Appendix D:
Geology and Soils Supporting Information

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D.1 - Geotechnical Exploration Report

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GEOTECHNICAL EXPLORATION REPORT
on
PROPOSED RESIDENTIAL SUBDIVISION
at
APN: 041-170-009
3090 Browns Valley Road
Napa, California
for
EDENBRIDGE HOMES



By

KC ENGINEERING COMPANY

Project No. VV5181

21 September 2021

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A SUBSIDIARY OF MATERIALS TESTING, INC.

Project No. VV5181
21 September 2021

Mr. Eric Zweig
Edenbridge Homes
21771 Stevens Creek Blvd., Suite 200A
Cupertino, CA 95014-1175

Subject: Proposed Residential Subdivision
3090 Browns Valley Road
Napa, California (APN: 041-170-009)
GEOTECHNICAL EXPLORATION REPORT

Dear Mr. Zweig:

In accordance with your authorization, **KC ENGINEERING COMPANY** has explored the geotechnical conditions of the surface and subsurface soils of the proposed residential subdivision to be constructed at the subject site.

The accompanying report presents our conclusions and recommendations based on our exploration. Our findings indicate that the proposed residential subdivision is geotechnically feasible for construction on the subject site provided the recommendations of this report are carefully followed and are incorporated into the project plans and specifications.

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

REGISTERED PROFESSIONAL ENGINEER
DAVID V. CYMANSKI
GE 2585
EXP. 6-30-22
GEOTECHNICAL
STATE OF CALIFORNIA

Respectfully Submitted,
KC ENGINEERING COMPANY

David V. Cymanski, G.E.
Principal Engineer

Copies: 3 mail & email to Client

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GEOTECHNICAL EXPLORATION

Purpose and Scope

The purpose of the geotechnical exploration for the proposed residential subdivision to be located at 3090 Browns Valley Road in Napa, California was to determine the surface and subsurface soil conditions at the subject site. Based on the results of the exploration, geotechnical criteria were established for the grading of the site, design of foundations, slabs-on-grade, retaining walls, pavement sections, drainage, and the construction of other related facilities on the property.

In accordance with your authorization, our exploration services included the following tasks:

a. A review of available geotechnical and geologic literature concerning the site and vicinity;
b. Site reconnaissance by the Geotechnical Engineer to observe and map surface conditions;
c. Drilling and logging of five exploratory test borings and sampling of the subsurface soils;
d. Laboratory testing of the samples obtained to determine their classification and engineering characteristics;
e. Analysis of the data and formulation of conclusions and recommendations; and
f. Preparation of this written report.

Site Location and Description

The 3.4-acre site is designated as APN 041-170-009, located at 3090 Browns Valley Road in Napa, California as shown on Figure 1, “Aerial Vicinity Map”. The site is bounded on the north by Browns Valley Creek, on the east and west sides by residential properties, and on the south by Browns Valley Road. The property is developed with a residential structure, carport, a guest house, a barn and various outbuildings. The residential structures and barn/outbuildings are accessed via a paved driveway on the eastern side of the property. The barn and other outbuildings are constructed on and partially over the creek bank on the northwest portion of the site. Evidence of undocumented fill containing pipes and concrete debris is present on the northeast portion of the site adjacent to the creek bank and eastern property. The fill and debris appear to extend into the eastern property.

The southern half of the site is relatively flat to gently sloping eastward as shown on Figure 4, “Local Geologic Map”. The central portion in the area of the residential structure is elevated about 5 feet above the southern portion on a broad ridge. The broad ridge slopes down to the northeast about

15 feet to a relatively flat terrace above Green Valley Creek. The creek banks were noted to be about 15 feet near vertical and undercut in some locations. Some water and creek flow was present. Numerous mature trees are present along the property boundaries and around the structures. The northeastern terrace and southern portion of the site contain native grasses and weeds.

The above description is based on a reconnaissance of the site by the Geotechnical Engineer, a review of a Google Earth images and a Conceptual Site Plan by RSA Consulting Civil Engineers, Surveyors dated 7/26/21. The Google Aerial image was used as the basis for our "Aerial Vicinity Map" and the Conceptual Site Plan was use for the "Site Plan" included as Figures 1 and 2, respectively in the Appendix of this report.

Proposed Construction

The proposed construction is planned to consist of developing a residential subdivision as shown on Figure 2, "Site Plan". Based on our review of the conceptual site plan, the proposed residential subdivision will consist of constructing 11 lots for single family residences. The structures are expected to be two-story, wood-framed structures with post-tension slab foundations. Structural loads are expected to be typical for this type of construction. Additional site improvements are planned to consist of underground utilities, concrete and asphalt pavements, sidewalks, driveways, landscaping and storm water bio-filtration detention swales and/or basins.

Demolition of the existing buildings and removal of exiting foundations, underground utilities/pipes, along with designated tree removal will be required prior to earthwork grading. A septic tank and leach field and other buried items may be present which will require removal. Debris laden fill is present near the creek bank on the northeast as shown on Figure 2. Earthwork grading is expected to consist of various cuts and fills to establish the proposed building pads, street bio-filtration basins. Relatively low-height retaining walls may be required on the project. Also, the existing well is planned to be demolished and removed per county requirements.

Field Exploration

The field exploration was performed 8/24/21 and included a reconnaissance of the site and the drilling of five exploratory borings at the approximate location shown on Figure 2, "Site Plan". Representative bulk samples of the near surface soils were also obtained.

The borings were drilled to a maximum depth of 36.5 feet below the existing ground surface. The drilling was performed with Mobile B-24 rig using a power-driven, 4-inch diameter continuous flight solid augers. Visual classifications were made from the auger cuttings and the samples in the field. As the drilling proceeded, relatively undisturbed tube samples were obtained by driving a 3-inch

O.D., California Modified split-tube sampler, containing thin brass liners, into the boring bottom in accordance with ASTM D3550. Disturbed samples were also obtained by driving a 2-inch O.D., split-barrel SPT sampler into the boring bottom in accordance with ASTM D1586. The samplers were driven into the in-situ soils under the impact of a 140 pound hammer having a free fall of 30 inches. The number of blows required to advance the sampler 12 inches into the soil were adjusted to the standard penetration resistance (N-Value). The raw blow counts obtained using the California sampler were corrected to equivalent N-Values using Burmister's (1948) 65% energy and diameter correction formula. When the sampler was withdrawn from the boring bottom, the brass liners containing the relatively undisturbed samples were removed, examined for identification purposes, labeled and sealed to preserve the natural or in-situ moisture content.

The samples were then transported to our laboratory for testing. Classifications made in the field were verified in the laboratory after further examination and testing. The stratification of the soils, descriptions, location of undisturbed soil samples and standard penetration resistance are shown on the respective "Log of Test Boring" contained within the Appendix.

Laboratory Testing

The laboratory testing program was directed towards providing sufficient information for the determination of the engineering characteristics of the site soils so that the recommendations outlined in this report could be formulated. The laboratory test results are presented in the Appendix.

Moisture content and dry density tests (ASTM D2937) were performed on representative relatively undisturbed soil samples in order to determine the consistency of the soil and the moisture variation throughout the explored soil profile as well as estimate the compressibility of the underlying soils.

The strength parameters of the foundation soils were determined from unconfined compression tests (ATSTM D2166) and direct shear tests (ATSTM D3080) performed on selected relatively undisturbed soil samples. Standard field penetration resistance (N-Values) and pocket penetrometer readings also assisted in the determination of strength and bearing capacity. The test results, standard penetration resistances readings and penetrometer readings are recorded on the respective "Log of Test Boring".

In order to assist in the identification and classification of the subsurface soils, sieve analysis and hydrometer tests (ASTM D6913) (ASTM D422) and Atterberg Limits tests (ASTM D4318) were performed on selected soil samples. The Atterberg Limits test results were used to estimate the expansion potential of the near surface soils. The results also aided in our liquefaction analysis.

An R-Value test (Cal Test 301) was performed on a composite bulk sample representative of the proposed subgrade to assist in pavement section design.

Representative bulk samples of the near-surface pad soils were obtained and tested to evaluate the presence and concentration of water-soluble sulfates in accordance with ASTM C1580. These test results were used to identify the corrosion potential of the soils to at or below grade concrete. Additional corrosivity indicator tests were performed including soil pH, minimum resistivity and chlorides.

Subsurface Conditions

Based on our field exploration and laboratory test results, the sites surface and subsurface soils consist of variably stratified alluvial fan and stream terrace deposits underlain by weathered bedrock. At Boring 1, the upper 11 feet consist of firm to very stiff, highly expansive silty and sandy clay, underlain by hard gravelly clay to 17 feet, further underlain by highly weathered and strong tuffaceous cinder. At Boring 2, the upper 9 feet consist of moderately expansive, stiff to very stiff sandy and silty clay, underlain by hard gravelly clay to 15 feet, further underlain by medium dense to very dense clayey and sandy gravels to a depth of 20 feet. At Borings 3 and 4, the upper 13 to 18 feet consists of moderately expansive, stiff to hard silty and sandy clays, underlain by highly weathered and weak sandstone bedrock. At Boring 5, the upper 5 feet consists of firm clayey silt, underlain by stiff silty clay to 9 feet, underlain by medium dense clayey sand with gravel to 15 feet, underlain with hard sandy clay to 22 feet, underlain by medium dense clayey sand to 32 feet, further underlain by stiff to very stiff fine sandy clay to the maximum depth explored of 36.5 feet below the surface.

Perched groundwater was encountered in Boring 1 at a depth of 12 feet over a hard clay layer, then dry to 19 feet. No groundwater was encountered in Borings 2, 3 and 4. In Boring 5, groundwater was encountered at 20 feet below grade at the time of drilling. Fluctuations in the groundwater conditions can occur with variations in seasonal rainfall, irrigation on the site, creek flows, and variations in subsurface stratification.

A more thorough description and stratification of the soils encountered along with the results of the laboratory tests are presented on the respective Boring Logs in the Appendix. The approximate locations of the borings are shown on Figure 2, “Site Plan”.

Soil Corrosivity

A representative composite sample of the near surface building pad soils (upper 5 feet) was collected and transported to Sunland Analytical in Rancho Cordova for testing of water soluble sulfates, pH, minimum resistivity and chlorides per ASTM and California Test Methods.

The testing indicates a sulfate content of 20.5 ppm (mg/kg), a chloride content of 7.2 ppm, a minimum resistivity of 1,420 ohm-cm, and a soil pH of 5.69 for the sample collected. It is noted that the sulfate test results indicate low or "S0" sulfate exposure to concrete as identified in the Durability Requirements, Section 1904 of the 2019 California Building Code, and Tables 19.3.1.1 of ACI 318-14 Building Code Requirements for Structural Concrete. No cement type restriction is required, however, we do recommend that a Type II cement be utilized in concrete mixes for additional sulfate and corrosion resistance.

The Caltrans Corrosion Guidelines[1] defines a corrosive site as one where the soil and/or water has a sulfate concentration of 1,500 ppm or more, a chloride concentration of 500 ppm or more, a pH of 5.5 or less, and a minimum resistivity less than 1,500 ohm-cm. Based on these criteria, and the low resistivity, the soils at the site have a higher propensity for corrosion to buried metal.

KC Engineering Company is not a corrosion engineering firm. Therefore, to further define the soil corrosion potential and interpret the above test results, or to design cathodic protection or grounding systems, a licensed Corrosion Engineer should be consulted.

Site Geology

According to the Geologic Map of The Napa 7.5' Quadrangle[2], the geologic deposits at the site are mapped as Holocene-aged stream terrace and alluvial fan deposits underlain by bedrock of the Sonoma Volcanics. The West Napa Fault bisects the site in a northwesterly direction on the northern portion of the property. A Regional and Local Geologic Map are included as Figures 3 and 4, respectively in the Appendix. The subsurface deposits encountered during our exploration generally agree with geologic mapping, except for the weathered sandstone encountered in Borings 3 and 4.

[1] California Department of Transportation, Division of Engineering Services, Materials Engineering and Testing Services Corrosion Branch, *Corrosion Guidelines*, Version 3.2, May 2021.

[2] Clahan et al., 2004, *Geologic Map of the Napa 7.5' Quadrangle*, California Geological Survey.

Geo-Hazards

Seismicity & Ground Motion Analysis

The site is located within an Alquist-Priolo Earthquake Fault Zone[3]. The West Napa Fault bisects the property in the location shown on Figure 4 of this report and as determined by Bajada Geosciences in their report "Fault Evaluation Report", dated 7/28/21. Napa is located in a seismically-active region and earthquake related ground shaking should be expected during the design life of structures constructed on the site. The California Geological Survey has defined an active fault as one that has had surface displacement in the last 11,700 years, or has experienced earthquakes in recorded history.

Based on our review of the Fault Activity Map of California[4] and the USGS National Seismic Hazard Maps-Source Parameters[5], the nearest active faults are the West Napa Fault, the Green Valley Fault, and the Hayward-Rodgers Creek Fault. The West Napa Fault bisects the site as noted above. The Green Valley Fault is located 8.5 miles east, and the Hayward-Rodgers Creek Fault is located 12.9 miles west. Various other active faults in the Bay Area such as the San Andreas Fault can produce seismic shaking at the site.

The 2019 CBC specifies that the potential for liquefaction and soil strength loss should be evaluated, where applicable, for the Maximum Considered Earthquake Geometric Mean (MCE_G) peak ground acceleration with an adjustment for site class effects in accordance with American Society of Civil Engineer (ASCE 7-16)[6]. The MCE_G peak ground acceleration is based on the geometric mean peak ground acceleration with a 2 percent probability of exceedance in 50 years. Based on ASCE 7-16, the MCE_G peak ground acceleration with adjustment for site class effects (PGA_M) was calculated to be 0.922g using the SEA/OSHPD seismic design maps web-based tool with a site coefficient (F_{PGA}) of 1.1 for Site Class D.

Structures at the site should be designed to withstand the anticipated ground accelerations. Based on the SEA/OSHPD U.S Seismic Design Maps website and ASCE 7-16, the 2019 CBC earthquake design values are as follows. The US seismic design summary report is included in the Appendix.

[3] Parish, J.G., 2018 *Earthquake Fault Zones,* California Geological Survey, Special Publication 42, Revised 2018.
[4] Jennings, C.W. and Bryant, W.A., 2010, *Fault Activity Map of California*, California Geological Survey Geologic Data Map No. 6, scale 1:750,000
[5] U.S. Geological Survey, 2008 National Seismic Hazards Maps – Source Parameters, accessed 6/21/19, from USGS web site: https://earthquake.usgs.gov/cfusion/hazfaults_2008_search/query_main.cfm
[6] American Society of Civil Engineer (ASCE), 2016, Minimum Design Loads for Buildings and Other Structures, Standard 7-16 and Supplement 1, dated 12/12/18

Site Class:	D
Mapped Acceleration Parameters:	S_S = 2.013g; S_1 = 0.729g
Design Spectral Response Accelerations:	S_{DS} = 1.342g; S_{D1} = 0.826

The provided values are based on a stiff clay soil profile or Site Class D for the upper 100 feet. In our opinion, a ground motion hazard analysis is not necessary per ASCE 7-16, Section 11.4.8, Exception 2. The seismic response coefficient Cs should be determined by Eq. (12.8-2) for values of $T \leq 1.5T_S$ and taken as equal to 1.5 times the value computed in accordance with either Eq. (12.8-3) for $T_L \geq T > 1.5T_S$ or Eq. (12.8-4) for $T > T_L$. This should be evaluated and verified by the Structural Engineer.

Fault Rupture

The site is located within an Alquist-Priolo Earthquake Fault Zone and the West Napa Fault crosses the property as shown on Figure 4. As discussed in the "Fault Evaluation Report" by Bajada Geosciences, dated 7/28/21, a 25 feet setback from the fault line to residential structures is recommended. Due to the fault crossing, it is our opinion that there is a potential for fault surface rupture at the identified fault crossing.

Landsliding

The subject site is relatively flat and not subject to seismically induced landslide hazards. However, the northern portion of the site is bounded Browns Valley Creek. Our observations of the creek bank revealed slope inclinations ranging from 1H:1V (horizontal to vertical) to near vertical. Localized areas were partially undercut. Signs of past sloughing and erosion were apparent. In our opinion, additional sloughing and erosion can be anticipated as a result of high creek flows and seismic events. Due to this condition, we recommend a minimum structure setback defined by a 2H:1V line extending up from the toe of the existing creek bank.

Liquefaction

Soil liquefaction is a phenomenon in which loose and saturated cohesionless soils are subject to a temporary, but essentially total loss of shear strength, due to pore pressure build-up under the reversing cyclic shear stresses associated with earthquakes. Soils typically found most susceptible to liquefaction are saturated and loose, fine to medium grained sand having a uniform particle range and less than 35% fines passing the No. 200 sieve, and a corrected standard penetration blow count $(N_1)_{60}$ less than 30. According to Special Publication 117A by the California Geological Survey, the assessment of hazards associated with potential liquefaction of soil deposits at a site must consider translational site instability (i.e. lateral spreading, etc.) and

more localized hazards such as bearing failure and settlement. The acceptable factor of safety against liquefaction is recommended in SP117 to be 1.3 or greater.

Based on our site exploration and laboratory test data, the soil profile for the majority of the site generally consists of firm to hard cohesive soils with some medium dense clayey sands and gravels which are not liquefiable. However, a potentially liquefiable clayey sand layer below the water table was encountered in Boring 5 at a depth between 22 to 32 feet below grade. The layer was found to be medium dense with 34% fines passing the No. 200 sieve.

A liquefaction analysis was performed for the layer in Boring 5 using the data from our field and lab exploration per the recommended analysis methods of the NCEER report[7]. The high groundwater modeled in the analysis was 15 feet below the ground surface. A geometric mean peak ground acceleration of 0.92g was used based on the latest data from the US Seismic Design Maps website. A maximum magnitude of 6.7 was used for the on-site West Napa Fault. Based on our analysis, the layer in Boring 4 was found to have a factor of safety of 1.4, and is therefore not considered to be susceptible to liquefaction.

According to Ishihara[8], the potential for surface manifestation (i.e. sand boils, ground fissures, etc…) is unlikely considering the depth of the potentially liquefiable soil layer and overburden clay soils. Lateral spreading is also not considered to be a hazard.

[7] Youd, T.L., et al., 2001 "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils," in Journal of Geotechnical Geoenvironmental Engineering, October 2001

[8] Ishihara, K., 1985, *Stability of Natural Deposits During Earthquakes,* Proceedings of the Eleventh International Conference on Soil Mechanics and Foundation Engineering, San Francisco, CA, Volume 1, p. 321-376, August.

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

General

From a geotechnical point of view, the proposed residential subdivision and associated improvements are considered to be feasible for construction on the subject site provided the recommendations presented in this report are incorporated into the project plans and specifications.

All grading and foundation plans for the development should be reviewed by ***KC ENGINEERING CO.*** prior to contract bidding or submittal to governmental agencies to ensure that the geotechnical recommendations contained herein are incorporated and utilized in design.

KC ENGINEERING CO. should be notified at least two working days prior to site clearing, grading, and/or foundation operations on the property. This will give the Soil Engineer ample time to discuss the geotechnical characteristics of the site that may be encountered in the field.

Field observation and testing during the grading and/or foundation operations shall be provided by representatives of ***KC ENGINEERING CO.*** to enable them to form an opinion regarding the adequacy of the site preparation, the acceptability of fill materials, and the extent to which the earthwork construction and the degree of compaction comply with the specification requirements. Any work related to the grading and/or foundation operations performed without the full knowledge and under the direct observation of the Soil Engineer will render the recommendations of this report invalid.

Geotechnical Considerations

The primary geotechnical considerations for the site are the presence of near-surface moderately to highly expansive clays, the presence of the West Napa Fault crossing the site, the expected disturbance from removal of the existing structures, underground utilities and trees, the near vertical creek bank on the north, and the presence of undocumented fills on the northeast. The site's near surface soils are considered moderately to highly expansive and prone to heave and shrink movements with changes in moisture content and, consequently, must be carefully considered in the design of foundations, drainage, and landscaping. Specific grading, drainage and foundation recommendations are provided herein.

Due to the presence of the West Napa Fault crossing the site, significant seismic shaking can be expected along with potential structure distress cracking. As discussed above, a minimum structure setback of 25 feet from the identified fault line has been recommended and should be

accounted for in the civil design. In addition, the near vertical creek bank on the north can be expected to undergo sloughing and landsliding during seismic events and erosion during high creek flows. Due to this condition, we recommend a minimum structure setback defined by a 2H:1V line extending up from the toe of the existing creek bank.

Upon removal of the trees, underground utilities and demolition of the structures and foundations, we expect the ground surface to be disturbed in the upper 2 feet and will require processing and compacting the upper 2 feet of existing materials as engineered fill. In addition, undocumented fills with concrete debris is present along the northeastern property line and creek bank. These materials will need to be removed and the area replaced with engineered fill.

Considering the presence of highly expansive soils and the potential for strong seismic shaking, we recommend that a uniformly thickened post-tension slab foundation system be utilized to support the structures to minimize differential movements and structure disteress.

Demolition

As noted above, the site contains numerous mature trees, various old buildings, a septic tank and leach field, underground utilities, an old water well, and debris laden fills. Demolition should include the complete removal of all vegetation and tree roots, as well as surface and subsurface structures, pipelines, foundations, concrete flat work, wooden power poles, concrete rubble, debris and deleterious material. It is vital that ***KC ENGINEERING CO.***, intermittently observe the demolition operations and test backfill of such areas.

Excavations made by the removal of the above items should be left open by the demolition contractor for backfill in accordance with the requirements for engineered fill. The removal of any underground structures should be done under the observation of the Soil Engineer to assure adequacy of the removal and that subsoils are left in proper condition for placement of engineered fills. Any soil exposed by the demolition operations, which are deemed soft or unsuitable by the Soil Engineer, shall be excavated as uncompacted fill soil and be removed as required by the Soil Engineer during grading. The demolition operation should be approved by the Soil Engineer prior to commencing grading operations. Any resulting excavations should be properly backfilled with engineered fill under the observation of the Soil Engineer. Should the location of any localized excavation be found to underlie any new structure, backfill should be compacted to a minimum relative compaction of 95% or the excavation widened to extend 5 feet beyond the footprint of the structure and backfilled to the specifications for engineered fill as recommended in the “Grading” section herein.

Grading

Grading activities may be performed during the rainy season, however, achieving proper compaction will be difficult due to excessive moisture; and delays may occur. Grading performed during the dry months will minimize the occurrence of the above problems. When project grading plans become available for our review, supplemental grading recommendations may be required.

After demolition, the site should be stripped of vegetation and removed from the site. Any loose or soft soil materials must be excavated to undisturbed native ground. The undocumented debris laden fill on the northeast should be removed and replaced as engineered fill. The approximate location of the debris fill is shown on Figures 2 and 4. Additionally, it is pointed out that the three Fault Study trenches were loosely backfilled and must be over-excavated and then replaced as engineered fill. The location of the Fault Study trenches are shown on Figure 4. Excavated soil materials may be used as engineered fill with the approval of the Soil Engineer provided they do not contain debris or excessive organics.

After demolition and clearing of vegetation, we recommend the upper 2 feet of the existing site grades be processed and compacted as engineered fill. We recommend that the exposed upper 12 inches be over-excavated, followed by the bottom 12 inches scarified in-place, moisture conditioned and compacted to a minimum degree of relative compaction of 90% at 3% or more above optimum moisture content as determined by ASTM D1557 Laboratory Test Procedure. After processing and compacting the lower 12 inches, the site may be brought to the desired finished grades by placing engineered fill in lifts of 8 inches in un-compacted thickness and compacting to a relative compaction of 90% at 3% or more above optimum moisture in accordance with the aforementioned test procedure. The over-excavation and compaction of the upper 2 feet should occur for the building pads plus a 5 feet minimum over-build. All soils encountered during our investigation are suitable for use as engineered fill when placed and compacted at the recommended moisture content.

The site is relatively level, however low-height (5 feet or less) cut and fill slopes may be required. Maximum cut and fill slopes of 2H:1V (horizontal to vertical) may be utilized within the subdivision. Slopes should be rounded at the upper extremities. Graded slopes should not be left exposed through a winter season without the completion of erosion control measures.

Should select import material be needed to meet design grades for the building pads or be required for general fill, the import material should be approved by the Soil Engineer before it is brought to the site. Where select import soil is to be used, it should meet the following requirements:

a. Have a Plasticity Index not higher than 15;
b. Not more than 15% passing the No. 200 sieve;
c. No rocks larger than 3 inches in maximum size;

The fill materials shall be placed in uniform lifts of not more than 8 to 12 inches in uncompacted thickness depending on size and weight of equipment used. Each layer shall be spread evenly and shall be thoroughly blade mixed during the spreading to obtain uniformity of material in each layer. Before compaction begins, the fill shall be brought to a water content that will permit proper compaction by either (a) aerating the material if it is too wet, or (b) spraying the material with water if it is too dry.

Prior to compaction, each layer should be spread evenly and should be thoroughly blade mixed during the spreading to obtain uniformity of material in each layer. The fill should be brought to a water content noted above by either (a) aerating the material if it is too wet, or (b) spraying the material with water if it is too dry. Compaction should be performed by footed rollers or other types of approved compaction equipment and methods. Compaction equipment should be of such design that they will be able to compact the fill to the specified density. Rolling of each layer should be continuous over its entire area and the equipment should make sufficient trips to ensure that the required density has been obtained. No ponding or jetting is permitted.

The standard test used to define maximum densities and optimum moisture content of all compaction work shall be the Laboratory Test procedure ASTM D1557 and field tests shall be expressed as a relative compaction in terms of the maximum dry density and optimum moisture content obtained in the laboratory by the foregoing standard procedure. Field density and moisture tests shall be made in each compacted layer by the Soil Engineer in accordance with ASTM D6938, respectively. When footed rollers are used for compaction, the density and moisture tests shall be taken in the compacted material below the surface disturbed by the roller. When these tests indicate that the compaction requirements for any layer of fill, or portion thereof, have not been met, the particular layer, or portion thereof, shall be reworked until the compaction requirements have been met.

Surface Drainage

A very important factor affecting the performance of structures and surrounding flatwork is the proper design, implementation, and maintenance of surface drainage, as well as maintaining uniform moisture conditions around the structures and improvements. The site soils are considered to be highly expansive and subject to volume changes due to variations in moisture content. Ponded water will cause swelling and/or loss of soil strength and may also seep under structures. Should surface water be allowed to seep under the structures, differential foundation

movement resulting in structural damage and/or standing water under the slab will occur. This may cause dampness to the floor which may result in mildew, staining, and/or warping of floor coverings. To minimize the potential for the above problems, dampproofing, waterproofing and foundation drainage should be provided as required by Section 1805 of the 2019 CBC. In addition, the following surface drainage measures are recommended and must be maintained by the property owner in perpetuity:

a) Positive building pad slopes and drainage must be provided by the project Civil Engineer to remove all storm water from the pad and to prevent storm and/or irrigation water from ponding adjacent to the structure foundations. The finished pad grade around the structures should be compacted and sloped 5% away from the exterior foundations and as required in Section 1804.4 of the 2019 CBC and be directed to yard swales and drainage outlets. Earth swales should slope a minimum of 2% to suitable outlet.

b) Enclosed or trapped planter areas adjacent to the structure foundations should be avoided if possible. Where enclosed planter areas are constructed, these areas must be provided with adequate measures to drain surface water (irrigation and rainfall) away from the foundation. Positive surface gradients and/or controlled drainage area inlets should be provided. Care should be taken to adequately slope surface grades away from the structure foundations and into area inlets. Drainage area inlets should be piped to a suitable discharge facility.

c) Adequate measures for storm water discharge from the roof gutter downspouts must be provided by the project Civil Engineer and maintained by the property owners at all times, such that no water is allowed to pond next to the structure. Closed pipe discharge lines and/or splash blocks should be connected to downspouts and discharged into a suitable drainage swales, bio-filtration basins and storm drain facilities.

d) Site drainage should be designed by the project Civil Engineer. Civil engineering, hydraulic engineering, and surveying expertise are necessary to design proper surface drainage to assure that the flow of water is directed away from the foundations.

e) Over-irrigation of plants is a common source of water migrating beneath a structure. Consequently, the amount of irrigation should not be any more than the amount necessary to support growth of the plants. Foliage requiring little irrigation (drip system) is recommended for the areas immediately adjacent to the structures.

f) Landscape mounds or concrete flatwork should not be constructed to block or obstruct the surface drainage paths. The Landscape Architect or other landscaper should be made aware of these landscaping recommendations and should implement them as designed. The surface drainage facilities should be constructed by the contractor as designed by the Civil Engineer.

Foundations

Based on the results of the field and laboratory investigation, the site's foundation soils are considered to be moderately to highly expansive and subject to differential heave and shrink movements. Provided that the residential building pads are constructed in accordance with the "Grading" section above, we recommend the single-family homes be supported by properly designed and constructed uniformly thickened post-tensioned slab foundation systems. Foundation recommendations are presented below.

Post-tensioned slabs should be a minimum 10 inches in thickness (for uniform thickness slabs) and designed using the following criteria which is based on the design method of the "Standard Requirements for Design of Shallow Post-Tensioned Concrete Foundations on Expansive Soils", dated May 2008, Third Edition, prepared by the Post Tensioning Institute:

Edge Moisture Variation Distance:

e_m (Edge Lift)	=	4.3 feet
e_m (Center Lift)	=	8.2 feet

Differential Movement:

y_m (Edge Lift)	=	1.75 inches
y_m (Center Lift)	=	-1.25 inches

Estimated Differential Settlement: = 0.5 inches

In addition to the recommendations and guidelines in the Third Edition by the PTI, the following recommendations should also be incorporated into the design and construction for the above structural mat foundation systems:

a) An allowable bearing capacity of 1,000 p.s.f. may be utilized and may be increased by one-third to resist short-term wind and seismic loading.

b) To resist lateral loading, a coefficient of friction between the perimeter concrete thickened edge and the soil of 0.28 may be used.

c) All areas to receive slabs should be thoroughly soaked to a depth of 12 inches prior to placing the underslab components. This work should be performed under the observation of the Soil Engineer and approved prior to vapor barrier and concrete placement.

d) The reinforcement and/or cables shall be placed in the center of the slab unless otherwise designated by the Structural Engineer.

e) A vapor retarder membrane should be installed between the prepared building pad and the interior slab to minimize moisture condensation under the floor coverings and/or upward vapor transmission. The vapor barrier membrane should be a minimum 15-mil extruded polyolefin plastic that complies with ASTM E1745 Class A and have a permeance of less than 0.01 perms per ASTM E96 or ASTM F1249. It is noted that polyethylene films (visqueen) do not meet these specifications. The vapor barrier must be adequately lapped and taped/sealed at penetrations and seems in accordance with ASTM E1643 and the manufacturer's specifications. The vapor retarder must be placed continuously across the slab area.

f) The slabs should be thickened at the perimeter to extend below pad grade at least 4 inches for a width of 12 inches to create frictional resistance for lateral loading, to provide additional edge rigidity, and to minimize moisture infiltration under the slab.

g) Water vapor migrating to the surface of the concrete can adversely affect floor covering adhesives. Provisions should be provided in the concrete mix design to minimize moisture emissions. This should include the selection of a water-cement ratio which inhibits water permeation (0.45 max). Additional suitable admixtures to limit water transmission may also be utilized. The slabs should not be subjected to rainfall or cleaning water prior to placement of the floor coverings. In addition, we recommend that a Type II cement be utilized in the concrete mix to provide an additional protection against sulfate attack.

h) Exterior porches, garages and attached covered patios areas should also be designed as part of the same post-tension foundation system.

i) We recommend that appropriate provisions be provided by the Structural Engineer and Contractor to minimize slab cracking, such as curing measures and/or admixtures to minimize concrete shrinkage and curling. American Concrete Institute methods and guidelines of curing, such as wet curing or membrane curing, are recommended to minimize drying shrinkage cracking.

j) The foundation plans, specifications, calculations and concrete mix designs should be provided to the Structural Engineer and us for review prior to construction to ensure conformance with the above recommendations.

Slab-on-Grade Construction

Exterior concrete slabs/flatwork, including pedestrian sidewalks, driveways and non-structural detached patios and general flatwork may experience some cracking due to finishing and curing methods as well as from heaving or shrinking from moisture variations within the underlying clay soils. We should note that City maintained curbs, gutters, sidewalks and driveway aprons should be designed and constructed per the City of Napa Standards, Specifications and Plans. To reduce the potential cracking of the slabs-on-grade, the following recommendations are made:

a) All areas to receive slabs should be thoroughly wetted and soaked to seal any desiccation cracks prior to placing concrete. This work should be done under the observation of the Soil Engineer.

b) Slabs should be underlain by a minimum of 4 inches of angular gravel or clean crushed rock material placed between the finished subgrade and the slabs to serve as a capillary break between the subsoil and the slab. The gravel should not have more that 10% passing the No. 4 sieve per CBC Section 1805.4.1.

c) Driveway slabs should be a minimum of 5 inches thick and reinforced with a minimum of No. 4 rebar spaced 18 inches center to center, each way. Exterior pedestrian walkways should be a minimum of 4 inches thick with #3 rebar at 18 inches on center each way. Additional concrete pavement recommendations are provided in the “Pavement Areas” section of this report. The actual slab thickness and reinforcement should be determined by the project Structural Engineer in accordance with the structural requirements and the anticipated loading conditions. The reinforcement shall be placed in the center of the slab unless otherwise designated by the design engineer.

d) Slabs for driveways, and exterior flatwork should be placed structurally independent of the foundations. A 30-pound felt strip, expansion joint material, or other positive separator should be provided around the edge of all floating slabs to prevent bonding to the foundation. As an added measure to minimize vertical deflections between the foundation and exterior slabs, rebar doweling can be provided. Details should be provided by the Structural Engineer.

e) Slabs should be provided with crack control saw cut joints, tool joints or other methods to allow for expansion and contraction of the concrete. In general, contraction joints should be spaced no more than 20 times the slab thickness in each direction. The layout of the joints should be determined by the project Structural Engineer and/or Architect.

f) To minimize moisture infiltration under slabs where located adjacent to landscape areas, we recommend that slabs be thickened at the edges to extend below the aggregate base layer to the soil subgrade for a minimum width of 6 inches.

g) Curing of slabs should follow the guidelines provided by the American Concrete Institute and the CBC to minimize shrinkage cracking.

Pavement Areas

The roadways are anticipated to consist of either asphalt concrete (AC) or Portland cement concrete (PCC) surfaces. Recommendations for both pavement surfaces are presented below. We emphasize that the performance of the pavement is critically dependent upon adequate and uniform compaction of the subgrade soils, as well as engineered fill and utility trench backfill within the limits of pavements. Pavements will typically have poor performance and shorter life where water is allowed to migrate into the aggregate base and subgrade soils. The main source of water into a pavement section is landscape planters constructed within or adjacent to pavement areas. Where this is planned, it is recommended to extend the curbs into the soil subgrade at least 2 inches. The construction of all pavements should conform to the requirements set forth by the latest Standard Specifications of the Department of Transportation of the State of California (Caltrans) and the City of Napa.

R-Value: A composite bulk sample was obtained of the near surface soils within the planned roadway that is relatively representative of the anticipated subgrade soils. The sample was tested in accordance with the California Test Method 301 to determine the R-Value for the site soils. An R-Value of 18 was determined for the sample as shown in the Appendix. Due to variations in the clay materials on site, we recommend a maximum R-value of 15 be used for design.

Preparation of Subgrade: After underground utilities have been placed in the areas to receive pavement and removal of excess material has been completed, the upper 12 inches of the subgrade soil shall be scarified, moisture conditioned and compacted to a minimum relative compaction of 95% at a moisture content at 3% or more above optimum in accordance with the grading recommendations specified in this report. Prior to placement of aggregate baserock, it is recommended that the subgrade be proof rolled and observed for deflection by the Soils

Engineer. Should deflection and/or pumping conditions be encountered, stabilization recommendations, such as use of Tensar NX750 geogrid or lime treatment, will be provided by the Geotechnical Engineer based on actual field conditions.

Aggregate Base: All aggregate base material placed subsequently should also be compacted to a minimum relative compaction of 95% based on the ASTM Test Procedure D1557. Aggregate base should be crushed and angular and meet the minimum requirements of Caltrans Class 2 per Section 26. The recommended aggregate base thicknesses for asphalt concrete pavements are noted in the table below. The minimum aggregate base thickness for PCC roadway pavements is 6 compacted inches.

Asphalt Concrete: Asphalt concrete shall conform with Section 39 of Caltrans Standard Specifications and shall be per the City of Napa Standards. Based on an R-Value of 15 and a range of traffic indices provided by the City of Napa Table 3.1, the recommended pavement sections were calculated in accordance with Topic 608 of the California Department of Transportation Highway Design Manual. The appropriate traffic index (TI) and any minimum pavement sections should be determined by the Civil Engineer in conformance with the City of Napa Specifications.

Traffic Condition	Traffic Index (TI)	Asphalt Concrete (inches)	Class II Aggregate Base[1] (inches)
Residential Local Streets	5.5	4.0	8.0
Residential Collector	7.0	4.0	13.0
Arterial	9.0	5.5	17.5

NOTES:
(1) Minimum R-Value = 78 per Section 26
(2) All layers in compacted thickness to CalTrans Standard Specifications.

Portland Cement Concrete: Where PCC pavement areas are utilized, the concrete should be poured on the compacted aggregate base layer. The concrete section should be a minimum of 6 inches thick and reinforced with #4 rebar at 16 inches on center each way, or as determined by the project Structural Engineer. City maintained PCC sections, such as streets and driveway aprons, should be designed and constructed per City of Napa Standards, Specifications and Plans. Driveway slabs should be designed and constructed per the recommendations in the “Slab-on-Grade” section of this report.

Retaining Walls

Any retaining walls that are to be incorporated into the project should be designed to resist lateral pressures exerted from a media having an equivalent fluid weight as follows:

Gradient of Back Slope	Equivalent Fluid Weight (p.c.f.)			Coefficient of Friction
	Unrestrained Condition (Active)	Restrained Condition (At Rest)	Passive Resistance	
Horizontal	60	80	200	0.28
2:1	80	100	200	0.28

It should be noted that the effects of any surcharge or compaction loads behind the walls must be accounted for in the design of the walls. We recommend that the project Structural Engineer use the formula P_Q = QHKa where Q = uniform surcharge load in psf, Ka = 0.5, and H = wall height. Because the surcharge pressure acting on the retaining wall is considered relatively uniform, the resultant force P_Q should be applied at mid-height of the wall.

Per Section 1803.5.12 of the 2019 California Building Code, dynamic lateral earth pressures on retaining walls supporting more than 6 feet of backfill in height are required. Based on the Mononobe-Okabe & Seed-Whitman equations, a total unit weight of 120 pcf and a Kh of ½ PGAm, an earthquake load of $21H^2$ should be applied at 1/3H where H = wall height, from the bottom of the wall is applicable.

Low height retaining walls (less than 5 feet), including dry stack non-mortared walls, may be founded on continuous spread footings that extend to a minimum depth of 24 inches below lowest adjacent pad grade (i.e., trenching depth). At this depth, the recommended design bearing pressure for continuous and isolated footings should not exceed 2,000 p.s.f. due to dead plus live loads. The above allowable pressures may be increased by 1/3 due to all loads which include wind and seismic. All foundations must be adequately reinforced to provide structural continuity and resist the anticipated loads as determined by the project Structural Engineer. To accommodate lateral building loads, the passive resistance of the foundation soil can be utilized. The passive soil pressures can be assumed to act against the front face of the footing below a depth of 1 foot below the ground surface. It is recommended that a passive pressure equivalent to that of a fluid weighing 200 p.c.f. be used. For design purposes, an allowable friction coefficient of 0.28 can be assumed at the base of the spread footings. These two modes of resistance should not be added unless the frictional component is reduced by 50 percent since the mobilization of the passive resistance requires some horizontal movement, effectively reducing the frictional resistance.

The above criteria are based on fully drained conditions. In order to achieve fully-drained conditions, a gravel drainage filter blanket should be placed behind the wall. The gravel blanket should be a minimum of 12 inches thick and should extend to within 12 inches of the surface and capped with compacted soil. If the excavated area behind the wall exceeds 12 inches, the entire excavated space behind the 12-inch blanket should consist of compacted engineered fill or blanket material. The gravel drainage blanket material may consist of either granular crushed rock or drain pipe fully encapsulated in geotextile filter fabric (Mirafi 140N or equivalent) or Class II permeable material that meets CalTrans Specification, Section 68. A 4-inch diameter SDR35 perforated drain pipe should be installed in the bottom of the drainage blanket and should be underlain by 4 inches of filter type material. Piping with a minimum gradient of 2% should be provided to discharge water that collects behind the walls to an adequately controlled discharge system away from the structure foundations.

If mechanically stabilized earth, segmental block retaining walls such as Anchor, Basalite or Keystone walls are utilized, the design and construction of these proposed flexible modular retaining wall systems should conform to the recommendations of the manufacturer and the National Concrete Masonry Association (NCMA). The following soil parameters would be applicable for design using on-site soil materials within the reinforced, retained and bearing zones: φ = 22 degrees, c = 250 p.s.f., γ = 120 p.c.f. The wall backfill within the reinforced zone may consist of the on-site soil materials provided it has a maximum Liquid Limit of 40 and a maximum Plasticity Index of 20. The wall embedment should conform to the recommendations by the manufacturer or NCMA.

Soundwalls

Non-mortared dry stacked masonry block sound walls and/or any free standing conventional grouted CMU sound walls should be founded on pier foundations with inter-connecting, reinforced tie beams. Piers should be a minimum of 12 inch diameter and 8 feet deep designed on the basis of skin friction acting between the soil and that portion of the pier that extends below a depth of 2 feet below finished grade. For the soils at the site, an allowable skin friction value of 400 p.s.f. can be used for combined dead and live loads, below the upper 2 feet from grade. This value can be increased by one-third for total loads which include wind or seismic forces. Spacing should be determined as required by the load distribution, but minimum spacing should not be less than 3 pier diameters, center to center. Maximum spacing and the minimum depth of piers is to be determined by the Structural Engineer. To resist lateral loads, the passive resistance of the soil can be used. The soil passive pressures can be assumed to act against the lateral projected area of the pier described by the vertical dimension of twice the pier diameter. It is recommended that a passive pressure equivalent of that of a fluid weighing 200 p.c.f. be used below 2 feet.

Underground Utility and Excavations

Groundwater was encountered at a depths ranging from 12 to 20 feet below the existing ground surface. Therefore, depending on the time of year of underground construction groundwater may be encountered, especially in deeper utilities. Temporary dewatering and shoring are the responsibility of the Contractor.

Should groundwater be encountered, the utility construction should begin at its lowest point and proceed uphill. The utility trench should be over-excavated 6 to 12 inches below the Napa required pipe bedding material. Open-graded 1.5-inch crushed aggregate should be placed in the bottom of the trench followed by the City standard bedding material. A sump area should be excavated at the lowest point of the open excavation/trench to facilitate pumping of collected water. The collected water should be pumped to a City approved discharge facility.

Utility excavations extending underneath all traffic areas must be backfilled with native or approved import material and compacted to relative compaction of 90% to within 12 inches of the subgrade. The upper 12 inches should be compacted to 95% relative compaction in accordance with Laboratory Test Procedure ASTM D1557. Backfilling and compaction of these excavations must meet the requirements set forth by the City of Napa, Department of Public Works.

Applicable safety standards require that excavations in excess of 5 feet must be properly shored or that the walls of the excavation slope back to provide safety for installation of lines. If excavation wall sloping is performed, the inclination should vary with the soil type. The soils at the site are considered to be OSHA Type C. During excavation operations, the underground contractor should consult with the Soil Engineer for additional recommendations as deemed necessary.

With respect to state-of-the-art construction or local requirements, utility lines are generally bedded with granular materials. These materials can convey surface or subsurface water beneath the structures. It is, therefore, recommended that all utility trenches which possess the potential to transport water be sealed with a compacted impervious cohesive soil material or lean concrete where the trench enters/exits the building perimeter. This impervious seal should extend a minimum of 2 feet away from the building perimeter.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. It should be noted that it is the responsibility of the owner or his representative to notify ***KC ENGINEERING CO.***, in writing, a minimum of two working days before any clearing, grading, or foundation excavation operations can commence at the site.

2. The recommendations of this report are based upon the assumption that the soil conditions do not deviate from those disclosed in the borings and from a reconnaissance of the site. Should any variations or undesirable conditions be encountered during the development of the site, ***KC ENGINEERING CO.***, will provide supplemental recommendations as dictated by the field conditions.

3. This report is issued with the understanding that it is the responsibility of the owner, or his representative, to ensure that the information and recommendations contained herein are brought to the attention of the Architect and Engineer for the project and incorporated into the plans and that the necessary steps are taken to see that the Contractor and Subcontractors carry out such recommendations in the field.

4. At the present date, the findings of this report are valid for the property investigated. With the passage of time, significant changes in the conditions of a property can occur due to natural processes or works of man on this or adjacent properties. In addition, legislation or the broadening of knowledge may result in changes in applicable standards. Changes outside of our control may render this report invalid, wholly or partially. Therefore, this report should not be considered valid after a period of two (2) years without our review, nor should it be used, or is it applicable, for any properties other than those investigated.

5. Not withstanding, all the foregoing applicable codes must be adhered to at all times.

APPENDIX

Aerial Vicinity Map

Site Plan

Regional Geologic Map

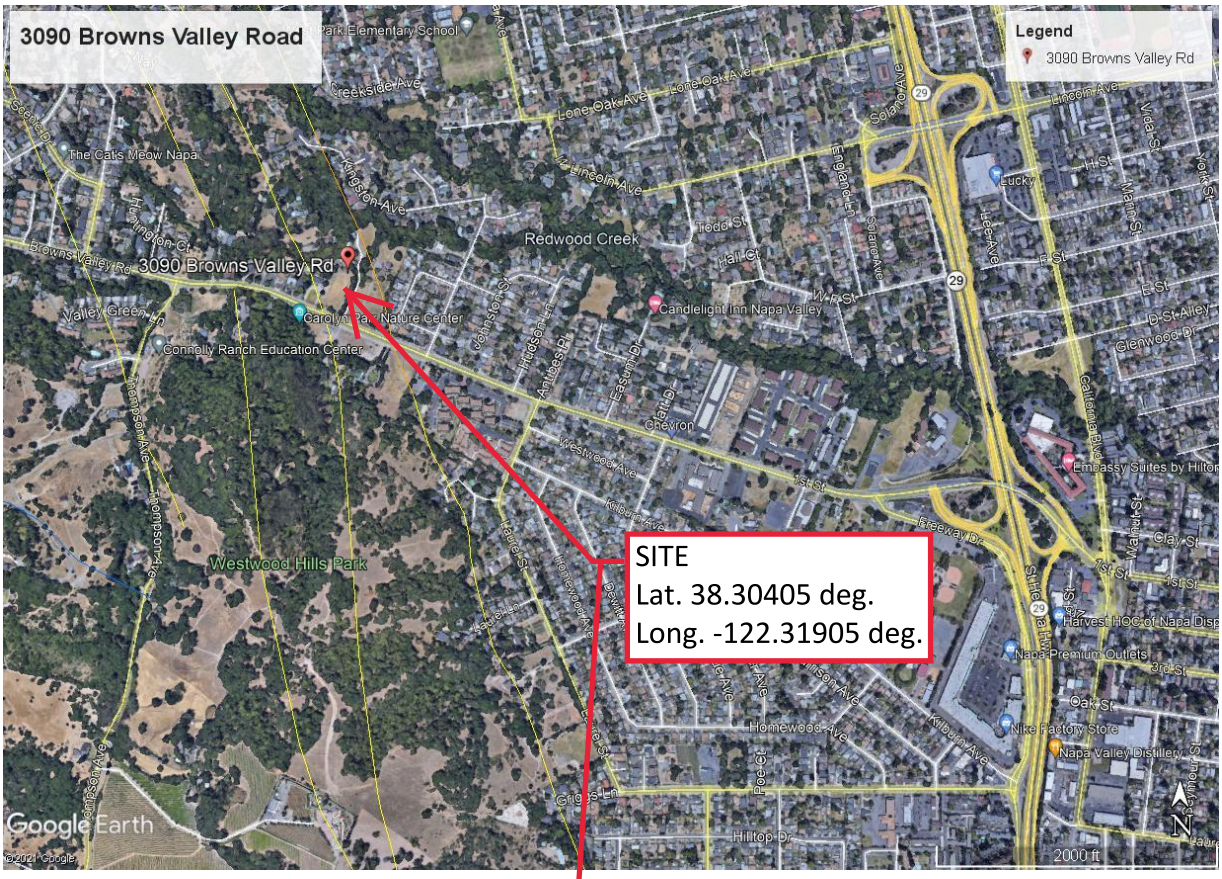
Local Geologic Map

Log of Test Borings

Subsurface Exploration Legend

Laboratory Test Results

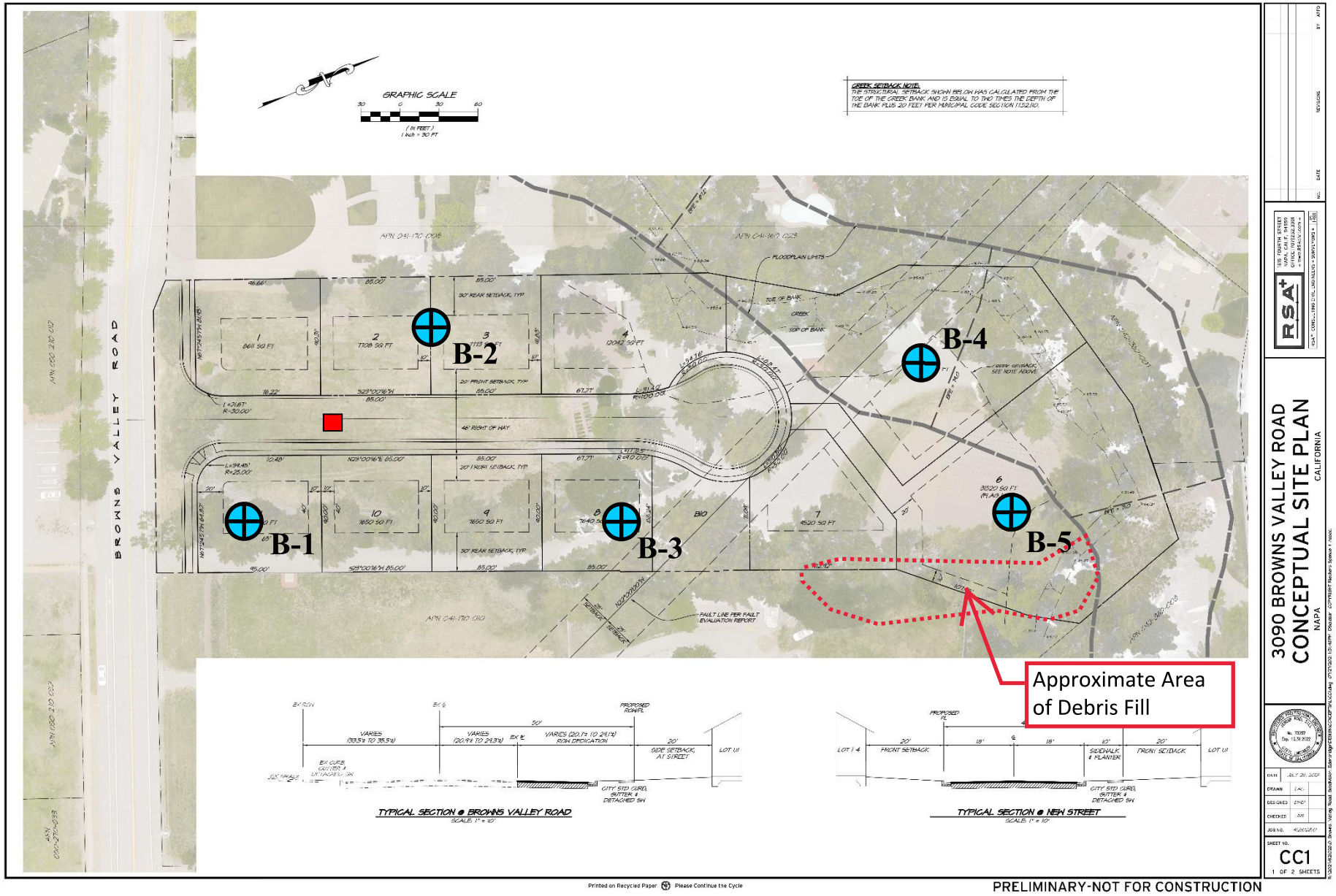
US Seismic Design Report





KC ENGINEERING COMPANY
865 Cotting Lane, Suite A
Vacaville, CA 95688
707.447.4025

Project No. VV5181
Proposed Residential Subdivision
3090 Browns Valley Road, Napa, CA
Figure 1 – AERIAL VICINITY MAP



PRELIMINARY-NOT FOR CONSTRUCTION

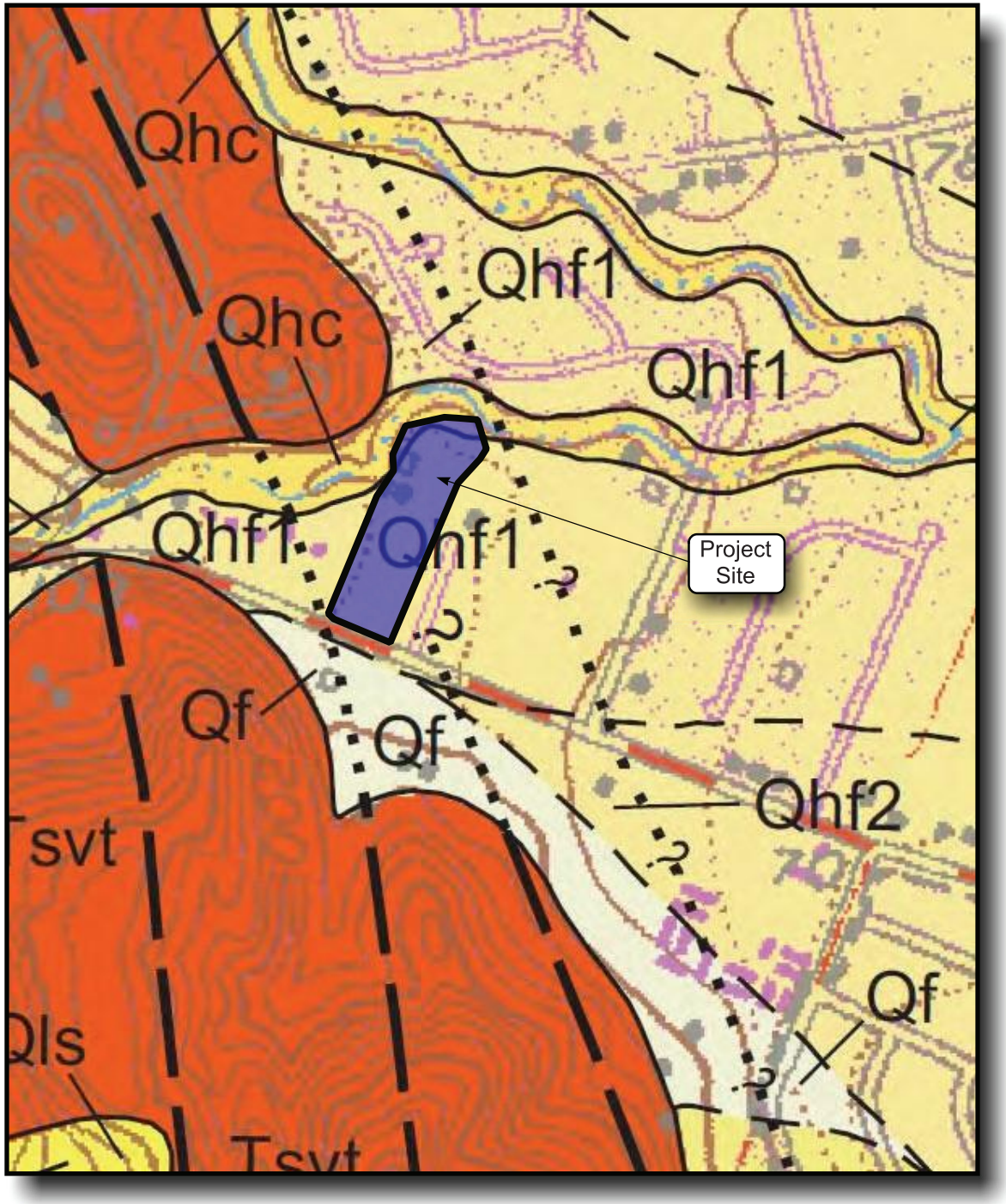
LEGEND

Approximate Boring Location

R-Value Location

KC ENGINEERING COMPANY
865 Cotting Lane, Suite A
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707-447-4025

Project No. VV5181
Proposed Residential Subdivision
3090 Browns Valley Road, Napa, California
Figure 2 – SITE PLAN



N

Qhc — Stream channel deposits (latest Holocene <1,000 years) - Deposits in active, natural stream channels, consists of loose alluvial sand, gravel, and silt.

Qhf (Qhf1, Qhf2) — Alluvial fan deposits (Holocene) - Alluvial fan sediment deposited by streams emanating from mountain drainages onto alluvial valleys, composed of moderately to poorly sorted sand, gravel, silt and clay.

Qf — Alluvial fan deposits (Latest Pleistocene <~30,000 years to Holocene) - Sand, gravel, silt and clay mapped on gently sloping, fan-shaped, relatively undissected alluvial surfaces.

Sonoma Volcanics (late Miocene to Pliocene) - Mafic lava flows and tuffs, rhyolite to dacite ash flow tuff, lava flows, intrusions, breccia, also includes tuffaceous sediment. The Sonoma Volcanics are divided into the following subunits:

Tsv (Tsvbn, Tsvm, Tsvaa, Tsvfh, Tsvr, Tsvdg, Tsvdgp, Tsvtt, Tsvm, Tsvt)

Tsvbn - Breccia of Napa - Dacite breccia underlying the low hills east of Napa. This unit is likely a resurgent dome within a caldera. It is capped by Tsvrn an aphanitic rhyolite.

Tsvaa - Andesite of Atlas Peak - Dark to grey, plagioclase phyric, andesite interbedded with tuff. Locally has a platy foliation.

Tsvfh - Lava flows of Huichica Creek - Dark glassy flow rock with highly variable phenocryst assemblage, including plagioclase, pale olivine, and possible amphibole or pyroxene. Appears to be interlayered with a plagioclase phyric dacite.

Tsvr - Rhyolite ash flow tuff - Black to light grey vitrophyre with angular lithic clasts overlying welded tuff with flattened pumice lapilli and unwelded pumice lapilli tuff. This unit overlies the older rocks with angular unconformity.

Tsvdg - Dacite of Mt. George - Flows and domes of gray to tan porphyritic dacite. The dacite is typically strongly flow banded. The upper surfaces of flows are commonly perlitic. K-Ar ages for the dacite are 4.3±0.2 and 3.73±1.23 Ma (Mankinen, 1972; Fox and others, 1985).

Tsvdgp - Pumice breccia, pumice lapilli tuff, and pumice lapilli tuff with lithic fragments and perlitic glass fragments that mantle flows and domes and occur between dacite flows.

Tsvtt - Tuff of Tulucay Creek - Pumice lapilli tuff interbedded with tuffaceous volcanic agglomerate. Perlitic glass fragments are abundant in some tuff beds.

Tsvm - Mafic flows and breccias - Basalt, basaltic andesite and andesite flows and breccias, interbedded with volcanic agglomerate and tuff.

Tsvt - Light colored tuff, lithic rich in places. Locally includes tuffaceous, diatomaceous lacustrine sediments.

Base map from Clahan et al., (2004). Scale undetermined.

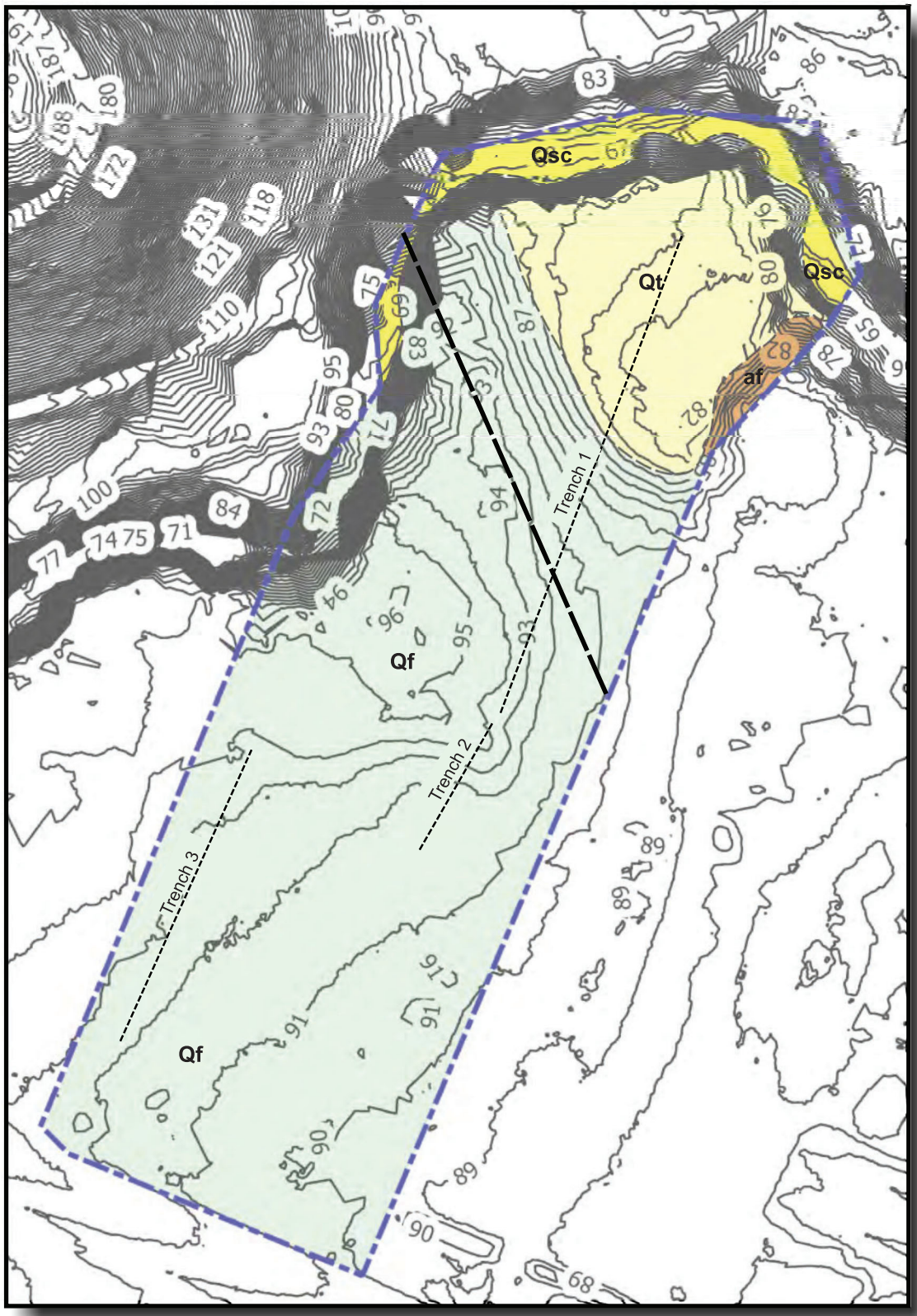
REGIONAL GEOLOGIC MAP

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Figure No. 3

BAJADA Geosciences, Inc.

Project no. VV5181



0 50 100

Scale: 1”=100’
1:1,200

Contour Intervals: 1’

af	Artificial Fill
Qsc	Stream Channel Deposits
Qt	Stream Terrace Deposits
Qf	Alluvial Fan Deposits
— —	West Napa Fault

Topography derived from processed open-source LiDAR.

LOCAL GEOLOGIC MAP

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Figure No.
4

BAJADA Geosciences, Inc.

Project no.
VV5181

LOG OF TEST BORING
BORING NO.: 1

PROJECT: Browns Valley Road Subdivision
CLIENT: Edenbridge Homes
LOCATION: 3090 Browns Valley Road, Napa, CA
DRILLER: California Geo-Tech
DRILL RIG: Mobile B-24
DEPTH TO WATER: INITIAL ▽ : 12'

PROJECT NO.: VV5181
DATE: 08/24/21
ELEVATION: n/a
LOGGED BY: DVC
BORING DIAMETER: 4"
FINAL: ▼ : AFTER: HRS

DEPTH	SAMPLE NO.	SAMPLER	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	SOIL CLASSIFICATION	CONVERTED SPT BLOW COUNT (BLOWS/FT.)	DRY DENSITY (PCF)	MOISTURE CONTENT (PERCENT)	Qp (t.s.f.) Penetrometer	ADDITIONAL TESTS AND REMARKS (LL, PI, UCC, ø&c, Gradation)
0				Dark Brown Sandy CLAY w/ Gravels; dry & desiccated to moist, firm to very stiff, roots.	CH					
	1-1					20	91.9	21.0	4.5	LL=51 PI=32 UCC=24,629 psf
5										
	1-2			As Above, no gravels.		16	97.7	17.0	4.0	
10				Dark Yellowish Brown Sandy CLAY; wet, stiff. ▽	CL					
	1-3			Dark Red/ Dark Gray Gravelly CLAY; moist, hard.	CL	50-5"	81.1	37.7		
15				Dark Red Tuffaceous CINDER; highly weathered, strong.	Rx					
	1-4			Boring Terminated @ 19'. Perched water @ 12' then dry.		50-6"				
20										
25										

This information pertains only to this boring and is not necessarily indicative of the whole site.

KC ENGINEERING CO.

Figure 5

LOG OF TEST BORING
BORING NO.: 2

PROJECT: Browns Valley Road Subdivision
CLIENT: Edenbridge Homes
LOCATION: 3090 Browns Valley Road, Napa, CA
DRILLER: California Geo-Tech
DRILL RIG: Mobile B-24
DEPTH TO WATER: INITIAL ▽ : FINAL: ▼ : AFTER: HRS

PROJECT NO.: VV5181
DATE: 08/24/21
ELEVATION: n/a
LOGGED BY: DVC
BORING DIAMETER: 4"

DEPTH	SAMPLE NO.	SAMPLER	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	SOIL CLASSIFICATION	CONVERTED SPT BLOW COUNT (BLOWS/FT.)	DRY DENSITY (PCF)	MOISTURE CONTENT (PERCENT)	Qp (t.s.f.) Penetrometer	ADDITIONAL TESTS AND REMARKS (LL, PI, UCC, ø&c, Gradation)
0										
	2-1			Brown Sandy CLAY; dry top 18" then moist, stiff.	CL	12	85.5	16.0	4.0	LL=42 PI=22 ϕ=22° c=542 psf %<200=70%
5										
	2-2			Dark Reddish Brown Silty CLAY; moist, very stiff.	CL	21	110.7	14.9	4.5	
				Mottled Reddish Brown Gray & Yellowish Brown Gravelly CLAY; moist, hard.	CL					
10	2-3					40	110.8	17.7		
15				Brown Clayey GRAVELS w/ Sand; wet, medium dense.	GC					
	2-4					22	109.7	20.4		%<200=32%
				Gray Sandy GRAVELS; moist, very dense.	GC					
20	2-5					75				
				Boring Terminated @ 20'. No Groundwater Encountered.						
25										

This information pertains only to this boring and is not necessarily indicative of the whole site.

KC ENGINEERING CO.

Figure 6

LOG OF TEST BORING
BORING NO.: 3

PROJECT: Browns Valley Road Subdivision
CLIENT: Edenbridge Homes
LOCATION: 3090 Browns Valley Road, Napa, CA
DRILLER: California Geo-Tech
DRILL RIG: Mobile B-24
DEPTH TO WATER: INITIAL ▽ :

PROJECT NO.: VV5181
DATE: 08/24/21
ELEVATION: n/a
LOGGED BY: DVC
BORING DIAMETER: 4"
FINAL: ▼ : AFTER: HRS

DEPTH	SAMPLE NO.	SAMPLER	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	SOIL CLASSIFICATION	CONVERTED SPT BLOW COUNT (BLOWS/FT.)	DRY DENSITY (PCF)	MOISTURE CONTENT (PERCENT)	Qp (t.s.f.) Penetrometer	ADDITIONAL TESTS AND REMARKS (LL, PI, UCC, ø&c, Gradation)
0				2" Asphalt Concrete.						
				4" Aggregate Base.						
	3-1			Brown Sandy CLAY; dry to moist, very stiff, porous, some roots.	CL	18	103.9	13.3	4.0	UCC=7,003 psf
5				Mottled Yellowish & Reddish Brown Silty CLAY; moist, very stiff.	CL					
	3-2					25	110.8	15.8	4.5	
10										
	3-3			Mottled Gray & Brown Silty SANDSTONE; highly weathered, weak.	Rx	50-5"				
15										
20	3-4			As Above.		50-6"				
				Boring Terminated @ 21'.						
				No Groundwater Encountered.						
25										

This information pertains only to this boring and is not necessarily indicative of the whole site.

KC ENGINEERING CO.

Figure 7

LOG OF TEST BORING
BORING NO.: 4

PROJECT: Browns Valley Road Subdivision
CLIENT: Edenbridge Homes
LOCATION: 3090 Browns Valley Road, Napa, CA
DRILLER: California Geo-Tech
DRILL RIG: Mobile B-24
DEPTH TO WATER: INITIAL ▽ :

PROJECT NO.: VV5181
DATE: 08/24/21
ELEVATION: n/a
LOGGED BY: DVC
BORING DIAMETER: 4"
FINAL: ▼ : AFTER: HRS

DEPTH	SAMPLE NO.	SAMPLER	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	SOIL CLASSIFICATION	CONVERTED SPT BLOW COUNT (BLOWS/FT.)	DRY DENSITY (PCF)	MOISTURE CONTENT (PERCENT)	Qp (t.s.f.) Penetrometer	ADDITIONAL TESTS AND REMARKS (LL, PI, UCC, ø&c, Gradation)
0				3" Gravel Driveway						
				Brown Sandy CLAY; moist, stiff.	CL					
	4-1					11	99.6	15.6	4.5	LL=36 PI=17
5				Brown Silty CLAY w/ Few Coarse Sands; moist, very stiff.	CL					
	4-2					25	111.1	13.2	4.5	
10				Brown Fine Sandy CLAY; moist, hard.	CL					
	4-3					42	113.6	17.3	4.5+	
15				Brown Clayey SANDSTONE; highly weathered, weak.	Rx					
20	4-4					69				
				Boring Terminated @ 21.5'. No Groundwater Encountered.						
25										

This information pertains only to this boring and is not necessarily indicative of the whole site.

KC ENGINEERING CO.

Figure 8

LOG OF TEST BORING
BORING NO.: 5

PROJECT: Browns Valley Road Subdivision
CLIENT: Edenbridge Homes
LOCATION: 3090 Browns Valley Road, Napa, CA
DRILLER: California Geo-Tech
DRILL RIG: Mobile B-24
DEPTH TO WATER: INITIAL ▽ : 20'

PROJECT NO.: VV5181
DATE: 08/24/21
ELEVATION: n/a
LOGGED BY: DVC
BORING DIAMETER: 4"
FINAL: ▼ : AFTER: HRS

DEPTH	SAMPLE NO.	SAMPLER	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	SOIL CLASSIFICATION	CONVERTED SPT BLOW COUNT (BLOWS/FT.)	DRY DENSITY (PCF)	MOISTURE CONTENT (PERCENT)	Qp (t.s.f.) Penetrometer	ADDITIONAL TESTS AND REMARKS (LL, PI, UCC, ø&c, Gradation)
0				Brown Clayey SILT; dry, firm.	ML					
	5-1					7			4.5	
5				Brown Silty CLAY; moist, stiff.	CL					
	5-2					9	89.2	11.4	4.0	
				Brown & Gray Clayey SAND w/ Gravel; moist, medium dense, gravel to 1½".	SC					
10	5-3					20	92.8	11.8		%<200=27%
15				Brown Sandy CLAY w/ Few Gravels; hard, moist.	CL					
	5-4					51	114.2	14.1		
20				▽						
				Brown Clayey SAND w/ Gravel; wet, medium dense.	SC					
25	5-5					21	111.9	18.8		%<200=34%

This information pertains only to this boring and is not necessarily indicative of the whole site.

KC ENGINEERING CO.

Figure 9

LOG OF TEST BORING
BORING NO.: 5

PROJECT: Browns Valley Road Subdivision
CLIENT: Edenbridge Homes
LOCATION: 3090 Browns Valley Road, Napa, CA
DRILLER: California Geo-Tech
DRILL RIG: Mobile B-24
DEPTH TO WATER: INITIAL ▽ : 20'

PROJECT NO.: VV5181
DATE: 08/24/21
ELEVATION: n/a
LOGGED BY: DVC
BORING DIAMETER: 4"
FINAL: ▼ : AFTER: HRS

DEPTH	SAMPLE NO.	SAMPLER	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	SOIL CLASSIFICATION	CONVERTED SPT BLOW COUNT (BLOWS/FT.)	DRY DENSITY (PCF)	MOISTURE CONTENT (PERCENT)	Qp (t.s.f.) Penetrometer	ADDITIONAL TESTS AND REMARKS (LL, PI, UCC, ø&c, Gradation)
30				Brown Fine Sandy CLAY; wet, stiff to very stiff.	CL					
35	5-6			Boring Terminated @ 36.5'. Groundwater Encountered @ 20'.		25				
40										
45										
50										
55										

This information pertains only to this boring and is not necessarily indicative of the whole site.

KC ENGINEERING CO.

Figure 9

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOLS		TYPICAL NAMES
COARSE GRAINED SOILS More than half of material is retained on the No. 200 Sieve	GRAVEL More than half of coarse fraction is larger than No. 4 sieve	Clean gravels (<5% fines)	GW		Well graded gravels, gravel-sand mixtures, little or no fines (Cu≥4 & 1≤Cc≤3)
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines (Cu < 4 and/or 1>Cc>3)
		Gravel with fines (>12% fines)	GM		Silty gravels and gravel-sand-silt mixtures (PI<4 or below "A" line)
			GC		Clayey gravels and gravel-sand-clay mixtures (PI>7 & on or above "A" line)
	SAND Half or more of the coarse fraction is smaller than No. 4 sieve	Clean sands (<5% fines)	SW		Well graded sands, gravelly sands, little or no fines (Cu≥6 & 1≤Cc≤3)
			SP		Poorly graded sands, gravelly sands, little or no fines (Cu<6 and/or 1>Cc>3)
		Sand with fines (>12% fines)	SM		Silty sands and gravel-sand-silt mixtures (PI<4 or below "A" line)
			SC		Clayey sands and gravel-sand-clay mixtures (PI>7 & on or above "A" line)
FINE GRAINED SOILS Half or more of the material passes the No. 200 Sieve	SILTS AND CLAYS Liquid Limit is less than 50%		ML		Inorganic silts with gravel and sand having slight plasticity (PI<4 or below "A" line)
			CL		Inorganic clays of low to med. plasticity with gravel and sand (PI>7 & on or above "A" line)
			OL		Organic silts and clays of low plasticity
	SILTS AND CLAYS Liquid Limit is 50% or more		MH		Inorganic elastic silts (PI below "A" line)
			CH		Inorganic clays of high plasticity, fat clays (PI on or above "A" line)
			OH		Organic silts and clays of medium to high plasticity
HIGHLY ORGANIC SOILS			Pt		Peat and other highly organic soils

MTI-KC ENGINEERING COMPANY
865 Cotting Lane, Ste A, Vacaville, CA 95688
8798 Airport Road, Redding, CA 96002

SAMPLER AND LAB TESTING LEGEND

- Auger
- Bulk Sample, taken from auger cuttings
- California Sampler
- Bulk/Grab Sample
- Pitcher
- Standard Penetration Test
- Shelby Tube
- No Recovery

LL=Liquid Limit (%)
PI=Plasticity Index
¦ =Friction Angle
C=Cohesion
UCC=Unconfined Compression
R value=Resistance Value
Consol=Consolidation Test

SOIL GRAIN SIZE

U.S. STANDARD SIEVE OPENINGS

	#200		#40		#10		#4	¾"		3"		12"
CLAY	SILT	SAND						GRAVEL			COBBLES	BOULDERS
		FINE		MEDIUM		COARSE		FINE		COARSE		
0.002		0.075		0.425		2.00		4.75		19.0	75	300

SOIL GRAIN SIZE IN MILLIMETERS

RELATIVE DENSITY (Coarse-grained soils)

SANDS & GRAVELS	BLOWS/FOOT[1]
Very Loose	0 – 4
Loose	4 – 10
Medium Dense	10 – 30
Dense	30 – 50
Very Dense	> 50

CONSISTENCY (Fine-grained soils)

SILTS & CLAYS	STRENGTH[2]	BLOWS/FOOT[1]
Very Soft	< 500	0 – 2
Soft	500 – 1,000	2 – 4
Firm	1,000 – 2,000	4 – 8
Stiff	2,000 – 4,000	8 – 15
Very Stiff	4,000 – 8,000	15 – 30
Hard	> 8,000	>30

1 – Number of blows of 140 pound hammer falling 30 inches to drive a 2-inch O.D. split spoon sampler (ASTM D1586)
2 – Unconfined compressive strength in lb/ft^2 as determined by lab testing or approximated by the standard penetration test (ASTM D1586) or pocket penetrometer.

WEATHERING (Bedrock)

Fresh	No visible sign of decomposition or discoloration; rings under hammer impact
Slightly weathered	Slight discoloration inwards from open fractures; little or no effect on normal cementation; otherwise similar to Fresh
Moderately weathered	Discoloration throughout; weaker minerals decomposed; strength somewhat less than fresh rock but cores can not be broken by hand or scraped with knife; texture preserved; cementation little to not affected; fractures may contain filling
Highly weathered	Most minerals somewhat decomposed; specimens can be broken by hand with effort or shaved with knife; texture becoming indistinct but fabric preserved; faint fractures
Completely weathered	Minerals decomposed to soil but fabric and structure preserved; specimens can be easily crumbled or penetrated

STRENGTH (Bedrock)

Plastic	Very low strength
Friable	Crumbles easily by rubbing with fingers
Weak	An unfractured specimen will crumble under light hammer blows
Moderately strong	Specimen will withstand a few heavy hammer blows before breaking
Strong	Specimen will withstand a few heavy ringing blows and will yield with difficulty only dust and small flying fragments
Very strong	Specimen will resist heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments

BEDDING (Bedrock)	SPACING (inches)
Very thickly bedded	> 48
Thickly bedded	24 to 48
Thin bedded	2.5 to 24
Very thin bedded	5/8 to 2.5
Laminated	1/8 to 5/8
Thinly laminated	<1/8

FRACTURING (Bedrock)	SPACING (inches)
Very little fractured	> 48
Occasionally fractured	12 to 48
Moderately fractured	6 to 12
Closely fractured	1 to 6
Intensely fractured	5/8 to 1
Crushed	<5/8

Materials Testing, Inc.

8798 Airport Road
Redding, California 96002
(530) 222-1116, fax 222-1611

865 Cotting Lane, Suite A
Vacaville, California 95688
(707) 447-4025, fax 447-4143

Client: Edenbridge Homes
21771 Stevens Creek Boulevard, Suite 200A
Cupertino, CA 95014

Project: Browns Valley Road Subdivision
3090 Browns Valley Road, Napa, California

Client No.: VV5181
Report No.: 0300-001
Date: 09/16/2021

Submitted by: KC Engineering
Date Submitted: 09/07/2021

DENSITY OF SOIL IN PLACE BY THE DRIVE-CYLINDER METHOD / LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX OF SOILS

(ASTM D2937 / ASTM D4318)

Sample #	Description	Dry Density p.c.f.	Moisture Content %	Liquid Limit	Plastic Limit	Plastic Index
1-1 @ 3.0’	Dark Grayish Brown Clay with Organics (visual)	91.9	21.0	51	19	32
1-2 @ 8.0’	Dark Brown Silty Clay (visual)	97.7	17.0	---	---	---
1-3 @ 13’	Reddish Brown/Dark Gray Gravelly Clay (visual)	81.1	37.7	---	---	---
2-1 @ 2.0’	Brown Sandy Clay (visual)	85.5	16.0	42	20	22
2-2 @ 6.0’	Dark Brown Silty Clay (visual)	110.7	14.9	---	---	---
2-3 @ 11.0’	Mottled Dark Brown Gravelly Clay (visual)	110.8	17.7	---	---	---
2-4 @ 16.0’	Brown Clayey Gravel with Sand (visual)	109.7	20.4	---	---	---
3-1 @ 2.5’	Brown Sandy Clay with Gravel (visual)	103.9	13.3	---	---	---
3-2 @ 8.0’	Brown Silty Clay (visual)	110.8	15.8	---	---	---

Tested by John Hubbard.
The samples were tested according to the referenced standard test procedures and relate only to the items inspected or tested.
Results are not transferable and shall not be reproduced, except in full, without written permission from MTI.

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(707) 447-4025, fax 447-4143

Client:	Edenbridge Homes 21771 Stevens Creek Boulevard, Suite 200A Cupertino, CA 95014	**Client No.:** **Report No.:** **Date:** **Page No.:**	VV5181 0300-001 09/15/2021 1 of 2
Project:	Browns Valley Road Subdivision 3090 Browns Valley Road, Napa, California	**Submitted by:** **Date Submitted:**	KC Engineering 09/07/2021

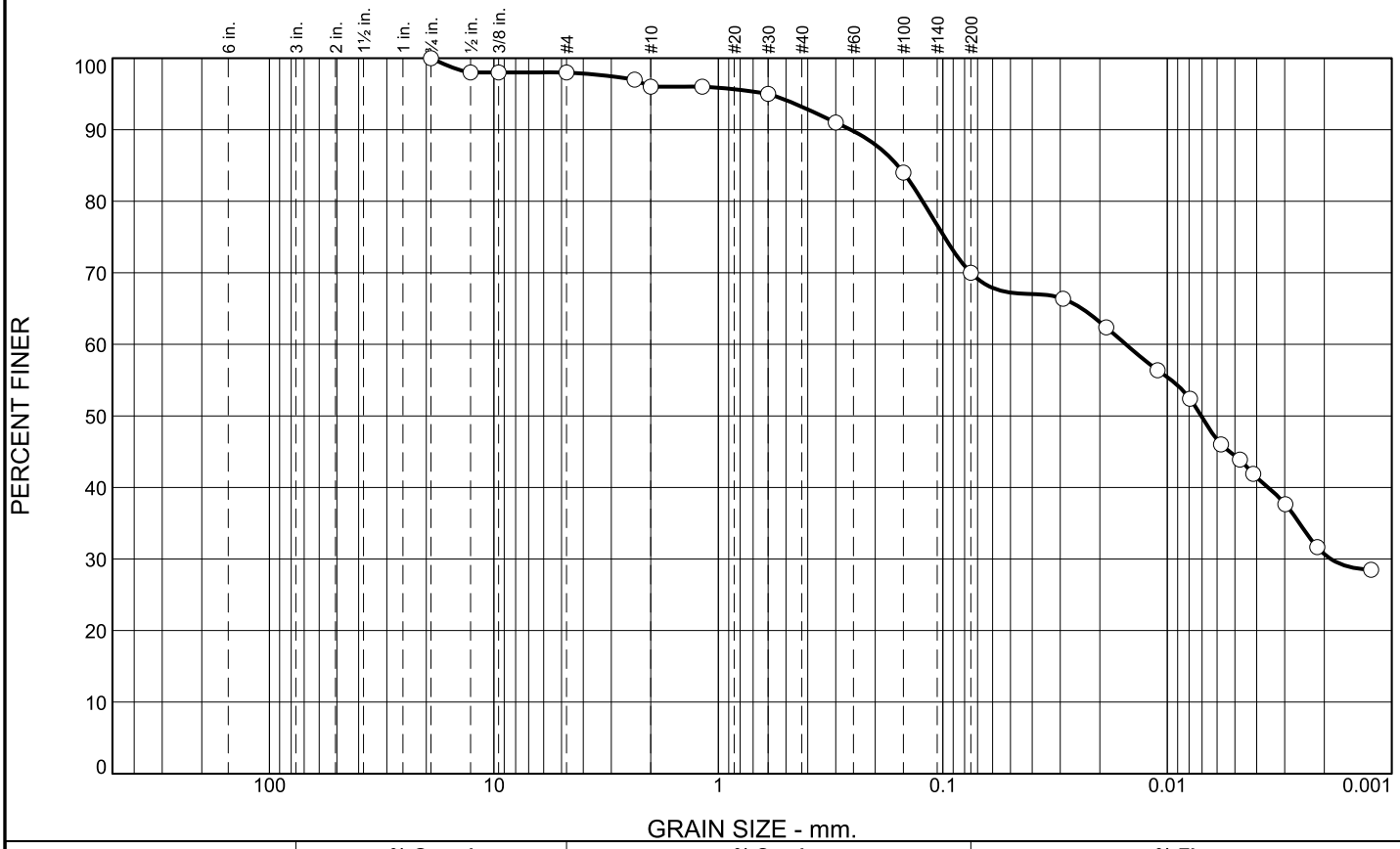
DENSITY OF SOIL IN PLACE BY THE DRIVE-CYLINDER METHOD / LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX OF SOILS

(ASTM D2937 / ASTM D4318)

Sample #	Description	Dry Density p.c.f.	Moisture Content %	Liquid Limit	Plastic Limit	Plastic Index
4-1 @ 3.0’	Brown Sandy Clay (visual)	99.6	15.6	36	19	17
4-2 @ 8.0’	Brown Silty Clay (visual)	111.1	13.2	---	---	---
4-3 @ 13.0’	Brown Clay (visual)	113.6	17.3	---	---	---
5-2 @ 6.0’	Brown Silty Clay (visual)	89.2	11.4	---	---	---
5-3 @ 11.0’	Brown Clayey Sand with Gravel (visual)	92.8	11.8	---	---	---
5-4 @ 16.0’	Mottled Brown Sandy Clay with Gravel (visual)	114.2	14.1	---	---	---
5-5 @ 24.0’	Brown Clayey Sand with Gravel (visual)	111.9	18.8	---	---	---

Tested by John Hubbard.
The samples were tested according to the referenced standard test procedures and relate only to the items inspected or tested.
Results are not transferable and shall not be reproduced, except in full, without written permission from MTI.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	2	2	3	23	26	44

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100		
1/2"	98		
3/8"	98		
#4	98		
#8	97		
#10	96		
#16	96		
#30	95		
#50	91		
#100	84		
#200	70		

* (no specification provided)

Material Description

Brown Sandy Clay

Atterberg Limits

PL= 20 LL= 42 PI= 22

Coefficients

D_{90}= 0.2577 D_{85}= 0.1593 D_{60}= 0.0153
D_{50}= 0.0071 D_{30}= 0.0019 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(14)

Remarks

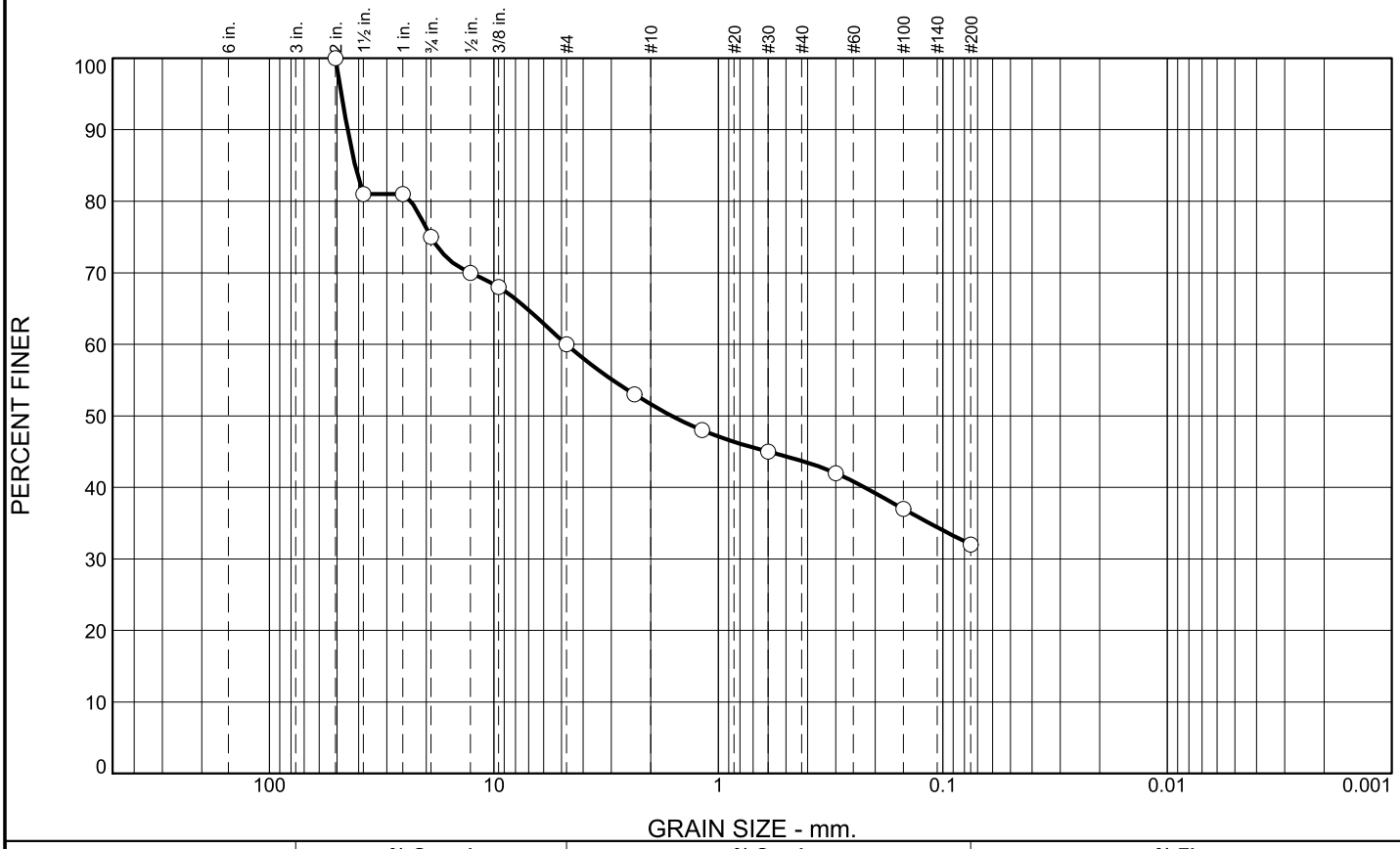
Material tested in accordance with ASTM D422.

Location: 2-1
Sample Number: 4 **Depth:** 2.0' **Date:** 09/16/2021

Client: Edenbridge Homes
Project: Browns Valley Road Subdivision
3090 Browns Valley Road, Napa, California
Project No: VV5181 **Figure** 0300-002

Tested By: John Hubbard

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	25	15	8	8	12	32	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2"	100		
1 1/2"	81		
1"	81		
3/4"	75		
1/2"	70		
3/8"	68		
#4	60		
#8	53		
#16	48		
#30	45		
#50	42		
#100	37		
#200	32		

* (no specification provided)

Material Description

Brown Clayey Gravel with Sand (visual)

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 44.7949 D_{85}= 41.5395 D_{60}= 4.7500
D_{50}= 1.6111 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= GC AASHTO=

Remarks

Material tested in accordance with ASTM D6913.

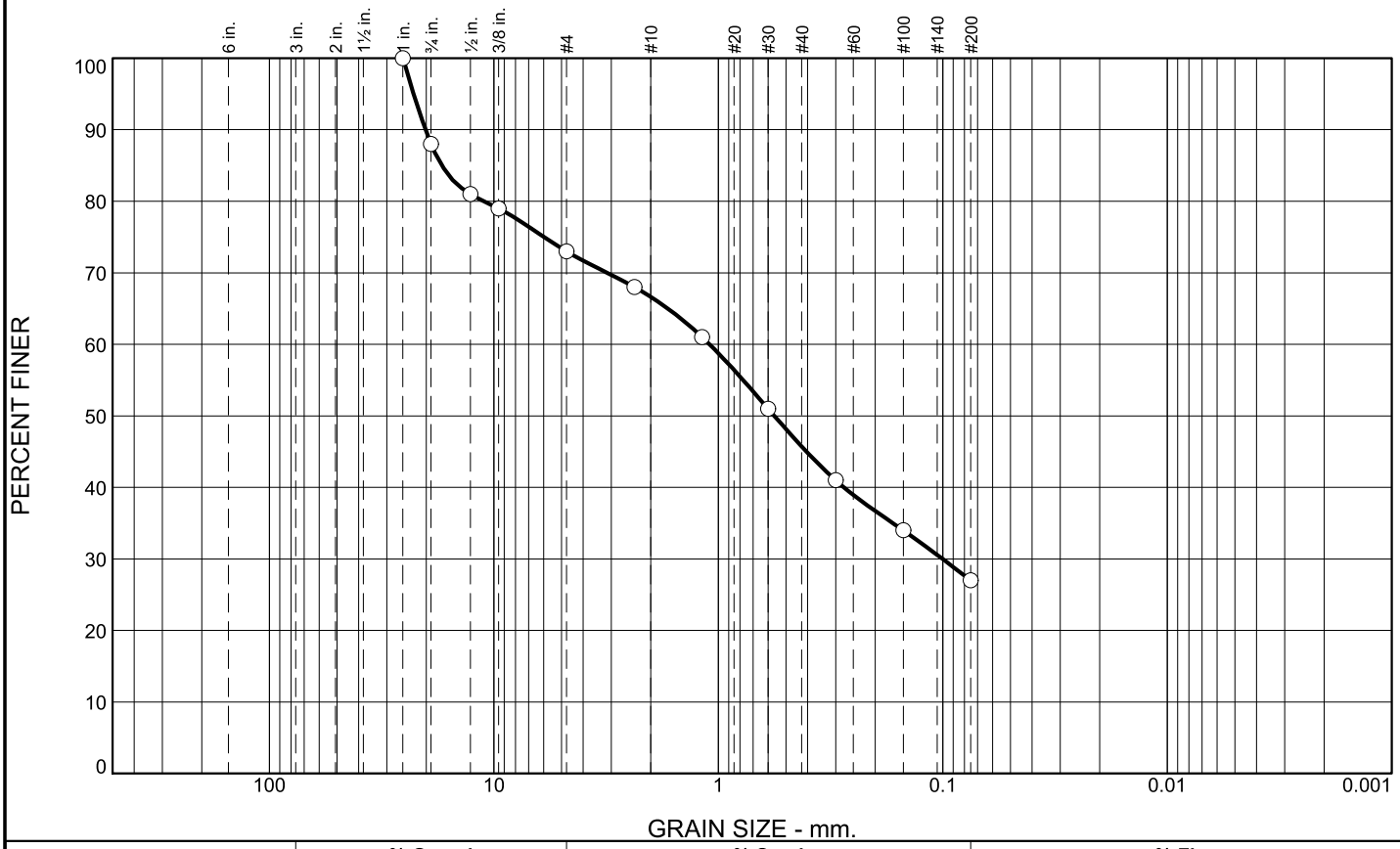
Location: 2-4
Sample Number: 7 **Depth:** 16.0' **Date:** 09/16/2021

MATERIALS TESTING M T I INCORPORATED

Client: Edenbridge Homes
Project: Browns Valley Road Subdivision
3090 Browns Valley Road, Napa, California
Project No: VV5181 **Figure** 0300-003

Tested By: Jack Bianchin

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	12	15	6	21	19	27	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100		
3/4"	88		
1/2"	81		
3/8"	79		
#4	73		
#8	68		
#16	61		
#30	51		
#50	41		
#100	34		
#200	27		

* (no specification provided)

Material Description

Brown Clayey Sand with Gravel (visual)

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 20.1784 D_{85}= 17.0360 D_{60}= 1.0937
D_{50}= 0.5629 D_{30}= 0.1003 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

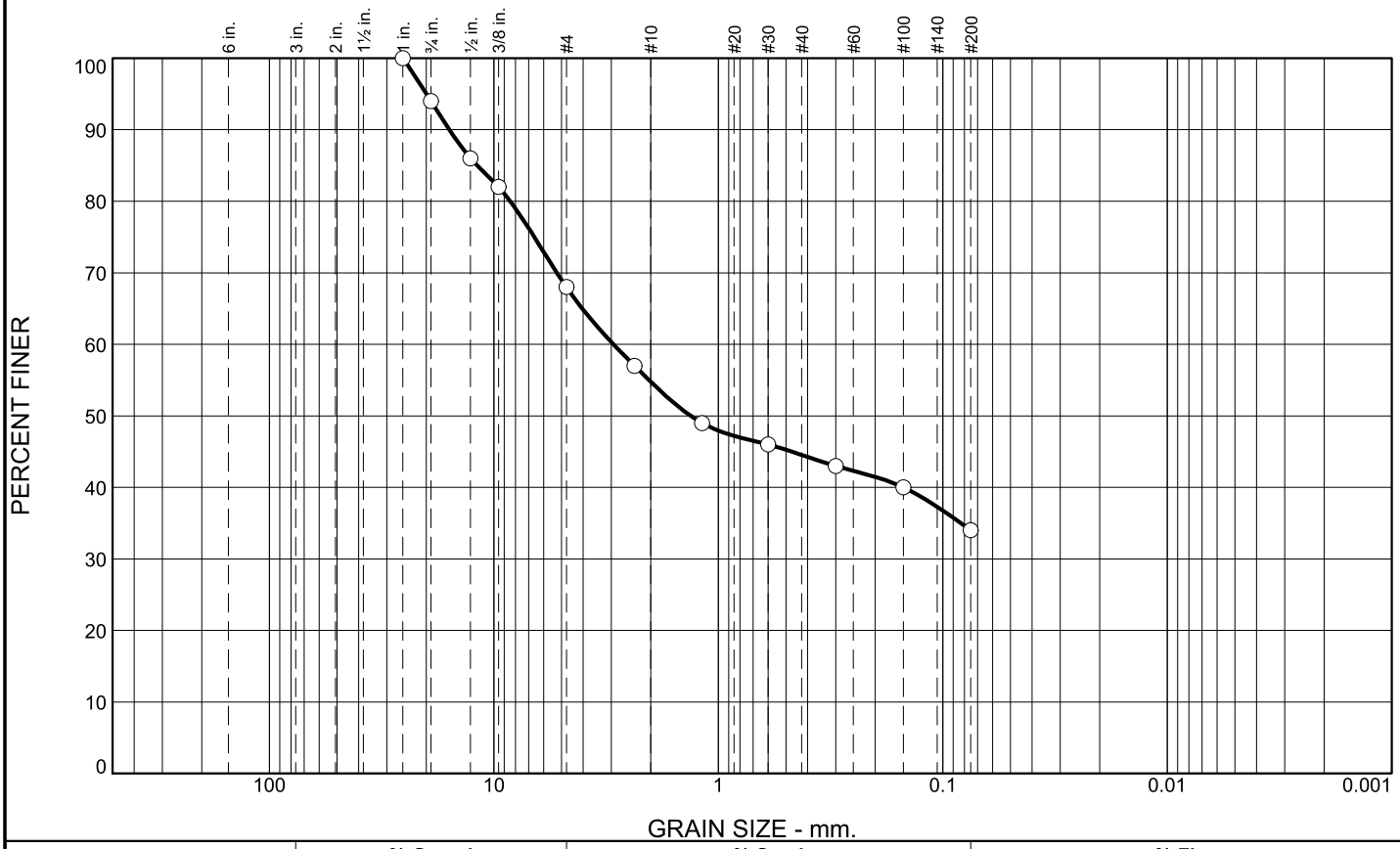
Material tested in accordance with ASTM D6913.

Location: 5-3
Sample Number: 15 **Depth:** 11.0' **Date:** 09/16/2021

Client: Edenbridge Homes
Project: Browns Valley Road Subdivision
3090 Browns Valley Road, Napa, California
Project No: VV5181 **Figure** 0300-004

Tested By: Jack Bianchin

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	6	26	13	10	11	34	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100		
3/4"	94		
1/2"	86		
3/8"	82		
#4	68		
#8	57		
#16	49		
#30	46		
#50	43		
#100	40		
#200	34		

* (no specification provided)

Material Description

Brown Clayey Sand with Gravel (visual)

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 15.7749 D_{85}= 11.8634 D_{60}= 2.9297
D_{50}= 1.3264 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

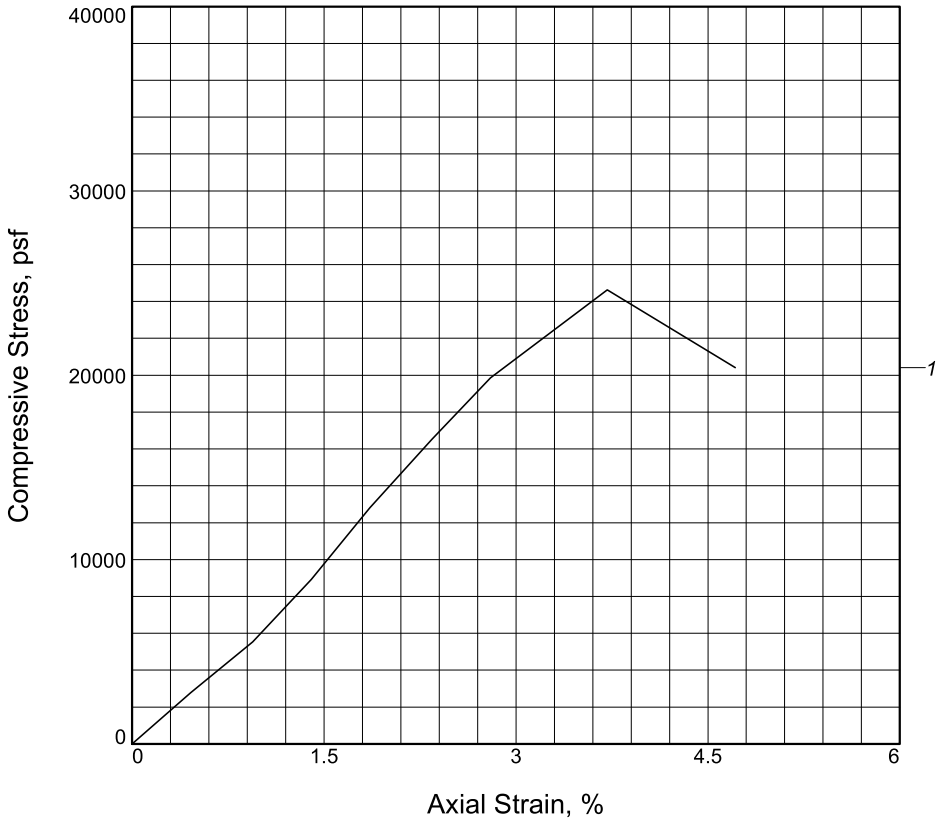
Material tested in accordance with ASTM D6913.

Location: 5-5
Sample Number: 17 **Depth:** 24.0' **Date:** 09/16/2021

Client: Edenbridge Homes
Project: Browns Valley Road Subdivision
3090 Browns Valley Road, Napa, California
Project No: VV5181 **Figure** 0300-005

Tested By: Jack Bianchin

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	24629			
Undrained shear strength, psf	12314			
Failure strain, %	3.7			
Strain rate, in./min.	0.040			
Water content, %	16.1			
Wet density, pcf	115.2			
Dry density, pcf	99.1			
Saturation, %	59.8			
Void ratio	0.7504			
Specimen diameter, in.	2.41			
Specimen height, in.	3.50			
Height/diameter ratio	1.45			

Description: Brown Siltstone (visual)

LL =	**PL =**	**PI =**	**GS=** 2.78	**Type:** Tube

Project No.: VV5181
Date Sampled: 09/16/2021

Remarks:
Material tested in accordance with ASTM D2166.
Type of Failure - Columnar

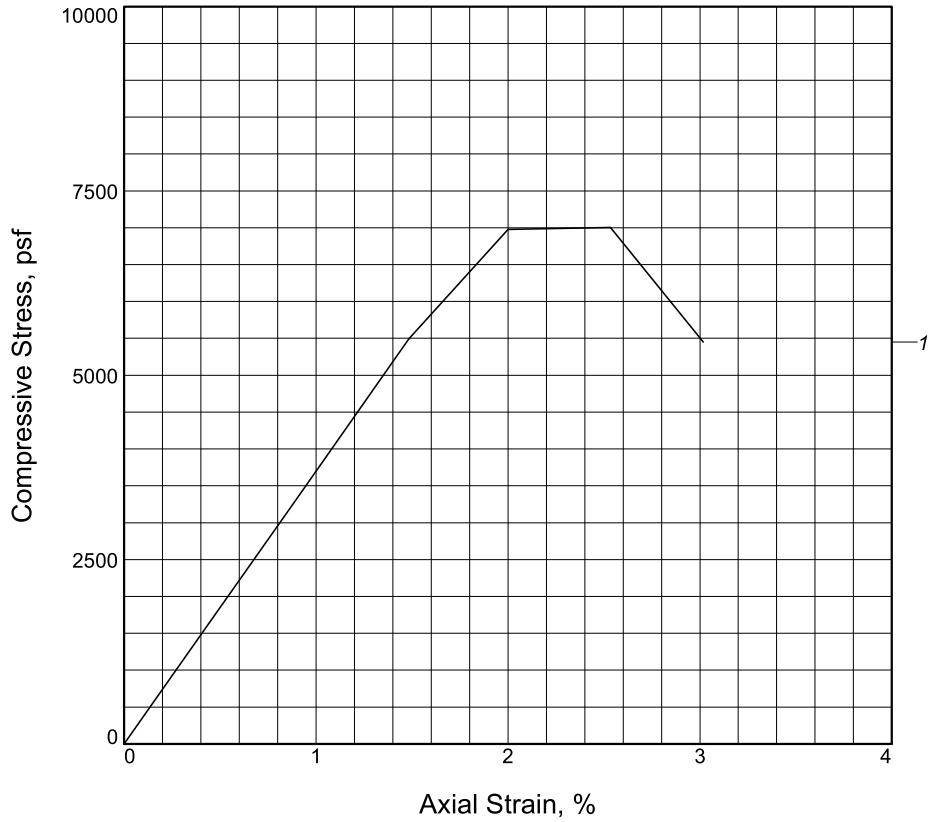
Figure 0300-006

Client: Edenbridge Homes

Project: Browns Valley Road Subdivision
3090 Browns Valley Road, Napa, California
Location: 1-1
Sample Number: 21 **Depth:** 2.0' - 3.0'

Tested By: Cindy Gooden

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	7003			
Undrained shear strength, psf	3501			
Failure strain, %	2.5			
Strain rate, in./min.	0.065			
Water content, %	13.3			
Wet density, pcf	116.6			
Dry density, pcf	102.9			
Saturation, %	53.6			
Void ratio	0.6930			
Specimen diameter, in.	2.41			
Specimen height, in.	5.80			
Height/diameter ratio	2.41			

Description: Brown Sandy Clay with Gravel (visual)

LL =	**PL =**	**PI =**	**GS=** 2.79	**Type:** Tube

Project No.: VV5181
Date Sampled: 09/16/2021

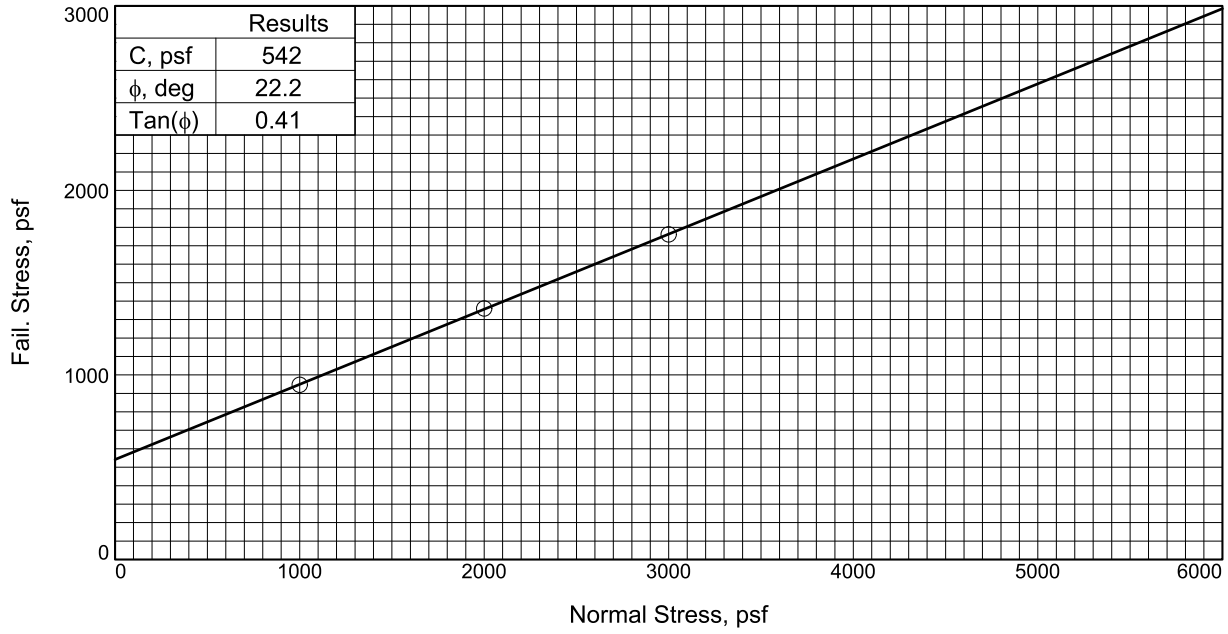
Remarks:
Material tested in accordance with ASTM D2166.
Type of Failure - Columnar

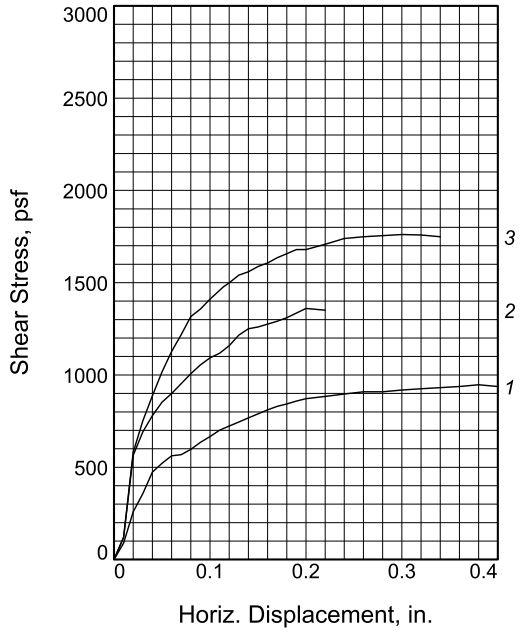
Figure 0300-007

Client: Edenbridge Homes

Project: Browns Valley Road Subdivision
3090 Browns Valley Road, Napa, California
Location: 3-1
Sample Number: 8 **Depth:** 2.5'

Tested By: Cindy Gooden





Sample No.		1	2	3
Initial	Water Content, %	16.0	16.0	16.0
	Dry Density, pcf	82.9	92.1	82.9
	Saturation, %	42.8	53.5	42.8
	Void Ratio	0.9870	0.7897	0.9870
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.00	1.00	1.00
At Test	Water Content, %	30.4	30.4	28.1
	Dry Density, pcf	74.3	81.4	68.9
	Saturation, %	65.8	78.3	53.4
	Void Ratio	1.2192	1.0239	1.3903
	Diameter, in.	2.41	2.41	2.41
	Height, in.	1.12	1.13	1.20
Normal Stress, psf		1000	2000	3000
Fail. Stress, psf		947	1361	1761
Displacement, in.		0.38	0.20	0.30
Ult. Stress, psf				
Displacement, in.				
Strain rate, in./min.		0.002	0.002	0.002

Sample Type: Tube
Description: Brown Sandy Clay

LL= 42 **PL=** 22 **PI=** 20
Specific Gravity= 2.64
Remarks: Material tested in accordance with ASTM D3080.

Figure 0300-008

Client: Edenbridge Homes

Project: Browns Valley Road Subdivision
3090 Browns Valley Road, Napa, California
Location: 2-1
Sample Number: 4 **Depth:** 2.0'
Proj. No.: VV5181 **Date Sampled:** 09/16/2021

Tested By: Cindy Gooden

Materials Testing, Inc.

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Redding, California 96002
(530) 222-1116, fax 222-1611

865 Cotting Lane, Suite A
Vacaville, California 95688
(707) 447-4025, fax 447-4143

Client:	Edenbridge Homes 21771 Stevens Creek Boulevard, Suite 200A Cupertino, CA 95014	**Client No:** **Report No:** **Date:**	VV5181 0300-009 09/16/2021
Subject:	Browns Valley Road Subdivision 3090 Browns Valley Road, Napa, California	**Submitted by:** **Submitted Date:**	KC Engineering 09/07/2021

"R" VALUE TEST REPORT
(ASTM D2844)

Sample:	Subgrade
Description:	Brown Sandy Clay (visual)
Location:	---

SIEVE ANALYSIS

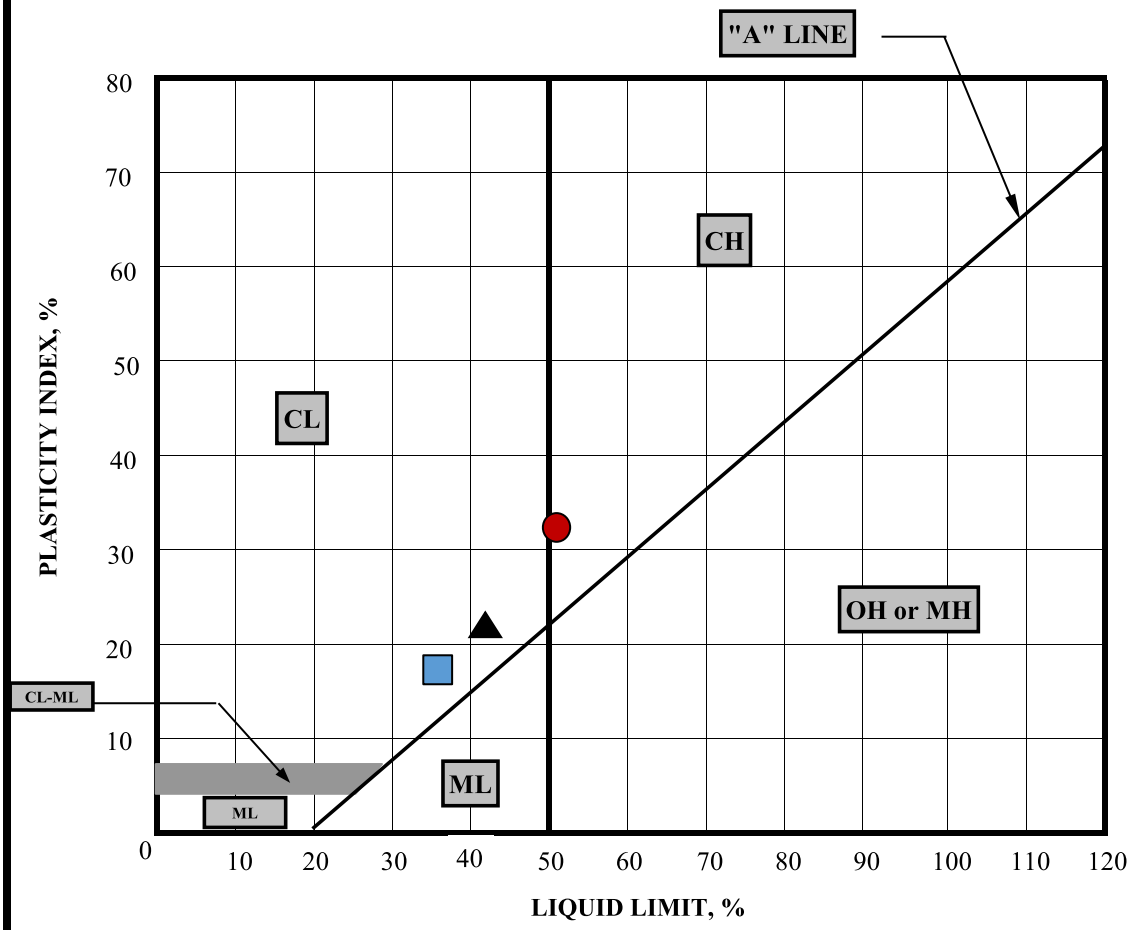
Sieve Size	1"	3/4"	1/2"	3/8"	#4
"As Received" (Percent Pass)	---	---	---	---	100
"As Used" (Percent Pass)	---	---	---	---	100

RESISTANCE VALUE

Specimen Number	Dry Unit Weight, PCF	Moisture (%)	Exudation Pressure (PSI)	Expansion Pressure Dial Reading & PSF		R-Value
1	119.6	14.1	761	61	264	52
2	117.1	15.5	426	32	139	29
3	113.2	17.1	265	8	35	14

R-Value @ 300 PSI Exudation Pressure = **18**

Tested by John Hubbard.
The samples were tested according to the referenced standard test procedures and relate only to the items inspected or tested.
Results are not transferable and shall not be reproduced, except in full, without written permission from MTI.



KEY SYMBOL	SAMPLE NUMBER	DEPTH	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	LIQUIDITY INDEX	UNIFIED SOIL CLASSIFICATION SYMBOL
●	1-1	3.0'	N/A	51	19	32	N/A	CH
▲	2-1	2.0'	N/A	42	20	22	N/A	CL
■	4-1	3.0'	N/A	36	19	17	N/A	CL

Note: Atterberg Limits tested in accordance with ASTM D4318.

Materials Testing, Inc.

PLASTICITY CHART AND DATA

Browns Valley Road Subdivision

3090 Browns Valley Road, Napa, California

Project No:	Date:	Figure No:
VV5181	9/16/2021	0300-010

Sunland Analytical
11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557

Date Reported 09/01/2021
Date Submitted 08/27/2021

To: David Cymanski
K.C. Engineering
865 Cotting Lane Suite A
Vacaville, CA 95688

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following location:
Location : VV5181 Site ID : B1,B2,B3 0-5.
Thank you for your business.

* For future reference to this analysis please use SUN # 85615-178505.

EVALUATION FOR SOIL CORROSION

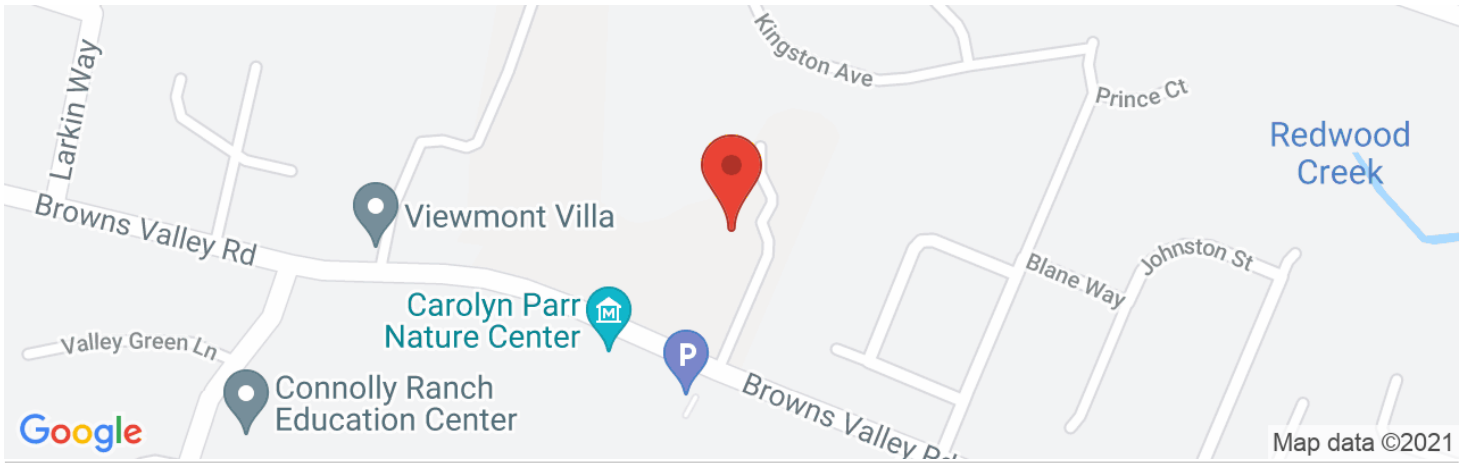
Soil pH	5.69		
Minimum Resistivity	1.42 ohm-cm (x1000)		
Chloride	7.2 ppm	0.00072	%
Sulfate-SO4	20.5ppm	0.00205	%

METHODS
pH and Min.Resistivity CA DOT Test #643 Mod.(Sm.Cell)
Sulfate-SO4 ASTM C1580, Chloride CA DOT Test #422m

OSHPD

3090 Browns Valley Road, Napa

Latitude, Longitude: 38.30405, -122.31905



Date	9/20/2021, 10:44:34 AM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	2.013	MCE_R ground motion. (for 0.2 second period)
S_1	0.729	MCE_R ground motion. (for 1.0s period)
S_{MS}	2.013	Site-modified spectral acceleration value
S_{M1}	1.240	Site-modified spectral acceleration value
S_{DS}	1.342	Numeric seismic design value at 0.2 second SA
S_{D1}	0.826	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	null -See Section 11.4.8	Seismic design category
F_a	1	Site amplification factor at 0.2 second
F_v	1.7	Site amplification factor at 1.0 second
PGA	0.838	MCE_G peak ground acceleration
F_{PGA}	1.1	Site amplification factor at PGA
PGA_M	0.922	Site modified peak ground acceleration
T_L	8	Long-period transition period in seconds
SsRT	2.013	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	2.192	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	2.337	Factored deterministic acceleration value. (0.2 second)
S1RT	0.729	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.796	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.819	Factored deterministic acceleration value. (1.0 second)
PGAd	0.968	Factored deterministic acceleration value. (Peak Ground Acceleration)
C_{RS}	0.918	Mapped value of the risk coefficient at short periods
C_{R1}	0.916	Mapped value of the risk coefficient at a period of 1 s

Project No.
11602.000.003

May 19, 2022

Mr. Michael Allen
Senior Planner
City of Napa Community Development Department
P.O. Box 660
Napa, CA 94559-0660

Subject: 3090 Browns Valley Road
Napa, California

GEOLOGICAL PEER REVIEW

References:

1. Bajada Geosciences, Inc., Fault Evaluation Report, West Napa Fault, 3090 Browns Valley Road, City of Napa, California, July 28, 2021, Project No. 2101.0118.
2. California Geological Survey, Earthquake Zones of Required Investigation, Napa Quadrangle, Napa and Solano County, California, January 11, 2018.
3. California Geological Survey Fault Evaluation Report FER-256, West Napa Fault in the Napa and Cuttings Wharf 7.5-minute Quadrangles Napa and Solano County, California, January 11, 2018.

Dear Mr. Allen:

At your request, we have completed our review of the fault study performed by Bajada Geosciences, Incorporated (BGI) at 3090 Browns Valley Road, Napa, California. Our scope included a review of the above-referenced documents. We also made site visits on June 9 and 11, 2021, during the trench exploration to consult with BGI and view Trench exposures. Based on our observations, we concurred with BGI's interpretations of trench exposures.

BACKGROUND

The project site is located at 3090 Browns Valley Road, Asscessor's Parcel Number (APN) 041-170-009 in the City of Napa, California. The project site is approximately 3.4 acres and is located just north of Browns Valley Road. As depicted on Plate 3 of Reference 1, the project site is located entirely within the defined State Earthquake Fault Zone, based on updated fault hazard mapping described in References 2 and 3. Active fault traces depicted on the state map are shown traversing the northern portion of the site as shown on Plate 3 of Reference 1. The 2014 Napa earthquake produced surface fault rupture on several traces a few thousand feet west of the site, but there was no documented ground rupture on the traces mapped across the site.

BGI reviewed several fault evaluation reports for sites in the vicinity as part of their fault investigation. The reports are included in Appendix A of the BGI report. In 2008, Wesling & Hanson observed the West Napa fault within a creek bank along Browns Valley Creek at the northwestern portion of the site. BGI also reviewed historical aerial photographs,

LIDAR data and excavated and logged three trenches to a maximum depth of 8 feet below the ground surface.

BAJADA GEOSCIENCES INVESTIGATION AND FINDINGS

Between June 9 and 11, 2021, BGI excavated and logged three exploratory trenches across the site. As described in Reference 1, the trenches exposed alluvial stream terrace deposits, alluvial fan deposits, and a relatively thin layer of artificial fill.

Exploratory Trench 1 exposed a thin layer (½' to 2' thick) of artificial fill from Sta 0+00 to 1+50 overlying stream terrace deposits. BGI identified alluvial fan deposits exposed from Sta 1+50 to the terminus of the trench. BGI identified tightly spaced vertical discontinuities within an approximately 4 to 6 feet wide zone of relatively soft and sheared soil within the trench at approximately Sta 2+42. BGI interpreted this shear zone as the West Napa fault which had a strike of N22W and a dip of 87N to vertical.

Exploratory Trench 2 was essentially the southern extension of Trench 1. BGI identified alluvial fan deposits with an overlying approximately 3-foot-thick pedogenic A horizon for the entire length of Trench 2. BGI observed no evidence of faulting within Trench 2.

BGI identified alluvial fan deposits with an overlying approximately 1½- to 2-foot-thick pedogenic A horizon for the entire length of Trench 3. BGI observed no evidence of faulting within Trench 3.

Based on the findings, BGI concludes that the West Napa fault extends across the northern portion of the property. BGI recommends a setback for habitable structures from the fault encountered at the site. Based on the limited width of the fault zones encountered during the exploration BGI considers a setback of 25 feet is reasonable for this site.

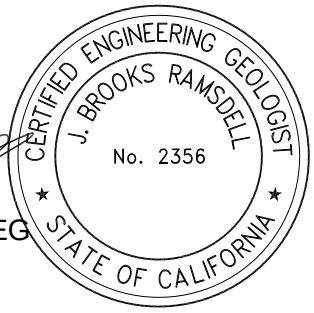
CONCLUSIONS

We conclude that the BGI findings and recommendations are reasonably supported by the conditions revealed on their trench logs and in the exposures in the trenches that we observed in the field. In our opinion, if a structural setback of 25 feet is recommended, consideration should be given to incorporating structural design criteria for building foundations to accommodate minor surface displacement associated with secondary cracking.

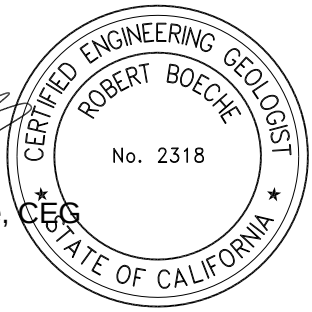
If you have any questions regarding the contents of this letter, please do not hesitate to contact us.

Sincerely,

ENGEO Incorporated



J. Brooks Ramsdell, CEG



Robert H. Boeche, CEG

jbr/rhb/ca

D.2 - Fault Evaluation Report

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FAULT EVALUATION REPORT

West Napa Fault
3090 Browns Valley Road
City of Napa, California

EDENBRIDGE HOMES

Submitted To:

Mr. Dave Cymanski, P.E., G.E.
Materials Testing, Inc., dba
KC Engineering Company
865 Cotting Lane, Suite A
Vacaville, CA 95688

Prepared by:
Bajada Geosciences, Inc.

July 28, 2021
Project No. 2101.0118

BAJADA
Geosciences, Inc.

BAJADA
Geosciences, Inc.
1003 Market Street, Suite 201
Redding, CA 96001
(530) 638-5263
DBE #46532

July 28, 2021
2101.0118

Mr. Dave Cymanski, P.E., G.E.
MATERIALS TESTING, INC., dba
KC ENGINEERING COMPANY
865 Cotting Lane, Suite A
Vacaville, California 95688

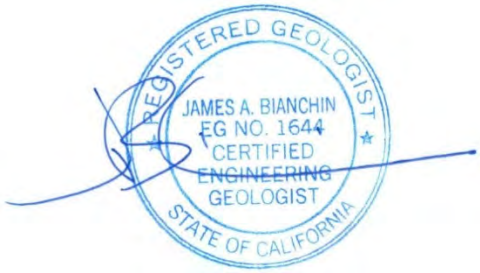
Subject: **Fault Evaluation Report**
West Napa Fault
3090 Browns Valley Road, Napa, California

Dear Mr. Cymanski:

Bajada Geosciences, Inc., is pleased to submit this fault evaluation report to KC Engineering Company, for the proposed Edenbridge Homes development located at 3090 Browns Valley Road, in Napa, California. This report is being submitted in accordance with our proposal dated May 3, 2021. This fault evaluation report discusses previous work reviewed that identifies proximal locations of the West Napa fault to the site, field mapping and explorations performed for this study, findings of that exploration, and an opinion regarding the fault location and proposed habitable structure setbacks from the fault.

We appreciate the opportunity to perform this study. If you have any questions pertaining to this report, or if we may be of further service, please contact us at (530) 638-5263 at your earliest convenience.

Sincerely,
BAJADA GEOSCIENCES, INC.



James A. Bianchin, P.G., C.E.G.
Principal Engineering Geologist

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CITY OF NAPA, CALIFORNIA

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CITY OF NAPA, CALIFORNIA

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APPENDICES

Appendix A ..... Fault Evaluation Reports by Others

1 GENERAL

This report presents the results of our surface fault rupture evaluation for a proposed residential development located within the City of Napa (City), California. Bajada Geosciences, Inc. (BAJADA), has prepared this report at the request of KC Engineering Company (KC), the project geotechnical engineer retained by Edenbridge Homes, the project developer. The project site is shown on Plate 1 – Site Location Map.

The following sections present our understanding of the project, the purpose of our surface fault rupture evaluation, and the findings, conclusions, and recommendations developed during this study. Our services were performed in general accordance with our proposal dated May 3, 2021.

1.1 *PROJECT LOCATION*

The project is located at 3090 Browns Valley Road in the City of Napa California. The properties Assessor's Parcel Number for the property is 041-170-009. Latitude and longitude for the approximate center of the study area are as follows:

APPROXIMATE PROJECT COORDINATES		
Coordinates	**Degrees, Minutes, Seconds**	**Decimal Degrees**
Latitude	38° 18' 13.0"	38.303628°
Longitude	-122° 19' 9.2"	-122.319167°

1.2 *PROJECT UNDERSTANDING*

We understand that a new housing development has been proposed on the approximately 3.4-acre site. The site has been identified as having a fault, labeled the West Napa fault (WNF), projecting through the northern third of the property (Rubin, 2018; Ponti et al, 2019), as shown on Plate 2 – Proximal Traces of West Napa Fault. In addition, another strand of the WNF has been mapped extending south of the southern property line, but close to the property. The State of California (State) has identified the WNF as a Holocene-active fault. Per the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (AP Act), special studies zones (SSZ) have been identified on the subject project that require site-specific fault location studies to identify faults that require setbacks for habitable structures on the property (see Section 1.5 below). Plate 3 – Project Special Studies Zones, shows the locations of those SSZs relative to the site. This report presents the results of a site-specific fault hazard evaluation for the project site, to satisfy the requirements of the AP Act and to provide setback recommendations to Edenbridge Homes.

1.3 STUDY PURPOSE

The purpose of this study was to evaluate whether surface fault rupture has occurred on the subject property site and, if so, to provide recommendations on fault set-back distances for future development of habitable structures.

1.4 SCOPE OF SERVICES

Services performed for this study are in general conformance with the proposed scope of services presented in our May 3, 2021 proposal. Our scope of services included:

- Site reconnaissance of the project site and nearby properties to observe geomorphic conditions potentially associated with faulting;
- Review of historical aerial photographs of the project region to identify potential lineations that might infer faulting;
- Collection and processing of open-source LiDAR data to create hillshade models of the project region to help identify lineations and geomorphic features potentially associated with faulting;
- Review of geologic data relevant to the project area;
- Identification and compilation of available site-specific fault rupture studies that are located in the vicinity of the project site;
- Excavation of exploratory fault trenches on the site. Location of trenches are shown on Plate 4 – Trench Location Map. Logs of fault evaluation trenches are presented as Plates 5.1 through 5.5 – Exploratory Trench Logs;
- Preparation of this report presenting our findings, conclusions, and recommendation from this study.

1.5 REGULATORY SETTING

The State of California designates faults as Holocene-age or Pre-Holocene-age depending on the recency of movement that can be substantiated for a fault. Fault activity is rated as follows:

FAULT ACTIVITY RATINGS		
Fault Activity Rating	**Geologic Period of Last Rupture**	**Time Interval (Years)**
Holocene-Active	Holocene	Within last 11,700 Years[1]
Pre-Holocene	Quaternary & Older	>11,700 Years[1]
Age Undetermined	Unknown	Unknown
[1] – California Geological Survey Special Publication 42, revised 2018		

The California Geologic Survey (CGS) evaluates the activity rating of a fault in fault evaluation reports (FER). FERs compile available geologic and seismologic data and evaluate

if a fault should be zoned as Holocene-active, pre-Holocene, or age undetermined. If an FER evaluates a fault as Holocene-active or has a geomorphic expression that implies it is "sufficiently active" or "sufficiently well defined", then it is typically incorporated into a SSZ in accordance with the AP Act. SSZs require site-specific evaluation of fault location for structures for human occupancy and require a habitable structure setback if the fault is found traversing a project site. Those regulations are defined in California Code of Regulations Title 14, Division 2, Chapter 8, Subchapter 1, Article 3 CCR § 3600 and California Public Resources Code PRC, Division 2, Chapter 7.5, Sections 2621 – 2630.

1.6 *WEST NAPA FAULT*

The WNF is an 18- to 20-mile-long fault zone that extends northwest from San Pablo Bay along the western margin of the Napa Valley to about St Helena, as shown on Plate 6 – West Napa Fault Alignment. The WNF zone is considered part of the greater San Andreas fault system, accommodating a relatively minor amount of accumulated strain within that overall fault system. It is subparallel to the Holocene-active Hayward/Rodgers Creek/Maacama and Green Valley/Huntington/Berryessa fault systems. It is also oriented in a similar trend as the Calaveras/Franklin fault system and some conjecture that the WNF is the northern extension of that system.

In the project region, the WNF encompasses a zone that is up to about 1.2 miles wide and composed of seven primary fault strands with numerous subordinate splays (Ponti et al., 2019). The fault has a predominant right-lateral expression but includes some oblique-slip movement (Rubin, 2018) with the westerly side of the fault uplifted. The fault has an estimated slip rate of less than 2 millimeters per year and a recurrence interval for a M_W 6.7 earthquake of greater than 1,000 years (Field et al., 2015).

The WNF was responsible for the August 24, 2014 M_W 6.0 South Napa Earthquake. That earthquake resulted in surface displacement of the WNF for about 7.6 miles along its length (DeLong et al., 2016). Right lateral displacements of up to 1.6 feet along primary fault strands were measured, with as much as about 4 inches of right-lateral displacement occurring on subordinate splays (Rubin, 2018). Significant post-seismic slip occurred along the westerly-most primary fault strand following the earthquake (Ponti et al., 2019). According to DeLong et al. (2016), postseismic slip exceeded coseismic slip along much of the southern part of the main rupture trace with total slip approaching 1.5 feet one year after the earthquake, at locations where only a few inches were measured the day of the earthquake.

1.7 *PREVIOUS WORK PERFORMED & REFERENCES REVIEWED*

A number of previous surface fault rupture evaluation and paleoseismic studies have been performed along select portions of the WNF . Locations of those previous studies are

shown on Plate 7 – Proximal Relevant Previous Studies. Copies of the reports are presented in Appendix A – Fault Evaluation Reports by Others. Those reports include:

- Western Geological Consultants (1980) performed a fault evaluation study on a 7.8-acre site located south and west of the intersection of Browns Valley Road and Robinson Lane, on APNs 050-270-033, & -035 (3057, 3067, and 3077 Browns Valley Road). One exploratory fault trench was excavated and the WNF was exposed where a photo lineament was noted. That fault was expressed as a 0.4-foot-wide zone of black slickensided soils that offset an alluvial marker bed by one foot, with the westerly side being lower. The overall fault zone had a maximum width of 4 feet and the fault orientation was reported as ten degrees west of north, plunging 75 degrees to the northeast.

- J.H. Kleinfelder & Associates (1983) performed a fault evaluation study at a 4.5-acre property located at 3189 Laurel Street in Napa. That study excavated six exploratory trenches at various locations on the property. No faulting was observed. The authors concluded that the WNF was likely located 200 feet west of the western property line.

- Taber Consultants (1986). This study is referenced by Rubin (2018) but was not obtained during this study. We contacted the California Geological Survey and the City of Napa to see if a copy of this report could be located and provided. Unfortunately, no copy had been obtained at the time this report was written.

- Wesling & Hanson (2008) observed the WNF within a creek bank along Browns Valley Creek at the northwestern portion of the property, as shown on Plate 7. That exposure of the fault identified alluvial soils juxtaposed against Sonoma Volcanics. Radiocarbon dating of charcoal within the alluvium found the fault had ruptured within the last approximately 600 years.

- Berlogar Stevens & Associates (2014) performed a surface fault rupture study on an 80-acre parcel at a location about 1.3 miles due south of the project site. That study was performed following the South Napa Earthquake along fault strand F noted by Ponti et al. (2019), which is the easterly-most fault strand within the WNF zone. A total of 12 exploratory fault trenches were excavated and logged during this study. Their study identified Holocene-active faulting occurring across the site.

In addition to the site-specific studies noted above, we primarily relied upon reports and maps presented by Rubin (2018), Ponti et al. (2019), DeLong et al. (2016), and Wesling and Hanson (2008)

2 FINDINGS

2.1 *SITE CONDITIONS*

The project site is located on a 3.4-acre parcel. It is bounded on the west and east sides by residential properties. The property is bounded to the south by Browns Valley Road. To the north, the property is bounded by Browns Valley Creek. Elevations at the parcel range from about 83 to 94 feet (RSA, 2021)

The property is developed with a residential structure, a barn, and various outbuildings. The residential structure is accessed from Browns Valley Road via a paved access road. Aside from the structures, the property is fallow and covered with seasonal grasses, has relatively mature trees along the access road, westerly property boundary and around the residence, and has landscaping in the vicinity of the residence.

2.2 *Regional Geology*

The project site is located within the Coast Ranges Physiographic province of California. The Coast Ranges province is a northwest-trending mountain range that is about 50 miles wide and extends about 400 miles from its southern terminus in Santa Barbara County north into Shasta County and southern Oregon. It is bordered to the west by the Pacific Ocean, to the south by the Transverse Ranges Province, to the east by the Great Valley province, and to the north by the Klamath Mountains Province.

The Coast Ranges province is composed predominantly of Cenozoic- and Mesozoic-age sedimentary rocks. Lesser amounts of Pleistocene-aged volcanic rocks occur locally within the province (such as in Clear Lake) as do granitic rocks of the Salinian Block, located west of the San Andreas fault.

The province is separated into the Northern and Southern Coast Ranges at the Golden Gate (Hinds, 1952). The project site is located at the southern end of the Northern Coast Ranges on the east side of the Sonoma Mountains in Napa Valley. The Sonoma Mountains are composed of Cenozoic-age sedimentary and volcanic rocks.

Plate 8 – Regional Geologic Map presents the geologic conditions in the area surrounding the project site (Clahan et al., 2004). As noted on that map, the underlying bedrock in the area is the Sonoma Volcanics of Miocene- to Pliocene-age. Overlying the volcanics are various surficial sedimentary materials consisting of alluvial fan and stream channel deposits ranging in age from Pleistocene to recent.

2.3 *Local Geologic Setting*

As shown on Plate 9 – Local Geologic Map , the site is underlain by Quaternary- and Holocene-aged alluvial fan and stream terrace deposits, and artificial fill.

Artificial fill materials are present beneath the home currently on the site and other ancillary structures and infrastructure. Those materials were predominantly granular and were likely imported to the site in order to construct the pad on which the property and outlying structures were built. Based on observations within our exploratory trenches, it appears that the artificial fill materials are up to about 2 feet thick. Those relatively thin zones of artificial fill are not depicted on Plate 9 due to their limited thicknesses.

Stream terrace deposits were encountered in the northern third of the property. Those materials consisted of loosely consolidated, interbedded sandy silt, silty sand, sand with silt, and sand with gravel. Locally, some interbeds contained local to abundant charcoal and organic materials.

Alluvial fan deposits underlie the artificial fill and stream terrace deposits and consist of silty clay, gravelly clay, and clay. The alluvial fan deposits were relatively massive, had a well-developed pedogenic A horizon, may have buried paleosols, as observed in Trench 3, and were not fully penetrated during this study. It is anticipated that the alluvial fan deposits are underlain by the Sonoma Volcanics.

2.4 *Geomorphology*

The southern approximately two-thirds of the property is flat to gently inclined towards the northwest at elevations ranging from about 92 to 94 feet (RSA, 2021) with no noticeable geomorphic inflections.

North of the residence, the topography descends by about 6 feet to a relatively flat terrace that has an elevation of about 83 feet. The slope descending to the northern terrace has geomorphology that could be related to fault displacement or erosion due to flows from the adjacent Browns Valley Creek. When trenching the northern terrace and descending slope, it was apparent that the slope had historically been modified by grading to flatten the slope and that fill materials had been placed on the terrace, as shown on Plate 5.1. Also exposed within the trench at the northern terrace were fluvial deposits associated with Browns Valley Creek. Based on our observations, it is our opinion that the slope descending to the northern terrace is not tectonically related but is an erosional surface descending to a strath terrace associated with Browns Valley Creek and coincident with a projected strand of the WNF.

2.5 *Groundwater*

Groundwater was not observed in trenches excavated for this study. The depth to groundwater is unknown.

3 SITE SPECIFIC INVESTIGATION AND METHODS

3.1 GENERAL

The following section discusses surface fault rupture evaluations performed for this project.

3.2 AERIAL PHOTOGRAPHY REVIEW

A variety of historical aerial photographs were reviewed during this study, as noted in the following table:

AERIAL PHOTOGRAPHS REVIEWED				
DATE	**SCALE**	**PHOTO ID**	**TYPE**	**SOURCE[1]**
6-30-1940	1:20,000	C&P CR. 1-60, -61	Stereo B/W	UCSB
3-1-1947	1:6,000	NA	B/W	EDR
6-18-1957	1:24,000	CAS-1957 Napa1	B/W	UCSB
3-24-1959	1:6,000	NA	B/W	EDR
7-2-1965	1:12,000	NAP 62-20, -21, -256, -257	Stereo B/W	UCSB
4-20-1968	1:6,000	NA	B/W	EDR
9-27-1973	1:6,000	NA	Color	EDR
7-8-1982	1:6,000	NA	False color	EDR
7-6-1993	1:6,000	NA	Color	EDR
[1] – UCSB = Imagery library at U.C. Santa Barbara. EDR = Environmental Dara Resources.				

Based on our aerial photographic review, a number of lineations were identified projecting through the project region that could be fault related. The most prominent lineation corresponds to where the WNF was identified by Western Geological Consultants (1980) in their exploratory trench. Plate 10 – Prominent Lineation, shows the lineation on the 1982 false color aerial photograph of the project area. That lineation projects through the subject property on alignment to intersect the fault exposure noted by Wesling & Hanson (2008).

3.3 HILLSHADE EVALUATIONS

Open-source LiDAR data was obtained for the project area and processed to produce a hillshade model of the project area. That hillshade model is presented on Plate 11 – Hillshade Model. The vertical exaggeration and light orientations of the hillshade model were parametrically adjusted to present, in our opinion, favorable parameters to highlight geomorphic features that might be indicative of faulting on or near the project site. As noted on Plate 11, a prominent geomorphic inflection is visible on the hillshade model that is coincident with the lineation noted on Plate 10, both of which correspond to fault exposures identified by Western Geological Consultants (1980) and Wesling & Hanson (2008).

3.4 *SITE RECONNAISSANCE*

BAJADA personnel performed a site reconnaissance across the subject property along with adjacent and nearby properties, to help identify geomorphic and geologic features that could be indicative of faulting. During that reconnaissance we did not observe any evidence of ground rupture or cracking that might have been associated with the 2014 South Napa Earthquake. On-site, we did observe some geomorphic features that could have been fault related, specifically inflections in the ground surface; however, those inflections were later identified to be erosional from the adjacent Browns Valley Creek.

3.5 *FIELD INVESTIGATION*

BAJADA's field investigations consisted of the excavation and logging of three exploratory fault trenches, performed between June 9 and 11, 2021. Those logs are presented on Plates 5.1 through 5.5. Trench locations are shown on Plate 4.

Trenches 1 and 2 are essentially one contiguous trench; however, the presence of buried utilities beneath low oak trees in one area posed difficult access issues for the excavator without damaging the utilities or trees. Because of that, a relatively narrow section of soil about 10 horizontal feet long, between Trenches 1 and 2 was left in place. Trenches 1 and 2 are located along the northern two-thirds of the property on its eastern side. Trenches 1 and 2 total about 410 and 120 feet long, respectively. Trench 3 was located on the southern portion of the property along its western margin and totaled about 210 feet long.

Trenching was performed using a Caterpillar 308E excavator equipped with a three-foot-wide bucket. The excavator was provided by Benchmark Civil Construction, Inc., of Napa. The trench was excavated to depths of up to about 7.5 feet and was shored using hydraulic speed shores to reduce trench collapse risks in areas where we were logging.

Once excavated, the trench sidewalls were cleaned using hand scraping tools. Horizontal stringlines were then placed as control for logging. A laser level was used to confirm that the stringlines were horizontal and to adjust the stringline levels when trench grades increased or decreased. A 100-foot-long engineer's tape was used to establish stationing during logging.

The following sections discuss our observations within the trenches excavated for this study.

3.5.1 Exploratory Trench 1

Exploratory trench 1 exposed alluvial (stream terrace deposits) and alluvial fan deposits. The alluvial sediments were exposed between about Station Nos. 0+00 and 1+50 and consisted of stratified sandy silt, silty sand, and gravelly sand present within the strath terrace. Those soils locally contained abundant organics and charcoal fragments. Individual layers within the alluvium ranged in thickness from inches to about 2 feet. Artificial fill

materials consisting of sandy gravel with varying amounts of debris were present within the upper six inches to two feet of the soil column above the alluvium. No faulting was observed within the alluvial soils.

Alluvial fan deposits were exposed within the trench south of Station 1+50 to the terminus of trench 1 at Station 3+36. Those materials consisted of silty clay to clay with local interbeds of clayey coarse sand and gravel. Between about Station 1+50 to 2+46, grading had removed the upper portion of the soil column leaving a pedogenic soil horizon (A horizon) that gradually thickened towards the south. From Station 2+46 to 3+36, that A horizon was relatively prominent and ranged in thickness from about 2 to 4 feet. Soils beneath the A horizon were relatively massive except where the clayey sand and gravel were present.

At about Station 2+42, relatively tightly spaced near vertical discontinuities were observed in the soil with one of those discontinuities having an approximate 0.3- to 0.6-inch-wide aperture extending from near the trench bottom to near the top of trench. A zone approximately 2 to 3 feet wide on either side of these vertical discontinuities was sheared and had a relatively soft consistency and sheared texture that soils outside of that zone lacked. Projections of the discontinuity orientations from the east to the west side of the trench were measures and found the discontinuities oriented 22 degrees west of north with a vertical plunge. This zone of disturbance is coincident with the lineament projected across the property and is in alignment with the mapped trace of the WNF. It is our opinion the WNF was encountered at Station 2+42 within Trench 1.

3.5.2 Exploratory Trench 2

Exploratory Trench 2 exposed alluvial fan deposits for the entire trench length. Those materials consisted of silty clay to clay with a pedogenic soil horizon (A horizon) at the top of the soil column of at least 3 feet thick. No faulting was observed in this trench.

3.5.3 Exploratory Trench 3

Trench 3 exposed alluvial fan deposits for its entire length. A 1.5- to 2-foot-thick pedogenic horizon (A horizon) was present along the entire length of the trench. Below that A horizon was a massive silty clay to clay that was up to 3 feet thick. That soil was underlain by a darker silty clay to clay that contained charcoal and carbon and is likely a paleosol. Underlying the paleosol was a silty clay to clay soil. No faulting was observed within this trench.

3.6 *PEER REVIEW*

Our trench exposures and fault location were observed by a third-party engineering geologist that provides peer review services to the City. Those observations and review services were provided by Mr. Phil Steucheli, PG, CEG, employed with EnGeo. Mr. Steucheli visited the site on June 9, 2021 and on June 11, 2021. Based upon discussions with Mr. Steucheli at the

conclusion of his June 11, 2021 visit, we understand that he is in agreement with our fault observations made during this study.

4 RECOMMENDATIONS

4.1 *HABITABLE STRUCTURE SETBACKS FROM FAULT*

Based upon our study and trench observations, it is our opinion that the WNF extends across the northern third of the property, as shown on Plate 4. We recommend that all habitable structures be setback from the fault, in accordance with the AP Act. According to the California Code of Regulation, Title 14, Division 2, Section 3603 (a):

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

Based on the language above, there appears to be latitude to reduce setbacks of habitable structures from active faults from a minimum of 50 feet to a lesser distance.

Studies have been performed that show deformation along faults decreases with distance from the primary fault trace and by the age of the soils. Borchardt (2010) indicated that between 77 to 85 percent of deformation associated with fault rupture occurs on the primary fault within the rupture zone. With increased distance from that zone the fault rupture deformation significantly decreases such that there is less than 0.13 percent of total offset in soils that have not previously been sheared due to faulting (Borchardt, 2010). This implies that areas adjacent to fault zones that are observed to be very narrow, have a lower chance of fault rupture and deformation at any significant distance outside of that primary rupture zone.

As discussed in Western Geological Consultants (1980) and Wesling and Hanson (2008), the splay of the WNF that they encountered and which traverses the subject property was limited in width. In both cases, the fault zone width was less than 6 feet. The zone in which the soils surrounding the active fault were observed within our exploratory trench was also up to about 6 feet in width. These three studies imply that the splay of the WNF extending through the subject property has a relatively narrow zone that projects through relatively old soils. The age of those soils is considered Holocene but could be many thousands of years old.

Using arguments by Borchardt (2010) and the limited fault zone width observed during this study, Western Geological Consultants (1980), and Wesling and Hanson (2008), reducing the

minimum habitable structure offset from the fault from 50 feet to 25 feet appears reasonable for this project site.

4.2 *FAULT TRENCH BACKFILL AND COMPACTION*

The fault trenches excavated for this study were loosely backfilled with the excavated soils then track walked at the surface. If structures of improvements are to be constructed over these trenches, we recommend that the soils be re-excavated and compacted in accordance with recommendations made by the geotechnical consultant working on this project.

5 LIMITATIONS

This report has been prepared in substantial accordance with the generally accepted engineering geological practice, as it existed in the site area at the time our services were rendered. No other warranty, either express or implied, is made.

Conclusions and recommendations contained in this report were based on the conditions encountered during our field investigation and are applicable only to those project features specifically addressed and described herein (see Section 1.1 – Project Understanding). Soil and rock deposits can vary in type, strength, and other geotechnical properties between points of observation and exploration. Additionally, groundwater and soil moisture conditions can also vary seasonally and for other reasons. Therefore, we do not and cannot have a complete knowledge of the subsurface conditions underlying the project site. The conclusions and recommendations presented in this report are based upon the findings at the points of exploration, and interpolation and extrapolation of information between and beyond the points of observation and are subject to confirmation based on the conditions revealed by construction. If conditions encountered during construction differ from those described in this report, or if the scope or nature of the proposed construction changes, we should be notified immediately in order to review and, if deemed necessary, conduct additional studies and/or provide supplemental recommendations. When final site design plans (grading, foundation, retaining walls, etc.) become available, BAJADA should have the opportunity to review the plans to ensure the recommendations presented in this report remain valid and applicable to the proposed project.

The scope of services provided by BAJADA for this project did not include the investigation and/or evaluation of toxic substances, or soil or groundwater contamination of any type. If such conditions are encountered during site development, additional studies may be required. Further, services provided by BAJADA for this project did not include the evaluation of the presence of critical environmental habitats or culturally sensitive areas. This report may be used only by our client and their agents and only for the purposes stated herein, within a reasonable time from its issuance. Land use, site conditions, and other

factors may change over time that may require additional studies. In the event significant time elapses between the issuance date of this report and construction, BAJADA shall be notified of such occurrence in order to review current conditions. Depending on that review, BAJADA may require that additional studies be conducted and that an updated or revised report is issued.

Any party other than our client who wishes to use all or any portion of this report shall notify BAJADA of such intended use. Based on the intended use as well as other site-related factors, BAJADA may require that additional studies be conducted and that an updated or revised report be issued. Failure to comply with any of the requirements outlined above by the client or any other party shall release BAJADA from any liability arising from the unauthorized use of this report.



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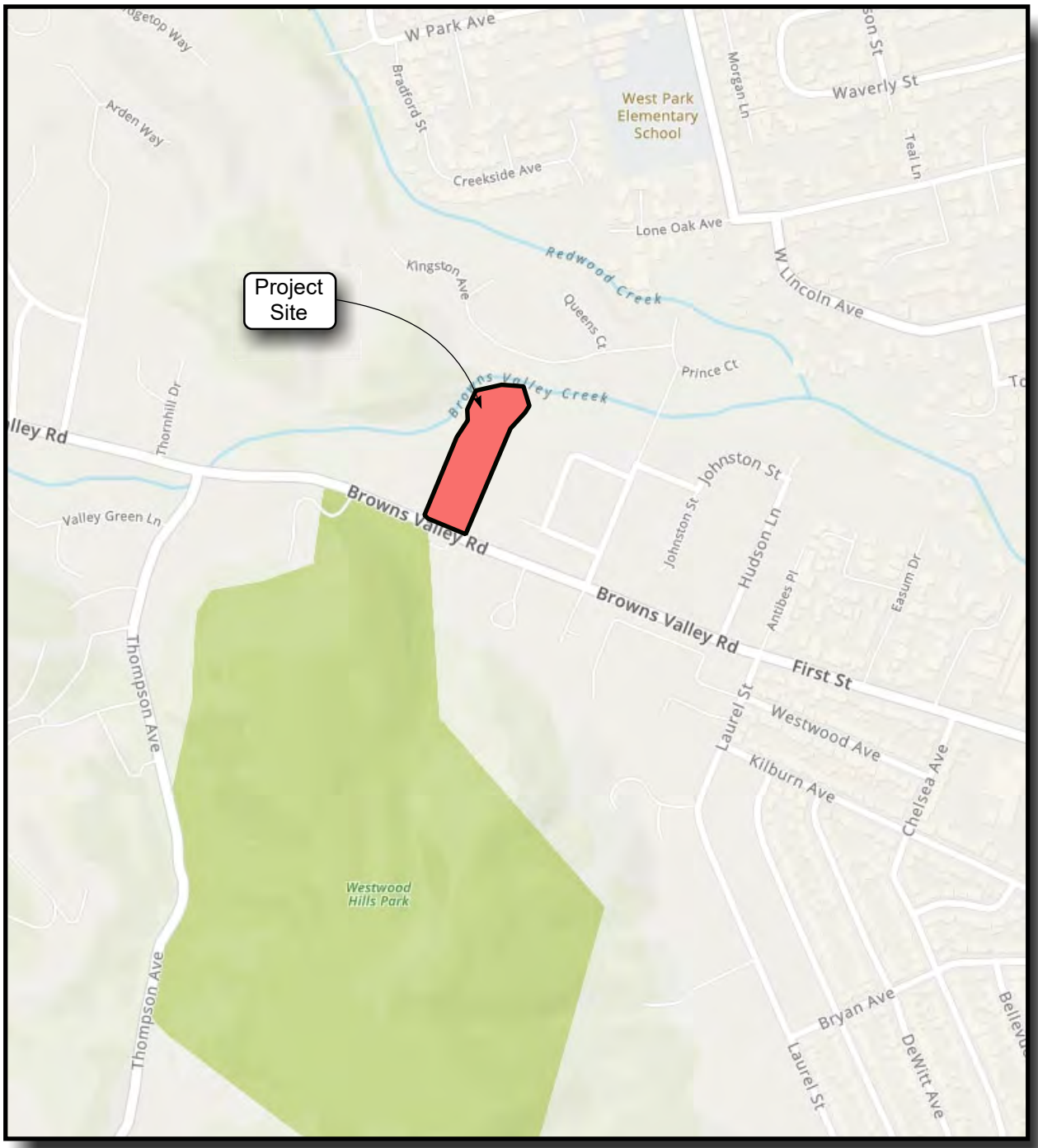
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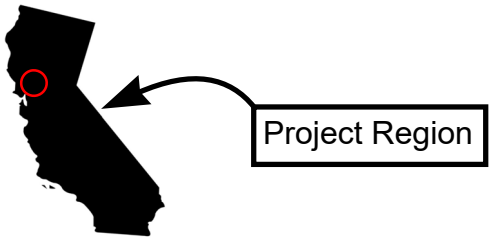
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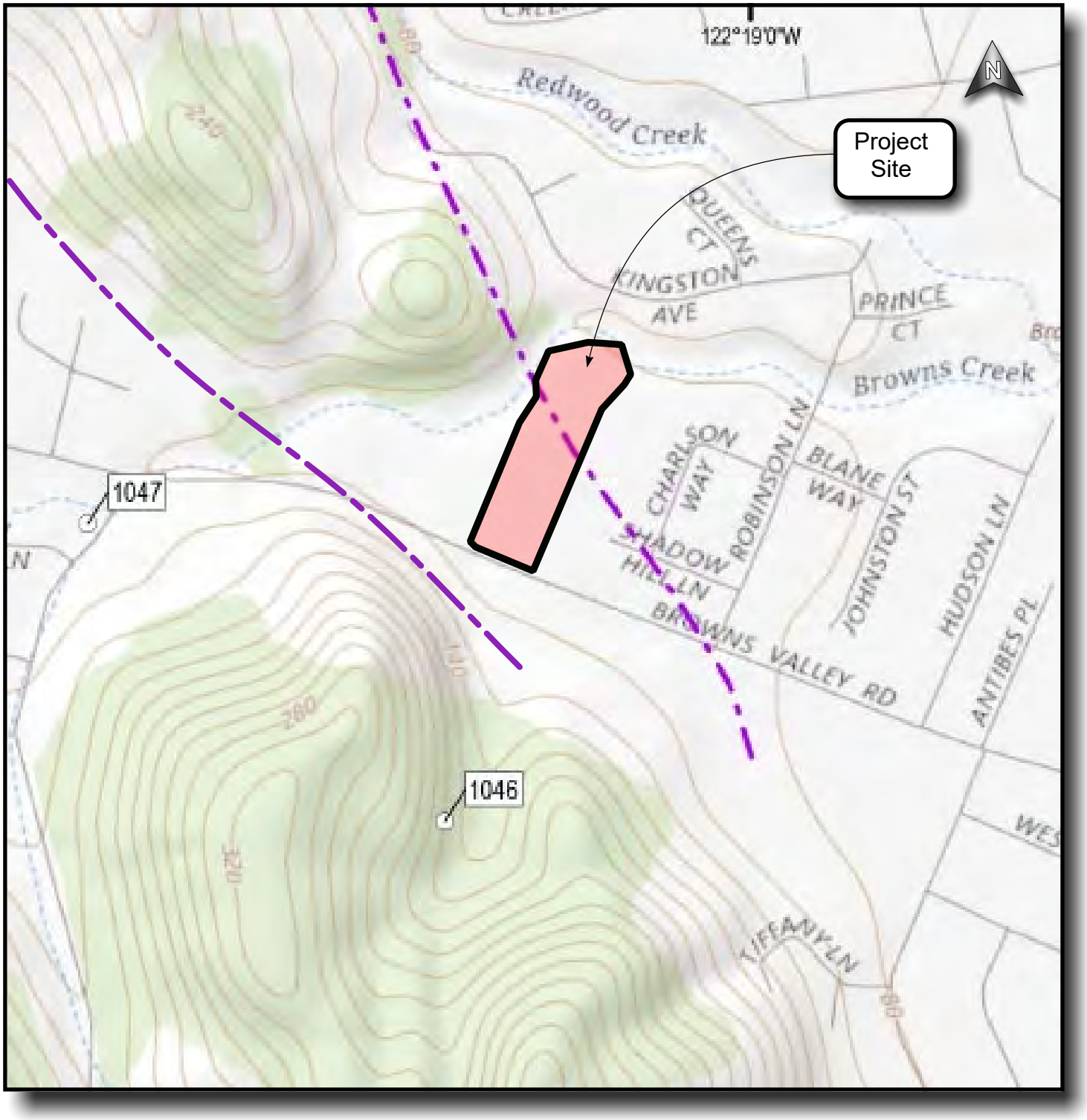
SITE LOCATION MAP

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 1

BAJADA Geosciences, Inc.

Project no. 2101.0118



Map modified from Ponti et al, 2019

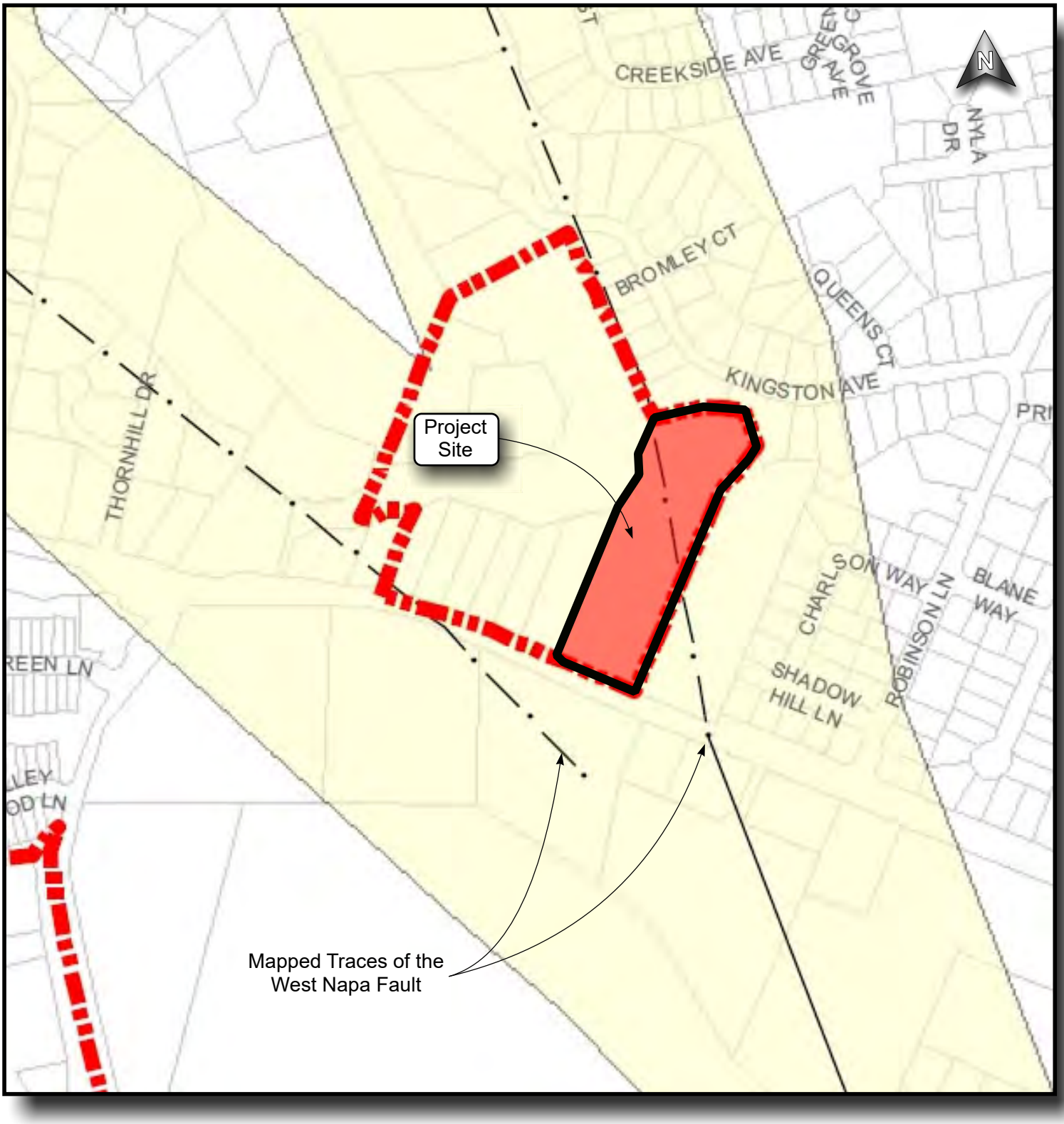
PROXIMAL TRACES OF WEST NAPA FAULT

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 2

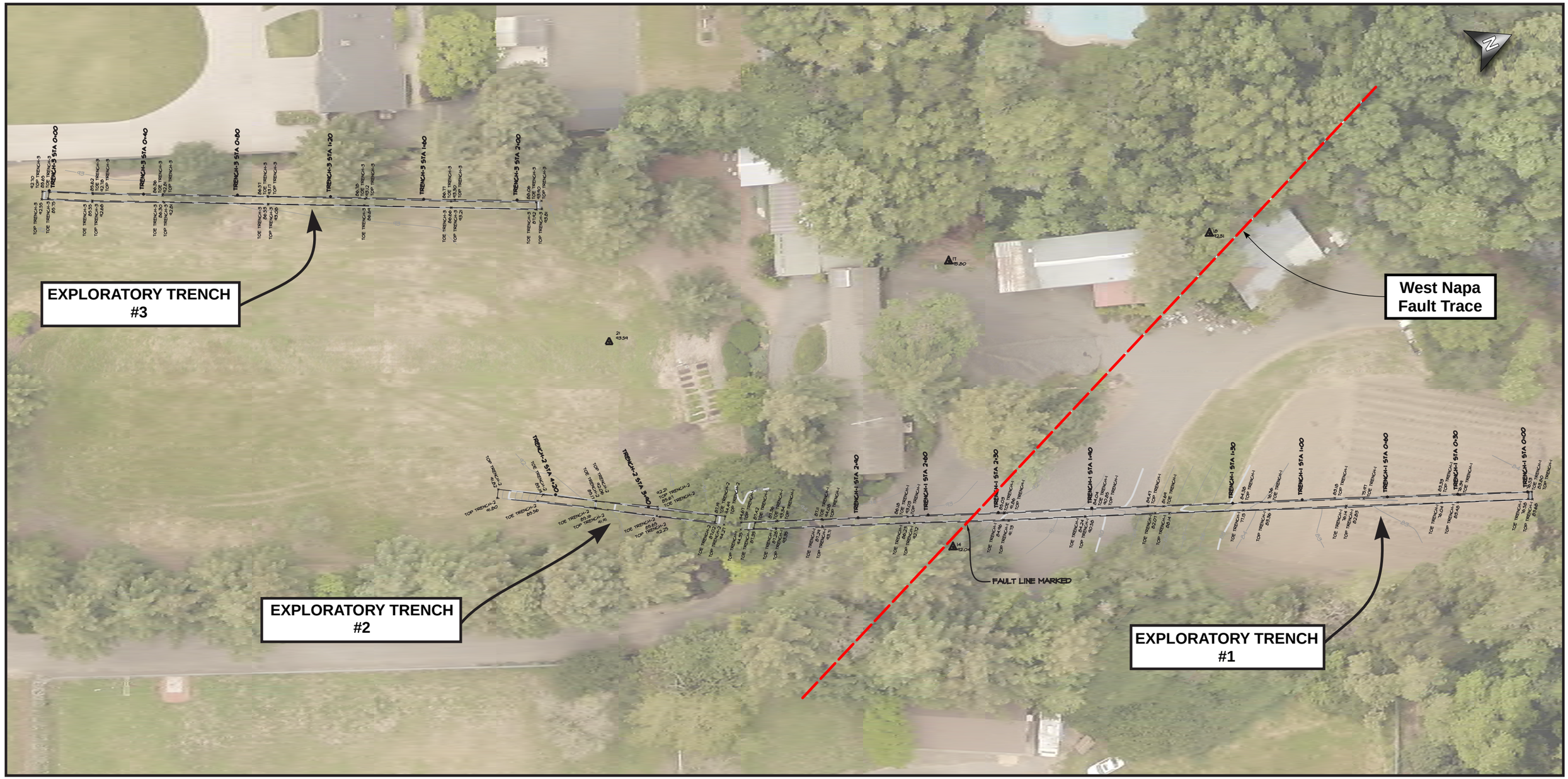
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Project no. 2101.0118



Alquist-Priolo Special Studies Zone

PROJECT SPECIAL STUDIES ZONES	
West Napa Fault Evaluation 3090 Browns Valley Road City of Napa, California	Plate No. 3
BAJADA Geosciences, Inc.	Project no. 2101.0118



GRAPHIC SCALE

30 0 20 40

(IN FEET)

Map provided by RSA Consulting Civil Engineering & Surveying (2021)

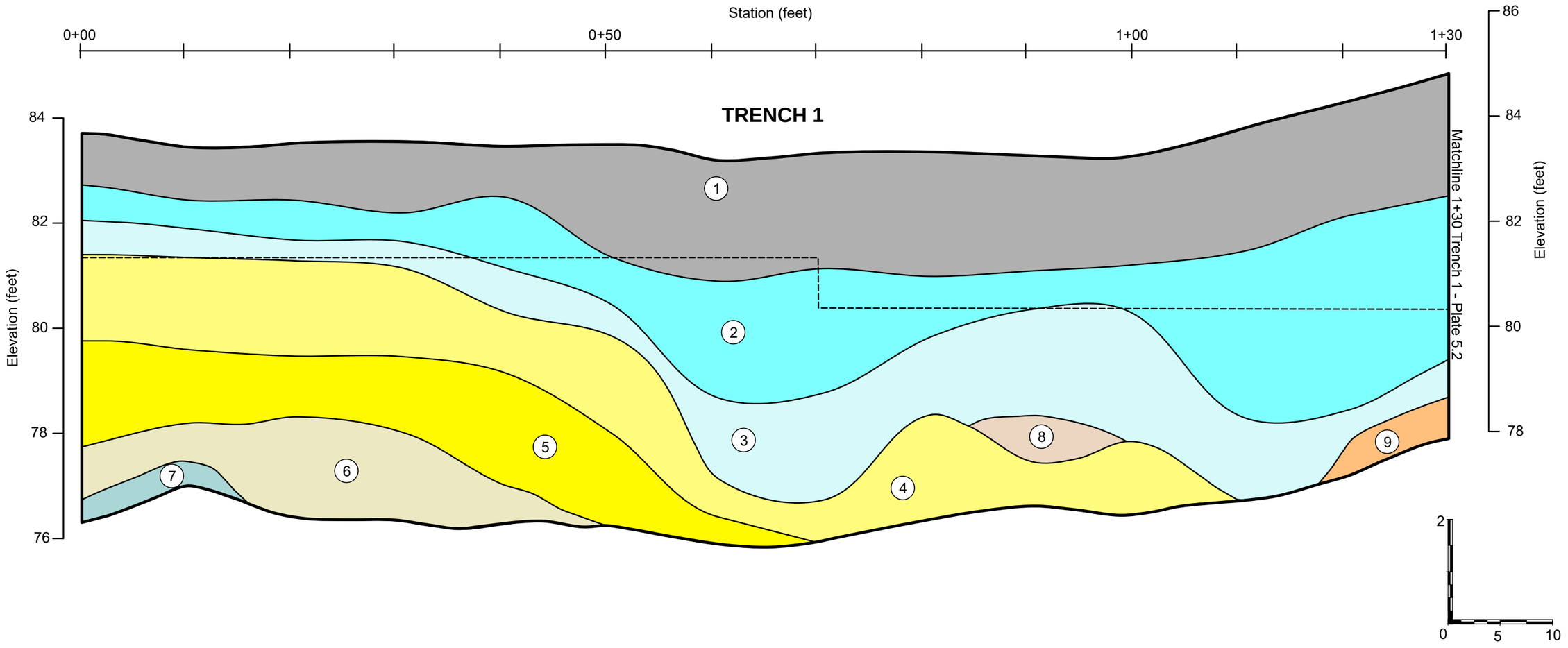
TRENCH LOCATION MAP

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 4

BAJADA Geosciences, Inc.

Project no. 2101.0118



See Plate 5.5 for true scale sections

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1 Artificial Fill, moderate to dark brown with debris.

2 Sandy silt with gravel, moderate brown massive, dry to damp, fine sand, with fine subangular gravel

3 Sandy silt, light tan, dry, massive, fine sand

4 Silty sand, moderate brown, dry, friable, fine grained, with charcoal

5 Sand, moderate to dark brown, dry, fine to medium grained

6 Silty sand, moderate brown, dry, friable, fine grained, with charcoal

7 Sand with silt, light brown, dry, friable, fine grained.

8 Sand with gravel, moderate brown, dry, friable, fine to coarse grained with fine to medium subangular gravel.

9 Sand with gravel, moderate brown, dry, friable, fine to coarse grained with fine to medium subangular gravel.

---------- Stringline Location, used for logging control

Elevations from RSA (2021)

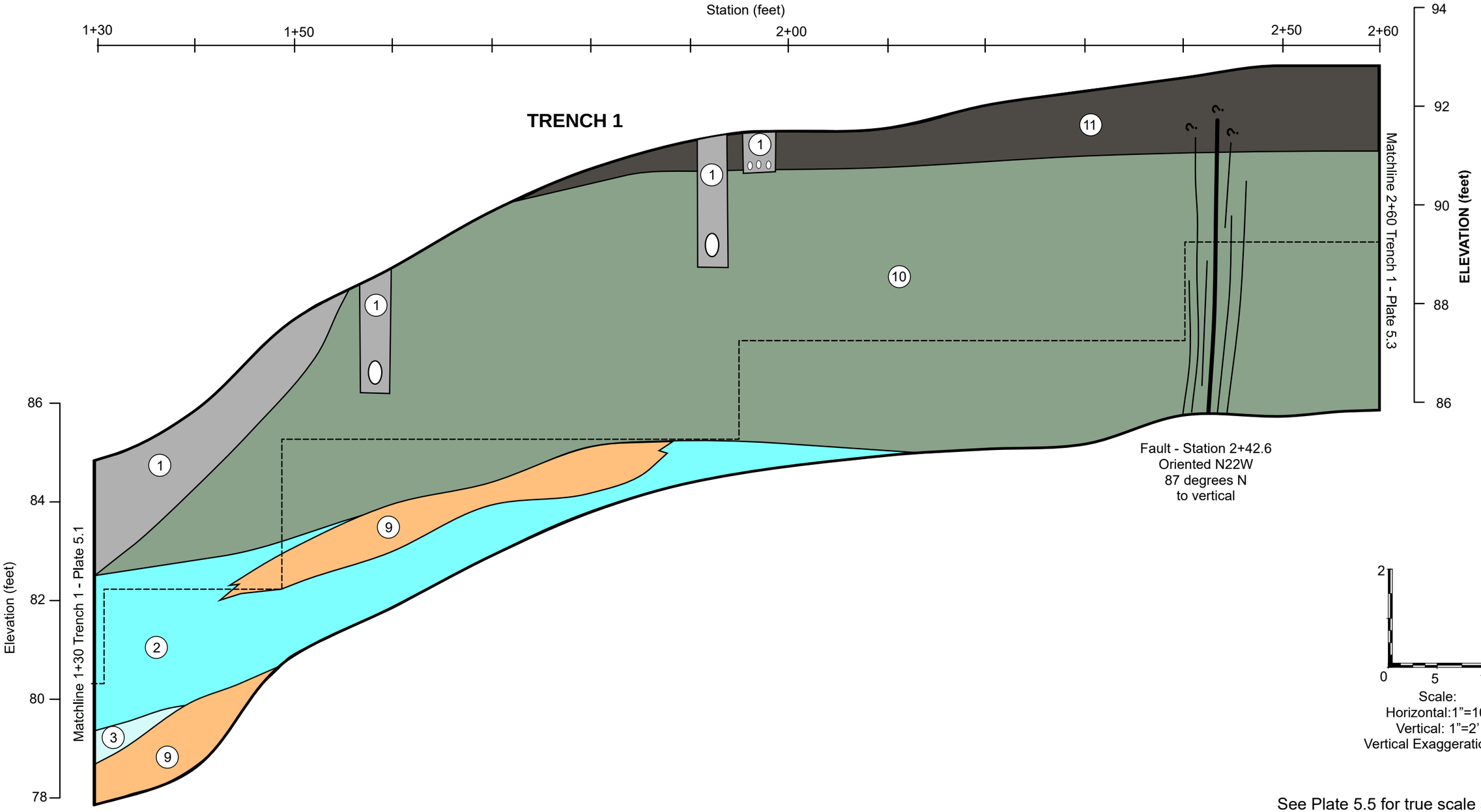
TRENCH LOG

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 5.1

BAJADA Geosciences, Inc.

Project no. 2101.0118



2

0 5 10

Scale:
Horizontal:1”=10’
Vertical: 1”=2’
Vertical Exaggeration 5x

See Plate 5.5 for true scale sections

1 Artificial Fill, moderate to dark brown with debris and pipelines/conduits.

2 Sandy silt with gravel, moderate brown massive, dry to damp, fine sand, with fine subangular gravel

3 Sandy silt, light tan, dry, massive, fine sand

9 Sand with gravel, moderate brown, dry, friable, fine to coarse grained with fine to medium subangular gravel.

10 Sandy to silty clay, medium to dark brown, damp to moist, with abundant blocky to prismatic peds.

11 Sandy to silty clay, medium to dark brown, damp to moist, with abundant blocky to prismatic peds, pores & roots. A-horizon.

--------- Stringline Location, used for logging control

Elevations from RSA (2021)

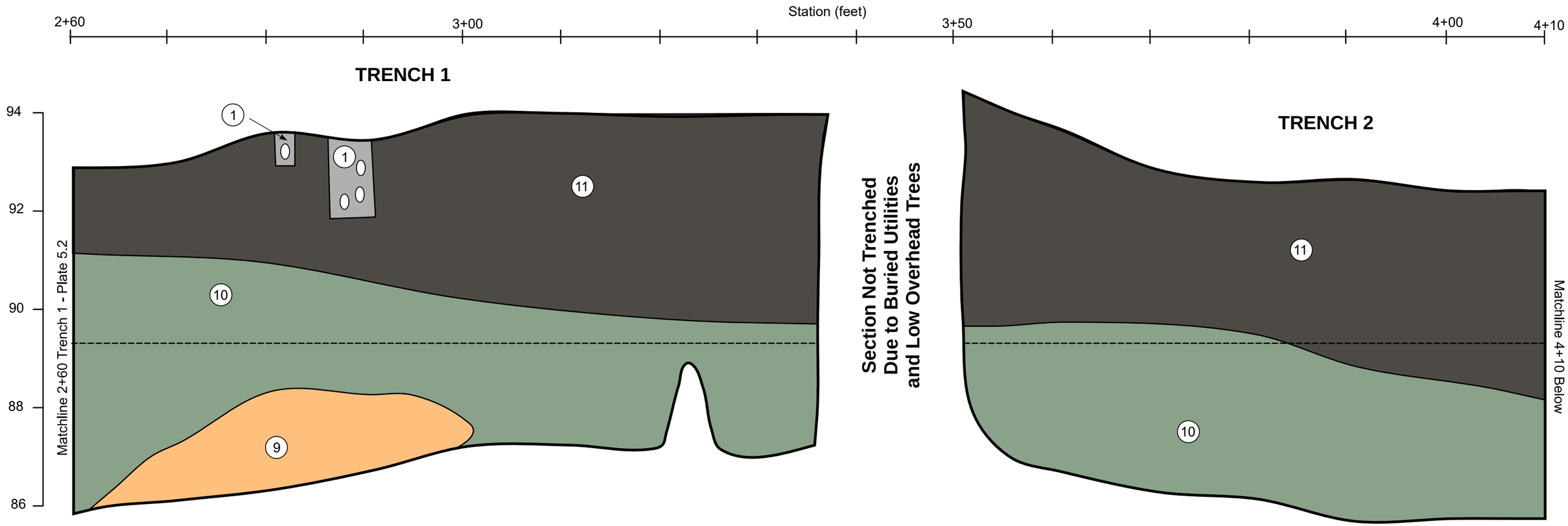
TRENCH LOG

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 5.2

BAJADA Geosciences, Inc.

Project no. 2101.0118



See Plate 5.5 for true scale sections

Elevations from RSA (2021)

TRENCH LOG

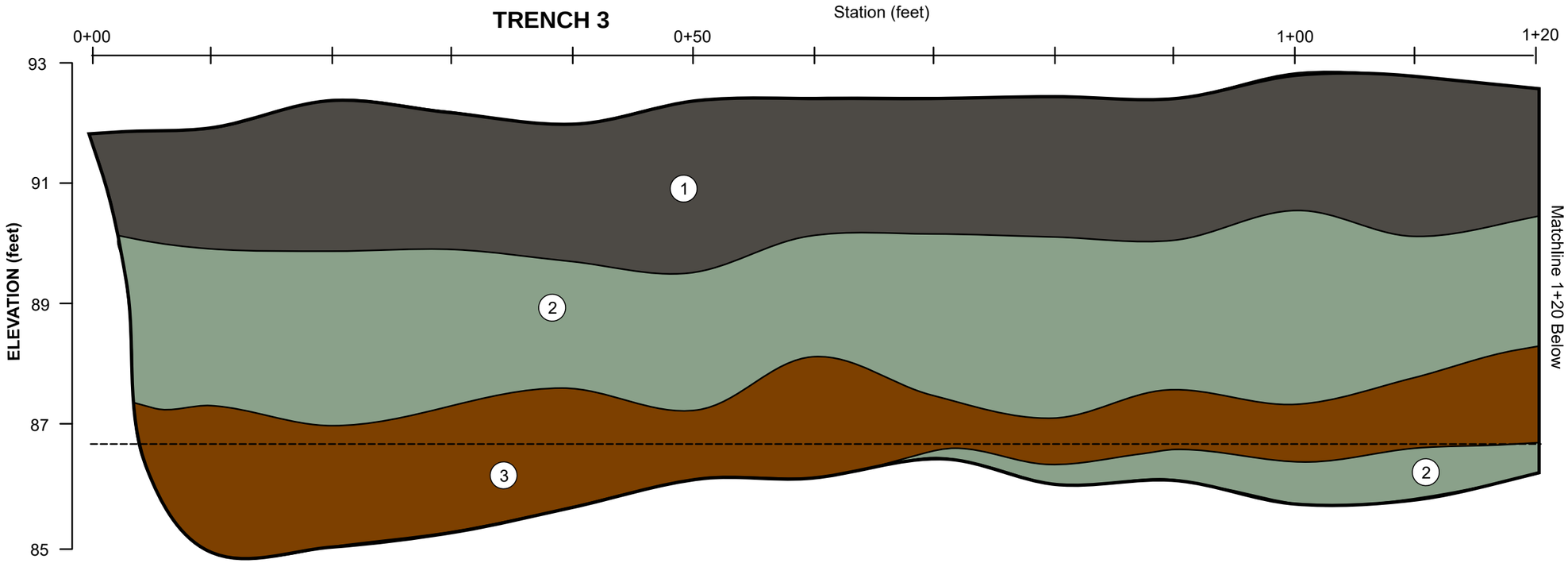
West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

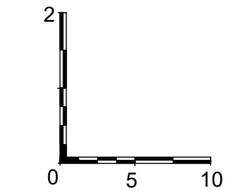
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BAJADA Geosciences, Inc.

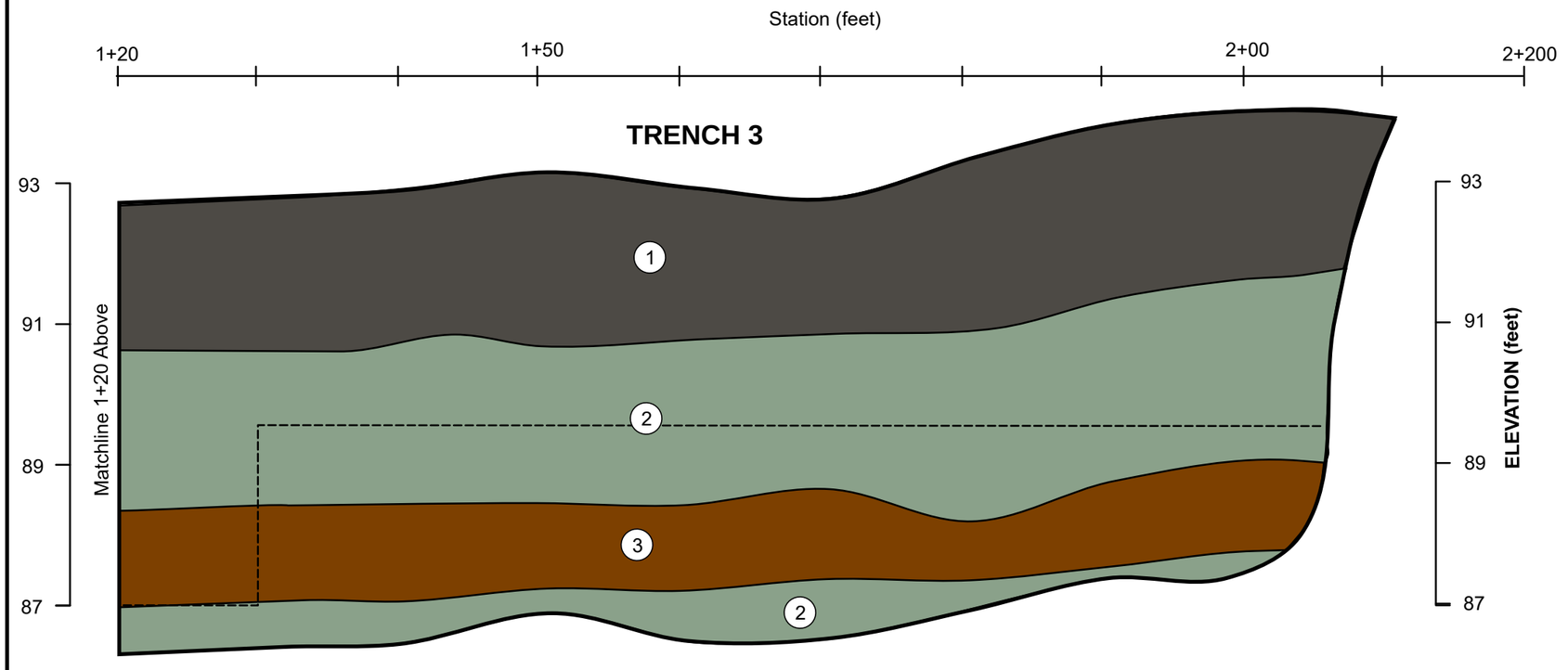
Project no. 2101.0118

TRENCH 3





Scale:
Horizontal:1”=10’
Vertical: 1”=2’
Vertical Exaggeration 5x



1 Sandy to silty clay, medium to dark brown, damp to moist, with abundant blocky to prismatic peds, pores & roots. A-horizon.

2 Sandy to silty clay, medium to dark brown, damp to moist, with abundant blocky to prismatic peds.

3 Sandy to silty clay, medium to dark brown, damp to moist, with abundant blocky to prismatic peds, pores & roots. Possible paleosol.

---------- Stringline Location, used for logging control

See Plate 5.5 for true scale sections

Elevations from RSA (2021)

TRENCH LOG

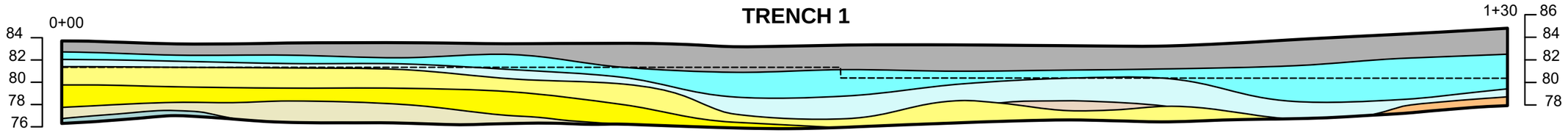
West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 5.4

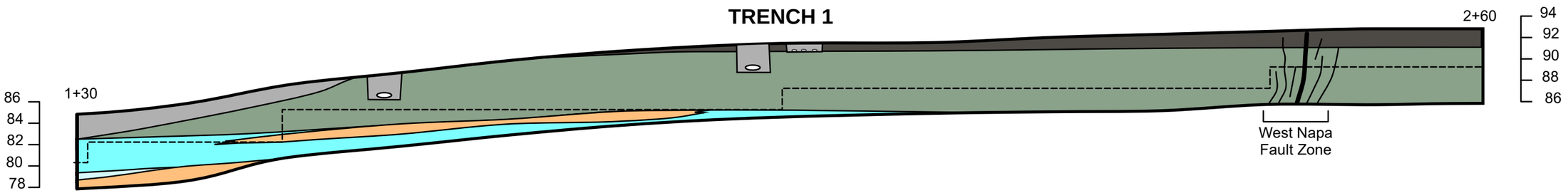
BAJADA Geosciences, Inc.

Project no. 2101.0118

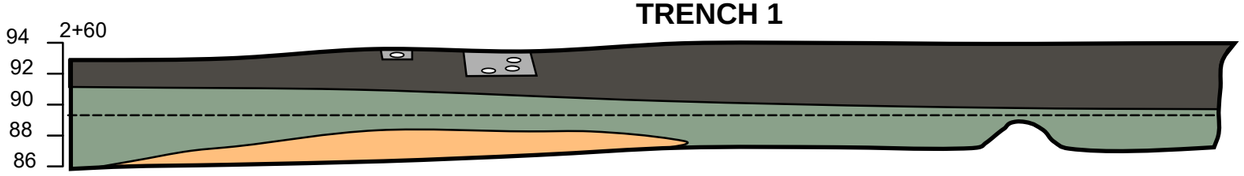
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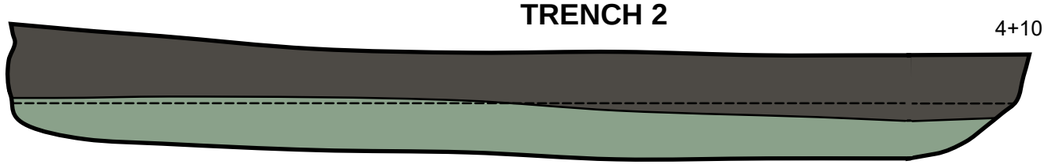
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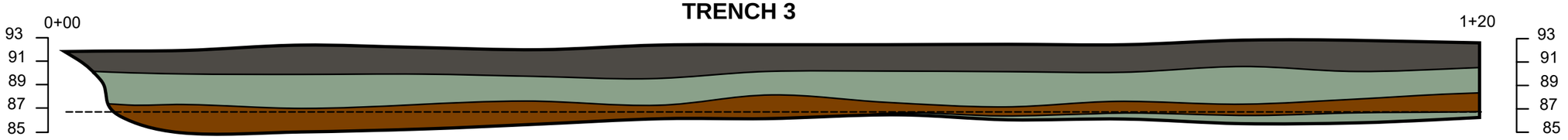
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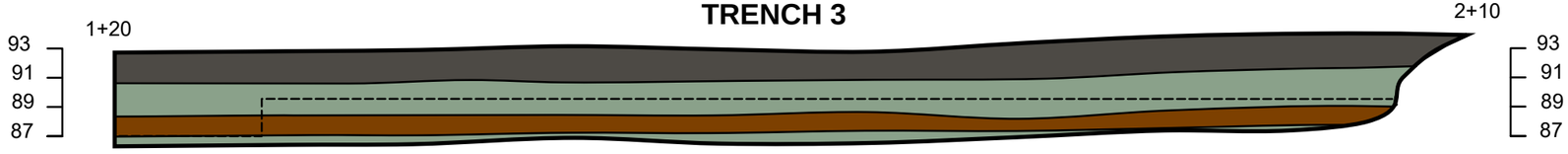
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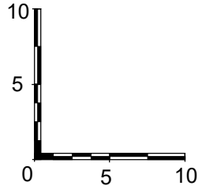


TRENCH 3



TRENCH 3





Scale:
Horizontal:1”=10’
Vertical: 1”=10’
Vertical Exaggeration 1x

Elevations from RSA (2021)

TRENCH LOG

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 5.5

BAJADA Geosciences, Inc.

Project no. 2101.0118

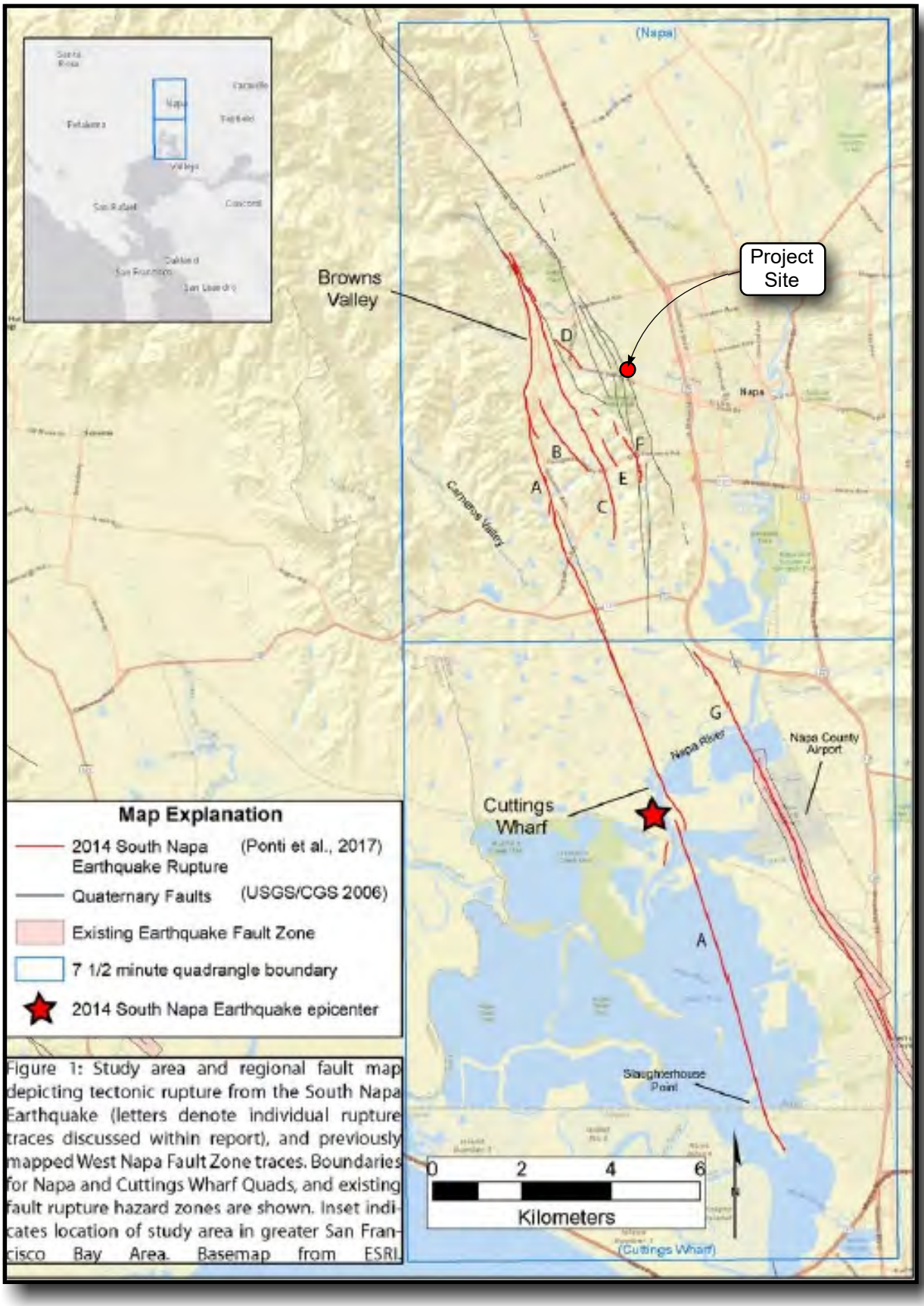


Figure 1: Study area and regional fault map depicting tectonic rupture from the South Napa Earthquake (letters denote individual rupture traces discussed within report), and previously mapped West Napa Fault Zone traces. Boundaries for Napa and Cuttings Wharf Quads, and existing fault rupture hazard zones are shown. Inset indicates location of study area in greater San Francisco Bay Area. Basemap from ESRI.

Base map from Rubin, 2018

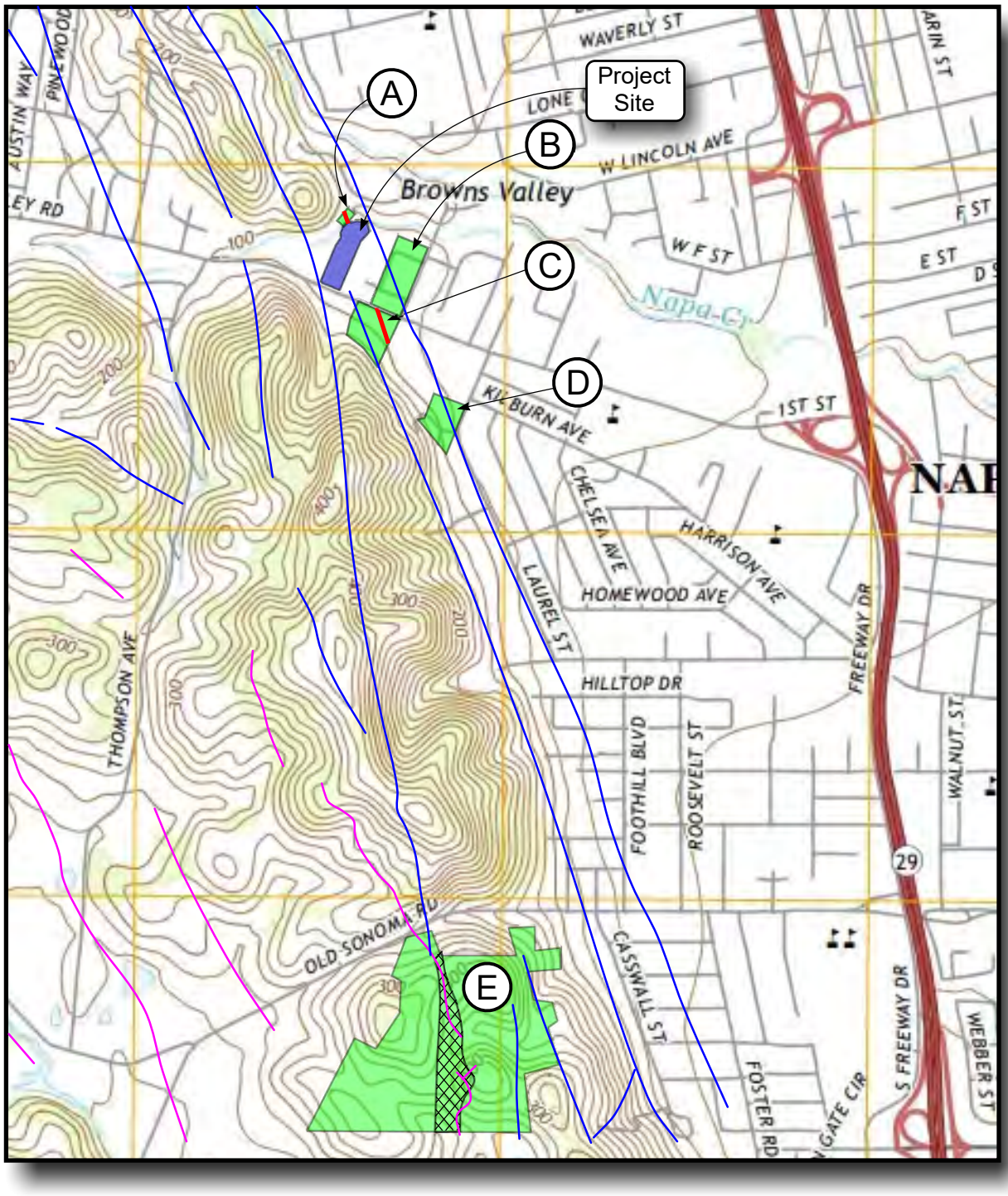
WEST NAPA FAULT ALIGNMENT

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 6

BAJADA Geosciences, Inc.

Project no. 2101.0118



Fault location noted by previous consultant studies

Mapped fault rupture traces from 2014 South Napa Earthquake

Fault mapped by Wagner & Gutierrez (2016) & Clahan et al. (2004)

Fault zone mapped by Berlogar Stevens & Associates (2014)

Previous Consultant's Reports

(A) Wesling & Hanson (2008)

(B) Taber Consultants (1986)

(C) Western Geological Consultants (1980)

(D) J.H. Kleinfelder (1983)

(E) Berlogar Stevens & Associates (2014)

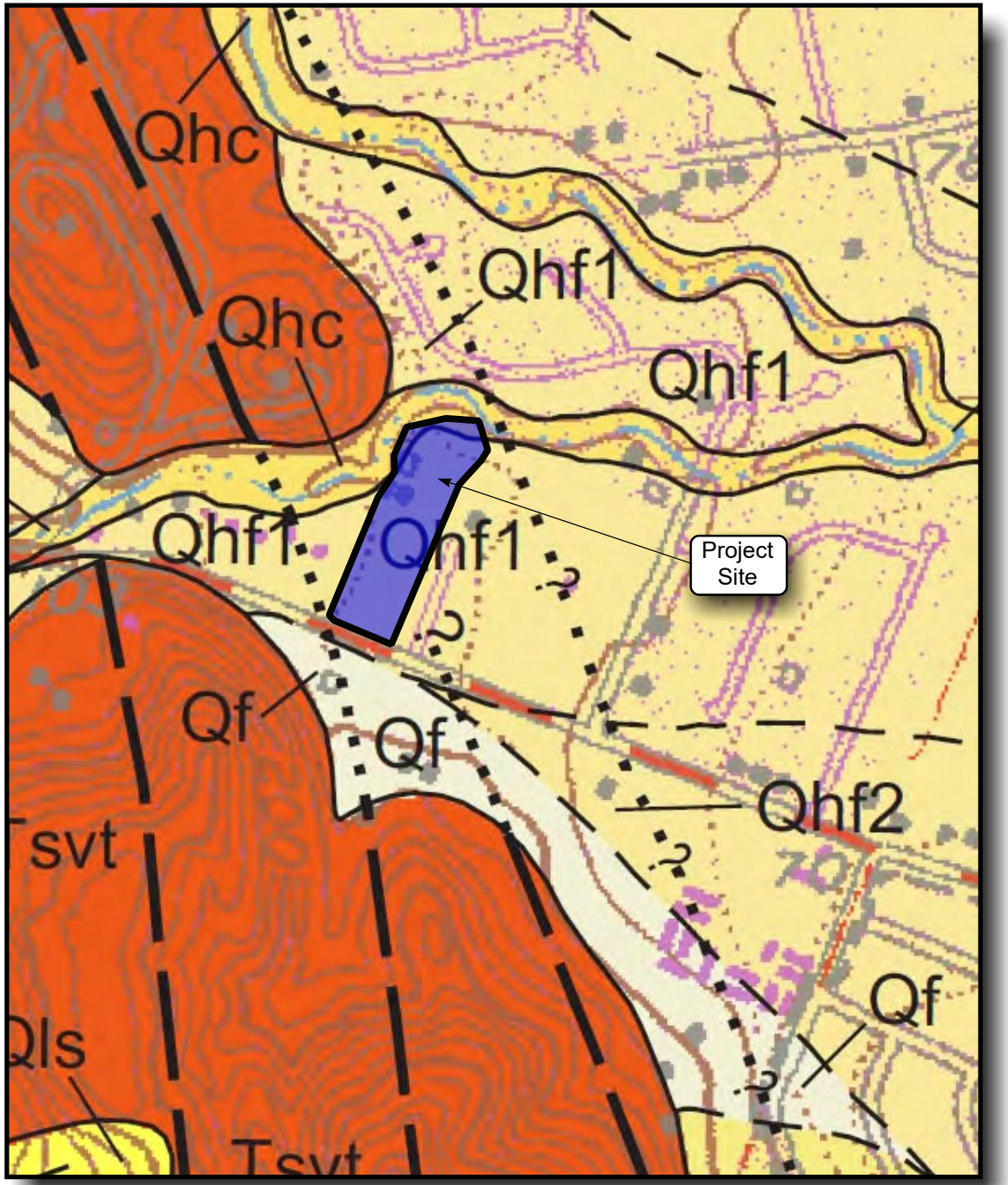
PROXIMAL PREVIOUS RELEVANT STUDIES

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 7

BAJADA Geosciences, Inc.

Project no. 2101.0118



N

Qhc — Stream channel deposits (latest Holocene <1,000 years) - Deposits in active, natural stream channels, consists of loose alluvial sand, gravel, and silt.

Qhf (Qhf1, Qhf2) — Alluvial fan deposits (Holocene) - Alluvial fan sediment deposited by streams emanating from mountain drainages onto alluvial valleys, composed of moderately to poorly sorted sand, gravel, silt and clay.

Qf — Alluvial fan deposits (Latest Pleistocene <~30,000 years to Holocene) - Sand, gravel, silt and clay mapped on gently sloping, fan-shaped, relatively undissected alluvial surfaces.

Sonoma Volcanics (late Miocene to Pliocene) - Mafic lava flows and tuffs, rhyolite to dacite ash flow tuff, lava flows, intrusions, breccia, also includes tuffaceous sediment. The Sonoma Volcanics are divided into the following subunits:

Tsv (Tsvbn, Tsvm, Tsvaa, Tsvfh, Tsvr, Tsvdg, Tsvdgp, Tsvtt, Tsvm, Tsvt)

Tsvbn - Breccia of Napa - Dacite breccia underlying the low hills east of Napa. This unit is likely a resurgent dome within a caldera. It is capped by Tsvrn an aphanitic rhyolite.

Tsvaa - Andesite of Atlas Peak - Dark to grey, plagioclase phyric, andesite interbedded with tuff. Locally has a platy foliation.

Tsvfh - Lava flows of Huichica Creek - Dark glassy flow rock with highly variable phenocryst assemblage, including plagioclase, pale olivine, and possible amphibole or pyroxene. Appears to be interlayered with a plagioclase phyric dacite.

Tsvr - Rhyolite ash flow tuff - Black to light grey vitrophyre with angular lithic clasts overlying welded tuff with flattened pumice lapilli and unwelded pumice lapilli tuff. This unit overlies the older rocks with angular unconformity.

Tsvdg - Dacite of Mt. George - Flows and domes of gray to tan porphyritic dacite. The dacite is typically strongly flow banded. The upper surfaces of flows are commonly perlitic. K-Ar ages for the dacite are 4.3±0.2 and 3.73±1.23 Ma (Mankinen, 1972; Fox and others, 1985).

Tsvdgp - Pumice breccia, pumice lapilli tuff, and pumice lapilli tuff with lithic fragments and perlitic glass fragments that mantle flows and domes and occur between dacite flows.

Tsvtt - Tuff of Tulucay Creek - Pumice lapilli tuff interbedded with tuffaceous volcanic agglomerate. Perlitic glass fragments are abundant in some tuff beds.

Tsvm - Mafic flows and breccias - Basalt, basaltic andesite and andesite flows and breccias, interbedded with volcanic agglomerate and tuff.

Tsvt - Light colored tuff, lithic rich in places. Locally includes tuffaceous, diatomaceous lacustrine sediments.

Base map from Clahan et al., (2004). Scale undetermined.

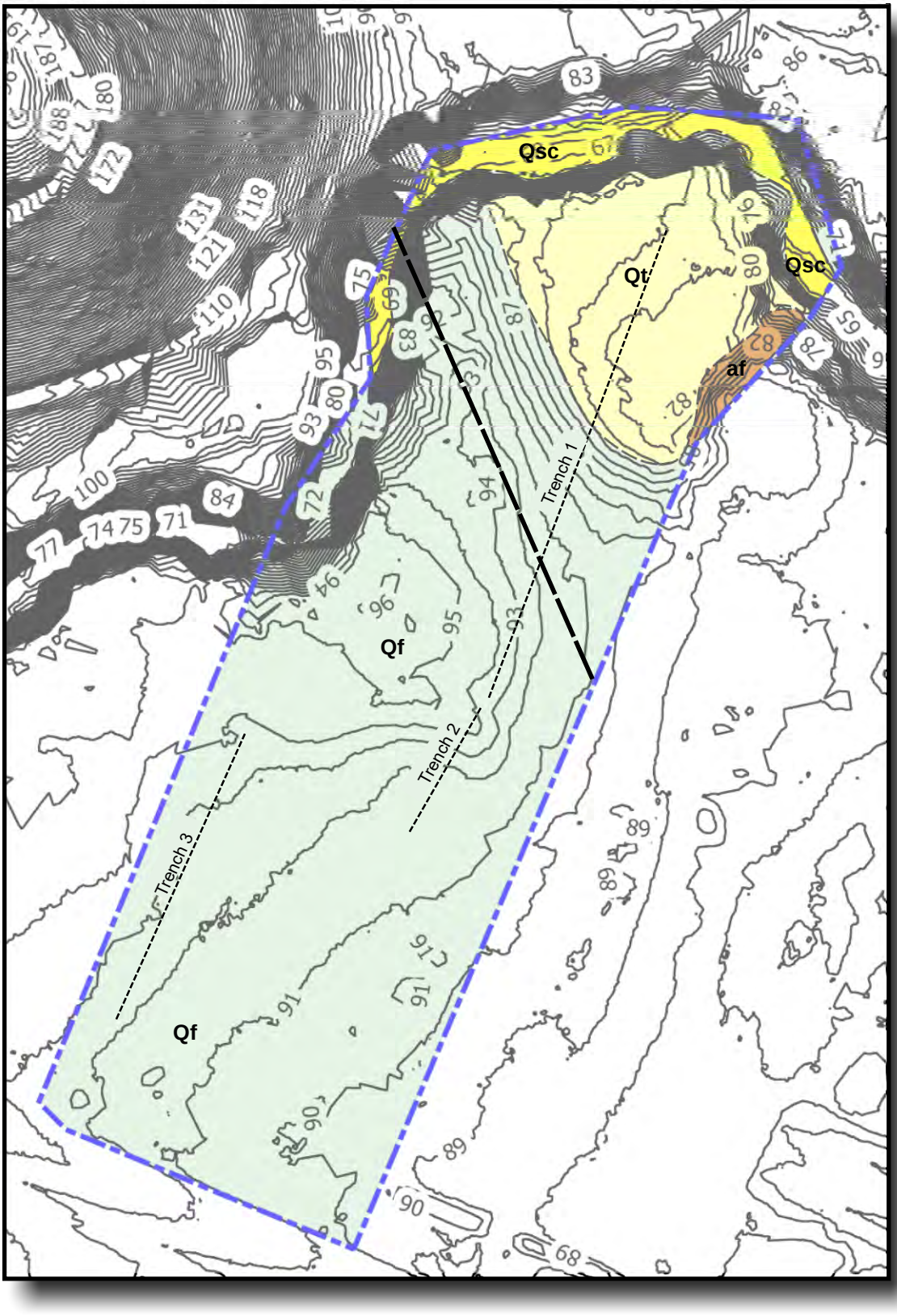
REGIONAL GEOLOGIC MAP

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 8

BAJADA Geosciences, Inc.

Project no. 2101.0118



0 50 100

Scale: 1”=100’
1:1,200

Contour Intervals: 1’

af	Artificial Fill
Qsc	Stream Channel Deposits
Qt	Stream Terrace Deposits
Qf	Alluvial Fan Deposits
— —	West Napa Fault

Topography derived from processed open-source LiDAR.

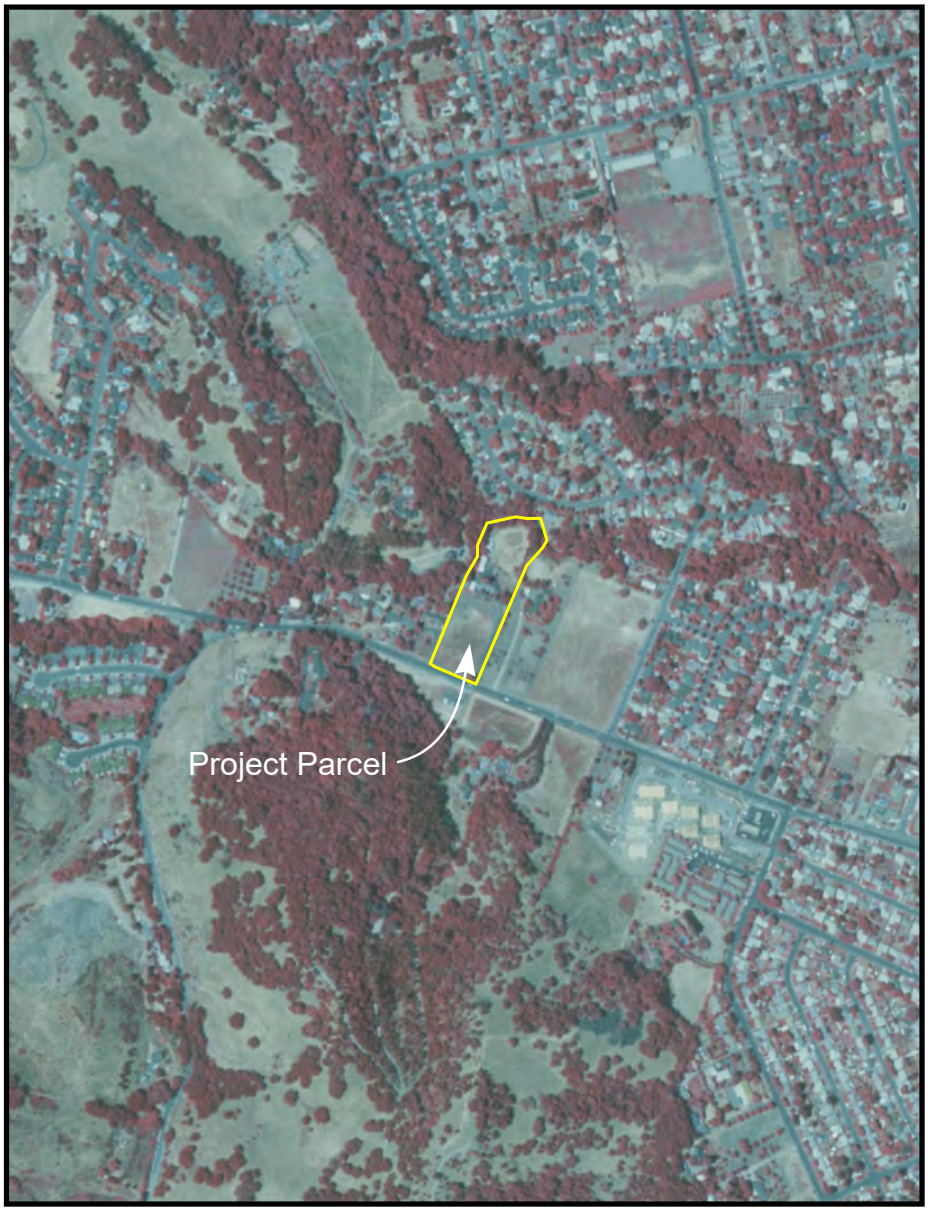
LOCAL GEOLOGIC MAP

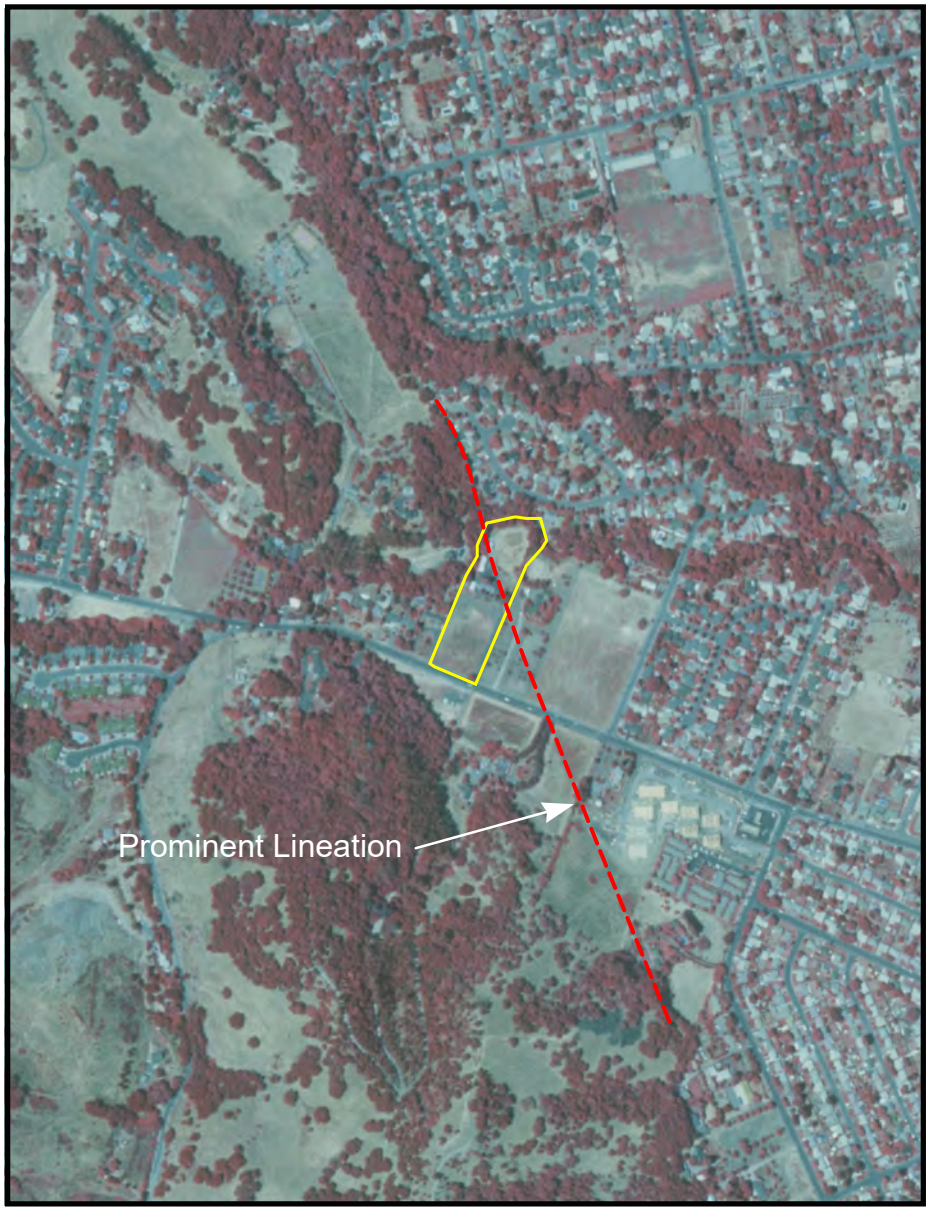
West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 9

BAJADA Geosciences, Inc.

Project no. 2101.0118





1982 false color aerial image

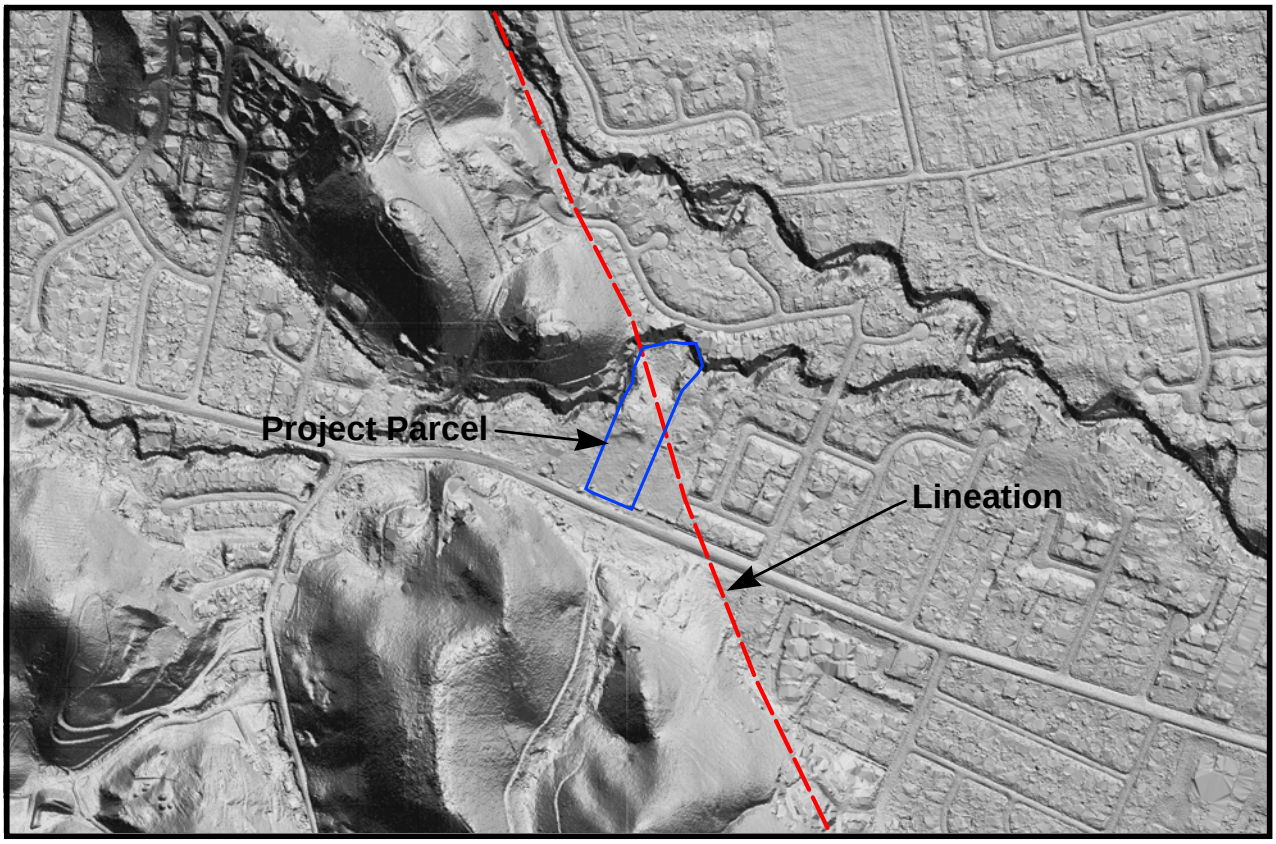
PROMINENT LINEATIONS

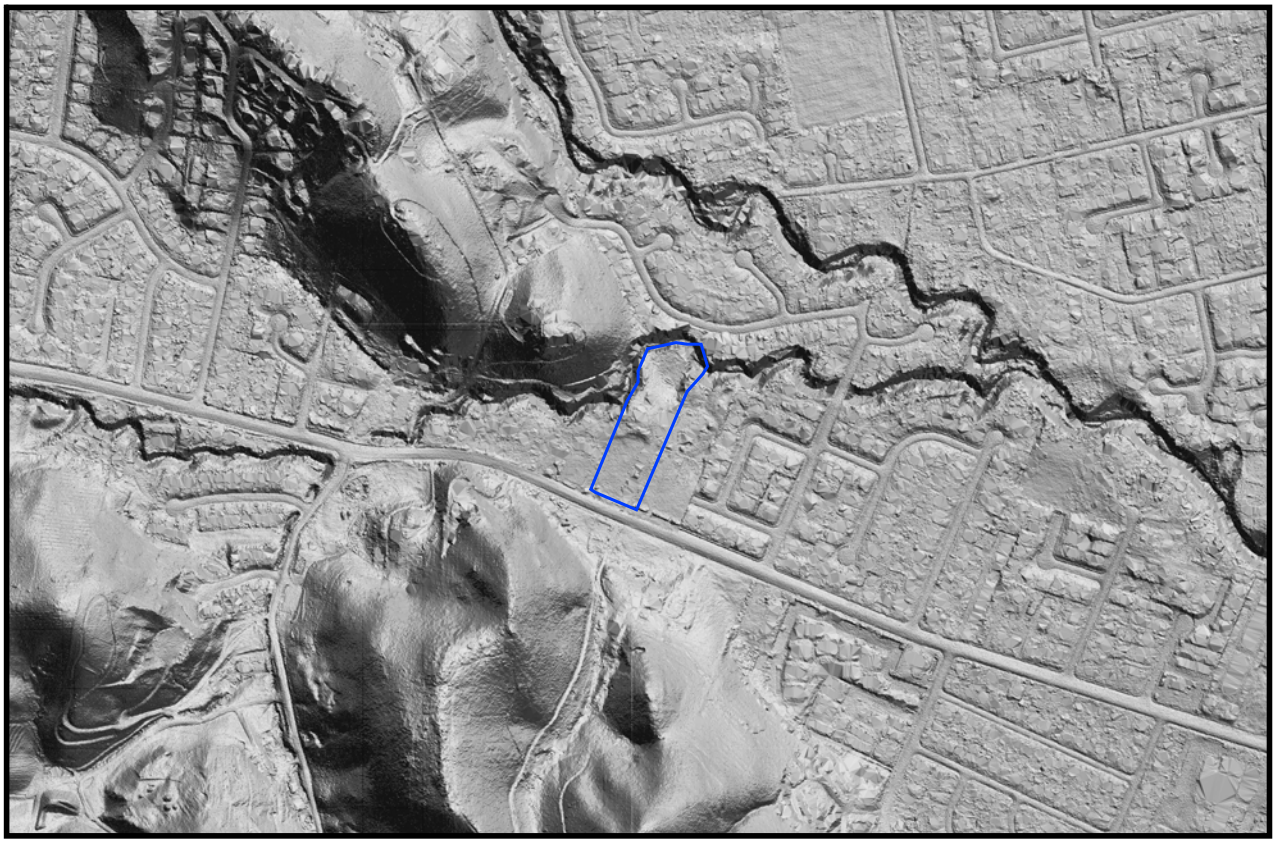
West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No. 10

BAJADA Geosciences, Inc.

Project no. 2101.0118





HILLSHADE MODEL

West Napa Fault Evaluation
3090 Browns Valley Road
City of Napa, California

Plate No.
11

BAJADA Geosciences, Inc.

Project no.
2101.0118

Hillshade models derived from processed open-source LiDAR data.

APPENDIX A

Fault Evaluation Reports By Others

C-396

(Phone 415-557-0413)

Jean
Please put
in C-file

April 29, 1980

Mr. John Lindblad
Public Works Director
County of Napa
P.O. Box 660
Napa, CA 94558

Dear Mr. Lindblad:

The two fault study reports for sites in Brown Valley have been forwarded to me by Jack Bennett of our Division for use in our future fault evaluation and zoning work. The reports will be placed in our informal consulting-report file.

As supervisor of the States fault zoning program, I would appreciate if copies of fault investigation reports were sent directly to me at our San Francisco District Office.

Earl W. Hart
Senior Geologist

EWH/fnl

cc: Jack Bennett

STATE OF CALIFORNIA

OFFICE MEMO
STD. 100 (REV. 11-75)

DATE 4/24

TO:
EARL HART

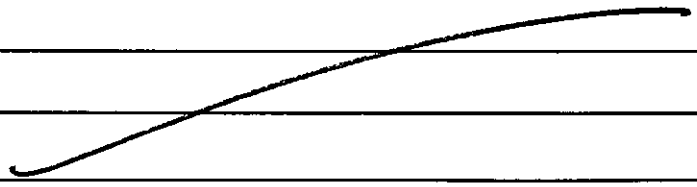
ROOM NUMBER

FROM:
JACK BENNETT

PHONE NUMBER

SUBJECT: NAPA VALLEY FAULTS

FOR YOU - THE "APPROPRIATE PERSON"



80 APR 28 A9:2[illegible]
SAN FRANCISCO D.O.

CITY OF NAPA
PUBLIC WORKS DEPARTMENT
P.O.Box 660
Napa, California 94558
Telephone (707) 252-7711

LETTER OF TRANSMITTAL

DATE	April 21, 1980
ATTENTION	Jack Bennett
RE:	Location of faults in Napa Area

TO State of California Dept. of Conservation
Division of Mines & Geology
Resources Building, Room 1341
1416 9th Street
Sacramento, Ca. 95814

GENTLEMEN:

WE ARE SENDING YOU ☒ Attached ☐ Under separate cover via _____ the following items:

☐ Prints ☐ Change Order #_____ ☐ Plans ☐ Quantity & Cost Estimates

☐ Descriptions ☐ Pay Estimate #_____ ☐ Specifications ☐ _____

COPIES	DATE	NO.	DESCRIPTION
1	1/80		Fault Study Browns Valley Area
1	5/79		Fault Study Browns Valley Area

THESE ARE TRANSMITTED as checked below:

☐ For signature ☐ Approved as submitted ☐ Resubmit _____ copies for approval

☒ For your file ☐ Approved as noted ☐ Submit _____ copies for distribution

☐ As requested ☐ Returned for corrections ☐ Return _____ corrected prints

☐ For review and comment ☐ For your information ☐ _____

REMARKS These are 2 soils reports where they located the faults in the Browns Valley Area. I wasn't sure if you handled these or not, but if you don't please give them to the appropriate person.

John W. Lindblad, P.E.
Public Works Director

by: Daniel Cardwell
CIVIL ENGINEERING ASSOCIATE

DTC:sms
Attached

FORM E-98 3x NCR

GEOLOGIC HAZARDS INVESTIGATION
BROWNS VALLEY ROAD & ROBINSON LANE
NAPA, CALIFORNIA

For

Mr. Kailash Chaudhary
Chaudhary & Associates, Inc.
3754 Bel-Aire Plaza
Napa, California 94558

By

WESTERN GEOLOGICAL CONSULTANTS
Concord, California

RECEIVED
CHAUDHARY & ASSOCIATES
JAN 11 1980
NAPA

WGC Western Geological Consultants

Mt. Diablo Office • 724 Santa Ana Lane • Concord, California 94518
Telephone (415) 798-3240

January 8, 1980
File No. 94-47-7

Mr. Kailash Chaudhary
Chaudhary & Associates, Inc.
3754 Bel-Aire Plaza
Napa, California 94558

RE: GEOLOGIC HAZARDS INVESTIGATION
Browns Valley Rd. & Robinson Ln.
Napa, California

Dear Mr. Chaudhary:

In response to your authorization WGC conducted a geologic hazards investigation on the above parcel of land which is owned by the Greentree Trading Company, Inc.

The subject site is located on the south side of Browns Valley Road near its intersection with Robinson Lane, Napa, California. Most of the property is relatively flat except towards the south side where a northerly trending hill protrudes into the property.

PROPOSED DEVELOPMENT

The parcel encompasses an area of about 7.8 acres and it is proposed to subdivide the property into four lots. Parcel D will contain 4.8 acres and the other three parcels will be about one acre in size.

PURPOSE

The purpose of our study was to determine whether traces of the west Napa fault were located on the parcel. Investigations of this nature are required by Napa County and City in areas where fault zones have been mapped by the U.S. Geological Survey or the California Division of Mines and Geology.

STUDY METHOD

Our investigation at the site consisted of excavating an exploration trench to locate traces of the West Napa fault. In addition we reviewed various geological publications, listed at the end of this report, to obtain data pertinent to the site. The site location and relevant fault data is shown on Figure Nos. 1 and 2 and the exploration trench log is included on Figure No. 3.

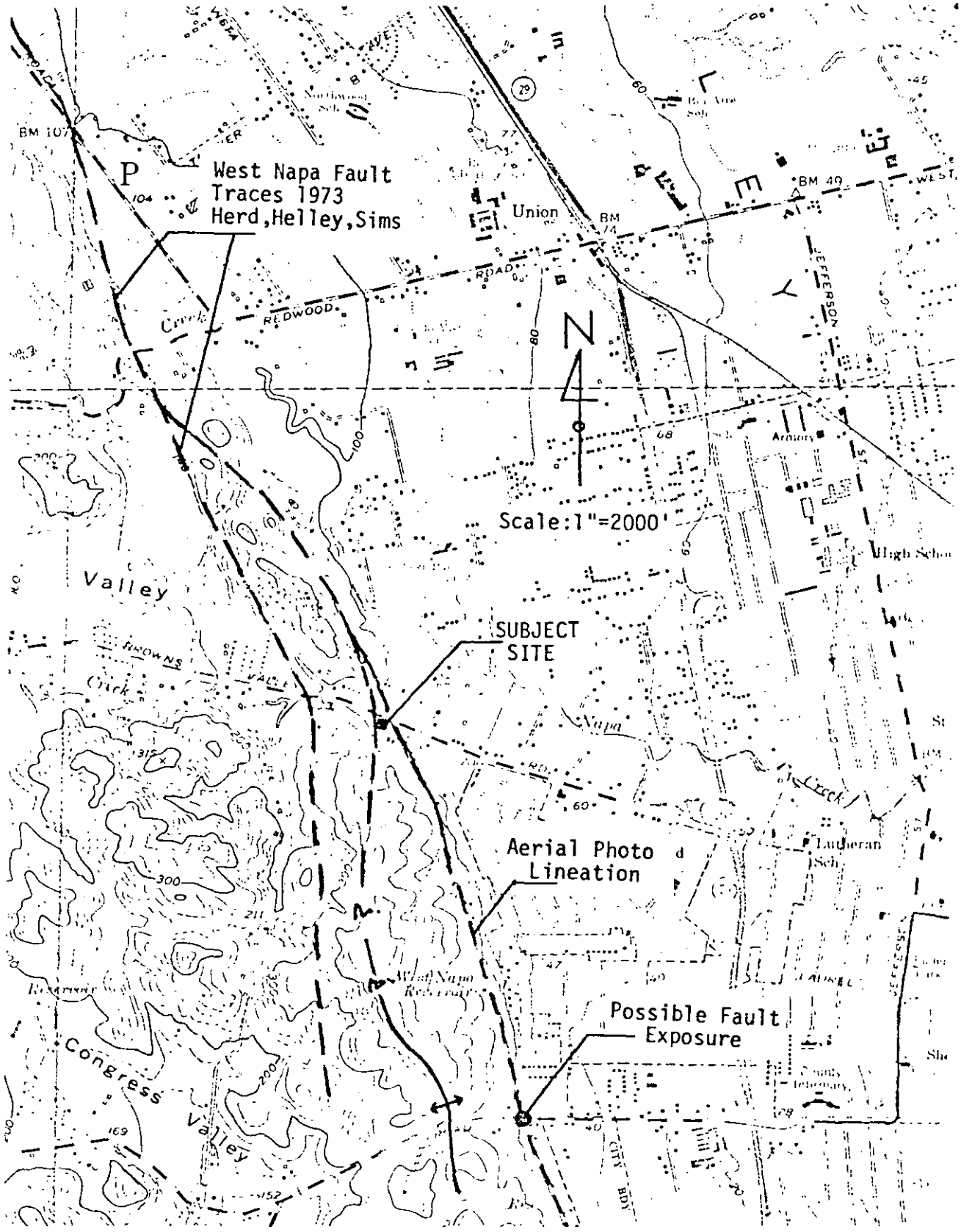
SITE GEOLOGY

Quaternary alluvium covers the site from the low foothills on the west and south to beyond the east property boundary. These materials consist of sand, silt, clay and gravels derived from erosion of the hills to the west. Such deposits are thought to have originated from erosion of the sedimentary and volcanic rocks flanking the west side of the Napa Valley. The alluvium grades westerly into alluvial fan deposits along the perimeter of the hillsides near the study area. The fan materials are often finer grained then the alluvium and have been incised by channels which are partially filled with various types of sediments.

AREA FAULT DATA

Various authors have reported faults west of the City of Napa in the mixed volcanic and sedimentary rock sequence along the west side of the Napa Valley. Weaver's mapping in 1949 located the Browns Valley and Mill Valley faults. Since his early work in the area other authors from the U.S. Geological Survey have mapped additional faults along the west side of the Napa Valley, (see references). This area is known in recent geologic publications

WGC



SITE & VICINITY FAULT MAP
Browns Valley Road, Napa

Western Geological Consultants	FILE 94-74-7	FIGURE 1

as the West Napa Fault Zone. Mapping by Sims, et. al., and Herd and Helley show three traces of the West Napa Fault Zone near the site. The trace farthest west is near the intersection of Thompson Avenue and Browns Valley Road. The other fault traces on these maps may possibably be on or close to the east side of the subject site. A study by Engeo, Inc., 1977, located a trace of the fault west of the site in the vicinity of Scenic Drive.

AERIAL PHOTOGRAPHIC DATA

The aerial photographs examined for this study showed a topographic break which extended from south of Lilienthal Avenue to north of Browns Valley Road. Depressed or trough areas were also noted west of the site along Thompson Avenue and in the ridge area on the north side of the site. It is assumed that these features were considered to be fault related by the U.S. Geological Survey geologists (Herd, Helley and Sims) who mapped the West Napa Fault Zone. Some of these lineations were examined during our study of the Libby property at 327 Foothill Boulevard. The above mentioned topographic break was trenched during this study and evidence of faulting was not found. A tonal variation due to a color change in the surface soils was also observed which extended southeasterly from the driveway on Parcel B to the tree cluster on the east property line. Subsequent trenching revealed that this lineation was likely due to a color change in soils found in the trench.

SOILS DATA

Soils which were encountered in the exploration trench are described on the trench log, Figure No. 3. The soils represent alluvial deposits typical

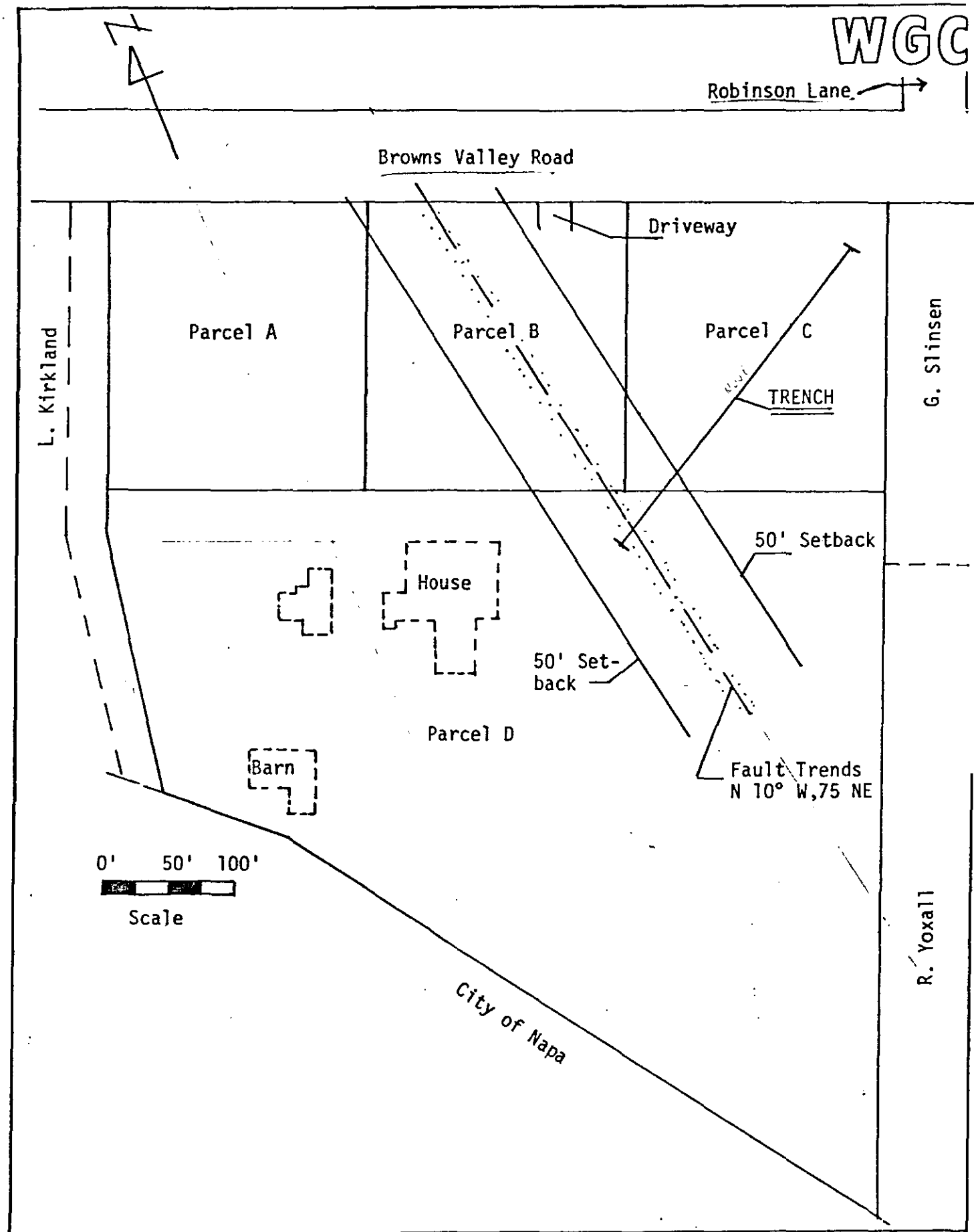
of the area except for a claystone bed near the west end of the trench. These soils consist of silty clays, sandy clays, silty sands and silty sandy gravels. Most of the soils were very damp. A few of the sand and gravel layers flowed water into the trench at an estimated rate of 3 to 4 gallons/minute. The claystone was firm, blocky and contained 1/4 inch pebbles with traces of sand.

SITE FAULT DATA

A northwest trending fault zone was located near the west end of the Exploration Trench, Figure 3. Its location and projected trend is shown on Figure 2. The fault is characterized by a black slickensided band 0.4 feet wide and a zone of nearly vertically oriented blocky, gray claystone mixed with soft, brown sandy clay. The fault trends N 10° W, 75 NE and its maximum width is 4 feet. The west side of the fault has dropped down about 1 foot and offsets recent alluvial soils by this amount. Movement appears to have been in a reverse direction. Slickensides in the fault were not well defined but there is some suggestion of horizontal movement. The fault should be considered active since geologically young materials have been involved in tectonic movement. Thus a 50 foot building setback, in accordance with the California Division of Mines and Geology criteria for active faults, is required.

CONCLUSIONS

Exploration trenching at the site revealed the presence of active faulting on the property. It is concluded, however, that structures can be constructed on the parcel if they are located 50 feet from the fault trace. It will



SITE TRENCHING PLAN
Browns Valley Road, Napa

Western Geological Consultants	FILE 94-74-7	FIGURE 2

therefore be necessary to change the lot lines. The site is located in an active seismic area and structures there will be subjected to earthquake shaking. Therefore, all dwellings should be constructed in accordance with current earthquake design criteria.

LIMITATIONS

The conclusions and recommendations contained herein are professional opinions based on generally accepted practices and principles of engineering geology. This report is subject to review by the Napa City Planning Department and there is no guarantee that building permits will be issued based on the data contained herein or that further geotechnical work will not be required. This warranty is in lieu of all other warranties either expressed or implied pertaining to this particular project.

Thank you for your consideration of WGC on this project. Please call if you have any questions or if we can be of further service in this matter.

Very truly yours,

H. W. Short

HARRY W. SHORT
Principal Engineering
Geologist, EG 130

REFERENCES

File No. 94-74-7

California Division of Mines and Geology, 1951, Geologic Guidebook of the San Francisco Bay Counties, Bulletin 154.

Engeo, Inc., 1977, Geologic Investigation for the Mead Property, Napa County, California.

Helley, E.J. and Herd, D.G., 1977, Map Showing Faults With Quaternary Displacements, Northeastern San Francisco Bay Region, MF 881, Scale: 1" = about 2 miles.

Herd, D.G. & Helley, E.J., 1976, Faults With Quaternary Displacement Northwestern San Francisco Bay Region, California, Map MF 818, 1:125,000.

Kunkel, F. and Upson, J.E., 1960, Geology and Ground Water In Napa and Sonoma Valleys, Napa and Sonoma Counties, California, U.S. Geological Survey Water Supply Paper 1495.

Napa County Planning Department, 1974, Seismic Safety Element of the Napa County General Plan.

Pacific Aerial Surveys, 1979, Site Stereo Pair Aerial Photographs, AV 1700-07-07 and 08, Scale 1" = 4,500'.

Sims, J.D. and Others, 1973, Preliminary Geologic Map of Solano County and Parts of Napa, Contra Costa, Marin and Yolo Counties, California, Basic Data Contribution No. 54.

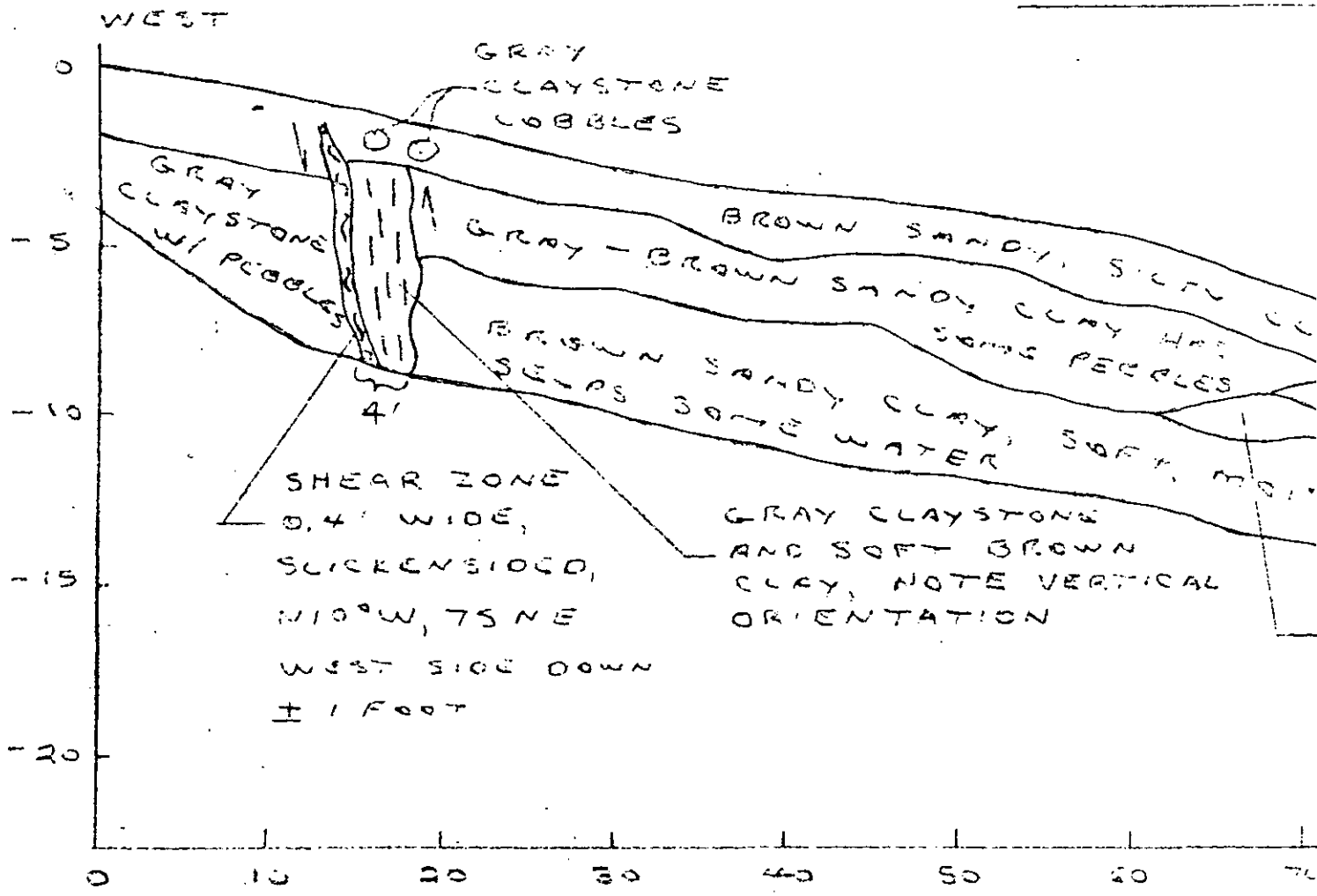
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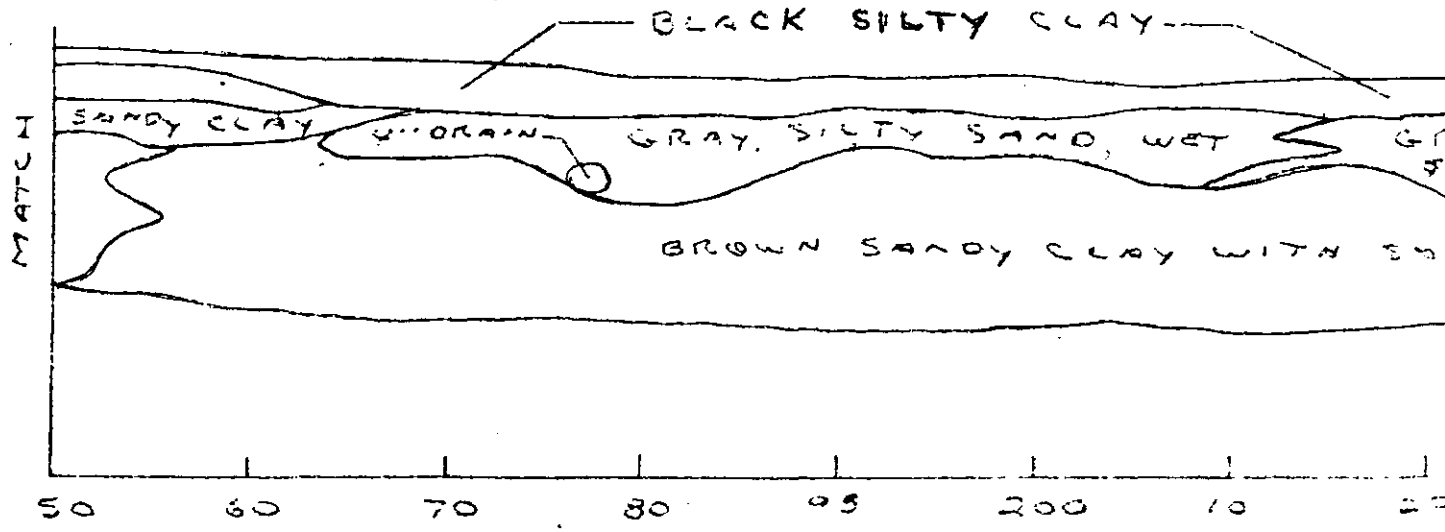
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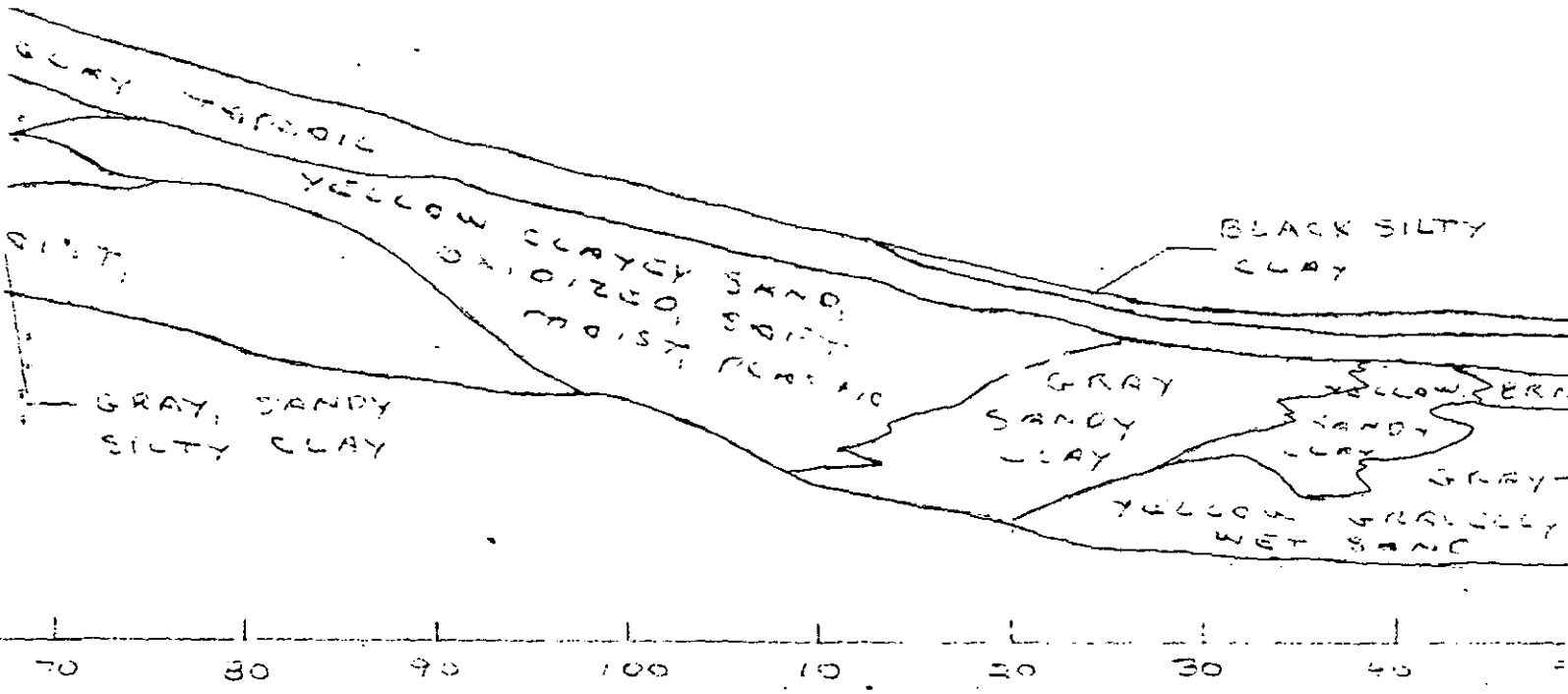
_____, 1979, Geologic Hazards Investigation and Exploration Trenching for The West Napa Fault Zone, 327 Foothill Boulevard, Napa, California.

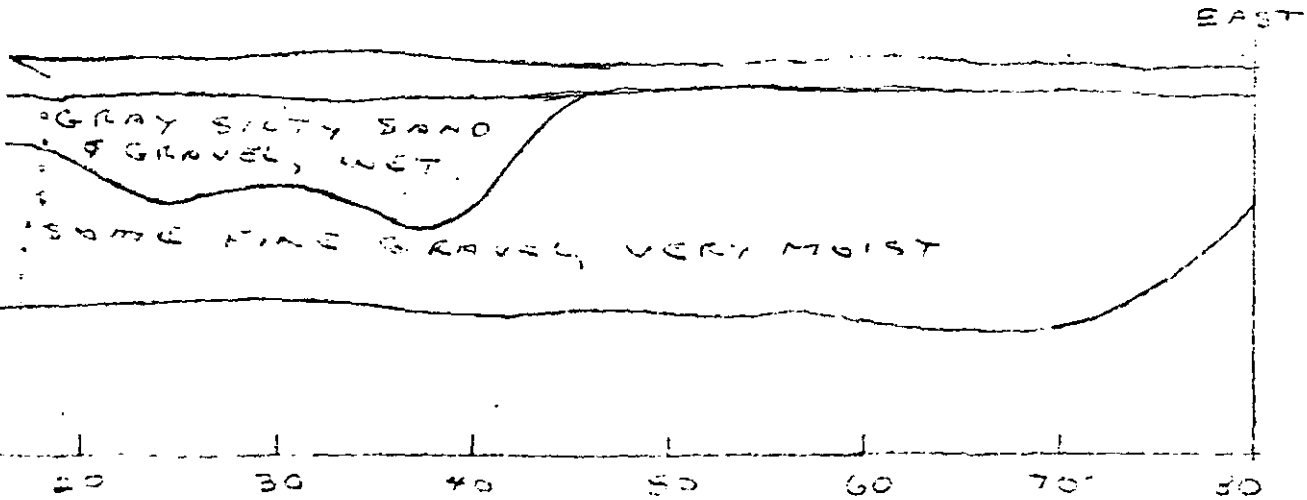
EXPLORA


WEST
GRAY CLAYSTONE COBBLES
GRAY CLAYSTONE W/ PEBBLES
BROWN SANDY, SILTY
GRAY - BROWN SANDY CLAY
SOME PEBBLES
BROWN SANDY CLAY, SOFT,
SEEPS SOME WATER
4'
SHEAR ZONE 0.4' WIDE, SLICKENSIDED, N10°W, 75NE WEST SIDE DOWN ± 1 FOOT
GRAY CLAYSTONE AND SOFT BROWN CLAY, NOTE VERTICAL ORIENTATION
0
5
10
15
20
0
10
20
30
40
50
60


BLACK SILTY CLAY
SANDY CLAY
GRAIN
GRAY, SILTY SAND, WET
BROWN SANDY CLAY WITH
ALLUVIUM
50
60
70
80
95
200
10

RATION TRENCH LOG





FIGURE

Prepared for: James Knittel

G 05 0806

RECEIVED
JUL 30 1985
LAFCOM

Fault Investigation Report
3189 Laurel Street
Napa, California

ENTERED MAR 4 1986

J. H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING
LAND AND WATER RESOURCES

February 1983

J. H. KLEINFELDER & ASSOCIATES

GEOTECHNICAL CONSULTANTS • MATERIALS TESTING
LAND & WATER RESOURCES

1901 OLYMPIC BOULEVARD, SUITE 300
WALNUT CREEK, CA 94596-5063

(415) 938-5610

February 17, 1984
File No.: C-1402-1

Mr. James Knittel
1751 Silverado Trail
Napa, CA 94558

Subject: Fault Investigation Report
3189 Laurel Street
Napa, California

Dear Mr. Knittel:

We are pleased to submit our fault investigation study for your proposed development of 3189 Laurel Street in Napa, California. The following report provides a description of the investigation and our conclusions and recommendations.

In summary, based on the results of our study, we believe that the West Napa Fault does not cross your property. (See Plate 1 for site location). Consequently, we have recommended that no limitations should be made on construction of structures for human occupancy with respect to the hazard of fault rupture.

We appreciate the opportunity of serving you on this project and trust that the report meets your needs. If you have any questions concerning the information presented herein, please contact us.

Very truly yours,

J. H. KLEINFELDER & ASSOCIATES

Michael L. Siembieda
Staff Geologist

Neil A. Thomsen
Senior Geologist
R.G. 3762

RC:bw

FAULT INVESTIGATION
3189 Laurel Street
Napa, California

I. INTRODUCTION

This report presents the results of a geological investigation for the purpose of evaluating the hazard of surface fault rupture at the proposed development at 3189 Laurel Street, Napa, California. This investigation is required by the City and County of Napa for areas where fault zones have been mapped by the U.S. Geological Survey or the California Division of Mines and Geology.

A. Project Description

The proposed development will be located on an approximate 4.5-acre parcel of land located on Laurel Street south of Browns Valley Road. We understand that the proposed development will consist of approximately 13 condominiums with the continued use of some of the structures already built at the site.

B. Purpose and Scope of Work

The scope of work for this project was defined in a proposal letter to Mr. James Knittel dated January 6, 1984. The purpose of this investigation is to evaluate the hazard of surface fault rupture for the proposed development. The work performed for the investigation included the following:

- Brief review of published and unpublished literature and records concerning the geology of the site.

- Stereoscopic interpretation of aerial photographs to detect fault-related topography, vegetation and soil contrasts and other lineaments of possible fault origin.

- Site visit and observation of geologic features.

- Excavation and logging of trenches at the site for the purpose of directly observing and mapping geologic units.

Following the field exploration and office study program described above, we have prepared and submitted a geology report which includes the following items:

- description of the field investigation and office study,

- map showing the location of trenches excavated at the site,

- geologic log of the trench walls, and

- recommendations for building locations.

C. Authorization

Work covered by this report was performed in accordance with a contract between J. H. Kleinfelder & Associates and Mr. James Knittel which was signed on January 6, 1984.

III. FIELD INVESTIGATION

Six trenches were excavated on February 6, 1984, for the purpose of the Fault Investigation and for the collection of bulk soil samples for possible future testing. The trenches were excavated with a Case 580c backhoe supplied by Mr. Knittel. The trenches were approximately 2 to 6 feet deep with length ranging from 15 to 160 feet in length.

The trenches were backfilled with uncompacted native material at the completion of our examination on February 6, 1984.

The trenches were logged by Michael L. Siembieda, Engineering Geologist. The trenches were located so as to possibly intersect a fault trace identified by Western Geological Consultants in a Geologic Hazards Investigation for property located at Browns Valley Road and Robinson Lane. The Unified Soil Classification System (ASTM D-2487) was used to classify the soil units at the site. The units were examined and classified shortly after the trenches were excavated. Disturbed bulk soil samples were collected for possible future testing. Lines shown separating the various geologic units on the trench logs may represent approximate boundaries since actual transition between units may be gradational.

III. Site Conditions

The proposed development site is approximately 4.5 acres in area. The site is bounded on the east by Laurel Street and private residences on the north by a housing complex with undeveloped land to the west and south. A number of existing structures are located on the property and include: the main residence, a large house reportedly built in 1907, guest house, carriage house, swimming pool and pool house. These buildings did not appear to exhibit signs of structural distress indicative of fault movement at the time of our site visit. An asphalt concrete paved road that leads from Laurel Street to the main house bisects the site. The road did not exhibit cracking and/or distress that would be consistent with either surface faulting or creep.

The site consists of gentle to moderate east-facing slopes with steeper slopes occurring in the western portion of the site. Elevations vary from 68 feet in the eastern corner to over 165 feet in the western sections. No geomorphic evidence of a fault trace are apparent based on surface observations.

IV. REGIONAL GEOLOGY

The project is located in the North Coast Range Geomorphic Province of California. This geomorphic province is characterized by a series of northeasterly trending folds and faults. The Northern Coast Ranges contain mostly Mesozoic and Cenozoic sedimentary rocks. This region has undergone a complex geologic history of sedimentation, volcanism, folding, faulting, uplift and erosion.

The site is located on the western side of the Napa Valley. A ridge consisting of Sonoma Volcanics and Great Valley Sediments lie to the west. The Sonoma Volcanics consist of a variable series of rocks consisting of andesites, basalts, rhyolites, tuffs and other related pyroclastic rocks. The rocks are believed to range in age from Miocence to early Pleistocene. The Great Valley sequence consists of marine sedimentary rocks that are probably of lower Cretaceous to Upper Jurrasic in age.

V. REGIONAL FAULT HAZARD EVALUATION

The San Francisco Bay Area is recognized by geologists and seismologists as one of the most active seismic regions in the United States. The significant earthquakes which occur in the Bay Area are associated with crustal movements along well defined active fault zones which trend in a northwesterly direction.

The site and the entire San Francisco Bay Area is seismically dominated by the presence of the active San Andreas Fault System. In the theory of plate tectonics, the San Andreas Fault System is a transform fault which forms the boundary between the northward moving Pacific Plate (west of the fault) and the southward moving North American Plate (east of the fault). In the Bay Area, this movement is distributed across a complex system of strike-slip, right lateral parallel and subparrallel faults which include the San Andreas, Hayward, Calaveras, Greenville and West Napa Fault, among others.

Napa County has experienced only three large earthquakes with Modified Mercalli intensities of VII or greater in recorded history (Seismic Safety Element-Napa County, 1975). These occurred in 1891, 1898 and 1906. The 1891 and 1989 earthquakes apparently had epicenters in Napa County or nearby Solano County. The 1906 event known as the Great San Francisco Earthquake had an epicenter in Marin County near the head of Tomales Bay.

There are no known faults with documented surface displacement occurring within the last 100 years in Napa County. Nearby active faults with known surface displacement in the last 100 years and their closest distance from the project site are as follows (Wagner, 1982, and Herd, 1977):

Green Valley Fault	-	9.0 miles to the southeast
Hayward Fault	-	21 miles to the southwest
San Andreas Fault	-	31 miles to the west

VI. SITE GEOLOGY AND FAULT HAZARD INVESTIGATION

A. Subsurface Conditions

The surface soils exposed in the trenches generally consist of dark brown silty clays with traces of gravel and sand. The clay appeared to be moderately plastic with a low to moderate expansive potential. The clay varies in depth from approximately 2 feet to over 5 feet, with the thicker accumulations occurring in the lower portions of the property. The surface soils are underlain by andesites and other rocks belonging to the Sonoma Volcanics Formation. The rocks varied from weathered to fresh. In trench No. 4, below the surficial clay, a soil unit probably representing old landslide deposits was encountered. They consist of a stiff brown mollted clay with gravel. Observation of the hillside topography immediate west of the trench and occurring west of the property line indicate shallow soil creep.

Some irregular short cracks in the soil along with a humocky appearance to the hillside indicate that soil creep or a shallow debris flow is occurring in these steep slopes west of the Knittel property line. In trench No. 5, very wet silty clay were encountered. Immediately after excavation, the water began to fill up the trench. Water was flowing into the trench from a very soft slightly more coarse layer occurring approximately 2 to 3 feet below the ground surface.

B. Site Fault Hazard Investigation and Evaluation

Aerial photographs of the site supplied by Charles W. Shinnamon, Consulting Civil Engineers, Napa, California, along with photos at Napa City Engineering Office were examined for this investigation. The photographs supplied by Shinnamon were 8,678, 1-1 and 1-2, dated 9-8-83 (scale: 1 inch = 200'). Photographs examined at the City of Napa Engineering Office were 075-3662-30 and 076-3662-31 (scale: 1 inch = 400'). Our examination of these photo sets indicate that the West Napa Fault or other Fault does not cross the subject property. No geomorphic features indicating Holocene Fault movement were observed at the Knittel property. A distinct lineament, with an approximate strike of north-northwest was observed approximately 200 feet west of the property. This lineament lines up with a fault trace identified by Western Geological Consultants for a parcel of land at Browns Valley Road and Robinson Lane (see Plate 2). Geomorphic features of this lineament include: deflected drainage, break in-slope and tonal changes.

VII. CONCLUSIONS

Based on the investigation we have performed, our conclusions for the fault investigation study are as follows:

1. The surface trace of the West Napa Fault does not cross the subject property.

2. A lineament, identified through aerial photograph interpretation, occurs approximately 200 feet west of the property.

3. That this lineament is probably the surface trace of the West Napa Fault and is an extension of a fault trace identified by Western Geological Consultants.

VIII. RECOMMENDATIONS

Our recommendations for the proposed development are as follows:

1. No limitation should be made on construction of structures for human occupancy with respect to the hazard of fault rupture.

2. No further fault location studies are required for this project for the purposes of evaluating the hazards of surface fault rupture.

3. The risk of damage to buildings due to surface fault displacement along an active fault, constructed for the proposed development is low to non-existent.

IX. ADDITIONAL SERVICES AND LIMITATIONS

A. Additional Services

If the information presented in this report is used as a basis for the preparation of plans for construction, Kleinfelder & Associates must review such plans for compatibility with the geologic conditions present at the site. Field observations by us during construction are also necessary. If Kleinfelder & Associates is not retained for these

services, the client agrees to assume our responsibility for any claims that may arise during or after construction attributed to information provided in this report.

B. Limitations

The conclusions and recommendations presented in this report are for design purposes for the proposed development as described in the text of this report. The study was conducted in accordance with the generally accepted standard of practice in California at the time of this report. No other warranty, expressed or implied, is made. All evaluations were based on the information available. This information included:

(1) A brief review of published and unpublished literature.

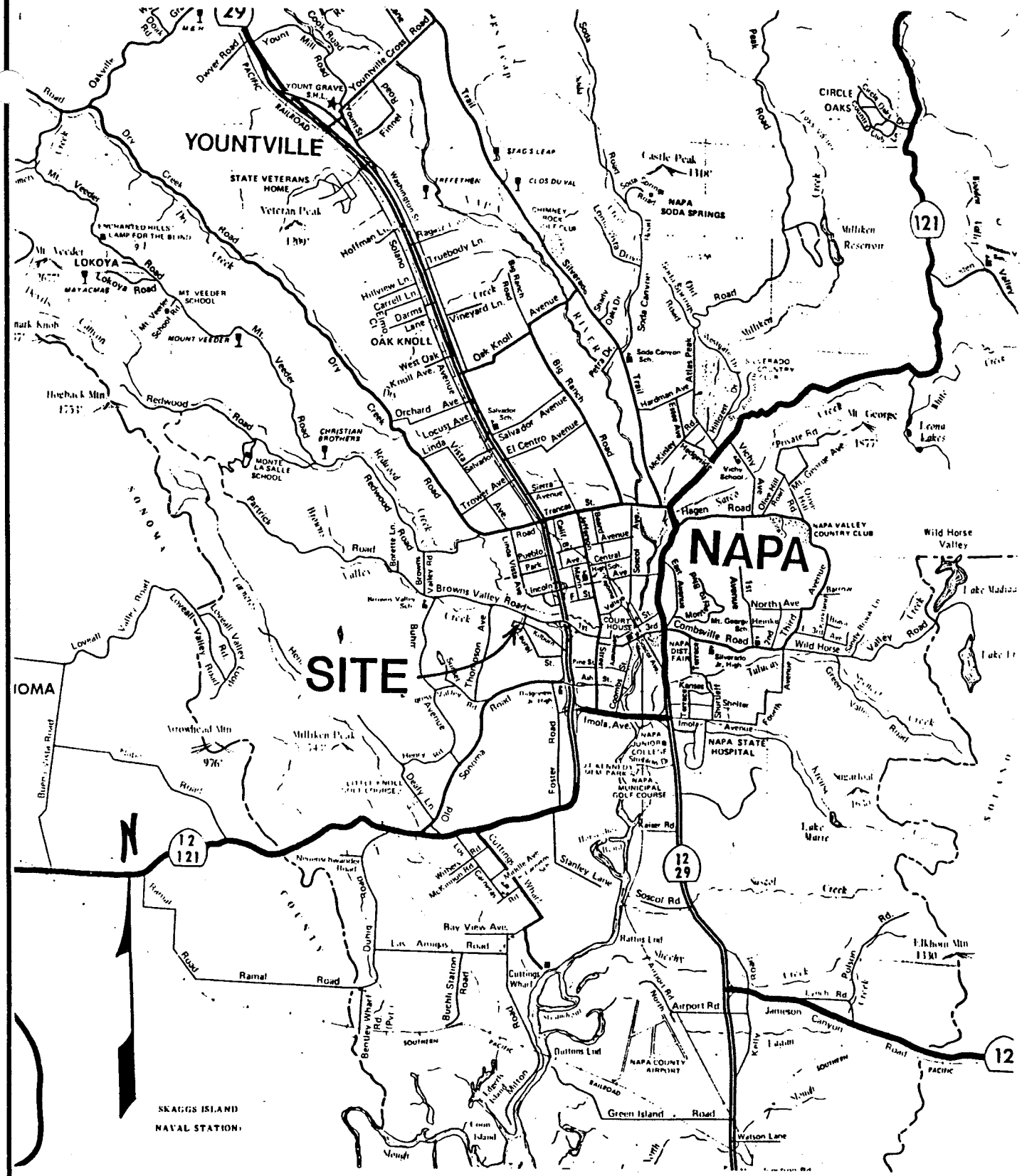
(2) Examination and interpretation of aerial photographs of the project site.

(3) Excavation and examination of trenches at the site.

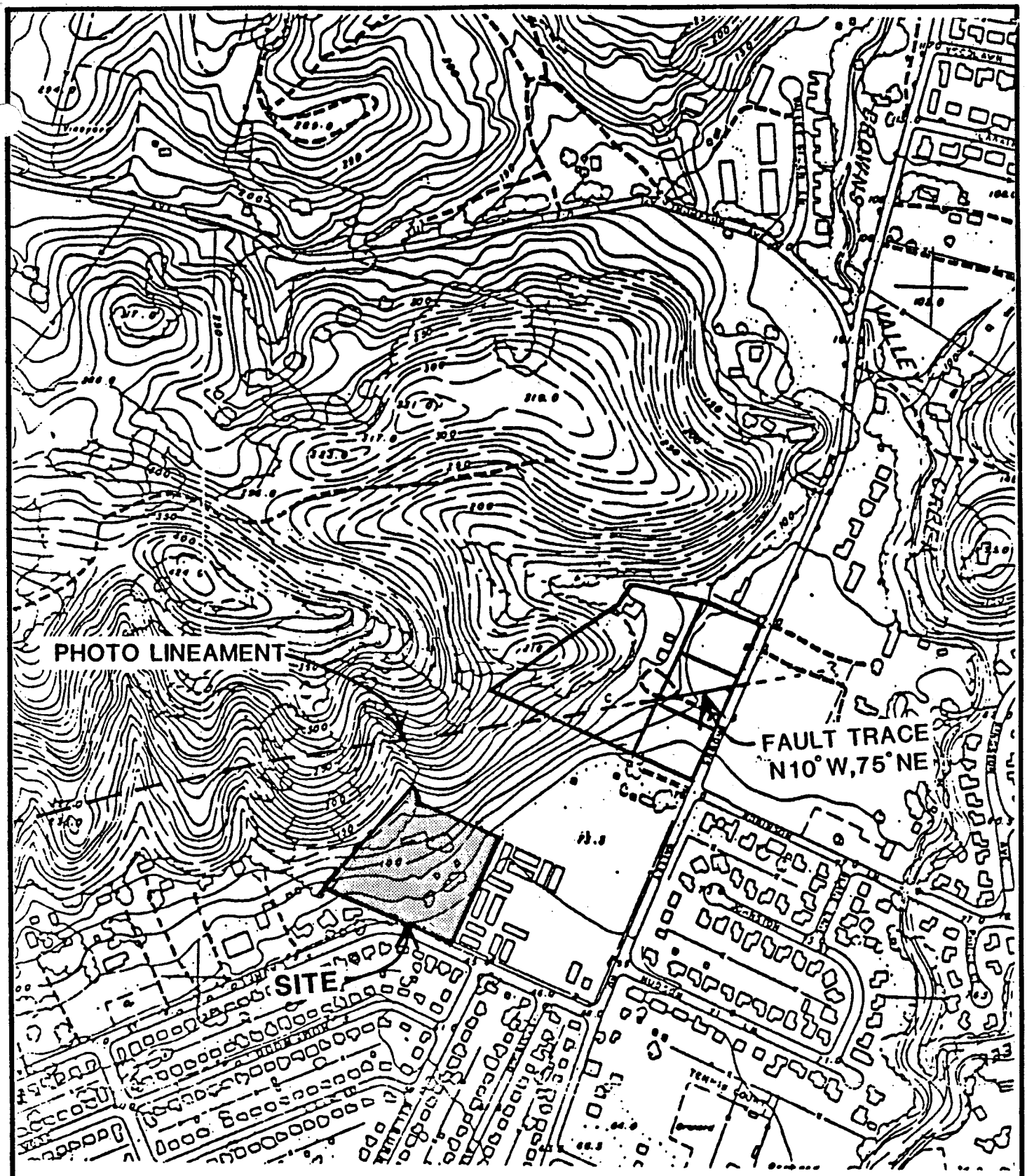
(4) The observations of our engineering geologist.

(5) Our experience in the area.

It is possible that variations in geologic conditions between or beyond the trenches excavated at the site for this investigation could exist. It is possible that additional information will be developed in the future that would alter the conclusions or recommendations of this report. If new information is developed, it may be necessary to re-evaluate and revise the contects of this report.

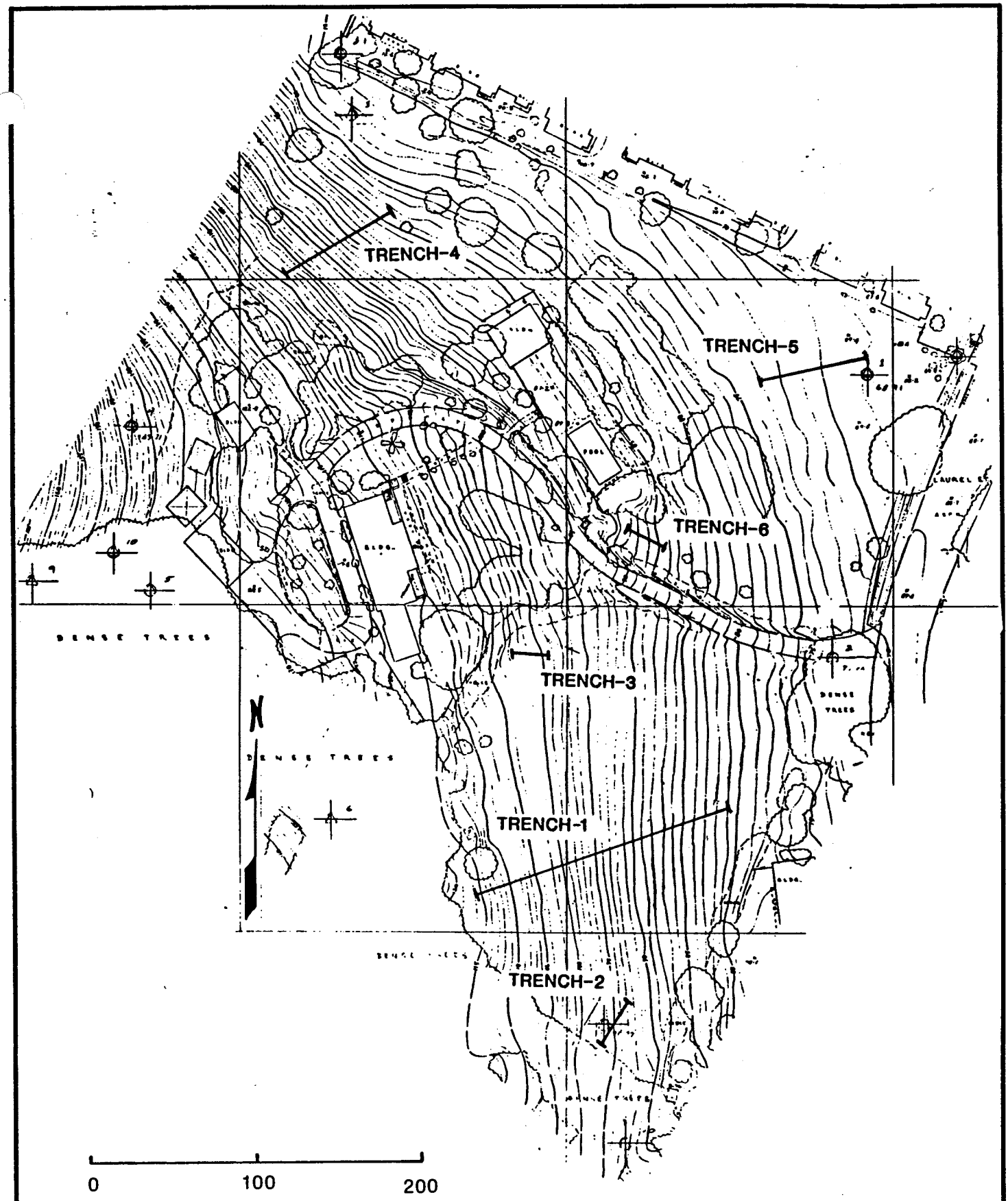


J.H. KLEINFELDER & ASSOCIATES GEOTECHNICAL CONSULTANTS • MATERIALS TESTING	KNITTEL-FAULT INVESTIGATION SITE LOCATION	PLATE 1
PROJECT NO.		



SCALE 1 INCH = 500 FEET

J.H. KLEINFELDER & ASSOCIATES GEOTECHNICAL CONSULTANTS • MATERIALS TESTING	KNITTEL-FAULT INVESTIGATION LINEAMENT LOCATION	PLATE 2
PROJECT NO.		



J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO.

KNITTEL-FAULT INVESTIGATION

TRENCH LOCATION

PLATE

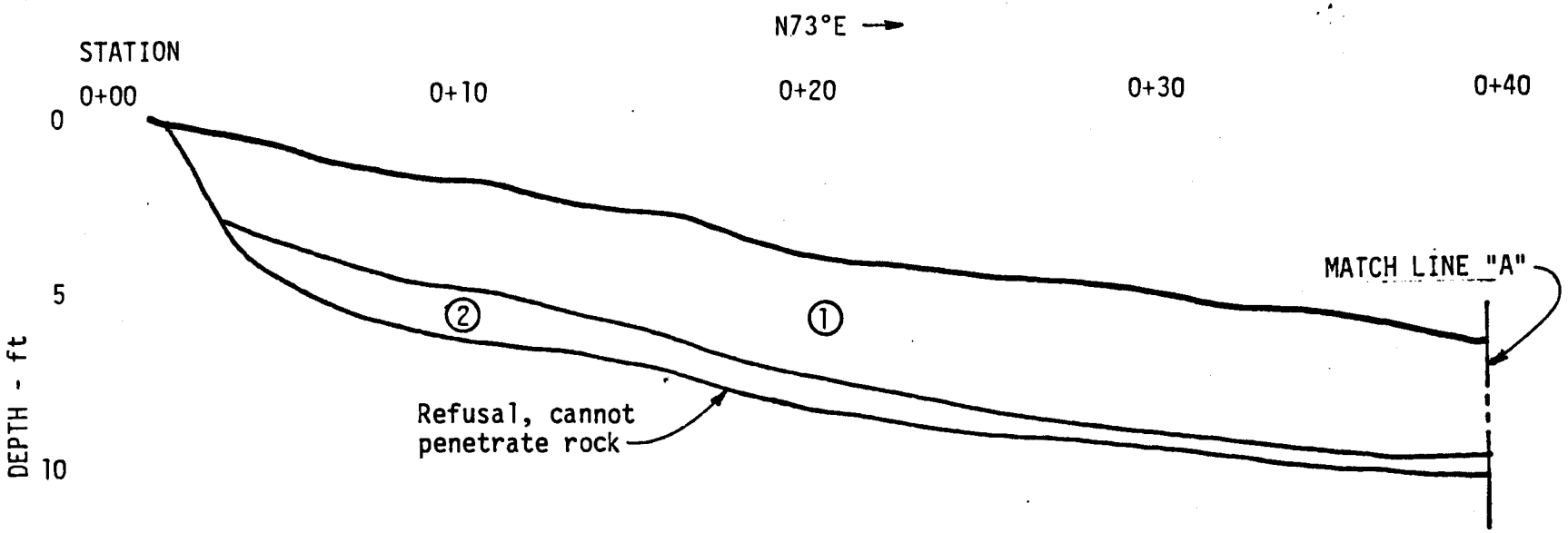
3

J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 1



LEGEND

① SILTY CLAY (CL) - dark brown, soft, very moist to wet, trace sand, organics, roots near surface.

② BEDROCK - gray, hard, slightly weathered.

PLATE 4

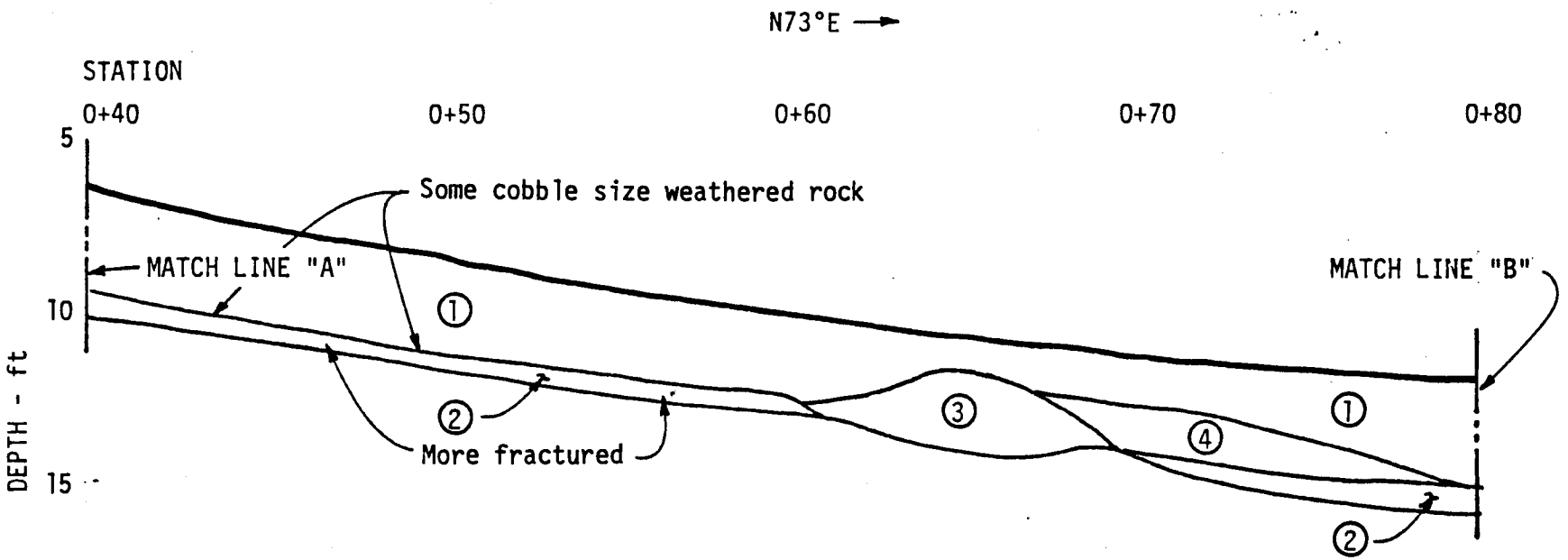
J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 1

PLATE 5



LEGEND

① SILTY CLAY (CL) - dark brown, soft, very moist to wet
trace sand, organics, roots near surface

② BEDROCK - gray, hard, slightly weathered.

③ HIGHLY WEATHERED BEDROCK (CLAY) - greenish gray, stiff,
rock structures visible.

④ CLAY AND GRAVEL - brown, wet, gravel is weathered.

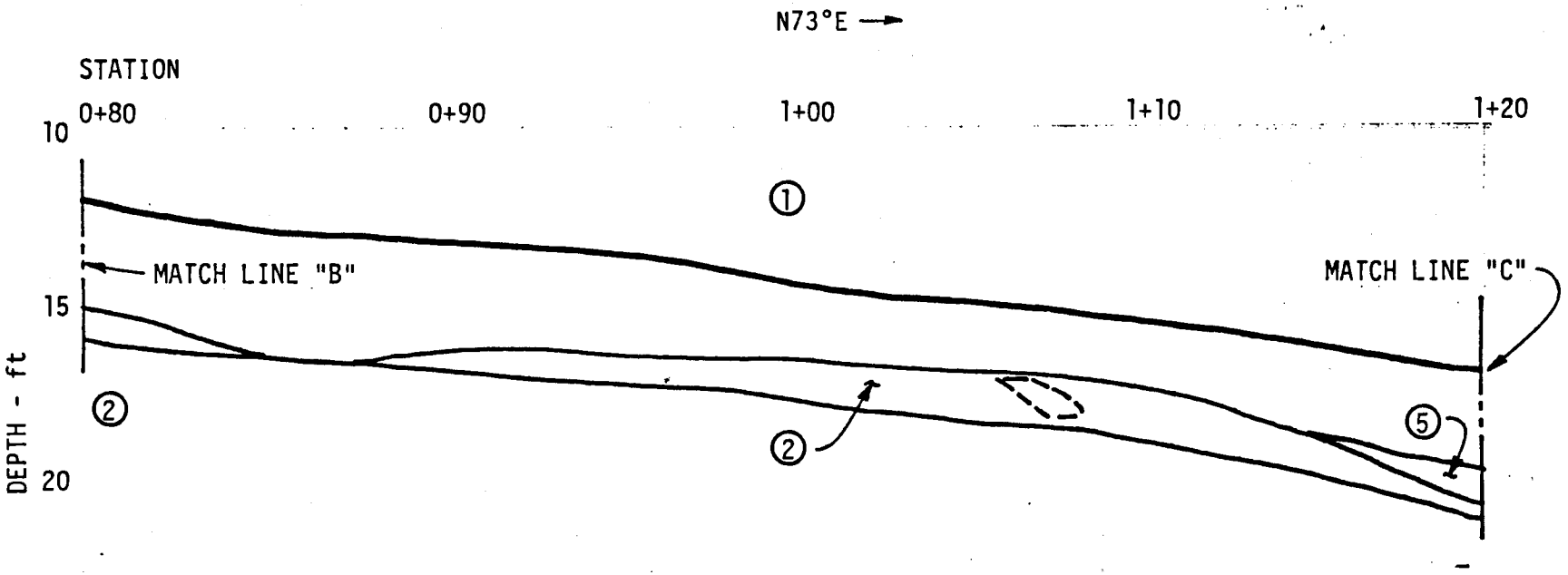
J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH I

PLATE 6



LEGEND

① SILTY CLAY (CL) - dark brown, soft, very moist to wet trace sand, organics, roots near surface.

② BEDROCK - gray, hard, slightly weathered.

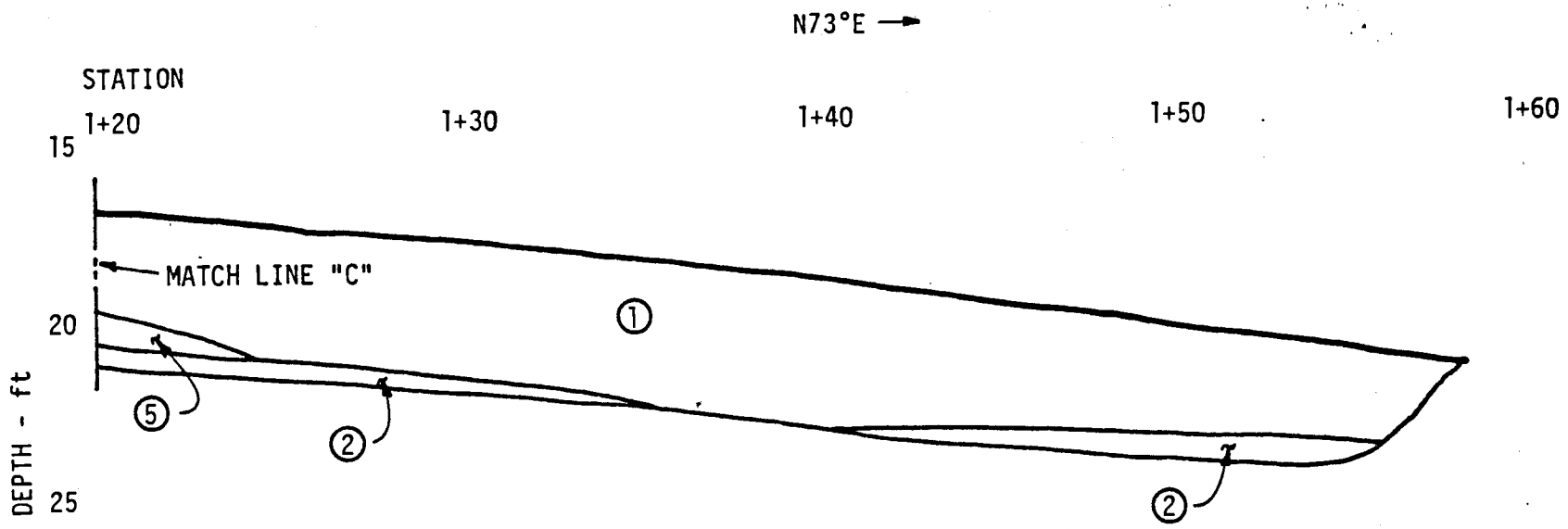
⑤ CLAY (CH)(older colluvium) - brown, stiff, highly plastic, moist.

J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 1



LEGEND

① SILTY CLAY (CL) - dark brown, soft, very moist to wet
trace sand, organics, roots near surface

② BEDROCK - gray, hard, slightly weathered.

⑤ CLAY (CH)(older colluvium) - brown, stiff, highly plastic, moist.

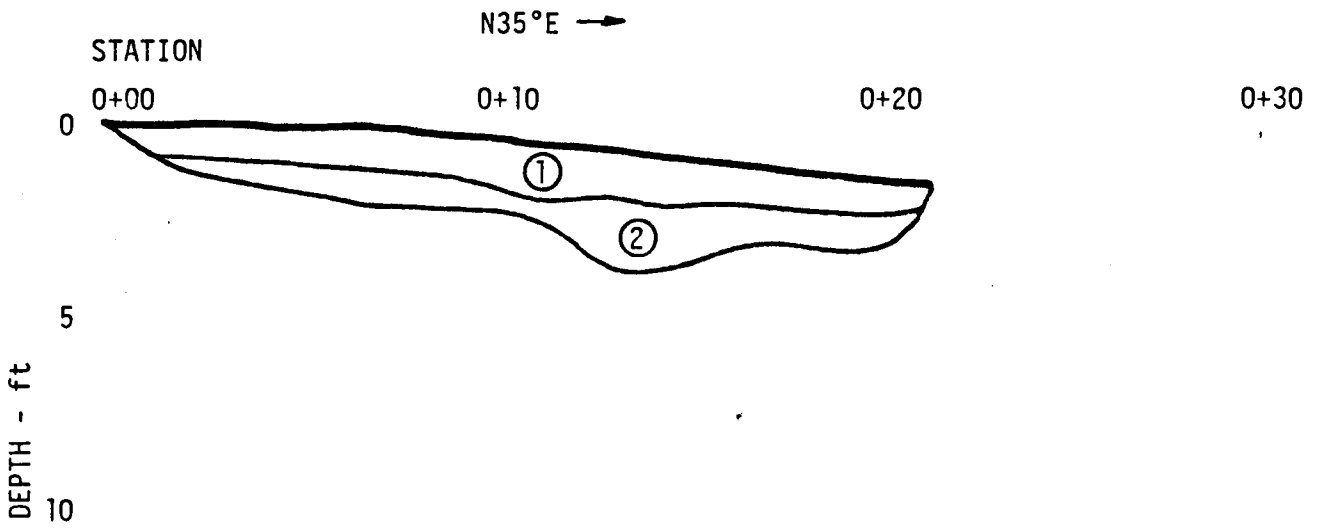
PLATE 7

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GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 2



LEGEND

① SILTY CLAY (CL) - brown, wet, soft, plastic, some sand, gravel and cobbles.

② SLIGHTLY WEATHERED BEDROCK - hard with some softer more weathered zones.

PLATE 8

LEGEND

① SILTY CLAY (CL) - brown, very moist, stiff to soft, some sand and gravel.

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GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 3

PLATE 9

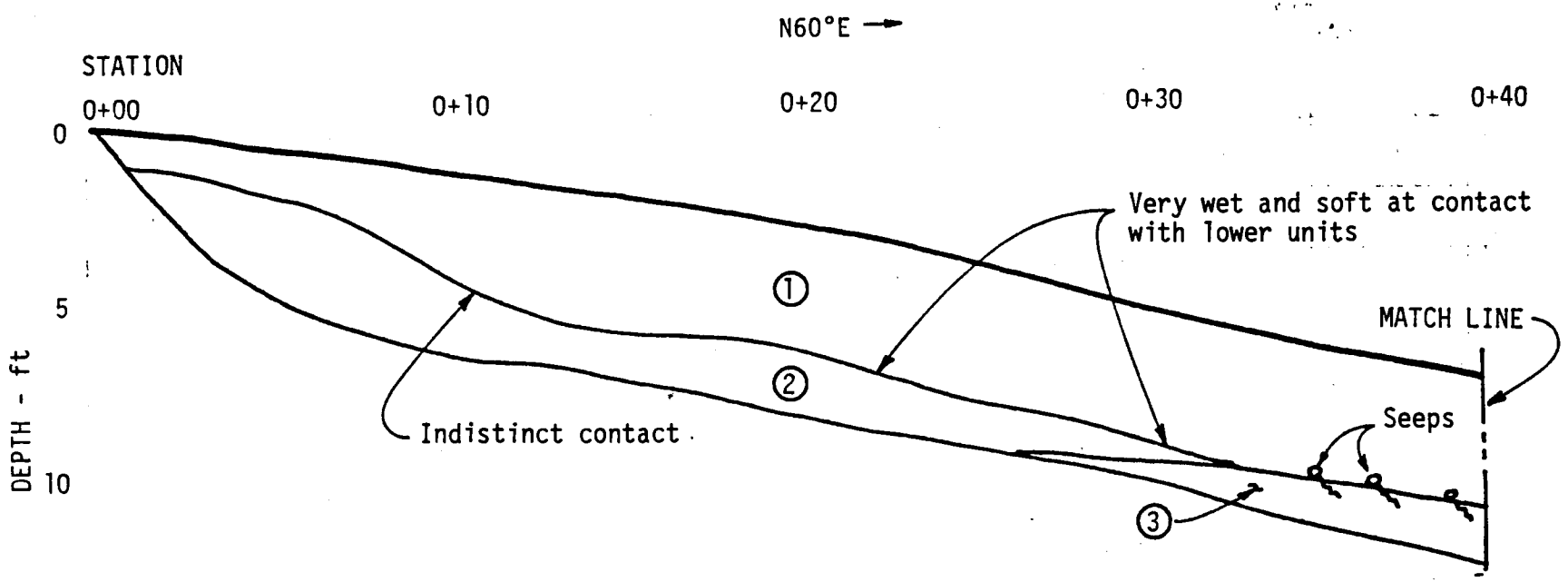
J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 4

PLATE 10



LEGEND

① SILTY CLAY (CL) - brown, soft, wet, plastic, some sand and gravel.

② CLAY (CL-CH)(older colluvium) - brown, mottled, stiff, highly weathered, rock in clay matrix, appears somewhat cemented.

③ HIGHLY WEATHERED BEDROCK - weathering to clay, olive gray, brown, moist, higlhy plastic, very stiff, original rock structure visible.

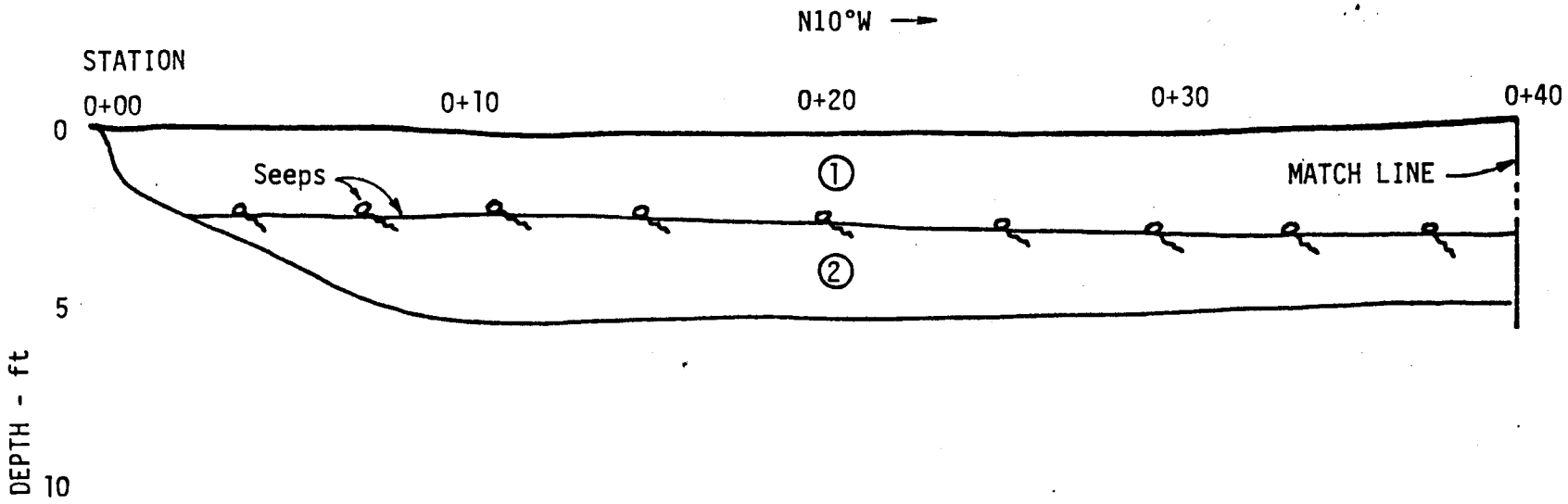
J H KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 5

PLATE 12



LEGEND

① SILTY CLAY (CL) - dark gray, wet to saturated, soft, some sand and gravel at bottom contact.

② SILTY CLAY (CL) - brown, moist, stiff to hard, some sand.

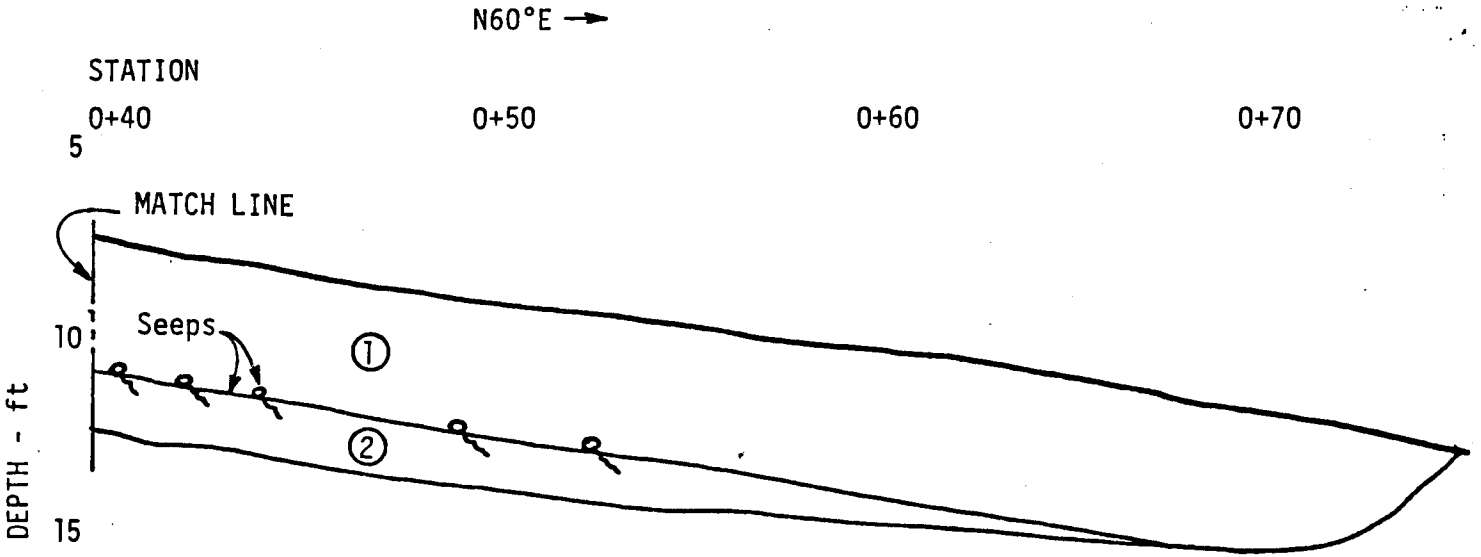
J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 4

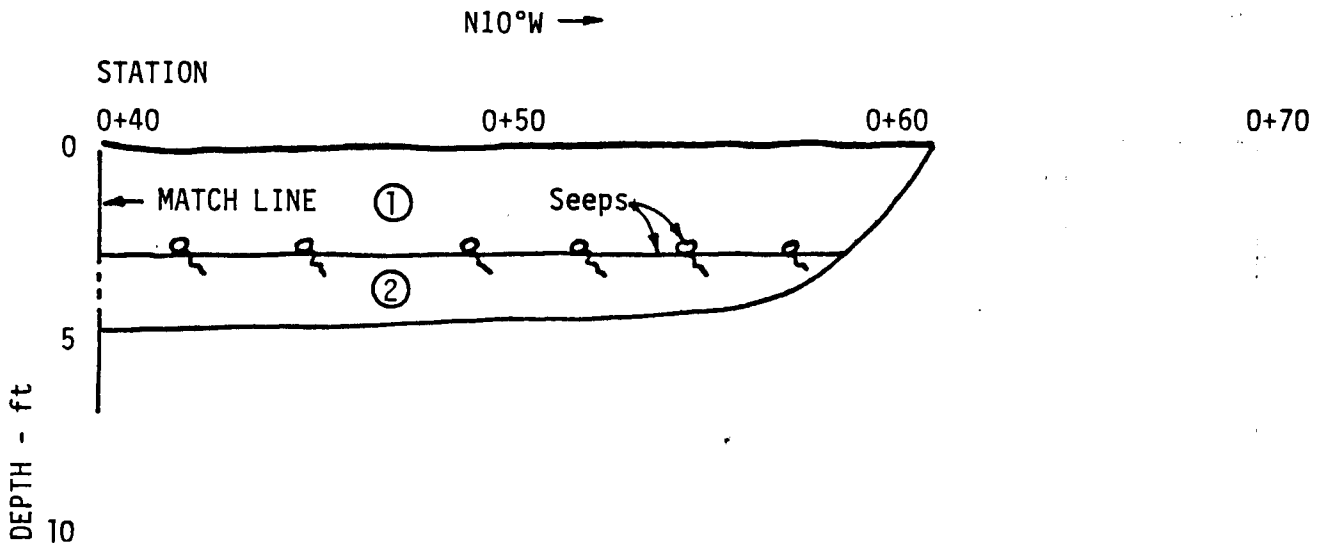
PLATE 11



LEGEND

① SILTY CLAY (CL) - brown, soft, wet, plastic, some sand and gravel.

② CLAY (CL-CH)(older colluvium) - brown, mottled, stiff, highly weathered, rock in clay matrix, appears somewhat cemented.



LEGEND

① SILTY CLAY (CL) - dark gray, wet to saturated, soft, some sand and gravel at bottom contact.

② SILTY CLAY (CL) - brown, moist stiff to hard, some sand.

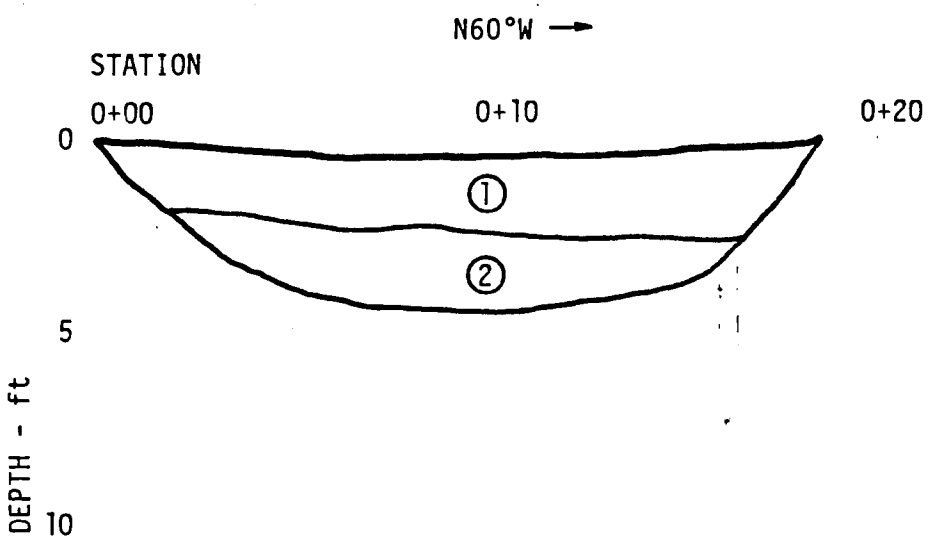
J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 5

PLATE 13



LEGEND

① SILTY CLAY (CL) - brown, moist, moderately stiff, gravel and cobbles.

② WEATHERED BEDROCK - becoming harder with depth.

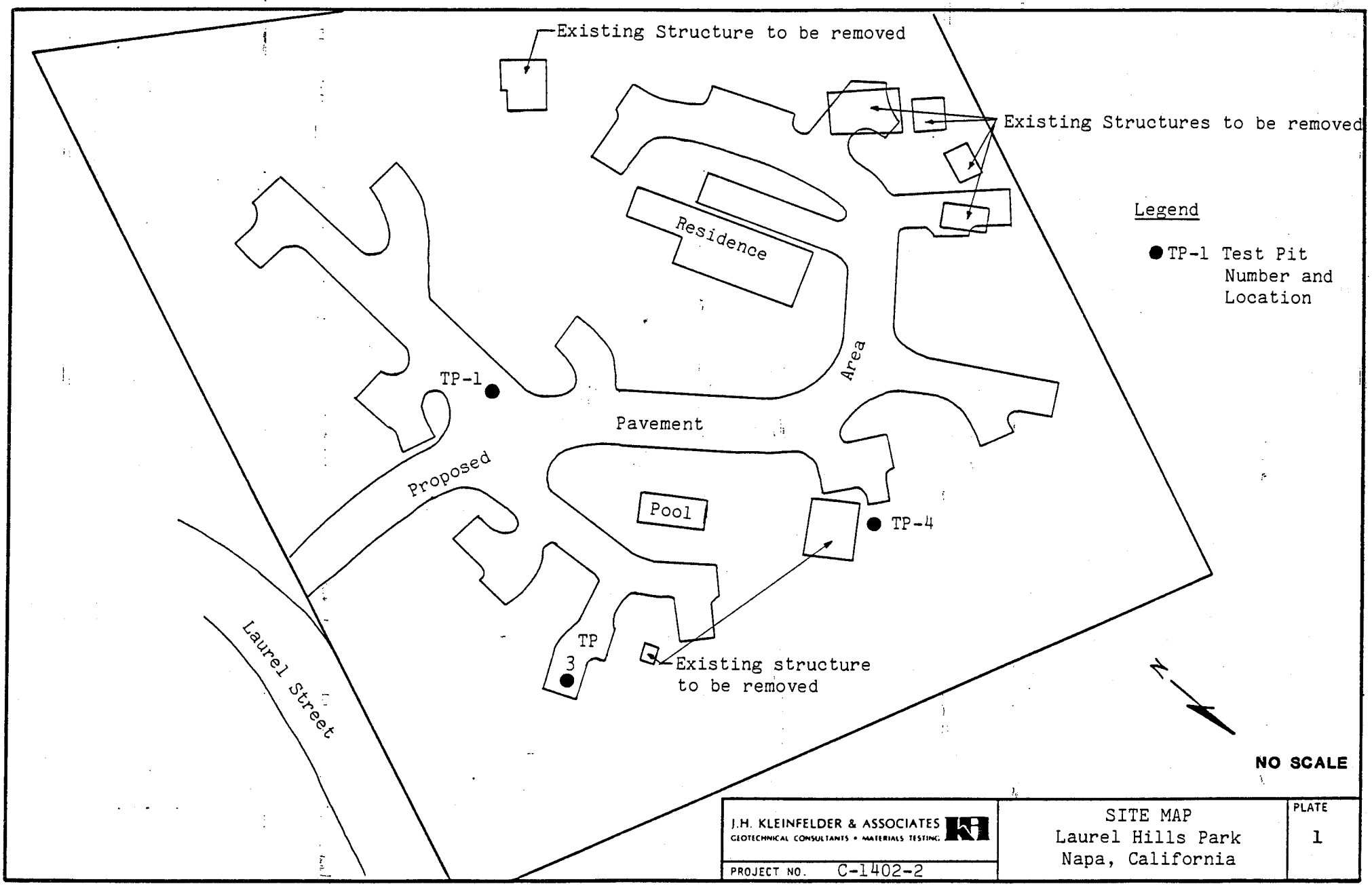
J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-1

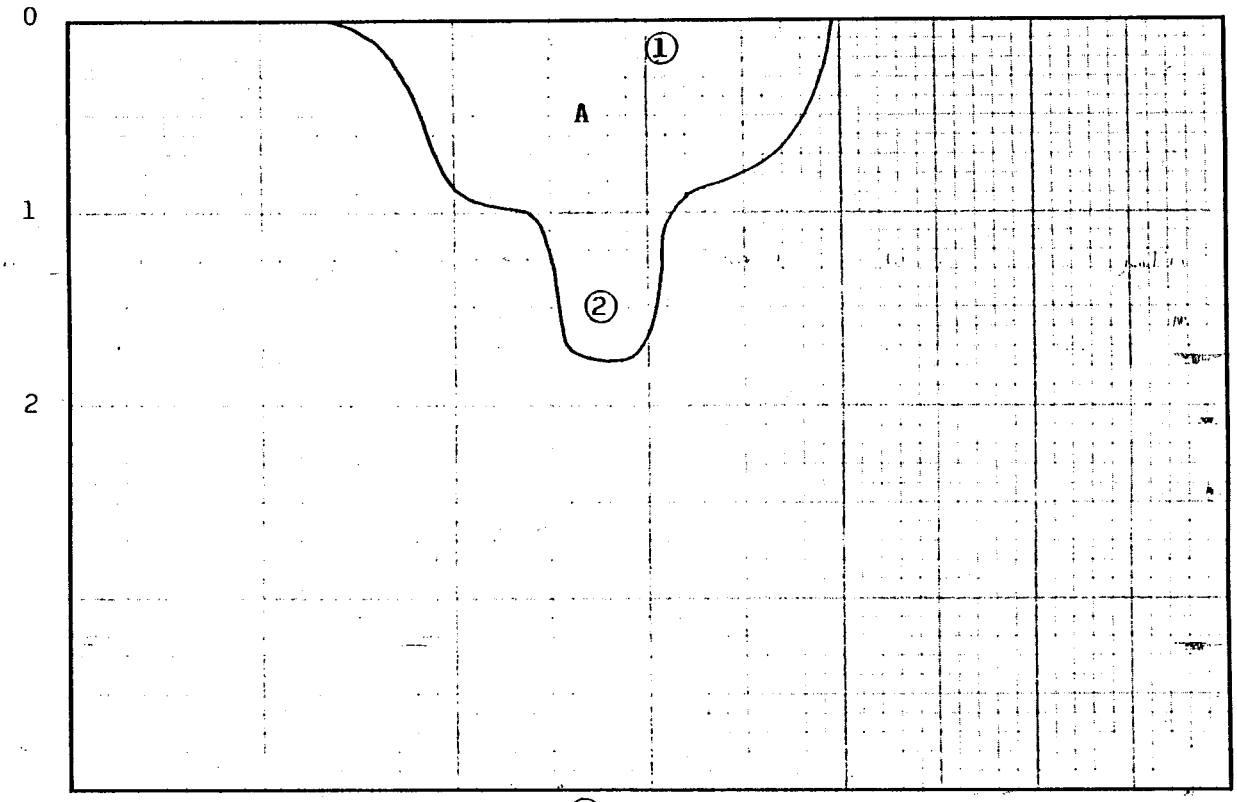
KNITTEL-FAULT INVESTIGATION

LOG OF TRENCH 6

PLATE 14



J.H. KLEINFELDER & ASSOCIATES GEOTECHNICAL CONSULTANTS • MATERIALS TESTING PROJECT NO. C-1402-2	SITE MAP Laurel Hills Park Napa, California	PLATE 1



① Bulk surface sample taken
② Hand driven sample at 1.5 ft

DEPTH IN FEET	MATERIAL DESCRIPTION
0-1.5	A. CLAY: Silty with coarse grained sand and small medium size gravels, brown, wet, soft.

J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

Laurel Hills Park
Napa, California

LOG OF TEST PIT NO. 1

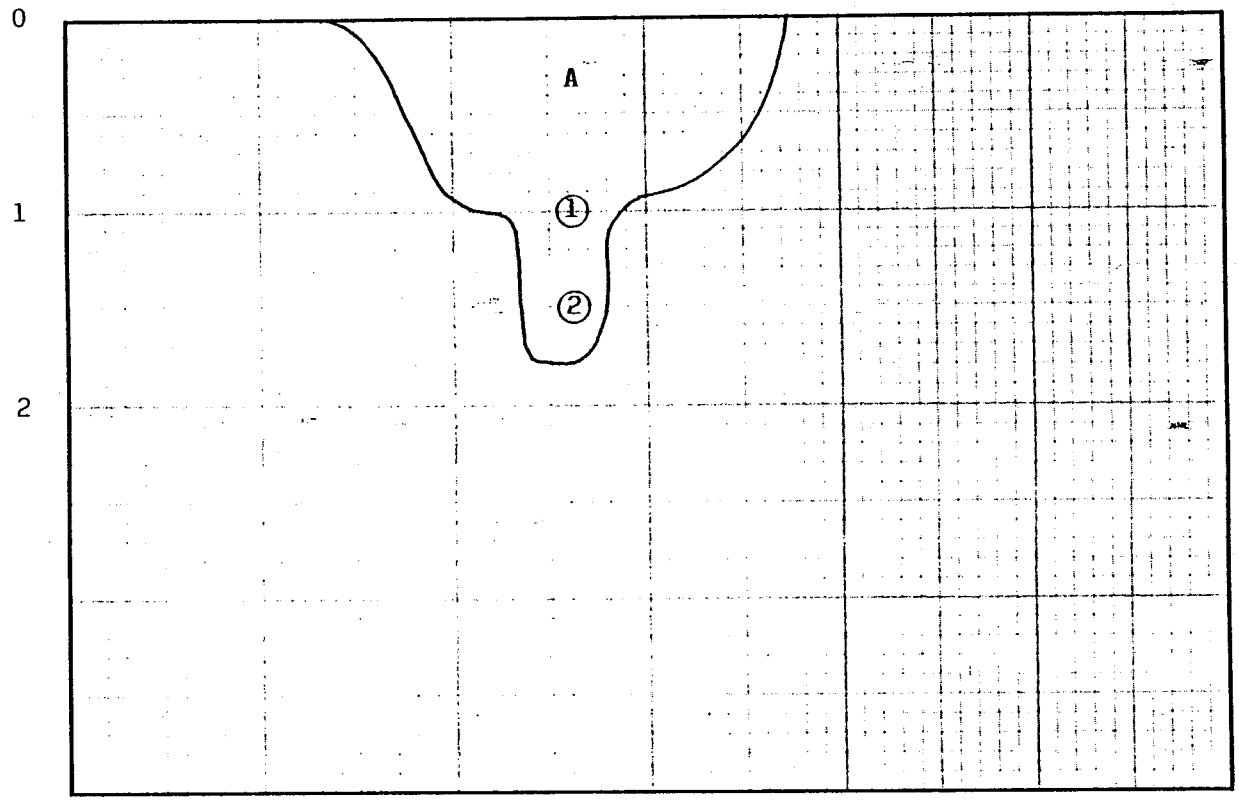
PLATE 2

PREPARED BY: GP DATE: March 1985

CHECKED BY: RC DATE: March 1985

PROJECT NO. C-1402-2

JHK & A Form R-7



① Bulk sample taken at 1 ft
② Hand driven sample at 1.5 ft

DEPTH IN FEET	MATERIAL DESCRIPTION
0-1.5	A. CLAY: Silty with coarse grained sand and small medium size gravels, brown, wet, soft.

J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

Laurel Hills Park
Napa, California

LOG OF TEST PIT NO. 2

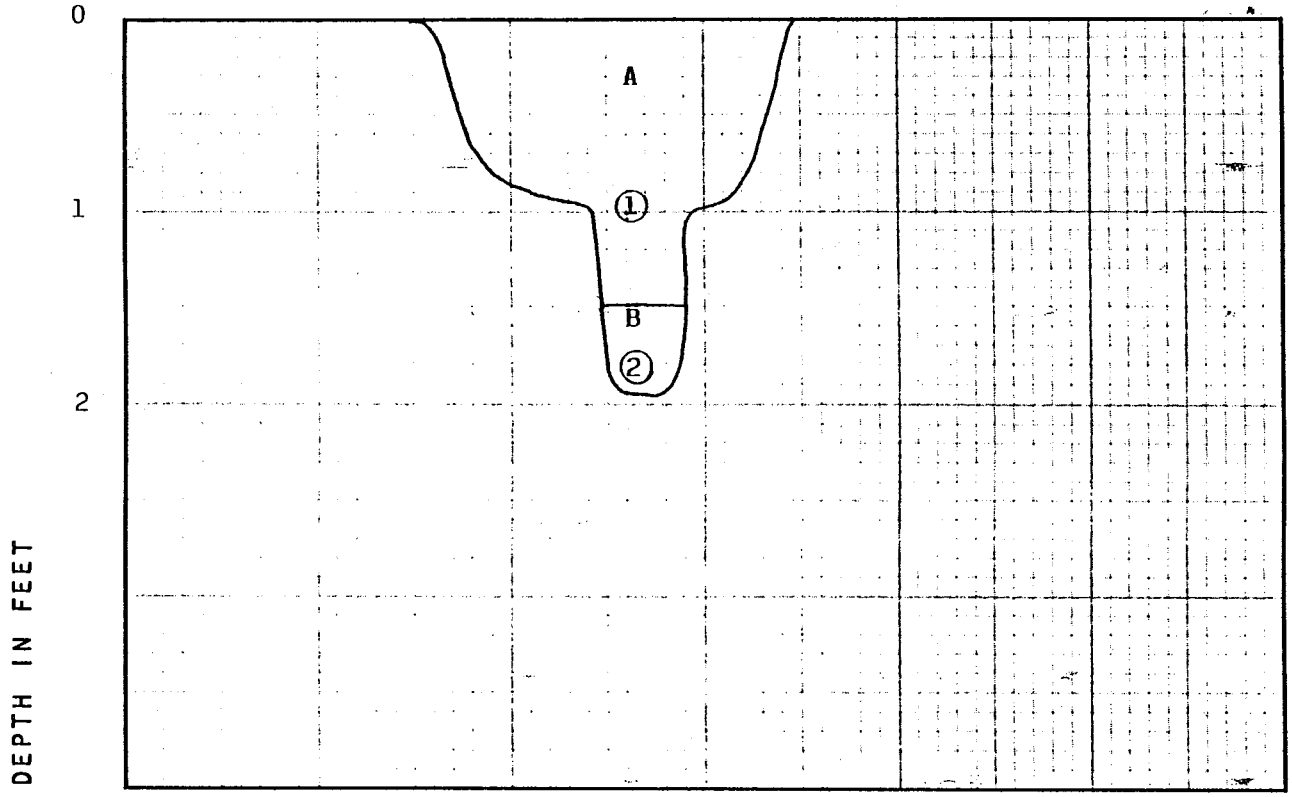
PLATE 3

PREPARED BY: GP DATE: March 1985

CHECKED BY: RC DATE: March 1985

PROJECT NO. C-1402-2

JHK & A Form R-7



① Bulk sample taken at 1 ft
② Hand driven sample at 1.5 ft

DEPTH IN FEET	MATERIAL DESCRIPTION
0-1.5	A. CLAY: Silty with coarse grained sand and small medium size gravels, brown, wet, soft.
1.5-2.0	B. CLAY: Silty, some coarse grained sand, red brown, wet, soft.

J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PREPARED BY: GP DATE: March 1985
CHECKED BY: RC DATE: March 1985

Laurel Hills Park
Napa, California

LOG OF TEST PIT NO. 3

PROJECT NO. C-1402-2

PLATE 4

JHK & A Form R-7

J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-2

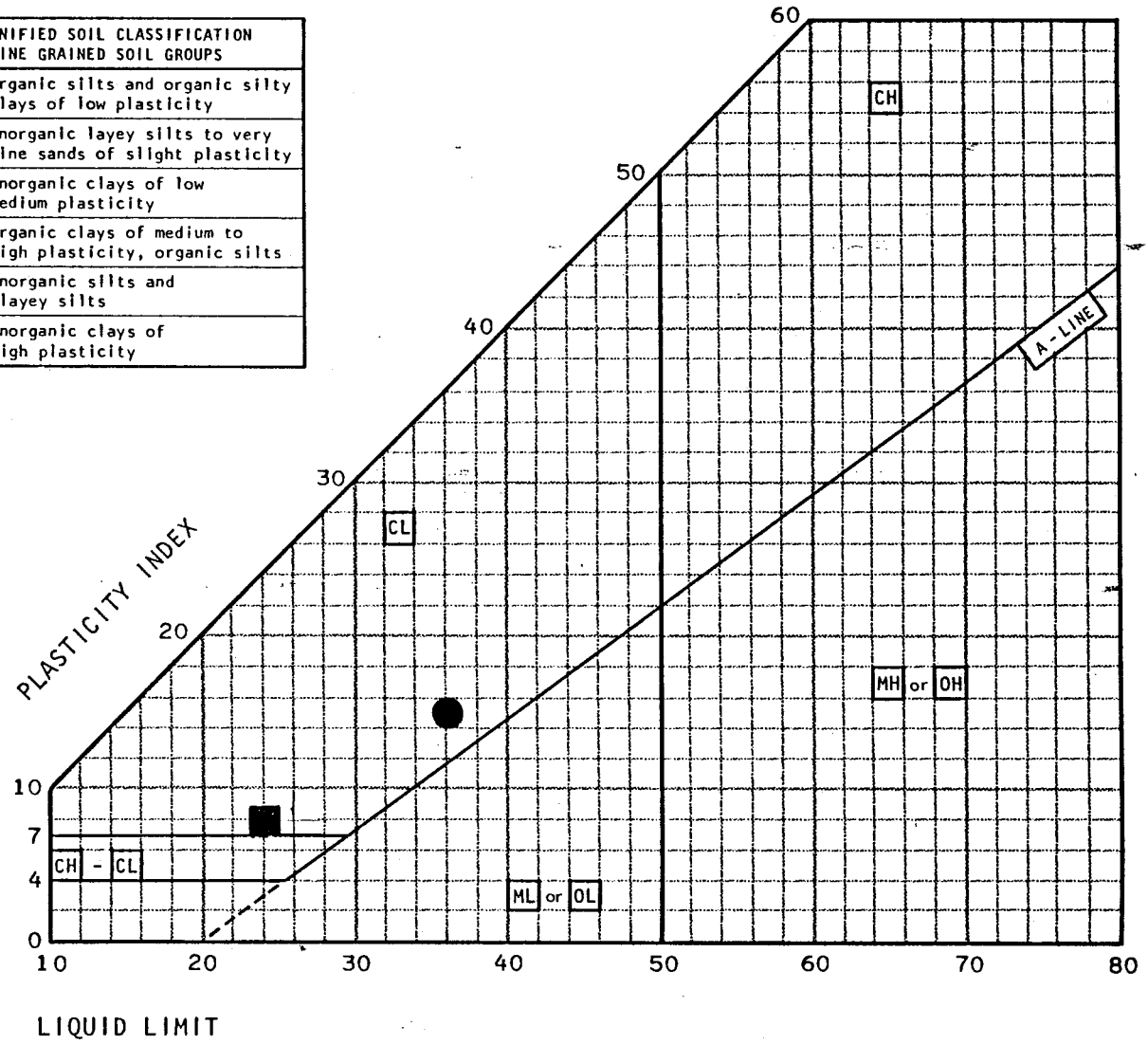
Laurel Hills Park
Napa, California

LABORATORY TESTS

PLATE 5

TEST PIT No.	DEPTH	DRY UNIT WEIGHT lb/ft³	MOISTURE CONTENT % OF DRY WEIGHT	GRADING ANALYSES — SIEVE SIZE - PERCENT PASSING						HYDROMETER ANALYSES			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH kips/ft²
				1"	3/4"	4	10	40	200	SILT SIZE	CLAY SIZE	COLLOIDS	L.L.	P.I.	
1	Surface												36	15	
2	1.0′												24	8	
1	1.5′	103	17												0.4

GROUP SYMBOL	UNIFIED SOIL CLASSIFICATION FINE GRAINED SOIL GROUPS
OL	Organic silts and organic silty clays of low plasticity
ML	Inorganic layey silts to very fine sands of slight plasticity
CL	Inorganic clays of low medium plasticity
OH	Organic clays of medium to high plasticity, organic silts
MH	Inorganic silts and clayey silts
CH	Inorganic clays of high plasticity



TEST SYMBOL	TEST PIT NO.	DEPTH FEET	LIQUID LIMIT	PLASTICITY INDEX	CLASSIFICATION
●	1	0.5	36	15	Silty Clay
■	2	1.0	24	8	Silty Sandy Clay

J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-2

Laurel Hills Park
Napa, California

PLASTICITY CHART

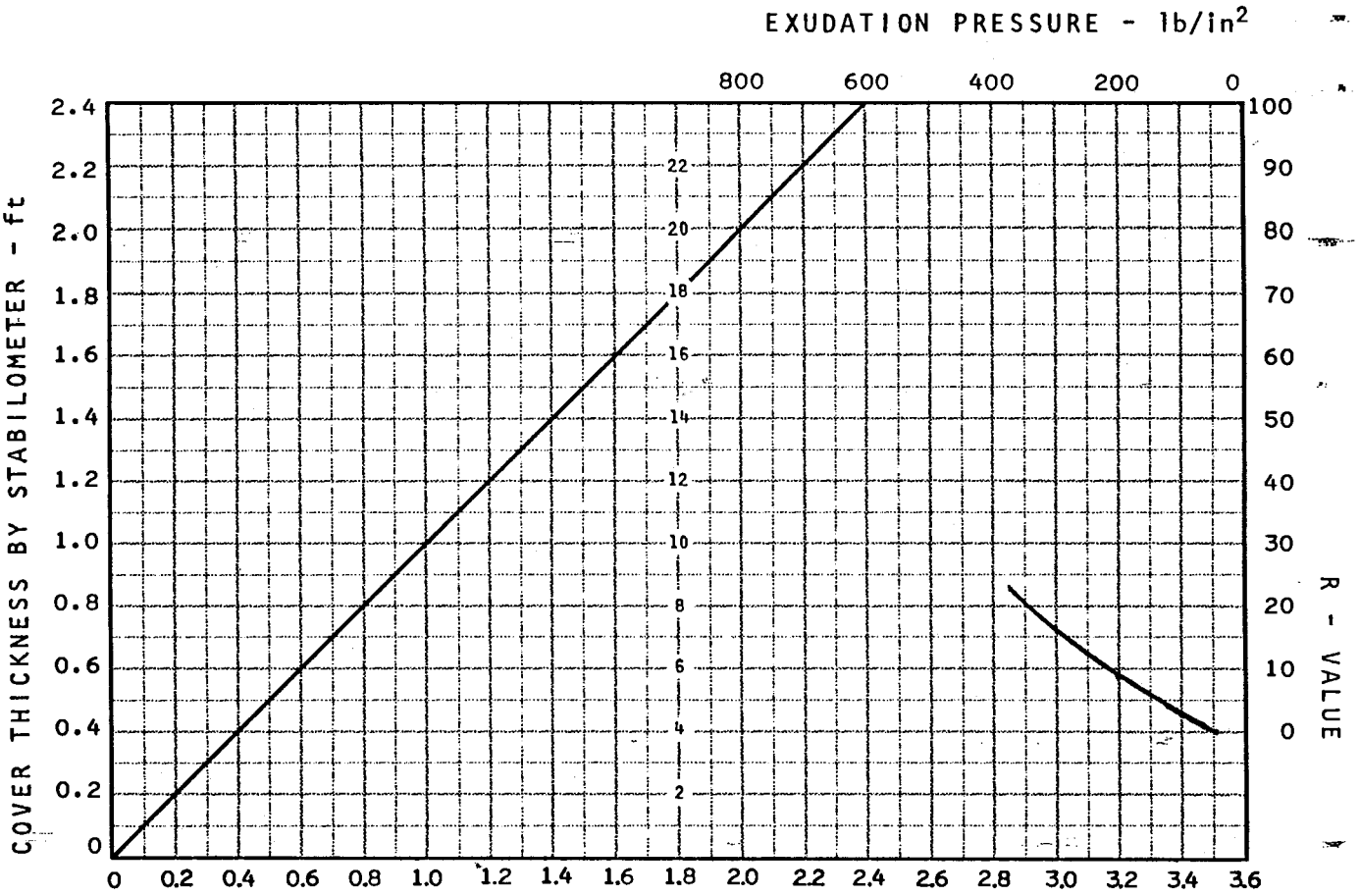
PLATE 6

IHK & A Form R-5

SAMPLE LOCATION: Test Pit No. 1

SAMPLE DESCRIPTION: Silty Sandy Clay

DATE SAMPLED: March 27, 1985



SPECIMEN	A	B	C
EXUDATION PRESSURE, lb/in²	48	200	376
EXPANSION DIAL (.0001")			
EXPANSION PRESSURE, lb/ft²	0	43	108
RESISTANCE VALUE, R	0	9	22
% MOISTURE AT TEST	29	22	11
DRY DENSITY AT TEST, lb/ft³	90.8	104.3	115.5
R VALUE AT 300 lb/in² EXUDATION PRESSURE		17	
R VALUE BY EXPANSION PRESSURE (TI =)			

J.H. KLEINFELDER & ASSOCIATES
GEOTECHNICAL CONSULTANTS • MATERIALS TESTING

PROJECT NO. C-1402-2

Laurel Hills Park
Napa, California

RESISTANCE VALUE

PLATE 7

FAULT INVESTIGATION REPORT
NAPA OAKS
OLD SONOMA ROAD
NAPA, CALIFORNIA

FOR
DAVIDON HOMES
December 19, 2014

Job No. 3280.002

BERLOGAR STEVENS & ASSOCIATES

Via E-Mail and Mail

December 19, 2014
Job No. 3280.002

BERLOGAR
STEVENS &
ASSOCIATES

Mr. Steve Abbs
Davidon Homes
1600 South Main, Suite 150
Walnut Creek, California 94596

Subject: Fault Investigation Report
Napa Oaks
Old Sonoma Road
Napa, California

Dear Mr. Abbs:

INTRODUCTION

This report presents the results of our investigation of surface fault rupture potential at the Napa Oaks site. The site consists of open ranchland on the south side of Old Sonoma Road in Napa, California. The approximate location of the site is shown on the attached Vicinity Map, Plate 1.

Prior studies had established a fault setback zone for the proposed development. Following the August 24, 2014 South Napa Earthquake, ground cracks were observed outside the previously established fault setback zone (Phoenix Geotechnical, 1994).

AUGUST 24, 2014 M 6.0 SOUTH NAPA EARTHQUAKE

On August 24, 2014, a M6.0 earthquake occurred with the epicenter located about 6 miles southwest of the City of Napa, California. Strong ground motions from the earthquake caused damage to several older buildings in the downtown area, deformed roadways and pipelines, and damaged homes.

The earthquake event is considered to have occurred on a fault splay within the West Napa fault zone with surface rupture reported on 2 main fault strands along the west side of Napa. The report for the event prepared by the Earthquake Engineering Research Institute (EERI) shows a "Western Strand" located about 1¼ miles west of the Napa Oaks site and an "Eastern Strand" which crosses through the Napa Oaks site. Earthquake epicenters for the main event and associated aftershocks were located on the western strand defined in the EERI report. There were no epicenters plotted on the eastern strand. The eastern strand is the fault studied as part of this project. The approximate location of the epicenter from the August 24, 2014 M6.0 South Napa Earthquake is shown on the Quaternary Fault Map on Plate 2. The faults shown on that map were obtained from the KML (Keyhole Markup Language) files for the West Napa fault (Fault No. 36a) in the Quaternary Fault and Fold database provided by the U.S. Geological Survey.

PURPOSE AND SCOPE OF SERVICES

The purpose of this investigation was to evaluate the potential for surface fault rupture at the site based on the new information obtained from the August 24, 2014 South Napa earthquake and to provide revised setbacks for buildings intended for human occupancy. The site is not located within a current State of California designated earthquake fault zone for active faults; however, we conducted this study as if it were within a State-designated Alquist-Priolo Earthquake Fault Zone and utilizing State of California Note 49, Guidelines For Evaluating The Hazard Of Surface Fault Rupture. Our scope of services for this project included the following tasks:

1. Site reconnaissance mapping of ground cracks associated with the August 24, 2014 earthquake.
2. Geologic research on the West Napa fault.
3. Review of previous fault studies for the Napa Oaks site.
4. Coordination with the survey team from ***dk*** Consulting to accurately locate ground cracks and trench locations throughout the site.
5. Excavation and logging of 12 exploratory trenches totaling about 1,709 lineal feet.
6. Interaction and coordination with geologists from the California Geological Survey and U. S. Geological Survey seismic hazards programs.
7. Giving site tours to representatives from the Napa Planning and Engineering Departments as well as members of the Napa City Council.
8. Interaction and coordination with the City of Napa peer reviewer (ENGEO Incorporated).
9. Evaluation of the information collected as part of this project.
10. Consultation with the design team and you regarding building setbacks based on the results of this study.
11. Preparation of this report summarizing our findings and recommending setbacks for buildings intended for human occupancy.

PREVIOUS FAULT STUDIES AT THE NAPA OAKS SITE

Engeo Incorporated conducted geotechnical study of the site in 1989. The Engeo study included drilling 18 borings, excavating 5 exploratory test pits, excavation of a 75-foot long trench and performing 2 seismic lines. The Engeo study provided preliminary recommendations for site development but did not encounter a fault trace at the site. The location of the exploratory trench excavated by Engeo was planned to evaluate the nature of the contact between the Domengine Sandstone formation and Sonoma Volcanics. The approximate trench location is shown on the Fault Setback Map, Plate 4.

Phoenix Geotechnical performed a geotechnical feasibility study of the site in 1994. The study included excavating and logging 6 exploratory trenches to evaluate fault hazards at the site. Based on their evaluation of the site, Phoenix recommended a residential setback zone for a

splay of the West Napa fault identified in their report. Phoenix discussed Trench 6 as follows: "Trench 6 did not expose any obvious fault feature, however, between 30 and 40 feet, the bedrock was very sheared, soft and wet. This zone of deformation appears to correlate with the highly sheared zones of Trenches 4, 5, 5a and 5b, and the set back was continued to include this area." Phoenix performed an additional fault study at the site in 1998. The 1998 study focused on potential faulting in the northeast corner of the site, near Casswall Street. Based on 3 trench exposures, Phoenix concluded that there was no active faulting expressed in that portion of the property.

FIELD INVESTIGATION

Our field investigation was conducted between September 2 and November 3, 2014. The field investigation consisted of site reconnaissance mapping of surface cracks and the excavation and logging of 12 exploratory trenches totaling about 1,709 lineal feet.

During our site reconnaissance, we observed fairly continuous ground cracks from the barn area at the north end of the site to the southern property line. The surface cracks were located in the field by our engineering geologist who marked the locations with 6-feet long plastic snow stakes and marking paint. The locations of the snow stakes were surveyed by ***dk*** Consulting using a portable pole-mounted GPS unit. The surveyed locations of the surface cracks are shown on the Fault Setback Map. In general, the cracks were in a continuous pattern; however, they were not well expressed where they crossed through the root zones or under the canopy of oak trees.

Exploratory trenches were excavated up to about 15 feet deep with a track-mounted Kobelco 115 excavator. Both the north and south trench walls were cleaned using a pressure washer and additional fine cleaning was performed with hand picking tools where needed. The south wall of trench exposures was logged by an engineering geologist in the field at a graphic scale of 1 inch equals 5 feet. Soil colors noted on the logs are based on the Munsel Soil Color Chart and the Rock Color Chart published by the Geological Society of America (GSA). Trench exposures and logs were reviewed in the field by Napa's third party peer reviewer for this project, Engeo Incorporated. Trench exposures were also reviewed by several geologists from the California Geological Survey (CGS) and U.S. Geological Survey (USGS). The trenches were loosely backfilled with the excavated materials using a D-4 dozer by Binstock Engineering. Some settlement and rutting of the trench backfill should be expected.

As part of our investigation, we retained Dr. Glenn Borchardt of Soil Tectonics to provide age estimations of selected soil horizons near faults exposed in Trenches T-1 and T-6. The results of the pedocronological study by Dr. Borchardt are provided in the Appendix.

AGENCY INVOLVEMENT

Historically, the West Napa fault was poorly defined north of the Napa Airport and the fault hazard scenario through the Napa Valley was not well understood. Since we observed a significant amount of fault-related deformation at the site, we invited representatives from the CGS and USGS to view the site conditions during our subsurface trenching program. Several representatives from the seismic hazards programs from the CGS and USGS visited the site to

view the trench exposures and discuss features associated with active faulting at the site. Additionally, due to the multiple events recorded in the stratigraphic record at the active fault zone in the eastern end of Trench T-6, we allowed geologists from the CGS, in conjunction with our geologist, to undertake a detailed paleoseismic study including age estimations of previous event horizons preserved in the soil stratigraphy. The detailed results of that study are not available at this time.

FINDINGS

SITE DESCRIPTION

The site consists of roughly 80 acres of land southwest of the intersection of Old Sonoma Road and Casswall Street. The site is generally bound by Old Sonoma Road on the north, the rear of lots along Casswall Street to the east and vineyard land to the south and west, and residential properties to the northwest. The site is undeveloped ranchland except for the single-family residence and barn facilities located in the northern portion of the site. Portions of the site were previously graded to create farm road cuts and to create broad plateaus. The grading resulted in changes to the landform by cutting into hills and placing fill in swales. Dirt roads provide access to the majority of the site.

Site topography is dominated by a north trending ridgeline with rounded knobs and small intervening valleys. The highest knob along the ridge is located in the south central portion of the site and reaches an elevation of about 340 Feet Mean Sea Level (MSL). The topographically lowest portion of the site is the swale along the southern property boundary which is at about elevation 195 MSL. A narrow valley trends north along the west side of the prominent ridge. West of the narrow valley the ground surface is more subdued.

GEOLOGIC CONDITIONS

The site is located in the Coast Ranges geomorphic province of California. The Coast Ranges are characterized by a series of northwest trending folded and faulted mountain chains and valleys. Folding and faulting of the region is generally the result of relative motions between the Pacific and North American tectonic plates. The majority of deformation is believed to have occurred during the past few million years.

In this portion of the province, the site is located along a northwest trending ridge. Regional geologic maps covering the site by the CGS (Clahan *et al*, 2004) and the USGS (Fox *et al*, 1973; Helley and Herd, 1977) show the eastern two-thirds of the site to be underlain by bedrock belonging to the Sonoma Volcanics and the western third of the site to be underlain by the Domengine Sandstone. The Sonoma Volcanics are a series of flow rocks and ash deposits that erupted from a broad volcanic field between 2.5 and 8 million years ago. The flow rocks generally consist of dark blue-gray to dark gray basalt, andesite, and dacite. These rocks are very strong and form the prominent knobs along the ridgeline. The tuff (ash) is generally yellow-white to orange, light in weight and moderately strong to strong. The Domengine Sandstone consists of thick beds of moderately strong to strong sandstone, siltstone and

claystone that were deposited during the Eocene epoch of geologic time, roughly 33.9 to 56 million years before present. A portion of the 2004 Clahan map is provided on Plate 3.

The contact between the two geologic units mentioned above is shown as a fault contact on both regional maps. However, Engeo (1989) found no evidence of faulting in their trench across the contact (T-1). The contact exposed in the trench was interpreted to be an erosional unconformity, meaning the younger Sonoma Volcanics were deposited upon an eroded surface that exposed the much older Domengine Sandstone. The regional maps also show a fault lineament trending through the site through the ridge and another fault along the base of the hills to the east.

REGIONAL FAULTING AND SEISMICITY

The State of California considers a fault active if it has demonstrated activity within Holocene time, roughly the past 11,700 years. The site is in an area considered to have relatively high seismicity due to the proximity of several active faults in the region. The nearest faults considered active include, but are not limited to, a splay of the West Napa fault as defined through the site in this project, additional splays of the West Napa fault zone located about 1¼ miles west of the site and ½-mile east of the site, the Green Valley fault located about 7 miles northeast of the site, the Cordelia fault located about 10 miles to the southeast, the Rodgers Creek fault located about 1 miles to the southwest, the northern end of the Hayward fault located about 17½ miles to the southwest and the San Andreas fault located about 31 miles to the southwest.

WEST NAPA FAULT ZONE

The West Napa fault is a roughly 56-kilometer long, right-lateral strike-slip fault that extends from the Carquinez straits at the south end to the just west of Town of St Helena to the north. In general, the West Napa fault is believed to form the western margin of a deep Tertiary to Quaternary aged basin created by offset along the West Napa fault (Wesling and Hanson, 2008). Displacement along the fault zone is right-lateral strike slip with a significant down to the east vertical component. The surface expression of the fault includes offset drainage courses, east-facing scarps, linear drainages and apparent geomorphic lineaments such as saddles and linear breaks in slope. The rate of movement along the main trace of the West Napa fault is believed to be between about 1 to 4 millimeters per year. The slip rate along secondary branch fault splays is considered much less.

As previously mentioned, an active fault is defined as a fault that has demonstrated activity within the Holocene epoch of geologic time, within the past roughly 11,700 years. Similarly, potentially active faults are those that have demonstrated activity with the Pleistocene epoch of geologic time, roughly 11,700 to 1.6 million years before present. The Alquist-Priolo Earthquake Fault Zoning Act (A-P Act) indicates that faults are to be zoned for special studies where the fault is “sufficiently active” and “sufficiently well-defined” and that buildings intended for human occupancy should be set back from active fault traces.

The State of California seismic hazards zonation program compiles fault information and evaluates fault activity for zonation in accordance with the A-P Act based on Fault Evaluation Reports. The West Napa fault was evaluated by the State of California in 1982 and the results were published as Fault Evaluation Report 129 (FER-129). According to FER-129, the West Napa fault was classified active and sufficiently well-defined in the southern reaches between the Napa Airport and the Carquinez Straits and is zoned in accordance with the A-P Act. North of the Napa Airport, the fault was previously not well-defined and Holocene activity was not sufficiently well-defined. The main trace of the West Napa fault was believed to run along the base of the hills on the west side of the Napa Valley and smaller secondary fault splays are interpreted further to the west in the hills and along the west side of Congress Valley.

Near the Napa Oaks site, 4 fault possible splays of the West Napa Fault Zone are discussed in FER-129 that cross near the site. They are discussed as Branch Faults B, C, D and the Saddle Lineament. Branch fault A is located west of the site near Congress Valley and may correlate with the seismogenic rupture trace from August 24, 2014 South Napa earthquake. Branch fault B crosses through the site along the west flank of the main ridge. FER-129 notes that Branch fault B does not systematically offset drainages nor show evidence for recent fault activity. The location of Branch fault B generally corresponds with the location of the fault zone defined in the 1994 Phoenix report.

Branch fault C trends along the base of the hills near the eastern site boundary. The fault investigation by Phoenix in 1998 did not encounter evidence of a fault at that location. If there is a branch fault along the base of the hills it is located outside the project boundary east of the site. The saddle lineament and Branch fault D cross between rounded knobs along the main ridge. While the branch fault and lineament have differing trends, they pass through the same saddle that was trenched (Trench T-3) by Phoenix in 1994. No evidence of faulting was encountered in the Phoenix trench.

AERIAL PHOTOGRAPH INTERPRETATION

We reviewed 10 sets of stereo-paired aerial photographs covering the site vicinity from the years 2005, 1997, 1992, 1989, 1984, 1979, 1970, 1968, 1963 and 1956. Aerial photographs were obtained from the archive library at the Geospatial (formerly Pacific Aerial) office in Oakland, California. These photographs were analyzed by our engineering geologist with emphasis on fault-related lineaments and features. Of the aerial photographs viewed, we found the 1956 and 1984 sets to provide the best viewing of site conditions. In general, the photographs indicate a crude northwest trending orientation of bedrock structure, soil slip scars and run out paths on the east-facing slope along the eastern site boundary, and numerous episodes of ranchland grading.

With respect to fault morphology, such features are somewhat denuded by differential erosion at the site. Prior to our trenching program, there are no real clear indications of fault alignment other than lining up saddles and ridges as noted in FER-129. After the August 24, 2014 event and with the findings from our trenches, we conclude that there is a subtle lineament that can be drawn between the saddles and the recent surface rupture in Trench T-6. The northwest deflection of the fault around the high knob is not visible in the aerial photographs and would not have been identified without the aid of the recent surface rupture and our trenches. Based on the amount of erosion and prior grading, fault-related geomorphic features are subtle and obscured

but with the aid of our trench exposures, the low rolling ground in the western third of the site, west of the fault zone defined herein, appears to form a shutter ridge.

TRENCH DESCRIPTIONS

We excavated and logged 12 exploratory trenches to define the limits of active and potentially active faulting at the site. Trench locations are shown on Plate 4. General descriptions and interpretations of the findings from the trenches are provided below, for detailed descriptions; refer to the trench logs on Plates 5 through 11.

Trench T-1

Trench T-1 was excavated in the northern portion of the site, just south of the corral area. The trench totaled about 206 lineal feet and was positioned to cross the surface rupture from the August 24, 2014 earthquake. The surface rupture resulted in about 4 inches of up to the west vertical offset just south of the trench and about 2 to 3 inches at the trench (somewhat disturbed by excavation). The August 24, 2014 surface rupture was encountered at Station 1+02 where we observed an open fissure extending to the bottom of the trench. We did not observe gouge or shearing at that location due to the granular nature of the materials near the surface. The recent surface fault rupture is located on a fault that has truncated Holocene soils at least 2½ feet (refer to Plate 5) from previous fault rupture events. The soil on the uphill side of the fault is about 2½ feet thick and is clearly Holocene in age. The bedrock type on the east and west sides of the fault are different on each side of the fissure.

The eastern limit of previous fault deformation was located at Station 0+65 where we encountered a roughly 15 feet wide soil-filled graben. At station 1+10 bedrock has been thrust over colluvial soil (from past earthquake events) and may define the western limit of active faulting. Downslope of the fault zone, we encountered a very dense layer of colluvium (unit V on Plate 5) with Pleistocene soil development. Additionally, unit W (on Plate 5) appears to be a Pleistocene aged alluvial deposit. The fault zone is concentrated between Stations 0+65 and 1+10. There are no fault features in the Pleistocene soils to the west; we encountered competent bedrock west of Station 1+50 where the trench exposed Sonoma Volcanics bedrock below the Pleistocene deposits. The slope that the trench crossed is a fault scarp with significant up to the east Pleistocene into Holocene movement.

Trench T-2

Trench 2 was located about 300 feet south of Trench T-1 and was also positioned to cross the surface rupture from the August 24, 2014 earthquake and the southern end of the scarp encountered in T-1. We encountered the recent surface rupture at Station 0+70 where it deformed a ground rodent burrow complex causing compression and buckling. The surface cracks were fissures up to 2 inches wide at the ground surface; however, we could not trace them into the granular infill deposits. Although the fissures did not extend down into granular soils at depth, they were continuous for another 75 feet to the south and 50 feet to the north of Trench T-1 and are judged to be surface rupture from the August 24, 2014 earthquake.

The eastern limit of faulting was encountered at Station 0+63 where a 1 to 2-foot wide shear zone consisting of foliated layers of rock fragments and soil infill has developed at the contact between Sonoma Volcanics bedrock to the east and the granular infill deposits to the west. Between stations 0+63 and 1+68, the upper 10 plus feet of material consists of cobbles and boulders in a granular matrix, the majority of which are Pleistocene in age. The western limit of faulting is interpreted to be at Station 1+68 where we encountered a sharp, steeply dipping contact between the granular infill deposits to the east and Sonoma Volcanics bedrock to the west. A small colluvial wedge at that location may be a very early Holocene soil.

Trench T-3

Trench T-3 was about 80 feet long and located in the center of the site and also crossed the recent surface rupture. The trench exposed 3 faults within 26-foot wide zone of sheared highly weathered rock bound by shears at stations 0+18 and 0+44. The fault at Station 0+18 consisted of a 9 to 18-inch wide zone of foliated soil infill and rock slabs. The fault encountered at Station 0+18 is a straight line projection from surface rupture observed about 30 feet south of the trench and about 10 feet upslope of the eastern end of Trench T-4, therefore 0+18 is also an active fault. The trench crossed the recent surface rupture at Station 0+28 where a 1½-inch wide fissure extended down to a faintly sheared clay-rich zone that is about 6 inches wide. The western limit of faulting in this trench, at Station 0+44, consists of a sharp contact between the weathered disrupted materials in the fault zone and competent bedrock to the west. At the contact we observed an about ½ to ¾ inch thick layer of foliated clay gouge with a slickensided (polished from shearing) surface. The east and west ends of the trench were limited by the tree canopy and branches.

Trench T-4

Trench T-4 was located about 75 feet south of T-3 to extend coverage to the west. Trench T-4 extended east up to the tree line where 2 surface cracks with up to 1½ inches dilation and an inch of vertical, west side up, motions from the recent earthquake were present. We were able to reach the lower of the two cracks at Station 0+10 where the surface crack extends down to a narrow crushed zone in the bedrock. This is judged the continuation of fault rupture encountered in Trench T-3 at Station 0+28.

A 2-foot wide gravel and soil infill zone was observed in the bedrock at Station 0+90, that we interpreted as a possible fault since the rock quality drastically decreased to the west. Another fault was encountered at Station 1+45. At that location, the zone of faulting consists of a 2-inch thick layer of black clay gouge within a broader 18 to 24-inch wide zone of sandy rubble. The western limit of the fault zone is located at Station 1+90 where it appears that the rock broke away and a small colluvial wedge formed. The conglomerate layer (Unit Q on Plate 8) is composed of volcanic rocks in a volcanic origin sand matrix. Strong cementation of the matrix suggests this is an older alluvial deposit formed during or shortly after deposition of the Sonoma Volcanics.

Trench T-5

Trench T-5 is located near the southern edge of the high knob along the ridgeline. The trench was about 230 feet long and trended down the flank of the hillside to the west. The trench crossed the location of discontinuous cracks east of the main surface rupture as well as the main active fault where the fault trends up the hillside just before it bends to the northwest around the high knob.

Trench T-5 crossed a short segment of ground cracks at Station 0+17. At that location the cracks were dilated about ½-inch with no lateral or vertical movement observed. A thin fissure extended to the bottom of the trench through a 1 to 2-feet wide zone of crushed rock. It was noted that the crushed zone was much less defined on the north wall of the trench. Additionally, the surface cracks were not continuous for significant distances and end about 30 feet north of the trench.

The surface rupture from the August 24, 2014 earthquake crosses the trench obliquely through a roughly 18 feet wide zone of crushed disrupted bedrock. The crushed zone has soil and gravel infills as well as brecciated rock fragments between about Stations 0+46 to 0+64. The recent surface rupture crossed through the trench at Station 0+64 on the south wall and 0+56 on the north wall. We logged the south wall and noted where the cracks cross the north wall. Where the surface rupture crosses the trench, we observed 1 to 2 inches dilation with small (less than 2 inches) right-lateral offsets. The remainder of the trench exposed continuous un-faulted Sonoma Volcanics bedrock.

Trench T-6

Trench T-6 is located in the swale along the southern property line and encountered 2 discrete fault zones. Both fault zones were studied in the field by the CGS, USGS and our geologist.

The trench was about 450 feet long and crossed the surface rupture from the August 24, 2014 earthquake at Station 0+90. At that location we encountered a broad fault zone that disrupted several soil horizons. The trench exposure indicates a Holocene active fault with at least 3 possibly 4 rupture events documented in the stratigraphy. The zone of potential surface deformation is about 20 feet wide between Stations 0+80 to 0+97. The main fault is a 12-inch wide shear zone that trends N5E at the bottom of the trench. Above the main shear, the fault bifurcates into several smaller splays that extend to different soil horizons in the trench. The shear zone suggests 3 to 4 interpreted rupture events based on progressively offset soil horizons across the fault zone as shown on Plate 10. The features in the trench suggest the following rupture history:

- The oldest event documented in the trench appears to be significant rupture event that created a trough in which the colluvial wedge (Unit G on Plate 10) was deposited.
- The wedge was then offset twice with shears extending to the base of Unit F. The second offset of the wedge appears to breach to the base of Unit B.
- The recent August 24, 2014 surface rupture occurred on the splay that appeared to stop at the base of Unit F in prior events.

The trench exposed possible older fault zones at Stations 1+90 and 2+30. The feature at 1+90 is a crushed zone in the bedrock with some fracture infill. There appears to be some minor soil thickening across the feature; however the feature does not project well across the trench and is judged a crushed zone in the bedrock. At Station 2+30 we encountered a 2 feet wide shear zone between the contact of tuff to the east and claystone to the west. The shear zone included weathered clasts of the tuff and has slickensided surfaces along the top of the claystone unit and appears to be subparallel to bedding planes noted on the logs through this section of the trench. The claystone and similar siltstone units extend to Station 2+80 where we observed stringers of Sonoma Volcanics in the sedimentary rocks. The claystone and siltstone are not part of the much older Domengine Sandstone and are either late Sonoma Volcanics or a younger sedimentary bedrock layer. Neither possible fault zones appear to be a Holocene active feature nor do they appear capable of seismogenic fault rupture. They are both located between the 2 main faults discussed herein and are within the fault zone shown on Plate 4.

At the west end of the trench, we crossed through the fault zone previously defined by Phoenix in 1994. We encountered a broad alluvial channel deposit between Stations 3+10 to about 3+90. The western end of the channel is obscured by a landslide deposit. The channel morphology is fault controlled, i.e. the channel was formed in response to fault movement and/or erosion of the weak materials along the fault. At the bottom of the trench we encountered 4 faults as shown on Plate 10. All 4 features include 2 to 3 inches of sheared clay gouge and slickensided surfaces; however nearly all stratigraphic units above the shears are continuous and do not appear to be offset. We were able to trace thin shears that are generally less than ¼ inch wide mineralized fissures extending up through several layers but the layers are not offset. The fissures appear to rotate some pebbles. Based on our interpretations, the channel deposits indicate the following general timeline:

- Pleistocene aged faulting in the lowest units creating a channel and well-defined shears.
- Deposition in the channel occurred. The pedocronological report by Dr. Borchardt (Appendix A) suggests the lowest channel deposit has an estimated age of about 22,000 years before present.
- Deposition in the channel of Units V and F.
- A landslide occurred on the west side of the channel which was subsequently reworked as the toe of the landslide was eroded.
- Deposition of a thick channel deposit, Unit U.
- Following deposition of Unit U, it appear 2 small channels were downcut into the older channel and were quickly filled with coarse pebble deposits.
- Additional deposition followed by 2 feet of pond sediments. The soils directly below the pond sediments are estimated to be 10,000-year old Holocene soils according to Dr. Borchardt. The faint shears noted above and on the log do not penetrate into the younger Holocene soils.

Trench T-7

Trench T-7 was located along the north side of the barn in the northern portion of the site. The trench was about 120 feet long and positioned to cross the zone of cracks in the A.C. pavement. The fault zone was encountered between Stations 0+22 and 0+84. The eastern limit of faulting is a sharp contact between Sonoma Volcanics to the east and colluvial infill to the west. The main zone of faulting appears to have occurred along the shear at Station 0+53 based on the location of pavement cracks. At that location we observed a 2-feet wide deformed zone near a sharp down to the east drop in the bedrock surface. The western end of the fault zone is located at Station 0+83 where we encountered a crushed zone adjacent to ½-inch thick layer of black clay gouge trending N10E. We encountered sandstone and siltstone of the Domengine Sandstone west of the fault zone.

Trench T-8

Trench T-8 was located along the west side of the valley about 200 feet south of T-4 and between the Trench T-5 swarm excavated by Phoenix in 1994. The trench exposed shears defining a fault zone between Stations 0+08 and 0+52. The shears at 0+08 show offset to claystone beds that appear to be part of the Domengine formation but prior grading has removed all soil from above the shears. The main shear on the trench was located at Station 0+40 where we encountered a 6- to 9-inch thick layer of sheared clay trending N10E through the trench. At this location the Domengine sedimentary rocks to the east are juxtaposed against the Sonoma Volcanics to the west. At the west end of the interpreted fault zone, we encountered a 12-inch wide zone of crushed rock with a 1½-inch wide zone of foliation along the western margin. This fault is located entirely within the Sonoma Volcanics and shows minor shear foliation.

Trenches T-9 through T-12

Trenches T-9 through T-12 are located on the flank of the main ridge in the southern portion of the site. Trench T-9 was positioned to cross the segment of the fault that is trending northwest down the hillside as the fault bends around the main knob along the ridge. The trench indicates that up to the west motions truncating Holocene soils at the ground surface have occurred at this location prior to the recent event. The fault at this location showed up to 2 inches of up to the southwest thrust fault motion.

Trenches T-10 and T-11 were positioned across discontinuous cracks at the top of the hill. The trenches indicate that the crushed deformed zones observed along the main rupture to the south are dying out to the north where the deformation zone is much less significant. In fact T-11 did not encounter a deformation zone at the projection of surface cracks from T-5 Station 0+18.

Trench T-12 was excavated across a ground crack that appeared after ***dk*** Consulting surveyed the surface ruptures at the site. At that location, the crack formed over a fissure fill that is estimated by Dr. Borchardt to be 120,000 years old. The surface cracks were not continuous for more than 50 feet in either direction from the trench.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

The results of this project indicate the presence of Holocene active faulting crossing through the Napa Oaks site. The fault zone generally correlates with a splay of the West Napa fault discussed as "Branch fault B" in Fault Evaluation Report FER-129, with some modification to the actual fault alignment. At the site, we generally encountered 2 main fault zones in the southern portion of the site that merge near the northern portions of the site, somewhere between T-1 and 2. The faults generally form the east and west boundaries of the Fault Zone shown on the Fault Setback Map. The slip rate of faults in the area is low, estimated to be on the order of about 1mm per year according to the USGS. Erosion of the site has occurred at a much faster rate than the rate of tectonic slip which has generally eroded features, thus masking signs of previous fault movement. The high rate of erosion compared to the low slip rate has obscured surface manifestations of fault-related features at the site.

Based on our observations and interpretation of fault-related features exposed in the trenches, the Holocene active portions of the fault are concentrated along the eastern margin of a broader zone of Pleistocene faulting. The combined fault zone is shown on Plate 4. Holocene activity along the fault shows strong evidence for repeatability in close proximity to the surface rupture observed after the August 24, 2014 M6.0 South Napa earthquake. Therefore, future movement of the fault should be expected to occur along the eastern margin of the fault zone defined herein with a similar rupture pattern as observed in this study. Trench exposures also suggest a broad zone of older, most likely Pleistocene to possibly very early Holocene aged deformation. For the purpose of this project, we combined the Holocene and Pleistocene fault zones into one large zone as shown on Plate 4.

The locations of earthquake epicenters from the August 24 main event and dozens of aftershocks were plotted by the CGS. The plots suggest the main rupture segment that produced the seismogenic rupture (the trace where energy was released) were located on a west-dipping fault splay located at least 1¼ miles west of the Napa Oaks site. There were no epicenters plotted along the fault splay that ruptured through the Napa Oaks site; therefore, the fault crossing through the Napa Oaks site experienced triggered slip in response to the main rupture segment to the west. The approximate location of the epicenter for the main rupture relative to the Napa Oaks site is shown on Plate 2 for reference; all epicenters are plotted along the same fault trace but are not shown for clarity.

Based on the results of this and previous fault investigations at the site, all faults mapped through the site by the CGS and USGS have been evaluated. We defined the faulting in the Branch fault B area. The western portion of the site was evaluated by Phoenix in 1998 based on the possible location of Branch fault C at the site. No indications of active faulting were encountered in their trenches; therefore, any fault in that location would be located to the east under the alluvium and does not cross the Napa Oaks site. Branch fault D does not exist at the site based on the 1994 Phoenix investigation where Trench T-2 crossed the saddle and found continuous bedrock. Our study generally addresses the suspected branch fault B location and definition of the fault zone is provided herein.

ACTIVE FAULT ZONE

The easternmost fault trace encountered in the trenches is the primary fault trace at the Napa Oaks site (this trace is not the main trace of the West Napa fault zone). The fault shows strong evidence of repeated Holocene activity. The active fault trends roughly N10 to 20E into the site from the south, trends north up towards the high knob along the ridge, bends to the northwest downslope into the valley margin where it has a more continuous northwest trend to the north end of the site. The variable trend of the fault through the site reflects a dipping fault bending around the hard bedrock underlying the high knob at the ridgeline. The location of this active fault trace is shown on Plate 4 noted along the east margin of the fault zone.

The best trench exposures of the active fault are in Trenches T-1 and T-6 where Holocene soils were systematically offset multiple times. Where soil development was sufficient to evaluate fault offset in the trenches (Trenches T-1 and T-6), we observed repeated Holocene rupture focused at the same location on discrete fault zones. At the east end of Trench T-6, the fault shows evidence for at least 3 rupture events. At the north end of the site in Trench T-1, the fault truncates Holocene soils by at least 2½ feet with differing rock types on either side of the fault (refer to Trench Log T-1).

POTENTIALLY ACTIVE FAULT ZONE

A potentially active fault is a fault that has not moved during the Holocene but shows evidence for Pleistocene activity, older than 11,700 but younger than 1.6 million years before present. At the site, the broader fault zone extending west of the active fault has Pleistocene soil development on the infill deposits suggesting the deformation occurred in the Pleistocene. Holocene soils overlying the Pleistocene deposits were continuous and not offset except for the small colluvial wedge at the west end of the fault zone in Trench T-2 and T-4. Multiple soil horizons exposed in Trench T-6 were deposited between 10,000 and 22, 000 years before present in a trough created by older faulting. The soil horizons in these trenches have not been systematically offset or truncated during the Holocene. The older fault zone appears to merge with the active fault zone between Trenches T-1 and T-2.

ZONE OF DISCONTINUOUS SURFACE CRACKS

High on the ridge and east of the main rupture trace, we encountered zone of surface cracks that are discontinuous and appear to be secondary features formed by the fault bending around the knob and strong ground motions alongside of the ridge. The zone of discontinuous cracks is shown on the Fault Setback Map.

RECOMMENDED BUILDING SETBACKS

The determination of setbacks for buildings intended for human occupancy is based on evidence for the repeatability of surface fault rupture and associated ground deformation from any given earthquake event. Therefore, it is important to not only define the location of the fault, but also to evaluate the area of potential surface deformation as well as the limits of competent ground where surface deformation is not expected. At the Napa Oaks site, we have clearly defined a zone of active Holocene faulting as well as a zone of older potentially active faulting. Buildings for human occupancy are required to be set back from active faults. Despite the evidence suggesting the westernmost fault at the site is no longer active and Holocene slip is concentrated on the active fault at the east end of the zone, we recommend a more conservative approach providing building setbacks from the active and potential active fault zone for the following reasons:

1. The possibly inactive fault is subparallel to the active fault and in our opinion the current tectonic stress regime still applies to the rupture potential.
2. T-2 and possibly T-4 subtly suggests Holocene activity based on the colluvial soils draped across escarpments.
3. Soil development along the west side of the fault zone is insufficient to adequately characterize activity.

Based on the results of this project, we recommend excluding residential construction within the fault zone shown on the Fault Setback Map and providing a 25-foot (minimum) setback from the fault zone for buildings intended for human occupancy. The 25-foot setback sites the buildings on competent bedrock outside both the active and older potentially active fault zones.

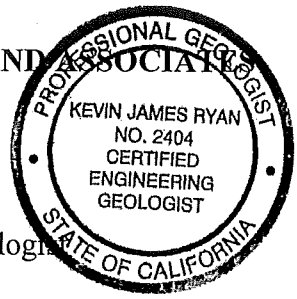
The fault zone which combines the active and potentially active fault zones as well as the associated 25-foot setbacks are shown on the Fault Setback Map. The limits of the fault zone on the Fault Setback Map are based on the fault locations noted on the trench logs. However, in Trench T-1 we used the presence of unfaulted Sonoma Volcanics bedrock at Station 1+50 to represent the western limit of potential faulting. Similarly, in Trench T-6, we placed the western limit of potential faulting at Station 4+00 due to the possibility that the landslide noted on the logs may have buried and hidden another fault splay. In our opinion, setbacks from the zone of discontinuous cracks are not needed provided the buildings are not located directly on top of the cracks and the building foundations are designed to accommodate minor surface deformation during strong ground motions.

LIMITATIONS

The results of this report are based upon the information provided to us regarding site improvements, the results of previous site studies, the findings of our field investigation and professional judgment. This project has been conducted in accordance with currently accepted engineering geologic and geotechnical engineering standards only; no other warranty is expressed or implied. The site conditions and locations of features discussed in the text of the report are those that existed at the time of our field visits in September through November 2014 and are not necessarily representative of other features, locations or times. If the subsurface conditions encountered during construction activities vary from those interpreted in this report, our firm should be contacted to review the conditions for any changes in our recommendations. The review would be acknowledged in writing.

Respectfully submitted,

BERLOGAR STEVENS AND ASSOCIATES





Kevin James Ryan
Consulting Engineering Geologist
CEG 2404

Frank Berlogar
RCE 20383

KJR/FB:jmo

Attachments:

References
Plate 1 – Vicinity Map
Plate 2 – Quaternary Fault Map - Fault No. 36a
Plate 3 – Regional Geologic Map
Plate 4 – Fault Setback Map
Plates 5 through 11 – Trench Logs
Appendix – Pedochronological Report by Soil Tectonics

Copies: Addressee (6)

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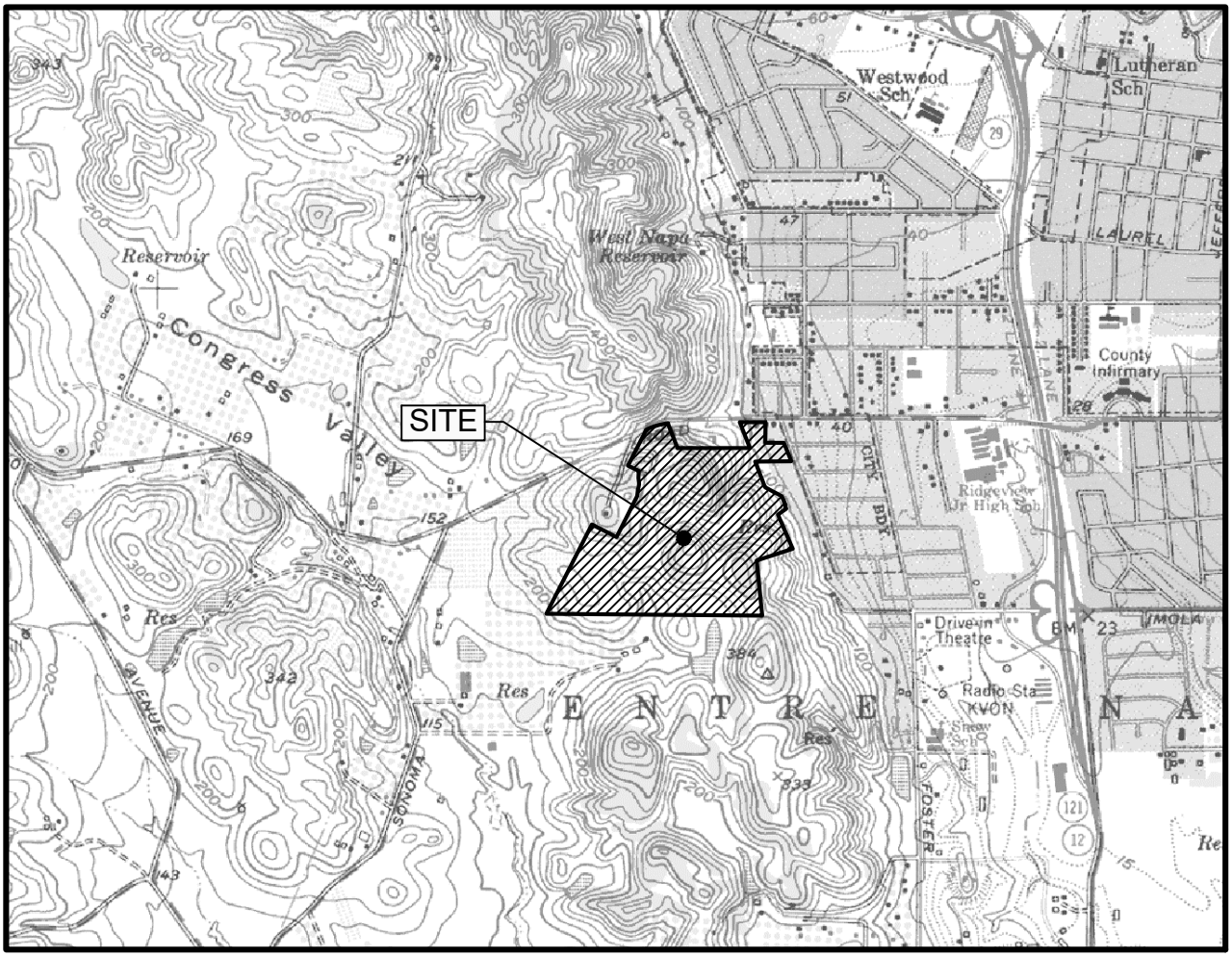
TRC, May 29, 2008, Fault Investigation, 3075 Laurel Street, Napa, California.

Phoenix Geotechnical, January 20, 2009, Geotechnical report, Riordan Subdivision, Napa, California.

AERIAL PHOTOGRAPHS

FILM ID	FLIGHT LINE	FRAMES	NOMINAL SCALE	DATE FLOWN
KAV 8930	13	20,21	1:15,000	2/03/2005
NAP AV 5461	4	15,16	1:12,000	7/29/1997
CIR AV 4314	5	9,10	1:12,000	8/21/1992
AV 3601	1	6,7	1:36,000	7/18/1989
AV 2475	3	10,11	1:12,000	5/17/1984
AV 1700	8	8	1:54,000	5/11/1979
AV 844	12	10,11	1:30,000	4/10/1968
AV 550	7	5,6	1:36,000	7/25/1963
AV 231	01	4,5,6	1:20,500	8/22/1956

JOB NUMBER: 3280.002 DATE: 12-2-14 BY: CC



VICINITY MAP

NAPA OAKS

OLD SONOMA ROAD AND CASSWALL STREET

NAPA, CALIFORNIA

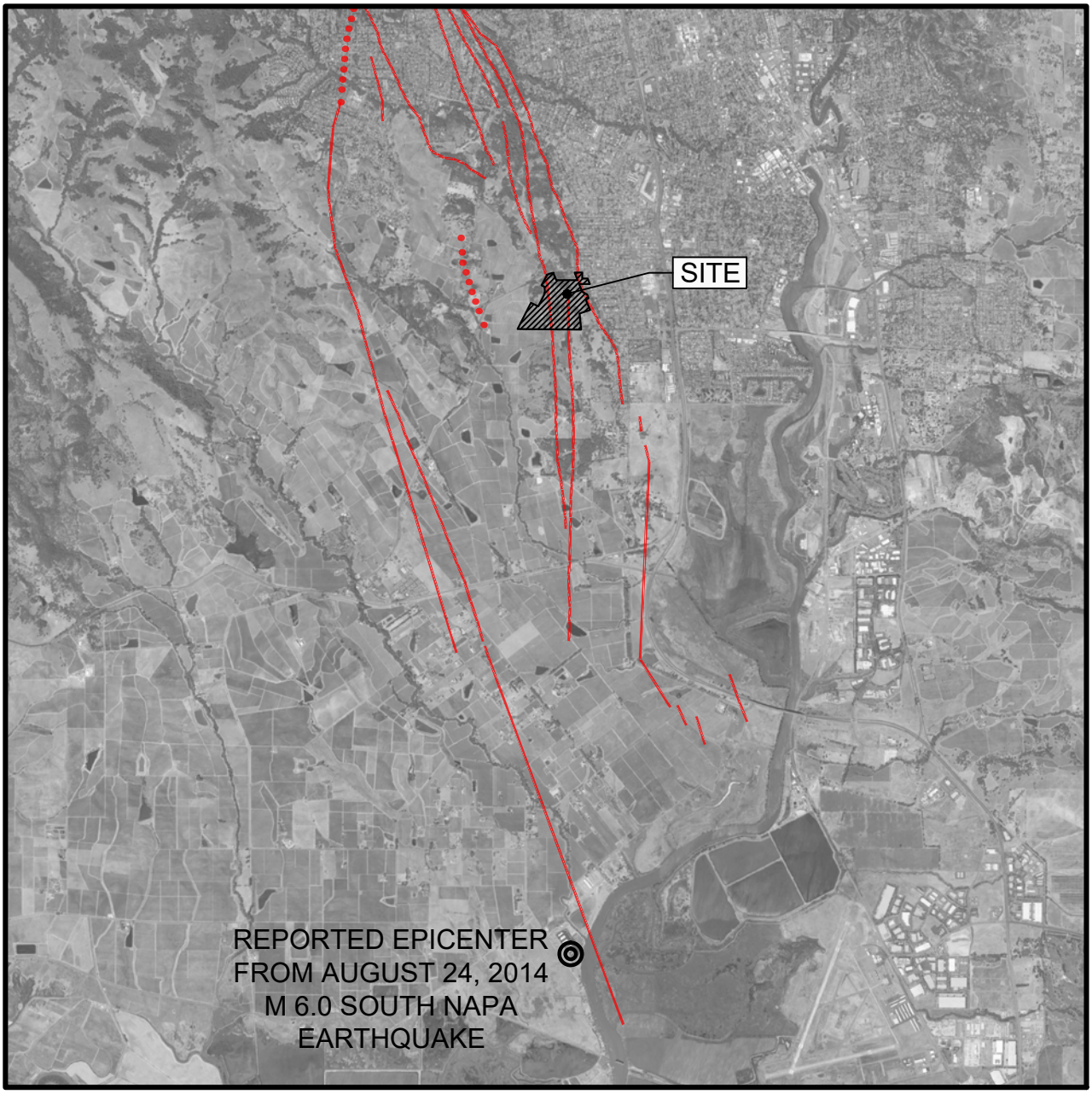
FOR

DAVIDON HOMES

BASE: PORTION OF U.S.G.S. 7.5 MINUTE TOPOGRAPHIC QUADRANGLE, NAPA, CALIFORNIA, AT A SCALE OF 1:24,000.

PLATE 1

JOB NUMBER: 3280.002 DATE: 12-2-14 BY: CC



0 6000

1"=6000'

EXPLANATION

QUATERNARY FAULT TRACES IN THE DATABASE FOR FAULT NO. 36A

QUATERNARY FAULT MAP

FAULT NUMBER 36A

WEST NAPA FAULT, BROWNS VALLEY SECTION

NAPA OAKS

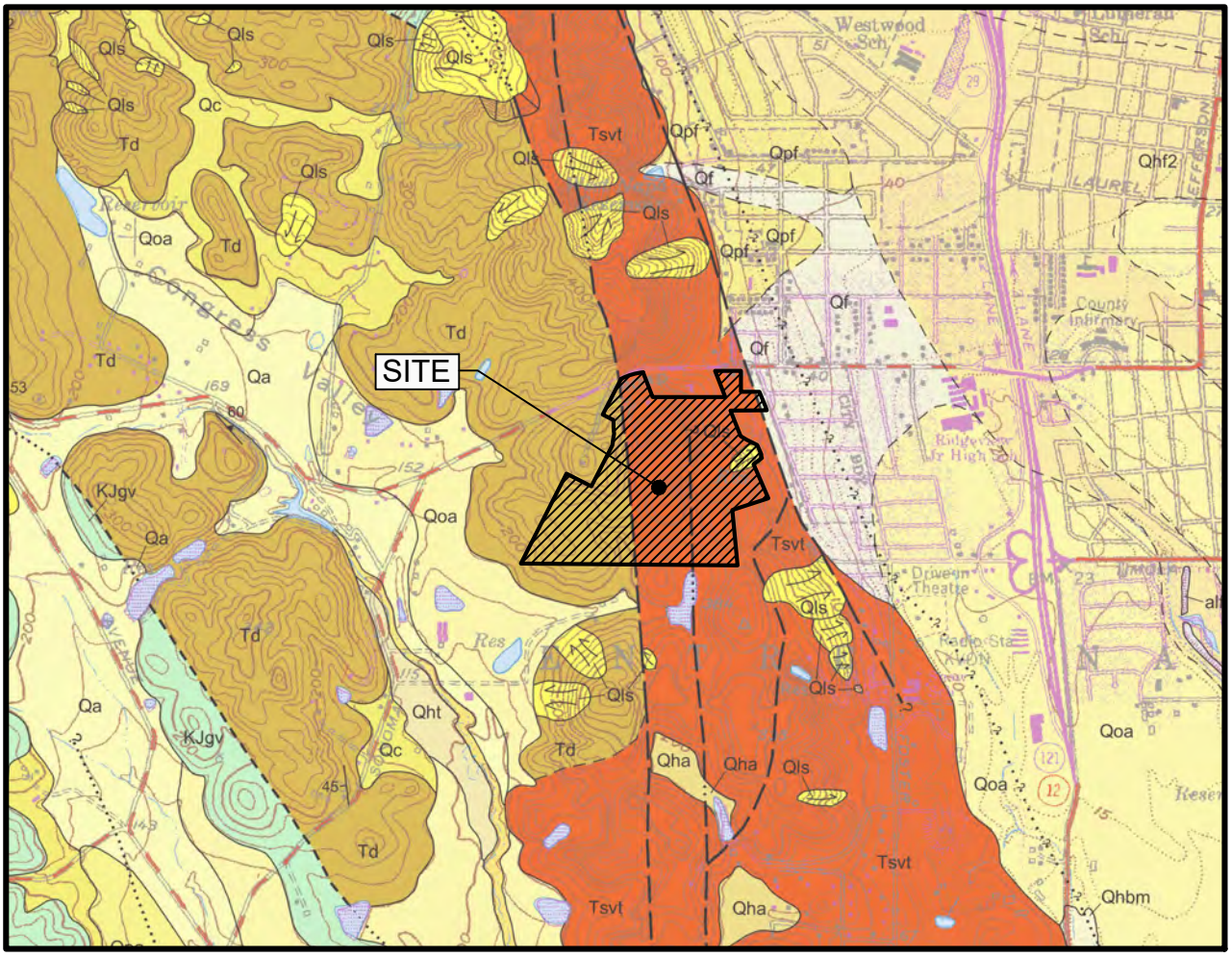
OLD SONOMA ROAD AND CASSWALL STREET

NAPA, CALIFORNIA

BASE: BRYANT, W.A., COMPILER, 2000, FAULT NUMBER 36A, WEST NAPA FAULT, BROWNS VALLEY SECTION, IN QUATERNARY FAULT AND FOLD DATABASE OF THE UNITED STATES: U.S. GEOLOGICAL SURVEY WEBSITE, HTTP://EARTHQUAKES.USGS.GOV/HAZARDS/QFAULTS

PLATE 2

JOB NUMBER: 3280.002 DATE: 12-10-14 BY: CC



EXPLANATION

CONTACT BETWEEN MAP UNITS - SOLID WHERE ACCURATELY LOCATED, DASHED WHERE APPROXIMATELY LOCATED, DOTTED WHERE CONCEALED, QUERIED WHERE UNCERTAIN

FAULT - SOLID WHERE ACCURATELY LOCATED, DASHED WHERE APPROXIMATELY LOCATED, DOTTED WHERE CONCEALED, QUERIED WHERE UNCERTAIN

Qf — ALLUVIAL FAN DEPOSITS
SAND, GRAVEL, SILT AND CLAY MAPPED ON GENTLY GENTLY SLOPING, FAN-SHAPED, RELATIVELY UNDISSECTED ALLUVIAL SURFACES

Qa — ALLUVIUM UNDIVIDED
FLAT, RELATIVELY UNDISSECTED FAN, TERRACE, AND BASIN DEPOSITS

Qpf — ALLUVIAL FAN DEPOSITS
COMPOSED OF POORLY TO MODERATELY SORTED SAND, SILT, CLAY AND GRAVEL

Qoa — ALLUVIUM
COMPOSED OF CONSOLIDATED SAND, SILT, CLAY AND GRAVEL
TOPOGRAPHY IS MODERATELY ROLLING WITH LITTLE OR NO ORIGINAL ALLUVIAL SURFACES PRESERVED, DEEPLY DISSECTED

Qls — LANDSLIDE DEPOSITS
INCLUDES DEBRIS FLOWS AND BLOCK SLIDES

Tsvt — LIGHT COLORED TUFF, LITHIC RICH PLACES. LOCALLY INCLUDES TUFFACEOUS, DIATOMACEOUS LACUSTRINE SEDIMENTS

Td — DOMENGINE SANDSTONE
BROWN QUARTZO-FELSPATHIC SANDSTONE WITH MINOR THIN CLAYSTONE INTERBEDS

AREA GEOLOGIC MAP

NAPA OAKS

OLD SONOMA ROAD AND CASSWALL STREET

NAPA, CALIFORNIA

FOR

DAVIDON HOMES

0 2000'

1"=2000'

BASE: PORTION OF GEOLOGIC MAP OF THE NAPA 7.5 MINUTE QUADRANGLE, NAPA COUNTY, CALIFORNIA, AT A SCALE OF 1:24,000.

PLATE 3

DATE: 12-9-14
DRAWN BY: CC
JOB NUMBER: 3280.002

OLD SONOMA ROAD
CASSWALL STREET
RIEDEL SHEARS IN FILL
CONCENTRATED CRACKS IN PAVEMENT
DISCONTINOUS CRACKS
TRENCH 1
TRENCH 2
TRENCH 3
TRENCH 4
TRENCH 5
TRENCH 6
TRENCH 7
TRENCH 8
TRENCH 9
TRENCH 10
TRENCH 11
TRENCH 12
FAULT ZONE
MARTIN APN 043-040-009
DEGOEDE APN 043-040-024
LYON APN 043-040-007
LYON APN 043-040-006
ANTHONY M. & JO ANN M. TRUCHARD APN 043-040-004
ANTHONY M. & JO ANN M. TRUCHARD PARCEL B
PARCEL 2 12 PS 10
APN 043-040-022
APN 043-040-023 PEDRELLI
LINDSTROM 04-400-002
SCRIVEN 04-400-003
04-400-008 RUARK
04-400-004 MORRIS
FISCHER APN 04-400-005
PARCEL A 9 PM 64
PARCEL A 18 PM 99
DEVITA APN 043-050-008
34 RS 18
ACCESS & UTILITY EASEMENT 1759 OR 921

N89°59'39"W 518.03'
N89°59'39"W 263.13'
N89°49'57"E 391.39'
N21°37'14"W 19.50'
N21°37'14"W 82.63'
N63°02'21"W 129.61'
N01°16'32"E 77.00'
N05°36'53"W 50.18'
N05°36'53"W 20.36'
N12°28'16"E 49.03'
N06°59'49"E 78.41'
N26°57'33"E 399.28'
N63°02'21"W 1300.00'
N26°57'33"E 1085.10'
N89°29'25"W 2335.32'
N59°49'21"W 76.00'
N62°57'21"W 128.25'
N23°12'21"W 108.00'
N09°54'39"E 14.50'
N21°24'21"W 27.45'
N55°23'39"E 112.00'
N23°26'21"W 400.14'
N71°41'39"E 409.10'
N00°59'11"W 599.29'
N62°50' 2.66'
N63°32'16"E 342.07'

T-1
T-2
T-2a
T-3
T-4
T-5
T-5a
T-6
ET-1

0 100
1"=100'

EXPLANATION

- PROJECT BOUNDARY
- TRENCH 12 — TRENCH LOCATION (THIS STUDY)
- T-6 — TRENCH LOCATION (PHOENIX 1998)
- T-3 — TRENCH LOCATION (PHOENIX 1993)
- ET-1 — TRENCH LOCATION (ENGEO 1989)
- GROUND CRACKS FROM AUGUST 24, 2014 MAGNITUDE 6.0 SOUTH NAPA EARTHQUAKE
- FAULT ZONE
- 25 FEET SETBACK LINE

FAULT SETBACK MAP

NAPA OAKS

OLD SONOMA ROAD AND
CASSWALL STREET
NAPA, CALIFORNIA
FOR
DAVIDON HOMES

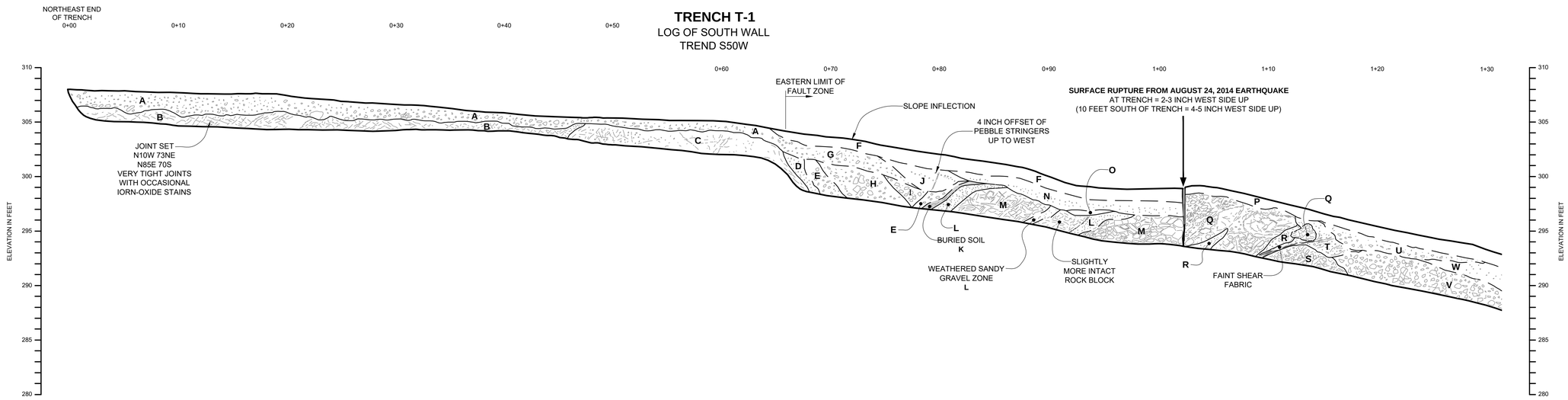
Berlogar Stevens & Associates
SOIL ENGINEERS * ENGINEERING GEOLOGISTS

BASE: NAPA OAKS BASE FILES, SENT VIA EMAIL DATED 4-10-13, PREPARED BY DK CONSULTING INC.

PLATE 4

0 5
1"=5'

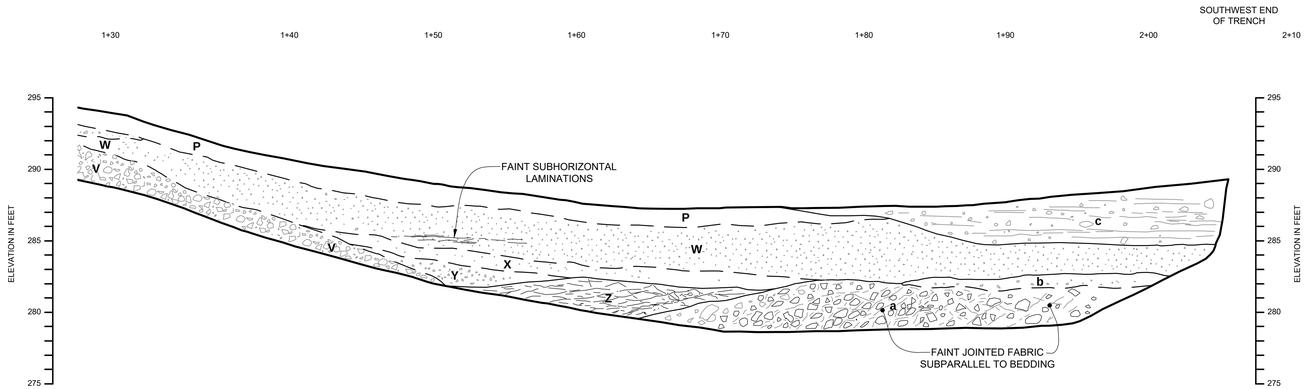
TRENCH T-1
LOG OF SOUTH WALL
TREND S50W



EXPLANATION

———	GROUND SURFACE AND BOTTOM OF TRENCH
— — —	GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL
A	SANDY CLAY WITH GRAVEL, DARK BROWN (7.5 YR 3/4), DRY, STIFF, SOME ANGULAR GRAVEL OF UNDERLYING BEDROCK UP TO 3 INCHES (RESIDUAL SOIL)
B	ANDESITE, DARK BLUE-GRAY, SLIGHTLY WEATHERED, VERY STRONG, OCCASIONALLY FRACTURED, IRON OXIDE STAINED JOINTS
C	FLOW BRECCIA (ANDESITE), DARK BLUE-GRAY, SLIGHTLY WEATHERED, VERY STRONG, OCCASIONALLY FRACTURED, IRON OXIDE STAINED JOINTS
D	SILTY CLAY WITH GRAVEL, DARK REDDISH BROWN (2.5 YR 3/2), DRY, STIFF, ANGULAR GRAVEL UP TO 1 INCH (COLLUVIUM)
E	GRAVELLY CLAY, REDDISH GRAY (5 YR 5/2), DRY STIFF, FAINTLY POROUS, ANGULAR GRAVEL UP TO 1-1/2 INCH (COLLUVIUM)
F	SANDY CLAY, STRONG BROWN (7.5 YR 4/6), DRY, MEDIUM STIFF TO STIFF, SOME ANGULAR GRAVEL CONSISTING OF TUFF AND MINOR ANDESITE (RESIDUAL SOIL)
G	SANDY CLAY WITH GRAVEL, YELLOWISH RED (5 YR 6/4), DRY, STIFF, ANGULAR TUFF FRAGMENTS (COLLUVIUM)
H	GRAVELLY CLAY WITH SAND, LIGHT BROWN (7.5 YR 5/3), DRY, STIFF, ANGULAR GRAVELS OF TUFF (COLLUVIUM)
I	GRAVELLY SAND, YELLOWISH RED (5 YR 6/4), DRY, STIFF, COARSE-GRAINED SAND, ANGULAR GRAVELS OF TUFF (COLLUVIUM)
J	SILTY CLAY, REDDISH BROWN (5 YR 4/4), DRY, STIFF, TRACE PEBBLES (COLLUVIUM)
K	SILTY CLAY, VERY DARK BROWN (7.5 YR 2.5/3), DRY, STIFF, BLOCKY PED STRUCTURE (BURIED SOIL Bt)
L	GRAVELLY SANDY CLAY, REDDISH YELLOW (7.5 YR 7/8), DRY, STIFF (DEEPLY WEATHERED TUFF)
M	WELDED TUFF, VERY PALE ORANGE TO WHITE (FRESH), RED-BROWN (WEATHERED), MODERATELY WEATHERED, HIGHLY FRACTURED TO CRUSHED
N	SILTY CLAY, DARK BROWN (7.5 YR 3/3), DRY TO MOIST, STIFF, TRACE PEBBLES (TUFF), FAINTLY POROUS (RESIDUAL SOIL)
O	SANDY CLAY, STRONG BROWN (7.5 YR 4/6), DRY TO MOIST, STIFF (BURIED SOIL Bt)
P	GRAVELLY CLAY WITH SAND, DARK BROWN (7.5 YR 3/4), DRY, STIFF, ROUNDED ANDESITE PEBBLES
Q	ANDESITE, BLUE-GRAY (FRESH) TO REDDISH YELLOW (7.5 YR 7/8) (WEATHERED), HIGHLY WEATHERED, MODERATELY STRONG, CRUSHED DILATED STRUCTURE (SONOMA VOLCANICS)
R	PEBBLY SAND, YELLOW (2.5 Y 6/8), DRY, DENSE (WEATHERED BEDROCK)
S	SANDY GRAVEL, STRONG BROWN (7.5 YR 8/8), DRY, DENSE
T	GRAVELLY CLAY, STRONG, BROWN (7.5 YR 6/8), DRY, DENSE (COLLUVIUM)
U	SANDY SILT WITH PEBBLES, DARK BROWN (7.5 YR 3/4), DRY, POROUS (COLLUVIUM)
V	SANDY CLAYEY GRAVEL, LIGHT BROWN (7.5 YR 3/6), DRY, DENSE (COLLUVIUM)
W	SANDY CLAY, DARK REDDISH BROWN (5 YR 3/4), DRY, VERY STIFF, TRACE ROUNDED PEBBLES (PLEISTOCENE ALLUVIUM)
X	SANDY CLAY, YELLOWISH RED (5 YR 5/8), DRY, STIFF, POROUS, TRACE PEBBLES
Y	GRAVELLY CLAY, REDDISH YELLOW (7.5 YR 7/8), DRY, STIFF
Z	WELDED TUFF, VERY PALE ORANGE TO WHITE, MODERATELY WEATHERED, STRONG, OCCASIONALLY TO MODERATELY FRACTURED
a	AGGLOMERATE / FLOW BRECCIA(?), DARK BLUE, ANDESITE BLOCKS IN A LITHIFIED RED-BROWN GRANULAR MATRIX, HIGHLY WEATHERED, MODERATELY FRACTURED, STRONG
b	SANDY CLAY, YELLOWISH RED (5 YR 6/4), DRY, VERY STIFF, SOME SUBROUNDED COBBLES
c	SILTY CLAY WITH SAND, TAN-BROWN, BROWN AND GRAY, MOIST, STIFF, TRACE COBBLES (FILL)

TRENCH T-1
LOG OF SOUTH WALL CONTINUED
TREND S50W



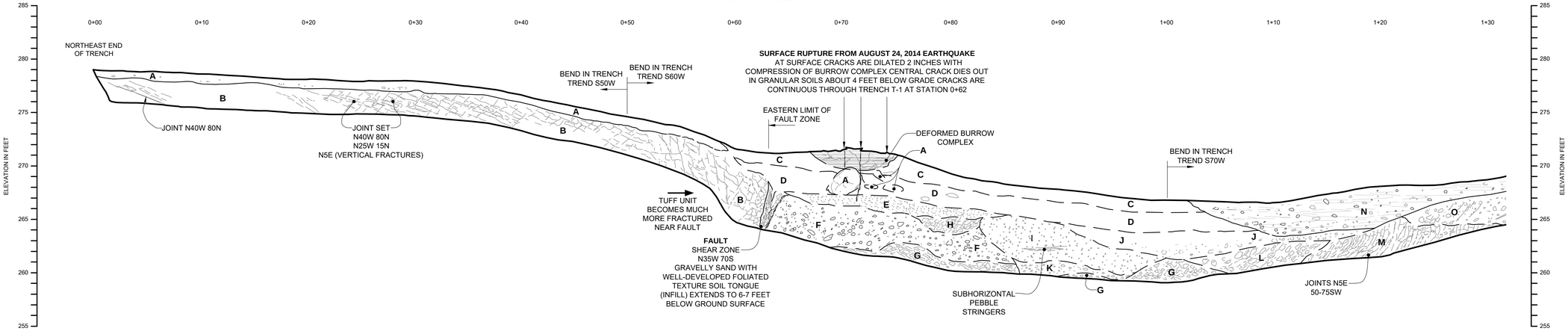
FAULT TRENCH LOG
TRENCH T-1
NAPA OAKS
OLD SONOMA ROAD AND
CASSWALL STREET
NAPA, CALIFORNIA
FOR
DAVIDON HOMES

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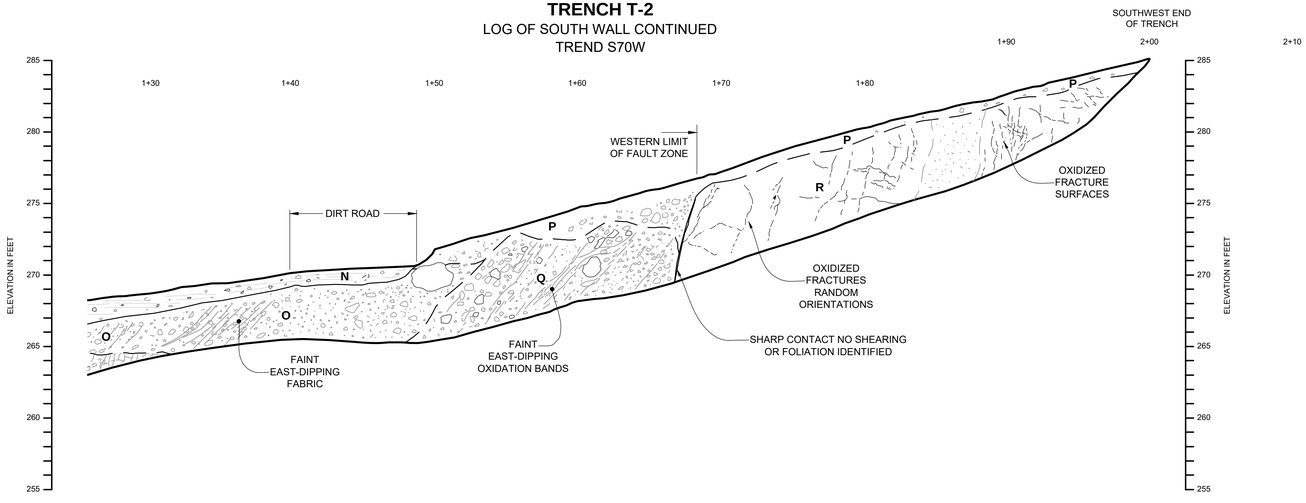
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0 5
1"=5'

TRENCH T-2
LOG OF SOUTH WALL
TREND VARIABLE



TRENCH T-2
LOG OF SOUTH WALL CONTINUED
TREND S70W



EXPLANATION

———	GROUND SURFACE AND BOTTOM OF TRENCH
— — —	GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL
A	SANDY CLAY, DARK BROWN (7.5 YR 3/2), DRY, STIFF, TRACE PEBBLES OF UNDERLYING TUFF
B	WELDED TUFF, MODERATE ORANGE PINK TO GRAYISH PINK, MODERATELY WEATHERED, OCCASIONALLY FRACTURED (SONOMA VOLCANICS)
C	SILTY CLAY, DARK BROWN (10 YR 3/3), DRY, STIFF, FAINT BLOCKY PED STRUCTURE
D	SILTY CLAY WITH SAND, DARK YELLOWISH BROWN (10 YR 4/3), DRY, STIFF, POROUS, TRACE PEBBLES
E	SANDY SILT, PALE BROWN (10 YR 6/3), DRY, VERY STIFF TO WEAKLY CEMENTED, TRACE PEBBLES
F	CONGLOMERATE/SANDY GRAVEL, LIGHT BROWN (7.5 YR 6/3), DRY, STIFF, ROUNDED GRAVEL UP TO 2 INCHES
G	GRAVELLY SAND WITH CLAY, REDDISH YELLOW (7.5 YR 7/8), DRY, HARD, ANGULAR TUFF FRAGMENTS WITH FAINT JOINTED PATTERN LOOKS SIMILAR TO AGGLOMERATE IN T-1 JUST MUCH WEAKER AND NOT AS LITHIFIED IN MATRIX
H	GRAVEL WITH SILT, DARK RED-BROWN (5 YR 3/4), DRY, VERY DENSE TO WEAKLY LITHIFIED
I	SANDY SILT, LIGHT BROWN (7.5 YR 6/3), DRY, VERY STIFF, COARSE-GRAINED SAND, FAINTLY POROUS SOME PEBBLES (Qal)
J	CLAYEY SILT, LIGHT BROWN (7.5 YR 6/4), DRY, STIFF, TRACE FINE-GRAINED SAND
K	GRAVELLY SAND, LIGHT BROWN (7.5 YR 6/3), DRY, HARD TO WEAKLY LITHIFIED (INFILL DEPOSIT)
L	BRECCIATED TUFF, WHITISH-GRAY, HARD, HIGHLY FRACTURED WITH SOIL INFILL ALONG FRACTURES, SOME BLOCKS ARE SUBROUNDED, SOME ARE SLABS WITH REMNANT JOINTED STRUCTURE
M	WELDED TUFF, WHITISH-GRAY (FRESH) TO ORANGE-BROWN (WEATHERED), HIGHLY WEATHERED, HIGHLY FRACTURED, SOME DILATION OF FRACTURES REMNANT JOINT PATTERN IS INTACT
N	SILTY CLAY, MIXED BROWN, TAN-BROWN AND YELLOW-BROWN, DRY, STIFF, SOME ANGULAR GRAVEL UP TO 3 INCHES (FILL)
O	GRAVELY SAND, DRY, VERY DENSE, SUBROUNDED TO ANGULAR TUFF CLASTS, FINE-TO COARSE-GRAINED SAND
P	SANDY CLAY, DARK YELLOW-BROWN (10 YR 4/4), DRY, STIFF, SOME ANGULAR GRAVEL OF TUFF
Q	GRAVELLY SAND, REDDISH BROWN (7.5 YR)
R	TUFF, VERY PALE ORANGE, SLIGHTLY WEATHERED, STRONG, OCCASIONALLY FRACTURED

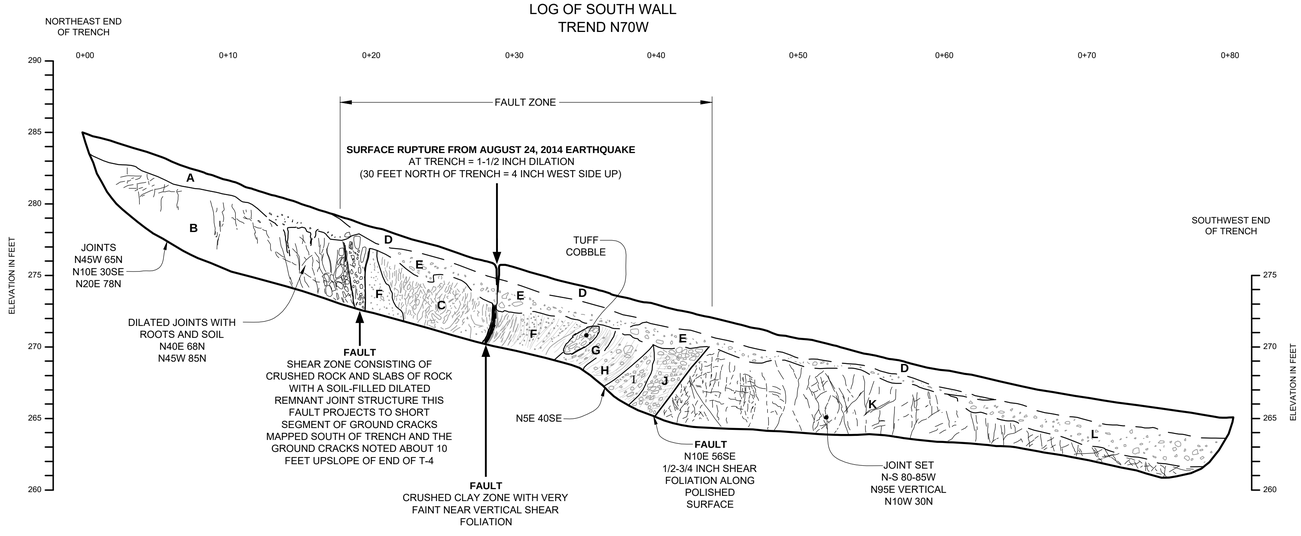
FAULT TRENCH LOG
TRENCH T-2
NAPA OAKS
OLD SONOMA ROAD AND
CASSWALL STREET
NAPA, CALIFORNIA
FOR
DAVIDON HOMES

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DATE: 12-16-14
JOB NUMBER: 3280.002

0 5
1"=5'

TRENCH T-3
LOG OF SOUTH WALL
TREND N70W



EXPLANATION

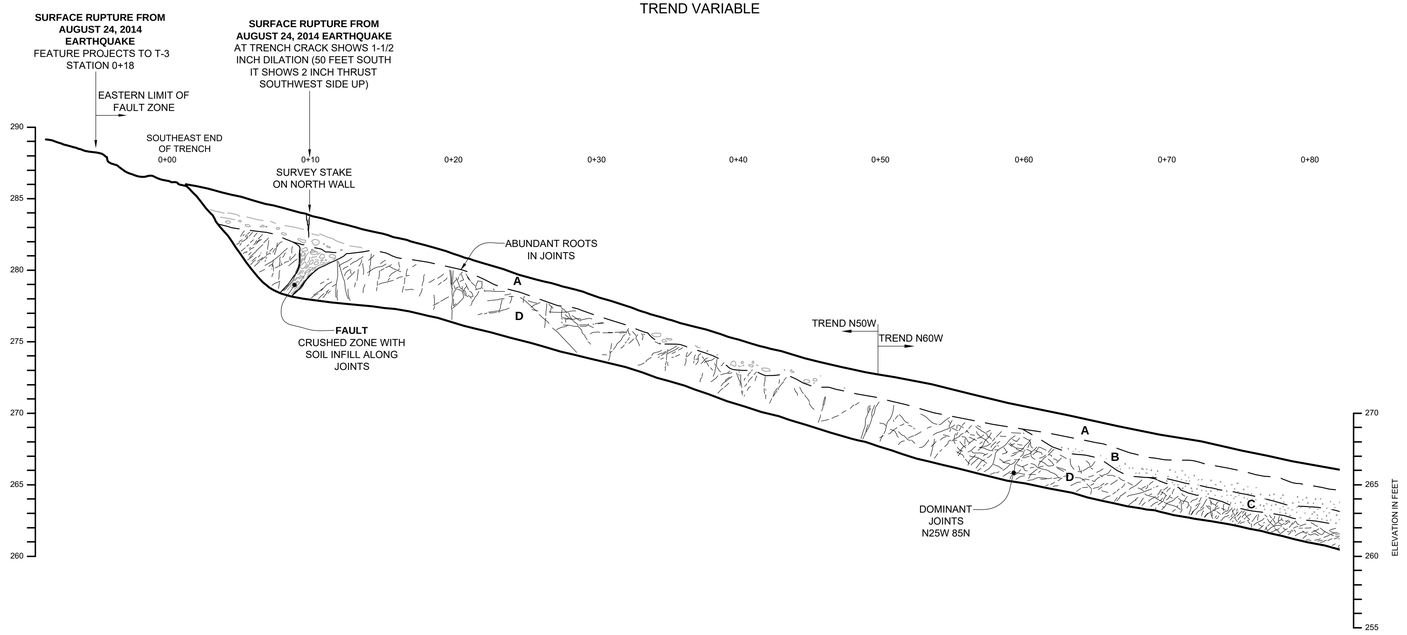
———	GROUND SURFACE AND BOTTOM OF TRENCH
— — —	GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL
A	SILTY CLAY, DARK BROWN (7.5 YR 3/3), DRY, STIFF, POROUS, BLOCKY PED STRUCTURE
B	TUFF, LIGHT BLUEISH GRAY (5B 7/1), SLIGHTLY WEATHERED, MODERATELY STRONG, MODERATELY FRACTURED
C	BRECCIATED AND WEATHERED TUFF, BLUEISH WHITE (5B 9/1), DRY, DENSE, ANGULAR ROCK FRAGMENTS IN SANDY SILT MATRIX, RESIDUAL ROCK STRUCTURE BUT OBVIOUSLY DISRUPTED
D	SILTY CLAY, DARK YELLOWISH BROWN (10 YR 3/4), DRY, STIFF, BLOCKY PED STRUCTURE
E	SILTY CLAY, DARK YELLOWISH BROWN (10 YR 4/4), DRY, STIFF, TRACE PEBBLES AND ANGULAR GRAVEL UP TO 2 INCHES
F	GRAVELLY SILT, BLUEISH GRAY (5B 7/1), DEEPLY WEATHERED AND DISRUPTED TUFF
G	GRAVELLY SILT, VERY PALE ORANGE (10 YR 8/2), DEEPLY WEATHERED AND DISRUPTED TUFF, VERY FAINT RESIDUAL ROCK STRUCTURE
H	SILTY GRAVEL, PALE GREENISH YELLOW (10 Y 8/2), DEEPLY WEATHERED AND DISPUTED TUFF, FAINT RESIDUAL ROCK STRUCTURE
I	SANDY GRAVEL, DARK YELLOWISH ORANGE (10 YR 6/6), DEEPLY WEATHERED AND DISRUPTED TUFF
J	BRECCIATED TUFF YELLOW-GRAY (5Y 7/2), HIGHLY WEATHERED, DILATED JOINTS WITH SOIL IN-FILL
K	TUFF, YELLOWISH GRAY (5 Y 7/2), SLIGHTLY WEATHERED, MODERATELY STRONG, HIGHLY FRACTURED
L	SILTY CLAY, BROWN (10 YR 4/3), DRY, STIFF, COBBLES OF UNDERLYING TUFF

DRAWN BY: CC
DATE: 12-16-14
JOB NUMBER: 3280.002

FAULT TRENCH LOG
TRENCH T-3
NAPA OAKS
OLD SONOMA ROAD AND
CASSWALL STREET
NAPA, CALIFORNIA
FOR
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TRENCH T-4
LOG OF SOUTH WALL
TREND VARIABLE

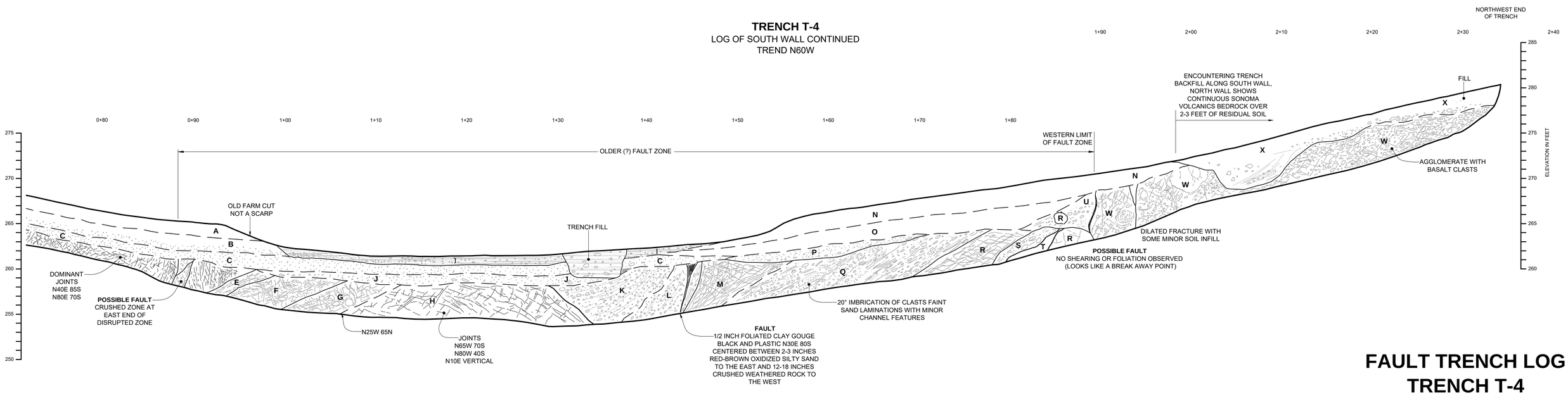


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1"=5'

EXPLANATION

———	GROUND SURFACE AND BOTTOM OF TRENCH	L	GRAVELLY SAND WITH CLAY, YELLOWISH RED (5 YR 4/6), DRY, VERY DENSE, ANGULAR CLASTS OF TUFF AND ANDESITE(?) (GRABEN INFILL)
— — —	GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL	M	SILTSTONE, HIGHLY WEATHERED, WEAK, CRUSHED WITH DILATION OF ROCK STRUCTURE
A	SILTY CLAY, DARK BROWN (10YR 3/3), DRY, STIFF, FAINTLY POROUS	N	SILTY CLAY, DARK BROWN (10 YR 3/5), DRY, STIFF
B	SILTY CLAY, DARK YELLOW-BROWN (10 YR 4/4), DRY, STIFF, TRACE FINE-GRAINED SAND	O	SILTY CLAY, DARK YELLOW-BROWN (10 YR 4/4), DRY, STIFF, TRACE PEBBLES
C	SANDY SILT WITH CLAY, BROWN (7.5 YR 4/3), DRY, STIFF TO WEAKLY CEMENTED	P	SANDY CLAY, BROWN (10 YR 5/3), DRY, STIFF, POROUS COARSE SAND, SOME ANGULAR GRAVE OF TUFF
D	TUFF, BLUEISH-WHITE (5B 9/1), SLIGHTLY WEATHERED, WEAK TO MODERATELY STRONG, HIGHLY FRACTURED, TRACE PEBBLES AND PUMICE FRAGMENTS	Q	CONGLOMERATE WITH SAND MATRIX
E	TUFF, PALE GREENISH YELLOW (10 Y 8/2), DEEPLY WEATHERED, FRIABLE, CRUSHED WITH SOME DILATION OF STRUCTURE	R	SANDSTONE, PALE YELLOW, HIGHLY WEATHERED, WEAK
F	TUFF, YELLOWISH GRAY (5 Y 7/2), DEEPLY WEATHERED, FRIABLE, CRUSHED TO SLIGHTLY DILATED STRUCTURE	S	GRAVELLY SILT, PALE YELLOW (5Y 8/3), DRY, STIFF, ANGULAR SANDSTONE FRAGMENTS
G	TUFF, LIGHT GREENISH GRAY (5G 8/1), HIGHLY WEATHERED, FRIABLE, CRUSHED	T	SANDY CLAY, STRONG BROWN (7.5 YR 4/6), DRY, STIFF, POROUS
H	TUFF, MODERATE ORANGE PINK (5 YR 8/4), DEEPLY WEATHERED, MODERATELY STRONG, HIGHLY FRACTURED, ABUNDANT IRON OXIDE STAINING	U	GRAVELLY CLAY, BROWN (7.5 YR 4/6), DRY, STIFF, ROUNDED TUFF AND BASALT COBBLES (COLLUVIAL WEDGE)
I	GRAVELLY CLAY, OLIVE-YELLOW (2.5 Y 7/8) TO OLIVE-BROWN (2.5Y 4/4), DRY, STIFF (FILL)	W	AGGLOMERATE, STRONG, MODERATELY FRACTURED, SUBANGULAR TO ROUNDED CLASTS OF TUFF, ANDESITE AND BASALT
J	PEBBLY CLAY, DARK YELLOW-BROWN (10 YR 4/6), DRY, STIFF, SUBANGULAR PEBBLES AND FINE GRAVEL OF OVERLYING TUFF	X	GRAVELLY CLAY, BROWN (10 YR 4/4), DRY, STIFF (FILL)
K	GRAVELLY SAND WITH CLAY, YELLOWISH RED (5 YR 5/8), DRY, VERY DENSE, ANGULAR CLASTS OF TUFF AND ANDESITE(?) (GRABEN INFILL)		

TRENCH T-4
LOG OF SOUTH WALL CONTINUED
TREND N60W

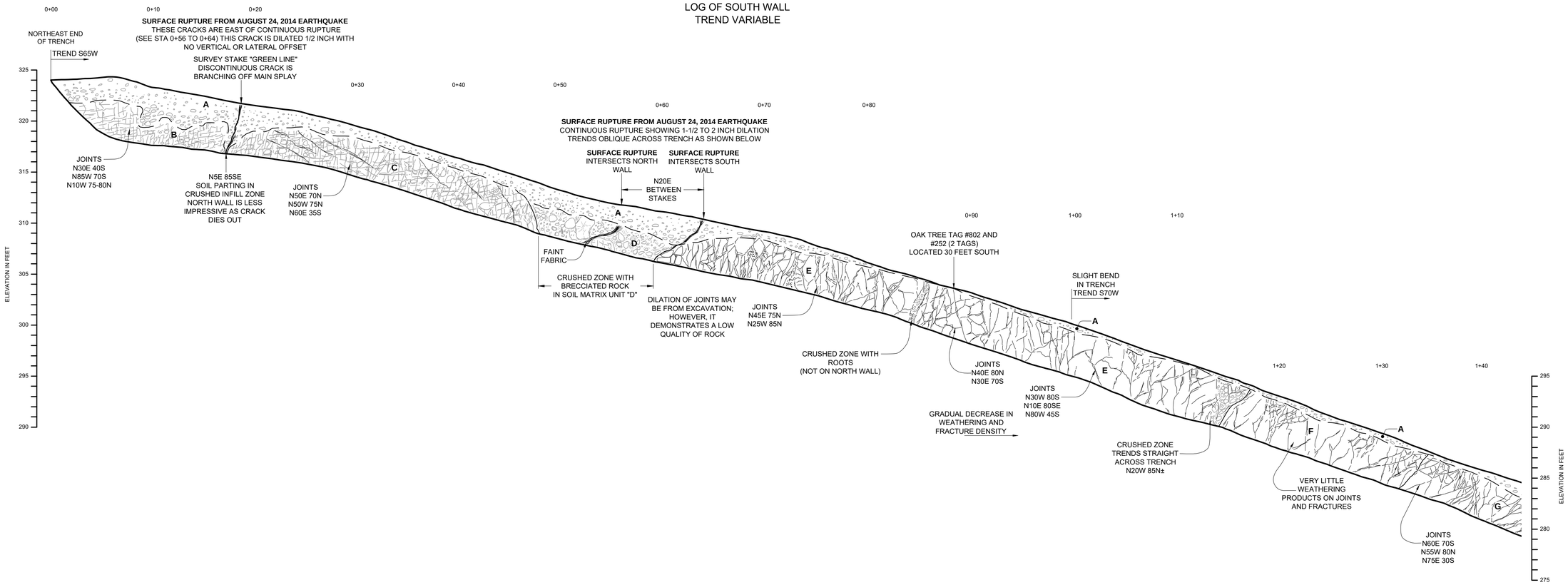


FAULT TRENCH LOG
TRENCH T-4
NAPA OAKS
OLD SONOMA ROAD AND
CASSWALL STREET
NAPA, CALIFORNIA
FOR
DAVIDON HOMES

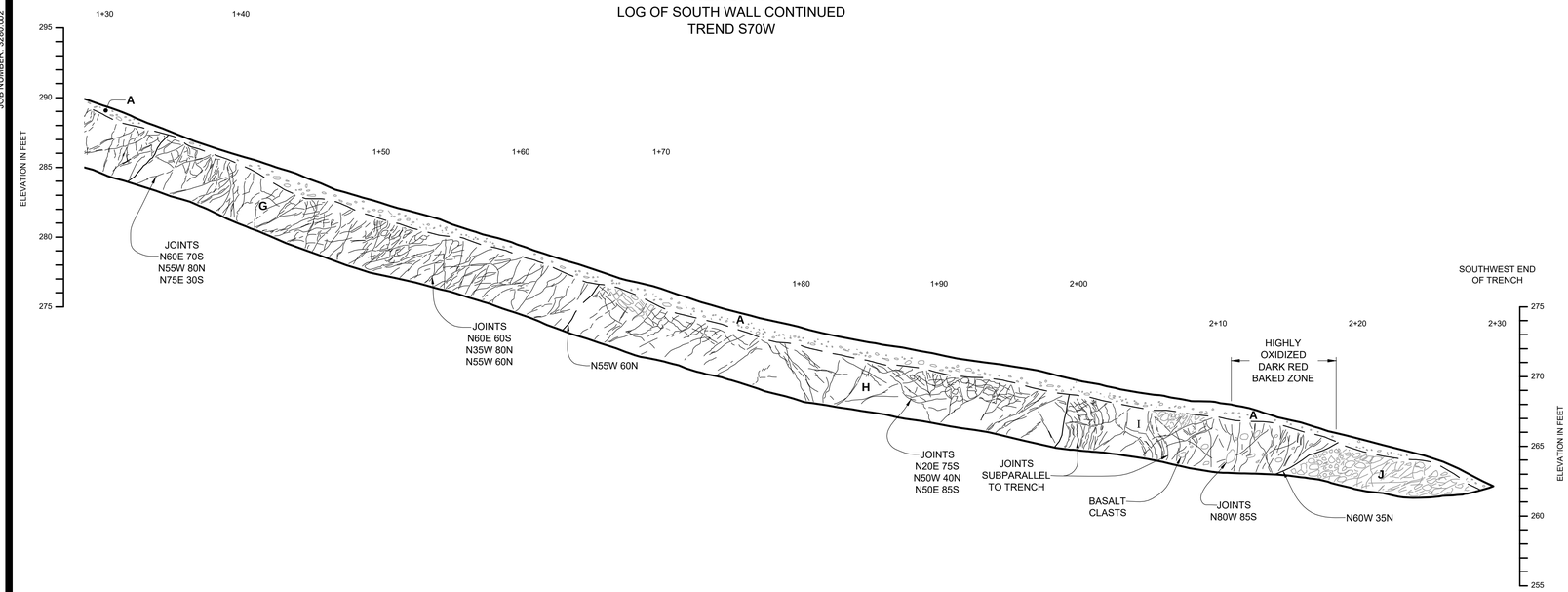
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SOIL ENGINEERS * ENGINEERING GEOLOGISTS

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DATE: 12-16-14
JOB NUMBER: 3280.002

TRENCH T-5
LOG OF SOUTH WALL
TREND VARIABLE



TRENCH T-5
LOG OF SOUTH WALL CONTINUED
TREND S70W



EXPLANATION

———	GROUND SURFACE AND BOTTOM OF TRENCH
— — —	GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL
A	GRAVELLY CLAY DARK YELLOW BROWN (10 YR 3/4), DRY, STIFF, PEBBLES AND COBBLES UP TO 8 INCHES OF UNDERLYING BEDROCK
B	TUFF, MODERATE YELLOW (5 Y 7/6) FRESH TO YELLOW-RED (5 YR 5/8) WEATHERED, HIGHLY WEATHERED, WEAK, CRUSHED, IRON OXIDE STAINED JOINTS
C	TUFF, LIGHT BLUEISH GRAY (5 B 7/1) FRESH TO YELLOW-RED (5YR 5/8) WEATHERED, MODERATELY WEATHERED, MODERATELY STRONG, HIGHLY FRACTURED, IRON OXIDE STAINED JOINTS, SOME MANGANESE OXIDE STAINS
D	SILTY CLAY WITH GRAVEL, LIGHT BROWN (7.5 YR 6/4), DRY, STIFF, SUBANGULAR CLASTS OF ADJACENT BEDROCK UNITS
E	TUFF, BLUEISH GRAY (5B 7/1) MODERATELY WEATHERED, MODERATELY STRONG, MODERATELY TO HIGHLY FRACTURED (SONOMA VOLCANICS)
F	TUFF, GRAYISH ORANGE PINK (10 R 8/2) SLIGHTLY WEATHERED, WEAK TO MODERATELY STRONG, OCCASIONALLY TO MODERATELY FRACTURED, ROUNDED PEBBLES OF ANDESITE AND PUMICE (SONOMA VOLCANICS)
G	TUFF VERY LIGHT GRAY (N 8) TO PINKISH GRAY (5 YR 8/1) SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, HIGHLY FRACTURED, ROUNDED PEBBLES OF ANDESITE AND PUMICE (SONOMA VOLCANICS)
H	TUFF, PALE GREENISH YELLOW (10 Y 8/2) SLIGHTLY WEATHERED, WEAK, OCCASIONALLY FRACTURED, SOME FAINT IRON OXIDE STAINS ON JOINTS (SONOMA VOLCANICS
I	TUFF, LIGHT BROWNISH GRAY (5 YR 6/1) HIGHLY WEATHERED, STRONG, CLASTS OF VESICULAR BASALT (SONOMA VOLCANICS)
J	TUFF, YELLOW-GRAY (5 Y 7/2) FRESH TO GRAYISH YELLOW (5 Y 8/4) HIGHLY WEATHERED, FRIABLE TO WEAK, CRUSHED WITH SOME DILATION OF ROCK MASS (SONOMA VOLCANICS)

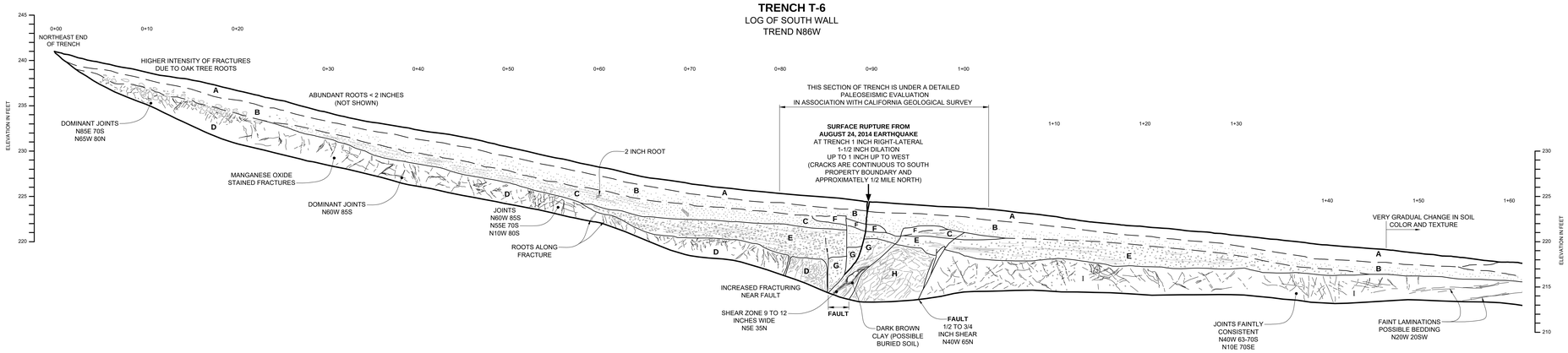
FAULT TRENCH LOG
TRENCH T-5
NAPA OAKS
OLD SONOMA ROAD AND
CASSWALL STREET
NAPA, CALIFORNIA
FOR
DAVIDON HOMES

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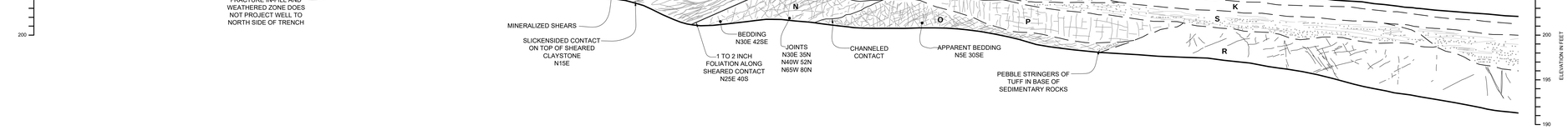
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DATE: 12-16-14
JOB NUMBER: 3280.002

0 5
1"=5'

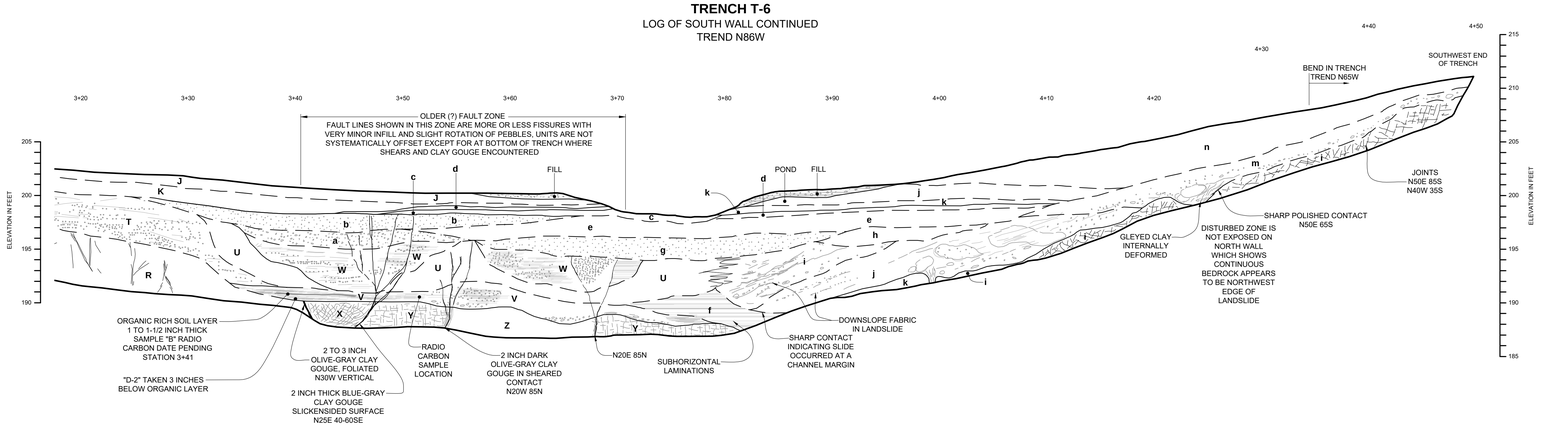
TRENCH T-6
LOG OF SOUTH WALL
TREND N86W



TRENCH T-6
LOG OF SOUTH WALL CONTINUED
TREND N86W



TRENCH T-6
LOG OF SOUTH WALL CONTINUED
TREND N86W



EXPLANATION

- GROUND SURFACE AND BOTTOM OF TRENCH
- GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL

A	SILTY CLAY, DARK BROWN (10 YR 3/3), DRY, STIFF, POROUS, BLOCKY PED STRUCTURE
B	SANDY SILT WITH CLAY, DARK GRAYISH BROWN (10 YR 4/2), DRY, STIFF, FINE-GRAINED SAND, TRACE ANGULAR PEBBLES
C	SANDY SILT WITH ANGULAR PEBBLES, DARK YELLOWISH BROWN (10 YR 4/4), DRY , STIFF (SLOPE WASH)
D	TUFF, VERY PALE ORANGE (10 YR 8/2), MODERATELY WEATHERED, MODERATELY STRONG, MODERATELY FRACTURED
E	PEBBLY SILT WITH CLAY, GRAY-BROWN (10 YR 5/2), DRY, STIFF, SUBANGULAR TO SUBROUNDED PEBBLES OF TUFF AND ANDESITE
F	SANDY SILT, DARK YELLOW-BROWN (10 YR 6/4), DRY, STIFF, TRACE TO SOME PEBBLES, TRACE CLAY (RESIDUAL SOIL ON Qal)
G	GRAVELLY SILT, PINKISH WHITE (7.5 YR 8/2), DRY, STIFF, ANGULAR TUFF CLASTS UP TO 2 INCHES (WEDGE IN-FILL DERIVED FROM TUFF)
H	TUFF, DUSKY YELLOW (5Y 6/4), DEEPLY WEATHERED, WEAK, CLAY-RICH PUMICE FRAGMENTS, ARCUATE JOINTS WITH FAINT DILATION
I	TUFF, GRAYISH YELLOW (5Y 8/4), MODERATELY WEATHERED, WEAK, OCCASIONALLY FRACTURED, TRACE PEBBLES
J	SILTY CLAY, DARK GRAYISH BROWN (10 YR 4/2), DRY, STIFF, TRACE ANGULAR PEBBLES (RESIDUAL SOIL AB)
K	SANDY CLAY WITH SILT, BROWN (10 YR 4/3), DRY, STIFF, FINE-GRAINED SAND (RESIDUAL SOIL B)
L	DEEPLY WEATHERED TUFF
M	SHEARED CLAYSTONE, GRAYISH OLIVE-GREEN (5GY 3/2) TO BLACK, HIGHLY WEATHERED, PLASTIC WITH SLICKENSIDED SURFACES THROUGHOUT, FAINT FOLIATION N30E - N40E 40-45SE, ABUNDANT IRON OXIDE COATING OF VERTICAL JOINTS
N	SILTSTONE, DUSKY YELLOW (5Y 6/4), HIGHLY WEATHERED, WEAK, HIGHLY FRACTURED, IRON OXIDE COATED JOINTS
O	CLAYEY SILTSTONE, YELLOWISH GRAY (5Y 7/2), HIGHLY WEATHERED WITH IRON OXIDE STAINED JOINTS
P	SILTY CLAY, OLIVE-BROWN (2.5Y 4/3), COLUMNAR PED STRUCTURE WITH DUSKY RED (5Y 4/4) CLAY COATINGS, MOIST, HARD
Q	SILTY SAND, GRAY (10 YR 6/1), DRY, DENSE, ROUNDED PEBBLES OF VOLCANICS (ALLUVIUM)
R	TUFF, GRAYISH YELLOW (5Y 8/4), MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG, OCCASIONALLY FRACTURED
S	SANDY SILT, BROWN (10 YR 5/3), DRY, STIFF TO VERY STIFF, TRACE PEBBLES (CHANNEL DEPOSIT)
T	SANDY SILT, LIGHT OLIVE-BROWN (2.5Y 5/4), DRY, HARD, TRACE TO SOME PEBBLES, FAINTLY POROUS (ALLUVIAL CHANNEL DEPOSITS)
U	CLAYEY SILT WITH FINE-GRAINED SAND, MOTTLED OLIVE-YELLOW (2.5Y 6/8) TO LIGHT GREENISH GRAY (5GY 1), DRY, VERY STIFF, FAINT BLOCKY PED STRUCTURE, IRON OXIDE MOTTLING (CHANNEL DEPOSIT)
V	SILTY SAND, LIGHT OLIVE-BROWN (2.5 Y 5/4), WITH FAINT OXIDIZED LAMINATIONS, FINE-GRAINED SAND, HORIZONTAL LAMINATIONS (ALLUVIUM)
W	SANDY SILT, STRONG BROWN (7.5 YR 5/6), DRY, HARD, SOME PEBBLE CHANNELS WITH SUBHORIZONTAL LAMINATIONS (CHANNEL DEPOSIT)
X	SHEARED CLAY(STONE), DUSKY YELLOW-GREEN (5GY 5/2), DUCTILE, CRUSHED WITH SLICKENSIDED SURFACES THROUGHOUT
Y	SHEARED/BRECCIATED CLAYSTONE/SILTSTONE, MOTTLED DUSKY YELLOW-GREEN (5GY 5/2) TO DARK YELLOW-ORANGE (10YR 6/6)
Z	SILTSTONE, PALE OLIVE (10Y 6/2), DEEPLY WEATHERED TO NEAR SOIL CONSISTENCY, FRIABLE, TRACE CLAY
a	SILTY SAND (POND SEDIMENTS)
b	SILTY SAND WITH PEBBLES (POND SEDIMENTS)
c	SILTY CLAY, DARK GRAY-BROWN (10 YR 4/2) DRY, STIFF, BLOCKY PED STRUCTURE (Bt) (POND SEDIMENTS)
d	SANDY SILT, LIGHT GRAY (10 YR 7/1) DRY, STIFF, FINE-GRAINED SAND, HORIZONTAL LAYER (POND SEDIMENTS)
e	SILTY CLAY, DARK GRAY-BROWN (2.5Y 4/2) DRY, STIFF, BLOCKY PED STRUCTURE (Bt)
f	CLAYEY SILT, LAYERED/MOTTLED PALE YELLOW (2.5Y 8/3) TO LIGHT GRAY (2.5Y 7/1) MOIST, STIFF, SUBHORIZONTAL SAND STRINGERS
g	SANDY SILT, VERY PALE BROWN (10 YR 7/3) MOIST, STIFF, FINE-GRAINED SAND
h	SILTY CLAY, DARK YELLOW-BROWN (10YR 4/3) MOIST, VERY STIFF, BLOCKY PED STRUCTURE (Bt ON SLIDE SURFACES)
i	SANDY CLAY, OLIVE-BROWN (2.5Y 6/8) MOIST, STIFF TO VERY STIFF, COARSE-GRAINED SAND, BLOCKY PED STRUCTURE (LANDSLIDE DEPOSIT)
j	SANDY CLAY, OLIVE-BROWN (2.5Y 4/3) MOIST, STIFF TO VERY STIFF, COARSE-GRAINED SAND, BLOCKY PED STRUCTURE (LANDSLIDE DEPOSIT)
k	SILTSTONE, DARK YELLOWISH ORANGE (10YR 6/6) HIGHLY WEATHERED, FRIABLE CRUSHED
l	SANDSTONE, FINE-GRAINED, MODERATELY WEATHERED, MODERATELY STRONG, HIGHLY FRACTURED (DOMENGINE SANDSTONE)
m	CLAYEY SILT, DARK YELLOWISH BROWN (10 YR 4/6) DRY, STIFF, SOME PEBBLES (SLOPE WASH)
n	SANDY SILT, VERY PALE BROWN (10 YR 7/4) DRY, STIFF, FINE-GRAINED SAND

SHEARS IN FAULT ZONE (STATION 0+85 TO STATION 0+95) ARE REPRESENTED BY 1/2 TO 1 INCH DILATIONS IN SOIL (PARTINGS) THAT HAVE IN-FILLED WITH SOIL.

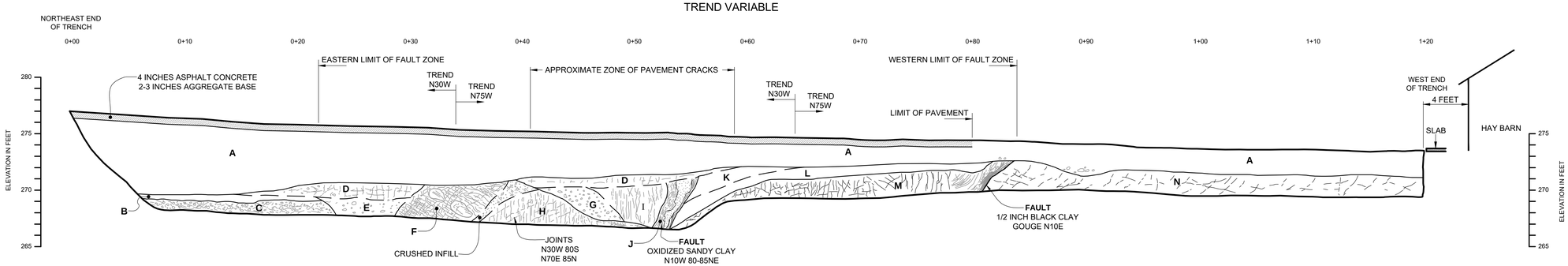
- UNIT G IS BROKEN WITH UP TO ABOUT 2 FEET VERTICAL OFFSET
- UNIT F IS DISCONTINUOUSLY BROKEN ACROSS SHEARS
- UNIT A IS NOT OFFSET BUT 2014 EVENT BREAKS TO GROUND SURFACE

FAULT TRENCH LOG
TRENCH T-6
NAPA OAKS
OLD SONOMA ROAD AND
CASSWALL STREET
NAPA, CALIFORNIA
FOR
DAVIDON HOMES

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DATE: 12-16-14
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TRENCH T-7
LOG OF SOUTH WALL
TREND VARIABLE

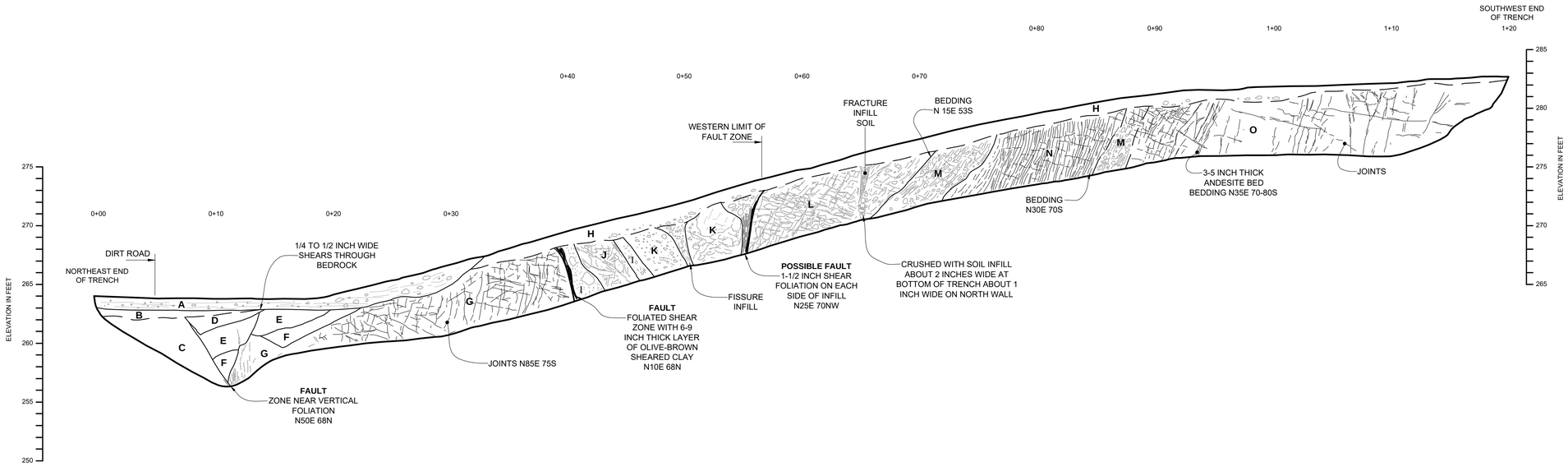


T-7 EXPLANATION

0 5
1"=5'

———	GROUND SURFACE AND BOTTOM OF TRENCH
— — —	GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL
A	SILTY CLAY, DARK REDDISH BROWN (5 YR 3/4), MOIST, STIFF, TRACE PEBBLES (FILL?)
B	SANDY CLAY, BROWN (7.5 YR 4/3), MOIST, VERY STIFF, BLOCKY PED STRUCTURE
C	FLOW BRECCIA, DARK YELLOWISH ORANGE (10 YR 6/6), MODERATELY WEATHERED, STRONG, HIGHLY FRACTURED
D	SILTY CLAY, DARK BROWN (10YR 3/3), MOIST, STIFF, COLUMNAR PED STRUCTURE WITH CLAY SKINS ON SURFACES, TRACE TUFF GRAVEL
E	GRAVELLY CLAY, BROWN (10 YR 5/3), MOIST, STIFF, SUBANGULAR TUFF GRAVEL UP TO 2 INCHES
F	BRECCIATED TUFF, HIGHLY WEATHERED, MODERATELY STRONG, CRUSHED WITH FAINT DILATION OF FRACTURES
G	GRAVELLY SILT, DARK BROWN (10 YR 6/3), MOIST, STIFF, ANGULAR TUFF GRAVEL UP TO 1 INCH (INFILL)
H	TUFF, PALE GREENISH YELLOW (10 Y 8/2), HIGHLY WEATHERED, WEAK TO MODERATELY STRONG, HIGHLY FRACTURED
I	SILTY CLAY, YELLOWISH BROWN (10 YR 5/6), MOIST, STIFF (INFILL SOILS)
J	CLAYEY SAND, GRAYISH-BROWN (10 YR 5/2), MOIST, STIFF, COARSE-GRAINED SAND
K	SILTY CLAY, DARK YELLOW-BROWN (10 YR 4/4), MOIST, STIFF, BLOCKY PED STRUCTURE
L	SILTY CLAY, BROWN (10 YR 4/3), MOIST, STIFF, TRACE FINE-GRAINED SAND
M	SANDY SILTSTONE, HIGHLY WEATHERED, WEAK, CRUSHED WITH SOME DILATION OF JOINTS
N	TUFF, LIGHT BLUEISH GRAY, MODERATELY WEATHERED, WEAK TO MODERATELY STRONG, OCCASIONALLY FRACTURED

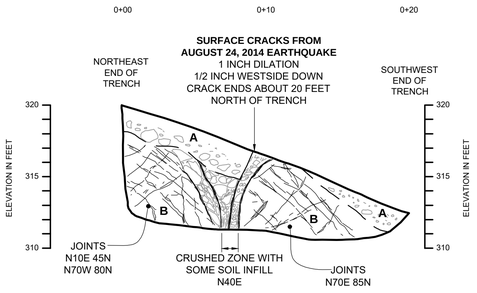
TRENCH T-8
LOG OF SOUTH WALL
TREND N59E



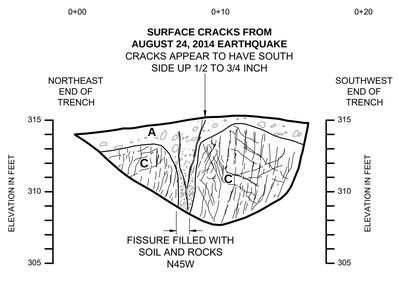
T-8 EXPLANATION

———	GROUND SURFACE AND BOTTOM OF TRENCH
— — —	GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL
A	GRAVELLY CLAY, MIXED BROWN AND TAN, DRY, STIFF, TRACE GRAVEL (FILL)
B	SILTY CLAY, DARK YELLOWISH BROWN (10 YR 4/4), DRY, STIFF, BLOCKY PED STRUCTURE
C	SANDSTONE, FINE-TO MEDIUM-GRAINED, DARK YELLOWISH ORANGE (10 YR 6/6), MODERATELY WEATHERED, WEAK TO MODERATELY STRONG
D	CLAYSTONE, DARK YELLOWISH ORANGE (10 YR 6/6), HIGHLY WEATHERED, FRIABLE, CRUSHED WITH ARCUATE JOINTS
E	CLAYSTONE, GREENISH GRAY (5 GY 6/1), HIGHLY WEATHERED, FRIABLE, CRUSHED WITH MANGANESE STAINED ARCUATE JOINTS
F	CLAYSTONE, MOTTLED DARK YELLOWISH ORANGE (10 YR 6/6) TO YELLOWISH GRAY (5 Y 8/1), HIGHLY WEATHERED, FRIABLE, CRUSHED WITH ARCUATE JOINTS
G	SANDY SILTSTONE, DARK YELLOWISH ORANGE (10 YR 6/6), HIGHLY WEATHERED, FRIABLE TO WEAK, HIGHLY FRACTURED
H	SILTY CLAY, VERY DARK GRAYISH BROWN (10 YR 3/2), DRY, STIFF, TRACE PEBBLES OF UNDERLYING ROCK
I	SILTY SAND, DRY, STIFF, COARSE-GRAINED SAND, SOME ANGULAR SILTSTONE CLASTS (DEEPLY WEATHERED/DISRUPTED BEDROCK)
J	BRECCIATED SILTSTONE (UNIT G), DILATED FRACTURES, SHEAR FOLIATIONS, SUBPARALLEL TO MAIN SHEAR AT STATION 0+39
K	BRECCIATED AGGLOMERATE (UNIT C), DEEPLY WEATHERED
L	AGGLOMERATE, DARK YELLOWISH ORANGE (10 YR 6/6), MODERATELY WEATHERED, HIGHLY TO MODERATELY FRACTURED, TUFF CLASTS, TUFFACEOUS MATRIX, OCCASIONAL BASALT CLASTS, STRONG
M	AGGLOMERATE, GRAYISH ORANGE (10 YR 7/4), MODERATELY WEATHERED SAME AS UNIT L WITH PREDOMINATELY BASALT COBBLES (SONOMA VOLCANICS)
N	TUFF, BLUISH WHITE (5 B 9/1), MODERATELY WEATHERED, WEAK, HIGHLY FRACTURED, THINLY BEDDED (SONOMA VOLCANICS)
O	TUFF, YELLOWISH GRAY (5Y 7/2), FRESH TO MODERATE BROWN (5 YR 5/2), WEATHERED, STRONG, MODERATELY FRACTURED (SONOMA VOLCANICS)

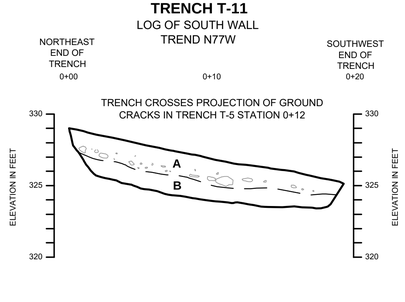
TRENCH T-9
LOG OF SOUTH WALL
TREND N74W



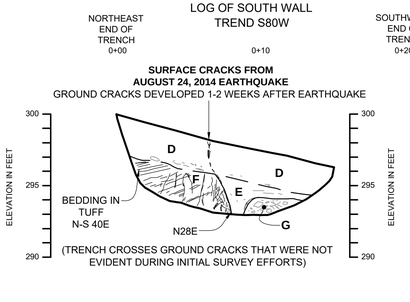
TRENCH T-10
LOG OF SOUTH WALL
TREND S40W



TRENCH T-11
LOG OF SOUTH WALL
TREND N77W



TRENCH T-12
LOG OF SOUTH WALL
TREND S80W



T-9 THROUGH T-12 EXPLANATION

———	GROUND SURFACE AND BOTTOM OF TRENCH
— —	GEOLOGIC CONTACT, SOLID WHERE SHARP, DASHED WHERE GRADATIONAL
A	SILTY CLAY, DARK GRAY-BROWN (10 YR 4/2), DRY, STIFF, SOME ANGULAR GRAVEL UP TO 12 INCHES, ABUNDANT ROOTS
B	TUFF, LIGHT BLUEISH GRAY (5 B 7/1), MODERATELY WEATHERED, STRONG, MODERATELY FRACTURED
C	TUFF, PINKISH GRAY (5 YR 8/1) FRESH TO MODERATE ORANGE PINK (5 YR 8/4) MODERATELY WEATHERED, MODERATELY STRONG, HIGHLY FRACTURED
D	SILTY CLAY, DARK YELLOW-BROWN (10 YR 4/4), DRY, STIFF, TRACE PEBBLES
E	SILTY CLAY, DARK REDDISH BROWN (5 YR 3/4), MOIST, VERY STIFF, BLOCKY PED STRUCTURE
F	TUFF, GRAYISH ORANGE PINK (10 R 8/2) SLIGHTLY WEATHERED, WEAK TO MODERATELY STRONG, OCCASIONALLY TO MODERATELY FRACTURED, ROUNDED PEBBLES OF ANDESITE AND PUMICE (SONOMA VOLCANICS)
G	SANDY CLAY WITH GRAVEL, YELLOWISH RED (5 YR 6/4), DRY, STIFF, ANGULAR TUFF FRAGMENTS (COLLUVIUM)

FAULT TRENCH LOGS
TRENCH T-7
THROUGH T-12

NAPA OAKS

OLD SONOMA ROAD AND
CASSWALL STREET
NAPA, CALIFORNIA
FOR
DAVIDON HOMES

Berlogar Stevens & Associates
SOIL ENGINEERS * ENGINEERING GEOLOGISTS

DRAWN BY: CC
DATE: 12-16-14
JOB NUMBER: 3280.002

APPENDIX

Pedochronological Report by Soil Tectonics

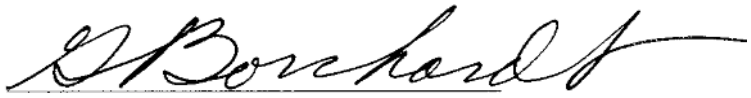
APPENDIX A

PEDOCHRONOLOGICAL REPORT FOR THE NAPA OAKS SUBDIVISION, NAPA, CALIFORNIA

Prepared for Berlogar Stevens & Associates, Pleasanton, California

2014-11-06

Soil Tectonics
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INTRODUCTION

An assessment of seismic and landslide risk due to ground movement can be aided greatly by the techniques of pedochronology (Borchardt, 1992, 1998), soil dating. This is because the youngest geological unit overlying fault traces is generally a soil horizon. The age and relative activity of ground movement often can be estimated by evaluating the age and relative disturbance of overlying soil units, as well as buried soils called paleosols. Terms, prefixes, and suffixes are defined in the Soils Glossary at the end of this report.

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

METHOD

The first step in studying a soil is the compilation of the data necessary for describing it (Birkeland, 1999; Borchardt, 2010). At minimum, this requires a Munsell color chart, hand lens, acid bottle, and instruments for 1:1 soil:water pH and conductivity measurements. The second step may involve collecting samples of each horizon of the soil profile column for laboratory analysis of particle size. This is done to check the textural classifications made in the field and to evaluate the genetic relationships between horizons and between different soils in the

landscape. When warranted, the clay mineralogy and chemistry of the soil also is analyzed to provide additional information on the changes undergone by the initial material from which the soil weathered. The last step is the comparison of this accumulated soil data with that for soils having developed under similar conditions, preferably in the same region. Such information is scattered in soil survey reports (e.g., Welch, 1981), soil science journals, and consulting reports. In a particular locality, there is seldom enough comparative data available for this purpose. That is why, at the very least, the study of one soil profile always makes the evaluation of the next that much easier.

RESULTS OF THIS EVALUATION

In this study I evaluated soils along two subparallel traces of the West Napa fault at the proposed Napa Oaks Subdivision: 1) the eastern trace and 2) the western trace. The eastern trace experienced surface fault rupture (SFR) during the M6.0 event of August 24, 2014. The western trace did not.

EASTERN TRACE

The SFR along this trace varied from a few millimetres of extension to as much as 6 cm of horizontal (near trench T-6) and 13 cm of vertical offset (near trench T-1, Figure 1). Trench T-1, excavated perpendicular to the SFR, showed that the A horizon was offset down to the east by about 12-cm along with significant extension occurring in the Bt horizon below (Figure 2).

Soil Profile No. 1

This profile was described at station 100', a meter to the east of the fissure that was produced by the SFR at station 103' (Table 1).

Modern Soil

The modern (historically active) soil at this site has a 20-cm thick brown loam A horizon with the medium strong granular structure with many fine continuous random tubular pores and many fine to medium spherical interstitial pores typical of nearly all the younger soil horizons at Napa Oaks. Beneath this is a 44-cm thick dark yellowish brown (10YR3/4m) gravelly clay loam Bt1 horizon with many medium thick clay films coating and bridging sand grains and clasts and lining pores. Although the colors appear typical of Holocene soils, much of the clay appears to have been inherited via mixing from the underlying horizons representing a relict paleosol that was formed as part of a previous landscape and climate much wetter than the present.

Relict Paleosol

The Bt2 horizon from the 64 to 79 cm depth is a dark reddish brown (5YR3/4m) gravelly silty clay loam with strong granular to subangular blocky structure and many medium thick to thick clay films coating and bridging sand grains and clasts and lining pores (Figure 3).

The Bt horizon of Soil Profile No. 1 was interrupted by a wavy clay lamella (see glossary) designated the Bt3 horizon (Figure 4 and Figure 5). Bands of clay like this have been

observed in the lower portions of sandy Holocene soils (see the "Clay lamellae references). They seem to be "micro-Bt" horizons that form as the wetting front rises within the soil under a drying climate. Thus, the transition from the wet Pleistocene to the dry Holocene climate in California appears ideal for their formation. Here the single clay lamella at the 80-cm depth may have been a response to that transition at 10 ka.

Another roughly horizontal feature existed immediately west of the described profile at a depth of 92 to 97 cm (Figure 4). The characteristics of this material indicate that it may be the lower portion of a paleo soil tongue formed during the penultimate earthquake (Table 1). Of particular note is that it has 7.5YR color and only a "few thin clay films lining pores," while the horizons above and below have 5YR colors and medium thick to thick clay films (Figure 6). Charcoal from this material might offer a date for the major event prior to our recent M6.0 earthquake of August 24. Unfortunately, no charcoal was found upon cursory examination.

Within Soil Profile No. 1 itself, the Bt4 horizon at 80-97 cm was, as mentioned, a reddish brown (5YR4/3m) gravelly silty clay loam with fine strong granular to subangular blocky structure and many medium thick to thick clay films coating and bridging sand grains and clasts and lining pores. Note that the two sides of the trench have a significant difference, with the north wall having a remnant of a strong angular blocky to prismatic paleosol (2Btb1) (Figure 7, Table 1). The presence of such a strong dark reddish brown (5YR3/3) clay paleosol at the 56-cm depth is another indication that Holocene soil development mostly has not had an influence below the 56 or 60 cm depth.

Soil Profile No. 2

This profile was described at station 106', a meter to the west of the fissure that was produced by the SFR at station 103' (Figure 9, Table 1).

The 20-cm thick A horizon was brown (10YR4/3m) loam with fine to coarse strong granular structure.

Relict Paleosol

The underlying 20-cm thick horizon was dark reddish brown (5YR3/2m) subrounded cobble to 8 cm with silty clay loam matrix with few fine to medium faint mangans and many medium thick to thick clay films on clasts. The underlying 14-cm thick dark reddish gray (5YR4/2m) silty clay loam was a 3Btb2 horizon that also had many medium thick to thick clay films. Beneath this was a reddish brown (5YR4/4m) 4Btb3 horizon from 54 to 83 cm with subangular cobbles to 6 cm with few fine to medium faint mangans and loose structure. It also had many medium thick to thick clay films on clasts and lining pores. The bottom horizon was a 4Crtb3, which had reddish brown (5YR4/3m) angular interlocking joints in tuffaceous bedrock with few fine faint mangans in a silty clay loam matrix to 160 cm. Like the other reddish brown horizons, this one had many medium thick to thick clay films.

Soil pH and Conductivity

Soil pH is provided as part of a proper soil description. Unweathered bedrock, such as the tuff at Napa Oaks, normally has a pH generally around neutral. Thus, in a preliminary study at Napa Oaks, the relatively unweathered light brownish gray (2.5Y6/2m, 7/2d) tuff sampled at 100-200 cm in trench T-1 near Casswall Street had a pH of 6.7 (Sample No. 98B043, Borchardt, 1998, p. A-6). However, acid rainfall and subsequent leaching at well-drained sites generally causes soil pH to drop over time—that is one indication that we are dealing with soil rather than bedrock. In this respect, both Soil Profile Nos. 1 and 2 were very acid, with the pH decreasing with depth (Figure 10). Soil Profile No. 1 on the east side of the eastern trace was not as acid as Soil Profile No. 2 on the western side of the trace. The pH is compatible with the observation that uplift on the west caused older, redder, more acid horizons to be exposed nearer the surface. As in the pH analyses, the conductivity measurements demonstrated significant differences across the fault trace (Figure 11). In particular, the conductivity at the top and bottom of Soil Profile No. 1 was higher than the other horizons. The reddish brown paleosol remnant in trench T-12 that I used for soil calibration had a similarly low pH (4.2), and had the lowest conductivity of all (Table 1, Sample 14B126).

Soil Age Calibration

As mentioned above, the paleosol remnant in trench T-1 represents the best developed, oldest soil at the site (Figure 8). It had medium thick to thick clay films and 5YR colors. In California, 5YR colors are typical of soils that are older than 100,000 years. The best developed and presumably the oldest soil at Napa Oaks was the 2Btb horizon of a paleosol remnant beneath the 70-cm thick colluvium in trench T-12 (Figure 8). It had dark reddish brown (5YR3/3m, 4/4d) clay with medium strong angular blocky structure and many medium thick to thick clay films. It had an extremely low pH of 4.2 and conductivity of only 20 uS (Table 1)—properties typical of ancient soils. The pH decreases dramatically as a result of acid rainfall and extensive leaching, which also results in the low soluble salt contents indicated by the low conductivity. Remnants of a similar reddish brown soil were observed in a previous study and were deemed to be at least 80 ka (Borchardt, 1998c). Ventura River terraces start having 7.5YR colors after 38 ka, but did not have 5YR colors until after 80 ka (Rockwell and others, 1985, p. 317).

To put this in context, a 7-ka soil developed in similar material from the eruption of Mt. Mazama (Borchardt, 1970) had only yellowish colors and no clay film development (Figure 12), much like the unweathered tuff of the Sonoma Volcanics at Napa Oaks. Like the Mazama soil, most of the colluvium at the Napa site exhibits little soil development with 10YR colors and few, if any, clay films. As seen along the Foothills of the western Sierra, the existing 130-ka soil seems to have been severely eroded during the Pleistocene-Holocene climatic transition (Borchardt and others, 1980). Similarly, there seems to be no evidence that the Sonoma Volcanics underwent more than one such transition. The base of the colluvium and derived alluvium in the Foothills was dated at 10 ka, just like the alluvium derived from the Sonoma Volcanics near the Cordelia fault (Wright and others, 1994; Gilpin and others, 1999; Borchardt,

2004). The upshot is that I estimate that remnants of the reddish brown paleosol at Napa Oaks began to form after the penultimate glacial-interglacial transition about 130,000 years ago.

Soil Ages and Paleoseismology

Soil Profile No. 1 provides evidence for both Holocene and Pleistocene soil development in Trench T-1. The dark 10YR colors extending to 56 cm are contained within the vertical offset that has occurred along this eastern trace since 10 ka. Soil Profile No. 2, on the other hand, has dark 10YR colors extending only to 20 cm. The difference: 36 cm, apparently represents the total amount of vertical offset at this point along the eastern trace during the Holocene (0.036 mm/yr). The various upper horizons on the western side of the eastern trace show signs of local transport, with only the 4Crtb3 horizon in the lower half of the profile being relatively stable. Had the uplift been much more significant, this 130-ky horizon would not exist on this side of the fault at all—it would have eroded away. At 0.036 mm/yr, it would be 4.68 m higher than it is now and thus would not have any of the 5YR colors and thick clay films that it has now.

The upshot of the above analysis is that the westerly uplift observed along this trace is mostly a result of horizontal topographic offset rather than of significant ongoing vertical movement. Apparently, this is why there is no obvious up on the west scarp along this eastern trace.

WESTERN TRACE

The western trace was studied where it crossed the western end of trench T-6. Soil Profile No. 3 was developed in a channel fill above the western trace. Although there were remnants of slightly older channel fills to the east and west, Soil Profile No. 3 represented the youngest complete section over a prominent offset in the underlying clayey bedrock.

The surface consists of a 25-cm thick very dark grayish brown silty clay loam ABt horizon with strong granular to subangular blocky structure and common thin clay films on peds and lining pores (Table 2, Figure 13). Note that this is rather unusual in that A and AB horizons normally do not have clay films. It is possible that the true A horizon was removed during grading or sheet erosion. Beneath this was a 25-cm thick dark brown silty clay loam Bt horizon with common thin clay films on peds and lining pores. The top of the next horizon seems to have been partially eroded away.

The eroded section has a 5-cm thick grayish brown silty clay 2Btb1 horizon with many medium thick clay films (Figure 14). It has an abrupt wavy boundary and appears to be an eroded remnant of a correlative paleosol that is about 20’ to the west. That 16-cm thick 2Btb1 horizon was a dark grayish brown clay with medium strong angular to subangular blocky structure and many medium thick to thick clay films. The underlying horizon was a 90-cm thick grayish brown clay loam 2BCt1b1 with many fine to medium prominent dark brown mottles due to many medium thick to thick clay films lining pores (Figure 15). The underlying 99-cm thick horizon was a dark brown clayey sand 2BCt2b1 with common thin to medium thick clay films lining pores. A vertical fissure in this horizon (Figure 16) contained dark brown silty clay with very fine weak vertically oriented platy structure and common thin to medium thick clay films.

The underlying horizon at 244-305 cm was dark grayish brown sand 3CBtb1with a few fine faint brownish yellow mottles due to iron oxides. It had a few thin to thick clay films lining pores. Beneath this was a grayish brown gravelly sand 4CBtb1 horizon at 305-374 cm. It had common fine to medium distinct brownish yellow mottles due to iron oxides.

Finally, the above upward fining sequence was underlain by a grayish brown (2.5Y5/2m) clay 5CBb2 horizon at 374-440+ cm. It had many fine to medium prominent brownish yellow mottles due to iron oxides with rare fine continuous random tubular pores and medium calcite filaments (Figure 17). Of particular notice was a prominent east dipping shear about 4' to the east at station 345 (Figure 18). The soil on the other side of the shear was a light olive gray (5Y6/2m) clay 5Cb2 horizon, also at a depth of 374-440+ cm. Although it had a few rare medium thick clay films lining pores, it had none of the iron oxide mottles found in the 5CBb2 horizon on the other side of the shear.

Soil pH and Conductivity

Like the profiles along the eastern trace, this one had low pHs, with the upper two horizons being extremely acid even though they otherwise have the dark colors and thin clay films characteristic of young soils (Figure 19). Of special note is the fact that the pH of the thicker phase of the 2Btb1 at station 370' was 5.7 instead of 5.2 like that within Soil Profile No. 3 itself. A similar effect was noted for the conductivity measurements, for which the 2Btb1 at station 370' was 630 uS instead of 195 uS like that within Soil Profile No. 3 itself (Figure 20). A similar effect occurred for measurements from the vertical fissure discovered in the 2BCt2b1 horizon (Sample No. 14B135b, Table 2 and Figure 19 and Figure 20). In this case, soil that was not fissured was clayey sand, while the soil in the fissure itself was silty clay. All of this follows a general pattern in soil horizons having extra clay (see also the base of Soil Profile No. 1, Figure 11). In other words, clays tend to trap constituents that otherwise would leach from the profile.

Soil Age Calibration

For the most part, primary age determinants in soils, such as clay films and extremely low pHs, are absent in Holocene soils of California. Soil Profile No. 3, however, had both characteristics even in the upper horizons (Table 2; Figure 19). In particular, medium thick to thick clay films (Figure 15) exist in the profile at depths as great as 305 cm (Table 2). However, it is well known that the addition of clays and fine silts to the surface of soils via wind (Borchardt and others, 1968) or alluviation affords the opportunity for extraordinary clay illuviation into coarse underlying parent materials. This seems to be the case in Soil Profile No. 3.

The presence of the extra thick clayey 2Btb1 horizon only 20' west of the profile (Figure 21) suggests that much of the clay in the profile was inherited from material washed down from the landslide along the Domengine sandstone slope to the west (Figure 22). Cursory examination of the material below the horizon showed very few clay films like those coating peds and lining

pores in the horizons beneath the thin version of the 2Btb1 in Soil Profile No. 3 itself (Figure 22).

Nonetheless, clay illuviation to depths much greater than a meter in northern California normally is considered an indication of climatic conditions much wetter than at present. Where not blocked by an extra thick, intervening clay layer, water carrying highly acid clay in suspension was able to penetrate the relatively porous channel fill to depths over 3 m (Table 2). Very likely, this occurred during the Pleistocene when precipitation in California was two to three times greater than during the Holocene (McFadden, 1982). The ideal time for the deep cutting reflected in the presence of the channel fill occurred at about 22 ka. This was when the base level for drainage in the area would have been at its lowest point during the last glacial maximum. Sea level then was about 120 m lower than at present, with San Francisco Bay being completely empty at that time. Trench T-6 is only 2.6 km from the Napa River, which also would have been cutting a deep channel to the ancestral Sacramento River at that time. The channel overlying bedrock in our trench would have rapidly filled as base level rose with increasing sea level and the flooding of San Francisco Bay. Consistent upward fining in the section shows there were no interruptions in the filling process. Also, the fact that there were no deeper cuts in the bedrock implies that this channel was cut in response to changes in base level produced by the late Wisconsin glaciation, which produced the greatest drop in sea level during the Pleistocene.

Soil Ages and Paleoseismology

As mentioned above, the alluvial section above the western trace is estimated to have been deposited after 22 ka (Table 2). Although there is obvious shearing between the two units of the underlying clay bedrock, no clear offset has been identified in the contact with the overlying cobbly alluvium. The fissures (e.g., Figure 16) within the channel fill described in Soil Profile No. 3 show no vertical offset, although some horizontal motion cannot be ruled out. The charcoal sampled at station 553' within the 4CBtb1 horizon should be slightly less than 22 ka. The upshot of the above analysis is that the western trace has had no significant SFR during the last 22,000 years.

CONCLUSIONS

1. At the proposed Napa Oaks Subdivision, almost all of the offset due to the West Napa fault occurs along the eastern trace, which had SFR during the M6.0 earthquake of August 27, 2014.
2. The oldest soil on the site is the 130,000-year old reddish brown paleosol in trench T-12.
3. The channel fill above the western trace of the West Napa fault is about 22,000 years old and has not experienced significant SFR during that time.
4. The western trace experienced over a meter of offset within clayey bedrock before 22,000 years ago.

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Table 1. Description of Soil Profile Nos. 1 and 2 excavated across the surface fault rupture (SFR) that occurred during the M6.0 event of August 24, 2014 on the West Napa fault at the proposed Napa Oaks development south of Old Sonoma Road, Napa, California. These were studied to assess the age of the soil one meter east and one meter west of the SFR. Abbreviations and definitions are given in Schoeneberger and others (2012) and Soil Survey Staff (1993, 1999, 2010).

Description of soils developed in colluvium and bedrock of the Sonoma Volcanics by Glenn Borchardt, who measured and sampled the soils on October 21, 2014 at latitude N38.28564^{o} and longitude W122.31565^{o} at stations 100' and 106' in the south wall of Trench T-1 at an elevation of 298' Google Earth (325' GPS). Mediterranean climate with mean annual precipitation of 23.03"/yr at Napa (1948-1965). Slope 5^{o}. Aspect west. Excellent drainage. Water table deep. The parent material is colluvium over welded tuff of the Sonoma Volcanics. Soil pH is medium acid in the surface, becoming strongly to extremely acid in the subsurface. Soil in the area is mapped as: *Forward (61 cm) and Kidd (36 cm) complex, Typic and Lithic Vitrandepts, 50-75% slopes.*

Horizon Depth, cm Description

Soil Profile No. 1

One Meter East of Surface Fault Rupture

A 0-20 Brown (10YR4/3m, 5/3d) loam; medium strong granular structure; slightly sticky and slightly plastic when wet, firm when moist, and very hard when dry; common fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; peds have repellent surfaces; clear smooth boundary; pH 5.7; conductivity 330 uS; Sample No. 14B111.

B 20-64 Dark yellowish brown (10YR3/4m, 5/3d) gravelly clay loam; fine to coarse strong granular to subangular blocky structure; sticky and plastic when wet, friable when moist, and very hard when dry; common fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; peds have repellent surfaces; many medium thick clay films coating and bridging sand grains and clasts and lining pores; gradual wavy boundary; pH 5.2; conductivity 150 uS; Sample No. 14B112.

*ESTIMATED AGE:	t_o	=	10	ka
	t_b	=	0	ka
	t_d	=	10	ky

Bt1 64-79 Dark reddish brown (5YR3/4m, 6/2d) gravelly silty clay loam with many coarse distinct yellowish red (5YR5/6m, 6/6d) mottles on clasts; fine to coarse strong granular to subangular blocky structure; very sticky and very plastic when wet, very friable when moist, and very hard when dry; few fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; many medium thick to thick clay films coating and bridging sand grains and clasts and lining pores; very abrupt wavy boundary; pH 5.1; conductivity 165 uS; Sample No. 14B113.

Bt2 79-80 Dark reddish brown (5YR3/4m, 6/4d) silty clay lamella; fine strong granular to subangular blocky structure; very sticky and very plastic when wet, very friable when moist, and very hard when dry; very few very fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; many medium thick to thick clay films coating and bridging sand grains and lining pores; very abrupt wavy boundary; pH 5.2; conductivity 170 uS; Sample No. 14B114.

Bt3 80-97 Reddish brown (5YR4/3m, 6/4d) gravelly silty clay loam with common medium distinct yellowish red mottles on clasts; fine strong granular to subangular blocky structure; very sticky and very plastic when wet, very friable when moist, and very hard when dry; very few very fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; many medium thick to thick clay films coating and bridging sand grains and clasts and lining pores; abrupt irregular boundary; pH 5.2; conductivity 170 uS; Sample No. 14B115.

3Btb2 97-120 Dark reddish brown (5YR3/3m, 5/3d) silty clay loam matrix (5%) in fractured bedrock (95%); fine moderate granular to subangular blocky structure; very sticky and very plastic when wet, very friable when moist, and soft when dry; very few very fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; many thick clay films coating and bridging sand grains and clasts and lining pores; pH 5.4; conductivity 450 uS; Sample No. 14B116.

*ESTIMATED AGE:	t_o	=	130	ka
	t_b	=	10	ka
	t_d	=	120	ky

Horizontal fissure fill:

Soil tongue 92-97 Dark brown (7.5YR4/4m, 6/4d) gravelly silty clay loam; fine to medium moderate subangular blocky to granular structure; very sticky and very plastic when wet, very friable when moist, and very hard when dry; very few very fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; few thin clay films lining pores; abrupt smooth boundary; pH 4.4; conductivity 420 uS; Sample No. 14B117.

*ESTIMATED AGE:	t_o	=	1	ka
	t_b	=	**0**	ka
	t_d	=	1	ky

Paleosol on the north wall:

2Btb1 56-72 Dark reddish brown (5YR3/3m, 5/3d) clay with common fine distinct white mottles due to tuffaceous sand grains; medium strong angular blocky to prismatic structure; very sticky and very plastic when wet, firm when moist, and extremely hard when dry; very few very fine roots; many fine continuous random tubular pores; many medium thick to thick clay films coating and bridging sand grains and clasts and lining pores; pH 4.9; conductivity 300 uS; Sample No. 14B118.

*ESTIMATED AGE:	t_o	=	130	ka
	t_b	=	10	ka
	t_d	=	120	ky

Soil Profile No. 2

One Meter West of Surface Fault Rupture

A 0-20 Brown (10YR4/3m, 5/3d) loam; fine to coarse strong granular structure; slightly sticky and slightly plastic when wet, firm when moist, and very hard when dry; common fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; clear smooth boundary; pH 4.9; conductivity 140 uS; Sample No. 14B121.

*ESTIMATED AGE:	t_o	=	10	ka
	t_b	=	**0**	ka
	t_d	=	10	ky

2Btb1 20-40 Dark reddish brown (5YR3/2m, 6/3d) subrounded cobble to 8 cm with silty clay loam matrix with few fine to medium faint mangans; fine strong granular structure; sticky and plastic when wet, very friable when moist, and very hard when dry; common very fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; many medium thick to thick clay films on clasts; clear smooth boundary; pH 4.7; conductivity 80 uS; Sample No. 14B122.

*ESTIMATED AGE:	t_o	=	40	ka
	t_b	=	10	ka
	t_d	=	30	ky

3Btb2 40-54 Dark reddish gray (5YR4/2m, 5/2d) silty clay loam; fine strong granular to medium weak subangular blocky structure; sticky and plastic when wet, very friable when moist, and very hard when dry; many very fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; many medium thick to thick clay films on clasts and lining pores; clear smooth boundary; pH 3.6; conductivity 120 uS; Sample No. 14B123.

*ESTIMATED AGE:	t_o	=	80	ka
	t_b	=	40	ka
	t_d	=	40	ky

4Btb3 54-83 Reddish brown (5YR4/4m, 6/4d) subangular cobbles to 6 cm with few fine to medium faint mangans; loose structure; matrix sticky and plastic when wet, very friable when moist, and extremely hard when dry; many very fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; many medium thick to thick clay films on clasts and lining pores; clear smooth boundary; pH 3.5; conductivity 130 uS; Sample No. 14B124.

4Crtb3 83-160 Reddish brown (5YR4/3m, 6/6d) bedrock with angular joints with few fine faint mangans and 5% silty clay loam matrix in joints; loose structure; matrix sticky and plastic when wet, very friable when moist, and extremely hard when dry; few very fine roots; many fine continuous random tubular pores and many fine to medium spherical interstitial pores; many medium thick to thick clay films on clasts and lining pores; pH 3.7; conductivity 80 uS; Sample No. 14B125.

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

Paleosol remnant from T-12 used for calibration (Figure 8):

2Btb 70-90 Dark reddish brown (5YR3/3m, 4/4d) clay; medium strong angular blocky structure; very sticky and very plastic when wet, firm to friable when moist, and very hard when dry; many fine continuous random tubular pores; many medium thick to thick clay films coating peds and sand grains and lining pores; pH 4.2; conductivity 20 uS; Sample No. 14B126.

*ESTIMATED AGE:	t_o	=	130.0	ka
	t_b	=	10.0	ka
	t_d	=	120.0	ky

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

t_o = date when soil formation or aggradation began, ka

t_b = date when soil or strata was buried, ka

t_d = duration of soil development or aggradation, ky

Table 2. Description of Soil Profile No. 3 studied above the western fault trace in Trench T-6 at the southernmost end of the proposed Napa Oaks development south of Old Sonoma Road, Napa, California. Abbreviations and definitions are given in Schoeneberger and others (2012) and Soil Survey Staff (1993, 1999, 2010).

Description of soil developed in colluvium and bedrock of the Sonoma Volcanics by Glenn Borchardt, who measured and sampled the soil on October 27, 2014 at latitude N38.28229^{o} and longitude W122.31519^{o} at station 349' in the south wall of Trench T-6 at an elevation of 231' Google Earth (206' GPS). Mediterranean climate with mean annual precipitation of 23.03"/yr at Napa (1948-1965). Slope 8^{o}. Aspect west. Excellent drainage. Water table deep. The parent material is colluvium over clay of the Sonoma Volcanics. Soil pH is extremely acid in the surface, becoming strongly to medium acid in the Bt and very strongly acid at depth. Soil in the area is mapped as: *Forward (61 cm) and Kidd (36 cm) complex, Typic and Lithic Vitrandepts, 50-75% slopes.*

Horizon Depth, cm Description

Soil Profile No. 3

ABt 0-25 Very dark grayish brown (10YR3/2m, 6/2d) silty clay loam; fine to medium strong granular to subangular blocky structure; slightly sticky and slightly plastic when wet, very friable when moist, and extremely hard when dry; few very fine roots; many fine continuous random tubular pores and many medium spherical interstitial pores; common thin clay films on peds and lining pores; gradual smooth boundary; pH 4.4; conductivity 90 uS; Sample No. 14B131.

Bt 25-50 Dark brown (10YR4/2m, 6/2d) silty clay loam; fine to medium strong subangular blocky to granular structure; sticky and plastic when wet, very friable when moist, and extremely hard when dry; very few very fine roots; many fine continuous random tubular pores and many medium spherical interstitial pores; common thin clay films on peds and lining pores; clear wavy boundary; pH 4.4; conductivity 60 uS; Sample No. 14B132.

*ESTIMATED AGE:	t_o	=	10	ka
	t_b	=	0	ka
	t_d	=	10	ky

2Btb1 50-55 Grayish brown (10YR5/2m, 7/2d) silty clay; fine to medium strong subangular blocky structure; very sticky and very plastic when wet, very friable when moist, and extremely hard when dry; very few very fine roots; many fine continuous random tubular pores and many medium spherical interstitial pores; many medium thick clay films on peds and lining pores; abrupt wavy boundary; pH 5.2; conductivity 195 uS; Sample No. 14B133.

[Thicker paleosol horizon from station 370' to the west:

2Btb1 60-76 Dark grayish brown (10YR4/2m, 6/2d) clay with few fine to medium distinct pale brown (10YR6/3m, 7/3d) mottles; medium strong angular to subangular blocky structure; very sticky and very plastic when wet, very friable when moist, and very hard when dry; very few very fine roots; many fine continuous random tubular pores and many medium spherical interstitial pores; many medium thick to thick clay films on peds and lining pores; abrupt smooth boundary; pH 5.7; conductivity 630 uS; Sample No. 14B133b.]

2BCt1b1 55-145 Grayish brown (10YR5/2m, 7/2d) clay loam with many fine to medium prominent dark brown (10YR3/3md) mottles due to clay films in pores; fine to coarse strong subangular blocky structure; sticky and plastic when wet, firm when moist, and extremely hard when dry; many fine continuous random tubular pores and many medium spherical interstitial pores; many medium thick to thick clay films lining pores; abrupt smooth boundary; pH 5.0; conductivity 140 uS; Sample No. 14B134.

2BCt2b1 145-244 Dark brown (10YR3/3m, 7/2d) clayey sand; medium strong subangular blocky structure; sticky and plastic when wet, firm to friable when moist, and extremely hard when dry; many fine continuous random tubular pores and common medium spherical interstitial pores; common thin to medium thick clay films lining pores; clear wavy boundary; pH 5.0; conductivity 130 uS; Sample No. 14B135.

[From the fissure at station 350':

2BCt2b1 145-244 Dark brown (10YR3/3m, 7/2d) silty clay; very fine weak prismatic structure; sticky and plastic when wet, very friable when moist, and very hard when dry; many to common fine continuous random tubular pores; common thin to medium thick clay films lining pores; pH 5.2; conductivity 180 uS; Sample No. 14B135b.]

3CBtb1 244-305 Dark grayish brown (10YR4/2m, 7/2d) sand with few fine faint brownish yellow (10YR6/8md) mottles due to iron oxides; loose to medium weak subangular blocky structure; nonsticky and nonplastic when wet, loose to very friable when moist, and very hard when dry; few fine continuous random tubular pores; few thin to thick clay films lining pores; clear smooth boundary; pH 5.0; conductivity 200 uS; Sample No. 14B136.

4CBtb11 305-374 Grayish brown (10YR5/2m, 7/2d) gravelly sand with common fine to medium distinct brownish yellow (10YR6/8md) mottles due to iron oxides; loose to medium weak subangular blocky structure; nonsticky and nonplastic when wet, loose to very friable when moist, and very hard when dry; clear smooth boundary; pH 4.9; conductivity 150 uS; Sample No. 14B137. (Charcoal sample 14B140 from station 553'.)

*ESTIMATED AGE:	t_o	=	22	ka
	t_b	=	10	ka
	t_d	=	12	ky

5CBb2 374-440+ Grayish brown (2.5Y5/2m, 7/2d) clay with many fine to medium prominent brownish yellow (10YR6/8md) mottles due to iron oxides; massive structure; very and very plastic when wet, very friable when moist, and slightly hard when dry; very few fine continuous random tubular pores; rare medium calcite filaments; pH 5.3; conductivity 240 uS; Sample No. 14B138.

*ESTIMATED AGE:	t_o	=	30	ka
	t_b	=	22	ka
	t_d	=	8	ky

From Station 345 on other side of an east dipping shear:

5Cb2 374-440+ Light olive gray (5Y6/2m, 8/2d) clay; massive structure; very sticky and very plastic when wet, very friable when moist, and extremely hard when dry; very few fine continuous random tubular pores; very few medium thick clay films lining pores; pH 4.9; conductivity 140 uS; Sample No. 14B139.

*ESTIMATED AGE:	t_o	=	30	ka
	t_b	=	22	ka
	t_d	=	8	ky

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

t_o = date when soil formation or aggradation began, ka

t_b = date when soil or strata was buried, ka

t_d = duration of soil development or aggradation, ky



Figure 1. Surface fault rupture (SFR) produced by the M6.0 event of August 24, 2014 on the southern portion of the West Napa fault. This segment had both horizontal and vertical offset, with the west side being as much as 20 cm higher than the east side. SFR continued into trench T-1 at station 103'. View south.



Figure 2. SFR extending into the fractured tuff at station 103' in trench T-1 between Soil Profile Nos. 1 and 2. Note the extension represented by the vertical fissure in the A horizon of the soil and the separation between the rock fragments below. The yellow part of the handle of the pedological deobfuscator is 12 cm long. View south.



Figure 3. Soil Profile No. 1 at station 100', one meter east of the SFR in trench T-1. The dark, 10YR, color is typical of Holocene soils. View south.

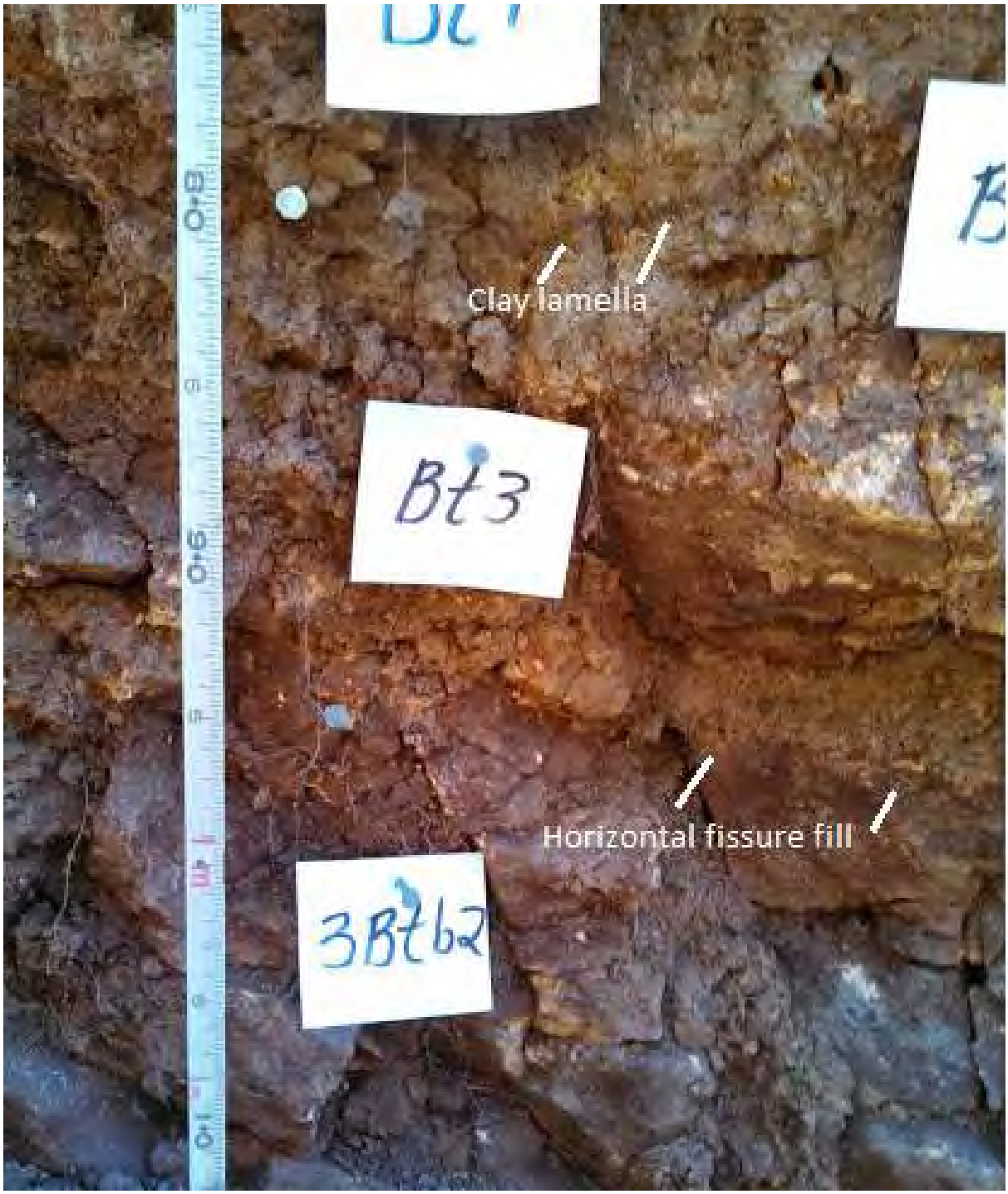


Figure 4. Lower portion of Soil Profile No. 1 one meter east of the SFR produced by the M6.0 event of August 24, 2014 M6.0 on southern portion of the West Napa fault. Trench T-1 at station 100'. Note the clay lamella at 80 cm and the horizontal fissure fill between 90 and 97 cm. View south.



Figure 5. Close up of the wavy cm-thick clay lamella in Soil Profile No. 1. View south.



Figure 6. Close up of the horizontal portion of the paleo soil tongue or fissure at the 92-97-cm depth east of the recent SFR. Note the loose granular nature of the soil in the fissure and the dark reddish clay films that coat the overlying and underlying tuff but not the soil tongue. View south. Sample 14B117 (Table 1).



Figure 7. Paleosol on the north wall opposite Soil Profile No. 1.



Figure 8. Paleosol remnant beneath the colluvium on the north wall of trench T-12. The 2Btb horizon between 70 and 90 cm was used for age calibration of the other soils. It had dark reddish brown (5YR3/3m) clay with strong angular blocky structure and many medium thick to thick clay films. These are soil properties typical soils in California that are at least 100,000 years old. Sample No. 14B126.

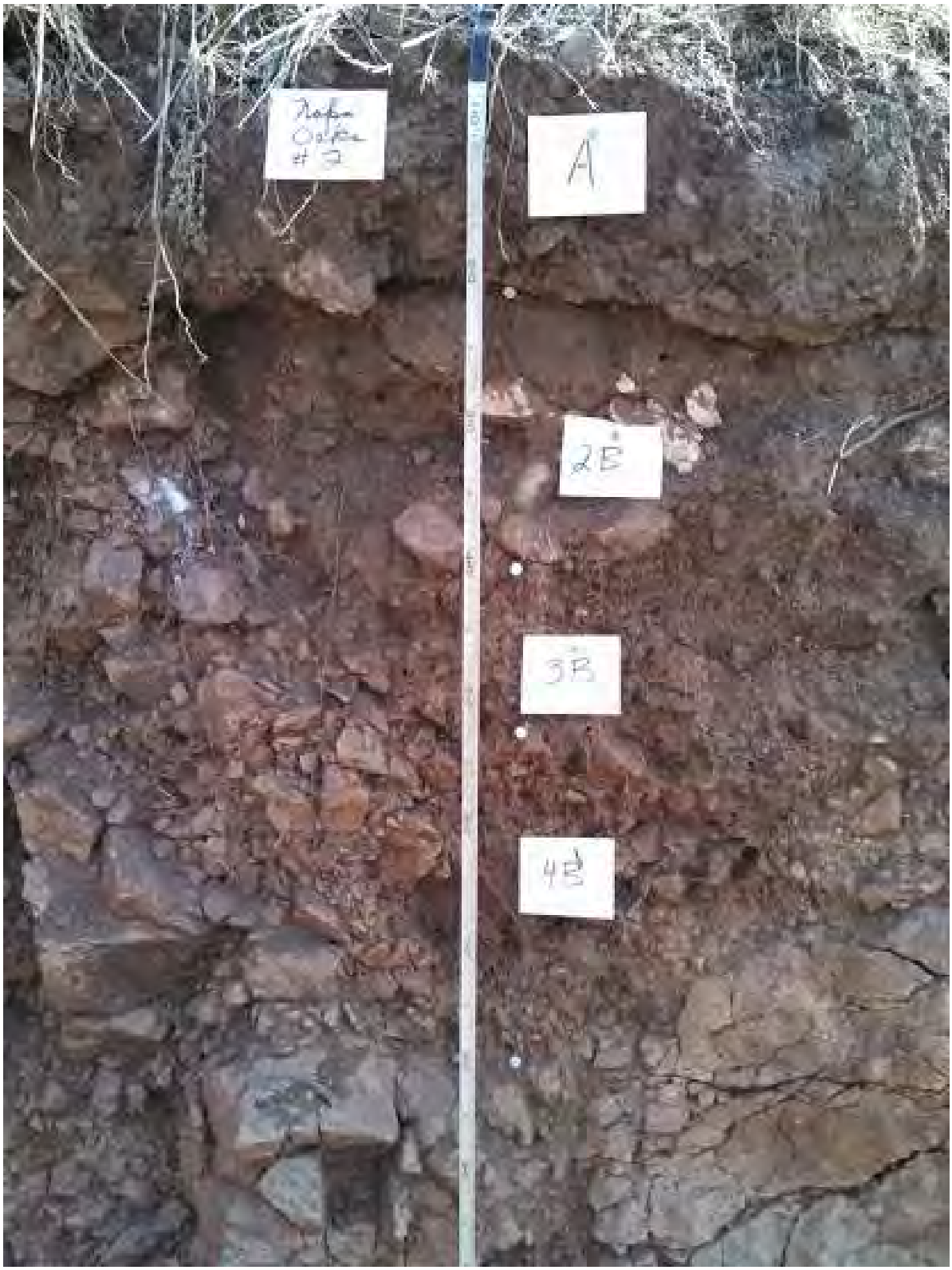


Figure 9. Soil Profile No. 2 showing soil development in shattered tuff of the Sonoma Volcanics one meter west of the SFR of the M6.0 earthquake of August 24, 2014. View south.

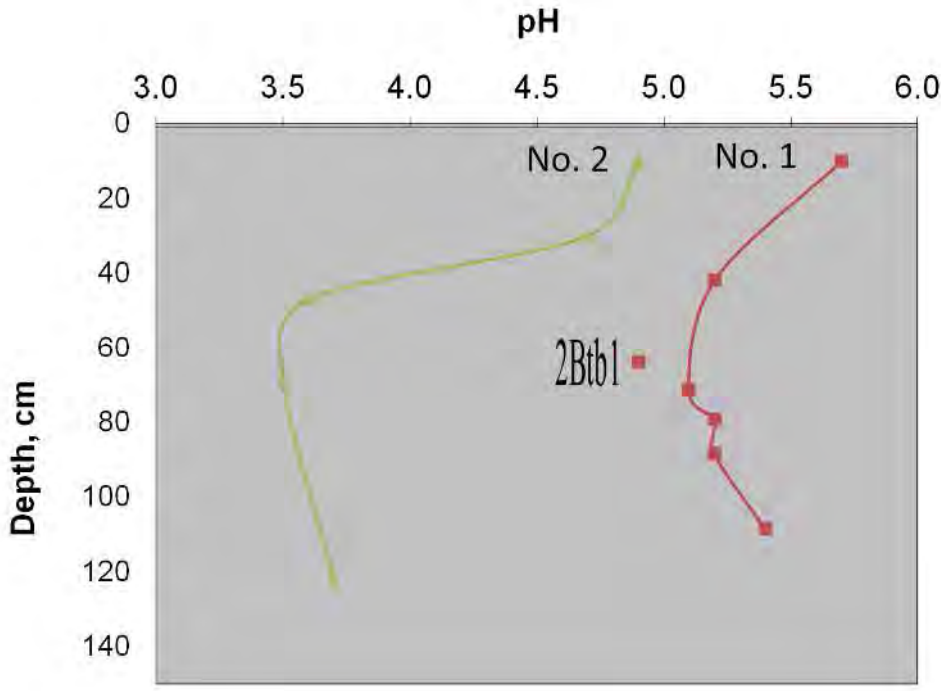


Figure 10. The pH in Soil Profile No. 2 west of the fault is much lower than it is in Soil Profile No. 1 east of the fault. The lone analysis to the left of No. 1 was for the 2Btb1 of the paleosol on the trench wall opposite Soil Profile No. 1.

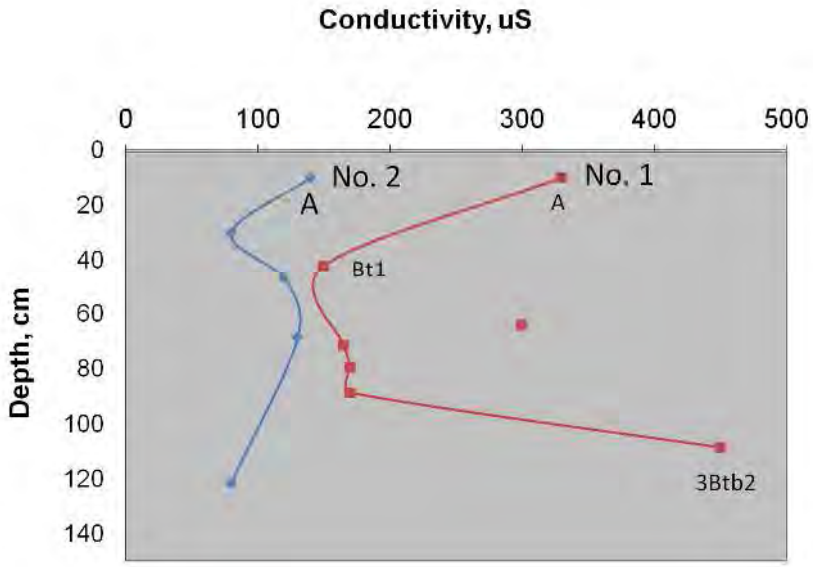


Figure 11. Soil conductivity (related to salt content) in Soil Profile Nos. 1 (east) and 2 (west) generally decreases with depth, with significant increases in the clayey 2Btb1 paleosol horizon on the north wall and in the 3Btb2 horizon of Soil Profile No. 1 east of the fault.



Figure 12. Soil profile developed on well-drained dacitic pumice in Oregon during the last 7,000 years.



Figure 13. Upper portion of Soil Profile No. 3 developed in the gully fill overlying the western trace. View south.



Figure 14. Upper two thirds of Soil Profile No. 3 developed in the gully fill overlying the western trace. The paleosol to the right of the tape was formed in an early channel fill that was removed by the channel represented by the material to the left of the tape. View south.



Figure 15. Medium thick to thick dark clay films on peds in the 2BCt1b1 horizon of Soil Profile No. 3. The upper right ped has a horizontal width of 2 mm.



Figure 16. Fissure in the 2BCt2b1 horizon between the 145 to 244-cm depths. It contains dark brown silty clay with very fine weak prismatic structure and common thin to medium thick clay films. Nail at bottom for scale. View south.

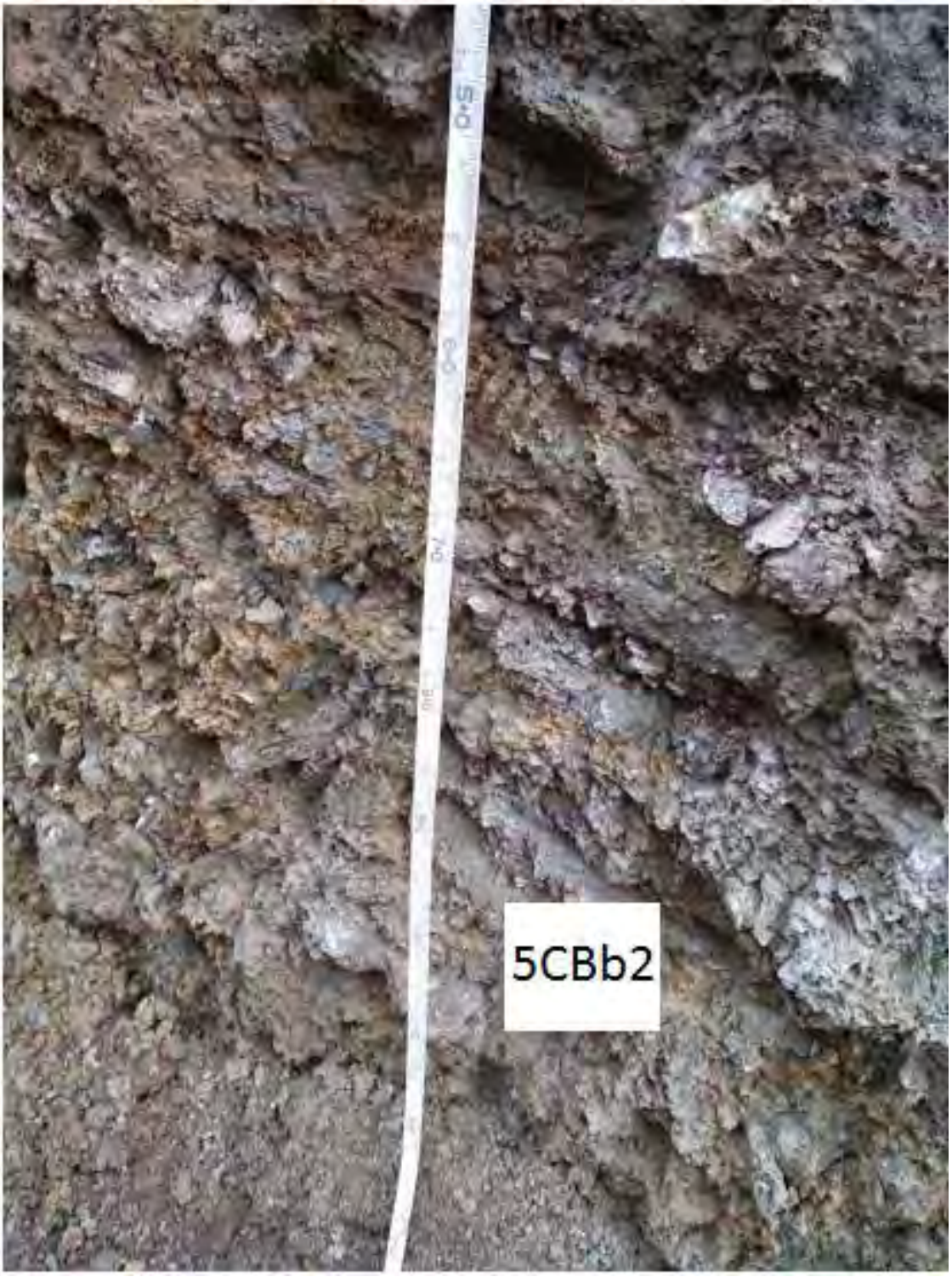


Figure 17. Eroded paleosol at the base of Soil Profile No. 3 developed in a clayey unit within the Sonoma Volcanics. The yellowish colors are iron oxide stains. View south.

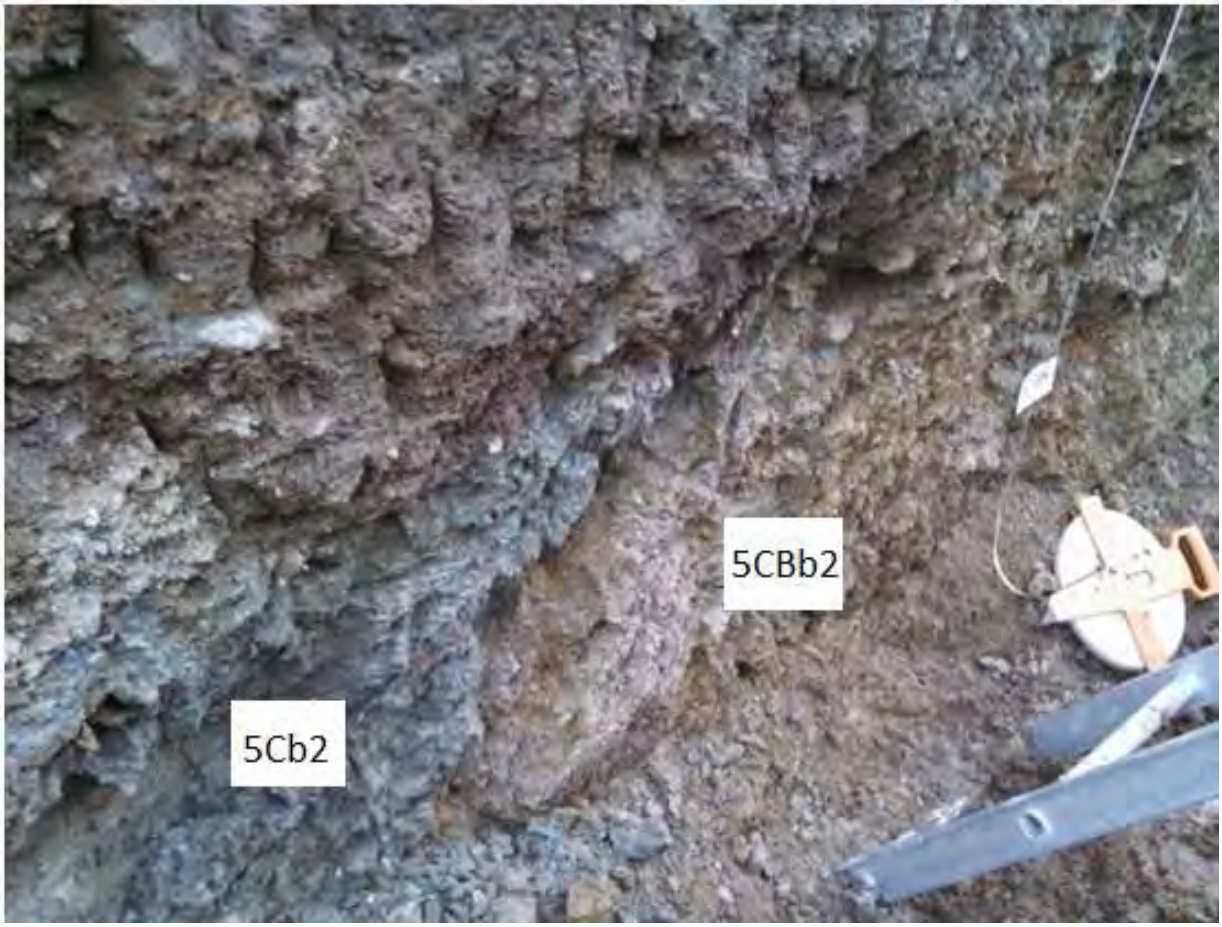


Figure 18. Fault contact between the unweathered 5Cb2 horizon and the slightly weathered 5CBb2 horizon. The overlying alluvial unit (rounded clasts) appears to have little, if any, offset despite the presence of what may be a few tectonic shears in the gully fill above. Soil Profile No. 3 was studied along the tape to the right. View SSW.

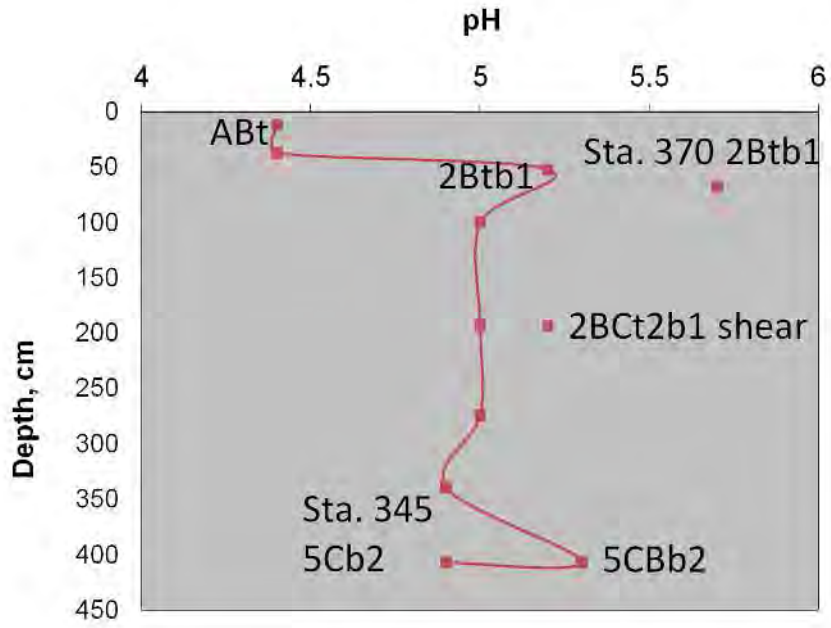


Figure 19. The pH in Soil Profile No. 3 along the western trace of the fault is much lower than might be expected for Holocene soil.

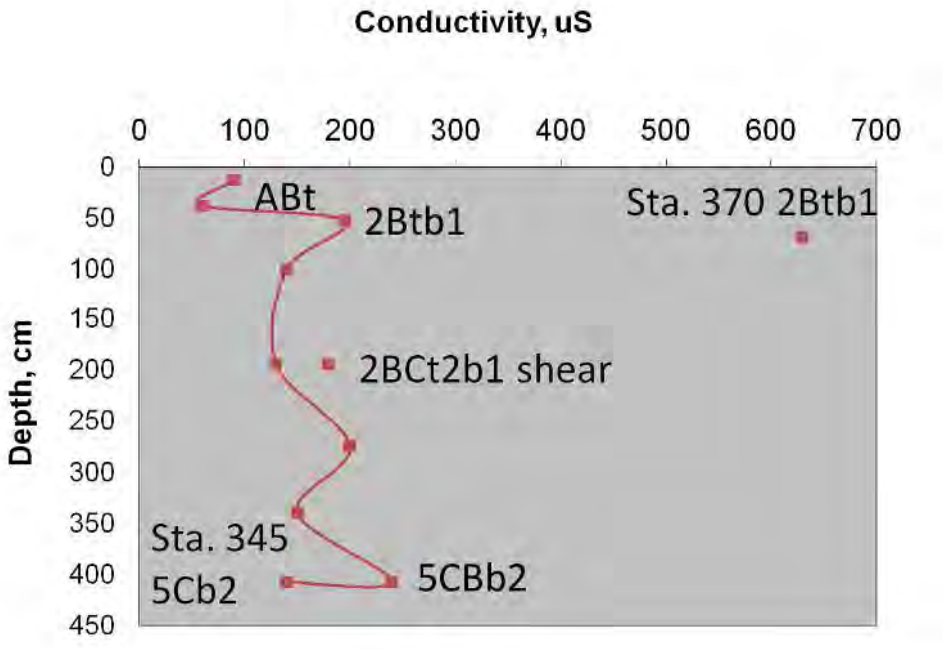


Figure 20. Soil conductivity in Soil Profile No. 3 along the western trace of the fault reflecting the porous nature of the channel fill. The thick clayey 2Btb1 paleosol at station 370' about 20' to the west had a relatively high salt content. In addition, it appeared to have very few clay films in the horizons beneath it.



Figure 21. The clayey 2Btb1 horizon about 20’ west of Soil Profile No. 3. This much thicker version of the 2Btb1 horizon in the profile apparently was inherited via deposition from the eroded landslide on the Domengine Sandstone to the west (Figure 22). View south.



Figure 22. The clayey 2Btb1 horizon of Figure 21 extends westerly, becoming even thicker over the landslide eroded from the Domengine Sandstone at the foot of the slope. View west.

November 2, 2014

SOILS GLOSSARY

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

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

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

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

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

ARGILLAN. (See Clay Film.)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CLAY LAMELLAE. Thin, generally wavy subhorizontal bands that appear as multiple micro-Bt horizons at the base of the solum generally in sandy Holocene deposits. Each lamella generally is 1-3 cm in thickness. There may be two to six or more clay lamellae between 5 and 30 cm apart.

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

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

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

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

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

CONDUCTIVITY. The ability of a soil solution to conduct electricity, generally expressed as

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

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

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

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

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

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

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

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

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

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

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

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

CUTAN. (See Clay Film.)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

GRAVEL. Rounded or angular fragments of rock 2 to 75 mm in diameter. Soil textures with

>15% gravel have the prefix "gravelly" and those with >90% gravel have the suffix "gravel."

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

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

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

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

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

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

"Suffix Symbols

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

a Highly decomposed organic material

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

b Buried genetic horizon

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

c *Concretions or nodules*

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

co *Coprogenous earth*

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

d *Physical root restriction*

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

di *Diatomaceous earth*

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

e *Organic material of intermediate decomposition*

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

f *Frozen soil or water*

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

ff *Dry permafrost*

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

g *Strong gleying*

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

h *Illuvial accumulation of organic matter*

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

i *Slightly decomposed organic material*

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

j *Accumulation of jarosite*

Jarosite is a potassium or iron sulfate mineral that is commonly an alteration product of pyrite that has been exposed to an oxidizing environment. Jarosite has hue of 2.5Y or yellower and normally has chroma of 6 or more, although chromas as low as 3 or 4 have been reported. [Note: No longer used to indicate "juvenile."]

jj *Evidence of cryoturbation*

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

k *Accumulation of secondary carbonates*

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

kk *Engulfment of horizon by secondary carbonates*

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

m *Cementation or induration*

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

ma *Marl*

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

mn *Mangans*

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

n *Accumulation of sodium*

This symbol indicates an accumulation of exchangeable sodium.

o *Residual accumulation of sesquioxides*

This symbol indicates a residual accumulation of sesquioxides.

p *Tillage or other disturbance*

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

q *Accumulation of silica*

This symbol indicates an accumulation of secondary silica.

r *Weathered or soft bedrock*

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

s *Illuvial accumulation of sesquioxides and organic matter*

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

se *Presence of sulfides*

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

ss *Presence of slickensides*

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

t *Accumulation of silicate clay*

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

u *Presence of human-manufactured materials (artifacts)*

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

v *Plinthite*

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

w *Development of color or structure*

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

x *Fragipan character*

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

y *Accumulation of gypsum*

This symbol indicates an accumulation of gypsum (<50% by volume).

yy *Dominance of gypsum*

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

z *Accumulation of salts more soluble than gypsum*

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

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

ILLUVIATION. The deposition by percolating water of solid particles, mostly clay or humus,

within a soil horizon.

INTERFLUVE. The land lying between streams.

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

KROTOVINA. An animal burrow filled with soil.

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

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

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

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

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

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

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

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

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

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

the fluvial channel.

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

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

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

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

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

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

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

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

t_o = age when soil formation or aggradation began, ka

t_b = age when the soil or stratum was buried, ka

t_d = duration of soil development or aggradation, ky

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

PEDOCHRONOPALEOSEISMOLOGY. The study of prehistoric earthquakes by using pedochronology.

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

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

PERCOLATION. The downward movement of water through the soil.

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

Extremely acid	<4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	>9.0
Used if significant:	
Very slightly acid	6.6 to 6.9
Very mildly alkaline	7.1 to 7.3

PHREATIC SURFACE. (See Water Table.)

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

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

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

QUATERNARY. A period of geologic time that includes the past 1.8 Ma. It consists of two

epochs--the Pleistocene and Holocene.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TECTOTURBATION. Soil disturbance resulting from tectonic movement.

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

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

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

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

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

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

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

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

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

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

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D.3 - Paleontological Resources Record Search Results

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Kenneth L. Finger, Ph.D.
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May 27, 2022

Dana DePietro
FirstCarbon Solutions
1350 Treat Boulevard, Suite 380
Walnut Creek, CA 94597

Re: Paleontological Records Search: Browns Valley Subdivision Project (3552.0021), City of Napa, Napa County

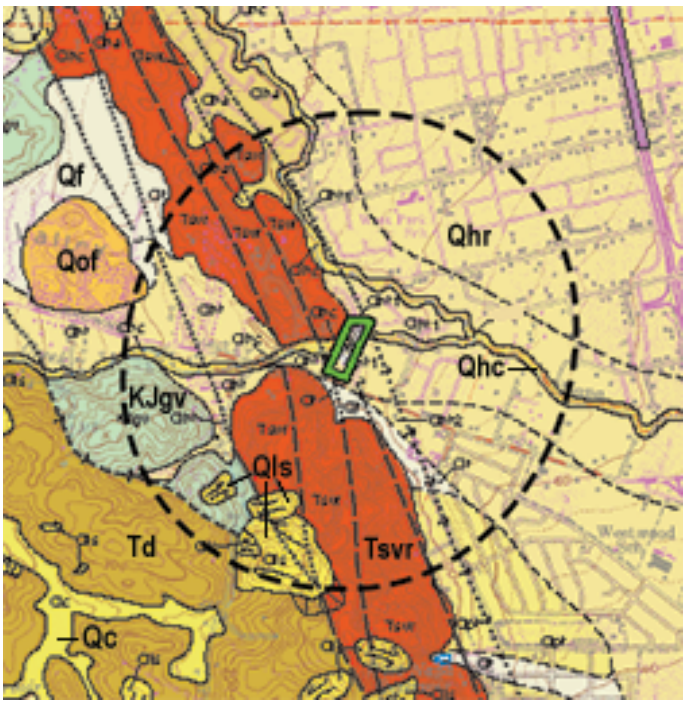
Dear Dr. DePietro:

As per your request, I have performed a records search on the University of California Museum of Paleontology (UCMP) database for the proposed Browns Valley Project in Napa. Its Public Land Survey (PLS) location is NE, SE¼, SE¼, Sec. 5, T5N, R4W, Napa quadrangle (USGS 7.5-series topographic map). The project site is at 3090 Browns Valley Road and crosses a tributary of the Napa River as it extends north to Kingston Avenue. The applicant is proposing demolition of existing structures and construction of 11 new single-family homes with landscaping and a new public cul-de-sac street with driveways on a 3.77-acre residential infill site.

Geologic Units

Geologic Units Shown on Map

Qhc	Stream channel deposits (latest Holocene)
Qf	Alluvial fan deposits (latest Pleist.–Holocene)
Qc	Colluvium (late Pleistocene–Holocene)
Qof	Alluvial fan deposits (early to late Pleistocene)
Qpa	Alluvium, undivided (latest Pleistocene)
Qls	Landslide deposits (Holocene & Pleistocene)
Tsvr	Sonoma Volcanics rhyolite ashflow tuff (Late Miocene–Pliocene)
Td	Domengine Formation (L. Eocene or E. Miocene)
KJgu	Great Valley Sequence (Early Cretaceous & Late Jurassic)



According to the part of the geologic map by Clahan et al. (2004) shown here, the project site (green outline at center) is on latest Holocene stream channel deposits (Qhc), latest Pleistocene-Holocene alluvial fan deposits (Qf), and Late Miocene–Pliocene Sonoma Volcanics (Tsvr). Also within the half-mile search area are colluvium (Qc), alluvial fan deposits (Qof), landslide deposits (Qls), the Late Eocene or early Miocene Domengine

Formation (Td), and the Early Cretaceous and Late Jurassic Great Valley Sequence (KJgv). Pleistocene deposits usually have unpredictable paleontological potentials, but those listed in the following table are based on their records in Napa and Sonoma counties:

Geological Unit		Age	Sensitivity	Potential
Qhc	Stream channel deposits	latest Holocene (<1000 years)	none	none
Qf	Alluvial fan deposits	latest Pleistocene–Holocene	high	very low
Qpa	Alluvium, undivided	latest Pleistocene	high	very low
Qc	Colluvium	late Pleistocene–Holocene	none	none
Qof	Alluvial fan deposits	early to late Pleistocene	high	very low
Qls	Landslide deposits	Holocene & Pleistocene	none	none
Tsvr	Sonoma Volcanics tuff	Late Miocene-Pliocene	high	moderate
Td	Domengine Formation	Late Eocene or Early Miocene	low	none
KJgu	Great Valley Sequence	Early Cretaceous & Late Jurassic	none	none

Records Search Results

The records search performed on the UCMP database and found no vertebrate or plant localities in the Pleistocene of Napa County or adjacent Sonoma County. In contrast, there are nine vertebrate and no plant localities in the Pleistocene of adjacent Solano County, but none are within five miles of the project site; their composite assemblage of 25 specimens includes *Mammuthus* (mammoth), *Equus pacificus* (Pacific horse), *Cervus* (elk), *Camelops* (camel), *Glossotherium harlani* (Harlan's ground sloth), and *Sigmodon lindsayi* (cotton rat).

Pliocene Sonoma Volcanics at locality -1356 (Portland Cement Co.) in Sonoma County yielded 33 Pliocene vertebrates (mostly unidentified genera), including *Equus occidentalis* (western horse). In Napa County, Sonoma Volcanics at V6317 (Ritchie Creek) in Calistoga yielded two specimens of *Equus*. Pliocene plants were recovered from 10 localities in the Sonoma Tuffs: nine are in Sonoma County more than 25 miles west of the Browns Valley and one (P4201, Napa–Mt. George) is in Napa County 4.5 miles east-northeast of the project site. Their paleoflora was documented by Dorf (1930) and Axelrod (1944). The P4201 assemblage comprises *Abies concoloroides* (fir), *Amorpha condone* (false indigo), *Arctostaphylos fergusoni* (bearberry), *Castanopsis perplexa* and *C. sonomensis* (chinquapins), *Ceanothus edenensis* (buckhorn), *Cercocarpus cuneatus* and *C. linearifolius* (mountain mahoganies), *Holodiscus harneyensis* (arrowwood), *Mahonia reticulata* (barberry), *Persea coalingensis* (laurel), *Photinia sonomensis* (magnolia), *Pinus* (pine), and *Platanus paucidentata* (sycamore).

The only significant fossils in the Domengine Formation are a single Eocene *Carcarodon* (shark) tooth from a locality in Kings County and Eocene several fish teeth and scales from a locality in Fresno County.

Remarks and Recommendations

A paleontological walkover survey is not recommended because the surface of the project site appears to be heavily disturbed. Paleontological monitoring is also not recommended because it is not clear from the map plot of the site whether the Sonoma Tuff, which is the geologic unit of most concern here, actually extends into the project site and no significant fossils have been recorded within four miles of it. Although unlikely, should any vertebrate (i.e., bones, teeth, or unusually abundant and well-preserved invertebrates) or well-preserved plant remains be unearthed, the

construction crew should not attempt to remove them**,** as they could be extremely fragile and therefore prone to crumbling, and their position would need to be properly recorded; instead, all work in the immediate vicinity of the discovery should be diverted at least 15 feet away from the find until it is assessed by a professional paleontologist and, if deemed significant, salvaged in a timely manner. All recovered fossils should be deposited in an appropriate repository, such as the UCMP, where they will be properly curated and made accessible for future study.

Sincerely,



References Cited

Axelrod, D.I., 1944, The Sonoma flora, *in* R.W. Chaney (ed.), Pliocene floras of California and Oregon. Carnegie Institute of Washington Publication 553: 167–206.

Dorf, E., 1930, The Pliocene floras of California: Sonoma flora. Carnegie Institute of Washington Publication 412: 37–48.

Clahan, K.B., Wagner, D.L., Saucedo, G.J., Randolph-Loar, C.E., and Sowers, J.M., 2004. Geologic map of the Napa 7.5' quadrangle, Napa County, California: a digital database, version 1.0. <ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/Prelim_geo_pdf/Calistoga_24k_v1-0.pdf >

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