Appendix F1: Feasibility-Level Geotechnical Evaluation

PETRA GEOSCIENCES INC.

SOLID AS A ROCK

REVISED FEASIBILITY-LEVEL GEOTECHNICAL EVALUATION
KPC COACHELLA PROJECT
2,850-ACRES± OF VACANT LAND NORTH OF INTERSTATE 10
AND EAST OF THE ALL-AMERICAN CANAL
CITY OF COACHELLA, RIVERSIDE COUNTY, CALIFORNIA

THE KPC GROUP

March 23, 2023
J.N. 16-368
Revision 2

ENGINEERS + GEOLOGISTS + ENVIRONMENTAL SCIENTISTS

March 23, 2023
J.N. 16-368
Revision 2

THE KPC GROUP
6800 Indiana Avenue, Suite 130
Riverside, California 92506

Attention: Mr. Stan McNaughton

Subject: Revised Feasibility-Level Geotechnical Evaluation, *KPC Coachella Project*, 2,850 Acres± of Vacant Land, North of Interstate 10 and East of the All-American Canal, City of Coachella, Riverside County, California

Dear Mr. McNaughton:

Pursuant to your request, **Petra Geosciences, Inc. (Petra)** is presenting this revised feasibility-level geotechnical evaluation report for the proposed KPC Coachella project located in the city of Coachella, California. The primary geotechnical issues addressed within this report include:

- Faulting and Local Seismicity
- Earthwork and Grading Considerations
- Excavation and Engineering Characteristics of the On-site Earth Materials
- Depths of Native Soils Prone to Excessive Consolidation and/or Hydro-Collapse
- Approximate Removal Depths that will be Required to Mitigate Excessive Foundation Settlement
- Shrinkage and Subsidence Estimates
- Cut Slope Construction and Presence of Locally Adverse Geologic Structure
- Fill Slope Construction and Stability
- Slope Maintenance Recommendations

Petra appreciates the opportunity to provide you with geotechnical consulting services. If you have any questions or should you require any additional information, please contact us at (760) 250-9747.

Respectfully submitted,

PETRA GEOSCIENCES, INC.

Alan Pace, CEG
Senior Associate Geologist

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

ATTACHMENTS

FIGURE 1 – SITE LOCATION MAP

FIGURE 2 – TYPICAL CROSS SECTION A-A'

PLATE 1 – GEOLOGIC AND FIELD EXPLORATION MAP

PLATE 2 – 800-SCALE CONCEPTUAL GRADING PLAN (KIMLEY HORN, 2023)

PLATE 3 – CONCEPTUAL GRADING PLAN/GEOLOGIC OVERLAY MAP

APPENDIX A – EXPLORATORY BORING AND TEST PIT LOGS

APPENDIX B – LABORATORY TESTING

APPENDIX B – LABORATORY TESTING (PETRA, 2013)

APPENDIX C – SLOPE STABILITY ANALYSIS (PETRA, 2023, 2013)

APPENDIX D – DYNAMIC SETTLEMENT ANALYSIS OF DRY SAND

APPENDIX E – SEISMIC DESIGN PARAMETERS

REVISED FEASIBILITY-LEVEL GEOTECHNICAL EVALUATION
KPC COACHELLA PROJECT
2,850-ACRES± OF VACANT LAND NORTH OF INTERSTATE 10
AND EAST OF THE ALL-AMERICAN CANAL
CITY OF COACHELLA, RIVERSIDE COUNTY, CALIFORNIA

PURPOSE AND SCOPE OF SERVICES

The objectives of this evaluation are to obtain additional information pertaining to geotechnical conditions at the site and to provide a summary of the geotechnical constraints that may have an impact on proposed design, as well as general mitigation measures, in order to facilitate the preliminary/conceptual design process. The purpose of this revision is to update the report pursuant to third party review comments (Lilburn Corporation, 2023).

Because development plans are in the formative stage, the approach to this phase of geotechnical investigation is to first refine the geologic map prepared in the fault investigation (Kenney, 2022). In doing so, the geologic units present on the site have been delineated. Field exploration consisted of geologic mapping and subsurface exploration for the purpose of geologic definition and obtaining representative samples of each geologic unit. Laboratory testing focused on the engineering properties inherent in each of these geologic units. Subsequent analysis identified the potential impact of these properties on the various aspects of development in order to assist in the planning process. By quantifying the geotechnical impact, such as liquefaction-prone areas, removal depths, slope stability issues, expansive soil types, etc., the conceptual development plan can be further refined. This report provides a preliminary evaluation of the engineering properties of each geologic unit for correlation with the geologic map. Further geotechnical evaluation will be needed as more detailed grading plans become available.

Based on our preliminary review of Petra's previous work and available background literature, and on the experience of our firm with similar projects in the area of the subject site, the primary geotechnical issues addressed during our feasibility geotechnical evaluation includes the following:

- The presence of native Young alluvial soils that may be prone to excessive consolidation or hydro-collapse.
- Approximate removal depths that will be required to mitigate excessive settlement.
- Potential for hard rock or oversize materials to affect site grading.
- Potential for perched groundwater and/or seepage.
- Potential for expansive soils.
- Shrinkage and subsidence estimates of soil units due to remedial grading.
- Presence of locally adverse geologic structure (cut slope instability).

To address the above concerns and provide sufficient geotechnical/geologic information for conceptual design, as previously noted, our scope of services consisted of the following:

1. Perform supplemental geologic mapping within the site.

2. Review available published geotechnical literature and maps, as well as the previous site-specific geologic/geotechnical reports prepared by previous consultants to determine existing soil and geologic conditions within and adjacent to the subject property.

3. Coordinate with the local underground utilities locating service (Underground Service Alert) to obtain an underground utility clearance prior to commencement of the subsurface exploration.

4. Drill and log 17 exploratory borings ranging from 16 to 71 feet in depth.

5. Excavate 24 exploratory test pits to evaluate near-surface geologic conditions ranging from 3 to 11 feet in depth.

6. Collect representative bulk and undisturbed soil samples for supplemental laboratory analysis.

7. Perform appropriate laboratory analyses on soil samples, including determination of in-situ density and moisture content, maximum density and optimum moisture content, shear strength, expansion potential, grain size distribution, Plasticity Index, and general corrosivity indicators (soluble sulfate and chloride content, soil pH and minimum resistivity).

8. Perform preliminary liquefaction analyses, where appropriate, to evaluate general liquefaction potential.

9. Perform preliminary slope stability analyses for potential cut and fill slope configurations anticipated to be part of the project design.

10. Consultation at the completion of our field and laboratory work to discuss our findings and conclusions.

11. Perform appropriate geologic and engineering analyses on all data collected.

12. Prepare a feasibility-level geotechnical report presenting our evaluation methodologies, findings, conclusions, and recommendations within the framework of the conceptual plan.

The report includes, but not necessarily be limited to, the following:

1. Site description, including previously graded areas, existing structures and improvements, past land uses, previously graded areas, existing structures, vegetation, topography, drainage, etc. This will include a site location map.

2. Descriptions and discussion of geologic conditions on the site, including geologic settings; geologic units on the site and their engineering properties; subsurface conditions based on literature review and exploratory excavations; depths to groundwater; faulting, including locations of nearby Holocene-active, pre-Holocene, and age-undetermined faults; subsidence potential; and other potential geologic hazards as deemed appropriate.

3. A geotechnical map showing the distribution of geologic units, areas potentially needing slope stabilization, special foundation zones, areas of potentially expansive soils, and anticipated removal depths.

4. Discussions of site seismicity, including anticipated ground shaking; site accelerations for anticipated earthquakes; liquefaction potential; lateral spreading potential, ground rupture potential; site coefficient for soil characteristics for 2019 CBC earthquake forces; site period; and other secondary effects from earthquakes. Note that fault surface rupture hazards are not included in this scope of work.

5. Conclusions and recommendations relative to the proposed development for shrinkage, subsidence, excavation characteristics, long-term/short-term settlement based on existing/anticipated loading, fill slope stability, cut slope stability, temporary excavation stability, anticipated depths of over-excavation of unsuitable soil or bedrock materials, oversized materials, fill replacement, suitability of onsite soil for use as fill, expansion potential, compaction requirements, clearing, and general grading.

6. The discussions of findings will include presentation in a format that identifies and elaborates on the properties of each geologic unit noted on the geologic map.

7. Preliminary recommendations for foundation design of typical lightly loaded residential and commercial structures.

Please note that studies related to geologic fault hazards issues at the site are not included within this report.

SITE LOCATION AND DESCRIPTION

The site encompasses approximately 2,850 acres and is located immediately north of Interstate 10 (I-10), east Dillion Road of the east end of Vista Del Norte, and northeast of the All-American Canal in the city of Coachella, Riverside County, California (Figure 1). The site is on the eastern flank of Coachella Valley north of the Salton Sea. Topographically, the site lies between the relatively flat-lying alluvial floor of the Coachella Valley to the west and bedrock highlands of the Little San Bernardino and Orocopia Mountains to the northeast, east and southeast. Several southwest trending ridges of relatively low relief with intervening alluvial drainages exist within the property. Elevations across the site range from approximately 500 feet to approximately 1,250 feet above mean sea level (msl). Surface drainage is generally by sheet flow and directed toward the southwest. Vegetation typically consists of scattered small shrubs, creosote, ocotillo, and small dispersed trees. The property is currently vacant and undeveloped. Man-made features within the site include, earthen flood control embankments, and electrical and gas transmission lines along the northern portion of the site.

BACKGROUND INFORMATION

The site contains State of California Earthquake Fault Zones (EFZ's) and areas where Petra has identified to contain Holocene-active faults, pre-Holocene faults, and age-undermined faults during our fault evaluation for the Project during our investigations between 2004 and 2007. The regulatory fault hazard zones encompass areas thought to bound the Indio Hills and Coachella Fan fault zones. The San Andreas fault is located less than 1,000 feet southwest of the site, and its regulatory fault hazard zone extends into the property.

Petra investigated most of the project area through geologic mapping, aerial photo review, and geologic logging of over 43,000 feet of fault trench. We did not complete a report documenting our findings due to the economic downturn in 2008. The faulting investigation has since been completed Kenny Geosciences (2022) and reviewed and approved by the City of Coachella.

Geotechnical related work was not conducted by Petra during the previous fault hazard investigation studies. A preliminary geotechnical investigation was performed by Leighton and Associates, Inc. in 2007 for a 220-acre piece (noted as the McNaughton site) in the south-central area of the subject site. The Leighton 2007 report was submitted to their client as DRAFT and not submitted to regulatory agencies for their review and approval. Petra has a copy of that draft report and incorporated their data in our geotechnical evaluation.

PROPOSED DEVELOPMENT AND GRADING

The KPC Coachella Specific Plan proposes a master planned residential community on approximately 2,850 acres of currently undeveloped land within the City of Coachella (Plate 2). The plan proposed the following land uses:

- A mixture of residential product types, including very low, low, medium, and high density;
- A potential active adult community;
- Mixed-use areas, which include commercial retail, high-density residential, resort/casino, and entertainment uses;
- Institutional areas including three elementary schools and one middle school;
- An overlay district for a wellness university;
- Parks, greenways, and amenity centers;
- Circulation uses, including arterials, major, and secondary roadways;
- Agricultural Production areas; and
- Natural open space, including drainage channels and trails.

The KPC Coachella community will include an extension of Vista Del Norte Road from the west and a connection with the new Avenue 50 interchange at Interstate 10 which is proposed to be developed as part of the La Entrada community to the south.

The previously noted conceptual grading plan by Kimley Horn indicates the site will initially be mass graded to create large super pads, access streets and storm drainage channels. The super pads will be re-graded at a later date to create individual building sites for construction of residential homes, commercial buildings, and schools. Except for road crossings, natural canyons will remain unimproved. Many areas of the site are designated as Open Space and will remain ungraded. The super pads will be graded to a sheet flow configuration with drainage generally directed to the southwest. Cut and fill slopes throughout the development are planned at an inclination of 2:1 (h:v) to maximum heights of approximately 50 and 100 feet, respectively. The majority of cut and fill slopes planned throughout the interior of the development, however, are proposed at vertical heights of approximately 35 to 40 feet and less. The highest proposed interior cut slope, located in the ridge area in the northwestern portion of the site, is depicted in a cross section identified as A - A' (Figure 2; Plate 1). The highest fill slope is associated with the proposed interchange at I-10 and Avenue 50 at the south-central edge of the site. The amphitheater proposed near the south-central portion of the property will be bordered by cut and fill slopes varying up to heights of approximately 20 feet and 15 feet, respectively. These slopes may be modified based upon type of construction for the amphitheater.

FIELD EVALUATION AND LABORATORY TESTING

Field Evaluation

The field exploration of the site was conducted in January and February 2021 and consisted of geologic mapping and the drilling of 12 borings, advanced to depths ranging from approximately 16 to 71 feet. These borings were drilled utilizing a track-mounted, hollow-stem auger drill rig. Additionally, 24 test pits were excavated with a rubber tire backhoe to depths ranging from approximately 3 to 11 feet below the ground surface. A geologist from this firm logged the borings and test pits. Soil and bedrock materials encountered within the borings were visually classified and logged in general accordance with the Unified Soil Classification System (ASTM D 2488) and the Engineering Geology Field Manual by the U.S. Department of the Interior, Bureau of Reclamation, respectively. Approximate locations of the exploratory borings and test pits are shown on the Geologic and Field Exploration Map, Plate 1 and descriptive logs for the field excavations are presented in Appendix A.

Associated with the subsurface exploration was the collection of bulk samples and undisturbed samples for laboratory testing. Bulk samples consisted of selected soil and bedrock materials obtained at various depth intervals from the exploratory borings. Undisturbed samples were obtained from the borings using a 3-inch outside diameter (OD) modified California split-spoon soil sampler lined with brass rings. The soil sampler was driven mechanically to a depth of 18 inches with successive 30-inch drops of a 140-pound automatic trip hammer. Blow counts were recorded for each 6-inch driving increment. The total of the blow counts for the last 12 inches are reported on the boring logs. The central portions of the driven core samples were placed in sealed containers and transported to our laboratory for testing.

Standard Penetration (SPT) tests were also performed at selected depth intervals in accordance with ASTM D 1586. This method consists of mechanically driving an unlined, 2.0-inch outside diameter (OD) standard split-barrel sampler 18 inches into the soil with successive 30-inch drops of the 140-pound automatic trip hammer. Blow counts for each 6-inch driving increment were recorded on the exploration logs. The number of blows required to drive the standard split-spoon sampler for the last 12 of the 18 inches was identified as the uncorrected standard penetration resistance (N). Disturbed soil samples from the unlined standard split-spoon samplers were placed in sealed plastic bags and transported to our laboratory for testing.

Laboratory Testing

To assist in a preliminary evaluation of the engineering properties of the on-site earth materials, laboratory testing was performed on selected representative “bulk” and relatively “undisturbed” samples obtained during the field exploration. Laboratory testing included the determination of in-situ dry density and moisture content, maximum dry density and optimum moisture content, expansion potential, Atterberg limits, grain size distribution by wet sieve and hydrometer methods, sand equivalent, shear strength parameters, soluble sulfate and chloride contents, pH and resistivity. A description of laboratory test procedures and summaries of the laboratory test data are provided in Appendix B. The results of the in-situ dry density and moisture content determinations are presented in the exploratory boring logs, Plates A-1 through A-12, Appendix A.

Select laboratory test data also utilized in this evaluation was determined in the geotechnical assessment of the La Entrada site (Petra, 2013), situated adjacent to the subject site on the south and across Interstate 10. The La Entrada site consists of the same geologic formations and much of the laboratory data is appropriate for engineering analysis of the subject site. Relevant data from the La Entrada site evaluation is reiterated herein. An evaluation of the laboratory test data is reflected throughout the “Conclusions and Recommendations” section of this report.

FINDINGS

Regional Geologic and Geomorphic Setting

The proposed development lies within the Salton Trough region 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 right-laterally past each other along a somewhat diffuse array of faults comprising the San Andreas Fault System (Powell, 1993). The Salton Trough, however, formed 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.

The modern Salton Trough is the northern part of the Gulf of California rift basin formed by oblique strike-slip motion between the North American and Pacific plates. The basin itself continues to form, engendered mainly by activity of the San Andreas Fault System. Sediments deposited within the lowland area cause partial filling of the Salton Trough. The major contributors of sediments to the Salton Trough include erosion of the San Jacinto Mountains along the western margins, the San Bernardino and Little San Bernardino Mountains to the north and northeast, respectively. And the Orocopia Mountains to the east. Additionally, Colorado River delta sediments were deposited in the Salton Trough and eventually separated the Salton Trough from the ocean, which produced a region of interior drainage (a basin), which is now evident as the Salton Sea.

Three- to five-million-year-old sediments within the Salton Trough basin are typically associated with shallow seas (marine: Imperial Formation) and lakes (lacustrine: Palm Spring Formation). These deposits are typically comprised of salt beds, fine-grained muds (silts and clays) and relatively minor sand and channel gravels. Pleistocene age sediments within the basin generally consist of relatively fine-grained terrestrial sediments associated with lakes, slow moving streams, and sand dunes. Basin sediments typically pinch out and interfinger with coarser-grained sediments of similar age along the trough margins which include the Canebrake Formation, Ocotillo Conglomerate, and relatively young alluvial fan deposits.

Throughout the Pleistocene epoch (past 2 million years), this region has received relatively fine-grained sediments similar to those deposited within the basin, that interfinger with relatively coarser-grained sediments derived from erosion of the hills and mountains toward the north and east. Locally, these deposits include fine-grained deposits of the Palm Spring Formation and coarse-grained sediments of the Ocotillo Conglomerate, and unnamed relatively younger alluvial fan deposits.

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. Old shorelines can be seen around the margins of the Salton Trough and are clearly visible in the 1932 aerial photographs near the southeastern portion of the property west of the current location of the All-American Canal. There have been approximately five to six high-stands of Lake Cahuilla in the City of Coachella area during the past twelve thousand years (Philibosian and others, 2011).

Local Geology

The subject property is underlain by mid- to late-Quaternary sediments consisting of the lower (late Pliocene to early Pleistocene) and upper (mid-Pleistocene) members of the Palm Spring Formation (oldest), fluvial fan deposits represented by the Ocotillo Conglomerate (mid- to late-Pleistocene), and relatively younger fluvial deposits (latest-Pleistocene to Holocene) laid down within the current drainage system. Additionally, slopewash deposits are present along the slopes of the incised channels of the older uplifted geologic units. Minor areas in the site contain surficial artificial fill and fill associated with storm water control. The geologic units are described below from relatively youngest to oldest. The Geologic and Field Exploration Map (Plate 1) shows the approximate locations and distribution of the major geologic units on the site.

Quaternary Artificial Fill (Afu)

Minor amounts of disturbed cut and artificial fill areas exist in the western portion of the property. The artificial fill is associated with the abandoned agricultural development. The artificial fill typically consists of locally derived reworked soils. Storm water control fill berms were noted in the natural canyon drainages in the western portion of the property. Riprap exists on the up-gradient side of the northernmost berm.

Quaternary Slopewash Deposits (no map symbol)

Late Quaternary age slopewash (Qsw) deposits occur along the natural slopes of the incised channels of the older uplifted geologic units and interfinger with fluvial fan deposits within the current drainages (Plate 1). This unit typically consists of reworked Palm Spring and Ocotillo Formations located directly upslope. Unit Qsw is generally dry, loose, medium brown, and is typically composed of fine to coarse sand and gravels. Based on observations from the exploratory test pits, the thickness of the slopewash is usually less than 2 feet. However, thicker deposits were observed, such as TP-4, where the slopewash was approximately 7 feet thick. The thicker slopewash deposits are located at the bottom of slopes along the main canyons of the site.

Many of the natural slopes throughout the site contain residual gravel. This coarse material occurs where the finer grained portion of the native formation has been eroded away, leaving a thin (usually less than one foot) layer of cobbles and occasional small boulders. Many of the minor drainages within the northern portion of site contain variable concentrations of cobbles and small boulders, as a result of down slope movement of this residual material.

Quaternary Fluvial Fan Deposits (Qfy)

Holocene fan deposits are the one of the most common geologic units on the site. These deposits are generally comprised of light gray, dry to slightly moist, fine- to coarse-grain sand with gravel and cobble of granitic and metamorphic origin. At depth locally, this material consisted of sandy gravel and sandy cobble composition. The upper one to two feet of this unit is porous and contain localized roots/rootlets. Continuous and discontinuous laminations and cross bedding is not uncommon. In general, this unit represents the modern washes and drainage channels on the alluvial fan surfaces, where the upper approximately one to two feet is relatively loose sand. Based on information from the geotechnical borings, the characteristics of the alluvial fan deposits are fairly consistent at depth (see Exploration Logs, Appendix A).

Quaternary Fluvial Fan Deposits (Qfo)

Latest Pleistocene fan deposits are the one of the least common geologic units on the subject site. Where encountered within the subject property, this unit consisted mostly of light gray to olive gray, dry, loose to medium dense, fine- to coarse-grain sand with minor subangular gravel. Although most common in the northern portion of the subject site, small remnants were noted throughout the property, in direct contact with younger fan deposits (Qfy), suggesting recent erosion of the older fan deposits (Qfo).

Quaternary Ocotillo Conglomerate (Qo)

The mid- to late-Pleistocene Ocotillo Conglomerate consists of coarse-grained fluvial fan deposits derived from the Little San Bernardino Mountains north-northeast of the property. This unit convers a majority of the subject property. The Ocotillo Conglomerate is divided into two members: a relatively younger member (QoU) and a lower member (QoL); however, the older member is not encountered within the subject property and may be the Canbrake formation (Kenney, 2022). The Upper Member of the Ocotillo Conglomerate contains massive to fairly well-bedded sand and gravels, and some boulders. Where encountered in our borings and test pits, this unit was found to be moderately well to well indurated and weathered. More detailed discussion of the age of the Ocotillo Conglomerate is included in the Kenney fault investigation report (Kenny, 2022).

The Ocotillo Conglomerate (Qo) forms the uppermost coarse-grained deposit along ridge tops, and typically erodes to form moderately steep slopes. Occasional 2- to 5-foot-high cliffs are associated with moderately well indurated, typically debris flow, members.

Bedding within the Ocotillo Conglomerate ranges from gently to moderately dipping to over 20 degrees. The bedding structure generally dips to the southwest but is variable in folded and faulted areas. Based upon the conceptual nature of the 800-scale mass grading plan by Kimley Horn (Plate 2), general geologic conditions associated with the highest proposed cut slope are depicted in cross section A – A', shown on Figures 2, utilizing a west to southwest dip of approximately 5 to 10 degrees for the area (Kenney, 2022).

Quaternary Upper Palm Spring Formation (Qpu)

The Palm Spring Formation (Group) is exposed in isolated areas in the Coachella Hills and in the southwestern portion of the site along the southwestern flanks of the Coachella Hills. The Palm Spring Group within the project has been subdivided into two formational units: Palm Spring Upper (younger) and Palm Spring Lower (Kenney, 2022).

The upper member of the Palm Spring Formation (Qpu) is mid-Pleistocene in age, which generally is exposed on low ridges and isolated outcrops in the western part of the site and canyon walls of the eastern part.

The upper Palm Spring Formation generally consists of dense to very dense, dry to moist, fairly well sorted to very well sorted interbedded clays, silts, and sands with occasional local gravels. The formation is dominantly composed of easily eroded, well sorted, olive brown, silt. Coarse-grained members contain well sorted, medium coarse sand to poorly sorted sand, and sub-rounded to well-rounded pebbles and cobbles. Coarse-grained members range from friable to highly indurated with little to no reaction to acid solution. Some gravels are distinctly iron oxidized orange to pinkish red. Member contacts are typically abrupt. Fine-grained members of the Palm Spring Formation contain un-deformed gypsum crystals, and calcium carbonate precipitates.

Some clays, particularly a dark brick-red unit, appear highly sheared with horizontal, wavy, foliated planes. Lateral spreading (landslides) occurred along basal shear surfaces within clayey, clayey silt, and fine sandy units commonly characterized by a brittle, waxy, dark mossy green gouge, parallel or nearly parallel to bedding, which appears moderately to highly sheared. Small slumps and landslides are mapped in this unit in the southwestern portion of the subject property, in proximity to Holocene Fluvial Fan Deposits (Qfy) near the southern property boundary. In addition, there is evidence of liquefaction occurring in units composed of very well sorted clean fine sands, especially when bounded by relatively impermeable sandy silt layers. These liquefiable layers were also observed to accommodate basal shearing associated with lateral spreading. In addition, unit Qpu also exhibits numerous shear surfaces along weathered volcanic ash deposits.

Cut slopes will expose geologic units consisting of the Palm Spring Formation (Qpu) within the southwestern portion of the subject property. Based on our geologic mapping, subsurface exploration, and stability calculations, cut slopes exposing these materials are expected to be grossly stable. However, the Palm Spring Formation is interbedded with clay and silt materials, and also exhibits numerous shear surfaces along weathered volcanic ash deposits. Consequently, cut slopes in the Palm Spring Formation may locally expose adverse out-of-slope bedding and may require replacement with an equipment-wide stabilization fill or possibly buttress fill. Identification of cut slopes that may expose an adverse out-of-slope bedding condition should be based on additional subsurface exploration by the project geotechnical engineer and engineering geologist at the time finalized Tentative Tract Maps are being prepared. In addition, all cut slopes should be carefully observed by the project engineering geologist during grading to identify any adverse bedding.

Unit Qpl is in both conformity and angular unconformity contact with the overlying Qou within the subject property. This indicates that deformation (faulting, tilting, and folding) occurred within unit Qpu in some places across the site prior to deposition of unit Qou.

Quaternary Lower Member of the Palm Spring Formation (Qpl)

The Pliocene to early Pleistocene lower member occurs stratigraphically below the Palm Spring Formation upper member and crops out at two locations near the southern edge of the property only. As encountered in boring B-9, the composition of this unit consists of grayish brown to light gray, dry, and very hard sandy siltstone. In the Kenney Geoscience fault investigation report (Kenney, 2022) this unit is described as essentially deeper members of the upper unit (Qpu).

The two Qp members may represent a relatively continuous depositional unit (no unconformities) and are defined as Qpu being younger beds containing the Bishop Ash and is tilted (folded) to the degree of unit Qpl. Member Qpl typically dips 30 to 80 degrees and occurs as the “core” of the Coachella Hills. Unit Qol represents fluvial sandstones that are interbedded with unit Qpl. These units are best exposed immediately north of Interstate Highway 10 and immediately south of the property boundary in the southernmost portion of the Coachella Hills in the site. For simplicity, it is mapped as unit Qpl within the Kenney report (Kenney, 2022). Unit Qol may represent the Canebrake Formation that is mapped locally by the author south of the Site (Petra, 2007a). This suggestion is based on the well sorted and fluvial nature of unit Qol, which is in contrast to unit Qou which are clearly alluvial fan debris flows and poorly sorted "fluvial" deposits (Kenney, 2022).

Groundwater

Groundwater was not encountered in the geotechnical borings, which extended to a maximum depth of 71 feet (B-8). Furthermore, no groundwater was encountered at the contact between the fan deposits and the older comparatively much denser and impermeable upper Palm Spring formation.

The project site is situated over the Desert Hot Springs subbasin of the Coachella Groundwater Basin (Goldrath and others, 2007). The San Andreas fault, located generally along the southwest edge of the site, forms a groundwater barrier between the Whitewater/Indio subbasin to the southwest, which contains accessible groundwater compared with the areas northeast of the fault, where wells are rare. No groundwater wells are known to exist on or near the site.

Groundwater depths in wells located in the vicinity of the subject property were reviewed on the California Department of Water Resources website (DWR, 2022). One inactive irrigation well at the Terra Lago Golf Course South Course, identified as State Well Number 05S08E18G001S, is mapped approximately 3 miles northwest of the subject property. Between April 2012 and July 2022 groundwater depths were reported to vary from approximately 122 to 156 feet below the ground surface (bgs). An irrigation well mapped at Citrus Ranch 5 on Dillion Road, approximately 3.5 miles north-northwest of the site, is not identified by a state well number. Between October 2011 and July 2022 groundwater depths were reported to vary from approximately 156 to 169 feet below the ground surface (bgs). A second well, a short distance northeast of the previous well on Dillion Road, is mapped at Citrus Ranch 3. The irrigation well is identified as State Well Number 05S08E05P001S. Between October 2011 and July 2022 groundwater depths were reported to vary from approximately 112 to 136 feet below the ground surface (bgs).

TECTONIC SETTING

Faults

The Coachella segment of the San Andreas fault is located roughly along the trend of the All-American Canal, just to the southwest of the site (see Plate 1). Based on the unpublished geologic fault investigation by Petra (2005 to 2007) and the recent *Fault Investigation Report* by Kenney Geoscience (Kenney, 2022), faulting is identified throughout the site associated with four fault zones consisting of the San Andreas fault zone, the Berdoo Canyon fault zone, the Painted Canyon "Central" fault zone, and the Coachella Fan fault zone. Fault trenches excavated within the subject property indicated that the only faults observed during the field investigation to displace Holocene age sediments (i.e., Holocene-active fault) was within the Berdoo Canyon fault zone (Kenney Geoscience, 2022). The Berdoo Canyon and Painted Canyon "Central" fault zones are considered secondary fault systems to the San Andreas Fault zone located immediately west of the western most property boundary and likely derive from a northeasterly dip of the San Andreas Fault at depth (Kenney Geosciences, 2022).

An additional dominantly strike-slip fault zone was identified in this study in that is herein called the Painted Canyon "central" fault zone as mapping in this study suggests it connects to the southeast with strands of the Painted Canyon fault zone in are region where it splays to numerous strands. This fault zone is evaluated as not exhibiting surface rupture during the Holocene (Kenney Geosciences, 2022).

The second mode of faulting in the site is associated with the Coachella Fan Fault zone, which occurs across the entire site and also is a secondary form of deformation as these faults may have only exhibited motion during strong ground motion (co-sesimic) in combination with being more saturated.

Additional information is provided in the Kenney Geoscience Fault Investigation Report for the KPC Coachella project, dated September 20, 2021 and revised January 2022. The fault investigation report was recommended for approval by the Lilburn Corporation in their August 8, 2022 *Third Party Fault Hazard Report Review of the KPC Coachella Project* for the City of Coachella.

Historical Seismicity

The subject property has experienced strong earthquake-induced ground shaking and fault surface rupture during Quaternary time that will occur again. Ground surface rupture can be expected as indicated by the continuing, periodic movement along known Holocene-active faults or age-undermined faults. The Holocene-active San Andreas fault (Coachella-Indio segment) extends across the western edge of the property, in proximity to easements associated with the All-American Canal and flood control berms constructed many years ago (Kenney Geosciences, 2022). Additionally, several other previously unnamed Holocene-active and pre-Holocene faults are located east of the San Andreas fault and were the focus of the recent fault investigation (Kenney Geoscience, 2022). These faults consist of the Berdoo Canyon fault zone, the Painted Canyon Fault zone, and the Coachella Fan Fault zone. 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 Spring earthquake (Williams, 1986).

The most recent surface-rupturing earthquake on the Coachella segment of the San Andreas fault likely occurred in the late 1600's (Fumal, 2002, Philibosian and others, 2011). Prior to that, apparently five paleo earthquakes 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, 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, 2002).

GEOLOGIC AND SEISMIC HAZARDS

Holocene-Active Fault Zones – Surface Rupture Hazard

According to State of California fault definitions (CGS, 2018), a Holocene-active fault has had displacement within the Holocene epoch or last 11,700 years. A pre-Holocene fault is a fault that does not have evidence of movement within the last 11,700 years, but has moved within Quaternary period, the last 2.6 million years. Pre-Holocene faults are not placed within Alquist-Priolo Earthquake Fault Zones, but are considered when placing such critical structures as dams and nuclear power plants, etc.

Age-undetermined faults are "where the recency of fault movement has not been determined." Faults can be 'age-undetermined' if the fault in question has not been studied to determine its recency of movement. Faults can also be age-undetermined due to limitations in the ability to ascertain the recency of faulting. Examples of such faults are where evidence of recency of movement has been eradicated due to disturbance, either by natural or anthropogenic processes, of Holocene-age deposits. Within the framework of the A-P Act, age-undetermined faults within regulatory Earthquake Fault Zones are "considered Holocene-active until proved otherwise" (CGS, 2018) Age-undetermined faults are located in the western portion of the subject property, where surficial soils have been disturbed by previous agricultural activities.

The Coachella segment of the San Andreas Fault zone is located roughly along the trend of the All-American Canal, just to the southwest of the site and the Berdoo Canyon Fault zone extending northwest-southeast across the central portion of the subject property (see Plate 1). These faults are Holocene-active faults, as discussed above, and has accordingly been placed within a State of California Alquist-Priolo Earthquake Fault Zone (Hart and Bryant, 2007).

Two modes of faulting were identified in the Kenney Geosciences report (Kenney, 2022) within the site, which include strike-slip faults associated with the Berdoo Canyon and Painted Canyon "central" Fault zones, and coseismic "sliding" faults associated with the Coachella Fan Fault zone. The first mode of faulting includes the right-lateral strike slip Berdoo Canyon Fault zone, which is Holocene-active, and has been extended further southeast than previous mapped (i.e., Byrant, 2015, FER250). It trends northwest through the center of the site. The data contained in the Kenney Geoscience report (Kenney, 2022) provides the best evidence of the age and style of faulting of the Berdoo Canyon Fault zone to date. The extent of the fault zone in the site was evaluated with fault trenching and mapping low relief and degraded fault scarps on Ocotillo Conglomerate fan surfaces. As encountered during the Kenney Geoscience investigation, this fault zone last surface rupturing event occurred in the early Holocene. The only faults observed during the field investigation to displace Holocene age sediments (i.e., Holocene-active fault) was within the Berdoo Canyon Fault zone (Kenney, 2022).

Based on the previous geologic study by Petra (2005 to 2007) and the recent Kenney Geosciences Fault Investigation Report (Kenney, 2022), subsidiary faults associated with the Coachella Fan fault zone are located within the site. Most of the faults are pre-Holocene faults, small-scale faults located within the formational units of the Ocotillo and Palm Spring formations. Evidence from the trench exploration, however, does indicate that there are some subsidiary faults on the site that are pre-Holocene faults. This issue is discussed further below in the "Geologic and Seismic Hazard" section of this report.

However, it should be noted that according to the USGS Unified Hazard Tool website and/or 2010 CGS Fault Activity Map of California, the Coachella Segment of the San Andreas Fault zone, located along the southwest portion of the subject site, would probably generate the most severe site ground motions and, therefore, is the majority contributor to the deterministic minimum component of the ground motion models. The approximate middle portion of the subject site is located at a distance of less than 6.25 miles (10 km) from the surface projection of this fault system, which is capable of producing a magnitude 8 or larger events with a slip rate along the fault greater than 0.04 inch per year. As such, the site should be considered as a **Near-Fault Site** in accordance with ASCE 7-16, Section 11.4.1.

Strong Ground Motion (Shaking)

The subject site is expected to experience strong ground shaking during the life span of the proposed residential development due to its proximity primarily to the San Andreas fault, but also other known Holocene-active faults in the region. Primary geotechnical hazards associated with strong ground shaking at the property include near surface fracturing, lateral spreading, liquefaction, and landslides. Based on probabilistic analysis from the California Geological Survey web site, the peak ground acceleration at the site is estimated to be approximately 1.218 g, based on a probability of 2 percent in 50 years.

<u>Secondary Seismic Effects</u>

Secondary effects of seismic activity that are typically considered as possible hazards to a particular site include several types of ground failure as well as induced flooding. The general types of ground failure that can occur as a consequence of severe ground shaking include; ground lurching/surface fracturing, landsliding, liquefaction, and lateral spreading. The probability of occurrence of each type of ground failure depends on the severity of the earthquake, distance from the causative fault, topography, subsoils and groundwater conditions, in addition to other factors. These factors are discussed in more detail below.

<u>Seismically Induced Ground Lurching/Surface Fracturing</u>

Near surface fracturing of unconsolidated granular soils was observed in our previous fault exploration trenches (Petra, 2005). Trenching data indicated that within zones of fracturing, new fractures were typically produced, and older fractures abandoned. Evidence for this is provided by upward termination of most of the fractures at the top of the older portions of the fan deposits. These data indicate the random nature of the location of the fractures and the potential for new ones to be produced in the future essentially anywhere across the site in areas of unconsolidated sediments or even near the tops of bedrock ridges. The fractures do not represent en-echelon structures produced from tectonic stresses but are likely expressed within fine grained sediments above older pre-Holocene faults in bedrock.

The fractures were not placed within fault zones because they are technically not faults and they are ubiquitous to the site. Engineering measures should be taken to mitigate their potential harmful effects to potential structures for the majority of the site. These measures may involve special foundation design, and/or rough grading practices. Based on our evaluation of the observed fractures, it is likely that the mitigation measures could treat the potential fracture hazard as a differential settlement and ground shaking problem. This conclusion is based on our determination that the fractures are due to seismic shaking within unconsolidated sediments.

<u>Seismically Induced Landsliding</u>

Localized evidence of landsliding is observed on the site**.** Local failures along steepened wash banks were observed in the southwestern portion of the subject property (Plate 1)**.** Where mapped, failures are associated with the Upper Member of the Palm Springs Formation (map symbol Qpu). Slumps and small landslides will be entirely removed during site grading, either as a part of normal operations or remedial earthwork.

As part of the preparation of this report, this firm performed stability analyses of selected proposed cut and fill slopes that will expose a variety of geologic units**.** Pseudo-static slope stability analyses were performed in accordance with guidelines for preparation of geotechnical reports**.** The results of these calculations (included herein) meet or exceed minimum requirements for both static and pseudo-static conditions.

Kenney proposed that the majority of the normal dip-slip faults of the Coachella Fan fault zone primarily resulted from lateral spreading and translational sliding induced by strong ground shaking and wetter conditions during the Pleistocene (Kenney, 2007, 2022). Hence, that sliding occurred when the sediments were wetter and heavier, and during strong ground motions (co-seismic).

Seismically Induced Flooding

Seismically induced flooding that might be considered a potential hazard to a site normally includes flooding due to tsunami or seiche (i.e., a wave-like oscillation of the surface of water in an enclosed basin that may be initiated by a strong earthquake) or failure of a major reservoir or retention structure upstream of the site**.** No major reservoir is located near, or upstream of the site so the potential for seiche or inundation is considered negligible**.** Because of the inland location of the site, flooding due to a tsunami is also considered negligible at the site.

Liquefaction Potential

Owing to the absence of shallow groundwater and the presence of dense soils at the site, the potential for liquefaction at the site is considered to be negligible.

Lateral Spreading

As discussed above, evidence exists that large scale lateral spreading occurred in the bedrock units, primarily the Palm Spring Formation. The lateral spreading represents a form of landsliding produced during saturated conditions in the Palm Spring Formation in combination with strong local ground shaking. Mid- to late-Pleistocene lateral spreading of the Palm Spring Formation also deformed the overlying Ocotillo Conglomerate. Current geologic conditions are much different, as the Palm Spring Formation materials are semi consolidated and dense. In addition, groundwater is much deeper in the site area due to the dryer Holocene climate and relative uplift of the Coachella Valley margins. The potential for lateral spreading at the site is, therefore, is considered to be low.

CONCLUSIONS AND RECOMMENDATIONS

General Feasibility

From a soils engineering and engineering geologic point of view, the subject property is considered suitable for the proposed development. Based on our geotechnical evaluation of the site, it is our opinion the building sites will be free of hazard from landslide, liquefaction, settlement, and slippage and will remain so provided the recommendations of this report are incorporated into the design criteria and project specifications. Furthermore, it is our opinion that the proposed grading and construction will not adversely affect the geologic stability of adjoining properties provided grading and construction are performed in accordance with current standards of practice, all applicable grading ordinances and the recommendations presented in this report.

In addition to residential development, the KPC Coachella Conceptual Site Plan depicts proposed development of the subject property for public education (three elementary schools, one middle school, a wellness university), healthcare (wellness complex), and entertainment (casino and hotel entertainment center and performing arts amphitheater). During future tentative map studies, it is recommended that additional site-specific geotechnical investigations are performed to evaluate Holocene-age fault and age-undermined fault setbacks as well as ground shaking, ground fracturing, and slope stability. In particular, studies for public schools, skilled nursing facilities, and essential services buildings should assess geology, geologic hazards, and seismology in accordance with California Geological Survey (CGS) – Note 48. Adjustment in site-specific building setback zones may be recommended.

Grading Plan Review

This report has been prepared based on the 800-scale conceptual grading plan prepared by Kimley Horn (2023) (Plate 2). As such, the recommendations provided in this report should be considered tentative until finalized grading and development plans (Tentative Tract Maps) are available and reviewed by the geotechnical consultant. Additional recommendations and/or modification of the recommendations provided herein may be necessary depending on the results of a detailed grading plan review.

Ingress and Egress Offsite Construction

I-10 and Avenue 50 Interchange

A detailed geotechnical investigation and foundation design report is recommended for the proposed I-10 and Avenue 50 interchange. The subsurface geotechnical investigation and foundation report should be prepared in accordance with the California Department of Transportation "Highway Design Manual" (Caltrans, 2012) and "Standard Specifications" (Caltrans, 2018).

Primary Geologic and Geotechnical Concerns

Building Restriction Zones

Building restriction zones, as presented in Kenney Geoscience (Kenney, 2022) fault investigation, are shown on the Geologic Map, Plate 1 and on the mass grading plan/geologic map overlay, Plate 3.

Site Specific Geotechnical Investigations

During future tentative map studies, it is recommended that additional geotechnical investigations be performed within each tentative tract map area in order to prepare site specific grading and foundation construction recommendations.

Engineering Characteristics of Soil and Bedrock Materials

Soil Material Classification

As shown on Plate 3, the proposed mass grading has been transposed onto the Geologic Map to evaluate the distribution and general areal extent of the different geologic units that will be encountered during grading. Based on this generalized evaluation, it is estimated that the Fan Deposits (Qfy and Qfo) and Ocotillo Conglomerate (Qo) occur within approximately 80 to 85 percent of the site areas to be graded with the fan deposits being the more common geologic unit. The Quaternary Upper Palm Spring Formation (Qpu) is estimated to occur in less than 5 percent. Other geologic units that will be encountered within localized areas include slopewash (Qsw). that exist along the flanks of natural slopes and artificial fill (Afu) that exists along the southerly property boundary in association with flood control structures. Grain size distribution, hydrometer analysis and Atterberg limits tests were performed on selected samples to classify the on-site soils in accordance with the Unified Soil Classification System (ASTM D2487). A brief description of the predominate soil types comprising the various geologic units is provided in the following table.

Geologic Unit	Map Symbol	Description of Predominate Soil Types	Unified Soil Classification Symbols
Fan Deposits	Qfy and Ofo	Fine- to coarse-grained gravelly sand with occasional cobbles and boulders.	SW, SP and SM
Ocotillo Conglomerate	Qo	Coarse-grained gravelly sand and silty sand with variable concentrations of cobbles and small boulders.	SW, SP, SM and GP
Palm Spring Formation	Qpu	Interbedded clayey silts, sandy silts, and fine- to coarse-grained sands with occasional gravel.	CL, ML, SM, SW, and SP
Slopewash	Qsw	Fine- to coarse-grained gravelly sands with local concentrations of cobbles and small boulders	SW and SP
Artificial Fill	Afu	Locally derived reworked soils	Possibly SW, SP and SM

Excavation Characteristics

Based upon the results of our subsurface exploration and experience associated with grading of similar projects in the vicinity of the subject site, it is our opinion that the on-site earth materials can be excavated with conventional earth moving equipment. However, pre-ripping may be required in the Palm Spring

Formation (Qpu) to facilitate excavation of these materials. Pre-ripping may also be required in local areas where dense to very dense materials of the Ocotillo Conglomerate (Qo) are encountered.

Soil Suitability for Use as Fill and Backfill

General

On-site earth materials are generally considered suitable for use as engineered fills in the construction of building pads, roadways, and fill slopes.

Fill Slope Construction

Care should be taken in the selection of fill materials to be used in the construction of the outer 10 to 15 feet of fill slope faces to avoid clean sands with little or no fines content (silts and clays). Such materials are highly erodible and will require special treatment to improve the surficial stability of the slope face. Over size rock fragments should not be placed within 15 feet, measured horizontally, of slope faces.

Building Pad Construction

Materials derived from the Palm Spring Formation may be clayey in nature, a sample of which was determined to be of medium expansion potential. As such, these materials should be avoided, if practical, in the construction of the upper five feet of building pads to avoid the requirement for special foundation design, such as post-tension slab-on-ground foundations.

Street Subgrade

As with building pad construction, the use of clayey soils derived from the Palm Spring Formation should be avoided in the upper two feet of pavement subgrade. Such clayey soils will have a low R-value which will require substantially thicker pavement sections.

Trench Backfill

The majority of the sands comprising the fan deposits (Qfy and Qfo) and Ocotillo Conglomerate (Qo) exhibit sand equivalent (SE) values in excess of 30. As such, the sands are considered well-suited for use as structural backfill behind retaining structures and for backfilling of utility trenches; however, the sands utilized for these purposes should first be screened to rid the soils of gravels/cobbles exceeding a maximum dimension of 3 inches.

Oversize Materials

Variable amounts of oversized materials (boulders greater than 12 inches in maximum diameter) will be generated from the Fan Deposits (Qfy and Qfo), Ocotillo Conglomerate (Qo) and slopewash deposits

(Qsw). Oversize materials also exist at the surface in many areas of the site. Oversized materials should be handled as recommended in the "Earthwork Recommendations" section of this report.

Earthwork Adjustments

Volumetric changes in earthwork quantities (shrinkage and bulking) will occur when excavated on-site soils are placed as compacted fill. Additional adjustment factors will be necessary due to subsidence when exposed bottom surfaces in over-excavated areas are scarified and recompacted in accordance with the recommendations presented in the "Earthwork" section of this report. The following estimated earthwork adjustment factors are recommended for use by project planners in an effort to balance earthwork quantities.

Geologic Unit	Map Symbol	Shrinkage and Bulking Adjustment Factors	Subsidence Factors
Fan Deposits	Qfy and Qfo	Upper 5 feet: Shrinkage of 10 to 15 percent Below 5 feet: Shrinkage of 0 to 5 percent	0.10 to 0.15 feet
Ocotillo Conglomerate	Qo	Upper 2 feet: Shrinkage of 5 to 10 percent Below 2 feet: Shrinkage of 5 percent to Bulking of 5 percent	0.05 to 0.10 feet
Palm Spring Formation	Qpu	Bulking of 0 to 5 percent	Negligible
Slopewash	Qsw	Shrinkage of 10 to 15 percent	Not applicable
Artificial Fill	Afu	Shrinkage of 5 to10 percent	Not applicable

The above estimates of shrinkage, bulking and subsidence are based on available subsurface data and should not be considered absolute values. Therefore, contingencies should be made during the initial phases of site development for balancing earthwork quantities based on actual shrinkage and bulking that will occur during the initial phases of grading.

Low-Density Surface Soils and Compressibility

Surficial soil deposits overlying the various geologic units are compressible in their existing state and will require removal to underlying competent materials from all areas planned to receive fill. Estimated depths of removal of unsuitable materials are indicated in the following table. These materials, once properly moisture-conditioned, will be suitable for use as engineered fill.

Geologic Unit	Map Symbol	Estimated Depths of Unsuitable Surficial Deposits
Fan Deposits	Qfy and Qfo	Upper 5 to 15 feet
Ocotillo Conglomerate	Qo	Upper 1 to 3 feet
Palm Spring Formation	Qpu	Upper 1 to 3 feet
Slopewash	Qsw	Varies from 1-foot to greater than 14 feet
Artificial Fill	Afu	Undetermined (possibly up to 15 feet)

Seismically Induced Dynamic Settlement of Dry Sands

The entire site subject to development is underlain at various depths by formational sedimentary bedrock. The bedrock materials are typically dense to very dense and, as such, are not subject to seismically induced settlement. However, the natural drainages, which are present throughout the site, are naturally infilled with loose to medium dense, fluvial fan deposits. Although relatively shallow in depth, such materials are granular in nature and may be subject to dynamic settlement. While portions of the major natural drainages are to be left undeveloped, many of the drainages, as well as portions of the drainage boundaries will be graded and subsequently developed.

To evaluate the potential for earthquake-induced dry sand settlement in the areas of natural drainages and its impact on the proposed improvements, we performed a settlement analysis of the data from our boring B-4, drilled in Fan Deposits (Qfy and Qfo). We considered a design groundwater level at a depth of 100 feet below the existing ground surface, peak ground acceleration for maximum considered earthquake (Design PGA, approximately equivalent to a return period of 2,475 years [2 percent chance of exceedance in 50 years]) in the site vicinity to be approximately 1.218g, and a predominant earthquake magnitude of 7.34 Mw.

The results of our dynamic settlement analysis indicate that the loose and medium dense, silty sand fluvial fan deposits, encountered below the ground surface to the depth of approximately 20 feet in our boring, appear to be prone to dry sand settlement during seismic shaking. The calculation resulted in a free field dynamic settlement of 5.88 inches and a corresponding weighted settlement of 4.78 inches. The differential settlement is estimated to be two-thirds of the total settlement, 3.9 and 3.2 inches for the free field and weighted settlements, respectively, over a distance of 20 feet.

The total dynamic settlement amounts noted above reflect no remedial grading to reduce the magnitude of thew settlement. The graph of the cumulative total settlements with depth indicate that approximately one-half of the settlement occurs in the upper 10 feet. Assuming remedial removal and re-compaction of the upper 10 feet of the fluvial deposits, the total weighted dynamic settlement would be reduced to approximately 2.4 inches with a corresponding differential settlement of approximately 1.6 inches. A summary of our dry sand settlement analysis is presented in Appendix E. The estimated dry sand dynamic settlement should be considered during the structural design of the foundation system of the proposed improvements as it pertains to structural integrity.

Expansion Potential

Selected earth materials were tested for expansion potential in accordance with ASTM D 4829. The test results indicate the majority of the on-site soils are granular in nature and non-expansive, exhibiting Expansion Indices of less than 20. However, an Expansion Index of 81 (Medium expansion potential) was determined for a sample of interbedded clayey silt materials of the Palm Spring Formation (Qpu) from the adjacent La Entrada project (Petra, 2013).

Global Stability of Proposed Cut and Fill Slopes

As noted previously, cut and fill slopes throughout the development are planned at an inclination of 2:1 (h:v) to maximum heights of approximately 50 and 100 feet (the proposed interchange at I-10 and Avenue 50), respectively. The majority of cut and fill slopes planned throughout the interior of the development, however, are proposed at vertical heights of approximately 35 feet and less. The highest proposed cut slope is located in the ridge area in the western portion of the site (Figures 2, 2b). The highest fill slope (100 feet) is associated with the proposed interchange at I-10 and Avenue 50 at the south-central edge of the site, which is not a part of this evaluation.

Limit equilibrium slope stability calculations have been performed for the highest cut slopes planned within the Ocotillo Conglomerate (Qo) and Palm Spring Formation (Qpu) (Petra, 2013). Excluding the I-10 interchange, which is not a part of this evaluation, the proposed maximum heights of the cut slopes in these materials are approximately 30 and 35 feet, respectively. Stability calculations were also performed for a generalized 50-foot-high fill slope. The shear strength parameters utilized in the stability calculations are based on direct shear tests performed on selected soils remolded to 90 percent of maximum dry density and on selected relatively undisturbed samples of the in-situ materials. The following table presents a summary of the selected shear strength parameters utilized in the calculations. A summary (matrix) of all direct shear test results is also presented in Table B-2, Appendix B (Laboratory Testing).

Geologic Unit	Map Symbol	Undisturbed or Remolded	Ultimate Values		Peak Values	
			Angle of Internal Friction (φ)	Cohesion (c) psf	Angle of Internal Friction (φ)	Cohesion (c) psf
Ocotillo Conglomerate	Qo	Undisturbed	33	200	44	460
Palm Spring Formation	Qpu	Undisturbed	30	126	36	300
Palm Spring Formation	Qpu	Undisturbed	28	66	27	180
Compacted Fill	--	Remolded	34	10	40	180

Ultimate and peak shear strength values were utilized in the stability calculations for static and pseudo-static (seismic) loading conditions, respectively. Due to the proximity of the San Andreas Fault zone, a horizontal earthwork coefficient (kh) of 0.25 g was utilized in the pseudo-static analyses. All calculations for global (gross) stability resulted in acceptable factors of safety exceeding 1.5 for static loading and 1.1 for pseudo-static loading. A summary of the calculations is provided in the following table and printouts of the computer-generated calculations are presented in Appendix C.

Geologic Unit	Map Symbol	Slope Description	Gross Stability Factors of Safety	
			Static	Pseudo-Static
Ocotillo Conglomerate	Qo	40-foot-high, 2:1 Cut slope	1.96	1.19
Palm Spring Formation	Qpu	35-foot-high, 2:1 Cut slope	1.58	1.11
Compacted Fill	--	50-foot-high, 2:1 Fill slope	1.54	1.35

Surficial Slope Stability

The proposed cut and fill slopes are anticipated to be marginally surficially stable due to the granular nature of the formational materials exposed in the cut slopes and comprising the fill slopes. The standard calculations for surficial stability are based on an infinite slope height and a vertical depth of saturation of 4 feet with seepage parallel to the slope face. The analysis utilizes soil shear strength parameters of angle of internal friction and cohesion. However, because of the low values of cohesion inherent in the on-site materials, the calculations typically do not reflect the minimum factor of safety of 1.5.

It should be noted, however, that where the soils or bedrock comprising the slope face are sufficiently dense and do not expose clean, running sands, the primary concern is that of erosion, rather than shallow instability. To that end, several methods are available to enhance erosion resistance of the slope face. While general measures are discussed in the Slope Landscaping and Maintenance section of this report below, measures specifically intended to reduce erosion potential of the slope face include:

Enhanced Compaction of Fill Slope Face

Grading specifications typically require that fill comprising the fill slope be compacted to 90 percent or more relative compaction, extending to the slope face. Specifying a higher compaction requirement, such as 95 percent relative compaction, reduces the permeability of the soils, thereby increasing the in-situ soil strength and reducing the potential for saturation. The compaction standard notwithstanding, however, overbuilding the slope face and trimming back to the compacted core is preferred over the method of constructing the slope face to finish grade with periodic grid-rolling and final track-walking of the slope surface. A uniformly compacted slope face is essential to both long-term surficial stability and erosion resistance.

Select Landscaping

All engineered slopes should be landscaped as soon as practical at the completion of grading. As noted, the landscaping should consist of a deep-rooted, drought-resistant, and maintenance-free plant species. Hydro-seeding with select plant species native to the area that exhibit the aforementioned properties can expedite the process of establishing vegetation prior to periods of heavy or extended rainfall. Depending on the time of year, initial irrigation may be required to establish the plant growth.

Jute Mat

If landscaping cannot be established within a reasonable period of time, jute matting or equivalent should be considered as a short-term measure to inhibit surface erosion.

Chemical Stabilizer

Spray-on products designed to seal slope surfaces and reduce erosion potential are an option to jute mat.

Geo-Textile Fabrics

Geotextile fabrics are commercially available for use in the construction of fill slopes which are either over-steepened or subject to erosion. Such fabrics are utilized in the placement of engineered fill to construct a geotextile-wrapped slope face. Such measures are comparatively expensive and are usually reserved for specialty applications.

Earthwork Recommendations

General Earthwork and Grading Specifications

All earthwork and grading should be accomplished under the observation and testing of the project soils engineer and engineering geologist or his/her authorized representative. Earthwork and grading should be performed in accordance with the following recommendations prepared by Petra, the grading code of the City of Coachella, Chapter 33 Appendix J of the 2019 California Building Code (CBC), and Petra's "Standard Grading Specifications" presented in Appendix F.

Site Clearing and Grubbing

All weeds, grasses, brush, shrubs, trees, and similar vegetation should be stripped and removed from the site prior to any grading, as should all trash and debris. Large shrubs and trees, when removed, should be grubbed out so as to include their stumps and major root systems, and these organic materials removed from the site. Remaining roots exposed during grading will require hand labor for proper removal.

The project geotechnical consultant should be notified at the appropriate times to provide observation and testing services during clearing operations to verify compliance with the above recommendations. In addition, should any buried structures or unusual or adverse soil conditions be encountered during grading that are not described or anticipated herein, these conditions should be brought to the immediate attention of the project geotechnical consultant for corrective recommendations.

Pre-Watering

In-situ moisture contents of the on-site earth materials range from approximately 1 to 2 percent at the time of exploration. Due to the dry condition of the on-site soils, it is recommended that the site be pre-watered prior to grading to facilitate moisture-conditioning of the soils. Pre-watering should be performed over a period of 2 to 3 weeks utilizing a rainbird system.

Ground Preparation

Low-density surficial soil deposits overlying the various geologic units, artificial fill (Afu) and slopewash deposits (Qsw) are compressible in their existing state and will require removal to underlying competent native materials from all areas planned to receive fill to mitigate possible excessive settlement of building foundations and street improvements. Competent native materials are defined as undisturbed bedrock or native Ocotillo Conglomerate and Fan Deposits possessing an in-place relative compaction of 90 percent or more. Estimated depths of removal of unsuitable materials range from 1-foot to locally potentially greater than 15 feet (see table of removals provided in a previous section). The estimated removal depths are based on exploratory boring and test pit data, and our laboratory test results. However, it is emphasized that the required depths of removal can, and usually do, vary between points of exploration. For this reason, the actual removal depths will have to be determined during grading on the basis of in-grading observations and testing performed by representatives of the project geotechnical consultant.

All existing low-density surficial soils, once properly moisture-conditioned, will be suitable for use as engineered fill. Remedial grading and ground preparation should be performed prior to placing any planned fills. Prior to placing structural fill, exposed bottom surfaces in each removal area approved for fill should first be scarified to a depth of at least 6 inches, watered as necessary to achieve a moisture content that is equal to or slightly above optimum moisture content, and then recompacted in-place to a minimum relative compaction of 90 percent.

Any low-density surficial soils exposed at finish grade in cut areas should also be removed and replaced as compacted fill.

Re-Compaction of Fault Investigation Trench Backfill

Petra's and Kenney Geoscience's geotechnical fault investigations (Petra, 2005, 2007) (Kenney, 2022) entailed the excavation of 212 trenches totaling a length of approximately 9.7 miles. The trenches varied from approximately 8 to 15 feet deep and approximately 15 to 20 feet wide. Following logging, the trenches were loosely backfilled with little to no compaction effort. Therefore, where fault trenches exist within proposed fill areas, the loose backfill materials should be re-excavated with scrapers and the soils replaced as compacted fill. The removals should extend to underlying competent native materials. In cut areas, any remaining loose backfill materials should also be removed and replaced as compacted fill. Approximate locations of the fault trenches are shown on the Geologic Trench Maps, in Appendix E of the Kenney Fault Investigation report (revised January 2022).

Observation of Ground Preparation

All removal bottoms should be observed, tested, and approved by the project geotechnical consultant and/or engineering geologist prior to fill placement.

Canyon Subdrains

Because the majority of the site is underlain by formational materials that are themselves fairly permeable, the potential build-up of hydrostatic pressures below compacted fills due to infiltration of surface waters is not likely. However, where the axes of major canyons and tributaries to be filled expose or are immediately underlain by the Palm Spring Formation, subdrains will be required where the depth of fill exceeds approximately 15 feet. Subdrains should be constructed in accordance with Plate SG-1, Appendix F. Subdrain locations should be determined in the field during grading based on exposed geologic conditions. The project geotechnical consultant should designate the location of the subdrain systems on the grading plans.

Fill Placement

All fills should be placed in 6- to 8-inch-thick maximum lifts, watered as necessary to achieve a moisture content that is equal to or slightly above optimum moisture content, and then compacted in-place to a 90 percent or more relative compaction with reference to ASTM D1557. All fill subsequently placed shall be compacted to 90 percent or more relative compaction, except where the fill depths exceed 50 feet, in which case all fill placed deeper than 50 feet from finish grade should be compacted to 95 percent or more relative compaction. The laboratory maximum dry density and optimum moisture content for each change in soil type should be determined in accordance with Test Method ASTM D 1557.

Settlement Monitoring

Post-grading settlement of deep fills will occur due to their own weight. The fills within the site will be derived from soil and bedrock materials that are primarily granular, have low clay contents, and have a very low expansion potential (with the exception of the Palm Spring Formation bedrock materials). Based on these conditions, it is expected that total primary consolidation of the new fill materials will be reached immediately at the completion of grading within areas underlain by 30 feet of compacted fill or less. In addition, considering the anticipated granular nature of the fill materials, long-term secondary settlement of these materials is expected to be negligible. However, in areas underlain by approximately 30 feet (or more) of compacted fill, it is recommended that settlement monitoring be performed.

Surface monuments should be installed at finished grade in these deep fill areas immediately following completion of grading to verify post-grading settlement. Where relatively deep fills are proposed within the main canyon of a temporarily mass-graded area, monuments should be installed as soon as temporary design grades are reached. The survey monuments should be monitored on a weekly basis for the first three weeks, then once every two weeks for a total of one month. Subsequent readings should be taken once a month for three months, or whenever the settlement appears to stabilize. Additional settlement monuments may be required once finish pad grades are reached following future rough grading. Building construction should not proceed until it is determined by this firm that primary consolidation has occurred and that any further anticipated settlement will be within acceptable tolerable limits.

Benching

Fills placed on or against natural slope surfaces inclining at 5:1 (h:v) or steeper should be placed on a series of level benches excavated into competent bedrock or competent native soil materials. These benches should be provided at vertical intervals of approximately 3 to 5 feet. Typical benching details are shown on Plates SG-5 through SG-8, Appendix F.

Mixing

In order to prevent layering of different soil types and/or different moisture contents, thorough mixing of materials will be necessary prior to final compaction of each fill lift. Discing may be required for mixing of excessively dry materials.

Disposal of Oversize Rock

Oversize rock is defined as hard irreducible boulders exceeding 12 inches in maximum dimension. Oversize rock generated during grading operations should be removed from the site or placed in the lower portions of the deeper fills utilizing the typical detail shown on Plate SG-4, Appendix F. Any oversize materials buried on site should be placed individually or in windrows, and in a manner to avoid nesting, and then completely covered with granular on-site earth materials. The in-fill materials should be thoroughly watered and rolled to ensure closure of all voids. Oversize rock should not be placed within the upper 10 feet of finish grade within building sites or street areas where they may interfere with footing and utility trenches, or in areas where they may interfere with the future construction of swimming pools and/or spas. In areas where the in-situ quantity of cobble- and boulder-sized rock makes this 10-foot limit unfeasible, the limit and rock size limitations may be modified at the discretion of the geotechnical engineer. Please note that where rock size limitations are increased, the associated cost of utility and foundation construction will increase accordingly.

The above requirements also apply to inert construction debris (asphalt, concrete, etc.) provided that the materials are reduced to a maximum size of 6 inches.

Processing of Cut Areas

In shallow cut areas where unsuitable surficial materials are not removed in their entirety, these materials should be over excavated to underlying competent materials and then brought back to grade with properly compacted fill. In deep cut areas where competent materials are exposed at grade, no special remedial work such as scarification or re-compaction will generally be required, other than processing the upper 1 foot of the building pads.

Cut/Fill Transitions

To mitigate distress to building structures related to the potential adverse effects of excessive differential settlement, cut/fill transitions should be eliminated from all building sites where the depth of fill placed within the "fill" portion exceeds proposed footing depths (e.g., 12 inches and 18 inches for one-story and two-story structures, respectively). This should be accomplished by over excavating the "cut" portions and replacing the excavated materials as properly compacted fill. Recommended depths of over excavation will depend on maximum depths of compacted fill placed on the "fill" portions but will generally follow the guidelines provided below. Horizontal limits of over excavation should extend beyond the perimeter building lines to a distance of 5 feet or to a distance equal to the required depth of over excavation, whichever is greater. It is anticipated that finalized building locations will be unknown at the time the initial mass grading is performed to create the super pads. Therefore, elimination of cut/fill transitions will likely have to be performed when final grading operations are performed to develop individual building sites. If this is the case, cut/fill transition lines should be accurately shown on the as-built mass grading plans.

Depth of Fill	Depth of Over excavation
Up to 3 feet	Equal depth
3 to 6 feet	3 feet
Greater than 6 feet	One-half of greatest fill depth placed on the "fill" portion; to 15 feet maximum

Recommendations for providing a uniform bearing medium for support of the proposed water reservoir tank should be submitted by the geotechnical consultant based on a review of a detailed grading plan and tank foundation plan.

Deep Fill/Shallow Fill Transitions

To mitigate the detrimental effects of excessive differential settlement, deep fill/ shallow fill transitions should also be eliminated from all building areas. This should be accomplished by over excavating the "shallow" fill portions of each building area and replacing the excavated materials as properly compacted fill. Generally, the depths of over excavation within the shallow fill area should equal one-half the thickness of the maximum depth of fill underlying the building area to a maximum depth of 15 feet.

Haul Roads

Haul roads should be selected to avoid disturbing terrain which is to remain in a natural state. Also, haul roads traversing compacted fill areas should be coordinated and planned to avoid or minimize generation of loose spill fills thereon. When this condition is unavoidable, close coordination with the project soils engineer and his representative will be required to eliminate intermingling of engineered and non-engineered fill.

During grading, special care should be exercised to avoid spilling and depositing of loose soil or debris onto slope areas and into areas programmed to remain in a natural state. Any loose slough, debris or other deleterious materials deposited or accumulated on natural areas will have to be removed by the contractor upon completion of grading.

Shrinkage/Bulking

Volumetric changes in earth quantities will occur when excavated on-site soil and bedrock materials are replaced as properly compacted fill. Estimated shrinkage, bulking and subsidence factors were provided in a previous section. The estimates are exclusive of any oversize rock that is removed from the site and not buried within designated rock disposal areas.

Geotechnical Observations and Testing During Grading

Observations of the clearing operations, removal of low-density surficial soils, keyway excavations, observation of cut slopes, and general grading procedures should be performed by a representative of the project geotechnical consultant. It should be the grading contractor's responsibility to notify the project geotechnical consultant when fill areas and fill keys are ready for observation. A representative of the project geotechnical consultant should be present on site during all major grading operations to verify proper placement and adequate compaction of all fills, as well as to verify compliance with the other recommendations presented herein.

Slope Construction

Slope Drainage and Terracing

Cut and fill slopes exceeding a height of 30 feet should be provided with terraces and interceptor drains at vertical intervals specified in Section J109, Chapter 33 Appendix J of the 2019 CBC. Top-of-slope interceptor drains should be provided along the tops of cut slopes as specified in Section J109.3, Chapter 33 Appendix J of the 2019 CBC.

Cut Slopes

Cut slopes are planned at a ratio of 2:1 (h:v) and to a maximum height of approximately 35 to 40 feet. Cut slopes will expose geologic units consisting mostly of the Ocotillo Conglomerate (Qo), and to a lesser extent the Palm Spring Formation (Qpu) and latest Pleistocene Fluvial Fan Deposits (Qfo). Based on our geologic mapping, subsurface exploration, and stability calculations, cut slopes exposing these materials are expected to be grossly stable. However, the Palm Spring Formation is interbedded with clay and silt materials, locally expose adverse out-of-slope bedding, and also exhibits numerous shear surfaces along weathered volcanic ash deposits. Consequently, cut slopes in the Palm Spring Formation (Qpu) may require replacement with an equipment-wide stabilization fill or possibly buttress fill. Identification of cut slopes that may expose an adverse out-of-slope bedding condition should be based on additional subsurface exploration by the project geotechnical engineer and engineering geologist at the time finalized Tentative Tract Maps are being prepared. In addition, all cut slopes should be carefully observed by the project engineering geologist during grading to identify any adverse bedding.

Fill Slopes

Fill slopes are proposed at a slope ratio of 2:1 (h:v) and to a maximum of approximately 70 feet. Based on our stability calculations, proposed fill slopes constructed with on-site earth materials will be grossly stable to the maximum height planned. However, the primary source of fill materials will consist of relatively clean sands derived from the Ocotillo Conglomerate and Fan deposits. Additional recommendations for construction of fill slopes are provided below.

Fill Keys

Fill keys excavated into competent bedrock or competent native soils will be required at the base of all proposed fill slopes to be constructed on slope surfaces inclining at 5:1 (H:V) or steeper. The fill keys should be excavated to a minimum depth of 2 feet into competent materials and have a minimum width of 15 feet or a width equal to one-half of the slope height, whichever is greater. The bottoms of the fill keys should be tilted back at a minimum of 2 percent towards the heel of the key. Internal backdrains may be required in the keyways at the discretion of the engineering geologist to prevent entrapment of irrigation water and rainwater in the key bottoms. Typical details for construction of the backdrains are shown on plates SG-2 and SG-3, Appendix F.

Surface Compaction

The finish surfaces of all fill slopes should be compacted to a minimum relative compaction of 90 percent. Final surface compaction should be achieved by overfilling the slopes during construction and then trimming the slopes back to the compacted inner core. As a secondary alternative, surface compaction should be obtained by back-rolling during construction to achieve at least 90 percent relative compaction within 6 to 8 inches of the finish surfaces. This initial back-rolling should be performed at vertical intervals not exceeding 4 to 5 feet. Final surface compaction should then be achieved by rolling the slope surface with a cable-lowered sheepsfoot and then re-rolling with a grid roller. During final surface compaction, it is critical that the moisture content of the surface soils be maintained at near optimum moisture content or slightly higher.

Fill-Over-Cut Slopes

Where fill-over-cut transition slopes are proposed, a keyway excavated into competent bedrock or competent native soil should be provided at the contact. The keyway should be at least 15 feet wide and tilted back into the slope at a minimum gradient of 2 percent.

Slopes Adjacent to Water Reservoir Tank

Cut and fill slopes proposed adjacent to the amphitheater pad vary up to maximum heights of approximately 20 feet and 15 feet, respectively. The cut slope, which is proposed within the Ocotillo Conglomerate (Qo), and the fill slope are expected to be grossly stable provided they are constructed in accordance with the recommendations presented in this report.

Post-Grading Considerations

Utility Trenches

All applicable requirements of the California Construction and General Industry Safety Orders, the Occupational Safety and Health Act of 1970, and the Construction Safety Act should be followed with respect to excavation of trenches for subsurface utilities. In general, the majority of the on-site soils consist of relatively clean, cohesionless sands and are classified as Type C soil in accordance with CAL/OSHA regulations. Accordingly, the sidewalls of open trenches should be sloped back at a ratio of 1.5:1 (h:v) or flatter. Trench shields should also be considered as added protection for workers entering the trenches.

All utility trenches backfill should be compacted to a minimum relative compaction of 90 percent. Where on-site soils are utilized as backfill, mechanical compaction will be required. Density testing, along with probing, should be performed by a representative of the project geotechnical consultant to verify proper compaction.

For deep trenches with vertical walls, backfill should be placed in approximately 2-foot-thick maximum lifts, moisture conditioned to establish optimum or slightly above optimum moisture content, and then mechanically compacted with a hydra-hammer, pneumatic tampers, or similar equipment that can achieve the desired compaction. For deep trenches with sloped walls, backfill materials should be placed in approximately 8- to 12-inch-thick maximum lifts, and then compacted by rolling with a sheepsfoot tamper or similar equipment.

For shallow trenches where pipe may be damaged by mechanical compaction equipment, such as under building floor slabs, clean on-site sands having a sand equivalent (SE) value of 30 or greater should be utilized for backfill that is jetted or flooded into place, and then tamped into place. No specific relative compaction will be required; however, observation, probing, and if deemed necessary, testing should be performed by the project geotechnical consultant to verify that an adequate degree of compaction is achieved.

To avoid point loads and subsequent distress to asbestos, clay, cement, or plastic pipe, clean sand bedding should be placed at least l-foot above all pipe in areas where excavated trench materials contain oversize rock. Sand bedding materials should be thoroughly jetted prior to placement of backfill.

Where utility trenches are proposed parallel to any building footing (interior and/or exterior trenches), the bottom of the trench should not extend below a 1:1 plane projected downward from the outside bottom edge of the adjacent footing.

Development of underground utilities across the proposed fault setback zones should take into account potential fault displacement. For the Berdoo Canyon fault zone, it should be anticipated that relatively small magnitude vertical and horizontal displacement would likely occur across a wide zone. It is possible that a “primary” right-lateral strike-slip fault within this zone may exhibit a total of 2 to 5 feet of offset. Geotechnical Engineers designing such utilities could utilize the fault scarp mapping shown in the recent Kenney fault investigation report (Kenney, 2022).

<u>Pad Drainage</u>

Positive surface drainage systems consisting of a combination of sloped concrete flatwork, sheet flow gradients and earth swales, and surface area drains (where needed) should be provided around each building and within yard areas to collect and direct all surface waters to the adjacent streets. Sheet-flow-graded ground surfaces should be inclined at a minimum gradient of 2 percent away from building foundations and similar structures. Surface waters should not be allowed to collect or pond against building foundations and within the level areas of the lots, or to flow onto adjacent slopes. Roof gutters with downspouts should be used on the sides of houses where there is insufficient area to construct effective yard drainage devices and/or where roof drainage is directed onto adjacent slopes.

For unimproved graded lots to remain idle for a long period of time, pad drainage should be designed for a minimum gradient of 1 percent toward the adjacent streets.

Water Quality Management Plans

Development of the subject site will require post grading low impact development best management practices to mitigate water quality impacts. When considering types and locations, consideration should be given to design of water quality management plans (WQMPs) to limit storm water infiltration in proximity to graded or natural slopes. Dependent upon subsurface soil and formation conditions, concentrated subsurface water infiltration has the potential to decrease stability of natural, cut, and fill slopes. Graded and natural slopes within the Upper Member of the Palms Spring Formation may be the most susceptible to this affect.

Slope Landscaping and Maintenance

Proper slope and pad drainage are essential in the design of grading for the subject property. The overall stability of the graded slopes should not be adversely affected provided all drainage provisions are properly constructed and maintained thereafter, and provided all engineered slopes are landscaped with a deep-rooted, drought-resistant, and relatively maintenance-free plant species. Additional comments and recommendations are presented below with respect to slope drainage, landscaping, and irrigation.

1. Proper drainage provisions for engineered slopes should consist of concrete terrace drains, downdrains, and energy dissipaters (where required) constructed in accordance with County of Riverside grading codes. Provisions should also be made for construction of compacted earth berms along the tops of all engineered slopes.
2. All engineered slopes should be landscaped as soon as practical at the completion of grading. As noted, the landscaping should consist of a deep-rooted, drought-resistant, and maintenance-free plant species. If landscaping cannot be provided within a reasonable period of time, jute matting or equivalent, or a spray-on product designed to seal slope surfaces should be considered as a temporary measure to inhibit surface erosion.
3. Irrigation systems should be considered on the engineered slopes and a watering program then implemented which maintains a uniform, near optimum moisture condition in the soils. Overwatering and subsequent saturation of the slope soils should be avoided.
4. Irrigation systems should be constructed at the surface only. Construction of sprinkler lines in trenches should not be allowed without prior approval from the soils engineer and engineering geologist.
5. During construction of terrace drains and downdrains, care must be taken to avoid placement of loose soil on the slope surfaces.

6. A permanent slope maintenance program should be initiated. Proper slope maintenance must include the care of drainage and erosion control provisions, rodent control, and repair of leaking irrigation systems.

7. Provided the above recommendations are followed with respect to slope drainage, maintenance and landscaping, the potential for deep saturation of slope soils is considered very low.

Preliminary Foundation Design Recommendations

General

For planning purposes, we provide the following preliminary foundation design recommendations based on anticipated conditions at the completion of rough grading. Final design recommendations should be provided by the project geotechnical consultant based on final as-graded soil conditions existing within the building sites.

Seismic Design Parameters

Earthquake loads on earthen structures and buildings are a function of ground acceleration which may be determined from the site-specific ground motion analysis. Alternatively, a design response spectrum can be developed for certain sites based on the code guidelines. To provide the design team with the parameters necessary to construct the design acceleration response spectrum for this project, we used two computer applications. Specifically, the first computer application, which was jointly developed by Structural Engineering Association of California (SEAOC) and California's Office of Statewide Health Planning and Development (OSHPD), the SEA/OSHPD Seismic Design Maps Tool website, https://seismicmaps.org, is used to calculate the ground motion parameters. The second computer application, the United Stated Geological Survey (USGS) Unified Hazard Tool website, https://earthquake.usgs.gov/hazards/interactive/, is used to estimate the earthquake magnitude and the distance to surface projection of the fault.

A seismic risk category of II was assigned to the proposed building(s) in accordance with 2019 CBC, Table 1604.5. An average shear wave velocity of 2,000 feet per second for the upper 100 feet was used for the site based on the determination that the majority of the site exposes sedimentary bedrock with localized deposits of fluvial fan deposits with the main drainages. As such, in accordance with ASCE 7-16, Table 20.3-1, Site Class C has been assigned to the subject site to provide a preliminary evaluation of site seismic design parameters. This preliminary site class assignment is subject to review and post-grading evaluation in view of localized conditions throughout the site.

The following table, Table 1, provides parameters required to construct the design acceleration response spectrum based on the 2019 CBC guidelines. A printout of the computer output is attached in Appendix E.

TABLE 1

Seismic Design Parameters

Ground Motion Parameters	Specific Reference	Parameter Value	Unit
Site Latitude (North)	-	33.702266	°
Site Longitude (West)	-	-116.103395	°
Site Class Definition	Section 1613.2.2 (1), Chapter 20 (2)	C (4)	-
Assumed Seismic Risk Category	Table 1604.5 (1)	II	-
M_w - Earthquake Magnitude	USGS Unified Hazard Tool (3)	7.34 (3)	-
R – Distance to Surface Projection of Fault to Site Center	USGS Unified Hazard Tool (3)	2.46 (3)	km
S_s - Mapped Spectral Response Acceleration Short Period (0.2 second)	Figure 1613.2.1(1) (1)	2.272 (4)	g
S_1 - Mapped Spectral Response Acceleration Long Period (1.0 second)	Figure 1613.2.1(2) (1)	0.965 (4)	g
F_a – Short Period (0.2 second) Site Coefficient	Table 1613.2.3(1) (1)	1.2 (4)	-
F_v – Long Period (1.0 second) Site Coefficient	Table 1613.2.3(2) (1)	1.4 (4)	-
S_{MS} – MCE_R Spectral Response Acceleration Parameter Adjusted for Site Class Effect (0.2 second)	Equation 16-36 (1)	2.726 (4)	g
S_{M1} - MCE_R Spectral Response Acceleration Parameter Adjusted for Site Class Effect (1.0 second)	Equation 16-37 (1)	1.351 (4)	g
S_{DS} - Design Spectral Response Acceleration at 0.2-s	Equation 16-38 (1)	1.817 (4)	g
S_{D1} - Design Spectral Response Acceleration at 1-s	Equation 16-39 (1)	0.901 (4)	g
$T_o = 0.2\ S_{D1}/\ S_{DS}$	Section 11.4.6 (2)	0.099	s
$T_s = S_{D1}/\ S_{DS}$	Section 11.4.6 (2)	0.496	s
T_L - Long Period Transition Period	Figure 22-14 (2)	8 (4)	s
PGA - Peak Ground Acceleration at MCE_G (*)	Figure 22-9 (2)	1.218	g
F_{PGA} - Site Coefficient Adjusted for Site Class Effect (2)	Table 11.8-1 (2)	1.2 (4)	-
PGA_M –Peak Ground Acceleration (2) Adjusted for Site Class Effect	Equation 11.8-1 (2)	1.173 (4)	g
Design PGA ≈ (⅔ PGA_M) - Slope Stability (†)	Similar to Eqs. 16-38 & 16-39 (2)	0.812	g
Design PGA ≈ (0.4 S_{DS}) – Short Retaining Walls (‡)	Equation 11.4-5 (2)	0.727	g
C_{RS} - Short Period Risk Coefficient	Figure 22-18A (2)	0.878 (4)	-
C_{R1} - Long Period Risk Coefficient	Figure 22-19A (2)	0.868 (4)	-
SDC - Seismic Design Category (§)	Section 1613.2.5 (1)	E (4)	-

References:
(1) California Building Code (CBC), 2019, California Code of Regulations, Title 24, Part 2, Volume I and II.
(2) American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI), 2016, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, Standards 7-16.
(3) USGS Unified Hazard Tool - https://earthquake.usgs.gov/hazards/interactive/
(4) SEI/OSHPD Seismic Design Map Application – https://seismicmaps.org

Related References:
Federal Emergency Management Agency (FEMA), 2015, NEHERP (National Earthquake Hazards Reduction Program) Recommended Seismic Provision for New Building and Other Structures (FEMA P-1050).

Notes:
* PGA Calculated at the MCE return period of 2475 years (2 percent chance of exceedance in 50 years).
† PGA Calculated at the Design Level of ⅔ of MCE; approximately equivalent to a return period of 475 years (10 percent chance of exceedance in 50 years).
‡ PGA Calculated for short, stubby retaining walls with an infinitesimal (zero) fundamental period.
§ The designation provided herein may be superseded by the structural engineer in accordance with Section 1613.2.5.1, if applicable.

Building Clearances from Ascending Slopes

To conform with Section 1808.7.1 and Figure 1808.7.1 of the 2019 CBC, minimum clearances of H/2 (one-half of the total slope height) to a maximum of 15 feet should be maintained between buildings and the toe of any adjacent ascending slope. Retaining walls may be constructed at the base of the slopes to achieve the required building clearances.

Footing Setbacks from Descending Slopes

To conform with Section 1808.7.2 and Figure 1808.7.1 of the 2019 CBC, building footings to be constructed on or near descending slopes should be deepened, as necessary, to provide a minimum footing setback of H/3 (one-third of the total slope height). The footing setbacks should be 5 feet minimum where the slope height is 15 feet or less and vary up to 40 feet maximum where slope heights exceed 15 feet. The footing setbacks should be measured along a horizontal line projected from the lower outside bottom edges of the footings to the face of the adjacent descending slope.

Preliminary Foundation Design Recommendations

Results of the laboratory expansion index tests performed in accordance with ASTM D 4829 indicate a majority of the on-site soil and bedrock materials exhibit a Very Low expansion potential, i.e., non-expansive. However, a sample of clayey silt material from the Palm Spring Formation was found to exhibit a Medium expansion potential. Therefore, based on the distribution of the various geologic units within the site and the anticipated grading, it is expected that upon the completion of rough grading that the majority of the soils underlying the building sites will exhibit a Very Low. It is also anticipated that the foundations materials in building sites that are excavated to grade within the Palm Spring Formation, or building sites constructed with fill derived from this formation, will likely exhibit a Medium expansion potential.

Section 1808.6.2 of the 2019 CBC specifies that slab-on-ground foundations (floor slabs) resting on expansive soils should be designed in accordance with Wire Reinforcement Institute (WRI) publication "Design of Slab-on Ground Foundation," that was last updated in 1996. The design procedures outlined in the WRI publication are based on the expansion potential and the weighted plasticity index of the different soil layers existing within the upper 15 feet of each building site. Therefore, since the individual lots will be underlain by soil and bedrock materials with variable expansion potentials, final foundation design recommendations should be provided by the project geotechnical consultant on a lot-by-lot basis and should be based on the actual expansion potentials and weighted plasticity indices of the soil and bedrock materials underlying each individual lot. However, the following recommendations are provided for preliminary design purposes.

Allowable Soil Bearing Capacities

Pad Footings

An allowable soil bearing capacity of 1,500 pounds per square foot may be utilized for design of isolated 24-inch-square footings founded at a minimum depth of 12 inches below the lowest adjacent final grade for pad footings that are not a part of the slab system and are used for support of such features as roof overhang, second-story decks, patio covers, etc. This value may be increased by 20 percent for each additional foot of depth and by 10 percent for each additional foot of width, to a maximum value of 2,500 pounds per square foot. The recommended allowable bearing value includes both dead and live loads and may be increased by one-third for short duration wind and seismic forces.

Continuous Footings

An allowable soil bearing capacity of 1,500 pounds per square foot may be utilized for design of continuous footings founded at a minimum depth of 12 inches below the lowest adjacent final grade. This value may be increased by 20 percent for each additional foot of depth and by 10 percent for each additional foot of width, to a maximum value of 2,500 pounds per square foot. The recommended allowable bearing value includes both dead and live loads and may be increased by one-third for short duration wind and seismic forces.

Estimated Footing Settlement

Static

Under the above recommended bearing values, total static settlements due to new building loads are expected to be less than 3/4 inch, and differential settlement between adjacent footings is expected to be less than 1/2 inch over a span of 30 feet. The majority of the anticipated settlement is expected to take place during construction as building loads are applied.

Dynamic (Seismically-Induced) Settlement

As stated previously in this report, the total, weighted dynamic settlement, specifically where the foundation is underlain by undisturbed Fluvial Fan Deposits, is estimated to be 4.78 inches. Assuming remedial removal and re-compaction of the upper 10 feet of fluvial fan deposits, the estimated weighted dynamic settlement is 2.4 inches with a corresponding differential settlement of 1.6 inches over an estimated span of 20 feet. The project structural engineer should determine whether the static and dynamic settlement estimates provided herein should be considered additive for purposes of their structural design.

Lateral Resistance

A passive earth pressure of 250 pounds per square foot per foot of depth, to a maximum value of 2,500 pounds per square foot, may be used to determine lateral bearing resistance for footings. In addition, a coefficient of friction of 0.30 times the dead load forces may be used between concrete and the supporting soils to determine lateral sliding resistance. The above values may be increased by one-third when designing for transient wind or seismic forces. It should be noted that the above values are based on the condition where footings are cast in direct contact with compacted fill or competent native soils. In cases where the footing sides are formed, all backfill placed against the footings upon removal of forms should be compacted to at least 90 percent of the applicable maximum dry density.

Conventionally Reinforced Slab-on-Ground Foundation System

A portion of onsite soils may be considered expansive per Section 1803.5.3 of the 2019 CBC. For soils that are considered expansive, Section 1808.6.2 of the 2019 CBC specifies that non-prestressed slab-on-grade foundations constructed on expansive materials should be designed in accordance with the latest edition of the Wire Reinforcement Institute (WRI) publication "Design of Slab-on-Ground Foundations". The design procedures outlined in the WRI publication are based on the weighted plasticity index of the various soil layers existing within the upper 15 feet of the building site.

The WRI publication states that the weighted plasticity index (P.I.) of each building site should be modified (multiplied) by correction factors that compensate for the effects of sloping ground and the unconfined compressive strength of the supporting soil or bedrock materials. Since the buildings will be constructed on level building pads, and in consideration of the estimated unconfined compressive strength of the onsite soils, it is recommended that the weighted plasticity index, as provided herein, be multiplied by a factor of 1.2 in order to determine the value of the effective plasticity index (per Figure 9 of the WRI publication). For preliminary design purposes, the project structural engineer may assume an effective plasticity index of 18 for soils with Expansion Index (E.I.) between 21 and 50, an effective plasticity index of 25 and for soils with an Expansion Index (E.I.) between 51 and 90 and an effective plasticity index of 35 and for soils with an Expansion Index (E.I.) between 91 and 130.

Final foundation design criteria should be made at the completion of grading, based on "as-graded" soil conditions. As such, the footing and slab configuration, and reinforcement recommendations should be considered preliminary and subject to review, pending evaluation of expansive soil characteristics and "as-graded" conditions at the conclusion of grading operations.

Footings

1. The following table presents recommended minimum depths, widths and reinforcement for exterior and interior continuous footings supporting one- and two-story light framed structures.

Continuous Footings – Conventionally Reinforced Slabs

Foundation Element	Expansion Index (E.I.) (Expansion Potential)											
	E.I. ≤ 20[1] (Very Low)			E.I. 21 – 50 (Low)			E.I. 51 – 90 (Medium)			E.I. 91 – 130 (High)		
	Number of Stories											
	1, 2	3	4	1, 2	3	4	1, 2	3	4	1, 2	3	4
Exterior Cont. Footing Depth[2] (in.)	12	18	18	15	18	18	18	18	18	24	24	24
Interior Cont. Footing Depth[3] (in.)	10	10	10	12	12	12	15	15	15	18	18	18
Width (in.)-2019 CBC Table 1809.7	12	15	18	12	15	18	12	15	18	12	15	18
Reinforcement	Two #4 bars; one top, one bottom			Two #4 bars; one top, one bottom			Four #4 bars; two top, two bottom			Four #4 bars; two top, two bottom		

1. No special foundation design methodology is indicated by the 2019 CBC for soil characterized as having an Expansion Index less than or equal to 20.
2. Depth below lowest adjacent final grade.
3. Depth below top of finish floor.

2. A minimum 12-inch-wide grade beam founded at the same depth as adjacent footings should be provided across the garage entrances or similar openings (such as large doors or bay windows). The grade beam should be reinforced in a similar manner as recommended above.

3. The following table presents recommended minimum dimensions, depths, and reinforcement for interior isolated pad footings supporting one- through four-story light framed structures.

Interior Isolated Pad Footings – Conventionally Reinforced Slabs

Foundation Element	Expansion Index (E.I.)							
	E.I. ≤ 20 (Very Low)		E.I. 21 – 50 (Low)		E.I. 51 – 90 (Medium)		E.I. 91 – 130 (High)	
	Number of Stories							
	1, 2	3, 4	1, 2	3, 4	1, 2	3, 4	1, 2	3, 4
Minimum Footing Depth[1] (in.)	12	15	12	15	12	15	15	18
Minimum Footing Dimension (in.)	24 x 24		24 x 24		24 x 24		24 x 24	
Reinforcement	#4 bars @ 18” o.c. both ways, placed near footing bottom		#4 bars @ 18” o.c. both ways, placed near footing bottom		#4 bars @ 18” o.c. both ways, placed near footing bottom		#4 bars @ 18” o.c. both ways, placed near footing bottom	

1. Depth below top of finish floor.

4. The following table presents recommended minimum dimensions, depths, and reinforcement for exterior isolated pad footings supporting roof overhangs such as second-story decks, patio covers and similar appurtenances.

Exterior Isolated Pad Footings – Conventionally Reinforced Slabs

Foundation Element	**Expansion Index (E.I.)**							
	E.I. ≤ 20 (Very Low)		**E.I. 21 – 50 (Low)**		**E.I. 51 – 90 (Medium)**		**E.I. 91 – 130 (High)**	
	Number of Stories							
	1, 2	**3, 4**	**1, 2**	**3, 4**	**1, 2**	**3, 4**	**1, 2**	**3, 4**
Footing Depth[1] (in.)	18	24	18	24	24	24	30	30
Footing Dimension (in.)	24 x 24		24 x 24		24 x 24		24 x 24	
Reinforcement[2]	#4 bars @ 18" o.c. both ways, placed near footing bottom		#4 bars @ 18" o.c. both ways, placed near footing bottom		#4 bars @ 18" o.c. both ways, placed near footing bottom		#4 bars @ 18" o.c. both ways, placed near footing bottom	

1. Depth below lowest adjacent final grade.
2. Exterior isolated pad footings may need to be connected to adjacent pad and/or continuous footings via tie beams at the discretion of the project structural engineer.

5. The spacing and layout of the interior concrete grade beam system required below floor slabs should be determined by the project architect or structural engineer in accordance with the WRI publication using the effective plasticity index value.

6. The minimum footing dimensions and reinforcement recommended herein may be modified (increased or decreased subject to the constraints of Chapter 18 of the 2019 CBC) by the structural engineer responsible for foundation design based on his/her calculations and engineering experience and judgment.

<u>Building Floor Slabs</u>

1. The following table presents recommended minimum thicknesses and reinforcement for concrete floor slabs. Slab dimension, reinforcement type, size and spacing should be designed by the structural engineer/slab designer to account for internal concrete forces that may occur (e.g., thermal, shrinkage and expansion), as well as external forces (e.g., applied loads).

Concrete Floor Slabs – Conventionally Reinforced Slabs

Slab Element		Expansion Index (E.I.)			
		E.I. ≤ 20 (Very Low)	**E.I. 21 – 50 (Low)**	**E.I. 51 – 90 (Medium)**	**E.I. 91 – 130 (High)**
Floor Slab Thickness (in.)		4	4	4	6
Reinforcement	Effective. P.I. < 20	#3 bars @ maximum 24" o.c. both ways	#3 bars @ maximum 18" o.c. both ways	#3 bars @ maximum 18" o.c. both ways	#3 bars @ maximum 15" o.c. both ways
	Effective P.I. ≥ 20	N/A	N/A	#3 bars @ maximum 15" o.c. both ways	#4 bars @ maximum 20" o.c. both ways
Alternative Reinforcement[1]		6x6/W2.9xW2.9 WWF	6x6/W2.9xW2.9 WWF	N/A	N/A

N/A – Not applicable.

All slab reinforcement should be supported on concrete chairs or brick to ensure the desired placement near mid-depth. Care should be exercised to prevent warping of the welded wire mesh between the chairs in order to ensure its placement at the desired mid-slab position.

[1] If recommended by the structural engineer - welded wire fabric (WWF) sheets only, no rolls.

2. Living area concrete floor slabs and areas to receive moisture sensitive floor covering should be underlain with a vapor retarder consisting of a minimum 10-mil-thick polyethylene or polyolefin membrane that meets the minimum requirements of ASTM E96 and ASTM E1745 for vapor retarders (such as Husky Yellow Guard®, Stego® Wrap, or equivalent). The membrane should be properly lapped and sealed was well as sealed around all plumbing lines and other openings. At least 2 inches of clean sand should be placed over the membrane to promote uniform curing of the concrete. It is essential to prevent damage to the moisture retarder membrane. To reduce the potential for punctures, the membrane should be placed on a pad surface that has been graded smooth without any sharp protrusions. If a smooth surface cannot be achieved by grading, consideration should be given to lowering the pad finished grade an additional inch and then placing a 1-inch-thick leveling course of sand across the pad surface prior to the placement of the membrane. Penetration of the membrane with screed guides during concrete placement should be avoided. A 4-inch-thick layer of non-expansive sand and gravel should be placed below the vapor retarder membrane on lots where the soil is indicated as having an Expansion Index of 91 or greater.

At the present time, some slab designers, geotechnical professionals and concrete experts view the sand layer below the slab (blotting sand) as a place for entrapment of excess moisture that could adversely impact moisture-sensitive floor coverings. As a preventive measure, the potential for moisture intrusion into the concrete slab could be reduced if the concrete is placed directly on the vapor retarder. However, if this sand layer is omitted, appropriate curing methods must be implemented to ensure that the concrete slab cures uniformly. A qualified materials engineer with experience in slab design and construction should provide recommendations for alternative methods of curing and supervise the construction process to ensure uniform slab curing. Additional steps would also need to be taken to prevent puncturing of the vapor retarder during concrete placement.

3. Garage floor slabs should have the same minimum thickness and reinforcement as living area floor slabs. Garage floor slabs should be poured separately from adjacent wall footings with a positive separation maintained using ¾-inch minimum felt expansion joint material. To aid in reducing the propagation of shrinkage cracks, garage floor slabs should be quartered with weakened plane joints. Consideration should be given to placement of a moisture vapor retarder below the garage slab, similar to that recommended in Item 2 above, should the garage slab be overlain with moisture sensitive floor covering.

4. Prior to placing concrete, the subgrade soils below floor slabs should be pre-watered as recommended in the following table.

Subgrade Moisture Content – Conventionally-Reinforced Slabs

Parameter	Expansion Index (E.I.)			
	E.I. ≤ 20 (Very Low)	E.I. 21 – 50 (Low)	E.I. 51 – 90 (Medium)	E.I. 91 – 130 (High)
Moisture Content (percent of optimum)	100	120	130	140
Pre-watering Depth Below Subgrade (in.)	12	12	18	24

5. The minimum dimensions and reinforcement recommended herein for building floor slabs may be modified (increased or decreased) by the structural engineer responsible for foundation design based on his/her calculations and engineering experience and judgment.

6. In addition to the potential effects of expansive soils, the foundations should be designed in consideration of the estimated potential total and differential settlements presented herein.

Preliminary Retaining Wall Design Recommendations

Temporary Backcut Slopes

To comply with CAL/OSHA regulations, temporary backcut slopes associated with construction of retaining walls should be excavated at a ratio of 1.5:1 (h:v). Steeper backcuts will require approval by the engineering geologist.

Allowable Bearing Values and Lateral Resistance

Retaining wall footings may be designed using the allowable soil bearing and lateral resistance values recommended previously for design of building footings. However, when calculating passive resistance, the upper 6 inches of the soils should be ignored in areas where the footings will not be covered with concrete flatwork.

On-Site Soils Used for Backfill

On-site soils derived from the Fan deposits and Ocotillo Conglomerate consist predominately of clean sands exhibiting a very low expansion potential and sand equivalent (SE) values exceeding 30. Therefore, these soil materials are considered well-suited for use as backfill behind retaining walls provided, they are cleared of cobbles exceeding a maximum dimension of 3 inches. Active earth pressures equivalent to fluids having densities of 35 and 51 pounds per cubic foot may be used for design of cantilevered walls retaining a level backfill and ascending 2:1 backfill, respectively. For walls that are restrained at the top, at-rest earth pressures of 53 and 78 pounds per cubic foot (equivalent fluid pressures) should be used. The above values are for retaining walls that have been supplied with a proper subdrain system. All walls should be designed to support any adjacent structural surcharge loads imposed by other nearby walls or footings in addition to the above-recommended active and at-rest earth pressures.

Drainage and Waterproofing

Perforated pipe and gravel subdrains should be installed behind all retaining walls to prevent entrapment of water in the backfill. Perforated pipe should consist of 4-inch-minimum diameter PVC Schedule 40, or ABS SDR-35, with the perforations lain down. The pipe should be encased in a 1-foot-wide column of 3/4-inch to 1½-inch open-graded gravel. If on-site sandy soils are used as backfill, the open-graded gravel should extend above the wall footings to a minimum height of 1-foot above the footing. The open-graded gravel should be completely wrapped in filter fabric consisting of Mirafi 140N, or equivalent. Solid outlet pipes should be connected to the subdrains and then routed to a suitable area for discharge of accumulated water. The backfilled sides of retaining walls should be coated with an approved waterproofing compound or covered with a similar material to inhibit migration of moisture through the walls.

Wall Backfill

Where on-site soils are used for backfilling, they should be placed in approximately 6- to 8-inch-thick maximum lifts, watered as necessary to achieve near optimum moisture conditions, and then mechanically compacted in place to a minimum relative compaction of 90 percent. Flooding or jetting of the backfill materials should be avoided. A representative of the project geotechnical consultant should observe the backfill procedures and test the wall backfill to verify adequate compaction.

Preliminary Recommendations for Masonry Block Walls

Construction Near the Tops of Descending Slopes

Continuous footings for masonry screen walls proposed on or within 5 feet from the top of a descending slope should be deepened such that a horizontal clearance of 5 feet or more is maintained between the outside bottom edge of the footings and the slope face. The footings should be reinforced with two No. 4 bars, one top and one bottom, or as recommended by the structural engineer.

Construction on Level Ground

Where masonry screen walls are proposed on level ground and 5 or more feet from the tops of descending slopes, the footings for these walls may be founded at a depth of 12 inches or more below the lowest adjacent final grade. These footings should also be reinforced with two No. 4 bars, one top and one bottom, or as recommended by the structural engineer.

Construction Joints

In order to mitigate the potential for unsightly cracking related to the effects of differential settlement, positive separations (construction joints) should be provided in the walls at horizontal intervals of approximately 25 feet and at each corner. The separations should be provided in the blocks only and not extend though the footings. The footings should be placed monolithically with continuous rebars to serve as effective grade beams along the full lengths of the walls.

Preliminary Recommendations for Exterior Concrete Flatwork

General

It is expected that a majority of the as-graded building pads will be underlain with subgrade soils exhibiting a very low expansion potential and some being underlain with subgrade soils exhibiting a medium low expansion potential. The following preliminary design recommendations are provided for concrete flatwork depending on the expansion potential of the subgrade soils.

Thickness and Joint Spacing

Very Low and Low Expansion Potential

To reduce the potential of unsightly cracking, concrete walkways, patio-type slabs, large decorative slabs and concrete subslabs to be covered with decorative pavers should be at least 4 inches thick and provided with construction joints or expansion joints every 6 feet or less. Private driveways that will be designed for the use of passenger cars for access to private garages should also be at least 4 inches thick and provided with construction joints or expansion joints every 10 feet or less. Concrete pavement that will be designed based on an unlimited number of applications of an 18-kip single-axle load in public access areas, segments of roads that will be paved with concrete (such as bus stops and cross-walks) or access roads that will be subject to heavy truck loadings should have a minimum thickness of 5 inches and be provided with control joints spaced at maximum 10-foot intervals. A modulus of subgrade reaction of 125 pounds per cubic foot may be used for design of the public and access roads.

Medium Expansion Potential

Concrete walkways, patio-type slabs, large decorative slabs and concrete subslabs to be covered with decorative pavers should be at least 4 inches thick and provided with construction joints or expansion joints every 6 feet or less. Private driveways that will be designed for the use of passenger cars for access to private garages should also be at least 5 inches thick and provided with construction joints or expansion joints every 10 feet or less. Concrete pavement that will be designed based on an unlimited number of applications of an 18-kip single-axle load in public access areas or access roads that will be subject to heavy truck loadings should have a minimum thickness of 6 inches and be provided with control joints spaced at maximum 10-foot intervals. A modulus of subgrade reaction of 100 pounds per cubic foot may be used for design of the public and access roads.

Reinforcement

Very Low and Low Expansion Potential

All concrete flatwork having their largest plan-view panel dimension exceeding 10 feet should be reinforced with a minimum of No. 3 bars spaced 24 inches on centers, both ways. Alternatively, the slab reinforcement may consist of welded wire mesh of the sheet type (not rolled) with 6x6/W1.4xW1.4 designation in accordance with the Wire Reinforcement Institute (WRI). The reinforcement should be properly positioned near the middle of the slabs.

Medium Expansion Potential

All concrete walkways, patio-type slabs, large decorative slabs, concrete subslabs to be covered with decorative pavers and private driveways that will be designed for the use of passenger cars for access to private garages should be reinforced with a minimum of No. 3 bars spaced 18 inches on centers, both ways. Alternatively, the slab reinforcement may consist of welded wire mesh of the sheet type with 6x6/W2.9xW2.9 designation in accordance with the Wire Reinforcement Institute (WRI). Concrete pavement that will be designed based on an unlimited number of applications of an 18-kip single-axle load in public access areas, segments of road that will be paved with concrete (such as bus stops and cross-walks) or access roads that will be subject to heavy truck loadings should be reinforced with a minimum of No. 3 bars spaced 18 inches on centers, both ways. Alternatively, the slab reinforcement may consist of welded wire mesh of the sheet type with 6x6/W2.9xW2.9 designation in accordance with the Wire Reinforcement Institute (WRI). The reinforcement should be properly positioned near the middle of the slabs. All reinforcements should continue through the joints.

Subgrade Preparation

Compaction

To reduce the potential for distress to concrete flatwork, the subgrade soils below concrete flatwork areas to a minimum depth of 12 inches (or deeper, as either prescribed elsewhere in this report or determined in the field) should be moisture conditioned to at least equal to, or slightly greater than, the optimum moisture content and then compacted to a minimum relative compaction of 90 percent. Where concrete public roads, concrete segments of roads and/or concrete access driveways are proposed, the upper 6 inches of subgrade soil should be compacted to a minimum 95 percent relative compaction.

Pre-Moistening

As a further measure to reduce the potential for concrete flatwork cracking, subgrade soils should be thoroughly moistened prior to placing concrete. The moisture content of the soils should be at least 1.2 times the optimum moisture content and penetrate to a minimum depth of 12 inches into the subgrade. Flooding or ponding of the subgrade is not considered feasible to achieve the above moisture conditions since this method would likely require construction of numerous earth berms to contain the water. Therefore, moisture conditioning should be achieved with sprinklers or a light spray applied to the subgrade over a period of few to several days just prior to pouring concrete. Pre-watering of the soils is intended to promote uniform curing of the concrete, reduce the development of shrinkage cracks, and reduce the potential for differential expansion pressure on freshly poured flatwork. A representative of the project geotechnical consultant should observe and verify the density and moisture content of the soils, and the depth of moisture penetration prior to pouring concrete.

Preliminary Pavement Design

For feasibility-level design purposes, Petra has compiled a table of structural pavement sections based on a range of Traffic Indices (TIs), ranging from 5.5 to 11.0, and R-values of 10 and 50, representing both the silt/clay and granular on-site materials, respectively. The pavement sections were calculated using the Caltrans design program CalFP ver 1.1, utilizing a 20-year design life. Summarized in the following table, the pavement sections reflect Riverside County Transportation Standard No. 114 and Specification 8.07.minimum section.

Be advised that soil samples deemed representative of the as-graded subgrade should be collected near the completion of rough grading and tested for R-value. The laboratory R-value data, along with the established TI for selected streets, are to be used in the final determination of the pavement sections.

Estimated Pavement Sections

Traffic Index	R-value	Pavement Section*	Traffic Index	R-value	Pavement Section*
5.5	10	0.25’ AC / 0.90’ AB	5.5	50	0.25’ AC / 0.50’ AB
6.0	10	0.27’ AC / 1.05’ AB	6.0	50	0.27’ AC / 0.50’ AB
7.0	10	0.35’ AC / 1.15’ AB	7.0	50	0.35’ AC / 0.50’ AB
8.0	10	0.40’ AC / 1.35’ AB	8.0	50	0.40’ AC / 0.50’ AB
9.0	10	0.46’ AC / 1.60’ AB	9.0	50	0.46’ AC / 0.55’ AB
10.0	10	0.53’ AC / 1.80’ AB	10.0	50	0.53’ AC / 0.65’ AB
11.0	10	0.58’ AC / 2.00’ AB	11.0	50	0.58’ AC / 0.75’ AB

Notes:
AC = Asphalt Concrete
AB = Aggregate Base
* Notes minimum asphalt concrete thickness per Standard No. 114

Subgrade soils immediately below the aggregate base (base) should be compacted to 95 percent or more relative compaction based on ASTM D1557 to a depth of 12 inches or more. Final subgrade compaction should be performed prior to placing base and after utility trench backfills have been compacted and tested. *Subgrade shall be firm and unyielding*, as exhibited by proof-rolling, prior to placement of base.

Base materials should consist of Class 2 aggregate base conforming to Section 26-1.02B of the State of California Standard Specifications; crushed aggregate base conforming to Section 200-2.2 of the Standard Specifications for Public Works Construction (Greenbook); or crushed miscellaneous base conforming to Section 200-2.4 of the Greenbook. Base materials should be compacted to 95 percent or more relative compaction based on ASTM D1557. The base materials should be at or slightly above optimum moisture content when compacted. Asphalt-concrete materials and construction should conform to Section 203 of the Greenbook.

Corrosivity Screening

As a screening level study, limited chemical and electrical tests were performed on samples considered representative of the onsite soils to identify potential corrosive characteristics of these soils. The common indicators that are generally associated with soil corrosivity, among other indicators, include water-soluble sulfate (a measure of soil corrosivity on concrete), water-soluble chloride (a measure of soil corrosivity on metals embedded in concrete), pH (a measure of soil acidity), and minimum electrical resistivity (a measure of corrosivity on metals embedded in soils). Test methodology and results are presented in Appendix B.

> *It should be noted that Petra does not practice corrosion engineering; therefore, the test results, opinion and engineering judgment provided herein should be considered as general guidelines only. Additional analyses, and/or determination of other indicators, would be warranted, especially for cases where buried metallic building materials (such as copper and cast or ductile iron pipes) in contact with site soils are planned for the project. In many cases, the project geotechnical engineer may not be informed of these choices. Therefore, for conditions where such elements are considered, we recommend that other, relevant project design professionals (e.g., the architect, landscape architect, civil and/or structural engineer, etc.) to be involved. We also recommend considering a qualified corrosion engineer to conduct additional sampling and testing of near-surface soils during the final stages of site grading to provide a complete assessment of soil corrosivity. Recommendations to mitigate the detrimental effects of corrosive soils on buried metallic and other building materials that may be exposed to corrosive soils should be provided by the corrosion engineer as deemed appropriate.*

In general, a soil's water-soluble sulfate levels and pH relate to the potential for concrete degradation; water-soluble chlorides in soils impact ferrous metals embedded or encased in concrete, e.g., reinforcing steel; and electrical resistivity is a measure of a soil's corrosion potential to a variety of buried metals used in the building industry, such as copper tubing and cast or ductile iron pipes. The table below, presents test results with an interpretation of current code approach and guidelines that are commonly used in the building construction industry. The table includes the code-related classifications of the soils as they relate to the various tests, as well as a general recommendation for possible mitigation measures in view of the potential adverse impact of corrosive soils on various components of the proposed structures in direct contact with site soils. The guidelines provided herein should be evaluated and confirmed, or modified, in their entirety by the project structural engineer, corrosion engineer and/or the contractor responsible for concrete placement for structural concrete used in exterior and interior footings, interior slabs on-ground, garage slabs, wall foundations and concrete exposed to weather such as driveways, patios, porches, walkways, ramps, steps, curbs, etc.

Soil Corrosivity Screening Results

Sample ID Map Symbol	Test (Test Method Designation)	Test Results	Classification	General Recommendations
TP-2 @ 0-5' Qfy TP-12 @ 3' Qo	Soluble Sulfate (Cal 417)	SO_4^{2-} < 0.10 % by weight	**S0[1] - Not Applicable**	Type II cement; minimum f_c'[2] = 2,500 psi; no water/cement ratio restrictions.
TP-4 @ 7-8' Qpu	Soluble Sulfate (Cal 417)	0.10 ≤ SO_4^{2-} < 0.20 % by weight	**S1[1] - Moderate**	Type II cement; maximum water/cement ratio of the fresh concrete should not exceed 0.50, f_c'[2] should not be less than 4,000 psi.
TP-2 @ 0-5' Qfy TP-12 @ 3' Qo	pH (Cal 643)	7.9 – 8.4	**Moderately Alkaline**[3]	No special recommendations
TP-4 @ 7-8' Qpu	pH (Cal 643)	– 9.0	**Strongly Alkaline**[3]	No special recommendations
TP-2 @ 0-5' Qfy TP-12 @ 3' Qo	Soluble Chloride (Cal 422)	< 500 ppm	**C1[1] - Moderate**	Residence: No special recommendations; f_c'[2] should not be less than 2,500 psi.
TP-4 @ 7-8' Qpu	Soluble Chloride (Cal 422)	≥ 500 ppm	**C1[1] - Moderate**	Residence: Increase concrete cover thickness; f_c'[2] should not be less than 2,500 psi. Consult a corrosion engineer
TP-4 @ 7-8' Qpu	Soluble Chloride (Cal 422)	≥ 500 ppm	**C2[4] - Severe**	Pools/Decking: Increase concrete cover thickness; Maximum water/cement ratio of the fresh concrete should not exceed 0.40; f_c'[2] should not be less than 5,000 psi.
TP-2 @ 0-5' Qfy TP-12 @ 3' Qo	Resistivity (Cal 643)	5,000 – 10,000 Ohm-cm	**Moderately Corrosive**[5]	Protective wrapping/coating of buried pipes; corrosion resistant materials
TP-4 @ 7-8' Qpu	Resistivity (Cal 643)	< 1,000 Ohm-cm	**Extremely Corrosive**[5]	Consult a corrosion engineer

Notes:
1. ACI 318-14, Section 19.3
2. f_c', 28-day unconfined compressive strength of concrete
3. The United States Department of Agriculture Natural Resources Conservation Service, formerly Soil Conservation Service
4. Exposure classification C2 applies specifically to swimming pools and appurtenant concrete elements
5. Pierre R. Roberge, "Handbook of Corrosion Engineering"

REPORT LIMITATIONS

This feasibility geotechnical report is based on the proposed project and geotechnical data as described herein. The materials encountered on the project site, described in other literature, and utilized in our laboratory investigation are believed representative of the total project area, and the conclusions and recommendations contained in this report are presented on that basis. However, soils can vary in characteristics between points of exploration, both laterally and vertically, and those variations could affect the conclusions and recommendations contained herein. As such, observation and testing by a geotechnical consultant during the construction phase of the project are essential to confirming the basis of this report. To provide the greatest degree of continuity between the design and construction phases, consideration should be given to retaining Petra Geotechnical, Inc. for construction services.

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 should be reviewed and updated after a period of one year or if the site conditions, ownership or project concept changes from that described herein. This report has not been prepared for use by parties or projects other than those named or described herein and may not contain sufficient information for other parties or other purposes.

This report is subject to review by the controlling authorities for this project. Should you have any questions, please do not hesitate to call.

Respectfully submitted,

PETRA GEOSCIENCES, INC.

PROFESSIONAL GEOLOGIST
NO. EG1952
CERTIFIED
ENGINEERING
GEOLOGIST
STATE OF CALIFORNIA

3/23/23

Alan Pace
Senior Associate Geologist
CEG 1952

Grayson R. Walker
Principal Engineer
GE 871

REGISTERED PROFESSIONAL ENGINEER
GRAYSON R. WALKER
GE 871
GEOTECHNICAL
STATE OF CALIFORNIA

AP/EPL/GRW/lv

REFERENCES

American Concrete Institute, 2008, Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary.

American Society for Testing and Materials (ASTM), 2017 Standard – Section Four – Construction, Volume 04.08 Soil and Rock.

Al Atik, Linda, and Sitar, Nickolas, 2007, Development of Improved Procedures for Seismic Design of Buried and Partially Buried Structures, PEER 2007/06, dated June.

American Society for Testing and Materials (ASTM) – Standard – Section Four – Construction, Volume 04.08 Soil and Rock.

American Society of Civil Engineers (ASCE) 7-05 Minimum Design Loads for Buildings and Other Structures.

California Building Code (2019), California Code of Regulations, Title 24, Par 2, Volume 2 of 2, Based on the 2018 International Building Code, California Building Standards Commission.

California Department of Water Resources, 2004, California Groundwater - Bulletin 118.

_______, 2022, Water Data Library, accessed May, http://www.water.ca.gov/waterdatalibrary/groundwater/

California Department of Transportation (Caltrans) 2003 – Bridge Design Specifications.

_______, (Caltrans) 2018 – Standard Specifications.

_______, (Caltrans) 2018 – California Test Methods.

_______, (Caltrans) 2012 – Highway Design Manual.

California Geological Survey (CGS), 2008, Special Publication 117A.

_______, 2018, Earthquake Fault Zones, A Guide for Government Agencies, Property Owners/Developers, and Geoscience Practitioners for Assessing Fault Rupture Hazards in California, CGS Special Publication 42, revised.

_______, 2019, Checklist for the Review of Engineering Geology and Seismology Reports for California Public Schools, Hospitals, and Essential Services Buildings, CGS Note – 48, dated November.

_______, 2023, California Earthquake Hazard Zone Application (EQZApp), https://maps.conservation.ca.gov/cgs/EQZApp/app/.

Cao, T., et al., 2003, Revised 2002 California Probabilistic Seismic Hazard Maps, June 2003: California Geological Survey.

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).

Fumal, T. E., Rymer, M.J., 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.

REFERENCES

Gary S. Rasmussen & Associates, Inc., 1999, Subsurface Engineering Geology Investigation, Proposed Coachella Transfer Station, Coachella Area, Riverside County, California; Project Number 3133.1, dated July 21.

GeoSoils, Inc., 2004, Report of Due Diligence Geotechnical Review, 1,621-acre McNaughton Property and adjacent 589-acre property (Section 6), City of Coachella, Riverside County, California; report prepared for KB Home Coastal, Inc., W.O. 4266-A-SC, dated April 16.

Google Earth™ 2022, by Google Earth, Inc., http://www.google.com/earth/index.html, accessed September.

Hart, E.W., and Bryant, W.A., 1997, Fault-rupture hazard zones in California, Alquist-Priolo Earthquake Fault Zoning Act with index to Earthquake Fault Zone Maps: Calif. Div. Mines and Geol. Spec. Pub. 42, 38 p.

______, 2007, Fault-Rupture Hazard Zones in California, Alquist-Priolo Earthquake Fault Zoning Act with Index to Earthquake Fault Zones Maps, California Geological Survey, Special Publication 42.

Hauksson, E., 1992, Seismicity, Faults and Earthquake Potential in Los Angeles, Southern California: *in* Association of Engineering Geologists, Special Publication No. 4, pp. 167-179.

Helms, John, CEG, 2021, Soil Stratigraphy Study and Relative Age Estimates for a Fault Rupture Hazard Investigation for the Proposed KPC Coachella Development, City of Coachella, Riverside County, California, for Kenney Geoscience, dated July 26.

Hilltop Geotechnical, Inc., 2004, Preliminary Evaluation of On-site Faulting, Proposed Desert Lakes Project, Residential and Commercial Development, City of Coachella, Riverside County, California; report prepared for Pulte Homes/Del Webb, Project Number 420-A04, Report No. 2, dated June 24.

Ishihara, K., 1985, Stability of Natural Deposits During Earthquakes, 11th International Conference on Soil Mechanics and Foundation Engineering, Proceedings, San Francisco, Vol. 1., pp. 321-376.

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.

Kenney Geoscience, 2022, Fault Investigation Report, ~2850-acre KPC Coachella Project, City of Coachella, Riverside County, California, Job No. 745-19, September 20, 2021, revised January.

Kimley-Horn, 2019, KPC Coachella Specific Plan, Draft.

_______, 2023, Conceptual Mass Grading Exhibit, KPC Coachella

Lightstone Acquisitions, LLC, 2013, Preliminary Geotechnical Investigation, Approximately 2,200-Acre La Entrada Project, City of Coachella, County of Riverside, California; J.N. 11-376, dated April 15.

Lilburn Corporation, 2023, Third Party Geotechnical Report Review, Proposed KPC Coachella Project, City of Coachella, Project No. 1521-01, dated January 12.

Moss Et. Al., 2006, CPT-Based Probabilistic Assessment of Seismic Soil Liquefaction Initiation, Pacific Earthquake Engineering Research Center, PEER 2005/15, dated April.

National Earthquake Information Center, 2004, Historical Earthquake Information Database http://neic.usgs.gov/.

Office of Statewide Health Planning and Development (OSHPD), 2022, Seismic Design Maps, U.S. Seismic Design Maps (seismicmaps.org).

REFERENCES

Petersen, M.D. et al, 1996, Probabilistic Seismic Hazard Assessment for the State of California: California Division of Mines and Geology, Open-File Report 96-08.

Petersen, M.D., and Wesnouski, S.G., 1994, Fault Slip Rates and Earthquake Histories in Southern California: Bulletin of the Seismological Society of America, Vol. 84, No. 5, pp. 1608-1649, dated October.

Petra Geotechnical, Inc., 2007, Review of "(Draft) Preliminary Geotechnical Investigation for Due-Diligence Purposes, Proposed Mixed-Use Sites, APN 603-190-004, North of and adjacent to Interstate 10, Coachella Valley, County of Riverside, California"; prepared by Leighton and Associates, report dated January 31st, 2007, PN 121945-001; prepared for McNaughton, LLC, dated April 25.

______, 2013, Preliminary Geotechnical Investigation, Approximately 2,200-Acre La Entrada Project, City of Coachella, County of Riverside, California, *prepared for Lightstone Acquisitions, LLC*, J.N. 11-376, dated April 15.

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.

Pradel, D., 1998, Procedure to Evaluate Earthquake-Induced Settlements in Dry Sandy Soils; Journal of Geotechnical and Geoenvironmental Engineering: Vol. 124, No. 4.

Proctor, R. J., 1968, Geology of the Desert Hot Springs-Upper Coachella Valley area, California; California Division of Mines and Geology, Special Report 94.

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., 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, dated April 17.

Sarna-Wojcicki, A. M., Pringle, M.S., and Wijbrans, J. (2000). "New Ar-40/Ar-39 age of the Bishop Tuff from multiple sites and sediment rate calibration for the Matuyama-Brunhes boundary." Journal of Geophysical Research-Solid Earth V. 105(B9): p. 21431-21443.

Seed, H.B., and Whitman, R.V., 1970, Design of Earth Retaining Structures for Dynamic Loads, Proceedings, Specialty Conference on the Lateral Stresses in the Ground and the Design of Earth Retaining Structures, ASCE, Ithaca, New York, dated June.

Seed, H.B., Tokimatsu, K., Harder, L.F., and Chung, R.M., 1985, Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations; Journal of the Geotechnical Engineering Division, ASCE, vol. 111, no. GT12, pp. 1425-1445.

Sieh, K. E., 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.

Southern California Earthquake Center (SCEC, 1998), Seismic Hazards in Southern California: Probable Earthquakes, 1994 to 2024: by Working Group on California Earthquake Probabilities.

REFERENCES

Southern California Earthquake Center (SCEC, 1999), Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction Hazards in California: organized through the Southern California Earthquake Center, University of Southern California.

Standard Specifications for Public Works Construction (Greenbook), 2009, BNI Publishers.

Stewart, J.P., Bray, J.D., McMahon, D.J.; Kropp, A.L.; 1995; Seismic Performance of Hillside Fills; Landslides Under Static and Dynamic Conditions: Analysis, Monitoring, and Mitigation: Geotechnical Special Publication No. 52, ASCE, Reston, Va., 76-95.

Stewart Jonathan P., Bray Jonathan D., McMahon David J., Smith Patrick M., Kropp Alan L., 2001, Seismic Performance of Hillside Fills, Journal of Geotechnical and Geoenvironmental Engineering, American Society of Civil Engineers (ASCE), Volume 127, No. 11, , p 905-919, dated November.

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

Tokimatsu, K.; Seed, H.B., 1987, Evaluation of settlements in sands due to earthquake shaking; Journal of Geotechnical Engineering: Vol. 113, No. 8, p. 861-879.

United States Geologic Survey (U.S.G.S.), 1996a, Probabilistic Seismic Hazard Assessment for the State of California, Open-File Report 96-706.

_______, 1996b, National Seismic-Hazards Maps, Open-File Report 96-532.

_______, 2007, Preliminary Documentation for the 2007 Update of the United States National Seismic Hazard Maps, Seismic Hazards Mapping Project, Open-File Report 2007-June Draft.

_______, 2011a, Seismic Hazard Curves and Uniform Hazard Response Spectra – v5.1.0-February.

_______, 2011b, Earthquake Ground Motion Parameters, Version 5.1.0, utilizing ASCE 7 Standard Analysis Option, dated February 10.

_______, 2021, Unified Hazard Tool Calculator, Unified Hazard Tool (usgs.gov)

USGS, 2008, Open File Report 2008-1128.

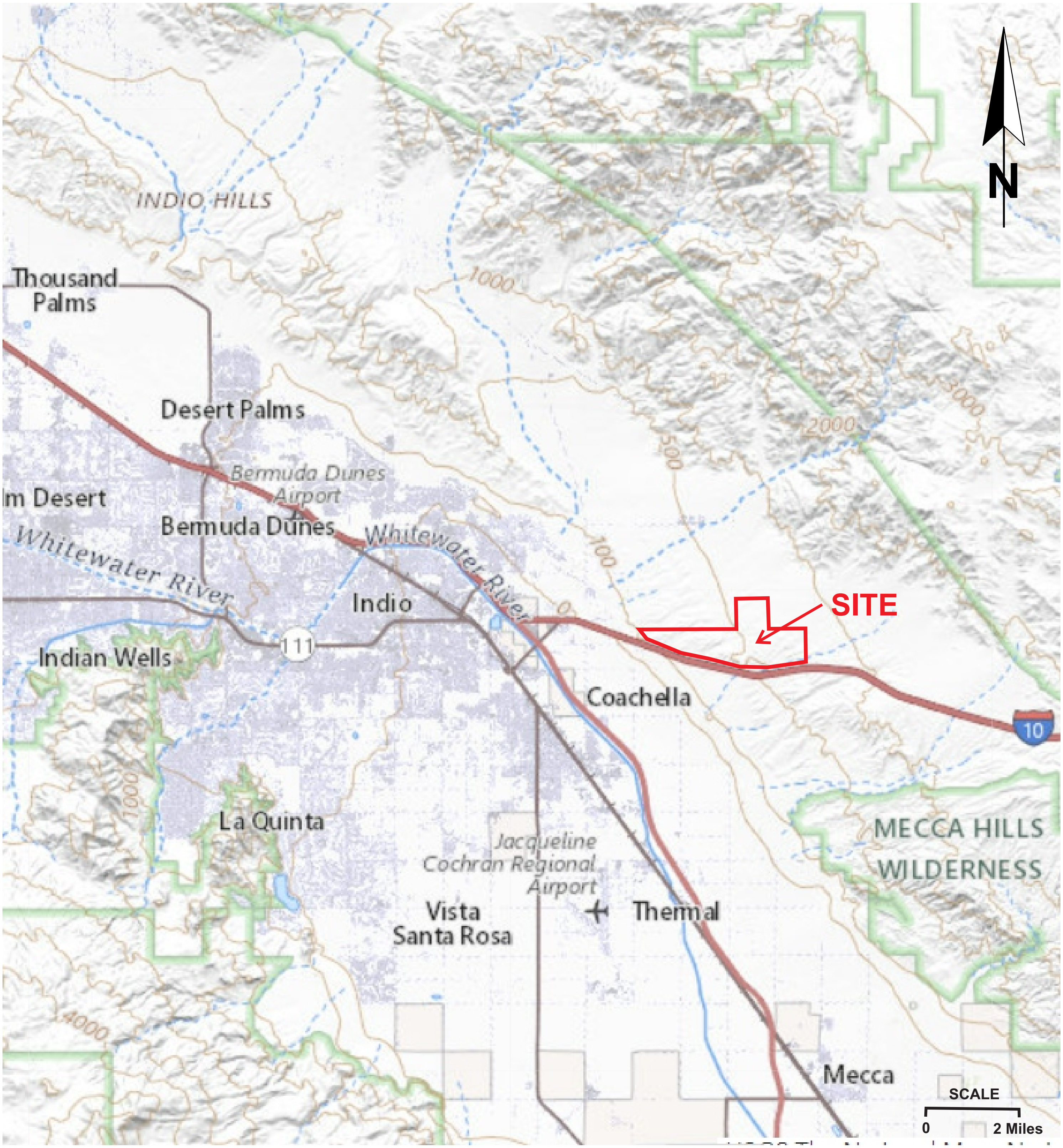
_______, 2011, Online Interactive Deaggregation Tool, http://eqint.cr.usgs.gov/deaggint/2008/index.php.

Williams, P., Fagerson, S., Sieh, K., 1986, Triggered Slip of the San Andreas Fault after the July 8, 1986 North Palm Spring Earthquake; EOS v. 67 (n. 44): p. 1090.

Wire Reinforcement Institute (WRI), 1996, Design of Slabs on Ground.

Zeiser Geotechnical, I., 1988, Geotechnical review for EIR preparation GPA 88-8/specific plan 88-3, City of Coachella, Riverside County, California, PN 88231-1, dated October 7.

FIGURES



- Reproduced from: USGS, 2022, The National Map Viewer

LEGEND

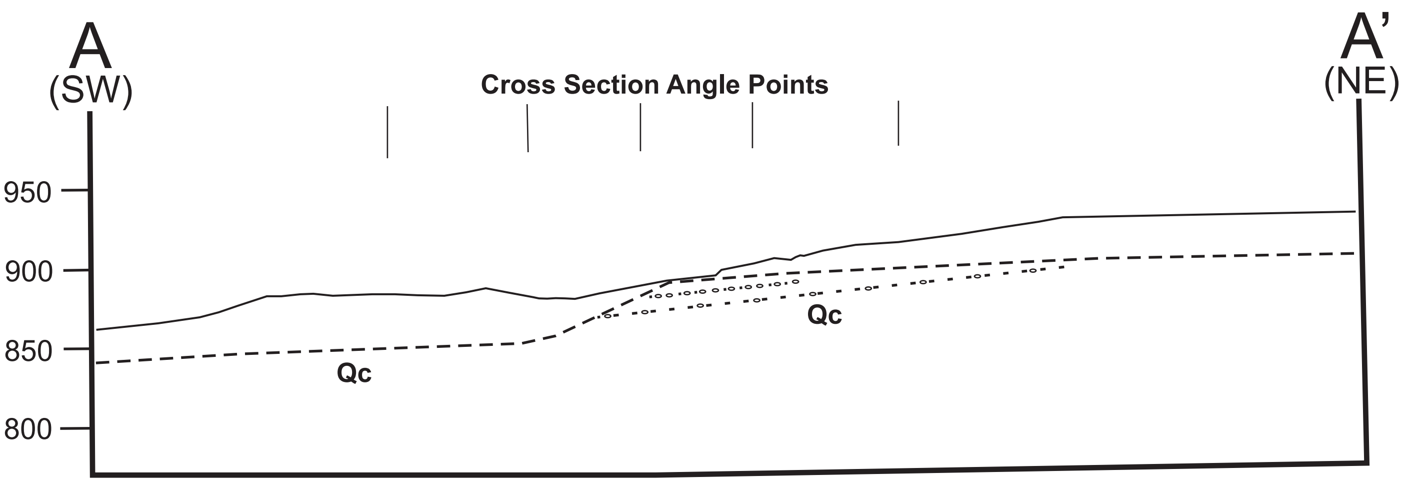
- Approximate Site Location

PETRA GEOSCIENCES, INC.
40880 COUNTY CENTER DRIVE, SUITE M
TEMECULA, CALIFORNIA 92591
PHONE: (951) 600-9271
COSTA MESA MURRIETA PALM DESERT SANTA CLARITA

Site Location Map

KPC Coachella Project
City of Coachella, Riverside County, California

DATE: March 2023	J.N.: 16-368	**Figure 1**
DWG BY: EPL	SCALE: see above	



- Base Map: Kimley Horn, 2023, KPC Group Coachella, Conceptual Grading Exhibit, Scale 1"=500', print date March 7.

LEGEND

Qc - Mid- to late Pleistocene Ocotillo Conglomerate

- Existing Natural Surface Topography

- Proposed Graded Surface

PETRA GEOSCIENCES, INC.
40880 COUNTY CENTER DRIVE, SUITE M
TEMECULA, CALIFORNIA 92591
PHONE: (951) 600-9271
COSTA MESA MURRIETA PALM DESERT SANTA CLARITA

Typical Cross Section A – A'

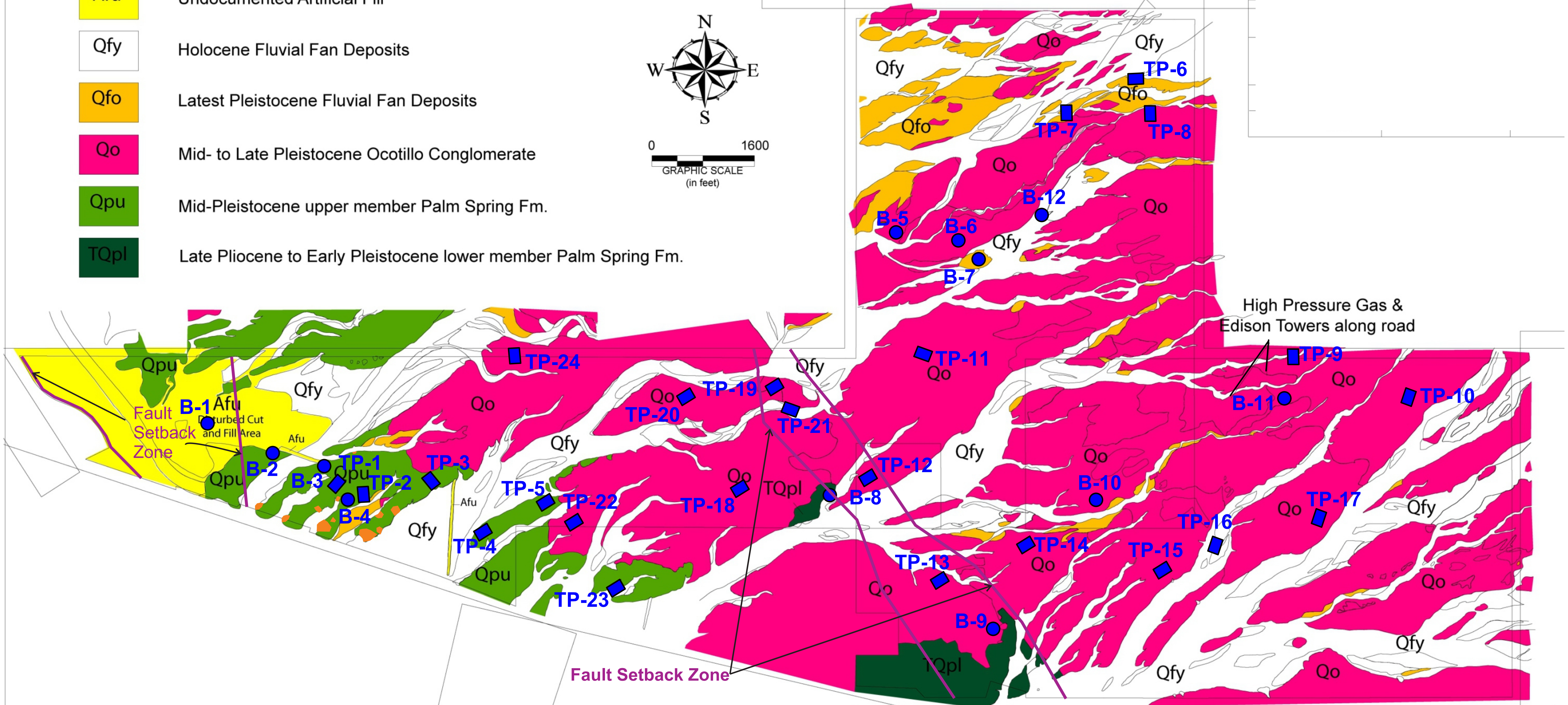
KPC Coachella
Riverside County, California

DATE: March 2023	J.N.: 16-368	**Figure 2**
DWG BY: epl	SCALE: NTS	

PLATES

EXPLANATION

Afu	Undocumented Artificial Fill
Qfy	Holocene Fluvial Fan Deposits
Qfo	Latest Pleistocene Fluvial Fan Deposits
Qo	Mid- to Late Pleistocene Ocotillo Conglomerate
Qpu	Mid-Pleistocene upper member Palm Spring Fm.
TQpl	Late Pliocene to Early Pleistocene lower member Palm Spring Fm.



LEGEND

- Approximately Location of Slump or Small Slide
- Fault Setback Zone

B-12 - Approximate Location of Exploratory Boring

TP-24 - Approximate location of Exploratory Test Pit

Base Map Reference: .

PETRA GEOSCIENCES, INC.
40880 County Center Drive, Suite M
Temecula, California 92591
PHONE: (714) 549-8921
COSTA MESA TEMECULA VALENCIA PALM DESERT CORONA

Geologic and Field Exploration Map

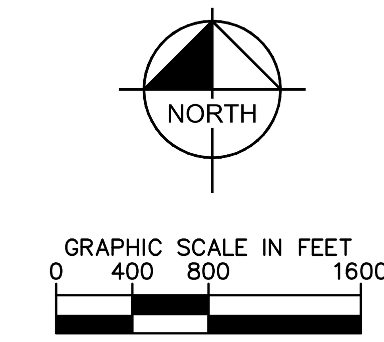
KPC Coachella Project
City of Coachella, Riverside County, California

PETRA GEOSCIENCES INC.

DATE: March 2023

J.N.: 16-368

PLATE 1

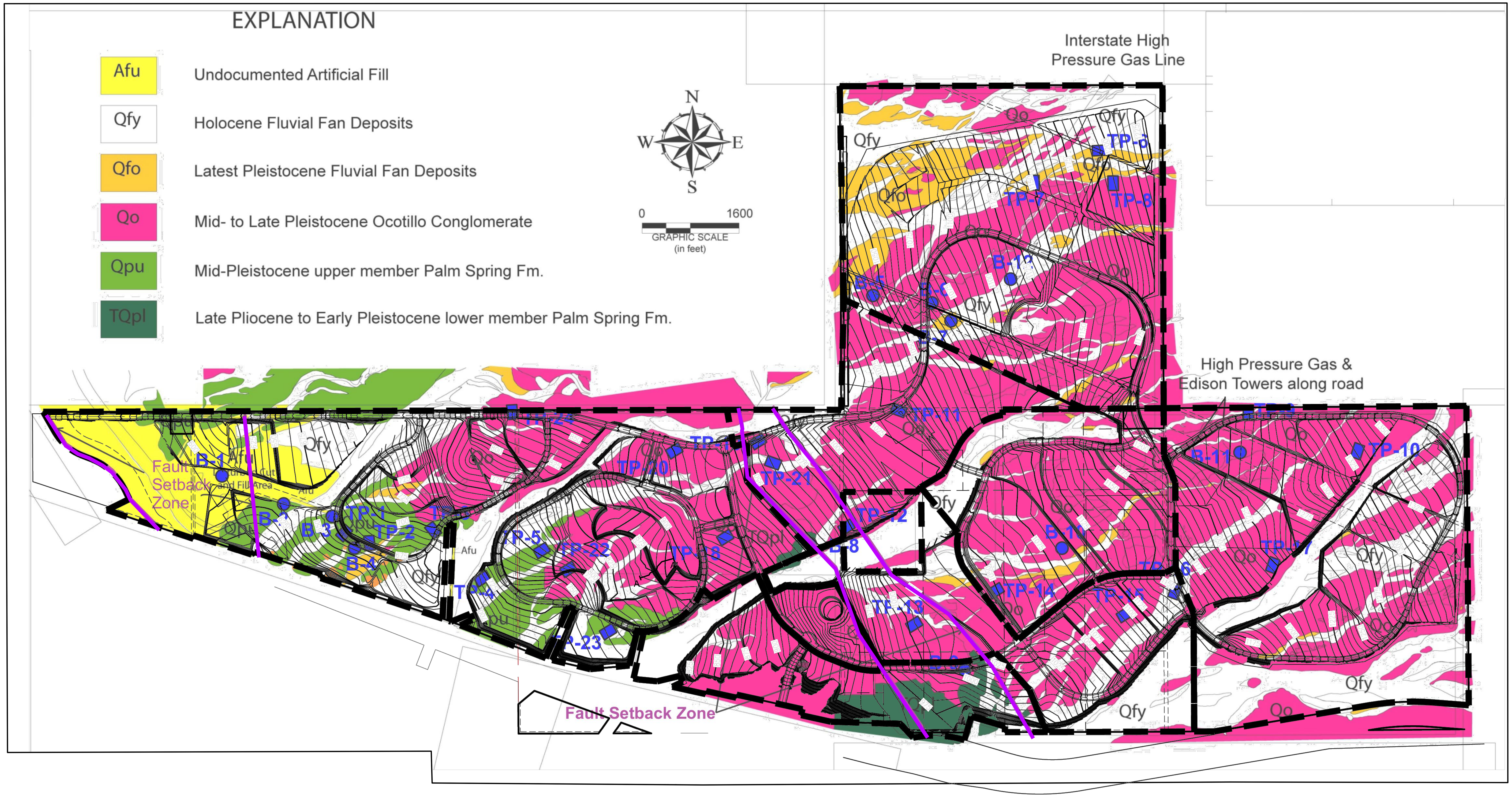


KPC GROUP COACHELLA
CONCEPTUAL GRADING EXHIBIT
SCALE 1" = 800'

PLATE 2

Kimley»Horn
3801 UNIVERSITY AVE, SUITE 300, RIVERSIDE, CA 92501
PHONE: (951) 543-9868 WWW.KIMLEY-HORN.COM

PROJ. NO.
SHEET 1
OF 1 SHEETS



LEGEND

- Approximately Location of Slump or Small Slide
- Fault Setback Zone

B-12 ● - Approximate Location of Exploratory Boring

TP-24 ▮ - Approximate location of Exploratory Test Pit

A ⊢—⊣ A' - Approximate Location of Cross Section

KPC GROUP COACHELLA
CONCEPTUAL GRADING EXHIBIT

PETRA GEOSCIENCES, INC.
40880 County Center Drive, Suite M
Temecula, California 92591
PHONE: (714) 549-8921
COSTA MESA TEMECULA VALENCIA PALM DESERT CORONA

Geologic and Field Exploration Map

KPC Coachella Project
City of Coachella, Riverside County, California

PETRA GEOSCIENCES

DATE: March 2023

J.N.: 16-368

PLATE 3

NORTH

GRAPHIC SCALE IN FEET
0 400 800 1600

Kimley»Horn
3801 UNIVERSITY AVE, SUITE 300, RIVERSIDE, CA 92501
PHONE: (951) 543-9868 WWW.KIMLEY-HORN.COM

PROJ. NO.
SHEET 1
OF 1 SHEETS

APPENDIX A

EXPLORATORY BORING AND TEST PIT LOGS

Soil Classification

PETRA

4 Moisture Content

Dry
Slightly Moist
Moist
Very Moist
Wet (Saturated)

Modifiers

Trace	< 1 %
Few	1 - 5%
Some	5 - 12 %
Numerous	12 - 20 %

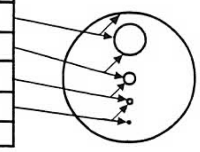
Soil Classification Should Include:

PREFERRED ORDER

1. Group Name
2. Group Symbol
3. Color
4. Moisture Content
5. Relative Density / Consistency
6. Grain Size Range
7. Structure
8. Odor
9. Additional comments indicating soil characteristics which might affect engineering properties

6 Grain Size

Description		Sieve Size	Grain Size	Approximate Size
Boulders		>12"	>12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	coarse	#10 - #4	0.079 - 0.19"	Rock salt-sized to pea-sized
	medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock salt-sized
	fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized to
Fines		Passing #200	<0.0029"	Flour-sized and smaller



1 2 Unified Soil Classification System

				Symbol	Typical Names
Coarse-grained Soils > 1/2 of materials is larger than #200 sieve	The No. 200 U.S. Standard Sieve is about the smallest particle visible to the naked eye	GRAVELS more than half of coarse fraction is larger than #4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
				GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
			Gravels with fines	GM	Silty Gravels, poorly-graded gravel-sand-silt mixtures
				GC	Clayey Gravels, poorly-graded gravel-sand-clay mixtures
		SANDS more than half of coarse fraction is smaller than #4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, gravelly sands, little or no fines
				SP	Poorly-graded sands, gravelly sands, little or no fines
			Sands with fines	SM	Silty Sands, poorly-graded sand-gravel-silt mixtures
				SC	Clayey Sands, poorly-graded sand-gravel-clay mixtures
Fine-grained Soils > 1/2 of materials is smaller than #200 sieve		SILTS & CLAYS Liquid Limit Less Than 50		ML	Inorganic silts & very fine sands, silty or clayey fine sands, clayey silts with slight plasticity
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
				OL	Organic siltys & clays of low plasticity
		SILTS & CLAYS Liquid Limit GreaterThan 50		MH	Inorganic silts, micaceous or diatomaceous fine sand or silt
				CH	Inorganice clays of high plasticity, fat clays
				OH	Organic silts and clays of medium-to-high plasticity
Highly Organic Soils				PT	Peat, humus swamp soils with high organic content

5 Consistency - Fine Grained Soils

Apparent Density	SPT (# blows/foot)	Modified CA Sampler (# blows/foot)	Field Test
Very Soft	<2	<3	Easily penetrated by thumb; exudes between thumb and fingers when squeezed in hand
Soft	2-4	3-6	Easily penetrated one inch by thumb; molded by light finger pressure
Firm	5-8	7-12	Penetrated over 1/2 inch by thumb with moderate effort; molded by strong finger pressure
Stiff	9-15	13-25	Indented about 1/2 inch by thumb but penetrated only with great effort
Very Stiff	16-30	26-50	Readily indented by thumbnail
Hard	>30	>50	Indented with difficulty by thumbnail

5 Relative Density - Coarse Grained Soils

Apparent Density	SPT (# blows/foot)	Modified CA Sampler (# blows/foot)	Field Test
Very Loose	<4	<5	Easily penetrated with 1/2-inch reinforcing rod pushed by hand
Loose	4-10	5-12	Easily penetrated with 1/2-inch reinforcing rod pushed by hand
Medium Dense	11-30	13-35	Easily penetrated 1-foot with 1/2-inch reinforcing rod driven with a 5-lb hammer
Dense	31-50	36-60	Difficult to penetrated 1-foot with 1/2-inch reinforcing rod driven with a 5-lb hammer
Very Dense	>50	>60	Penetrated only a few inches with 1/2-inch reinforcing rod driven with a 5-lb hammer

EXPLORATION LOG

Project: **KPC Coachella**			Boring No.: **B-1**
Location: **Coachella, CA**			Elevation: **109'**
Job No.: **16-368**	Client: **The KPC Group**		Date: **02-02-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**		Logged By: **TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**SLOPEWASH (Qsw)** Silty Sand (SM): Light gray, dry, loose, fine- to coarse- grained sand, with some gravel up to 2".							
		Upper Member Palm Springs Formation (Qpu) Sandy Siltstone (SM): Grayish-brown, dry, loose to medium dense, fine- to coarse-grained sand, highly weathered.							
5		becomes medium dense.		5 7 14	■		4.2	104.0	
		Siltstone (ML): Brown, dry, hard to very hard, fine-to coarse-grained sand, moderately weathered.							
10				13 27 40	■		2.8	112.2	
15		with some caliche.		21 35 50	■		2.6	122.7	
20				27 50	■		7.6	124.9	
25				27 50	■		10.0	124.0	
		Total Depth - 26.5' No groundwater encountered Backfilled.							
30									

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project: **KPC Coachella**		Boring No.:	**B-2**
Location: **Coachella, CA**		Elevation:	**106'**
Job No.: **16-368**	Client: **The KPC Group**	Date:	**02-02-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**	Logged By:	**TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**SLOPEWASH (Qsw)** Silty Sand (SM): Light gray, dry, loose, fine- to coarse- grained sand, with some gravel up to 2". **Upper Member Palm Springs Formation (Qpu)** Sandy Siltstone (SM): Grayish-brown, dry, dense to very dense, very fine- to medium-grained sand, highly weathered.							
5		Siltstone (ML): Grayish Brown, dry, very hard, fine- to coarse-grained sand, moderately weathered.		10 30 40	■		1.4	119.8	
10		with some gravel, cobbles.		19 50	■		3.3	102.0	
		drilling becomes difficult, rocky.							
15		with gravel, cobbles to 3".		40 50	■		0.6	110.4	
20				6 30 50	■		0.4	112.5	
25				28 50	■		5.4	114.4	
		Total Depth - 26.5' No groundwater encountered Backfilled.							
30									

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project: **KPC Coachella**			Boring No.: **B-3**
Location: **Coachella, CA**			Elevation: **105'**
Job No.: **16-368**	Client: **The KPC Group**		Date: **02-02-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**		Logged By: **TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**SLOPEWASH (Qsw)** Silty Sand (SM): Light gray, dry, loose, very fine- to coarse-grained sand, with some gravel, cobbles. **Upper Member Palm Springs Formation (Qpu)** Sandy Siltstone (SM): Grayish-brown, dry, dense to very dense, fine- to coarse-grained sand lenses, highly weathered.							
5		Siltstone (ML): Grayish Brown, dry, very hard, with occasional fine- to coarse-grained sand lenses, moderately weathered.		24 50	■		2.1	120.8	
10		with some gravel, cobbles.		15 28 40	■		1.4	121.4	
15				24 50	■		2.5	115.4	
20				24 50	■		0.8	Disturbed	
25				50	■		0.8	Disturbed	
		Total Depth - 26.5' No groundwater encountered Backfilled.							
30									

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project:	**KPC Coachella**			Boring No.:	**B-4**
Location:	**Coachella, CA**			Elevation:	**103**
Job No.:	**16-368**	Client:	**The KPC Group**	Date:	**02-02-2021**
Drill Method:	**8" HSA**	Driving Weight:	**140 lb/30"**	Logged By:	**TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**Fluvial Fan Deposits (Qfo)** Silty Sand (SM): Light gray, dry, loose to medium dense, very fine- to medium-grained sand, some gravel.							
5		becomes medium dense, fine- to coarse-grained sand.		7 12 15	■		0.8	Disturbed	
10		becomes medium dense to dense, with some gravel, cobbles.		12 16 20	■		0.9	Disturbed	
15				8 16 20	■		1.3	108.9	
20		**Lower Member Palm Springs Formation (TQpl)** Silty Sand (SM): Brown to grayish-brown, dry, hard to very hard, with some gravel, highly weathered.		13 18 35	■		0.8	104.7	
25		Siltstone (ML): Brown to graylsh-brown, hard to very hard, moderately weathered; with occasional fine- to coarse-grained sand lenses with some gravel, cobbles.		47 50	■		10.3	119.3	
30				34 50	■		7.3	119.3	

Petra Geosciences, Inc.

EXPLORATION LOG

Project:	KPC Coachella	Boring No.:	B-4
Location:	Coachella, CA	Elevation:	103
Job No.:	16-368 Client: The KPC Group	Date:	02-02-2021
Drill Method:	8" HSA Driving Weight: 140 lb/30"	Logged By:	TD

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
35				31 50	■		2.1	104.9	
40				39 50	■		2.8	103.8	
45				50	■		9.1	Disturbed	
50				50	■		---	---	
		Total Depth-50.5' No groundwater encountered Backfilled.							
55									
60									
65									

PLATE

Petra Geosciences, Inc.

E X P L O R A T I O N   L O G

Project:	**KPC Coachella**	Boring No.:	**B-5**
Location:	**Coachella, CA**	Elevation:	
Job No.: **16-368**	Client: **The KPC Group**	Date:	**03-01-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**	Logged By:	**TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**Ocotillo Formation (Qo)** Sandy Gravel (GP): Gray, dense, dry, fine- to coarse-grained sand, with subangular gravel up to 3", few cobbles of granitic and metamorphic origin up to 6".							
		becomes light gray to light brownish-gray, coarse to very-coarse sand; possible large boulder.							
5		No Recovery. becomes very hard.		50					
		becomes reddish-brown.							
10		No recovery.		25 50					
15		No Recovery.		25 50					
		No Recovery.		48 50					
20		No Recovery.		17 50					
		No Recovery.		50					
25		No Recovery.		37 50					
		Total Depth-26' No Groundwater encountered Backfilled.							
30									

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project:	**KPC Coachella**	Boring No.:	**B-6**
Location:	**Coachella, CA**	Elevation:	
Job No.: **16-368**	Client: **The KPC Group**	Date:	**03-01-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**	Logged By:	**TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**Ocotillo Formation (Qo)** Sandy Gravel (GP): Reddish-brown, dry, hard, angular gravel up to 3", some cobbles of granitic and metamorphic origin up to 6", highly weathered. becomes light grayish-brown, very hard. Silty Sand with Gravel (GP-SP): Light brownish-gray to light greenish-gray, dry, very hard, fine- to coarse-grained sand, subangular gravel and cobbles of granitic and metamorphic origin up to 3".				■ (1–5 ft)			
5									
10						■ (10–11 ft)			
15						■ (15–16 ft)			
18.5		Total Depth-18.5' Boring terminated due to refusal No groundwater encountered Backfilled.							
20									
25									
30									

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project: **KPC Coachella**		Boring No.:	**B-7**
Location: **Coachella, CA**		Elevation:	
Job No.: **16-368**	Client: **The KPC Group**	Date:	**03-01-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**	Logged By:	**TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**FLUVIAL FAN DEPOSITS (Qfo)** Silty Gravelly Sand (SM/GM): Light olive gray, dry, medium dense, fine- to coarse-grained sand, subangular gravel up to 3".				■ (1–5 ft)			
4		**Ocotillo Formation (Qo)** Gravelly Sand/Sandy Gravel (SP/GP): Light reddish-brown to grayish-brown, dry, very hard, highly weathered, with subangular gravel of granitic and metamorphic origin up to 3".							
5				20 50	■				
10		same as above.		32 44 50	■		1.5	Disturbed	
15				30 50	■		1.5	Disturbed	
20		same as above.		50	■				
25				24 50	■				
30		same as above.		50	■		0.9	Disturbed	

PLATE

EXPLORATION LOG

Project:	KPC Coachella		Boring No.: B-7
Location:	Coachella, CA		Elevation:
Job No.: 16-368		Client: The KPC Group	Date: 03-01-2021
Drill Method: 8" HSA		Driving Weight: 140 lb/30"	Logged By: TD

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
35				50	■				
40		same as above.		50	■				
45				50	■				
50				50	■				
51		Total Depth-51' No groundwater encountered Backfilled.			■				
55									
60									
65									

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project:	**KPC Coachella**	Boring No.:	**B-8**
Location:	**Coachella, CA**	Elevation:	
Job No.: **16-368**	Client: **The KPC Group**	Date:	**03-02-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**	Logged By:	**TD**

Depth (Feet)	Lithology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**YOUNG FAN DEPOSITS (Qfy)** Silty Sand (SP-SM): Light gray to gray, dry, loose, very fine- to coarse-grained sand, few subangular cobbles to 6".							
		becomes very dense, possible boulder.							
5		**Lower Member Palm Spring Formation (TQpl)** Sandy Siltstone (SM): Olive brown to olive, dry, very hard, highly weathered; excavates to silty fine- to coarse-grained sand with some fine gravel.		50					
10		with few coarse gravel.		46 50					
15		with trace clay nodules, possible clay interbeds.		50					
20		same as above.		50					
25				50					
30		becomes dry to slightly moist.		50					

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project:	KPC Coachella		Boring No.:	B-8
Location:	Coachella, CA		Elevation:	
Job No.:	16-368	Client: The KPC Group	Date:	03-02-2021
Drill Method:	8" HSA	Driving Weight: 140 lb/30"	Logged By:	TD

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
35		steam from borehole.		50					
40				50					
45				50					
50		with flat, white carbonate flecks up to 0.1".		50					
55				50					
60				50					
65		with some fracured rock gravel.		50					

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project:	**KPC Coachella**	Boring No.:	**B-8**
Location:	**Coachella, CA**	Elevation:	
Job No.: **16-368**	Client: **The KPC Group**	Date:	**03-02-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**	Logged By:	**TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
70				50					
		Total Depth-71' No groundwater encountered Backfilled.							
75									
80									
85									
90									
95									
100									

PLATE

E X P L O R A T I O N   L O G

Project: **KPC Coachella**			Boring No.: **B-9**
Location: **Coachella, CA**			Elevation:
Job No.: **16-368**	Client: **The KPC Group**		Date: **03-03-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**		Logged By: **TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**Ocotillo Formation (Qo)** Silty Sandy Gravel (GM/SM): Grayish brown to brown, dry, medium dense, fine- to coarse-grained sand, highly weathered with subangular gravel/cobbles of granitic and metamorphic origin up to 6".							
10				3 10 13					
15		becomes hard.		5 14 21					
20		**Lower Member Palm Spring Formation (TQpl)** Sandy Siltstone (SM): Grayish brown to light gray, dry, very hard, steam from borehole.		34 50					
25				25 50					
30				38 50					
		Total Depth-31' No groundwater encountered Backfilled.							

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project:	KPC Coachella		Boring No.:	B-10
Location:	Coachella, CA		Elevation:	
Job No.:	16-368	Client: The KPC Group	Date:	03-03-2021
Drill Method:	8" HSA	Driving Weight: 140 lb/30"	Logged By:	TD

Depth (Feet)	Lithology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**SLOPEWASH (Qsw)** Silty Sand (SM): Light gray to light grayish-brown, dry, loose, fine- to coarse-grained sand, gravel up to 3", with trace cobbles of granitic and metamorphic origin.							
		Ocotillo Formation (Qo) Gravelly Sand (GP-SP): Grayish-brown, loose to medium dense, dry, fine- to coarse-grained sand, with few subangular to subrounded gravel and cobbles up to 6", highly weathered.							
5		becomes medium dense.		5 10 14					
10		becomes dense.		14 19 21					
15		becomes very dense.		15 24 44					
20				19 23 49					
		Total Depth-21.5' No groundwater encountered Backfilled.							
25									
30									

PLATE

Petra Geosciences, Inc.

E X P L O R A T I O N   L O G

Project: **KPC Coachella**			Boring No.: **B-11**
Location: **Coachella, CA**			Elevation:
Job No.: **16-368**	Client: **The KPC Group**		Date: **03-03-2021**
Drill Method: **8" HSA**	Driving Weight: **140 lb/30"**		Logged By: **TD**

Depth (Feet)	Lith-ology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**Ocotillo Formation (Qo)** Silty Sandy Gravel: Light brown to light grayish-brown, dry, medium dense, fine- to coarse-grained sand, subangular to subrounded cobbles of granitic and metamorphic origin to 4". becomes very hard, rocky drilling.							
5				33 50	■		1.7	Disturbed	
10		same as above.		33 50	■		1.4	Disturbed	
15				7 50	◩				
20				11 50	◩				
		Total Depth-21' No groundwater encountered Backfilled.							
25									
30									

PLATE

Petra Geosciences, Inc.

EXPLORATION LOG

Project:	KPC Coachella	Boring No.:	B-12
Location:	Coachella, CA	Elevation:	
Job No.: 16-368	Client: The KPC Group	Date:	03-03-2021
Drill Method: 8" HSA	Driving Weight: 140 lb/30"	Logged By:	TD

Depth (Feet)	Lithology	Material Description	WATER	Samples: Blows per 6 in.	Samples: Core	Samples: Bulk	Laboratory Tests: Moisture Content (%)	Laboratory Tests: Dry Density (pcf)	Laboratory Tests: Other Lab Tests
0		**YOUNG FAN DEPOSITS (Qfy)** Sandy Gravel (GP-SP): Light gray, dry, dense, fine- to coarse-grained sand, subangular gravel and cobbles of granitic and metamorphic origin up to 6", very rocky.							
		Ocotillo Formation (Qo) Silty Sandy Gravel (SM/GM): Gray to light grayish-brown, dry, very hard, fine- to coarse-grained sand.							
5				13 33 42	■		2.1	114.7	
10				10 27 39	■		1.2	Disturbed	
15				17 29 50	◩				
		Total Depth-16' No groundwater encountered Backfilled.							
20									
25									
30									

PLATE

Petra Geosciences, Inc.

TEST PIT LOGS

Test Pit Number	Depth	Description
TP-1	0 – 0.5’	**Slopewash** – light gray, silty SAND (SM) with gray and black angular cobbles, loose, occasional rootlets, dry.
	0.5’ – 3.5’	**Weathered Upper Palm Springs Formation (Qpu)** - light gray, silty fine-grain SAND (SM), loose to firm, friable, fine- to coarse-grain sand lenses from 0.5’ – 1’, highly micaceous, dry.
	3.5’ – 5’	gray to light brown, SILTSTONE (ML) with thinly bedded fine-grain sand lenses 0.25” to 0.5” thick, medium stiff, blocky cleavage, dry.
		T.D. @ 5 feet No sloughing Hole backfilled
TP-2	0 – 0.5’	**Topsoil** – light gray, silty SAND (SM) with gravel, loose, porous common rootlets, dry.
	0.5’ – 4’	**Fluvial Fan Deposits (Qfy)** - light brown, silty SAND (SM) with occasional gravel to 2.5’, predominantly fine- to medium-grain with traces of small gravel below, minor rootlets to 3’, micaceous, dry.
	4’ – 9’	light brown, predominantly fine- to coarse-grain SAND (SP) with variable concentrations of gravel and occasional cobbles, loose to slightly dense at 6’, poorly graded, micaceous, dry.
	9 – 9.5’	**Weathered Upper Palm Springs Formation (Qpu**) – light gray-brown, SILTSTONE (ML), trace sand lenses, medium hard and blocky, light weight hand samples, highly micaceous, dry.
		T.D. @ 9.5 feet Minor sloughing Hole backfilled Bulk sample from 0-5’

TEST PIT LOGS

Test Pit Number	Depth	Description
TP-3 (north)	0 – 0.5’	**Slopewash** – light greenish gray, silty fine-grain SAND (SP) with gravel mantle, loose, porous, dry.
	0.5’ – 3’	**Weathered Upper Palm Springs Formation (Qpu)** – light olive gray, SILTSTONE (ML) with very minor clay, medium stiff, brittle, localized orange staining related to relict organic fragments, dry.
	3’ – 3.5’	light gray, silty fine-grain SANDSTONE (SP), medium stiff, brittle, blocky cleavage, dry.
TP-3 (middle)	0 – 1’	**Slopewash** – light gray, silty fine-grain SAND (SM), loose, porous, crumbly, dry.
	1 – 3’	**Weathered Upper Palm Springs Formation (Qpu)** – light olive brown, silty fine- to medium grain SANDSTONE, slightly indurated, friable, poorly graded micaceous, dry.
TP-3 (south)	0 – 2.5’	**Fluvial Fan Deposits (Qfy)** – light brown to light gray, silty fine- to medium-grain SAND (SM), loose, friable, dry.
	2.5’ - 3’	light brown-light olive gray, silty SAND (SM), loose, soft, friable dry.
		T.D. @ 3 feet Minor sloughing Hole backfilled
TP-4	0 – 1.5’	**Topsoil/Slopewash** – light brown – brownish gray, silty SAND (SM) with surface cobbles, loose, porous trace rootlets, caliche at 0.5’, dry.
	1.5’ - 5’	**Slopewash** – light brownish gray, silty fine- to medium-grain SAND (SM) with occasional cobbles, loose, friable, porous, trace rootlets, dry.
	5’ – 7’	rock fragment size increase to 1 to 2 ‘ in one dimension.
	7’ – 8’	**Weathered Upper Palm Springs Formation (Qpu)** – light gray brown, CLAYSTONE (CL) and SILTSTONE (ML) with thin sandy lenses, medium stiff, brittle, blocky cleavage, caliche or gypsum growths along bedding, slightly moist.
		T.D. @ 7 feet No sloughing Hole backfilled Bulk sample from 7-8’

TEST PIT LOGS

Test Pit Number	**Depth**	**Description**
TP-5	0 – 0.5’	**Topsoil/Slopewash** – light brown to light olive brown with surface cobbles, loose, porous, caliche at 0.5’, trace rootlets, dry.
	0.5’ – 3’	**Weathered Upper Palm Springs Formation (Qpu)** – olive brown, silty fine-grain SANDSTONE (SM), coarse-grain sand in upper 1’, medium dense, poorly graded, friable, micaceous, slightly moist.
	3’ – 7’	olive brown, silty fine- to medium-grain SANDSTONE, with localized cobbles from 4.5’ to 7’, medium dense, friable, massive, micaceous, slightly moist.
		T.D. @ 7’ No sloughing Hole backfilled
TP-6	0 – 3.5’	**Fluvial Fan Deposits (Qfo)** – light gray, gravelly SAND (SP), fine- to coarse-grain, laminated, friable, rootlets to 1’, dry.
	3.5’ – 5’	Red brown, clayey SAND (SC) – silty SAND (SM) with clay, porous, crumbly, common angular to rounded rock fragment from 1” to 6”, poorly graded, dry.
	5’ – 9’	Red brown – brown, silty SAND (SM) and sandy CONGLOMERATE (GP), lower excavation difficulty associated with decreasing cobbles towards bottom, dry.
		T.D. @ 9 feet Minor sloughing Hole backfilled Bulk sample from 5-7’
TP-7	0 – 2’	**Fluvial Fan Deposits (Qfo)** – light gray, fine- to coarse-grain SAND (SM) with gravel and cobbles, loose, porous, friable, dry.
	2’ – 5.5’	Red brown, predominantly medium- to coarse-grain SAND (SP) with medium to large gravel, firm with limited sloughing, slightly moist.
		T.D. @ 5.5 feet Sloughing from 0 – 2’ Hole backfilled

TEST PIT LOGS

Test Pit Number	Depth	Description
TP-8	0 – 2'	**Fluvial Fan Deposits (Qfo)** – light to medium brown, fine- to coarse-grain SAND (SP) with surface cobbles and cobbles at base, loose, porous, minor sloughing, rootles to 2.5', dry.
	2' – 3.5'	similar to above with noticeable less cobbles and increased sloughing, laminated from 2 to 3', dry.
	3.5 – 7.5'	red and orange-brown, fine- to coarse-grain SAND (SP) with gravel-cobbles and rare boulders, moderately indurated, dry.
		T.D. @ 7.5 feet Sloughing from 0 to 2' Hole backfilled
TP-9	0 – 0.5'	**Topsoil** – brown, silty SAND (SM) with surface gravel, loose, porous, trace rootlets, dry.
	0.5' – 3'	**Weathered Ocotillo Conglomerate (Qo)** – brown, silty fine- to occasional coarse-grain SAND (SM) with minor clay, minor medium to coarse gravel lenses, moderately well indurated, dry.
	3' – 7'	brown olive, gravelly SAND (GP), medium dense, traces of isolated pin-hole pores, sub rounded cobbles, massive, dry.
		T.D. @ 7 feet No sloughing Hole backfilled Bulk sample from 6-7 feet
TP-10	0 – 0.5'	**Topsoil** – brown, silty SAND (SM) with surface gravel, loose, porous, trace rootlets, dry.
	0.5' - 4'	**Weathered Ocotillo Conglomerate (Qo)** – light brown, predominantly coarse-grain SAND (SP) with minor "fines" laminated with sandy COBBLES (GP), poorly graded, minor rootlets to 2', dry.
		T.D. @ 4' Minor sloughing due to cobbles Hole backfilled

TEST PIT LOGS

Test Pit Number	**Depth**	**Description**
TP-11	0 – 1.5’	**Topsoil** – brown, silty SAND (SM) with surface gravels - cobbles, loose, porous, occasional insert burrows, dry.
	1.5’ – 5’	**Weathered Ocotillo Conglomerate (Qo)** – brown and gray, interbedded gravelly SAND (SP) and sandy GRAVEL (GP), moderately well indurated, subrounded to angular gravel and cobbles, slightly moist.
		T.P @ 5 feet No sloughing Hole backfilled
TP-12	0 – 2’	**Weathered Ocotillo Conglomerate (Qo)** – light brown, silty fine- to coarse-grain SAND (SM) with surface gravel, loose, friable, no obvious signs of porosity, minor rootlets and small gravel, dry.
	2’ – 7’	light brown, silty fine- to coarse-grain SAND (SM) with discontinuous locally common subangular to subrounded cobbles, friable, dry.
		T.P. @ 7 feet No sloughing Hole backfilled Bulk sample from 0-3 feet
TP-13	0 – 1’	**Weathered Ocotillo Conglomerate (Qo)** – light brown, silty fine- to coarse-grain SAND (SM), common surface gravel, lose, porous minor rodent burrows and root hairs, dry.
	1’ – 5’	brown and gray, SAND (SP) and sandy GRAVEL (GP), rock fragments up to 8” in one dimension, cobbles increasing in concentration from 4-5’, moderately well indurated, friable, dry.
		T.P. @ 5 feet Minor sloughing Hole backfilled

TEST PIT LOGS

Test Pit Number	Depth	Description
TP-14	0 – 1’	**Weathered Ocotillo Conglomerate (Qo)** – light brown, silty fine- to coarse-grain SAND (SM), common surface gravel, lose, porous minor rodent burrows and root hairs, dry.
	1’	1” thick caliche layer orientated N50E / 35 NW
	1’ – 3.5’	brown, gravelly SAND (SP) to sandy GRAVEL (GP), well indurated, difficult excavation, dry.
	3.5’ – 4’	brown, gravelly SAND (SP), well indurated, slightly difficult excavation, dry.
		T.D. @ 4 feet Sloughing from 0-1’ Hole backfilled
TP-15	0 – 1’	**Slopewash** – brown, silty SAND (SM), occasional gravel, loose, porous, locally common rootlets, dry.
	1’ – 4’	**Weathered Ocotillo Conglomerate (Qo)** – brown, silty fine- to coarse-grain SAND (SM) interbedded with sandy GRAVEL (GP), brittle and hard to friable, rock fragments up to 8” in one dimension, locally matrix supported, caliche visible from 1.5’ to 3’, mottled light brown irregular layer below with some relict worm/insect borrows, slightly to moderately well indurated, sloughing below caliche, dry.
	4’ – 5’	light brown, sandy GRAVEL (GP), slightly crumbly angular to rounded rock fragments up to 1’ in one dimension, difficult excavation, thin sand interbedded with cobbles, dry.
		T.D. @ 5 feet Sloughing @ 2’ to 4’ Hole backfilled

TEST PIT LOGS

Test Pit Number	Depth	Description
TP-16	0 – 2’	**Fluvial Fan Deposits (Qfy)** – light gray brown, fine- to coarse-grain SAND (SM), 0.25” to 3” laminations, loose, friable, minor root hairs to 2’, dry.
	2’ – 5’	light brown and light gray, interbedded coarse-grain SAND (SP) with coarse-grain SAND with gravel with fine- to medium-grain SAND (SP) with gravel, hint of crossbedding, fine-grain sand dips slightly toward center of drainage, dry to slightly moist.
	5’ – 10’	red brown, predominantly medium- to coarse-grain SAND (SP) with gravel, slightly indurated, hint of porosity from 5-6’, poorly graded, no sloughing, slightly moist.
	10’ – 11’	red brown, gravelly medium- to coarse-grain SAND (SP), friable, slightly moist.

T.D. @ 11 feet
Minor sloughing
Hole backfilled

Test Pit Number	Depth	Description
TP-17	0 – 1.5’	**Weathered Ocotillo Conglomerate (Qo)** – light brown, silty SAND (SM), loose, porous, friable, root hairs to 1,5’, dry.
	1.5’ – 3.5’	light brown, fine- to coarse-grain SAND (SP) with gravel, poorly graded, slightly to moderately well indurated, friable, minor isolated cobbles, sloughing, dry.
	3.5’ – 9’	light brown, fine- to coarse-grain SAND (SP) with gravel - cobble, poorly graded, slightly to moderately well indurated, friable, isolated rock fragments up to 1’ in one dimension, sloughing, dry.

T.D. @ 9 feet
Heavy sloughing
Hole backfilled
Bulk sample from 7-9’

TEST PIT LOGS

Test Pit Number	Depth	Description
TP-18	0 – 3'	**Weathered Ocotillo Conglomerate (Qo)** – light brown, silty SAND (SM) with gravel/cobbles up to 6" in one dimension, common surface gravel, loose, porous, dry.
	3'	Caliche bed 0.5" thick orientated E-W / 30S
	3' – 7'	light brown, sandy GRAVEL (GP) and gravelly SAND (SP), subrounded rock fragments up to 10" in one dimension, sloughing common below caliche layer, moderately well indurated, dry.
		T.D. @ 7 feet Sloughing from 3-7 feet Hole backfilled
TP-19	0 – 3'	**Weathered Ocotillo Conglomerate (Qo)** – brown, silty fine- to occasional coarse-grain SAND (SM) and fine-grain sandy SILT (ML), occasional gravel, loose, moderately porous, friable, insert burrows to 1.5', dry.
	3' – 9'	red brown, sandy SILT (ML) and silty fine- to medium-grain SAND (SM) with minor coarse-grain sand, moderately well indurated, moderately friable, trace of isolated pores, localized caliche veins, dry.
	9'	discontinuous sandy cobble layer
	9' – 11'	red brown, fine- to coarse-grain SAND with silt (SM), moderately well indurated, local isolated pores, brittle, poorly graded, dry to slightly moist.
		T.D. @ 11 feet Sloughing from 0-3' Hole backfilled Bulk sample from 10-11 feet

TEST PIT LOGS

Test Pit Number	Depth	Description
TP-20	0 – 2’	**Weathered Ocotillo Conglomerate (Qo)** – brown, silty fine- to occasional coarse-grain SAND (SM) and fine-grain sandy SILT (ML), occasional gravel, loose, moderately porous, friable, 1’ thick caliche lens observed in SW test pit only. dry.
	2’ – 10’	light brown, medium- to coarse-grain SAND (SP) with cobbles and gravel, localized caliche noted with gravel/cobble lenses that are irregular and discontinuous, concentrations of coarse-grain sand increases with depth, moderately well indurated, dry.
		T.D. @ 10 feet Sloughing from 0-4 feet Hole backfilled
TP-21	0 – 1’	**Fluvial Fan Deposits (Qfy)** – light gray, fine- to medium-grain SAND (SP), loose, friable, discontinuous laminations are sub-horizontal, dry.
	1- 2’	brown, fine- to medium-grain SAND (SP), loose, friable, discontinuous gravel layers, dry.
	2’ – 3’	brown, medium- to coarse-grain SAND (SP) with discontinuous gravel layers, friable, dry.
	3’ – 11’	brown, fine- to coarse-grain SAND (SW) with isolated gravel, rock fragment size increases to 6-8” below 5’, well graded, firm, micaceous, very rare rootlets at 9.5’, dry to slightly moist from 8’.
		T.D. @ 11 feet Sloughing from 0-3’ Hole backfilled

TEST PIT LOGS

Test Pit Number	Depth	Description
TP-22	0 – 3’	**Topsoil** – light gray, fine- to medium-grain SAND (SP) interbedded with medium- to coarse-grain SAND, occasional floating gravel, loose, porous, root hairs to 0.5’, dry.
	3’ – 7’	**Weathered Ocotillo Conglomerate (Qo)** – olive brown, sandy SILT (ML) and silty fine-grain SAND (SM), moderately well indurated, slightly platey cleavage, upper 1’ contains minor rootlets and orange organic fragments, highly micaceous, slightly moist.
		T.D. @ 7 feet Minor sloughing from 0-3’ Hole backfilled Bulk sample from 5-7 feet
TP-23	0 – 1’	**Fluvial Fan Deposits (Qfy)** – light gray, fine- to coarse-grain SAND (SW), occasional gravel, loose, porous, laminated, minor root hairs, dry.
	1’ – 2’	light brown, fine- to coarse-grain SAND (SW), occasional gravel, loose, porous, laminated, dry.
	2’ – 2.5’	red brown, fine- to coarse-grain SAND (SW) with minor floating gravel, very minor root hairs, dry.
	2.5’ – 3.5’	light gray, gravelly SAND (SP) and sandy GRAVEL (GP), discontinuous gravel on west side of test pit, red brown sand associated with gravel- and cobble-size fragments, friable, minor rootlets, dry to slightly moist.
	3.5’ – 8’	light gray and light brown, interbedded gravelly SAND (SP) and sandy GRAVEL (GP), loose with sloughing due to cobble removal, cobble lenses are approximately 1’ thick with 1’ thick sand lenses between, slightly moist.
	8’ – 9.5’	**Weathered Upper Palm Spring Formation (Qpu)** – medium to dark brown, SILTSTONE (ML) and fine-grain sandy SILTSTONE, thinly laminated in upper section and massive below, moderately well indurated, some caliche stringers, moist.
		T.D. @ 9.5’ Sloughing from 3.5-8’ Hole backfilled

TEST PIT LOGS

Test Pit Number	**Depth**	**Description**
TP-24	0 – 4’	**Ocotillo Conglomerate (Qo)** – light brown, sandy GRAVEL (GP), no continuous sand lenses, matrix supported, porous with root hairs, friable, sloughing, slightly moist.
	4’ - 7’	light brown, interbedded medium- to coarse-grain SAND (SP) with coarse-grain SAND and fine-grain sandy SILT (ML), less than 10 percent gravel, moderately well indurated, dry to slightly moist.

T.D. @ 7 feet
Sloughing from 0-4 feet
Hole backfilled

APPENDIX B

LABORATORY TESTING

LABORATORY TEST PROCEDURES

Soil Classification

Soil materials encountered within the property were classified and described in accordance with the Unified Soil Classification System and in general accordance with the current version of Test Method ASTM D 2488. The assigned group symbol is presented on Plate B-1.

Moisture Content and In Situ Moisture Content and Dry Unit Weight

Moisture content of selected bulk samples, if applicable, and in- place moisture content and dry unit weight of selected, relatively undisturbed soil samples were determined in accordance with the latest version of Test Method ASTM D 2435 and Test Method ASTM D 2216, respectively. Test data are presented in the exploration logs, Appendix A.

Laboratory Maximum Dry Unit Weight and Optimum Moisture Content

The maximum dry unit weight and optimum moisture content of the on-site soils were determined for a selected bulk sample in accordance with current version of Method A of ASTM D 1557. The results of these tests are presented on Plate B-1.

Atterberg Limits

The Atterberg limits (liquid limit and plastic limit) were determined for selected bulk samples of representative materials in accordance with the latest version of Test Method ASTM D 4318. The results of these tests are included on Plate B-2.

Expansion Index

An expansion index test was performed on a selected bulk sample of the on-site soils in accordance with the current version of Test Method ASTM D 4829. The test result is presented on Plate B-1.

Corrosivity Screening

Chemical and electrical analyses were performed on a selected bulk sample of onsite soils to determine soluble sulfate content, chloride content, pH (acidity) and minimum electrical resistivity. These tests were performed in accordance with the current versions of California Test Method Nos. CTM 417, CTM 422 and CTM 643, respectively. The results of these tests are presented on Plate B-1.

Grain Size Distribution

Grain size analysis was performed on selected bulk samples of onsite soils in accordance with the latest versions of Test Method ASTM D 136 and/or ASTM C 117, or Test Method ASTM D 422 and/or ASTM D 6913. The test result is graphically presented on Figures B-3 through B-6.

Direct Shear

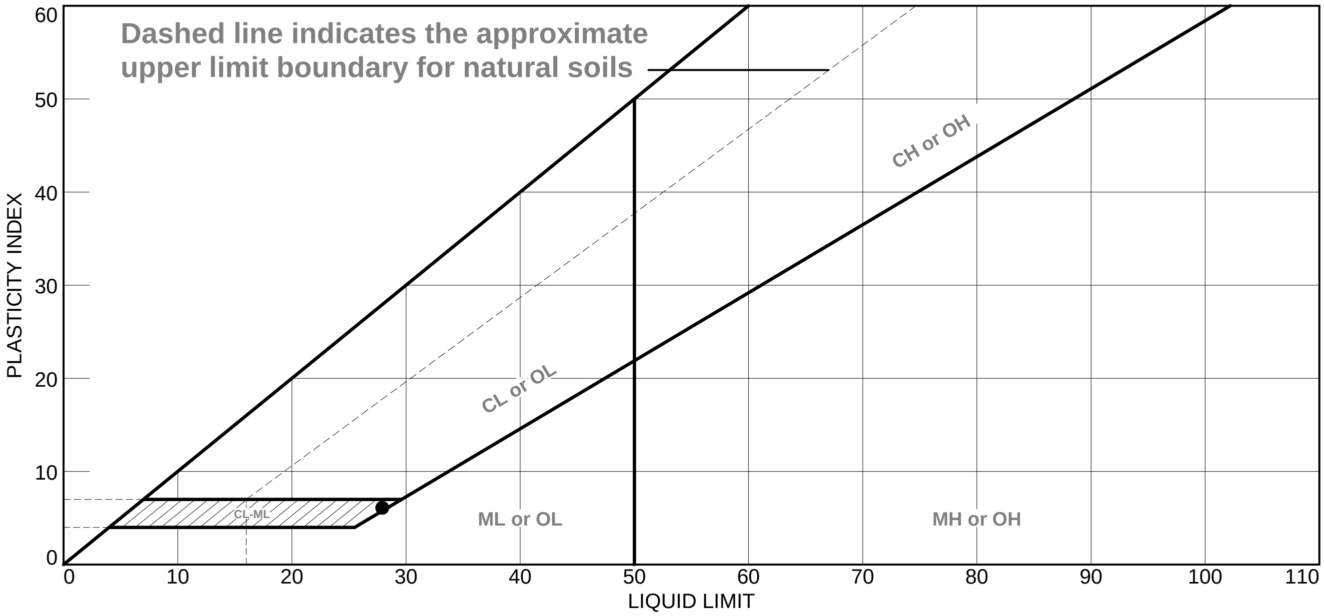
The Coulomb shear strength parameters, i.e., angle of internal friction and cohesion, were determined for selected, relatively undisturbed and/or reconstituted-bulk samples of onsite soil. This test was performed in general accordance with the latest version of Test Method ASTM D 3080. Three specimens were prepared for each test. The test specimens were inundated and then sheared under various normal loads at a constant strain rate of 0.005 inch per minute. The results of the direct shear test are graphically presented on Figures B-7 and B-8.

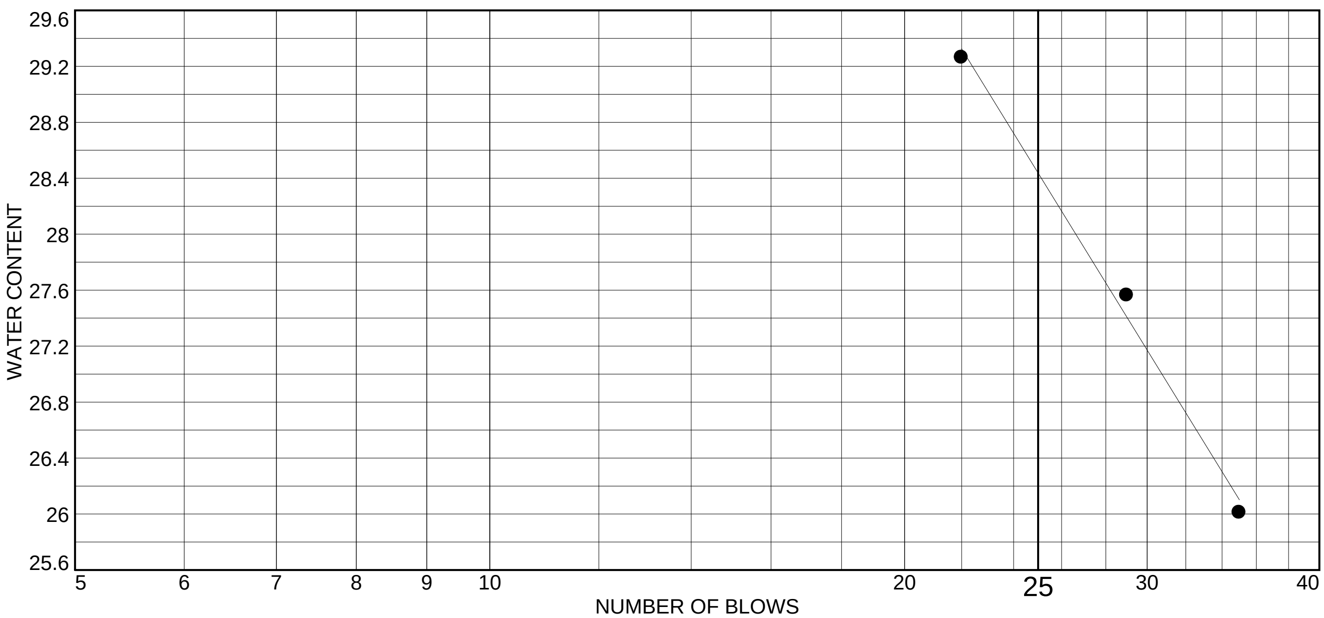
LABORATORY DATA SUMMARY*												
Sample Location	**Sample Depth (ft.)**	**Soil Description**	**Max. Dry Density[1] (pcf)**	**Optimum Moisture[1] (%)**	**Expansion Index[2]**	**CBC Soil Classification[3]**	**Sand Equivalent[4]**	**Sulfate Content[5] (%)**	**Chloride Content[6] (ppm)**	**pH[7]**	**Minimum Resistivity[7] (Ohm-cm)**
B-6	1-5	Gravelly Sand	136.5	5.8	----	SP	----	0.0372	1800	5.4	300
B-8	1-5	Silty f-c Sand	124.5	11.4	----	SM	----	----	----	----	----
TP-2	5	f-c Sand	----	----	----	SP	----	0.0018	225	8.14	6100
TP-4	7-8	Siltstone	----	----	17	ML	----	0.1125	3000	8.80	210
TP-12	0-3	f-c Sand	----	----	----	SM	----	0.0003	240	8.3	6400
TP-22	5-7	Sandy Silt	----	-----	11	ML	----	----	----	----	----

Test Procedures:

[1] Per ASTM Test Method D 1557
[2] Per ASTM Test Method D 4829
[3] Per ASTM Test Method D 4829 Table 1, Per CBC 2010
[4] Per ASTM Test Method D2419
[5] Per Caltrans Test Method 417
[6] Per Caltrans Test Method 422
[7] Per Caltrans Test Method 643
[8] Per ASTM Test Method D 1140

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Grayish Brown, Sandy Silt	28	22	6			

Project No. 16-368 **Client:** KPC Coachella

Project: Desert Lakes

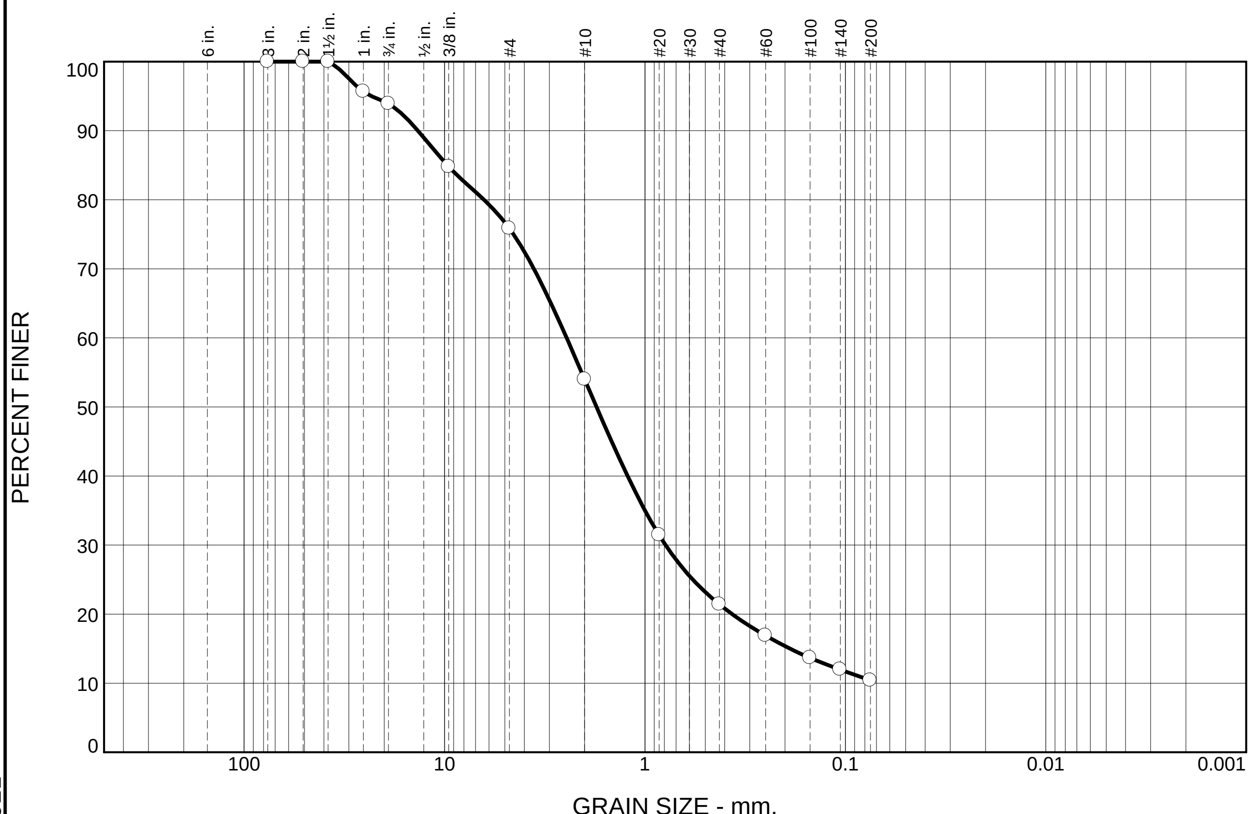
Source of Sample: Atterberg and Sieve Data **Depth:** 7'-8'
Sample Number: TP-4

Remarks:

PETRA GEOSCIENCES INC.

Figure B-2

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.1	18.0	21.9	32.6	11.0	10.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	100.0		
1.5	100.0		
1	95.7		
.75	93.9		
.375	84.8		
#4	75.9		
#10	54.0		
#20	31.5		
#40	21.4		
#60	16.9		
#100	13.7		
#140	12.0		
#200	10.4		

* (no specification provided)

Material Description

Light Brown Gravelly Silty Fine to Coarse Sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 13.5768 D_{85}= 9.6784 D_{60}= 2.4589
D_{50}= 1.7445 D_{30}= 0.7891 D_{15}= 0.1886
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Source of Sample: Proctor Data **Depth:** 1-5
Sample Number: B-6

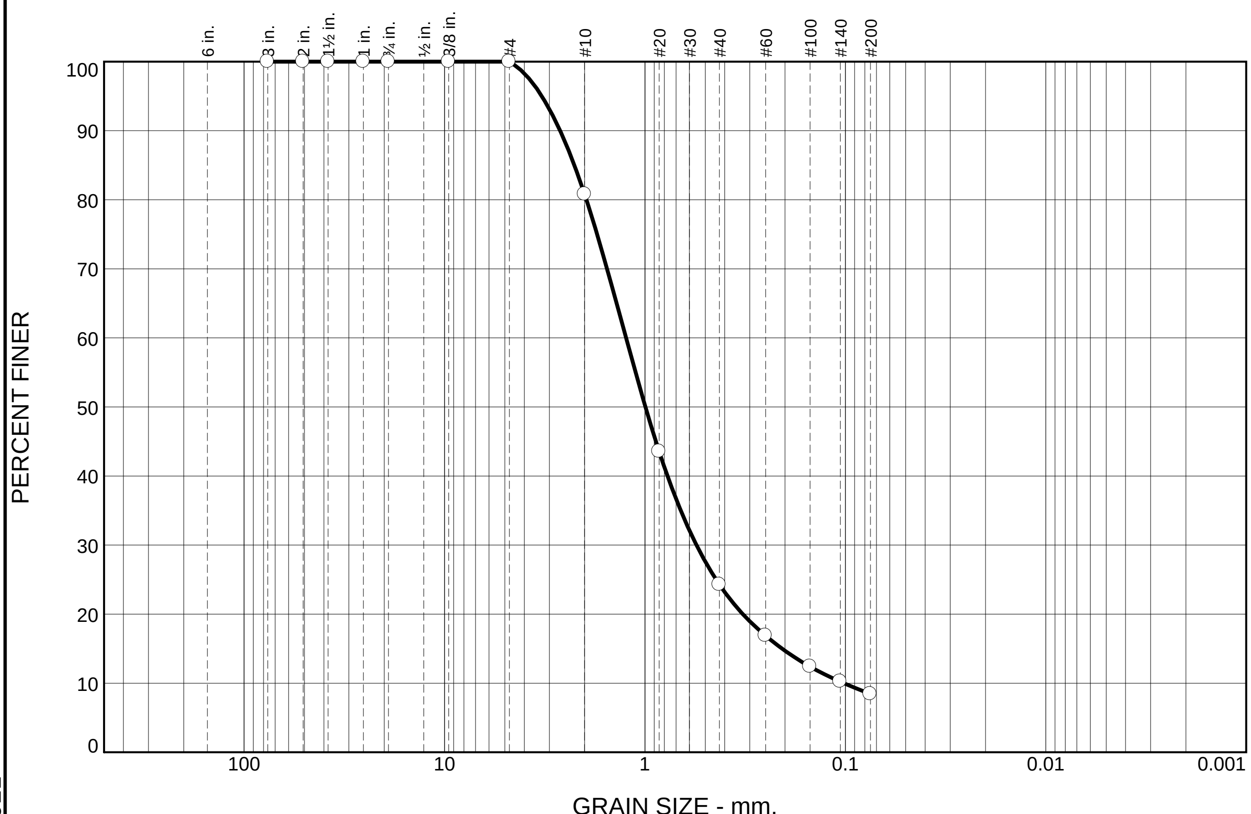
Date: 4/29/2021

PETRA GEOSCIENCES INC.

Client: KPC Coachella
Project: Desert Lakes
Project No: 16-368 **Figure B-3**

Laboratory:
1251 West Pomona Road, Unit #103, Corona, Ca 92882 Phone #. 714.549.8921

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	19.2	56.5	15.9	8.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0		
#4	100.0		
#10	80.8		
#20	43.5		
#40	24.3		
#60	16.9		
#100	12.4		
#140	10.2		
#200	8.4		

* (no specification provided)

Material Description

Light Brown Fine to Coarse Sand with Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 2.6495 D_{85}= 2.2498 D_{60}= 1.2420
D_{50}= 0.9945 D_{30}= 0.5533 D_{15}= 0.2068
D_{10}= 0.1016 C_u= 12.22 C_c= 2.42

Classification

USCS= AASHTO=

Remarks

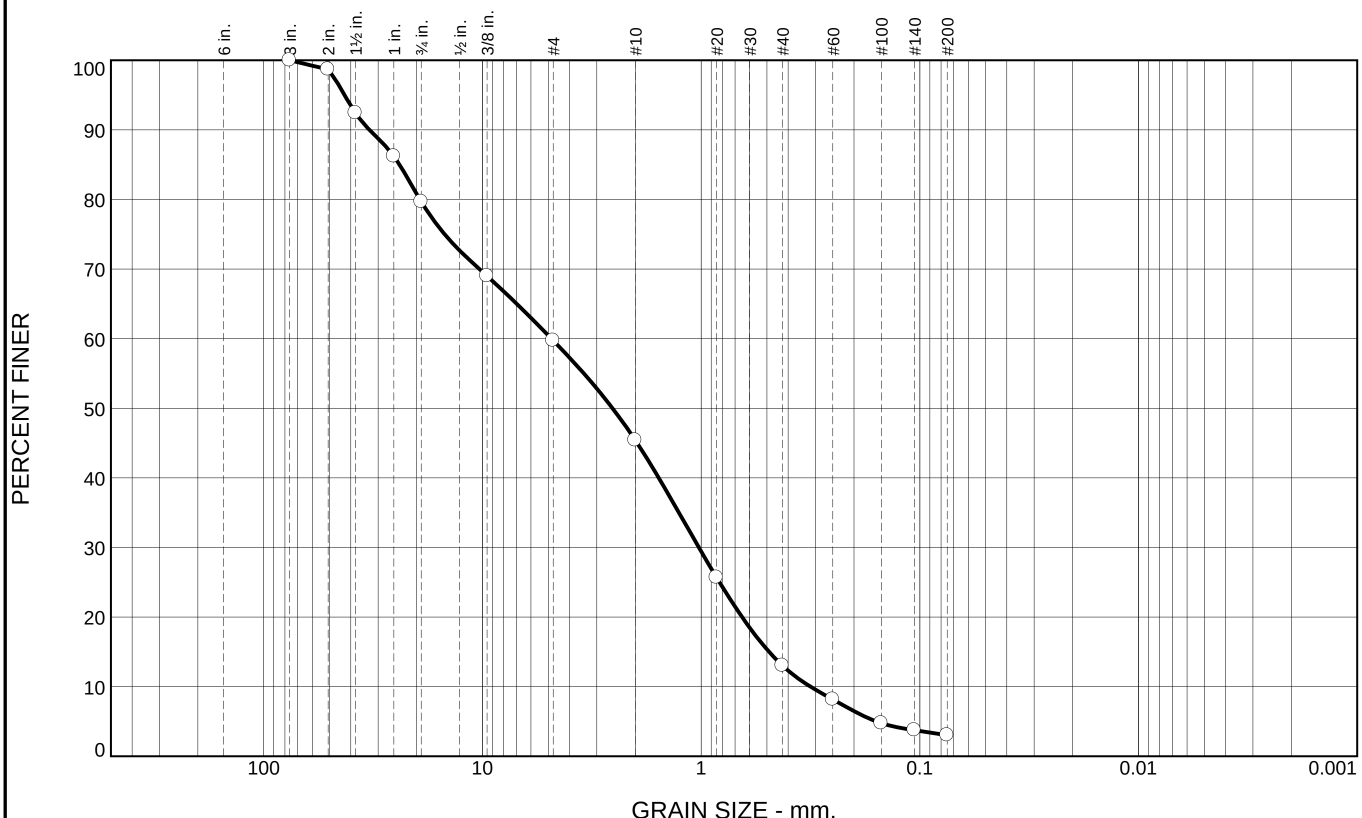
Source of Sample: Proctor Data **Depth:** 1-5
Sample Number: B-8 **Date:** 4/29/2021

PETRA GEOSCIENCES INC.

Client: KPC Coachella
Project: Desert Lakes
Project No: 16-368 **Figure B-4**

Laboratory:
1251 West Pomona Road, Unit #103, Corona, Ca 92882 Phone #. 714.549.8921

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	20.3	20.0	14.3	32.4	10.0	3.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	98.7		
1.5	92.4		
1	86.2		
.75	79.7		
.375	69.0		
#4	59.7		
#10	45.4		
#20	25.7		
#40	13.0		
#60	8.2		
#100	4.8		
#140	3.8		
#200	3.0		

* (no specification provided)

Material Description

Light Brown, Gravelly fine to coarse Sand with Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 32.8690 D_{85}= 23.9276 D_{60}= 4.8356
D_{50}= 2.5419 D_{30}= 1.0238 D_{15}= 0.4888
D_{10}= 0.3159 C_u= 15.31 C_c= 0.69

Classification

USCS= SP AASHTO=

Remarks

Source of Sample: Atterberg and Sieve Data **Depth:** 6'-7'
Sample Number: TP-6

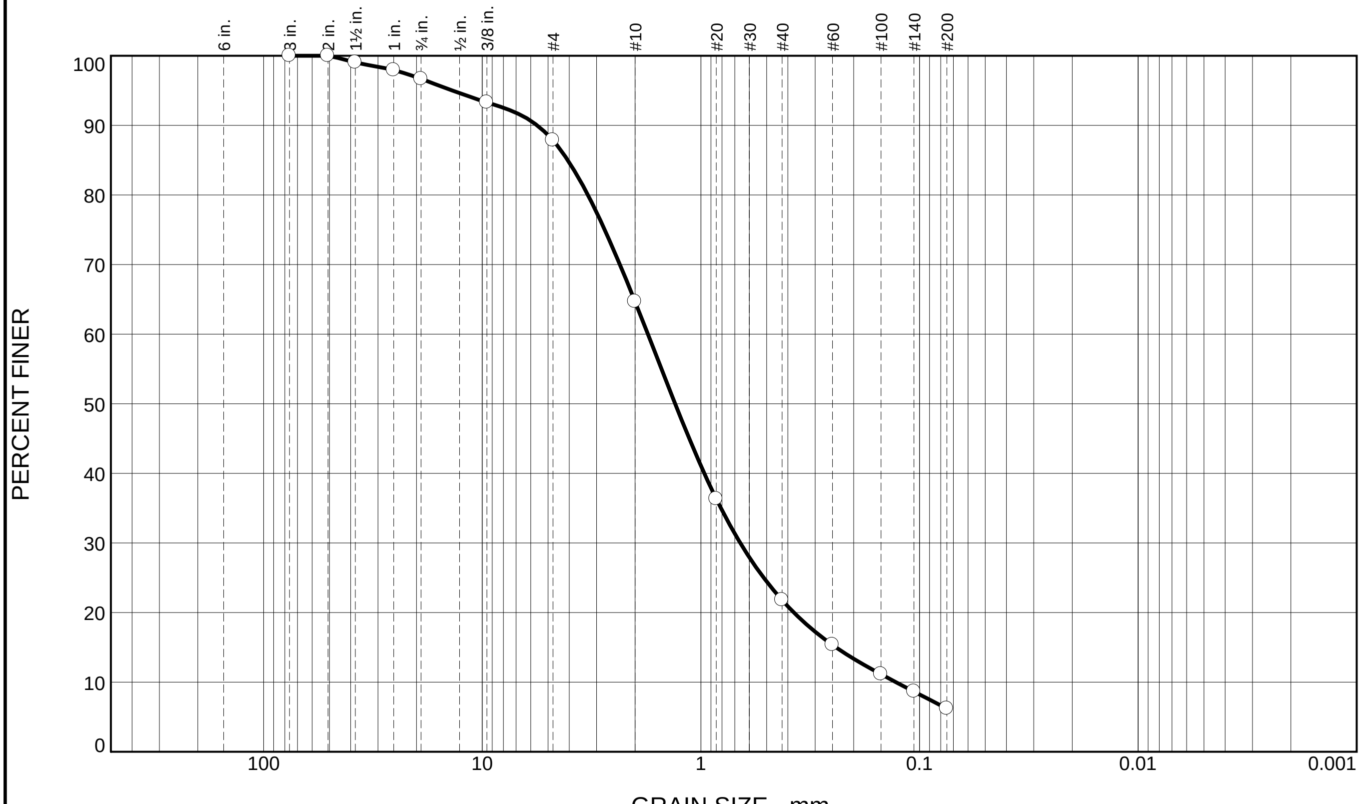
Date: 2/11/2021

PETRA GEOSCIENCES INC.

Client: KPC Coachella
Project: Desert Lakes

Project No: 16-368 **Figure B-5**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.3	8.8	23.2	42.9	15.6	6.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	100.0		
1.5	99.0		
1	97.9		
.75	96.7		
.375	93.3		
#4	87.9		
#10	64.7		
#20	36.3		
#40	21.8		
#60	15.4		
#100	11.1		
#140	8.7		
#200	6.2		

* (no specification provided)

Material Description

Light Brown, Gravelly fine to coarse Sand with Silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 5.6046 D_{85}= 4.0614 D_{60}= 1.7472
D_{50}= 1.3107 D_{30}= 0.6604 D_{15}= 0.2407
D_{10}= 0.1280 C_u= 13.65 C_c= 1.95

Classification

USCS= AASHTO=

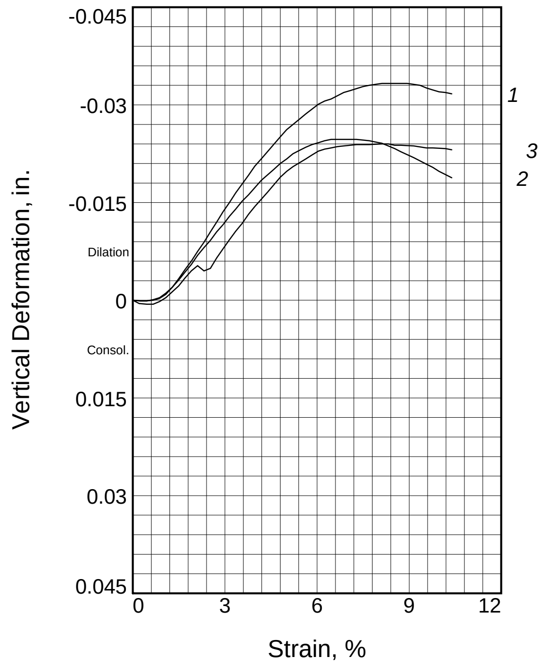
Remarks

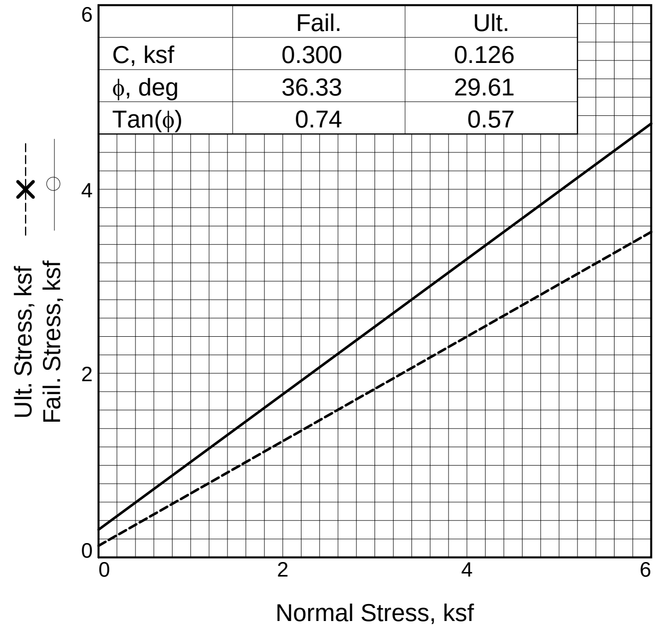
Source of Sample: Atterberg and Sieve Data **Depth:** 6'-7'
Sample Number: TP-9 **Date:** 2/11/2021

PETRA GEOSCIENCES INC.

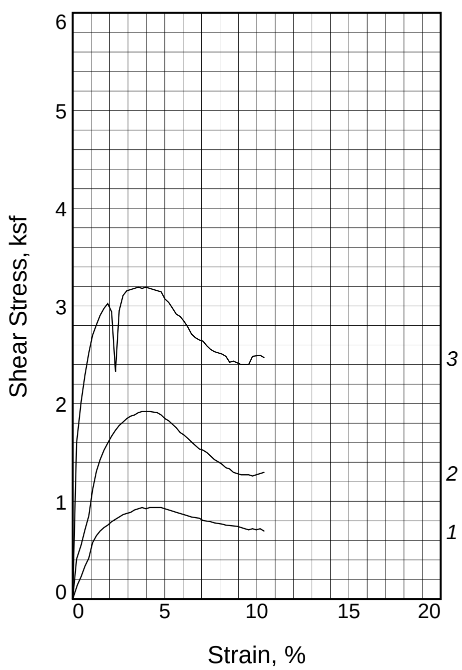
Client: KPC Coachella
Project: Desert Lakes

Project No: 16-368 **Figure B-6**





	Fail.	Ult.
C, ksf	0.300	0.126
ϕ, deg	36.33	29.61
Tan(ϕ)	0.74	0.57



	Sample No.	1	2	3
Initial	Water Content, %	1.4	1.4	1.4
	Dry Density, pcf	118.1	118.1	114.7
	Saturation, %	9.2	9.2	8.3
	Void Ratio	0.4007	0.4007	0.4427
	Diameter, in.	2.416	2.416	2.416
	Height, in.	1.000	1.000	1.000
At Test	Water Content, %	14.5	14.1	15.5
	Dry Density, pcf	119.5	120.3	117.4
	Saturation, %	99.7	99.5	100.0
	Void Ratio	0.3846	0.3746	0.4096
	Diameter, in.	2.416	2.416	2.416
	Height, in.	0.989	0.981	0.977
	Normal Stress, ksf	1.000	2.000	4.000
	Fail. Stress, ksf	0.936	1.920	3.192
	Strain, %	3.8	3.8	3.6
	Ult. Stress, ksf	0.696	1.260	2.400
	Strain, %	10.4	9.8	9.6
	Strain rate, in./min.	0.040	0.040	0.040

Sample Type: Undisturbed

Description: Light Brown, Silty fine to coarse Sand

Specific Gravity= 2.65

Remarks:

Client: KPC Coachella

Project: Desert Lakes

Source of Sample: Shear Data **Depth:** 5

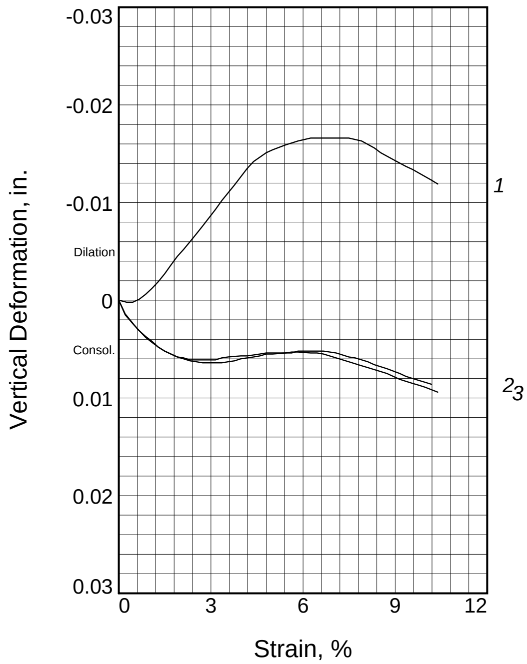
Sample Number: B-2

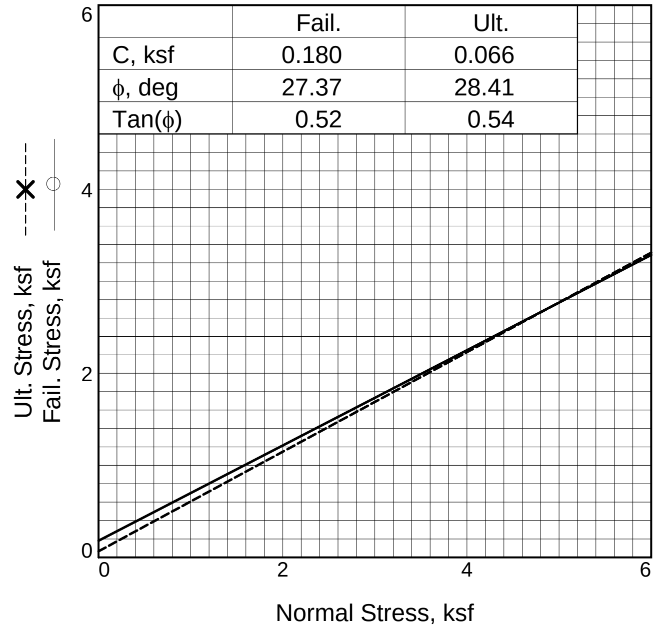
Proj. No.: 16-368 **Date Sampled:** 4/3/2021

PETRA GEOSCIENCES INC.

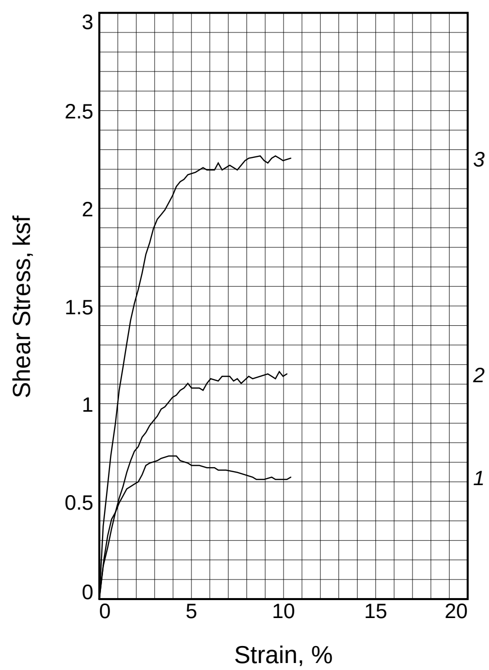
Figure B-7

Laboratory:
1251 West Pomona Road, Unit #103, Corona, Ca 92882 Phone #. 714.549.8921





	Fail.	Ult.
C, ksf	0.180	0.066
ϕ, deg	27.37	28.41
Tan(ϕ)	0.52	0.54



	Sample No.	1	2	3
Initial	Water Content, %	0.8	0.8	0.8
	Dry Density, pcf	103.8	103.8	103.8
	Saturation, %	3.6	3.6	3.6
	Void Ratio	0.5939	0.5939	0.5939
	Diameter, in.	2.416	2.416	2.416
	Height, in.	1.000	1.000	1.000
At Test	Water Content, %	21.4	20.4	19.8
	Dry Density, pcf	105.6	107.4	108.4
	Saturation, %	100.0	99.8	99.9
	Void Ratio	0.5665	0.5404	0.5267
	Diameter, in.	2.416	2.416	2.416
	Height, in.	0.983	0.966	0.958
	Normal Stress, ksf	1.000	2.000	4.000
	Fail. Stress, ksf	0.732	1.164	2.268
	Strain, %	3.8	9.8	8.7
	Ult. Stress, ksf	0.612	1.140	2.232
	Strain, %	8.5	10.0	9.1
	Strain rate, in./min.	0.040	0.040	0.040

Sample Type: Undisturbed

Description: Light Brown, Silty fine to coarse Sand

Specific Gravity= 2.65

Remarks:

Client: KPC Coachella

Project: Desert Lakes

Source of Sample: Shear Data **Depth:** 20

Sample Number: B-4

Proj. No.: 16-368 **Date Sampled:** 4/6/2021

PETRA GEOSCIENCES INC.

Figure B-8

Laboratory:
1251 West Pomona Road, Unit #103, Corona, Ca 92882 Phone #. 714.549.8921

APPENDIX B

LABORATORY TESTING (Petra, 2013)

APPENDIX B

LABORATORY TESTING

Soil Classification

Soil and bedrock materials encountered within the property were classified and described in accordance with the Unified Soil Classification System and the Engineering Geology Field Manual by the U.S. Department of the Interior, Bureau of Reclamation, respectively, and in general accordance with the current version of Test Method ASTM D 2488. The assigned group symbols are presented in the exploration and test pit logs, Appendix A.

In- Situ Moisture Content and Density

In-situ moisture content and dry density of undisturbed soil and bedrock materials were determined for samples obtained from representative strata in accordance with the current versions of Test Methods ASTM D 2435 and ASTM D 2216, respectively. Test data are presented in the exploration logs, Appendix A.

Laboratory Maximum Dry Density and Optimum Moisture Content

The maximum dry density and optimum moisture content of the on-site soil and bedrock materials were determined for selected bulk samples in accordance with current version of Test Method ASTM D 1557. The results of these tests are presented on Plate B-1.

Expansion Index

Expansion index tests were performed on selected bulk samples of the on-site soil and bedrock materials in accordance with the current version of Test Method ASTM D 4829. The test results are presented on Plate B-1.

Chemical Analysis

Chemical analyses were performed on selected bulk samples of onsite soil and bedrock materials to determine their soluble sulfate and chloride contents. These tests were performed in accordance with the current versions of California Test Method Nos. CTM 417 and CTM 422, respectively. The results of these tests are included on Plate B-1.

pH and Minimum Resistivity

pH and resistivity tests were performed on selected bulk samples of onsite soil and bedrock materials to determine their acidity and electrical resistance. These tests were performed in accordance with the current versions of California Test Method No. CTM 643. The results of these tests are included in Plate B-1.

Atterberg Limits

The Atterberg limits (liquid limit, plastic limit and plasticity index) were determined for selected bulk samples of representative materials in accordance with the current version of Test Method ASTM D 4318. The results of these tests are included on Plate B-1.

Sand Equivalent

Sand equivalent tests were performed on selected samples of representative materials in accordance with the current version of Test Method ASTM D 2419. The sand equivalent is an empirical value relative to the amount, fineness, and character of claylike material present in the test specimen. The results of these tests are included on Plate B-1.

Grain Size Distribution

Grain size distribution and hydrometer analyses were performed on bulk samples of onsite soil and bedrock materials in accordance with the current versions of Test Methods ASTM D 136 and/or ASTM D 422. The test results are graphically presented on Plate B-2 through B-10.

APPENDIX B

LABORATORY TESTING (CONT"D)

Consolidation

Volume change (settlement or heave) characteristics of select undisturbed soil and bedrock materials were determined by one-dimensional consolidation tests. These tests were performed in general accordance with the current version of Test Method ASTM D 2435. Axial loads were applied in several increments to laterally restrained 1-inch-high samples. Loads were applied in a geometric progression by doubling the previous load, and the resulting deformations were recorded at selected time intervals. The test samples were inundated at an overburden pressure of 2,000 pounds per square foot in order to evaluate the effect of a sudden increase in moisture content (e.g., hydro-collapse potential or heave). Results of these tests are graphically presented on Plates B-11 through B-17.

Direct Shear

The Coulomb shear strength parameters, i.e., angle of internal friction and cohesion, were determined for selected undisturbed and/or reconstituted-bulk samples of onsite soils and bedrock materials. This test was performed in general accordance with the current version of Test Method ASTM D 3080-04. Three specimens were prepared for each test. The test specimens were inundated and then sheared under varying normal loads at a constant strain rate of 0.005 inch per minute. Shear strength values for bedrock along bedding planes are based on resheared samples of undisturbed bedrock. The bedrock samples were resheared several times until relatively constant values were obtained. The results of the direct shear tests are summarized in Table B-2 and individual tests are graphically presented on Plates B-18 through B-34.

Table B-2
Summary of Direct Shear Test Data

Sample Location	Description and Geologic Unit	Undisturbed or Remolded	Ultimate Values		Peak Values	
			Angle of Internal Friction (φ)	Cohesion (c) psf	Angle of Internal Friction (φ)	Cohesion (c) psf
B-1 @ 0-5	Sand (SW) Fan Deposits (Qf)	Remolded	35	0	39	230
B-2 @ 0-5	Sand (SW-SM)) Fan Deposits (Qf)	Remolded	32	20	41	125
B-6 @ 0-4	Sand (SW-SM)) Fan Deposits (Qf)	Remolded	34	0	41	220
COMPOSITE OF ABOVE THREE TESTS			34	10	40	180
B-13 @ 0-5	Clayey Silt (CL) Palm Spring FM (Qpu)	Remolded	31	70	32	320
B-18 @ 15-19	Silty Sand (SM) Ocotillo Cong. (Qo)	Remolded	33	20	43	140
B-19 @ 5-10	Clayey Silt (CL) Palm Spring FM (Qpu)	Remolded	29	100	27	290
B-25 @ 0-4	Sand (SP-SM) Fan Deposits (Qf)	Remolded	34	0	38	340
Outcrop #1	Clayey Silt (CL) Palm Spring FM (Qpu)	Remolded	27	120	24	370
B-2 @ 15	Silty Sand (SM) Palm Spring FM (Qpu)	Undisturbed	32	40	42	0
B-3@ 10	Sand (SW) Fan Deposits (Qf)	Undisturbed	38	60	40	350
B-9 @ 30	Sandy Silt (ML) Palm Spring FM (Qpu)	Undisturbed	33	180	44	1040
B-12 @ 15	Sandy Silt (ML) Palm Spring FM (Qpu)	Undisturbed	31	70	36	270
B-14 @ 5	Sand (SW) Fan Deposits (Qf)	Undisturbed	30	280	41	310
B-16 @ 15	Sandy Silt (ML) Palm Spring FM (Qpu)	Undisturbed	32	60	33	210
B-18 @ 10	Silty Sand (SM) Ocotillo Cong. (Qo)	Undisturbed	33	200	44	460
B-21 10	Sand (SP) Fan Deposits (Qf)	Undisturbed	37	60	44	40

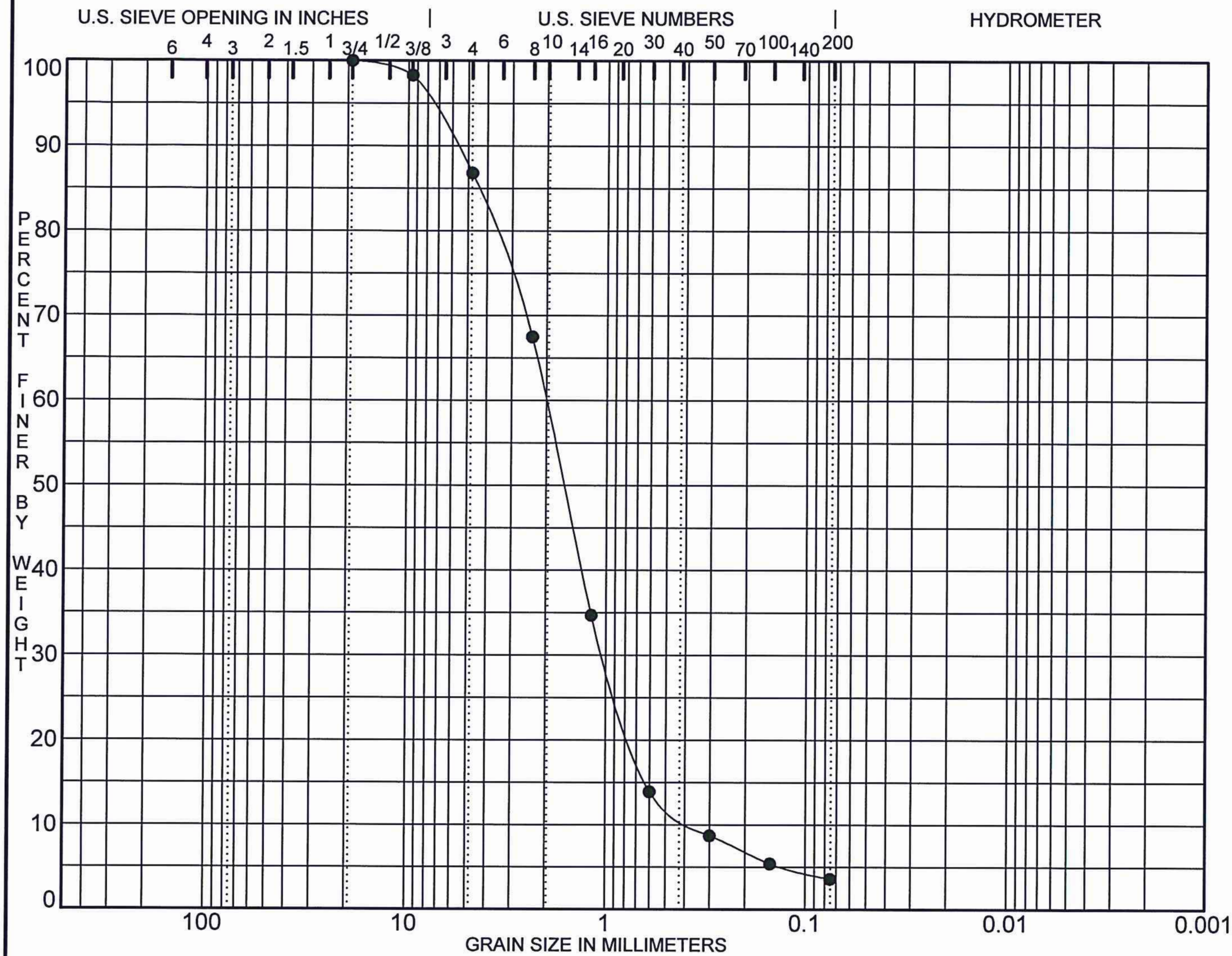
Highlighted values selected for slope stability calculations – see text in report

LABORATORY DATA SUMMARY

Boring/ Test Pit Number	Sample Depth (ft)	Soil Description	Max. Dry Density[1] (pcf)	Optimum Moisture[1] (%)	Expansion Index[2]	Expansion Potential[3]	Atterberg Limits[4]			Sulfate Content[5] (%)	Chloride Content[6] (ppm)	pH[7]	Minimum Resistivity[8] (Ohm-cm)	Sand Equivalent[9]
							LL	PL	PI					
B-1	0-5	Sand (SW)	117.5	11.0	0	Very Low				0.0040	128	7.0	18,000	81
B-2	0-5	Sand (SW-SM)	121.0	12.0	0	Very Low				0.0040	125	7.2	14,000	64
B-6	0-4	Sand (SW-SM)	127.0	9.0	0	Very Low				0.0040	125	7.2	5,200	69
B-13	0-5	Sand y Silt (ML)	125.5	9.5	0	Very Low	30	22	8	0.1458	155	7.0	520	
B-18	15-19	Silty Sand (SM)	124.5	10.5	0	Very Low				0.0040	130	7.3	10,000	
B-19	5-10	Sand y Silt (ML)	122.5	13.0	7	Very Low				0.0445	142	7.0	170	
B-25	0-4	Sand (SP-SM)	121.0	9.5	0	Very Low				0.0040	125	7.4	13,000	79
TP-19	0-1	Silt (ML)			11	Very Low	NP	NP	NP					
Outcrop* #1	0	Clayey Silt (CL)	111.5	14.0	81	Medium	43	21	22	0.4140	177	7.0	110	7

* Local outcrop of Palm Spring Formation (Qpu)

Test Procedures:
[1] Per ASTM Test Method D 1557
[2] Per ASTM Test Method D 4829
[3] Per ASTM Test Method D 4829
[4] Per ASTM Test Method D 4318
[5] Per Caltrans Test Method 417
[6] Per Caltrans Test Method 422
[7] Per Caltrans Test Method 532
[8] Per Caltrans Test Method 643
[9] Per ASTM Test Method D 1140



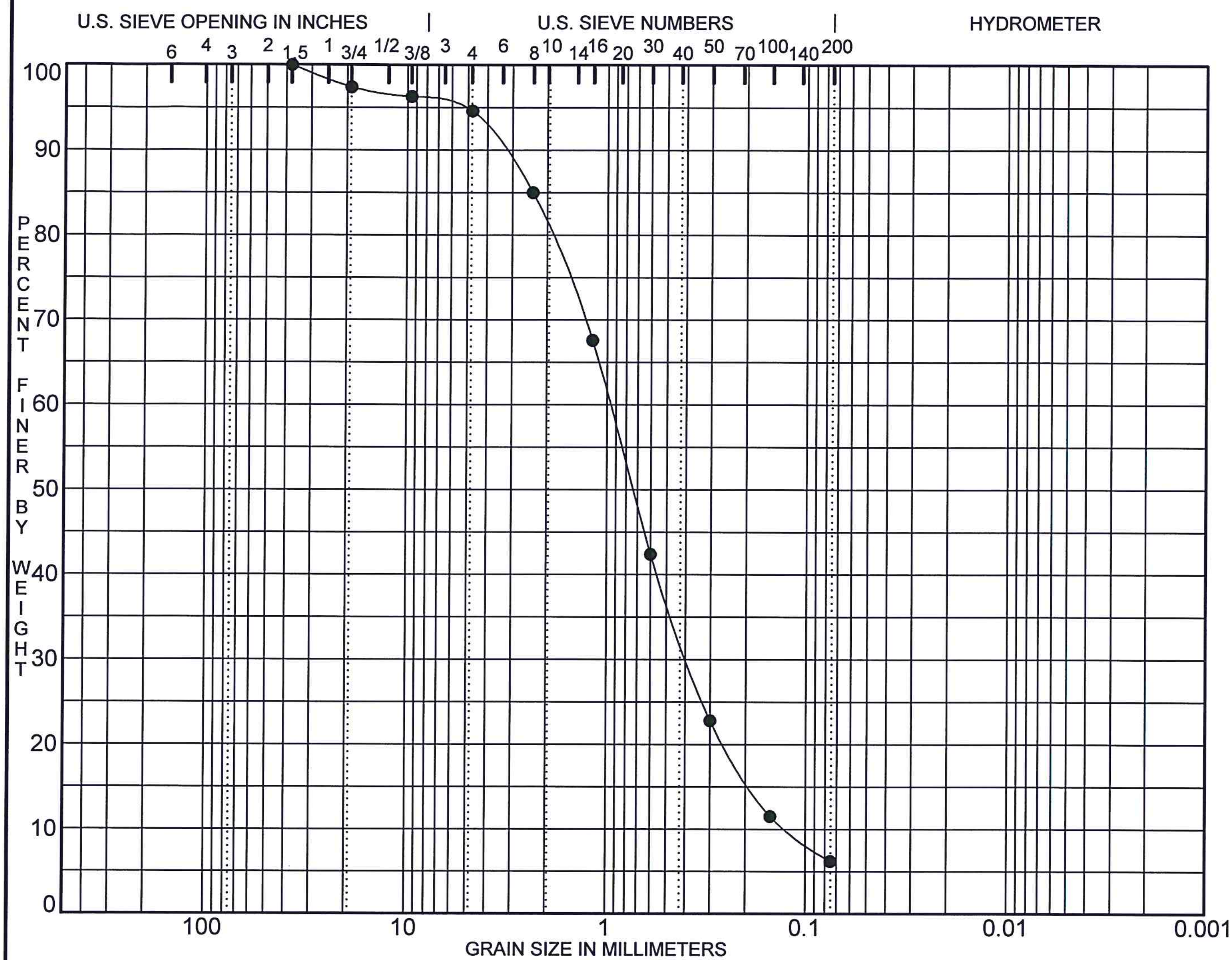
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	B- 1	0.0	Sand (SW) - Fan Deposits					1.43	5.6

	Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
●	B- 1	0.0	19.00	2.01	1.013	1.6304	13.2	83.2	3.6	

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	GRAIN SIZE ANALYSIS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-2



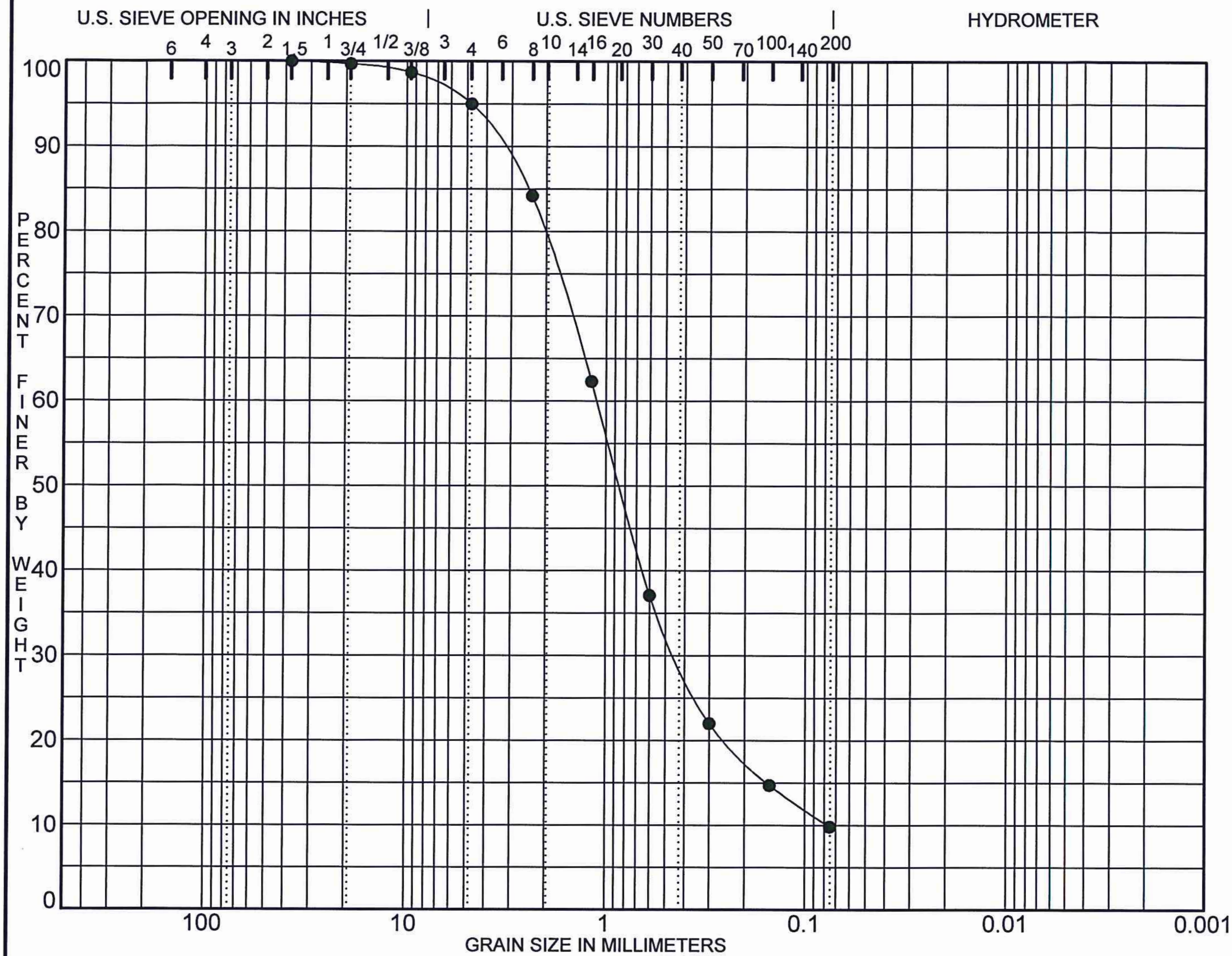
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	B- 2	0.0	Sand (SW-SM) - Fan Deposits					1.26	7.8

	Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
●	B- 2	0.0	37.50	0.96	0.387	0.7358	5.4	88.4	6.2	

J.N. 376-11	**GRAIN SIZE ANALYSIS**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-3**

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13



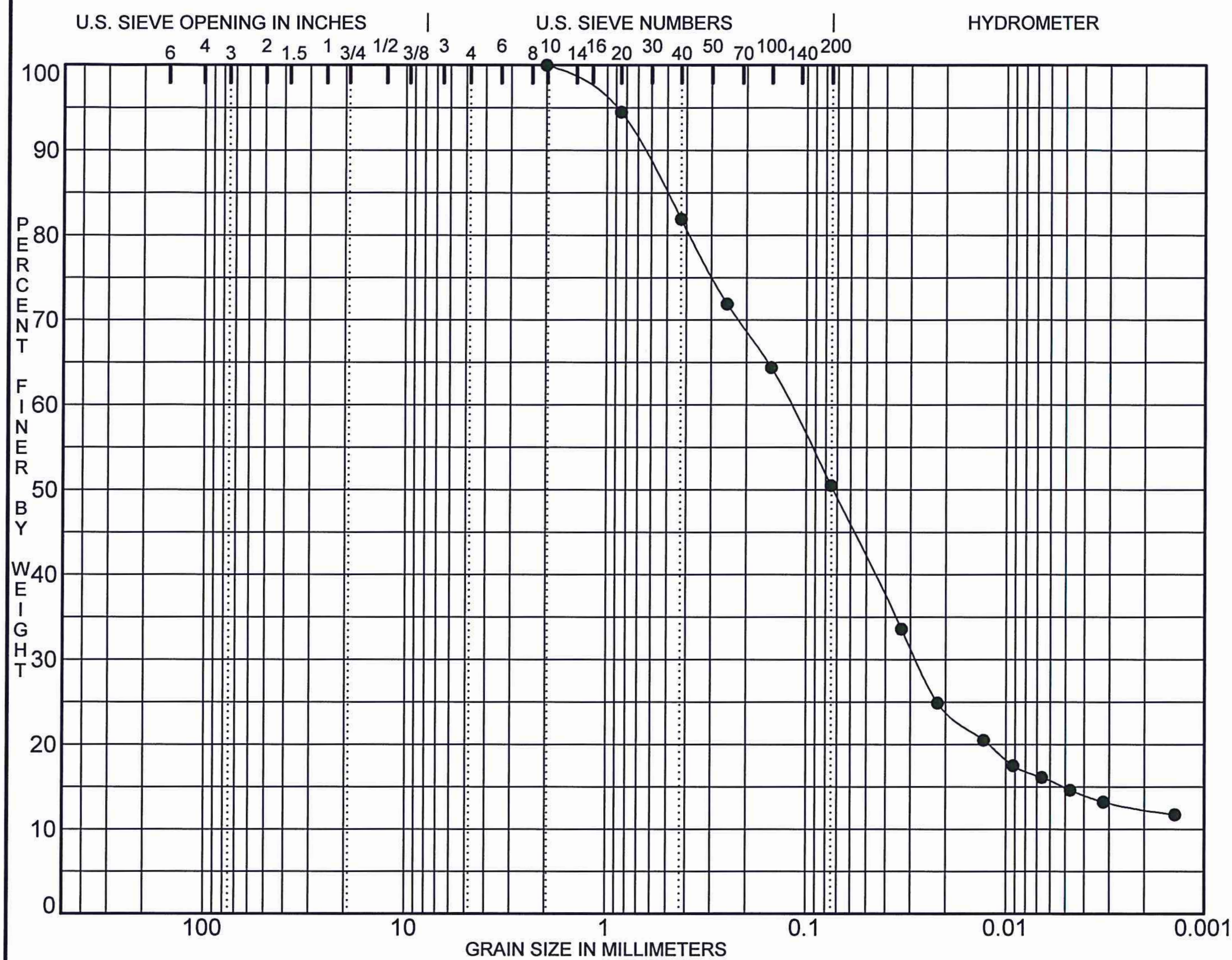
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	B- 6	0.0	Sand (SW-SM) - Fan Deposits					2.19	14.4

	Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
●	B- 6	0.0	37.50	1.11	0.433	0.8482	5.0	85.2	9.8	

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	GRAIN SIZE ANALYSIS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-4



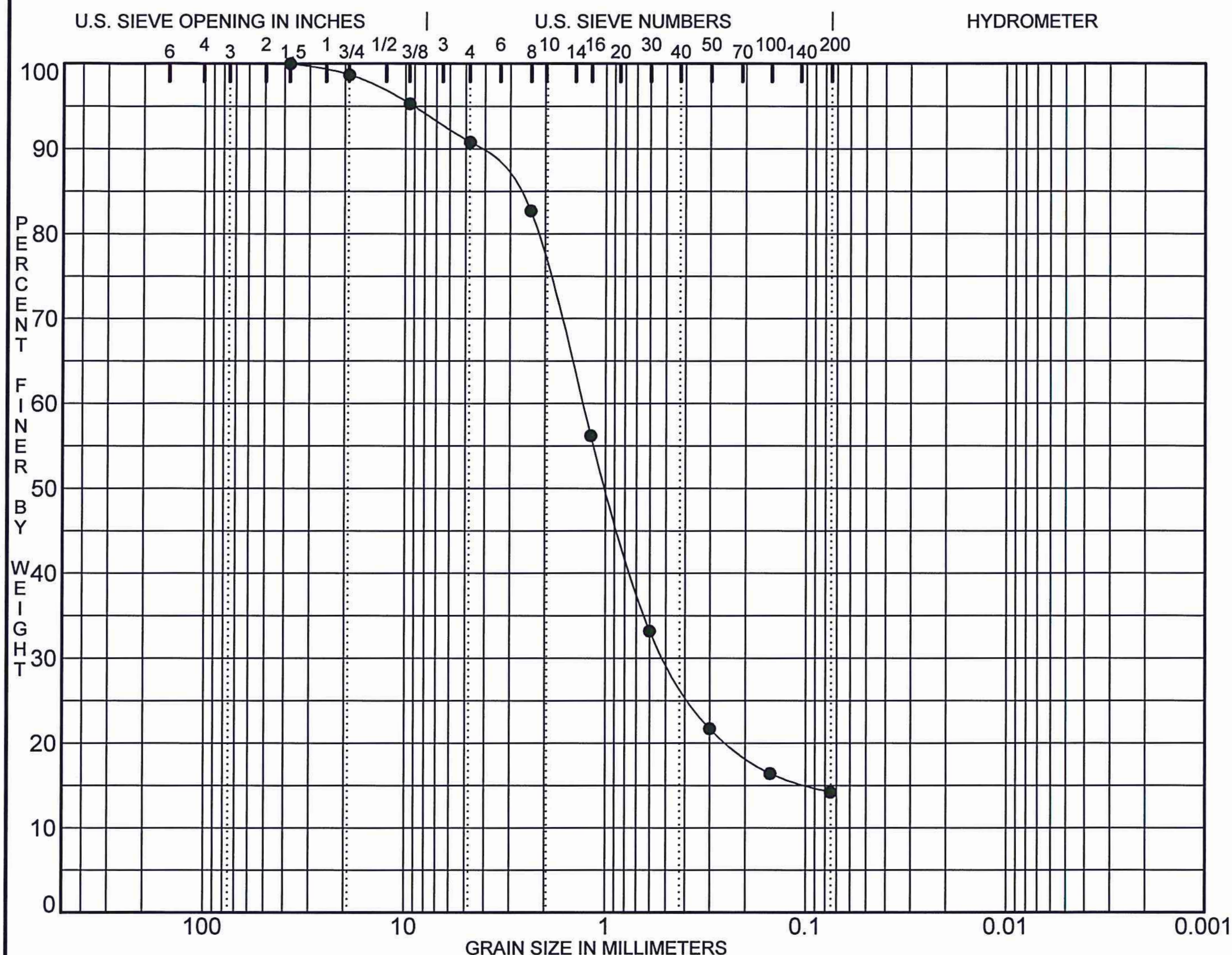
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	B-13	0.0	Sandy Silt (ML) - Palm Spring Formation		30	22	8		

	Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
●	B-13	0.0	2.00	0.12	0.028	0.0732	0.0	49.5	35.6	14.9

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	GRAIN SIZE ANALYSIS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-5



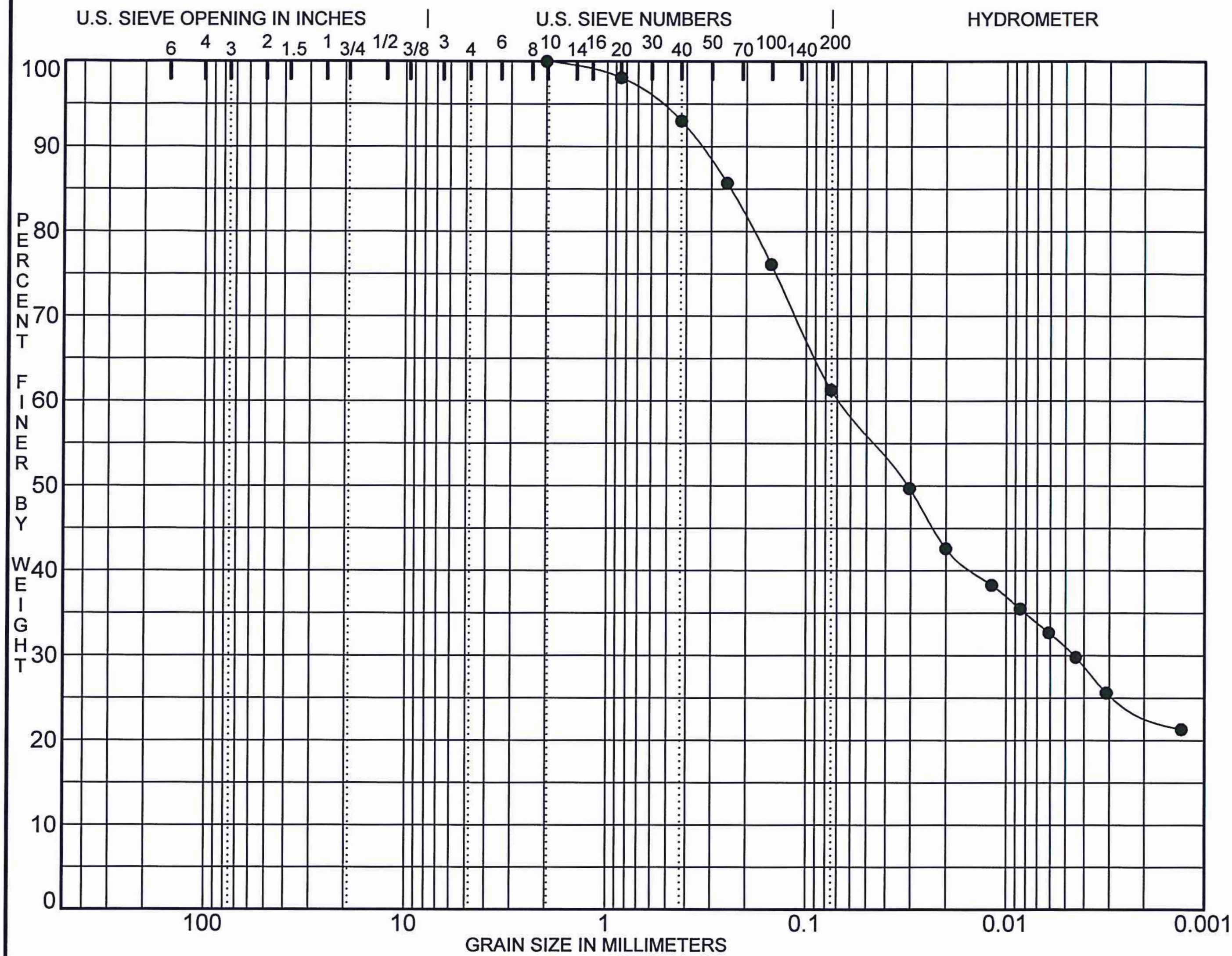
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
● B-18	15.0	Silty Sand (SM) - Ocotillo Conglomerate						

Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
● B-18	15.0	37.50	1.30	0.495	0.9833	9.2	76.6	14.2	

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	GRAIN SIZE ANALYSIS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-6



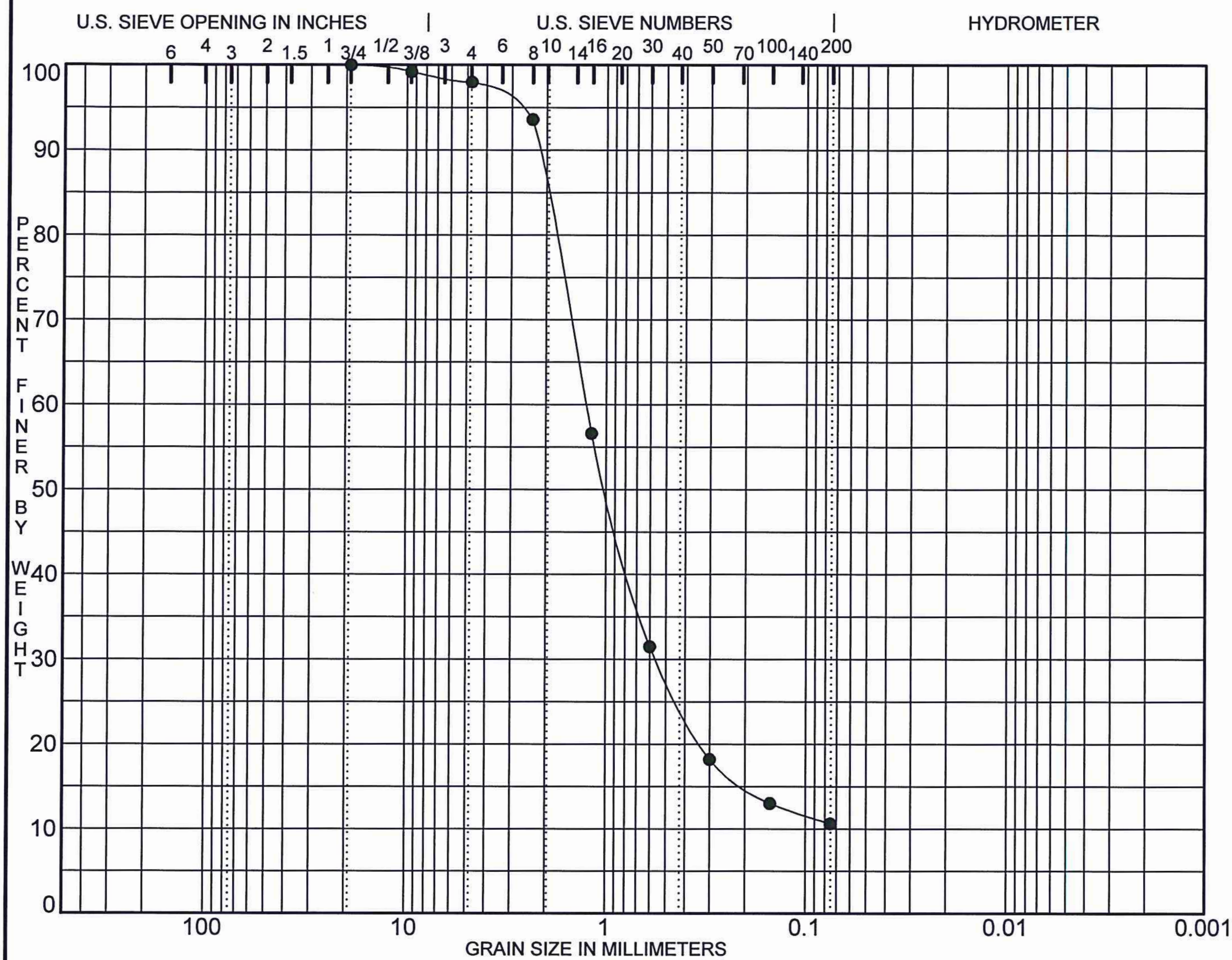
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	B-19	5.0	Sandy Silt (ML) - Palm Spring FM		27	15	12		

	Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
●	B-19	5.0	2.00	0.07	0.005	0.0311	0.0	38.7	30.4	30.9

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	GRAIN SIZE ANALYSIS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-7



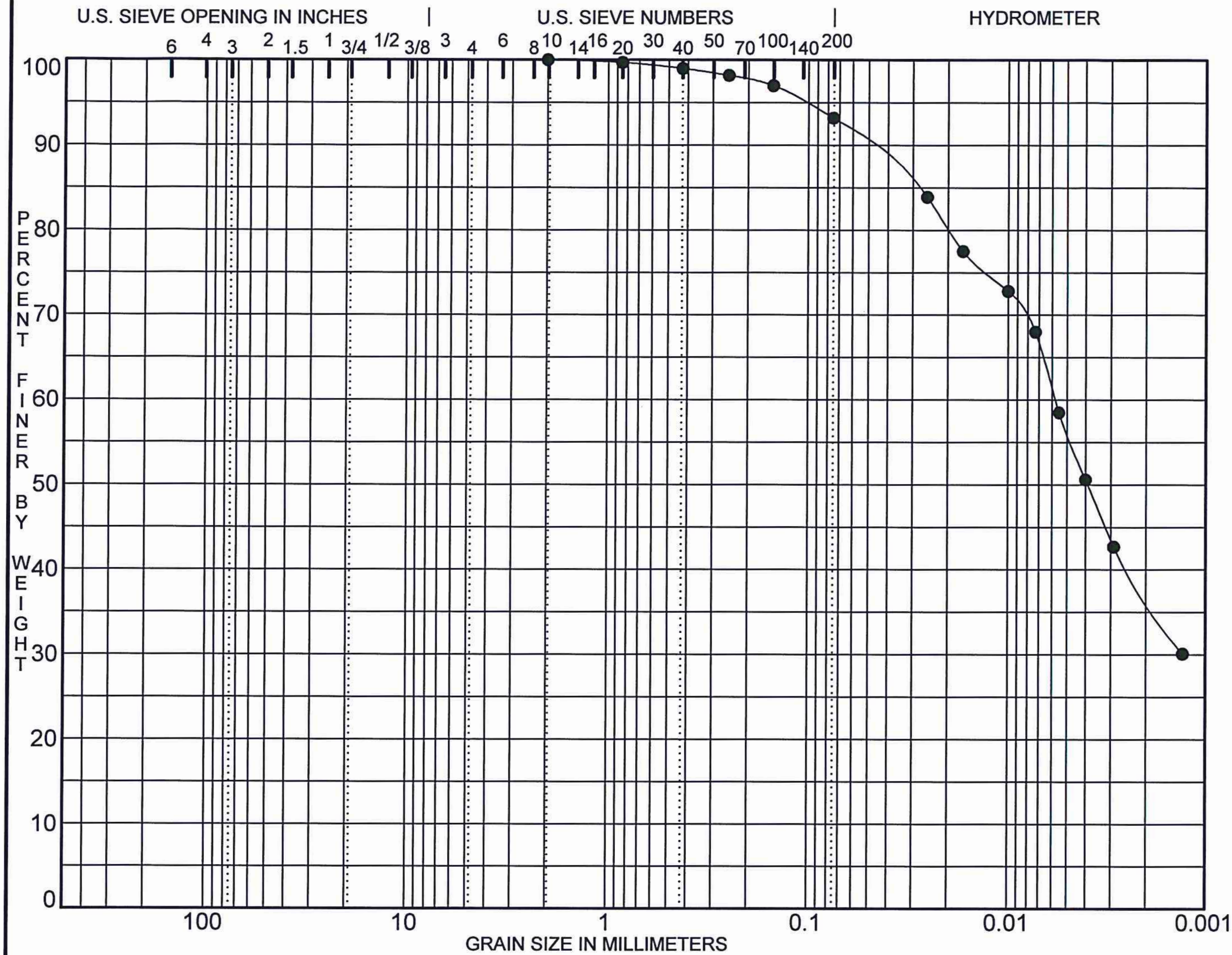
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	B-25	0.0	Sand (SP-SM) - Fan Deposits					3.88	19.9

	Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
●	B-25	0.0	19.00	1.26	0.555	0.9877	2.0	87.4	10.6	

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	**GRAIN SIZE ANALYSIS**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-8**



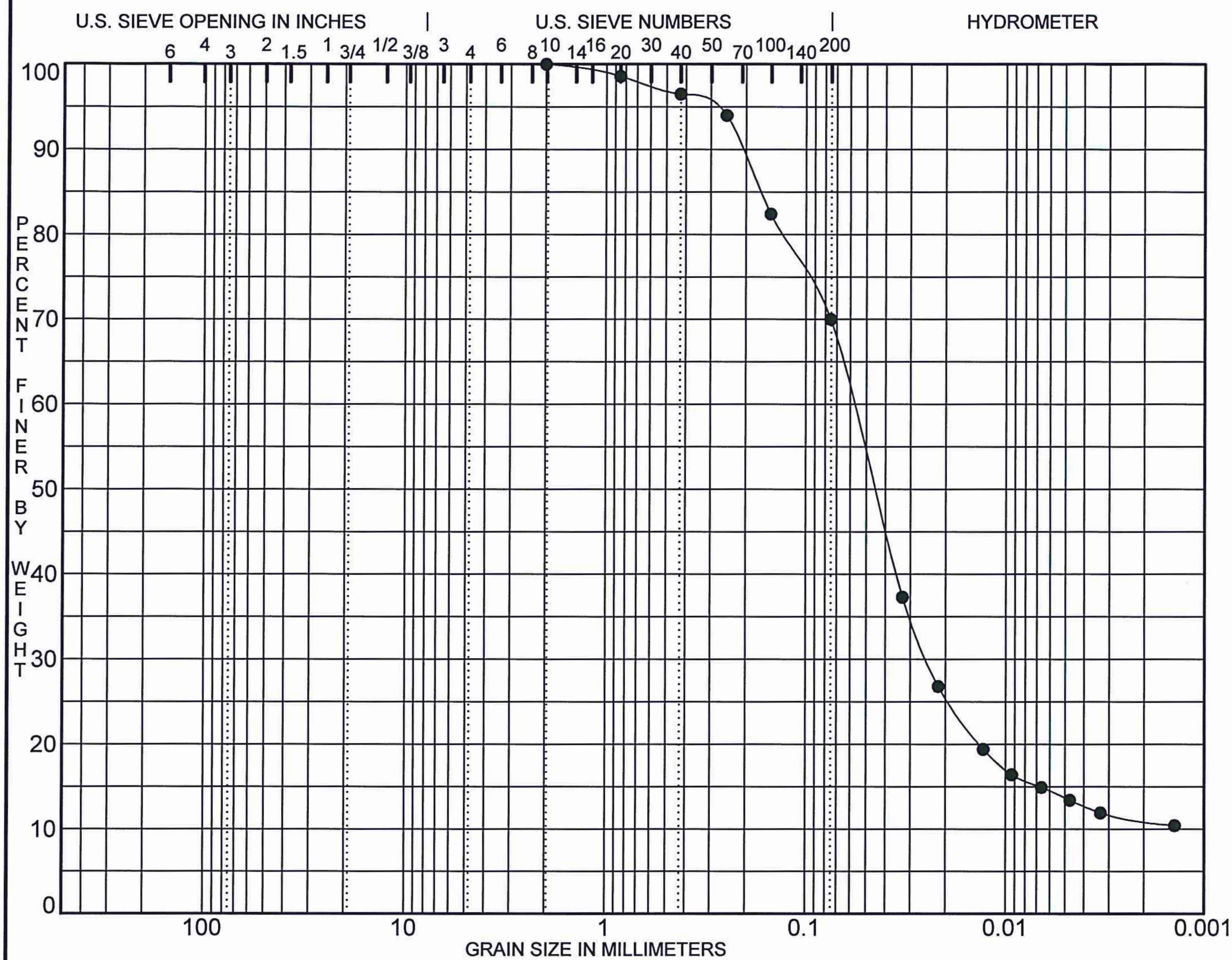
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	Outcrop#1	0.0	Clayey Silt (CL) - Palm Spring FM		43	21	22		

	Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
●	Outcrop#1	0.0	2.00	0.01		0.0039	0.0	6.8	37.1	56.1

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	GRAIN SIZE ANALYSIS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-9



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

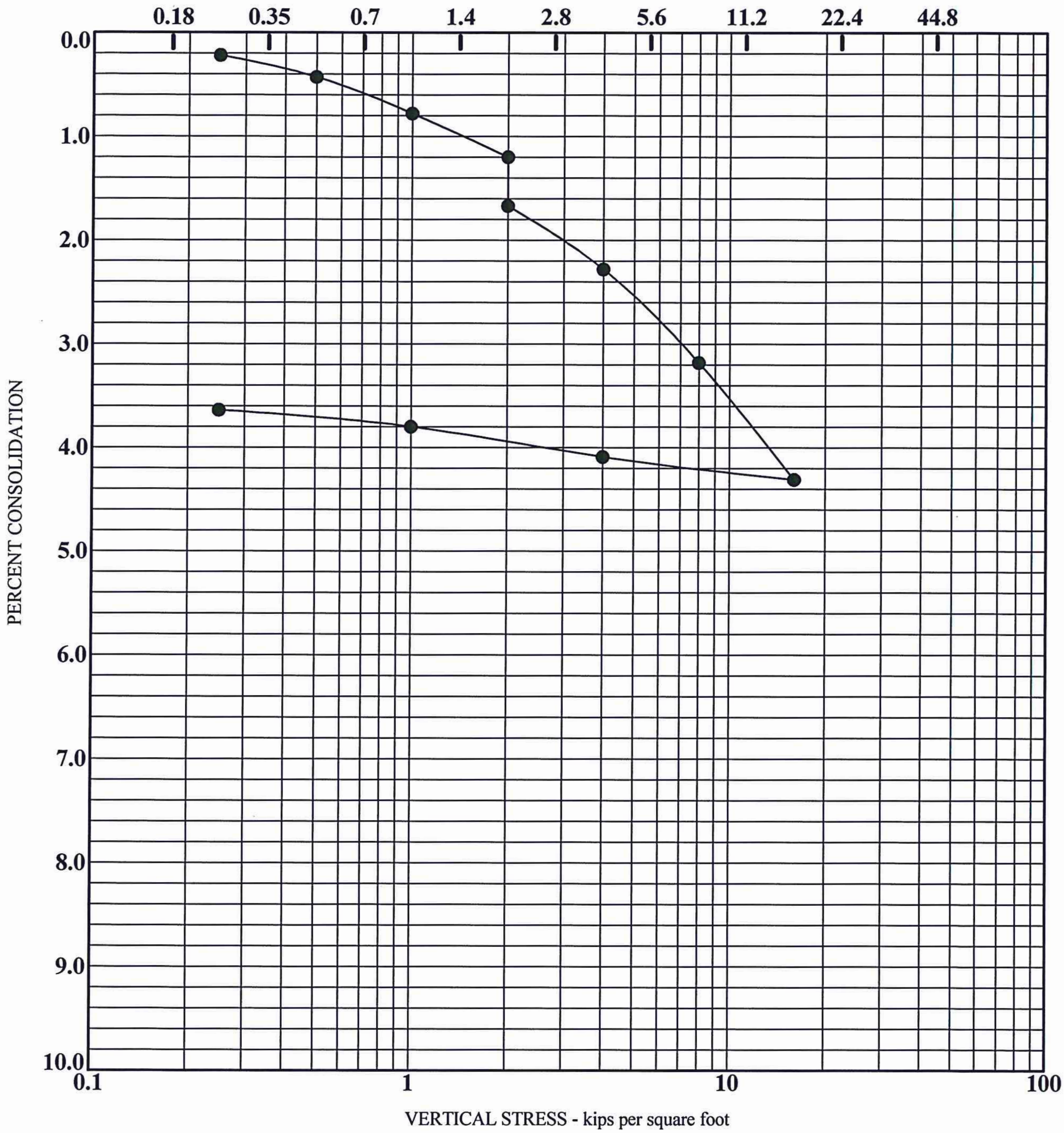
	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	TP-19	0.0	Silt (ML) - Palm Spring FM		NP	NP	NP		

	Specimen Identification		D100	D60	D30	D50	%Gravel	%Sand	%Silt	%Clay
●	TP-19	0.0	2.00	0.06	0.025	0.0452	0.0	30.0	56.3	13.7

GRAIN SIZE - V1 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	GRAIN SIZE ANALYSIS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-10

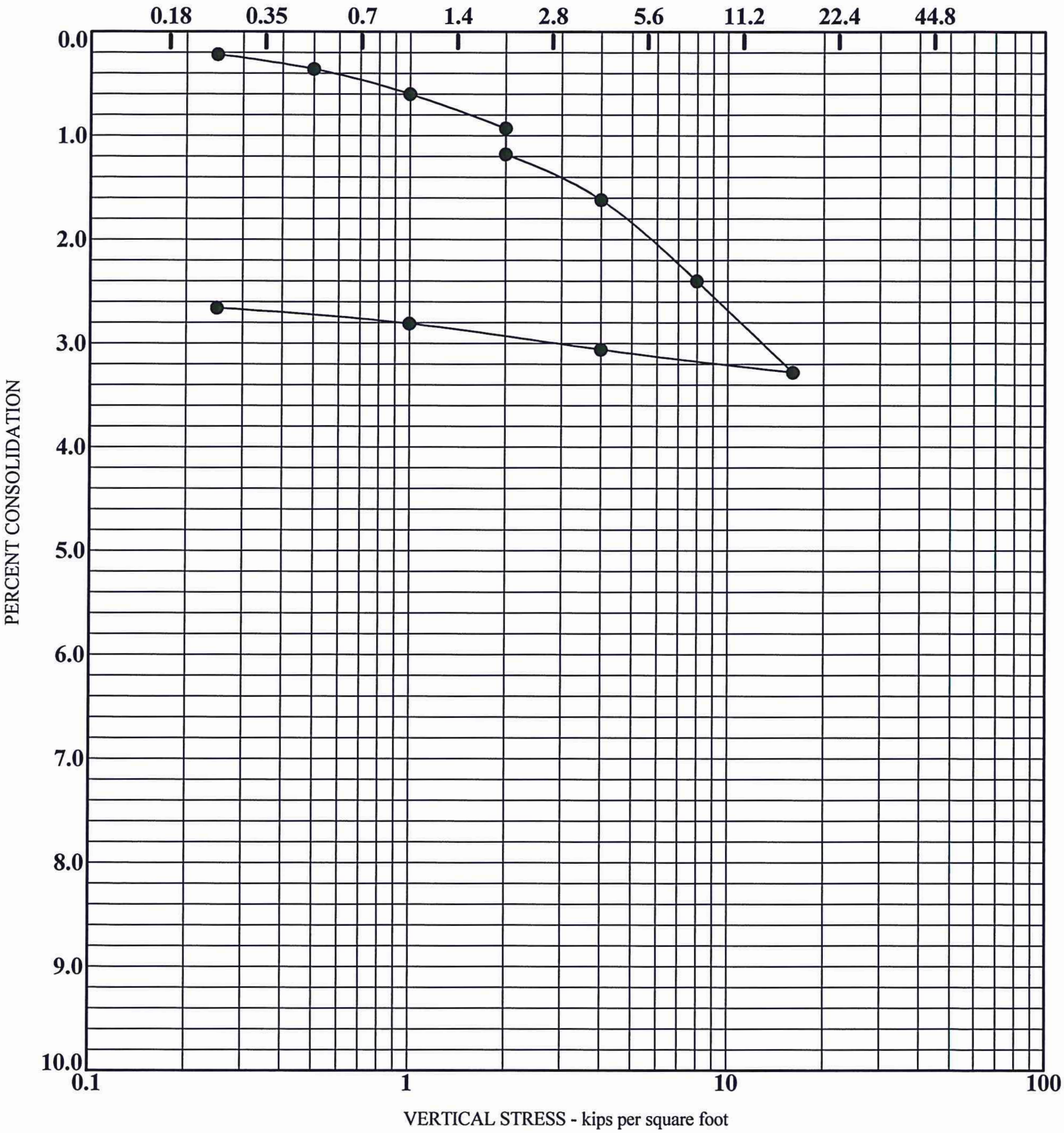
SAMPLE LOCATION	MATERIAL DESCRIPTION	INITIAL DENSITY (pcf)	INITIAL MOISTURE (%)	INITIAL SATURATION (%)	INUNDATED LOAD (ksf)
● B- 1 @ 7.5	Sand (SW) - Fan Deposits	119.4	1.2		



CONSOLIDATION - STRAIN 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	CONSOLIDATION TEST RESULTS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-11

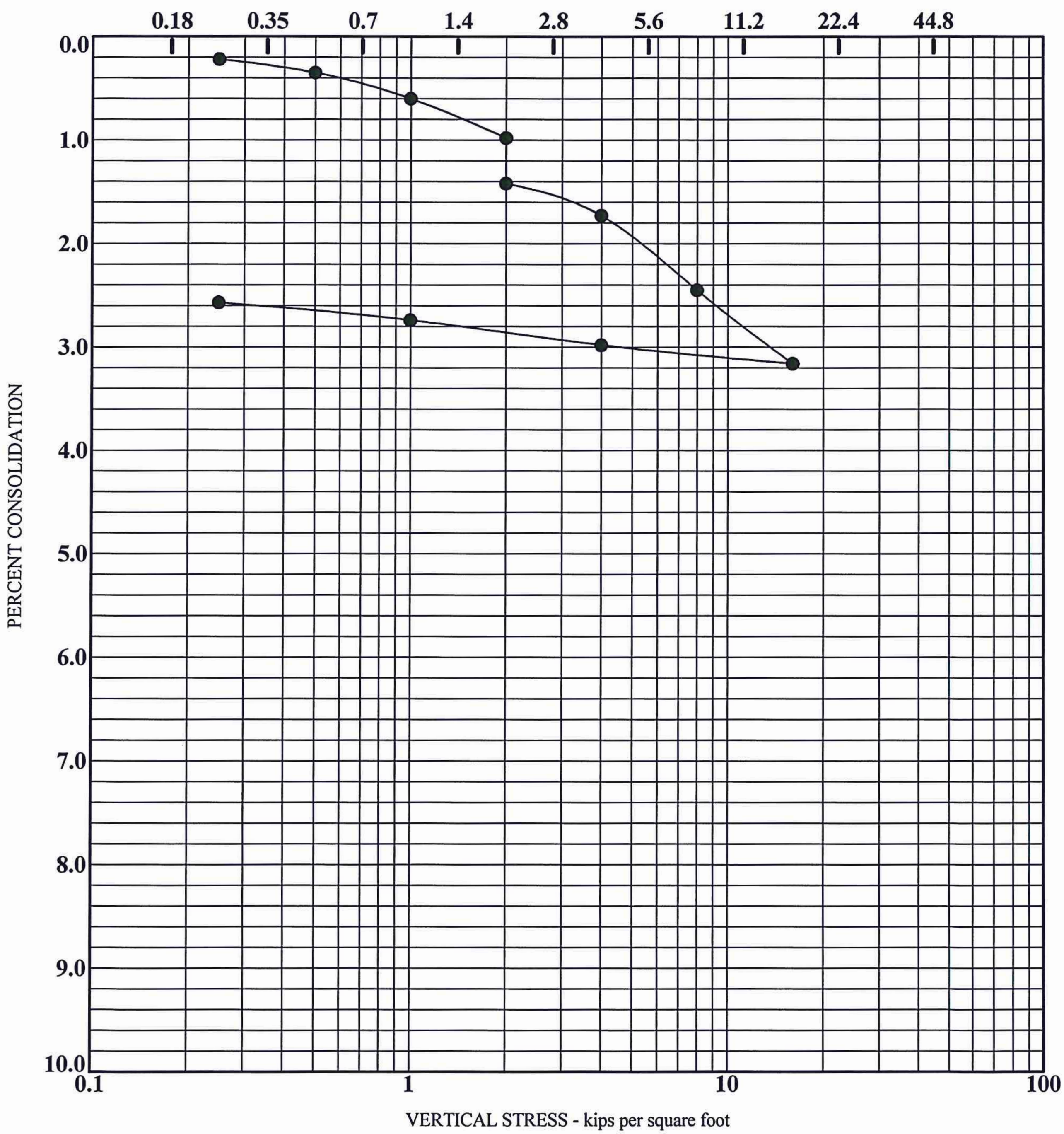
SAMPLE LOCATION	MATERIAL DESCRIPTION	INITIAL DENSITY (pcf)	INITIAL MOISTURE (%)	INITIAL SATURATION (%)	INUNDATED LOAD (ksf)
● B- 2 @ 5.0	Sand (SW-SM) - Fan Deposits	111.3	2.3		



CONSOLIDATION - STRAIN 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	CONSOLIDATION TEST RESULTS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-12

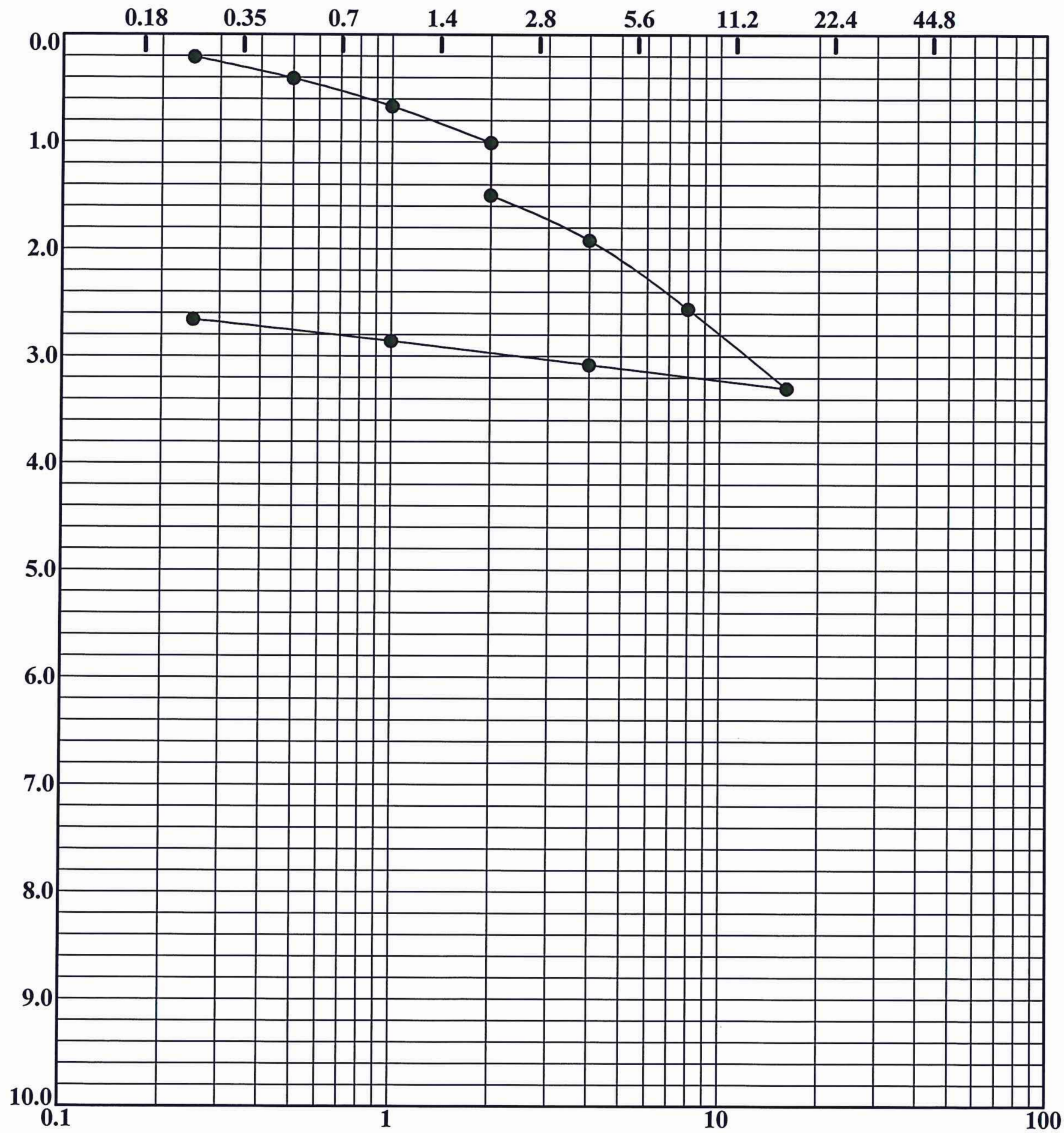
SAMPLE LOCATION	MATERIAL DESCRIPTION	INITIAL			INUNDATED
		DENSITY (pcf)	MOISTURE (%)	SATURATION (%)	LOAD (ksf)
● B- 3 @ 5.0	Sand (SW) - Fan Deposits	113.1	0.6		



CONSOLIDATION - STRAIN 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	CONSOLIDATION TEST RESULTS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-13

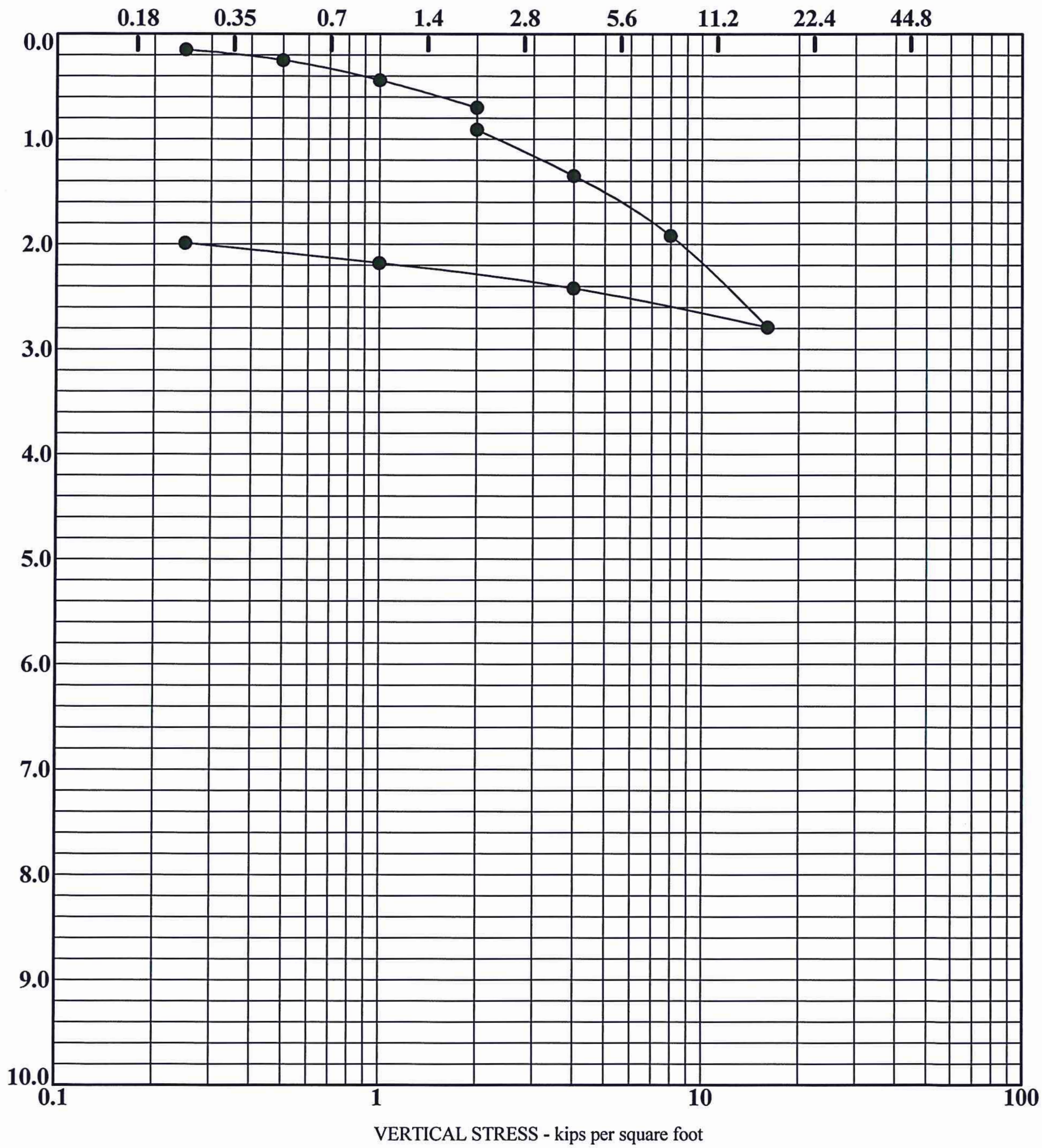
SAMPLE LOCATION	MATERIAL DESCRIPTION	INITIAL DENSITY (pcf)	INITIAL MOISTURE (%)	INITIAL SATURATION (%)	INUNDATED LOAD (ksf)
● B- 4 @ 10.0	Sand (SW-SM) - Fan Deposits	113.9	0.8		



CONSOLIDATION - STRAIN 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	CONSOLIDATION TEST RESULTS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-14

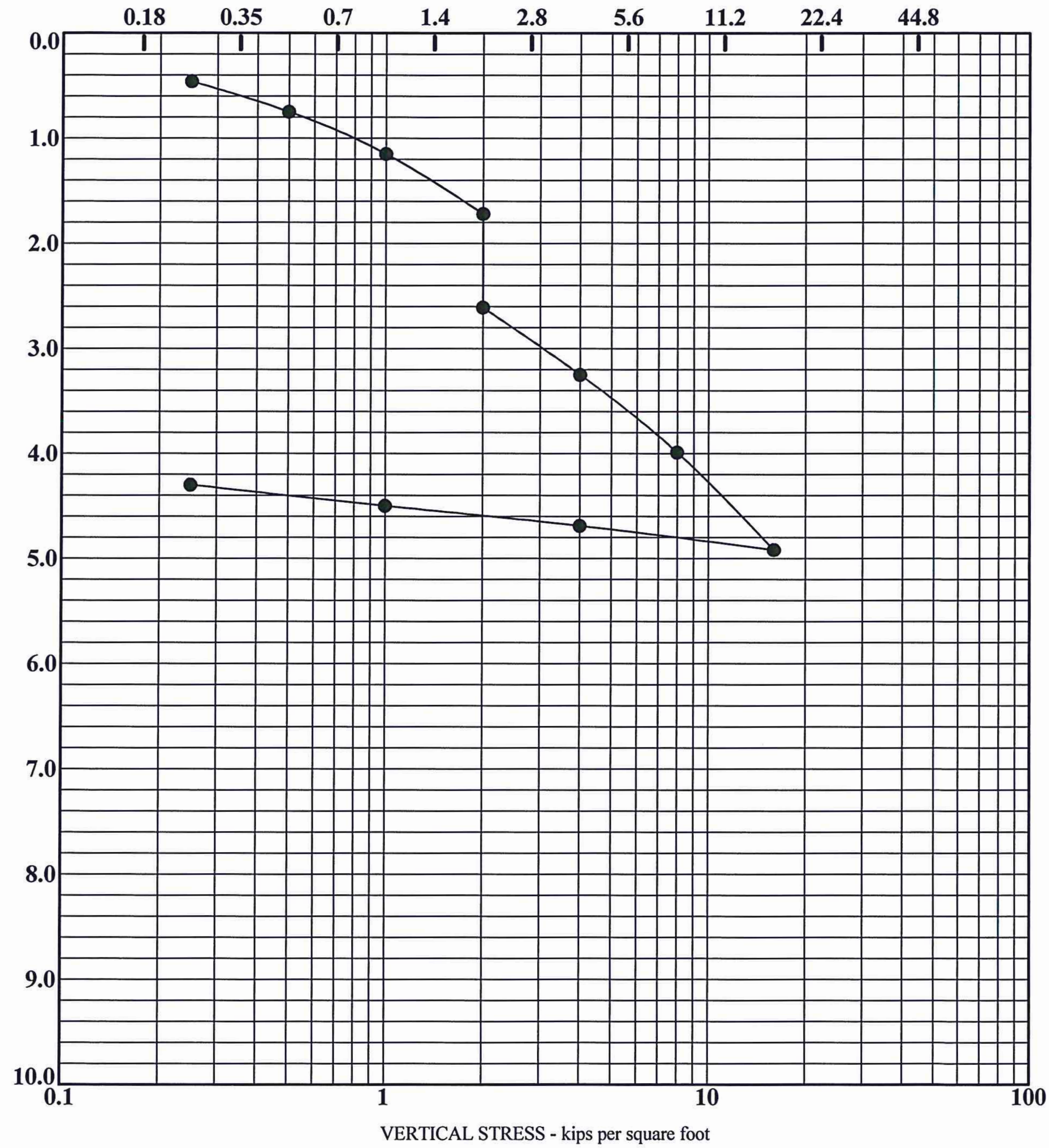
SAMPLE LOCATION	MATERIAL DESCRIPTION	INITIAL			INUNDATED
		DENSITY (pcf)	MOISTURE (%)	SATURATION (%)	LOAD (ksf)
● B- 7 @ 5.0	Sand (SW) - Fan Deposits	111.5	0.8		



CONSOLIDATION - STRAIN 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	CONSOLIDATION TEST RESULTS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-15

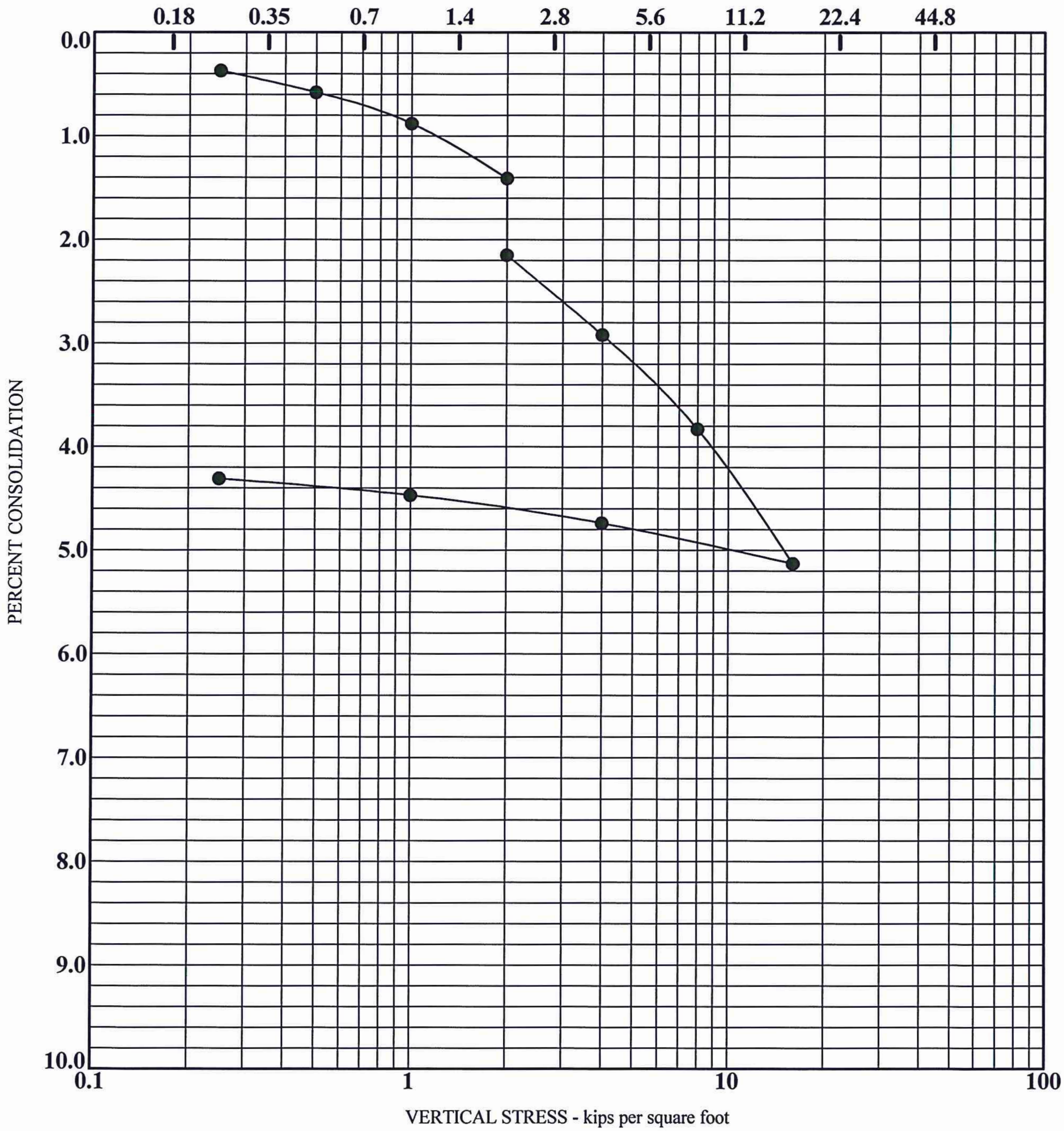
SAMPLE LOCATION	MATERIAL DESCRIPTION	INITIAL			INUNDATED
		DENSITY (pcf)	MOISTURE (%)	SATURATION (%)	LOAD (ksf)
● B-17 @ 5.0	Sand (SP) - Ocotillo Fm.	115.6	1.2		



CONSOLIDATION - STRAIN 376-11LAB.GPJ PETRA.GDT 2/4/13

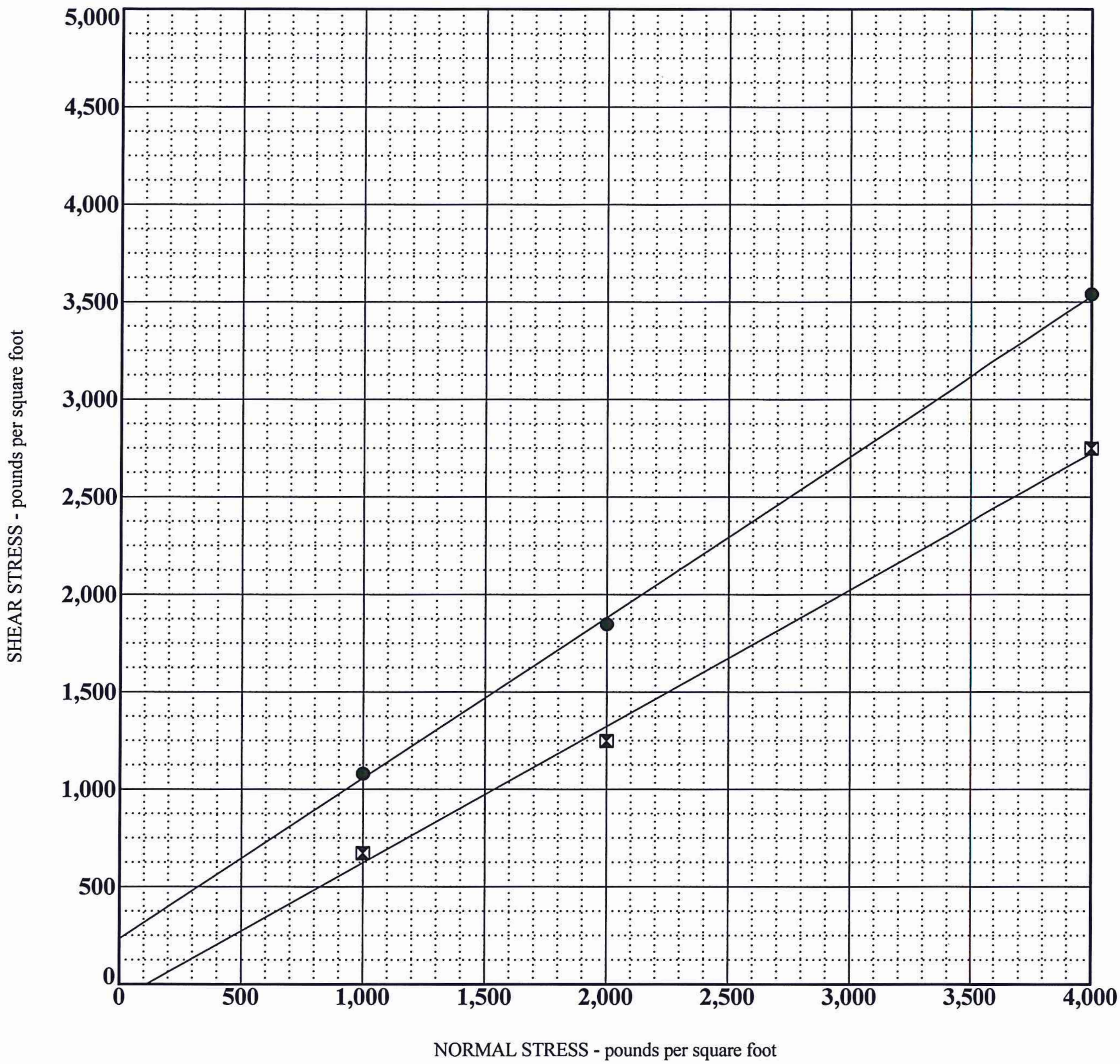
J.N. 376-11	CONSOLIDATION TEST RESULTS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-16

SAMPLE LOCATION	MATERIAL DESCRIPTION	INITIAL DENSITY (pcf)	INITIAL MOISTURE (%)	INITIAL SATURATION (%)	INUNDATED LOAD (ksf)
● B-18 @ 10.0	Silty Sand (SM) - Ocotillo Conglomerate	110.1	1.4		



CONSOLIDATION - STRAIN 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	CONSOLIDATION TEST RESULTS	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-17



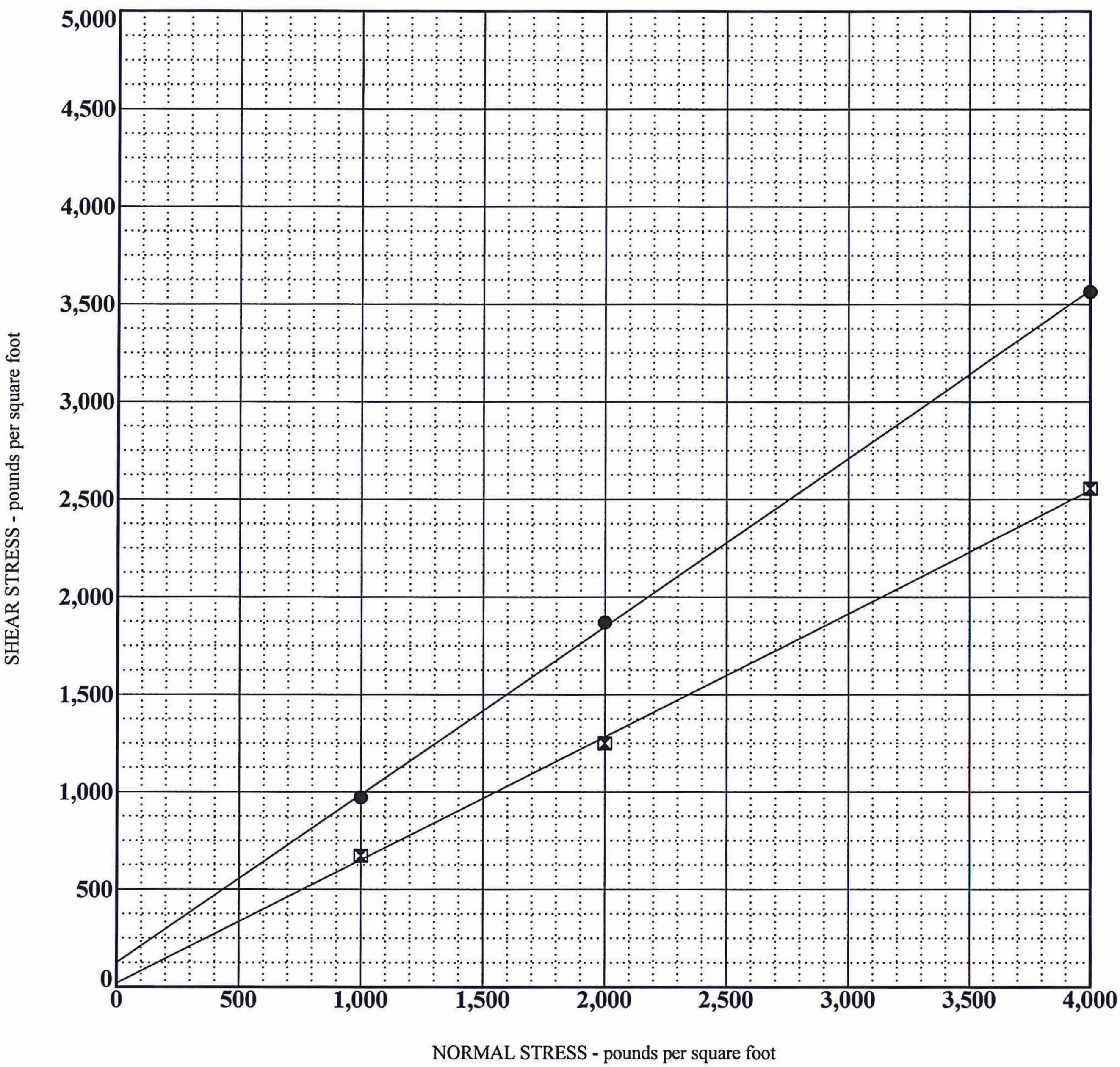
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B- 1 @ 0.0	Sand (SW) - Fan Deposits - Peak	39	230
⊠ B- 1 @ 0.0	Sand (SW) - Fan Deposits - Ultimate	35	0

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-18

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



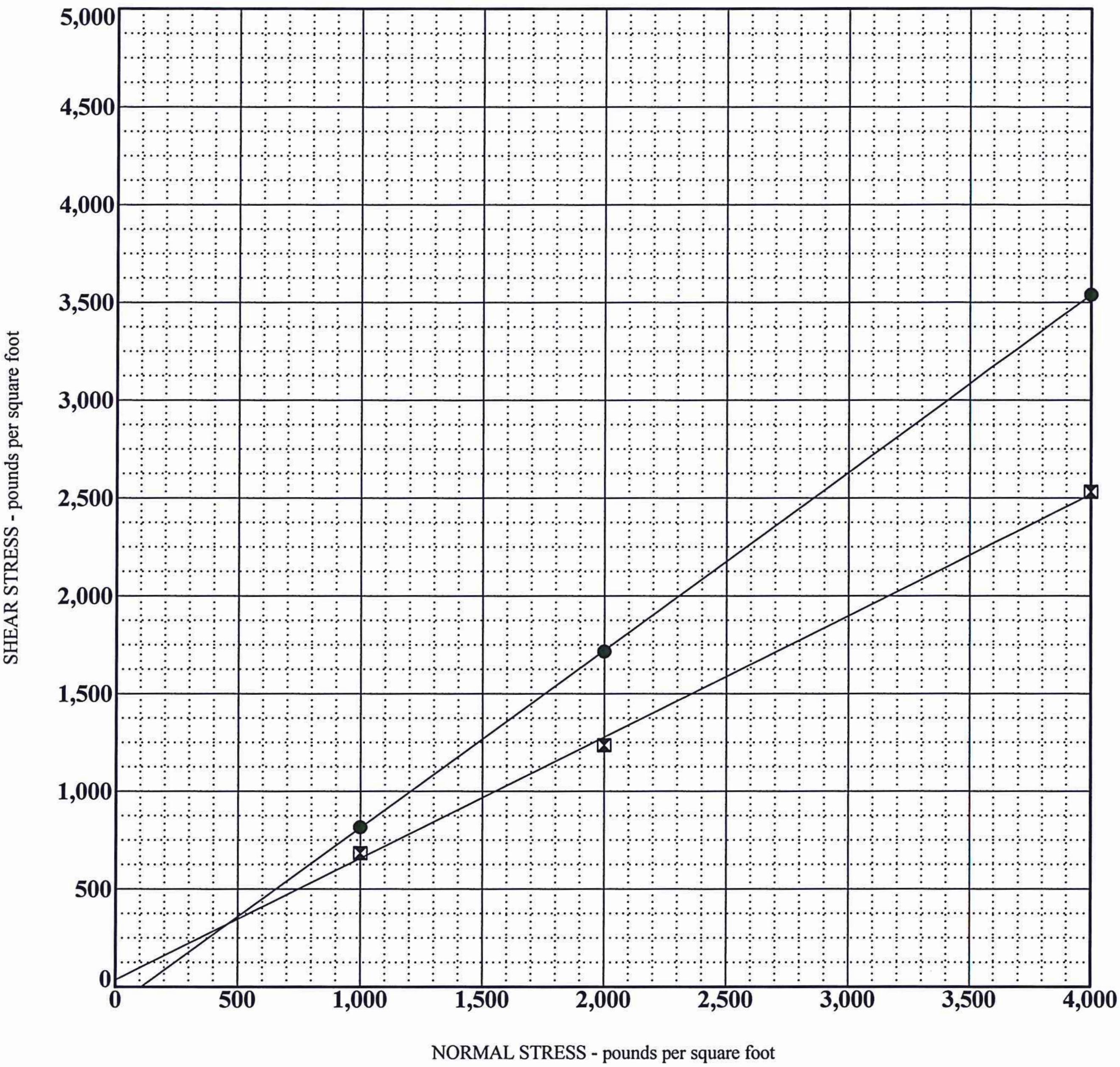
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B- 2 @ 0.0	Sand (SW-SM) - Fan Deposits - Peak	41	125
⊠ B- 2 @ 0.0	Sand (SW-SM) - Fan Deposits - Ultimate	32	20

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	**DIRECT SHEAR TEST DATA**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-19**



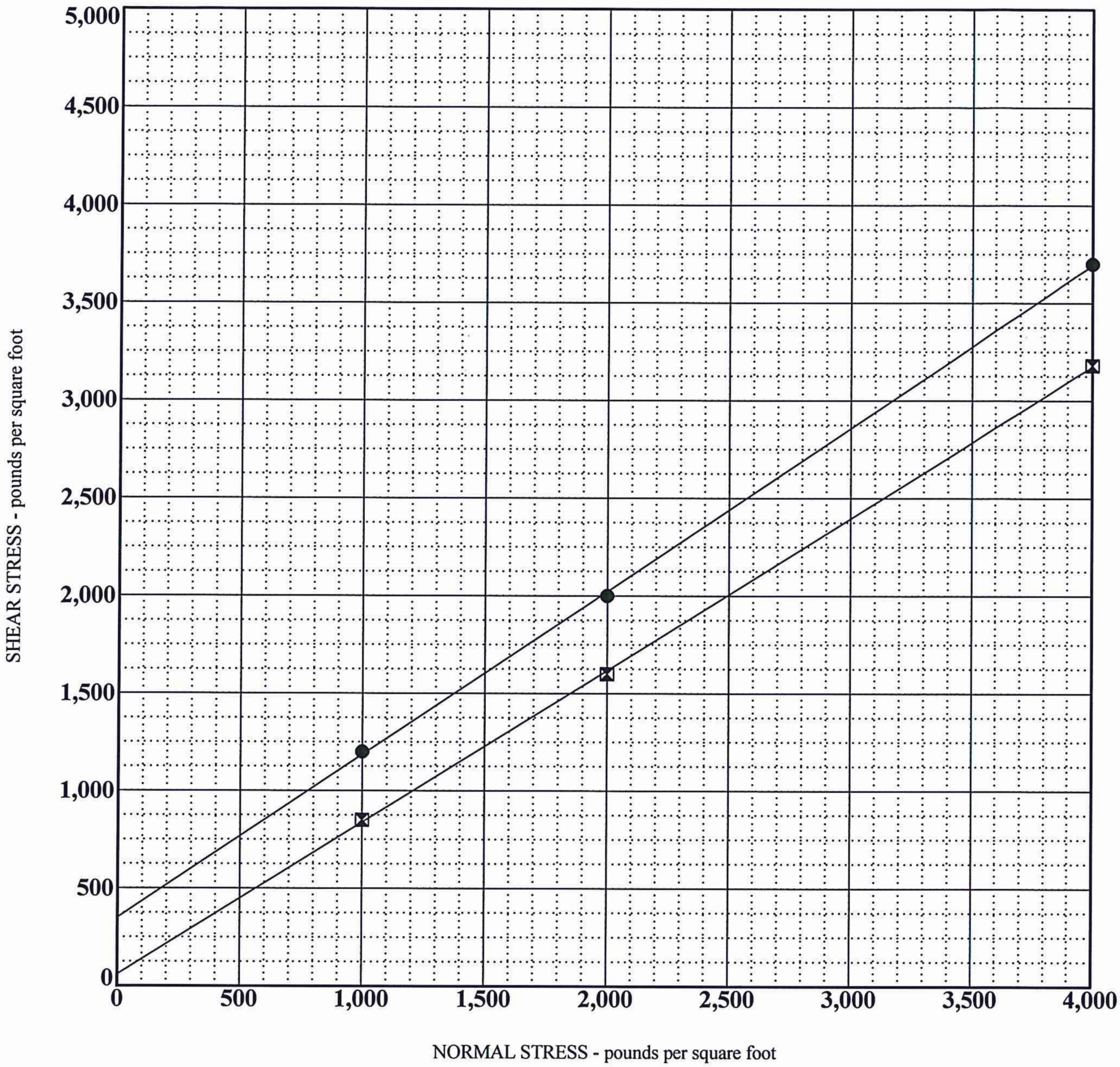
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B- 2 @ 15.0	Silty Sand (SM) Palm Spring Fm - Peak	42	0
⊠ B- 2 @ 15.0	Silty Sand (SM) Palm Spring Fm - Ultimate	32	40

NOTES:

Undisturbed Test Samples
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	**DIRECT SHEAR TEST DATA**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-20**

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



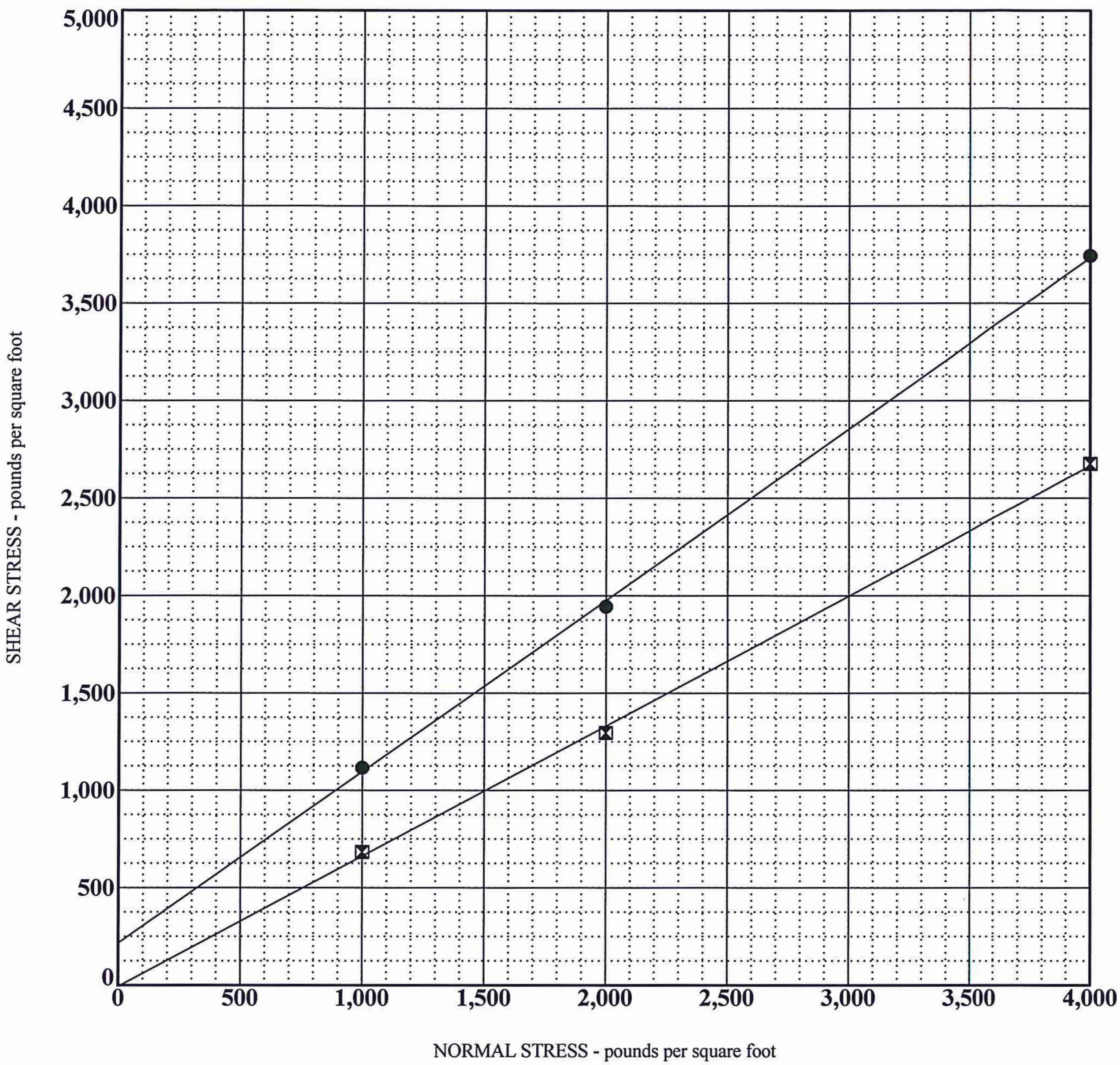
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B- 3 @ 10.0	Sand (SW) - Fan Deposits - Peak	40	350
⊠ B- 3 @ 10.0	Sand (SW) - Fan Deposits - Ultimate	38	60

NOTES:

Undisturbed Test Samples
All Samples Were Presoaked Prior to Shearing

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-21



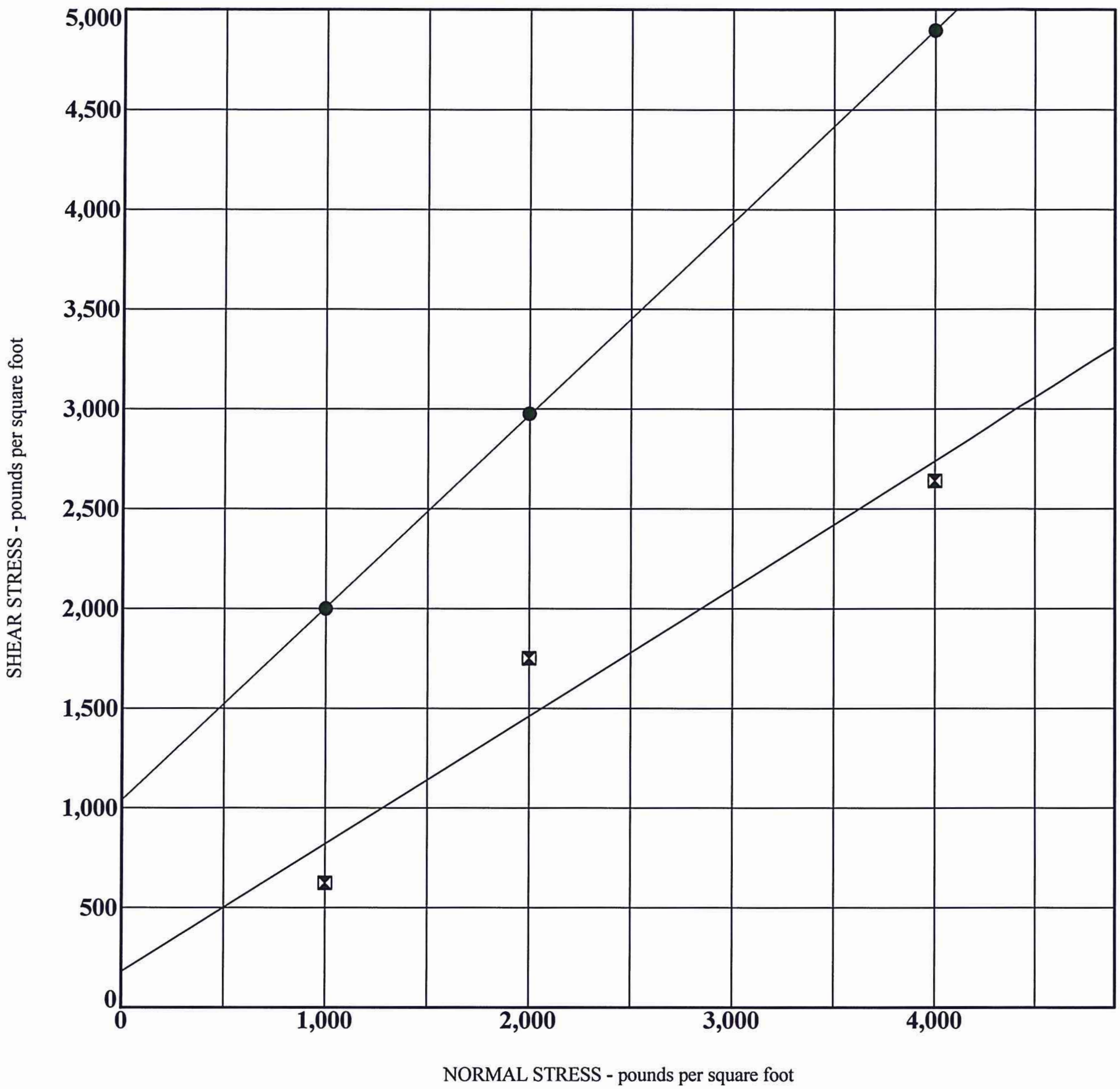
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B- 6 @ 0.0	Sand (SW-SM) - Fan Deposits - Peak	41	220
⊠ B- 6 @ 0.0	Sand (SW-SM) - Fan Deposits - Ultimate	34	0

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-22

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



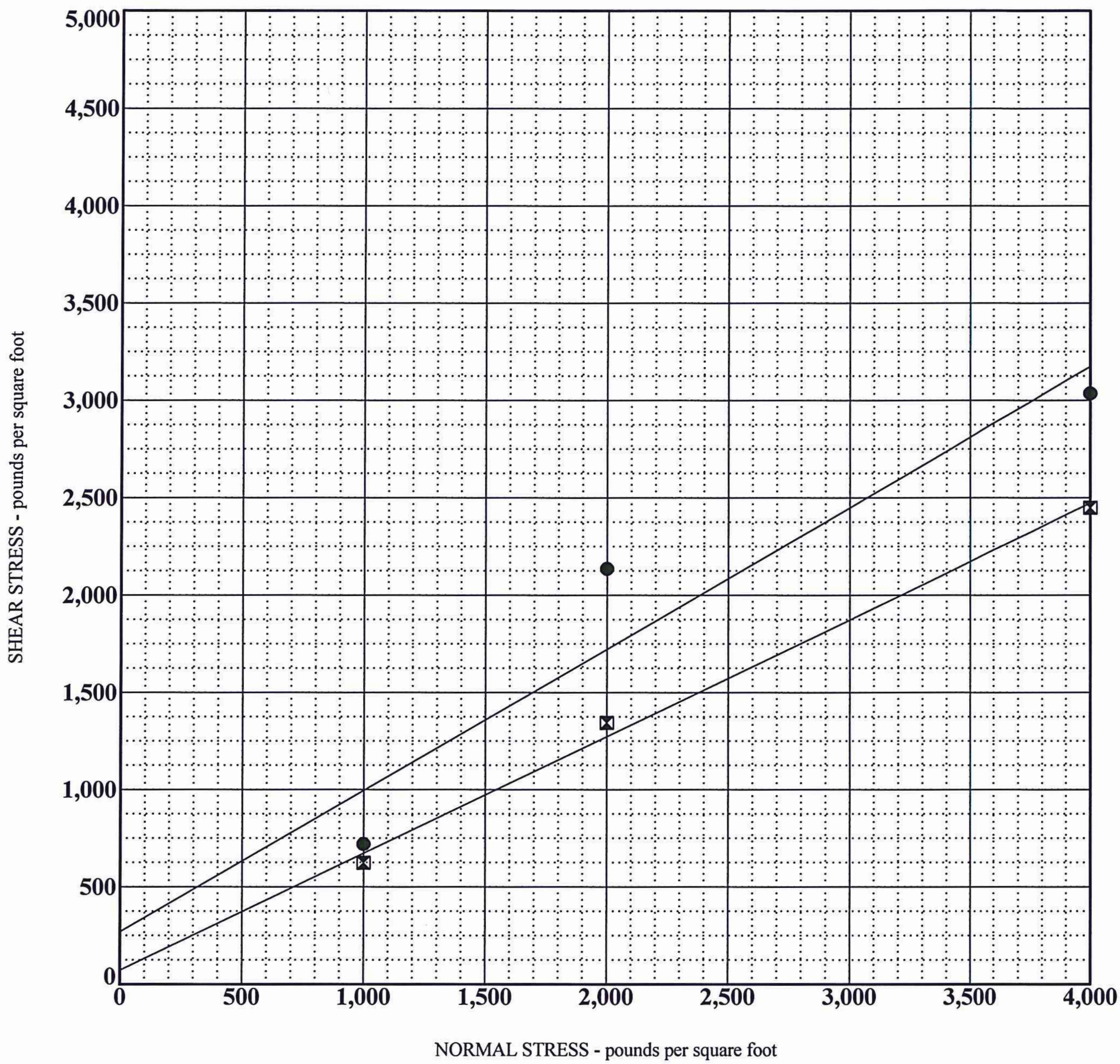
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B- 9 @ 30.0	Sandy Silt (ML) - Palm Spring Fm. - Peak	44	1040
⊠ B- 9 @ 30.0	Sandy Silt (ML) - Palm Spring Fm. - Ultimate	33	180

NOTES:

Undisturbed Test Samples
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-23

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



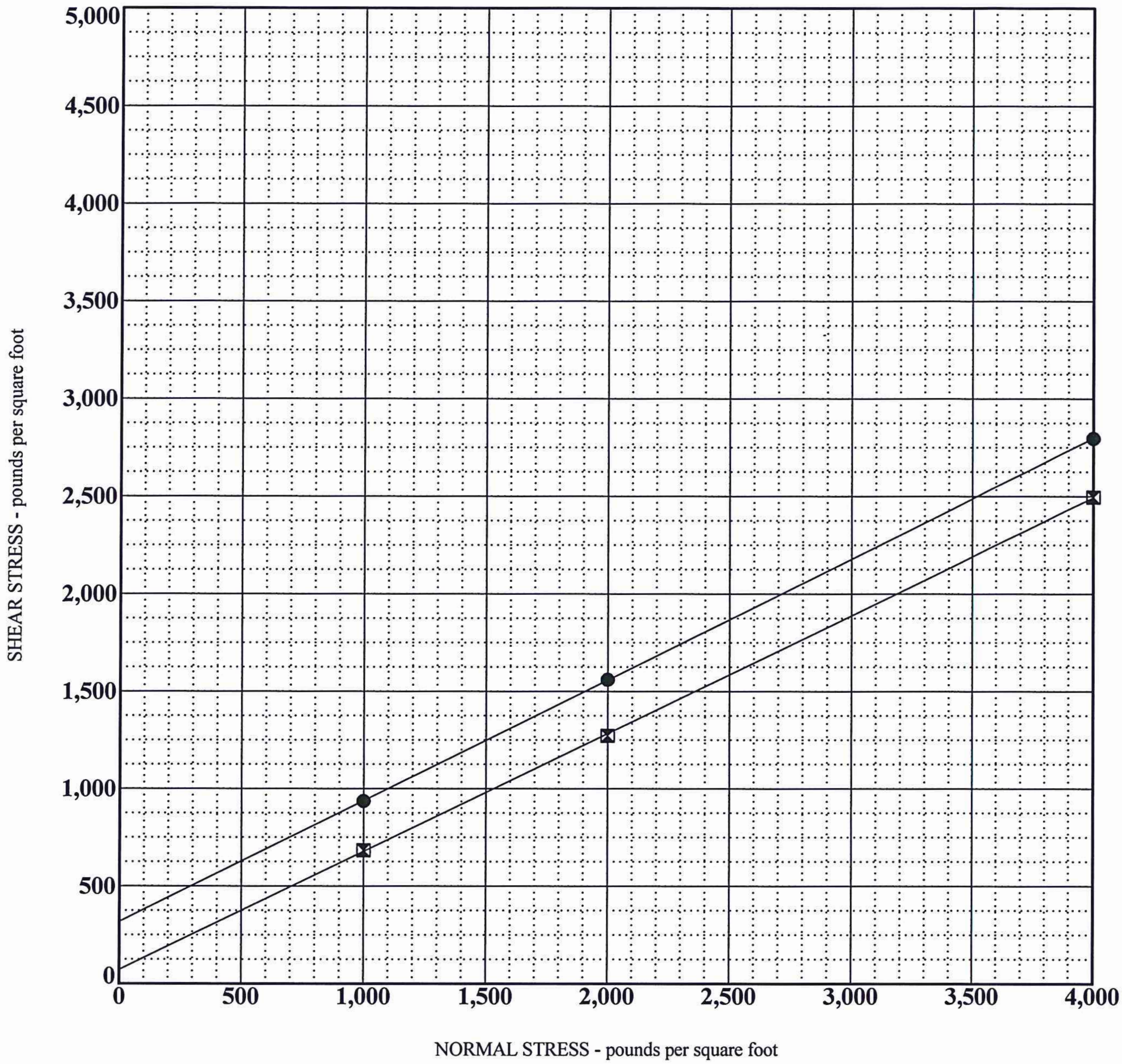
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-12 @ 15.0	Sandy Silt (ML) - Palm Spring Fm - Peak	36	270
⊠ B-12 @ 15.0	Sandy Silt (ML) - Palm Spring Fm - Ultimate	31	70

NOTES:

Undisturbed Test Samples
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-24

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



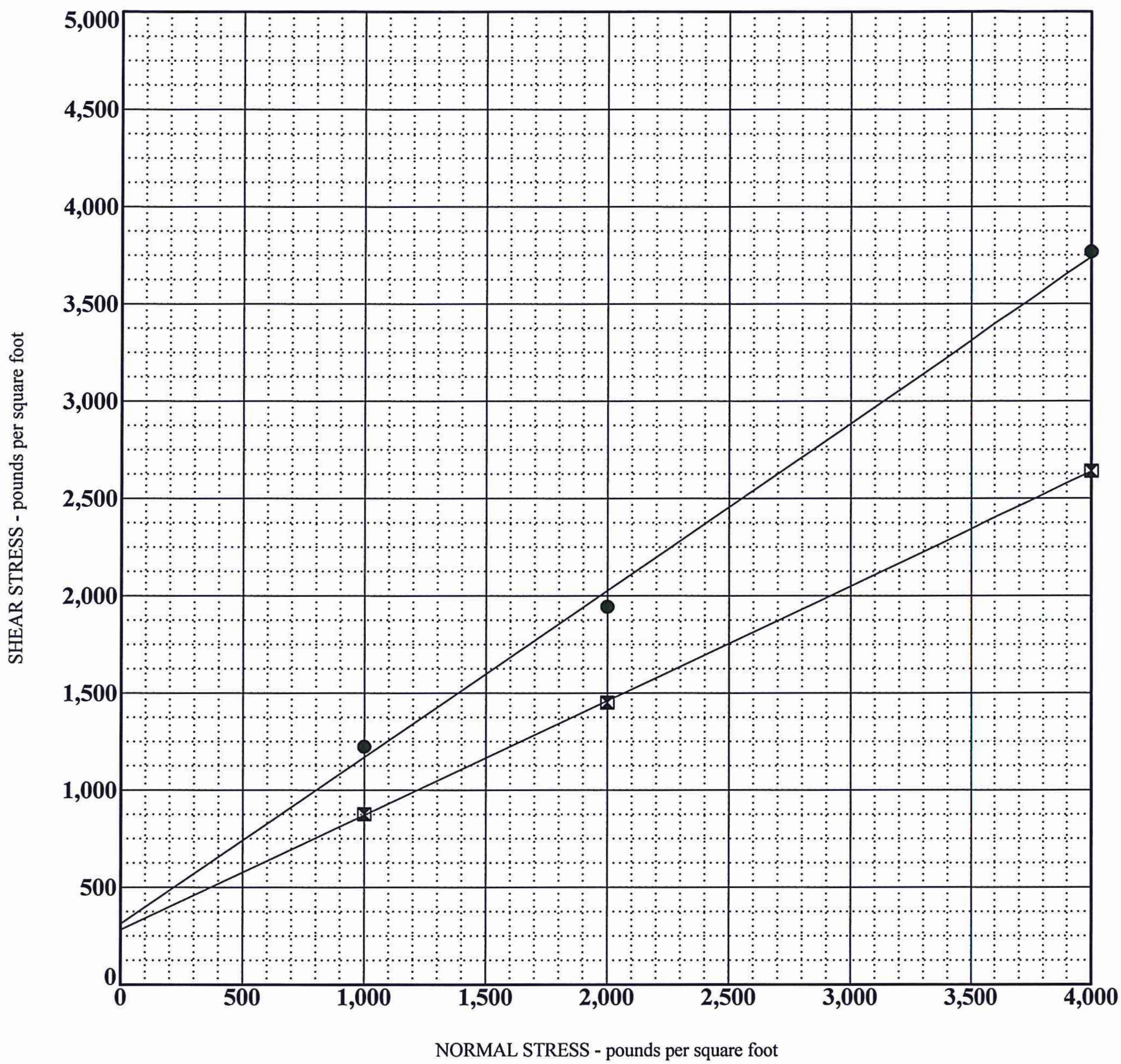
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-13 @ 0.0	Sandy Silt (ML) Palm Spring FM - Peak	32	320
⊠ B-13 @ 0.0	Sandy Silt (ML) Palm Spring FM - Ultimate	31	70

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-25



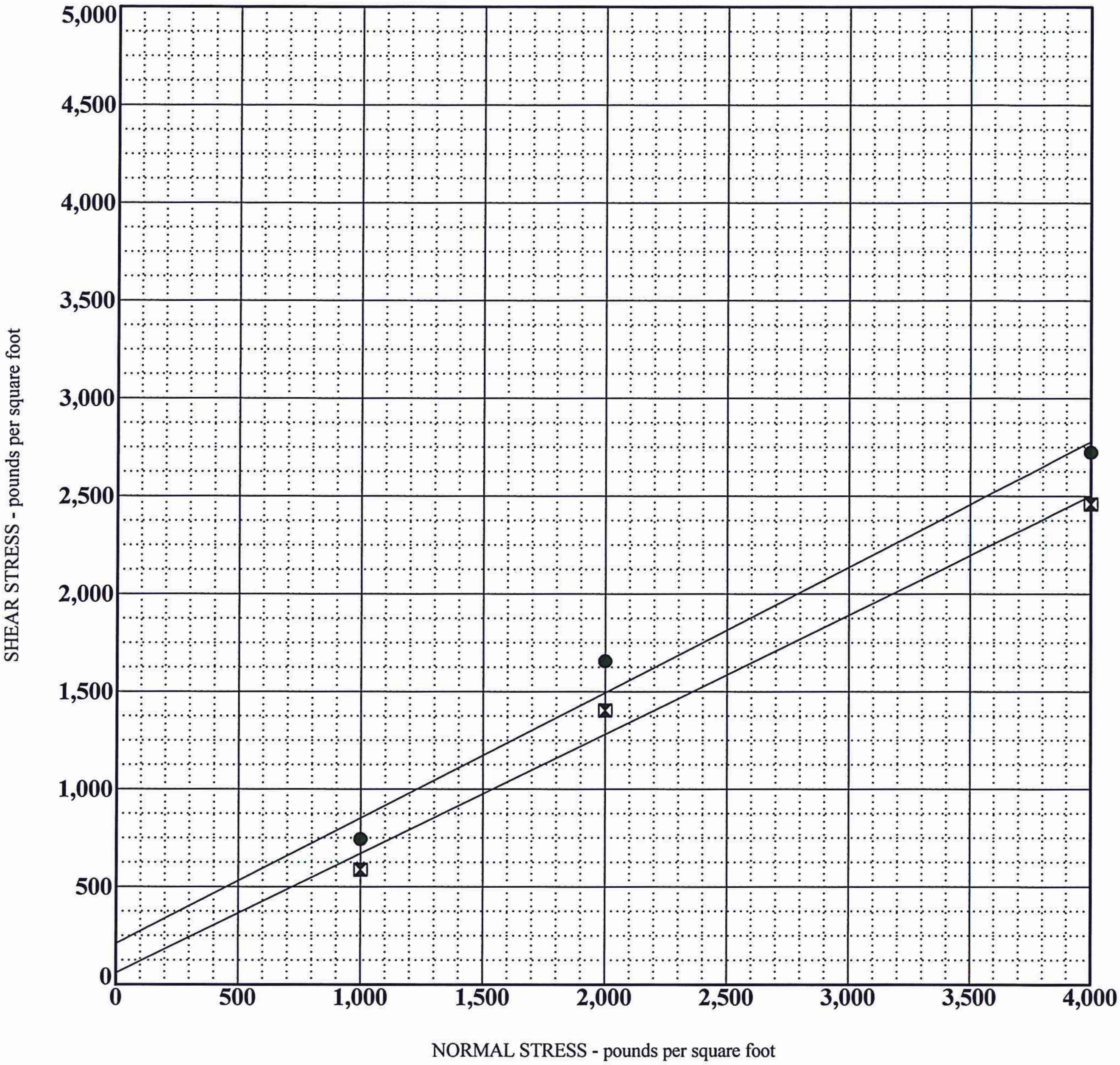
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-14 @ 5.0	Sand (SW) - Fan Deposits - Peak	41	310
⊠ B-14 @ 5.0	Sand (SW) - Fan Deposits - Ultimate	30	280

NOTES:

Undisturbed Test Samples
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-26

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



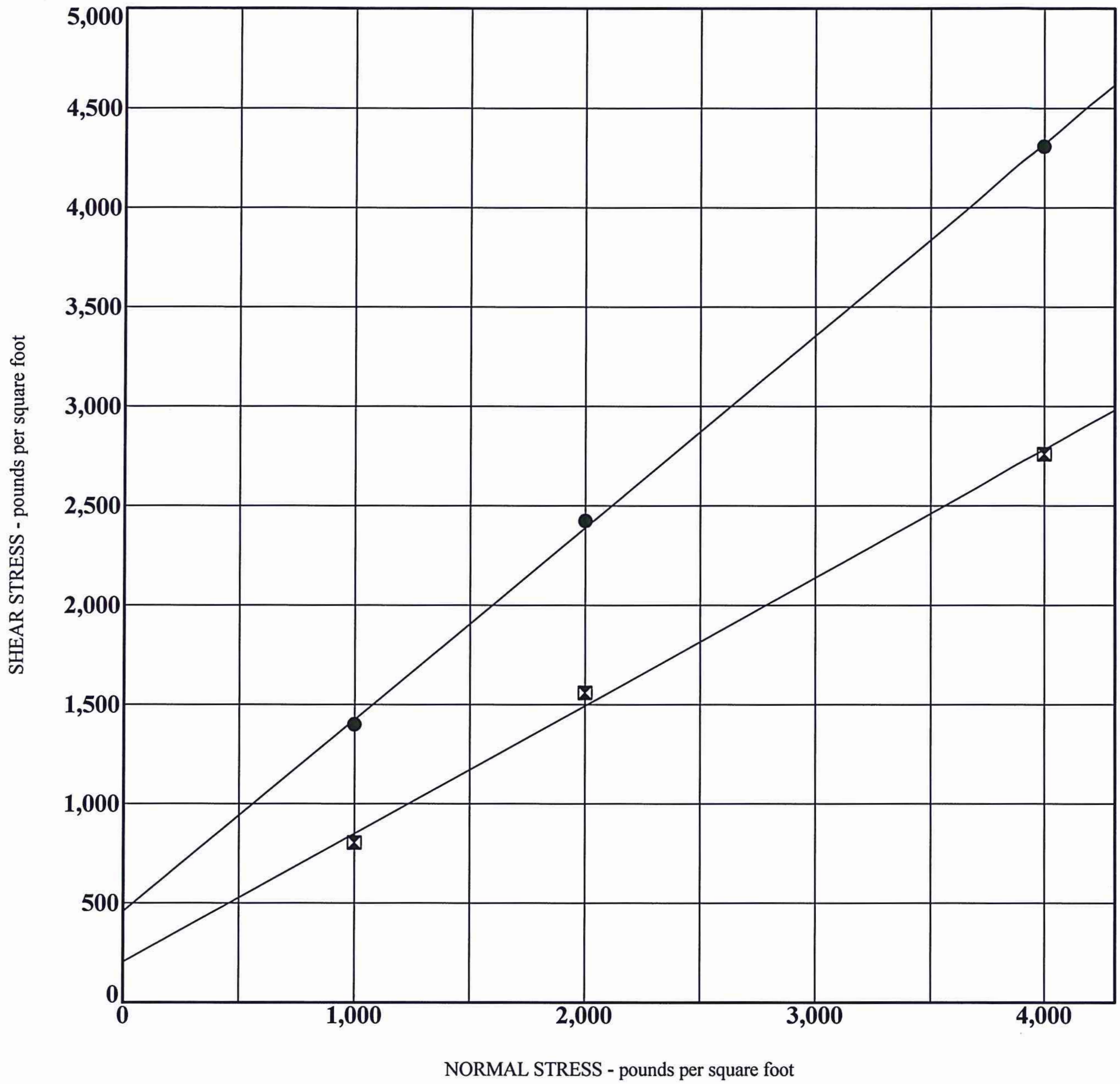
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-16 @ 15.0	Sandy Silt (ML) - Palm Spring Fm - Peak	33	210
☒ B-16 @ 15.0	Sandy Silt (ML) - Palm Spring Fm - Ultimate	32	60

NOTES:

Undisturbed Test Samples
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	**DIRECT SHEAR TEST DATA**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-27**

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



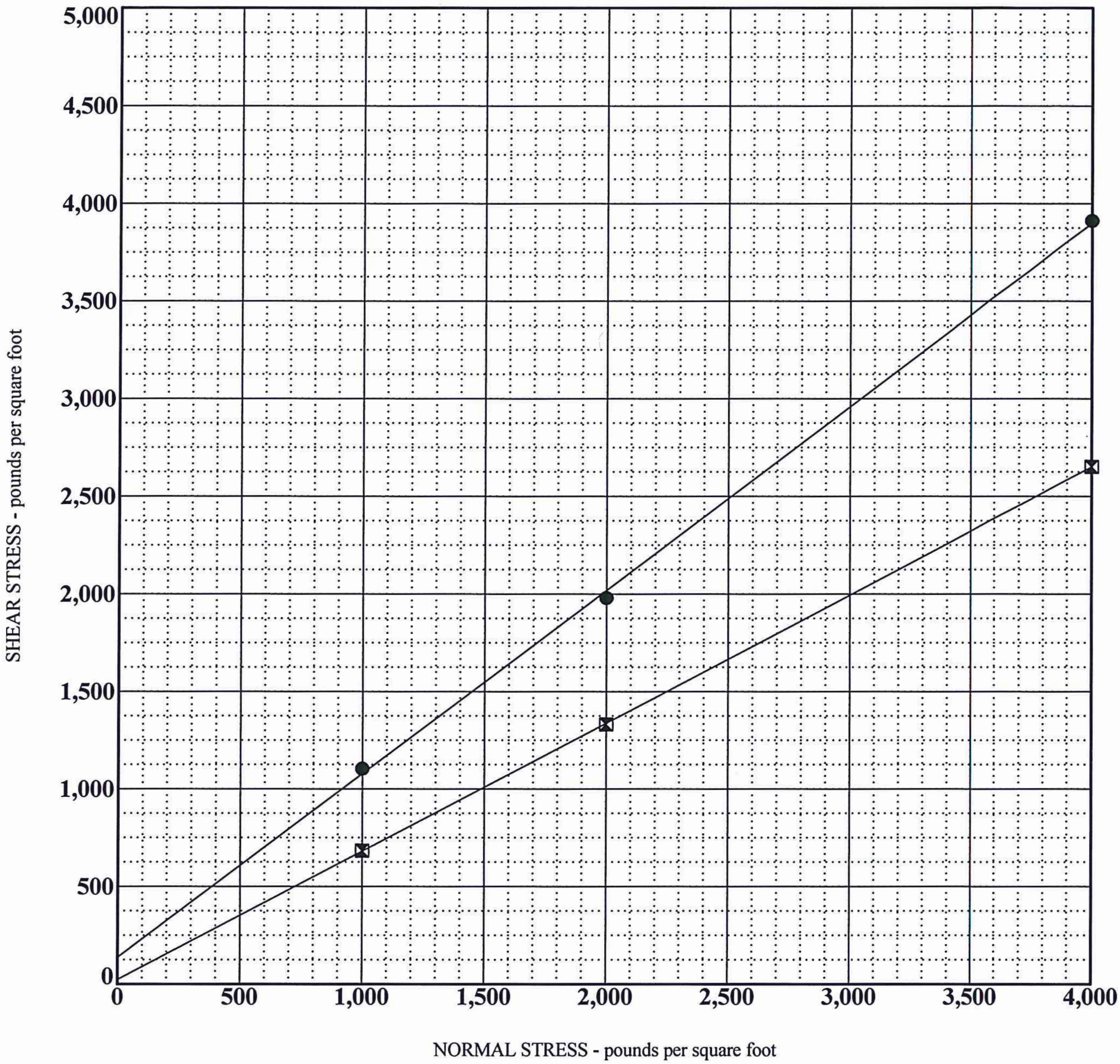
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-18 @ 10.0	Silty Sand (SM) - Ocotillo - Peak	44	460
⊠ B-18 @ 10.0	Silty Sand (SM) - Ocotillo - Ultimate	33	200

NOTES:

Undisturbed Test Samples
All Samples Were Presoaked Prior to Shearing

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13

J.N. 376-11	**DIRECT SHEAR TEST DATA**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-28**



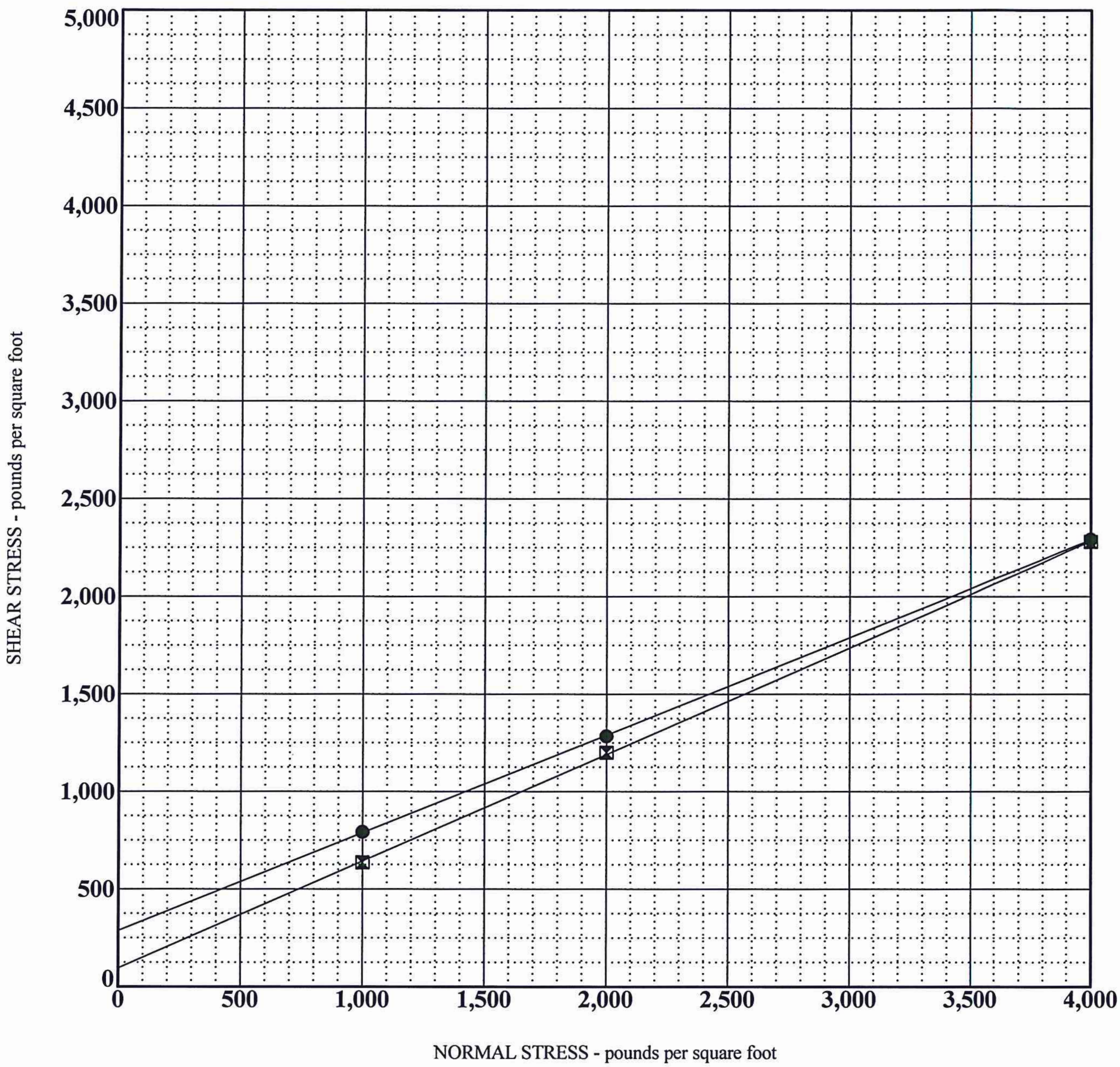
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-18 @ 15.2	Silty Sand (SM) - Ocotillo - Peak	43	140
⊠ B-18 @ 15.2	Silty Sand (SM) - Ocotillo - Ultimate	33	20

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-29

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13

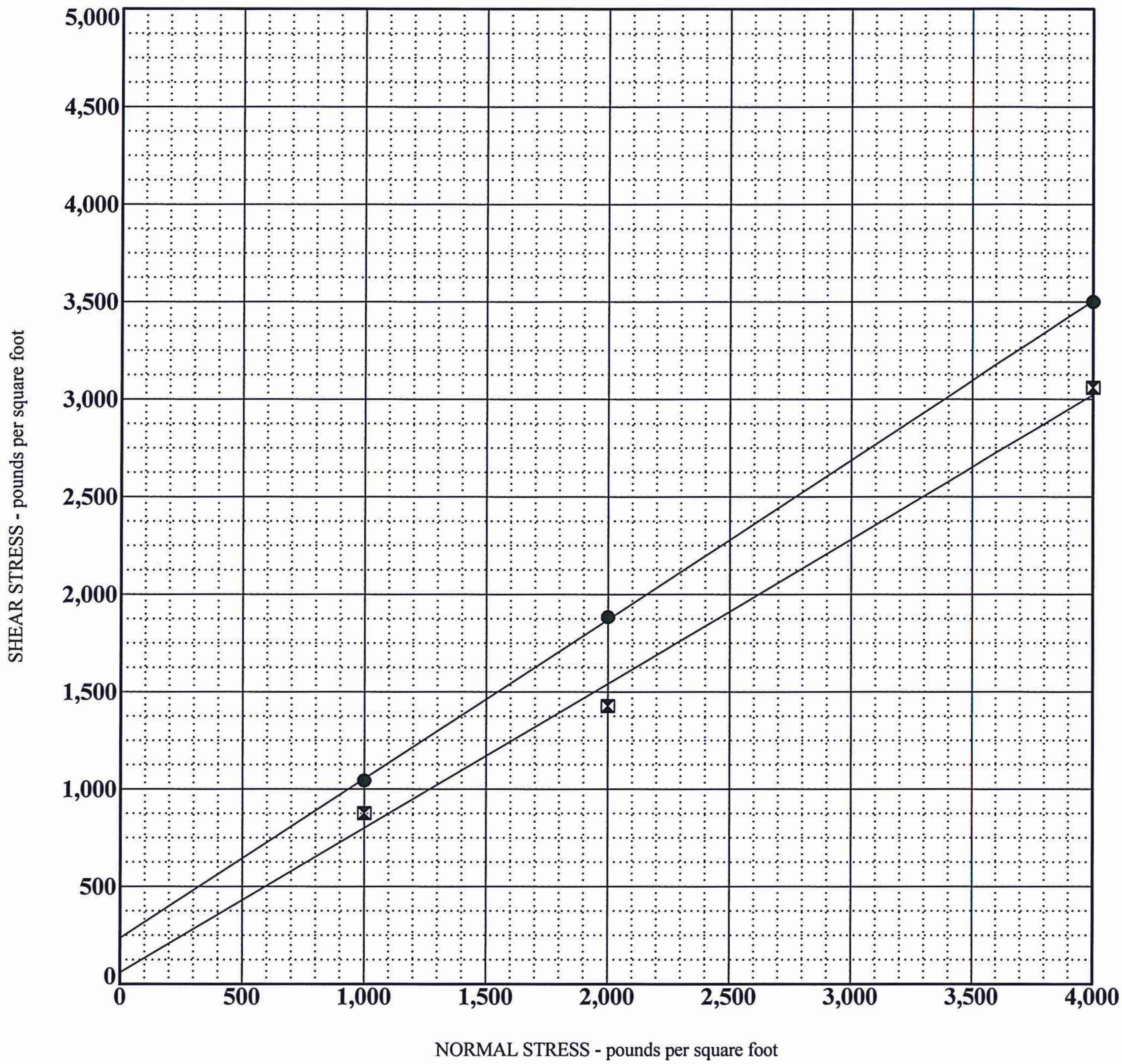


SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-19 @ 5.1	Sandy Silt (ML) - Palm Spring FM - Peak	27	290
⊠ B-19 @ 5.1	Sandy Silt (ML) - Palm Spring FM - Ultimate	29	100

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-30



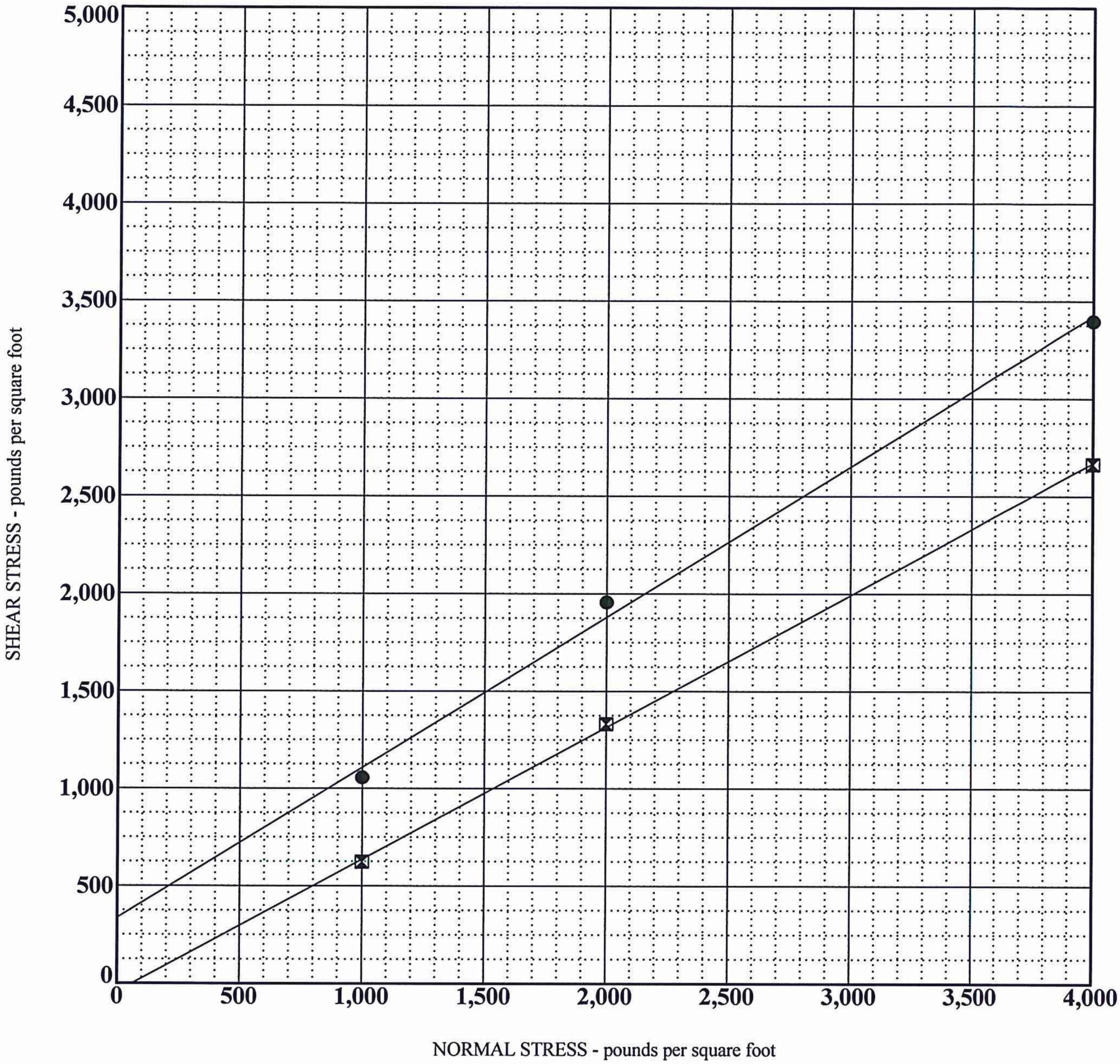
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-21 @ 10.0	Sand (SP) - Fan Deposits - Peak	39	240
⊠ B-21 @ 10.0	Sand (SP) - Fan Deposits - Ultimate	37	60

NOTES:

Undisturbed Test Samples
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	**DIRECT SHEAR TEST DATA**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-31**

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



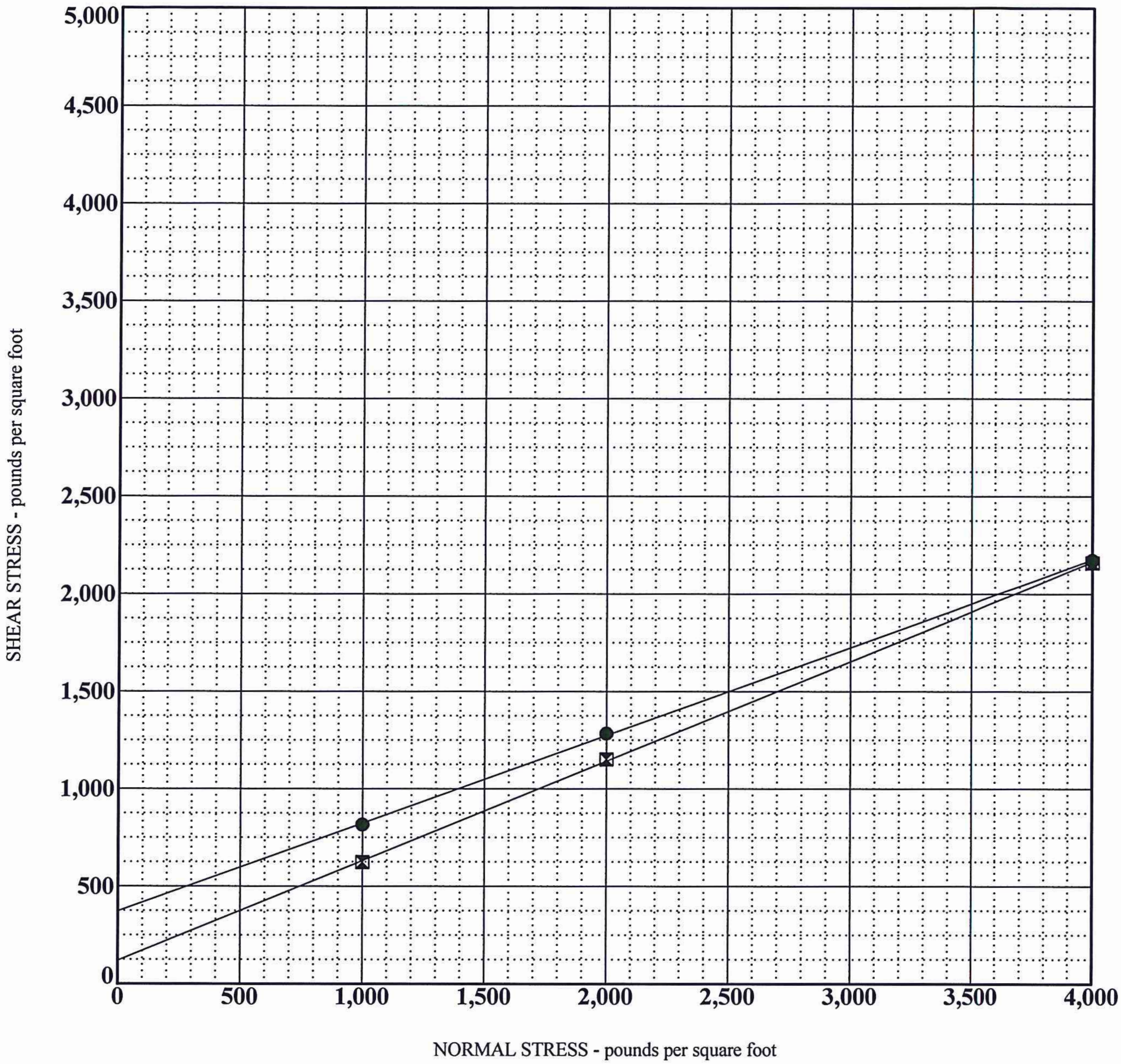
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● B-25 @ 0.0	Sand (SP-SM) - Fan Deposits - Peak	38	340
☒ B-25 @ 0.0	Sand (SP-SM) - Fan Deposits - Ultimate	34	0

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	DIRECT SHEAR TEST DATA	February, 2013
PETRA GEOTECHNICAL, INC.		PLATE B-32

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



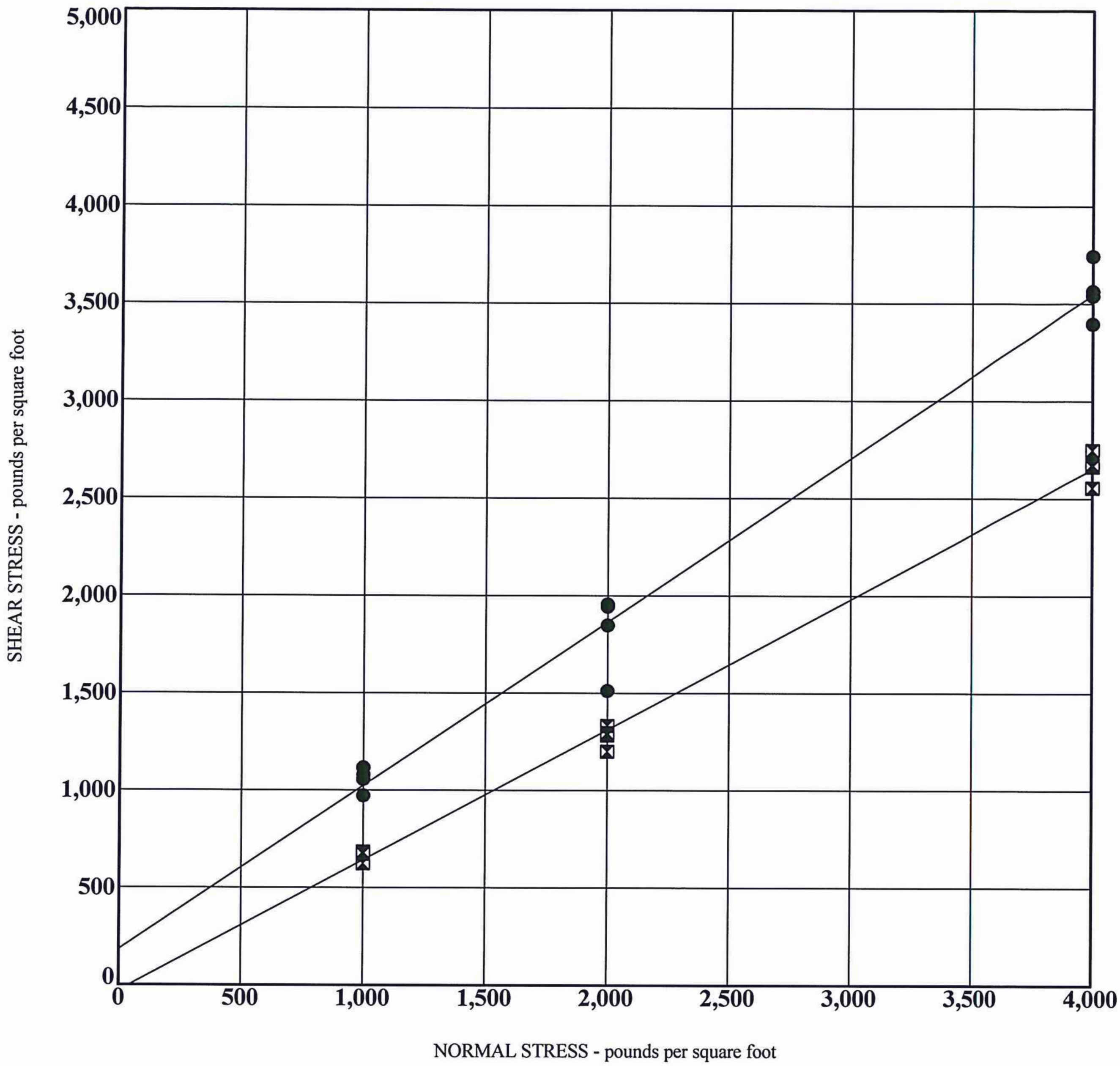
SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● Outcrop#1 @ 0.0	Clayey Silt (CL) - Palm Spring FM - Peak	24	370
⊠ Outcrop#1 @ 0.0	Clayey Silt (CL) - Palm Spring FM - Ultimate	27	120

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	**DIRECT SHEAR TEST DATA**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-33**

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13



SAMPLE LOCATION	DESCRIPTION	FRICTION ANGLE (°)	COHESION (PSF)
● Qf-Comp-Rem @ 0.0	Sand (SW/SP) - Fan Deposits - Peak	40	180
⊠ Qf-Comp-Rem @ 0.1	Sand (SW/SP) - Fan Deposits - Ultimate	34	0

NOTES:

Samples Remolded to 90% of Maximum Dry Density
All Samples Were Presoaked Prior to Shearing

J.N. 376-11	**DIRECT SHEAR TEST DATA**	**February, 2013**
PETRA GEOTECHNICAL, INC.		**PLATE B-34**

DIRECT SHEAR 376-11LAB.GPJ PETRA.GDT 2/4/13

APPENDIX C

SLOPE STABILITY ANALYSIS (Petra, 2013)

```
                              ***  GSTABL7  ***
               ** GSTABL7 by Dr. Garry H. Gregory, Ph.D.,P.E.,D.GE **
          ** Original Version 1.0, January 1996; Current Ver. 2.005.3, Feb. 2013 **
                  (All Rights Reserved-Unauthorized Use Prohibited)
     *********************************************************************************
                       SLOPE STABILITY ANALYSIS SYSTEM
            Modified Bishop, Simplified Janbu, or GLE Method of Slices.
            (Includes Spencer & Morgenstern-Price Type Analysis)
            Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
            Nonlinear Undrained Shear Strength, Curved Phi Envelope,
            Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
            Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
     *********************************************************************************
     Analysis Run Date:         3/20/2023
     Time of Run:               09:16AM
     Run By:                    GWalker
     Input Data Filename:       s:\!PROJECTS\2014 - 2019\2016\300s\16-368\Slope Stability An
 alysis\16-368 cut slope, ocotillo conglomerate - seismic.in
     Output Filename:           s:\!PROJECTS\2014 - 2019\2016\300s\16-368\Slope Stability An
 alysis\16-368 cut slope, ocotillo conglomerate - seismic.OUT
     Unit System:               English
     Plotted Output Filename:   s:\!PROJECTS\2014 - 2019\2016\300s\16-368\Slope Stability An
 alysis\16-368 cut slope, ocotillo conglomerate - seismic.PLT
     PROBLEM DESCRIPTION:  40' 2:1 Cut Slope, Ocotillo Conglomerate
                            - SEISMIC
     BOUNDARY COORDINATES
         3 Top   Boundaries
         3 Total Boundaries
     Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
        No.        (ft)       (ft)       (ft)       (ft)     Below Bnd
         1          0.00      30.00      50.00      30.00        1
         2         50.00      30.00     130.00      70.00        1
         3        130.00      70.00     200.00      70.00        1
     Default Y-Origin = 0.00(ft)
     Default X-Plus Value = 0.00(ft)
     Default Y-Plus Value = 0.00(ft)
    ISOTROPIC SOIL PARAMETERS
      1 Type(s) of Soil
     Soil  Total  Saturated  Cohesion Friction   Pore   Pressure   Piez.
     Type Unit Wt. Unit Wt. Intercept   Angle  Pressure Constant Surface
      No.  (pcf)    (pcf)     (psf)     (deg)    Param.   (psf)     No.
       1   125.0    125.0     200.0     33.0    0.00       0.0      0
     Specified Peak Ground Acceleration Coefficient (A) =   0.812(g)
     Specified Horizontal Earthquake Coefficient (kh) =   0.250(g)
     Specified Vertical Earthquake Coefficient (kv) =   0.000(g)
     Specified Seismic Pore-Pressure Factor =   0.000
     A Critical Failure Surface Searching Method, Using A Random
     Technique For Generating Circular Surfaces, Has Been Specified.
     1500 Trial Surfaces Have Been Generated.
       50 Surface(s) Initiate(s) From Each Of    30 Points Equally Spaced
     Along The Ground Surface Between  X =  40.00(ft)
                                     and  X =  60.00(ft)
     Each Surface Terminates Between   X = 120.00(ft)
                                    and   X = 150.00(ft)
     Unless Further Limitations Were Imposed, The Minimum Elevation
     At Which A Surface Extends Is  Y =     10.00(ft)
     10.00(ft) Line Segments Define Each Trial Failure Surface.
     Following Are Displayed The Ten Most Critical Of The Trial
           Failure Surfaces Evaluated. They Are
           Ordered - Most Critical First.
           * * Safety Factors Are Calculated By The Modified Bishop Method * *
           Total Number of Trial Surfaces Attempted =  1500
           Number of Trial Surfaces With Valid FS = 1500
           Statistical Data On All Valid FS Values:
              FS Max =   2.197   FS Min =   1.192   FS Ave =   1.539
              Standard Deviation =    0.220   Coefficient of Variation =   14.31 %
           Failure Surface Specified By 12 Coordinate Points
             Point      X-Surf      Y-Surf
              No.        (ft)        (ft)
```

1	51.034	30.517
2	61.033	30.661
3	70.987	31.622
4	80.829	33.396
5	90.492	35.970
6	99.911	39.327
7	109.025	43.444
8	117.770	48.293
9	126.089	53.843
10	133.925	60.055
11	141.226	66.888
12	144.048	70.000

Circle Center At X = 54.384 ; Y = 151.929 ; and Radius = 121.457

Factor of Safety

*** 1.192 ***

Individual data on the 12 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	10.0	3034.8	0.0	0.0	0.	0.	758.7	0.0	0.0
2	10.0	8539.8	0.0	0.0	0.	0.	2135.0	0.0	0.0
3	9.8	12848.7	0.0	0.0	0.	0.	3212.2	0.0	0.0
4	9.7	15879.9	0.0	0.0	0.	0.	3970.0	0.0	0.0
5	9.4	17605.9	0.0	0.0	0.	0.	4401.5	0.0	0.0
6	9.1	18054.1	0.0	0.0	0.	0.	4513.5	0.0	0.0
7	8.7	17305.0	0.0	0.0	0.	0.	4326.3	0.0	0.0
8	8.3	15490.2	0.0	0.0	0.	0.	3872.6	0.0	0.0
9	3.9	6663.2	0.0	0.0	0.	0.	1665.8	0.0	0.0
10	3.9	5642.7	0.0	0.0	0.	0.	1410.7	0.0	0.0
11	7.3	5958.0	0.0	0.0	0.	0.	1489.5	0.0	0.0
12	2.8	548.7	0.0	0.0	0.	0.	137.2	0.0	0.0

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	51.724	30.862
2	61.715	31.290
3	71.644	32.482
4	81.452	34.432
5	91.081	37.128
6	100.476	40.554
7	109.581	44.690
8	118.342	49.512
9	126.707	54.990
10	134.628	61.094
11	142.058	67.787
12	144.164	70.000

Circle Center At X = 51.246 ; Y = 160.728 ; and Radius = 129.867

Factor of Safety

*** 1.195 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	51.034	30.517
2	61.027	30.122
3	71.008	30.735
4	80.876	32.351
5	90.532	34.952
6	99.877	38.513
7	108.815	42.998
8	117.256	48.359
9	125.114	54.544
10	132.309	61.489
11	138.768	69.123
12	139.369	70.000

Circle Center At X = 59.976 ; Y = 129.069 ; and Radius = 98.957

Factor of Safety

*** 1.198 ***

Failure Surface Specified By 11 Coordinate Points

Point X-Surf Y-Surf

```
   No.        (ft)        (ft)
    1         53.793       31.897
    2         63.787       32.236
    3         73.709       33.482
    4         83.477       35.625
    5         93.010       38.647
    6        102.228       42.522
    7        111.057       47.219
    8        119.422       52.699
    9        127.254       58.916
   10        134.489       65.819
   11        138.140       70.000
Circle Center At X =    55.062 ; Y =   141.821 ; and Radius =   109.932
       Factor of Safety
      ***    1.202   ***
Failure Surface Specified By 11 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         52.414       31.207
    2         62.387       31.932
    3         72.268       33.476
    4         81.987       35.829
    5         91.479       38.975
    6        100.680       42.891
    7        109.527       47.553
    8        117.960       52.927
    9        125.922       58.978
   10        133.358       65.664
   11        137.447       70.000
Circle Center At X =    48.612 ; Y =   152.442 ; and Radius =   121.295
       Factor of Safety
      ***    1.202   ***
Failure Surface Specified By 12 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         51.034       30.517
    2         61.017       31.109
    3         70.938       32.359
    4         80.756       34.262
    5         90.426       36.809
    6         99.907       39.990
    7        109.157       43.789
    8        118.136       48.191
    9        126.804       53.177
   10        135.124       58.724
   11        143.060       64.809
   12        148.975       70.000
Circle Center At X =    47.151 ; Y =   181.367 ; and Radius =   150.900
       Factor of Safety
      ***    1.203   ***
Failure Surface Specified By 12 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         52.414       31.207
    2         62.372       32.122
    3         72.246       33.706
    4         81.990       35.954
    5         91.560       38.853
    6        100.913       42.392
    7        110.006       46.554
    8        118.797       51.320
    9        127.247       56.668
   10        135.316       62.574
   11        142.969       69.011
   12        143.995       70.000
Circle Center At X =    43.931 ; Y =   178.730 ; and Radius =   147.767
       Factor of Safety
      ***    1.203   ***
Failure Surface Specified By 12 Coordinate Points
  Point      X-Surf      Y-Surf
```

No.	(ft)	(ft)
1	50.345	30.172
2	60.322	29.499
3	70.314	29.894
4	80.208	31.351
5	89.889	33.855
6	99.249	37.376
7	108.179	41.875
8	116.580	47.300
9	124.354	53.590
10	131.413	60.673
11	137.677	68.468
12	138.660	70.000

Circle Center At X = 61.670 ; Y = 122.889 ; and Radius = 93.406

Factor of Safety

*** 1.204 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	50.345	30.172
2	60.304	31.070
3	70.160	32.761
4	79.850	35.235
5	89.310	38.476
6	98.481	42.462
7	107.304	47.170
8	115.722	52.567
9	123.682	58.620
10	131.132	65.291
11	135.613	70.000

Circle Center At X = 44.114 ; Y = 154.989 ; and Radius = 124.972

Factor of Safety

*** 1.205 ***

Failure Surface Specified By 12 Coordinate Points

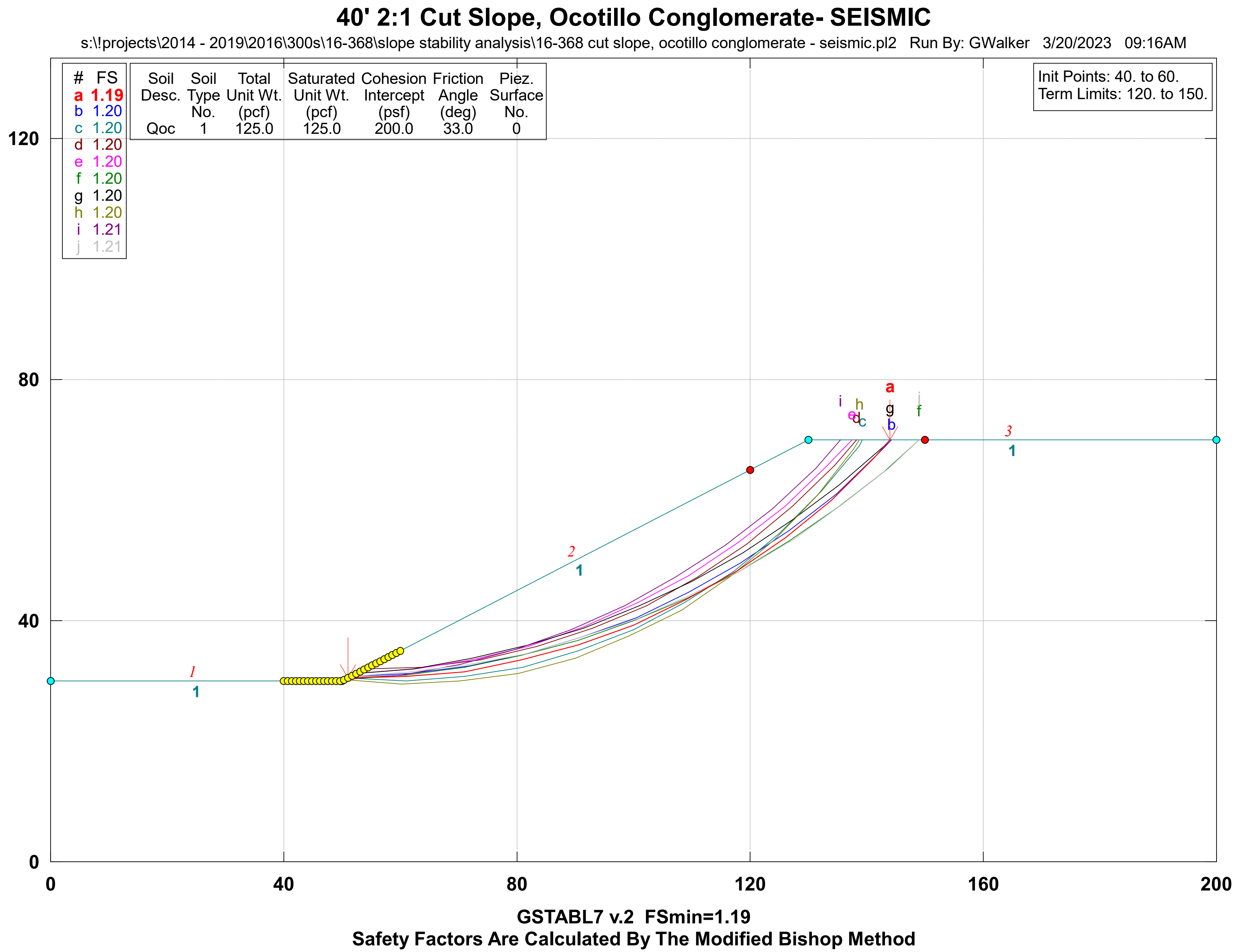
Point No.	X-Surf (ft)	Y-Surf (ft)
1	51.724	30.862
2	61.707	31.448
3	71.629	32.695
4	81.446	34.598
5	91.115	37.149
6	100.594	40.336
7	109.840	44.146
8	118.812	48.561
9	127.472	53.562
10	135.780	59.127
11	143.701	65.232
12	149.104	70.000

Circle Center At X = 48.002 ; Y = 180.838 ; and Radius = 150.022

Factor of Safety

*** 1.206 ***

**** END OF GSTABL7 OUTPUT ****


40' 2:1 Cut Slope, Ocotillo Conglomerate- SEISMIC
s:\!projects\2014 - 2019\2016\300s\16-368\slope stability analysis\16-368 cut slope, ocotillo conglomerate - seismic.pl2 Run By: GWalker 3/20/2023 09:16AM
FS
a 1.19
b 1.20
c 1.20
d 1.20
e 1.20
f 1.20
g 1.20
h 1.20
i 1.21
j 1.21
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No.
Qoc | 1 | 125.0 | 125.0 | 200.0 | 33.0 | 0
Init Points: 40. to 60.
Term Limits: 120. to 150.
GSTABL7 v.2 FSmin=1.19
Safety Factors Are Calculated By The Modified Bishop Method

***** GSTABL7 *****

```
          ** GSTABL7 by Dr. Garry H. Gregory, Ph.D.,P.E.,D.GE **
   ** Original Version 1.0, January 1996; Current Ver. 2.005.3, Feb. 2013 **
            (All Rights Reserved-Unauthorized Use Prohibited)
*********************************************************************************
                  SLOPE STABILITY ANALYSIS SYSTEM
       Modified Bishop, Simplified Janbu, or GLE Method of Slices.
       (Includes Spencer & Morgenstern-Price Type Analysis)
       Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
       Nonlinear Undrained Shear Strength, Curved Phi Envelope,
       Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
       Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.
*********************************************************************************
    Analysis Run Date:        3/20/2023
    Time of Run:              09:26AM
    Run By:                   GWalker
    Input Data Filename:      S:\!PROJECTS\2014 - 2019\2016\300s\16-368\Slope Stability An
alysis\16-368 cut slope, ocotillo conglomerate - static.in
    Output Filename:          S:\!PROJECTS\2014 - 2019\2016\300s\16-368\Slope Stability An
alysis\16-368 cut slope, ocotillo conglomerate - static.OUT
    Unit System:              English
    Plotted Output Filename:  S:\!PROJECTS\2014 - 2019\2016\300s\16-368\Slope Stability An
alysis\16-368 cut slope, ocotillo conglomerate - static.PLT
    PROBLEM DESCRIPTION:  40' 2:1 Cut Slope, Ocotillo Conglomerate
                       - STATIC
    BOUNDARY COORDINATES
        3 Top   Boundaries
        3 Total Boundaries
    Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
       No.        (ft)       (ft)       (ft)       (ft)     Below Bnd
        1          0.00      30.00      50.00      30.00        1
        2         50.00      30.00     130.00      70.00        1
        3        130.00      70.00     200.00      70.00        1
    Default Y-Origin = 0.00(ft)
    Default X-Plus Value = 0.00(ft)
    Default Y-Plus Value = 0.00(ft)
   ISOTROPIC SOIL PARAMETERS
     1 Type(s) of Soil
    Soil  Total  Saturated  Cohesion Friction   Pore   Pressure   Piez.
    Type Unit Wt. Unit Wt. Intercept   Angle  Pressure Constant Surface
     No.  (pcf)    (pcf)     (psf)     (deg)    Param.   (psf)     No.
      1   125.0    125.0     200.0     33.0    0.00       0.0      0
    Specified Peak Ground Acceleration Coefficient (A) =   0.812(g)
    Specified Horizontal Earthquake Coefficient (kh) =   0.250(g)
    Specified Vertical Earthquake Coefficient (kv) =   0.000(g)
    Specified Seismic Pore-Pressure Factor =   0.000
    EARTHQUAKE DATA HAS BEEN SUPPRESSED
    A Critical Failure Surface Searching Method, Using A Random
    Technique For Generating Circular Surfaces, Has Been Specified.
    1600 Trial Surfaces Have Been Generated.
      40 Surface(s) Initiate(s) From Each Of    40 Points Equally Spaced
    Along The Ground Surface Between  X =  40.00(ft)
                                 and  X =  60.00(ft)
    Each Surface Terminates Between   X = 120.00(ft)
                                and   X = 150.00(ft)
    Unless Further Limitations Were Imposed, The Minimum Elevation
    At Which A Surface Extends Is  Y =     10.00(ft)
    10.00(ft) Line Segments Define Each Trial Failure Surface.
    Following Are Displayed The Ten Most Critical Of The Trial
          Failure Surfaces Evaluated. They Are
          Ordered - Most Critical First.
          * * Safety Factors Are Calculated By The Modified Bishop Method * *
          Total Number of Trial Surfaces Attempted =  1600
          Number of Trial Surfaces With Valid FS = 1600
          Statistical Data On All Valid FS Values:
             FS Max =   3.408   FS Min =   1.957   FS Ave =   2.482
             Standard Deviation =    0.338   Coefficient of Variation =   13.61 %
          Failure Surface Specified By 11 Coordinate Points
            Point      X-Surf      Y-Surf
             No.        (ft)        (ft)
```

1	50.769	30.385
2	60.769	30.351
3	70.722	31.322
4	80.527	33.288
5	90.084	36.230
6	99.298	40.117
7	108.074	44.910
8	116.324	50.561
9	123.965	57.013
10	130.918	64.200
11	135.497	70.000

Circle Center At X = 56.107 ; Y = 129.625 ; and Radius = 99.384

Factor of Safety

*** 1.957 ***

Individual data on the 11 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	10.0	3146.2	0.0	0.0	0.	0.	0.0	0.0	0.0
2	10.0	8754.3	0.0	0.0	0.	0.	0.0	0.0	0.0
3	9.8	12877.8	0.0	0.0	0.	0.	0.0	0.0	0.0
4	9.6	15404.4	0.0	0.0	0.	0.	0.0	0.0	0.0
5	9.2	16322.2	0.0	0.0	0.	0.	0.0	0.0	0.0
6	8.8	15719.9	0.0	0.0	0.	0.	0.0	0.0	0.0
7	8.3	13781.7	0.0	0.0	0.	0.	0.0	0.0	0.0
8	7.6	10778.0	0.0	0.0	0.	0.	0.0	0.0	0.0
9	6.0	6306.4	0.0	0.0	0.	0.	0.0	0.0	0.0
10	0.9	720.2	0.0	0.0	0.	0.	0.0	0.0	0.0
11	4.6	1659.9	0.0	0.0	0.	0.	0.0	0.0	0.0

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	50.256	30.128
2	60.252	29.819
3	70.229	30.491
4	80.092	32.138
5	89.747	34.745
6	99.099	38.286
7	108.059	42.727
8	116.540	48.025
9	124.461	54.129
10	131.745	60.980
11	138.322	68.513
12	139.382	70.000

Circle Center At X = 58.452 ; Y = 131.357 ; and Radius = 101.560

Factor of Safety

*** 1.964 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	51.282	30.641
2	61.255	31.371
3	71.137	32.907
4	80.861	35.240
5	90.364	38.353
6	99.583	42.226
7	108.459	46.834
8	116.931	52.146
9	124.944	58.128
10	132.447	64.740
11	137.519	70.000

Circle Center At X = 47.280 ; Y = 153.815 ; and Radius = 123.239

Factor of Safety

*** 1.969 ***

Failure Surface Specified By 11 Coordinate Points

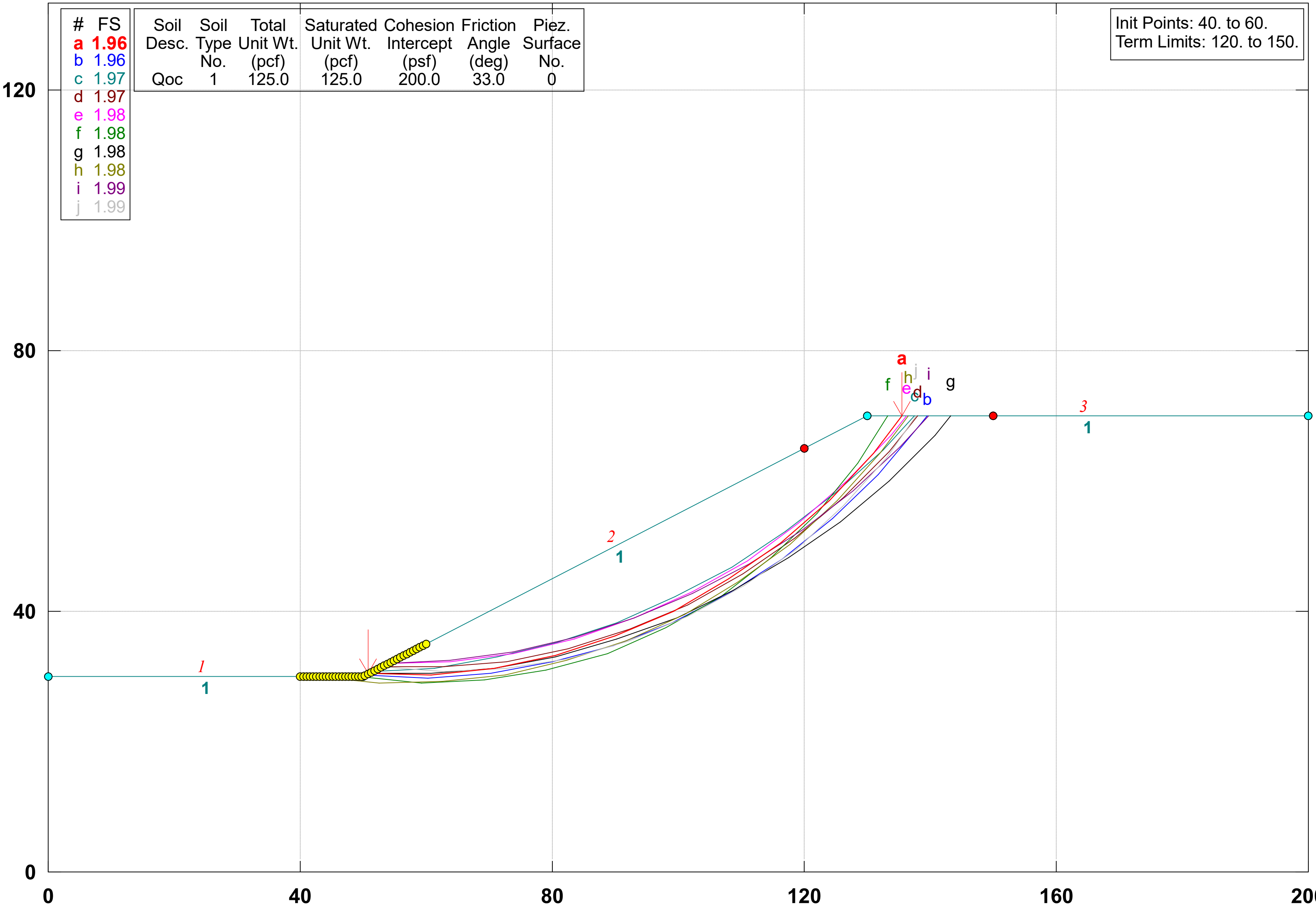
Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.821	31.410
2	62.821	31.401

```
     3         72.774       32.364
     4         82.587       34.292
     5         92.165       37.164
     6        101.419       40.955
     7        110.259       45.629
     8        118.604       51.140
     9        126.372       57.437
    10        133.491       64.460
    11        138.108       70.000
Circle Center At X =    57.917 ; Y =   133.948 ; and Radius =   102.665
       Factor of Safety
      ***    1.970   ***
Failure Surface Specified By 11 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
     1         53.846       31.923
     2         63.841       32.250
     3         73.759       33.526
     4         83.510       35.742
     5         93.007       38.876
     6        102.161       42.901
     7        110.891       47.778
     8        119.116       53.465
     9        126.763       59.910
    10        133.761       67.053
    11        136.142       70.000
Circle Center At X =    55.423 ; Y =   136.796 ; and Radius =   104.885
       Factor of Safety
      ***    1.975   ***
Failure Surface Specified By 11 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
     1         49.231       30.000
     2         59.191       29.108
     3         69.186       29.415
     4         79.073       30.916
     5         88.709       33.589
     6         97.956       37.397
     7        106.680       42.284
     8        114.757       48.181
     9        122.070       55.001
    10        128.514       62.648
    11        133.333       70.000
Circle Center At X =    61.635 ; Y =   112.467 ; and Radius =    83.394
       Factor of Safety
      ***    1.983   ***
Failure Surface Specified By 12 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
     1         50.769       30.385
     2         60.769       30.453
     3         70.727       31.365
     4         80.573       33.115
     5         90.236       35.690
     6         99.647       39.072
     7        108.738       43.236
     8        117.446       48.153
     9        125.708       53.787
    10        133.464       60.099
    11        140.659       67.044
    12        143.245       70.000
Circle Center At X =    55.053 ; Y =   148.129 ; and Radius =   117.822
       Factor of Safety
      ***    1.983   ***
Failure Surface Specified By 12 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
     1         42.564       30.000
     2         52.524       29.101
     3         62.523       29.213
```

```
    4         72.460       30.335
    5         82.232       32.456
    6         91.740       35.554
    7        100.887       39.597
    8        109.577       44.544
    9        117.723       50.344
   10        125.241       56.938
   11        132.054       64.258
   12        136.404       70.000
Circle Center At X =    56.456 ; Y =   127.485 ; and Radius =    98.470
       Factor of Safety
      ***    1.984   ***
Failure Surface Specified By 11 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         53.846       31.923
    2         63.835       32.400
    3         73.747       33.725
    4         83.510       35.889
    5         93.053       38.875
    6        102.309       42.662
    7        111.208       47.223
    8        119.687       52.524
    9        127.685       58.528
   10        135.142       65.190
   11        139.682       70.000
Circle Center At X =    53.242 ; Y =   149.368 ; and Radius =   117.446
       Factor of Safety
      ***    1.985   ***
Failure Surface Specified By 11 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         52.821       31.410
    2         62.801       30.780
    3         72.789       31.259
    4         82.663       32.841
    5         92.301       35.507
    6        101.585       39.224
    7        110.400       43.946
    8        118.638       49.615
    9        126.197       56.161
   10        132.985       63.504
   11        137.772       70.000
Circle Center At X =    63.484 ; Y =   120.940 ; and Radius =    90.163
       Factor of Safety
      ***    1.985   ***
          **** END OF GSTABL7 OUTPUT ****
```

40' 2:1 Cut Slope, Ocotillo Conglomerate- STATIC

s:\!projects\2014 - 2019\2016\300s\16-368\slope stability analysis\16-368 cut slope, ocotillo conglomerate - static.pl2 Run By: GWalker 3/20/2023 09:26AM



GSTABL7 v.2 FSmin=1.96

Safety Factors Are Calculated By The Modified Bishop Method

APPENDIX D

DYNAMIC SETTLEMENT ANALYSIS OF DRY SAND

APPENDIX E:
LIQUEFACTION AND DRY SAND SETTLEMENT ANALYSIS

16-368 KPC Coachella Site

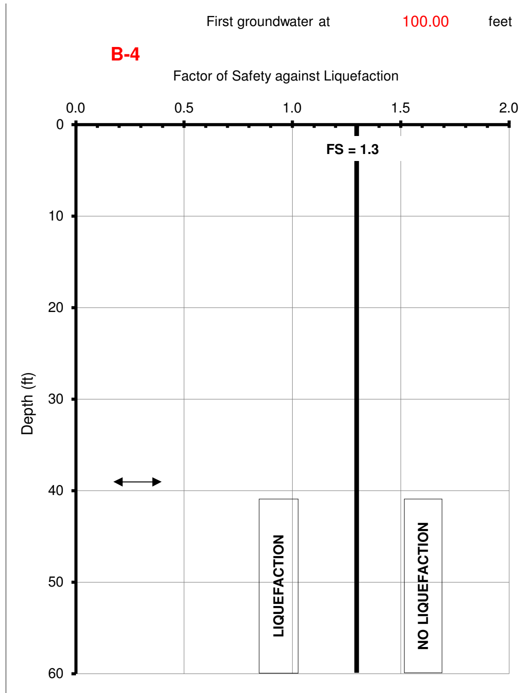
References:
T.L.Youd, I.M.Idriss - Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils
D. Pradel - Procedure to Evaluate Earthquake-Induced Settlements in Dry Sandy Soils
K.Tokimatsu, H.B.Seed - Evaluation of Settlements in Sands Due to Earthquake Shaking, ASCE JGE Vol.113, No.8, August 1986
G.Zhang, P.K.Robertson, R.W.I.Brachman - Estimating Liquefaction-Induced Ground Settlements From CPT for Level Ground (CGJ39,2002)

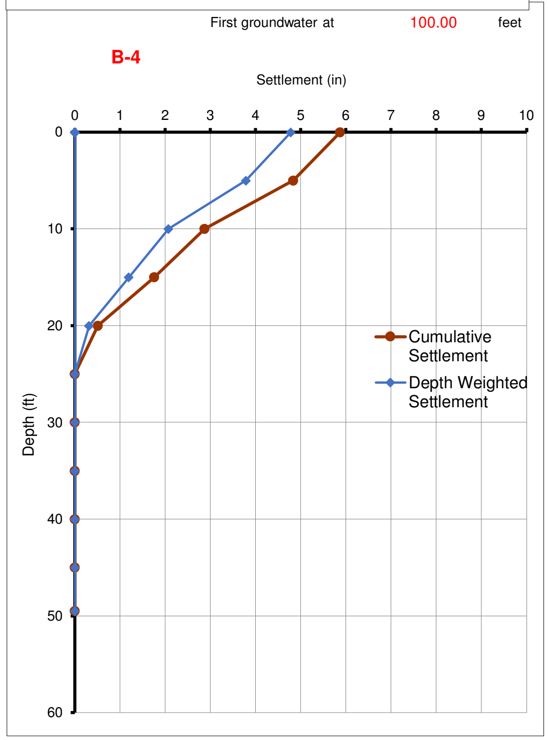
Boring B-4	Summary of analysis	
Total liquefaction settlement	0.00	inches
Total dry sand settlement	5.88	inches
Total earthquake-induced settlement	5.88	inches
Number of evaluated intervals	19	
Number of potentially liquefiable intervals	0	
Average Factor of Safety	no liquefaction	
Depth to first groundwater	100.00	feet
Total thickness of evaluated profile	50.50	feet
Profile thickness susceptible to liquefaction	0.00	feet

Earthquake loading: M 7.34
PGA 1.218 Depth to Use for Depth Weighting Depth (ft) = 59.0

Depth to Layer Top	Depth to Layer Bottom	SPT - N	Fines %	$FS_{SPT,cs,Ko}$	Interpreted Factor of Safety against liquefaction		Free Field Settlement	Depth Weighted Settlement	Cumulative Free Field Settlement	Cumulative Depth Weighted Settlement
feet	feet						in	in	in	in
0	5	18	15	no liq	Not liquefiable	- no groundwater	1.04	1.00	5.88	4.78
5	10	18	15	0.59	Not liquefiable	- no groundwater	1.96	1.71	4.84	3.79
10	15	24	15	no liq	Not liquefiable	- no groundwater	1.12	0.88	2.87	2.07
15	20	24	15	no liq	Not liquefiable	- no groundwater	1.25	0.88	1.76	1.19
20	25	36	15	no liq	Not liquefiable	- no groundwater	0.51	0.31	0.51	0.31
25	30	65	65	no liq	Not liquefiable	- no groundwater	0.00	0.00	0.00	0.00
30	35	56	65	no liq	Not liquefiable	- no groundwater	0.00	0.00	0.00	0.00
35	40	54	65	no liq	Not liquefiable	- no groundwater	0.00	0.00	0.00	0.00
40	45	100	65	no liq	Not liquefiable	- no groundwater	0.00	0.00	0.00	0.00
45	49.5	100	65	no liq	Not liquefiable	- no groundwater	0.00	0.00	0.00	0.00
49.5	50.5	100	65	no liq	Not liquefiable	- no groundwater	0.00	0.00	0.00	0.00
0	0	100	25	no liq	Not liquefiable	- too dense	0.00	0.00	0.00	0.00
0	0	100	68	no liq	Not liquefiable	- fines > 50%	0.00	0.00	0.00	0.00
0	0	100	68	no liq	Not liquefiable	- fines > 50%	0.00	0.00	0.00	0.00
0	0	100	95	no liq	Not liquefiable	- fines > 50%	0.00	0.00	0.00	0.00
0	0	100	10	no liq	Not liquefiable	- too dense	0.00	0.00	0.00	0.00
0	0	100	10	no liq	Not liquefiable	- too dense	0.00	0.00	0.00	0.00
0	0	100	10	no liq	Not liquefiable	- too dense	0.00	0.00	0.00	0.00
0	0	100	10	no liq	Not liquefiable	- too dense	0.00	0.00	0.00	0.00

Total Free Field Settlement (Unweighted) = 5.88
Total Depth Weighted Settlement = 4.78



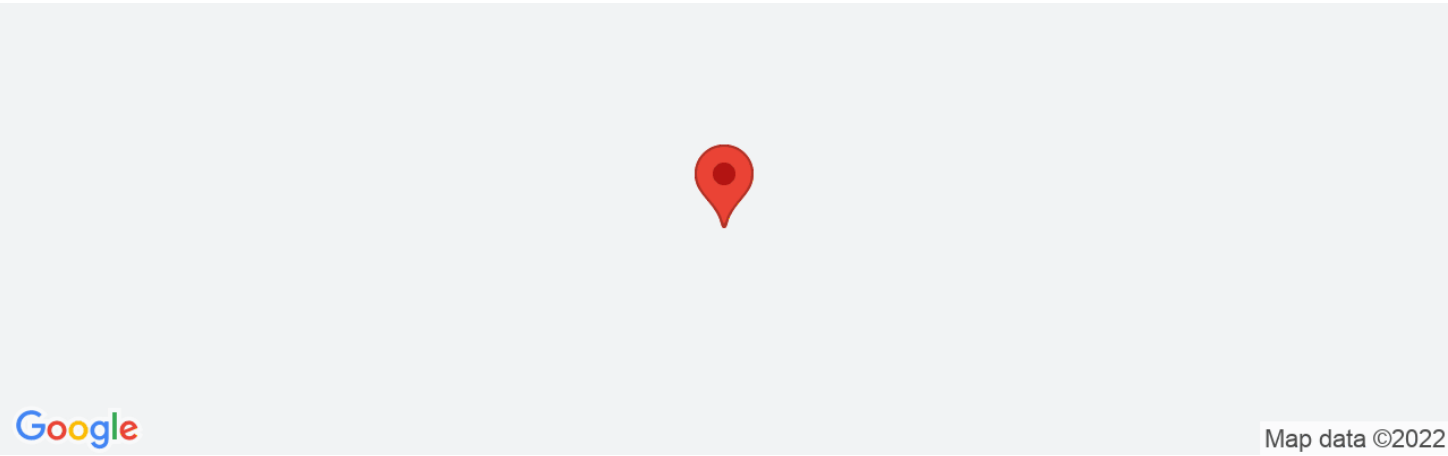


APPENDIX E

SEISMIC DESIGN PARAMETERS

KPC Coachella

Latitude, Longitude: 33.702266, -116.103395



Date	10/6/2022, 2:01:32 PM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	C - Very Dense Soil and Soft Rock

Type	Value	Description
S_S	2.272	MCE_R ground motion. (for 0.2 second period)
S_1	0.965	MCE_R ground motion. (for 1.0s period)
S_{MS}	2.726	Site-modified spectral acceleration value
S_{M1}	1.351	Site-modified spectral acceleration value
S_{DS}	1.817	Numeric seismic design value at 0.2 second SA
S_{D1}	0.901	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	E	Seismic design category
F_a	1.2	Site amplification factor at 0.2 second
F_v	1.4	Site amplification factor at 1.0 second
PGA	0.978	MCE_G peak ground acceleration
F_{PGA}	1.2	Site amplification factor at PGA
PGA_M	1.173	Site modified peak ground acceleration
T_L	8	Long-period transition period in seconds
SsRT	2.633	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	3	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	2.272	Factored deterministic acceleration value. (0.2 second)
S1RT	1.077	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	1.241	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.965	Factored deterministic acceleration value. (1.0 second)
PGAd	0.978	Factored deterministic acceleration value. (Peak Ground Acceleration)
PGA_{UH}	1.19	Uniform-hazard (2% probability of exceedance in 50 years) Peak Ground Acceleration
C_{RS}	0.878	Mapped value of the risk coefficient at short periods
C_{R1}	0.868	Mapped value of the risk coefficient at a period of 1 s
C_V	1.3	Vertical coefficient

DISCLAIMER

While the information presented on this website is believed to be correct, SEAOC /OSHPD and its sponsors and contributors assume no responsibility or liability for its accuracy. The material presented in this web application should not be used or relied upon for any specific application without competent examination and verification of its accuracy, suitability and applicability by engineers or other licensed professionals. SEAOC / OSHPD do not intend that the use of this information replace the sound judgment of such competent professionals, having experience and knowledge in the field of practice, nor to substitute for the standard of care required of such professionals in interpreting and applying the results of the seismic data provided by this website. Users of the information from this website assume all liability arising from such use. Use of the output of this website does not imply approval by the governing building code bodies responsible for building code approval and interpretation for the building site described by latitude/longitude location in the search results of this website.

U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Input

Edition

Dynamic: Conterminous U.S. 2014 (update…

Latitude

Decimal degrees

33.702266

Longitude

Decimal degrees, negative values for western longitudes

-116.103395

Site Class

537 m/s (Site class C)

Spectral Period

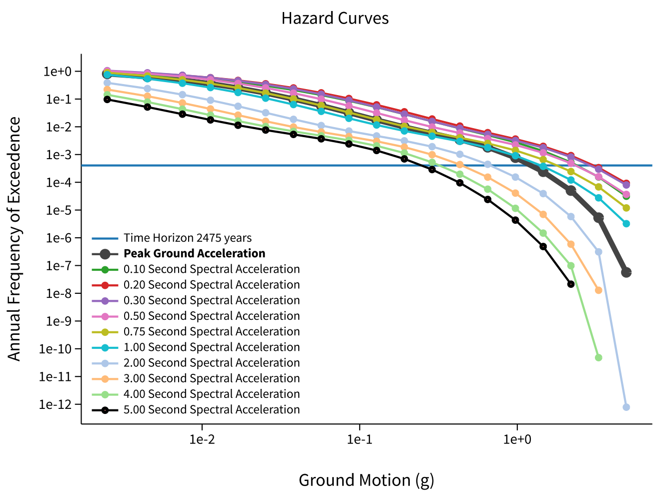
Peak Ground Acceleration

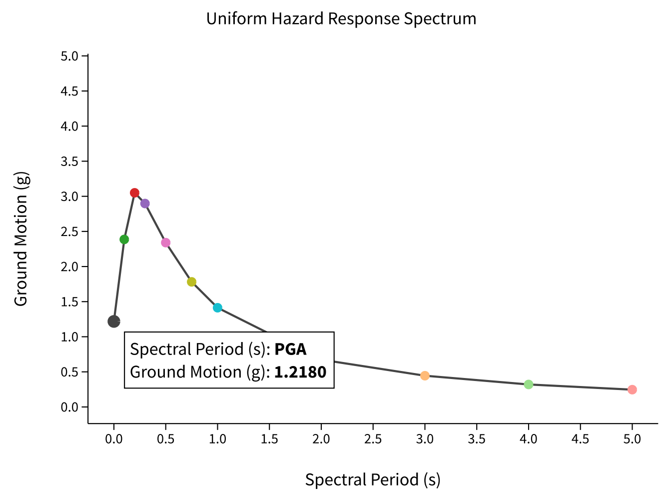
Time Horizon

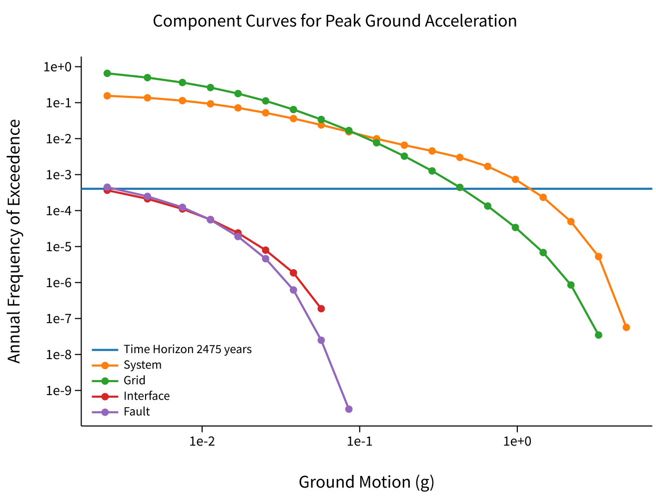
Return period in years

2475

Hazard Curve





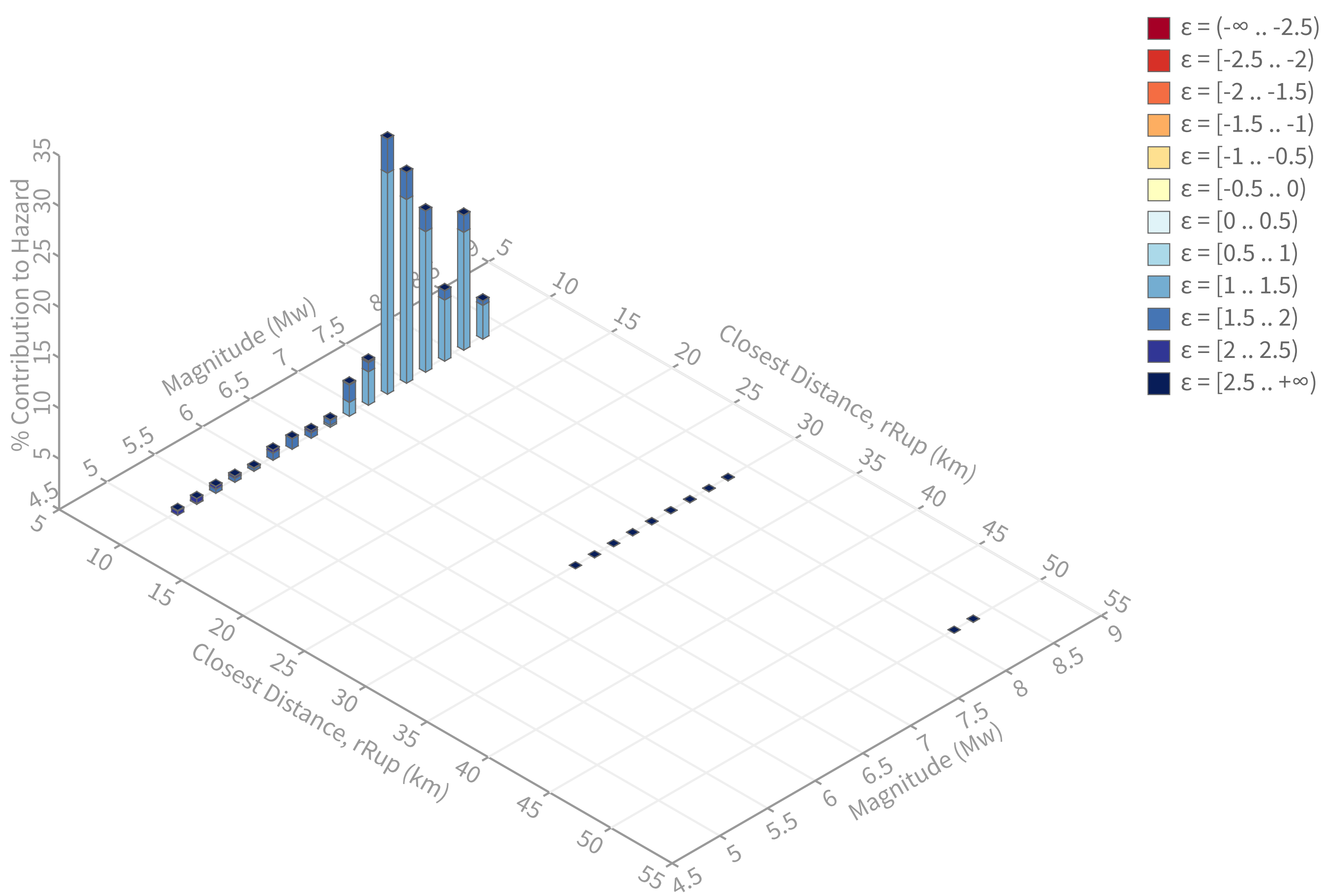


View Raw Data

Deaggregation

Component

Total



Summary statistics for, Deaggregation: Total

Deaggregation targets

Return period: 2475 yrs
Exceedance rate: 0.0004040404 yr^{-1}
PGA ground motion: 1.2180457 g

Recovered targets

Return period: 2898.1271 yrs
Exceedance rate: 0.00034505043 yr^{-1}

Totals

Binned: 100 %
Residual: 0 %
Trace: 0.04 %

Mean (over all sources)

m: 7.49
r: 2.61 km
ε_0: 1.41 σ

Mode (largest m-r bin)

m: 7.34
r: 2.46 km
ε_0: 1.41 σ
Contribution: 25.25 %

Mode (largest m-r-ε_0 bin)

m: 7.34
r: 2.45 km
ε_0: 1.35 σ
Contribution: 21.87 %

Discretization

r: min = 0.0, max = 1000.0, Δ = 20.0 km
m: min = 4.4, max = 9.4, Δ = 0.2
ε: min = -3.0, max = 3.0, Δ = 0.5 σ

Epsilon keys

ε0: [-∞ .. -2.5)
ε1: [-2.5 .. -2.0)
ε2: [-2.0 .. -1.5)
ε3: [-1.5 .. -1.0)
ε4: [-1.0 .. -0.5)
ε5: [-0.5 .. 0.0)
ε6: [0.0 .. 0.5)
ε7: [0.5 .. 1.0)
ε8: [1.0 .. 1.5)
ε9: [1.5 .. 2.0)
ε10: [2.0 .. 2.5)
ε11: [2.5 .. +∞]

Deaggregation Contributors

Source Set ↳ Source	Type	r	m	ε_0	lon	lat	az	%
UC33brAvg_FM31	System							48.56
San Andreas (Coachella) rev [2]		2.45	7.57	1.38	116.122°W	33.687°N	226.79	47.08
UC33brAvg_FM32	System							48.48
San Andreas (Coachella) rev [2]		2.45	7.56	1.38	116.122°W	33.687°N	226.79	46.87
UC33brAvg_FM31 (opt)	Grid							1.48
UC33brAvg_FM32 (opt)	Grid							1.48

Appendix F2: Fault Investigation Report

Fault Investigation Report, ~2850-acre KPC Coachella Project, City of Coachella, Riverside County, California

PREPARED FOR:

Dr. Kali P. Chaudhuri MD
VP Real Estate and Construction
KPC Development Company LLC
9 KPC Parkway, 3rd Floor,
Corona, CA 92879

PREPARED BY:

Dr. Miles D. Kenney, PhD, PG
Kenney GeoScience
Vista, CA 92083
Cell: 760-845-9596
Email: miles.kenney@yahoo.com

PROJECT NUMBER 745-19

SEPTEMBER 20, 2021
REVISED JANUARY, 2022

REVISED: JANUARY 2022

VP Real Estate and Construction
KPC Development Company LLC
9 KPC Parkway, 3rd Floor,
Corona, CA 92879

Attention: Dr. Kali P. Chaudhuri MD

Subject: **Fault Investigation Report for Land Planning Purposes, ~2850-acres KPC Coachella Project, City of Coachella, Riverside County, California**

In accordance with your request and authorization, Kenney GeoScience has completed a fault investigation for the contiguous approximately 2850-acre KPC Coachella Project property (Project) located entirely within the City of Coachella, Riverside County, California. This report provides our findings, conclusions and recommendations (mitigation) regarding potential fault surface rupture per State of California AP Act (1972) guidelines utilizing the California Geological Survey Fault Investigation Guidelines in Special Publication 42 (1973, Revised 2018).

Based on our findings, the proposed development of habitable, essential, and critical, structures as defined by the AP Act (1972) is feasible across most of the property in terms of potential fault surface rupture as most areas of the Project property were evaluated to not exhibit Holocene-age faulting. Holocene-age faulting was identified within the Project within the northwest trending right-lateral strike slip Berdoo Canyon Fault Zone located in the central area of the site. Mitigation via a fault setback zone bounding this region is provided. Fault setbacks are also provided for areas in the western most portion of the Project as the age of faulting was difficult to evaluate due to local grading associated with construction of the All American Canal and flood control berm.

This report provides significant edits and revisions associated with the detailed and thoughtful review by Lilburn Corporation, Report Letter dated November 3, 2021 and prepared by Mr. Steve Kupferman. The Lilburn Corporation letter report is provided in Appendix H in addition to a KGS Response Letter Report addressing each of the comments.

This report supersedes the findings and conclusions of the KGS Fault Investigation Report Dated September, 2021.

Respectively submitted,

KENNEY GEOSCIENCE

Miles Kenney PhD, PG

Distribution:

Electronic Copy: (1) Addressee, Steve Kupferman (Geologic reviewer for the City of Coachella); and Dr. Kali Chaudhuri & Mr. Stan McNaughton with KPC

Hard Copy: (1) Steve Kupferman (Geologic Reviewer fort the City of Coachella)

TABLE OF CONTENTS

LIST OF FIGURES (Located at after Reference Section 13.0)

LIST OF APPENDICES

APPENDIX A	Helms (2007 & 2021) Soils Stratigraphy with Numerical Ages Reports for the KPC Coachella Property; Helms (2005) Soil Stratigraphy Report for the 845-acre Stonewater Property; Shlemon (2005) Soils Report for Fiesta (La Entrada) 2200-acre Property; and Photographs of Selected Trenches (Plates TP1 through TP5)
APPENDIX B	Historical Aerial Imagery Lineament Mapping by KGS and CGS (Plates LM1, LM2 and LM3)
APPENDIX C	Generalized Folding Across Site (Plates FS1 and FS2)
APPENDIX D	Berdoo Canyon Fault Zone Field Scarp Mapping Data (Plates BFZ1, BFZ2 and BFZ3)
APPENDIX E	Geologic Trench Maps (Plates GTM0 through GTM19)
APPENDIX F	Professional Survey Location Report of Selected Faults and Trench Locations Report by Kimley-Horn (2021)
APPENDIX G	Fault Zone Maps and Fault Setback Maps (Plates FZM1 through FZM8)
APPENDIX H	City of Coachella Review Letter by Lilburn Corporation by Steve Kupferman dated November 3, 2021, and KGS Review Comments Letter
APPENDIX I	Trench Logs List (Trench Logs T1 through T212 – Provided in Volumes 1 and 2) and Table 1 indicating trench lengths, Petra verses current study trench, and whether trenches are backfilled.
APPENDIX J	Geologic Map of Entire Site at scale 1”=400’

EXECUTIVE SUMMARY

This report provides the findings of a large fault investigation in the approximately 2850-acre KPC Coachella property located in the City of Coachella, Riverside County, California. The property extends approximately 4-miles east to west, and 2-miles north to south with the southern border "hugging" the north side of Interstate Highway 10, and the western boundary reaching the All American Canal located at the eastern limit of the "flatlands" of Coachella Valley.

Faulting has been known to occur in the property for decades based on scientific publications and numerous fault investigations in the Site surrounding areas, many of which were conducted by the author. The western boundary of the site reaches the San Andreas Fault, which is active, and considered overdue for a major surface rupturing earthquake.

From 2005 to 2007, Petra conducted a large-scale fault investigation at the site that entailed over 7.5-miles of subsurface trenching and associated logging. This project was managed by the author (Dr. Miles Kenney) and these data are utilized in this report. An additional approximately 2-miles of trench was conducted for the current study. Thus, a total of ~9.7 miles of fault trench logs are provided in this report, and is the primary method utilized in this report to determine fault activity.

State of California AP Fault Hazard Zones currently cover approximately 42% of the site since the publication of the California Geological Survey Fault Evaluation Report FER-2015 (Bryant, 2015). However, AP Fault Hazard Zones only covered approximately 5.4 % of the site prior to publication of FER-250. It was clearly understood by the author that the State AP Fault Hazard Zones were inadequate during the Petra 2005-2007 fault investigation, and for other projects in the Coachella Fan area as it was clear the area exhibited a high density of faulting, and that that faulting in terms of age was poorly understood. Hence, the author, when managing the Petra 2005-2007 Site fault investigation, among other nearby properties conducted extensive trenching based on observed onsite faulting, and thus outside of State AP Fault Hazard Zones.

With the exclusion of the active San Andreas fault zone occurring within an easement at the western property boundary, there are two modes of faulting in the site, which include strike-slip faults associated with the Berdoo Canyon and Painted Canyon "central" fault zones, and coseismic "sliding" faults associated with the Coachella Fan fault zone. The first mode of faulting includes the right-lateral strike slip Berdoo Canyon fault zone, which is a Holocene-active, and has been extended further southeast than previous mapped (i.e. Byrant, 2015, FER250). It trends northwest through the center of the site. It exhibits a wide zone of faulting ranging from 400 to 1000 feet wide. The data contained in this report provides the best evidence of the age and style of faulting of the Berdoo Canyon fault zone ever obtained. The extent of the fault zone in the Site was evaluated with fault trenching and mapping low relief and degraded fault scarps on Ocotillo Conglomerate fan surfaces. This fault zone last surface rupturing event occurred in the early Holocene (this study). The only faults observed during the field investigation to displace Holocene age sediments (i.e. active fault) was within the Berdoo Canyon fault zone.

An additional dominantly strike-slip fault zone was identified in this study in that is herein called the Painted Canyon "central" fault zone as mapping in this study suggests it connects to the southeast with strands of the Painted Canyon fault zone in are region where it splays to numerous strands. This fault zone is evaluated as not exhibiting surface rupture during the Holocene.

The second mode of faulting is the Coachella Fan fault zone that is approximately 3 miles wide in a southwest to northeast direction, and 5 miles long in a northwest to southeast direction. The Coachella Fan fault zone has been mapped by various authors for decades and likely this is because it is primarily identified as many well developed, but degraded scarps developed in over 70,000-year old fan surfaces of the Ocotillo Conglomerate. The Coachella Fan fault zone is dominated by northwest striking, normal dip-slip faults with strikes close to topographic contours. Kenney (2007) proposed that the Coachella Fan fault zone resulted from lateral spreading (lower elevations) and land sliding (upper elevations) associated with strong ground-shaking (coseismic - major earthquake on the San Andreas fault), and moisture soil conditions occurring during glacial periods (Quaternary). Whether this is accurate or not, the shear surfaces observed in this study are treated as faults. Faults associated with the Coachella Fan fault zone exhibited a higher density (lateral distance between faults) of faulting soon after the Palm Spring formation was deposits (0.75 Ma), and progressively less density of faulting toward the end deposition of the Ocotillo Conglomerate (Petra, 2007a). In addition, the activity of the Coachella Fan fault zone ruptured in limited areas by early to mid Late Pleistocene, and became inactive by the late Late Pleistocene (~30 to 50kya).

Local incised drainages eroded into Ocotillo Conglomerate (Qo) and Palm Spring Formation (Qp) exhibit very similar stratigraphy across the site. These sediments were deposited between 80 kya (unit Qf5) to the present time (Q1). Fault activity was primarily evaluated within the incised drainages where nearly laterally continuous deposits of Late to Latest Pleistocene occurred, which if not faulted, indicated no active faults occur there (Unit Qf5 through QfoU).

Fault Rupture Mitigation:

- A fault setback zone is provided in this report for the Berdoo Canyon fault zone that ranges in width of 800 to over 1400 feet.
- Fault setback zones are also provided in this report for areas in the western most portion of the property, much of which is within an easement for the All American Canal and flood control berm.
- The is the findings of this report that no habitable, critical, or essential structures as defined by the State of California AP Act of 1972, be built within the proposed fault setback zones.
- Various types of utility lines can be constructed within the proposed fault setback zones but for subsurface utilitie, their design should be evaluated by Geotechnical Engineers. Fault scarp mapping of numerous strands of the Berdoo Canyon fault zone provided in this report would be useful for Geotechnical Engineers to design fault displacement mitigation designs (i.e. fault slip vector analysis).
- Trenching during this study investigated all State of California AP Fault Hazard Zones, which cover 42% of the property. Most of that land was evaluated to not exhibit active faulting.
- The Berdoo Canyon fault zone does occur within the AP Fault Hazard Zones with the exception in the southern portion of the site where this study has placed a fault setback zone outside of the State AP zone.
- No Holocene-age faulting (i.e. active faulting – older term) was identified in any other AP Fault Hazard Zones or anywere investigated during this study other than associated within the Berdoo Canyon fault zone.
- Age-undetermined fault (i.e. potentialy active faults – older term) were identified in this study in some trenches, and they were either placed in a fault setback zone, or investigated further and determined to be inactive.
- Trenching was also conducted in large areas of the Site not in AP Zones based on determining if identified lineaments in older sediments bounding the washes were associated with faults and determine their activity.
- Coseismic (during ground-shaking) fracturing may occur at the site and it is the opinion of the author that this type fault related deformation can be mitigated with

engineering. For example over-excavation of lots (minimum 3-foot) and post-tension slap foundations.

- Landslides occur at the site that may also be triggered by strong ground-shaking, particularly in areas of Palm Spring Formation (Qp) that exhibits numerous fine-grained member (some clayey). Some of these slides utilize parallel to bedding shear surfaces that should be considered in future Geotechnical Engineering studies.
- The provided fault setback zones in this report should be provided to Project Land Planners so that their accurate locations can be applied to grading plans that will eventually be submitted to the City of Coachella Land Planning Department.
- Easements associated with the northwest to southeast utility lines (high pressure gas and electrical) transecting the central region of the property were not investigated in this study. To our knowledge not development is allowed in this region.
- It is recommended that no habitable, essential, or critical structures be constructed within the proposed fault setback zones.
- Existing trenches, whether backfilled with loose sediments or left open should be considered during a grading plan review by the City of Coachella Land Planning Department.
- The detailed trench logging and field mapping of scarps within the Berdoo Canyon fault zone
- The potential for temporary coseismic "shearing" across Pre-Holocene faults contained in older "bedrock" units (Ocotillo Conglomerate and Palm Spring Formation), that can lead to overlying shearing looser deposits should be evaluated by a Geotechnical Engineer. At a minimum, it is recommended that lots planned for habitable structures of any kind by overexcavated approximately 3 feet, and post tension slab be utilized when possible.
- Potential development groundwater seepage into underlying sediments (anthropogenic) that could potentially exhibit coseismic sliding if water reaches these deposits is recommended to be mitigated. If groundwater does reach the underlying Palm Spring Formation, strong groundshaking induces sliding potentially could occur.
- Dig Alert tickets were obtained for the subsurface investigation for areas where trenches were excavated.

1.0 INTRODUCTION - OVERVIEW

This report provides the results of Kenney GeoScience (KGS) fault investigation for the KPC Coachella property (Project, Figure 1A) to understand the style, location, and age of faulting within and near the Project. The site extends approximately 4 miles east to west, and 2 miles north to south comprising approximately 2850-acres (Figure 1B). Geology at the site consists of Late Pliocene to early Quaternary fluvial valley deposits which are overlain by mid to late Quaternary alluvial deposits composed of detrital material shed from the Little San Bernardino Mountains. Deformation consisting of faulting, uplift and folding have occurred in the site associated with long term activity of the San Andreas Fault Zone, Berdoo Canyon, Painted Canyon "central" and the Coachella Fan fault zones.

Much of the site exhibits exposed Ocotillo Conglomerate deposits and abandoned surfaces. These deposits were shed from the Little San Bernardino Mountains to the northeast and are deposited over the older deposits of the Palm Spring Group in angular unconformity. However, the Ocotillo Conglomerate is tilted, uplifted and folded along the herein named Coachella Hills and Little Coachella Hills respectively (Unit Qco on Figure 2). Entrenched antecedent drainages occur into these older deposits (Palm Spring Group and Ocotillo Conglomerate) resulting in abandoned fan surfaces on the Ocotillo Conglomerate. Late Pleistocene to Holocene age sediments occur within the antecedent drainages. The stratigraphy of these washes is consistent across the entire site and the age of faulting was determined primarily via understanding the age of various wash stratigraphic members. Due to the consistency of stratigraphy in the inset drainages across the Project, the same unit designations for the late Pleistocene to Holocene could be utilized across the entire site. However, evidence of Holocene age faulting was also identified on preserved fan terrace surfaces developed on the Ocotillo Conglomerate where dip-slip faulting exhibiting relatively minor vertical displacements allowed for the development or relatively young deposits and soils in fault grabens that also provided evidence of Holocene age faulting within the Berdoo Canyon fault zone.

Faulting is complex, and occurs across most of the site; however, Holocene-active faults was only identified associated with the Berdoo Canyon Fault Zone that strikes northwest through the central portion of the property and along the eastern side of the herein named Coachella Hills. The Berdoo Canyon Fault Zone is a right lateral strike-slip fault and can be considered a secondary "tectonic" fault the San Andreas Fault Zone (Bryant, 2015) similar to the Painted Canyon fault zone and Indio Hills fault zone. Setbacks are proposed bounding the Berdoo Canyon Fault Zone as mitigation for the development of habitable, essential and critical structures across Holocene-active faults. Other proposed fault setbacks occur in the western portion of the Project where evaluating activity of the faults was difficult due to grading of surface sediments to construct the All American Canal and associated flood control berms built decades ago.

There are various modes of faulting across the property and the age of their age of activity also varies. Two are strike-slip fault zones and the other is the complex Coachella Fan fault zone. The Berdoo Canyon Fault

Zone discussed earlier is a secondary fault to the San Andreas fault zone, and is a right lateral strike-slip fault zone that has also contributed to exhibited uplift of the Coachella Hills (Figure 1B). The Coachella Hills exhibits deeply incised drainages with hills exposing moderate to steeply folded Palm Spring Formation, and moderate to strong uplift of the Ocotillo Conglomerate. The second right-lateral strike-slip fault zone identified in the Site is the Painted Canyon fault zone "central" which is located in the region of the northwest trending herein named Little Coachella Hills in the eastern portion of the site (Figure 1B). Uplift of the Coachella Hills and Little Coachella Hills likely resulted from strain associated with the two strike-slip fault zones. The Berdoo Canyon fault zone exhibits Holocene age faulting, whereas the Painted Canyon Fault is determined to have last had activity in the Late Pleistocene.

A second mode of faulting occurs across the remainder of the property associated with the Coachella Fan fault zone. It is characterized by a high density of typically north to northwest trending normal dip-slip faults that dip toward the west to southwest with relatively small-scale apparent separation (i.e. less than 2 feet). The density of Coachella Fan faults is higher in older sediments (i.e. Palm Spring Group), and progressively less in the Ocotillo Conglomerate, very low in Late Pleistocene sediments (i.e. 40,000 years old). These are the most common types of faults occurring at the site and they occur throughout the site.

Petra has conducted numerous fault studies in the Coachella Fan area including this study that provide considerable evidence that the vast majority of the bedrock faults (i.e. in Palm Spring Group or Ocotillo Conglomerate) in the Coachella Fan area represent a period of deformation during the mid to late-Pleistocene that is no longer active. Kenney (2007) proposed that the majority of the normal dip-slip faults of the Coachella Fan fault zone primarily resulted from lateral spreading and translational sliding induced by strong ground shaking and wetter conditions during the Pleistocene (Kenney, 2007). Low angle basal shear surfaces and associated overlying listric normal faults are commonly identified in the Palm Spring Formation particularly at lower elevations. However, in this study, shear surfaces associated with the normal dip-slip faults are treated as faults in terms of the State of California AP Act (1972). However, due to the abundant evidence supporting the lateral spreading/landslide model of deformation, consideration to minimize infiltrating anthropogenic related water to reach potential slide plane surfaces is prudent.

A quantitative analysis of seismic shaking deformation (secondary seismic deformation) such as liquefaction, lateral spreading, and earth surface shattering (joints and fracturing) were not conducted as part of this report. However, a short discussion regarding lateral spreading (land sliding), and near-surface fracturing deformation is provided based on data acquired during Petra fault investigations in the region and at the site (Petra 2007a, 2007b).

The western most boundary of the property is within the State of California AP fault hazard zone in the area of easements associated with the All American Canal and flood control berms constructed many decades ago. It is likely that Holocene-active fault strands of the San Andreas Fault Zone do occur within the Project but were not investigated due to the existing easements that will not allow for future development.

2.0 SITE LOCATION, DESCRIPTION, GEOMORPHOLOGY & TOPOGRAPHY

The site consists of approximately 2850-acres that extends 4 miles east to west, and 2 miles north to south (Figure 1A). The site occurs immediately north of Interstate Highway 10, essentially east of the All American Canal, and the two east to west trending property boundaries occur along the latitude of Vista Del Norte and Avenue 44 (Figure 1B). Topographically, the northeaster portion of the site generally slopes gently toward the southwest associated with Coachella Fan that is disrupted by gentle warping and uplift along the Little Coachella Hills (Figure 1B). The central portion of the site exhibits the Coachella Hills that have a maximum local relief from hilltop to bottom of adjacent washes of approximately 170’. The southwestern portion of the site represents the southwestern flanks of the Coachella Hills which essentially terminate along Interstate Highway 10. The very most western boundary of the property extends onto Coachella Valley in the region of the All American Canal and associated flood control berm.

Most active drainage systems flow toward the southwest emanating from the Little San Bernardino Mountains to the northeast, and eventually extending under Interstate Highway 10 to pond behind flood control berms constructed immediately northeast of the All American Canal (Figure 1B and Figure 2). The majority of the site exhibits natural sparse desert vegetation with abundant areas of exposed sand and gravel on the surface.

The property is undeveloped but does include utility power lines, and subsurface high pressure gas lines within the same northwest to southeast trending easement. Graded dirt roads within this easement is one of the primary ways to visit the site as there are no paved roads within the property. Other man-made structures occur in the property that are likely also part of a building restriction easement that include the All American Canal (water canal) and flood control berms. Most of these structures occur in the western most portion of the property and along the southern boundary of the site to divert surface water under Interstate Highway 10 (Figure 1B).

3.0 PURPOSE & SCOPE OF INVESTIGAION & PROJECT HISTORY

The purpose of the investigation is to evaluate potential fault surface rupture within the Project to satisfy State of California statutes associated with the Alquist-Priolo Earthquake Fault Zoning Act (AP Act, 1972, initially called Alquist-Priolo Special Studies Zones Act) and following investigative guidelines provided in the California Geological Survey (CGS) Special Report SP-42 (1973, and revised 2018). The CGS is required to delineate Fault Hazard Zones bounding Holocene-active faults in the State of California which will require a fault investigation be conducted for proposed developments of habitable structures, a report be prepared and then submit the report to the appropriate regulatory agency (i.e. County, City or the CGS). The CGS published AP Fault Hazard Zones are generally shown on 7.5-minute topographic maps and can be modified or new ones added as new knowledge regarding Holocene-active and Age-undetermined faulting becomes available.

For example, AP Fault Hazard Zone maps were published by the CGS for the area of the site in the early 1974 soon after the AP Act was adopted (Figure 4, Bryant, 2015). The CGS published Fault Evaluation Report FER-250 (Bryant, 2015) and issued revised maps that significantly added more aerial coverage of AP Fault Hazard Zones primarily associated with secondary faults, some unnamed, located east of the San Andreas Fault, which is where the Project is located (Figure 1B). For example, prior to 2015, only ~5% of the Project was within a Fault Hazard Zone requiring an investigation, which increased to ~42% since 2015 once FER-250 was published (compare Figure 4 with Figure 1B).

The City of Coachella issued a Fault Hazard Zone Map for their local area in 1996 (Figure 4) and thus prior to the revised state AP Fault Hazard Zone maps of 2015. The City added Fault Hazard Zones outside of the current AP Zone map of 1974 primarily associated with fault zones northeast of the San Andreas fault (Figure 4). A search for a current or revised version of the City's 1996 Fault Hazard Zone Map did not find a map more recent than 1996.

The scope of the investigation requires that the onsite AP Fault Hazard Zones be investigated and use reasonable judgement to investigate areas outside of the AP Fault Hazard Zones based on site specific information discovered during the investigation. This was accomplished utilizing subsurface fault trenches that generally exposed sedimentary deposits of various ages allowing for age determination of most faults.

The scope of work for the current project involves the fact that a fault investigation study was conducted at the site from 2005 to 2007 by Petra Geotechnical (now Petra Geosciences, Inc -Petra). The field investigation and fault investigation report were never completed. At that time, the Desert Lakes project did not include a 40-acre, 160-acre (i.e. Stonefield property) and 220-acre (McNaughton property) parcels that are now part of the current contiguous Project property (Figure 1B). However, during the 2005-2007 period of time, Petra was hired by a company called Stonefield, to conduct a fault investigation in their 160-acre property, and to conduct that study in concert with the Lennar project. Five trenches were excavated and logged within the Stonefield property and managed by Dr. Kenney, and field managed by Mr. Butler CEG. Petra also excavated and logged a trench within the 220-acre McNaughton property during that time to assist Leighton and Associates that conducted a Geotechnical Investigation of the property (LA, 2007). Leighton and Associates also conducted a fault investigation in the McNaughton property, but to the authors knowledge, that report was not formally submitted to the City of Coachella. Leighton and Associates did provide copies of trench logs to KGS for the current study, but these data were considered not useable because the logs were not associated with even a draft Fault Investigation Report describing the units, soil ages, etc.

In total, the 2005-2007 Petra fault investigations in the Project involved geologic mapping, evaluation of site stratigraphy, and a subsurface investigation (trenching) of approximately 7.54 miles of linear trench. The raw field logs and scans of the logs in addition to numerous maps were provided to KGS for the current study by Petra. During the Desert Lakes investigation, Mr. John Helms CEG provided a stratigraphic soils report for a single profile (Trench T-59; High Desert Consulting, 2006).

All these data obtained from the past studies have been incorporated into the current study, and Mr. Butler CEG was hired for the current study strongly motivated by his knowledge of site geology, structure and stratigraphy. In addition, Mr. Helms CEG was hired for the current study and evaluated an additional 6 soil profiles and associated estimated ages of the observed stratigraphy.

The scope of the current project was determined by many factors. These include:

- Additional trenching to cover the greatly expanded Fault Hazard Zones aerial extent associated with CGS FER-250 (Bryant, 2015)
- Additional trenching within the Berdoo Canyon Fault Zone to better resolve its location and style of faulting
- Adding trenches during this investigation to provide new exposures to assist in evaluating fault activity
- Additional geologic mapping
- Additional soil profile analyses (Helms – Appendix A)
- A more refined lineament analysis utilizing Google Earth Pro Historical Imagery

4.0 PROPOSED DEVELOPMENT

Land planners Kimley-Horn provided a tentative planning map indicating that Project development will include in part: Residential home developments of various densities, mixed use, institutional schools, casino, parks greenways and amenity centers, new agricultural production, active drainages (mostly preserving active washes), roadways and bridges. From the tentative design plan, most developments occur on the relatively elevated surfaces exposing Ocotillo Conglomerate that is tens of thousands of years old.

5.0 GEOLOGIC SETTING AND HISTORICAL ACCOUNTS OF SEISMICITY

5.1 Regional Geologic Setting

The Project is located along the eastern Coachella Valley primarily residing on alluvial slope sediments emanating from the Little San Bernardino Mountains (Figure 2). The Little San Bernardino Mountains are comprised of primarily igneous and metamorphic rocks ranging in age of over a billion years to approximately 80 million years old. The San Andreas Fault occurs near the geomorphic boundary between the relatively flat and planar Coachella Valley to the southwest, and the alluvial slopes and hills commonly occurring on the northeastern side of the fault zone. The San Andreas Fault Zone in the eastern Coachella

Valley exhibit numerous uplifted, faulted and folded terrains associated with continuing tectonic activity of the San Andreas Fault and secondary faults during the late Quaternary (see Byrant, 2015). In part, these include the Indio Hills northwest of the site, and the Mecca Hills to the southeast, that are well known, but less known and not researched in detail to date, are the local hills in the Project that continue south of Highway 10 (Figure 2). The geomorphically dominant uplifted area in the Project is the Coachella Hills (Figure 1B). These series of uplifted and deformed hills northeast of the San Andreas Fault exhibit folded Palm Spring Formation that is a minimum of 770,000 years old, indicating that uplift has occurred since that time.

5.2 Regional Historical Seismicity

The subject property has experienced strong earthquake-induced ground shaking and fault surface rupture during Quaternary time that will occur again. Seismic strong ground shaking could occur in the region of the Project from local Holocene-active faults such as the Berdoo Canyon and San Andreas fault zones (Figure 2, Figure 3A and Figure 3B). In addition, strong seismic ground shaking could occur from regional active faults such as the San Jacinto fault to the southwest, and the Brawley-Imperial faut zones to the southeast (Figure 3A and Figure 3B).

Ground surface rupture can be expected as indicated by the continuing, periodic movement of local Holocene-active faults. The Holocene-active San Andreas fault (Coachella-Indio segment) occurs near the western most boundary of the Project. Secondary fault zones are common to emanate from the northeast side of the San Andreas Fault in eastern Coachella Valley. The Indio Hills and Berdoo Canyon fault zones are examples of these secondary faults (Figure 2, Figure 3A and Figure 3B). The secondary faults genesis may be associated with hanging wall deformation due to a northeastern dip of the San Andreas Fault zone in Coachella Valley (Fuis, et al., 2017). The Painted Canyon fault zone located in the northern Mecca Hills is another secondary fault zone northeast of the San Andreas fault.

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 Spring earthquake (Williams, 1986).

Fumal et. al. (2002) indicated that the most recent surface-rupturing earthquake on the Coachella segment of the San Andreas fault likely occurred in the late 1600's. 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). Their data indicate that the average repeat time for surface-rupturing earthquakes on the Coachella-Indio segment of the San Andreas Fault Zone is approximately 215 +/- 25 years, and that the last surface-rupturing event occurred approximately 325 years ago.

A more recent paleoseismic study on the San Andreas Fault was conducted near the Project in the City of Indio near Dillon Road and indicates a shorter surface rupture recurrence interval of 116 to 221 years, and best-estimate average recurrence interval of 180 years (Philibosian et. al., 2011). This study also indicates that the last major surface rupturing event on the San Andreas Fault occurred in the year 1690, which is more than 300 years ago, hence suggesting that the San Andreas Fault in Coachella Valley is overdue for a major earthquake. One reason a major earthquake has not occurred during its "regular" cycle is that the San Andreas Fault in Coachella Valley may be "triggered" to rupture when ancient Lake Cahuilla is full. Although the work conducted by Philobosian et al. (2011) did not see a correlation of lake levels and major earthquakes on the San Andreas Fault, work by Saha et al. (2020) did. They indicate that the last ancient Lake Cahuilla high-stand where lake waters inundated the City of Indo and City of Coachella occurred between 1630-1700 AD, which correlates the last major earthquake on the San Andreas Fault. Hence, the San Andreas Fault may have not had a major surface rupturing earthquake due to lake levels have not reached high stands in the region of the Project since that time.

Recently, a new Holocene-active fault zone has been identified that strikes parallel to, and slightly west of the currently mapped location of the San Andreas fault along from the Salton Sea to north of the City of Coachella called the East Shoreline Fault zone (Figure 3A, Janecke et al., 2018). Their work suggests that major earthquakes on the San Andreas fault zone may have nucleation sites associated with the interaction of the close proximity of the San Andreas, East Shoreline and Brawley fault zones near the south end of the Salton Sea (Figure 3A).

Numerous moderate to major earthquakes have occurred to the south in the Imperial Valley associated with the southern end of the San Andreas fault (Hanks and Allen, 1989; Gurrola and Rockwell, 1996; Thomas and Rockwell, 1996; Shearer, et al. 2005). In this region the San Andreas fault trends into the Brawly Seismic Zone and a number of faults including the Brawly and Imperial, and also appears to merge with the southern end of the San Jacinto fault zone (Superstition Hills and Superstition Mountain faults). Historical earthquakes in this region occurred in 1940 (Imperial fault), 1979 (Imperial and Brawly faults), 1987 (Superstition Hills and Elmore Ranch faults).

6.0 GEOLOGIC TIME SCALE UTILIZED

The age of most geologic events discussed in this report occurred primarily during the Quaternary Periods. The Neogene Period is subdivided into the Pliocene and Miocene Epochs and the Quaternary Period is subdivided into the Holocene and Pleistocene Epochs. The name and associated time interval designations utilized in this report include (kya = thousand years ago; Ma = million years ago).

PERIOD	EPOCH	TIME PERIOD
QUATERNARY	HOLOCENE	
	Latest Holocene (Historical)	~past 200 years
	Late Holocene	4 kya to 200 years ago
	Mid- Holocene	8 to 4 kya
	Early Holocene	~12 to 8 kya
	PLEISTOCENE	
	Latest Pleistocene	~15 to 12 kya
	Late Pleistocene	125 to 20 kya
	Middle Pleistocene	670 to 125 kya
	Early Pleistocene	~2.6 Ma to 670 kya
NEOGENE	PLIOCENE	
	Late Pliocene	3.6 to 2.6 Ma
	Early Pliocene	5.3 to 3.6 Ma

Although not of critical importance to this study, the time of the boundary between the Pliocene and Pleistocene varies considerably in the literature. This dilemma has resulted from the definition of the boundary of the Pliocene/Pleistocene, which is supposed to coincide with the onset of the first northern hemisphere glaciation. The Pleistocene is the Epoch characterized as the "ice age", hence experiencing periods of major glaciations and interglacial periods of time. The date of the beginning of the Pleistocene has changed as new studies refine the age of the initiation of the ice ages and disagreements within the scientific community. Age ranges "accepted" for the beginning of the Pleistocene (and Quaternary) vary from 2.6 to 1.6 Ma. There is also disagreement regarding the end of the Pleistocene as it was a gradual transition from about 12 to 10 kya. However, the California Geological Survey utilizing primarily findings from Walker et. al (2009) adopted 11.7 kya as the "official" definition of the Holocene based on a proposal to the International Stratigraphic Commission reflecting a change in Oxygen isotopic ($O^{18/16}$) composition of an ice core from Greenland. For the purposes of this study, the end of the Pleistocene is simply rounded to 12 kya as the accuracy of the soil profile ages provided in this report could exhibit errors (+ or -) of 20% to possibly 30% (this is discused in Section7.2).

7.0 SITE STRATIGRAPHY

7.1 Regional Stratigraphy

Pertinent regional Geologic formations in the region of Coachella Valley, Salton Sea and Borrego Valley consist of the Brawley Formation and Ocotillo Conglomerate, both of which were deposited within the past

1.1 Ma (Kirby et al., 2007). The Brawley Formation is generally considered to be sediments deposited on geomorphically low relief landscapes such as a valley floor meandering streams and deltas. The Brawley Formation generally consists of well bedded and well sorted sands and occasional clay beds. The interbedded Ocotillo Conglomerate are considered coarse grained typically fan deposits resulting from the erosion of local hills and mountains (Kirby et al., 2007). In this study and most geologic studies and scientific publications have utilized the name Palm Spring Formation (Group) for similar deposits. However, the Palm Spring Formation (Group) represents older sediments deposited in similar geomorphic conditions as the younger Brawley Formation. In addition, the coarse grained equivalent to the younger Ocotillo Conglomerate deposited at the same time as the Palm Spring Group is referred to as the Canebrake and West Butte Conglomerate (Kirby et al., 2007). The primary motivation to create a Brawley/Ocotillo Conglomerate Group deposited from 1.1 Million to present times, and a Palm Spring/Canebrake-West Brutte Conglomerate deposited from approximately from the late Pliocene to early Pleistocene, is an angular unconformity often occurs between the formational Groups (Lutz, et al., 2006; Kirbey, et al., 2007) . The angular unconformity occurs due to a change in tectonism in the region that cause the creation of the San Jacinto fault zone in the southwestern Salton Trough region (Lutz, et al., 2006; Kirbey, et al., 2007). This depositional and tectonic related deformational history is very similar to that observed in the eastern Coachella Valley.

Within this report however, the term Palm Spring Formation (Qps) will be utilized due to its regular use for decades by Geotechnical consultants and the scientific community (Rymer, et al., 2004). Another reason to utilize the term Palm Spring Formation and not Brawley Formation is that Palm Spring Formation was utilized for all the trench logs and geologic mapping for the Desert Lakes (Lennar) and Stonefield fault investigations by Petra.

The local Brawley Formation (herein referred to as the Palm Spring Formation), and the Ocotillo Conglomerate continue to be deposited today. The Brawley Formation is being deposited across Coachella Valley, and the Ocotillo Conglomerate along the flanks of the mountain ranges bounding the Coachella Valley. Younger alluvial fan deposits along the southern flanks of the Little San Bernardino Mountains can thus be considered part of the Ocotillo Conglomerate but is subdivided into various members based on their age for the purposes of this study and nearly all Geotechnical studies in the area.

7.2 Local Stratigraphy (Site Specific)

In terms of surface exposures across the site, the Ocotillo Conglomerate and its subdivided younger members cover most of the Project (Figure 2, Units Qal and Qco). Palm Spring Formation (Group) is exposed in isolated areas in the Coachella Hills and in the southwestern portion of the site along the southwestern flanks of the Coachella Hills (Plate LM2 in Appendix B). The Palm Spring Group within the project has been subdivided into two formational units: Palm Spring Upper (younger) and Palm Spring Lower (older; Figure 5B). The two Qp members may represent a relatively continuous depositional unit (no unconformities) and are defined as QpU being younger beds containing the Bishop Ash and does tilted (folded) to the degree of unit QpL. Member QpL typically dips 30 to 80 degrees and occurs as the "core" of the Coachella Hills. Unit QoL is described on Figure 5C and represents fluvial sandstones that interbedded with unit QpL. These units are best exposed immediately north of Interstate Highway 10 and immediately south of the property boundary in the southern most portion of the Coachella Hills in the site. For simplicity, it is mapped as unit QpL within this report. Unit QoL may represent the Canebrake formation that is mapped locally by the author to the south of the Site (Petra, 2007a). This suggestion is based on the well sorted and fluvial nature of unit QoL, which is in contrast to unit QoU which are clearly alluvial fan debris flows and poorly sorted "fluvial" deposits.

The coarse grained dominantly alluvial fan fluvial-braided flow deposits and debris flows members of the Ocotillo Conglomerate are subdivided into primarily 4 depositional groups. These include from oldest to youngest, Qf5, Qf4, Qfo, and Qf3 (Figure 5A). These units are described in Figure 5A and in the Soils Stratigraphic Reports of Helms (2006, 2021; Appendix A). These units a subsequently also subdivided into various members as shown on Figure 5A. Units Qf5 to Qfo represent late to latest Pleistocene deposits of approximately 80 to 15 thousand years old (kya, Figure 5A).

Units Qf1 and Qf2 represent primarily fluvial deposits within active wash areas, however minor debris flows occur and generally exhibit less than 1 to 2 feet of stratigraphic thickness. Depositional units Qf1 through Qf5 occur within all "active wash" areas in the Project and are confined to drainage areas within the antecedent drainages through Coachella Hills, Little Coachella Hills eroded into bounding highlands of Ocotillo Conglomerate or Palm Spring Formation (Figure 5C Cross Section B-B'). Upslope, and northeast of the Coachella Hills, units Qf1 through Qf5 occur in active wash areas, but preserved fan surfaces of units Qfo, Qf4 and Q5 can be more common (Figure 5C Cross Section A-A' and Plate LM2). However, in some places, preserved fan surfaces of unit Qf4 and Qf5 exhibit a small elevational relief difference to older Ocotillo Conglomerate. Preserved fan surfaces within the "active" wash regions of unit Qf3 are very common (Plate LM2).

In general, units Qf4, Qfo and Qf3 exhibit approximately 1 to 3 feet stratigraphic thicknesses, and only minor erosion occurred at the base of units and various members of Qfo and Qf3. A relatively large magnitude of basal erosion occurred associated with Unit Qf4. Basal erosion of unit Qf4 was of sufficient magnitude to erode away most if not all of underlying unit Qf5. The stratigraphy exposed in the majority of trenches (typically 8 to 10 feet deep) for this study, exhibit a total stratigraphic thickness of units Qf1 of about 1 to 7 feet, and thus either Ocotillo Conglomerate or Palm Spring Formation is exposed at the basal portions of most trenches. This is of course not the case for trenches excavated on preserved Ocotillo Conglomerate surfaces.

Various minor other units are mapped at the site. These include aeolian (sand dunes) and landslides (Qls, Plate LM2). The aeolian deposits occur in the southwestern most region of the Project and are associated with ancient Lake Cahuilla shoreline activity. The last Lake Cahuilla high lake stand where it reached the City of Coachella was approximately 300 years ago (Philibosian et al., 2001).

Photographs of most of these units are provided in Appendix A.

8.0 NUMERICAL SOIL PROFILE AGES

8.1 Late Pleistocene to Holocene Age Sediments

Numerical age analysis of the Late Pleistocene to Holocene depositional units was conducted by Mr. John Helms CEG. He conducted 7 soil profile analyses in various trenches across the site (Appendix A; Helms, 2006 and 2021). The numerical age results are summarized in the stratigraphic column of Figure 5A. It is commonly understood that soil profile analysis numerical ages provide minimum age estimates. Hence, numerical soil profile ages would generally be older than the age estimated. This occurs for many reasons with the most important criteria involving identifying a locality where the soil has been nearly perfectly preserved and allowed to develop without surface erosion during its development. In alluvial fan environments, abandoned fan terrace surfaces can easily begin to erode soon after abandonment. A second reason is that nearly all the buried soils evaluated are truncated, hence, missing their A and portions of the upper B horizons which are key soil parameters for evaluating age.

Soil profile analyses by Helms CEG (2006, 2021; Appendix A) were conducted for various stratigraphic and morphostratigraphic relationships. For example, Soil Profiles in Trench T-59 exhibited moderately preserved surface soils (minor surface degradation) of units Qfo and Qf4, and thus these soils had an opportunity to form continuously over time with a relatively low magnitude of surface erosion compared to buried soils that are typically truncated and lead to erroneously young age estimates. Hence, soil profile analyses exposing an abandoned fan surface at the surface that has experienced relatively low erosion leads to more accurate soil age estimates (thus unit age) compared to evaluating cumulate soil (unit) ages associated with stacked units where often erosion has occurred between the units.

It is agreed that numerical ages derived from numerous sources with some stemming from Geochemistry methods such as radiocarbon (14C) or optically stimulated luminescence (OSL) can provide good independent data which to evaluate the age of deposits. However, both of these methods are difficult to either achieve, or may lead to erroneous data that can lead to the incorrect conclusions. In terms of 14C, all field loggers and including the author looked for carbon samples (charcoal, or plant matter) that could be sampled and dated for numerical dating. Essentially none was found. This is very common in alluvial fan depositional environments, and it is the primary reason nearly no C14 dating was done for fault investigations in the Coachella Fan region (i.e. La Entrada to the south, Stonewater to the north (see Plate

LM3 in Appendix B). If carbon samples have been found, then they would have been sparse, and very likely not in sufficient quantity stratigraphically to be useful. In other words, if only two samples were found, and say units Qf3 and Qfo, and one value was erroneous from how old the sediments really are, there would not be sufficient additional samples to figure out what sample had the wrong age. Thus, in the authors opinion, a sufficient number of 14C samples need to be collected such that there are multiple samples in the same designated units and that this is the case for multiple units.

The OSL dating method is problematical in terms of accurately dating alluvial fan deposits because the sand grains when migrating in a flood or stream flow may or may not have been exposed to the sun. The OSL method essentially is dating when the sand grains were last exposed to the sun. Wash flow in alluvial fan systems very commonly exhibit a muddy and sandy matrix that is cloudy and easily not allow for grains to be exposed to sunlight during flow. From the authors experience, OSL works very well with aeolian deposits where all the sand grains moved in the air and all exposed to sunlight due to the nature of how they travelled prior to deposition.

On the other hand, soil profile stratigraphic dating has proven to be a sound method for dating various stratigraphic units within alluvial fan systems as abandoned fan surfaces of various ages are typically exposed to provide a reasonable age estimate of when that surface was abandoned. The age of the deposits themselves are clearly older than the abandoned fan surface, but that age difference is not considered by the author. The numerical ages of fan deposits, thus various alluvial units in this study (i.e. Qf1, Qf2, Qf3, Qfo, Qf4, Qf5 and QoU) are best estimated where a particular unit is exposed on the surface as a preserved fan terrace as this is where their deposits have been exposed to surface processes that cause soil development occur. Even in this case however, soil profile estimates are generally understood to provide a minimum age for the deposits as most desert alluvial fan terrace surfaces have exhibited some erosion.

It is argued that the soil age estimates provided in this report are robust for numerous reasons. One is that the site is so large that good examples of preserved fan surfaces and buried soil stratigraphy can be identified and evaluated. Second, the large site allowed for the development of site stratigraphy that is relatively complete exhibiting units ranging from the present to the Late Pleistocene without much "breaks". In other words, evaluating age estimates for the various units via soil stratigraphy requires that all the units need to be included and basically "fit" into a reasonable series of ages relative to one another.

Third, Mr. Helms has evaluated soils across the Coachella Fan for numerous large-scale projects in the Coachella Fan region (i.e. Stonewater and Fiesta; see Plate LM3 in Appendix B) and has worked closely with the author to compare data on the relative ages of the various deposits, their preserved fan geomorphic positions, their morphostratigraphic positions within trenches, etc).

Fouth, it is clear from reading the findings of CGS FER250 that the author (Bryant, 2015) to a certain extent sufficient for him delineating new AP Zones, that he agreed with some of the soil stratigraphic ages of the early stages of work conducted at the then called Desert Lakes Project, which is not the KPC Coachella Project (this study). Prior to publication of CGS FER250 (2015), only a small area of the Site was within a State AP Zone. Bryant (2015) greatly expanded the AP Zone coverage in the Site based on identified faults from the original Petra data which he was provided, but he also did NOT place many areas into AP Zones at the time based on his agreement with the Petra evaluation that many faults were inactive associated with the Coachella Fan fault zone. Thus, the Petra fault trench, geologic mapping, soil stratigraphy, preliminary fault zone map (all created by the author herein) was at his disposal for evaluation, and he agreed with many of the areas of extensive faulting Petra identified as being Pre-Holocene based on the existing Petra stratigraphy. Hence, he agreed for the most part with the initial Petra evaluation of unit ages.

There are other ways to look at the soil data as well. Most desert soil scientists would agree that unit Qf1 and Qf2 are less of equal to 3 kya, and that the robust red soil observed in unit Qf4 is clearly a minimum of 35 kya. Soil scientists Dr. Shlemon and Dr. Thomas Rockwell (personal communication in the field) also evaluated a fairly well preserved Qf3 surface at the La Entrada (Lomas Del Sol project, Petra, 2007a) and estimated a minimum of 3 to 5 kya (average 4 kya). This soil profile was anything from impressive, as it exhibited a 3” to 4” thick Bw horizon with very little soil development in terms of an Av horizon, had essentially not secondary clay associated with a Bt horizon, and the soil profile mostly consisted of a yellowing of the sand grains near the surface. The weak soil profile development over the course of 3 to 4 kya is primarily the result of low rainfall in the area (~4”/year).

Stratigraphy identified in the trenches indicates that unit Qf3 exhibits 3 members (Qf3U, Qf3 and QfL). These units do not occur everywhere, but their identification and respective soils indicate that each of these units required its own independent period of time to deposit. The observation that there are three distinct Qf3 units deposited at different times, and each exhibiting their own upper soil, most of which are buried, indicates that each member is clearly older than 3-4 kya and more likely about 4 to 5 kya. Based on the increased induration of unit Qf3L and more internal sand grain weathering, it likely required closer to 5 kya to develop. Thus, the age of all Qf3 units would be collectively a minimum of 12 Kya.

In the trenches, it is very easy to observe the difference between Qf3 units, which are ligher gray in color similar to unweathered “tonalite” granitic rocks, and Qfo units which exhibit a penetrative yellowish brown hue. In addition, the top of the Qfo units (QfoU typically), is a ledge former in the trench, and the first one encountered if Qf3L is not present. The “ledge” identified at the top of unit QfoU and one exists for QfoL as well, are Bt horizons. It is postulated that the Qfo units were deposited at the end of the last Glacial Maximum of about 30,000 to 16,000 years ago due to the abundance of basal gravels, fining upward sequences, some debris flows containing relatively large clasts. Units Qf3U and Qf3L generally exhibit finer grained sediments typical of mid to late Holocene fan deposition regionally.

Another way of looking at the soils ages is to evaluate a reasonable depositional history between end members. For example, units Qf3 and Qfo must have ages between the two end members of Qf1/Qf2 and Qf4, which would range of say 3 kya to 35 kya. It is clear that the red soil of unit Qf4 is a minimum of 35 kya. This means that units Qf3 and Qfo were deposited during the period of time of 3 to 35 kya. Byrant (2015) points out that a paucity of alluvial fan units for a period of time is problematical (see discussion on Stonewater and Desert Lakes soil ages in CGS FER250). It is reasonable that Qfo units represent the Late to Latest Pleistocene (15 to 35 kya) and that Qf3 units represent Latest Pleistocene to late Holocene. It is clear that depositional rates on the Coachella Fan are slow as the entire stratigraphic thickness of units Qf1 through Qf5 are commonly exposed in the upper 5 to 7 feet across the site in the main drainages. There were erosional events prior to deposition of the older units Qf4 and Qf5 in addition to erosion occurring at the base of unit QfoL.

In summary, the soil profile ages provided in this report include knowledge of other soils evaluated in the Coachella Fan area, numerous profiles evaluated both of preserved surfaces, their morphostratigraphic relationships to one another, consideration of global climate since the Late Pleistocene, and comparison to numerically dates soils in the Mojave Desert region. Thus, the soil numerical ages utilized in this report don't only take into account the numerical ages estimated by a professional soil pedologist such as Mr. Helms.

8.2 Middle to Late Pleistocene Age Sediments

Middle to Late Pleistocene age sediments identified at the site include the Palm Spring Formation (units QpU and QpL) and the Ocotillo Conglomerate (Units QoU and QoL). The Bishop volcanic ash occurs in the Palm Spring Formation upper members (QpU) in the western portion of the site in various fault trenches (See Appendix I). As discussed later, an ash identified in the Ocotillo Conglomerate in the southeastern portion of the Site immediately north of Highway 10 may also be the Bishop Ash. It is generally considered to be approximately 0.7 million years old (Izett et all., 1970), but more recent work determined that the average age of numerous samples from many localities of 0.758.9 million years old +/- 1.8 thousand years (Sarna-Wojcicki, et al., 2000). The Bishop Ash (or Tuff) was also identified interbedded in the Palm Springs Upper formation immediately south of the Project and immediately south of Highway 10 in the Lomas Del Sol/Fiesta Project conducted by Petra (now called La Entrada; Petra 2007a), and in the Indo Hills (Rymer, et al., 2004).

The Ocotillo Conglomerate in the Project area and eastern Coachella Valley exhibits a similar depositional and deformational history as documented in the Borrego Badlands located in the southwestern Salton Trough region (Figure 3A). Lutz et al. (2006) and Kirby et al., (2007) indicate that the Ocotillo Conglomerate began to be deposited (by definition) and expanded its depositional area approximately 1.1

million years ago due to the creation of the newly developed San Jacinto fault zone. The genesis of the San Jacinto fault zone approximately 1.1 million years ago caused a change in tectonism in the Coachella Valley-Salton Trough-Borrego Valley area and it was about this time that uplift and folding increased along the eastern side of the San Andreas fault in the eastern Coachella Valley. Lutz et al. (2006) indicated that the Ocotillo Conglomerate in the Borrego Badlands area is known to range in age of 1.1 to 0.5 million years. This age range is the same as the Brawley Formation which is consistent with the two formations being deposited at the same time but in different geologic environments (Lutz et al, 2006, Kirby, et al., 2007) as discussed earlier. Thus, the age of the Ocotillo Conglomerate in any one locality will be within that range but can also be younger than 0.5 million years old as it simply represents alluvial deposits shed from local mountain ranges. In the eastern Coachella Valley area, the Ocotillo Conglomerate is clearly younger than the Bishop Ash (~0.76 Ma) as the ash bed resides in the underlying Palm Spring Formation (upper). Preserved Ocotillo Conglomerate fan surfaces in the region of the Project are a minimum of ~70 to 160 thousand years old (Helms, 2021; Soil Profile 1; Appendix A). This is a minimum age range and based on the magnitude of uplift, folding and drainage incision of the Ocotillo Conglomerate in the Coachella Hills (in Project), it is likely that exposures of Ocotillo Conglomerate at the surface within the Coachella Hills is a minimum of 160 thousand years old. The Ocotillo Conglomerate in the Coachella Fan area exhibits numerous strong calcic soil horizons each of which are 60 to over 100 thousand years old. This indicates that the Ocotillo Conglomerate was deposited over a period of hundreds of thousands of years in the eastern Coachella Valley.

Likely soon after the Bishop Ash was deposited in the upper members of the local Palm Spring Formation, the Ocotillo Conglomerate was deposited over the site. Hence, it is possible that the uppermost members of the Palm Spring Formation were being deposited at the same time as initial deposition (lowest members) of the Ocotillo Conglomerate. This transition of local deposition likely occurred between 600,00 to 700,00o thousand years ago and may represent a time of an increase uplift rate of the Little San Bernardino Mountains. However, a 6" to 1-foot thick ash layer identified in the Ocotillo Conglomerate immediately north of Highway 10 in the southeastern area of the site may be the Bishop Ash as to the authors knowledge, there is no other volcanic ash deposit that would be over 6" thick of similar age in the region. If this is true, it indicates the Ocotillo Conglomerate was deposited in the eastern and likely northern portions of the site at the same time Palm Spring Formation was deposited in the lower elevations of the western and southwestern portions of the site.

9.0 SITE STRUCTURE

The Site is approximately 4 miles wide east-west, and a maximum of 2 miles wide in a north-south direction. The entire site resides across the Coachella Fan which has been uplifted in the Quaternary likely due to a southeastern dip of the San Andreas fault zone which that structure also led to the development of secondary strike-slip faults northeast of the San Andreas fault zone like the Painted Canyon, Berdoo Canyon and Indio Hills fault zones. Two northwest striking strike-slip fault zones transect the property that include the Berdoo Canyon and newly identified in the region of the site Painted Canyon "central" fault zone (Figure 6). The region bounding these fault zones exhibits faulting associated with the Coachella Fan fault zone.

9.1 Faulting

9.1.1 The Coachella Fan Fault Zone

The Coachella Fan Fault Zone (Bryant, 2015) exhibits a high density of north to northwest striking, west to southwest dipping normal displacement faults. The normal faults typically exhibit small scale apparent displacements of less than two feet, thus observable quite often in trench exposures. The dip of the normal faults is generally steep, however in many instances the faults have been rotated to lower dips with associated change of dips of sedimentary layers bounded by the normal faults. These structures suggest that the normal fault are listric and likely connect to a basal shear surface at relatively shallow depths. This structural interpretation is supported by the identification of basal shear surfaces approximately parallel to bedding identified in the relatively fine grained Palm Spring Formation in the Site, and also in the La Entrada site to the south (Lomas Del Sol site – Petra, 2007a; see Plate LM3 in Appendix B). Although more rare, basal shear surfaces which the overlying listric normal faults have also been identified in the coarser grained Ocotillo Conglomerate.

As mentioned earlier, Kenney (2007) proposed that the majority of the normal dip-slip faults of the Coachella Fan fault zone primarily resulted from lateral spreading and translational sliding induced by strong ground shaking and wetter conditions during the Pleistocene (Kenney, 2007). Hence, that sliding occurred when the sediments were more saturated and heavy, and during strong ground motions (coseismic). In this model, it proposed that the Palm Spring Formation may have at one time encroached to an area beneath the Coachella Fan, and that the approximate limits of the buried deposits may be delineated by where Coachella Fan faults are identified on the surface (Kenney, 2007). Subsequent to Palm Spring Formation being deposited, Ocotillo Conglomerate sediments were deposited likely associated with uplift of the Little San Bernardino Mountains.

Most Coachella Fan faults exhibit thick granular and carbonate rich gouge that appear well "healed", thus show no evidence of shearing. Identified Coachella Fan Faults in the current washes rarely exhibit flower structure indicating that the upper portions of these faults have been eroded away. Numerous Coachella Fan faults have displaced Ocotillo Conglomerate preserved fan surfaces resulting in scarps of various magnitudes. Most of the mapped lineaments on the Ocotillo Fan surfaces are strongly degraded. It is common to identify a higher density of Coachella Fan faults in trenches located in local washes than clear scarps/lineaments on Ocotillo Conglomerate fan surfaces. These data suggest that a higher density of Coachella Fan faults occurred during Ocotillo Conglomerate deposition but subsided once the fan surfaces were abandoned. Evidence for a decrease of fault density during Ocotillo Conglomerate deposition was also observed at the La Entrada (Lomas Del Sol) site to the south (Petra, 2007a).

9.1.2 The Berdoo Canyon and Painted Canyon "central" fault zones

The Berdoo Canyon and Painted Canyon "central" fault zone transect the central and east-central portions of the Site (Figure 6 and Figure 7). Both fault zones trend toward the northwest and are right-lateral strike slip. Bryant (2015) mapped the Berdoo Canyon fault zone to extend toward the southeast to close the northern boundary of the Site. Work conducted in this study clearly indicates that the Berdoo Canyon Fault extends through the Site, and data from the La Entrada fault investigation (Fiesta, Lomas Del Sol, Petra, 2007a) indicates that it extends immediately south of Highway 10. Lineament and geomorphic mapping suggest that the Berdoo Canyon fault zone likely extends with the Painted Canyon fault zone to the southeast (Figure 6 and Figure 7).

Based on interpretation of trenching and soil profile (Hellms this study in Appendix A) data on deformed but preserved Ocotillo Conglomerate fan surfaces (trench log T-4 and T-41B in Appendix I), the Berdoo Canyon fault zone last had a surface rupturing event in the early Holocene, and that two to possibly three previous near surface to surface rupturing events are recorded in the since the Late Pleistocene.

Surface rupture along the Berdoo Canyon fault zone occurs over a wide zone approximately 700 to 1000 feet wide. Surface rupture occurs on many splays of various trends with northwest trending splays likely accommodating most right-lateral slip, and cross faults exhibiting a strong magnitude of dip-slip separation (see thin black lines on Plate BFZ1, Plate BFZ2, and BFZ3 in Appendix D). It is likely that folding and uplift to produce the Coachella Hills is associated with the Berdoo Canyon fault zone.

The Painted Canyon "central" fault zone is identified in the eastern third of the Site and trends toward the northwest. It is likely that the minor folding and uplift to produce the Little Coachella Hills is associated with the Painted Canyon "central" fault zone. Trench data across this fault zone indicates that it is no longer active (i.e. pre-Holocene fault), but was likely active in the early part of the Late Pleistocene.

9.2 Folding

Folding was identified in the Ocotillo Conglomerate (Qo) and Palm Spring Formation (Qp) throughout the Site. Open folds in the Ocotillo and Palm Spring Formation are identified in cliff exposures and trenches northeast of the Coachella Hills (Plate FS1, Appendix C). Fold limbs dip generally range from 5 to 20 degrees but are slightly higher in the region of the Little Coachella Hills where increased uplift occurred near the Painted Canyon fault zone "central" (Figure 6, Figure 7, Plate FS1, Appendix C). Between the Painted Canyon fault zone "central" and Berdoo Canyon fault zone, the Ocotillo Conglomerate and underlying Palm Spring Formation (QpU) exhibit a gentle southwestern dip that is attributed primarily to tectonic stress as the dip is generally greater than a typical alluvial fan slope of 2 to 3 degrees, and unit QpU dips approximately equal to that of overlying QoU and unit QpU was deposited in a nearly flat depositional environment. In the southwestern region of the site, along the southwest flanks of the Coachella Hills, unit QoU and QpL dip gently toward the southwest approximately 5 to 20 degrees (Plate FS1, Appendix C).

9.3 Unconformities

Within the Coachella Hills a strong angular unconformity occurs between units QoU and QpL. Unit QpL exhibits dips of 30-80 degrees primarily toward the southwest, and overlying QoU exhibits dips 10 to 60 degrees less. This indicates that folding and uplift occurred after QpL deposition and prior to QoU deposition.

Folding and associated erosion occurred in unit QoU across most of the site. Paleo-surface soils (pedons) are common at the top of unit QoU immediately below younger Late to Latest Pleistocene units of this study. The soils formed in unit QoU (parent material) on a paleo-erosional surface, and indicates that QoU erosional surfaces were commonly abandoned allowing a soil to develop. The age of the upper QoU paleosurfaces varies depending on how long the surface had been exposed, but commonly are reddish brown suggesting that are over 25 to 35 thousand years old. Thus, Late to Latest Pleistocene deposits overly unit QoU commonly exhibit an angular unconformity with QoU bedding, but a "disconformity" with the QoU erosion surface. These observations indicate that onsite antecedent-ancestral drainages developed tens of thousands of years prior to deposition of unit Qf5.

10.0 METHODS OF INVESTIGATION

10.1 Published Literature & Reports

As referenced in this report, there are numerous publications utilized for this report that include pertinent Fault Investigation Reports by Geotechnical companies, peer review scientific publications.

Some fault investigations have been conducted near the site. These include older studies from 1992 and 1992 conducted by Rasumssen & Associates, and Leighton & Associates (Rasmussen, 1992a, 1992b, 1999; Leighton, 1992). These studies were located in the landfill site (the Pyramid, and Transfer Station) located approximately a half mile north of the northwestern boundary of the Site. Faults were identified in these studies and are essentially part of the Coachella Fan fault zone, which also occurs in the Project. Their numerical soil age estimates in the authors opinion are incorrect, and more importantly, these study areas exhibited very limited Late Pleistocene to Holocene deposits to allow for a determination of fault activity.

Petra (2007a) conducted fault investigation immediately south of the Project. This study involved a 2200-acre site and exhibits very similar faulting, and thus the same fault zones (Coachella Fan and Berdoo Canyon fault zones). The Petra (2007a) study consisted of a similar scale fault investigation as this study involving tens of thousands of feet of trenching. In this study, it was discovered that the mode of faulting involving southwest dipping faults, striking to the northwest, and with predominantly normal apparent dip-slip displacement are inactive (i.e. pre-Holocene fault). Kenney (2007) proposed based on data collected during the Petra 2007a fault investigation that this mode of faulting was due to lateral spreading and stacked translational sliding that occurred during strong ground shaking and when sediments at depth were wetter than Holocene times. The stratigraphic section utilized in the Petra (2007) fault investigation, which was managed by the author, was utilized as a starting point and thus augmented for the stratigraphy of the current Project.

10.2 Surficial Investigation – Geologic Mapping & Photolineament Analysis

Geologic mapping was conducted within the Site and the results of the mapping are provided throughout the report. Mapping was conducted at a scale of 1"=400' in the field on hard copy maps, and that data. Strike and dip attitudes of bedding were utilized to provide general stratigraphic structure across the site as shown on Plates FS1 and FS2 (Appendix C). This mapping primarily occurred within older formation at the site (i.e. Qo and Qp).

Preserved alluvial fan surfaces such as Qf3, Qfo, Qf4 and Qf5 were mapped via a combination of field mapping, utilizing trench stratigraphy, and aerial mapping in Google Earth Pro Historical Imagery. The results of this mapping are shown on various plates in this report, but most easily reviewed on Plates GTMO through GTM19 in Appendix E.

An air-photo lineament analysis was conducted for the site primarily utilizing Historical Imagery in Google Earth Pro. Historical imagery in Google Earth is in color and of reasonably sufficient resolution to identify even subtle tonal and geomorphic lineaments (see below). For example, it is common in the Google Earth Historical imagery for creosote bushes only 2 feet in diameter be clearly observed. Imagery is available in for the Site that is in color and good resolution from years 2002 to 2021, and for some years images from different months are available. In addition, an ortho aerial photograph with resolution between 6 inches to 1 foot was acquired during the Petra Fault Investigation for the Desert Lakes Project. That image was also used for the lineament analysis of this study.

Lineaments were evaluated as either Tonal (color contrast) or Geomorphic (geomorphic relief occurs). The results of the lineament mapping is provided on Plates LM1and LM2 (Appendix B). The results of the lineament analysis are also provided on Plate FZM2 (Appendix G) where all fault trenches are also shown in relation to State AP Fault Hazard Zones.

Bryant (2015) compiled numerous published lineament and fault maps for the region of the site (Plate LM3, Appendix B). In general, the lineament map prepared for this study is consistent with maps conducted for publications dating back decades.

10.3 Subsurface Investigation – Fault Trenching

This investigation utilized subsurface fault trenching to evaluate site stratigraphy, structure, and location and activity of onsite faulting. In total, 50,942 feet (~9.65 miles) of fault trenches were excavated across the site, primarily within State of California AP Fault Hazard Zones. Trenches are logged at a scale of 1"=10'. It is understood that this is not the typical scale for trench logs (i.e. 1"=5'), and the motivation for the 1"=10' scale is that the data required to demonstrate fault activity can very readily be communicated at the smaller scale. For example, most trenches are located in washes that exhibit 3 to 5 units (i.e. Qf3/QfoU/QfoL/Qf4/QoU) within a typical 8 to 10-foot deep trench. Also, the contacts between these units are typically sharp erosion surfaces where apparent dip-slip displacement of less than an inch could readily be observed. The 1"10' scale also greatly assists in seeing the lateral stratigraphy and structure across the site as typically over 200 feet of linear trench can be shown on an 11x17 inch plate (Plates T1 through T212, Appendix I).

Most trench locations in the local washes were chosen where possible to exhibit a Qf3 age degraded surface at the surface so that surficial sediments of Qf3 were not eroded away and its surface soil was preserved. Other trenches were excavated on older fan surfaces to evaluate lineaments that may be faults, and to provide good soil stratigraphy for a soil stratigraphic (pedon) evaluation (Helms reports in Appendix A). Some short trenches (essentially test pits) were excavated to evaluate surface soil age to understand which unit it is, and for the morphostratigraphic analysis of units (Figure 5C). Morphostratigraphic analysis basically entails understanding how preserved fan surface deposits correlate with buried deposits within the trenches. It is a principle tool utilized for this fault investigation.

Of the 50,942 feet of fault trenches utilized in this study, 39,825 feet (~754 miles) are from the Petra (2005 to 2007) fault investigation (See Table F1, Appendix I). Over 3 months of full-time work was undertaken by the author to evaluate the Petra trench logs in terms of stratigraphy and evaluation of fault activity. One of the main goals in the review of the Petra trench logs was to apply the stratigraphy of the Late Pleistocene to Holocene that had evolved toward the end of the Petra investigation in 2007 (Figure 5A). Some of the early Petra trench logs circa 2005, are simply not very clear in terms of stratigraphy of the Late to Latest Pleistocene and Holocene deposits overlying older units such as QoU and QpU. However, by early 2006, this issue was identified and corrected once the author (Dr. Kenney) began to manage the project. For example, additional trenches were excavated parallel to the original trench to provide better stratigraphy (often further into a wash) and fault activity interpretation, and some trenches were relogged utilizing the adopted standardize method provided by Dr. Kenney. The revised logging method improved their clarity, consistency, accuracy, and ease of interpretation.

During the current study, an additional 11,117 feet (~2.11 miles) of trench was excavated and logged across the Project (Table F1, Appendix I). Trench number designations were chosen during the current study to either coincide with Petra 2005-2007 trench designations such that their logs will reside in sequential order thus aligning in order as a series of Plates (Appendix I). For example, if KGS excavated a new trench near an older Petra 2005-2007 trench labeled T-79, the Petra trench would be assigned T-79A, and the new KGS trench would be assigned T-79B. In other instances, KGS thus study chose a "fill in" numerical gaps where Petra 2005-2007 had not utilized a trench designation number, and during the current KGS study, these numbers were utilized when possible. A good example of this occurring are the Stonefield investigation where their 5 trenches were assigned T-61, T-62, T-63, T-64 and T-65 (Table F1, Appendix I).

The KGS current study trenches occur across the site and were dug for numerous reasons, but most of them were to "fill in the gaps" where the older Petra 2005-2007 study had not investigated across the new State of California AP Fault Hazard Zones which were greatly expanded in 2015 (Bryant, 2015). One trench, T-59B was dug to provide an exposure of Qf4 and Qfo abandoned fan surfaces so that Helms CEG could conduct a soil stratigraphic (pedon) analysis of a preserved, but degraded Qf4 surface. Trench T-69A Cross Trench 1 (T-69A CT1) was excavated to be an access ramp, but also to evaluate a fault deformed (uplifted a few inches to a foot) fan surface within the Berdoo Canyon fault zone by Helms CEG (his soil Profile No.6, Appendix A located at Latitude 33° 42.815'N, Longitude 116° 6.891'W). KGS did not log T-69A CT1 but it was observed in the field that the units in T-69A CT1 did laterally connect with units in T-69A (the primary trench).

Other trenches not intended to just "fill in the AP Fault Hazard Zones" were excavated within the Berdoo Canyon fault zone as this fault zone had not been fully understood by the end of the Petra 2005-2007 study. These trenches include: T-69A, T-69B, T-4, T-41B, T-43B and T-34C. Trench T-4 and T-43B were excavated to determine if very subtle linear scarps identified where relatively coarse-grained verses fine grained surface gravel lag on a preserved QoU surface resulted from fault surface rupture within the Berdoo Canyon Fault Zone (see Plate TP1, Appendix A). It was confirmed from Trenches T-4 and T-43B that the subtle scarps were created by faulting. Field mapping identified similar scarps, and some exhibiting scarp relief between 1 to 3 feet across numerous QoU surfaces (Plate BFZ1, Plate BFZ2, Plate BFZ3 in Appendix D). This mapping and confirmation from the T-4 and T-43B that the scarps are produced by Holocene-active faulting, provided strong evidence to support the delineation of the proposed fault setback zones associated with the Berdoo Canyon Fault (Appendix G).

Some trenches were excavated to attempt to take a second look via new stratigraphy of a fault observed in a trench where the fault activity could not be accurately determined. Some examples of these trenches include T-75B and T-75C that were motivated to evaluate Petra 2005-2007 "faults" that were consider by the auther to have not been logged correctly in the past. Another example is trench T-37AEE-W2 that provided a new exposure of a fault in T-37AEE. The new exposure exhibited Late to Latest Pleistocene sediments overlying the fault without disruption, and thus the fault was evaluated as Pre-Holocene.

Fault trench maps are provided in Appendix E (Plates GTM0 through GTM19) show the location of fault trenches, fault trend and location, and local geology. How fault activity was determined during this study is discussed below.

10.4 Fault Activity and Chronology

An evaluation of fault activity was conducted in accordance with the State of California AP Fault Hazard Zone guidelines of CGS Special Publication 42 (Bryant, 2007) that indicates that a fault is "active" (now referred to as Holocene-active) if it has exhibited surface rupture during the past 11.7 thousand years (Holocene time). Hence, if a fault is clearly shown to be overlain by unfaulted sediments that are older than the Holocene, that provides sufficiently strong evidence that the fault is not active (inactive this study; Pre-Holocene term currently used).

For this study, faults were determined to be Pre-Holocene if they did not displace overlying units QfoL, QfoU, Qf4 or Qf5 as all of these units are clearly of Late to Latest Pleistocene age. Although unit Qf3L is numerically dated to extend into the Latest Pleistocene, its age range included the Early Holocene, and thus was not considered as strong enough criteria to be utilized to determine fault activity.

Some faults identified in the trenches were determined to be pre-Holocene based on the strong soil profile development in the upper Ocotillo Conglomerate (QoU). As discussed earlier, reddish brown soil profiles of a minimum of 25,000 years old commonly formed on erosion surfaces into unit QoU, and then this surface was commonly buried by younger sediments. However, in some places the sufficiently old Late to Latest Pleistocene deposits did not occur overlying the fault, but if the QoU surface soil was not displaced, and not fault was identified in the soil, and a paucity of fault gouge, the fault was determined to be pre-Holocene age faults.

11.0 CONCLUSIONS

11.1 Location of Faulting Locally and within the Project

Faulting is identified throughout the site associated with the Coachella Fan, the Berdoo Canyon, and the Painted Canyon "central" fault zones. The Berdoo Canyon and Painted Canyon "central" fault zones are considered are considered secondary fault systems to the San Andreas fault zone located immediately west of the western most property boundary and likely derive from a northeasterly dip of the San Andreas Fault at depth. Hence, "hanging wall" strain. These types of faults are common in the region. For example, the Indio Hills fault zone in the Indio hills to the northwest, and Painted Canyon fault zone in the Mecca Hills to the southeast. Most of these secondary fault zones occur approximately 8000 to 1000 feet northeast of the surface expression of the San Andreas fault zone. The second mode of faulting in the site is associated with the Coachella Fan fault zone which occurs across the entire Project and also is a secondary form of deformation as these faults may have only exhibited motion during strong groundmotion (cosesimic) in combination with being more saturated.

11.2 Type of Faults and Nature of Anticipated Displacement

Mode 1 faulting at the site (Berdoo Canyon and Painted Canyon "central" fault zones) consists of right-lateral strike slip faulting. The Painted Canyon "central" fault zone is determined to be pre-Holocene in this study, hence, future displacements across this fault system is considered very low. The Berdoo Canyon fault zone is determined to be Holocene-active and anticipated movement during a future surface rupturing event will likely exhibit right-lateral motion across numerous small scale fault strands of varying trends and type of displacement across a wide zone. The magnitude of displacement across various fault will vary with most of the displacement occurring within the center of the fault zone and progressively less displacement toward the outer limits of mapped Berdoo Canyon fault zone (i.e. center region of the proposed fault setbacks – See Plates in Appendix G and Appendix D)

11.3 Probability of Future Fault Surface Rupturing Events

The probability of Site fault surface rupture is likely low in terms of the next 50 to 100 years due to the long recurrence interval of the Berdoo Canyon fault zone. Faulting was identified in trenches T-4 and T-43B that indicate that multiple events had occurred since the mid Late Pleistocene approximately, and some events only within the Ocotillo Conglomerate. The last event on the Berdoo Canyon fault zone is offsets the early Pleistocene surface soil, and the surface of the same age. This indicates that the fault zone likely had a surface rupturing event in the early Holocene as no younger deposits or soil development has occurred associated with those faults (i.e. a stable QoU surface). The recurrence interval of the Berdoo Canyon fault zone is unknown, however it may be as short as 10,000 years, and thus, it is possible that its full average recurrence interval of time has elapsed.

The San Andreas fault zone has experienced approximately 100 years past its average recurrence interval for a major earthquake. As discussed earlier in this report, this may be due to ancient Lake Cahuilla not filling up to a level of the City of Coachella area, but it is currently unknown. What is known, is that the San Andreas fault zone is Holocene-active, overdue for a large earthquake, and located within tens of feet of the western boundary of the property. Hence, it is considered to have a high probability of fault surface rupture in terms of the "life-span" or duration of built habitable structures on the property. However, this is more of a concern regarding seismic shaking. Actual fault surface rupture caused by a major earthquake on the San Andreas Fault will likely only extend under the All American Canal, and possibly a bit more northeast to the area between the canal and the flood control berm. Site fracturing caused by seismic ground shaking from the San Andreas fault zone will likely occur in places across the site.

11.4 Potential Surface Fracturing Overlying Pre-Holocene Faults

In some trenches within wash areas, near vertical fracturing was observed in relatively young, unconsolidated fluvial fan deposits. Similar structures were observed for the La Entrada site (Fiesta, then Lomas Del Sol property; Petra, 2007a), but these structures were much more prevalent there. The fractures exhibited no displacement, but instead simply a loss of unit integrity where sand grains would fall out (collapse) within the fracture. These features typically occurred above a pre-Holocene fault suggesting that some minor mechanical shearing/movement of sediments across the fault moved slightly during strong ground shaking. No net displacement occurred once shaking subsided, but a breakdown of unit integrity overlying the pre-Holocene fault. These structures are not faults and thus do not require fault setback mitigation, however, for development purposes, engineering mitigation for potential secondary seismic effects of strong ground shaking should be considered for the majority of the site (i.e. post tension foundations for habitable, essential and critical structures).

11.5 Association of Lineaments and Faulting

Most identified lineaments both tonal and geomorphic (Appendix B) were identified on older deposits such as units QoU and QpU. These units are exposed in the surface in relatively high relief areas of the site (Plate LM1, Appendix B). These areas expose unit QoU across most of the site, and unit QpU in the southwestern region of the site (Plate LM2, Appendix B). Fault trenching in the site indicates that most of the geomorphic lineaments (geomorphic relief) were associated with faulting, and many were confirmed in the field as fault scarps on the QoU preserved fan surfaces.

The number of lineaments identified in progressively younger surface deposits decreases with decreasing age of the deposits. This is demonstrated by a higher number of lineaments in unit QoU, and fewer on unit Qf5 fan surfaces, and only one lineament associated with a QoU and Qf4 fan surface geologic contact (Plate LM2, Appendix B). This is consistent with faulting of the Coachella Fan fault system decreasing over time and cessation (inactivity) since the Late Pleistocene of the Eastern Berdoo Canyon fault zone. These observations are observed in the northern portion of the Project.

11.6 Degree of Confidence in and Limitations of Data and Conclusions

The confidence of the Conclusions provided in this report is dependent on whether sufficient trenching was accomplished, and the confidence regarding the numerical ages of the stratigraphic units and whether those units occurred across the site. It is the opinion of the author that sufficient trenching was conducted in the State of California AP Fault Hazard Zones as the only zones not investigated via trenching are within easements where no building will be allowed (Plate FZM2, Appendix G). This is the case in the far western margin of the property due to an easement associated with the All American Canal and flood control berm; however this areas is placed in a mitigating fault setback zone in this report. Other areas were the entire AP Fault Hazard Zones show a paucity of trenching across their entire AP Zone width do exhibit trenches that investigated strong lineaments that likely motivated the State of California AP zone in the first place. Hence, the faults postulated faults motivating the State to place the zone there were investigated. This condition occurs in the northeastern portion of the Site immediately northeast of the utility line easement (Plate FZM2, Appendix G).

The numerical ages determined for this study by Helms CEG (2006, 2021; Appendix A) are believed to exhibit any reasonable errors in age where the findings of this study would not increase motivation for additional fault setbacks. As discussed earlier, soil pedon numerical age evaluations like those provided by Helms CEG in this report are generally understood to provide minimum ages for sediments, hence, if the soil age estimates are incorrect, the deposits are likely older than what the soil analysis will determine. Second, the soils work that Helms CEG conducted was in conjunction with the authors evaluation of the morphostratigraphic evaluation of the site where the relative age of all units is understood, and locations where preserved alluvial fan surfaces for various units can be identified. An lastly, Helms CEG has conducted work for adjacent properties in conjunction with the author (Petra 2007a, Petra 2007b among others) and the results of those reports greatly assist in our understanding of the depositional history in the Coachella Fan area.

Lastly, the degree of confidence evaluating fault activity is considered robust as remarkably similar stratigraphy occurs in drainages across the site. Hence, the Late to Latest Pleistocene units of Qf3/Qfo/Qf4/Qf5 is identified in every major wash in the site which is where the vast majority of trenches occur (Figure 5C)

11.7 Geotechnical Issues with Fault Trenches (backfill and Grading)

Some trenches excavated during this study which includes the Petra and current KGS investigations were both backfilled or were not. Table 1 in Appendix I provides a list of all the trenches and indicates which have been backfilled and which have not (remain open). Most trenches were backfilled subsequent to the Petra (2007) fault investigation, and only a few were backfilled during the current fault investigation. All trenches that have been backfilled did not involve geotechnical engineered fill placement, and were simply filled via loose backfill.

The excavation open pit (unbackfilled trenches) and currently backfilled trenches should be considered by Geotechnical Engineers in terms of finish grade of pads and other infrastructure when acquiring City of Coachella grading plan permits.

11.8 Preliminary assessment of Utility Lines within Fault Setback Zones

Development of underground utilities across the proposed fault setback zones should take into account potential fault displacement. For the Berdoo Canyon fault zone, it should be anticipated that relatively small magnitude vertical and horizontal displacement would likely occur across a wide zone. It is possible that a "primary" right-lateral strike-slip fault within this zone may exhibit a total of 2 to 5 feet of offset. Geotechncial Engineers designing such utilities could utilize the fault scarp mapping shown in Appendix D (thin black lines) and fault trench data.

12.0 RECOMMENDATIONS

12.1 Fault Setback from Holocene-active and Age-Undetermined Faults

Faults observed to offset Holocene age units are considered Holocene-active and faults observed to not offset overlying units of Late to Latest Pleistocene age are evaluated to be Pre-Holocene faults. Identified Holocene-active are placed within fault setback zones (see Plates in Appendix G). Faults identified that are overlain by only Holocene age units (i.e. Qf1/Qf2/Qf3 series) are considered Age-undetermined, and thus were either more fully investigated via an additional trench with older overlying stratigraphy, or the fault is recommended for fault setback mitigation.

12.2 Proposed Project Development Mitigation - Utility Lines, and construction of habitable, essential and critical structures

Fault setbacks are proposed as mitigation for potential fault surface rupture in the site (Plate FZM3, Plate FZM4 and Plate FZM5 in Appendix G). The primary fault setback zone in the Site is associated with the active right-lateral strike slip Berdoo Canyon fault zone. Fault setbacks of a minimum of 50-feet from Holocene-active faults, or faults believed to be Holocene-active particularly associated with the Berdoo Canyon fault zone was conducted. However, due to the wide and complex nature of surface rupture along the Berdoo Canyon fault zone, an approximately minimum of 100-foot setback is established, and in many locations the proposed fault setbacks are approximately 150-feet.

Key survey points were acquired for various faults and trenches to assist in delineating the proposed setback zone bounding the Berdoo Canyon fault zone. Other portions of the proposed fault setback zone bounding the Berdoo Canyon fault zone utilized Google Earth Pro relative to mapped scarps (Plates BFZ1 through BFZ3) where a minimum of 50-feet was measured to acquire the latitude and longitude of the setback zone boundary.

Kimley Horn provides a report of their survey points for the Berdoo Canyon fault zone in Appendix F and a map prepared by them is provided in Appendix G (Plate FZM6). These survey data were for the original proposed fault setbacks in the KGS September, 2021 Fault Investigation Report but are still useful for the now significantly wider proposed fault setbacks in the current report (see Plates in Appendix G). The revised current proposed setbacks are located utilizing latitudes and longitudes obtained in Google Earth Pro.

The proposed fault setback zones in the western most region of the property was not surveyed, but instead utilized Google Earth Pro to determine latitude and longitude locations a minimum of 50-feet from age-undetermined faults.

It is recommended that no habitable structures be constructed within the proposed fault setback zones. These include habitable, essential, or critical structures (i.e. home dwellings, office buildings, fire stations, police stations, hospitals, schools etc).

Development of underground utilities across the proposed fault setback zones should take into account potential fault displacement. For the Berdoo Canyon fault zone, it should be anticipated that relatively small magnitude vertical and horizontal displacement would likely occur across a wide zone. It is possible that a "primary" right-lateral strike-slip fault within this zone may exhibit a total of 2 to 5 feet of offset. Geotechncial Engineers designing such utilities could utilize the fault scarp mapping shown in Appendix D (thin black lines) and fault trench data.

It is recommended that the locations of the proposed current (this report) fault setback zones be added to future Land Plans and certainly grading plans that are submitted to the City of Coachella Land Planning Department.

From the authors perspective, the largest seismic hazard to the property is strong ground shaking particularly associated with the San Andreas Fault. Ground shaking will likely cause some ground fracturing, and landslide type deformation may occur particularly in lower elevations where unit Qp is close to the surface. Mitigation for these issues is beyond the scope of this study, however, the results of this study should be utilized by Project developers and their engineers.

12.3 Limitations of the Investigation – Need for additional Studies

It is the authors opinion that the magnitude of this investigation provides sufficient data to support its findings and that the data and analysis is sufficient to satisfy the State of California AP Special Report SP-42 investigation guidelines.

13.0 REFERENCES

Bryant, W.A., and Hart, E.W., 2007 (Revised 2018), Fault-rupture hazard zones in California: California Geological Survey Special Publication 42, (digital version only, electronic document available at ftp://ftp.consrv.ca.gov/pub/dmg/pubs/sp/Sp42.pdf).

Bryant, W., 2015; California Geological Survey, Fault Evaluation Report FER-250, San Andreas, Skeleton Canyon, Indio Hills, NW Painted Canyon, Coachella Fan, Berdoo Canyon Canyon, and related faults, Riverside County, California; Report date December 1, 2015, p. 35.

Earth Technology Corporation, 1990, Seismic geologic report for three existing buildings at the Coachella sanitary landfill, Riverside County, California: unpublished consultant's report, Project No. 90-663, March 14, 1990. [State of California report AP-2392]

Fuis, G., Bauer, K., Goldman, M., Ryberg, T., Langenheim, V., Scheirer, D., Rymer, M., Stock, J., Hole, J., Catchings, R., Graves, R., Aagaard, B., 2017, Subsurface Geometry of the San Andreas Fault in Southern California: Results from the Salton Seismic Imaging Project (SSIP) and Strong Ground Motion Expectations; Bulleting of the Seismological Society of America, v. 107, no. 4, p. 1642-1662. 20-A04; Report dated June 24, 2004.

Hilltop Geotechnical, 2004; Preliminary evaluation of on-site faulting, proposed Desert Lakes Project, residential and recreational development, City of Coachella, Riverside County, California; Report prepared for Pulte Homes/Dell Webb; Job No. 4

Izett, G., Wilcox, E., Powers, A., Desborough, G., 1970; The Bishopo ash bed, a Pleistocene marker bed in the Western United States; Quaternary Research, v. 1, issue 1, p. 121-132.

Janecke, S., Markowski, D., Evans, J, Peraud, P., Kenney, M., 2018; Durmid ladder structure and its implications for the nucleation sites of the next M>7.5 earthquake on the San Andreas fault or Brawley seismic zone in southern California; Lithosphere, v. 10, no. 5, p.602-631.

Jennings, C.W., 1994, Fault activity map of California and adjacent areas with locations, and ages of recent volcanic eruptions: California Department of Conservation, Division of Mines and Geology Data Map Series No. 6, 92 p., 2 plates, map scale 1:750,000.

Kenney, M., 2007; Late Quaternary deformation and sedimentation in the Coachella Fan region between the Mecca and Indio Hills, northeast of San Andreas fault, California"; Association of Engineering Geologists (AEG), 2007 meeting.

Kirby, S., Janecke, S., Dorsey, R., Bernard, D., Housen, B., Langenheim, V., McDougall, K., Steely, A., 2007; Pleistocene Brawley and ocotillo Formations: Evidence for Initial Strike-Slip Deformation along the San Felipe and San Jacinto Fault Zones, Southern California; Journal of Geology, v. 115, p. 43-62.

Leighton and Associates, 1992; Geological evaluation of possible Holocene faulting within the Coachella Landfill Site, Section 22, T.5S, R.8E SBB&M; Report prepared for The County of Riverside Waste Management; Job No. 6910975-02, Report dated March 5, 1992.

Lutz, A., Dorsey, R., Housen, B., and Janecke, S., 2006; Stratigraphic record of Pleistocene faulting and basin evolution in the Borrego Badlands, San Jacinto fault zone, Southern California; v. 118, no. 11/12, p. 1377-1397.

Petra, 2007a, Updated geotechnical fault investigation report for land planning purposes, approximately 2200-acre property (Lomas Del Sol), City of Coachella, Riverside County, California: unpublished consultant's report, J.N. 4604-04, January 15, 2007. [State of California report AP-3413].

Petra, 2007b, Fault investigation report for land planning purposes, approximately 746-acre Stone Water property, Riverside County, California: unpublished consultant's report, J.N. 645-05, May 29, 2007 (un-submitted report). [State of California report AP-3477].

Philibosian, B., Fumal, T., Weldon, R., 2011; San Andreas Fault Earthquake Chronology and Lake Cahuilla History at Coachella, California; Bulletin of the Seismological Society of America, vol. 101, no. 1, p. 13-38.

Rasmussen & Associates, 1992a; Subsurface engineering Geology investigation of Faulting shown on Alquist-Priolo map within the active landfill Coachella Sanitary Landfill, East of Indio, California; Report prepared for the County of Riverside Waste Management, Job No. 3133, Report dated August 17, 1992.

Rasmussen & Associates, 1992b; Geologic evaluation of faulting, Coachella Sanitary Landfill Expansion, southern portion of Section 22, T5S, R8E, east of Indio, California; Report prepared County of Riverside Waste Management; Job No. 3118, report dated October 12, 1992.

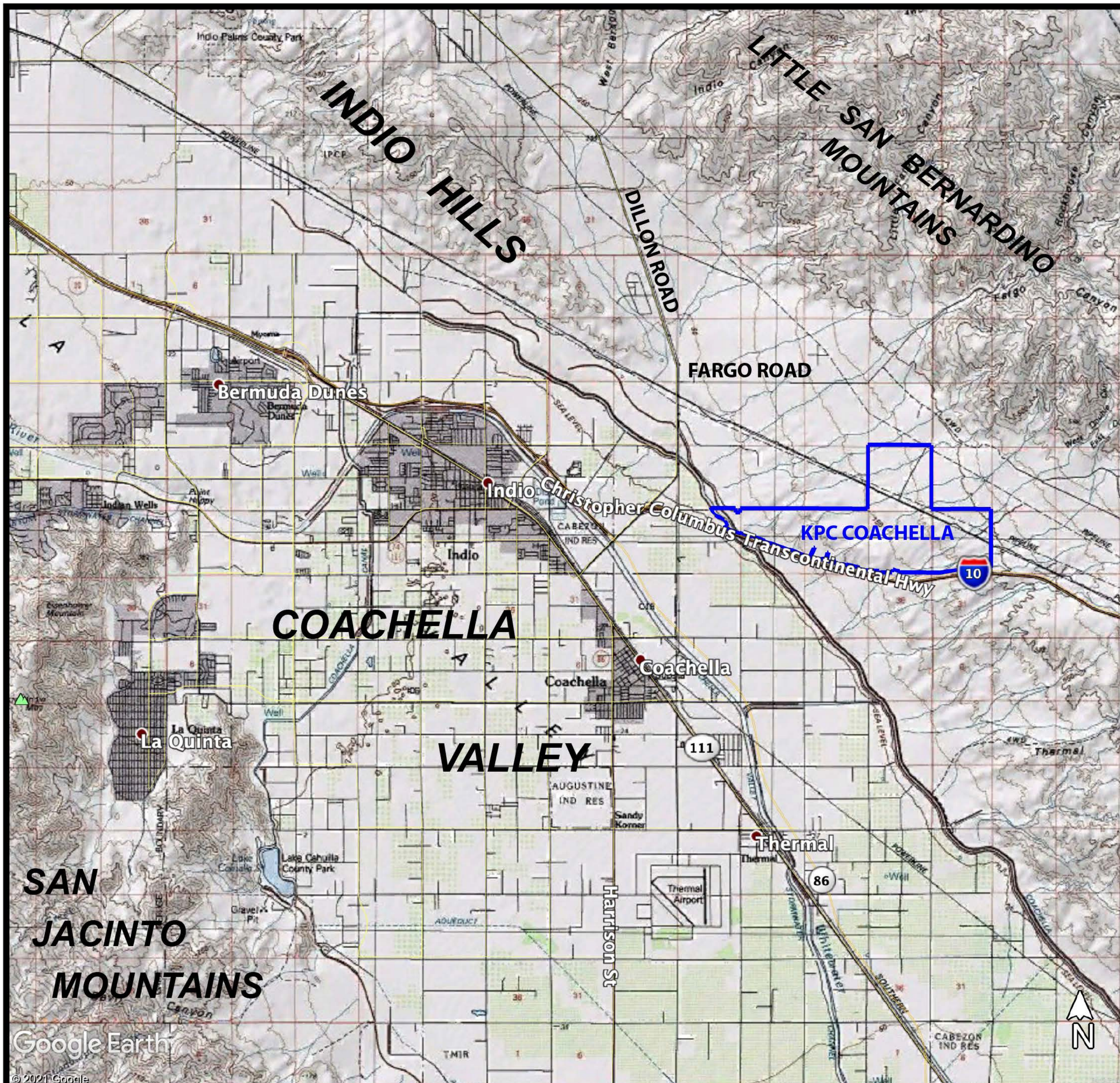
Rasmussen & Associates, 1999; Subsurface Engineering Geology Investigation, proposed Coachella Transfer Station, Coachella Area, Riverside County, California; Report prepared for Burrtec Waste Industries; Project No. 3133.1, Report dated July 21, 1999.

Rymer, M., Fumal, T., Sarna-Wojcicki, Weldon, R., Laganda, G., Stephenson, W., Rockwell, T, 2004; Geology of the San Andreas Fault in the Indio and Mecca Hills, Coachella Valley, southern California, a field guide to and discussion of features and process at two locations within the San Andreas fault zone; Seismological Society of America Annual meeting, April 17, 2004.

Saha, S., Moon, S., Rockwell, T.K., Scharer, K.M., and Brown, N.D. 2020. Reconstructing long-term subsidence and paleoseismic history of the ancient Lake Cahuilla along the southern San Andreas fault in Coachella, California. *Poster Presentation at 2020 SCEC Annual Meeting, poster #022.*

Sarna-Wojcicki, A., Pringle, M., Wijbrans, J., 2000; New 40Ar/39Ar age of the Bishop Tuff from multiple sites and sediment rate calibration for the Matuyama-Bruhnes boundary; Journal of Geophysical Research, v. 105, no. B9, p. 431-443.

FIGURES



Map created utilizing Google Earth Pro
and Earthpoint in Google Earth Pro

0 1 2
Miles

N W E S

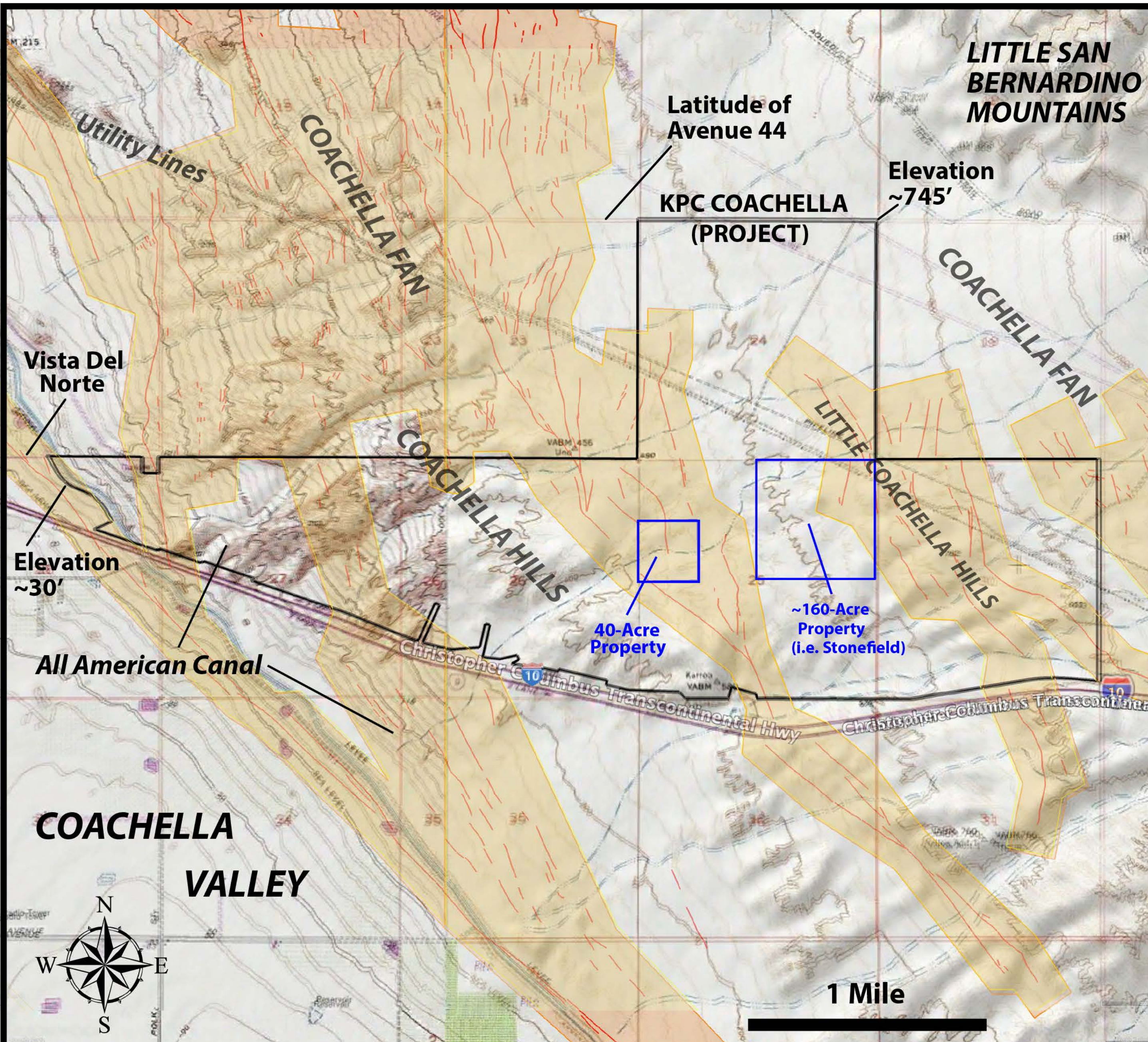
SITE LOCATION

KENNEY GEOSCIENCE
VISTA, CA

Kenney GeoScience

KPC Coachella

DATE Jan. 2022	J.N. 745-19	**FIGURE 1A**
DWG: MDK		



MAP EXPLANATION

EARTHQUAKE FAULT ZONES

Earthquake Fault Zones
Zone boundaries are delineated by straight-line segments; the boundaries define the zone encompassing active faults that constitute a potential hazard to structures from surface faulting or fault creep such that avoidance as described in Public Resources Code Section 2621.5(a) would be required.

Zoned fault traces

AP Zones and fault trances mapped via CGS GIS files utilized in Google Earth

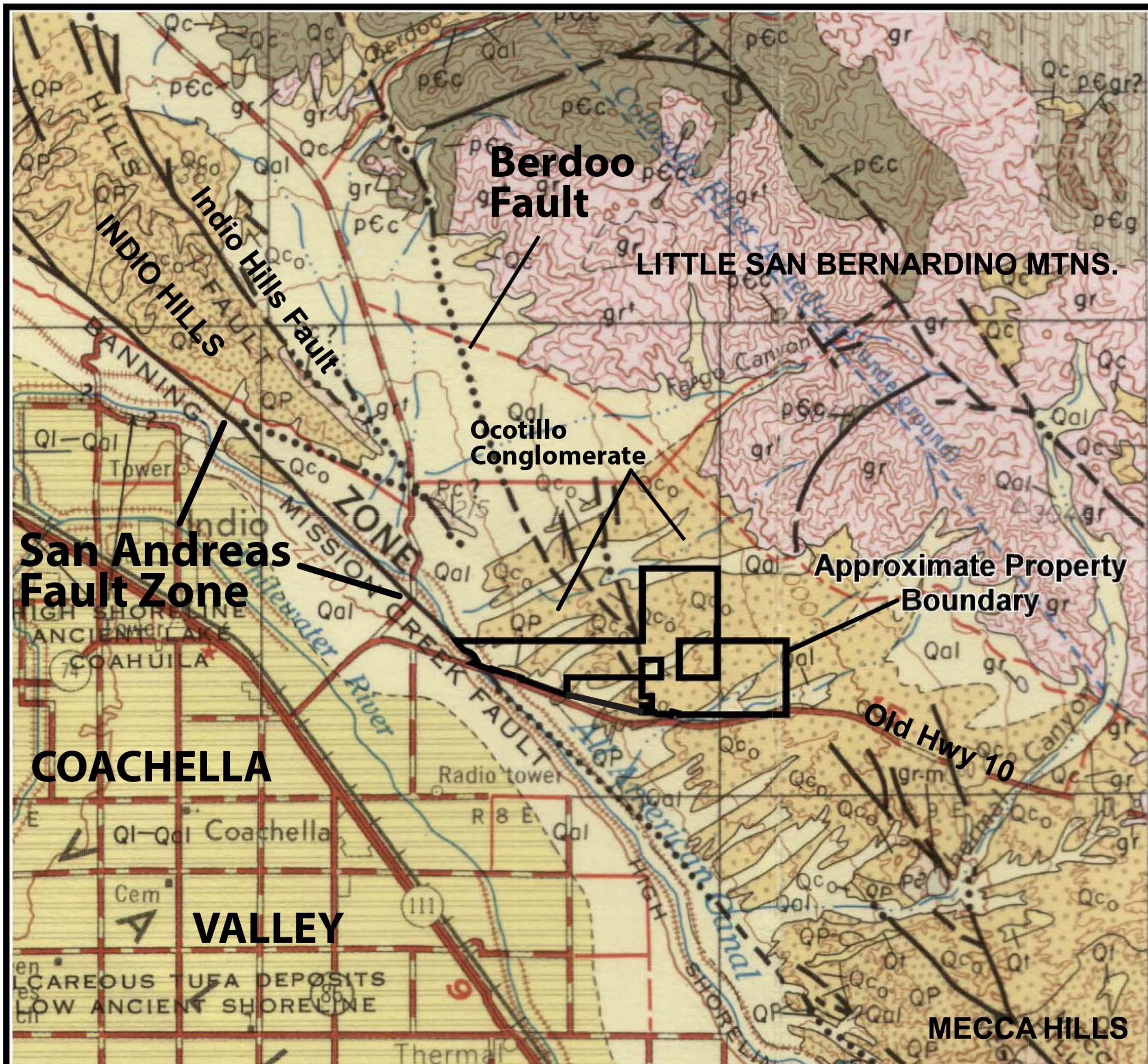
Map created utilizing Google Earth Pro and Earthpoint in Google Earth Pro. Topographic map from Earth Point Topo Map.

SITE LOCATION, INTERNAL PROPERTIES & STATE OF CA AP ZONES

KENNEY GEOSCIENCE
VISTA, CA

KPC Coachella

DATE Jan. 2022	JN: 745-19	FIGURE 1B
DWG: MDK		



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

N W E S

0 5
GRAPHIC SCALE
(in miles)

EXPLANATION

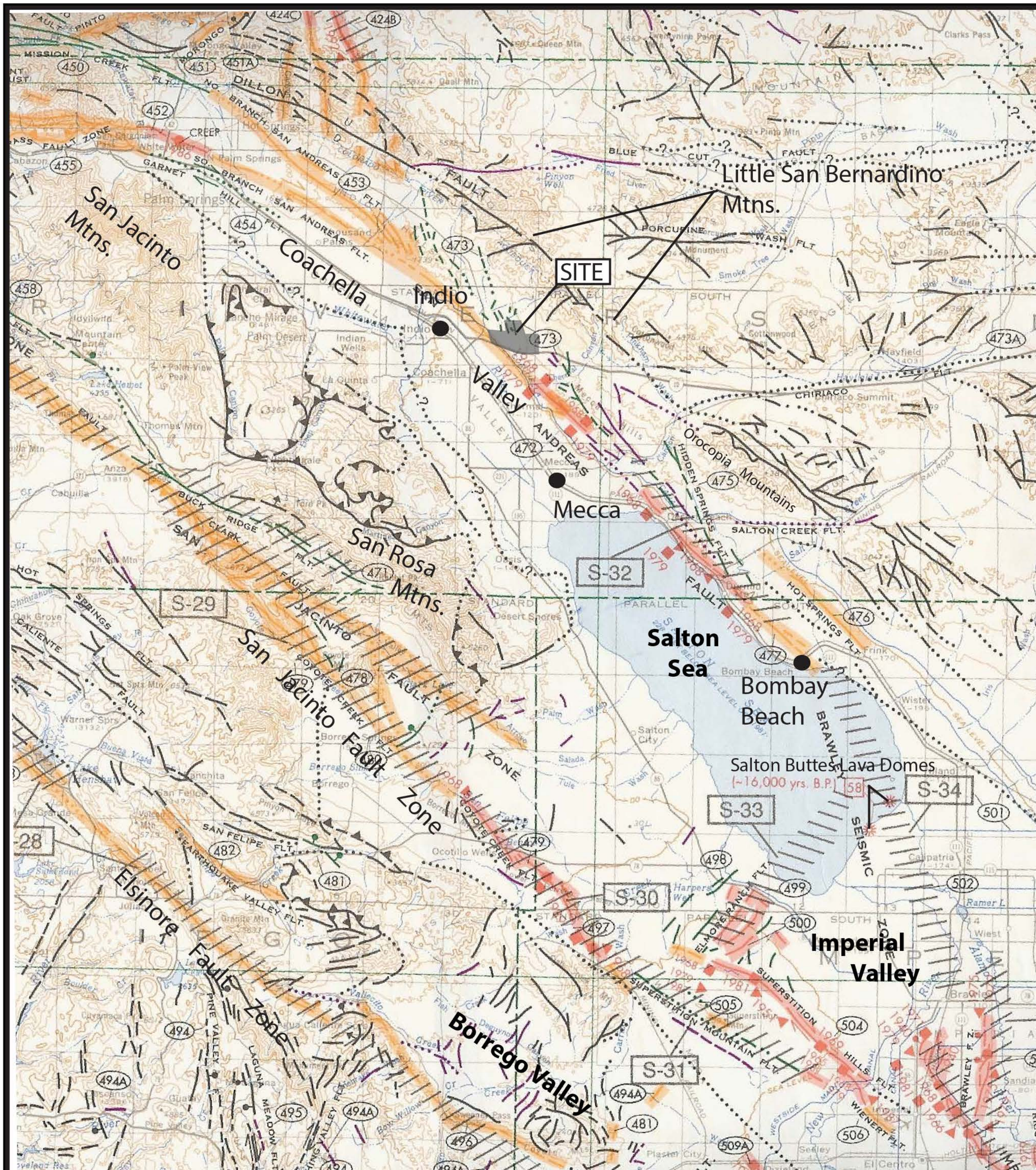
- Qc — Pleistocene nonmarine
- Qal — Alluvium
- gr — Mosozoic granitic rocks

REGIONAL GEOLOGY

KENNEY GEOSCIENCE
VISTA, CA

KPC Coachella

DATE Jan. 2022	J.N. 745-19	FIGURE 2
DWG: MDK		



(Reference: Jennings, C.W., 1994; Fault Activity Map of California and Adjacent Areas, With Locations and Ages of Recent Volcanic Eruptions; California Division of Mines and Geology, Geologic Data Map No. 6.)

N
W E
S

~12 Miles

See Figure 3B for Explanation of Symbols

REGIONAL FAULTING

KENNEY GEOSCIENCE
VISTA, CA

KPC Coachella

DATE Jan. 2022	J.N. 745-19	FIGURE 3A
DWG: MDK		

Geologic Time Scale			Years Before Present (Approx.)	Fault Symbol	Recency of Movement	DESCRIPTION: ON LAND	DESCRIPTION: OFFSHORE
Quaternary	Late Quaternary	Historic	200			Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep.	
Quaternary	Late Quaternary	Holocene	11,700		? ? ? ?	Displacement during Holocene time.	Fault offsets seafloor sediments or strata of Holocene age.
Quaternary	Late Quaternary	Pleistocene	700,000		? ? ?	Faults showing evidence of displacement during late Quaternary time.	Fault cuts strata of Pleistocene age.
Quaternary	Early Quaternary	Pleistocene	1,600,000		? ?	Undivided Quaternary faults – most faults in this category show evidence of displacement during the last 1,600,000 years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age.	Fault cuts strata of Quaternary age.
						Late Cenozoic faults within the Sierra Nevada, including parts of, but not restricted to, the Foothills fault system. These faults may have been active in Quaternary time.	
Pre-Quaternary			4.6 Billion (Age of Earth)			Faults without recognized Quaternary displacement or showing evidence of no displacement during Quaternary time. Not necessarily inactive. Pre-Quaternary faults not shown in Nevada and Oregon.	Fault cuts strata of Pliocene or older age.

S-25

Fault segment associated with a significant linear trend of accurately located earthquake epicenter (magnitude 0.2 or greater). Generally aligned along strike slip faults having Quaternary displacement, but not necessarily with historic surface rupture. Lack of seismic activity along any fault is no indication that the fault may not be active in the future (e.g. San Andreas fault north of San Francisco). Epicenter data are derived from closely spaced seismic stations and include either continuing microseismicity or aftershocks associated with relatively large earthquakes.

Cinder cone and other types of volcanoes. Most were active in Pleistocene time, some are Holocene, a few are historic.

21 8 Number in box or circle refers to Table 4 (Recent Volcanic Eruptions) in accompanying report. (Box refers to California, circle to Nevada).

(1786 A.D.) = Date of historic volcanic eruption.

(9,500 B.P.) = Eruption occurrence in years before present (B.P.).

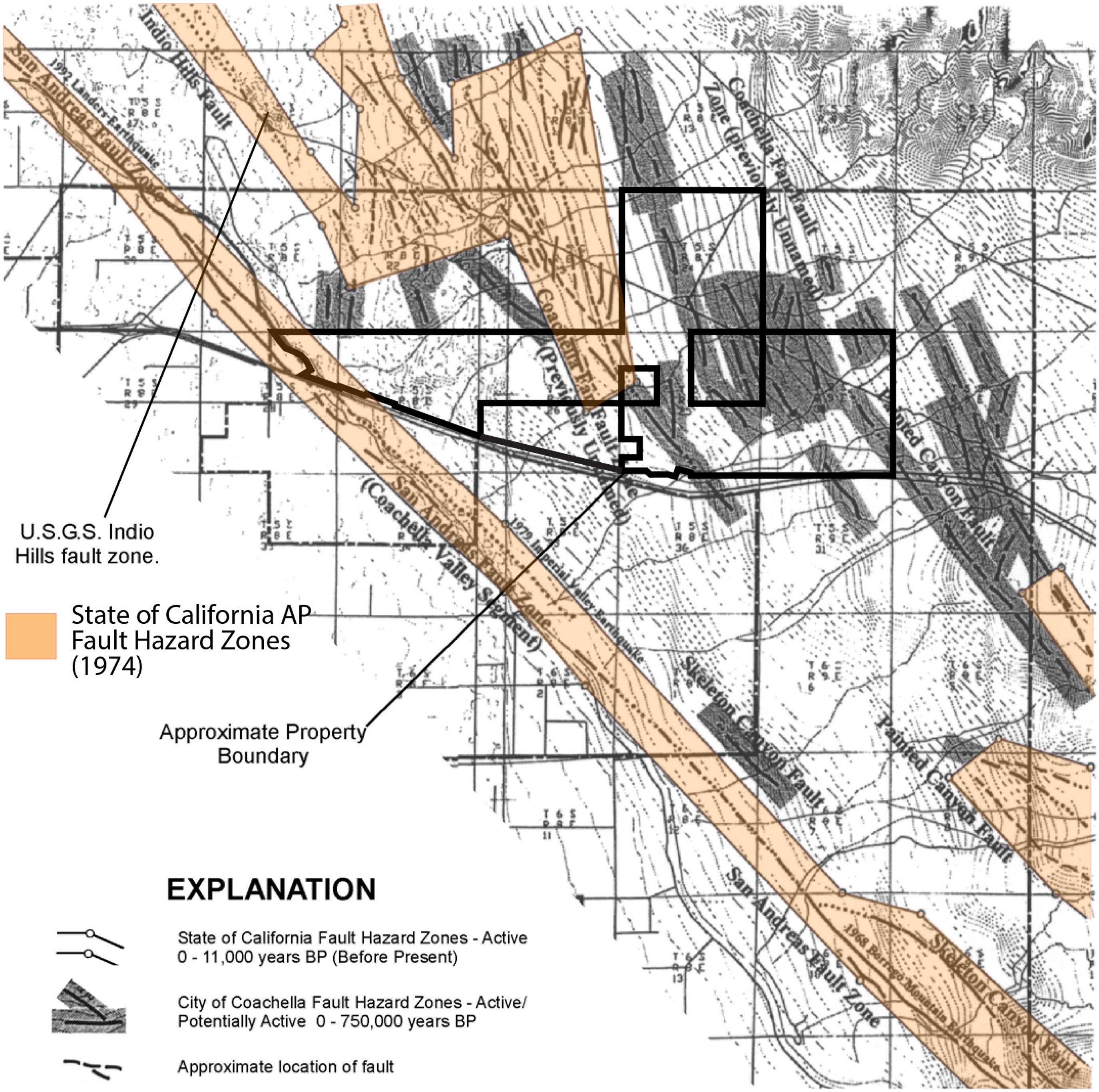
REGIONAL FAULTING - Legend

Kenney GeoScience

KENNEY GEOSCIENCE
VISTA, CA

KPC Coachella

DATE Jan. 2022	J.N. 745-19	FIGURE 3B
DWG: MDK		



U.S.G.S. Indio Hills fault zone.

State of California AP Fault Hazard Zones (1974)

Approximate Property Boundary

EXPLANATION

State of California Fault Hazard Zones - Active 0 - 11,000 years BP (Before Present)

City of Coachella Fault Hazard Zones - Active/ Potentially Active 0 - 750,000 years BP

Approximate location of fault

Approximate location of concealed fault

N W E S

0 6000
GRAPHIC SCALE (in feet)

References: City of Coachella General Plan, Figure 42 Fault Rupture Hazards, June 1996.

CITY OF COACHELLA FAULT HAZARD ZONES		
Kenney GeoScience	KENNEY GEOSCIENCE VISTA, CA	
KPC Coachella		
DATE Jan. 2022	J.N. 745-19	FIGURE 4
DWG: MDK		

Color	Unit	Age (Kya)	Unit Descriptions	Age Characteristics
(white)	Qf1	0-1	**Fluvial:** Light gray, well sorted, F-C sand, gravel, bedded, friable (active channel deposits)	No soil development
(white)	Qf2	1-3	**Fluvial:** Light gray, well sorted, F-C sand, gravel, bedded, friable.	Weak Av & Bw or Btj soil, low CaC03,
(light yellow)	Qed	1-5	**Sand Dunes (Aeolian):** Friable F-M sand, deposited along ancient shorelines of Lake Cahuilla	No soil properties observed
(blue)	Qls	1-5	**Landslides:** Age unknown, but likely Holocene Landslides with geomorphic expression on the surface (i.e. headscarps) occuring within unit QpU.	Age unknown. Likely mid to late Holocene Note that abundant landsliding occured in unit QpU throughouth the Coachella Fan area.
(yellow-green)	Qf3U	3-4	**Fluvial:** Gray to slight reddish, F-C sand +/- gravel, well bedded, friable, fining upward sequence common	First cliff former, no grussified diorite, weak Bw (2-3") rare CaCO3 pipes, minor lamellae.
(yellow-green)	Qf3	4-10	**Fluvial:** Similar to Qf3U but with Increased induration Units not know to be Qf3U, or Qf3L are logged simply as Qf3.	Stronger cliff former, Bw (3-5" thick), minor diorite some weakly grussified, numerous lemallae e with moderate HCL fizz.
(yellow-green)	Qf3L	10-15	**Fluvial:** Similar to Qf3U, Increased induration than Qf3 (cliff former), light brown to gray.	Stronger cliff former, Bw (5-7" thick), rare CaCO3 pipes, abundant lamallae.
(tan)	QfoU	15-35	**Fluvial:** Sand, gravel and cobbles, moderately bedded to massive, fining upward sequence common, first "yellowish brown" unit (darker than Qf3 units)	First Bw below Qf3, units exhibits, multiple Bw, carbonate horizons, lamallae, moderately strong CaCO3 fizz, no to few CaCO3 pipes
(brown)	QfoL	15-35	**Fluvial:** Sand, gravel and cobbles, moderately bedded to masive debris flows, fining upward common, penetrative yellowish brown, in places increased common 2nd "ledge" below surface.	Scattered CaCO3 pipes, weak Bt remnant typically truncated, CaCO3 clast coatings, common lamellae, diorite clasts weakly gruesified.
(orange)	Qf4U	35-50	**Fluvial:** Distinct reddish brown unit below Qfo units, increased induration to overlying Qfo units, varies from moderately well bedded sands to gravels to massive debris flows, inter-member channels common. debris flows, inter-member channels common.	Upper contact ersional with presumed B horizon eroded away when buried, lamellae occur, minor CaCo3 vertical pipes, reddish color from age of unit & re-worked QoU soils upslope on the Coachella fan.
(orange)	Qf4	35-50	**Fluvial:** Essentially the same as Qf4U but a second distinct member. Or, units are logged Qf4 if it is unknown if the unit if Qf4U or Qf4L.	
(orange)	Qf4L	35-50	**Fluvial:** Color varies from reddish brown in medial fan areas (upslope) to medium gray to olive downslope (southern portion of the site), color variations due to parent source material as the Qf4L is dominantly composed of eroded unit QpU. Finely bedded well sorted F-C sand, dense, rip up pieces of underlying unit Qf5 and/or QpU are common, deep erosional scour undulatory basal erosion surface common.	
(purple)	Qf5U	50-80	**Debris Flows:** Gray, brown or pale reddish brown, dominantly gravel with clayey matrix, dense, diorite clasts more grussified than in unit Qf4, but less than in unit QoU. Erosional basal contact.	Bk CaCO3 horizons common, secondary clay coatings, conglomerate matrix exhibits secondary clay.
(purple)	Qf5L	50-80	**Debris Flows:** Strong reddish brown, silty to sandy with gravel, well developed clast silt-clay coatings, crudely bedded, erosional basal contact.	Bk CaCO3 horizons common, Abundant secondary , silt-clay, carbonate pipes.

STRATIGRAPHIC SECTION CONTINUED ON
FIGURE 5B

**SITE STRATIGRAPHY
UNITS Qf1 to Qf5L**

Kenney GeoScience

KENNEY GEOSCIENCE
VISTA, CA

KPC Coachella

DATE 08/11/2021	J.N. 745-19	FIGURE 5A
DWG: MDK		

CONTINUED FROM FIGURE 5A

Color	Unit	Age (Kya)	Unit Descriptions	Age Data
	QoU	~80-600+	**Ocotillo Conglomerate** (Upper member): Well bedded to massive fine to coarse sand and gravels and some boulders, diorite clasts strongly guessified, typicall bedded and folded similar to underlying QpU. Unit commonly tilted and folded. The age deposition ceased on Site is unkown.	Stage III to IV carbonate common, "surface" soil that is commonly buried with ages of Qfo, Qf4 to Qf5 common in trenches located in washes. Multiple inter-unit truncated soils are common suggesting that QoU likely hundreds of thousands of years old.
	QpU	~600-775+	**Palm Spring Formation** (upper member): fluvial, plain, Interbedded well sorted sands (gray to olive), silty sands (olive), relativel thin clay beds, landslide shear surfaces are common. Unit is commonly tilted and folded. The time when deposition started on Site is unknown.	Age from numerical age of ***Bishop Ash*** (~775 kya) in upper members of unit.
	QpL		**Palm Spring Formation** (lower member): fluvial plain. This unit is essentially deeper members of unit QpU.	Unit exhibits moderate to steap tilting and folding similar to overlying unit QoL.
	QoL		**Ocotillo Conglomerate** (Lower Member) May only occur exposed along Highway 10 along the south central portion of the property. Well bedded sands and gravels,	Unit exhibits moderate to steap tilting and folding similar to unit QpL. This unit may be the Canebrake Formation and reside below unit QpL.

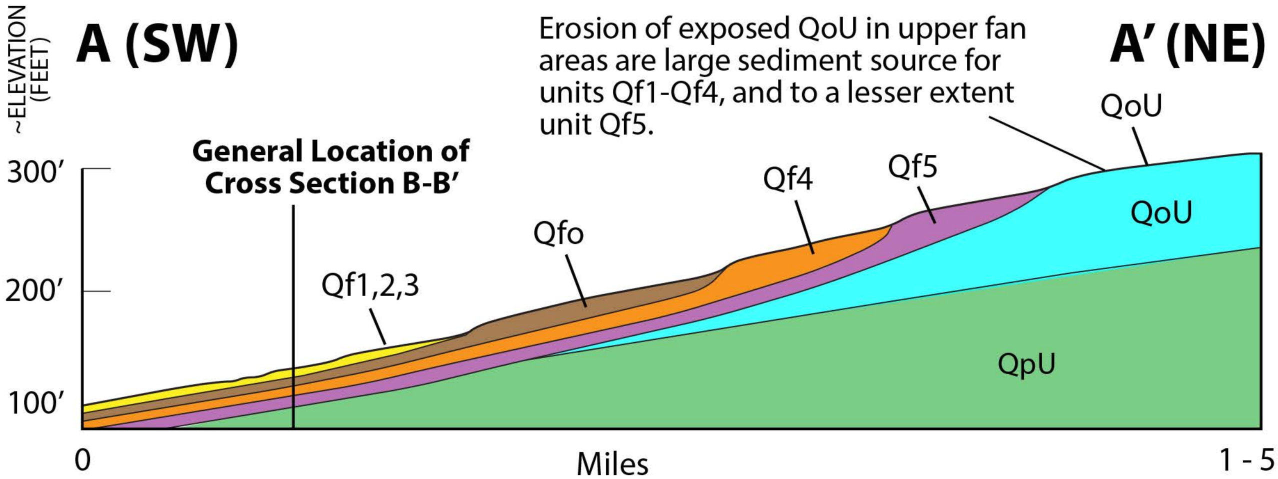
SITE STRATIGRAPHY
UNITS QoU to QoL

KENNEY GEOSCIENCE
VISTA, CA

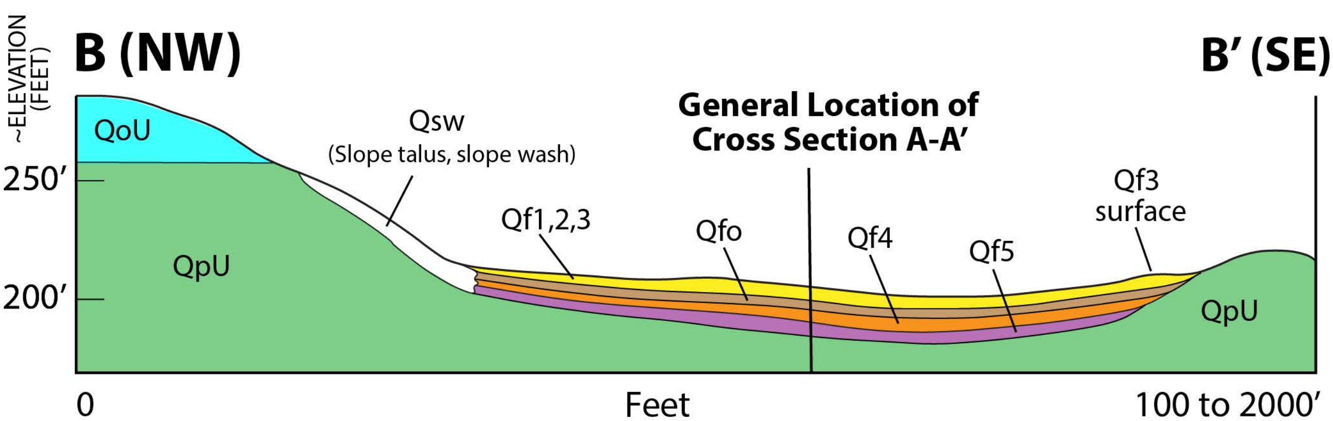
KPC Coachella

DATE Jan. 2022 | J.N. 745-19 | DWG: MDK | **FIGURE 5B**

Cross Section A-A' shows the generalized stratrigraphy going up a typical wash in the subject site extending close to the southern property boundary to the northern property boundary. Most trenches in this study excavated in the washes trend ~parallel to this cross section (See Plate GM1).

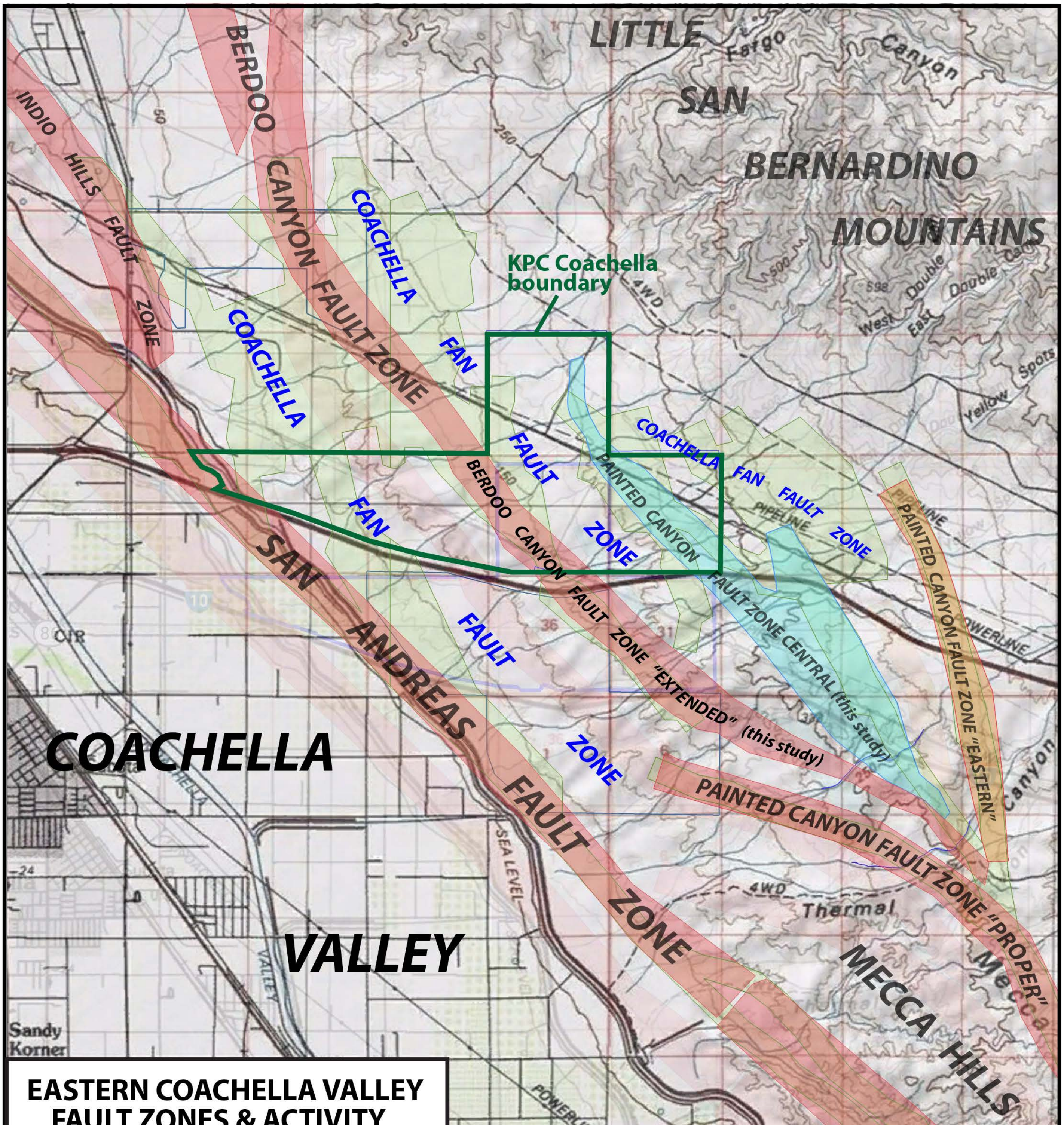


Cross Section B-B' shows the generalized stratigraphy across a typical drainage (wash) in the subject site in the southwestern portion of the site. Secion extends from exposures of Qou/QpU, or could be unit QpU or QpL. Most trenches in this study occuring in the washes occur perpendicular to this cross section. (See Plate GM1).



GENEARLIZED STRATIGRAPHIC CROSS SECTIONS SHOWING MORPHOSTRATIGRAPHIC RELATIONSHIPS OF SITE UNITS

MORPHOSTRATIGRAPHIC REGIONSHIPS OF SITE UNITS		
KENNEY GEOSCIENCE VISTA, CA		
KPC Coachella		
DATE Jan. 2022	J.N. 745-19	FIGURE 5C
DWG: MDK		



EASTERN COACHELLA VALLEY FAULT ZONES & ACTIVITY

KENNEY GEOSCIENCE
VISTA, CA

KPC Coachella

DATE Jan. 2022	J.N. 745-19	FIGURE 6
DWG: MDK		

FAULT ZONE ACTIVITY

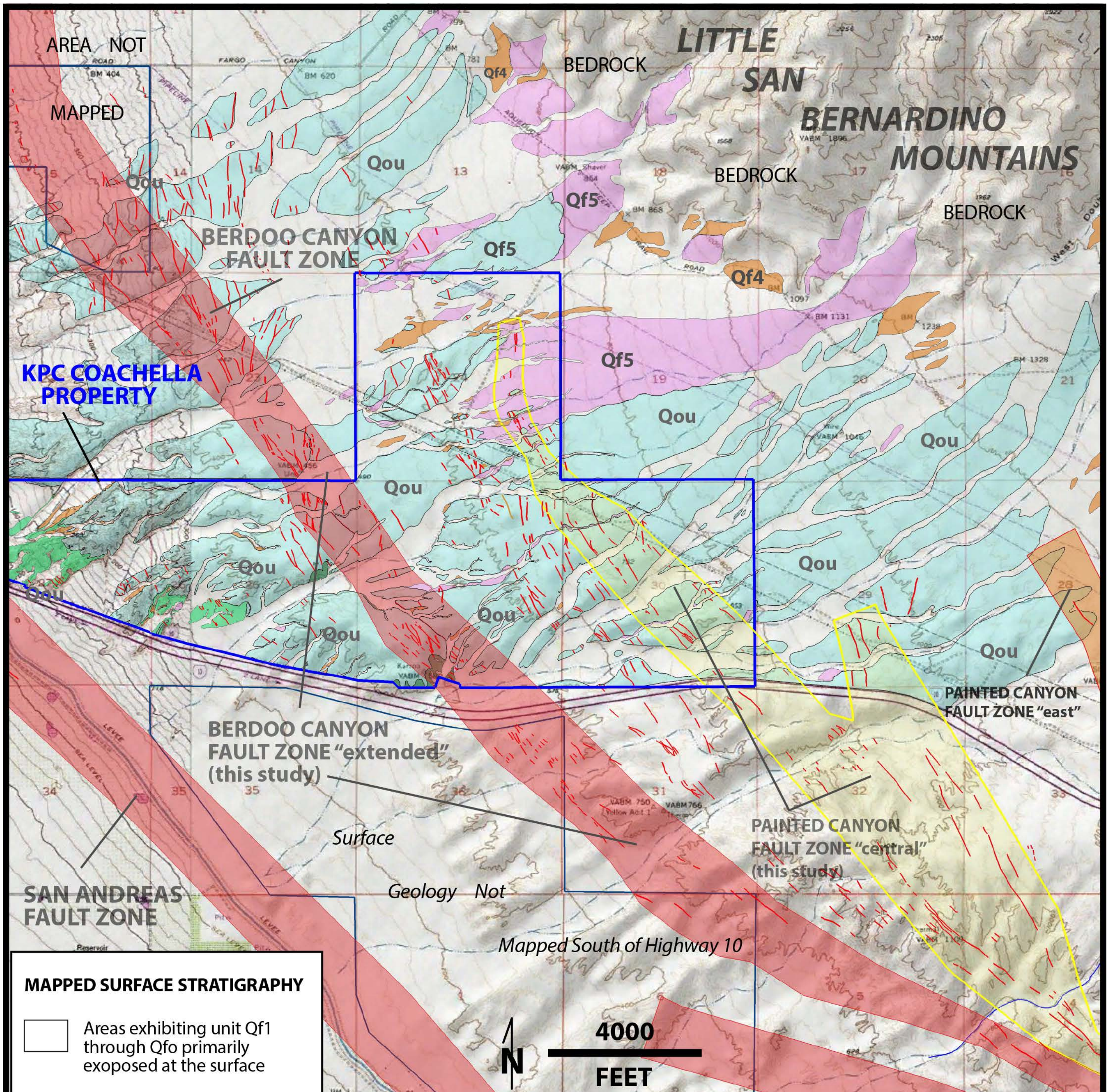
- Pre-Holocene (active in Late Pleistocene)
- Holocene-active or Late Pleistocene active (Likely active)
- Holocene-active

STATE OF CALIFORNIA AP FAULT HAZARD ZONES

- Boundary of the State of California AP Fault Zones requiring an investigation for planned development

N

6000 FEET



MAPPED SURFACE STRATIGRAPHY

- Areas exhibiting unit Qf1 through Qfo primarily exposed at the surface
- Unit Qf4 of this report
- Unit Qf5 of this report
- Unit QoU of this report
- Unit QpU of this report
- Unit QpL of this report

FAULT ZONE ACTIVITY

- Pre-Holocene (active in Late Pleistocene)
- Holocene-active or Pre-Holocene active (i.e. Late Pleistocene)
- Holocene-active
- Lineaments (tonal and geomorphic - this study)

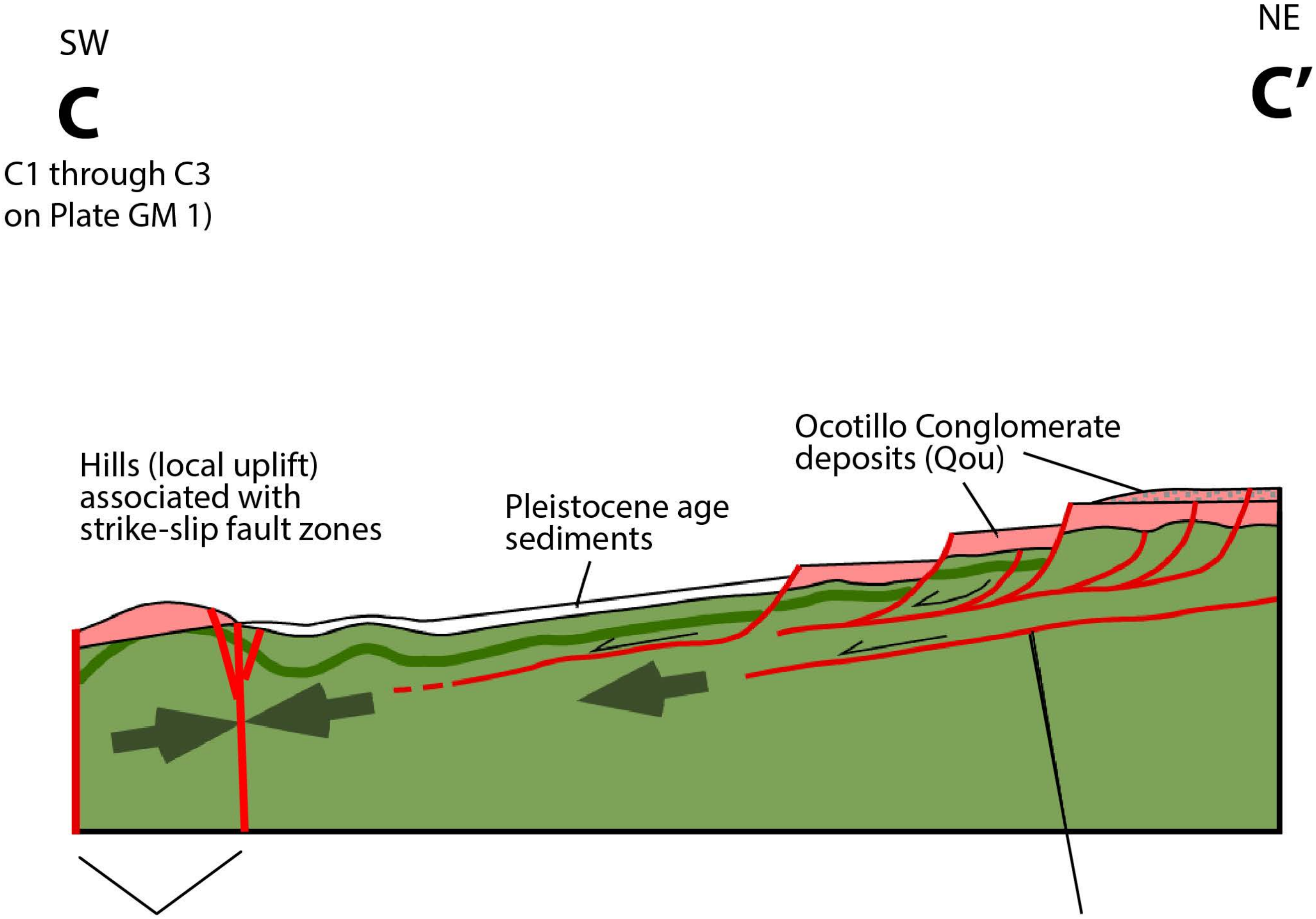
QUATERNARY DEPOSITION MAP OF THE COACHELLA FAN

KENNEY GEOSCIENCE
VISTA, CA

KPC Coachella

DATE Jan. 2022	JN 745-19	FIGURE 7
DWG: MDK		

GENERALIZED STRUCTURE OF THE COACHELLA FAN FAULT ZONE AND RELATION TO STRIKE-SLIP FAULT ZONES



Strike-slip fault zones (Berdoo Canyon, Painted Canyon “central”). Also the San Andreas fault zone south of the site (La Entrada Project south of Highway 10. See Plate LM3).

Basal shear surfaces

GENERALIZED FAULTING STRUCTURE OF THE COACHELLA FAN FAULT ZONE		
Kenney GeoScience	**KENNEY GEOSCIENCE VISTA, CA**	
KPC Coachella		
DATE Jan. 2022	J.N. 745-19	**FIGURE 8**
DWG: MDK		

Appendix F3: Geotechnical Feasibility of 85-foot-tall Building

June 20, 2025
J.N. 16-368

THE KPC GROUP
6800 Indiana Avenue, Suite 130
Riverside, California 92506

Attention: Mr. Stan McNaughton

Subject: Geotechnical Feasibility of 85-Foot-Tall Building, *KPC Coachella Project*, 2,850 Acres± of Vacant Land, North of Interstate 10 and East of the All-American Canal, City of Coachella, Riverside County, California

Reference: Revised Feasibility-Level Geotechnical Evaluation, *KPC Coachella Project,* 2,850 Acres± of Vacant Land, North of Interstate 10 and East of the All-American Canal, City of Coachella, Riverside County, California; Revision 2, J.N. 16-368 dated March 23, 2023

Dear Mr. McNaughton:

Pursuant to your request, **Petra Geosciences, Inc. (Petra)** is presenting this letter regarding the feasibility of an 85-foot-tall building on the subject project site. Based on the geotechnical information gathered and analyzed in the referenced report, it is our opinion that an 85-foot-tall building is feasible at the KPC Coachella project, provided additional geotechnical investigation is conducted at the location of the subject building site and the results of the additional investigation are incorporated into the design and construction of the building.

Petra appreciates the opportunity to provide you with geotechnical consulting services. If you have any questions or should you require any additional information, please contact us at (760) 250-9747.

Respectfully submitted,

PETRA GEOSCIENCES, INC.

Alan Pace
Senior Associate Geologist
CEG 1952

AP/lv

W:\2014-2019\2016\300\16-368\Reports\16-368 110 Geotechnical Feasibility of 85-foot tall Building.docx