GEOTECHNICAL AND FOUNDATION INVESTIGATION
PROPOSED BUTTERFIELD BOULEVARD EXTENSION
MORGAN HILL, CALIFORNIA
(100% Submittal)

PROJECT 2309E
(2010.0150)

For

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1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical investigation for the proposed Butterfield Boulevard Extension project in Morgan Hill, California. The approximate location of the project is shown on the Vicinity Map included with the Site Plan, Figure 1, of this report. A layout of the proposed roadway, drainage channel and detention pond is shown on Figure 1.

This report is based on the design information provided to us. This information and our recommendations in this report are intended for the 100% project submittal to the City. If changes are made to the project design, we should be notified to review the changes and evaluate if revisions to our conclusions and recommendations are necessary.

This report presents our conclusions and geotechnical recommendations for design and construction of the proposed roadway, over-crossing, drainage channel, detention pond, culverts and retaining structures. These conclusions and recommendations are based on subsurface information collected during this investigation. The conclusions and recommendations in this report should not be extrapolated to other areas or used for other projects without our review.

1.2 PROJECT DESCRIPTION

We understand the proposed project includes the following elements.

Butterfield Boulevard Extension: Butterfield Boulevard will be extended from its existing southern terminus near Tennant Avenue to west of Monterey Road and Watsonville Road, crossing Fisher Avenue and Railroad Avenue (see Figure 1), for a distance of approximately 4,700 feet. The new road will have two traffic lanes in each direction and a 4 to 12 foot wide median. Sidewalks, planter areas and retaining structures are also proposed along sections of the roadways. Other improvements will include new storm drainage facilities, underground utilities and light standards.

Over-crossing at Railroad Avenue and UPRR: A new over-crossing is proposed at Railroad Avenue and Union Pacific Railroad (UPRR). The proposed over-crossing will be a two-span structure approximately 222 feet long (measured along “B” Line) and 86 feet wide. The interior spans will be about 92 and 130 feet long. Along “B” Line, the top of bridge will be at Elevation 353.08 feet at Abutment 1 and Elevation 353.26 feet at Abutment 3. The abutments and interior bent will be located outside of the UPRR right-of-way.

Approach Ramps and Retaining Structures: An approach ramp up to about 35 feet high will be constructed at each end of the proposed over-crossing. Each side of the ramps will slope down at an inclination of 3:1 (horizontal:vertical) to a mechanically stabilized embankment (MSE) up to about 16 feet high. The MSEs are identified as Retaining Wall No. 1 (RW1) through Retaining Wall No. 4 (RW4) on the design plans. The ends of the approach fills in front of the abutments will have an inclination of 1½:1 (h:v) and paved with concrete.

Retaining Wall No. 5 will be constructed on the western bank of the proposed drainage channel on the east side of new Butterfield Boulevard and south of Tennant Avenue. This wall will be about 408 feet long, about 4 to 6 feet high, and extend between roughly 61 feet left of Station “B” 156+92.99 and roughly 55 feet left of Station “B” 158+93.41.

We understand a retaining wall up to about 2 feet high is proposed along the west side of new Butterfield Boulevard, in the area of Stations “B” 158 to 159.

Realignment of Existing Roadways: A section of Fisher Avenue near the new Butterfield Boulevard and a section of Watsonville Road west of Monterey Road will be realigned to meet the new Butterfield Boulevard.

New Culverts: New culverts are proposed at the realigned Fisher Avenue, at Monterey Road and Watsonville Road, and at Maple Avenue.

A new culvert will be constructed along the proposed drainage channel to convey water beneath the realigned Fisher Avenue. This structure will be about 112 feet long and consist of a double 10-foot by 7.5-foot reinforced concrete box culvert. The culvert will have an invert elevation of 314.26 feet at the north end, with 313.70 feet at the south end. The bottom of the culvert will be about 9 to 10 feet below the existing ground surface. Wing walls up to 12 feet high will be constructed at both ends of the culvert.

A new culvert will be constructed along the proposed drainage channel to convey water beneath Maple Avenue. This structure will be about 112 feet long and consist of a double 14-foot by 4-foot reinforced concrete box culvert. The culvert will have an invert elevation of 308.66 feet at the north end, with 308.10 feet at the south end. The bottom of the culvert will be about 6.5 to 8 feet below the existing ground surface. Wing walls up to 11 feet high will be constructed at both ends of the culvert.

Two new culverts are proposed at the intersection of Monterey Road and Watsonville Road. West of Monterey Road, a new 120-foot long, double 4-foot by 10-foot reinforced concrete box culvert is proposed under the realigned section of Watsonville Road. The culvert will have an invert elevation of 311.25 feet at the west end, with 310.51 feet at the east end. At the east end of the new culvert, a wing wall up to 10 feet high will be constructed. Along the northern creek bank between the east end of the new culvert under Watsonville Road and the west end of the existing culvert under Monterey Road, a Caltrans Type 1 retaining wall about 12 feet high will be constructed.

East of Monterey Road, a new 88-foot long, double 4-foot by 10-foot reinforced concrete box culvert is proposed extending the existing culvert under Monterey Road into West Little Llagas Creek. The culvert will have an invert elevation of 309.87 feet at the east end, with 310.18 feet at the west end. The bottom of the culvert will be about 2 feet below the bottom of the creek channel. Wing walls up to 12 feet high will be constructed at the east end of the culvert.

Pipe Jacking: Bore and jack will be used north of the proposed over-crossing for installation of a 6-inch diameter force main sewer pipeline and a 12-inch diameter water main under the railroad tracks through a 20-inch diameter steel casing. The bore pits are anticipated to be about 20 feet by 25 feet in plan dimension and about 10 feet deep.

Flood Control Channel: A new drainage channel, about 4 to 10 feet deep, will be constructed as a part of the project. The new channel will begin at the southern terminus of the existing channel at Tennant Avenue, continue along the east side of new Butterfield Boulevard, cross under the realigned Fisher Avenue via a box culvert, turn south at Railroad Avenue and continue south along the east side of Railroad Avenue, cross Maple Avenue via a new box culvert, continue south and then turn west along the south side of the proposed detention basin to west of Seymour Avenue. The new channel will have a bottom width of about 10 feet and a side slope of 2:1 (h:v).

An earth check dam will be constructed inside the new flood control channel just south of the concrete weir on the west side of the detention basin. The check dam will have a crest width of 10 feet and 4:1 (horizontal:vertical) side slopes. The top of the check dam will be a minimum of 15 inches below the adjacent top of channel. Three 24-inch diameter HDPE culverts will be installed at the bottom of the check dam to allow water flow. Energy dissipators, consisting of 4-inch minimum diameter rocks set in 8-inch thick concrete slabs, will be constructed at the inlets and outlets of the culvert. The center of the dam will be covered by a 6-inch thick concrete slab for maintenance vehicle access. The remaining surface of the check dam will be covered by erosion control matting.

Detention Basin: The proposed detention basin, covering an area of about 38 acres, will be constructed between Maple Avenue in the north, Railroad Avenue on the west, Llagas Creek on the south, and Seymour Avenue on the west. A levee, with a crest elevation of 314½ feet, is proposed around the perimeter of the pond. The levee will have side slopes of 4:1 (h:v) and a crest width of 10 feet. The pond bottom will vary from roughly Elevation 308½ feet in the northwestern portion to roughly Elevation 306.2 feet in the southeastern portion. The 100-year design flood water level is at Elevation 311.8 feet.

Water in the adjacent drainage channel will enter the pond through a concrete-lined weir in the western portion of the pond. A pipe system will drain the pond water to Llagas Creek near Seymour Avenue.

About 100,000 cubic yards of soils are anticipated to be generated from construction of the basin. Some of the soils will be used for construction of the pond levees. The remaining soils from the basin and soils excavated from the drainage channel extension will be used for construction of the proposed Butterfield Boulevard.

Detention/Bio-Filtration Basin: The basin will be constructed southeast of Monterey Road and new Butterfield Boulevard. The basin will be about 5 to 6 feet deep, with bottom elevation of 310.2 feet and side slopes of 4:1 (h:v).

1.3 PURPOSE AND SCOPE OF INVESTIGATION

The purpose of this investigation was to evaluate the subsurface soil conditions at the project areas and to provide geotechnical recommendations for use in the design and construction of the proposed improvements. The following scope of work was performed for this investigation.

1. Review of available geologic and geotechnical information pertinent to the project.

2. Reconnoitering of the project areas to observe surface conditions and mark locations of our subsurface exploration.

3. Obtaining an encroachment permit from the City of Morgan Hill (City) and deep boring permits from Santa Clara Valley Water District (SCVWD) for our subsurface exploration work. Rights-of-entry for private properties were provided by the City.

4. Notifying Underground Service Alert for utility clearance.

5. Coordination of our drilling schedule with the City, SCVWD and private property owners and tenants.

6. Performance of a subsurface exploration program which included sixteen conventional drill holes, a Cone Penetrometer Test (CPT) probe, and four pavement holes.

7. Collection of seven bulk samples of near-surface soil along the proposed roadway and drainage channel alignments and from the proposed detention basin area.

8. Laboratory testing of selected soil samples to measure their physical and engineering properties.

9. Engineering analysis of information from our literature research, field investigation and laboratory testing.

10. Preparation of draft reports for the 25%, 50% and 100% submittals.

11. Preparation of this 100% submittal final report summarizing our findings, conclusions and recommendations. Specifically, the report includes the following:

    - Project description
    - Scope of work
    - Field investigation and laboratory testing
    - Geotechnical conditions, including site geology, surface conditions, subsurface conditions, and depth to groundwater
    - Seismic data, including faulting, seismicity, site acceleration, liquefaction potential, and Caltrans design ARS for the proposed over-crossing
    - Geologic hazards including tsunami, seiche, earthquake induced flooding, landslides, ground rupture, seismic shaking and scour
    - Geotechnical analysis, including embankment settlements, settlement periods, slope stability, and local borrow soils for project construction
    - Soil corrosion potential
    - Earthwork recommendations, including site preparation, excavations, re-compaction of near-surface soil, subgrade preparation, material for engineered fill, fill placement and compaction, and backfilling of utility trenches

- Foundation recommendations for the proposed over-crossing including recommended foundation type, pile data table, lateral load responses, and pile foundation settlement
- Foundations for culverts and retaining structures
- Parameters for design of Mechanically Stabilized Embankments
- Lateral earth pressures and resistance for abutments, wing walls and retaining structures
- Structural pavement sections
- A Vicinity Map showing the project area and Site Plan showing the approximate locations of our field exploration and sampling
- Logs of our drill holes and CPT probes
- Laboratory test results

1.4 INFORMATION PROVIDED

For this investigation, the following was provided to us.

- A set of four sheets of preliminary civil design plans for the proposed roadway extension, prepared by MH Engineering, dated November 2009
- A set of two sheets of preliminary grading plan and grading cross sections for the proposed detention pond, prepared by MH Engineering, dated November 2009
- Preliminary bridge design plan prepared by Mark Thomas & Company, with updated version received via email on November 9, 2009
- Preliminary bridge foundation loads and footing elevations by Mark Thomas & Company
- Design traffic index for Butterfield Boulevard by MH Engineering
- A set of Improvement Plans for Butterfield Boulevard South Extension for the 25% submittal
- A set of Improvement Plans for Butterfield Boulevard South Extension for the 90% submittal

2. FIELD INVESTIGATION AND LABORATORY TESTING

Our field investigation consisted of a surface reconnaissance and a subsurface exploration program. The site reconnaissance was to observe existing surface conditions along the proposed roadway and drainage channel alignments, at the proposed over-crossing and at the proposed detention pond. The subsurface exploration program was to explore soil conditions at selected locations within the project areas and at the supports of the proposed over-crossing.

2.1 SUBSURFACE EXPLORATION

Our subsurface exploration program consisted of sixteen exploratory drill holes (DH-1 through DH-17; DH-4 was not drilled because right-of-entry could not be obtained from the property owner), one Cone Penetrometer Test hole (CPT-1) and four pavement holes (PH-1 through PH-4). The drill holes, CPT hole and pavement holes were located in the field by referencing to existing site features and pacing; therefore, their locations are approximate. The approximate locations of the drill holes, CPT hole and pavement holes are shown on Figure 1.

The drill holes and CPT hole were backfilled with cement grout, as required by the Santa Clara Valley Water District, and topped off with cold patch asphalt in paved areas. The pavement holes were backfilled with cold patch asphalt.

2.1.1 Drill Holes

The drill holes were advanced between October 19 and November 4, 2009 using a truck-mounted drill rig. Holes DH-8, DH-9 and DH-10 were advanced using mud rotary drilling method. The remaining holes were advanced using 8-inch diameter hollow-stem augers. Maximum depth of exploration ranged between 20 and 100 feet below ground surface (bgs). In the field, our personnel visually classified the materials encountered and maintained a log of each drill hole.

Soil samples were obtained from the drill holes using a 2-inch outside diameter (1.4-inch inside diameter) split-barrel sampler (also called a Standard Penetration Test sampler), a 3-inch outside diameter (2½-inch inside diameter) split barrel sampler with 6-inch-long liners, and a 3-inch diameter thin-walled Shelby tube. Drive samples were obtained by driving a soil sampler up to 18 inches into the earth material using a 140-pound hammer falling 30 inches. The hammer was operated using a wire winch and pulley system. The number of blows required to drive the samplers was recorded for each 6-inch penetration interval. The number of blows required to drive the sampler the last 12 inches, or the penetration interval indicated on the log where harder material was encountered, is shown as blows per foot (blow count) on the drill hole logs. The Shelby tubes were hydraulically pushed into the soil. The pressure used to push the Shelby tubes and the depths of penetration are shown on the boring logs.

Visual classification of soils encountered in our drill holes was made in general accordance with the Unified Soil Classification System (ASTM D 2487 and D 2488). The results of our laboratory tests were used to refine our field classifications. Two Keys to Soil Classification, one for fine grained soils and one for coarse grained soils, are included in Appendix A together with the logs of the drill holes.

2.1.2 Cone Penetrometer Test

CPT-1 was performed by John Sarmiento & Associates on October 30, 2009, to a depth of approximately 74 feet below existing ground surface, where refusal to advancement was encountered. CPT involves pushing a small diameter (10 cm^2 cross-sectional area) steel probe into the ground using a hydraulic jack attached to a truck mounted rig. The tip of the probe is instrumented and takes almost continuous measurements (roughly every 1 inch) of tip resistance, side friction resistance, and pore pressure. The CPT data and typical interpreted soil properties, presented at about 6-inch depth intervals, are included in Appendix B and include the following:

Symbol	Explanation
Qc	Tip bearing resistance
Qc'	Tip bearing resistance normalized for overburden
Fs	Sleeve friction resistance
Rf	Tip/sleeve friction Ratio
SPT (N)	Equivalent standard penetration blow count
SPT' (N')	Corrected equivalent standard penetration blow count
EffVtStr	Estimated effective overburden stress
PHI	Interpreted internal friction angle
Su	Interpreted undrained shear strength
Soil Behavior type	Interpreted soil behavior type
Density Range	Estimated range of total soil density

2.1.3 Pavement Holes

The four pavement holes (PH-1 through PH-4) were drilled on May 27, 2010, for the section of existing Butterfield Boulevard south of Tennant Avenue to explore the thickness of the existing pavement section. The measured thicknesses of asphalt concrete and aggregate base are presented in Section 3.3.

2.1.4 Bulk Sampling

A total of seven bulk samples of the near-surface soils (Bulks B-1 through B-7) were collected near drill holes DH-12, DH-1, DH-15, DH-14, DH-13, DH-7 and DH-3, respectively.

2.2 LABORATORY TESTING

Laboratory tests were performed on selected soil samples. The geotechnical tests included water content, dry density, Atterberg limits, grain size distribution, percent passing No. 200 sieve, unconfined compressive strength, unconsolidated undrained triaxial shear (TXUU), consolidation, corrosion potential and laboratory compaction. Other test includes corrosion potential on six selected samples by CERCO Analytical.

Most of the laboratory test results are presented on the drill hole logs at the corresponding sample depths. The results of the Atterberg Limits, unconfined compressive strength, triaxial UU, grain size distribution, R-value and laboratory compaction tests are presented on Figures C-1 through C-31 in Appendix C. The results of the corrosion potential tests from CERCO Analytical are included in a separate sheet after Figure C-31.

3. SITE GEOLOGY AND SITE CONDITIONS

3.1 SITE GEOLOGY

The project site lies within the city of Morgan Hill, which is situated in the Llagas subbasin of the southern Santa Clara Valley. Geology of the Santa Clara Valley has been extensively studied and mapped by the United States Geological Survey (USGS), California Geological Survey (CGS), and other investigators. The site lies where two alluvial fans meet, and thus have two different sediment sources (Mactec, 2006, 2007). Knudsen and others (2000) map all but the southern tip of the segment as underlain by latest Pleistocene (between approximately 11,000 and 2 million years) alluvial fan deposits (map unit Qpf) that are derived from the Diablo Range to the east, and are part of a large-scale alluvial fan with a Coyote Creek source. The southernmost tip of the segment is mapped as being underlain by latest Pleistocene to Holocene alluvial fan deposits (map unit Qf) derived from the Santa Cruz Mountains, and deposited by Little Llagas Creek. These sediments are thus slightly younger than sediments to the north. Wentworth and others (1999) map the entire segment as being underlain by Upper (latest) Pleistocene alluvial fan deposits; they do not subdivide deposits in the area.

A Ground Movement Potential Map (GMP) was prepared by Pacific Geotechnical Engineering (1994) for the City of Morgan Hill. The GMP shows the segment as being “relatively stable ground” composed of unconsolidated colluvium or alluvium.

3.2 SURFACE CONDITIONS

The project site is located in a flat-lying area of Morgan Hill. The proposed roadway and drainage channel alignments will cross vacant lands, farm buildings, farm lands, Fisher Avenue, Railroad Avenue, Maple Avenue and UPRR tracks. Fisher Avenue, Railroad Avenue and Maple Avenue have one lane of traffic in each direction, with unpaved shoulders and overhead power lines. The UPRR tracks are several feet higher in elevation than Railroad Avenue.

The site of the proposed detention pond is currently farm land with several buildings in the northeastern portion. The area is essentially flat-lying and the ground surface has been disced for farming purposes.

3.3 EXISTING BUTTERFIELD BOULEVARD PAVEMENT SECTIONS

The measured asphalt concrete and aggregate base thicknesses of Butterfield Boulevard south of Tennant Avenue in PH-1 through PH-4 drilled on May 27, 2010, are tabulated below.

Table 3.3-1
Measured Pavement Section Thicknesses

Probe Hole	Measured Asphalt Concrete Thickness (inches)	Measured Aggregate Base Thickness (inches)	Total Measured Thickness (inches)
PH-1*	3	3	6
PH-2	4	6 - 7	10 - 11
PH-3	4	6	10
PH-4	4 - 5	6	10 - 11

* PH-1 appears to be a parking area

3.4 SUBSURFACE CONDITIONS

A brief description of the materials encountered at the site is presented below. For more details of the soils encountered in our drill holes and CPT probe, refer to the drill hole logs in Appendix A and the CPT data sheets in Appendix B.

Proposed Over-crossing at Railroad Avenue and UPRR: Drill holes DH-8, CPT-1 and DH-9 were advanced for Abutment 1, Bent 2 and Abutment 3, respectively. Below the ground surface at DH-8, layers of clayey sand and clayey gravel were encountered to a depth of about 47 feet. The sand and gravel layers are medium dense to dense in relative density and contain variable amounts of cobbles. Between depths of 47 and 59½ feet is a layer of very stiff to hard fat clay. The fat clay is predominantly underlain by dense to very dense clayey sands to the maximum explored depth of about 100 feet. Two layers of very stiff to hard clay to fat clay were encountered within the clayey sand layers, between depths of 69 and 72½ feet and between depths of 84 and 87 feet.

In DH-9, layers of clayey sand and clayey gravel with variable amounts of cobbles were encountered to a depth of about 33 feet below ground surface. The sand and gravel layers are generally medium dense to very dense except for the upper few feet which are loose to medium dense. Between depths of 33 and 37 feet is a very stiff clay layer. This clay layer is underlain by interbedded layers of medium dense to very dense clayey sand and clayey gravel, and firm to very stiff lean clay and sandy clay to the maximum explored depth of about 100 feet.

In CPT-1, the interpreted soil behavior types include sandy soils to a depth about 32 feet below ground surface, clayey soils to a depth of about 38 feet, sandy soils to a depth of about 43 feet, clayey soils to a depth of about 59 feet, sandy soils to a depth of about 65 feet, clayey soils to a depth of about 73 feet, and sandy soils to the maximum explored depth of about 74 feet where refusal to advancement was encountered.

Proposed Detention Basin: Drill holes DH-14 through DH-17 were advanced for the proposed detention basin. In DH-14 and DH-15, the surficial soil layer consists of medium dense to dense clayey sand and well graded gravel with silt and sand to a depth of about 3 to 4½ feet. In DH-16 and DH-17, a layer of very stiff clay was encountered below ground surface to a depth of about 3 feet. These soils are underlain by medium dense to very dense clayey sand and clayey gravel to the maximum explored depth of about 20 feet.

Butterfield Boulevard Extension, Drainage Channel and Bio-filtration Basin: Drill holes DH-1 through DH-13 were located along the proposed alignments of the Butterfield Boulevard extension and drainage channel, and near the bio-filtration basin.

The surficial layer of soil consists generally of loose to medium dense silty sand, clayey sand and clayey gravel and locally stiff sandy lean clay. The surficial soils are underlain predominantly by medium dense to dense clayey sands and clayey gravels with interbedded layers of stiff to very stiff clay and soft to firm lean clay/silt.

3.5 GROUNDWATER

Groundwater was encountered in several of the drill holes and in CPT-1. Groundwater level was not established in DH-6, DH-8, DH-9 and DH-10 because mud rotary drilling method was used. In DH-6, mud rotary drilling was used initially, followed by hollow stem auger drilling.

Groundwater was not encountered in the other drill holes because of their relatively shallow depth and the short time between completion of drilling and grouting of the holes.

The measured depths to groundwater table in our drill holes and CPT-1 are tabulated below.

Table 3.5-1
Measured Depth to Groundwater

Hole	Measured Depth to Groundwater Immediately After Completion of Drilling (feet)
CPT-1	23.2
DH-5	20
DH-7	20
DH-13	17.7
DH-14	17.1
DH-15	17
DH-17	14.9

Fluctuations in the groundwater level may occur due to water level in the drainage channel, seasonal variations in rainfall and temperature, pumping from wells, irrigation or other factors that were not evident at the time of our investigation.

3.6 VARIATIONS IN SUBSURFACE CONDITIONS

Our interpretations of soil and groundwater conditions, as described in this report, are based on data obtained from our subsurface exploration and laboratory testing for this study. Our conclusions and geotechnical recommendations are based on these interpretations. Please realize the project area has undergone different phases of development and grading. Therefore, it is likely that undisclosed variations in subsurface conditions exist at the site, such as old foundations, abandoned utilities and localized areas of deep and loose fill.

Careful observations should be made during construction to verify our interpretations. Should variations from our interpretations be found, we should be notified to evaluate whether any revisions should be made to our recommendations.

4. SEISMIC DATA AND EVALUATION

4.1 SEISMIC DATA

The greater San Francisco Bay Area is one of the most seismically active regions in the United States. The area is seismically dominated by the active San Andreas Fault system, the tectonic boundary between the northward moving Pacific Plate (west of the fault) and the North American Plate (east of the fault). This movement is distributed across a complex system of generally strike-slip, right-lateral, subparallel faults.

Regional faults that have a potential to generate large magnitude earthquakes and significant ground shaking at the site are listed below, and selected faults are described in detail in Appendix D of this report. The distances listed below are derived from the USGS Quaternary Fault and Fold database (http://earthquake.usgs.gov/regional/qfaults/).

Table 4.1-1
Fault Distances and Orientation

Fault	Approximate Distance		Orientation from Project Site to Fault
	Project North	Project South	
Calaveras	3¾ mi	4¼ mi	Northeast
Sargent	7½ mi	6½ mi	Southwest
Monte Vista-Shannon	8½ mi	8½ mi	Northwest
San Andreas	9¾ mi	9 mi	Southwest
Hayward (southeast extension)	12½ mi	13 mi	Northwest
Zayante-Vergeles	12¾ mi	12¼ mi	Southwest
Greenville	13½ mi	14 mi	Northeast
Ortigalita	22 mi	22½ mi	Northeast
San Gregorio-Hosgri	34 mi	33 mi	Southwest

No known faults have been mapped crossing the site. The project site is not located in an Alquist-Priolo Earthquake Fault Zone as defined by Special Publication 42 (revised 1997) published by the California Division of Mines and Geology (CDMG).

The probabilistic horizontal peak ground acceleration (PGA) value was estimated using the United States Geological Survey (USGS)/California Geological Survey (CGS) Probabilistic Seismic Hazards Assessment Model 2002 (revised April 2003). For the proposed over-crossing site (alluvial soil, longitude 121.6311W, and latitude 37.1106N), the estimated PGA value for a 10% probability of being exceeded in a 50-year time period is 0.64g.

The combined probability of large earthquakes occurring on one of the active faults in the area has been estimated by the Working Group on California Earthquake Probabilities (1990, 1999, 2003, 2008), with probabilities refined through several iterations. The greatest changes have been in the treatment of fault segments, rupture scenarios, and in the progressive consideration of more potential seismic sources. Current estimates (WGCEP, 2003, 2008) suggest that there is a 62% probability of a large magnitude (6.7 or greater) earthquake in the San Francisco Bay Region as a whole in the 30-year period ending in 2031.

4.2 CALTRANS ARS FOR OVER-CROSSING DESIGN

The proposed over-crossing will be designed following Caltrans guidelines. Therefore, we have developed a Caltrans Acceleration Response Spectrum (ARS) based on Caltrans Seismic Design Criteria (SDC) Version 1.5 (November 2010) for design of the proposed over-crossing. The procedures outlined in SDC Version 1.5 develop a deterministic response spectrum and a probabilistic response spectrum. The design response spectrum is the upper envelope of the spectral values of the deterministic and probabilistic response spectra across the period spectrum. The design ARS for the proposed over-crossing is presented in Figure 2.

4.3 LIQUEFACTION AND DYNAMIC COMPACTION

Soil liquefaction is a phenomenon in which saturated, cohesionless soils (generally sands) lose their strength due to the build-up of excess pore water pressure during cyclic loading, such as that induced by earthquakes. Soils most susceptible to liquefaction are saturated, clean, loose, fine-grained sands and silts. The primary factors affecting soil liquefaction include: 1) intensity and duration of seismic shaking; 2) soil type and relative density; 3) overburden pressure; and 4) depth to ground water.

The project area is not located within a Santa Clara County liquefaction hazard zone. A more recent map prepared by Knudsen and others (2000) and incorporated current liquefaction and engineering analysis, shows the project area as having a low susceptibility to liquefaction.

The Liquefaction Potential Map prepared by Pacific Geotechnical Engineering (1994) for the City of Morgan Hill shows the project area as having a "low" potential for ground surface movement due to liquefaction; deposits associated with Little Llagas Creek are shown as an "area of potential liquefaction."

Geotechnical information from this investigation allows a site-specific liquefaction assessment. Our liquefaction assessment was based on a PGA value of 0.64 (see Section 4.1), earthquake moment magnitude of 8, and a groundwater depth of 10 feet based on our review of available groundwater data. The results of our assessment suggest the potential for liquefaction of the soils encountered in our drill holes and CPT probe is low, except for some localized sand layers. Using the procedure proposed by Tokimatsu and Seed (1987), liquefaction-induced ground surface settlement was estimated to be on the order of ¼ to ¾ inch. Research has shown that actual settlements could range from 50% to 200% of the estimated values.

4.4 ADDITIONAL GEOLOGIC HAZARDS CONSIDERATIONS

Tsunami: The project area is located in an interior valley, and is not subject to tsunami hazards (CGS Note 55).

Seiche: The project area is not located near the margin of a body of water subject to seiche (flood hazard associated with seismically-induced oscillation).

Earthquake Induced Flooding: A review of on-line FEMA FIRM flood hazard maps (accessed 11/20/09 through City of Morgan Hill link to FEMA FIRM at http://www.morganhill.ca.gov/index.aspx?NID=749) indicates that the southern approximately one-quarter of the project area lies within "Zone AE" (floodway) that is associated with Little Llagas Creek.

The project area is located within the potential inundation area in the event of a sudden failure of Anderson Dam (Anderson Reservoir), located east of Morgan Hill (SCVWD, online Sheet 7 accessed at http://www.valleywater.org/uploadedFiles/Services/CleanReliableWater/WhereDoesYourWaterComeFrom/Reservoirs/AndersonDam/Anderson%20Dam%20Flood%20Inundation%20Maps%20Sheet%207.pdf?n=4660).

Landslides: The risk of landsliding is low because topography of the site is generally flat.

Ground Rupture: The risk of seismically induced ground rupture is low because the site is not crossed by any mapped active or potentially active faults.

Seismic Shaking: The project site is in an area of high seismicity. Based on general knowledge of the site seismicity, it should be anticipated that, during its useful life, the proposed project will be subject to at least one severe earthquake (magnitude 7 to 8+) that could cause considerable ground shaking at the site. It is also anticipated that the subject site will periodically experience small to moderate magnitude earthquakes.

Scour: Scour is not a consideration at the proposed over-crossing site because it does not cross a body of water. However, scour is likely at the drainage channel, detention basin and bio-filtration basin.

5. GEOTECHNICAL ANALYSIS AND CORROSION EVALUATION

5.1 DESIGN PARAMETERS

The engineering parameters used in our analyses were developed based on the field and laboratory data from this investigation. For slope stability analyses, the soil friction angles were lowered and a cohesion component was added (see Sections 5.2.2 and 5.3). In our opinion, this approach provides more representative factors of safety.

Based on depths to groundwater measured in our drill holes and CPT hole, we used a design groundwater level of 20 feet below existing ground surface for the proposed over-crossing and approach ramps, and 17 feet below existing ground surface for the proposed detention pond.

5.2 APPROACH FILLS

Approach fills up to about 35 feet above existing grades will be required at both ends of the over-crossing. Each side of the fill embankments will have a slope of 3:1 (horizontal:vertical) down to a mechanically stabilized embankment (MSE) up to about 16 feet high. The ends of the approach fills in front of the abutments will have an inclination of 1½:1 (h:v) and paved with concrete.

5.2.1 Settlement of Fill Embankments

The weight of the approach fill embankments will induce consolidation settlement in the underlying soils. We have estimated the magnitude of primary consolidation settlement in the subsurface soils under the various thicknesses of fills, presented in Table 5.2-1 below. The thickness and configuration of the fill were based on the project design plans, with the MSE walls incorporated.

Table 5.2-1
Estimated Primary Consolidation Settlement

Station	Approximate Fill Thickness (feet)	Estimated Settlement (inches)
179+00 & 181+30	35	3 to 6
177+40 & 183+70	30	3 to 6
176+20 & 184+90	25	2 to 5
175+30 & 185+80	20	1 to 4
174+30 & 187+00	15	1 to 3

Primary consolidation settlement in the sand and gravel layers is expected to occur as the fill is being placed. Consolidation settlements in the clay layers will take longer. Based on the results of the laboratory consolidation tests, we have estimated 1 to 1½ months will be required to complete approximately 90 percent of the estimated primary settlement. A settlement period of at least 45 days is recommended. The actual rate of settlement should be monitored in the field to allow adjustment of the estimated settlement period.

5.2.2 Stability of Approach Fill Embankments

The stability of the approach fill embankments was evaluated. The cross-section used in our analysis includes a 35-foot high fill embankment located 25 feet away from the proposed drainage channel. The fill embankment has a 3:1 (h:v) side slope down to a 16-foot high MSE wall. A 240-psf vertical surcharge was applied at the top of the embankment to simulate traffic loads, typical of Caltrans design. The side slopes of the drainage channel has an inclination of 2:1 (h:v) and a vertical height of 10 feet. Groundwater was modeled at 20 and 0 feet below the ground surface. The properties of the soil materials used in our analysis and the calculated factors of safety are tabulated below.

Table 5.2-2
Soil Strengths Used in Stability Analysis of Approach Fills

Material	Total Unit Weight (pcf)	Effective Stress Envelope	
		Φ' (degrees)	c' (psf)
Engineered Fill	145	32	300
Upper Native Soil - Clayey Sand and Gravel	130	28	300
Native Alluvium at Depth - Clayey Sand and Gravel	140	35	100

Table 5.2-3
Results of Slope Stability Analysis of Approach Fills

Minimum Factor of Safety			
Static Stability		Seismic Stability (k_{eq} = 0.2)	Rapid Drawdown
GW @ 20'	GW @ 0'	GW @ 20'	GW @ 20'
1.74	1.7	1.2	1.6

5.3 DETENTION BASIN SLOPE STABILITY

The cross-section used in our slope stability analysis of the detention basin levee and bank includes a 3.5-foot high levee with 4:1 (h:v) side slopes on both the inboard and outboard sides. The levee is situated on a 1.5-foot high basin bank with a side slope of 4:1 (h:v). A 1-foot deep swale is adjacent to the toe of the pond bank. The proposed drainage channel is located 25 feet away from the basin. The drainage channel has a vertical height of 3.5 feet and a side slope inclination of 2:1 (h:v). The soil properties in Table 5.2-2 were used in our analysis.

Table 5.3-1
Results of Slope Stability Analysis of Detention Pond

Minimum Factor of Safety			
Static Stability		Seismic Stability (k_{eq} = 0.2)	Rapid Drawdown
GW = 17'	GW = 0'	GW @ 17'	GW @ 0'
5.3	4.7	2.8	4.0

5.4 LOCAL BORROW MATERIALS

It is anticipated that soils excavated from the proposed drainage channel, culverts, detention basin and bio-filtration basin will be used for construction of the proposed roadways, approach fills and levees for the basins. Based on the results of our grain size analyses, the materials from the upper approximately 10 feet below ground surface consist an average of 41 percent gravels, 44 percent sands and 15 percent of fines (silts and clays). In our opinion, these materials are generally acceptable for use as engineered fill in the construction of the proposed roadways and approach fills.

Recommendations for materials for the construction of levees around the proposed detention basin and bio-filtration basin are presented in Section 6.5, “Material for Engineered Fill,” of this report. Near-surface soils from the vicinity of DH-15 may not contain sufficient fines per Section 6.5. Mixed soils from the vicinity of DH-16 and DH-17 appear to be more suitable for levee construction.

5.5 CORROSION EVALUATION

Six selected soil samples from our drill holes were tested for corrosion potential. The laboratory test results are included in Appendix C and summarized in Table 5.4-1 below.

Table 5.4-1
Corrosion Test Results

Sample Boring Number and Depth	pH	Sulfate (ppm)	Minimum Resistivity (ohm-cm)	Chloride (ppm)
DH-1, 3-4 feet	7.6	N.D.	7,400	N.D.
DH-7, 5.5-6.5 feet	6.9	16	8,600	N.D.
DH-8, 15.5-16.5 & 20.5-21.5 feet	7.8	N.D.	5,600	N.D.
DH-8, 30.5-31.5 ft & 34.5 feet	7.7	N.D.	3,100	18
DH-9, 65.5 feet	7.6	N.D.	1,600	N.D.
DH-14 thru DH-17, 1 foot	6.8	46	3,700	16
N.D. = None detected based on a detection limit of 15 ppm				

According to Corrosion Guidelines Version 1.0, dated September 2003, prepared by Corrosion Technology Branch, Materials Engineering and Testing Services, Division of Engineering Services, California Department of Transportation, a site is considered to be corrosive if one or more of the following conditions exist for the representative soil and/or water samples taken at the site.

> *Chloride concentration is 500 ppm or greater, sulfate concentration is 2,000 ppm or greater, or the pH is 5.5 or less.*

Based on the above guidelines and laboratory test results, the samples tested do not meet Caltrans guidelines to be considered as “corrosive.”

6. EARTHWORK RECOMMENDATIONS

Earthwork construction should conform to the City of Morgan Hill Standards. General recommendations are presented below.

6.1 DEMOLITION, CLEARING AND GRUBBING

Prior to construction, areas to receive improvements should be cleared of designated existing improvements, deleterious materials, debris, obstructions, and stumps and primary roots of trees and brush (roots over 1 inch in diameter or longer than about 3 feet in length). Holes, depressions and voids that extend below the proposed finish grade should be cleaned and backfilled with engineered fill compacted to the recommendations in this report.

After clearing, surface vegetation and organic laden soils should be stripped. Organic laden soils are defined as soils with more than 3 percent by weight of organic content. The required stripping depth should be determined in the field by the geotechnical engineer at the time of construction. Stripped material may be stockpiled for use in landscape areas if approved by the project landscape architect, or otherwise removed from the site.

6.2 EXCAVATIONS

Excavations for this project will be required to achieve design grades, remove unsuitable materials, trench for underground utilities, and construct foundations, drainage channel, detention pond, bio-filtration basin, culverts, and bore pits. Construction, shoring and bracing of excavations should comply with the current CAL-OSHA safety standards and City of Morgan Hill requirements. The stability and safety of excavations, braced or unbraced, is the responsibility of the contractor.

Trench excavations adjacent to existing or proposed foundations should be above an imaginary plane having an inclination of 1½:1 (horizontal to vertical) extending down from the bottom edge of the foundations.

6.3 RECOMPACTION OF NEAR-SURFACE SOIL

Much of the surface and near-surface soils have been disturbed as a result of past agricultural activities. Therefore, after site clearing and stripping, areas to receive engineered fills and pavements should be over-excavated and re-compacted. The depth of over-excavation below existing ground surface should be a minimum of 24 inches in areas of the proposed approach fills (including the MSEs), and a minimum of 12 inches in areas of at-grade roadways and levees. The over-excavations should extend a minimum of 5 feet beyond the limits of the proposed improvements. Soil surfaces exposed by over-excavation should be prepared as recommended under Section 6.4 “Subgrade Preparation” below prior to further construction activities.

6.4 SUBGRADE PREPARATION

Subgrade soil in areas to receive engineered fills and pavements should be scarified to a minimum depth of 8 inches; moisture conditioned to about 1 to 3 percent above the laboratory optimum value, and compacted to the recommendations given under Section 6.6 “Engineered

Fill Placement and Compaction." Prepared soil subgrades should be non-yielding when proof-rolled by a fully loaded water truck or equipment of similar weight.

Subgrade preparation should extend a minimum of 5 feet beyond the limits of proposed improvements unless it is restrained by existing improvements. After the subgrades have been properly prepared, the areas may be raised to design grades by placement of engineered fill.

Soil with moisture content above optimum value should be anticipated during and shortly after rainy seasons. Unstable, wet or soft soil will require processing before compaction can be achieved. If construction schedule does not allow for air drying, other means such as lime treatment, excavation and replacement, geogrids or geotextile fabrics may be considered. The method to be used should be determined at the time of construction based on the actual site conditions. We recommend obtaining unit prices for subgrade stabilization during the construction bid process.

6.5 MATERIAL FOR ENGINEERED FILL

In general, on-site soils with an organic content of less than 3 percent by weight, free of any hazardous or deleterious materials, and meeting the gradation requirements below may be used as general engineered fill to achieve project grades, except when special material is required. The contractor should recognize that the on-site soil contains variable amounts of cobbles. Cobbles, if crushed into fragments smaller than 3 inches, may be used as part of the structural fill; otherwise, cobbles will have to be removed. The contractor should also recognize that some of the on-site soils may contain less fines than recommended below, and it may be necessary to blend some of the on-site soils to achieve a suitable soil mixture for project construction.

Except for the fills for construction of the proposed levees, engineered fill materials should not contain rocks or lumps larger than 3 inches in greatest dimension, should not contain more than 15 percent of the material larger than 1½ inches, and should contain a minimum of 13 percent passing the No. 200 sieve. In addition to these requirements, import fill, if necessary, should have a low expansion potential as indicated by Plasticity Index of 15 or less, or Expansion Index of less than 20.

Engineered fills for construction of the levees for the proposed detention basin and the bio-filtration basin should contain a minimum of 20 percent passing the No. 200 sieve and 100 percent passing the 2-inch sieve. The soils should have a Plasticity Index of between 8 and 40, and a maximum Liquid Limit of 45.

All import fills should be approved by the project geotechnical engineer prior to delivery to the site. At least five (5) working days prior to importing to the site, a representative sample of the proposed import fill should be delivered to our laboratory for evaluation.

6.6 ENGINEERED FILL PLACEMENT AND COMPACTION

Engineered fill should be placed in horizontal lifts each not exceeding 8 inches in thickness, moisture conditioned to the recommended moisture content, and mechanically compacted to the recommendations below. Relative compaction or compaction is defined as the percentage ratio of field dry density of soil to the laboratory maximum dry density determined by ASTM Test Method D1557, latest edition. Moisture conditioning of soils should consist of adding water to the soils if they are too dry and allowing the soils to dry if they are too wet.

Engineered fills should be compacted to a minimum of 90 percent relative compaction at moisture content between 1 and 3 percent above the laboratory optimum value unless noted otherwise.

The upper 18 inches of soil below the MSE walls and the MSE wall fill (reinforced soil zone) should be compacted to a minimum of 95 percent relative compaction. Except for the outer 5 feet measured horizontally from the embankment side slopes, the full width of embankment within 150 feet of bridge abutments should be compacted to a minimum of 95 percent relative compaction. The 150-foot limit of 95 percent compaction should be measured horizontally from the bridge abutment and either parallel or concentric with the roadway centerline. The rest of the approach fill embankments should be compacted to a minimum of 93 percent relative compaction.

A relative compaction of not less than 95 percent should be obtained for embankments under retaining wall footings without pile foundations within the limits established by inclined planes sloping 1.5:1 (horizontal:vertical) out and down from lines one foot outside the bottom edges of the footing.

In roadway areas, the upper 8 inches of the subgrade should be compacted at a minimum of 95 percent relative compaction. If fill is placed in roadway areas, the upper 24 inches below top of pavement should be compacted to a minimum of 95 percent relative compaction. Aggregate base in pavement areas should also be compacted to a minimum of 95 percent relative compaction at slightly above the optimum moisture content.

6.7 UTILITY TRENCH BACKFILL

Trench construction, including bedding and backfill, should conform to the City of Morgan Hill specifications. The City specifications call for 95 percent minimum relative compaction for trench backfill. Refer to Section 6.2 “Excavations” of this report for a discussion on utility trench excavations.

6.8 WET WEATHER CONSTRUCTION

If site grading and construction is to be performed during the winter rainy months, the owner and contractors should be fully aware of the potential impact of wet weather. Rainstorms can cause delay to construction and damage to previously completed work by saturating compacted pads or subgrades, or flooding excavations.

Earthwork during rainy months will require extra effort and caution by the contractors. The contractor should be responsible to protect his work to avoid damage by rainwater. Standing pools of water should be pumped out immediately. Construction during wet weather conditions should be addressed in the project construction bid documents and/or specifications. We recommend the grading contractor submit a wet weather construction plan outlining procedures they will employ to protect their work and to minimize damage to their work by rainstorms.

7. FOUNDATION RECOMMENDATIONS

7.1 BRIDGE FOUNDATIONS

7.1.1 Bridge Pile Foundations - Axial Capacity

The abutments and interior bent of the proposed over-crossing may be supported on reinforced concrete cast-in-drilled-hole (CIDH) piles. The required lengths of the CIDH piles to carry the design vertical loads provided by the project structural engineer were calculated based on adhesion or skin friction between the pile shafts and the surrounding soils. The CIDH piles should have a minimum diameter of 24 inches.

Piles should be spaced at least three pile diameters apart, center to center. At this pile spacing, a pile group efficiency value of 1.0 is recommended for axial capacity.

Table 7.1-1 below presents the design loads, bottom of footing elevations, design tip elevations, and specified tip elevations for the CIDH piles at each support.

Table 7.1-1
Pile Data Table for CIDH Piles

Location	Pile Type	Nominal Resistance (kips)		Bottom of Pile Footing Elev. (feet)	Design Tip Elevations (feet)	Specified Tip Elevation (feet)
		Compression	Tension			
Abutment 1	24-inch CIDH	400	0	335.0	287 (1) 287 (3) 287 (4)	287
Bent 2	24-inch CIDH	500	250	312.0	254 (1) 269 (2) 254 (3) 254 (4)	254
Abutment 3	24-inch CIDH	400	0	335.0	287 (1) 287 (3) 287 (4)	287
Abut. 1 & Abut. 3 Wing Walls	24-inch CIDH	100	0	347.0 or 349.0	327 (1) 327 (3) 327 (4)	327

The axial pile capacity was calculated using the computer program AllPile Version 7 which uses the procedures described in the Federal Highway Administration manual “Drilled Shafts: Construction Procedures and Design Methods” (FHWA-IF-99-025). For Abutment 1, Bent 2 and Abutment 3, the soil properties from DH-8, CPT-1 and DH-9 were used, respectively, in our analysis. We considered the average undrained shear strength of the clayey soils and the average SPT blow counts of the sandy and gravelly soils. A factor of safety of 2 was used between allowable loads and ultimate loads.

Downdrag force on piles due to ground settlement under the fill embankments was neglected because primary consolidation is expected to be essentially completed at the end of the settlement period. No downdrag force due to liquefaction-induced settlement was included because liquefaction is not a major factor for the proposed over-crossing.

The CIDH piles are anticipated to be constructed through granular soils with little or no cohesion. Temporary steel casings should be provided to prevent caving of the CIDH holes.

The CIDH piles for the center bent are likely to extend below groundwater table. Design and construction of these CIDH piles should consider the presence of groundwater.

7.1.2 Pile Settlement

Settlement of the pile foundations will be due to elastic shortening of the piles and compression of the soils supporting the piles. For the loads presented in Table 7.1-1, the estimated post-construction total settlement of a CIDH pile is less than 3/4 inch, with estimated differential settlement of ½ inch between adjacent supports.

The above settlement value is in addition to the settlements induced by the approach fills at the abutments. To reduce downdrag force on the piles due to settlements induced by the approach fills, the piles should be constructed after the approach fills have completed their settlement. Refer to Section 5.2.1 of this report for recommended settlement period.

7.1.3 Lateral Pile Capacity

The lateral load resistance of a pile is a function of the stiffness of the surrounding soil, the stiffness of the pile, the allowable deflection at the top of the pile, the allowable moment capacity of the pile cross section. The ability of a 24-inch diameter CIDH pile to resist lateral load applied at the top of the pile was evaluated using the computer program AllPile Version 7. The analysis was based on properties of soil encountered in our drill holes and CPT hole, concrete compressive strength (f_c') of 4,000 psi and concrete modulus of elasticity (E) of 3,600 kips per square inch. The results of our analysis for an isolated pile under free head condition are summarized in Table 7.1-2 below. For fixed head condition, the results of our analysis are summarized in Table 7.1-3 below.

Table 7.1-2
Results of Lateral Load Analysis on a CIDH Pile for Free Head Condition

Location	Pile Type	Pile Head Displacement (inches)	Shear at Pile Head (kips)	Maximum Bending Moment in Piles (kips-feet)	Depth to Maximum Bending Moment (feet)
Abutment 1	24-inch CIDH	0.25	31	120.8	7
		0.5	57	237.5	7
		1.0	92	430.8	7.7
		2.0	142	755.8	8.5
Bent 2	24-inch CIDH	0.25	39	154.2	6
		0.5	72	289.2	6.5
		1.0	124	507.5	6.7
		2.0	188	866.7	7.5
Abutment 3	24-inch CIDH	0.25	30	113.3	6.5
		0.5	56	228.3	6.8
		1.0	89	407.5	7.5
		2.0	137	712.5	8.2

Table 7.1-3
Results of Lateral Load Analysis on a CIDH Pile for Fixed Head Condition

Location	Pile Type	Pile Head Displacement (inches)	Shear at Pile Head (kips)	Maximum Bending Moment in Piles (kips-feet)	Depth to Maximum Bending Moment (feet)
Abutment 3	24-inch CIDH	0.25	30	113.3	6.5
		0.5	56	228.3	6.8
		1.0	89	407.5	7.5
		2.0	137	712.5	8.2
Abutment 1	24-inch CIDH	0.25	140	450	±7.5
		0.5	235	815	±8.5
		1.0	395	1445	±9
Bent 2	24-inch CIDH	0.25	180	520	±7.5
		0.5	290	920	±7.5-8.5
		0.75	395	1305	±8-8.5
Abutment 3	24-inch CIDH	0.25	125	400	±8
		0.5	220	760	±8.5
		0.75	295	1065	±8.5-9
		1.0	360	1345	±9

The lateral loads presented in Tables 7.1-2 and 7.1-3 are for short-term loading conditions. For sustained lateral loads, 80 percent of the lateral loads should be used. For piles in a group, a group capacity reduction factor should be used as shown below.

Center-to-Center Pile Spacing (Pile Diameters)	Lateral Resistance Reduction Factor
6	1.0
5	0.9
4	0.8
3	0.7

In general, the allowable lateral displacement is 0.25 inches for the abutments which are designed for service load conditions and 1 inch for the interior bent which is designed for ultimate load condition.

7.2 CULVERTS

The proposed culverts at Fisher Avenue, Maple Avenue, Monterey Road and Watsonville Road will consist of Caltrans standard cast-in-place, reinforced concrete double box culverts (Caltrans Standard Plans, Sheet D81) with standard wingwalls (Caltrans Standard Plans, Sheets D84).

Table 7.2-1
Anticipated Foundation Soil Conditions for Culverts

Culvert Location	Approximate Average Culvert Invert Elevation (Feet)	Approximate Average Bottom of Wing Wall Footing Elevation (Feet)	Anticipated Foundation Soil Conditions
Fisher Avenue	314	309.7 (south) 310.3 (north)	Medium dense well graded gravel with sand and clay
Maple Avenue	308.4	304.1 (south) 304.7 (north)	Dense clayey sand with gravel
Watsonville Road	310.9	307.2 (west) 306.5 (east)	Medium dense poorly graded gravel with sand and clay
Monterey Road	310	305.9	Medium dense poorly graded gravel with sand and clay

For evaluation of the proposed culvert and wing wall foundations, a net allowable soil bearing pressure of 3,000 pounds per square foot is recommended based on the materials encountered in our drill holes in the vicinity of the proposed culverts.

The proposed cutoff walls at the upstream and downstream ends of the culverts and the footings for the culvert wing walls should extend a minimum of 12 inches below the anticipated depth of scour.

7.3 MECHANICALLY STABILIZED EMBANKMENTS

Mechanically Stabilized Embankments (MSEs), identified as Retaining Wall No. 1 through Retaining Wall No. 4 on the project plans, will be constructed along both sides of the approach fill embankments at both ends of the proposed over-crossing. The MSEs will be up to about 16 feet high. The slope above the MSEs will have an inclination of 3:1 (h:v) up to the roadway surface.

We understand Caltrans standard MSE walls are being considered. Two loading conditions are provided in Caltrans Bridge Design Aids Section 3-8, Interim, dated September 2008. Loading Condition 1 is for MSEs with a level backfill and a 240-psf surcharge load above. Loading Condition 2 is for MSEs with a 2:1 (h:v) continuous backfill slope. Loading Condition 2 is more applicable for the proposed MSEs for this project. Under Loading Condition 2, the minimum base width should equal to the design height of the MSE wall which is the sum of the exposed height and the embedment depth of the MSE wall above the top of the leveling pad.

Assuming the excavated soils from construction of the proposed drainage channel and detention pond will be used for construction of the MSE walls, the following parameters may be used for design of the MSE walls.

Soil internal friction angle (reinforced and retained soils) = 34 degrees

Soil internal friction angle (foundation soil) = 32 degrees

Soil unit weight = 120 pounds per cubic foot (reinforced, retained and foundation soils)

Factors of safety against bearing capacity, sliding, overturning, and global stability for the proposed MSE structures should comply with FHWA guidelines. For seismic design, one-third of the factored PGA value or 0.2g, whichever is less, may be used in the evaluation of seismic stability. This approach is accepted by Caltrans.

Preparation of soil subgrade under the MSE should be as recommended under Section 6, “Earthwork Recommendations.”

7.3.1 Structural Backfill for MSE Walls

Structural backfill should consist of material free from organic material and substantially free of shale or other soft, poor durability particles, should not contain slag aggregate or recycled materials, such as glass, shredded tires, Portland cement concrete rubble, or asphaltic concrete rubble, or other unsuitable material as determined by the Geotechnical Engineer. Structural backfill should also comply with the following requirements. The backfill should have a minimum angle of internal friction, ϕ, of 34 degrees when compacted as recommended under Section 6.6, “Engineered Fill Placement and Compaction.”

Gradation Requirements		
Sieve Size	**Percentage Passing**	**California Test**
159 mm (6”)	100	202
75 mm (3”)	78 – 100	202
4.75 mm (No. 4)	- -	202
600 μm (No. 30)	0 – 60	202
75 μm (No. 200)	0 – 25	202

Property Requirements		
Test	**Requirement**	**California Test**
Sand Equivalent	12 min.	217
Plasticity Index	10 max.	204
Minimum Resistivity	1500 ohm-cm min.	643
Chlorides	< 500 ppm	422
Sulfates	< 2000 ppm	417
pH	5.5 to 10.0	643
Note: If 12 percent or less passes the No. 200 (75 μm) sieve and 50 percent or less passes the No. 4 (4.75 mm) sieve, the sand equivalent and plasticity index requirements may be waived.		

Water used within 500 feet of the earth retaining structures with metallic soil reinforcement should comply with Section 90-2.03, “Water,” of the Caltrans Standard Specifications.

Structural backfill material should be placed and compacted simultaneously with the erection of the facing panels. Placement and compaction should be accomplished without distortion of the soil reinforcement or displacement of facing panels. Structural backfill at the front of the wall should be completed before backfilling more than 15 feet above the bottom of the lowermost face element.

Hand-held or hand-guided compaction equipment should be used to compact structural backfill material within 3 feet of the facing panels. At each level of the soil reinforcement, the structural backfill should be constructed to a plane 0.1 foot above the elevation of the soil reinforcement connection, and should start 3 feet from the back of the face panel and extend at least the remaining length of soil reinforcement. This grading should be complete before placing the next layer of soil reinforcement.

7.3.2 Drainage System for MSE Walls

The drainage system should conform to the details shown on the plans. Permeable material should be Class 1, Type B, conforming to the provisions in Section 68-1.025, “Permeable Material,” of the Caltrans Standard Specifications, and should meet the requirements for minimum resistivity, chlorides, sulfates and pH listed in Section 7.3.1 above.

7.4 ABUTMENTS AND WING WALLS

The abutments and wing walls for the proposed over-crossing should be designed to resist earth pressures due to adjacent soil (given below) and any surcharge loads adjacent to the walls.

Lateral Earth Pressure	Equivalent Fluid Weight (lb/ft^3)
Active Earth Pressure	37
At Rest Earth Pressure	56
Seismic Active Earth Pressure	30
Passive Earth Pressure (ultimate)	300

Active earth pressure should be used for walls where the top of walls is allowed to move laterally at least 0.5 percent of the total wall height. Where walls are restrained to allow sufficient lateral movement at the top, the at-rest earth pressure should be used in design. In addition to the lateral earth pressures above, the Bridge Design Specifications indicate a traffic live load surcharge equals to 2 feet of soil should be applied to the abutment walls. A minimum soil density of 120 pcf may be used for this purpose.

To account for seismic effect on the wall, we have calculated the seismic surcharge based on the Mononabe-Okabe procedures using an acceleration value equal to one-half of the factored horizontal peak ground acceleration of 0.6g. The seismic earth pressure should be applied to the wall at a height of 0.6H above the base of the wall in addition to the active or at-rest earth pressure. H is defined as the vertical height of the design plane from the wall base to the ground surface above.

The lateral earth pressures above are for level backfill slope behind the walls and fully drained wall backfill. Refer to Caltrans Standard Plan BO-3 (Caltrans, 2006) for drainage behind walls. The wall backfill material should not be placed until the walls have gained sufficient strength as determined by the Engineer.

7.5 OTHER RETAINING WALLS

7.5.1 Retaining Wall at Watsonville Road and Monterey Road

A Caltrans Type 1 retaining wall is proposed along the northern bank of Llagas Creek between the east end of the new culvert under Watsonville Road and the west end of the existing culvert under Monterey Road. This wall will be about 12 feet high and about 48 feet long.

This wall should be designed using the lateral soil pressures provided in Section 7.4, "Abutments and Wing Walls" above, plus any applicable surcharge forces, except that the passive earth pressure should be reduced by 50 percent for wall footing founded on slopes with inclination of 2:1 (horizontal:vertical). Based on the design plans, the bottom of the wall footing will be at approximately elevation 306.3 feet. At this elevation, the wall footing would be bearing on a stiff to very stiff clay layer (see DH-12). For this clay layer, a net allowable soil bearing pressure of 3,300 pounds per square foot may be used in the design of the wall footing for dead plus live load condition. This allowable soil bearing pressure may be increased by one-third when including short-term transient loads, such as seismic loading. The bottom of the wall footings should be a minimum of 12 inches below the anticipated depth of scour.

A subsurface drain should be provided behind the walls as shown on the Caltrans standard plans for Type 1 retaining wall.

7.5.2 Retaining Wall No. 5

Retaining Wall No. 5 will be constructed on the western bank of the proposed drainage channel along the east side of new Butterfield Boulevard and south of Tennant Avenue. This wall will be about 408 feet long, about 4 to 6 feet high, and extend between roughly 61 feet left of Station "B" 156+92.99 and roughly 55 feet left of Station "B" 158+93.41.

This wall should be designed using the lateral soil pressures provided in Section 7.4, "Abutments and Wing Walls" above, plus any applicable surcharge forces. Based on the design plans, the top of the wall footing will be at approximately elevation 324.32 or 323.32 feet. Assuming standard Caltrans Type 5 wall footing depth of 1 foot 4 inches for design wall height of 4 and 6 feet, the bottom of wall footing will be at roughly elevation 323 to 322 feet. At these elevations, the wall footing is anticipated to be bearing on medium dense to dense silty sand and clayey sand (see DH-1 and DH-2). For this soil layer, a net allowable soil bearing pressure of 3,300 pounds per square foot may be used in the design of the wall footing for dead plus live load condition. This allowable soil bearing pressure may be increased by one-third when including short-term transient loads, such as seismic loading.

The bottom of the wall footings should extend to such depth to provide a minimum horizontal offset of 5 feet below the face of the creek bank and the face of the wall footing at the bottom of footing level, but not less than 12 inches below the anticipated depth of erosion or scour, whichever provides a deeper embedment.

A subsurface drain should be provided behind the walls as shown on the Caltrans standard plan Sheet B0-3.

7.5.3 Retaining Wall along West Side of New Butterfield Boulevard

A retaining wall up to about 2 feet high is proposed along the west side of new Butterfield Boulevard and south of Tennant Avenue, as shown on Sheet 17 of the project plans. This wall will be roughly 100 to 120 feet long.

This wall should be designed using the lateral soil pressures provided in Section 7.4, "Abutments and Wing Walls" above, plus any applicable surcharge forces. A net allowable soil bearing pressure of 3,000 pounds per square foot may be used in the design of the wall footing for dead plus live load condition. This allowable soil bearing pressure may be increased by one-third when including short-term transient loads, such as seismic loading. The bottom of the wall footings should be a minimum of 12 inches below the lowest adjacent finish grade.

A subsurface drain should be provided behind the walls as shown on the Caltrans standard plan Sheet B0-3.

7.6 PAVEMENTS

New roadway pavements will be constructed for the Butterfield Boulevard extension and the realignment of Fisher Avenue and Watsonville Road. We understand the new section of Butterfield Boulevard will have a design traffic index of 8.0.

Laboratory R-value tests were performed on six bulk samples collected for this investigation. The measured R-values range from 44 to 70 for the five samples collected from the proposed Butterfield Boulevard and drainage channel areas. An R-value of 12 was measured on a bulk sample collected from the proposed detention pond area. R-values of 10 and 40 were used to calculate the recommended minimum pavement sections presented in Table 7.5-1 below, for traffic indices of 6.5, 7.0, 7.5 and 8.0.

The recommended minimum pavement sections for subgrade R-value of 40 may be used for at-grade roadways. Where fill will be placed to achieve design subgrade, the upper 12 inches of the fill should have a minimum R-value of 40. This would restrict the use of the material from the proposed detention pond area, with a measured R-value of 12. If this lower R-value material is to be used as pavement subgrade, a structural pavement section corresponding to subgrade R-value of 10 should be used.

Table 7.6-1
Recommended Minimum Structural Pavement Sections

SUBGRADE R-VALUE	TRAFFIC INDEX	ASPHALT CONCRETE (inches)	CLASS 2 AGGREGATE BASE (inches)	TOTAL (inches)
10	6.5	3.5	13.5	17.0
	7.0	4	14.5	18.5
	7.5	4.5	15.5	20.0
	8.0	4.5	17.0	21.5
40	6.5	4*	8*	12.0
	7.0	4*	8*	12.0
	7.5	4.5	8	12.5
	8.0	4.5	9	13.5

* The City minimum structural section of 4 inches of asphalt concrete over 8 inches of Class 2 Aggregate Base governs.

Pavement sections should be constructed on soil subgrades that have been prepared as outlined in the “Earthwork Recommendations” section of this report.

Asphalt Concrete should comply with the City of Morgan Hill specifications and Section 39 of the Caltrans Standard Specifications, latest edition. In the case of two asphalt concrete lifts, the first lift should be the base course, Type B, ¾-inch maximum aggregate size. The second lift should be the surface course, Type B, ½-inch maximum aggregate size. The Class 2 Aggregate Base material should conform to Section 26 of the Caltrans Standard Specifications.

8. POST-REPORT GEOTECHNICAL SERVICES

Post-report geotechnical services by Pacific Geotechnical Engineering (PGE), typically consisting of pre-construction design consultations and reviews, construction observation and testing services, are necessary for PGE to confirm the recommendations contained in this report. This report is based on limited sampling and investigation, and by those constraints may not have discovered local anomalies or other varying conditions that may exist on the project site. Therefore, this report is only preliminary until PGE can confirm that actual conditions in the ground conform to those anticipated in the report. Accordingly, as an integral part of this report, PGE recommends post-report geotechnical services to assist the project team during design and construction of the project. PGE requires that it perform these services if it is to remain as the project geotechnical engineer-of-record.

During design, PGE can provide consultation and supplemental recommendations to assist the project team in design and value engineering, especially if the project design has been modified after completion of our report. It is impossible for us to anticipate every design scenario and use of construction materials during preparation of our report. Therefore, retaining PGE to provide post-report consultation will help address design changes, answer questions and evaluate alternatives proposed by the project designers and contractors.

Prior to issuing project plans and specifications for construction bidding purposes, PGE should review the grading, drainage and foundation plans and the project specifications to determine if the intent of our recommendations has been incorporated in these documents. We have found that such a review process will help reduce the likelihood of misinterpretation of our recommendations which may cause construction delay and additional cost.

Construction phase services can include, among other things, the observation and testing during site clearing, stripping, excavation, mass grading, subgrade preparation, fill placement and compaction, backfill compaction, foundation construction and pavement construction activities.

Pacific Geotechnical Engineering would be pleased to provide cost proposals for follow-up geotechnical services. Post-report geotechnical services may include additional field and laboratory services.

9. LIMITATIONS

In preparing the findings and professional opinions presented in this report, we have endeavored to follow generally accepted principles and practices of the engineering geologic and geotechnical engineering professions in the area and at the time our services were performed. No warranty, express or implied, is provided.

The conclusions and recommendations contained in this report are based, in part, on information that has been provided to us. In the event that the general development concept or general location and type of structures are modified, our conclusions and recommendations shall not be considered valid unless we are retained to review such changes and to make any necessary additions or changes to our recommendations. To remain as the project geotechnical engineer-of-record, PGE must be retained to provide geotechnical services as discussed under the Post-report Geotechnical Services section of this report.

Subsurface exploration is necessarily confined to selected locations and conditions may, and often do, vary between these locations. Should conditions different from those described in this report be encountered during project development, PGE should be consulted to review the conditions and determine whether our recommendations are still valid. Additional exploration, testing, and analysis may be required for such evaluation.

Should persons concerned with this project observe geotechnical features or conditions at the site or surrounding areas which are different from those described in this report, those observations should be reported immediately to Pacific Geotechnical Engineering for evaluation.

It is important that the information in this report be made known to the design professionals involved with the project, that our recommendations be incorporated into project drawings and documents, and that the recommendations be carried out during construction by the contractor and subcontractors. It is not the responsibility of Pacific Geotechnical Engineering to notify the design professionals and the project contractors and subcontractors.

The findings, conclusions and recommendations presented in this report are applicable only to the specific project development on this specific site. These data should not be used for other projects, sites or purposes unless they are reviewed by PGE or a qualified geotechnical professional.

Report prepared by,

PACIFIC GEOTECHNICAL ENGINEERING

Chalerm (Beeson) Liang
GE 2031

Copies: addressee (10)

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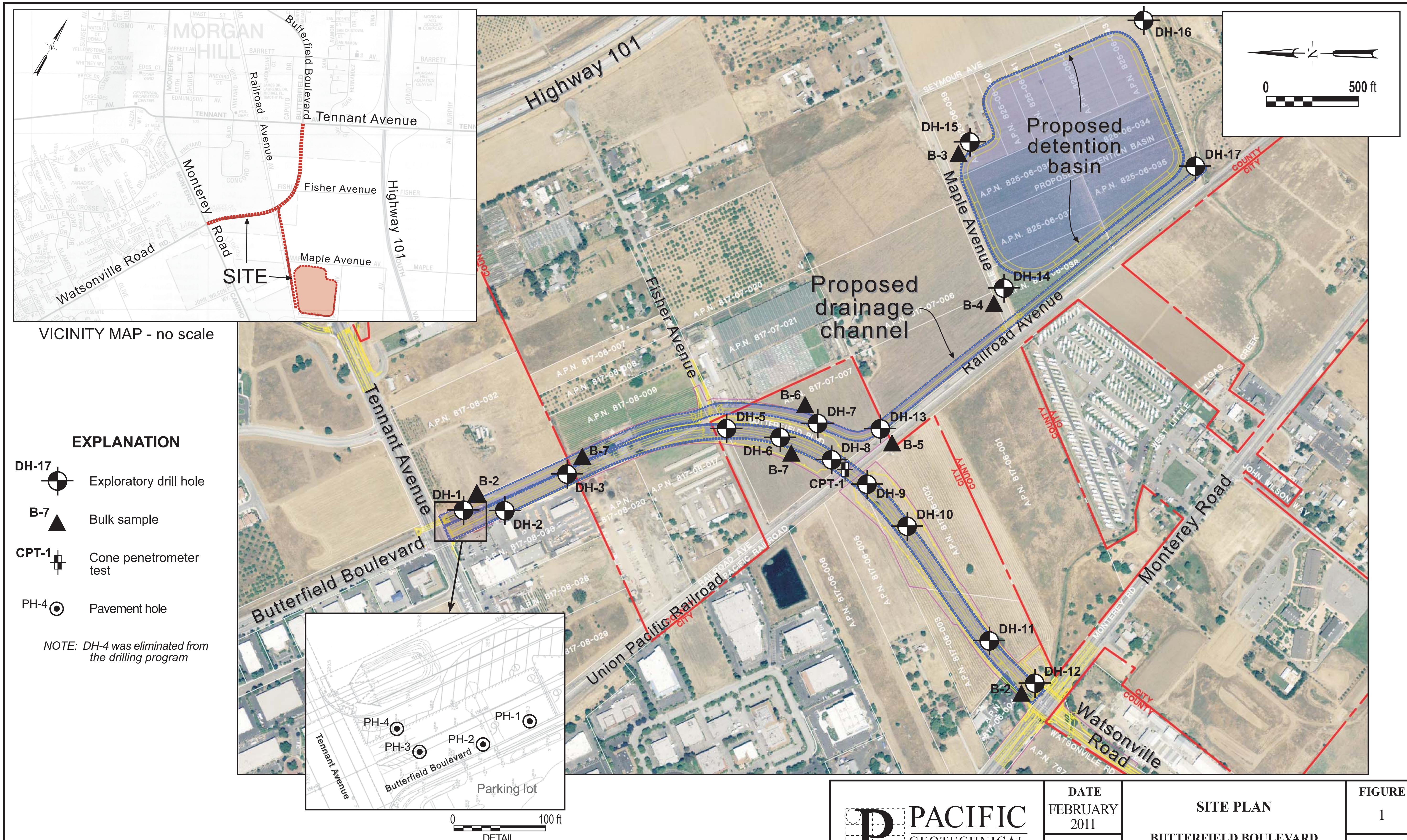
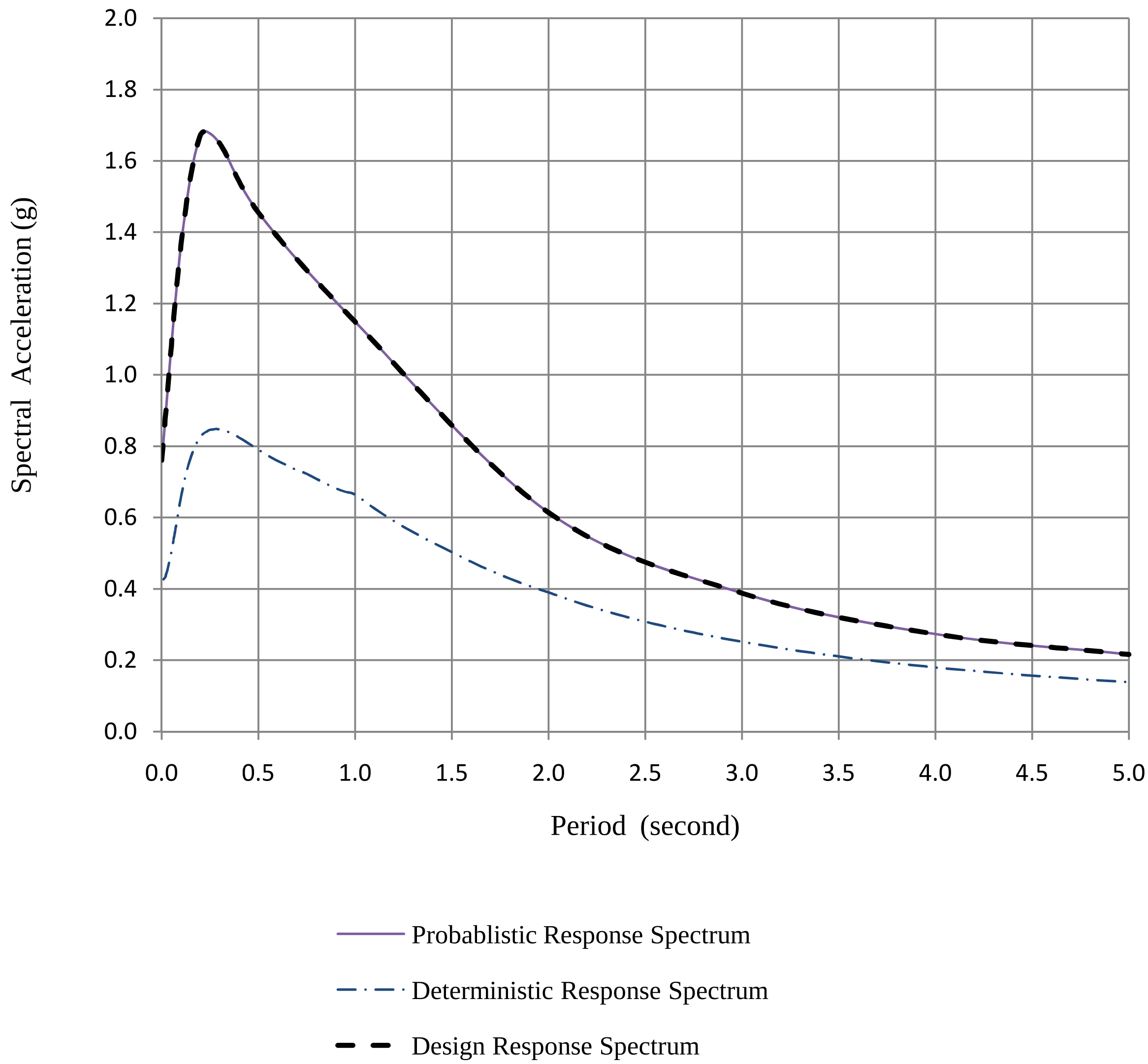


BASE: "Butterfield Boulevard South Extension Project." City of Morgan Hill, 9/9/09.

PACIFIC GEOTECHNICAL ENGINEERING	DATE FEBRUARY 2011	SITE PLAN BUTTERFIELD BOULEVARD EXTENSION MORGAN HILL, CALIFORNIA	FIGURE 1 PROJECT 2309E

DESIGN RESPONSE SPECTRUM
(5% DAMPING)



PACIFIC GEOTECHNICAL ENGINEERING
16055 Caputo Drive, Suite D, Morgan Hill, CA 95037

DESIGN ARS CURVE
BUTTERFIELD BOULEVARD EXTENSION
MORGAN HILL, CALIFORNIA

PLATE
2

Drafted by:		Date:	February-11
Checked by:		Revision:	

PROJECT
2309E

APPENDIX A

KEYS TO SOIL CLASSIFICATION

AND

DRILL HOLE LOGS

KEY TO SOIL CLASSIFICATION - FINE GRAINED SOILS

(50% OR MORE IS SMALLER THAN NO. 200 SIEVE SIZE)

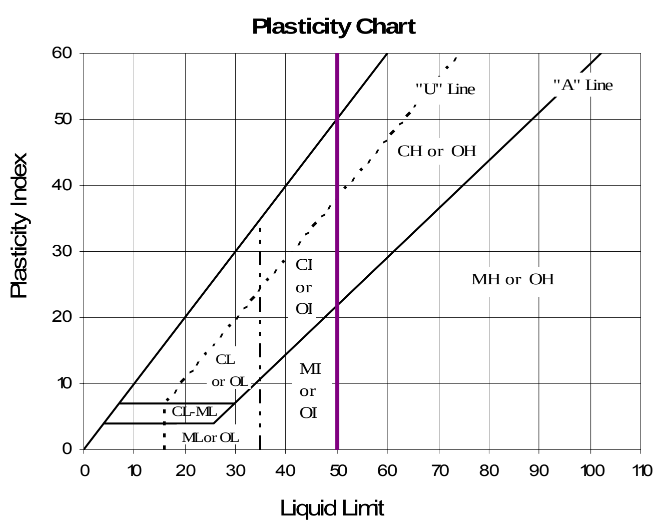
(modified from ASTM D2487 to include fine grained soils with intermediate plasticity)

MAJOR DIVISIONS			GROUP SYMBOLS	GROUP NAMES
SILTS AND CLAYS (Liquid Limit less than 35) Low Plasticity	Inorganic	PI < 4 or plots below "A" line	ML	Silt, Silt with Sand or Gravel, Sandy or Gravelly Silt, Sandy or Gravelly Silt with Sand or Gravel
	Inorganic	PI > 7 or plots on or above "A" line	CL	Lean Clay, Lean Clay with Sand or Gravel, Sandy or Gravelly Lean Clay, Sandy or Gravelly Lean Clay with Sand or Gravel
	Inorganic	PI between 4 and 7	CL-ML	Silty Clay, Silty Clay with Sand or Gravel, Sandy or Gravelly Silty Clay, Sandy or Gravelly Silty Clay with Sand or Gravel
	Organic	See footnote 3	OL	Organic Silt (below "A" Line) or Organic Clay (on or above "A" Line) (1,2)
SILTS AND CLAYS (35 ≤ Liquid Limit < 50) Intermediate Plasticity	Inorganic	PI < 4 or plots below "A" line	MI	Silt, Silt with Sand or Gravel, Sandy or Gravelly Silt, Sandy or Gravelly Silt with Sand or Gravel
	Inorganic	PI > 7 or plots on or above "A" line	CI	Clay, Clay with Sand or Gravel, Sandy or Gravelly Clay, Sandy or Gravelly Clay with Sand or Gravel
	Organic	See footnote 3	OI	Organic Silt (below "A" Line) or Organic Clay (on or above "A" Line) (1,2)
SILTS AND CLAYS (Liquid Limit 50 or greater) High Plasticity	Inorganic	PI plots below "A" line	MH	Elastic Silt, Elastic Silt with Sand or Gravel, Sandy or Gravelly Elastic Silt, Sandy or Gravelly Elastic Silt with Sand or Gravel
	Inorganic	PI plots on or above "A" line	CH	Fat Clay, Fat Clay with Sand or Gravel, Sandy or Gravelly Fat Clay, Sandy or Gravelly Fat Clay with Sand or Gravel
	Organic	See note 3 below	OH	Organic Silt (below "A" Line) or Organic Clay (on or above "A" Line) (1,2)

1. If soil contains 15% to 29% plus No. 200 material, include "with sand" or "with gravel" to group name, whichever is predominant.
2. If soil contains ≥30% plus No. 200 material, include "sandy" or "gravelly" to group name, whichever is predominant. If soil contains ≥15% of sand or gravel sized material, add "with sand" or "with gravel" to group name.
3. Ratio of liquid limit of oven dried sample to liquid limit of not dried sample is less than 0.75.

CONSISTENCY	UNCONFINED SHEAR STRENGTH (KSF)	STANDARD PENETRATION (BLOWS/FOOT)
VERY SOFT	< 0.25	< 2
SOFT	0.25 – 0.5	2 – 4
FIRM	0.5 – 1.0	5 – 8
STIFF	1.0 – 2.0	9 – 15
VERY STIFF	2.0 – 4.0	16 – 30
HARD	> 4.0	> 30

MOISTURE	CRITERIA
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below the water table



PACIFIC GEOTECHNICAL ENGINEERING

KEY TO SOIL CLASSIFICATION – COARSE GRAINED SOILS

(MORE THAN 50% IS LARGER THAN NO. 200 SIEVE SIZE)

(modified from ASTM D2487 to include fines with intermediate plasticity)

MAJOR DIVISIONS			GROUP SYMBOLS	GROUP NAMES[1]
GRAVELS (more than 50% of coarse fraction is larger than No. 4 sieve size)	Gravels with less than 5% fines	Cu ≥ 4 and 1 ≤ Cc ≤ 3	GW	Well Graded Gravel, Well Graded Gravel with Sand
		Cu < 4 and/or 1 > Cc > 3	GP	Poorly Graded Gravel, Poorly Graded Gravel with Sand
	Gravels with 5% to 12% fines	ML, MI or MH fines	GW-GM	Well Graded Gravel with Silt, Well Graded Gravel with Silt and Sand
			GP-GM	Poorly Graded Gravel with Silt, Poorly Graded Gravel with Silt and Sand
		CL, CI or CH fines	GW-GC	Well Graded Gravel with Clay, Well Graded Gravel with Clay and Sand
			GP-GC	Poorly Graded Gravel with Clay, Poorly Graded Gravel with Clay and Sand
	Gravels with more than 12% fines	ML, MI or MH fines	GM	Silty Gravel, Silty Gravel with Sand
		CL, CI or CH fines	GC	Clayey Gravel, Clayey Gravel with Sand
		CL-ML fines	GC-GM	Silty Clayey Gravel; Silty, Clayey Gravel with Sand
SANDS (50% or more of coarse fraction is smaller than No. 4 sieve size)	Sands with less than 5% fines	Cu ≥ 6 and 1 ≤ Cc ≤ 3	SW	Well Graded Sand, Well Graded Sand with Gravel
		Cu < 6 and/or 1 > Cc > 3	SP	Poorly Graded Sand, Poorly Graded Sand with Gravel
	Sands with 5% to 12% fines	ML, MI or MH fines	SW-SM	Well Graded Sand with Silt, Well Graded Sand with Silt and Gravel
			SP-SM	Poorly Graded Sand with Silt, Poorly Graded Sand with Silt and Gravel
		CL, CI or CH fines	SW-SC	Well Graded Sand with Clay, Well Graded Sand with Clay and Gravel
			SP-SC	Poorly Graded Sand with Clay, Poorly Graded Sand with Clay and Gravel
	Sands with more than 12% fines	ML, MI or MH fines	SM	Silty Sand, Silty Sand with Gravel
		CL, CI or CH fines	SC	Clayey Sand, Clayey Sand with Gravel
		CL-ML fines	SC-SM	Silty, Clayey Sand; Silty, Clayey Sand with Gravel

US STANDARD SIEVES	3 Inch	¾ Inch	No. 4	No. 10	No. 40	No. 200
	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES & BOULDERS	GRAVELS		SANDS			SILTS AND CLAYS

RELATIVE DENSITY (SANDS AND GRAVELS)	STANDARD PENETRATION (BLOWS/FOOT)
Very Loose	0 - 4
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 - 50
Very Dense	50+

1. Add “with sand” to group name if material contains 15% or greater of sand-sized particle. Add “with gravel” to group name if material contains 15% or greater of gravel-sized particle.

MOISTURE	CRITERIA
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soi is below the water table

PACIFIC GEOTECHNICAL ENGINEERING

DATE: 10/19/2009	**LOG OF EXPLORATORY DRILL HOLE**		**DH- 1**
PROJECT NAME: Butterfield Blvd. Extension		**PROJECT NUMBER:** 2309 E	
DRILL RIG: Mobile B53, 140# downhole hammer and wire winch		**LOGGED BY:** CSS	
HOLE DIAMETER: 8" hollow stem auger		**HOLE ELEVATION:** -----	
SAMPLER: D = 3" OD, 2½" ID Split-spoon X = 2½" OD, 2" ID Split-spoon I = Standard Penetrometer (2" OD SPT) S = Slough in sample		**GROUND WATER DEPTH:**	**Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: SILTY to CLAYEY SAND with GRAVEL: Dark brown (10YR 5/3), moist; medium dense; fine to coarse, subangular to subrounded sand; with fine to coarse, mostly rounded gravel	SM/ SC	1	S D D	17		15	22	7	4	91		
		2										
		3	S I I	32								
at 2.5 feet, yellowish brown (10YR 5/4); grades coarser with depth		4										
		5	S D D	26		9		7		92		
		6										
		7										
		8										
CLAYEY GRAVEL with SAND to CLAYEY SAND with GRAVEL: Dark grayish brown (10YR 4/2), moist, medium dense; fine to coarse sand; fine to coarse gravel; with cobbles	GC/ SC	9	S D D	33								
		10										
		11										
		12										
		13										
dense		14	S I I	42								
LEAN CLAY to LEAN CLAY with SAND: Dark yellowish brown (10YR 4/6), moist, very stiff to hard; with fine sand	CL	15										
		16										
		17										
		18										
BOTTOM OF HOLE = 20 Feet No Groundwater Encountered		19	S I I	48				17				
		20										

DATE: 10/19/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 2

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
8 to 10 inches asphalt; no baserock												
ALLUVIUM: CLAYEY SAND with GRAVEL: Dark brown (10YR 3/3), moist; medium dense; fine to coarse, subangular to subrounded sand; with fine to coarse, mostly rounded gravel and cobbles	SC	1	S									
		2	D D	23				8		92		
very dense		3	S D D	69								
		4										
		5	S									
dense		6	I I	32								
		7										
		8										
		9	S I I	34								
		10						25				
		11										
		12										
		13										
		14	S I I	33		19		9				
		15										
		16										
		17										
		18										
very dense		19	S D	91/								
BOTTOM OF HOLE = 20 Feet No Groundwater Encountered		20	D	11"				11		134		

DATE: 10/21/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 3

PROJECT NAME: Butterfield Blvd. Extension — **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch — **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger — **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
<u>ALLUVIUM</u>: CLAYEY SAND: Brown (10YR 4/3), moist; loose to medium dense; fine to medium subangular to subrounded sand	SC	1	SDD	14				12		107		
CLAYEY GRAVEL with SAND to CLAYEY SAND with GRAVEL: Dark brown (10YR 3/3), moist; medium dense; variable concentrations of fine to coarse, subangular to rounded sand and gravel; with cobbles; minor boulders likely	GC/SC	2										
		3	SDD	24								
		4										
		5										
medium dense to dense		6	SDD	46				5		146		
		7										
		8										
medium dense		9	SII	21		13		8				
		10										
		11										
		12										
		13										
minor intervals of SILTY CLAY to SILTY CLAY with SAND		14	SII	10								
		15										
		16										
		17										
		18										
		19	SDD	32				11				
BOTTOM OF HOLE = 20 Feet No Groundwater Encountered		20										

PACIFIC GEOTECHNICAL ENGINEERING

Drill Hole DH-4 was not drilled because right-of-entry was not obtained.

DATE: 10/21/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 5

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** 20 feet (end of drilling)

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist; loose to medium dense; fine to coarse, subangular to subrounded sand; fine to coarse, mostly subrounded gravel	SC/ GC	1	SDD	16		31		10		113		
		2										
		3	SDD	7								
		4										
WELL GRADED GRAVEL with SAND and CLAY: Dark brown (10YR 3/3), moist, medium dense; fine to coarse gravel; with fine to coarse sand and minor cobbles	GW-GC	5										
		6	SDD	25		12		10		122		
		7										
		8										
		9	SII	14								
		10										
		11										
		12										
		13										
		14	SII	18								
SILTY CLAY: Dark brown (10YR 3/3), moist, stiff	CL-ML	15										
		16										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: as above	SC/ GC	17										
		18										
		19	SDD	21								
SILTY CLAY: as above; with fine sand	CL-ML	20										
BOTTOM OF HOLE = 20 Feet												

DATE: 11/2/2009

LOG OF EXPLORATORY DRILL HOLE

DH- 6

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: CLAYEY SAND: Dark brown (10YR 3/3), moist; loose to medium dense; mostly fine to medium, subangular to rounded sand; with minor coarse sand and fine to coarse, subrounded to rounded gravel and cobbles	SC	1 2										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Brown to dark brown (10YR 4/3 to 3/3), moist; medium dense; variable concentrations of fine to coarse sand and gravel; sands are subangular to rounded; gravels are subrounded to rounded; with cobbles	SC/ GC	3 4 5 6 7 8 9	S D D	30				12		124		
dense		10 11 12	S I I	46								
CLAYEY SAND with GRAVEL: Brown (10YR 4/3), moist to wet; medium dense; fine to coarse sand; with fine gravel	SC	13 14	S I I	23		12		9				
15 feet: switch to 8" hollow stem augers with Mobile B61 rig, 140# downhole hammer and wire winch		15 16 17 18										
medium dense to dense		19 20	S I I	30								

DATE: 11/2/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 6
PROJECT NAME: Butterfield Blvd. Extension	PROJECT NUMBER: 2309 E	
DRILL RIG: Mobile B53, 140# above ground hammer and wire winch	LOGGED BY: CSS	
HOLE DIAMETER: 4" rods; mud rotary	HOLE ELEVATION: -----	
SAMPLER: D = 3" OD, 2½" ID Split-spoon; X = 2½" OD, 2" ID Split-spoon; I = Standard Penetrometer (2" OD SPT); S = Slough in sample	GROUND WATER DEPTH: Initial: --- Final: ---	

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND with GRAVEL: continued	SC											
		21										
		22										
		23										
very dense		24	SII	66								
		25										
		26										
CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist to wet; medium dense; fine to coarse gravel; with fine to coarse sand (locally grading to CLAYEY SAND with GRAVEL)	GC (SC)	27										
		28										
		29	SII	29		13		9				
		30										
		31										
		32										
		33										
dense		34	SII	37								
		35										
		36										
LEAN CLAY: Dark yellowish brown (10YR 4/4), moist; hard; feels silty; with manganese specks	CL	37										
		38										
		39	SDD	76/ 9"								
see next page		40										

DATE: 11/2/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 6

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist to wet; very dense; fine to coarse gravel; fine to coarse sand	SC/ GC	41										
	CI	42										
CLAY: Dark yellowish brown (10YR 4/4), moist; hard; minor fine sand; feels silty; with manganese specks		43										
		44	S D D	35	4.5 4.5			26		102		
		45										
		46										
		47										
Shelby was hard to push after 1 foot		48	Shelby	0 to 500 psi								
very stiff		49					49	27	24	95	11	5070 (TXUU)
at 50 feet, mottled strong brown (7.5YR 4/6) and pale brown (10YR 6/3)		50										
		51	S I I	30								
TXUU denotes unconsolidated undrained triaxial shear test		52										
		53										
		54										
		55	S I I	19	3.5 4.0			30				
		56										
		57										
		58										
		59										
BOTTOM OF HOLE = 60 Feet Groundwater Undetermined		60	S I I	32				25				

PACIFIC GEOTECHNICAL ENGINEERING

DATE: 10/21/2009	**LOG OF EXPLORATORY DRILL HOLE**	**DH- 7**

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** 20 feet (end of drilling)

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
<u>ALLUVIUM</u>: CLAYEY SAND: Dark brown (10YR 3/3), moist to wet; loose to medium dense; fine to medium, subangular to subrounded sand	SC	1	S D D	13				11		119		
		2										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist; medium dense; fine to coarse, subangular to rounded sand and gravel; with cobbles to boulders	SC/ GC	3	S D D	28				5		132		
		4										
		5	S I I	23								
		6										
		7										
		8										
medium dense to dense		9	S I I	30				5				
		10										
		11										
CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist, dense; fine to coarse gravel; with fine to coarse sand (locally grading to CLAYEY SAND with GRAVEL)	GC (SC)	12										
		13										
		14	S I I	42		13		9				
		15										
		16										
		17										
		18										
		19	S I I	34								
BOTTOM OF HOLE = 20 Feet		20										

PACIFIC GEOTECHNICAL ENGINEERING

DATE: 10/30/2009

LOG OF EXPLORATORY DRILL HOLE

DH- 8

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: CLAYEY SAND to CLAYEY SAND with GRAVEL: Dark brown (10YR 3/3), moist; medium dense; mostly fine to medium, subangular to rounded sand; with coarse sand and fine to coarse, subrounded to rounded gravel and cobbles	SC	1										
		2										
		3										
		4										
		5										
		6	S D D	37				10		137		
		7										
CLAYEY GRAVEL with SAND: Brown to dark brown (10YR 4/3 to 3/3), wet; dense; variable concentrations of fine to coarse, subangular to rounded sand and subrounded to rounded gravel	GC	8										
		9										
		10	S I I	39		13		14				
		11										
		12										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Brown to dark brown (10YR 4/3 to 3/3), moist; medium dense; fine to coarse, subangular to rounded sand; fine to coarse, subrounded to rounded gravel	SC/ GC	13										
		14										
		15										
		16	S I I	26								
		17										
		18										
		19										
		20										

DATE: 10/30/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 8

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: Initial: --- Final: ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: continued	SC/ GC	21	S I I	46								
		22										
		23										
		24										
CLAYEY GRAVEL with SAND: Brown (10YR 4/3), moist to wet; dense; fine gravel; with fine to coarse sand (locally grading to CLAYEY SAND with GRAVEL)	GC (SC)	25										
		26	S I I	41		14		13				
		27										
		28										
		29										
		30										
		31	S I I	53								
		32										
		33										
CLAYEY SAND: Brown (7.5YR 4/3 to 4/4), moist, medium dense to dense; mostly fine to medium subangular to subrounded sand	SC	34										
		35	S D D	46		28		16		124		
		36										
		37										
		38										
		39										
		40										

DATE: 10/30/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 8

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: Initial: --- Final: ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND: continued	SC		S I I	33								
		41										
		42										
		43										
		44										
		45										
		46										
		47										
FAT CLAY: Brown (7.5YR 4/4), moist; very stiff; minor fine sand; manganese specks	CH	48	Shelby	16 to 20 psi								
		49			3.4		58	28	33	94		
		50										
		51										
		52										
		53										
		54										
		55										
at 55 feet: brown (10YR 5/3) mottled with strong brown (7.5YR 4/3); hard		56	S D D	57	4.5 4.5+			23		103	15	8830 (TXUU)
TXUU denotes unconsolidated undrained triaxial shear test		57										
		58										
		59										
CLAYEY SAND: see next page	SC	60										

DATE: 10/30/2009	**LOG OF EXPLORATORY DRILL HOLE**	**DH- 8**

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND: Brown (7.5YR 4/4), moist; very dense	SC	61	S D	50/6"		41		16		123		
		62										
		63										
		64										
		65										
		66										
		67										
		68										
SANDY CLAY: Strong brown (7.5YR 5/6), moist; very stiff to hard; mostly fine sand	CI	69										
		70	S I I	48	4.5	60		21				
		71										
		72										
CLAYEY SAND: Dark grayish brown (10YR 5/2), wet; dense; mostly fine sand	SC	73										
		74										
		75										
		76	S I I	42		15		19				
		77										
		78										
		79										
		80										

DATE: 10/30/2009	**LOG OF EXPLORATORY DRILL HOLE**	**DH- 8**

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND: continued	SC											
		81										
		82										
		83										
CLAY to FAT CLAY with SAND: Mottled pale brown and strong brown (10YR 6/3 and 7.5YR 4/6), moist; very stiff; with minor specks of manganese	CI/ CH	84										
		85	S					32				
		86	I I	22								
CLAYEY SAND: Dark grayish brown (10YR 5/2), wet; dense; mostly fine to medium, subrounded to rounded sand	SC	87										
		88										
		89										
		90	S			15		22				
		91	I I	52								
		92										
		93										
		94										
		95										
		96										
		97										
		98										
BOTTOM OF HOLE = 100 Feet Groundwater Undetermined due to Mud Rotary Drilling Method		99	S I	53								
		100	I									

DATE: 11/3/2009

LOG OF EXPLORATORY DRILL HOLE

DH- 9

PROJECT NAME: Butterfield Blvd. Extension

PROJECT NUMBER: 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch

LOGGED BY: CSS

HOLE DIAMETER: 4" rods; mud rotary

HOLE ELEVATION: -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: CLAYEY SAND: Dark brown (10YR 3/3), moist; loose to medium dense; fine to coarse subangular to subrounded sand	SC											
		1										
		2										
CLAYEY SAND with GRAVEL: Brown (10YR 4/3), wet; medium dense; fine to coarse sand; with fine gravel and local cobbles	SC	3										
		4										
		5	S									
		6	I I	21		17		17				
		7										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Brown (10YR 4/3), moist; medium dense; variable concentrations of fine to coarse sand and gravel; with cobbles	SC/ GC	8										
		9										
		10	S									
		11	I I	25				15				
		12										
		13										
		14										
		15	S									
medium dense to dense		16	I I	30				15				
		17										
		18										
		19										
		20										

DATE: 11/3/2009

LOG OF EXPLORATORY DRILL HOLE

DH- 9

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: continued	SC/GC	21	S I I	34								
		22										
		23										
		24										
		25										
medium dense		26	S I I	24				16				
		27										
		28										
CLAYEY SAND with GRAVEL: Brown (10YR 4/3), wet; very dense; fine to coarse sand; with fine to coarse gravel	SC	29										
		30										
		31	S I	50/5"		12		13				
		32										
CLAY: Mottled brown and strong brown (10YR 5/3 to 7.5YR 4/6), moist, very stiff	CI	33										
		34										
		35										
		36	S D D	30	3.5 3.25			24		105		
CLAYEY SAND with GRAVEL: Brown (10YR 4/3), moist; medium dense; variable concentrations of fine to coarse subangular to rounded sand; with fine gravel	SC	37										
		38										
		39										
		40										

DATE: 11/3/2009	**LOG OF EXPLORATORY DRILL HOLE**	**DH- 9**

PROJECT NAME:	Butterfield Blvd. Extension	**PROJECT NUMBER:**	2309 E
DRILL RIG:	Mobile B53, 140# above ground hammer and wire winch	**LOGGED BY:**	CSS
HOLE DIAMETER:	4" rods; mud rotary	**HOLE ELEVATION:**	-----
SAMPLER:	D = 3" OD, 2½" ID Split-spoon X = 2½" OD, 2" ID Split-spoon I = Standard Penetrometer (2" OD SPT) S = Slough in sample	**GROUND WATER DEPTH:**	**Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND with GRAVEL: continued	SC		S I I									
		41		45		19		14				
		42										
		43										
		44										
		45										
LEAN CLAY: Brown (7.5YR 4/4), moist; very stiff; minor fine sand	CL	46										
		47	S D D		2.5			17		119		
CLAYEY SAND with GRAVEL: Brown (10YR 4/3), moist, medium dense; fine to coarse sand; with fine to coarse gravel	SC	48		27								
		49										
		50										
		51										
LEAN CLAY: Brown (7.5YR 4/4), moist; very stiff; with manganese specks	CL	52										
		53										
		54										
		55										
		56	Shelby	400 to 500-700 psi			34	21	14	97		
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: as above	SC/GC	57										
		58										
		59										
LEAN CLAY to CLAY: see next page	CL/CI	60										

DATE: 11/3/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 9

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: Initial: --- Final: ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
LEAN CLAY to CLAY: Brown (7.5YR 4/4), moist, very stiff; with manganese specks	CL/ CI											
		61										
		62										
		63										
		64										
at 65 feet: hard; with manganese specks		65	S									
		66	D D	81	4.5+ 4.5+			22		111		
		67										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Brown (10YR 4/3), moist; very dense; variable concentrations of fine to coarse, subangular to rounded sand and gravel	SC/ GC	68										
		69										
		70	S									
		71	I I	63								
		72										
		73										
		74										
Strong brown (7.5YR 4/6); mostly fine sand		75	S									
		76	I I	90/ 11"		15		11				
		77										
		78										
		79										
LEAN CLAY to CLAY: see next page		80	S									

DATE: 11/3/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 9

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
LEAN CLAY to CLAY: Yellowish brown (10YR 4/6), moist, firm	CL/CI	81	SII	13								
CLAYEY SAND: Yellowish brown (10YR 4/6), moist, dense; mostly fine to medium, subangular to subrounded sand	SC	82										
		83										
		84										
		85	SII									
		86		47		15		20				
		87										
		88										
		89										
CLAY to SANDY CLAY: Yellowish brown (10YR 5/6), moist; stiff; with fine sand	CI	90	SII									
		91		22				19				
		92										
CLAYEY SAND with GRAVEL: Strong brown (7.5 YR 4/6), moist, dense; mostly fine sand; with fine gravel	SC	93										
		94										
		95	SII									
		96		32				23				
SANDY CLAY: Strong brown (7.5 YR 5/6), moist, stiff; with fine sand		97										
		98										
	CI	99	SII	21				31				
BOTTOM OF HOLE = 100 Feet Groundwater Undetermined due to Mud Rotary Drilling Method		100										

DATE: 11/4/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 10

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: CLAYEY SAND: Dark brown (10YR 3/3), moist; loose to medium dense; fine to coarse, subangular to subrounded sand; with minor subrounded to rounded gravel	SC	1										
		2										
		3										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist; dense; variable concentrations of fine to coarse, subangular to rounded sand and fine to coarse, subrounded to rounded gravel; with cobbles	SC/ GC	4										
		5										
		6	SII	37				13				
		7										
		8										
		9										
		10										
		11	SII	38				14				
		12										
		13										
		14										
LEAN CLAY/SILT: brown (10YR 4/3), moist; soft to firm; minor fine sand	CL/ ML	15										
		16	SII	15	0.25			24				
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist; dense; variable concentrations of fine to coarse, subangular to rounded sand and fine to coarse subrounded to rounded gravel	SC/ GC	17										
		18										
		19										
		20										

DATE: 11/4/2009

LOG OF EXPLORATORY DRILL HOLE

DH- 10

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: continued, very dense	SC/ GC	21	S I I	50/6"								
		22										
		23										
		24										
		25	S									
dense to very dense		26	I I	51		15		15				
		27										
		28										
at 29 to 30 feet: drills gravelly; possible cobbles		29										
		30	S									
		31	I I	56								
		32										
		33										
CLAY: Mottled yellowish brown (10YR 5/4) and strong brown (7.5YR 5/6), moist; very stiff; with minor manganese specks	CI	34										
		35	S									
		36	D D	24	3.25 2.5			27		100	15	4839
		37										
		38										
SILTY SAND: Mottled brown and dark yellowish brown (10YR 5/3 and 4/4), moist; medium dense; fine sand	SM	39										
		40										

DATE: 11/4/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 10

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# above ground hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 4" rods; mud rotary **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: Initial: --- Final: ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
SILTY SAND: continued	SM		S									
		41	I	18								
			I			40	24	24	2			
		42										
LEAN CLAY: Mottled light grayish brown (10YR 6/2) and strong brown (7.5YR 4/6), moist; stiff to very stiff; with minor fine sand; feels silty; with manganese specks	CL	43										
		44										
		45	S									
		46	I	14								
			I									
		47										
		48										
		49										
		50	Shelby	50								
		51		100								
				150								
stiff		52		450				40		81	7	3350
TXUU denotes unconsolidated undrained triaxial shear test				psi	3.5							(TXUU)
		53										
		54										
		55	S									
		56	D	26	4.5+							
			D		3.5			34		92		
		57										
very stiff		58										
BOTTOM OF HOLE = 60 Feet Groundwater Undetermined due to Rotary Wash Drilling Method		59	S									
			D	39	4.5+							
		60	D		4.5+			45		76	8	4224 (TXUU)

DATE: 10/19/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 11

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: SANDY LEAN CLAY to CLAYEY SAND: Dark yellowish brown (10YR 4/4), moist; stiff clay/loose to medium dense sand; mostly fine, subangular to subrounded sand	CL/SC	1	SDD	12				13		120		
		2										
		3	SDD	10				13		118		
		4										
		5										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Brown (10YR 4/3), moist; very dense; concentrations of fine to coarse, subangular to subrounded sand and gravel	SC/GC	6	SD	50/5"								
		7										
		8										
		9	SII	57				7				
		10										
		11										
		12										
		13										
		14	SDD	69				8		133		
		15										
		16										
LEAN CLAY to CLAY: Mottled pale brown (10YR 6/3) and dark yellowish brown (10YR 4/6), moist, stiff	CL/CI	17										
		18										
		19	SDD	42	0.5 3.0			26		101		
BOTTOM OF HOLE = 20 Feet No Groundwater Encountered		20										

DATE: 10/19/2009	**LOG OF EXPLORATORY DRILL HOLE**	**DH- 12**

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** ---

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
<u>ALLUVIUM</u>: CLAYEY SAND: Very dark grayish brown (10YR 3/2), moist; loose to medium dense; fine sand	SC	1	S D D	11		38		14		120		
		2										
POORLY GRADED GRAVEL with SAND and CLAY: Brown (10YR 4/3), moist; very dense; fine to coarse, mostly rounded gravel; with fine to coarse sand	GP-GC	3	S D D	69								
		4										
		5	S D	50/5"		12		6		111		
		6										
		7										
		8										
medium dense		9	S I I	19								
		10										
		11										
LEAN CLAY to CLAY: Mottled pale brown (10YR 6/3) and dark yellowish brown (10YR 4/6), moist, stiff to very stiff; with fine sand	CL/CI	12										
		13										
		14	S D D	29	1.5 1.5			22		107	14	1600
		15										
		16										
		17										
		18										
		19	S D D	56	3.0- 4.0							
BOTTOM OF HOLE = 20 Feet No Groundwater Encountered		20										

DATE: 10/20/2009	**LOG OF EXPLORATORY DRILL HOLE**	**DH- 13**

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** 17.7 feet (End of drilling)

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: CLAYEY SAND: Very dark grayish brown (10YR 3/2), moist; medium dense; fine sand	SC	1	S D D	22				11		116		
		2										
CLAYEY SAND with GRAVEL: Brown (10YR 3/3), moist; medium dense to dense; fine to coarse, subrounded sand; with fine to coarse, subrounded to rounded gravel; with cobbles and boulders	SC	3	S I I	41								
		4										
medium dense		5–6	S I I	27		18		8				
		7										
		8										
		9–10	S I I	29								
		11										
		12										
		13										
dense		14–15	S I I	41		16		12				
		16										
		17										
		18										
very dense		19	S I	50/6"								
BOTTOM OF HOLE = 19.5 Feet		20										

DATE: 10/20/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 14

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** 17.1 feet (End of drilling)

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: **CLAYEY SAND:** Dark brown (10YR 3/3), moist; medium dense; fine sand	SC	1	S D D	23				9		113		
		2										
		3	S D D	41								
		4										
CLAYEY SAND with GRAVEL: Brown (10YR 3/3), moist; very dense; fine to coarse, mostly subangular to subrounded sand; with fine to coarse, subrounded to rounded gravel and cobbles	SC	5	D	50/5"								
		6										
		7										
		8										
medium dense to dense		9	S I I	31		12		9				
		10										
		11										
		12										
		13										
very dense		14	S I I	69								
		15										
		16										
wet		17										
		18										
		19	S I I	54								
		20										
BOTTOM OF HOLE = 20 Feet												

PACIFIC GEOTECHNICAL ENGINEERING

DATE: 10/20/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 15

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** 17 feet (End of drilling)

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
<u>ALLUVIUM</u>: WELL GRADED GRAVEL with SILT and SAND: Dark yellowish brown (10YR 4/4), moist; medium dense; fine to coarse, subangular to rounded gravel; with fine to coarse sand	GW-GM	1	S D D	38		10	23	6	5	119		
		2										
CLAYEY GRAVEL with SAND: Brown (10YR 4/3), moist to wet; medium dense to dense; variable amounts of fine to coarse, subangular to rounded sand and gravel (locally grading to CLAYEY SAND with GRAVEL)	GC (SC)	3	S D D	27				9		117		
		4										
		5	S I I	38		12		5				
		6										
		7										
		8										
dense		9	S I I	39								
		10										
		11										
		12										
		13										
medium dense		14	S I I	22								
		15										
		16										
		17										
		18										
wet, very dense		19	S I I	74								
		20										
BOTTOM OF HOLE = 20 Feet												

DATE: 10/20/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 16

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** 14.1 feet (End of drilling)

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: LEAN CLAY with SAND: Very dark grayish brown (10YR 3/2), moist; hard; with mostly fine sand	CL	1	S D	50/6"								
		2										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Very dark grayish brown (10YR 3/2), moist; medium dense to dense; variable amounts of fine to coarse, subangular to rounded sand and gravel	SC/ GC	3	S I I	62		32		9				
		4										
		5										
		6	S I I	27		12		5				
		7										
		8										
		9	S I I	36								
		10										
		11										
		12										
		13										
very dense		14	I	50/ 2½"								
		15										
		16										
		17										
wet		18										
		19	S I I	76								
BOTTOM OF HOLE = 20 Feet		20										

DATE: 10/20/2009	LOG OF EXPLORATORY DRILL HOLE	DH- 17

PROJECT NAME: Butterfield Blvd. Extension **PROJECT NUMBER:** 2309 E

DRILL RIG: Mobile B53, 140# downhole hammer and wire winch **LOGGED BY:** CSS

HOLE DIAMETER: 8" hollow stem auger **HOLE ELEVATION:** -----

SAMPLER:
D = 3" OD, 2½" ID Split-spoon
X = 2½" OD, 2" ID Split-spoon
I = Standard Penetrometer (2" OD SPT)
S = Slough in sample

GROUND WATER DEPTH: **Initial:** --- **Final:** 14.9 feet (End of drilling)

DESCRIPTION OF EARTH MATERIALS	SOIL TYPE	DEPTH (ft)	SAMPLE	BLOWS PER FOOT	POCKET PEN (tsf)	% PASSING #200 SIEVE	LIQUID LIMIT	WATER CONTENT	PLASTICITY INDEX	DRY DENSITY (pcf)	FAILURE STRAIN (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)
ALLUVIUM: SANDY CLAY: Dark yellowish brown (10YR 4/4), moist; very stiff; with mostly fine sand	CI	1	S D D	20		68		16		115		
		2										
CLAYEY SAND with GRAVEL: Dark yellowish brown (10YR 3/4), moist, very dense to dense; fine to coarse sand; with fine gravel	SC	3	S D	50/5"								
		4										
		5										
		6	S I I	33		14		9				
		7										
CLAYEY SAND with GRAVEL to CLAYEY GRAVEL with SAND: Dark yellowish brown (10YR 3/4), moist; dense to very dense; variable amounts of fine and coarse, subangular to rounded sand and gravel	SC/ GC	8										
		9	S I I	59								
		10										
		11										
		12										
		13										
		14	S I I	77								
		15										
		16										
		17										
wet		18										
		19	S I I	88								
BOTTOM OF HOLE = 20 Feet		20										

APPENDIX B

CONE PENETROMETER TEST RESULTS

PROJECT: BUTTERFIELD BOULEVARD EXTENSION CPT NO.: CPT-1
LOCATION: Morgan Hill CA DATE : 10-30-2009
PROJ. NO.: 2309E(PGE-08) TIME : 10:59:07
Terminated at 74.0 feet Groundwater measured at 23.3 feet

PACIFIC GEOTECHNICAL
cpts by John Sarmiento & Associates

DEPTH (feet)	Qc (tsf)	Qc' (tsf)	Fs (tsf)	Rf (%)	SPT (N)	SPT' (N')	EffVtStr (ksf)	PHI (deg.)	SU (ksf)	SOIL BEHAVIOR TYPE	DENSITY RANGE (pcf)
0.52	1.8	2.88	0.68	12.0	2	3	0.06	----	0.35	Organic Material	100-110
1.01	36.4	58.2	0.85	2.3	15	23	0.13	----	4.84	Sandy SILT to Clayey SILT	130-140
1.55	39.2	62.72	1.27	3.2	20	31	0.20	----	5.21	Clayey SILT to Silty CLAY	"
2.02	62.8	100.54	2.67	4.3	31	50	0.26	----	8.36	"	"
2.52	54.3	86.94	1.50	2.8	22	35	0.33	----	7.22	Sandy SILT to Clayey SILT	"
3.00	110.2	176.35	1.90	1.7	37	59	0.39	41	----	Silty SAND to Sandy SILT	"
3.51	95.8	153.26	1.98	2.1	32	51	0.46	40	----	"	"
4.02	61.6	98.50	1.32	2.2	21	33	0.53	38	----	"	"
4.54	78.5	125.57	2.13	2.7	31	50	0.60	----	10.42	Sandy SILT to Clayey SILT	"
5.00	86.8	138.90	2.09	2.4	29	46	0.66	40	----	Silty SAND to Sandy SILT	"
5.56	268.8	430.05	7.35	2.7	134	215	0.74	46	----	SAND to Clayey SAND *	"
6.03	119.0	189.96	2.75	2.3	40	63	0.80	42	----	Silty SAND to Sandy SILT	"
6.51	76.0	116.37	2.09	2.8	30	47	0.87	----	10.07	Sandy SILT to Clayey SILT	"
7.02	118.7	173.58	3.13	2.6	40	58	0.94	41	----	Silty SAND to Sandy SILT	"
7.55	118.8	165.81	2.39	2.0	40	55	1.01	41	----	"	"
8.04	63.0	85.68	2.47	3.9	31	43	1.08	----	8.32	Clayey SILT to Silty CLAY	"
8.50	158.2	210.26	3.53	2.2	53	70	1.14	42	----	Silty SAND to Sandy SILT	"
9.01	134.6	174.07	3.18	2.4	45	58	1.21	41	----	"	"
9.51	226.4	284.70	7.35	3.2	113	142	1.28	44	----	SAND to Clayey SAND *	>140
10.02	268.4	328.40	7.88	2.9	134	164	1.35	45	----	"	"
10.54	186.7	222.09	2.60	1.4	37	44	1.42	43	----	SAND	130-140
11.03	142.3	164.79	3.49	2.5	47	55	1.48	41	----	Silty SAND to Sandy SILT	"
11.55	209.3	236.65	5.20	2.5	70	79	1.55	43	----	"	"
12.05	166.7	184.33	6.91	4.1	166	184	1.62	----	22.12	Very Stiff Fine Grained *	>140
12.54	154.9	167.49	4.39	2.8	52	56	1.69	41	----	Silty SAND to Sandy SILT	130-140
13.06	172.2	182.07	4.16	2.4	57	61	1.76	41	----	"	"
13.57	124.7	129.78	5.61	4.5	125	130	1.83	----	16.51	Very Stiff Fine Grained *	>140
14.05	211.3	216.58	5.05	2.4	70	72	1.90	42	----	Silty SAND to Sandy SILT	130-140
14.56	188.3	189.87	5.67	3.0	63	63	1.97	42	----	"	"
15.05	233.5	233.38	7.98	3.4	117	117	2.03	43	----	SAND to Clayey SAND *	>140
15.56	227.4	226.91	7.68	3.4	114	113	2.10	43	----	"	"
16.01	163.5	162.92	8.11	5.0	163	163	2.17	----	21.65	Very Stiff Fine Grained *	"
16.54	191.0	190.03	7.47	3.9	95	95	2.24	42	----	SAND to Clayey SAND *	"
17.01	189.2	188.04	6.16	3.3	95	94	2.31	42	----	"	130-140
17.52	193.9	192.41	7.17	3.7	97	96	2.38	42	----	"	>140
18.02	166.6	165.09	5.25	3.1	55	55	2.44	41	----	Silty SAND to Sandy SILT	130-140
18.58	191.8	188.62	5.40	2.8	64	63	2.52	42	----	"	"
19.02	257.1	247.60	9.50	3.7	128	124	2.58	43	----	SAND to Clayey SAND *	>140
19.53	262.3	246.48	8.05	3.1	131	123	2.65	43	----	"	"
20.02	291.6	267.27	9.72	3.3	146	133	2.72	44	----	"	"
20.53	271.3	242.59	7.04	2.6	90	81	2.79	43	----	Silty SAND to Sandy SILT	130-140
21.05	306.7	266.90	10.22	3.3	153	133	2.86	44	----	SAND to Clayey SAND *	>140
21.54	336.7	285.59	8.04	2.4	67	57	2.93	44	----	SAND	130-140
22.00	308.8	255.38	12.12	3.9	154	128	2.99	43	----	SAND to Clayey SAND *	>140
22.53	210.3	171.84	8.94	4.3	210	172	3.07	----	27.83	Very Stiff Fine Grained *	"
23.00	233.5	189.05	6.56	2.8	78	63	3.13	42	----	Silty SAND to Sandy SILT	130-140
23.50	330.2	266.03	7.61	2.3	66	53	3.17	44	----	SAND	"
24.01	287.1	230.12	5.26	1.8	57	46	3.20	43	----	"	"
24.55	257.2	204.92	5.16	2.0	51	41	3.24	42	----	"	"
25.00	218.6	173.30	7.13	3.3	109	87	3.28	41	----	SAND to Clayey SAND *	>140
25.52	321.3	253.32	7.30	2.3	64	51	3.32	43	----	SAND	130-140
26.04	218.6	171.39	3.46	1.6	44	34	3.36	41	----	"	"
26.53	137.7	107.35	9.41	6.8	138	107	3.39	----	18.11	Very Stiff Fine Grained *	>140
27.03	317.0	245.74	9.70	3.1	158	123	3.43	43	----	SAND to Clayey SAND *	"
27.52	283.5	218.61	10.24	3.6	142	109	3.47	43	----	"	"

PROJECT: BUTTERFIELD BOULEVARD EXTENSION CPT NO.: CPT-1
LOCATION: Morgan Hill CA DATE : 10-30-2009
PROJ. NO.: 2309E(PGE-08) TIME : 10:59:07
Terminated at 74.0 feet Groundwater measured at 23.3 feet

PACIFIC GEOTECHNICAL
cpts by John Sarmiento & Associates

DEPTH (feet)	Qc (tsf)	Qc' (tsf)	Fs (tsf)	Rf (%)	SPT (N)	SPT' (N')	EffVtStr (ksf)	PHI (deg.)	SU (ksf)	SOIL BEHAVIOR TYPE	DENSITY RANGE (pcf)
28.04	225.5	172.90	5.68	2.5	75	58	3.51	41	----	Silty SAND to Sandy SILT	130-140
28.53	421.2	321.17	8.08	1.9	84	64	3.54	45	----	SAND	"
29.04	307.1	232.85	6.88	2.2	61	47	3.58	43	----	"	"
29.56	260.4	196.25	7.68	3.0	130	98	3.62	42	----	SAND to Clayey SAND *	>140
30.04	246.4	184.68	9.30	3.8	123	92	3.66	42	----	"	"
30.55	33.1	24.69	2.11	6.4	33	25	3.69	----	4.14	CLAY	130-140
31.01	72.0	53.36	2.78	3.9	36	27	3.73	----	9.32	Clayey SILT to Silty CLAY	"
31.52	166.6	122.73	6.41	3.8	83	61	3.77	39	----	SAND to Clayey SAND *	>140
32.02	117.2	85.82	5.67	4.8	117	86	3.81	----	15.34	Very Stiff Fine Grained *	"
32.57	17.7	12.85	1.18	6.7	18	13	3.85	----	2.06	CLAY	130-140
33.04	17.1	12.40	1.16	6.7	17	12	3.88	----	1.98	"	"
33.53	21.1	15.21	1.28	6.0	21	15	3.92	----	2.51	"	"
34.08	28.5	20.39	1.27	4.4	19	14	3.96	----	3.49	Silty CLAY to CLAY	"
34.52	31.4	22.35	2.04	6.5	31	22	3.99	----	3.88	CLAY	"
35.00	36.7	25.98	2.96	8.1	36	26	4.02	----	4.57	"	"
35.55	108.6	76.51	5.87	5.4	108	76	4.07	----	14.16	Very Stiff Fine Grained *	>140
36.00	66.8	46.87	5.40	8.1	67	47	4.10	----	8.58	"	130-140
36.55	85.7	59.82	5.04	5.9	86	60	4.14	----	11.09	"	>140
37.07	70.6	49.06	5.26	7.5	71	49	4.18	----	9.08	"	"
37.53	144.6	99.99	6.26	4.3	144	100	4.22	----	18.94	"	"
38.03	159.4	109.72	6.77	4.2	159	110	4.26	----	20.91	"	"
38.55	159.6	109.36	4.95	3.1	53	36	4.29	39	----	Silty SAND to Sandy SILT	130-140
39.00	143.2	97.70	5.14	3.6	72	49	4.33	38	----	SAND to Clayey SAND *	"
39.51	179.2	121.72	5.35	3.0	60	41	4.36	39	----	Silty SAND to Sandy SILT	"
40.01	186.4	125.94	6.87	3.7	93	63	4.40	39	----	SAND to Clayey SAND *	>140
40.51	128.0	86.05	7.60	5.9	128	86	4.44	----	16.69	Very Stiff Fine Grained *	"
41.04	129.6	86.69	5.06	3.9	65	43	4.48	37	----	SAND to Clayey SAND *	"
41.57	138.7	92.33	3.97	2.9	46	31	4.52	38	----	Silty SAND to Sandy SILT	130-140
42.00	116.7	77.38	6.06	5.2	117	77	4.55	----	15.18	Very Stiff Fine Grained *	>140
42.56	118.7	78.28	4.33	3.6	47	31	4.59	----	15.44	Sandy SILT to Clayey SILT	130-140
43.01	31.8	20.88	3.20	10.1	32	21	4.63	----	3.85	CLAY	"
43.55	12.3	8.05	1.11	9.0	12	8	4.66	----	1.25	"	120-130
44.00	13.1	8.53	1.10	8.4	13	8	4.69	----	1.35	"	"
44.54	18.9	12.27	1.24	6.5	19	12	4.73	----	2.12	"	130-140
45.01	18.5	11.94	1.33	7.2	18	12	4.76	----	2.06	"	"
45.57	20.8	13.32	1.34	6.5	21	13	4.80	----	2.35	"	"
46.04	26.4	16.88	1.72	6.5	26	17	4.84	----	3.11	"	"
46.52	26.0	16.53	1.81	7.0	26	16	4.87	----	3.04	"	"
47.06	17.0	10.72	1.32	7.8	17	11	4.91	----	1.83	"	"
47.58	21.6	13.58	1.42	6.6	21	13	4.95	----	2.45	"	"
48.05	18.2	11.38	1.08	6.0	18	11	4.98	----	1.98	"	"
48.51	20.0	12.45	1.06	5.3	19	12	5.02	----	2.22	"	"
49.07	29.3	18.17	1.56	5.3	28	18	5.06	----	3.45	"	"
49.55	32.4	20.08	1.79	5.5	31	19	5.09	----	3.87	"	"
50.01	28.2	17.40	1.58	5.6	27	17	5.13	----	3.31	"	"
50.50	26.4	16.24	1.37	5.2	25	15	5.16	----	3.07	"	"
51.06	21.7	13.30	1.02	4.7	20	12	5.20	----	2.44	"	"
51.52	15.2	9.27	0.81	5.3	13	8	5.23	----	1.56	"	120-130
52.05	24.3	14.79	1.09	4.5	22	13	5.27	----	2.77	"	130-140
52.52	28.6	17.28	1.29	4.5	18	11	5.30	----	3.33	Silty CLAY to CLAY	"
53.05	57.3	34.53	3.00	5.2	55	33	5.34	----	7.16	CLAY	"
53.57	185.9	111.58	9.50	5.1	185	111	5.38	----	24.30	Very Stiff Fine Grained *	>140
54.01	136.0	81.34	11.30	8.3	136	81	5.42	----	17.65	"	"
54.57	109.0	64.87	8.25	7.6	109	65	5.46	----	14.04	"	"
55.04	40.2	23.81	3.70	9.2	40	24	5.49	----	4.85	CLAY	130-140

PROJECT: BUTTERFIELD BOULEVARD EXTENSION CPT NO.: CPT-1
LOCATION: Morgan Hill CA DATE : 10-30-2009
PROJ. NO.: 2309E(PGE-08) TIME : 10:59:07
Terminated at 74.0 feet Groundwater measured at 23.3 feet

PACIFIC GEOTECHNICAL
cpts by John Sarmiento & Associates

DEPTH (feet)	Qc (tsf)	Qc' (tsf)	Fs (tsf)	Rf (%)	SPT (N)	SPT' (N')	EffVtStr (ksf)	PHI (deg.)	SU (ksf)	SOIL BEHAVIOR TYPE	DENSITY RANGE (pcf)
55.55	21.4	12.62	1.74	8.1	21	12	5.53	----	2.35	"	"
56.00	31.8	18.69	2.09	6.6	31	18	5.56	----	3.73	"	"
56.54	39.9	23.39	2.25	5.6	39	23	5.60	----	4.81	"	"
57.02	50.4	29.40	3.43	6.8	49	29	5.64	----	6.20	"	"
57.53	39.7	23.06	2.95	7.4	39	23	5.67	----	4.77	"	"
58.03	37.9	21.91	3.09	8.2	37	21	5.71	----	4.52	"	"
58.52	39.0	22.45	3.09	7.9	38	22	5.75	----	4.66	"	"
59.00	49.1	28.20	4.28	8.7	48	28	5.78	----	6.01	"	"
59.53	141.1	80.67	12.30	8.7	141	80	5.82	----	18.28	Very Stiff Fine Grained *	>140
60.01	204.8	116.55	11.52	5.6	204	116	5.86	----	26.76	"	"
60.58	254.8	144.30	13.86	5.4	255	144	5.90	----	33.43	"	"
61.02	195.7	110.36	10.57	5.4	196	110	5.94	----	25.53	"	"
61.51	149.5	83.95	9.52	6.4	150	84	5.98	----	19.37	"	"
62.03	162.8	91.01	11.50	7.1	163	91	6.02	----	21.14	"	"
62.50	208.3	116.11	8.87	4.3	208	116	6.05	----	27.21	"	"
63.01	249.3	138.43	7.57	3.0	125	69	6.09	40	----	SAND to Clayey SAND *	"
63.50	190.6	105.47	7.89	4.1	191	105	6.13	----	24.83	Very Stiff Fine Grained *	"
64.03	187.0	103.13	10.37	5.5	187	103	6.17	----	24.36	"	"
64.50	226.2	124.33	9.60	4.2	226	124	6.21	----	29.57	"	"
65.02	209.2	114.57	10.74	5.1	209	115	6.25	----	27.31	Very Stiff Fine Grained *	"
65.52	107.8	58.79	7.50	7.0	108	59	6.29	----	13.77	"	"
66.00	39.2	21.33	2.78	7.1	39	21	6.32	----	4.63	CLAY	130-140
66.53	44.9	24.35	3.92	8.7	45	24	6.36	----	5.39	"	"
67.03	49.4	26.67	4.09	8.3	49	27	6.40	----	5.97	"	"
67.52	48.9	26.30	3.99	8.2	49	26	6.43	----	5.90	"	"
68.04	52.9	28.38	4.48	8.5	53	28	6.47	----	6.43	"	"
68.51	52.8	28.23	4.20	8.0	53	28	6.50	----	6.41	"	"
69.04	62.9	33.51	4.45	7.1	63	33	6.54	----	7.76	Very Stiff Fine Grained *	"
69.52	53.1	28.21	3.54	6.7	53	28	6.58	----	6.45	CLAY	"
70.02	52.5	27.77	3.64	6.9	52	28	6.61	----	6.36	"	"
70.50	52.8	27.87	3.59	6.8	53	28	6.65	----	6.40	"	"
71.01	48.1	25.27	2.63	5.5	48	25	6.69	----	5.76	"	"
71.52	45.1	23.63	2.73	6.0	45	24	6.72	----	5.36	"	"
72.01	42.3	22.06	2.73	6.5	42	22	6.76	----	4.98	"	"
72.53	40.7	21.17	2.32	5.7	41	21	6.80	----	4.77	"	"
73.01	68.8	35.68	4.35	6.3	69	36	6.83	----	8.51	Very Stiff Fine Grained *	"
73.54	101.6	52.45	6.49	6.4	102	52	6.87	----	12.87	"	"
74.01	138.6	71.31	7.79	5.6	139	71	6.91	----	17.80	"	"

DEPTH = Sampling interval (.1 feet)
Qc = Tip bearing resistance TotStr = Total Stress using est. density**
Fs = Sleeve friction resistance Phi = Soil friction angle*
Rf = Tip/Sleeve ratio Su = Undrained Soil Strength* (Nk=10 for Qc<9 tsf)
SPT = Equivalent Standard Penetration Test* (Nk=12 for Qc=9 to 12 tsf) (Nk=15 for Qc>12 tsf)
References: * Robertson and Campanella, 1988
** Olsen, 1989 *** Durgunoglu & Mitchell, 1975

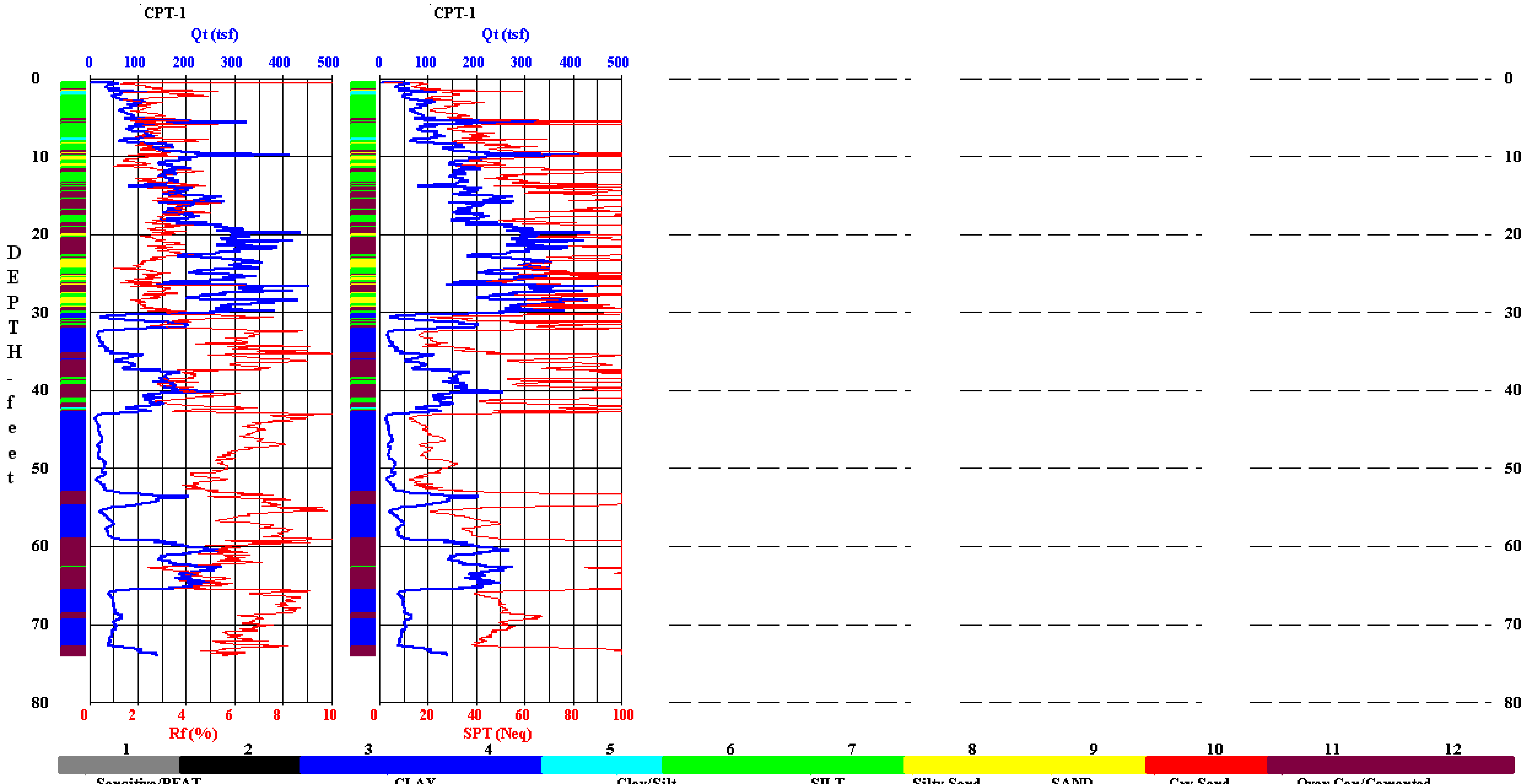
Youd, T.L., Idriss, I.M. Andrus, R.D. Arango, I., Castro, G., Christian, J.T., Dobry, R., Liam Finn, W.D.L., Harder, L.F., Jr., Hynes, M.E., Ishihara, K., Koester, J.P., Liao, S.S.C., Marcuson, W.F., III, Martin, G.R., Mitchell, J.K., Moriwaki, Y., Power, M.S., Robertson, P.K., Seed, R.B., Stokoe, K.H., II, 2001, Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, ASCE, Journal of Geotechnical and Geoenvironmental Engineering, V. 127, No. 10, p 817-833.

Youd, T.L. and Hoose, S.N., 1978, Historic ground failures in northern California triggered by earthquakes: USGS Prof. Paper 993.

AERIAL PHOTOGRAPHS (Black and white unless indicated)

Date	Approx. Scale	Project	Roll/Frame No.	Source
10/20/39	1:24,000	CIV-294	294/54, 55	Nat'l Archives; PGE
8/10/53	1:30,000	GS-YF	5/145, 146	PGE
6/26/74	1:24,000	SF Bay Area 4	9/196, 195	PGE
4/3/85	1:30,000	WAC 85CA	7/198, 197	WAC; PGE
4/7/88	1:6,000	AV 3275	5/7, 6	Pacific Aerial Survey; PGE
5/10/88	1:12,000	AV 3281	5/8,9	Pacific Aerial Survey; PGE

PROJECT: RAILROAD AVENUE SITE LOCATION: Morgan Hill CA



John Sarmiento & Associates *Cone Penetration Services* *Graphics Copywrite 1996*

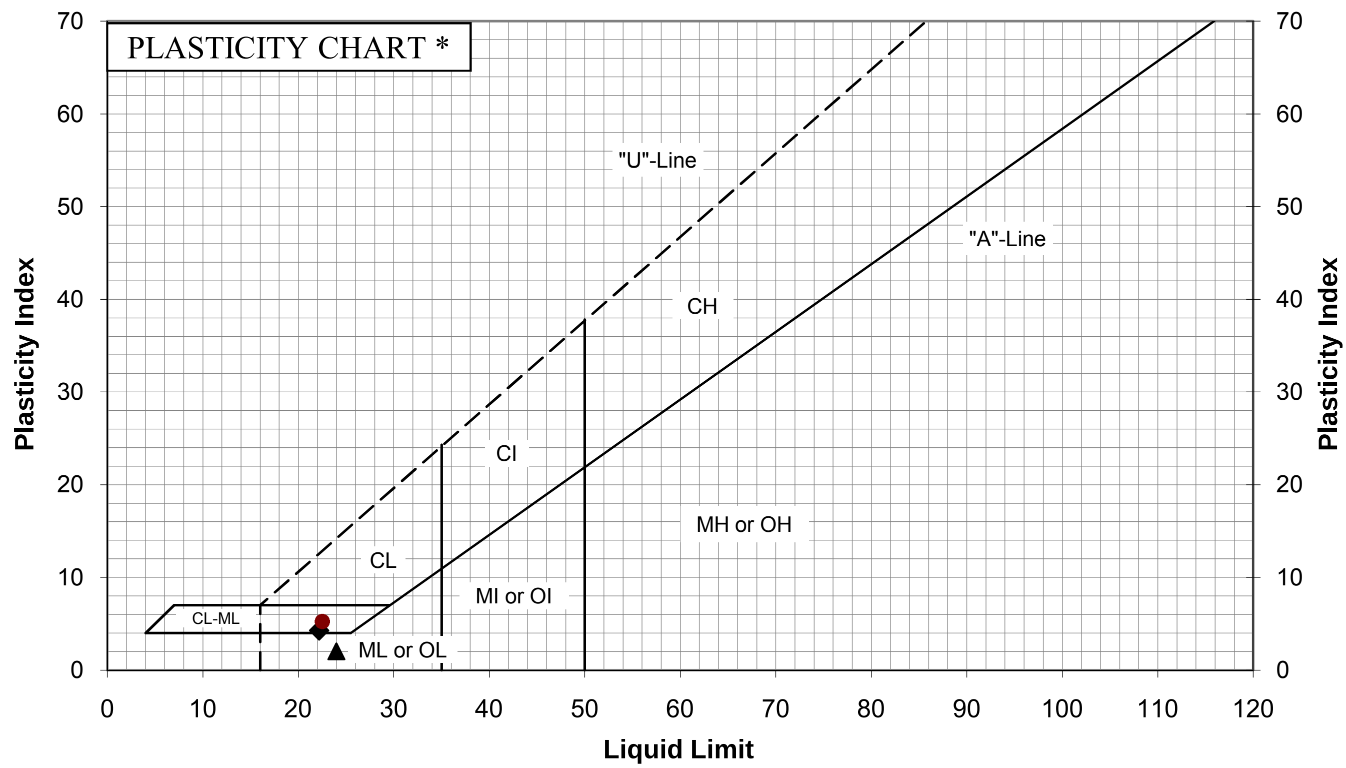
APPENDIX C

LABORATORY TEST RESULTS

ATTERBERG LIMITS TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension	PROJECT No.	2309 E

DATE OF TEST	11/17/2009	11/19/2009	11/19/2009		
KEY SYMBOL	♦	▲	●		
DRILL HOLE No.	1	10	15		
DEPTH (ft)	1.5	40.5	1.5		
NATURAL WATER CONTENT (%)	7	24	6		
% Retained No. 40 SIEVE (Est.)	45	0	45		
% PASSING No. 200 SIEVE	15	40	6		
LIQUID LIMIT	22	24	23		
PLASTIC LIMIT	18	22	17		
PLASTICITY INDEX	4	2	5		
CLASSIFICATION SYMBOL	CL-ML	ML	CL-ML		

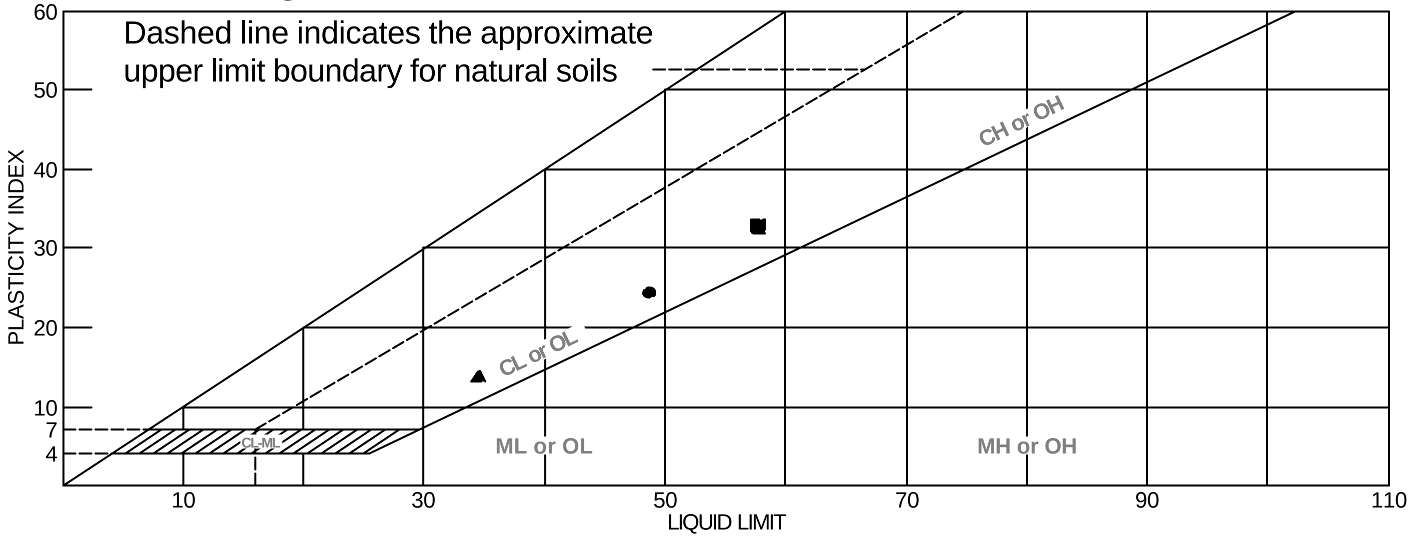


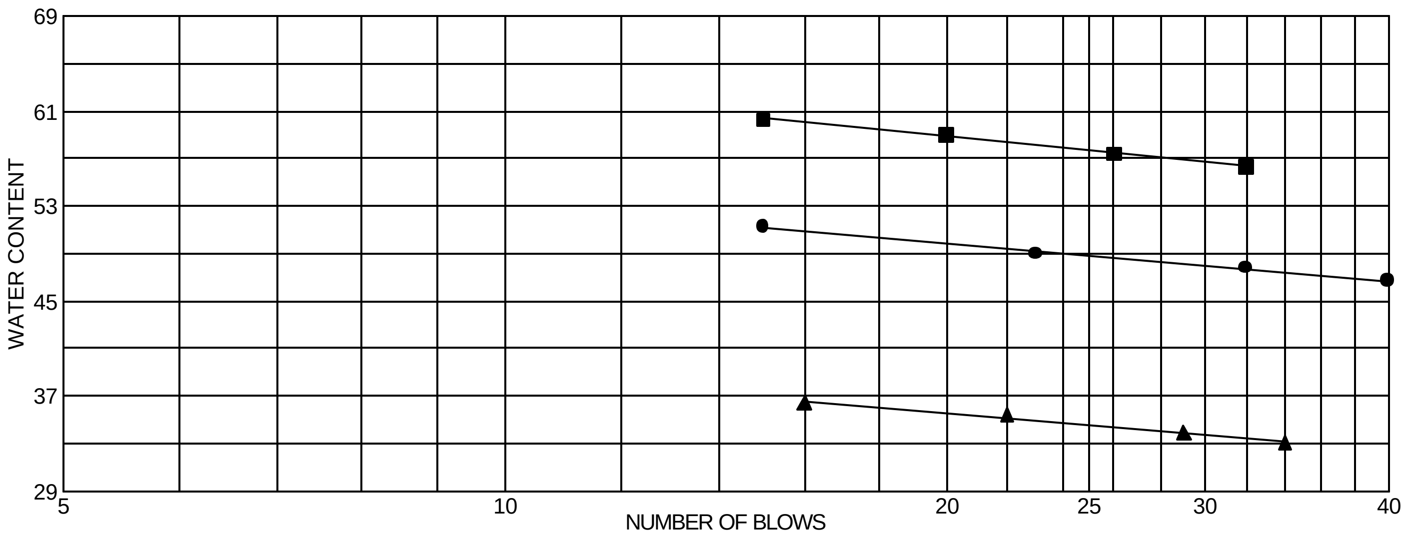
* Based on the Unified Soil Classification System modified to incorporate the "intermediate" classifications CI, MI, and OI for soils with liquid limits between 35 and 50. In the unmodified Unified Soil Classification System, such soils would be classified as CL, ML and OL, respectively.

PACIFIC GEOTECHNICAL ENGINEERING	Figure C-1

Rev030106

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown Lean CLAY, trace Sand	48.8	24.5	24.3			
■	Reddish Brown Fat Clayey SAND	57.7	25.0	32.7			
▲	Reddish Brown Lean CLAY w/ Sand	34.5	20.6	13.9			

Project No. 226-185 **Client:** Pacific Geotechnical Engineering

Project: Butterfield Blvd. Extension - 2309E

● **Source:** DH-6 **Elev./Depth:** 47-49.5'

■ **Source:** DH-8 **Elev./Depth:** 47-49.5'

▲ **Source:** DH-9 **Elev./Depth:** 55-57.5'

Remarks:

●

■

▲Sample was prepared using the wet prep method.

LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

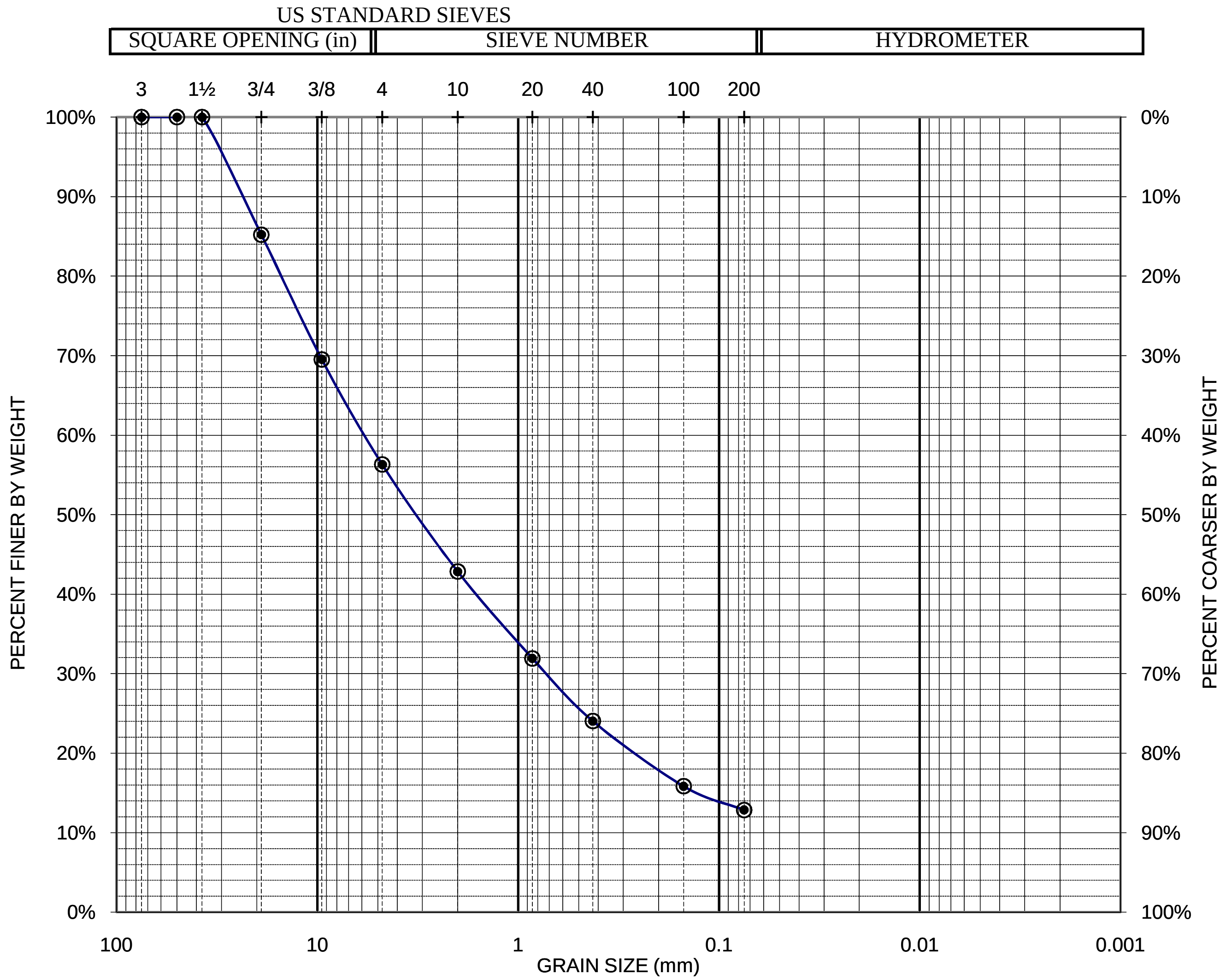
Figure C-2

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	3	**DEPTH (ft)**	9-10	**SAMPLE**	0	**DATE OF TEST**	11/12/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist



COBBLES	GRAVEL (COARSE / FINE)	SAND (COARSE / MEDIUM / FINE)	SILT & CLAY
	43.7%	43.5%	12.8%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING

Figure C-3

RevOct20070

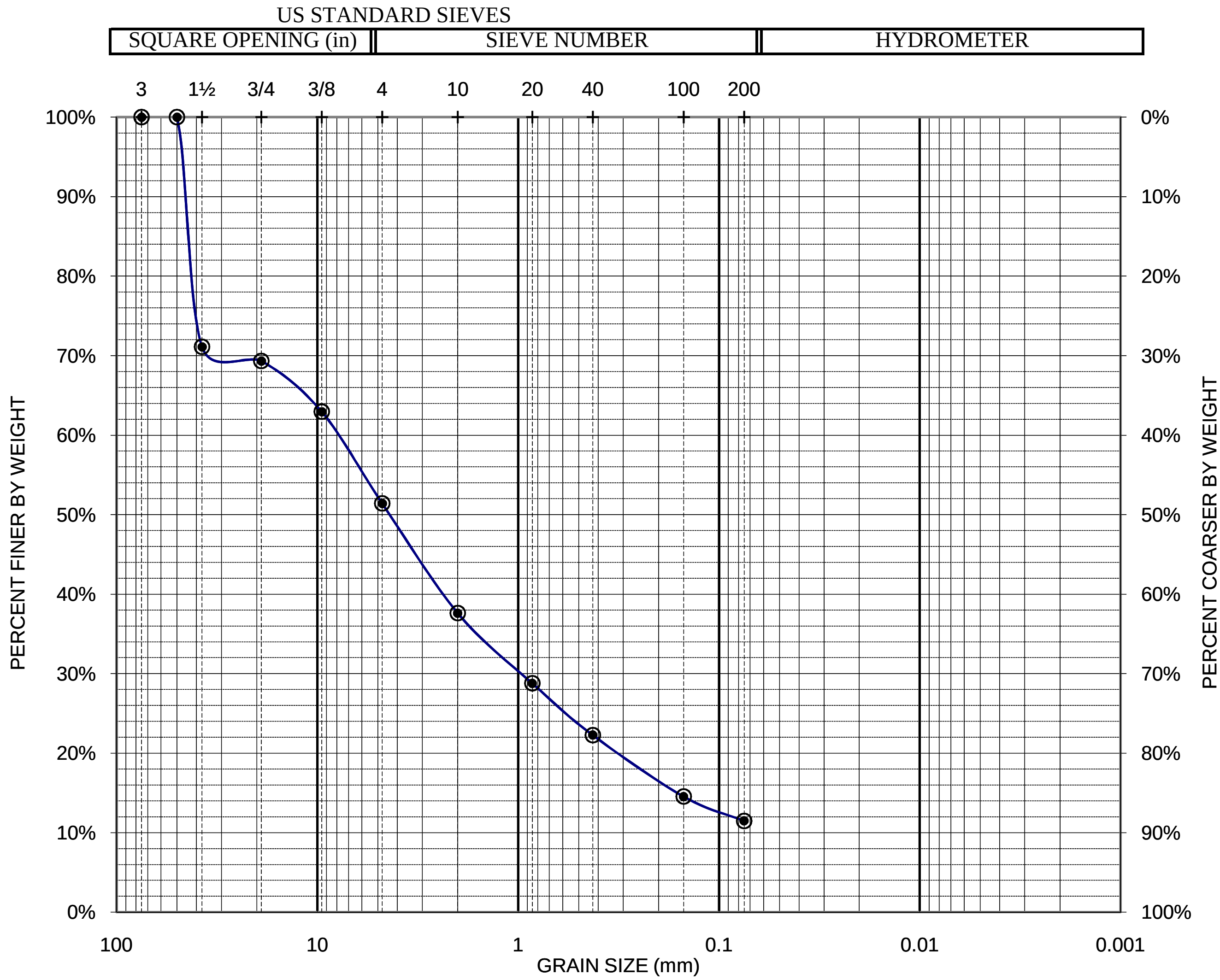
GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension	**PROJECT No.**	2309 E

DRILL HOLE No. 5	**DEPTH (ft)** 6.0	**SAMPLE** 0	**DATE OF TEST** 11/12/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: WELL GRADED GRAVEL with SAND: Dark brown (10YR 3/3), moist



COBBLES	GRAVEL (COARSE / FINE)	SAND (COARSE / MEDIUM / FINE)	SILT & CLAY
	48.6%	39.9%	11.5%

REMARKS:

RevOct20070 PACIFIC GEOTECHNICAL ENGINEERING

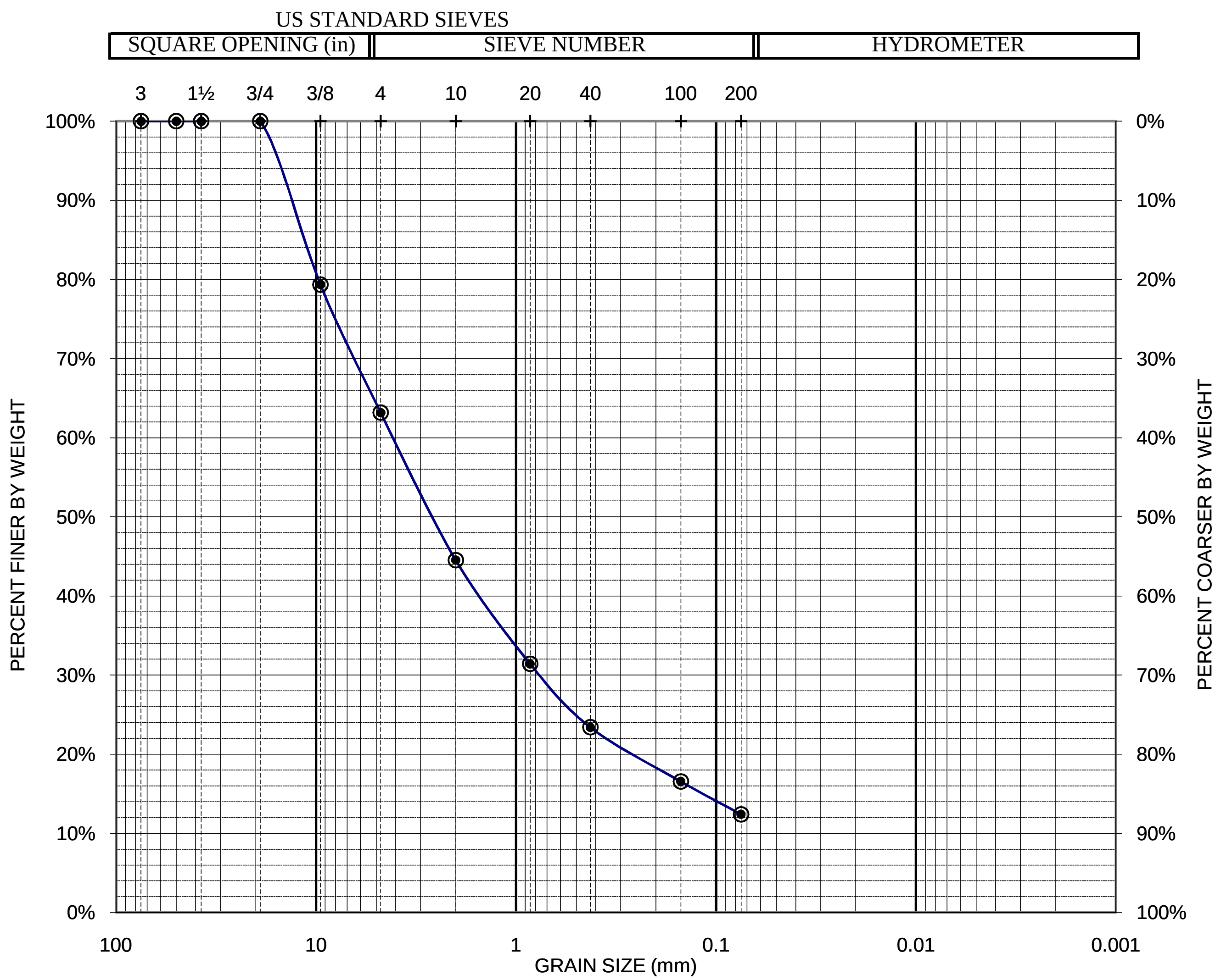
Figure C-4

GRAIN SIZE TEST RESULTS

PROJECT NAME Butterfield Blvd. Extension		**PROJECT No.**	2309 E
DRILL HOLE No. 6	**DEPTH (ft)** 14-15	**SAMPLE** 0	**DATE OF TEST** 11/12/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Brown (10YR 4/3), moist to wet



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	36.8%		50.7%			12.4%

REMARKS:

RevOct20070

PACIFIC GEOTECHNICAL ENGINEERING

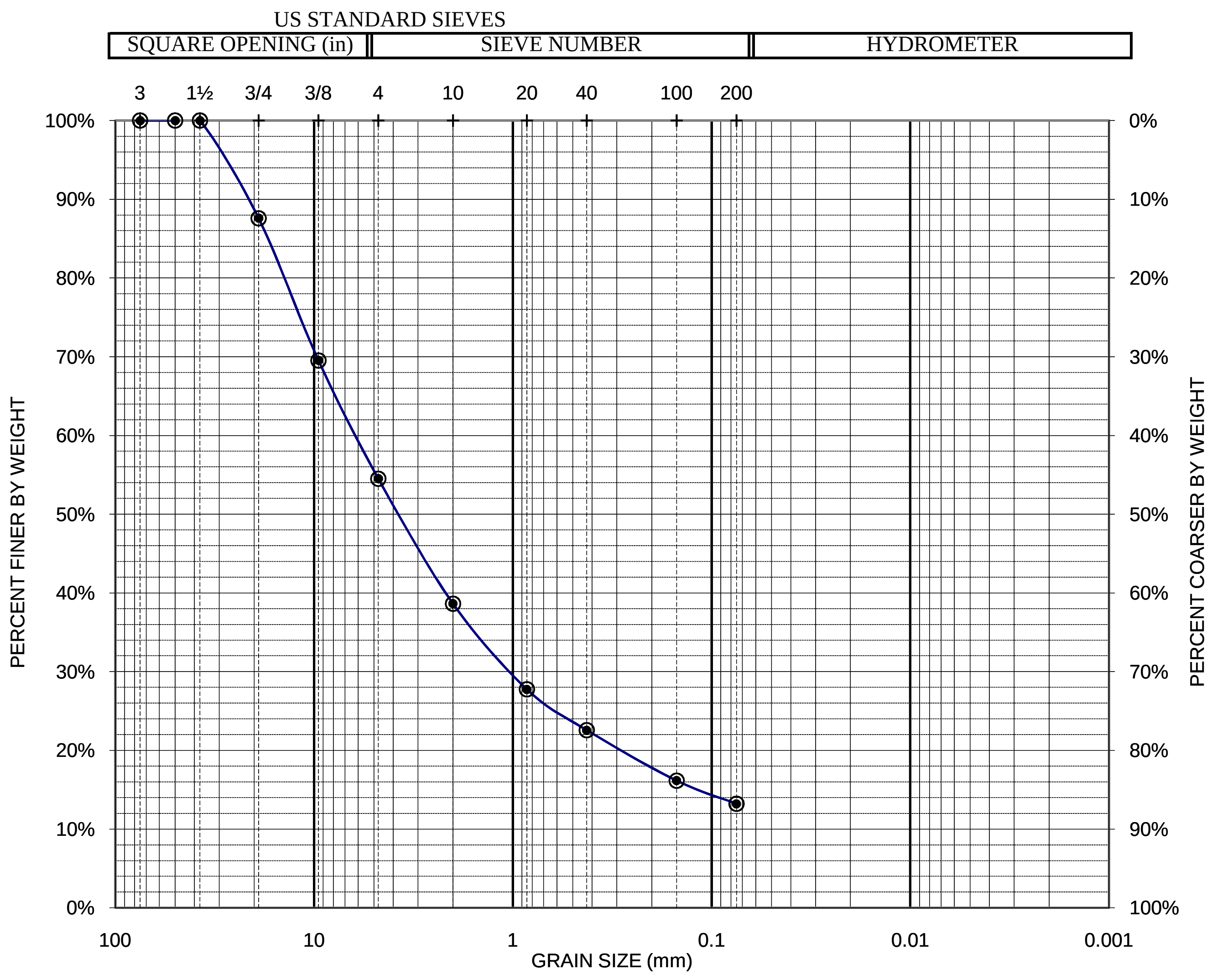
Figure C-5

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	6	**DEPTH (ft)**	29-30	**SAMPLE**	0	**DATE OF TEST**	11/12/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist to wet



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	45.5%		41.3%			13.2%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING

Figure C-6

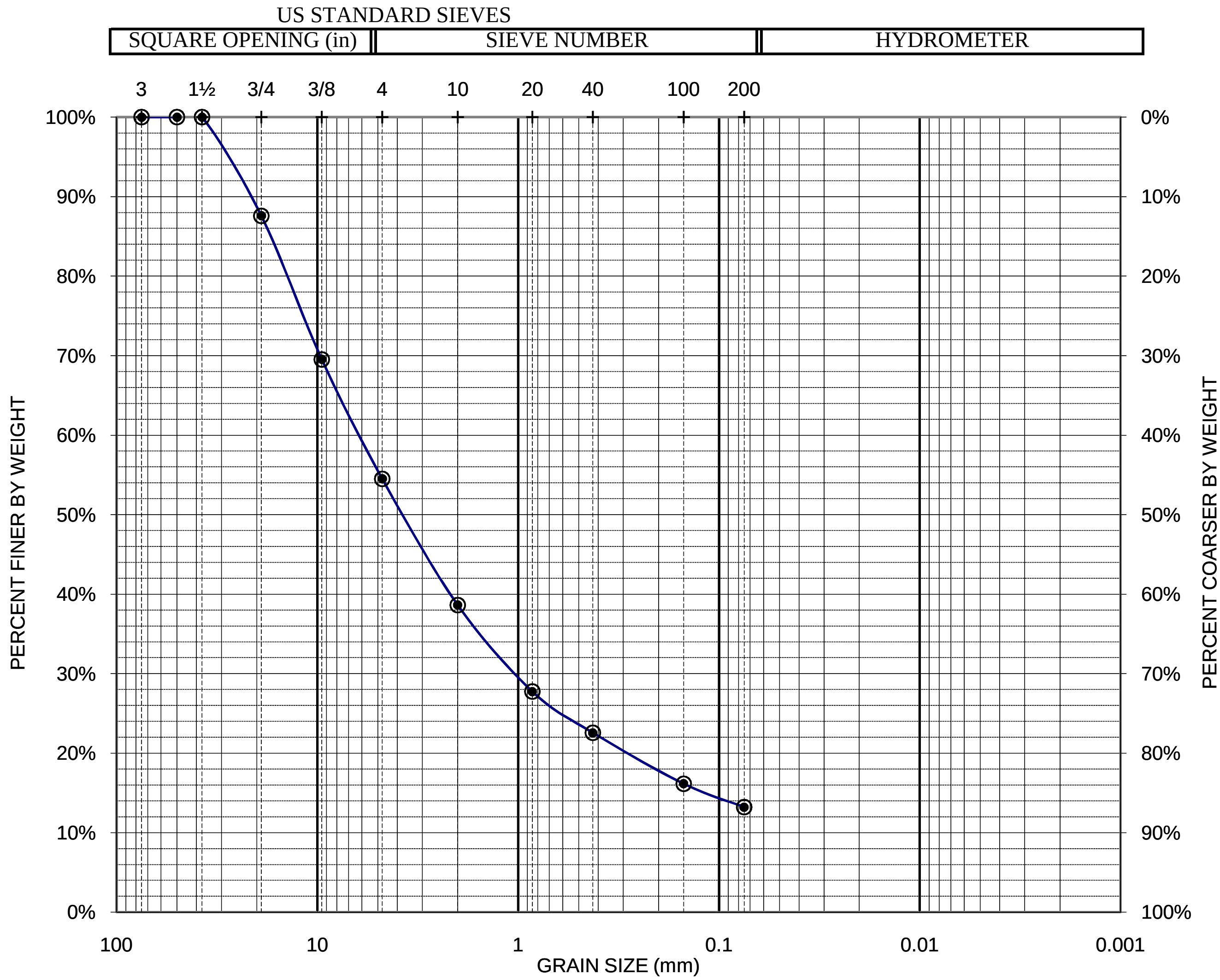
RevOct20070

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	7	**DEPTH (ft)**	14-15	**SAMPLE**	0	**DATE OF TEST**	11/12/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY GRAVEL with SAND: Dark brown (10YR 3/3), moist



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	45.5%		41.3%			13.2%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING

Figure **C-7**

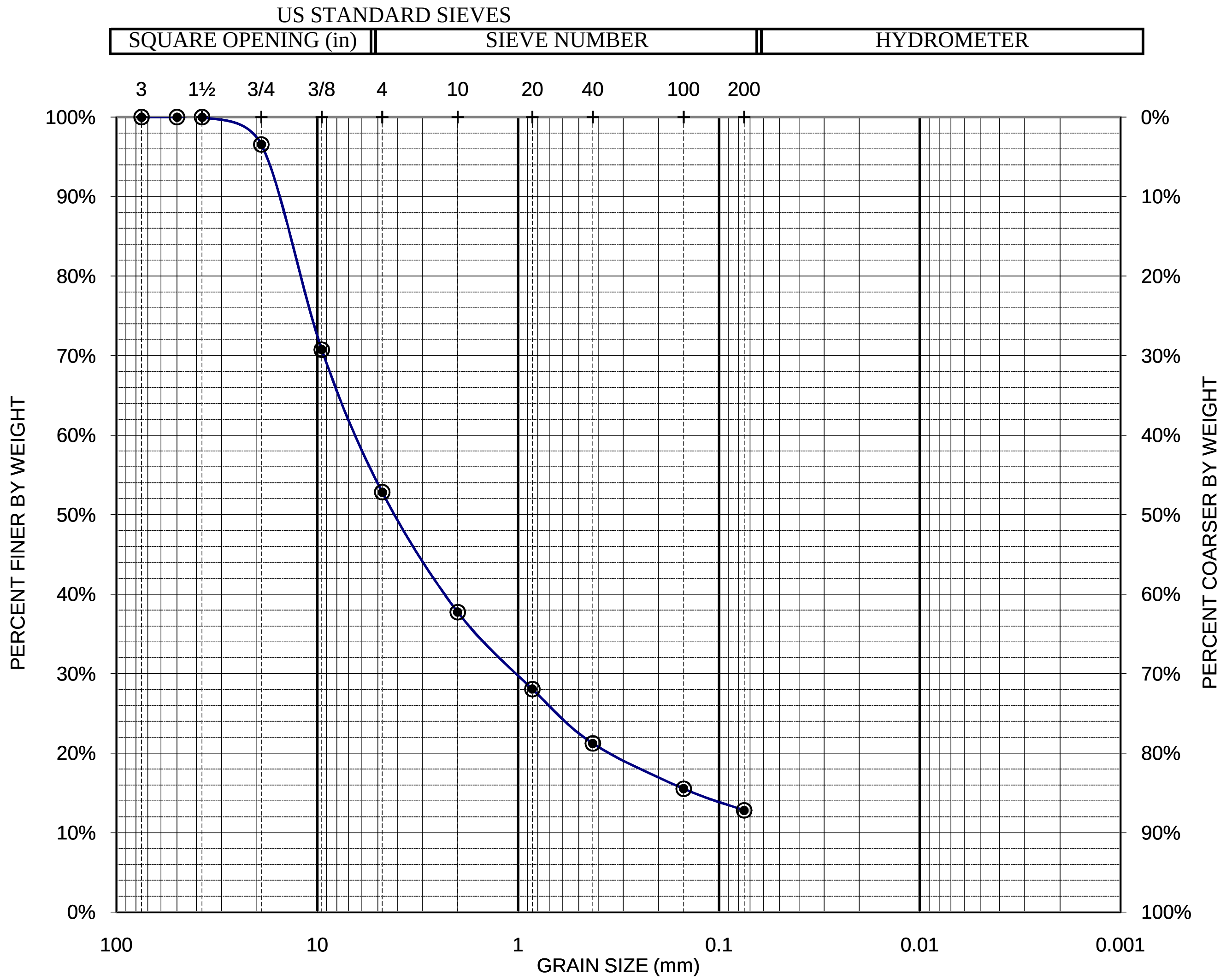
RevOct20070

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	8	**DEPTH (ft)**	9-10	**SAMPLE**	0	**DATE OF TEST**	11/12/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY GRAVEL with SAND: Brown to dark brown (10YR 4/3 to 3/3), wet



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	47.2%		40.0%			12.8%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING

Figure C-8

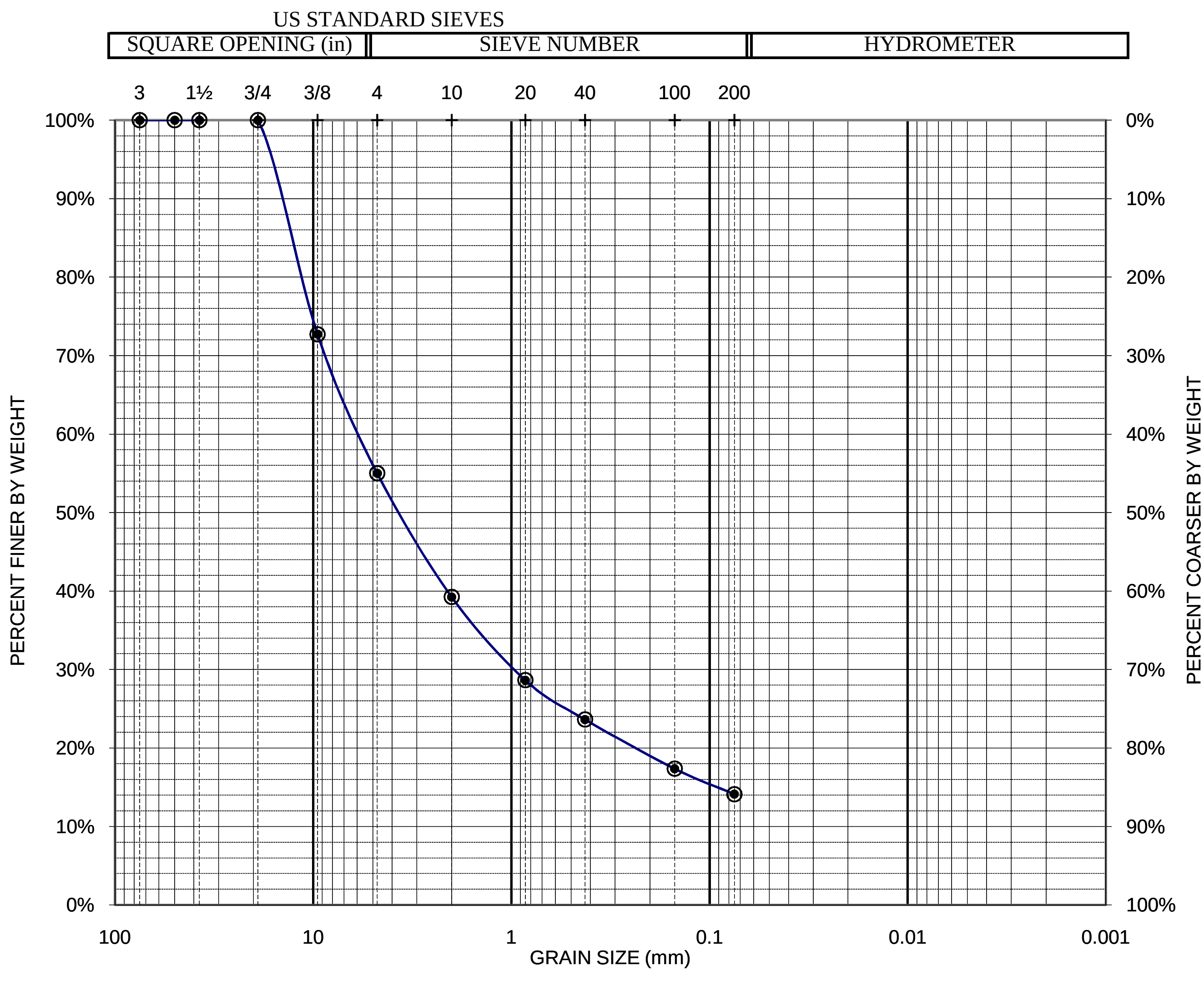
RevOct20070

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	8	**DEPTH (ft)**	25.5-26.5	**SAMPLE**	0	**DATE OF TEST**	11/12/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY GRAVEL with SAND: Brown (10YR 4/3), moist to wet



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	45.0%		40.9%			14.1%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING | **Figure C-9**

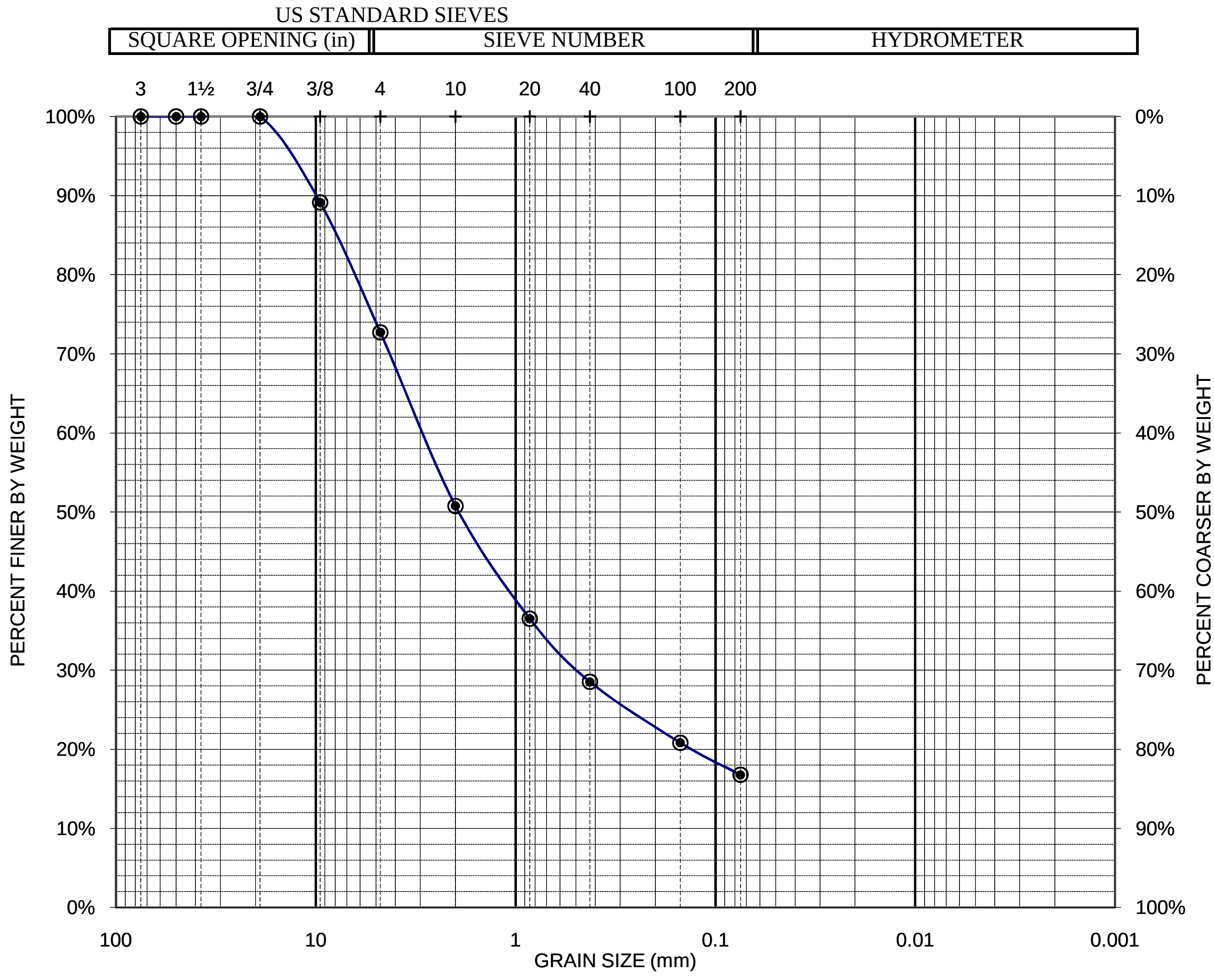
RevOct20070

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield				**PROJECT No.**	2309E
DRILL HOLE No.	9	**DEPTH (ft)**	5.5-6.5'	**SAMPLE**	**DATE OF TEST**	11/11/2009

SOURCE/QUARRY: native

DESCRIPTION OF SOIL: CLAYEY SAND W/GRAVEL: Brown (10YR4/3), wet



COBBLES	GRAVEL (COARSE / FINE)	SAND (COARSE / MEDIUM / FINE)	SILT & CLAY
	27.3%	55.9%	16.8%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING

Figure C-10

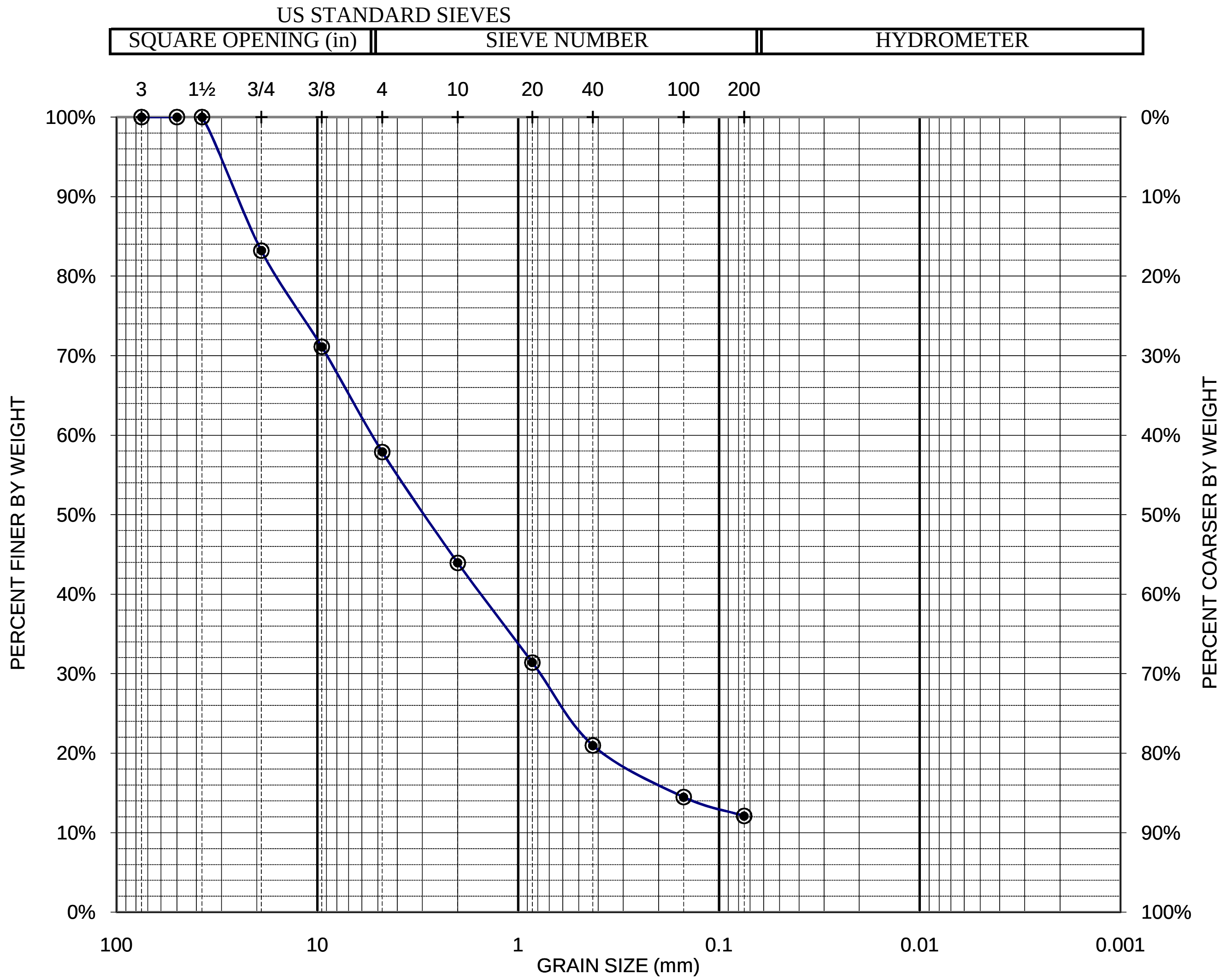
RevOct20070

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	9	**DEPTH (ft)**	30.5-31.5	**SAMPLE**	0	**DATE OF TEST**	11/16/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Brown (10YR 4/3), wet



	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	42.1%		45.8%			12.1%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING

Figure C-11

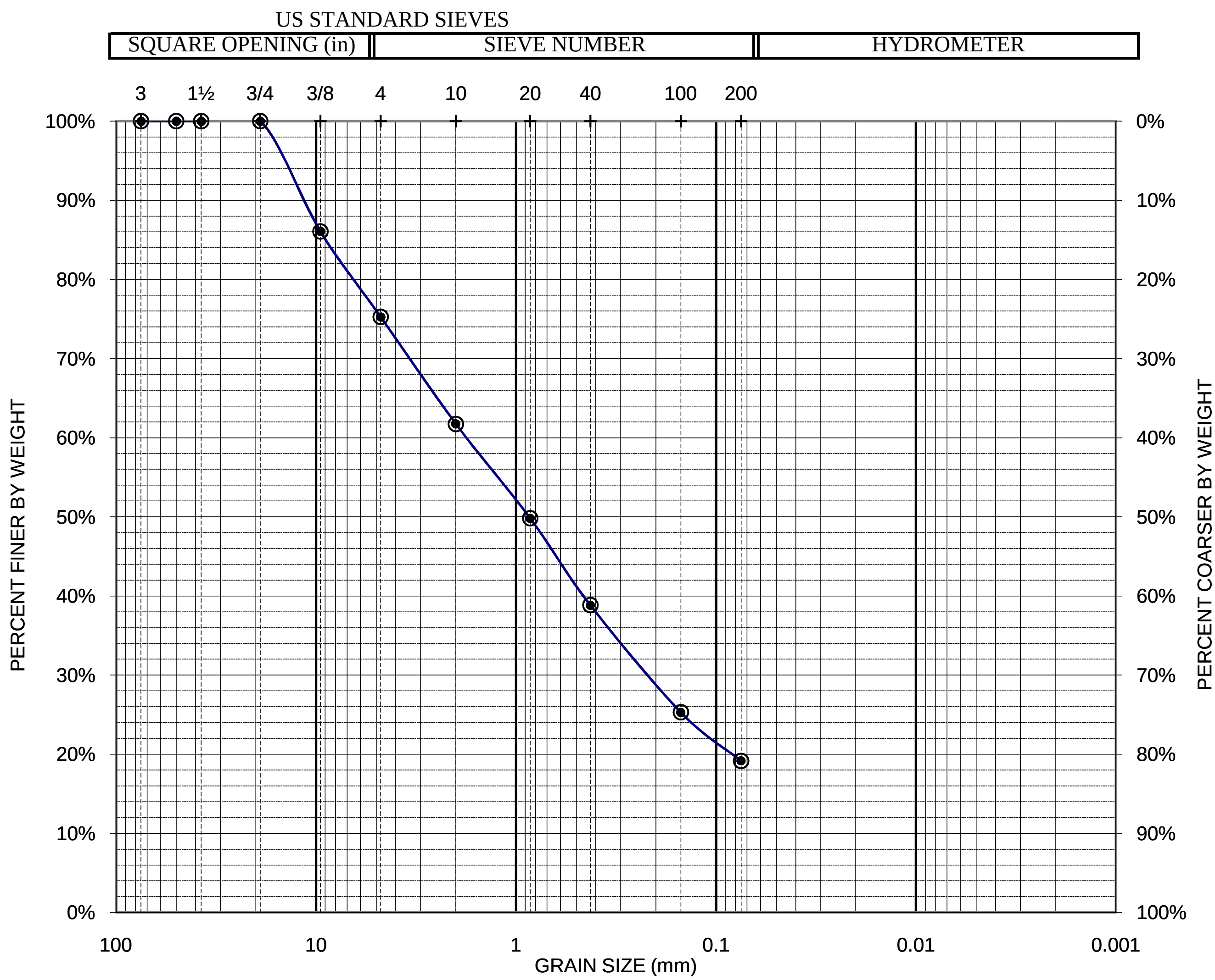
RevOct20070

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	9	**DEPTH (ft)**	40.5-41.5	**SAMPLE**	0	**DATE OF TEST**	11/16/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Brown (10YR 4/3), moist



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	24.7%		56.1%			19.2%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING

RevOct20070

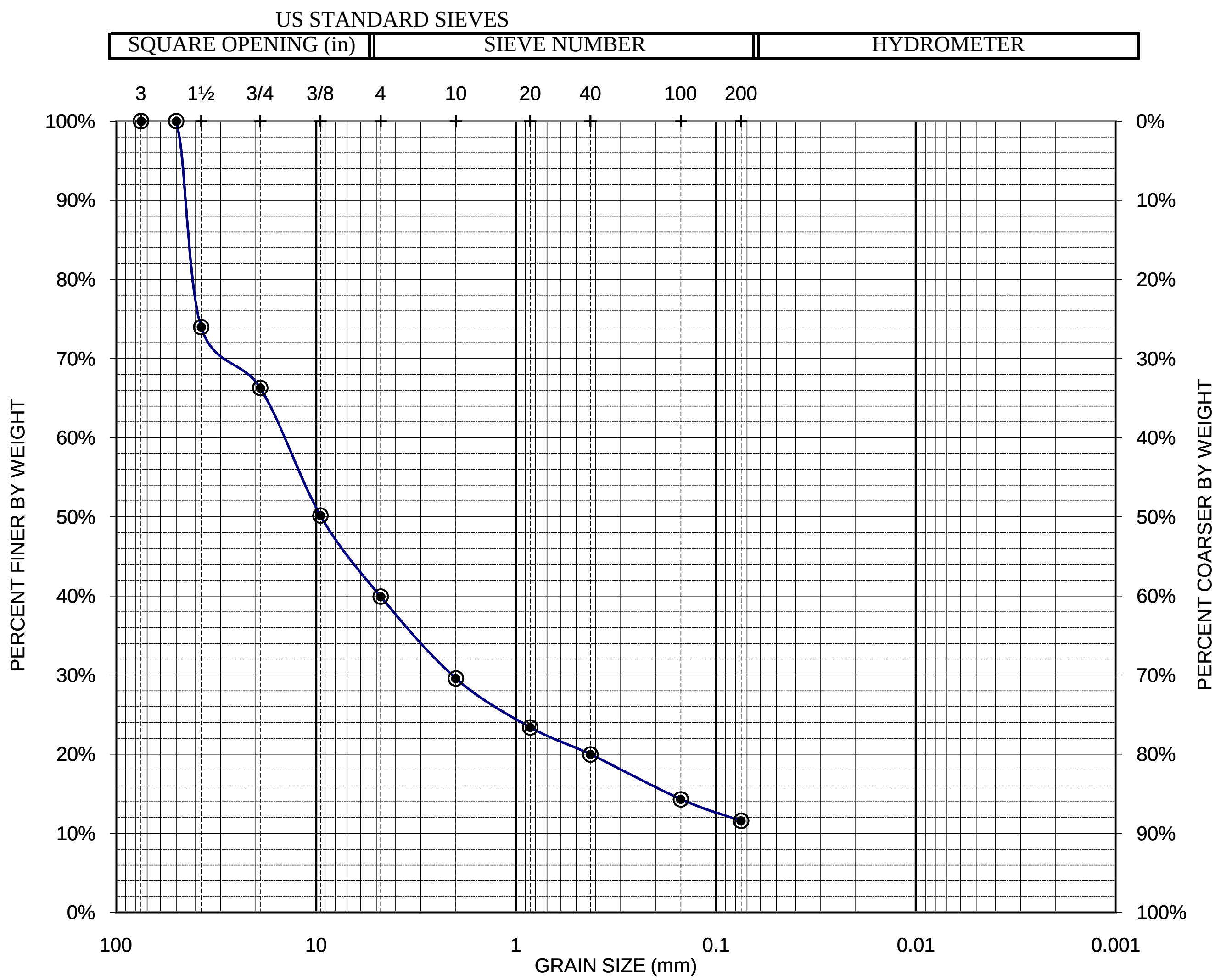
Figure C-12

GRAIN SIZE TEST RESULTS

PROJECT NAME Butterfield Blvd. Extension		**PROJECT No.**	2309 E
DRILL HOLE No. 12	**DEPTH (ft)** 5.5	**SAMPLE** 0	**DATE OF TEST** 11/16/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: POORLY GRADED GRAVEL with SAND and CLAY: Brown (10YR 4/3). moist



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	60.1%		28.3%			11.6%

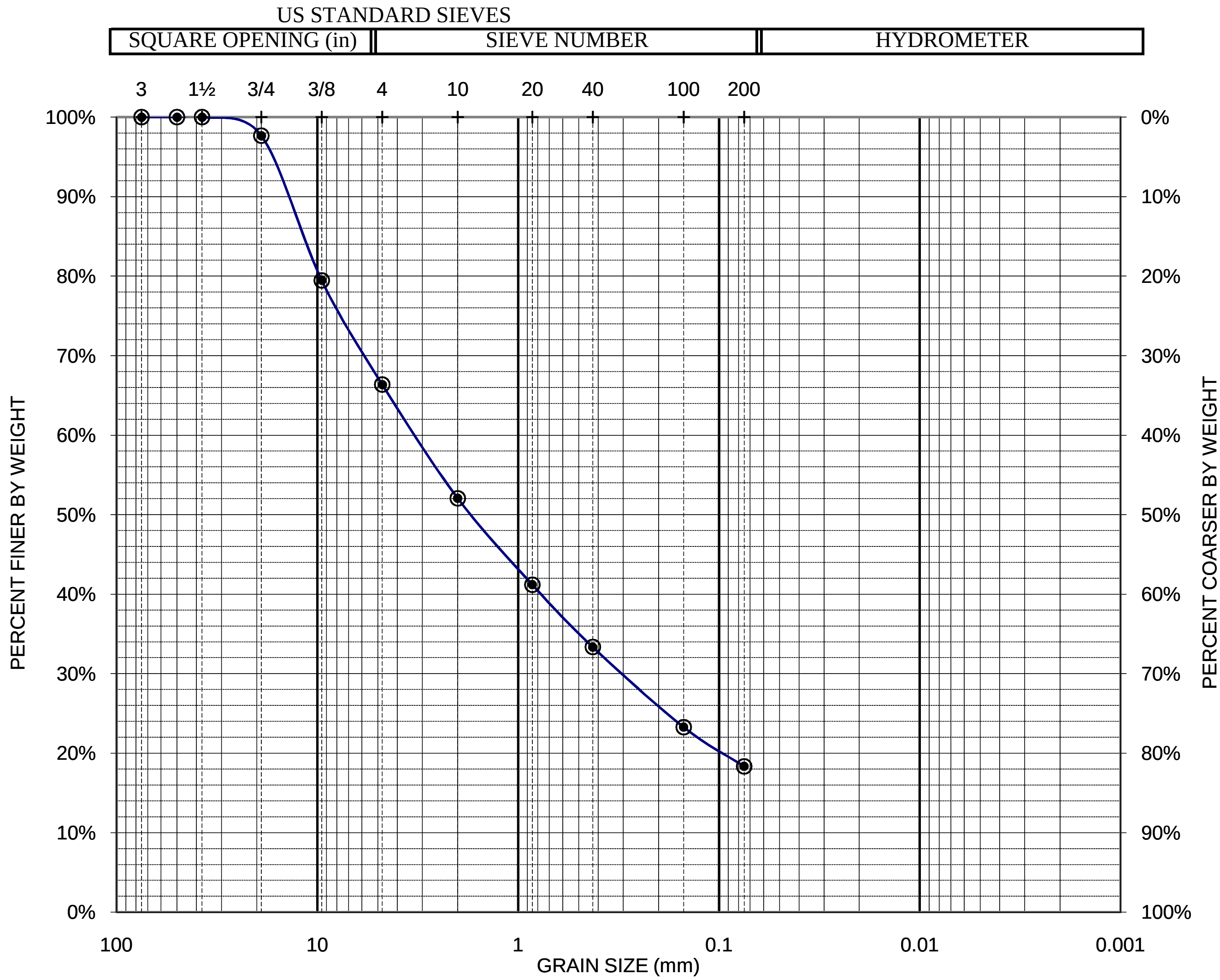
REMARKS:

GRAIN SIZE TEST RESULTS

PROJECT NAME Butterfield Blvd. Extension		**PROJECT No.**	2309 E
DRILL HOLE No. 13	**DEPTH (ft)** 5.5-6.0	**SAMPLE** 0	**DATE OF TEST** 11/17/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Brown (10YR 3/3), moist



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	33.6%		48.0%			18.3%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING — **Figure C-14**

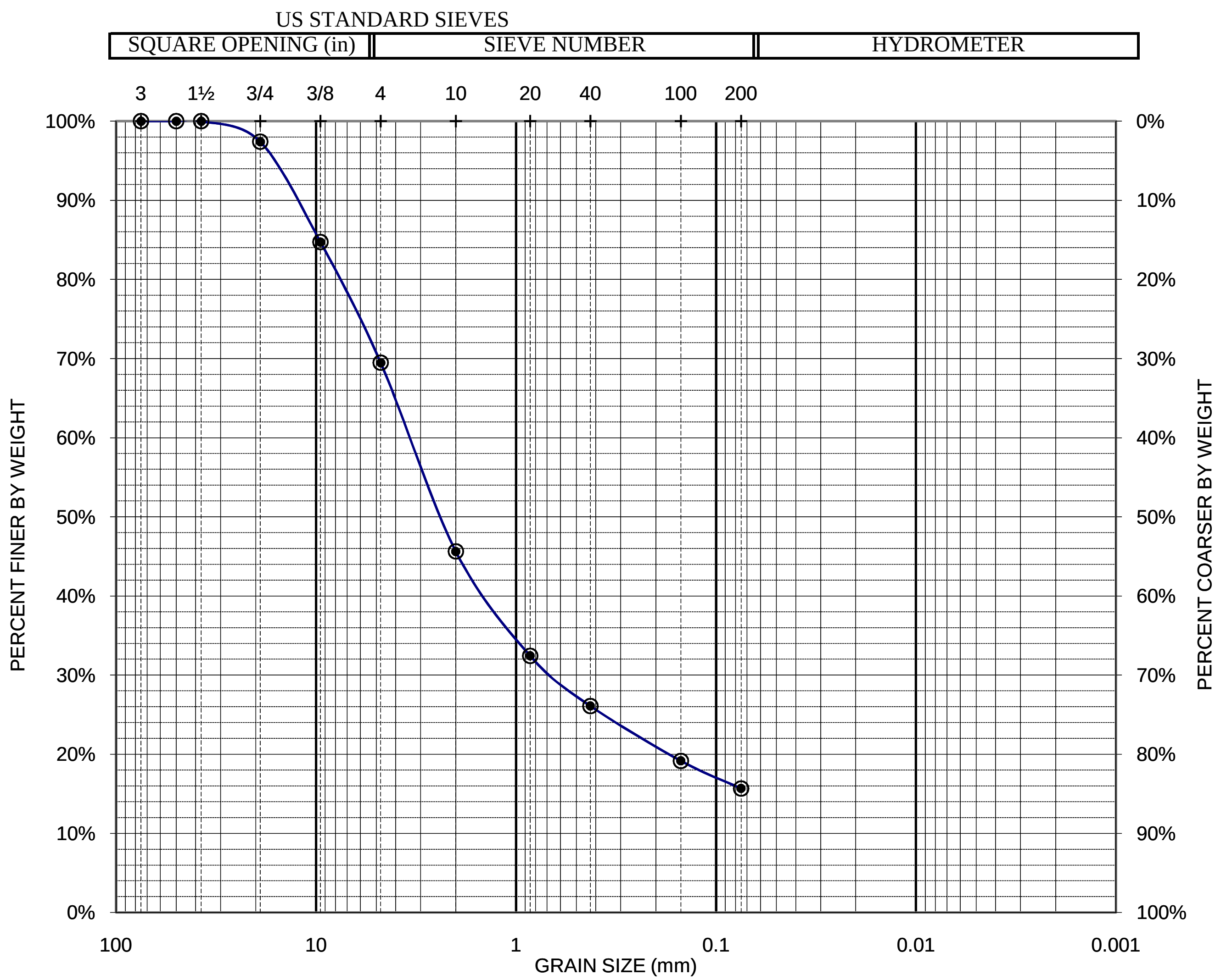
RevOct20070

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	13	**DEPTH (ft)**	14-15	**SAMPLE**	0	**DATE OF TEST**	11/17/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Brown (10YR 3/3), moist



	GRAVEL		SAND			SILT & CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	30.5%		53.8%			15.7%

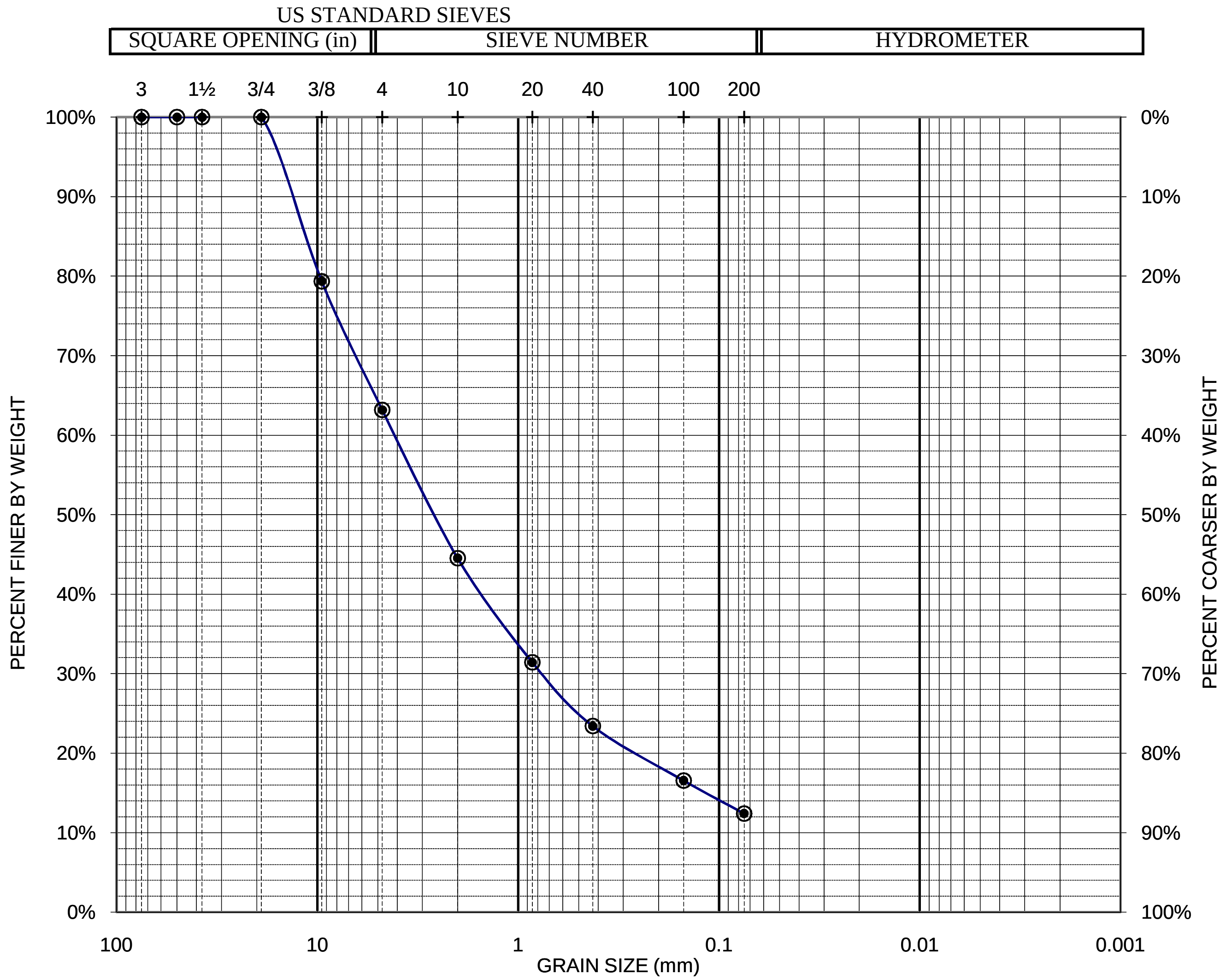
REMARKS:

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	14	**DEPTH (ft)**	9-10	**SAMPLE**	0	**DATE OF TEST**	11/9/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Brown (10YR 3/3), moist



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	36.8%		50.7%			12.4%

REMARKS:

RevOct20070

PACIFIC GEOTECHNICAL ENGINEERING

Figure **C-16**

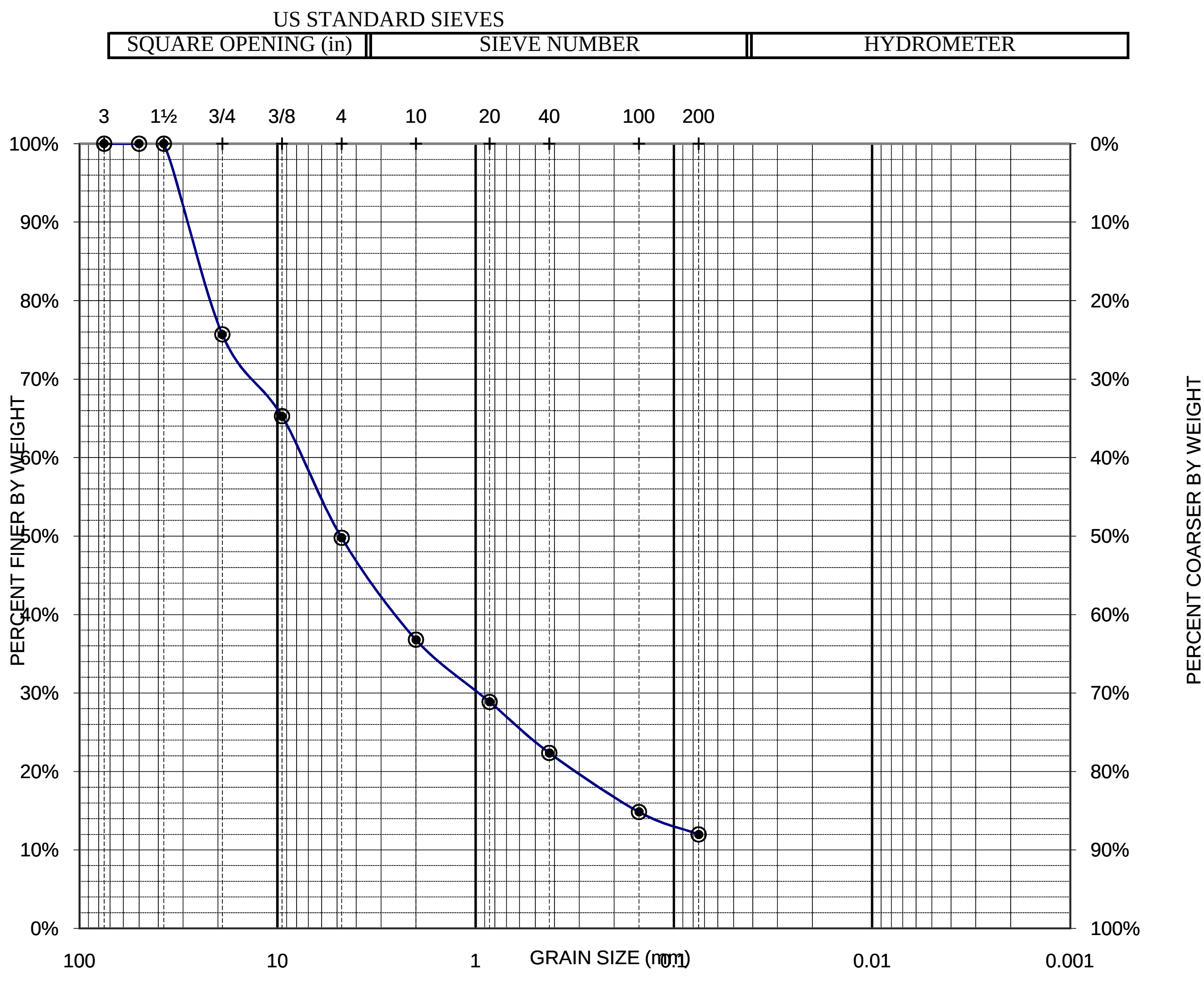
GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension	**PROJECT No.**	2309 E

DRILL HOLE No.	15	**DEPTH (ft)**	5.5-6.5	**SAMPLE**	0	**DATE OF TEST**	11/12/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY GRAVEL with SAND: Brown (10YR 4/3), moist to wet



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	50.2%		37.8%			12.0%

REMARKS:

PACIFIC GEOTECHNICAL ENGINEERING

Figure C-17

RevOct20070

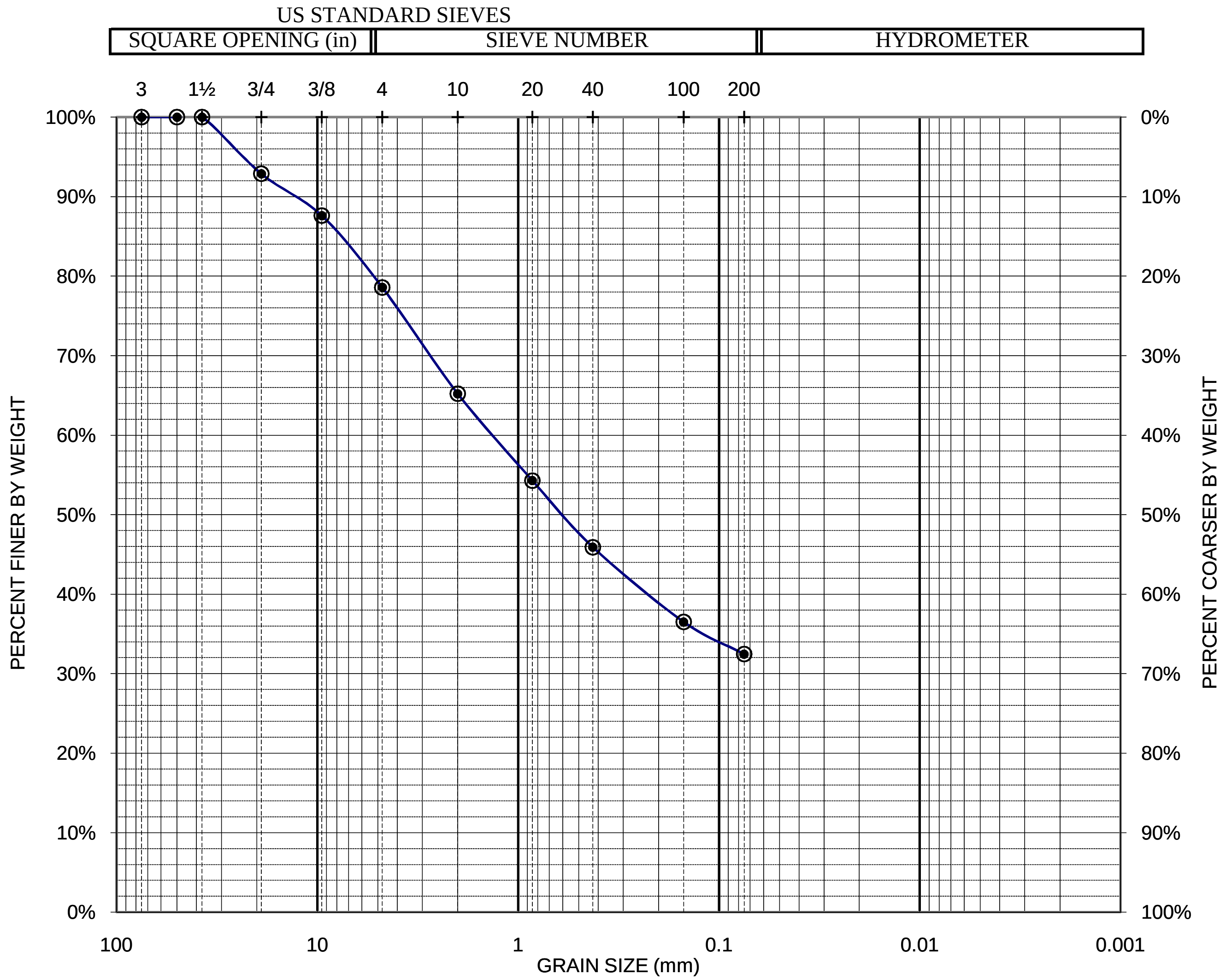
GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension	**PROJECT No.**	2309 E

DRILL HOLE No.	16	**DEPTH (ft)**	3-4	**SAMPLE**	0	**DATE OF TEST**	11/9/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Brown to dark brown (10YR 4/3 to 3/3), moist



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	21.4%		46.1%			32.4%

REMARKS:

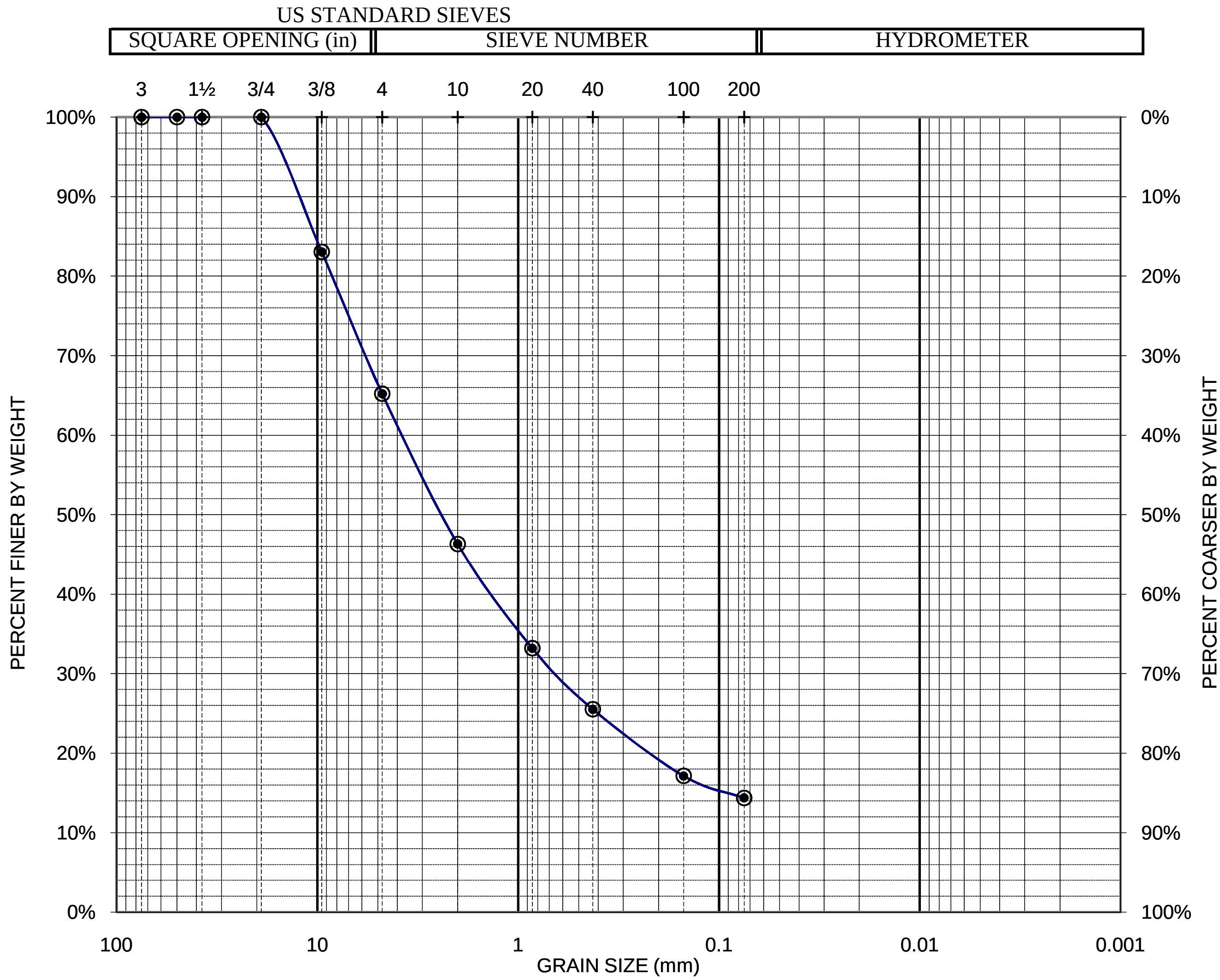
RevOct20070 PACIFIC GEOTECHNICAL ENGINEERING | **Figure C-18**

GRAIN SIZE TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension					**PROJECT No.**	2309 E
DRILL HOLE No.	17	**DEPTH (ft)**	5.5-6.0	**SAMPLE**	0	**DATE OF TEST**	11/9/2009

SOURCE/QUARRY: ---

DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Dark yellowish brown (10YR 3/4), moist



	COARSE	FINE	COARSE	MEDIUM	FINE	
COBBLES	GRAVEL		SAND			SILT & CLAY
	34.8%		50.8%			14.4%

REMARKS:

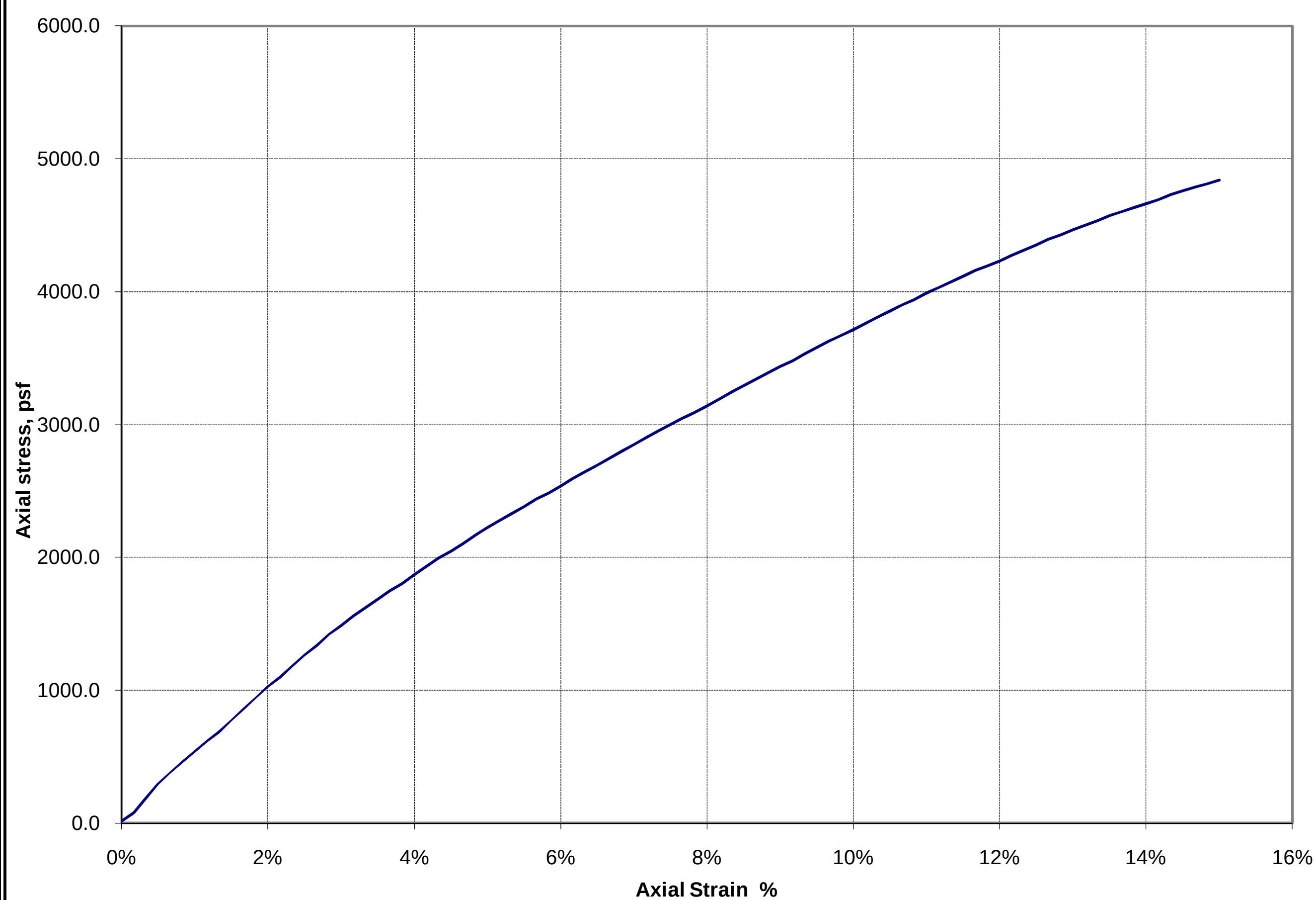
PACIFIC GEOTECHNICAL ENGINEERING

Figure C-19

RevOct20070

UNCONFINED COMPRESSION TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension			**PROJECT No.**	2309 E
DRILL HOLE No. 10	**DEPTH (ft)** 36.0	**SAMPLE**		**DATE OF TEST**	11/16/2009
DESCRIPTION OF SOIL	CLAY: Mottled yellowish brown (10YR 5/4) and strong brown (7.5YR 5/6), moist				
LENGTH OF SAMPLE:	6.00 **in.**		**WATER CONTENT:**	27%	
DIAMETER OF SAMPLE:	2.37 **in.**		**DRY DENSITY:**	100	**pcf**
HEIGHT TO DIA. RATIO:	2.5		**MAX COMPRESSIVE STRENGTH:**	4839	**psf**
STRAIN RATE:	1.23% **per minute**		**STRAIN AT MAX STRENGTH:**	15.0%	



REMARKS: Maximum strength taken at 15% strain.

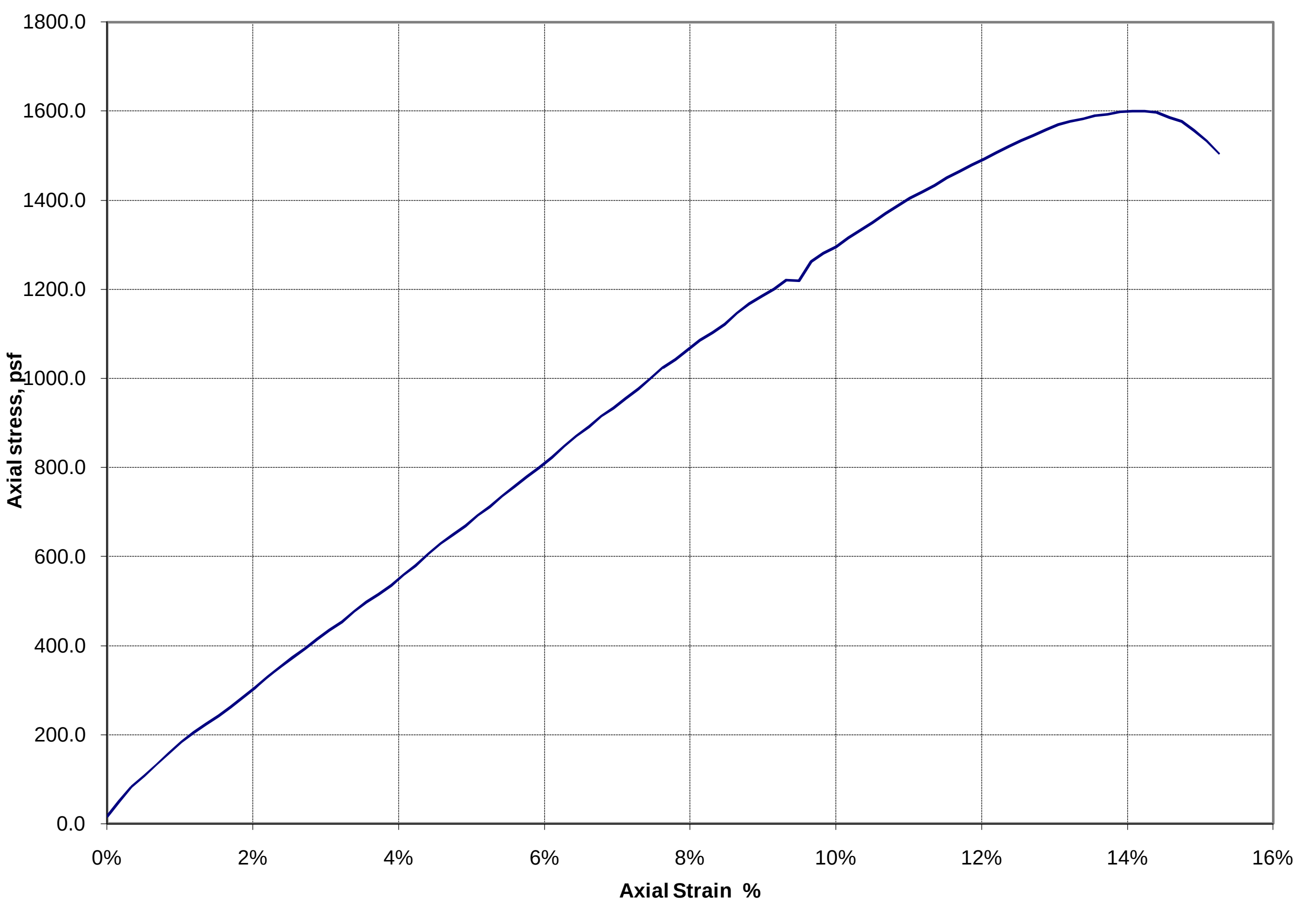
Rev 032806

PACIFIC GEOTECHINCAL ENGINEERING

Figure C-20

UNCONFINED COMPRESSION TEST RESULTS

PROJECT NAME	Butterfield Blvd. Extension			**PROJECT No.**	2309 E
DRILL HOLE No.	12	**DEPTH (ft)** 14.5	**SAMPLE**	**DATE OF TEST**	11/16/2009
DESCRIPTION OF SOIL	LEAN CLAY/CLAY: Mottled pale brown (10YR 6/3) and dark yellowish brown (10YR 4/6), moist				
LENGTH OF SAMPLE:	5.90 **in.**			**WATER CONTENT:**	22%
DIAMETER OF SAMPLE:	2.40 **in.**			**DRY DENSITY:**	107 **pcf**
HEIGHT TO DIA. RATIO:	2.5			**MAX COMPRESSIVE STRENGTH:**	1600 **psf**
STRAIN RATE:	1.30% **per minute**			**STRAIN AT MAX STRENGTH:**	14.1%



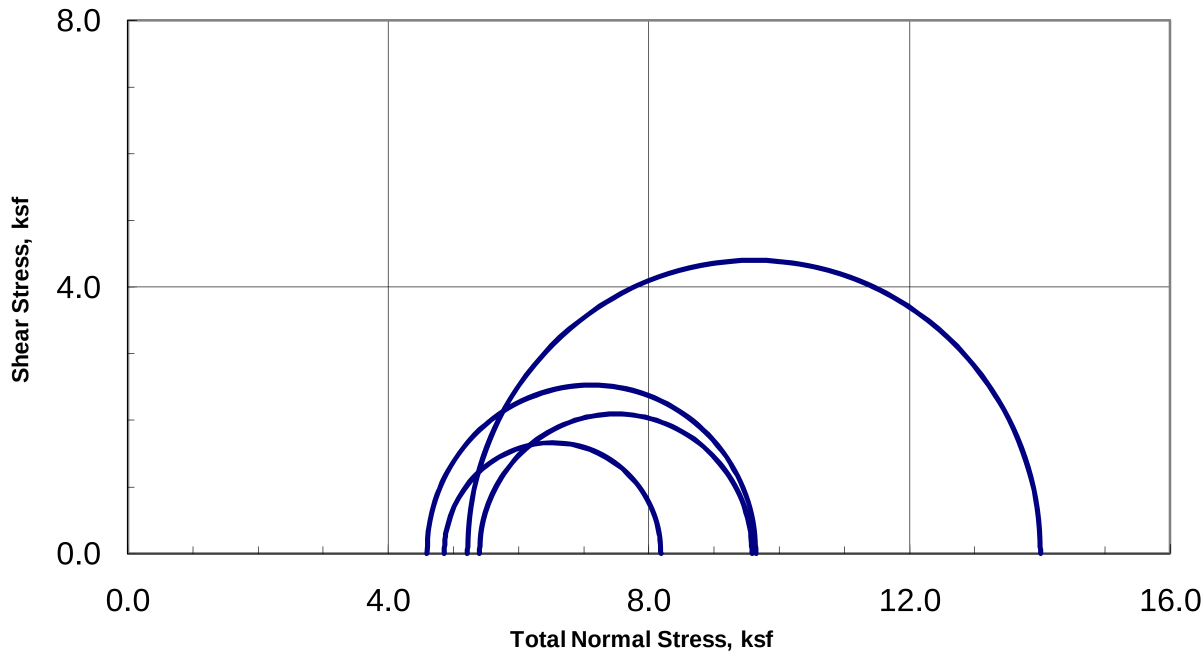
REMARKS:

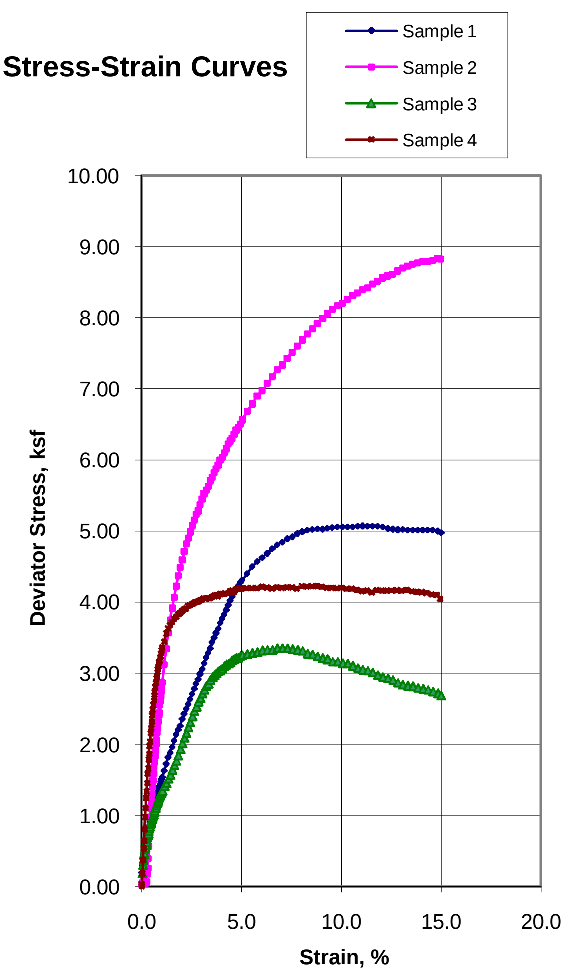
Rev 032806

PACIFIC GEOTECHINCAL ENGINEERING

Figure C-21

Unconsolidated-Undrained Triaxial Test
ASTM D-2850





Sample Data				
	1	2	3	4
Moisture %	26.7	23.3	37.9	45.3
Dry Den,pcf	94.9	103.3	80.6	75.8
Void Ratio	0.776	0.631	1.092	1.225
Saturation %	92.9	99.8	93.8	99.8
Height in	6.00	5.03	6.00	5.02
Diameter in	2.85	2.45	2.85	2.43
Cell psi	31.9	36.2	33.7	37.5
Strain %	10.80	14.80	6.80	8.00
Deviator, ksf	5.070	8.833	3.351	4.224
Rate %/min	1.00	1.00	1.00	1.00
in/min	0.060	0.050	0.060	0.050
Job No.:	**226-185**			
Client:	**Pacific Geotechnical Engineering**			
Project:	**Butterfield Blvd. Extension - 2309E**			
Boring:	DH-6	DH-8	DH-10	DH-10
Sample:				
Depth ft:	47-49.5	56	50-52.5	60

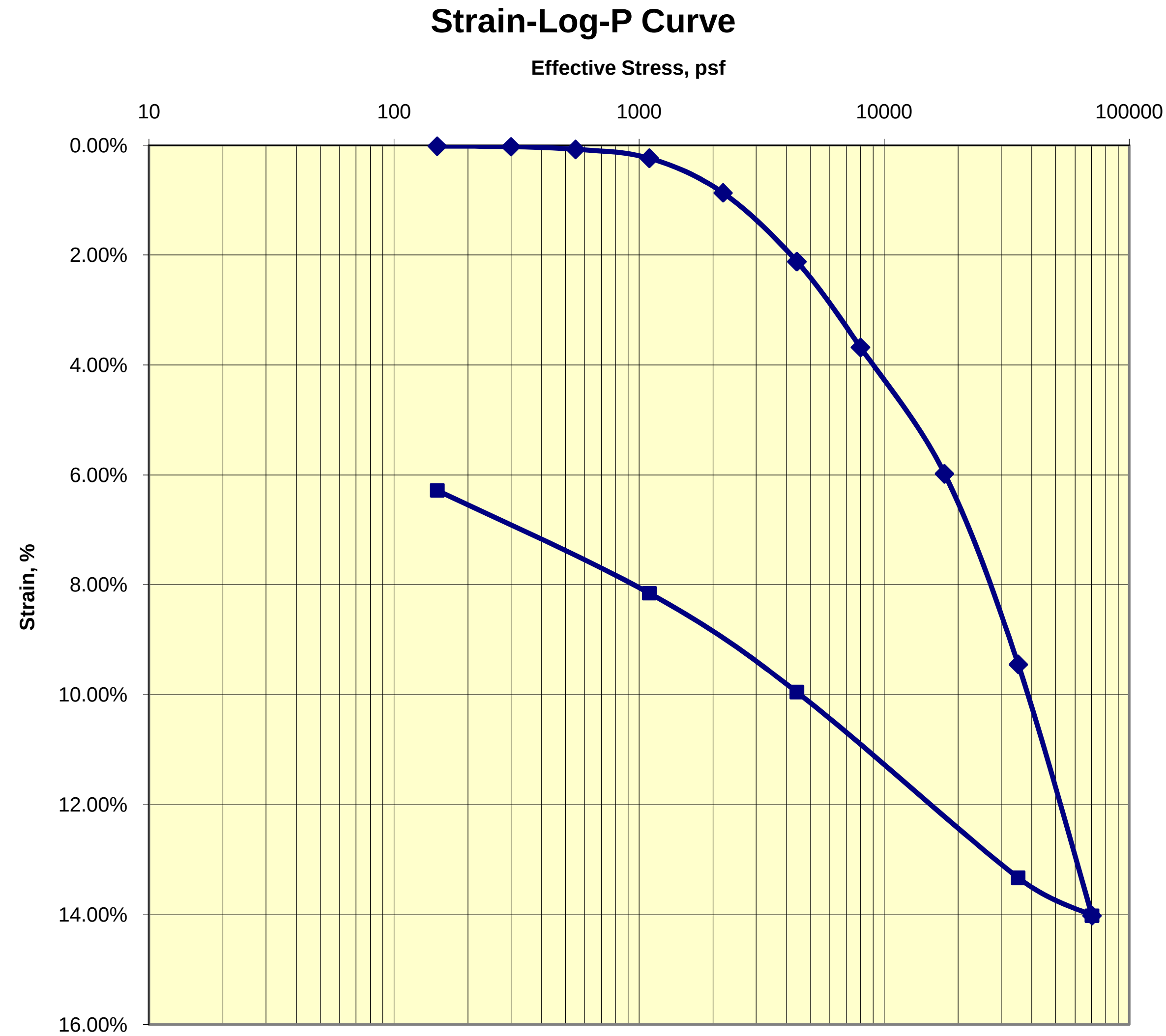
Visual Soil Description	
Sample #	
1	Brown CLAY, trace Sand
2	Strong Brown CLAY w/ Sand
3	Gray & Brown CLAY
4	Bluish Gray CLAY

Remarks:

Figure C-22

Consolidation Test
ASTM D2435

Job No.:	226-185	**Boring:**	DH-8	**Run By:**	MD
Client:	Pacific Geotechnical Eng.	**Sample:**		**Reduced:**	PJ
Project:	Butterfield Blvd. Extension - 2309E	**Depth, ft.:**	47-49.5	**Checked:**	PJ/DC
Soil Type:	Reddish Brown CLAY, trace Sand			**Date:**	11/19/2009



Ass. Gs = 2.8	**Initial**	**Final**
Moisture %:	27.5	27.4
Dry Density, pcf:	94.4	99.0
Void Ratio:	0.851	0.765
% Saturation:	90.6	100

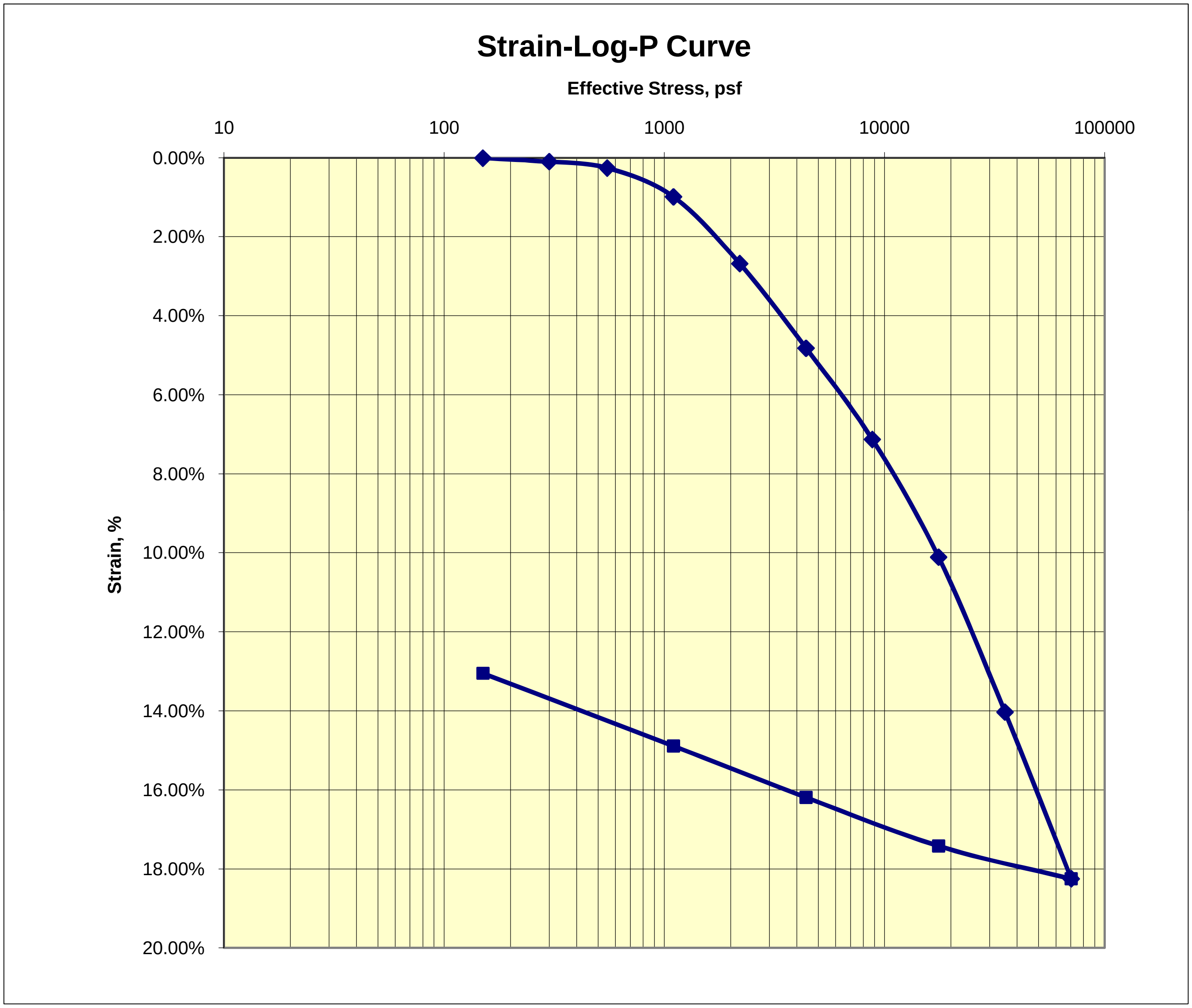
Remarks: The sample tube was egg-shaped. In order to minimize the chance of testing a disturbed sample, this test was run on material about 4 inches above the end of the tube.

Figure C-23

Consolidation Test

ASTM D2435

Job No.:	226-185	**Boring:**	DH-9	**Run By:**	MD
Client:	Pacific Geotechnical Eng.	**Sample:**		**Reduced:**	PJ
Project:	Butterfield Blcd. Extension - 2309E	**Depth, ft.:**	55-57.5	**Checked:**	PJ/DC
Soil Type:	Reddish Brown CLAY w/ Sand (pending PI results)			**Date:**	11/20/2009



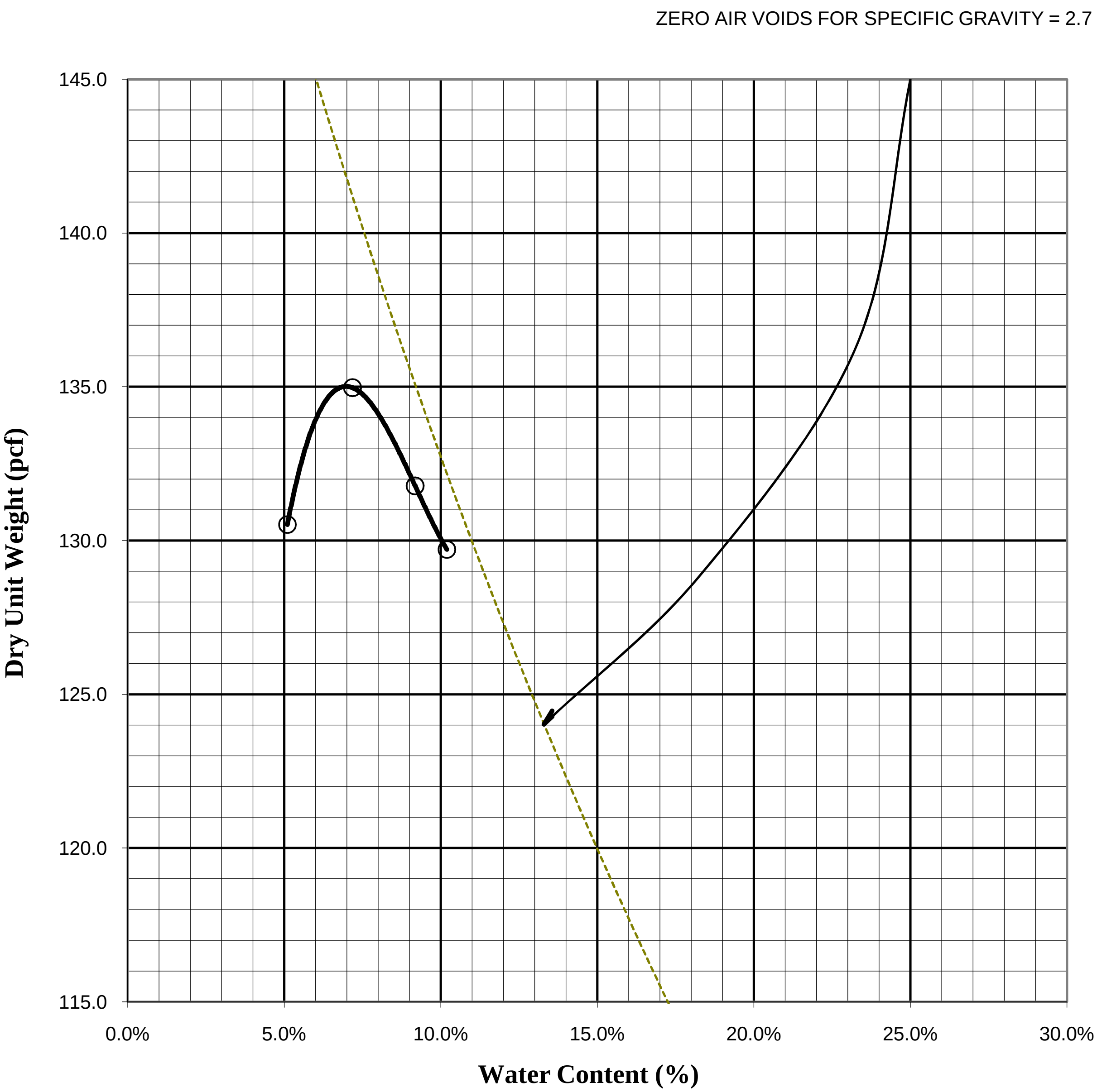
Ass. Gs = 2.8	**Initial**	**Final**
Moisture %:	21.4	20.9
Dry Density, pcf:	96.6	110.3
Void Ratio:	0.810	0.585
% Saturation:	73.9	100

Remarks: The sample tube was badly dented and egg-shaped. In order to minimize the chance of testing a disturbed sample, this test was run on material from near the top of the tube.

Figure C-24

COMPACTION TEST RESULTS

PROJECT NAME: Butterfield Blvd. Extension			**PROJ. No.**: 2309/E
TEST & METHOD ASTM D1557-91 C	**SAMPLE**: B-6 DH-7	**DEPTH**: 0.0-3.0'	**DATE:** 11/6/2009
DESCRIPTION OF SOIL: CLAYEY SAND with GRAVEL: Pale Brown (10YR 6/4), moist-dry			
MAXIMUM DRY UNIT WEIGHT(pcf): 135.0		**OPTIMUM WATER CONTENT(%):** 7.0	



COOPER TESTING LABORATORY

R-value Test Report (Caltrans 301)

Job No.:	226-185	**Date:**	11/19/09	**Initial Moisture,**	1.9%
Client:	Pacific Geotechnical Engineering	**Tested**	MD	**R-value by Stabilometer**	70
Project:	Butterfield Blvd. Extension - 2309E	**Reduced**	RU		
Sample	B1;DH12 @ 0-2'	**Checked**	DC	**Expansion Pressure**	20 psf
Soil Type:	Brown Clayey SAND w/ Gravel				

Specimen Number	A	B	C	D
Exudation Pressure, psi	184	800	306	
Prepared Weight, grams	1300	1300	1300	
Final Water Added, grams/cc	105	80	90	
Weight of Soil & Mold, grams	3339	3274	3248	
Weight of Mold, grams	2120	2107	2091	
Height After Compaction, in.	2.64	2.55	2.52	
Moisture Content, %	10.2	8.2	9.0	
Dry Density, pcf	126.9	128.1	127.6	
Expansion Pressure, psf	0.0	34.4	21.5	
Stabilometer @ 1000				
Stabilometer @ 2000	77	21	35	
Turns Displacement	3.98	3.98	3.7	
R-value	44	81	71	

Remarks:

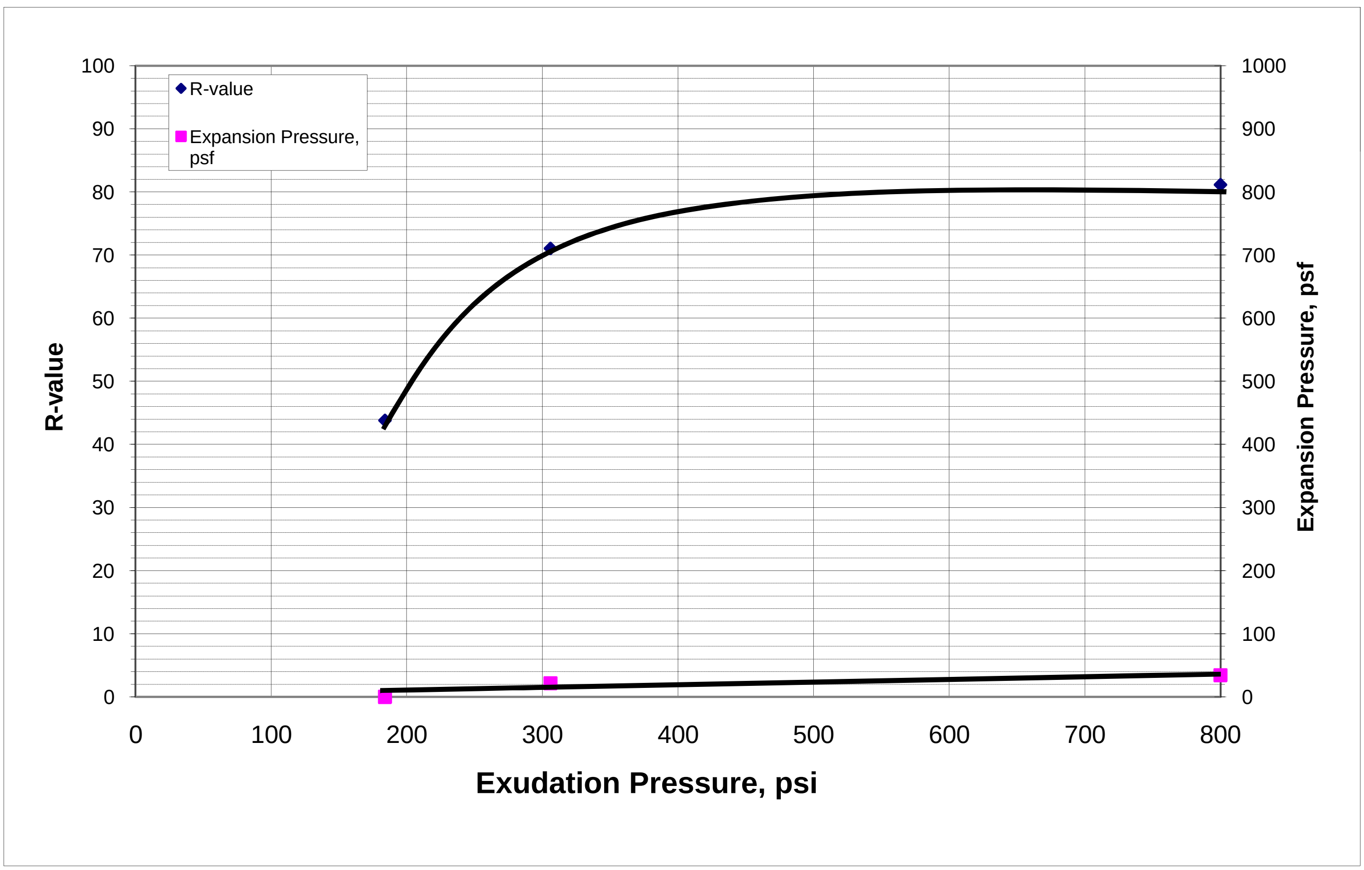


Figure C-26

R-value Test Report (Caltrans 301)

Job No.:	226-185	**Date:**	11/19/09	**Initial Moisture,**	2.0%
Client:	Pacific Geotechnical Engineering	**Tested**	MD	**R-value by Stabilometer**	**66**
Project:	Butterfield Blvd. Extension - 2309E	**Reduced**	RU		
Sample	B2;DH1 @ 0-2'	**Checked**	DC	**Expansion Pressure**	**40** psf
Soil Type:	Brown Clayey SAND w/ Gravel				

Specimen Number	A	B	C	D
Exudation Pressure, psi	790	238	540	
Prepared Weight, grams	1300	1300	1300	
Final Water Added, grams/cc	90	100	95	
Weight of Soil & Mold, grams	3261	3305	3263	
Weight of Mold, grams	2079	2104	2093	
Height After Compaction, in.	2.57	2.65	2.52	
Moisture Content, %	9.0	9.8	9.4	
Dry Density, pcf	127.7	125.0	128.5	
Expansion Pressure, psf	64.5	30.1	38.7	
Stabilometer @ 1000				
Stabilometer @ 2000	24	51	27	
Turns Displacement	4	3.8	3.9	
R-value	79	62	76	

Remarks:

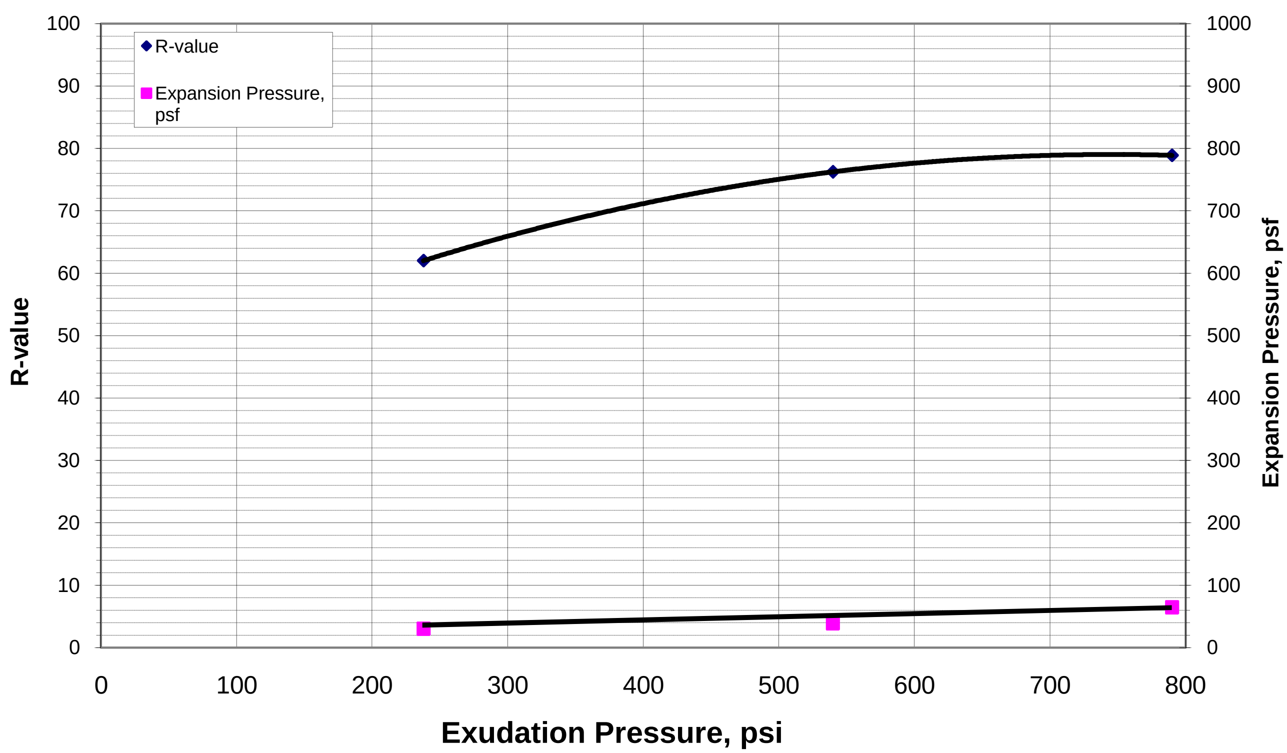


Figure C-27

R-value Test Report (Caltrans 301)

Job No.:	226-185	**Date:**	11/19/09	**Initial Moisture,**	11.3%
Client:	Pacific Geotechnical Engineering	**Tested**	MD	**R-value by Stabilometer**	**12**
Project:	Butterfield Blvd. Extension - 2309E	**Reduced**	RU		
Sample	B3;DH15 @ 0-2'	**Checked**	DC	**Expansion Pressure**	**0** psf
Soil Type:	Brown Clayey SAND				

Specimen Number	A	B	C	D
Exudation Pressure, psi	280	223	330	
Prepared Weight, grams	1200	1200	1200	
Final Water Added, grams/cc	50	65	33	
Weight of Soil & Mold, grams	3232	3179	3176	
Weight of Mold, grams	2100	2093	2100	
Height After Compaction, in.	2.6	2.54	2.45	
Moisture Content, %	15.9	17.3	14.4	
Dry Density, pcf	113.7	110.3	116.3	
Expansion Pressure, psf	0.0	0.0	0.0	
Stabilometer @ 1000				
Stabilometer @ 2000	137	144	131	
Turns Displacement	3.74	4.1	3.35	
R-value	11	6	14	

Remarks:

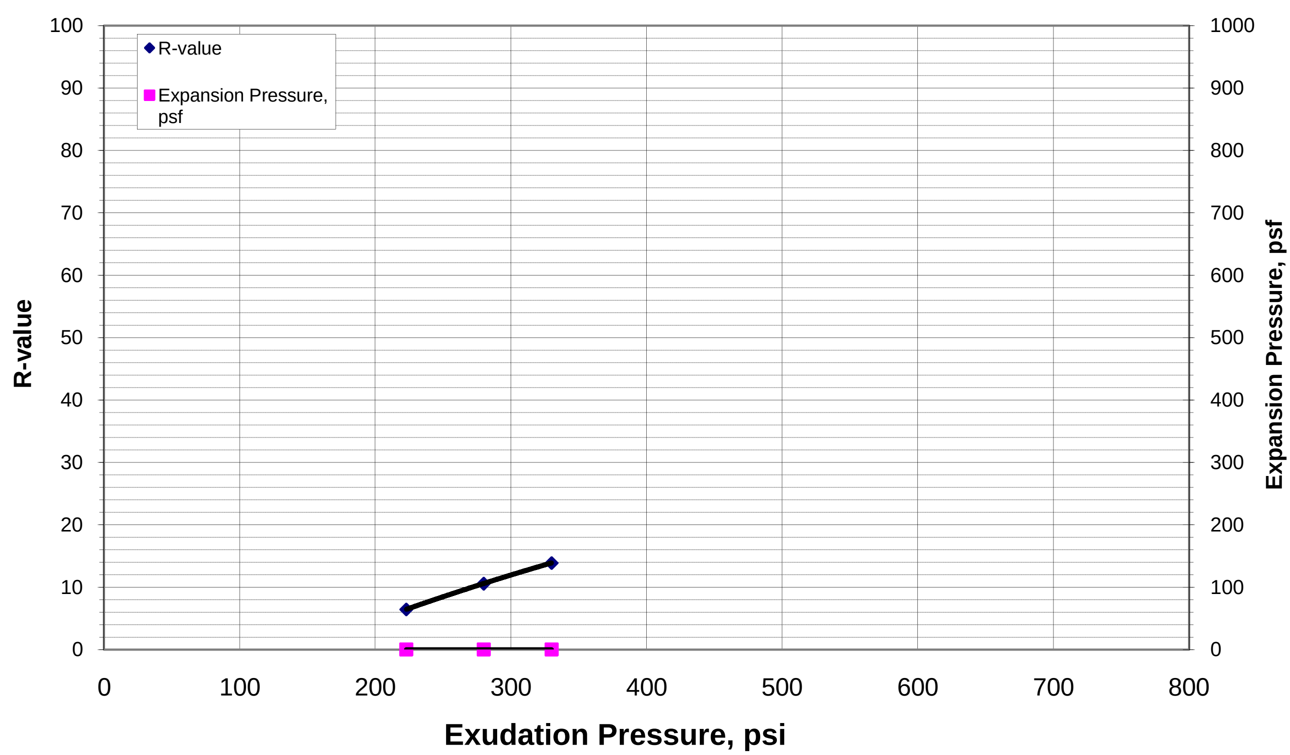


Figure C-28

R-value Test Report (Caltrans 301)

Job No.:	226-185	**Date:**	11/16/09	**Initial Moisture,**	1.9%
Client:	Pacific Geotechnical Engineering	**Tested**	MD	**R-value by Stabilometer**	**56**
Project:	Butterfield Blvd. Extension - 2309E	**Reduced**	RU		
Sample	B4;DH14 @ 0-2'	**Checked**	DC	**Expansion Pressure**	**0** **psf**
Soil Type:	Brown Sandy CLAY w/ Gravel				

Specimen Number	A	B	C	D
Exudation Pressure, psi	122	800	249	328
Prepared Weight, grams	1300	1300	1300	1300
Final Water Added, grams/cc	110	95	103	99
Weight of Soil & Mold, grams	3351	3244	3318	3307
Weight of Mold, grams	2107	2100	2093	2120
Height After Compaction, in.	2.7	2.45	2.68	2.56
Moisture Content, %	10.5	9.3	9.9	9.6
Dry Density, pcf	126.3	129.4	125.9	128.1
Expansion Pressure, psf	0.0	0.0	0.0	0.0
Stabilometer @ 1000				
Stabilometer @ 2000	100	32	71	52
Turns Displacement	4.45	3.55	4.1	3.9
R-value	29	73	48	59

Remarks:

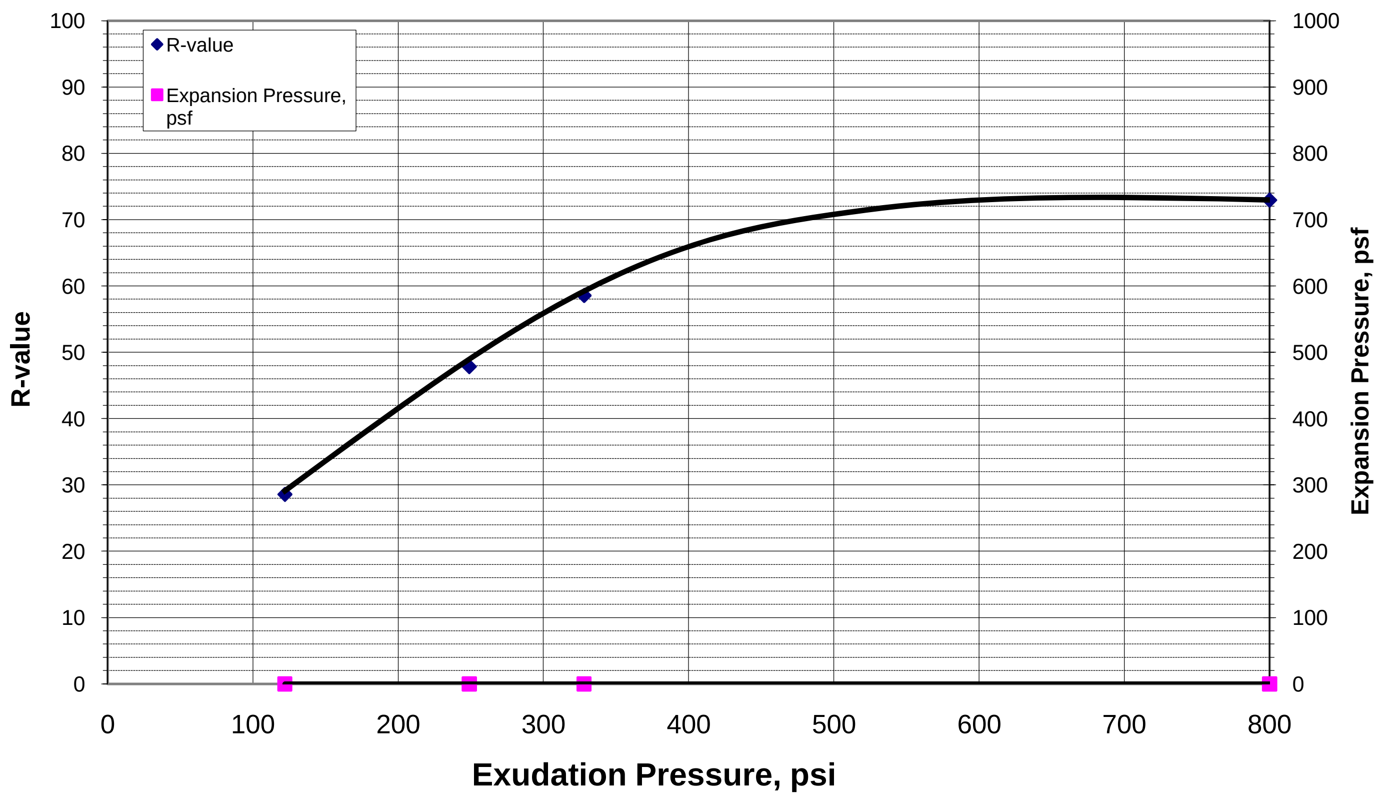


Figure C-29

R-value Test Report (Caltrans 301)

Job No.:	226-185	**Date:**	11/16/09	**Initial Moisture,**	2.2%
Client:	Pacific Geotechnical Engineering	**Tested**	MD	**R-value by Stabilometer**	**44**
Project:	Butterfield Blvd. Extension - 2309E	**Reduced**	RU		
Sample	B5;DH13 @ 0-2'	**Checked**	DC	**Expansion Pressure**	**40** psf
Soil Type:	Brown Clayey SAND w/ Gravel				

Specimen Number	A	B	C	D
Exudation Pressure, psi	248	572	800	
Prepared Weight, grams	1300	1300	1300	
Final Water Added, grams/cc	100	85	80	
Weight of Soil & Mold, grams	3334	3287	3247	
Weight of Mold, grams	2086	2078	2096	
Height After Compaction, in.	2.64	2.57	2.4	
Moisture Content, %	10.1	8.9	8.5	
Dry Density, pcf	130.0	130.8	133.8	
Expansion Pressure, psf	30.1	77.4	86.0	
Stabilometer @ 1000				
Stabilometer @ 2000	82	55	32	
Turns Displacement	3.74	3.6	3.5	
R-value	42	59	72	

Remarks:

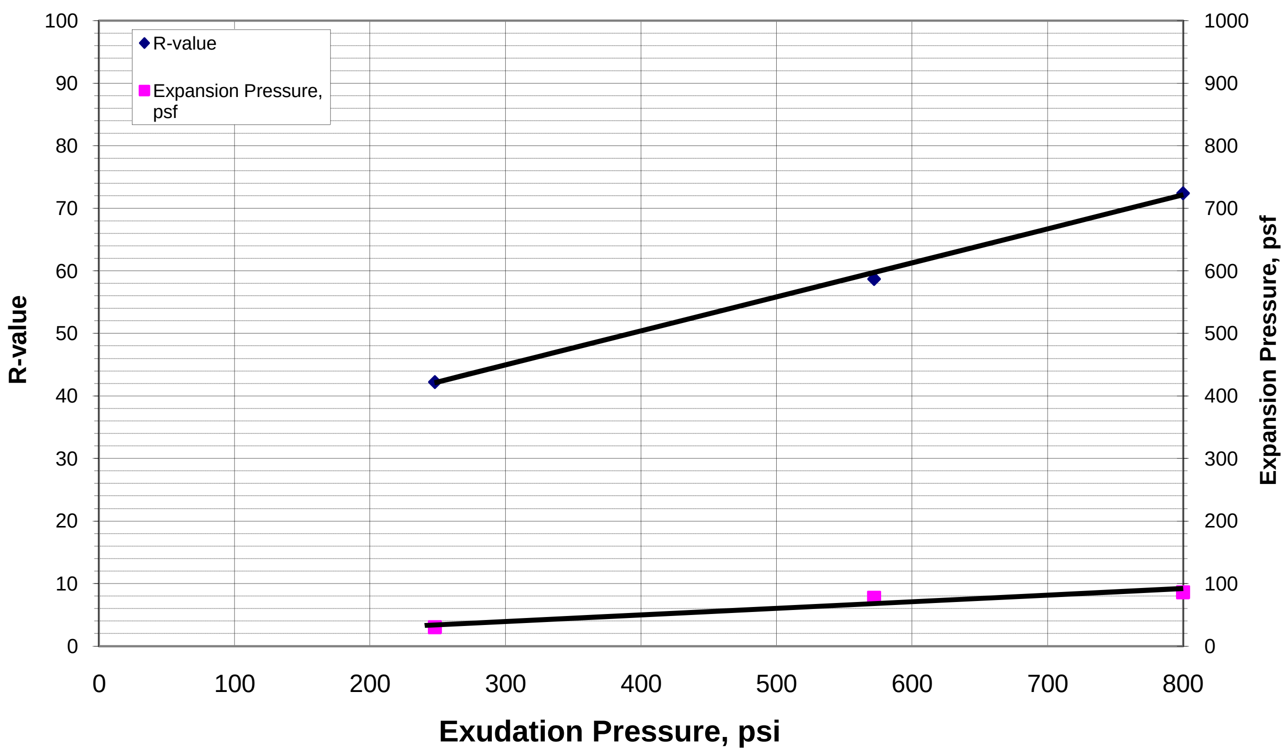


Figure C-30

R-value Test Report (Caltrans 301)

Job No.:	226-185	**Date:**	11/16/09	**Initial Moisture,**	2.5%
Client:	Pacific Geotechnical Engineering	**Tested**	MD	**R-value by Stabilometer**	**51**
Project:	Butterfield Blvd. Extension - 2309E	**Reduced**	RU		
Sample	B7;DH3 @ 0-2'	**Checked**	DC	**Expansion Pressure**	**0** psf
Soil Type:	Brown Clayey SAND w/ Gravel				

Specimen Number	A	B	C	D
Exudation Pressure, psi	190	555	341	620
Prepared Weight, grams	1300	1300	1300	1300
Final Water Added, grams/cc	90	80	85	77
Weight of Soil & Mold, grams	3304	3310	3265	3328
Weight of Mold, grams	2086	2106	2089	2109
Height After Compaction, in.	2.62	2.54	2.53	2.58
Moisture Content, %	9.6	8.8	9.2	8.6
Dry Density, pcf	128.4	131.9	128.9	131.8
Expansion Pressure, psf	0.0	0.0	0.0	0.0
Stabilometer @ 1000				
Stabilometer @ 2000	86	42	59	42
Turns Displacement	3.6	3.64	3.7	3.65
R-value	40	66	54	67

Remarks:

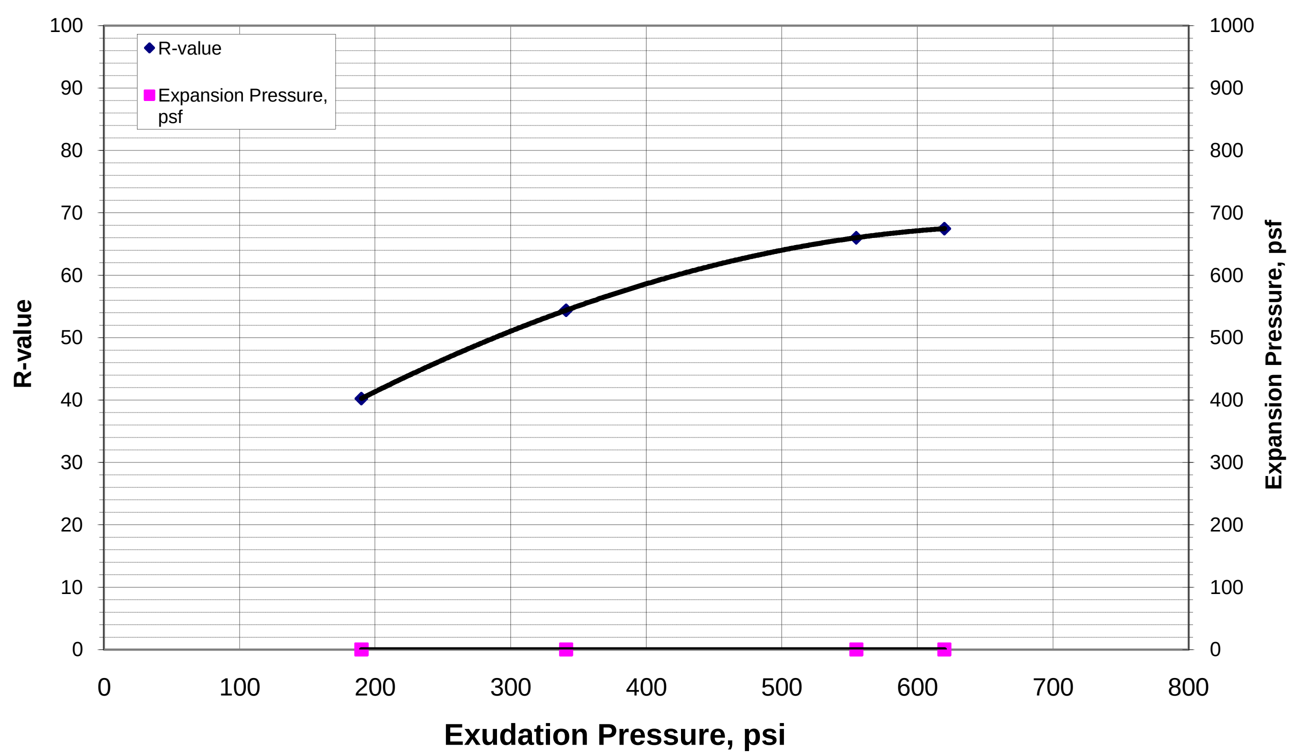


Figure C-31

California State Certified Laboratory No. 2153

CERCO analytical
1100 Willow Pass Court, Suite A
Concord, CA 94520-1006
925 **462 2771** Fax: 925 **462 2775**
www.cercoanalytical.com

Client: Pacific Geotechnical Engineering
Client's Project No.: Not Indicated
Client's Project Name: Butterfield
Date Sampled: 6-Nov-09
Date Received: 9-Nov-09
Matrix: Soil
Authorization: Chain of Custody

Date of Report: 3-Dec-2009

Job/Sample No.	Sample I.D.	Moisture (%)	pH	Min.Resistivity (ohms-cm)**	Sulfide (mg/kg)*	Chloride (mg/kg)*	Sulfate (mg/kg)*
0911062-001	DH1 @ 3-4'	-	7.6	7,400	-	N.D.	N.D.
0911062-002	DH7 @ 5.6-6.5'	-	6.9	8,600	-	N.D.	16
0911062-003	DH8 @ 30.5'31.5' & 34.5'	-	7.7	3,100	-	18	N.D.
0911062-004	DH9 @ 65.5'	-	7.6	1,600	-	N.D.	N.D.
0911062-005	DH8 @ 15.5-16.5' & 20.5-21.5'	-	7.8	5,600	-	N.D.	N.D.
0911062-006	DH14-17 @ 1'	-	6.8	3,700	-	16	46

	Moisture	pH	Min.Resistivity	Sulfide	Chloride	Sulfate
Method:	226	CT 532/643	CT 532/643	-	CT 422/ASTM D4327	CT 417/ASTM D4327
Detection Limit:	-	-	-	50	15	15
Date Analyzed:	-	30-Nov-2009	30-Nov-2009	-	30-Nov-2009	30-Nov-2009

Cheryl McMillen
Cheryl McMillen
Laboratory Director

* Results Reported on an "As Received" Basis
N.D. - None Detected
** Smaller box used as limited amount of soil

Quality Control Summary - All laboratory quality control parameters were found to be within established limits

APPENDIX D

SELECTED REGIONAL FAULT DATA

SELECTED REGIONAL FAULT DATA

Calaveras fault – The Calaveras fault passes through the lower foothills of the Diablo Range and roughly marks the eastern margin of the southern Santa Clara Valley. The creeping southern segment of this fault merges with the San Andreas fault near Hollister. The northern and central segments of the Calaveras fault have generated a number of earthquakes greater than moment magnitude (M_w) 5.0 during historic time alone: 1861, 1897, 1899, 1911, 1943, 1949, 1955, 1979, and 1984 (Witter and others, 2003). All but the first of these occurred on the central segment. The magnitudes for many of these earthquakes were fairly close, suggesting a characteristic earthquake of M_w6.2 for the central segment. Current research (CGS, 1996, 2003; WGCEP, 2003) indicates that the maximum earthquakes for the northern, central and southern segments of the Calaveras fault are M_w6.8, 6.2, and 5.8 respectively. The maximum earthquake for a combined central- and southern-segment rupture would likely be M_w6.4.

Hayward fault – The Hayward fault forms the eastern margin of the San Francisco Bay basin, and is linked by a step-over at its northern end to the Rodgers Creek fault north of San Pablo Bay, although the behavior of the two faults appears independent (WGCEP, 2003). The last major earthquake on the Hayward fault occurred in 1868 along the southern segment of the fault, and had an estimated magnitude of M_w6.8. Until recently, it was thought that a similar-magnitude earthquake in 1836 occurred on a northern segment of the fault. However, recent research suggests that the 1836 earthquake occurred somewhere in the vicinity of San Juan Bautista, and not on either the Hayward or San Andreas faults (Toppozada and Borchardt, 1998; Bakun, 1999). The maximum earthquake for a combined northern- and southern-segment rupture of the Hayward fault is estimated to be M_w6.9 (CGS, 1996; WGCEP, 2003). Seismicity data indicate that the southern end of the Hayward fault joins with the Calaveras fault at depth; the portion of the Hayward fault nearest this junction ("Hayward southeast extension") is not considered a separate seismic source by the WGCEP (2003).

Monte Vista/Shannon fault – The Monte Vista/Shannon seismic source essentially composites several separately mapped frontal thrust faults along the northeastern margin of the Santa Cruz Mountains. While some of these west-dipping faults are not considered seismically capable, this aggregate seismic source is considered capable of a M_w6.7 earthquake (CGS, 2003).

Monterey Bay/Tularcitos fault – This relatively short fault lies essentially within Monterey Bay, and it accommodates some of the right-lateral slip carried solely by the San Gregorio fault in areas farther north, in addition to reverse motion. This fault is considered capable of a M_w7.3 earthquake (CGS, 1996, 2003), and it is included in the CGS statewide probabilistic seismic hazards model (CGS, 2003).

San Andreas fault – The San Andreas fault system extends about 700 miles through California, passing through the greater Bay Area from beyond Pt. Reyes to the north, down the San Francisco Peninsula, and extending on beyond Hollister to the south. This fault has generated at least four large, damaging earthquakes during historic time: 1838, 1857, 1906 and 1989. The earthquake of 1838 probably occurred on the Peninsula segment of the fault; it had an estimated magnitude of M_w6.8 (Bakun, 1999) to M_w7.5 (Toppozada and Borchardt, 1998). The earthquake of 1857 occurred in San Luis Obispo County; it had an estimated magnitude of approximately M_w7.9. The 1906 earthquake was probably centered just offshore of the Golden Gate of San Francisco Bay, and had an estimated magnitude of M_w7.9. The 1989 Loma Prieta earthquake was epicentered in the Santa Cruz Mountains. This M_w6.9 earthquake caused 64 deaths, about 4,000 injuries and about 6 billion dollars of damage in the Bay Area.

The maximum earthquake for the Peninsula segment of the San Andreas fault is currently considered to be M_w7.1 (CGS, 2003; WGCEP, 2003). The maximum earthquake for the Santa Cruz Mountains segment is considered to be M_w7.0. Both segments were considered by the CGS (1996) to have the same 400-year return intervals for the maximum earthquake, although more recent work suggests a shorter return interval (e.g. Hall and others, 1999). A "1906"-style rupture involving several segments would likely be an M_w7.9 event (WGCEP, 2003), and is considered more likely than a multiple-segment event involving the Peninsula and Santa Cruz Mountains segments (WCCEP, 2003).

San Gregorio fault – The San Gregorio fault is a part of the San Andreas fault system located offshore of Monterey Bay. The fault comes onshore near Año Nuevo near the San Mateo/Santa Clara County line, and it is transitional northward to the Seal Cove fault. The northern segment of the fault has a relatively high slip rate of 7mm/yr (+/- 3mm) and is considered to have a maximum earthquake of M_w7.2, while the southern portion is capable of a M_w7.0 (CGS, 2003; WGCEP, 2003). A combined northern- and southern-segment rupture would likely be a maximum of M_w7.4.

Sargent fault - The Sargent fault is considered part of the San Andreas fault system as it splays off from the San Andreas fault north of the City of Santa Cruz. Like other thrust faults east of the San Andreas fault, the Sargent fault is thought to be tectonically coupled with the San Andreas fault at depth. However, Nolan and others (1995) suggest that the Sargent fault may not be tectonically coupled with the San Andreas, and that movement may be associated with distributed shear across the region. The WGCEP (2003) has deleted this fault as a seismic source from their probabilistic model; formerly (WGCEP, 1996) it was considered capable of a M_w6.8 earthquake.

Zayante-Vergeles fault – The Zayante-Vergeles fault accommodates strike-slip and reverse motion. It lies largely parallel to and west of the San Andreas fault in northern San Benito, Monterey, and southern Santa Cruz Counties. The CGS (2003) considers it to be capable of a M_w7.0 earthquake.