PETRA

FAULT INVESTIGATION REPORT FOR LAND PLANNING PURPOSES ALPINE ~280 PROPERTY LOCATED EAST OF TYLER STREET, WEST OF POLK STREET, SOUTH OF I-10 AND NORTH OF AVENUE 48, CITY OF COACHELLA, RIVERSIDE COUNTY, CALIFORNIA

AVENUE 48 INVESTMENT GROUP LLC
39755 BERKEY DRIVE, SUITE A
PALM DESERT, CALIFORNIA 92201

April 9, 2007
J.N. 621-05

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Mr. Mark T. Deveau
AVENUE 48 INVESTMENT GROUP LLC
39755 Berkey Drive, Suite A
Palm Desert, California 92201

Subject: Fault Investigation Report for Land Planning Purposes, Alpine ~280 Property Located East of Tyler Street, West of Polk Street, South of I-10, and North of Avenue 48, City of Coachella, California.

Dear Mr. Deveau:

Petra Geotechnical, Inc., (**Petra**) is pleased to submit this report presenting the results of our fault investigation for land planning purposes for the proposed development. The 280-acre site is located east of Tyler Street, west of Polk Street, south of I-10, and north of Avenue 48 in the City of Coachella, California. Currently there is a conceptual land use plan, prepared by Templeton Planning Group, dated May 4, 2006. This plan shows a street layout, areas dedicated to commercial development, parks, schools, and blocks proposed for various types of residential dwelling units. Our study was focused on providing an evaluation of surface rupture associated with faulting within the subject site. Our work was performed in accordance with the scope of services outlined in our original proposal to you, dated October 17, 2005 (Petra, 2005a), and in accordance with information provided by you during the course of the project.

This report includes a recommended building restriction zone (fault setback zones) bounding the San Andreas Fault Zone. A level of hazard associated with potential surface rupture throughout the remaining portion of the property, areas not specifically trenched during this study, is also provided. New evidence for limited surface paleo-liquefaction was identified during this study and is provided to augment the liquefaction analysis provided in the Petra Geotechnical Investigation Report for the property (2006a). Additionally, grading recommendations for the uncertified (uncompacted) fill within the backfilled fault trenches is discussed.

It should be noted that this fault investigation does not address soil contamination or other environmental issues which may affect the property. During the course of this study, Petra representatives met in the field with the City of Coachella Geotechnical (Mr. Steven Suitt) and Paleontological reviewers.

It is a pleasure to be of continuing service to you on this project. Should you have any questions regarding the contents of this report, or should you require additional information, please do not hesitate to contact us.

Respectfully submitted,
PETRA GEOTECHNICAL, INC

Dr. Miles D. Kenney, PG
Senior Project Geologist
Fault Hazard Specialist

Distribution: (5) Addressee

MDK/AP/lc

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INTRODUCTION

Petra Geotechnical, Inc. is pleased to present the results of our subsurface fault investigation for the subject property. The main purpose of this investigation was to provide preliminary building restriction zones associated with potential ground surface rupture from faulting (a form of primary seismic deformation). Our geotechnical investigation report (Petra 2006a) addressed the nature of subsurface soil conditions and presented general geotechnical design recommendations with respect to site clearing and grading, and design and construction of new building foundations, retaining walls, pavement surfaces and other improvements. That report also included an analysis of liquefaction potential on the site in the event of a strong, nearby earthquake.

This investigation included a review of published and unpublished literature, geotechnical maps and aerial photographs with respect to active and potentially active faults located within the site that may have an impact on the proposed development. The northeastern portion of the site lies within a State of California, regulatory "Alquist-Priolo Earthquake Fault Zone" (formerly known as an "Alquist-Priolo Special Studies Zone"), revised by the state and now called an Earthquake Fault Hazard Zone (Hart and Bryant, 1997; Slosson, 1974). Throughout the report the State of California Fault Hazard Zone within the property will be referred to as FHZ.

SITE LOCATION AND DESCRIPTION

The irregularly shaped site, consisting of four attached parcels, comprises approximately 280 acres and is located east of Tyler Street, west of Polk Street, south of I-10, and north of Avenue 48 in the City of Coachella, California. The area of study is indicated on the Site Location Map provided as Figures 1 and 2. The entire site slopes gradually down to the southwest, from a high of approximately 25 feet in the northeasterly corner to a low of approximately 60 feet below sea level in the southwesterly corner.

The subject property is mixed-use; most of it, in the northerly and southwesterly portions, is vacant, undeveloped native terrain; the east-southeasterly approximately 90 acres is under active grape cultivation. This area is irrigated by water from a reservoir at the northwesterly corner. There is an empty abandoned reservoir, vacant house and sheds in approximately the center of the subject property. Some of this central portion also has been farmed in the past, and includes an abandoned citrus orchard. There are scattered waste mounds, trash, and debris over the entire property. The City of Coachella owns a number of water lines that traverse under portions of the property.

PROPOSED DEVELOPMENT

The conceptual land use plan indicates that the proposed grading at the site will ultimately accommodate development of lots for residential structures, associated streets and other improvements such as a school and parks. It should be noted that development and grading plans were not available for our review.

PURPOSE

The purpose of our investigation was to identify areas of active and potentially active faulting for land planning purposes, and provide building restriction zones from active faults. The active San Andreas fault has been identified northeast of the northeast corner of the site on published geologic maps (Dibblee, 1953; Clark, 1984; Sieh and Williams, 1990; Jennings, 1994).

California legislation (Alquist-Priolo Earthquake Fault Zoning Act) defines an "active fault" as "a fault that has had surface displacement within Holocene time (about the last 11,000 years)," (Hart and Bryant, 1997, rev. 2003). A State of California regulatory Fault Hazard Zone (FHZ) exists in the northeast portion of the property bounding the San Andreas fault (Figure 3). The location of the site with respect to the FHZ for the San Andreas fault is shown on the State Fault Hazard Zone Map (Figure 3) and the Fault Map (Plate 1).

SCOPE OF SERVICES

Our scope of work included review of a geotechnical investigation report conducted for the site, aerial photograph analysis, geologic reconnaissance of the site and surrounding area, geomorphic and geologic mapping of the site, geologic logging of trenches excavated on the site for this investigation, review of sediment age dating techniques, and review of available published and unpublished data. The following presents a description of each task performed.

Previous Work

A geotechnical investigation was conducted for the property by Sladden Engineering (2005). Their investigation included drilling 8 exploratory borings to a maximum depth of 51.5 feet, collecting soil samples, and laboratory testing to determine physical characteristics of the soils for foundation design purposes and make recommendations for site preparation. Sladden (2005) indicated that the site was in an earthquake fault hazard zone and recommended a fault hazard investigation be performed. In 2006, Petra conducted a Geotechnical Investigation of the property involving test pits, borings, and CPT soundings (Petra, 2006a). The Petra 2006 Geotechnical Report contains a detailed liquefaction analysis for the property. To our knowledge, no fault investigation reports have been prepared for the property.

Aerial Photograph Interpretation

Stereo-paired black-and-white aerial photographs were reviewed to identify lineaments (possible faults) within and adjacent to the property, to map geologic units, and to identify remnant geomorphic surfaces. Aerial photographs for years 1932, 1939, 1949, 1951, and 1956 were reviewed as part of our investigation. Table 1 presents a list of the photographs from the Fairchild Collection at Whittier College reviewed as part of this investigation. The photos are a part of Petra's in-house aerial photograph collection.

TABLE I

Aerial Photographs Reviewed

Flight No.	Frames	Date	Scale	Type
C-1940C	142-144	2/1932	1"=1200'	B/W
C-6060	568-571	10/1939	1"=1500'	B/W
C14031	134-136	7/21/1949	1"=2000'	B/W
C-16107	134-137	1/31/1951	1"=1667'	B/W
C22693	1-37, 1-38	11/30/1956	1"=5280'	B/W

Lineaments are relatively linear surface features that are typically due to either topographic relief (geomorphic) or tonal contrasts. Lineaments can result from a number of factors including faulting, groundwater variations leading to vegetation lines, erosion, or geologic contacts to name a few. Two general classes of lineaments were identified: (1) tonal lineaments, including vegetation lineaments that represent approximately linear changes in color; and (2) geomorphic lineaments that identify remnant linear ridges across abandoned geomorphic surfaces, or linear erosional gullies. The "strength" of lineaments was also evaluated as weak, moderate or strong. A weak lineament generally is discontinuous over a lateral length of hundreds of feet (dotted or short dashed lines) while a strong lineament represents a continuous linear feature the generally extends laterally on the order of hundreds of feet (solid lines). Moderate strength lineaments fall between weak and strong.

Analysis of the air-photos indicate that surficial soils at the site consist primarily of sedimentary wind blown sand, alluvial fan, and lake deposits (Figures 4 and 5). The lake deposits are associated with ancient Lake Cahuilla that likely had a high stand of 53 feet (Suitt, 1996) above sea level approximately 300 years ago (See "High Lake Stand" on Figure 4).

The aerial photographs utilized for our analysis were flown in 1951 and were considered to provide the best tonal contrast and coverage of the property out of the photos referenced in Table

1. Figures 4 and 5 present interpreted photographs for years 1932 and 1952 respectively. The results of our analysis are discussed in the Findings section of this report.

Geologic Site Reconnaissance

A geologic reconnaissance of the site and surrounding area was conducted on October 5, 2005. At the time of our reconnaissance, the eastern and extreme northwestern portions of the site were cultivated with groves and vineyards. The southwestern and north-central portions of the site were vacant and sparse weeds and brush occupied these portions of the site. An existing reservoir was in use in the northeast portion of the site. Residences and outbuildings were observed in the extreme northwestern portion of the site. An existing residence, numerous outbuildings, supplies, equipment, trash and debris were observed in the north-central portion of the property, near the I-10 freeway. Evidence for past agricultural activities was observed in the southwestern portion of the site.

Land surrounding the site was either vacant or utilized for agriculture. A grove, vineyards, and row crops are found growing east and south of the site. Interstate 10 and the All American Canal are located along portions of the northeast boundary of the site (Figure 1). Small earthen reservoirs were observed in use south and southwest of the site in the field.

Subsurface Investigation – Trenching

Trench excavation and logging took place intermittently from November of 2005, through August of 2006. During that time, four trenches were excavated using a track-mounted excavator with a 4-foot wide bucket to depths on the order of 18 to 30 feet below the ground surface (bgS). For safety, a 5 to 7 foot wide horizontal bench was placed for each 5 to 6 vertical feet excavated. Approximately 2,380 linear feet of trench was excavated. The approximate trench locations are shown on the Fault Map included as Plate 1. Graphic logs of the trench walls, at a scale of 1-inch equals 5 feet, are presented on Plates 2 through 5.

Trenches FT-1 through FT-4 were excavated across and beyond the state FHZ to evaluate the potential presence of faulting. An existing retention basin was located partially within the A-P Zone in the northern portion of the site (Plate 1). The locations of FT-1, FT-2 and FT-3 were placed to provide "continuous" overlapping subsurface coverage for northwest trending faults within and outside of the state FHZ. Trench FT-4 was placed to investigate whether or not a north-south trending fault, defining the westward extent of the San Andreas fault zone observed in FT-1, extended beyond the FHZ.

At least one wall in each trench was cleaned to remove smeared and disturbed soils. Where faults were encountered, the other side of the trench was also cleaned in order to obtain the orientation (strike) of the fault plane. As shown on the logs (Plates 2 through 5), faults are shown as red solid lines, and fractures as dashed red lines. Field evaluation of faults included amount and sense of apparent dip-slip (vertical) offset, gouge characteristics, and whether or not evidence of strike-slip offset was observed. The logs portray bedding and unit contacts as solid, or long or short dashed lines. Solid lines represent abrupt contacts, such that approximately 1 to 2 inches of offset would be readily identified. Long dashed lines represent contacts that are moderately diffuse, such that offsets along a fault of between 2 and 6 inches can be discerned. Short dashed lines are diffuse contacts that likely require greater than about 6 inches of vertical displacement on a fault to clearly identify offset.

All fault trenches were logged by Petra geologists and reviewed by a State of California Professional Geologist with Petra. Shell and coal samples were collected within FT-1 for age numerical age determination. The numerical age of sediments within trenches FT-2, FT-3 and FT-4 were evaluated by correlation of a distinctive dated marker bed in FT-1. The faults and surface limits of the trench excavations were surveyed by Dudek Engineering. Also surveyed, were the surface projections of faults identified in FT-1. The survey point locations of the trenches and surface projected fault locations were utilized in Plate 1.

Once logged and reviewed by the Paleontological reviewers (Paleoenvironmental Associates) and the City of Coachella consulting Geologist, the trenches were backfilled with the uncompacted excavated soils. Please refer to the conclusion section of this report for grading recommendations regarding removal and recompaction of the unconsolidated fill soils within the trenches.

Sediment Age Dating Techniques

The age of the site geologic units within the trenches was numerically determined utilizing carbon-14 age dating techniques on shell and charcoal samples. The type of material (shell or charcoal), age and depths for the dated units are shown on the trench log for FT-1. These ages provide approximate ages of 4,150 years before present (ybp) at depths of 10 to 11 feet, 5,800 ybp at depths of 15 to 16 feet, and 6400 ybp at depths of 17 to 18 feet. These ages indicate that the sediments observed near the base to middle portions of the trenches are approximately mid-Holocene. It should be mentioned that we utilized the conventional radiocarbon age in our analysis and not the generally older 2 sigma calibrated results (Appendix A).

Accordingly, the soils observed as part of this study do not provide direct evidence for identification of faulting during the early to mid Holocene. However, geologists practicing in the Coachella Valley have reasoned that the observation of unfaulted sediments to depths of 15 to 25 feet below the natural ground surface in portions of the site suggests that the hazard from surface fault rupture in these portions of the site is low. This is based on considering that the recurrence of surface rupturing earthquake events on the San Andreas Fault in this region has been determined to be about 215 +/- 25 years (Fumal *et al.,* 2002), and that most identified faults within the San Andreas Fault Zone extend to within a few feet of the surface. It should be mentioned that the recurrence interval for large earthquakes on the San Andreas fault in the Coachella Valley estimated by Fumal et. al. (2002) is considered a maximum. This indicates that the average recurrence interval may be a shorter length of time than the 215 +/- year estimate.

REGIONAL GEOLOGIC AND TECTONIC SETTING

The property lies within the Salton Trough that comprises a portion of the Colorado Desert Geomorphic Province. The Salton Trough region is well known for its exposures of the San Andreas and related faults that form the margin between the Pacific and North American Plates. In southern California, these plates move past each other along a somewhat diffuse array of faults comprising the San Andreas Fault System (Powell, 1993). Geologic development of the Salton Trough began as a major half-graben basin when regional crustal extension affected much of western North America in Miocene time prior to the development of the San Andreas Fault System. During the past 12 to 15 million years, the modern Salton Trough has continued to develop during formation of the northern part of the Gulf of California rift basin. This is due to "pull-apart" oblique strike-slip motion between the North American and Pacific plates within the Sea of Cortez (Gulf of Mexico), which continues into the southern Salton Trough region.

The Salton Trough, part of which is below sea level, has progressively been filling with sediments eroded from highlands that surround the trough, including the San Jacinto and Santa Rosa Mountains along the western margins, the San Bernardino Mountains and Little San Bernardino Mountains to the north and northeast, respectively, the Orocopia Mountains to the east, and sediments derived from erosion by the Colorado River to the southeast. Sediments in the Salton Trough are estimated to be over three miles thick.

Lake Cahuilla extended over much of the current Salton Trough from 300 A.D. to about 1600 A.D. with an estimated high-stand of 53 feet above mean sea level (Suitt, 1996). Old shorelines can be seen around the margins of the Salton Trough (Jenkins, 1962) and are clearly visible in the 1932 aerial photographs (Figure 4) of the northeastern part of the property and west of the All American Canal. Very preliminary data from fault studies of the mid to late Holocene basin sediments indicate that there have been a minimum of four to five relatively long lived individual lake stands in the City of Coachella area during the past four to five thousand years. Evidence for these long-lived lake stands is provided by one to two foot thick fine grained lake deposits in the trenches. Trench log data also suggests the possibility that other, possibly shorter lived lake stands may have occurred in the area of the property since the mid-Holocene.

SITE GEOLOGY

Most of the site is underlain by lacustrine (lake), sand dune, and distal fan deposits. On the trench logs, these units are generally identified as Ql, Qs, and Qf respectively. The lacustrine deposits are associated with former high stands of ancient Lake Cahuilla. A number of geotechnical investigations within the Coachella Valley provide evidence that numerous lakes once filled the valley and subsequently dried up during the past 6000 years. Alluvial fan deposits, consisting of sands and gravels, are associated with southwest trending distal fan deposits from the Coachella fan area (Figure 1). Aeolian (sand dune) sediments underlie the northern, western, and extreme southern portions of the site. Based on air photo analysis, it is likely that the sand dune deposits have migrated toward the southeast. Relatively thin dune sands are shown as Qsd_1 and thicker dune sands are mapped as Qsd_2 on Figures 4 and 5. Based on data collected during the Petra Geotechnical Investigation (2006a) from test pits, CPT and hollow stem auger borings, units Ql, Qs, and Qf are interbedded, and exhibit bedding relatively parallel with existing surface contours (moderate southwest dip) across the entire property (see Petra, 2006a for test locations). However, in the region of the fault trenches (Plate 1), sand dune deposits are more prevalent within the upper 5 feet with deeper sediments generally dominated by lacustrine and distal fan deposits. Locally, small concentrations of artificial fill materials were encountered on the site. Generalized descriptions of the units encountered in our subsurface investigation are presented below.

Lake Deposits (QL)

The lake (lacustrine) sediments are primarily interbedded silty fine sands and sandy silts, brown to dark yellow-brown in color, medium dense or stiff, and moist. Bedding within these silts was generally indistinct, without persistent fine laminations. Exceptions to this include lake bed deposits in the western portion of FT-3 that exhibited fine laminated silts and clays. Some of the lake deposits contained scattered shell fragments. There were indications of oxidation in the silt beds, with scattered orange iron oxide staining. Some of the iron oxide stained layers provided distinct marker beds that could be correlated across the fault zone and between trenches. Flecks of scattered charcoal were found at several locations at depths of 4 to 5 feet.

Alluvial Fan Deposits (Qf)

The alluvial fan deposits represent distal fan facies associated with the Coachella Fan to the northeast (Figures 1 and 2). The fan deposits consist generally of moderate to well sorted, fine- to coarse-grained sand with lenses of gravel and some thin scattered silt layers, and fossil shell fragments. They are medium dense, dry to moist, and primarily gray in color. Cross-bedding is common within members. Basal erosion contacts are generally gently dipping but occasionally exhibit near vertical channel walls. The distal fan deposits formed during times when the lake had receded from the area.

Sand Dune Deposits (Qsd_1 and Qsd_2)

Based on aerial-photograph analysis, the sand dune deposits have likely developed from wind blown sand derived from areas toward the northwest including the upper Coachella Valley, San Jacinto Mountains, and San Bernardino Mountains. In the area of the site, two units of sand dune deposits were mapped on the air-photographs. These include Qsd_1 and Qsd_2 that represent relatively thin and thick sand dune deposits respectively. The mapped area of these units is provided on Figures 4 and 5. These deposits encountered onsite are primarily dry, loose to very loose, fine-grained sand, poorly sorted and contain scattered fossil shell fragments. The sand dune deposits are relatively thin in the northern and northeastern portions of the site, and thicken into sand dunes in the western and extreme southern portions of the site. The sand dunes are found as topographic highs, projecting up to 20 feet above the generally flat surrounding elevations.

Artificial Fill (No Map Unit)

Limited areas of artificial fill were identified, primarily as reservoir berms, tilled soil horizons, and as loose piled mounds. The berms are compacted but undocumented; the mounds are loose and composed of sands and silts, with varying amounts of trash and debris.

GROUNDWATER

The California Department of Water Resources showed the site located within the boundary of a "shallow semiperched ground water body" identified north of the Salton Sea (Werner, 1979). The depth to groundwater in the southern portion of the site was approximately 10 to 15 feet in 1957, 10 feet in 1961, and less than 10 feet in 1966-1967 (Werner, 1979).

Free groundwater was encountered during the preliminary geotechnical investigation (Petra, 2006a) in test pits and borings ranging in depths of approximately 10 to 17 feet below the ground surface in the western portion of the site. Rainfall, irrigation and other possible factors that may not have been evident at the time of our preliminary investigation may change local groundwater and perched water conditions. Our preliminary investigation estimated the depth to high ground water to be on the order of 7 feet bgs across the western portion of the site. In the northeastern portion of the site, groundwater was not encountered to depths of 12 to 25 feet within trench excavation FT-1 through FT-4.

HISTORICAL SEISMICITY & SECONDARY SEISMIC EFFECTS

Historical seismicity and secondary earthquake deformational effects (deformation associated with ground shaking) are discussed below; however, these issues are discussed in more detail in the site Geotechnical Investigation Report prepared by Petra (2006a).

Historical Earthquakes

A listing of historical earthquakes published by the National Earthquake Information Center (2006) indicates that the largest earthquake occurring within a radius of approximately 62 miles (100 kilometers) of the site was the Magnitude 7.3 Landers earthquake in 1992. This event, along with the associated aftershocks, occurred approximately 35 miles northeast of the subject property. The closest documented earthquake, greater than magnitude 6.0, was a magnitude 6.3 Joshua Tree earthquake that occurred approximately 17 miles north of the site in 1992.

The most recent surface-rupturing earthquake on the Coachella segment of the San Andreas fault likely occurred in the late 1600's (Fumal *et al.,* 2002). Prior to that, apparently five paleoearthquakes occurred on the Coachella segment in about A.D. 825, 982, 1231, 1502, and 1680 based on a trenching study at Thousand Palms Oasis (Fumal *et al.,* 2002). These data indicate that the average repeat time for surface-rupturing earthquakes on the Coachella-Indio segment of the San Andreas fault is approximately 215 +/- 25 years, and that the last surface-rupturing event occurred approximately 325 years ago (Fumal *et al.,* 2002).

The following six historical earthquakes have significantly affected the immediate vicinity of the site in the last 100 years, based upon the available data:

- *Desert Hot Springs Earthquake*: On December 4, 1948, an earthquake of moment magnitude 6.0 occurred east of Desert Hot Springs. This event was strongly felt in the Palm Springs area.

- *Palm Springs Earthquake*: On July 8, 1986, an earthquake of moment magnitude 6.2 occurred in the Painted Hills causing minor surface creep of the Banning segment of the San Andreas Fault. This event was strongly felt in the Palm Springs area and reportedly caused various structural damages and injuries to the residents of that area.

- *Joshua Tree Earthquake*: On April 22, 1992, an earthquake of moment magnitude 6.1 occurred in the mountains 9 miles east of Desert Hot Springs. Structural damage and minor injuries occurred in the Palm Springs area as a result of this earthquake.

- *Landers and Big Bear Earthquake*: On June 28, 1992, an earthquake of moment magnitude 7.3 occurred near Landers. Surface rupture reportedly occurred just south of the town of Yucca Valley and extended some 43 miles toward Barstow. Another earthquake, on the same day of moment magnitude 6.4 occurred near Big Bear Lake. No structural damage from these earthquakes was reported in the Palm Springs area as a result of this earthquake.

- *Hector Mine Earthquake*: On October 16, 1999, an earthquake of moment magnitude 7.1 occurred on the Lavic Lake and Bullion Mountain faults north of Twentynine Palms. No structural damage from this earthquake was reported in the Coachella Valley area as a result of this earthquake.

Earthquake Triggered Surface Cracking and Creep

Coseismic triggered surface displacements and creep caused by historical regional earthquakes have occurred on the Coachella segment of the San Andreas fault following the April 23, 1992 Joshua Tree and June 28, 1992 Landers earthquakes (Rymer 2000), and the July 8, 1986 North Palm Springs earthquake (Williams *et al.,* 1986). Dr. Rymer (2000) observed that most of the surface cracking and creep triggered by regional earthquakes occurred along the trace of known active faults. For example, the 1992 Landers earthquake in the eastern Mojave Desert triggered surface deformation along known active faults in the Coachella Valley.

Strong Ground Motion

Strong ground shaking from earthquakes along the San Andreas fault, represent a type of primary seismic hazard to the site. The maximum magnitude earthquake that is believed to be tectonically possible along the San Andreas fault is estimated to be 8.0 (Cao *et al.,* California Geological Survey, 2003).

While accurate earthquake predications are not possible, various agencies have conducted statistical seismic risk analysis (seismic forecasting). According to the working group of California Earthquake Probabilities (WGCEP, 1995) there is a 22 percent conditional probability that a magnitude 7 or greater earthquake may occur between 1994 and 2024 along the Coachella segment of the San Andreas fault.

A site-specific probabilistic seismic hazard analysis (PSHA) was performed for our geotechnical investigation (Petra, 2006a) using the computer program FRISKSP (Version 4.0) which was originally developed by the United States Geological Society (USGS) and later adapted by Thomas F. Blake (2000). FRISKSP estimates the probability of experiencing various ground accelerations within the site over a period of time and the probability of exceeding expected ground accelerations within the lifetime of the proposed structures from all significant earthquakes within a specific radius of search. For the present case, a search radius of 62 miles (100 kilometers) was selected. The earthquake magnitudes used in our evaluation are based on fault models developed by the California Geological Survey (formerly known as the California Division of Mines and Geology) and the USGS. These models are described in Peterson et al., (1996) and Cao *et al.,* (2003).

Three attenuation relationships for Holocene-age alluvial soils proposed by Bozorgnia, Campbell and Niazi (1997), Sadigh et al., (1997), and Boore et al., (1997) were used to establish the PSHA for the site. In addition, in order to account for differences in duration of various earthquake magnitudes, magnitude weighting with respect to a Magnitude 7.5 earthquake was performed using a magnitude-weighting factor recommended by Idriss (1995). The estimated magnitude-weighted peak ground acceleration as determined by probabilistic methods and defined as having a 10% chance of exceedance in 50 years was determined to be 0.95g.

FINDINGS

Aerial Photograph Lineament Analysis

The aerial photographs were utilized primarily to identify lineaments that may be associated with faulting (fault trace), but also assisted in the geologic mapping of unit contacts. Figures 4 and 5 show the interpretative results of our analysis for photos dated 1932 and 1951, respectively.

Some strong geomorphic lineaments (red) were identified near the property that represent geomorphic expression due to movement across the San Andreas fault (labeled on Figures 4 and 5). These lineaments correlate very well with the previously mapped location of the San Andreas fault (Figure 3). Extension of this lineament toward the Alpine ~280 property correlated extremely well with the San Andreas fault zone identified in trench FT-1 (See Figures 1, 6, and 7). The short geomorphic (red) lineaments east of the property on Figure 4 may or may not be associated with faulting. These lineaments do not project into the property. No other geomorphic lineaments were identified within or trending toward the property.

Some tonal lineaments (green) were identified that likely represent linear lines of variations of vegetation density or type or even possibly the edge of migrating sand dunes. Figures 4 and 5 show that the geomorphic lineament associated with the San Andreas fault gradually becomes a moderately strong tonal lineament as it approaches the site. This is likely associated with relatively shallower groundwater east of the fault. As mentioned earlier, these lineaments were investigated by trench FT-1. Other weak tonal lineaments identified within the central portion of the site are considered to be associated with the edge of migrating sand dune deposits. Evidence for this is that the lineaments are not consistent from the 1932 to the 1951 photos, and the lineaments appear to be somewhat geomorphic and may represent the relatively steep downwind side of sand dune deposits. The changes in these lineaments from 1932 to 1951 indicate that the dune deposits might migrate or decrease in size (thus dynamic) over time, which is typical sand dune behavior. Mapping in the field identified sand dune deposits in the area of the lineaments that rise 4 to 10 feet above the surrounding ground. It is our opinion that the lineaments within the central portion of the site are not associated with faulting, but instead by erosional and depositional sand dune processes.

Many of the weak lineaments identified in Figures 4 and 5 represent shorelines of ancient Lake Cahuilla (blue). These lineaments generally represent bands parallel to contours that alternate from light to dark. Similar shoreline lineaments are observed toward the northwest and southwest for many miles and are not observed above the elevation of the highest lake level shown on Figure 4.

<u>Faulting</u>

We performed trenching in the northeastern corner of the property to investigate the potential for faulting within and outside of the State of California Fault Hazard Zone (FHZ) for the San Andreas fault (Plate 1). Evidence of faulting was found in the property within the State of California FHZ in Fault Trench 1 (FT-1) at the locations indicated on the trench log for FT-1 (Plate 2b) and the Fault Map (Plate 1). Because active faulting was identified so close to the southwestern boundary of the State of California FHZ, we performed an additional approximately 1,000 feet of trench outside of the FHZ (FT-1, FT-2, and FT-3 on Plate 1). Fault trench FT-4 found that the western most active fault within the San Andreas Fault Zone identified in FT-1 did not continued southward and beyond the FHZ. No faulting was observed outside of the State of California FHZ within FT-1 through FT-4.

The San Andreas Fault Zone identified in FT-1 consists of a large flower structure approximately 260 feet wide (Plates 1 and 2b). Most of the faults identified in FT-1 show thickening and thinning of units across the faults indicating strike-slip (horizontal) movement. Most of the faults within the central portion of the faulting zone were identified as 'major' in the sense that they exhibit deformation likely associated with multiple surface rupturing events on the San Andreas Fault. These faults are shown on Plate 1 as relatively thicker lines and represent a zone approximately 140 feet wide. Evidence for multiple ruptures on these faults includes a decrease in offset and rotation of units toward the surface (progressively younger units are less deformed). The average trend of the major faults in FT-1 is north 44 degrees west (N44W), which is nearly parallel to the FHZ boundary and published orientations of the San Andreas fault in this region.

To the east and west of the major zone of faulting, a number of smaller scale faults (minor) exist that demonstrate 6 inches or less of apparent dip-slip offset, a lack of tilted sediments, and a fairly consistent amount of apparent dip-slip offset within the trench exposure. The minor faults generally trend more northerly than the faults within the major fault zone. The minor faults identified in FT-1 can be considered secondary splays that result from the relatively high magnitude of deformation within the main zone. For strike-slip faults, these types of splays are common and generally die out away from the main fault zone. For example, FT-4 determined that the western most minor splay of the identified San Andreas Fault Zone in FT-1 did not cross the FHZ toward the south.

The faulting identified in FT-1 occupies a zone with numerous faults offsetting sediments of mid to late Holocene age based on carbon-14 dating of the sediments sampled by Petra and analyzed by Beta Analytic (Appendix A). The numerical carbon-14 dates on buried shells and charcoal yielded ages of 4,150 years before present (ybp) at depths of 10 to 11 feet, 5,800 ybp at depths of 15 to 16 feet, and 6,400 ybp at depths of 17 to 18 feet. These ages indicate that the sediments observed near the base to middle portions of the trenches are approximately mid-Holocene. Thus, all faults identified during this study are considered active and are placed within a building restriction zone (Plate 1).

The fault zone in FT-1 was essentially exactly where we had predicted prior to site trenching, based on extrapolation of the strong northwest trending lineament associated with the San Andreas fault northwest of the site (Figures 4 and 5). In fact, the style, age, width, and structure of faulting identified at the site is very similar to that identified at the Monaco project located 1 ½ miles southeast of the site (Figures 4 and 5). Based on these fault studies, we believed that the mapped location of the San Andreas fault on the State of California Fault Hazard Zone maps was incorrect prior to trenching the site. The State of California Fault Hazard Zone maps (Indio and Thermal Canyon 7.5-minute Quadrangles) show the San Andreas fault east of the All American Canal south of Interstate 10 (Figure 3). Fault studies conducted by Petra have found the San Andreas fault to be located primarily southwest of the All American Canal from approximately 1 mile north of Interstate 10 to approximately 2 miles southeast of the property (Figures 6 and 7).

<u>Revised Location and Geomorphic Analysis of the San Andreas Fault Zone</u>

Figures 6 and 7 show identified locations of the San Andreas Fault Zone from approximately 2 ½ miles northwest of Interstate 10 to approximately 5 miles toward the southeast of Interstate 10. The known locations include the strong geomorphic and tonal lineaments northwest of Interstate 10, the subject site, the Monaco Development site (Petra, 2006b), and the Lomas Del Sol property toward the southeast (Petra, 2005b). The San Andreas fault was not identified during trenching of the Lomas Del Sol site where it is mapped on the State of California Fault Hazard Zone maps (compare Figure 3 with Figure 6). Alignment of the known locations of the San Andreas Fault Zone results in a very linear structure extending over 5 miles south of Interstate 10.

Additional evidence for the linear extrapolation of the San Andreas fault in this area, particularly southeast of Interstate 10, is the lack of geomorphic expression of the fault at the surface. It was presumed that the lack of geomorphic expression along this stretch of the San Andreas fault was possibly due to erosion and deposition of the area associated with numerous ancient lakes alternating with active fan deposition. It is true that the depositional rate in the area along this stretch of the San Andreas is likely in the range of 2 to 2 ½ feet per thousand years. This is fairly rapid, however, we suggest that if the San Andreas fault had a major surface rupturing event nearly every 200 years, and if a local releasing bend or restraining bend existed in this area, the local uplift or down-dropping of sediments near the bend would be expressed on the surface if it existed. For example, assume the San Andreas fault moves 20 feet per event horizontally during each major event (a low estimate), and if there was a local bend in the fault, the local vertical motion was 2% of the total horizontal motion (a low estimate), then this leads to a vertical motion of approximately 2 feet per thousand years. We believe that approximately equal estimates of depositional rate and potential vertical motion due to a possible bend in the fault, would eventually lead to a geomorphic expression (basin or hill) over time.

CONCLUSIONS AND RECOMMENDATIONS

Fault Building Restriction Zone

Based on our findings in this report, it is our professional opinion that Holocene-age faulting (active faulting) is present within the site and is limited to the locations presented on Plate 1. Accordingly, we recommend a building restriction zone as shown on Plate 1. The area within the building restriction zone is based on the existing fault data (FT-1 through FT-4) and is considered to provide the minimum area not recommended for construction of buildings intended for a "structure for human occupancy" as described in section 3601 of Special Publication 42 (Hart and Bryant, 1997). However, additional trenching within the building restriction zone could refine its location.

The location of the building restriction zone (BRZ) is not surveyed in, but is referenced to survey locations of the western most fault in FT-1 (Fault A) as it projects to the surface. Point A on Plate 1 represents a point where the strike of Fault A projects toward the northern property boundary. From Point A, the BRZ projects west 50-feet to Point B. From Point B the BRZ projects due south for 540-feet to Point C. From Point C the BRZ extends approximately 40 feet at an azimuth of south 46 degrees east to Point D. From Point D, the BRZ projects 290-feet due east to Point E. From Point E, the BRZ projects due south 240-feet to Point F, and from Point F, the BRZ projects 443-feet at an azimuth of south 46 degrees east.

Based on the existing fault data from the property, from similar projects in the region, and our air photo analysis, we believe that the level of hazard associated with fault surface rupture throughout the property outside of the recommended building restriction zone is low. Additionally, we believe that the level of hazard of near surface deformation associated with lateral spreading and liquefaction is low presuming near surface soils do not become saturated. Considerations for future anthropogenic water infiltration should be considered during planning. We recommend that hazards associated with potential liquefaction and lateral spreading should be considered by the Geotechnical Engineer of record during the grading plan review.

Implications of New Location of the San Andreas Fault

We recommend that our revised location for the San Andreas fault between Interstate 10 and 5 miles towards the southeast (Figures 6 and 7), as compared to published maps (Figure 3), be considered for future fault studies along this section of the fault.

Future Improvements and/or Grading

Please refer to the Geotechnical Investigation Report for the property prepared by Petra (2006a) for site improvement recommendations. It should be made clear here that the fault trenches shown on Plate 1 were backfilled with non-structural fill. If structures are proposed across these areas then mitigation for the non-structural fill will be required. These mitigations could include complete removal and recompaction of the non-structural fill or a foundation design that includes caissons that bottom below the base of the non-structural fill. The dimensions of the fill within the trench areas include the surveyed surface area shown on Plate 1, and maximum depths down the center of the trench locations that can be obtained from the trench logs (Plates 2a through 5b).

LIMITATIONS

This report has been prepared consistent with the level of care being provided by other professionals providing similar services at the same locale and in the same time period. This report provides our professional opinions and as such, they are not to be considered a guaranty or warranty. This report has not been prepared for use by parties or projects other than those named or described herein.

This opportunity to be of service is greatly appreciated. Should you have any questions regarding the methodology or scope of this work, please do not hesitate to contact us.

Respectfully submitted,
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LITERATURE REVIEWED

BLAKE, T.F., 1998, UBCSEIS, A Computer Program for the Deterministic Prediction of Anticipated Maximum Moment Magnitude (Mw) and an Anticipated Slip Rate.

BLAKE, T. F., 1999, FRISKSP, A Computer Program for the Probabilistic Estimation of Peak Acceleration and Uniform Hazard Spectra Using 3-D Faults as Earthquake Sources, Version 4.0.

BLAKE, T.F., 2000, EQSEARCH, A Computer Program for the Estimation of Peak Horizontal Acceleration from California Earthquake Catalogues, Version 3.00.

BLAKE, T.F., 2000, EQFAULT, A Computer Program for the Deterministic Prediction of Peak Horizontal Acceleration from Digitized California Faults, Version 3.00.

CALIFORNIA DIVISION OF MINES AND GEOLOGY, 1998, "Maps of Known Active Fault Near-Source Zones in California and Adjacent Portions of Nevada": published by International Conference of Building Officials.

CAMPBELL, K. W. AND BOZORGNIA, Y., 1994, Near-Source Attenuation of Peak Horizontal Acceleration from Worldwide Accelerograms Recorded from 1957 to 1993, Proceedings, Fifth U.S. National Conference on Earthquake Engineering, Vol. III, Earthquake Engineering Research Institute, pp. 283-292.

CAO, T., BRYANT, W.A., 2003, "Revised 2002 California Probabilistic Seismic Hazard Maps": California Geological Survey, June 2003.

CLARK, M.M., 1984, "Map showing recently active breaks along the San Andreas fault and associated faults between Salton Sea and Whitewater River-Mission Creek, California": United States Geological Survey, Miscellaneous Investigations Series Map I-1483 (scale 1:24,000).

COUNTY OF RIVERSIDE SAFETY ELEMENT, Chapter 6 of the General Plan (adopted October 7, 2003).

DIBBLEE, T.W., 1953, "Generalized geologic map of Imperial Valley region, California": *in* Jahns, R.A., (ed.), 1954, Geology of southern California: California Division of Mines and Geology Bulletin 170 (scale 1" = 6 miles).

LITERATURE REVIEWED (continued)

FUMAL, T. E., RYMER, M.J., and SEITZ, G.G., 2002, "Timing of large earthquakes since A.D. 800 on the Mission Creek strand of the San Andreas Fault Zone at Thousand Palms Oasis, near Palm Springs, California." Bulletin of the Seismological Society of America, v. 92(no. 7): p. 2841-2860.

HART AND BRYANT, 1997, "Fault-Rupture Hazard Zones in California, Alquist-Priolo Earthquake Fault Zoning Act with Index to Earthquake Fault Zones Maps": Supplements 1, 2 and 3, added 2003, California Geological Survey, Special Publication 42.

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS, 2001, 2001 California Building Code, California, Code of Regulations, Title 29, Part 2, Volume 2.

IDRISS I.M., Et al (1995), Investigation and Evaluation of Liquefaction Related Ground Displacements at Moss Landing during the 1989 Loma Prieta Earthquake, UC Davis Center for Geotechnical Modeling.

ISHIHARA, K., 1985, Stability of Natural Deposits During Earthquakes, Proceedings of the Eleventh International Conference on Soil Mechanics and Foundation Engineering, San Francisco, California, Vol. 1, pp. 321-376, No. 3.

JENKINS, O.P., 1962, "Geologic Map of California – San Diego-El Centro Sheet", scale 1:250,000,

JENNINGS, C. W., 1994, "Fault Activity Map of California and Adjacent Areas, with Locations and ages of Recent Volcanic Eruptions, Divisions of Mines and Geology": California Division of Mines and Geology Map No. 6 (scale 1: 750,000).

LIQUEFYPRO, Version 5 (Civiltech, 2006).

NCEER Workshop on Evaluation of Liquefaction Resistance of Soils. Youd, T.L., and Idriss, I.M., eds., Technical Report NCEER 97-0022.

NATIONAL EARTHQUAKE INFORMATION CENTER, 2006 Historical Earthquake Information Database http://neic.usgs.gov/

PETERSON, M. D., BRYANT, W. A., CRAMER, C. H., CAO, T., REICHLE, M. S., FRANKEL, A. D., LIENKAEMPER, J. J., MCCRORY, P. A., AND SCHWARTZ, D. P., 1996, "Probabilistic Seismic Hazard Assessment for the State of California": CDMG Open File Report No. 96-08. .

LITERATURE REVIEWED (continued)

PETRA GEOTECHNICAL, INC., 2005a, "Proposal for limited Phase I Geotechnical investigation and preliminary fault investigation for land planning purposes, 279-acre Bozick property"; dated October 17, 2005, P.N. 1529-05.

PETRA GEOTECHNICAL, INC, 2005b (in review), "Geotechnical Fault Investigation Report for Land Planning Purposes, Approximately 2200-acre Property, Lomas Del Sol, City of Coachella, Riverside County, California"; Prepared for Fiesta Development, Inc., Report dated November, 2005; Report updated January 15' 2007, Petra Job Number 460-04

PETRA GEOTECHNICAL, INC., 2006a, "Preliminary Geotechnical Investigation for Land Planning Purposes, Alpine 280, Located East of Tyler Street, South of I-10, West of Polk Street, City of Coachella, California"; Prepared for Avenue 48 Investment Group LLC, report dated August 1, 2006.

PETRA GEOTECHNICAL, INC., 2006b, "Geotechnical Fault Investigation Report for Land Planning Purposes, 90-Acre Property, Avenue 50 and Fillmore Street, City of Coachella, Riverside County, California"; Prepared for Monaco Development, LLC., Report dated October 24, 2006, Revised November 17, 2006, Petra Job Number 283-06.

POWELL, R. E., (Ed.), 1993, "Balanced palinspastic reconstruction of pre-late Cenozoic paleogeology, southern California: Geologic and kinematic constraints on evolution of the San Andreas Fault System. The San Andreas Fault System: Displacement, Palinspastic Reconstruction, and Geologic Evolution. Boulder, Colorado, Geological Society of America, Memoir 178".

RYMER, M. J., 2000, "Triggered surface slips in the Coachella Valley area associated with the 1992 Joshua Tree and Landers, California, earthquakes"; Bulletin of the Seismological Society of America v. 90(No. 4): p. 832-848.

RYMER, M. J., FUMAL, T.E., SARNA-WOJCICKI, A.M., WELDON, R.J., LAGANDA, G., STEPHENSON, W.J., and Rockwell, T., 2004, "Geology of the San Andreas Fault in the Indio and Mecca Hills, Coachella Valley, southern California"; A field Guide for the Seismological Society of American Annual Meeting, April 17th, 2004.

SEEBER, L., and ARMBRUSTER, J.G., 1995, "The San Andreas Fault System Through the Transverse Ranges as Illuminated by Earthquakes"; Journal of Geophysical Research, Vol. 100, No. B5, p. 8285-8310.

SIEH, K. E., and WILLIAMS, P.L., 1990, "Behavior of the southernmost San Andreas fault during the past 300 years"; Journal of Geophysical Research, v. 95(n. B5): p. 6629-6645.

LITERATURE REVIEWED (continued)

SLADDEN ENGINEERING, INC., 2005, "Geotechnical Investigation, proposed residential development, NWC Avenue 48 and Polk Street, Coachella, California"; dated February 25.

SLOSSON, J.E., "Indio Quadrangle, California – Riverside County, 7.5 Minute Series (Topographic)"; State of California Special Studies Zones Official Map, map dated July 1, 1974.

SUITT, S. C., 1996, "City of Coachella General Plan, Fault Rupture Hazards."

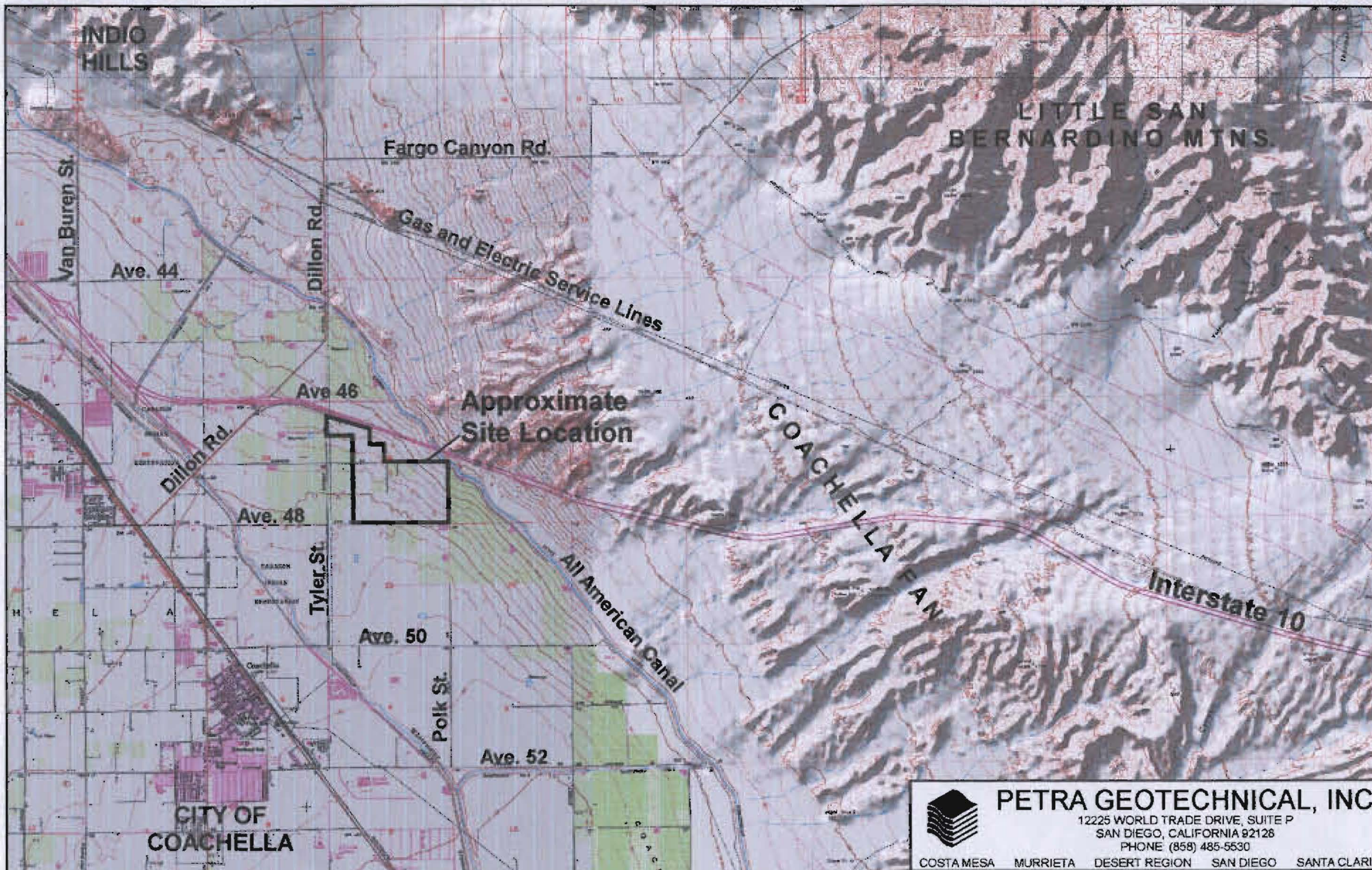
TOKIMATSU, K., and SEED, H.B., 1987, "Evaluation of Settlements in Sands Due to Earthquake Shaking"; Journal of the Geotechnical Engineering Division, ASCE, vol. 113, no. 8, pp. 861-878.

WILLIAMS, P., FAGERSON, S., and SIEH, K., 1986, "Triggered slip of the San Andreas fault after the July 8, 1986 North Palm Springs Earthquake"; EOS v. 67(n. 44): p. 1090.

WERNER, S.L. 1979, "Coachella Valley Area Well Standards Investigation, Memorandum Report".

WORKING GROUP ON CALIFORNIA EARTHQUAKE PROBABILITIES, 1995, "Seismic Hazards in Southern California; Probable Earthquakes, 1994-2006"; Bulletin of the Seismological Society of America, Vo. 85, No. 2, pp. 379-439.

FIGURES



Base Map: All Topo Maps V7 Professional Map Reference Set, California Release 2, Indio and Thermal Quads.

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COSTA MESA MURRIETA DESERT REGION SAN DIEGO SANTA CLARITA

Site Location Map

Avenue 48 Investment Group LLC
Alpine ~ 280, City of Coachella, California

DATE:	April 2007	J.N.:	621-05	FIGURE 1
DWG BY:	LAW	SCALE:	See scale	

Base Map: Geologic Map of California, Olaf P. Jenkins Edition, Santa Ana Sheet, Compilation by Thomas H. Rogers, 1965.

EXPLANATION

- Qc — Pleistocene nonmarine
- Qal — Alluvium

N / W / E / S

0 — 2

GRAPHIC SCALE (in miles) HORIZONTAL = VERTICAL

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Regional Geology Map

Avenue 48 Investment Group LLC
Alpine ~ 280, City of Coachella, California

DATE: April 2007	J.N.: 621-05	FIGURE 2
DWG BY: LAW	SCALE: 1:125,000	