Geng Development, LLC
950 South Spring Meadow Drive
West Covina, California 91791

Preliminary Geologic Hazards Report
Route 66 Shooting Sports Park & Modular Addition
15818 Cajon Boulevard (Old Route 66)
APN 0350-07-101 & 134
Keenbrook Area, San Bernardino County,
California

June 22, 2018

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File No.: 302145-001
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Geng Development, LLC
950 South Spring Meadow Drive
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Attention: Mr. Geng Nie & Mr. Kevin Kollack

Subject: **Preliminary Geologic Hazards Report**

Projects: **Route 66 Shooting Sports Park & Modular Addition**
15818 Cajon Boulevard (Old Route 66)
APN 035-007-101 & 134
Keenbrook Area, San Bernardino County, California

Earth Systems Pacific (Earth Systems) is pleased to present this Preliminary Geologic Hazards Report for the proposed approximately 85-acre sports park located in the Keenbrook area of San Bernardino County, California. This report presents our findings and recommendations with respect pertinent geologic hazards and the proposed development. This report should stand as a whole and no part of the report should be excerpted or used to the exclusion of any other part.

This report completes our scope of services in accordance with our proposal, dated May 17, 2018 and authorized on May 21, 2018. Unless requested in writing, the client is responsible for distributing this report to the appropriate governing agency or other members of the design team.

We appreciate the opportunity to provide our professional geologic services. Please contact our office if there are any questions or comments concerning this report or its recommendations.

Respectfully submitted,
EARTH SYSTEMS PACIFIC

Mark S. Spykerman, EG #1174
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Section 1
INTRODUCTION

1.1 Project Description

This Preliminary Geologic Hazards Report has been prepared for the proposed 84.8-acre property located west of Interstate 15, easterly of Cajon Boulevard, and approximately 2.3 miles northwest of the Kenwood Avenue/Interstate 15 exit in the Keenbrook area of San Bernardino County, California. The purpose of this report is to describe potential geologic conditions or hazards that might affect future site development.

Current development plans include the construction of a shooting park sports complex. Some site grading is anticipated to improve existing roads, clear vegetation for shooting ranges, and locate one new modular building. Anticipated grading is expected to have cut and/or fill slopes no greater than 10 feet high. Minimal appurtenant site work is anticipated other than landscaping and installation of utilities and a leachfield system for the modular building.

1.2 Site Description

The approximately 85-acre irregular-shaped property is located immediately east of Cajon Boulevard, west of Interstate 15, San Bernardino County, California. The coordinates near the center of the property are Latitude 34.25624°N and Longitude 117.45899°W. The proposed modular building is to be located in the southwest portion of the site near coordinates 34.25580°N/117.46099°W. Plate 1 in Appendix A presents the approximate site location. The site is described as a portion of the south 1/2 Section 13, Township 2 North, Range 6 West, San Bernardino base and meridian. Most of the property is within the southeast quarter of Section 13. The site is bounded on the west by Cajon Boulevard and Cajon Creek, on the north by vacant land, on the east by Interstate 15 and vacant land, and on the south/southwest sparse residential developments and vacant land.

Topographically, the property is predominantly hillside with a northeast to east trending valley that drains to the southwest towards Cajon Creek. Hillsides are steep with moderate to gently sloping grades within the valley and along the westerly portion of the property adjacent to Cajon Boulevard. Elevations range from approximately 2,520 feet above mean sea level (msl) in the southwest portion of the site to approximately 2,830 feet msl in the northwest portion of the site.

The site is currently partially developed with multiple residences, a pool, pool building, maintenance buildings, dirt roadways, and associated underground utilities. Significant site grading to accommodate the current structures, shooting ranges, ponds, drainage control berms, and other improvements exist. Cut and fill slopes are generally less than 20 feet high. Vegetation includes native desert scrub in the hillside and upper elevation areas, with deciduous trees in the valley portion and around the existing structures. Most of the structures are clustered near the mouth of the valley at the southeast portion of the site.

1.3 Purpose and Scope of Services

The purpose for this study was to evaluate the general geologic conditions and to provide professional opinions and recommendations, from a geologic hazards point of view, geologic conditions and constraints that may affect the site, including the proposed modular building site. We understand that the project will be developed under the regulation of the County of San Bernardino and the current California Building Code (2016).

The conclusions and recommendations included in this report are based upon the data collected for this commission and past professional experience with similar projects in southern California. The scope of services included:

<u>Task 1 - Literature and Photograph Reviews</u>

We began our services by reviewing select geologic and geotechnical literature pertaining to the project. This included a review of various hazard, fault, and geologic maps prepared by the California Geological Survey, the U.S. Geological Survey, the County of San Bernardino, and other governmental agencies as they relate to the project area. Historical aerial photographs were reviewed using Google™ earth and review of readily available stereo aerial photographs at the County of San Bernardino.

<u>Task 2 - Field Reconnaissance</u>

A senior engineering geologist from our firm performed a limited reconnaissance on June 18, 2018 of the site area to verify noted conditions gathered during the literature and aerial photograph reviews.

<u>Task 3 – Analysis and Report</u>

Earth Systems analyzed the data obtained, performed geologic analyses, and provided conclusions and recommendations pertaining to the noted geologic constraints that might affect the site. Our report includes:

- A description of the proposed project including a site plan showing the general location;
- A description of anticipated surface and subsurface site conditions including groundwater conditions;
- A description of the site geologic setting and possible associated geology-related hazards, including fault rupture, liquefaction, lateral spreading, subsidence, and seismic settlement;
- A site specific geologic map;

- A discussion of regional geology and site seismicity, including regional geology maps;
- A description of local and regional active faults, their distances from the site, their potential for future earthquakes;
- A discussion of other geologic hazards such as fault rupture, ground shaking, landslides, flooding, and tsunamis;
- A "General Procedure" seismic analysis including recommendations for seismic design coefficients and soil profile type in accordance with the 2016 California Building Code;

Not Contained in This Report: Although available through Earth Systems, the current geologic scope of our services does not include:

- ➢ An environmental Phase 1 assessment.
- ➢ A detailed geotechnical engineering report or percolation report.
- ➢ An investigation for the presence or absence of wetlands, hazardous or toxic materials in the soil, surface water, groundwater, or air on, below, or adjacent to the subject property.

Section 2
DISCUSSION

2.1 Soil & Rock Conditions

The field reconnaissance and literature review indicates that site geologic materials consist generally of locally derived artificial fill (af), Quaternary younger alluvial soils (Qa), Quaternary slopewash (Qsw), Quaternary Landslide Debris (Qls), Quaternary older alluvium (Qoa), highly elevated older alluvial fan deposits (Qog), and pre-Tertiary Pelona schist (ps). Refer to Plates III and V for the general distribution of mapped units.

The proposed modular building is to be located in the southwesterly portion of the site on an elevated older alluvial terrace deposit. Soils are coarse grained and consist of silty and clayey sands and gravelly sands.

2.2 Groundwater

No data is readily available on the Watermaster or Department of Water Resources data bases. However, based on the site geomorphology and presence of faulting (easterly portion of the site), we anticipate that groundwater levels vary dramatically under the site. Near the faults in the northeastern portion of the site, several springs are identified on historical topographic maps, suggesting free flowing and shallow ground water. Groundwater levels within the valley portion of the site are seasonally variant and affected by the water flow in Cajon Creek, and can be assumed to be relatively shallow (<100 feet deep) during spring runoff periods.

An on-site private well is located near the pool buildings at an approximately elevation of 2,572 feet msl. The well location is down-gradient from the mapped Punchbowl faults. Static water level (as reported by the client is near 140 feet deep (text communication on June 19, 2018), with a water-surface elevation of approximately 2,432 feet msl.

The proposed modular building site ground surface, near elevation 2,580 msl, is approximately 95 feet higher in elevation than the base-line flow for Cajon Creek (elevation 2,485 feet msl). Base-line gradients for the on-site drainage located east of the building site are near elevation 2,515 feet msl, or about 65 feet lower in elevation than the building site. Groundwater elevations under the proposed modular building site will be predominantly controlled by the groundwater flow into or from these intermittent drainage courses. Peak or highest anticipated groundwater levels under the site would be during the spring runoff, when the streams are running and infiltration into the adjacent subsurface is occurring. It can be expected that the highest (shallowest) static groundwater levels (seasonally) could be near the base line elevations of the adjacent streams, or perhaps slightly higher during really wet winter/spring seasonal periods. As such, we estimate that the highest anticipated groundwater level below the proposed modular building site is at least 50 feet below the ground surface.

2.3 Geologic Setting

Regional Geology: The site is situated in the Transverse Ranges Geomorphic Province of California. The Transvers Ranges Province is a distinct geomorphic region characterized as a complex series of west to east oriented mountain ranges and valleys generally oblique to faults composing the San Andreas rift zone. The Transverse Ranges Province is further described by sub-units, which include the San Gabriel Mountains and San Bernardino Mountains. The project site is at the western limits of the San Bernardino Mountains.

Regional earth units consist predominantly of igneous rocks of the southern California batholith, Mesozoic meta-sedimentary rocks, and Quaternary alluvial deposits (Plate III and V). Regional active and potentially active faults in the vicinity of the project site include the San Jacinto, Punchbowl, and San Andreas faults.

Regional active and potentially active faults in the vicinity of the project site include the San Jacinto fault zone and San Andreas fault (see Plates II, III, IV and V). No mapped active faults are within the immediate vicinity of the proposed new modular building. Segments of the Punchbowl fault trend through and near the northeast portion of the property (see Plate III and IV) approximately 0.3 miles northeast of the proposed new modular building site.

Local Geology: The site is located at the western terminus of the San Bernardino Mountains. Per Dibblee (2003), geologic units consist of Pelona schist, older alluvium, and younger alluvium. Thin deposits of slopewash, landslide debris, and artificial fill associated with past grading, are present.

Pelona Schist (ps): Pre-Tertiary metamorphic rock consisting of gray to black well-foliated schist. Structurally the schist has a foliation consistently dipping steeply to the east when exposed westerly of the Punchbowl fault. East of the Punchbowl fault, foliations dip steeply to the southwest. The schist is exposed along the margins of the hillsides and typically has a shallow cover of slopewash.

Highly Elevated Older Alluvial Fan Deposits (Qog): Remnant older alluvial deposits consisting sand, gravel and boulders. Caps the ridge at the northwest portion of the site.

Older Alluvium (Qoa): Older alluvial fan and terrace deposits consist of generally coarse-grained sediments generally derived from pre-Holocene deposition associated with Cajon Creek during the Pleistocene epoch. Soils are typically silty sands, gravelly sands and sandy gravels. On the project the older terrace deposit occur along the western margin of the site, and are elevated above Cajon Creek.

Younger Alluvium (Qa): Younger alluvial soils consist of modern soils within and adjacent to Cajon Creek and the on-site drainage course. Also coarse-grained silty sands, sands, gravelly sands, and sandy gravels associated with modern depositional processes.

Slopewash (Qsw): Locally derived deposits consisting of coarse grained sands and silty sands with gravel and cobbles. Locally found along the toes of the ridge slopes.

Landslide Debris (Qls): Holocene landslide debris, as noted during the aerial photograph review. Generally, consists of materials similar to the slope wash deposits.

Artificial Fill (af): Fills are locally derived materials used over the decades to grade roads, berms and permitted building pads. We are assuming that the fills are undocumented. Fill slopes are generally under 20 feet high and at typical 2:1 slope gradients.

Regional Faulting: No active faults have been mapped in the proximity of the planned new modular building based upon local and regional select published geologic maps by the California Geologic Survey (2010) or United States Geologic Survey fault database (2006). No geomorphic evidence of faulting was noted on the aerial photographs or during the site reconnaissance. The modular building site is not located within a currently designated Alquist-Priolo Earthquake fault zone (Cajon Quadrangle).

The nearest mapped fault is the mapped traces of the Punchbowl fault located about 0.3 miles northwest of the project (Dibblee, 2003 & CGS, 1974). This mapped fault is not thought to be active. However, the nearby segments of the active San Jacinto fault (Glen Helen segment), considered to be one of the most historically active fault zones in southern California, are located approximately 0.3 miles southwest of the modular building site. The San Andreas fault is located approximately 0.8 miles northeast of the proposed modular building site.

Local Faulting and Lineaments: A lineament analysis of areas surrounding the site was performed. This lineament analysis included review of historical aerial photographs on Google earth as well review of stereo aerial photographs available at San Bernardino County's photo library. A summary of the lineament analysis follows:

Photos obtained from County of San Bernardino Dept. of Public Works, 825 E. 3rd Street, San Bernardino, California.

Reviewed by Darrin Hasham, CEG, on June 6th, 2018

Date	Flight	Frames	Scale	Format	Quality
01/01/1938	1938-1	67-49, 67-50	1"=5,280'	B & W	poor
No apparent lineaments crossing the site. Two or 3 generations of stream terraces are present. The oldest forms an approximately triangular shaped area at the mouth of the canyon and extending northwestward at the main stream channel, the intermediate terrace is east and north of the oldest terrace, forming a nearly north-south trending stream bank. Possibly a third terrace is present and appears to be an area where a crop like hay is being grown. Indications of two small potential landslides are within proximity of the site; a potential landslide is on the ridge that forms the northern boundary of the canyon at its confluence with the main stream. It is overgrown and gives the impression of some antiquity. The direction of movement appears to be southward into the canyon. Another potential landslide is offsite approximately 1,000 southeast of the site on a slope facing southwest towards the main stream channel. It is a little peculiar in its nearly perfectly round footprint.					
11/07/1955	W-74	I-2-21, I-2-22, R-5, I-3-1	1"=1,000'	B & W	good
A house has been built and a small orchard has been established at the mouth of the canyon. The transmission towers have been erected and a fuel break established across the ridge to the northwest. A third landslide is evident in the side drainage approximately 1,200' northeast of the proposed modular building site. The scarp appears fresh and light colored, movement appears southward into the drainage. The indications of the landslide on the northern boundary are diminished and grown over. Agricultural and development indications are similar to the 1938 photo, although more developed, but not necessarily over a larger footprint.					
01/19/2005	C-553	21-5, 21-6	1"=1,000'	B & W	good
The house in the north part of the canyon has been built since 1955. Roads and landscape in the main activity area are more refined. Agricultural activities still apparent. The landslide near the northern boundary is no longer apparent. Landslide on the northern hillside is less apparent. An anomalous feature in the small drainage directly north of the small house at the north end of the canyon may be slide debris, slopewash, or an outcrop weathering out. An apparent trail has been constructed up the drainage complicating the image.					

Summary: No indications of surface faulting were apparent in the photos available. Several generations of stream terraces are present on site and may be the result of westward migration of Cajon Creek in the canyon. The migration may be the result of tectonic uplift of the highlands to the north/northwest.

Two small surficial landslides were observed in proximity to the site (see Plate V)and third was just offsite. The landslides appear to be of the shallow slump or surficial type and no large deep-seated slides were apparent. The location of the proposed modular building appears to be upon the oldest stream terrace described from the 1938 photograph.

2.4 Geologic Hazards

Geologic hazards that may affect the region include seismic hazards (ground shaking, surface fault rupture, soil liquefaction, and other secondary earthquake-related hazards), slope instability, flooding, ground subsidence, and erosion. A discussion follows on the specific hazards to this site.

2.4.1 Seismic Hazards

Seismic Sources: Several active faults or seismic zones lie within 42 miles of the project site as shown on Table 1 in Appendix A. The primary seismic hazard to the site is strong ground shaking from earthquakes along regional faults including the San Andreas and San Jacinto faults.

Surface Fault Rupture: The project modular building site does not lie within a currently delineated State of California, *Alquist-Priolo* Earthquake Fault Zone (CGS, 2018). Well-delineated fault lines cross through this region as shown on California Geological Survey [CGS] maps (Jennings, 2010) or United States Geologic Survey fault database (2006). No active faults are mapped in the immediate vicinity of the modular site. However, the northeast approximately 1/3 of the property is encompassed by the CGS Earthquake Fault Zone for the Punchbowl fault.

We anticipate that the potential for future surface fault rupture in the proximity of the total property is moderate to high in the northeastern 1/3 of the site, essentially within the currently delineated CGS Earthquake Fault Zone. The potential for surface fault rupture in the westerly 2/3 of the total property is considered low. While fault rupture would most likely occur along previously established fault traces, future fault rupture could occur at other locations.

Historic Seismicity: The site is located within an active seismic area in southern California where large numbers of earthquakes are recorded each year. Approximately 33 magnitude 5.5 or greater earthquakes have occurred within 60 miles of the property since the late 1800's (see Table 2). Of significance is the multiple earthquake events along the San Jacinto fault at the turn of the century in 1858, 1892, 1894, 1899, 1918, and 1923. Additional earthquakes in the region along this fault zone occurred in 1937 and 1954 suggesting that the San Jacinto fault is a significant source of large to major earthquakes. Regional earthquakes of note include the 1857 Fort Tejon earthquake, 1923 San Bernardino earthquake, the noted other earthquakes on the San Jacinto fault zone, the 1910 Glen Ivy Hot Springs earthquake, 1986 Palm Springs earthquake, and 1992 Landers and Big Bear earthquakes.

While the San Andreas fault, San Jacinto fault, and Elsinore faults are the primary probably sources of damaging earthquake activity in the Keenbrook area, there are multiple other fault in the southern California area that are capable of generating damaging earthquakes in the project area. These include the multiple faults in the Eastern California shear zone in the Mojave Desert and faults within the Los Angeles Basin.

Seismic Risk: While accurate earthquake predictions are not possible, various agencies have conducted statistical risk analyses. In 2002 and 2008, the California Geological Survey [CGS] and the United States Geological Survey [USGS] completed probabilistic seismic hazard maps. We have used these maps in our evaluation of the seismic risk at the site. The recent Working Group of California Earthquake Probabilities (WGCEP, 2007) estimated a 59-percent conditional probability that a magnitude 6.7 or greater earthquake may occur between 2008 and 2038 along the southern segment of the San Andreas fault, 11 percent for the Elsinore fault, and 31 percent along the San Jacinto fault.

Secondary seismic hazards related to ground shaking include soil liquefaction, ground subsidence, tsunamis, and seiches. Other hazards include flooding and slope instability. The site is far inland, so the hazard from tsunamis is non-existent.

Soil Liquefaction and Lateral Spreading: Liquefaction is the loss of soil strength from sudden shock (usually earthquake shaking), causing the soil to become a fluid mass. In general, for the effects of liquefaction to be manifested at the surface, groundwater levels must be within 50 feet of the ground surface and the soils within the saturated zone must also be susceptible to liquefaction. The project is not situated in a zone designated by San Bernardino County to have a significant liquefaction potential due to relatively deep groundwater, so the potential for liquefaction to occur at this site is considered low because groundwater is generally greater than 50 feet below the ground surface. Where shallow bedrock or older alluvium exists, the potential for liquefaction is considered nil to low due to the density of the underlying materials.

However, for those portions of the site near the noted springs (Punchbowl fault zone) or within and adjacent to the on-site primary drainage channel during the spring runoff, when shallow groundwater may be present, there may be a liquefaction potential for younger alluvial soils assuming a significant earthquake occurs during the shallow groundwater periods.

The potential for lateral spreading is considered nil to low for most of the site due to deep (+50') groundwater levels or dense geologic materials. However, within and near the main drainage channel along the eastern portion of the site free-face conditions do exist due to site grading and drainage channel bluffs. During seasonal shallow groundwater conditions, there may be a potential for seismic induced liquefaction and associated lateral spreading within the primary drainage channel area.

Specifically, for the proposed modular building site, it is our opinion that this location is not subject to liquefaction or lateral spreading due to deep groundwater levels and dense geologic materials (Older alluvium).

Seismic Settlement: The amount of settlement is dependent on relative density of the soil, ground motion, and earthquake duration. For this project site specific geotechnical analysis of seismic induced settlement should be evaluated by the project geotechnical engineer. However, due to the anticipated uniform geologic strata under the site, it is anticipated that differential settlement associated with seismic induced settlement should be within tolerable limits of the planned modular construction.

Ground Subsidence: Most alluvial filled valleys in southern California are designated as susceptible to areal subsidence from groundwater withdrawal. As areal subsidence typically occurs on a regional basis, the effects of subsidence on structures within the site should be insignificant.

Seismic Hazard Zones: This portion of San Bernardino County has not been mapped for the California Seismic Hazard Mapping Act (Ca. PRC 2690 to 2699).

Site Acceleration and Seismic Coefficients: In developing site specific seismic design criteria, the characteristics of the earth units underlying the site are an important input to evaluate the site response at a given site. Based on the results of our evaluation, the project modular building site is underlain by Quaternary older alluvial deposits. Therefore, the site classification for site response is Site Class D according to Table 20.3-1 of ASCE7-10. The D characterization is defined as a soil profile consisting of stiff soil with shear wave velocities between 600 to 1,200 fps.

Probabilistic Analysis and General Procedure: The Seismic Design Category for this site is E. Soils profiles indicate a Site Class D. The Code seismic parameter S_s is 2.783 g, and S_1 is 1.185 g. PGAm is 1.014g. The modular building site is not within a designated CGS Earthquake Fault Zone and the modular site is not susceptible to liquefaction. For comparative analysis, a probabilistic analysis using the California Geologic Survey Ground Motion Interpolator website suggests a peak 2% probability of exceedance in 50-year horizontal acceleration value of about 1.33 g. Very high seismic induced ground motions should be anticipated for this site.

2016 CBC Seismic Coefficients: The California Building Code [CBC] seismic design parameters criteria are based on a Design Earthquake that has an earthquake ground motion $^2/_3$ of the lesser of 2 percent probability of occurrence in 50 years or maximum 84^{th} percentile of the mean deterministic maximum considered earthquake. The seismic and site coefficients given in Chapter 16 of the 2016 California Building Code are provided in Section 4.1 of this report.

2.4.2 Other Hazards

Slope Instability: The site is a combination of moderately sloping to flat alluvial areas with adjacent highlands with steep hillsides. Aerial photograph reviews indicate past surficial style landslide in the hillsides, with suggestive more extensive possible older landslides. Therefore, slope stability issues on the hillside areas of the site are possible. **For the modular building site, there are no apparent landslide issues.** Erosion of surficial soils should be anticipated.

Existing cut and fill slopes are apparent due to past modifications to the site. Cut and fill slopes are predominantly composed of alluvium or alluvial derived materials (silty sands and gravelly sands). No evidence of significant surficial instability was noted on the existing cut or fill slopes, despite being present for decades.

Flooding: The proposed modular building site does not lie within a designated FEMA 100-year flood plain or dam inundation area.

The overall project site is in an area where sheet flooding and erosion could occur. Seasonal flooding is also a possibility within the primary drainage course along the eastern margin of the total property.

Debris flow occurrence issuing from defined drainage courses within the hillside areas are also considered a moderate to high potential. Appropriate project design, construction, and maintenance can minimize flooding and debris flow potentials.

The site is far inland, thus the potential for flooding from a tsunami is nil.

Seiches: Seiching is defined as a periodic oscillation of liquid within a container or reservoir.

One small water storage tank near the pool building, the pool, and two ponds exist in the eastern portion of the site. Oscillation of water within any of these structures could occur during an earthquake with possible minor flooding. In the event of seiching and associated flooding, it is likely that any flood water would follow existing drainages within the eastern portion of the site and not pose a significant threat to any current building or the proposed modular building site.

Section 3
CONCLUSIONS

The following is a summary of our conclusions and professional opinions based on the data obtained from a review of selected technical literature and the site evaluation.

Geologic Constraints and Mitigation:

- The primary geologic hazard is moderate to severe ground shaking from earthquakes originating on local and regional faults. A major earthquake originating on the nearby segments of the San Andreas fault, Elsinore fault, San Jacinto fault, and other regional faults would be the critical seismic event that may affect the site within the design life of the project. Strong to severe ground shaking should be anticipated. Engineered design and earthquake-resistant construction increase safety and allow development of seismic areas.
- The underlying geologic condition for seismic design is Site Class D. The site is about 0.3 to 0.8 miles from the closest segment of a Type A seismic source as defined by the California Geological Survey. A qualified professional should design any permanent structure constructed on the site. The *minimum* seismic design should comply with the 2016 edition of the California Building Code.
- The proposed modular building site is not within the County of San Bernardino designated fault zone, nor is the site within a currently designated California Geological Survey Earthquake Fault Zone. No obvious aerial photograph lineament were noted during our photograph review suggestive of on-site faulting at the proposed modular building site. Therefore, the potential for surface fault rupture at the proposed modular building site is considered very low.
- The potential for future surface fault rupture within the defined CGS Earthquake Fault Zone (Plate 4) is considered moderate to high.
- Ground subsidence, liquefaction, and seismic induced subsidence hazards are considered low for the proposed modular building site.
- Liquefaction and lateral spreading hazards are a low to moderate potential within the defined drainage course area along the eastern margin of the site and in the proximity of the Punchbowl fault related springs.
- The site is not within an area of documented significant areal subsidence. It is anticipated that areal subsidence would occur on a regional basis and have relatively low impacts on site development.
- Landslide or debris flow hazards are considered low at the proposed modular building area.
- Landslide and debris flow hazards potentials are considered moderate to high within the hillside portions of the site.
- Seasonal flooding, erosion, and debris flows within the defined intermittent drainage course along the eastern portions of the site is possible.
- The soils are susceptible to wind and water erosion. Preventative measures to reduce seasonal flooding and erosion should be incorporated into site grading plans. Dust control

should also be implemented during construction. Site grading should be in strict compliance with the requirements of the South Coast Air Quality Management District [SCAQMD].

- On-site soils are alluvial in nature. Shallow fills are present and are assumed to be unsuitable for support of structures. Geotechnical constraints relating to consolidation, expansion, and corrosion should be addressed in site specific geotechnical studies and during remedial grading.

Section 4
RECOMMENDATIONS

Based upon the data collected to date, the following recommendations are provided relative to the proposed residential development and noted geologic hazards.

1. The propose modular structure and associated site improvements should be designed in accordance with at least minimum building code standards as described in the 2016 California Building Code. Construction should allow for all plumbing and utility services to be connected with flexible connections and provided with convenient shutoffs.
2. Site improvements should be designed to accommodate seasonal sheet flooding.
3. The on-site earth materials are susceptible to erosion. Measures to minimize erosion should be incorporated into the overall project design.
4. Site specific geotechnical reports should address engineering issues of the site soils as related to proposed site improvements.
5. Site-specific geologic (fault hazards) studies should be performed for any planned habitable structure proposed in the northeast 1/3 of the entire site, within the currently designated CGS Earthquake Fault Zone. The approximate limits of the currently delineated CGS Earthquake Fault Zone is shown on Plate V.
6. For future projects on or adjacent to the ascending hillsides, site-specific geologic and geotechnical studies may be warranted to address potential slope stability and debris flow potentials.
7. This geologic report only defines the general liquefaction hazards for the property. Site specific geotechnical studies will be necessary to quantify liquefaction and lateral spreading hazards within the primary drainage course area and valley portion of the site along the eastern portion of the property.

4.1 Seismic Design Criteria

This site is subject to strong ground shaking due to potential fault movements along regional faults including the San Jacinto and San Andreas faults zones. Engineered design and earthquake-resistant construction increase safety and allow development of seismic areas. The *minimum* seismic design should comply with the 2016 edition of the California Building Code. The seismic design category is D. General Procedure site seismic parameters are presented below.

2016 CBC Seismic Parameters

Seismic Category:	E
Site Class:	D
Maximum Considered Earthquake [MCE] Ground Motion	
Short Period Spectral Response S_s:	2.783 g
1 second Spectral Response, S_1:	1.185 g
Site Coefficient, F_a:	1.00
Site Coefficient, F_v:	1.50
Code Design Earthquake Ground Motion	
Short Period Spectral Response, S_{DS}	1.855 g
1 second Spectral Response, S_{D1}	1.185 g
Peak Ground Acceleration (PGA_M)	1.014 g

The intent of the CBC lateral force requirements is to provide a structural design that will resist collapse to provide reasonable life safety from a major earthquake, but may experience some structural and nonstructural damage. A fundamental tenet of seismic design is that inelastic yielding is allowed to adapt to the seismic demand on the structure. In other words, *damage is allowed*. The CBC lateral force requirements should be considered a *minimum* design. The owner and the designer may evaluate the level of risk and performance that is acceptable. Performance based criteria could be set in the design. The design engineer should exercise special care so that all components of the design are fully met with attention to providing a continuous load path. An adequate quality assurance and control program is urged during project construction to verify that the design plans and good construction practices are followed. This is especially important for sites lying close to the major seismic sources.

Estimated peak horizontal site acceleration, based upon a probabilistic analysis (2 percent probability of occurrence in 50 years), is approximately 1.33 g for a stiff soil site. Actual accelerations may be more or less than estimated. Vertical accelerations are typically ⅓ to ⅔ of the horizontal accelerations, but can equal or exceed the horizontal accelerations, depending upon the local site effects and amplification.

Section 5
LIMITATIONS AND ADDITIONAL SERVICES

5.1 Uniformity of Conditions and Limitations

Our preliminary findings and recommendations in this report are based on a limited site reconnaissance, literature review, and our understanding of the proposed project. Furthermore, our findings and recommendations are based on the assumption that geologic conditions do not vary significantly from those presented in this report. Variations in soil or groundwater conditions could exist. The nature and extent of these variations may not become evident until construction. Variations in soil or groundwater may require additional studies, consultation, and possible revisions to our recommendations.

Our evaluation of geologic conditions at the site has considered anticipated subgrade soil and groundwater conditions present at the time of our study. It should be recognized that definition and evaluation of subsurface conditions are difficult. Judgments leading to conclusions and recommendations are generally made with incomplete knowledge of the subsurface conditions due to the limitation of data from field studies. The availability and broadening of knowledge and professional standards applicable to engineering services are continually evolving. As such, our services are intended to provide the Client with a source of professional advice, opinions and recommendations based on the information available as applicable to the project location and scope. If the scope of the proposed construction changes from that described in this report, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed, and the conclusions of this report are modified or approved in writing by Earth Systems. This geologic hazards report should not be construed to be a site specific geotechnical engineering report.

Findings of this report are valid as of the issued date of the report. However, changes in conditions of a property can occur with passage of time, whether they are from natural processes or works of man, on this or adjoining properties. In addition, changes in applicable standards occur, whether they result from legislation or broadening of knowledge.

Accordingly, findings of this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and should not be relied upon after a period of one year.

This report is issued with the understanding that the owner or the owner's representative has the responsibility to bring the information and recommendations contained herein to the attention of the architect and engineers for the project so that they are incorporated into the plans and specifications for the project. The owner or the owner's representative also has the responsibility to verify that the general contractor and all subcontractors follow such recommendations. It is further understood that the owner or the owner's representative is responsible for submittal of this report to the appropriate governing agencies.

Earth Systems has striven to provide our services in accordance with generally accepted geologic practices in this locality at this time. No warranty or guarantee, express or implied, is made. This report was prepared for the exclusive use of the Client and the Client's authorized agents.

Earth Systems should be provided the opportunity for a general review of final design and specifications in order that our recommendations may be properly interpreted and implemented in the design and specifications. If Earth Systems is not accorded the privilege of making this recommended review, we can assume no responsibility for misinterpretation of our recommendations. The owner or the owner's representative has the responsibility to provide the final plans requiring review to Earth Systems' attention so that we may perform our review.

Any party other than the client who wishes to use this report shall notify Earth Systems of such intended use. Based on the intended use of the report, Earth Systems may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release Earth Systems from any liability resulting from the use of this report by any unauthorized party.

The current scope of our services does not include site specific geotechnical studies or an environmental assessment or an investigation for the presence or absence of wetlands, hazardous or toxic materials in the soil, surface water, groundwater, or air on, below, or adjacent to the subject property.

-o0o-

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Aerial Photographs:

Google earth: 1994-2017

County of San Bernardino, Flood Control Planning Aerial Photos Archives 1938-2005 (See Section 2.3 of this report for photograph details)

APPENDIX A

Plate I – Site Vicinity Map
Plate II – Regional Geologic Map
Plate IIb – Abbreviated Explanation
Plate III – Local Geologic Map
Plate IV – Alquist-Priolo Earthquake Fault Map
Plate V – Site Specific Geologic Map
Plate VI – Earthquake Epicenter Map

Table 1- Fault Parameters
Table 2 – Historic Earthquakes

Table 1
Fault Parameters

Fault Section Name	Distance (miles)	Distance (km)	Avg Dip Angle (deg.)	Avg Dip Direction (deg.)	Avg Rake (deg.)	Trace Length (km)	Fault Type	**Mean Mag**	Mean Return Interval (years)	Slip Rate (mm/yr)
San Jacinto (San Bernardino)	0.3	0.5	90	225	180	45	A	**7.4**	205	6
San Andreas (San Bernardino N)	0.8	1.3	90	212	180	35	A	**7.5**	103	22
Cleghorn	2.8	4.4	90	187	0	25	B	**6.7**		3
Cucamonga	5.3	8.6	45	347	90	28	B	**6.6**		5
San Andreas (Mojave S)	6.5	10.5	90	206	180	98	A	**7.7**	102	29
Fontana (Seismicity)	8.2	13.2	80	313	na	24	B'	**6.7**		
San Gabriel (Extension)	9.7	15.6	61	6	180	62	B'	**7.2**		
North Frontal (West)	11.7	18.9	49	171	90	50	B	**7.2**		1
San Andreas, (North Branch, Mill Creek)	12.3	19.9	76	204	180	106	A	**7.5**	110	17
San Andreas (San Bernardino S)	15.5	24.9	90	210	180	43	A	**7.6**	150	16
San Jose	16.3	26.3	74	334	30	20	B	**6.6**		0.5
Sierra Madre	18.4	29.6	53	19	90	57	B	**7.2**		2
San Jacinto (San Jacinto Valley) rev	20.9	33.6	90	223	180	18	A	**7.4**	199	18
Clamshell-Sawpit	22.0	35.4	50	334	90	16	B	**6.6**		0.5
Chino, alt 2	22.4	36.0	65	234	150	29	B	**6.7**		1
Chino, alt 1	22.4	36.1	50	236	150	24	B	**6.6**		1
Yorba Linda	26.9	43.2	90	153	na	18	B'	**6.5**		
San Gorgonio Pass	29.3	47.1	60	11	na	29	B'	**6.9**		
Whittier, alt 1	29.7	47.8	70	24	150	46	A	**7.1**	530	2.5
Whittier, alt 2	29.7	47.8	75	24	150	46	A	**7.1**	530	2.5
Helendale-So Lockhart	29.9	48.1	90	51	180	114	B	**7.4**		0.6
Elsinore (Glen Ivy) rev	30.4	48.9	90	218	180	26	A	**7.0**	222	5
Raymond	30.9	49.7	79	348	60	22	B	**6.7**		1.5
San Jacinto (San Jacinto Valley, stepover)	32.2	51.9	90	224	180	24	A	**7.4**	199	9
San Jacinto (Stepovers Combined)	32.2	51.9	90	229	180	25	B'	**6.7**		
San Jacinto (Anza, stepover)	32.3	52.0	90	224	180	25	A	**7.6**	151	9
Puente Hills	32.5	52.3	25	20	90	44	B	**7.1**		0.7
Richfield	32.9	52.9	28	353	na	6	B'	**6.2**		
Peralta Hills	33.0	53.1	50	3	na	14	B'	**6.5**		
Puente Hills (Coyote Hills)	33.9	54.6	26	358	90	17	B	**6.8**		0.7
Mission Creek	35.8	57.6	65	5	180	31	B'	**6.9**		
North Frontal (East)	38.1	61.4	41	187	90	27	B	**6.9**		0.5
Elysian Park (Upper)	38.7	62.3	50	15	90	20	B	**6.6**		1.3
Puente Hills (Santa Fe Springs)	38.9	62.7	29	347	90	11	B	**6.6**		0.7
Elysian Park (Lower, CFM)	39.4	63.4	22	33	na	41	B'	**6.8**		
Elsinore (Glen Ivy stepover)	39.7	63.9	90	216	180	11	A	**7.1**	322	2.5
Elsinore (Stepovers Combined)	39.7	63.9	90	224	180	12	B'	**6.3**		
Verdugo	40.5	65.1	55	31	90	29	B	**6.8**		0.5
Elsinore (Temecula stepover)	40.8	65.7	90	212	180	12	A	**7.6**	725	2.5
Puente Hills (LA)	42.9	69.0	27	20	90	22	B	**6.9**		0.7

Reference: USGS OFR 2007-1437 (CGS SP 203) Based on Site Coordinates of 34.2558 Latitude, -117.46099 Longitude

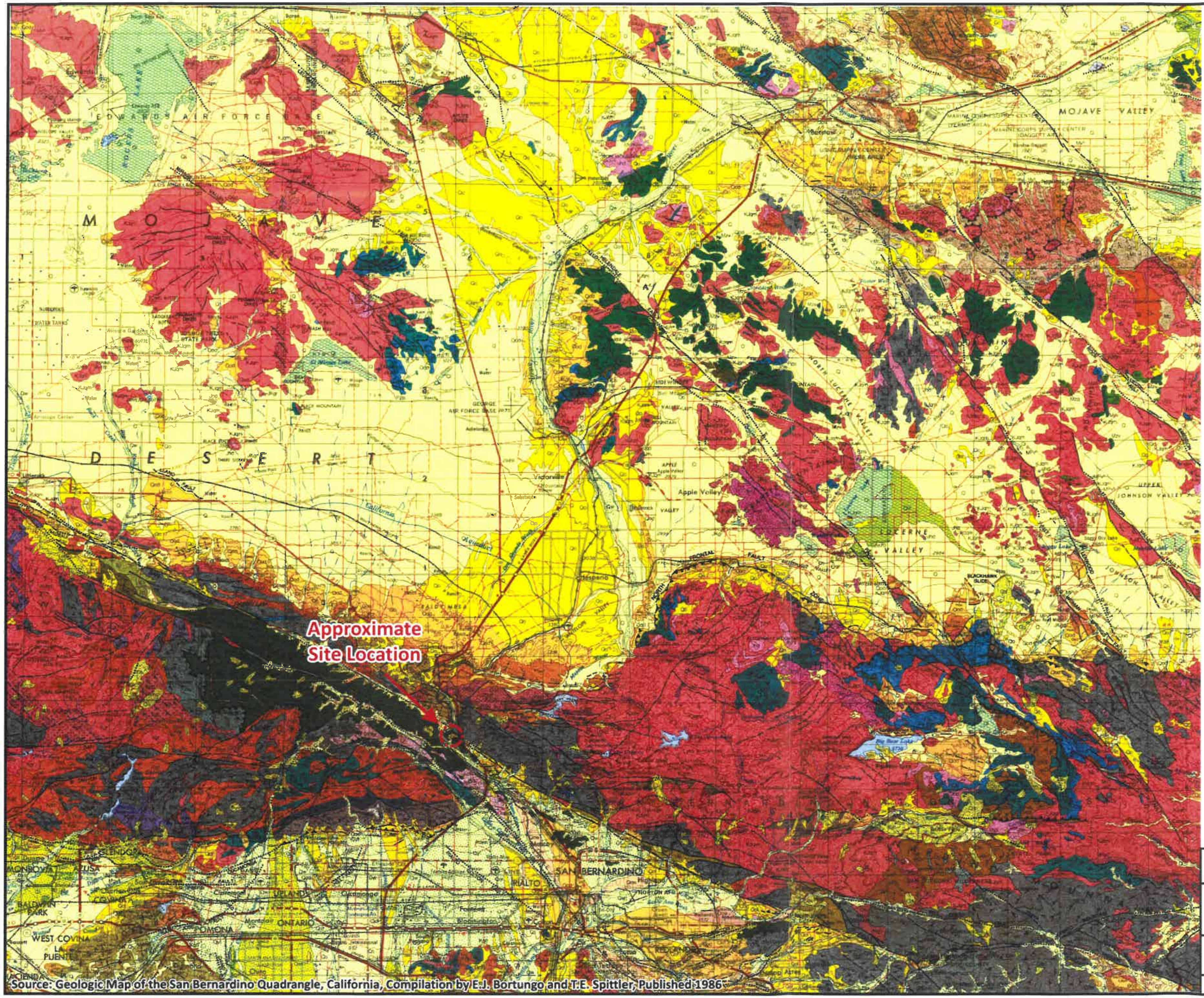
Mean Magnitude for Type A Faults based on 0.1 weight for unsegmented section, 0.9 weight for segmented model (weighted by probability of each scenario with section listed as given on Table 3 of Appendix G in OFR 2007-1437). Mean magntude is average of Ellworths-B and Hanks & Bakun moment area relationship.

Site Coordinates: 34.256 N 117.461 W

Table 2
Historic Earthquakes in Vicinity of Project Site, M > 5.0

Day	*Year*	*Epicenter* *Latittude*	*Epicenter* *Longitude* (*Degrees*)	*Distance from Site (mi)*	*Magnitude* M_W	Estimated Site PGA (g)
07/22	1899	34.30	117.50	*4*	**6.4**	0.34
06/14	1892	34.20	117.50	*4*	5.5	0.19
12/16	1858	34.20	117.40	*5*	**6.0**	0.23
07/22	1899	34.20	117.40	*5*	5.9	0.21
07/30	1894	34.30	117.60	*8*	**6.2**	0.18
12/08	1812	34.37	117.65	*13*	**7.5**	0.28
09/20	1907	34.20	117.10	*21*	5.8	0.06
07/23	1923	34.00	117.25	*21*	**6.2**	0.08
08/28	1889	34.20	117.90	*25*	5.6	0.04
06/28	1991	34.26	118.00	*31*	5.8	0.04
11/22	1880	34.00	117.00	*32*	5.5	0.03
12/19	1880	34.00	117.00	*32*	5.9	0.04
01/16	1930	34.20	116.90	*32*	5.5	0.03
06/28	1992	34.16	116.85	*35*	5.5	0.03
00/00	1803	34.20	118.10	*37*	5.5	0.03
06/28	1992	34.17	116.83	*37*	**6.5**	0.05
01/16	1857	34.52	118.04	*38*	**6.3**	0.04
10/01	1987	34.07	118.08	*38*	**6.0**	0.04
07/11	1855	34.10	118.10	*38*	**6.0**	0.04
05/15	1910	33.70	117.40	*39*	**6.0**	0.03
12/25	1899	33.80	117.00	*41*	**6.7**	0.05
04/21	1918	33.75	117.00	*44*	**6.8**	0.05
02/07	1889	34.10	116.70	*45*	5.6	0.02
03/11	1933	33.70	118.00	*49*	**6.4**	0.02
07/08	1986	34.00	116.61	*52*	**6.0**	0.03
03/11	1933	33.68	118.05	*52*	5.5	0.02
04/12	1880	34.70	118.20	*52*	5.9	0.02
02/09	1971	34.41	118.40	*55*	**6.6**	0.02
02/09	1971	34.41	118.40	*55*	5.8	0.04
02/09	1971	34.41	118.40	*55*	5.8	0.02
09/05	1928	35.00	117.00	*58*	5.5	0.02
01/17	1994	34.26	118.47	*58*	**6.2**	0.02
06/28	1992	34.20	116.44	*59*	**7.3**	0.02
06/28	1992	34.13	116.41	*61*	5.7	0.05
06/29	1992	34.10	116.40	*61*	5.5	0.02
01/17	1994	34.21	118.54	*61*	**6.7**	0.01

Notes:
1.) Earthquakes from California Geological Survey website (Map Sheet 49 database)
2.) Before 1932, Epicenters of earthquakes are approximate, indicated to nearest 0.5 to 0.1 degree.
3.) Estimated Site PGA based on average of 1997 BJF, Campbell and Sadigh attentuation relationships from epicentral distance.



LEGEND

- Approximate Site Location

N

Approximate Scale: 1" = 6½ Miles

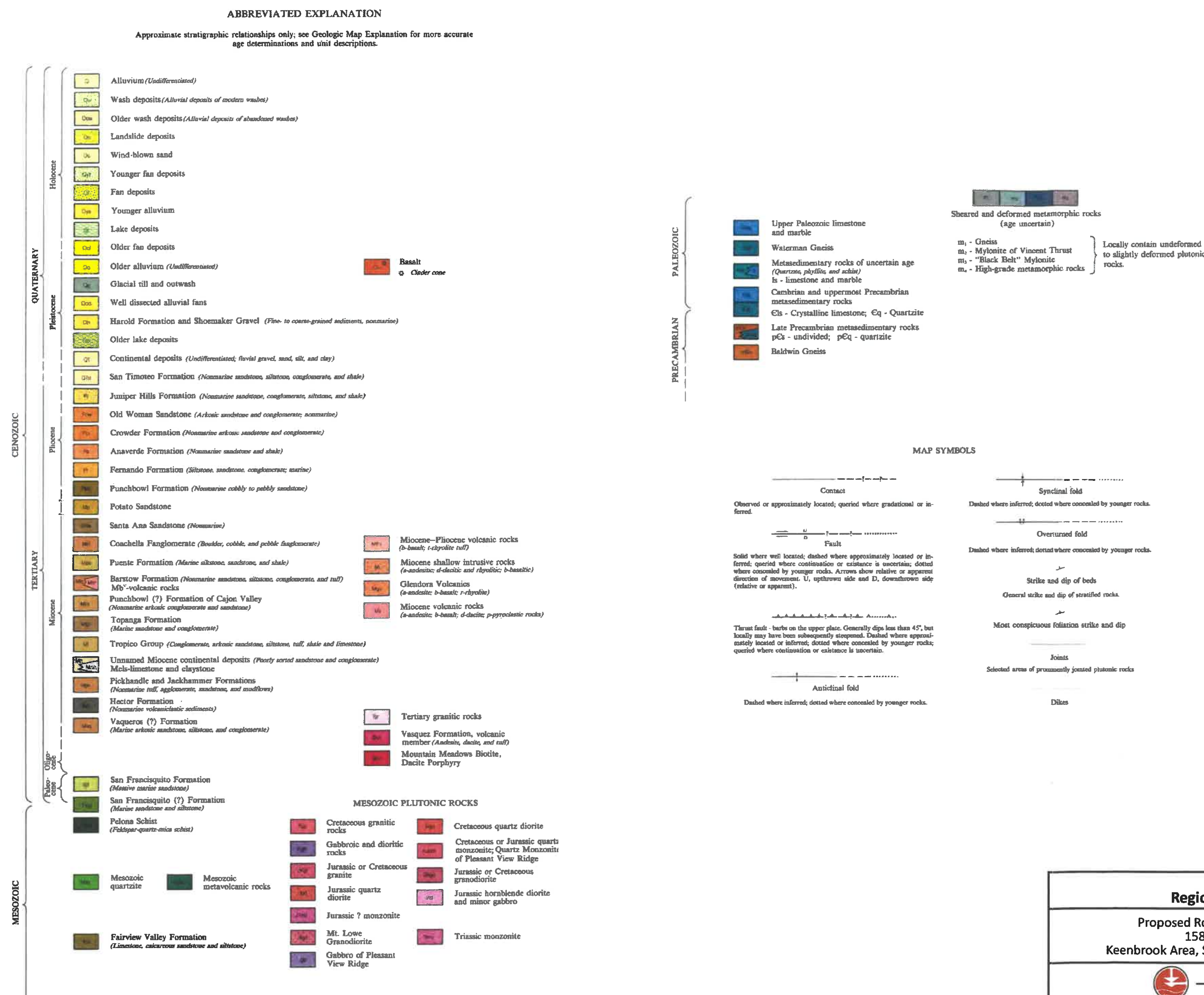
0 | 6½ Miles | 13 Miles

Plate II
Regional Geologic Map

Proposed Route 66 Shooting Sport Park
15818 Cajon Boulevard
Keenbrook Area, San Bernardino County, California

Earth Systems

6/22/2018 | File No.: 302145-001



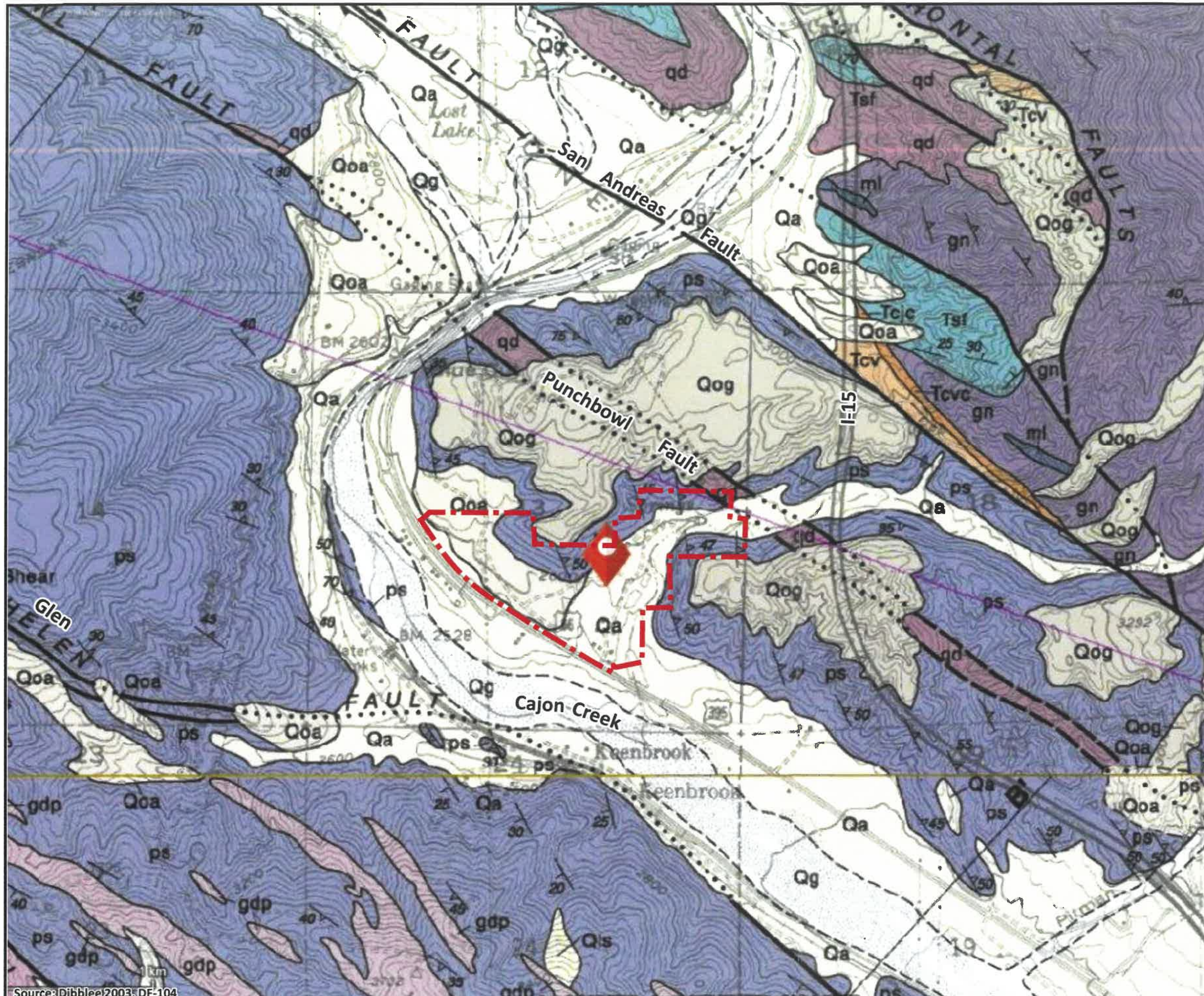
Source: Geologic Map of the San Bernardino Quadrangle, California, Compilation by E.J. Bortungo and T.E. Spittler, Published 1986

Plate IIb
Regional Geologic Map

Proposed Route 66 Shooting Sport Park
15818 Cajon Boulevard
Keenbrook Area, San Bernardino County, California

Earth Systems

6/22/2018	File No.: 302145-001



LEGEND

- Approximate Site Boundary

Qa - Quaternary Younger Alluvium

Qg - Quaternary Alluvial Sands of Cajon Creek

Qoa - Quaternary Older Alluvium

Qog - Quaternary Elevated Older Fan Deposits

gd - Pre-Tertiary Quartz Diorite

ps - Pre-Tertiary Pelon Schist

N

Approximate Scale: 1" = 1,150'

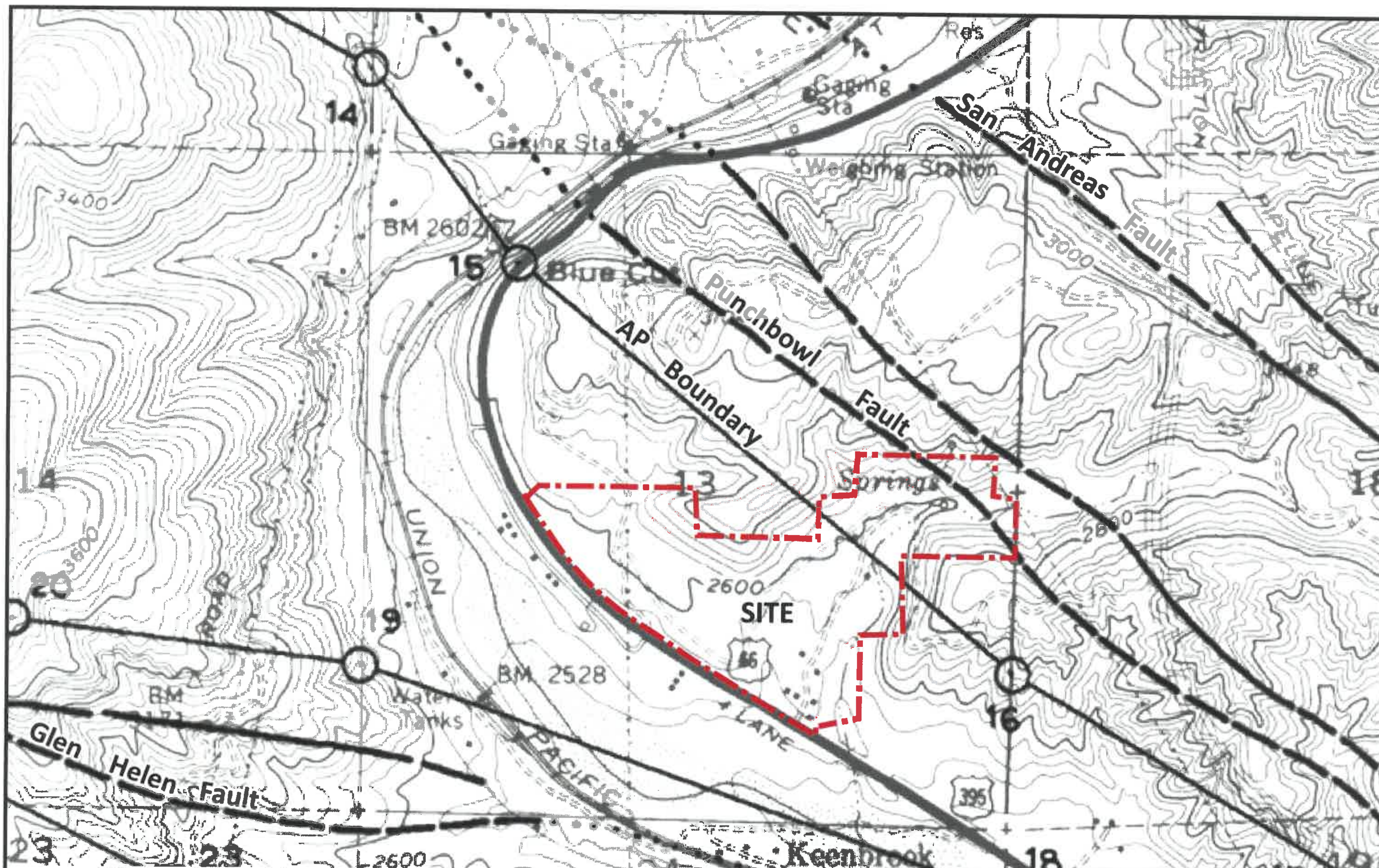
0 1,150' 2,300'

Plate III
Local Geologic Map

Proposed Route 66 Shooting Sport Park
15818 Cajon Boulevard
Keenbrook Area, San Bernardino County, California

Earth Systems

6/22/2018 | File No.: 302145-001



Source: CDMG AP Earthquake Fault Zone - Cajon Quadrangle.

N

LEGEND

Approximate Site Boundary

Approximate Scale: 1" = 1,125'

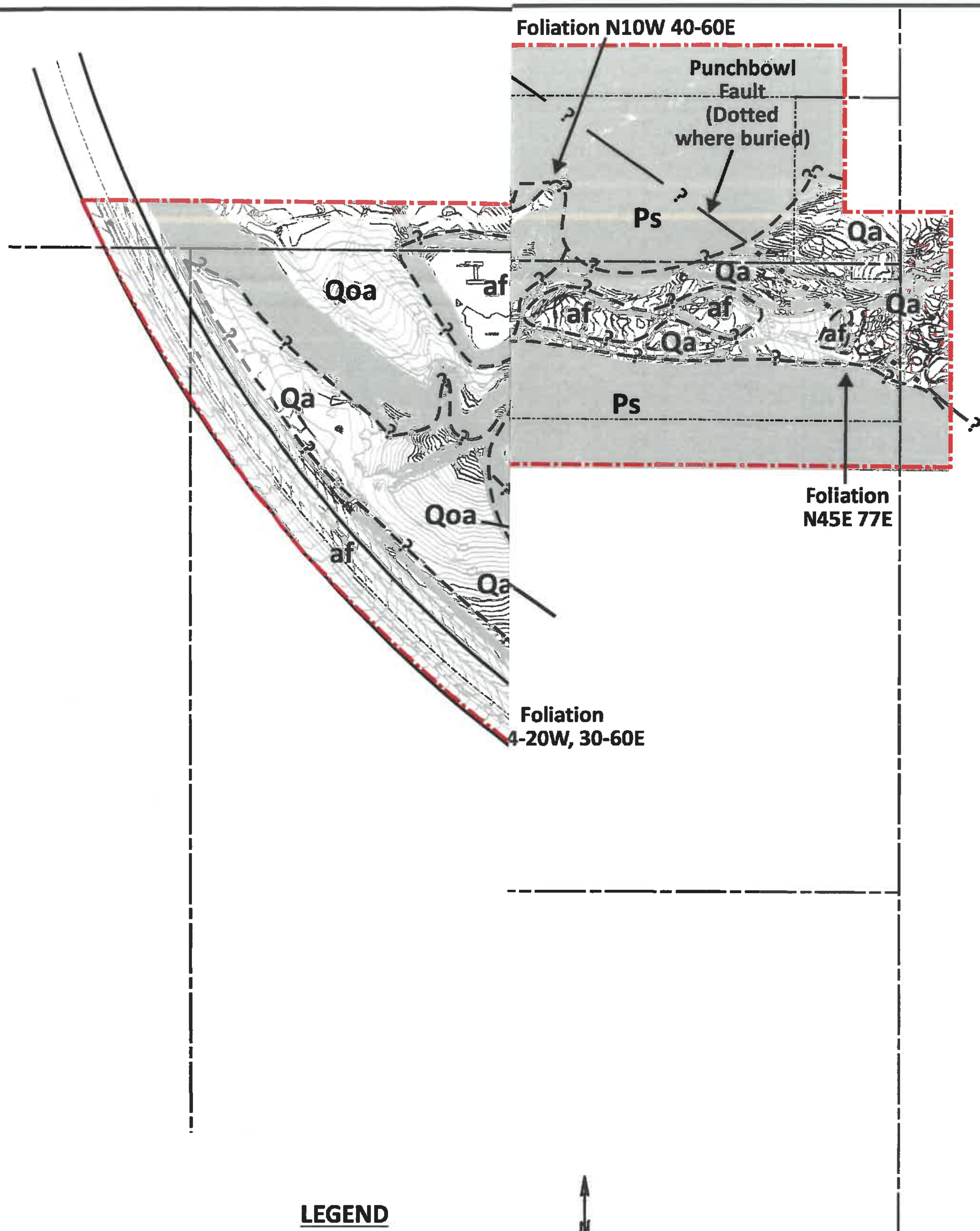
0 1,125' 2,250'

Plate IV
Alquist-Priolo Earthquake Fault Map

Proposed Route 66 Shooting Sport Park
15818 Cajon Boulevard
Keenbrook Area, San Bernardino County, California

Earth Systems

6/22/2018 | File No.: 302145-001



LEGEND

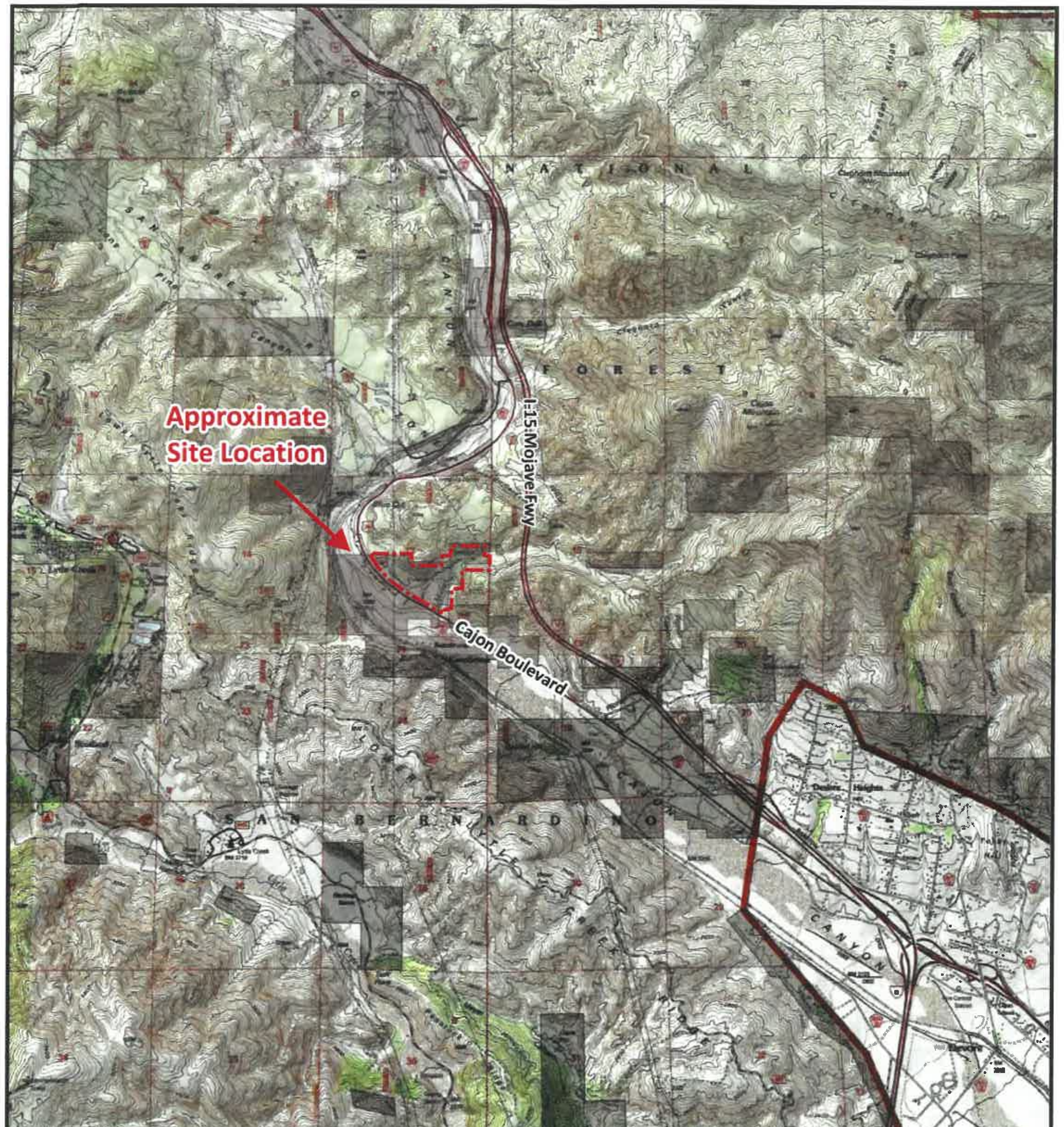
- Approximate Site Boundary
- Contact: Dashed Where Approximate
- Approximate Well Location

Plate V
Site-Specific Geologic Map

Proposed Route 66 Shooting Sport Park
15818 Cajon Boulevard
Keenbrook Area, San Bernardino County, California

Earth Systems

6/22/2018 | File No.: 302145-001



Source: Google Earth satellite image with USGS topographic map overlay dated 2/19/2018.

LEGEND

Approximate Site Location

Approximate Scale: 1" = 1 Mile

0 1 Mile 2 Miles

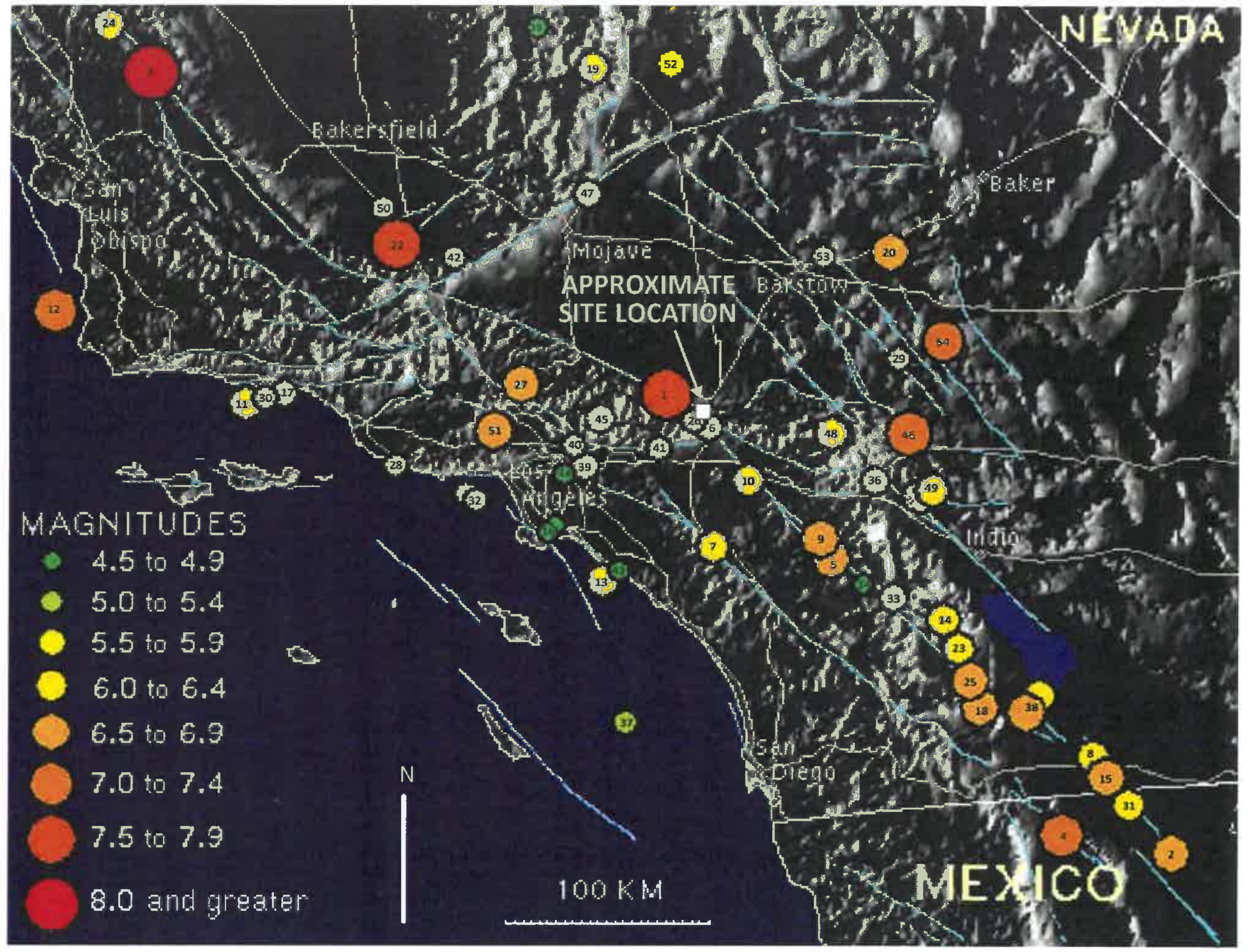
N

Plate I
Site Vicinity Map

Proposed Route 66 Shooting Sport Park
15818 Cajon Boulevard
Keenbrook Area, San Bernardino County, California

Earth Systems

6/22/2018 | File No.: 302145-001



HISTORIC EARTHQUAKES AND EPICENTERS

1. 1812, WRIGHTWOOD
2. 1852, VOLCANO LAKE
3. 1857, FORT TEJON
4. 1892, LAGUNA SALADA
5. 1899, SAN JACINTO
6. 1899, CAJON PASS
7. 1910, ELSINORE
8. 1915, IMPERIAL VALLEY
9. 1918, SAN JACINTO
10. 1923, NORTH SAN JACINTO
11. 1925, SANTA BARBARA
12. 1927, LOMPOC
13. 1933, LONG BEACH
14. 1937, SAN JACINTO
15. 1940, IMPERIAL VALLEY
16. 1941, TORRANCE-GARDENA
17. 1941, SANTA BARBARA
18. 1942, FISH CREEK MOUNTAINS
19. 1946, WALKER PASS
20. 1947, MANIX
21. 1948, DESERT HOT SPRINGS
22. 1952, KERN COUNTY
23. 1954, SAN JACINTO
24. 1966, PARKFIELD
25. 1968, BORREGO MOUNTAINS
26. 1970, LYTLE CREEK
27. 1971, SAN FERNANDO
28. 1973, POINT MAGU
29. 1975, GALWAY LAKE
30. 1978, SANTA BARBARA
31. 1979, IMPERIAL VALLEY
32. 1979, MALIBU
33. 1980, WHITE WASH
34. 1982, ANZA GAP
35. 1983, DURRWOOD MEADOWS SWARM
36. 1986, NORTH PALM SPRINGS
37. 1986, OCEANSIDE
38. 1987, ELMORE RANCH & SUPERSTITION HILLS
39. 1987, WHITTIER NARROWS
40. 1988, PASADENA
41. 1988, UPLAND
42. 1988, TEJON RANCH
43. 1989, NEWPORT BEACH
44. 1989, MONTEBELLO
45. 1991, SIERRA MADRE
46. 1992, LANDERS
47. 1992, MOJAVE
48. 1992, BIG BEAR
49. 1992, JOSHUA TREE
50. 1993, WHEELER RIDGE
51. 1994, NORTHRIDGE
52. 1995, RIDGECREST
53. 1997, CALICO
54. 1999, HECTOR MINE

MAP SHOWING LOCATIONS OF SIGNIFICANT HISTORICAL EARTHQUAKES IN SOUTHERN CALIFORNIA FROM 1812 TO 2000

SOURCE: SOUTHERN CALIFORNIA EARTHQUAKE CENTER, WEB PAGE, 2000

Plate VI
Earthquake Epicenter Map

Proposed Route 66 Shooting Sport Park
15818 Cajon Boulevard
Keenbrook Area, San Bernardino County, California

Earth Systems

6/22/2018	File No.: 302145-001