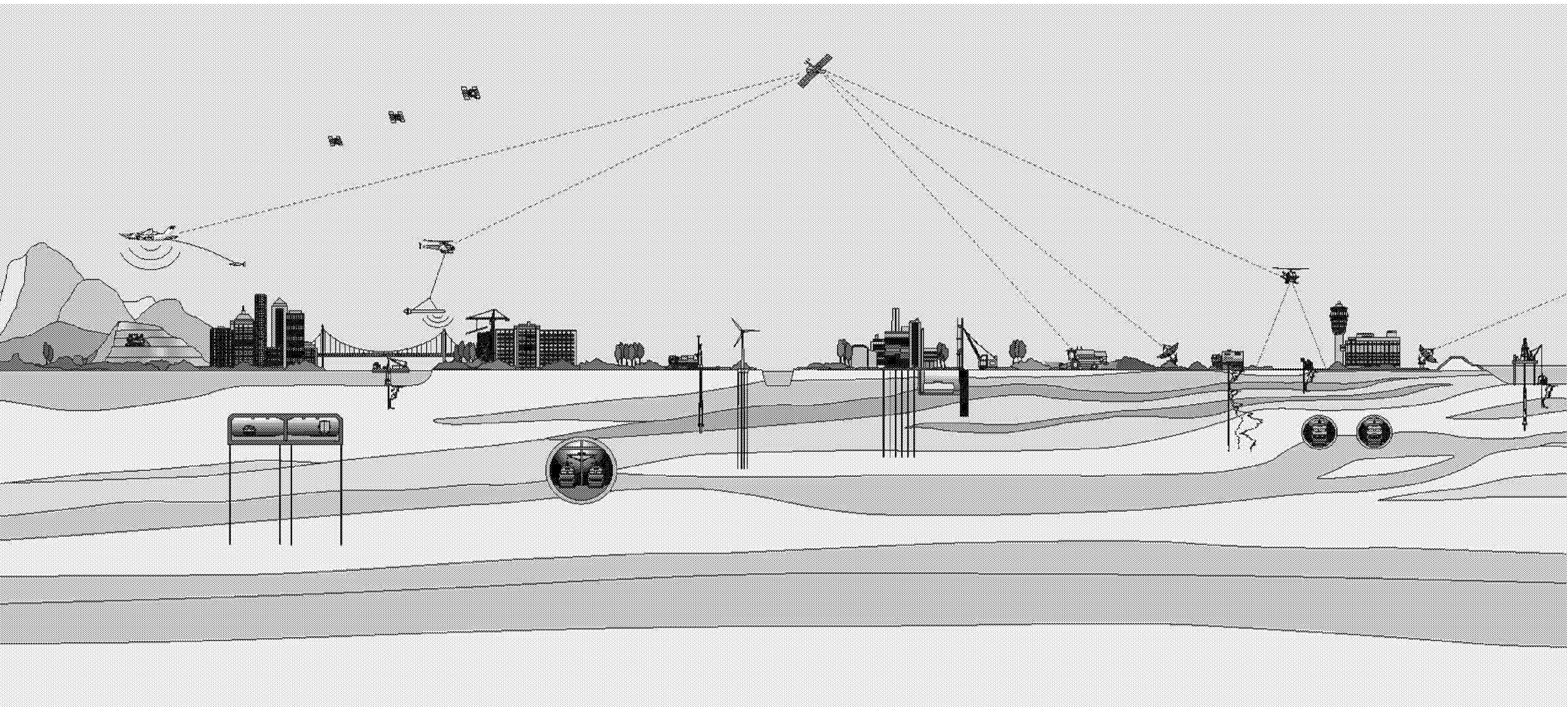
FUGRO WEST, INC.

GEOTECHNICAL REPORT
SANTA ROSA CREEK ROAD SLIP OUT
0.9 MILES WEST OF STATE ROUTE 46
SAN LUIS OBISPO COUNTY, CALIFORNIA

Prepared for:
San Luis Obispo County

March 30, 2010



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March 30, 2010
Project No. 3014.040

County of San Luis Obispo
Public Works Department
County Government Center, Room 207
San Luis Obispo, California 93408

Attention: Mr. Mike Britton

Subject: Geotechnical Report, Santa Rosa Creek Road, Slip out 0.9 miles north of State Route 46, San Luis Obispo County, California

Dear Mr. Britton:

Fugro is pleased to submit this Geotechnical Report for the design of a repair that occurred on Santa Rosa Creek Road about 0.9 miles north of Highway 46 in San Luis Obispo County, California. The purpose of this report is to provide geotechnical recommendations for the restoration of the slope above Rocky Creek using geosynthetic reinforcement and rock slope protection. This report was prepared in accordance with the scope of services presented in our proposal dated February 25, 2010, and authorized by the County Blanket Purchase Order No. 25005649 dated March 5, 2010.

Conceptual alternatives to restore the slope were presented in our draft memorandum to the County dated March 10, 2010. The concept incorporating geosynthetic reinforcement and rock slope protection was selected during our meeting on March 23, 2010 because the team felt it is the most consist with the environmental documents for the project. This report presents data collected from our field exploration and laboratory testing programs, results of slope stability analyses, and recommendations for the design of the slope restoration.

Please contact the undersigned if you have questions regarding this report, or require additional information.

Sincerely,

FUGRO WEST, INC.

REGISTERED PROFESSIONAL ENGINEER
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Copies: 3 – Addressee, 1 PDF

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1.0 SITE AND PROJECT DESCRIPTION

The project generally consists of repairs to a landslide that occurred on Santa Rosa Creek Road about 0.9 miles west of Highway 46. The location of the site relative to nearby streets and geographic landmarks is shown on Plate 1, Vicinity Map. The existing topography and layout of the site is shown on Plate 2, Field Exploration Plan.

1.1 EXISTING SITE

The existing site grades are shown on plans and cross sections provided by the County (2010). At this location Santa Rosa Creek Road is constructed along a northeast facing hillside above Rocky Creek. The roadway is paved with asphalt and graded with northbound side fills and south side cuts. In the vicinity of the slip out, the northbound side of the road is bordered by an approximately 35 feet high, relatively steep slope that is inclined to about 1.1h:1v (horizontal to vertical). The eastbound side of the road is cut into the hillside to height of approximately 30 feet. The cut slope is as steep as about ¾:1, but is locally eroded or has experienced instability that appears to have caused the slope face to flatten and become irregular. The grade of the road slopes down to the bridge at Rocky Creek. The grade of the roadway near the center of the slide (about Sta. 13+00) is elevation (el.) 1,335 feet with the corresponding water level of Rocky Creek at approximately el. 1,304 feet. Rocky Creek flows south through the site.

The slope within the slip-out is inclined to about ½:1 to near vertical. The head of the slide is at approximately the existing edge of pavement. At the time of our 2010 field exploration program and site visits, the upper approximately 1/3 of the slide area was covered with a tarp secured with cords and sandbags. An asphalt berm had been placed along the northbound shoulder through the slide area.

Approximately 1- to 2-inch wide tension cracks extending up to the edge of pavement were observed during our site visits. The cracks appear recent, and suggest that recent movement and likely extension of the instability of the slope has occurred in association with this winter's rain. The limits of the slide and observed instability were noted on the County (2010) topography (see Plate 2).

1.2 BACKGROUND

The County previously developed a concept to repair the instability at this location in 2005 (San Luis Obispo County 2005). The concept generally consisted of placing rock slope protection (RSP) along the base of the slope and reconstructing the slope using geosynthetic reinforced earth (GRE). The finished slope shown on the 2005 plan is shown inclined to ¾h:1v within the RSP and to ½h:1v within the GRE. The limits of the slide shown on the 2005 plan extends approximately 60 feet along the westerly bank of the creek. This plan is the basis for the currently approved Negative Declaration and supporting environmental permits for the project.

Fugro (2010) submitted a memo that presented a similar GRE concept and other conceptual alternatives to repair the slope. Based on consultations and a meeting with the

County on March 23, 2010, it was decided that the design of the repair should be similar to the concept and limits shown on the previous County (2005) plan to substantially conform to the environmental permits.

1.3 PROPOSED PROJECT

The proposed project will generally consist of reconstructing the slope as a GRE with RSP armoring placed along the toe of the slope to protect against stream bank erosion and scour. The slope will be approximately 30 to 35 feet in height and extend along approximately 120 feet of the stream bank based on survey measurements by the County (2010). The restored slope will be designed to match into the existing approximately 1.1h:1 slopes either side of the slide area. The RSP will extend at least above the elevation of the opposite stream bank.

2.0 WORK PERFORMED

2.1 PURPOSE

The purpose of this report is to provide recommendations for the design of the slope restoration. The primary geotechnical considerations that we evaluated for the project are characterization of the subsurface materials, alternatives to repair the slope, slope stability, and the design of the slope using geosynthetic reinforcement.

2.2 SCOPE OF WORK

To evaluate the geotechnical considerations for the project, we performed the following scope of work:

- Consulted with the County to review our approach to providing geotechnical services, and obtain background information, existing topography, cross sections, and previous plans available for use in our evaluation;
- Prepared a health and safety plan for our work, visited the site to mark the locations of the explorations and review site conditions, and contacted Underground Services Alert (USA) to review the locations relative to underground utilities;
- Performed a one-day field effort to drill a boring along the top of the slope to a depth of approximately 50 feet below the road surface, map various geologic features observed at the site, and obtain rock samples from outcrops in the project area;
- Performed laboratory tests on soil and rock samples recovered from the field exploration;
- Prepared a memorandum (Fugro 2010) to summarize geotechnical conditions at the site, characteristics of the observed slope instability, conditions that impact the project and existing roadway, and geotechnical alternatives to repair the slope along this stretch of the road;

- Evaluated the stability of the existing slope and proposed GRE slope repair concept as a basis for providing the recommendations in this report; and
- Prepared this Geotechnical Report, with supporting graphics and the data collected, for the design of the selected the concept to restore the slope using geosynthetic reinforcements and rock slope protection.

2.3 FIELD EXPLORATION

Field exploration consisted of drilling and sampling a hollow-stem-auger boring, collecting rock samples, and geologic mapping. The field exploration was performed on March 9, 2010. The log for the boring is presented in Appendix A. The boring and sample locations, discontinuity data collected, and selected geologic features observed at the site are shown on Plate 2.

2.3.1 Hollow Stem Auger Drilling and Rock Coring

The drilling subcontractor for the project was GeoSolutions of San Luis Obispo, California. GeoSolutions used a CME55 track-mounted drill rig equipped with 8-inch-diameter hollow-stem augers to advance the boring. The hollow stem auger was used to advance the boring to a depth of approximately 20 feet below the existing ground surface. The boring was then advanced to the total depth of 50 feet using rock coring.

During auguring, the boring was sampled using a 2-inch outside diameter standard penetration test (SPT) split-spoon sampler and a 3-inch outside diameter modified California split-spoon sampler. The SPT sampler was used without liners. The modified California sampler was used with brass liners. The samplers were driven into the materials at the bottom of the drill hole using a 140-pound automatic trip hammer with a 30-inch drop. The blow count (N-value) is the number of blows from the hammer that were needed to drive the sampler 1 foot after the sampler had been seated at least 6 inches into the material at the bottom of the hole. Bulk samples were collected from the drill cuttings retrieved from the auger flights. The sample intervals, N-values, a description of the subsurface conditions encountered and other field and laboratory data are presented on the logs of the borings in Appendix A.

Below 20 feet, the boring was sampled using a CME triple-tube NQ sized rock core system. The core barrel is run on a wireline system and was advanced using a diamond bit with drilling fluid delivered directly to the tip of the rock coring bit. Rock cores 1-7/8 inches in diameter were taken in 5-foot long runs. Rock quality designation (RQD) and percent recovery are noted on the boring log. Photographs for the rock core samples are also presented in Appendix A.

2.3.2 Block Samples

Block samples were taken by hand from various outcrops during the field exploration program. The samples were taken by collecting blocks of rock from the face of slopes, outcrops, or slide material where the rock was exposed. Descriptions of samples obtained are included in the laboratory results. The locations of the samples are noted on Plate 2.

2.3.3 Geologic Mapping

Geologic mapping consisted of noting selected geologic features observed at the site such as rock types at outcroppings, springs, limits of instability, and predominant bedding and joint discontinuities. Discontinuity measurements generally consist of using a hand-held compass to estimate the strike and dip of bedding and joint planes within the rock. The data collected is summarized graphically on Plate 2. The strike represents the orientation of the discontinuity plane in the horizontal direction. The dip represents the inclination and direction of that plane.

2.4 LABORATORY TESTING

Laboratory testing was performed on selected samples obtained during the field exploration. Laboratory tests for unit weight, moisture content, grain size, plasticity (Atterberg limits), direct shear strength, point load strength index for intact rock, and laboratory compaction (modified Proctor) were performed as part of this program. The tests were performed in general accordance with the applicable standards of ASTM. Results of laboratory testing are presented in Appendix B.

2.5 GENERAL CONDITIONS

Fugro prepared the conclusions, recommendations, and professional opinions of this report in accordance with the generally accepted geotechnical principles and practices at this time and location. This warranty is in lieu of all other warranties, either expressed or implied. This report was prepared for the exclusive use of the County of San Luis Obispo and their authorized agents only. It is not intended to address issues or conditions pertinent to other parties, projects or for other uses. The report and the drawings contained herein are not intended to act as construction drawings or specifications. Explorations and services have not been requested nor performed to assess the presence or absence of hazardous or toxic materials.

The scope of services did not include any environmental assessments for the presence or absence of hazardous/toxic materials in the soil, surface water, groundwater, or atmosphere. Any statements, or absence of statements, in this report or data presented herein regarding odors, unusual or suspicious items, or conditions observed are strictly for descriptive purposes and are not intended to convey engineering judgment regarding potential hazardous/toxic assessment.

Soil and rock deposits can vary in type, strength, and other geotechnical properties between points of observations and exploration. Additionally, groundwater and soil moisture conditions also can vary seasonally or for other reasons. Therefore, we do not and cannot have a complete knowledge of the subsurface conditions underlying the site. The conclusions and recommendations presented in this report are based upon the findings at the points of exploration, and interpolation and extrapolation of information between and beyond the points of observation, and are subject to confirmation based on the conditions revealed by construction.

3.0 SITE CONDITIONS

3.1 GEOLOGIC SETTING

The regional geology is mapped by Hall et al. (1979). Hall et al. mapped the hillside in the site vicinity as being underlain by sedimentary bedrock of the Toro Formation. Locally the bedrock surface is concealed by surficial sediments of artificial fill, colluvium, and landslide deposits. The Toro Formation is typically interbedded shale or claystone and sandstone. Alluvium is deposited along the creek. As exposed at the site, the rock is predominantly massive claystone that is locally interbedded with units of shale, sandstone and conglomerate. Hall et al mapped the Toro Formation as being in fault contact with units of serpentine and Franciscan Rocks upslope of the site. The fault appears to be a splay within the Oceanic Fault zone. The Oceanic fault is associated with the 2003 San Simeon Earthquake; however, no fault splays are shown as being mapped through the site.

3.2 SUBSURFACE CONDITIONS

Our description of the soil and groundwater conditions is based on the results of the field exploration and laboratory testing programs performed for this study. The locations of the explorations are shown on Plate 2 and the logs and corresponding field data are presented in Appendix A. The subsurface conditions encountered at the site consist of various surface sediments of artificial fill, colluvium and landslide deposits overlying Toro Formation bedrock. The area along the creek is underlain by alluvium. The predominant geologic units encountered at the site are described below.

Landslide Deposits (Qls): The predominant areas of landsliding and slope instability are noted on Plate 2. The subject landslide is located on the relatively steep northeast facing slope below the northbound shoulder of Santa Rosa Creek Road. The landslide deposits are generally talus deposited at the base of the landslide that was composed of displaced material from the artificial fill, colluvium and Toro Formation. Tension cracks observed adjacent to the road were used to approximate the limits of the landslide. There also appears to be a landslide within the creek bank adjacent to the south abutment of the Rocky Creek Bridge.

Slope instability such as erosion, rock fall, and slumping of materials is also present along the cut slope that borders the southbound shoulder of Santa Rosa Creek Road. The predominant area of slope instability noted on Plate 2, appears to be associated with erosion and displaced over burden soil (colluvium) that has wasted downslope as a result of a daylighting spring and seepage conditions on the slope.

Artificial Fill (Af). Artificial fill generally consists of pavement and embankment fill placed as part of the construction of Santa Rosa Creek Road. Artificial fill was encountered in DH-01 to approximately 4.5 below the road surface. The artificial fill consisted predominantly of lean clay and clayey sand with varying amounts of gravel. The gravel clasts were mostly subangular and are likely derived from the local bedrock and colluvium materials. The overlying pavement consisted of approximately 6 inches of asphalt over about 8 inches of a base material. The artificial fill was underlain by colluvium in DH-1.

Plasticity (Atterberg limits) tests performed on a bulk sample of clayey sand obtained from the artificial fill had a liquid limit of 36 and a plasticity index of 20. The laboratory compaction (modified Proctor) test performed on the same sample had a maximum dry unit weight of approximately 133 pounds per cubic foot (pcf) at an optimum moisture content of about 8 percent. The shear strength characteristics of the remolded material estimated from direct shear tests had a friction angle of approximately 28 degrees and a cohesion of approximately 800 pounds per square foot.

Colluvium (Qcol): Colluvium is generally displaced and eroded material that has been deposited downslope by gravity and erosion. Approximately 1.5 feet of colluvium was encountered below the artificial fill in DH-1 and was sampled on the slope surface at location X5 (see Plate 2). Colluvium was also locally exposed along the hillsides above and below Santa Rosa Creek Road. The colluvium generally consisted of very stiff to hard gravelly clay. The colluvium also contains rock fragments of sandstone and claystone ranging from cobble to boulder size material.

Laboratory tests performed on a sample of the colluvium had a dry unit weight of approximately 116 pcf and a corresponding moisture content of 13 percent. Plasticity (Atterberg limits) tests performed on a sample of clay obtained from the colluvium had a liquid limit of 37 and a plasticity index of 18.

Alluvium (Qa): Alluvium is deposited along the channel of Rocky Creek and likely underlies the flat lying areas east of the creek. The alluvium exposed along the creek is predominantly gravel, cobble and boulder sized materials. The clasts within the alluvium are mostly angular to subangular and range up to about 2 to 3 feet in size where exposed. The alluvium appears to pinch out against the west bank of the creek where bedrock was locally exposed in the creek banks.

Toro Formation (KJt). Toro Formation was encountered below the artificial fill and colluvium in DH-1 and is exposed at various locations along the road cut and creek banks at the site. The Toro Formation was encountered at approximately 6 feet below the road surface in DH-1 and was encountered to the total 50-foot depth of that exploration. As noted on the log for DH-1, the rock was very intensely to intensely fractured and water circulation was commonly lost during the coring. Losses of 100 to 300 gallons of water are noted on the log as being lost at various depths during the drilling. The Toro Formation generally consisted of two units: an upper oxidized olive brown rock and a less oxidized dark grey rock.

The oxidized unit of the Toro Formation was exposed along the roadside at the site and was encountered to approximately 18 feet in DH-1. The oxidized rock consisted predominantly of soft to moderately soft olive brown claystone and fine sandstone. The oxidized material is generally decomposed to intensely weathered and fractured at or near the surface of the rock. The oxidized unit was interbedded with sandstone and shale. Sand and soil deposits were observed along joints and fractures in the shallower units of the Toro Formation.

Dark grey, less oxidized, Toro Formation was encountered at approximately 18 feet below the road surface in DH-1 and was exposed along the downstream flank of the landslide adjacent to Rocky Creek. The dark grey rock was generally very intensely to intensely fractured or sheared, moderately weathered, moderately hard claystone.

Bedding observed within the Toro Formation was observed within an outcrop adjacent to Rocky Creek. The bedding had a dip of approximately 42 degrees to the southwest, into the hillside, with a strike of N55W. A predominant set of joints was observed within the scarp of the upstream side of the landslide. The joint set appeared to be a controlling structure of the landslide feature and had a dip of approximately 56 degrees to the northeast, down slope, with a strike of N55W. A set of joints at the same location was observed to dip approximately 38 degrees southeast, into the hillside, with a strike of S65W. Our field measurements are shown on Plate 2.

The results of laboratory tests performed on samples of Toro Formation had dry unit weights ranging between approximately 126 to 150 pounds per cubic foot and moisture contents ranging between approximately 3 to 6 percent. Plasticity (Atterberg limits) tests performed on sediments of the claystone had a liquid limit of 32 and a plasticity index of 14 indicating the sediment is classified as “lean clay (CL)”.

Point load tests performed on block samples of the oxidized Toro Formation had compressive strengths ranging from approximately 98 to 4,200 pounds per square inch (psi) corresponding to extremely weak to medium strong rock. Point loading commonly resulted in failure along healed joint and discontinuities within the oxidized rock. Point load tests performed on core samples of the less oxidized Toro Formation had compressive strengths of 1,900 to 6,900 psi corresponding to weak to medium strong rock.

Joint strength was estimated from direct shear tests on samples of rock that were precut or secured to shear along the joint prior to testing. The shear strength along the precut and joint surfaces was estimated from the test as having a friction angle of approximately 19 to 27 degrees. The cohesion was “0” along the precut joint, and approximately 200 psf along the natural joint, which was slightly irregular.

3.3 GROUNDWATER

Groundwater was not encountered in DH-1 prior to adding water to the hole at 20 feet deep to begin rock coring. As noted on Plate 2, springs were observed daylighting along the base of the slope and ditch along the southbound shoulder of the road. Water was flowing in Rocky Creek at the time of our March 2010 field exploration program. The approximate limits of the water surface are noted on County (2010) topographic map. Stream flow, groundwater and soil moisture conditions will vary seasonally due to changes in runoff, storm conditions, rainfall and other factors.

4.0 SLOPE STABILITY ANALYSIS

Slope stability analyses were performed to evaluate the existing slope conditions relative to potential causes of failure to check the reasonableness of our slope model, and as a basis for providing recommendations for the design of the slope restoration using geosynthetic reinforced earth. A cross section through approximately the center of the landslide, near Sta. 13+12, was selected for the analyses. The ground surface profile along the section was estimated using topography and cross section information provided by the County (2010). Slope stability analyses were performed for static loading and for pseudostatic (earthquake) loading conditions. The slopes were evaluated with respect to the stability criteria discussed below. Output and results from the stability analyses are presented in Appendix C.

4.1.1 Slope Stability Criteria

Slope stability criteria were selected in accordance with the State's Guidelines for Evaluating and Mitigating Seismic Hazards (CDMG 1997) and San Luis Obispo County. For the purpose of evaluating analytical results, slopes are considered stable when the estimated factor of safety is at least 1.5 under static loading conditions, and at least 1.1 under pseudostatic (earthquake) loading conditions when using a horizontal pseudostatic coefficient of 0.15. A factor of safety 1.0 represents the theoretical boundary below which a slope is no longer stable and experiences failure. Factors of safety greater than 1.0 are theoretically stable; however, a factor of safety of at least 1.5 is typically used to define stable slope conditions in practice to help account for uncertainties associated with characterizing subsurface conditions and limitations associated with the geotechnical analyses used to evaluate slope stability.

4.1.2 Analysis Methods

The slope stability analyses were performed using the computer program GSTABL7 with STEDwin, Version 2.005 (Gregory 2006). GSTABL7 was used to estimate factors of safety for slope stability under static and pseudostatic loading conditions. GSTABL7 requires the user to input the surface and subsurface profile boundaries; soil properties including unit weight (γ), friction angle (ϕ) and cohesion (c); groundwater levels; and the analysis method to be used.

For geosynthetic reinforced slope conditions, the user also inputs the bottom and top elevation of the reinforced portion of the slope, the length of reinforcing, the strength of geosynthetic material, and the vertical spacing between layers of reinforcement. The parameters for the geosynthetic reinforced slope are varied by the user to estimate the limits and strength of geosynthetic that will satisfy the slope stability criteria.

The soil properties and conditions used for our analyses are presented in Appendix C. Slope stability analyses were performed using the modified Bishop method to estimate factors of safety for circular failure surfaces. A key to the results of our slope stability analyses is presented on Plate C-1 in Appendix C.

4.1.3 Selection of Shear Strength Parameters

Effective shear strength parameters (ϕ and c) were selected for slope stability analyses based on laboratory direct shear tests, characterization of the rock mass, and assumed strength parameters for imported materials. Laboratory tests were performed on driven ring samples obtained from the field exploration program.

Anisotropic strength parameters (strength parameters defined in two directions in one type of material) were used to characterize the strength of the Toro Formation and account for predominant joint discontinuities within the rock that potentially influence the stability of the slope. For potential slip surfaces inclined between 45 and 65 degrees in the downslope direction, the strength of the material was considered cohesionless and the friction angle was estimated from pre-cut direct shear tests performed on a rock sample (ϕ = 19 degrees). For potential slip surfaces oriented outside of those limits (crossing the predominant joint sets), the rock mass strength of the Toro Formation was estimated using rock properties and Hoek-Brown classification. The Mohr-Coulomb fit (ϕ and c) were then estimated using the computer program RocLab (Rocscience 2007).

The selected strength properties were then used to analyze the existing and assumed previous slope conditions to check and essentially calibrate the slope stability for subsequent analyses. The shear strength parameters were then checked to estimate whether or the not the factors of safety estimated for the existing and previous slope conditions seemed reasonable: near 1 for the existing slope condition and less than 1 for the previous slope condition. Once calibrated, the slope stability model and selected parameters were used to analyze proposed slope conditions.

4.1.4 Groundwater Considerations

Groundwater was not encountered in the drill hole, however, groundwater was included in our analysis of the adjacent near-vertical slope to simulate groundwater seepage that may be occurring during storm events or periodically flows along joints or fractures within the rock. As discussed in this report, we observed springs on the slope above the roadway and water was flowing in the creek at the time of our exploration. A groundwater surface approximately along the boundary between the oxidized and less oxidized units of the Toro Formation was used for the analyses, although the groundwater movement and conditions within the Toro Formation are generally not known. The location of the groundwater table is noted on the slope stability analysis results that are included in Appendix C. The groundwater was assumed to be effectively drained for the analyses performed for the geosynthetic reinforced slope condition, as is recommended in this report.

4.1.5 Summary and Discussion of Slope Stability Results

The slope can be restored to a relatively stable condition using geosynthetic reinforcement as recommended in this report. The analyses were used to estimate the reinforcement needed to construct a 1h:1v geosynthetic reinforced earth slope to support the roadway. Detailed recommendations (the strength, length, spacing, backfill) for the design and placement of the reinforcement are provided in the subsequent sections of this report. The recommendations provide for the minimum estimated factors of safety used to define stable slope conditions under static and pseudostatic loads. A summary of the slope stability analyses is provided below. The results of these analyses are presented in Appendix C.

The observed instability of the existing slope appears to be influenced by erosion of the toe of the slope along Rocky Creek, the presence of adversely oriented joint sets within the Toro

Formation that weaken the rock mass relative to slope stability, and potential groundwater seepage or increased moisture conditions within the rock. Additionally, the upper portion of the slope appears to have been inclined to about 1.1h:1v within the overlying artificial fill and colluvium soil units. The approximately 1h:1 inclination is generally too steep and potentially unstable for a soil slope. The estimated factor of safety is approximately 0.9 for the previous slope condition considered (with the slope assumed to be inclined to about 1.1 prior to the slope failure along the section analyzed). The estimated factor of safety for the existing slope condition is approximately 1.06 (with the slope inclined to about 0.5h:1v to 1:1h:v along the section analyzed). The existing slope is considered potentially unstable, and the estimated failure surfaces associated with instability of the slope would likely extend into Santa Rosa Creek Road.

5.0 CONCLUSIONS AND RECOMMENDATIONS

We prepared the conclusions and recommendations for this report based on our geotechnical evaluation of the site conditions and discussions with the County.

5.1 SUMMARY OF FINDINGS

- Within the project limits, Santa Rosa Creek Road is constructed along a relatively steep northeast facing hillside above Rocky Creek. The road is constructed with upslope cuts and relatively shallow down hill fills that were been placed over the steep banks (inclined to about 1.1h:1v) of Rocky Creek.
- The hillside and roadway are underlain by fractured and weathered rock of the Toro Formation. The rock is compromised of claystone with interbedded shale and sandstone. The strength, quality and hardness of the rock are variable. Laboratory tests on intact rock specimens indicate an extremely weak to moderately strong formation.
- The observed instability of the slope below Santa Rosa Creek appears to be associated with erosion of the toe of the slope due to stream flow along Rocky Creek, adverse joint sets within the Toro Formation that weaken the rock relative to slope stability, and potentially unknown groundwater seepage and moisture conditions within the slope.
- The slope can be restored to a relatively stable condition using geosynthetic reinforcement as recommended in this report. We have provided recommendations to design the slope to an inclination of 1h:1v using geosynthetic reinforced earth to support the roadway. That face of the slope should be covered with erosion control matting to assist in establishing vegetation on the slope. Rock should be placed along the base of the slope help protect the slope from stream bank erosion. Detailed recommendations for the design and placement of the reinforcement are provided in the subsequent sections of this report.
- The temporary backslope should be designed by the contractor; however, based on limited slope stability analyses and the slope conditions observed at the site, we

suggest that the temporary backslope for the GRE be cut no steeper than 1:1, which is similar to the existing slope inclinations downslope of Santa Rosa Creek Road. The geologic conditions exposed by the excavation should be reviewed by the contractor and geotechnical professional during construction to further evaluate the stability and characteristics of the rock once it is exposed.

5.2 GRADING – GENERAL

5.2.1 Grading

Fill placement and grading operations should be performed according to the grading recommendations of this report. We recommend that, unless otherwise noted, fill and backfill materials be compacted to at least 90 percent relative compaction, as determined by the latest approved edition of ASTM Test Method D1557, except that material placed below the pavement within the upper 3 feet of the fill should be compacted to at least 95 percent relative compaction.

5.2.2 Suggested Material Specifications

The following presents suggested specifications for materials discussed or recommended in this report.

Compacted fill material shall consist of imported or on-site material free of organics, oversize rock (greater than 3 inches), trash, debris, corrosive, and other deleterious materials. Imported fill materials shall be reviewed by the geotechnical engineer prior to being brought to the site. On-site soil or imported materials shall conform to the requirements where the material is being placed.

Drainage material to be placed in subsurface drains shall conform to Section 68-1.025 of the Caltrans Standard Specifications for Class 2 permeable material. Specific measures shall be taken to avoid segregation of the material during transport and placement of the material at the site. Filter fabric shall not be within the limits of the geosynthetic reinforced embankment.

Geogrid Reinforcement, used to improve surficial stability in the transition zones where slope inclinations are steeper than 2:1, shall consist of primary and intermediate reinforcement. Primary reinforcement shall have a long term design strength (LTDS) of at least 3,000 pounds per foot in the machine direction as determined by the Geosynthetic Research Institute Test Method GG4. Intermediate geogrid reinforcement shall have a tensile strength at 5 percent strain of at least 500 pounds per foot in the machine and cross machine direction as determined by ASTM D6637. Geogrid shall be a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil. Geogrid shall obtain pullout resistance from the soil by a combination of shearing on the plane surfaces parallel to the direction of shearing and soil bearing on transverse grid surfaces normal to the direction of grid movement.

Geogrid shall meet the following requirements:

1. Geogrid shall have an open area between 50 and 90 percent.

2. At the long term design strength in the machine direction, the maximum strain shall not exceed 5 percent.

3. Geogrid shall be resistant to naturally occurring alkaline and acidic soil conditions and to attack by bacteria.

4. Geogrid shall be stabilized with at least 1 percent carbon black to be resistant to the effects of long-term exposure to ultra-violet rays.

Geotextile for separation (filter fabric) shall be placed around open-graded materials (pea gravel). The geotextile shall conform to the requirements of Section 88-1.03 of the Caltrans Standard Specifications for Filter Fabric-underdrains,.

Geotextile (filter fabric) to be placed below rock slope protection shall consist of geotextile that conforms to the requirements outlined in Section 88-1.04 of the Caltrans Standard Specifications for Rock Slope Protection Fabric.

Geosynthetic Reinforced Embankment Backfill placed more than 2 feet horizontal from the finished slope face shall consist of imported material conforming to Section 19-3.06, “Structure Backfill,” of the Standard Specifications and shall have a sand equivalent value of at least 30. Backfill placed within the outer 2 feet of the embankment shall be onsite soil or material approved by Engineer suitable for supporting the planned vegetation.

Gravel to be placed around the collector pipe of the drainage system shall conform to ASTM C-33 No. 8 coarse aggregate (pea gravel). The gravel shall be enclosed in a filter fabric and be outlet to a solid pipe and discharged beyond the slope face.

5.2.3 Clearing and Grubbing

Prior to commencing grading operations in areas that will receive compacted fill, soil containing debris, landslide deposits, organics, pavement, uncompacted fill, or other unsuitable materials, should be removed. Depressions or disturbed areas left from the removal of such material should be replaced with compacted fill. Following the removal of the existing landslide debris, the geotechnical professional should review the exposed subgrade (and/or temporary construction slope) to confirm that the landslide materials are removed, and whether or not deepening or widening of the excavation is recommended prior to placing fill.

5.2.4 Fill Placement

In areas to receive the fill, soil exposed subgrade should be scarified to a depth of 9 inches, moisture conditioned, and compacted in-place to at least 90 percent relative compaction. If the subgrade is in rock, fill can be placed directly on the undisturbed subgrade material. Fill materials can then be placed to finished grade according to the recommendations of this report.

Fill should be placed and compacted to at least the minimum relative compaction recommended in this report. The moisture content of the fill should be between 2 percent below to 2 percent above the optimum. Each layer should be spread evenly and should be thoroughly blade-mixed during the spreading to provide relative uniformity of material within each layer. Soft or yielding materials have relatively low strength and can compromise the stability of the embankment slope if left in place. We recommend that any soft or yielding materials encountered during fill placement be removed and be replaced with properly compacted fill material prior to placing the next layer. Fill materials should be mechanically compacted. Ponding or jetting should not be permitted. Rock, gravel and other oversized material, greater than 3 inches in diameter, should be removed from the fill material being placed. Rocks should not be nested and voids should be filled with compacted material.

When the moisture content of the fill material is below that sufficient to achieve the recommended compaction, water should be added to the fill. While water is being added, the fill should be bladed and mixed to provide relatively uniform moisture content throughout the material. When the moisture content of the fill material is excessive, the fill material should be aerated by blading or other methods. Fill should be spread in lifts no thicker than approximately 8 inches prior to being compacted. Fill and backfill materials may need to be placed in thinner lifts to achieve the recommended compaction with the equipment being used.

5.3 GEOSYNTHETIC REINFORCED EMBANKMENT

A geosynthetic reinforced embankment (GRE) can be used to restore the slope below Santa Rosa Creek Road. Prior to placing the GRE materials, the geotechnical professional should review the exposed rock and soil conditions exposed by construction. The purpose of the review is to check that potentially unstable landslide materials have been removed, to check bedding and joint orientations within the bedrock to evaluate if potentially unstable material is present, and to confirm that the subgrade is suitable for placement of the fill. The design of the temporary slope is the responsibility of the contractor. However, we recommend that the temporary slope behind the GRE be constructed no steeper than 1:1. The contractor should evaluate and design a suitable inclination for the temporary slope with consideration of the construction and worker safety in accordance with OSHA and other applicable requirements.

5.3.1 GRE Slope Design

A typical section and typical profile summarizing our recommendations for design of the GRE is presented on Plates 3a and 3b – Geosynthetic Reinforced Embankment Detail. To provide an estimated factor of safety of at least 1.5, we recommend that the slope be designed to a slope inclination of 1h:1v or flatter. The toe of the slope should catch on the existing embankment slope. The recommended reinforcement should be continued through the entire limits of the slope restoration.

The slope should be reinforced with primary and intermediate geosynthetic reinforcement conforming to the suggested materials recommendations in this report. Primary geogrid should be placed at 3-foot vertical intervals within the fill and be embedded at least 17 feet into the slope. Intermediate reinforcement should be placed at 1-foot vertical intervals between primary reinforcements and be embedded at least 4 feet into the slope. The same geogrid spacing and layout should be used through the transition to the adjacent slopes either side of the repair.

The GRE should be initiated from a base key excavated at the base of slope, and below the estimated maximum scour depth along Rocky Creek. The base of the excavation should be scarified to a depth of 9 inches, moisture conditions and compacted in-place to at least 90 percent relative compaction.

Geogrid should comply with the suggested materials specifications of this report. The primary geogrid reinforcement should have a long term allowable design strength (LTDS) of at least 3,000 pounds per foot in the machine direction. The intermediate geogrid reinforcement should be biaxial material having a tensile strength at 5 percent strain of at least 500 pounds per foot in the machine and cross machine direction. Each layer of geogrid should be placed level on compacted fill with the machine direction running parallel to the face of the slope.

The first layer of intermediate reinforcement should be placed no more than 1 foot above the compacted subgrade within the toe key. The first layer of primary reinforcement should be placed no more than 3 feet above the compacted subgrade within the toe key. Geosynthetic reinforcement should be terminated at the grade of the finished 1h:1v slope. The fill for the slope should be overbuilt beyond the reinforcement, and then be cut back to expose compacted material and at the end of the reinforcements and slope face. A layer of permanent erosion control matting/blanket should be placed over the finished slope to protect against erosion and assist with establishing vegetation on the slope.

Geogrid Placement. Geosynthetic reinforcement should be placed level and laid such that the working tensile strength of the material is oriented perpendicular to the roadway centerline. Spliced and sewn joints should not be used in the direction of the working tensile stress, unless it is demonstrated that the connection meets the same strength requirements for long-term design strength as the intact reinforcement material.

Because the planned GRE slope is located on a horizontal curve, layers of geogrid placed perpendicular to the slope face will likely overlap with adjacent layers of reinforcement. A few inches of soil backfill should be placed between reinforcement layers where these overlaps in adjacent layers of reinforcement occur.

Drainage. A layer of drainage material should be placed on the backslope behind the GRE backfill material. The drain should extend upward from about the streambed elevation to 5 feet below finished grade (see Plate 3a). The purpose of the drain is to intercept groundwater flowing from the backslope into the GRE. A perforated collector pipe should be placed at the base of the drainage material. The collector pipe should be placed in 1 cubic foot of pea gravel per foot of drain. The pea gravel should be fully encased in a filter fabric. The subsequent drainage material should be placed such that a continuous 1-foot thick layer of the material is maintained against the temporary slope.

The backfill drain should outlet to a solid pipe. The pipe should discharge beyond the slope face. Splash blocks or rock should be provided at the pipe outlet to protect against erosion. Drainage materials should conform to the suggested materials specifications in this report.

GRE Backfill. Fill for the GRE construction should consist of Structure Backfill placed according to the Standard Specifications. Embankment fill material should be compacted to at least 90 percent relative compaction, except that fill placed within 3 feet of finished grade should be compacted to at least 95 percent compaction. During spreading and compacting of the backfill material, at least 6 inches, measured vertically, of soil should be maintained between the geosynthetic reinforcement and construction equipment. Equipment or vehicles should not be operated or driven directly on the geosynthetic reinforcement, unless specifically permitted with supporting data supplied by the manufacturer. The face of the GRE slope should be prepared such that there is compacted material at the slope face. The contractor should submit the materials and methods to be used for construction of the GRE for review by the geotechnical professional in advance of construction.

Erosion Control. The outer 2 feet of the GRE fill should consist of onsite soil or material approved by Engineer that is suitable for supporting the planned vegetation. The face of the slope should be covered with a heavy nondegradable erosion control matting, unless the selected vegetation is capable of stabilizing the 1h:1v with degradable matting. Overlaps in the matting should be at least 2 feet with the upslope, upstream side of the overlap place above the downslope/downstream side of the fabric. The matting should be anchored and pinned to the slope according to the manufacturers recommendations. Matting placed near or below the anticipated flood levels should be material that is capable of tolerating stream flows. The type and thickness of the erosion matting should be approved by the Engineer and landscape designer. Landscaping and maintenance of slopes should be provided to assist vegetation to be established on slopes, and reduce the potential for erosion.

5.4 SURFACE DRAINAGE

Drainage should be provided such that surface water does not run over slopes or pond on pavements. It is our experience that a 2% slope is needed to provide positive drainage that can be easily graded and maintained. The top of slopes should be graded to direct drainage away from the slopes, or be provided with dikes and ditches that will direct surface water to controlled drainage structures. Concentrated flows and runoff should not be permitted to discharge onto slopes. Down drains, solid pipes, or lined ditches should be provided to carry water to the base of the slope. Energy dissipation and erosion control devices should be provided at the outlet of drainage pipes and in areas of concentrated flow and runoff to reduce the potential for erosion.

5.5 CONSTRUCTION CONSIDERATIONS

5.5.1 Excavation

Toro Formation claystone, sandstone and shale were encountered at the site as described in this report. The Toro Formation is of variable quality, fracturing, and strength. The formation will likely contain zones of extremely weak to strong rock based on the geologic classification of the material. We expect that the rock can likely be excavated by ripping and excavating with typical heavy construction equipment.

5.5.2 Use of On-site Soil

On-site soil and rock materials are anticpated to consist of clayey soil and rock materials that are not considered suitable for construction of the GRE slope or specified materials. If approved in advance, the on-site soil may be suitable for placement as landscape material within the outer 2 feet of the GRE. The onsite formation will likely need to be processed and segregated to breakdown and remove oversized material into a soil-like state prior to use as compacted fill. The Toro Formation contains clay materials that can be sensitive to changes in moisture content and relatively difficult to compact. Proper control of the moisture and compaction layer thickness will be needed to achieve the recommended compaction.

5.6 OPERATIONS AND MAINTENANCE

Site conditions, particularly on sloping ground adjacent to an open creek, are dynamic and should be considered in the operation and maintenance of the facility. Ongoing erosion, changes in drainage, and landsliding are some of the factors that should be reviewed on an ongoing basis.

The top of the adjacent stream banks, cut slopes, and other areas along Santa Rosa Creek Road contain areas of erosion and slope instability. Further instability and erosion along the route should be anticipated, especially as a result of periods of storm runoff or precipitation, ongoing weathering of the slope, earthquakes or other factors. Ongoing maintenance should be provided to help maintain the slope, reduce the potential for raveling or erosion along the face of the slope.

6.0 CONTINUATION OF SERVICES

The geotechnical evaluation consists of an ongoing process involving the planning, design, and construction phases of the project. To provide this continued service, we recommend that the geotechnical engineer be provided the opportunity to review the project plans and specifications, and observe portions of the construction.

6.1 REVIEW OF PLANS AND SPECIFICATIONS

The geotechnical engineer should review the foundation and grading plans for the project. The purpose of the review is to evaluate if the plans and specifications were prepared in general accordance with the recommendations of this report.

6.2 GEOTECHNICAL OBSERVATION AND TESTING

Field exploration and site reconnaissance provides only a limited view of the geotechnical conditions of the site. Substantially more information will be revealed during the excavation and grading phases of the construction. Subsurface conditions, excavations and fill placement should be observed by the geotechnical professional during construction to evaluate if the materials encountered during construction are consistent with those assumed for this report.

7.0 REFERENCES

California Division of Mines and Geology (1997), *Guidelines for Evaluating and Mitigating Seismic Hazards in California*, Special Publication 117.

Fugro West, Inc. (2010), "Project Memorandum: Concept Alternatives, Santa Rosa Creek Road, Slip out at 0.9 miles west of State Route 46, San Luis Obispo County, California", prepared for County of San Luis Obispo, Project No. 3014.040, draft dated March 10.

Gregory, G. H. (2006), "GSTABL7 with STEDwin, Version 2.005", Gregory Geotechnical Software: Fort Worth, Texas.

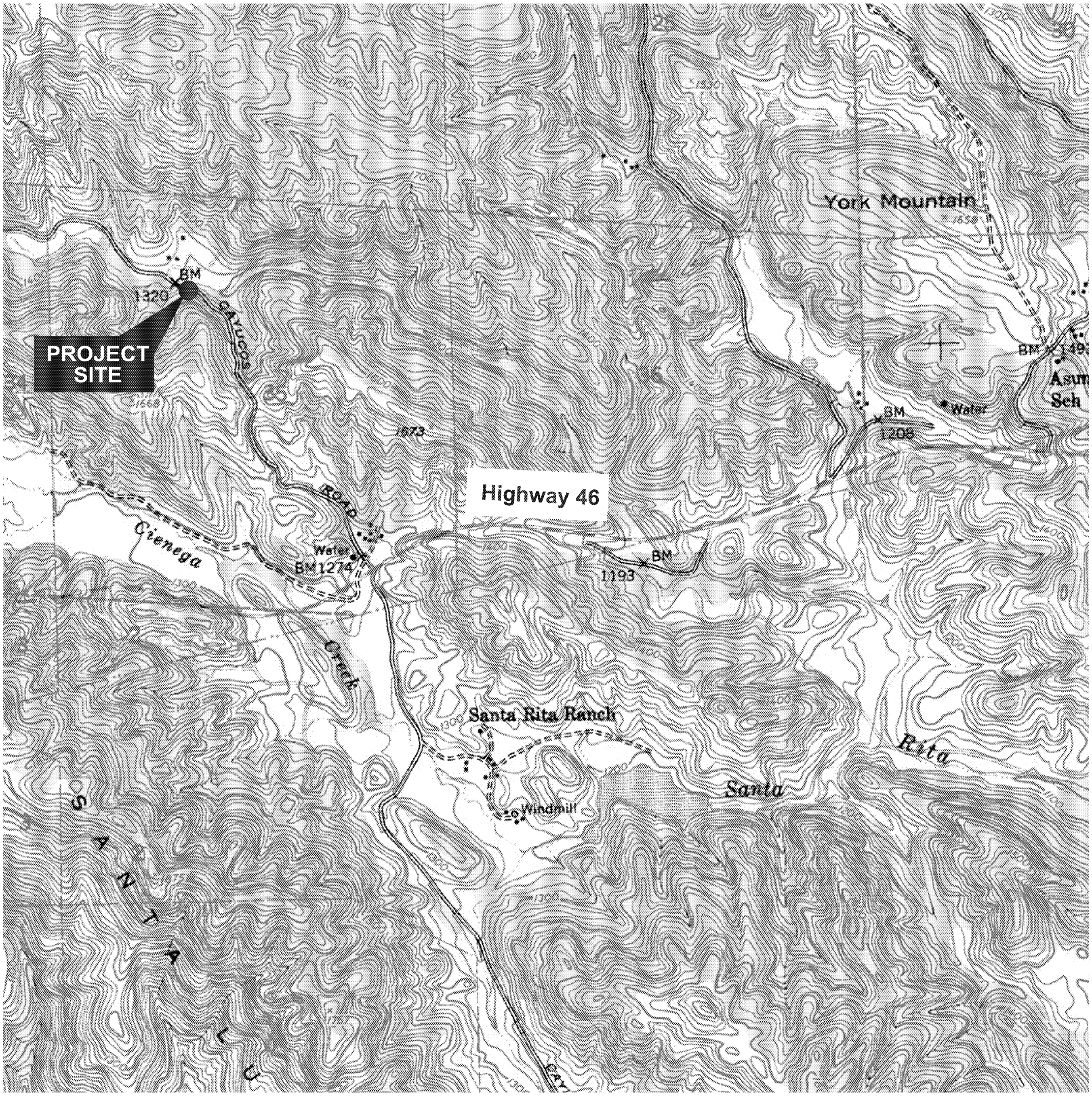
Hall, C.; Prior, S.; and Wiese, J. (1979). *Geologic Map of the San Luis Obispo-San Simeon Region*, California, U.S. Geological Survey Map I-1097, Scale: 1:48,000.

San Luis Obispo County (2005), "Roadway Slope Maintenance Plan, Santa Rosa Creek Road, Sheet 1 of 1, dated October 27.

San Luis Obispo County (2010), 10-scale and 20-scale topographic site plans and cross sections with print date of March 22. Stream flow analysis and stone weights per calculations dated March 4.

End of Text

PLATES



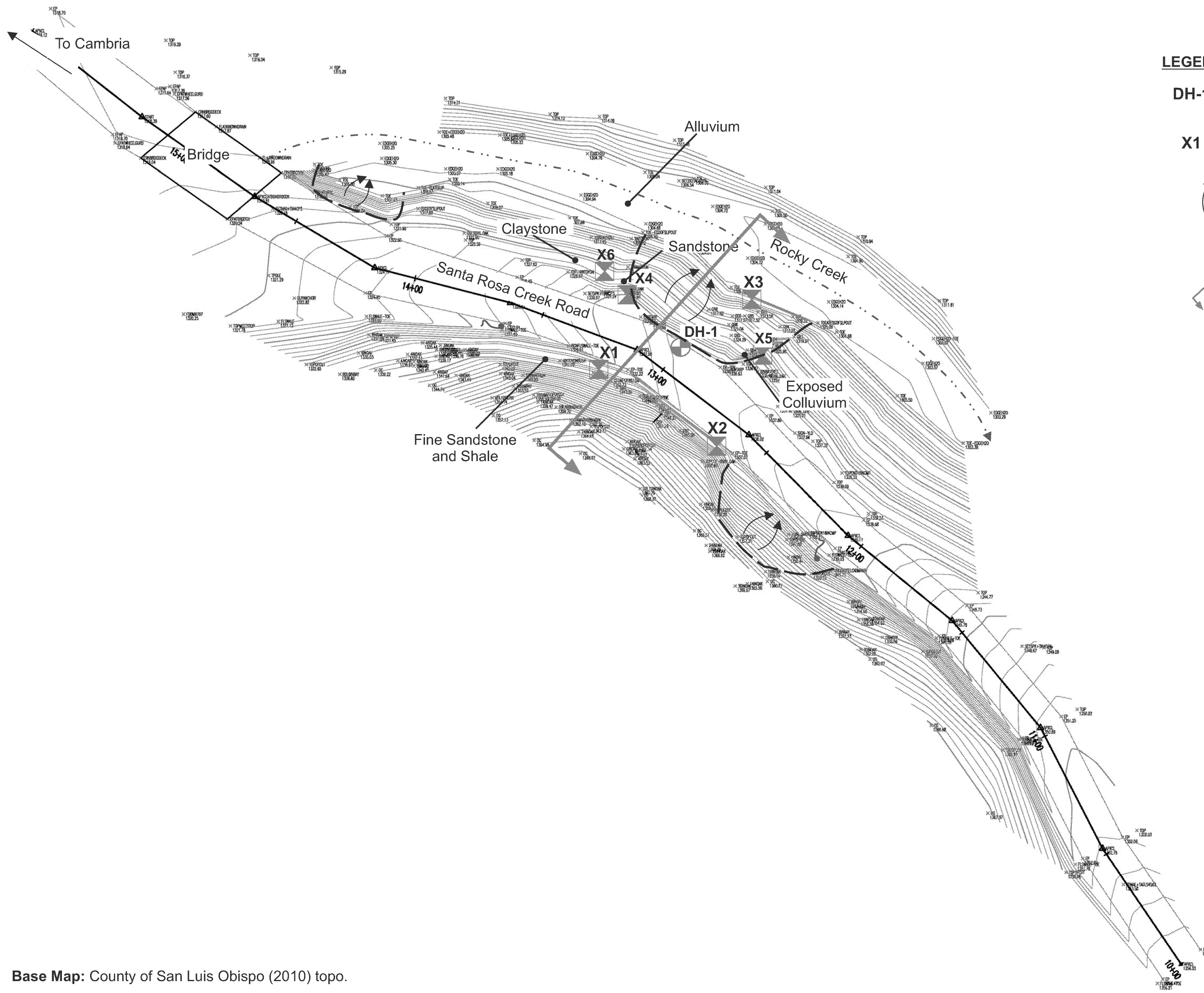
BASE MAP SOURCE: USGS 15' SE/4 Adelaida Quadrangle, 1979 (rev.).

NORTH

0 1000 2000
FEET

VICINITY MAP
Santa Rosa Creek Road
0.9 miles north of Highway 46
San Luis Obispo County, California

PLATE 1



LEGEND

- **DH-1** Fugro (2010) boring location
- **X1** Block sample from rock outcrop or exposure
- Landslide or slope instability
- Spring or seep
- Cross section location used in slope stability analyses

All locations and dimensions are approximate.

Elevations shown are from an assumed datum and may differ from other maps or plans.

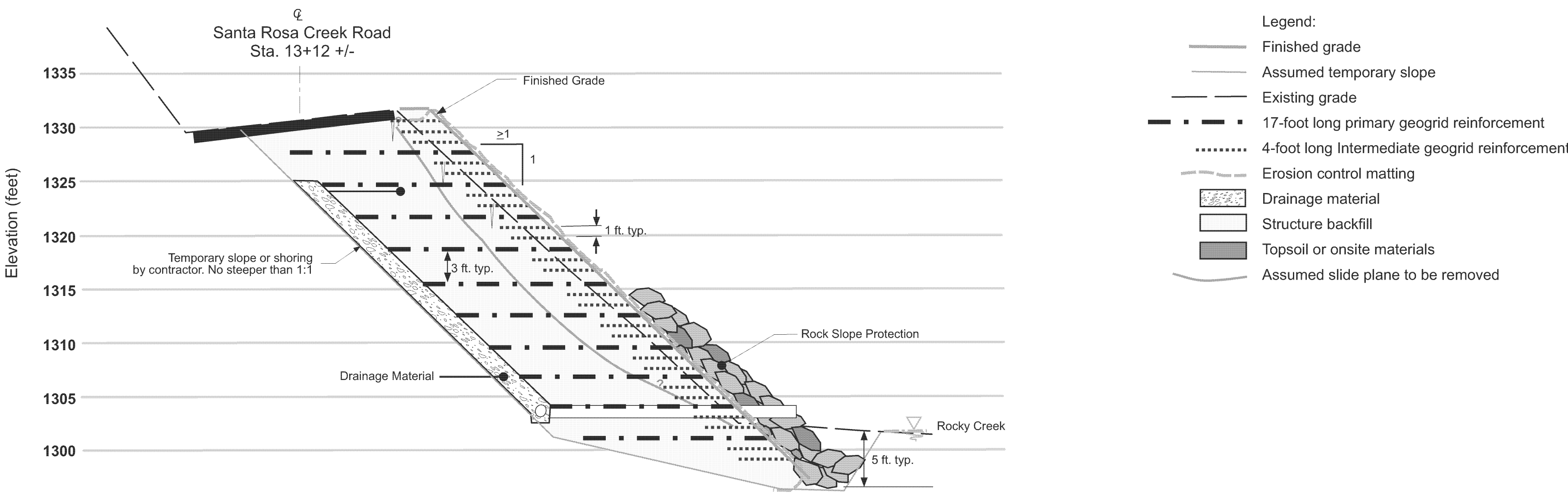
NORTH

0 40 FEET

FIELD EXPLORATION PLAN
Santa Rosa Creek Road
0.9 miles north of Highway 46
San Luis Obispo County, California

PLATE 2

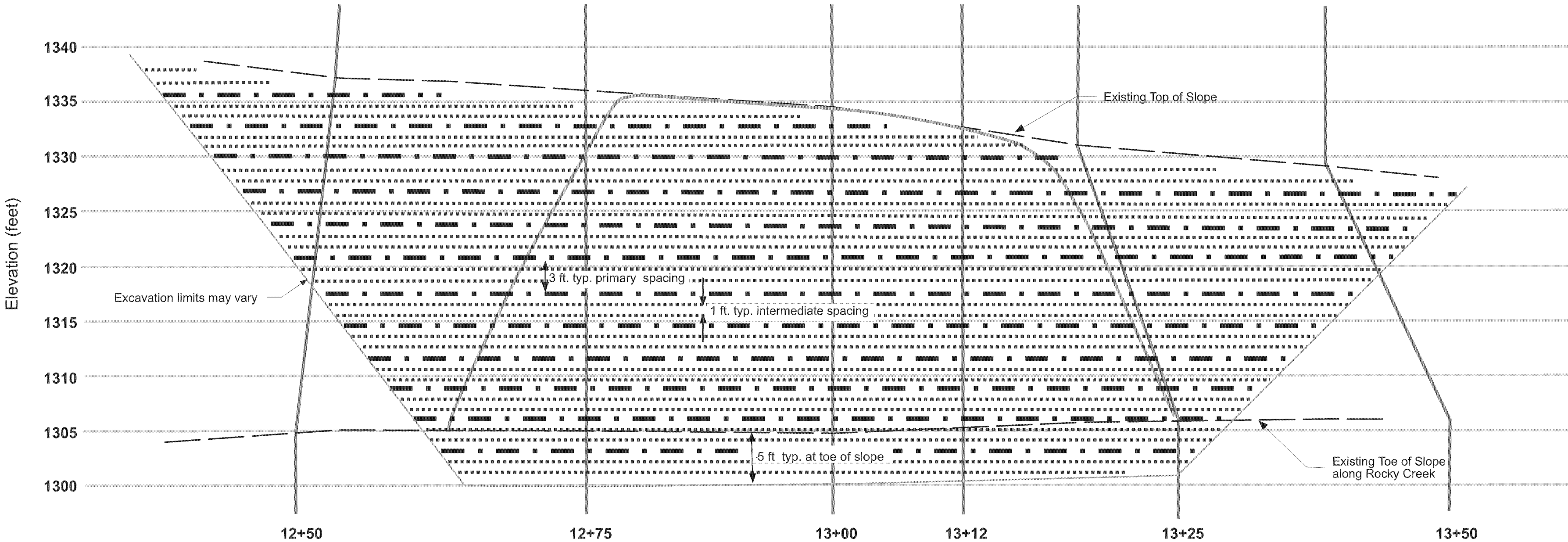
Base Map: County of San Luis Obispo (2010) topo.



TYPICAL CROSS SECTION
1" = 10' +/-

GEOSYNTHETIC REINFORCED EMBANKMENT DETAIL
Santa Rosa Creek Road
0.9 miles north of Highway 46
San Luis Obispo County, California
PLATE 3a

Base Map: San Luis Obispo County topography (2010)



TYPICAL ELEVATION VIEW
1" = 10' +/-

Note: Station lines are offset to account for curvature along toe of slope

Legend:
- Assumed temporary slope/excavation limits
- Existing grade
- Primary geogrid reinforcement embedded 17 feet
- Intermediate geogrid reinforcement embedded 4 feet materials
- Assumed limits of landslide to be removed

GEOSYNTHETIC REINFORCED EMBANKMENT DETAIL
Santa Rosa Creek Road
0.9 miles north of Highway 46
San Luis Obispo County, California
PLATE 3b

Base Map: San Luis Obispo County topography (2010)

APPENDIX A

ELEVATION, ft	DEPTH, ft
-12	2
-14	4
-16	6
-18	8
-20	10
-22	12
-24	14
-26	16
-28	18
-30	20
-32	22
-34	24
-36	26
-38	28
-40	30
-42	32
-44	34
-46	36
-48	38

SAMPLE NO.	BLOW COUNT / REC"/DRIVE"
1	25
2	(25)
3	(25)
4	(25)
5	18"/ 30"
6	
7	
8	20"/ 24"
9	(25)
10	30"/ 30"
11	20"/ 24"
12	
13	

LOCATION: The drill hole location referencing local landmarks or coordinates

SURFACE EL: Using local, MSL, MLLW or other datum

MATERIAL DESCRIPTION	
Well graded GRAVEL (GW)	COARSE GRAINED
Poorly graded GRAVEL (GP)	COARSE GRAINED
Well graded SAND (SW)	COARSE GRAINED
Poorly graded SAND (SP)	COARSE GRAINED
Silty SAND (SM)	COARSE GRAINED
Clayey SAND (SC)	COARSE GRAINED
Silty, Clayey SAND (SC-SM)	COARSE GRAINED
Elastic SILT (MH)	FINE GRAINED
SILT (ML)	FINE GRAINED
Silty CLAY (CL-ML)	FINE GRAINED
Fat CLAY (CH)	FINE GRAINED
Lean CLAY (CL)	FINE GRAINED
CONGLOMERATE	ROCK
SANDSTONE	ROCK
SILTSTONE	ROCK
MUDSTONE	ROCK
CLAYSTONE	ROCK
BASALT	ROCK
ANDESITE BRECCIA	ROCK
Paving and/or Base Materials	

General Notes

Soil Texture Symbol

Sloped line in symbol column indicates transitional boundary

Samplers and sampler dimensions (unless otherwise noted in report text) are as follows:

Symbol for:

1	SPT Sampler, driven 1-3/8" ID, 2" OD
2	CA Liner Sampler, driven 2-3/8" ID, 3" OD
3	CA Liner Sampler, disturbed 2-3/8" ID, 3" OD
4	Thin-walled Tube, pushed 2-7/8" ID, 3" OD
5	Bulk Bag Sample (from cuttings)
6	CA Liner Sampler, Bagged
7	Hand Auger Sample
8	Rock Core Sample
9	Pitcher Sample
10	Lexan Sample
11	Vibracore Sample
12	No Sample Recovered
13	Sonic Soil Core Sample

Sampler Driving Resistance

Number of blows with 140 lb. hammer, falling 30" to drive sampler 1 ft. after seating sampler 6"; for example,

Blows/ft	Description
25	25 blows drove sampler 12" after initial 6" of seating
86/11"	After driving sampler the initial 6" of seating, 36 blows drove sampler through the second 6" interval, and 50 blows drove the sampler 5" into the third interval
50/6"	50 blows drove sampler 6" after initial 6" of seating
Ref/3"	50 blows drove sampler 3" during initial 6" seating interval

Blow counts for California Liner Sampler shown in ( )

Length of sample symbol approximates recovery length

Classification of Soils per ASTM D2487 or D2488

Geologic Formation noted in bold font at the top of interpreted interval

Strength Legend

Q = Unconfined Compression
u = Unconsolidated Undrained Triaxial
t = Torvane
p = Pocket Penetrometer
m = Miniature Vane

Water Level Symbols

- Initial or perched water level
- Final ground water level
- Seepages encountered

Rock Quality Designation (RQD) is the sum of recovered core pieces greater than 4 inches divided by the length of the cored interval.

KEY TO TERMS & SYMBOLS USED ON LOGS

PLATE A-1

BEDDING SPACING	
Descriptor	**Thickness or Spacing**
Massive	> 10 ft
Very thickly bedded	3 to 10 ft
Thickly bedded	1 to 3 ft
Moderately bedded	3-5/8 inches to 1 ft
Thinly bedded	1-1/4 to 3-5/8 inches
Very thinly bedded	3/8 inch to 1-1/4 inches
Laminated	< 3/8 inch

WEATHERING DESCRIPTORS FOR INTACT ROCK

	Diagnostic Features					
	Chemical Weathering-Discoloration-Oxidation		Mechanical Weathering and Grain Boundary Conditions	Texture and Solutioning		
Descriptor	**Body of Rock**	**Fracture Surfaces**		**Texture**	**Solutioning**	**General Characteristics**
Fresh	No discoloration, not oxidized	No discoloration or oxidation	No separation, intact (tight)	No change	No solutioning	Hammer rings when crystalline rocks are struck.
Slightly Weathered	Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull	Minor to complete discoloration or oxidation of most surfaces	No visible separation, intact (tight)	Preserved	Minor leaching of some soluble minerals may be noted	Hammer rings when crystalline rocks are struck. Body of rock not weakened.
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe-Mg minerals are "rusty"; feldspar crystals are "cloudy"	All fracture surfaces are discolored or oxidized	Partial separation of boundaries visible	Generally preserved	Soluble minerals may be mostly leached	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation (refer to grain boundary conditions)	All fracture surfaces are discolored or oxidized; surfaces are friable	Partial separation, rock is friable; in semi-arid conditions, granitics are disaggregated	Altered by chemical disintegration such as via hydration or argillation	Leaching of soluble minerals may be complete	Dull sound when struck with hammer; usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures or veinlets. Rock is significantly weakened.
Decomposed	Discolored of oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay		Complete separation of grain boundaries (disaggregated)	Resembles a soil; partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete		Can be granulated by hand. Resistant minerals such as quartz may be present as "stringers" or "dikes".

Note: Combination descriptors (such as "slightly weathered to fresh") are used where equal distribution of both weathering characteristics is present over significant intervals or where characteristics present are "in between" the diagnostic feature. However, combination descriptors should not be used where significant identifiable zones can be delineated. Only two adjacent descriptors shall be combined. "Very intensely weathered" is the combination descriptor for "decomposed to intensely weathered".

RELATIVE STRENGTH OF INTACT ROCK	
Descriptor	**Uniaxial Compressive Strength (psi)**
Extremely Strong	> 30,000
Very Strong	14,500 - 30,000
Strong	7,000 - 14,500
Medium Strong	3,500 - 7,000
Weak	700 - 3,500
Very Weak	150 - 700
Extremely Weak	< 150

CORE RECOVERY CALCULATION (%)

$$\frac{\Sigma \text{ Length of the recovered core pieces (in.)}}{\text{Total length of core run (in.)}} \times 100$$

RQD CALCULATION (%)

$$\frac{\Sigma \text{ Length of intact core pieces} > 4 \text{ in.}}{\text{Total length of core run (in.)}} \times 100$$

ROCK HARDNESS	
Descriptor	**Criteria**
Extremely Hard	Specimen cannot be scratched with pocket knife or sharp pick; can only be chipped with repeated heavy hammer blows
Very hard	Specimen cannot be scratched with pocket knife or sharp pick; breaks with repeated heavy hammer blows
Hard	Specimen can be scratched with pocket knife or sharp pick with heavy pressure; heavy hammer blows required to break specimen
Moderately Hard	Specimen can be scratched with pocket knife or sharp pick with light or moderate pressure; breaks with moderate hammer blows
Moderately Soft	Specimen can be grooved 1/6 in. with pocket knife or sharp pick with moderate or heavy pressure; breaks with light hammer blow or heavy hand pressure
Soft	Specimen can be grooved or gouged with pocket knife or sharp pick with light pressure, breaks with light to moderate hand pressure
Very Soft	Specimen can be readily indented, grooved, or gouged with fingernail, or carved with pocket knife; breaks with light hand pressure

FRACTURE DENSITY	
Descriptor	**Criteria**
Unfractured	No fractures
Very Slightly Fractured	Lengths greater 3 ft
Slightly Fractured	Lengths from 1 to 3 ft, few lengths outside that range
Moderately Fractured	Lengths mostly in range of 4 in. to 1 ft, with most lengths about 8 in.
Intensely Fractured	Lengths average from 1 in. to 4 in. with scattered fragmented intervals with lengths less than 4 in.
Very Intensely Fractured	Mostly chips and fragments with few scattered short core lengths

Reference: Caltrans (2007) Soil and Rock Logging Manual, Fig. 5-16.

TERMS AND DEFINITIONS USED FOR ROCK

Santa Rosa Creek Road Slipout
San Luis Obispo County, California

LOCATION: Approximately 4' southwest of top of slope, approximately 12' southeast of western tarp edge

SURFACE EL: 2553 ft +/- (rel. Surveyor's topographical (assumed) datum)

CORE/SAMPLE NO.	BLOW COUNT OR CORE RECOVERY-RQD %	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf
A		**ARTIFICIAL FILL (af)** 6" asphalt pavement over 8" base		120	11	34	36	20	
		Lean CLAY (CL): olive brown, moist, approximately 25% coarse sand to fine subangular gravel, claystone gravel clasts							
1A	(40)	**COLLUVIUM (Qcol)** Gravelly lean CLAY (CL): very stiff to hard, olive brown, moist, approximately 45% fine subangular gravel	131	116	13		37	18	
		TORO FORMATION (KJf) CLAYSTONE (Rx): olive brown, intensely weathered to decomposed, very soft, very intensely fractured, oxidation staining on all surfaces							
		CLAYSTONE (Rx): olive brown, intensely weathered, moderately soft to soft, discolored/oxidized fracture surfaces, with polished fracture surfaces, moist							
2A	(89/10")	- interbed of silty SAND with gravel (SM), reddish brown, moist, decomposed fine subangular gravel, sandstone gravel clasts		120	6				
3A	(50/2")		134	126	6				
		CLAYSTONE (Rx): dark gray, moderately weathered, moderately hard, micaceous							
4A	(50/2")								
R1	20%-0%								
R1A							32	14	
R2	10%-0%	- lost approximately 300 gallons of water in drilling fluid circulation							
R2A									
R3	17%-0%	- joint dipping at approximately 12°, dull planar surface, very intensely fractured, wet, massive, lost approximately 300 gallons of water in drilling fluid circulation							
R3A									

ELEVATION, ft: 2552, 2550, 2548, 2546, 2544, 2542, 2540, 2538, 2536, 2534, 2532, 2530, 2528, 2526, 2524, 2522, 2520

DEPTH, ft: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

COMPLETION DEPTH: 50.0 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings/Concrete
DRILLING DATE: March 9, 2010

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger, 1-7/8" NQ Rock Core
HAMMER TYPE: Automatic Trip
DRILLED BY: GeoSolutions, Inc.
LOGGED BY: G Eckrich
CHECKED BY: J Blanchard

LOG OF BORING NO. DH-1

Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE A-3a

LOCATION: Approximately 4' southwest of top of slope, approximately 12' southeast of western tarp edge

SURFACE EL: 2553 ft +/- (rel. Surveyor's topographical (assumed) datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	CORE/SAMPLE NO.	SAMPLERS	BLOW COUNT OR CORE RECOVERY-RQD %	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf
2518	36		R4		30%-0%	- approximately 3" seam of gravelly fat CLAY (CH), lost approximately 300 gallons of water in drilling fluid circulation							
2516	38		R4A R4B										
2514	40		R5 R5A		33%-0%	- shear dipping at 45° to subvertical, irregular slickened surface							
2512	42					- lost approximately 150 gallons of water in drilling fluid circulation							
2510	44		R5B R5C				154	150	3				
2508	46		R6		30%-0%	- approximately 1/2" seam of fat CLAY (CH) lost approximately 150 gallons of water in drilling fluid circulation							
2506	48												
2504	50					- two joints dipping at approximately 30°, smooth planar surfaces - approximately 1/2" seam of fat CLAY (CH), slickensided - shear dipping at 40°, smooth planar surface							
2502	52												
2500	54					Note: No groundwater encountered to 20 feet. Water added below 20 feet to assist with rock coring.							
2498	56												
2496	58												
2494	60												
2492	62												
2490	64												
2488	66												
2486													

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

COMPLETION DEPTH: 50.0 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings/Concrete
DRILLING DATE: March 9, 2010

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger, 1-7/8" NQ Rock Core
HAMMER TYPE: Automatic Trip
DRILLED BY: GeoSolutions, Inc.
LOGGED BY: G Eckrich
CHECKED BY: J Blanchard

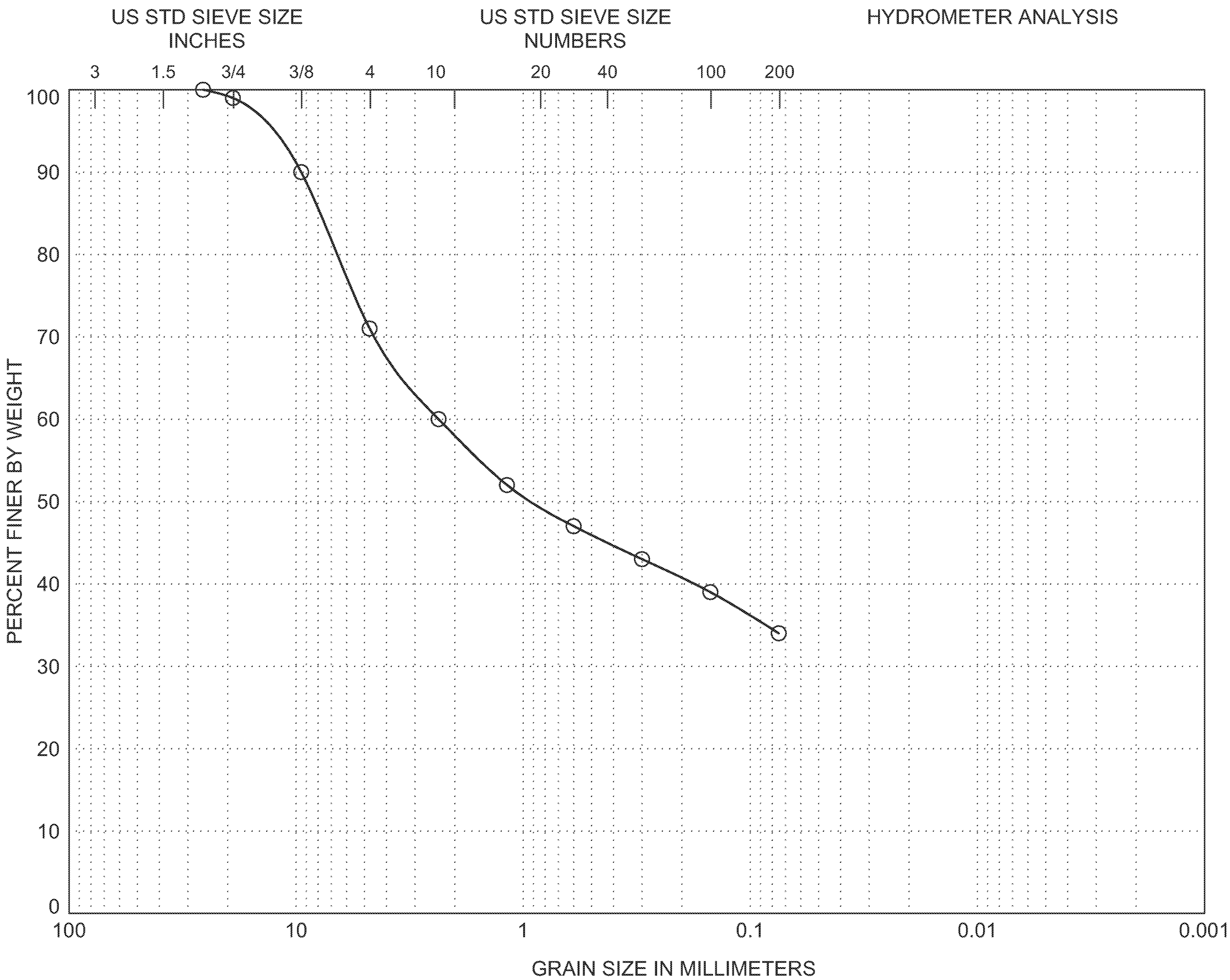
LOG OF BORING NO. DH-1
Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE A-3b

Reference: Drilling of DH-01 occurred on March 9, 2010. See boring logs and report for description and information on cores.

ROCK CORE PHOTOS for DH-01
Santa Rosa Creek Road Slipout
San Luis Obispo County, California

APPENDIX B

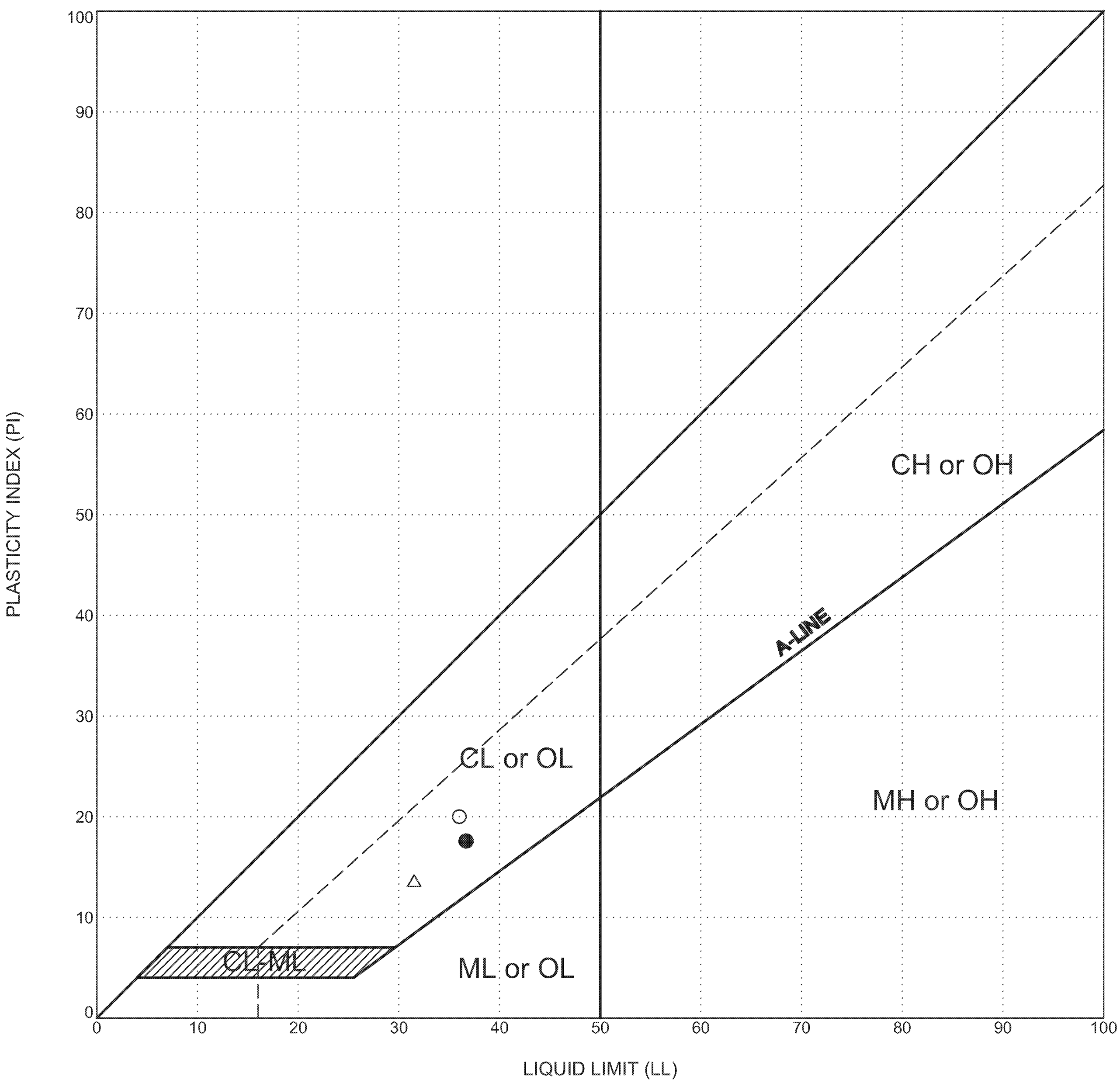


GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

LEGEND (location)	(depth,ft)	CLASSIFICATION	Cc	Cu
○ DH-1	0.0	Clayey SAND with gravel (SC)		

GRAIN SIZE CURVES
Santa Rosa Creek Road Slipout
San Luis Obispo County, California

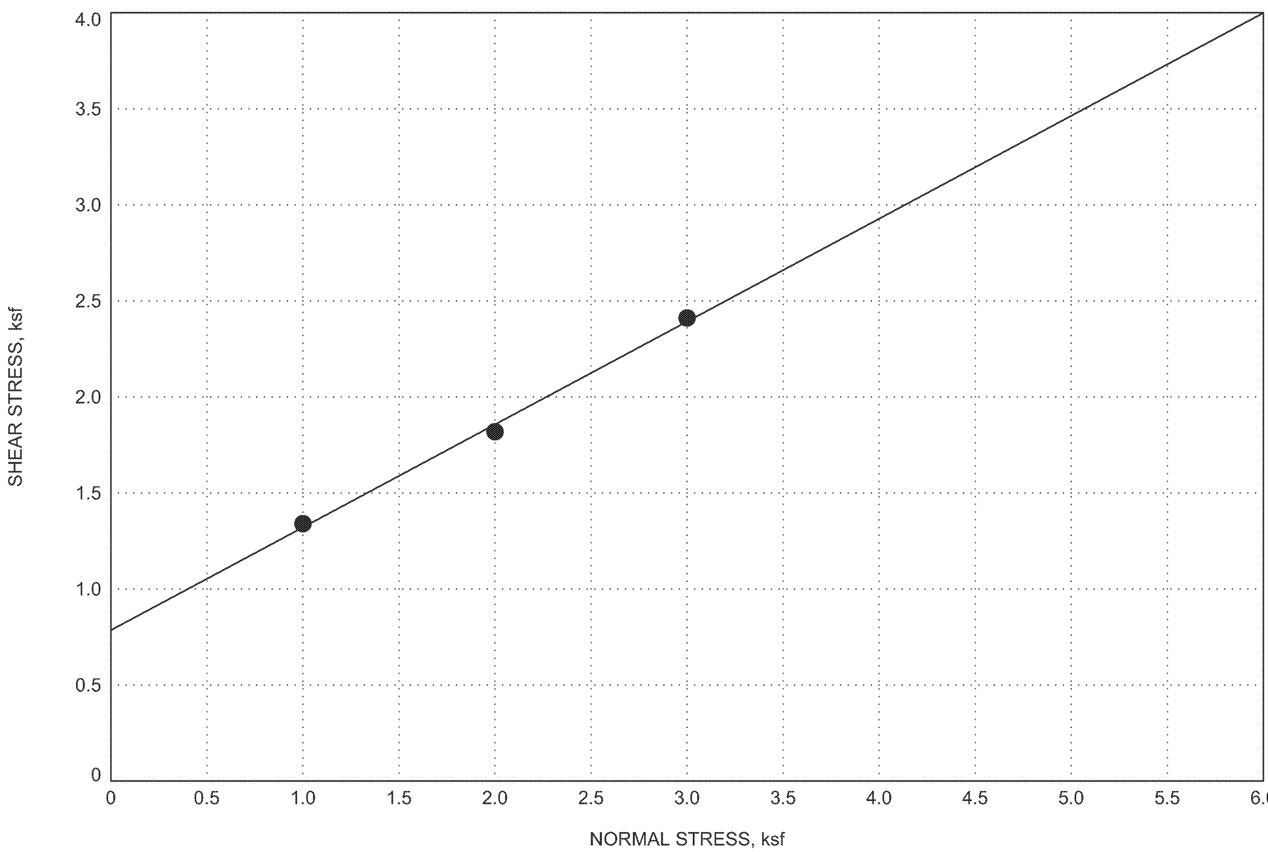
PLATE B-1



LEGEND	location	depth, ft	CLASSIFICATION	ATTERBERG LIMITS TEST RESULTS LIQUID LIMIT(LL)	PLASTIC LIMIT(PL)	PLASTICITY INDEX (PI)
○	DH-1	0.0	Clayey SAND with gravel (SC)	36	16	20
●	DH-1	5.0	Lean CLAY (CL)	37	19	18
△	DH-1	23.0	CLAYSTONE (Cx), "Lean CLAY (CL)"	32	18	14

PLASTICITY CHART
Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE B-2

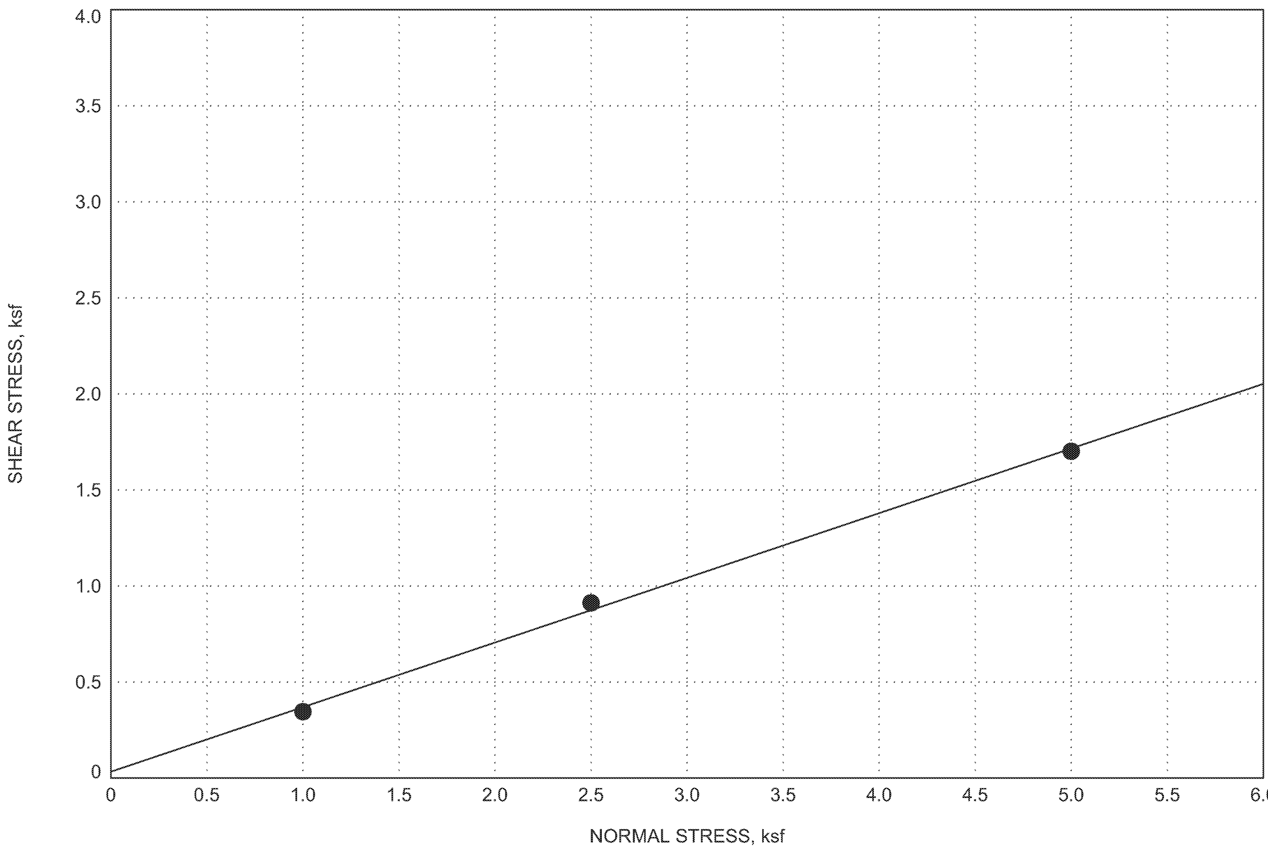


COHESION, ksf	0.8
ANGLE OF INTERNAL FRICTION, deg	28
LOCATION	DH-1
DEPTH, ft	0
MOISTURE CONTENT, %	11
UNIT DRY WEIGHT, pcf	120
MATERIAL DESCRIPTION	Clayey SAND with gravel (SC)
SAMPLE CONDITION	Remold

DIRECT SHEAR TEST RESULTS

Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE B-3a

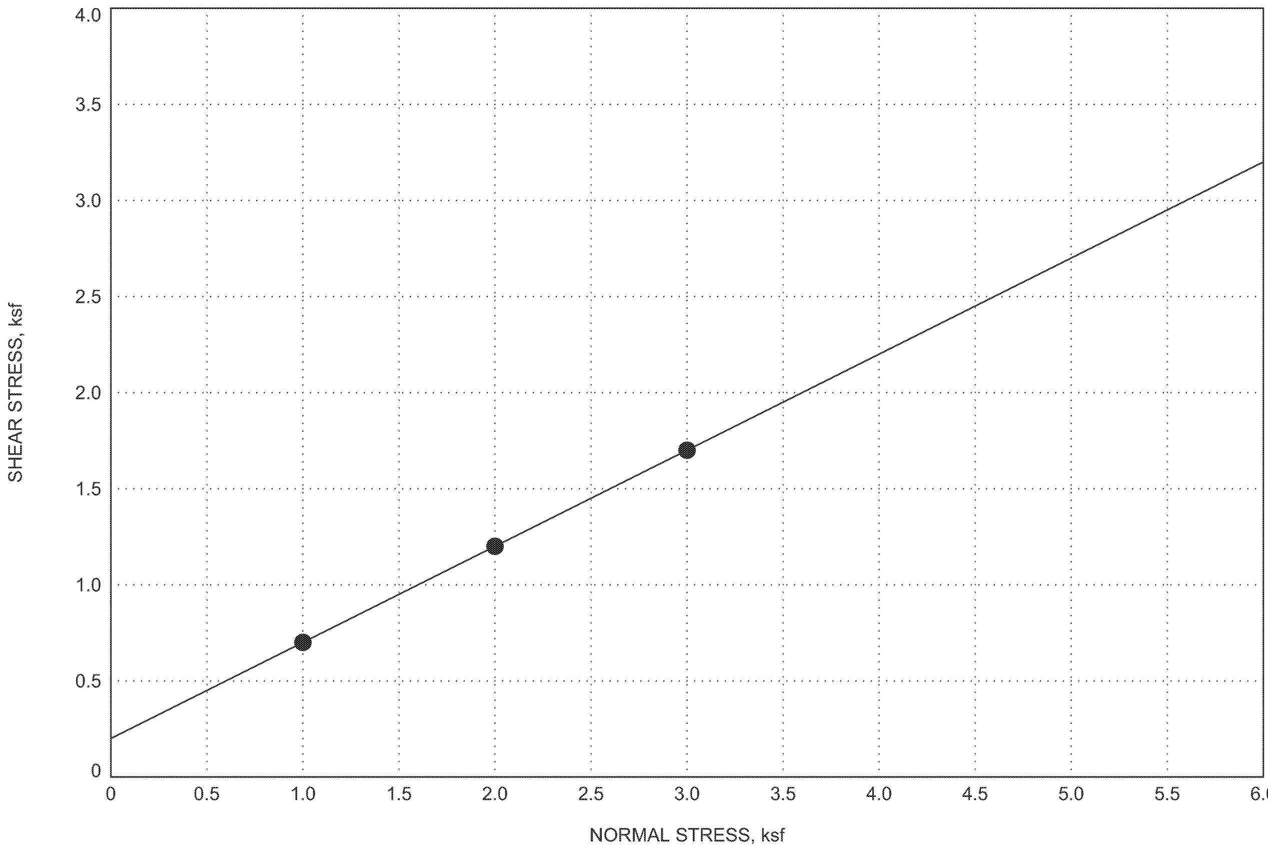


COHESION, ksf	0.0
ANGLE OF INTERNAL FRICTION, deg	19
LOCATION	DH-1
DEPTH, ft	10
MOISTURE CONTENT, %	6
UNIT DRY WEIGHT, pcf	120
MATERIAL DESCRIPTION	CLAYSTONE (Cx), "Lean CLAY (CL)"
SAMPLE CONDITION	Ring - Precut shear plane

DIRECT SHEAR TEST RESULTS

Santa Rosa Creek Road Slipout
San Luis Obispo County, California

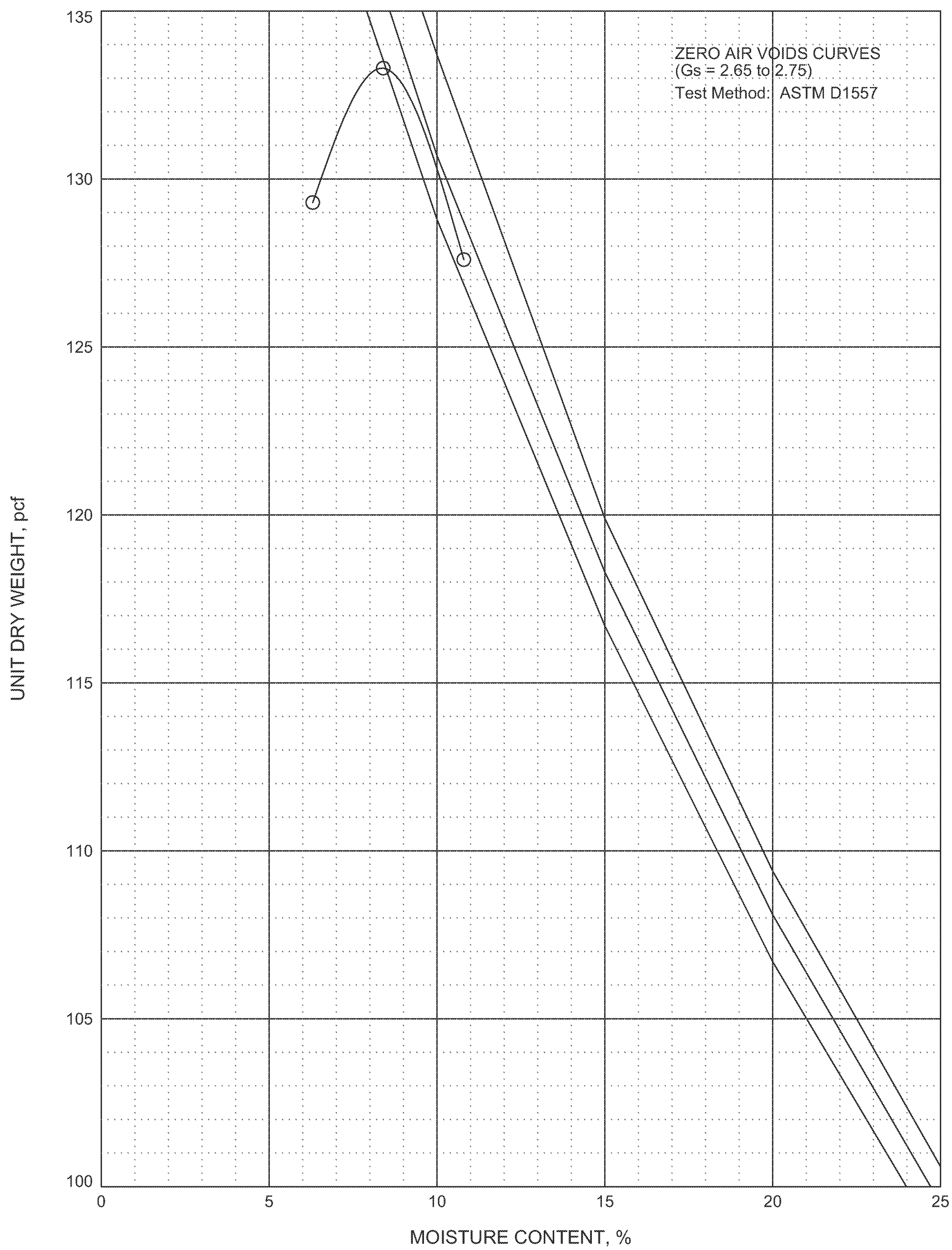
PLATE B-3b



COHESION, ksf	0.2
ANGLE OF INTERNAL FRICTION, deg	27
LOCATION	DH-1
DEPTH, ft	43
MOISTURE CONTENT, %	
UNIT DRY WEIGHT, pcf	
MATERIAL DESCRIPTION	CLAYSTONE (Cx), "Lean CLAY (CL)"
SAMPLE CONDITION	Ring Sample

DIRECT SHEAR TEST RESULTS
Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE B-3c



LEGEND (location)	(depth), ft	CLASSIFICATION	MAXIMUM UNIT DRY WEIGHT, pcf	OPTIMUM WATER CONTENT, %
O DH-1	0.0	Clayey SAND with gravel (SC)	133.3	8.4

COMPACTION TEST RESULTS
Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE B-4

SAMPLE ID

Boring Number	x1
Sample Number	x1
Depth (ft)	0.0
Break Date	12 Mar, 2010
Sample Description	CLAYSTONE (Cx), "Lean CLAY (CL)": dark grayish brown, moderately weathered, moderately hard, moderately to intensely fractured
Moisture Condition	As Recovered

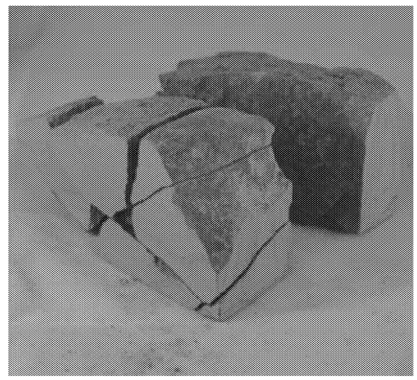
TEST INFORMATION

Specimen Type	Irregular Lump
Length, L (in)	1.283
Depth, D (in)	1.373
Width, W_1 (in)	1.534
Width, W_2 (in)	1.556
Area, A (in^2)	2.12
D^2_e (in^2)	2.70
Size Corr. Factor, F	0.92

TEST SUMMARY

Load at Failure, F (lbs)	90
Uncorrected PLI, I_s (psi)	33
Size Corrected PLI, $I_{s(50)}$ (psi)	31
Compressive Strength σ_c (psi)	800

Test Method: ASTM D5731
Remarks: Structural failure along discontinuity.



SAMPLE ID

Boring Number	x2
Sample Number	x2
Depth (ft)	0.0
Break Date	12 Mar, 2010
Sample Description	SANDSTONE (Sx), "Clayey SAND (SC)": brown, moderately weathered, moderately hard, moderately fractured
Moisture Condition	As Recovered

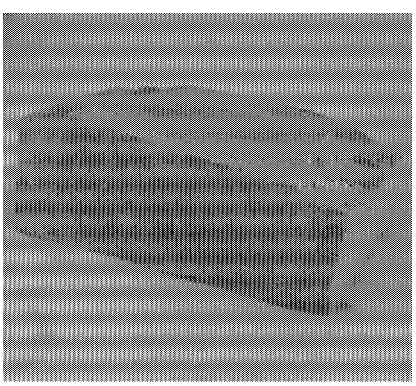
TEST INFORMATION

Specimen Type	Irregular Lump
Length, L (in)	1.460
Depth, D (in)	1.184
Width, W_1 (in)	1.641
Width, W_2 (in)	1.411
Area, A (in^2)	1.81
D^2_e (in^2)	2.30
Size Corr. Factor, F	0.89

TEST SUMMARY

Load at Failure, F (lbs)	400
Uncorrected PLI, I_s (psi)	174
Size Corrected PLI, $I_{s(50)}$ (psi)	155
Compressive Strength σ_c (psi)	4200

Test Method: ASTM D5731
Remarks:



POINT LOAD STRENGTH INDEX OF ROCK

Santa Rosa Creek Road Slipout
San Luis Obispo County

SAMPLE ID

Boring Number	x3
Sample Number	x3
Depth (ft)	0.0
Break Date	12 Mar, 2010
Sample Description	CLAYSTONE (Cx), "Lean CLAY (CL)": dark grayish brown, moderately weathered, moderately hard, moderately to intensely fractured
Moisture Condition	As Recovered

TEST INFORMATION

Specimen Type	Irregular Lump
Length, L (in)	1.106
Depth, D (in)	1.184
Width, W_1 (in)	1.466
Width, W_2 (in)	1.593
Area, A (in^2)	1.81
D^2_e (in^2)	2.31
Size Corr. Factor, F	0.89

TEST SUMMARY

Load at Failure, F (lbs)	50
Uncorrected PLI, I_s (psi)	22
Size Corrected PLI, $I_{s(50)}$ (psi)	19
Compressive Strength σ_c (psi)	520

Test Method: ASTM D5731
Remarks: Structural failure along discontinuity.


SAMPLE ID

Boring Number	x4
Sample Number	x4
Depth (ft)	0.0
Break Date	12 Mar, 2010
Sample Description	CLAYSTONE (Cx), "Lean CLAY (CL)": dark grayish brown, moderately weathered, moderately hard, moderately fractured
Moisture Condition	As Recovered

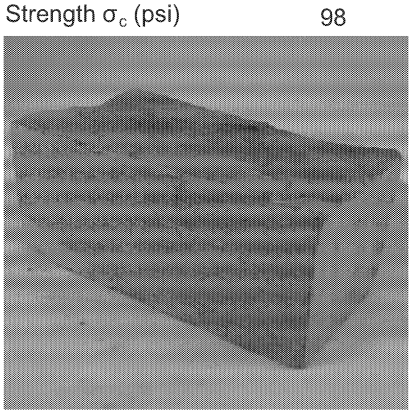
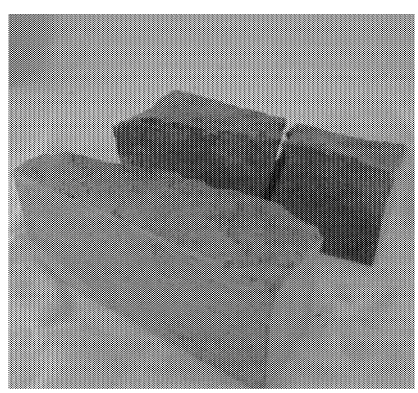
TEST INFORMATION

Specimen Type	Irregular Lump
Length, L (in)	1.389
Depth, D (in)	1.285
Width, W_1 (in)	1.522
Width, W_2 (in)	1.468
Area, A (in^2)	1.92
D^2_e (in^2)	2.45
Size Corr. Factor, F	0.90

TEST SUMMARY

Load at Failure, F (lbs)	10
Uncorrected PLI, I_s (psi)	4
Size Corrected PLI, $I_{s(50)}$ (psi)	4
Compressive Strength σ_c (psi)	98

Test Method: ASTM D5731
Remarks: Structural failure along discontinuity.

POINT LOAD STRENGTH INDEX OF ROCK

Santa Rosa Creek Road Slipout
San Luis Obispo County

SAMPLE ID	Boring Number	x6	TEST INFORMATION	Specimen Type	Irregular Lump
	Sample Number	x6		Length, L (in)	1.417
	Depth (ft)	0.0		Depth, D (in)	1.180
	Break Date	12 Mar, 2010		Width, W_1 (in)	1.489
	Sample Description	CLAYSTONE (Cx), "Lean CLAY (CL)": dark grayish brown, moderately weathered, moderately hard, moderately to intensely fractured		Width, W_2 (in)	1.560
				Area, A (in^2)	1.80
				D^2_e (in^2)	2.29
	Moisture Condition	As Recovered		Size Corr. Factor, F	0.89

TEST SUMMARY

Load at Failure, F (lbs)	60	Test Method: ASTM D5731
Uncorrected PLI, I_s (psi)	26	Remarks: Structural failure along discontinuity.
Size Corrected PLI, $I_{s(50)}$ (psi)	23	
Compressive Strength σ_c (psi)	630	

POINT LOAD STRENGTH INDEX OF ROCK

Santa Rosa Creek Road Slipout

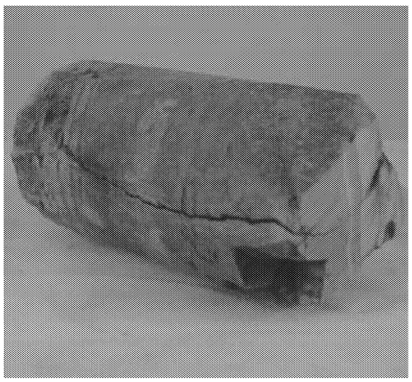
San Luis Obispo County

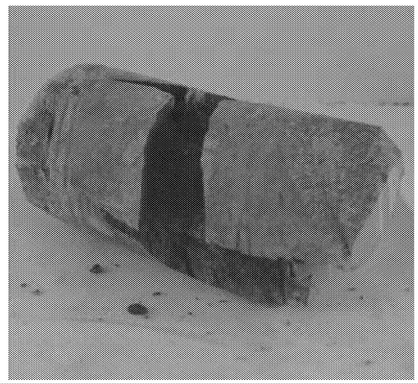
SAMPLE ID			TEST INFORMATION		
	Boring Number	DH-01		Specimen Type	Diametral
	Sample Number	R1A		Length, L (in)	1.478
	Depth (ft)	23.0		Depth, D (in)	1.762
	Break Date	11 Mar, 2010		D^2_e (in^2)	3.10
	Sample Description	CLAYSTONE (Cx), "Lean CLAY (CL)": bluish gray, fresh, hard, moderately fractured		Size Corr. Factor, F	0.95
	Moisture Condition	As Recovered			

TEST SUMMARY

Load at Failure, F (lbs)	250
Uncorrected PLI, I_s (psi)	81
Size Corrected PLI, $I_{s(50)}$ (psi)	77
Compressive Strength σ_c (psi)	1900

Test Method: ASTM D5731
Remarks: Invalid break geometry. Structural failure along discontinuity.

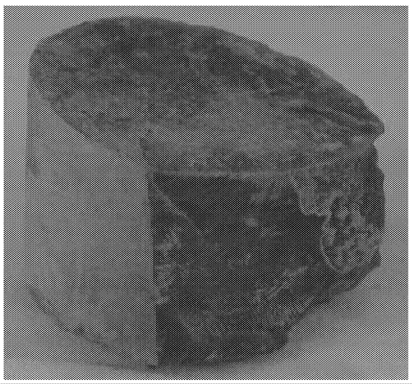




POINT LOAD STRENGTH INDEX OF ROCK
Santa Rosa Creek Road Slipout
San Luis Obispo County

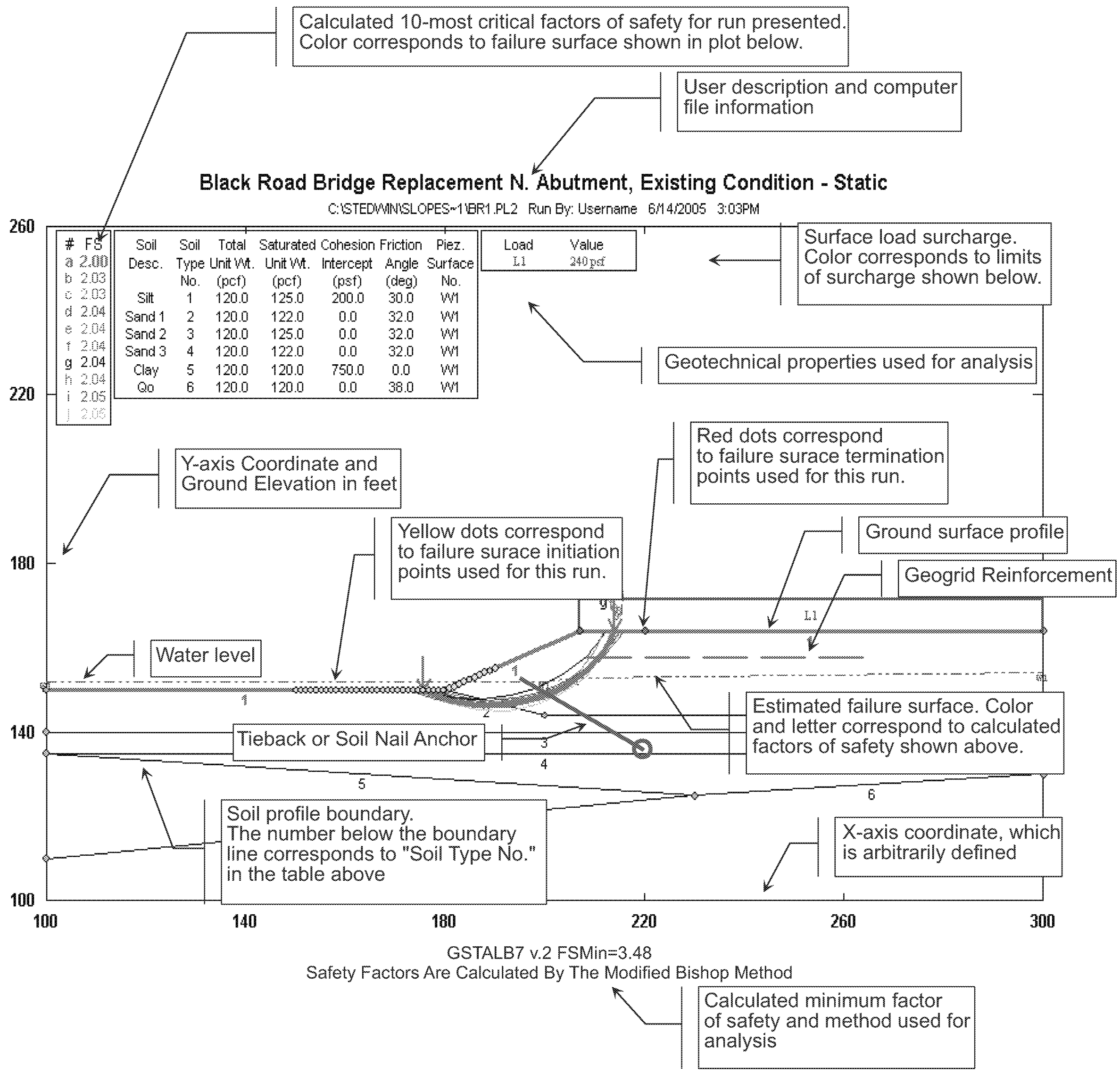
SAMPLE ID	Boring Number	DH-01	TEST INFORMATION	Specimen Type	Axial
	Sample Number	R5B		Height, D (in)	1.112
	Depth (ft)	43.0		Diameter, W (in)	1.768
	Break Date	15 Mar, 2010		Area, A (in^2)	1.97
	Sample Description	CLAYSTONE (Cx), "Lean CLAY (CL)": bluish gray, fresh, hard, moderately fractured		D^2_e (in^2)	2.50
				Size Corr. Factor, F	0.91
	Moisture Condition	As Recovered			

TEST SUMMARY	Load at Failure, F (lbs)	720	Test Method: ASTM D5731
	Uncorrected PLI, I_s (psi)	288	Remarks:
	Size Corrected PLI, $I_{s(50)}$ (psi)	261	
	Compressive Strength σ_c (psi)	6900	



POINT LOAD STRENGTH INDEX OF ROCK
Santa Rosa Creek Road Slipout
San Luis Obispo County

APPENDIX C



Notes:

1. Plots are shown for run with least calculated factor of safety. Additional termination and initiation limits may have been considered. Typically over 100 surfaces are calculated for each run.

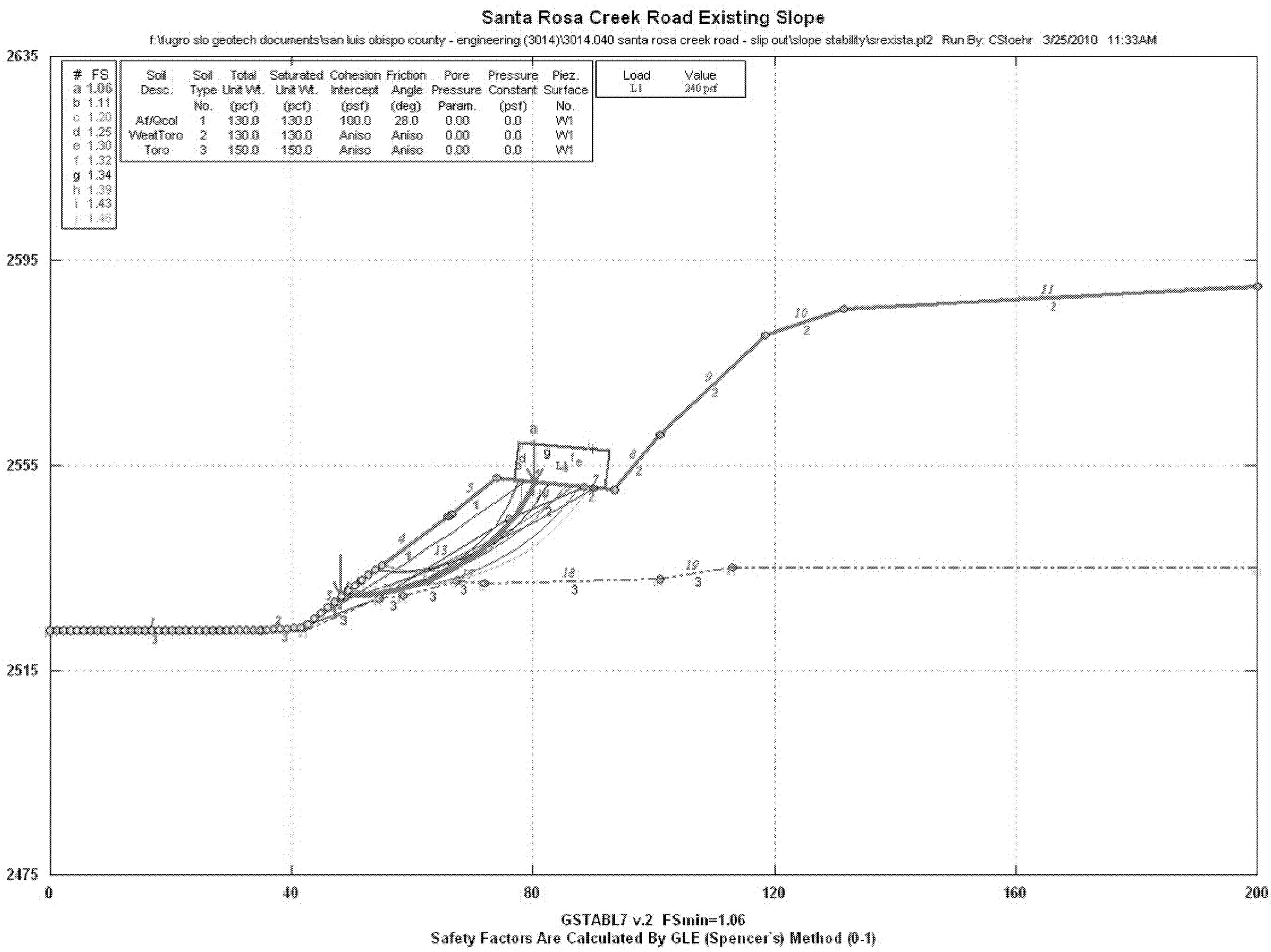
2. Discussion of the results and methodology is provided in the text of the report.

3. The surface and subsurface boundaries are approximate and represent only a generalization of interpreted and inferred subsurface conditions estimated from limited points of exploration.

KEY TO SLOPE STABILITY PLOTS

Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE C-1



GSTABL7

ESTIMATED FACTORS OF SAFETY

Static Loading Condition: 1.06

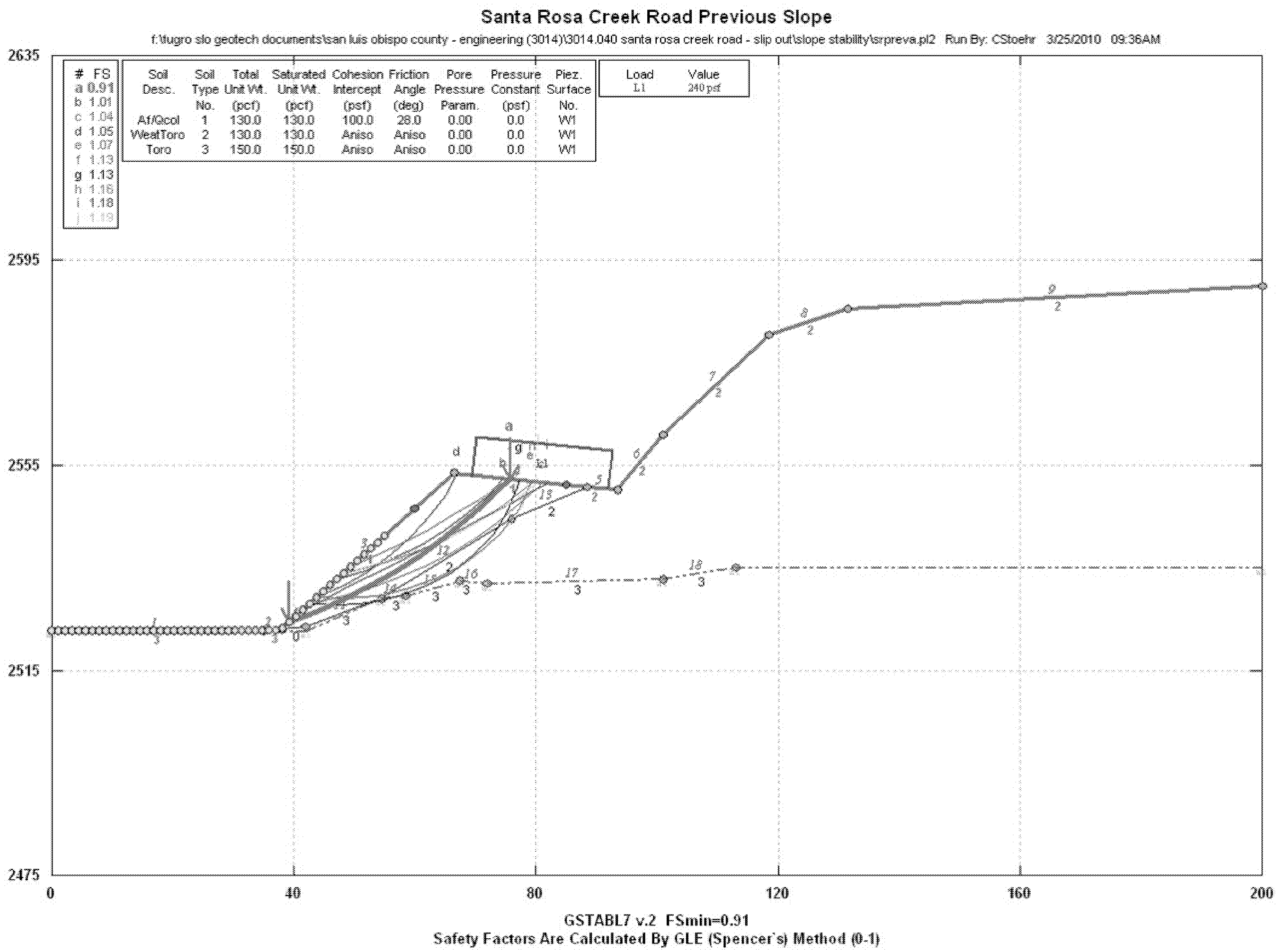
Pseudostatic Loading Condition: –

Pseudostatic Coefficient: –

Condition: Existing Slope

SLOPE STABILITY PLOT - EXISTING SLOPE
Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE C-2



GSTABL7

ESTIMATED FACTORS OF SAFETY

Static Loading Condition: 0.91

Pseudostatic Loading Condition: –

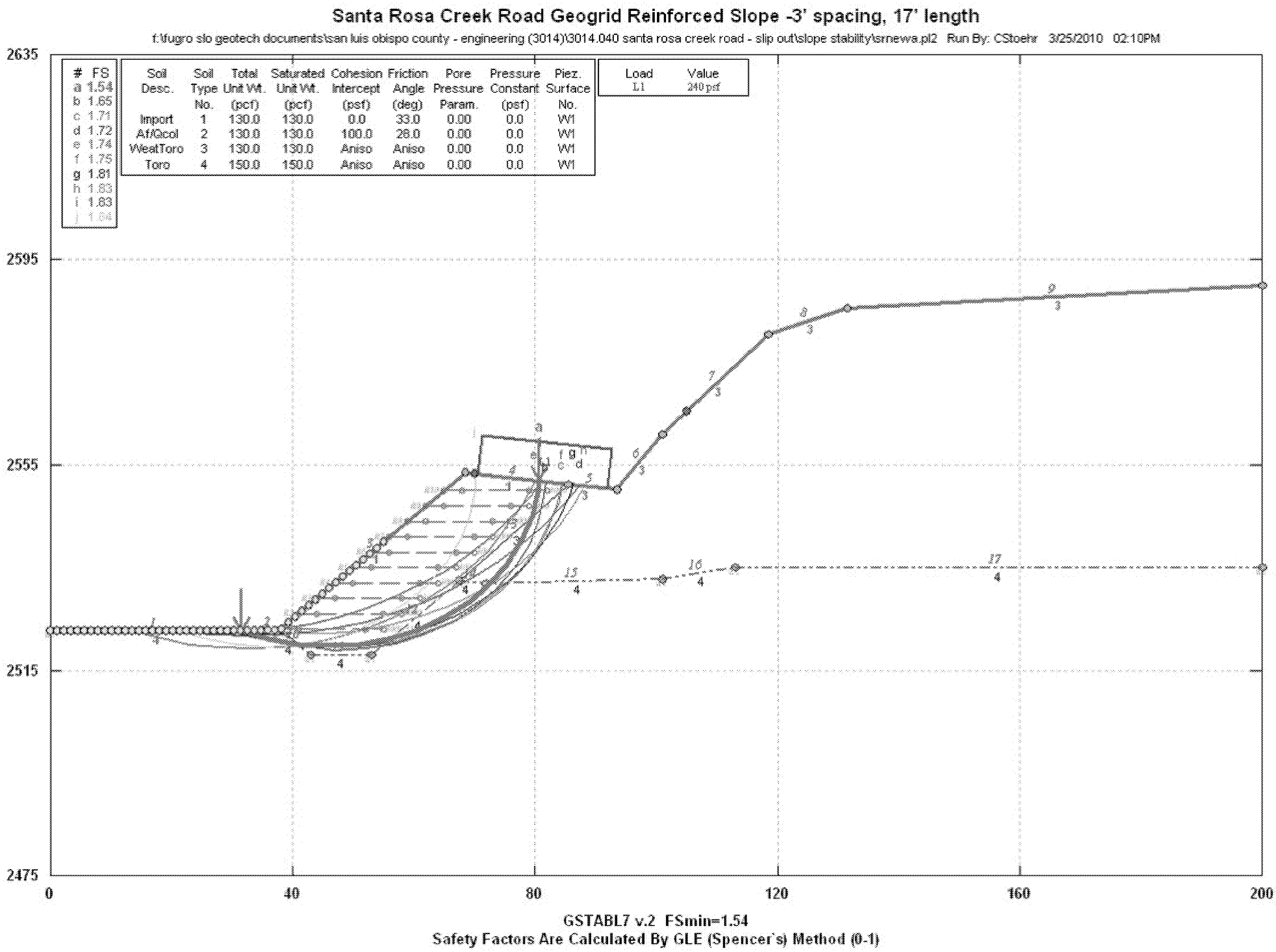
Pseudostatic Coefficient: –

Condition: Assumed Previous Slope

SLOPE STABILITY PLOT - PREVIOUS SLOPE CONDITION

Santa Rosa Creek Road Slipout
San Luis Obispo County, California

PLATE C-3



GSTABL7

ESTIMATED FACTORS OF SAFETY

Static Loading Condition: 1.54

Pseudostatic Loading Condition: 1.21

Pseudostatic Coefficient: 0.15

Condition: 1:1 GRE, L = 17', Sv = 3'

SLOPE STABILITY PLOT - 1:1 GEOSYNTHETIC REINFORCED SLOPE CONDITION

Santa Rosa Creek Road Slipout

San Luis Obispo County, California

PLATE C-4