PRELIMINARY GEOLOGIC AND GEOTECHNICAL ASSESSMENT

On

SAN BRUNO A

At

Glenview Drive and San Bruno Avenue
San Bruno, California

For
City Ventures

By
Quantum Geotechnical, Inc.

Project No. K024.G
November 29, 2023

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Ms. Samantha Hauser
Senior Vice President of Development
City Ventures
444 Spear Street,
Suite 200
San Francisco, CA 94105

Subject: Proposed Residential Development
San Bruno A
Glenview Drive at San Bruno Avenue,
San Bruno, California
PRELIMINARY GEOLOGIC AND GEOTECHNICAL ASSESSMENT

Dear Ms. Hauser,

In accordance with your authorization, ***Quantum Geotechnical, Inc.,*** has reviewed previous geotechnical reports performed within the subject site to provide a preliminary geotechnical assessment and recommendations for the subject project located in San Bruno, California

Our assessment indicates that development of the site for the proposed development is feasible and we have provided preliminary geotechnical recommendations for preliminary design and construction of the project. A design level investigation will be needed at a later date when final development details and layouts have been designed.

Should you have any questions relating to the contents of this report or should additional information be required, please contact our office at your convenience.

Sincerely,
Quantum Geotechnical, Inc.

Simon Makdessi, P.E., G.E.
President

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Principal Geologist

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PRELIMINARY GEOLOGIC AND GEOTECHNICAL ASSESSMENT

PURPOSE AND SCOPE

The purpose of this preliminary geologic and geotechnical assessment for the proposed new development located at the corner of Glenview Drive and San Bruno Avenue in San Bruno, California, was to review previous geotechnical investigations performed on the site, evaluate the general subsurface soil conditions at the site and provide preliminary geotechnical criteria and recommendations for grading of the site, the design of foundations for the proposed development, design of retaining walls, drainage pavements, and the construction of other related facilities on the property, to assist in planning of the project. subject site.

Our assessment included the following:

a. Field reconnaissance by the Soil Engineer;
b. Evaluate the major geotechnical concerns of the site
c. Determine the general seismicity of the site in accordance with the 2022 CBC;
d. Analysis of the data and formulation of preliminary conclusions and recommendations; and
e. Preparation of this written report.

PROPOSED DEVELOPMENT

The proposed project would include demolishing and removing two existing buildings, pavements, exterior flatwork and miscellaneous landscaping and redevelop the existing property for a residential subdivision consisting of 58 townhome units within 9 buildings, utility improvements, and new interior access drives, parking stalls. Three bio-retention vaults are planned at the site to provide stormwater treatment. The site will be accessed by a new access road from Glenview Drive at the west property line. We understand the townhome buildings would be two or three-story, wood-frame type structures, supported on a post-tension slab foundation system. Due to the terraced nature of the land and the presence of berms and surficial layers of undocumented fills in areas of the site, a moderate amount of grading is anticipated to implement the development concept. Preliminarily, cuts and fills up to approximately 7 to 8 feet are anticipated. A perimeter wall along the eastern side of the development area is planned to retain soil and also act as protection against potential landsliding on the eastern slopes.

SITE DESCRIPTION

The site is located on the northeast side of the intersection of San Bruno Avenue and Glenview Drive in San Bruno, California. Topographically, the site is located on a terraced ridgetop with a drainage (San Bruno Creek) located on the east of the site. Relatively steep slopes are present between San Bruno Creek and the site. The site is accessed on the west side directly from Glenview Drive and is currently developed within its northern portion with a church building (abandoned) and associated exterior flatwork and pavements, landscaping shrubbery and trees and other landscaping features. There is an existing residence in the northeastern corner of the property which will be demolished as part of the development activities. We understand that the site received some grading activity as part of the mass grading of Glenview Drive in the 1950's and the church site in the 1960's (EIC, 2016).

GENERAL GEOLOGIC CONDITIONS

Geologic mapping of the site indicates the site is in an area underlain by Franciscan bedrock ("sheared rock") (Pampeyan, 1994). Surficial undocumented fill and colluvium overlie the bedrock locally. The undocumented fill has a variable thickness with the maximum occurring along the crest of the easterly downslope (EIC, 2013). The sheared rock is characterized as having inclusions of sandstone and serpentinite in clay matrix. The serpentinite was described as mostly crushed and sheared with occasional hard blocks and cobbles with polished surfaces (BAGG, 2003). The mélange also contains sheared silica carbonate fragments, altered serpentinite and highly sheared remnants of shale, and claystone in a clayey matrix (Romig Engineers, Inc., 2008).

The site is located within a state-designated regulatory zone for earthquake fault hazards (CDMG, 1982) due to the site's proximity to the active San Andreas Fault. The eastern, sloping portion of the site is within a state-designated regulatory zone for earthquake induced landslide hazards (CGS, 2018). The site is not within a state-designated regulatory zone for liquefaction hazards (CGS, 2018). These regulatory maps are not based on site-specific information but are interpretive in nature and based on assumptions and projection of information. They are used primarily for planning purposes in triggering the need for site specific studies addressing these aspects of the local geologic setting.

SUMMARY OF PREVIOUS GEOLOGIC AND GEOTECHNICAL STUDIES

Due in part to the regulatory geologic mapping on the immediate area, the site has been the subject of several geotechnical and geologic investigations extending between 2006 and 2021, and an environmental Initial Study/Mitigated Negative Declaration was conducted in in 2021. These studies were for a proposed residential subdivision, somewhat larger than the presently proposed development concept. A site plan showing all previous geologic and geotechnical studies along with the borings are attached to Appendix A. The following briefly summarizes the outcome of each investigation conducted at the site:

Earth Investigations Consultants ("EIC") (2006). EIC conducted an investigation which included the drilling and logging of seven exploratory borings at various locations across the site. The focus was on the geotechnical aspects of the site. We did not have access to that report, but the boring logs were available.

Romig (2008). In 2008 Romig conducted a fault investigation at the site which included the logging two continuous (35 and 42 foot-long), east-west oriented trenches excavated across the central portion of the site. We did not have access to their report but the results of the Romig were discussed in a subsequent report by EIC in 2008 (see below). EIC indicated that Romig encountered a 14-foot wide fault zone within their trench and based on that, they recommended a building setback along the trend of the fault which they projected through the site.

EIC (2008). EIC re-investigated the fault previously identified by Romig (2008) at the site. EIC excavated and logged two offset trenches. Trench T-1 was just north of the Romig trench and was 38.5 feet long and on average 12 feet deep. Trench T-2 was located on the south side of Romig's trench and was 34.5 feet long and on average 5 feet deep. EIC worked in the field with a soil dating expert (Soil Tectonics) who determined that the age of the soils overlying the fault were a minimum of 130,000 years old which indicated the fault is not active according to the state criteria. EIC concluded that the fault is a pre-Quaternary, discontinuous fault feature confined to the Franciscan bedrock unit. The previously established building setback was removed from that development concept. Additionally EIC conducted advancing 3 borings in the southwestern part of the site which ranged from 10 feet to 22 feet in depth.

EIC, In 2013. In 2013 EIC conducted eight exploratory borings across the site, ranging from 10 to 26.5 feet deep. Their study included laboratory analyses of the collected soil samples and development of grading, drainage and foundation recommendations for a residential development. They determined that a buried seasonal drainage swale located in the east-central portion of the site was infilled with approximately up to 16 feet of undocumented fill. Uncontrolled runoff has resulted in localized debris slides in the on the northeastern part of the site, however these features were planned to be mitigated by remedial grading of the undocumented fill during mass grading. They determined that the residential subdivision was feasible from a geotechnical point of view, provided that their recommendations were followed for the development.

EIC, In 2016. In 2013 EIC conducted three additional exploratory borings across the site, ranging from 7 feet to 10 feet depth.

Geocon, 2019. As part of a Initial Study conducted by Raney, Geocon in 2019 peer reviewed the earlier work of EIC.

Geosphere, 2020. It should be noted that in 2017, Earth Investigations Consultants, Inc. (EIC), merged with Geosphere Consultants, Inc. (Geosphere). This Geosphere 2020 report was a response to a peer review (Geocon) of the EIC report (2016) for the project. As part of this study, Geosphere conducted three additional borings along the easterly slope crest ranging from 29 feet to 30 feet beneath the ground surface. As part of this work, they provided a geotechnical update which included the drilling of three additional borings along the easterly slope crest and slope stability analyses conducted along cross sections that trended across the site and down the steep, easterly slope. They concluded that the EIC investigations substantially demonstrated that the proposed project (of 2013) was exposed to a low risk for future surface fault rupture from major earthquakes. Their analyses indicated marginal slope stability calculated at two of their cross sections where potential seismic failure surfaces were calculated near the eastern property boundary along the slope crest. They recommended the use of stitched piers along the northeast and southeast property corners, in order to “mitigate potential localized future slope regression by surface erosion.

Offsite Fault Investigations

Earth Systems Consultants, Inc., 1989: In 1989, ESC conducted a geotechnical investigation for proposed additions to Sky Crest Shopping Center located on the south side of San Bruno Avenue. As part of this investigation, ESC conducted fault trenches at their site. They reportedly did not encounter evidence of faulting within their trenches. Their report was not available but their trench logs were provided within the Geosphere 2020 compilation.

BAGG, 2003: Located on the south side San Bruno Avenue, and in alignment with the general trend of the San Andreas Fault, BAGG conducted a fault investigation for the Sky Crest Residential Development. Their trenching (four fault trenches) provided block clearance or a large portion of that site. They concluded that property was not transected by active faulting. Their report was not available but the results discussed and their trench logs were provided within the Geosphere 2020 compilation.

BAGG, 2007: This study for the existing Lunardi's Market (located on the north side of the Sky Crest Residential Development) consisted of conducting two fault trenches and two borings. They did not encounter evidence of faulting at that site. Their report was not available but their conclusion on faulting was discussed and their trench logs were provided within the Geosphere 2020 compilation.

SUMMARY OF SUBSURFACE CONDITIONS

In general, the subsurface conditions consist of a surface layer of fill up to 3 feet thick over most of the site, with some areas consisting of native sandy clay soil at the surface. In the central eastern part of the site up to 1\6 feet of fill was encountered. The fill is underlain by either native residual clay soil or colluvium clay soil. The fill and native soil, are underlain by bedrock. Depth to bedrock generally ranges from 3 to 10 feet, with the bedrock locally deeper in the central eastern part of the site where it was encountered at 22 feet. No groundwater was encountered in any of the previous borings drilled.

PRELIMINARY EVALUATION OF GEOLOGIC AND GEOTECHNICAL CONDITIONS

2022 CBC SEISMIC DESIGN CRITERIA

The potential damaging effects of regional earthquake activity should be considered in the design of structures. As a minimum, seismic design should be in accordance with Chapter 16 of the 2019 California Building Code (CBC). The 2019 CBC utilizes the design procedures outlined in the ASCE 7-16 Standard.

Using the criteria in Chapter 20 of ASCE 7-16, in its current condition, the site is classified as Site Class C, due to the presence of relatively shallow bedrock. The seismic design parameters have been developed using the online "Seismic Design Maps" tool by the Structural Engineering Association (SEA) and Office of Statewide Health Planning and Development (OSHPD) and a site location based on longitude and latitude. The seismic design parameters generated for the subject site for a latitude of 37.705955° N, and longitude of 121.871631° W, are presented in Table I:

Table I
2022 CBC Seismic Design Criteria

Seismic Parameter	Coefficient	Value
Site Class – Stiff Soil		C
Peak Ground Acceleration (Site Modified)	PGA_M	0.723
Mapped MCE Spectral Acceleration at Short-Period 0.2 secs	S_s	1.577
Mapped MCE Spectral Acceleration at a Period of 1.0s	S_1	0.60
Adjusted MCE, 5% Damped Spectral Response Acceleration at Short Period of 0.2s	S_{MS}	1.577
Adjusted MCE, 5% Damped Spectral Response Acceleration at Period of 1.0s	S_{M1}	1.02
Design 5% Damped Spectral Response Acceleration at Short Period of 0.2s for Occupancy Category I/II/III	S_{DS}	1.051
Design 5% Damped Spectral Response Acceleration at Period of 1.0s for Occupancy Category I/II/III	S_{D1}	0.680

LIQUEFACTION POTENTIAL EVALUATION

Liquefaction occurs primarily in relatively loose, saturated, cohesionless soils. Under earthquake stresses, these soils become “quick”, lose their strength and become incapable of supporting the weight of the overlying soils or structures. The data used for evaluating liquefaction potential of the subsurface soils consisted of the penetration resistance, the soil gradation, the relative density of the materials, and the groundwater level.

Loose to medium dense cohesionless soil such as sands and some soft to firm silts and low plasticity clays are potentially liquefiable, while dense and very dense cohesionless sands and gravels are considered to have a very low potential for liquefaction.

Due to lack of groundwater and presence of shallow bedrock, the potential for liquefaction is nil.

LANDSLIDE POTENTIAL

This Geosphere 2020 report included the drilling of three additional borings along the easterly slope crest and slope stability analyses conducted along cross sections that trended across the site and down the steep, easterly slope. Their slope stability analyses indicated marginal slope stability calculated at two of their cross sections where potential seismic failure surfaces were calculated near the eastern property boundary along the slope crest. They recommended the use of stitched piers along the northeast and southeast property corners, in order to “mitigate potential localized future slope regression by surface erosion.

PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

GENERAL

1. From a geotechnical point of view, the site is suitable for the construction of the proposed development. Preliminary geotechnical recommendations presented in this report for planning and project design. A design level geotechnical investigation will be performed at a later date when final development details are known.

2. The most prominent geotechnical features of this site are;

   a. The previous site investigations, and peer review of those investigations indicates that the site is not crossed by an active fault and no mitigation for fault surface rupture (i.e., building setbacks) is needed.

   b. Eroded gullies and soil-infilled gullies have been identified within the east edge of the site in previous site investigations (EIC, 2006, 2013, and 2016). These areas will need to be addressed as part of future site mass grading.

   c. The site is not in an area of suspected large or moderate scale landsliding, However, an analysis of slope stability along portions of the easterly slope crest was performed by Geosphere (2020), and it was determined to be potentially unstable locally in seismic conditions. To address this, we recommend the use of stitched (closely spaced) piers along portions of the eastern part of the site to protect the site from uphill regression of any surficial landslides that have been assessed to potentially occur just downslope of the development area. A design level geotechnical investigation report will be performed to provide specific design criteria for the layout and design of the stitch pier wall. A site plan conceptually showing the possible layout of the stitch pier wall is attached to Appendix A.

   d. A surface layer of undocumented fill generally 3 to 4 feet in thickness was encountered across the site and locally was as thick as 16 feet in the central eastern part of the site near the eastern slope crest. The undocumented fill requires mitigation by sub-excavation and re-compaction, or removal during mass grading activities.

DEMOLITION

3. Prior to any grading, demolition of the existing structures on the site should be completed. Demolition should include the complete removal of all surface and subsurface structures. In addition, all known underground structures must be located on the grading plans so that proper removal may be carried out, and all excavations are left open for proper backfilling. It is vital that Quantum Geotechnical Inc., intermittently observe the removal of subsurface structures and excavations, and be notified in ample time to ensure that no subsurface structures or excavations are covered. If Quantum Geotechnical Inc., is not contacted to observe the demolition and removal of subsurface structures, further backhoe exploratory investigation will need to be performed prior to the commencement of grading.

4. Excavations made by the removal of the structures and grubbing of trees may create disturbed/loose areas, and where this occurs the loose material should be excavated and replaced as engineered fill, or if it is less than 1 foot in thickness, can be compacted in place, prior to placing fill. We recommend that excavations greater than 1 foot deep be left open by the demolition contractor for backfill in accordance with the requirements for engineered fill. The removal of underground structures should be done under the observation of the Soil Engineer to verify adequacy of the removal and that subsoils are left in proper condition for placement as engineered fills. Any soil exposed by the removal operations which are deemed soft or unsuitable by the Soil Engineer, shall be excavated as uncompacted fill and be removed as required by the Soil Engineer during grading. Any resulting excavations should be properly backfilled with engineered fill under the observation of the Soil Engineer. It is important that Quantum Geotechnical Inc., be present during removal activities to verify that all excavations created by removal of subsurface structures are left open and located on a grading plan. If any excavations are loosely backfilled without our knowledge and these excavations are not located and backfilled during grading, future settlement of these loosely filled excavations could occur and may cause damage to structures and improvements.

GRADING

5. Grading activities during the rainy season will be hampered by excessive moisture. Grading activities may be performed during the rainy season, however, achieving proper compaction may be difficult due to excessive moisture; and delays may occur. In addition,

measures to control potential erosion may need to be provided. Grading performed during the dry months will minimize the occurrence of the above problems.

6. Currently, parts of the site contains a dense coverage of grasses and shrubs and small trees. Vegetation conditions may be different at the time of grading, and the extent of any stripping, mowing or discing as part of site preparation, will be revaluated at the time of grading. Any strippings will be stockpiled in an approved area that is unaffected by grading operations until their future use. Organically contaminated soil material may be utilized in landscape areas located outside the building footprints.

7. The majority of the site is covered by non-engineered fill, and this material must be sub-excavated until non-yielding native soil or bedrock is encountered.

8. After the removal of any old fill, and prior to the placement of any fill, the top 8 inches of exposed native ground for fill areas should be scarified and compacted to a degree of relative compaction of at least 90% at 2 to 3 percent above optimum moisture content as determined by ASTM D1557-12 Laboratory Test Procedure.

9. The site may be brought to the desired finished grades by placing engineered fill in lifts of 8 inches in uncompacted thickness and compacting to the relative compaction requirements stated above, of at least 90% at 2 to 3 percent above optimum moisture content as determined by ASTM D1557-12 Laboratory Test Procedure..

10. If any pads are created such that a portion of the pad is in cut and a portion is in fill, we recommend that the cut portion of the pad be sub-excavated to a depth of 1 to 2 feet depending on the relative thickness of cut and fill, and the excavation be backfilled with the mixed sub-excavated material as engineered fill. If the base of the sub-excavation is found to be dry, we recommend that the base be ripped moisture conditioned and recompacted in place to the requirements of engineered fill.

11. All soils encountered during our investigation except those that may contain organic material from landscape areas, are suitable for use as engineered fill when placed and compacted at the recommended moisture content and provided it does not contain any debris. Concrete and asphaltic concrete pavement from the demolition can be used as in the fill provided the concrete and AC is

broken down to pieces less than 6 inches in size and thoroughly mixed with soil material. However, we recommend that AC not be present in the upper 2 feet of soil in landscape areas, as the AC may affect plant growth. If import soil is needed, we recommend that the import soil preferably have a plasticity Index (PI) of 20 or less. Higher PI soil may be considered subject to our approval.

SURFACE DRAINAGE

12. All finish grades should be provided with a positive gradient to an adequate discharge point in order to provide rapid removal of surface water runoff away from all foundations and improvements. No ponding of water should be allowed on the pad or adjacent to the foundations. Surface drainage must be designed by the project Civil Engineer and maintained by the property owners at all times. The individual lot pads should be graded in a manner that surface flow is to a controlled discharge system.

13. Lot slopes and drainage must be provided by the project Civil Engineer to remove all storm water from the pad and to minimize storm and/or irrigation water from seeping beneath the structures. Should surface water be allowed to seep under the structure, foundation movement resulting in structural cracking and damage could occur. In addition, surface water seeping under the structure may cause vapor transmission issues affecting floor coverings near the building perimeter.

14. Section 1804.4 of the 2022 CBC, provides guidance on the required site grading immediately adjacent a building foundation. In general, this section of the code indicates that the ground must be sloped away from the building at a minimum slope of 5% over a distance of 10 feet, and if lot lines prohibit the 10 feet of horizontal distance, swales may be used sloped not less than 2 percent. In addition, impervious surfaces within 10 feet of the building foundation shall be sloped not less than 2% away from the building.

15. The creation of planter areas confined on all sides by concrete walkways or decks and the residence or commercial structure foundation is not desirable since any surface water due to rain or irrigation becomes trapped in the planter area with no outlet. If such a landscape feature is necessary, surface area drains in the planter area or a subdrain along the foundation perimeter must be installed.

BIO-FILTRATION FACILITIES

16. Three bio-retention vaults are planned for the site. These vaults are planned to be constructed as reinforced concrete vaults with a bottom and four sides. These vaults do not have the ability to provide subsurface infiltration. These vaults will be located close to and adjacent building structures and retaining walls. The vaults will need to be designed to accommodate the loads from adjacent buildings or wall foundations. In addition, retaining walls downslope of the vaults will need to be designed to accommodate the loading from the vaults.

FOUNDATIONS

17. Provided the site is prepared as recommended in the "Grading" section, a post-tensioned slab foundation may be satisfactorily used for the residential structures. Preliminary recommendations follow.

Post Tensioned Slab-on-Grade

18. Post-tensioned slabs should be designed using the following criteria which is based on the design method presented in the Post-Tensioning Institute, Standard Requirements for Design and Analysis of Shallow Post-Tensioned Concrete Foundations on Expansive Soils (PTI DC10.5-12), 2012. Using the relevant site soil and climatic parameters, the recommended geotechnical criteria for use in the design of the post-tensioned slabs is as follows;

	Swelling Mode	
	Center Lift	Edge Lift
Edge Moisture Variation Distance (e_m)	8.8 feet	4.5 feet
Differential Soil Movement (y_m)	0.69 inches	1.06 inches

The maximum allowable bearing pressure at the base of the post-tensioned slab and for localized thickened footings should not exceed 2,000 p.s.f. for dead plus sustained live loads.

General Construction Requirements for Post Tensioned Slab-on-Grade

19. Prior to construction of the post-tensioned slab, the slab subgrade should be observed by the Soil Engineer to verify that all under-slab utility trenches greater than 18 inches in width have been properly backfilled and compacted, and that no loose or soft soils are present on the slab subgrade.

20. The slab subgrade should be soaked to saturation (minimum 5% above optimum) to a depth of 12 to 18 inches prior to placement of the capillary break or vapor retarder/barrier. This should be verified and approved by the Soil Engineer. The penetration of a thin metal probe to a depth of 10-12 inches generally indicates sufficient saturation.

21. The four (4) inch (minimum thickness) layer of gravel typically placed to provide a capillary break beneath concrete slab-on-grade floors may be omitted beneath the monolithically poured post-tensioned slab foundations provided that the slabs are at least 10 inches thick as recommended above. If it is desired to use a 4 inch layer or thinner of gravel section, the gravel should consist of broken stone, crushed or uncrushed gravel, quarry waste, or a combination thereof. The aggregate shall be free from deleterious substances. It shall be of such quality that the absorption of water in a saturated dry condition does not exceed 3% of the oven dry weight of the sample. The material shall be ¾” minus material with no more than 3% passing the #200 sieve.

22. A moisture vapor retarder/barrier is recommended beneath all slabs-on-grade that will be covered by moisture-sensitive flooring materials such as vinyl, linoleum, wood, carpet, rubber, rubber-backed carpet, tile, impermeable floor coatings, adhesives, or where moisture-sensitive equipment, products, or environments will exist. We recommend that design and construction of the moisture vapor retarder/barrier conform to Section 1805 of the 2022 CBC and relevant sections of American Concrete Institute (ACI) guidance documents 302.1R-04, 302.2R-06 and 360R-10.

23. The moisture vapor retarder/barrier can be placed above the 4 inches of gravel or directly on the soil subgrade and should consist of a minimum 15 mils Class A vapor retarder membrane, such as Stego® Wrap, and have a maximum perm rating of 0.3 in accordance with ASTM E 1745. Seams in the moisture vapor retarder/barrier should be overlapped no less than 6 inches or in accordance with the manufacturer’s recommendations. Joints and penetrations should be sealed with the manufacturer’s recommended adhesives, pressure-sensitive tape, or both. The contractor must avoid damaging or puncturing the moisture vapor retarder/barrier and repair any punctures

with additional polyethylene properly lapped and sealed. The installation of the vapor retarder membrane must be in conformance with ASTM E1643.

24. It is our understanding that the preferred post-tensioned slab section is to consist of a post-tensioned slab with concrete having a water/cement ratio of no greater than 0.45, over a 15 mil vapor retarder membrane underlain by soil subgrade. This is acceptable from a geotechnical point of view.

MISCELLANEOUS CONCRETE FLATWORK

25. Miscellaneous flatwork, such as driveways and walkways may be designed with a minimum thickness of 4.0 inches. Flatwork that is underlain by a gravel section will allow any surface water to pond beneath the slab and initiate heave. We, therefore, recommend the gravel cushion be omitted and the concrete flatwork placed directly on moisture conditioned subgrade soil. If gravel is eliminated for the driveway slabs, we recommend the driveway slabs be thickened to 6 inches and reinforced with #3 rebar spaced at 12 inches on center each way. Control joints should be constructed to create squares or rectangles with a maximum spacing of 15 feet on large slab areas. Walkways should be separated from foundations with a thick expansion joint filler. Control joints should be constructed into walkways at a maximum of 5 feet spacing.

RETAINING WALLS

26. Retaining walls should be designed to resist lateral pressures exerted from a media having an equivalent fluid weight as follows:

Active Condition	=	50 p.c.f. for horizontal backslope
Seismic Condition	=	45 p.c.f. (regular triangle in addition to static pressure) for site walls greater than 6 feet high
At-rest Condition	=	70 p.c.f.
Passive Condition	=	250 p.c.f.
Coefficient of Friction	=	0.30

27. For a non-horizontal backslope, the active condition equivalent fluid weight can be increased by 1.5 p.c.f. for each 2 degree rise in slope from the horizontal.

28. Active conditions occur when the top of the wall is free to move outward. At-rest conditions apply when the top of wall is restrained from any movement.

29. It should be noted that the effects of any surcharge, traffic or compaction loads behind the walls must be accounted for in the design of the walls.

30. The above criteria are based on fully drained conditions. If drained conditions are not possible, then the hydrostatic pressure must be included in the design of the wall. An additional linear distribution of hydrostatic pressure of 63 p.c.f. should be adopted, in this case.

31. In order to achieve fully-drained conditions, a drainage filter blanket should be placed behind the wall. The blanket should be a minimum of 12 inches thick and should extend the full height of the wall to within 12 inches of the surface. If the excavated area behind the wall exceeds 12 inches, the entire excavated space behind the 12-inch blanket should consist of compacted engineered fill or blanket material. The drainage blanket material may consist of either granular crushed rock and drain pipe fully encapsulated in geotextile filter fabric or Class II permeable material that meets CalTrans Specification, Section 68, with drainage pipe but without fabric. A 4-inch perforated drain pipe should be installed in the bottom of the drainage blanket and should be underlain by at least 4 inches of filter type material. A 12-inch cap of clayey soil material should be placed over the drainage blanket. All back drains should be outlet to suitable drainage devices. Retaining wall less than 3 feet in height may be provided with backdrains or weep holes where appropriate.

32. As an alternate to the 12-inch drainage blanket, a pre-fabricated strip drain (such as Miradrain) may be used between the wall and retained soil. In this case, the wall must be designed to resist an additional lateral hydrostatic pressure of 30 p.c.f.

33. Piping with adequate gradient shall be provided to discharge water that collects behind the walls to an adequately controlled discharge system away from the structure foundation.

34. Site retaining walls and any soundwalls planned for the site may be founded on a spread footing foundations or on a pier foundation system. Spread footing and pier design criteria are given below.

RETAINING WALL/SOUNDWALL FOUNDATION - SPREAD FOOTINGS

35. Spread footings are recommended where there is level ground for a distance of at least 10 feet beyond the base of the retaining wall. Spread footings should have a minimum depth of eighteen (18) inches below lowest adjacent pad grade (i.e., trenching depth) for soil subgrade. At this depth, the recommended design bearing pressure for continuous footings should not exceed 2,500 p.s.f. due to dead plus sustained live loads and 3,300 p.s.f. due to all loads which include wind and seismic.

36. To accommodate lateral loads, the passive resistance of the foundation soil can be utilized. The passive soil pressures can be assumed to act against the front face of the footing below a depth of one foot below the ground surface. It is recommended that a passive pressure equivalent to that of a fluid weighing 250 p.c.f. be used. The weight of the soil above the footing can be used in the frictional calculations. For design purposes, an allowable friction coefficient of 0.30 can be assumed at the base of the spread footing.

RETAINING WALL/SOUNDWALL FOUNDATION - PIER FOOTINGS

37. For site retaining walls located on a slope or where there is less than 10 feet of flat area in front of the wall, we recommend the wall be founded on a pier foundation system. The piers should be designed on the basis of skin friction acting between the soil and the pier. For the soils at the site, an allowable skin friction value of 500 p.s.f. can be used for combined dead and live loads, below a depth of 3 feet. This value can be increased by one-third for total loads which include wind or seismic forces. Given the moderately expansive nature of the soil, we recommend that any grade beams footings or bottom of soundwall panels that are buried into the ground, should be designed for an uplift pressure of 1,500 p.s.f. acting against the bottom of the grade beam/soundwall panel and an uplift adhesion of 300 p.s.f. acting along the upper 3 feet of the pier. Resistance to uplift is to be provided by the pier foundations, and an allowable skin friction value of 500 p.s.f can be used below 3 feet. The size, depth and spacing of the piers is to be determined by the structural engineer.

38. To resist lateral loads, the passive resistance of the soil can be used. The soil passive pressures can be assumed to act against the lateral projected area twice the pier diameter. It is

recommended that a passive pressure equivalent to that of a fluid weighing 250 p.c.f be used below 3 feet of final pad grade.

FLEXIBLE PAVEMENT AREAS

39. No R-value tests were previously performed by other consultants. Due to the extent of grading, the soil expected at subgrade level is not known and depends on the planned grading. Assuming the subgrade material will consist of the moderately expansive clay material, we will assume an R-value of 5 for preliminary design.

40. Based on an R-Value of 5, and using the methods presented in Topic 608 of the California Department of Transportation Highway Design Manual, the recommended design thicknesses presented in the following table

Traffic Index	AC (inches)	Class II[1] AB (inches)
4.5	4.0	7.0
5.0	4.0	8.5
5.5	4.0	10.0
6.0	4.0	11.5
7.0	4.0	15.5
8.0	5.0	17.5
9.0	6.0	19.5
11.0	6.0	27.0

Notes: [1]Minimum R-Value = 78
R-Value = Resistance Value
All Layers in compacted thickness to Cal-Trans Standard Specifications

41. After underground facilities have been placed in the areas to receive pavement and removal of excess material has been completed, the upper 6 inches of the sub-grade soil shall be scarified, moisture conditioned, and compacted to a minimum relative compaction of 95% in accordance with the grading recommendations specified in this report.

42. All aggregate base material placed subsequently should be compacted to a minimum relative compaction of 95% based on the ASTM Test Procedure of D1557-12 (latest edition). The

construction of the pavement areas should conform to the requirements set forth by the latest Standard Specifications of the Department of Transportations of the State of California and/or City San Bruno, Department of Public Works.

43. If planter areas are provided within or immediately adjacent to the pavement areas, provisions should be made to control irrigation water from entering the pavement subgrade. Water entering the pavement section at subgrade level, which does not have a means for discharge, could cause softening of this zone.

Rigid PCC Pavement Areas

44. Portland Cement Concrete vehicular pavements may be used for the project. Where used, we preliminarily recommend that they consist of 6 inches reinforced concrete over 6 inches Class II aggregate base. Where used for trash enclosure pads, we recommend the pavement consist of 7 inches reinforced concrete over 7 inches Class II aggregate base. The upper 6 inches of the sub-grade soil shall be scarified, moisture conditioned, and compacted to a minimum relative compaction of 95%, and the Class II aggregate base should be compacted to a minimum relative compaction of 95%.

Utility Trenches

45. Applicable safety standards require that trenches in excess of 5 feet must be properly shored or that the walls of the trench slope back to provide safety for installation of lines. If trench wall sloping is performed, the inclination should vary with the soil type. The underground contractor should request an opinion from the Soil Engineer as to the type of soil and the resulting inclination.

46. With respect to state-of-the-art construction or local requirements, utility lines are generally bedded with granular materials. These materials can convey surface or subsurface water beneath the structures. It is, therefore, recommended that all utility trenches which possess the potential to transport water be sealed with a compacted impervious cohesive soil material or lean concrete where the trench enters/exits the building perimeter.

47. Utility trenches extending underneath all traffic areas must be backfilled with native or approved import material and compacted to a relative compaction of 90% to within 6 inches of the subgrade. The upper 6 inches should be compacted to 95% relative compaction in accordance

with Laboratory Test Procedure ASTM D1557 (latest edition). Backfilling and compaction of these trenches must meet the requirements set forth by the City of San Bruno, Department of Public Works. Utility trenches within landscape areas may be compacted to a relative compaction of 85%.

PROJECT REVIEW AND CONSTRUCTION MONITORING

48. All grading and foundation plans for the development must be reviewed by the Soil Engineer prior to contract bidding or submitted to governmental agencies so that plans are reconciled with soil conditions and sufficient time is allowed for suitable mitigative measures to be incorporated into the final grading specifications.

49. ***Quantum Geotechnical, Inc.*** should be notified at least two working days prior to site clearing, grading, and/or foundation operations on the property. This will give the Soil Engineer ample time to discuss the problems that may be encountered in the field and coordinate the work with the contractor.

50. Field observation and testing during the demolition and/or foundation operations must be provided by representatives of ***Quantum Geotechnical, Inc.*** to enable them to form an opinion regarding the adequacy of the site preparation, the acceptability of fill materials, and the extent to which the earthwork construction and the degree of compaction comply with the specification requirements. Any work related to the grading and/or foundation operations performed without the full knowledge and under the direct observation of the Soil Engineer will render the recommendations of this report invalid. This does not imply full-time observation. The degree of observation and frequency of testing services would depend on the construction methods and schedule, and the item of work.

REFERENCES

Earth Investigations Consultants, Inc., 2008, Engineering Geologic Investigation, Earthquake Fault Rupture Potential, 850 Glenview Drive, San Bruno, California, their job no. 2271.01.00, dated October 17, 2008.

Earth Investigations Consultants, Inc., 2013, Geotechnical Investigation, Proposed Glenview Terrace, Phase 2. 850 Glenview Drive, San Bruno, California. August 4.

Earth Investigations Consultants, Inc., 2016, Supplemental Geotechnical Investigation and Update. Proposed Glenview Terrace (Phase II), 850 Glenview Drive & 2880-2890 San Bruno Avenue, San Bruno, California. February 15.

Earth Systems Consultants, Inc., 1989, Geotechnical report, Proposed additions to Sky Crest Shopping Center, San Bruno, California: Geotechnical consultant's July 6 report to Highsmith Investments, Job C6-2796-C1, 24 pgs. with illustrations.

Geocon Consultants, Inc. 2019, Proposed Glenview Terrace Residential Subdivision, 2880 San Bruno Avenue, San Bruno California, Geotechnical and Geologic Peer Review. August 27.

Romig Engineers, Inc., 2008, Engineering geologic hazard investigation, 12-unit subdivision, 850 Glenview Drive, San Bruno, California: Geotechnical consultant's September 2 report to Goldenwood Construction, Inc., 2 pgs., with illustrations. Note: this report, listed in the geosphere report, was not available for our direct review, but was discussed in the EIC 2008 report.

Raney Planning and Management, 2021, Glenview Terrace Project, Initial Study/Mitigated Negative Declaration, April.

Soil Tectonics, 2008, Pedochronological Report for Peace Lutheran Church, 850 Glenview Drive, San Bruno, California, their proj. No. 2271, dated, October 8, 2023.

Structural Engineers Association and Office of Statewide Health Planning and Development. 2022. "Seismic Design Maps". Accessed from web site: https://seismicmaps.org/.

APPENDIX A

Earth Investigation Consultants Engineering Geologic Investigation , Earthquake Fault Rupture Potential October 17, 2008

Site Plan Showing Conceptual Layout of Stitch Pier Wall

Geosphere Site Engineering Geologic Map

Earth Investigation Consultants Boring Logs 2006, 2008, 2013, 2016

Geosphere Consultants Boring Logs 2020

AP3417

ENGINEERING GEOLOGIC INVESTIGATION
Earthquake Fault Rupture Potential
850 Glenview Drive
San Bruno, California

Prepared for:
Peace Lutheran Church
850 Glenview Drive
Sna Bruno, California 94066-2722

Attention: Dr. Gail Cromack

Dated: October 17, 2008
Job 2271.01.00

Earth Investigations Consultants
P.O. Box 795
Pacifica, California 94044
Phone 650-557-0262
Fax 650-557-0264
earthinvestigations@comcast.net

Earth Investigations Consultants

October 17, 2008
Job 2271.01.00

Peace Lutheran Church
850 Glenview Drive
San Bruno, California 94066-2722

Attention: Dr. Gail Cromack

RE: ENGINEERING GEOLOGIC INVESTIGATION
Earthquake Fault Rupture Potential
850 Glenview Drive
San Bruno, California

Dear Dr. Cromack:

Pursuant to your authorization, we have completed our investigation of earthquake faulting across your property. The findings confirm the property is underlain by tectonically deformed bedrock material known as Franciscan sheared rock. It is mantled in the southern part by a wedge of fill, and more importantly, an ancient soil horizon (estimated 130,000 years old) exhibiting no evidence of tectonic deformation across the projected trace of a fault purported by Romig Engineers, Inc. (2008) as potentially active. In other words, the age of tectonic deformation to the rock underlying the projected trace occurred thousands of years before Holocene time, and is therefore inactive as defined by the State of California Alquist-Priolo Act. Hence, the "no build" zone delineated by Romig is unjustified. Further, the absence of evidence for active faulting in the rest of their trench exposure on the southern property line coupled with geologic data from a geologic investigation by BAGG (2003) on the southern side of San Bruno Avenue indicates your property is not transected by active faulting associated with the San Andreas fault. Based upon the body of geologic knowledge for this area of San Bruno, active faulting is expected to be between Glenview Drive and Skyline Boulevard, at least 200 feet southwest of the site.

Geologists & Engineers
P.O. Box 795 ● Pacifica, CA 94044 ● (650) 557-0262 ● Fax (650) 557-0264

We trust this report provides you with the information you require at this time. Please call us if you have any questions or require additional information.

Very truly yours,

Earth Investigations Consultants

REGISTERED GEOLOGIST
JOEL E. BALDWIN, II
No. EG 1132
CERTIFIED
ENGINEERING
GEOLOGIST
STATE OF CALIFORNIA

Joel E. Baldwin, II
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JEB:jb:gi
Distribution: 3 copies mailed to addressee and copy to Panko Architects

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INTRODUCTION

Location of Investigation

This investigation was performed in the southern part of the Peace Lutheran Church property located at 850 Glenview Drive, San Bruno, California, near the intersection with San Bruno Avenue, in San Bruno, California (Plate 1, Vicinity Map, and Plate 2, Engineering Geologic Map and Generalized Cross Section A-A'), and within the eastern part of the State of California designated Earthquake Fault Zone (Plate 3, Earthquake Fault Zone Map).

Purpose of Investigation and Scope of Services

This investigation was undertaken to evaluate the southern part of your property for the presence of a purported, potentially active, splay fault (Romig Engineers, Inc., 2008). The findings, conclusions and recommendations in this report are based upon the following scope of services:

- Review of pertinent geologic maps and reports pertaining to the site area. Plate 4, Geologic Map, depicts the site area geologic setting;
- Geomorphic interpretation of pertinent historic versions of the San Mateo, 15-minute topographic quadrangle (1899, 1915, 1942). Plate 5 (Historic Topographic Map) depicts site area geomorphic setting in 1915;
- Photogeologic interpretation of panchromatic, stereo, aerial photographs taken of the site area between 1943 and 1975 from our files, the U.S. Geological Survey in Menlo Park, California, and Pacific Aerial Surveys, in Oakland, California;
- Engineering geologic mapping of surficial features in the southern part of the property (Plate 2);
- Preliminary soil profile characterization by advancing 3 borings in the southwestern part of the site. Continuous samples of the earth materials encountered were obtained by advancing a 1 ½ -inch O.D., split spoon

sampler with a portable, gas-powered Wacker BHF 30S percussion hammer that imparts 35 ft. lbs. of axial force on the sampler at a rate of 1270 blows per minute. The borings ranged from 3 to 22 feet deep. The borings were supervised, logged and sampled by our field engineer. The boring locations and an interpretative soil profile are illustrated on Plate 2. The Logs of Borings are contained in Appendix A;

- ASTM laboratory index testing was performed on selected, representative samples from the borings. Tests included moisture content and dry density. The laboratory test results are tabulated on the logs at the respective sample depths;
- Excavation and geologic logging of 2, 24-inch wide backhoe trenches with a rubber tire backhoe roughly perpendicular to the purported, approximately 14-foot wide fault trace. Trench 1 (T-1, Plate 2) was 38.5 feet long and on average 12 feet deep. Trench 2 (T-2) was 34.5 feet long and on average 5 feet deep. The geologic logs of the trench exposures are presented in Appendix B.
- Age assessment by Glenn Borchardt, Principal Soil Scientist of Soil Tectonics in Berkeley, California of the colluvial soil overlying sheared bedrock in T-1. The results of his work is contained in Appendix B;
- Analysis of the data and preparation of this report.

PHYSICAL SETTING

Topography and Drainage

The area of this investigation is characterized by a graded, relatively flat topographic surface bordered on the northeast by a steep, densely vegetated slope that drains to San Bruno Creek (Plates 1 and 2). This topography is a product of mass grading during the middle to late 1950's for improvement of San Bruno Avenue and Glenview Drive, and late 1950's to early middle 1960's for development of the church facility. Historic aerial photographs indicate at least 20 feet of earth was removed from the dissected, linear ridgeline that originally characterized the site area (Plate 5). From the aerial photographs, it is apparent much of the investigation area is a cut surface with undocumented fill extending over the steep slope bordering the eastern side. This slope descends eastward approximately 150 vertical feet to San Bruno Creek (Plate 1).

The top of the undocumented fill slope has been subjected to uncontrolled runoff which probably caused relatively shallow debris sliding near the exploration areas (Plate 2). The larger scar is on the undeveloped slope and the smaller one is on the slope above the parsonage pad. We suspect this activity is more than a decade old given the relative roundness of the scars and density of vegetation covering the distal part. There was no observed debris deposit.

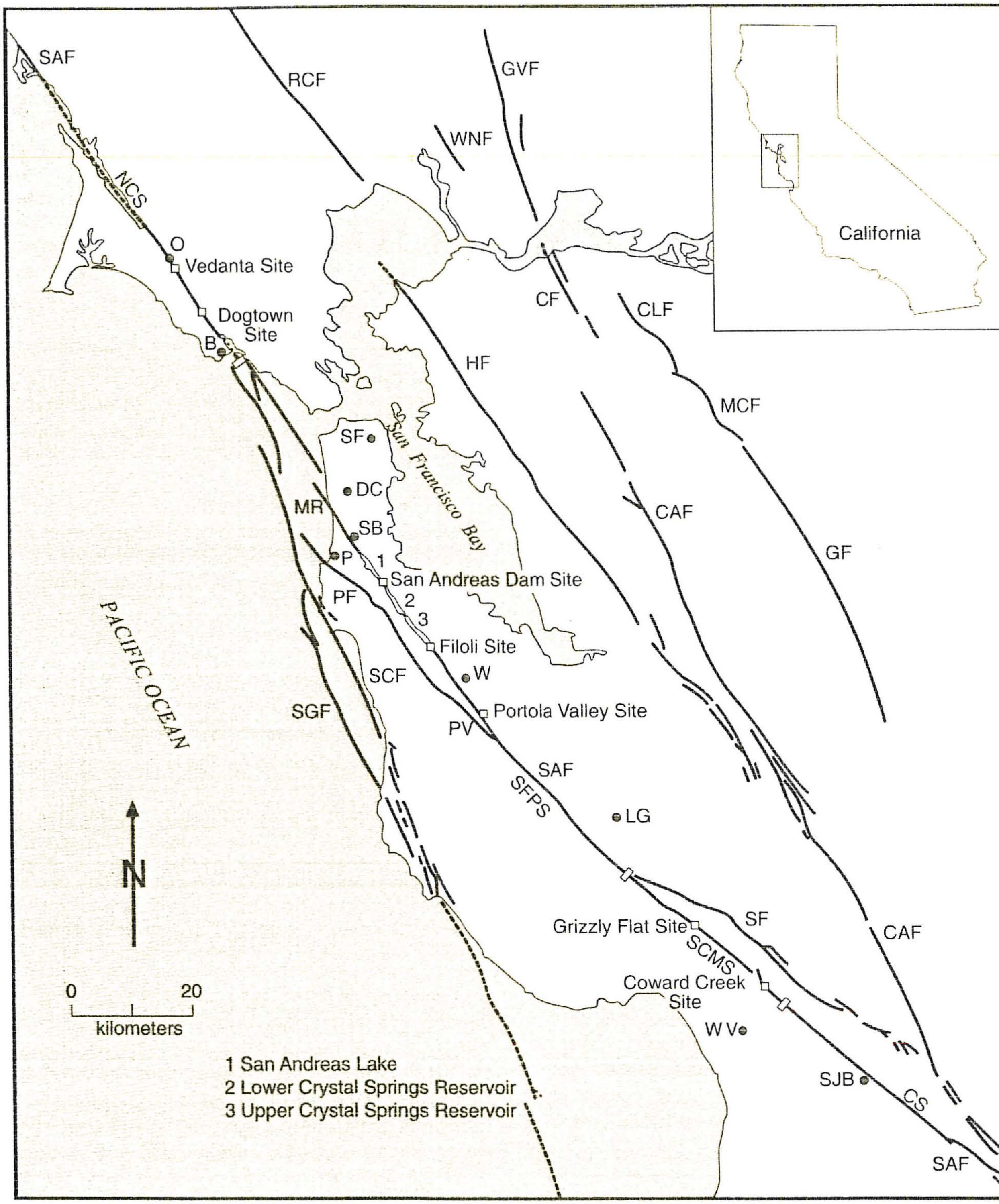
Geology

The site occupies the middle of a semi-circular body of Juro-Cretaceous Franciscan assemblage sheared rock bounded on the east by a curvilinear, inferred trace of the Serra fault, and on the west by the San Andreas fault zone (Leighton and Associates, 1976; Pampeyan, 1994; Plate 4). There are abundant exposures in road cuts between the site and Highway 92 to the southwest, which exhibit randomly and complexly distributed, often hard blocks (knockers) of ultramafic rock, including serpentinite and silica carbonate rock supported in a "matrix" of pulverized rock having the consistency of firm to stiff, usually plastic, gravelly and sandy clay and clayey sand. Pampeyan (1994) reports it is often referred to as mélange, as it occurs as several hundred feet of soft, light to dark gray sheared shale, siltstone, and greywacke with various-size tectonic inclusions of Franciscan rock, on the order of 100 million years old (Bailey and others, 1964).

On the site, the sheared rock is mantled by a variable thickness of undocumented fill, thickest on the steep easterly slope. Several geologic investigation reports for nearby developments describe the bedrock as breccia: angular lithic fragments in clay matrix, fragments of calcareous shale, sheared serpentinite and serpentine in clay (trench exposures; Bay Soils, Inc., 1978); serpentine and greywacke rock fragments and knockers in shale matrix in weathered to silty clay, greenstone and altered volcanic rocks with clay along remnant fracture surfaces (trench exposures; JCP, 1984); white breccia, serpentine, mylonite, clayey sand with greenstone fragments (cut slope exposures; Earth Systems Consultants, 1985); weathered greenstone, sandstone and shale similar to bedrock similar to that described in previous investigation (cut slope and borings; Earth Systems Consultants, 1989); clay matrix around greenstone or basalt with sign of shearing (borings; Hallenbeck & Associates, 1989); sandstone inclusions in matrix of sheared rock, greenstone clasts in clay matrix, mélange of sheared clayey shale, and siltstone mixed and contorted with inclusions of sandstone and serpentinite in clay matrix, serpentinite mostly crushed and sheared with occasional hard blocks and cobbles with polished surfaces (trench exposures; BAGG, 2003); sheared silica carbonate fragments, altered serpentinite and highly sheared remnants of shale, and claystone in a clayey matrix (trench exposures; Romig Engineers, Inc\., 2008).

Active Faults and Seismicity

The site lies on the westerly side of a 60-mile wide northwest trending band of active and potentially active faults known as the San Andreas fault system (fig. 1). Faults in this zone are predominately right-lateral, strike slip faults that have collectively, over the past 29 million years, accommodated most of the relative motion between the Pacific Plate on the southwest side and the North American Plate on the northeast side (Wallace, 1990). The most extensive and active of



Geographic Locations: O=Olema, B=Bolinas, SF=San Francisco, DC=Daly City, P=Pacifica, W=Woodside, PV=Portola Valley, LG=Los Gatos, WV=Watsonville, SJB=San Juan Bautista, MR=Mussel Rock, SB=San Bruno
Faults: SAF=San Andreas, RCF=Rodgers Creek, WNF=West Napa, PF=Pilarcitos, CAF=Calaveras, GF=Greenville, SCF=Seal Cove, SGF=San Gregorio, SF=Sargent, MCF=Marsh Creek, CLF=Clayton, CF=Concord, GVF=Green Valley
Note: Open rectangles are the approximate location of segment boundaries of the Northern California section of the SAF and between the Northern California and Central California sections (NCS=North Coast, SFPS=San Francisco Peninsula, SCMS=Santa Cruz Mountains, CS=Central California; modified from WGCEP, 1990).

Figure 1. Map of the San Andreas fault system in San Francisco Bay area (after Hall and others, 2001)

the faults is the San Andreas fault with a landward extent of nearly 800 miles between the Imperial Valley and Mendocino coastline. Crustal movement along this fault has been responsible for several, major California earthquakes.

The reach of the San Andreas fault in the site area is known as the San Francisco Peninsula Segment (SFPS, fig. 1). Hall and others (2001) report it exhibits an average right lateral slip rate of approximately 0.7 inches per year. Historically, the segment between the Golden Gate and Los Gatos has been responsible for the magnitude 8, 1906, San Francisco earthquake and strong ground shaking in the site area (Lawson, 1908), and Hall and others (2001) believe the SFPS was responsible for an earlier, major, 1906-type earthquake in 1838. Lawson (1908) described the 1906 surface rupture as a continuous, gigantic mole track, up to 10 feet wide, sometimes branching out to several furrows over a width of up to 100 feet, with the typical occurrence of a straight line of raised sod blocks, broken and partly overturned along a North 35 West fault trace extending from just southeast of Mussel Rock to San Andreas Lake. Offset along this reach was right lateral, with a negligible vertical component.

The SFPS also produced a magnitude 5.3 earthquake in 1957 with weak ground shaking in the site area (Oakeshott, 1959). The magnitude 7 Loma Prieta earthquake, centered on the Santa Cruz Mountain segment (SCMS; fig. 1), was responsible for the magnitude 7, 1989 Loma Prieta earthquake with moderate to strong ground shaking in the site area (Plafker and Galloway, 1989). There was no apparent fault rupture associated with that event (Hart and others, 1990).

The Serra fault, separating Franciscan rocks from much younger, Tertiary marine Merced formation, is not considered an active fault (California Division of Mines and Geology, 1982).

FAULT RUPTURE HAZARD

According to Hart (1994), an active fault is one that has sustained ground rupture in the past 11,000 calendar years (Holocene geologic epoch). There are no mapped faults across the site, nor did we detect from historic aerial photographs northwest trending rift features indicative of Holocene fault rupture affecting the site. The southwest corner of the site lies approximately 300 feet northeast of the known trace of the 1906 rupture and active master trace of the SFPS (Plate 3). Its relative position, places it on the eastern margin of the approximately 1400-foot wide Earthquake Fault Zone which bounds the local active fault trace. This zone is perceived by the State Geologist as having potential for fault rupture in the event of a future, major earthquake on the SFPS (Plate 3; Hart, 1994). Earthquake Fault Zones have been established along the San Andreas fault zone since 1974, and locally revised as a result of new information based upon earthquake activity and findings from subsequent geologic investigations. The Serra fault, mapped approximately 250 feet to the west, was originally zoned active then later downgraded to inactive in 1982.

Hall and others (2001) describe active faulting on the SFPS as a zone of intense shearing, 10 to 12 feet wide, vertical on the southwest side, with an associated zone, up to 100 feet wide, of ground surface deformation and en echelon ground cracking usually on the northeast side. Sometimes, linear troughs and ridge segments bordering closed depressions (sag ponds), and aligned saddles are surface manifestations of Holocene fault rupture.

From historic maps and aerial photographs the mapped North 35-40 degree West trend of the master trace of the San Andreas fault on the east side of Skyline Boulevard, between San Bruno Road and Sneath Lane coincides with a distinct linear trough containing a small, northward creek channel (Plate 5). On the west side of Skyline Boulevard, the northwest trending grain of the landscape is marked by a broad trough containing San Andreas Lake and Crystal Springs Reservoir, and further west by a sharp northwest trending, linear ridge and valley system.

Smith (1981) mapped from photogeologic studies two suspected splay faults that diverge northward from the main trace near San Bruno Avenue (faults A and B, Plate 3). They are mapped approximately 250 and 400 feet from the site. We detected from aerial photographs that these two features coincide with divergent linear troughs extending to the southern flank of San Bruno Creek. 1941 aerial photographs reveal the north end of splay fault A coincides with a linear notch in the top of the creek bank, and southern terminus borders the west side of a closed depression (sag pond) where visible on pre-grading aerial photographs appears to have been improved as a stock pond. The post-grading remnant of the sag is visible today as a concentric depression on the west side of Glenview Drive just north of the intersection with San Bruno Avenue. Smith (1981) believed this feature is indicative of either recent tectonic or gravitational movement and thereby recommended its inclusion and two linear features in the fault hazard zone.

Research of previous geologic investigations treating active fault potential on 3 properties near the site provided some information on the location of potentially active faulting (Plate 6). The investigation on Site 1 (Hallenbeck & Associates, 1989) was for a residential development on Earl Avenue at the southeast corner of Sneath Lane and Skyline Boulevard, approximately 2000 feet northwest of the site where the main trace of the San Andreas fault, trending North 25 degrees West, was interpreted to cross the west side of the property. The fault trace location was based on literature research, photogeologic interpretation, and subsurface exploration including borings and geophysical techniques, plots with a more northerly orientation, approximately 50 feet southwest of the trace depicted by the California Division of Mines and Geology (1982). They characterized the fault as greenstone and sheared rock astride a strong linear trough.

Three geologic investigations were conducted on Site 2 between 1978 and 1985, each reflecting a different interpretation of the location and orientation of active fault traces across mélange and greenstone terrane (Plate 6). Bay Soils (BS, 1978) excavated 3 trenches on the property. Two of the trenches reportedly encountered active, vertical faulting in the northeast corner of the site trending North 43 degree West, and separating Monterey formation from Franciscan rocks. Monterrey formation is not known to occur in this area, hence they reported an erroneous geologic interpretation of rock distribution when compared to currently accepted regional mapping by Pampeyan (1994). Study of their data indicates the reported faulting trends approximately 10 degrees more westward than the reported North 53 degrees west trend, which is approximately 15-20 degrees more westerly than the North 33 West trend of 1906 ground surface rupture mapped in this area by Lawson (1908).

Another investigation at Site 2 was by JCP (1984) who, through trenching, interpreted an approximately 7-foot wide zone of vertical active faulting separating Franciscan sheared rock on the southwest side from greenstone on the northeast side.

The third investigation by Earth Systems Consultants (ESC, 1985) identified the trace of the 1906 rupture on the basis of geologic mapping of roadcuts and correlation with trench logs from the 2 earlier investigations,. They interpreted two traces bifurcating in the northwest direction from a point in the southern third of the property. One trace was along a trend of North 10-17 degrees West, eventually bending to North 37 degrees West at the northeast corner of the site. They inferred the trace eventually joins the linear feature and closed depression mapped by Smith (1981). The westerly trace they mapped across Site 2 extends to the northwest corner of the site along a trend of North 40 degrees West. None of the faults project across the subject site.

On site 3, BAGG (2003) excavated more than 350 linear feet of active fault exploration trenches on property adjoining the Lunardi grocery stone on the east of Glenwood Drive south of San Bruno Avenue. While they encountered a wide zone of sheared rock, as mentioned earlier, there was no evidence of active faulting encountered. They indicate that the previous work by Earth Systems Consultants (1989) was unuseful in their assessment of active faulting because much of the cut slope logged by them was obscured by man-made features.

Romig Engineers, Inc. (2008) for a proposed residential subdivision on the site excavated an approximately 280-foot long trench on the southern property line extending northeastward from the southwest property corner. They encountered sheared rock with a purported 12- to 14-foot wide, North 38 degree West fault zone they characterized as potentially active on the basis of relative shearing and weathering in the ancient Franciscan bedrock. Two other exploration trenches they respectively excavated across the projected trend of the purported fault approximately 30 and 80 feet northwest of the initial exploration trench encountered differing geologic relations without evidence of a pervasive fault zone. In addition, a relatively thick colluvial soil sequence overlying an easterly sloping sheared rock surface in the northern-most trench were unfaulted.

FAULT INVESTIGATION

Our fault investigation was two-fold. First we drilled 3 borings in the site area as a preliminary assessment of the near-surface geologic profile (Plate 2; Appendix A). The borings, ranged from 3 to 22 feet deep, encountered undocumented fill consisting of clayey sand with a mixture of gravel ranging from 1 ½ to 14 ½ feet. On the western side of the site, the fill rested directly on sheared rock. On the eastern side, near the top of the steep slope, the fill was underlain by 3 to 6 feet of medium dense, clayey sand with gravel, and stiff, sandy clay. Sheared rock and sandstone were encountered beneath the surficial deposits.

The second phase entailed excavation of two trenches to investigate the site for the purported potentially active fault of Romig, Engineers, Inc. (2008). Trench 1 (T-1, Plate 2 and Appendix A) was excavated for a distance of 38.5 feet and to an average depth of 12 feet across the projected fault trace approximately 7 feet north of Romig's Trench 2. A second trench (T-2, Plate 2 and Appendix A) was excavated approximately 12 feet north of Romig's Trench 1 for a distance of 34.5 feet to an average depth of 5 feet across the purported fault trace. The southeast walls and selected parts of the northwest walls of each trench were cleared of smear from the backhoe bucket, and logged at a scale of 1 inch to 5 feet. The logs of the trenches are illustrated on Plate A5.

<u>Trench 1</u>

Trench 1 encountered a relatively monotonous sequence of sheared rock. With the exception of an apparent easterly slope to hard, angular silica-carbonate rock between Sta. 32 and 37, this bedrock material consisted mainly of randomly distributed coarse gravel- locally to block-size fragments of angular to subrounded sometimes polished serpentinite, and mostly angular and hard silica--carbonate rock in a stiff, sandy clay matrix. There was an indistinct, curvilinear parting between Station 28.5 and 32 that, when projected downward to the east, would encounter a block of granulated, highly weathered shale. The surface of the bedrock was un-deformed and exhibited a relatively uniform 20-degree, easterly slope toward San Bruno Creek.

The sheared rock was overlain by approximately 10 feet of massive, dark brown to dark grayish brown, very stiff to hard, clayey, gravelly, silty sand, colluvium containing angular to subrounded clasts of moderately hard to hard serpentinite, silica-carbonate rock and sandstone. It was dark brown and slightly moist in the upper 1 feet grading to dark yellowish brown and moist below. The inferred, areal distribution of colluvium is depicted on Plate 2. A detailed description of this unit and rationale for an age assignment of 130,000 years is contained in Appendix B.

A wedge of undocumented fill from historic grading activity was encountered in the eastern third of the exposure. It consisted of slightly moist clayey, silty sand with occasional concrete debris.

Trench 2

Trench 2 encountered only sheared bedrock in this cut area of the site. Between Sta. 0 and 24, the sheared rock was characterized by a matrix similar to that in T-1 that supported relatively large blocks of very weathered and sheared serpentinite and harder silica-carbonate rock. There was an unsheared seam of sandy clay (Structure D), exhibiting a cross-trench orientation of North 25 degrees West, which contained subrounded pea-gravel-size serpentinite fragments. It was intersected at the top by Structure C, a 1/8-inch wide, approximately East-West trending clay seam.

Structure B was an approximately 1-inch thick, stiff, unsheared sandy clay containing angular to subrounded fine to medium gravel-size fragments of weathered serpentinite, soft to brittle shale and hard silica-carbonate rock. The west margin separated Unit 3 from 3a. The matrix of Unit 3a was similar to 3, but was dark yellowish brown and supported smaller angular to subrounded inclusions of serpentinite and silica-carbonate rock.

DISCUSSION AND CONCLUSIONS

The results of this investigation indicate the site lies east of active faulting associated with the San Andreas fault. There was no geomorphic or subsurface geologic relations indicative of active or potentially active faulting across the site as purported by Romig Engineers, Inc. (2008). Moreover, the undeformed colluvial unit overlying the ancient Franciscan bedrock encountered in T-1 is approximately 130,000 years old. This demonstrates that the tectonic deformation exhibited in the exposures of Franciscan sheared bedrock is many thousands of years older than Holocene time. Hence, the "no build" zone Romig Engineers, Inc. projected northwesterly across the site from the southern property line is unjustified. In addition, the absence of active faulting in the other part of the Romig's Trench 1 coupled with data from the investigation by BAGG (2003), we conclude there are no active faults across your property. From the available geologic data, we judge the nearest active fault is between Glenview Drive and Skyline Boulevard at least 200 feet southwest of the site.

INVESTIGATION LIMITATIONS

This report has been prepared in accordance with generally accepted engineering geological principles and practices, and is in accordance with the standards and practices set by the geotechnical consultants in the area. We offer no warranties or guarantees.

REFERENCES

BAGG, 2003, Geologic fault hazards study, Sky Crest Center, San Bruno Avenue @ Glenview Drive, San Bruno, California: Geologic consultant's December 31 report to Sky Crest Partners, LP, Job KENMAR-02-01, 4 pgs with illustrations.

Bailey, E.H., Irwin, W.P. and Jones, D.L., 1964, Franciscan and related rocks, and their significance in the geology of western California: California Division of Mines and Geology, Bulletin 183, 177 pgs.

Bay Soils, Inc., 1978, Soil investigation on proposed development, San Bruno Avenue at Skyline Boulevard, San Bruno, California: Geotechnical consultant's January 4 report to Highsmith Realty Corporation, Job 204-GE, 16 pgs. with illustrations.

Borcherdt, R.D., Gibbs, J. F., Lajoie, K.R., 1975, Maps showing maximum earthquake intensity predicted in the southern San Francisco Bay region, California, for large earthquakes on the San Andreas and Hayward faults: U.S. Geological Survey Misc. Field Studies Map MF-709, scale 1:125,000.

California Division of Mines and Geology 1981, Fault evaluation report, San Andreas fault, northern San Mateo County, in San Francisco south and Montara Mountain 7 ½-minute quadrangles, with supplement #1; map scale 1:24,000.

California Division of Mines and Geology, 1982, Earthquake fault zones, Montara Mountain 7 ½-minute quadrangle: California Department of conservation, map scale 1:24,000.

Earth Systems Consultants, 1985, Geologic and seismic hazards evaluation, proposed storage facility, San Bruno and Skyline Boulevard, San Bruno, California: Geotechnical consultant's report to City of San Bruno Building Department, 27 pgs. with illustrations.

______, 1989, Geotechnical report, proposed additions to Sky Crest Shopping Center, San Bruno, California: Geotechnical consultant's July 6 report to Highsmith Investments, Job C6-2796-C1, 24 pgs. with illustrations.

Hall, T.N., Wright, R.H. and Prentice, C.S., 2001, Studies along the Peninsula segment of the San Andreas fault, San Mateo and Santa Clara Counties, California, *in* Ferriz, H. and Anderson, R, Engineering geology practice in northern California: Association of Engineering Geologists Special Publication, pgs. 193-209.

Hallenbeck & Associates, 1989, Geologic and geotechnical engineering investigations, 2901 Sneath Lane, San Bruno, California: Geotechnical consultant's June 5 report to Mr. A. Hussain, 28 pgs. with illustrations.

Hart, E.W., Bryant, W.A., Wills, C.J. and Treiman, J.A., 1990, The search for fault rupture and significance of ridgetop fissures, Santa Cruz Mountains, California *in* (McNutt, S.R. and Sydnor, R.H., eds.) The Loma Prieta (Santa Cruz Mountains), California earthquake of 17 October 1989: California Division of Mines and Geology Special Publication 104, pgs. 83-94.

Hart, E.W., 1994, Fault-rupture hazard zones in California, Alquist-Priolo Earthquake Fault Zoning Act with index to earthquake fault zone maps: California Division of Mines and Geology Special Publication 42, 33 pgs.

Ironside & Associates, undated, Geotechnical and flood hazards, City of San Bruno, California: Planning consultant's Sheet 25, prepared for the City of San Bruno, approximate map scale 1 in. = 1850 ft.

JCP, 1984, Geologic and soil foundation studies for proposed storage building on Glenview Drive, San Bruno, California: Geotechnical consultant's October 9 report to Michael Fogil Custom Builder, Job JCP-1325, 13 pgs. with illustrations.

Jennings, C.W., 1994, Fault activity map of California and adjacent areas with locations of ages of recent volcanic eruptions: California Division of Mines and Geology, Map No. 6, scale 1:750,000.

Lawson, A.C. (ed.), 1908, The California earthquake of April 18, 1906: Report of the California State Earthquake Investigation Commission: Carnegie Institution, Washington, D.C., v. 1, 451 pgs.

Leighton and Associates, 1976, Geotechnical hazards synthesis map of San Mateo County, California: Geotechnical consultant's June report to the San Mateo County Planning Department, Sheet 2, scale 1:24,000.

Oakeshott, G.B., (ed.), 1959, San Francisco earthquake of March 1957: California Division of Mines and Geology Special Report 57, 127 pgs.

Pampeyan, E.H., 1994, Geologic map of the Montara Mountain and San Mateo 7 ½' quadrangles, San Mateo County, California: U.S. Geological Survey Miscellaneous Investigations Map I-2390, scale 1:24,000.

Petersen, M., Beeby, D., Bryant, W, Cao, C., Cramer, C., Davis, J., Reichle, M., Saucedo, G., Tan, S., Taylor, G., Toppozada, T., Treiman, J. and Wills, C., 1999, Seismic shaking maps of California: California Division of Mines and Geology Map 48.

Plafker, G., and Galloway, J. P., 1989, Lessons learned from the Loma Prieta California earthquake of October 17, 1989: U.S. Geological Survey Circular 1045, 48 pgs.

Romig Engineers, Inc., 2008, Engineering geologic hazard investigation, 12-unit subdivision, 850 Glenview Drive, San Bruno, California: Geotechnical consultant's September 2 report to Goldenwood Construction, Inc., 2 pgs. with illustrations.

San Mateo County Health Services Agency, 2002, Case closure of Site #880027, 2880 San Bruno Avenue, San Bruno, California: May 23, 1-pg. letter to Dianne Fafoutis.

Sarna-Wojcicki, A.M., Pampeyan, E.H., and Hall, N.T., 1975, Map showing active breaks along the San Andreas fault between central Santa Cruz Mountains and the northern Gablin Range, California: United States geological Survey, Miscellaneous Field Studies Map, MF-650, map scale 1:24,000.

Smith, T.C., 1981, Fault evaluation report, San Andreas fault, Montara Mountain 7 ½-minute quadrangle: California Division of Mines and Geology FER-120, with Supplement #1, 15 pgs. with illustrations.

Wallace, R.E., 1990, General features, in Wallace, R.E., ed., The San Andreas fault system, California: U.S. Geological Survey Professional Paper, 1515. 283 pgs.

Working Group on California Earthquake Probabilities, 1990, Probabilities of large earthquakes in the San Francisco Bay region, California: U.S. Geological Survey Circular, 51 pgs.

AERIAL PHOTOGRAPHS

Source: Soil Conservation Service, United States Department of Agriculture

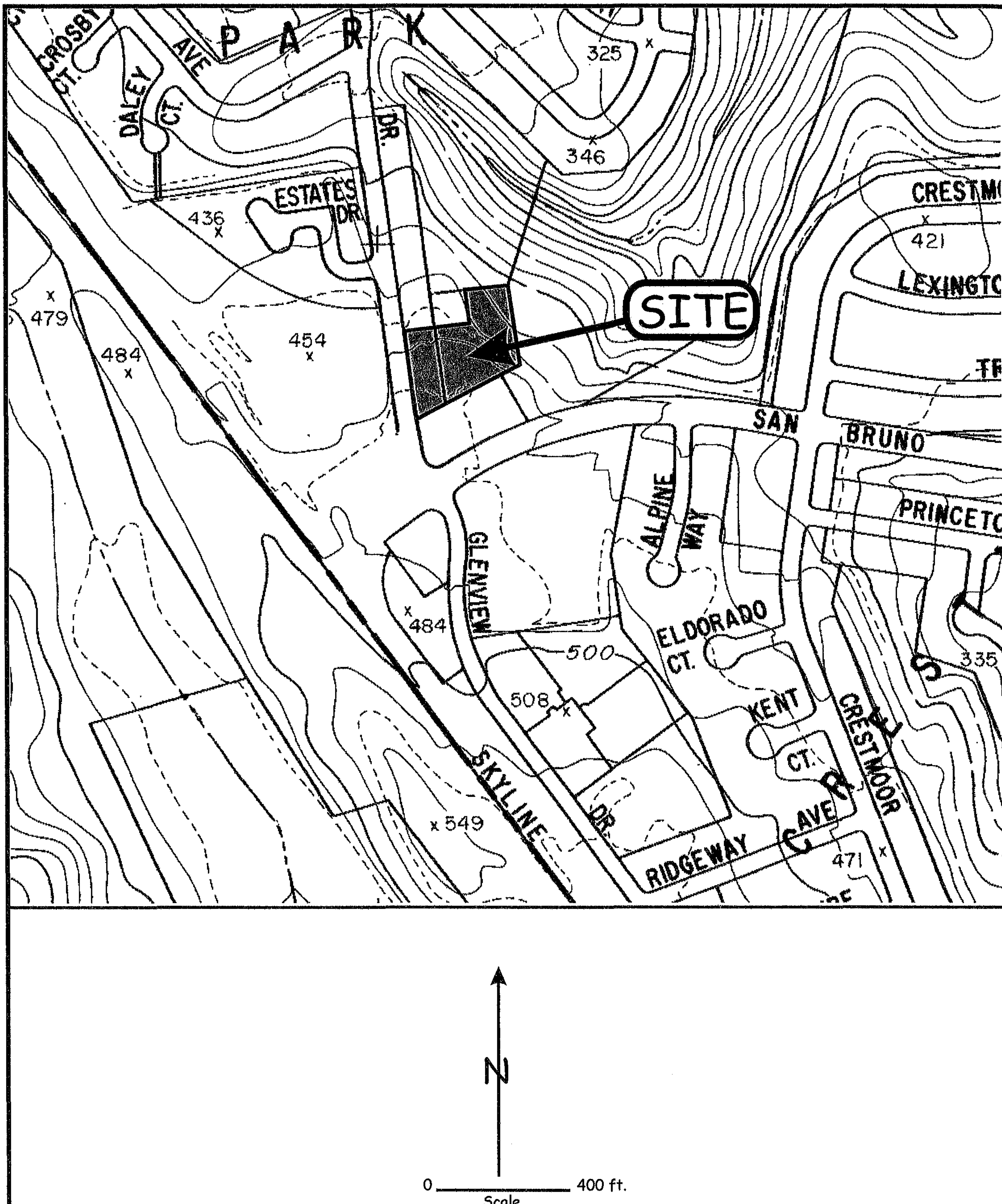
Date	Job No	Flight Line	Frames	Scale
1943	DDB	2B	180-181	1:20,000
1956	DDB	1R	66-67	1:20,000

Source: Pacifica Aerial Surveys, Oakland, California

1946	AV 9	3	3- 4	1::23,600
1955	AV170	5	24-26	1:10000
1961	AV132	4	23-24	1:12,000

Source: United States Air Force (U.S. Geological Survey, Menlo Park)

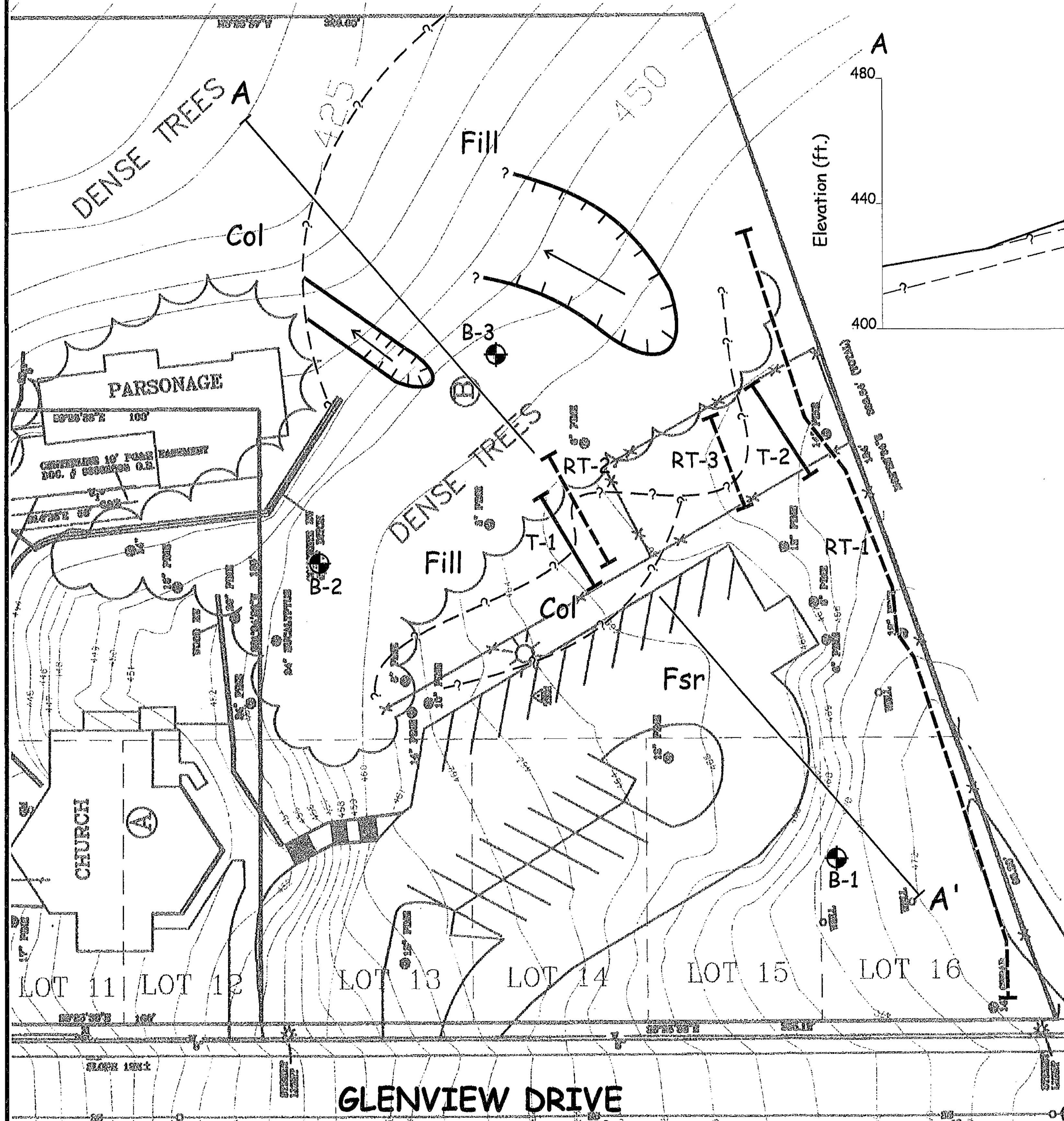
1970	GS-VCMI	2	183-184	1:80,000

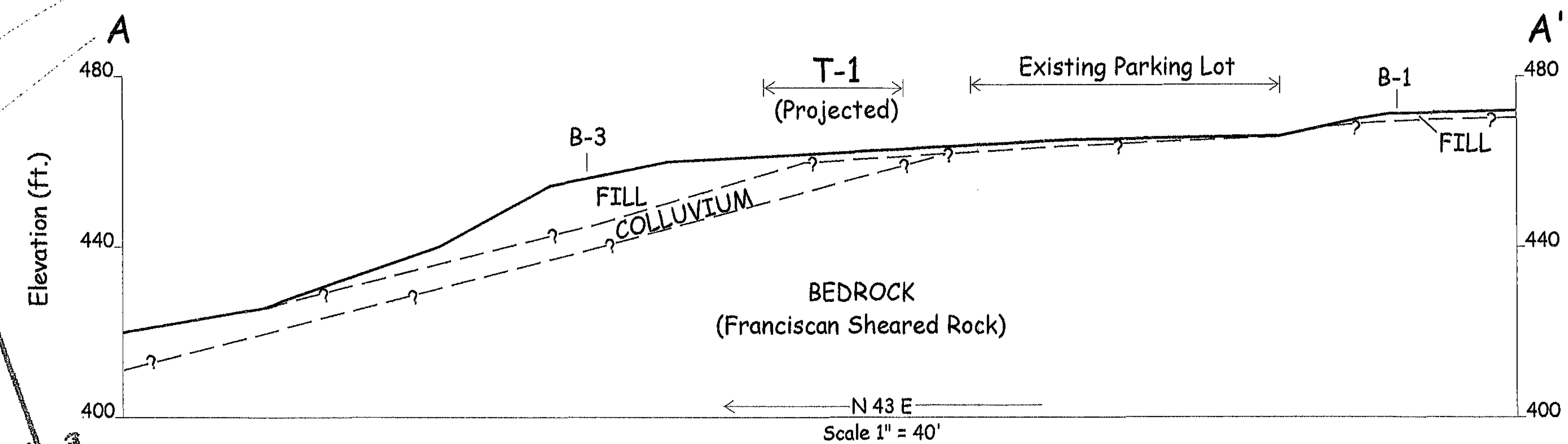


San Mateo County Topographic Map 5C (1/1/96)

Contour interval = 20'

Earth Investigations Consultants	**Job No.** 2271.01.00 **Date** 10/13/08	**VICINITY MAP** 850 Glenview Drive San Bruno, California	**Plate** 1





EXPLANATION

Fill	Undocumented, man-placed soil
Col	Native soil
Fsr	Franciscan sheared rock
— — ? —	Inferred geologic contact
(symbol)	Debris slide scar; arrow points in apparent movement direction
B-1	Approximate boring location
T-1	Approximate fault trench location
A — A'	Line of cross section A-A'
RT-1	Approximate fault trench location from Romig (September, 2008)

0 — 40 ft.
Scale

Base map from Professional Land Services (5/12/2008)

Earth Investigations Consultants	Job No. 2271.01.00 Approved Revised Date 10/28/08	ENGINEERING GEOLOGIC MAP & GENERALIZED CROSS SECTION A-A' 850 Glenview Drive San Bruno, California	Plate 2

EXPLANATION

Potentially Active Faults

1906 C Ⓑ Ⓐ

Fault considered to have been active during Holocene time and to have a relatively high potential for surface rupture; solid line where accurately located, long dash where approximately located, short dash where inferred, dotted where concealed; query (?) indicates additional uncertainty. Evidence of historic offset indicated by year of earthquake-associated event or C for displacement caused by creep or possible creep. Ⓐ & Ⓑ potential subsidiary splay fault segment identified by geomorphic expression on 1941 aerial photographs and in FER-120 (California Division of Mines and Geology, 1981).

Earthquake Fault Zone

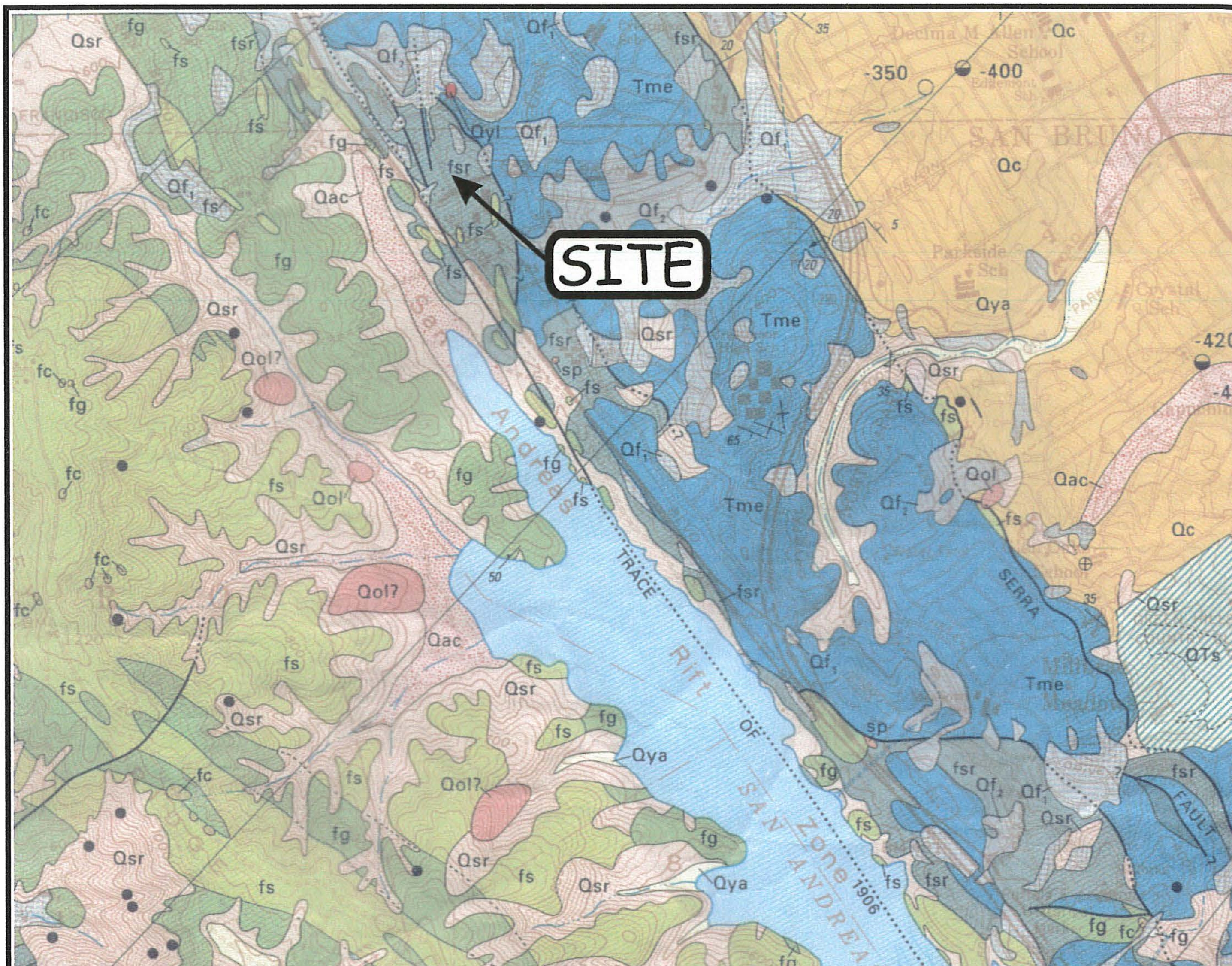
These are delineated as straight-line segments that connect encircled turning points so as to define studies zone segment (CDMG; 1982)

N

0 ______ 1000 ft.

After California Division of Mines and Geology (1982)

Earth Investigations Consultants	Job No. 2271.01.00 Date 10/13/08	**EARTHQUAKE FAULT ZONE MAP** 850 Glenview Drive San Bruno, California	**Plate** 3



EXPLANATION

UNITS

Surficial Deposits

Qf	Artificial fil
Qac	Coarse-grained alluvium
Qsr	Slope wash, ravine fill and colluvium
Qyl	Younger landslide deposits
Qol	Older landslide deposits

Bedrock

Tme	Merced formation
KJf	Franciscan assemblage
fs	Sandstone
fg	Greenstone
fc	Chert
fsr	Sheared rock

SYMBLOLS

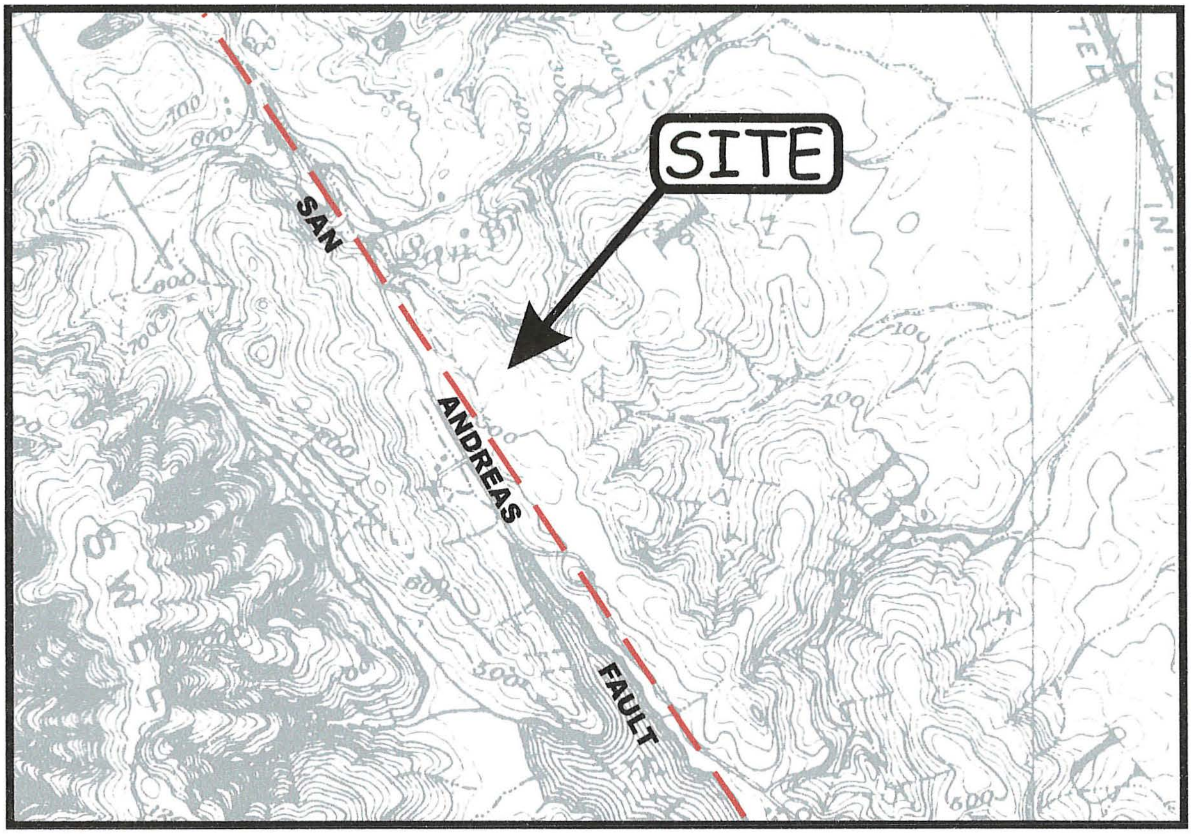
——— — — ....?.	Fault - dashed where inferred; dotted where concealed; queried where existence or extension is uncertain
●	Shallow landslide, commonly in surficial material
65	Bedding attitude
—+—	Vertical
-400	Borehole, showing altitude of basement rocks

N

0 ——— 2000 ft.
Scale

from Earl H. Pampeyan (1994)

Earth Investigations Consultants	Job No. 2271.01.00 Date 10/13/08	GEOLOGIC MAP 850 Glenview Drive San Bruno, California	Plate 4



Historic topographic map of site area from U. S. Geological Survey (1915 San Mateo, California 15-minute topographic quadrangle).

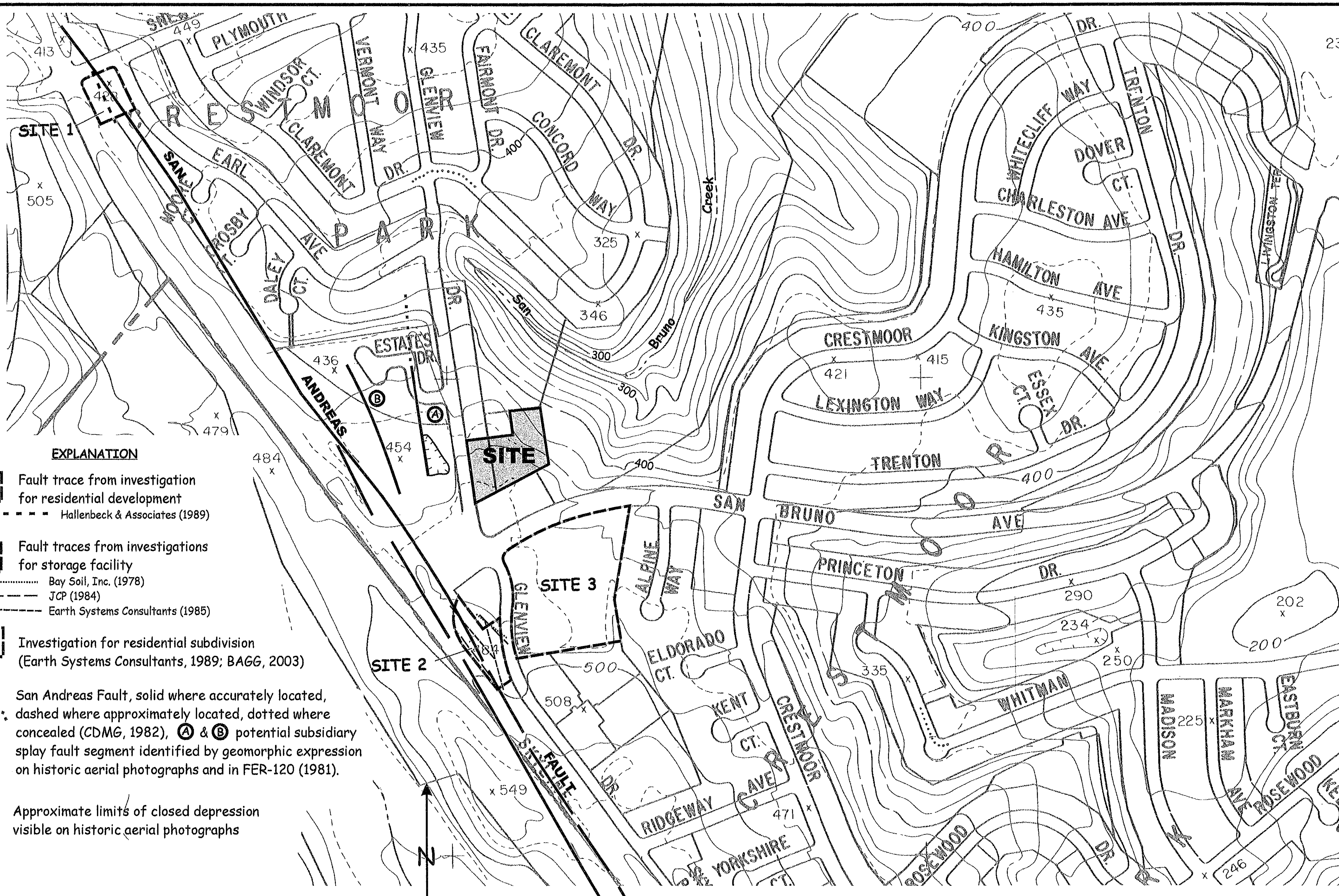
EXPLANATION

San Andreas Fault (Lawson, 1908)
Approximate 1906 surface rupture trace

N

0 ____ 0.5 mile
Scale

Earth Investigations Consultants	Job No. 2271.01.00 Date 10/13/08	HISTORIC TOPOGRAPHIC MAP 850 Glenview Drive San Bruno, California	Plate 5



EXPLANATION

SITE 1 — Fault trace from investigation for residential development
- - - - Hallenbeck & Associates (1989)

SITE 2 — Fault traces from investigations for storage facility
.... Bay Soil, Inc. (1978)
— — — JCP (1984)
-------- Earth Systems Consultants (1985)

SITE 3 — Investigation for residential subdivision (Earth Systems Consultants, 1989; BAGG, 2003)

CDMG — San Andreas Fault, solid where accurately located, dashed where approximately located, dotted where concealed (CDMG, 1982), Ⓐ & Ⓑ potential subsidiary splay fault segment identified by geomorphic expression on historic aerial photographs and in FER-120 (1981).

Approximate limits of closed depression visible on historic aerial photographs

0 ____ 400 ft.
Scale
Contour interval = 20'

San Mateo County Topographic Map 5C (1/1/96)

Earth Investigations Consultants	Job No. 2271.01.00 Approved Date 10/13/08	RELATIVE FAULT RUPTURE HAZARD MAP 850 Glenview Drive San Bruno, California	Plate 6

APPENDIX A

This appendix contains the following logs of explorations we performed in the site between August 14, 2008, and September 30, 2008:

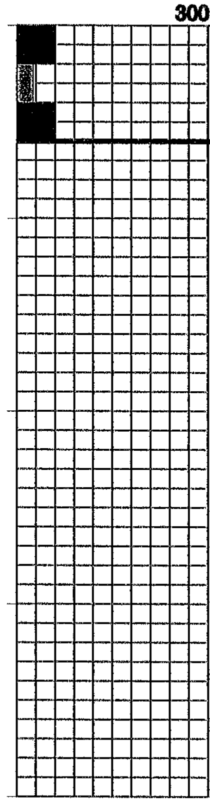
Plate A1 – Log of Boring 1
Plate A2 – Log of Boring 2
Plate A3 – Log of Boring 3
Plate A4 – Key to Borings
Plate A5 – Rock Hardness Criteria
Plate A6 – Logs of Trenches 1 and 2

BORING 1

Equipment Portable Percussion Rig
Elevation ~470' **Date** 8/14/2008

Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Depth (ft.)	Sample	USCS	Description
			0	Continuous	SM	Yellowish brown Gravelly Silty SAND, moist, medium dense (FILL)
124.9	7.1			Continuous	ROCK	Yellowish brown and dark yellowish brown SHEARED ROCK, very weathered, closely fractured, soft (BEDROCK)
			5			Terminated at 3'

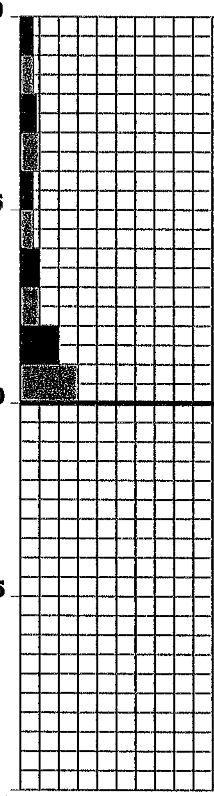
Penetration Rate (sec./ft.) 300



BORING 2

Elevation ~457' **Date** 8/14/2008

Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Depth (ft.)	Sample	USCS	Description
			0	Continuous	SC	Yellowish brown and dark yellowish brown Gravelly Clayey SAND, moist, medium dense (FILL)
101.4	6.4					
107.2	9.1		5			
120.9	12.0				SC	Dark brown Clayey SAND with Gravel, moist, medium dense (COLLUVIUM)
112.5	9.1				ROCK	Yellowish brown SANDSTONE, very weathered, closely fractured, soft (BEDROCK)
			10			Terminated at 10'
			15			



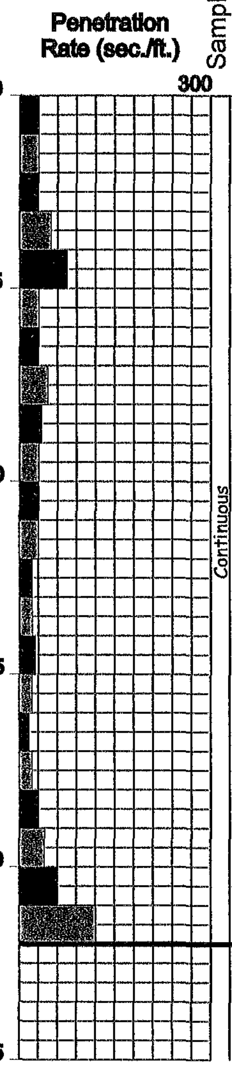
Earth Investigations Consultants	Job No. 2271.01.00 Date 10/13/08	LOGS OF BORINGS 850 Glenview Drive San Bruno, California	Plate A1

BORING 3

Equipment Portable Percussion Rig

Elevation ~457' **Date** 8/14/2008

Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Depth (ft.)	USCS	Description
			0	SC	Yellowish brown and dark yellowish brown Gravelly Clayey SAND, moist, medium dense (FILL)
114.3	8.4				
123.9	6.5		5		
123.4	6.7				
118.8	6.7		10		
102.9	15.4	3.0	15	CL	Dark yellowish to greyish brown Sandy CLAY, damp, stiff (COLLUVIUM)
118.1	15.4				
117.9	11.8		20	ROCK	Yellowish brown and grey SHEARED ROCK, very weathered, closely fractured, soft (BEDROCK)
					Terminated at 22'
			25		



Earth Investigations Consultants

Job No.	2271.01.00
Date	10/13/08

LOG OF BORING

850 Glenview Drive
San Bruno, California

Plate A2

Primary Divisions			Group Symbol	Secondary Divisions
COARSE GRAINED SOILS — MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVELS — MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.
		GRAVEL WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
	SANDS — MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	SW	Well graded sands, gravelly sands, little or no fines.
			SP	Poorly graded sands or gravelly sands, little or no fines.
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures, non-plastic fines.
			SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS — MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS — LIQUID LIMIT IS LESS THAN 50%		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Orangic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS — LIQUID LIMIT IS GREATER THAN 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils.

Definition of Terms

U.S. Standard Series Sieve: 200	40	10	4		Clear Square Sieve Openings: 3/4"	3"	12"
SILTS AND CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

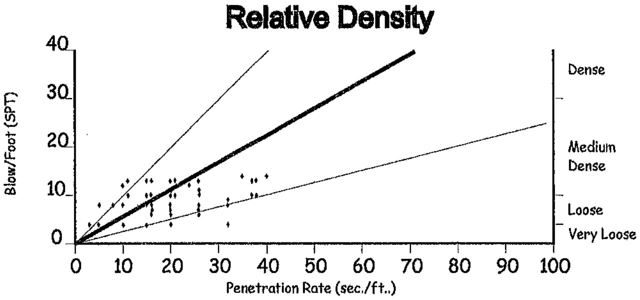
Grain Sizes

Unified Soil Classification System (ASTM D-2487)

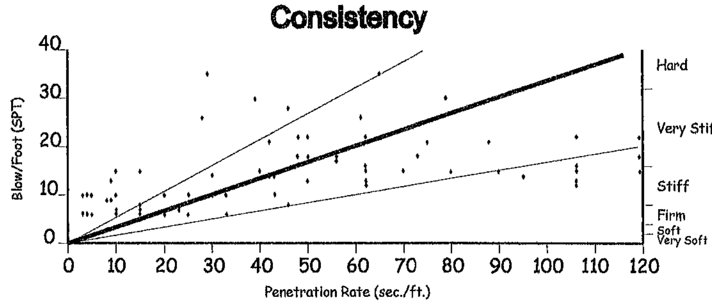
SAND AND GRAVELS	PENETRATION RATE*
VERY LOOSE	0 - 7
LOOSE	7 - 18
MEDIUM DENSE	18 - 53
DENSE	53 - 88
VERY DENSE	OVER 88

SILTS AND CLAYS	STRENGTH**	PENETRATION RATE*
VERY SOFT	0 - 1/4	0 - 6
SOFT	1/4 - 1/2	6 - 11
FIRM	1/2 - 1	11 - 23
STIFF	1 - 2	23 - 47
VERY STIFF	2 - 4	47 - 94
HARD	OVER 4	OVER 94

Relative Density



Consistency



* Seconds per foot, based on a portable percussion rig advancing a 1 1/2-inch diameter split-spoon sampler with a force of 35 ft. lb. at a rate of 1270 blows per minute.

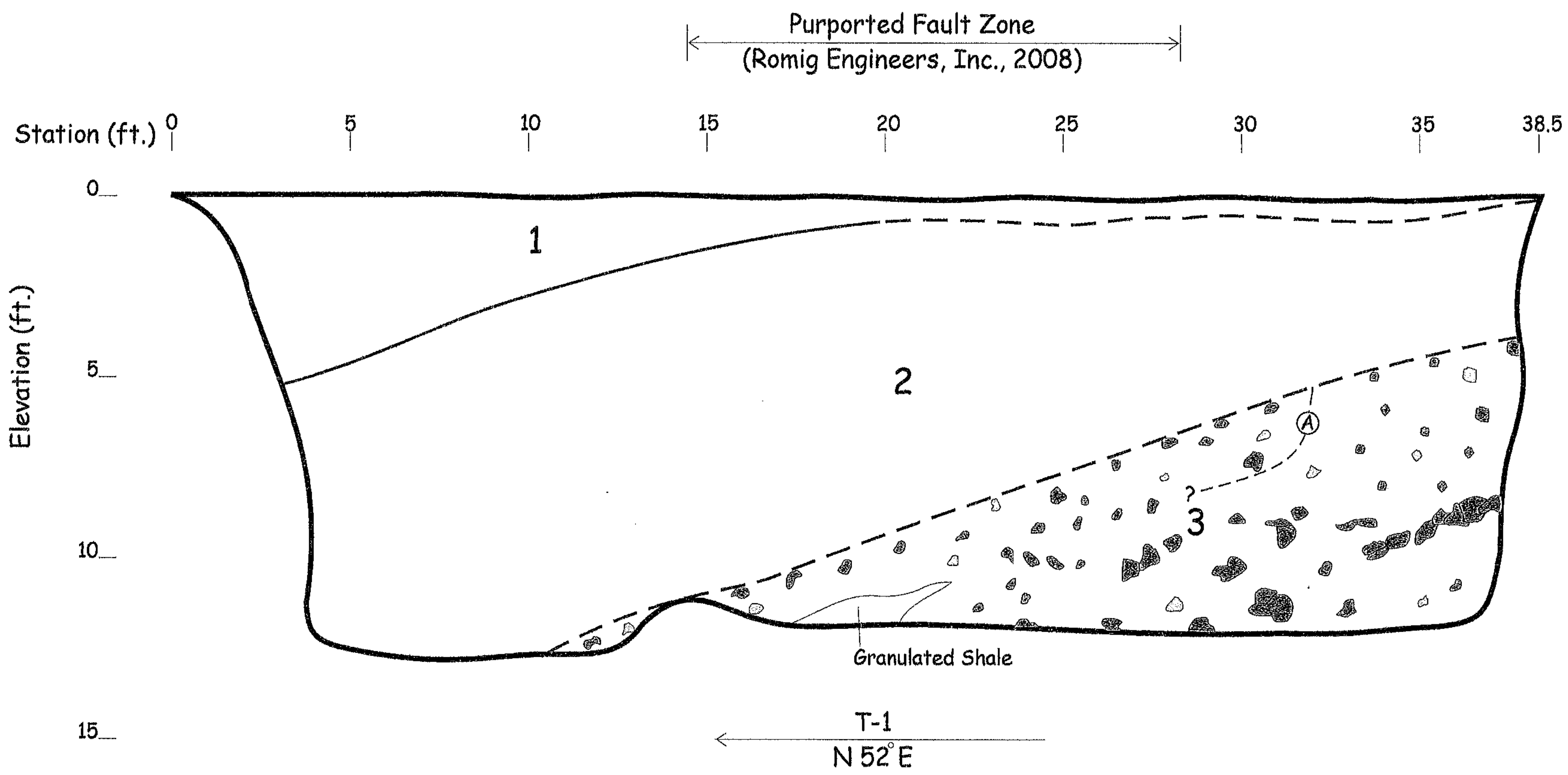
** Unconfined compressive strength in tons/sq. ft. as determined by laboratory testing or approximated by the standard penetration test (ASTM D-1586), pocket penetrometer, torvane, or visual observation.

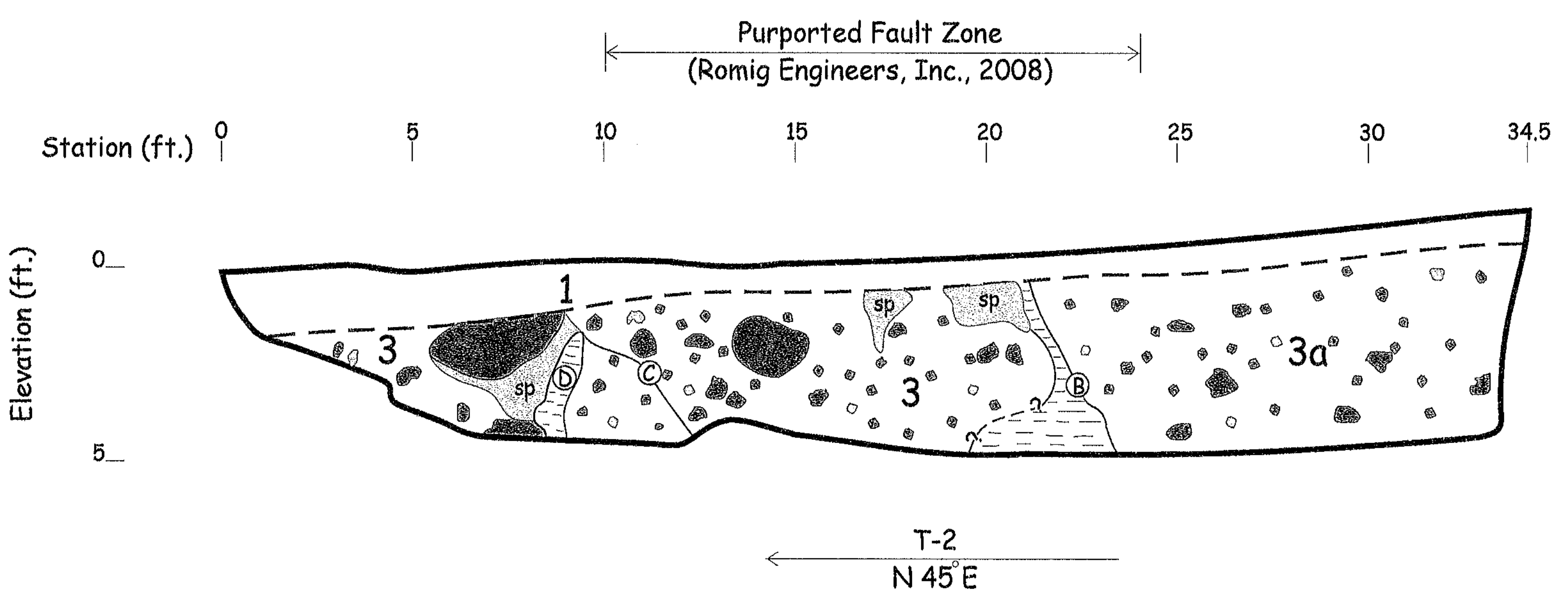
Earth Investigations Consultants	**Job No.** 2271.01.00 **Date** 10/13/08	**KEY TO BORINGS** 850 Glenview Drive San Bruno, California	**Plate** A3

ROCK HARDNESS CRITERIA

Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimen requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately Hard	Can be scratched with knife or pick. Gouges or grooves to 1/4 inch deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 inch deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1 inch maximum size by hand blows of the point of geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of pick point. Small thin pieces can be broken by finger pressure.
Very Soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1 inch or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Subsurface Manual for Design and Construction of Foundations of Buildings, 1976
Published by American Society of Civil Engineers.





EXPLANATION

Symbol

1 — Unit

Unit contact; solid where sharp, dash where indistinct, queried where uncertain

Random of Silica-carbonate fragment to block size

sp — Random of Serpentinite fragment to block size

Gravelly Sandy CLAY

Unit

1. UNDOCUMENTED FILL: Light yellowish brown, Clayey, Silty SAND with occasional construction concrete debris to boulder size; loose; slightly moist; loose in upper foot to medium dense; trace roots in eastern part of TR-1.

2. COLLUVIUM: Dark brown in upper 1 foot to dark yellowish brown, Clayey, Gravelly, Silty SAND; angular to subrounded clasts of dark gray SILICA-CARBONATE, less discernable SERPENTINITE to 4 inches, and very pale brown, soft to moderately hard, fine-grained SANDSTONE; massive; porous; slightly moist in upper 2 feet moist to damp below, very stiff to hard (approx. age of 130,000 years; see Appendix B).

3. FRANCISCAN SHEARED ROCK: Mainly grayish and yellowish brown SERPENTINITE and dark brown SHALE(?) crushed/granulated to massive, stiff, fine Gravelly Sandy CLAY matrix supporting mainly angular to subrounded, randomly oriented, hard to soft, coarse gravel- to cobble-size fragments of dark olive brown SERPENTINITE and hard, dark olive gray, slightly vesicular SILICA-CARBONATE rock; locally contains (in TR-2) relative concentration of dark olive gray, soft to moderately hard, subangular to subrounded, SERPENTINITE boudinage(?) to 1-foot across, and angular, dense and very hard, dark olive gray, slightly vesicular, SILICA-CARBONATE blocks locally to 3 feet across.

3a FRANCISCAN SHEARED ROCK: Similar to 3 in texture and composition but lacks the larger serpentinite and silica-carbonate fragments.

Structures

T-1

A. Between Sta. 28.5 and 32 indistinct, curvilinear parting that when projected northeastward coincides with granulated shale at base of excavation between Sta. 17.5 and 21.5.

T-2

B. Approximately 1 inch thick, dark brown, stiff, unsheared Sandy CLAY containing angular to subrounded fine to medium gravel-size fragments (approx. 10%) of soft to moderately hard serpentinite and shale, and hard silica-carbonate rock that indistinctly widens on eastern side to approx. 3 feet. Bounded on west side by wavy parting oriented North 5 degrees East to North 5 degrees West.

C. Approximately 1/8-inch wide, East-West trending, stiff, unsheared CLAY seam.

D. Approximately 6-inch wide seam of dark olive green, stiff, unsheared fine to coarse, Sandy CLAY exhibiting cross-trench orientation of approximately North 25 degrees West.

Earth Investigations Consultants	Job No. 2271.01.00 Approved Date 10/13/08	LOGS OF TRENCHES 850 Glenview Drive San Bruno, California	Plate A5

APPENDIX B

This appendix contains the following 24-page report prepared by Soil Tectonics on October 3, 2008:

Pedochronological report for Peace Lutheran Church, 850 Glenview Drive, San Bruno, California

PEDOCHRONOLOGICAL REPORT FOR PEACE LUTHERAN CHURCH, 850 GLENVIEW DRIVE, SAN BRUNO, CALIFORNIA

Earth Investigations Consultants, Pacifica, CA, Project No. 2271

October 3, 2008

Soil Tectonics
P.O. Box 5335
Berkeley, CA 94705

G Borchardt

Glenn Borchardt

Principal Soil Scientist
Certified Professional Soil Scientist No. 24836

PEDOCHRONOLOGICAL REPORT FOR PEACE LUTHERAN CHURCH, 850 GLENVIEW DRIVE, SAN BRUNO, CALIFORNIA

Earth Investigations Consultants, Pacifica, CA, Project No. 2271

October 3, 2008

Glenn Borchardt

INTRODUCTION

An assessment of seismic and landslide risk due to ground movement can be aided greatly by the techniques of pedochronology (Borchardt, 1992, 1998), soil dating. This is because the youngest geological unit overlying fault traces and landslide features is generally a soil horizon. The age and relative activity of ground movement often can be estimated by evaluating the age and relative disturbance of overlying soil units.

Soil horizons exhibit a wide range of physical, chemical, and mineralogical properties that evolve at varying rates. Soil scientists use various terms to describe these properties. A black, highly organic "A" horizon, for example, may form within a few centuries, while a dark brown, clayey "Bt" horizon may take as much as 40,000 years to form. Certain soil properties are invariably absent in young soils. For instance, soils developed in granitic alluvium of the San Joaquin Valley do not have Munsell hues redder than 10YR until they are at least 100,000 years old (Birkeland, 1999; Harden, 1982). Still other properties, such as the movement and deposition of clay-size particles and the precipitation of calcium carbonate at extraordinary depths, indicate soil formation during a climate much wetter than at present. In the absence of a radiometric age date for the material from which a particular soil formed, an estimate of its age must take into account all the known properties of the soil and the landscape and climate in which it evolved.

METHOD

The first step in studying a soil is the compilation of the data necessary for describing it (Birkeland, 1999; Borchardt, 2004). At minimum, this requires a Munsell color chart, hand lens, acid bottle, meter for 1:1 soil:water pH and conductivity measurements. The second step may involve the collection of samples of each horizon for laboratory analysis of particle size. This is done to check the textural classifications made in the field and to evaluate the genetic relationships between horizons and between different soils in the landscape. When warranted, the clay mineralogy and chemistry of the soil also is analyzed to provide additional information on the changes undergone by the initial material from which the soil weathered. The last step is the comparison of this accumulated soil data with that for soils having developed under similar conditions. Such information is scattered in soil survey reports (e.g., Welch, 1981), soil science journals, and consulting reports. In a particular locality, there is seldom enough comparative data available for this purpose. That is why, at the very least, the study of one soil profile always makes the evaluation of the next that much easier.

RESULTS OF THIS EVALUATION

A soil profile was measured, sampled, and described to assess the hazard due to ground fault rupture across a north-westerly trending shear zone on the northeast side of the San Andreas fault in Trench T-1 at Peace Lutheran Church (Fig. 1). Previous work had identified a zone of sheared bedrock, but had not evaluated the age of the soil above it.

Soil Profile No. 1

This profile consists of a cumulic soil developed in late Pleistocene colluvium overlying the remnants of a residual paleosol developed in silica carbonate of the Franciscan Assemblage (Table 1, Figs. 2 and 3). The 71-cm thick very dark grayish brown A horizon is silt loam, while the 177-cm thick Bt horizon changes from silty clay loam at the top to silty clay at the bottom. Colors in the Bt range from brown to dark yellowish brown (Figs. 2 and 3). The pH decreases from 6.7 in the surface to 5.7 in the Bt, as seen in other moderately well-developed soils (Fig. 4). Conductivity is low, with a slight increase in salt content beneath the 153-cm depth, which is presumably indicative of the maximum extent of the modern wetting front (Fig. 5). The leached area beneath the 248-cm depth appears to be a relict from a time of greater leaching depth during the Pleistocene. Of particular note is the presence of "common thin to medium thick clay films lining pores and coating peds" in the B2t and "many medium thick clay films lining pores and coating peds and clasts" in the B4t (Table 1).

SOIL AGE

The extensive clay-film development in this soil profile is indicative of soil ages suitable for assessing ground fault rupture hazard along this shear zone. The parent material for this soil consists of colluvium, as confirmed by the reddish clasts/peds that appear to have been reworked from a previous soil (Fig. 3). The great age of this soil is apparent from its thick Bt horizon (177 cm) in which medium thick clay films line pores and coat peds and saprolitic clasts. Such thick Bt horizons generally are found only in soils with development ages greater than 10 ka. The 3-m thick soils in the Livermore Valley, for example, are considered to be 40 to 80 ka (Borchardt, 1985; 1989; 1999). Colluvial soils radio-carbon dated at 9-15 ky B.P. apparently lack clay films and have such relatively low densities that they may produce debris flows under intense rainfall (Reneau and others, 1986; 1989; 1990). The clay film development within this soil apparently holds this soil together even though it was on a 20° slope before it was overlain by artificial fill.

Judging by the sharply angular fragments that it contains, the paleosol remnant beneath the colluvium has formed *in situ* from Franciscan bedrock. There were no red peds or other indications that it had significant colluvial contributions. Its high clay content, implies that it, too, has considerable age. The erosion that removed the upper horizons within this soil probably occurred right after the last major interglacial period about 80,000 years ago.

CONCLUSIONS

1. Soils in this trench record over 130,000 years of pedogenesis uninterrupted by fault movement.

2. There was no evidence of soil offset, shearing, warping, or other manifestation of tectonism within the soil horizons estimated to have formed within the last 130,000 years.

REFERENCES

Birkeland, P.W., 1999, Soils and geomorphology (3rd ed.): New York, Oxford University Press, 430 p.

Borchardt, G., 1985, Quaternary stratigraphy of soils in the Greenville fault zone, Livermore, California, *in* Seeley, M.W., ed., Evaluation of active faulting and other potential geologic hazards: 145 acre parcel at Northfront and Laughlin Roads near Livermore, California: Pleasanton, CA, Merrill, Seeley, Mullen, Sandefur Inc., p. D1-D34.

Borchardt, G., 1989, Pedochronological report for Quint Investment Associates 40 acre property, Laughlin Road, Livermore, California, *in* Berger, T.W., Glick, D.C., and Eskandari, A.Y., eds., Report: Geologic and seismic hazards investigation and preliminary soils investigation for Quint Investment Associates 40 Acre property, Laughlin Road, Livermore, California: Pleasanton, CA, BSK & Associates Geotechnical Consultants, Inc., p. B1-B33.

Borchardt, G., 1999, Pedochronological report for lots 9, 10, and 15 of tract 6068, Livermore, California, *in* Finnigsmier, J.L., and Korbay, S.R., eds., Surface fault rupture hazard study: Lots 9, 10 & 15, tract 6068, Livermore, California: Pleasanton, CA, Kleinfelder, Inc., p. A-1 to A-21.

Borchardt, Glenn, 1992, Pedochronology along the Hayward fault, *in* Borchardt, G., Hirschfeld, S.E., Lienkaemper, J.J., McClellan, P., Williams, P.L., and Wong, I.G., eds., Proceedings of the Second Conference on Earthquake Hazards in the Eastern San Francisco Bay Area, California Department of Conservation, Division of Mines and Geology Special Publication 113, p. 111-117.

Borchardt, Glenn, 1998, Soil tectonics: Geotimes, v. 36, p. 72-84.

Borchardt, Glenn, 2002, Mineralogy and soil tectonics, *in* Dixon, J. B., and Schulze, D. G., eds., Soil mineralogy with environmental applications: Soil Science Society of America Book Series No. 7: Madison, WI, Soil Science Society of America, p. 711-736.

Borchardt, Glenn, 2004, Soil stratigraphy for trench logging (2nd ed.): Berkeley, CA, Soil Tectonics, 68 p.

Reneau, S.L., Dietrich, W.E., Donahue, D.J., Jull, A.J.T., and Rubin, M., 1990, Late Quaternary history of colluvial deposition and erosion in hollows, central California Coast Ranges: Geological Society of America Bulletin, v. 102, p. 969-982.

Reneau, S.L., Dietrich, W.E., Dorn, R.I., Berger, C.R., and Rubin, M., 1986, Geomorphic and paleoclimatic implications of latest Pleistocene radiocarbon dates from colluvium-mantled hollows, California: Geology, v. 14, p. 655-658.

Reneau, S.L., Dietrich, W.E., Rubin, M., J., D.D., and Jull, A.J.T., 1989, Analysis of hillslope erosion rates using dated colluvial deposits: Journal of Geology, v. 97, p. 45-63.

Soil Survey Staff, 1992, Keys to soil taxonomy, 5th edition, SMSS Technical Monograph No. 19: Pocahontas Press, Inc., Blacksburg, VA, 541 p.

Soil Survey Staff, 1993, Soil survey manual (3rd edition): USDA-SCS Agriculture Handbook 18, U.S. Government Printing Office, Washington, DC, 457 p.

Soil Survey Staff, 1999, Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys: USDA-SCS Agriculture Handbook 436, U.S. Government Printing Office, Washington, DC, 900 p.

Welch, L. E., 1981, Soil survey of Alameda County, California, western part, U.S. Department of Agriculture, Soil Conservation Service in cooperation with University of California Agriculture Experiment Station, 103 p.

Table 1. Soil Profile No. 1 from Trench T-1 excavated northeast of the parking lot at Peace Lutheran Church at 850 Glenview Drive, San Bruno, California. Abbreviations and definitions are given in Soil Survey Staff (1992; 1993; 1999).

Soil description by Glenn Borchardt, who measured and sampled the soil on September 30, 2008 at latitude N37° 37.204' and longitude W122° 26.496' at station 10.3' in the southeast wall of Trench T-1 at an elevation of 454'. Mediterranean climate. Precipitation is 18.8"/yr (478 mm/yr) at San Mateo from 1948-1978. Vegetation consist of ornamentals and poison oak. Slope was 20° before filling. Aspect northeast. Well drained. Water table deep. The parent material is Quaternary colluvium over Franciscan Assemblage. Soil pH ranges from neutral in the surface to medium acid in the Bt horizon.

Horizon	Depth, cm	Description
Af	50	Artificial fill.

A 0-71 Very dark grayish brown (10YR3/2m, 7/2d) silt loam; medium strong subangular blocky to granular structure; slightly sticky and slightly plastic when wet, very friable when moist, and very hard when dry; few fine roots; many fine continuous and discontinuous random tubular pores; clear smooth boundary; pH 6.7; conductivity 20 uS; Sample No. 08B331.

B1t 71-87 Dark brown (10YR3/3m, 7/2d) silty clay loam with few medium faint yellowish brown (10YR5/4m) mottles due to saprolitic sandstone; medium strong subangular blocky structure; sticky and plastic when wet, friable when moist, and very hard when dry; common fine continuous and discontinuous random tubular pores; few thin clay films lining pores and coating peds; clear smooth boundary; pH 6.1; conductivity 30 uS; Sample No. 08B332.

B2t 87-133 Dark grayish brown (10YR4/2m, 6/3d) silty clay loam with few medium faint yellowish brown (10YR5/4m and 10YR5/8m) mottles due to saprolitic sandstone; medium strong subangular to angular blocky structure; very sticky and very plastic when wet, firm when moist, and very hard when dry; common fine continuous and discontinuous random tubular pores; common thin to medium thick clay films lining pores and coating peds; diffuse smooth boundary; pH 5.8; conductivity 30 uS; Sample No. 08B333.

B3t 133-153 Dark grayish brown (10YR4/2m, 6/3d) silty clay with few medium faint yellowish brown (10YR5/4m and 10YR5/8m) mottles due to saprolitic sandstone; medium strong subangular blocky to prismatic structure; very sticky and very plastic when wet, firm when moist, and very hard when dry; many fine continuous and discontinuous random tubular pores; many medium thick clay films lining pores and coating peds and clasts; diffuse smooth boundary; pH 5.7; conductivity 40 uS; Sample No. 08B334.

B4t 153-248 Dark brown (10YR3/3m, 6/3d) silty clay with few medium faint yellowish brown (10YR5/4m and 10YR5/8m) mottles due to saprolitic sandstone; medium to coarse moderate subangular blocky to prismatic structure; very sticky and very plastic when wet, firm when moist, and very hard when dry; many fine continuous and discontinuous random tubular pores; many medium thick clay films lining pores and coating peds and clasts; diffuse smooth boundary; pH 5.8; conductivity 80 uS; Sample No. 08B335 (level line at 164 cm).

BCt 248-307 Dark yellowish brown (10YR4/4m, 6/4d) silty clay loam with few medium faint yellowish brown (10YR5/4m and 10YR5/8m) mottles due to saprolitic sandstone and few black mottles due to mangans; medium to coarse moderate subangular blocky structure; very sticky and very plastic when wet, firm when moist, and very hard when dry; many fine continuous and discontinuous random tubular pores; many medium thick clay films lining pores; gradual smooth boundary; pH 6.1; conductivity 20 uS; Sample No. 08B336.

*ESTIMATED AGE:	t_o	=	80	ka
	t_b	=	0	ka
	t_d	=	80	ky

Crtb 307-317+ Grayish brown (10YR5/2m, 6/4d) gravelly clay with few medium faint yellowish brown (10YR5/4m and 10YR5/8m) mottles due to saprolitic sandstone and few black mottles due to mangans; medium to coarse moderate subangular blocky structure; very sticky and very plastic when wet, firm when moist, and very hard when dry; common fine continuous and discontinuous random tubular pores; many medium thick to thick clay films lining pores and coating angular weathered silica carbonate clasts to 9 cm; pH 6.5; conductivity 110 uS; Sample No. 08B337.

*ESTIMATED AGE:	t_o	=	130	ka
	t_b	=	80	ka
	t_d	=	50	ky

*Pedochronological estimates based on available information. All ages should be considered subject to ±50% variation unless otherwise indicated (Borchardt, 1992). Bold dates are absolute.

t_o = date when soil formation or aggradation began, ka

t_b = date when soil or strata was buried, ka

t_d = duration of soil development or aggradation, ky

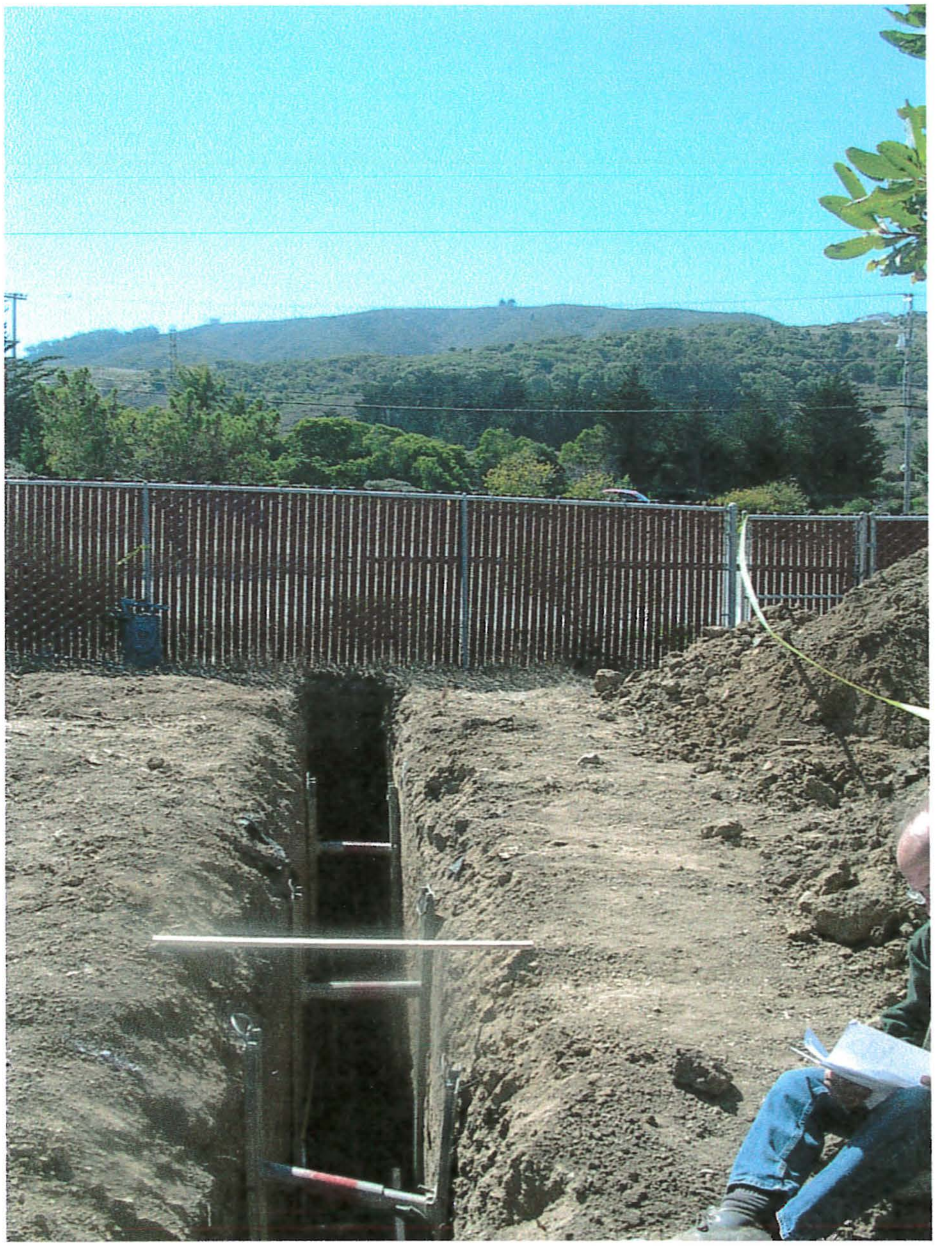


Figure 1. Trench T-1 at Peace Lutheran Church, San Bruno, CA. View SW.

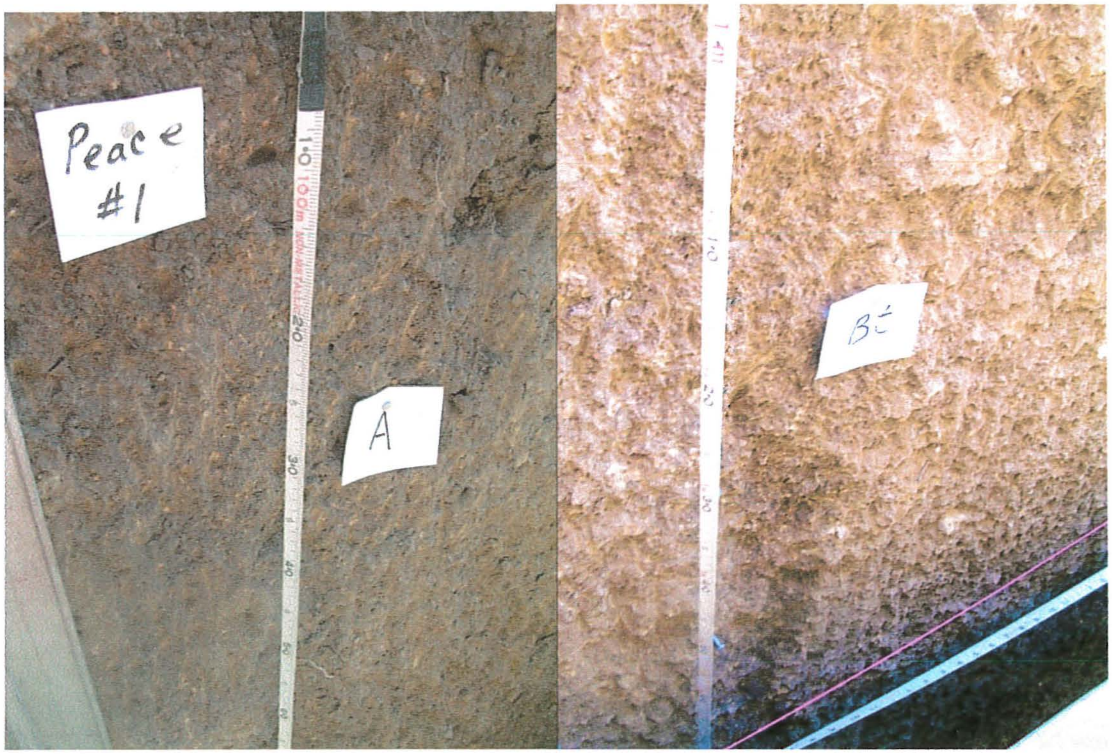


Figure 2. Soil Profile No. 1 showing the 71-cm A horizon and the upper portion of the 177-cm thick Bt horizon developed in colluvium. View SE.

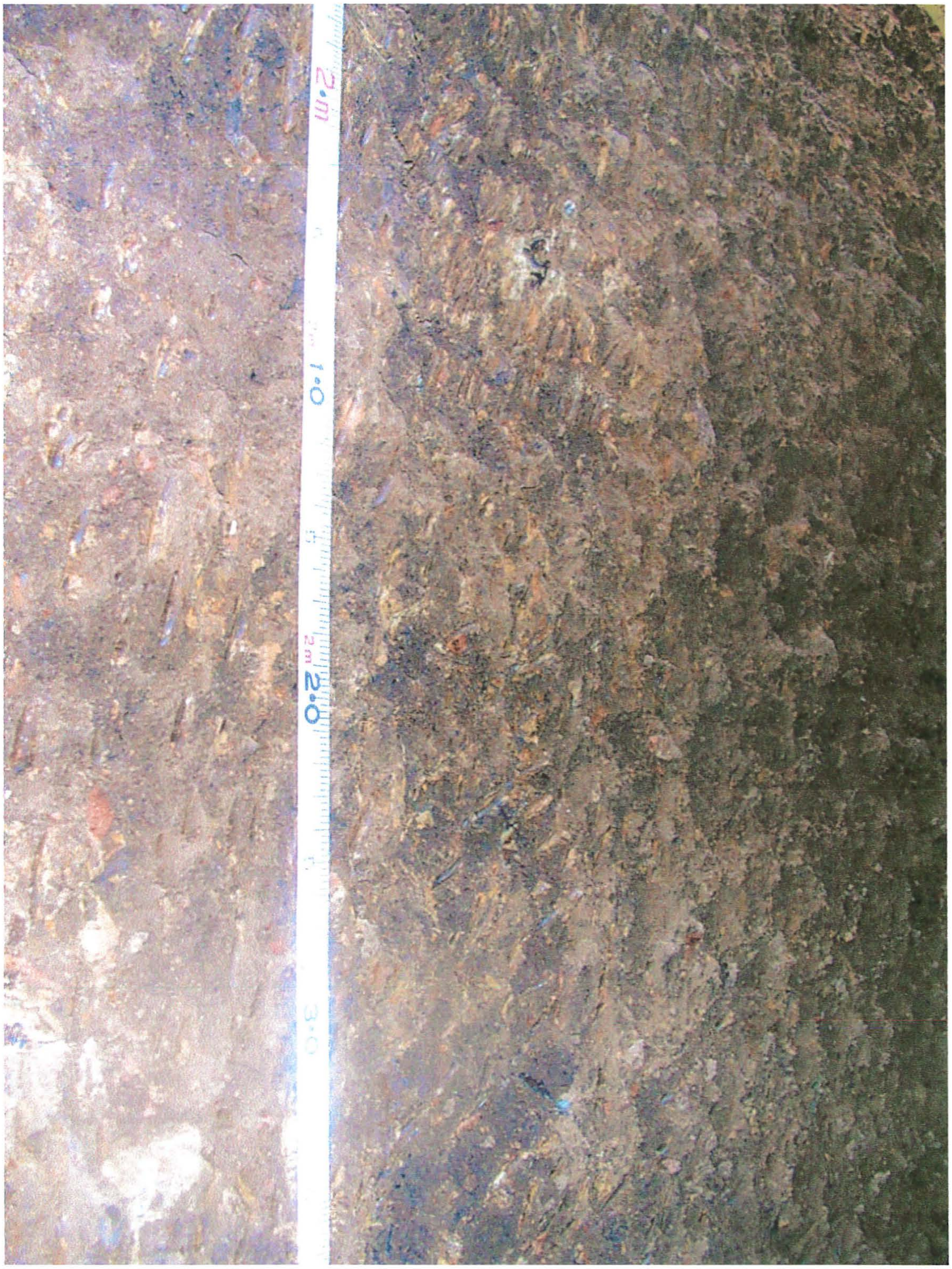


Figure 3. Soil Profile No. 1 showing the lower portion of the 177-cm thick Bt horizon developed in colluvium. Medium thick clay films line pores and coat peds and saprolitic clasts throughout. The reddish clasts/peds were reworked from a previous soil during the Pleistocene. View SE.

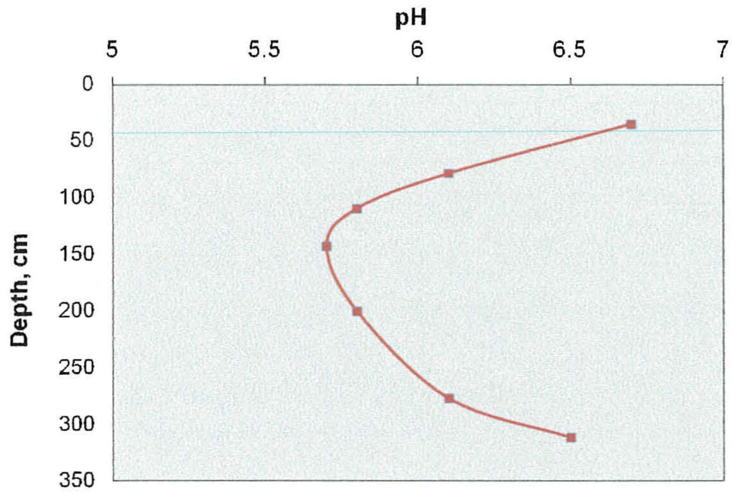


Figure 4. Depth function for pH in Soil Profile No. 1 at San Bruno. The low pH's in the subsoil are indicative of extensive soil leaching by acid rainfall. The pH tends to increase in the surface due to recycling of calcium by plants.

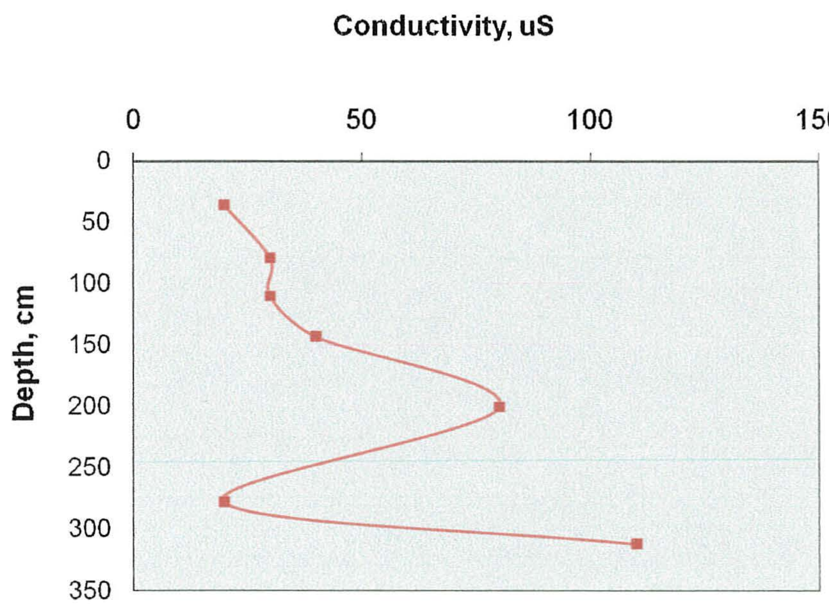


Figure 5. Depth function for conductivity in Soil Profile No. 1 at San Bruno. An increase in conductivity often occurs beneath the modern-day wetting front (at the 150-cm depth in this profile). The low conductivity at 280 cm probably is a remnant produced by leaching during the Pleistocene. Current rainfall (478 mm/yr) apparently does not lead to leaching of that area.

GLOSSARY

AGE. Elapsed time in calendar years. Because the cosmic production of C-14 has varied during the Quaternary, radiocarbon years (expressed as ky B.P.) must be corrected by using tree-ring and other data. Abbreviations used for corrected ages are: ka (kilo anno or years in thousands) or Ma (millions of years). Abbreviations used for intervals are: yr (years), ky (thousands of years). radiocarbon ages = yr B.P. Calibrated ages are calculated from process assumptions, relative ages fit in a sequence, and correlated ages refer to matching unit. (See also yr B.P., HOLOCENE, PLEISTOCENE, QUATERNARY, PEDOCHRONOLOGY).

AGGRADATION. A modification of the earth's surface in the direction of uniformity of grade by deposition.

ALKALI (SODIC) SOIL. A soil having so high a degree of alkalinity (pH 8.5 or higher), or so high a percentage of exchangeable sodium (15 % or more of the total exchangeable bases), or both, that plant growth is restricted.

ALKALINE SOIL. Any soil that has a pH greater than 7.3. (See Reaction, Soil.)

ANGULAR ORPHANS. Angular fragments separated from weathered, well-rounded cobbles in colluvium derived from conglomerate.

ARGILLAN. (See Clay Film.)

ARGILLIC HORIZON. A horizon containing clay either translocated from above or formed in place through pedogenesis.

ALLUVIATION. The process of building up of sediments by a stream at places where stream velocity is decreased. The coarsest particles settle first and the finest particles settle last.

ANOXIC. (See also GLEYED SOIL). A soil having a low redox potential.

AQUICLUDE. A saturated body of sediment or rock that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients.

AQUITARD. A body of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs but may serve as a storage unit for groundwater.

ATTERBERG LIMITS. The moisture content at which a soil passes from a semi-solid to a plastic state (plastic limit, PL) and from a plastic to a liquid state (liquid limit, LL). The plasticity index (PI) is the numerical difference between the LL and the PL.

BEDROCK. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

BISEQUUM. Two soils in vertical sequence, each soil containing an eluvial horizon and its underlying B horizon.

BOUDIN, BOUDINAGE. From a French word for sausage, describes the way that layers of rock break up under extension. Imagine the hand, fingers together, flat on the table, encased in soft clay and being squeezed from above, as being like a layer of rock. As the spreading clay moves the fingers (sausages) apart, the most mobile rock fractions are drawn or squeezed into the developing gaps.

BURIED SOIL. A developed soil that was once exposed but is now overlain by a more recently formed soil.

CALCAREOUS SOIL. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

CATENA. A sequence of soils of about the same age, derived from similar parent material and occurring under similar climatic conditions, but having different characteristics due to variation in relief and drainage. (See also TOPOSEQUENCE.)

CEC. Cation exchange capacity. The amount of negative charge balanced by positively charged ions (cations) that are exchangeable by other cations in solution (meq/100 g soil = cmol(+)/kg soil).

CLAY. As a soil separate, the mineral soil particles are less than 0.002 mm in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

CLAY FILM. A coating of oriented clay on the surface of a sand grain, pebble, soil aggregate, or ped. Clay films also line pores or root channels and bridge sand grains. Frequency classification is based on the percent of the ped faces and/or pores that contain films: very few--<5%; few--5-25%; common--25-50%; many--50-90%; and continuous--90-100%. Thickness classification is based on visibility of sand grains: thin--very fine sand grains standout; moderately thick--very fine sand grains impart microrelief to film; thick--fine sand grains enveloped by clay and films visible without magnification. Synonyms: clay skin, clay coat, argillan, illuviation cutan.

CLAY LAMELLAE. Thin, generally wavy bands that appear as multiple micro-Bt horizons at the base of the solum in sandy Holocene deposits. The lamellae generally are 1-3 cm in thickness and 5 to 30 cm apart. There may be two to six or more clay lamellae comprising the Bt horizon of such a soil.

COBBLE. Rounded or partially rounded fragments of rock ranging from 7.5 to 25 cm in diameter.

COLLUVIUM. Any loose mass of soil or rock fragments that moves downslope largely by the force of gravity. Usually it is thicker at the base of the slope.

COLLUVIUM-FILLED SWALE. The prefailure topography of the source area of a debris flow.

COMPARATIVE PEDOLOGY. The comparison of soils, particularly through examination of features known to evolve through time.

CONCRETIONS. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

CONDUCTIVITY. The ability of a soil solution to conduct electricity, generally expressed as the reciprocal of the electrical resistivity. Electrical conductance is the reciprocal of the resistance ($1/R = 1/ohm = ohm^{-1}$ = mho [reverse of ohm] = siemens = S), while electrical conductivity is the reciprocal of the electrical resistivity (EC = 1/r = 1/ohm-cm = mho/cm = S/cm or mmho/cm = dS/m). EC, expressed as uS/cm, is equivalent to the ppm of salt in solution when multiplied by 0.640. Pure rain water has an EC of 0, standard 0.01 N KCl is 1411.8 uS at 25C, and the growth of salt-sensitive crops is restricted in soils having saturation extracts with an EC greater than 2,000 uS/cm. Measurements in soils are usually performed on 1:1 suspensions containing one part by weight of soil and one part by weight of distilled water.

CONSISTENCE, SOIL. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are --

Loose.--Noncoherent when dry or moist; does not hold together in a mass.

Friable.--When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.--When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.--When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.--When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.--When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.--When dry, breaks into powder or individual grains under very slight pressure.

Cemented.--Hard and brittle; little affected by moistening.

CTPOT. Easily remembered acronym for climate, topography, parent material, organisms, and time; the five factors of soil formation.

CUMULIC. A soil horizon that has undergone aggradation coincident with its active development.

CUTAN. (See Clay Film.)

DEBRIS FLOW. Incoherent or broken masses of rock, soil, and other debris that move downslope in a manner similar to a viscous fluid.

DEBRIS SLOPE. A constant slope with debris on it from the free face above.

DEGRADATION. A modification of the earth's surface by erosion.

DURIPAN. A subsurface soil horizon that is cemented by illuvial silica, generally deposited as opal or microcrystalline silica, to the degree that less than 50 percent of the volume of air-dry fragments will slake in water or HCl.

ELUVIATION. The removal of soluble material and solid particles, mostly clay and humus, from a soil horizon by percolating water.

EOLIAN. Deposits laid down by the wind, landforms eroded by the wind, or structures such as ripple marks made by the wind.

FAULT-LINE SCARP. A scarp that has been produced by differential erosion along an old fault line.

FAULTSLIDE. A landslide that shows physical evidence of its interaction with a fault.

FIRST-ORDER DRAINAGE. The most upstream, field-discernible concavity that conducts water and sediments to lower parts of a watershed.

FLOOD PLAIN. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

FOSSIL FISSURE. A buried rectilinear chamber associated with extension due to ground movement. The chamber must be oriented along the strike of the shear and must have vertical and horizontal dimensions greater than its width. It must show no evidence of faunal activity and its walls may have silt or clay coatings indicative of frequent temporary saturation with ground water. May be mistaken for an animal burrow. Also known as a paleofissure.

FRIABILITY. Term for the ease with which soil crumbles. A friable soil is one that crumbles easily.

GENESIS, SOIL. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum (A and B horizons) from the unconsolidated parent material.

GEOMORPHIC. Pertaining to the form of the surface features of the earth. Specifically, geomorphology is the analysis of landforms and their mode of origin.

GLEYED SOIL. A soil having one or more neutral gray horizons as a result of water logging and lack of oxygen. The term "gleyed" also designates gray horizons and horizons having yellow and gray mottles as a result of intermittent water logging.

GRAVEL. Rounded or angular fragments of rock 2 to 75 mm in diameter. Soil textures with >15% gravel have the prefix "gravelly" and those with >90% gravel have the suffix "gravel."

HIGHSTAND. The highest elevation reached by the ocean during an interglacial period.

HOLOCENE. The most recent epoch of geologic time, extending from 10 ka to the present.

HORIZON, SOIL. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major soil horizons:

> O horizon.--The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.
>
> A horizon.--The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).
>
> E horizon -- This eluvial horizon is light in color, lying beneath the A horizon and above the B horizon. It is made up mostly of sand and silt, having lost most of its clay and iron oxides through reduction, chelation, and translocation.
>
> B horizon.--The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these.
>
> C horizon.--The relatively unweathered material immediately beneath the solum. Included are sediment, saprolite, organic matter, and bedrock excavatable with a spade. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a number precedes the letter C.
>
> R layer.--Consolidated rock not excavatable with a spade. It may contain a few cracks filled with roots or clay or oxides. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Major horizons may be further distinguished by applying prefix Arabic numbers to designate differences in parent materials as they are encountered (e.g., 2B, 2BC, 3C) or by applying suffix numerals to designate minor changes (e.g., B1, B2).

Thereafter, these lower-case letters may be appended (e.g., 2B2tkb):

a *Highly decomposed organic material*
This symbol is used with O to indicate the most highly decomposed organic materials, which have a fiber content of less than 17 percent (by volume) after rubbing.

b *Buried genetic horizon*

This symbol is used in mineral soils to indicate identifiable buried horizons with major genetic features that were developed before burial. Genetic horizons may or may not have formed in the overlying material, which may be either like or unlike the assumed parent material of the buried soil. This symbol is not used in organic soils, nor is it used to separate an organic layer from a mineral layer.

c *Concretions or nodules*

This symbol indicates a significant accumulation of concretions or nodules. Cementation is required. The cementing agent commonly is iron, aluminum, manganese, or titanium. It cannot be silica, dolomite, calcite, or more soluble salts.

d *Physical root restriction*

This symbol indicates noncemented, root-restricting layers in naturally occurring or human-made sediments or materials. Examples are dense basal till, plowpans, and other mechanically compacted zones.

e *Organic material of intermediate decomposition*

This symbol is used with O to indicate organic materials of intermediate decomposition. The fiber content of these materials is 17 to 40 percent (by volume) after rubbing.

f *Frozen soil or water*

This symbol indicates that a horizon or layer contains permanent ice. The symbol is not used for seasonally frozen layers or for dry permafrost.

ff *Dry permafrost*

This symbol indicates a horizon or layer that is continually colder than 0 °C and does not contain enough ice to be cemented by ice. This suffix is not used for horizons or layers that have a temperature warmer than 0 °C at some time of the year.

g *Strong gleying*

This symbol indicates either that iron has been reduced and removed during soil formation or that saturation with stagnant water has preserved it in a reduced state. Most of the affected layers have chroma of 2 or less, and many have redox concentrations. The low chroma can represent either the color of reduced iron or the color of uncoated sand and silt particles from which iron has been removed. The symbol g is not used for materials of low chroma that have no history of wetness, such as some shales or E horizons. If g is used with B, pedogenic change in addition to gleying is implied. If no other pedogenic change besides gleying has taken place, the horizon is designated Cg.

h *Illuvial accumulation of organic matter*

This symbol is used with B to indicate the accumulation of illuvial, amorphous, dispersible complexes of organic matter and sesquioxides if the sesquioxide component is dominated by aluminum but is present only in very small quantities. The organosesquioxide material coats sand and silt particles. In some horizons these coatings have coalesced, filled pores, and cemented the horizon. The symbol h is also used in combination with s as "Bhs" if the amount of the sesquioxide component is significant but the color value and chroma, moist, of the horizon are 3 or less.

i *Slightly decomposed organic material*

This symbol is used with O to indicate the least decomposed of the organic materials. The fiber content of these materials is 40 percent or more (by volume) after rubbing.

j *Accumulation of jarosite*

Jarosite is a potassium or iron sulfate mineral that is commonly an alteration product of pyrite that has been exposed to an oxidizing environment. Jarosite has hue of 2.5Y or yellower and normally has chroma of 6 or more, although chromas as low as 3 or 4 have been reported.

jj *Evidence of cryoturbation*

Evidence of cryoturbation includes irregular and broken horizon boundaries, sorted rock fragments, and organic soil materials occurring as bodies and broken layers within and/or between mineral soil layers. The organic bodies and layers are most commonly at the contact between the active layer and the permafrost.

k *Accumulation of carbonates*

This symbol indicates an accumulation of alkaline earth carbonates, commonly calcium carbonate.

l *Undefined as of 2006.*

If used, it could be confused with the Arabic number "1".

m *Cementation or induration*

This symbol indicates continuous or nearly continuous cementation. It is used only for horizons that are more than 90 percent cemented, although they may be fractured. The cemented layer is physically root restrictive. The predominant cementing agent (or the two dominant cementing agents) may be indicated by adding defined letter suffixes, singly or in pairs. The horizon suffix km indicates cementation by carbonates; qm, cementation by silica; sm, cementation by iron; ym, cementation by gypsum; kqm, cementation by lime and silica; and zm, cementation by salts more soluble than gypsum.

n *Accumulation of sodium*

This symbol indicates an accumulation of exchangeable sodium.

o *Residual accumulation of sesquioxides*

This symbol indicates a residual accumulation of sesquioxides.

p *Tillage or other disturbance*

This symbol indicates a disturbance of the surface layer by mechanical means, pasturing, or similar uses. A disturbed organic horizon is designated Op. A disturbed mineral horizon is designated Ap even though it is clearly a former E, B, or C horizon.

q *Accumulation of silica*

This symbol indicates an accumulation of secondary silica.

r *Weathered or soft bedrock*

This symbol is used with C to indicate cemented layers (moderately cemented or less cemented). Examples are weathered igneous rock and partly consolidated sandstone, siltstone, or shale. The excavation difficulty is low to high.

s *Illuvial accumulation of sesquioxides and organic matter*

This symbol is used with B to indicate an accumulation of illuvial, amorphous, dispersible complexes of organic matter and sesquioxides if both the organic-matter and sesquioxide components are significant and if either the color value or chroma, moist, of the horizon is 4 or more. The symbol is also used in combination with h as "Bhs" if both the organic-matter and sesquioxide components are significant and if the color value and chroma, moist, are 3 or less.

ss *Presence of slickensides*

This symbol indicates the presence of slickensides. Slickensides result directly from the swelling of clay minerals and shear failure, commonly at angles of 20 to 60 degrees above horizontal. They are indicators that other vertic characteristics, such as wedge-shaped peds and surface cracks, may be present.

t *Accumulation of silicate clay*

This symbol indicates an accumulation of silicate clay that either has formed within a horizon and subsequently has been translocated within the horizon or has been moved into the horizon by illuviation, or both. At least some part of the horizon should show evidence of clay accumulation either as coatings on surfaces of peds or in pores, as lamellae, or as bridges between mineral grains.

u *User defined*

This symbol must be defined with each use. A Bu horizon, for example, might have an extraordinary accumulation of mangans (manganese oxide coatings). It has been used in the past as a symbol for "unweathered," but this appears redundant for C and R horizon. It was not included in the Internet Glossary of Soil Science Terms in 2006.

v *Plinthite*

This symbol indicates the presence of iron-rich, humus-poor, reddish material that is firm or very firm when moist and hardens irreversibly when exposed to the atmosphere and to repeated wetting and drying.

w *Development of color or structure*

This symbol is used with B to indicate the development of color or structure, or both, with little or no apparent illuvial accumulation of material. It should not be used to indicate a transitional horizon.

x *Fragipan character*

This symbol indicates a genetically developed layer that has a combination of firmness and brittleness and commonly a higher bulk density than the adjacent layers. Some part of the layer is physically root-restrictive.

y *Accumulation of gypsum*

This symbol indicates an accumulation of gypsum.

z *Accumulation of salts more soluble than gypsum*

This symbol indicates an accumulation of salts that are more soluble than gypsum.

HUMUS. The well-decomposed, more or less stable part of the organic matter in mineral soils.

ILLUVIATION. The deposition by percolating water of solid particles, mostly clay or humus, within a soil horizon.

INTERFLUVE. The land lying between streams.

ISOCHRONOUS BOUNDARY. A gradational boundary between two sedimentary units indicating that they are approximately the same age. Opposed to a nonisochronous boundary, which by its abruptness indicates that it delineates units having significant age differences.

KROTOVINA. An animal burrow filled with soil.

LEACHING. The removal of soluble material from soil or other material by percolating water.

LOWSTAND. The lowest elevation reached by the ocean during a glacial period.

MANGAN. A thin coating of manganese oxide (cutan) on the surface of a sand grain, pebble, soil aggregate, or ped. Mangans also line pores or root channels and bridge sand grains.

MODERN SOIL. The portion of a soil section that is under the influence of current pedogenetic conditions. It generally refers to the uppermost soil regardless of age.

MODERN SOLUM. The combination of the A and B horizons in the modern soil.

MORPHOLOGY, SOIL. The physical make-up of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

MOTTLING, SOIL. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance--few, common, and many; size--fine, medium, and coarse; and contrast--faint, distinct and prominent. The size measurements are these: fine, less than 5 mm in diameter along the greatest dimension; medium, from 5 to 15 mm, and coarse, more than 15 mm.

MRT (MEAN RESIDENCE TIME.) The average age of the carbon atoms within a soil horizon. Under ideal reducing conditions, the humus in a soil will have a C-14 age that is half the true age of the soil. In oxic soils humus is typically destroyed as fast as it is produced, generally yielding MRT ages no older than 300-1000 years, regardless of the true age of the soil.

MUNSELL COLOR NOTATION. Scientific description of color determined by comparing soil to a Munsell Soil Color Chart (Available from Macbeth Division of Kollmorgen Corp., 2441 N. Calvert St., Baltimore, MD 21218). For example, dark yellowish brown is denoted as 10YR3/4m in which the 10YR refers to the hue or proportions of yellow and red, 3 refers to value or lightness (0 is black and 10 is white), 4 refers to chroma (0 is pure black and white and 20 is the pure color), and m refers to the moist condition rather than the dry (d) condition.

OVERBANK DEPOSIT. Fine-grained alluvial sediments deposited from floodwaters outside of the fluvial channel.

OXIC. A soil having a high redox potential. Such soils typically are well drained, seldom being waterlogged or lacking in oxygen. Rubification in such soils tends to increase with age.

PALEO SOIL TONGUE. A soil tongue that formed during a previous soil-forming interval.

PALEOSEISMOLOGY. The study of prehistoric earthquakes through the examination of soils, sediments, and rocks.

PALEOSOL. A soil that formed on a landscape in the past with distinctive morphological features resulting from a soil-forming environment that no longer exists at the site. The former pedogenic process was either altered because of external environmental change or interrupted by burial.

PALINSPASTIC RECONSTRUCTION. Diagrammatic reconstruction used to obtain a picture of what geologic and/or soil units looked like before their tectonic deformation.

PARENT MATERIAL. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

PED. An individual natural soil aggregate, such as a granule, a prism, or a block.

PEDOCHRONOLOGY. The study of pedogenesis with regard to the determination of when soil formation began, how long it occurred, and when it stopped. Also known as soil dating. Two ages and the calculated duration are important:

t_o = age when soil formation or aggradation began, ka
t_b = age when the soil or stratum was buried, ka
t_d = duration of soil development or aggradation, ky

Pedochronological estimates are based on available information. All ages should be considered subject to $\pm$50% variation unless otherwise indicated.

PEDOCHRONOPALEOSEISMOLOGY. The study of prehistoric earthquakes by using pedochronology.

PEDOLOGY. The study of the process through which rocks, sediments, and their constituent minerals are transformed into soils and their constituent minerals at or near the surface of the earth.

PEDOGENESIS. The process through which rocks, sediments, and their constituent minerals are transformed into soils and their constituent minerals at or near the surface of the earth.

PERCOLATION. The downward movement of water through the soil.

pH VALUE. The negative log of the hydrogen ion concentration. Measurements in soils are usually performed on 1:1 suspensions containing one part by weight of soil and one part by weight of distilled water. A soil with a pH of 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid or "sour" soil is one that gives an acid reaction; an alkaline soil is one that gives an alkaline reaction. In words, the degrees of acidity or alkalinity are expressed as:

Extremely acid------- <4.5
Very strongly acid--- 4.5 to 5.0
Strongly acid-------- 5.1 to 5.5
Medium acid---------- 5.6 to 6.0
Slightly acid-------- 6.1 to 6.5
Neutral-------------- 6.6 to 7.3
Mildly alkaline------ 7.4 to 7.8
Moderately alkaline-- 7.9 to 8.4
Strongly alkaline---- 8.5 to 9.0
Very strongly alkaline >9.0

Used if significant:
Very slightly acid--- 6.6 to 6.9
Very mildly alkaline- 7.1 to 7.3

PHREATIC SURFACE. (See Water Table.)

PLANATION. The process of erosion whereby a portion of the surface of the Earth is reduced to a fundamentally even, flat, or level surface by a meandering stream, waves, currents, glaciers, or wind.

PLEISTOCENE. An epoch of geologic time extending from 10 ka to 1.8 Ma; it includes the last Ice Age.

PROFILE, SOIL. A vertical section of the soil through all its horizons and extending into the parent material.

QUATERNARY. A period of geologic time that includes the past 1.8 Ma. It consists of two epochs--the Pleistocene and Holocene.

PROGRADATION. The building outward toward the sea of a shoreline or coastline by nearshore deposition.

RELICT SOIL. A surface soil that was partly formed under climatic conditions significantly different from the present.

RUBIFICATION. The reddening of soils through the release and precipitation of iron as an oxide during weathering. Munsell hues and chromas of well-drained soils generally increase with soil age.

SALINE SOIL. A soil that contains soluble salts in amounts that impair the growth of crop plants but that does not contain excess exchangeable sodium.

SAND. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 mm. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

SECONDARY FAULT. A minor fault that bifurcates from or is associated with a primary fault. Movement on a secondary fault never occurs independently of movement on the primary, seismogenic fault.

SHORELINE ANGLE. The line formed by the intersection of the wave-cut platform and the sea cliff. It approximates the position of sea level at the time the platform was formed.

SILT. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very find sand (0.05 mm.) Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

SLICKENSIDES. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may form along a fault plane; at the bases of slip surfaces on steep slopes; on faces of blocks, prisms, and columns undergoing shrink-swell. In tectonic slickensides the striations are strictly parallel.

SLIP RATE. The rate at which the geologic materials on the two sides of a fault move past each other over geologic time. The slip rate is expressed in mm/yr, and the applicable duration is stated. Faults having slip rates less than 0.01 mm/yr are generally considered inactive, while faults with Holocene slip rates greater than 0.1 mm/yr generally display tectonic geomorphology.

SMECTITE. A fine, platy, aluminosilicate clay mineral that expands and contracts with the absorption and loss of water. It has a high cation-exchange capacity and is plastic and sticky when moist.

SOIL. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

SOIL SEISMOLOGIST. Soil scientist who studies the effects of earthquakes on soils.

SOIL SLICKS. Curvilinear striations that form in swelling clayey soils, where there is marked change in moisture content. Clayey slopes buttressed by rigid materials may allow minor amounts of gravitationally driven plastic flow, forming soil slicks sometimes mistaken for evidence of tectonism. Soil slicks disappear with depth and the striations are seldom strictly parallel as they are when movement is major. (See also SLICKENSIDES.)

SOIL TECTONICS. The study of the interactions between soil formation and tectonism.

SOIL TONGUE. That portion of a soil horizon extending into a lower horizon.

SOLUM. Combined A and B horizons. Also called the true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

STONELINE. A thin, buried, planar layer of stones, cobbles, or bedrock fragments. Stonelines of geological origin may have been deposited upon a former land surface. The fragments are more often pebbles or cobbles than stones. A stoneline generally overlies material that was subject to weathering, soil formation, and erosion before deposition of the overlying material. Many stonelines seem to be buried erosion pavements, originally formed by running water on the land surface and concurrently covered by surficial sediment.

STRATH TERRACE. A gently sloping terrace surface bearing little evidence of aggradation.

STRUCTURE, SOIL. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are--platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

SUBSIDIARY FAULT. A branch fault that extends a substantial distance from the main fault zone.

TECTOTURBATION. Soil disturbance resulting from tectonic movement.

TEXTURE, SOIL. Particle size classification of a soil, generally given in terms of the USDA system which uses the term "loam" for a soil having equal properties of sand, silt, and clay. The basic textural classes, in order of their increasing proportions of fine particles are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sand clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

TOPOSEQUENCE. A sequence of kinds of soil in relation to position on a slope. (See also CATENA.)

TRANSLOCATION. The physical movement of soil particles, particularly fine clay, from one soil horizon to another under the influence of gravity.

UNIFIED SOIL CLASSIFICATION SYSTEM. The particle size classification system used by the U.S. Army Corps of Engineers and the Bureau of Reclamation. Like the ASTM and AASHO systems, the sand/silt boundary is at 80 um instead of 50 um used by the USDA. Unlike all other systems, the gravel/sand boundary is at 4 mm instead of 2 mm and the silt/clay boundary is determined by using Atterberg limits.

VERTISOL. A soil with at least 30% clay, usually smectite, that fosters pronounced changes in volume with change in moisture. Cracks greater than 1 cm wide appear at a depth of 50 cm during the dry season each year. One of the ten USDA soil orders.

WATER TABLE. The upper limit of the soil or underlying rock material that is wholly saturated with water. Also called the phreatic surface.

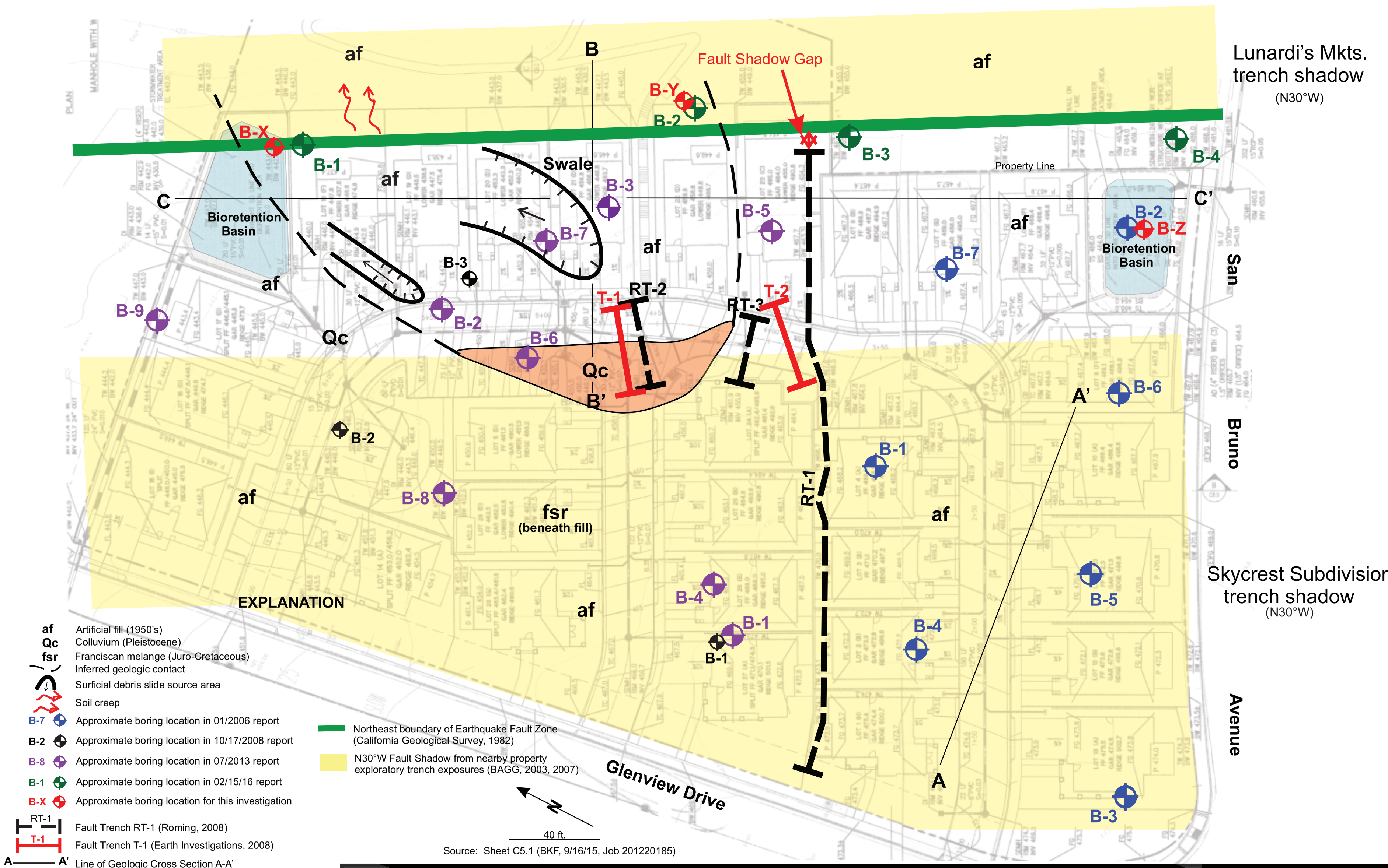
WAVE-CUT PLATFORM. The relatively smooth, slightly seaward-dipping surface formed along the coast by the action of waves generally accompanied by abrasive materials.

WEATHERING. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

WETTING FRONT. The greatest depth affected by moisture due to precipitation.

yr B.P. Uncorrected radiocarbon age expressed in years before present, calculated from 1950. Calendar-corrected ages are expressed in ka, or, if warranted, as A.D. or B.C.

SITE PLAN SHOWING CONCEPTUAL LAYOUT OF STITCH PIER WALL



Source: Sheet C5.1 (BKF, 9/16/15, Job 201220185)

Geosphere Consultants, Inc.

Job No.:	91-04747-A
Approved:	JEB
Date:	01.27.2020

SITE ENGINEERING GEOLOGIC MAP

Glenview Terrace Residential Development
2880 San Bruno Avenue
San Bruno, California

Plate
3

Major Divisions			Group Symbol	Secondary Divisions
COARSE GRAINED SOILS — MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVELS — MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.
		GRAVEL WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
	SANDS — MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	SW	Well graded sands, gravelly sands, little or no fines.
			SP	Poorly graded sands or gravelly sands, little or no fines.
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures, non-plastic fines.
			SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS — MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS — LIQUID LIMIT IS LESS THAN 50%		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Orangic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS — LIQUID LIMIT IS GREATER THAN 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils.

U.S. Standard Series Sieve — Clear Square Sieve Openings

	200		40	10	4	3/4"	3"	12"
SILTS AND CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

Grain Sizes

SAND AND GRAVELS	BLOWS/FOOT*
VERY LOOSE	0 -4
LOOSE	4 -10
MEDIUM DENSE	10 - 30
DENSE	30 - 50
VERY DENSE	OVER 50

Relative Density

SILTS AND CLAYS	STRENGTH **	BLOWS/FOOT*
VERY SOFT	0 - 1/4	0 - 2
SOFT	1/4 - 1/2	2 - 4
FIRM	1/2 - 1	4 - 8
STIFF	1 - 2	8 - 16
VERY STIFF	2 - 4	16 - 32
HARD	OVER 4	OVER 32

Consistency

* Number of blows of 140 pound hammer falling 30 inches to drive a split spoon, SPT sampler (ASTM D-1586)

** Unconfined compressive strength in tons/sq. ft. as determined by laboratory testing or approximated by the standard penetration test (ASTM D-1586), pocket penetrometer, torvane, or visual observation.

■ Sample location

☒ Grab sample

59 Total number of SPT blow counts for sampling interval. Bar graph represents individual 6-inch intervals for bottom 12 inches of 18-inch drive sample.

Unified Soil Classification System (ASTM D-2487)

Geosphere Consultants, Inc.

Job No.: 91-04747-A
Approved: JEB
Date: 01.21.2020

KEY TO BORINGS

Glenview Terrace Residential Development
2880 San Bruno Avenue
San Bruno, California

Plate E1

Primary Divisions				Group Symbol	Secondary Divisions
COARSE GRAINED SOILS	MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.
			GRAVEL WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
				GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
		SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	SW	Well graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands or gravelly sands, little or no fines.
			SANDS WITH FINES	SM	Silty sands, sand-silt mixtures, non-plastic fines.
				SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS	MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT IS LESS THAN 50%		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
				OL	Orangic silts and organic silty clays of low plasticity.
		SILTS AND CLAYS LIQUID LIMIT IS GREATER THAN 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic.
				CH	Inorganic clays of high plasticity, fat clays.
				OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS				Pt	Peat and other highly organic soils.

Definition of Terms

	U.S. Standard Series Sieve 200	40	10	4	Clear Square Sieve Openings 3/4"	3"	12"	
SILTS AND CLAY	SAND			GRAVEL		COBBLES	BOULDERS	
	FINE	MEDIUM	COARSE	FINE	COARSE			

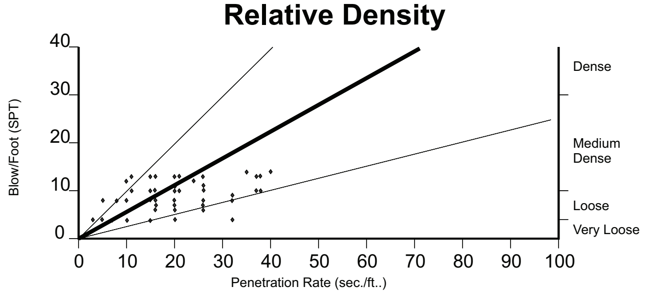
Grain Sizes

Unified Soil Classification System (ASTM D-2487)

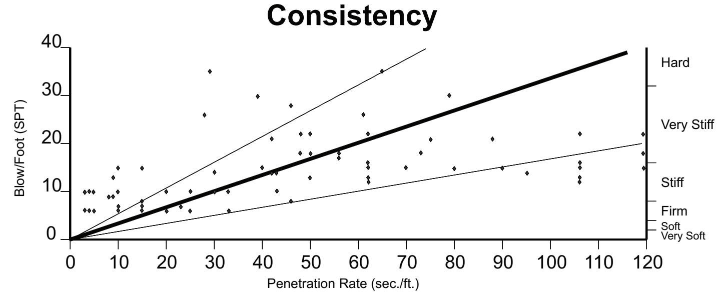
SAND AND GRAVELS	PENETRATION RATE*
VERY LOOSE	0 - 7
LOOSE	7 - 18
MEDIUM DENSE	18 - 53
DENSE	53 - 88
VERY DENSE	OVER 88

SILTS AND CLAYS	STRENGTH **	PENETRATION RATE*
VERY SOFT	0 - 1/4	0 - 6
SOFT	1/4 - 1/2	6 - 11
FIRM	1/2 - 1	11 - 23
STIFF	1 - 2	23 - 47
VERY STIFF	2 - 4	47 - 94
HARD	OVER 4	OVER 94

Relative Density



Consistency



* Seconds per foot, based on a portable percussion rig advancing a 1½-inch diameter split-spoon sampler with a force of 35 ft. lb. at a rate of 1270 blows per minute.

** Unconfined compressive strength in tons/sq. ft. as determined by laboratory testing or approximated by the standard penetration test (ASTM D-1586), pocket penetrometer, torvane, or visual observation.

Geosphere Consultants, Inc.

Job No.:	91-04747-A
Approved:	JEB
Date:	01.21.2020

KEY TO SOIL PROBES

Glenview Terrace Residential Development
2880 San Bruno Avenue
San Bruno, California

Plate

E2

ROCK HARDNESS CRITERIA

Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimen requires several hard blows of geologist's pick.
Moderately Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Hard	Can be scratched with knife or pick. Gouges or grooves to 1/4 inch deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 inch deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1 inch maximum size by hand blows of the point of geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of pick point. Small thin pieces can be broken by finger pressure.
Very Soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1 inch or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Subsurface Manual for Design and Construction of Foundations of Buildings, 1976
Published by American Society of Civil Engineers.

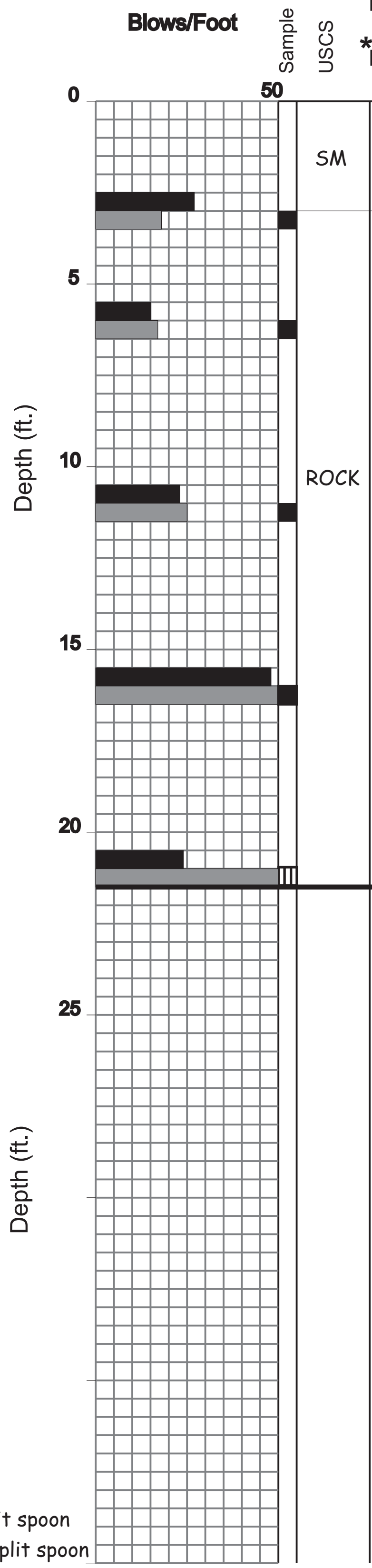
Earth Investigations Consultants
Job No. 2052.01.01
10/2006

BORING 1

Equipment Truck Mounted CME-75 Auger

***Elevation** ~340′ **Date** 2/2/05

Dry Density (pcf)	Moisture Content (%)	Blows/Foot	Depth (ft.)	USCS	Description
			0	SM	Dark yellowish brown Gravelly Silty SAND, damp, medium dense (FILL)
123.5	9.1	45		ROCK	Dark yellowish brown, dark brown and dark grey SHEARED ROCK, damp, very weathered, closely fractured, soft to moderately hard (BEDROCK)
123.2	11.5	32	5		
123.9	10.5	48	10		
137.2	5.9	98	15		
122.4	8.3	74/10″	20		
					Terminated at 21′ 4″



EXPLANATION

* Arbitrary datum, see Plate 2

■ Modified California sampler, 3″ O.D. split spoon

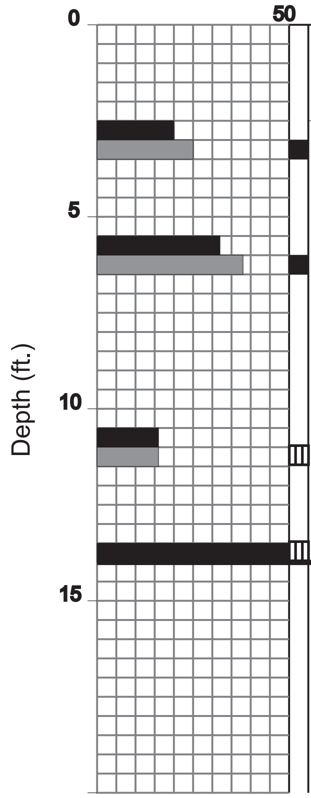
Ⅲ Standard Penetration sampler, 2″ O.D. split spoon

Earth Investigations Consultants	Job No. 2052.01.01 Date 10/16/06	LOG OF BORING 1 2880 San Bruno Avenue Burlingame, California	Plate E4

BORING 2

Equipment: Truck Mounted CME-75 Auger

*Elevation: ~332′ Date: 2/2/2005

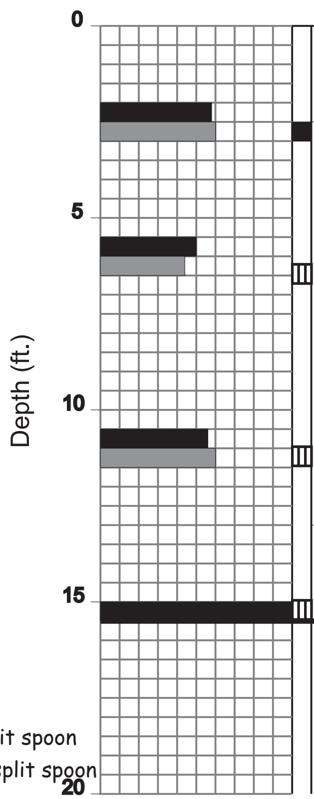


Dry Density	Moisture	Blow/Foot	USCS	Description
			SM	Dark yellowish brown Silty SAND with Gravel, damp, medium dense (FILL)
118.6	10.1	45	ROCK	Dark yellowish brown, dark brown and dark grey SHEARED ROCK, damp, very weathered, closely fractured, soft to moderately hard (BEDROCK)
123.7	8.4	70		
114.3	7.5	32		
		50/2″		

Terminated at 14′ 2″

BORING 3

*Elevation: ~343′ Date: 2/2/2005



Dry Density	Moisture	Blow/Foot	USCS	Description
			SM	Dark yellowish brown Gravelly Silty SAND, damp, medium dense (FILL)
124.7	8.6	59	ROCK	Dark yellowish brown GREENSTONE, very weathered, closely fractured, soft to moderately hard (BEDROCK)
119.6	5.0	47		
114.5	8.6	58		
116.2	8.4	50/3″	ROCK	Dark grey SHEARED ROCK, veery weathered, closely fractured, soft to moderately hard (BEDROCK)

Terminated at 15′ 9″

EXPLANATION

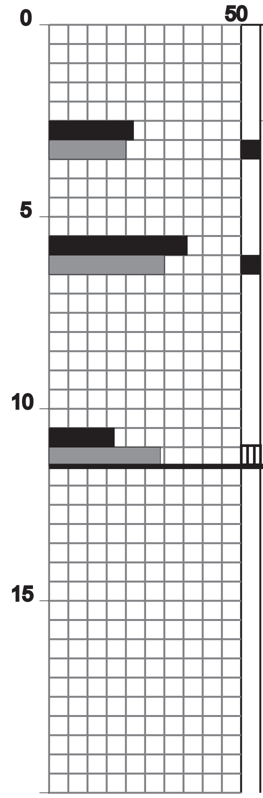
- * Arbitrary datum, see Plate 2
- ▽ Ground water elevation after drilling
- ■ Modified California sampler, 3″ O.D. split spoon
- ▥ Standard Penetration sampler, 2″ O.D. split spoon

Earth Investigations Consultants	Job No. 2052.01.01 Date 10/16/06	LOGS OF BORINGS 2 & 3 2880 San Bruno Avenue Burlingame, California	Plate E5

BORING 4

Equipment Truck Mounted CME-75 Auger

***Elevation** ~342′ **Date** 2/2/2005

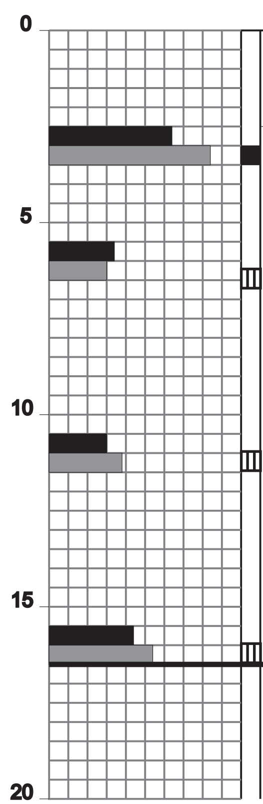


Dry Density (pcf)	Moisture Content (%)	Blow/Foot	USCS	Description
			SM	Dark yellowish brown Gravelly Silty SAND, damp, medium dense (FILL)
126.2	7.5	42	ROCK	Dark yellowish brown, GREENSTONE, very weathered, closely fractured, soft to moderately hard (BEDROCK)
137.9	6.7	66		
118.9	7.3	46		

Terminated at 11 ½ '

BORING 5

***Elevation** ~341′ **Date** 2/2/2005



Dry Density (pcf)	Moisture Content (%)	Blow/Foot	USCS	Description
			SM	Dark yellowish brown Gravelly Silty SAND, damp, medium dense (FILL)
125.4	7.3	74	ROCK	Dark yellowish brown GREENSTONE, very weathered, closely fractured, soft to moderately hard (BEDROCK)
		32		No recovery
113.2	8.4	34		
126.5	10.0	49		

Terminated at 16 ½ '

* Arbitrary datum, see Plate 2
▼ Ground water elevation after drilling
■ Modified California sampler, 3" O.D. split spoon
▥ Standard Penetration sampler, 2" O.D. split spoon

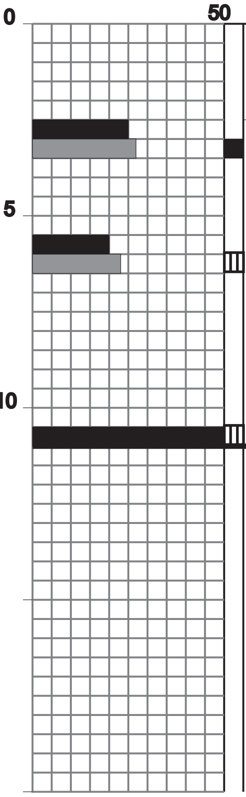
Earth Investigations Consultants	Job No. 2052.01.01 Date 10/16/06	LOGS OF BORINGS 4 & 5 2880 San Bruno Avenue Burlingame, California	Plate E6

BORING 6

Equipment: Truck Mounted CME-75 Auger

*Elevation: ~336′ Date: 2/2/2005

Dry Density (pcf)	Moisture Content (%)	Blow/Foot	Depth (ft.)	Sample	USCS	Description
			0		SM	Dark yellowish brown Gravelly Silty SAND, damp, medium dense (FILL)
132.4	7.4	62		Modified California	ROCK	Dark yellowish brown, GREENSTONE, very weathered, closely fractured, soft to moderately hard (BEDROCK)
118.7	5.4	43	5	Standard Penetration	ROCK	
		50/5″	10	Standard Penetration	ROCK	

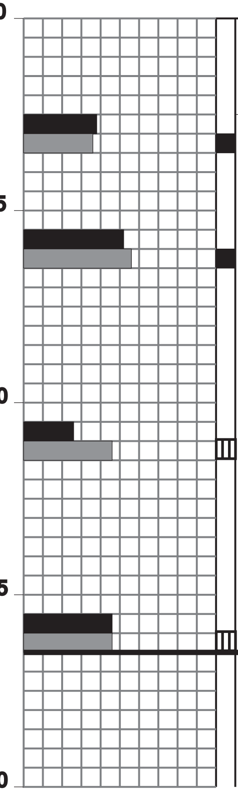


Terminated at 10′ 11″

BORING 7

*Elevation: ~335′ Date: 2/2/2005

Dry Density (pcf)	Moisture Content (%)	Blow/Foot	Depth (ft.)	Sample	USCS	Description
			0		SM	Dark yellowish brown Silty SAND with Gravel, damp, medium dense (FILL)
118.1	11.4	37		Modified California	ROCK	Dark yellowish brown SHEARED ROCK, damp, very weathered, closely fractured, soft to moderately hard (BEDROCK)
123.0	9.5	54	5	Modified California	ROCK	
114.0	8.7	36	10	Standard Penetration	ROCK	
117.7	6.8	46	15	Standard Penetration	ROCK	



Terminated at 16 ½ ′

EXPLANATION

- * Arbitrary datum, see Plate 2
- ■ Modified California sampler, 3″ O.D. split spoon
- Ⅲ Standard Penetration sampler, 2″ O.D. split spoon

Earth Investigations Consultants	Job No. 2052.01.01 / Date 10/16/06	LOGS OF BORINGS 6 & 7 — 2880 San Bruno Avenue, Burlingame, California	Plate E7

Earth Investigations Consultants, Inc.
Job No. 2271.01.00
10/2008

BORING 1 (Soil Probe)

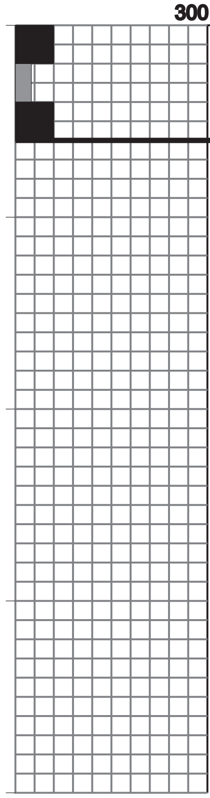
Equipment: Portable Percussion Rig

Elevation: ~470' Date: 8/14/2008

Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Depth (ft.)	Sample	USCS	Description
			0	Continuous	SM	Yellowish brown Gravelly Silty SAND, moist, medium dense (FILL)
124.9	7.1				ROCK	Yellowish brown and dark yellowish brown SHEARED ROCK, very weathered, closely fractured, soft (BEDROCK)

Terminated at 3'

Penetration Rate (sec./ft.) 300

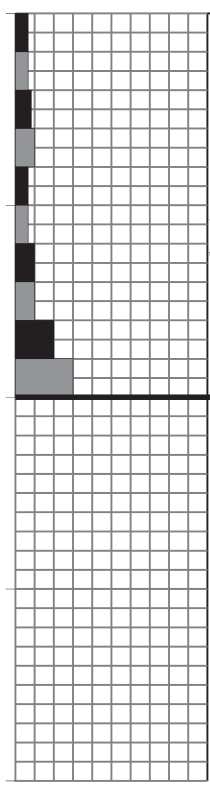


BORING 2 (Soil Probe)

Elevation: ~457' Date: 8/14/2008

Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Depth (ft.)	Sample	USCS	Description
			0	Continuous	SC	Yellowish brown and dark yellowish brown Gravelly Clayey SAND, moist, medium dense (FILL)
101.4	6.4					
107.2	9.1		5			
120.9	12.0				SC	Dark brown Clayey SAND with Gravel, moist, medium dense (COLLUVIUM)
112.5	9.1		10		ROCK	Yellowish brown SANDSTONE, very weathered, closely fractured, soft (BEDROCK)

Terminated at 10'



Earth Investigations Consultants	Job No. 2271.01.00 Date 10/13/08	LOGS OF BORINGS 1 & 2 (Soil Probes) 850 Glenview Drive San Bruno, California	Plate E8

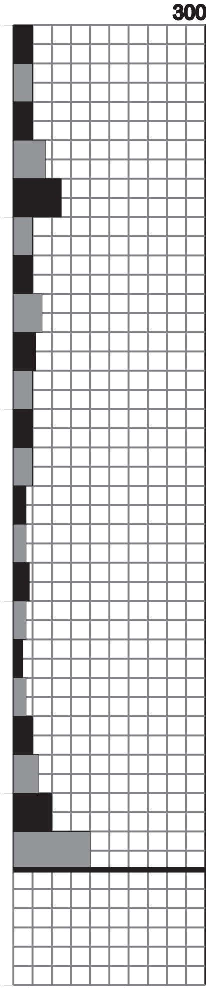
BORING 3 (Soil Probe)

Equipment: Portable Percussion Rig

Elevation: ~457' Date: 8/14/2008

Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Depth (ft.)	Sample	USCS	Description
			0	Continuous	SC	Yellowish brown and dark yellowish brown Gravelly Clayey SAND, moist, medium dense (FILL)
114.3	8.4					
123.9	6.5		5			
123.4	6.7					
118.8	6.7		10			
102.9	15.4	3.0	15		CL	Dark yellowish to greyish brown Sandy CLAY, damp, stiff (COLLUVIUM)
118.1	15.4					
117.9	11.8		20		ROCK	Yellowish brown and grey SHEARED ROCK, very weathered, closely fractured, soft (BEDROCK)
			25			

Penetration Rate (sec./ft.) 300



Terminated at 22'

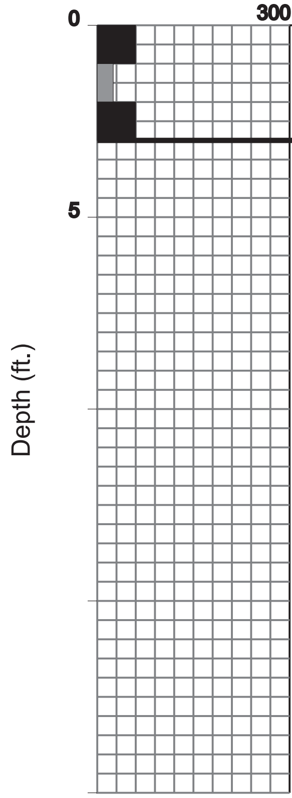
Earth Investigations Consultants	Job No. 2271.01.00 Date 10/13/08	LOG OF BORING 3 (Soil Probe) 850 Glenview Drive San Bruno, California	Plate E9

BORING 1 (Soil Probes)

Equipment: Portable Percussion Rig
Elevation✦: ~470' Date: 8/14/2008

Dry Density (pcf)*	Moisture Content (%)	Pocket Pen (tsf)	Sample	USCS	Description
			Continuous	SM	Yellowish brown Gravelly, Silty SAND, moist, medium dense (FILL)
124.9	7.1		Continuous	ROCK	Yellowish brown and dark yellowish brown SHEARED ROCK, very weathered, closely fractured, soft (FRANCISCAN ASSEMBLAGE)

Terminated at 3'

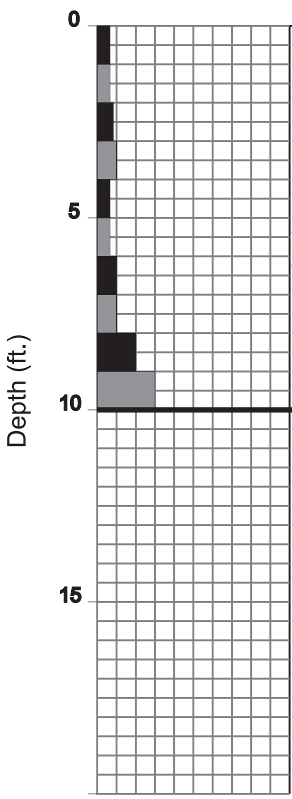


BORING 2 (Soil Probes)

Elevation✦: ~457' Date: 8/14/2008

Dry Density (pcf)*	Moisture Content (%)	Pocket Pen (tsf)	Sample	USCS	Description
101.4	6.4		Continuous	SC	Yellowish brown and dark yellowish brown Gravelly, Clayey SAND, moist, medium dense (FILL)
107.2	9.1		Continuous	SC	
120.9	12.0		Continuous	SC	Dark brown Clayey SAND with Gravel, moist, medium dense (COLLUVIUM)
112.5	9.1		Continuous	ROCK	Yellowish brown SANDSTONE, very weathered, closely fractured, soft (FRANCISCAN ASSEMBLAGE)

Terminated at 10'



Note to Reader:
Probes are from the EIC 2008 report; and are included in the 2013 report (Appendix A).

✦ Elevation from Plate 2 - Site Plan
* Disturbed sample

Earth Investigations Consultants	Job No. 2479.02.00 Date 8/4/13	LOGS OF BORINGS 1 & 2 (Soil Probes) 850 Glenview Drive San Bruno, California	Plate E10

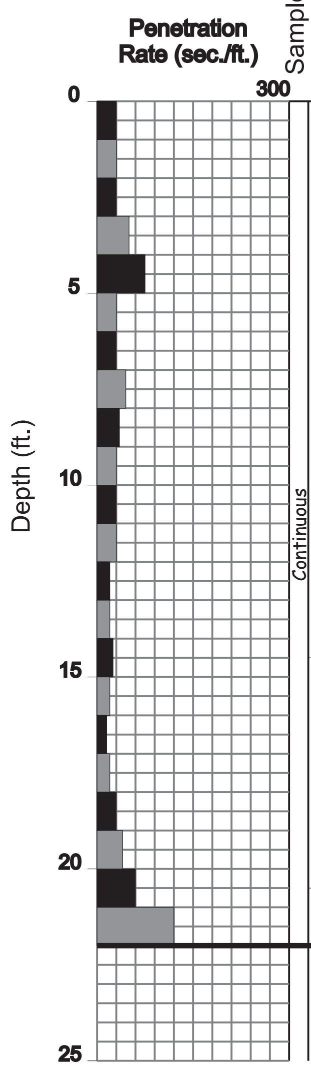
Earth Investigations Consultants, Inc.
Job No. 2479.02.00
08/2013

BORING 3 (Soil Probe)

Equipment Portable Percussion Rig

Elevation✦ ~457' **Date** 8/14/2008

Dry Density (pcf)✶	Moisture Content (%)	Pocket Pen (tsf)
114.3	8.4	
123.9	6.5	
123.4	6.7	
118.8	6.7	
102.9	15.4	3.0
118.1	15.4	
117.9	11.8	



USCS	Description
SC	Yellowish brown and dark yellowish brown Gravelly, Clayey SAND, moist, medium dense (FILL)
CL	Dark yellowish to greyish brown Sandy CLAY, damp, stiff (COLLUVIUM)
ROCK	Yellowish brown and grey SHEARED ROCK, very weathered, closely fractured, soft (FRANCISCAN ASSEMBLAGE)

Terminated at 22'

Note to Reader:
Probes are from the EIC 2008 report; and are included in the 2013 report (Appendix A).

✦ Elevation from Plate 2 - Site Plan

Disturbed sample

Earth Investigations Consultants	Job No. 2479.02.00 Date 8/4/13	LOG OF BORING 3 (Soil Probe) 850 Glenview Drive San Bruno, California	Plate E11

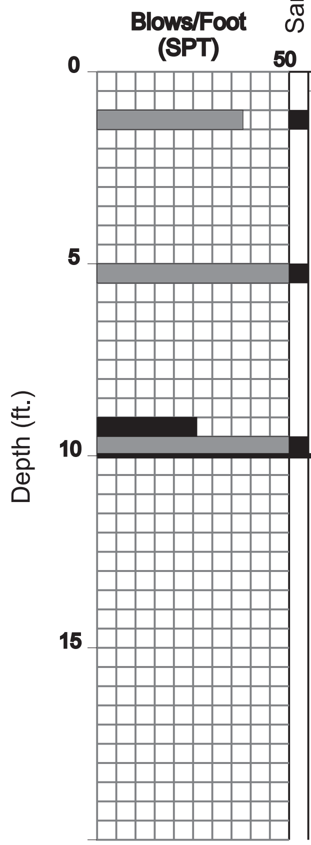
BORING 4

Equipment Truck-Mounted Flight Auger

Elevation✦ ~466′ **Date** 6/25/2013

Dry Density (pcf)	Moisture Content (%)	Blows/Foot (SPT)	Depth (ft.)	USCS	Description
		38/3″	0–1	SM	Yellowish brown Silty SAND, moist, medium dense (FILL)
		50/4″	5	ROCK	Yellowish brown and dark yellowish brown SHEARED ROCK, very weathered, closely fractured, soft to moderately hard (FRANCISCAN ASSEMBLAGE)
121.9	7.8	76	10		

Terminated at 10′

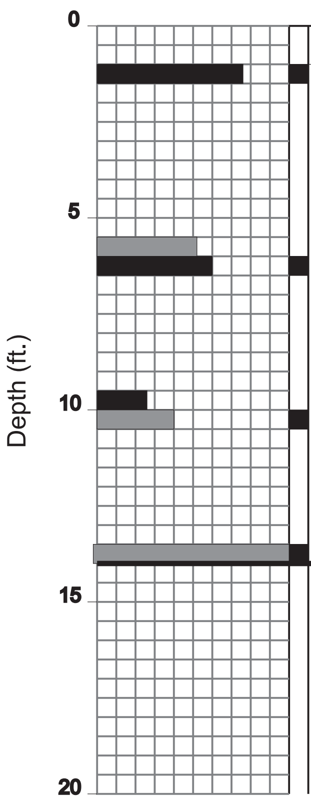


BORING 5

Elevation✦ ~467″ **Date** 6/25/2013

Dry Density (pcf)	Moisture Content (%)	Blows/Foot (SPT)	Depth (ft.)	USCS	Description
		38/3″	0–1	SM	Yellowish brown Gravelly, Silty SAND, moist, medium dense (FILL)
113.9	6.7	56	6	ROCK	Dark yellowish brown and dark grey SHEARED ROCK, very weathered, closely fractured, soft to moderately hard (FRANCISCAN ASSEMBLAGE)
100.5	13.8	23	10		
		50/5″	14		

Terminated at 13′ 11″



✦ Elevation from Plate 2 - Site Plan

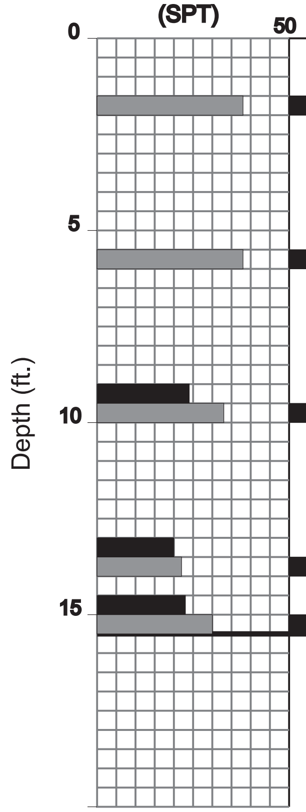
Earth Investigations Consultants	Job No. 2479.02.00 Date 8/4/13	LOGS OF BORINGS 4 & 5 850 Glenview Drive San Bruno, California	Plate E12

BORING 6

Equipment Truck-Mounted Flight Auger

Elevation✦ ~463′ **Date** 6/25/2013

Dry Density (pcf)	Moisture Content (%)	Blows/Foot (SPT)
111.4	9.3	38/3″
122.9	11.4	38/3″
108.2	14.3	57
		42
121.6	9.7	53



USCS	Description
SM	Brown Gravelly Silty SAND, moist, very dense (FILL)
SC	Dark yellowish brown Clayey SAND with Gravel, moist, very dense (COLLUVIUM)
CL	Dark yellowish brown Sandy CLAY with Gravel, damp, hard (COLLUVIUM)
ROCK	Dark yellowish brown and greyish brown SHEARED ROCK, very weathered, closely fractured, soft (FRANCISCAN ASSEMBLAGE)

Terminated at 15½′

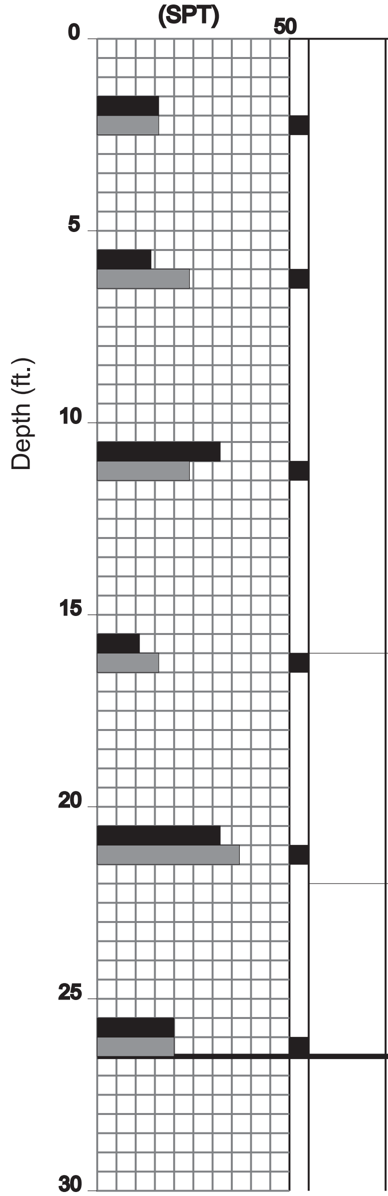
✦ Elevation from Plate 2 - Site Plan

Earth Investigations Consultants	Job No. 2479.02.00 Date 8/4/13	LOG OF BORING 6 850 Glenview Drive San Bruno, California	Plate E13

BORING 7

Equipment: Truck-Mounted Flight Auger

Elevation✦: ~457' Date: 6/25/2013



Dry Density (pcf)	Moisture Content (%)	Blows/Foot (SPT)	Description
			Brown Silty SAND with Gravel, moist, dense (FILL)
113.8	6.1	32	color changes to dark yellowish brown, grades to Gravelly Silty SAND with Clay
118.9	5.7	38	
			color changes yellowish brown at 8'
		56	
104.8	14.5	27	Dark brown Sandy CLAY with Gravel, damp, very stiff to hard (COLLUVIUM)
			color changes to dark yellowish brown at 19'
106.5	18.1	69	
			Dark grey SHEARED ROCK, very weathered, closely fractured, soft (FRANCISCAN ASSEMBLAGE)
118.6	11.61	40	
			Terminated at 26½'

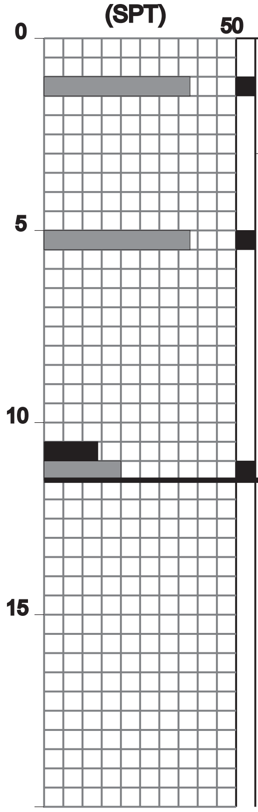
✦ Elevation from Plate 2 - Site Plan

Earth Investigations Consultants	Job No. 2479.02.00 Date 8/4/13	LOG OF BORING 7 850 Glenview Drive San Bruno, California	Plate E14

BORING 8

Equipment: Truck-Mounted Flight Auger

Elevation✦ ~461′ Date 6/25/2013

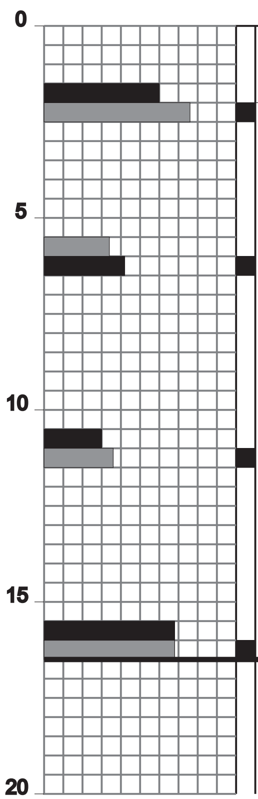


Dry Density (pcf)	Moisture Content (%)	Blows/Foot (SPT)	Description
120.4	5.3	38/5″	Yellowish brown Gravelly Silty SAND, moist, very dense (FILL)
		38/5″	Yellowish brown SANDSTONE, very weathered, closely fractured, hard (FRANCISCAN ASSEMBLAGE)
112.1	5.8	90/11″	

Terminated at 11′ 11″

BORING 9

Elevation✦ ~441″ Date 6/25/2013



Dry Density (pcf)	Moisture Content (%)	Blows/Foot (SPT)	USCS	Description
			SC	Dark yellowish brown Clayey SAND with Gravel, moist, very dense (FILL)
112.1	11.5	68/9″	ROCK	Dark yellowish brown and dark grey SHEARED ROCK, very weathered, closely fractured, soft (FRANCISCAN ASSEMBLAGE)
110.6	11.3	38		
120.0	8.7	33		
133.4	9.8	68		

Terminated at 16½′

✦ Elevation from Plate 2 - Site Plan

Earth Investigations Consultants

Job No. 2479.02.00

Date 8/4/13

LOGS OF BORINGS 8 & 9

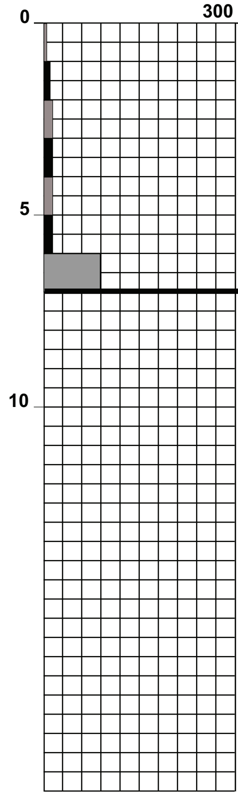
850 Glenview Drive
San Bruno, California

Plate E15

Earth Investigations Consultants, Inc.
Job No. 2479.02.00
02/2016

BORING 3 (Soil Probe)

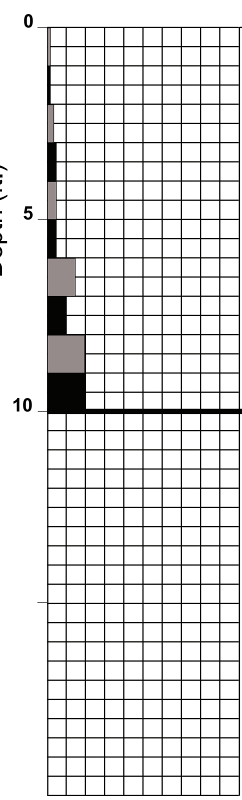
Equipment: Portable Percussion Rig
Elevation: ~465' **Date:** 01/15/16



Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Sample	USCS	Description
124.5	8.8		Continuous	CL	Yellow brown Sandy CLAY with Gravel, damp, firm (FILL?)
		>4.5			color changes to yellow brown & dark yellow brown @ 2 ½'
106.8	17.8				
		>4.5			
					Refusal @ 7'

BORING 4 (Soil Probe)

Elevation: ~465' **Date:** 01/15/16



Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Sample	USCS	Description
105.2	22.4		Continuous	CL	Yellow brown, dark yellow brown and grey Sandy CLAY with Gravel, damp, firm (FILL?)
		3.0			
108.9	18.9				
		>4.5		ROCK	Dark brown SHEARED ROCK very weathered, closely fractured, soft
119.1	9.0	>4.5			color changes to yellow brown @ 9'
					Refusal @ 10'

Earth Investigations Consultants, Inc.	Job No. 2479.02.00 Approved By: JEB Date 02/13/16	LOGS OF BORINGS 3 & 4 (Soil Probes) 850 Glenview Drive, 2880 & 2890 San Bruno Avenue San Bruno, California	Plate E16

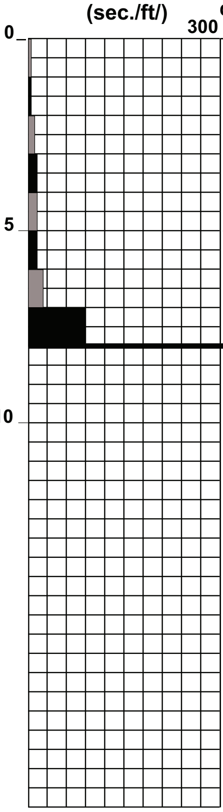
BORING 1 (Soil Probe)

Equipment: Portable Percussion Rig

Elevation: ~465'   Date: 01/15/16

Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Depth (ft.)	Sample	USCS	Description
110.9	8.4		0	Continuous	CL	Dark yellow brown Gravelly Sandy CLAY, damp, firm (FILL)
			5		SC	Yellow brown Gravelly Clayey SAND, moist, medium-dense (FILL?)
125.3	7.6				ROCK	Yellow brown SHEARED ROCK(?) very weathered, closely fractured, moderately hard
			10			Refusal @ 8'

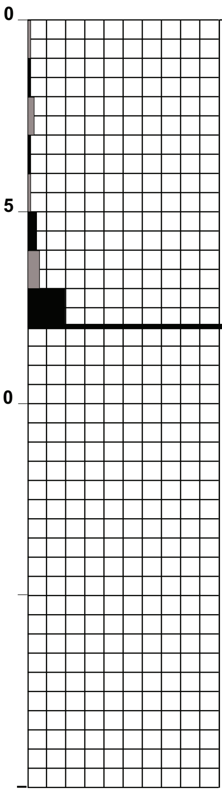
Penetration Rate (sec./ft/) 0–300



BORING 2 (Soil Probe)

Elevation: ~465'   Date: 01/15/16

Dry Density (pcf)	Moisture Content (%)	Pocket Pen (tsf)	Depth (ft.)	Sample	USCS	Description
85.5	22.7		0	Continuous	SC	Yellow brown Gravelly Clayey SAND, damp, loose to medium dense (FILL)
115.0	16.1		5		CL	Dark yellow brown Sandy CLAY, damp, firm (COLLUVIUM)
112.4	15.2	1.0			ROCK	Dark yellow brown SHEARED ROCK(?), very weathered, closely fractured, soft
			10			Refusal @ 8'

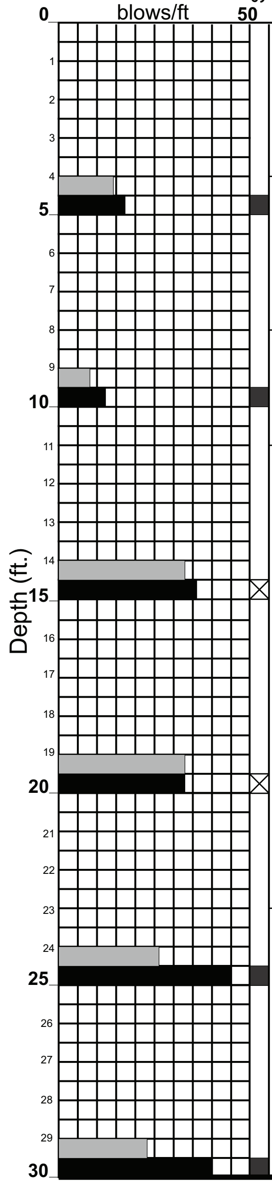


Geosphere Consultants, Inc.
Job No. 91-04747-A
01/2020

BORING X

Equipment Hollow Stem Flight Auger

Elevation ~465 ft. **Date** 12/06/19



Depth (ft.)	-200 Sieve (%)	Dry Density (pcf)	Moisture Content %	Blows/Foot (SPT)	USCS	Description
0–4					SW	2½" AC/Grayish brown Gravelly SAND (Baserock) sewer pipe @ 3'
4–8	54.3	81.7	40.6	31	MH	Yellow brown & dark yellow brow Sandy CLAY with Gravel, damp stiff (FILL)
8–11	33.4	110.8	6.9	20	SC	Dark yellow brown Sandy CLAY with Gravel, damp, very stiff (COLLUVIUM)
11–23				70 66	ROCK	Yellow brown SANDSTONE, very weathered, closely fractured, moderately hard hard
23–30	19.4	126.4	9.7	70 63	ROCK	Yellow brown Sandy CLAYSTONE very weathered, closely fractured, moderately hard

Terminated @ 30'

Geosphere Consultants, Inc.

Job No.: 91-04747-A
Approved: JEB
Date: 01.21.2020

LOG OF BORING X

Glenview Terrace Residential Development
2880 San Bruno Avenue
San Bruno, California

Plate E18

BORING Y

Equipment Hollow Stem Flight Auger

Elevation ~465 ft. **Date** 12/06/19

Blows/Foot (SPT)	Depth (ft.)	Sample	USCS	Description
	0–2		CL	Dark brown Sandy CLAY with Gravel, damp, firm (FILL)
	2–4		ROCK	Yellow brown & dark yellow brown SHEARED ROCK, very weathered, closely fractured, moderately hard
38	4–5	X	ROCK	hard
	12		ROCK	becomes grayish brown & dark grayish brown @ 12’
90	14–15	X	ROCK	
50	19–20	X	ROCK	
74	24–25	X	ROCK	
	29			Terminated @ 29’

Geosphere Consultants, Inc.	**Job No.:** 91-04747-A **Approved:** JEB **Date:** 01.21.2020	**LOG OF BORING Y** Glenview Terrace Residential Development 2880 San Bruno Avenue San Bruno, California	**Plate** E19

BORING Z

Equipment Hollow Stem Flight Auger

Elevation ~332 ft. **Date** 12/06/19

Blows/Foot (SPT)	Depth (ft.)	Sample	USCS	Description
	0		CL	Dark brown Sandy CLAY with Gravel, damp, firm (FILL)
	2½		CL	becomes yellow brown and more Clayey @ 2½'
38/5"	4	X	ROCK	Yellow brown, dark yellow brown, & grayish brown SHEARED ROCK, very weathered, closely fractured, moderately hard
38	9	X	ROCK	becomes gray & grayish brown @ 9'
50/5"	14	X	ROCK	
76/11"	19	X	ROCK	
	23		ROCK	becomes yellow brown @ 23'
	29			Terminated @ 29'

Geosphere Consultants, Inc.

Job No.: 91-04747-A
Approved: JEB
Date: 01.21.2020

LOG OF BORING Z

Glenview Terrace Residential Development
2880 San Bruno Avenue
San Bruno, California

Plate E20