FAULT EVALUATION REPORT

PROPOSED FIRE STATION (APN 087-053-010)
360 BUTANO CUTOFF
PESCADERO, CALIFORNIA

Submitted to:
Ms. Theresa Yee
County of San Mateo
555 County Center, 5th Floor
Redwood City, CA 94063

Prepared by:
ENGEO Incorporated

July 21, 2016

Project No:
11780.000.001

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GEOTECHNICAL
ENVIRONMENTAL
WATER RESOURCES
CONSTRUCTION SERVICES

Project No.
11780.000.001

July 21, 2016

Ms. Theresa Yee
County of San Mateo
555 County Center, 5th Floor
Redwood City, CA 94063

Subject: Proposed Fire Station (APN 087-053-010)
360 Butano Cutoff
Pescadero, California

FAULT EVALUATION REPORT

Dear Ms. Yee:

With your authorization, we prepared this report describing the results of our fault exploration for a proposed fire station to be potentially located at a portion of the existing Pescadero High School (APN 087-053-010) located at 360 Butano Cutoff in Pescadero, California. The accompanying report presents the findings of our exploration and our conclusions and recommendations regarding potential fault hazards at the site.

Evidence of faulting was not encountered in the fault trenches excavated at the site. In our opinion, hazards associated with fault rupture at the site can be mitigated by implementation of the fault setback recommendations provided in this report. Additional design-level exploration services will be required in the future in order to present grading, drainage, and foundation design recommendations. We are pleased to have been of service to you on this project and are prepared to consult further with you and your design team as the project progresses.

Sincerely,

ENGEO Incorporated

PROFESSIONAL GEOLOGIST GREGORY CUBBON No. 2645 CERTIFIED ENGINEERING GEOLOGIST STATE OF CALIFORNIA

Greg Cubbon, CEG
gc/rhb/bvv

PROFESSIONAL GEOLOGIST ROBERT BOECHE No. 2318 CERTIFIED ENGINEERING GEOLOGIST STATE OF CALIFORNIA

Robert H. Boeche, CEG

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this study was to evaluate the potential for surface fault rupture along a portion of the Coastways section of the San Gregorio fault at the subject site as identified on the Alquist-Priolo Earthquake Fault Zone map for the Franklin Point Quadrangle (1982). Our scope of work included the following:

- Review of publicly available regional geologic maps.
- Review of the California Geological Survey (CGS) Alquist-Priolo Earthquake Fault Hazard Map for the Franklin Point Quadrangle and supporting documentation provided in the California Geological Survey (CGS) Fault Evaluation Report and United States Geological Survey (USGS) Quaternary Fault and Fold Database (QFFD) for the San Gregorio Fault.
- Review of single and stereo-paired historic aerial images flown between 1958 and 2002, and available historic topographic maps.
- Excavation and logging of two trenches at the site.
- Soil profile dating by Soil Tectonics, Inc.
- Preparation of this report.

The documents and maps reviewed for this study are described in the References. The results of the Soil Tectonics soil profile analysis are summarized in Appendix A.

This report was prepared for the exclusive use of our client and their consultants. In the event that any changes are made in the character, design or layout of the development, we must be contacted to review the conclusions and recommendations contained in this report to determine whether modifications are necessary.

1.2 ALQUIST-PRIOLO EARTHQUAKE FAULT ZONE ACT

The Alquist-Priolo program requires the State Geologist, via the CGS to establish regulatory zones around fault traces that are considered active and sufficiently well defined to create the potential for surface fault rupture hazards to structures. A fault trace is considered "active" if it is judged to have had identifiable surface rupture during the Holocene (defined by the CGS as the last 11,000 years). The State requires geological investigations prior to construction of new structures within Earthquake Fault hazard zones as described in CGS Special Publication 42 and Note 49. The policies and criteria of the State Mining and Geology Board with reference to the Alquist-Priolo Earthquake Fault Zoning Act are described in CGS Special Publication 42, Specific Criteria that include:

Appendix B Section 3603 (a): No structure for human occupancy, identified as a project under Section 2621.6 of the Act, shall be permitted to be placed across the trace of an active fault. Furthermore, as the area within fifty (50) feet of such active faults shall be presumed to be underlain by active branches of that fault unless proven otherwise by an appropriate geologic investigation and report prepared as specified in Section 3603(d) of this subchapter, no such structures shall be permitted in this area.

Appendix C Guidelines for Evaluating the Hazards of Surface Rupture: Setback distances of proposed structures from hazardous faults. The setback distance generally will depend on the quality of data and type and complexity of fault(s) encountered at the site.

1.3 PROJECT LOCATION

Based on conversations with you, it is our understanding that the proposed San Mateo County fire station may be constructed within the southwestern portion of APN 087-053-010 in Pescadero, California (Figure 1). Based on recent site visits, the northeastern portion of the proposed development area is located within a paved parking area, while the remainder of the site is located within a fallow field with low height seasonal vegetation. At the time of our site visits, it appeared as though the fallow field had been tilled recently to control weeds. The remainder of the parcel located outside of the proposed development area is occupied by both agriculture and buildings/athletic fields associated with Pescadero High School.

The current topography of the site can generally be characterized as relatively flat with a gentle slope towards the west.

1.4 PROJECT DESCRIPTION

Although no formal plans are available at this time, it is our understanding that a new fire station may be constructed at the subject site. We anticipate project development will include the construction of one to two structures, paved parking areas, and landscaping.

1.5 REGIONAL GEOLOGY

The site is located within the Coast Ranges geomorphic province of California. The Coast Ranges province is typified by a system of northwest-trending, fault-bounded mountain ranges and intervening alluviated valleys. Bedrock in the Coast Ranges consists of igneous, metamorphic, and sedimentary rocks that range in age from Jurassic to Pleistocene. The present geology of the Coast Ranges is the result of deformation and deposition along the tectonic boundary between the North American plate and the Pacific plate. Plate boundary fault movements are largely concentrated along the well-known fault zones, which in the area include the San Andreas, Calaveras, and Hayward faults, as well as other lesser-order faults.

1.6 LOCAL GEOLOGY

The site geology has been mapped by Brabb et al. (2000 and 1998, Figure 3) as underlain by Holocene age, younger (outer) alluvial fan deposits (Qyfo) consisting of unconsolidated fine sand, silt, and clayey silt.

1.7 SAN GREGORIO FAULT

The history of mapping and identification of the San Gregorio fault zone in the vicinity of the site as identified on the Franklin Point 7.5 minute Quadrangle is described in the Fault Evaluation Report (FER-116) by Smith (1981). In 1976, the CDMG established Special Studies Zones (SSZ) around the San Gregorio fault zone based on the mapping of Weber (1975), Hall et al. (1974), Brown (1972), and Clark (1970). However, the limits of the SSZ and location of segments of the San Gregorio fault zone were revised in 1982 based on additional data by Weber and Lajoie (1980), Weber and Cotton (1980), and interpretation of aerial photographs by Smith (FER-116, 1981). Revisions to the Alquist-Priolo Earthquake Fault Hazard Map for the Franklin Point Quadrangle have not been made since publication of the revised map in 1982. Fault segments as shown on the Alquist-Priolo Earthquake Fault Hazard Map for the Franklin Point Quadrangle (1982) in the vicinity of the project (Figures 2 and 6) appear to be based on interpretation of aerial photographs and geomorphology. Specifically, FER-116 indicates the segment mapped just west and roughly parallel with Cloverdale Road is based on an apparent broad, topographic scarp with deflected drainage channels. This segment is located west of the project area. Three discontinuous segments mapped just south but not entering the site appear to be based on tonal lineaments and closed depressions observed in aerial photographs. Although removed from the current Alquist-Priolo Earthquake Fault Hazard Map for the Franklin Point Quadrangle (1982) and QFFD, the prior Earthquake Fault Hazard Map for the Franklin Point Quadrangle (1976) depicted a segment of the San Gregorio fault passing through the current school site, just east of the project area. A similar segment is still depicted on regional geologic maps prepared by Brabb et al. (2000 and 1998, Figures 2 and 6), and is shown to pass through or in close proximity to the northeastern corner of the site.

As described in FER-116 and the USGS QFFD, the San Gregorio fault zone is part of a larger fault zone, known as the San Gregorio-Hosgri fault zone,that extends over a distance of approximately 400 kilometers from roughly Bolinas in the north to Lompoc in the south. Near the project, the San Gregorio fault zone consists of a complex system of numerous fault strands that include but are not limited to the Frijoles segment, Seal Cove segment, Ano Nuevo segment, Greyhound Rock segment, and Coastways segment, which is the focus of this study. According to the QFFD, the Coastways segment mapped in the vicinity of the site is considered to be a Holocene age fault (i.e. defined as active within the last 11,000 years).

The QFFD indicates that estimated slip rates along the San Gregorio fault zone vary, with some estimates as low as 0.4 mm/year and others as high as 10 mm/yr. Movement along the San Gregorio fault zone is predominantly right lateral strike slip, although some segments may include a component of reverse movement. Recurrence intervals are estimated to be on the order of 400 to 1,000 years, with the last major earthquake on the fault occurring after 1200 to 1470 AD but before the arrival of Spanish missionaries in 1775 AD. As described in FER-116, few seismic events have been recorded in the project area, with most nearby seismic activity associated with the San Andreas fault.

1.8 REGIONAL SEISMICITY

Because of the presence of nearby active faults, the Central Coast Region of California is considered seismically active. Numerous small earthquakes occur every year in the region, and large (>M7) earthquakes have been recorded and can be expected to occur in the future. The site is located within the Earthquake Fault Hazard Zone for the San Gregorio fault (Figure 4). Figure 5 shows the approximate location of active and potentially active faults and significant historic earthquakes mapped within the project area. Based on the 2008 USGS National Seismic Hazard Maps database, the nearest active fault is the San Gregorio fault, located immediately west of the subject site. Other active or potentially active faults located near the site include the San Andreas fault, located approximately 11.9 miles to the northeast, the Monte Vista Shannon fault, located approximately 14 miles to the northeast; and the Zayante Vergeles fault, located approximately 24.3 miles to the southeast.

1.9 AERIAL PHOTOGRAPH REVIEW

We reviewed the following individual and stereo-paired images of the site:

TABLE 1.9-1
Aerial Photographs

Date	Film ID	Line Number	Photograph Numbers	Scale
10/13/2005	KAV 9200	8	28/29	1:15,000
8/15/2000	AV 6600	8	59/60	1:12,000
8/5/1997	AV 5434	8	54/55	1:12,000
8/8/1995	KAV 4905	4	19	1:24,000
8/27/1993	AV 4515	8	58/59/60	1:12,000
9/24/1991	KAV 4122	4	15/16	1:36,000
7/2/1991	AV 4075	8	66	1:12,000
6/21/1989	AV 3593	4	16/17	1:36,000
7/3/1985	AV 2664	4	16/17	1:36,000
11/2/1981	AV 2050	07	41	1:54,000
5/11/1979	AV 1700	06/07	37/38 & 34/35	1:54,000
9/4/1975	AV1215	07	35/36	1:54,000
9/8/1970	AV 965	965	35/36 & 40	1:48,000
2/20/1967	AV 784	22	05/06	1:36,000
4/21/1966	AV 710	07	47	1:36,000
7/9/1963	AV 550	06	39/40	1:36,000
8/22/1960	AV 385	09	22/23	1:30,000
3/1/1958	SF Area	01	126/127	1:36,000

Review of the above photographs indicates that the site was used as agricultural land since at least 1958. In the 1958 photographs, a small barn structure is visible in the southwest corner of the project area, roughly at the intersection of Cloverdale Road and Butano Cutoff. By the time of the photographs dated 1960, the barn had been demolished and the current school had been built. No significant changes to the project area are visible in the remaining photographs reviewed.

The project area appears to be located in a broad, linear alluvial valley that trends in a roughly northwest/southeast direction. A relatively linear, north/south trending prominent break in slope is visible to the west of Cloverdale Road. Additionally, tonal lineaments trending in a northwest/southeast direction are periodically visible in the open fields located south of the site. The features mentioned above are roughly coincident with the fault traces depicted by USGS QFFD mapping and the Alquist-Priolo Earthquake Fault Hazard Map for the Franklin Point Quadrangle (1982). It should be noted that none of the features described above appear to traverse the project area.

2.0 SITE EXPLORATION

2.1 TRENCH EXCAVATIONS

We excavated and logged a total of approximately 650 feet of trench as depicted on Figure 2. The trenches were excavated with a tracked excavator to depths ranging from approximately 8.5 to 13.5 feet. The trenches could not be excavated past a depth of approximately 13.5 feet due to high groundwater and unstable soils. The excavations were benched or shored for safety and the south walls of the trenches were cleaned of smeared materials and logged by ENGEO geologists as noted on the logs. The trench locations and significant features were located by measuring from existing landmarks.

The purpose of the trench excavations was to expose the alluvial deposits so that they could be closely examined for evidence of recent fault displacement. The geologic logging process included description of soil color, estimated grain size, structure and interpretation of geologic features such as development of soil weathering profiles, depositional layering and contacts between differing soil layers.

We retained Dr. Glenn Borchardt to provide a detailed pedochronologic description of represented weathering profiles developed in Trench 1-T1 at Station 48. The purpose of the pedochronologic description was to correlate the soils observed onsite with nearby dated profiles and to estimate the age of weathering profiles. The results of Dr. Borchardt's study are presented in Appendix A.

The trenches were excavated in a roughly southwest/northeast direction and were oriented roughly perpendicular to the trend of mapped fault traces in the project area. Trench 1-T1 was excavated on the eastern side of the project area in the existing parking lot to the limit of the eastern edge of the AP Earthquake Fault Hazard Zone (Figure 2). Trench 1-T2 was excavated from the western side to the eastern side of the project area in an open field and is entirely located within the AP Earthquake Fault Hazard Zone (Figure 2).

2.2 SUBSURFACE CONDITIONS

The following sections described the geologic units encountered in Trenches 1-T1 and 1-T2. The trench logs are included as Figure 7. Groundwater was encountered in both trenches at depths of roughly 10½ to 13 feet below the ground surface.

2.2.1 Artificial Fill (Unit 1 in 1-T1, Unit 1A and 1B in 1-T2)

Artificial fill was encountered across the extent of both trenches and ranged in thickness from approximately 1 to 2 feet, including soils disturbed as a result of tilling. The fill encountered was generally black to light brown lean clay with minor debris items (rusted metal, porcelain). Additionally, a leach line and remnants of a wooden septic tank was encountered between Stations 420 and 425 in 1-T2, in the vicinity of the former barn. In Trench 1-T1, the artificial fill is overlain by a pavement section consisting of approximately 2 inches of asphaltic concrete over 4 inches of aggregate base. Based on conversations with representatives of Pescadero High School, we understand that the school site may have been raised in the past to help reduce the potential for flooding. Additionally, we observed that the site is roughly 1 to 2 feet higher in elevation than agricultural fields to the south of the site.

2.2.2 Holocene Alluvium, A Horizon (Unit 2, Both Trenches)

An A Horizon, consisting of black silty lean clay, was observed underlying artificial fill across both trenches. Where encountered, this soil was generally porous and contained abundant rootlets and worm burrows. This unit is described as containing three separate A Horizons (A1, A2, and A3) in the report prepared by Dr. Borchardt (Appendix A).

2.2.3 Holocene Alluvium, Bt Horizon (Unit 3 in 1-T1, Unit 3A and Upper Unit 3 in 1-T2)

A Bt Horizon, consisting of brown and light brown silty lean clay was observed underlying the A Horizon across both trenches. Where encountered, this soil was observed to contain numerous root traces and worm burrows, with black clay coating the root trace and burrow surfaces. The upper portion of Unit 3 in 1-T2 is interpreted to include the Bt Horizon, although the moisture content and increased clay content of this soil between Station 450 and 540 made identifying the geologic contact with underlying soils difficult to discern. As such, a facies change is shown on the log for Trench 1-T2 at Station 450.

2.2.4 Holocene Alluvium, BC Horizon (Unit 4 in 1-T1, Unit 3B and Lower Unit 3 in 1-T2)

A BC Horizon, consisting of light yellowish brown silty lean clay was observed underlying the Bt Horizon across both trenches. Where encountered, this soil was observed to contain some root traces and worm burrows, with black clay coating the root trace and burrow surfaces. Additionally, the BC horizon contained noticeably more silt than the overlying Bt Horizon. The lower portion of Unit 3 in 1-T2 is interpreted to include the BC Horizon, although the moisture content and increased clay content of this soil between Station 450 and 540 made identifying the geologic contact with underlying soils difficult to discern. As such, a facies change is shown on the log for trench 1-T2 at Station 450. As discussed in the report prepared by Dr. Borchardt, the age of this soil is interpreted to be approximately 4,700 years.

2.2.5 Holocene Alluvium, Ab1/Btb1 Horizon (Unit 5 in 1-T1, Unit 4 in 1-T2)

An Ab1/Btb1 Horizon, consisting of dark brown and gray lean clay was observed underlying the BC Horizon across both trenches. Where encountered, this soil was observed to contain abundant root traces and worm burrows, with black clay coating the root trace and burrow surfaces. This soil appeared to have a moderate blocky structure. As discussed in the report prepared by Dr. Borchardt, the age of the lower portion (i.e. Btb1) of this soil is interpreted to be approximately 5,300 years.

2.2.6 Holocene Alluvium, Ab2 Horizon (Unit 6 in 1-T1, Unit 5 in 1-T2)

An Ab2 Horizon, consisting of brown silty lean clay was observed underlying the Ab2 Horizon across both trenches. Where encountered, this soil was observed to exhibit a moderate blocky structure with clay films on blocky surfaces. As discussed in the report prepared by Dr. Borchardt, the soil age is interpreted to be approximately 6,300 years.

2.3 FAULTING

No evidence of faulting, folding or warping was observed in the soils exposed in Trenches 1-T1 or 1-T2.

3.0 DISCUSSION AND RECOMMENDATIONS

Review of FER-116 indicates that the mapped traces of the San Gregorio fault (depicted on Figure 6) immediately west and south of the site are based on geomorphic expression and tonal lineaments observed through review of aerial photographs. The fault traces immediately south of the site are shown to be queried and discontinuous, while the fault trace to the west of the site (roughly coincident with Cloverdale Road) is located along a prominent break in slope. The locations of potential fault traces that are mapped on the Alquist-Priolo Earthquake Fault Hazard Map for the Franklin Point Quadrangle (1982) due to tonal lineaments to the south of the site and the linear break in slope to the west of the site and are in general agreement with similar features observed during our review of aerial photographs. None of the fault traces depicted on the Alquist-Priolo Zone map or QFFD are shown to pass through the site.

The trace of the San Gregorio fault shown in close proximity to or through the northeastern corner to the east of the site as mapped by Brabb et al. (1998, 2000) appears to be based on prior geologic data and is not included on the Alquist-Priolo Earthquake Fault Hazard Map for the Franklin Point Quadrangle (1982) or mapping by the QFFD. Additionally, the referenced maps prepared by Brabb et al. are small-scale regional geologic maps; therefore, fault traces as shown in a smaller, site-specific location may not be entirely accurate.

The base of the soil profile exposed in our trenches was estimated to be approximately 6,300 years in age (Appendix A), and no warping or offset of soils within the trenches was observed. The guidelines for implementation of the Alquist-Priolo act indicate that structures may not be constructed across the trace of an active fault, which CGS defines as a fault that has experienced movement in the last 11,000 years. As discussed in a previous section, recurrence intervals along the San Gregorio fault are estimated to be in the range of 400 to 10,000 years. Considering soils encountered in our trenches are up to 6,300 years in age, it is our opinion that offset or warping of soils should have been observed if active splays of the San Gregorio fault were present across the subject site. Dr. Borchardt, who concluded that the modern soil and underlying mid-Holocene paleosols observed in our trenches could be used to evaluate the potential for surface fault rupture at the site, drew a similar conclusion (Appendix A).

Considering the general absence of fault traces mapped through the site, lack of geomorphic evidence for an active fault traversing the site, and the age of un-faulted soils exposed in our trenches in conjunction with the recurrence interval of the San Gregorio fault, it is our opinion that the results of this study sufficiently satisfy the intent of the Alquist-Priolo act.

Based on the results of this study we have the following recommendations:

- Structures intended for human occupancy should be set back from the eastern edge of Trench 1-T1 and western edge of Trench 1-T2 a minimum of 50 feet as depicted on Figure 2.
- It will be acceptable to construct other improvements such as roads, parking lots, landscaping, and underground utilities within the recommended fault setback zones. However, these improvements may be susceptible to damage in the event of fault rupture.

4.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

If changes occur in the nature or design of the project, we should be allowed to review this report and provide additional recommendations, if any. It is the responsibility of the owner to transmit the information and recommendations of this report to the appropriate organizations or people involved in design of the project, including, but not limited to, developers, owners, buyers, architects, engineers, and designers. The conclusions and recommendations contained in this report are solely professional opinions and are valid for a period of no more than 2 years from the date of report issuance.

We strived to perform our professional services in accordance with generally accepted geotechnical engineering principles and practices currently employed in the area; no warranty is expressed or implied. There are risks of earth movement and property damages inherent in building on or with earth materials. We are unable to eliminate all risks or provide insurance; therefore, we are unable to guarantee or warrant the results of our services.

This report is based upon field and other conditions discovered at the time of report preparation. We developed this report with limited subsurface exploration data. We assumed that our subsurface exploration data is representative of the actual subsurface conditions across the site. If unexpected conditions are encountered, notify ENGEO immediately to review these conditions and provide additional and/or modified recommendations, as necessary.

Actual field or other conditions will necessitate clarifications, adjustments, modifications or other changes to ENGEO's documents. Therefore, ENGEO must be engaged to prepare the necessary clarifications, adjustments, modifications or other changes before construction activities commence or further activity proceeds. If ENGEO's scope of services does not include onsite construction observation, or if other persons or entities are retained to provide such services, ENGEO cannot be held responsible for any or all claims arising from or resulting from the performance of such services by other persons or entities, and from any or all claims arising from or resulting from clarifications, adjustments, modifications, discrepancies or other changes necessary to reflect changed field or other conditions.

SELECTED REFERENCES

Bryant, W.A., and Cluett, S.E., compilers, 1999, Fault number 60a, San Gregorio fault zone, San Gregorio section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 07/15/2016.

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California Geological Survey, Note 49, Guidelines for Evaluating the Hazard of Surface Fault Rupture.

California Geological Survey Special Publication 117A (2008). Guidelines for Evaluation and Mitigating Seismic Hazards in California.

Hart, E.W. and Bryant, W.A. (2007), Fault-Rupture Hazard Zones in California: California Division of Mines and Geology, Special Publication 42.

United States Geological Survey and the California Geological Survey; Quaternary fault and fold database for the United States, Google Earth KMZ.

FIGURES

Figure 1 – Vicinity Map
Figure 2 – Site Plan
Figure 3 – Regional Geologic Map
Figure 4 – Earthquake Fault Zone Map
Figure 5 – USGS Earthquakes and Faults
Figure 6 – Fault Compilation Map
Figure 7 – Trench Logs

F I G U R E S

BASE MAP SOURCE: GOOGLE EARTH MAPPING SERVICE

ENGEO Expect Excellence	VICINITY MAP PESCADERO FIRE STATION PESCADERO, CALIFORNIA	PROJECT NO.: 11780.000.001		FIGURE NO. 1
		SCALE: AS SHOWN		
		DRAWN BY: DLB	CHECKED BY: RHB	

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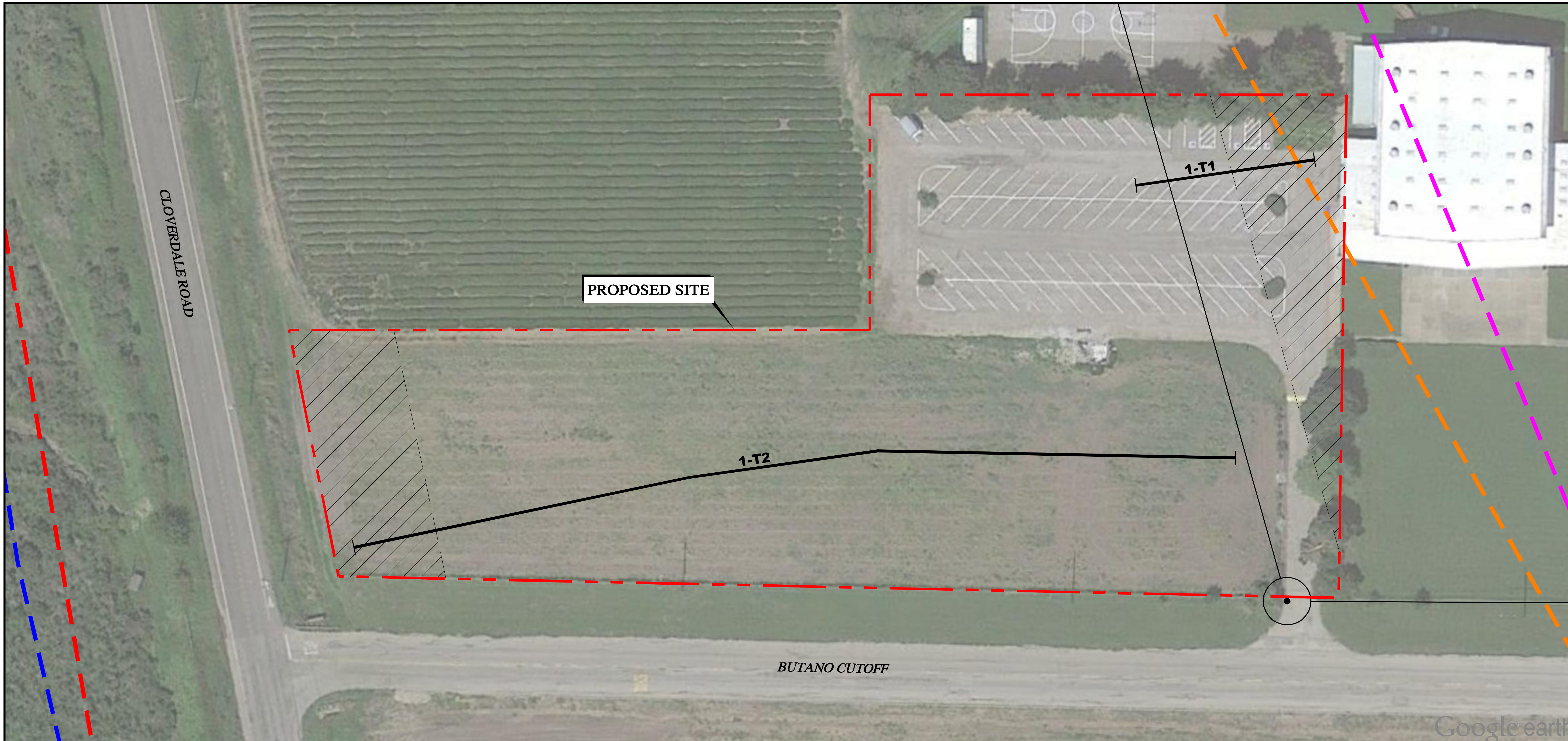
ORIGINAL FIGURE PRINTED IN COLOR



EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

- U.S.G.S QFFD
- FAULT (BRABB, GRAYMER, & JONES, 2000)
- FAULT (STATE OF CALIFORNIA SPECIAL STUDIES ZONES, 1982)
- FAULT (BRABB, GRAYMER, & JONES, 1998)
- EARTHQUAKE FAULT ZONE LIMIT
- 1-T2 FAULT TRENCH (ENGEO, 2016)
- PROPOSED HABITABLE STRUCTURE EXCLUSION ZONE

N

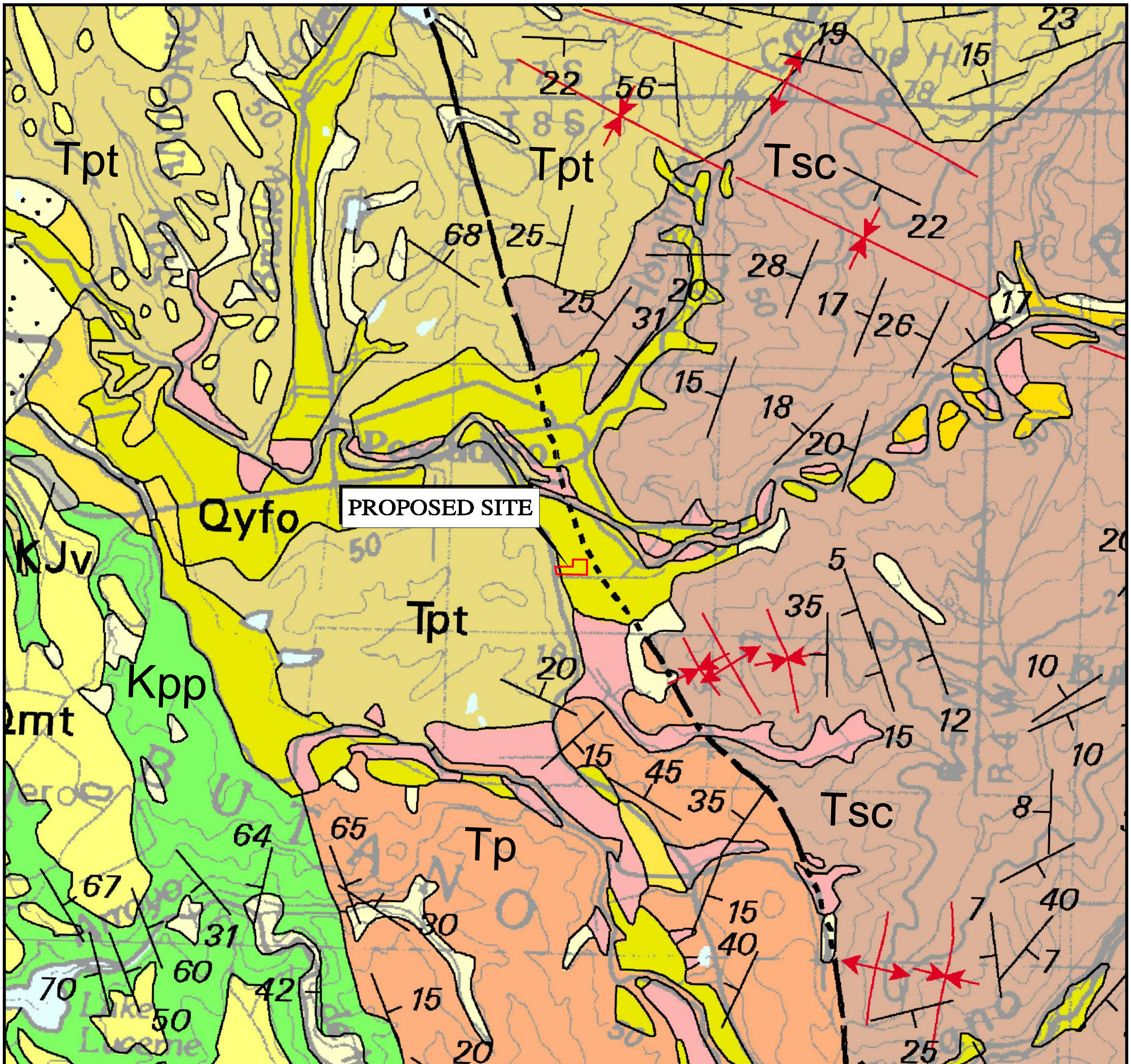
0 FEET 60
0 METERS 30

BASE MAP SOURCE: GOOGLE EARTH MAPPING SERVICE

ENGEO Expect Excellence	SITE PLAN PESCADERO FIRE STATION PESCADERO, CALIFORNIA	PROJECT NO.: 11780.000.001 SCALE: AS SHOWN DRAWN BY: DLB CHECKED BY: RHB	FIGURE NO. 2

G:\Drafting\DRAFTING2_Dwg_10000 to 12999\11780\000\GEX\11780000001-GEX-2-SitePlan-0716.dwg Plot Date: 7-25-16 llee

ORIGINAL FIGURE PRINTED IN COLOR



EXPLANATION

FAULT-DASHED WHERE APPROXIMATELY LOCATED, SHORT DASHED WHERE INFERRED, DOTTED WHERE CONCEALED, QUERIED WHERE LOCATION IS UNCERTAIN STRIKE-SLIP MOVEMENT

AXIS OF FOLD

ANTICLINE — SYNCLINE

STRIKE AND DIP OF STRATA

INCLINED — VERTICAL — OVERTURNED

Qyfo	YOUNGER ALLUVIAL FAN DEPOSIT
Tp	PURISIMA FORMATION
Tpt	TAHANA MEMBER
Tsc	SANTA CRUZ MUDSTONE
Kpp	PIGEON POINT FORMATION

N

0 FEET 3000
0 METERS 1500

BASE MAP SOURCE: BRABB, GRAYMER, JONES, 2000

ENGEO
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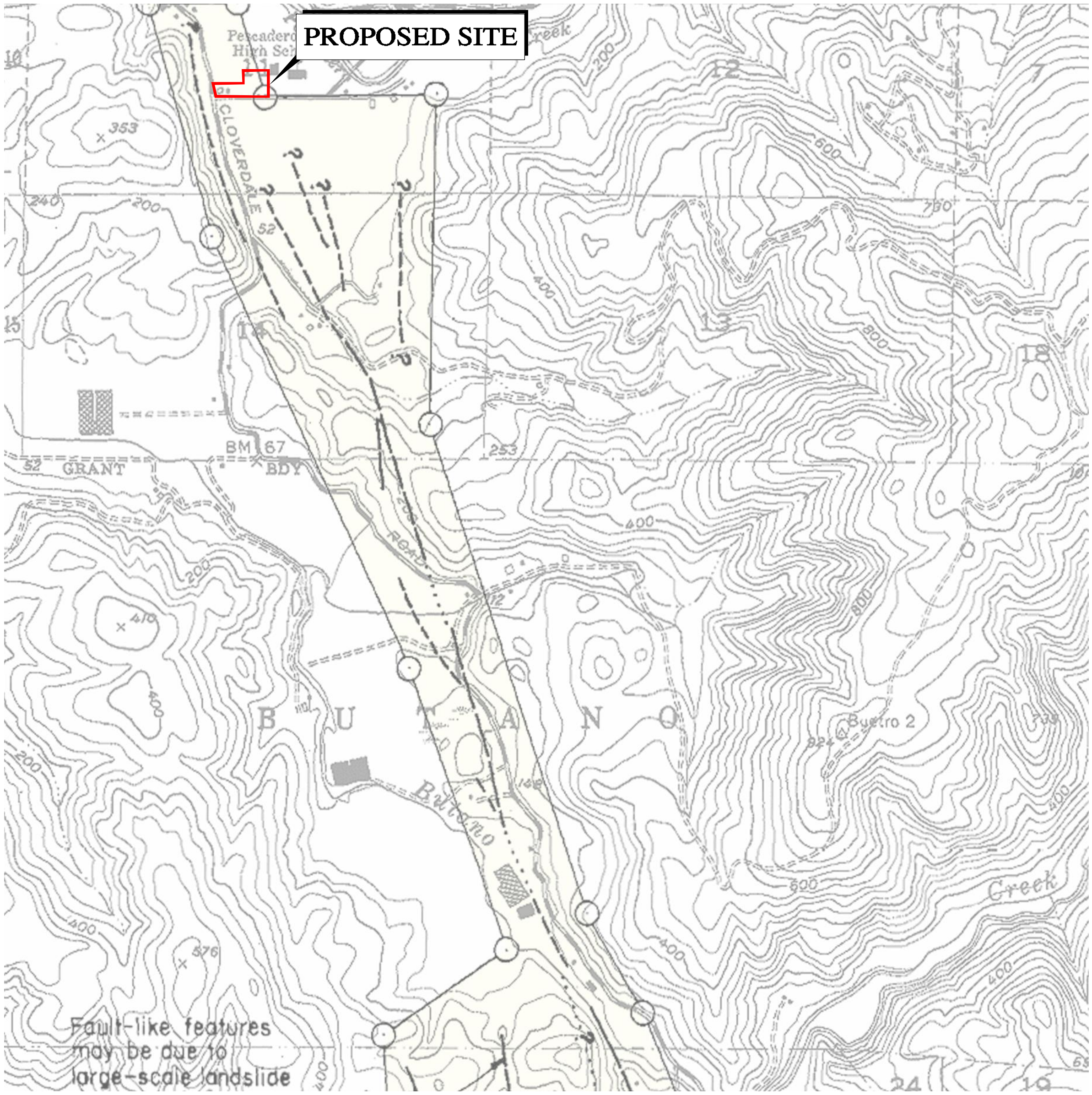
REGIONAL GEOLOGIC MAP
PESCADERO FIRE STATION
PESCADERO, CALIFORNIA

PROJECT NO.: 11780.000.001		FIGURE NO. 3
SCALE: AS SHOWN		
DRAWN BY: DLB	CHECKED BY: RHB	



EXPLANATION

1906 C

FAULTS 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

EARTHQUAKE FAULT ZONE BOUNDARIES; DELINEATED AS STRAIGHT-LINE SEGMENTS THAT CONNECT ENCIRCLED TURNING POINTS SO AS TO DEFINE EARTHQUAKE FAULT ZONE SEGMENTS

N

0 FEET 2000
0 METERS 1000

BASE MAP SOURCE: CDMG, 1982

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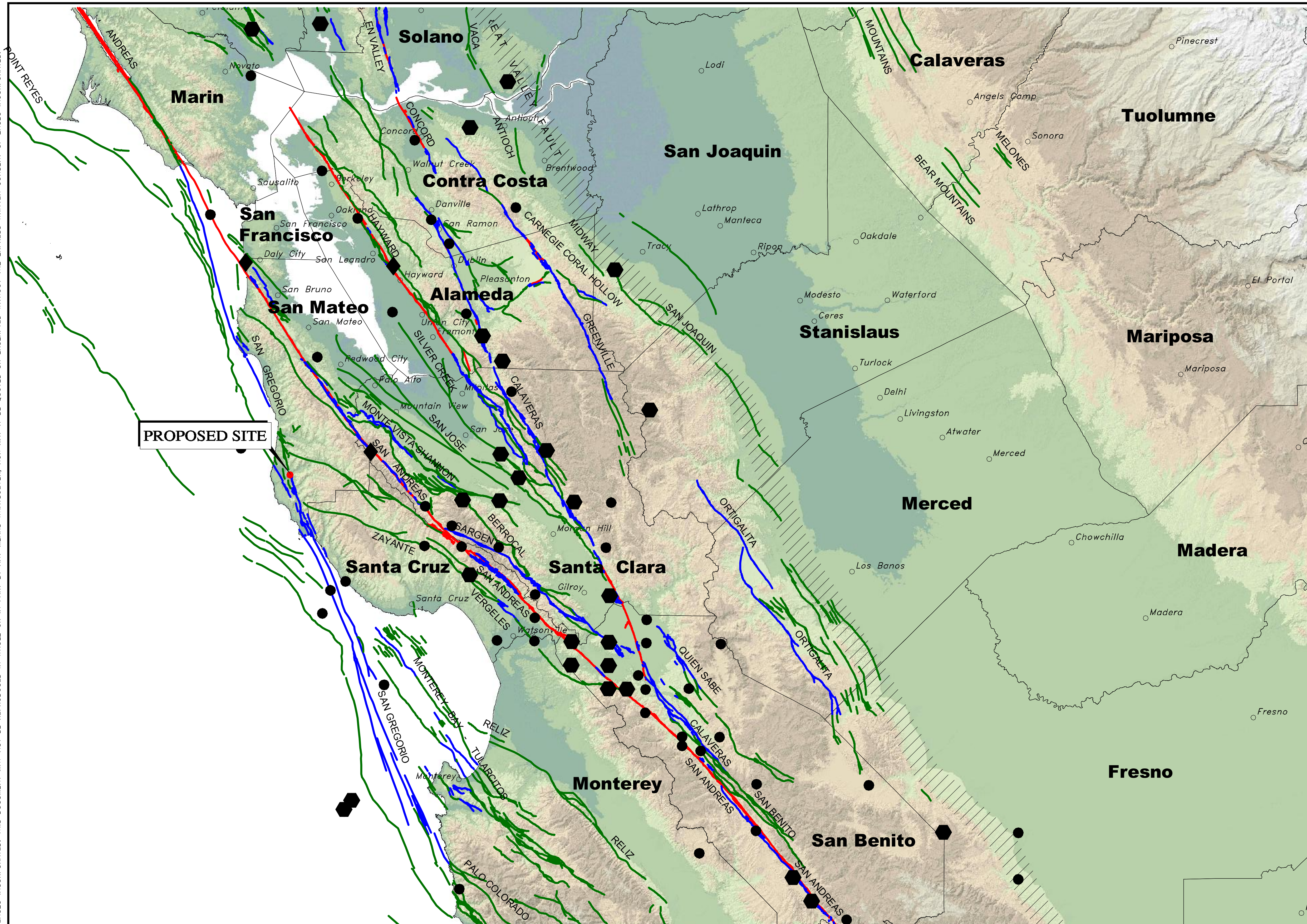
EARTHQUAKE FAULT ZONE MAP PESCADERO FIRE STATION PESCADERO, CALIFORNIA	PROJECT NO.: 11780.000.001		FIGURE NO. 4
	SCALE: AS SHOWN		
	DRAWN BY: DLB	CHECKED BY: RHB	

G:\Drafting\DRAFTING2_Dwg_10000 to 12999\11780\000\GEX\11780000001-GEX-4-EQ-Faultzone-0716.dwg Plot Date: 7-25-16 llee

ORIGINAL FIGURE PRINTED IN COLOR



N

0 MILES 15
0 KILOMETERS 30

EXPLANATION

- MAGNITUDE 7+
- MAGNITUDE 6-7
- MAGNITUDE 5-6
- HISTORIC FAULT
- HOLOCENE FAULT
- QUATERNARY FAULT
- HISTORIC BLIND THRUST FAULT ZONE

BASE MAP SOURCE:
COLOR HILLSHADE IMAGE BASED ON THE NATIONAL ELEVATION DATASET (NED) AT 30 METER RESOLUTION
U.S.G.S. QUATERNARY FAULT DATABASE, NOVEMBER, 2010
U.S.G.S. HISTORIC EARTHQUAKE DATABASE (1800–2000)

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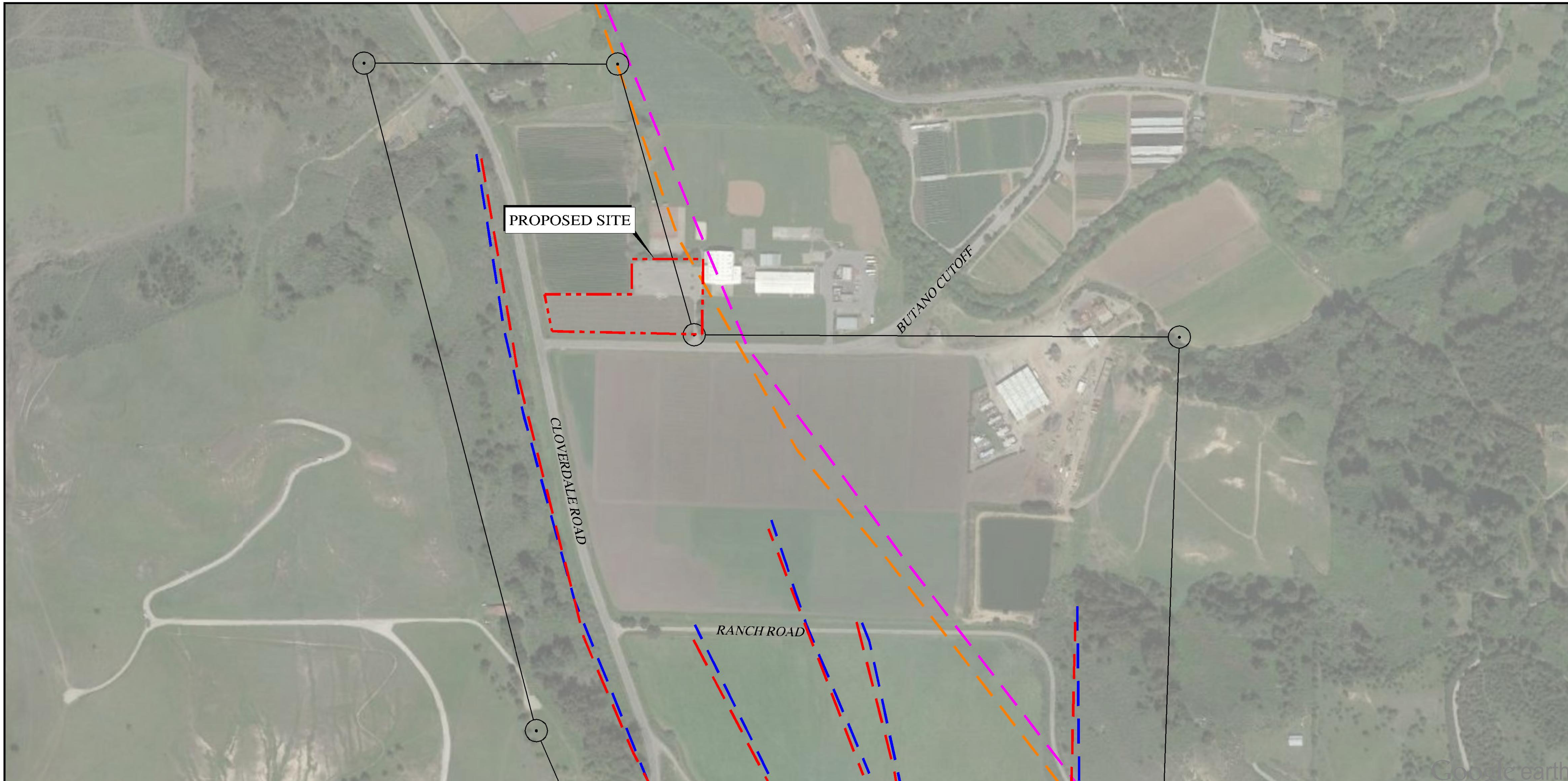
REGIONAL FAULTING AND SEISMICITY
PESCADERO FIRE STATION
PESCADERO, CALIFORNIA

PROJECT NO.: 11780.000.001	FIGURE NO
SCALE: AS SHOWN	5
DRAWN BY: DLB	CHECKED BY: RHB

G:\Drafting\DRAFTING2_Dwg_10000 to 12999\11780\000\GEX\11780000001-GEX-5-RegFTSS-0716.dwg Plot Date: 7-25-16 llee

ORIGINAL FIGURE PRINTED IN COLOR



EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

- U.S.G.S. QFFD
- FAULT (BRABB, GRAYMER, & JONES, 2000)
- FAULT (STATE OF CALIFORNIA SPECIAL STUDIES ZONES, 1982)
- FAULT (BRABB, GRAYMER, & JONES, 1998)
- EARTHQUAKE FAULT ZONE LIMIT

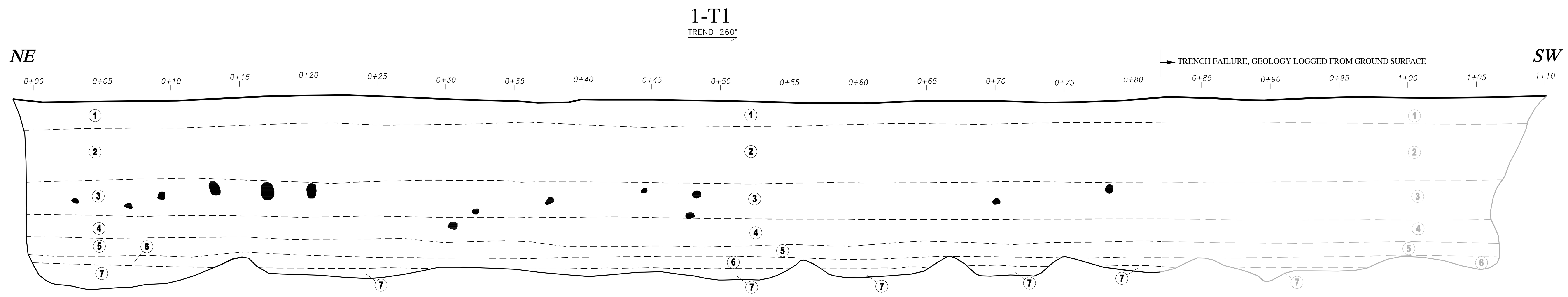
N

0 FEET 400
0 METERS 200

BASE MAP SOURCE: GOOGLE EARTH MAPPING SERVICE

ENGEO Expect Excellence	FAULT COMPILATION MAP PESCADERO FIRE STATION PESCADERO, CALIFORNIA	PROJECT NO.: 11780.000.001 SCALE: AS SHOWN DRAWN BY: DLB CHECKED BY: RHB	FIGURE NO. 6

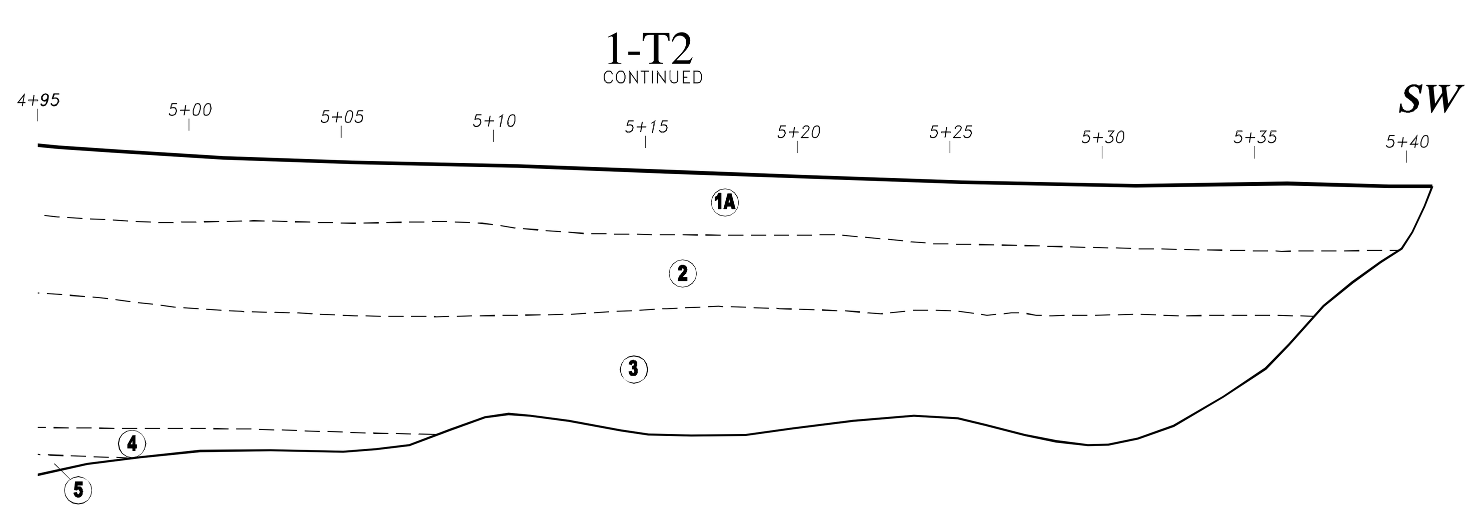
ORIGINAL FIGURE PRINTED IN COLOR



TRENCH 1-T1 EXPLANATION

1. Artificial Fill. Black and light brown silty lean CLAY. Covered by approximately 2 inches of asphaltic concrete over 4 inches of light yellowish brown aggregate base.
2. Holocene Alluvium. Black silty lean CLAY, porous, abundant rootlets and worm burrows. 'A' Horizon.
3. Holocene Alluvium. Mottled brown and light brown silty lean CLAY, contains worm burrows and root traces. Burrows and root trace surfaces covered with black clay coating. 'Bt' Horizon.
4. Holocene Alluvium. Light yellowish brown silty lean CLAY, contains some worm burrows and root traces. Contains more silt than Unit 3. Black clay coating on burrow and root trace surfaces. 'BC' Horizon.
5. Holocene Alluvium. Dark brown and gray lean CLAY, abundant root traces and worm burrows, clay coating on root trace and worm burrow surfaces. Moderate blocky structure. 'Ab1/Btb1' Horizon.
6. Holocene Alluvium. Dark brown and black lean CLAY. Moderately well developed blocky structure, abundant worm burrows and root traces with clay coating on surfaces. 'Ab2' Horizon.
7. Holocene Alluvium. Brown silty lean CLAY, moderate blocky structure, clay films on blocky surfaces. 'Btb2/Bctb2' Horizon.

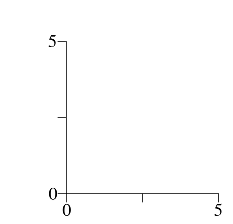
KROTOVINA



TRENCH 1-T2 EXPLANATION

- 1A Artificial Fill/Disturbed native soil from tilling. Black silty lean CLAY with orange mottling at base of unit. Contains abundant rootlets and worm burrows and occasional trash items (rusted metal bolts, porcelain).
- 1B Artificial Fill. Black silty lean CLAY with trash items (rusted metal, glass, some wood). Leach line and remnants of wooden septic box. Leach line consists of approximately 5 inch diameter clay pipe segments with gaps between segments, pipe surrounded with 1 inch diameter gravels.
- 2 Holocene Alluvium. Black silty lean CLAY, porous, abundant rootlets and worm burrows. 'A' Horizon.
- 3 Holocene Alluvium. Dark grey with orange mottling lean to fat CLAY, contains worm burrows and root traces. More abundant burrows and root traces visible in upper portion of unit. Burrows and root trace surfaces covered with black clay coating. Facies change at roughly Station 450 to Units 3A and 3B. Lower portion of unit much more clayey than Unit 3B. 'Bt/BC' Horizon. Analagous to Units 3 & 4 in trench 1-T1.
- 3A Holocene Alluvium. Brown and light brown silty lean CLAY, contains worm burrows and root traces. contains worm burrows and root traces. Burrows and root trace surfaces covered with black clay coating. Facies change at roughly Station 450 to Unit 3. 'Bt' Horizon. Analagous to Unit 3 in trench 1-T1.
- 3B Holocene Alluvium. Light yellowish brown silty lean CLAY, contains some worm burrows and root traces. Burrows and root trace surfaces covered with black clay coating. Contains more silt than Unit 3A. Facies change at roughly Station 450 to Unit 3. 'BC' Horizon. Analagous to Unit 4 in trench 1-T1.
- 4 Holocene Alluvium. Dark brown and gray lean CLAY, abundant root traces and worm burrows, clay coating on root trace and worm burrow surfaces. Moderate blocky structure. 'Ab1/Btb1' Horizon.
- 5 Holocene Alluvium. Dark brown and black lean CLAY. Moderately well developed blocky structure, abundant worm burrows and root traces with clay coating on surfaces. 'Ab2' Horizon.
- 6 Holocene Alluvium. Brown silty lean CLAY, moderate blocky structure, clay films on blocky surfaces. 'Btb2/Bctb2' Horizon.

KROTOVINA



ENGEO Expect Excellence

TRENCH LOGS PESCADERO FIRE STATION PESCADERO, CALIFORNIA	PROJECT NO.: 11780.000.001		FIGURE NO. 7
	SCALE: 1"=5'		
	DRAWN BY: DLB	CHECKED BY: RHB	

ORIGINAL FIGURE PRINTED IN COLOR

APPENDIX A

Soil Tectonics Report

APPENDIX A

APPENDIX A

PEDOCHRONOLOGICAL REPORT FOR PESCADERO FIRE STATION, PESCADERO, CALIFORNIA

Prepared for ENGEO, Inc., San Jose, California, Project No. 11780.000.001

July 12, 2016

Soil Tectonics
P.O. Box 5335
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Glenn Borchardt

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Certified Professional Soil Scientist No. 24836

PEDOCHRONOLOGICAL REPORT FOR PESCADERO FIRE STATION, PESCADERO, CALIFORNIA

Prepared for ENGEO, Inc., San Jose, California, Project No. 11780.000.001

July 12, 2016

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 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, as well as buried soils called paleosols. Terms, prefixes, and suffixes are defined in the Soils Glossary at the end of this report.

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 up to 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, 2010). At minimum, this requires a Munsell color chart, hand lens, acid bottle, and instruments for 1:1 soil:water pH and electrical conductivity (EC) measurements. The second step may involve collecting samples of each horizon of the soil profile column 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, preferably in the same region. 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

Soil Profile No. 1 was studied to assess the age of the soil in Trench 1-T1 excavated 192 m east of the mapped trace of the San Gregorio fault at Pescadero High School, Pescadero, California (Table 1). I did some previous pedochronology along the San Gregorio fault on the Sangamon terrace (122 ka) at Pillar Point near Half Moon Bay (Borchardt, 2001) and at Moss Beach (Borchardt, 2007).

Soil Profile No. 1

This profile was developed in clay to clayey very fine sand overbank deposits 192 m east of the mapped trace of the San Gregorio fault. It is essentially a three-part soil, with a moderately developed modern soil (Figures 1 to 3) underlain by two weakly developed paleosols (Figures 4 and 5). This sequence has been observed elsewhere in the Bay Area where sedimentation rates also are relatively high due to rapid sea level rise since 11 ka (WLA, 2003; Borchardt, 2008; Baldwin and others, 2009; Borchardt, 2012; 2016).

<u>Late Holocene Soil</u>

Buried beneath 65-cm of fill, the modern soil consists of a tri-part cumulic A horizon that is a 133-cm thick very dark brown to very dark grayish brown silty clay with medium moderate angular blocky structure and many fine to medium continuous random tubular pores (Table 1; Figures 1 and 2). These three A horizons overly a 76-cm thick dark brown silty clay Bt horizon with medium moderate to strong angular blocky to prismatic structure with many fine to medium continuous vertical to random tubular pores (Figure 3). It has many thin to medium thick black clay films lining pores. This overlies a 39-cm thick brown silty clay loam to clayey very fine sand 2BC horizon with medium moderate subangular blocky structure with a few fine continuous random tubular pores.

<u>Mid-Holocene Paleosol b1</u>

The second part of this profile is an extremely weak paleosol consisting of a 14-cm thick grayish brown silty clay 3Ab1 horizon with a few fine faint yellowish brown mottles, medium strong subangular blocky structure, a few fine continuous random tubular pores, and a few thin clay films lining pores (Table 1; Figure 4). This overlies an 18-cm thick brown silty clay 3Btb1 horizon with few to many fine faint yellowish brown mottles, medium moderate subangular to angular blocky structure, and many thin clay films lining a few fine continuous random tubular pores.

Mid-Holocene Paleosol b2

The third part of this profile is a weak paleosol consisting of a 20-cm thick very dark brown clay 4Ab2 horizon with medium to coarse strong subangular blocky structure and a few thin to medium thick clay films lining many fine to coarse continuous random tubular pores (Table 1; Figure 4). This overlies a 13-cm thick very dark grayish brown clay 4Btb2 horizon with common medium distinct yellow mottles, medium to coarse strong subangular blocky structure, and a few thin clay films lining many fine to coarse continuous random tubular pores (Figure 5). This overlies a >22-cm thick brown clay 4BCtb2 horizon with common medium distinct yellow mottles, medium to coarse strong subangular to angular blocky structure, and common thin to medium thick clay films lining many fine to coarse continuous random tubular pores.

Soil pH and Electrical Conductivity

The properties of young sediments of consistent texture generally are not expected to show much change with depth. That is why changes in chemical properties, such as soil pH and electrical conductivity (EC), supply information on the degree soil weathering. Such "depth functions" prove that pedogenesis indeed did occur, and help to support the judgements involved in preparing soil descriptions (Borchardt, 2016). Unweathered rocks and sediments usually have no changes in pH and EC with depth.

The pH in Soil Profile No. 1, for instance, is 5.75 in the surface of the modern soil, decreases in the A2 horizon, and then increases to 5.9 in the 2BC horizon (Figure 6). The slight increase in the A1 probably was produced by Ca-laden vegetative material deposited on the soil. The subsequent increase with depth probably reflects the young age of this soil. As mentioned, the pH of unweathered sediments generally is about 7.0.

The EC in Soil Profile No. 1 also increases with depth in the modern soil, reaching a maximum in the Bt horizon (Figure 7). This is 171 cm from the buried surface of the modern soil—a wetting front about 71 cm deeper than what would be expected under the current climate. I attribute this to the cumulic nature of the profile: Recent flooding appears to have contributed silts and clays to the surface, thickening the modern soil.

Soil Ages

Soil profiles estimated to be mid- to late-Holocene at Contra Costa Community College (CCCC) (WLA, 2003, Borchardt, 2008, Baldwin, 2009, Borchardt, 2012; 2016) are remarkably similar to the profile at our present site. In that study, we obtained bulk samples of the two Ab horizons to get the MRT (mean residence time) for C-14 in each (Borchardt, 2016). The Ab1 and Ab2 horizons had calibrated MRT ages of 3.375 ka and 4.040 ka. The difference between the two was 0.865 ky, which was slightly less than the 1 ky estimated in the field. Because MRT ages represent carbon from the beginning of soil development (t_o) to the end of soil development (t_b), I used the difference (0.865 ky) to estimate that the beginning of soil development in the Ab2 began at 4.47 ka and ended 865 years later at 3.61 ka. Similar calculations were performed for the Ab1 horizon. The 286-cm thick profile was deposited since 4.47 ka.

The present site affords almost the same situation. In this instance, we dated the top 1 cm of the 4Ab2 horizon at 5.3 ka (Table 2). The paleosols had Bt and solum horizon thicknesses of 8 and 32 cm for the b1 and 13 and 65 cm for the b2. When compared to the 76-cm Bt and 209-cm solum thicknesses of the modern soil, this yielded average t_d values of 0.6 ky for the b1 and 1.0 ky for the b2 (Table 1). The upshot is that pedogenesis in paleosol b2 adds 1.0 ky to the C14 age, yielding a 6.3-ka age for the base of the profile.

The sedimentation rate for the profile was 0.54 mm/yr for the last 6.3 ka (3.39 m in 6.3 ky). This was similar to the soil profile studied at CCCC, which had a sedimentation rate of 0.64 mm/yr for the last 4.5 ka (2.86 m in 4.5 ky). That is why the paleosols were so weak. They had less than a thousand years of exposure to the elements before the next series of floods buried them. Coincidentally, the modern soil at CCCC had a sedimentation rate of 0.53 mm/yr, which also was similar to the rate found for the bay marsh along the Hayward fault at Point Pinole (0.44 mm/yr) since 1.3 ka (Borchardt, 1988). These rates are commensurate with the worldwide rise in sea level that has occurred in geologically stable areas (Bloom, 1970). This suggests that rising sea level controls the base level and rate of overbank deposition in the Pescadero Creek drainage.

Seismic Hazard

The relatively high sedimentation rate in the area makes it impossible to safely excavate deep enough to uncover additional, still older paleosols. Nevertheless, the 6.3-ka age of the soil profile we examined should be sufficient for detecting any hazardous traces of the San Gregorio fault. A study of the fault at Moss Beach about 33 km to the north estimated that the Holocene slip rate was about 4 mm/yr (Simpson, Lettis, and Randolph, 1998). That site had a 1.5- to 6-m high east-facing scarp, with evidence for the most recent event having occurred 220 to 730 years ago (average 475 years ago). The penultimate event occurred between 620 and 1400 A.D. (average 1010 A.D.). These earthquakes are estimated to have been about M7 with offsets between 3 and 5 m. With the implied recurrence interval of about 500 years, the 6.3-ka soil at our site would have experienced about a dozen events had it been exposed to the San Gregorio fault. That level of activity would be obvious in seismic excavations despite the soil age being younger than desired.

CONCLUSIONS

1. Both the modern soil and the underlying mid-Holocene paleosols can be used to evaluate surface fault rupture (SFR) at this site.
2. Offsets or warping of the paleosols should be considered potential for SFR.

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Table 1. Soil profile described on the alluvial plain about 192 m east of the mapped trace of the San Gregorio fault near intersection of Cloverdale Road and Butano Cutoff, west of Pescadero High School at Pescadero, California. Abbreviations and definitions are given in Schoeneberger and others (2012) and Soil Survey Staff (1993, 1999, 2010).

Description of soil developed in overbank deposits by Glenn Borchardt, who measured and sampled the soil on June 22, 2016 at latitude N37.24768^{o} and longitude W122.36591^{o} at station 48' in the south wall of Trench 1-T1 at an elevation of 54'(54' Google Earth and 51' GPS). Mediterranean climate with mean annual precipitation of 26.62"/yr at Half Moon Bay (1948-2010). Slope 0% along trench (natural slope is 2.6% for a distance of 192 m west). Moderate drainage. Water at 396 cm. The parent material is silty clay overbank deposits. Soil pH is medium acid throughout. Soil in the area is mapped as: *Soquel loam, Cumulic Haploxerolls, 0-1% slope, with a solum thickness of 94 cm overlying a paleosol.*

Horizon	Depth, cm	Description
Fill	0-65	10-cm asphalt over 55 cm fill
A1	65-117	Very dark brown (10YR2/2m; 4/2d) silty clay; medium moderate angular blocky structure; sticky and plastic when wet, very friable when moist, and extremely hard when dry; many fine to medium continuous random tubular pores; few thin very dark brown clay films lining pores; diffuse smooth boundary; pH 5.75; conductivity 267 uS; Sample No. 16B031.
A2	117-160	Very dark brown (10YR2/2m; 5/2d) silty clay; medium moderate angular to subangular blocky structure; sticky and plastic when wet, very friable when moist, and very hard when dry; many fine to medium continuous random tubular pores; diffuse smooth boundary; pH 5.63; conductivity 277 uS; Sample No. 16B032.
A3	160-198	Very dark grayish brown (10YR3/2m; 5/2d) silty clay; medium moderate angular to subangular blocky structure; sticky and plastic when wet, very friable when moist, and very hard when dry; many fine to medium continuous random tubular pores; gradual wavy boundary; pH 5.70; conductivity 362 uS; Sample No. 16B033.
Bt	198-274	Dark brown (10YR3/3m; 6/4d) silty clay; medium moderate to strong angular blocky to prismatic structure; sticky and plastic when wet, very friable when moist, and very hard when dry; many fine to medium continuous vertical to random tubular pores; diffuse smooth boundary; many thin to medium thick black clay films lining pores; pH 5.80; conductivity 448 uS; Sample No. 16B034.

2BC 274-313 Brown (10YR5/3m; 7/4d) silty clay loam to clayey very fine sand; medium moderate subangular blocky structure; slightly sticky and slightly plastic when wet, very friable when moist, and very hard when dry; few fine continuous random tubular pores; clear wavy boundary; pH 5.92; conductivity 298 uS; Sample No. 16B035.

*ESTIMATED AGE:	t_o	=	4.7	ka
	t_b	=	0	ka
	t_d	=	4.7	ky

3Ab1 313-327 Grayish brown (10YR5/2m; 6/4d) silty clay with few fine faint yellowish brown (10YR5/6md) mottles; medium strong subangular blocky structure; slightly sticky and slightly plastic when wet, very friable when moist, and very hard when dry; few fine continuous random tubular pores; few thin clay films lining pores; clear wavy boundary; pH 5.89; conductivity 320 uS; Sample No. 16B036.

3Btb1 327-345 Brown (10YR4/3m; 7/4d) silty clay with few to many fine faint yellowish brown (10YR5/6md) mottles; medium moderate subangular to angular blocky structure; sticky and plastic when wet, very friable when moist, and very hard when dry; few fine continuous random tubular pores; many thin clay films lining pores; clear smooth boundary; pH 5.87; conductivity 309 uS; Sample No. 16B037.

*ESTIMATED AGE:	t_o	=	5.3	ka
	t_b	=	4.7	ka
	t_d	=	0.6	ky

4Ab2 345-365 Very dark brown (10YR2/2m; 5/2d) clay with very few fine faint yellow (10YR7/6md) mottles; medium to coarse strong subangular blocky structure; sticky and plastic when wet, very friable when moist, and very hard when dry; many fine to coarse continuous random tubular pores; few thin to medium thick clay films lining pores; clear smooth boundary; pH 5.91; conductivity 267 uS; Sample No. 16B038. [Upper 1-cm in sample 16B041 had a C-14 age of 5,295 calendar years.]

4Btb2 365-378 Very dark grayish brown (10YR3/2m; 5/2d) clay with common medium distinct yellow (10YR7/6md) mottles; medium to coarse strong subangular blocky structure; sticky and plastic when wet, very friable when moist, and extremely hard when dry; many fine to coarse continuous random tubular pores; few thin clay films lining pores; clear smooth boundary; pH 5.92; conductivity 235 uS; Sample No. 16B039.

4BCtb2 378-400+ Brown (10YR4/3m; 6/4d) clay with common medium distinct yellow (10YR7/6md) mottles; medium to coarse strong subangular to angular blocky structure; sticky and plastic when wet, very friable when moist, and very hard when dry; many fine to coarse continuous random tubular pores; common thin to medium thick clay films lining pores; pH 5.93; conductivity 330 uS; Sample No. 16B040.

*ESTIMATED AGE:	t_o	=	6.3	ka
	t_b	=	5.3	ka
	t_d	=	1.0	ky

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*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

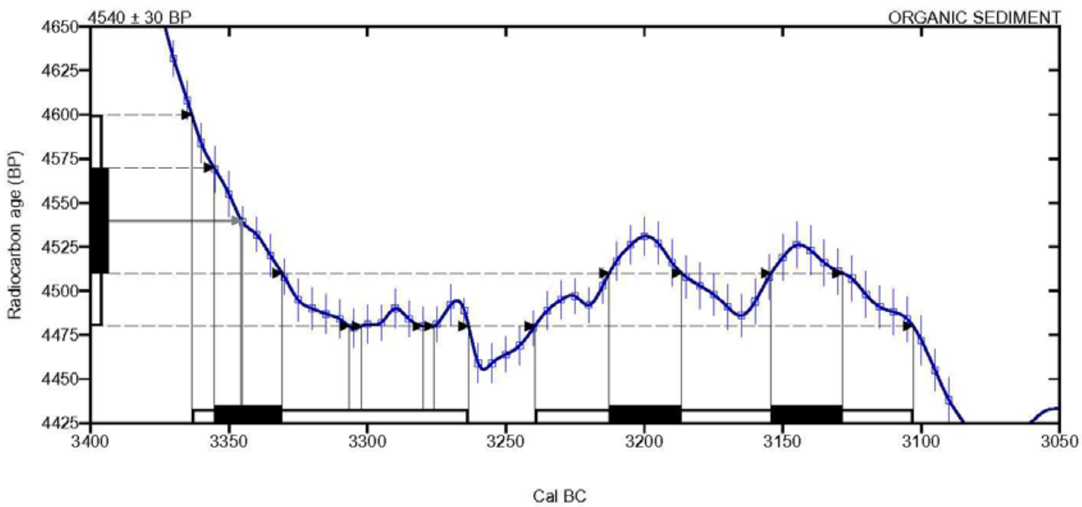
t_b = date when soil or strata was buried, ka

t_d = duration of soil development or aggradation, ky

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -25.3 o/oo : lab. mult = 1)

Laboratory number	**Beta-440519 : 16B041**
Conventional radiocarbon age	**4540 ± 30 BP**
Calibrated Result (95% Probability)	**Cal BC 3365 to 3265 (Cal BP 5315 to 5215)** **Cal BC 3240 to 3105 (Cal BP 5190 to 5055)**
Intercept of radiocarbon age with calibration curve	Cal BC 3345 (Cal BP 5295)
Calibrated Result (68% Probability)	Cal BC 3355 to 3330 (Cal BP 5305 to 5280) Cal BC 3215 to 3185 (Cal BP 5165 to 5135) Cal BC 3155 to 3130 (Cal BP 5105 to 5080)



Database used
INTCAL13

References
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322
References to INTCAL13 database
Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887., 2013.

Beta Analytic Radiocarbon Dating Laboratory
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Table 2. Analysis of the soil carbon in the upper 1-cm of the 4Ab2 horizon showing a calibrated age of 5,295 calendar years (5.295 ka).

Figure 1. Soil Profile No. 1 192 m east of the San Gregorio fault at Pescadero High School, Pescadero, California, showing the very dark brown A1 horizon. View S.

Figure 2. Base of the 133-cm thick A horizon showing krotovinas and/or remnants of the Bt horizon left behind by soil tongue development. View S.

Figure 3. Bt and 2BC horizons. Note the black krotovina in the middle of the Bt and the vertical root traces. View S.

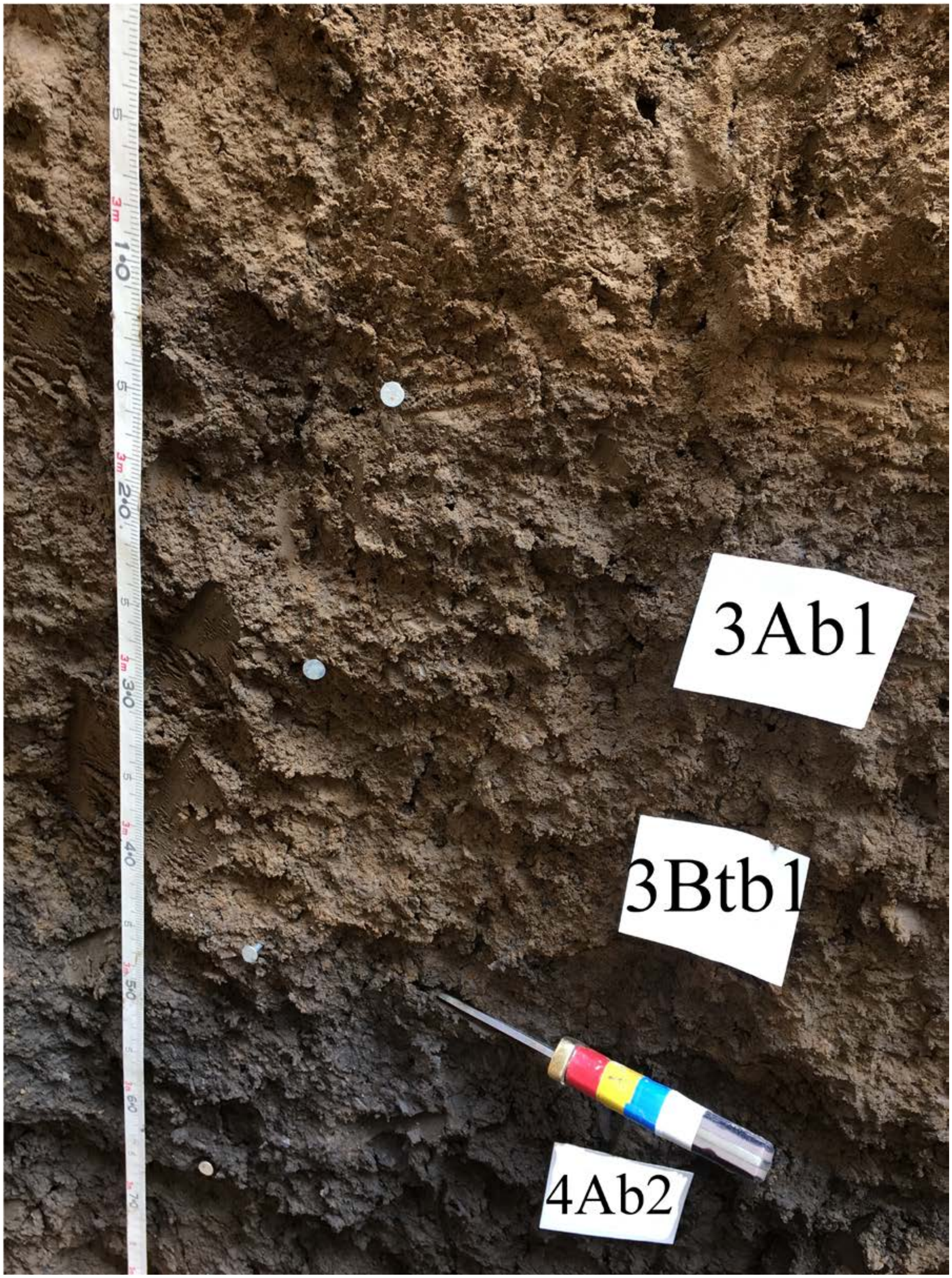

Figure 4. The short-duration b1 and b2 paleosols. The top 1cm of the Ab2 horizon had a C-14 age of 5.3 ka (Table 2). The b2 paleosol was estimated to have a t_d of 1 ka, yielding a t_o age for the profile of 6.3 ka.

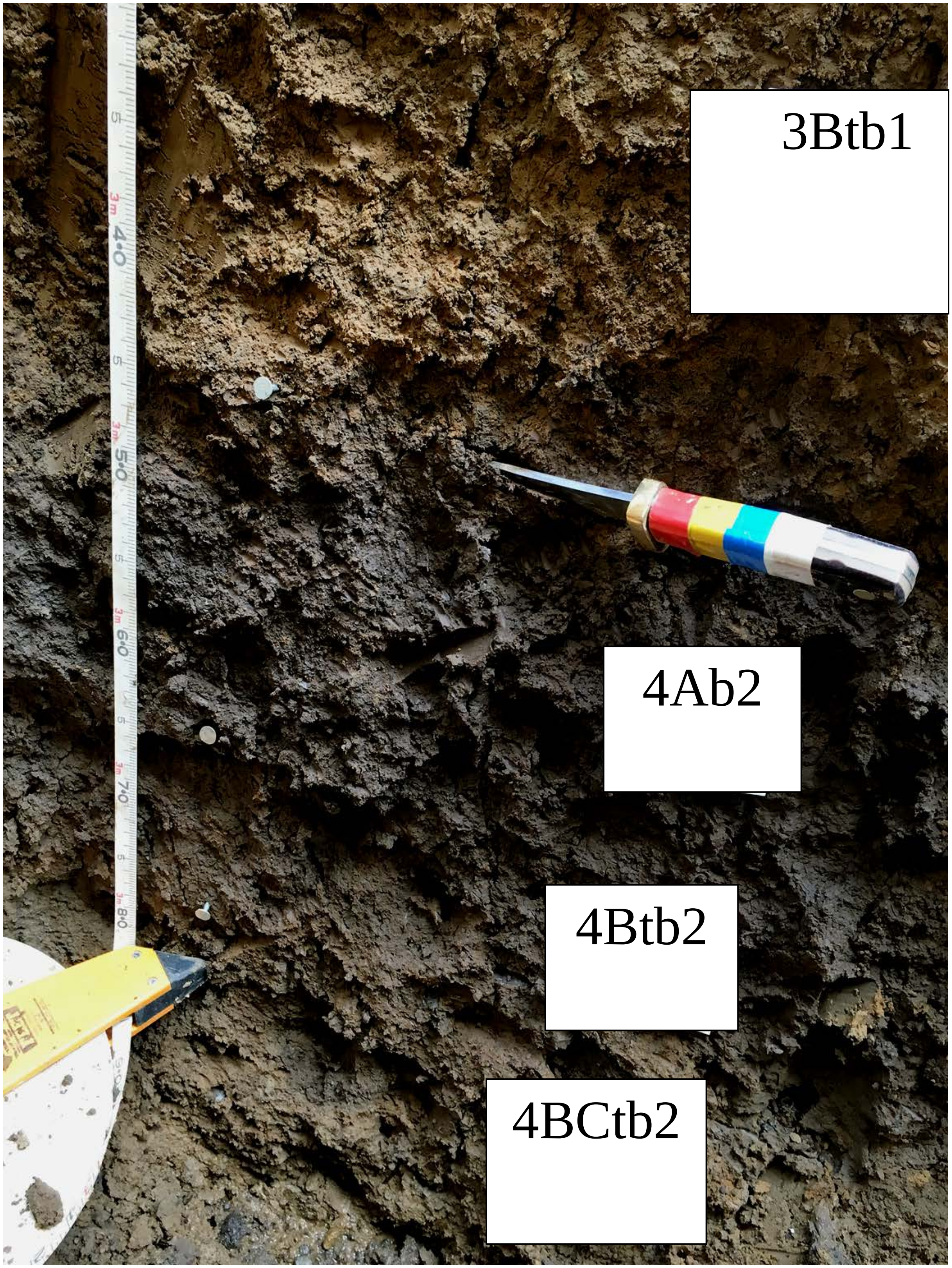

Figure 5. Paleosol b2 showing the location of the C-14 sample taken from the top 1 cm of the 4Ab2 horizon (at the tip of the knife). View S.

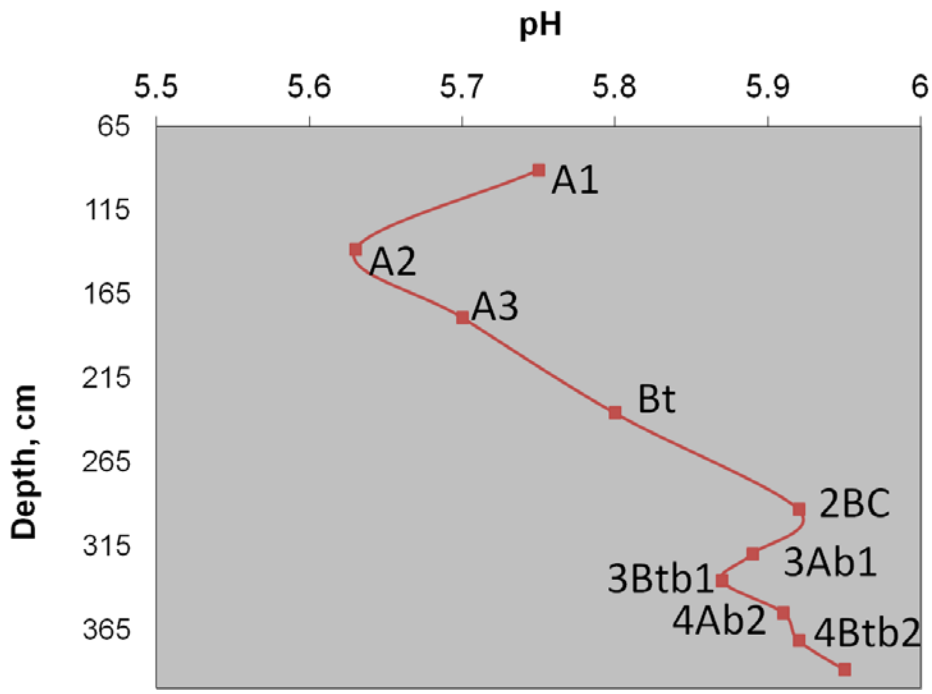

Figure 6. Depth function for pH in Soil Profile No. 1 192 m east of the San Gregorio fault at Pescadero High School, Pescadero, California.

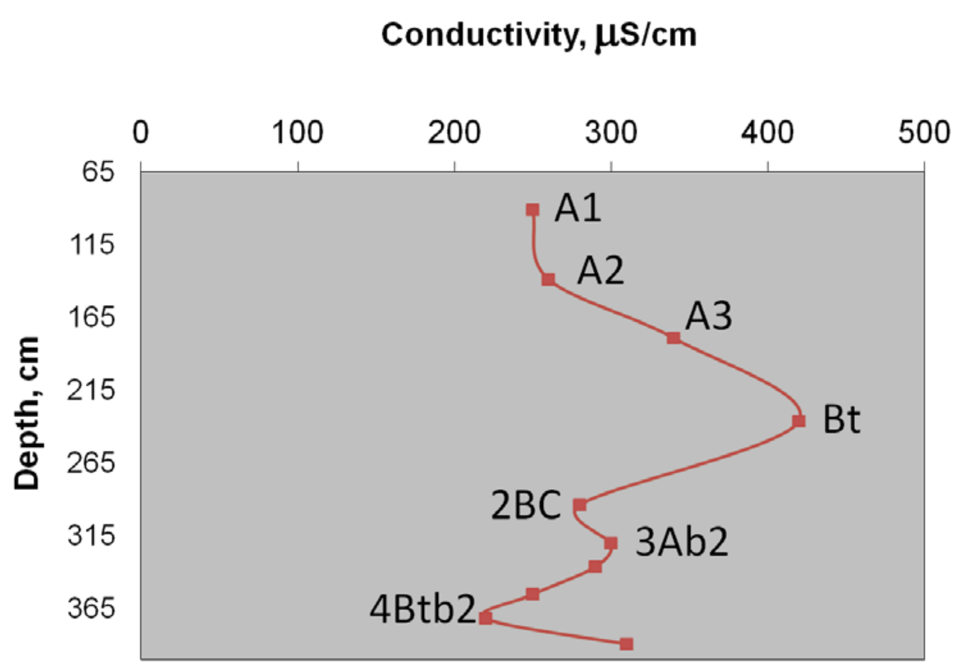

Figure 7. Depth function for electrical conductivity in Soil Profile No. 1 192 m east of the San Gregorio fault at Pescadero High School, Pescadero, California. The maximum indicates an area of salt entrapment. These often exist at the base of fine-textured paleosols (Borchardt, 2016).

SOILS 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 a matching unit. (See also yr B.P., HOLOCENE, PLEISTOCENE, QUATERNARY, PEDOCHRONOLOGY).

AGGRADATION. Deposition on the earth's surface in the direction of uniformity of grade.

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) 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.

CARBONATE MORPHOLOGY STAGES. Descriptive classes of calcite precipitation indicating increasing pedogenesis over time:

Stage	Description	Percent Carbonate
I	Bk horizon with few filaments and coatings	<10
I+	Bk with common filaments and continuous clast coatings	<10
II	Bk with continuous clast coatings, white masses, few nodules	>10
II+	Bk as above, but matrix is completely whitened, common nodules	>15
>II	K horizon that is 90% white, many nodules	>20
III+	K that is completely plugged	>40
IV	K as above, but upper part cemented and has weak platy structure	>50
V	K same as above, but laminar layer is strong with incipient brecciation	>50
VI	K brecciation and recementation, as well as pisoliths, are common	>50

CATENA. A sequence of soils of about the same age, derived from similar parent material and forming 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 horizon.--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).

The following is from the Natural Resources Conservation Service, except for the proposed addition of mn:

“Suffix Symbols

Lowercase letters are used as suffixes to designate specific kinds of master horizons and layers. The term “accumulation” is used in many of the definitions of such horizons to indicate that these horizons must contain more of the material in question than is presumed to have been present in the parent material. The suffix symbols and their meanings are as follows:

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.

co *Coprogenous earth*

This symbol, used only with L, indicates a limnic layer of coprogenous earth (or sedimentary peat).

d *Physical root restriction*

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

di *Diatomaceous earth*

This symbol, used only with L, indicates a limnic layer of diatomaceous earth.

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^{o} 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^{o} 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 slates 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 organo-sesquioxide 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. [Note: No longer used to indicate “juvenile.”]

jj *Evidence of cryoturbation*

Evidence of cryoturbation includes irregular and broken horizon boundaries, sorted rock fragments, and organic soil materials existing 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 secondary carbonates*

This symbol indicates an accumulation of visible pedogenic calcium carbonate (less than 50 percent, by volume). Carbonate accumulations exist as carbonate filaments, coatings, masses, nodules, disseminated carbonate, or other forms.

kk *Engulfment of horizon by secondary carbonates*

This symbol indicates major accumulations of pedogenic calcium carbonate. The suffix kk is used when the soil fabric is plugged with fine grained pedogenic carbonate (50 percent or more, by volume) that exists as an essentially continuous medium. The suffix corresponds to the stage III plugged horizon or higher of the carbonate morphogenetic stages (Gile et al., 1966).

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 dominant cementing agent (or the two dominant ones) may be indicated by adding defined letter suffixes, singly or in pairs. The horizon suffix km or kkm indicates cementation by carbonates; qm, cementation by silica; sm, cementation by iron; yym, cementation by gypsum; kqm, cementation by lime and silica; and zm, cementation by salts more soluble than gypsum.

ma *Marl*

This symbol, used only with L, indicates a limnic layer of marl.

mn *Mangans*

This symbol indicates an accumulation of manganese oxide, generally as ped coatings called mangans (First used by Borchardt on 20130418.)

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 slate. 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.

se *Presence of sulfides*

Typically dark colors (e.g., value <4, chroma <2); may have a sulphurous odor.

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 *in situ* within a 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 *Presence of human-manufactured materials (artifacts)*

This symbol indicates the presence of manufactured artifacts that have been created or modified by humans, usually for a practical purpose in habitation, manufacturing, excavation, or construction activities. Examples of artifacts are processed wood products, liquid petroleum products, coal, combustion by-products, asphalt, fibers and fabrics, bricks, cinder blocks, concrete, plastic, glass, rubber, paper, cardboard, iron and steel, altered metals and minerals, sanitary and medical waste, garbage, and landfill waste.

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 (<50% by volume).

yy *Dominance of gypsum*

This symbol indicates an accumulation of gypsum (>50% by volume); light colored (e.g., value >7, chroma <4); may be pedogenically derived or inherited transformation of primary gypsum from parent material.

z *Accumulation of salts more soluble than gypsum*

This symbol indicates an accumulation of salts that are more soluble than gypsum; e.g., NaCl.

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.

MAP. Mean annual precipitation.

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.

REFUGIUM. A place of refuge. Plants, animals, and soil minerals tend to accumulate only in the most ideal areas when surrounded by a hostile environment.

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.

SURFACE FAULT RUPTURE (SFR). Permanent disturbance of soil surface occurring as a result of tectonic offset. This may produce ground cracks, offsets, and warping of soil horizons.

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.