Appendix F

Preliminary Geotechnical Design Report (PGDR)

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Preliminary Geotechnical Design Report

For the

Las Positas Multi-Use Trail Project
Santa Barbara, California

Report Prepared For:

RRM Design Group
San Luis Obispo, California

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1.0 INTRODUCTION

The City of Santa Barbara, California, proposes to construct approximately 2.6 miles of multi-use, Class 1 trails along portions of Las Positas and Modoc Roads. The project Architect-Engineer (A-E), RRM Design Group of San Luis Obispo, California, contracted with Bengal Engineering, Inc. (BE) to provide geotechnical engineering and structural engineering services for the subject multi-use trail system.

As part of our scope of work, this Preliminary Geotechnical Design Report (PGDR) was prepared to present the results of our subsurface exploration, and geotechnical analysis, design and construction recommendations for the proposed project.

1.1 Site Location

The subject project site is located immediately north of and within the City of Santa Barbara's Las Positas Valley. The proposed trail alignment limits are shown on Figure 1 included in Appendix A. The trail alignment starts at a location on Modoc Road, just northwest of its intersection with Calle de Los Amigos (Lat/Long: 34.433º, -119.749º) and continues southeast alongside Modoc Road for approximately 1.0 mile towards the intersection of Modoc and Las Positas Roads. At this intersection the trail heads south alongside Las Positas Road for approximately 1.6 miles to its terminus at Cliff Drive (Lat/Long: 34.405º, -119.739º).

For reference, we refer to the Modoc Road trail segment and Las Positas Road trail segment throughout this preliminary geotechnical design report.

1.2 Project Description

The multiuse trail path will provide key connections between Santa Barbara's regional Crosstown and Coastal Bike Routes, the neighborhoods adjacent to the path, Elings Park, Arroyo Burro Beach and Park, and the Douglas Family Preserve. In addition to the multiuse path project itself, the overall project will include connection points to other bikeways and adjacent neighborhood sidewalks, which may include intersection improvements as necessary to enhance the multi-use path.

Conceptual trail alignment drawings, provided to Bengal by RRM Design Group in January 2016, serve as the base for the attached Plates 1 through 9 in Appendix B that show the location of the exploratory borings. Trail centerline profile information was not available as of the issuance of this report. Stationing, where referred to in this report, is based on the roadway centerline stationing (Las Positas Road) provided by the project A-E.

The paved Class 1 trail section is to be a minimum of twelve feet (12') wide with graded shoulders. Details of the recommended preliminary trail's structural sections will be provided in the Geotechnical Design Report (GDR).

Retaining walls will be required along numerous stretches of the trail alignment. Some segments of retaining wall alignments are shown on the conceptual trail plans. At this time retaining wall profiles are not available.

For the proposed Modoc Road trail segment, the conceptual trail alignment proposes earth retaining structures (ERS) at the following locations:

- Approximately 177' of retaining wall, approximately five feet (5') in height, west of the intersection of Modoc Road and Palermo Road

- Approximately 200' of retaining wall, approximately six feet (6') in height, along a portion of the trail between Palermo Drive and Veronica Springs Road

Along the Las Positas Road trail segment, the conceptual trail alignment plans propose retaining walls along most of the Las Positas creek reach (designed by others) and a segment of retaining wall along the east side of Las Positas, from Sta 12+10 to Sta 15+08. It appears that numerous stretches of additional retaining wall and/or slope grading will be required along the Las Positas trail segment.

Earthwork for the subject will include foundation excavation, and cut / fill for the construction of the proposed retaining walls. Grading for the subject project will also include cut and fill to achieve the desired trail finish grade, to prepare pavement subgrade and to facilitate both surface and subsurface drainage along the trail system.

As discussed in our proposal and approved scope of work, the following areas and/or items were not addressed either with our subsurface exploration or considered in our geotechnical engineering analyses:

- The 195-foot-long retaining wall (Sta 13+76 to Sta 15+71) along Las Positas Road that Caltrans "owns" and is currently planning on repairing.
- The section of trail along Las Positas creek, a tributary of Arroyo Burro creek, slated for restoration and currently the subject of engineering analysis and design by others.

1.3 Scope of Work

The scope of work completed by Bengal Engineering to prepare this Preliminary GDR included the following:

- Review of the trail alignment drawings provided by the project A-E.
- Several telephone discussions and email communications with RRM.
- Site reconnaissance visits, and collection and review of available pertinent regional and local geologic, seismic and geotechnical information.
- Review of available and pertinent geotechnical data by others.
- Development of a scope of work for field and laboratory investigations; including the type, locations and depths of exploration, sampling and testing.

- Conducted a field investigation comprised of twelve (12) eight-inch diameter hollow-stem borings.
- Conducted laboratory tests on selected samples obtained during the field investigation.
- Performed geotechnical data review, evaluation, analysis, and interpretation to characterize the subsurface conditions and to determine necessary soil parameters for design.
- Performed a site-specific Probabilistic Seismic Hazard Analysis (PSHA) to determine design ground motions and to evaluate soil liquefaction and related seismic hazards.
- Performed geotechnical engineering analysis to develop and provide geotechnical design and construction recommendations for the proposed improvements including earthwork and the ERS.
- Prepared this preliminary report to document the results of our geotechnical site exploration, laboratory testing, data evaluations, analyses performed, and to provide preliminary geotechnical design and construction recommendations for the proposed improvements.

2.0 SITE EXPLORATION

Site exploration consisted of the review of the available existing information, field exploration and laboratory testing performed by Bengal to investigate the subsurface conditions. Available existing geotechnical exploration and laboratory data relevant to the project alignment were collected, reviewed and, when appropriate, used in the preparation of this report. This section presents a summary of the available existing information reviewed, the types and methods of field investigation conducted and the laboratory tests performed for this project.

2.1 Review of Existing Geotechnical Information

In addition to regional geologic and seismic hazards reports/information, Bengal was provided with two (2) additional documents providing limited geotechnical data along portions of the proposed Las Positas Multi-Use Trail alignment. These geotechnical reports are as follows:

- Geolith Consultants (2004), Consolidated Report, *Geological and Geotechnical Conditions and Geotechnical Recommendations for Proposed Veronica Meadows Development*, Santa Barbara, California, APNs 047-010-16, 047-010-53 and 047-061-26, dated January 30.
- Caltrans (2013), *Preliminary Geotechnical Design Report, 05-SB-225-1.50, Replace Retaining Wall 05-1C1900,* prepared by the Division of Engineering Services – Geotechnical Services – MS5, dated May 24th.

The report by Geolith Consultants summarized their work for the now-defunct Veronica Meadows residential development, which would have been built on approximately 15-acres located on the west side of Arroyo Burro creek, along a corridor that extended from the end of Alan Road north to limits which coincide roughly with the intersection of Las Positas Road and Jerry Harwin Parkway.

The 2013 Caltrans report was prepared to address the proposed replacement or remedial repair of a portion of an existing retaining wall along the southbound lane of Las Positas Road. This 195-foot-long retaining wall is within the project limits and the alignment is shown on Plates 1 and 2 (Appendix B). Per the report, a forty foot long (40') section of retaining wall footing had been exposed. The Caltrans field investigation included three (3) mud rotary borings and twelve (12) dynamic cone penetrometer soundings along the retaining wall alignment. The borings and soundings encountered Quaternary-age alluvium underlain by Monterey Formation bedrock. The report copy provided to us contained neither the boring/sounding logs nor the locations of the subsurface explorations.

2.2 Field Exploration

Our field exploration, which consisted of twelve (12) hollow-stem borings, was performed to investigate the subsurface soil conditions along the trail alignment. The locations of the borings, designated as B-1 to B-12, are shown on the Plates 1 to 9 in Appendix B.

The exploratory borings were drilled in August, 2015. The purpose of the borings was to investigate subsurface soil types and conditions along the proposed trail alignment, and to obtain disturbed as well as relatively undisturbed representative soil samples for laboratory testing, and to conduct Standard Penetration Tests (SPT). The exploratory borings were completed using hollow-stem drilling equipment to depths ranging from sixteen and a half feet to sixty-one and a half feet (16½' – 61½') below existing grade.

Within the borings, soil samples were collected at roughly 5-foot intervals from the upper 40 feet. Disturbed samples of the subsurface soils were obtained using the SPT split spoon sampler. The SPT sampler's cutting shoe and the barrel have a nominal inside diameter of 1.375 and 1.50 inches, respectively. The SPT barrel has a nominal outside diameter of 2.0 inches. Relatively undisturbed soil samples were collected using the Modified California (MC) sampler.

The subsurface soils encountered during drilling were visually classified and logged by a field geologist. The logs of the exploratory borings are included in Appendix B. The soil descriptions in these boring logs were modified from the field descriptions, when necessary, based on laboratory testing. Soil samples tested in the laboratory and the types of tests performed are indicated on the logs of test borings sheets.

All field investigations were performed in accordance with the applicable ASTM Standards (ASTM, 2012).

2.3 Laboratory Testing

All soil samples collected during the field exploration were tested for in-situ moisture content. Samples retrieved using the California Modified Sampler were tested for in-situ density. Several soil samples were selected for additional laboratory testing. Samples and the types of laboratory tests performed were selected based on the project specific needs. Our sub-consultant, SubSurface Designs, Inc. of Sylmar, CA, performed the assigned laboratory tests. These tests included:

- Moisture and Density Tests
- Atterberg Limits Tests
- Sieve Analyses
- Maximum Density / Optimum Moisture Content
- Direct Shear Tests
- R-Value test, and
- Soil Chemistry/Corrosion Tests

Laboratory tests were performed in accordance with the applicable American Society of Testing and Material (ASTM, 2012) and/or State of California Test Methods. Results of the laboratory testing are included in Appendix C of this report.

3.0 SITE CONDITIONS

3.1 Site Description

The proposed trail alignment along the Modoc Road segment is approximately one (1.0) mile long and is located between Las Positas Road at the southeast end and Calle de Los Amigos to the northwest. The trail alignment traverses through a corridor bordered by a mix of residential development and open space to the south. Existing grades along the alignment vary from very gently sloping to undulating, with an overall elevation change of roughly twenty feet (20') over this trail segment.

Existing grades along the Las Positas segment of the trail decrease gently to the south/southwest from the Las Positas and Modoc Road intersection. The overall elevation change, from north to south, is on the order of approximately 110 feet.

At the southern terminus, the proposed trail alignment heads north along the east bank of Arroyo Burro creek with Elings Park open space along the east side of Las Positas Road. North of Jerry Harwin Parkway the proposed trail will skirt along the east side of the Stone Creek condominiums. Arroyo Burro creek turns to the northwest between the condominiums and Veronica Springs while the proposed trail alignment continues alongside the Las Positas Road southbound travel lane. Along this stretch the proposed trail is located between Los Positas Road and Las Positas creek, a tributary of Arroyo Burro creek. Residential track development is present along the west side of Las Positas creek, between Veronica Springs Road and Las Positas Place. North of Las Positas Place the trail profile steepens as the alignment travels through open space until intersecting the Modoc Road segment at the intersection of Las Positas and Modoc Roads.

3.2 Geologic Setting

3.2.1 Physiographic Setting

The Las Positas Multi-Use Trail project skirts along the northern trace of the Hope Ranch – La Mesa area (Modoc Road segment), while the Las Positas Road segment cuts through the coastal hills, following the traces of Las Positas Creek and Arroyo Burro Creek. Most of the Las Positas Road trail segment will be constructed atop the east bank of both Las Positas and Arroyo Burro Creeks.

Arroyo Burro creek flows a total of about seven (7.0) miles south from its headwaters in the Santa Ynez Mountains, at an elevation of 3,800 feet mean sea level (MSL), until it discharges into a small tidal estuary at Arroyo Burro Beach County Park (Hendry's Beach). Hendry's beach and the Arroyo Burro tidal estuary are located approximately 1,500 feet southwest of the southern extent of the Las Positas trail segment, or the intersection of Las Positas Road and Cliff Drive. The upper portions of the creek traverse rural estates and orchards, while the middle portions of the creek pass through dense residential and commercial development between Foothill Road and Highway 101. Downstream of Highway 101, the creek traverses a mixture of residential areas and open space. The watershed drains approximately 5,600 acres of land (Questa Engineering, 2005).

Most reaches of Arroyo Burro creek have moderately vegetated banks, cobble and sand substrate, while portions of the creek have been channelized north of Highway 101. As previously discussed, the portion of Las Positas creek immediately north of its confluence with Arroyo Burro creek (i.e. between Veronica Springs Road and Las Positas Place) is also channelized. Bank instability is a significant problem in middle and lower Arroyo Burro, especially in the Hidden Valley area (Questa Engineering, 2005). Arroyo Burro reaches, including those within the project limits, are susceptible to bank failure by hydraulic toe scour and undercutting of oversteepened banks, as well as more deep-seated geotechnical causes.

3.2.2 Regional Geology and Tectonic Setting

The project site is located within the Western Transverse Ranges physiographic province of Southern California. The Transverse Ranges are a complex series of east-west trending mountain ranges and valleys. Mountain ranges in the Transverse Ranges province are made up of rocks that are progressively older from the west to the east. The structural orientation of this province is transverse to the general north-northwest structural trend of the other geologic provinces in California. The Western Transverse Ranges extends from the Ventura County, west to Point Arguello, and is dominated by the east-west trending Santa Ynez Mountain Range. Cretaceous-Cenozoic sedimentary marine rocks and Miocene volcanic rocks dominate the Western Transverse Ranges region.

Structurally, the Santa Barbara coastal plain area is dominated by the Santa Barbara fold and fault belt (SBFFB) and the overlapping Santa Ynez Mountains uplift (Minor et al, 2009). The SBFFB is an east-west trending zone of potentially active folds and partly blind oblique-slip reverse and thrust faults that deform marine terraces, terrace deposits, and alluvial fans generally laid down over the past 1.6 million years.

The hills and elevated areas that comprise Hope Ranch-La Mesa area appear to have been uplifted by movement along the south-dipping More Ranch and Mesa faults. The Modoc Road trail segment closely follows the mapped trace of the Mesa fault (Figure 2, Appendix A). Uplift, whether by discrete movement along the More Ranch - Mesa faults or regional uplift, in combination with mid- to late-Pleistocene high and low sea level extremes is recorded by the flight of relatively flat, marine terrace surfaces along the South Coast region. In the Hope Ranch area, as many as four terrace surfaces, formed on four distinct levels of marine-terrace deposits, are preserved ranging in elevations from approximately 100 feet above mean sea level (MSL) to 300 feet above MSL (Minor et al, 2009).

3.2.3 Geologic Units

The exposed formations in the immediate vicinity vary from Miocene-age to recent (i.e. Holocene) deposits. These sedimentary rocks and sediments, from oldest to youngest, include the Rincon Shale (Tr) of early Miocene age, the shales of the early to late Miocene age Monterey Formation (Tm), the shallow marine deposits of the sand-rich Santa Barbara Formation (Qsb), upper-Pleistocene-age older alluvium (Qoal) and recent (i.e. Quaternary) alluvium (Qal) deposited along and within the creek channels. Additionally, earth fill (ef) from previous grading activities was noted in many areas. Major surficial geologic units are shown on the attached Figure 2 in Appendix A.

3.3 Subsurface Conditions

The subsurface conditions along the proposed trail alignments are summarized in this section. For additional information, refer to the boring logs enclosed in Appendix B.

3.3.1 Soil and Bedrock Units

Our description of the soil conditions is based on field exploration, mapping of geologic exposures, laboratory testing, and review of available geotechnical information for the project vicinity.

The subject trail alignment is about 2.6 miles long. Earth material profiles can only be obtained from individual exploration locations placed along the alignment. Considering the length of the alignment and economy, the subsurface exploration could only be conducted at selected locations spaced significantly apart along the alignment. Care should be exercised when using the earth profiles at these selected locations to determine changes in depth or thickness of the earth materials at other locations between explorations.

3.3.1.1 Earth Fill (ef)

Earth fill materials were encountered in several of our borings along the proposed trail alignment. Where distinguishable from the underlying native materials, the fill materials vary in composition from silty sand with gravel (SM) to sandy clay to clayey silt (ML). In general the fill materials were found to be dense or stiff. It is likely that fill materials were placed as compacted roadway fills.

3.3.1.2 Alluvium (Qal)

Alluvial deposits were encountered in most of the borings drilled along the trail alignment. The alluvial deposits are a mix of moderately sorted beds of both coarse-grained materials (silty sand and sandy silt) and fine-grained materials (clayey silt to silty clay). Fine-grained materials, clayey silt (ML) to sandy clay or clay (CL), are the dominant type of alluvium along the lower reaches of Arroyo Burro creek, as encountered in Borings B-9 to B-10. The alluvium along this reach likely includes mudflow or earth flow deposits derived from the local slopes underlain by weak bedrock materials, notably the Rincon Shale.

3.3.1.3 Landslide Debris (Qls)

While not encountered within the exploratory borings, areas of landslide debris and suspected landside debris are found in close proximity to the proposed trail alignment, particularly within the middle to southern portions of the Las Positas trail segment. Further subsurface exploration at locations both inside and outside the limits of the trail sections is necessary to determine if these deposits have the potential to adversely affect the global long-term stability along segments of the trail alignment. Such exploration is outside the scope of the current investigation.

3.3.1.4 Older Alluvuim (Qoal)

Older alluvium was encountered in Boring B-2, and possibly within Borings B-3 and B-4, drilled along the Modoc Road segment of the Las Positas Multi-Use Trail project. The older alluvium is often distinguished from younger alluvial deposits by its color, increased density and/or stiffness, and that it has been uplifted and slightly dissected by recent tectonic uplift. Where encountered, the older alluvium consists of a clayey silt (ML) to sandy silt (ML) and silty sand (SM) which is reddish brown to brown, dense to stiff and very stiff, and slightly moist.

3.3.1.5 Bedrock: Santa Barbara Formation (Qsb)

Dense to very dense to slightly hard, fine–to-coarse-grained marine sandstone with minor, subordinate siltstone of the Santa Barbara Formation was encountered in several borings (B-3, B-4, B-6, and B-7), all within the northern portion of the study area. The sediments are mostly pale-gray to cream-colored (fresh) to buff, pale-tan and pale-yellow, where weathered. The bedrock is typically massive to crudely stratified, is poorly exposed, and forms subdued, rounded hills.

Within the study limits the Santa Barbara Formation is exposed only to the north of the Lavigia fault, which trends roughly east-west and crosses the proposed trail alignment south of Veronica Springs Road (Figure 2, Appendix A). Where observed and mapped locally (Figure 2), bedding ranges from horizontal to shallow dips between 4º and 14º. In the La Mesa area, the formation is inferred to lap onto an erosional unconformity underlain by older, more steeply tilted strata of Rincon Shale and Monterey Formation (Minor et al, 2006).

3.3.1.6 Bedrock: Monterey Formation (Tml)

As mapped by Minor et al (2009), the Monterey Formation at the southern end of the study limits (Figure 2) is the lower calcareous unit. This formation was likely the bedrock unit encountered in Boring B-12.

The lower calcareous unit consists mainly of calcareous laminated mudstone and shale. The sediments range from moderately hard to very hard, are well-stratified, weather white to tan and are brown to gray brown on fresh surfaces. Hard beds of dolomite and porcelanite are occasionally encountered.

Of particular note within the study area is the suspected presence of a volcanic ash or tuff bed at the base of the Monterey Formation, i.e. the contact with the underlying Rincon Shale. This bed may be up to thirty feet (30') thick, though it does not crop out at the surface due to its softness and is locally absent from the stratigraphic section. The bed is a soft white tuff which is generally altered to a white and/or bentonitic clay. This unity was encountered and mapped by Geolith Consultants (2004) on the parcel(s) on the west side of Arroyo Burro creek, north of the terminus of Alan Road, which were part of the now-defunct Veronica Meadows Development.

3.3.1.7 Bedrock: Rincon Formation (Tr)

The Rincon Shale is characterized as being massive to poorly bedded, light gray to gray brown clay shale or claystone. The shale may be moderately hard, blue-gray (where freshly exposed) and commonly contains calcareous concretions.

The Rincon Shale is known as being highly susceptible to slope stability issues. The bedrock commonly forms smooth and rounded slopes mantled with fine-grained colluvium and soil (Minor et al, 2009). This unit is also capable of producing soils and weathered materials of high to extreme plasticity.

3.3.2 Geologic Structure

3.3.2.1 Bedding Structure

The La Mesa hills are part of an uplifted fault block, trending northwest-southeast, paralleling the coastline from Santa Barbara to Ellwood. Within the project limits, the hill (i.e. fault block) is bounded along the northwest by the Mesa fault (Figure 2, Appendix A). The bedrock has been regionally mapped as a monoclinal structure dipping toward the southwest (Dibblee, 1986 and Minor et al, 2009).

Where observed in road cuts along Las Positas Road, our mapping of bedrock bedding orientations within the Monterey Formation is consistent with the regional mapping (Minor et al, 2009).

3.3.2.2 Faulting and Folding

Two faults have been regionally mapped as trending through the study limits; the west-northwest-striking Mesa and Lavigia faults.

The Mesa fault, the surface trace of which parallels and is roughly coincident with the proposed Modoc Road trail segment alignment, is thought to be a southwest-dipping reverse or oblique-reverse fault that has been active as recently as late Pleistocene time, and there is no direct evidence to suggest it has been active within the Holocene (last 11,000 years).

Minor et al (2009) describe the Lavigia fault as a six kilometer (6 km) long, south-dipping thrust fault which is closely associated with an asymmetric anticline on its hanging-wall side in the study area. Within the study limits the fault thrusts Miocene rocks (Tr, Tml) over the Pleistocene Santa Barbara Formation (Qsb). Like the Mesa fault, the Lavigia fault is suspected of activity as recent as the mid- to late-Pleistocene.

3.3.3 Groundwater Conditions

Groundwater was encountered in several of our borings drilled along the proposed trail alignment. Groundwater was encountered at approximately twenty-six feet (26') to thirty-nine feet (39') below grade in five (5) of our borings.

It should be noted that some fluctuations in groundwater conditions should be expected occur for various reasons and with time. The depth to groundwater, when encountered in the explorations, is only an indication of the presence water during the time of the exploration. Changes may occur in this groundwater level due to climatic conditions and/or alterations in the existing groundwater recharge area (i.e. surface drainage and surface water infiltration conditions).

3.4 Soil Engineering Properties

This section provides engineering properties of the soils encountered in the exploratory borings and considered pertinent to the design, construction and performance of the proposed paved on-grade trails and earth retaining systems.

Based on the results of our field exploration and laboratory testing, the subject alignment is underlain by a relatively thin mantle of alluvium underlain by sedimentary bedrock. The bedrock along the northern segment of the trail consists of sandstone and siltstone of the Santa Barbara Formation. The southern part of the trail is underlain by Rincon Shale and Monterey Formation shale bedrock. Compacted artificial fill soils associated with the existing roadway construction were encountered in some of the borings.

The artificial fill and alluvial soils along the Modoc Road trail segment and within the northern portion of the Las Positas trail segment (Borings B-1 through B-8) consist of mainly silty sand (SM) with some layers of sandy silt (ML) and sandy lean clay (CL-ML, CL). Samples of the fine-grained soils exhibited Liquid Limit (LL) and Plasticity Index (PI) ranging from 26 to 47 and 4 to 24, respectively.

The subsurface alluvial soils along the southern portion of the Las Positas trail segment consist of mainly fined-grained soils with some layers of silt (ML) and silty sand (SM). The fined-grained soils within this segment of the alignment consist of mainly sandy, elastic silt (MH). The fined-grained soil samples from this area exhibited LL and PI ranging from 51 to 77 and 4 to 44, respectively.

The in-situ dry density and moisture content of the coarse-grained soils ranged mainly from about 110 to 124 pcf and 5 to 14 %, respectively.

The in-situ dry density and moisture content of the fined-grained soils ranged from about 84 to 92 pcf and 18 to 32%, respectively.

Sieve analysis performed on three samples indicated the fines content of these samples ranged from about 58 to 73 percent.

Results of four direct shear tests performed on representative sample of the soils along the trail alignment are presented in Figures S.1 through S.4 in Appendix C. These results are summarized in Table 1 below.

The R-values of two, near surface subgrade soil samples along the northern segment of the trail were measured to be 26 and 28, respectively.

Results of two chemical tests performed on selected site soils are presented in Appendix C. Based on these results, soils along the subject trail alignment are considered non-corrosive to common construction materials as per Caltrans' current corrosion guidelines (CALTRANS, 2013).

Table 1. Summary of Direct Shear Test Results

Sample Identification (Boring No./Sample Depth)	Soil Description	Cohesion (psf)	Friction Angle (degree)
B-1/5'	Sandy Clay (CL-ML)	500	24
B-7/5'	Sandy Silt (ML)	100	32
B-11/15'	Shale - Monterey Formation	500	28
B-12/5'	Sandy Silt (ML)	700	37

4.0 SEISMIC HAZARD EVALUATION

A site-specific seismic hazard evaluation was performed utilizing CALTRANS' ARS on-line (Version 2.3.06) tool. This hazard evaluation was performed at the northern and southern ends of the subject trail alignment.

For evaluating ground motion hazard, the soil profiles along the site can be classified as Type D, as defined in the Caltrans SDC (2013). The initial average shear wave velocity, designated as V_{s30}, for Type D Soil Profiles can be taken as about 270 m/sec.

The CALTRANS' ARS on-line tool provides estimates of deterministic ground motion for the significant nearby faults, as well as the probabilistic ground motions for a return period of 975 years. Based on the results of this analysis, the probabilistic ground motion controls the hazard at both ends of the alignment. The estimated Peak Ground Acceleration (PGA), the ground motion parameter of interest for the subject project, ranges from about 0.75g at the northern end to about 0.78g at the southern end of the trail alignment.

Based on the Caltrans ARS on-line tool, the Lavigia fault crosses the trail alignment at a location south of the intersection of the Las Positas Road and Jerry Hawkins Parkway, and the Mesa-Rincon Creek Fault runs parallel and immediately adjacent to the Modoc Road segment of the subject trail as shown in the attached Figure 7 in Appendix A. Both of these faults are reverse type. The Lavigia and Mesa-Rincon Creek Faults can generate a maximum earthquake of moment magnitude of 6.4 and 6.6, respectively.

In addition to the above faults, the Red Mountain Fault, located at a site-to-fault rupture surface distance (r_{rup}) of about 6.4 km, can also generate significant ground motion at the site. The Red Mountain is also a reverse fault. It is capable of generating a maximum earthquake of moment magnitude of 7.4.

The project alignment is not located within any State of California designated Alquist-Priolo Earthquake Fault Zone (EFZ). However, based on the above information, the project trail alignment may experience ground surface rupture in the event that either the Lavigia Fault or the Mesa-Rincon Creek Fault generate earthquakes of significant magnitude. Due to unknown slip rates (USGS, 2014), possibility due to very low values, the potential for such surface rupture is considered low.

The pavement structure and the ERS along the trail alignment are more likely to experience some distress in the form of differential settlement, cracking and ERS tilting, requiring repair work following significant seismic events generated by one of the above faults.

Based on the groundwater depths, when encountered in the borings, and the fine-grained nature or high density of subsurface soils below the groundwater table, the potential for soil liquefaction and related seismic hazards along the subject trail alignment is considered low.

No catastrophic failure, including bearing types of failure involving large movements, is likely since the proposed ERS are of relatively low height along the majority of the alignment and underlain by significant thickness of compacted fill and/or unsaturated soils.

Based on the 2009 State of California-County of Santa Barbara “Tsunami Inundation Map for Emergency Planning”, the subject trail is not considered susceptible to tsunami-related hazards generated by nearby or distant off-shore faults.

In the absence of an enclosed body of water such as lakes, reservoirs or water tanks etc. in the upstream or adjacent to the project site, the potential hazard associated with seiches or flooding at the site during seismic events is considered low.

4.0 FLOOD HAZRADS

Portions of the proposed Class I trail alignment are located in relatively flat areas currently designated as being within a 100-yr flood zone (Zone AE) in the Flood Insurance Rate Map (FIRM) prepared by Federal Emergency Management Agency (FEMA). As stated earlier, the project area has experienced several floods in the recent past.

5.0 GEOTECHNICAL RECOMMENDATIONS

5.1 General

This section presents our preliminary recommendations for the soil parameters, results of geotechnical analysis performed and our design recommendations for the proposed improvements.

Based on the available information, the subject trail construction will involve site grading to finish subgrade surface, trail pavement construction and earth retaining systems (ERS) on the order of six feet (6') in height or less.

5.2 Trail Pavement Design Recommendations

Recommended subgrade soil parameters for the preliminary design of trail pavement may be based on an average R-value of 26. The final pavement design should be based on R-value of the actual subgrade soils placed at the end of grading.

To facilitate drainage and reduce the pumping or rutting potential, the pavement section should consist of a base layer.

At the end of grading, but before placing pavement, exposed subgrade soils, in particular those consisting of a significant amount of clay, along the trail should sampled and tested for Atterberg Limits and Expansion Index (EI). Subgrade soils with EI>50, if any, should be lime-treated to a depth of at least 12 inches prior to pavement construction.

5.3 ERS Design Recommendations

The proposed ERS, with a maximum height of six feet (6'), may be constructed of conventional semi-gravity type reinforced concrete walls founded on spread footings.

Backfill of the ERS should consist of predominantly cohesionless soils. The proposed ERS backfilled with such soils may be designed to resist active earth pressures exerted by an equivalent fluid of density 36 pcf.

ERS retaining cuts or in-situ soils should be designed to resist active earth pressures exerted by an equivalent fluid of density 55 pcf.

All retaining footings should be placed on at least 12 inches of compacted fill, consisting of coarse-grained soils.

Excavated on site soils consisting of silty sand (SM) or Sandy Silt (ML) with little or no clay and PI<4 may be used as compacted backfill and/or subgrade soils.

Bearing capacity of soils depends on the width and depth of foundations. Based on our site exploration, and the applied Strength and Service Limit State Stress for a six feet (6') high retaining wall, Caltrans Type 1 or 5 Standard Plan (CALTRANS, 2010) walls are considered suitable at this site. That is, the these walls will have adequate bearing and lateral sliding stability as well as acceptable settlement provided the wall backfill and subgrade soils are placed as recommended above.

If walls of height greater than 6 feet are needed, wall footing width and depth specific bearing, sliding and settlement recommendations will be provided in the final geotechnical design report.

All retaining wall should be provided with adequate drainage to prevent build up water pressure behind wall and/or below the wall footing.

Based on our site exploration, the proposed retaining walls, with a maximum of height 6 feet, are considered adequately stable against global or overall stability type failure.

If walls of height greater than 6 feet are required, wall and location specific global/overall stability evaluation will be performed when exact locations and detailed cross section profiles are available. Results of such analysis, if needed, will be included in the final geotechnical design report.

6.0 CONSTRUCTION RECOMMENDATIONS

This section presents our construction recommendations for the proposed improvements.

- All construction activities should be planned and performed in conformance with the applicable requirements of the US and California Occupational Safety and Health Administration (OSHA/Cal-OSHA).

- All construction shall conform to the requirements of the Caltrans Standard Specifications (Caltrans, 2010), except as specified otherwise herein.

- All earthwork and foundation construction activities, including but not limited to soil excavation, slope grading, backfilling, subgrade preparation, and foundation installation, should be performed under the observation of the owner's geotechnical representative.

- Prior to any earthwork or grading activities, the trail alignment should be cleared of all trees, plants, vegetation, organics and other deleterious materials.

- We recommend that the subgrade soils be sterilized to preclude possible weed growth through the pavement.

- All surfaces to receive fills, pavement or foundations should be scarified, moisture conditioned, if necessary, and re-compacted to at least 90% of the maximum density determined as per ASTM Test Method D1557.

- If subgrade or subsurface conditions different that those encountered during the field exploration and utilized in the design of the proposed improvements are encountered during construction, this office should be contacted immediately so that actual ground conditions can be evaluated and, if necessary, revised or modified recommendations can be provided.

- Backfill behind fill type retaining walls shall be should comprise of predominantly granular soils and free of oversized (>1.5 inch) particles, organics, debris or other deleterious materials.

- Select excavated site soils consisting of silts (ML) with PI<4, silty sand and sand (SM) may be used as wall backfill, provided these soils are processed by mixing well and moisture conditioning to within 2 to 3 percent of the optimum, as per ASTM D1557 test method. Imported wall fills, if any, should be well graded with <15% passing #200, PI<4, and Sand Equivalent <20.

- Wet, soft/weak, pumping or yielding subgrade soils should be stabilized prior to additional construction activities including placement of compacted soil backfill or wall foundations. Stabilization may include removal and replacement of wet or soft materials to depths determined based on field conditions, especially those below the wall foundation, gravel and/or geotextile filters/reinforcement stabilizing layer to achieve non-yield subgrade or working surface.

- All compacted fill should be placed in horizontal lifts 8 inches or less in uncompacted thickness and compacted to at least 90% of the maximum dry density at moisture contents within 2 to 3 percent of the optimum as per ASTM D1557 method.

7.0 CONCLUSIONS

The following are our conclusions based on the results of geotechnical engineering study:

- The trail alignment is underlain by alluvial soils over bedrock of the Santa Barbara, Rincon Shale, and Monterey Formations. Compacted fills soils associated with the existing roadway construction were also encountered in some of the exploratory borings.

- Near surface soils along the northern segment of the trail alignment, including Modoc Road and part of the Las Positas Road are underlain by mainly cohesion soils. The southern part of the trail along the Las Positas Road is underlain by mainly cohesive soils with potentially medium to high expansion potential.

- The site is located in a highly seismically active area. Based on Caltrans ARS On-line tool (Version 2.3.06), the Lavigia Fault crosses the trail alignment along the Las Positas Road and the Mesa-Rincon Creek Fault runs immediately adjacent and parallel on the north side of the segment of the trail along Modoc Road.

- Based on the presence of the above faults, surface rupture hazard does exist at the subject trail. However, due to the unknown, and thus presumably low fault slip rates, the likelihood of surface fault rupture and related hazard to the trail facilities can be considered low for design. The existence of such hazards, however, should be considered as part of the overall emergency planning against earthquake hazards.

- Based on this ARS tool, the estimated PGA along the align corresponding to a 975 years return period ranges from about 0.75g at the north end to about 0.78g at the south end of the trail. Some cracking of trail pavement and movements of ERS should be expected in the event the trail experiences such high ground motion.

- The potential seismic hazard associated with seismic soil liquefaction and tsunami is considered low for the subject trail.

- It is our opinion that the proposed improvements are geotechnically feasible provided the recommendations provided herein are considered in the design and construction.

- Subgrade soils encountered along the trail alignment are considered adequate to support the proposed paved trail path and the retaining walls, provided recommendation provided herein are incorporated in the design and construction.

- Preliminary design of trail pavement section may be based on an average R-value of 26. Final design of the trail pavement sections should be based on testing of actual subgrade soils once the site grading to finish subgrade surface is completed.

- Potentially expansive subgrade soils, if encountered along the trail at the end of grading, should be lime-treated to a depth of at least 12 inches and allowed to cure sufficiently prior to pavement construction.

- The proposed ERS, with a maximum height of 6 feet, may be constructed with CALTRANS's Standard Plan Wall Type 1 or 5. These walls are considered adequate based on allowable settlement, and bearing, sliding and overall or global stability.

- Finally, it is our opinion that the subject site is suitable for the construction of the proposed trail, including ERS, provided recommendations provided herein are incorporated in the design and construction.

8.0 LIMITATIONS

Our analysis and evaluation of the subsurface conditions and recommended design soil parameters were based on field exploration and laboratory testing at isolated locations and depths, and interpolation and extrapolations of the soil conditions between exploration locations and depths.

Subsurface conditions at locations between and away from the exploration locations may differ. If subsurface conditions encountered during construction are found to be significantly different from those presented in this report and recommended for design, this office should be contacted immediately to review and provide additional or revised recommendations, as necessary.

Data, conclusions and recommendations contained in this report are solely for use by RRM for the design and construction of the proposed project features for the subject project.

This Preliminary Geotechnical Design Report was prepared in accordance with the generally accepted geotechnical practices at this time. We make no other warranty, either implied or expressed.

We appreciate this opportunity to be of service to RRM for this important project. If you have any questions or we can be of any further assistance, please do not hesitate to contact us.

Sincerely,

Md. Wahiduzzaman, C49838
Civil Engineer

Ed Pongracz-Bartha, CEG 2370
Engineering Geologist

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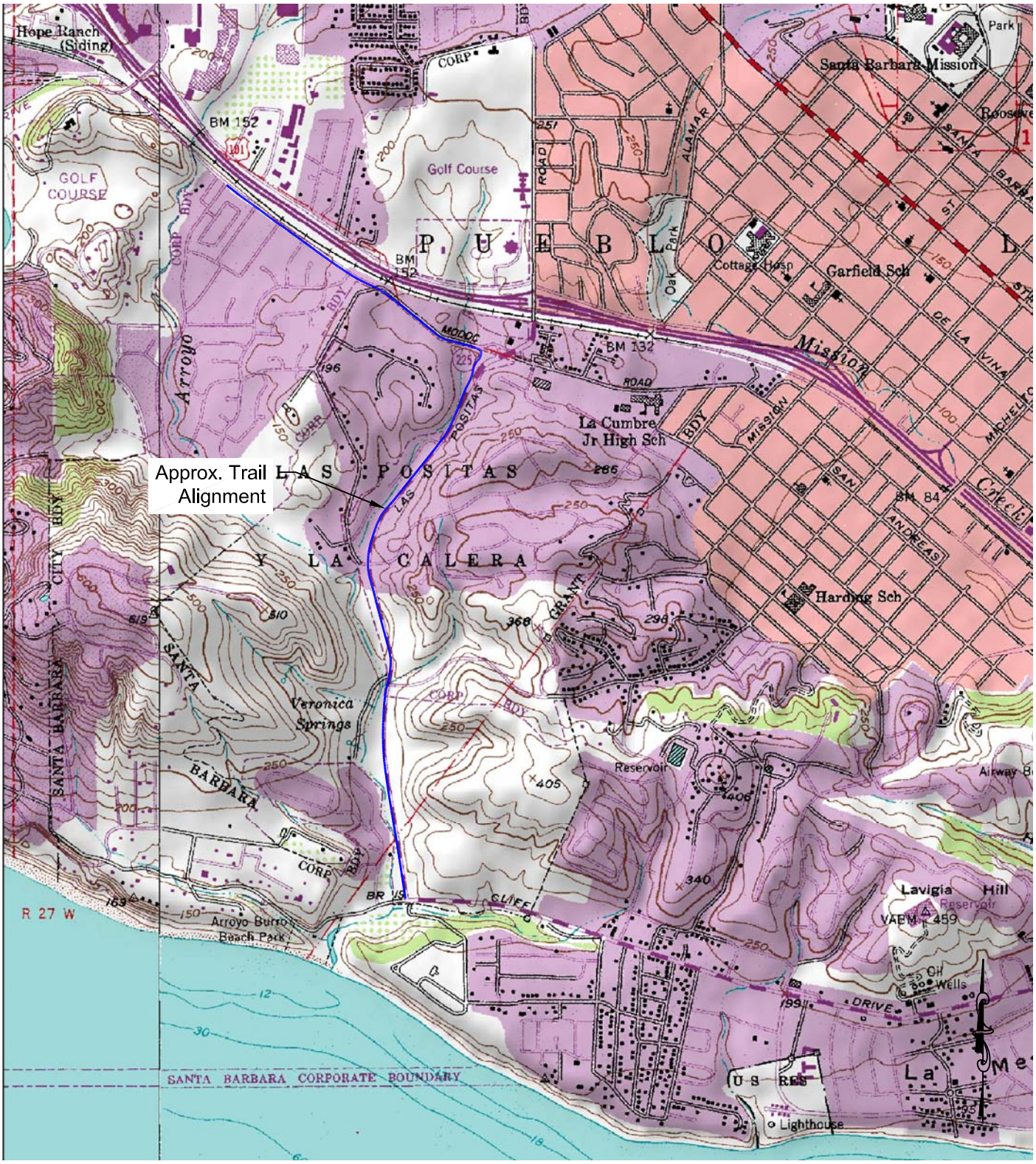
APPENDIX A

FIGURES



REFERENCE:
USGS Santa Barbara 7.5-Minute Quadrangle, 1995, 1:24,000 Scale.

Figure 1 - Vicinity Map
Las Positas Multi-Use Trail
Santa Barbara, CA

DATE Dec., 2015		SCALE 1" = 2000'

2000 0 2000 4000

Scale: 1" = 2,000'

REFERENCE:
Minor, Scott A., et al, 2009, Geologic Map of the Santa Barbara Coastal Plain Area, Santa Barbara County, California, USGS Scientific Investigations Map 3001.

LIST OF MAP UNITS

- af — **Artificial fill (Holocene)**
- Qa — **Active channel alluvium (Holocene)**
- Qb — **Beach deposits (Holocene)**
- Qe — **Estuarine deposits (Holocene)**
- Qas — **Asphalt deposits (Holocene)**
- Qdf — **Debris flow deposits (Holocene and/or upper Pleistocene)**
- Qac — **Alluvium and colluvium (Holocene and upper Pleistocene)**
- Qc — **Colluvium (Holocene and upper Pleistocene)**
- Qls — **Landslide deposits (Holocene and Pleistocene)**
- Qtc — **Travertine and/or caliche deposits (Holocene? and Pleistocene?)**
- Qia — **Intermediate alluvial deposits (upper Pleistocene)**
- Qmt — **Marine terrace deposits (upper Pleistocene)**
- Qoa — **Older alluvial deposits (upper and middle Pleistocene)**
- Qbx — **Shale-clast sedimentary breccia (middle Pleistocene)**
- Qsb — **Santa Barbara Formation (middle Pleistocene)**

Unnamed sedimentary rocks east of Goleta Pier (Pleistocene and Pliocene?)

- Qcg — **Conglomeratic unit (middle Pleistocene?)**
- Qss — **Sandstone unit (middle Pleistocene?)**
- QTst — **Siltstone unit (lower Pleistocene and/or upper Pliocene)**
- Tsq — **Sisquoc Formation (Pliocene and upper Miocene)**
- Tm — **Monterey Formation (Miocene)**
  - Tmu — **Upper siliceous unit (upper Miocene)**
  - Tmm — **Middle shale unit (upper and middle Miocene)**
  - Tml — **Lower calcareous unit (middle and lower Miocene)**
- Tr — **Rincon Shale (lower Miocene)**
  - Trs — **Siliceous shale interval (lower Miocene)**
- Tv — **Vaqueros Formation (upper Oligocene)**

Sespe Formation (upper Oligocene and upper Eocene)

- Tspu — **Upper sandstone and mudstone unit (upper Oligocene)**
- Tspm — **Middle conglomerate and sandstone unit (upper Oligocene)**
- Tspl — **Lower conglomerate and sandstone unit (upper Eocene)**
- Tcw — **Coldwater Sandstone (upper and/or middle Eocene)**

Contact—Long dashed where approximately located; short-dashed where inferred; dotted where concealed; tic shows direction and angle of dip

Contact—Inferred from 1928 air photos

Beveled surface border

Marine terrace shore line angle—Dashed where approximately located

Fault—Long-dashed where approximately located; short dashed where inferred; dotted where concealed; queried where uncertain; ball and bar on apparent downthrown side; pair of opposing arrows show sense of strike-slip component of movement, queried where uncertain; tic shows direction and angle of dip; arrow shows trend and plunge of slickenside striae

Fault—Inferred from 1928 air photos; dashed where inferred; dotted where concealed; ball and bar on apparent downthrown side

Thrust fault—Long dashed where approximately located; short dashed where inferred; dotted where concealed

Fault-line scarp—Inferred

Fold and warp axial traces—Long-dashed where approximately located; short-dashed where inferred; dotted where concealed

Anticline

Upwarp axis

Syncline

Downwarp axis

Inclined joint—Showing strike and dip

Horizontal bedding

Inclined bedding—Showing strike and dip

Vertical bedding—Showing strike

Overturned bedding—Sowing strike and dip

Inclined bedding—Showing approximate strike and direction of dip

Qas—Asphalt deposits

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Las Positas Multi-Use Trail

City of Santa Barbara

Santa Barbara, CA

Local Geologic Map

December, 2015

Figure 2

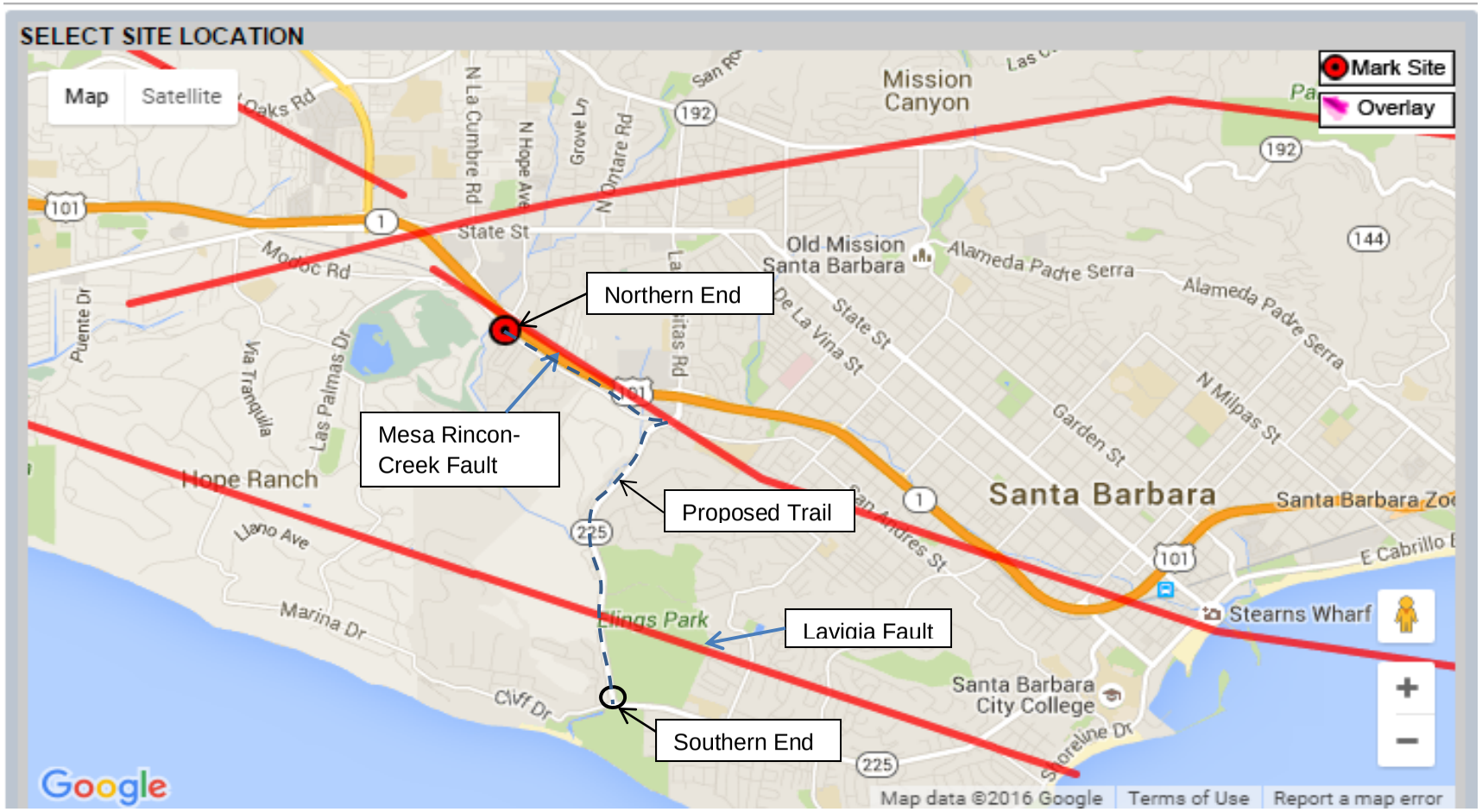
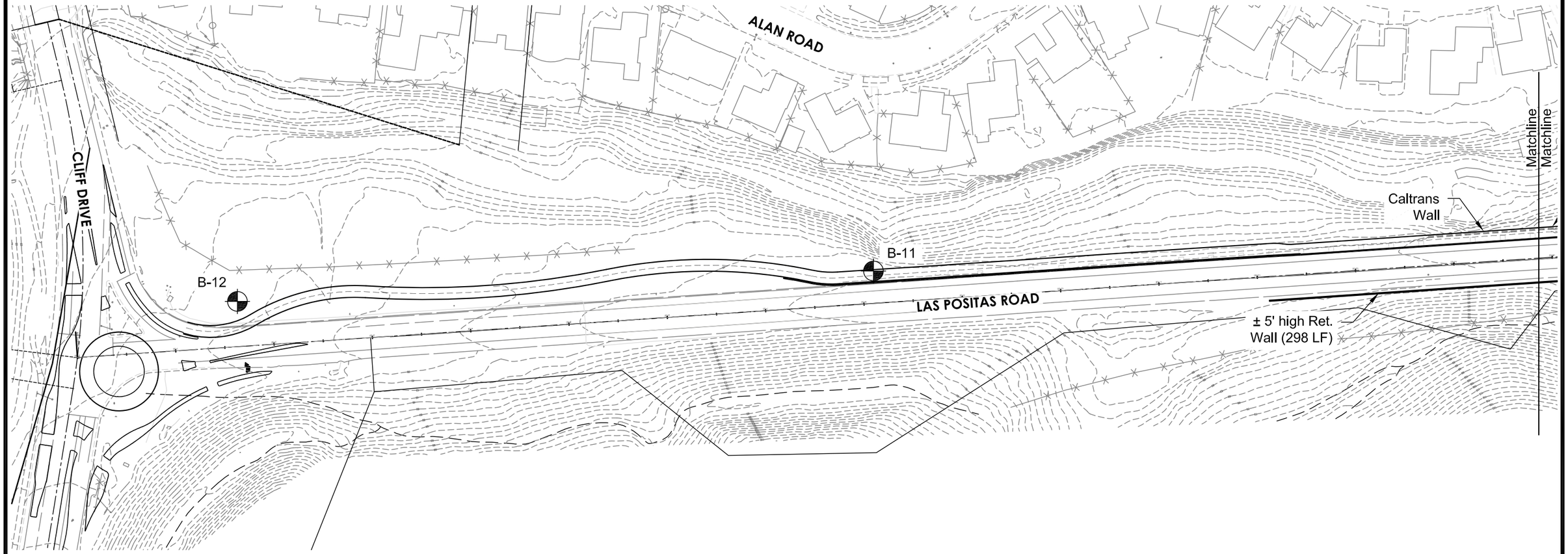


Figure 3. Fault Location Map (Reference: CALTRANS' ARS ON-LINE, Version 2.3.06, Accessed on 1/15/2016)

APPENDIX B

FIELD EXPLORATION



LEGEND

B-1 Location of Hollow-Stem Boring

0 100' 200'

Scale: 1" = 100'

Sheet 1 of 9

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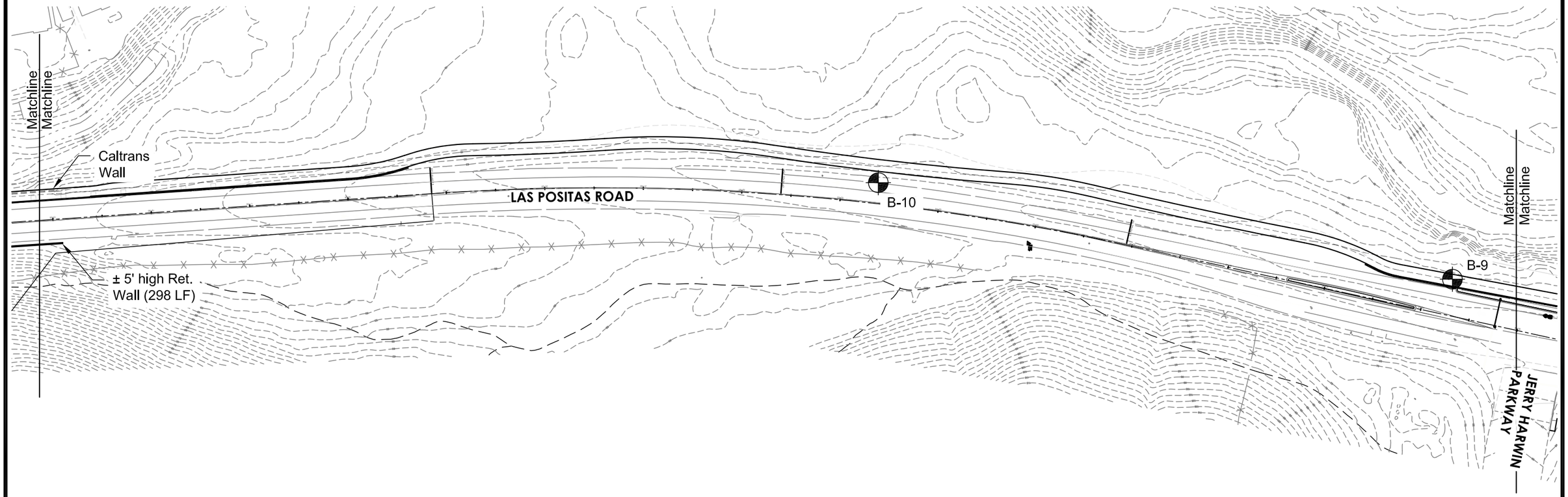
Las Positas Muti-Use Trail Project

Santa Barbara, CA

Subsurface Exploration Locations

January, 2016

Plate 1



LEGEND

B-1 Location of Hollow-Stem Boring

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Scale: 1" = 100'

Sheet 2 of 9

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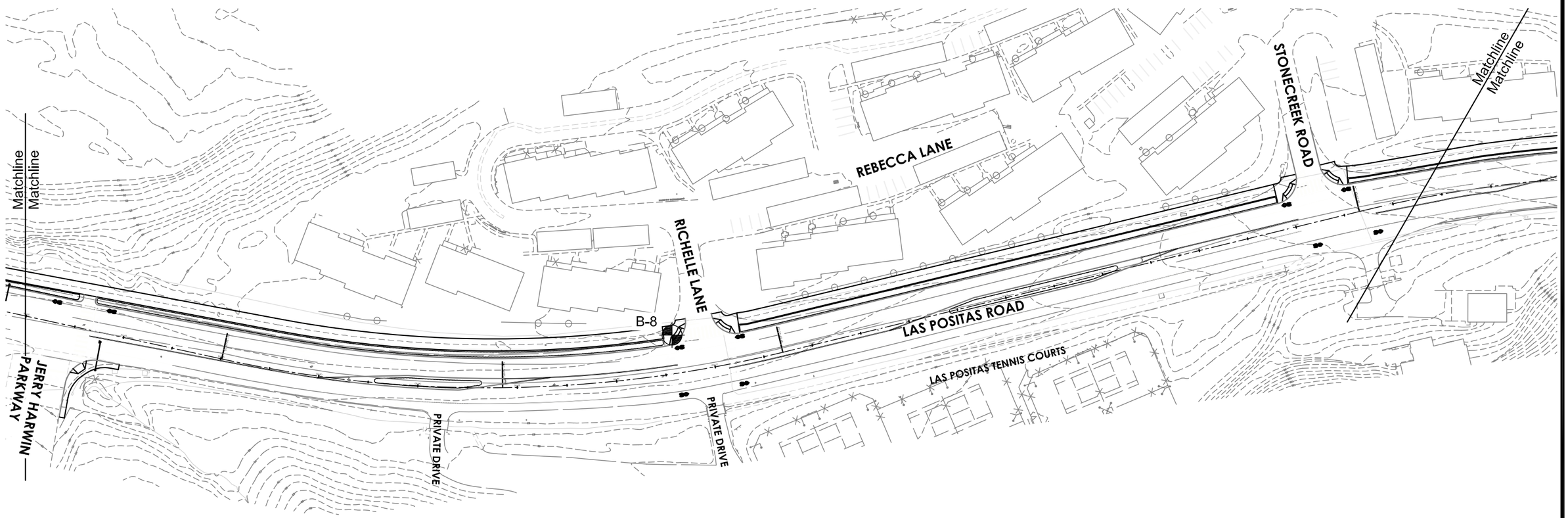
Santa Barbara, CA

Subsurface Exploration Locations

January, 2016

Plate 2



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B-1 Location of Hollow-Stem Boring

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Scale: 1" = 100'

Sheet 3 of 9

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Las Positas Muti-Use Trail Project

Santa Barbara, CA

Subsurface Exploration Locations

January, 2016

Plate 3

VERONICA PLACE

VERONICA SPRINGS ROAD

B-7

LAS POSITAS ROAD

LAS POSITAS ROAD

PORTESUELLO AVENUE

Matchline
Matchline

Matchline
Matchline

LEGEND

B-1 Location of Hollow-Stem Boring

0 100' 200'

Scale: 1" = 100'

Sheet 4 of 9

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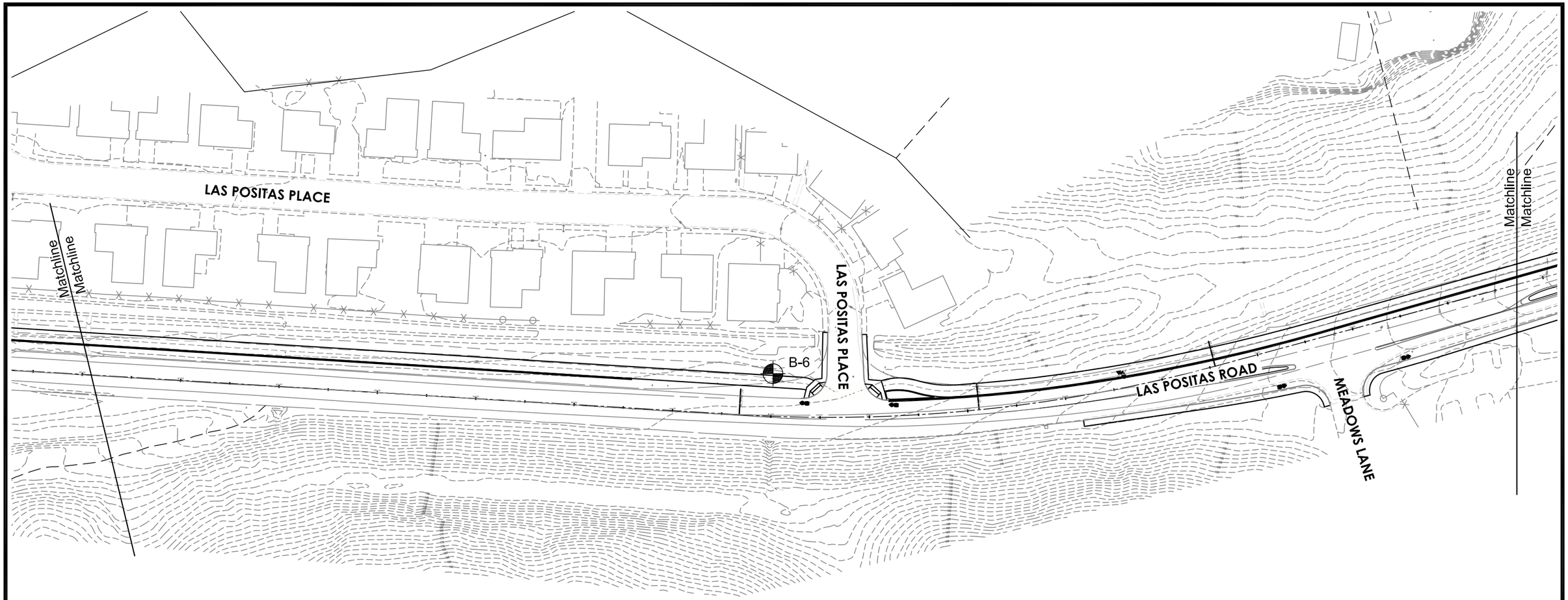
Subsurface Exploration Locations

January, 2016

Plate 4



LEGEND

B-1 Location of Hollow-Stem Boring

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Scale: 1" = 100'

Sheet 5 of 9

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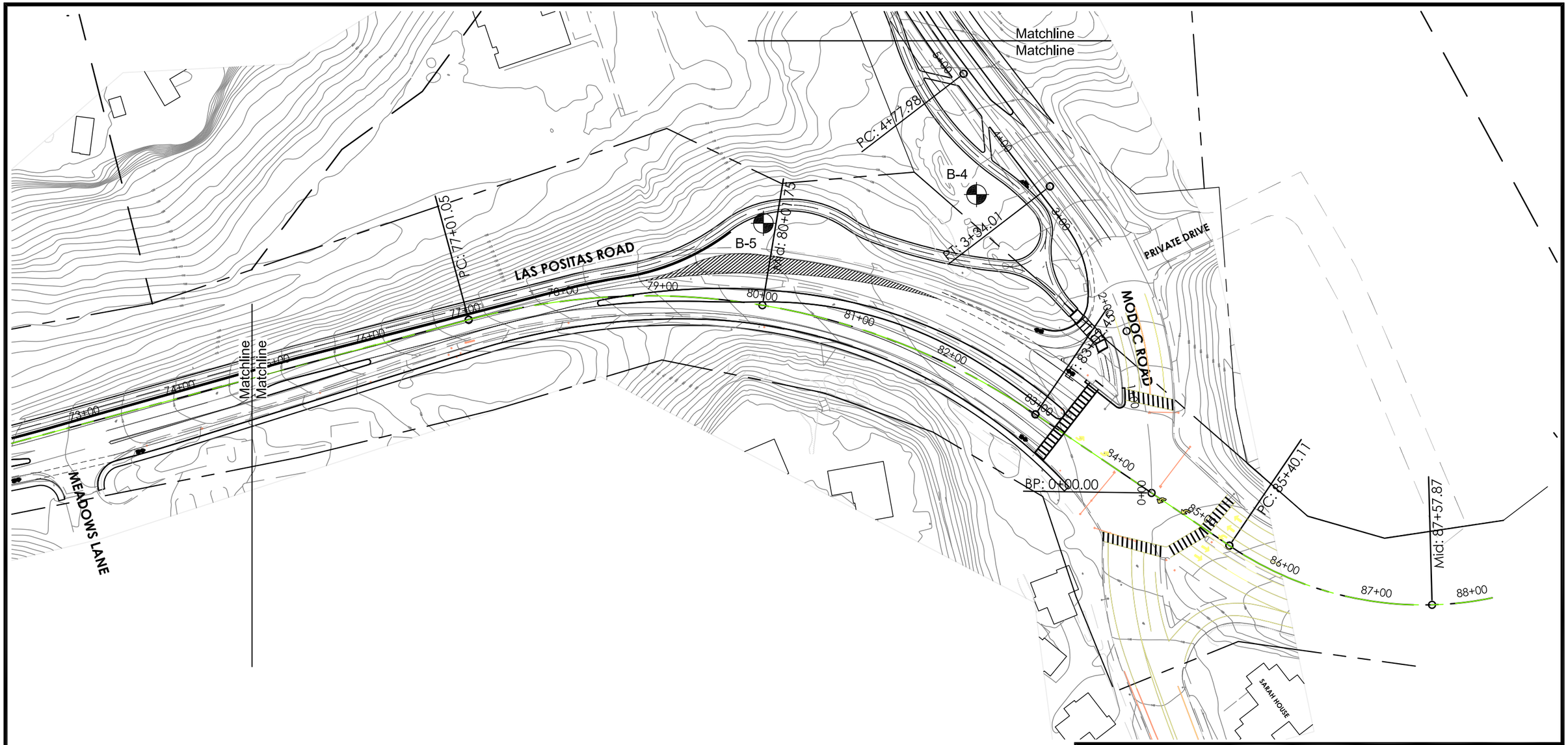
Las Positas Muti-Use Trail Project

Santa Barbara, CA

Subsurface Exploration Locations

January, 2016

Plate 5



LEGEND

B−1 Location of Hollow-Stem Boring

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Scale: 1" = 100'

Sheet 6 of 9

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Subsurface Exploration Locations

January, 2016

Plate 6

LEGEND

B-1 Location of Hollow-Stem Boring

0 100' 200'

Scale: 1" = 100'

Sheet 7 of 9

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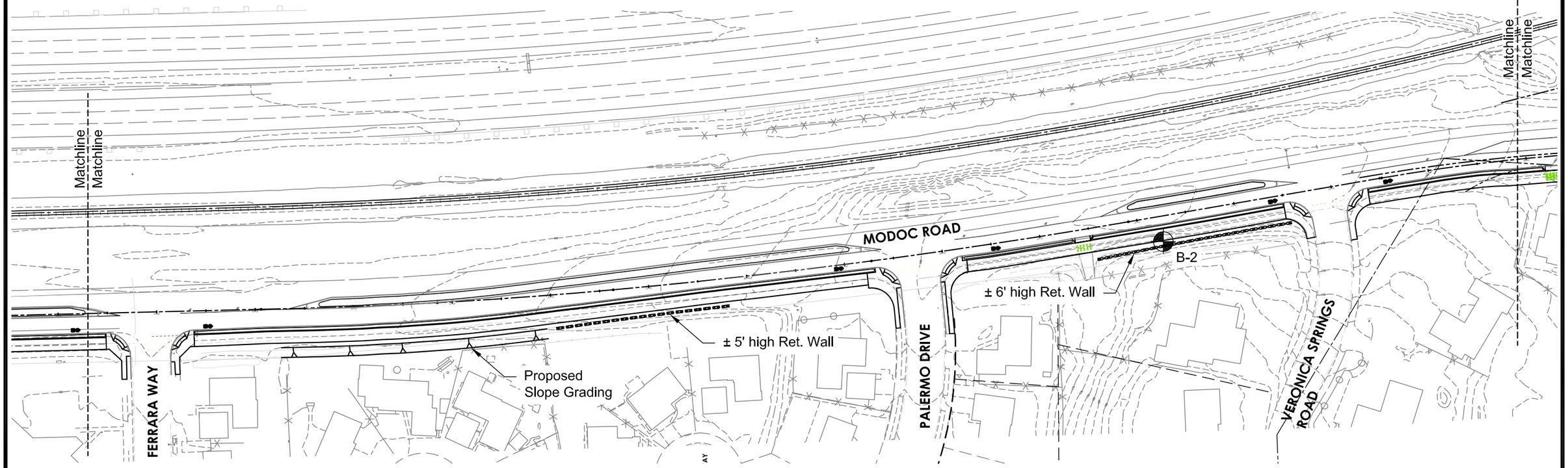
Las Positas Muti-Use Trail Project

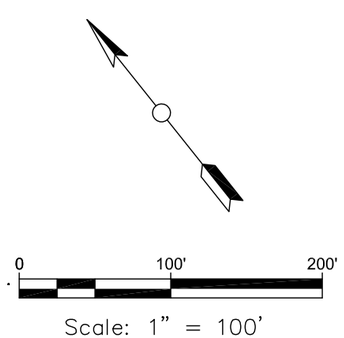
Santa Barbara, CA

Subsurface Exploration Locations

January, 2016

Plate 7





LEGEND

B-1 Location of Hollow-Stem Boring

Sheet 8 of 9

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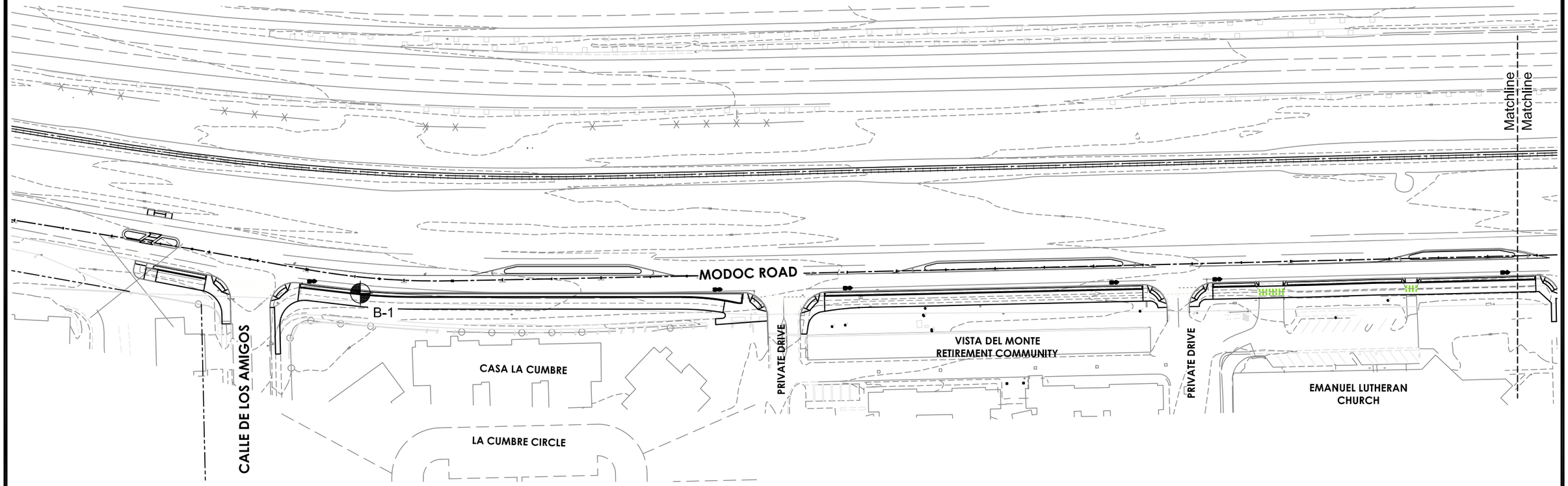
Las Positas Muti-Use Trail Project
Santa Barbara, CA

Subsurface Exploration Locations

January, 2016

Plate 8



LEGEND

B-1 Location of Hollow-Stem Boring

0 100' 200'

Scale: 1" = 100'

Sheet 9 of 9

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Las Positas Muti-Use Trail Project

Santa Barbara, CA

Subsurface Exploration Locations

January, 2016

Plate 9

CURRENT BORINGS (BENGAL, 2015)

Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
Telephone: (805) 563-0788

BORING NUMBER B-1

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/10/15 **COMPLETED** 8/10/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Alluvium (Qal)**								
		AU 1			Silty Sand (SM) - reddish brown, slightly moist		7						MAX
	5												
		MC 2	10-17-20 (37)		Sandy Silt (ML) - reddish brown, dense, slighly moist		8	121	26	20	6		DS
	10												
		SPT 3	4-4-4 (8)		Silty Sand (SM) - reddish brown, medium dense, slightly moist, fine-grained		2						
	15												
		MC 4	9-16-23 (39)		Clayey Silt (ML) - brown, stiff, slightly moist, scattered caliche stringers, locally slightly porous, few mottles		12	114					

Groundwater and/or seepage not encountered. Boring backfilled with native materials.
Bottom of borehole at 16.5 feet.

BENGAL GEOTECH BH V5 - BENGAL MOD GINT STD US LAB 2-10-10.GDT - 1/24/16 23:27 - C:\PROGRAM FILES (X86)\GINT\PROJECTS\LAS POSITAS MULTI-USE TRAIL.GPJ

Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
Telephone: (805) 563-0788

BORING NUMBER B-2

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/10/15 **COMPLETED** 8/10/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Older Alluvium (Qoal)**								
	5	MC 1	19-26		Clayey Silt (ML) - reddish brown, stiff to very stiff, slightly moist		13	121	47	22	25		
	10	SPT 2	8-9		Silt (ML) - light brown, stiff, slightly moist		9						
	15	MC 3	26-47		Sandy Silt (ML) - reddish brown, very stiff, slightly moist		9	127					
	20	SPT 4	10-23		Silty Sand (SM) - brown, dense, slightly moist, fine-grained		8						

Groundwater and/or seepage not encountered. Boring backfilled with native materials.
Bottom of borehole at 21.5 feet.

BENGAL GEOTECH BH V5 - BENGAL MOD GINT STD US LAB 2-10-10.GDT - 1/24/16 23:27 - C:\PROGRAM FILES (X86)\GINT\PROJECTS\LAS POSITAS MULTI-USE TRAIL.GPJ

Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
Telephone: (805) 563-0788

BORING NUMBER B-3

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/10/15 **COMPLETED** 8/10/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0	AU 1					7						MAX, R-Val
		MC 2	10-19-26 (45)		Clayey Silt (ML) - dark brown, stiff, slightly moist		9	127	26	19	7		
	10	SPT 3	5-7-3 (10)		Sandy Silt (ML/SW) - dark brown, medium dense, slightly moist		2					58	SIEVE
		MC 4	2-3-5 (8)		Silty Sand (SM) - brown, slightly dense, slightly moist, fine-grained		8	112					
	20	SPT 5	1-3-2 (5)		Silty Sand (SM) with clay binder - brown, slightly dense, slightly moist, fine-grained		14						
		MC 6	30-50/4"		**Bedrock: Santa Barbara Formation (Qsb)** Sandstone - light brown, very dense, slightly moist		7	117					
	30	SPT 7	37-21-13 (34)		Silty Sandstone - brown, very dense, slighlty moist, fine- to coarse-grained		7						
		MC 8	50/0"		No Recovery (NR) Groundwater and/or seepage not encountered. Boring backfilled with native materials.								

Bottom of borehole at 35.0 feet.

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Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
Telephone: (805) 563-0788

BORING NUMBER B-4

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/10/15 **COMPLETED** 8/10/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Alluvium (Qal)**								
	5	MC 1	10-17-25 (42)		Silty Sand/Sandy Silt (SM/ML) - brownish yellow, dense/stiff, slightly moist, fine-grained		5	124				72	SIEVE
	10	SPT 2	7-13-13 (26)		Silty Sand (SM) - yellowish and orange brown, dense, slightly moist, fine-grained		3						
					Bedrock: Santa Barbara Formation (Qsb)								
	15	MC 3	17-33-50 (83)		Sandstone - light gray brown, very dense, slightly moist, occasional rust orange mottling		13	120					
	20	SPT 4	13-17-28 (45)		Sandstone - gray to light brown, dense, slightly moist		7						

Groundwater and/or seepage not encountered. Boring backfilled with native materials.
Bottom of borehole at 21.5 feet.

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BORING NUMBER B-5

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/10/15 **COMPLETED** 8/10/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Earth Fill (ef)**								
		MC 1	22-44-50/4"		Silty Sand with gravel (SM) - light brown, compact, slightly moist, fine- to medium-grained		5	124					
					Older Alluvium (Qoal)								
	10	SPT 2	9-19-37 (56)		Silty Sand (SM) - light brown to brown, very dense, slighlty moist, fine- to coarse-grained		4						
		MC 3	19-24-36 (60)		Silty Sand (SM) - light brown, very dense, slightly moist, fine- to medium-grained		7	108					
	20	MC 4	8-14-25 (39)		Clayey Silt (ML) - brown, stiff, slightly moist		10						
		SPT 5	32-50/5"		Silty Sand (SM) - light brown to brown, very dense, slightly moist, fine- to coarse-grained		2						
	30	SPT 6	27-46-50 (96)		Silty Sand (SM) - light brown to brown, very dense, slightly moist, fine- to medium-grained		3						

Groundwater and/or seepage not encountered. Boring backfilled with native materials.

Bottom of borehole at 31.5 feet.

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Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
Telephone: (805) 563-0788

BORING NUMBER B-6

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/11/15 **COMPLETED** 8/11/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
∇ **AT TIME OF DRILLING** 26.00 ft
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Alluvium (Qal)**								
		MC 1	10-15-18 (33)		No Recovery (NR) - Silty Sand (SM) with gravel - brown, slightly moist								
	10	SPT 2	6-7-9 (16)		Silty Sand (SM) - light brown, dense, very moist, fine- to medium-grained		15						
		MC 3	5-9-13 (22)		Silty Sand (SM) with some clay - light brown, dense, moist, fine-grained		13	119					
	20	SPT 4	4-7-6 (13)		Silty Sand (SM) with some clay amd fine- to coarse-grained Sand with some silt (SP) - brown to light rust orange, dense, very moist, fine- to medium-grained, medium dense, moist		11						
		SPT 5	9-20-22 (42)		∇ **Bedrock: Santa Barbara Formation (Qsb)** Silty Sandstone - blue green to olive green, very dense, very moist, weakly lithified		21						
	30	SPT 6	11-16-30 (46)		Siltstone - blue green to olive green, very stiff to hard, moist, weakly lithified		18						
		SPT 7	12-20-34 (54)		Siltstone - blue green to olive green, slightly hard, moist, non-indurated		18						
	40	SPT			Silty fine-grained Sand/Sandstone - bluish gray, very moist, very dense		22						
		SPT 8	11-21-19 (40)		Groundwater at 26' below grade at conclusion of drilling. Boring backfilled with native materials.								

Bottom of borehole at 41.5 feet.

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Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
Telephone: (805) 563-0788

BORING NUMBER B-7

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/11/15 **COMPLETED** 8/11/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING 29.00 ft
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Earth Fill (ef)**								
		AU 1					6		NP	NP	NP		MAX, R-Val, CHEM
		MC 2	10-14-13 (27)		Sandy Clay (SC) - dark brown, stiff, moist, mottled		7	121					DS
	10				**Alluvium (Qal)**								
		SPT 3	3-4-8 (12)		Silty, Clayey fine-grained Sand (SC) to Clayey Silt (ML) - blue gray, medium stiff, moist, mottled		9						
		MC 4	5-9-11 (20)		Silty Sand (SM) - greenish gray to bluish gray, medium dense, moist, fine- to medium-grained		16	112					
	20												
		SPT 5	4-6-8 (14)		Silty Sand (SM) - green gray, medium dense, moist, fine-grained		13						
		SPT 6	5-5-5 (10)		Silty Sand (SM) - greenish gray, medium dense, moist, fine-grained		18						
	30												
		SPT 7	11-22-50/1"		Sandy Silt (ML) - green gray, very dense, very moist, with scattered shell fragments		18						
		SPT 8	50/1"		**Bedrock: Santa Barbara Formation (Qsb)** No Recovery (NR)								
	40												
		SPT 9	13-41-50/3"		Siltstone - gray, slightly hard, slightly moist, non-indurated		9						
		SPT 10	50/4"		No Recovery (NR)								
	50												
		SPT 11	50/3"		Clayey Silt/Siltstone - gray, slightly hard, slightly moist		11						

Groundwater at 29' below grade at conclusion of drilling.
Boring backfilled with native materials.
Bottom of borehole at 50.5 feet.

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Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
Telephone: (805) 563-0788

BORING NUMBER B-8

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/11/15 **COMPLETED** 8/11/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Alluvium (Qal)**								
	5	MC 1	5-5-6 (11)		Silty Sand (SM) - brown to dark brown, medium dense, slightly moist, fine-grained		9	115					
	10	SPT 2	4-4-4 (8)		Silty Sand (SM) - tan, medium dense, slightly moist, fine-grained		1						
	15	MC 3	4-6-9 (15)		Sandy Silt (ML) - brown, medium stiff, slightly moist		13	108					

Groundwater and/or seepage not encountered. Boring backfilled with native materials.
Bottom of borehole at 16.5 feet.

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Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
Telephone: (805) 563-0788

BORING NUMBER B-9

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/11/15 **COMPLETED** 8/11/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING 31.30 ft
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Earth Fill (ef)**								
		MC 1	6-9-12 (21)		Clayey Silt (matrix) (ML) with scattered to abundant small rock fragments - dark brown, stiff, moist, mottled		31	86	51	36	15	61	SIEVE
					Alluvium (Qal)								
	10	SPT 2	2-3-4 (7)		Sandy Silt (ML) to Silty Sand with Clay with rock fragments and scattered small gravel - tan to dark brown, medium dense, slightly moist		9						
		MC 3	2-4-5 (9)		Clayey Silt with trace fine Sand to fine-grained Sandy Silt - brown to dark brown, slightly stiff, slightly moist to moist		13	109					
	20	SPT 4	0-0-2 (2)		Clayey Silt (ML) - dark brown, soft, slightly moist		25		34	21	13		
		SPT 5	3-4-3 (7)		No Recovery (NR)								
	30	SPT 6	2-2-2 (4)		Sandy Silt (ML) with trace clay - brown, slightly stiff, very moist to wet		14						

Groundwater at 31.3' below grade at conclusion of drilling.
Boring backfilled with native materials.
Bottom of borehole at 31.5 feet.

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BORING NUMBER B-10

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/17/15 **COMPLETED** 8/17/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING 39.00 ft
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Earth Fill (ef)**								
		MC 1	7-11-14 (25)		Clayey Silt with small rock fragments to Gravelly Silt with clay -light brown to tan, stiff, moist, mottled		30	88					
					Alluvium (Qal)								
	10	SPT 2	4-4-5 (9)		Silty Clay (CL) with sand - dark brown, stiff, slightly moist		22						
		MC 3	3-5-6 (11)		Sandy Silt (ML) with clay - dark brown, slightly stiff, moist		11	92					
	20	SPT 4	3-4-8 (12)		Fine-grained Silty Sand (SM) and Clayey Silt (ML) - brown, medium stiff/medium dense, moist, fine-grained		15						
		SPT 5	3-5-8 (13)		Sandy Clay (SC) - gray to dark brown, stiff, moist		24						
	30	SPT 6	0-2-3 (5)		Clay (CL) with some Sand - dark brown, slightly stiff, moist		22						
		SPT 7	3-3-6 (9)		Clay (CL) with scattered small rock fragments - dark olive brown, medium stiff, very moist		27						
	40	SPT 8	1-1-4 (5)		No Recovery (NR)								
		SPT 9	0-3-4 (7)		Sandy, Clayey Silt (ML) with occasional small rock fragment - light brown to light blue-green, medium stiff, moist, poorly sorted		33						
	50	SPT 10	0-3-4 (7)		Clayey Silt (ML) with trace fine-grained sand -gray to olive brown, soft to slightly stiff, very moist		21						
		SPT 11	1-2-4 (6)		Silt with Sand (ML) - greenish gray, medium stiff, moist, contains few shale fragments		18						
	60	SPT 12	4-6-10 (16)		Clay with some sand (CL) - gray to dark brown, stiff, moist		25						

Groundwater at 39' below grade at conclusion of drilling.
Boring backfilled with native materials.
Bottom of borehole at 61.5 feet.

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Bengal Engineering
250 Big Sur Drive
Goleta CA 93117
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BORING NUMBER B-11

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/17/15 **COMPLETED** 8/17/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Alluvium (Qal)**								
		AU 1					28						CHEM
	5												
		SPT 2	9-11		Silty Sand (SM) with occasional gravel - light brown, dense, slightly moist		32						
	10												
		MC 3	26-41		**Bedrock: Monterey Formation (Tm)** Shale - light brown, slightly hard, slightly moist		22	83	51	47	4		
	15												
		MC 4	50		Shale - tan to orange brown, slightly hard, slightly moist		32	86					DS
	20												
		SPT 5			Shale - tan, slightly hard, slightly moist		22						

Groundwater and/or seepage not encountered. Boring backfilled with native materials.
Bottom of borehole at 21.5 feet.

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BORING NUMBER B-12

CLIENT RRM Design Group
PROJECT NAME Las Positas Multi-Use Trail
PROJECT NUMBER
PROJECT LOCATION Santa Barbara, CA
DATE STARTED 8/17/15 **COMPLETED** 8/17/15
GROUND ELEVATION **HOLE SIZE** 8" inches
DRILLING CONTRACTOR S&G Drilling
GROUND WATER LEVELS:
DRILLING METHOD HSA - CME 75
AT TIME OF DRILLING ---
LOGGED BY JVG **CHECKED BY** E. Pongracz
AT END OF DRILLING 26.00 ft
NOTES
AFTER DRILLING ---

ELEV (ft)	DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	GRAPHIC LOG	MATERIAL DESCRIPTION	UNDRAINED SHR STRENGTH (tsf)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	OTHER TESTS
	0				**Alluvium (Qal)**								
		MC 1	19-30-50 (80)		Sandy Silt (ML) - tan, stiff, slightly moist		19	84					DS
	10	SPT 2	6-7-6 (13)		Sandy Silt (ML) - dark brown, stiff, slightly moist		8		31	21	10		
		MC 3	5-8-10 (18)		Silty Sand (SM) - brown, medium dense, slightly moist, fine- to medium-grained		5	108					
	20	SPT 4	3-3-6 (9)		Silty Sand (SM) with clay binder - brown, medium dense, slightly moist		15						
		SPT 5	1-3-3 (6)		Clay with some samd (CL) - dark brown, medium stiff, slightly moist		39		77	43	34		
	30	SPT 6	3-4-3 (7)		Clay with some samd (CL) - dark brown, medium stiff, saturated (wet), occasional gravel		35						
		SPT 7	1-1-5 (6)		Silty Sand (SM) - brown, slightly dense, saturated, fine- to medium-grained		32						
	40	SPT 8	1-5-8 (13)		Silty Sand (SM) - brown, medium dense, saturated, fine- to medium-grained		21						
	50	SPT 9	13-10-9 (19)		**Bedrock: Monterey Formation (Tml)** Silt - blue/green, stiff, moist (weathered bedrock ?)		46						
		MC 10	11-15-25 (40)		Shale - blue gray, slightly hard, slightly moist		46	75					

Bottom of borehole at 56.5 feet.

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APPENDIX C

LABORATORY TEST RESULTS

SubSurface Designs Inc.

12848 Foothill Boulevard • Sylmar, California 91342
(818) 898-1595 • (Fax) 898-4003

PIN# 6435

Bengal Engineereing, Inc.
250 Big Sur Drive
Goleta, California 93117

Draft

Subject: Las Positas Multi-Use Trail
Results of Laboratory Testing

Dear Sirs:

Pursuant to your request please find attached hereto the results of soil engineering laboratory testing on the soil samples you provided. Sampling techniques, subsurface conditions, and other factors may vary across the subject site. Therefore, the test results may or may not be representative of the overall site conditions and care should be taken accordingly in interpreting the testing data provided. Interpretation of the laboratory test results and applications of the results on the design and construction of the project are beyond the scope of our work.

Services performed by this facility were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other warranties are either expressed or implied.

If you have any questions, please do not hesitate to contact this office.

Respectfully submitted:
SUBSURFACE DESIGNS, INC.

Jon Mahn
Principal Engineer
RCE 60293

JEM/mm: 6435.01L

Dist: (2) Addressee
(1) File

LABORATORY TESTING RESULTS

Laboratory Testing Method

Laboratory Recapitulation - Table I-1

Chemical Test Results - Table I-2

Atterberg Limits

Sieve Analysis

Shear Strength Diagram

Maximum Density Test

R-Value Test Results

LABORATORY TESTING METHODS

Soil Classification

Soils are visually classified in accordance with the latest version of ASTM D 2488. Soils are classified in accordance with the latest version of ASTM D 2487 when testing, such as laboratory determination of particle-size characteristics, liquid limit, and plasticity index, is performed.

Moisture and Density Tests

The moisture content and in-place dry density of all undisturbed samples obtained were determined. The test results are presented in the Laboratory Recapitulation - Table I. Tests are performed in accordance with the latest version of ASTM D 2216.

Direct Shear Tests

Direct single-shear tests were performed on representative undisturbed samples to determine their strength characteristics. The desired normal load was applied to the specimen and allowed to come to equilibrium. The rate of deflection on the samples ranged from approximately 0.005 to 0.001 inches per minute. All samples were saturated prior to shear testing. The results are plotted on the Shear Test Diagrams. Tests are performed in accordance with the latest version of ASTM D 3080.

Maximum Density

Maximum density tests are performed on representative samples to determine compactive characteristics and used to evaluate the present relative compaction of the in-place earth materials. The test was performed in accordance with the latest version of ASTM D 1557 (five layer).

Sieve Analysis

Dry Method:

A group of fourteen (14) sieves are assembled, with the sieve having the largest opening at the top, and the one having the smallest at the bottom. A solid collecting pan is placed below the bottom sieve. A 3000 gram specimen is weighed to within ±0.1g and placed in the topmost sieve. The assembly is completed by placing a solid cover over the top sieve. The sieve assembly is securely fastened into a mechanical sieve-shaking device. The group of assembled sieves is subjected to the action of the sieve shaker for a period of 300 seconds. Each sieve and the pan is weighed to within ±0.1g to determine the portion of the specimen retained. Tests are performed in accordance with the latest version of ASTM D 421.

Sieve Series	
Sieve #	Opening (mm)
3"	75.00
2"	50.00
1.5"	38.10
1"	25.40
¾"	19.00
⅜"	9.50
4	4.75
10	2.00
20	0.85
30	0.60
50	0.30
80	0.18
100	0.15
200	0.075
Pan	-

Atterberg Limits

This test covers the determination of the liquid limit, plastic limit, and the plasticity index of soils. Tests are performed in accordance with the latest version of ASTM D 4318.

LABORATORY RECAPITULATION - TABLE I-1

PIN 6435 / Bengal / Las Positas Multi-Use Trail

Location	Depth	Material Description	In Situ Dry Density (P.C.F.)	In Situ Water (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	%Passing # 200 Sieve	Max. Dry Density (pcf)	Optimum Moisture (%)	Expansion Index
B-1	2.0	Alluvium (Qal)		7.4							
B-1	5.0	Alluvium (Qal)	120.9	8.2	25.7	20.0	6		128.5	9.0	
B-1	10.0	Alluvium (Qal)		1.5							
B-1	15.0	Alluvium (Qal)	113.9	11.6							
B-10	5.0	Earth Fill (ef)	87.6	30.4							
B-10	10.0	Alluvium (Qal)		22.4							
B-10	15.0	Alluvium (Qal)	91.9	11.4							
B-10	20.0	Alluvium (Qal)		15.3							
B-10	25.0	Alluvium (Qal)		23.9							
B-10	30.0	Alluvium (Qal)		21.9							
B-10	35.0	Alluvium (Qal)		26.8							
B-10	45.0	Alluvium (Qal)		33.3							
B-10	50.0	Alluvium (Qal)		21.4							
B-10	55.0	Alluvium (Qal)		18.5							
B-10	60.0	Alluvium (Qal)		24.7							
B-11	3.0	Alluvium (Qal)		28.2							
B-11	5.0	Alluvium (Qal)		31.9							
B-11	10.0	Bedrock (Tml)	83.2	21.9	51.2	47.1	4				
B-11	15.0	Bedrock (Tml)	86.3	32.2							
B-11	20.0	Bedrock (Tml)		22.4							
B-12	5.0	Alluvium (Qal)	84.0	18.7							
B-12	10.0	Alluvium (Qal)		8.4	31.3	21.2	10				
B-12	15.0	Alluvium (Qal)	108.2	5.1							
B-12	20.0	Alluvium (Qal)		15.3							
B-12	25.0	Alluvium (Qal)		38.6	76.8	42.9	30				
B-12	30.0	Alluvium (Qal)		34.5							
B-12	35.0	Alluvium (Qal)		31.9							
B-12	40.0	Alluvium (Qal)		21.1							
B-12	50.0	Weathered Bedrock (Tml)		45.7							
B-12	55.0	Bedrock (Tml)	74.8	45.7							
B-2	5.0	Older Alluvium (Qoal)	121.1	12.9	47.2	22.2	30				
B-2	10.0	Older Alluvium (Qoal)		8.6							
B-2	15.0	Older Alluvium (Qoal)	127.3	8.6							
B-2	20.0	Older Alluvium (Qoal)		8.2							
B-3	3.0	Earth Fill (ef)		6.8							
B-3	5.0	Alluvium (Qal)	127.3	8.8	26.2	19.1	7		130.0	8.5	
B-3	10.0	Alluvium (Qal)		2.1							
B-3	15.0	Alluvium (Qal)	112.0	7.8				58.2			
B-3	20.0	Alluvium (Qal)		13.5							
B-3	25.0	Alluvium (Qal)	116.9	6.8							
B-3	30.0	Alluvium (Qal)		6.8							
B-4	5.0	Alluvium (Qal)	124.4	5.1				72.5			
B-4	10.0	Alluvium (Qal)		2.9							
B-4	15.0	Bedrock (Qsb)	120.2	12.9							
B-4	20.0	Bedrock (Qsb)		7.2							
B-5	5.0	Earth Fill (ef)	124.1	5.5							
B-5	10.0	Older Alluvium (Qoal)		3.8							
B-5	15.0	Older Alluvium (Qoal)	108.1	6.6							
B-5	20.0	Older Alluvium (Qoal)		10.0							
B-5	25.0	Older Alluvium (Qoal)		2.2							
B-5	30.0	Older Alluvium (Qoal)		3.5							
B-6	10.0	Alluvium (Qal)		15.1							
B-6	15.0	Alluvium (Qal)	118.7	13.3							
B-6	20.0	Alluvium (Qal)		11.0							
B-6	25.0	Bedrock (Qsb)		21.4							

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LABORATORY RECAPITULATION - TABLE I-1

PIN 6435 / Bengal / Las Positas Multi-Use Trail

Location	Depth	Material Description	In Situ Dry Density (P.C.F.)	In Situ Water (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	%Passing # 200 Sieve	Max. Dry Density (pcf)	Optimum Moisture (%)	Expansion Index
B-6	30.0	Bedrock (Qsb)		18.5							
B-6	35.0	Bedrock (Qsb)		18.3							
B-6	40.0	Bedrock (Qsb)		21.6							
B-7	2.0	Earth Fill (ef)		5.9	NP	NP	NP		129.5	9.5	
B-7	5.0	Earth Fill (ef)	121.5	6.8							
B-7	10.0	Alluvium (Qal)		9.2							
B-7	15.0	Alluvium (Qal)	112.2	16.4							
B-7	20.0	Alluvium (Qal)		13.1							
B-7	25.0	Alluvium (Qal)		18.0							
B-7	30.0	Alluvium (Qal)		17.6							
B-7	40.0	Bedrock (Qsb)		8.8							
B-7	50.0	Bedrock (Qsb)		10.6							
B-8	5.0	Alluvium (Qal)	115.1	9.4							
B-8	10.0	Alluvium (Qal)		1.2							
B-8	15.0	Alluvium (Qal)	108.4	13.1							
B-9	5.0	Earth Fill (ef)	85.7	31.0	50.5	36.2	20	60.7			
B-9	10.0	Alluvium (Qal)		9.0							
B-9	15.0	Alluvium (Qal)	108.7	12.7							
B-9	20.0	Alluvium (Qal)		24.7	34.1	20.7	10				
B-9	30.0	Alluvium (Qal)		14.0							

CHEMICAL TEST RESULTS

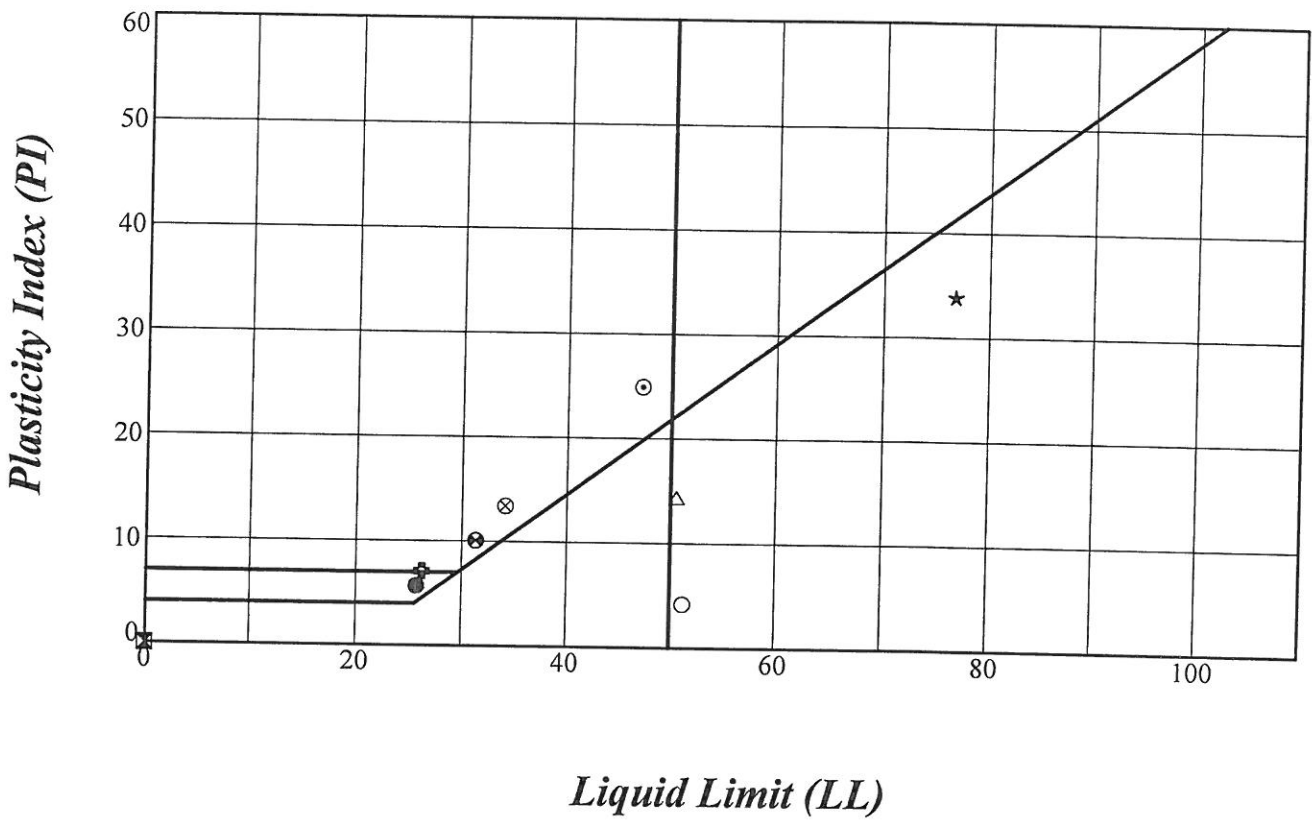
Table I-2

Location	Depth (ft)	Sulfate (ppm)	Chloride (ppm)	pH	Resistivity (Ohms-cm)
B-7	2.0	4	20	6.67	3800
B-11	3.0	798	40	6.74	650

ATTERBERG LIMITS

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*

PROJECT NUMBER: *PIN 6435*



Sample Identification			Material Description	LL	PL	PI
●	B-1	5.0'	Alluvium (Qal)	26	20	6
○	B-11	10.0'	Bedrock (Tml)	51	47	4
⊗	B-12	10.0'	Alluvium (Qal)	31	21	10
★	B-12	25.0'	Alluvium (Qal)	77	43	34
⊙	B-2	5.0'	Older Alluvium (Qoal)	47	22	25
✿	B-3	5.0'	Alluvium (Qal)	26	19	7
⊠	B-7	2.0'	Earth Fill (ef)	NP	NP	NP
△	B-9	5.0'	Earth Fill (ef)	51	36	15
⊗	B-9	20.0'	Alluvium (Qal)	34	21	13

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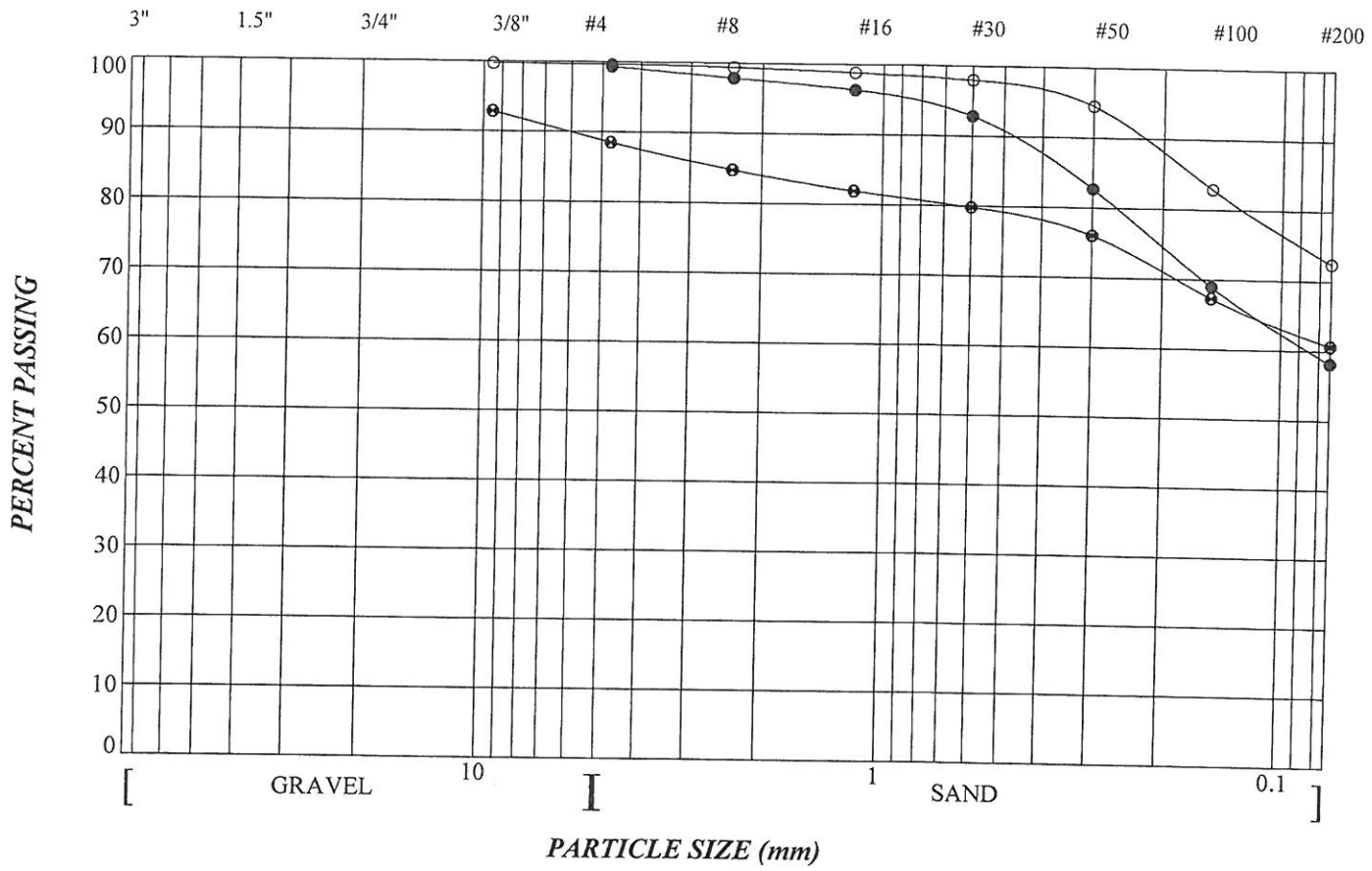
Figure A.1

SIEVE ANALYSIS

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*

PROJECT NUMBER: *PIN 6435*



Sample Identification			Material Description	LL	PL	PI	Cc	Cu
●	B-3	10.0'	Alluvium (Qal)					
○	B-4	5.0'	Alluvium (Qal)					
⊗	B-9	5.0'	Earth Fill (ef)	51	36	15		

Sample Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-3	10.0'	4.75	0.084				41.2	58.2	
○	B-4	5.0'	9.5				0.1	27.2	72.5	
⊗	B-9	5.0'	9.5				4.4	27.8	60.7	

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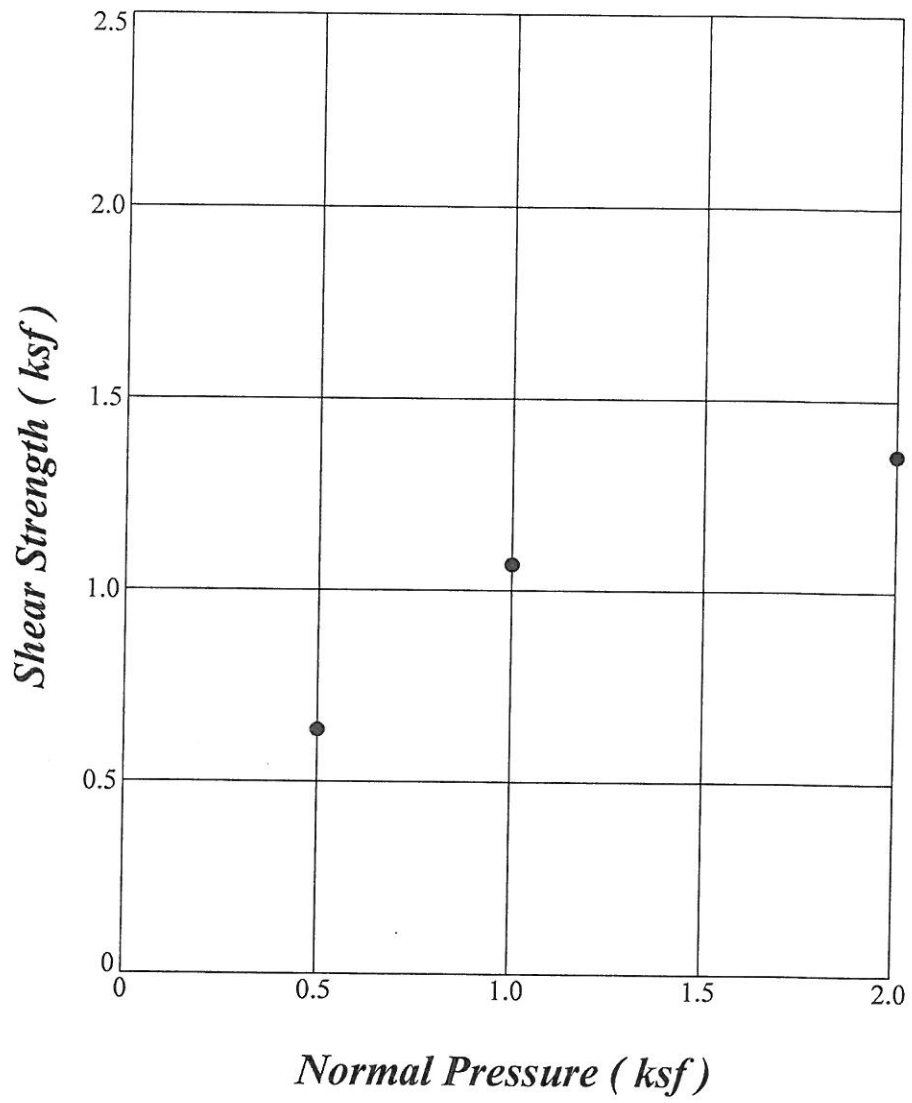
Figure SV.1

SHEAR TEST

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*	SAMPLE ID: *B-1 @ 5.00'*
PROJECT NUMBER: *PIN 6435*	MATERIAL DESCRIPTION: *Alluvium (Qal)*
TEST METHOD: *Ultimate Saturated Shear*	



MOISTURE CONTENT (%)		DENSITY (pcf)		RESULTS
In Situ:	*8.2*			Phi (deg.):
Saturated:	*17.3*	Dry Density:	*120.9*	Cohesion (ksf):

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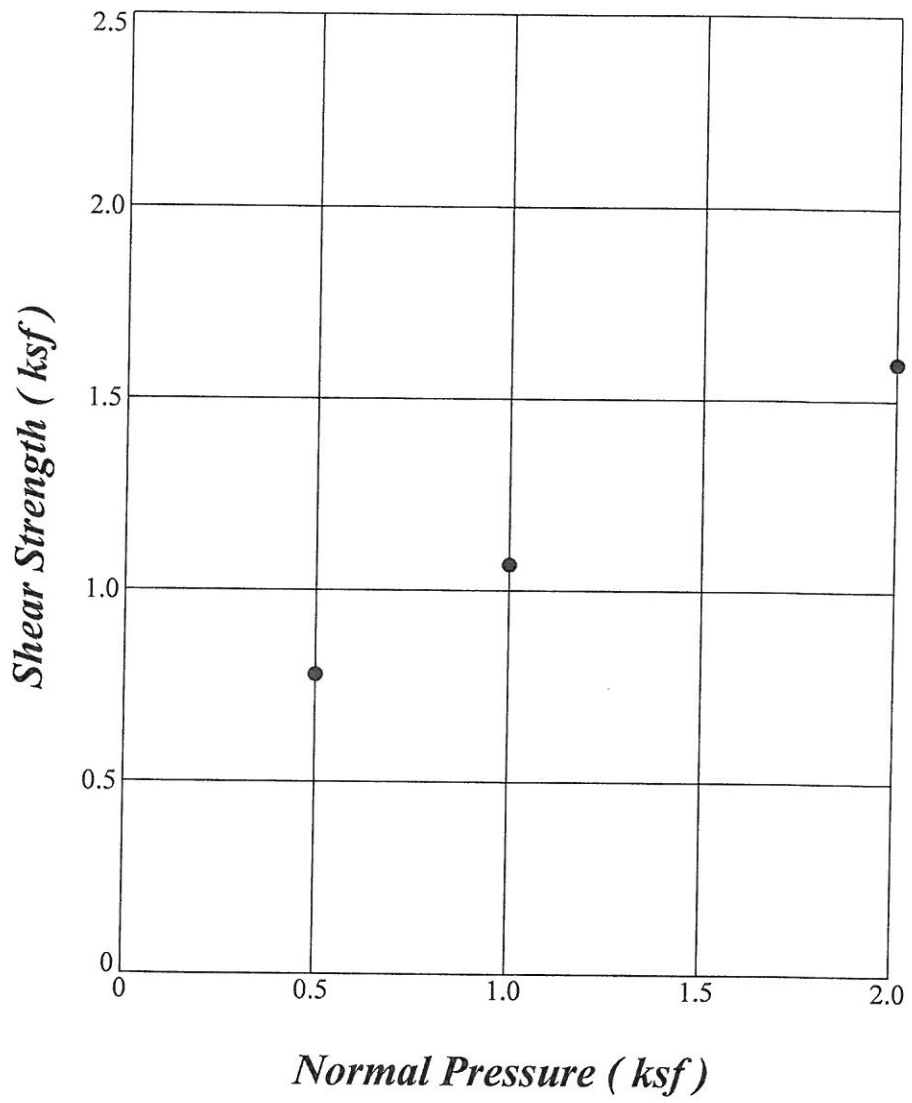
Figure S.1

SHEAR TEST

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*	SAMPLE ID: *B-11 @ 15.00'*
PROJECT NUMBER: *PIN 6435*	MATERIAL DESCRIPTION: *Bedrock (Tml)*
TEST METHOD: *Ultimate Saturated Shear*	



MOISTURE CONTENT (%)		DENSITY (pcf)		RESULTS
In Situ:	*32.2*			Phi (deg.):
Saturated:	*45.0*	Dry Density:	*86.3*	Cohesion (ksf):

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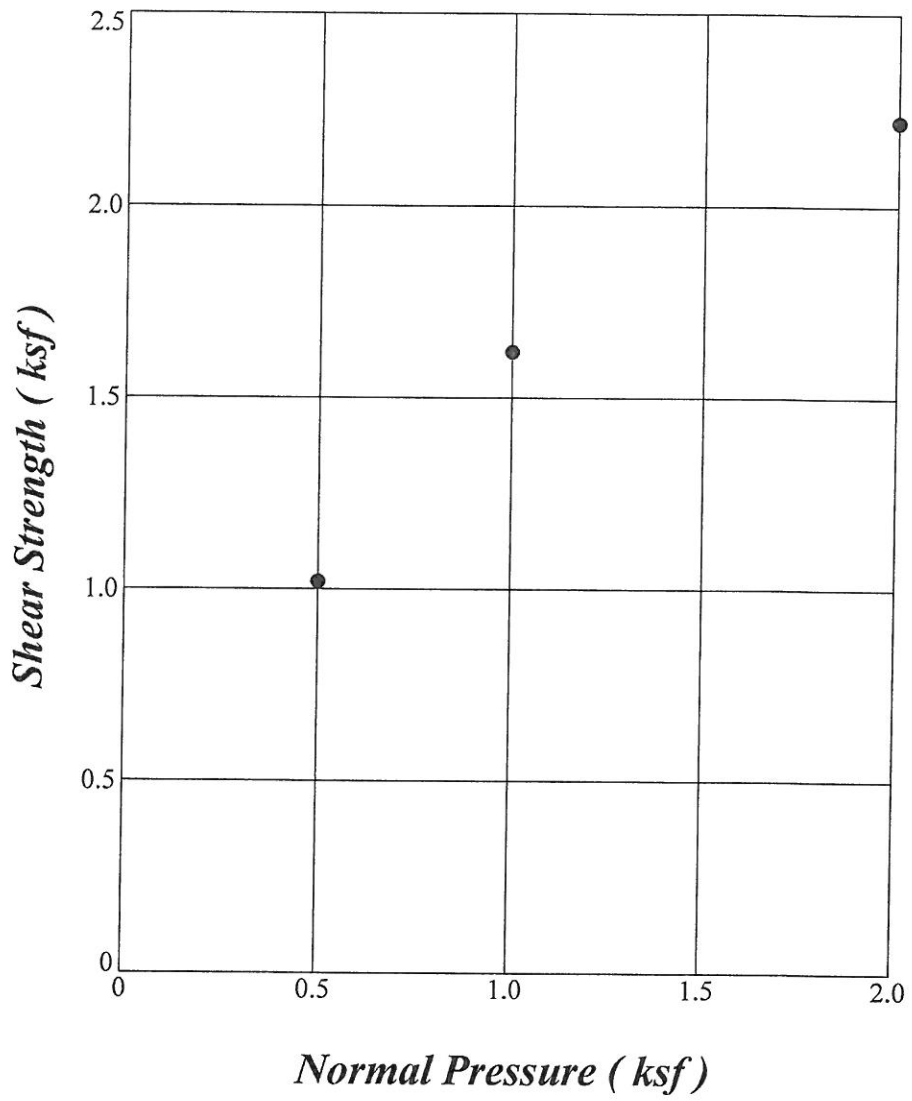
Figure S.2

SHEAR TEST

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*	SAMPLE ID: *B-12 @ 5.00'*
PROJECT NUMBER: *PIN 6435*	MATERIAL DESCRIPTION: *Alluvium (Qal)*
TEST METHOD: *Ultimate Saturated Shear*	



MOISTURE CONTENT (%)		DENSITY (pcf)		RESULTS
In Situ:	*18.7*			Phi (deg.):
Saturated:	*36.7*	Dry Density:	*84.0*	Cohesion (ksf):

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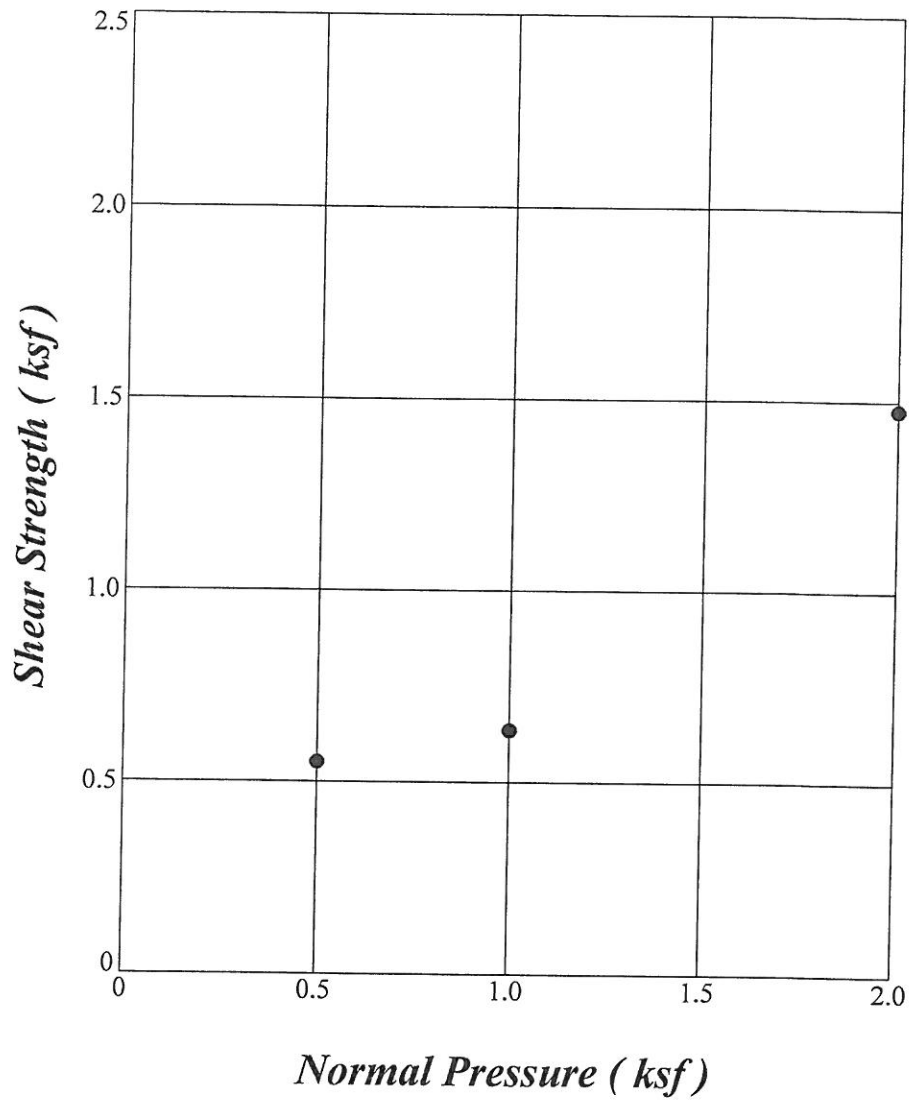
Figure S.3

SHEAR TEST

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*	SAMPLE ID: *B-7 @ 5.00'*
PROJECT NUMBER: *PIN 6435*	MATERIAL DESCRIPTION: *Earth Fill (ef)*
TEST METHOD: *Ultimate Saturated Shear*	



MOISTURE CONTENT (%)		DENSITY (pcf)		RESULTS
In Situ:	*6.8*			Phi (deg.):
Saturated:	*15.3*	Dry Density:	*121.5*	Cohesion (ksf):

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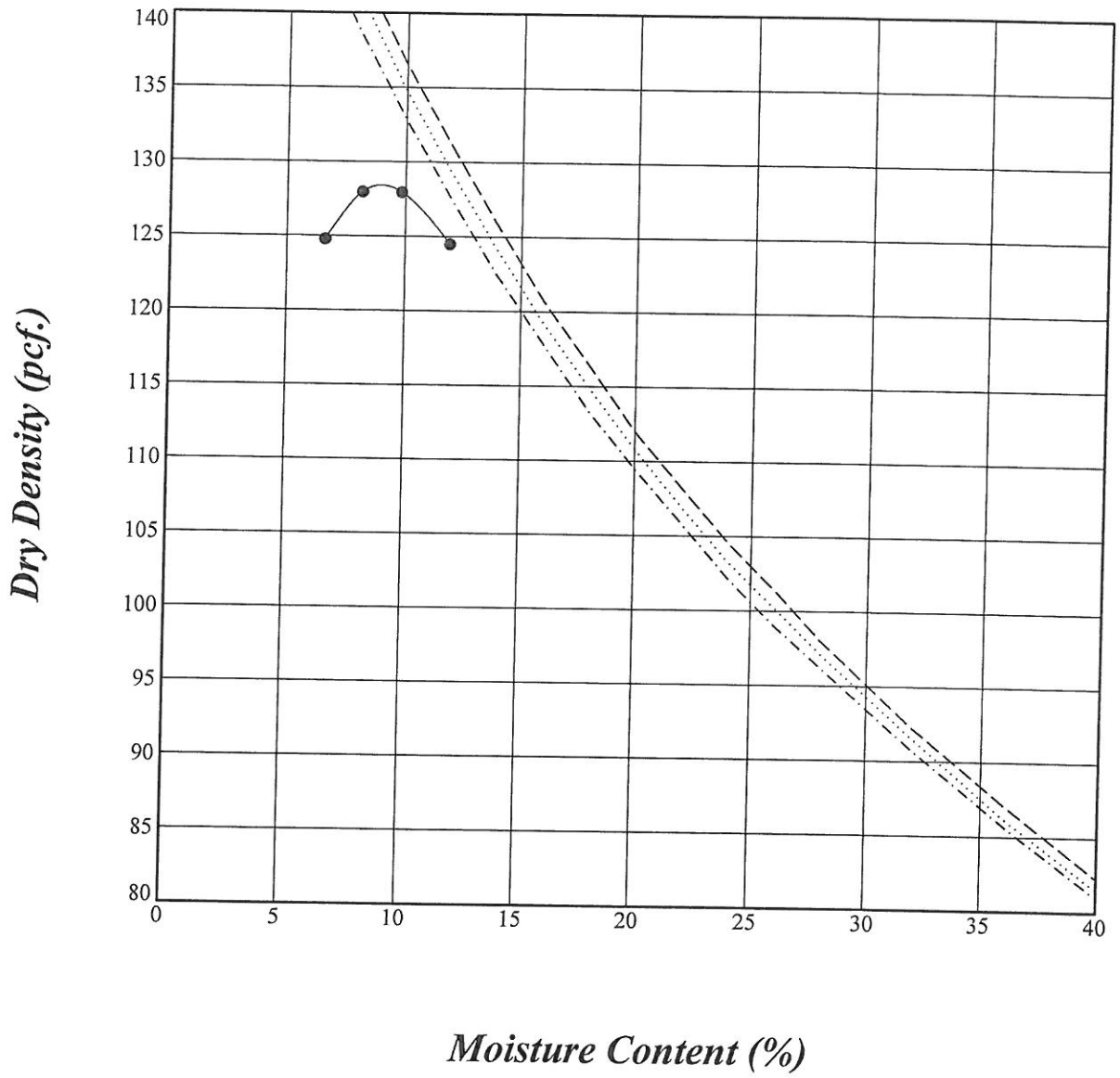
Figure S.4

MOISTURE CONTENT - DRY DENSITY CURVE (ASTM D1557)

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*	SAMPLE ID: *B-1 @ 2.00'*
PROJECT NUMBER: *PIN 6435*	MATERIAL DESCRIPTION: *Alluvium (Qal)*



Maximum Dry Density (pcf.) : *128.5*

Optimum Moisture Content (%) : *9.0*

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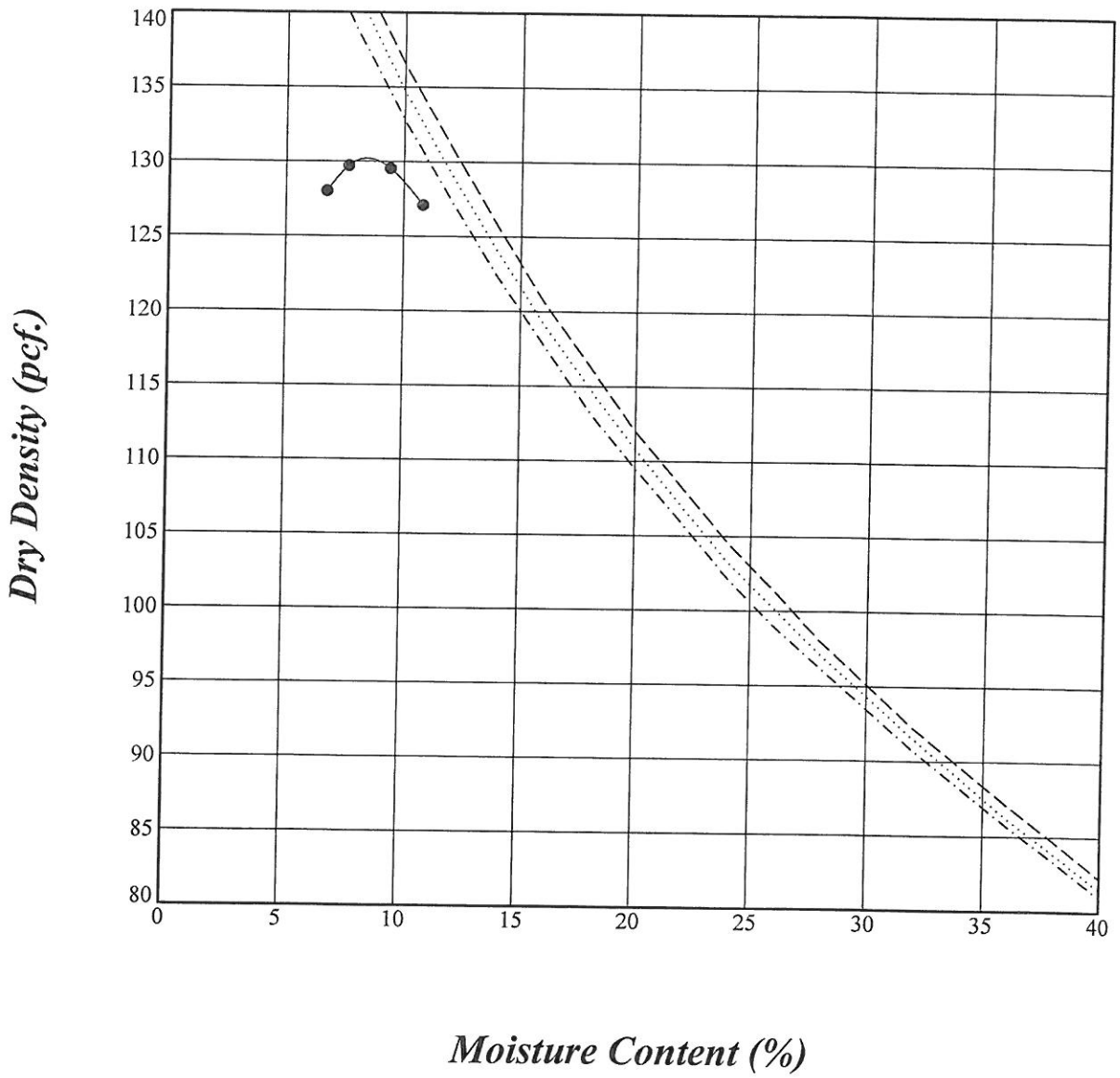
Figure M.1

MOISTURE CONTENT - DRY DENSITY CURVE (ASTM D1557)

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*	SAMPLE ID: *B-3 @ 3.00'*
PROJECT NUMBER: *PIN 6435*	MATERIAL DESCRIPTION: *Earth Fill (ef)*



Maximum Dry Density (pcf.) : *130.0*

Optimum Moisture Content (%) : *8.5*

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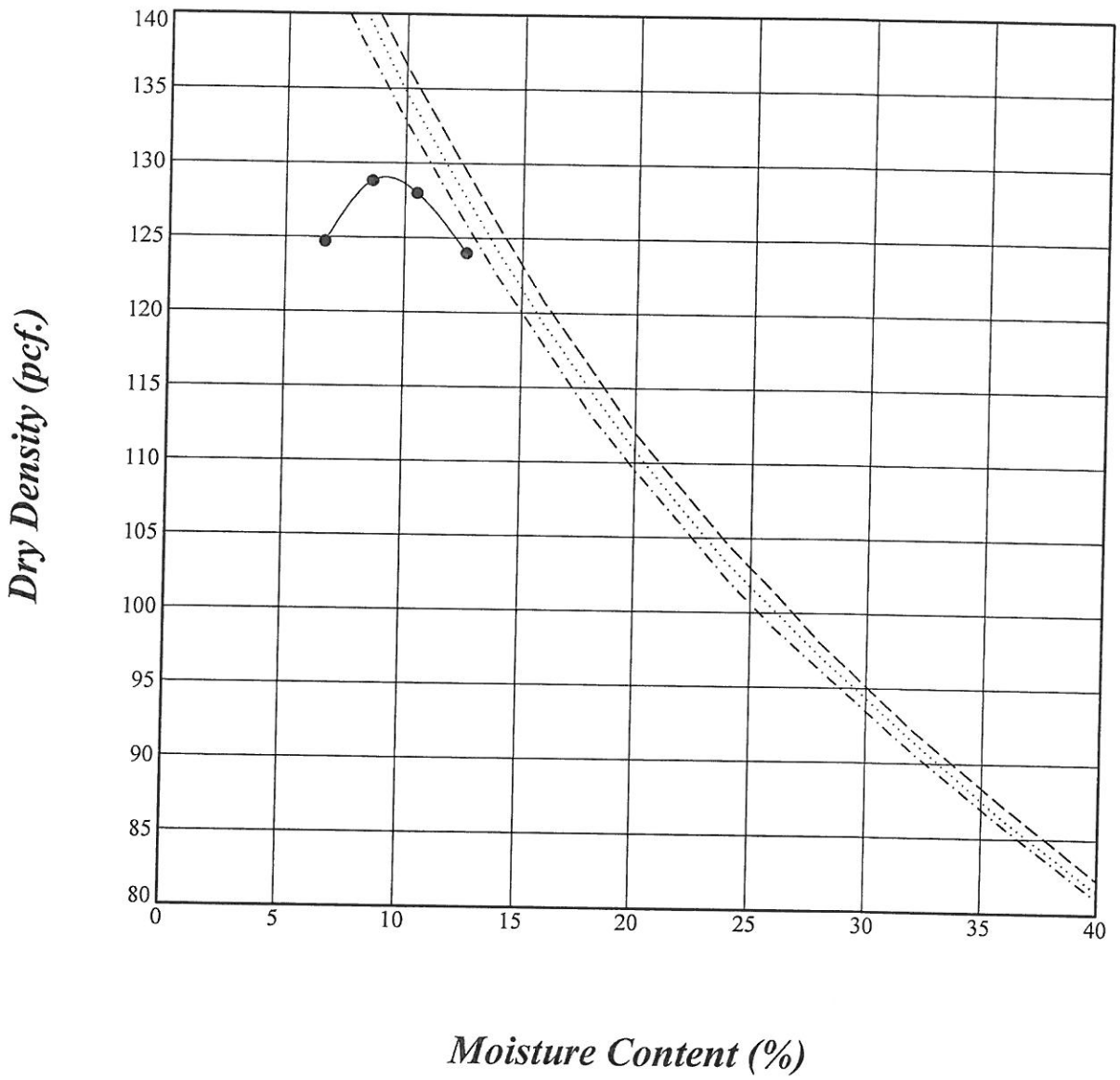
Figure M.2

MOISTURE CONTENT - DRY DENSITY CURVE (ASTM D1557)

PROJECT NAME: *Bengal / Las Positas Multi-Use Trail*	SAMPLE ID: *B-7 @ 2.00'*
PROJECT NUMBER: *PIN 6435*	MATERIAL DESCRIPTION: *Earth Fill (ef)*



Maximum Dry Density (pcf.) : *129.5*

Optimum Moisture Content (%) : *9.5*

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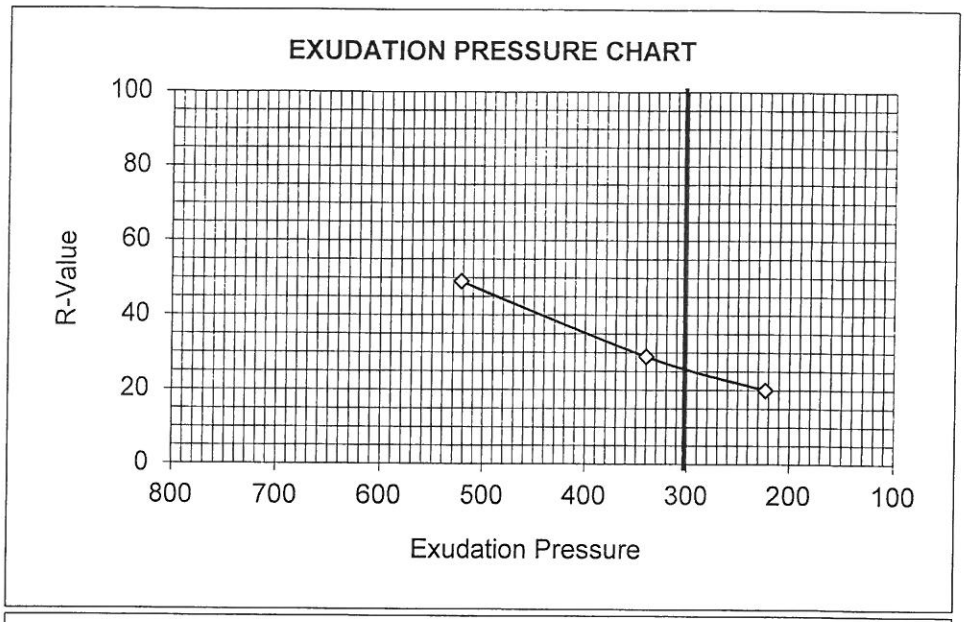
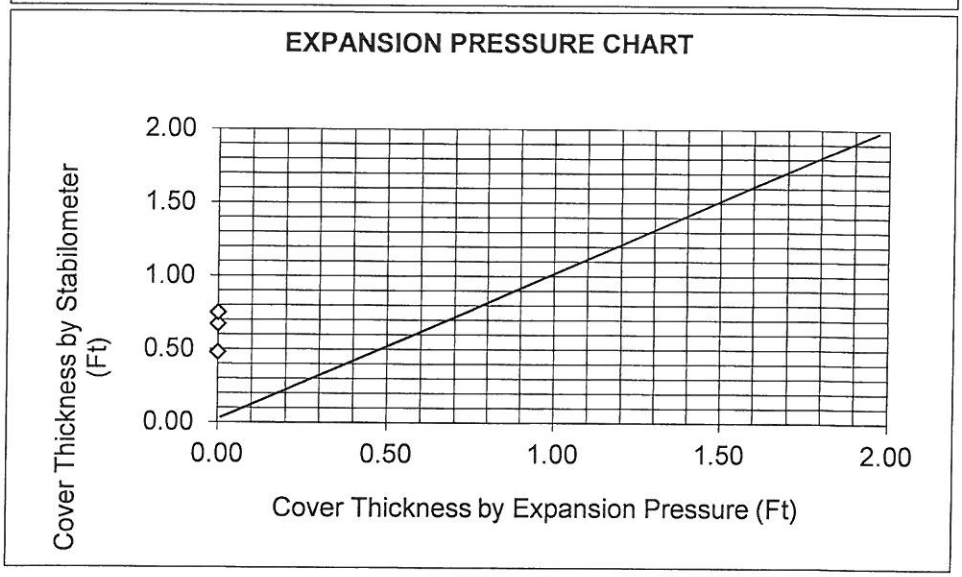
Figure M.3





JOB NAME: Subsurface Designs JN: 6435
SAMPLE I. D.: B3 @ 3'
SOIL DESCRIPTION: Very Silty Fine to Medium Sand (SM)

SPECIMEN NUMBER	A	B	C
EXUDATION PRESSURE	522	340	223
RESISTANCE VALUE	49	29	20
EXPANSION DIAL(0.0001")	0	0	0
EXPANSION PRESSURE (PSF)	0.0	0.0	0.0
% MOISTURE AT TEST	10.3	11.0	11.6
DRY DENSITY AT TEST	122.8	122.2	121.4

R-VALUE @ 300 PSI EXUDATION	**26**
R-VALUE by Expansion Pressure*	**100**

**Based on a Traffic Index of 5.0 and a Gravel Factor of 1.70*

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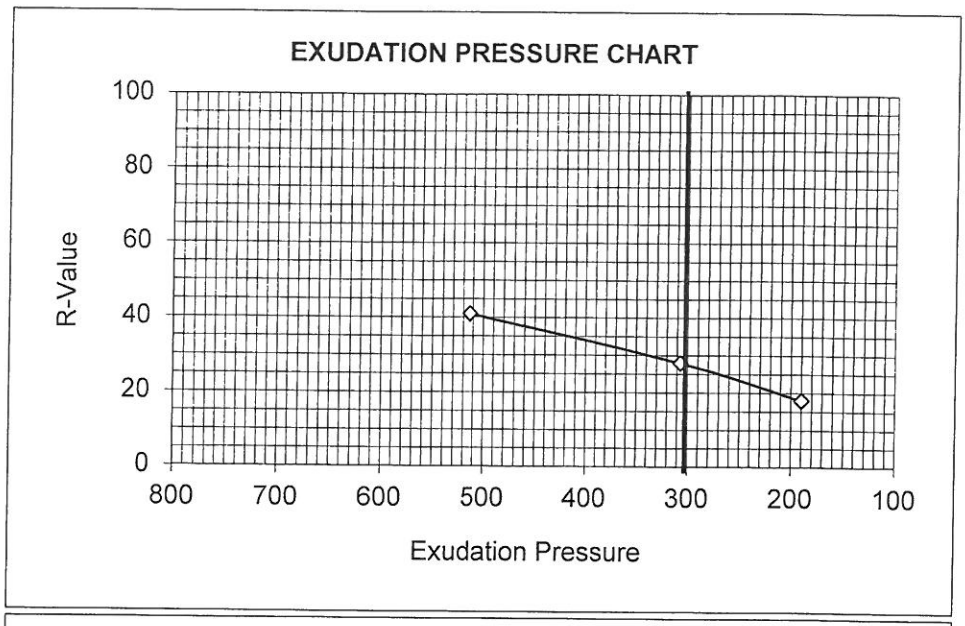

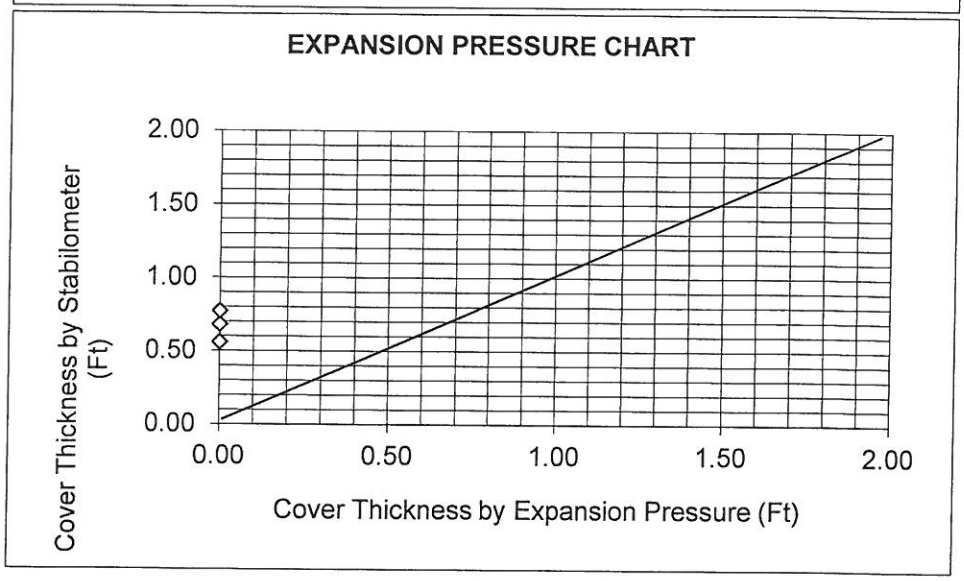

JOB NAME: Subsurface Designs JN: 6435
SAMPLE I. D.: B7 @ 2'-3'
SOIL DESCRIPTION: Very Silty Fine to Coarse Sand (SM)

SPECIMEN NUMBER	A	B	C
EXUDATION PRESSURE	513	307	190
RESISTANCE VALUE	41	28	18
EXPANSION DIAL(0.0001")	0	0	0
EXPANSION PRESSURE (PSF)	0.0	0.0	0.0
% MOISTURE AT TEST	11.0	11.9	12.5
DRY DENSITY AT TEST	124.8	120.7	119.9

R-VALUE @ 300 PSI EXUDATION	**28**
R-VALUE by Expansion Pressure*	**100**

**Based on a Traffic Index of 5.0 and a Gravel Factor of 1.70*

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