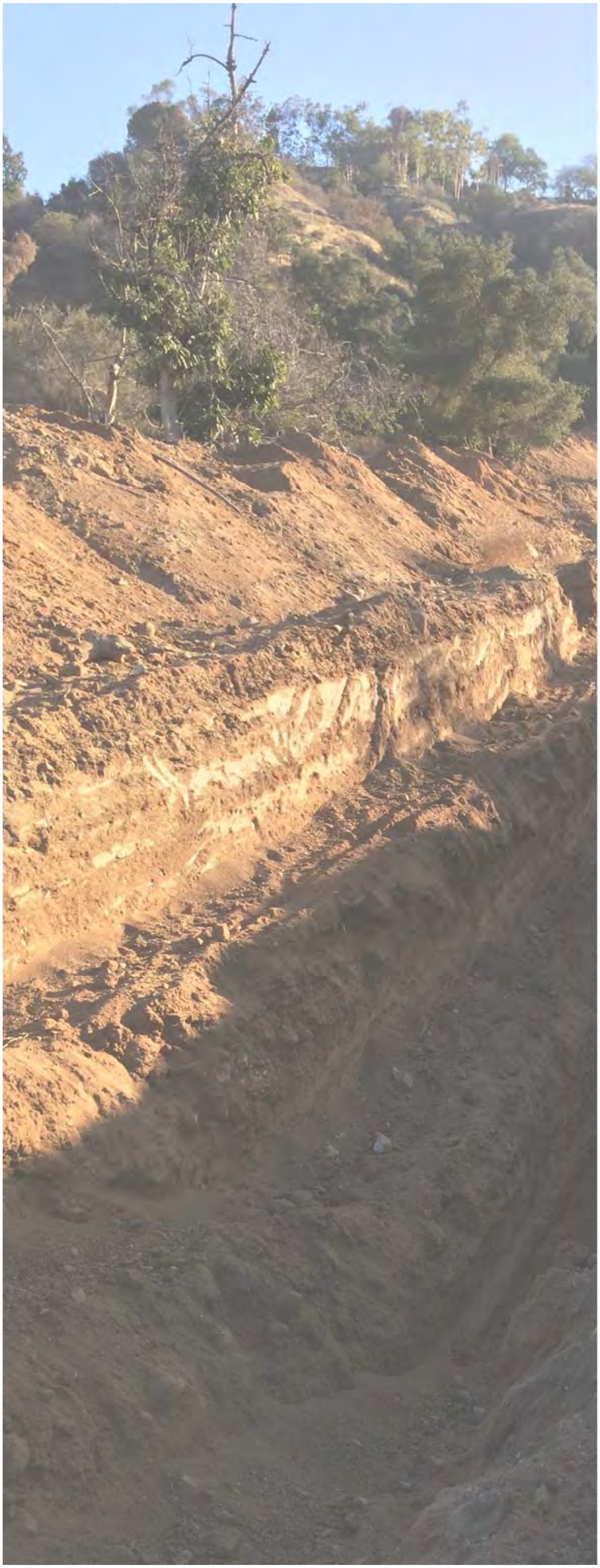


Fault Investigation for the Property at 1901 Royal Oaks Drive, Bradbury, Los Angeles County, California

Prepared for:
YIHE California PTY. LTD.

682 Deodar Lane
Bradbury, California 91008

Prepared by:
Earth Consultants International, Inc.

1642 E. 4th Street • Santa Ana
California • 92701
Telephone: (714) 544-5321

Project Number 3509
October 6, 2015

Project No. 3509
October 6, 2015

Earth Consultants International

To: **YIHE CALIFORNIA PTY. LTD.**
682 Deodar Lane
Bradbury, California 91008

Attention: **Mr. Ken He**

Subject: **Fault Investigation for the Property at 1901 Royal Oaks Drive, in the City of Bradbury, Los Angeles County, California**

Dear Mr. He,

Earth Consultants International, Inc. (ECI) is pleased to present this report summarizing our findings and conclusions of a study conducted at your request, and per your authorization, for the property at 1901 Royal Oaks Drive, in the city of Bradbury, Los Angeles County. The property is referred in this report as "the site." A residential building and another structure, both currently vacant, a pool, horse stables and horse arenas currently occupy the site. It is our understanding that the relatively flat southern portion of the site is to be subdivided into eight residential lots. The purpose of our study was to assess whether faults associated with the Sierra Madre fault system that would have the potential for future surface rupture extend beneath the portion of the site proposed to be re-developed, or within 50 feet north of the northernmost proposed building footprint. The specific branch of the Sierra Madre fault zone that has been inferred through the site is referred to as the Duarte fault.

To conduct this study we reviewed several publications and geological reports for other sites along the Duarte fault to summarize the current knowledge on this fault. We then excavated, cleaned, logged and photographed two trenches with a combined total length of about 540 feet. The trenches were excavated in a southerly direction, roughly perpendicular to the easterly trend of the Duarte fault as mapped through this area. The stratigraphic units exposed in the trenches were reviewed carefully for lateral truncations of units or offsets that would suggest faulting.

The subsurface data we collected indicate that the site is underlain by debris flow, sheet-food, and alluvial (stream) sediments emanating principally from the Bradbury Hills immediately to the north of the proposed development area. These sediments are generally coarse grained, varying in texture from sand to cobbles and boulders. Pedogenic (soil) development and intense weathering of the rock clasts observed in the deeper sections of the trenches indicate that the trenches were deep enough to expose sediments more than 11,700 years old, and thus Pleistocene in age. No breaks or disruptions in the lateral continuity of the sediments were observed in the trenches. Our observations indicate that there are no active faults beneath the area evaluated as part of this study. Therefore, measures designed to avoid or mitigate the potential for surface fault rupture are not deemed necessary for the proposed development. The trenches were reviewed by the City of Bradbury reviewing geologist. Once we completed our field documentation of the trenches, these were backfilled with the soils removed during the excavation; the backfill soils were placed at 90 percent or better of their maximum dry density. Soil technicians from Cal Land Engineering tested the backfill.

The following report describes in detail the trenches and sediments exposed therein, including an analysis of the age of the sediments, and our conclusions and recommendations regarding the surface fault rupture potential at the site.

We appreciate the opportunity to provide geological services for this project. Should you have any questions regarding the information presented herein, please do not hesitate to contact us at (714) 412-2654.

Respectfully submitted,
EARTH CONSULTANTS INTERNATIONAL, INC.
Registered Geologists and Certified Engineering Geologists

Tania Gonzalez, CEG 1859
Sr. Project Consultant / Vice-President

Report Distribution:
Addressee: 3 Hardcopies and 1 Digital Copy
Jeffrey B. Causey, Studio IE: 1 Digital Copy
Jack Lee, Cal Land Engineering: 1 Digital Copy

TABLE OF CONTENTS

Section No. **Page No.**

FIGURES, TABLES AND PLATES

APPENDICES

FAULT INVESTIGATION FOR THE PROPERTY AT1901 ROYAL OAKS DRIVE, IN THE CITY OF BRADBURY, LOS ANGELES COUNTY, CALIFORNIA

1.0 INTRODUCTION

1.1 Purpose of the Study, Scope of Work and Methodology

At your request, and per your authorization, we are pleased to present this report summarizing the results of a fault investigation we conducted for a site with street address at 1901 Royal Oaks Drive, in the city of Bradbury. The Alquist-Priolo Earthquake Fault Zone (APEFZ) map for the Azusa Quadrangle (California Geological Survey - CGS, 2014) shows that the entire site is located within the APEFZ for the Duarte fault, an inferred southern trace of the Sierra Madre fault zone (Figure 1). The APEFZ map shows that the Duarte fault in the site vicinity is thought to consist of one trace that extends across the subject site in an easterly to east-southeasterly direction. The State of California considers a fault active if it has moved at least once in the past about 11,000 to 11,700 years, during the Holocene (the Act says 11,000 years but the CGS is now using 11,700 years).

The study summarized herein was designed to evaluate whether or not active faults associated with the Duarte fault extend through the developable portion of the site, or within 50 feet to the north of the northernmost proposed building footprint. Geologic studies such as this one are required for properties within an APEFZ if the site is to be developed or re-developed for habitable purposes (the State requires these studies for a project of four or more units).

The purpose of this study was three-fold:

1) Investigate the area of the site proposed for development for the presence of faults;
2) Evaluate the age of the geologic units encountered in the trenches to assess whether or not Holocene-age deposits or surfaces are faulted; and
3) If faults were encountered, evaluate the potential for future fault displacement, and provide specific recommendations for mitigation, as warranted.

Specific tasks that we conducted as part of this study, and the methodology that we used, are described below.

- We obtained and reviewed readily available pertinent maps and publications summarizing the regional geology, including published reports on the Duarte fault, and consulting reports for the site vicinity that were readily available (see the list of References in Appendix A).

- We marked the trench locations (Photo 1) and notified Underground Services Alert (USA) to confirm that there were no underground utilities underneath the proposed trench locations (Photo 2). The trenches extended in a southerly direction from approximately 50 feet to the north of the northernmost proposed building footprint to the southern property boundary. The trenches were located so as to miss as much as possible the existing oak trees onsite, and to veer southwesterly, away from the active channel near the eastern property boundary.

Photo 1: Trench location was marked with white stakes and flagging.

Photo 2: Information on location of proposed trenches was sprayed painted at the site entrance to assist the Underground Services Alert (USA) utility locators that responded to our request.

- We subcontracted the excavation of one long trench (Trench 1a) that extended in a southwesterly direction across most of the study area (Photo 3). Trench 1a was almost 490 feet long, between about 10 and 14 feet deep, and oriented between about S4W and S65W. As mentioned above, the trench was curved southwesterly to avoid the mature oak trees on the property and to veer away from the channel near the site's eastern boundary. To investigate the southernmost portion of the site, we also excavated a shorter trench (Trench 1b) that extended from the southern fence northward to overlap with the longer trench (Figure 2). Trench 1b was approximately 50 feet long, not including the access ramp on its north end, between about 8.7 and 14.5 feet deep, and was oriented predominantly in a N22W direction (Photo 4). The trenches were excavated with a 320 Caterpillar excavator fitted with a 3-foot-wide bucket. For safety reasons, and in accordance with Cal-OSHA requirements, the trenches were benched, with each bench not exceeding 5 feet in height, and ramped on one end to allow entry into and exit out of their deeper portions (Photos 3 and 4).

- Once the trenches were dug, we used hand scrapers and brushes to clean the trench walls, removing smears left behind by the trackhoe's bucket and exposing a fresh surface for logging. To prepare the trenches for logging, we used string and nails to establish a level line on each bench to use as a reference, and marked stations at 5-foot intervals using spay paint directly on the trench walls, adjacent to the level lines. We then made a graphic representation of the eastern wall exposures (that is, we logged the eastern trench walls) by measuring from the level lines to the contacts between stratigraphic units and other pertinent features, such as top and bottom of the trenches and the benches. Discrete sedimentary layers, soil horizons, large boulders, animal burrows (krotovinas) and other features were plotted on the logs. The geologic units and soils exposed in the trenches were described, and the lateral continuity of these units was reviewed. We also photographed the trench walls. A photomosaic of Trench 1b is included in Plate 2.

Photo 3: View to the south of the excavation of Trench 1a, showing the excavator used for the job. Note the benches.

Photo 4: View to the north of the northeast wall of trench T-1b showing the benches, access ramp, level lines and flagged units.

- We looked for samples of organic material, such as detrital charcoal, that could be dated using the radiocarbon dating method. We did not find any samples that were reliably associated with undisturbed sediments (the charcoal samples that we did see were typically near or within animal burrows, or were in the uppermost layers of the trench, and thus not helpful in establishing the age of the sediments exposed at depth). We also proposed to collect one sample of sediment to be dated using the Optically Stimulated Luminescence (OSL) method. However, none of the laboratories that we contacted could provide an OSL age in less than 12 months. Thus, we estimated the age of the sediments using soil-stratigraphic methods that rely on the degree of soil development. Our soil descriptions are included in the trench logs. Additional information regarding soil-age dating methods is provided in Section 2.4, and our findings are presented in Section 3.2. We also noted the degree of weathering of the clasts (cobbles and boulders) and compared these observations to McFadden et al.'s (1982) clast weathering stages (Section 2.5).

- We notified the City of Bradbury and requested that their geological consultant review the trenches. Mr. Mark Schluter, Sr. Engineering Geologist with Converse Consultants, and the acting City of Bradbury geologist, reviewed the excavations on August 18, 2015.

- We located the trenches on a topographic map of the site prepared by and provided to us by Cal Land Engineering (CLE). To do so, we used a Brunton compass and measuring tape to locate the trenches relative to known points on the map, such as power poles, rock walls, and trees. Since we did not find any faults in the excavations, the services of a professional surveyor to locate the faults were not deemed necessary.

- We had the trenches backfilled using the soils removed during the excavation (Photo 5). The soils were moisture-conditioned and compacted to at least 90 percent of their maximum dry density. CLE provided observation and engineering testing services during the backfill. Their compaction report is included here in Appendix B.

Photo 5: View to the north-northeast of the site after Trench 1a had been backfilled.

- We prepared this report and accompanying illustrations summarizing our findings, conclusions and recommendations.

This investigation addresses only the hazard of surface fault rupture. Potential issues associated with slope instability, including earthquake-induced slope failure, were not part of our scope of work and are not addressed herein.

1.2 Site Location and Description

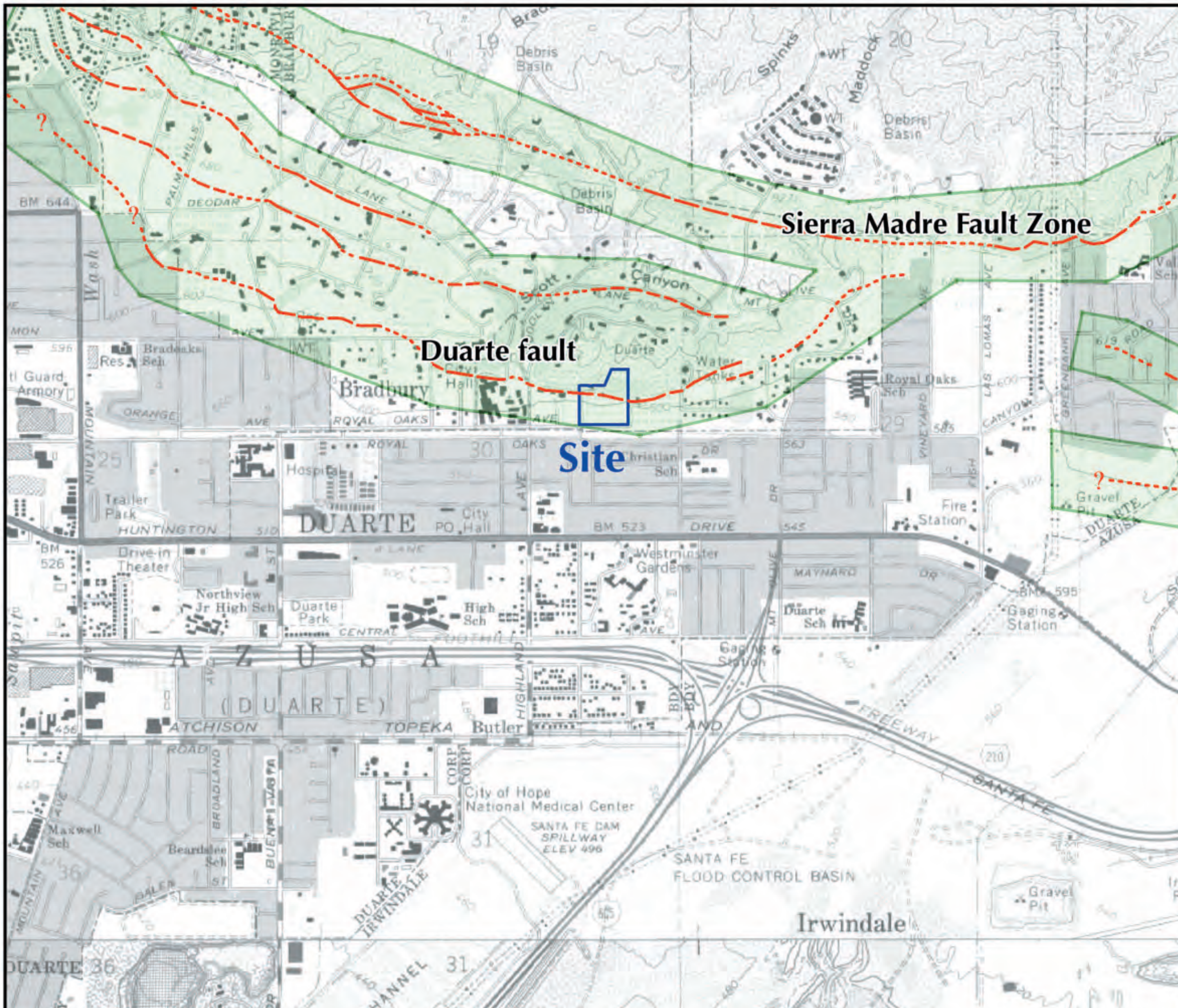
The site is located directly to the northeast of where Royal Oaks Drive and Royal Oaks Avenue come together, in the southeastern portion of the city of Bradbury, a hillside community at the base of the San Gabriel Mountains in eastern Los Angeles County, California. The property is irregular in shape: the southern approximately four-fifths form a rough square, topped to the northeast by a polygon-shaped section, as shown on Figure 1.

The southern portion of the site slopes gently to the south-southwest at a gradient that varies from about 5 feet vertical for every 40 feet horizontal (8:1), to about 5 feet vertical for 80 feet horizontal (16:1). In the northern portion of the site, the topography steepens significantly, to a gradient of more than 10 feet vertical for every 20 feet horizontal (2:1). Based on a site plan provided to us by CLE, elevations at the site range from 840 feet above mean sea level where the top of the ridgeline intersects the northern property boundary, to an elevation of 575 feet above mean sea level at the site's southeastern corner. Geomorphically, the portion of the site proposed for development is located at the base of the Bradbury Hills, or Bradbury piedmont, an elevated area south of the San Gabriel Mountains that is interpreted to be bound by elements of the Sierra Madre fault to the north and south, and in between (Treiman, 2013). Several small steep channels draining this elevated area flow into the gently sloping southern portion of the site, where they spread out at the break in slope. As a result, the southern portion of the site is underlain by a series of mudflow, sheet-flood and alluvial deposits. These geologic units are described in detail in Section 3.1.

At the time of our investigation, the site was occupied by a main residential structure, and a smaller, unattached structure to the west of the main house. Both buildings were, to our knowledge, uninhabited. A drained (dry) swimming pool was located immediately to the east of the main house. To the south, scattered throughout the site were a few small structures that appear to have been used for horse stables. Open areas, including one enclosed by short fencing, appeared to be used to exercise horses (horse arenas). The site was at one time also used as a fruit orchard, with several avocado and citrus trees present around the property, generally placed in terraced rows. Irrigation to these trees appears to have been stopped some time before we commenced our fieldwork; several of the trees appeared stressed and the irrigation lines that we intersected in our excavations were no longer in use. In addition to the fruit trees, the site has several oak trees, especially toward the northern half of the site and in the hillside area outside of where development is proposed. The southern property boundary abuts a Los Angeles County Flood Control District easement that includes a concrete-lined channel and a hiking trail. Residential properties are located to the east and west of the site, and to the south, south of the trail and Royal Oaks Drive.

1.3 Project Description

It is our understanding that the approximately 10.7-acre site is to be re-developed into eight residential lots of varying size, with the area of proposed construction limited to the southern, more gently sloping portion. The four southernmost lots will each be about one acre (ranging from 43,638 to 45,013 square feet, based on a site plan dated September 8, 2015 provided to us by CLE). The northern four lots will include the hillside portion of the property to the north of the area proposed for development. These lots will vary in area from 65,501 square feet for Lot 5 on the property's northwestern corner, to 102,479 square feet (Lot 7). An east-trending private driveway with a cul-de-sac at its eastern end will service all eight proposed lots, with this driveway separating the four southern lots from the four lots to the north (see Figure 2). The proposed driveway will veer southward along the site's western boundary, with access onto Royal Oaks Drive, essentially following the site's current entrance. The proposed building pads will all be near the proposed private street.



N
W E
S

2000 0 2000
Feet

Scale: 1:24,000

Base Map: Sure!Maps Raster, 1998

EXPLANATION

Approximate Site Location

ALQUIST-PRIOLO EARTHQUAKE FAULT ZONE OF REQUIRED INVESTIGATION (CGS, 2004)

Earthquake Fault Zone Boundaries delineated by straight-line segments that connect encircled turning points; boundaries define the zone encompassing active faults that constitute a potential hazard to structures from surface faulting such that avoidance would be required.

Faults considered to have been active during Holocene time and to have potential for surface rupture; solid line where accurately located, long dash where approximately located, short dash where inferred, dotted where concealed; queried (?) indicates additional uncertainty.

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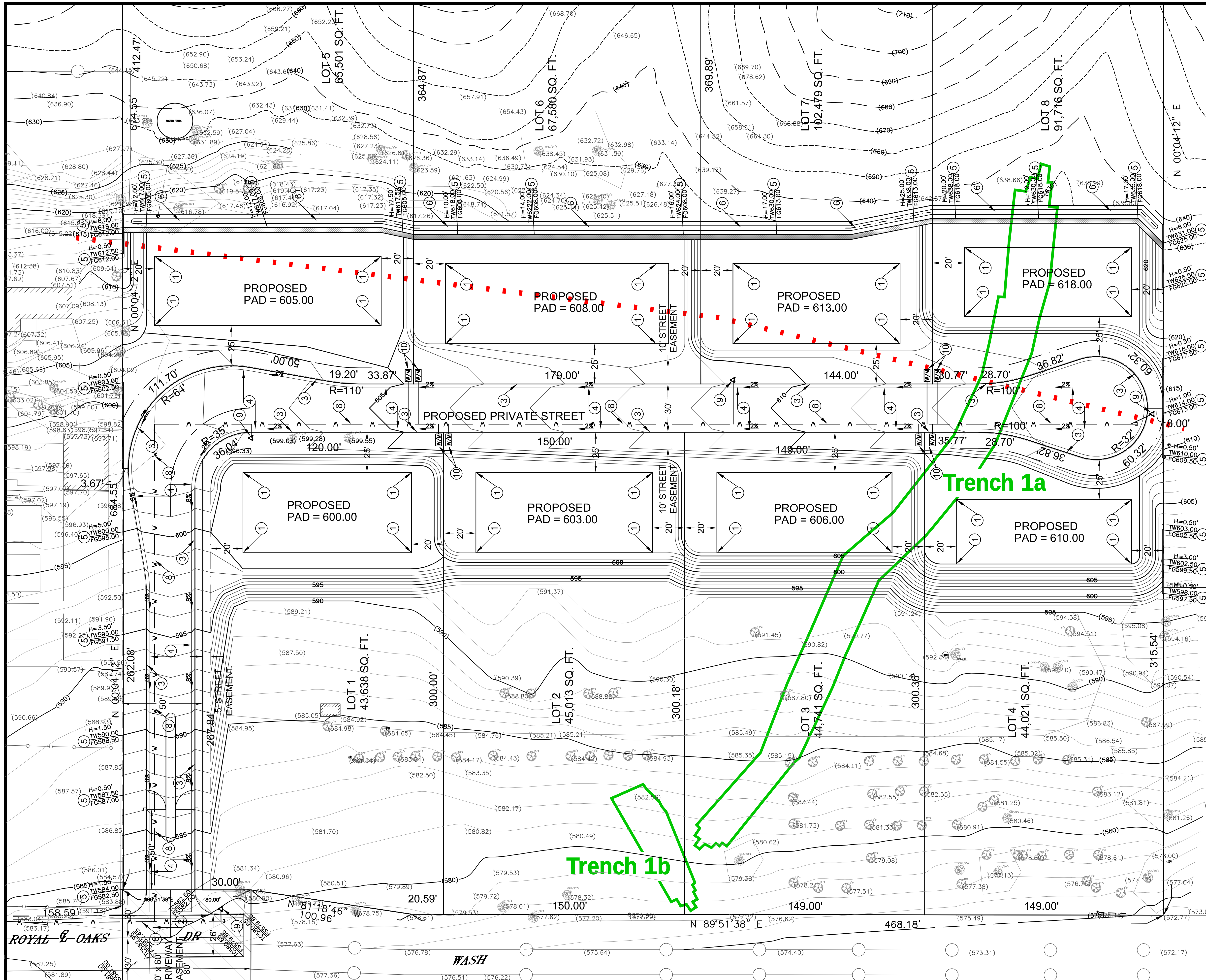
Date: 2015

Site Location Map Showing the Alquist-Priolo Earthquake Fault Zone Boundaries

1901 Royal Oaks Drive, Bradbury, California

Figure 1



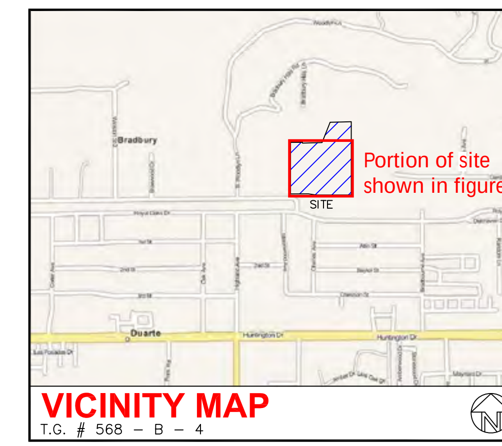
Trench Location Map Showing Inferred Duarte Fault and Location of Proposed Pads

1901 Royal Oaks Drive, Bradbury, California

N

0 40 80
(IN FEET)
1 inch = 60 ft.

Approximate fault location (from CGS, 2014)



Base Map Prepared by: Jack Lee, R.C.E. 40870
CalLand Engineering, Inc., 09/08/2015
County Benchmark Number 2348
RDBM TAG in S CB 2FT w/o BCR @ SW COR
Highland Ave. and Huntington Dr.
Elevation: 536.752'

Only the southern portion of the site is shown; see Vicinity Map above.

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Date: 2015

Figure 2

2.0 BACKGROUND

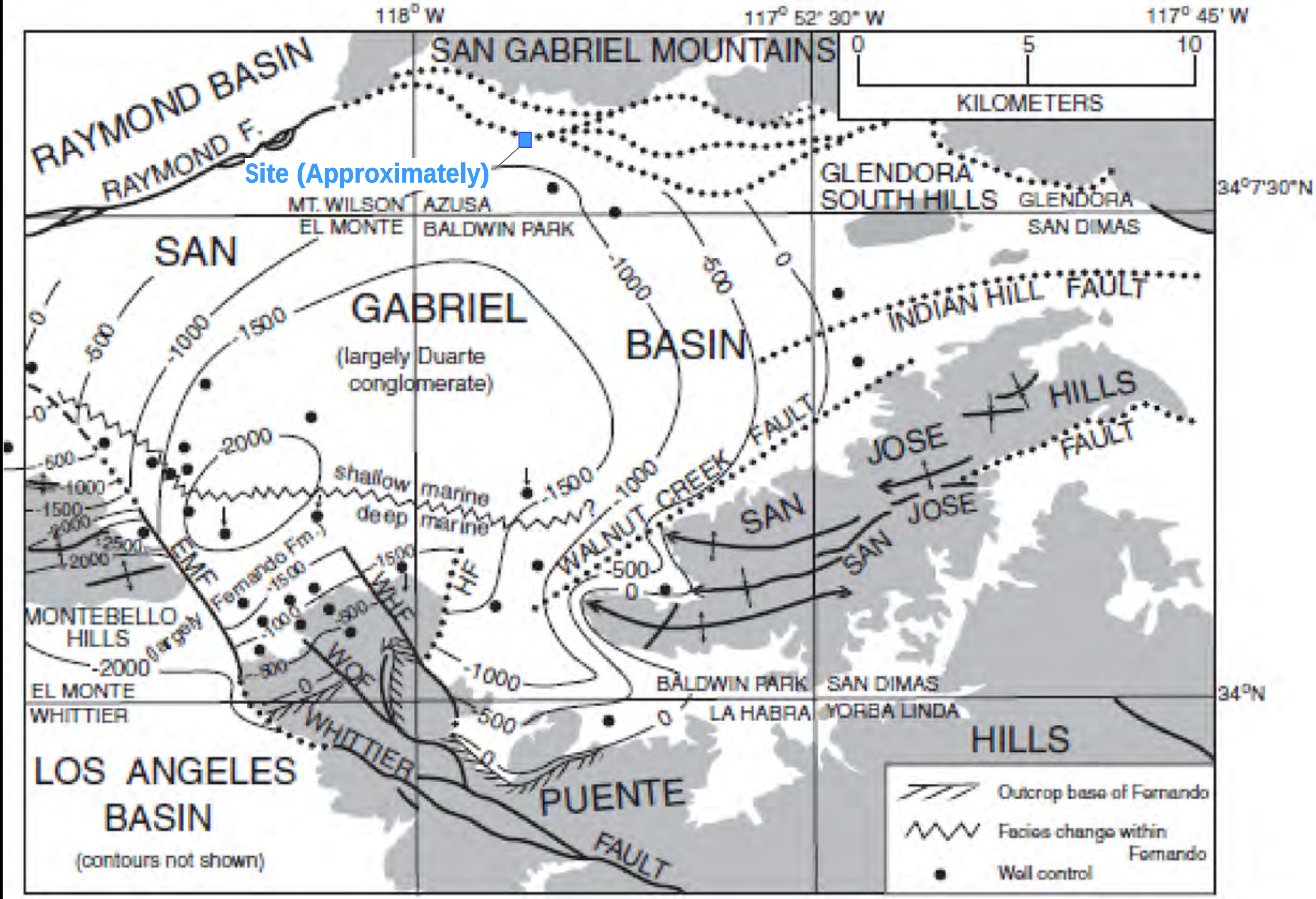
2.1 Regional Geologic Setting

The site is located at the transition zone between the Peninsular Ranges and the Transverse Ranges physiographic provinces of southern California. The Peninsular Ranges are characterized by northwest-trending geologic and physiographic features that are in turn dominated by zones of right-lateral strike-slip and oblique-slip faulting. Dominant features of the Peninsular Ranges include the San Andreas fault system, including the Elsinore-Whittier and Newport-Inglewood faults, to name only a few. Conversely, the Transverse Ranges are primarily controlled by west-trending physiographic and structural features, including the San Gabriel and Santa Monica Mountains, the reverse faults considered responsible for these uplifts, and the west-trending basins at the base of these highlands. Studies suggest that both the northwest- and west-trending systems of faults may be accommodating the north-south shortening (Yeats, 2004) and rotation that the Los Angeles region is currently experiencing in response to the "Big Bend" in the San Andreas fault to the north (Walls et al., 1998). In the site vicinity, the Transverse Ranges Southern Boundary fault system is defined by the Sierra Madre fault, a north-dipping reverse fault that extends for approximately 75 km from the northern San Fernando Valley eastward to San Antonio Canyon, where it connects with the Cucamonga fault (Yeats, 2004).

Most of the site is on the gently sloping floor of the San Gabriel Valley, a depositional basin on the south side of the San Gabriel Mountains, south of the main Sierra Madre fault. This roughly triangular-shaped basin plunges southwestward toward the Puente and Montebello hills, where the base of the Fernando Formation is approximately 6,500 (2,000 meters) below sea level. This deep-marine sedimentary unit grades northward and upward into a shallow marine and ultimately terrestrial facies called the Duarte Conglomerate (Yeats, 2004; see Figure 3). The Duarte Conglomerate crops out in the northern, steeper portion of the site, where it forms the base of the elevated area referred to by Treiman (2013) as the Bradbury piedmont. Additional information regarding the Duarte Conglomerate and other geologic units exposed at the site is provided in Section 3.1.

2.2 Duarte Fault

The Duarte fault is considered a southern element of the Sierra Madre Fault Zone (SMFZ), and some researchers have suggested that it is one of the youngest faults in the SMFZ as it appears to elevate the approximately 2.4-million-years-old Duarte Conglomerate 100 to 200 feet (30 to 60 meters) above the valley floor. Treiman (2013) indicates that the Duarte fault was first mapped by Eckis (1934), but that Shelton (1946) named it. The fault's location is inferred from geophysical profiles, groundwater elevation differences, and geomorphic indicators, but to date, to our knowledge, it has not been observed in trenches or exposures. In fact, Yeats (2004) shows the Duarte fault and other elements of the Sierra Madre fault bounding the San Gabriel Valley as buried or covered (see Figure 3). Crook et al. (1987), Dibblee (1998) and Morton and Miller (2006) also show the Duarte fault as buried (see Figures 4, 5, and 6, respectively), and Dibblee (1998) actually queries the fault through the site area, indicating that its "existence is doubtful." Note that Morton and Miller (2006) map the buried Duarte fault farther out in the valley, approximately along the site's southern boundary (Figure 6). Thus, the location, and even existence of this fault in the shallow subsurface are uncertain.



Structure contours, in meters, **of the base of the Fernando Formation.** In the San Gabriel Basin, the structure developed during Fernando deposition. Facies boundary is between a sequence of Duarte Conglomerate underlain by basal shallow-marine deposits, and a Los Angeles Basin sequence including deep-water Repetto and Pico Members.

Large **dots** indicate well control; dot with arrow indicates well did not reach base of the Fernando.

Faults are denoted by heavy lines and, where covered, by small dots.

From Figure 8 of Yeats, 2004

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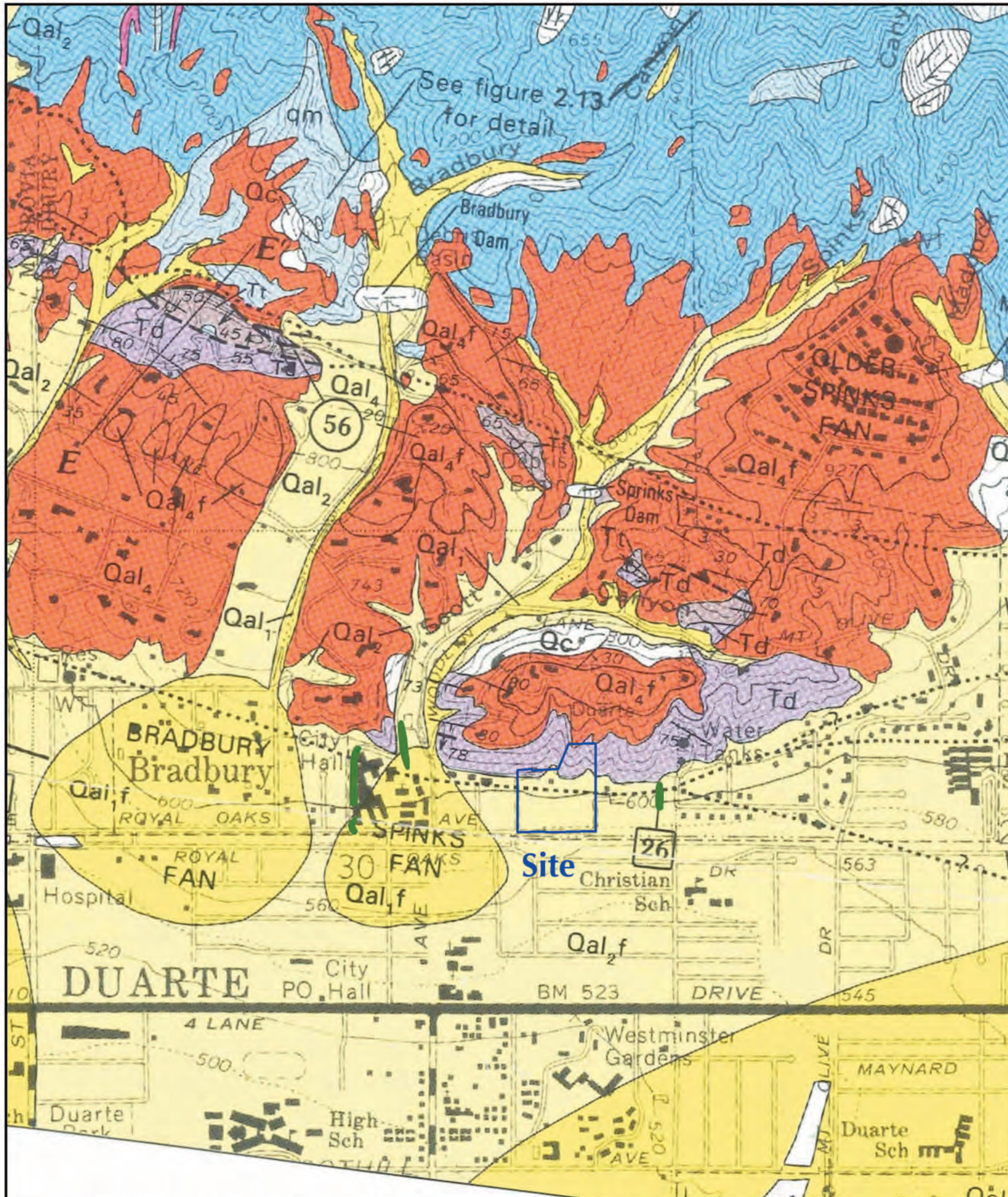
Date: 2015

Approximate Site Location Relative to the San Gabriel Basin and the Faults Bounding the Basin (Figure also shows the base of the Fernando Formation in the Basin)

Figure 3



Source: Modified from Crook et al. (1987)

EXPLANATION

Geologic Units (from youngest to oldest)

Qc Colluvium (Holocene) – Talus and slopewash, generally brown to reddish brown, poorly sorted, heterogeneous deposits of locally derived debris. These deposits are more abundant than indicated on the map but are generally too small to show.

Qal1 Unit 1 Alluvium (Holocene) – White to light gray unconsolidated fine to coarse sand and gravel containing abundant cobbles and boulders; includes deposits of present stream channels, flood plains, and alluvial fans (now mostly controlled by flood-control channels and dams). Qal1f = alluvial fan surface.

Qal2 Unit 2 Alluvium (Holocene) – Gray to pale brown unconsolidated fine to coarse sand and gravel containing abundant cobbles and boulders; includes deposits of stream terraces, recently abandoned flood plains, and alluvial fans with incipient soil. Qal2f = alluvial fan surface.

Qal4 Unit 4 Alluvium (Pleistocene) – Red to reddish brown or yellow unconsolidated to well-consolidated fine to medium sand and gravel containing few to many cobbles and boulders; all clasts are highly weathered, and deposits have moderate to moderately high clay content and are commonly fractured or jointed; includes terraces and highly dissected and (or) buried fans with highly developed soils. Qal4f = alluvial fan surface.

Td Duarte Conglomerate (Pliocene?) – Tan moderately consolidated boulder conglomerate with well-rounded clasts and a clayey sandy matrix.

Tt Topanga Formation (Miocene) – Tan to brown or reddish-brown, interbedded conglomeratic sandstone, sandstone, and shale.

qm Quartz Monzonite and Granodiorite (Cretaceous) – Gray to tan fine to medium-grained intrusive rocks.

wd Wilson Diorite of Miller (1934) (Cretaceous) – Gray hornblende-biotite-quartz diorite.

Symbols

Fault: Showing dip. Dashed where approximately located; dotted where concealed; queried where inferred.

Strike and Dip of Stratified Rocks:

73 Inclined Overturned

Trench: Approximate location of trenches excavated and logged by others in the site vicinity (from Treiman, 2013, 2014). See text for more information.

N W E S

1000 0 1000
Feet
Scale: 1:12,000

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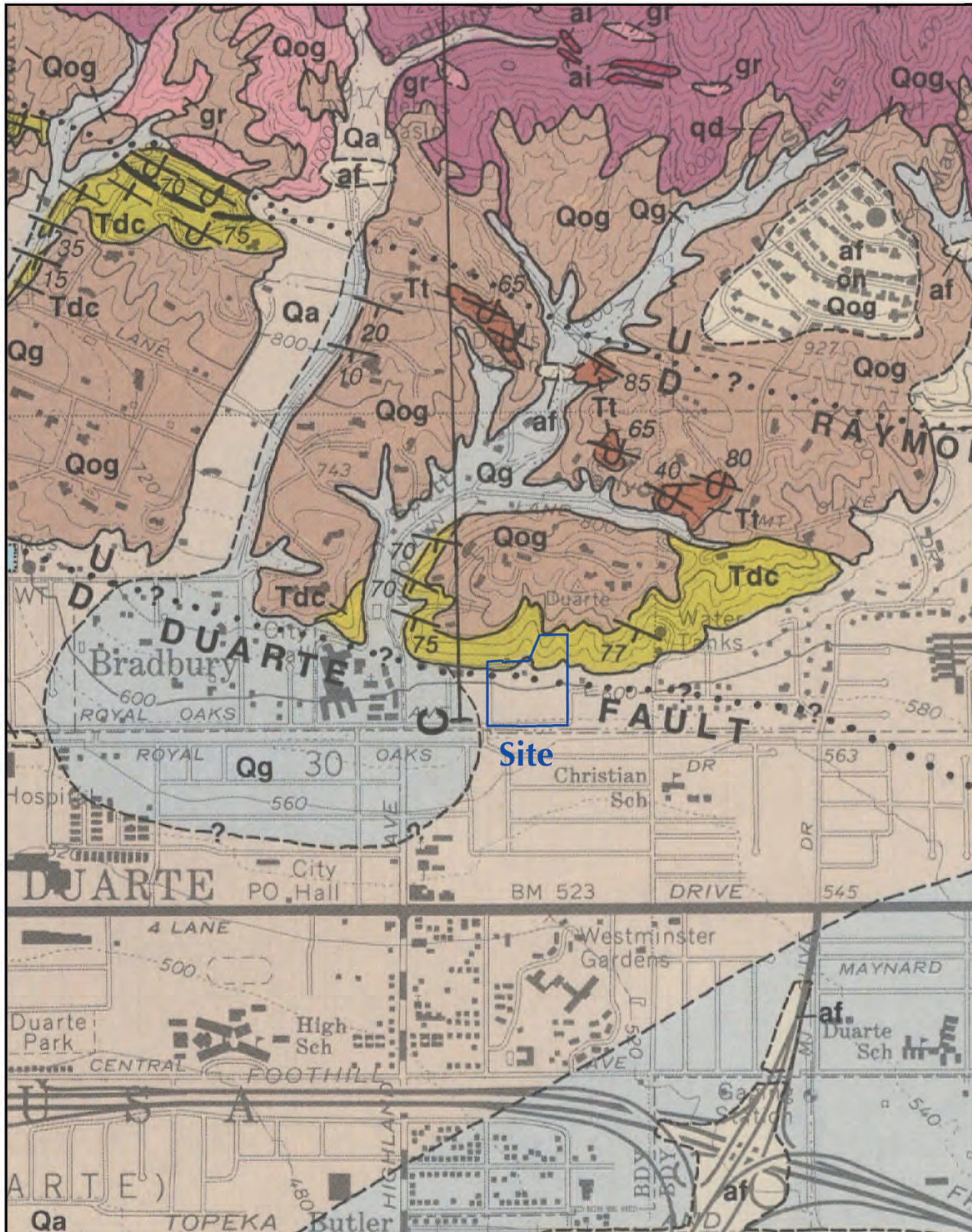
Project Number: 3509
Date: 2015

Geologic Map by Crook and Others

1901 Royal Oaks Drive,
Bradbury, California

Figure 4



EXPLANATION

Geologic Units (from youngest to oldest)

af	Artificial fill; not all areas shown
Qg	Gravel and sand of major stream channels and alluvial fan outwash from major channels
Qa	Alluvial gravel, sand and silt of valley areas
Qog	Elevated remnants of fan gravel and sand, includes San Dimas formation
Tdc	Duarte Conglomerate: gray, weakly indurated, vaguely bedded alluvial cobble conglomerate of mostly granitic and gneissic rocks
Tt	Topanga (?) Formation: tan to light gray moderately indurated fine to coarse grained sandstone
ai	dike rocks: thin dikes of light to medium gray-brown dacite to andesite
gr	granitic rocks, gray-white, medium- to fine-grained massive granitic rocks
qd	quartz diorite, gray, medium-grained, somewhat incoherent where weathered

Symbols

U ? D

Fault: Dashed where indefinite or inferred, dotted where concealed, queried where existence is doubtful. Relative vertical movement is shown by U/D (U = upthrown side, D = downthrown side).

Strike and Dip of Stratified Rocks:

Inclined vertical Overturned

N W E S

Source: Dibblee (1998)

1000 0 1000
Feet

Scale: 1:12,000

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Project Number: 3509
Date: 2015

Geologic Map by Dibblee

1901 Royal Oaks Drive,
Bradbury, California

Figure 5

Deep in the subsurface, the Duarte fault is imaged as a "moderately north-dipping" low-velocity zone and buried scarp that offsets velocity reflectors approximately 8,200 feet (2,500 meters) and extends at least 3.1 miles (5 km) into basement rocks, based on a deep seismic profile conducted as part of the Los Angeles Region Seismic Experiment (LARSE) (Fuis et al., 2001; Lutter et al., 1999). Shallower in the subsurface, the location of the fault has been inferred from steps in the depth to groundwater reported by the California Department of Water Resources (1966) and compiled by Crook et al. (1987). More recently, to the east of the San Gabriel River, in the Azusa area, geotechnical studies at Citrus College have shown the presence of a groundwater barrier and cascade that is presumed to coincide with the subsurface location of the fault (M&T Agra, 1993; Geobase, Inc., 2005, 2006a, 2006b, 2007; as reported in Treiman, 2013). We suggest, however, based in part on a review of aerial images of the region, that the changes in the depth to groundwater may be associated with the westward incision of a proto-Dalton Wash canyon during a low sea level stand, rather than faulting. Groundwater would collect at the bottom of the now-filled in canyon that was incised into the surrounding older alluvium in response to a glacial maximum, or perch on top of clay-rich layers filling in the old drainage. Similar groundwater depth anomalies in the Hollywood area originally assumed to be fault-related have been found to be associated with older, incised canyons, indicating that changes in groundwater depth need not be fault-controlled (Group Delta, 2015).

Geomorphic characteristics suggestive of the Duarte fault include "diffuse linear zones of steepened gradient" . . . and the "steep and abrupt front to the elevated piedmont surface on which much of the city of Bradbury is developed" (Treiman, 2013). According to Crook et al. (1987), incision of the older Holocene Qal2 surface north of the fault and deposition of young Holocene Qal1 deposits south of the fault indicate relatively recent fault activity (refer to the young fan surfaces on Figure 4). However, the locations where incision stops and deposition begins are north of the inferred trace of the fault and the presumed location where uplift has occurred as a result of reverse movement on the Duarte fault. The Qal1 and Qal2 surfaces do not show any geomorphic evidence of deformation, such as tilting or steepened gradient. These observations indicate that the drainages responsible for deposition of these units are not "seeing" the fault, and thus that the last movement on the fault, if present in this area, pre-dates deposition of these sediments. Given that the Qal2 unit is considered to be up to 11,000 years old, and that there is no 11,000- to 200,000-years-old Qal3 unit mapped in this area that can be used to assess its late Pleistocene tectonic history, it is possible that movement on the Duarte fault, if the fault indeed is present in the subsurface in this area, last occurred in the Pleistocene, more than 11,000 years ago. If that is the case, then this fault is not active.

Based on data presented in Treiman (2013), prior to this study, only two trenching studies conducted in the site vicinity across the mapped trace of the Duarte fault have been reported in the literature. The first of these, described in Crook et al., (1987), where it is referred to as site 26, was located immediately east of the property addressed in this report (see Figure 4). The study at site 26 consisted of a trench (their trench 19) that was excavated and logged in December 1977 by CalTech graduate students. The trench reportedly varied in depth between 6 and 17 feet, and exposed Duarte Conglomerate at the north end of the trench, and locally at its bottom. The bedrock was reportedly locally sheared, but the shears did not extend upward into the overlying colluvial sediments, and Crook et al. (1987) reported that no faulting was observed in the trench. Treiman (2014), however, considers this study inconclusive because Crook et al.'s description of the sediments "implies deposits that are too young to preclude

Holocene faulting." Furthermore, according to Treiman (2014), the unpublished field notes include a possible fault in the colluvium, near the south end of the trench, that was reportedly observed by an undergraduate assistant. That Crook et al. (1987) chose not to show this "possible" fault in the final description of the trench, as discussed in their report, suggests that they did not concur with the undergraduate assistant and did not observe or interpret a fault there.

The second, more recent study is west of the study site, at the mouth of Scott Canyon, where LeRoy Crandall and Associates (1989) excavated a 360-foot long trench as part of a fault location study for a proposed nursing facility (see Figure 4). Additional trenching at this site was conducted by Jerry Kovacs and Associates in 1997, who reportedly excavated five overlapping trenches in the southern portion of the property that shadowed the 1989 trench. The first trench exposed Duarte Conglomerate sporadically along its base in the northern approximately 160 feet, in addition to "better consolidated Holocene alluvium." The southern 200 feet of the trench reportedly exposed only young, poorly consolidated sediments. The 1997 trenches, which were up to 11 feet deep, exposed sediments considered to be Holocene in age. We suggest that the "better consolidated" alluvium may have in fact been older, as Holocene alluvium is not typically consolidated or semi-consolidated. Given this site's location at the mouth of a canyon, it is certainly expected that the sediments in the southern portion of the site would be young. Thus, we do agree that the studies at this site may have been inconclusive regarding the location and activity of the Duarte fault.

Given that none of the paleoseismic studies conducted across the mapped trace of the Duarte fault have found the fault, there are no data currently available on the fault's earthquake history, recency of activity, kinematics, or rate of slip. It is our understanding that our study is the first fault investigation conducted in the city of Bradbury since the APEFZ map zoning this segment of the Duarte fault was issued (Mr. David Gilbertson, City of Bradbury Engineer, personal communication).

2.3 Previous Geotechnical Studies Conducted by Others at the Site

Based on data provided to us by the current project engineer, a geotechnical review of the site was conducted in 1989 by Duco Engineering, Inc. (Duco). At the time, the proposed project consisted of subdividing the property into seven residential lots, and the geotechnical study evaluated the surface and near-surface soil conditions at the site to provide recommendations for grading of the property. The study by Duco included the excavation, logging and sampling of five test holes excavated with a backhoe to depths of between 6 and 10 feet. Relatively undisturbed and disturbed samples of soil were collected and analyzed in the laboratory for in-situ moisture, maximum density, expansion potential, and soil strength. Their report provided recommendations for site preparation, foundation support, retaining walls, and cut and fill slopes. The proposed project was deemed feasible from a geotechnical standpoint. The study did not include a fault evaluation as the fault that had already been inferred through the site by Crook et al. (1987) had not been zoned by the State as sufficiently active and well-defined. In 1991, Duco conducted a slope stability analysis for the site in support of a debris basin that was proposed at the site, and in 1992, additional analyses were provided in response to a review sheet received from the County of Los Angeles Department of Public Works regarding a proposed storm drain.

More recently, in March 2015, and in support of the current proposed development as described in Section 1.3, the geotechnical conditions at the site were reviewed and analyzed by Cal Land Engineering, Inc. dba Quartech Consultants (CLE). Their study included the excavation, logging and sampling of twelve backhoe test pits that were between 5 and 9 feet deep. CLE provided us with copies of their preliminary test pit logs, but we did not review their final geotechnical report. It is our understanding that while doing their study, the geotechnical engineers realized that the site is now located within an Alquist-Priolo Earthquake Fault Zone, and contacted us to provide the fault investigation services described herein.

2.4 Using Soils for Age Estimations

Undisturbed, in-situ organic materials such as charcoal that could be used to obtain an absolute age of the sedimentary deposits were not encountered in the trenches. We considered collecting samples of the sediments for analysis using the Optically Stimulated Luminescence dating method, but none of the laboratories that we contacted could provide us with results in a timely manner. As a result, we relied on non-absolute dating techniques to estimate the age of the sediments exposed. Specifically, we used soil development and clast weathering as indicators of the age of the sediments. Clast weathering is described in Section 2.5, whereas the use of soil development for age estimations is described further below.

The term soil as used here refers to a natural body of mineral and/or organic material consisting of layers (or horizons) that are different from the underlying geologic material in their "morphological, physical, chemical and mineralogical properties and their biological characteristics" (Birkeland, 1984). These differences are the result of weathering and the effects of five main soil-forming factors: parent material, climate, slope or topography, organisms, and time (Jenny, 1941). Time is an important factor because the longer a geologic deposit is exposed to the effects of weathering and soil formation, the better developed the soil characteristics become. We take advantage of this factor when using soils to estimate the age of the deposits.

Soil development occurs on stable geomorphic surfaces (a stable surface is one that is not significantly impacted by deposition or erosion). Soil development typically starts to occur as soon as a surface stops being eroded or deposited on. Therefore, in some environments, such as an alluvial plain or alluvial fan, it is common to find several weak to moderately well developed buried soils that rest one upon the other, sometimes separated by unaltered sediments (the parent material). The soils represent periods of sub-aerial weathering and soil formation that occurred in between periods of alluvial erosion and deposition. The age of the underlying primary deposits is estimated by summing the age of the individual overlying buried soils, recognizing that the soil-age estimates will provide a minimum age for the parent material, as the estimated ages do not account for the length of time it took for the sediments to be deposited. Furthermore, if portions of soil horizons, or even entire soil horizons, have been removed (truncated) from the area by erosion, that soil's data are no longer available for analysis and the age estimates will not include that period of soil formation, resulting in a potentially significant younger age estimate. Nevertheless, if these limitations are recognized, soils developed in fluvial or alluvial fan environments can provide useful information. In areas where suitable datable materials such as charcoal are not available or cannot be trusted due to intense bioturbation and mixing, soil-age estimations are particularly useful.

We described the near-surface and buried soils observed in the trenches excavated for this study using a combination of the characteristics and nomenclature established by the Soil Survey Staff (1975, 1992), the National Soil Survey Center (2012), and Birkeland (1984, 1999). Colors of the soil horizons were recorded by comparing the color of the matrix, mottles and clay films both in the dry and wet states to color chips in a Munsell Soil Color Chart. Characteristics that we recorded include: 1) texture, i.e., grain size distribution, including the presence of gravel, pebbles and cobbles, 2) structure, i.e., whether the soil mass breaks into distinctive peds, or is single-grained, 3) the amount, distribution and thickness of translocated clay forming films or stains on the soil ped faces and clasts, in pores, and in between sand grains (called bridges), 4) the looseness or induration of the soil peds when dry and moist, and 5) the stickiness and plasticity of the wet soil. Where the pebbles, cobbles and boulders showed signs of weathering, we also noted that information following McFadden et al.'s (1982) clast weathering criteria (see Section 2.5). Finally, the sharpness and relief characteristics of the contact (or boundary) between horizons were also noted. The soil descriptions are provided on the trench logs (Plates 1 and 2) and are summarized and discussed in Section 3.2.

To estimate the age of geologic deposits using soil-stratigraphic techniques we rely on a comparison of the characteristics of the soils in question with those of other soils in the region developed in similar parent materials that have been dated using both absolute and relative dating methods. For this quantitative comparison, the characteristics of the soils are assigned numerical values that are then used to calculate the soils' degree of development. We used two of these quantitative methods for this study: Harden's (1982) Soil Development Index (SDI), and Ponti's (1985) Maximum Horizon Index. The SDI values were then normalized to a depth of 200 cm to compare the results to equally normalized SDI values presented in the literature and in the regressions used. Both SDI and MHI values have been shown to be useful relative indicators of soil age, with older, better developed soils having higher SDI and MHI values (Harden, 1982; Harden and Taylor, 1983; Rockwell et al., 1984; Rockwell et al., 1990; Bornyasz and Rockwell, 1997). To obtain minimum age estimates for the soils described, we compared the soils' SDI and MHI values with the soil age regressions presented in Dolan et al. (1997), which are based on the chronosequences by Rockwell (1983), Rockwell et al. (1985), Harden (1982), and McFadden and Weldon (1987).

In these quantitative assessments, the characteristics of the parent material are "subtracted" from the characteristics of the soil being analyzed to develop a realistic estimate of the length of time that a geologic deposit has been subject to the effects of weathering and soil formation. Field studies have shown that all other conditions being equal, a soil developed in fine-grained sediments is better developed, with increased horizonation and illuviation, than a coarse-grained soil of similar age (Rockwell et al., 1985). We accounted for these differences when estimating the ages of the soils, as described below.

Review of the trenches indicates that two main sedimentation processes have occurred in this area: 1) fluvial deposition consisting of fining-upward sequences of gravelly sand and sand of differing grain sizes, and 2) alluvial fan or alluvial apron deposition consisting of poorly sorted to coarsening-upward mudflow or debris flow sediments that include gravel, cobbles and boulders up to a few feet in diameter. Some of the fluvial sections observed in the trenches may have been deposited in one single flood event, whereas others are bedded, with alternating sequences of coarse-grained and fine-grained sediments that suggest several flood events. The unaltered primary geologic unit that constitutes the parent material for the soils at the site appears to be predominantly sand, as observed and described at several locations (refer to Plates 1 and 2). However, to account for the potential minor concentration of finer-grained silt and clay, especially in the debris flow deposits, we used a loamy sand as the parent material. The ages that we have calculated are thus conservative and slightly younger than if we had used sand as the parent material. The SDI and MHI values calculated for the soils described for this study, and the age estimates provided by each method are summarized in Section 3.2.

The age estimates we calculated essentially indicate the approximate length of time that each of the soils observed in the trenches was exposed to soil-forming processes at the surface prior to burial. The soil regressions provide a median age estimate, and minimum and maximum values that capture 95 percent of the data used to generate the equations. To estimate the age of the entire section exposed in the trenches, we added the soil-age estimates calculated for each soil (that is, the surface soil and the buried soils we observed). This method provides a minimum age for the section, recognizing that this estimate does not account for the length of time it took for the sediments to be deposited, nor does it include any soils since removed by erosion that are no longer present in the record. In an effort to be as conservative as possible in our age estimates, we opted to use the average of the age estimates provided by the MHI and SDI (normalized and non-normalized) methods, and emphasize the minimum and median age estimates obtained. As shown in Section 3.2, even skewing the results toward the young end of the spectrum, we show that the trenches for this study exposed Pleistocene-aged sediments at depth.

2.5 Clast Weathering Stages as Age Indicators

General estimates of the age of the deposits were also made using the degree of weathering of pebbles, cobbles and boulders exposed in the different geologic units observed in the trenches. McFadden et al. (1982) defined cobble-weathering stages that can be used to estimate the approximate age of the deposits containing the cobbles. Simply put, older sediments have more weathered clasts. The clast weathering stages and age estimates defined by McFadden et al. (1982) are described below. Observations regarding the degree of weathering of the clasts are included in the trench logs and are summarized as appropriate in Section 3.1.

Stage 1: Unweathered bedrock, rings sharply to blow of hammer. Mafic rocks exhibiting Stage 1 weathering characteristics are estimated to have been exposed to weathering agents for less than about 1,000 years. Leucocratic (light-colored igneous rocks) exhibiting Stage 1 characteristics are thought to have been exposed to weathering agents for less than about 4,000 years.

Stage 2: Slightly weathered bedrock, incipient to moderate surface pitting, fractured, with oxidation rinds greater than 1-2 mm in thickness, yields moderate ring to blow of hammer. Stage 2 mafic rocks have been exposed to weathering agents for about 4,000 years, whereas Stage 2 leucocratic rocks could have been weathering for as much as about 10,000 years.

Stage 3: Substantially weathered bedrock, surface highly pitted, strongly fractured, mafic minerals and feldspars may be strongly altered, clasts can be broken with difficulty by hand, dull sound to blow of hammer. Stage 3 mafic rocks are estimated to have been exposed to weathering agents for 10,000 to 75,000 years; Stage 3 leucocratic rocks could have been weathering for as much as 400,000 years.

Stage 4: Very strongly weathered bedrock, easily disaggregated by hand into grus; very dull sound when struck with hammer. Stage 4 mafic rocks have weathered for more than about 75,000 years; Stage 4 leucocratic rocks have weathered for more than 400,000 years.

3.0 FINDINGS

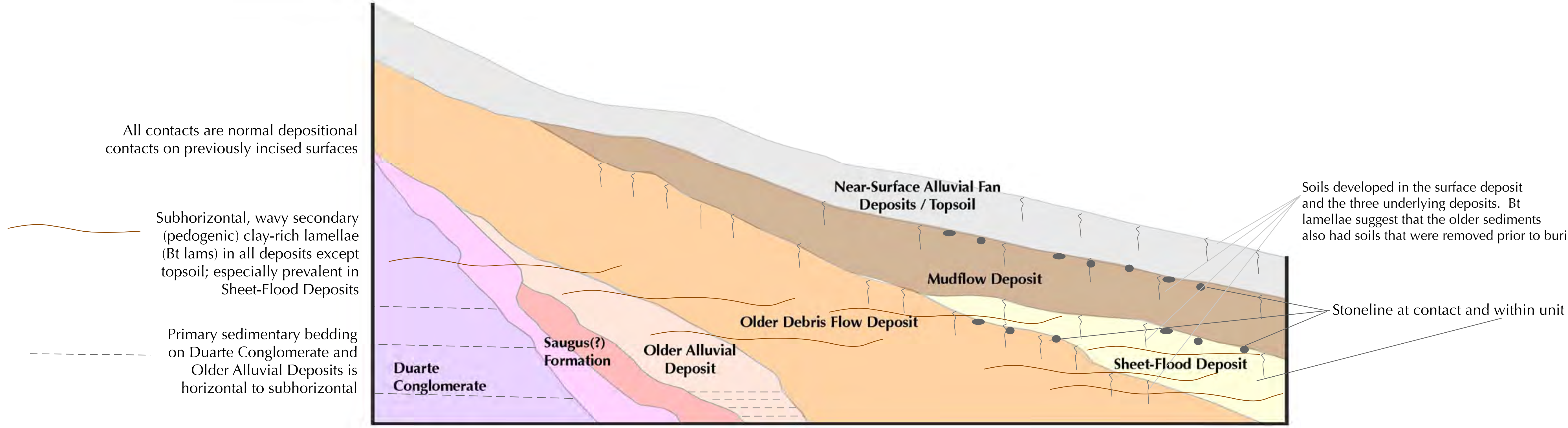
3.1 Geologic Units

The geologic units exposed in the trenches excavated and logged for this study include artificial fill, several alluvial and colluvial deposits including mudflows or debris flows, and unconsolidated to consolidated sediments assigned to the Saugus(?) Formation and Duarte Conglomerate. Several of these geological deposits have been modified by pedogenic processes and have soils developed in them. Generalized descriptions of the geologic units and soils exposed in the trenches are provided below, from oldest to youngest, and a stratigraphic column summarizing these units is provided in Figure 7. For a more detailed description of the geologic deposits and soils exposed in each trench refer to the trench logs in Plates 1 and 2.

3.1.1 Duarte Conglomerate (shown in light purple on Plate 1)

The north end of Trench 1a was excavated into the base of the steep hillside that defines the northernmost portion of the site. The geologic deposit exposed in this area consists of consolidated sandstone, gravelly sandstone and conglomerate with rounded to subrounded, weathered clasts of diorite, gneiss, and other lithologies. The clasts exposed in the trench were up to 2.5 feet long, and very strongly weathered, to Stage 4, as defined in Section 2.5. Moderately well-defined bedding could be discerned from the exposure in Trench 1a; the beds were horizontal to subhorizontal, indicating that at this location, this unit has not been deformed by folding or faulting (Photo 6). This observation is significant given that previous researchers have shown the bedrock underlying the Bradbury piedmont as being strongly deformed, with steep dips of between 70 and 77 degrees to the south, although the bedding measurements shown are generally to the north and west of the site (see Figures 4 and 5).

All geologic maps reviewed show Duarte Conglomerate in this area (Crook et al., 1987; Dibblee, 1998; Morton and Miller, 2006). Our description of the unit exposed at the north end of Trench 1a is consistent with their descriptions for the Duarte Conglomerate. Yeats (2004) indicates that in the western part of the San Gabriel Basin, the deep-water Fernando Formation changes facies to a largely non-marine sequence that includes conglomerate assigned to the Duarte Conglomerate. This unit crops out at the base of the San Gabriel Mountains, where Shelton (1955) showed it to be almost 1,500 feet (450 m) thick. The Duarte Conglomerate is considered to be late Tertiary in age, possibly Pliocene, and up to 2.4 million years old (Yeats, 2004).



Geologic Unit	Estimated Age	Generalized Description	Soil Profile Developed Therein
Near-Surface Alluvial Fan Deposits / Topsoil	>3,800 years old, with a median age of 11,900 years, and possibly up to 38,000 years old.	SANDY LOAM, **LOAM** and **SANDY CLAY LOAM** grading downward to **GRAVELLY SANDY CLAY LOAM**; brown (10YR 4/3 to 7.5YR 5/4) when dry, very dark brown, dark brown and very dark grayish brown (10YR 2.5/2 to 7.5YR 3/3) when moist; moderate fine to coarse subangular blocky and granular soil structure; few thin clay films on ped faces and bridging grains in A horizon; common thin and few moderately thick clay films bridging grains, many thin clay films on ped faces, many thin to moderately thick clay films on ped faces, and continuous moderately thick clay films in clast pockets in Bt horizon; organics-rich; rounded clasts to 3-inches in diameter.	A, A/Btj or A/Bt
Mudflow Deposits	>4,200 years old, with a median age of 25,200 years, and possibly up to 80,000 years old.	GRAVELLY SANDY CLAY, LOAMY SAND and **SANDY LOAM**; brown (7.5YR 5/4), dark brown to brown (7.5YR 3.5/3); moderate to strong coarse angular blocky soil structure; very hard to extremely hard when dry; many thin and few thick clay films on clasts, many thin clay films bridging grains, many thin clay films in pores; dark reddish brown (5YR 3/4 when moist) Bt lamellae; subangular to rounded gravel and cobbles to 6-inches in diameter weathered to Stages 2 to 4.	Bt
Sheet-flood Deposits	>15,500 years old, with a median age of about 51,000 years, and possibly up to 160,000 years old.	SANDY LOAM, **SANDY CLAY LOAM**, and **SANDY CLAY** to **CLAY**; brown (7.5YR 5/4) when dry, brown (7.5YR 4/4 when moist; weak to moderate fine to medium subangular blocky soil structure; few thin clay films on ped faces, common thin and few moderately thick clay films bridging grains, many to continuous moderately thick clay films on clasts; with dark reddish brown (5YR 3/3 when wet) Bt lamellae; subrounded to angular clasts weathered to Stages 2 to 4.	A/Bt/BC/Clam
Older Debris Flow	>20,000 years old, with a median age of about 64,000 years, and possibly up to 200,000 years old	SANDY CLAY LOAM to **SANDY CLAY**; brown to yellowish brown (7.5-10YR 5/3.5 to 5/4) when dry, dark brown to brown (7.5YR ¾ to 4/4) with dark reddish brown (5YR 3/3) clay films when moist; moderate medium angular to subangular blocky soil structure; common thin clay films on ped faces, many thin and common moderately thick clay films bridging grains, common thin clay films in pores, many thin and common moderately thick clay films on clasts; Bt lamellae ¼-inch thick spaced about 1 to 1.5 inches apart; many pores; clasts near top of unit weathered to Stages 3 to 4.	Bt
Older Alluvium	>200,000 years old	Bedded fine to coarse **SAND, SANDY GRAVEL** and **LOAMY SANDY GRAVEL** grading upward to massive **SAND to LOAMY SAND** with cobbles weathered to Stage 4; light yellowish brown (10YR 6/4) when dry, dark brown to dark yellowish brown (10YR 3.5/4 and 4/4) when moist; single-grained; with Bt lamellae ¼- to ½-inch thick, spaced 1 to 2 inches apart.	No soil horizons remained; with Bt lamellae
Saugus(?) Formation	Up to 1.8 million years old	SILTY SANDSTONE with rounded gravel and pebbles to 3-inches in diameter; yellowish brown (10YR 5/4) with reddish brown (5YR 4/4) mottles when dry, dark yellowish brown to brown (10-7.5YR 4/4) when moist; dense; continuous thick clay films on clast pockets, many thin and common moderately thick clay films on clasts; with Bt lamellae. Capped by **SILTY CLAYSTONE**; strong brown (7.5YR 5/6) when dry, reddish brown (5YR 4/4) when moist; strong medium angular blocky soil structure; very hard to extremely hard when dry, sticky and plastic when wet; many thin to moderately thick and few thick clay films on ped faces, many thin clay films in pores, many to continuous clay films bridging grains, continuous moderately thick to thick clay films on clasts and in clast pockets; clasts are weathered to stage 4.	Silty claystone appears to be a buried Bt horizon
Duarte Conglomerate	Up to 2.4 million years old	Fine to coarse **SANDSTONE** and **GRAVELLY SANDSTONE** with subrounded boulders to 2.5-feet in diameter weathered to Stage 4; brown and yellowish brown (10YR 5/4 and 6/4) when dry, brown (7.5YR 4/4 and 5/4) when moist; very dense; with dark reddish brown (5YR 3/4 when wet) Bt lamellae up to 1-inch thick, spaced about 4 to 5 inches apart, with common thin clay films bridging grains.	No soil observed; with Bt lamellae

Generalized Stratigraphic Column and Structural Relations Observed in the Trenches

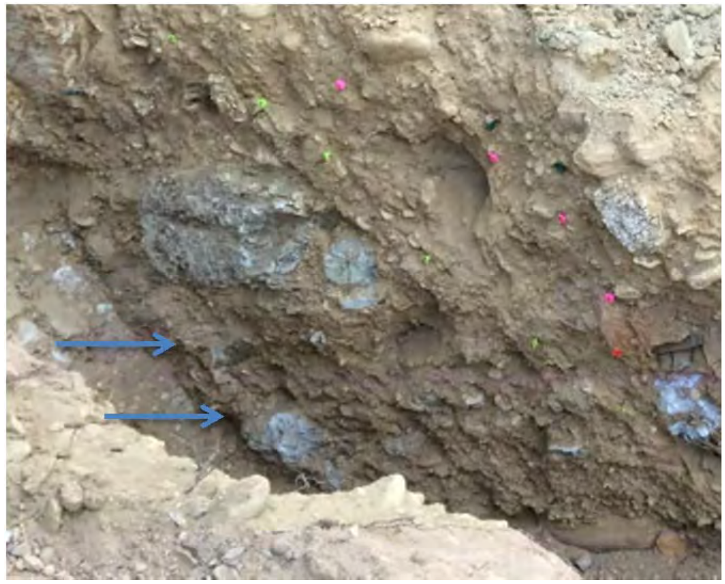
1901 Royal Oaks Drive, Bradbury, California

Earth Consultants International

Project Number: 3509
Date: 2015

Figure 7

Photo 6: View of the north end of trench 1a showing the geologic unit that we interpret as the Duarte Conglomerate. Note the large weathered rounded to subrounded boulders and the roughly horizontal to subhorizontal bedding (blue arrows). The light green and pink flags denote the bottom and top, respectively of the massive silty sandstone overlying the conglomerate. These south-dipping, contacts were irregular, with no evidence of shearing or gouge to indicate faulting.



3.1.2 Saugus(?) Formation (shown in pink and light red on Plate 1)

Also in the northern portion of the trench, at the bottom, between stations 0 and 10, unconformably deposited on top of the Duarte Conglomerate, we observed a sequence of sandstone and silty claystone that, based on its characteristics, appears to correlate with the exposures of possible Saugus Formation ("alternating beds of relatively clean sandstone, pebble- to cobble-size conglomerate, and red siltstone") described by Crook et al. (1987) in the Ruby Canyon – Monrovia Canyon area, about 2 miles to the west of the site. In Trench 1a these deposits included a bed of dense but friable, massive silty sandstone capped by a reddish brown silty claystone (Photo 7). The yellowish brown silty sandstone includes scattered rounded to subangular gravel and pebbles to 3-inches in diameter. Although internal, primary bedding was not apparent in the exposure, clay-rich lamellae (referred to as Bt lamellae or lams) that have formed as a result of secondary, pedogenic processes, were observed within the unit, especially toward its upper half. The lamellae were generally subhorizontal.

Photo 7: Close-up view of the possible Saugus Formation near Station 5 in Trench 1a, near its bottom, showing the sandstone and silty claystone layers comprising this unit. Although the matrix is fine-grained, gravel to pebble-sized clasts weathered to Stage 4 were observed in this deposit. Compare with Photo 6 and Plate 1.

Photo 8: Close-up view of the irregular, erosional contact between the reddish silty claystone assigned to the possible Saugus Formation and the overlying Older Alluvial deposits, at about Station 10, near the base of Trench 1a. Note the intensely weathered clasts in the Older Alluvium. Pink flags denote contact. White flag marks sediment sample location used to describe the claystone unit.

The silty claystone (Photo 8) has characteristics that indicate it was exposed to soil-forming processes for a long period of time, as evidenced by the strong angular blocky soil structure, and many to continuous clay films on ped faces, in pores, bridging grains and on clasts and clast pockets. The clasts observed within this unit were very strongly weathered; most could be disaggregated by hand into grus (Stage 4; see Section 2.5), consistent with this unit having been deposited and exposed to weathering processes for many tens to hundreds of thousands of years. This unit is considered Plio-Pleistocene in age, possibly about 1.8 million years old.

The contact between these deposits and the underlying Duarte Conglomerate was reviewed carefully; we found the contact to be irregular, with no evidence of shearing or gouge to suggest faulting or repeated movement (Photo 6 and Plate 1). The contact is south-dipping and listric, shallowing toward the bottom of the trench. We suggest that this contact could represent an old, thin-skinned, surficial landslide or shallow slump that occurred several hundreds of thousands of years ago, prior to the deposition of the alluvial and colluvial deposits described below. Alternatively, a thicker section of these sediments was deposited as a colluvial apron at the base of the hillside formed by the Duarte Conglomerate, with most of it subsequently removed by erosion before the older alluvial sediments described in Section 3.1.3 were deposited on top.

3.1.3 **Older Alluvial Deposits** (shown in light pink on Plate 1)

Buttressing and overlying the sediments described above, we observed the thin remains of an older alluvial deposit consisting of several horizontal to subhorizontal beds of well-sorted fine to coarse yellowish brown sand (channel deposits; Photo 9) overlain by a sand to loamy sand unit with gravel and cobbles (alluvial fan deposit; Photo 8). Primary sedimentary stratigraphy was observed in the beds near the bottom of the trench, between about stations 15 and 30 (Photo 9). The less well-sorted unit at the top was generally massive, but a few thin clay-rich, generally subhorizontal Bt lamellae were present. Bt lamellae were also present in the deeper fluvial deposits. The portion of this unit that remained was not modified extensively by pedogenic processes, but the exposure suggests that a significant thickness of this unit was removed by incision prior to the deposition of the overlying debris flow deposit. It is thus possible that this sedimentary deposit was capped by a soil, but that the soil has since been removed, leaving behind only the mostly unaltered, deeper sedimentary unit. The age of this deposit is unknown, but given that the clasts within it are extensively weathered, to Stage 4, we suggest that this unit is many hundreds of thousands years old, consistent with McFadden et al.'s (1982) age estimates using clast weathering stages, and possibly equivalent to, or even older than Crook et al.'s unit Qal4. Crook et al. (1987) estimated that their unit Qal4 is more than 200,000 years old.

Photo 9: View of the northeast wall of trench 1a, between stations 15 and 20, showing the older alluvial sediments exposed near the bottom of the trench (under and within the light yellow flags) against the reddish silty claystone of the Saugus? Formation (under pink flags). This photo is skewed, tilted down on the left, as indicated by the pink string in the middle of the photo that denotes a level, horizontal line. Also notice that many of the clasts in the coarser-grained Older Debris Flow Deposit are extensively weathered.

3.1.4 Older Debris Flow Deposits (shown in orange on Plates 1 and 2)

The next-youngest unit exposed in Trench 1a is a poorly sorted debris flow deposit that has been modified by soil-forming processes. This unit was exposed at the north end of the trench, where it overlies the Duarte Conglomerate and the other deposits described above, and along a significant portion of the bottom of the trench, as shown on Plate 1. This unit was also exposed at the bottom of Trench 1b (Photo 10).

This older debris flow deposit consists of gravelly sandy loam, sandy clay loam, to sandy clay, 7.5YR colors when dry and moist, with 5YR-hued clay-rich lamellae (Bt lamellae or Bt lams), common to many thin to moderately thick clay films, and clasts weathered to Stages 3 to 4. As expected, this unit is coarser grained at the northern end of the site, closer to the hillside (compare Photos 9 and 10). Based on the soil-age estimates we calculated for the profile exposed in Trench 1b, this deposit is thought to have a median age of about 64,000 years (with minimum and maximum age estimates of about 20,000 and 200,000 years, respectively, based on the lower and upper bounds of the envelopes that capture 95% of the data used to develop the soil age regressions used - see Table 2 in Section 3.2). Because the soil developed in this unit was truncated, and this and the overlying deposits show evidence of several periods where erosion dominated, these age estimates are considered minimum values. The degree of weathering of the clasts observed in this unit also suggests that it could be older.

Photo 10: View of the Older Debris Flow deposit at the bottom of Trench 1b at about Stations 30-32 (darker unit near the bottom, below the channel deposits). This unit has a significant concentration of secondary, pedogenic clay, and as a result, was easy to identify in the trenches. The pink string is the level line used as a reference to log the trench.

3.1.5 Sheet-Flood Deposits (shown in yellow in Plates 1 and 2)

The pedogenically altered debris flow deposits described above are overlain by a relatively thick sequence of finer-grained sediments that consist principally of sandy loam and fine to coarse sand. The unit appears to be predominantly massive, although nested channel deposits were observed locally within the deposit in Trench 1a (between stations 80 and 120, stations 150 and 180, and from about station 430 southward), and at the bottom of the unit in Trench 1b (channel deposits above the Older Debris Flow Deposit in Photo 10). Stonelines within this unit suggest that it was deposited by a series of sheet floods, rather than one flood event. Gravel and pebbles up to 4-inches in diameter were observed locally. The degree of weathering of these clasts varies between Stages 2 and 4. This unit was exposed from about Station 20 in Trench 1a southward to the southern property boundary, including in Trench 1b.

This deposit is characterized by wavy, clay-enriched reddish brown (5YR) lamellae typically ½- to 1-inch thick and spaced about 2- to 4-inches apart (Photo 11). The Bt lamellae extend laterally for tens of feet, and typically overlap. Bt lamellae (or lams) are thought to form at the bottom of the wetting front before an overlying argillic soil horizon develops further limiting the infiltration of water into the deeper part of the profile. In southern California, it is estimated that it takes approximately 5,000 years of near-surface exposure for Bt lamellae to form (Dr. Thomas Rockwell, personal communication). Bt lamellae are very useful secondary stratigraphic markers in fault investigations, especially when present in otherwise massive sediments, because they can help to highlight the zone of faulting, and can also be used to date the faulting event(s). For example, if the faulting pre-dates the formation of the lams, the fault plane often also acts as a barrier to the clay-enriched water, with the resultant deposition of reddish clay along the fault. If the faulting post-dates the formation of the Bt lamellae, these then show offsets that can be measured to determine the amount of movement and sense of displacement (Gonzalez, 1993). We reviewed the Bt lams along the full length of the trenches and did not find any evidence of these being offset or truncated by faulting, nor did we observe any Bt-lam-enhanced fault planes.

Photo 11: Close-up view of the sheet-flood deposits in the bottom bench of Trench 1a, at about Station 440, showing some of the clay-enriched Bt lamellae (arrows).

The Bt lams indicate that this sheet-flood deposit was exposed to soil-forming processes. An argillic (Bt) soil horizon was observed at the top of his unit in both trenches. The argillic horizon was capped by an A soil horizon of variable thickness in Trench 1b, and locally in Trench 1a, between Stations 20 and 30. As described in more detail in Section 3.2, the age of these sheet-flood deposits can be estimated by adding the time it took for this soil to develop when the geologic deposit was exposed at the surface, to the time it took to form all the overlying soils. Our estimate on the age of this unit is between about 15,500 (minimum) and 51,100 (median) years. Thus, this unit is Pleistocene in age, and consistent with Crook et al.'s (1987) Qal3 unit, although the soil observed in this unit is better developed than the soils described by them.

3.1.6 Mudflow Deposits (shown in brown in Plates 1 and 2)

The gently sloping portion of the site is underlain at relatively shallow depth by debris flow or mudflow sediments generated from the unstable slopes to the north during periods of intense rainfall. These deposits generally consist of poorly sorted, mixed fine- to coarse-grained sand with gravel, cobbles and boulders. Grain size typically decreases away from the mountain front, but the deposits can vary both laterally and vertically, with lenticular lenses or channel deposits that reflect the lateral migration of the high-energy braided streams that formed the coalescing alluvial fans. Randomly oriented pores that vary in size are reflective of the organic debris (including twigs, branches and leaves) that was incorporated into the mudflow sediment during transport and deposition, but that has since decomposed, leaving behind casts where the organic material used to be.

Photo 12: Close-up view of the pedogenically altered coarse-grained mudflow deposit observed in the middle bench of Trench 1a, at about Station 170. Notice the clay-coated clast pockets left behind on the trench wall.

Mudflow deposits in the near-surface were observed from about Station 10 southward to the southern end of Trench 1a, and along the full width of Trench 1b. The sediments consist of dark brown to dark reddish brown (7.5YR hues) gravelly to cobbly sandy loam to sandy clay loam (Photo 12), with subangular to rounded cobbles weathered to Stages 2 to 3.

An argillic soil horizon developed near the top of the unit was observed and described in both trenches. The degree of soil development represented by this now-buried argillic soil horizon as described in Trench 1b, combined with the age of the overlying surface soil, provides a minimum age for the mudflow deposits. This unit is estimated to be at least 8,000 years old (minimum age estimate), and possibly about 25,200 years old (median age estimate). The age of this unit could be older because the argillic soil horizon in Trench 1b that was used in the soil-age regressions has a loamy sand to sandy loam texture, whereas the argillic soil horizon preserved at the top of the mudflow unit in some portions of Trench 1a has a sandy clay loam texture. The finer-grained soil would give higher soil development index values that would return older age estimates.

3.1.7 Topsoil, Artificial Fill and Other Historical Deposits

We observed several near-surface deposits in both trenches, capping the older sediments described above. An organic-rich, dark brown, very dark brown to very dark grayish brown (10YR to 7.5YR hues) A soil horizon mantles the entire area. Starting at about Station 105 in Trench 1a, the A soil horizon is underlain by a weakly developed, dark brown (7.5YR hues) argillic soil horizon consisting of sandy clay loam. A similar, but more weakly developed argillic soil horizon was observed in Trench 1b, where we referred to it as a juvenile argillic (Btj) horizon (Photo 13). The modern soil is locally disturbed or mixed, the result of shallow excavations associated with the installation of plastic and metal irrigation pipes and concrete drainage pipes (Photo 14), and the felling of trees, leaving large roots behind. Large-sized fragments of charcoal were observed on top and within the A soil horizon. These are interpreted to be burnt fragments associated with a wildland fire that probably occurred in the past one or two decades in the site vicinity. Thick mats of organic debris consisting of horse manure and/or vegetation were exposed in the southern half of Trench 1a, starting at about Station 285. Finally, also predominantly in the southern portion of the site, as exposed in both trenches, the A soil horizon is covered with layers of light-colored soil that appear to have been imported or moved from elsewhere in the property.

Photo 13: Close-up view of the A and Btj soil horizons described in Trench 1b, at about Station 36. The top of the A soil horizon is defined by the 1-inch PVC pipe in the top center of the photo. The contact between the A and Btj horizons is etched into the trench wall, just above the pink level line.

Photo 14: View of the 2-foot wide concrete drain that we exposed at about Station 260 on the east wall of Trench 1a.

Because the historical deposits are not important to the conclusions of this investigation, we did not map them in great detail in our trench logs. The underlying surface soil, however, although weakly developed, has an argillic or juvenile argillic soil horizon that indicates the deposit that this soil is forming on has been at the surface for some time. Our estimates of the age of this soil, based on its characteristics as observed in Trench 1b, range from about 3,800 years (minimum) to 11,900 years (median). This age estimate is consistent with Crook et al.'s (1987) age estimate for their Qal2 deposit, which they mapped at the surface in the site vicinity, including the site proper (see Figure 4).

3.2 Soil-Age Estimates

Soil development, in the form of organic-rich A soil horizons, and clay-enriched, argillic (Btj and Bt) horizons were observed in the trenches excavated for this study. The presence of these soil horizons indicates that there have been relatively long periods of time, in the hundreds to thousands of years, when neither significant deposition nor erosion occurred on the valley floor, allowing these soils to develop. Essentially, these buried soils or paleosols represent prior surfaces of the valley floor, and the degree of soil development exhibited by each of these soils can be used to approximate the length of time that particular surface was exposed to soil-forming processes before it was buried by more recent alluvial fan, sheet-flood or debris flow deposition.

The soils we observed in the trenches developed within the stratified sequence of both fine- and coarse- grained sedimentary deposits described above. Soil formation within these deposits is represented by a stacked series of weak to moderately well developed soil profiles that rest one upon the other, locally separated by unaltered colluvial or alluvial sediments (the parent material). The soil age estimates we calculated provide a minimum age for the deposits that the soils formed into, especially in this environment, where portions of soil horizons, and sometimes even entire soil horizons appear to have been removed by erosion.

Trench 1b provided a fairly complete soil profile exposure that is also representative of the sediments and soils exposed in most of Trench 1a, as described in detail in Section 3.1 above. Not including the deposits assigned to the Duarte Conglomerate, the Saugus(?) Formation, and Older Alluvial Deposits described in Sections 3.1.1, 3.1.2 and 3.1.3, respectively, the site is underlain by sediments that, based on their soil characteristics, can be classified into four soils as follows: the soil currently at the surface that is actively developing, and three buried soils, each of which was at one time exposed at the surface. These soils, as observed in Trench 1b, are described further below, and their characteristics are summarized in Table 1.

The **surface soil** at the site has a weakly developed A/Btj profile. The A soil horizon has organic material mixed with the mineral fraction that gives it a dark brown, very dark brown, to very dark grayish brown color (with 10-7.5YR hues), especially when moist. Its texture varies from sandy loam to sandy clay loam. In many parts of the site, the A horizon has been modified by man-made activities associated with the past-uses of the site, such as the fruit orchard. Where this was apparent in the trenches, we labeled it as an Ap horizon in the logs (the "p" stands for plowed, but this suffix is also used for other man-made disturbances). The A horizon is typically about 40 cm (15 inches) thick.

The underlying juvenile argillic (Btj) horizon has a sandy loam, loam to sandy clay loam texture, dark brown to very dark brown (10YR to 7.5YR 3/2 to 2/2) colors, and common to many thin to moderately thick clay films. This horizon also has significant concentrations of organic matter, in addition to many roots and rootlets. The contact between this horizon and the underlying soil developed on an older surface is typically defined by a stoneline.

The presence of the juvenile argillic horizon indicates that this soil has been exposed to soil forming processes for at least a few thousand years, as it takes that long for an argillic soil horizon to develop in this region. Comparison with similar soils from southern California soils that have been dated indicates that this surface soil has been exposed to soil-forming processes for about 11,900 years (the average of the median ages computed using the soil's MHI, non-normalized SDI, and normalized SDI), with average minimum and maximum age estimates of 3,800 and 37,700 years, respectively (see Table 2).

The **first buried soil** observed in the trenches developed in a mudflow deposit (the unit described in Section 3.1.6). Only a section of an argillic soil horizon remained in Trench 1b (2Btb horizon). This horizon consists of loamy sand, sandy loam to sandy clay loam, dark brown to dark reddish brown in color (7.5YR hues), common to many thin and few moderately thick clay films, with rounded to subangular gravel, pebbles and cobbles weathered to Stages 2 to 3.

As above, the presence of an argillic horizon indicates that this soil was exposed to soil-forming processes at the ground surface for several thousands of years before it was buried. Comparison with similar soils that have been dated suggests that this soil took between about 4,200 (average of the minimum age estimates) and 13,300 (average of the median) years to develop before it was buried. By adding the age of the overlying soil to it, we estimate that the mudflow deposit that this soil formed in is between about 8,000 (minimum) and 25,200 (median) years old. The degree of weathering of the clasts is generally consistent with these age estimates.

The **second buried soil** observed in the trenches developed in a finer-grained sheet-flood deposit (described in Section 3.1.5). The soil that developed in this unit has a 3Ab/3Btb2/3BCb/4C_{lam} profile. In the trenches, this unit was characterized by the presence of subhorizontal, wavy clay-enriched lamellae (Bt lams) that extend laterally several feet. The A horizon capping this buried soil was observed in Trench 1b, and only locally in Trench 1a. The 3Ab horizon consists of very dark brown (7.5YR 2.5/3) sandy loam with weak subangular blocky and granular soil structure. This soil horizon has been overprinted by the overlying argillic soil horizon, and as a result, has common to many thin clay films. The underlying 3Btb2 horizon consists of dark brown to dark reddish brown (7.5-5YR ¾) sandy clay to clay, with moderate subangular blocky soil structure and common to continuous clay films. The underlying 3BCb horizon consists of dark brown to dark reddish brown sandy clay loam to sandy clay, with weak subangular blocky structure, many thin and few to common moderately thick clay films. A better-sorted fluvial deposit that is predominantly unaltered underlies the BC soil horizon in Trench 1b. We opted to group these units together, as the very limited soil development in the 4C_{lam} horizon contributed little to the overall age estimate for this second buried soil.

Table 1: Abbreviated Description of Soils Observed in Trench 1b

Horizon	Thickness (cm)	Texture	Color		Structure	Consistency				Clay Films	Comments
			Moist	Dry		Dry	Moist	Wet	Wet		
Surface Soil A	40	SL-L	7.5YR 3/2	10-7.5YR 5/4	sg	so-h	fri-slfi	so-ss	po-vsp	2nbr	Bioturbated, rootlets and root casts to 5mm
Btj	49	SL	7.5YR 3/2	7.5YR 4/2.5	1-2fsbk	sh	fr	so-ss	po-vsp	3-4ncl, 2npf, 3mkpo, 3n&2mkbr	Bioturbated; many roots and rootlets; lower boundary defined by stoneline
1st Buried Soil 2Btb	64	LS-SL	7.5YR 3/3 w/ 7.5YR 2.5/3 films	7.5YR 5/4 w/ 5YR 4/3 films	2-3csbk	sh	fr	so-ss	po	2ncl, 3nbr, 1npf, 2-3npo	Rootlets; cobbles weathered to stages 3-4
2nd Buried Soil 3Ab	52	SL	7.5YR 2.5/3	7.5YR 5/4 & 7.5YR 4/3	1fsbk-2fgr	so	Fri	so-ss	po	3n&2mkbr, 2npf, 2npo, 3-4ncl	Common randomly oriented pores to 3mm
3Btb2	46	SC-C	7.5-5YR 3/4	7.5YR 4.5/4	2msbk	vh-eh	slfi	s-vs	p	2mkpf, 4n&2mkbr, 3npo, 3ncl	Many randomly oriented pores to 3mm
3BCb	82	SCL-SC	7.5-5YR 3/3	7.5YR 3.5/4 w/ 5YR 4/3 films	1f-mbbk	vh-eh	fi	s	ps-p	3n&1mk-kpf, 3npo, 2k&3nbr	
4Clam	91	S	7.5YR 4/4	10-7.5YR 6/4	sg	lo	lo	so	po	1-2ncl	Few Bt lamellae
3rd Buried Soil 5Btb3	31+	SCL	7.5YR 4/4 w/ 5YR ¾ lams	10-7.5YR 5/4 w/ 5YR 3.5/4 lams	2mabk	h	fri	s	ps	2mkpf, 3n-mkbr, 2-3mkpo, 3ncl, 4mkbr in Bt lams	Mafic and dioritic clasts weathered to stage 3; few roots; pinhole-sized pores

ABBREVIATIONS:
TEXTURE: S = sand; LS = loamy sand; SL = sandy loam; L = loam; SCL = sandy clay loam; SC = sandy clay; CL = clay loam; Si = silt; SiL = silt loam; SiCL = silty clay loam; SiC = silty clay; C = clay. **STRUCTURE**: **Grade**: 1 = weak; 2 = moderate, 3 = strong. **Class**: 1f = very fine, f = fine, m = medium, c = coarse. **Type:** sg = single-grained; gr = granular, abk = angular blocky, sbk = subangular blocky. **CONSISTENCY**: **Dry**: lo = loose, so = soft, sh = slightly hard, h = hard, vh = very hard, eh = extremely hard. **Moist**: lo = loose, vfr = very friable, fr = friable, slfi = slightly firm; fi = firm, vfi = very firm, efi = extremely firm. **Wet**: ns = non-sticky, vss = very slightly sticky; ss = slightly sticky, s= sticky, vs = very sticky; np = non-plastic, vsp = very slightly plastic; sp = slightly plastic, p = plastic, vp = very plastic. **CLAY FILMS: Abundance:** 1 = few, 2 = common, 3 = many, 4 = continuous. **Thickness**: n = thin, mk = moderately thick, k = thick. **Location**: st = stains, cl = on clasts, clpo = on clast pockets, po = in pores, br = forming bridges between grains, pf = on ped faces.

This moderately developed and relatively well-preserved buried soil has characteristics that indicate that it was exposed to soil-forming processes for between about 8,500 (minimum) and 25,900 (median) years. Combined with the ages of the overlying soils, the sheet-flood deposit that this second buried soil developed in is estimated to be between about 15,500 and 51,100 years old. Longer periods of soil formation are possible, but we choose to emphasize the minimum and median age estimates provided by the soil-age regression equations to be conservative.

Table 2: Soil Development Age Estimates for Soils Observed in Trench 1b

Soil	Profile Index	Profile Index Value	Years Exposed to Soil Forming Processes	95% Predicted Age Confidence Interval		Approximate* Age of Section (years before present; minimum, median)
				Minimum (years)	Maximum (years)	
Surface Soil (A/Btj)	MHI	0.26	9,900	3,100	31,500	3,800; 11,900
	SDI (NN)	21.47	10,400	3,300	33,200	
	SDI (N-200)	46.15	15,400	4,900	48,500	
1st Buried Soil (2Btb)	MHI	0.28	11,400	3,600	35,700	8,000; 25,200
	SDI (NN)	18.49	9,900	3,100	31,700	
	SDI (N-200)	57.77	18,500	5,900	57,900	
2nd Buried Soil (3Ab/3Btb2/ 3BCb/4Clam)	MHI	0.48	32,500	11,000	94,900	16,500; 51,100
	SDI (NN)	71.53	23,100	7,400	71,500	
	SDI (N-200)	69.01	22,200	7,100	68,800	
3rd Buried Soil (5Btb3)	MHI	0.28	11,000	3,500	34,700	20,500; 63,700
	SDI (NN)	8.78	8,500	2,700	27,300	
	SDI (N-200)	56.67	18,200	5,800	56,900	
Estimated Age Entire Section	MHI		64,800	21,200	196,800	
	SDI (NN)		51,900	16,500	163,700	
	SDI (N-200)		74,300	23,700	232,100	

Abbreviations: MHI = Mean Horizon Index; SDI = Soil Development Index; NN = not normalized; N-200 = Normalized to 200 cm in thickness

* Approximate age calculated as an average of the three soil development indices calculated for each soil (that is, the average of the age calculated using the MHI, non-normalized SDI, and normalized SDI).

The **third** and deepest **buried soil** observed in both trenches developed in what we have referred to as the Older Debris Flow Deposit (described in Section 3.1.4). This unit was exposed at the bottom of both trenches, where it was easily recognized when we cleaned the trench walls because its high clay concentration made it significantly more resistant to scraping than the sediments above. Only a relatively thin portion of a truncated argillic soil horizon was exposed in Trench 1b, so the age estimates obtained for this unit are absolute minimums. The argillic soil horizon (5Btb3 horizon in Trench 1b) consists of brown (7.5YR 4/4) sandy clay loam with dark reddish brown (5YR ¾) lamellae, moderate angular blocky soil structure, with many thin and common to many moderately thick clay films. The clasts observed in this horizon were weathered to Stages 3 to 4, as described previously. The soil-age regressions suggest that this soil took between about 4,000 and 12,600 years to form (minimum and median age estimates, respectively). Combined with the ages of the overlying units, this deposit is estimated to be between 20,500 and 63,700 years old, but could be substantially older, as suggested by the weathered clasts.

4.0 INTERPRETATION AND CONCLUSIONS

Earth Consultants International conducted a fault study for the property at 1901 Royal Oaks Drive, in the city of Bradbury, to determine the potential for future surface fault rupture to impact the proposed re-development of the site. The site is within the Alquist-Priolo Earthquake Fault Zone (APEFZ) established by the California Geological Survey in 2014 for the Duarte fault, and as a result, this fault investigation was required before the site can be subdivided into eight residential lots. The Duarte fault is thought to be a southern element of the Sierra Madre Fault Zone, the principal fault at the base of the San Gabriel Mountains.

4.1 Interpretation of the Subsurface Conditions

To conduct this fault investigation we excavated and logged two trenches that extended in a southerly direction across the entire portion of the site that is to be developed, and at least 50 feet to the north of the most northerly proposed building footprint. The combined length of both trenches is approximately 540 feet. The trenches varied in depth between about 8.7 and 14.5 feet, with approximately 90% of the trench exposures exceeding 13 feet in depth.

The study area is underlain by a thick sequence of debris flow and fluvial (sheet-flood and channel) deposits consisting of poorly sorted gravelly to cobbly sand and loamy sand shed from the Bradbury piedmont and the San Gabriel Mountains to the north. Several discrete geologic units were recognized in the trenches, with the contacts between these units often defined by stonelines or soil horizons. The geologic deposits observed in the trenches extend unbroken across the area covered by this investigation. The contacts are typically wavy and clear. None of the contacts show evidence of shearing or gouge to suggest faulting.

Pleistocene-aged sediments were exposed in the bottom bench of both trenches, as determined from estimates of the age of the soils that have developed in them. The predominantly massive sheet-flood deposit observed along the bottom bench in both trenches is characterized by the presence of clay-enriched lamellae. We traced these lamellae laterally to look for evidence of fault-induced offsets or truncations that could have been otherwise masked in the massive sedimentary unit. We found no evidence for offsets or truncations in the lamellae. The contact between this massive unit and the overlying coarser-grained mudflow deposit is wavy, as expected given the high-energy environment of deposition, but again, this contact extends unbroken across the entire area investigated.

Older consolidated deposits possibly Plio-Pleistocene in age were exposed at the northern end of Trench 1a, at the base of the hillside that forms the northern portion of the site. These consolidated deposits, including the unit assigned to the Duarte Conglomerate that was exposed in the northernmost reach of Trench 1a, are not sheared, broken, tilted, or faulted; the beds in the Duarte Conglomerate and the Older Alluvial deposits at the bottom of the trench north of Station 30 are horizontal to subhorizontal. These observations indicate that these units have not been tectonically deformed in the site vicinity, contrary to the mapping by Crook et al. (1987) and Dibblee (1998) that show steep south-dipping beds of the Duarte Conglomerate to the north and west of the site. It is possible that deformation of the Bradbury piedmont is occurring to the north of this site, along some of the faults mapped by Treiman (2013) that are internal to the elevated surface. It is also possible, and the geomorphology suggests it, that the faults presumed to be responsible for uplift of the Bradbury piedmont are no longer active.

4.2 Conclusions

Based on the data presented above, we conclude the following:

- The study area is underlain by a thick sequence of debris flow and alluvial fan deposits of Holocene and late Pleistocene age. Conservatively, the sediments exposed in the bottom bench of our trenches are at least 20,000 years old, and most likely about 64,000 years old (Pleistocene in age). The sediments exposed in the middle bench could also be Pleistocene (16,500 to 51,000 years old). Thus, our trenches were deep enough to assess the potential for future surface fault rupture to impact the site, in accordance with standards of practice for fault investigations. These deposits, the contacts between them, and the soil horizons that have developed within these units are laterally continuous across the study area.

- The continuity of these primary and secondary layers indicates that there are no active faults underlying the area covered by this study, which includes the gently sloping portion of the site that is proposed for development, and the area at least 50 feet north of the northernmost proposed building footprint.

- Deposits at the base of the hillside that forms the northern portion of the site are thought to be older, possibly Plio-Pleistocene in age, and most likely correlative to the Duarte Conglomerate and possible Saugus Formation, as described by Crook et al. (1987). These deposits, where exposed in the northern portion of our Trench 1a, were not sheared, broken, tilted, or faulted, indicating that in this area, these sediments have not been tectonically deformed.

- Since Pleistocene-aged sediments in the study area are unbroken by faulting, it is our opinion that the potential for future surface fault rupture at the site (defined as the developable area of the project and the area 50 feet north of the northernmost proposed building footprint) is low to none. For this reason, structural setbacks to mitigate the hazard of surface fault rupture are not deemed necessary for the proposed project. The findings of this study apply only to the project depicted in Figure 2. Habitable structures should not be placed to the north of the area covered in this report without first conducting additional studies.

- Although the site is not impacted by faulting, it is located near several seismic sources that have the potential to generate strong ground shaking should they rupture in an earthquake. Moderate to strong levels of ground shaking should be considered in the design of the proposed structures, in accordance with the latest Building Code adopted by the City.

APPENDIX A: REFERENCES and SOURCES

APPENDIX A:
References and Sources

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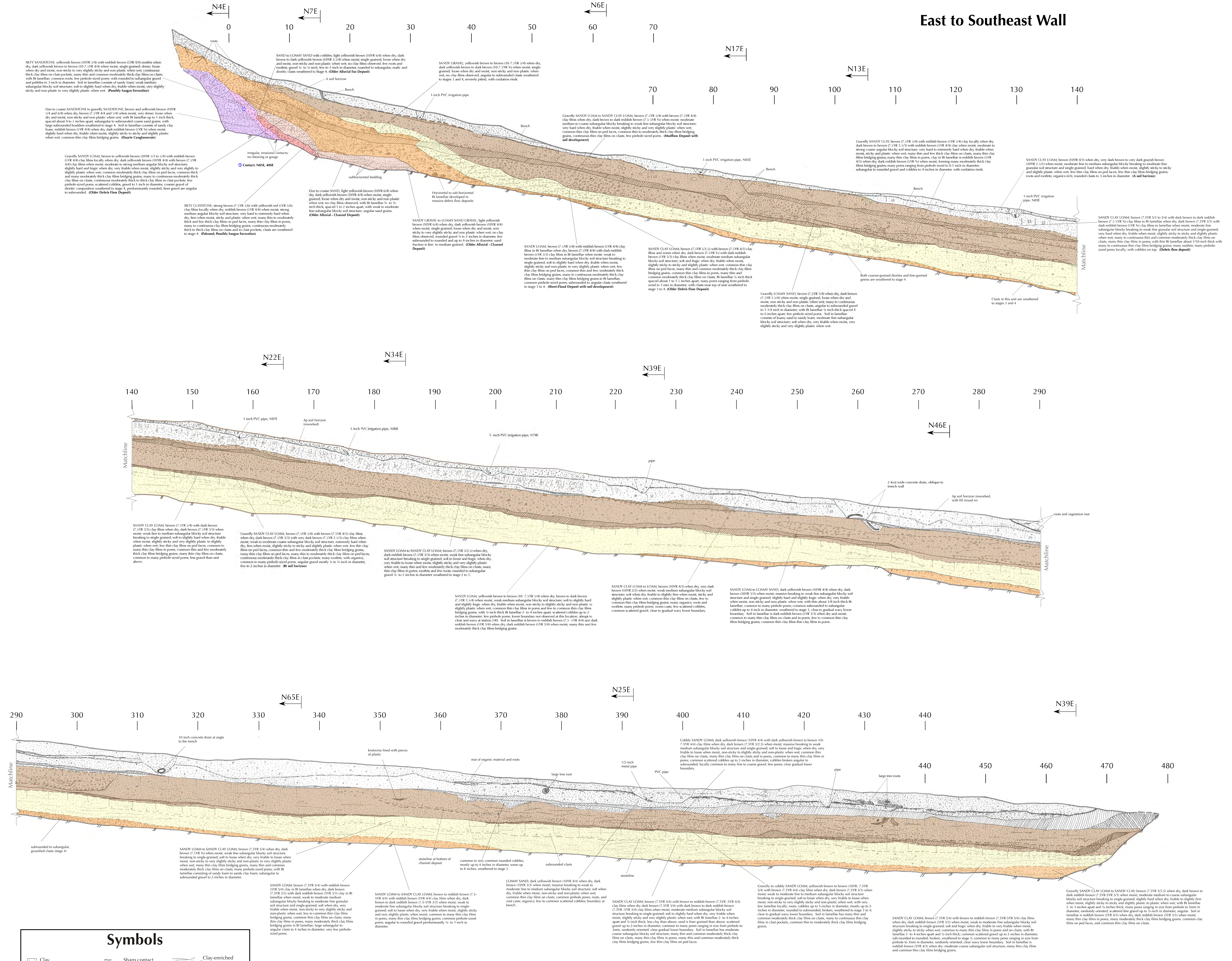
East to Southeast Wall



Symbols

- Clay
- Silt
- Sand
- Gravel and Pebbles
- Cobbles
- Sharp contact
- Approximate contact
- Uncertain contact
- Gradational contact, typically for soils
- Trench bench
- Clay-enriched lamellae
- Grussified clast
- Soil development
- Pipe
- Animal burrow (krotovina)

Scale

0 5 10

1 inch = 5 feet

no vertical exaggeration

Log of Trench T-1a

1901 Royal Oaks Drive, Bradbury, California

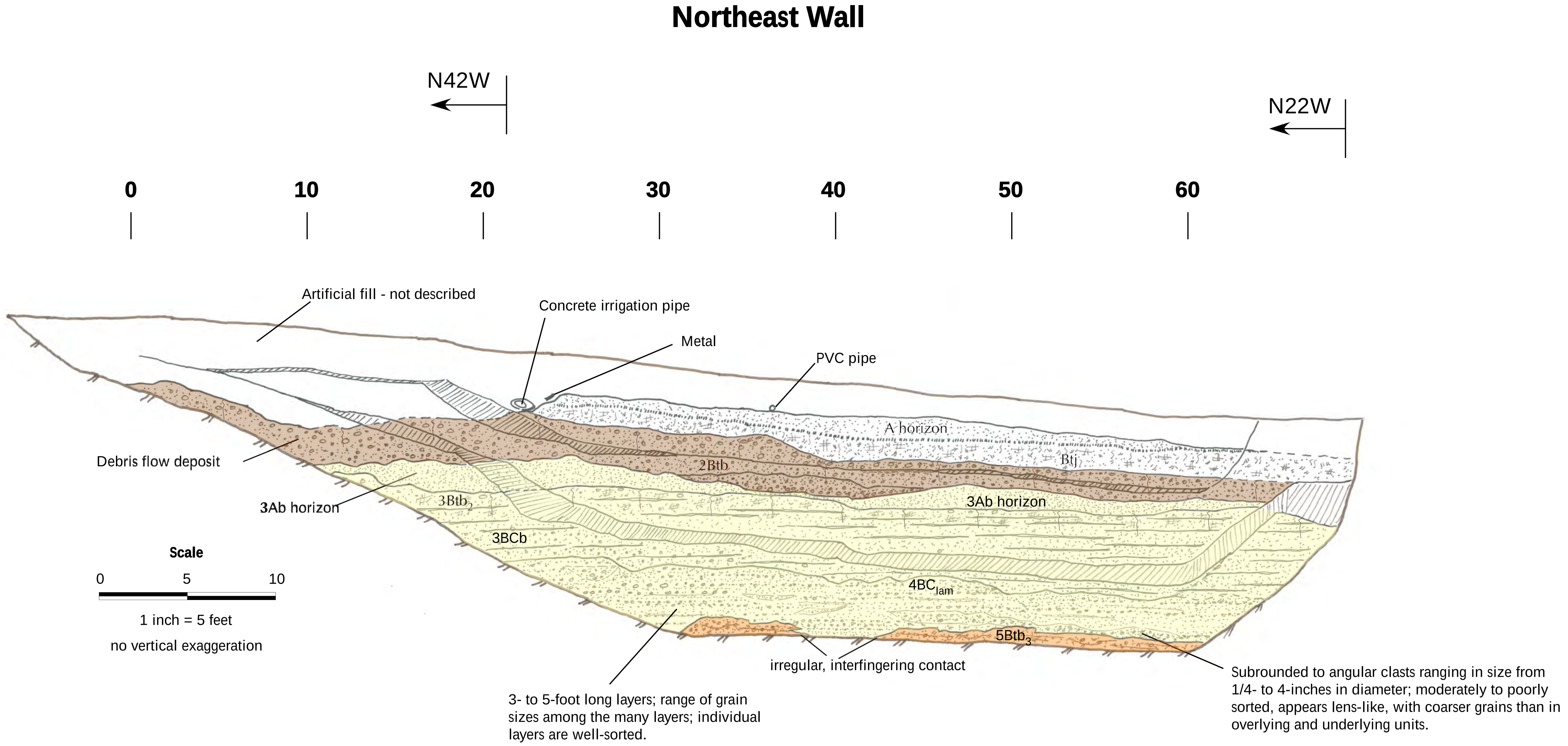
Earth Consultants International

Project Number: 3509

Date: 2015

Plate 1

Trench 1b



Photomosaic of Northeast Wall

ECI File No. 3509_Yihe_RoyalOaks
Mosaic created by MWP on 8/21/2015

Soil Descriptions

A horizon: SANDY LOAM to LOAM; brown to yellowish brown (10-7.5YR 5/4) when dry, dark brown (7.5YR 3/2) when moist; moderate medium subangular blocky breaking to moderate fine to medium granular soil structure; hard to soft when dry, friable to slightly firm when moist, non-sticky to slightly sticky and non-plastic to very slightly plastic when wet; common thin clay films bridging grains; bioturbated, with organics; common to many pinhole-sized pores; rootlets, few large root casts to 5mm in diameter; abrupt wavy lower boundary.

Btj horizon: SANDY LOAM; brown (7.5YR 4/2.5) when dry, dark brown (7.5YR 3/2) when moist; weak to moderate fine subangular blocky soil structure; slightly hard and fragic when dry, friable when moist, non-sticky to slightly sticky and non-plastic to very slightly plastic when wet; many to continuous thin clay films on clasts, common thin clay films on ped faces, many moderately thick clay films in pores, many thin and common moderately thick clay films bridging grains; bioturbated, many roots and rootlets; many fine pores; angular to subangular gravel to ¾-inch in diameter; clear wavy lower boundary defined by a stoneline.

2Btb horizon: LOAMY SAND to SANDY LOAM; brown (7.5YR 5/4) with reddish brown (5YR 4/3) clay films when dry, dark brown (7.5YR 3/3) with very dark brown (7.5YR 2.5/3) clay films when moist; moderate to strong coarse subangular block soil structure; slightly hard when dry, friable when moist, non-sticky to slightly sticky and non-plastic when wet; common thin clay films on clasts, many thin clay films bridging grains, few thin clay films on ped faces, common to many thin clay films in pores; common to many pores ranging from pinhole-sized up to 4 mm in diameter; rootlets; subangular to angular gravel to 2-inches in diameter, and large rounded to subangular cobbles up to 6-inches in diameter weathered to stages 3-4.

3Ab horizon: SANDY LOAM; brown (7.5YR 5/4 and 4/3) when dry, very dark brown (7.5YR 2.5/3) when moist; weak fine subangular blocky breaking to moderate fine granular soil structure; soft when dry, friable when moist, non-sticky to slightly sticky and non-plastic when wet; many thin and few moderately thick clay films bridging grains, common thin clay films on ped faces, common thin clay films in pores, many to continuous thin clay films coating clasts; common pores ranging from pinhole-sized to 3mm in diameter, randomly oriented; angular to rounded fine gravel; abrupt to clear and wavy lower boundary.

3Btb$_2$ horizon: SANDY CLAY to CLAY; brown (7.5YR 4.5/4) when dry, dark brown to dark reddish brown (7.5-5YR ¾) when moist; moderate medium subangular blocky soil structure; very hard to extremely hard when dry, slightly firm when moist, sticky to very sticky and plastic when wet; common moderately thick clay films on ped faces, continuous thin and common moderately thick clay films bridging grains, many thin clay films in pores, many thin clay films coating clasts; angular to subangular coarse sand and fine gravel to ½-inch in diameter; fining-upward; many pores ranging from pinhole-sized to 3mm in diameter, randomly oriented.

3BCb horizon: SANDY CLAY LOAM to SANDY CLAY; brown to dark brown (7.5YR 3.5/4) with few reddish brown (5YR 4/3) clay films when dry, dark brown to dark reddish brown (7.5-5YR 3/3) when moist; weak fine to medium subangular blocky structure; very hard to extremely hard when dry, firm when moist, sticky and slightly plastic to plastic when wet; many thin and few moderately thick to thick clay films on ped faces, many thin clay films in pores, common thick and many thin clay films bridging grains; common to many small pores; angular coarse sand and fine gravel to 1-inch in diameter; abrupt wavy lower boundary.

4C$_{lam}$ horizon: Fine to coarse SAND with GRAVEL beds and lenses; light yellowish brown to light brown (10-7.5YR 6/4) with yellowish red stains on clasts when dry, brown (7.5YR 4/4) when moist; single-grained; loose when dry and moist, non-sticky and non-plastic when wet; few Bt lamellae; few to common thin clay films on clasts; angular to rounded clasts; abrupt wavy to irregular lower boundary (Fluvial deposit).

5Btb$_3$ horizon: SANDY CLAY LOAM; brown to yellowish brown (10-7.5YR 5/4) when dry, brown (7.5YR 4/4) when moist; moderate medium angular blocky soil structure; hard and fragic when dry, friable when firm, sticky and slightly plastic when wet; with Bt lamellae that are dark reddish brown (5YR 3.5/4) when dry, dark reddish brown (5YR ¾) when moist; common moderately thick clay films on ped faces, many thin to moderately thick clay films bridging grains, common to many moderately thick clay films in pores, many thin clay films coating clasts, continuous moderately thick clay films bridging grains in Bt lamellae; angular coarse sand and gravel, mafic and dioritic clasts are weathered to stage 3; few roots; pinhole-sized pores; lower boundary not observed.

Symbols

- Clay
- Silt
- Sand
- Gravel and Pebbles
- Cobbles
- Sharp contact
- Approximate contact
- Uncertain contact
- Gradational contact, typically for soils
- Trench bench
- Clay-enriched lamellae
- Grussified clast
- Soil development
- Pipe
- Animal burrow (krotovina)

Log of Trench T-1b

1901 Royal Oaks Drive, Bradbury, California

Earth Consultants International

Project Number: 3509
Date: 2015

Plate 2

APPENDIX B: SOIL COMPACTION REPORT
by Cal Land Engineering, Inc.

September 22, 2015

Yihe California PTY, LTD
682 Deodar Lane
Bradbury, California 91008

Attention: Mr. Ken He

Subject: Soil Compaction Report, Trench Study Backfill,
1901 Royal Oaks Drive, APN: 8527-021-041, Bradbury, California
QCI Project No.: 13-034-007C

Gentlemen:

This report presents results of our field density tests performed on the trench backfill at the subject site. The trench was used for the evaluation of the fault trace at the site. The fault evaluation was performed by Earth Consultants International, Inc. The site conditions, field and laboratory test results, and post-grading recommendations are presented as follows:

SITE CONDITION

This report present result of our field density tests performed on the trench backfill. The trench was backfilled with the onsite-excavated soil. Backfilling was performed from August 19 through August 28, 2015. The bottom of the trench was approximately twelve feet below the adjacent grade. The soils within the trench backfill were brought to near optimum moisture content, placed in relatively thin lifts (8-inches bulk), then compacted to project standard. The approximate limits of the trench backfill are presented in the attached plate (Figure 1).

FIELD DENSITY TEST

1. Field density test was performed using the Nuclear Gauge Method (ASTM D-6938-10) and/or Sand Cone Method (ASTM D-1556-07). The field density test results are presented in Table I. Approximate locations of the test are shown on the enclosed Site Plan (Figure 1).

2. Field density tests were performed at random locations to check compaction effort provided by the contractor. The test results exceeded minimum required relative compaction of 90 percent. The test results herein are considered representative of the compacted area.

LABORATORY TESTING

The laboratory maximum dry density and optimum moisture content for the onsite soils were determined according to laboratory standard ASTM D-1557-09. The following table presents the test result of representative soil samples collected from the subject site:

TABLE II
LABORATORY TEST RESULTS

Soil Type	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
A- Medium brown silty sand	129.5	8.5
B-Light brown silty sand	128.5	9.0
C-Brown silty sand	132.0	8.0

POST-GRADING RECOMMENDATIONS

1. All utility backfill should be brought to near optimum moisture content and then compacted to obtain a minimum relative compaction of 90 percent of the laboratory standard.

2. Soils generated from footing excavations to be used on onsite should be compacted to 90 percent minimum relative compaction, whether it is to be placed in landscape areas or within areas to be improved. This material must not alter positive drainage patterns away from the structural areas.

3. All trench excavations should conform to CAL-OSHA and local safety codes.

REGULATORY COMPLIANCE

The field compaction tests were performed in accordance to the American Society for Testing and Materials (ASTM) standard procedures. The test results would not indicate the conditions of the subsurface materials underlying the fills. The engineering performance of the underlying materials and other materials are therefore not included in this report.

Our field observation and soil tests were conducted in conformance with generally accepted professional engineering practices, and no further warranty is implied nor made. This report is subjected to review by the controlling authorities of this project.

This opportunity to be of service is appreciated. If you should have any questions, please call the undersigned.

Respectfully submitted,
CalLand Engineering, Inc. (CLE)
dba Quartech Consultants (QCI)

REGISTERED PROFESSIONAL ENGINEER
JACK C. LEE
No. 2153
Exp. 5/2017
GEOTECHNICAL
STATE OF CALIFORNIA

Jack C. Lee, GE 2153
Principal Engineer

John Thurlo
Project Engineer

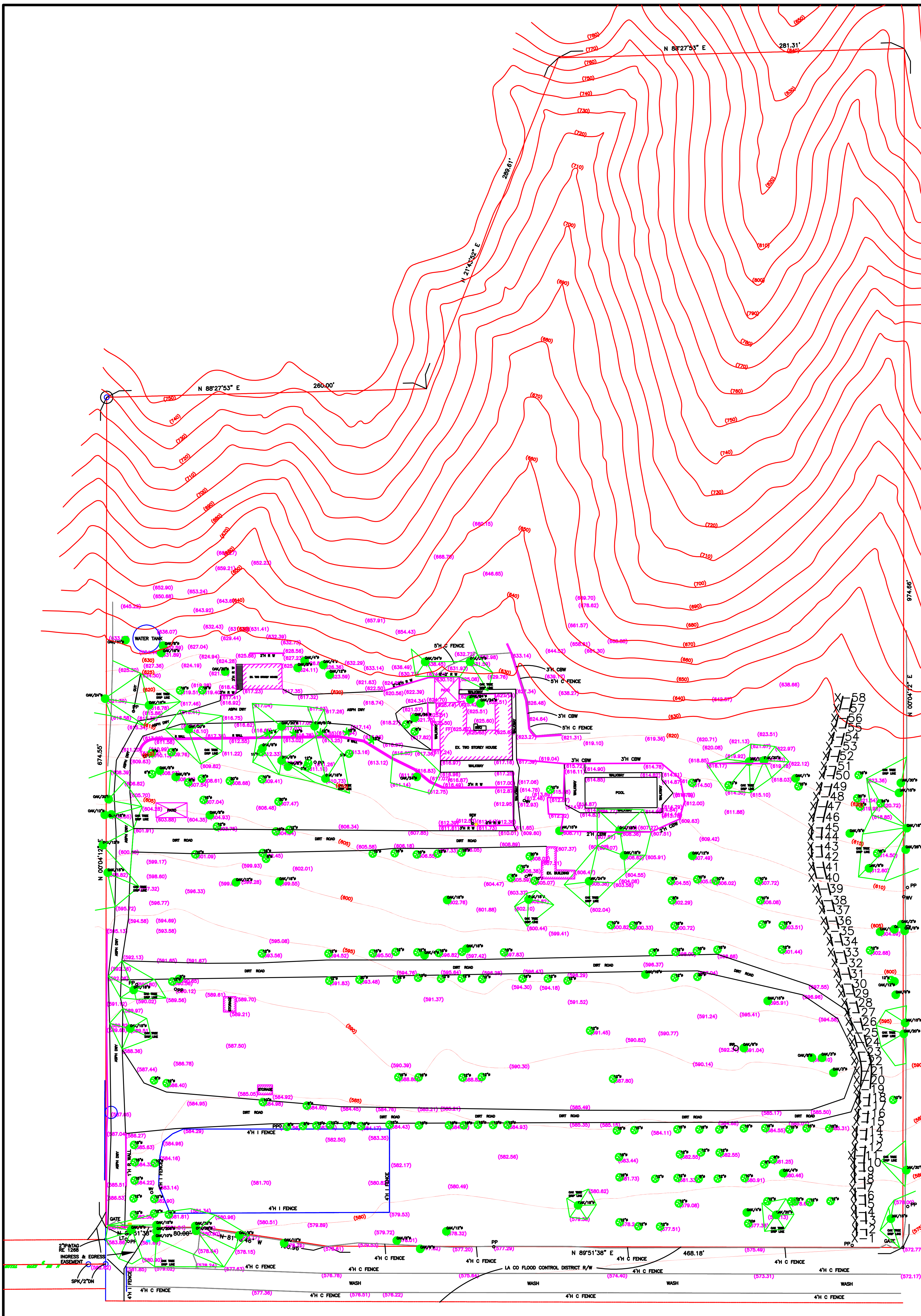
Encl.: Figure I – Site Plan
Dist: (4) Addressee

TABLE I
FIELD DENSITY TEST SUMMARY

Test NO.	Test Date	Test Location	Depth Below FS (ft)	Moisture Content (%)	Dry Density (pcf)	Relative Compaction (%)	Soil Type
X-1	8-19-15	Trench	FS	6.9	116.6	90.0	A
X-2	8-19-15	Trench	10	10.2	116.8	90.2	A
X-3	8-19-15	Trench	8	9.3	118.9	91.8	A
X-4	8-19-15	Trench	6	7.9	123.0	95.0	A
X-5	8-20-15	Trench	10	8.4	120.4	93.7	B
X-6	8-20-15	Trench	8	6.8	120.2	93.5	B
X-7	8-20-15	Trench	6	7.9	118.0	91.8	B
X-8	8-20-15	Trench	4	7.3	117.6	91.5	B
X-9	8-20-15	Trench	2	8.1	118.5	92.2	B
X-10	8-20-15	Trench	FS	8.6	121.3	94.4	B
X-11	8-20-15	Trench	10	8.2	116.2	90.4	B
X-12	8-20-15	Trench	8	8.6	119.4	92.9	B
X-13	8-20-15	Trench	6	7.9	117.3	91.3	B
X-14	8-20-15	Trench	4	7.6	116.5	90.7	B
X-15	8-20-15	Trench	2	8.4	119.0	92.6	B
X-16	8-20-15	Trench	FS	8.1	118.2	92.0	B
X-17	8-24-15	Trench	10	8.6	120.5	93.8	B
X-18	8-24-15	Trench	8	8.4	116.8	90.9	B
X-19	8-24-15	Trench	6	7.9	117.8	91.7	B
X-20	8-24-15	Trench	4	8.9	118.7	92.4	B
X-21	8-24-15	Trench	2	8.3	117.3	91.3	B
X-22	8-24-15	Trench	FS	8.7	116.9	91.0	B
X-23	8-24-15	Trench	10	6.4	120.2	93.5	B
X-24	8-24-15	Trench	8	6.9	119.6	93.1	B
X-25	8-24-15	Trench	6	7.3	118.5	92.2	B
X-26	8-24-15	Trench	4	7.0	116.7	90.8	B
X-27	8-24-15	Trench	2	6.8	117.8	91.7	B
X-28	8-24-15	Trench	FS	7.2	117.2	91.2	B
X-29	8-25-15	Trench	10	8.9	120.4	93.7	B

Test NO.	Test Date	Test Location	Depth Below FS (ft)	Moisture Content (%)	Dry Density (pcf)	Relative Compaction (%)	Soil Type
X-30	8-25-15	Trench	8	11.4	116.3	90.5	B
X-31	8-25-15	Trench	6	8.6	118.1	91.9	B
X-32	8-25-15	Trench	4	9.3	119.0	92.6	B
X-33	8-25-15	Trench	2	10.8	116.2	90.4	B
X-34	8-25-15	Trench	FS	9.5	117.1	91.1	B
X-35	8-26-15	Trench	10	9.6	118.2	92.0	B
X-36	8-26-15	Trench	8	7.3	121.2	94.3	B
X-37	8-26-15	Trench	6	6.9	119.1	92.7	B
X-38	8-26-15	Trench	4	7.4	117.3	91.3	B
X-39	8-26-15	Trench	2	8.2	116.0	90.3	B
X-40	8-26-15	Trench	FS	7.9	116.7	90.8	B
X-41	8-27-15	Trench	4	10.0	122.1	92.5	C
X-42	8-27-15	Trench	7	8.8	118.8	90.0	C
X-43	8-27-15	Trench	2	8.4	120.1	91.0	C
X-44	8-27-15	Trench	5	7.9	122.2	92.6	C
X-45	8-27-15	Trench	3	9.1	123.4	93.5	C
X-46	8-27-15	Trench	1	8.8	121.0	91.7	C
X-47	8-27-15	Trench	6	8.1	122.1	92.5	C
X-48	8-28-15	Trench	4	8.3	119.2	90.3	C
X-49	8-28-15	Trench	2	9.0	120.9	91.6	C
X-50	8-28-15	Trench	FS	10.4	119.3	90.4	C
X-51	8-28-15	Trench	6	9.7	121.2	91.8	C
X-52	8-28-15	Trench	4	10.3	118.8	90.0	C
X-53	8-28-15	Trench	2	11.0	121.3	91.9	C
X-54	8-28-15	Trench	FS	8.4	119.6	90.8	C
X-55	8-28-15	Trench	6	8.6	119.9	90.6	C
X-56	8-28-15	Trench	4	9.1	120.4	91.2	C
X-57	8-28-15	Trench	2	8.1	119.5	90.5	C
X-58	8-28-15	Trench	FS	8.0	119.1	90.2	C

Note: FS = Finish Surface



LEGEND

X-1 Approxmiate Field Density Test Location

— — — Approximate Limit of Compacted Fill Placed Under Purview of This Report

N

SCALE AS SHOWN

CalLand Engineering, Inc.
dba Quartech Consultants

Geotechnical, Enviromental & Civil Engineering Services

Project Address:

APN: 8527-021-041
1901 Royal Oaks Drive
Bradbury, California

SITE PLAN

9/15

FIGURE 1