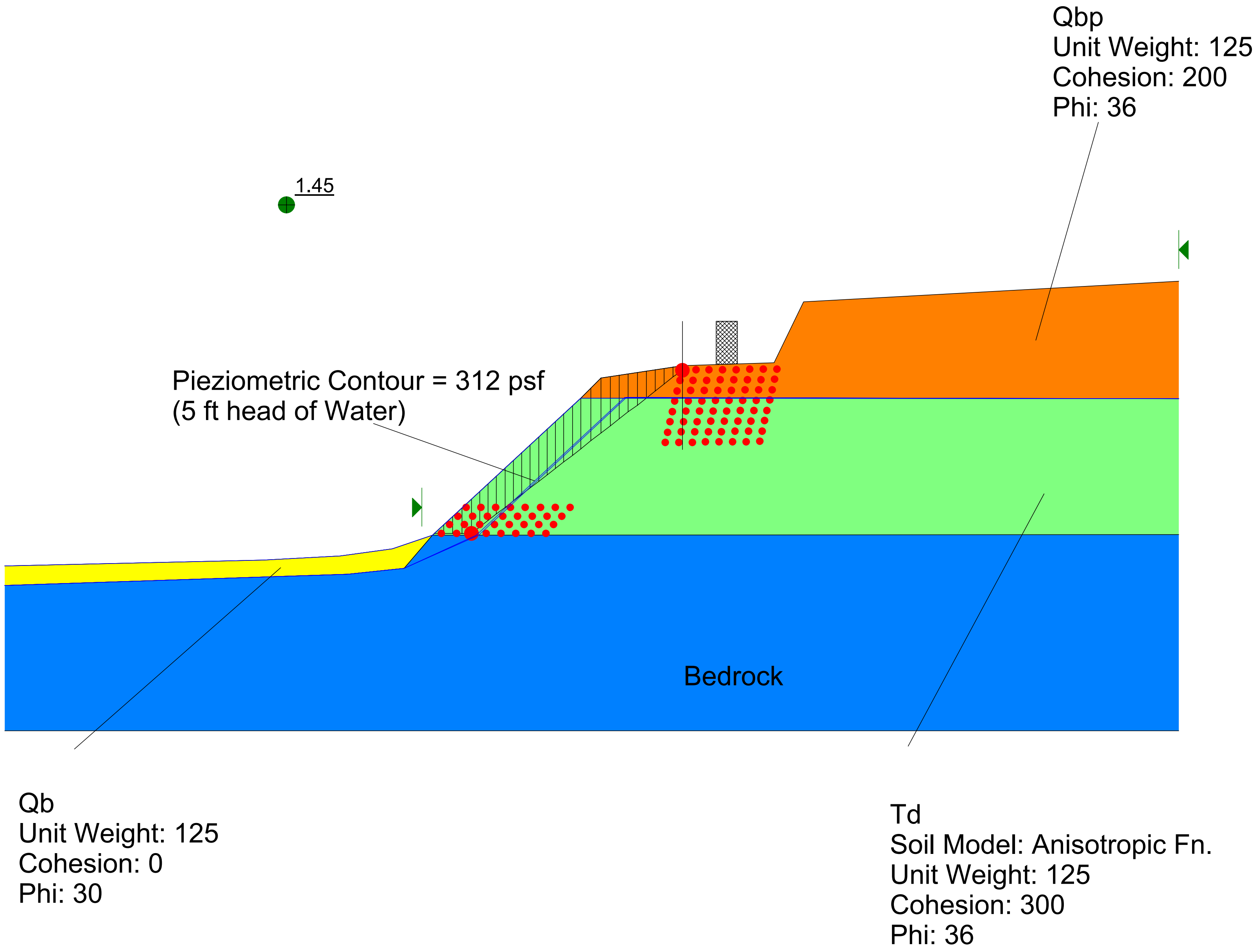


Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis, No Water
File Name: Section 22 Static 3.slz
Analysis Method: Spencer

Factor of Safety: 1.5

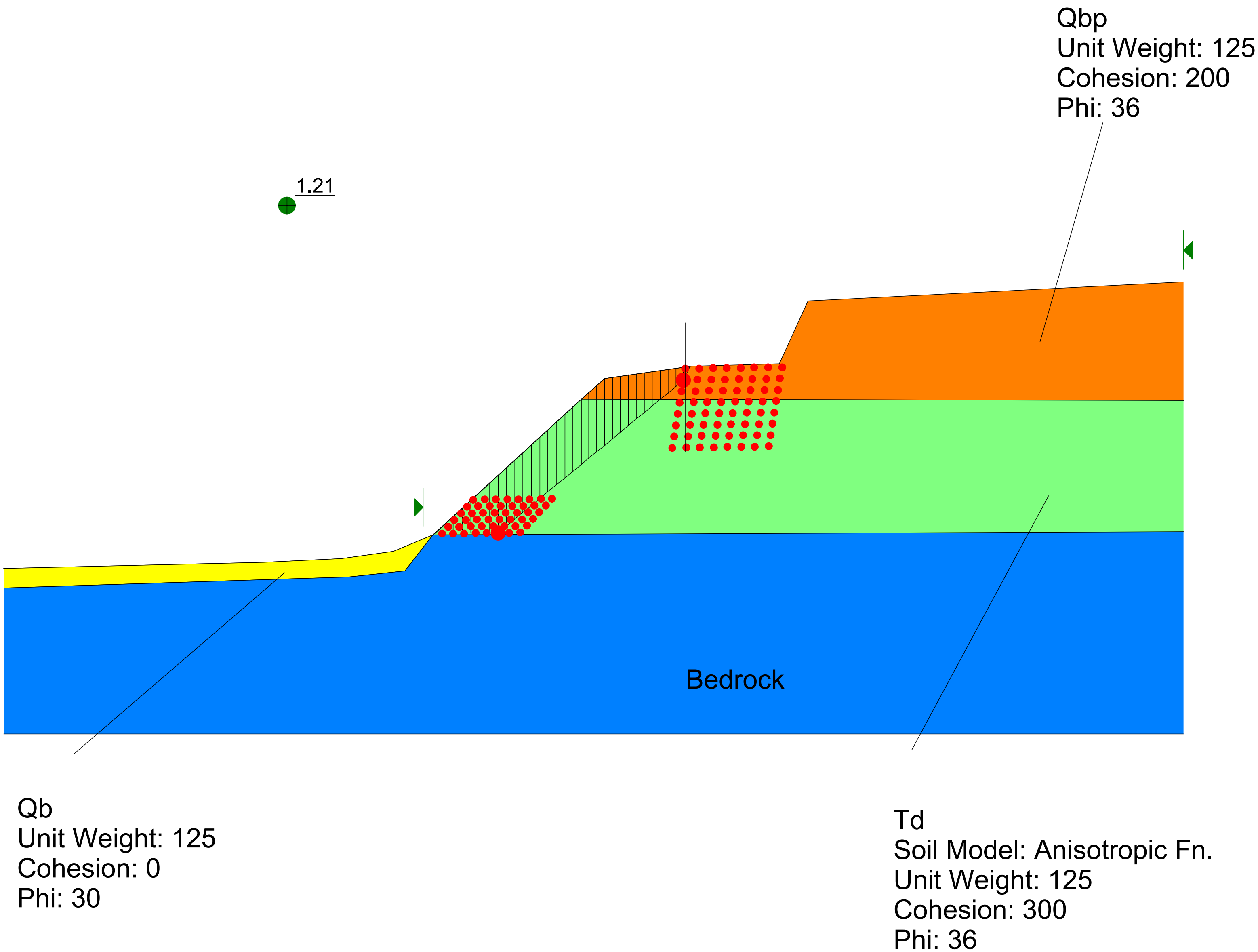


Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 5ft Water Static 4.slz
Analysis Method: Spencer
Factor of Safety: 1.45
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 Psuedo Static 2.slz
Analysis Method: Spencer

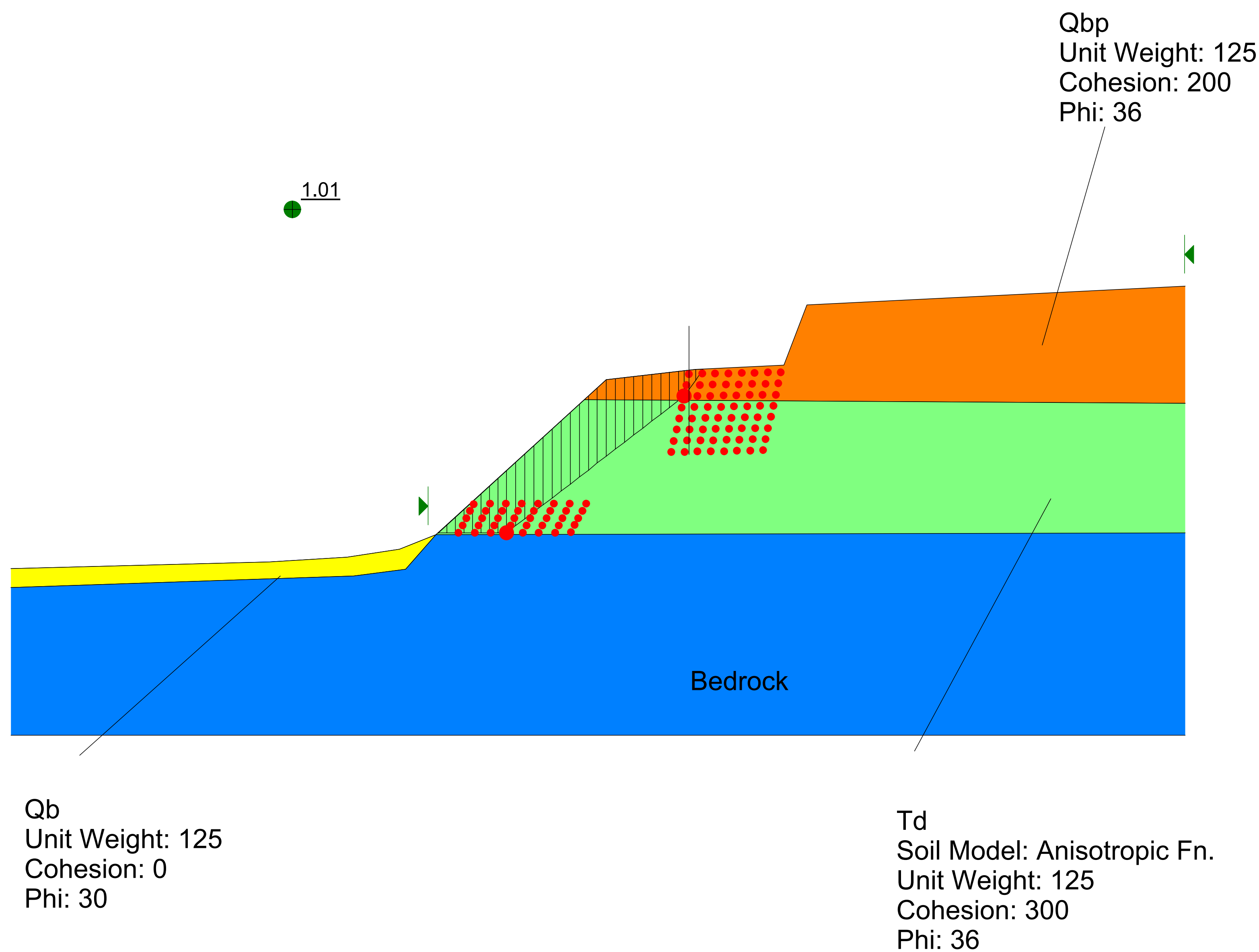
Factor of Safety: 1.21
Seismic Coeffiecient = 0.15



Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 Psuedo Static 3.slz
Analysis Method: Spencer

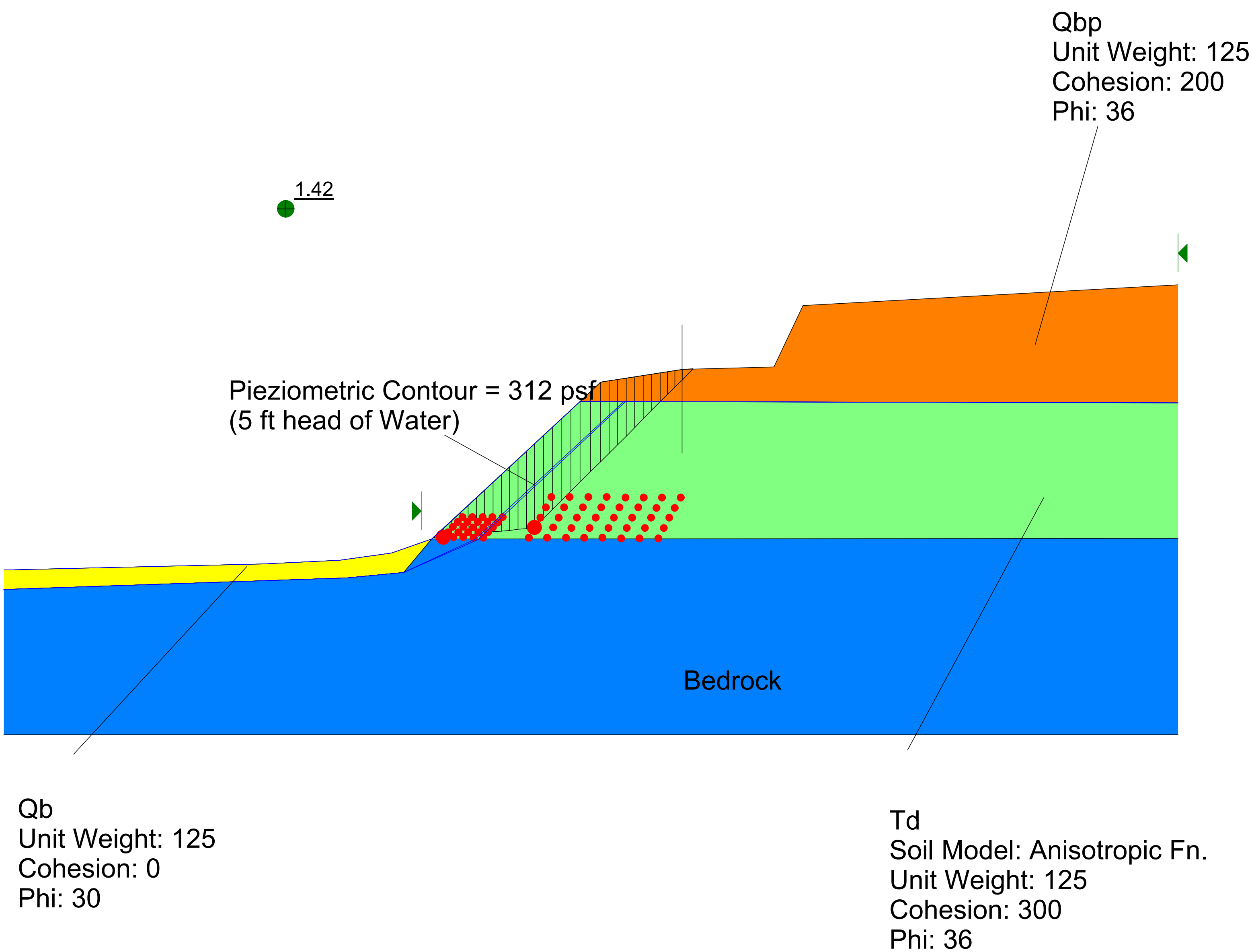
Factor of Safety: 1.01

Seismic Coefficient = 0.28



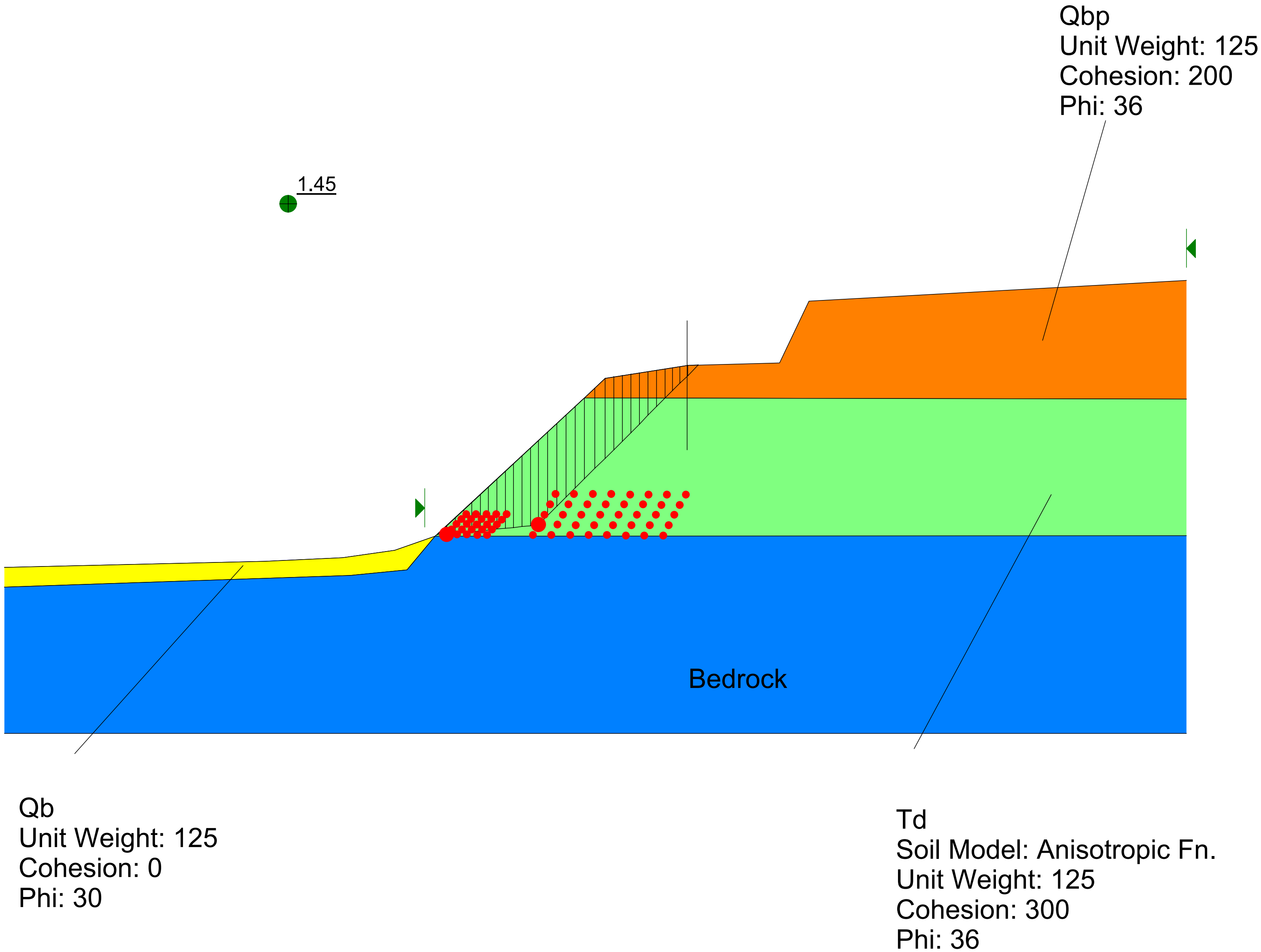
Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 5ft Water Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.42



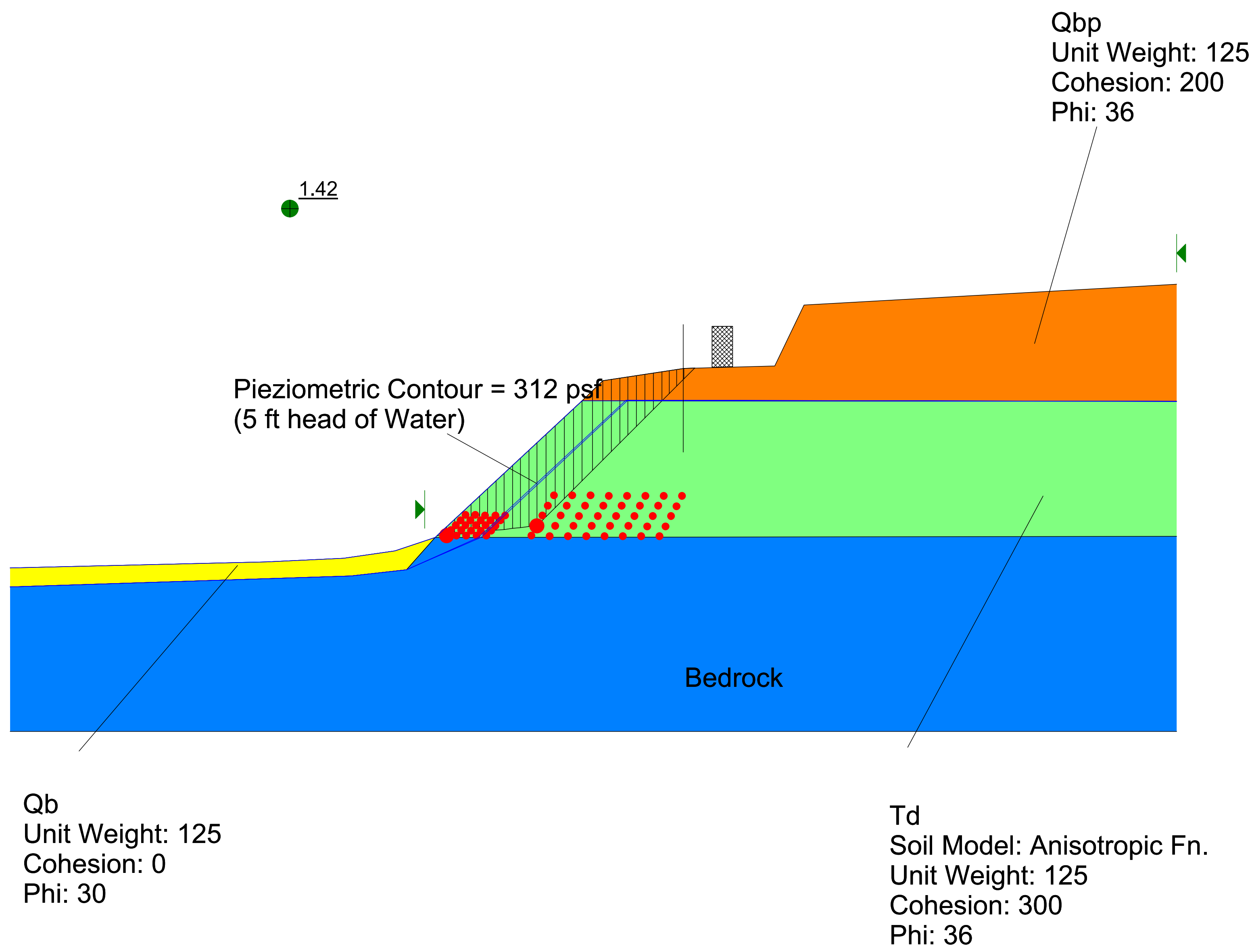
Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis, No Water
File Name: Section 22 Static 3B.slz
Analysis Method: Spencer

Factor of Safety: 1.45



Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 5ft Water Static 4B.slz
Analysis Method: Spencer

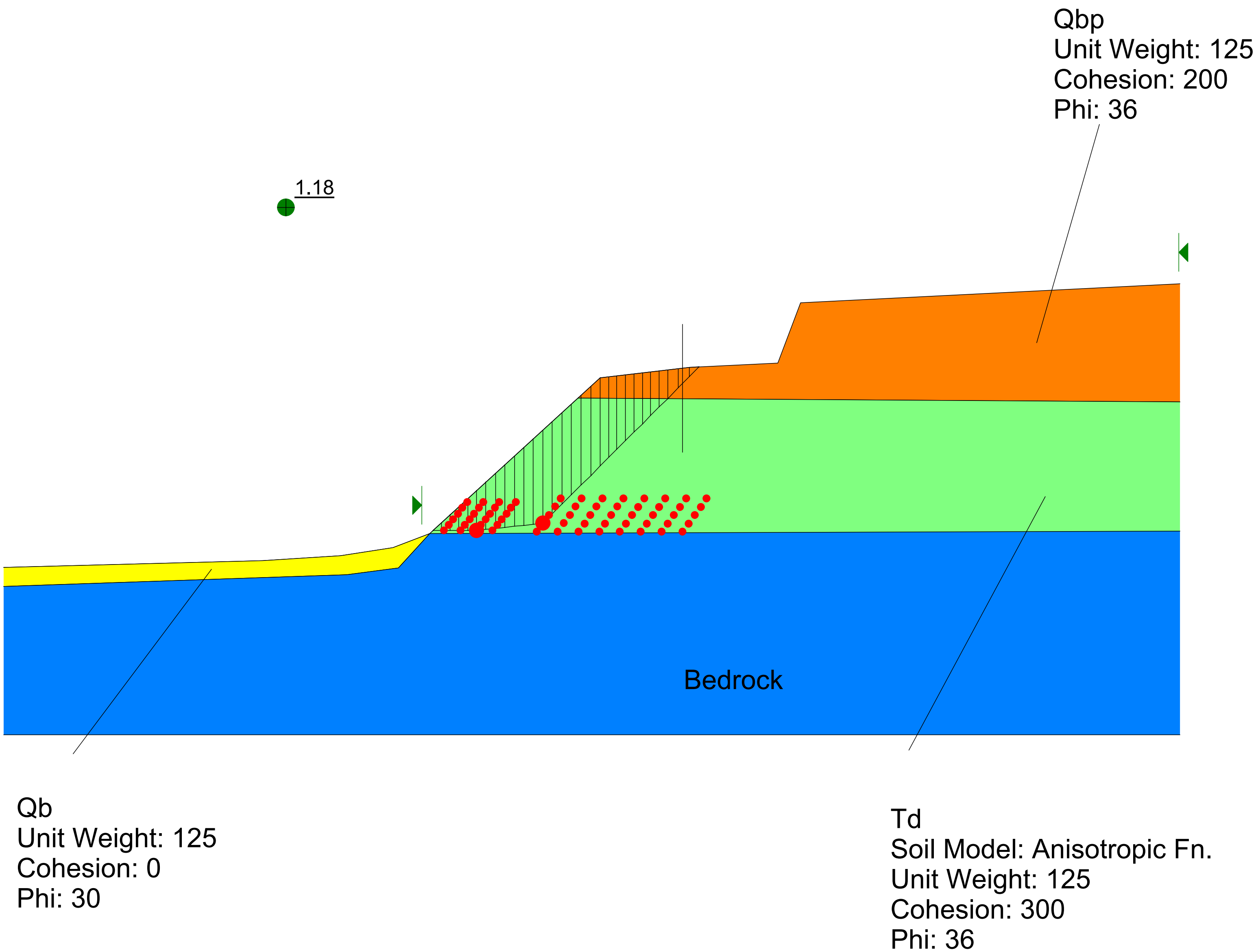
Factor of Safety: 1.42
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 Psuedo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.18

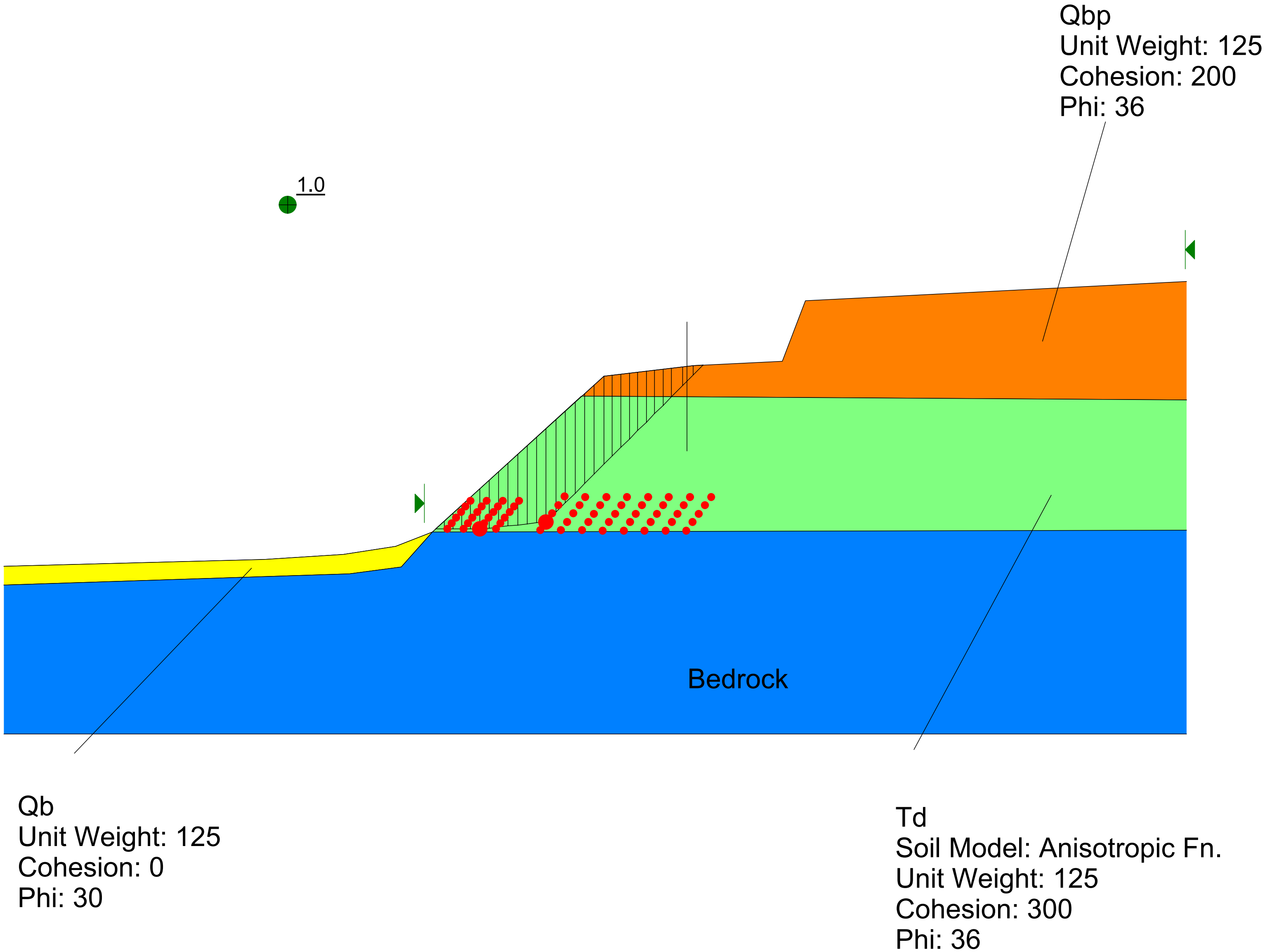
Seismic Coefficient = 0.15



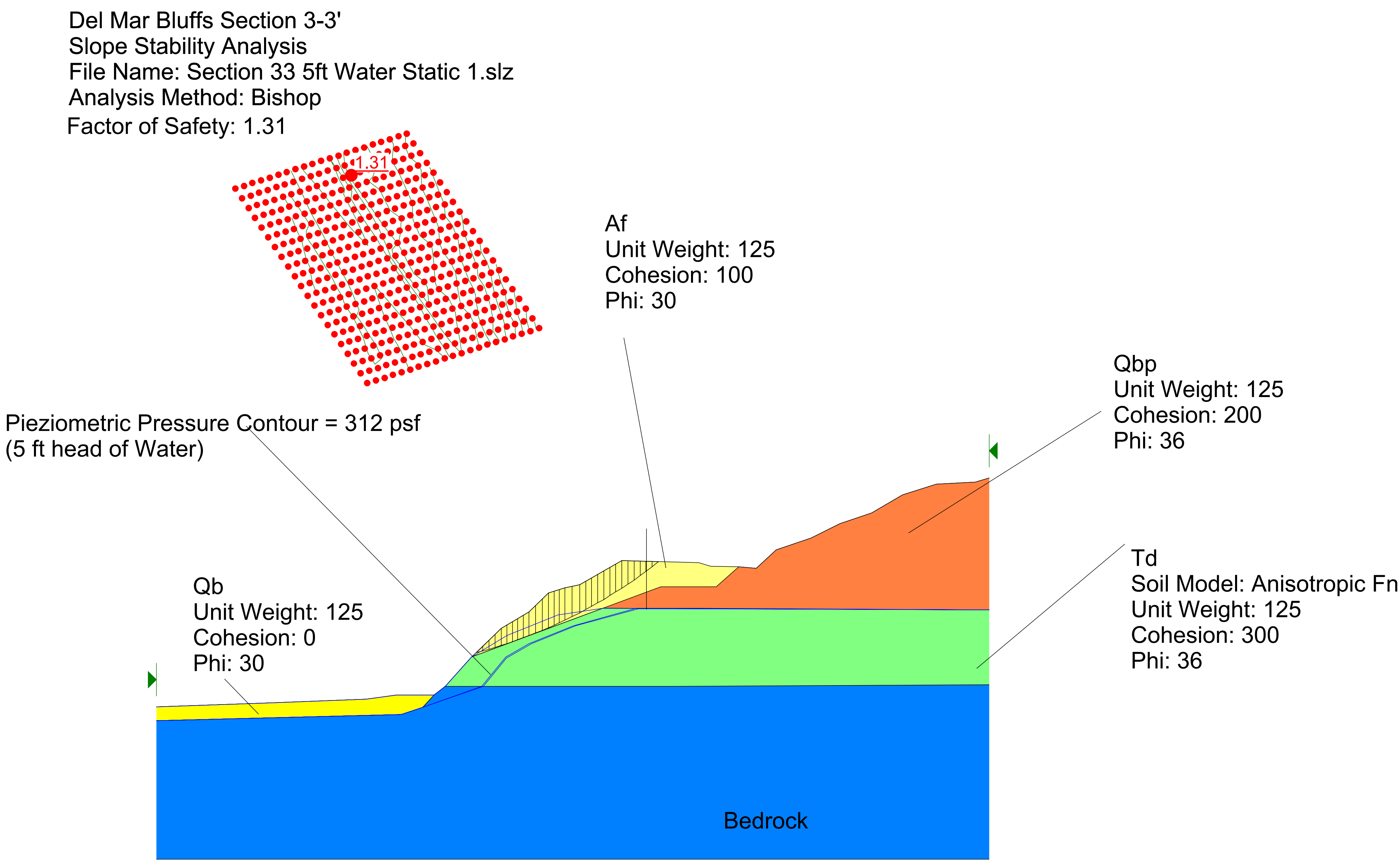
Del Mar Bluffs Cross Section 2-2'
Slope Stability Analysis
File Name: Section 22 Psuedo Static 4.slz
Analysis Method: Spencer

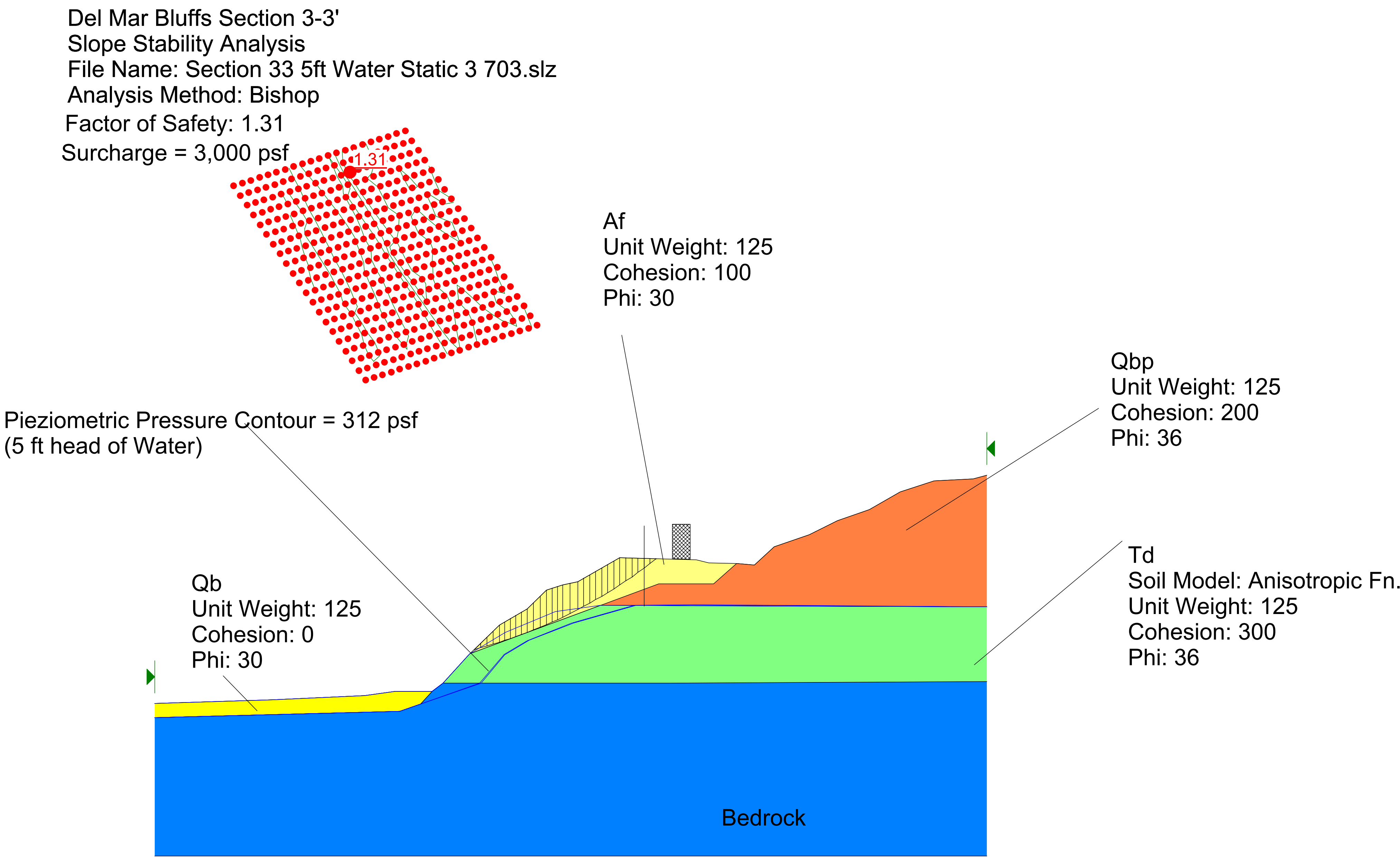
Factor of Safety: 0.98

Seismic Coefficient = 0.28



Cross Section 3-3’

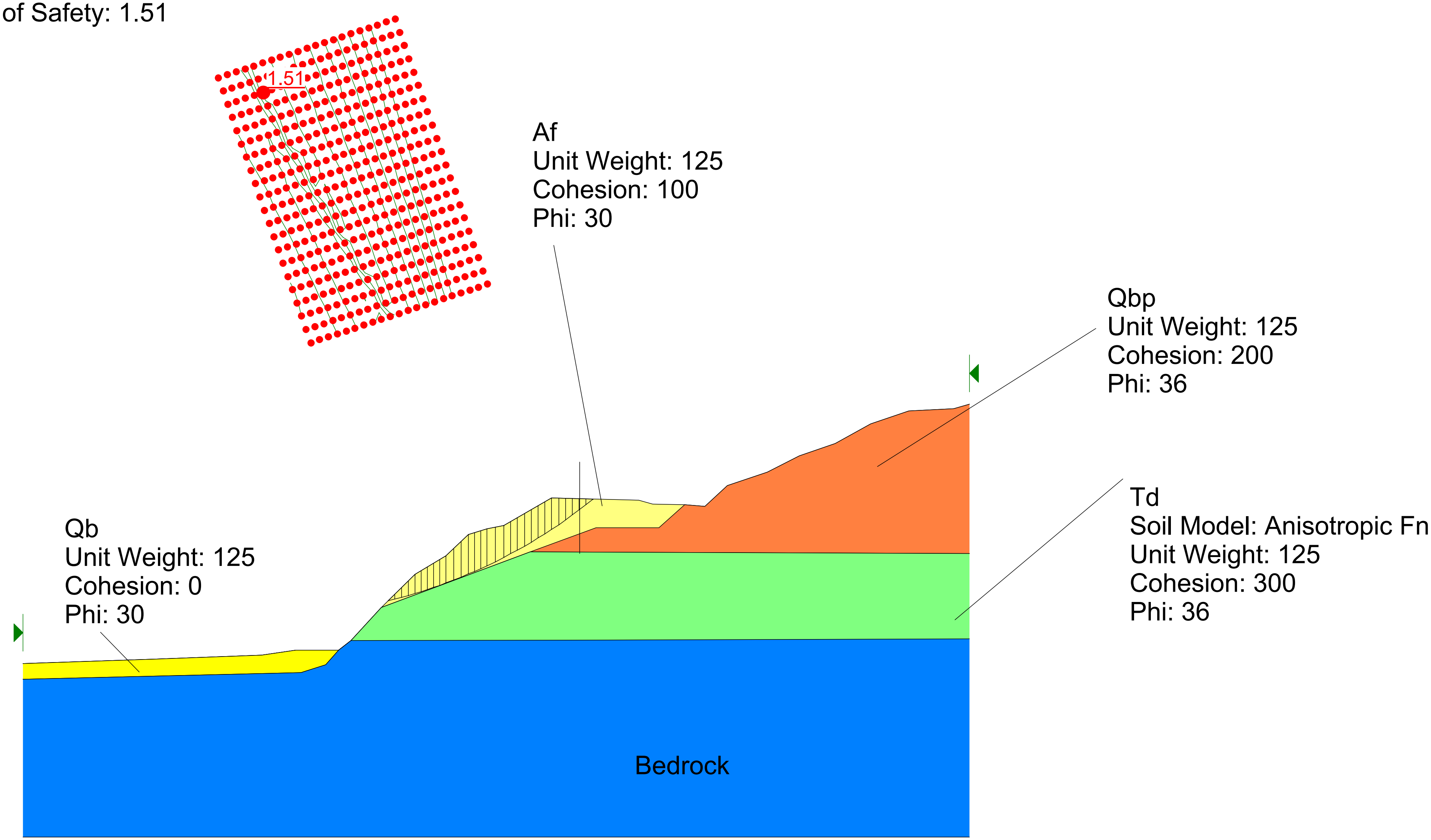

Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 5ft Water Static 1.slz
Analysis Method: Bishop
Factor of Safety: 1.31
1.31
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Pieziometric Pressure Contour = 312 psf
(5 ft head of Water)
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock



Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 5ft Water Static 3 703.slz
Analysis Method: Bishop
Factor of Safety: 1.31
Surcharge = 3,000 psf
1.31
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Pieziometric Pressure Contour = 312 psf
(5 ft head of Water)
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock

Del Mar Bluffs Section 3-3'
Slope Stability Analysis, No Water
File Name: Section 33 Static 5.slz
Analysis Method: Bishop

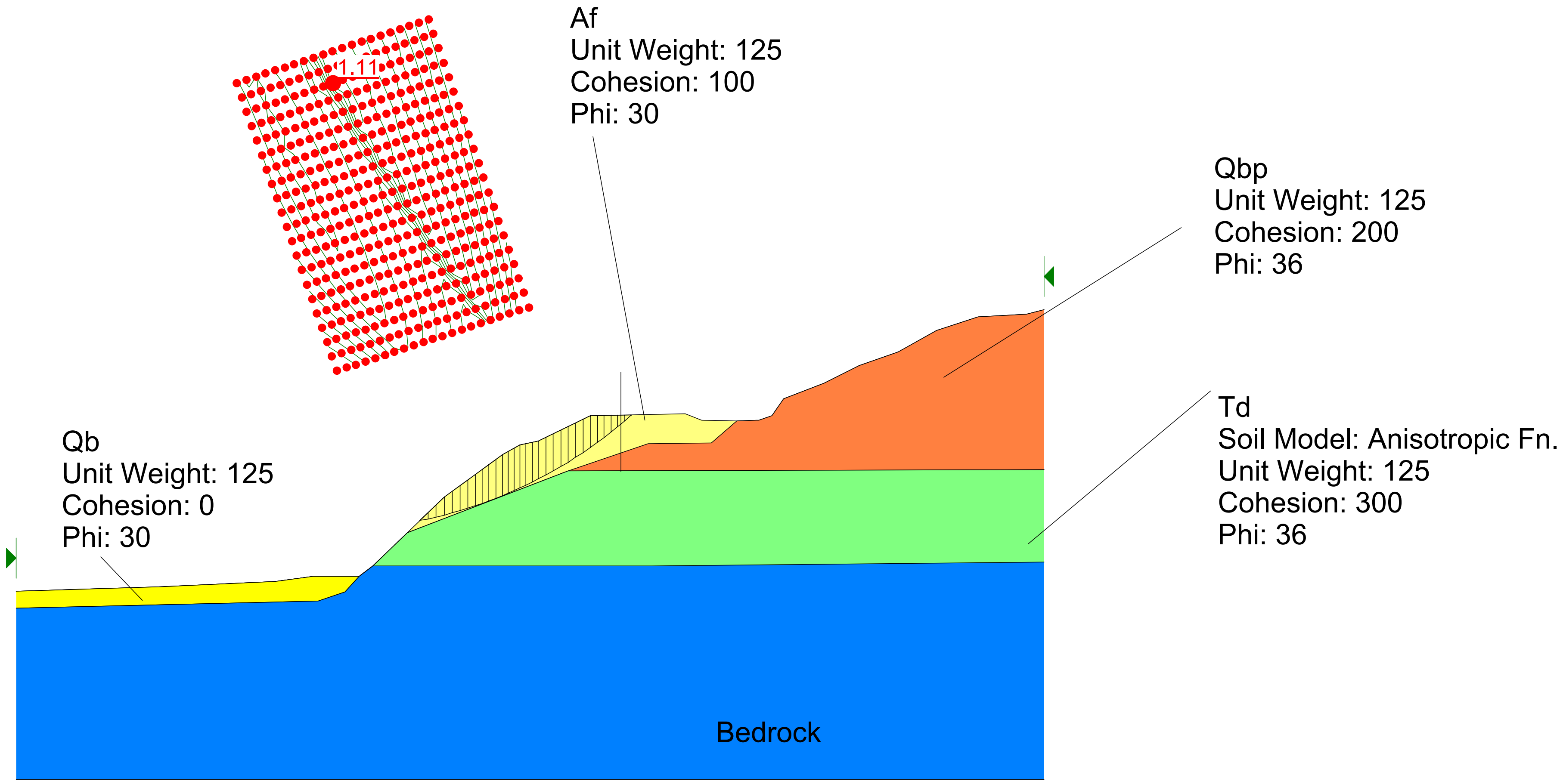
Factor of Safety: 1.51



Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 Psuedo Static 1.slz
Analysis Method: Bishop

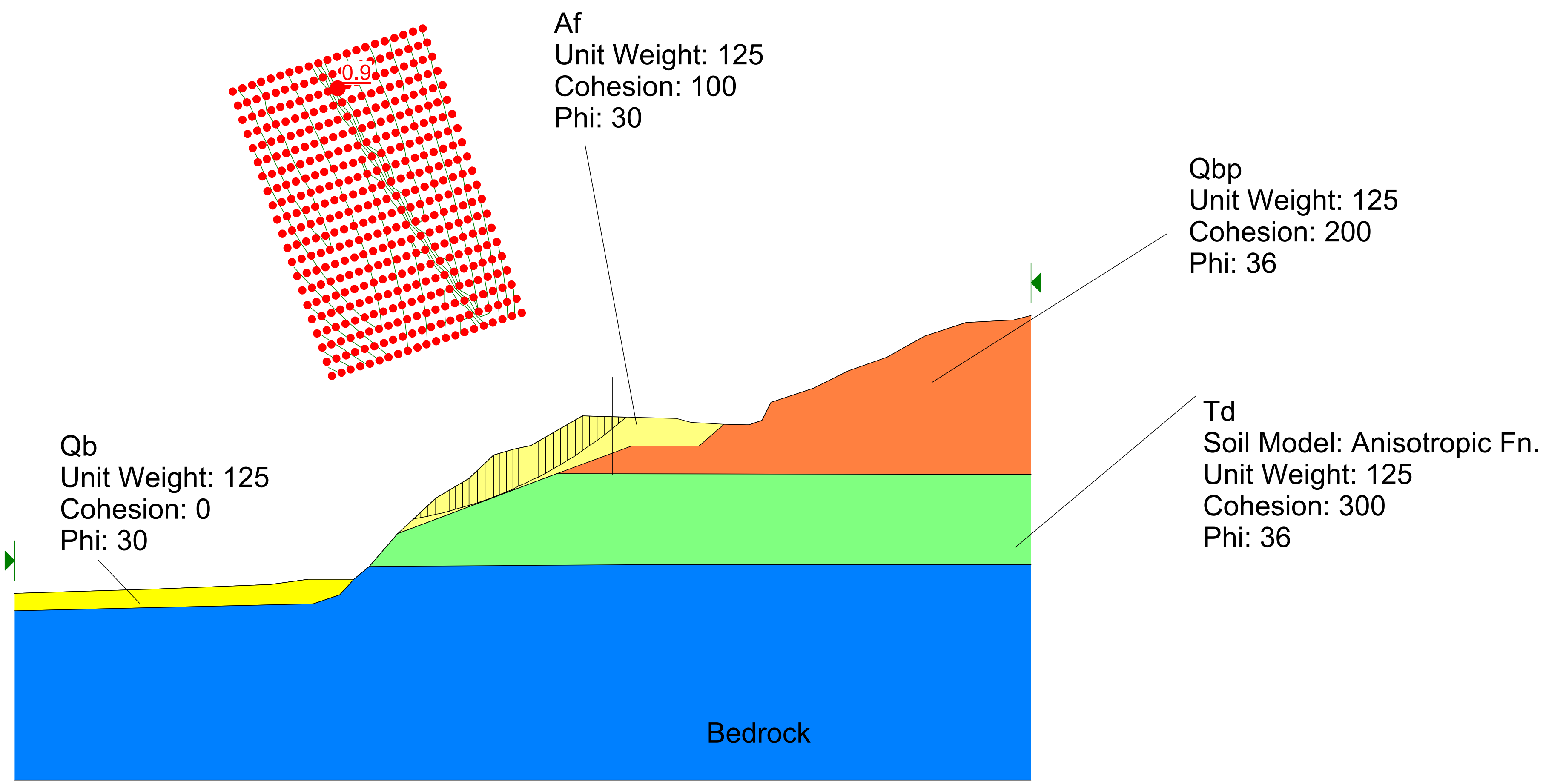
Factor of Safety: 1.11

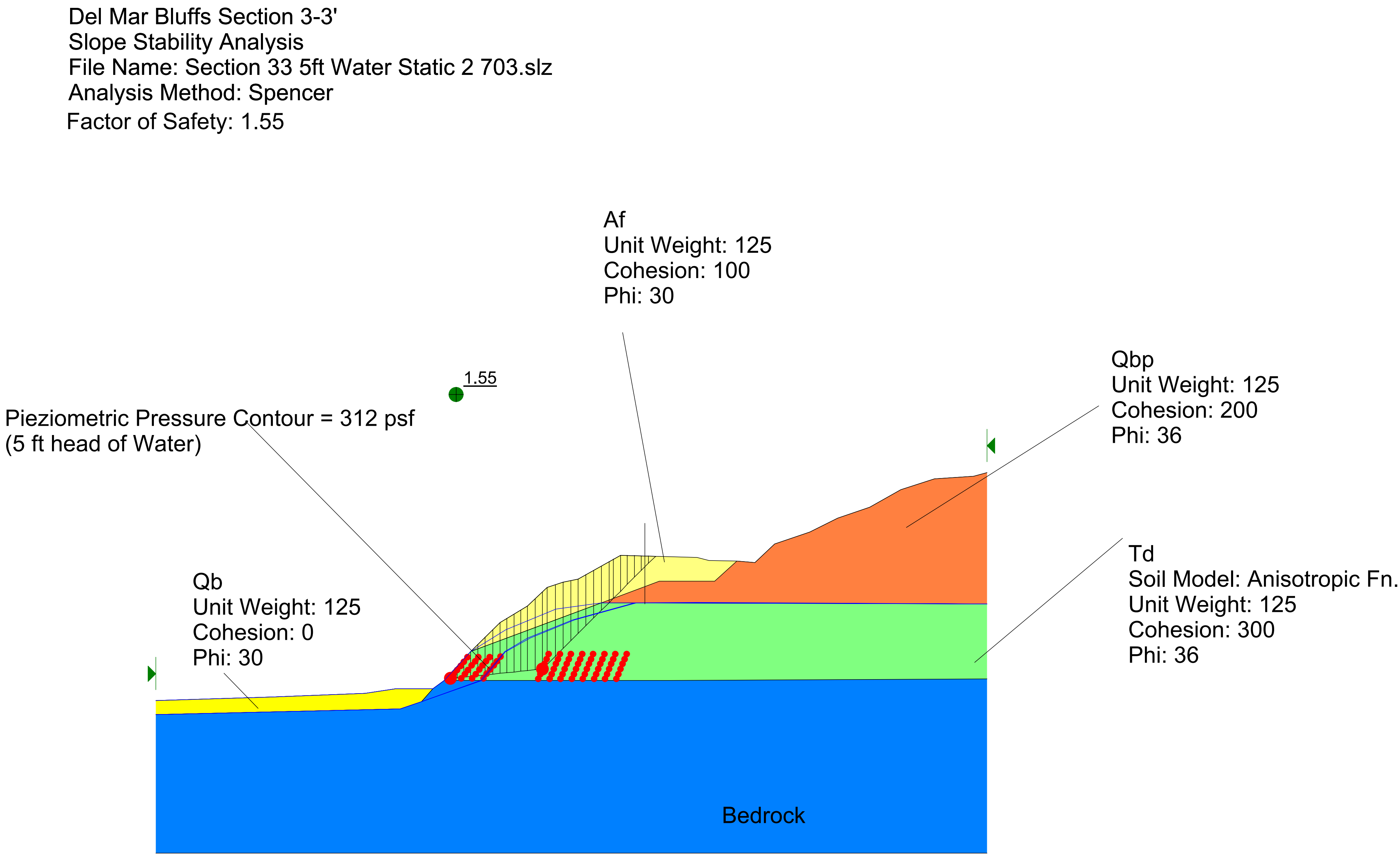
Seismic Coefficient = 0.15



Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 Psuedo Static 3.slz
Analysis Method: Bishop

Factor of Safety: 0.9
Seismic Coefficient = 0.28

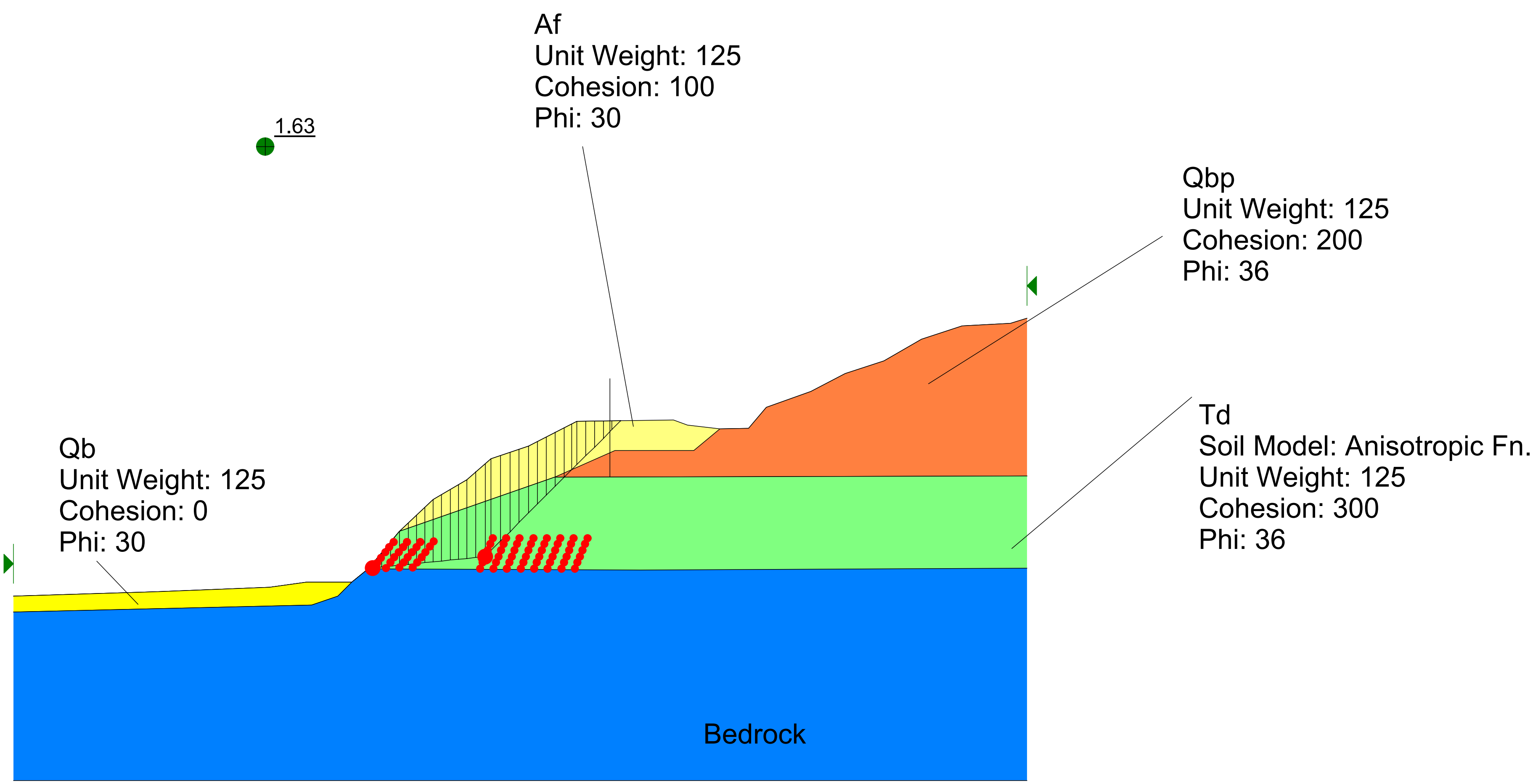




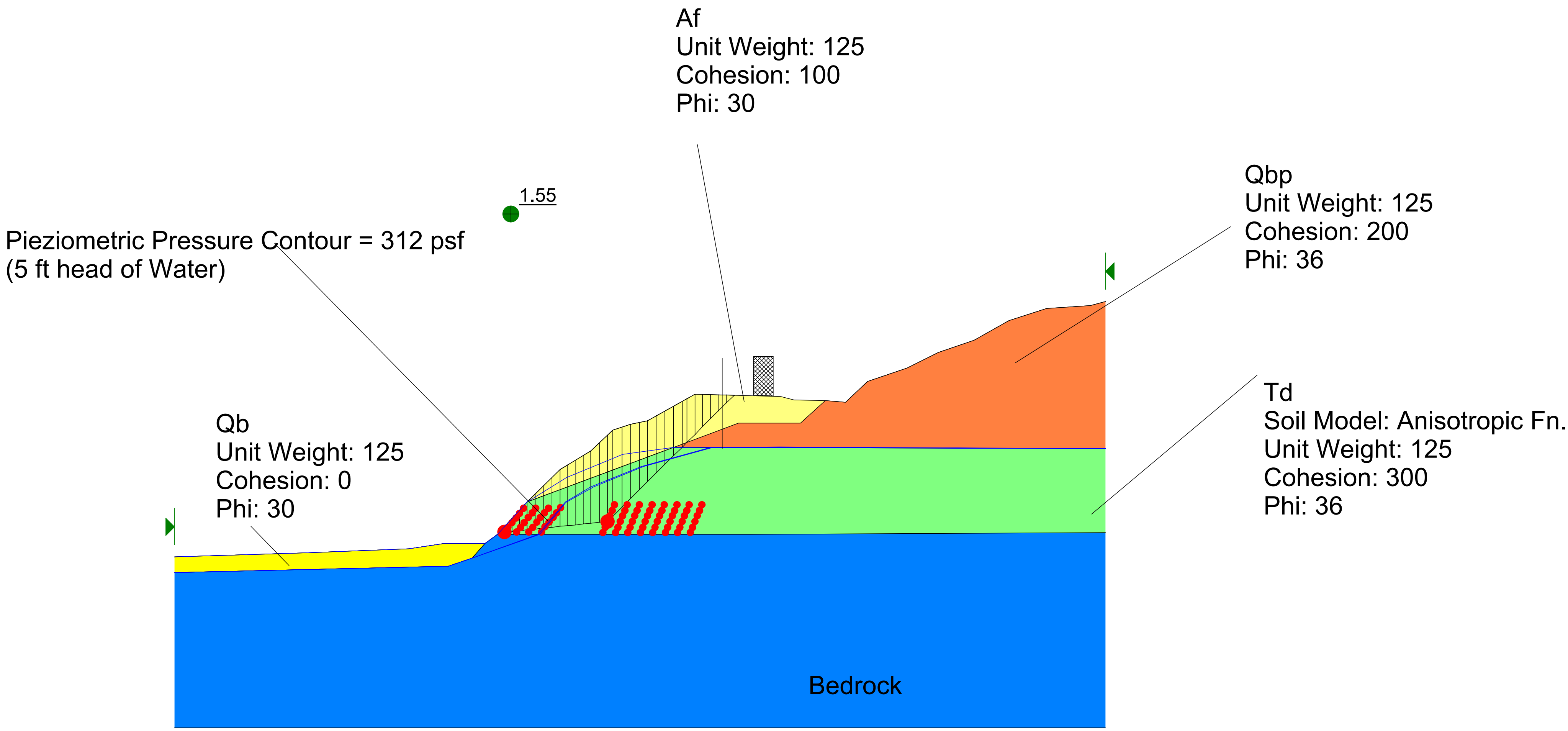
Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 5ft Water Static 2 703.slz
Analysis Method: Spencer
Factor of Safety: 1.55
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
1.55
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Pieziometric Pressure Contour = 312 psf
(5 ft head of Water)
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock

Del Mar Bluffs Section 3-3'
Slope Stability Analysis, No Water
File Name: Section 33 Static 6.slz
Analysis Method: Spencer

Factor of Safety: 1.63

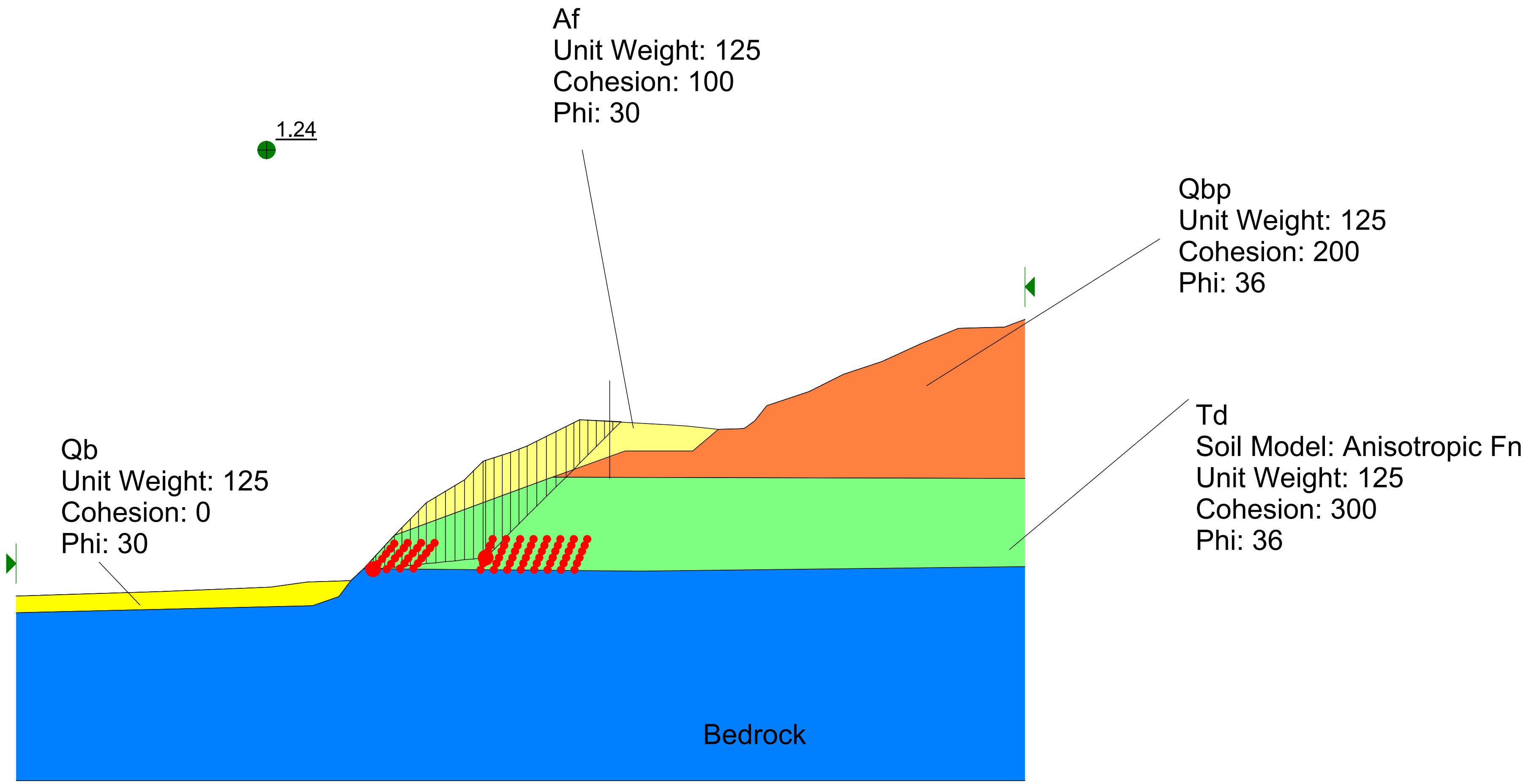


Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 5ft Water Static 4 703.slz
Analysis Method: Spencer
Factor of Safety: 1.55
Surcharge = 3,000 psf



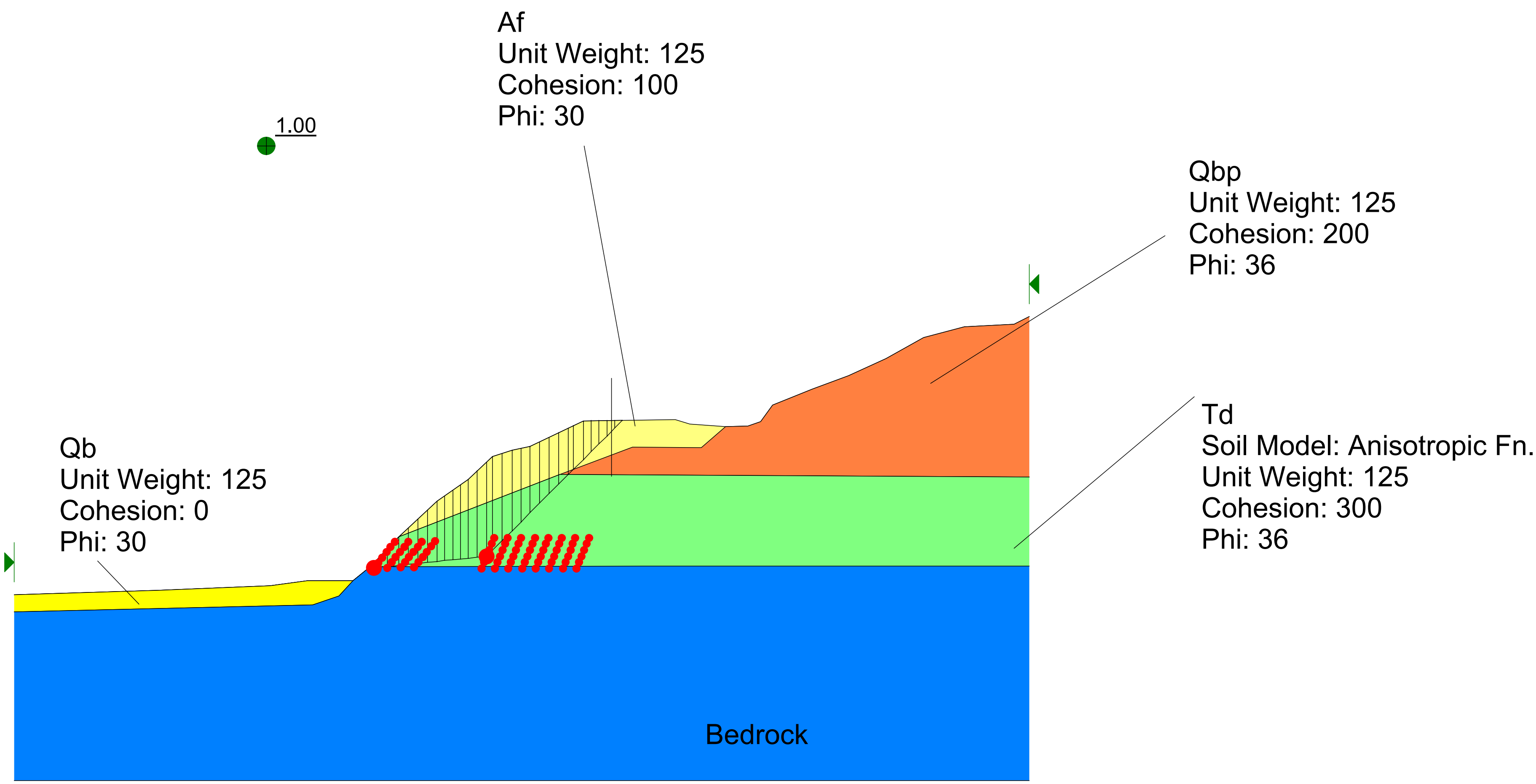
Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 Psuedo Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.24
Seismic Coefficient = 0.15



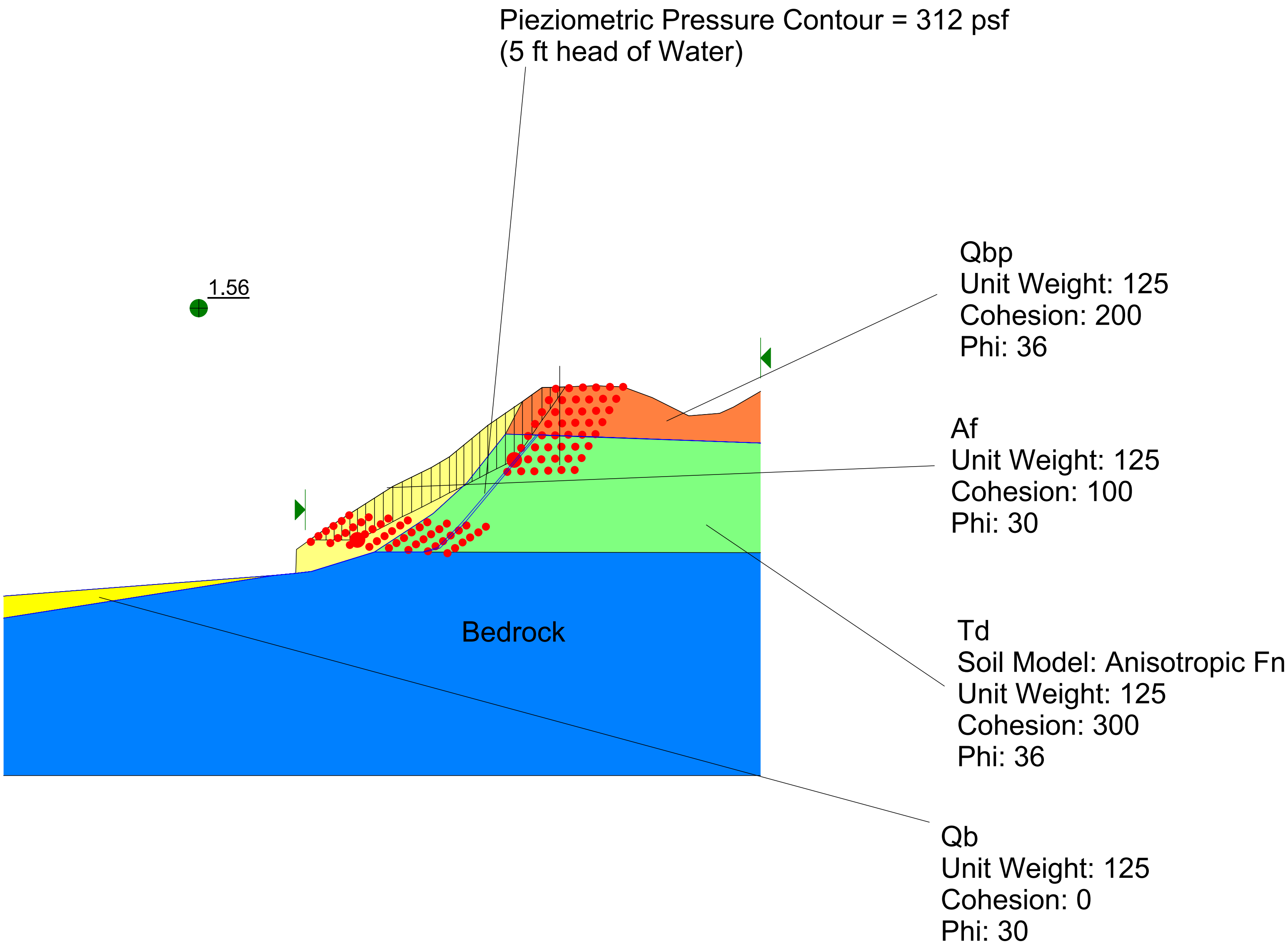
Del Mar Bluffs Section 3-3'
Slope Stability Analysis
File Name: Section 33 Psuedo Static 4.slz
Analysis Method: Spencer

Factor of Safety: 1
Seismic Coefficient = 0.28

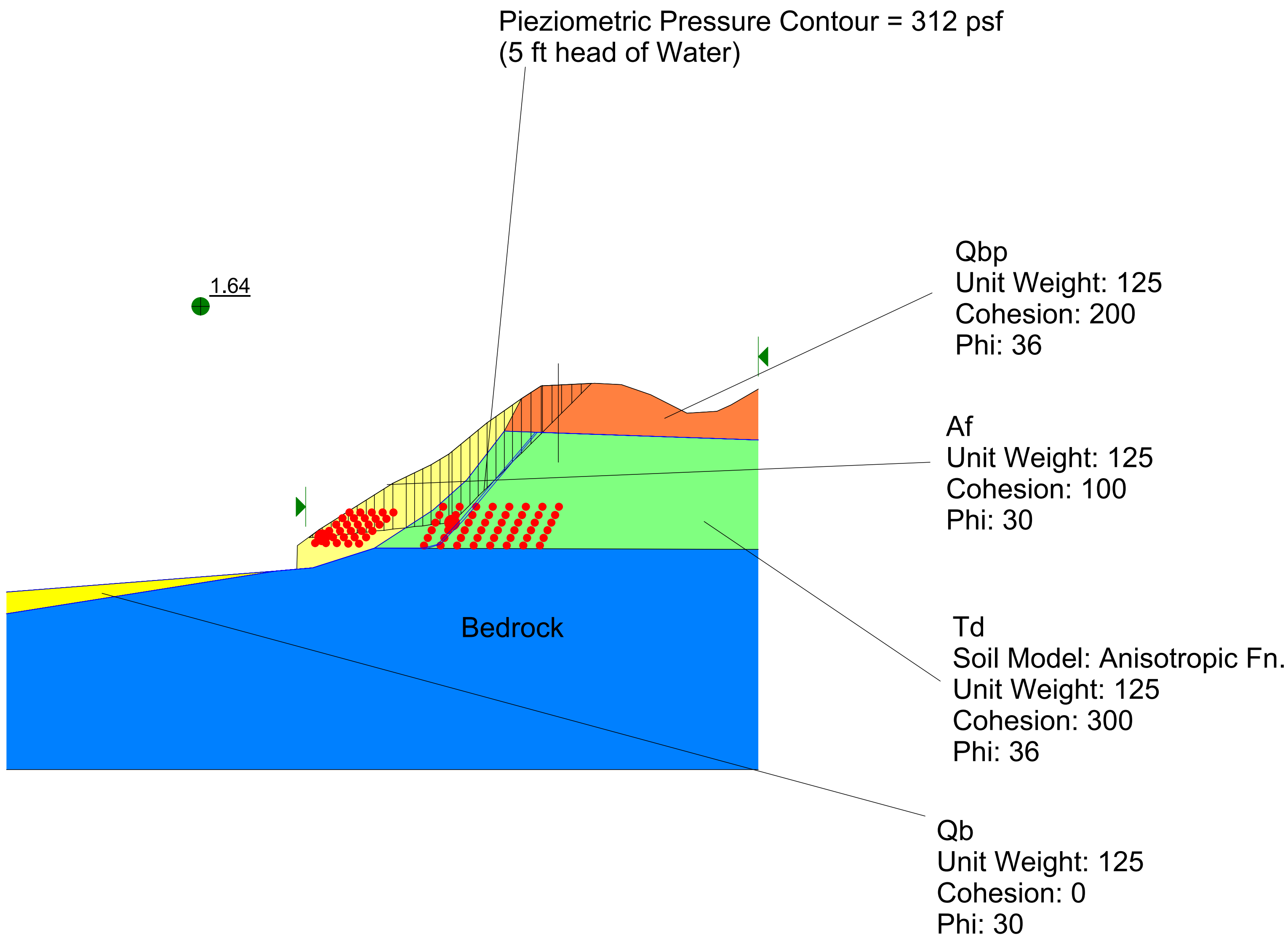


Cross Section 4-4’

Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 5ft Water Static 1.slz
Analysis Method: Spencer
Factor of Safety: 1.56

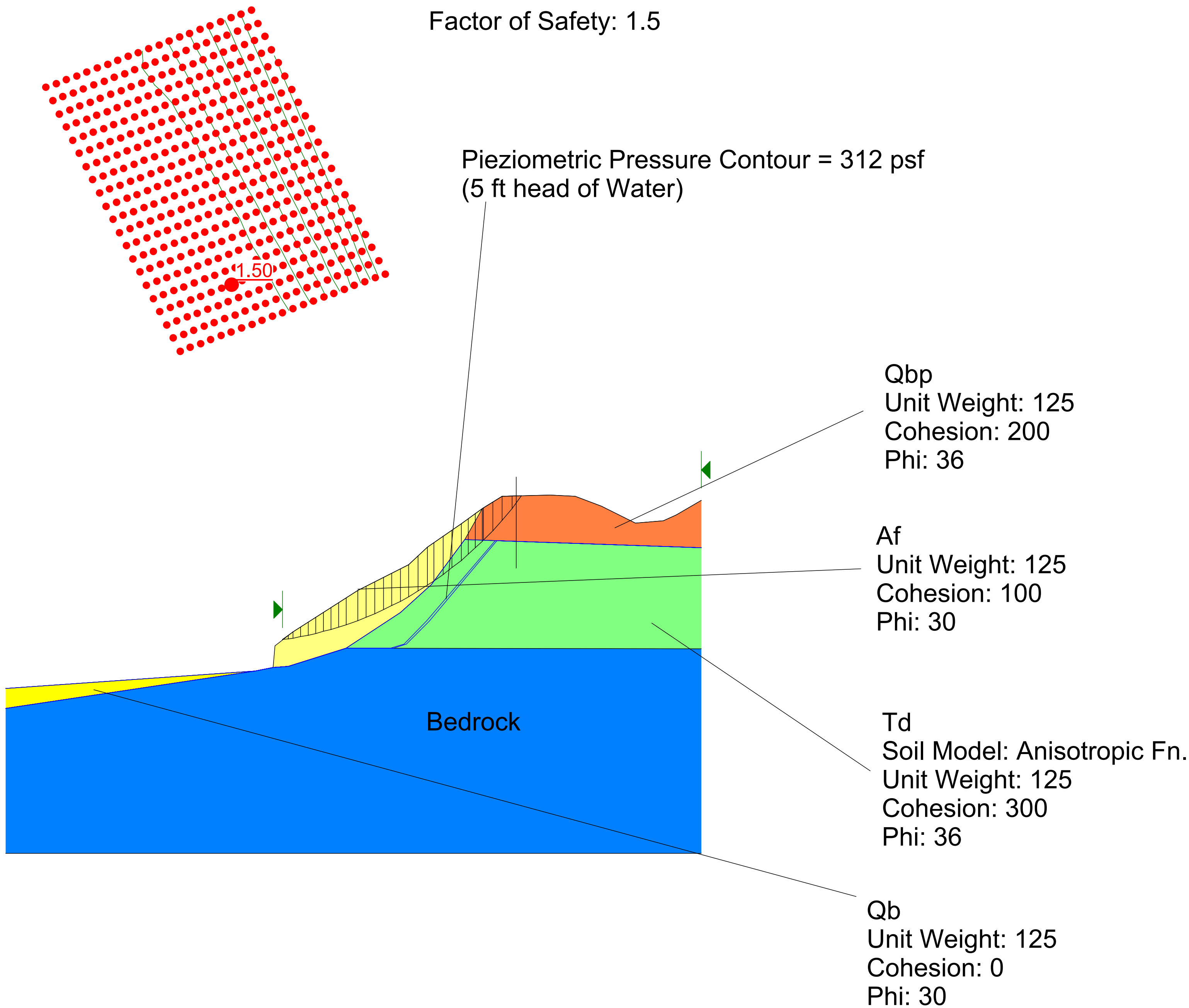


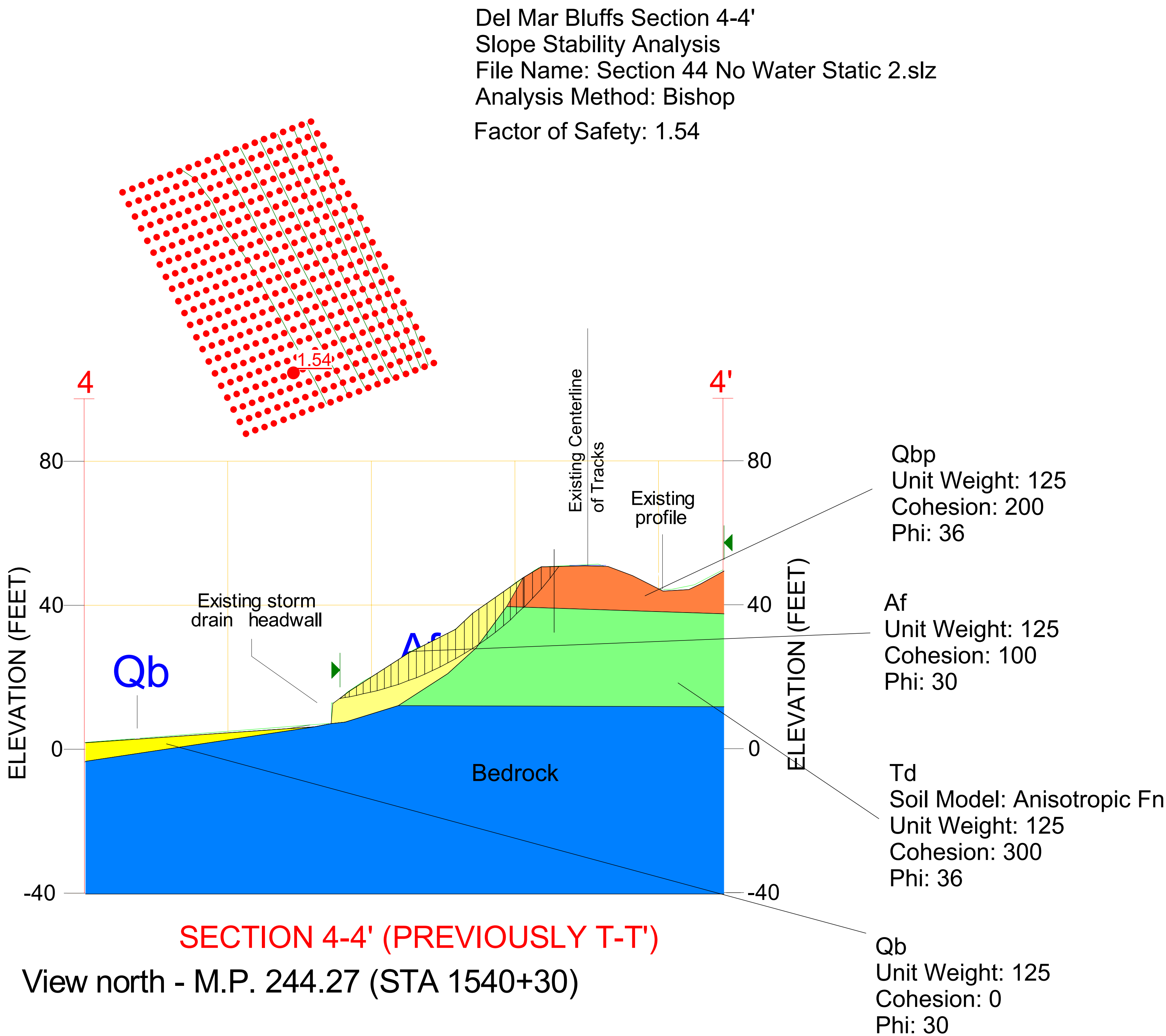
Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 5ft Water Static 1B.slz
Analysis Method: Spencer
Factor of Safety: 1.64



Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 5ft Water Static 2.slz
Analysis Method: Bishop

Factor of Safety: 1.5

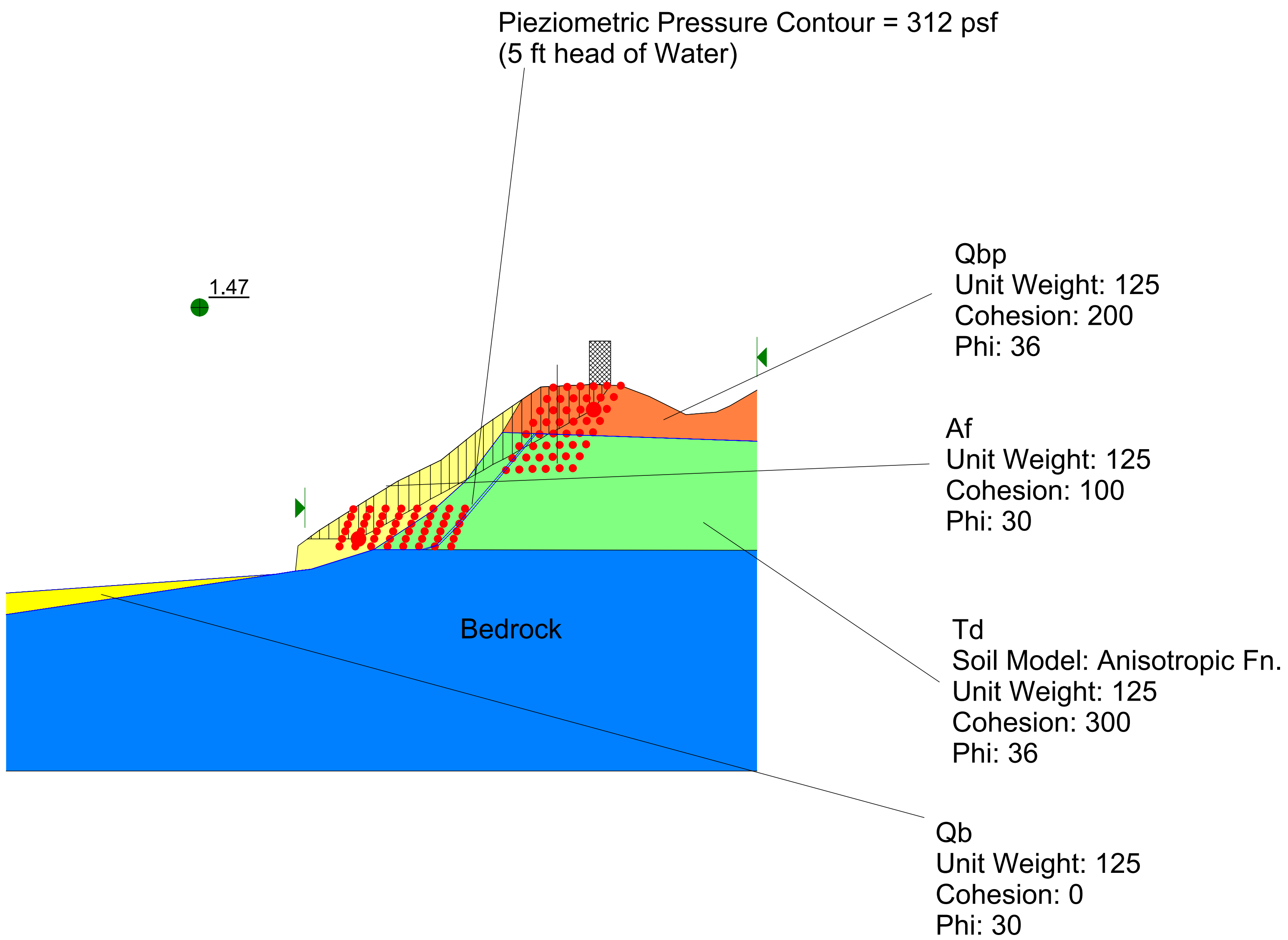



Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 No Water Static 2.slz
Analysis Method: Bishop
Factor of Safety: 1.54
1.54
4
4'
80
40
0
-40
ELEVATION (FEET)
Existing Centerline of Tracks
Existing profile
Existing storm drain headwall
Qb
Bedrock
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
SECTION 4-4' (PREVIOUSLY T-T')
View north - M.P. 244.27 (STA 1540+30)

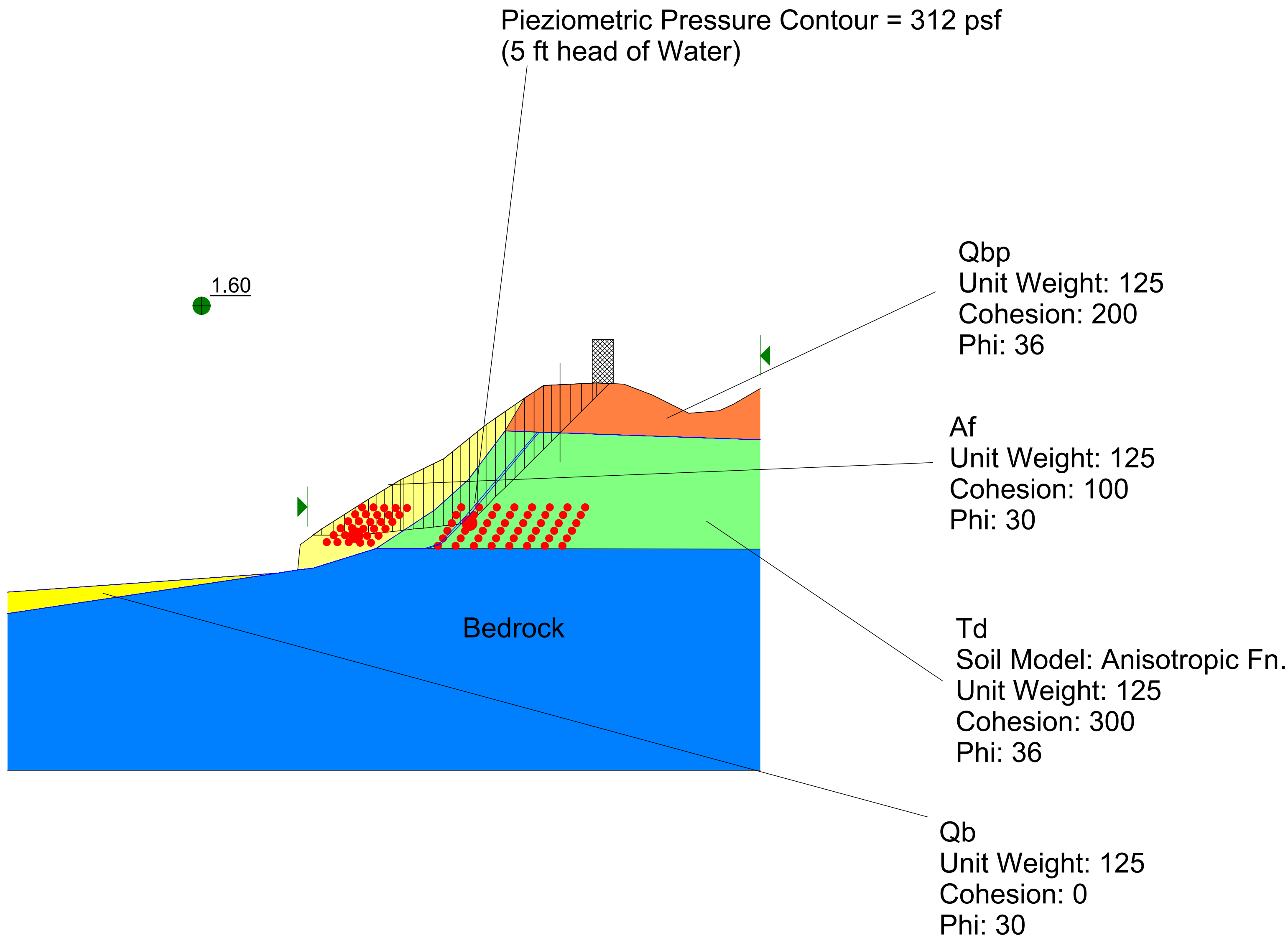
Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 5ft Water Static 3.slz
Analysis Method: Spencer

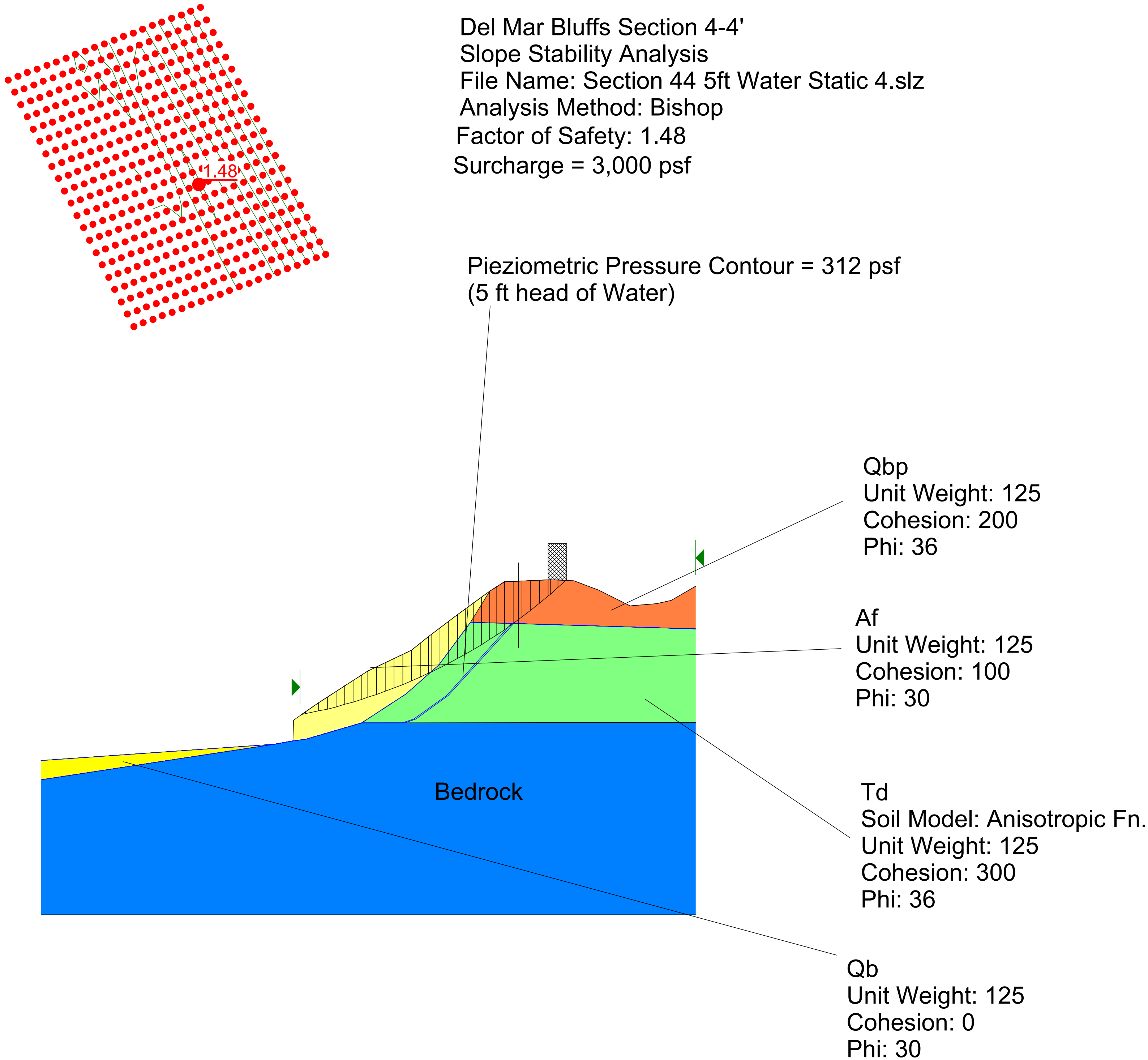
Factor of Safety: 1.47

Surcharge = 3,000 psf



Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 5ft Water Static 3B.slz
Analysis Method: Spencer
Factor of Safety: 1.6
Surcharge = 3,000 psf

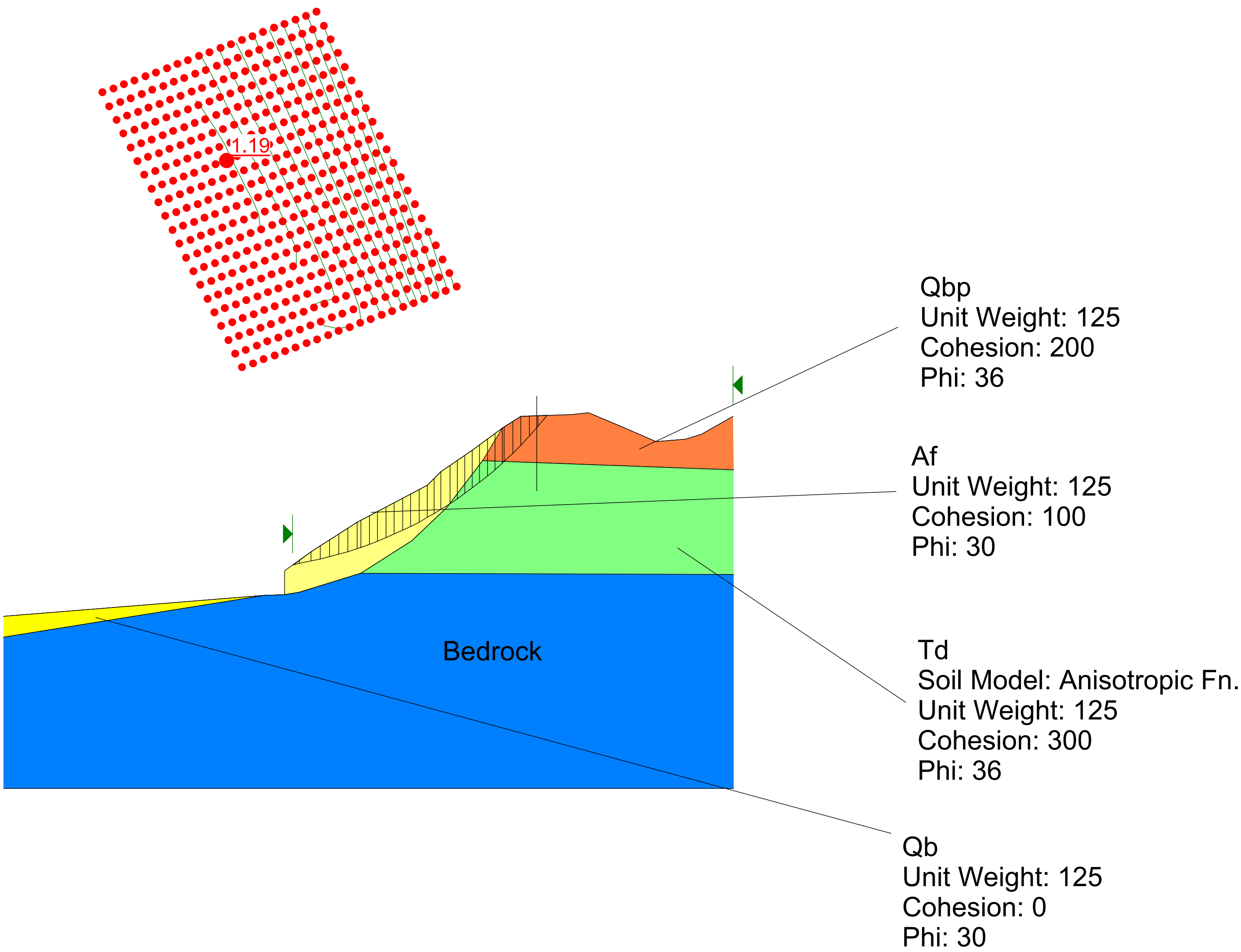




Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 5ft Water Static 4.slz
Analysis Method: Bishop
Factor of Safety: 1.48
Surcharge = 3,000 psf
1.48
Piezometric Pressure Contour = 312 psf
(5 ft head of Water)
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Bedrock
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30

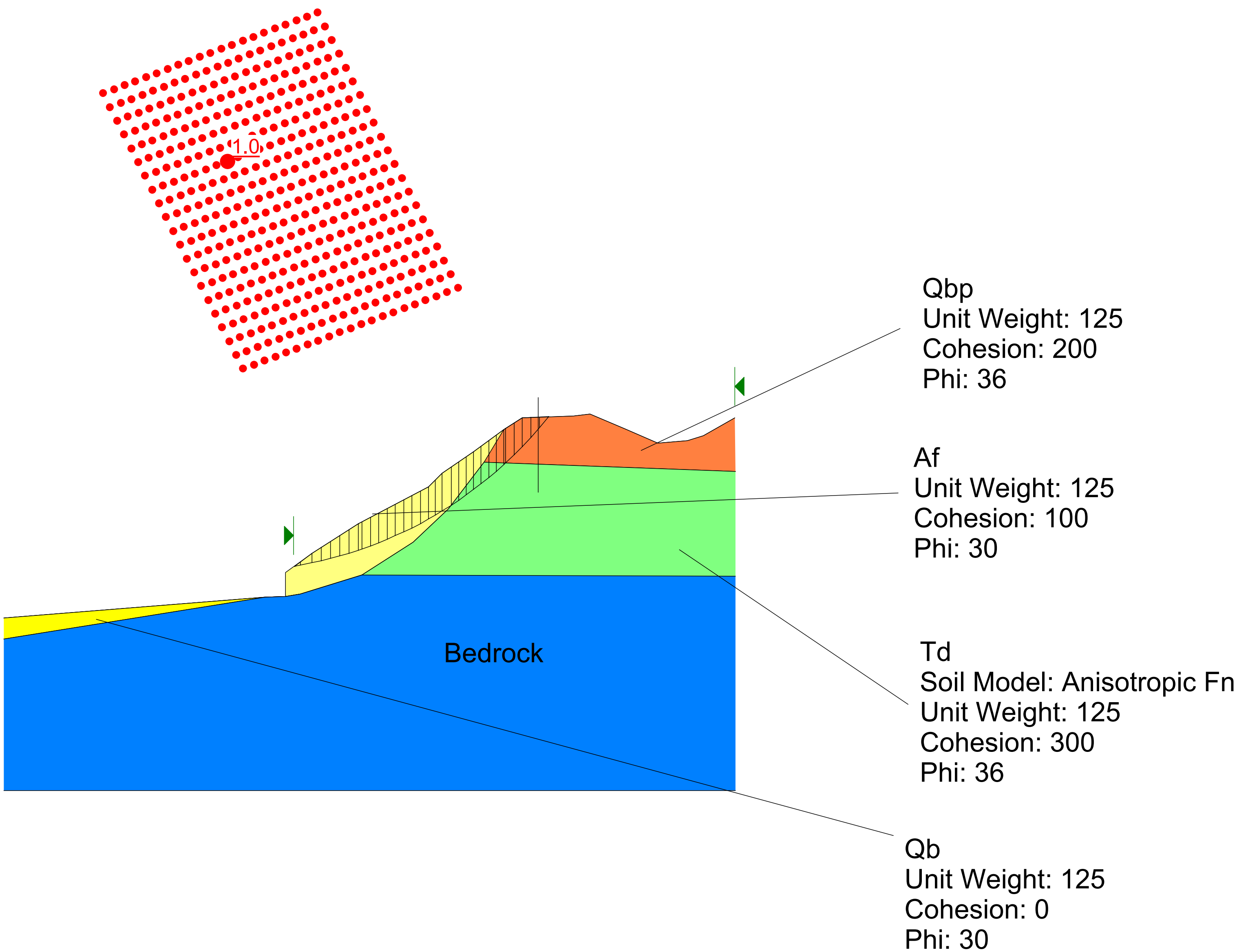
Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 Pseudo Static 1.slz
Analysis Method: Bishop

Factor of Safety: 1.19
Seismic Coefficient = 0.15

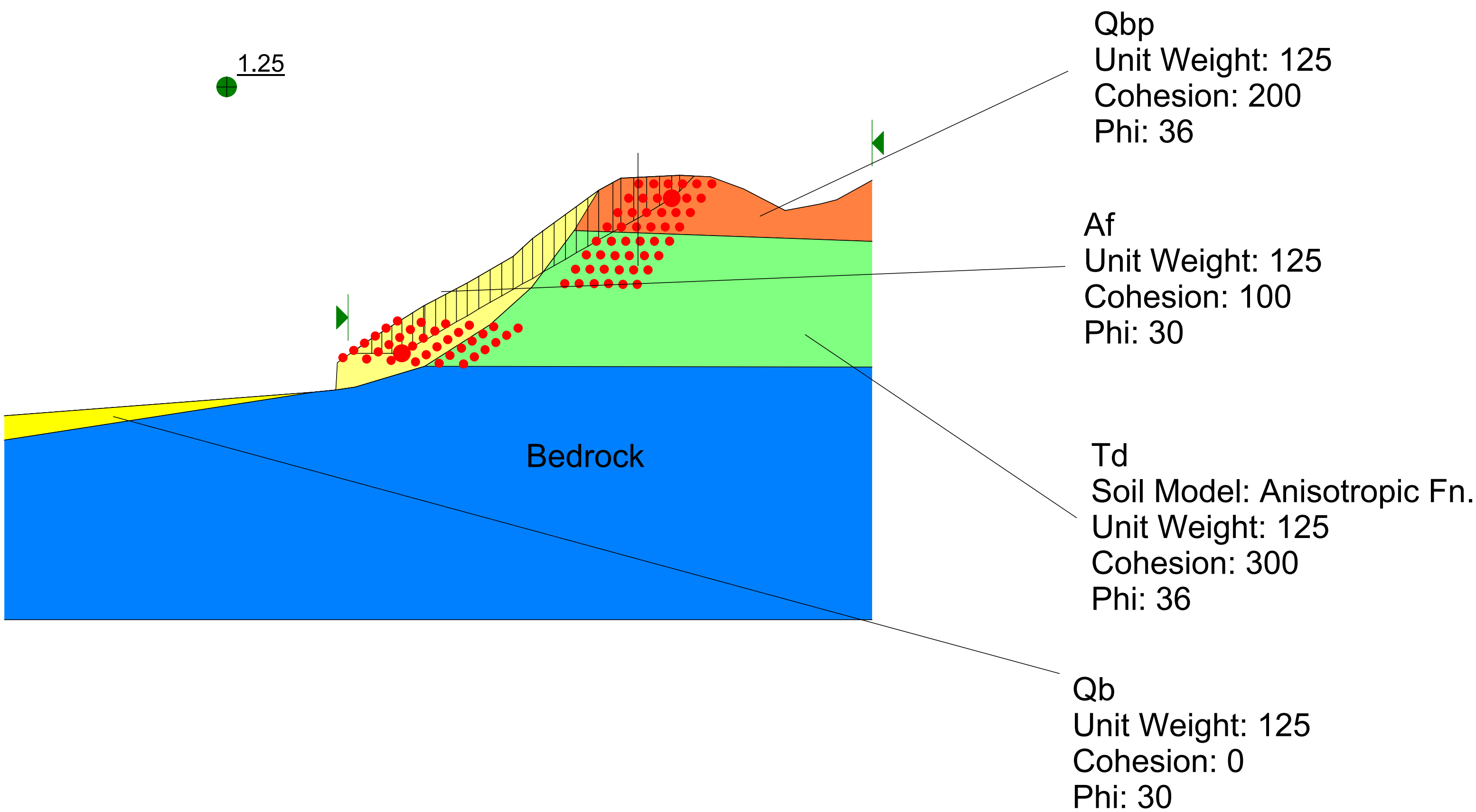


Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 Pseudo Static 2.slz
Analysis Method: Bishop

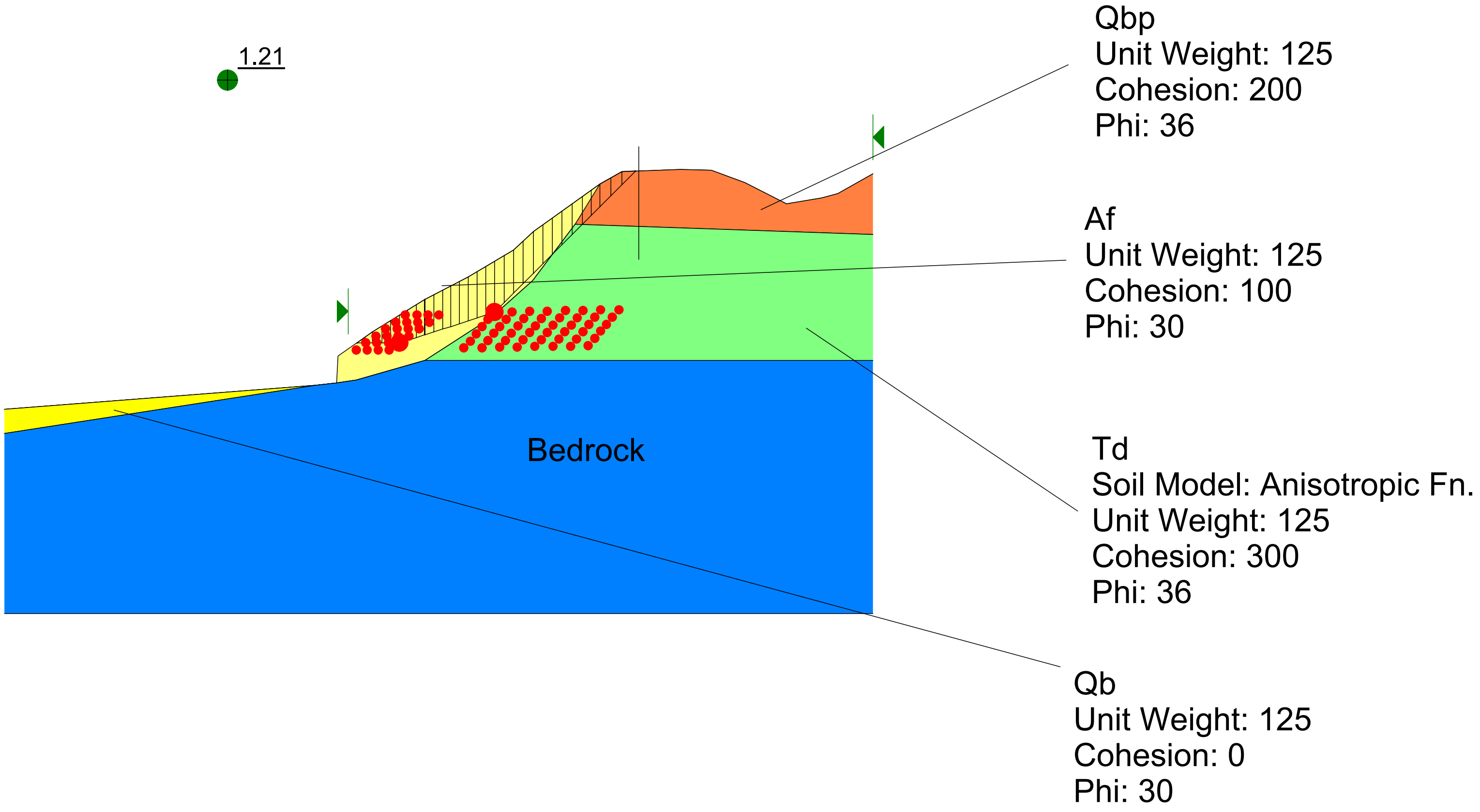
Factor of Safety: 0.96
Seismic Coefficient = 0.28



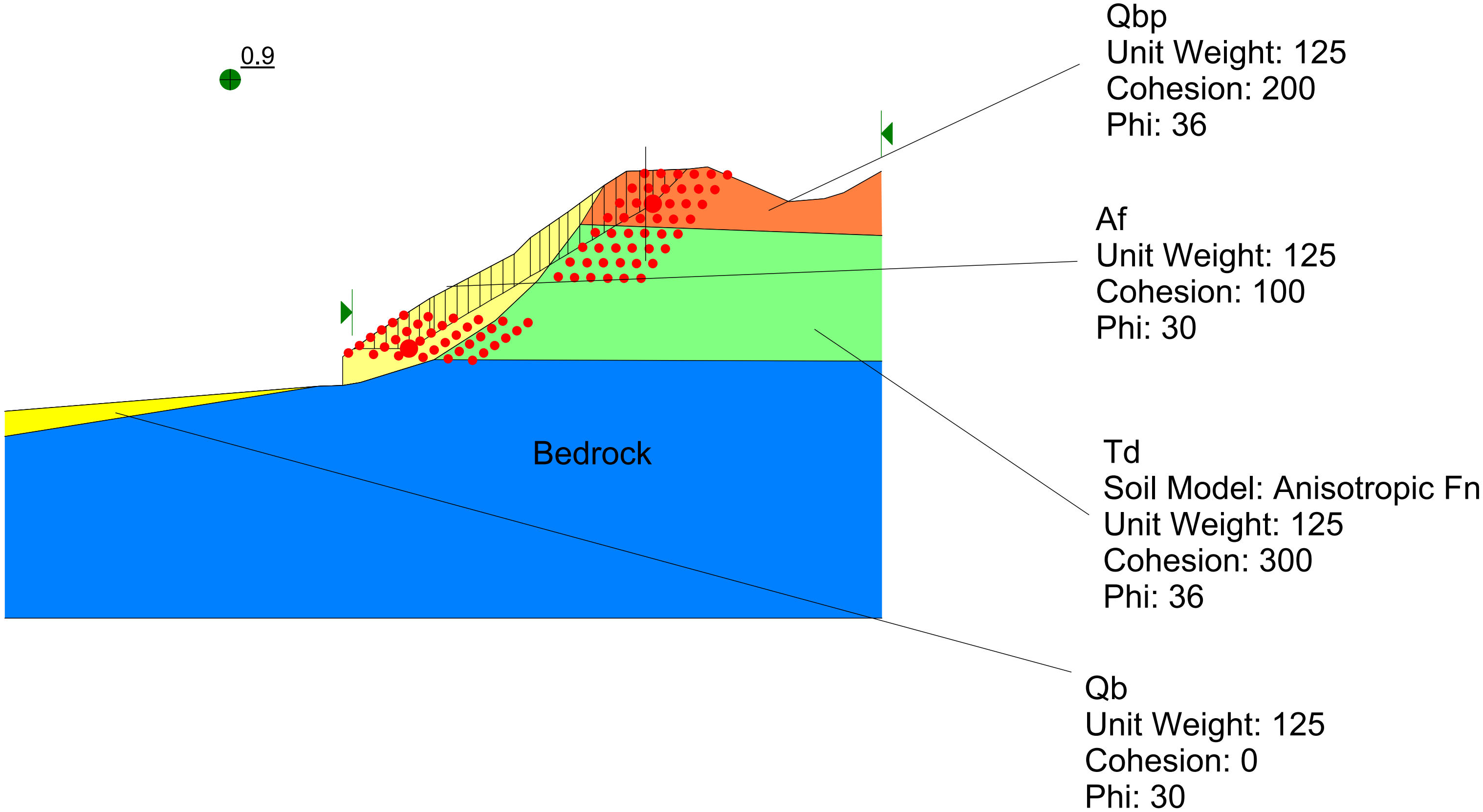
Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 Pseudo Static 3.slz
Analysis Method: Spencer
Factor of Safety: 1.25
Seismic Coefficient = 0.15



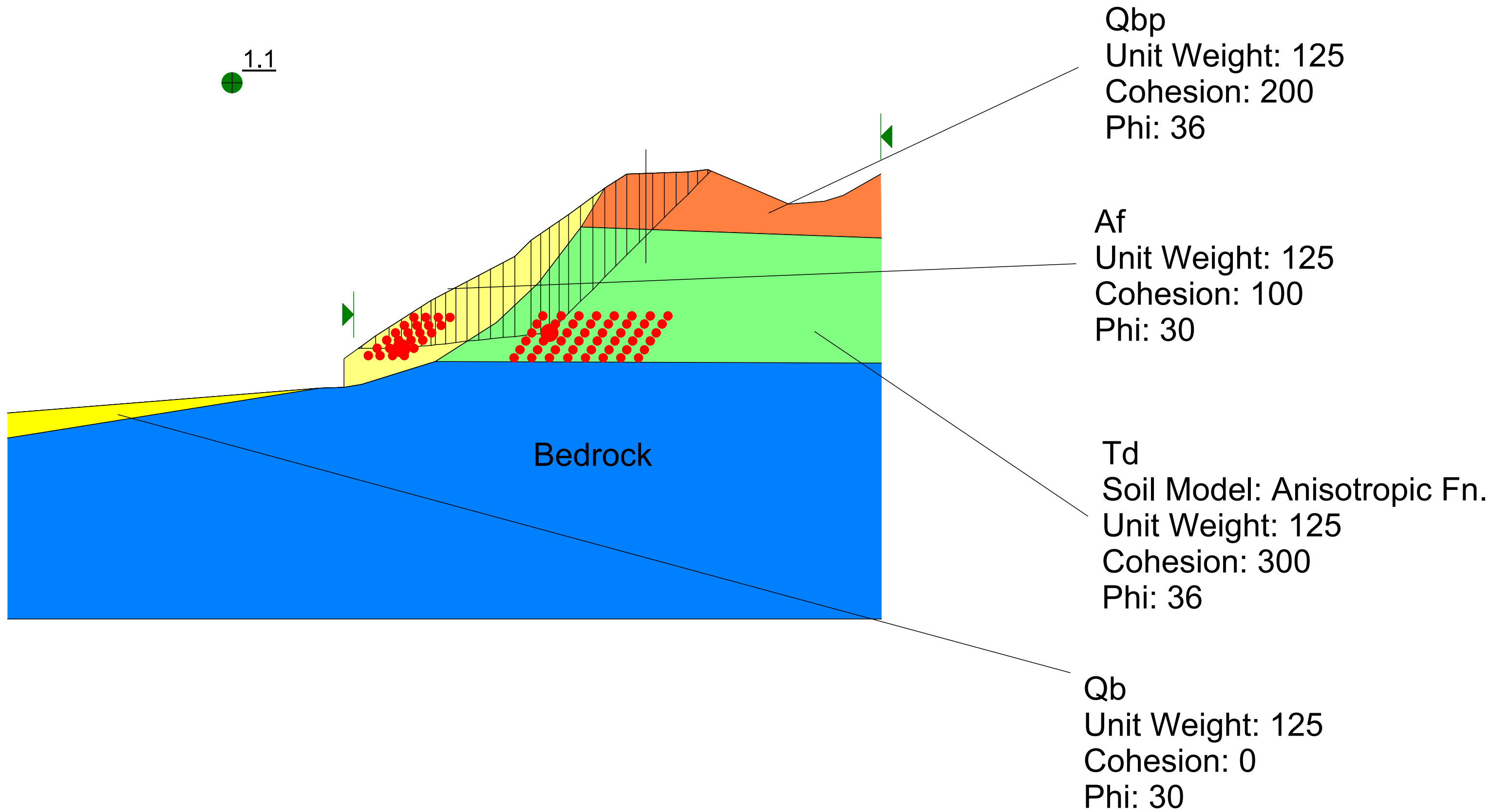
Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 Pseudo Static 3B.slz
Analysis Method: Spencer
Factor of Safety: 1.21
Seismic Coefficient = 0.15



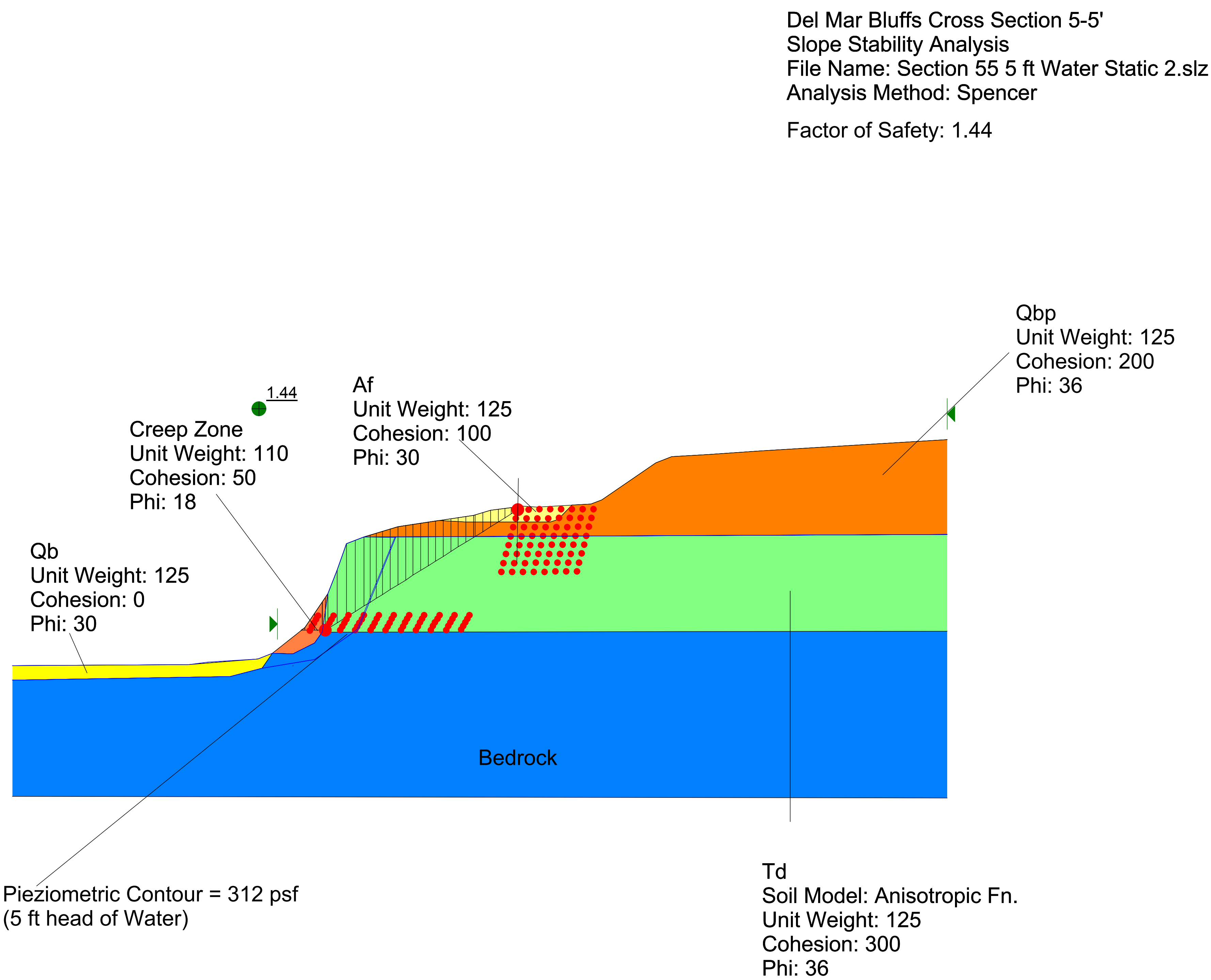
Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 Pseudo Static 4.slz
Analysis Method: Spencer
Factor of Safety: 0.93
Seismic Coefficient = 0.28



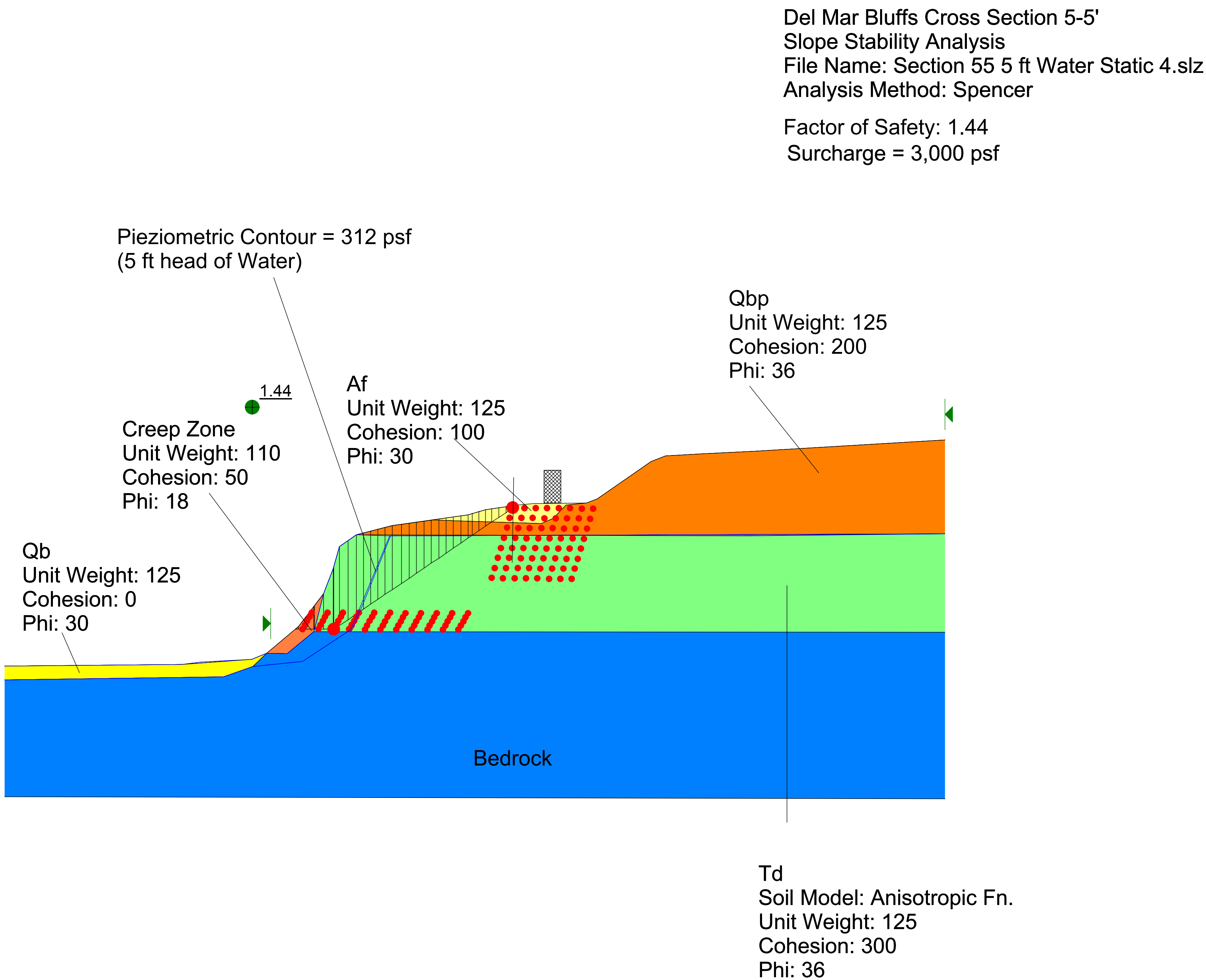
Del Mar Bluffs Section 4-4'
Slope Stability Analysis
File Name: Section 44 Pseudo Static 4B.slz
Analysis Method: Spencer
Factor of Safety: 1.1
Seismic Coefficient = 0.28

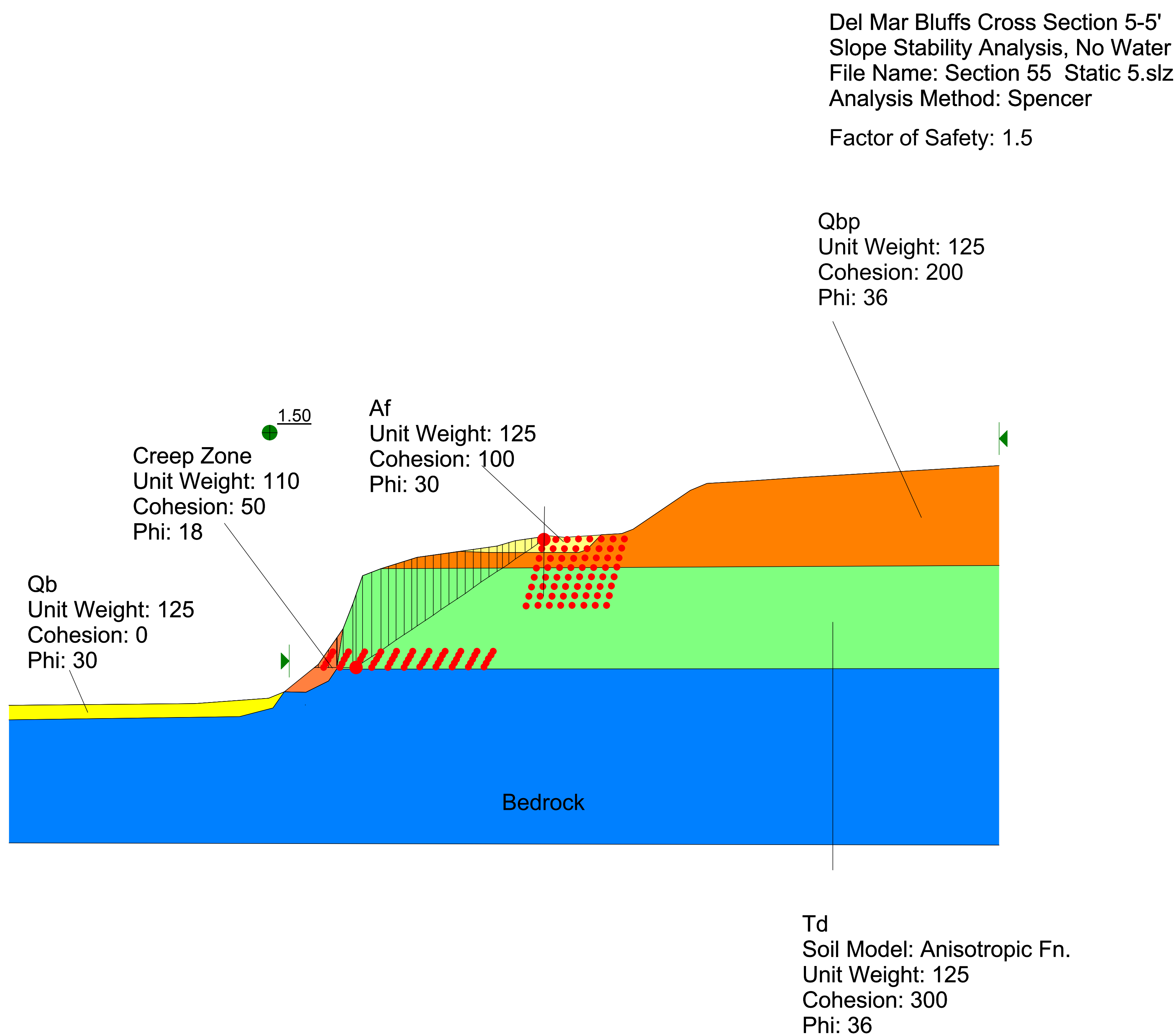


Cross Section 5-5’



Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 5 ft Water Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.44
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
1.44
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Creep Zone
Unit Weight: 110
Cohesion: 50
Phi: 18
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock
Pieziometric Contour = 312 psf
(5 ft head of Water)
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36

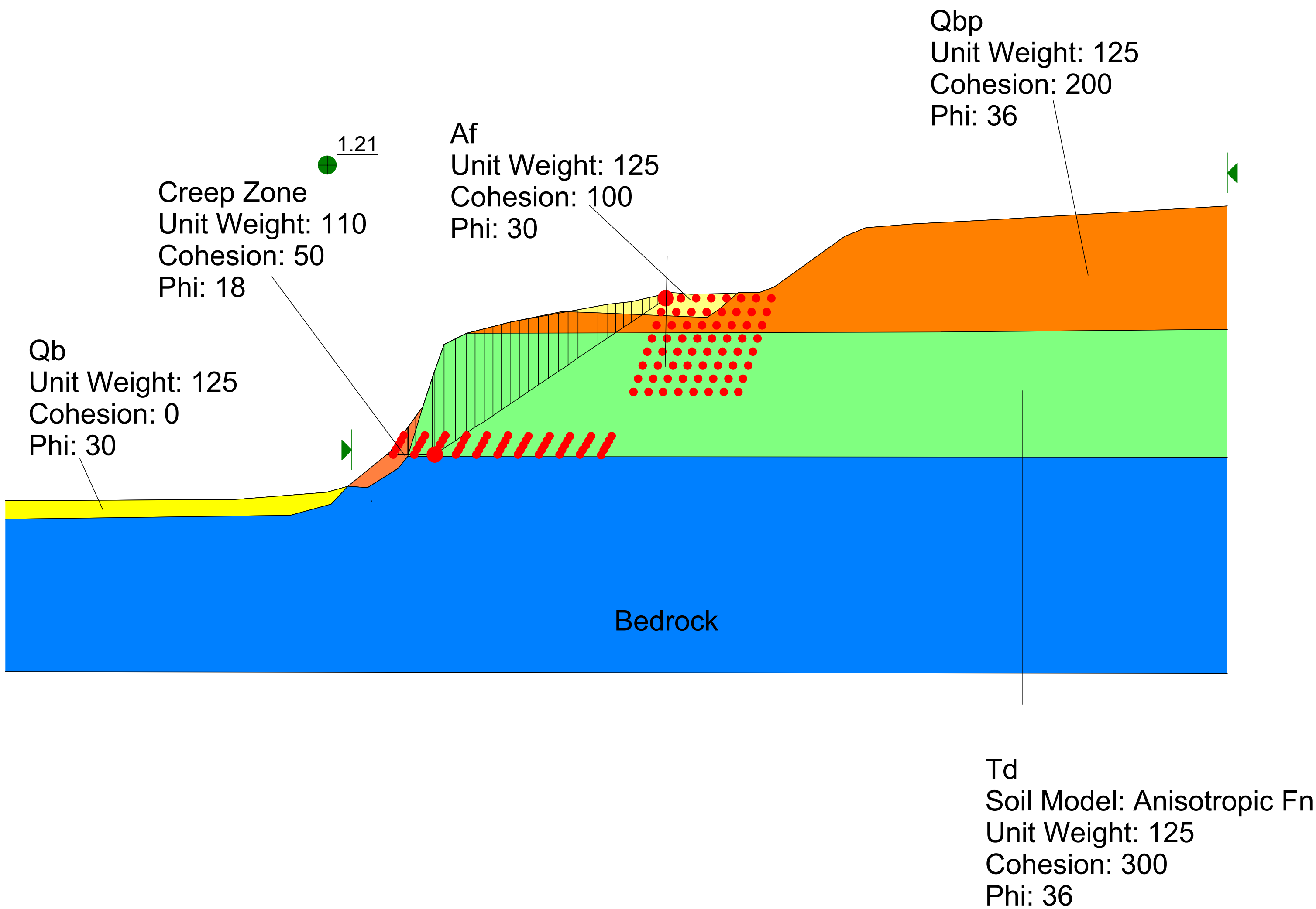

Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 5 ft Water Static 4.slz
Analysis Method: Spencer
Factor of Safety: 1.44
Surcharge = 3,000 psf
Pieziometric Contour = 312 psf
(5 ft head of Water)
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
1.44
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Creep Zone
Unit Weight: 110
Cohesion: 50
Phi: 18
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36

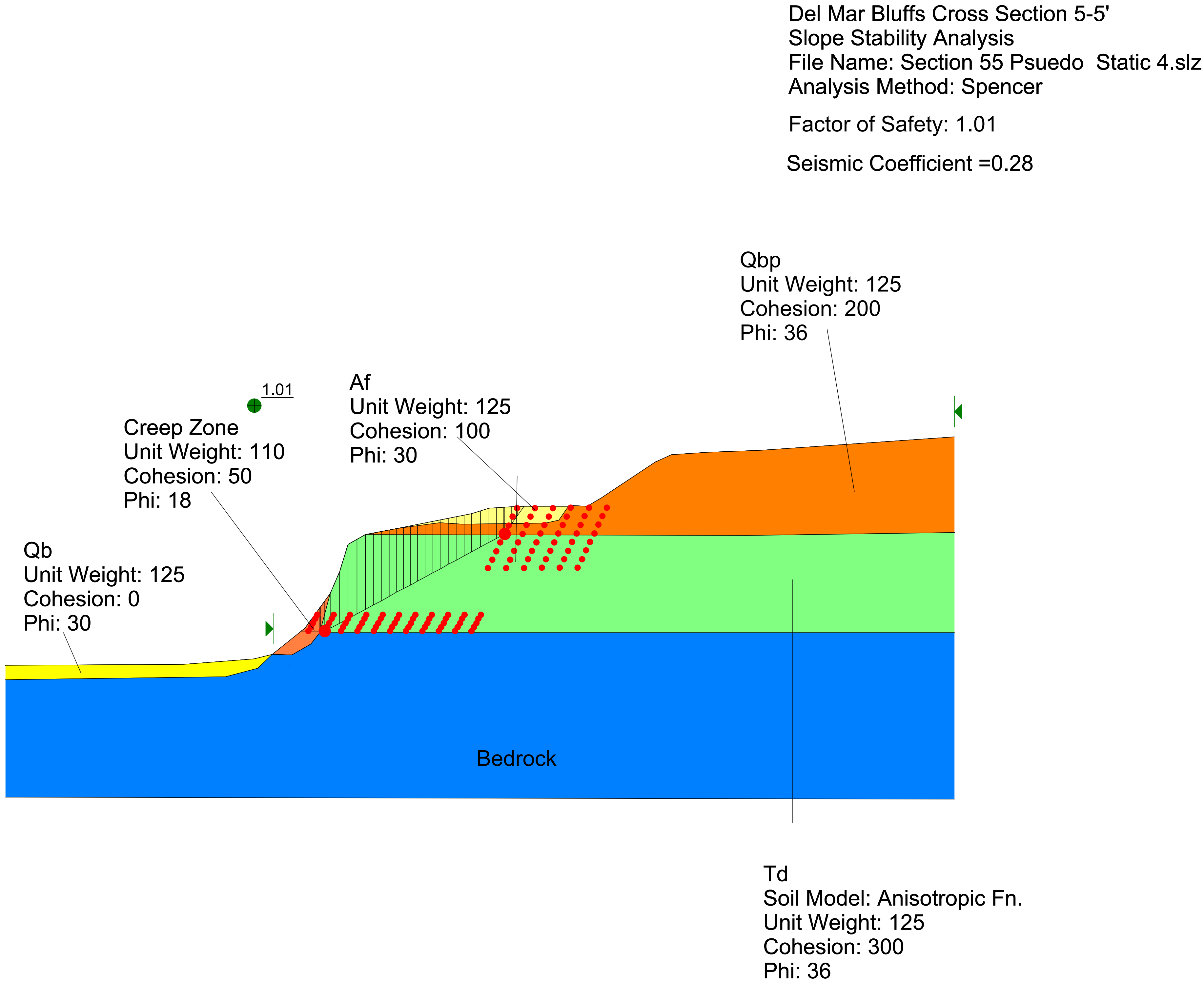

Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis, No Water
File Name: Section 55 Static 5.slz
Analysis Method: Spencer
Factor of Safety: 1.5
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
1.50
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Creep Zone
Unit Weight: 110
Cohesion: 50
Phi: 18
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36

Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 Psuedo Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.21

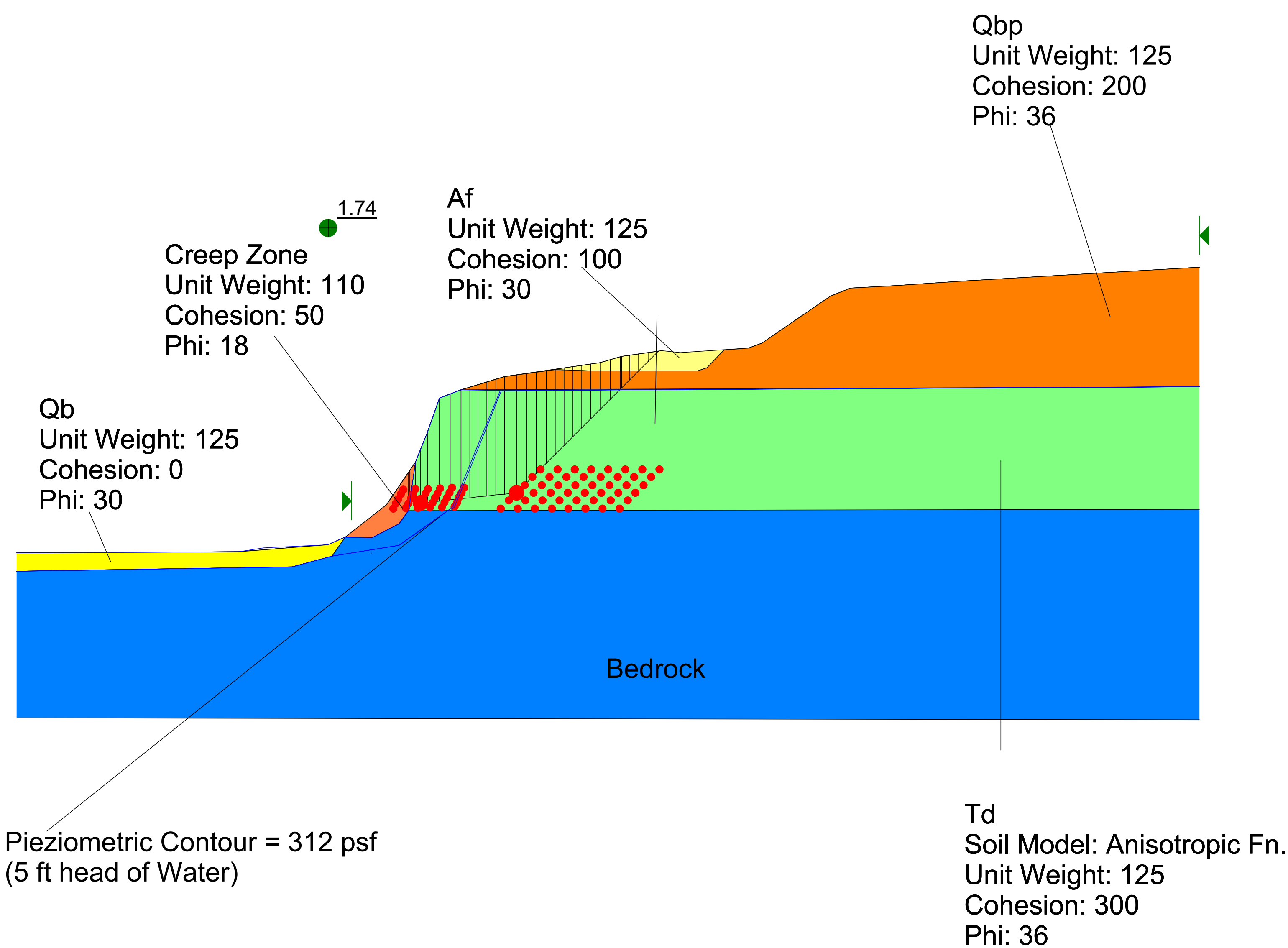
Seismic Coefficient =0.15

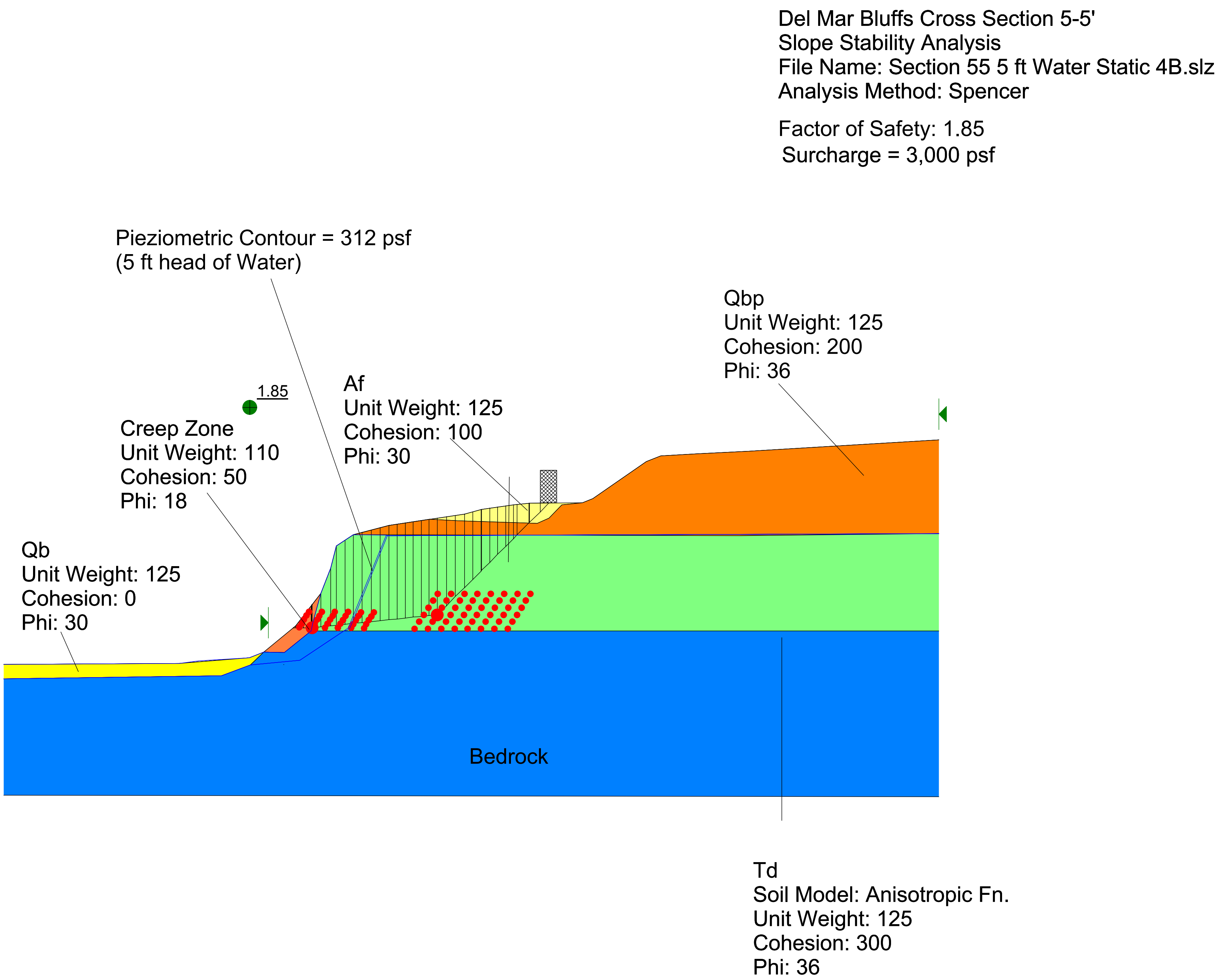



Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 Psuedo Static 4.slz
Analysis Method: Spencer
Factor of Safety: 1.01
Seismic Coefficient =0.28
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
1.01
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Creep Zone
Unit Weight: 110
Cohesion: 50
Phi: 18
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36

Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 5 ft Water Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.74



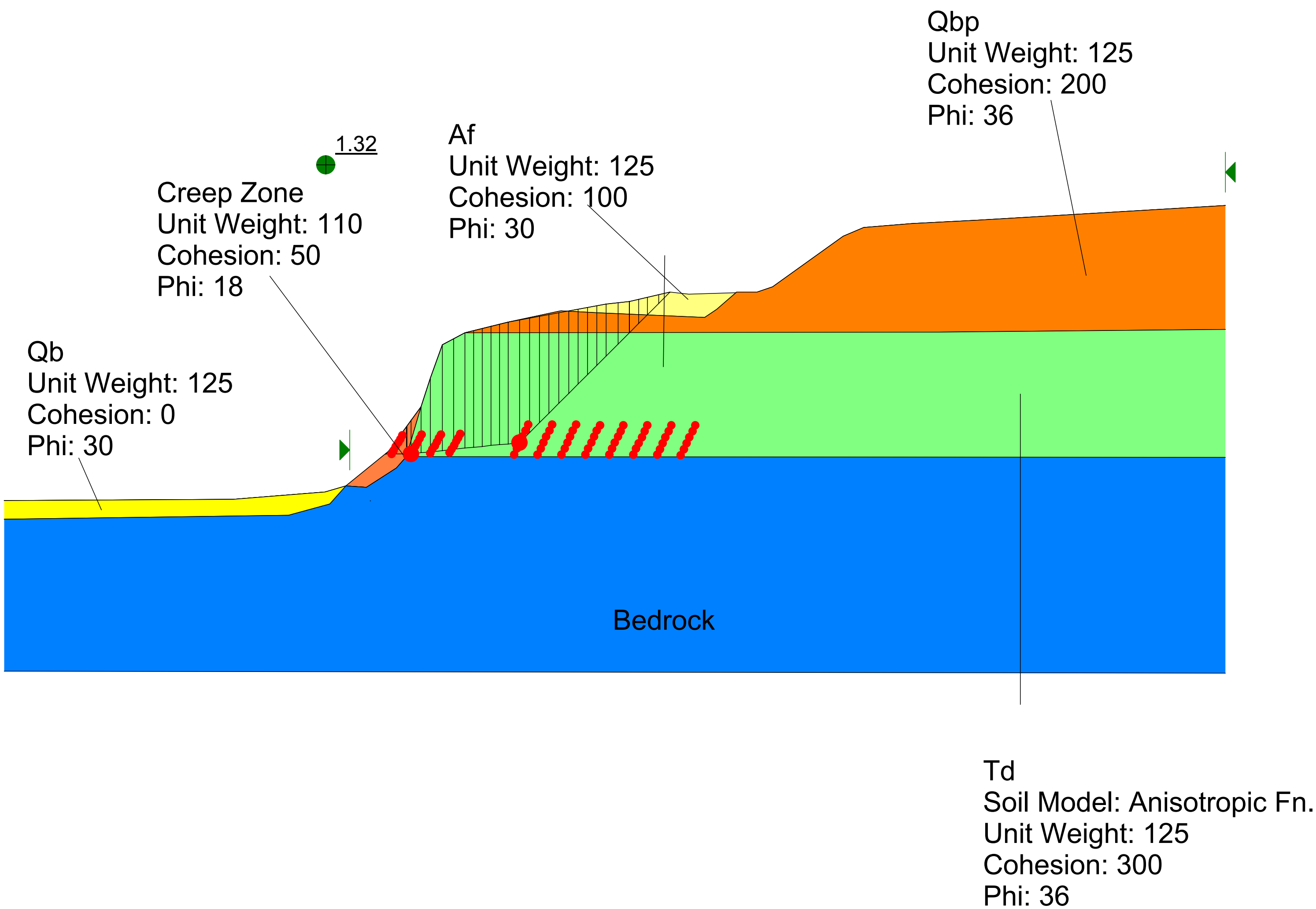


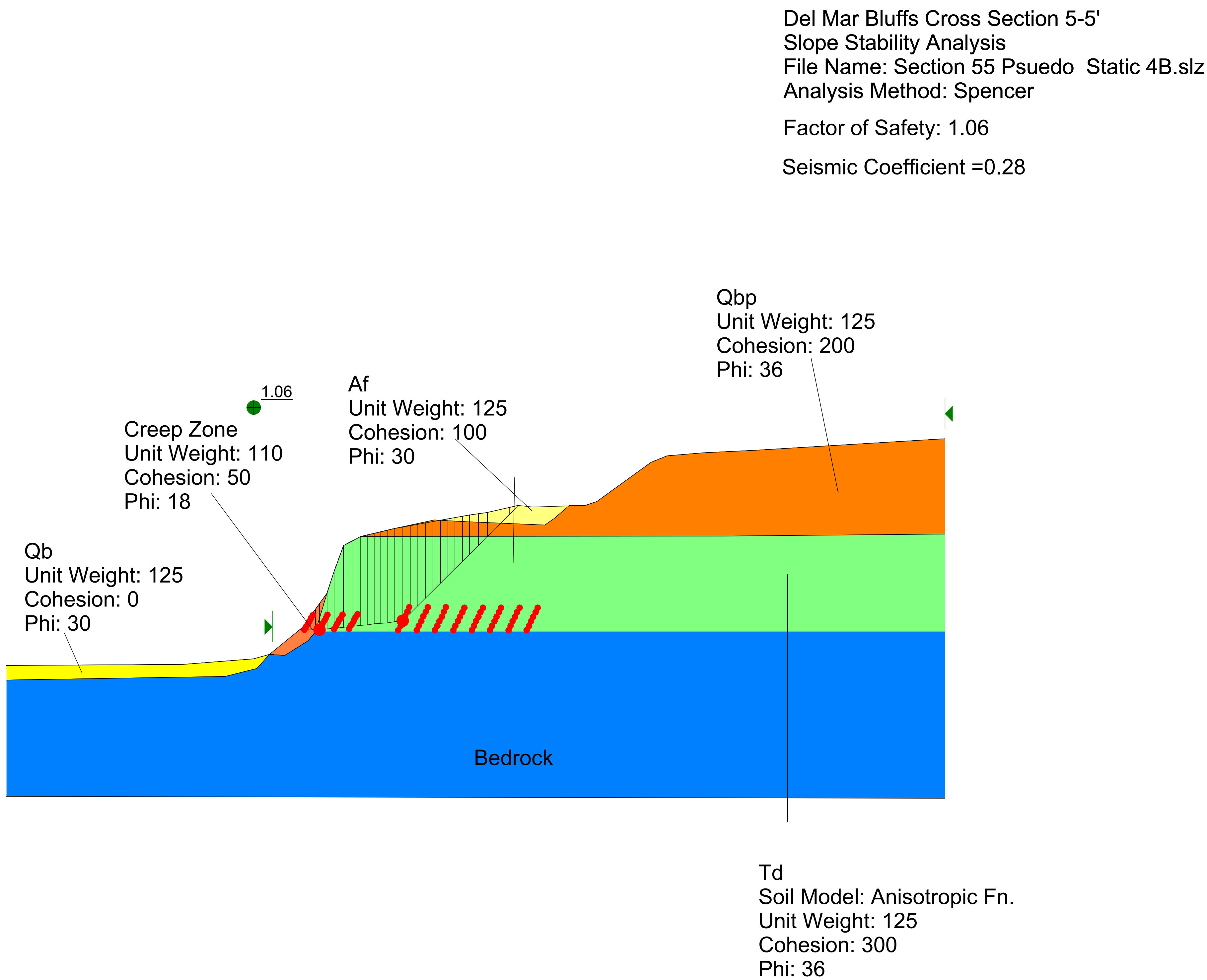
Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 5 ft Water Static 4B.slz
Analysis Method: Spencer
Factor of Safety: 1.85
Surcharge = 3,000 psf
Piezіometric Contour = 312 psf
(5 ft head of Water)
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
1.85
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Creep Zone
Unit Weight: 110
Cohesion: 50
Phi: 18
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36

Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 Psuedo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.32

Seismic Coefficient =0.15

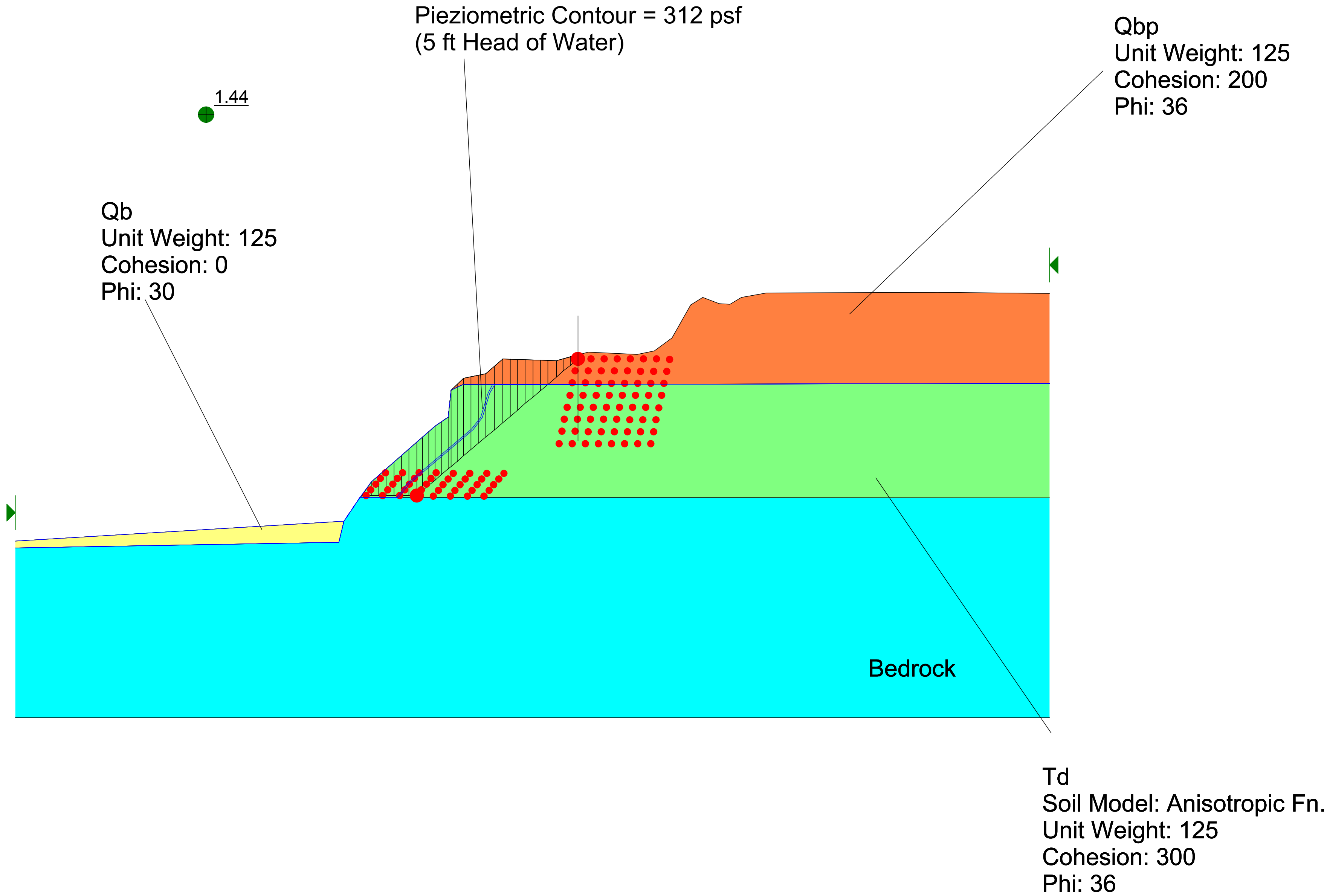




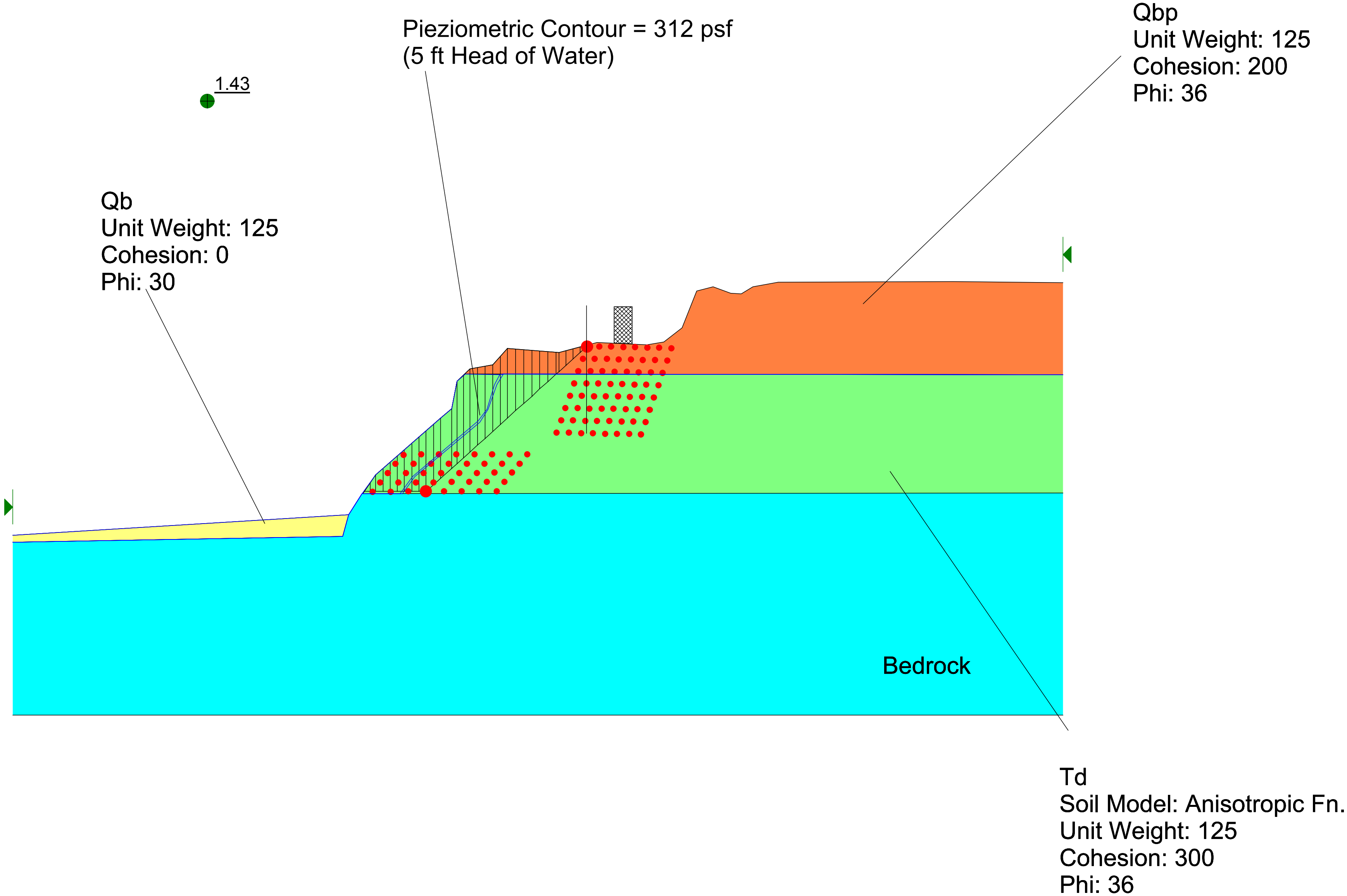
Del Mar Bluffs Cross Section 5-5'
Slope Stability Analysis
File Name: Section 55 Psuedo Static 4B.slz
Analysis Method: Spencer
Factor of Safety: 1.06
Seismic Coefficient =0.28
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
1.06
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Creep Zone
Unit Weight: 110
Cohesion: 50
Phi: 18
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Bedrock
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36

Cross Section 6-6’

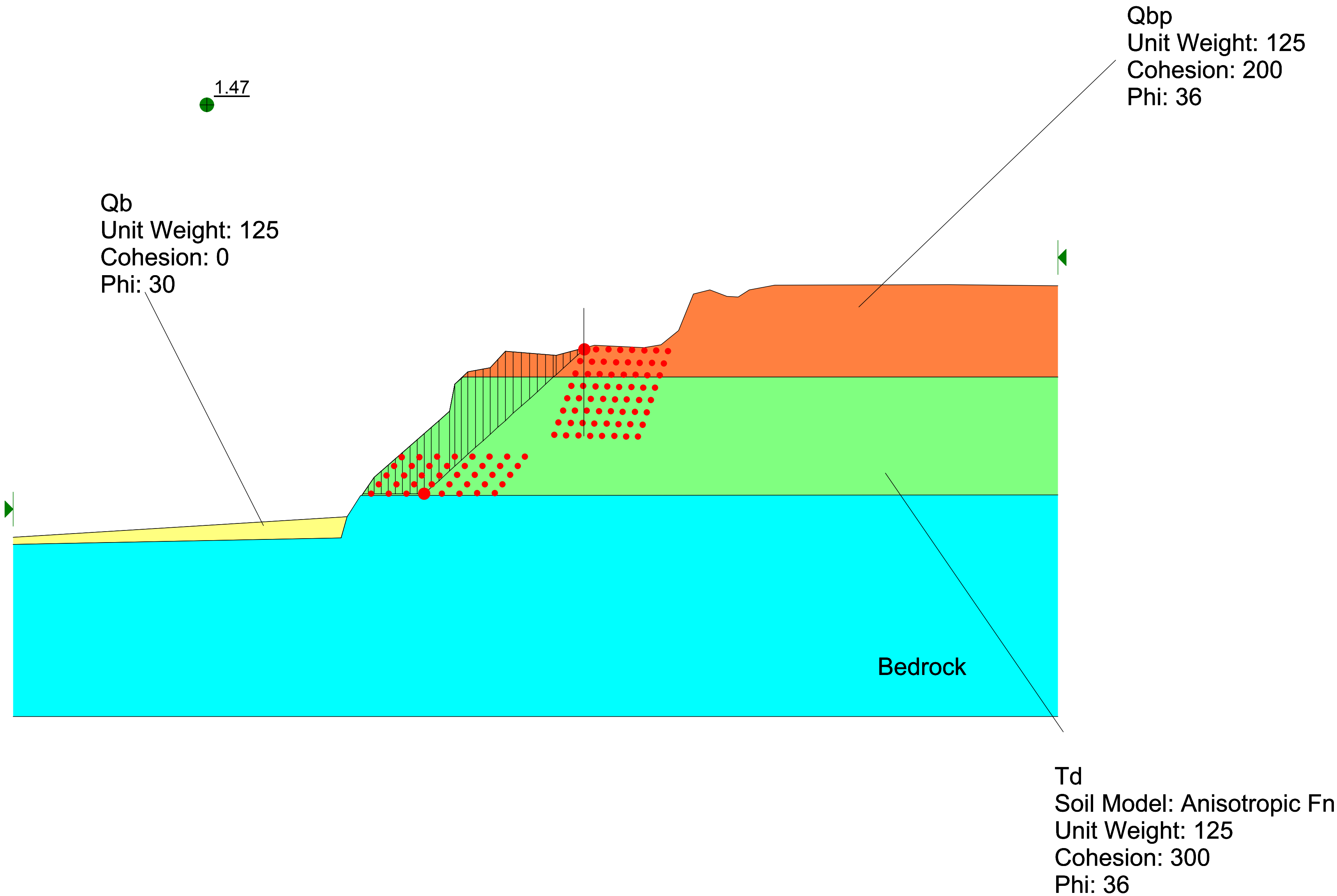
Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis
File Name: Section 66 Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.44



Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis
File Name: Section 66 Static 1.slz
Analysis Method: Spencer
Factor of Safety: 1.43
Surcharge = 3,000 psf

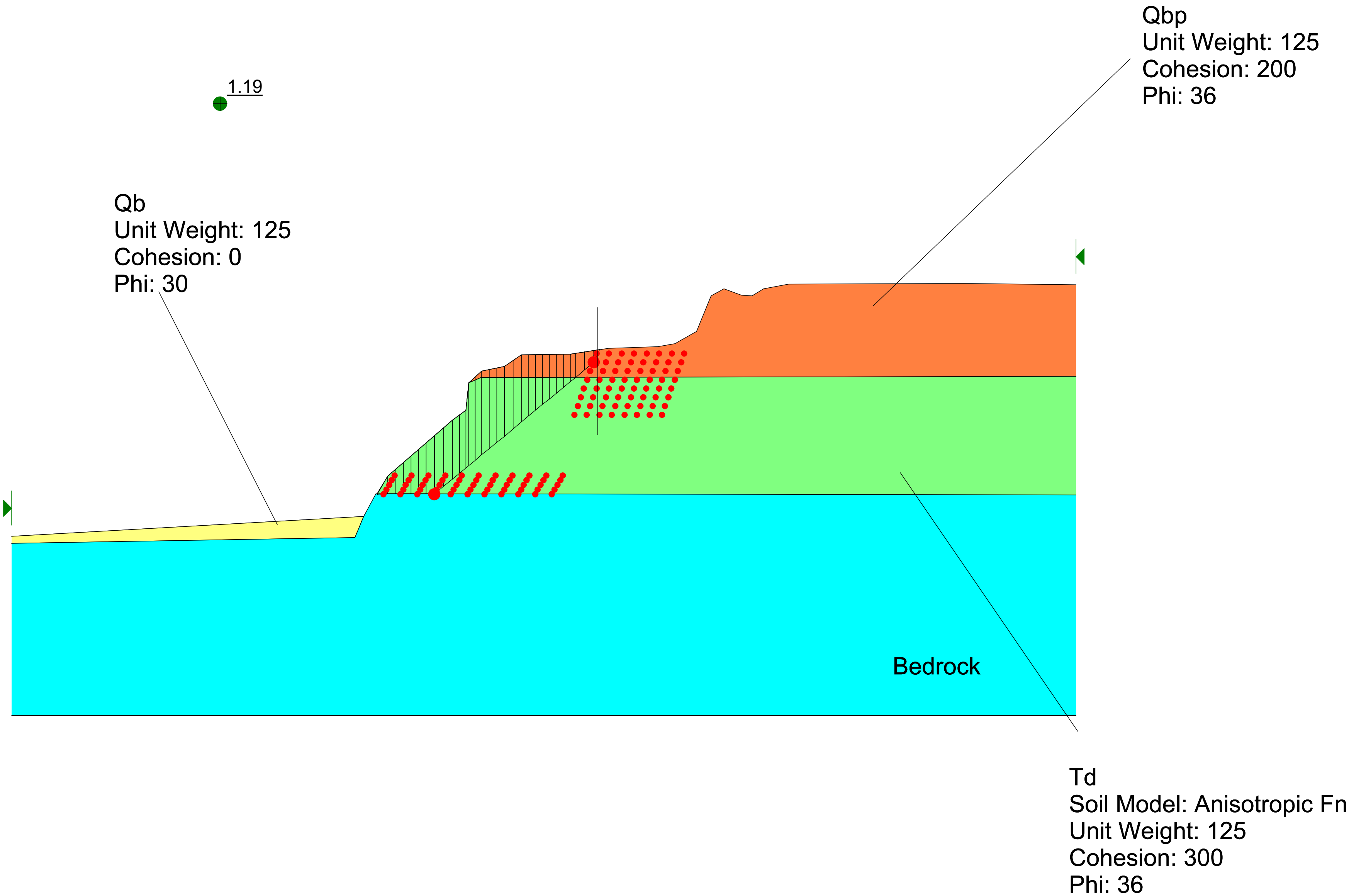


Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis, No Water
File Name: Section 66 Static 3.slz
Analysis Method: Spencer
Factor of Safety: 1.47

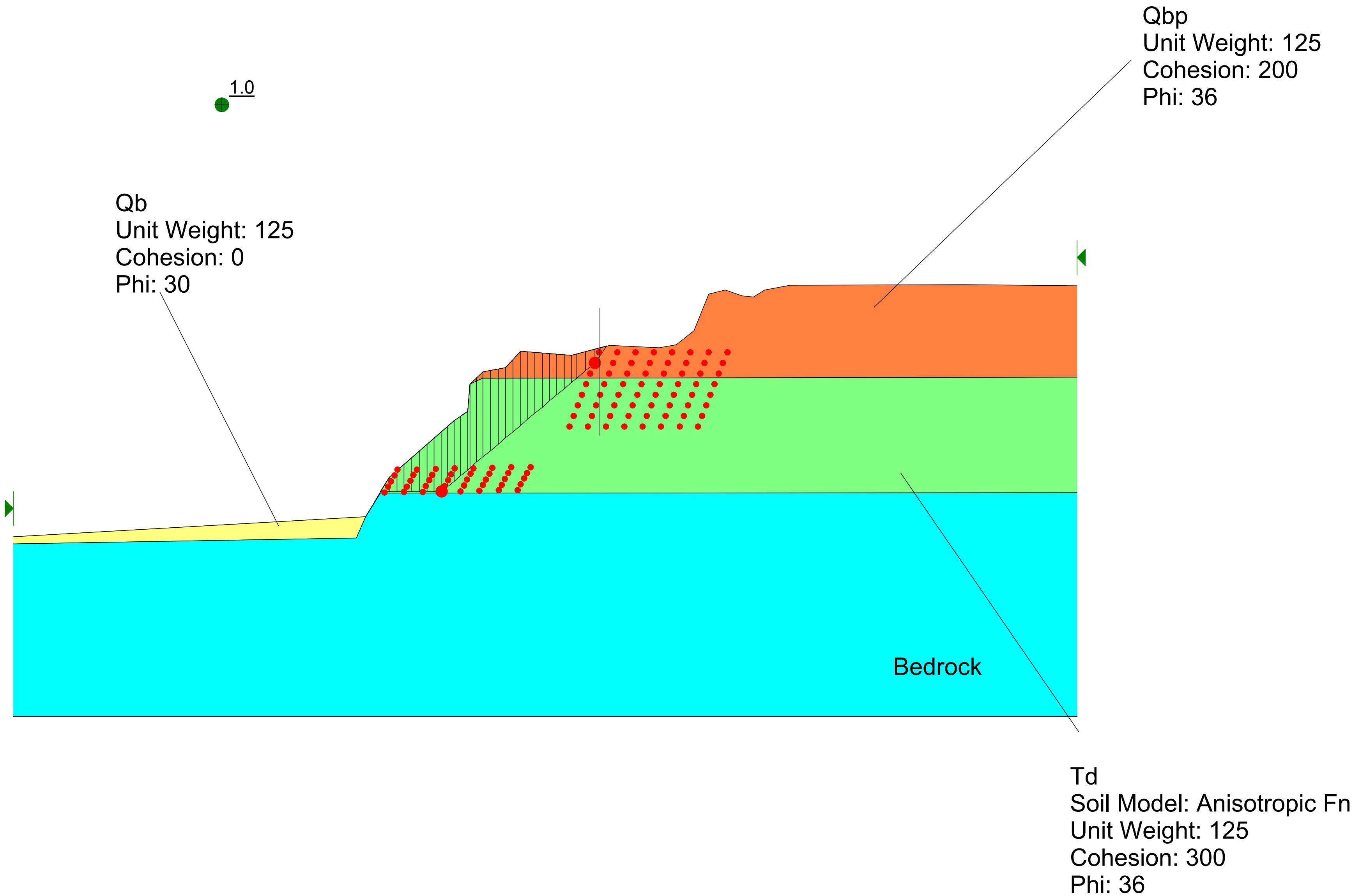


Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis
File Name: Section 66 Pseudo Static 2.slz
Analysis Method: Spencer

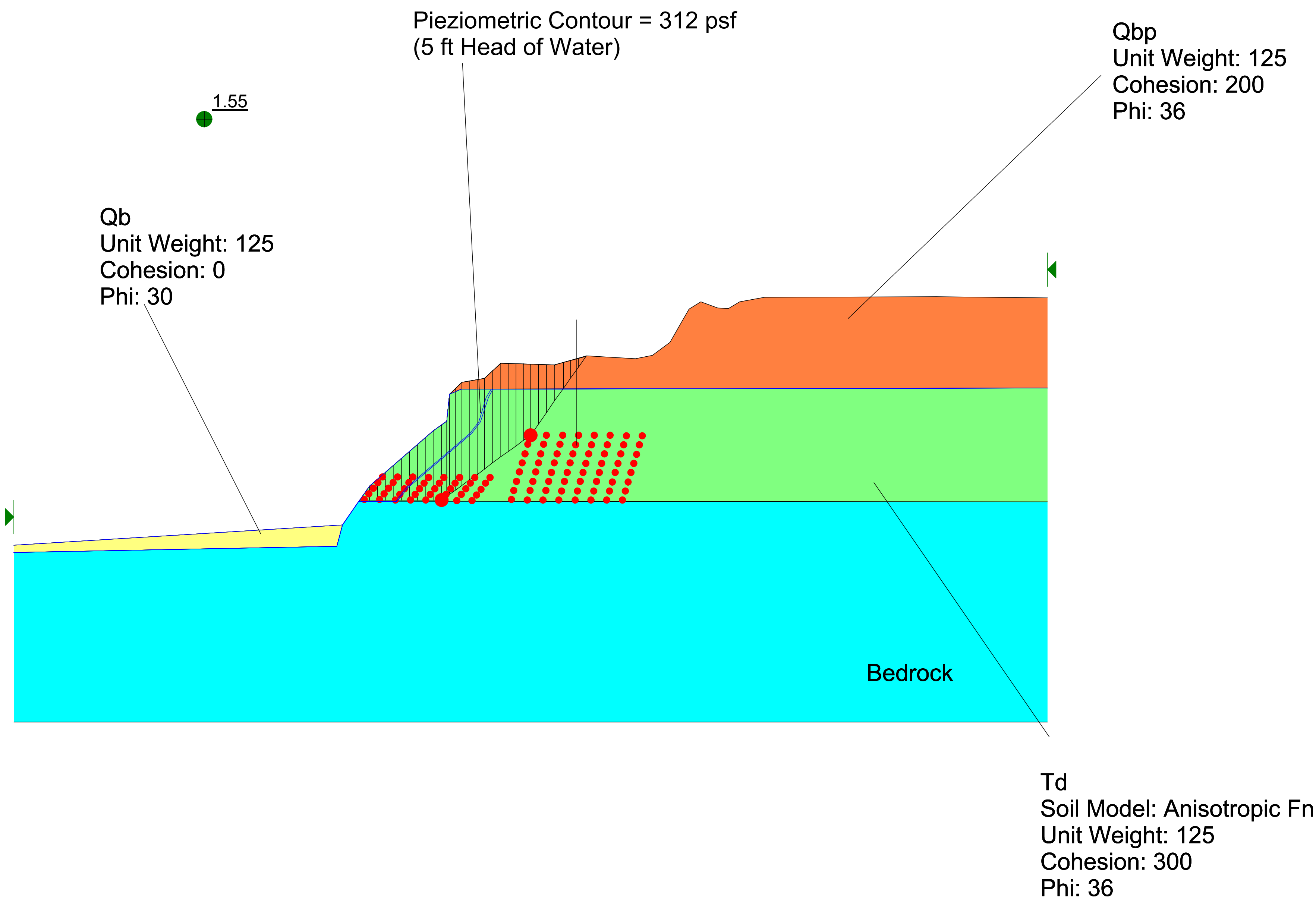
Factor of Safety: 1.19
Seismic coefficient=0.15



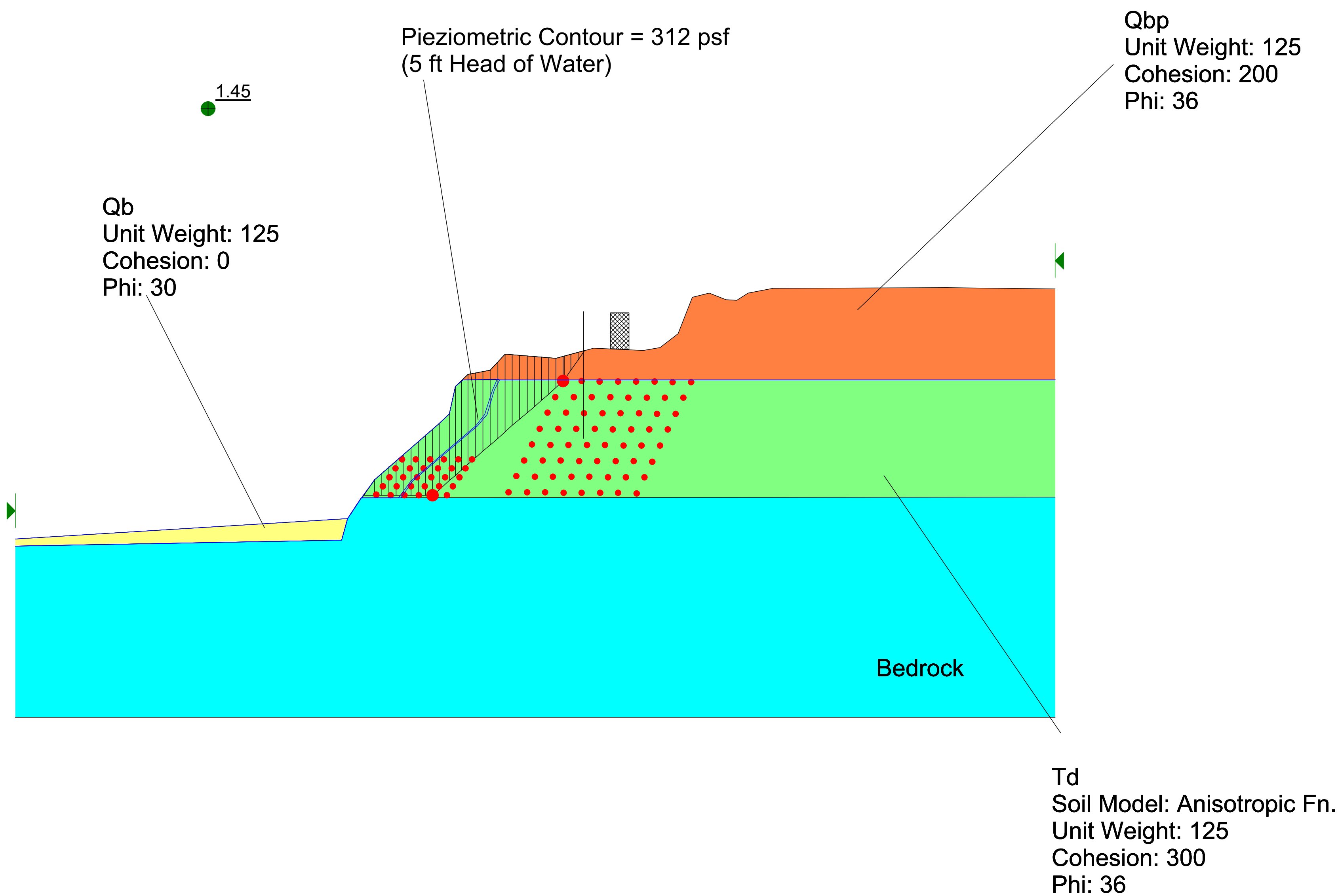
Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis
File Name: Section 66 Pseudo Static 1.slz
Analysis Method: Spencer
Factor of Safety: 0.99
Seismic coefficient=0.28



Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis
File Name: Section 66 Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 1.55

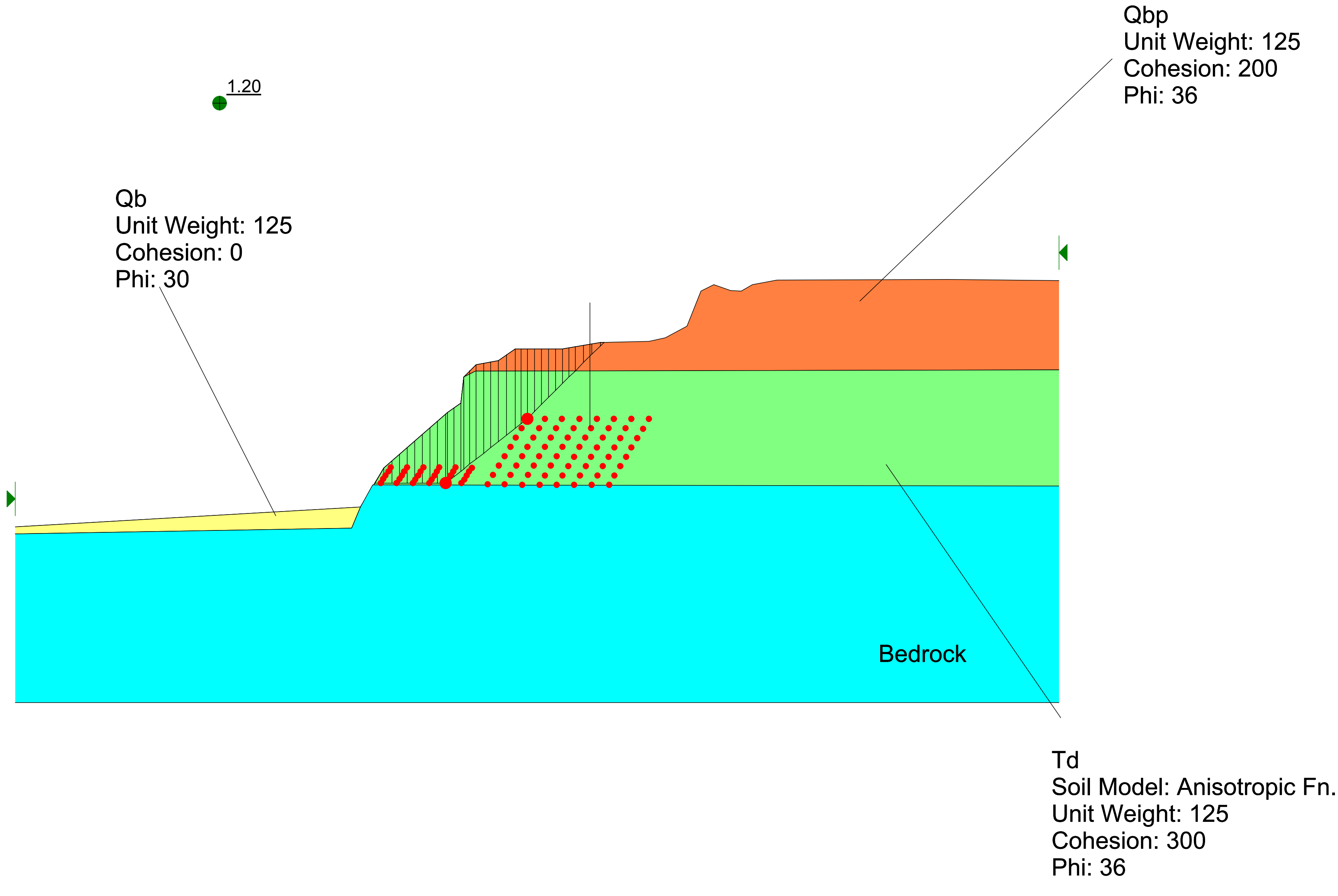


Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis
File Name: Section 66 Static 1B.slz
Analysis Method: Spencer
Factor of Safety: 1.45
Surcharge = 3,000 psf



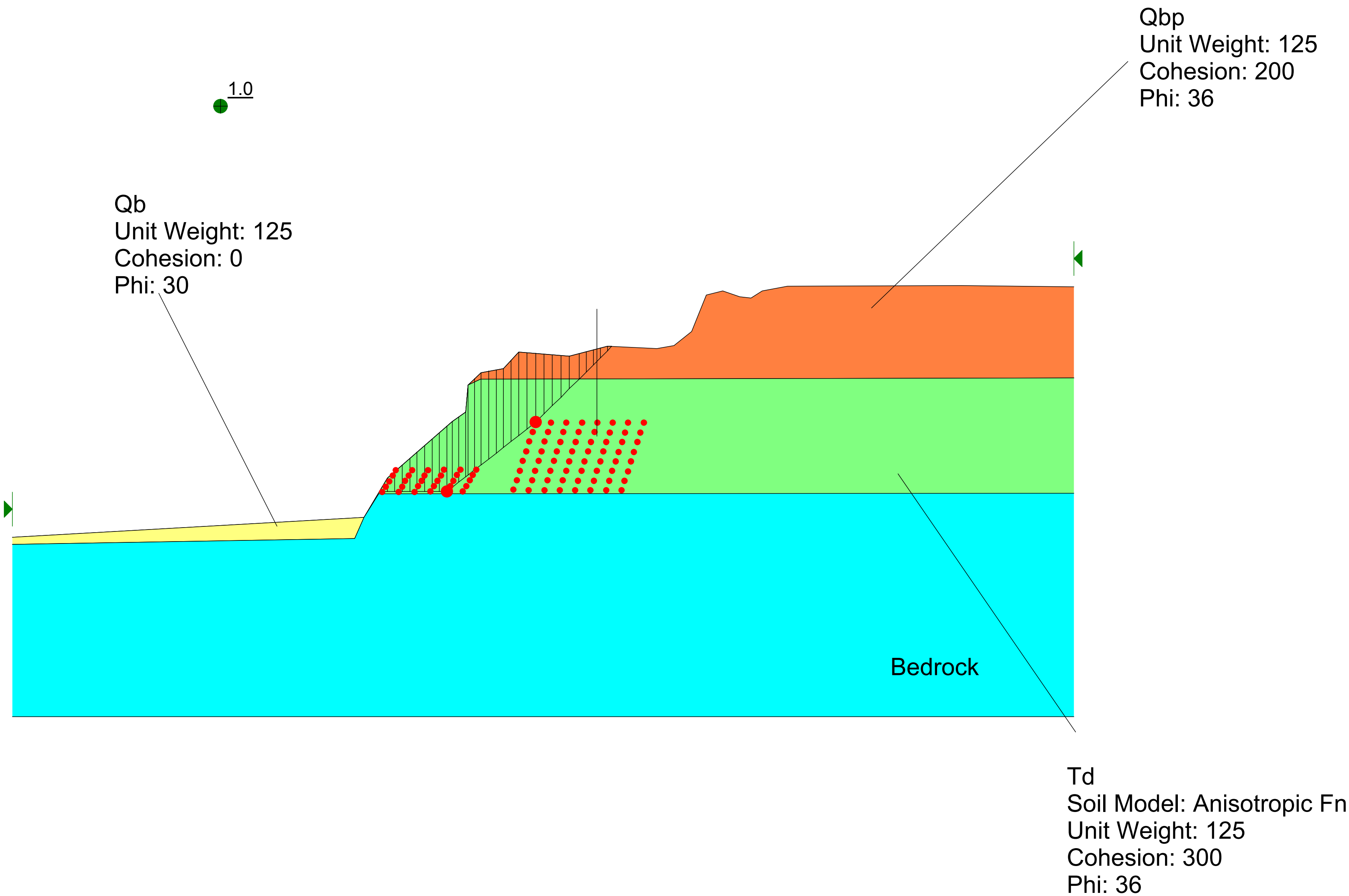
Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis
File Name: Section 66 Pseudo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.2
Seismic coefficient=0.15



Del Mar Bluffs Cross Section 6-6'
Slope Stability Analysis
File Name: Section 66 Pseudo Static 1B.slz
Analysis Method: Spencer

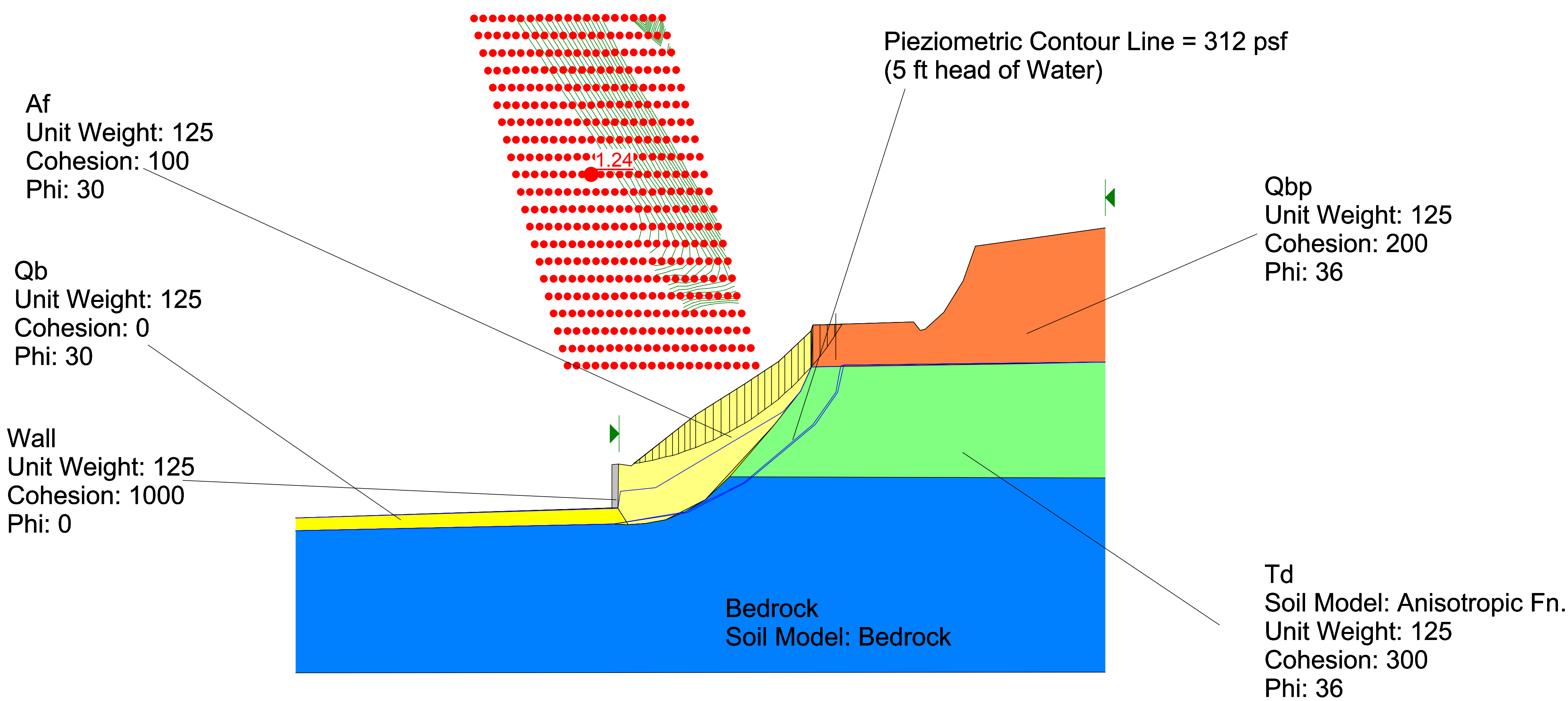
Factor of Safety: 1
Seismic coefficient=0.28



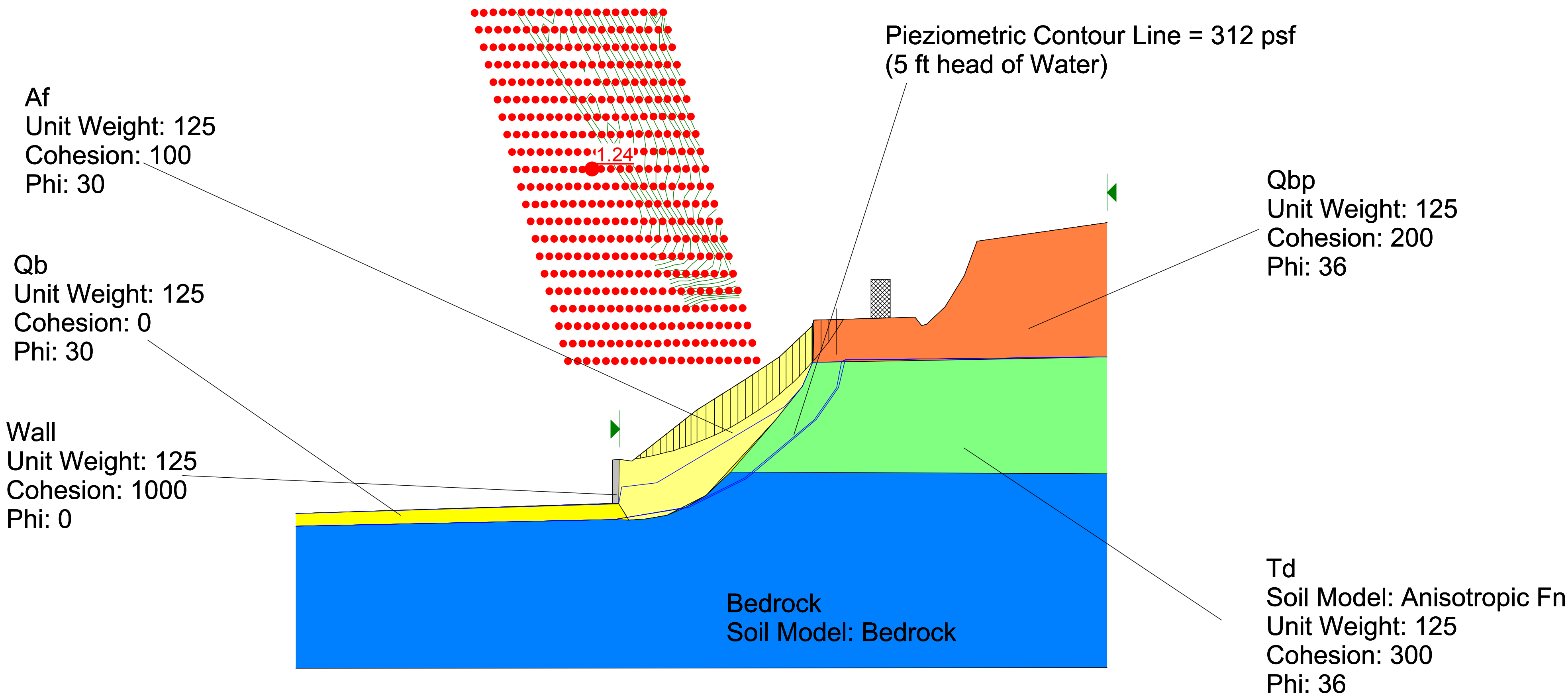
Cross Section 7-7’

Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 5 ft Water Static 1B.slz
Analysis Method: Bishop

Factor of Safety: 1.24

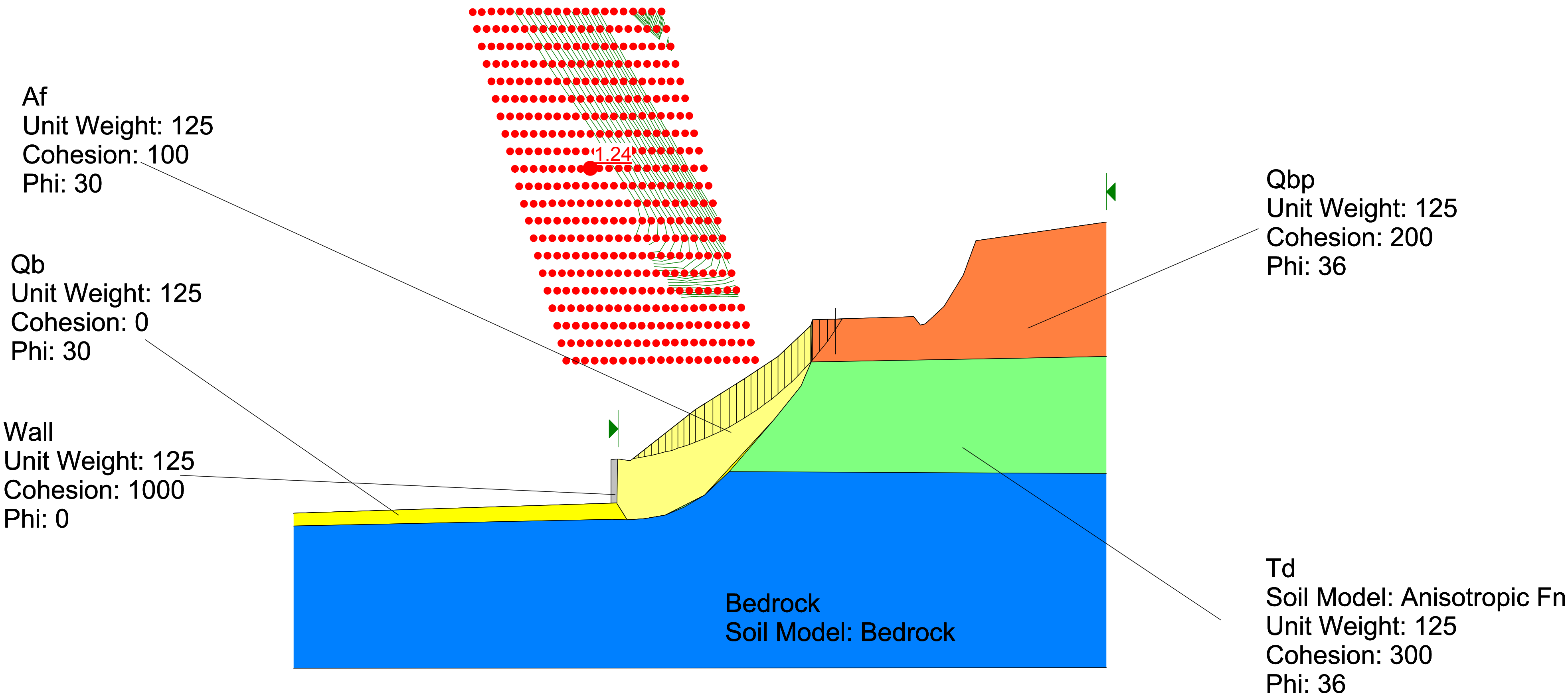


Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 5 ft Water Static 2.slz
Analysis Method: Bishop
Factor of Safety: 1.24
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis, No Water
File Name: Section 77 Static 5B.slz
Analysis Method: Bishop

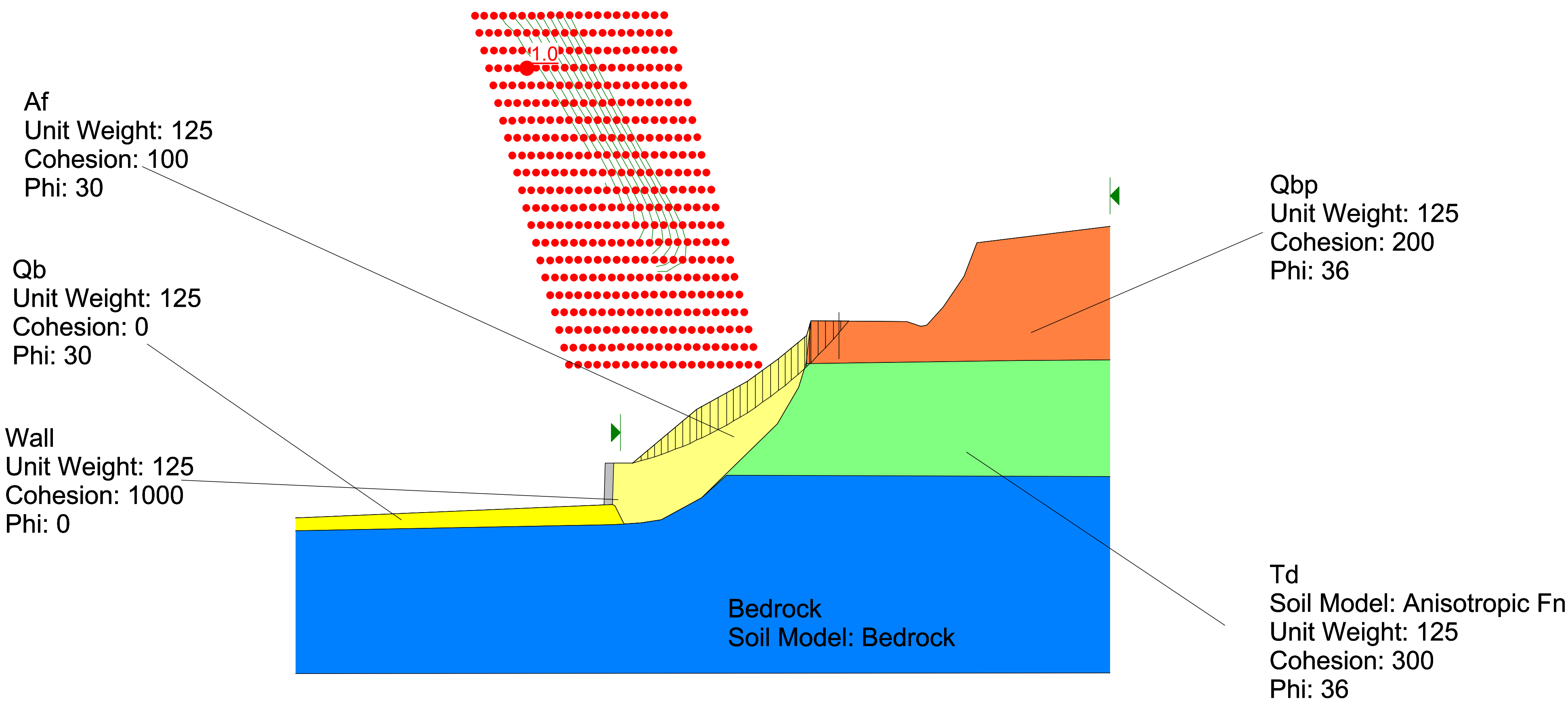
Factor of Safety: 1.24



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 Pseudo Static 1B.slz
Analysis Method: Bishop

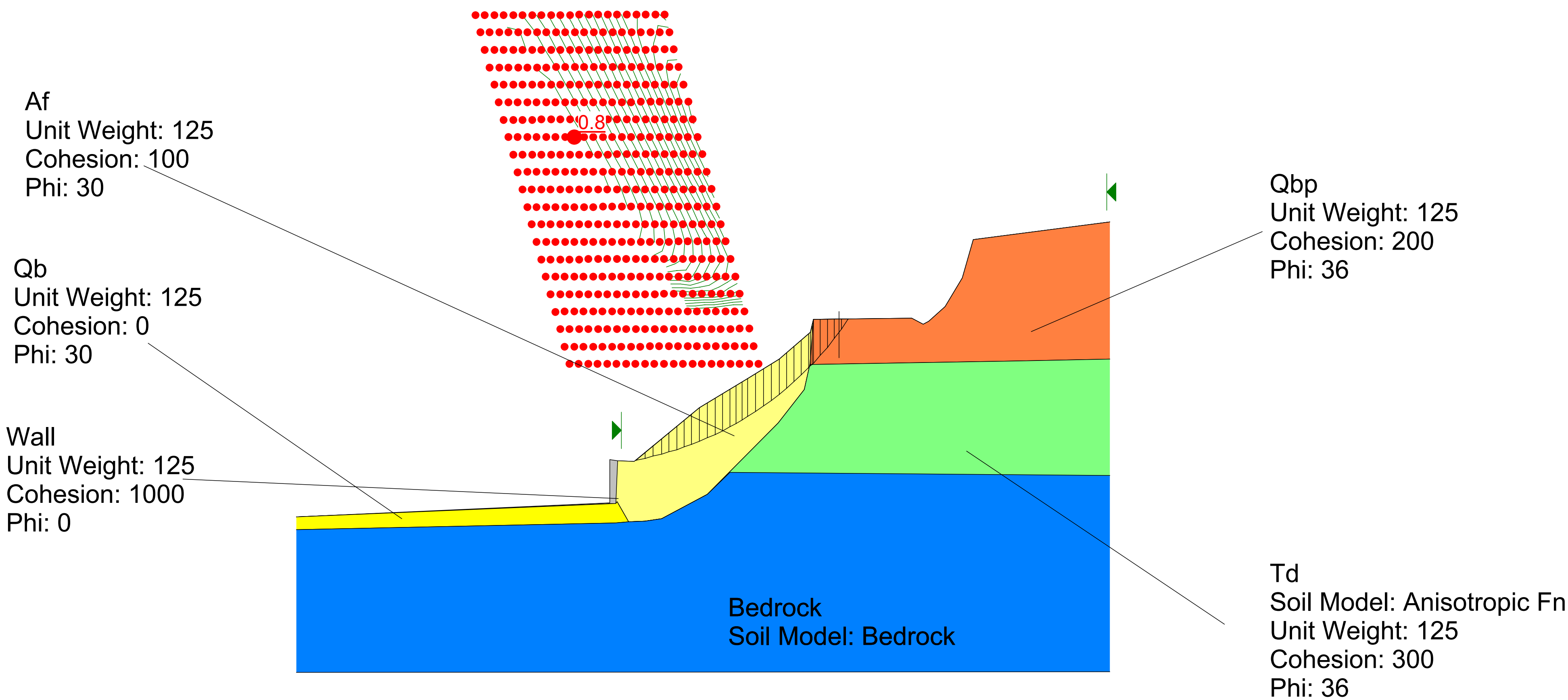
Factor of Safety: 0.98

Seismic Coefficient = 0.15



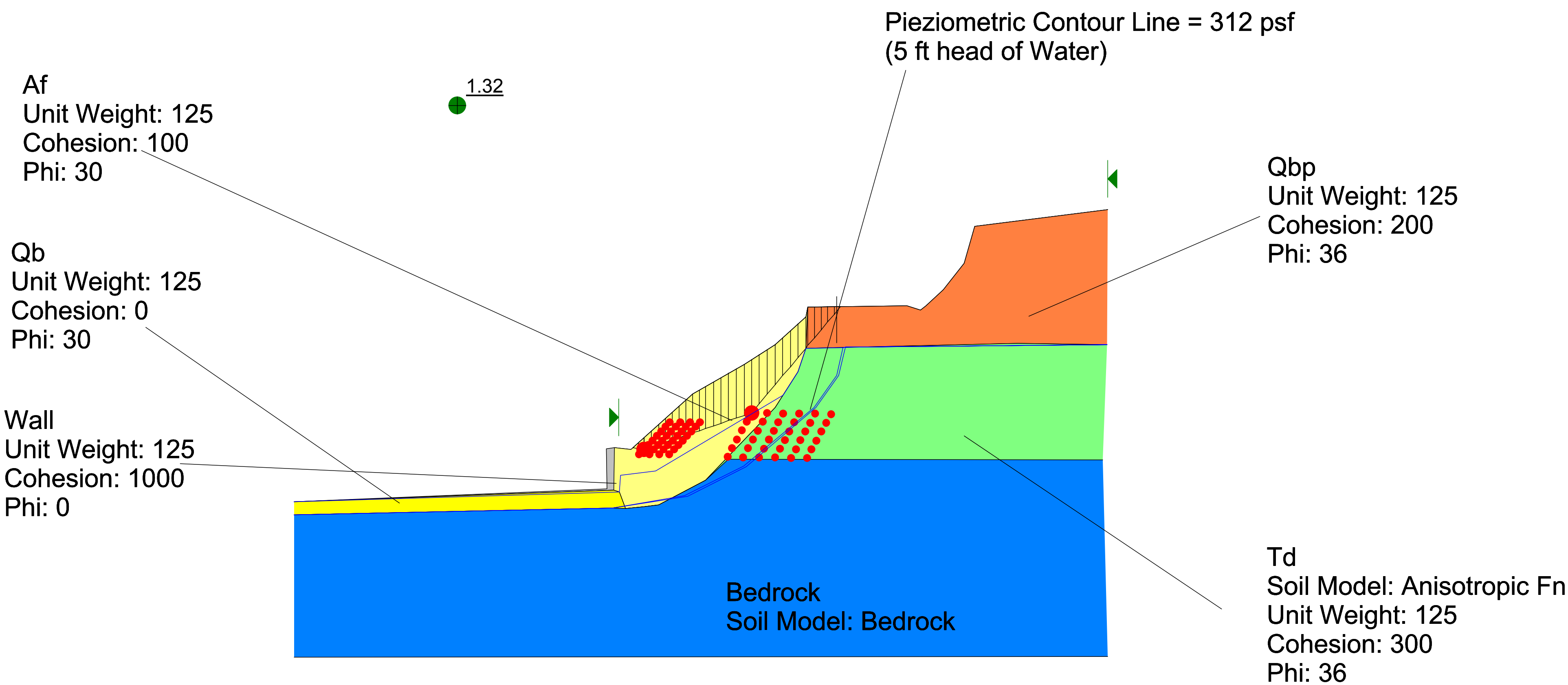
Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 Pseudo Static 2B.slz
Analysis Method: Bishop

Factor of Safety: 0.78
Seismic Coefficient = 0.28



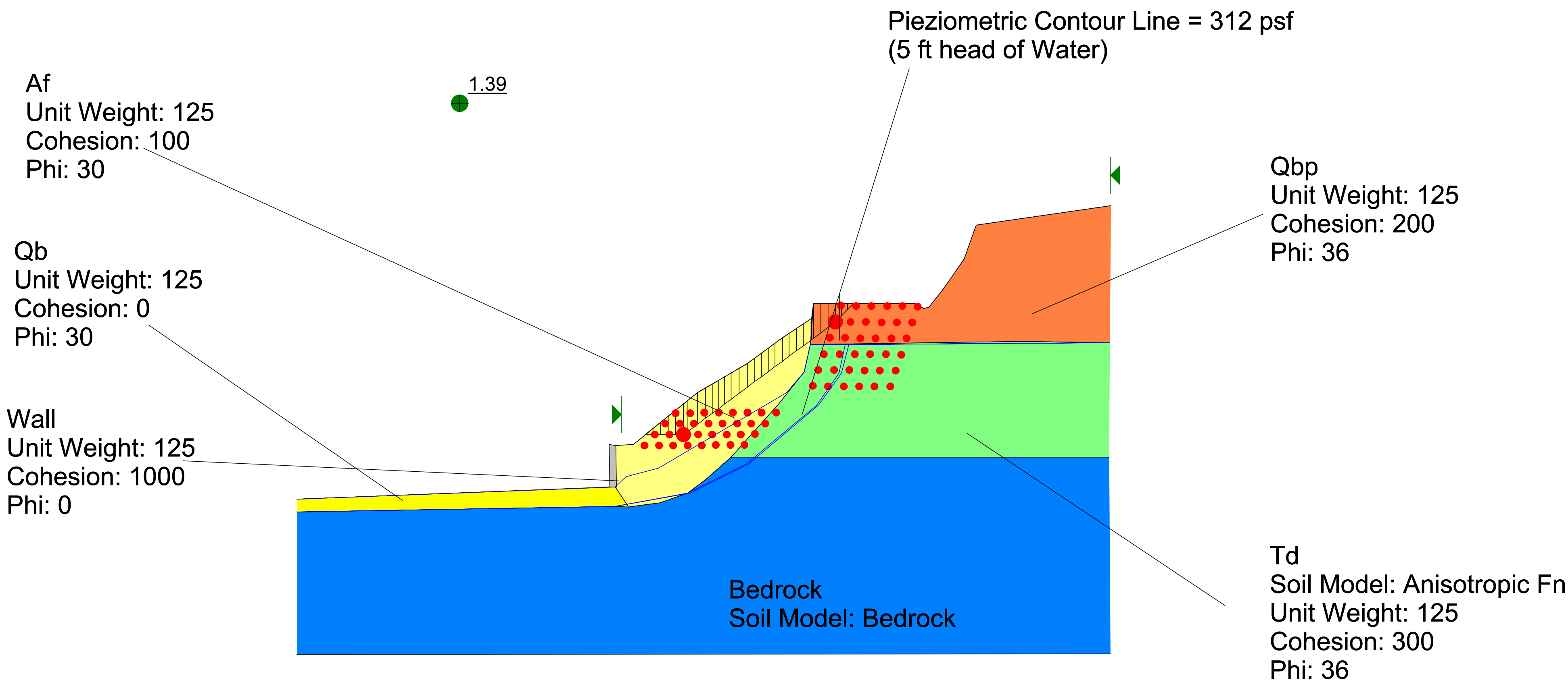
Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 5 ft Water Static 3B.slz
Analysis Method: Spencer

Factor of Safety: 1.32



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 5 ft Water Static 3C.slz
Analysis Method: Spencer

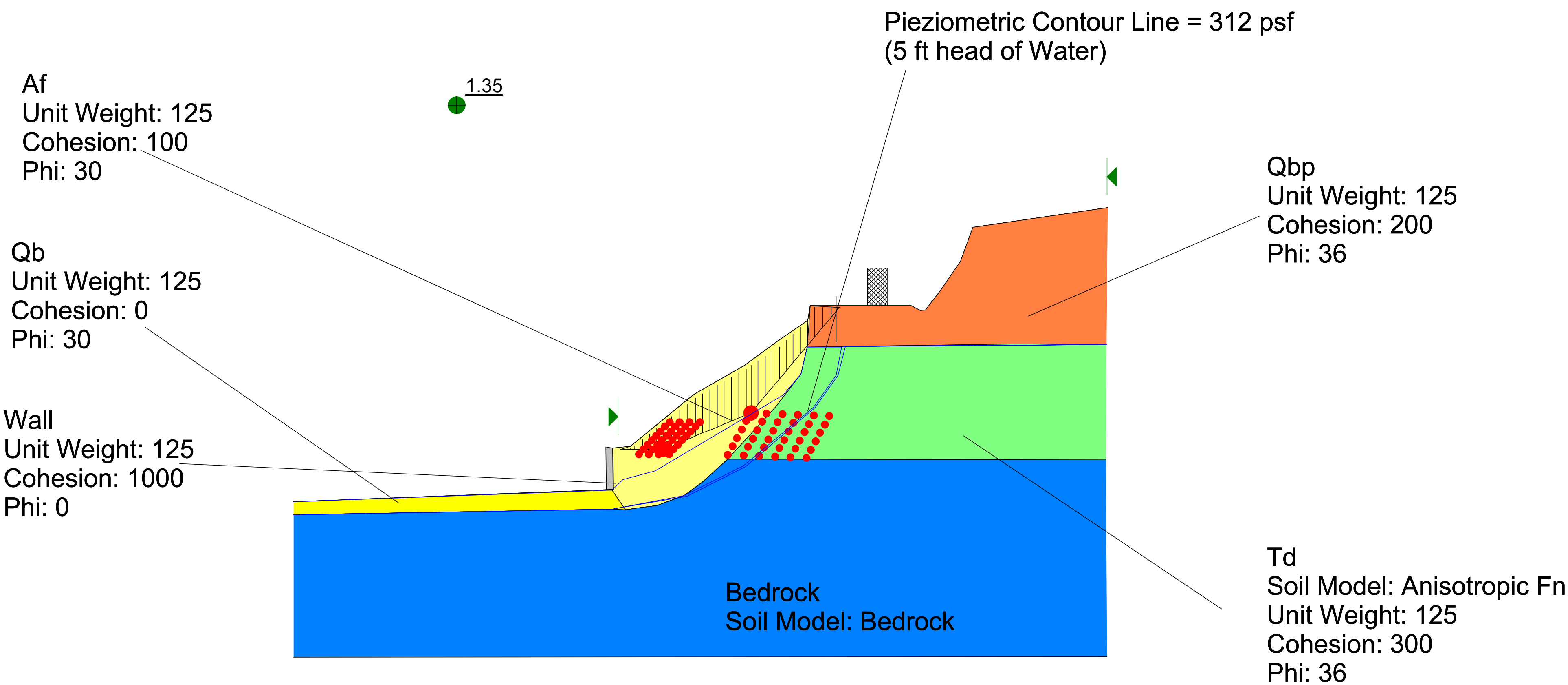
Factor of Safety: 1.39



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 5 ft Water Static 4B.slz
Analysis Method: Spencer

Factor of Safety: 1.35

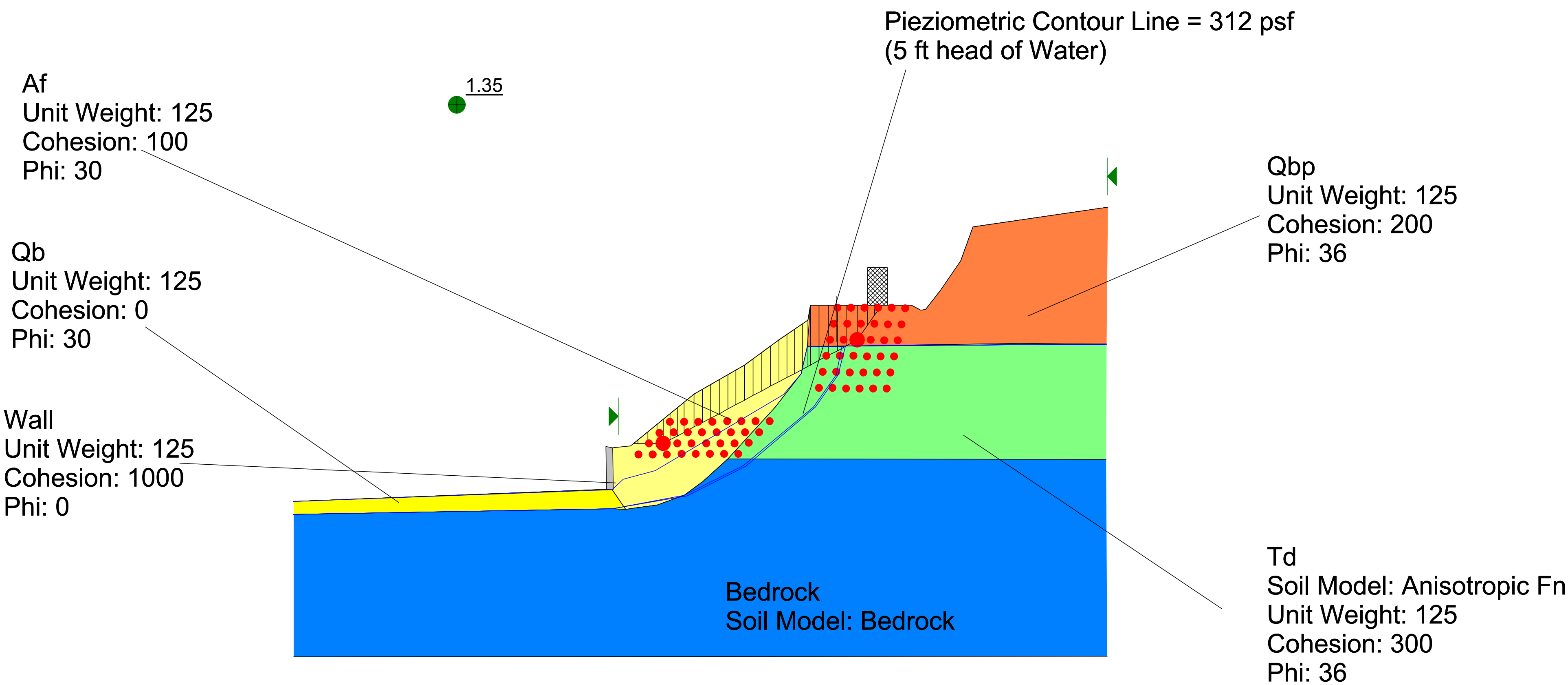
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 5 ft Water Static 4C.slz
Analysis Method: Spencer

Factor of Safety: 1.35

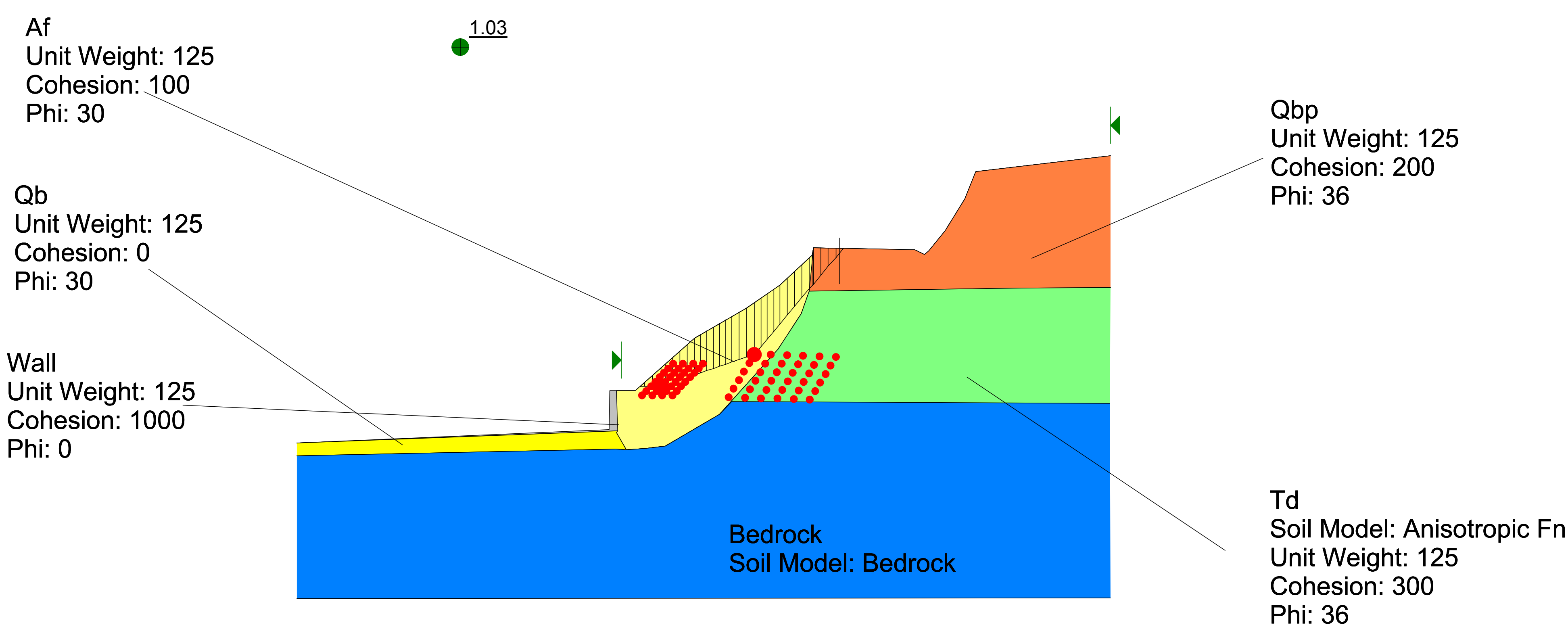
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 Pseudo Static 3B.slz
Analysis Method: Spencer

Factor of Safety: 1.03

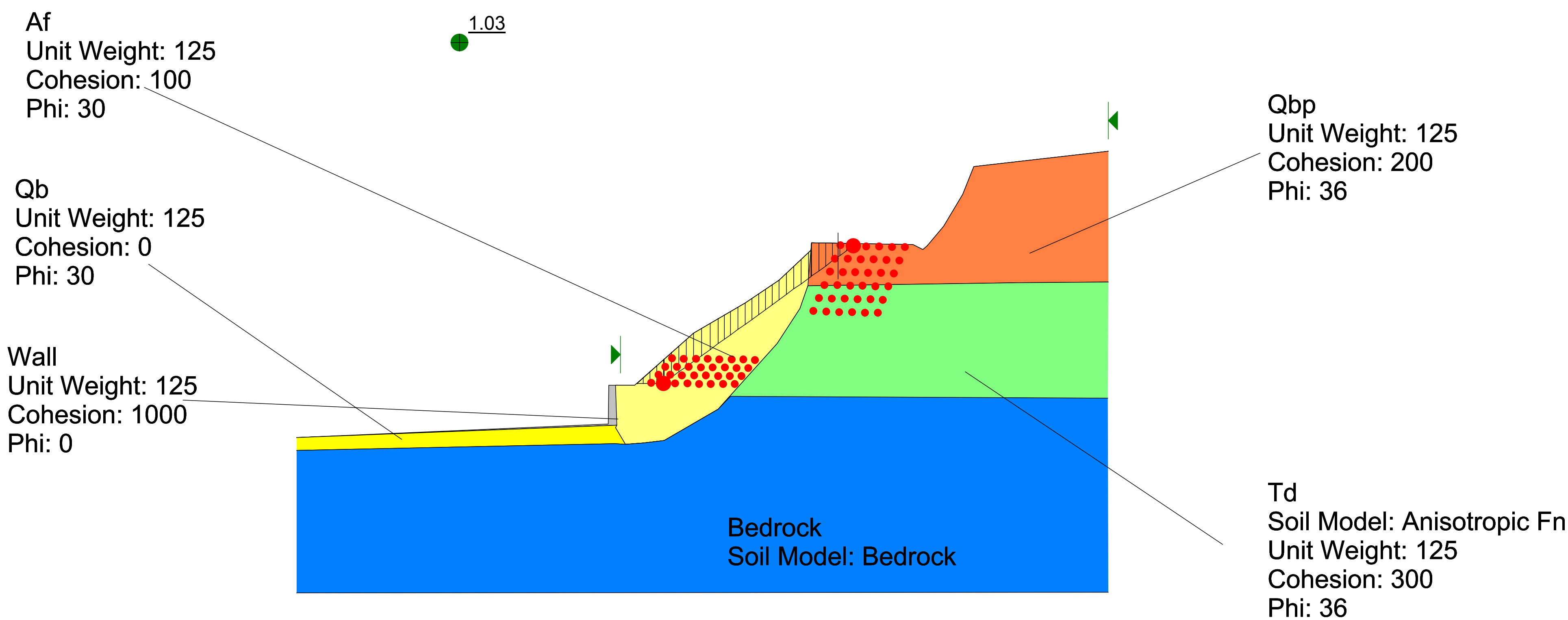
seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 Pseudo Static 3C.slz
Analysis Method: Spencer

Factor of Safety: 1.03

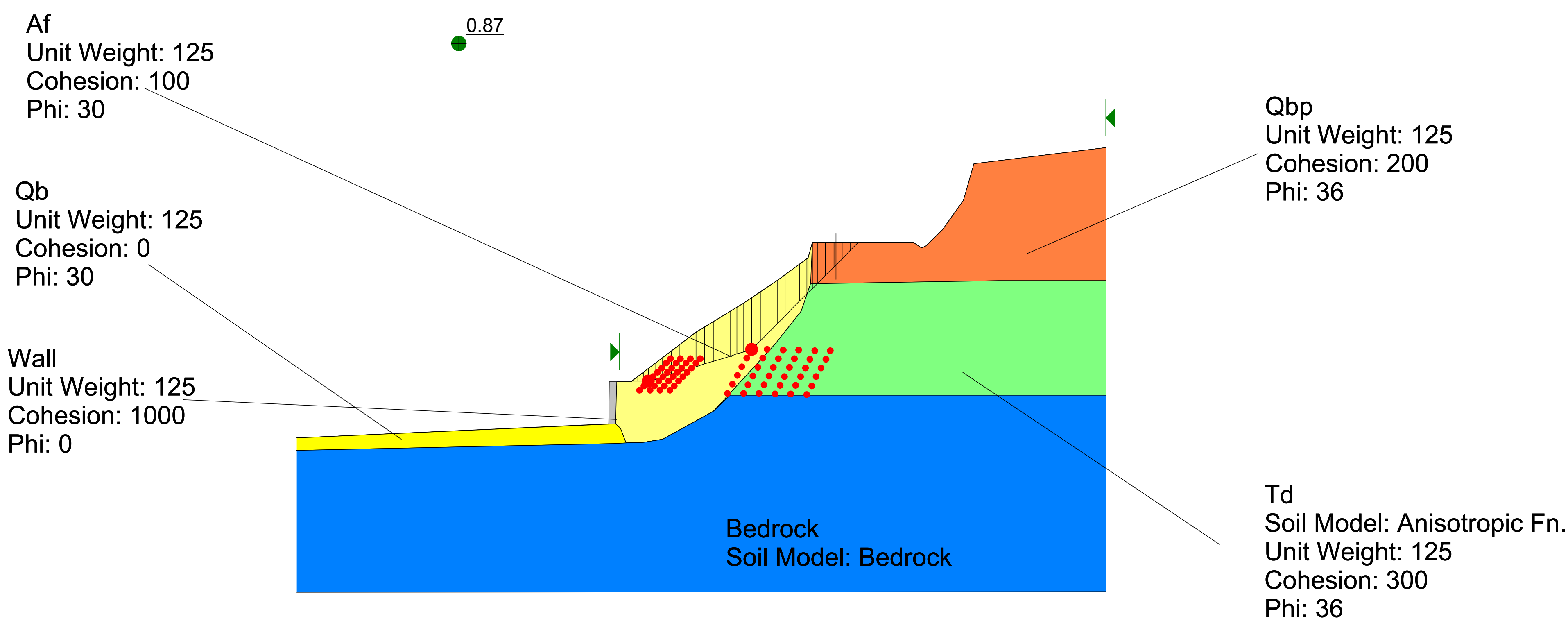
seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 Pseudo Static 4B.slz
Analysis Method: Spencer

Factor of Safety: 0.869

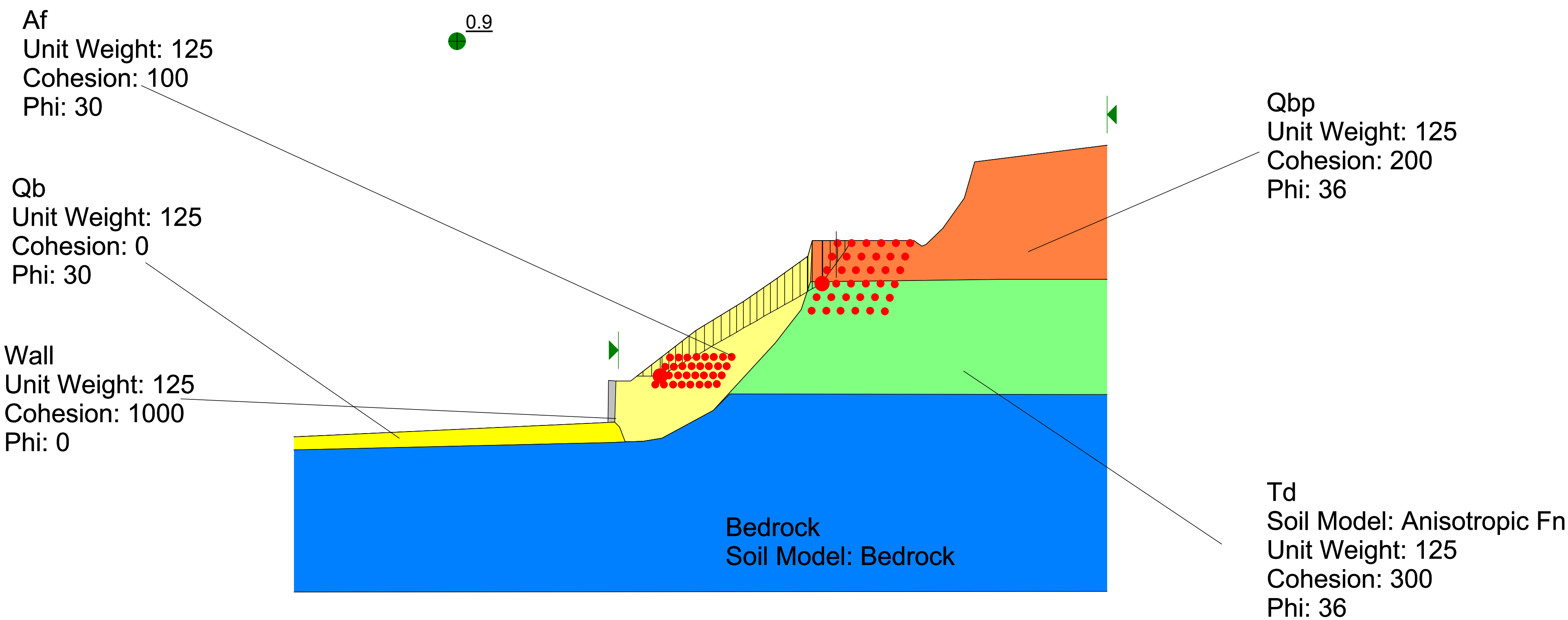
seismic Coefficient = 0.28



Del Mar Bluffs Cross Section 7-7'
Slope Stability Analysis
File Name: Section 77 Pseudo Static 4C.slz
Analysis Method: Spencer

Factor of Safety: 0.9

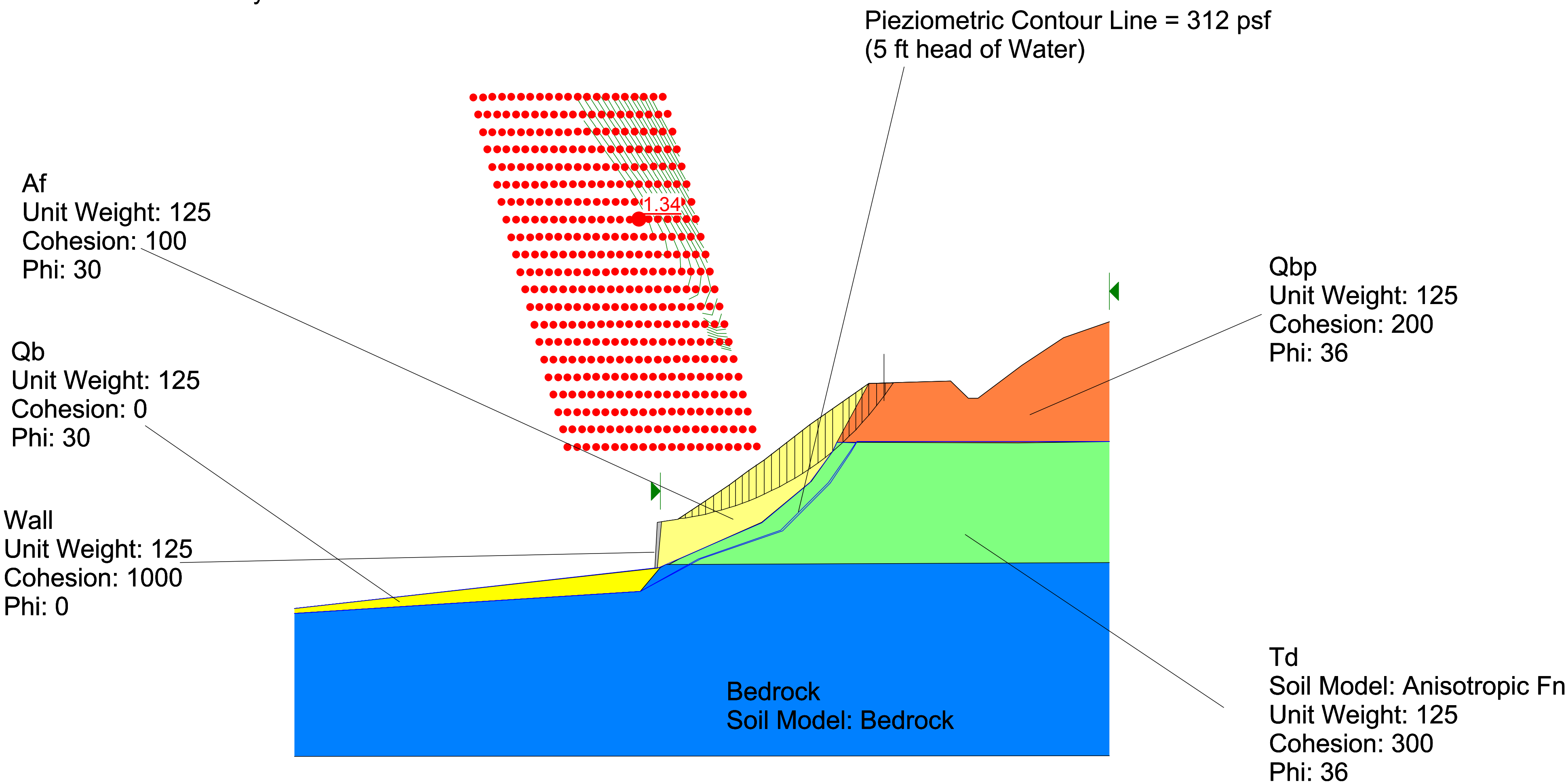
seismic Coefficient = 0.28



Cross Section 8-8’

Del Mar Bluffs Cross Section 8-8
Slope Stability Analysis
File Name: Section 88 5 ft Water Static 1C.slz
Analysis Method: Bishop

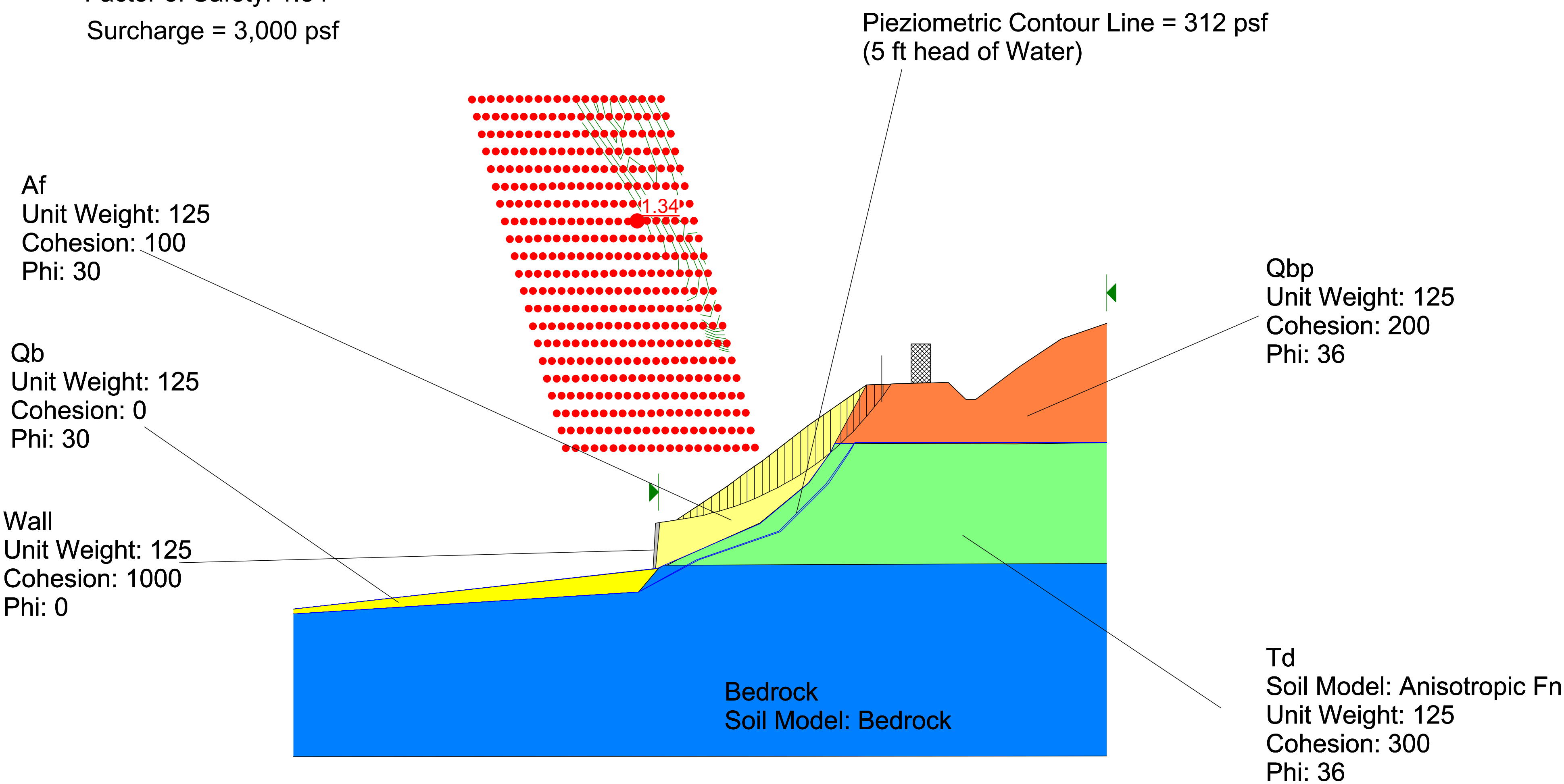
Factor of Safety: 1.34



Del Mar Bluffs Cross Section 8-8
Slope Stability Analysis
File Name: Section 88 5 ft Water Static 2.slz
Analysis Method: Bishop

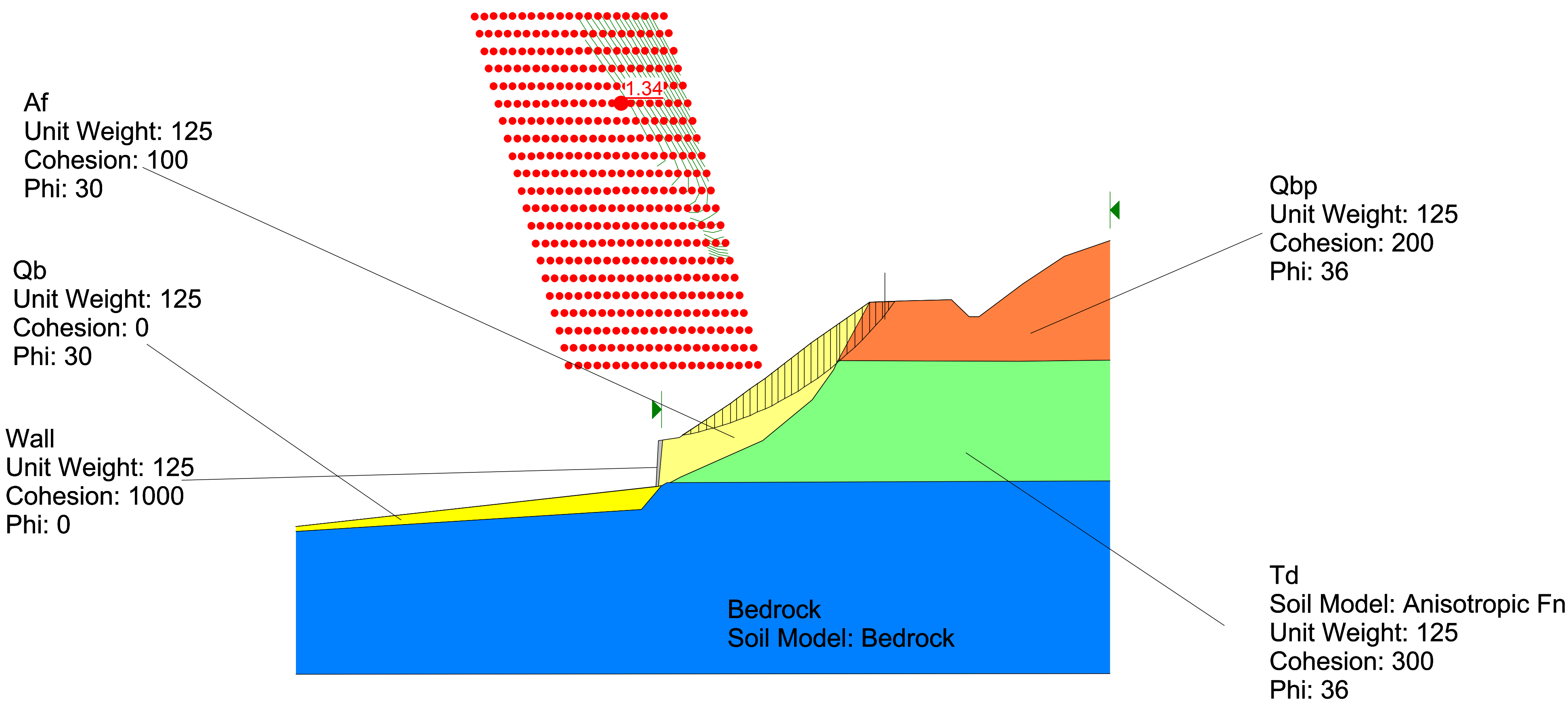
Factor of Safety: 1.34

Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 8-8
Slope Stability Analysis, No Water
File Name: Section 88 Static 3C.slz
Analysis Method: Bishop

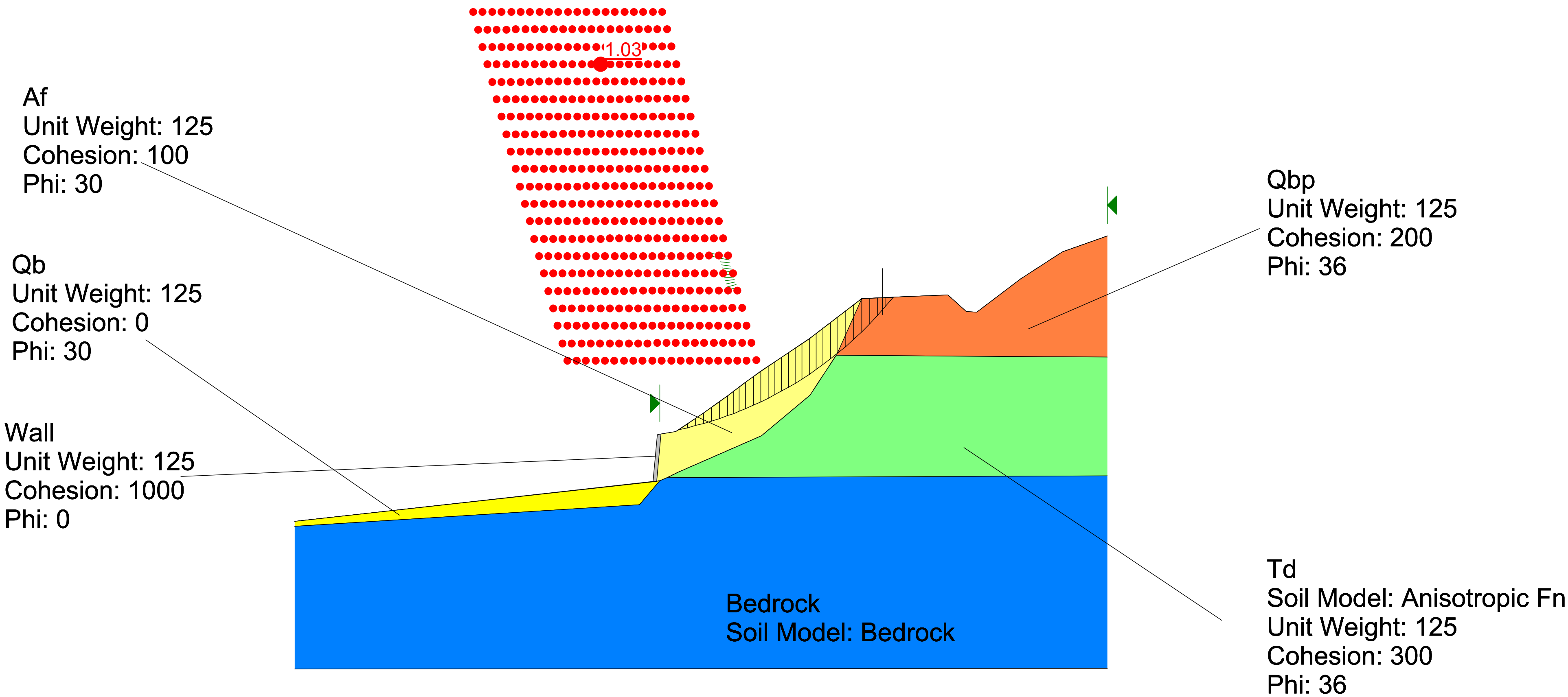
Factor of Safety: 1.34



Del Mar Bluffs Cross Section 8-8
Slope Stability Analysis
File Name: Section 88 Pseudo Static 1C.slz
Analysis Method: Bishop

Factor of Safety: 1.03

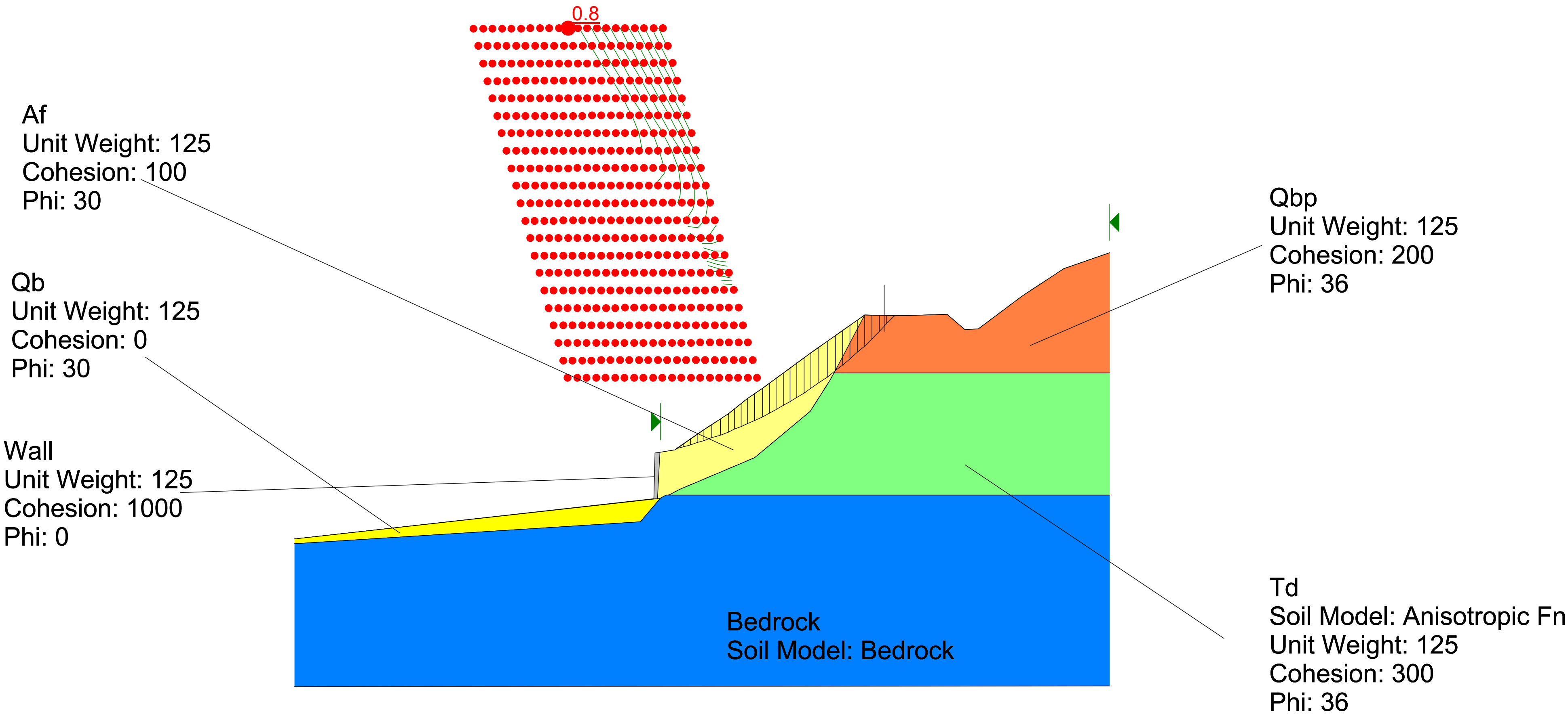
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 8-8
Slope Stability Analysis
File Name: Section 88 Pseudo Static 2C.slz
Analysis Method: Bishop

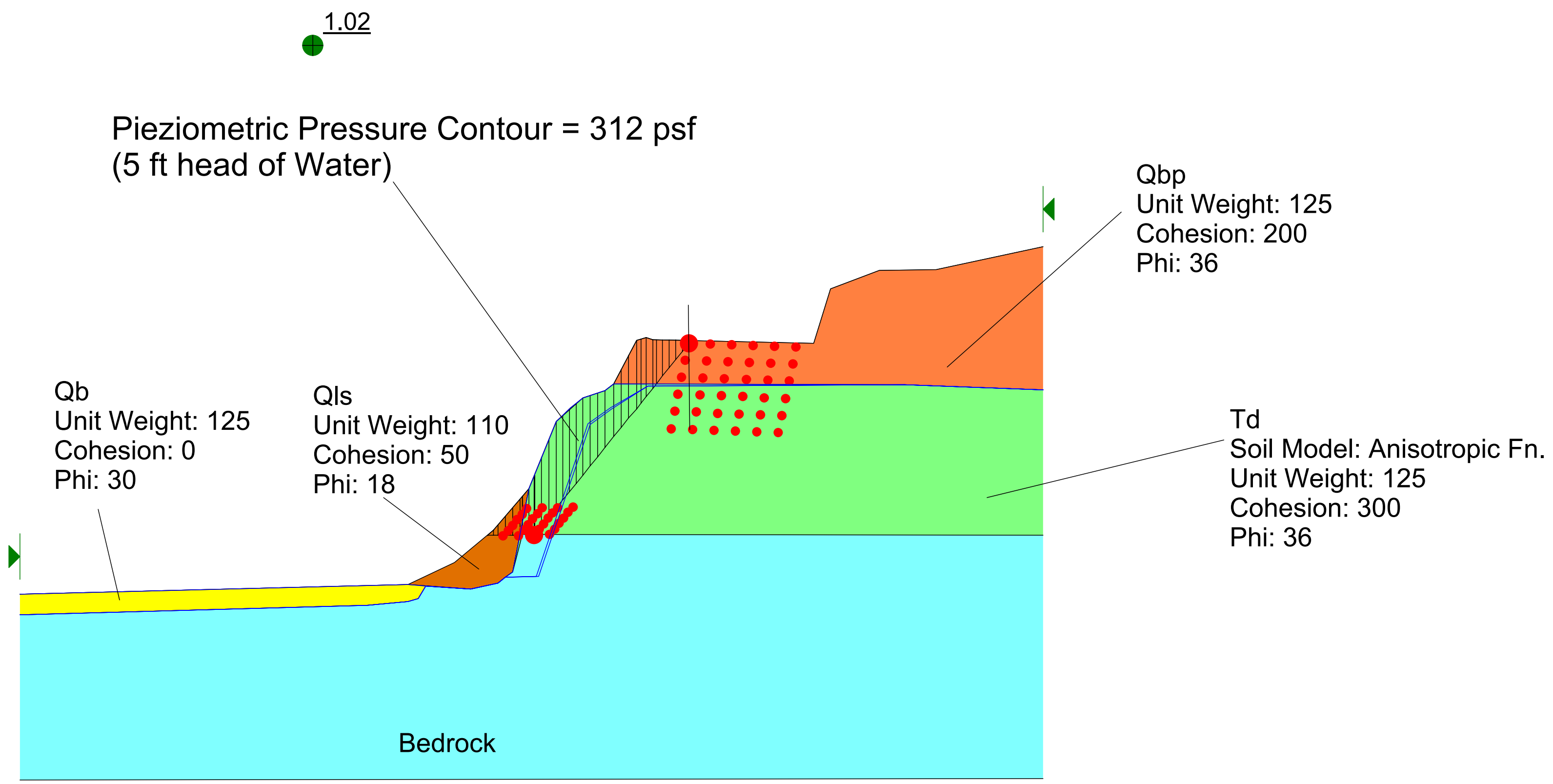
Factor of Safety: 0.84

Seismic Coefficient = 0.28



Cross Section 9-9’

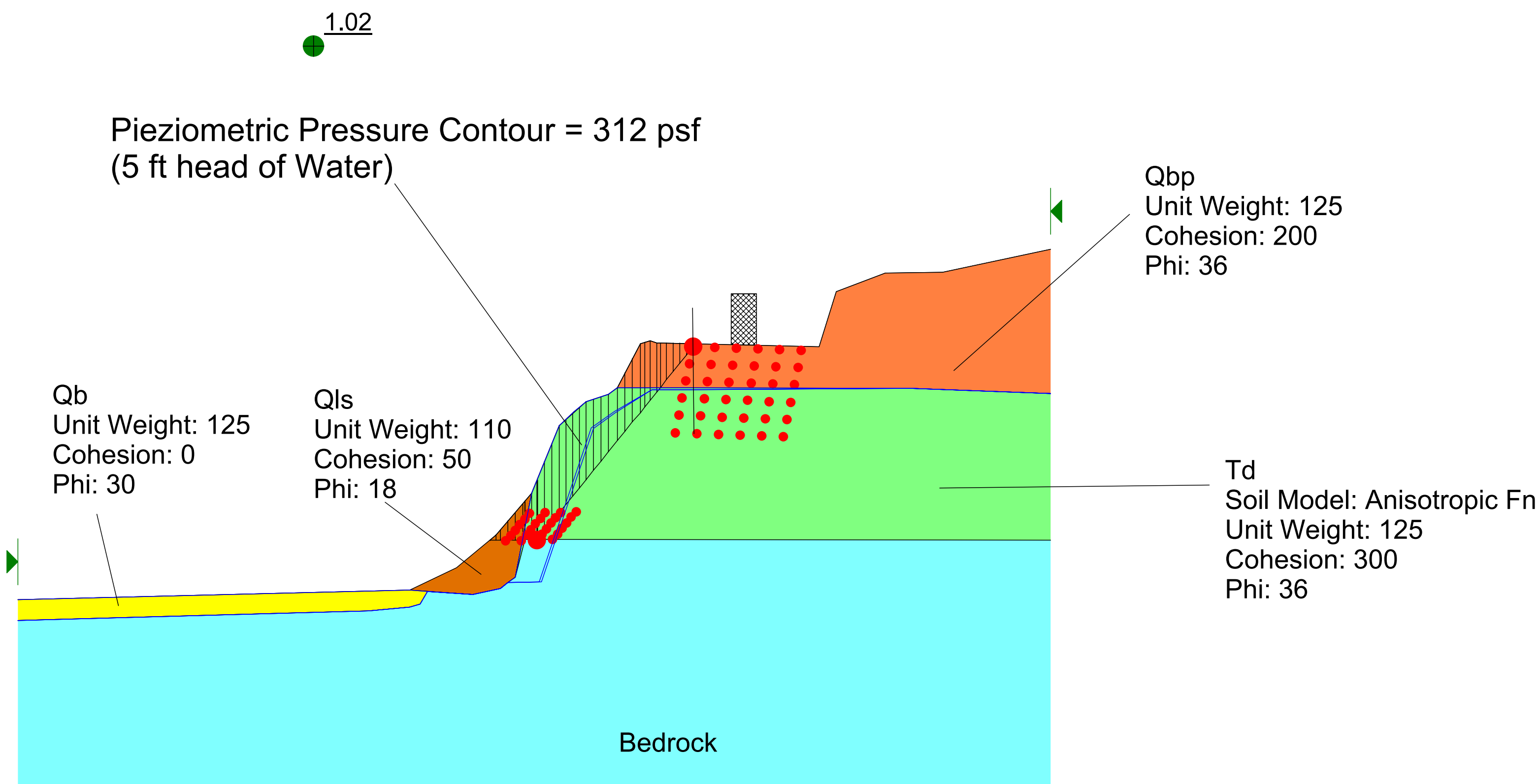
Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis
File Name: Section 99 Static With Water 2.slz
Analysis Method: Spencer
Factor of Safety: 1.02



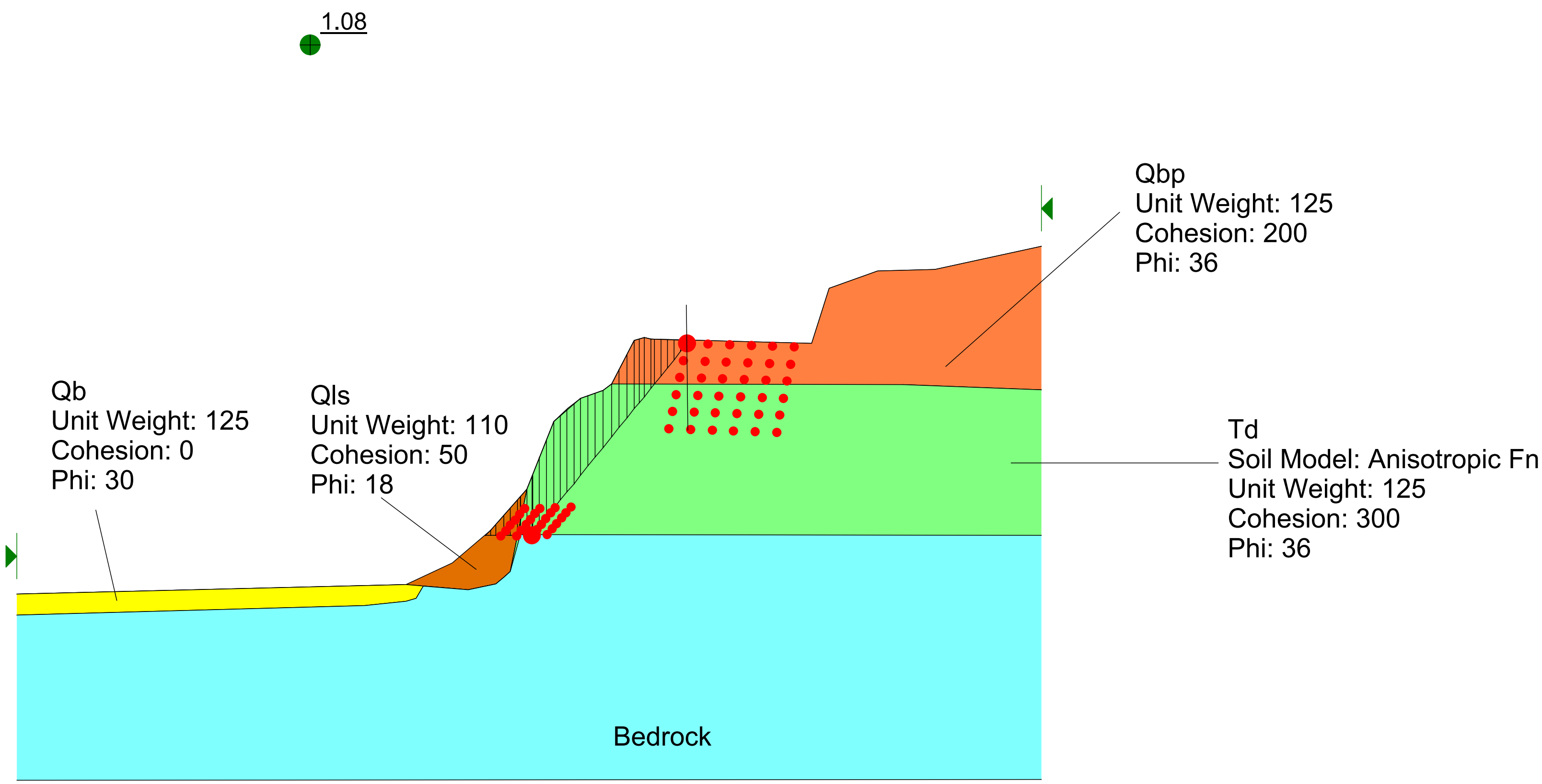
Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis
File Name: Section 99 Static With Water 3.slz
Analysis Method: Spencer

Factor of Safety: 1.02

Surcharge = 3,000 psf



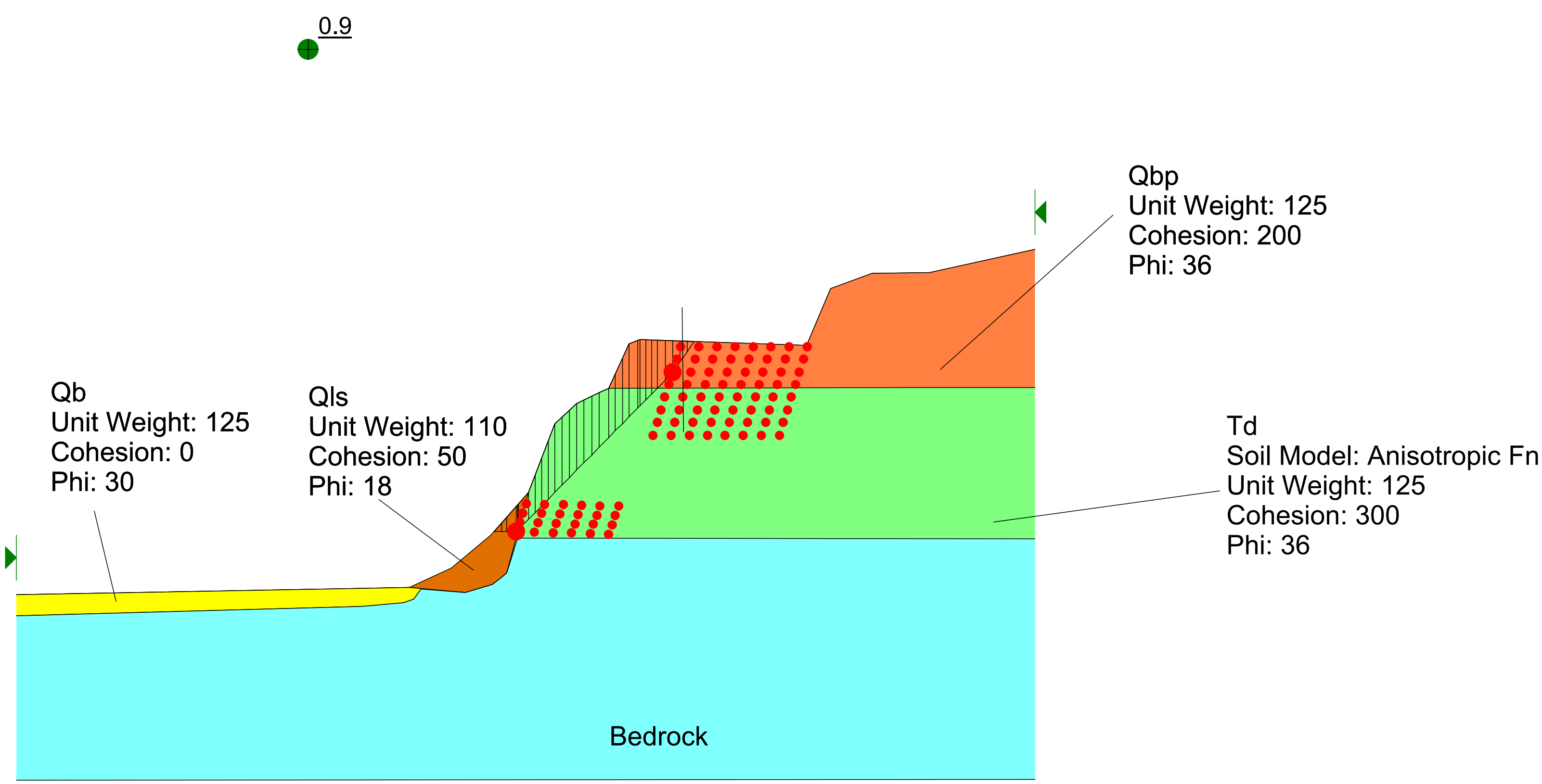
Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis, No Water
File Name: Section 99 Static 1.slz
Analysis Method: Spencer
Factor of Safety: 1.08



Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis
File Name: Section 99 Psuedo Static 2.slz
Analysis Method: Spencer

Factor of Safety: 0.94

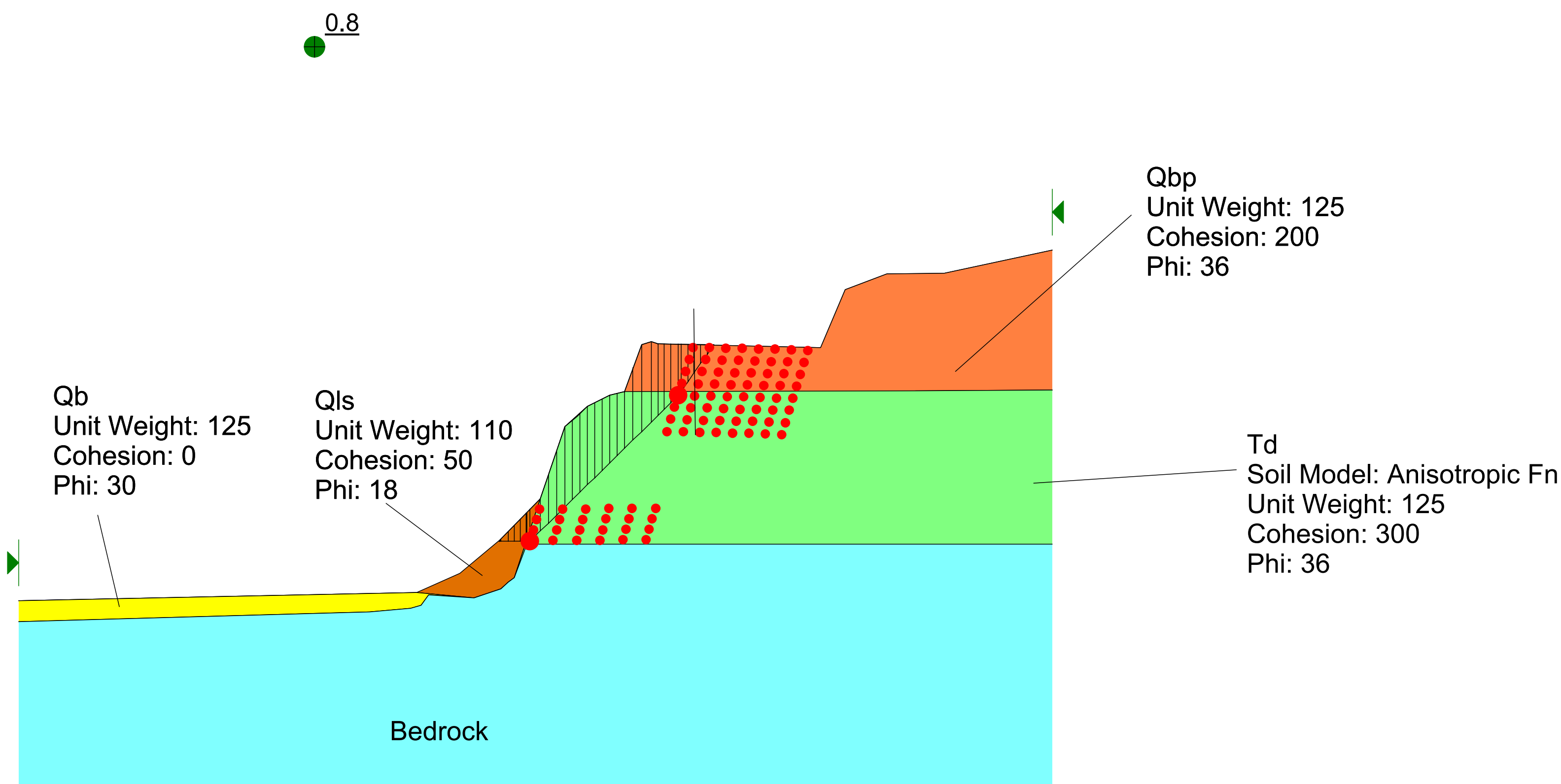
Seismic Coefficient = 0.15



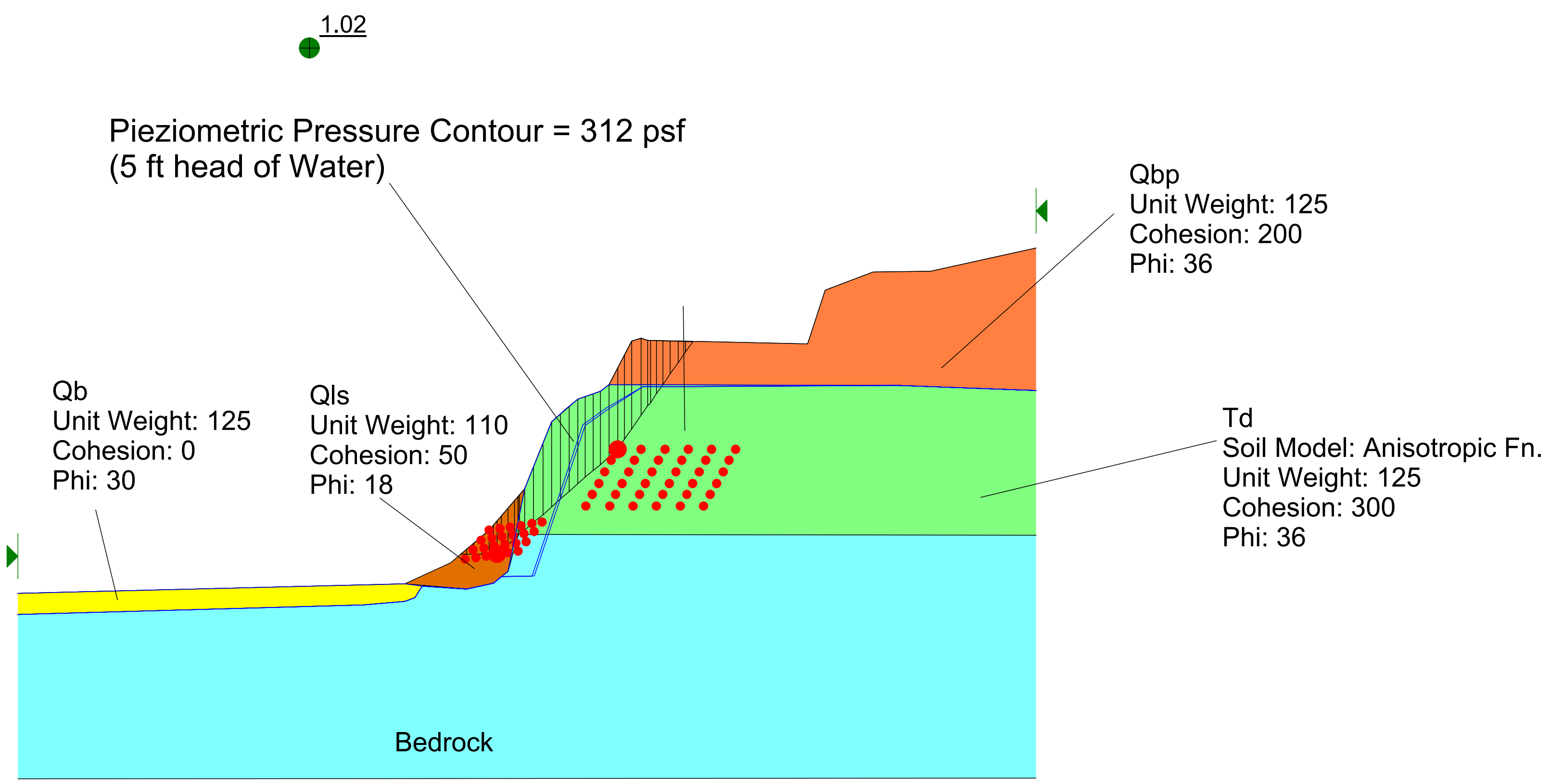
Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis
File Name: Section 99 Psuedo Static 3.slz
Analysis Method: Spencer

Factor of Safety: 0.79

Seismic Coefficient = 0.28



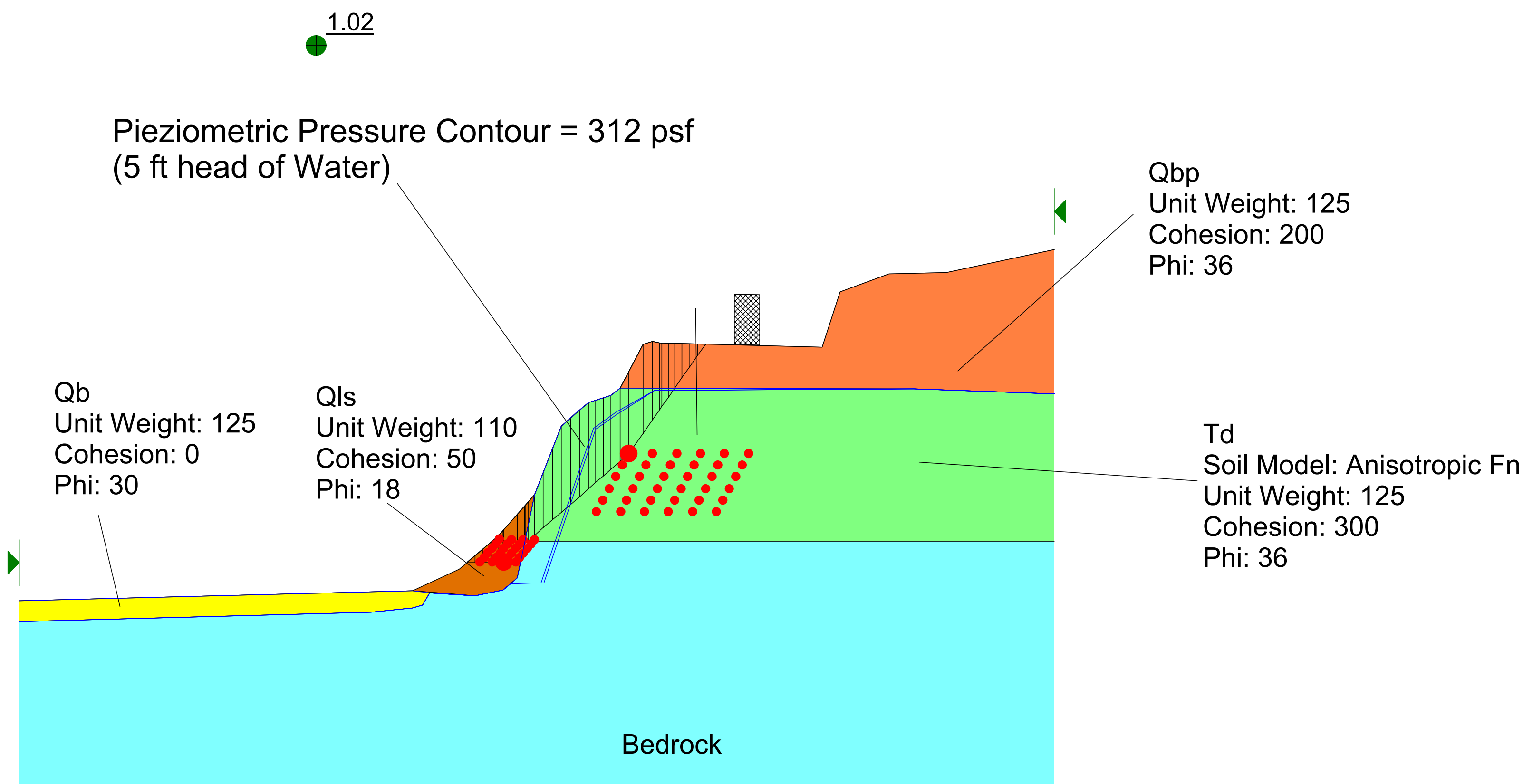
Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis
File Name: Section 99 Static With Water 2B.slz
Analysis Method: Spencer
Factor of Safety: 1.02



Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis
File Name: Section 99 Static With Water 3B.slz
Analysis Method: Spencer

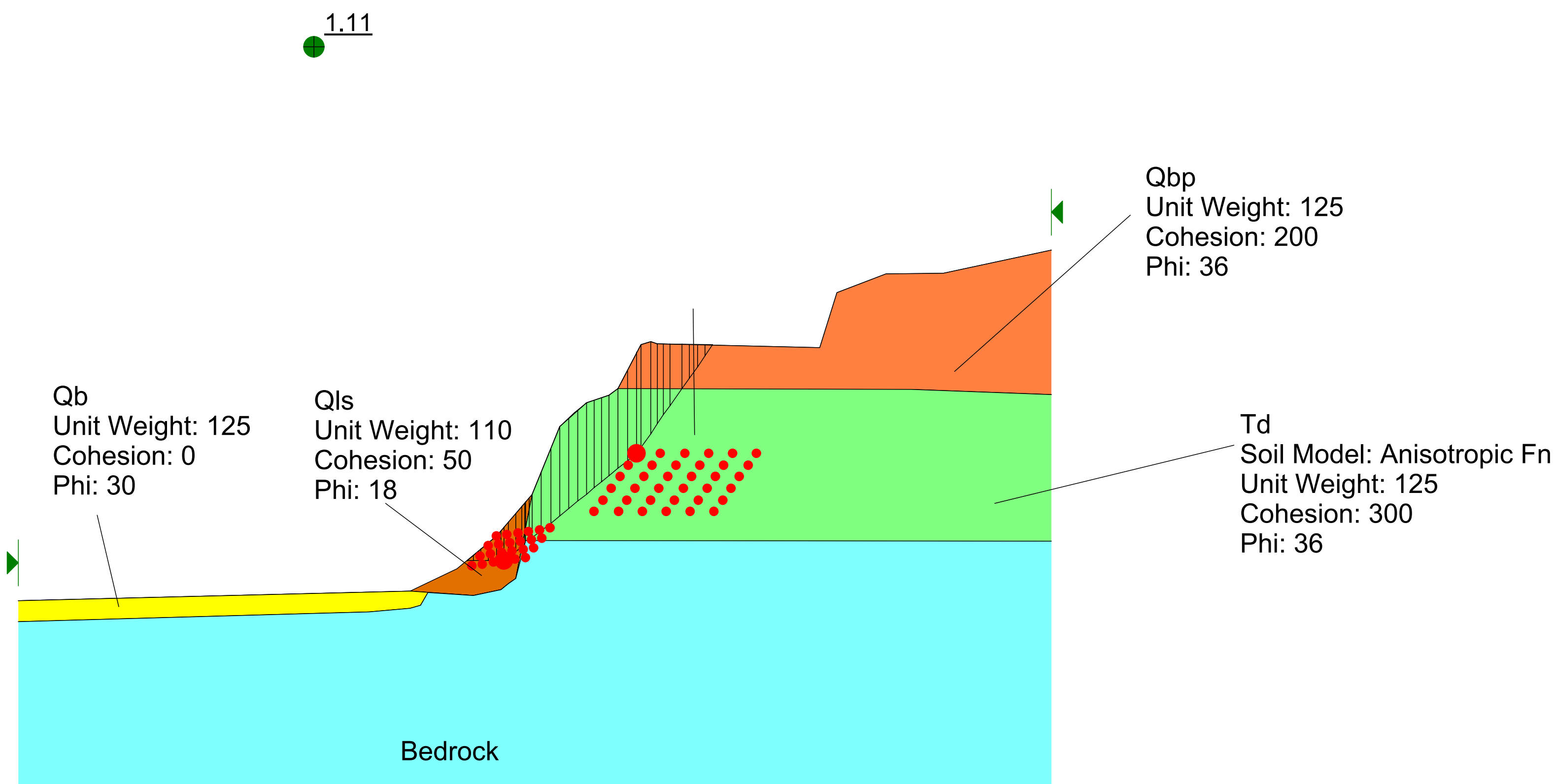
Factor of Safety: 1.02

Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis, No Water
File Name: Section 99 Static 1B.slz
Analysis Method: Spencer

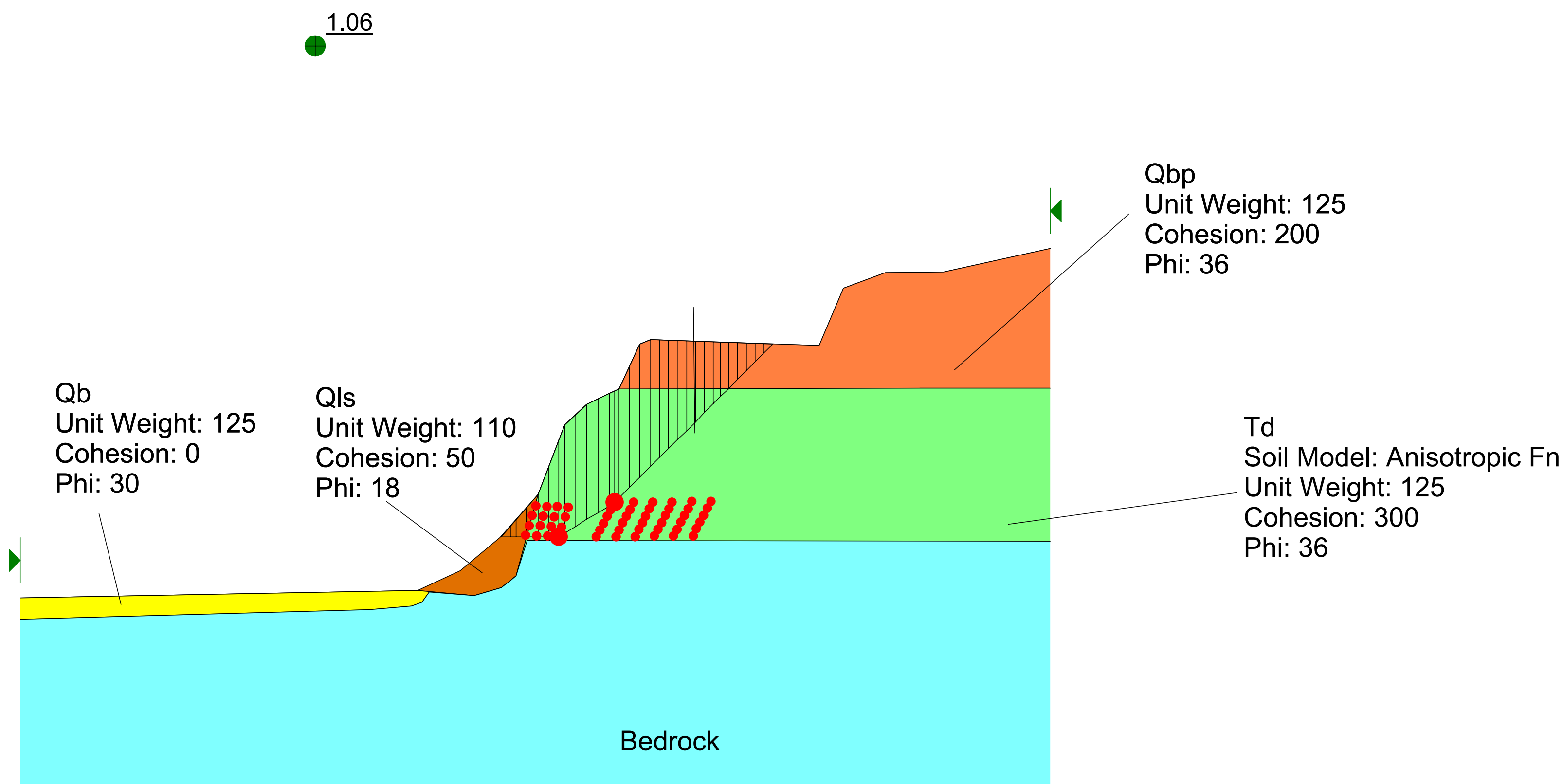
Factor of Safety: 1.11



Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis
File Name: Section 99 Psuedo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.06

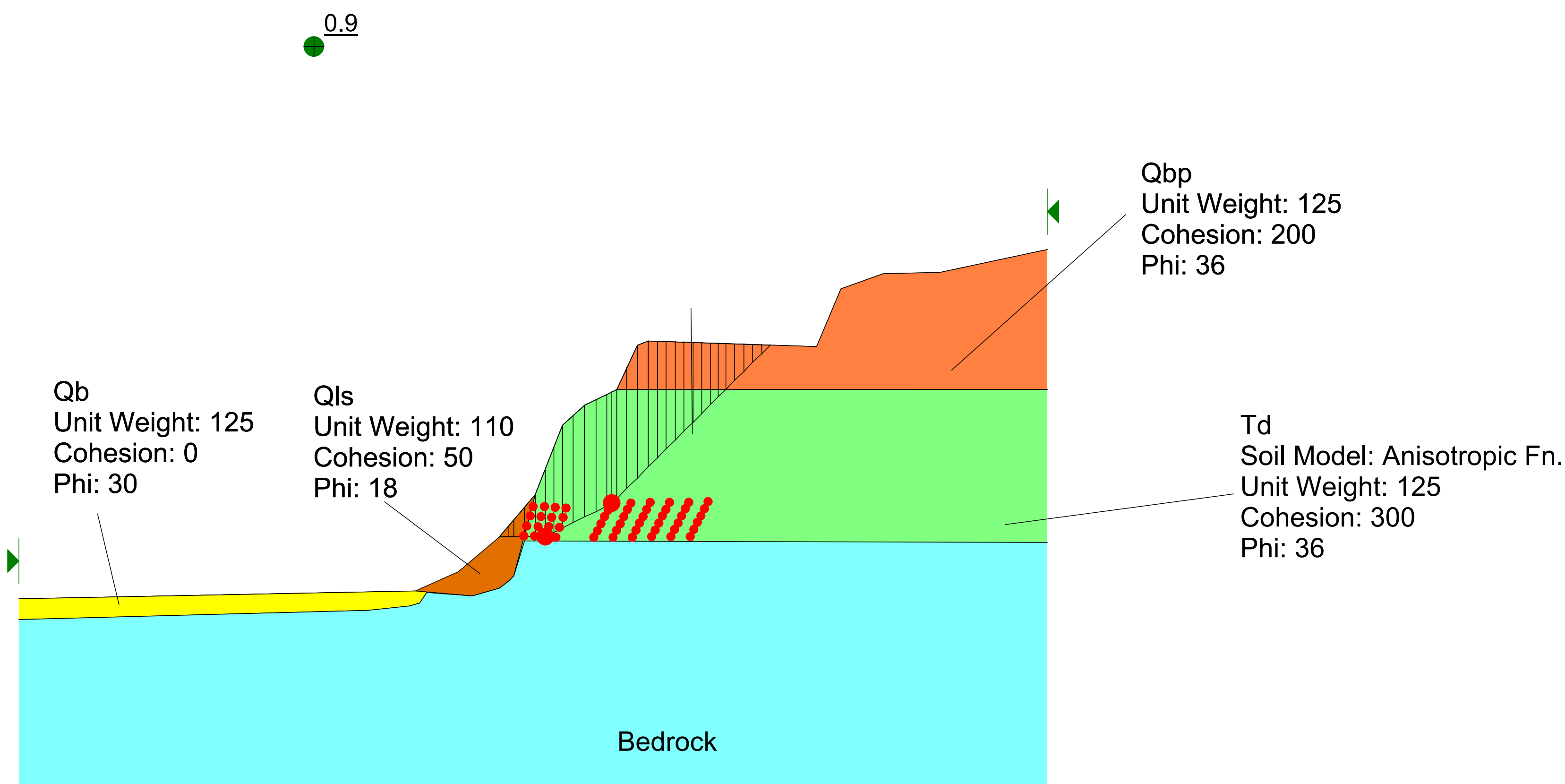
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 9-9'
Slope Stability Analysis
File Name: Section 99 Psuedo Static 3B.slz
Analysis Method: Spencer

Factor of Safety: 0.9

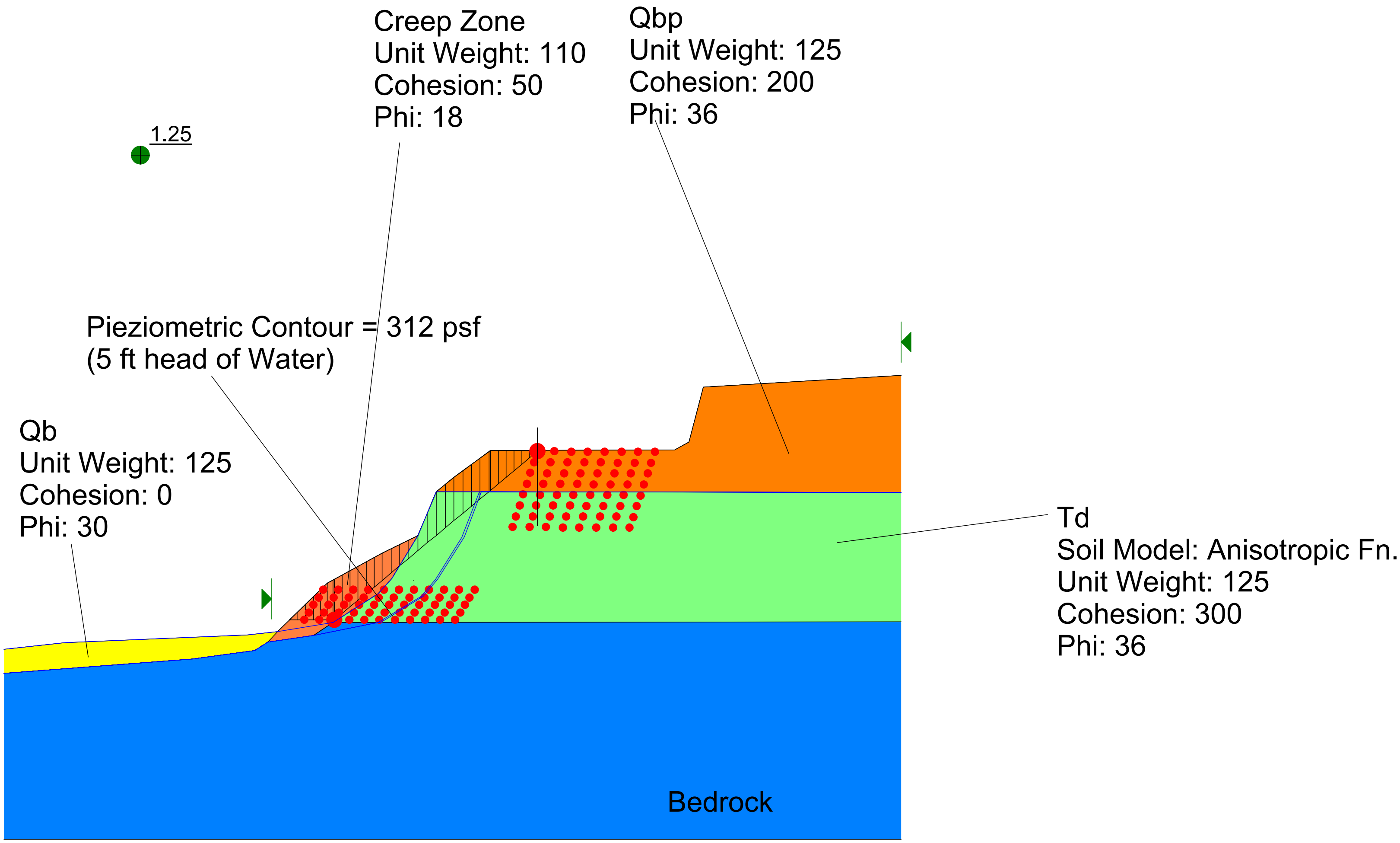
Seismic Coefficient = 0.28



Cross Section 10-10’

Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 5 ft Water Static 2.slz
Analysis Method: Spencer

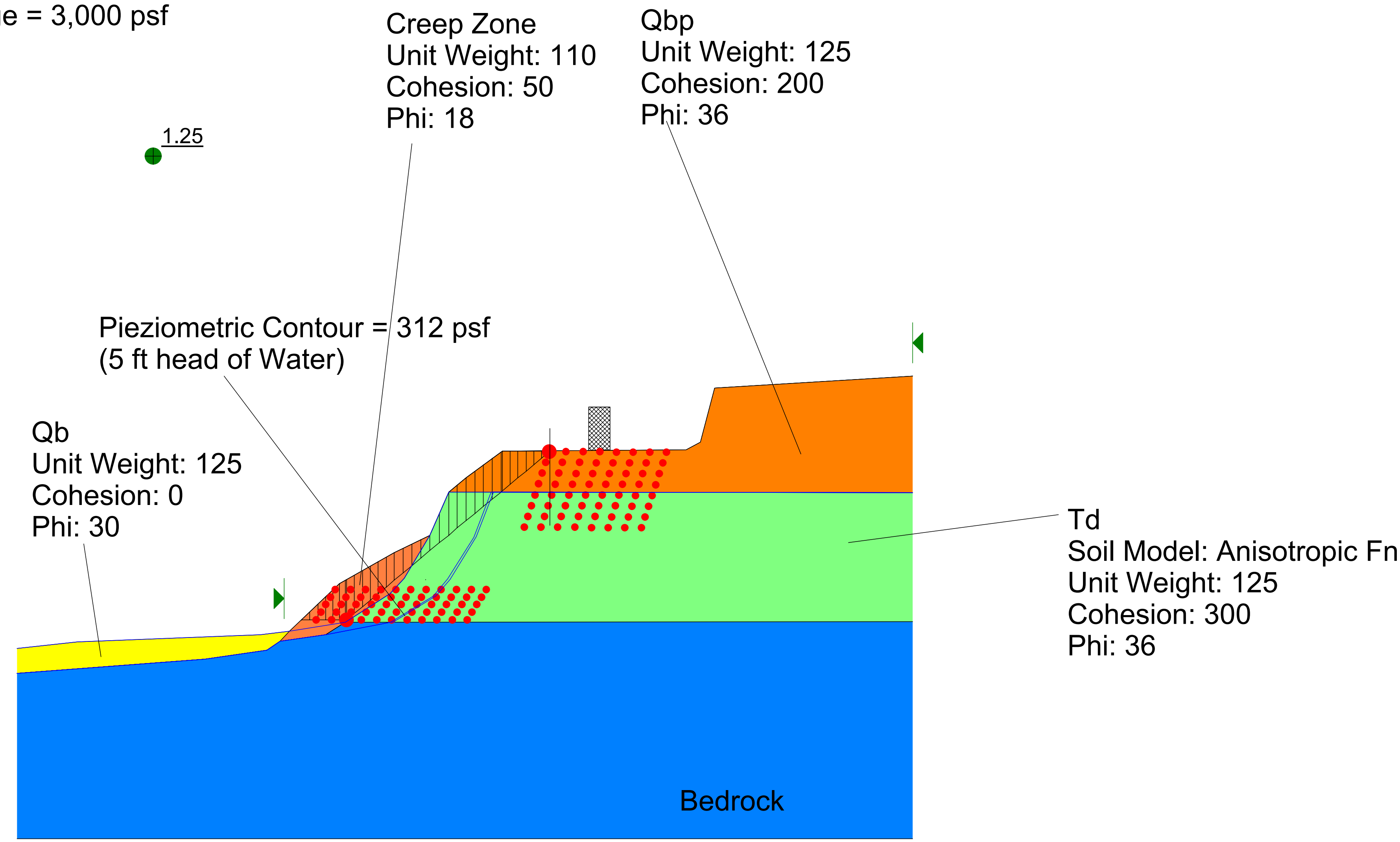
Factor of Safety: 1.25



Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 5 ft Water Static 2C.slz
Analysis Method: Spencer

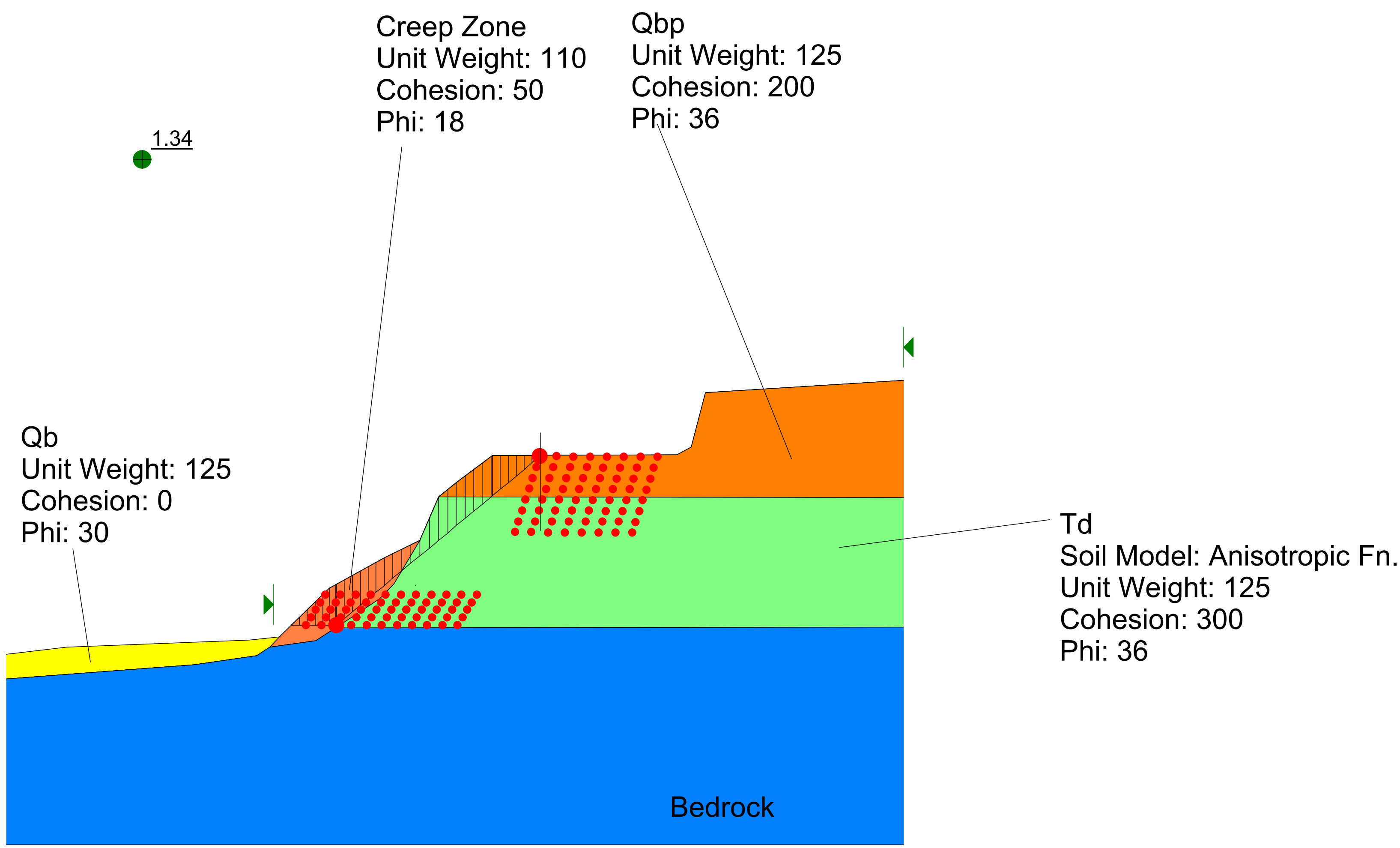
Factor of Safety: 1.25

Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis, No Water
File Name: Section 1010 Static 3.slz
Analysis Method: Spencer

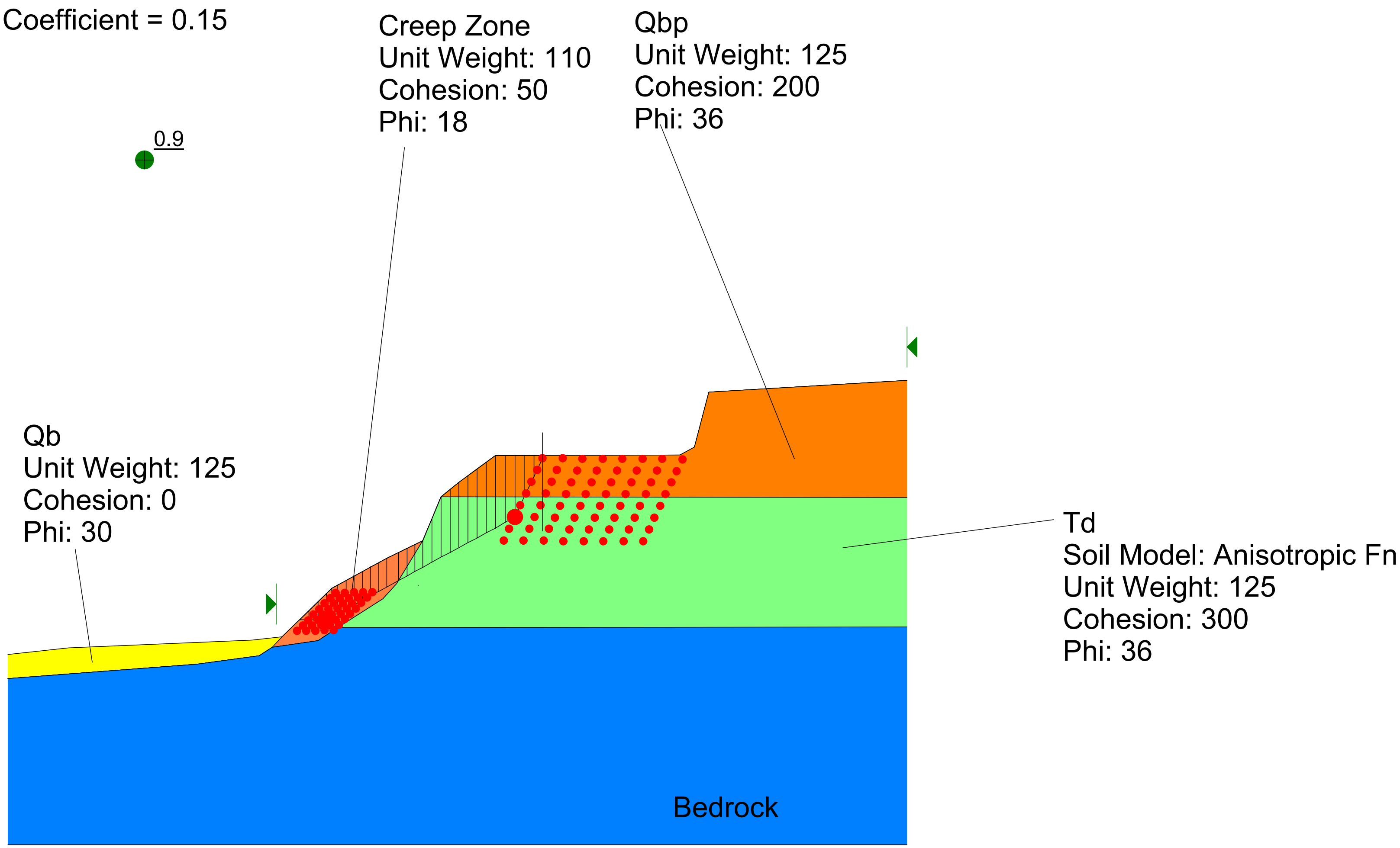
Factor of Safety: 1.34



Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 Psuedo Static 2.slz
Analysis Method: Spencer

Factor of Safety: 0.89

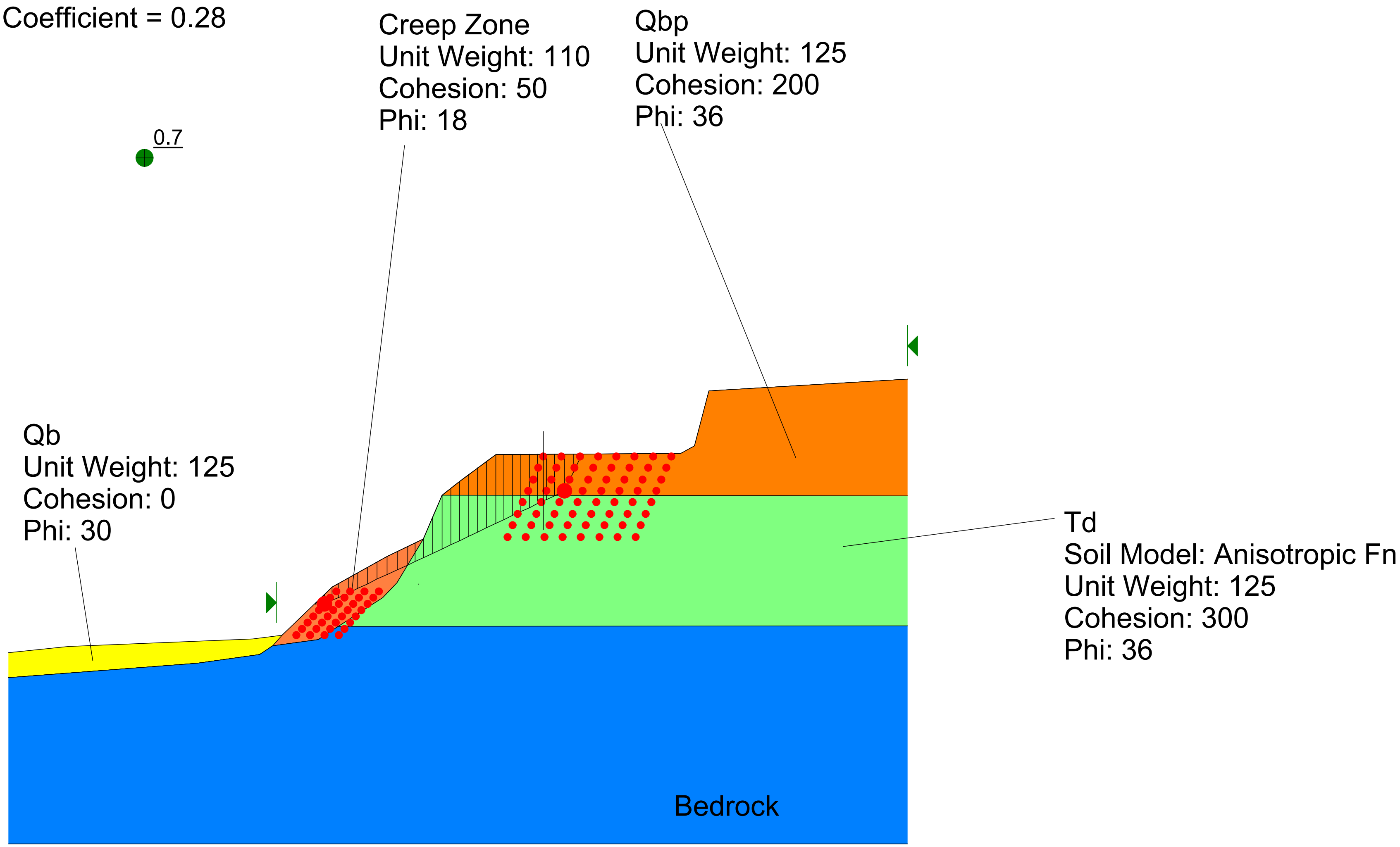
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 Psuedo Static 4.slz
Analysis Method: Spencer

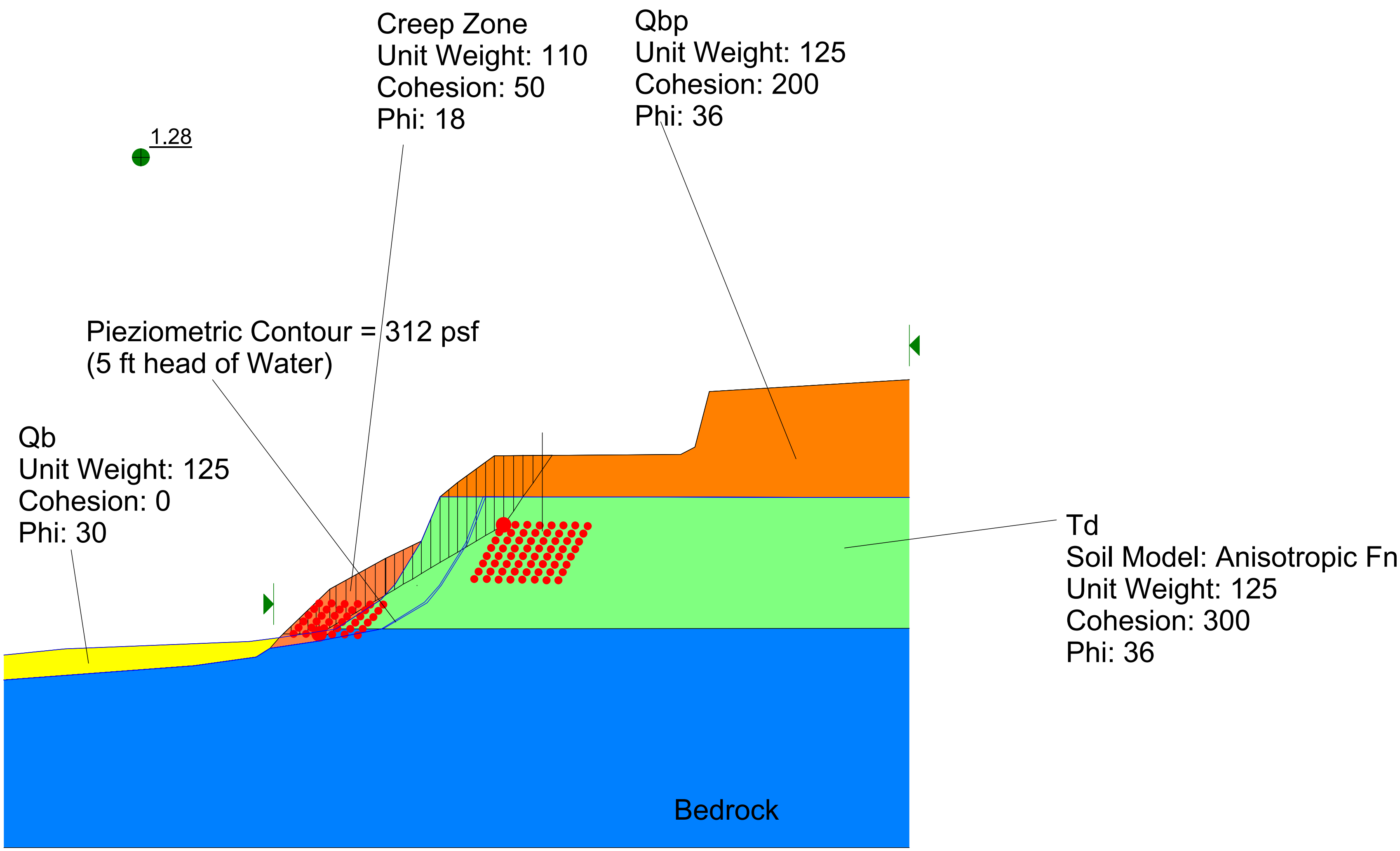
Factor of Safety: 0.69

Seismic Coefficient = 0.28



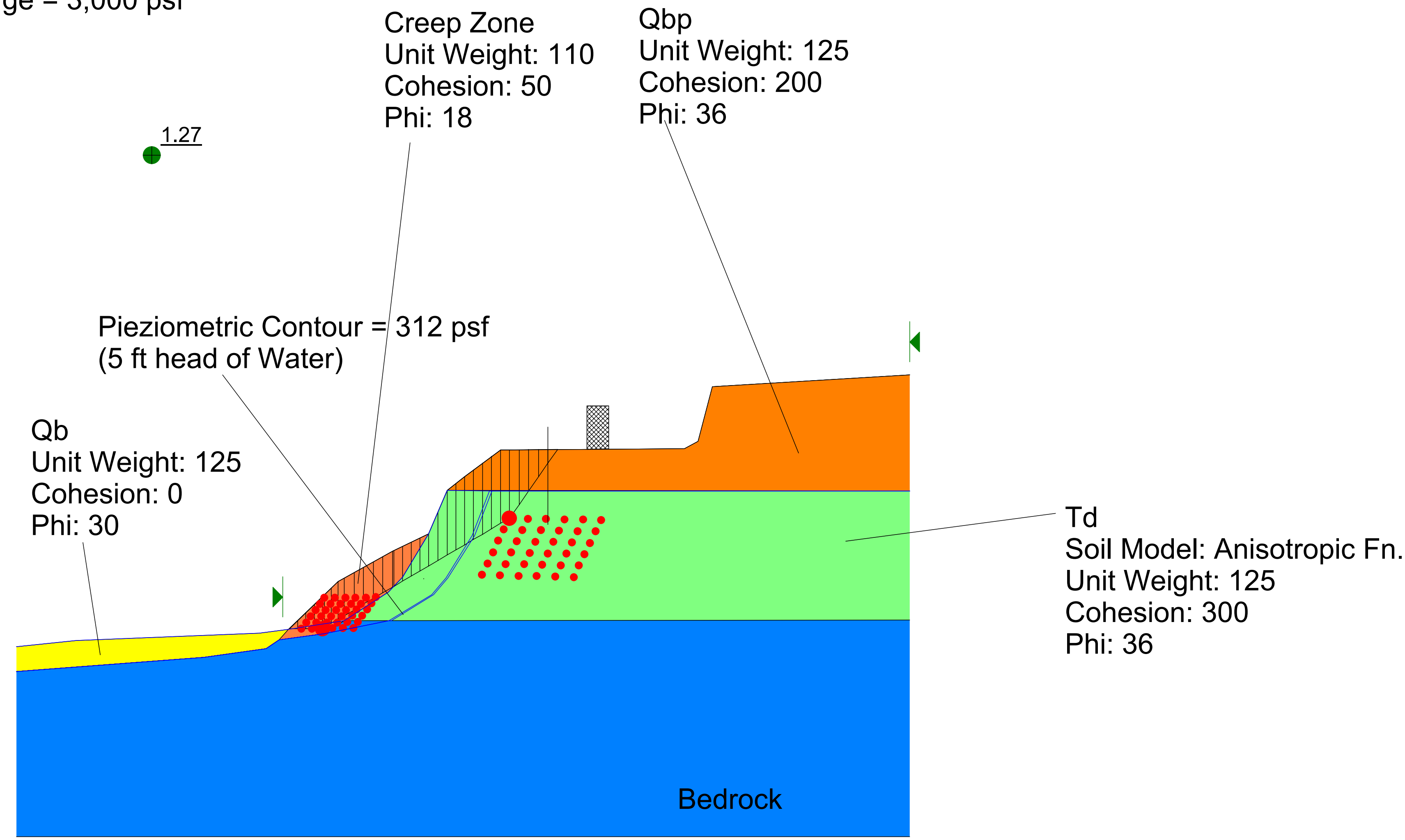
Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 5 ft Water Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.28



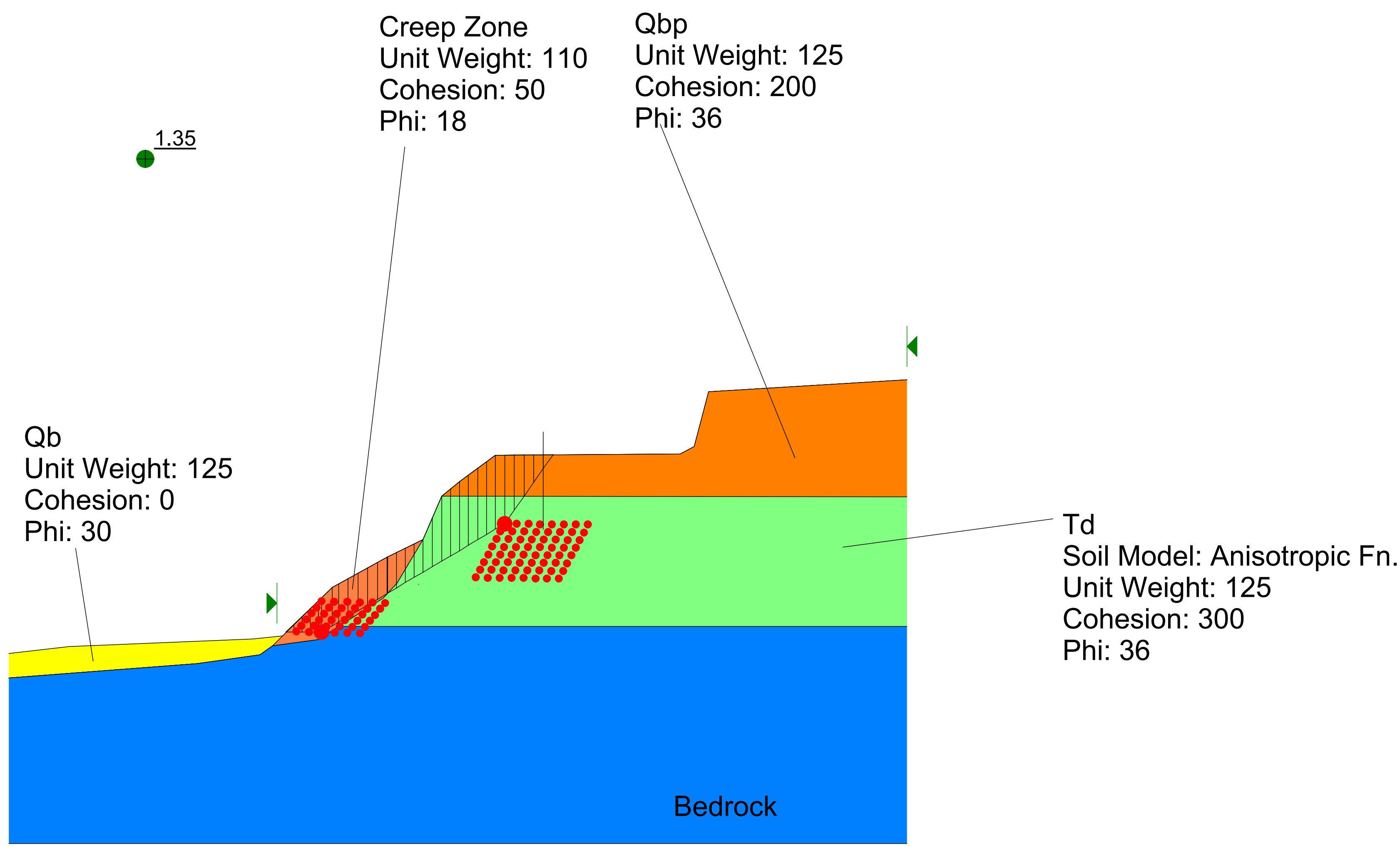
Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 5 ft Water Static 4B.slz
Analysis Method: Spencer

Factor of Safety: 1.27
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis, No Water
File Name: Section 1010 Static 3B.slz
Analysis Method: Spencer

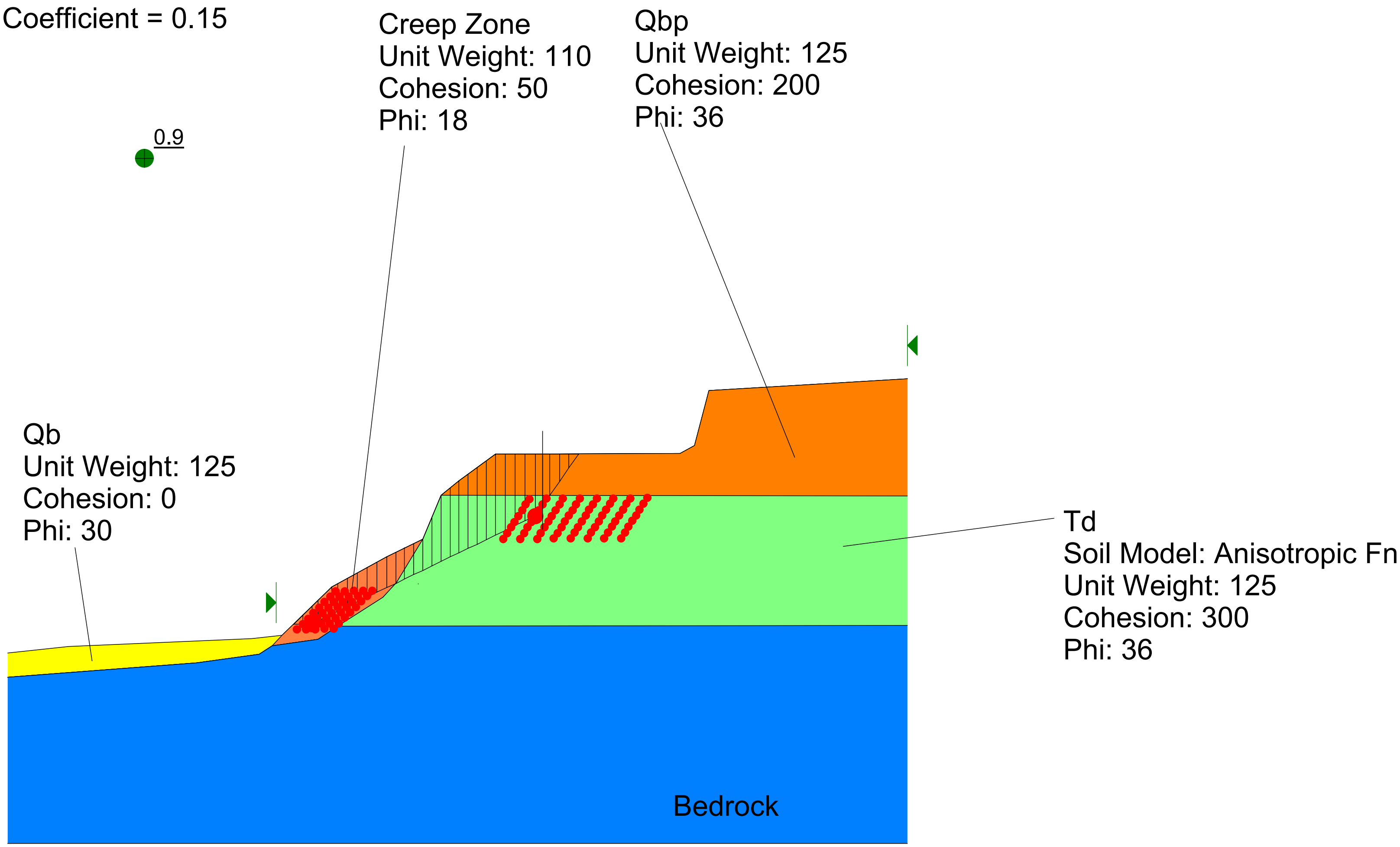
Factor of Safety: 1.35

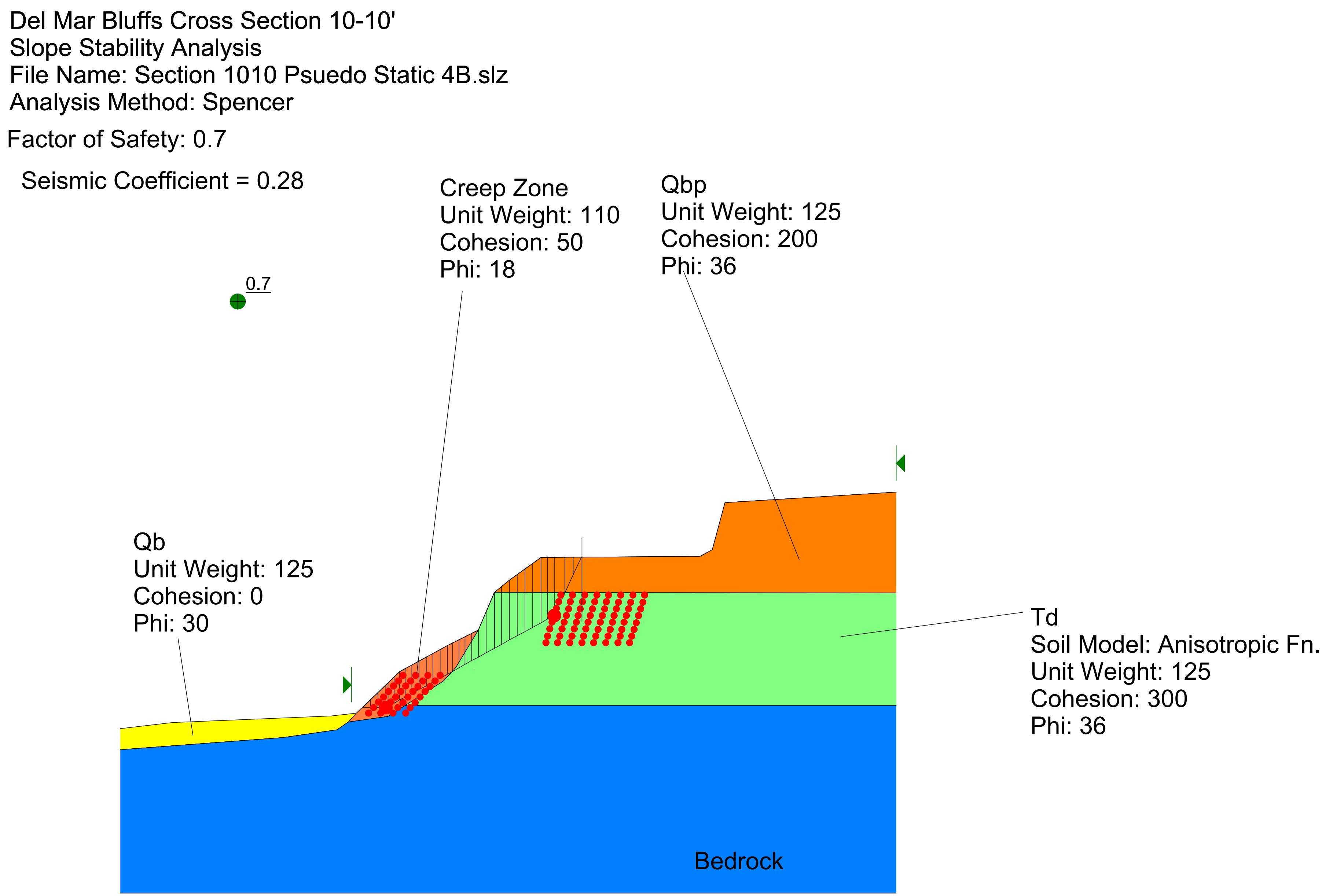


Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 Psuedo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 0.88

Seismic Coefficient = 0.15

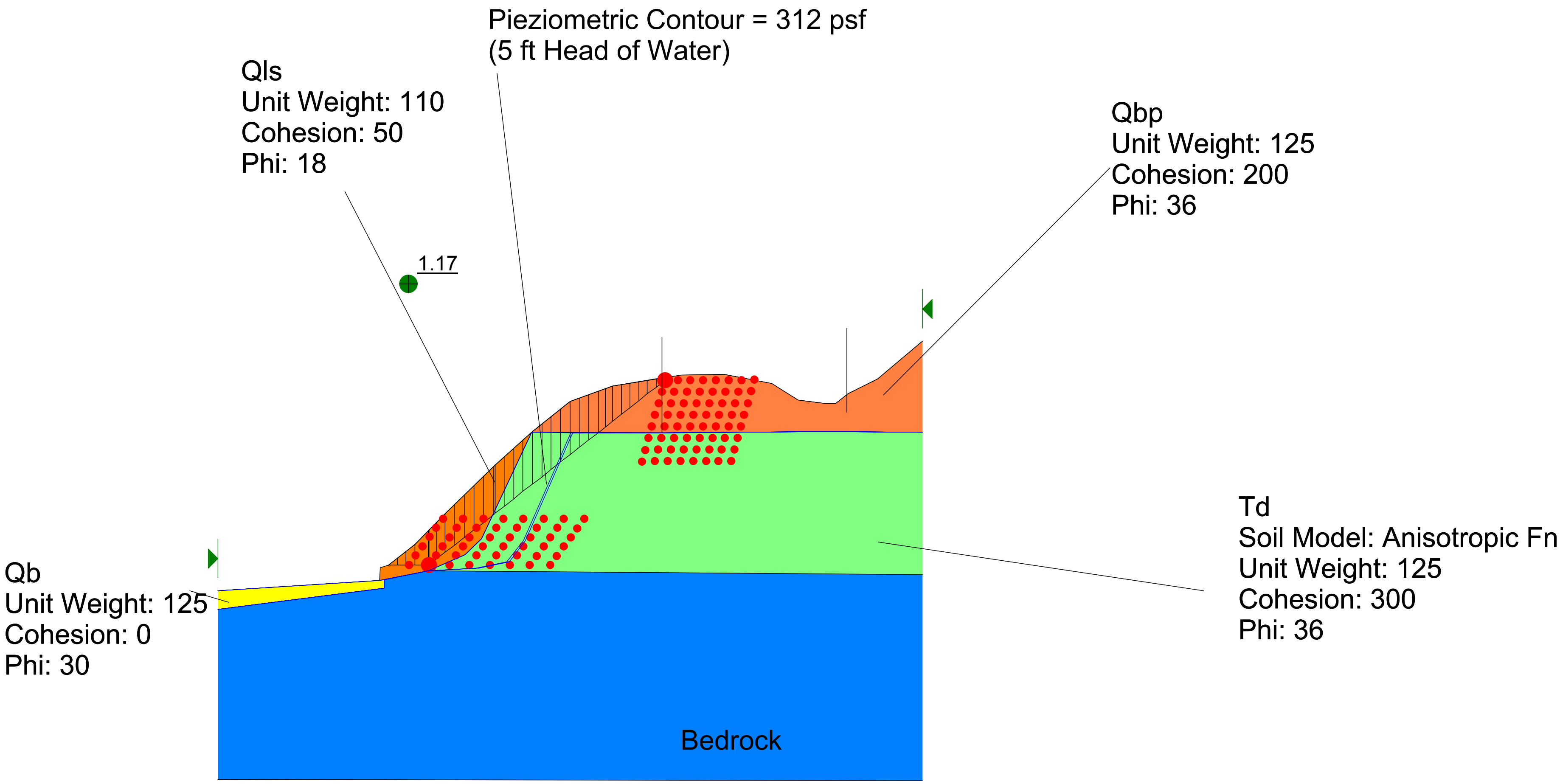



Del Mar Bluffs Cross Section 10-10'
Slope Stability Analysis
File Name: Section 1010 Psuedo Static 4B.slz
Analysis Method: Spencer
Factor of Safety: 0.7
Seismic Coefficient = 0.28
Creep Zone
Unit Weight: 110
Cohesion: 50
Phi: 18
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
0.7
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock

Cross Section 11-11’

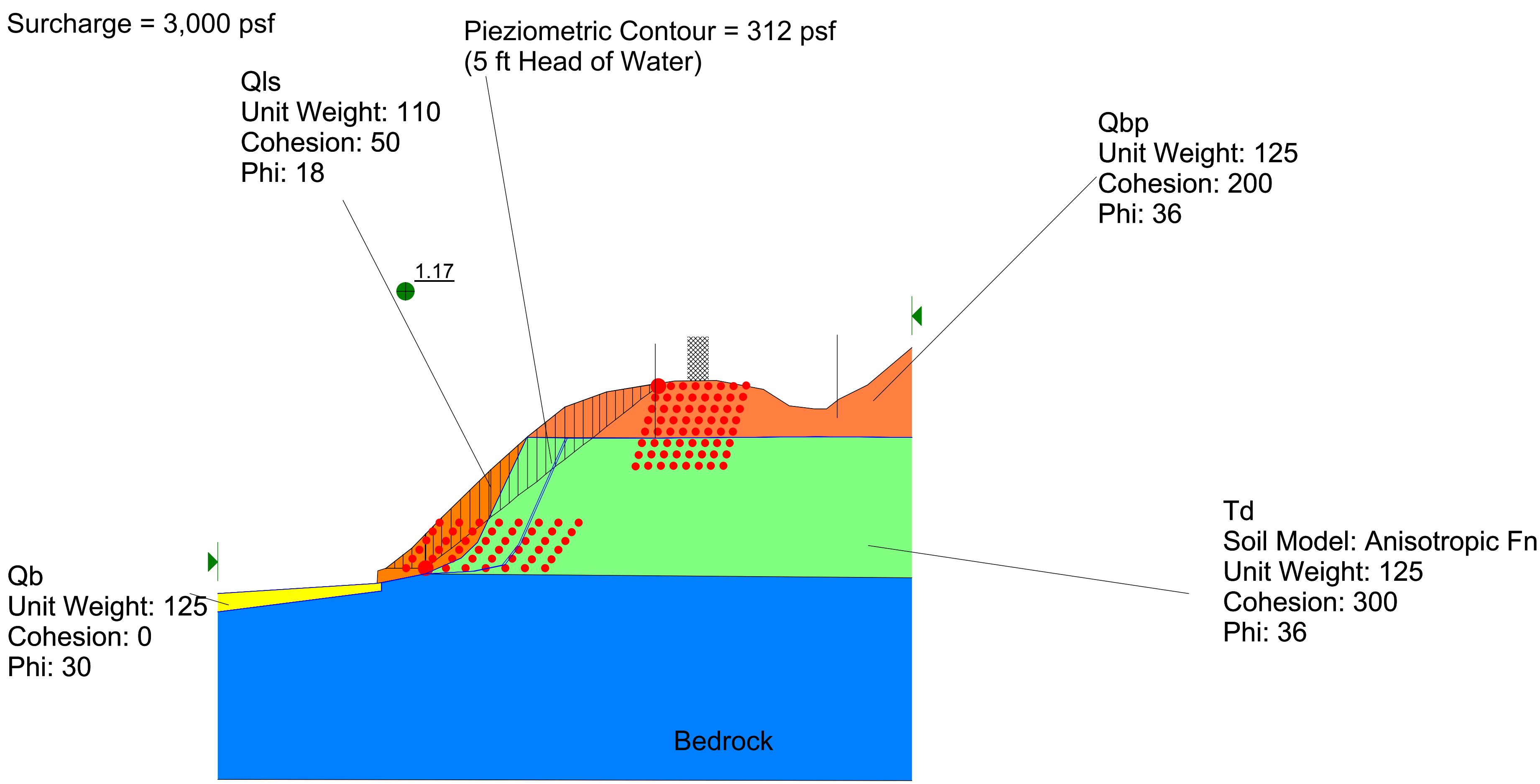
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis
File Name: Section 1111 Static 1.slz
Analysis Method: Spencer

Factor of Safety: 1.17



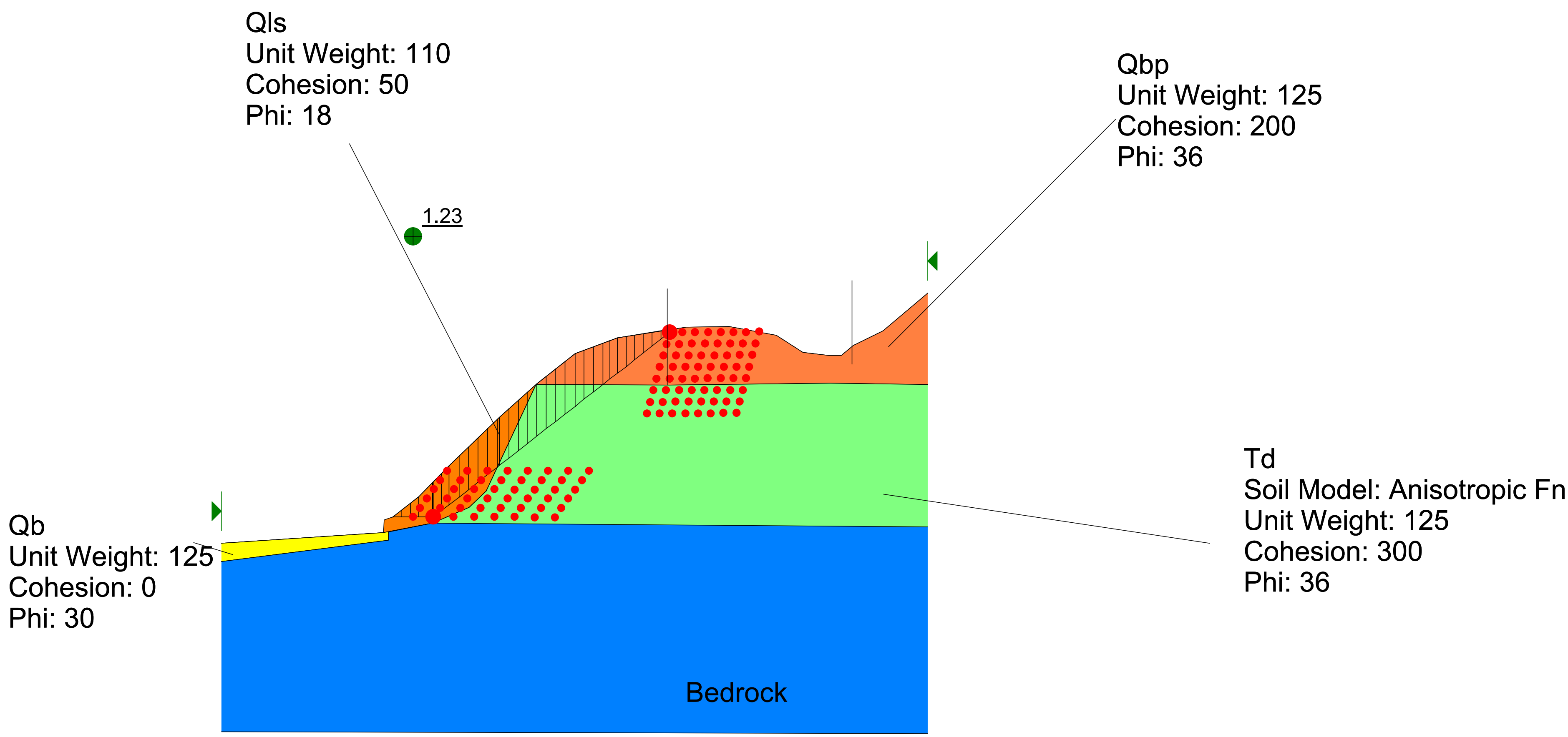
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis
File Name: Section 1111 Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.17



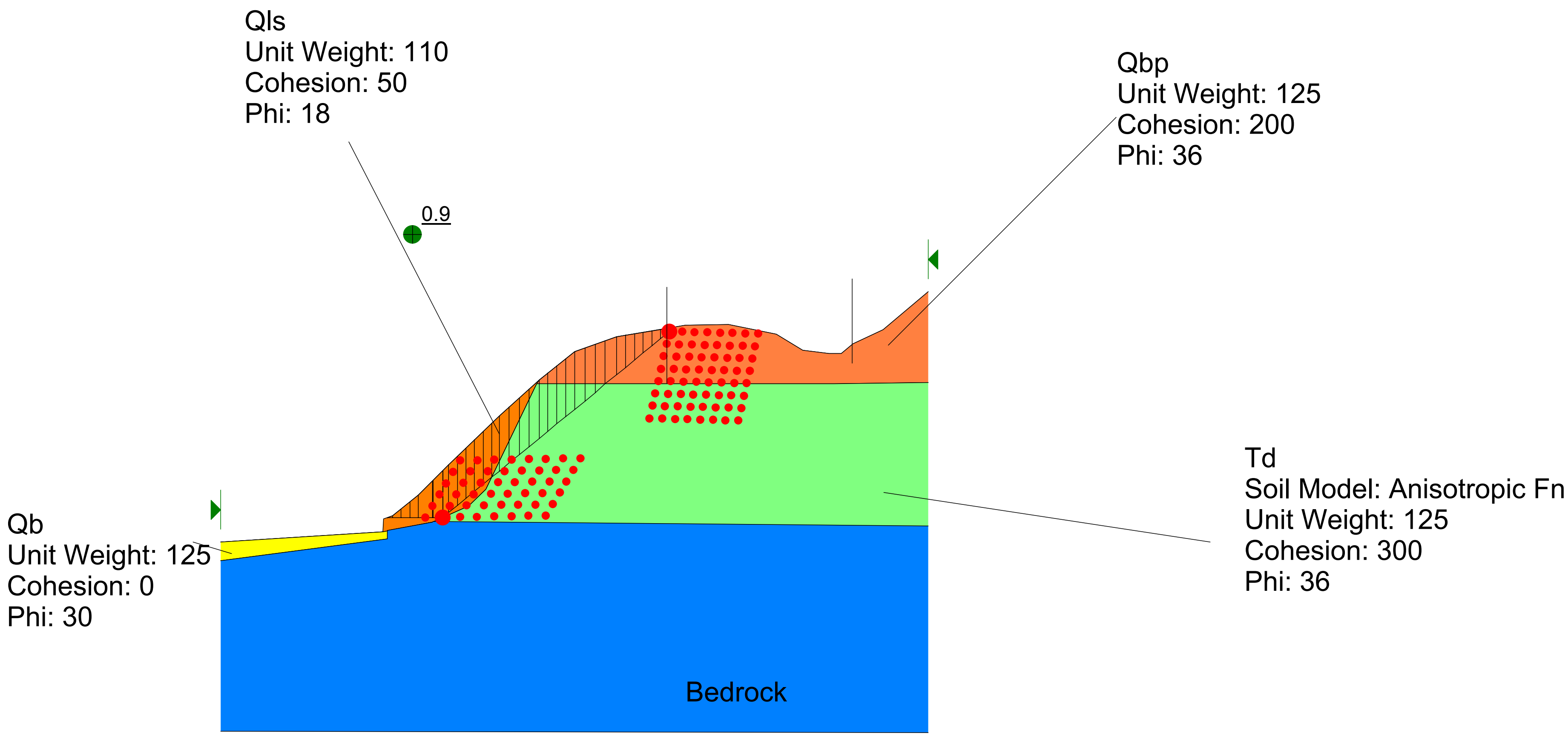
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis, No Water
File Name: Section 1111 Static 3.slz
Analysis Method: Spencer

Factor of Safety: 1.23



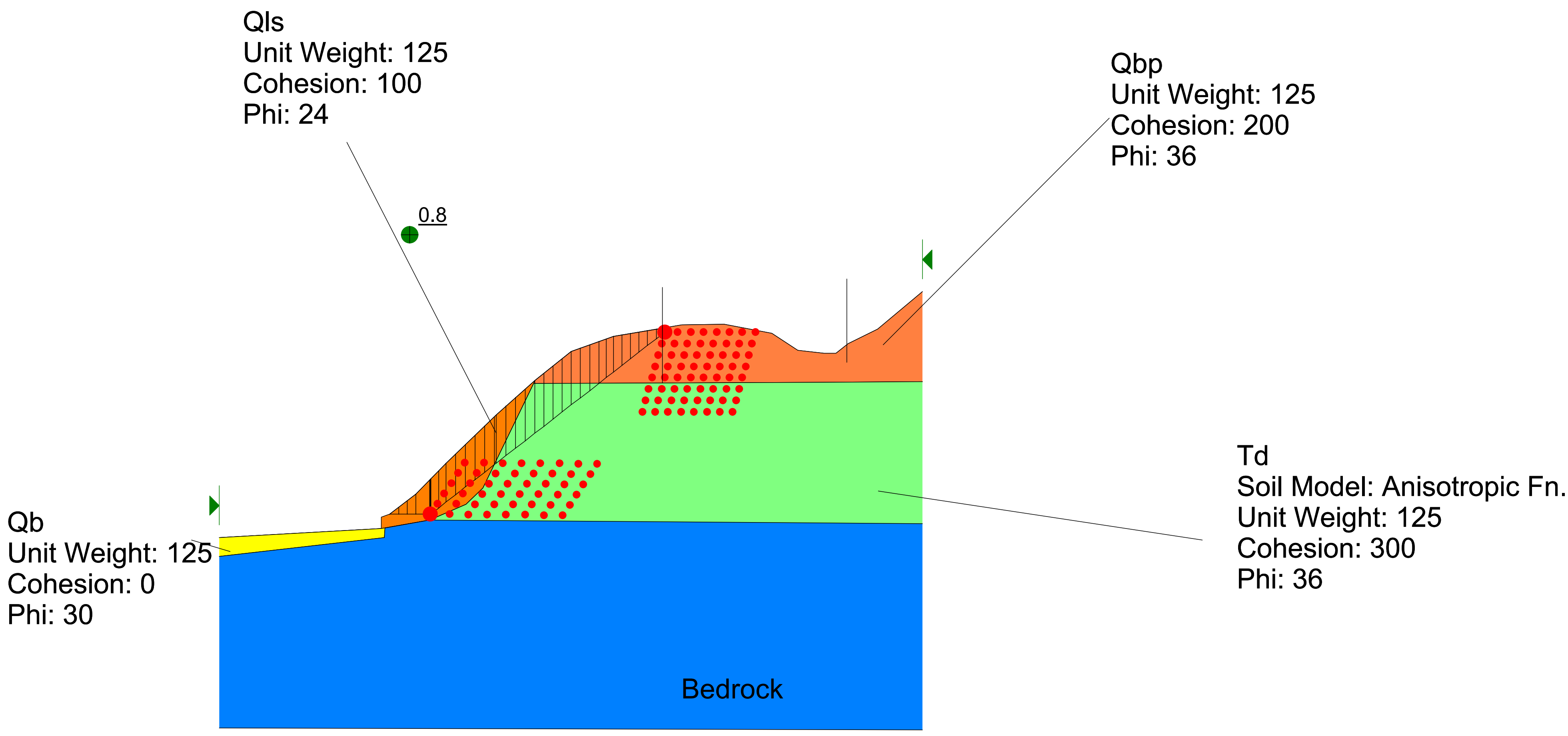
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis
File Name: Section 1111 Pseudo Static 1.slz
Analysis Method: Spencer

Factor of Safety: 0.9
Seismic Coefficient = 0.15



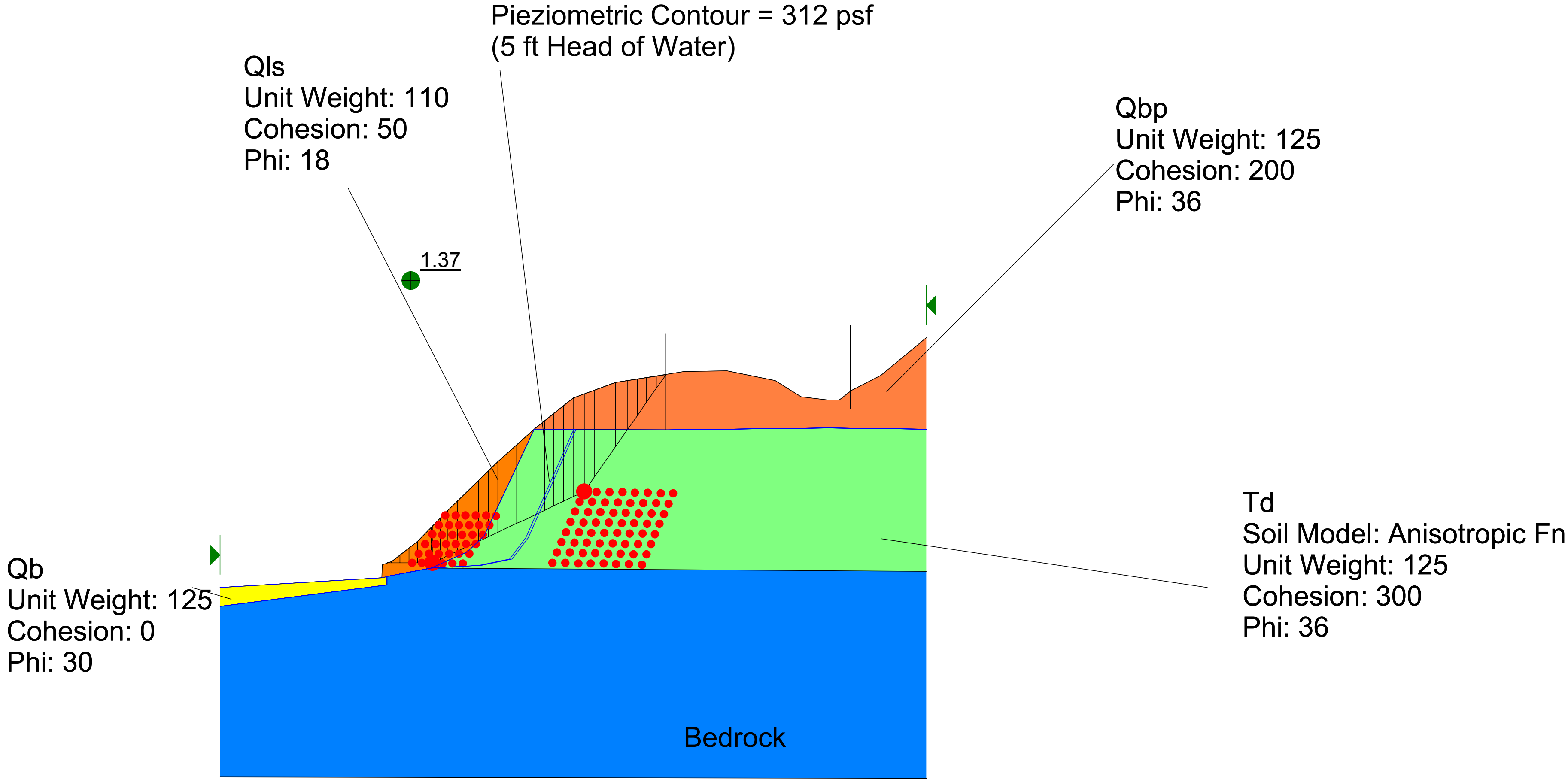
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis
File Name: Section 1111 Pseudo Static 2.slz
Analysis Method: Spencer

Factor of Safety: 0.77
Seismic Coefficient = 0.28



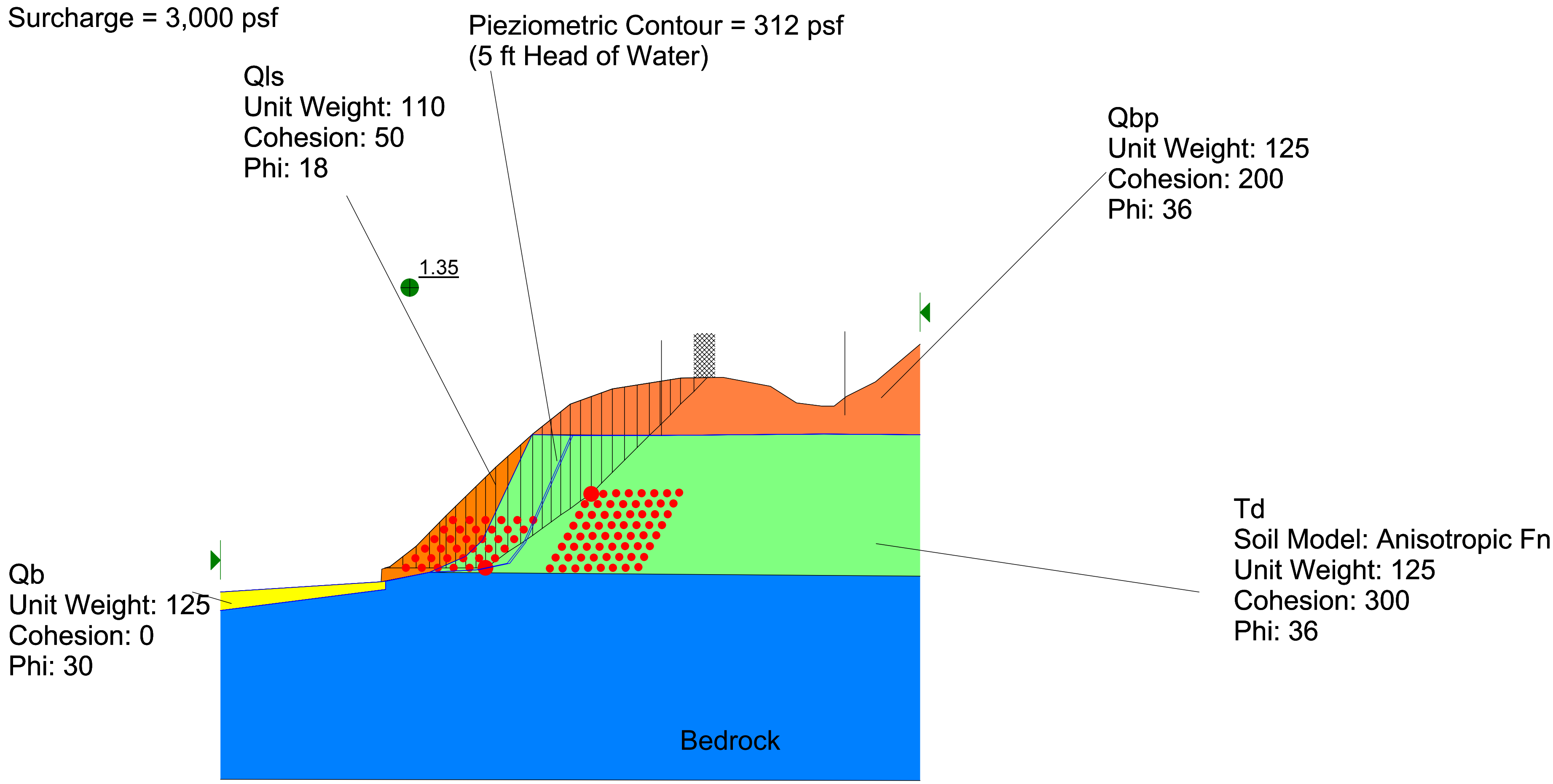
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis
File Name: Section 1111 Static 1B.slz
Analysis Method: Spencer

Factor of Safety: 1.37



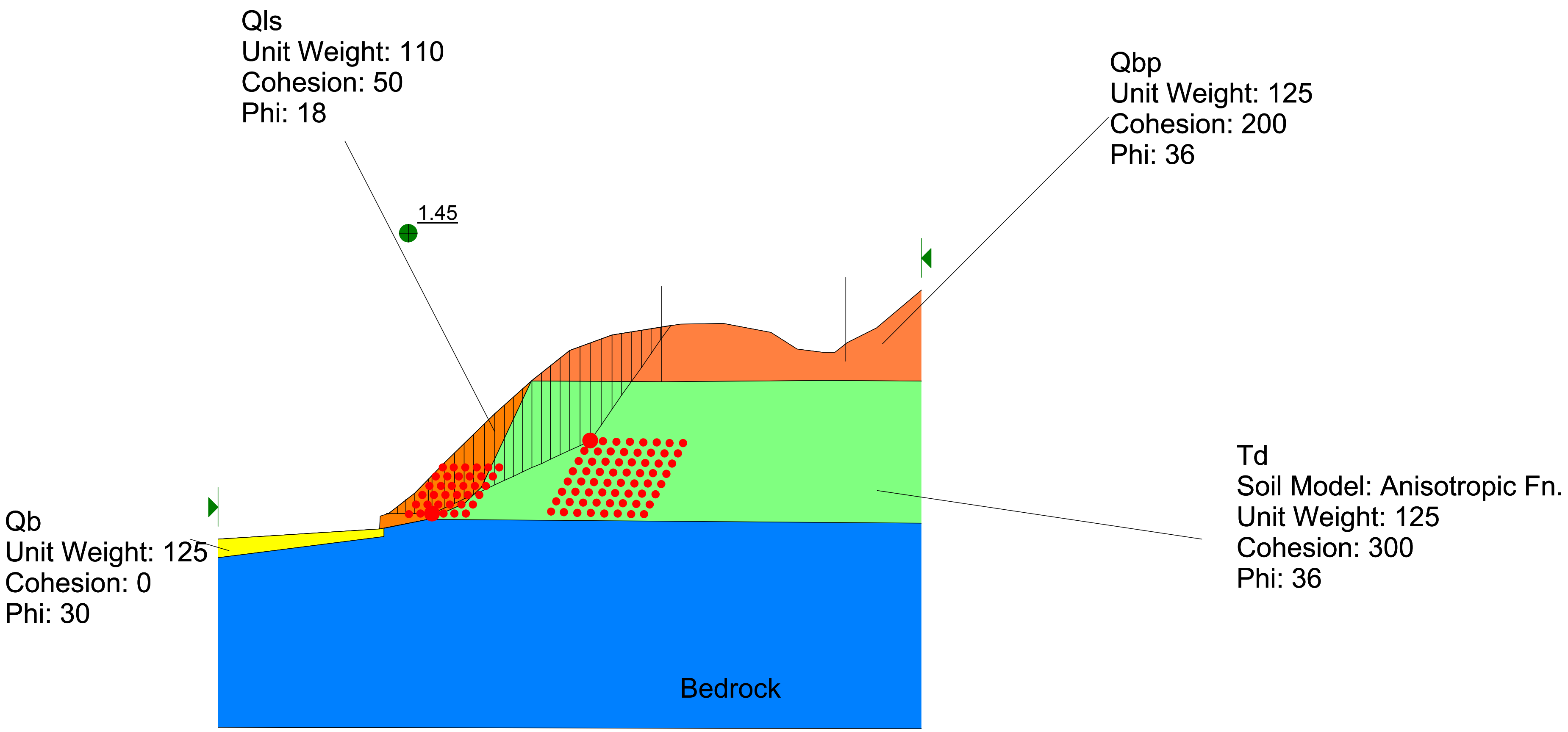
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis
File Name: Section 1111 Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.35



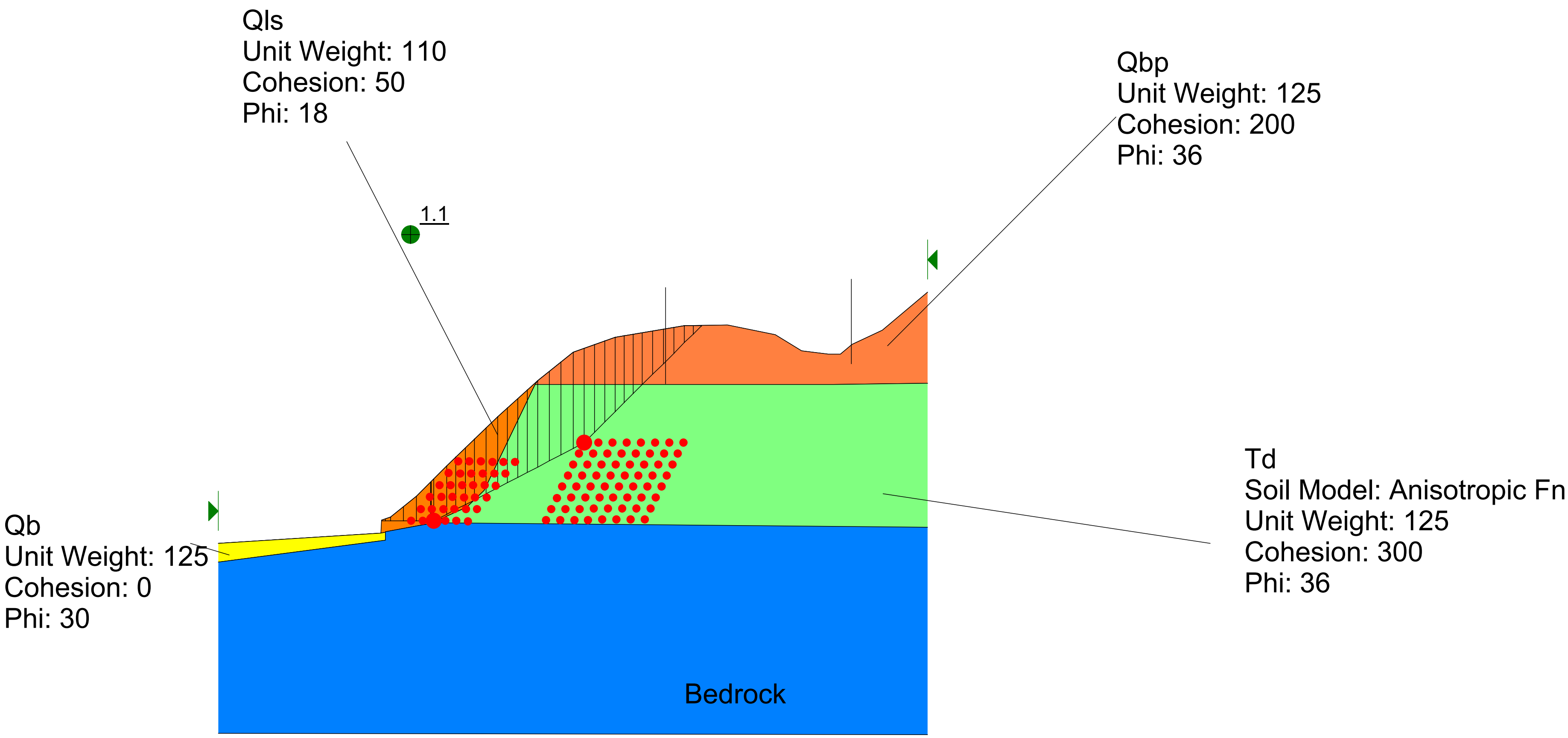
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis, No Water
File Name: Section 1111 Static 3B.slz
Analysis Method: Spencer

Factor of Safety: 1.45



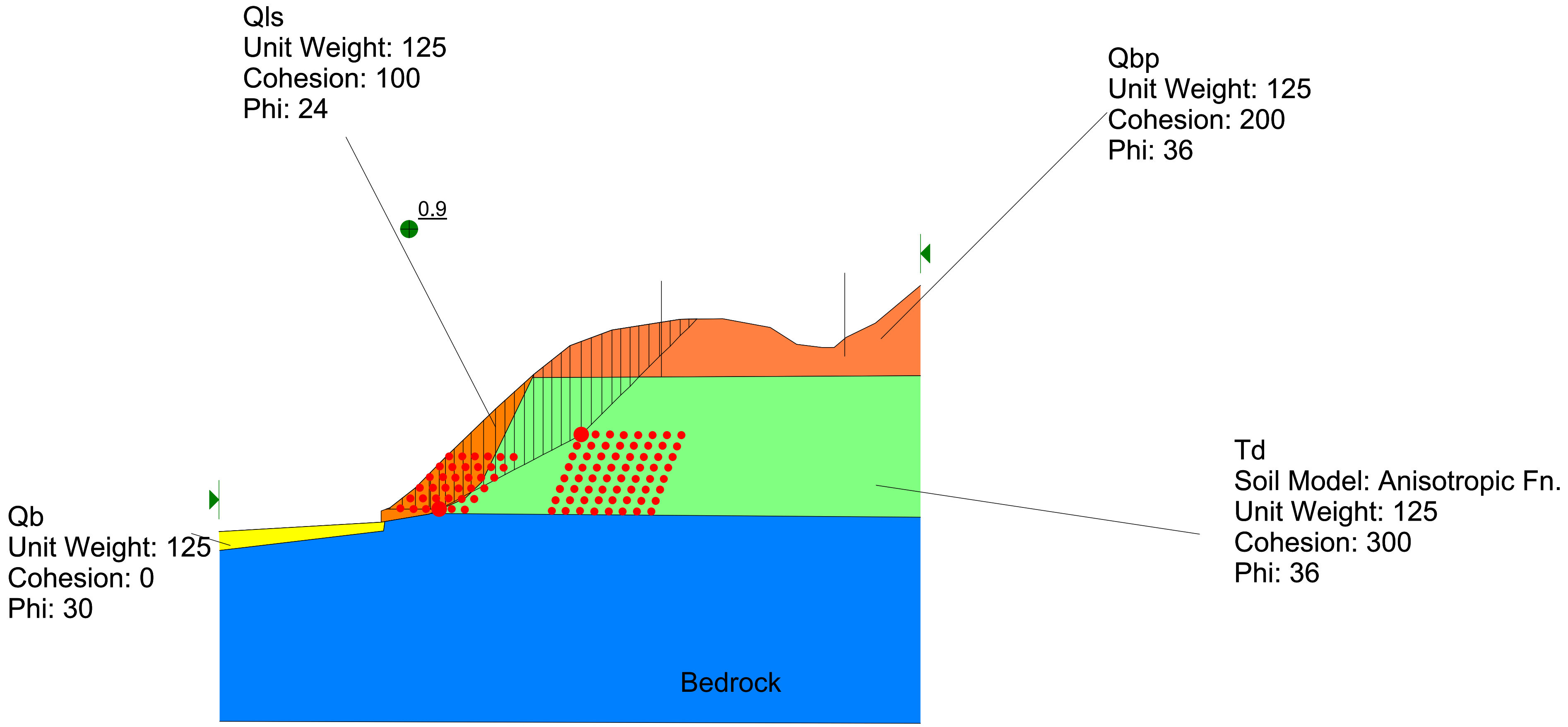
Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis
File Name: Section 1111 Pseudo Static 1B.slz
Analysis Method: Spencer

Factor of Safety: 1.1
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 11-11'
Slope Stability Analysis
File Name: Section 1111 Pseudo Static 2B.slz
Analysis Method: Spencer

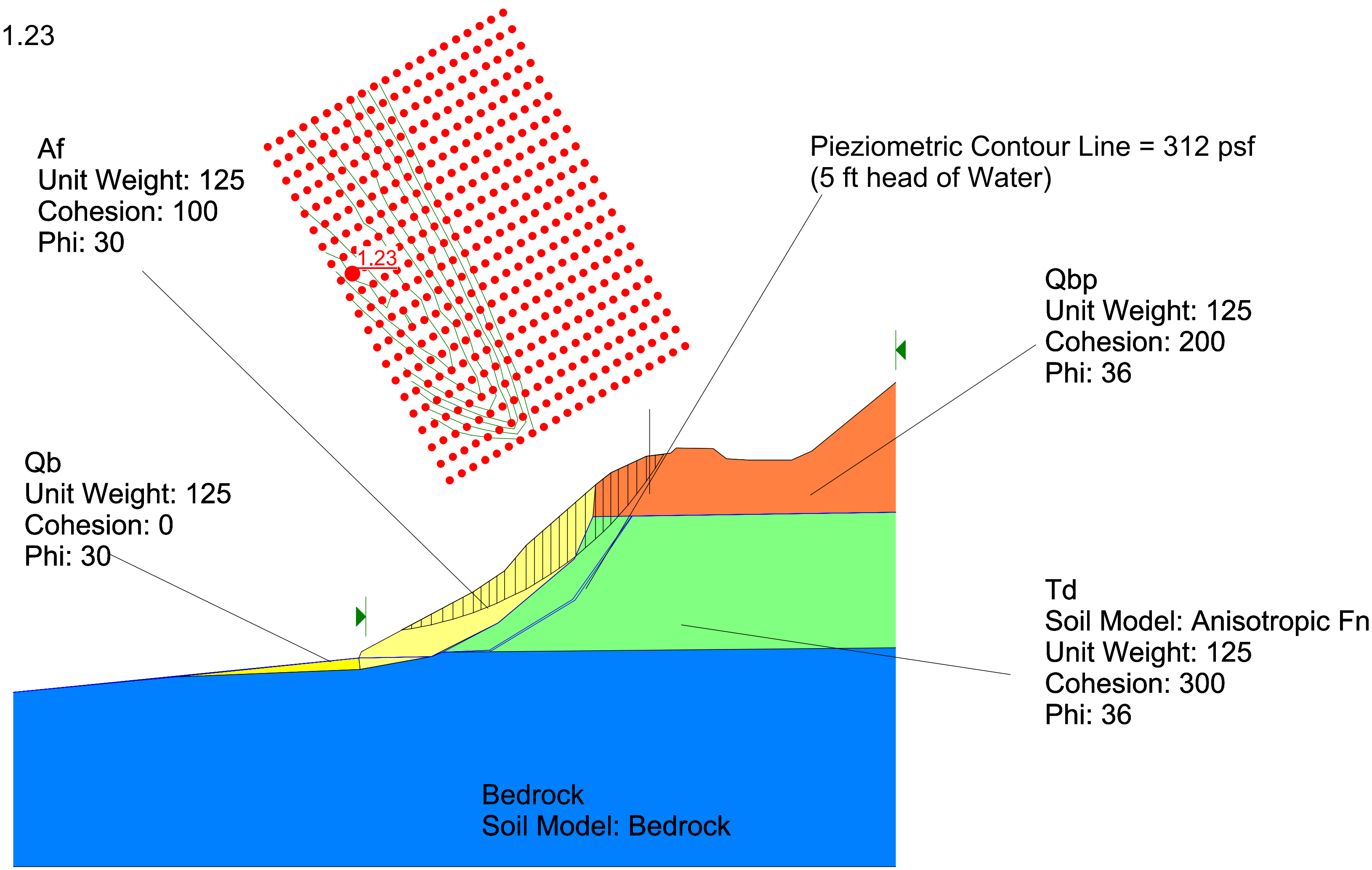
Factor of Safety: 0.94
Seismic Coefficient = 0.28



Cross Section 12-12’

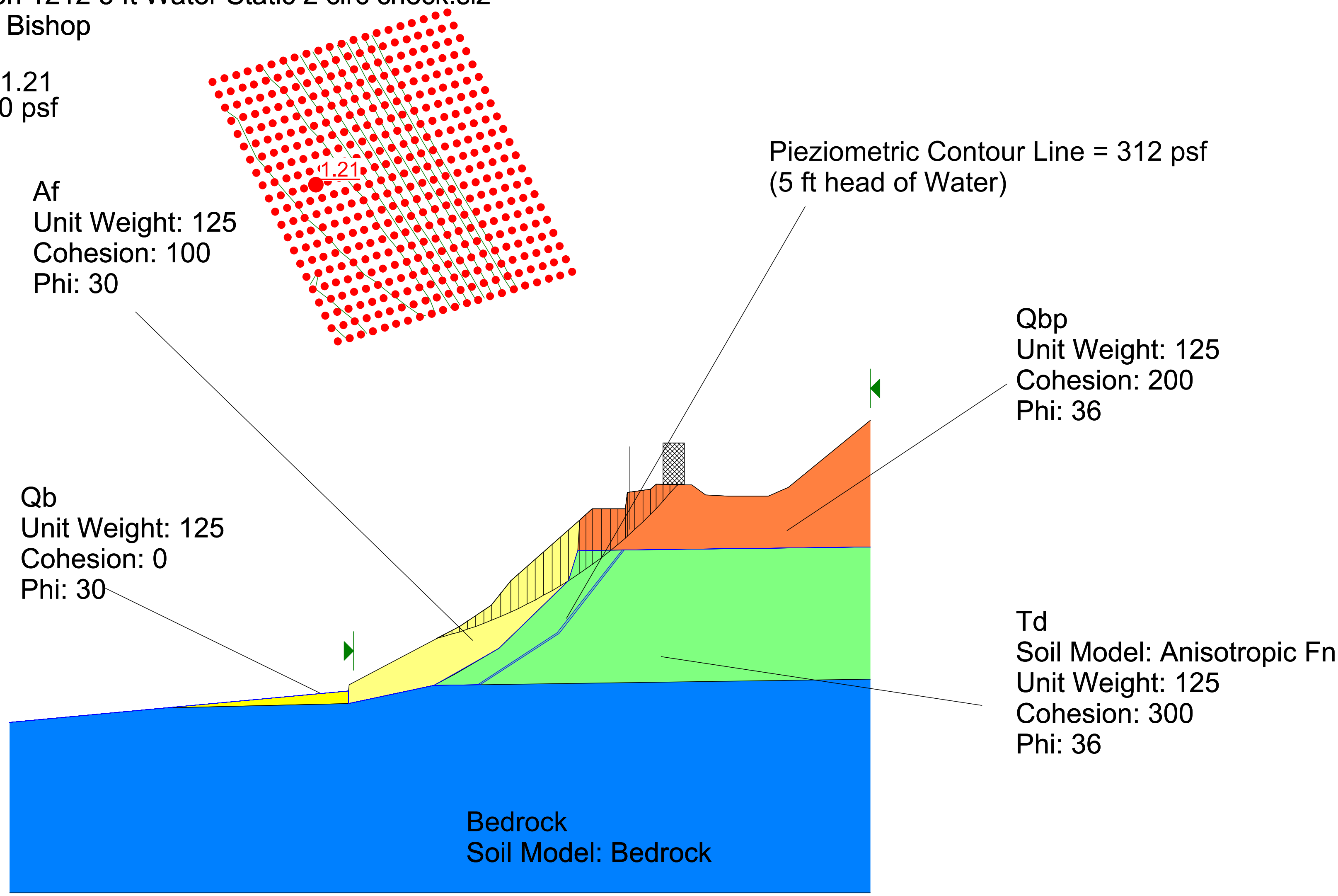
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 5 ft Water Static 1 circ check.slz
Analysis Method: Bishop

Factor of Safety: 1.23



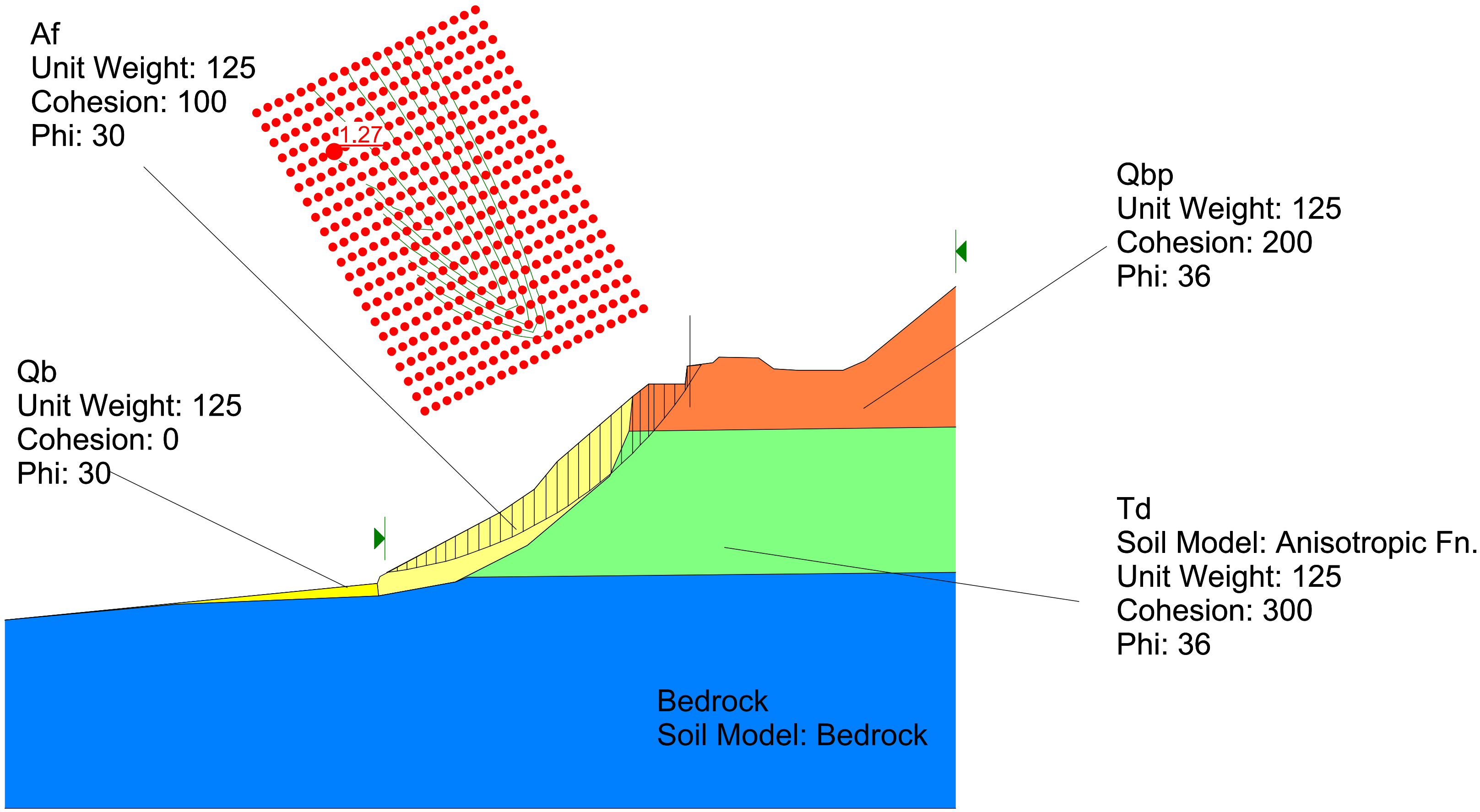
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 5 ft Water Static 2 circ check.slz
Analysis Method: Bishop

Factor of Safety: 1.21
Surcharge = 3,000 psf



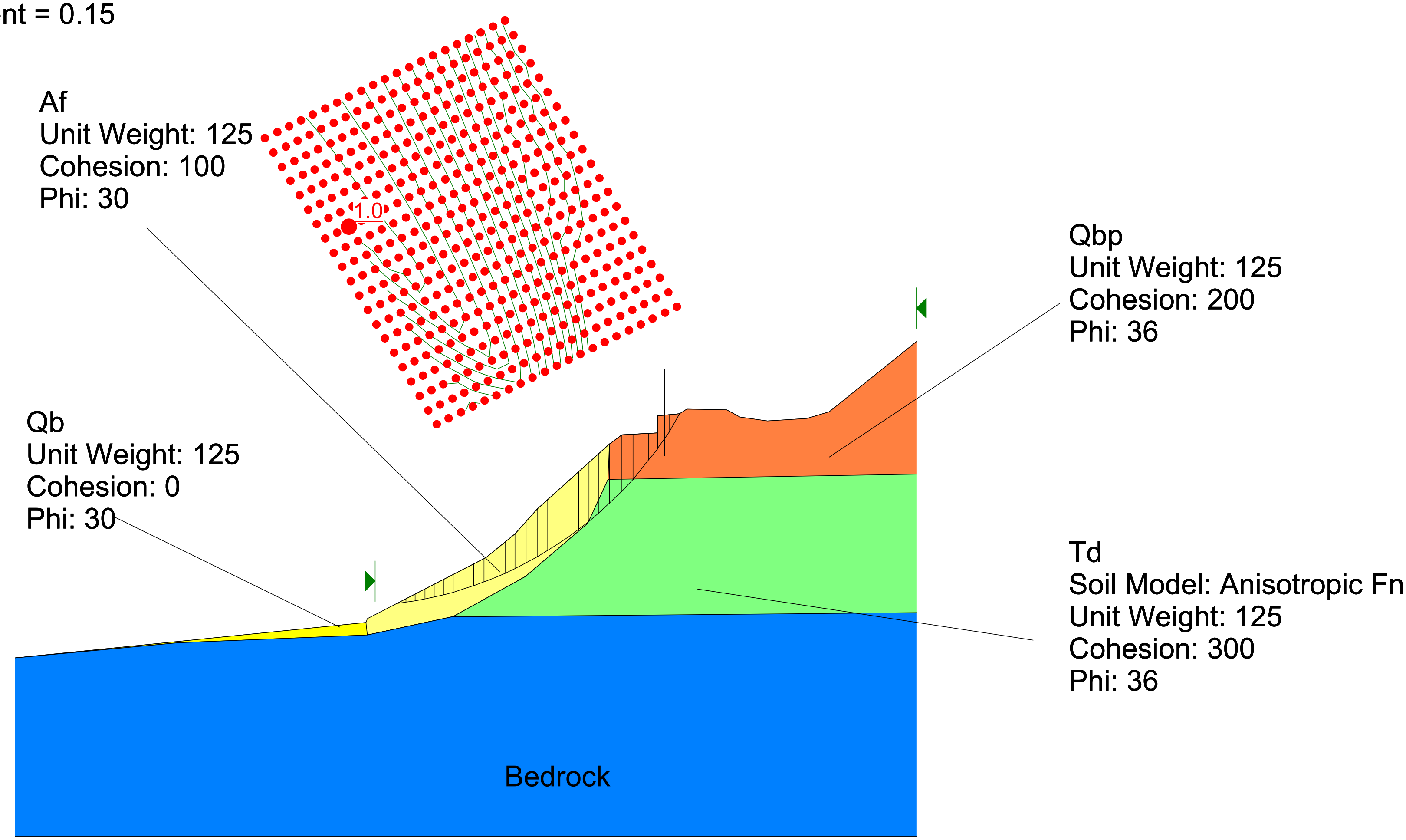
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis, No Water
File Name: Section 1212 Static 3 circ check.slz
Analysis Method: Bishop

Factor of Safety: 1.27



Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 Pseudo Static 1 circ check.slz
Analysis Method: Bishop

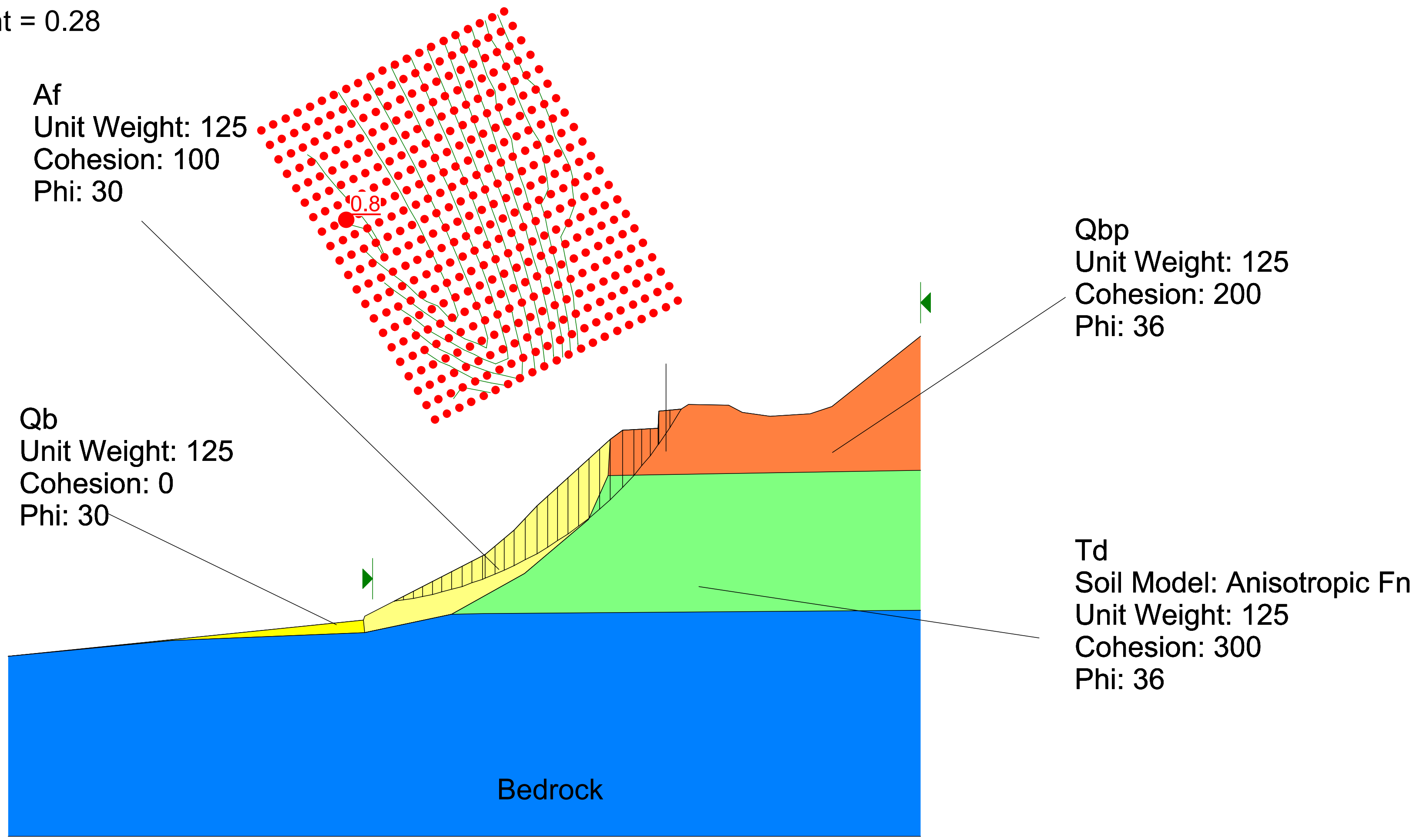
Factor of Safety: 0.97
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 Pseudo Static 2 circ check.slz
Analysis Method: Bishop

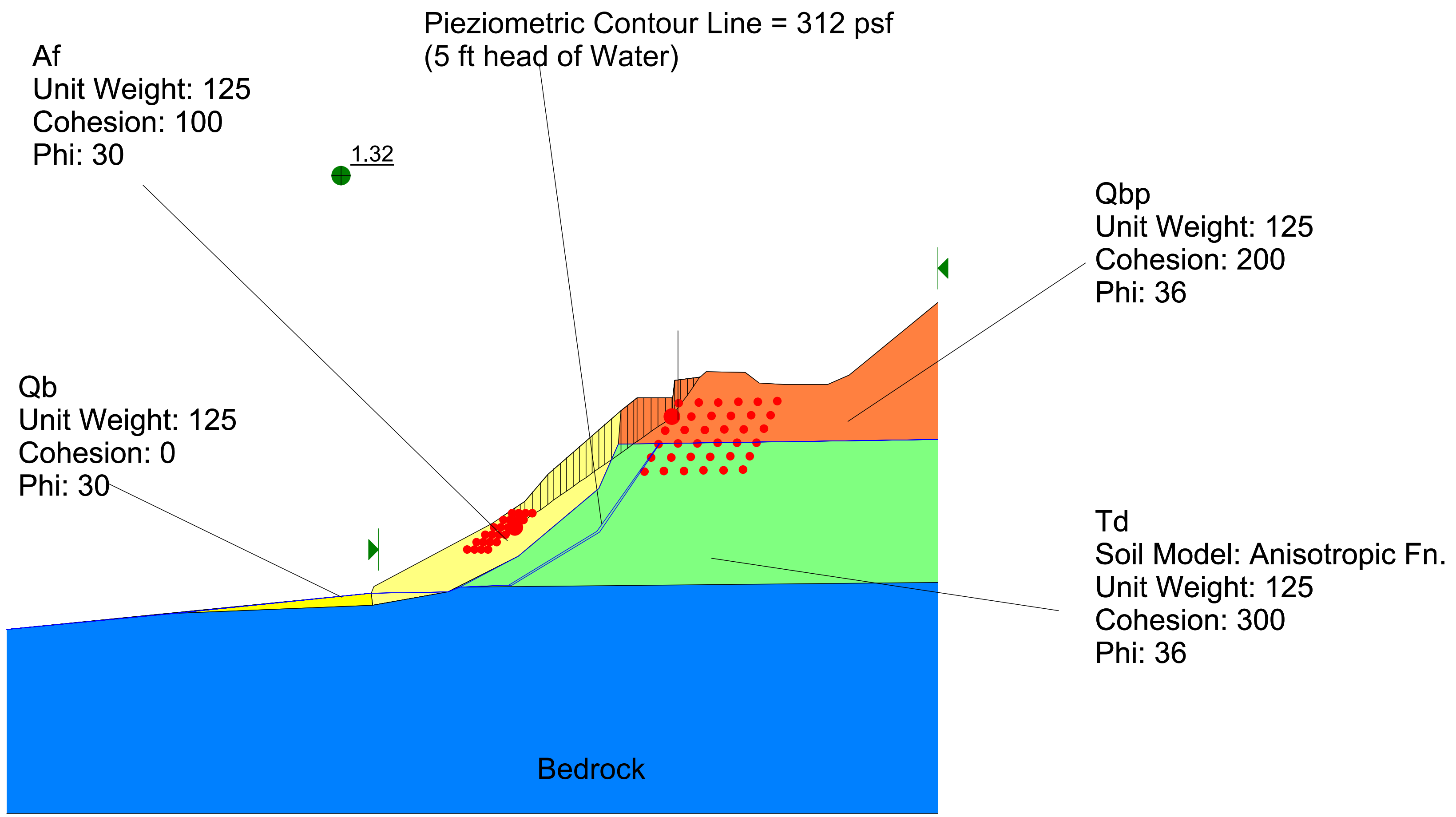
Factor of Safety: 0.79

Seismic Coefficient = 0.28



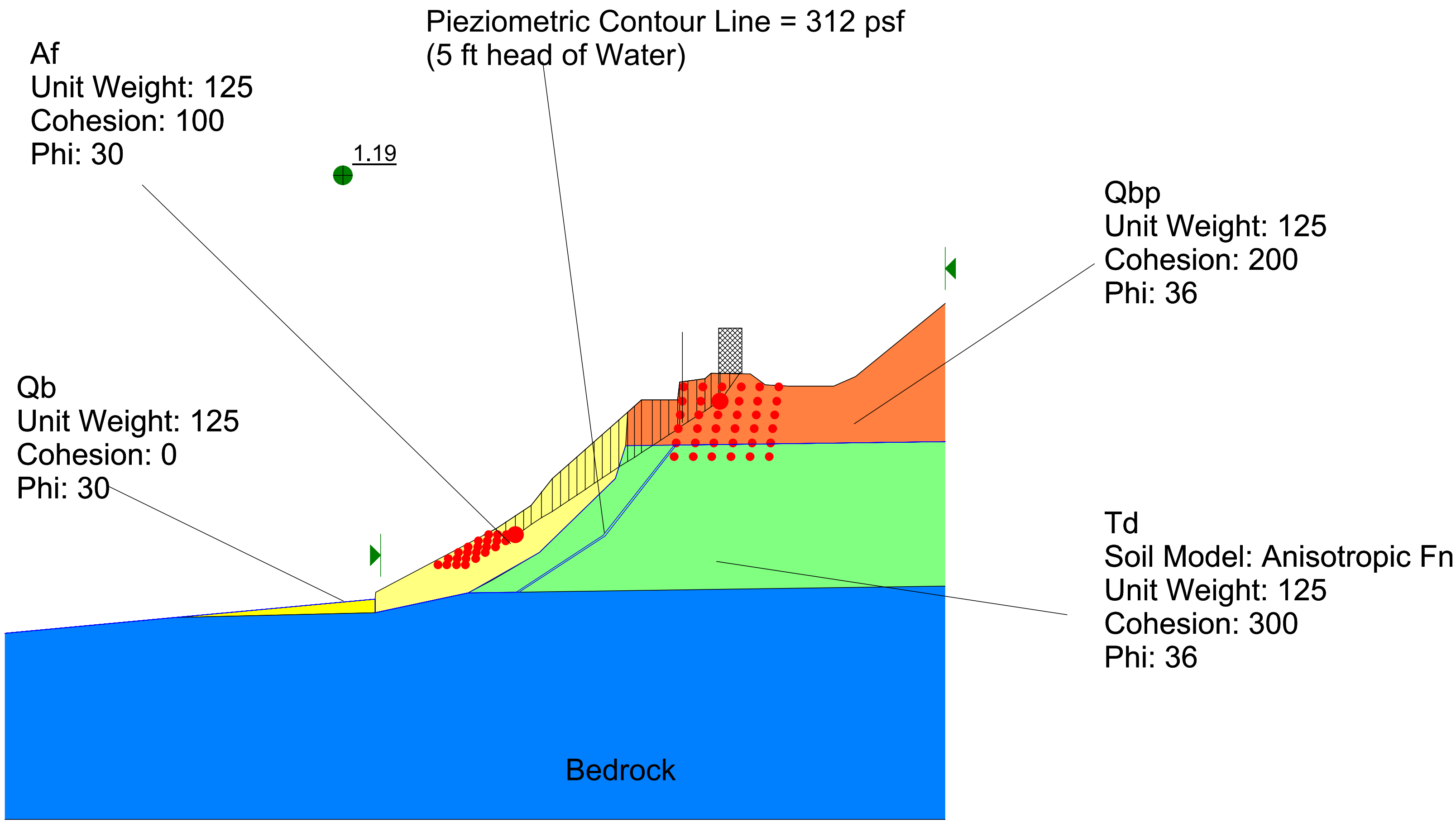
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 5 ft Water Static 1.slz
Analysis Method: Spencer

Factor of Safety: 1.32



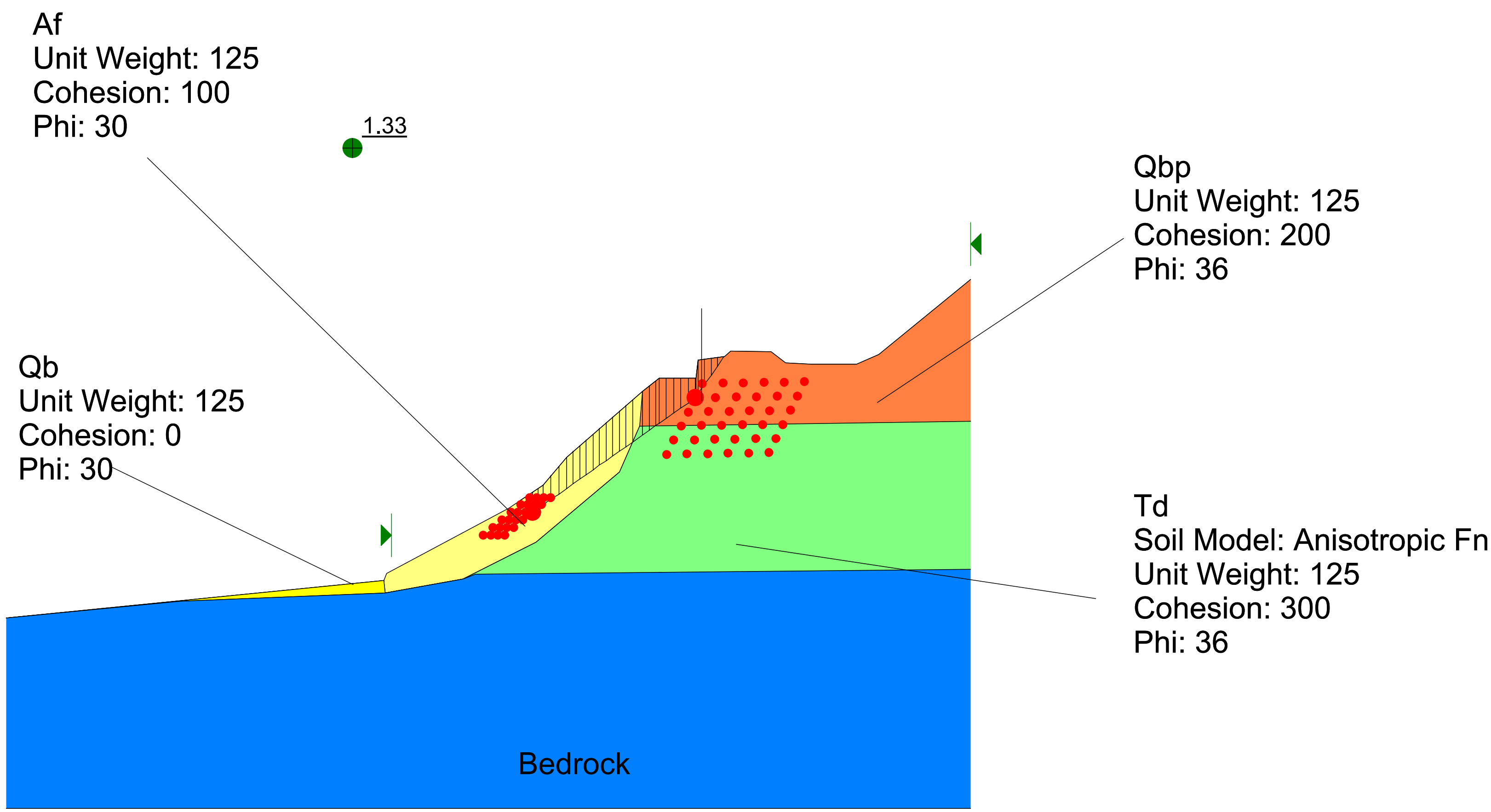
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 5 ft Water Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.19
Surcharge = 3,000 psf



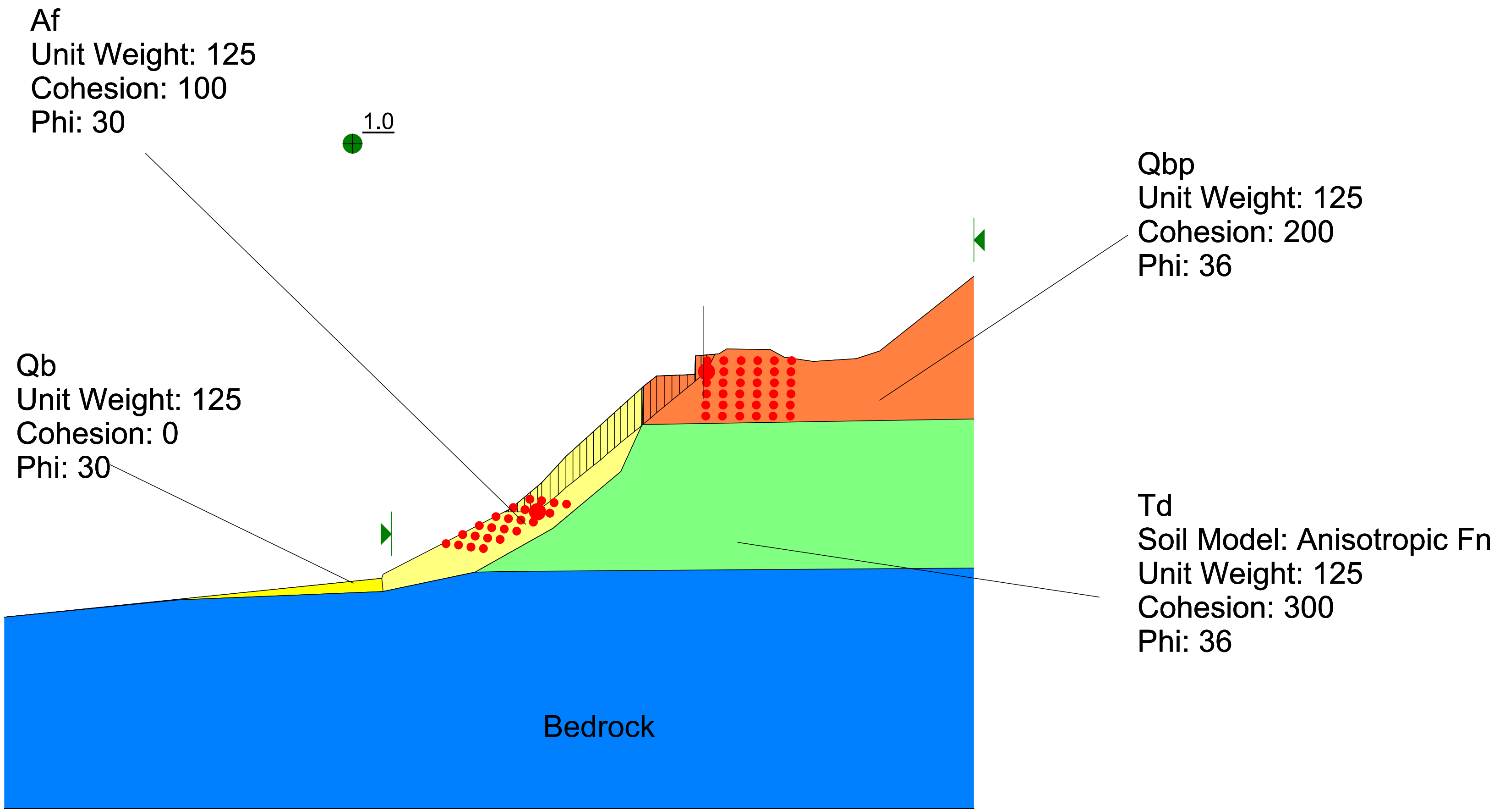
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis, No Water
File Name: Section 1212 Static 3.slz
Analysis Method: Spencer

Factor of Safety: 1.33



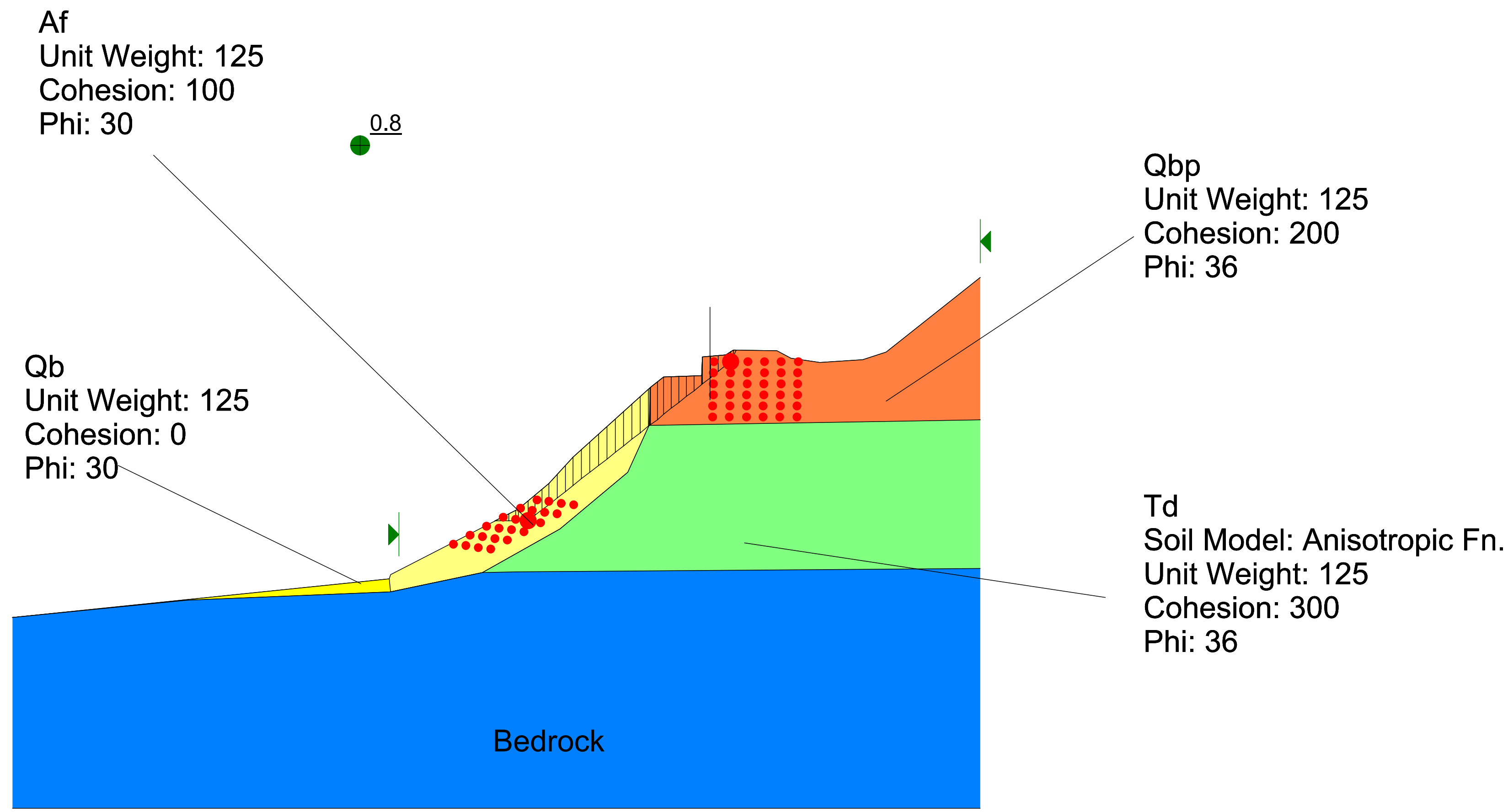
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 Pseudo Static 1.slz
Analysis Method: Spencer

Factor of Safety: 1
Seismic Coefficient = 0.15



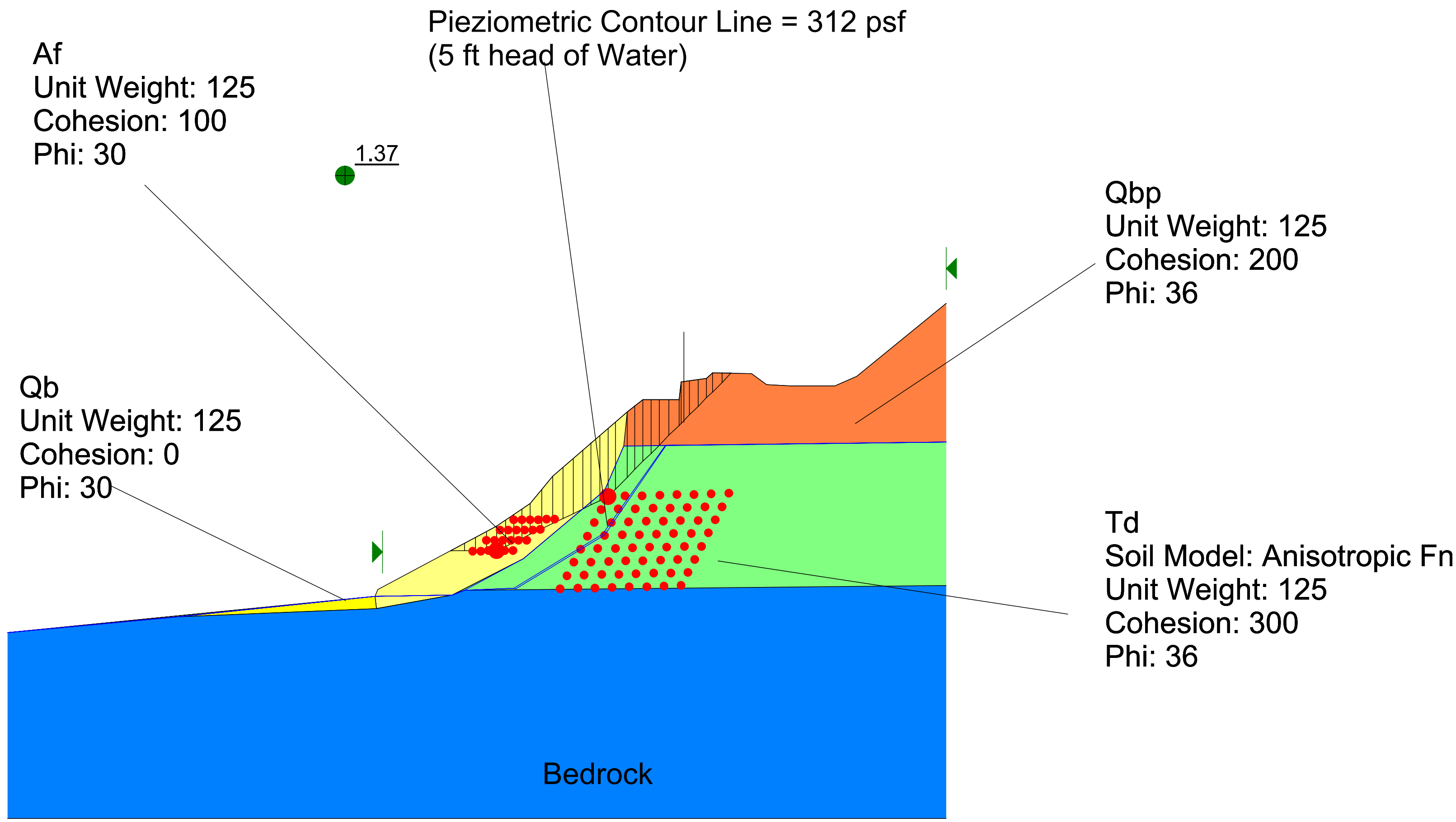
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 Pseudo Static 2.slz
Analysis Method: Spencer

Factor of Safety: 0.83
Seismic Coefficient = 0.28



Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 5 ft Water Static 1B.slz
Analysis Method: Spencer

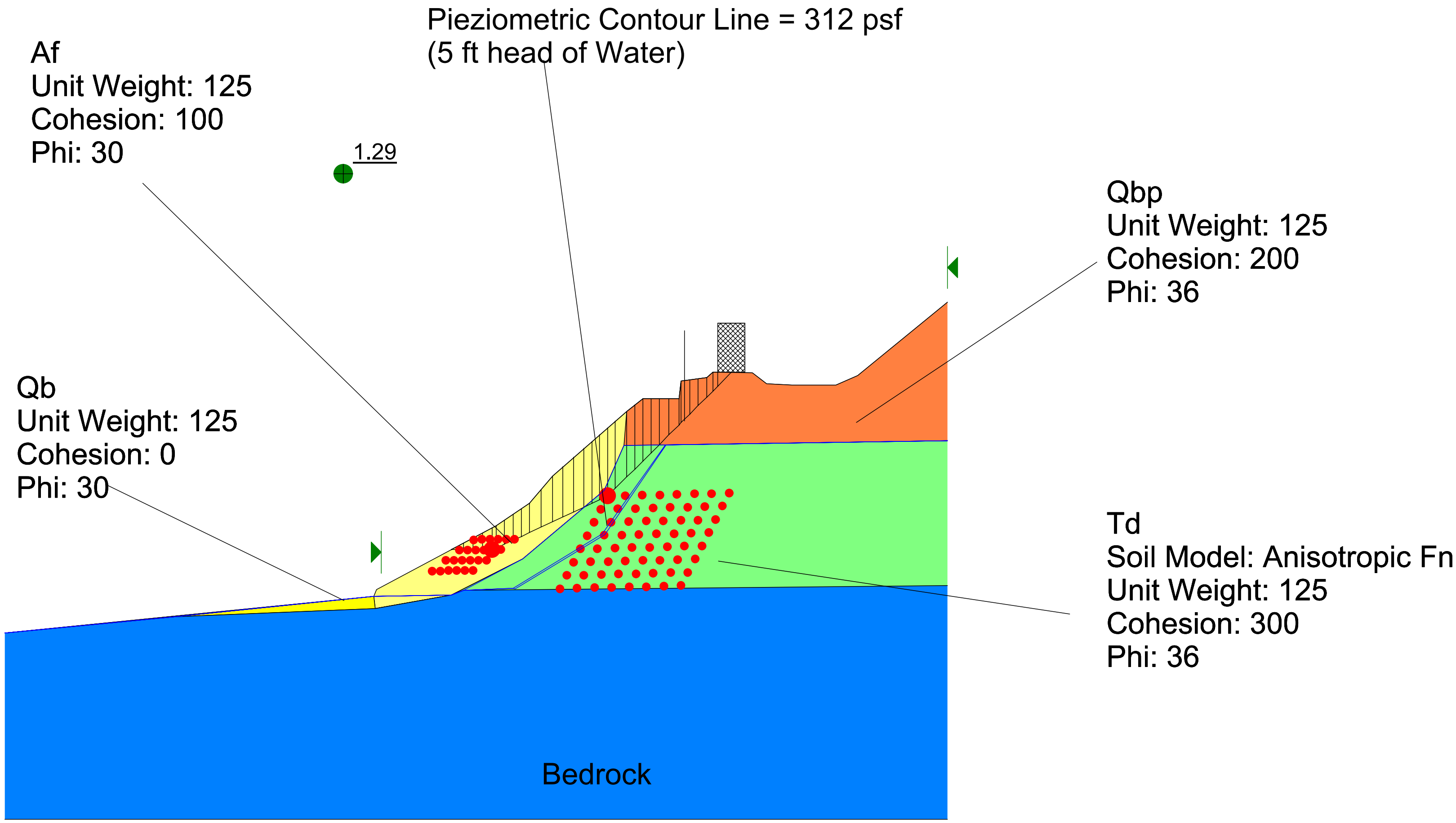
Factor of Safety: 1.37



Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 5 ft Water Static 2B.slz
Analysis Method: Spencer

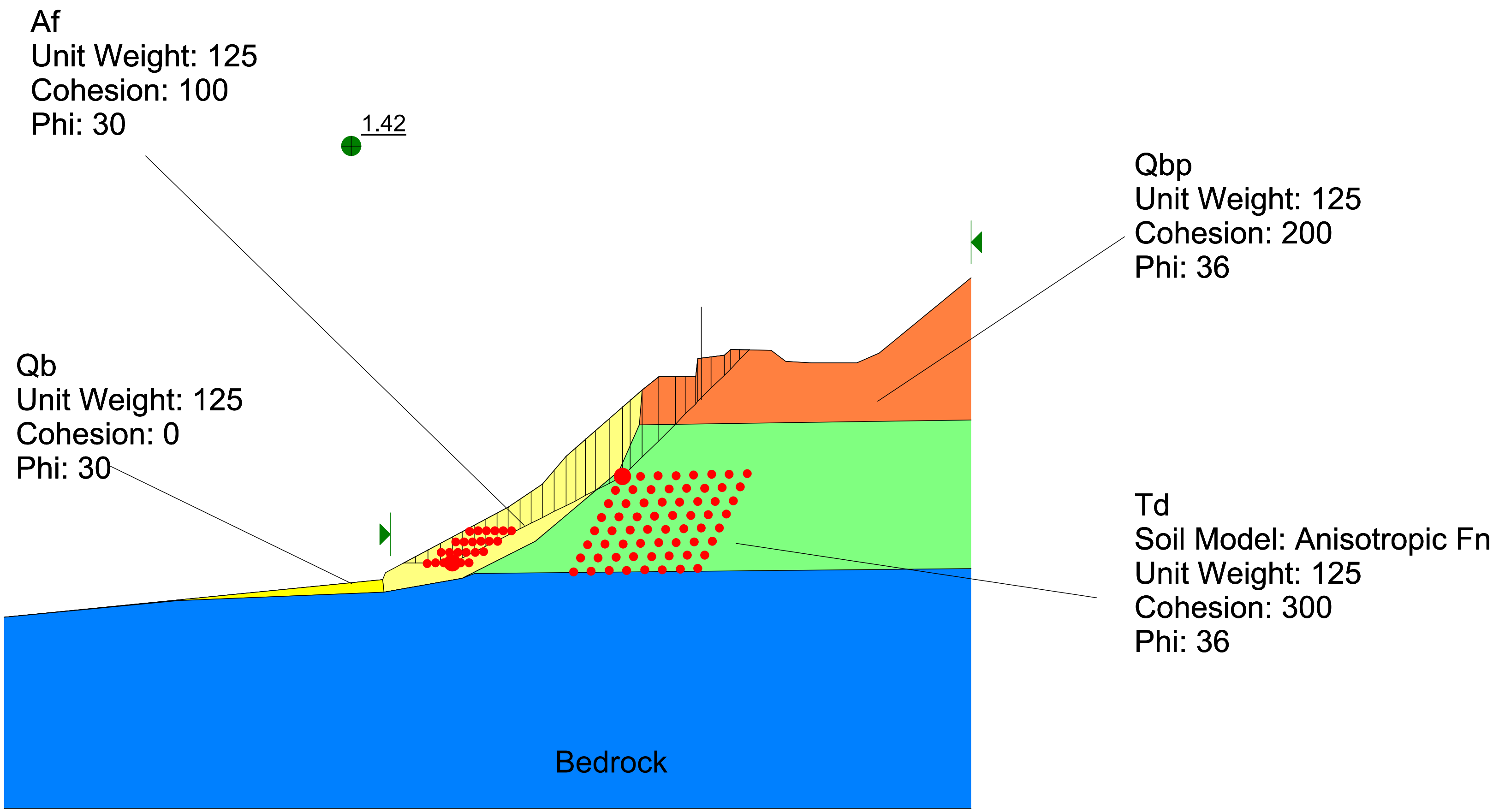
Factor of Safety: 1.29

Surcharge = 3,000 psf



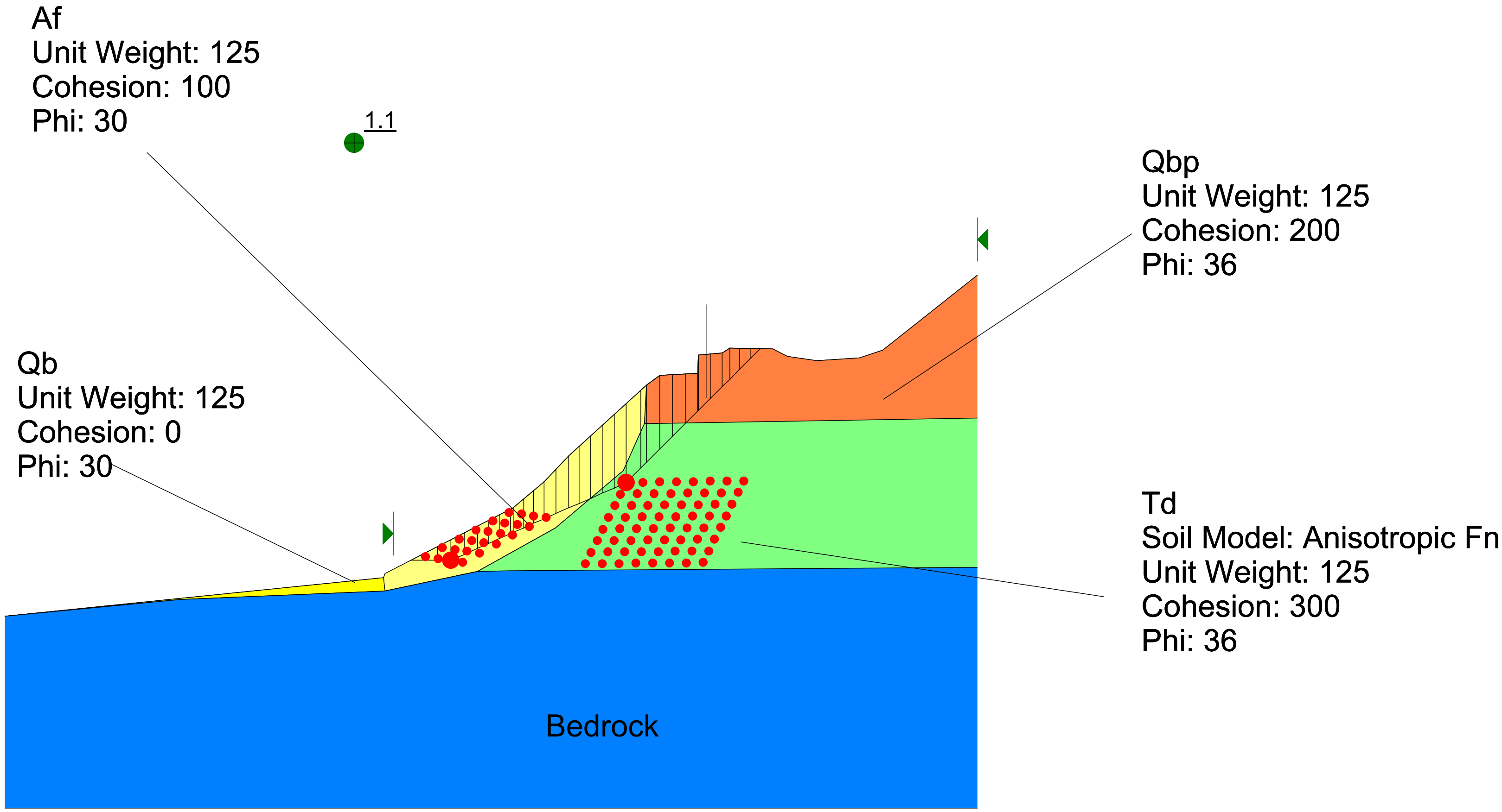
Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis, No Water
File Name: Section 1212 Static 3B.slz
Analysis Method: Spencer

Factor of Safety: 1.42



Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 Pseudo Static 1B.slz
Analysis Method: Spencer

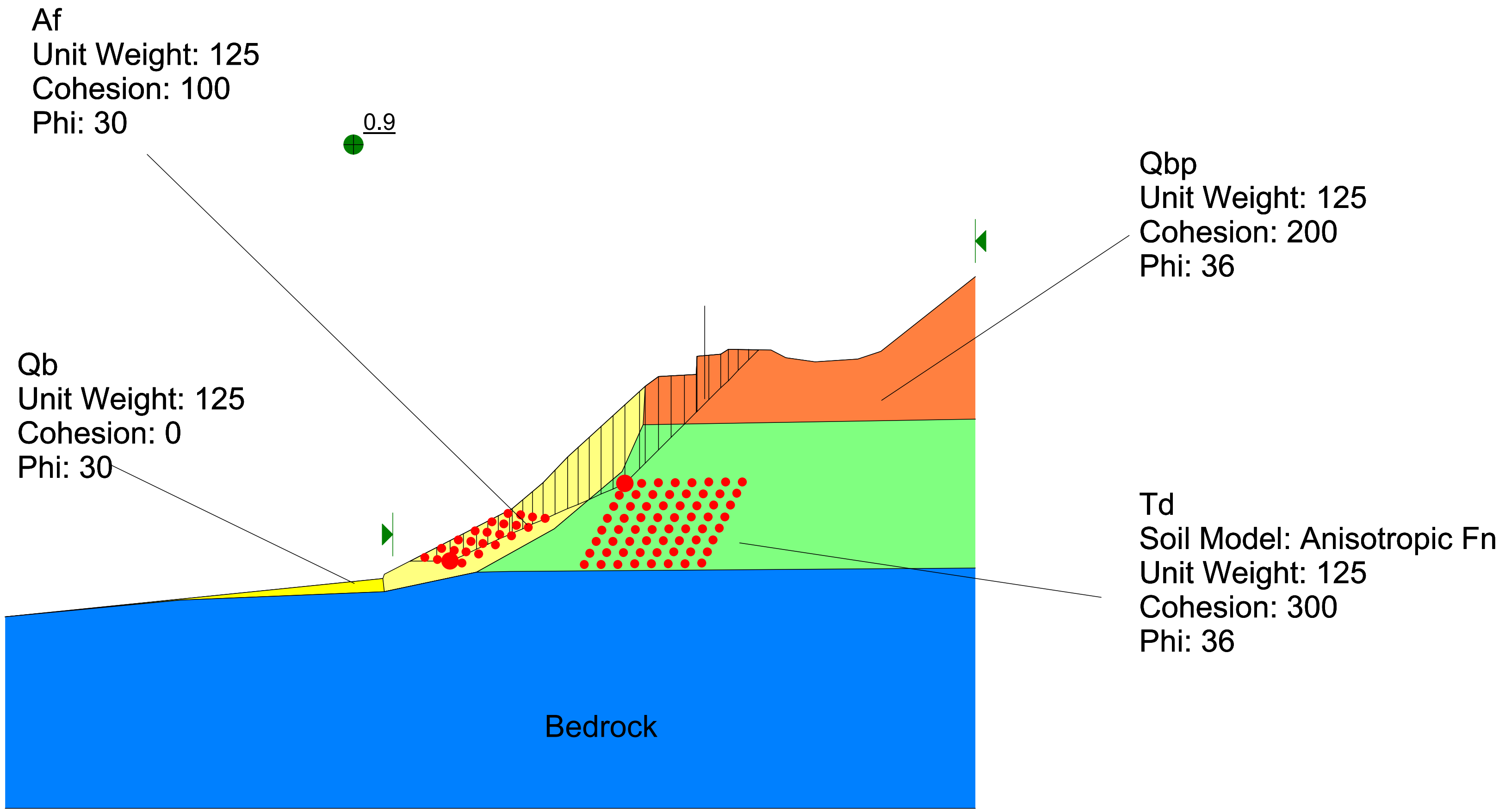
Factor of Safety: 1.1
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 12-12'
Slope Stability Analysis
File Name: Section 1212 Pseudo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 0.92

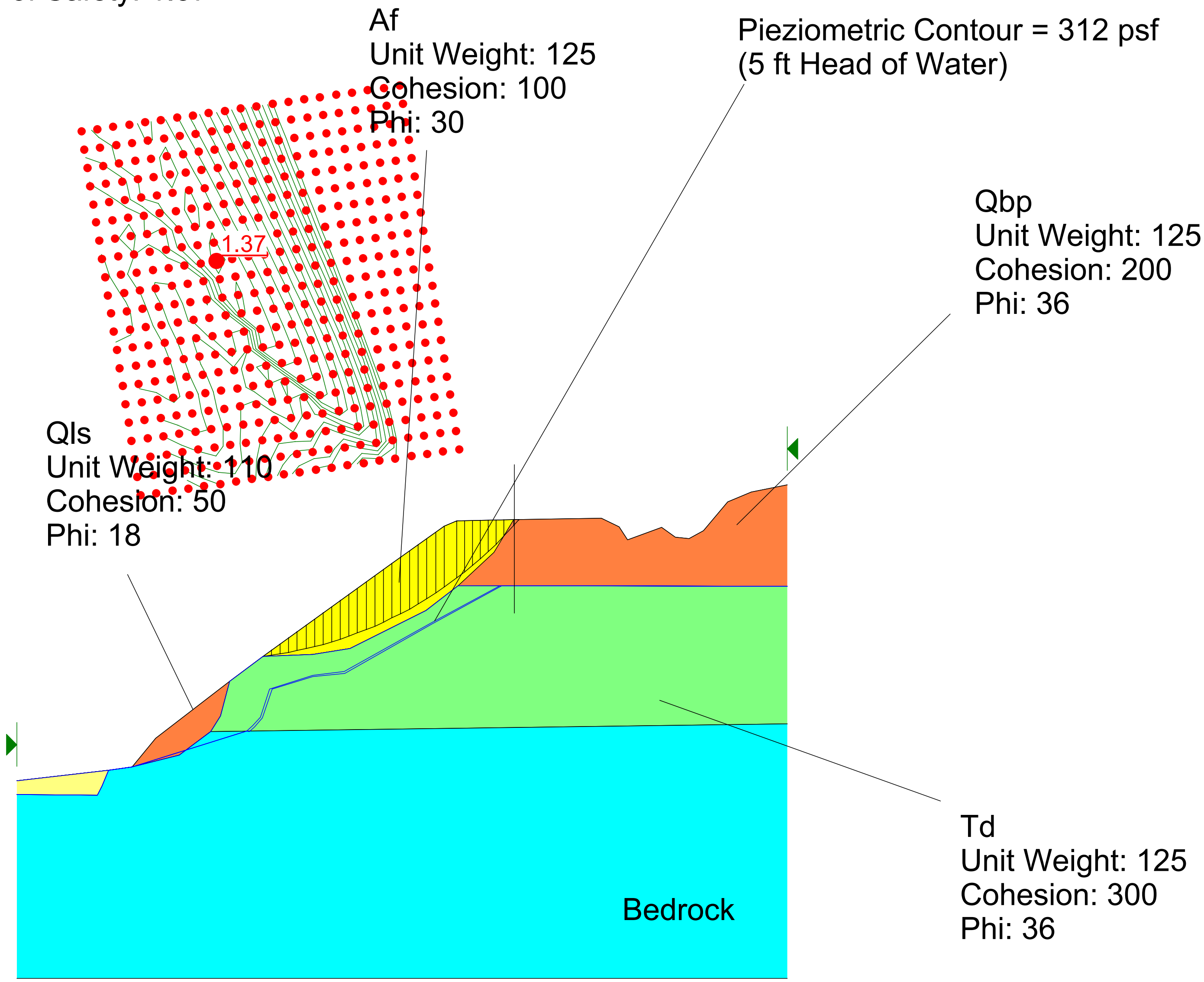
Seismic Coefficient = 0.28

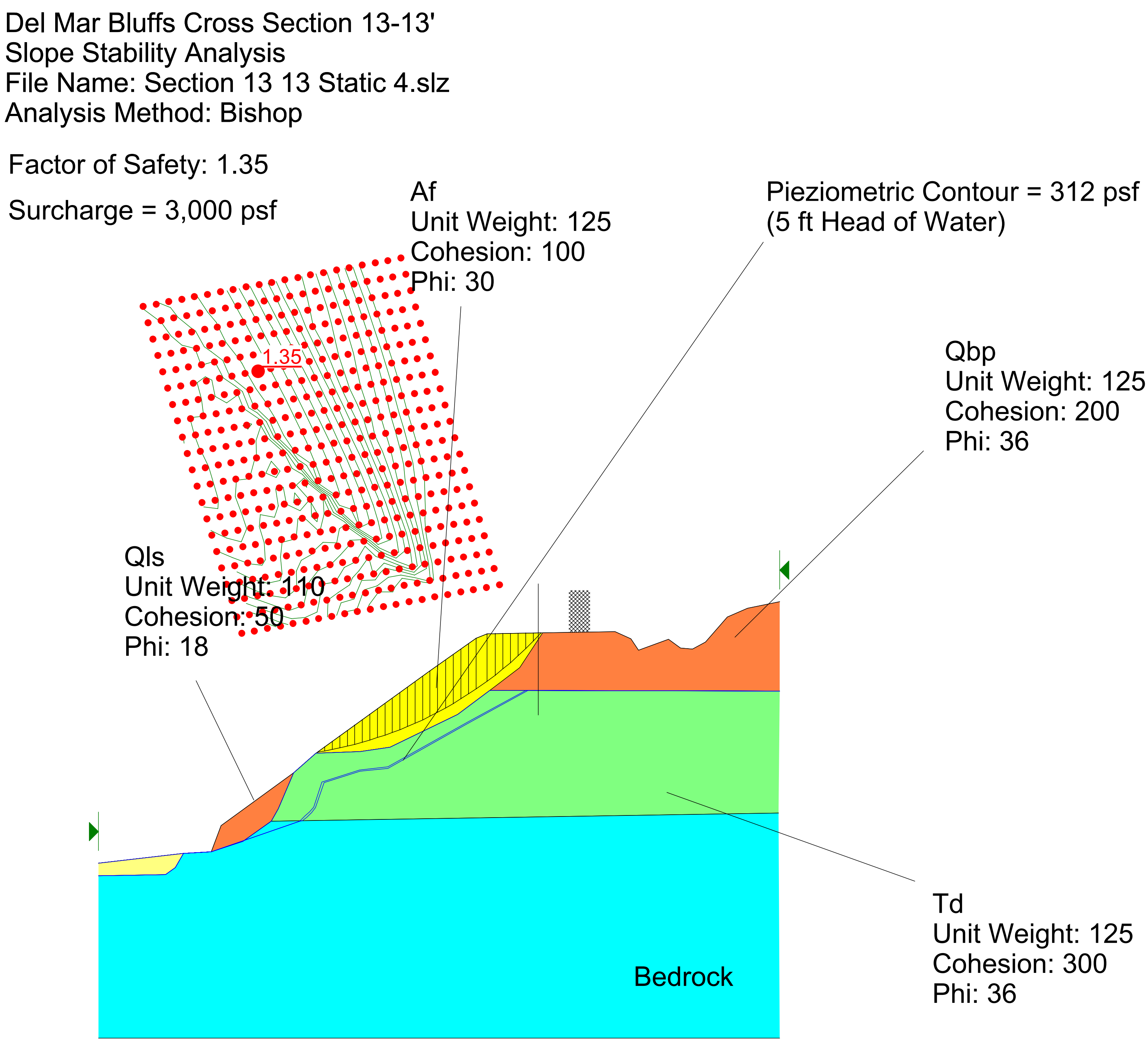


Cross Section 13-13’

Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Static 3.slz
Analysis Method: Bishop

Factor of Safety: 1.37

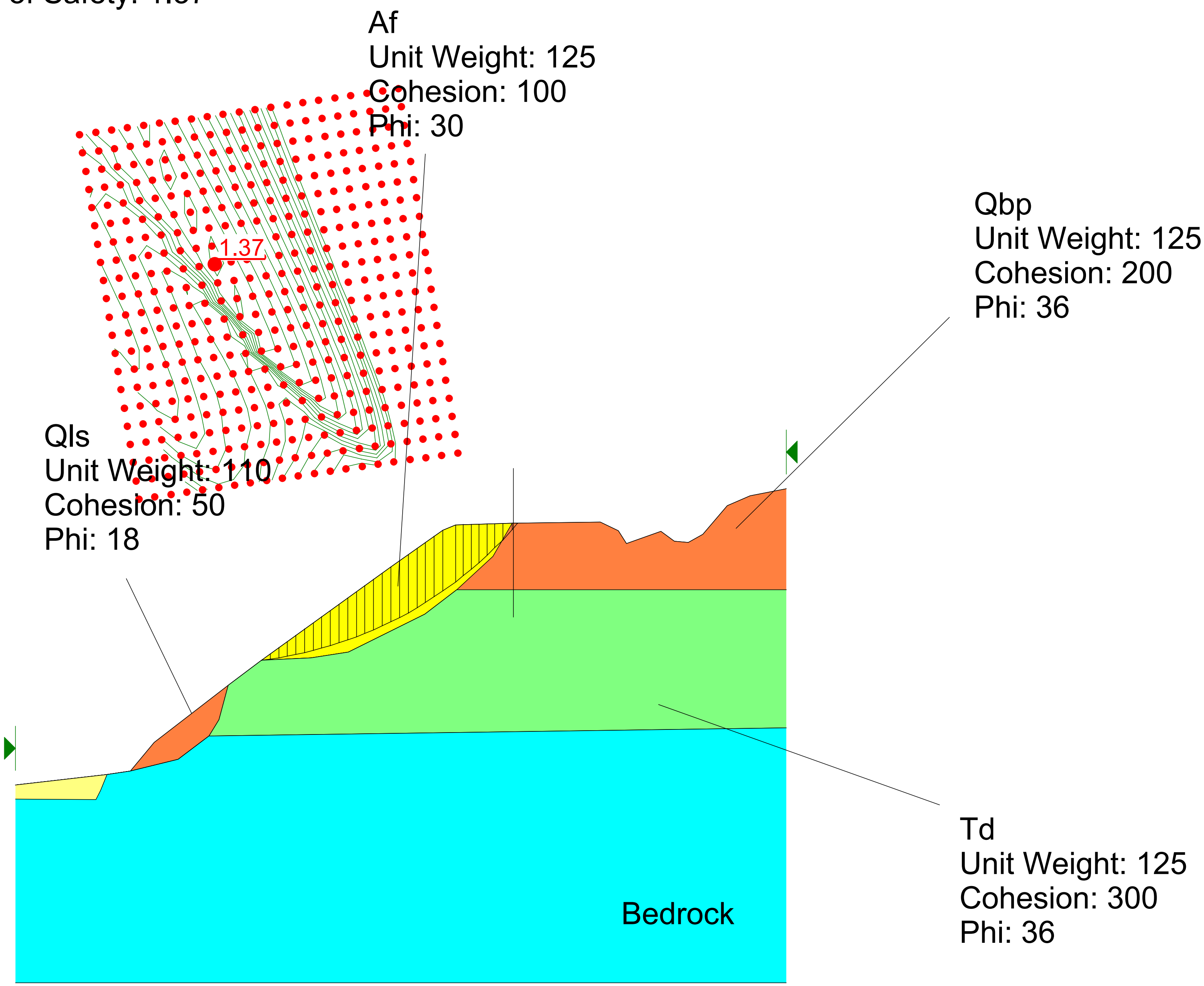




Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Static 4.slz
Analysis Method: Bishop
Factor of Safety: 1.35
Surcharge = 3,000 psf
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Pieziometric Contour = 312 psf
(5 ft Head of Water)
1.35
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Qls
Unit Weight: 110
Cohesion: 50
Phi: 18
Td
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock

Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis, No Water
File Name: Section 13 13 Static 3 no water.slz
Analysis Method: Bishop

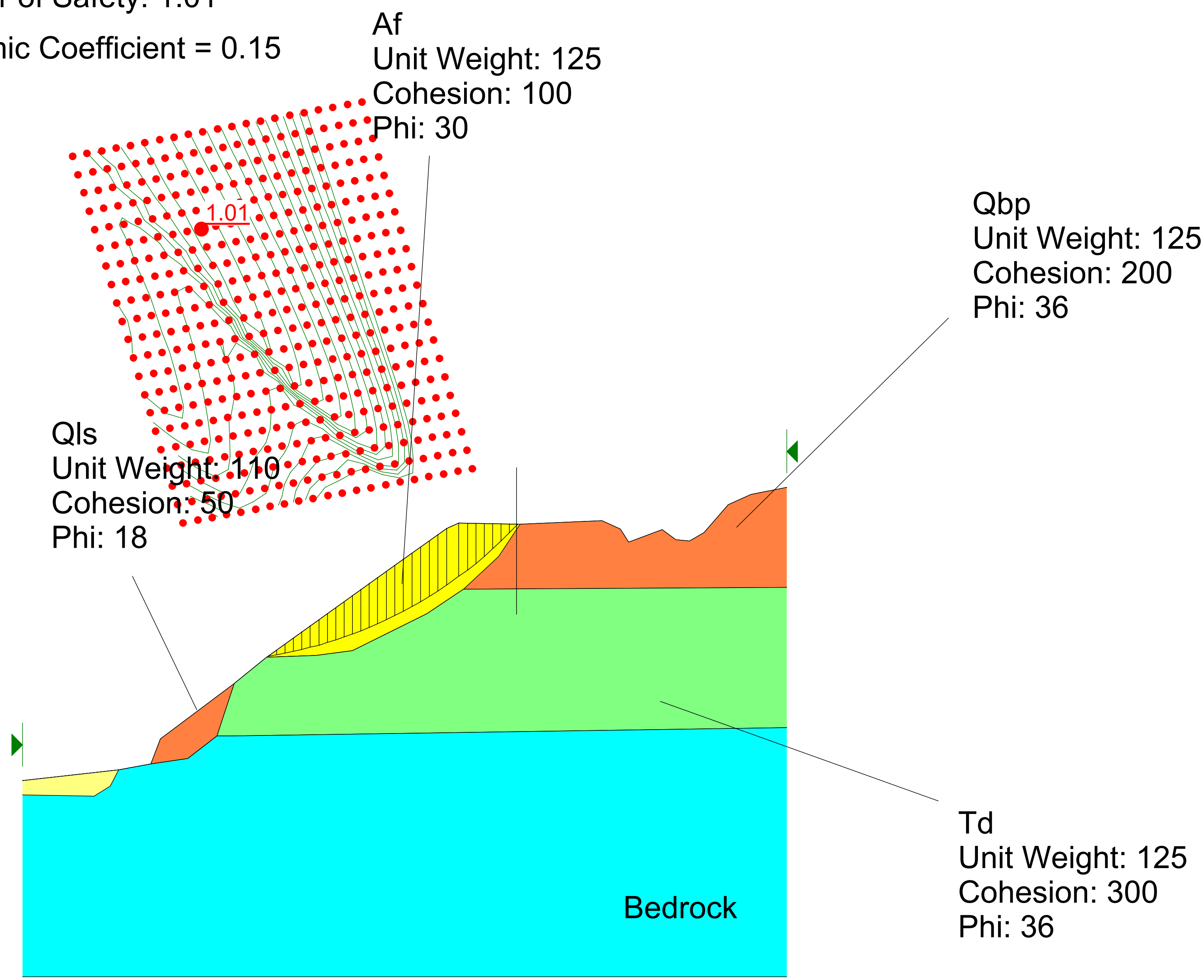
Factor of Safety: 1.37



Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Pseudo Static 1.slz
Analysis Method: Bishop

Factor of Safety: 1.01

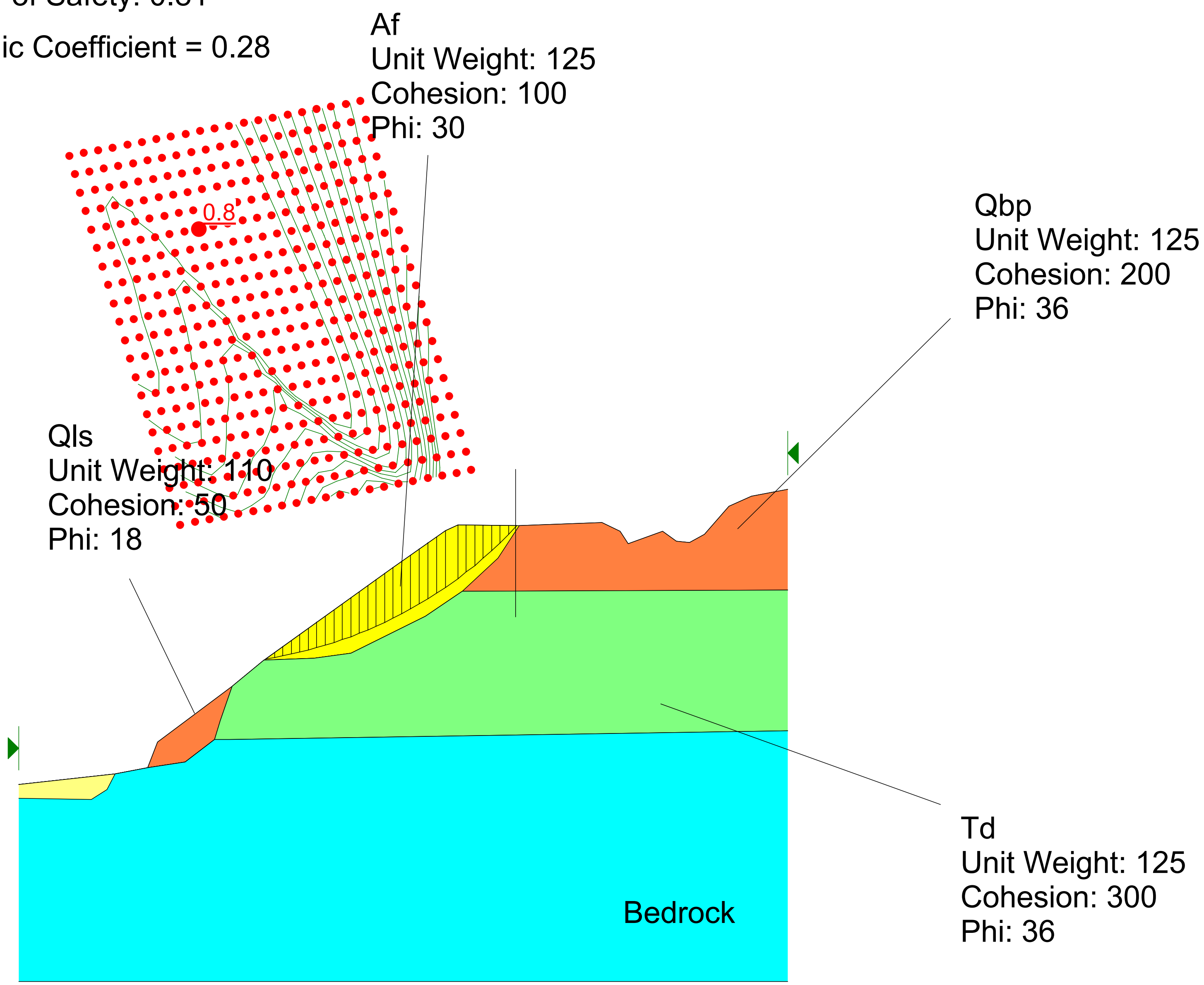
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Pseudo Static 3.slz
Analysis Method: Bishop

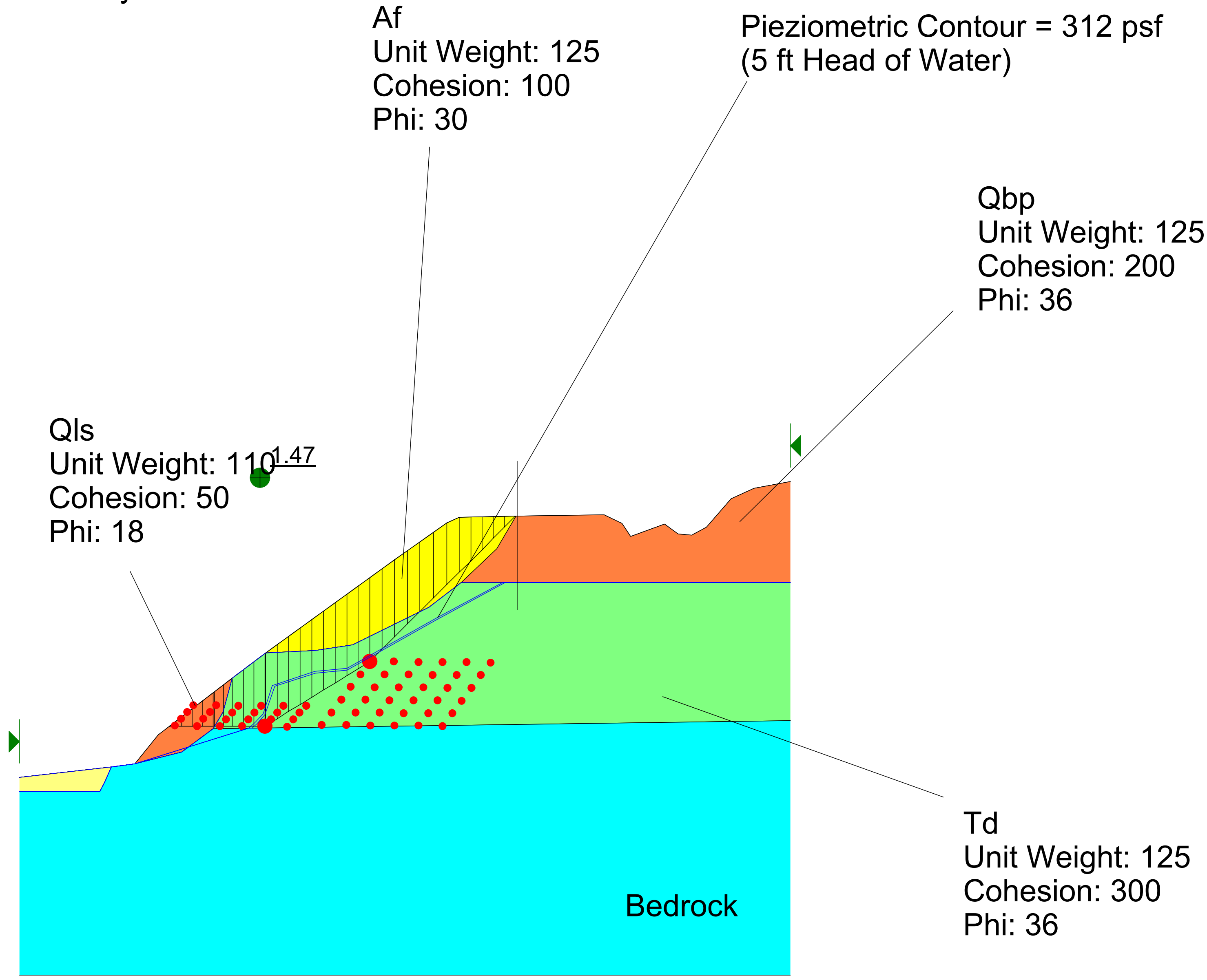
Factor of Safety: 0.81

Seismic Coefficient = 0.28

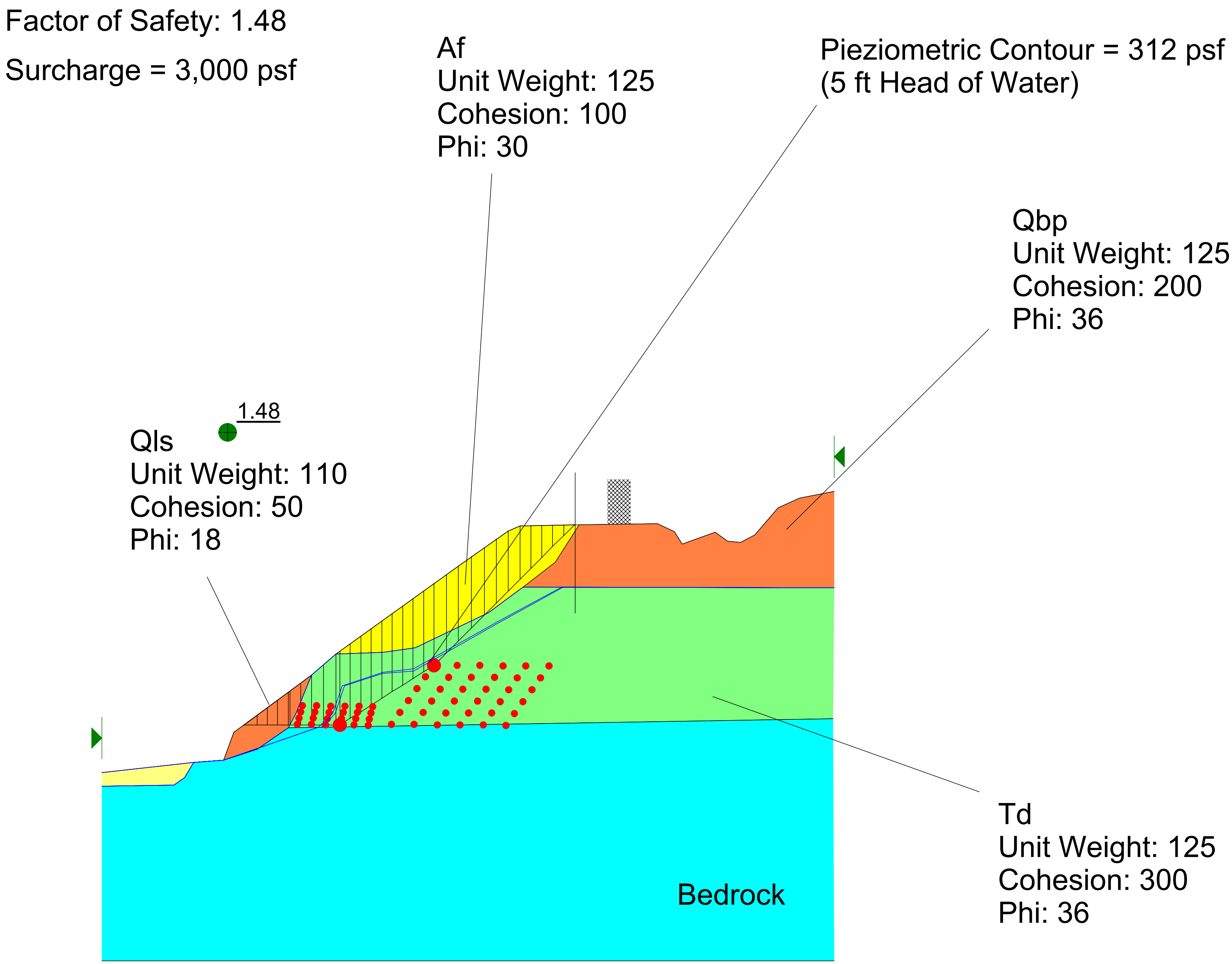


Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Static 3B.slz
Analysis Method: Spencer

Factor of Safety: 1.47

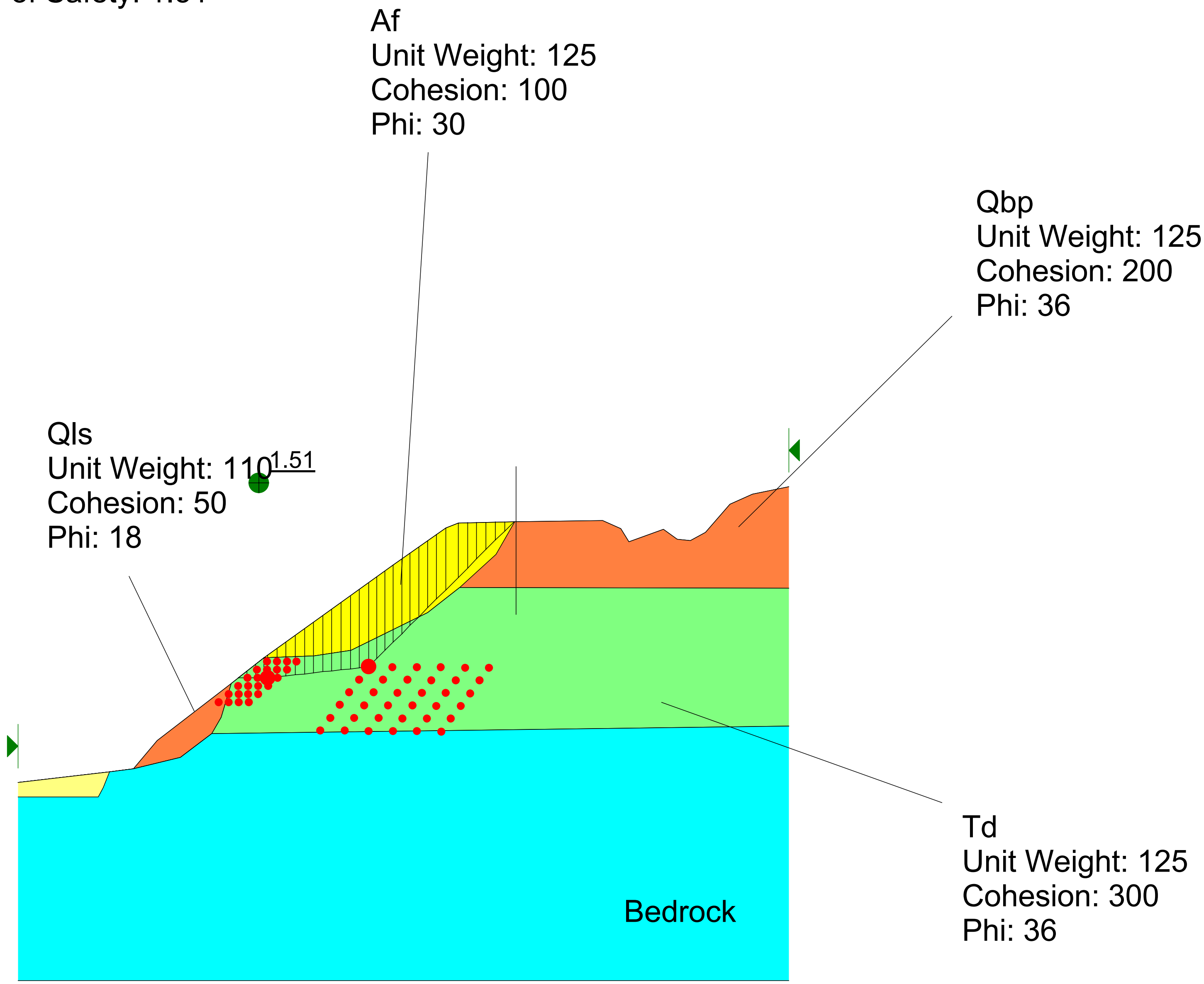


Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Static 4B.slz
Analysis Method: Spencer



Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis, No Water
File Name: Section 13 13 Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.51

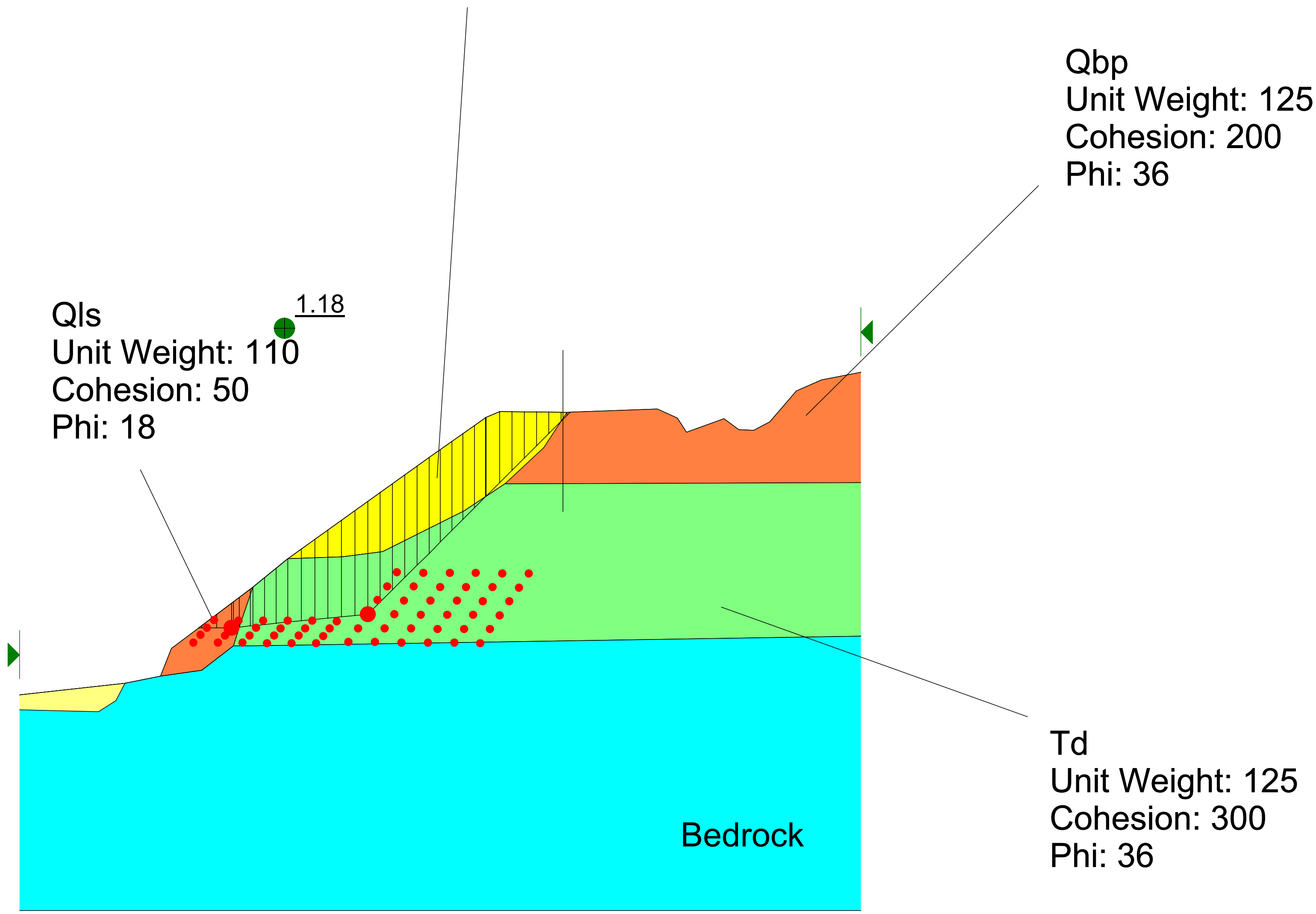


Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Pseudo Static 1B.slz
Analysis Method: Spencer

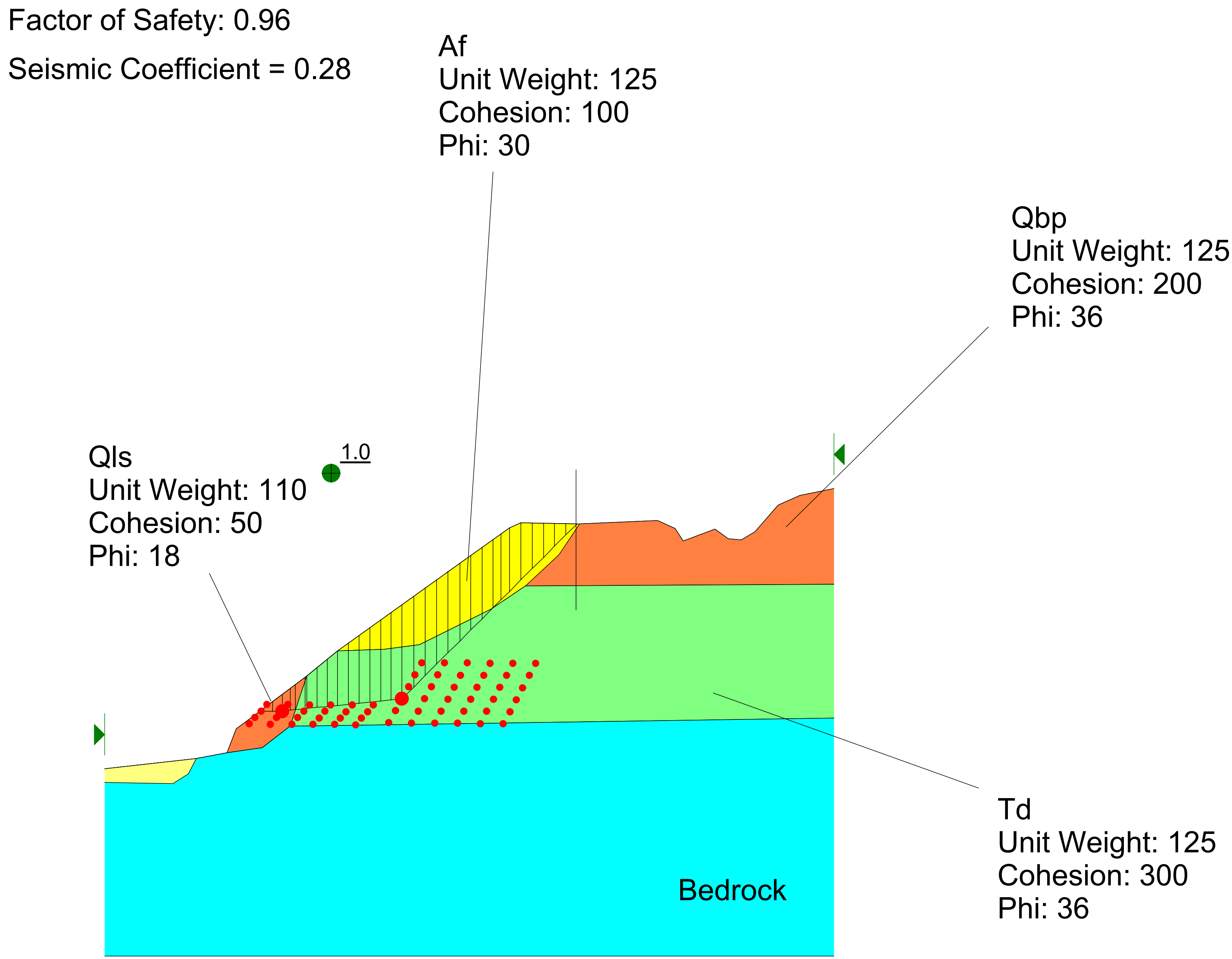
Factor of Safety: 1.18

Seismic Coefficient = 0.15

Af
Unit Weight: 125
Cohesion: 100
Phi: 30

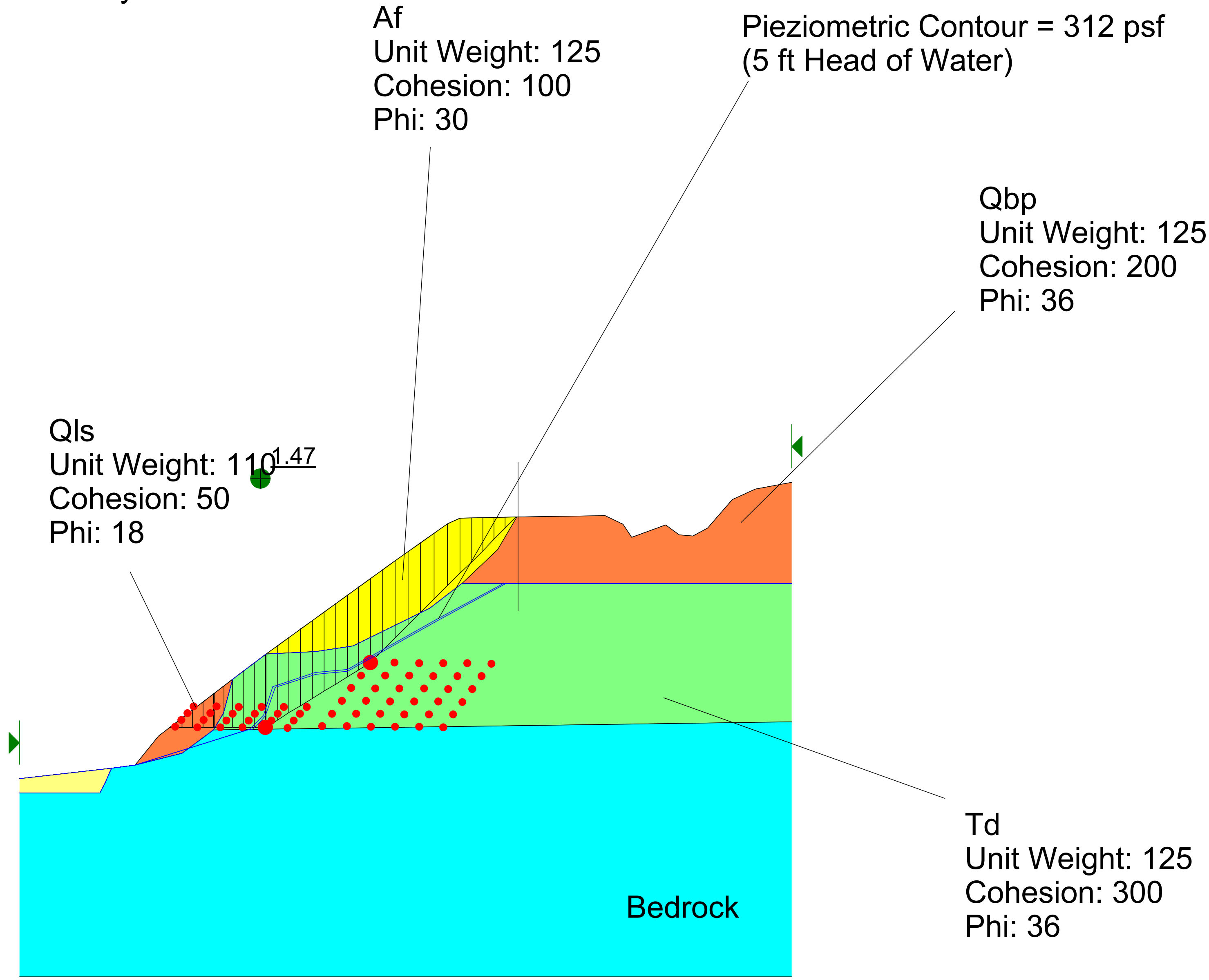


Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Pseudo Static 3B.slz
Analysis Method: Spencer



Del Mar Bluffs Cross Section 13-13'
Slope Stability Analysis
File Name: Section 13 13 Static 3B.slz
Analysis Method: Spencer

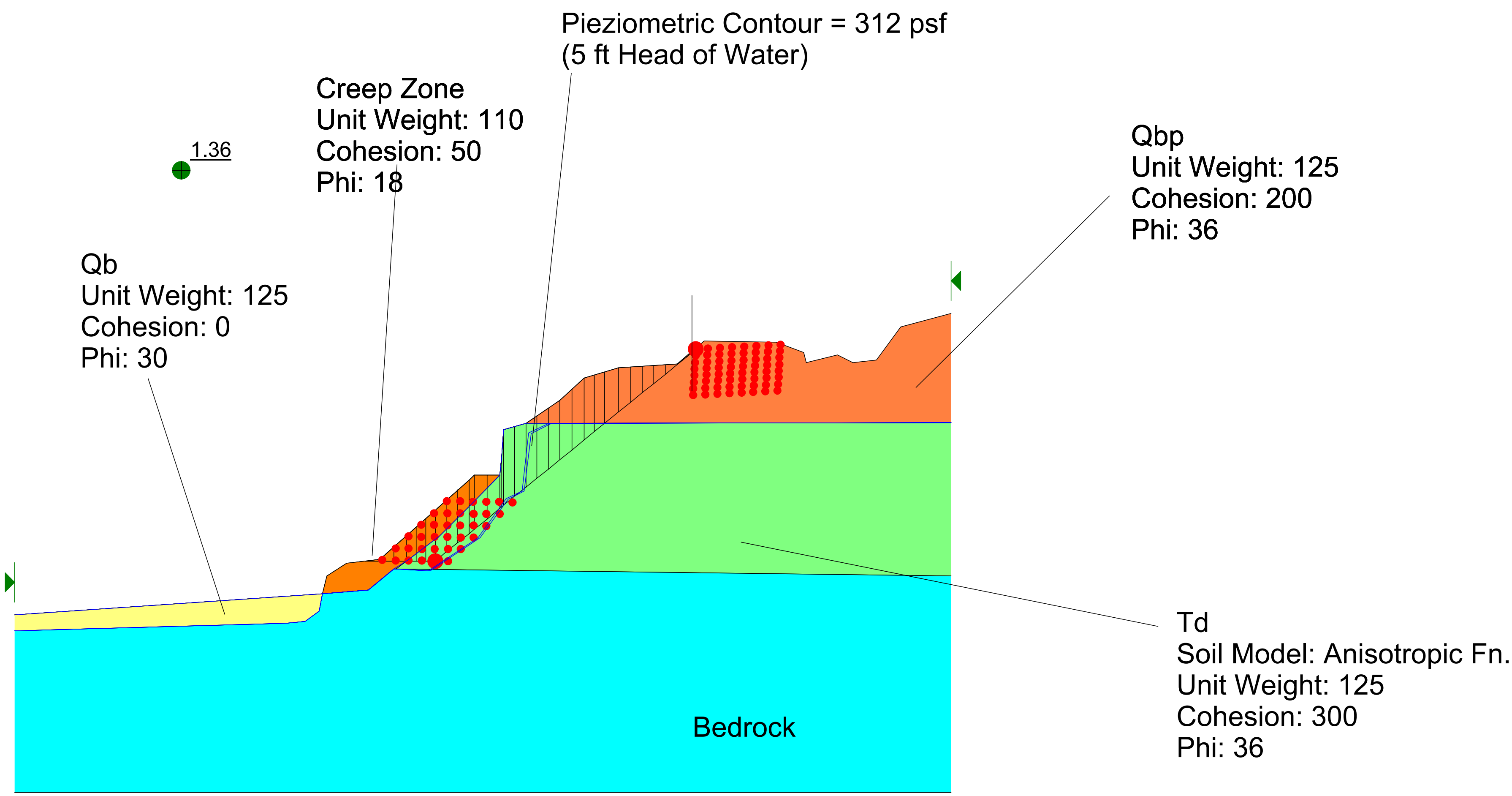
Factor of Safety: 1.47



Cross Section 14-14’

Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Static 2.slz
Analysis Method: Spencer

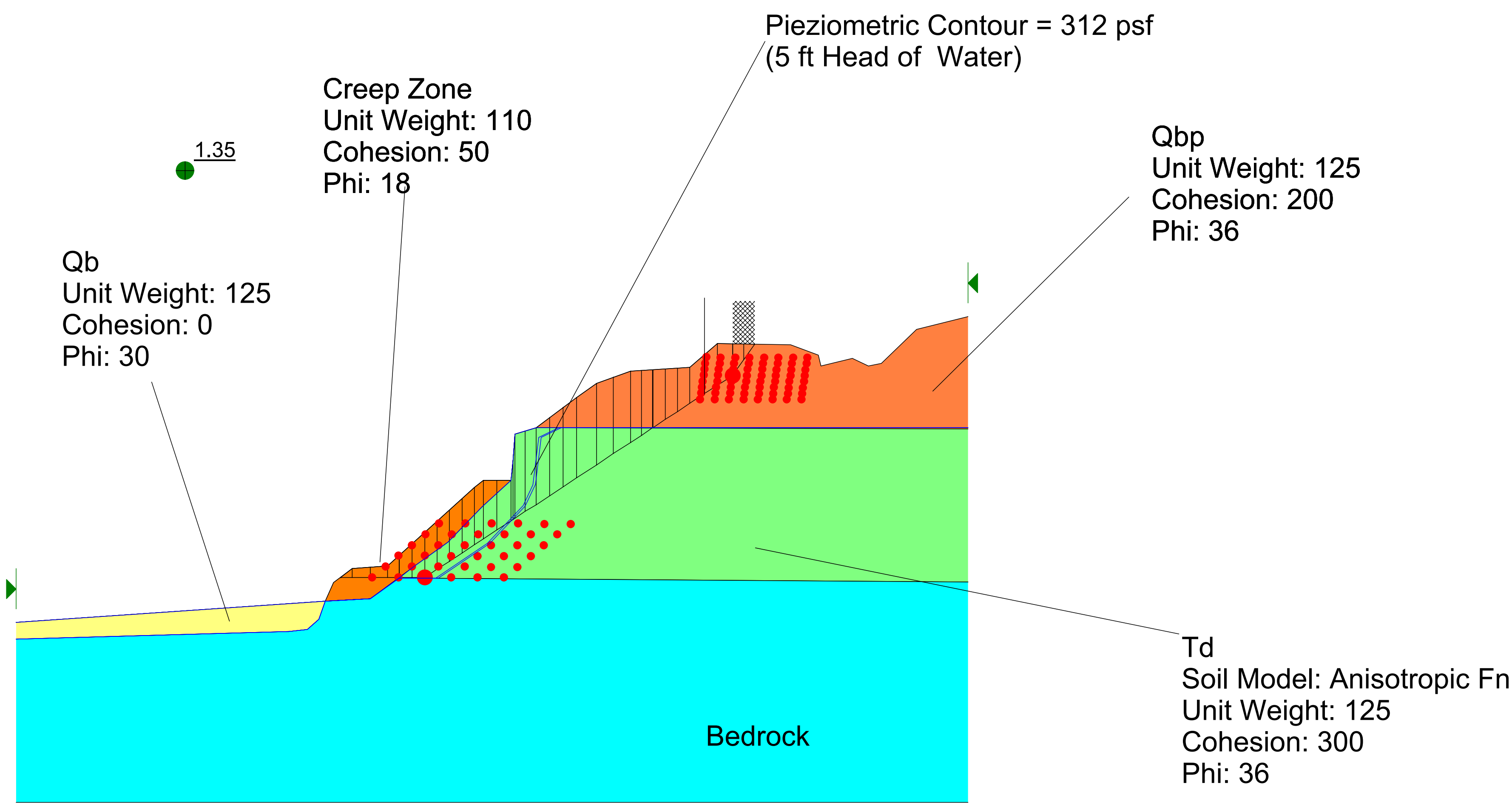
Factor of Safety: 1.36



Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Static 1.slz
Analysis Method: Spencer

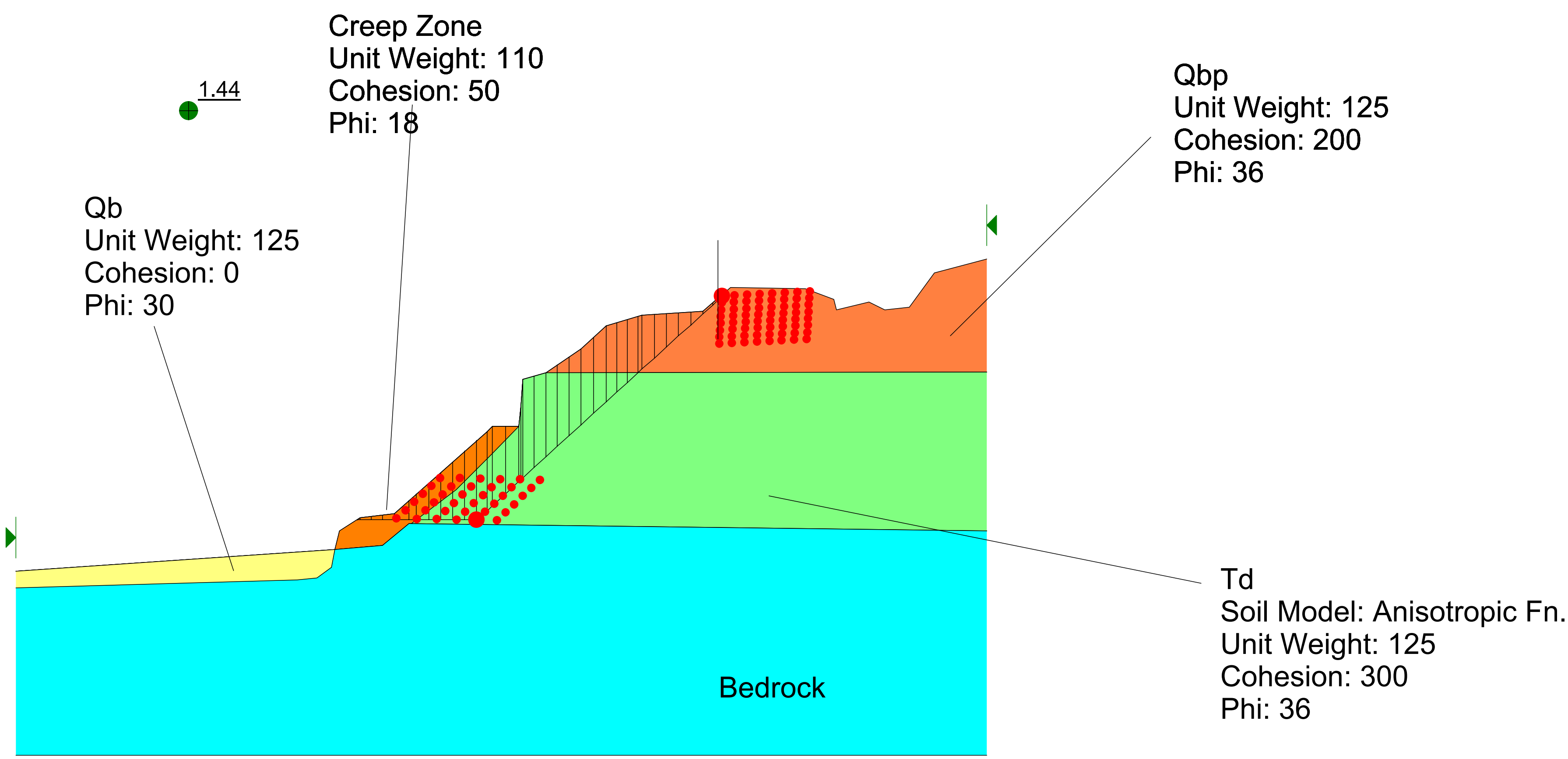
Factor of Safety: 1.35

Surcharge = 3,000 psf

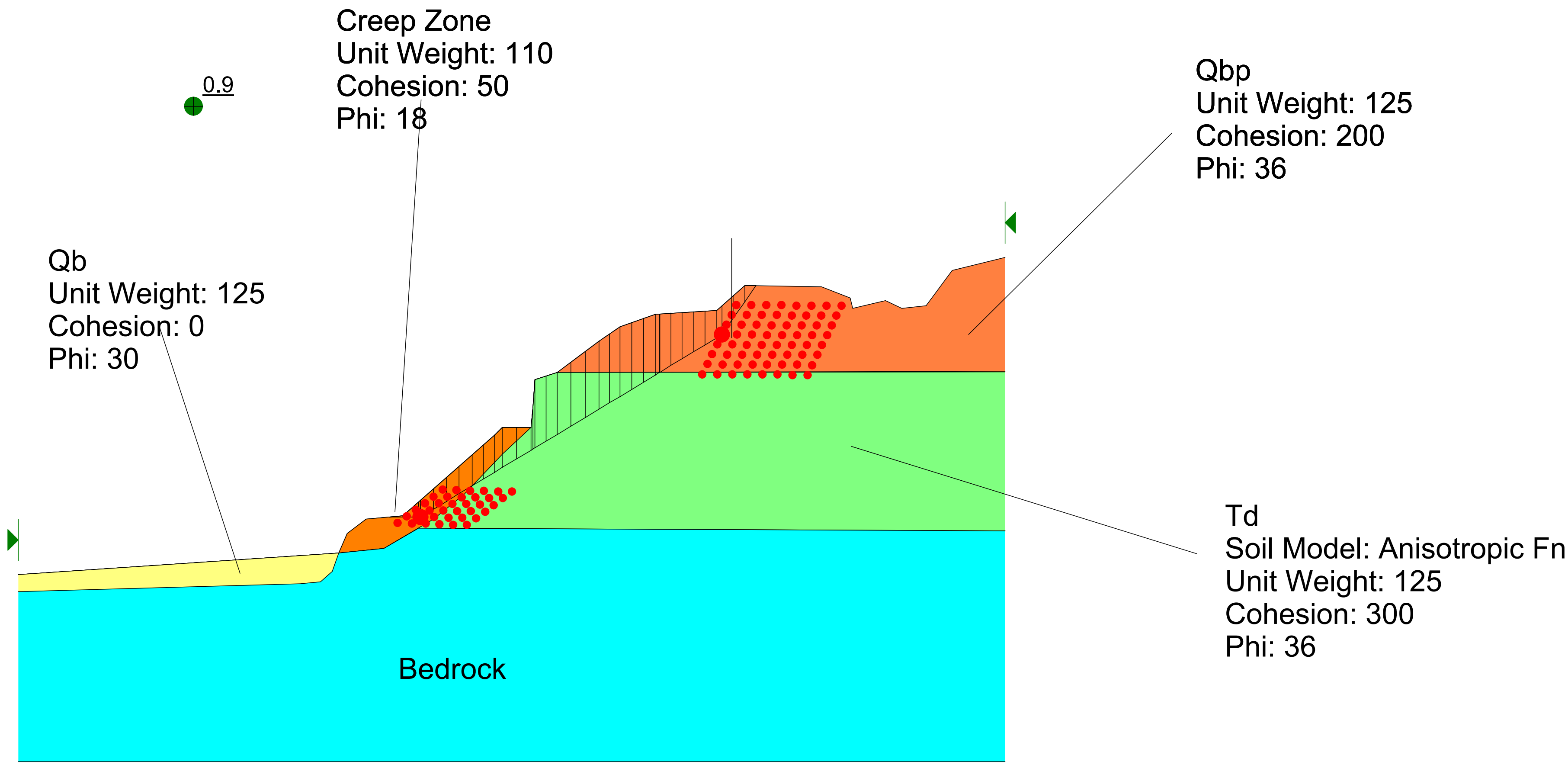


Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis, No Water
File Name: Section 14 14 Static 3 no water.slz
Analysis Method: Spencer

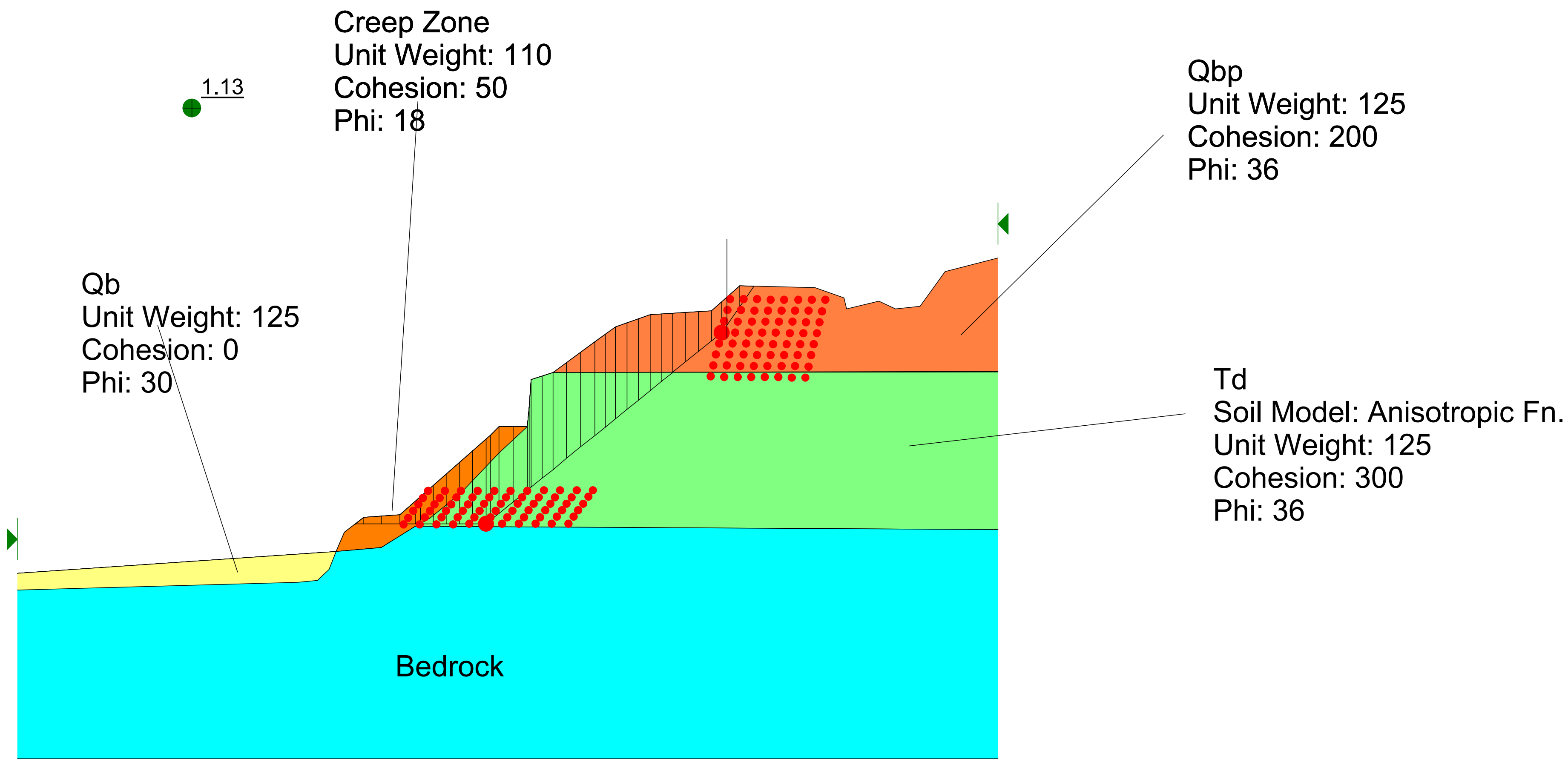
Factor of Safety: 1.44



Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Pseudo Static 2.slz
Analysis Method: Spencer
Factor of Safety: 0.9
Seismic Coefficient = 0.28

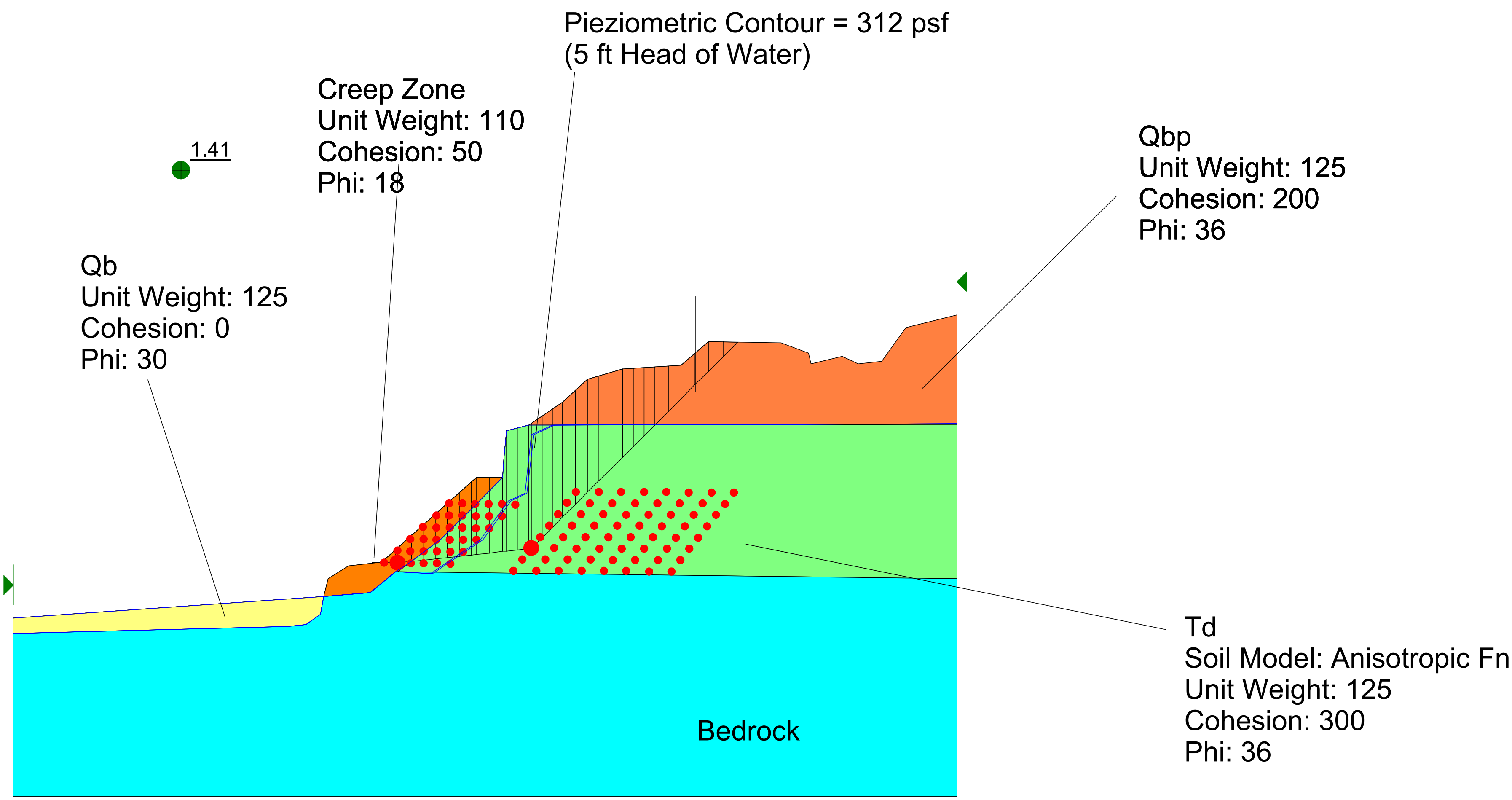


Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Pseudo Static 1B.slz
Analysis Method: Spencer
Factor of Safety: 1.13
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Static 2B.slz
Analysis Method: Spencer

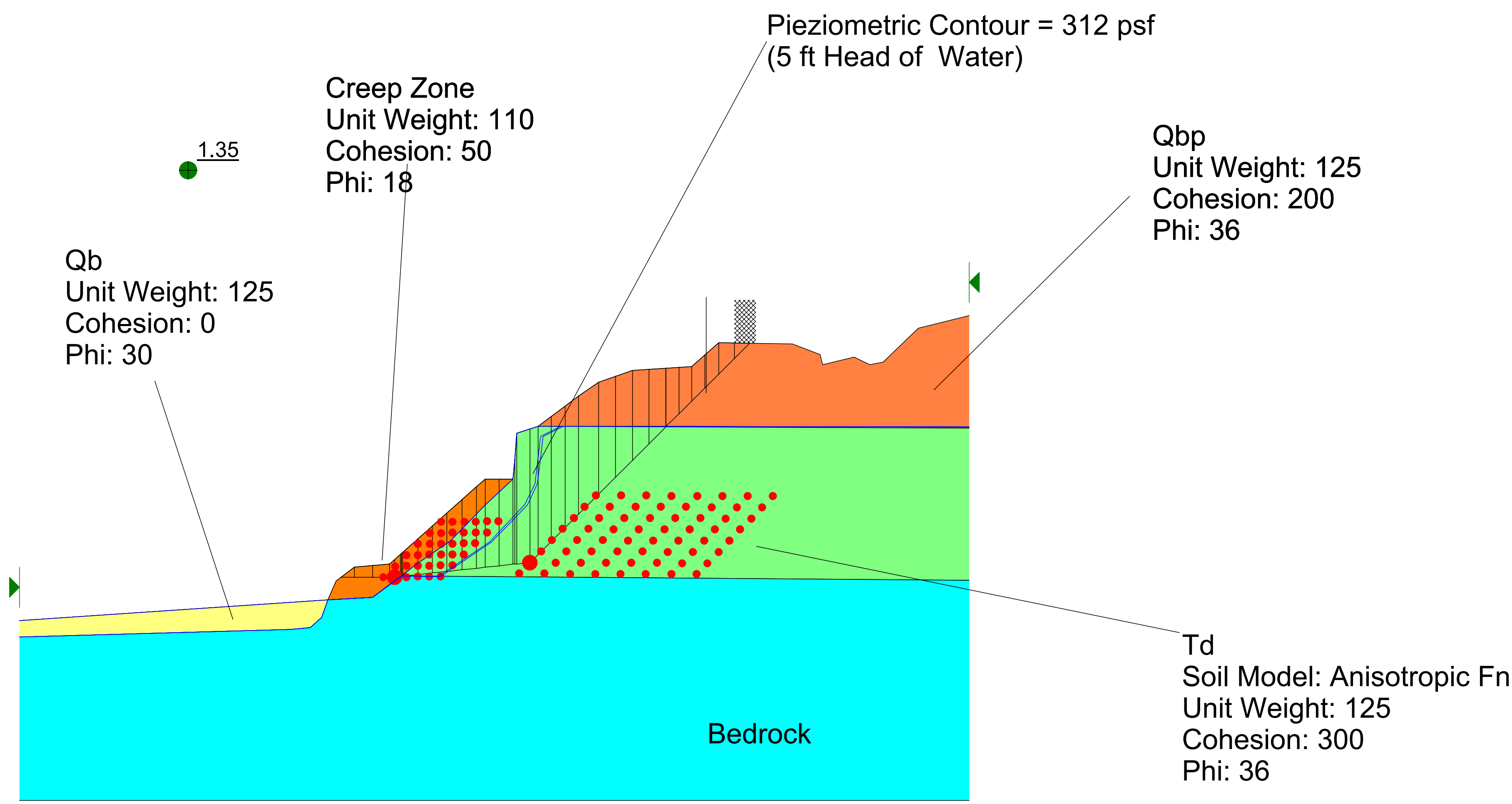
Factor of Safety: 1.41



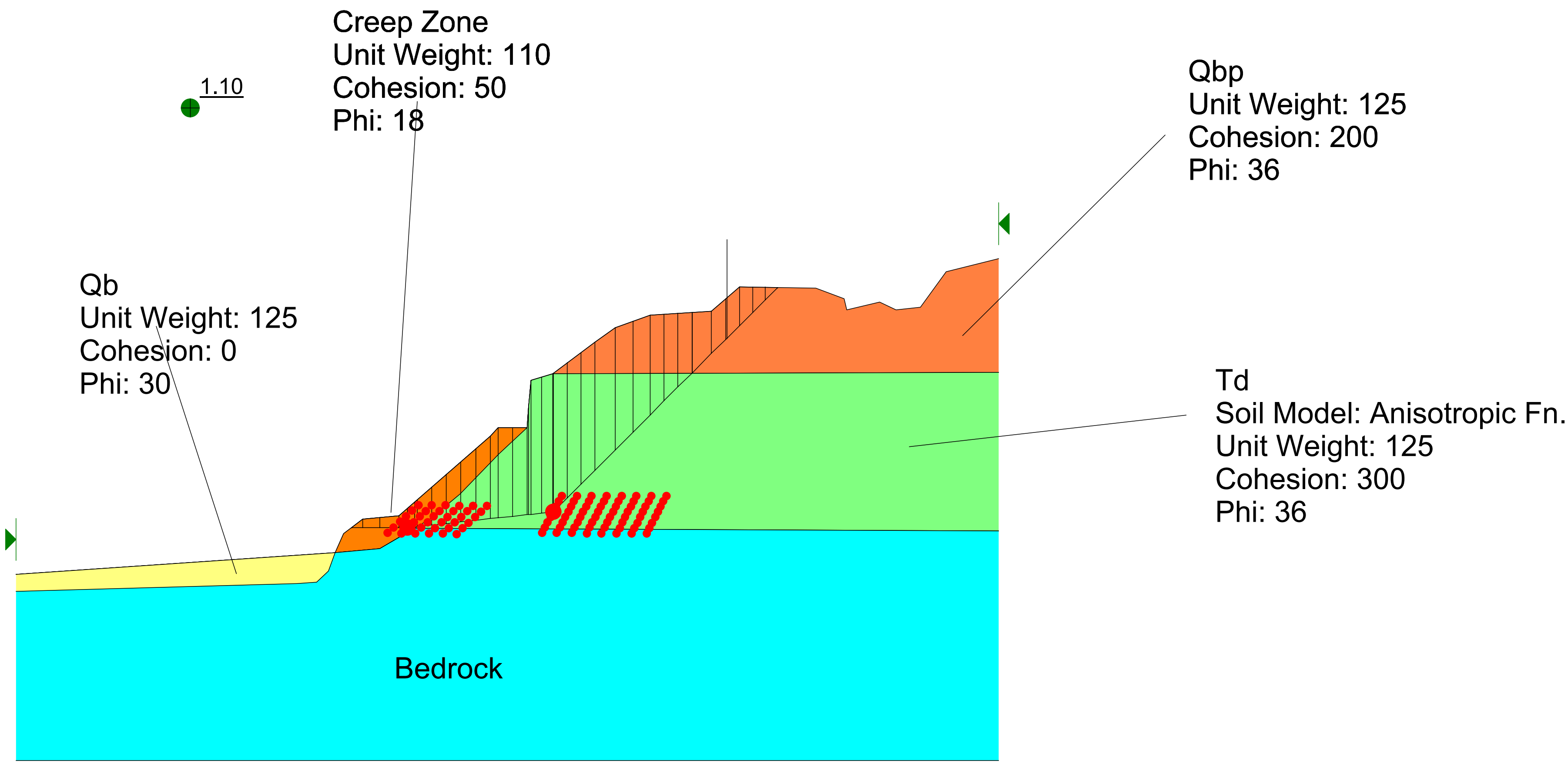
Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Static 1B.slz
Analysis Method: Spencer

Factor of Safety: 1.35

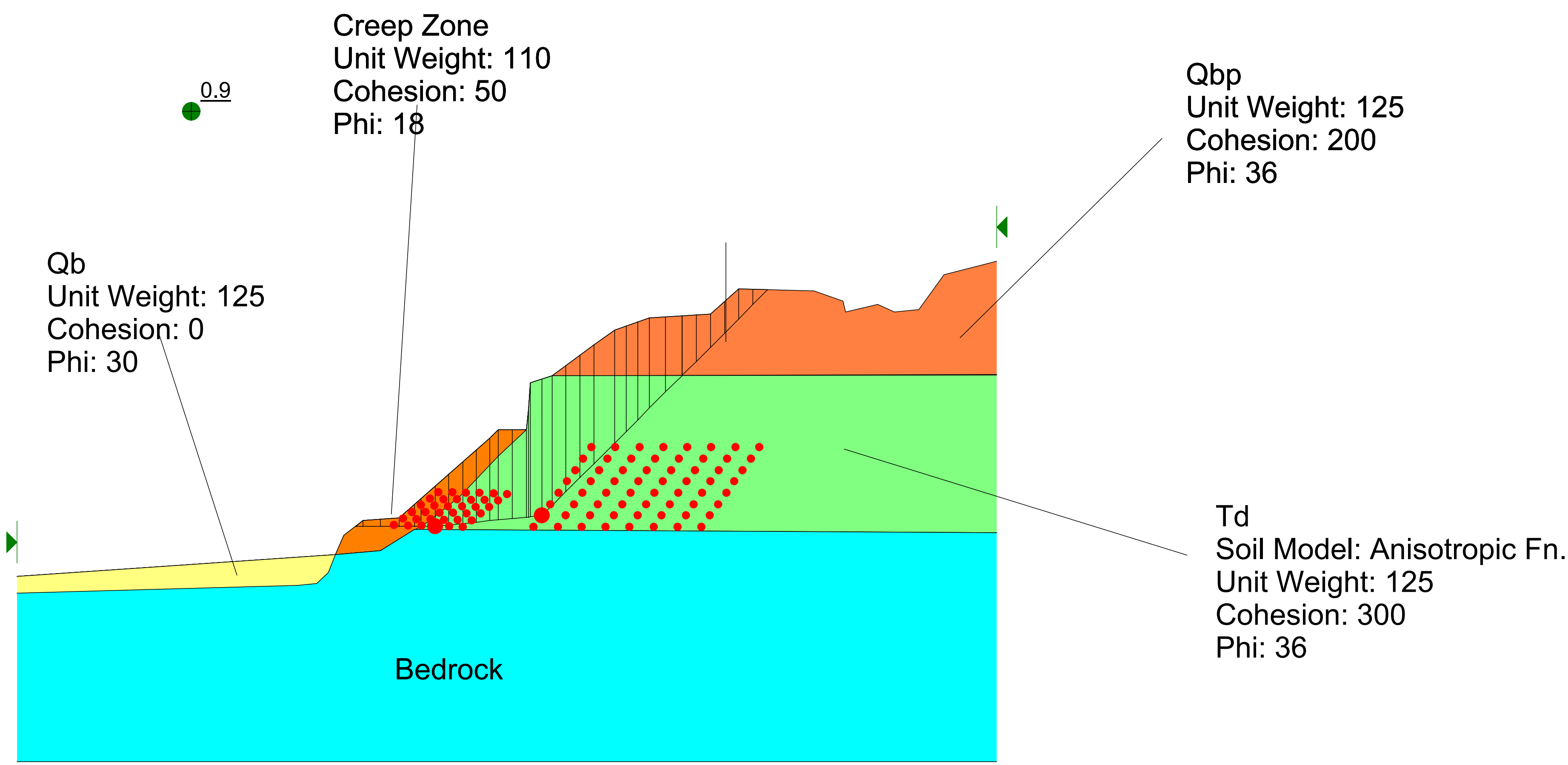
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Pseudo Static 1.slz
Analysis Method: Spencer
Factor of Safety: 1.1
Seismic Coefficient = 0.15



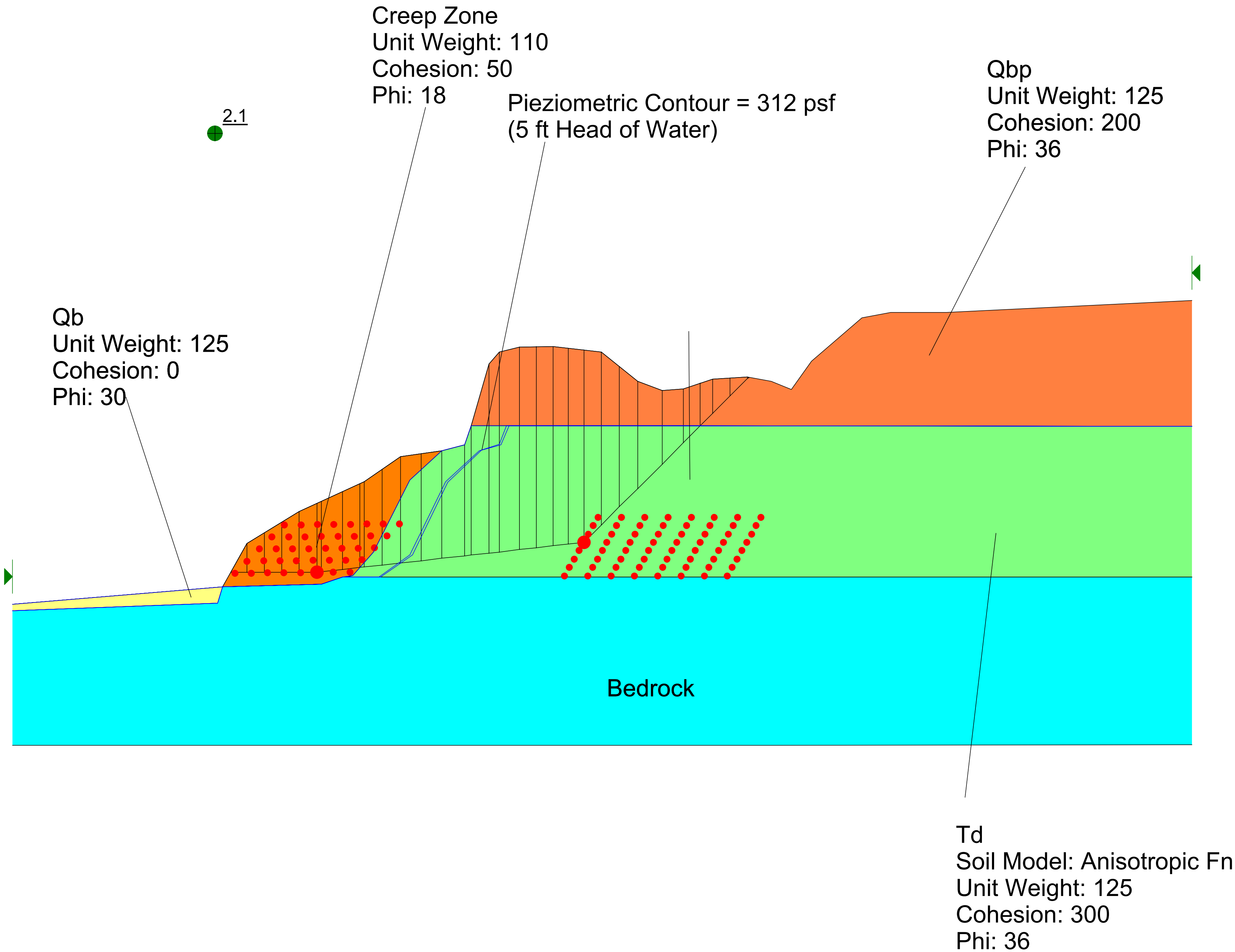
Del Mar Bluffs Cross Section 14-14'
Slope Stability Analysis
File Name: Section 14 14 Pseudo Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 0.91
Seismic Coefficient = 0.28



Cross Section 15-15’

Del Mar Bluffs Cross Section 15-15'
Slope Stability Analysis
File Name: Section 15 15 Static 1B.slz
Analysis Method: Spencer

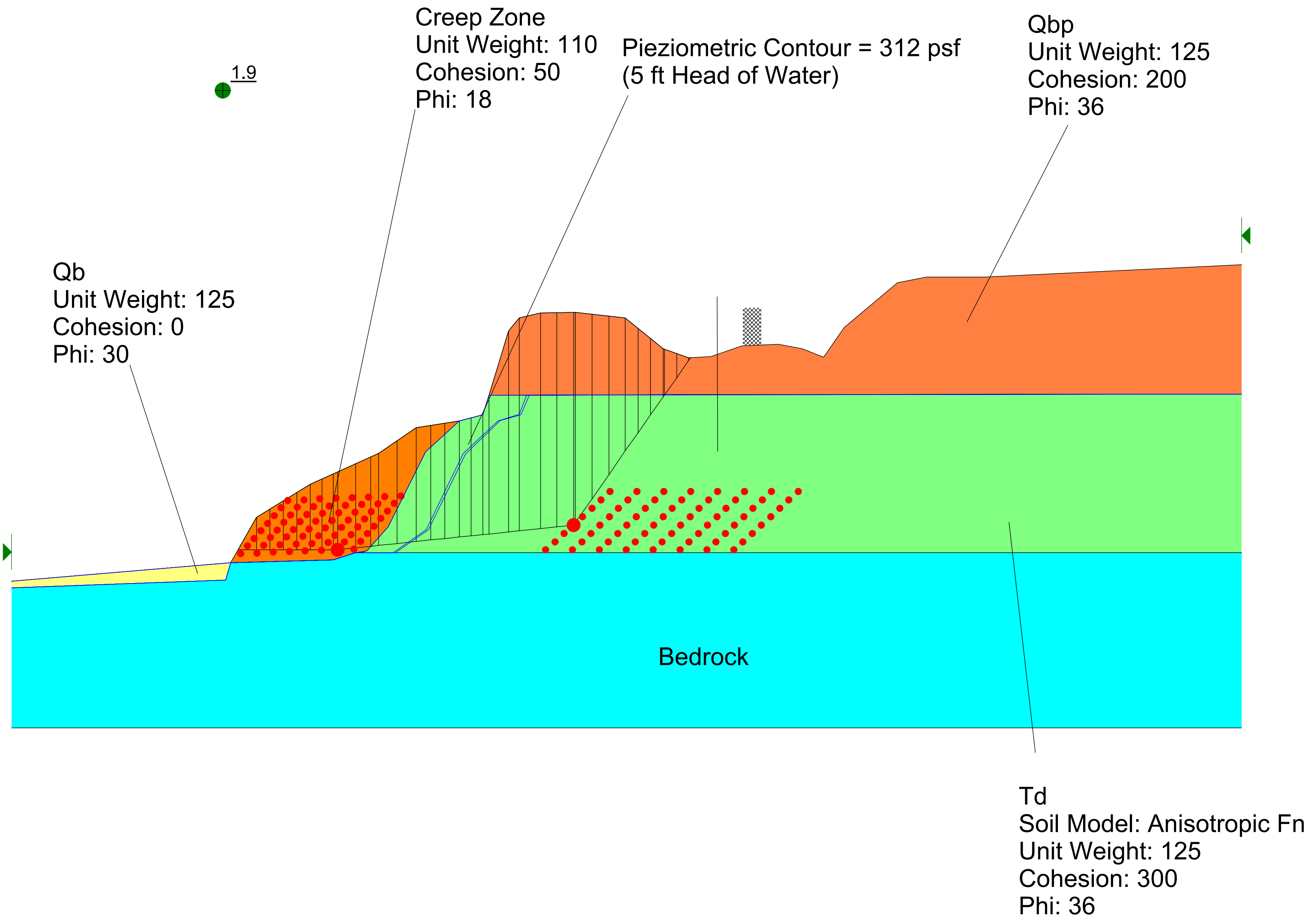
Factor of Safety: 2.1



Del Mar Bluffs Cross Section 15-15'
Slope Stability Analysis
File Name: Section 15 15 Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.9

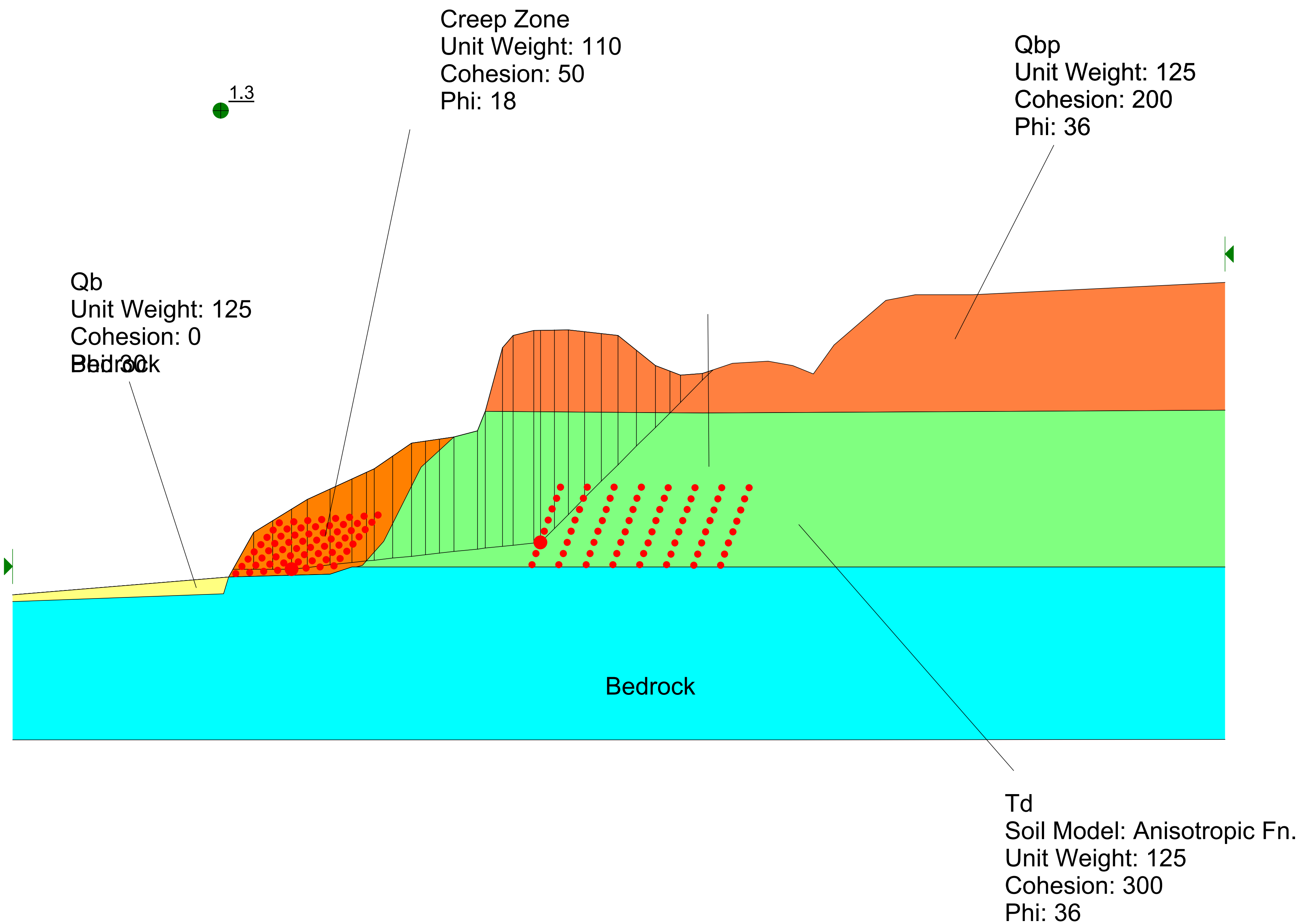
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 15-15'
Slope Stability Analysis
File Name: Section 15 15 Pseudo Static 1B.slz
Analysis Method: Spencer

Factor of Safety: 1.3

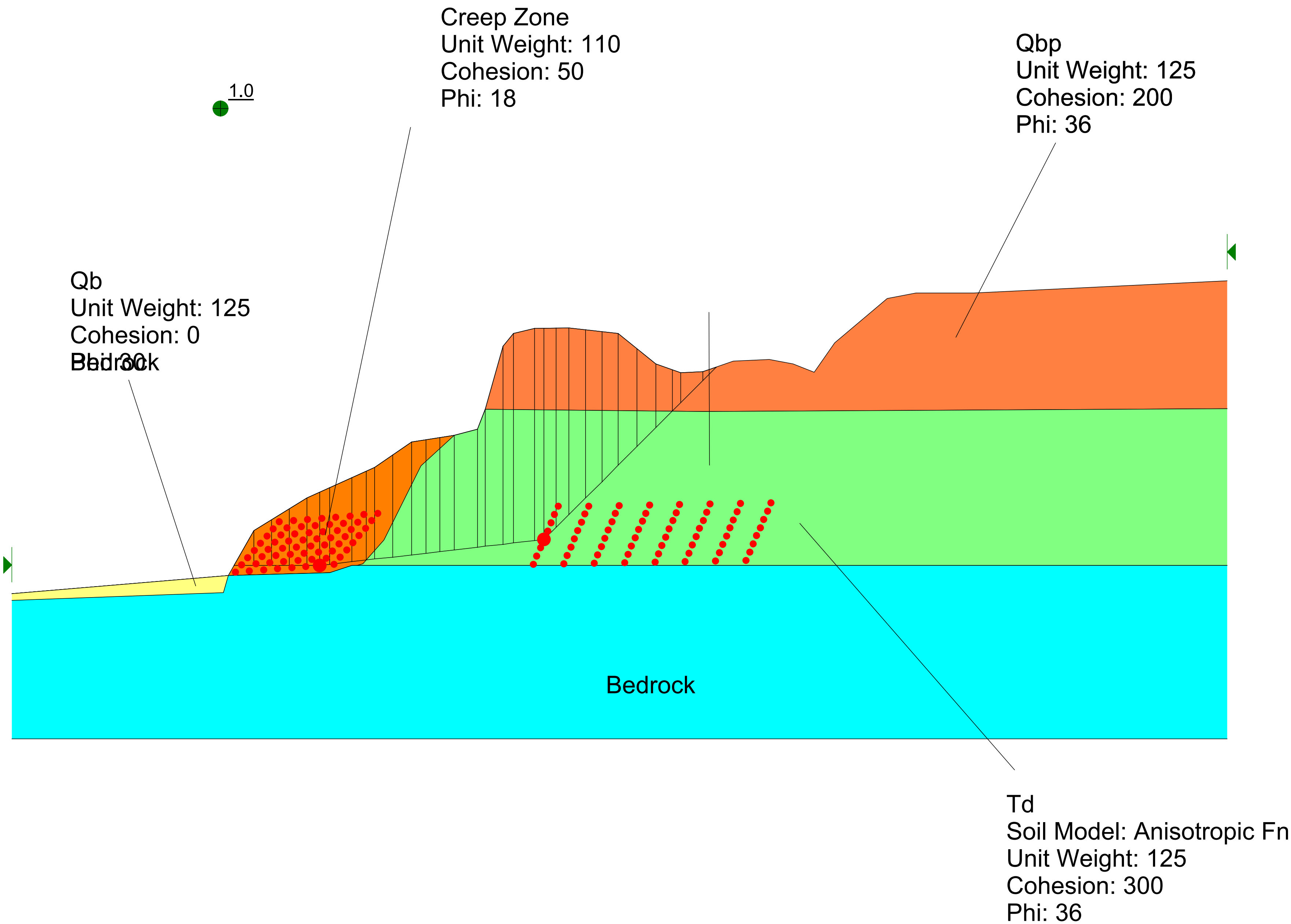
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 15-15'
Slope Stability Analysis
File Name: Section 15 15 Pseudo Static 2B.slz
Analysis Method: Spencer

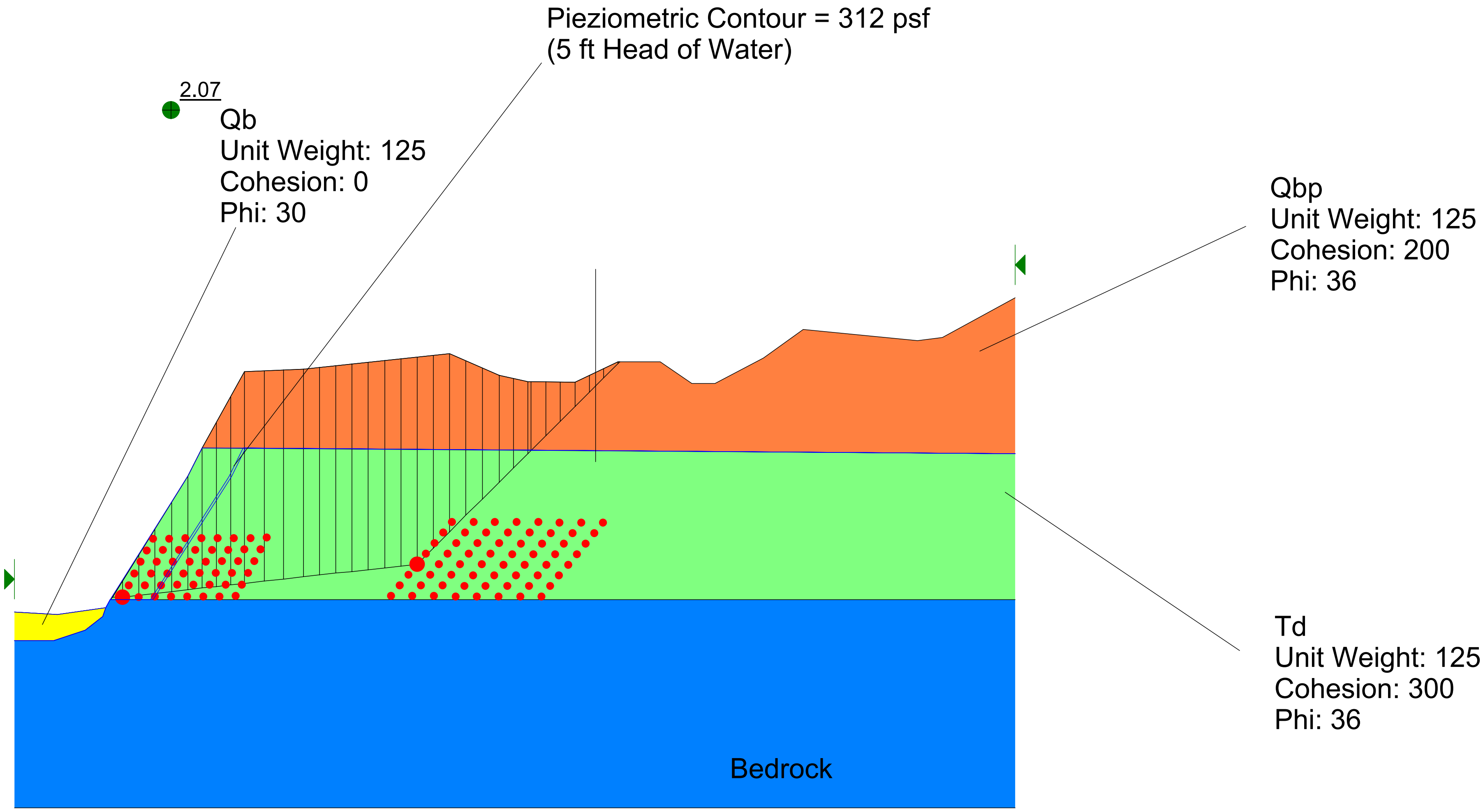
Factor of Safety: 1

Seismic Coefficient = 0.28



Cross Section 16-16’

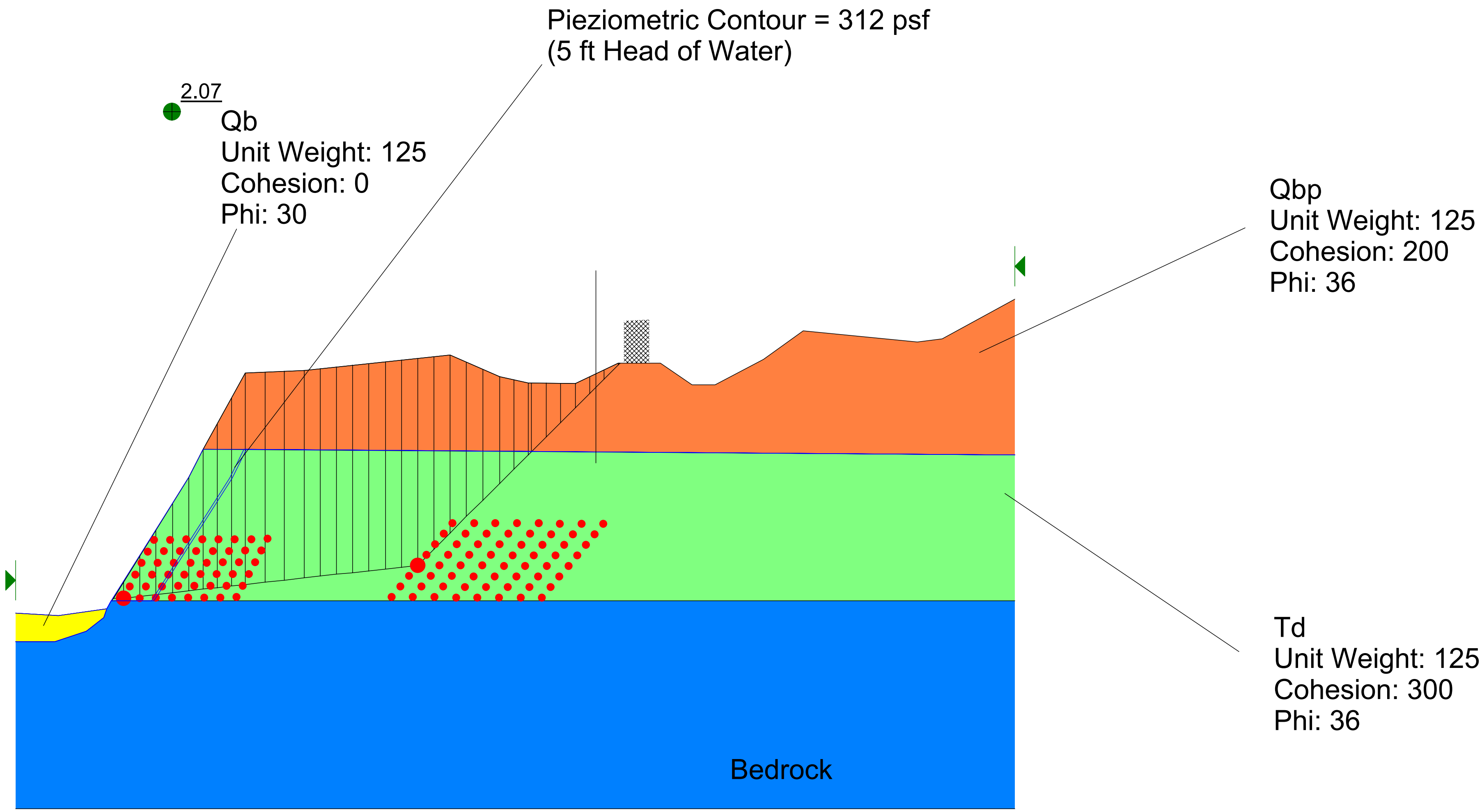
Del Mar Bluffs Section 16-16'
Slope Stability Analysis
File Name: Section 1616 Static 1B.slz
Analysis Method: Spencer
Factor of Safety: 2.07



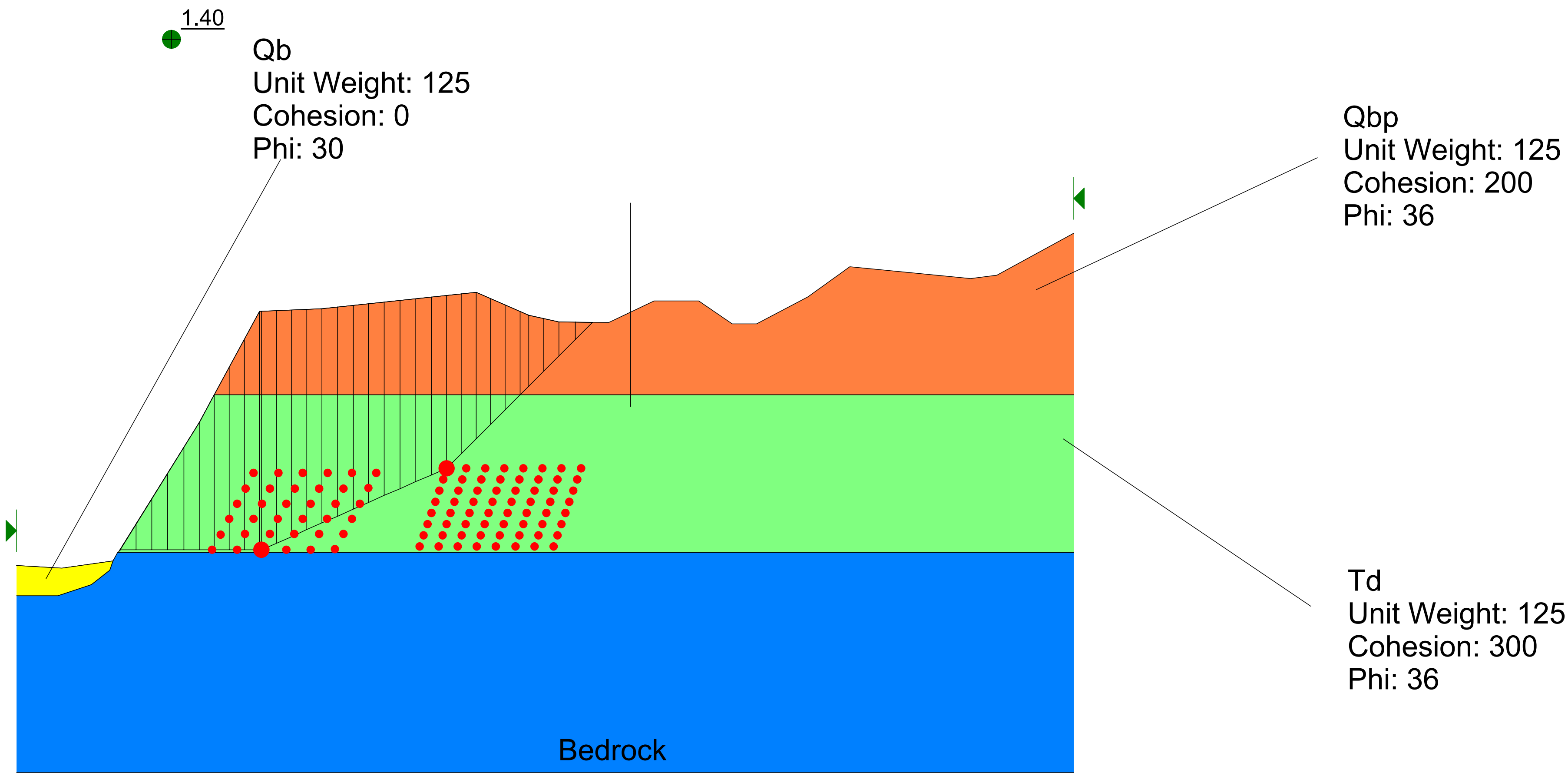
Del Mar Bluffs Section 16-16'
Slope Stability Analysis
File Name: Section 1616 Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 2.07

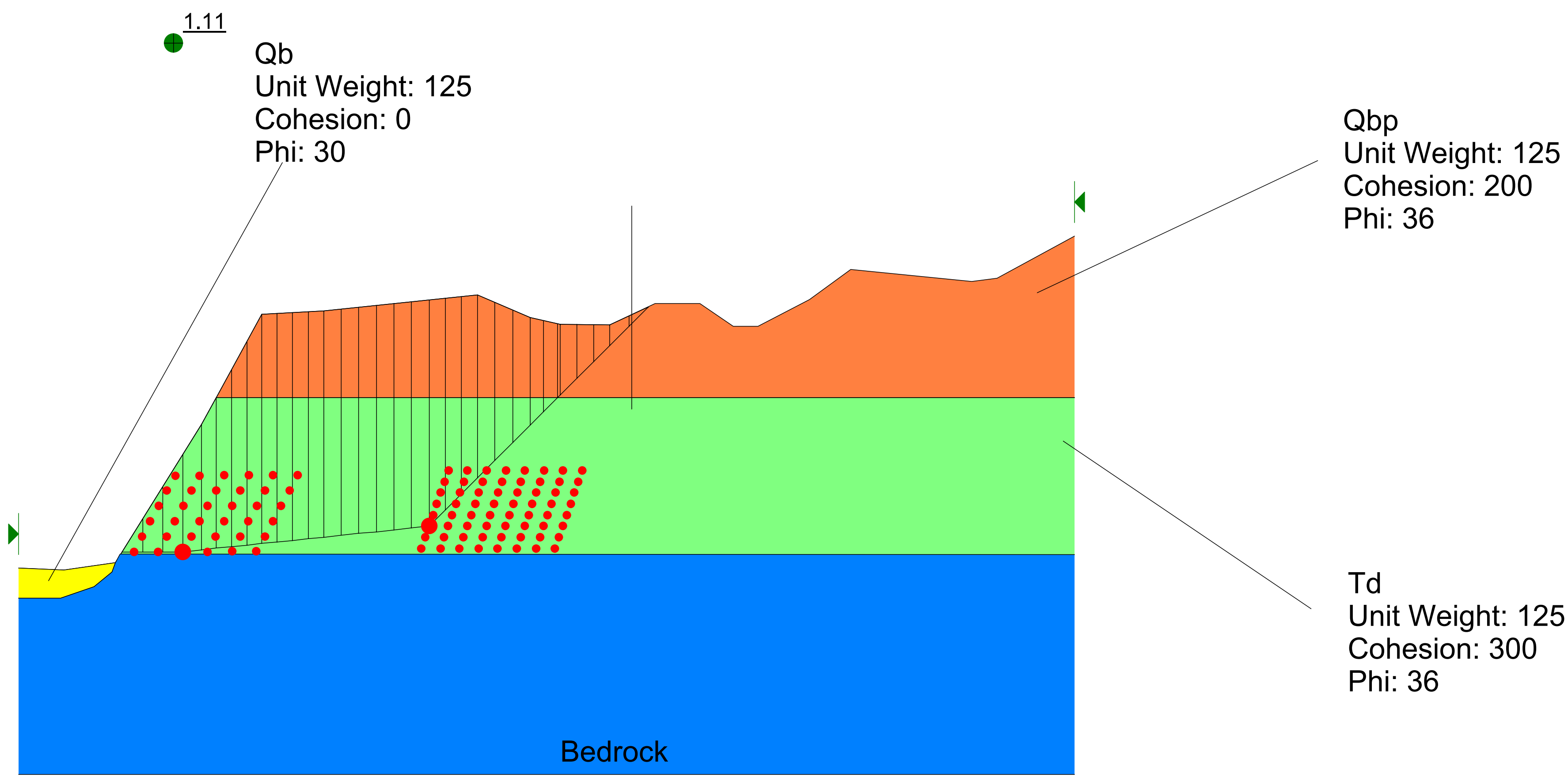
Surcharge = 3,000 psf



Del Mar Bluffs Section 16-16'
Slope Stability Analysis
File Name: Section 1616 Pseudo Static 1B.slz
Analysis Method: Spencer
Factor of Safety: 1.4
Seismic Coefficient = 0.15



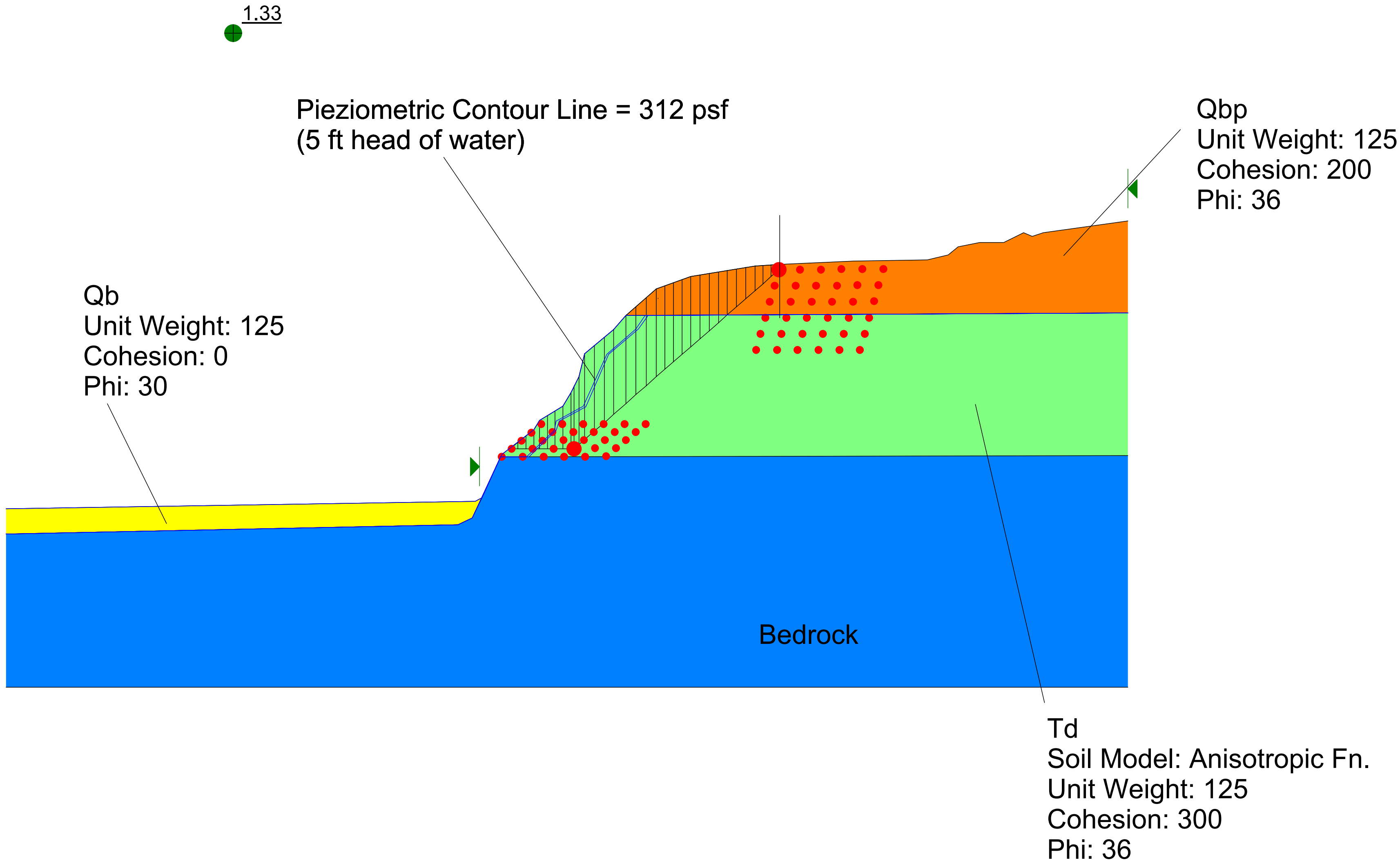
Del Mar Bluffs Section 16-16'
Slope Stability Analysis
File Name: Section 1616 Pseudo Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.11
Seismic Coefficient = 0.28



Cross Section 17-17’

Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis
File Name: Section 1717 5 ft water Static 2.slz
Analysis Method: Spencer

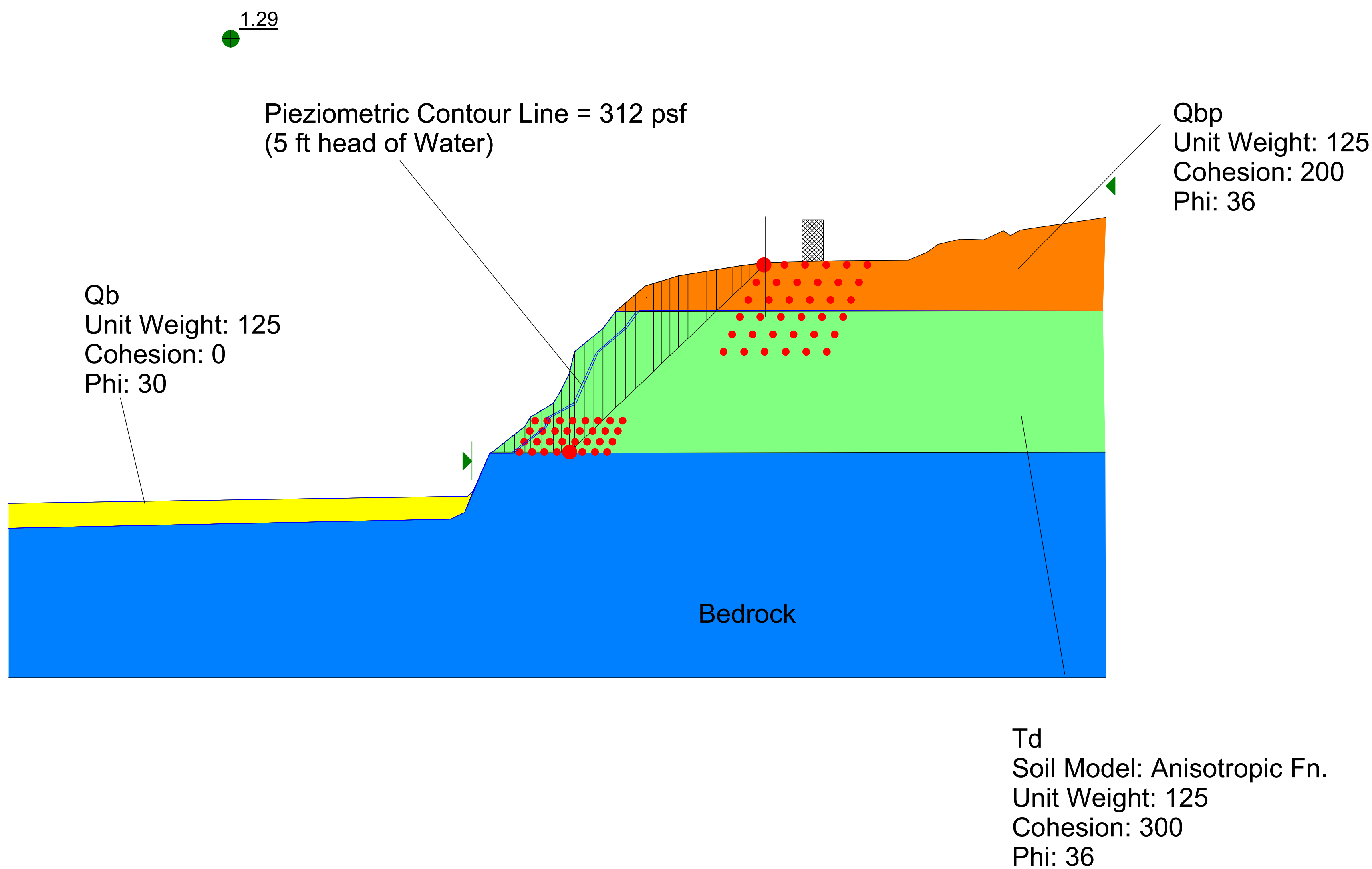
Factor of Safety: 1.33



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis
File Name: Section 1717 5 ft water Static 4.slz
Analysis Method: Spencer

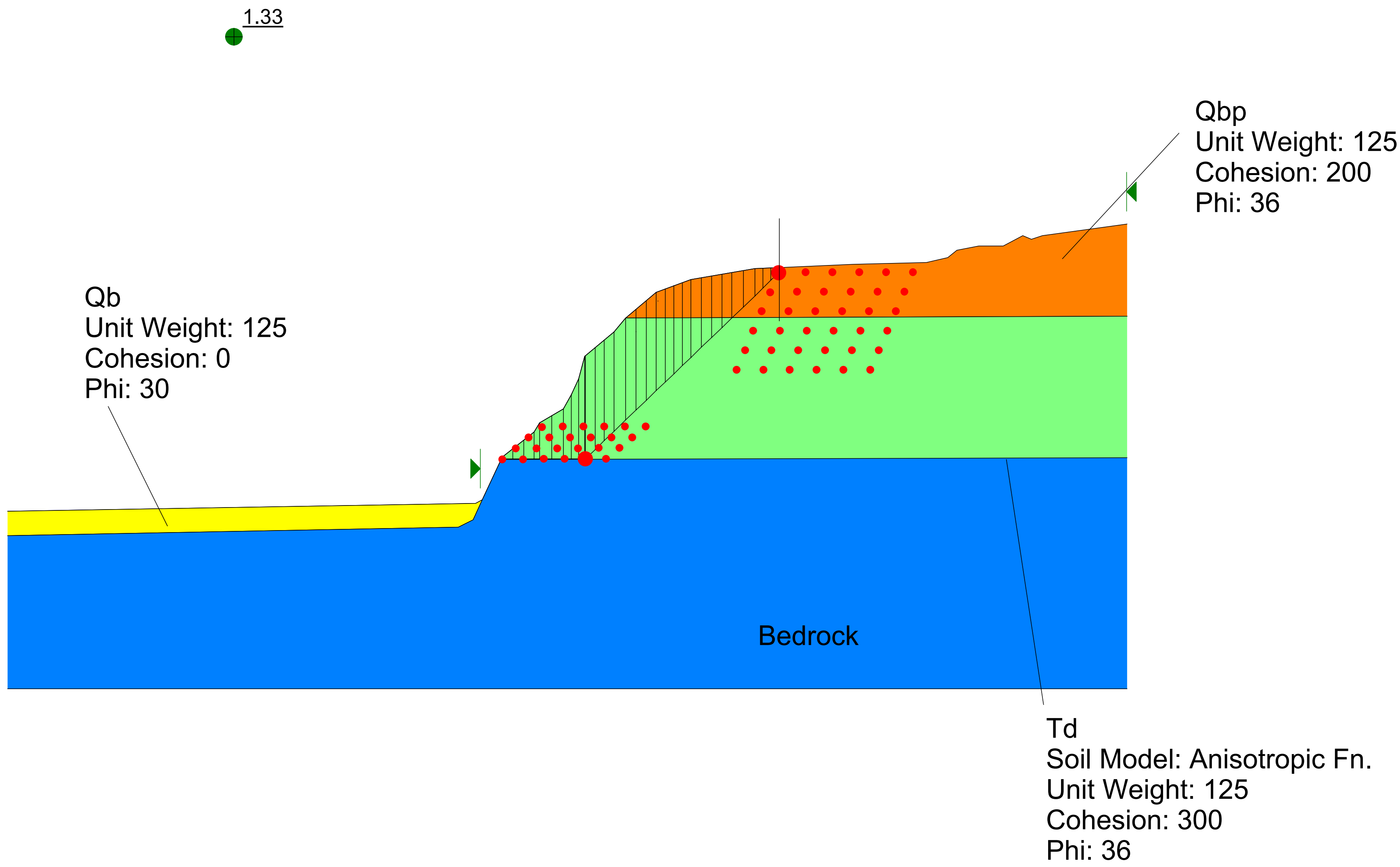
Factor of Safety: 1.29

Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis, No Water
File Name: Section 1717 Static 3 no water.slz
Analysis Method: Spencer

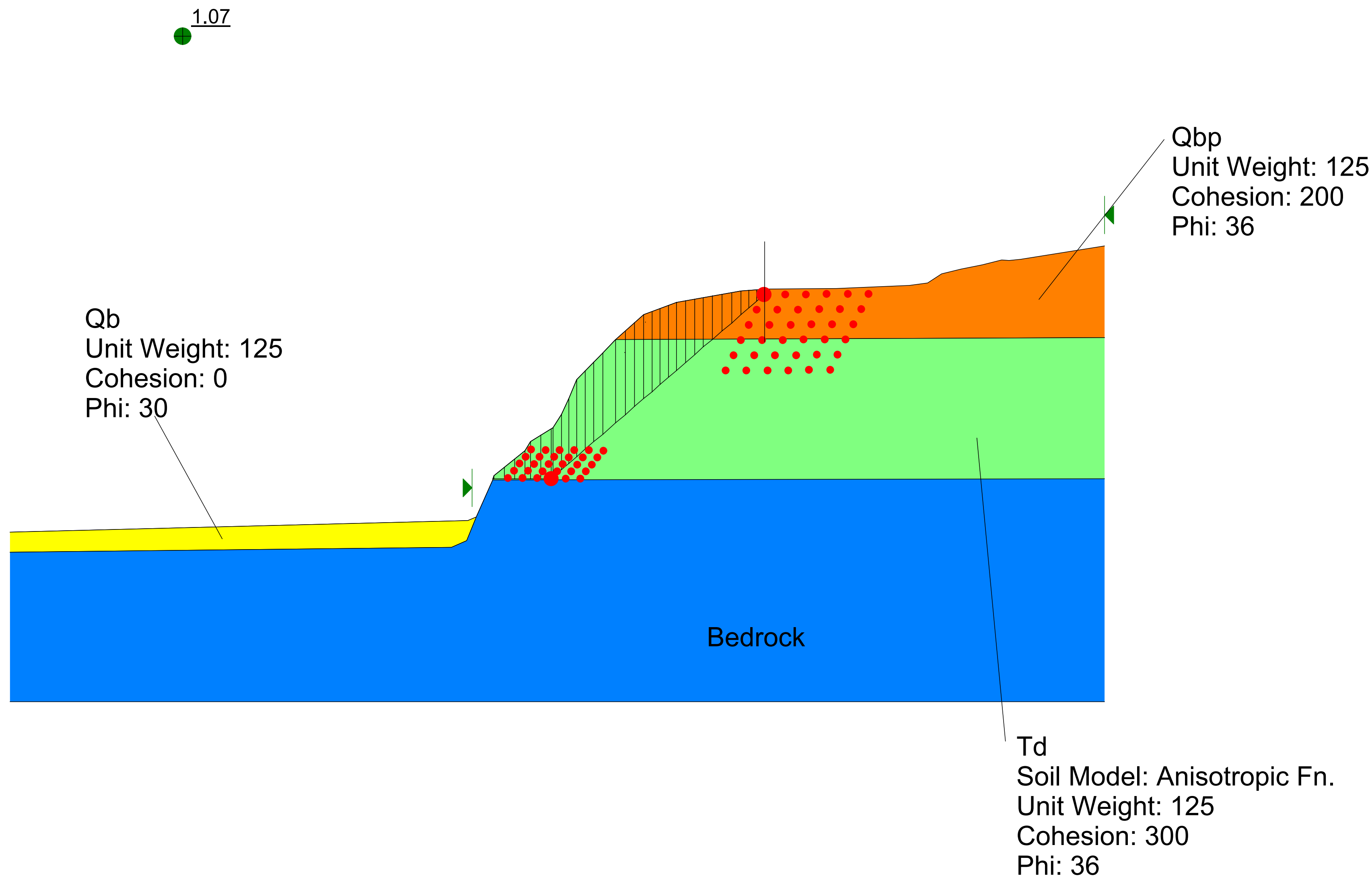
Factor of Safety: 1.33



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis
File Name: Section 1717 Psuedo Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.07

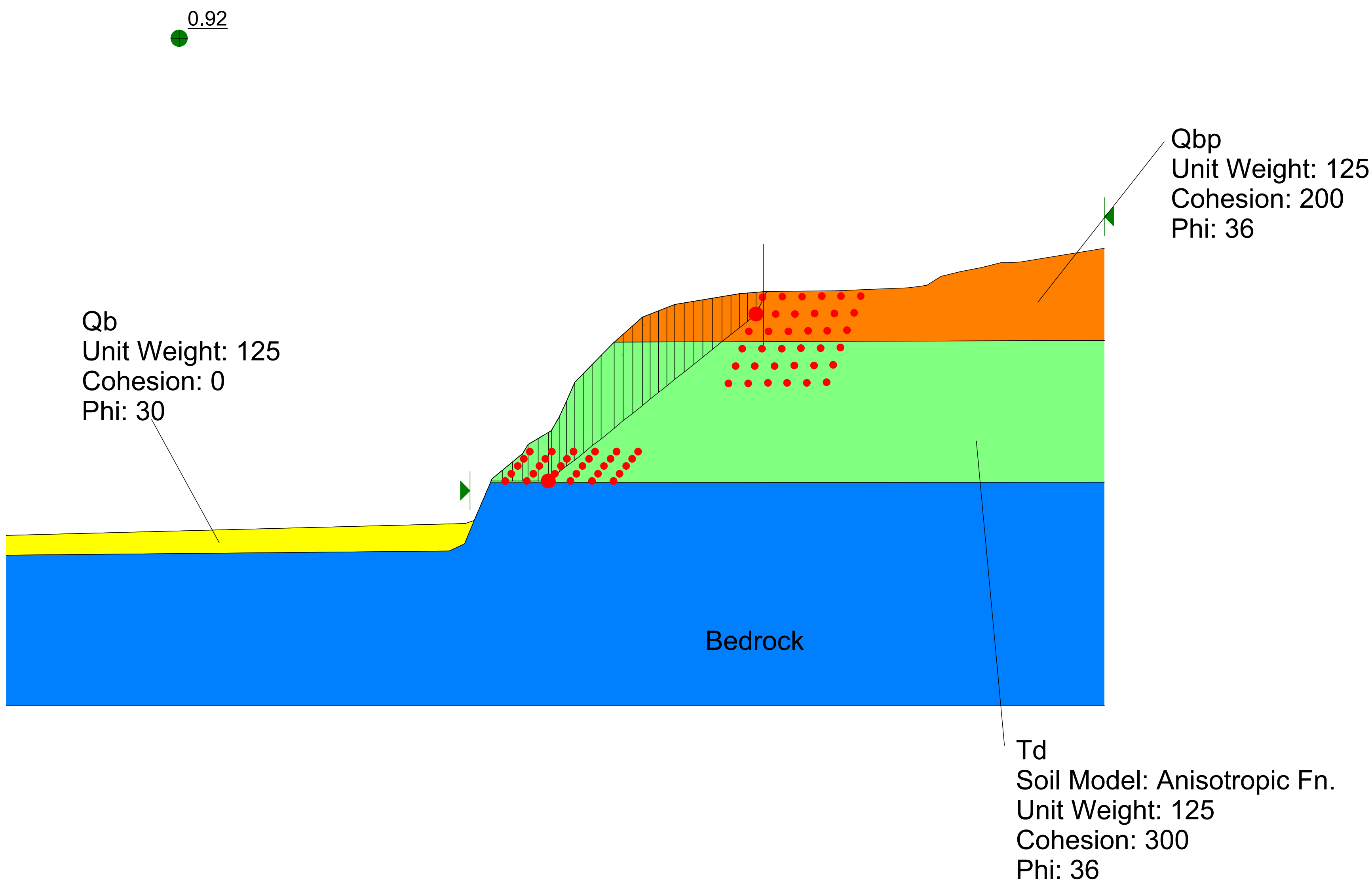
Seismic Coefficient - 0.15



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis
File Name: Section 1717 Psuedo Static 4.slz
Analysis Method: Spencer

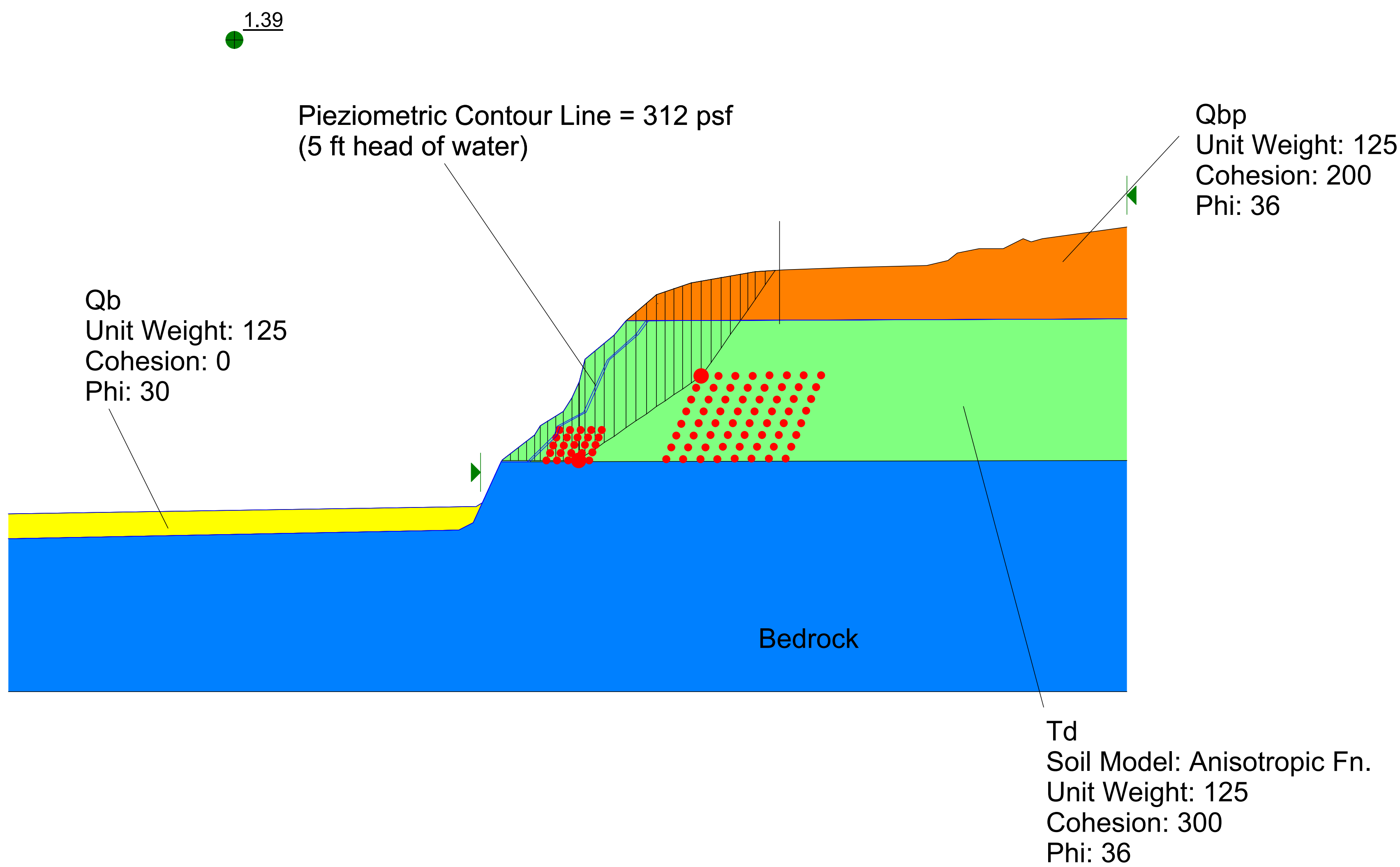
Factor of Safety: 0.92

Seismic Coefficient - 0.28



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis
File Name: Section 1717 5 ft water Static 2B.slz
Analysis Method: Spencer

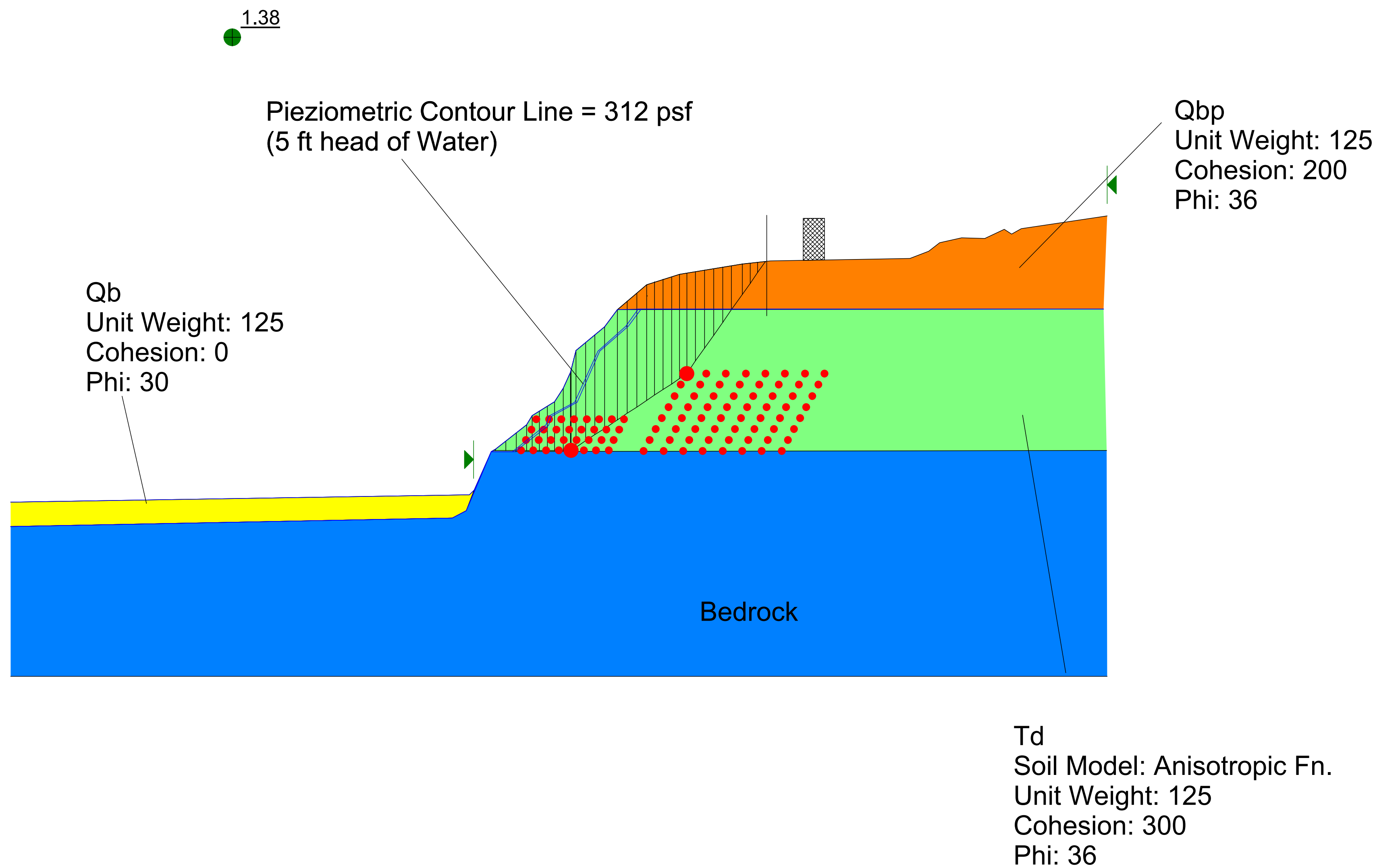
Factor of Safety: 1.39



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis
File Name: Section 1717 5 ft water Static 4B.slz
Analysis Method: Spencer

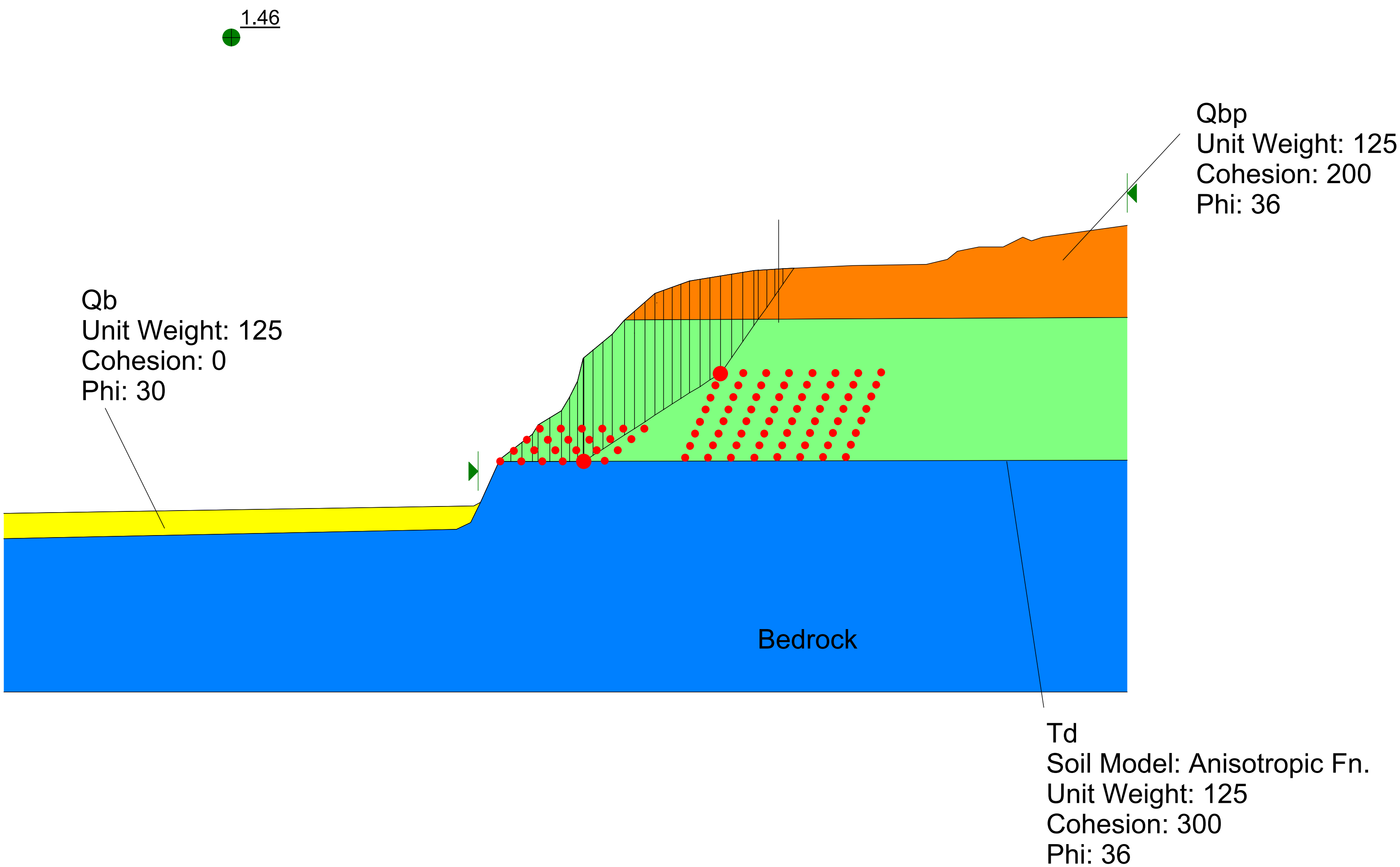
Factor of Safety: 1.38

Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis, No Water
File Name: Section 1717 Static 3B no water.slz
Analysis Method: Spencer

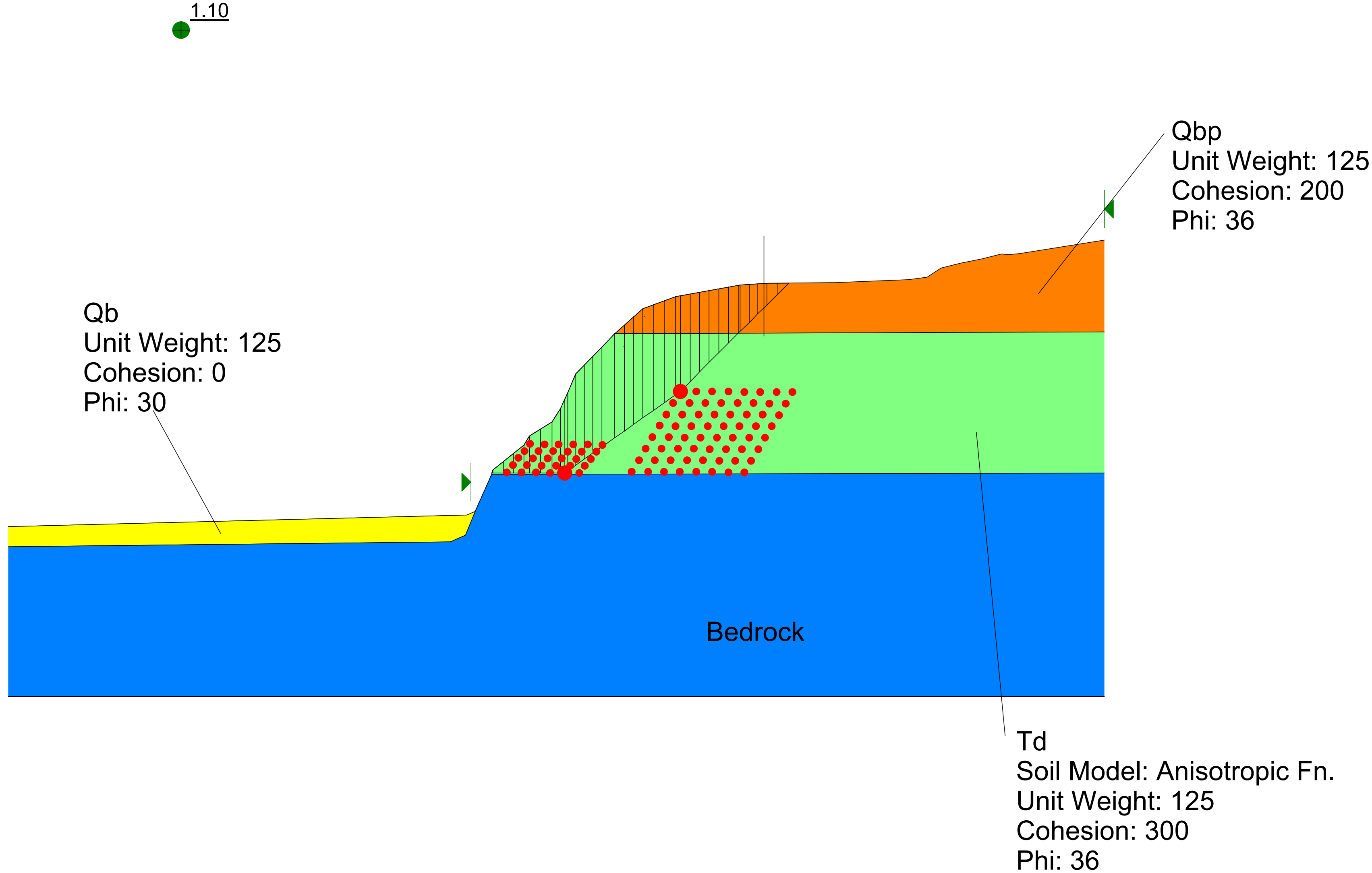
Factor of Safety: 1.46



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis
File Name: Section 1717 Psuedo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.1

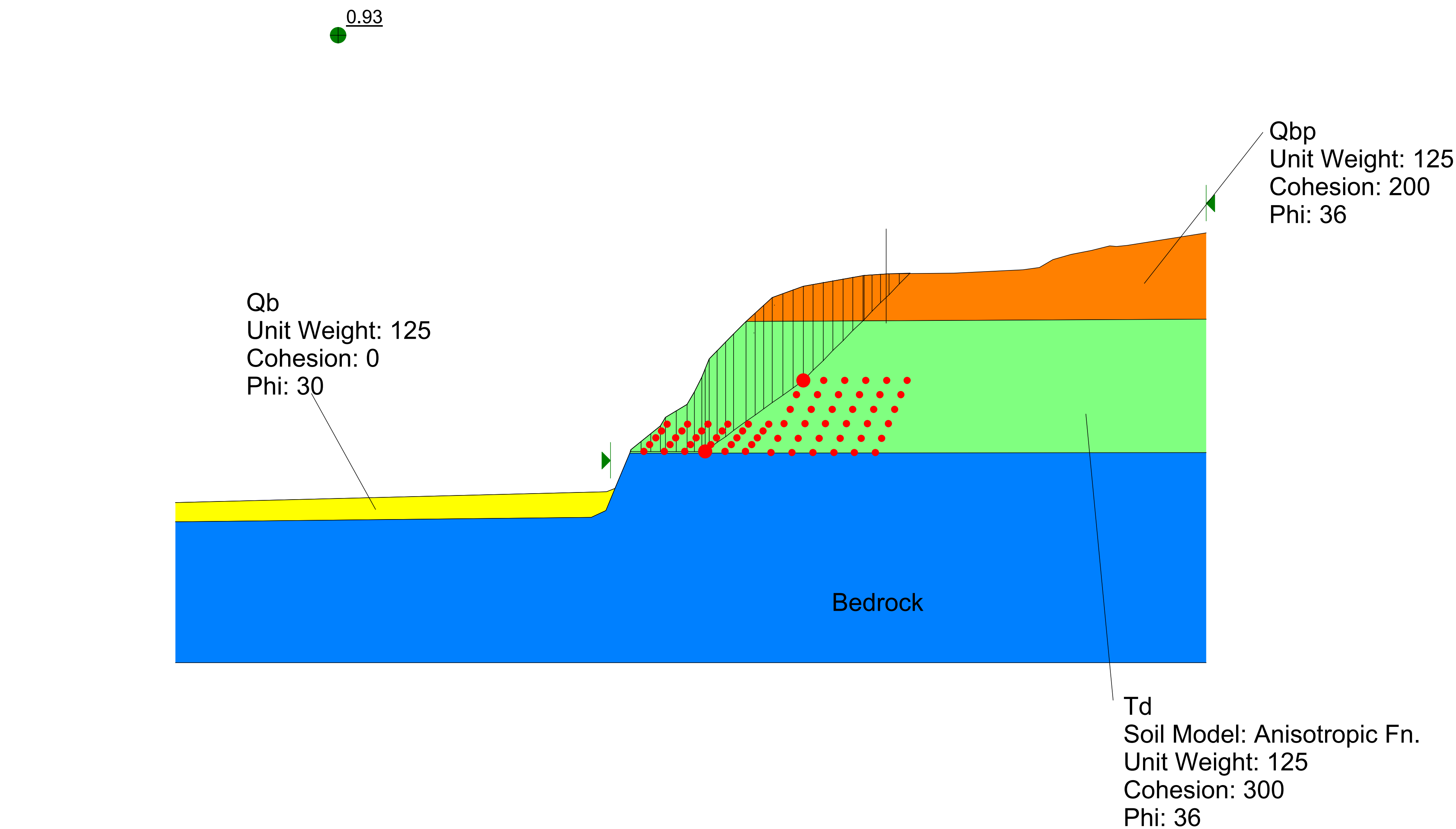
Seismic Coefficient - 0.15



Del Mar Bluffs Cross Section 17-17'
Slope Stability Analysis
File Name: Section 1717 Psuedo Static 4B.slz
Analysis Method: Spencer

Factor of Safety: 0.93

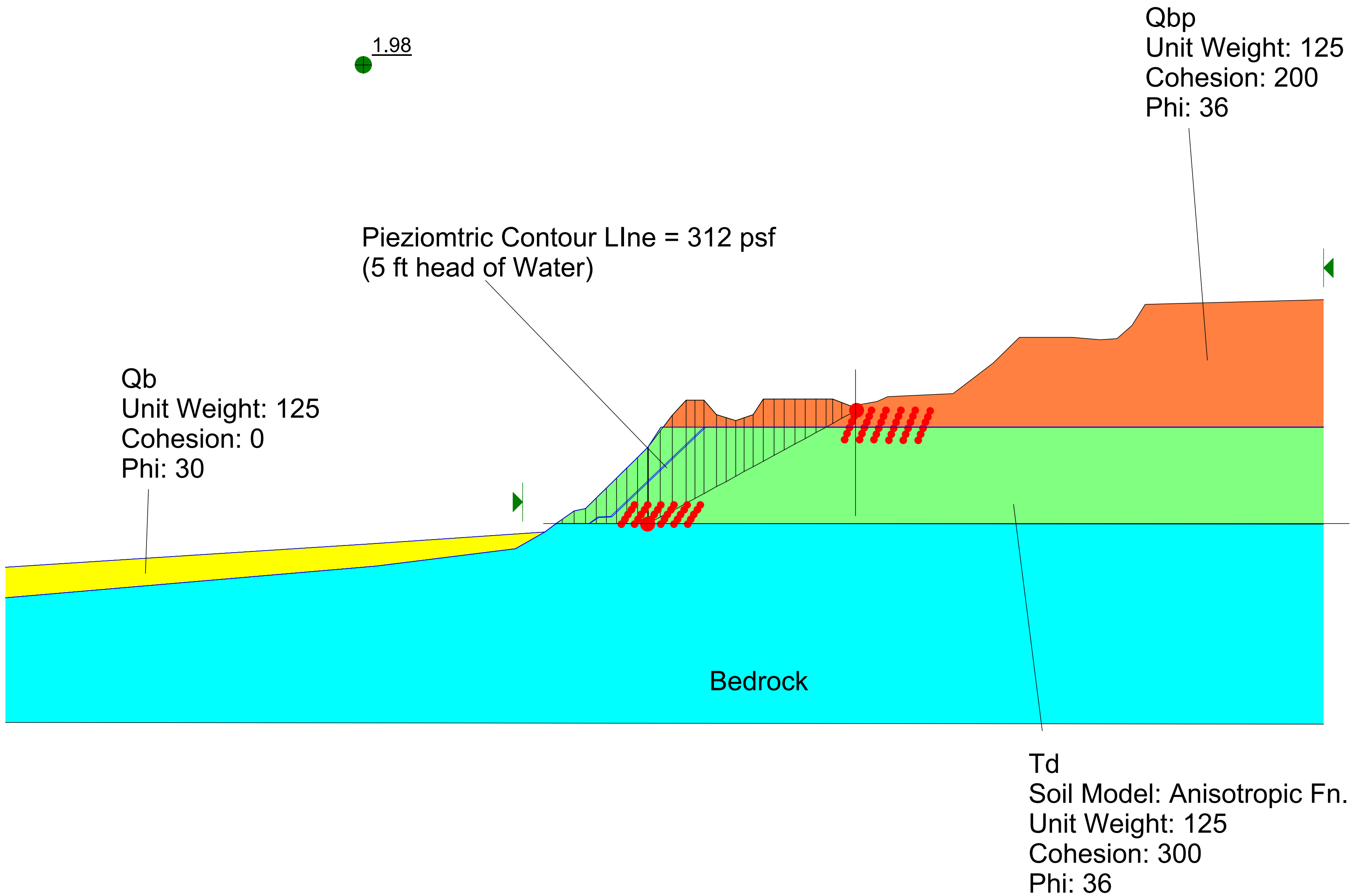
Seismic Coefficient - 0.28



Cross Section 18-18’

Del Mar Bluffs Cross Section 18-18'
Slope Stability Analysis
File Name: Section 1818 with 5 ft Water Static 2.slz
Analysis Method: Spencer

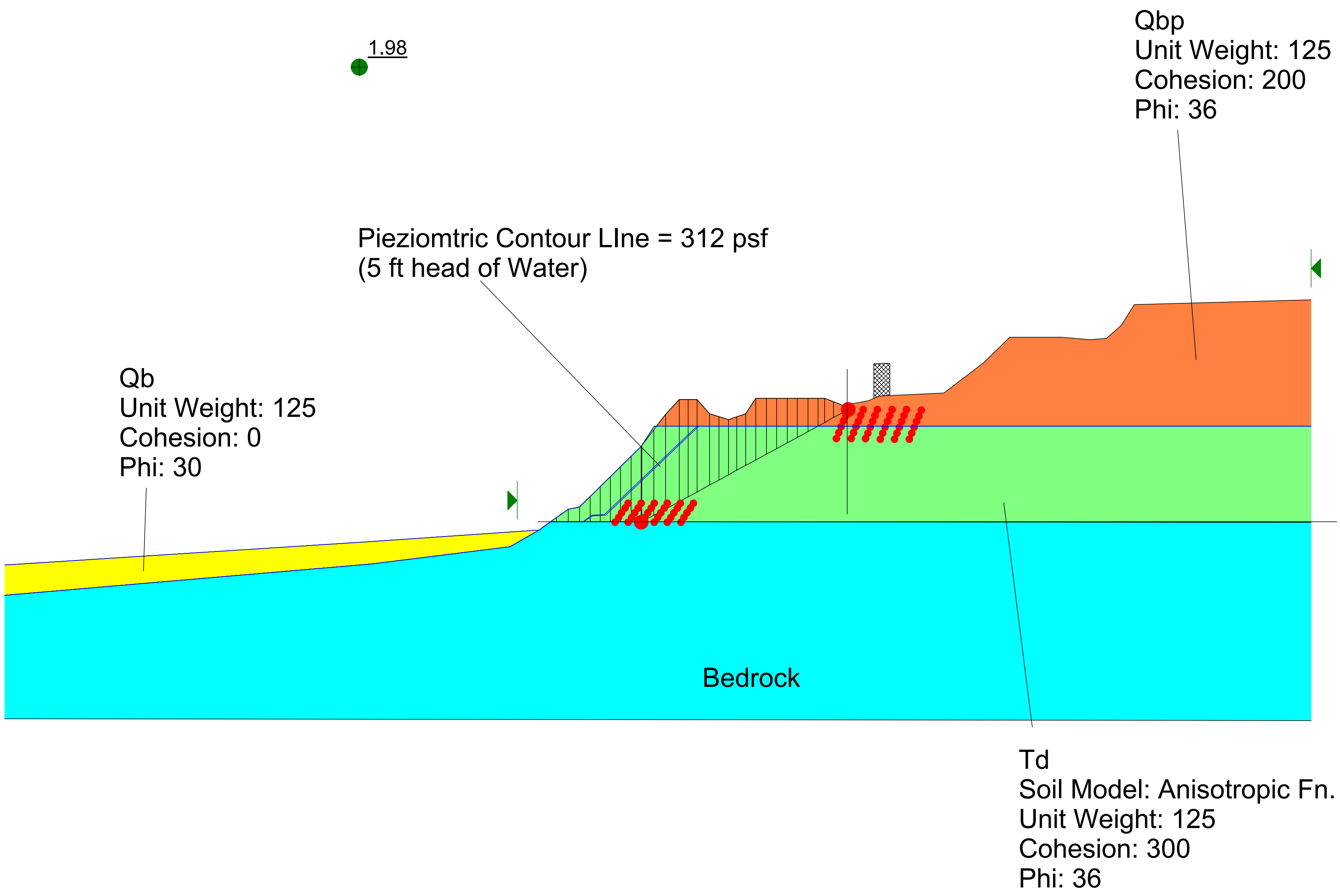
Factor of Safety: 1.98



Del Mar Bluffs Cross Section 18-18'
Slope Stability Analysis
File Name: Section 1818 with 5 ft Water Static 2C.slz
Analysis Method: Spencer

Factor of Safety: 1.98

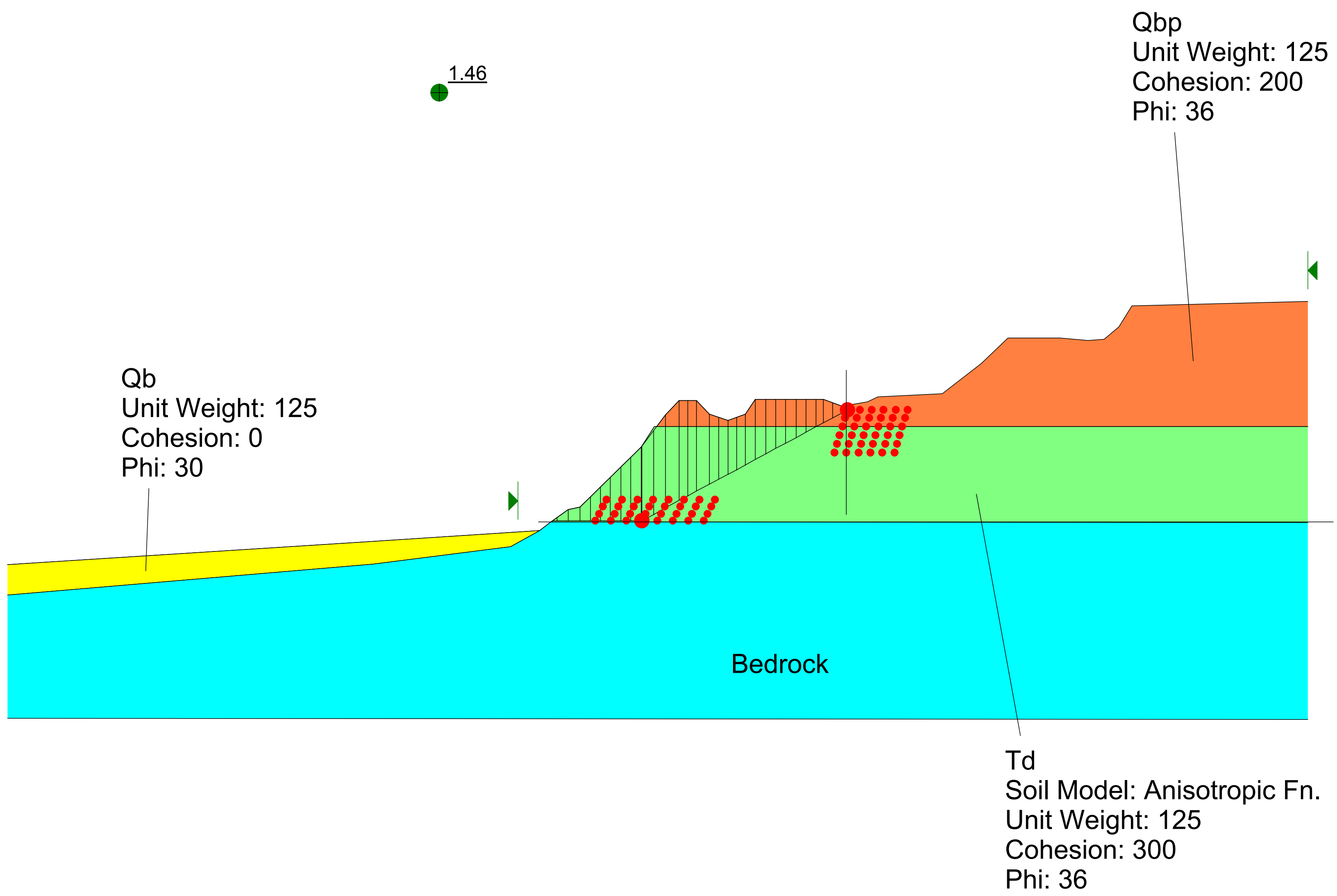
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 18-18'
Slope Stability Analysis
File Name: Section1818 Psuedo Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.46

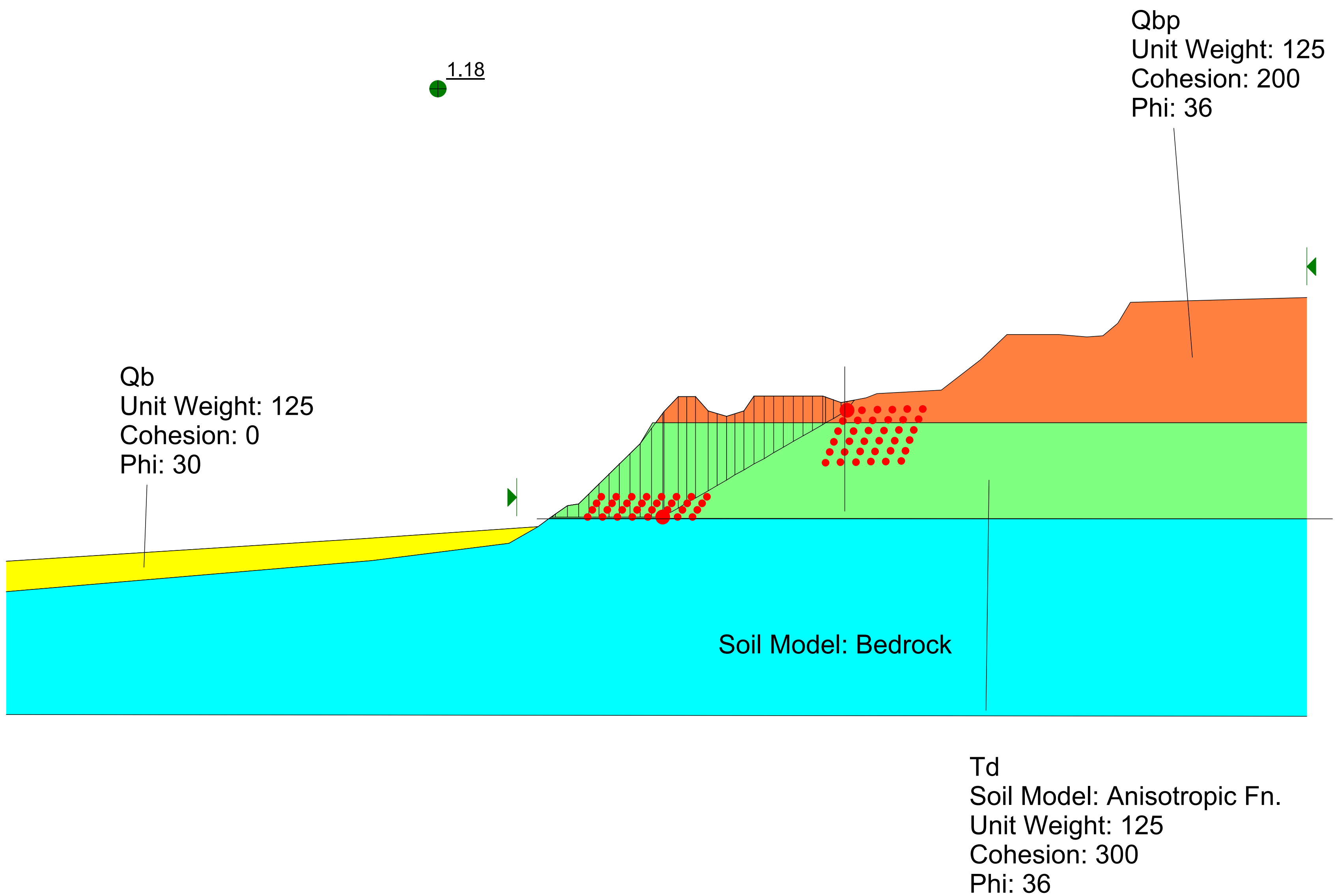
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 18-18'
Slope Stability Analysis
File Name: Section 1818 Psuedo Static 4.slz
Analysis Method: Spencer

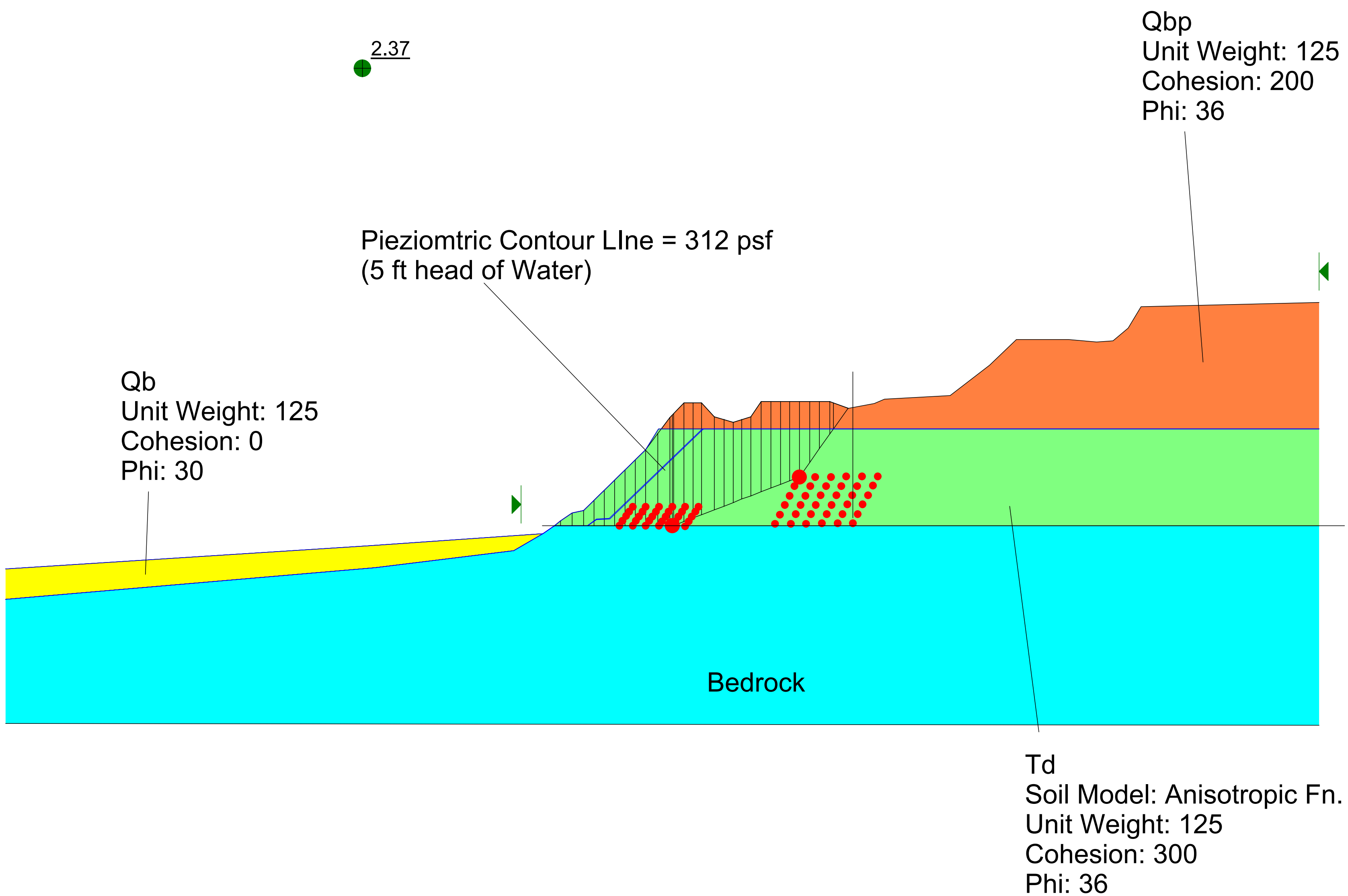
Factor of Safety: 1.18

Seismic Coefficient = 0.28



Del Mar Bluffs Cross Section 18-18'
Slope Stability Analysis
File Name: Section 1818 with 5 ft Water Static 2B.slz
Analysis Method: Spencer

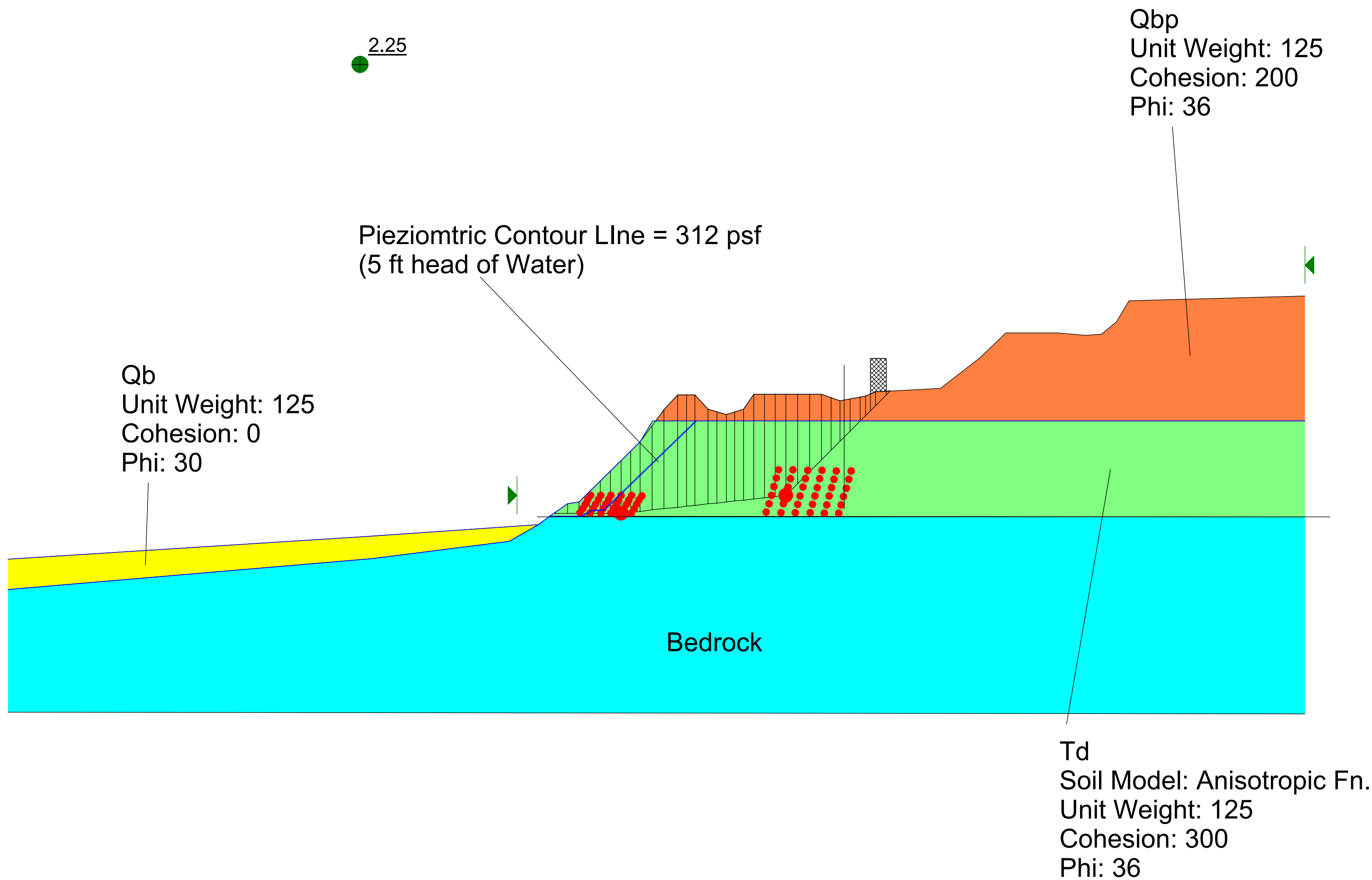
Factor of Safety: 2.37



Del Mar Bluffs Cross Section 18-18'
Slope Stability Analysis
File Name: Section 1818 with 5 ft Water Static 4B.slz
Analysis Method: Spencer

Factor of Safety: 2.25

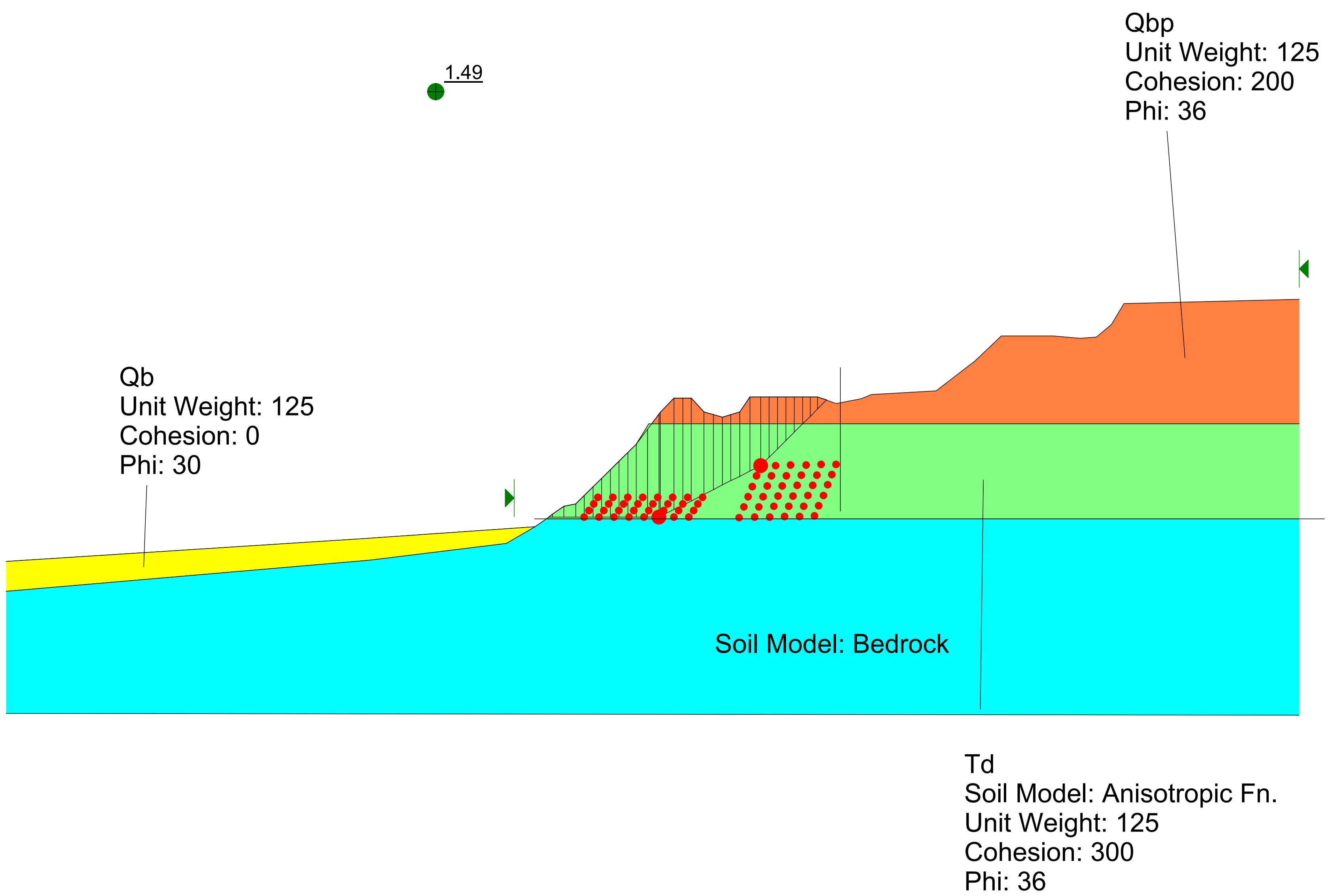
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 18-18'
Slope Stability Analysis
File Name: Section 1818 Psuedo Static 2B.slz
Analysis Method: Spencer

Factor of Safety: 1.49

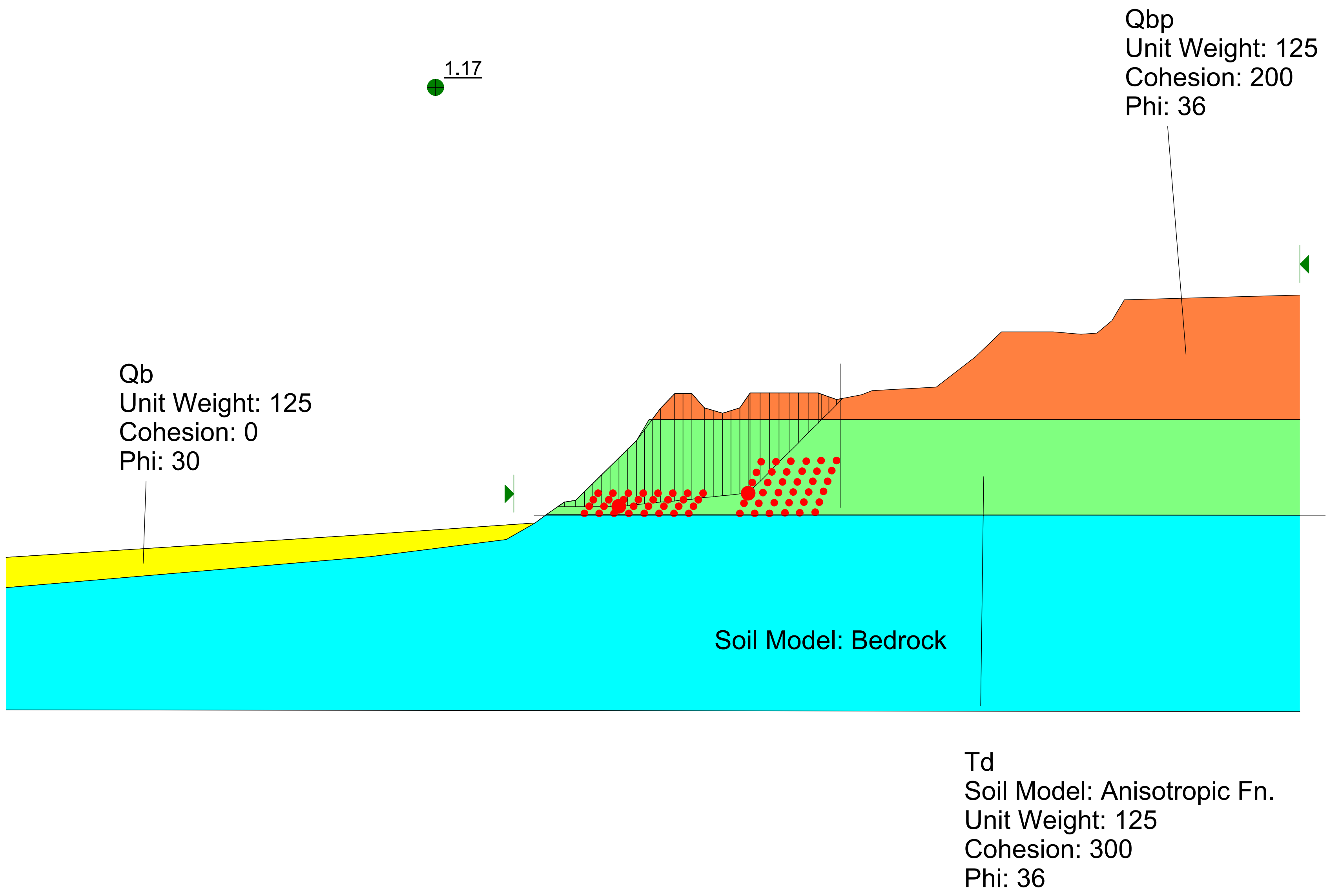
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 18-18'
Slope Stability Analysis
File Name: Section 1818 Psuedo Static 4B.slz
Analysis Method: Spencer

Factor of Safety: 1.17

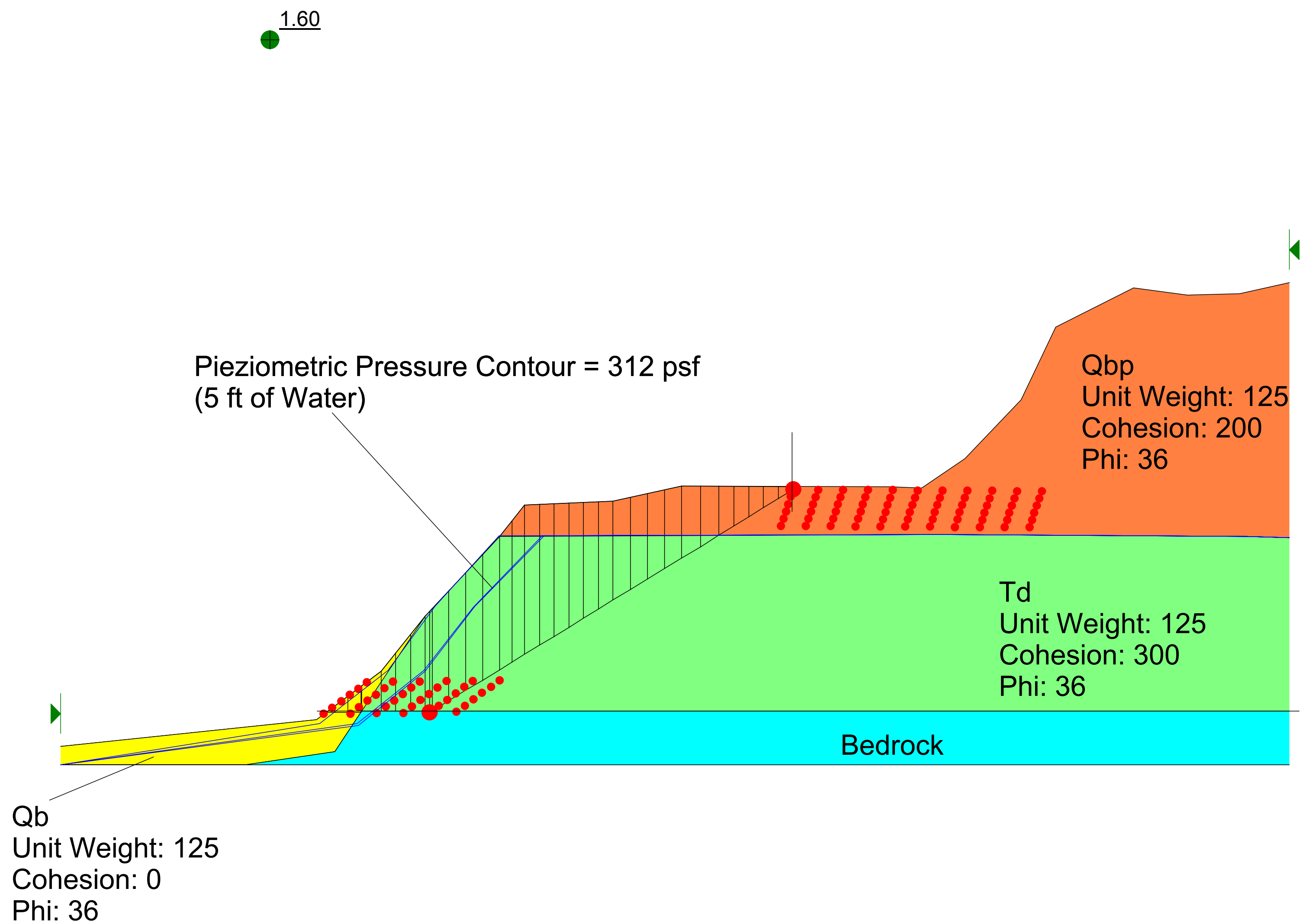
Seismic Coefficient = 0.28



Cross Section 19-19’

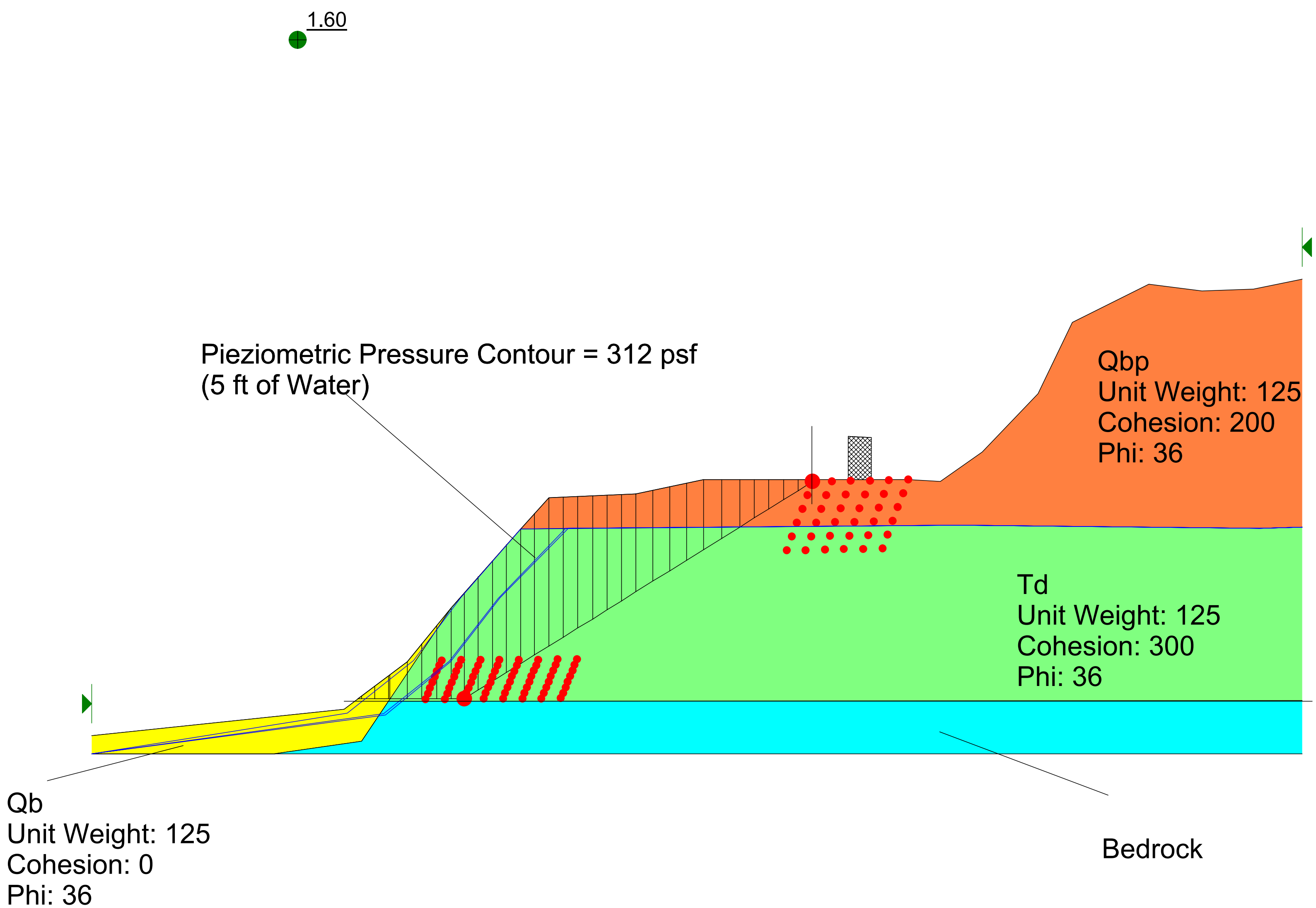
Del Mar Bluffs Cross Section 19-19'
Static Slope Analysis
File Name: Section 1919 Static With Water 3.slz
Analysis Method: Spencer

Factor of Safety: 1.6



Del Mar Bluffs Cross Section 19-19'
Static Slope Analysis
File Name: Section 1919 Static With Water 4.slz
Analysis Method: Spencer

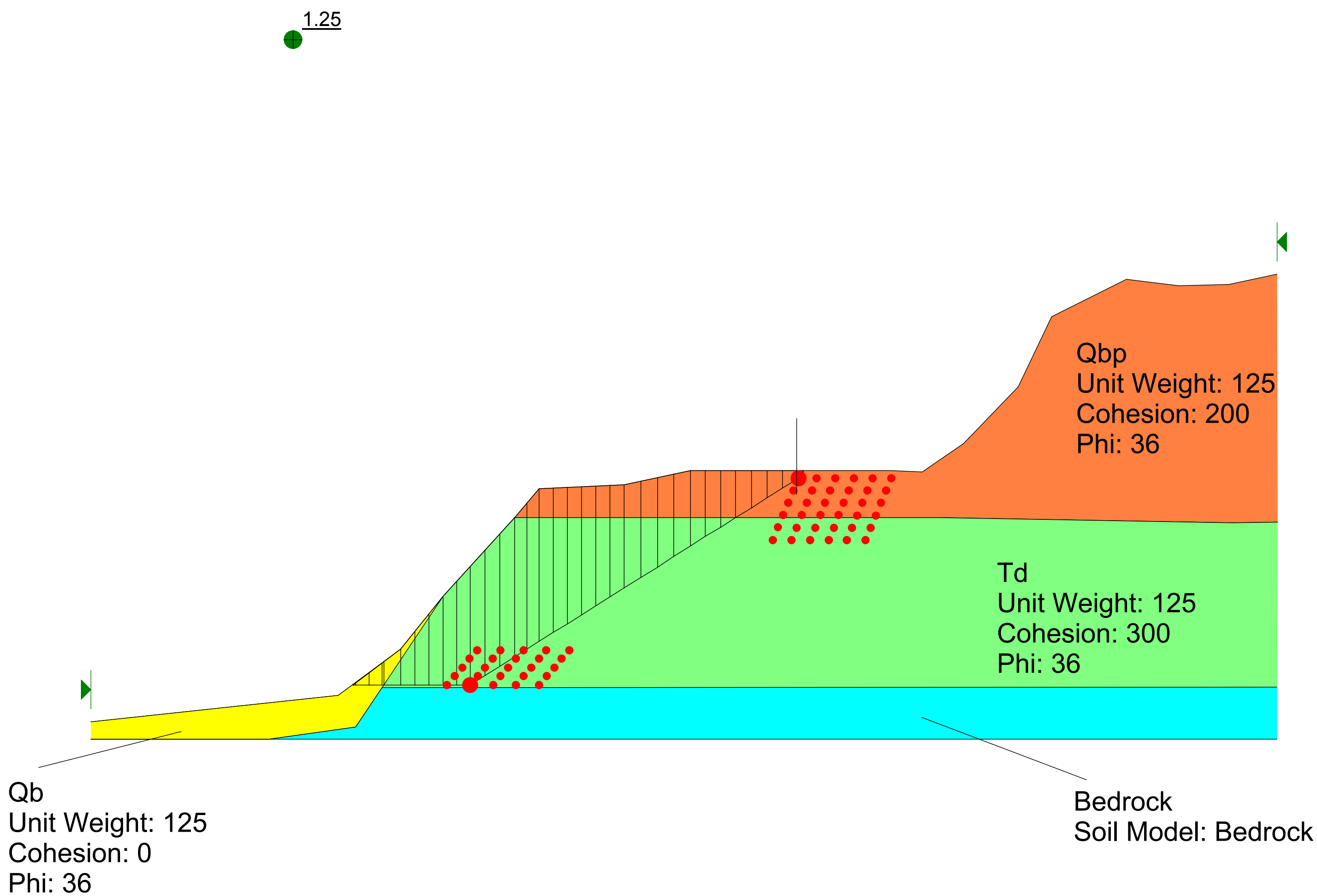
Factor of Safety: 1.6
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 19-19'
Static Slope Analysis
File NameSection 1919 Psuedo Static 3.slz
Analysis MethodSpencer

Factor of Safety: 1.25

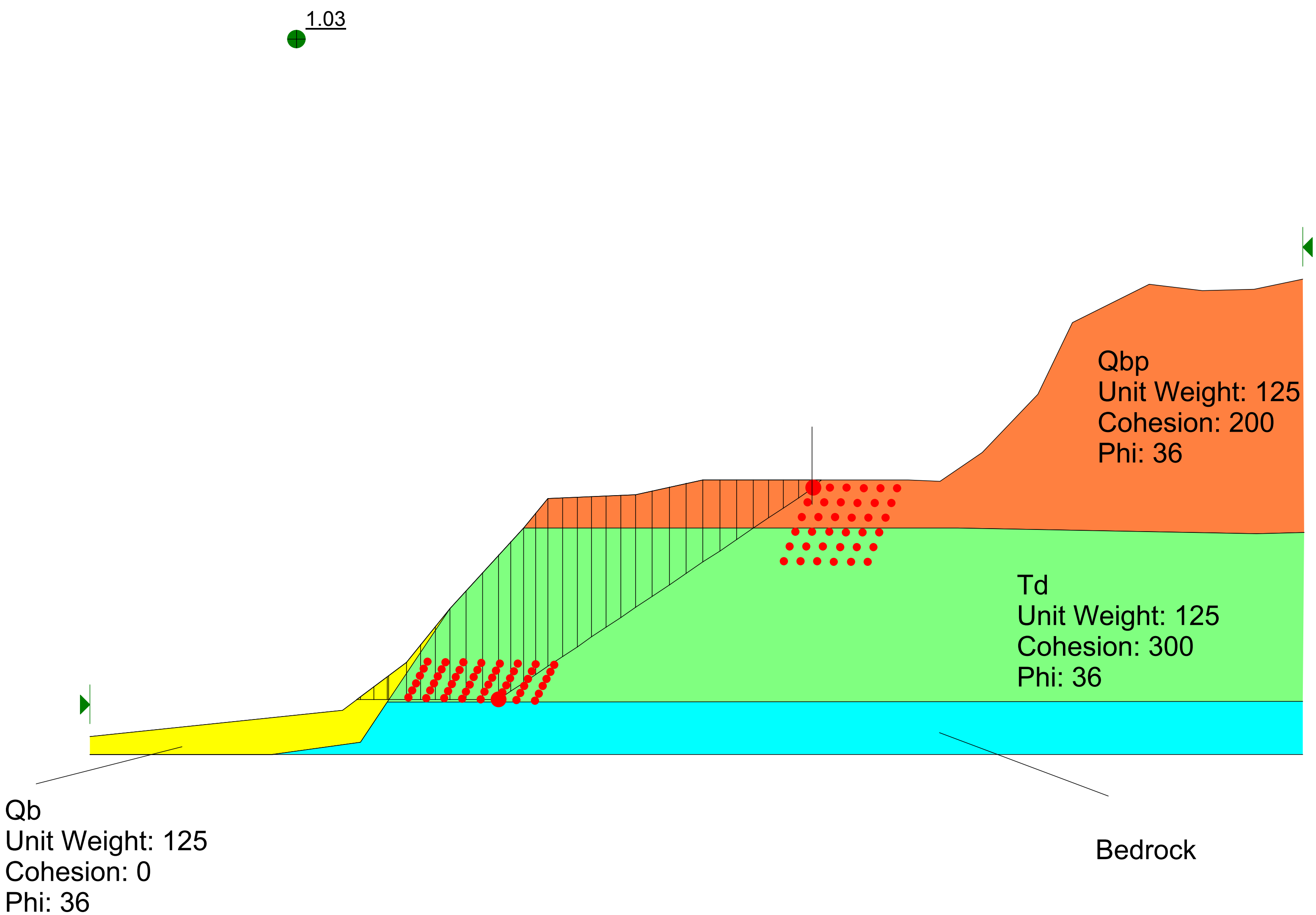
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 19-19'
Static Slope Analysis
File NameSection 1919 Psuedo Static 4.slz
Analysis MethodSpencer

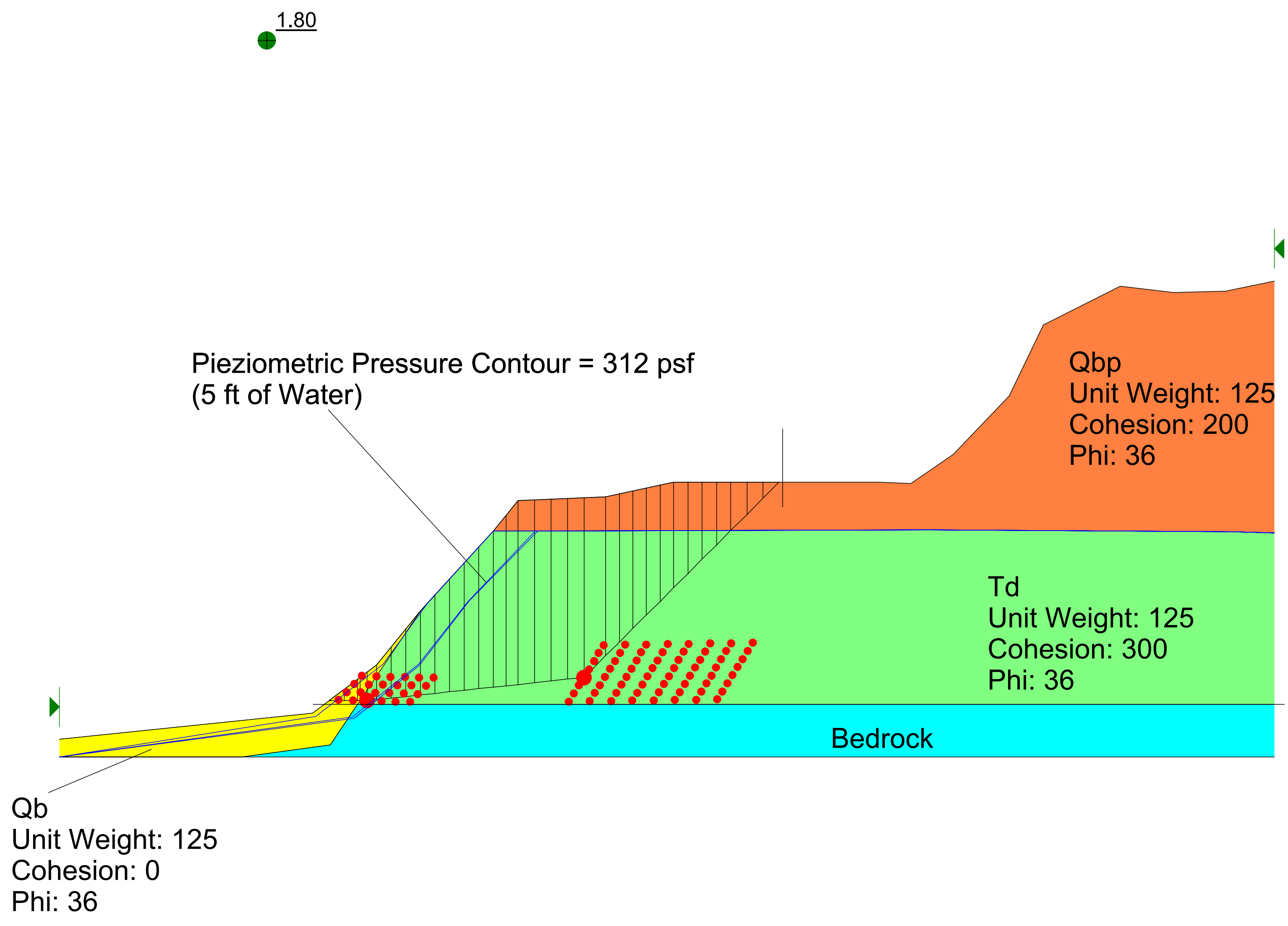
Factor of Safety: 1.03

Seismic Coefficient = 0.28



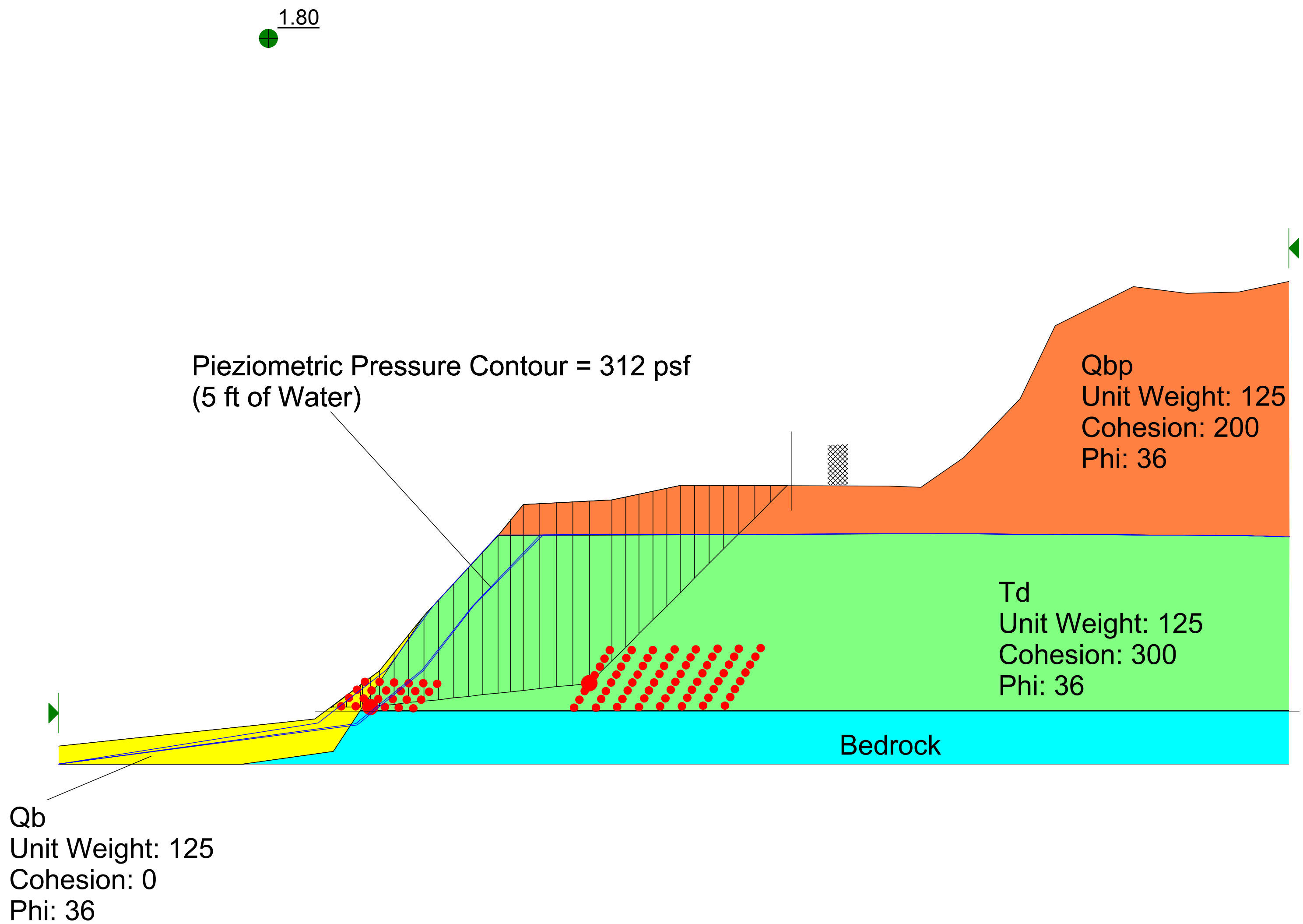
Del Mar Bluffs Cross Section 19-19'
Static Slope Analysis
File Name: Section 1919 Static With Water 3B.slz
Analysis Method: Spencer

Factor of Safety: 1.8



Del Mar Bluffs Cross Section 19-19'
Static Slope Analysis
File Name: Section 1919 Static With Water 4B.slz
Analysis Method: Spencer

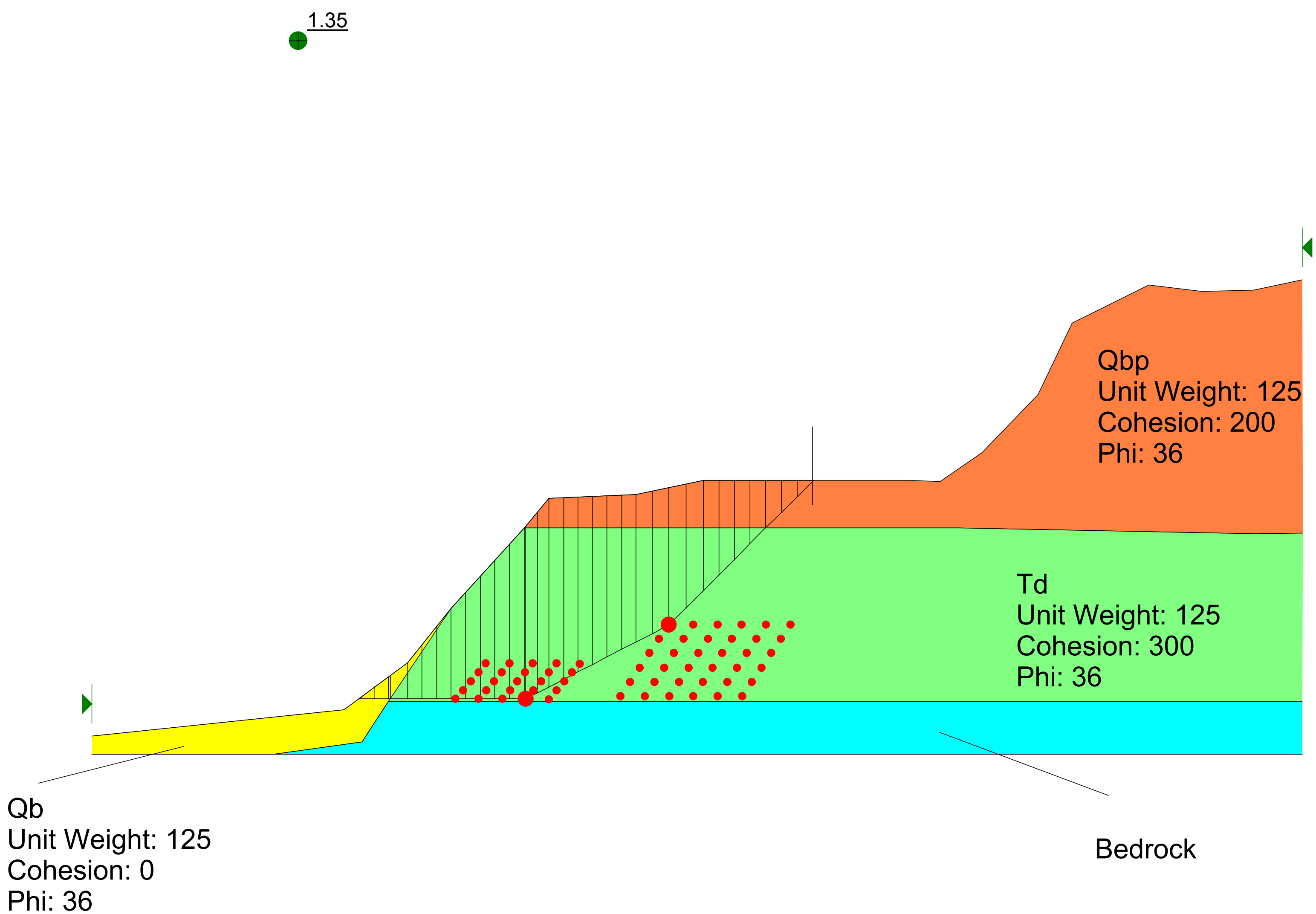
Factor of Safety: 1.8



Del Mar Bluffs Cross Section 19-19'
Static Slope Analysis
File NameSection 1919 Psuedo Static 3B.slz
Analysis MethodSpencer

Factor of Safety: 1.35

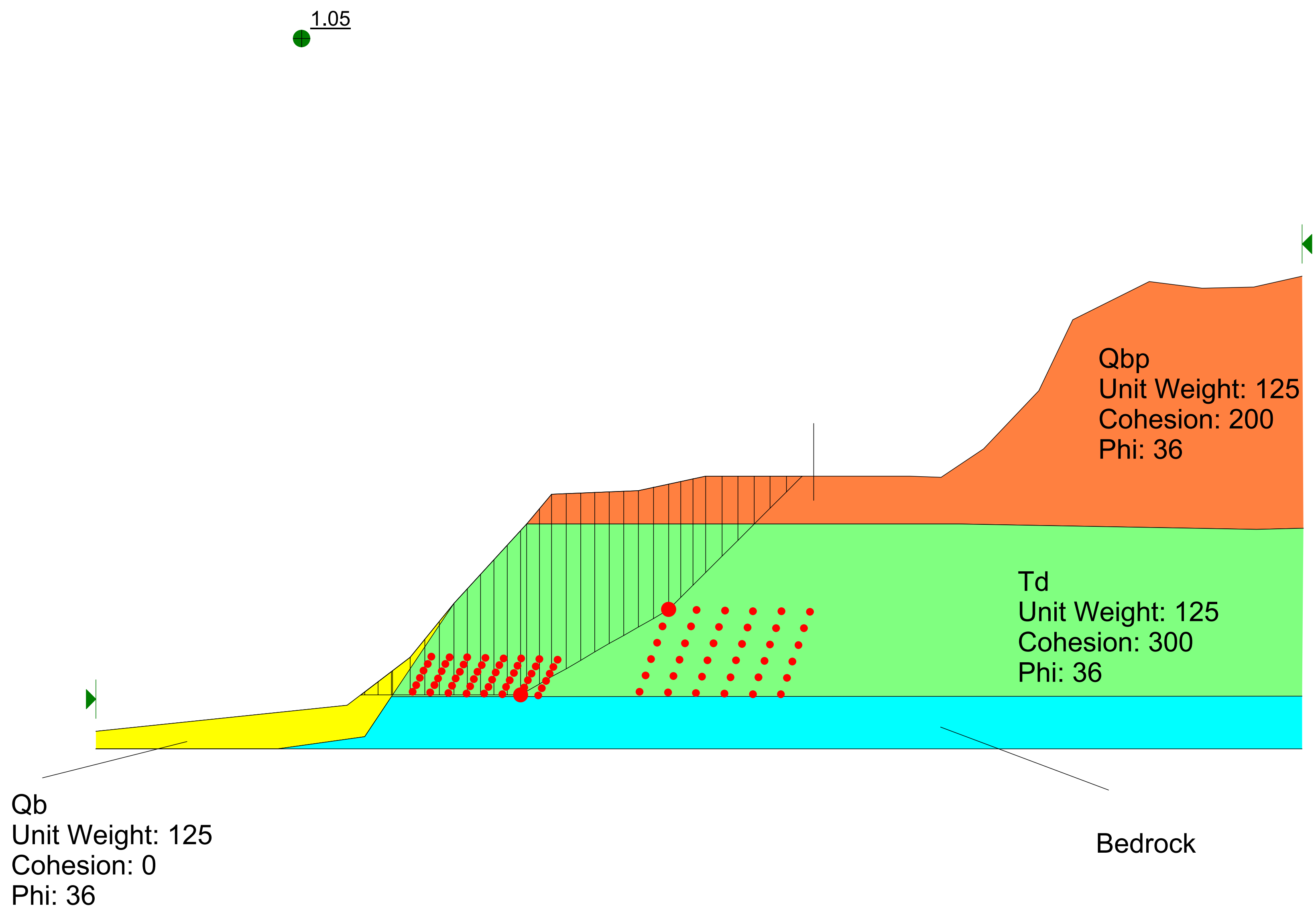
Seismic Coefficient = 0.15



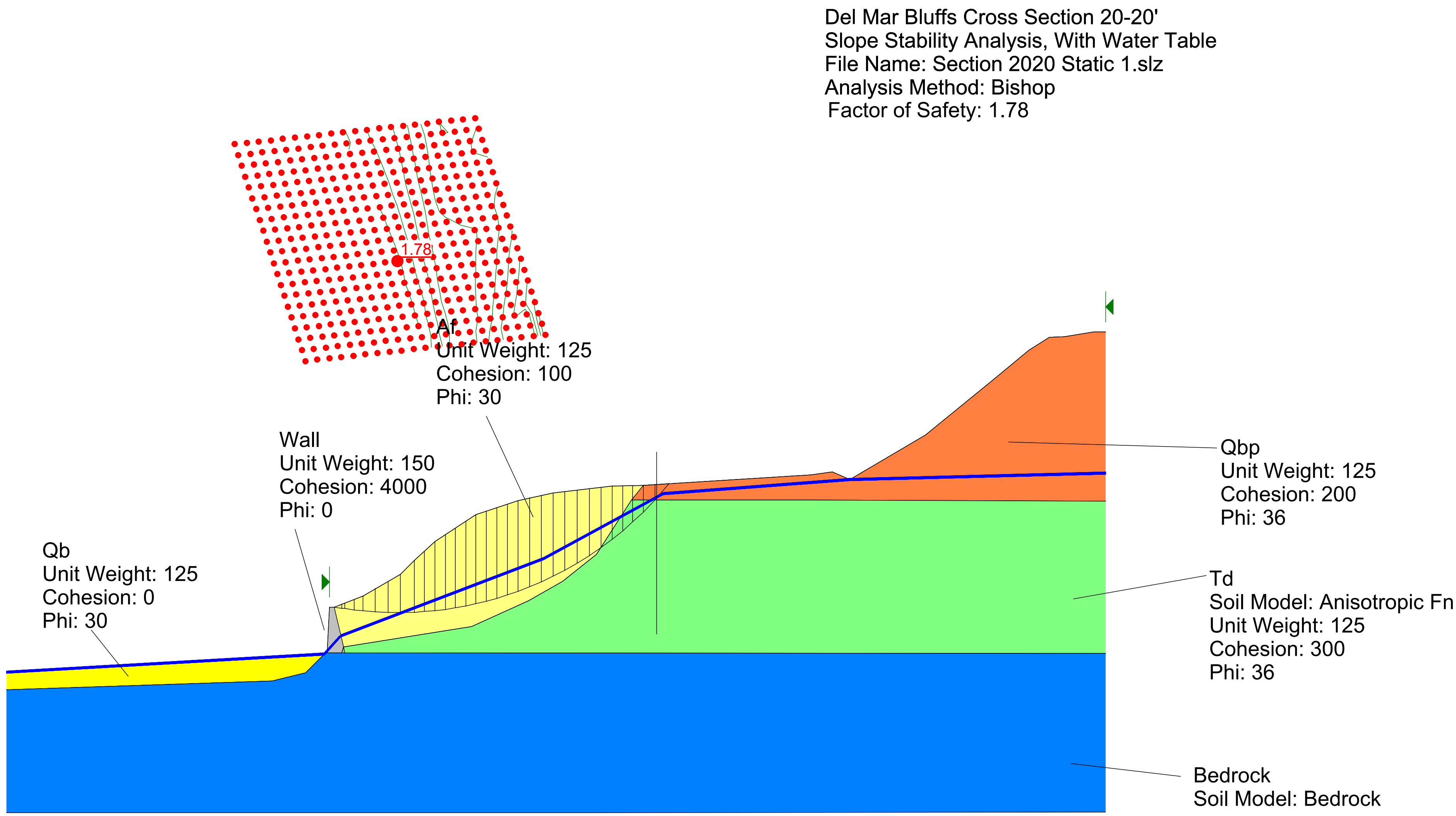
Del Mar Bluffs Cross Section 19-19'
Static Slope Analysis
File NameSection 1919 Psuedo Static 4B.slz
Analysis MethodSpencer

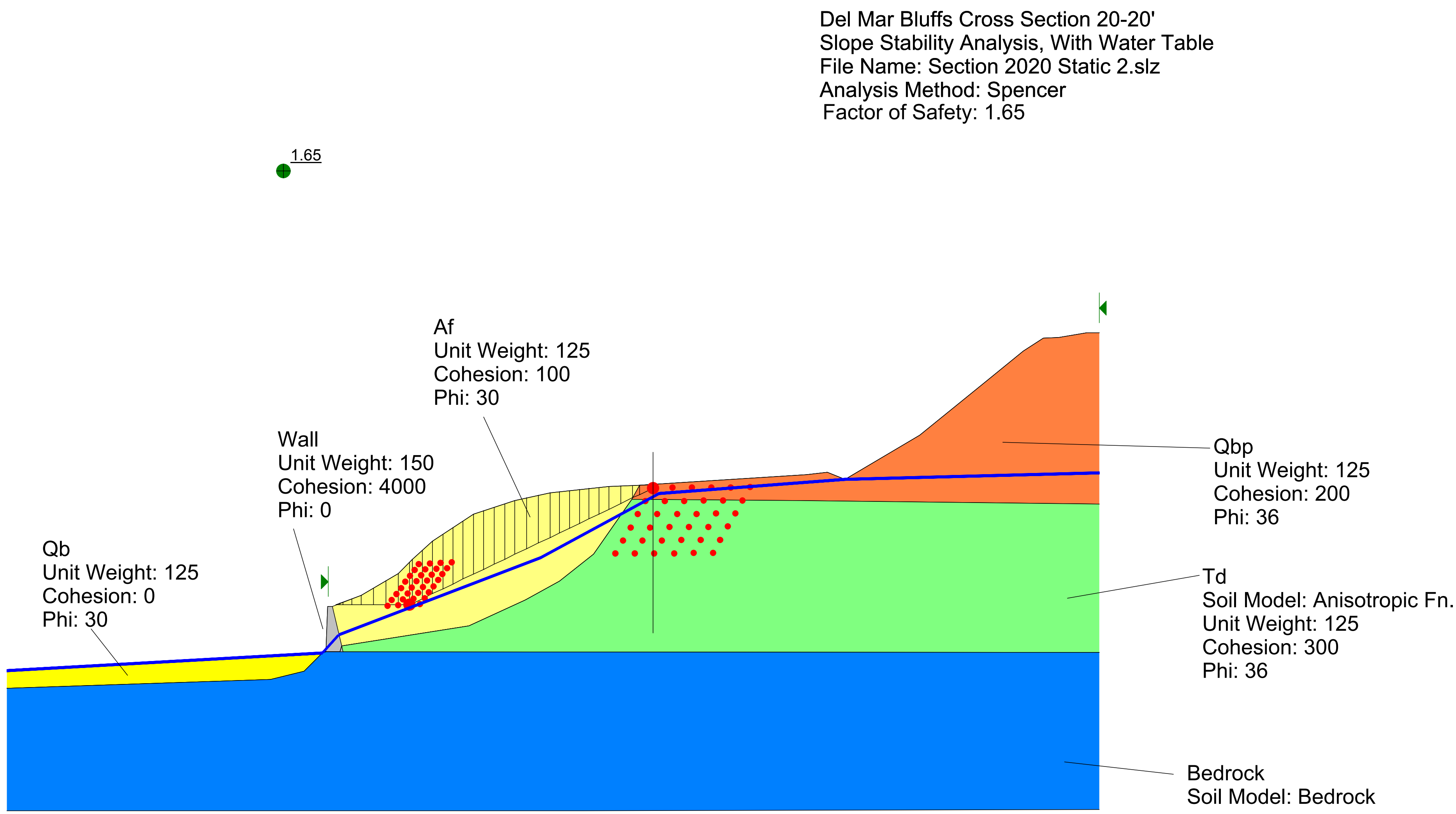
Factor of Safety: 1.05

Seismic Coefficient = 0.28

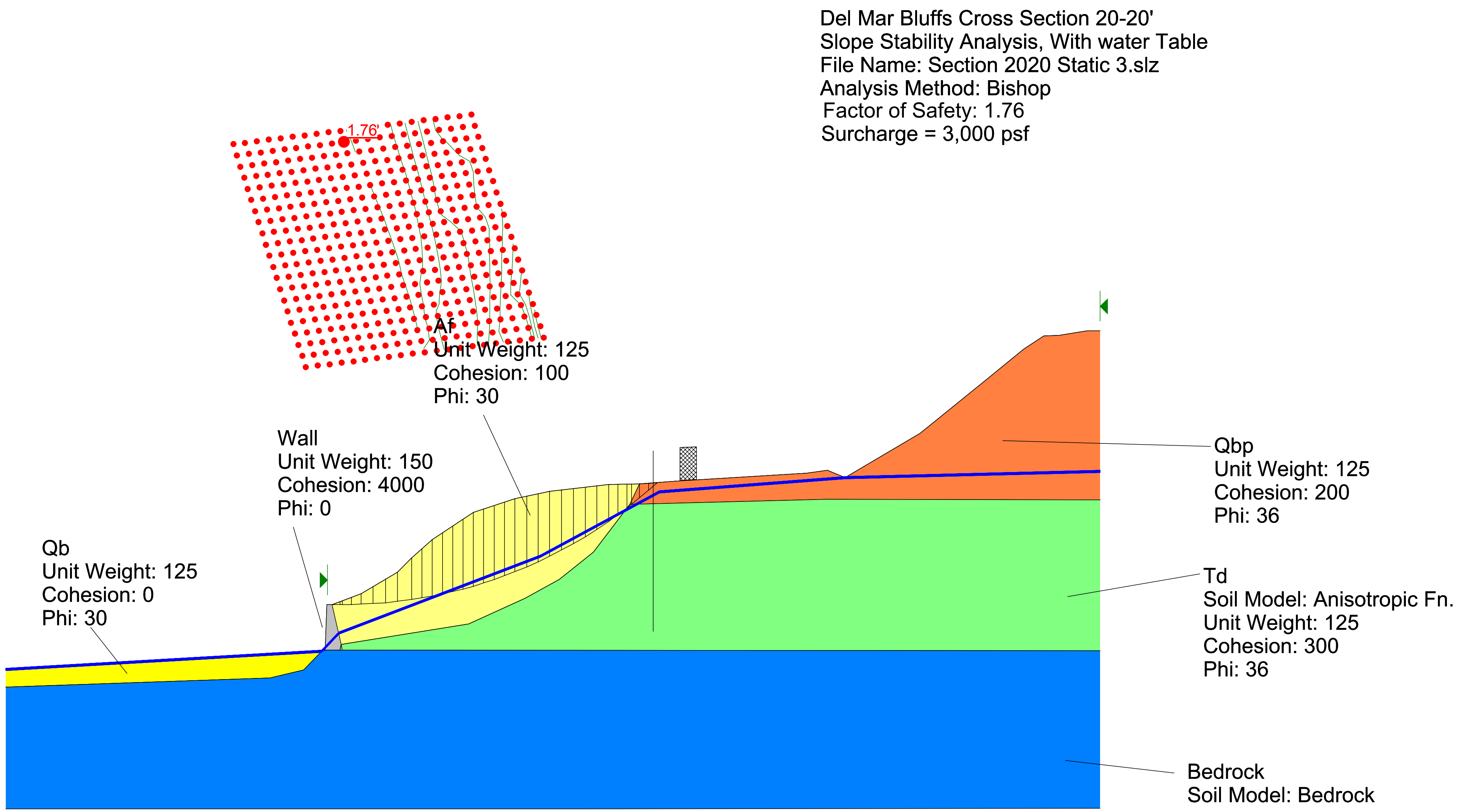


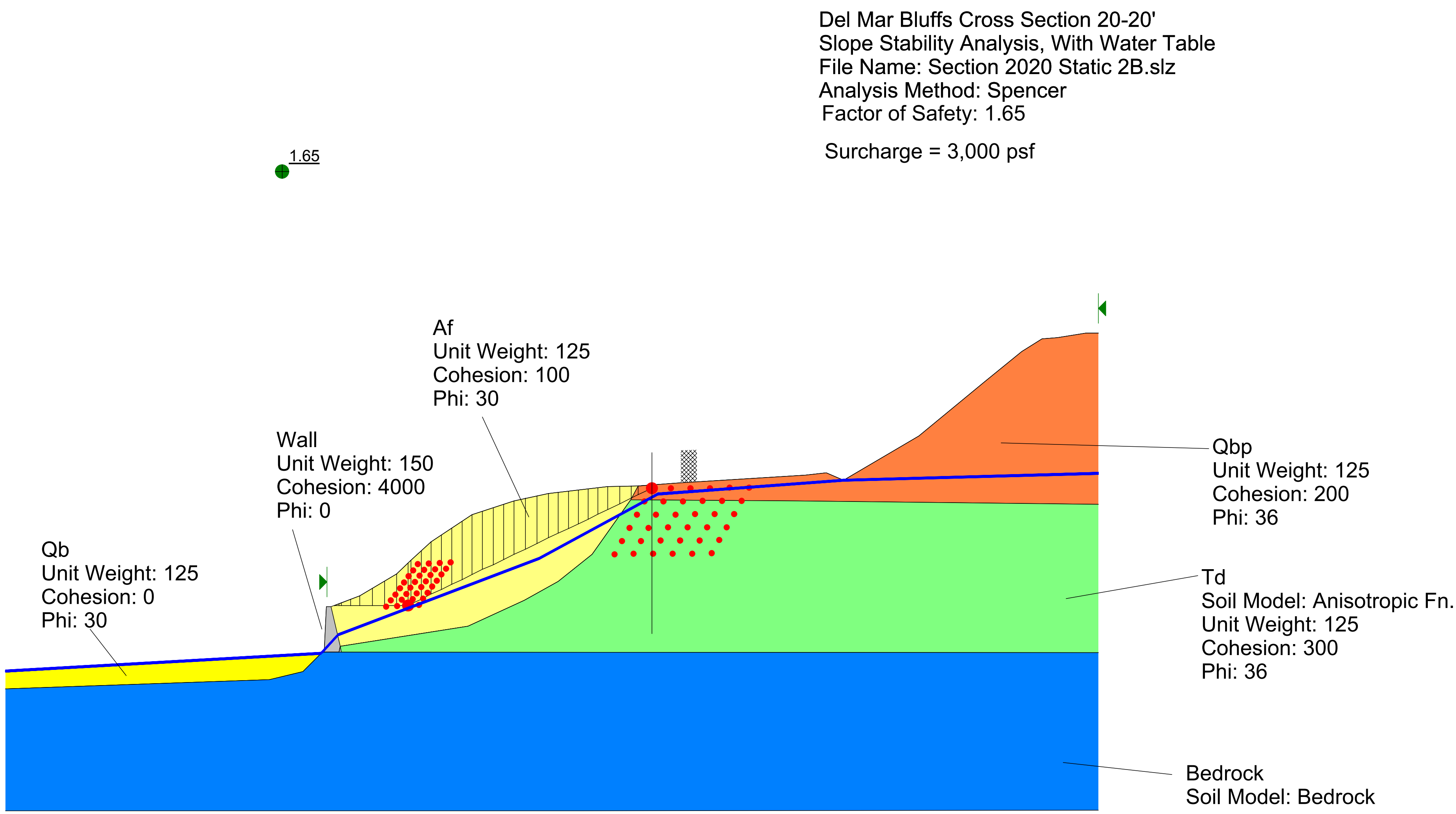
Cross Section 20-20’

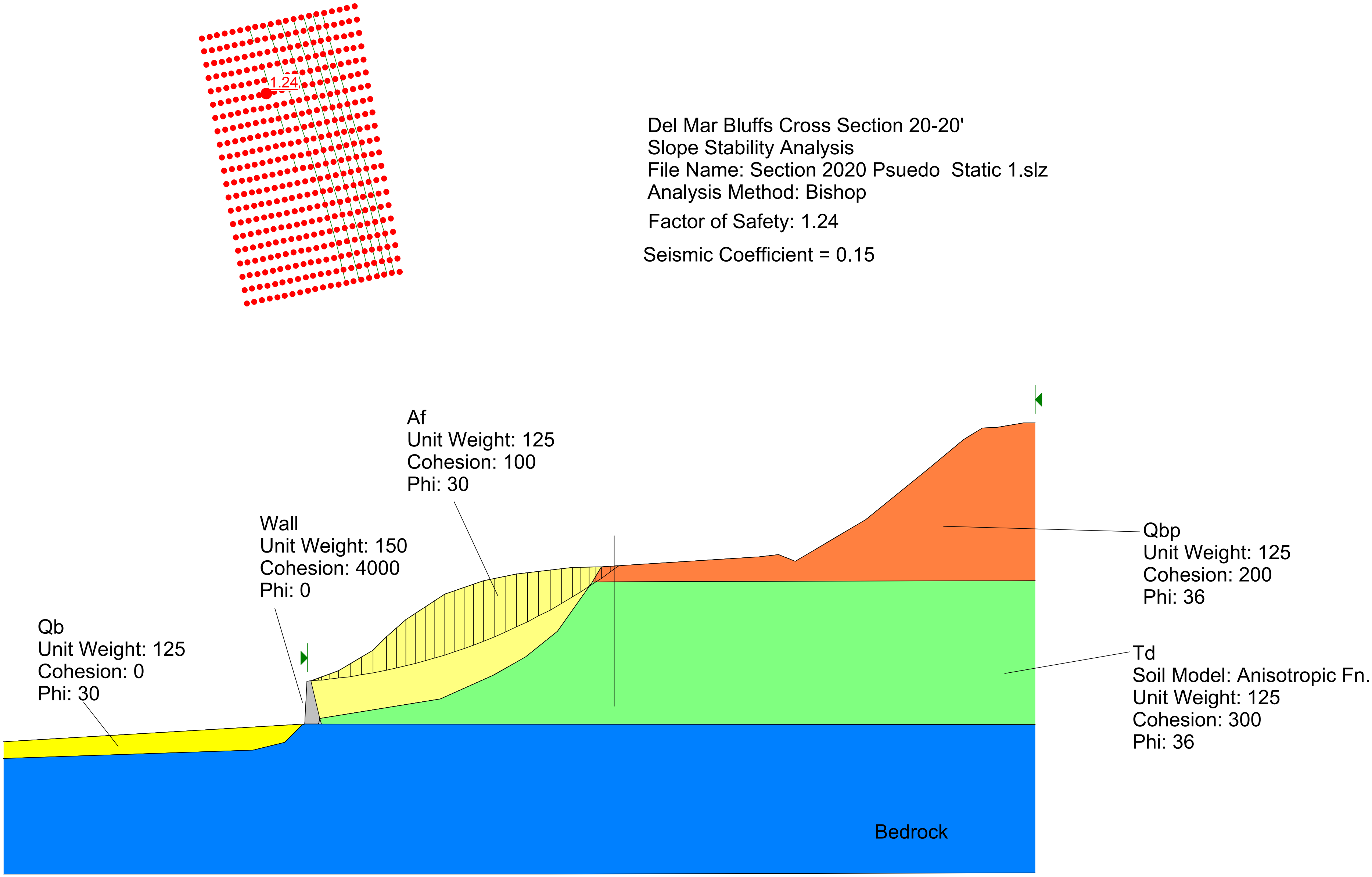

Del Mar Bluffs Cross Section 20-20'
Slope Stability Analysis, With Water Table
File Name: Section 2020 Static 1.slz
Analysis Method: Bishop
Factor of Safety: 1.78
1.78
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Wall
Unit Weight: 150
Cohesion: 4000
Phi: 0
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock
Soil Model: Bedrock



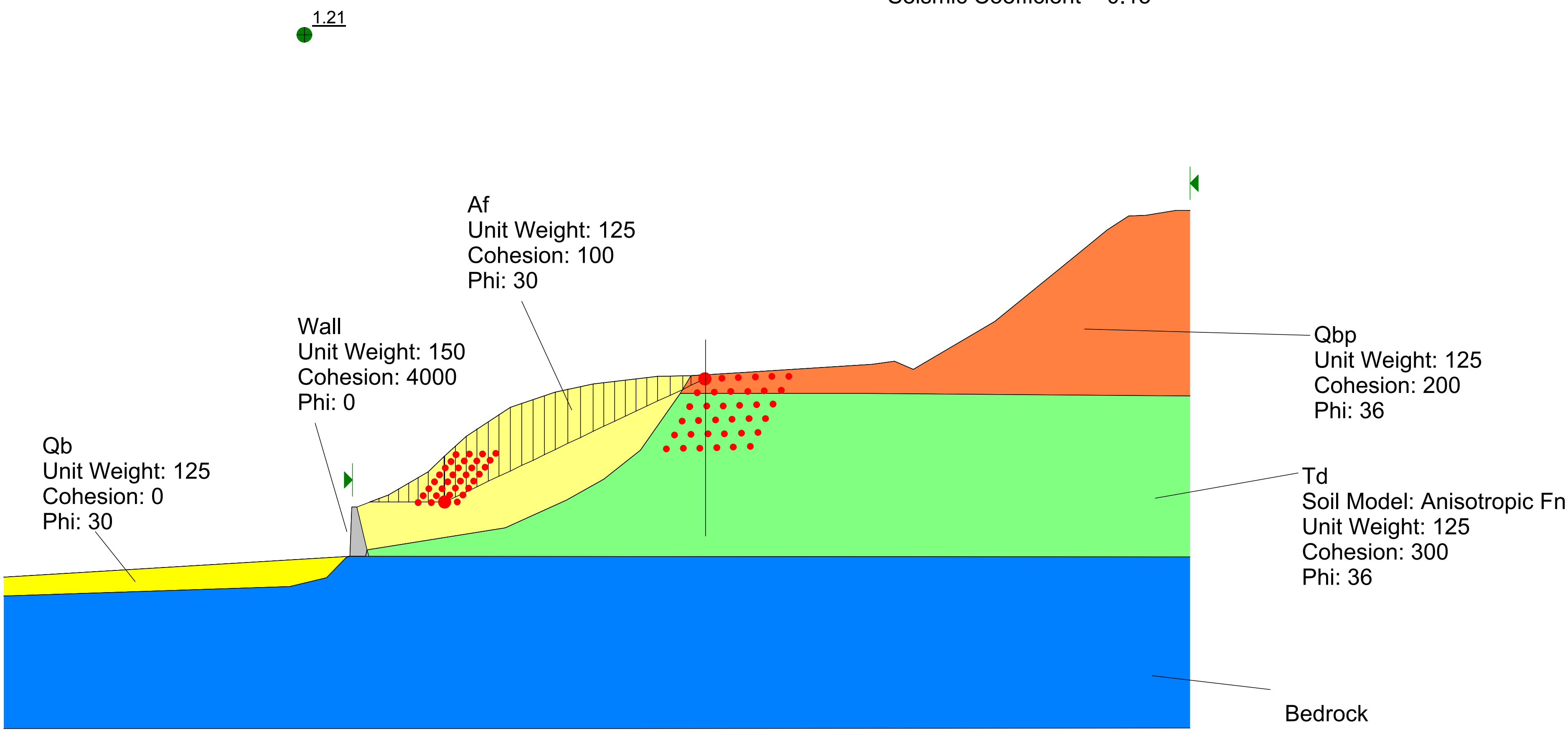
Del Mar Bluffs Cross Section 20-20'
Slope Stability Analysis, With Water Table
File Name: Section 2020 Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.65
1.65
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Wall
Unit Weight: 150
Cohesion: 4000
Phi: 0
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock
Soil Model: Bedrock

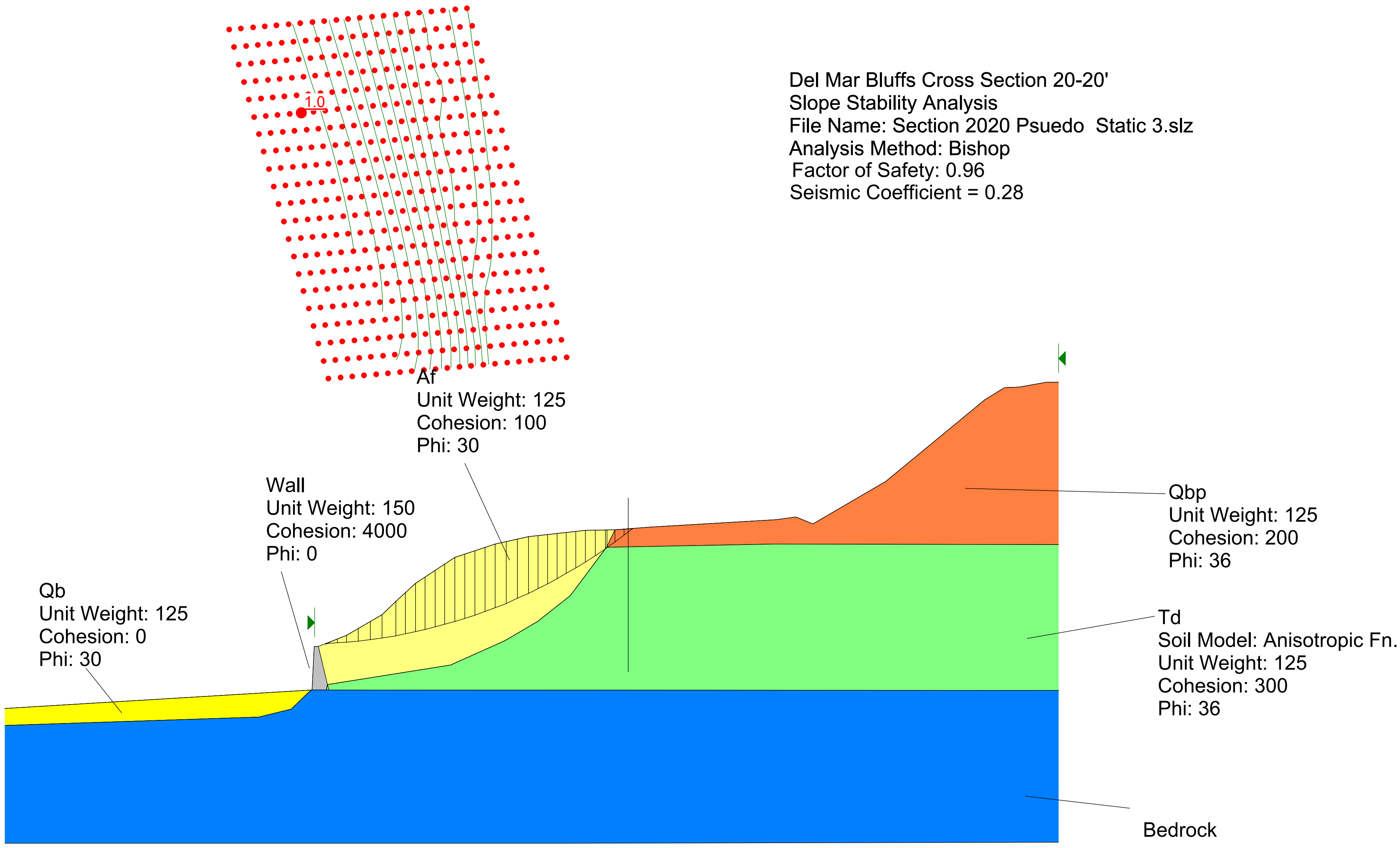

Del Mar Bluffs Cross Section 20-20'
Slope Stability Analysis, With water Table
File Name: Section 2020 Static 3.slz
Analysis Method: Bishop
Factor of Safety: 1.76
Surcharge = 3,000 psf
1.76'
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Wall
Unit Weight: 150
Cohesion: 4000
Phi: 0
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock
Soil Model: Bedrock


Del Mar Bluffs Cross Section 20-20'
Slope Stability Analysis, With Water Table
File Name: Section 2020 Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 1.65
Surcharge = 3,000 psf
1.65
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Wall
Unit Weight: 150
Cohesion: 4000
Phi: 0
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock
Soil Model: Bedrock

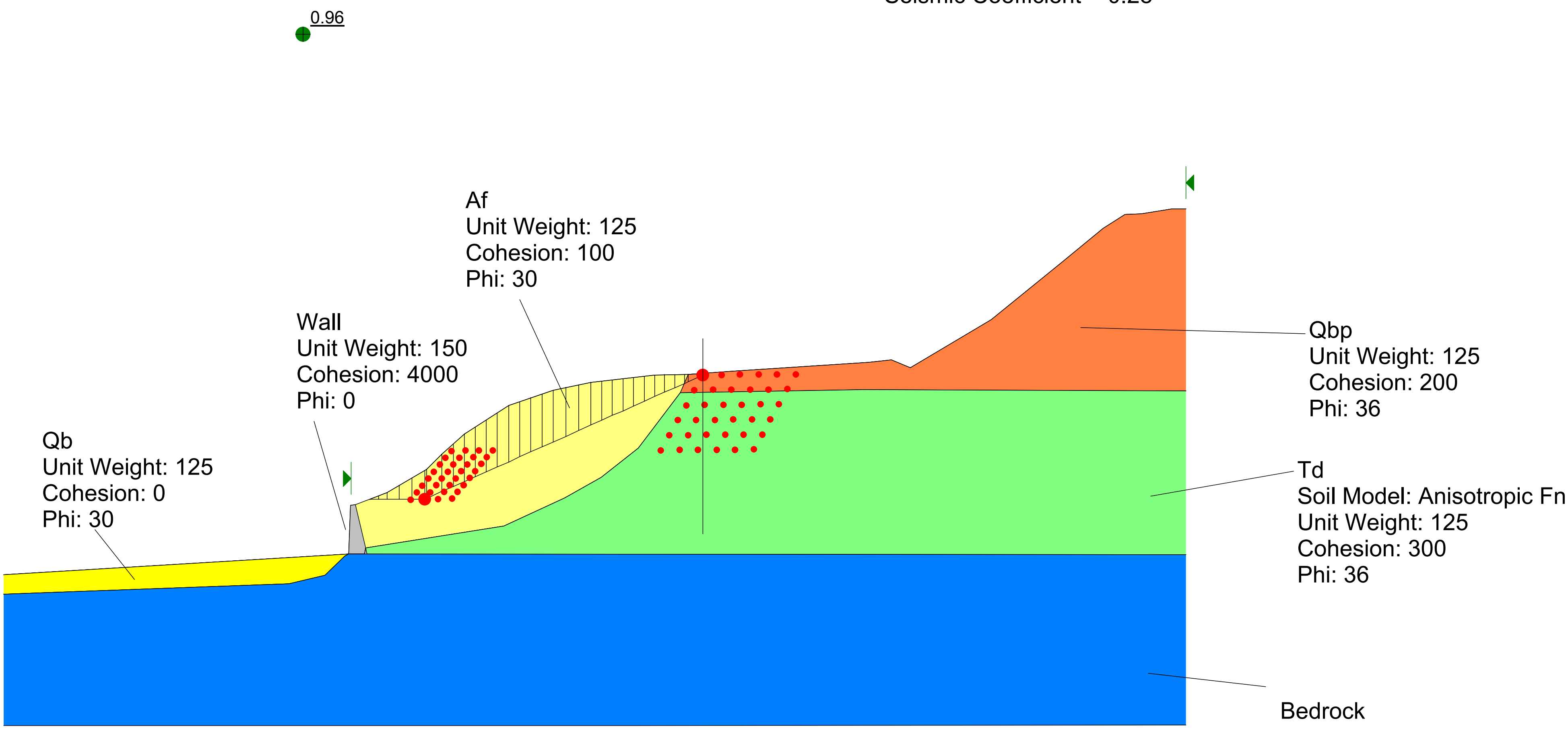

1.24
Del Mar Bluffs Cross Section 20-20'
Slope Stability Analysis
File Name: Section 2020 Psuedo Static 1.slz
Analysis Method: Bishop
Factor of Safety: 1.24
Seismic Coefficient = 0.15
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Wall
Unit Weight: 150
Cohesion: 4000
Phi: 0
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock

Del Mar Bluffs Cross Section 20-20'
Slope Stability Analysis
File Name: Section 2020 Psuedo Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.21
Seismic Coefficient = 0.15



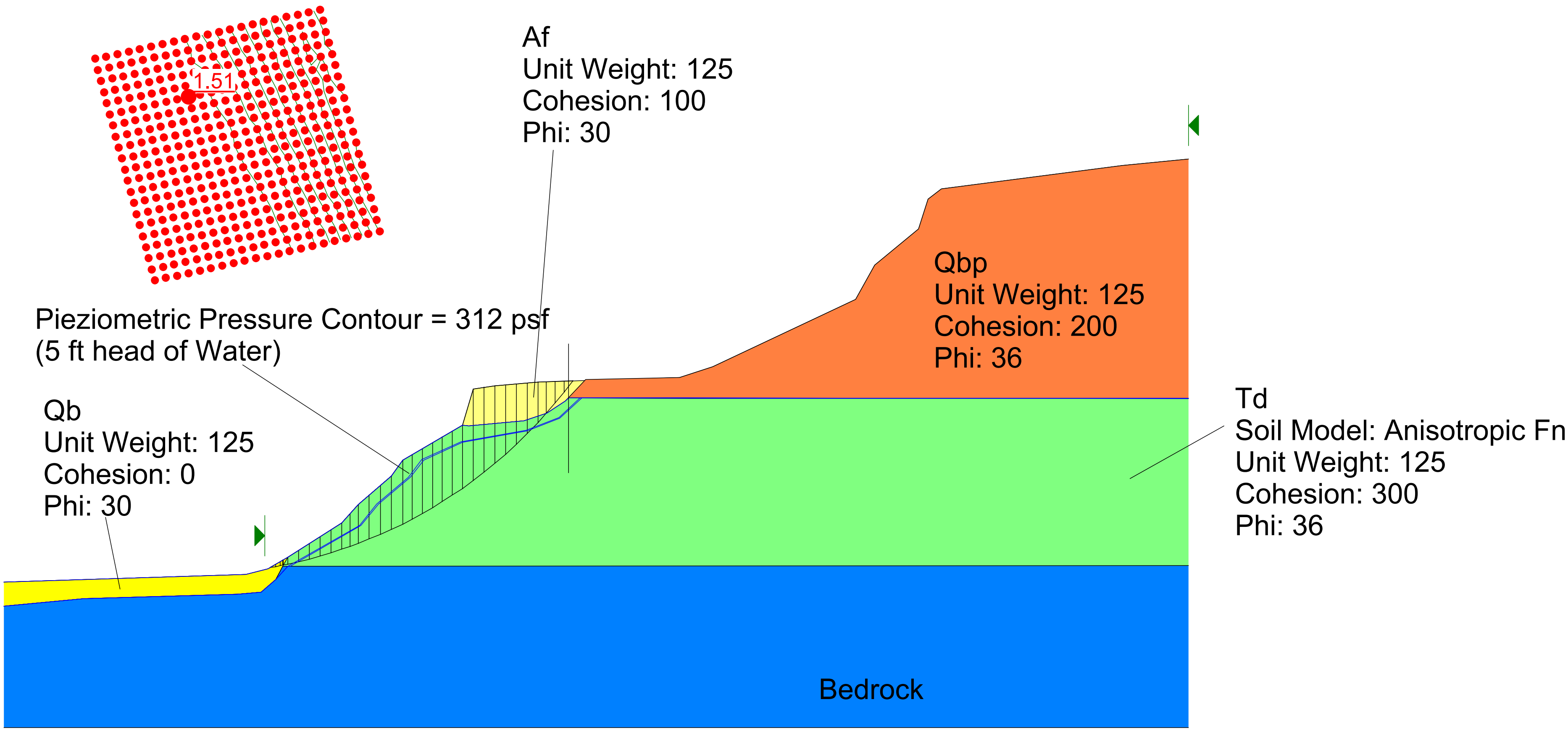

1.0
Del Mar Bluffs Cross Section 20-20'
Slope Stability Analysis
File Name: Section 2020 Psuedo Static 3.slz
Analysis Method: Bishop
Factor of Safety: 0.96
Seismic Coefficient = 0.28
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Wall
Unit Weight: 150
Cohesion: 4000
Phi: 0
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Qbp
Unit Weight: 125
Cohesion: 200
Phi: 36
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock

Del Mar Bluffs Cross Section 20-20'
Slope Stability Analysis
File Name: Section 2020 Psuedo Static 4.slz
Analysis Method: Spencer
Factor of Safety: 0.955
Seismic Coefficient = 0.28

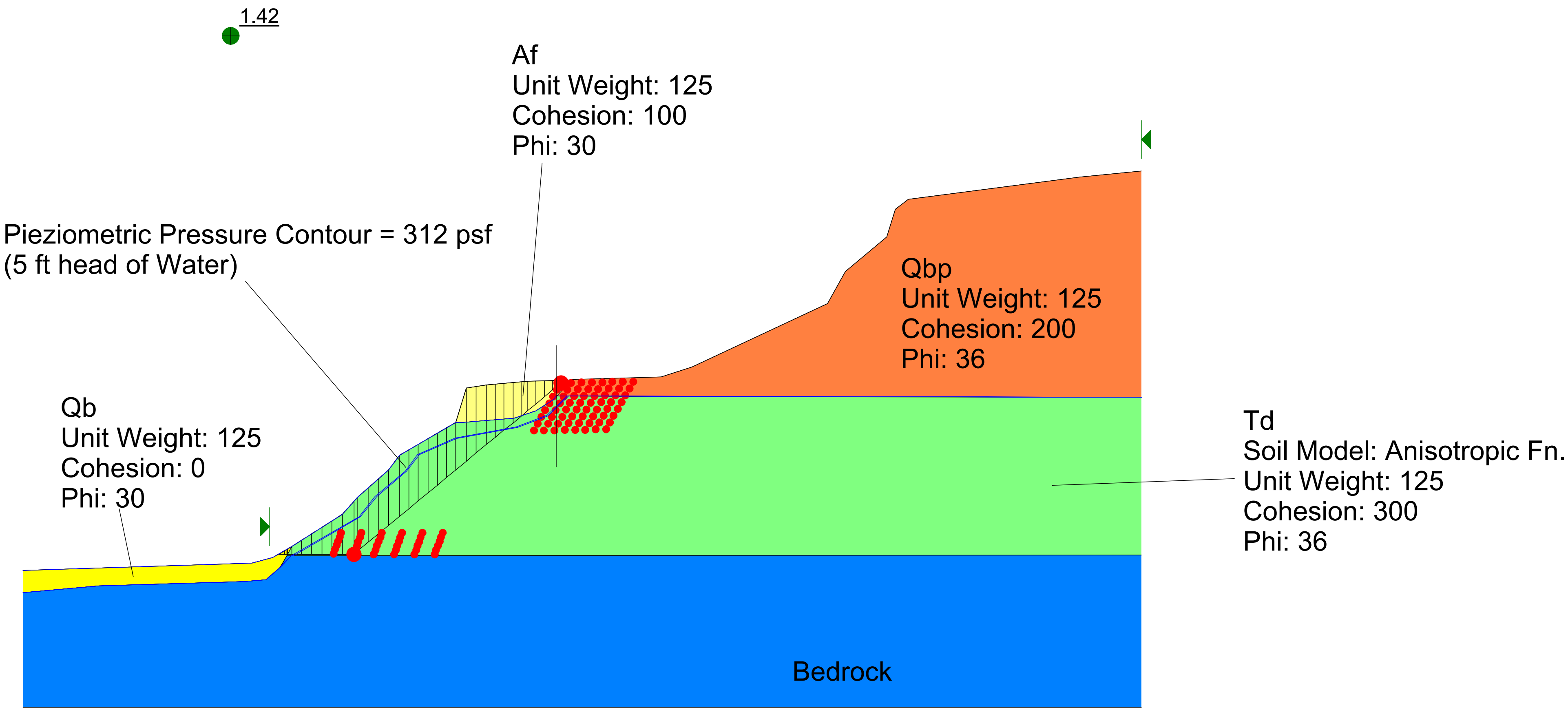


Cross Section 21-21’

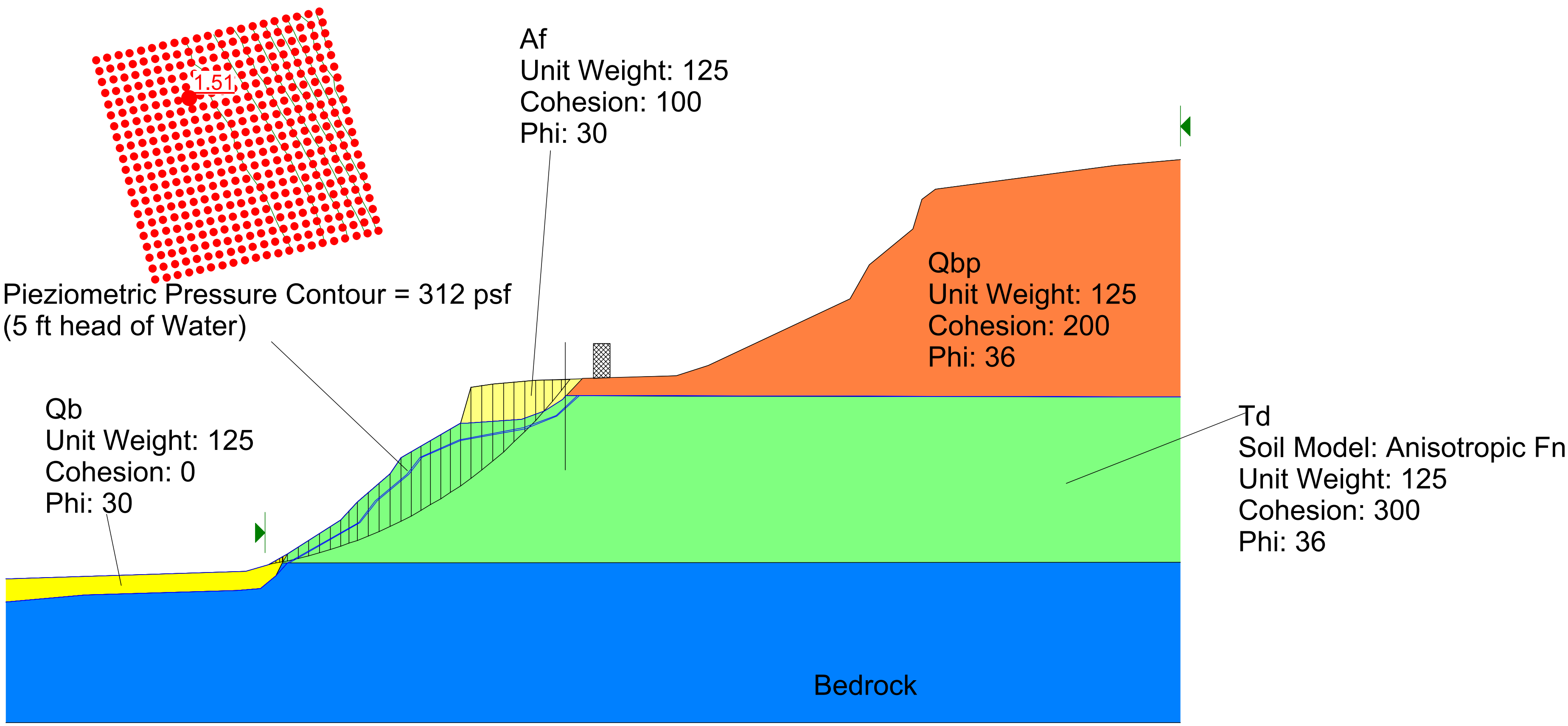
Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 5 ft Water Static 1.slz
Analysis Method: Bishop
Factor of Safety: 1.51



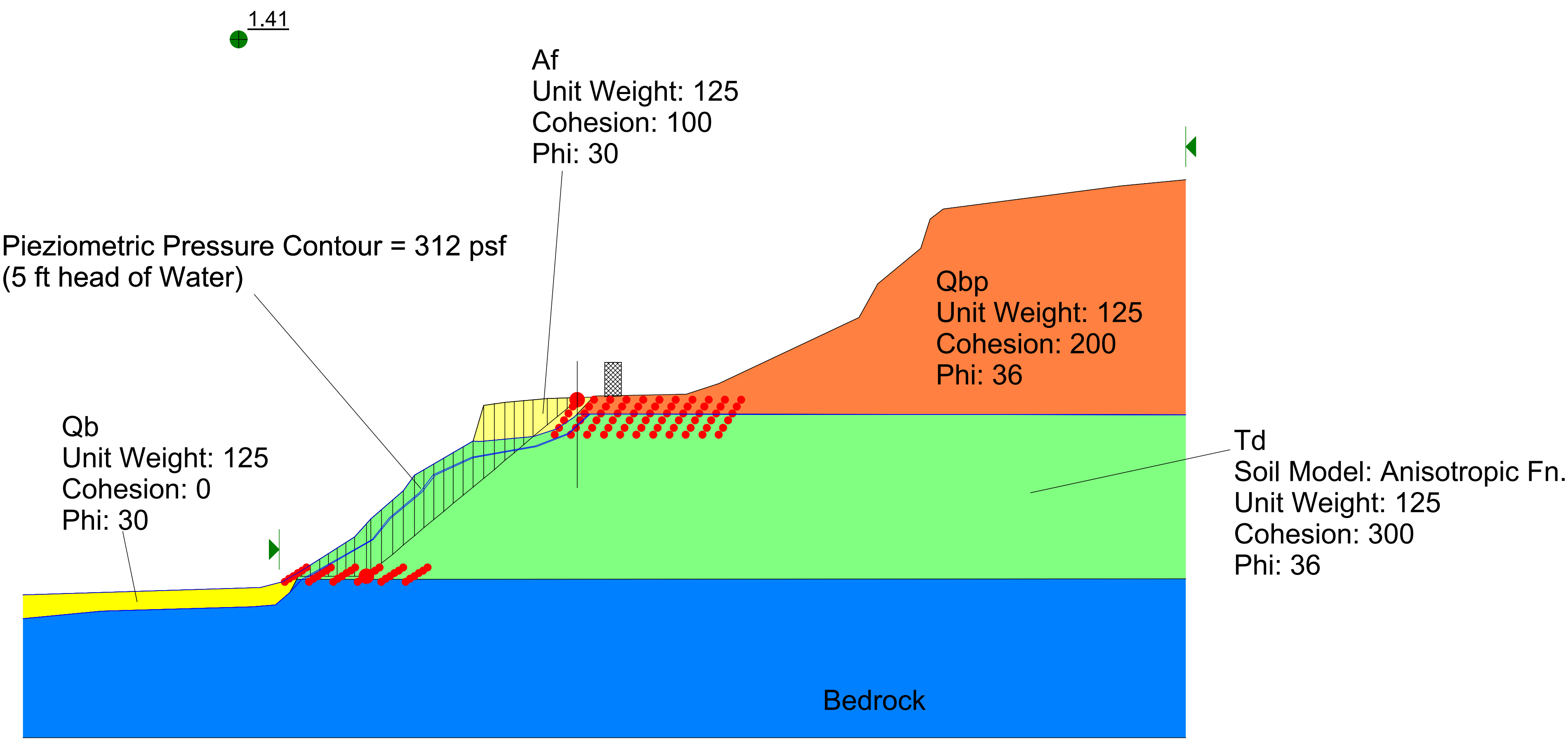
Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 5 ft Water Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.42



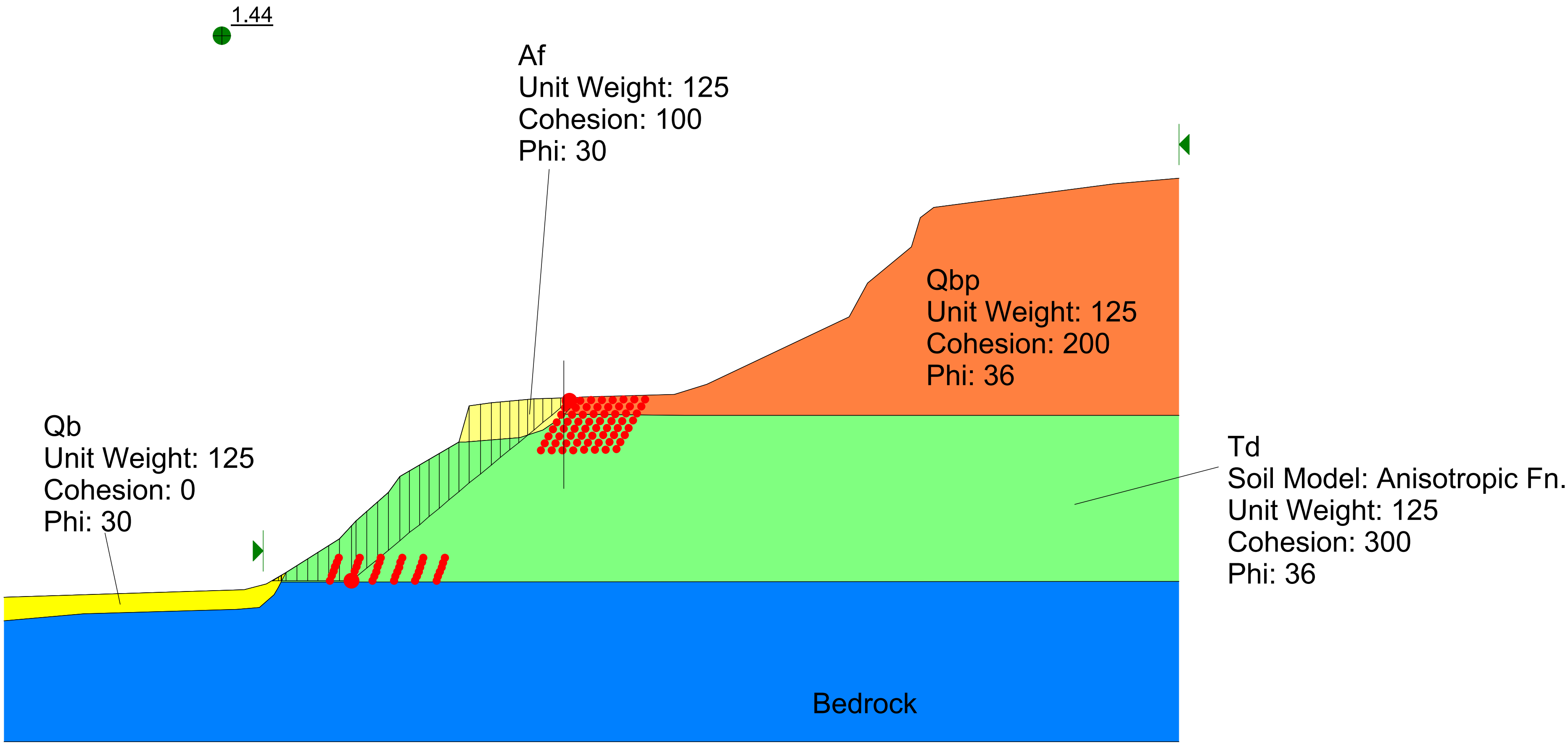
Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 5 ft Water Static 3.slz
Analysis Method: Bishop
Factor of Safety: 1.51
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 5 ft Water Static 4.slz
Analysis Method: Spencer
Factor of Safety: 1.41
Surcharge = 3,000 psf

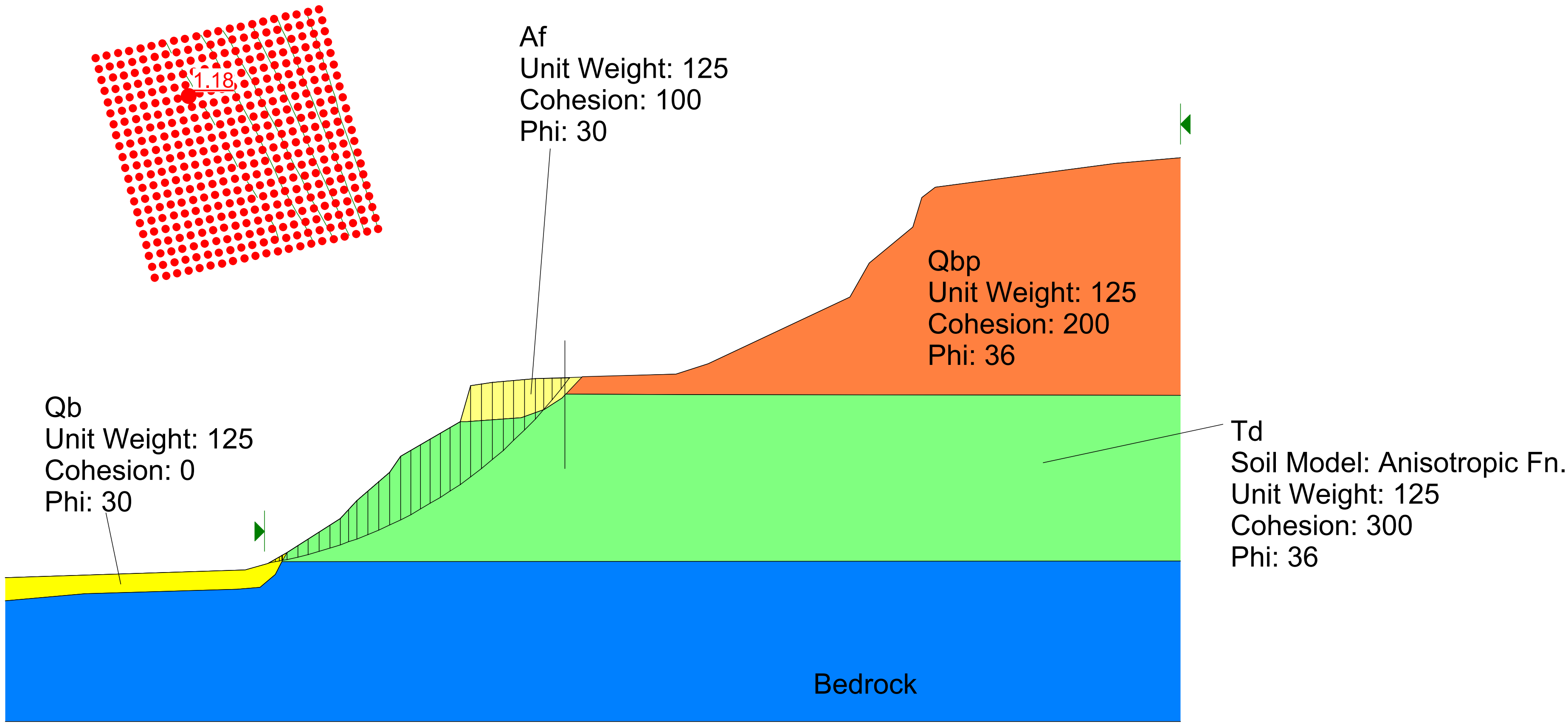


Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis, No Water
File Name: Section 2121 Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.44

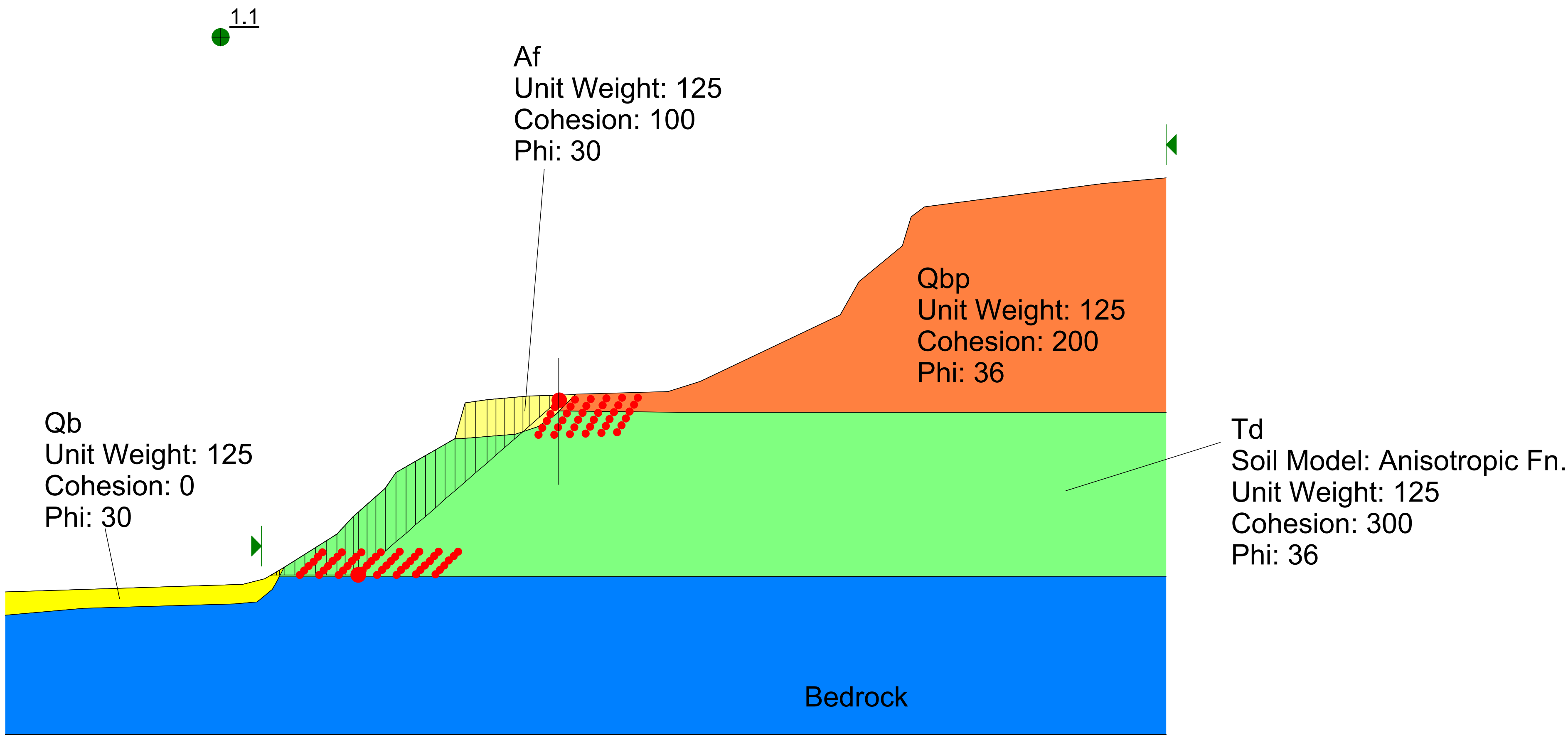


Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 Psuedo Static 1.slz
Analysis Method: Bishop
Factor of Safety: 1.18

Seismic Coefficient = 0.15

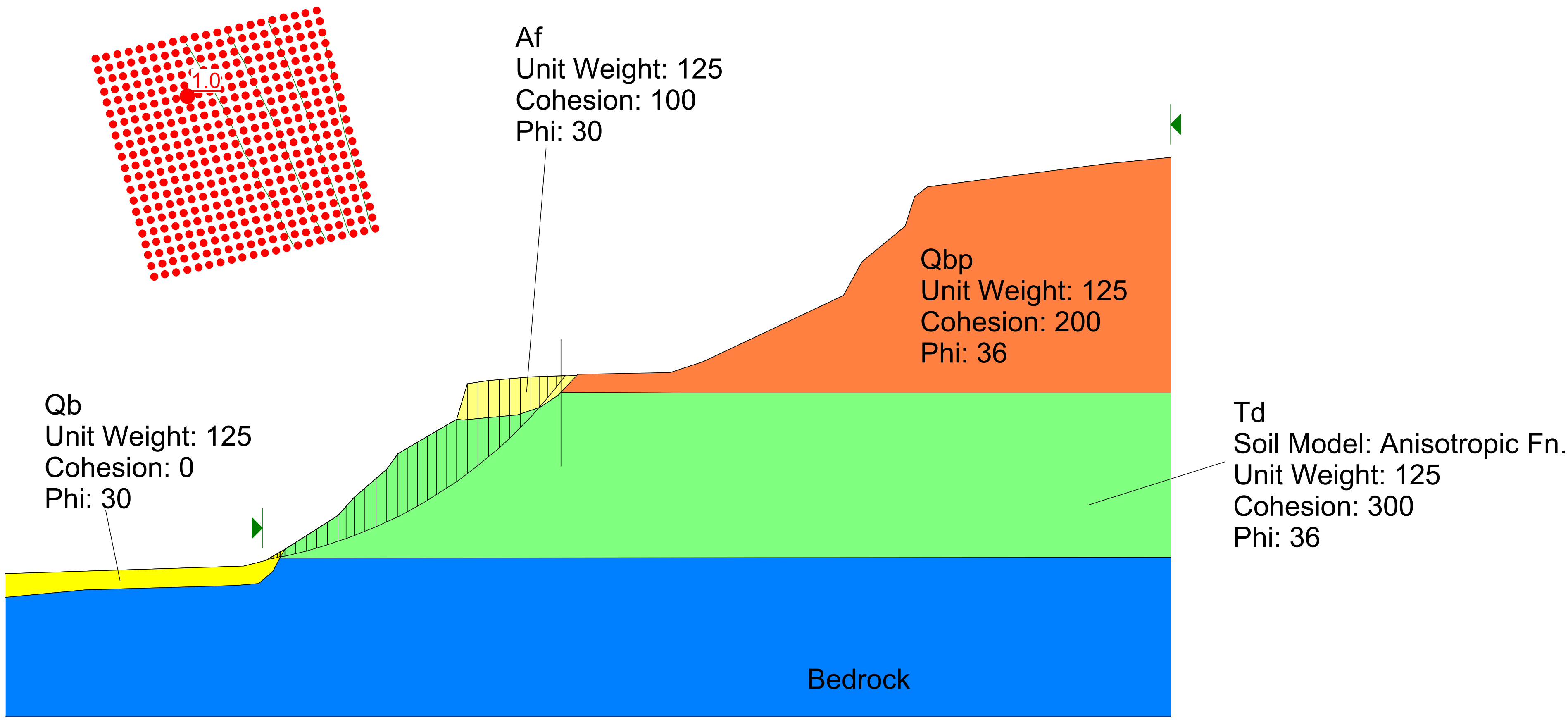


Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 Psuedo Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.1
Seismic Coefficient = 0.15

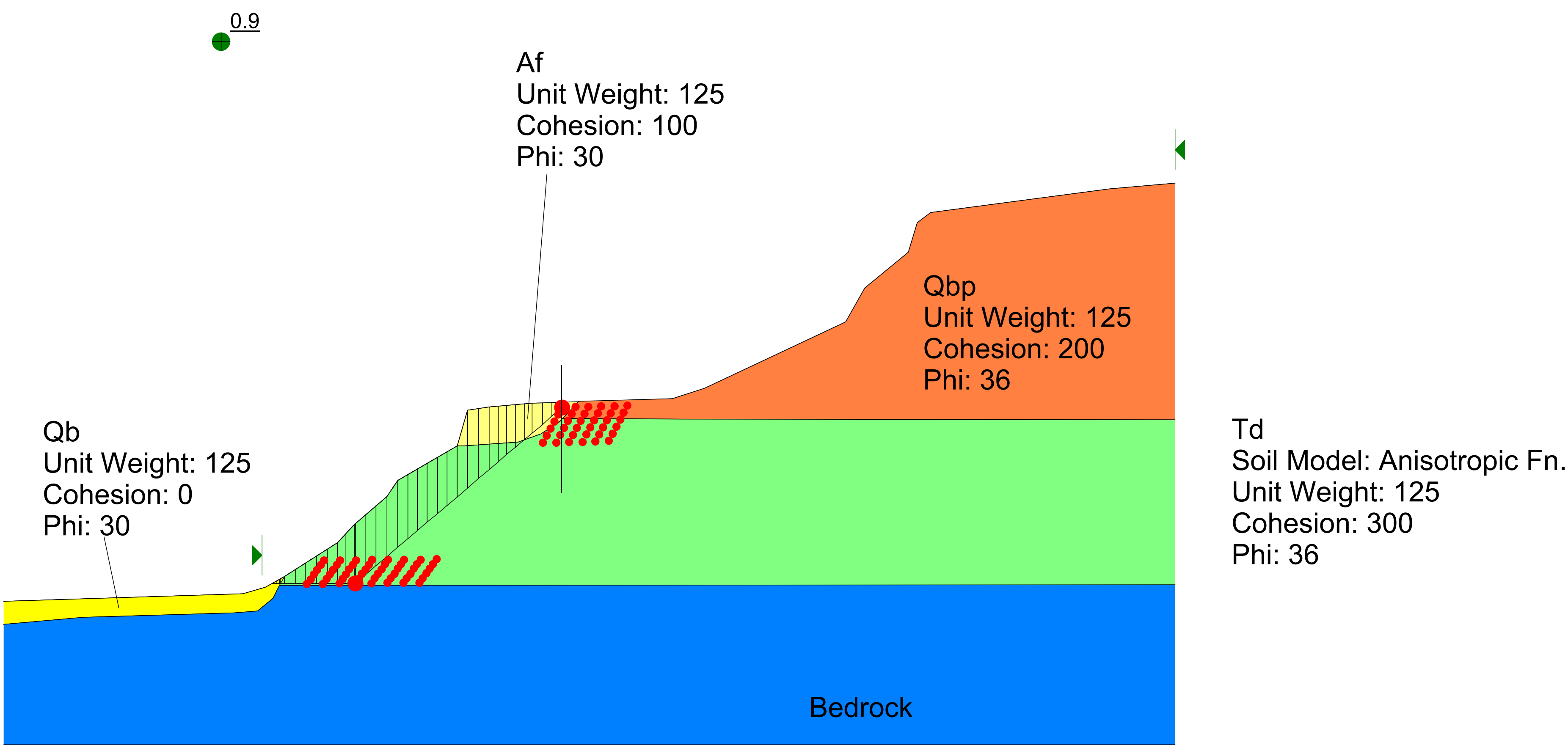


Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 Psuedo Static 3.slz
Analysis Method: Bishop
Factor of Safety: 0.97

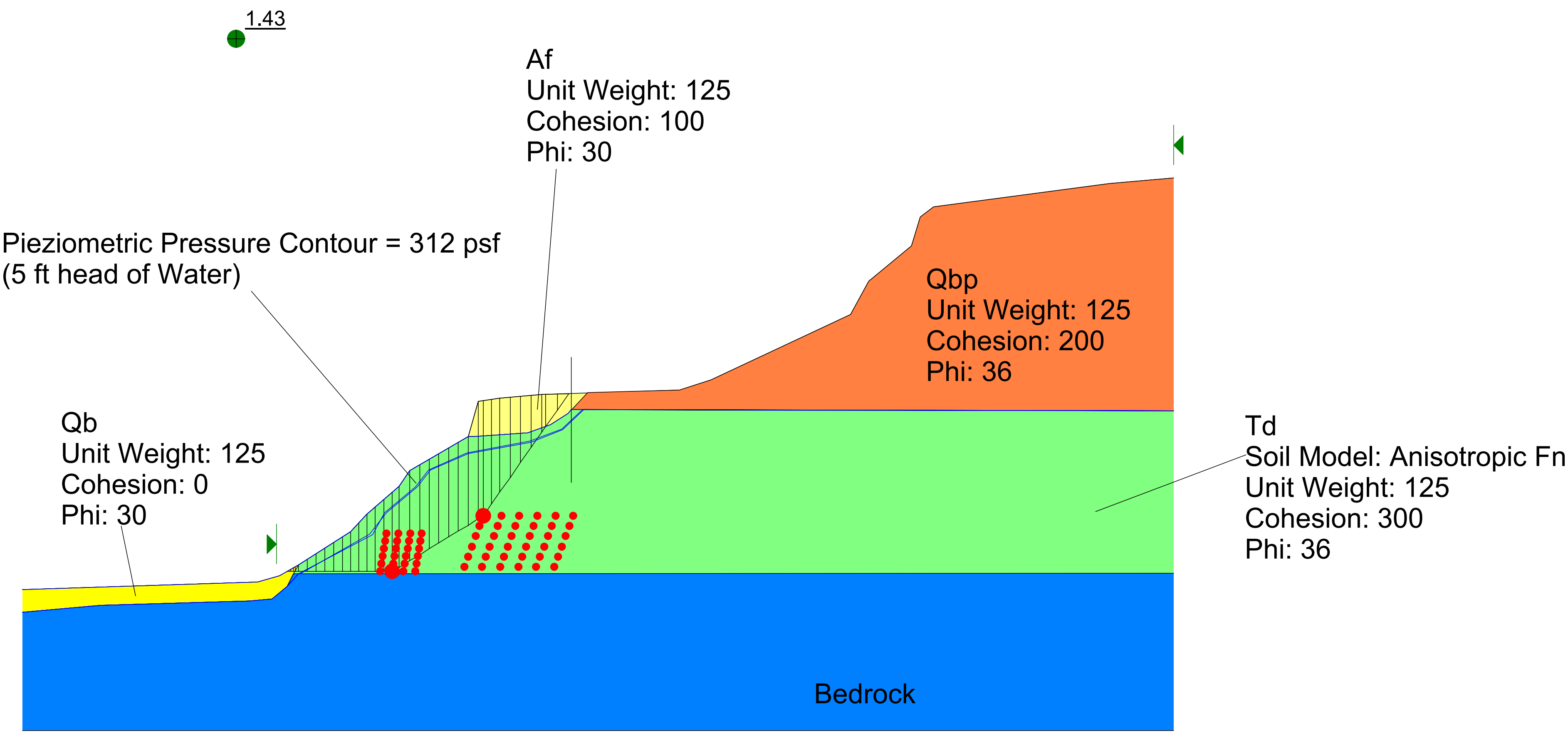
Seismic Coefficient = 0.28



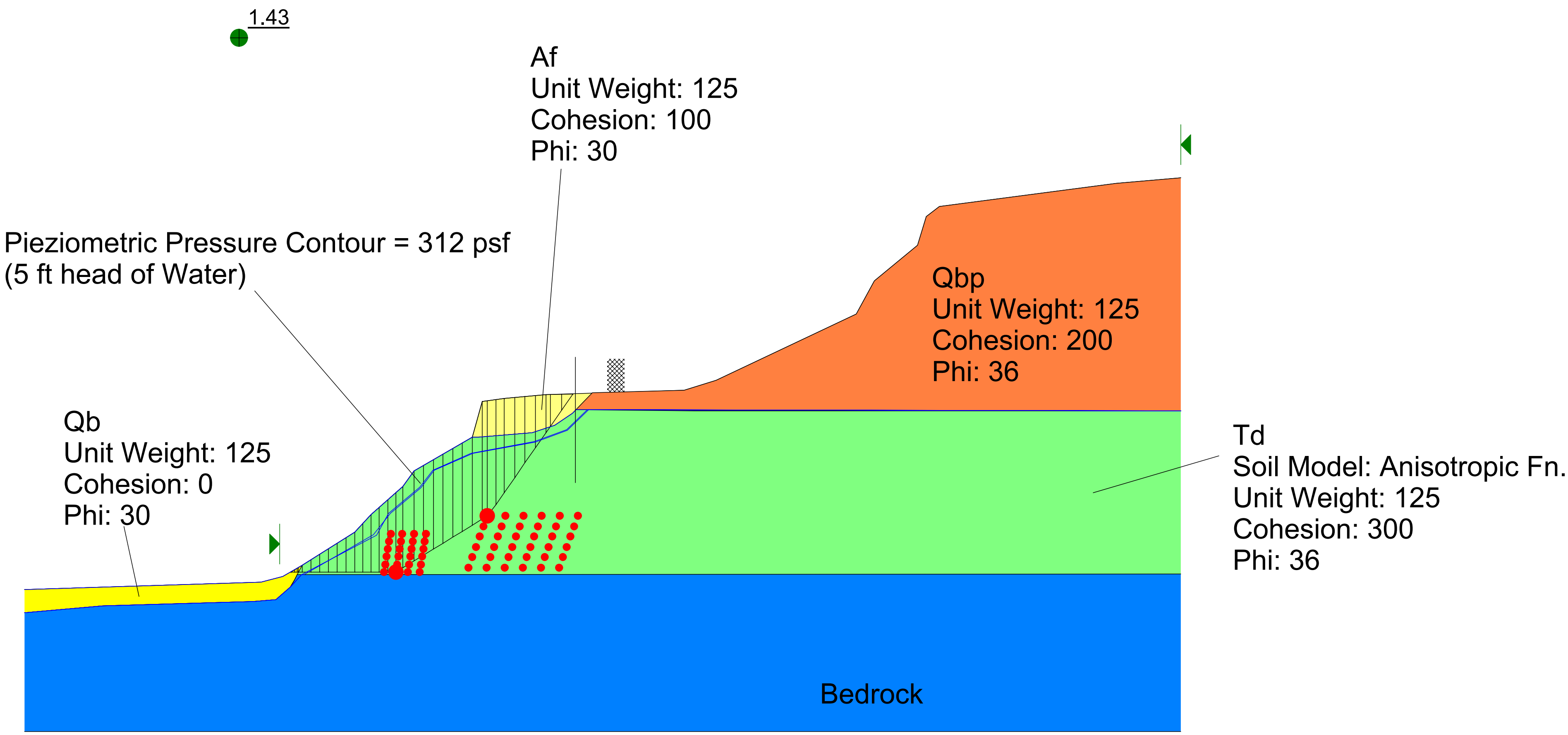
Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 Psuedo Static 4.slz
Analysis Method: Spencer
Factor of Safety: 0.92
Seismic Coefficient = 0.28



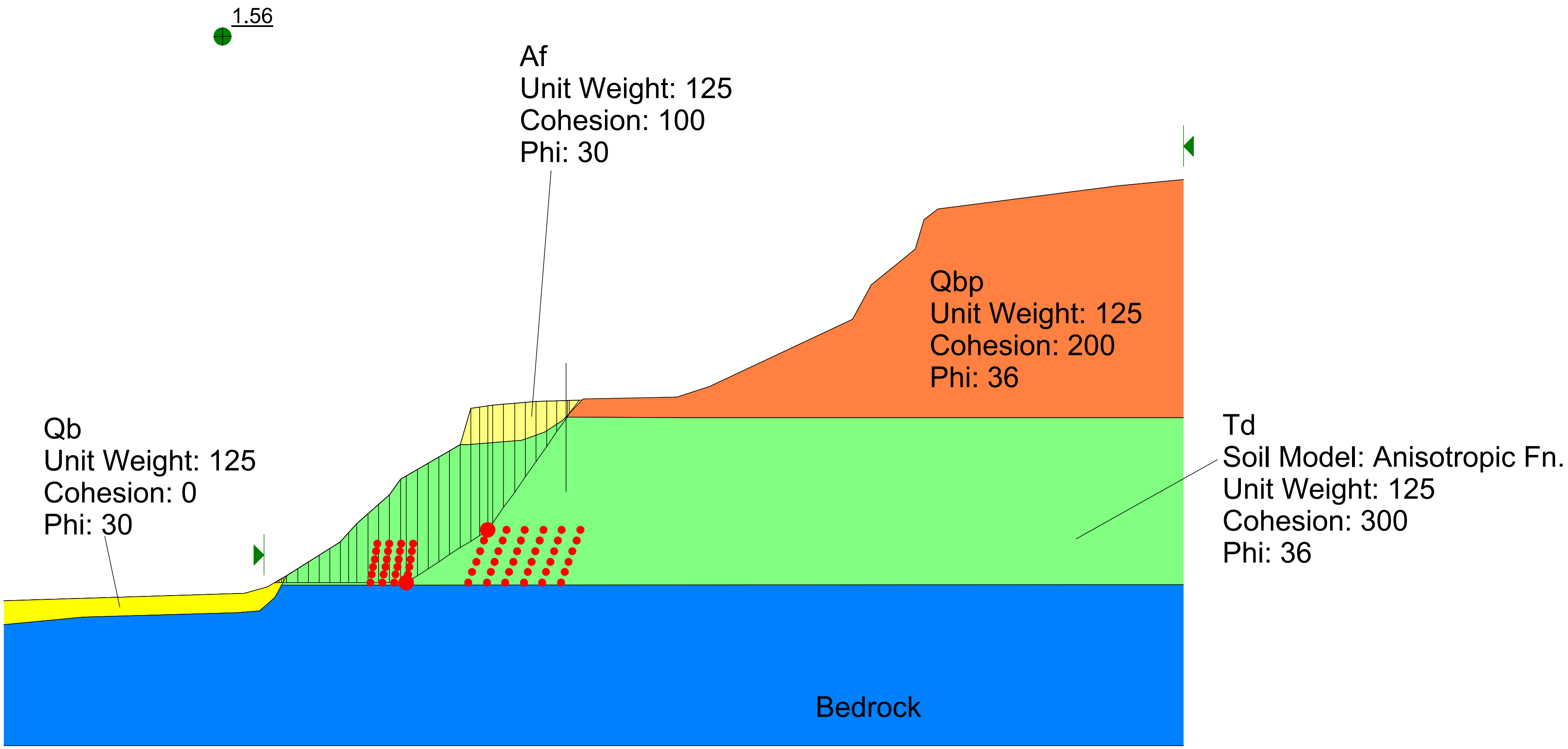
Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 5 ft Water Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 1.43



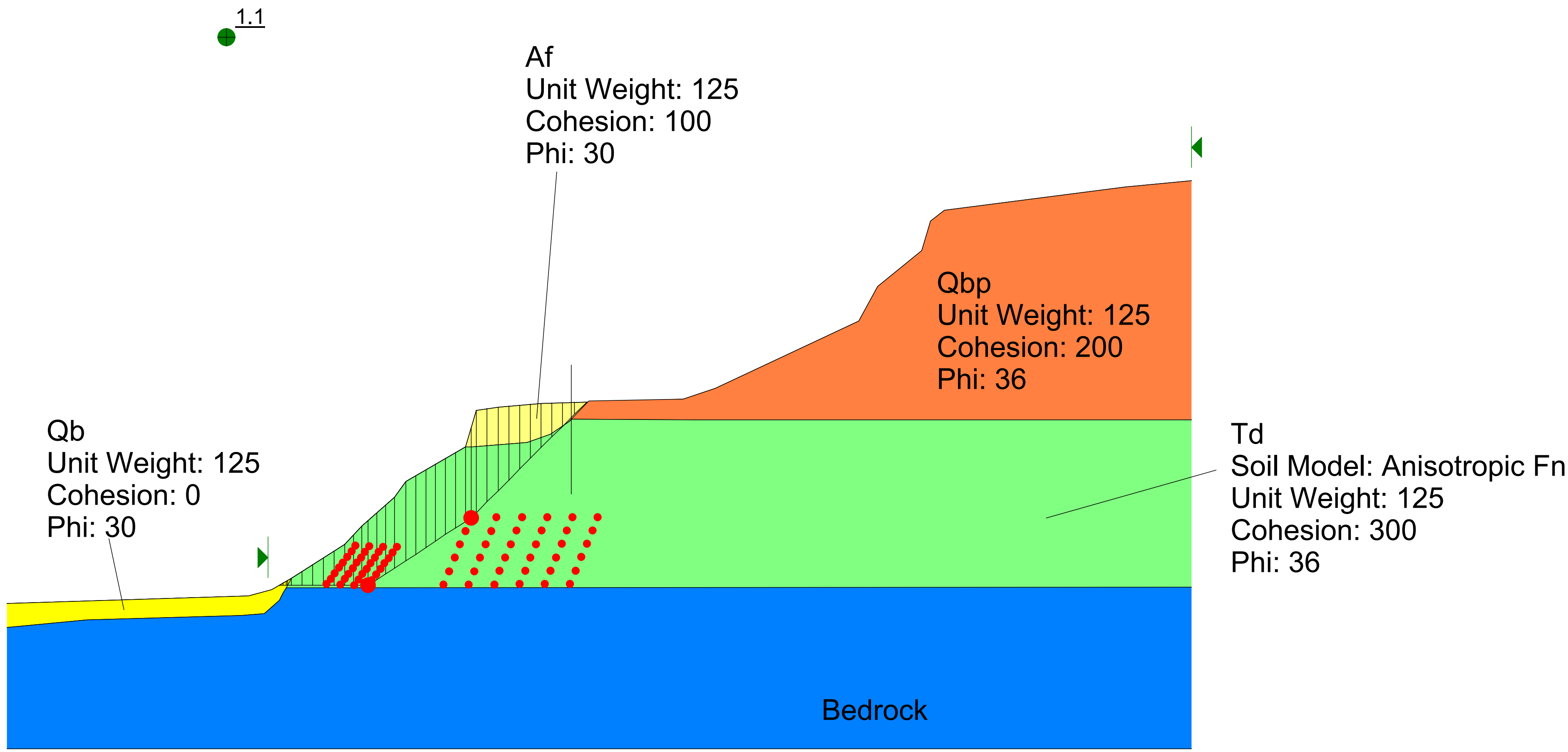
Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 5 ft Water Static 4B.slz
Analysis Method: Spencer
Factor of Safety: 1.43
surcharge = 3,000 psf



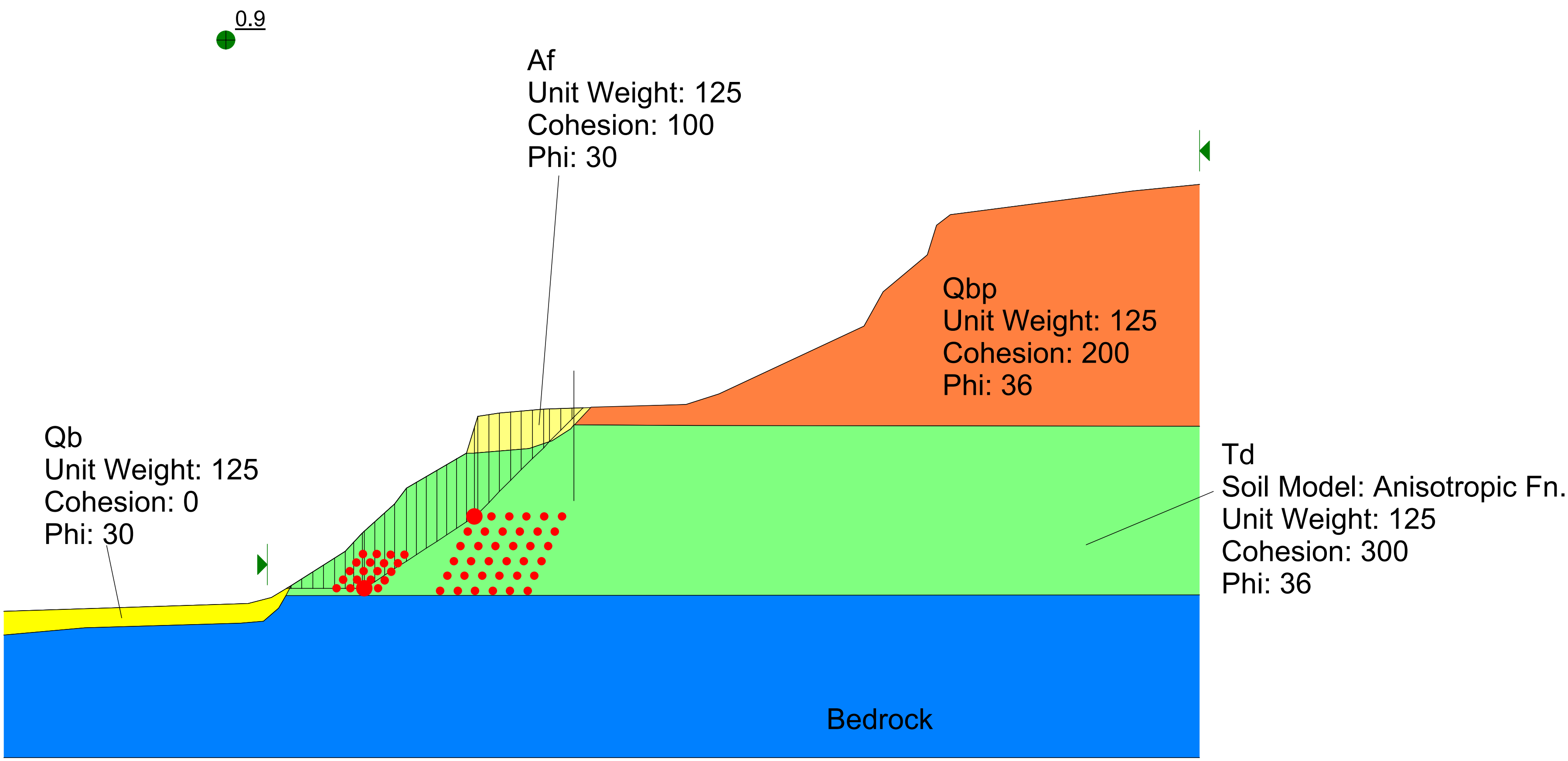
Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis, No Water
File Name: Section 2121 Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 1.56



Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 Psuedo Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 1.1
Seismic Coefficient = 0.15

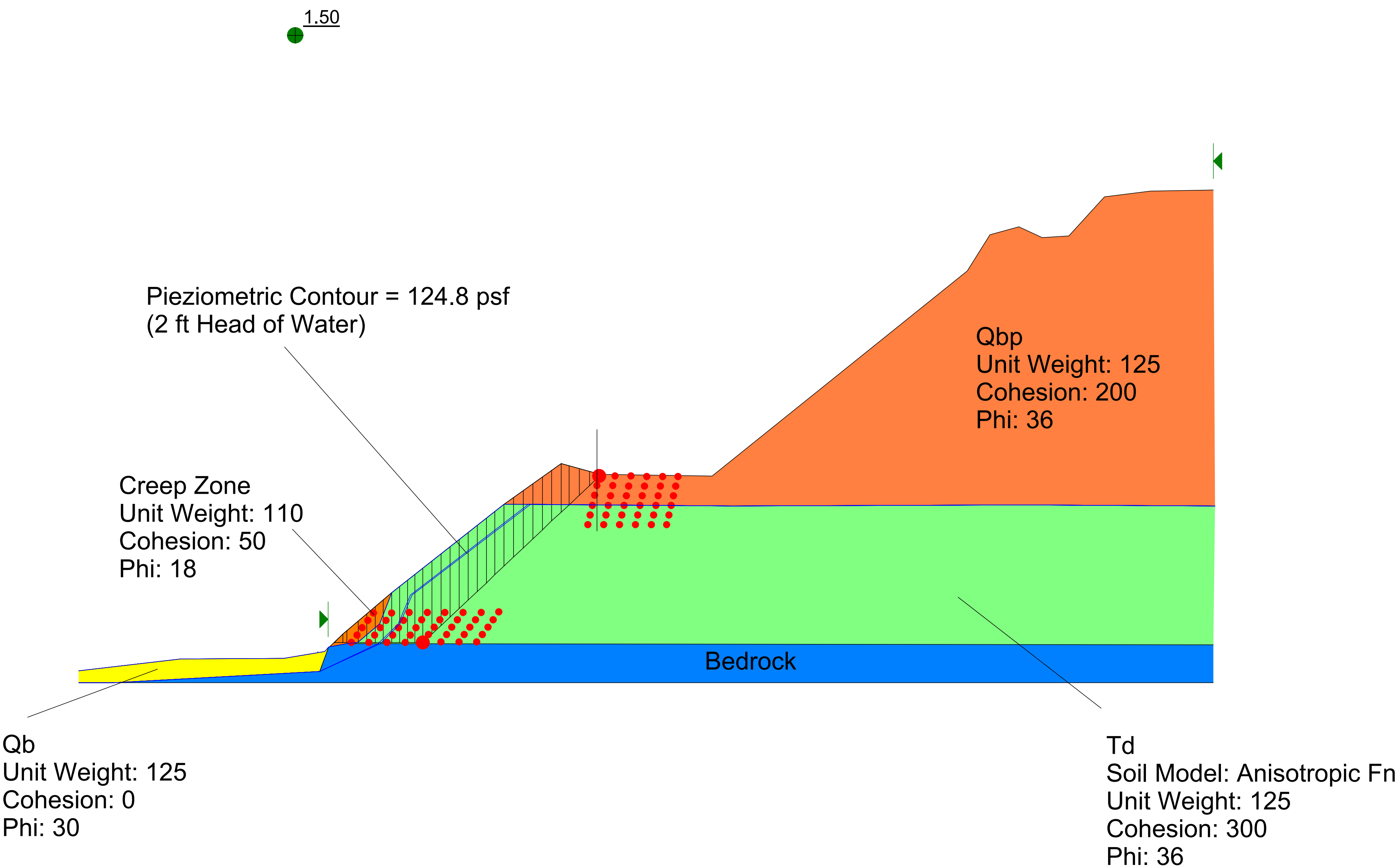


Del Mar Bluffs Cross Section 21-21'
C: Slope Stability Analysis
File Name: Section 2121 Psuedo Static 4B.slz
Analysis Method: Spencer
Factor of Safety: 0.91
Seismic Coefficient = 0.28

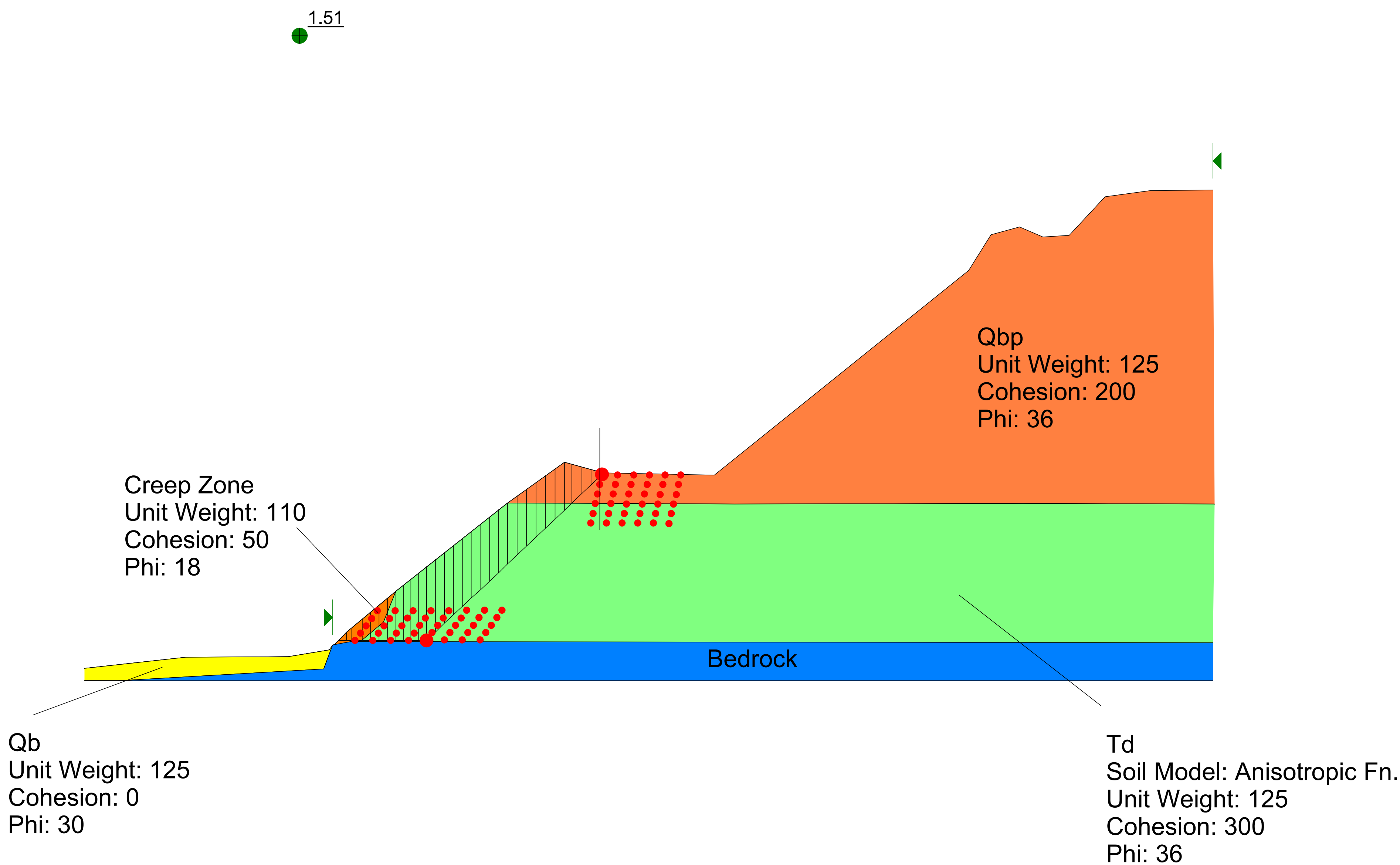


Cross Section 22-22’

Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Static 2.slz
Analysis Method: Spencer
Factor of Safety: 1.5

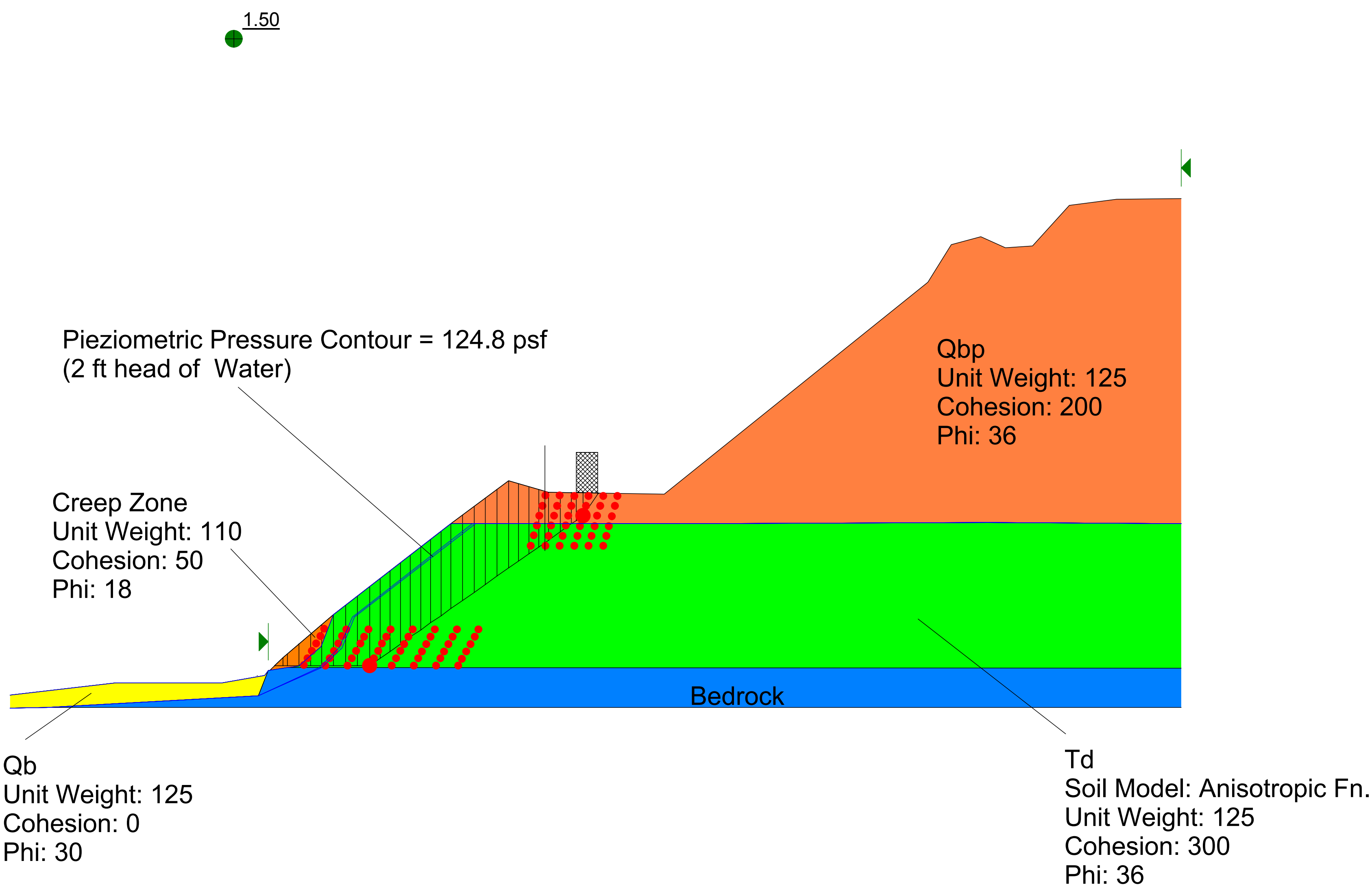


Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Static 2 No Water.slz
Analysis Method: Spencer
Factor of Safety: 1.51

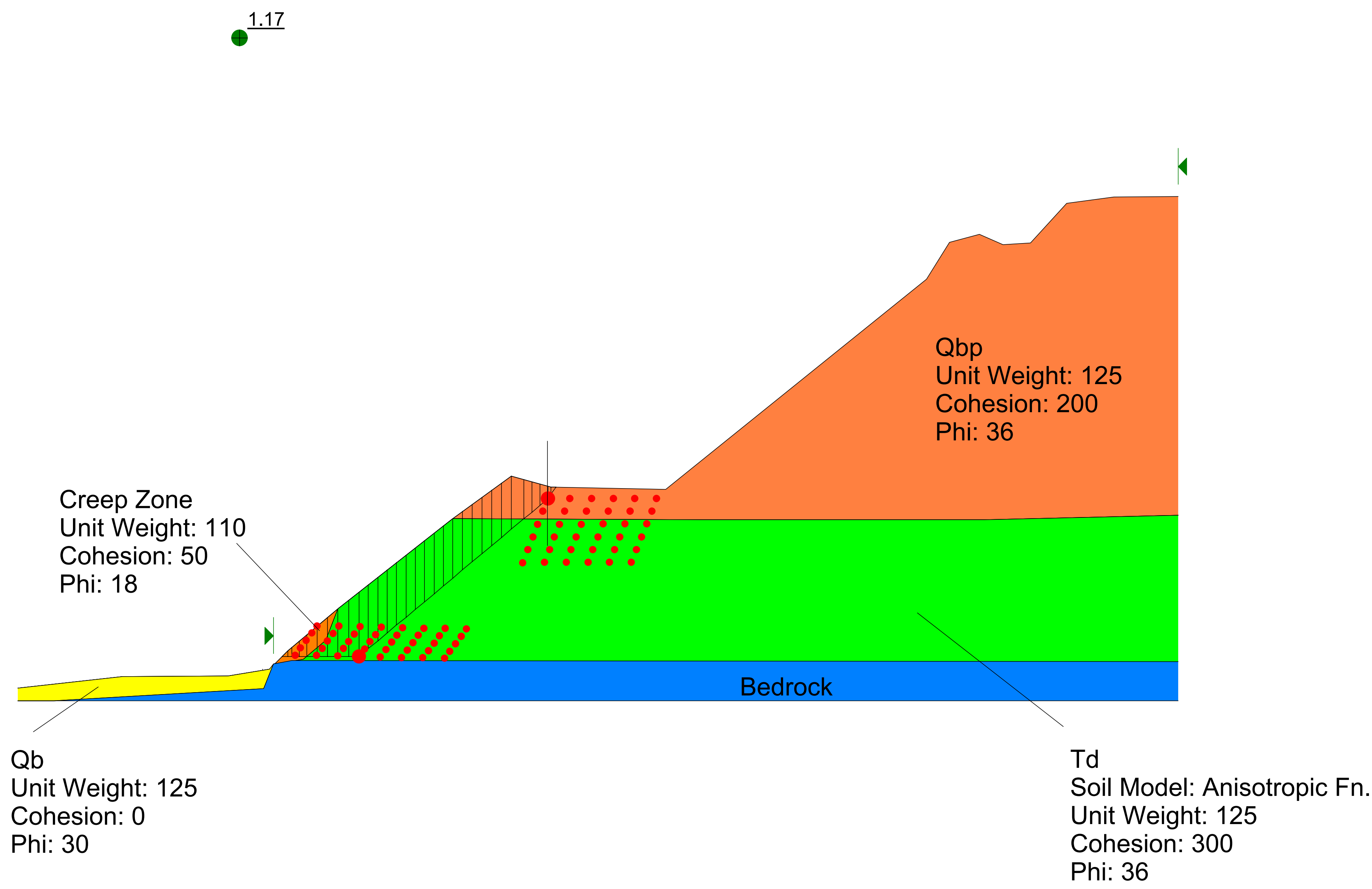


Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Static 4.slz
Analysis Method: Spencer
Factor of Safety: 1.5

Surcharge = 3,000 psf

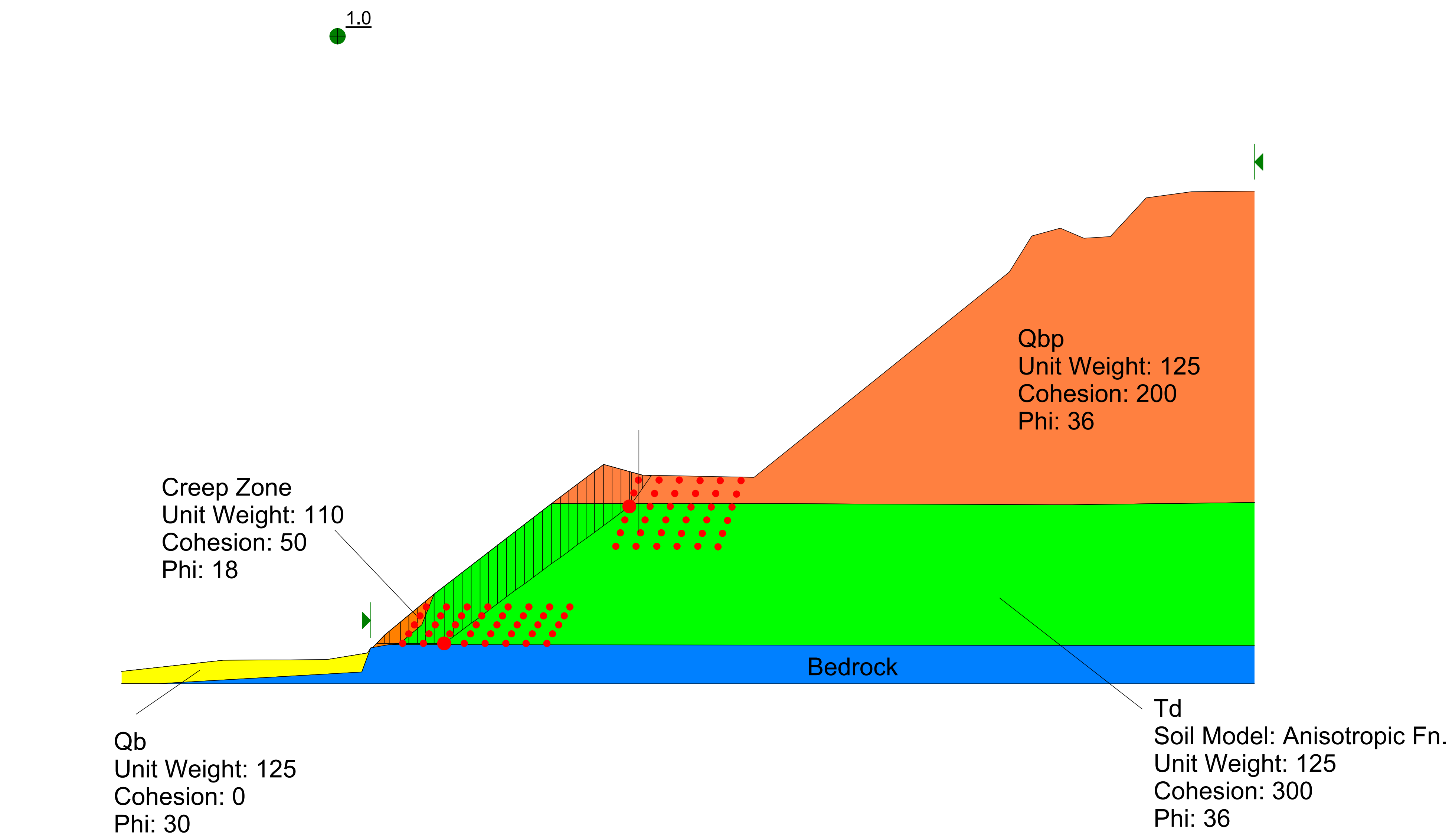


Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Psuedo Static 1.slz
Analysis Method: Spencer
Factor of Safety: 1.17
Seismic Coefficient = 0.15

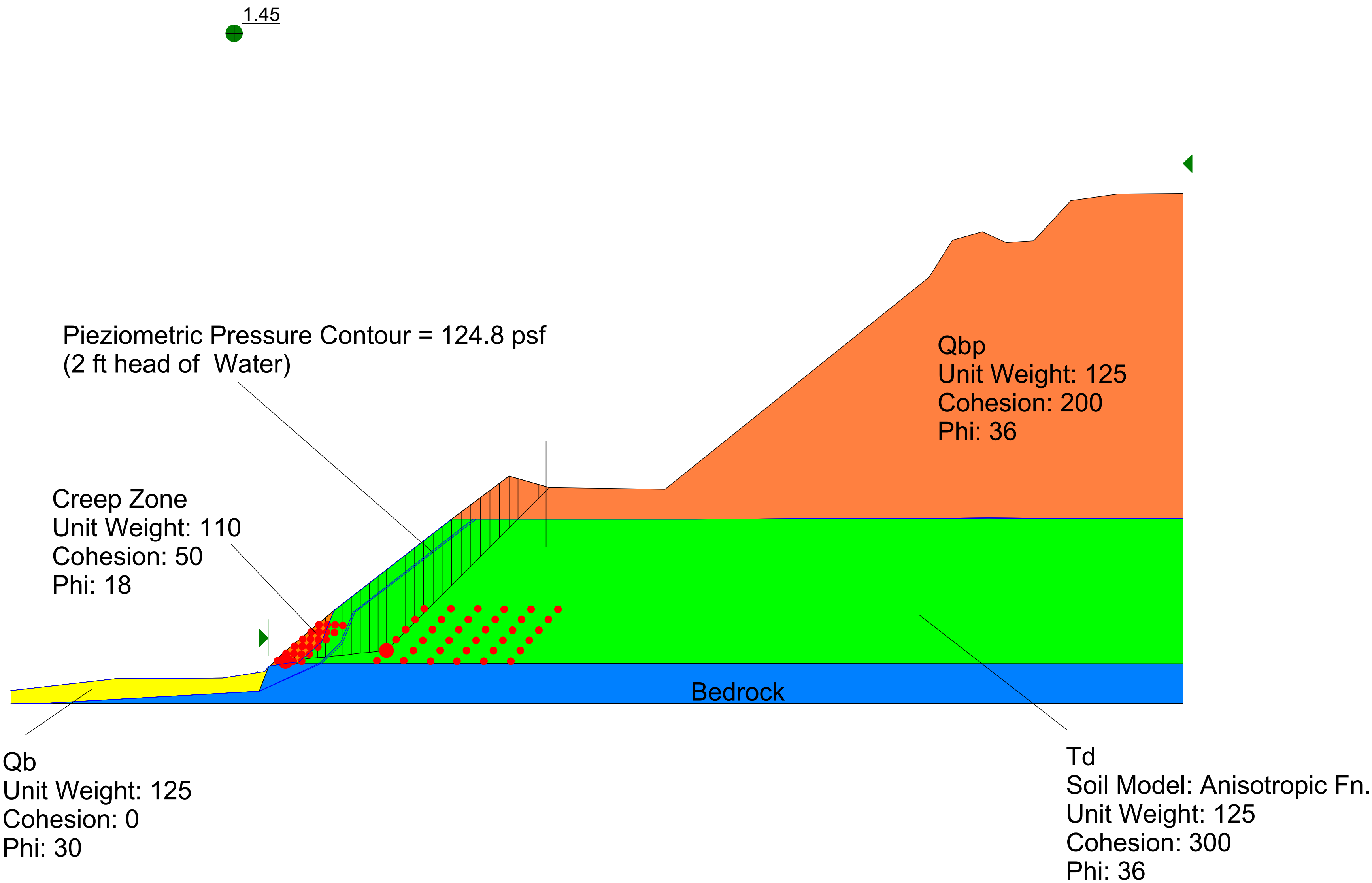


Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Psuedo Static 2.slz
Analysis Method: Spencer
Factor of Safety: 0.97

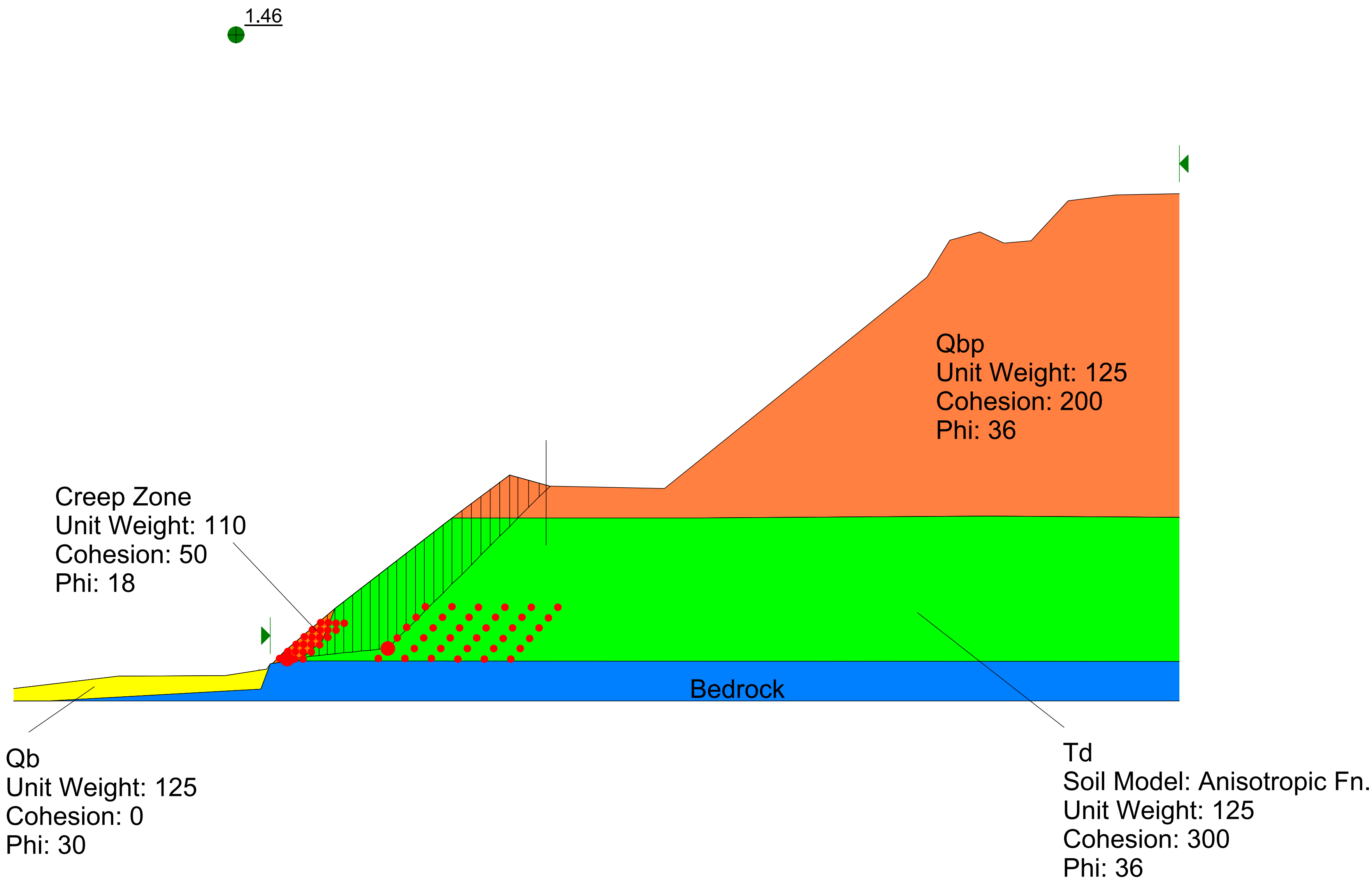
Siesmic Coefficient = 0.28



Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 1.45
Surcharge = 3,000 psf

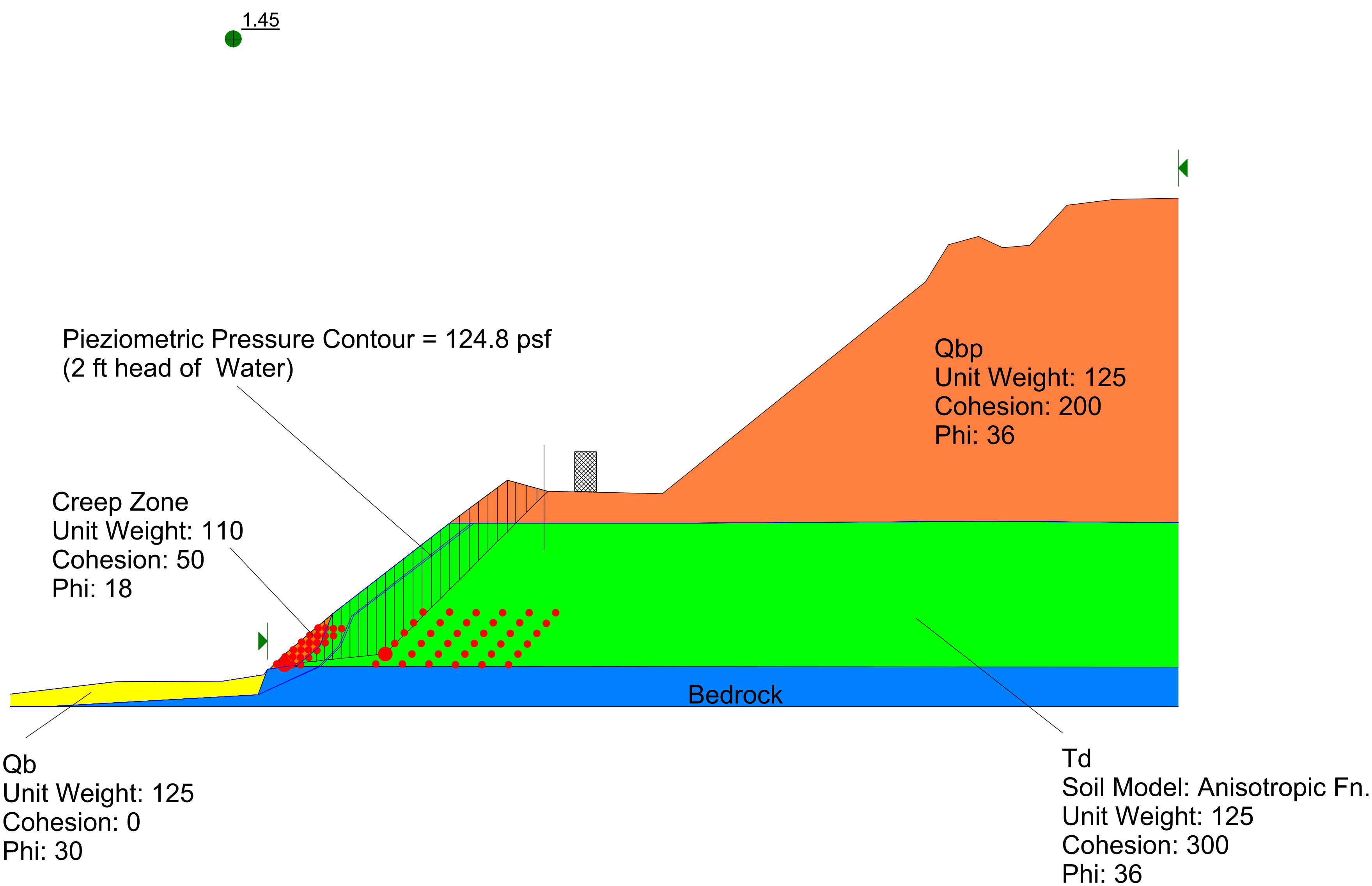


Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Static 2B No Water.slz
Analysis Method: Spencer
Factor of Safety: 1.46

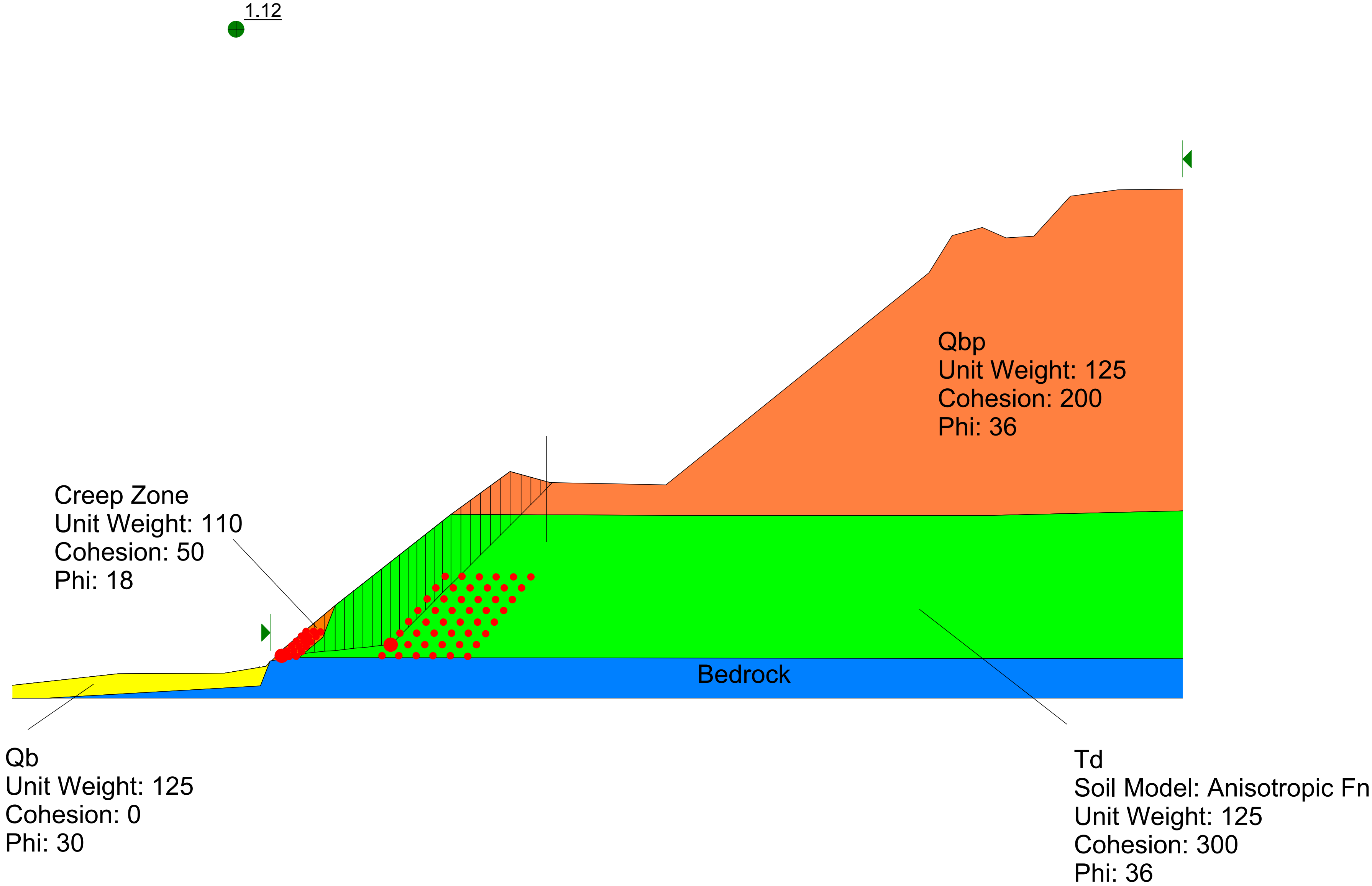


Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Static 4B.slz
Analysis Method: Spencer
Factor of Safety: 1.45

Surcharge = 3,000 psf

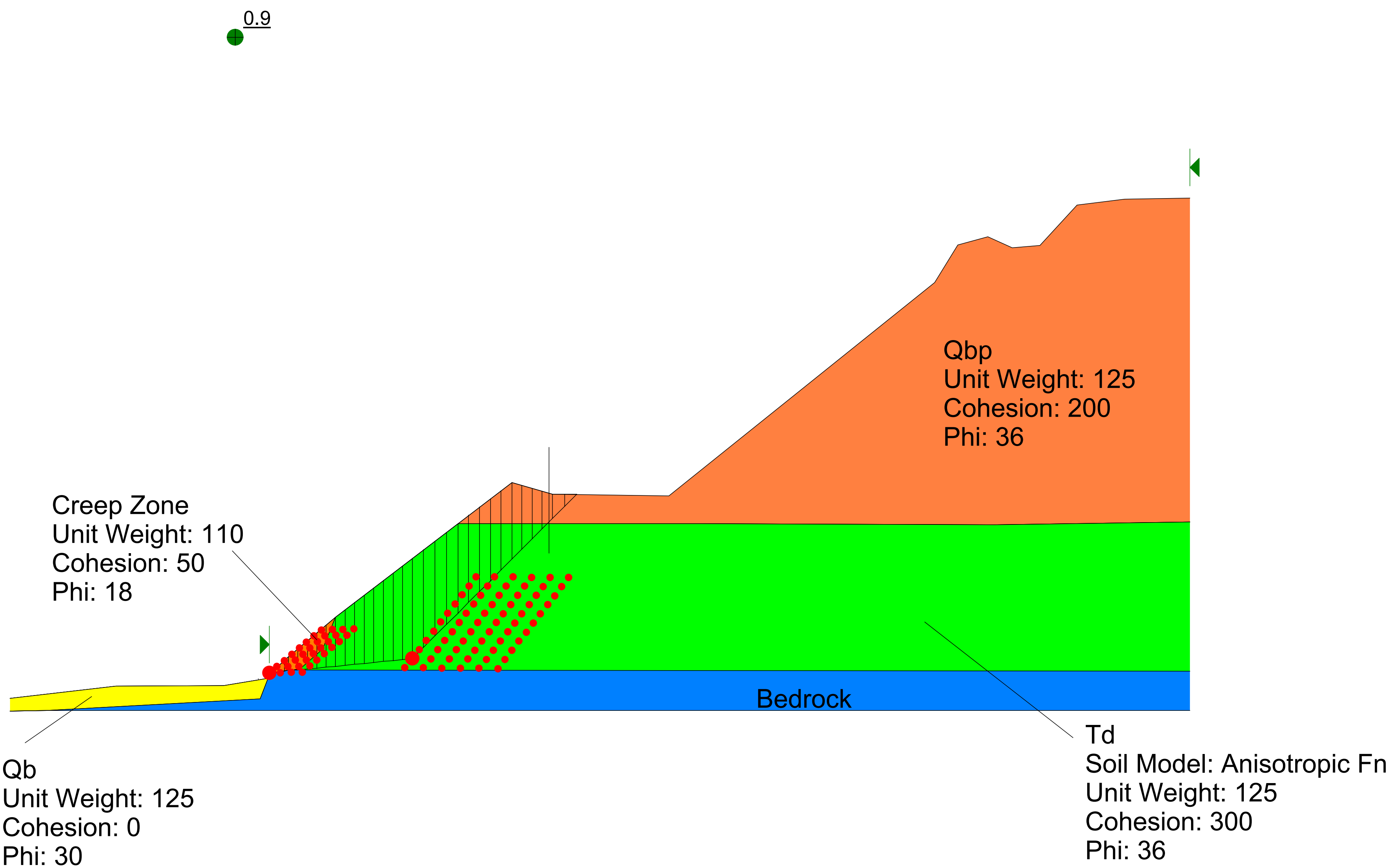


Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Psuedo Static 1B.slz
Analysis Method: Spencer
Factor of Safety: 1.12
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 22-22'
Slope Stability Analysis
File Name: Section 2222 Psuedo Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 0.94

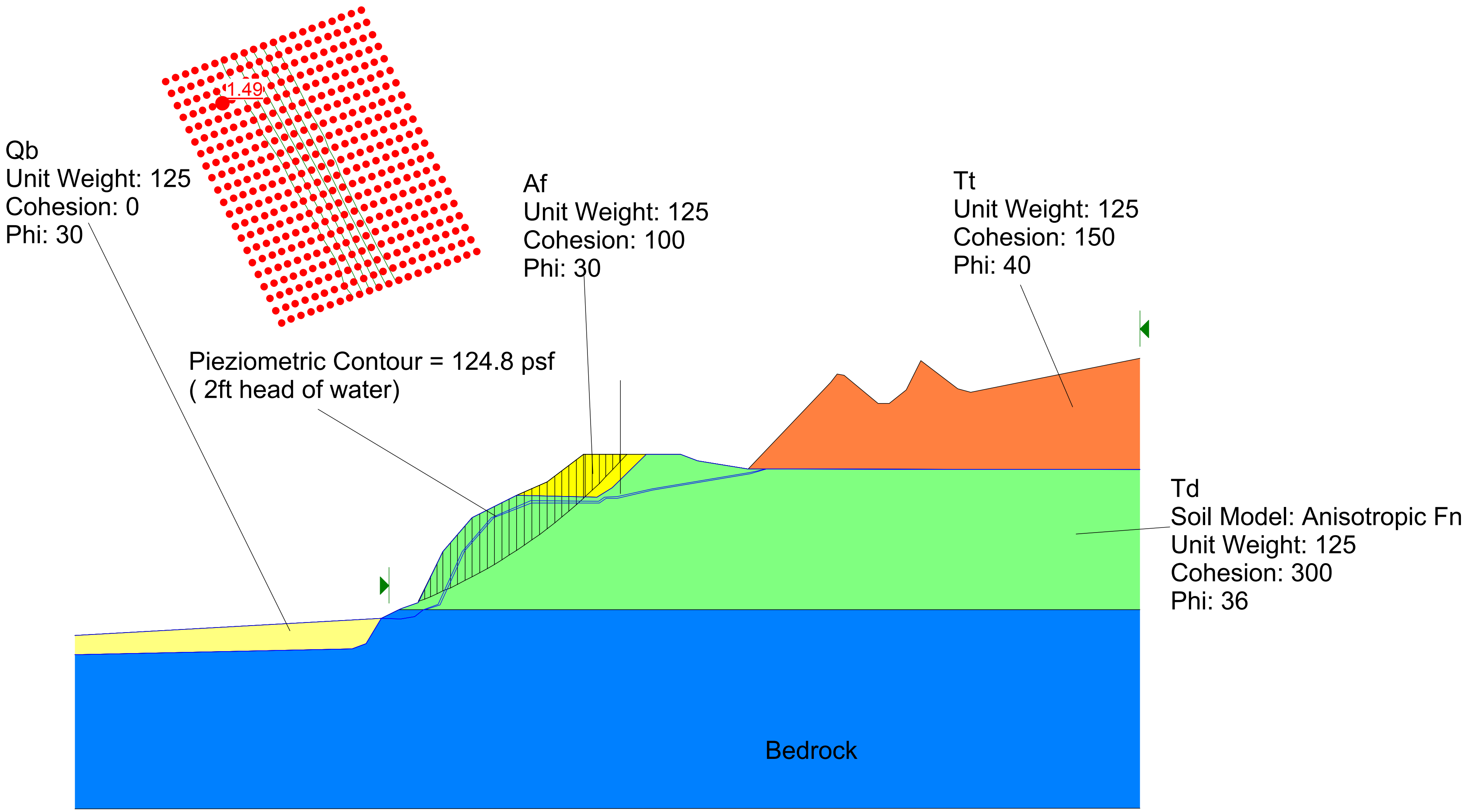
Siesmic Coefficient = 0.28



Cross Section 23-23’

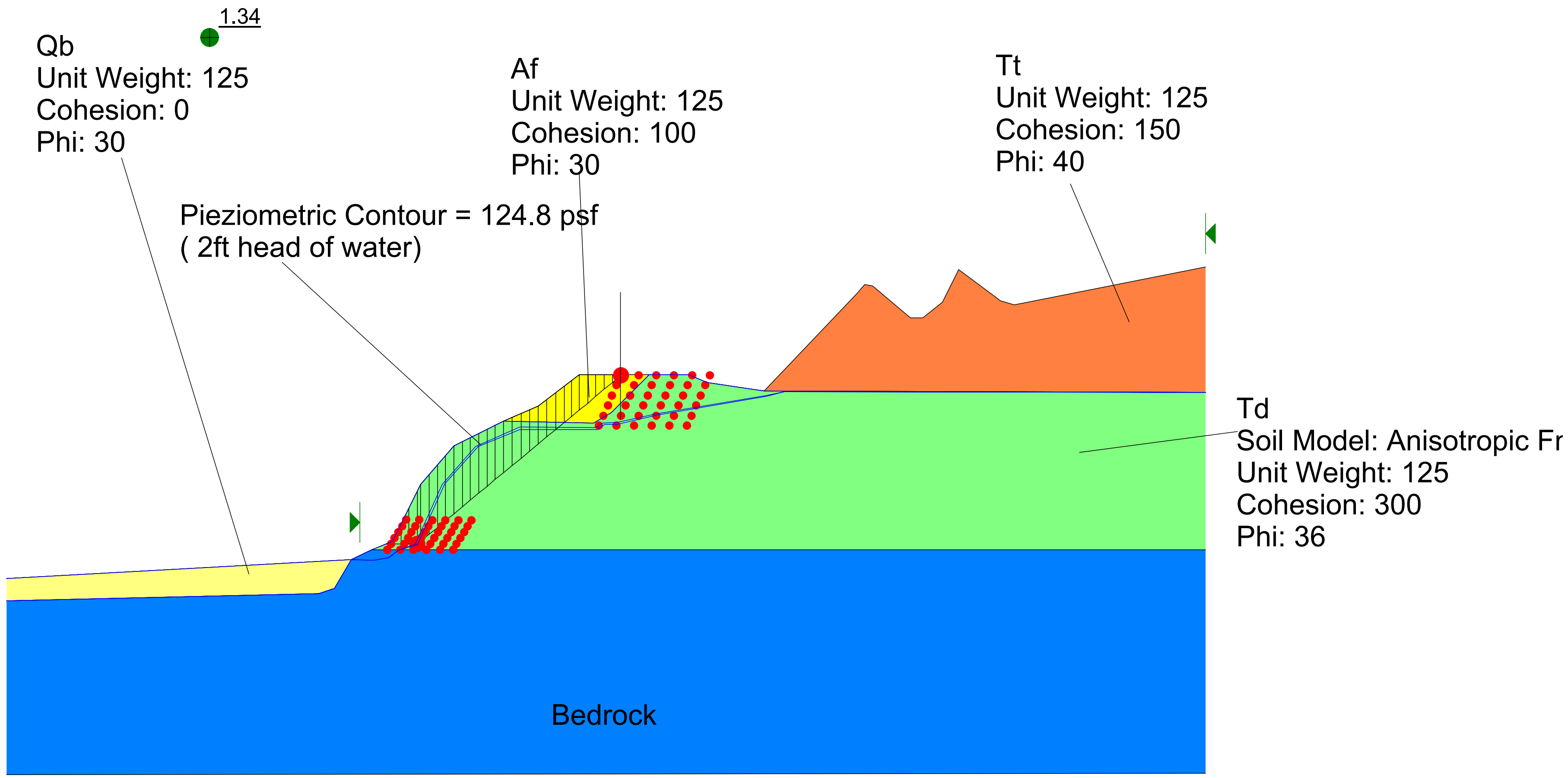
Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Static 1.slz
Analysis Method: Bishop

Factor of Safety: 1.49



Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Static 2.slz
Analysis Method: Spencer

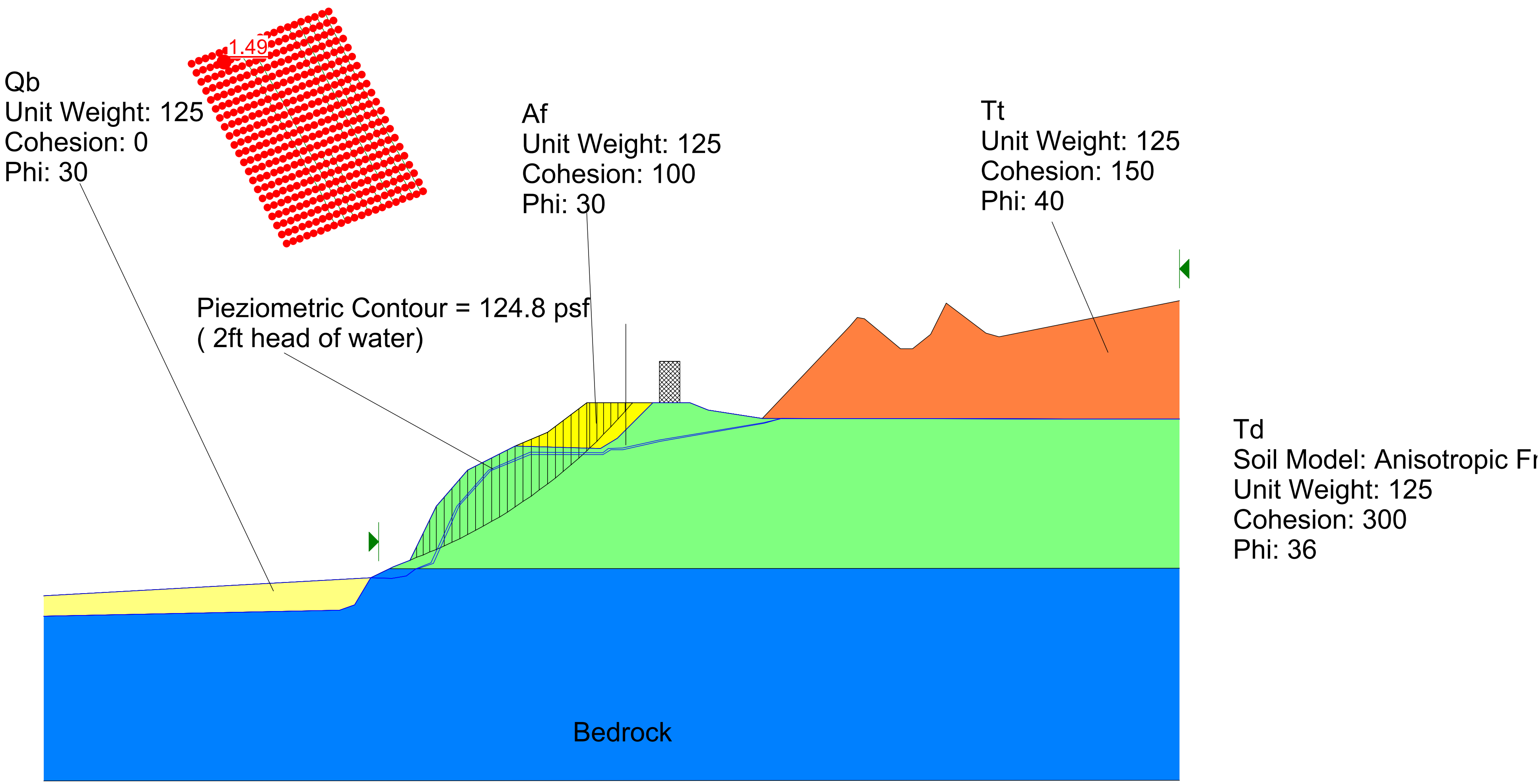
Factor of Safety: 1.34



Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Static 3.slz
Analysis Method: Bishop

Factor of Safety: 1.49

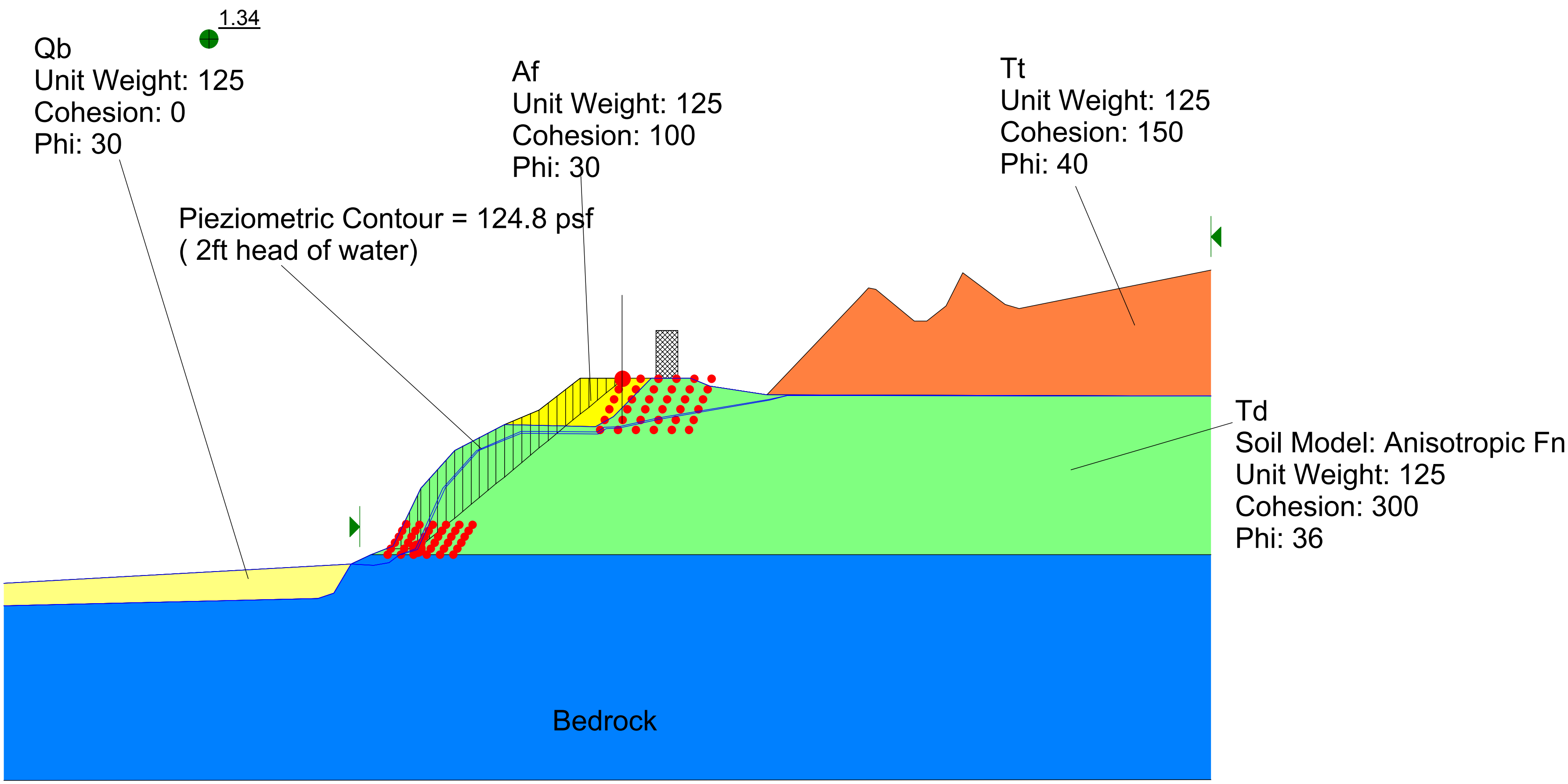
Surcharge = 3.000 psf



Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Static 4C.slz
Analysis Method: Spencer

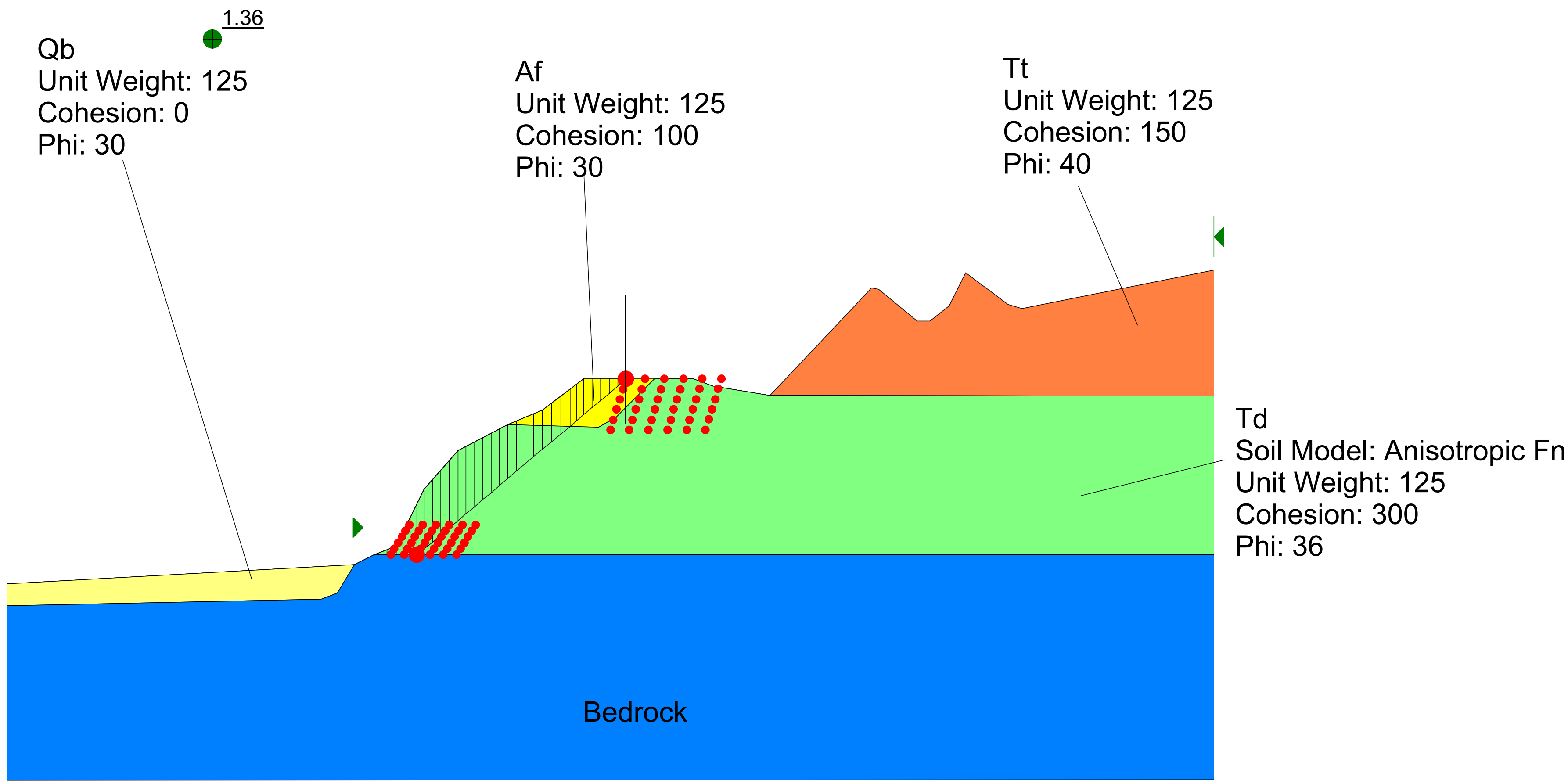
Factor of Safety: 1.34

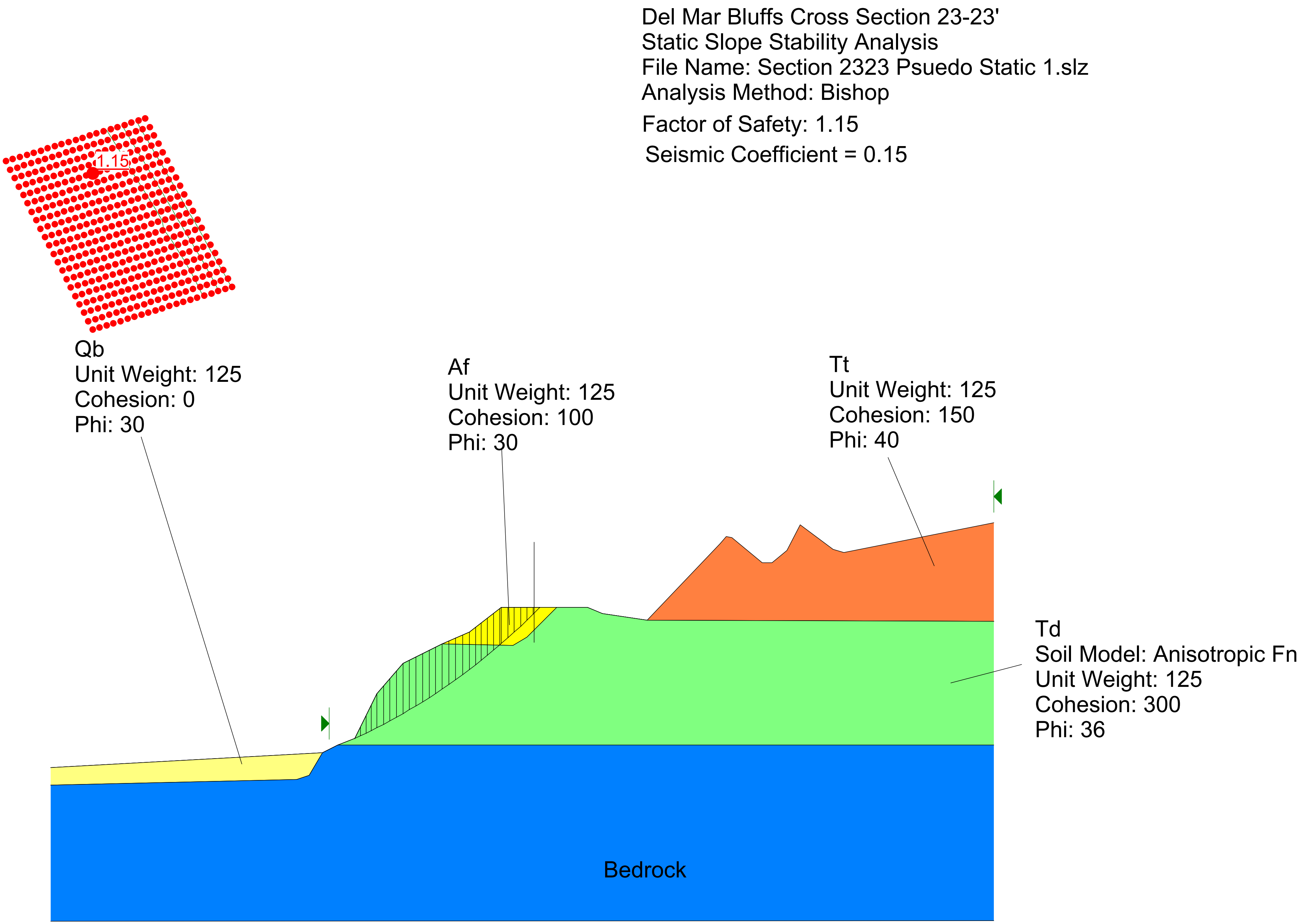
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis, No Water
File Name: Section 2323 Static 2 no water.slz
Analysis Method: Spencer

Factor of Safety: 1.36

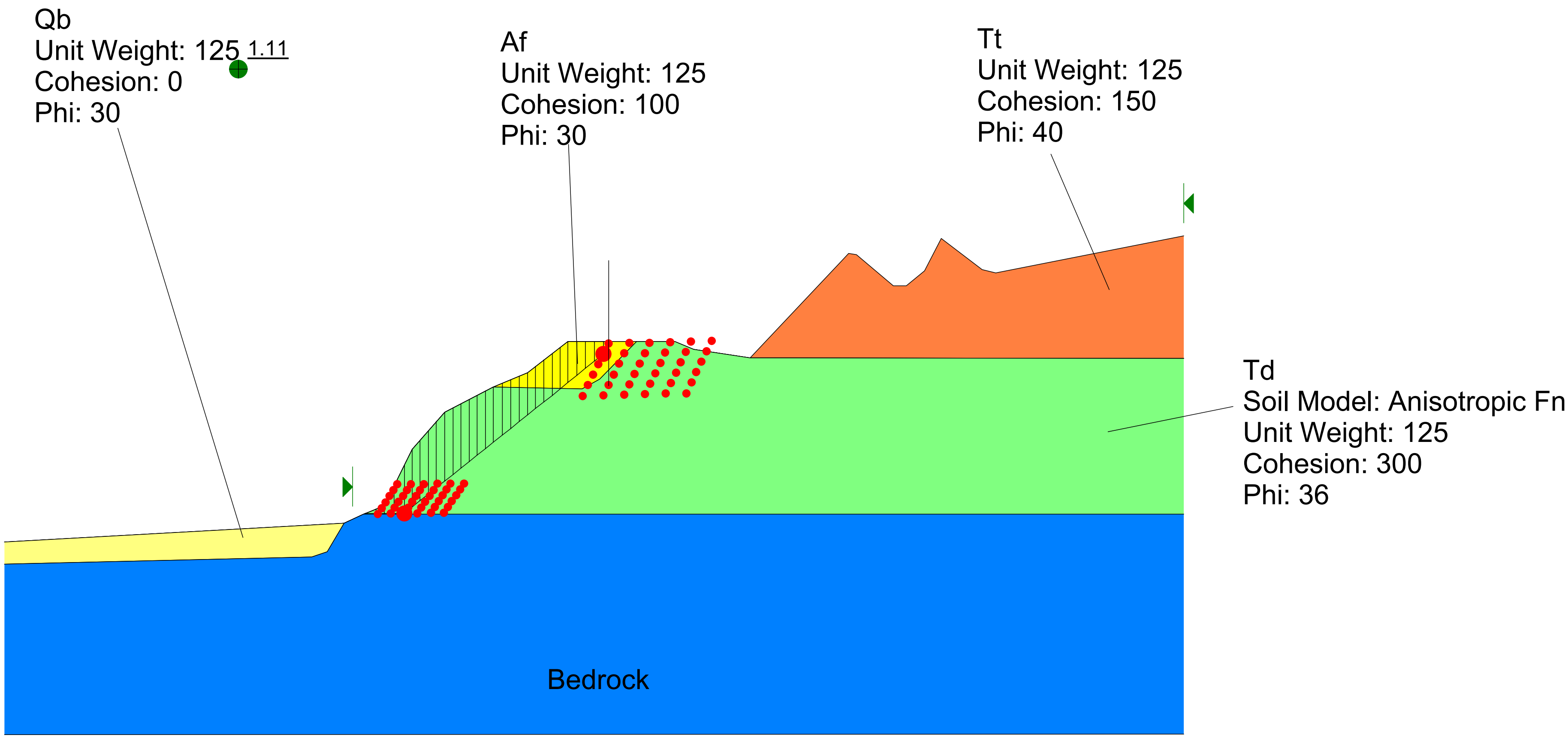


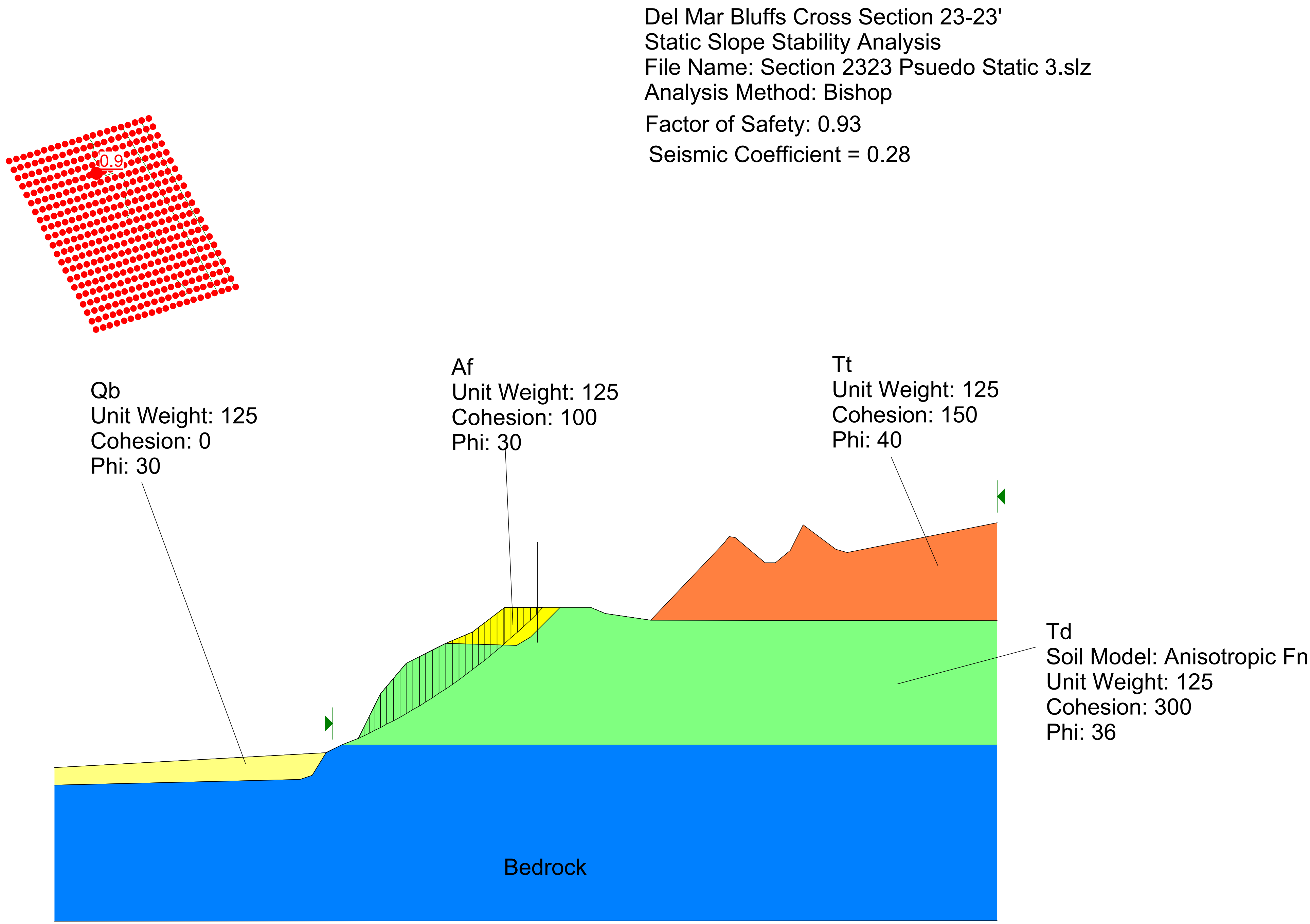

Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Psuedo Static 1.slz
Analysis Method: Bishop
Factor of Safety: 1.15
Seismic Coefficient = 0.15
1.15
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Tt
Unit Weight: 125
Cohesion: 150
Phi: 40
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock

Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Psuedo Static 2.slz
Analysis Method: Spencer

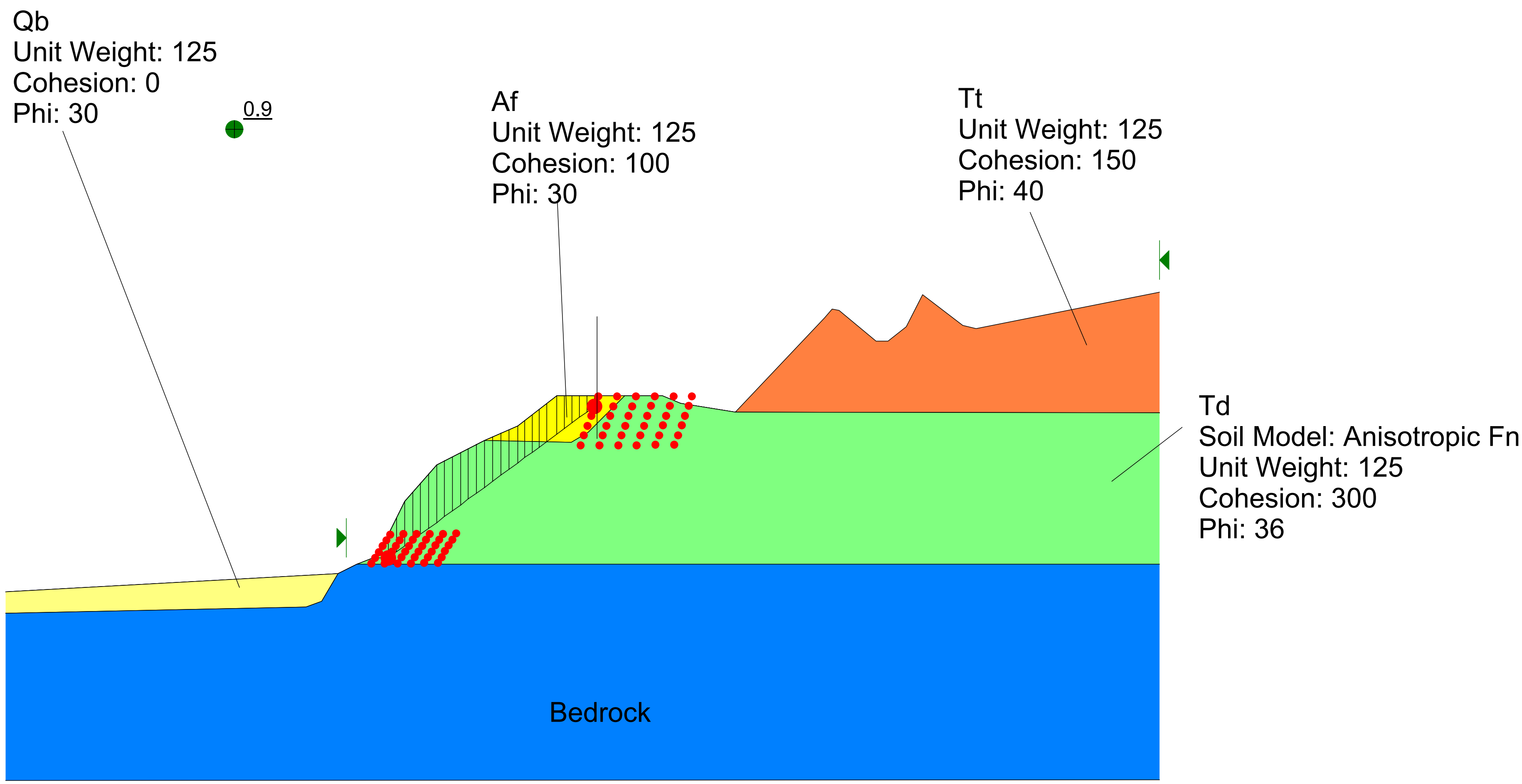
Factor of Safety: 1.11

Seismic Coefficient = 0.15



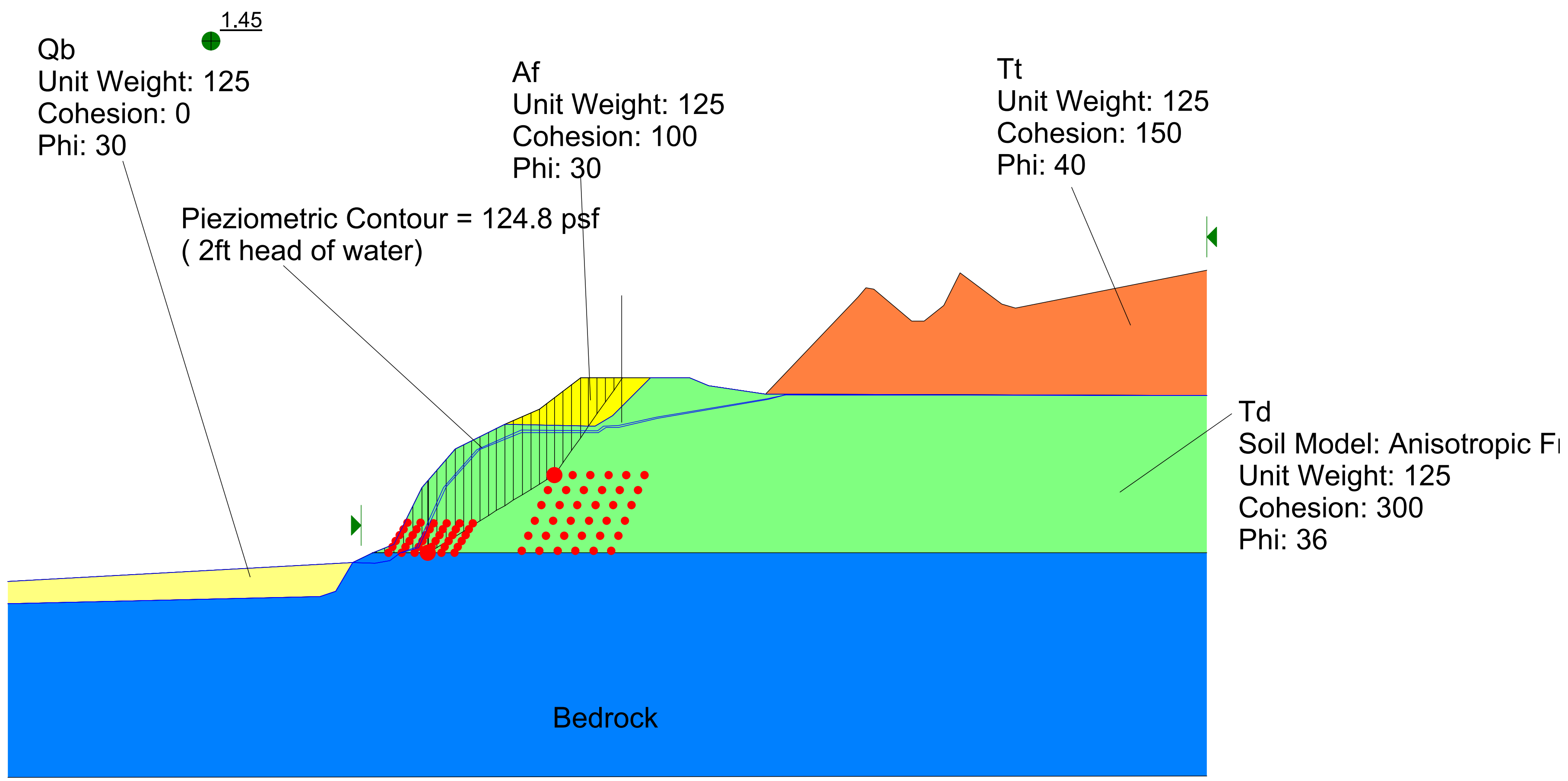

Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Psuedo Static 3.slz
Analysis Method: Bishop
Factor of Safety: 0.93
Seismic Coefficient = 0.28
0.9
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Tt
Unit Weight: 125
Cohesion: 150
Phi: 40
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock

Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Psuedo Static 4.slz
Analysis Method: Spencer
Factor of Safety: 0.92
Seismic Coefficient = 0.28



Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Static 2B.slz
Analysis Method: Spencer

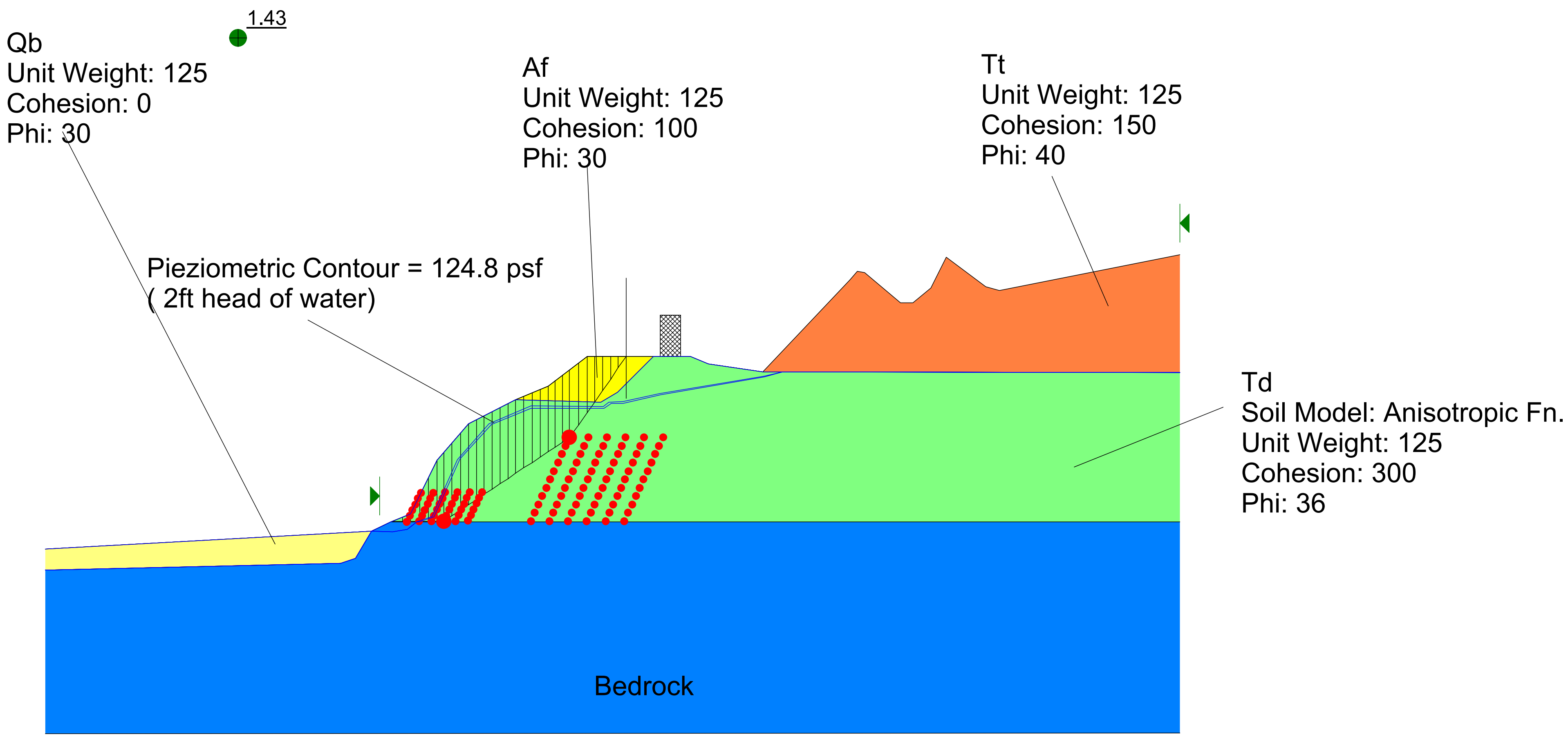
Factor of Safety: 1.45



Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Static 4B.slz
Analysis Method: Spencer

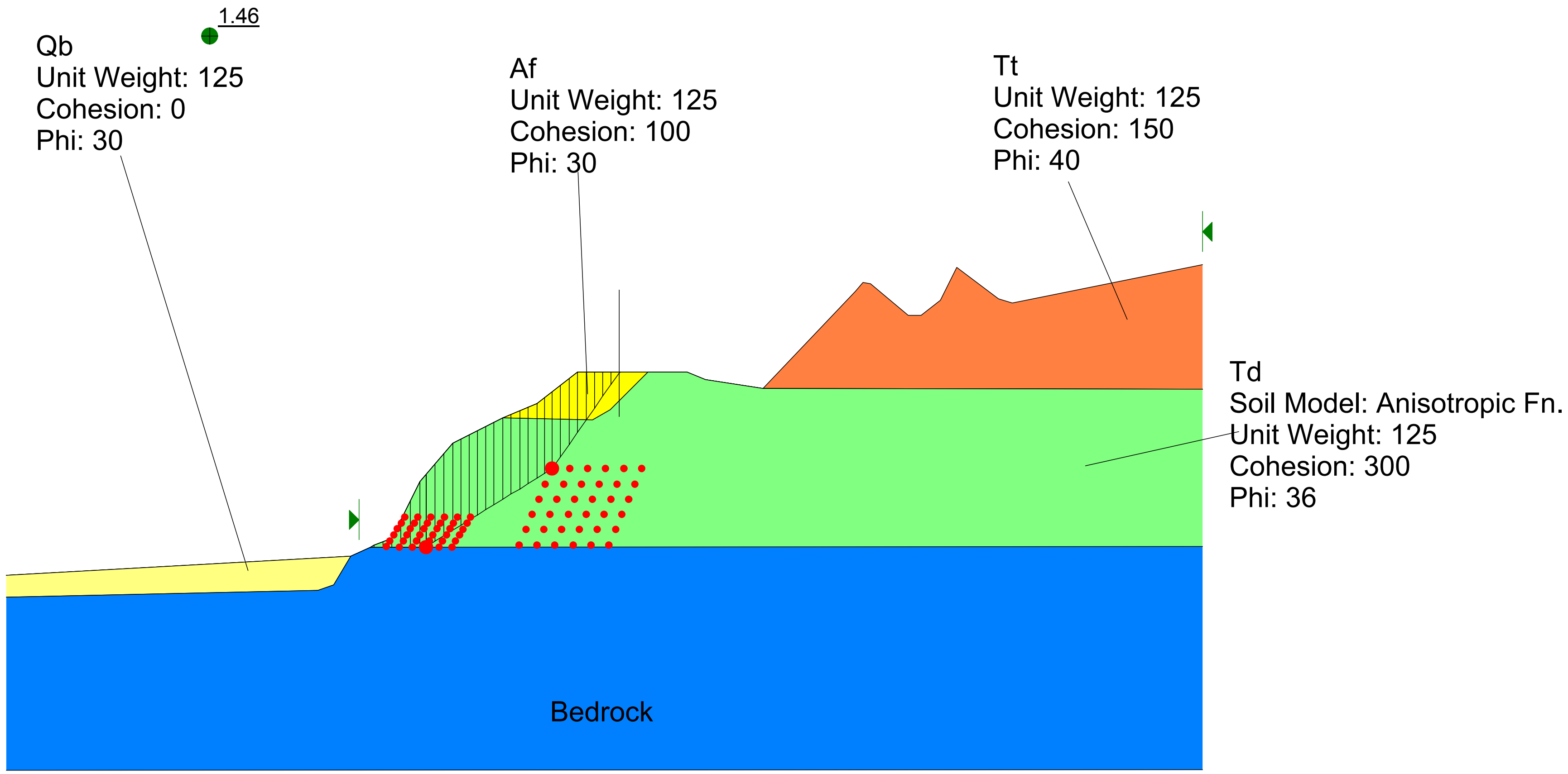
Factor of Safety: 1.43

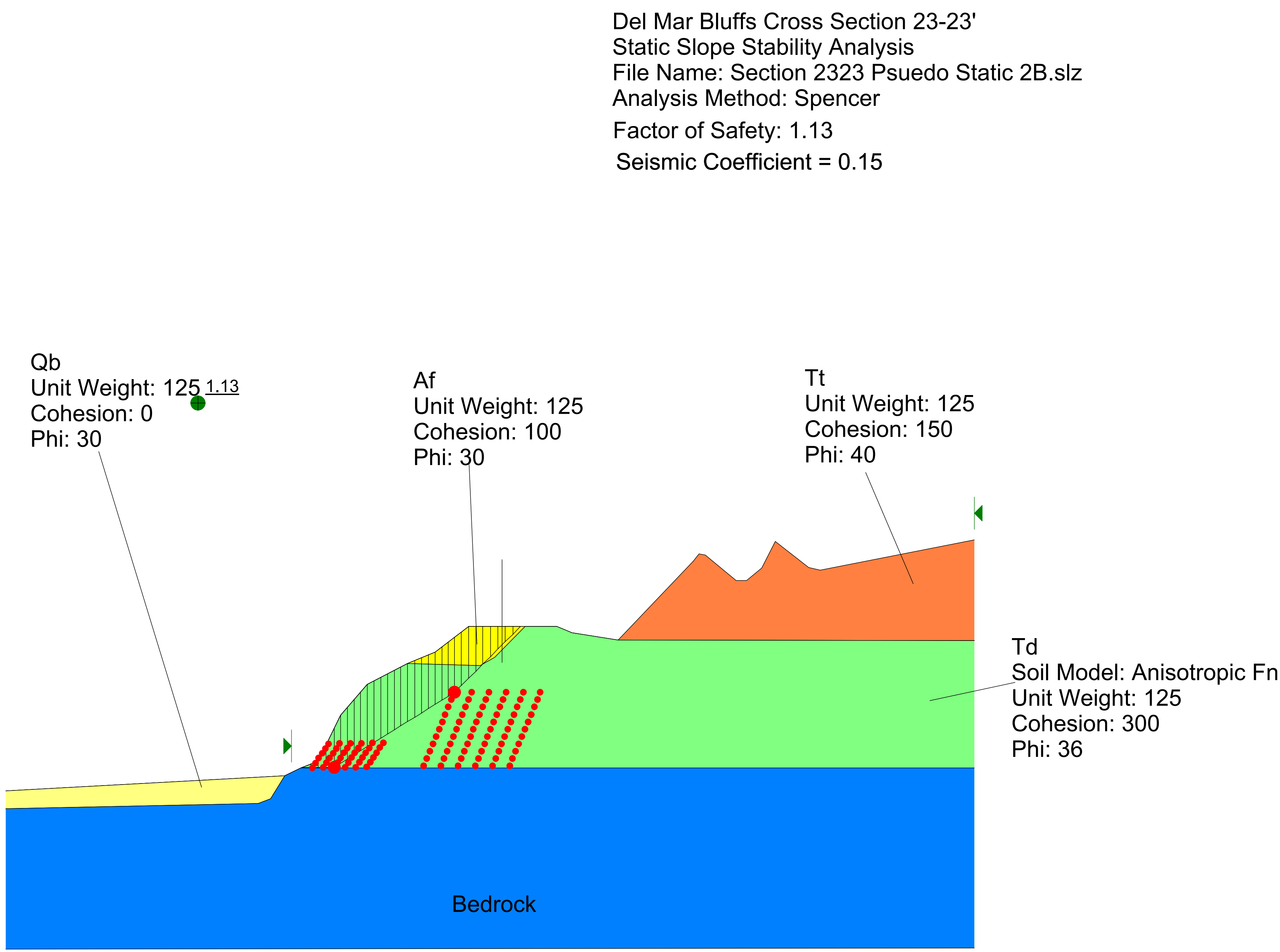
Surcharge = 3.000 psf



Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis, No Water
File Name: Section 2323 Static 2B No Water.slz
Analysis Method: Spencer

Factor of Safety: 1.46

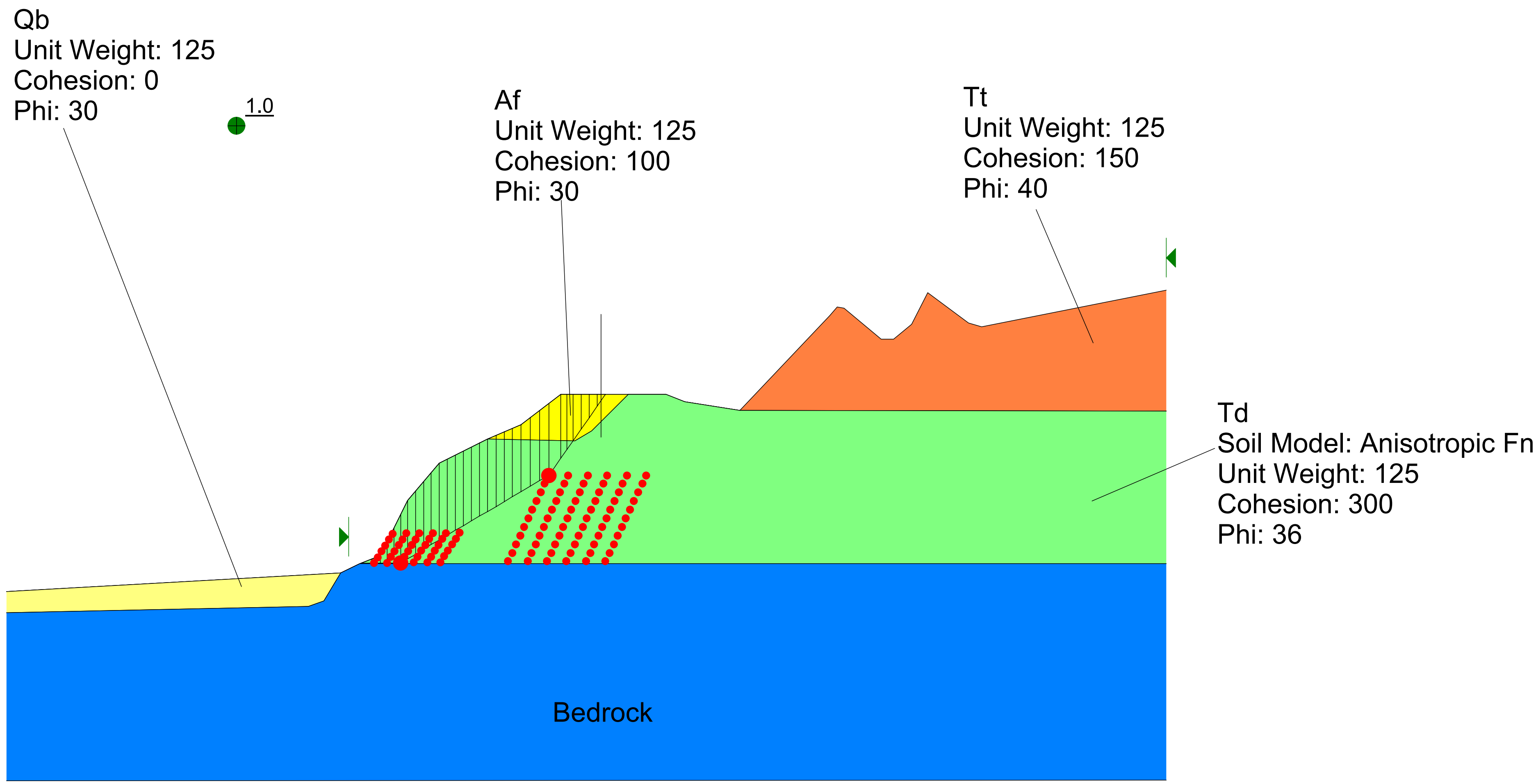



Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Psuedo Static 2B.slz
Analysis Method: Spencer
Factor of Safety: 1.13
Seismic Coefficient = 0.15
Qb
Unit Weight: 125
Cohesion: 0
Phi: 30
1.13
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Tt
Unit Weight: 125
Cohesion: 150
Phi: 40
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Bedrock

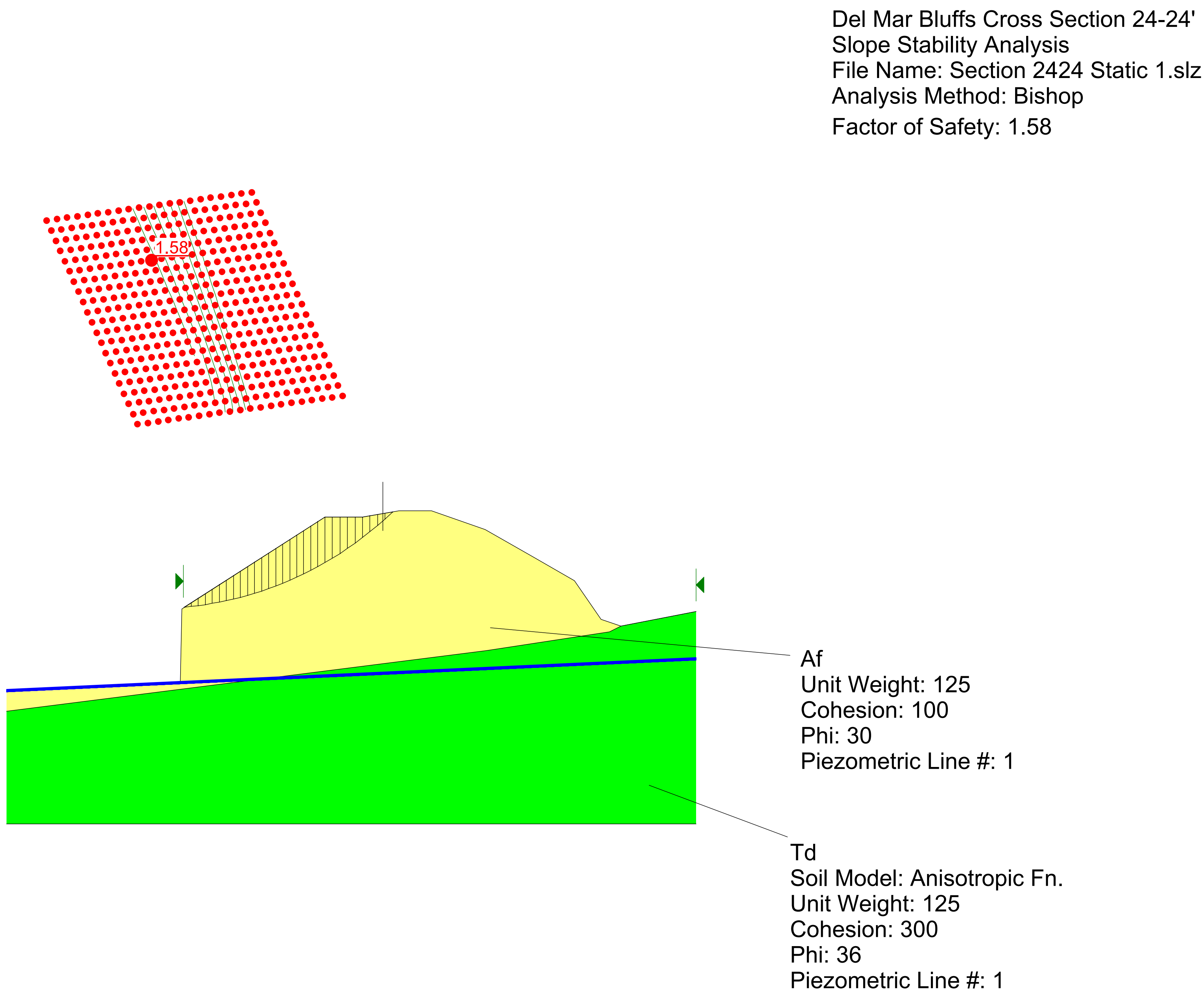
Del Mar Bluffs Cross Section 23-23'
Static Slope Stability Analysis
File Name: Section 2323 Psuedo Static 4B.slz
Analysis Method: Spencer

Factor of Safety: 0.96

Seismic Coefficient = 0.28



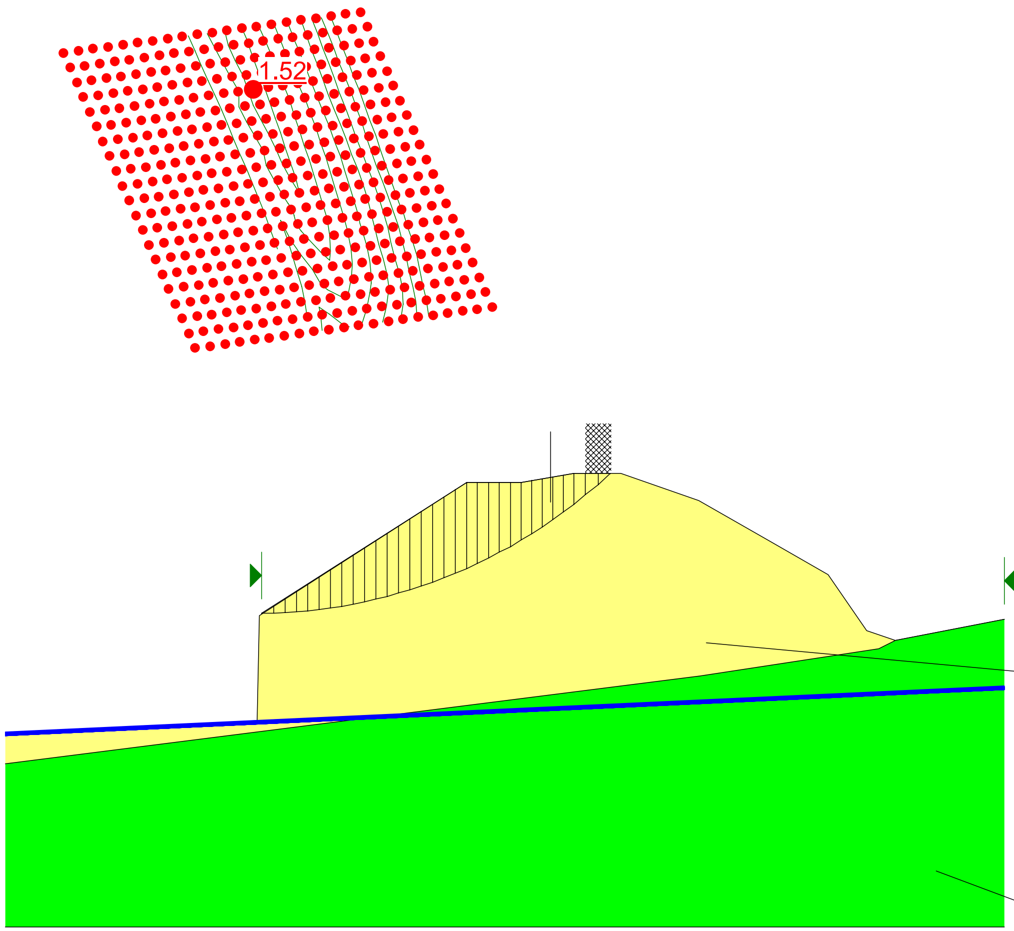
Cross Section 24-24’



Del Mar Bluffs Cross Section 24-24'
Slope Stability Analysis
File Name: Section 2424 Static 1.slz
Analysis Method: Bishop
Factor of Safety: 1.58
1.58
Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Piezometric Line #: 1
Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Piezometric Line #: 1

Del Mar Bluffs Cross Section 24-24'
Slope Stability Analysis
File Name: Section 2424 Static 2.slz
Analysis Method: Bishop
Factor of Safety: 1.52

Surcharge = 3,000 psf

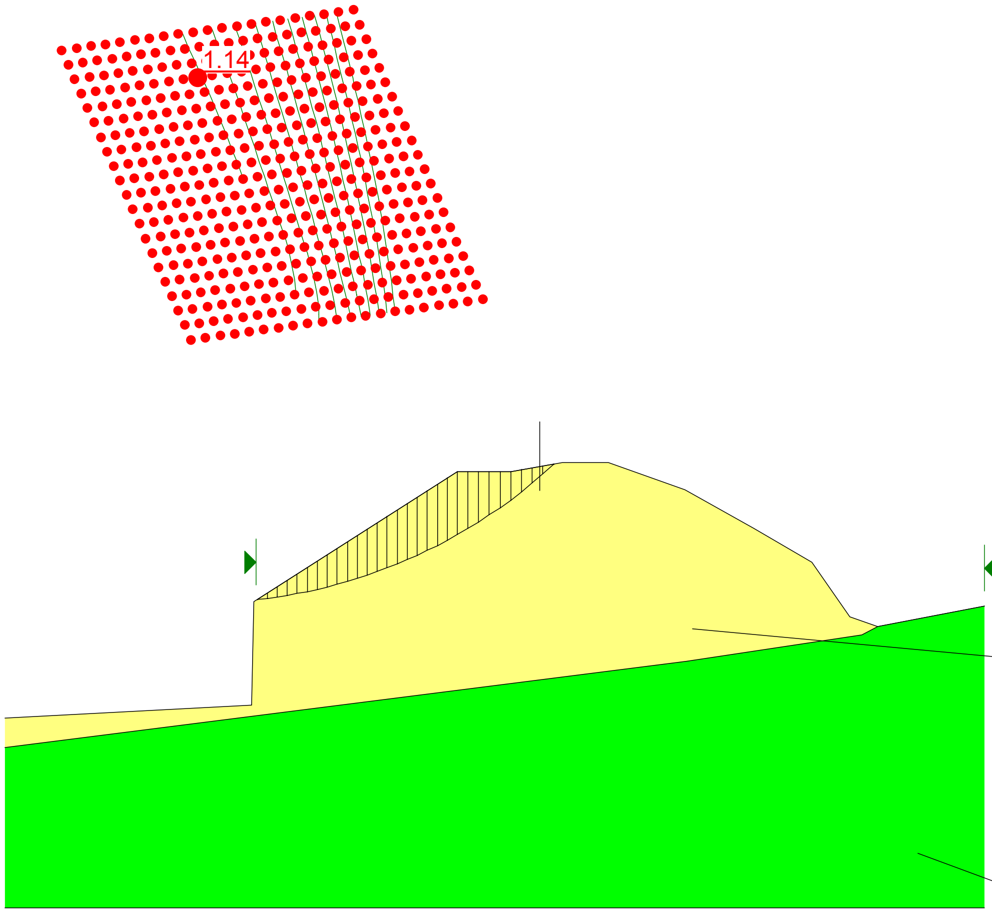


Af
Unit Weight: 125
Cohesion: 100
Phi: 30
Piezometric Line #: 1

Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36
Piezometric Line #: 1

Del Mar Bluffs Cross Section 24-24'
Slope Stability Analysis
File Name: Section 2424 Pseudo Static 1.slz
Analysis Method: Bishop
Factor of Safety: 1.14

Seismic Coefficient = 0.15

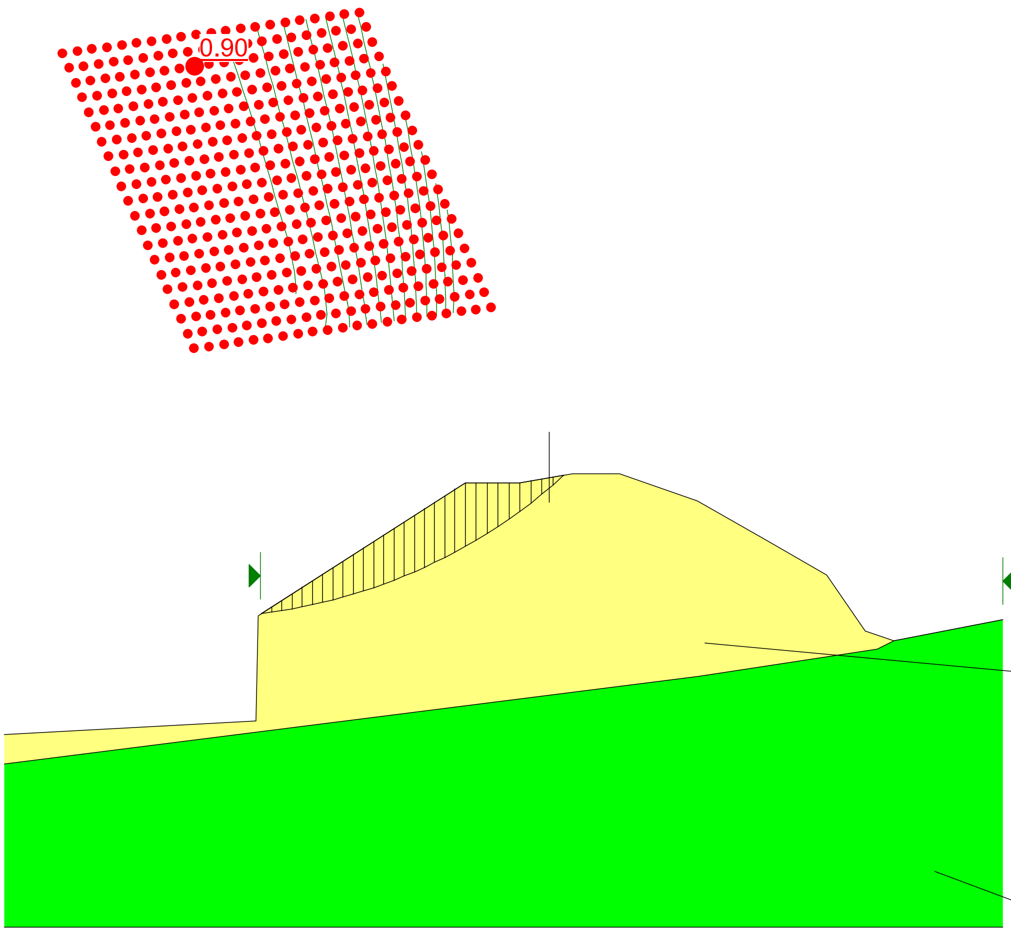


Af
Unit Weight: 125
Cohesion: 100
Phi: 30

Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36

Del Mar Bluffs Cross Section 24-24'
Slope Stability Analysis
File Name: Section 2424 Pseudo Static 2.slz
Analysis Method: Bishop
Factor of Safety: 0.904

Seismic Coefficient = 0.28



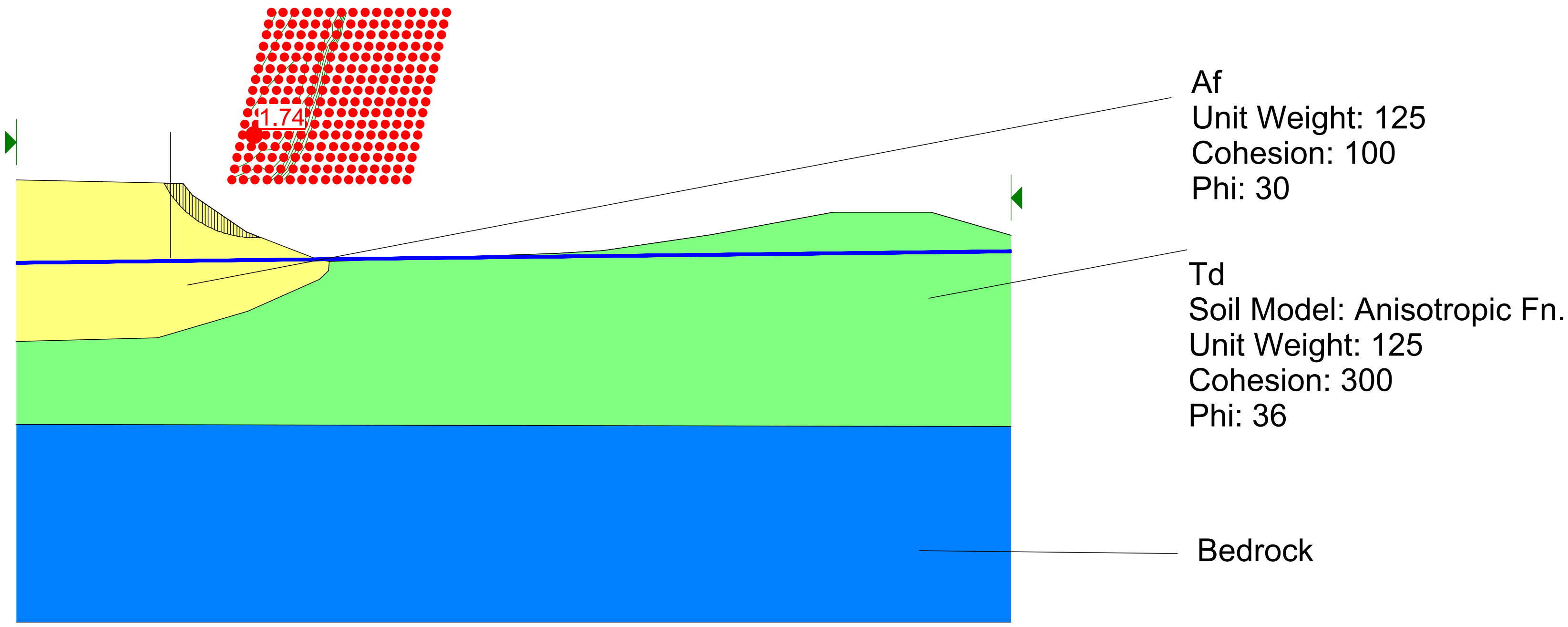
Af
Unit Weight: 125
Cohesion: 100
Phi: 30

Td
Soil Model: Anisotropic Fn.
Unit Weight: 125
Cohesion: 300
Phi: 36

Cross Section 25-25’

Del Mar Bluffs Cross Section 25-25'
Slope Stability Analysis
File Name: Section 2525 Water Static 1.slz
Analysis Method: Bishop

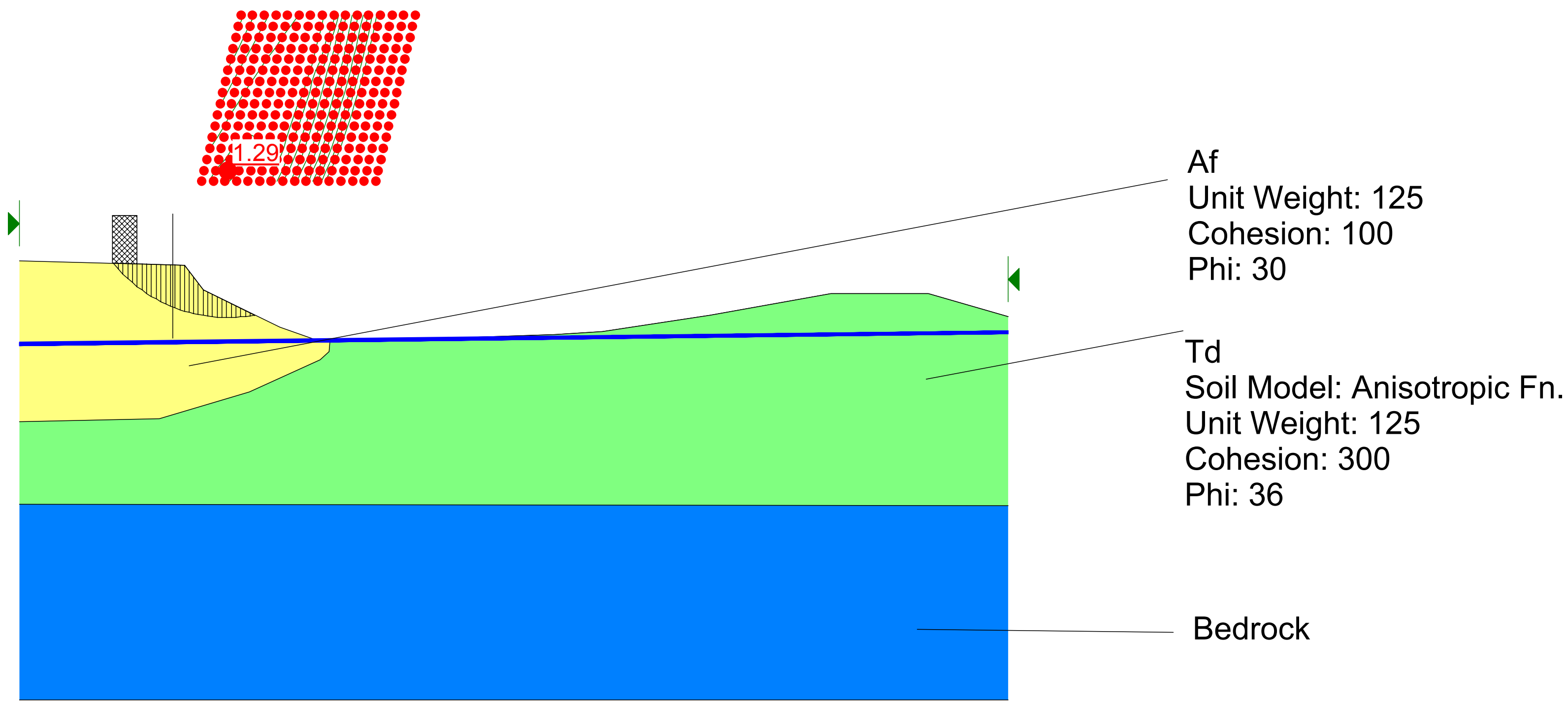
Factor of Safety: 1.74



Del Mar Bluffs Cross Section 25-25'
Slope Stability Analysis
File Name: Section 2525 Water Static 2.slz
Analysis Method: Bishop

Factor of Safety: 1.29

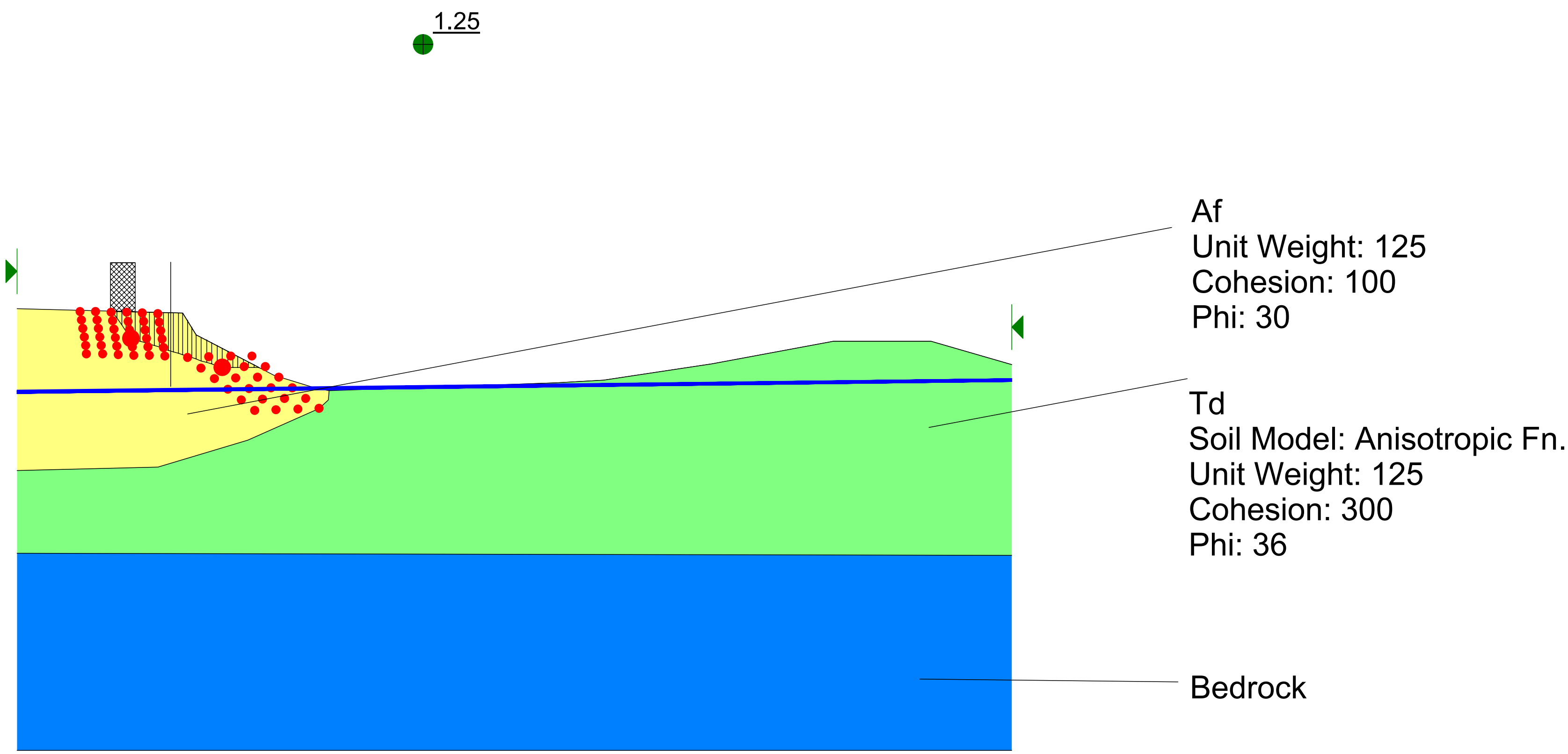
Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 25-25'
Slope Stability Analysis
File Name: Section 2525 Water Static 3.slz
Analysis Method: Spencer

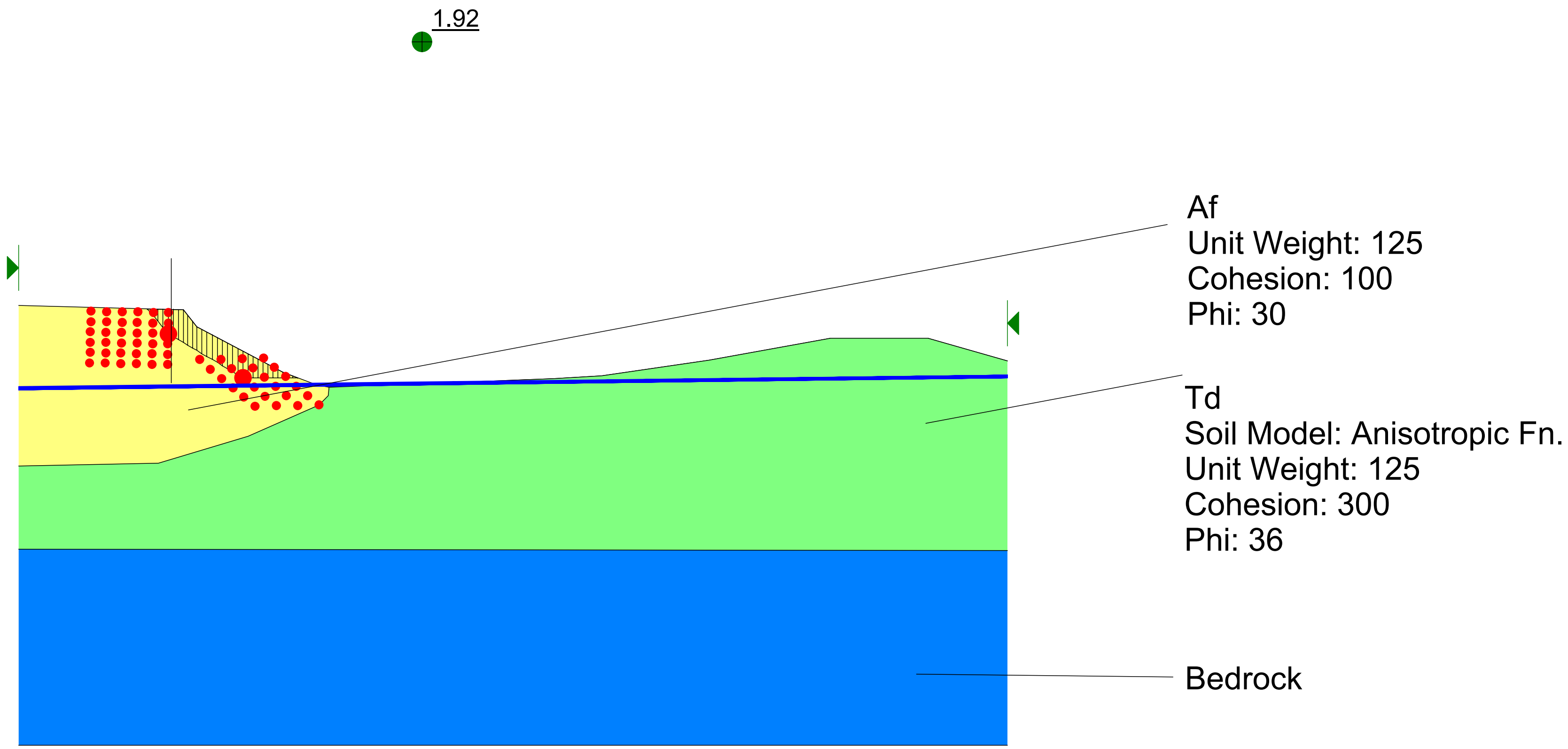
Factor of Safety: 1.25

Surcharge = 3,000 psf



Del Mar Bluffs Cross Section 25-25'
Slope Stability Analysis
File Name: Section 2525 Water Static 4.slz
Analysis Method: Spencer

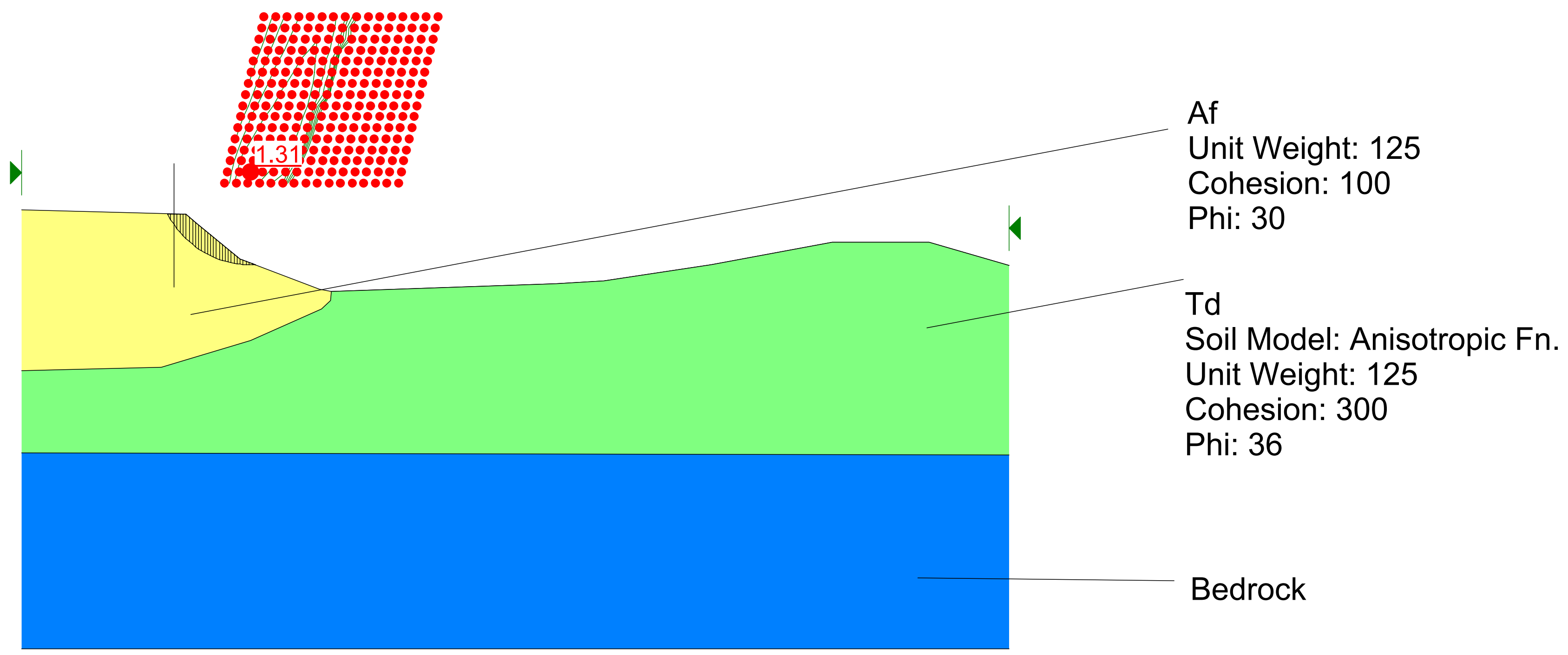
Factor of Safety: 1.92



Del Mar Bluffs Cross Section 25-25'
Slope Stability Analysis
File Name: Section 2525 Psuedo Static Static 1.slz
Analysis Method: Bishop

Factor of Safety: 1.31

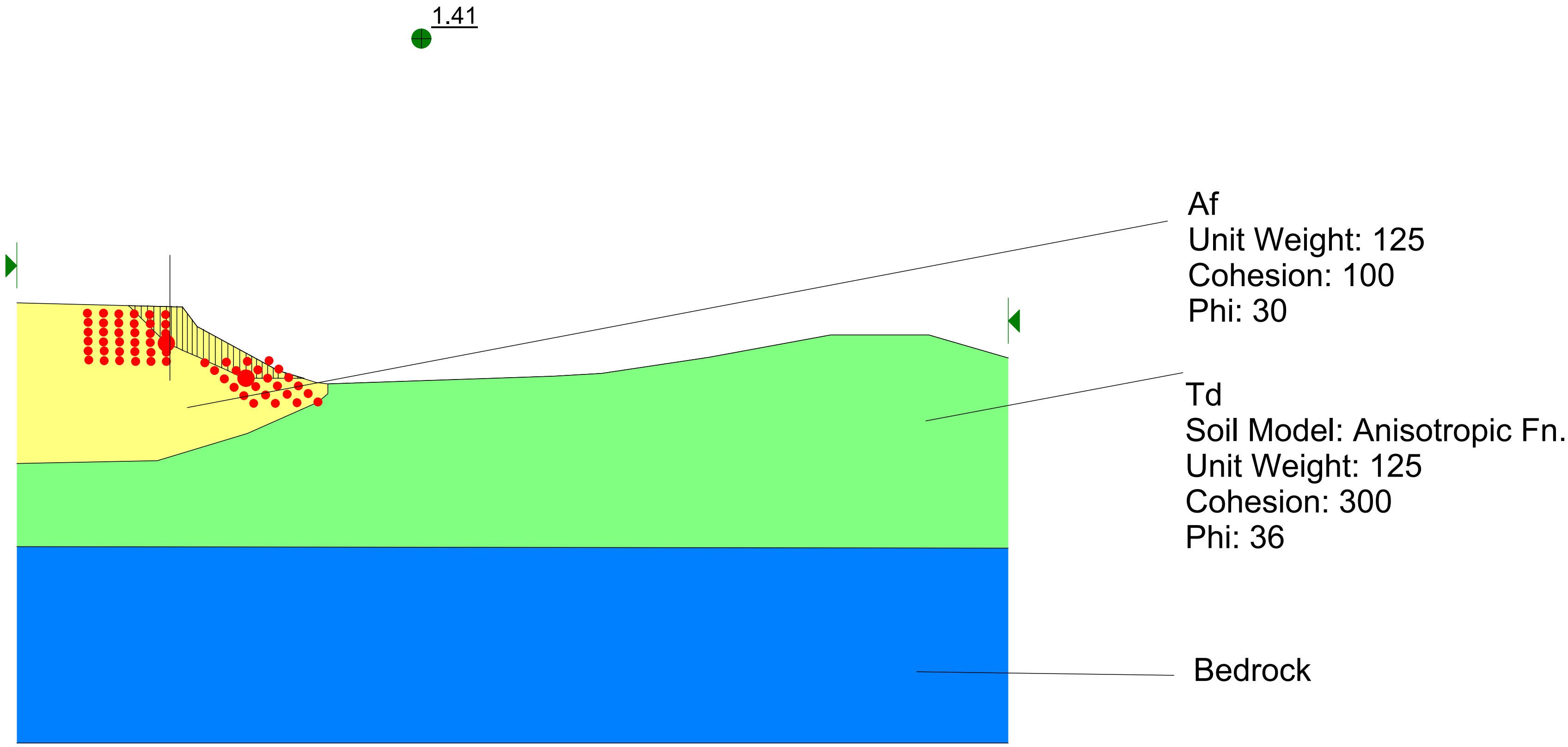
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 25-25'
Slope Stability Analysis
File Name: Section 2552 Psuedo Static Static 2.slz
Analysis Method: Spencer

Factor of Safety: 1.41

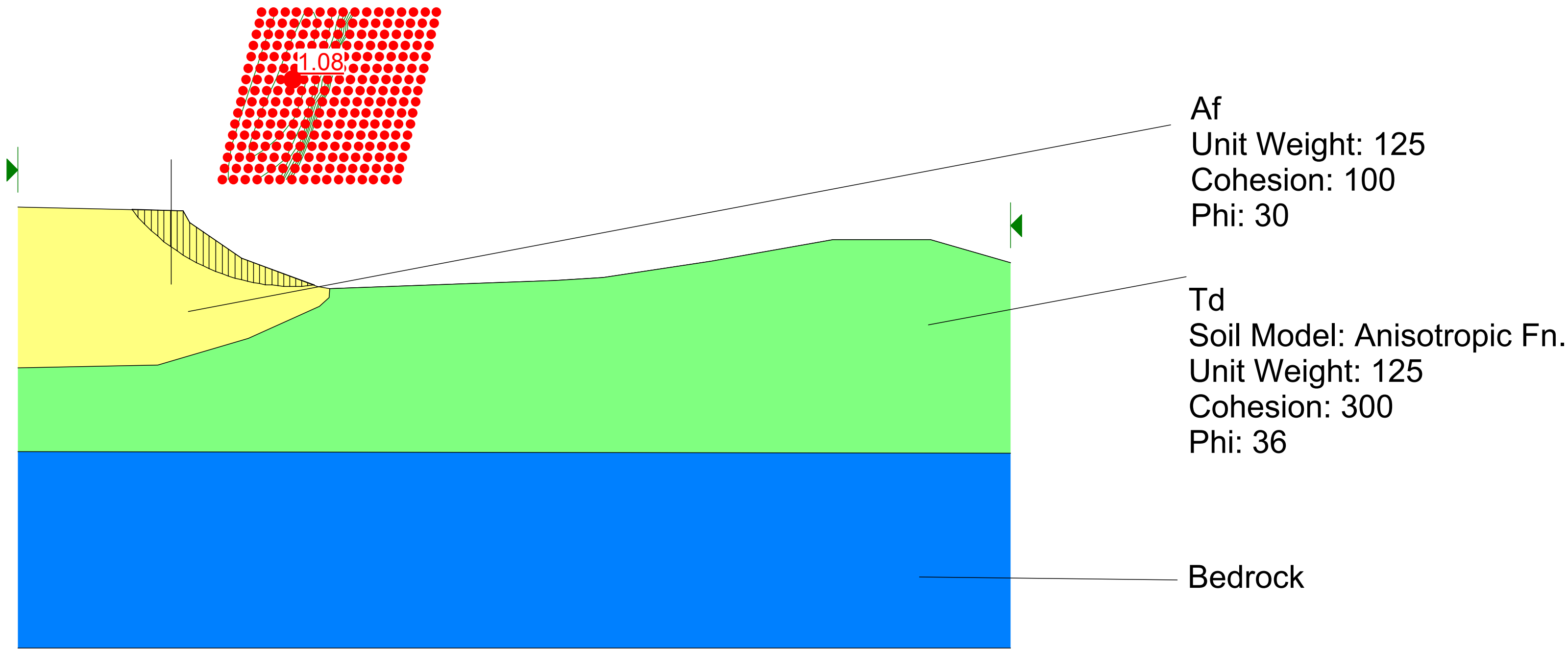
Seismic Coefficient = 0.15



Del Mar Bluffs Cross Section 25-25'
Slope Stability Analysis
File Name: Section 2525 Psuedo Static Static 3.slz
Analysis Method: Bishop

Factor of Safety: 1.08

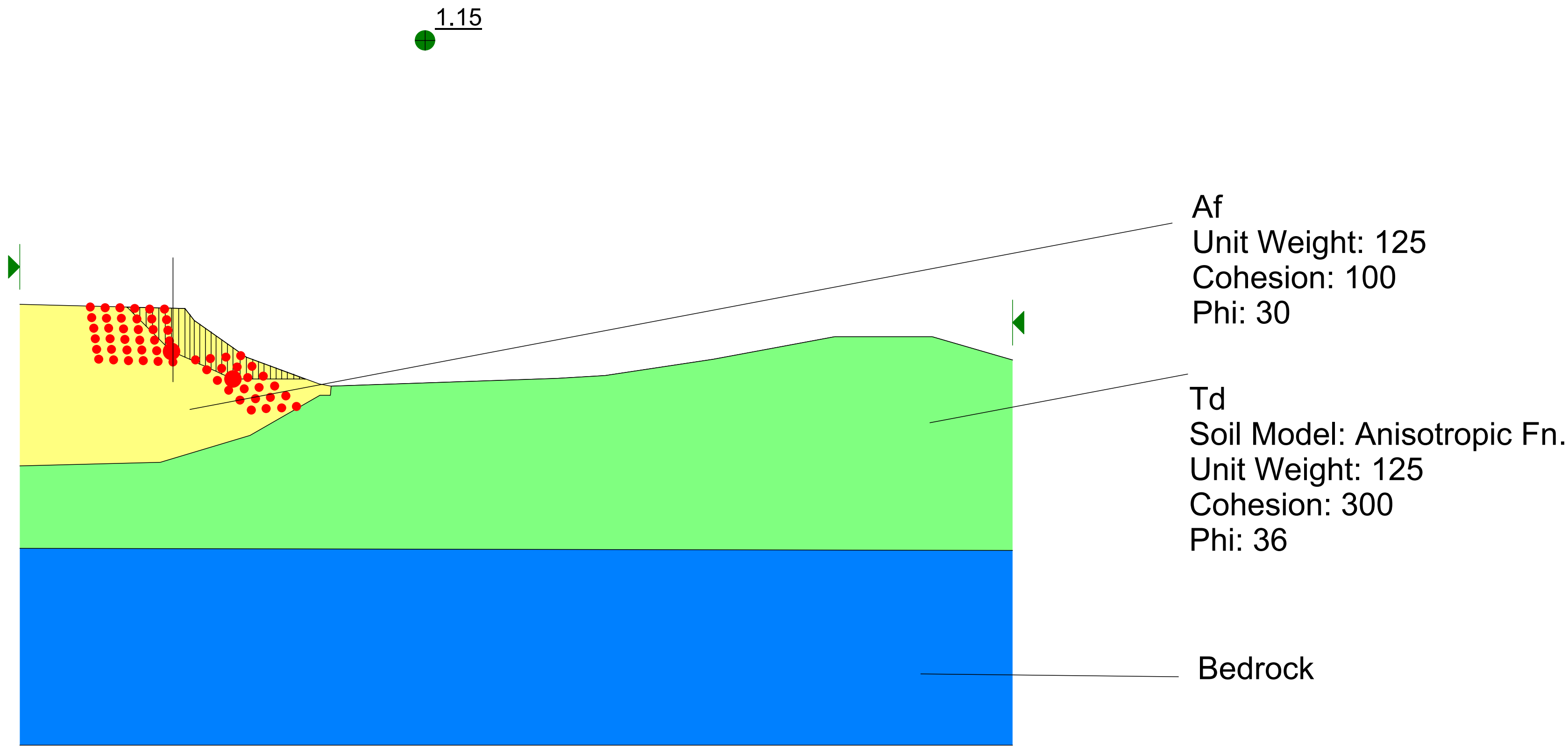
Seismic Coefficient = 0.28



Del Mar Bluffs Cross Section 25-25'
Slope Stability Analysis
File Name: Section 2525 Psuedo Static Static 4.slz
Analysis Method: Spencer

Factor of Safety: 1.15

Seismic Coefficient = 0.28

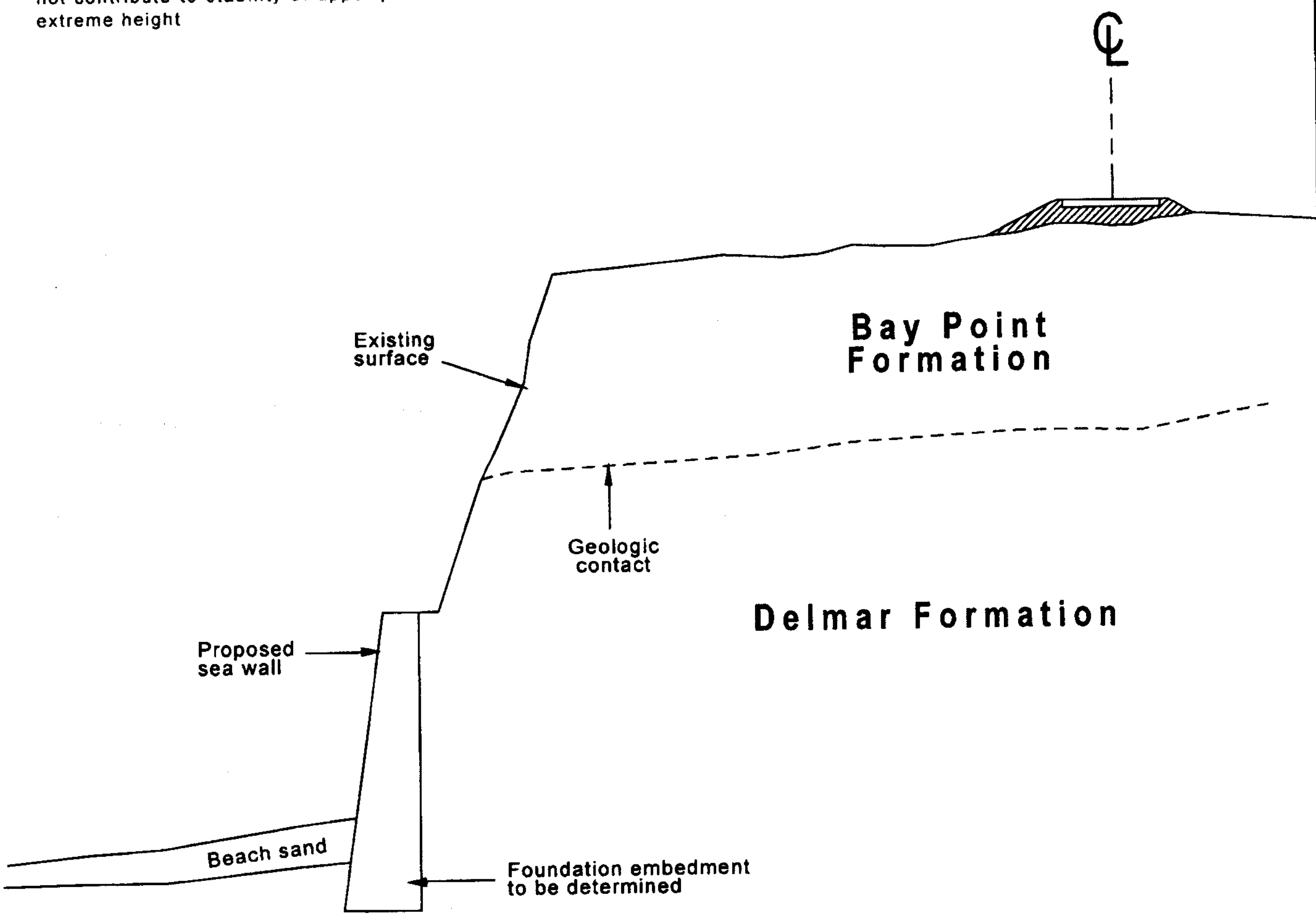


SEA WALL AND SETBACK

Wood or concrete seawalls at base of bluff to halt landward erosion. Walls to be embedded into competent bedrock. May require removal of wall if rail right of way is abandoned.

IMPROVEMENT

Will improve or maintain factor of safety for deep seated stability at toe; will improve surficial stability at lower portion of bluff; may not contribute to stability of upper portion of bluff unless wall is of extreme height



FORM OF MITIGATION	
☒	Toe
☒	Surficial
☒	Deep-seated

FIGURE 1: SEA WALL AT BLUFF TOE

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 3. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

040151-001

January 2001

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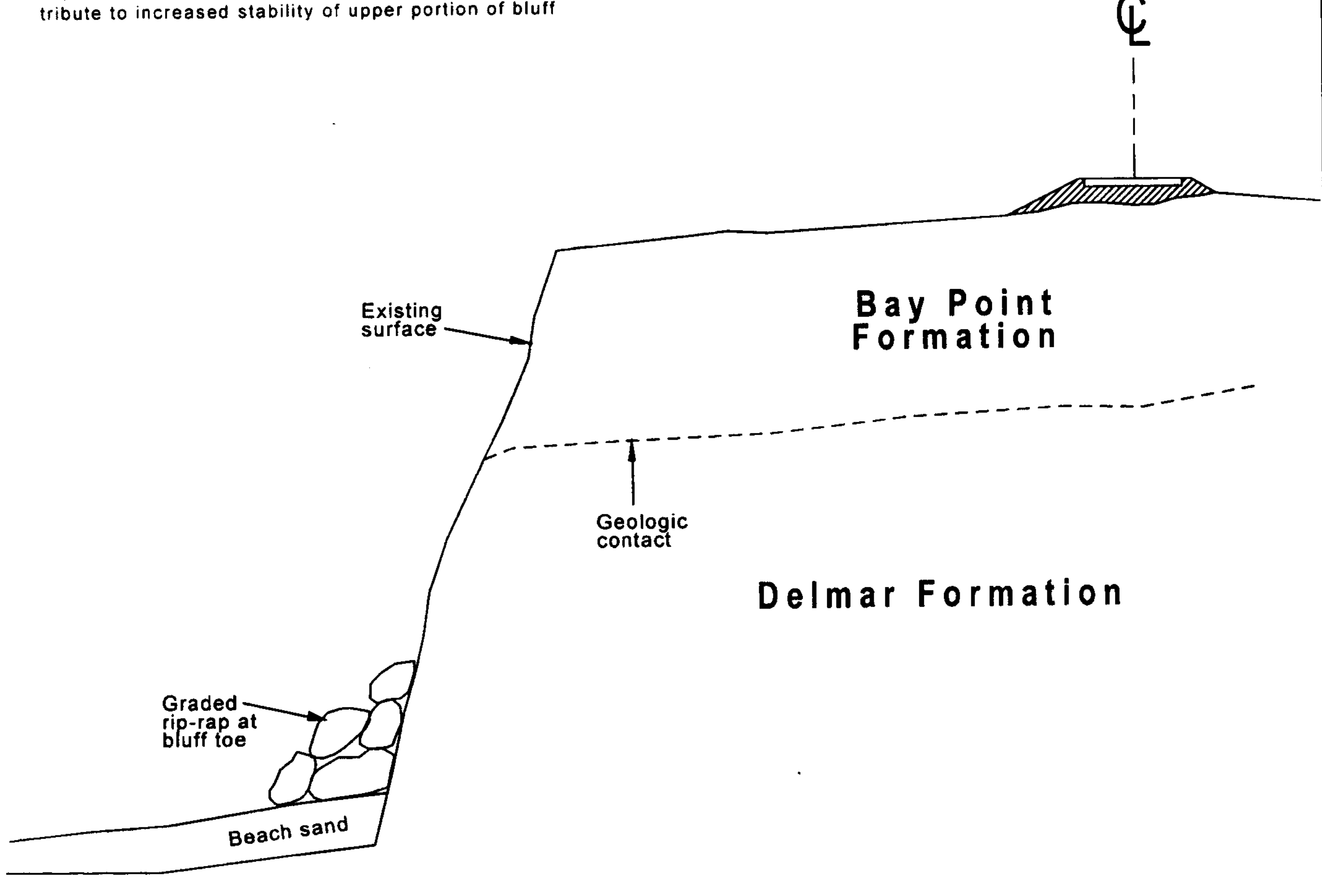
ROCK REVETMENT

Rock revetment at base of bluff to consist of large (2.8 ton) rock placed on geotextile fabric. Will reduce wave energy and bluff erosion. Some maintenance required.

IMPROVEMENT

Will increase surficial stability of toe area by reducing potential for continued erosion, with large amounts of rip-rap for a minor improvement in deep seated stability may be realized; will not contribute to increased stability of upper portion of bluff



FORM OF MITIGATION	
☒	Toe
☒	Surficial
☐	Deep-seated

FIGURE 2: ROCK REVETMENT (RIP-RAP AT BLUFF TOE)

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 4. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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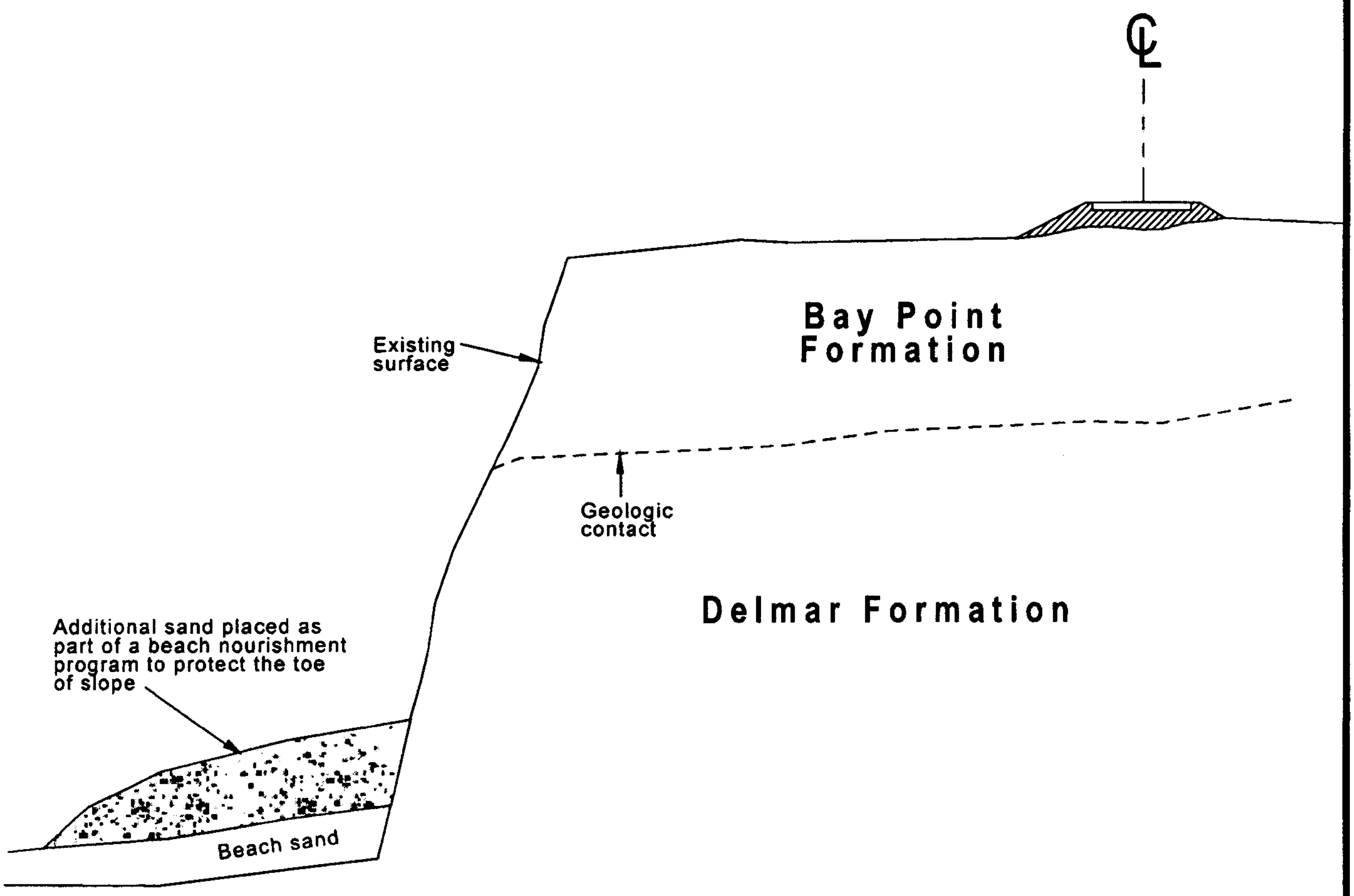
BEACH NOURISHMENT

Additional sand placed on beach to protect toe of slope. Sand placement will be subject to seasonal migration of sand and should be considered short term. Will require additional sand as erosion occurs.

IMPROVEMENT

Will add a buffer to erosion at toe; no measureable increase in factor of safety.



FORM OF MITIGATION

- [x] Toe
- [ ] Surficial
- [ ] Deep-seated

FIGURE 3: BEACH NOURISHMENT

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 5. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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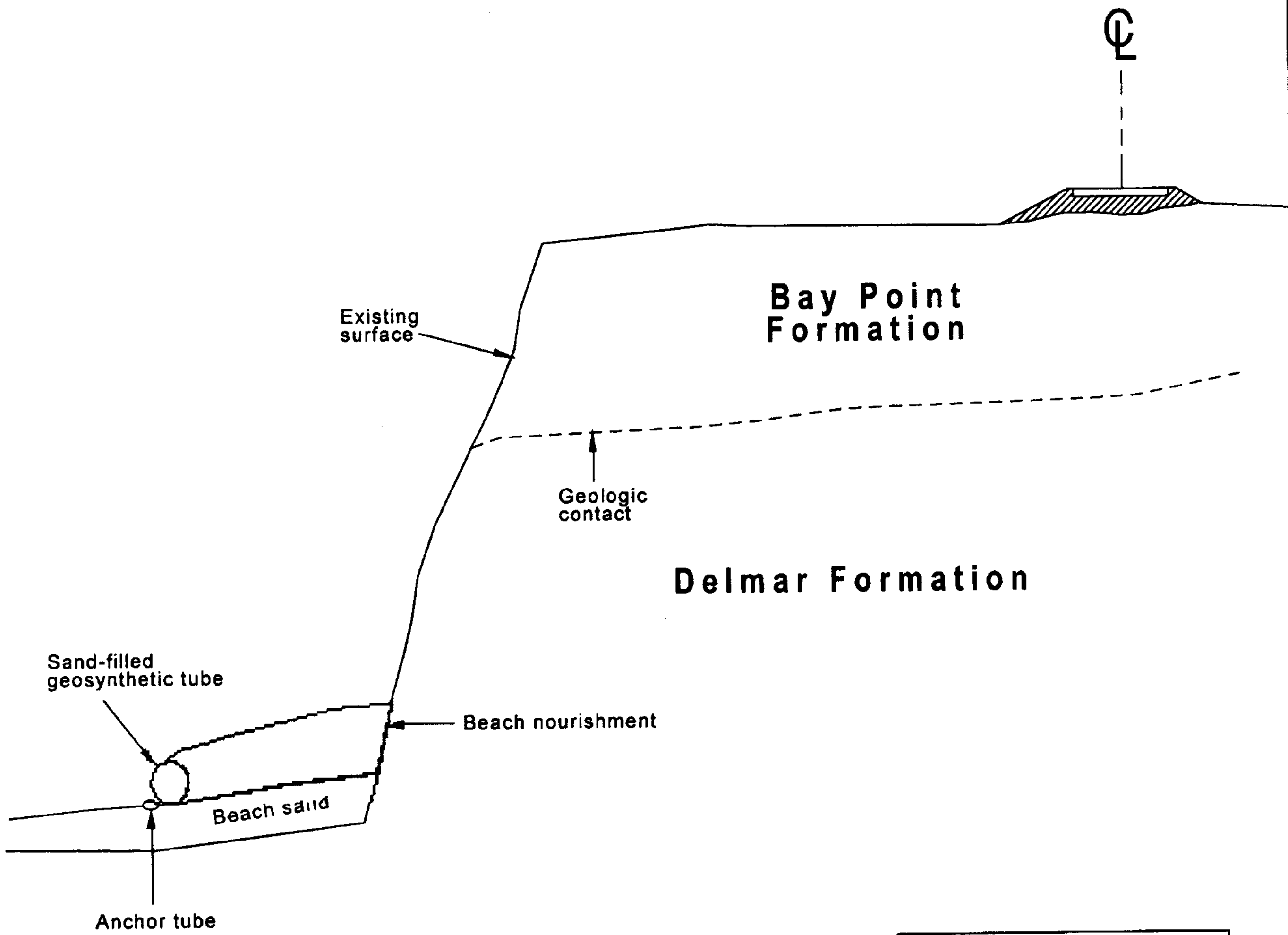
BEACH NOURISHMENT WITH GEOSYNTHETIC TUBE

Sand placed as toe protection as shown on Figure No. 5. Geosynthetic tube (longard tube) to protect minimize depletion of sand.

IMPROVEMENT

Will reduce potential for erosion at toe; no measurable increase in factor of safety.



FORM OF MITIGATION

- [x] Toe
- [ ] Surficial
- [ ] Deep-seated

FIGURE 4: BEACH NOURISHMENT WITH GEOSYNTHETIC TUBE

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 6. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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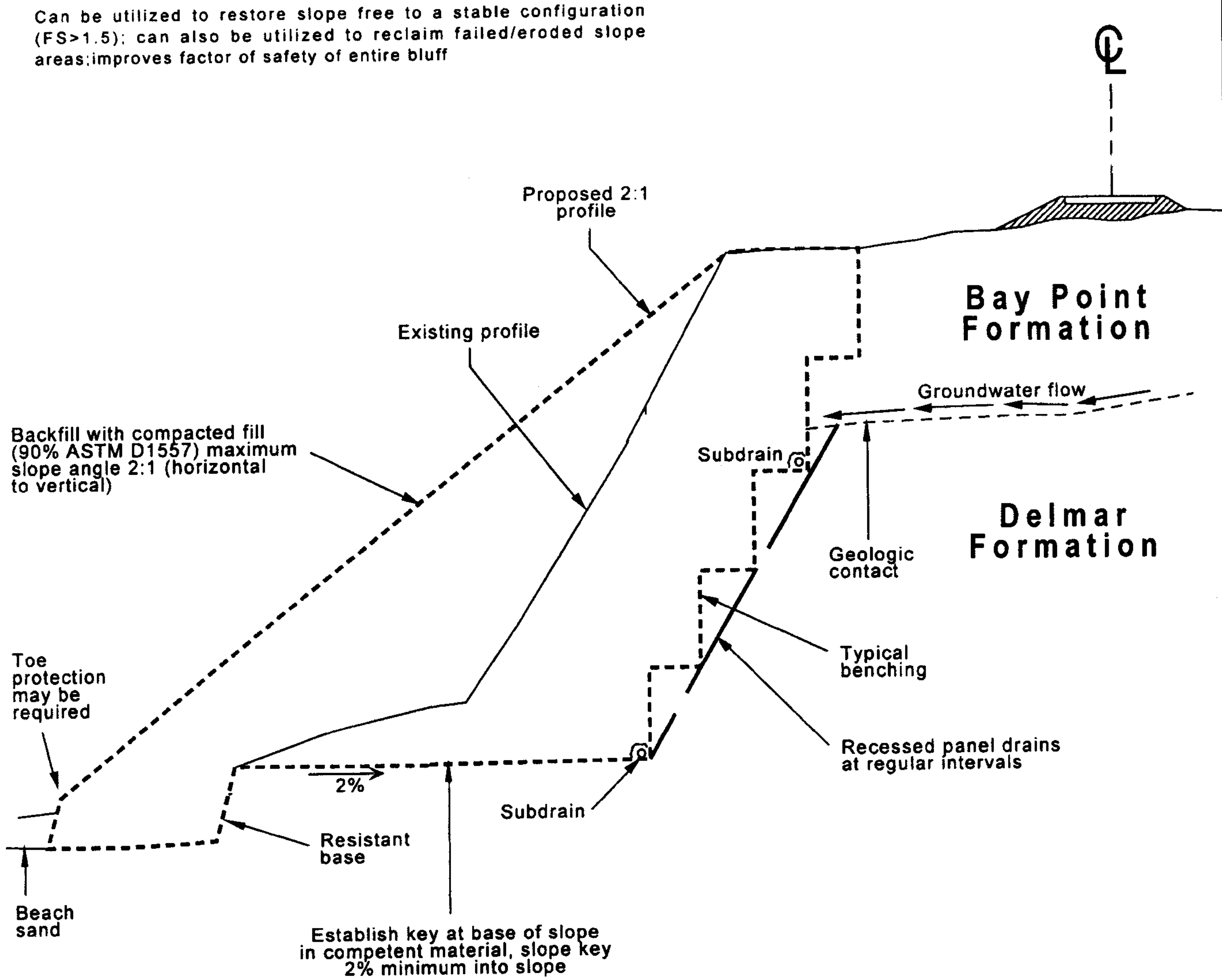
SLOPE GRADING

Regrade slope to flatter gradient to remove fractures and to provide support for oversteepened areas.

IMPROVEMENT

Can be utilized to restore slope free to a stable configuration (FS>1.5); can also be utilized to reclaim failed/eroded slope areas;improves factor of safety of entire bluff



FORM OF MITIGATION
☒ Toe
☒ Surficial
☒ Deep-seated

FIGURE 5: SLOPE GRADING

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 7. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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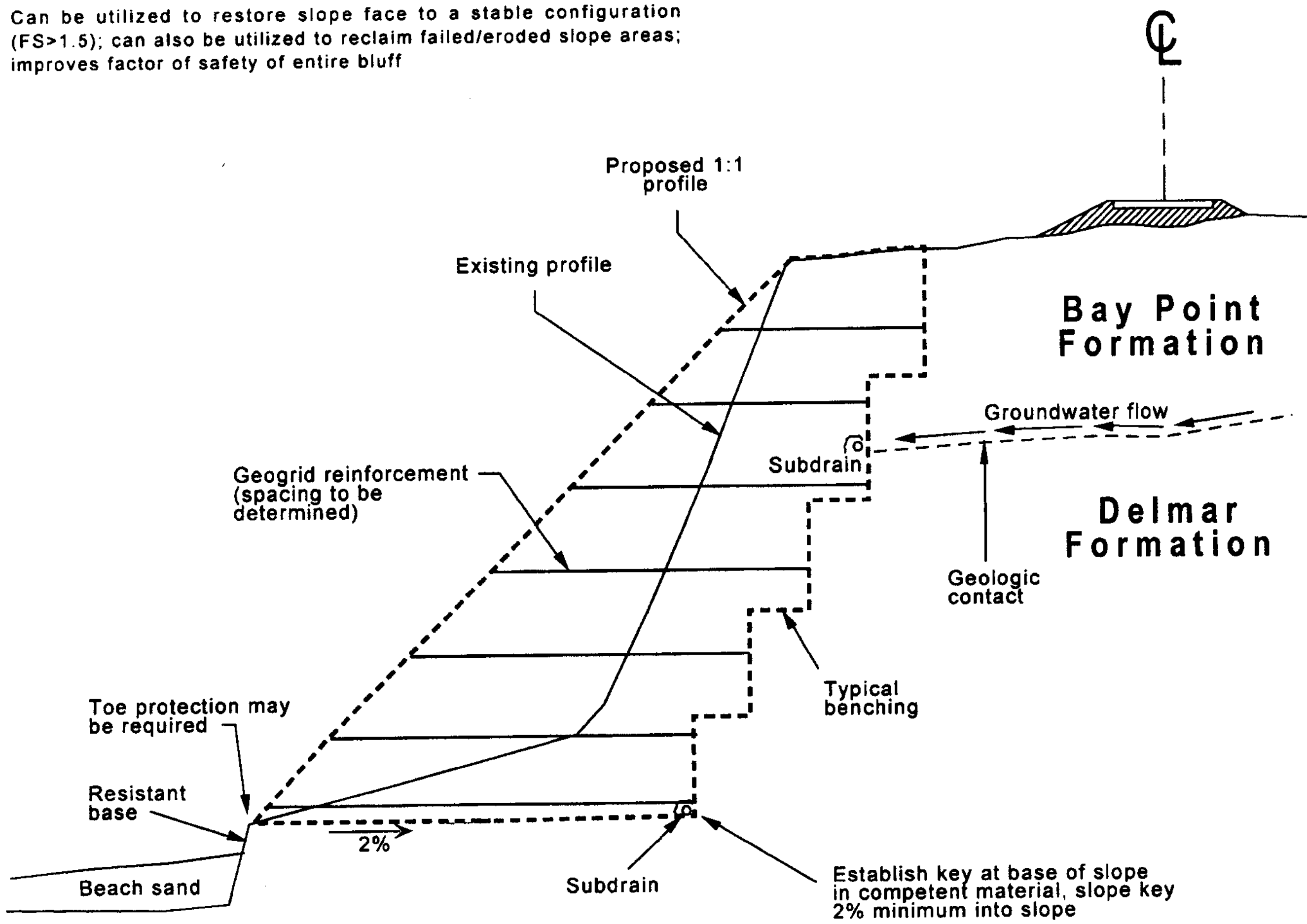
SLOPE GRADING WITH GEOGRID

Backfill with geogrid reinforced soil 1:1 (horizontal to vertical) maximum slope angle.

IMPROVEMENT

Can be utilized to restore slope face to a stable configuration (FS>1.5); can also be utilized to reclaim failed/eroded slope areas; improves factor of safety of entire bluff



FORM OF MITIGATION
☒ Toe
☒ Surficial
☒ Deep-seated

FIGURE 6: SLOPE GRADING WITH GEOGRID

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 8. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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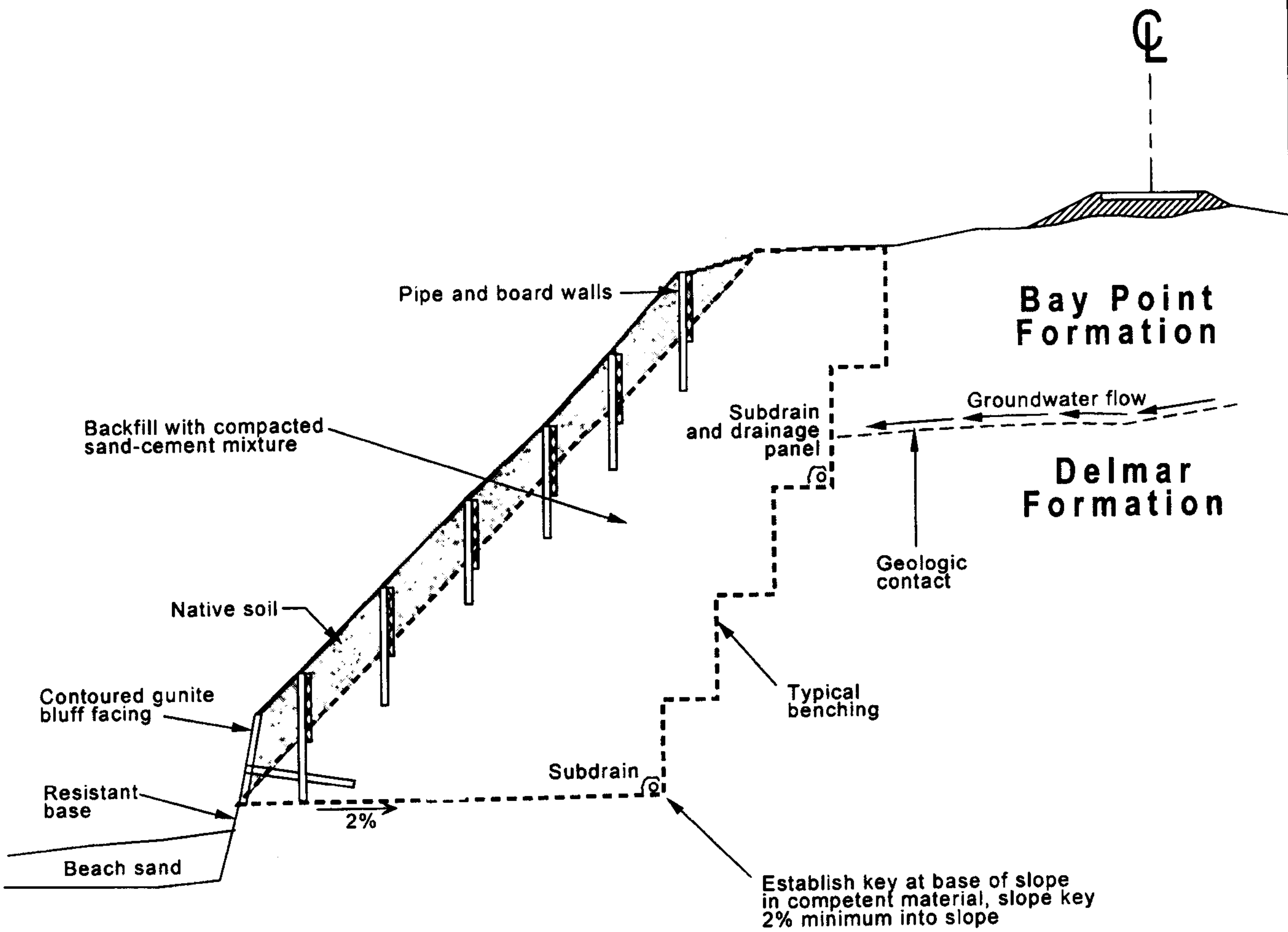
SLOPE GRADING WITH SOIL CEMENT

Backfill with soil-cement or sand-cement mixture, 1:1 (horizontal to vertical) maximum slope angle for soil cement mixture. Pipe and board walls to retain plantable soil on slope face are optional.

IMPROVEMENT

Can be utilized to restore slope face to a stable configuration (FS>1.5); can also be utilized to reclaim failed/eroded slope areas; improves factor of safety of entire bluff



FORM OF MITIGATION
☒ Toe
☒ Surficial
☒ Deep-seated

FIGURE 7: SLOPE GRADING WITH SOIL CEMENT

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives,* Figure 9. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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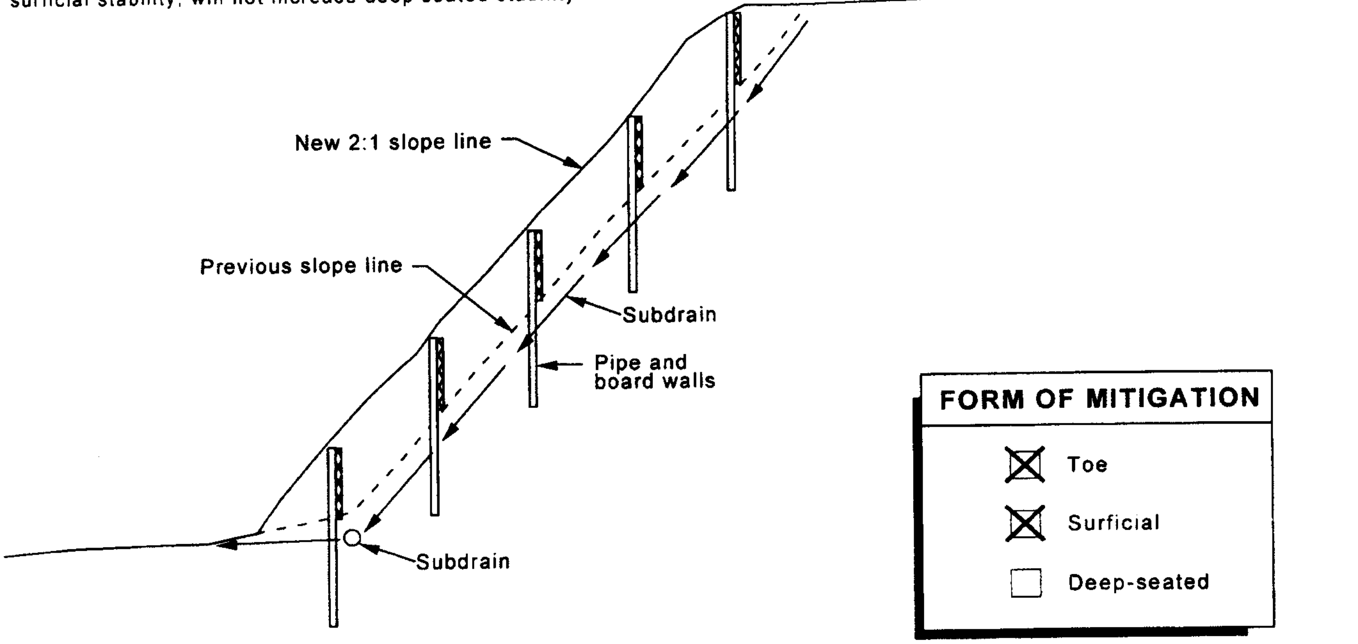
PIPE AND BOARD WALLS

Utilize for surficial slope repairs and stabilization of shallow backfill on steeper slopes. Also can be used to hold plantable soil that can be placed over soil cement buttress. Require minimal slope disturbances.

IMPROVEMENT

Best utilized for surficial and localized repairs; will improve surficial stability; will not increase deep seated stability



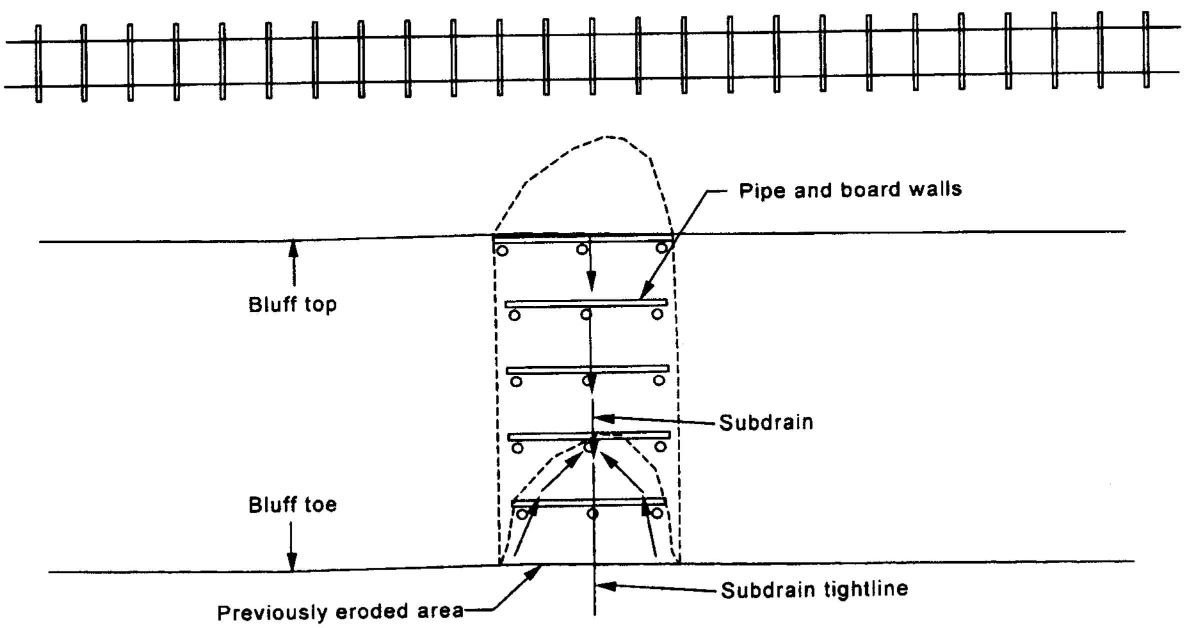


FIGURE 8: PIPE AND BOARD WALLS

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 10. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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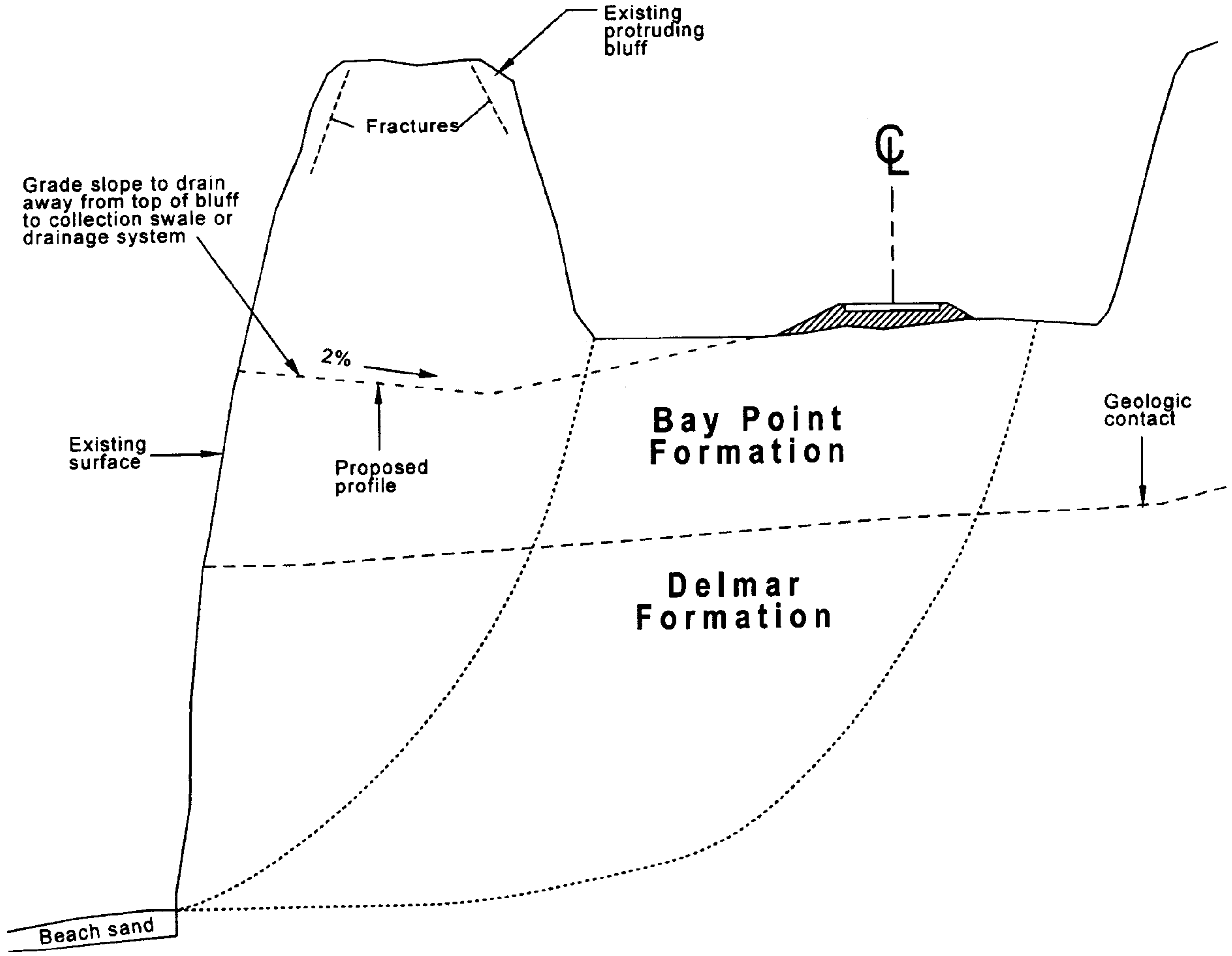
BLUFF TOP GRADING (CENTRAL PORTION OF BLUFF)

Improve stability of bluff face by reducing driving forces (weight). Generates material that can be used for slope repair/possible beach nourishment. Also reduces short term potential for block falls, improves views, provides possible source of beach nourishment and maintains positive drainage.



FORM OF MITIGATION

- ☐ Toe
- ☐ Surficial
- ☒ Deep-seated

IMPROVEMENT

Improves stability of bluff face by removing weight from bluff top; may not improve overall factor of safety for deep seated stability

FIGURE 9: BLUFF TOP GRADING (CENTRAL PORTION OF BLUFF)

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 11. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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SOLDIER PILE WALL

Can be utilized to support rail, where a projection from the tracks to the toe or local stability calculations indicate inadequate lateral support. Can be modified as needed for increased capacity. Can be constructed entirely within R.O.W.

IMPROVEMENT

Can be utilized to raise overall factor of safety.

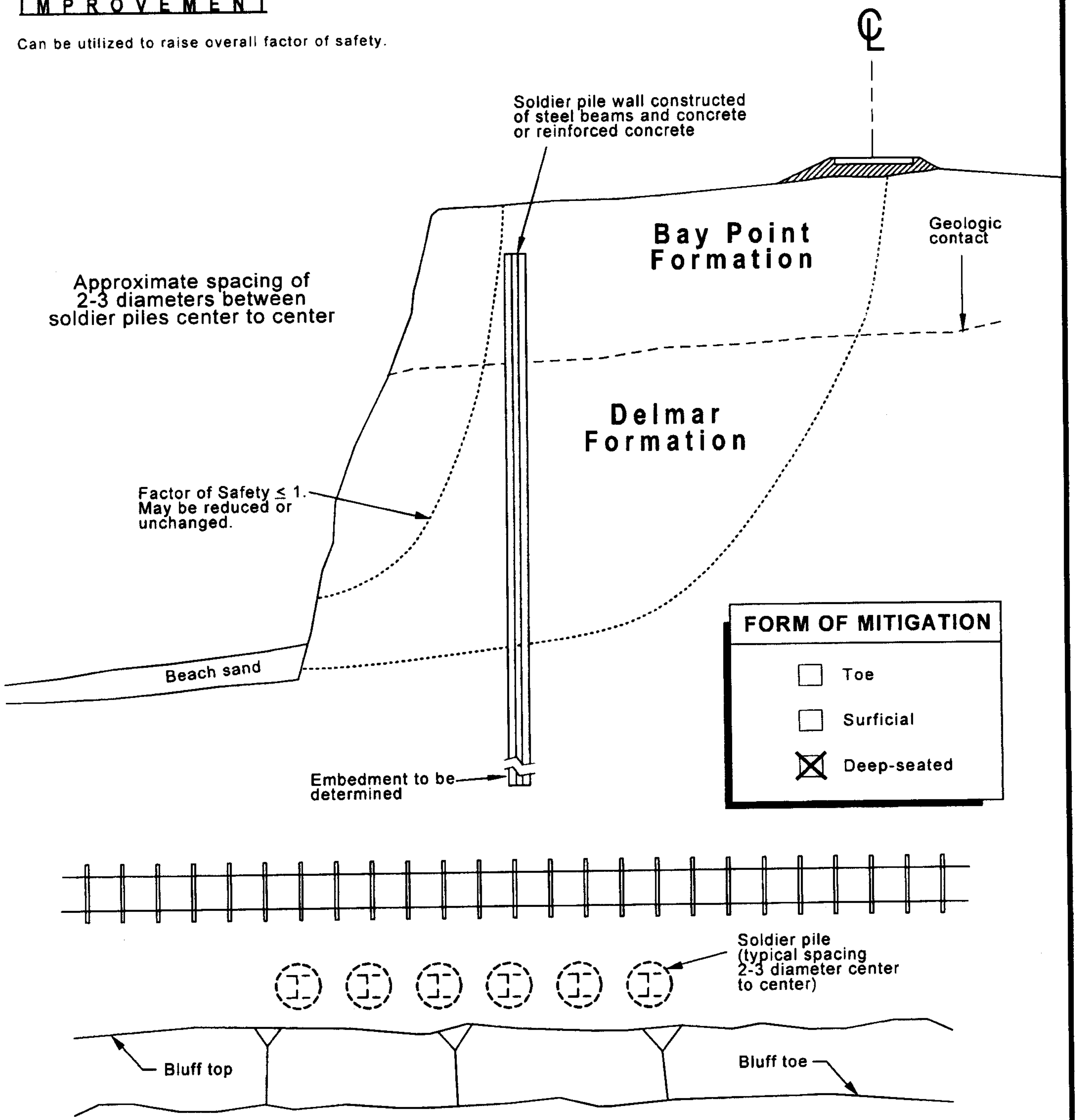

FIGURE 10: SOLDIER PILE STABILIZATION

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 12. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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SOLDIER PILE WALL WITH LAGGING

Wall can be designed with lagging type wall or modified from soldier piles as erosion progresses.

IMPROVEMENT

Can be utilized to raise overall factor of safety.

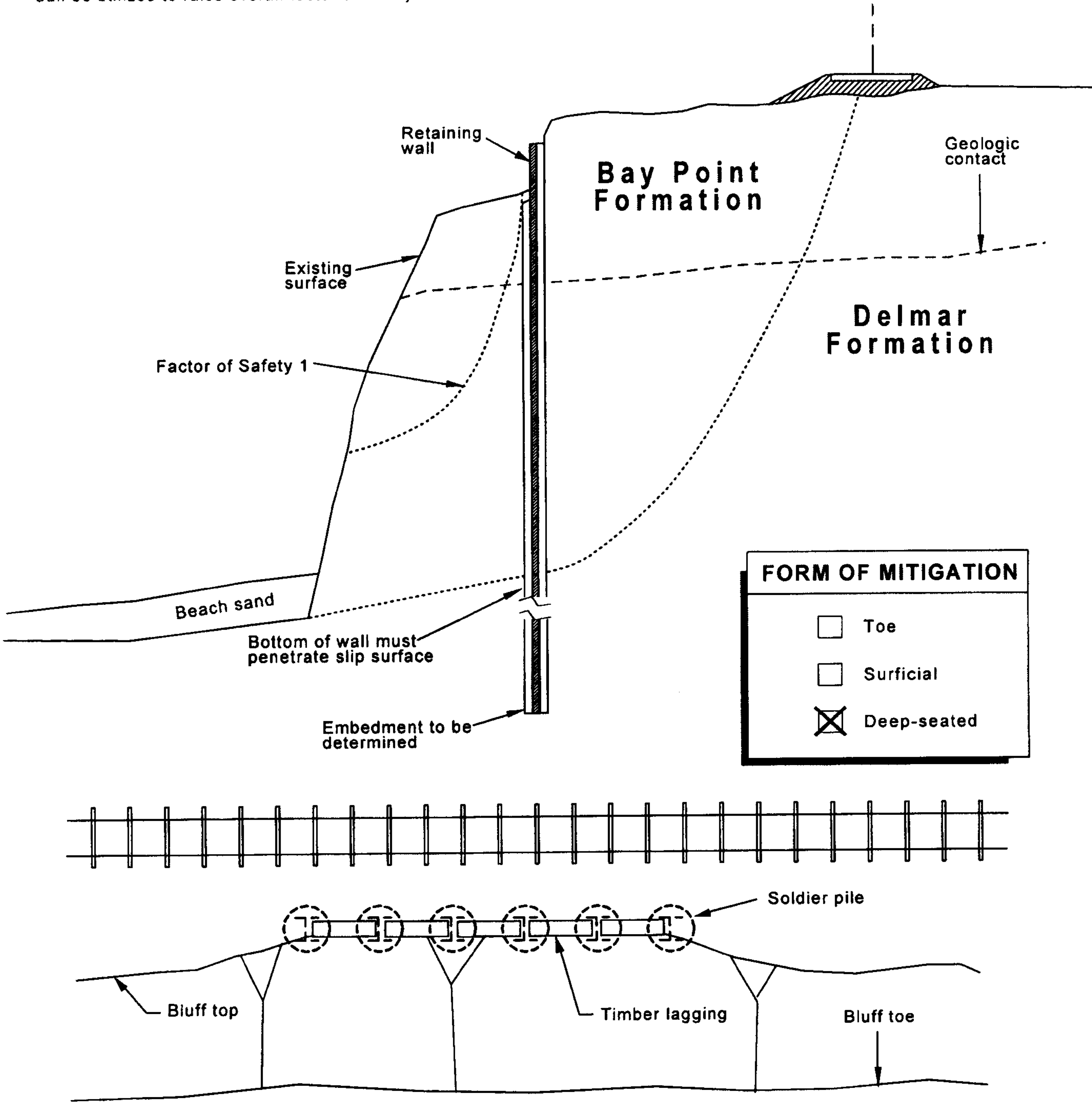

FIGURE 11: SOLDIER PILE WITH LAGGING

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 13. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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SOLDIER PILE WITH WALL AND TIEBACKS

Can be designed to support oversteepened areas, or modified from Figure No. 12 as erosion proceeds. Some bluff disturbance possible if utilized to stabilize oversteepened areas.

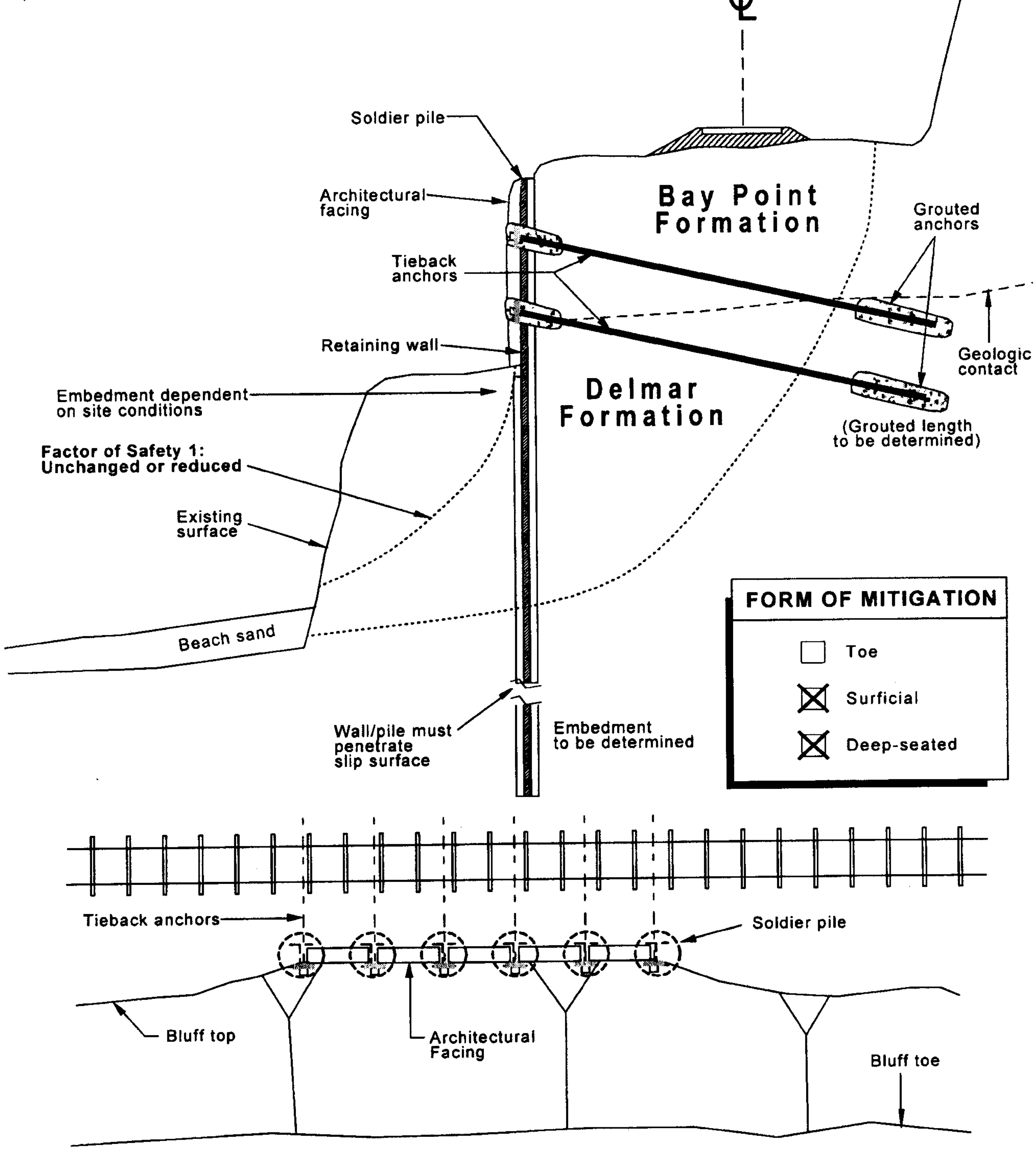

FIGURE 12: SOLDIER PILE WITH WALL AND TIEBACKS

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives*, Figure 14. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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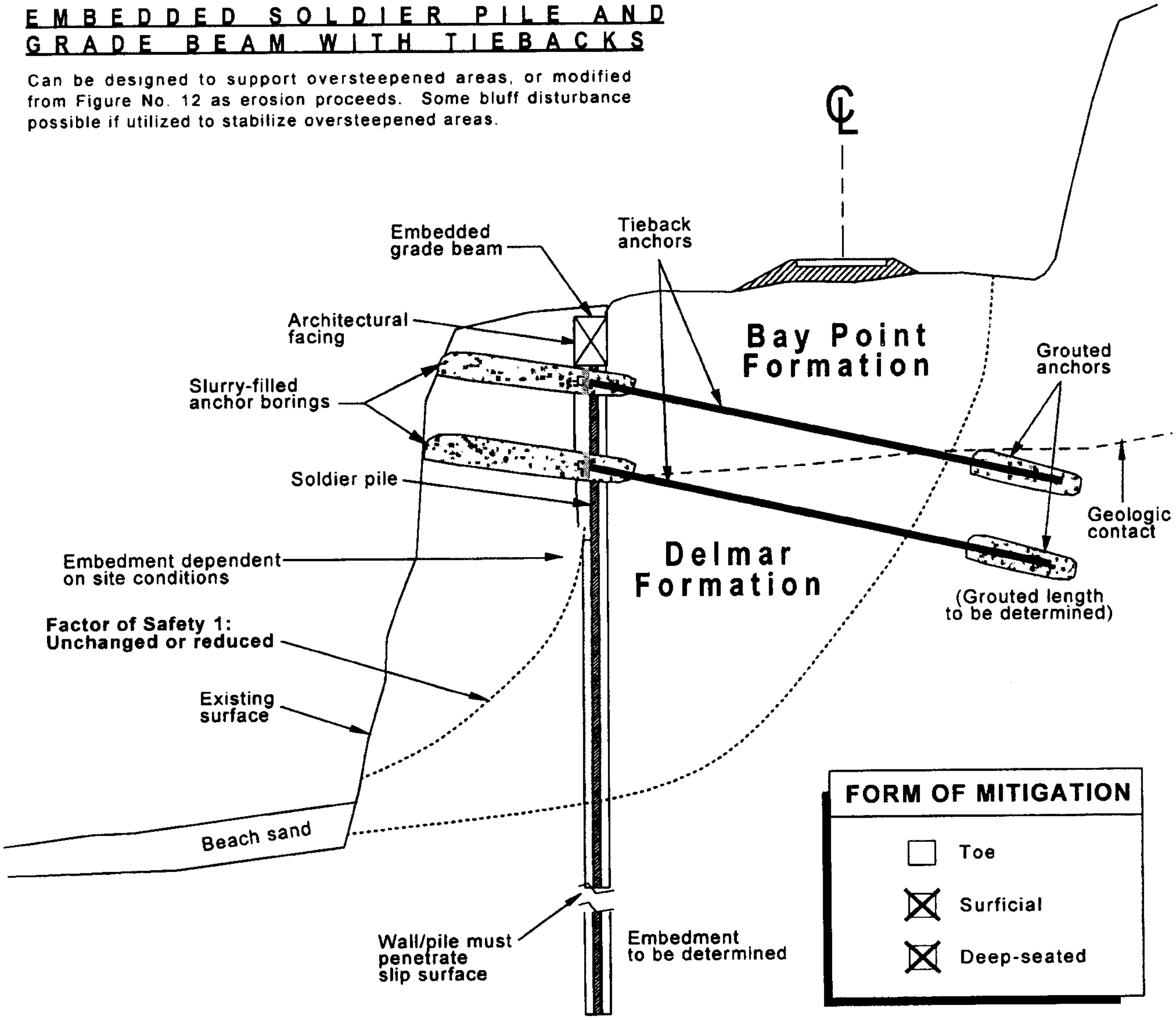
EMBEDDED SOLDIER PILE AND GRADE BEAM WITH TIEBACKS

Can be designed to support oversteepened areas, or modified from Figure No. 12 as erosion proceeds. Some bluff disturbance possible if utilized to stabilize oversteepened areas.



FORM OF MITIGATION	
☐	Toe
☒	Surficial
☒	Deep-seated

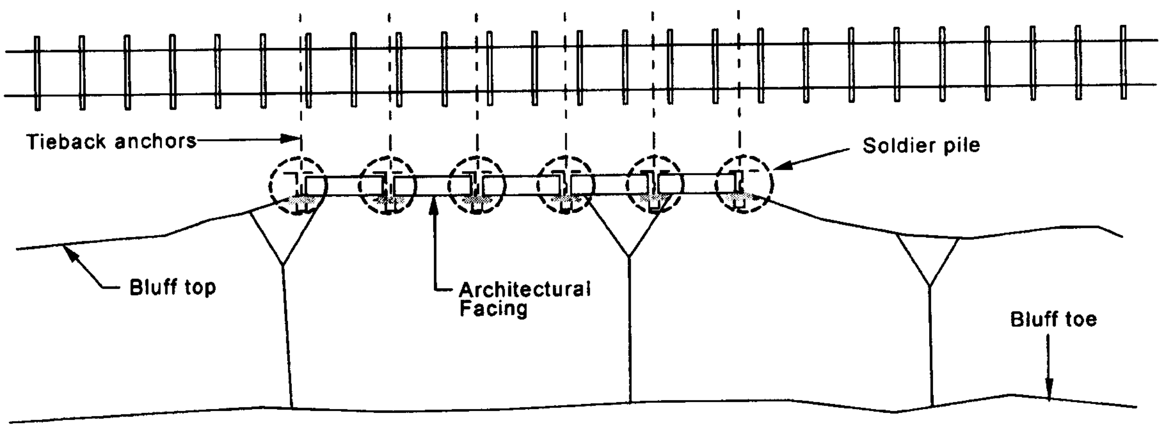


FIGURE 13: SOLDIER PILE WITH GRADE BEAM AND TIEBACKS

Source: *Del Mar Bluffs Geotechnical Study, Part 2: Conceptual Repair Alternatives,* Figure 22. Prepared by Leighton and Associates, Inc. for NCTD. January 2001.

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