APPENDIX 5 - GEOLOGY

Appendix 5
A: Fault Report

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June 6, 2014
Project No. S679-001

RONALD REAGAN CHARTER SCHOOL ALLIANCE
32326 Clinton Keith Road, Suite 202
Wildomar, California 92595

Re: Evaluation of Surface Fault Rupture Hazard
Proposed Sycamore Academy
SE Corner of Palomar Street and Harwood Lane
Assessor's Parcel Number 380-170-020
City of Wildomar, California

Ladies and Gentlemen:

At your request, we have completed a surface fault rupture hazard evaluation at the referenced site. The following report presents the findings of this study.

We appreciate the opportunity of being of service to you on this project. If you have any questions, please contact our office.

Respectfully,
INLAND FOUNDATION ENGINEERING, INC.

Daniel R. Lind
P.G. 7681, C.E.G. 2451

Donn C. Schwartzkopf
C.E.G. 1459, PGP 1002

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STATE OF CALIFORNIA

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INTRODUCTION

At your request, we have evaluated the subject property, which is located within a State of California Alquist-Priolo Earthquake Fault Zone and County of Riverside Fault Zone, for the presence, nature and extent of possible faulting in association with the Wildomar Fault (Elsinore Fault Zone), as shown on Figure 2. The purpose of this hazard zone is to regulate development near active faults to mitigate the hazard of surface fault rupture. We understand that the site is to be utilized for construction of a private charter school with associated structures, driveways, parking, and landscaping.

The intent of this investigation was to identify if active faults traverse the subject property, by means of subsurface exploration, in order to establish necessary restricted building zones that would prohibit the location of structures for human occupancy (defined as 2,000 person hours per year). This report has been prepared utilizing the suggested "Geologic Guidelines for Earthquake and/or Fault Hazard Reports" (State of California Board for Geology and Geophysicists, 1998), “Guidelines for Evaluating the Hazard of Surface Fault Rupture” (C.G.S., 2002), and the “Technical Guidelines for Review of Geotechnical and Geologic Reports” prepared by the Riverside County Building and Safety Department (2000).

SCOPE OF SERVICES

The following services, as outlined in our proposal dated December 13, 2013, were performed during this study, as authorized by you on January 13, 2014:

- Review of available published and unpublished literature and geologic data in our files pertaining to the site.
- Field meeting with the Riverside County Geologist (Mr. David Jones) to discuss and examine both the lithologic and structural characteristics of the exploratory trench.
- Photogeologic analysis of four sets of vertical black-and-white/color stereoscopic aerial photographs, from the years 1938 to 1974, that were obtained from the Riverside County Flood Control District and other sources.
- Geologic field reconnaissance and mapping of the site and adjacent areas by a Certified Engineering Geologist.
- Subsurface investigation by means of stratigraphic logging of 427 lineal feet of exploratory trench, ranging from 17 to 21± feet in depth.
- Conducting a geophysical survey using the seismic refraction method to aid in evaluating deeper subsurface lithology and structure. This survey was performed by a State of California licensed Professional Geophysicist.

- Preparation of a Site Fault Map, presenting the location of the exploratory excavation, geophysical survey, and other related geologic data, including the locations of the recommended “Restricted-Use Zone” and the “Buildable-Use Area.”

- Preparation of this report, presenting our findings, conclusions, and recommendations from a geologic standpoint, with respect to the proposed development.

Accompanying Maps, Illustrations and Appendices

Figure 1	-	Regional Geologic Map
Figure 2	-	Earthquake Fault Zone Map
Figure 3	-	Riverside County Land Information Map
Plate 1	-	Site Fault Map
Appendix A	-	Exploratory Trench Log (three sheets)
Appendix B	-	Seismic Refraction Survey
Appendix C	-	Carbon-14 Test Results
Appendix D	-	References

GEOLOGIC SETTING

The subject site is situated within a natural geomorphic province in southwestern California known as the Peninsular Ranges. It is characterized by steep, elongated ranges and valleys that trend northwesterly. More specifically, the site is situated along the Perris Block, an eroded mass of Cretaceous and older crystalline rock. Thin sedimentary and volcanic units mantle the bedrock in a few places, with alluvial deposits filling in the lower valley areas. The Perris Block has had a complex history, apparently undergoing relative vertical land movements of several thousand feet in response to movement on the Elsinore and San Jacinto Fault Zones. These movements of the geologic past, in conjunction with the semi-arid climate and the weathering resistance of the rock, are responsible for the formation and preservation of ancient, generally flat-lying erosion surfaces now present at various elevations that give this region its unique geologic character. The Perris Block, approximately 20 miles by 50 miles in extent, is bounded by the San Jacinto Fault Zone to the northeast, the Elsinore Fault Zone to the southwest, the Wildomar Fault Zone to the northwest, and to the southeast by the fringes of the Temecula basin, where the boundary is ill-defined.

More specifically, the site lies along the southwestern fringe of the Perris Block, with the Santa Ana Mountain Block just to the southwest. These two structural blocks are separated by the Elsinore Fault Zone. The Elsinore Fault Zone, within which the site is included, is one of the major structural features of southern California and can be traced from the Whittier Fault, near Whittier, through the Peninsular Ranges to the Gulf of California. The Elsinore Basin, which contains Lake Elsinore, is essentially a graben, a block or portion of the earth's crust which has been down-dropped along faults relative to the surrounding areas which have been uplifted.

Locally, as mapped by Kennedy and Morton (2003), the site is shown to be mantled by Holocene and late Pleistocene age young alluvial valley deposits (map symbol Qyv, see Figure 1), generally described as consisting of unconsolidated sand, silt, and clay-bearing alluvium. These deposits are in turn underlain by Pleistocene age sedimentary bedrock of the Pauba Formation, which is generally described as a moderately well-indurated channeled and filled siltstone, sandstone, and conglomerate facies. Locally, the Pauba Formation has been further subdivided into a sandstone member (map symbol Qpfs, see Figure 1), that is generally comprised of moderately well-indurated, cross-bedded sandstone, containing sparse cobble- to boulder-conglomerate beds

FAULTING

According to the State of California (C.D.M.G., 1980), the site is shown to be partially located within an Alquist-Priolo Earthquake Fault Zone, as shown on Figure 2. This fault is locally referred to as the Wildomar Fault, which is one of the central strands of the Elsinore

Fault Zone System (Temecula Segment), which runs from the Los Angeles Basin to the north, into Mexico to the south. The Wildomar Fault which is approximately 43 kilometers in length, is a right-lateral, strike-slip fault capable of producing an earthquake with an estimated maximum moment magnitude of M_W 6.9, and has an associated slip-rate of 5.0 ±2.0 mm/year (Cao et al., 2003 and Petersen et al., 2008). Dawson et al. (2008), estimates the Temecula fault segment to have a preferred mean recurrence interval of 600 ±150 years.

Locally, the main branch of the Wildomar fault is shown to traverse parallel along Palomar Street, which borders the northeastern property boundary. However, both Kennedy and Morton (2003) and the County of Riverside (2013) indicate a sub-parallel fault to traverse through the central portion of the site along a northwest-southeast direction, which can be seen on Figures 1 and 2, respectively. At the time of this study, the State of California (Bryant and Hart, 2007) has not yet identified this fault splay on the Earthquake Fault Zone Map as presented on Figure 2.

SUMMARY OF GEOPHYSICAL SURVEY

To aid in evaluating the local deeper subsurface lithology and structure, a geophysical survey was performed using the seismic refraction method. While the use of geophysical methods alone cannot determine the presence or absence of faulting, it does provide supporting data that can be used for analysis. The primary purpose of this survey was to identify the presence of offset stratigraphic units, steep lateral velocity contrasts, or groundwater differentials that would be suggestive of faulting at depth, using non-destructive and non-intrusive methods. A summary of the methodology, field procedures, and data processing is provided in Appendix B along with the accompanying seismic refraction survey line model (Seismic Line S-1). This survey line was performed prior to excavation of the exploratory trench and was located along the trench centerline, extending from the edge of the Palomar Street to the northeast for a distance of 610 feet, for the purpose of imaging beyond the intended subsurface exploration limits. The location of the seismic traverse line (S-1) is presented on Plate 1 for reference purposes.

The final seismic refraction model (Seismic Line S-1) was produced using refraction tomographic methods which do not create discrete velocity layers or boundaries but rather produces a “smoothed” tomographic image that displays the velocity gradient within the limits of the seismic wave ray coverage that was sampled. The data appeared to be of good quality which was verified by the Root Mean Square Error (RMS) that is displayed on the tomographic model, being 1.8%. The RMS error (misfit between picked and modeled first break times) is automatically calculated during the processing routine, with a value of less than 2.0% being preferred. This model indicates an unusual lateral velocity contrast zone that would suggest subsurface structural discontinuities and is annotated for reference. The anomalous zone at depth has a relatively lower velocity most likely due to

the crushed and shattered nature of the faulted sedimentary bedrock, with the upper low-velocity materials (i.e. 2,000 ft/sec velocity contour) indicating shallower, relatively higher velocity materials to the southwest. The limits of the anomalous low velocity zone were extrapolated towards the surface in an attempt to bracket the suspected fault zone.

SUMMARY OF FAULT INVESTIGATION

1. **Aerial Photographs**

Examination of stereo pairs of aerial photographs was utilized to assess the local and regional geologic and geomorphic characteristics with respect to the site. Four relevant sets of vertical black-and-white aerial photographs from the years of 1953 to 1974, at different scales (see References in Appendix D), were examined, which depict the site before modernization in an attempt to visualize the natural geomorphology. Based upon our photogeologic review, a fairly distinct lineation appears to traverse through the central portion of the site in a general northwest-southeast direction, which is coincident with the fault splay that is mapped by the County of Riverside (see Figure 3) and Kennedy and Morton (2003) as shown on Figure 1. This photolineation is marked by a linear feature that separates the alluvial valley to the northeast and the low lying hills along the southwest. The most persuasive photolineation observed within the local area generally parallels Palomar Street which borders the site along the northeast and is identified as being the Wildomar Fault (Bryant and Hart, 2007) as shown on the Earthquake Fault Zone Map, Figure 2. No other photographic and/or geomorphic expressions generally relating to faulting were observed to traverse through the subject site.

2. **Field Reconnaissance**

Due to previous grading and site modifications that have been performed at the site, surficial geomorphic features that may have been related to faulting are no longer present. Therefore, no distinct surficial geomorphic indicators are present to aid in assessing surface faulting potentials.

3. **Subsurface Trenching**

A total of 427 feet of lineal trench (Exploratory Trench T-1) was excavated and logged which ranged in depth from 17 to 21± feet. The trench was excavated in a northeast-southwest direction, being near normal as possible to the regional fault trend (northwest-southeast direction). Exploratory Trench T-1 was placed as close as safely possible to Palomar Avenue along the northeast in order to provide a continuous exposure across the proposed construction area toward the southwest as requested. A graphic geologic log has been prepared which depicts the conditions

and structure of the earth materials encountered locally and is presented within Appendix A for visual and reference purposes.

The sediments encountered within the exploratory trench excavation revealed uniform and stratigraphic continuous lithologic characteristics. Surficial materials where locally trenched, consist of a layer of artificial fill that was apparently placed during previous grading and extends to depths as much as 11± feet locally. These materials are primarily comprised of predominately fine- to coarse-gained clayey silty sand with minor gravel.

Below the artificial fill, near-horizontally and continuously stratified unconsolidated Holocene age alluvial deposits were encountered that presumably have originated as fluvial deposits from the locally surrounding highlands. These deposits are predominantly comprised of fine- to medium-grained massive to crudely stratified silty sands with interbedded and discontinuous thin lenses of thinly stratified fine- to coarse-grained sands. Locally observed within the sedimentary layers Units "C" through "F" (see Appendix A), were thin, generally vertically oriented calcium carbonate (caliche) stringers that are both discontinuous in both the vertical and horizontal directions, with no apparent sediment displacement. The presence of the calcium carbonate deposits (in the form of stringers), suggests that the sediments are at least mid-Holocene in age which would be necessary for this mineral to precipitate out of solution and be deposited by repeated water seepage. Also noted within Units "E" through "G" were occasional grussified cobbles and gravels (leucocratic and occasional mafic clasts), also suggesting mid-Holocene age deposits due to the amount of time necessary to weather the clasts in place.

The earth materials encountered at depth beginning around Station 3+70 reveal indurated sediments believed to be of the Pauba Formation (late Pleistocene non-marine fluvial deposits) as mapped by Kennedy and Morton (2003) and as exposed along the low-lying hills at and adjacent to the site. These materials consist of interbedded claystone, clayey siltstone, silty sandstone, and sandstone that are moderately-well indurated and highly faulted and fractured as discussed further below.

4. **Relative Age Dating**

As mapped by Kennedy and Morton (2003) the site is shown to be underlain by both Holocene age alluvial sediments and Pleistocene age sedimentary bedrock. Our observations of the diagnostic morphologic characteristics indicate that the alluvial sediments encountered are most likely mid- to late-Holocene in age. Locally, at a depth of 12±-feet in Exploratory Trench T-1 (around Station 0+24 to 0+28, Unit "E", see Exploratory Trench Log, Appendix A), a pocket of detrital carbon was found which

was located within a fine- to coarse-grained sand lens. The actual sample depth below the original ground surface is believed to be somewhere around 15± feet in depth, prior to any grading that was performed at the site. The sample was collected and sent to Beta Analytic, Inc. (Miami, Florida), for purposes of obtaining a radiocarbon date. This sample yielded a calibrated age of 4,840± 30 years BP (before present), with the data being presented in Appendix C for reference. It is apparent that subsurface trenching into older late Pleistocene alluvial sediments is generally not feasible at the site due to the depth of the anticipated older contact (greater than 30 feet based on an assumed sedimentary depositional rate locally of 323± years for every foot in depth, based on the Carbon-14 test results). Using this generalized depositional rate, the bottom of the exploratory trench is estimated to have exposed sediments on the order of 6,500 to 7,800 years BP, if the rate of deposition has been constant at the site during the past 11,000 years.

CONCLUSIONS AND RECOMMENDATIONS

General

Based upon this investigation, development of the subject site for habitable-type structures within the designated "Buildable-Use Area" appears to be feasible, from a geologic stand-point, provided that the conclusions and recommendations in this report are followed.

Conclusions

Based on a review of published geologic data, our field reconnaissance, photogeologic analysis, geophysical survey, and our subsurface exploration, active faulting as defined by the State of California (Bryant and Hart, 2007), traverses through the central portion of the site as indicated on the Site Fault Map as presented on Plate 1. Additionally, this faulting was directly observed within the limits of the exploratory trench locally where excavated. The sedimentary layers were very distinct and continuous, and easily traceable across the entire trench wall limits. Within the exploratory trench near Station 3+70, the Holocene age alluvial deposits (Units "D" and "F") appear to be offset against the Pleistocene age sedimentary bedrock of the Pauba Formation. Based on the age and superposition of the alluvial sediments faulted along the southwestern portion of the trench, the age of faulting at a minimum would be slightly older than the recovered detrital charcoal (4,840± 30 years BP) test result obtained from Unit "C." No distinct offsets or fault extensions into Unit "B" were observed locally. The other faults encountered within the sedimentary bedrock of the Pauba Formation may extend within the overlying Holocene age sediments, but locally were difficult to assess due to soil conditions. These faults should also be considered to be active based on proximity and association.

Recommendations

No structures for human occupancy (i.e., 2,000 person hours per year, or as defined by local agencies) should be constructed within the "Restricted-Use Zone" that have been delineated within the northeastern and southwestern portions of the site (see Plate 1).

The northeastern setback is necessary since the trench beginning is located within the mapped Earthquake Fault Zone and it is assumed that there is an active fault just beyond the end of the exploratory trench, unless proven otherwise. The "Building Setback Line" was established by measuring 50 feet in a southwesterly direction from trench Station 0+12) perpendicular to the delineated Earthquake Fault Zone (EFZ) trend which generally follows Palomar Street, then continuing in a parallel direction with the EFZ trend. Station 0+12 was selected as the beginning of the setback as this is the location where lithologic unit "E" (dated to be mid-Holocene) can be physically traced. This location appears to be practical as the estimated earthquake recurrence interval for the Temecula Segment (locally the Wildomar Fault) is on the order of 600± years, indicating that there could be as many as eight large events that may have caused ground rupture at the site. Since there were no faults observed within or below this layer, it is believed that there are no active faults within the mid-Holocene age alluvial deposits excavated at the site between Stations 0+12 to 3+70 where locally trenched.

The southwestern setback is necessary because active faulting was encountered. The "Building Setback Line" was established by measuring 50 feet in a southwesterly direction from trench Station 3+70) perpendicular to the measured North 45° West – South 45° East fault trend exposed along the trench bottom. Due to the relatively narrow boundaries of the site, additional trenching to establish the trend of the fault was not performed. The local measured trend of the exposed fault was used for extrapolation across the site boundaries, which also coincided with the mapped fault trace as well as the photogeologic evidence, and is considered to be accurate.

The limits of the exploratory trench, established fault zone, and the associated Restricted-Use Zones are considered accurate based on a survey that was performed by Dawson Surveying, Inc. (Colton, California) prior to backfilling of the trench.

CLOSURE

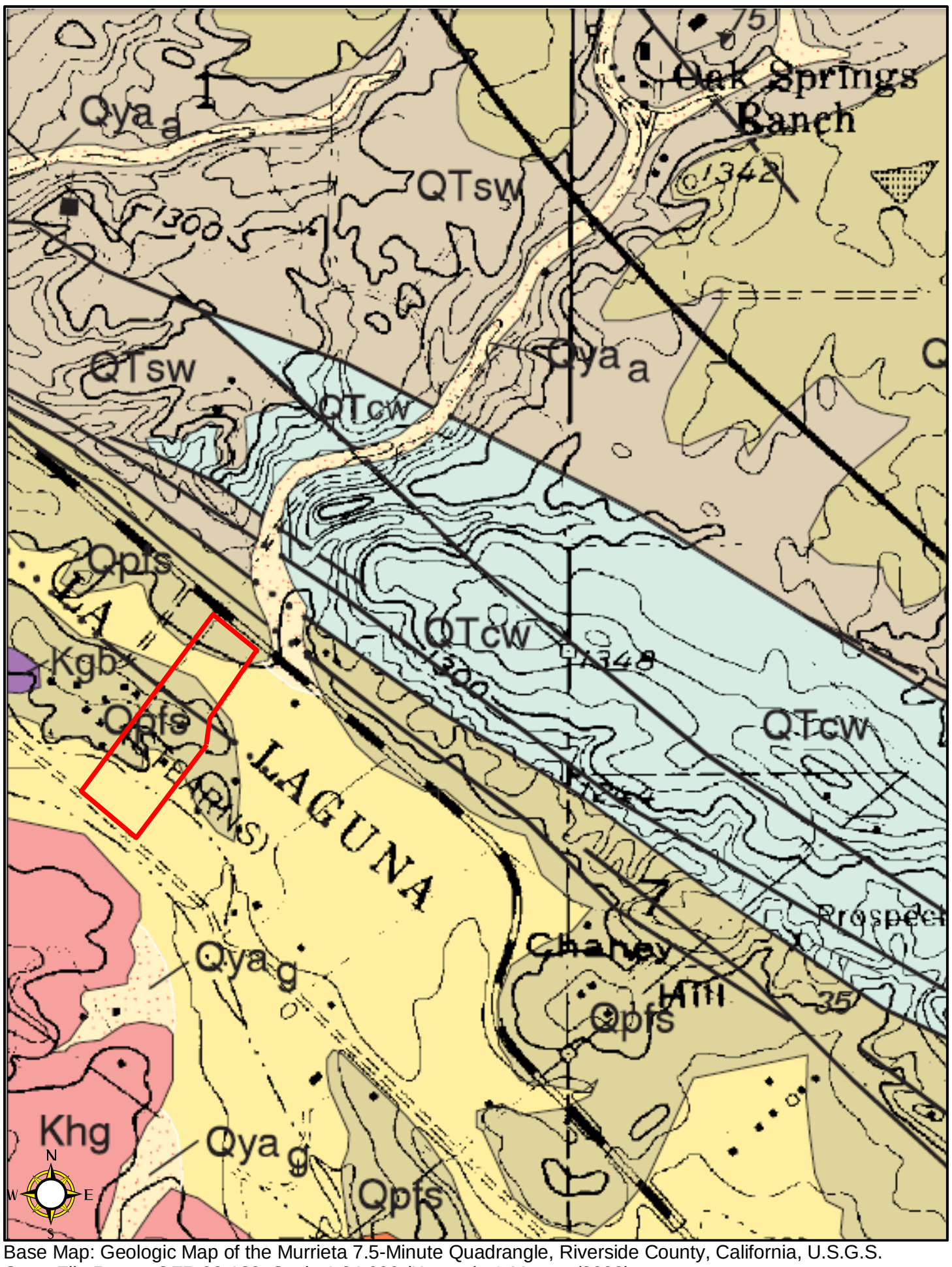
Our conclusions and recommendations are based on a surficial field reconnaissance, limited subsurface and geophysical exploration, photogeologic analysis, and an interpretation of available existing geologic/seismic data. We make no warranty, either express or implied. Should conditions be encountered at a later date or more information becomes available that appear to be different than those indicated in this report, we reserve

the right to reevaluate our conclusions and recommendations and provide appropriate mitigation measures, if warranted.

However remote, it is important to note that the potential for "new faulting" exists in the region, due to its location within a seismically-active and complex geologic region. Collins (1990) has described the process of "new faulting" and indicates that it is a normal process where stress is applied to earth masses of any size. He notes that during an earthquake, new faults can develop in several ways, such as by vertical extension (or growth) of a pre-existing fault or fault zone; by horizontal extension of a pre-existing fault or fault zone; by branching from a pre-existing fault or fault zone; and by faulting related to, but not an extension or branch of, a nearby fault (e.g. faulting created within a block of near-surface material subjected to coupling actions from nearby faults). Such examples of "new faulting" were believed to have been recently displayed during the 1992 Landers earthquake, wherein numerous branches, extensions, and transverse (cross-over) faults occurred (Ron et al., 2001). It is therefore prudent to assume that there is at least a remote probability that fault rupture could occur at the site during a large nearby seismic event and there is no way of predicting actual possibilities and/or probable locations. Such potential occurrences of "new faulting" should be made aware to the property owners so that they may decide on acceptable risk levels, based on the locations of their property in relation to seismically active areas.

It is assumed that all the conclusions and recommendations outlined in this report are understood and followed. If any portion of this report is not understood, it is considered to be the responsibility of the owner/contractor/engineer/governmental agency, etc., to contact this office for further clarification.

REGIONAL GEOLOGIC MAP



Base Map: Geologic Map of the Murrieta 7.5-Minute Quadrangle, Riverside County, California, U.S.G.S. Open-File Report OFR 03-189, Scale 1:24,000 (Kennedy & Morton (2003)

Qya

Young alluvial channel deposits (Holocene and latest Pleistocene)- Fluvial deposits along canyon floors. Consists of unconsolidated sand, silt, and clay-bearing alluvium

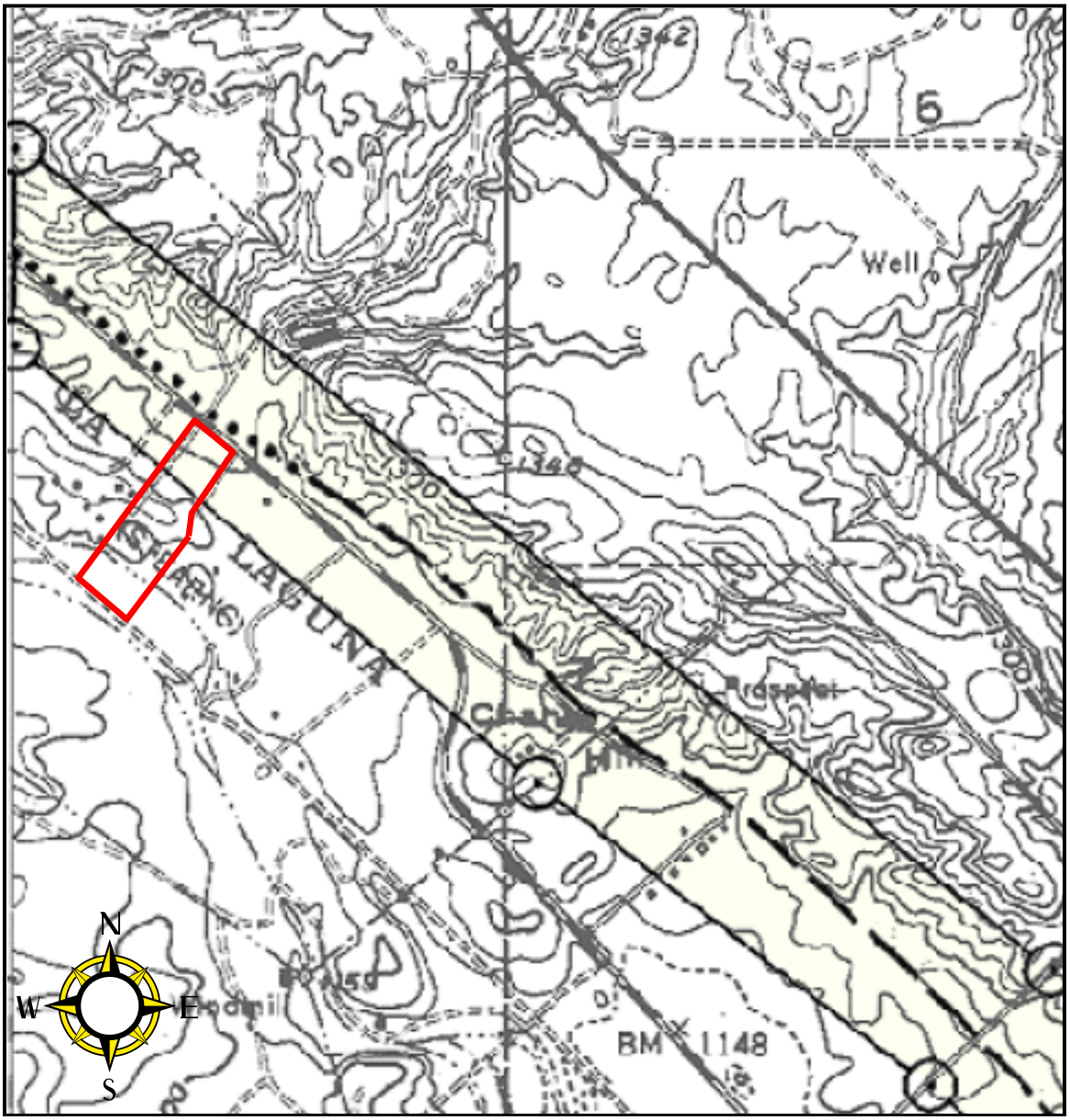
Qpfs

Pauba Formation (Pleistocene)-Siltstone, sandstone, and conglomerate. Named by Mann (1955) for exposures of in Rancho Pauba area about 3.2 km southeast of Temecula. Vertebrate fauna from Pauba Formation are of late Irvingtonian and early Rancholabrean ages (Reynolds and Reynolds, 1990a; 1990b). Includes two informal members:

Sandstone member-Brown, moderately well-indurated, cross-bedded sandstone containing sparse cobble- to boulder-conglomerate beds

Fault

EARTHQUAKE FAULT ZONE MAP



BASE MAP: California Division of Mines and Geology, 1990, Murrieta 7-1/2' Earthquake Fault Zone Map, Scale 1" = 2,000'.

MAP EXPLANATION

Active Faults

1906 C

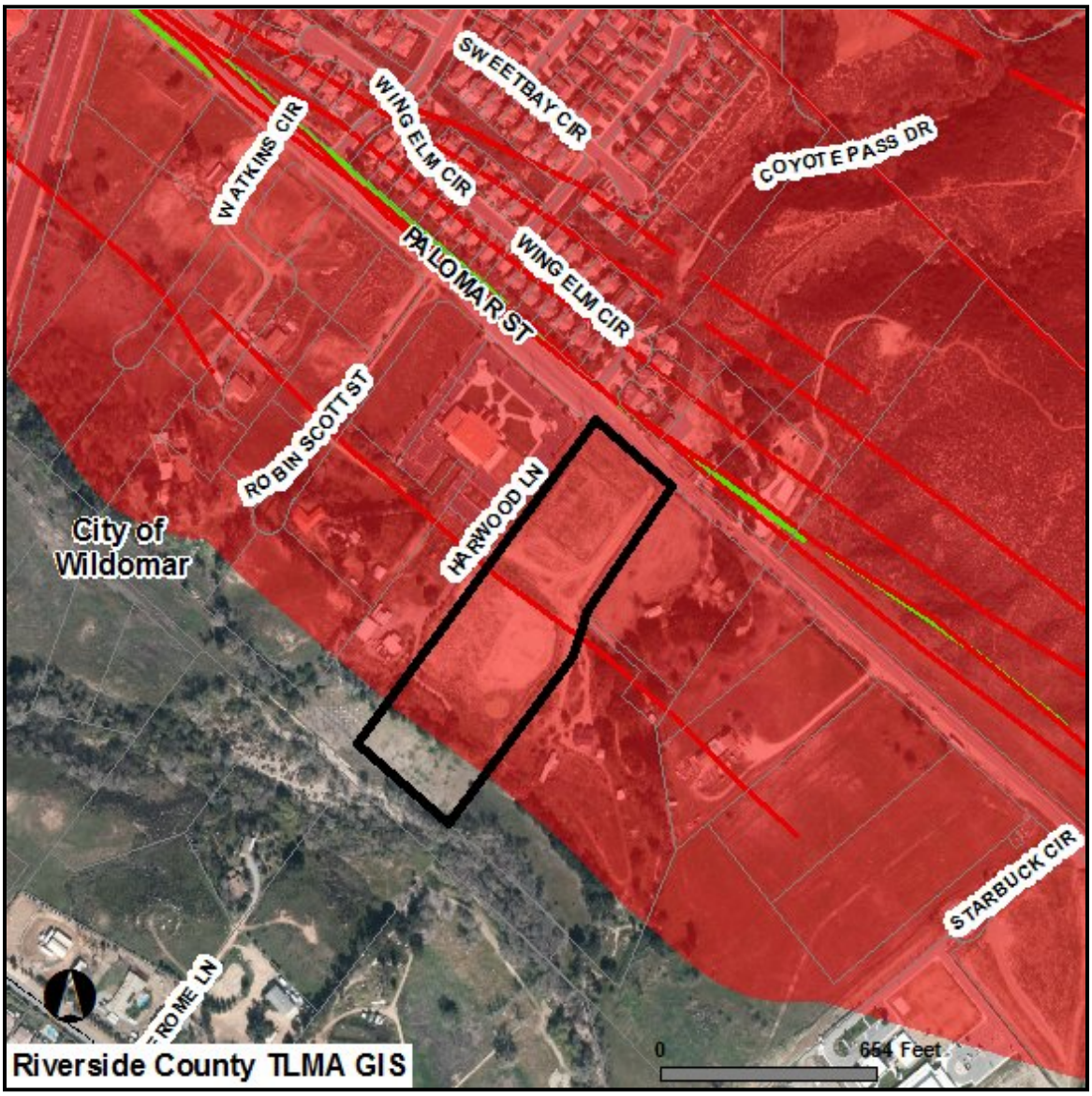
Faults considered to have been active during Holocene time and to have a relatively high potential for surface rupture; solid line where accurately located, long dash where approximately located, short dash where inferred, dotted where concealed; query (?) indicates additional uncertainity. Evidence of historic offset indicated by year of earthquake-associated event or C for displacement caused by creep or possible creep.

Earthquake Fault Zone Boundaries

These are delineated as straight-line segments that connect encircled turning points so as to define earthquake fault zone segments.

Seaward projection of zone boundary.

RIVERSIDE COUNTY LAND INFORMATION MAP

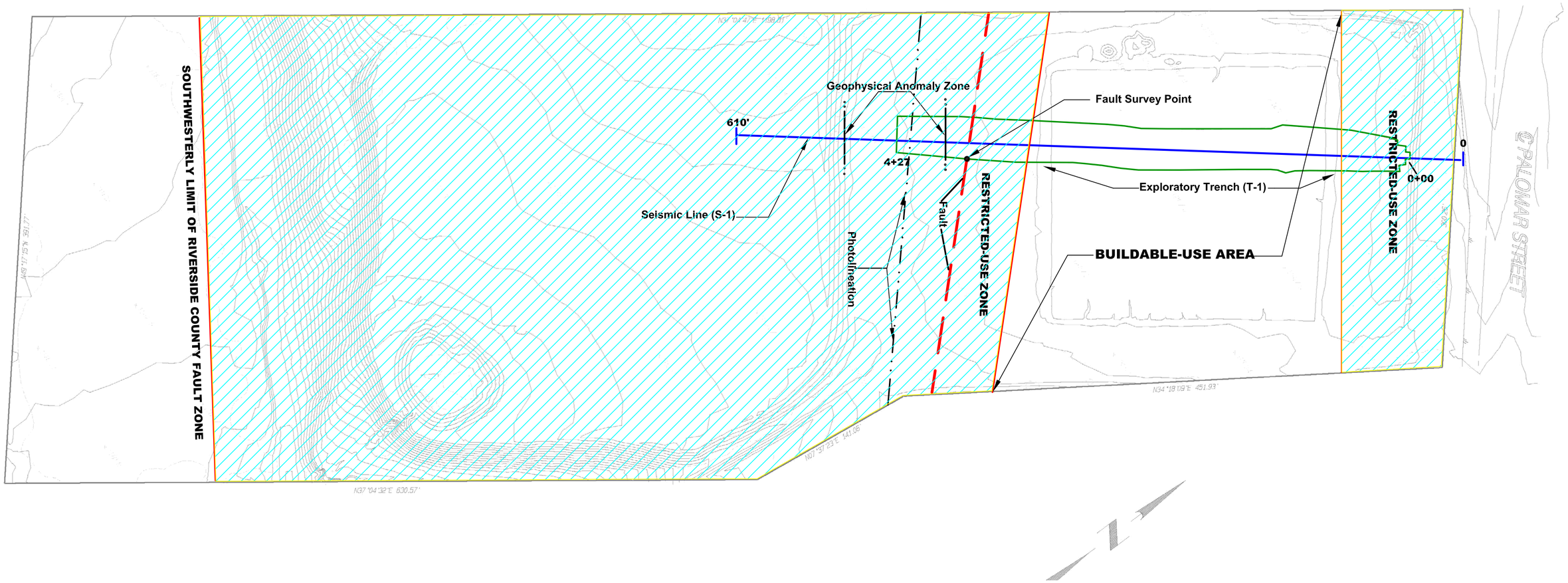


BASE MAP: Riverside County TMLA GIS, 2013

COUNTY FAULT ZONE

Fault

SITE FAULT MAP
PROPOSED SYCAMORE ACADEMY
Palomar Street, Wildomar, California
A.P.N. 380-170-020



GRAPHIC SCALE

60 0 30 60 120 240

1 INCH = 60 FT

INLAND FOUNDATION ENGINEERING, INC.
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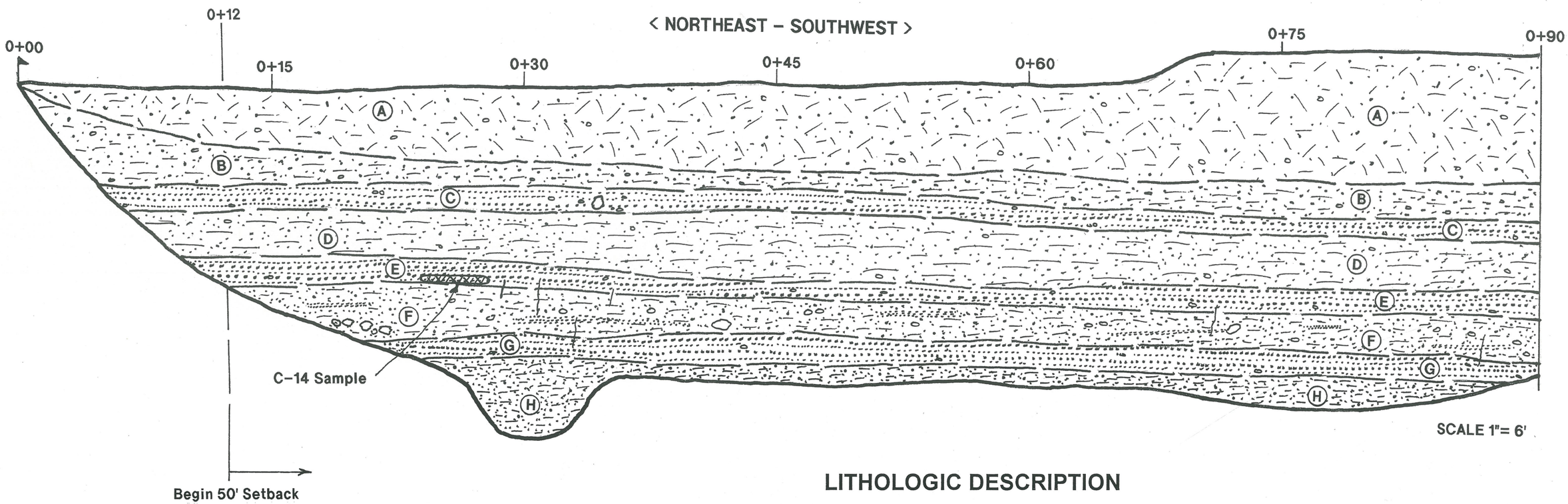
DRAWN BY: ES	JOB NO.: S679-001	
SCALE: 1"=60'	DATE: June 2014	Plate 1

APPENDIX A - Exploration Trench Log

EXPLORATORY TRENCH T-1



LITHOLOGIC DESCRIPTION

(A) - **CLAYEY SILTY SAND** (Artificial Fill): Variegated (Brown; 7.5Y 4/4 to Brown; 10YR 4/3), fine-coarse grained with scattered gravel, moderately layered, moist, clean contact at bottom.

(B) - **SILTY SAND** (late Holocene): Brown (10YR 5/3), fine- to coarse-grained with minor gravel, trace of clay, massive to crudely stratified, slightly moist, slightly cohesive.

(C) - **SAND** (late Holocene): Grayish Brown (10YR 5/2), fine-coarse grained, very well stratified, loose, dry, non-cohesive, thinly stratified, occasional gravel.

(D) - **SILTY SAND** (late-middle Holocene): Yellowish Brown (10YR 5/4), fine-medium grained with minor coarse, trace of gravel, massive structure, moist, slightly cohesive.

(E) - **SAND** (middle Holocene): Grayish Brown (10YR 5/2), fine-coarse grained, very well stratified, loose, slightly moist, non-cohesive, thinly stratified, occasional gravel, occasional caliche stringers, C-14 sample location.

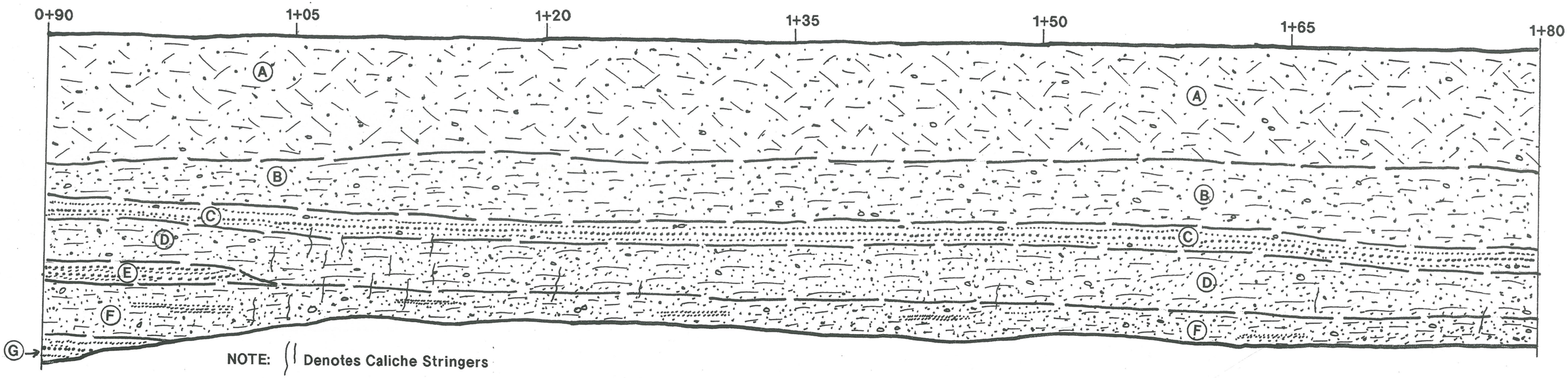
(F) - **SILTY SAND** (middle Holocene): Brown (10YR 5/3), fine-medium grained with minor coarse, occasional gravel and cobbles, occasional grussified clasts, slightly stratified with thin discontinuous fine sand lenses, occasional caliche stringers, massive structure, moist, slightly cohesive.

(G) - **SAND** (middle Holocene): Grayish Brown (10YR 5/2), fine-coarse grained, very well stratified, loose, slightly moist, non-cohesive, thinly stratified, occasional gravel, occasional caliche stringers.

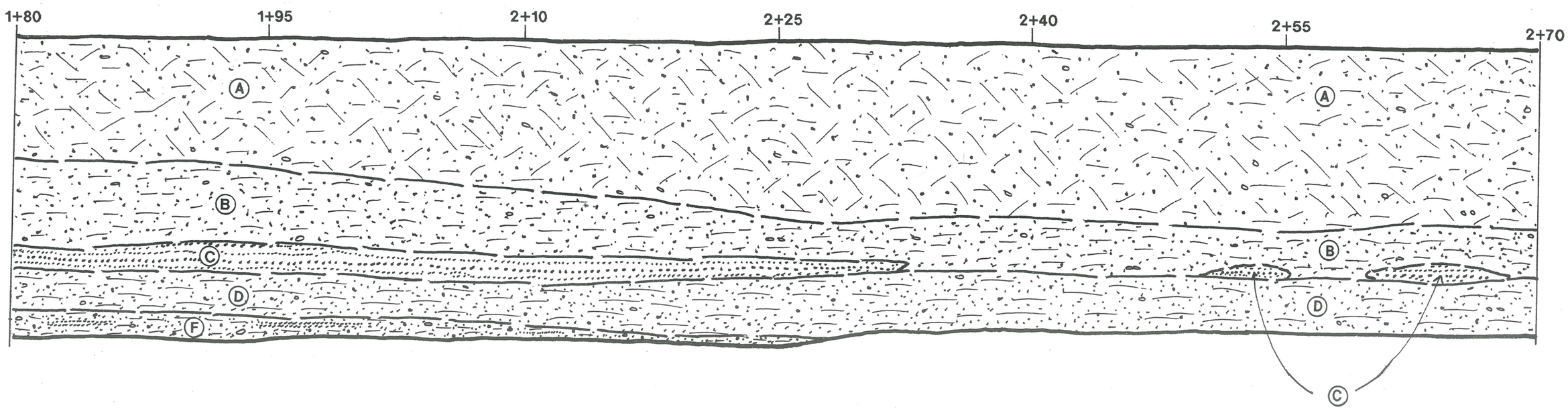
(H) - **SILTY SAND** (middle-early Holocene): Dark Yellowish Brown (10YR 3/4), fine- to medium-grained with minor coarse, massive structure, very moist, cohesive.

EXPLORATORY TRENCH T-1

< NORTHEAST - SOUTHWEST >

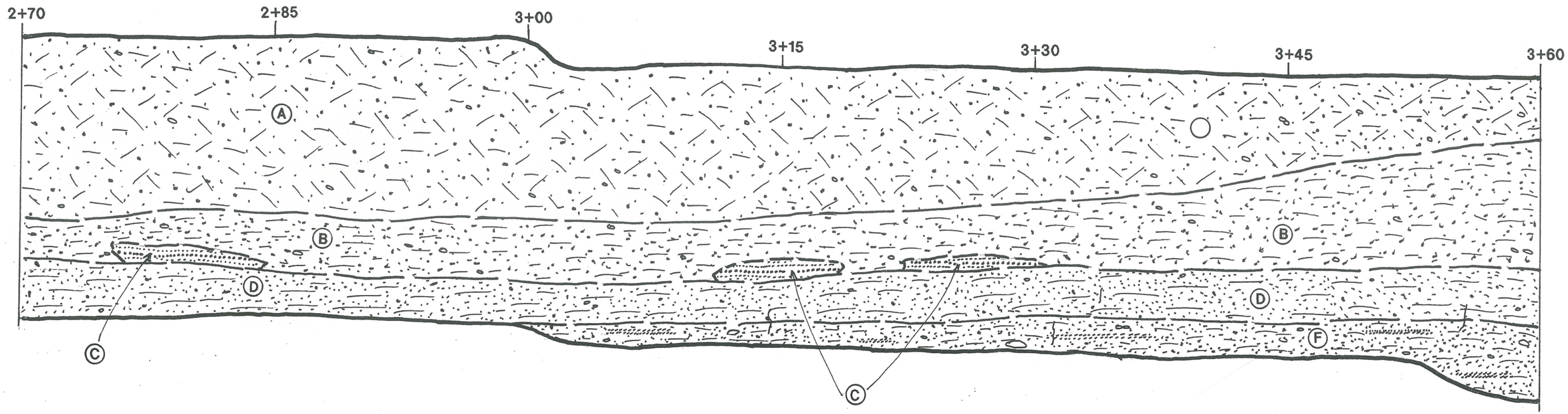


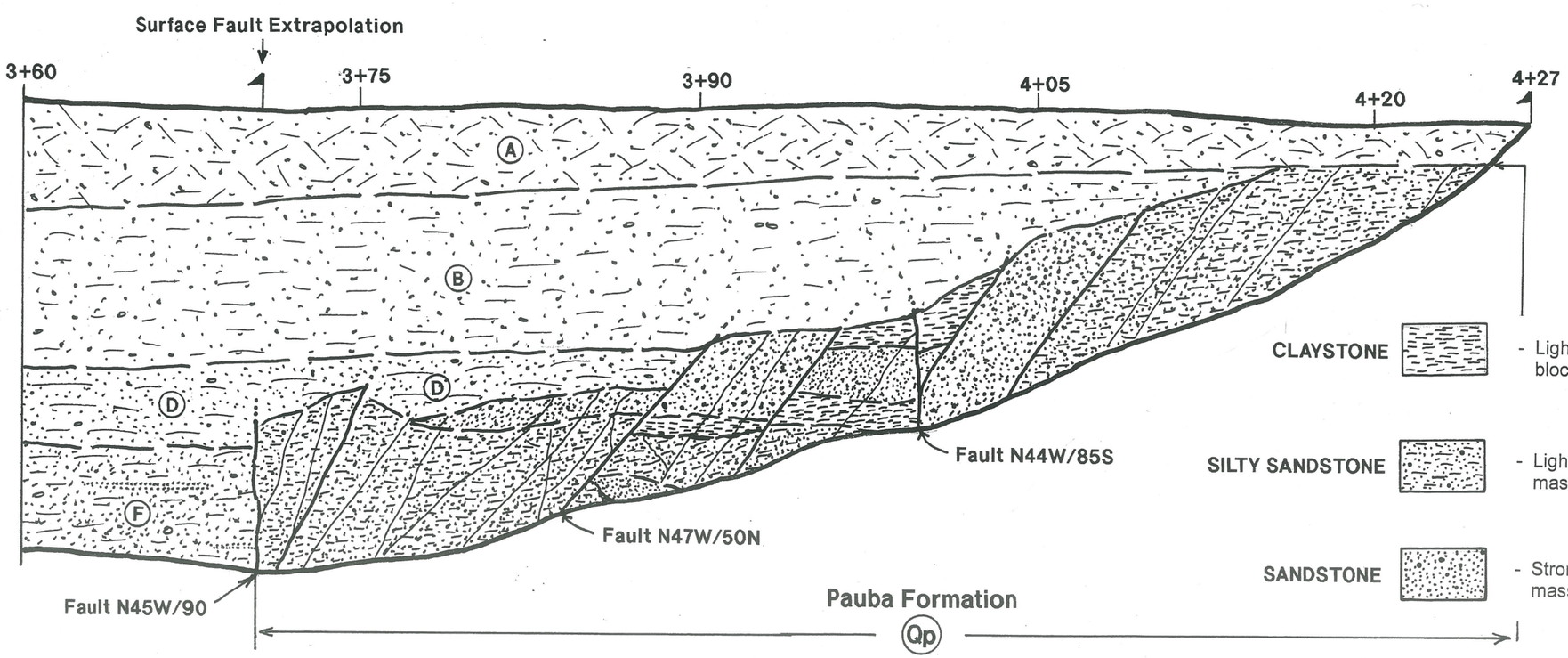
SCALE 1"= 6'



EXPLORATORY TRENCH T-1

< NORTHEAST - SOUTHWEST >





SCALE 1"= 6'

CLAYSTONE - Light Olive Brown (2.5Y 4/3), very fine-grained, slightly blocky structure, massive structure, indurated, fractured.

SILTY SANDSTONE - Light Olive Brown (2.5Y 5/3), fine- to medium-grained, massive to slightly stratified, fractured.

SANDSTONE - Strong Brown (7.5YR 4/6), fine- to coarse-grained massive, minor silt, indurated, fractured.

APPENDIX B - Seismic Refraction Survey

SEISMIC REFRACTION SURVEY

METHODOLOGY

The seismic refraction method consists of measuring (at known points along the surface of the ground) the travel times of compressional waves generated by an impulsive energy source and can be used to estimate the layering, structure, and seismic acoustic velocities of subsurface horizons. Seismic waves travel down and through the soils and rocks, and when the wave encounters a contact between two earth materials having different velocities, some of the wave's energy travels along the contact at the velocity of the lower layer. The fundamental assumption is that each successively deeper layer has a velocity greater than the layer immediately above it. As the wave travels along the contact, some of the wave's energy is refracted toward the surface where it is detected by a series of motion-sensitive transducers (geophones). The arrival time of the seismic wave at the geophone locations can be related to the relative seismic velocities of the subsurface layers in feet per second (fps), which can then be used to aid in interpreting both the depth and type of materials encountered.

The seismic refraction method is well suited to identify whether there is a distinct velocity change at depth which could represent a possible bedrock and/or groundwater table interface and other structural features. The principle of this method utilizes the fact that elastic waves (seismic waves) travel at different velocities in different rocks and/or sediments. By generating seismic waves at a point (shot point) and measuring the arrival times of these waves at pre-selected positions (geophone locations), it is possible to determine the velocity distribution and to locate subsurface interfaces where the waves are refracted.

FIELD PROCEDURES

Seismic Line S-1 consisted of three individual shorter survey spreads (each being 230 feet in length) which were overlapped and combined to produce one continuous 610-foot long survey line. All of the individual spreads consisted of a series of twenty-four geophones that were spaced at 10-foot centers, with six common geophones overlapped between each spread. These overlapped lines allowed for seismic wave depth penetration of over 100 feet while providing a continuous, unbroken subsurface profile therefore maintaining higher resolution models. A 16-pound sledge-hammer was used as an energy source to produce the seismic waves and twenty four, 40-Hz geophones (with 70% damping), were used to detect both the direct and refracted waves. The seismic wave arrivals were recorded on a 24-channel Geometrics StrataVisor™ NX model signal enhancement refraction seismograph. Seven shot points were utilized along each individual seismic line spread using offset, forward, reverse, and intermediate locations, in order to obtain sufficient data for velocity analysis and depth modeling purposes. During acquisition, the seismograph displays the seismic wave arrivals, of which are digitally recorded. The data on the paper record and/or display screen were used to analyze the arrival time of the primary seismic “P”-waves at each geophone station, in the form of a wiggle trace for quality control purposes in the field. Each geophone and seismic shot location was surveyed using a hand level and ruler for relative topographic correction, with “0” representing the lowest point along the survey line.

DATA PROCESSING

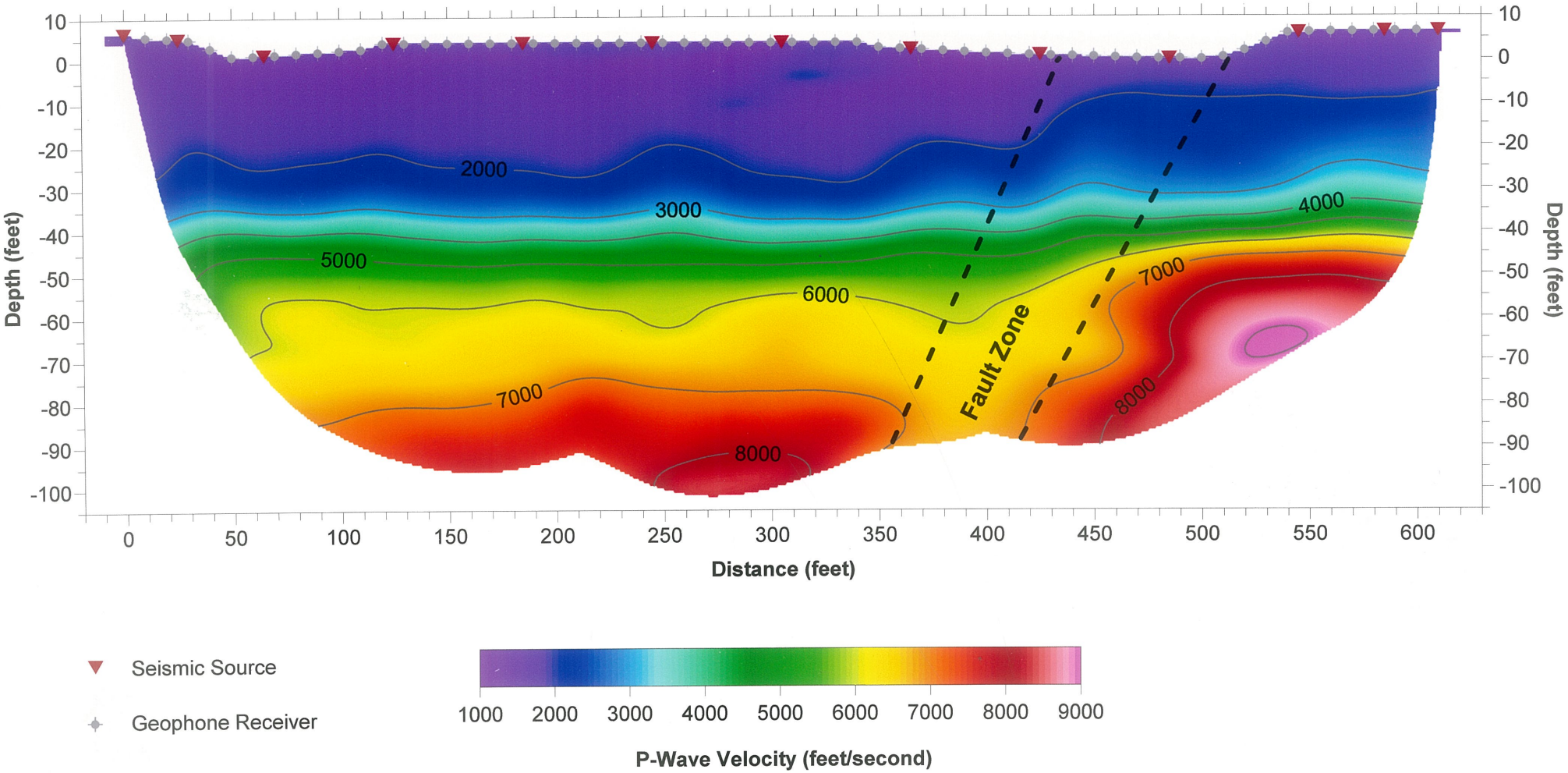
All of the recorded seismic data was subsequently transferred to our office computer for further processing, analyzing, and printing purposes using the computer program **Rayfract™** (Intelligent Resources, Inc., 1996-2014). **Rayfract™** is seismic refraction tomography software that models subsurface refraction, transmission, and diffraction of acoustic waves which generally indicates the relative structure and velocity distribution of the subsurface using first break energy propagation modeling. An initial 1D gradient model is created using the Delta-t-V method which gives a good initial fit between modeled and picked first breaks. This initial model is then refined automatically with a true 2D WET (Wavepath Eikonal Traveltime) tomographic inversion (Schuster and Quintus-Bosz, 1993). WET tomography models multiple signal propagation paths contributing to one first break, whereas conventional ray tracing tomography is limited to the modeling of just one ray per first break. This computer program performs the analysis by using the first-arrival P-wave times and line geometry that were derived from the **SIPwin** analysis.

The representative Refraction Tomographic Model (Seismic Line S-1) is presented within this appendix and has been annotated for visual and reference purposes.

SEISMIC LINE S-1

← Northeast - Southwest →

REFRACTION TOMOGRAPHIC MODEL



NOTE: Vertcal Exaggeration 2X

RMS error 1.8 %, Rayfract Version 3.31

APPENDIX C - Carbon-14 Test Results

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Consistent Accuracy . . .
. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

May 14, 2014

Mr. Dan Lind
Inland Foundation Engineering, Incorporated
1310 S. Santa Fe Avenue
San Jacinto, CA 92583
USA

RE: Radiocarbon Dating Result For Sample S679-001

Dear Dan:

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO-17025 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO-17025 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

The cost of the analysis was charged to the VISA card provided. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
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beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Dan Lind — Report Date: 5/14/2014

Inland Foundation Engineering, Incorporated — Material Received: 5/5/2014

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 379835	4840 +/- 30 BP	-24.6 o/oo	4850 +/- 30 BP

SAMPLE : S679-001
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 3690 to 3680 (Cal BP 5640 to 5630) and Cal BC 3660 to 3635 (Cal BP 5610 to 5585) and Cal BC 3550 to 3540 (Cal BP 5500 to 5490)

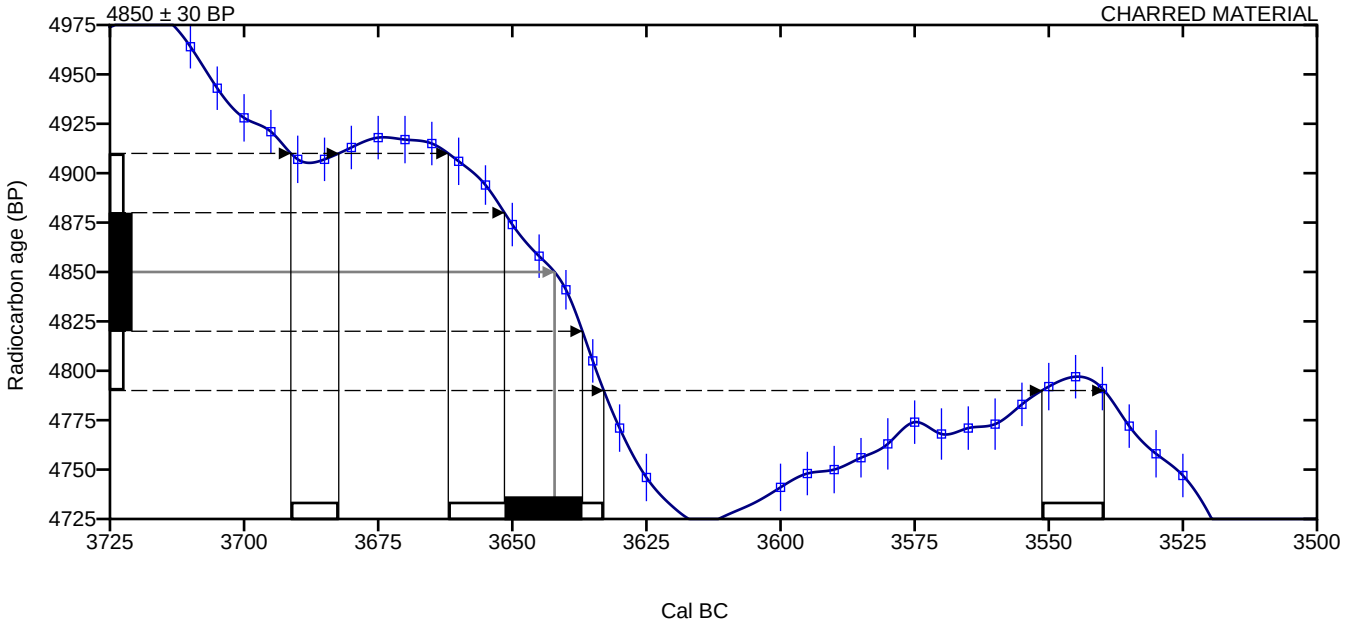
Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -24.6 o/oo : lab. mult = 1)

Laboratory number	**Beta-379835**
Conventional radiocarbon age	**4850 ± 30 BP**
2 Sigma calibrated result 95% probability	**Cal BC 3690 to 3680 (Cal BP 5640 to 5630)** **Cal BC 3660 to 3635 (Cal BP 5610 to 5585)** **Cal BC 3550 to 3540 (Cal BP 5500 to 5490)**
Intercept of radiocarbon age with calibration curve	Cal BC 3640 (Cal BP 5590)
1 Sigma calibrated results 68% probability	Cal BC 3650 to 3635 (Cal BP 5600 to 5585)



Database used

INTCAL13

References

Mathematics used for calibration scenario

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APPENDIX D - References

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