Appendix J

Geology Processes/Geologic Hazards
Supporting Information

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December 19, 2013 (Revised January 10, 2014)
Project No. 04.62130155

Sturgeon Services International
3120 Sturgeon Street
Bakersfield, California, 93308

Attention: Mr. Keith Kidwell Jr.

Subject Preliminary Geologic Hazards Evaluation, East Cat Canyon Oil Field, Sisquoc Area, Santa Barbara County, California

Dear Mr. Kidwell:

This letter-report provides the results of our preliminary geologic hazards assessment of the East Cat Canyon Oil Field located in the Sisquoc area of Santa Barbara County, California. Our services were performed in general accordance with our proposal dated October 22, 2013. Authorization for our work was provided by Sturgeon Services International's (SSI) Purchase Order with Fugro and by SSI's Letter Agreement Request/Proposal with AERA Energy (AERA) dated October 23, 2013. This report provides our preliminary assessment of the geologic hazards in the study area. Our services for the project also consisted of performing a Phase I preliminary geotechnical engineering study for the East Cat Canyon Oil Field and the findings and results of that study are provided under a separate cover.

INTRODUCTION AND PROJECT DESCRIPTION

Proposed Project

We understand that our assessment will be used to support Front End Load Engineering and Design work for potential oil and gas development in the lease areas owned by Aera Energy, LLC (Aera) in the East Cat Canyon Oil Field. Potential development work in the oil field is expected to involve the following elements:

- Well pads and access roads,
- Pipelines,
- Office area,
- Central processing plant and warehouse, and
- Steam Generator.

Actual locations of the proposed facilities have not been determined. However, preliminary sites for the new office, processing plant and steam generator have been selected and were shown on a map provided to us via email. Access to the site is from Palmer Road and Cat Canyon Road.

Site Description

The proposed oil field development area consists of eight lease areas located within Sections 19, 20, 28, 29, 31, and 32 of Township 9N/Range 32W, SBBM. The lease areas are shown on Plate 1 - Location Map - East Cat Canyon Area. That map also shows the extent of development in the area (roads, oil-well access roads and pads, the location of residential homes, industrial developments, very limited agricultural development, and drainage catchments.

The topography of the area consists of a series of north-south aligned subdued hills with elevations ranging from about +500 to +1,000 feet above mean sea level (MSL). Cat Canyon Creek, which is the principal stream in the area, is intermittent and flows to the north toward the community of Sisquoc. That creek, as well as those in Long Canyon and Olivera Canyon, is well entrenched along most of its course.

Work Performed

The scope of work for this preliminary geologic hazards study included the review of readily available published geologic maps for the study area (Woodring and Bramlette, 1950; Muir, 1964; Dibblee, 1994). We also obtained detailed (1:6,200) stereo-pair digital aerial photographs for the project study area (dated 04/16/11) from Central Coast Aerial Mapping and an electronic version of the site topographic base map (with 2-foot-contours). We used the published geologic maps and the stereo aerial photographs to prepare a preliminary geologic map of the study area at a scale of 1”=400’. That geologic map shows generalized geologic units, bedding orientations, and landslides.

After preparing the preliminary geologic map, we coordinated with SSI staff to schedule a two-day reconnaissance visit to the project site. The purpose of the reconnaissance visit was to observe geologic exposures, and supplement and update the preliminary geologic mapping and characterization work developed from our data review. We also reviewed the site conditions and made observations relative to land use and selected locations for preliminary soil borings for our preliminary geotechnical engineering evaluation study. Data gathered from our data review and site reconnaissance were used to evaluate and characterize potential geologic hazards that should be considered in the planning and preliminary design of proposed improvements at the East Cat Canyon Oil Field.

General Geologic Setting

The regional geologic conditions in the East Cat Canyon Oil Field area have been studied by others including Woodring and Bramlette (1950), Muir (1964); and Dibblee (1994). Plate 2 – Regional Geologic Map presents the regional geologic conditions as mapped by Dibblee (1994). As part of our work scope, we compiled a more detailed geologic map of the East Cat Canyon Oil Field using data from the referenced past researchers, data acquired from our review of selected aerial photographs, and observations made during our site reconnaissance. The results of our more detailed site-specific geologic mapping effort are shown on Plate 3 – Geologic Map. As illustrated on Plate 2, the project area contains a predominantly flat lying to slightly folded sequence of Pliocene and Pleistocene formations, which are unconformably underlain by structurally deformed and folded Miocene and older formations. The approximate locations of two anticlinal axes are shown on Plate 3, one near the southern margin of the area and one near

the northeastern margin. The subsurface formations and stratigraphic relationships are shown on Plate 2 in a south to north structural cross section (C-D) that accompanies the Dibblee geologic map of the area. In the study area, only the Plio-Pleistocene units are exposed and they include, from oldest to youngest, the Careaga and Paso Robles Formations.

The Careaga Formation is the oldest (Pliocene age) geologic unit exposed in the project area and it crops out as a linear band along the southerly edge of Field Fee and R & G lease area as shown on Plates 2 and 3. In that area, the Careaga Formation is divided into two members; the Cebada and the Graciosa Members. The Cebada fine-grained lower member consists primarily of very uniform fine-grained to very-fine-grained massive sandstone, which is light gray to yellow in color. Small stringers of shale pebbles and fossils are abundant. Fugro (2012) reports that the Cebada member attains a maximum thickness about 250 feet, and thins to the north in the subsurface. The upper member of the Careaga Formation is referred to as the Graciosa Member and in the project area commonly consists of coarse-grained sandstone with thin stringers of gravel. That member attains a maximum thickness of about 100 feet in the southerly part of the project area and thins out to zero thickness to the northeast (Fugro, 2012).

The Pleistocene-age Paso Robles Formation crops out in most of the project area and conformably overlies the Careaga Formation. The Paso Robles Formation is gently folded (with dips less than about 10 degrees) and is over 500 feet thick in the project area. The Paso Robles Formation is non-marine and primarily consists of poorly consolidated stream-deposited lenticular beds of gravel, sand, silt, and clay. The formation is exposed in numerous cut slopes throughout the study area and consists of very poorly sorted and heterogeneous (i.e., a wide range of grain size materials) mixtures of cobbles, gravel, and sand in a clay matrix.

Older alluvial deposits are present on the tops of ridges and hills between Cat Canyon Road, Long Canyon Road, and Olivera Canyon Road. Those deposits are of late Pleistocene age and primarily consist of mixtures of gravel, sand, and silt. In many locations, the older alluvial deposits are well cemented.

Deposits of Recent colluvium and alluvium are also present in the project area in the tributary canyons and valley floors. The colluvium and alluvium deposits generally consist primarily of poorly sorted mixtures of sand and gravel with some fine-grained materials. The thickness of those deposits likely vary from relatively limited (less than about 10 feet) in slope areas and minor drainage swales to greater than about 30 to 50 feet in more significant drainage and collection areas.

Throughout the oil field area, local deposits of artificial fill are present. Those fill materials were commonly placed to facilitate the construction of drilling and production pads, and access roads. Where recognized, the approximate distributions of some of the more significant of those fills are shown on Plate 3, but it is likely that not all of the fill materials have been detected or are shown on that map. The fill deposits appear to consist of locally derived earth materials that were typically placed in an uncompacted state. In some locations, the fill materials appear to contain concrete and other construction debris.

Groundwater was not encountered in the site-specific geotechnical drill holes excavated to depths of up to 30 feet and performed as part of our preliminary geotechnical engineering evaluation study. In addition, data reported in Fugro (2012) suggests the depth to groundwater

within the study area is anticipated to be greater than 100 to 200 feet below the ground surface. Although the depth to groundwater is anticipated to be relatively deep, there is a possibility for areas or zones of perched groundwater to be present at shallow depths (that is less than 30 feet deep) on at least a seasonal basis. Perched groundwater can occur in drainage channels or where changes in soil type or permeability occur within soil or rock materials. Groundwater seepage can occur where perched water daylights in cuts or at the ground surface.

Seismic Setting

No active faults have been mapped by others within the project boundaries and no faults were observed on the site during our reconnaissance surface mapping. However, two concealed older faults have been mapped through the project area (Plate 3) on the basis of published oil exploration data (California D.O.G., 1961; 1974; Hall, 1981; and Lettis et al., 2004).

The concealed northeast-dipping, normal fault mapped through the northeastern portion of the project area is referred to as the Garey fault (Hall, 1981). The concealed northeast-dipping, normal fault mapped through the southwestern portion of the area is unnamed on published maps (California D.O.G., 1974), but locally referred to as the Fuglar fault. A cross-section of the Olivera Canyon Area of the Cat Canyon oil field (California D.O.G., 1961) shows that the Garey fault only cuts rocks older than early Pliocene, therefore that fault would not be considered active. A cross-section of the East Area of the Cat Canyon oil field (California D.O.G., 1961) shows a similar pre-early Pliocene age for the Fuglar fault through the southwestern area, but California D.O.G. (1974) suggests that additional faulting (with a different sense of slip) may extend upward into the base of the Carreaga Formation rocks of late Pliocene age. In either case, the Fuglar fault would not be considered active. Consequently, neither of those two onsite faults are considered likely to pose a ground-surface fault-rupture hazard.

The site is located in California's seismically active central coast region and there are a number of active faults in the region that have the potential to produce strong ground motion at the site. Regional faults in the study area are shown on Plate 4 - Regional Fault Map. A list of those faults within about 50 miles of the area, along with selected fault parameters, is presented in Table 1.

Table 1. Seismogenic Fault Sources

Fault Name	Fault Type	Distance (miles)	Magnitude
San Luis Range	Reverse	3	7.2
Casmalia (Orcutt Frontal)	Reverse	5	6.7
Los Alamos – West Baseline	Thrust	5	6.9
Lions Head	Reverse	8	6.8
Santa Ynez	Strike Slip	21	7.2
Los Osos	Reverse	23	7.0
Hosgri	Strike Slip	26	7.3
San Juan	Strike Slip	29	7.1
Red Mountain	Reverse	31	7.4
Mission Ridge – Arroyo Parida – Santa Ana	Reverse	35	6.9
North Channel	Thrust	36	6.8
Rinconada	Strike Slip	36	7.5
Pitas Point	Reverse	37	7.3
San Andreas	Strike Slip	40	8.1
Santa Ynez (East)	Strike Slip	43	7.2

The peak ground accelerations with a 475-year and a 2,475-year return period were estimated for a location near the south central boundary of the area shown on Plate 3 (latitude: 34.8237, longitude: -120.2895) using the U.S. Geological Survey's 2008 Interactive Deagggregations web site. Those values, assuming the site conditions are represented by a $Vs_{(30)}$ of about 400 m/sec, are listed in Table 2 below.

Table 2. Preliminary Probabilistic Ground Motions

Return Period	Peak Ground Acceleration (g)
475 years	0.26
2,475 years	0.49

The design motion parameters for use with the 2013 California Building Code were estimated using the U.S. Geological Survey's Seismic Design Maps & Tools website. Table 3 summarizes those parameters estimated for a location near the south central boundary of the area shown on Plate 3 (latitude: 34.8237, longitude: -120.2895). Based on our reconnaissance-level effort, the geologic site conditions could potentially meet the criteria for either Site Class C or D conditions and code-based seismic criteria are provided in Table 3 for both Site Class C and D conditions.

Table 3. Preliminary Building Code Seismic Design Parameter

2010 Building Code Seismic Parameter	Site Class C value (g)	Site Class D Value (g)
S_S	1.116	1.116
S_{MS}	1.116	1.176
S_{DS}	0.744	0.784
S_1	0.425	0.425
S_{M1}	0.585	0.670
S_{D1}	0.390	0.446

SUMMARY OF GEOLOGIC HAZARDS

Fault Rupture and Strong Ground Shaking.

Because there are no known active or potentially active faults that traverse through the subject site, the potential for ground-surface rupture due to faulting at the site is considered low to very low. The potential for strong ground shaking at the site is considered moderate, with the preliminary 475-year and 2,475-year return period ground motions estimated at about 0.26g and 0.49g, respectively.

Soil Liquefaction and Seismically Induced Settlement.

Seismically induced liquefaction is a phenomenon that commonly affects loose, granular materials below the groundwater table. Seismic shaking causes transient shear stresses in the soil deposits, which in-turn result in partial densification of the loose materials. As the saturated materials densify, pore water pressures can increase causing the effective shear strength of the soil to reduce. If pore pressures build to a significant level during or shortly after an earthquake event, the soil may begin to behave like a viscous fluid and result in lateral ground movement. In addition, pore pressure dissipation following the earthquake shaking may be accompanied by consolidation, which can cause ground settlement.

On the basis of their Plio-Pleistocene age and sampler blow count data (N-value data) obtained from our site-specific soil drill holes, the older alluvium, and Paso Robles and Carreaga Formations are not likely to be susceptible to earthquake induced liquefaction or seismic settlement.

Sampler blow count (N-value) data from our site-specific geotechnical engineering drill holes indicate the colluvial and alluvial soils could be susceptible to liquefaction. However, the depth to groundwater at the locations explored exceeded a depth of 30 feet and liquefaction is not a hazard for soils located above the groundwater level. However, if alluvial and colluvial deposits present in the canyon and valley areas are or were to become saturated, those deposits are likely to experience earthquake-induced liquefaction and settlement associated with strong ground shaking events. Site-specific geotechnical exploration and analyses will be needed to determine the potential for liquefaction and seismic settlement.

Hydroconsolidation Potential.

Hydroconsolidation (collapse) is a phenomenon whereby unconsolidated soil materials settle (collapse) upon the addition of moisture. The moisture may come from the infiltration or seepage of water from the ground surface, or from a rise in the groundwater level. Commonly, such soil materials are slightly cemented by chemical precipitates or clayey minerals, and the addition of moisture causes those cementing materials to dissolve or soften allowing the soil particles to consolidate. Often collapsible soils exhibit visible pore spaces when undisturbed samples are broken open.

Because of their age, the Paso Robles and Carreaga Formation materials and older alluvium are not likely to be subject to hydroconsolidation. However, deposits of colluvium and alluvium on the site may be susceptible hydroconsolidation.

Site-specific geotechnical exploration and analyses will be needed to determine the potential for hydroconsolidation settlement.

Subsidence Due to Fluid Withdrawal.

Because the site is located within an area of active and proposed, oil and gas extraction, there is a potential for ground-surface subsidence due to subsurface fluid withdrawal. If appropriate formation pressurization procedures are implemented during fluid extraction, the potential for ground-surface subsidence can be reduced.

Landsliding and Slope Stability.

Our geologic reconnaissance mapping of the site has identified several locations that have geomorphology that suggests the presence of past landsliding. Those mapped landslide areas that are queried on Plate 3 are more speculative than the non-queried areas. No subsurface exploration has been performed to confirm the existence of the mapped landslides shown on Plate 3. Because of the generally granular nature of the onsite materials and the gentle dips of the bedding within the Paso Robles and Carrega Formations, we suspect that most of the onsite landslides are likely to be rotational failures, as opposed to translational failures.

Throughout the area, there are numerous manmade cut slopes created to facilitate hydrocarbon production. Most of those slopes are relatively steep (1H:1V or steeper) and they commonly exhibit signs of raveling, slumping, and erosion.

Deposits of colluvium are present on the natural slopes throughout the area. Where thick deposits of colluvium were recognized, they are mapped on Plate 3 (map unit Qc). Where present on slopes, the colluvium is generally unstable and creep-prone.

If possible, areas with suspected landslide geomorphology should be avoided. However, if structures are proposed in areas of possible landsliding, subsurface exploration should be performed to confirm the presence and geometry of the landslide deposits, and to evaluate the stability of the materials. If landslide deposits are confirmed and their natural stability is found to be inadequate, removal and replacement with compacted fill, providing structural support, or compacted-fill buttressing are possible mitigation measures.

Areas of colluvium on slopes above proposed developments should be removed or supported. Because most of the earth materials on the site are generally granular and uncemented, proposed cut

slopes probably should be graded at inclinations of 2H:1V or flatter. The granular and uncemented nature of the onsite materials also increases the potential for surface erosion at the site.

Expansive Soil.

Expansive soils are clayey materials that expand when wetted. Most of the bedrock materials on the site are granular; therefore the colluvial and alluvial materials derived from them are also generally granular. Because there is likely to be a limited amount of clayey soil present on the site, the potential for highly expansive soils is limited.

Geotechnical sampling and testing should be performed to confirm the presence or absence of expansive soil materials at the site.

Petroleum Hydrocarbon Materials.

Because the site has been actively producing hydrocarbon products for decades, it is likely that hydrocarbon-contaminated soil is present locally. We also understand that oil sands were placed in several of the canyon areas on site. In addition, petroleum hydrocarbon odors were noted during drilling and sampling work in three of the six site-specific drill holes excavated as part of our preliminary geotechnical engineering evaluation study (drill holes DH-2A, DH-2B, and DH-3). Soils containing petroleum hydrocarbons or other substances common to historical oilfield development may locally be present throughout the site and should be evaluated where new construction is planned.

CONCLUSIONS

Table 4 - Geologic Hazard Screening provides a summary of our opinions regarding the potential for geologic hazards associated with the various geologic units mapped on the site.

Table 4. Geologic Hazard Screening

Hazard Potential						
Geologic Hazard	**Paso Robles & Carreaga Formations**	**Landslide Deposits**	**Alluvium**	**Colluvium**	**Older Alluvium**	**Artificial Fill**
Ground Rupture	Low to very low	Low to very low	Low to very low	Low to very low	Low to very low	Low to very low
Strong Ground Shaking	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Liquefaction	Low	Low	Moderate to High	Moderate to High	Low	Moderate
Hydroconsolidation	Low	Moderate to High	High	High	Low	High
Landsliding and Slope Stability	Moderate	High	Low	Low to Moderate	Low	High
Expansive Soils	Low	Low	Low	Low	Low	Low

Qualitative remedial measures that could be required to reduce or mitigate geologic hazards are suggested in Table 5 - Qualitative Geohazard Measures.

Table 5. Qualitative Geohazard Measures

Geologic Hazard	Possible Mitigation Measures
Ground Rupture	No Action Anticipated
Strong Ground Shaking	Design for Moderate Ground Shaking
Liquefaction	Avoid Development in Areas Susceptible to Liquefaction Excavate and Replace Materials Susceptible to Liquefaction Ground Improvement Mitigations Using Cement Deep Soil Mixing Design Foundations for Possible Downdrag Loads and Settlement
Hydroconsolidation	Excavate and Replace (or Pre-saturate) Materials Susceptible to Hydroconsolidation Ground Improvement Mitigations Using Cement Deep Soil Mixing Design Foundations for Possible Downdrag Loads and Settlement
Landsliding and Slope Stability	Avoid Development in in Landslide Prone Areas Significant Geohazard Characterization and Assessment Required for Developments Planned on or Near Mapped or Queried Landslides May Require Large-Scale Ground Stabilization Measures would likely be Costly in Landslide Areas
Expansive Soils	Design Foundations for Expansive Soil Potential as Needed

We appreciate the opportunity to work with Sturgeon Services International and AERA Energy in the planning and preliminary design effort for future improvements at the East Cat Canyon Oil Field. Please contact us if you have any questions regarding our preliminary assessment or characterization of the geohazards in the study area,

Sincerely,

FUGRO CONSULTANTS, INC.

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Thomas F. Blake, C.E.G., G.E.
Principal Engineering Geologist/Geotechnical Engineer

Enclosures: Plate 1 - Location Map, East Cat Canyon Area
Plate 2 - Regional Geologic Map
Plate 3 – Geologic Map
Plate 4 – Regional Fault Map

REFERENCES

California D.O.G. (1961), California Oil and Gas Fields, Maps and Data Sheets, Part 2, Los Angeles-Ventura Basins and Central Coastal Regions, California Division of Oil and Gas, Cat Canyon Oil Field: East and Olivera Canyon Areas.

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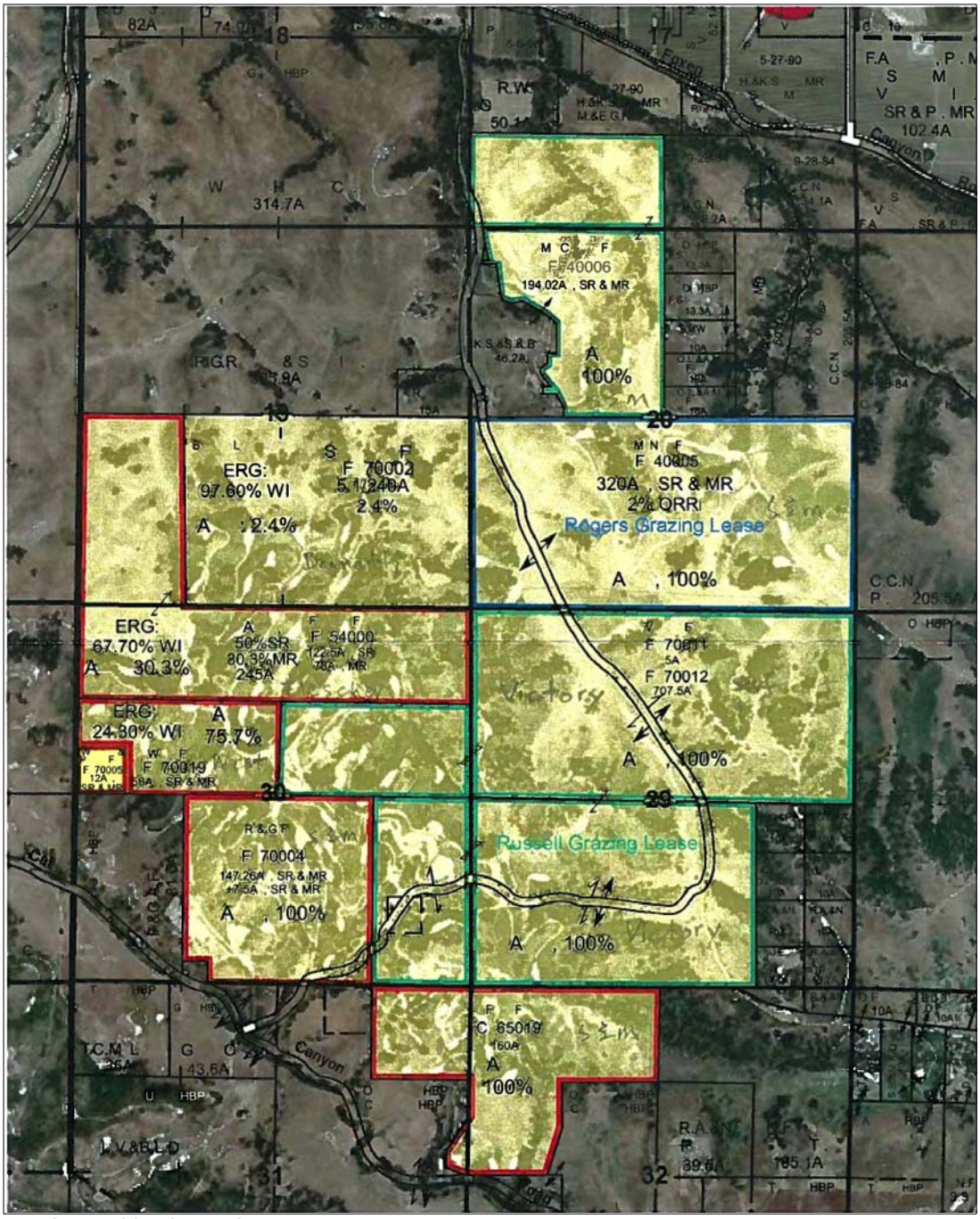
Woodring, W.P.; Bramlette, M.N. (1950), Geology and Paleontology of the Santa Maria District, California, Geological Survey Professional Paper 222.

PLATES



BASE MAP SOURCE: TJ Cross Engineers.

NORTH

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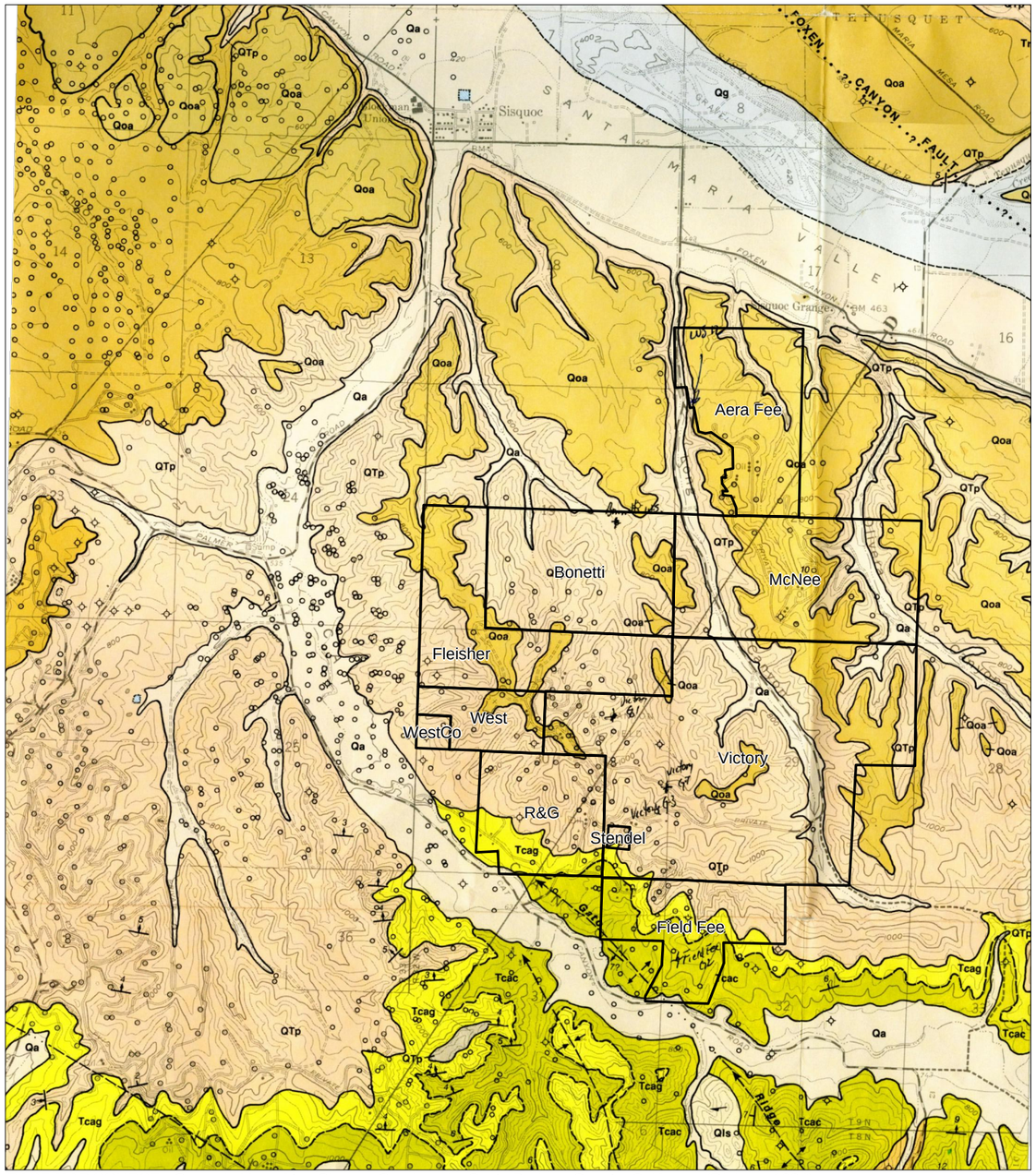
LOCATION MAP

East Cat Canyon Sisquoc Area

Santa Barbara County, California

PLATE 1



BASE MAP SOURCE: Geologic Map of the Sisquoc Quadrangle, Santa Barbara County, California, (Dibblee, 1994).

NORTH

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FEET

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LEGEND

Qa	Alluvium
Qg	Stream channel deposits
Qls	Landslide debris
Qoa	Older Alluvium
QTp	Paso Robles Formation
Tcag	Careaga Sandstone (Graciosa Member) - massive gray-white to tan sandstone
Tcac	Careaga Sandstone (Cebada Member) - massive tan to yellow, soft, fine grained sandstone
Tsqd	Sisquoc Formation
Tm	Monterey Shale

Formation Contact - dashed where inferred or indefinite

Fault - dashed where indefinite or inferred, dotted where concealed, relative vertical movement shown by U/D (U = upthrown side, D = downthrown side), short arrow indicates dip of fault plane, sawteeth are on upper plate of low angle thrust fault

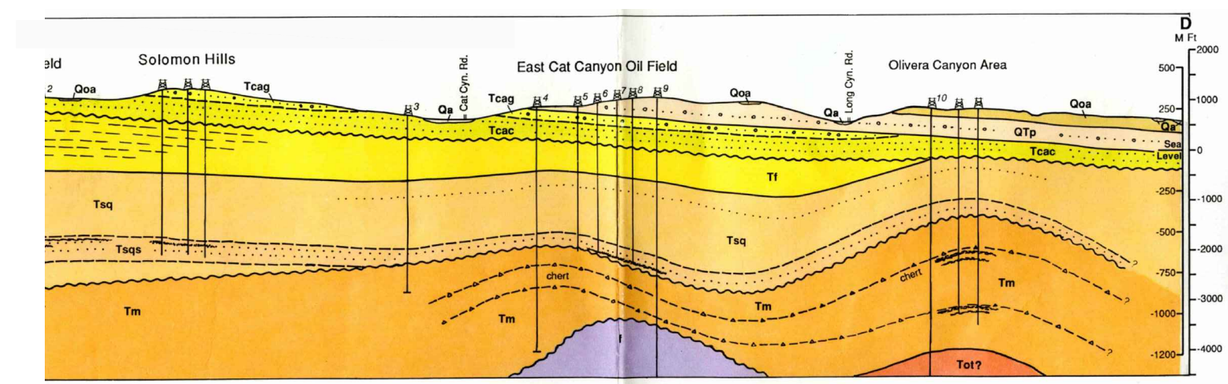
Anticline - dashed where inferred or indefinite

Syncline - dashed where inferred or indefinite

Strike and dip of beds:

20 Inclined

30 Vertical



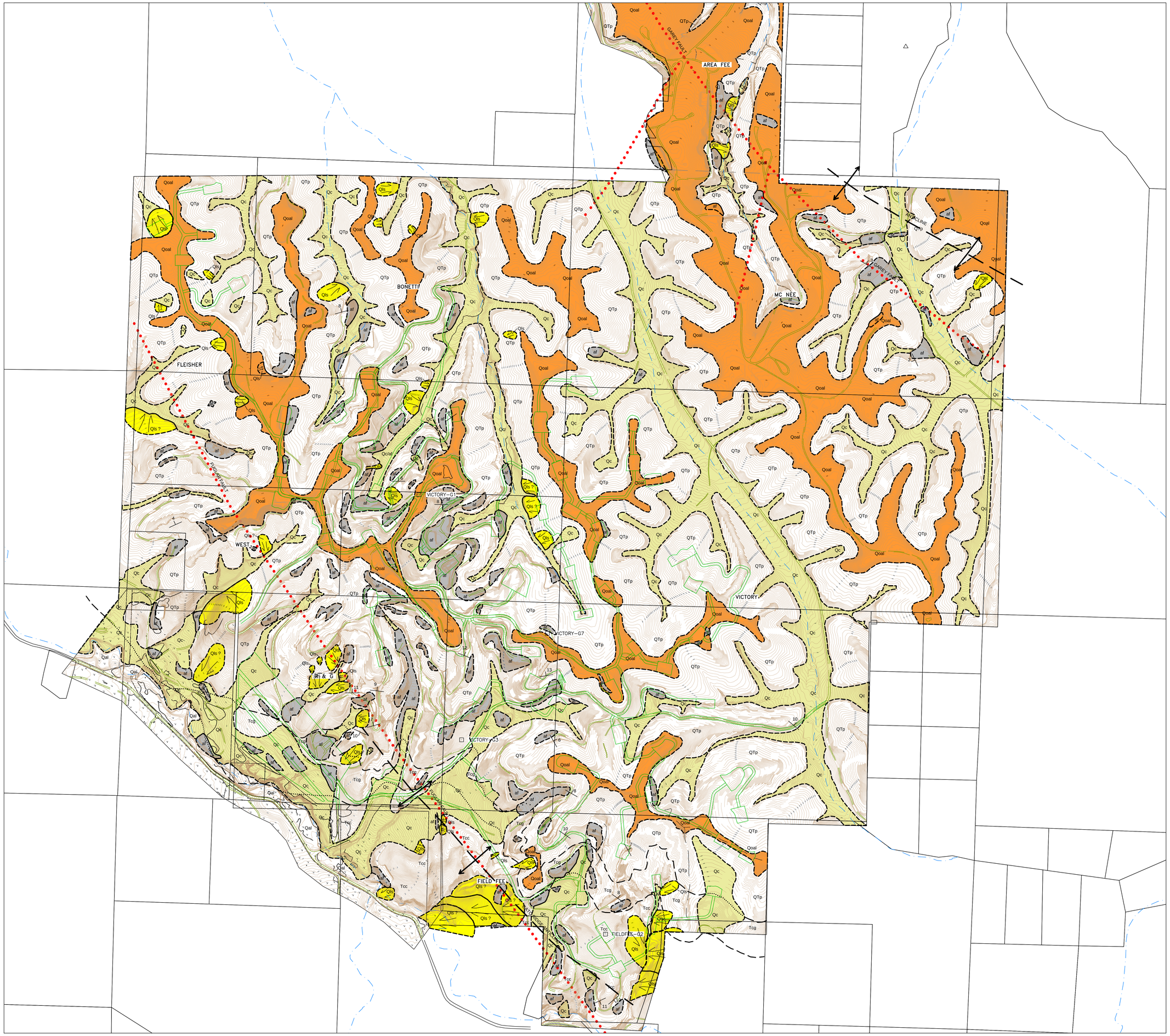
SOURCE: Section from Geologic Map of the Sisquoc Quadrangle, Santa Barbara County, California, (Dibblee, 1994).

3000
0
0 3000
Horizontal and Vertical Scales in Feet

Deep Wells shown:

3. Stone & Goodwin
4. R & G Oil Co., #11
5. R & G Oil Co., #5
6. R & G Oil Co., #6
7. Palmer-Stendel Oil Co., #9
8. Palmer-Stendel Oil Co., #10
9. Palmer-Stendel Oil Co., #20

REGIONAL GEOLOGIC MAP
East Cat Canyon Sisquoc Area
Santa Barbara County, California



LEGEND

af	Artificial fill
Qc	Colluvium
Qls	Landslide deposits
Qoal	Older Alluvium
QTp	Paso Robles Formation
Tcg	Carreaga Formation (Graciosa Coarse-Grained Member)
Tcc	Carreaga Formation (Cebada Fine-Grained Member)

Fault, dotted where concealed

Strike and dip of bedding

Anticline axis

NORTH

0 400 800 1200 1600
Feet

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GEOLOGIC MAP

Geohazards & Geotech Study AERA

Cat Canyon Oil Field
Santa Barbara County, California

Stugeon Services, International

04.62130155 | December 2013 | Plate 3

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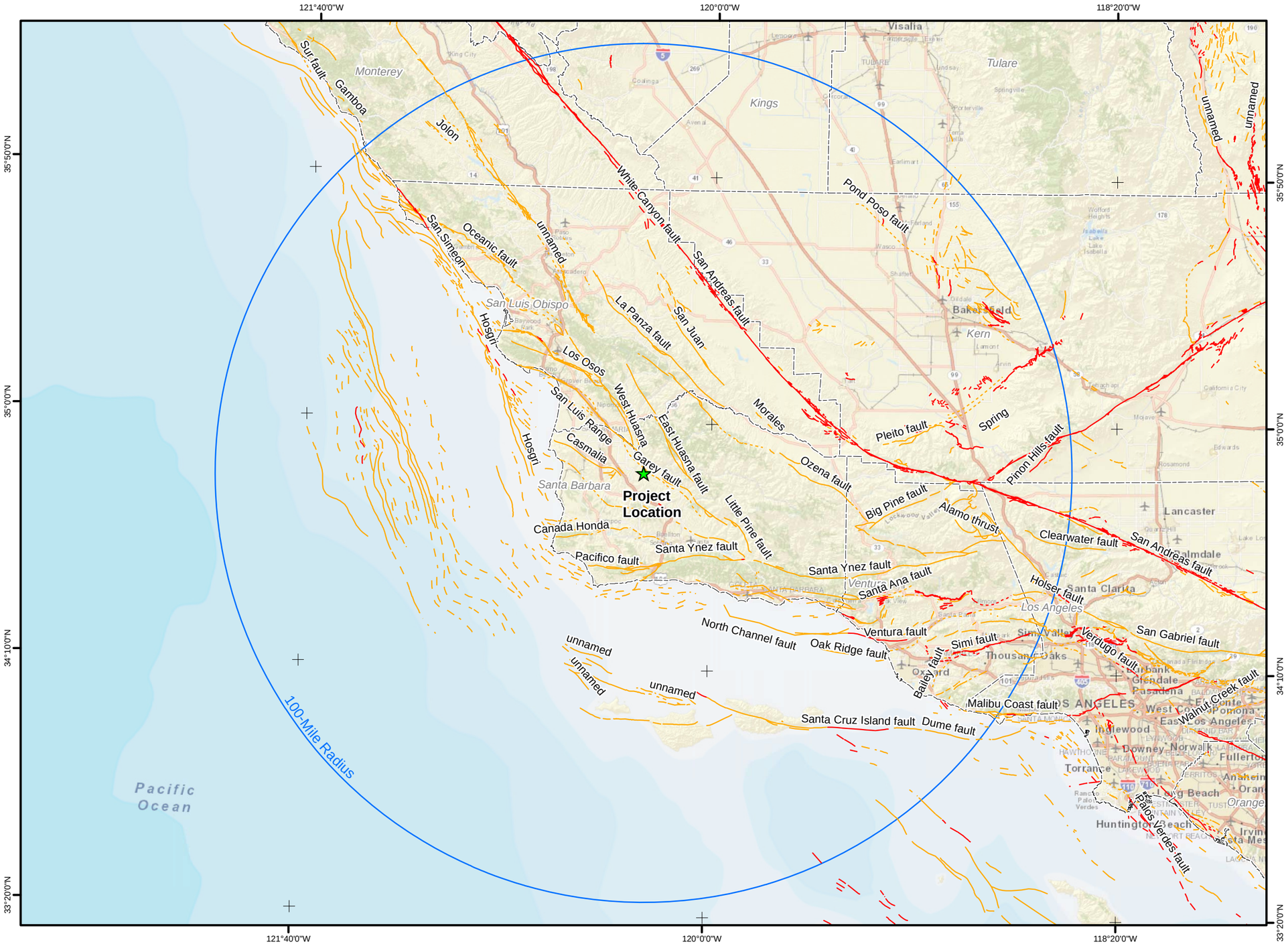

Legend

County Limits

Faults

Active Fault, dashed where inferred

Potentially Active Fault, dashed where inferred

Sources:

a) Bryant, 2005

b) Jennings, 1994

The Fuglar fault, discussed in the accompanying report, is not shown on this map because it is not recognizable at the scale of this regional map.

N

1:1,500,000

0 10 20 40 Miles

REGIONAL FAULT MAP
East Cat Canyon Oil Field, Sisquoc Area
Santa Barbara County, California

PLATE 4

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January 22, 2014
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3120 Sturgeon Street
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Attention: Mr. Keith Kidwell Jr.

Subject Phase I Services, Preliminary Geotechnical Engineering Study, East Cat Canyon Oil Field, Sisquoc Area, Santa Barbara County, California

Dear Mr. Kidwell:

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We note that additional geotechnical engineering and geologic services will be required to develop design-level recommendations for the project. We understand that those services will be performed as part of AERA's Phase II services for the project.

INTRODUCTION AND PROJECT DESCRIPTION

PROPOSED PROJECT

We understand that our assessment will be used to support Front End Load Engineering and Design (FELED) work for potential oil and gas development in the lease areas owned by Aera Energy, LLC (Aera) in the East Cat Canyon Oil Field. Potential development work in the oil field is expected to involve the following elements:

- Well pads and access roads,
- Pipelines,
- Office area,
- Central processing plant and warehouse, and
- Steam Generator.

Actual locations of the proposed facilities have not been determined. However, preliminary sites for the new office, processing plant and steam generator have been selected

and were shown on a map provided to us via email. Access to the site is from Palmer Road and Cat Canyon Road.

SITE DESCRIPTION

The proposed oil field development area consists of eight lease areas located within Sections 19, 20, 28, 29, 31, and 32 of Township 9N/Range 32W, SBBM. The lease areas are shown on Plate 1 - Location Map - East Cat Canyon Area. That map also shows the extent of development in the area (roads, oil-well access roads and pads, the location of residential homes, industrial developments, very limited agricultural development, and drainage catchments.

The topography of the area consists of a series of north-south aligned subdued hills with elevations ranging from about +500 to +1,000 feet above mean sea level (MSL). Cat Canyon Creek, which is the principal stream in the area, is intermittent and flows to the north toward the community of Sisquoc. That creek, as well as those in Long Canyon and Olivera Canyon, is well entrenched along most of its course.

WORK PERFORMED

The scope of work for this preliminary geotechnical study consisted of the following tasks:

- Evaluating data and discussion of geologic conditions and hazards at the East Cat Canyon Oil Field site summarized in our Preliminary Geologic Hazards report (Fugro 2013),
- Site reconnaissance and marking potential locations for geotechnical drilling and sampling,
- Utility clearance and coordination with AERA, SSI staff and our drilling subcontractor regarding the proposed field work,
- Excavating, sampling, and logging six hollow-stem auger drill holes at selected locations within the study area. The drilling and sampling activities were performed by our subcontractor, S/G Drilling of Lompoc, California. Drill holes were excavated to depths ranging from about 15 feet to 30 feet below the ground surface. The approximate locations of the geotechnical drill holes are shown on Plate 2 – Drill Hole Location Map.
- Performing geotechnical laboratory tests on selected samples recovered from the drilling and sampling program,
- Performing analytical (chemical tests) on selected sampled recovered during the exploration program that appeared to have a petroleum odor,
- Characterizing the geotechnical conditions from the drilling and laboratory data and developing preliminary geotechnical recommendations for used in the FELED work

- Preparing this letter-report summarizing our findings and preliminary recommendations.

GEOLOGIC SETTING AND SUBSURFACE CONDITIONS

The regional geologic conditions in the East Cat Canyon Oil Field are discussed in our Preliminary Geologic Hazards report (Fugro 2013). As described in that report the geologic conditions in the study area consist of predominantly flat lying to slightly folded sequence of Pliocene and Pleistocene formations consisting of the Carreaga and Paso Robles Formations. Older alluvial deposits are present on the tops of ridges and hills and deposits of Recent colluvium and alluvium are also present in the project area in the tributary canyons and valley floors. The subsurface formations and stratigraphic relationships as mapped by Dibblee (1994) are shown on Plate 3- Regional Geologic Map. A more detailed geologic map of the study area was generated as part of our Preliminary Geologic Hazards report. That geologic map is provided herein on Plate 4 – Geologic Map.

Carreaga Formation (Tcc/Tcg). As shown on Plates 2 and 3, the Careaga Formation crops out as a linear band along the southerly edge of the study area and is divided into two members; the Cebada and the Graciosa Members. The Cebada fine-grained lower member consists primarily of very uniform fine-grained to very-fine-grained massive sandstone, which is light gray to yellow in color. Small stringers of shale pebbles and fossils are abundant. The Graciosa Member commonly consists of coarse-grained sandstone with thin stringers of gravel.

Drill holes DH-1A and DH-4 were excavated into Carreaga (Graciosa Member) Formational materials. As observed from those drill holes, the Graciosa Member generally consists of soft, slightly to moderately weathered, massive sandstone and sandy claystone with gravel-size fragments of rock likely derived from the Monterey Formation. From a geotechnical engineering perspective, the material can be described as dense to very dense silty sand and clayey sand with gravel to stiff to hard sandy lean clay with gravel. Where encountered, the Carreaga Formational materials extended to the maximum depth explored.

Paso Robles Formation (QTp). The Pleistocene-age Paso Robles Formation is non-marine and primarily consists of poorly consolidated stream-deposited lenticular beds of gravel, sand, silt, and clay. The Paso Robles Formation crops out in most of the project area and conformably overlies the Careaga Formation and consists of very poorly sorted and heterogeneous (i.e., a wide range of grain size materials) mixtures of cobbles, gravel, and sand in a clay matrix. The formation is exposed in numerous cut slopes throughout the study area. The Paso Robles Formation is gently folded (with dips less than about 10 degrees).

Drill holes DH-1B and DH-2B were excavated into Paso Robles Formational materials. As observed from those drill holes, the Paso Robles Formation is similar to the Carreaga Formation and generally consists of soft, slightly to moderately weathered, massive sandstone and sandy claystone with gravel-size fragments of rock likely derived from the Monterey Formation. From a geotechnical engineering perspective, the material can be described as dense to very dense silty sand and clayey sand with gravel to stiff to hard sandy lean clay with gravel. Where encountered, the Paso Robles Formational materials extended to the maximum depth explored.

Older Alluvium (Qoal). Older alluvial deposits of late Pleistocene age are present on the tops of ridges and hills between Cat Canyon Road, Long Canyon Road, and Olivera Canyon Road. Drill holes DH-2A and DH-2B were excavated into older alluvial materials. The materials encountered in those drill holes generally consisted of dense to very dense poorly graded sand, silty sand, clayey sand and sandy silt with gravel, sand, and silt. In many locations, these deposits are well cemented.

Drill hole DH-2B likely extended into Paso Robles Formational materials at a depth of about 15 feet (elevation of about +1044 feet). Drill hole DH-2A encountered older alluvial soils to the maximum depth explored of 24 feet.

Colluvium (Qcol). Deposits of Recent colluvium also present in the project area in the tributary canyons and valley floors. Deposits of alluvium are also present on-site, however, for this report we have not differentiated between the colluvial and alluvial deposits. Colluvial soils were encountered in drill holes DH-3, DH-1A, and possibly DH-1B. In DH-1A and DH-1B the colluvial soils were encountered to depths of about 10 feet and those materials were underlain by Plio-Pleistocene formational materials. In DH-3, colluvial soils were encountered to the maximum depth explored of about 31 feet below the ground surface. The colluvial deposits generally consist primarily of loose to medium dense poorly sorted mixtures of sand and gravel with some fine-grained materials. The thickness of those deposits likely vary from relatively limited (less than about 10 feet) in slope areas and minor drainage swales to greater than about 30 to 50 feet in more significant drainage and collection areas.

Artificial Fill. Throughout the oil field area, local deposits of artificial fill are present. Those fill materials were commonly placed to facilitate the construction of drilling and production pads, and access roads. The fill deposits appear to consist of locally derived earth materials that were typically placed in an uncompacted state. In some locations, the fill materials appear to contain concrete and other construction debris.

Groundwater Conditions. Groundwater was not encountered in the site-specific geotechnical drill holes excavated to depths of up to 30 feet and performed as part of our preliminary geotechnical engineering evaluation study. In addition, data reported in Fugro (2012) suggests the depth to groundwater within the study area is anticipated to be greater than 100 to 200 feet below the ground surface. Although the depth to groundwater is anticipated to be relatively deep, there is a possibility for areas or zones of perched groundwater to be present at shallow depths (that is less than 30 feet deep) on at least a seasonal basis. Perched groundwater can occur in drainage channels or where changes in soil type or permeability occur within soil or rock materials. Groundwater seepage can occur where perched water daylights in cuts or at the ground surface.

PETROLEUM HYDROCARBON MATERIALS

Because the site has been actively producing hydrocarbon products for decades, it is likely that hydrocarbon-contaminated soil is present locally. We also understand that oil sands were placed in several of the canyon areas on site. In addition, petroleum hydrocarbon odors were noted during drilling and sampling work in three of the six site-specific drill holes excavated as part of our preliminary geotechnical engineering evaluation study (drill holes DH-2A, DH-2B, and DH-3). Analytical chemical tests were performed on three samples (DH-2A at 20.5 ft, DH-

2A at 21.5 ft, and DH-3 at 15 ft) to provide additional information on the petroleum hydrocarbons in the soil. The results of the tests are provided in Appendix C – Results of Analytical Testing. We note that the samples were collected using typical geotechnical sampling methods and were not placed in air tight containers or maintained in a chilled environment. However, the tests provide some relevant data for future evaluation of this issue.

In general, we note that soils containing petroleum hydrocarbons or other substances common to historical oilfield development may locally be present throughout the site and should be evaluated where new construction is planned.

SEISMIC SETTING AND INPUT TO SEISMIC DESIGN

No active faults have been mapped by others within the project boundaries and no faults were observed on the site during our reconnaissance surface mapping. However, two concealed older faults have been mapped through the project area (Plate 3) on the basis of published oil exploration data (California D.O.G., 1961; 1974; Hall, 1981; and Lettis et al., 2004).

The concealed northeast-dipping, normal fault mapped through the northeastern portion of the project area is referred to as the Garey fault (Hall, 1981). The concealed northeast-dipping, normal fault mapped through the southwestern portion of the area is unnamed on published maps (California D.O.G., 1974), but locally referred to as the Fuglar fault. A cross-section of the Olivera Canyon Area of the Cat Canyon oil field (California D.O.G., 1961) shows that the Garey fault only cuts rocks older than early Pliocene, therefore that fault would not be considered active. A cross-section of the East Area of the Cat Canyon oil field (California D.O.G., 1961) shows a similar pre-early Pliocene age for the Fuglar fault through the southwestern area, but California D.O.G. (1974) suggests that additional faulting (with a different sense of slip) may extend upward into the base of the Carreaga Formation rocks of late Pliocene age. In either case, the Fuglar fault would not be considered active. Consequently, neither of those two onsite faults are considered likely to pose a ground-surface fault-rupture hazard.

The site is located in California's seismically active central coast region and there are a number of active faults in the region that have the potential to produce strong ground motion at the site. Regional faults in the study area are shown on Plate 5 - Regional Fault Map. A list of those faults within about 50 miles of the area, along with selected fault parameters, is presented in Table 1.

Table 1. Seismogenic Fault Sources

Fault Name	Fault Type	Distance (miles)	Magnitude
San Luis Range	Reverse	3	7.2
Casmalia (Orcutt Frontal)	Reverse	5	6.7
Los Alamos – West Baseline	Thrust	5	6.9
Lions Head	Reverse	8	6.8
Santa Ynez	Strike Slip	21	7.2
Los Osos	Reverse	23	7.0
Hosgri	Strike Slip	26	7.3
San Juan	Strike Slip	29	7.1
Red Mountain	Reverse	31	7.4
Mission Ridge – Arroyo Parida – Santa Ana	Reverse	35	6.9
North Channel	Thrust	36	6.8
Rinconada	Strike Slip	36	7.5
Pitas Point	Reverse	37	7.3
San Andreas	Strike Slip	40	8.1
Santa Ynez (East)	Strike Slip	43	7.2

The peak ground accelerations with a 475-year and a 2,475-year return period were estimated for a location near the south central boundary of the area shown on Plate 3 (latitude: 34.8237, longitude: -120.2895) using the U.S. Geological Survey's 2008 Interactive Deagggregations web site. Those values, assuming the site conditions are represented by a $Vs_{(30)}$ of about 400 m/sec, are listed in Table 2 below.

Table 2. Preliminary Probabilistic Ground Motions

Return Period	Peak Ground Acceleration (g)
475 years	0.26
2,475 years	0.49

The design motion parameters for use with the 2013 California Building Code were estimated using the U.S. Geological Survey's Seismic Design Maps & Tools website. Table 3 summarizes those parameters estimated for a location near the south central boundary of the area shown on Plate 3 (latitude: 34.8237, longitude: -120.2895). Based on our reconnaissance-level effort, the geologic site conditions could potentially meet the criteria for either Site Class C or D conditions and code-based seismic criteria are provided in Table 3 for both Site Class C and D conditions.

Table 3. Preliminary Building Code Seismic Design Parameter

2010 Building Code Seismic Parameter	Site Class C Value (g)	Site Class D Value (g)
S_S	1.116	1.116
S_{MS}	1.116	1.176
S_{DS}	0.744	0.784
S_1	0.425	0.425
S_{M1}	0.585	0.670
S_{D1}	0.390	0.446

SOIL LIQUEFACTION AND SEISMICALLY INDUCED SETTLEMENT

Liquefaction. Seismically induced liquefaction is a phenomenon that commonly affects loose, granular materials below the groundwater table. Seismic shaking causes transient shear stresses in the soil deposits, which in-turn result in partial densification of the loose materials. As the saturated materials densify, pore water pressures can increase causing the effective shear strength of the soil to reduce. If pore pressures build to a significant level during or shortly after an earthquake event, the soil may begin to behave like a viscous fluid and result in lateral ground movement. In addition, pore pressure dissipation following the earthquake shaking may be accompanied by consolidation, which can cause ground settlement.

On the basis of their Plio-Pleistocene age and sampler blow count data (N-value data) obtained from our site-specific soil drill holes, the older alluvium, and Paso Robles and Carreaga Formations are not likely to be susceptible to earthquake induced liquefaction or seismic settlement.

Sampler blow count (N-value) data from our site-specific geotechnical engineering drill holes indicate the colluvial and alluvial soils could be susceptible to liquefaction. However, the depth to groundwater at the locations explored exceeded a depth of 30 feet and liquefaction is not a hazard for soils located above the groundwater level. However, if alluvial and colluvial deposits present in the canyon and valley areas are or were to become saturated, those deposits are likely to experience earthquake-induced liquefaction and settlement associated with strong ground shaking events. Site-specific geotechnical exploration and analyses will be needed to determine the potential for liquefaction and seismic settlement.

Seismic Settlement. Settlement from earthquake ground shaking can also occur in uncemented, granular soils above the groundwater. A description of the settlement caused by densification of the granular soils and procedures to evaluate the potential magnitude of settlement that could occur is provided in Tokimatsu and Seed (1978), Pradel (1998), and others. On the basis of the soil conditions encountered in our preliminary drill holes, we believe the potential for seismic settlement of the formational and older alluvial soils in the study area is relatively low. However, there is a potential for seismic settlements to occur in the existing unsaturated colluvial soils and artificial fill if those materials are subjected to strong ground shaking. On a preliminary basis, we anticipate the magnitude of settlement would likely be on

the order of an inch or less. Settlement from seismic shaking (and liquefaction) should be considered cumulatively with estimated settlements from static loads.

HYDROCONSOLIDATION POTENTIAL

Hydroconsolidation (collapse) is a phenomenon whereby unconsolidated soil materials settle (collapse) upon the addition of moisture. The moisture may come from the infiltration or seepage of water from the ground surface, or from a rise in the groundwater level. Commonly, such soil materials are slightly cemented by chemical precipitates or clayey minerals, and the addition of moisture causes those cementing materials to dissolve or soften allowing the soil particles to consolidate. Often collapsible soils exhibit visible pore spaces when undisturbed samples are broken open.

Because of their age, the Paso Robles and Carreaga Formation materials and older alluvium are not likely to be subject to hydroconsolidation. However, deposits of colluvium and alluvium on the site may be susceptible hydroconsolidation.

LANDSLIDING AND SLOPE STABILITY

Our geologic reconnaissance mapping of the site has identified several locations that have geomorphology that suggests the presence of past landsliding. Those mapped landslide areas that are queried on Plate 4 are more speculative than the non-queried areas. No subsurface exploration has been performed to confirm the existence of the mapped landslides shown on Plate 4. Because of the generally granular nature of the onsite materials and the gentle dips of the bedding within the Paso Robles and Carrega Formations, we suspect that most of the onsite landslides are likely to be rotational failures, as opposed to translational failures.

Throughout the area, there are numerous manmade cut slopes created to facilitate hydrocarbon production. Most of those slopes are relatively steep (1H:1V or steeper) and they commonly exhibit signs of raveling, slumping, and erosion.

Deposits of colluvium are present on the natural slopes throughout the area. Where thick deposits of colluvium were recognized, they are mapped on Plate 3 (map unit Qc). Where present on slopes, the colluvium is generally unstable and creep-prone.

If possible, areas with suspected landslide geomorphology should be avoided. However, if structures are proposed in areas of possible landsliding, subsurface exploration should be performed to confirm the presence and geometry of the landslide deposits, and to evaluate the stability of the materials. If landslide deposits are confirmed and their natural stability is found to be inadequate, removal and replacement with compacted fill, providing structural support, or compacted-fill buttressing are possible mitigation measures.

Areas of colluvium on slopes above proposed developments should be removed or supported. Because most of the earth materials on the site are generally granular and uncemented, proposed unreinforced cut and fill slopes probably should be graded at inclinations of 2H:1V or flatter. Because of the granular and uncemented nature of the onsite materials, cut and fill slopes should be properly vegetated and drainage benches and brow ditches should be

incorporated into the slope design and layout. Stability fills placed over cut slopes may also be required.

EXPANSIVE SOIL

Expansive soils are clayey materials that expand when wetted. Most of the bedrock materials on the site are granular; therefore the colluvial and alluvial materials derived from them are also generally granular. Because there is likely to be a limited amount of clayey soil present on the site, the potential for highly expansive soils is limited.

PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

Recommendations for Grading, Earthwork, and Excavation

Excavation Conditions. The drill holes for this study were excavated using a conventional truck-mounted hollow-stem-auger drilling rig and our explorations generally encountered loose to very dense silty sand, clayey sand and sandy silt with gravel and stiff to hard sandy lean clay with gravel. Groundwater and groundwater seepage was not noted in our explorations to the maximum depth explored of about 30 feet below the ground surface.

On the basis of our understanding of the site conditions, we anticipate that planned excavations can be constructed using conventional heavy-duty earthmoving equipment that is in good working condition. We note that temporary control of groundwater is probably not required for general, relatively shallow excavations. However, local control of seepage from perched or transient groundwater could be required, especially if grading work will occur in the winter months. Excavations should be kept free of water and surface runoff should be directed away from open excavations and should not be allowed to flow down slopes.

Clearing and Grubbing. Organic material and vegetation, hazardous materials, old foundations, unsuitable fill materials or other deleterious materials should be stripped, removed and wasted from construction areas. Abandoned underground structures such as wells, pipelines, old foundations, etc., not located prior to grading should be removed or treated in a manner prescribed by the controlling governmental agencies.

General Overexcavation and Remedial Grading. After the clearing and grubbing work has been completed and the soil materials have been removed to the design subgrade level, additional excavation and grading should be performed to help provide for more uniform conditions beneath the proposed structures. The overexcavation and remedial grading should be planned to remove existing artificial fill and colluvial soils beneath proposed structures and areas of development. The depth of overexcavation (remedial grading) required to remove existing fill and colluvial soils will vary across the site based on the soil conditions and proposed site grading. However, on a general basis and for initial planning purposes, overexcavation depths of about 5 feet below existing grade should be anticipated. However, overexcavation depths could locally exceed 10 feet below existing grade.

Overexcavation should extend laterally beyond the structure equal to a distance of at least 5 feet or the depth of the overexcavation, whichever is greater. Temporary shoring should

be installed as required to perform the overexcavation work. Loose, soft, or unsuitable materials, if encountered at the base of the overexcavation, should be removed.

Subgrade Conditions. Subgrade conditions at the base of the overexcavation will likely consist of silty sand, clayey sand and sandy lean clay with gravel. On the basis of our observations, we anticipate the subgrade soils will be relatively firm and capable of being scarified and compacted. However, there is some risk that the subgrade soils could be moist and potentially unstable and "pump" under the loads from compaction equipment. Measures to stabilize the subgrade may be required and provisions for stabilization work should be provided in the contract documents. Stabilization measures could potentially consist of placing compacted aggregate base or crushed rock on the unstable subgrade alone or in combination with geogrids or geotextile fabric.

Subgrade Preparation. Prior to the placement of fill materials, the excavation subgrade should be cut neat and observed by the geotechnical engineer. Loose, soft or unsuitable materials, if encountered at the planned subgrade level, should be removed and replaced with compacted fill. If no further overexcavation or soil removal is needed (as determined by the geotechnical engineer), the subgrade should be scarified to a depth of 6 inches, moisture-conditioned of 0 to 3 percent above optimum moisture, and recompacted to at least 95 percent of the maximum dry density determined from ASTM D1557.

Bedrock or dense cobble or boulder materials, where exposed in the subgrade may not necessarily need to be scarified and compacted, although the geotechnical engineer should review the exposed subgrade conditions and provide supplemental recommendations for subgrade preparation, if needed.

Fill Selection and Compaction

Fill Placement. Fill materials should be placed in layers that, when compacted, shall not exceed 6 inches in compacted thickness. Each layer should be spread evenly, moisture conditioned to within 0 to 3 percent above the optimum moisture content, and processed and compacted to obtain a uniformly dense layer. The fill should be placed and compacted on near-horizontal planes to a minimum of 90 percent of the maximum dry density determined from ASTM D1557 (relative compaction).

Fill placed on ground inclined at or steeper than 5h:1v should be properly keyed and benched into competent existing soil and bedrock materials. Existing fill and colluvial soils should be stripped from the slope area to be graded prior to placing compacted fill. A keyway fill should be constructed at the toe of the slope. For planning purposes, keyways should be a minimum of 15 feet wide and embedded at least 5 to 10 feet below the adjacent grade. Subdrainage should be incorporated into the keyway and may need to extend higher up the slope depending on the site conditions and slope design. Fill over cut slopes should be designed to incorporate a minimum 8-foot wide stability constructed in the cut portion of the slope. As discussed previously, we recommend that cut and fill slopes be planned at an inclination of 2h:1v or flatter. Steeper slopes may be possible where reinforcement such as soil nails or geogrids are incorporated into the design.

In addition, grading and site development should be planned to avoid placing structures over cut-fill transitions. Where those situations occur, the cut portion of the graded area should be overexcavated in a manner that minimizes the variation in fill thickness beneath the proposed structure footprint.

Select Fill Requirements. On-site soils primarily consist of silty sand, clayey sand and sandy lean clay with gravel. In general, we anticipate that those materials can be used as general fill beneath the proposed structures. However, there is a potential for moderately to highly plastic soils to be present on-site and, in general, we believe those soils will not be suitable for use as backfill for below structures, for below grade walls, or retaining walls. In addition, their use in embankment fill should be evaluated by the geotechnical engineer.

In our opinion, fill materials used as backfill for the below grade walls should be select granular soils (silty sand, sand with silt, or sand) with less than 20 percent passing the number 200 sieve. In addition, select fill should be free of oversize rock greater than three inches in diameter, organic material, trash or debris, and other deleterious materials. We note that on-site soils can be used as select fill provided the material meets these requirements. We recommend the geotechnical engineer should evaluate the suitability of select fill materials prior to their use.

Temporary Support Considerations

General. The contractor shall be responsible for all safety issues related to temporary slopes. Sloped excavations may be used for the proposed excavations where space is available. Temporary slopes should be monitored continuously by the contractor. Loose or unstable soil should be removed immediately. Temporary slopes and excavations should conform to OSHA regulations and other applicable local ordinances and building codes, as required. As a guide to the design of temporary excavations, the soils at the RVTWTP site can be considered to be Type B soils per OSHA classifications.

Shored Excavations. In areas where sloped excavations are not practical, shored excavations will be required. As noted above for sloped excavations, the contractor shall be responsible for the design, installation, and performance of shored excavations. In our opinion, relatively shallow temporary excavations (generally less than about 10 to 15 feet) can likely be shored using a cantilever shoring. Shoring for deeper excavations will likely need to incorporate lateral bracing or tieback anchors.

Generalized soil parameters and recommendations are provided below and are intended to aid in the contractor's evaluation and design of shoring systems.

Depth Range (ft)	Soil Material Type (USCS Classification)	Shear Strength Envelope	Total Soil Unit Weight (pcf)
0 to 30 ft	SM/SC	Φ = 30°, C = 150 psf	125

PRELIMINARY FOUNDATION DESIGN RECOMMENDATIONS

Introduction

We anticipate the proposed structures will be supported on shallow foundations (isolated and continuous footings), drilled cast in-place piles (drilled piers), or relatively rigid concrete mat-type foundations. In our opinion, those type of foundations are suitable provided recommendations from the geotechnical engineering consultant are followed and locally accepted, good quality, construction techniques are utilized. Preliminary recommendations for those foundation systems are outlined herein.

Shallow Foundation Design Criteria

Minimum Shallow Footing Embedment. We recommend that continuous and isolated column footings be founded on competent bedrock, older alluvial soils, or compacted fill placed as recommended in this report. Foundations for the proposed structures should be embedded at least 2 feet below the lowest adjacent grade or slab elevation, whichever is lower.

Continuous footings should be at least 24 inches wide and isolated footings should be at least 3 feet wide. The footing thickness should be determined by the structural engineer, but should not be less than 12 inches thick. Assuming footing elements are embedded to at least the minimum recommended depths noted above, shallow foundations and mats can be designed using a maximum allowable bearing pressure of 2,000 psf.

The recommended value for allowable bearing pressure provides an estimated factor of safety against shear failure in excess of about 3. A one-third increase in the allowable bearing pressure may be used for transient loads such as seismic or wind forces.

Sliding and Passive Resistance. Ultimate sliding resistance generated through a soil/concrete interface can be computed by multiplying the total dead weight structural loads by a coefficient of 0.35. The frictional resistance can be increased by 1/3 for wind or seismic loading conditions.

Passive Resistance. Passive resistance developed from lateral bearing of below-grade walls or footings bearing against compacted backfill or undisturbed native materials. Passive resistance can be estimated using an equivalent fluid pressure of 300 pcf. The passive resistance value is considered applicable to both static and short term loading conditions.

Safety Factors. Sliding resistance and passive pressure may be used together without reduction provided a minimum factor of safety of 1.5 is used for foundation overturning and sliding.

Settlement Estimates. Settlement will occur as static loads are applied to the earth through foundation elements. Both immediate (elastic) and long-term (consolidation) settlements may occur. Because subsurface materials are generally granular, settlements are generally expected to occur shortly after loads are applied. Total settlements of shallow foundations supporting static loads of up to about 200 kips and designed in accordance with the recommendations provided herein are not anticipated to exceed about 1 to 1-1/2 inches.

Differential settlements between similarly loaded foundations are not anticipated to exceed about one-half the estimated total settlement and should not exceed about 1/2 inch in 30 feet.

The above static settlement estimations do not take into consideration potential settlement that could occur as a result of seismic settlement or from potential hydroconsolidation discussed previously.

Modulus of Subgrade Reaction. The modulus of subgrade reaction was estimated using information provided in NAVFAC DM 7.1 (U.S. Navy 1986) and Terzaghi (1955). In our opinion, an elastic modulus of subgrade reaction of 150 pounds per cubic inch (pci) can be used for design. The modulus of subgrade reaction value is for a 1-foot-square plate, and should be scaled for mat size and shape, assuming sand subgrade conditions. On the basis of our interpretation of the subsurface conditions, the Young's Modulus and Poisson's Ratio of the native soils can be assumed equal to 5,000 psi and 0.3, respectively.

Drilled Shaft Foundations

Axial Capacity. On a preliminary basis, we believe that drilled cast-in-place piles or piers are a feasible foundation system that could be used to support proposed structural improvements at the site. We suggest that drilled shaft foundations be designed as straight shafts assuming the estimated frictional resistance acting along the sides of shafts alone. The end bearing resistance should be neglected so that downhole inspection and special cleaning of drilled shaft excavations will not be required. Bells at the bottom to the drilled shafts, typically used to provide additional end bearing capacity, are not recommended.

For preliminary input, we recommend drilled shafts be sized assuming an ultimate unit frictional resistance of 75D (in psf) where D is the depth below the top of the pier in feet (e.g. ultimate frictional resistance at 10 feet below the pier head/ground surface is equal to 750 psf). The unit frictional resistance can be assumed to increase linearly with depth up to a maximum value of 2,000 psf. The ultimate capacity of the pier (in pounds) can be estimated as the sum of the unit friction acting along the embedded length of the pier times the pier diameter.

The uplift capacity of drilled shaft foundations can be estimated as one-half of the maximum allowable downward frictional capacity. The frictional capacity can be increased by 1/3 when considering seismic or other transient loads.

Settlement of Drilled Shaft Foundations. Settlement of drilled shaft foundations will likely consist of elastic compression of the pile itself plus the elastic settlement of the materials within the alluvial fan deposits. We estimate that settlements of drilled shaft foundations should be less than approximately 1 inch total and approximately 1/2 inch differential between adjacent foundation elements.

Lateral Load Capacity of Drilled Shaft Foundations. We performed p-y type lateral pile analyses using LPILE Plus 6.0 (Ensoft 2011) in order to estimate pile head deflection and maximum bending moment as a function of lateral load at the pile head. Lateral load capacity results were derived assuming a granular soil profile. No factors of safety have been applied to the estimated soil properties or to the resulting pile response.

The lateral pile analyses were completed for a generic design case assuming an isolated 24-inch-diameter drilled shaft with a preliminary embedded length of 40 feet and an assumed axial load of 50 kips. The results indicate that lateral loading at the pile head of 15 kips and 20 kips could result in pile head deflections of 1/4 inch and 1/2 inch, respectively for free head conditions. Applied lateral loads at the pile head of about 30 kips and 50 kips could result pile head deflections of 1/4 and 1/2 inches, respectively for fixed head conditions.

We note that group effects will impact the lateral load capacity of the entire pile group. When estimating the lateral capacity of a drilled shaft group with a pile spacing of 3 pier diameters, the sum of the individual lateral capacities for a given deflection should be multiplied by 0.8 in the first row of shafts, 0.4 in the second row, and 0.3 in the third and any subsequent rows. If the pile spacing is increased to 5 pile diameters, the sum of the individual lateral capacities for a given deflection should be multiplied by 1.0 in the first row of shafts, 0.85 in the second row, and 0.7 in the third and any subsequent rows.

GENERAL FLOOR SLAB ON GRADE RECOMMENDATIONS

Minimum Slab Thickness and Reinforcement. We recommend that all floor slabs, including mats, be reinforced. Slab thickness and reinforcement should be designed by the structural engineer to resist structural loading and to satisfy pertinent code, temperature, and shrinkage requirements. As a minimum, we suggest that slabs be at least 5 inches thick.

Vapor Barrier. Floor slabs that will be covered with moisture sensitive flooring (e.g., vinyl tiles) should be protected against moisture vapor flow by a vapor barrier. In order to reduce the risk of distress to moisture sensitive flooring or due to moisture vapor penetration of the floor slab, a continuous impermeable membrane of, at least, 15-mil polyethylene sheet or similar commercial moisture vapor barrier can be installed below the slab. The vapor barrier should be covered with a layer of clean coarse sand (such as washed concrete sand) or fine gravel to promote curing of the slab and to protect against penetration or damage to the vapor barrier. Slabs should be tested before the installation of the flooring and sealed as required.

RETAINING WALL RECOMMENDATIONS

Static Conditions

General. The proposed filter/clarifier building, the washwater recovery basin and feed pump station structures will incorporate below grade basement walls designed integral with the foundation system. We do not anticipate that typical free-standing retaining structures will be required for the project to accommodate changes in site grades. However, recommendations for free-standing retaining walls are provided in this report if they are needed.

Retaining structures that are free to rotate or translate laterally through a horizontal distance to wall height ratio of no less than 0.004 are referred to as unrestrained or cantilevered retaining structures. Such walls can generally move enough to develop active conditions. Retaining structures that are unable to rotate or deflect laterally are referred to as restrained or non-yielding walls. We have assumed that the below grade walls for the proposed project elements will be restrained and should be designed for at-rest conditions.

As indicated previously, we recommend that select material be used as backfill behind proposed walls. In general, we recommend that select material be placed behind the walls within a wedge extending up from the base of the wall at 1h:1v.

Lateral Pressures. Lateral earth pressures for the design of braced and cantilever walls are provided in Table 4 – Recommended Lateral Earth Pressures. The values are expressed in terms of equivalent fluid weight and are based on an assumption that the backfill materials behind retaining or below-grade walls will consist of compacted select material and granular soils as recommended previously. Drained conditions are based on the assumption that subsurface drainage will be provided to prevent the buildup of groundwater behind the wall and that eliminate hydrostatic pressures. Undrained conditions incorporate the potential for hydrostatic pressures to develop. Undrained conditions should be used for walls that will be below the groundwater level or where positive subsurface drainage cannot be provided.

Table 4. Recommended Lateral Earth Pressures

Backfill Slope Inclination Behind Wall	Equivalent Fluid Weights (pcf)			
	Active Conditions / Unrestrained Walls		At-Rest Conditions / Restrained Walls	
	Drained	Undrained	Drained	Undrained
Level Backfill	35	80	50	90

The equivalent fluid weights should be applied to a vertical plane passing through the back most part of the heel. The height of the vertical plane should extend from the point where the vertical plane intersects the ground surface down to the elevation of the lowest retaining wall foundation element (e.g., bottom of shear key or passive pressure resisting element).

Surcharge loads induce additional pressures on earth retaining structures. Uniform area surcharge pressures for below-grade walls may be assumed equal to 0.5 of the applied surcharge pressure. Lateral pressures for other surcharge loading conditions can be provided, if required.

Compaction Adjacent to Walls. Backfill within 5 feet, measured horizontally, behind the retaining structures should be compacted with lightweight, hand-operated compaction equipment to reduce the potential for creation of large compaction-induced stresses. If large or heavy compaction equipment is used, compaction-induced stresses can result in increased lateral earth pressures on the retaining walls in addition to those presented in Table 4. If anything but lightweight, hand-operated compaction equipment is to be used, further evaluation of the potential for compaction-induced stresses is recommended.

Backfill material should be brought up uniformly around the below-grade or retaining walls (i.e., the backfill should be at about the same elevation all around the wall as the backfill is placed). That is, the elevation difference of the backfill surface around the wall should not be greater than about 2 feet, unless the wall is designed for those differences.

Dynamic Earth Pressures. For unrestrained walls, the increase in lateral earth pressure acting on the wall resulting from earthquake loading can be estimated using the

Mononobe-Okabe theory, as described by Seed and Whitman (1970). That theory is based on the assumption that sufficient wall movement occurs during seismic shaking to allow active earth pressure conditions to develop. For restrained walls, the increase in lateral earth pressure resulting from earthquake loading also can be estimated using the Mononobe-Okabe theory. Because that theory is based on the assumption that sufficient movement occurs so that active earth pressure conditions develop during seismic shaking, the applicability of the theory to restrained or basement walls is not direct. Nevertheless, there is a supporting reference (Nadim and Whitman, 1992) that suggests the theory can be used for such walls.

In the Mononobe-Okabe approach, the total dynamic pressure can be divided into static and dynamic components. The estimated dynamic lateral force increase (based on seismic loading conditions) for either unrestrained or restrained walls may be taken as 12 x H^2 pounds per linear foot of wall. In the above formulation, we assumed the ground acceleration to be equal to the PHGA (or about 0.26g in units of gravity, g, as appropriate, and H is the height of wall below the ground surface in feet. The centroid of the dynamic lateral force increment should be applied at a distance of 0.6*H above the base of the wall, while the static lateral force should be applied at a distance of one-third the wall height above the base of the wall base.

To estimate the total dynamic lateral force, the dynamic lateral force increase should be added to the static earth pressure force computed using recommendations for active lateral earth pressures presented previously. That recommendation is based on the concept that during shaking, earth pressures recommended for permanent conditions will be reduced to those more closely approximating active conditions.

Drainage Measures

Free-Draining Backfill. If drained lateral earth pressures are used for permanent conditions, then drainage measures must be implemented to help prevent the buildup of hydrostatic pressures behind the below-grade walls. This recommendation is in addition to using select material as backfill behind the walls.

For wall drainage, we recommend at least 2 feet (measured out from the back of the wall) of clean coarse-grained material be placed behind the wall. The free-draining backfill should consist of:

- "Pervious Backfill" conforming to Item 300-3.5.2, Standard Specifications for Public Works Construction (Greenbook, 2010);
- "Permeable Material" conforming to Item 68-1.025, Caltrans Standard Specifications (2010); or
- Crushed stone, sized between 1/4 and 1/2 inch.

Filter Fabric. A nonwoven filter fabric should be placed between the free-draining backfill and the soil or rock, compacted or otherwise, behind the free-draining backfill to protect against soil migration into the drain material. The filter fabric should conform to Section 213-4 of the "Greenbook," at least Type 180N. The filter fabric should be placed in general conformance with Section 300-9 for the "Greenbook."

Prefabricated Drainage Materials. In lieu of free-draining backfill materials of the types suggested above, manufactured drainage structures (e.g., Miradrain, manufactured by Mirafi, Inc., or similar) can be used against retaining or below-grade walls. Manufacturer recommendations for the installation of any of those products should generally be followed, although those recommendations should be reviewed by the geotechnical engineer.

Discharge. The drainage material behind retaining or below-grade walls should be hydraulically connected to the granular material and perforated drainpipe system. The entire drainage system should be tied to an exterior drainage exit.

Water Stops. Water stops should be installed in both expansion and/or construction joints along below-grade walls and foundation slabs.

Runoff. Provisions should be included for removal of surface runoff that may tend to collect behind the backs of the walls and for drainage of water away from the fronts of the walls. Also, provisions should be included to mitigate the infiltration of surface runoff into the free draining backfill by placing a minimum of 18 inches of fine-grained clayey soil (native lean to fat clay) compacted soil over the top of the free draining backfill.

CORROSION AND CEMENT SELECTION

Chemical tests to assess corrosion to metal and cement selection were performed on a selected sample of the near surface material recovered from DH-1A. The results of the corrosion tests are summarized below.

Table 5. Summary of Corrosion Test Results

Drill Hole No.	Sample Depth (ft)	Material Type	Resistivity (ohms/cm)	PH	Chloride (ppm)	Sulfate (ppm / %)
DH-1A	5	Silty Sand	4837	6.3	3	100 ppm 0.010 %

The data acquired for this study suggest that the corrosion potential to concrete and ferrous pipe materials from the on-site soils is relatively low. The results suggest the soils are non-aggressive to concrete and that typical Type II cement appears suitable for structures in contact with on-site soils. Our preliminary evaluations of corrosion potential are based on guidelines described in Caltrans (2012). We recommend that additional data be gathered regarding the corrosion potential of the on-site soils.

LIMITATIONS AND REPORT USE

The preliminary recommendations and opinions presented in this letter-report were developed by Fugro Consultants, solely for SSI and AERA for use in the planning and preliminary design of proposed improvements at the East Cat Canyon Oil Field. The findings, opinions, and preliminary recommendations presented herein were prepared in accordance with generally accepted local geotechnical engineering practice.

Although information contained in this report may be of some use for other purposes, it may not contain sufficient information for other parties or uses. If any changes are made to the project as described in this report, the conclusions and recommendations in this report shall not be considered valid unless the changes are reviewed and the conclusions and recommendations of this report are modified or validated in writing by Fugro.

POTENTIAL VARIATION IN SUBSURFACE CONDITIONS

Earth materials can vary in type, strength, and other geotechnical properties between points of observations and exploration. Additionally, groundwater and soil moisture conditions also can vary seasonally or for other reasons. Therefore, we do not and cannot have a complete knowledge of the subsurface conditions underlying the site. The conclusions and recommendations presented in this report are based on the findings at the points of exploration, interpolation and extrapolation of information between and beyond the points of observation, and are subject to confirmation (to the extent possible) based on the conditions revealed during construction.

CLOSURE

We appreciate the opportunity to work with Sturgeon Services International and AERA Energy in the planning and preliminary design effort for future improvements at the East Cat Canyon Oil Field. Please contact us if you have any questions regarding the findings, opinions, or preliminary recommendations provided in our Phase I Preliminary Geotechnical Engineering Study.

Sincerely,

FUGRO CONSULTANTS, INC.

Gregory S. Denlinger, G.E.
Principal Geotechnical Engineer

Attachments: **Plates**

Plate 1 - Location Map, East Cat Canyon Area
Plate 2 – Drill Hole Location Map
Plate 3 - Regional Geologic Map
Plate 4 – Geologic Map
Plate 5 – Regional Fault Map

Appendix A – Subsurface Exploration

Plate A-1 through A-6 - Log of Drill Hole
Plate A-7 – Key to Terms and Symbols Used on Logs

Appendix B – Laboratory Testing

Plate B-1 – Summary of Test Results
Plate B-2 – Grain Size Curves
Plate B-3 – Plasticity Chart
Plate B-4 – Direct Shear Results
Plate B-5 – Consolidation Test Results
Plate B-6 – Compaction Test Results

Appendix C – Results of Analytical Testing

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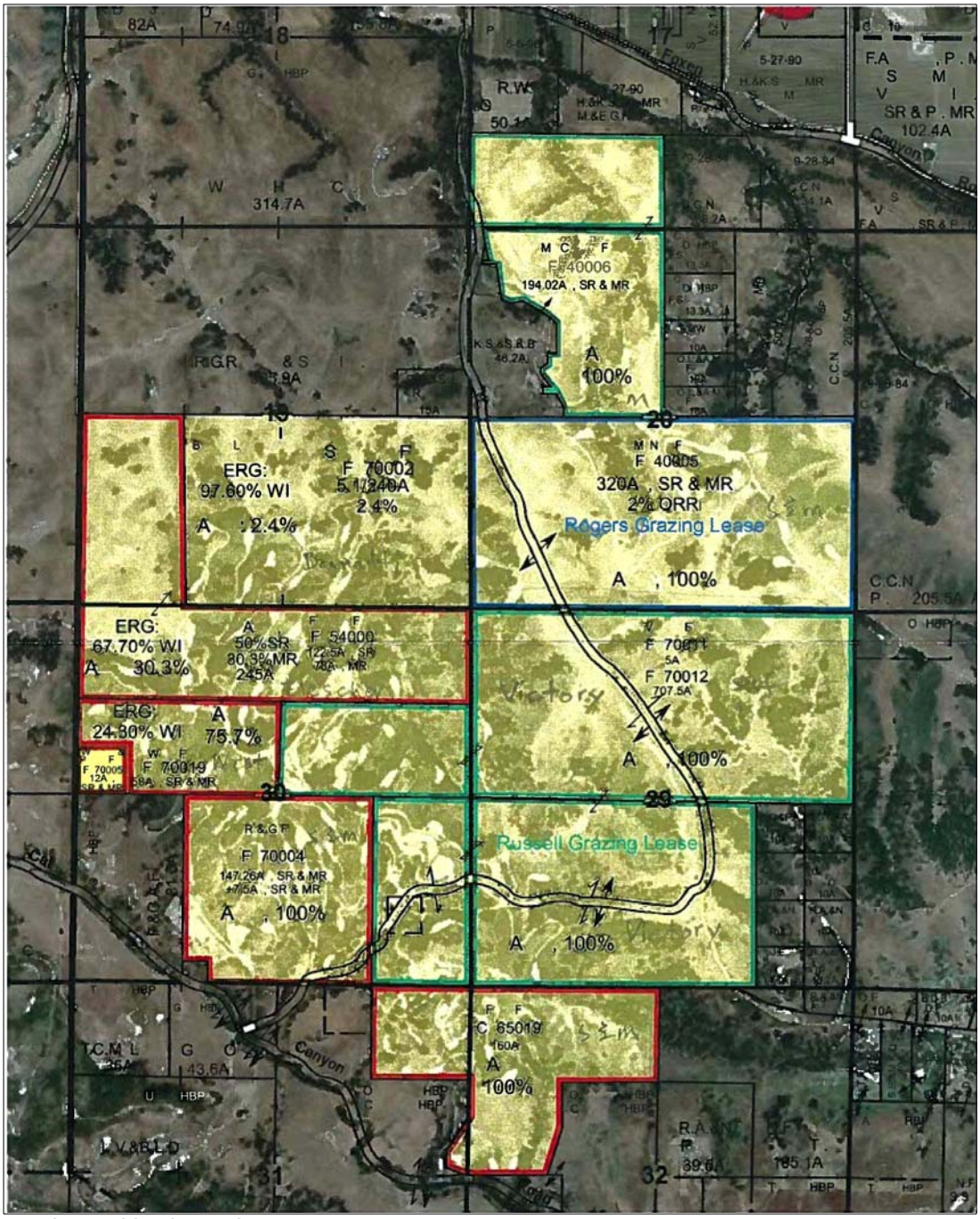
PLATES



BASE MAP SOURCE: TJ Cross Engineers.

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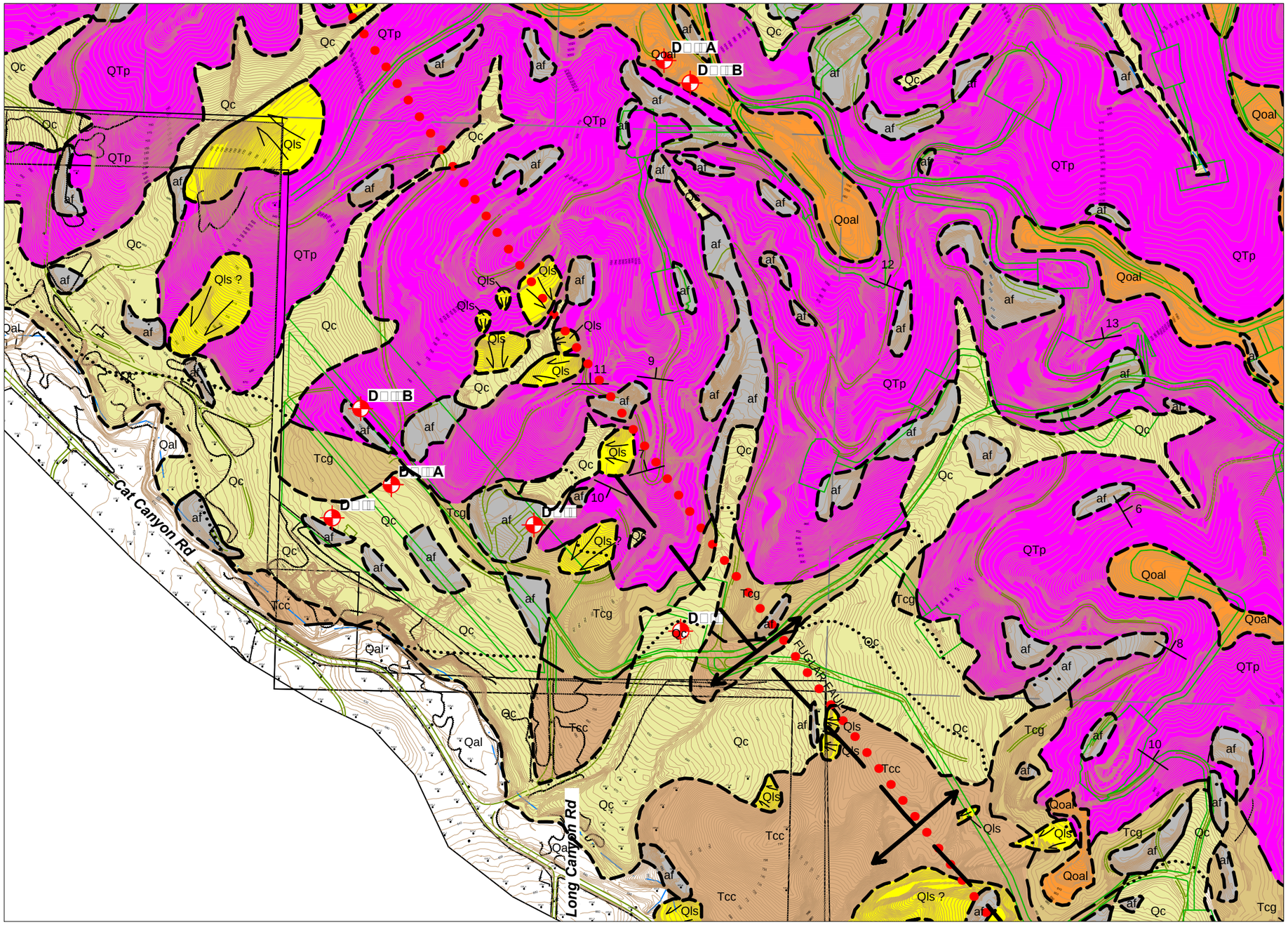
LOCATION MAP

East Cat Canyon Sisquoc Area

Santa Barbara County, California

PLATE 1



LEGEND

D	Approximate boring location
af	Artificial fill
Qal	Alluvium
Qc	Colluvium
Qls	Landslide deposits
Qoal	Older Alluvium
QTp	Paso Robles Formation
Tcg	Carreaga Formation (Graciosa Coarse-Grained Member)
Tcc	Carreaga Formation (Cebada Fine-Grained Member)
	Fault, dotted where concealed
	Anticline axis

NORTH

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DRILL □OLE LOCA□ION MAP
East Cat Canyon Sisquoc Area
Santa Barbara County, California

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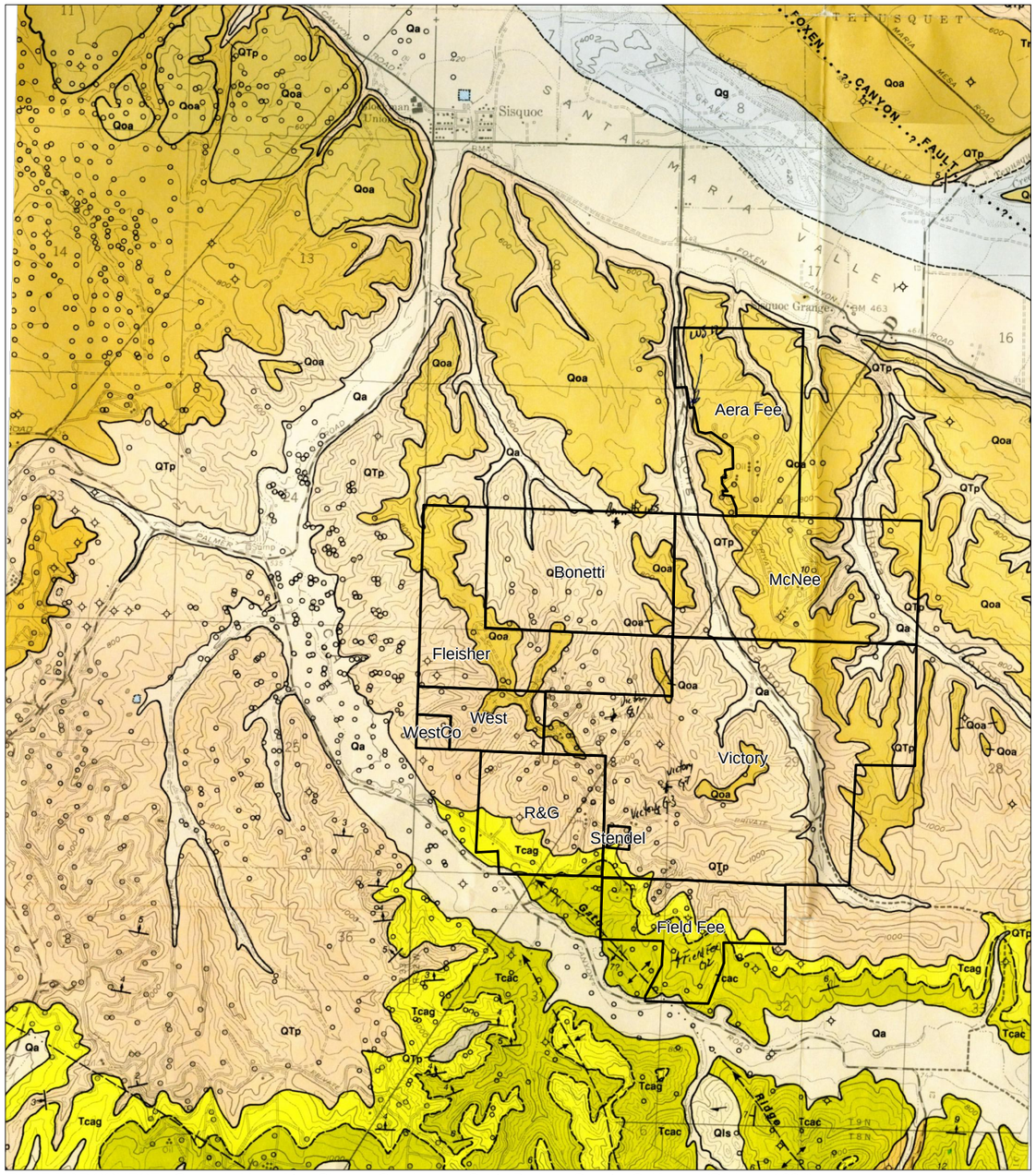

BASE MAP SOURCE: Geologic Map of the Sisquoc Quadrangle, Santa Barbara County, California, (Dibblee, 1994).

NORTH

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FEET

LEGEND

Qa	Alluvium
Qg	Stream channel deposits
Qls	Landslide debris
Qoa	Older Alluvium
QTp	Paso Robles Formation
Tcag	Careaga Sandstone (Graciosa Member) - massive gray-white to tan sandstone
Tcac	Careaga Sandstone (Cebada Member) - massive tan to yellow, soft, fine grained sandstone
Tsqd	Sisquoc Formation
Tm	Monterey Shale

Formation Contact - dashed where inferred or indefinite

Fault - dashed where indefinite or inferred, dotted where concealed, relative vertical movement shown by U/D (U = upthrown side, D = downthrown side), short arrow indicates dip of fault plane, sawteeth are on upper plate of low angle thrust fault

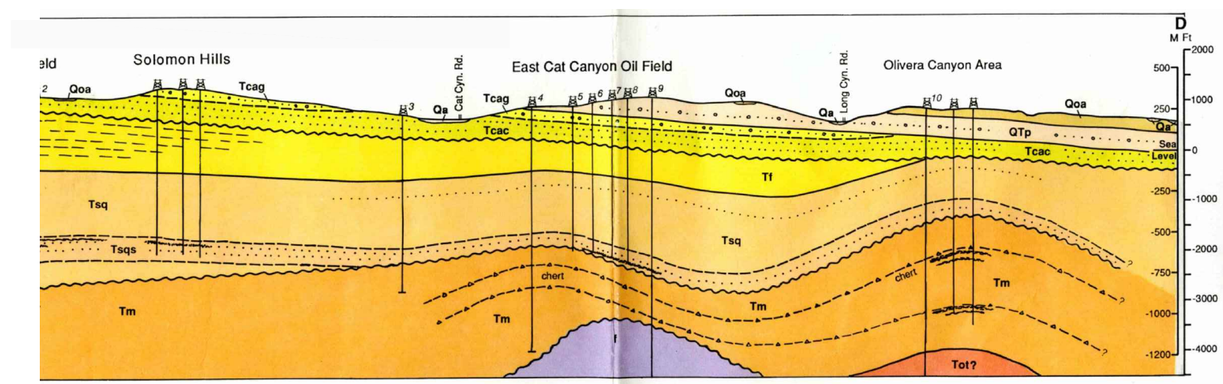
Anticline - dashed where inferred or indefinite

Syncline - dashed where inferred or indefinite

Strike and dip of beds:

20 Inclined

30 Vertical



SOURCE: Section from Geologic Map of the Sisquoc Quadrangle, Santa Barbara County, California, (Dibblee, 1994).

3000
0
0 3000
Horizontal and Vertical Scales in Feet

Deep Wells shown:

3. Stone & Goodwin
4. R & G Oil Co., #11
5. R & G Oil Co., #5
6. R & G Oil Co., #6
7. Palmer-Stendel Oil Co., #9
8. Palmer-Stendel Oil Co., #10
9. Palmer-Stendel Oil Co., #20

REGIONAL GEOLOGIC MAP
East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE 3

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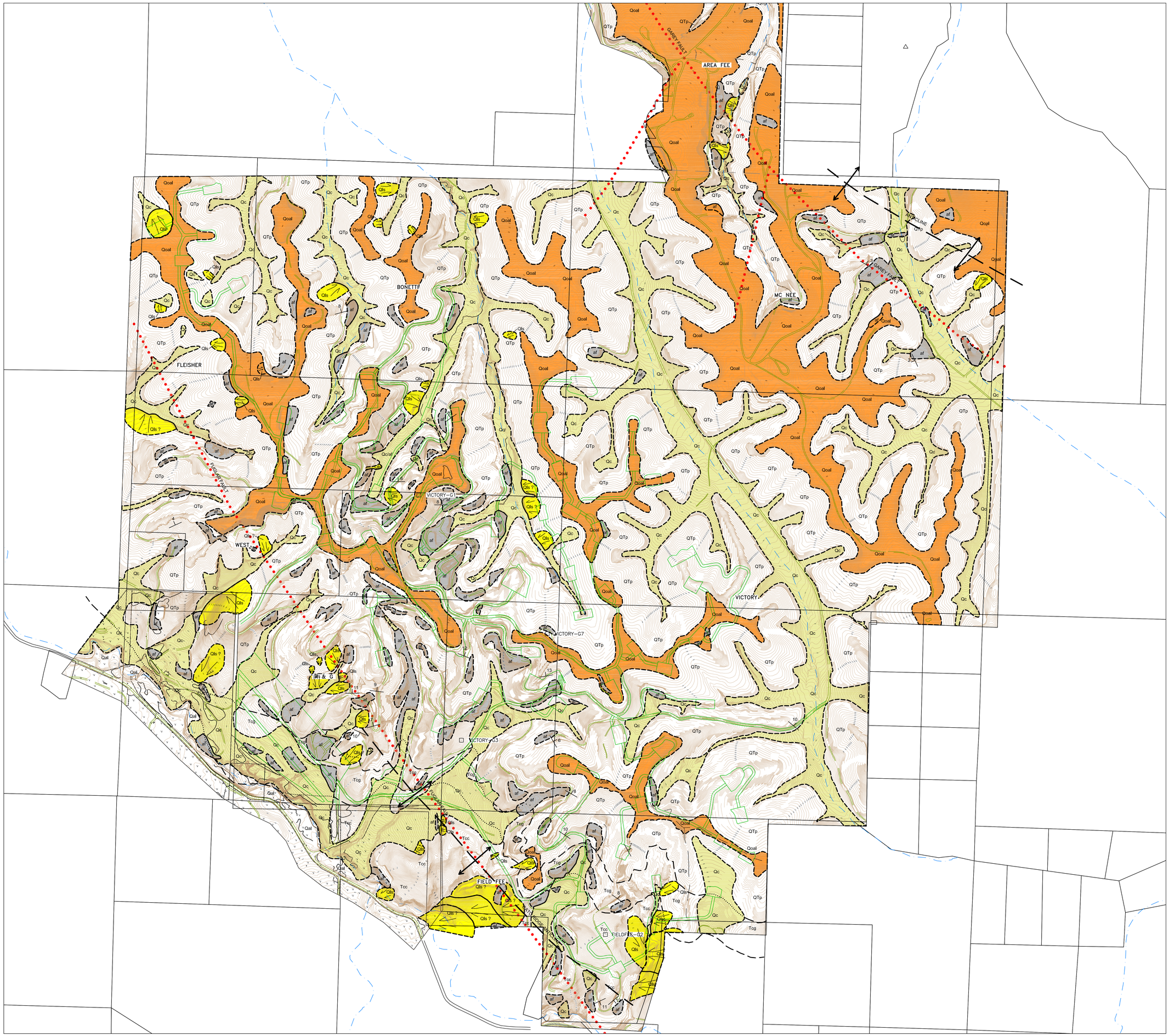

LEGEND

af	Artificial fill
Qc	Colluvium
Qls	Landslide deposits
Qoal	Older Alluvium
QTp	Paso Robles Formation
Tcg	Carreaga Formation (Graciosa Coarse-Grained Member)
Tcc	Carreaga Formation (Cebada Fine-Grained Member)
	Fault, dotted where concealed
9	Strike and dip of bedding
	Anticline axis

NORTH

0 400 800 1200 1600
Feet

FUGRO CONSULTANTS, INC
4820 McGrath St., Suite 100, Ventura, California 93003
Tel.: (805) 650-7000, FAX: (805) 650-7010

GEOLOGIC MAP

Geohazards & Geotech Study AERA

Cat Canyon Oil Field
Santa Barbara County, California

Stugeon Services, International

04.62130155 January 2014 Plate 4

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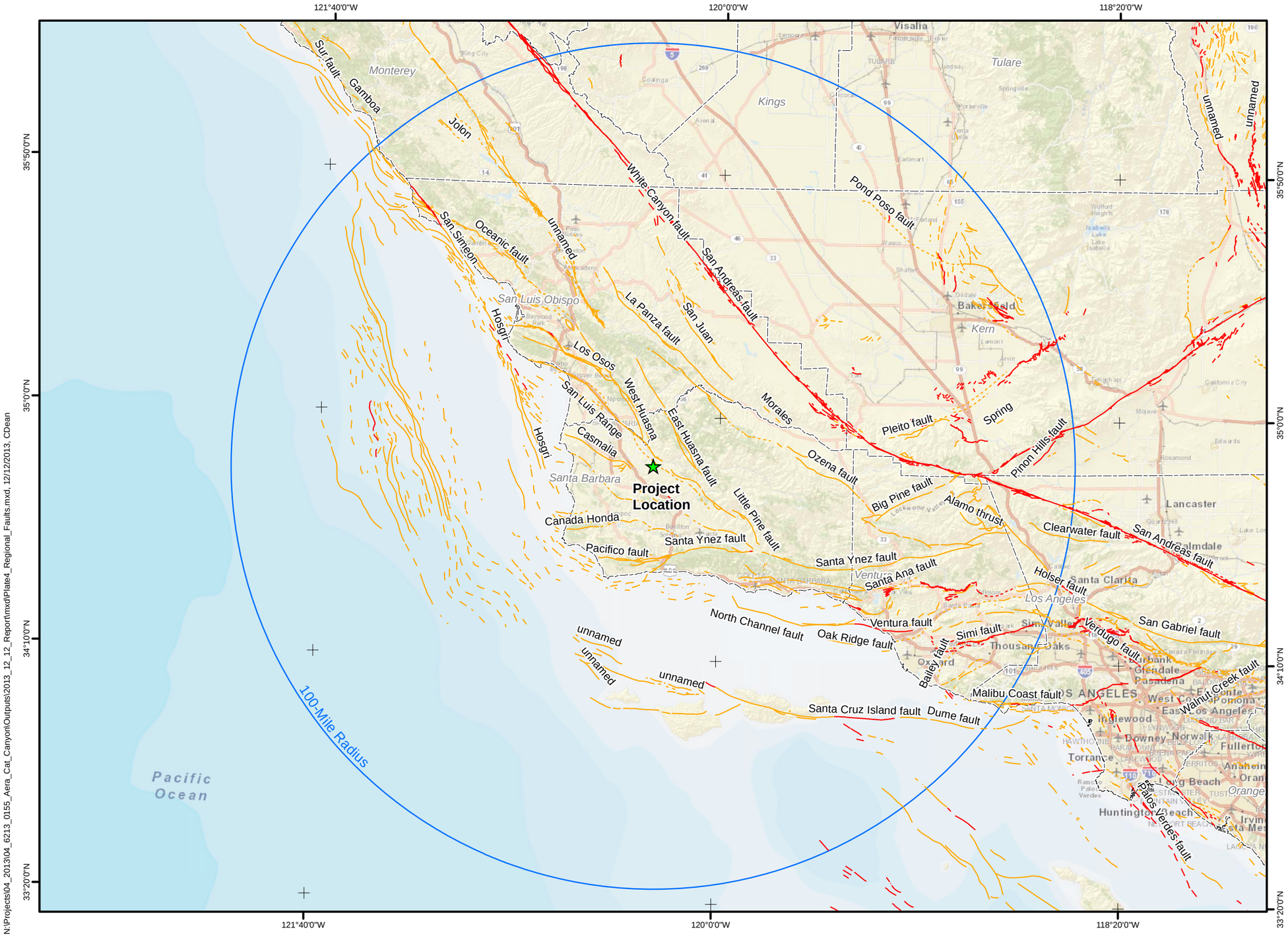

Legend

County Limits

Faults

Active Fault, dashed where inferred

Potentially Active Fault, dashed where inferred

Sources:

a) Bryant, 2005

b) Jennings, 1994

N

1:1,500,000

0 10 20 40 Miles

REGIONAL FAULT MAP
East Cat Canyon Oil Field, Sisquoc Area
Santa Barbara County, California

PLATE 5

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APPENDIX A
SUBSURFACE EXPLORATION

LOCATION: N 34.824 E 120.289 WGS84

SURFACE EL: 688 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	PHOTO IONIZATION DETECTOR, PID, ppm
			A			**COLLUVIUM (Qcol)** Silty SAND (SM): loose, brown, dry, fine							
686	2												
684	4		1		8								6.0
682	6												
680	8												
678	10		2		(33)	**CARREAGA FORMATION GRACIOSA MEMBER (Tcg)** SANDSTONE (Rx): very soft to soft, reddish brown, friable, slightly to moderately weathered, unfractured, [Silty SAND (SM): medium dense, reddish brown, moist]	121	114	6				15
676	12												
674	14		3		33	- dense below 15 feet							0.0
672	16												
670	18												
668	20		4		(88)	- with pockets of gray sandstone and fine gravel	128	115	11				
666	22												
664	24		5		35	- with dark reddish pockets and frequent white coarse sand to fine gravel							2.5
662	26					CLAYSTONE (Rx): soft, reddish brown, slightly to moderately weathered, unfractured, [Sandy lean CLAY (CL): stiff, reddish brown, moist, with white fine gravel and coarse sand, dark reddish pockets, gray to black fragments]							
660	28												
658	30		6		(33)		127	105	21		35	19	
656	32												

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

COMPLETION DEPTH: 31.0 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: November 26, 2013

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: 140 lb Automatic Trip
DRILLED BY: S/G Drilling Company
LOGGED BY: T Ferro
CHECKED BY: G S Denlinger

LOG OF DRILL HOLE NO. DH-1A

East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE A-1

LOCATION: N 34.824 E 120.289 WGS84

SURFACE EL: 706 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	PHOTO IONIZATION DETECTOR, PID, ppm
			A			**ARTIFICIAL FILL (af)** Silty SAND (SM): brown, dry, oiled							
704	2					**ARTIFICIAL FILL (af)/COLLUVIUM (Qcol)** Silty SAND (SM): loose, reddish brown, dry, fine to medium, with some fine chert gravel							
702	4												
			1		8								9.9
700	6												
698	8												
696	10				(47)	**PASO ROBLES FORMATION (Qtp)** SANDSTONE (Rx): very soft to soft, reddish brown, slightly to moderately weathered, unfractured, [Silty SAND (SM): dense, reddish brown, fine to medium, moist, with some fine chert gravel]							50
			2				126	116	9	30			
694	12												
692	14												
			3		90	- with light gray sand pockets							4.0
690	16												
688	18												
686	20				(50/5.5")	SANDSTONE (Rx): soft, reddish brown, slightly to moderately weathered, unfractured, [Clayey SAND (SC): very dense, reddish brown, moist, fine to medium]							2.5
			4				124	112	11				
684	22												
682	24												
			5		28	CLAYSTONE (Rx): soft, reddish brown, slightly to moderately weathered, unfractured, [Sandy lean CLAY (CL): stiff to very stiff, reddish brown, moist, with occasional fine gravel and light gray fine sand pockets]							2.5
680	26												
678	28												
676	30				(34)	- increased sand content							0.0
			6				130	110	18				
674	32												

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

COMPLETION DEPTH: 31.0 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: November 26, 2013

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: 140 lb Automatic Trip
DRILLED BY: S/G Drilling Company
LOGGED BY: T Ferro
CHECKED BY: G S Denlinger

LOG OF DRILL HOLE NO. DH-1B

East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE A-2

LOCATION: N 34.829 E 120.285 WGS84

SURFACE EL: 1078 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	PHOTO IONIZATION DETECTOR, PID, ppm
			A			**ARTIFICIAL FILL (af)** Silty SAND (SM): brown, dry							
1076	2												
						OLDER ALLUVIUM (Qoal) Poorly graded SAND with gravel (SP): dense to very dense, reddish brown, dry, fine to medium, fine gravel, weakly consolidated							
1074	4		1		50/4"								
1072	6												
1070	8												
1068	10		2		(68)		132						950
						- bluish gray, petroleum odor							
1066	12												
1064	14		3		54	- dark reddish brown, strong petroleum odor							230
1062	16												
1060	18												
1058	20		4		22	- gray, petroleum odor							230
1056	22												
			5		(66)	Poorly graded GRAVEL with clay and sand (GP-GC): medium dense to dense, dark reddish brown and gray	116	92	26				230
1054	24												
1052	26												
1050	28												
1048	30												
1046	32												

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

COMPLETION DEPTH: 24.0 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: November 26, 2013

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: 140 lb Automatic Trip
DRILLED BY: S/G Drilling Company
LOGGED BY: T Ferro
CHECKED BY: G S Denlinger

LOG OF DRILL HOLE NO. DH-2A

East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE A-3

LOCATION:

SURFACE EL: 1058 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	PHOTO IONIZATION DETECTOR, PID, ppm
					ARTIFICIAL FILL (af) Silty SAND (SM): brown, dry							36
1056	2											
					OLDER ALLUVIUM (Qoal) Silty, clayey SAND (SC-SM): dense, dark brown and yellowish brown, dry, some fine gravel, weakly consolidated							
1054	4	1	X	38								3.0
1052	6				- petroleum odor							
1050	8											
1048	10	2		(50/4")	Sandy SILT (ML): very dense/hard, light reddish brown to yellowish brown, dry to moist, some fine gravel	119	111	7				6.5
1046	12											
1044	14											
		3	X	53	**PASO ROBLES FORMATION (Qtp)** SANDSTONE (Rx): soft, light reddish brown, slightly to moderately weathered, unfractured, [Silty SAND (SM): dense to very dense, light reddish brown, moist, fine]							
1042	16											
1040	18											
1038	20			(78)	- reddish brown, fine to medium-grained							6.0
		4				127	112	13				
1036	22											
1034	24											
		5	X	32								0.0
1032	26				- increased clay content, with some fine black gravel at 26 feet				25			
1030	28											
1028	30	6		(15)	- reduced clay content	124	116	6				
1026	32											

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

COMPLETION DEPTH: 31.0 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: November 26, 2013

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: 140 lb Automatic Trip
DRILLED BY: S/G Drilling Company
LOGGED BY: T Ferro
CHECKED BY: G S Denlinger

LOG OF DRILL HOLE NO. DH-2B

East Cat Canyon Sisquoc Area
Santa Barbara County, California

BORING LOG VENTURA - PID N:\PROJECTS\04_2013\04_6213_0155_AERA_CAT_CANYON\EXPLORATIONS\GINT\2013\04_6213_0155_VAJ13B.GPJ 1/21/14 12:11 p

LOCATION: N 34.822 E 120.284 WGS84

SURFACE EL: 724 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	SAMPLE NO.	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	PHOTO IONIZATION DETECTOR, PID, ppm
		A		**ARTIFICIAL FILL (af)** Silty SAND (SM): brown, dry							
722	2										
720	4			Sandy, silty CLAY (CL-ML): medium stiff, dark gray to black, dry to moist, with greenish gray fine gravel and oil sand pockets							
		1	8								650
718	6										
716	8										
714	10										
		2	(20)	**COLLUVIUM (Qcol)** Silty SAND (SM): loose, brown, dry to moist, fine to medium, with few fine gravel							28
712	12										
710	14										
		3	9	- moist, petroleum odor							16
708	16										
706	18										
704	20	4	(23)	- fine-grained sand, with few greenish gray silt pockets	117	110	6				11
702	22										
700	24										
		5	9								11
698	26										
696	28										
694	30	6	(27)								
				- with lenses of greenish gray clay	123	110	12				
692	32										

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

COMPLETION DEPTH: 31.5 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: November 26, 2013

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: 140 lb Automatic Trip
DRILLED BY: S/G Drilling Company
LOGGED BY: T Ferro
CHECKED BY: G S Denlinger

LOG OF DRILL HOLE NO. DH-3

East Cat Canyon Sisquoc Area
Santa Barbara County, California

BORING LOG VENTURA - PID N:\PROJECTS\04_2013\04_6213_0155_AERA_CAT_CANYON\EXPLORATIONS\GINT\2013\04_6213_0155_VAJ13B.GPJ 1/21/14 12:11 p

LOCATION: N 34.828 E 120.289 WGS84

SURFACE EL: 666 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	PHOTO IONIZATION DETECTOR, PID, ppm
						CARREAGA FORMATION GRACIOSA MEMBER (Tcg) SANDSTONE (Rx): soft, brown to reddish brown, slightly to moderately weathered, unfractured, [Silty SAND (SM): medium dense, brown to reddish brown, moist, with some fine gravel]							
664	2												
662	4				(40)								
660	6		1				124	116	7	21			
658	8												
656	10		2		13								
654	12												
652	14												
					(76)	SANDSTONE (Rx): dense, reddish brown, moist, [Clayey SAND (SC): dense, reddish brown, moist, with fine gravel and light brown to gray sand pockets, some chert gravels]							
650	16		3				137	125	9				
648	18												
646	20												
644	22												
642	24												
640	26												
638	28												
636	30												
634	32												

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

COMPLETION DEPTH: 16.5 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: November 26, 2013

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: 140 lb Automatic Trip
DRILLED BY: S/G Drilling Company
LOGGED BY: T Ferro
CHECKED BY: G S Denlinger

LOG OF DRILL HOLE NO. DH-4

East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE A-6

APPENDIX B
LABORATORY TESTING

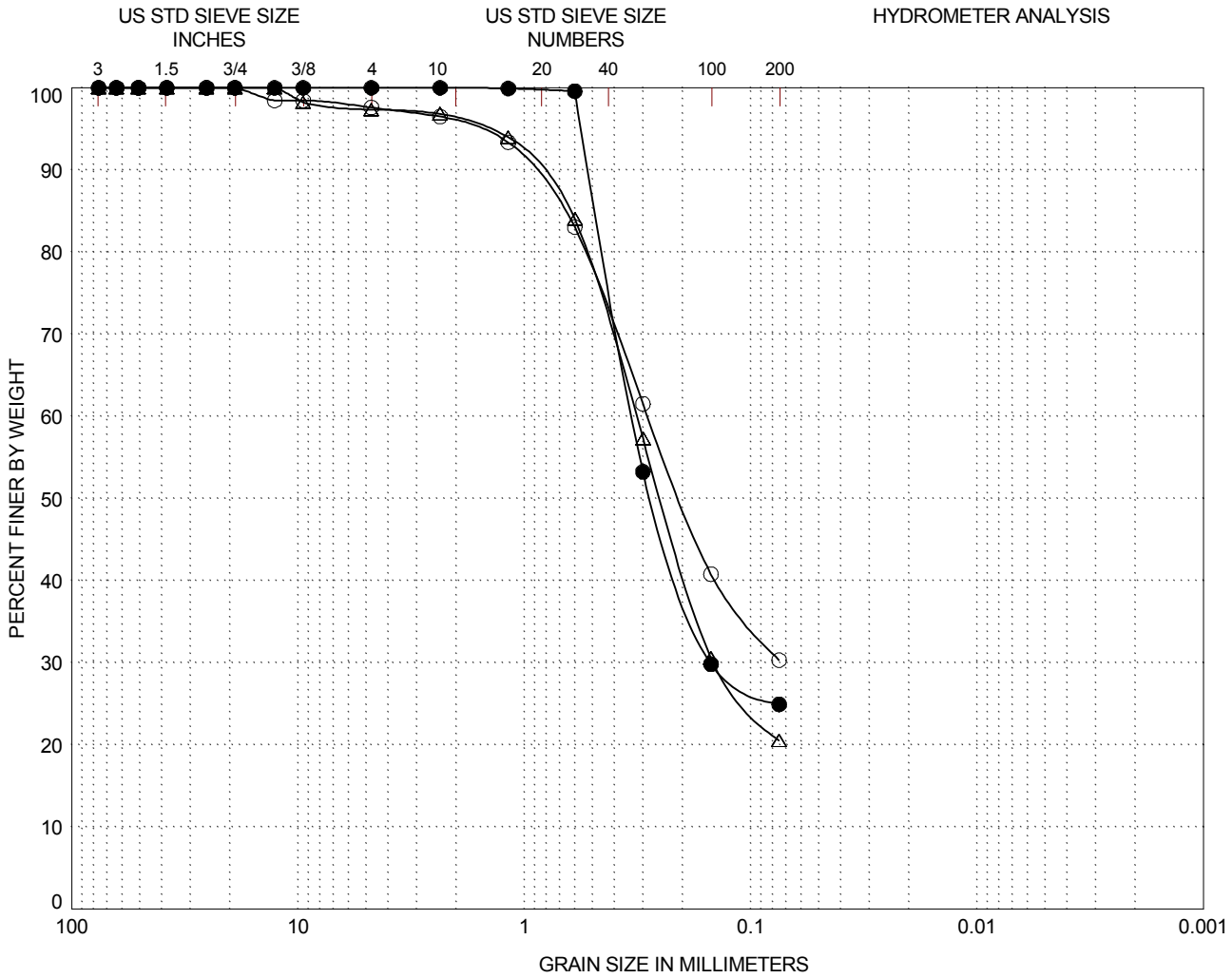
DRILL HOLE	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	ATTERBERG LIMITS		COMPACTION TEST		DIRECT SHEAR		COMPRESSIVE STRENGTH TESTS		CORROSIVITY TESTS				R-VALUE	EXPANSION INDEX	SAND EQUIVALENT (SE)	SPECIFIC GRAVITY
								LL	PI	MAX DD pcf	OPT MC %	C ksf	PHI deg	Qu, ksf	S_u (Cell Prs.) ksf	R	pH	Cl	So_4 (%)				
DH-1A	0.0	A	Silty SAND (SM)							127.9	8.1												
DH-1A	5.0	A	Silty SAND (SM)													4837	6.30	3	0.01				
DH-1A	10.0	2	Silty SAND (SM)	121	114	6						0.4	30										
DH-1A	20.5	4	SANDSTONE (Rx) [Silty SAND (SM)]	128	115	11																	
DH-1A	30.0	6	Sandy Lean CLAY (CL)	127	105	21		35	19														
DH-1B	10.5	2	SANDSTONE (Rx) [Silty SAND (SM)]	126	116	9	30																
DH-1B	20.5	4	SANDSTONE (Rx) [Silty SAND (SM)]	124	112	11																	
DH-1B	30.5	6	CLAYSTONE (Rx) [Sandy Lean CLAY (CL)]	130	110	18																	
DH-2A	10.5	2	Poorly graded SAND with gravel (SP)	132																			
DH-2A	23.5	5	Poorly graded GRAVEL with clay and sand (GP-GC)	116	92	26																	
DH-2B	10.5	2	Sandy SILT (ML)	119	111	7																	
DH-2B	20.5	4	SANDSTONE (Rx) [Silty Sand (SM)]	127	112	13																	
DH-2B	25.5	5	SANDSTONE (Rx) [Silty Sand (SM)]				25																
DH-2B	30.5	6	SANDSTONE (Rx) [Silty Sand (SM)]	124	116	6																	
DH-3	10.0	2	Silty SAND (SM)									0.2	33										
DH-3	20.0	4	Silty SAND (SM)	117	110	6																	
DH-3	31.0	6	Silty SAND with gravel (SM)	123	110	12																	
DH-4	5.0	1	SANDSTONE (Rx) [Silty SAND (SM)]	124	116	7	21																
DH-4	15.5	3	SANDSTONE (Rx) [Clayey SAND (SC)]	137	125	9																	

SUMMARY OF LABORATORY TEST RESULTS

East Cat Canyon Sisquoc Area
Santa Barbara County, California

LAB SUMMARY TABLE VENTURA N:\PROJECTS\04_2013\04_6213_0155_AERA_CAT_CANYON\EXPLORATIONS\GINT\2013\04_6213_0155_VAJ138.GPJ 12/19/13 03:56 PM-cab

Sturgeon Services International
Project No. 04.62130155

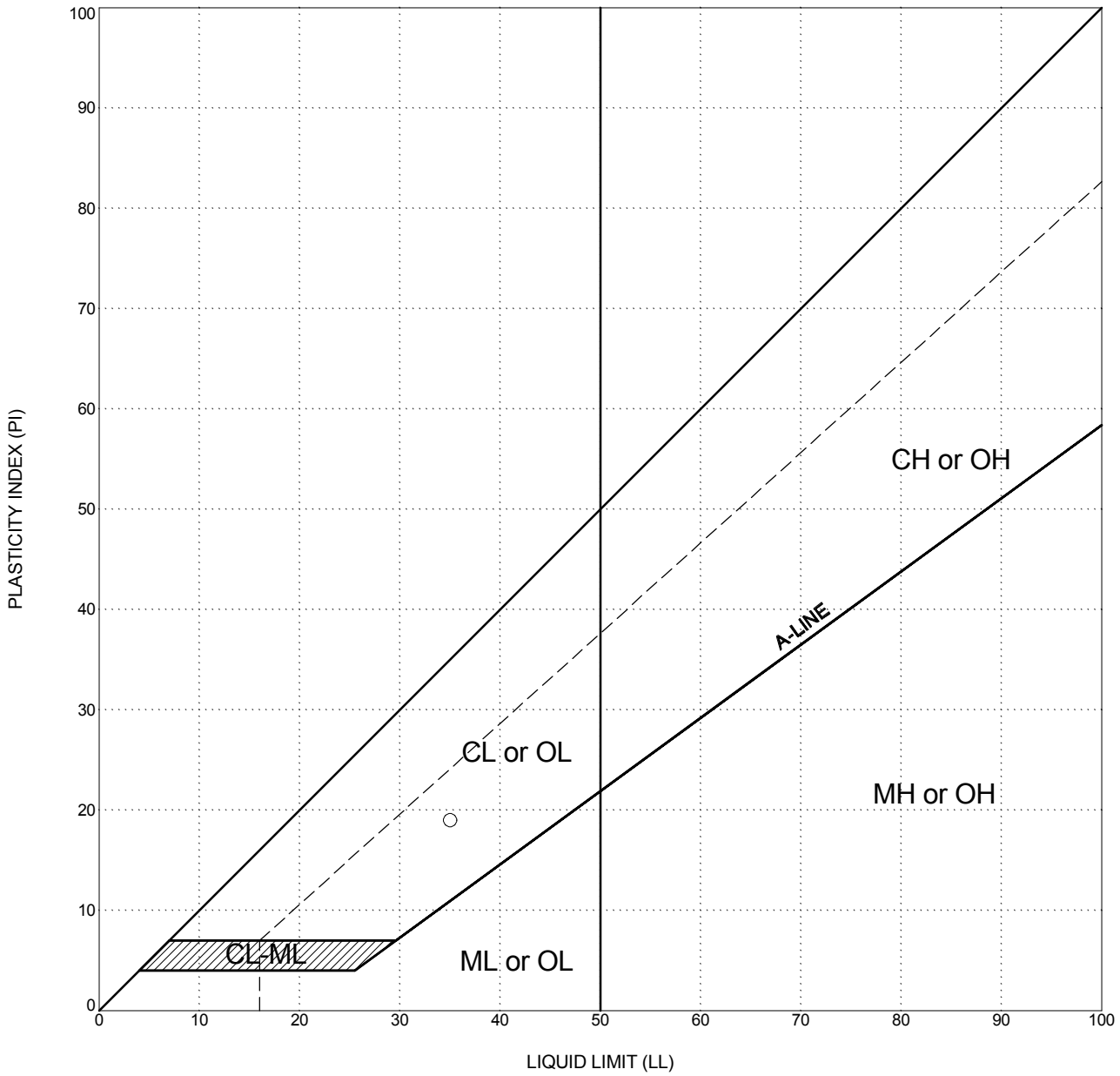


GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

LEGEND	(location)	(depth,ft)	CLASSIFICATION	Cc	Cu
○	DH-1B	10.5	SANDSTONE (Rx) [Silty SAND (SM)]		
●	DH-2B	25.5	SANDSTONE (Rx) [Silty Sand (SM)]		
△	DH-4	5.0	SANDSTONE (Rx) [Silty SAND (SM)]		

GRAIN SIZE CURVES
East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE B-2

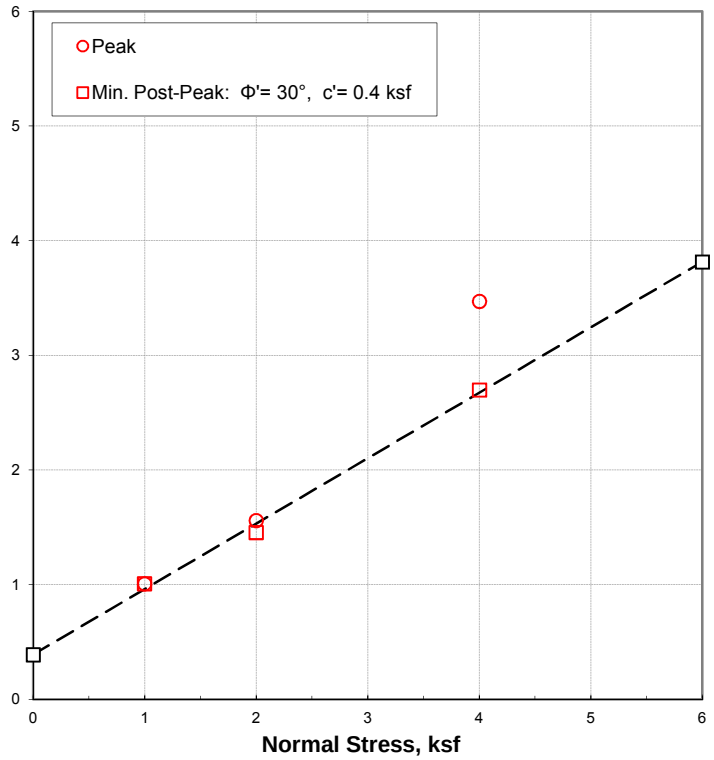


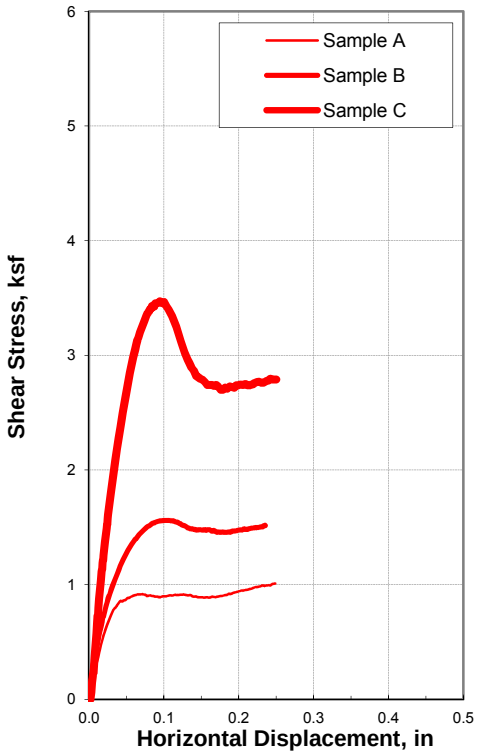
LEGEND	location	depth, ft	CLASSIFICATION	ATTERBERG LIMITS TEST RESULTS LIQUID LIMIT(LL)	PLASTIC LIMIT(PL)	PLASTICITY INDEX (PI)
○	DH-1A	30.0	Sandy Lean CLAY (CL)	35	16	19

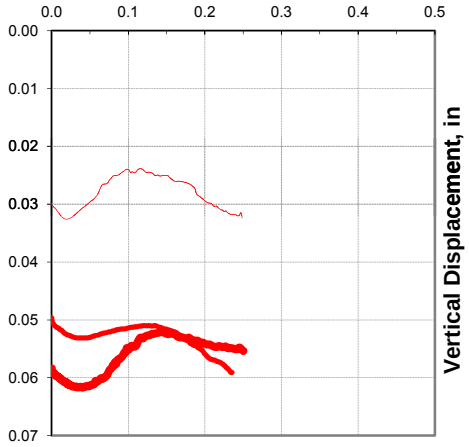
PLASTICITY CHART
East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE B-3

Sturgeon Services International
Project No. 04.62130155





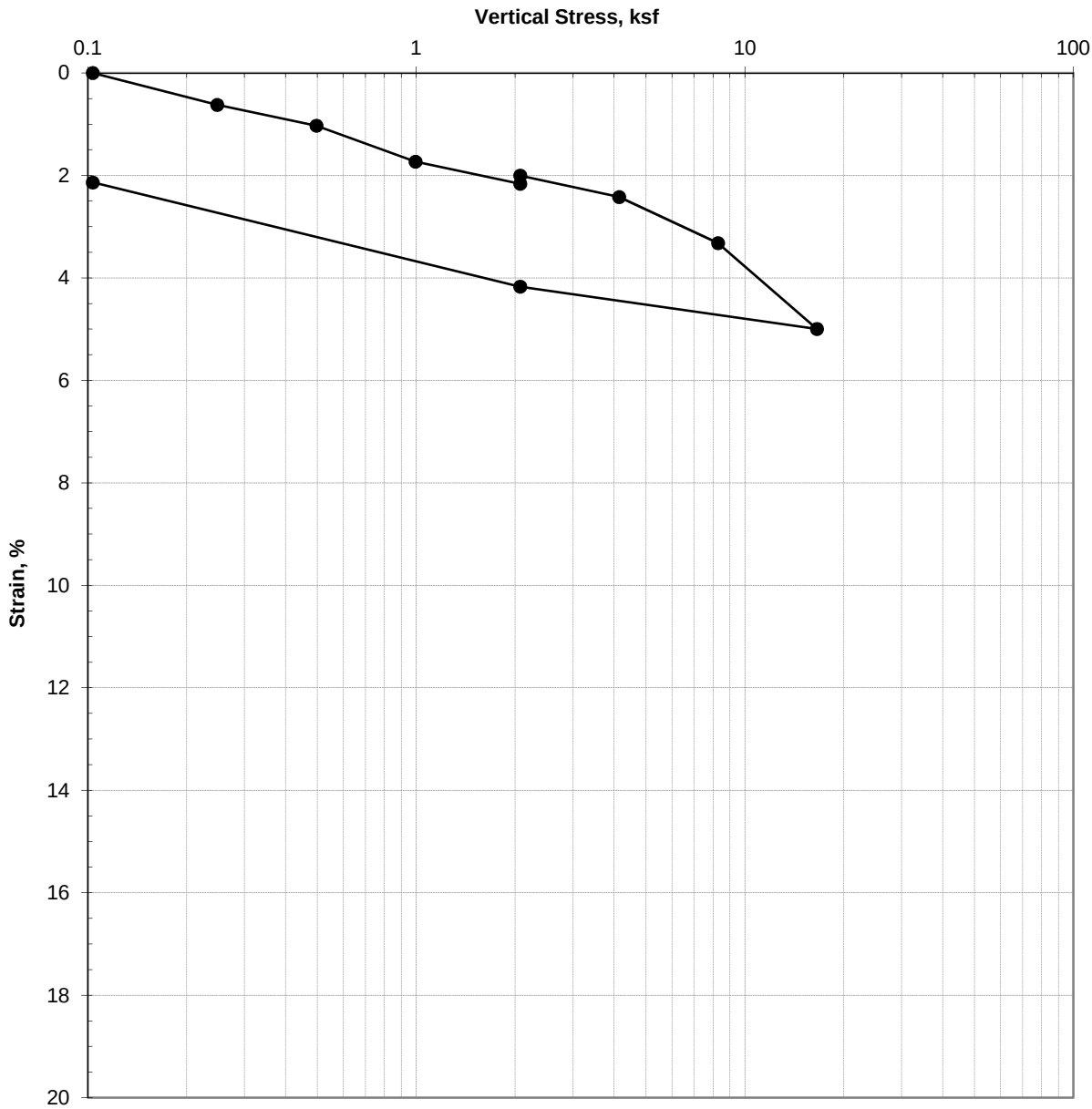


SAMPLE ID	Boring Number:	DH-1A			
	Sample Number:	2			
	Sample Depth:	10.0 ft			
	USCS Classification:	Silty SAND (SM): brown, moist, slightly cemented			
INITIAL	Specimen	A	B	C	D
	Water Content, %	6.1%	6.1%	6.1%	
	Dry Unit Weight, pcf	112.5	113.1	115.4	
	Saturation, %	34%	35%	37%	
	Void Ratio	0.47	0.46	0.43	
	Diameter, in	2.42	2.42	2.42	
	Height, in	1.00	1.00	1.00	
FINAL	Water Content, %	13.7%	13.7%	12.5%	
	Dry Unit Weight, pcf	119.5	119.4	123.7	
	Void Ratio	0.38	0.38	0.34	
TEST SUMMARY	Displacement at Peak, in	0.25	0.10	0.09	
	Displacement Rate, in/min	0.002	0.002	0.002	
	Normal Stress, ksf	1.0	2.0	4.0	
	Peak Shear Stress, ksf	1.01	1.56	3.47	
	Min. Post-Peak Stress, ksf	1.01	1.46	2.70	
	Strain at Nomal Stress, %	--	3.9%	4.2%	
	Strain at Normal Stress w/ H2O, %	--	5.0%	5.4%	
REMARKS	Test Method: ASTM D3080				

CLASSIFICATION	Sieve Size	% Passing
	3/8-in. (9.5mm)	---
	#4 (4.75mm)	100
	#16 (1.18mm)	96
	#30 (0.6mm)	85
	#100 (0.150mm)	31
	#200 (0.075mm)	22
	Atterberg Limits	
	Liquid Limit, %	---
	Plastic Limit, %	---
	Plasticity Index, %	---
	Estimated Gs	2.65
	k_{avg} 20ºC, cm/sec	---

DIRECT SHEAR TEST RESULTS
East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE B-4a



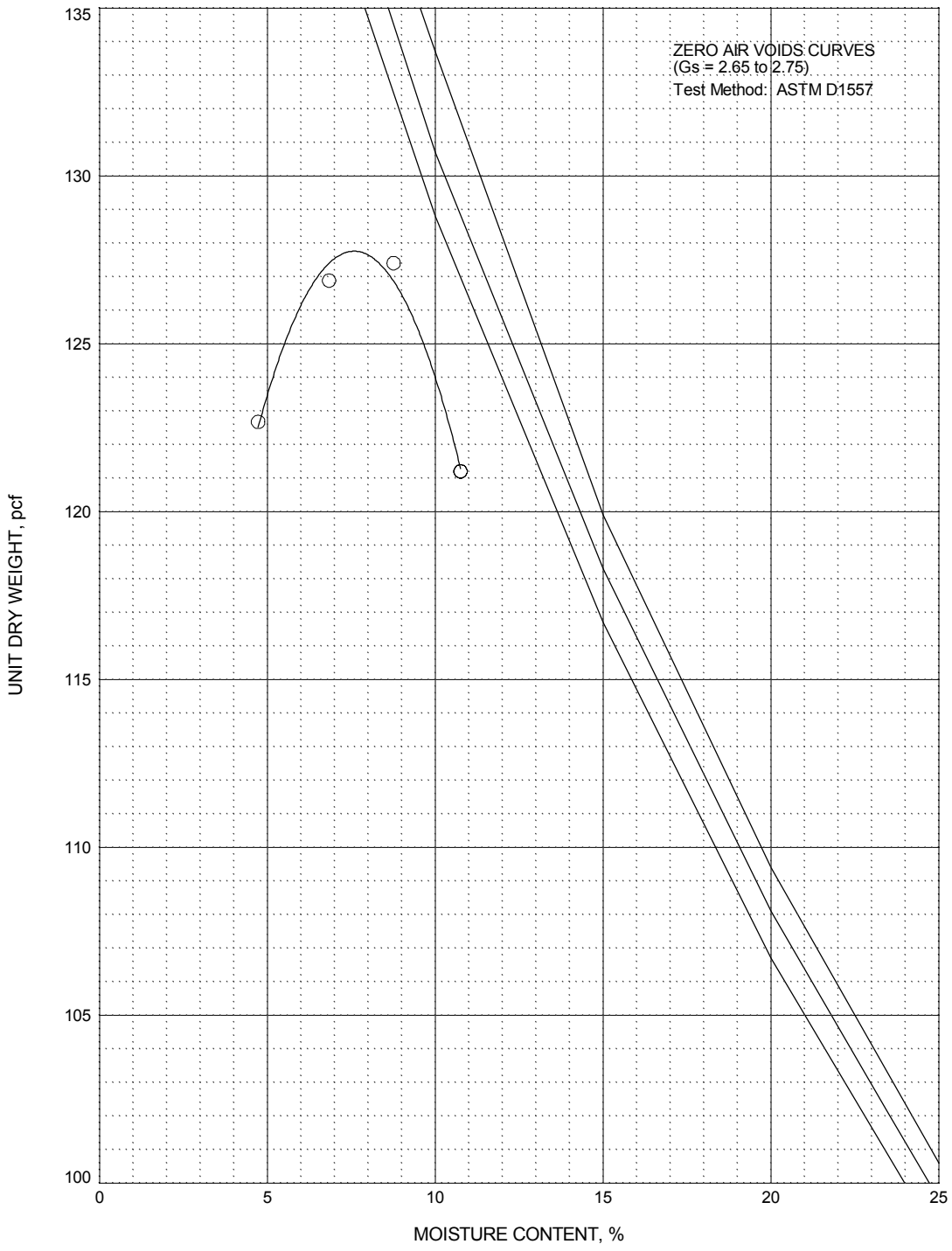
SAMPLE ID			
Boring, Sample #, Depth	DH-1A , #6 , 30.0 ft		
USCS Classification:	Sandy lean CLAY (CL): brown, moist		

PROPERTIES	Initial	Final
Water Content, %	20.7%	20.8%
Dry Unit Weight, pcf	104.5	106.8
Saturation, %	94%	100%
Void Ratio	0.59	0.56
Diameter, in	2.42	2.42
Height, in	0.81	0.79

SUMMARY	
Preconsolidation Pressure, ksf	---
Inundation Increment, ksf	2.07
Liquid Limit	35
Plastic Limit	16
Plasticity Index	19
Passing #200	---
Estimated Gs	2.66

REMARKS
Test Method: D2435

CONSOLIDATION TEST RESULTS
East Cat Canyon Sisquoc Area
Santa Barbara County, California



LEGEND (location)	depth, ft	CLASSIFICATION	MAXIMUM UNIT DRY WEIGHT, pcf	OPTIMUM WATER CONTENT, %
○ DH-1A	0.0	Silty SAND (SM)	127.9	8.1

COMPACTION TEST RESULTS
East Cat Canyon Sisquoc Area
Santa Barbara County, California

PLATE B-6

APPENDIX C
RESULTS OF ANALYTICAL TESTING

Prepared for: Fugro Consultants
4820 McGrath Street, Suite 100
Ventura, CA 93003
Attn: Terri Ferro

Report Date: December 19, 2013
Laboratory Number: 133583
Project Name: N/A
Sampled by: Client

On December 13, 2013, Capco Analytical Services, Inc.(CAS), received three(3) samples to be analyzed. The samples were identified and assigned the laboratory ID numbers listed below:

SAMPLE DESCRIPTION	CAS LAB NUMBER ID
PH2A 20.5 FEET	133583-01
DP2A 21.5 FEET	133583-02
DH03 15 FEET	133583-03

By my signature below, I certify that the results contained in this laboratory report comply with applicable standards for certification by the California Department of Public Health's Environmental Laboratories Accreditation Program (ELAP), both technically and for completeness, and that, based on my inquiry of the person or persons directly responsible for performing the analyses, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

Keith Chin-Yuan Chang, Ph.D.
Director - Analytical Operations

If you have any further questions or concerns, please contact me at your convenience.

This report consists of 3 pages excluding the cover letter and the Chain of Custody.

This report shall not be reproduced except in full without the written approval of CAS. The test results reported represent only the item being tested and may not represent the entire material from which the sample was taken.

Client: FUGRO
Matrix: SOIL
Analyst: RBA / BB

Date Sampled: <not specified>
Date Received: 12/13/13
Date Extracted: 12/16/13

TOTAL PETROLEUM HYDROCARBONS
EPA METHOD 8015M

Compound	Results mg/kg	Dilution Factor	PQL mg/kg	Surrogate %Recovery	Date Analyzed
CAS Lab # :	MB-121613-s				
Client ID :	METHOD BLANK				
TPH- C4-C12	BQL	1	5.0	101%	12/17/13
TPH- C12-C22	BQL	1	10	86%	12/16/13
TPH- C23+	BQL	1	10		
CAS Lab # :	133583 -01				
Client ID :	DH2A 20.5 feet				
TPH- C4-C12	BQL	1	5.0	93%	12/17/13
TPH- C12-C22	BQL	2	15	88%	12/16/13
TPH- C23+	BQL	1.5	15		
CAS Lab # :	133583 -02				
Client ID :	DH2A 21.5 feet				
TPH- C4-C12	23	1	5.0	97%	12/17/13
TPH- C12-C22	2300	2	15	88%	12/16/13
TPH- C23+	210	1.5	15		
CAS Lab # :	133583 -03				
Client ID :	DH03 15 feet				
TPH- C4-C12	BQL	1	5.0	93%	12/17/13
TPH- C12-C22	BQL	1	10	85%	12/16/13
TPH- C23+	BQL	1	10		

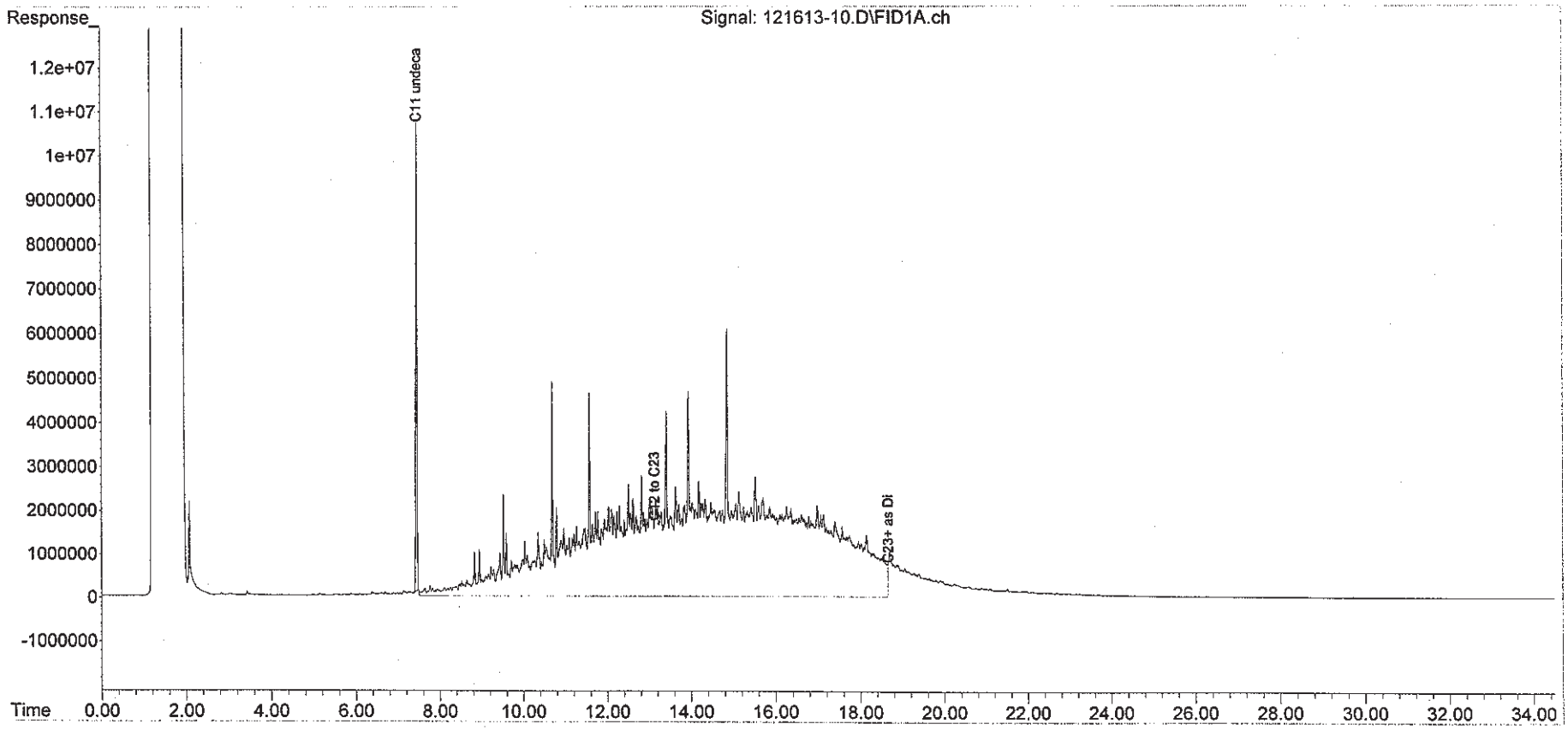
TPH C4-C12 Surrogate Control Limits for BFB: 75-125%
TPH C12+ Surrogate Control Limits for n-Undecane: 41-139%

Quantitation Report (QT Reviewed)

Data Path : C:\msdchem\3\data\2013\12-DEC\121613D\
Data File : 121613-10.D
Signal(s) : FID1A.ch
Acq On : 16 Dec 2013 18:38
Operator : RBA
Sample : Fugro 133583-02
Misc : DH2A 21.5 feet 20gm > 10ml < soil >
ALS Vial : 4 Sample Multiplier: 1

Integration File: baselinenowevents.e
Quant Time: Dec 17 08:29:05 2013
Quant Method : C:\msdchem\3\methods\DIESEL_CCV(10-01-13).m
Quant Title : C12-C22 Diesel
QLast Update : Tue Oct 01 17:04:05 2013
Response via : Initial Calibration
Integrator: ChemStation

Volume Inj. :
Signal Phase :
Signal Info :



QUALITY CONTROL REPORT

TOTAL PETROLEUM HYDROCARBONS BY EPA METHOD 8015M (GC-FID) FOR SOIL

DATE EXTRACTED 12/16/13

DATE ANALYZED 12/16/13

Surrogate (undecane): SV45-O
8015M Spike (petro. diesel): SV46-J

LAB CONTROL SPIKE Analysis

		LCS		LCSD		Average			
	Spike Level (mg/Kg)	(mg/Kg)	% Recovery	(mg/Kg)	% Recovery	% Recovery	% Recovery Limits	RPD	RPD Limit
Surrogate	33	27	82	25	75	79	41 - 139	9.7	20
8015M Spike	333	281	84	266	80	82	47 - 133	5.8	19

RPD: Relative percent difference

RBA
Principal Analyst

QUALITY CONTROL REPORT

TOTAL PETROLEUM HYDROCARBONS BY EPA METHOD 8015M (GC-FID) FOR SOIL

Surrogate (BFB): V0117E

8015M Spike (petro. GASOLINE): V0119I

DATE ANALYZED 12/17/13

LAB CONTROL SPIKE Analysis

		LCS		LCSD		Average			
	Spike Level (ug)	(ug)	% Recovery	(ug)	% Recovery	% Recovery	% Recovery Limits	RPD	RPD Limit
Surrogate	0.125	0.124	99	0.127	101	100	75 - 125	2.0	10
8015M Spike	20	25	124	25	124	124	75 - 125	0.0	10

BB

Principal Analyst

CAPCO ANALYTICAL SERVICES

1536 Eastman Avenue, Suite B
Ventura, CA 93003
(805) 644-1095 Fax 644-9947
www.capcoenv.com

CHAIN OF CUSTODY RECORD

REPORT
Company: Fugro.
Fax:
Address:
Email: tferro@fugro.com
Phone: 805 340 3573 Contact: Terri Ferro

BILL TO:
Company:
Address:
Phone: Contact:

P.O.#

PROJ. NO:
PROJECT NAME:

SAMPLERS: (Signature)

CONTAINER TYPES
A = AMBER B = BRASS G = GLASS
P = PLASTIC V = VOA VIAL O = OTHER

12/20

133583

SAMPLE NO.	DATE SAMPLED	TIME SAMPLED	COMP	GRAB	SAMPLE IDENTIFICATION	MATRIX: WATER	SOIL	SLUDGE	OTHER	CONTAINER #	TYPE	ANALYSIS: TPH Carbon Chain	TPH EPA 418.4							REMARKS
1					DH2A 20.5 feet		X					X	X							
2					DH2A 21.5 feet		X					X	X							
3					DH03 15 feet		X					X	X							

The undersigned hereby acknowledges having received a copy of the Fee Schedule/General Information and Conditions, the provisions of which are a part of this agreement.

Relinquished by: (Signature)	Date/Time	Received by: (Signature)
	12/13/13 14:10	
Relinquished by: (Signature)	Date/Time	Received by: (Signature)

TURN AROUND TIME
- STANDARD ☑ OTHER
- 24 HOURS ☐
- 48 HOURS ☐
- 72 HOURS ☐

CHECK ONE BOX:
- DISPOSE SAMPLES ☒
- RETURN SAMPLES ☐

WHITE COPY ____ CANARY COPY ____ PINK COPY ____

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

GEOHAZARDS STUDY
EAST CAT CANYON
NATURAL GAS IMPORT PIPELINE
ORCUTT AREA, SANTA BARBARA COUNTY, CALIFORNIA

Prepared for:
AERA ENERGY LLC

May 2017

1861 Knoll Drive ▪ Ventura, California 93003 ▪ 805-644-2220 ▪ www.padreinc.com

padre
associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

May 8, 2017
Project No. 1002-0455

Aera Energy LLC
330 Saturn Street, Suite 101
Brea, California 92821

Attention: Ms. Susan Perrell

Subject: Geohazards Study, East Cat Canyon Natural Gas Import Pipeline, Orcutt Area, Santa Barbara County, California

Dear Ms. Perrell:

Padre Associates, Inc. (Padre), is pleased to present the attached geohazards study report to Aera Energy LLC (Aera) describing the results of our geohazard evaluation services for the proposed East Cat Canyon natural gas import pipeline in the Orcutt area of Santa Barbara County, California. Services provided for this study were in general compliance with the scope of services presented in Padre's proposal dated March 24, 2017.

This final report incorporates the findings of Padre's research of readily available documentation and site reconnaissance, and presents our interpretations and opinions as to the extent and significance of the various geohazards in the area of the Project. We appreciate the opportunity to provide services to Aera on this Project and look forward to assisting you in the future.

If you have any questions regarding this study please contact us.

Sincerely,

PADRE ASSOCIATES, INC.

Eva von Thury
Project Geologist

PROFESSIONAL GEOLOGIST
JEROME K. SUMMERLIN
EG NO. 1950
CERTIFIED
ENGINEERING
GEOLOGIST
STATE OF CALIFORNIA

Jerome K. Summerlin, C.E.G., C.Hg.
Principal

Jeffrey T. Damron, G.E.
Principal

REGISTERED PROFESSIONAL ENGINEER
JEFFREY T. DAMRON
No. 2546
Exp. June 30, 2017
5/23/17
GEOTECHNICAL
STATE OF CALIFORNIA

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INTRODUCTION

PROJECT LOCATION AND UNDERSTANDING

The East Cat Canyon Natural Gas Import Pipeline Project (Project) consists of the design and construction of an approximately 14-mile long, 8-inch diameter natural gas pipeline and associated facilities. The proposed pipeline will be capable of providing 13 million standard cubic feet per day of natural gas to the Aera Energy Central Processing Facility, located at 6516 Cat Canyon Road in Orcutt, Santa Barbara County, California. The pipeline will begin at the Southern California Gas Company's (SoCalGas) Divide Station, located at 7002 Graciosa Road southwest of the community of Orcutt. The pipeline will traverse northward along Graciosa Road for approximately 2.65 miles, then along Orcutt Road for approximately 0.57 miles, and then turn east at Clark Avenue. The pipeline will then continue for 5.02 miles along Clark Avenue, crossing under U.S. Highway 101 to Dominion Road. At Dominion Road, the pipeline will extend along Dominion Road for 3.5 miles, then east along Palmer Road for 0.5 miles, then southward on Cat Canyon Road for 1.9 miles. The pipeline will then extend under Cat Canyon Creek and terminate within the proposed Central Processing Facility area on the Aera East Cat Canyon property located at 6516 Cat Canyon Road. The Project site is shown on Plate 1 - Site Location Map, and the pipeline route is presented on Plate 2 - Proposed Pipeline Route. For the purposes of this report in order to readily identify specific locations along the alignment, Padre has developed stationing starting with 0+00 at the SoCalGas Divide Station and ending with Station 741+23 at the Central Processing Facility.

Preliminary estimates of the pipeline invert depths are 42 inches along roadways that are constructed using traditional open trenching methods. The pipeline invert depths will vary at the proposed U.S. Highway 101 and Cat Canyon Creek crossings which will be constructed using horizontal directional drilling (HDD) methods. It is Padre Associates, Inc.'s (Padre's) understanding that the anticipated construction method will include some pipe jacking/micro-tunneling at major intersections.

METHODOLOGY

This Geohazards Report was prepared in general accordance with California Geological Survey Note 48 and Special Publication 117. The following sources of geologic and soils information were reviewed during preparation of this report:

- Fault evaluation reports prepared for the region by the California Geological Survey (CGS);
- Geologic maps prepared for the region by the Dibblee Geological Foundation, CGS, and the U.S. Geological Survey;
- Geotechnical and geohazards reports prepared by Fugro Consultants for the East Cat Canyon property or by California Department of Transportation (Caltrans) for highway roads and bridges along the proposed pipeline route;

- Historical aerial photography;
- Groundwater data; and
- Historical seismicity for the region of the Project Site.

Padre's findings and conclusions are discussed below.

SITE CONDITIONS

Topography

The pipeline alignment is located in the rolling hillside of Orcutt at the far west (Station 0+00 to 100+00) and east (Station 425+00 to 741+23) ends of the pipeline, while the middle section of the pipeline running along Clark Avenue (Station 100+00 to 425+00) stretches across relatively flat terrain. The pipeline traverses the width of the community of Orcutt from west to east. According to the United States Geological Survey (USGS) Orcutt and Sisquoc, California Quadrangle topographic maps, the Project site has elevations that range from a low of 414 feet above mean sea level (ft amsl) at its lowest point to 800 ft amsl at the highest elevation along the pipeline route corridor. Therefore, the Project site experiences approximately 390 ft change in elevation along the length of the proposed pipeline.

Site Usage

The proposed 14-mile pipeline alignment generally follows existing paved roads with few exceptions. During Padre's site reconnaissance performed on April 18, 2017, the proposed pipeline route was driven. The proposed route winds through ranch and agricultural land covered with trees, grasses, vineyards, and cattle; active oil fields and related facilities; and residential neighborhoods.

Based on a review of available historical aerial photographs from the University of California Map and Imagery Library (UCSB MIL) and the United States Department of Agriculture (USDA) Data Gateway National Agricultural Imagery Program (NAIP) imagery, Padre assessed that the proposed alignment was historically used for agriculture and cattle ranching. In 1908, oil was discovered in Cat Canyon and the oil field continues to produce oil to date. Aera, Greka Energy, B.E. Conway, ERG, and Vintage Petroleum own a majority of the oil leases located along the Eastern and Western ends of the proposed pipeline route. The community of Orcutt was established in 1904, laying the foundation for the existing residential and business community. The proposed pipeline runs along Clark Avenue, through former ranch and agricultural land that has been converted to the residential and commercial properties observed today.

Historical aerial photographs for the Project site were obtained through NAIP and UCSB MIL database searches. Historical aerial photographs included in that search are as follows.

Table 1. Historical Aerial Photographs Reviewed

Date	Scale	Flight No. / Frame No.	Database Searched
1938	1”=24,000’	c-4950 / A137, A138	UCSB MIL
9-20-1943	1”=20,000’	BTM-1943 / 2B-186, 2B-187	UCSB MIL
6-6-1954	1”=20,000’	BTM-1954 / 2K-64	UCSB MIL
5-14-1967	1”=20,000’	BTM-1967 / 2HH-189, 2HH-212	UCSB MIL
9-20-1978	1”=40,000’	USDA-40-06083 / 178-153, 178-174	UCSB MIL
6-12-1989	1”= 40,000’	NAPP / 1883-66	UCSB MIL
9-3-1994	1”=40,000’	NAPP-2C / 6921-104	UCSB MIL
2010	N/A	conas008 / 3512063NE, 3512064NW,	USDA NAIP
5-5-2012	1”=12,000’	C441 / N23NW, N911PJ	USDA NAIP
11-13-2014	1”=12,000’	hr4 / 3311901_NE_10	USDA NAIP
2016	1”=24,000’	C441, F406 / N27NW, N14NW	USDA NAIP

GEOLOGIC CONDITIONS

Regional Geology and Structure

The Project site is located within the Coast Range Geomorphic Province of California, which is characterized by northwest-trending mountains and valleys located between the Great Valley of California and the Pacific Ocean. The Coast Ranges stretch approximately 600 miles from the Oregon border to the Santa Ynez River and fall into two sub-provinces: the ranges north of San Francisco Bay and those from the bay south to Santa Barbara County. The Coast Ranges province is bounded on the north by Oregon, on the east by the South Fork Mountain and Coast Range thrusts bordering the Klamath Mountains and Great Valley province, on the south by the Santa Ynez Fault and Transverse Range province, and on the west by the continental borderland.

Geologically, the Coast Range province consists of a series of northwest trending mountain ranges. Extensive folding and faulting of the province has created the northwest trending ranges. The current landscape was a result of a mountain-building episode which began in late Pliocene and culminated in the mid-Pleistocene. The majority of the Coast Ranges contain sedimentary deposits of both marine and terrestrial origin underlain by either the Franciscan formation or granitic rocks of the Salinian Block.

The proposed pipeline is located on the southern margin of the Santa Maria Valley and northern margin of the Solomon Hills. The Santa Maria Valley is a sediment-filled basin situated between the foothills of the San Rafael Mountains to the northeast, the Casmalia Hills to the southwest and the Solomon Hills to the southeast. The Solomon Hills are generally characterized by northwest to southeast-trending folded Tertiary sedimentary rock. The Santa Maria Valley and Solomon Hills are situated within the Los Osos kinematic domain of south-central coastal California, which is a region of active Quaternary compressional deformation characterized by west-northwest striking reverse faults that bound eight similarly trending structural blocks. The compressional deformation creates vertical displacement among the structural blocks, which

themselves remain relatively rigid with little or no internal deformation. In general, topographic uplands within the domain coincide with uplifting structural blocks, and the lowlands coincide with subsiding, tilting, or static structural blocks. The Santa Maria Valley structural block is subsiding at present, or stagnant with respect to the uplifting Casmalia and Solomon Hills blocks to the south (Lettis, W.R. et al, 2004).

Site Geology

The majority of the Project site is composed of Quaternary surficial and older dissected surficial alluvial and aeolian sedimentary deposits. These deposits unconformably overly the late Pliocene to early Pleistocene Paso Robles formation and the slightly folded early Pleistocene Careaga Sandstone formation (Dibblee, 1989, 1994). Caltrans Log of Test Borings for Foxen Canyon Road Bridge over Cat Canyon Creek and the Clark Avenue Overcrossing Highway 101 reviewed by Padre indicate dense to very dense sand will be encountered during construction, with some interbedded layers of silty sand and clayey sand (CalTrans, 1966 and 1986). The site geology is shown on Plate 3 - Geology Map.

Younger Alluvium (Qa). Holocene alluvial deposits are found in the valley floors and flood plains. These deposits are comprised of surficial sediments composed of gravel and sand from the Sisquoc River and its tributaries (Dibblee, 1989 and 1994). The thickness of the alluvial deposits is likely to vary from relatively limited (less than about 10 feet) in slope areas and minor drainage swales to greater than about 30 to 50 feet in more significant drainage and collection areas (Fugro, 2014). The pipeline encounters the surface exposure of Qa along Graciosa Road on the west end (Station 0+00 to ~110+00) and again where Palmer turns into Cat Canyon Road (Station ~605+00 to 741+23) on the east end of the proposed pipeline.

Older Alluvium (Qo and Qos). Pleistocene older alluvium is composed of the remnants of weakly consolidated older alluvial sediments, much dissected. The wind-deposited aeolian dune sands (Qos) are weakly consolidated and thought to be a part of the Orcutt Sands (Qo; Dibblee, 1989 and 1994). The Orcutt Sand is the oldest and most extensive terrace deposit in Santa Maria Basin and consists primarily of sand interbedded with gravel. Much of the exposure of Orcutt Sand on the south side of the Santa Maria Valley is covered with inactive dune sand (Woodring and Bramlette, 1950). The older alluvial deposits are composed of tan to rusty brown wind-deposited sand that is locally pebbly at the base (Woodring and Bramlette, 1950 and Dibblee, 1989). The Orcutt Sands are poorly consolidated to locally indurated (Dibblee, 1989). Older alluvial deposits are well cemented in many areas (Fugro, 2014). The Orcutt Sand complex is primarily exposed along the Clark Road segment (Station ~125+00 to ~440+00) of the proposed pipeline as Qos and then as Qo along Dominion Road (Station ~440+00 to ~590+00).

Paso Robles formation (QTp). The middle to early Pleistocene and latest Pliocene. Paso Robles Formation is composed of weakly consolidated, alluvial sediments deposited in the valley from streams that drained from the San Rafael Mountains. Along the proposed pipeline route, the Paso Robles is observed as a light gray conglomerate or as a light greenish-gray to reddish gravel composed of alluvial sediments. The gravel is predominantly composed of white siliceous pebbles from the Monterey Shale formation in a sandy to clayey matrix. The beds vary from crudely defined to cross-bedded. Greenish gray, pebbly claystone and a marly gray-white,

hard impure limestone of lacustrine origin can be observed locally (Dibblee, 1989 and 1994). The proposed pipeline traverses the Paso Robles for the length of Palmer Road and portions of East Cat Canyon Road (Station ~590+00 to ~700+00).

Careaga Sandstone formation (Tca, Tcag, and Tcac). The late Pliocene Careaga Sandstone formation is a shallow marine clastic rock that was formed by transgressive and regressive seas. The Careaga is separated into two members and a third undifferentiated unit (Tca). The upper Graciosa Member (Tcag) is thickly bedded with grayish-yellow grains. Locally, the Graciosa is observed to be a pebbly, weakly indurated sandstone with a fossiliferous calcareous reef at its base. The Graciosa is partially non-marine, containing wind-deposited sediments. The lower Cebada Member (Tcac) is made up of massive tan to yellow, soft, fine grained sandstone or sand. Locally, small marine shell fragments have been observed in the Cebada (Woodring and Bramlette, 1950; Dibblee, 1989 and 1994). The Cebada and Graciosa Members attain maximum thicknesses of 250 and 100 feet, respectively in the Aera East Cat Canyon Lease, thinning northward (Fugro, 2014). The proposed pipeline runs through the surface exposures of the Careaga along Grasiosa Road (Station ~5+00 to ~20+00) and off of Cat Canyon Road at the gated entrance to the Aera East Cat Canyon Facility (Station~735+00 to 741+23).

Soil Survey

Soil data for the Project area was obtained from the USDA Natural Resources Conservation Services (NRCS) Soil Survey website (NRCS, 2017). The proposed pipelines extend across 26 soils series units, which are summarized below.

Table 2. Soil Units Along Pipeline Alignment

Soil Unit No.	Soil Unit Name
Arf	Arnold sand, 15 to 45 percent slopes
ArF3	Arnold sand, 9 to 45 percent slopes, severely eroded
BnB2	Betteravia loamy sand, dark variant, 0 to 5 percent slopes, eroded
BnD2	Betteravia loamy sand, dark variant, 5 to 15 percent slopes, eroded
BoA2	Botella loam, 0 to 2 percent slopes, eroded
BoD2	Botella loam, 2 to 15 percent slopes, eroded
CtA	Corralitos sand, 0 to 2 percent slopes
CtD	Corralitos sand, 2 to 15 percent slopes
CuA	Corralitos loamy sand, 0 to 2 percent slopes
CuC	Corralitos loamy sand, 2 to 9 percent slopes
CuD	Corralitos loamy sand, 9 to 15 percent slopes
GaC2	Garey sandy loam, 2 to 9 percent slopes, eroded
GaE3	Garey sandy loam, 5 to 30 percent slopes, severely eroded
GmG	Gaviota sandy loam, 30 to 75 percent slopes, MLRA 15
GuE	Gullied land
MaC	Marina sand, 2 to 9 percent slopes
MaE	Marina sand, 9 to 30 percent slopes

Table 2. (Continued)

Soil Unit No.	Soil Unit Name
MaE3	Marina sand, 9 to 30 percent slopes, severely eroded
OcD	Oceano sand, 2 to 15 percent slopes
PtD	Positas fine sandy loam, 9 to 15 percent slopes
Rs	Riverwash
SfD	San Andreas-Tierra complex, 5 to 15 percent slopes
SfE	San Andreas-Tierra complex, 15 to 30 percent slopes
Sh	Sandy alluvial land
TcG	Terrace escarpments, sandy
TdF	Terrace escarpments, loamy

The extent of these soil units along the proposed pipeline alignments is shown on Plate 4 - Soil Survey Map. These soils have the following reported characteristics.

Table 3. Soil Survey Data

Soil Unit No.	Grain-Size (%)[1]			Plasticity Index[1]	Liquid Limit[1]	K (um/sec)	Corrosivity	
	Clay	Silt	Sand				Concrete	Steel
Arf	2.5	1.5	96.0	0.0	0.0	92.0000	Moderate	Low
ArF3	2.5	1.5	96.0	0.0	0.0	92.0000	Moderate	Low
BnB2	7.5	9.0	83.5	4.0	23.0	92.0000	Moderate	Low
BnD2	7.5	9.0	83.5	4.0	23.0	92.0000	Moderate	Low
BoA2	21.0	37.4	41.6	14.0	37.0	9.0000	Low	Moderate
BoD2	21.0	37.4	41.6	14.0	37.0	9.0000	Low	Moderate
CtA	2.5	1.5	96.0	0.0	0.0	92.0000	Moderate	Low
CtD	2.5	1.5	96.0	0.0	0.0	92.0000	Moderate	Low
CuA	2.5	17.0	80.5	0.0	0.0	92.0000	Moderate	High
CuC	2.5	17.0	80.5	0.0	0.0	92.0000	Moderate	High
CuD	2.5	17.0	80.5	0.0	0.0	92.0000	Moderate	High
GaC2	7.5	23.7	68.8	4.0	21.0	28.0000	Moderate	Low
GaE3	7.5	23.7	68.8	4.0	21.0	28.0000	Moderate	Low
GmG	15.0	25.0	60.0	9.0	27.0	10.0000	Low	Moderate
GuE	NA	NA	NA	NA	NA	NA	NA	NA
MaC	2.5	1.5	96.0	0.0	0.0	92.0000	Moderate	Low
MaE	2.5	1.5	96.0	0.0	0.0	92.0000	Moderate	Low
MaE3	2.5	1.5	96.0	0.0	0.0	92.0000	Moderate	Low
OcD	3.5	1.5	95.0	1.0	17.0	92.0000	Moderate	Low
PtD	11.5	21.0	67.5	7.0	24.0	28.0000	Moderate	High
Rs	0.5	1.6	97.9	0.0	0.0	92.0000	NA	NA
SfD	13.0	16.5	70.5	8.0	29.0	28.0000	Moderate	Low
SfE	13.0	16.5	70.5	8.0	29.0	28.0000	Moderate	Low

Table 3. (Continued)

Soil Unit No.	Grain-Size (%)[1]			Plasticity Index[1]	Liquid Limit[1]	K (um/sec)	Corrosivity	
	Clay	Silt	Sand				Concrete	Steel
Sh	2.5	1.5	96.0	0.0	0.0	92.0000	Low	High
TcG	NA	NA	NA	NA	NA	NA	NA	NA
TdF	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

1 Run as surface layer. When "Surface Layer" is specified as the depth qualifier, only the surface layer or horizon is considered when deriving a value for a component, but keep in mind that the thickness of the surface layer varies from component to component. Obtained from NRCS (2017)

um micrometers

NA Not Available

Groundwater

Based on the review of available historical drill holes performed in the vicinity of the proposed pipeline, the depth to first groundwater in the area of the Project alignment is estimated to be 100 to 200 feet below ground surface (ft bgs). However, regional groundwater pumping associated with agricultural production activities may influence groundwater depths at various times of the year. Depending on the proximity of nearby wells, actual groundwater depths at the Project site may vary significantly from those noted. Although depth to ground water is estimated to be 100 ft bgs or more, there is the possibility for perched groundwater to be encountered prior to the actual groundwater table due to the presence of cohesive soils acting as an aquitard preventing vertical migration of the percolating water (Fugro, 2014; Caltrans, 1966).

Regional Faulting and Seismicity

The Project area is located in Seismic Zone 4, which has the greatest earthquake potential in the state of California. A Regional Fault Location Map, showing the general location of significant faults within 100 Kilometer or 62 miles from the Project site is included as Plate 5 - Regional Fault Map. There are over 350 named and unnamed faults within the buffer shown on Plate 5. Maximum earthquake magnitudes and distances from the Project site are also listed in Table 4. The distance value in the table are based on the distance from the approximate center of the proposed pipeline. Seismological data such as maximum historic earthquake on that fault and geologic data such as fault length and fault displacement parameters are also included. The faults listed are considered to have the greatest potential for impacting the Project site if they were to rupture.

Of the faults listed in Table 4, the Casmalia, Los Osos, and San Andreas fault zones have the greatest potential to impact the Project site based on their proximity to the Project site, potential maximum ground acceleration, and these faults are considered to be active or potentially active. A brief description of each of these faults is provided below based on information obtained from California Division of Mining and Geology (CDMG, 1996).

Casmalia Fault Zone. The Casmalia Fault zone is a potentially active fault system. This fault complex has an estimated overall length of about 5.2 miles (8.4 km). The complex intersects the segment of the proposed pipeline along Grasiosa Road at approximately Station 75+00. Mapped traces of the Casmalia that are believed to be potentially active are present between Grasiosa Road and Highway 101. The Casmalia Fault has an upper bound earthquake of 6.5 and a recurrence interval of 2,901 years.

Los Osos Fault. The Los Osos fault system is an active to potentially active southwest-dipping fault zone, with the Irish Hills section considered to be active. This fault complex has an estimated overall length of about 85 miles or 137 kilometers (km). The complex runs approximately 16 miles (25 km) northwest of the Project site. According to CDMG (1996), the Los Osos fault is thought to be a zone of reverse faulting. The Los Osos Fault is believed to have an estimated average slip rate of 0.5 millimeters per year (mm/yr), a maximum moment magnitude (Mw) earthquake of 6.8, and a recurrence interval of 1,925 years.

Table 4. Significant Quaternary Faults Located Within 100 Kilometers of the Project Site

Fault Name	Distance From Site		Fault Data		Upper Bound Earthquake[1, 2, and ,3] (M_w)
	Miles[1]	Kilometers[1]	Length[1] (ft)	Slip rate[1, 2, and 3] (mm/yr)	
Casmalia fault zone (Orcutt Oil Field fault)	0	0	27,574.95	0.25	6.5
San Luis Range fault system	3.86	6.21	55,673.62	Unknown	7.2
Los Alamos fault	7.43	11.95	33,383.54	0.70	6.8
Lions Head fault zone	9.61	15.47	64,257.69	0.02	6.6
Santa Ynez River fault zone	14.85	23.90	35,425.81	2.00	7.0
Los Osos fault zone	17.88	28.78	84,146.01	0.50	6.8
Hosgri fault zone	19.38	31.18	206,539.98	Unknown	7.5
San Juan fault zone	29.22	47.02	57,010.08	2	6.5
Oceanic fault zone	31.52	50.72	151,625.63	Unknown	6.75
Cambria fault	31.55	50.78	61,088.18	Unknown	7.0
Rinconada fault zone	31.65	50.94	195,996.64	1	7.3
San Andreas fault zone	41.49	66.76	39,693.53	14-34	8.0

Notes:

1 USGS Fault Map

2 Peterson, et al., 1996 (CGS Open-File Report 96-08,

3 http://www.conservation.ca.gov/cgs/rghm/psha/ofr9608/Pages/a_faults.aspx)
Southern California Earthquake Data Center (http://scedc.caltech.edu/significant/hosgri.html)

ft feet

mm/yr - millimeters per year

M_w - Moment Magnitude

San Andreas Fault. The San Andreas Fault is perhaps the most significant fault in California. The San Andreas has been the source of several major earthquakes during historic times, most notably the 1857 Fort Tejon, 1906 San Francisco, and 1989 Loma Prieta earthquakes. The San Andreas (Cholame-Carrizo Section) Fault is believed to have an estimated average slip rate of 14-34 mm/yr. The Mw earthquake is 8.0, and a recurrence interval of 25-550 years, depending on the segment of the fault that ruptures.

Preliminary Building Code Seismic Design Parameter

Preliminary seismic design parameters for the area of the Project site were performed by Padre using the United States Geologic Survey (USGS) Seismic Design Map web based computer software for building codes 2015 NEHRP Provisions - BETA, 2010 ASCE 7 (with March 2013 errata), and 2012/12 IBC (USGS, 2017). Design parameters were calculated for the east (34.83986°N, 120.3082°W), middle (34.86548°N, 120.37105°W), and west (34.82823°N, 120.44932°W) sections of the pipeline to provide the range of values that may be appropriate for use in design. Based on Padre's review of historical data and previous reports, soil classified as Site Class C or D could be encountered during construction, as geologic conditions vary along the route of the pipeline. Table 5 - Building Code Seismic Ground Motion Parameters provides site design parameters for soils found at Site Classes C and D.

Table 5. Building Code Seismic Ground Motion Parameters

Building Code	Seismic Parameter	Site Class C value (g)			Site Class D value (g)		
		Pipeline - West	Pipeline - Middle	Pipeline - East	Pipeline - West	Pipeline - Middle	Pipeline - East
2010 ASCE 7 (with March 2013 errata) and 2012/2015 International Building Code	S_S	1.075	1.066	1.093	1.075	1.066	1.093
	S_{MS}	1.075	1.066	1.093	1.150	1.145	1.162
	S_{DS}	0.716	0.711	0.729	0.767	0.763	0.775
	S_1	0.405	0.408	0.417	0.405	0.408	0.417
	S_{M1}	0.565	0.568	0.577	0.646	0.649	0.660
	S_{D1}	0.376	0.378	0.384	0.430	0.433	0.440
2015 NEHRP Provisions (BETA)	S_S	0.923	0.965	0.983	0.923	0.965	0.983
	S_{MS}	1.107	1.158	1.180	1.107	1.158	1.180
	S_{DS}	0.738	0.772	0.786	0.783	0.772	0.786
	S_1	0.345	0.361	0.367	0.345	0.361	0.367
	S_{M1}	0.517	0.542	0.551	0.674	0.700	0.710
	S_{D1}	0.345	0.361	0.367	0.449	0.47	0.473

GEOLOGIC HAZARDS ANALYSIS

GENERAL

The Project site is located within the seismically active Coast Ranges geomorphic province that was shaped by tectonic folding and faulting continues to affect the landscape of the California Central Coast. Geologic hazards such as fault rupture, seismic shaking, liquefaction, seismically-induced settlement, landslide and slope stability, expansive soils, subsidence, flood hazard, dam inundation, tsunami and seiche, naturally occurring asbestos, radon gas, and volcanic activity are known hazards on the California Central Coast. The potential for these hazards to affect the proposed pipeline during and post construction are discussed below (Plate 5 and Plate 6 - Geologic Hazard Map).

FAULT RUPTURE HAZARD EVALUATION

In 1972 the State of California passed the Alquist-Priolo Earthquake Fault Zoning Act (AP Act) to mitigate the hazard of surface faulting to structures utilized for human occupancy. The AP Act's primary purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The AP Act defines three categories of fault activity; active (demonstrated movement within the last 11,000 years), potentially active (movement within the past 11,000 to 2,000,000 years), and inactive (no movement within the past 2,000,000 years).

Since 1972, the California Geological Survey (CGS, formerly the California Division of Mines and Geology) has issued a series of 1"=2,000' scale maps delineating Earthquake Fault Zones (EFZs). Structures proposed within mapped EFZs require additional geologic investigations to demonstrate that the structures will not be constructed across the trends of active faults. If an active fault is identified within the boundaries of the Project site, the proposed structures must be set back generally a distance of 50 feet on either side of the identified fault location. The CGS mapping program is ongoing, and areas not currently identified as being within an EFZ may be included at some later time.

The proposed pipeline alignment does not intersect an identified EFZ at this time; however, known potentially active faults intersect or trend towards the proposed alignment. Therefore, it is Padre's opinion that the potential for damage to the proposed pipeline at the Project site due to fault rupture is moderate.

SEISMIC SHAKING

The Project site is located within a seismically active region, and the proposed pipeline will likely be subjected to seismic shaking during the life of the Project. Significant faults with historic seismicity include the Casmalia, Los Alamos, Lions Head, Los Osos, Santa Ynez, Hosgri, and San Andreas Fault systems. Acceleration due to seismic shaking is generally expressed as a percent of the force of gravity, and probabilistic site parameters generated by the USGS Earthquake Hazards Program indicate peak ground accelerations along the alignment ranged from 0.57g (2% probability of exceedance in 50 years) to 0.30g (10% probability of exceedance in 50 years). Peak ground acceleration (pga) values were calculated using the USGS Earthquake

Hazards Program, Beta - Unified Hazard Tool. Pga values were calculated for the west, middle, and east coordinate locations that were used in this report to calculate Building Code Seismic Design Parameters. Only the greatest pga values of the three locations evaluated have been provided herein.

LIQUEFACTION

Liquefaction is defined as the sudden loss of soil shear strength due to a rapid increase of soil pore water pressures caused by cyclic loading from a seismic event. In simple terms, it means that a liquefied soil acts more like a fluid than a solid when shaken during an earthquake. For liquefaction to occur, the following conditions are necessary:

- Granular soils (sand, silty sand, sandy silt, and some gravels);
- A high groundwater table; and
- A low density of the granular soils.

The County of Santa Barbara Office of Emergency Management (CSB OEM) published a Multi-Jurisdictional Hazard Mitigation Plan (HMP) for the area of Santa Barbara County in 2011 and updated the document in 2012. Padre has reviewed the evaluations of seismic hazards related to liquefaction and accompanying publishing maps put forth by CSB OEM. In this report, OEM rated the areas susceptible to liquefaction hazards in the event of an earthquake from low to high. Based on a review of the Santa Barbara County and City of Santa Maria sections of the HMP, liquefaction due to ground shaking along the proposed alignment is anticipated to be low to moderate.

SEISMICALLY-INDUCED SETTLEMENT

Seismically-induced settlement refers to settlement of unsaturated granular material as a result of densification and particle rearrangement due to earthquake shaking. Seismically induced settlement differs from settlement resulting from liquefaction because there is not a buildup of excess pore water pressure during the seismic shaking.

It is Padre's opinion that there may be a potential for seismically induced settlement to adversely affect specific, relatively isolated areas along the proposed alignment; however, without site-specific subsurface exploration and laboratory analyses, it is not possible to estimate the magnitude of that potential settlement. Padre recommends that site-specific geotechnical studies be completed to provide these data for design of the planned improvements.

LANDSLIDING AND SLOPE STABILITY

Landslides are defined as the rapid downslope movement of rock or soil, more generally defined as downslope movement (Keller, 2011). Downslope movement can be initiated by ground motion, saturated soils, or the processes of weathering and erosion. The HMP and Fugro (2014) have mapped areas of artificial fill, suspected landslide debris, and colluvium within Santa Barbara County and specifically the Orcutt area of the proposed pipeline, respectively. After review of both the CSB OEM and Fugro landslide hazard reports, in conjunction with Padre's site

reconnaissance of the pipeline route, landslide risks and slope instability are low along a majority of the pipeline route. Moderate risk of landslide along the pipeline route occurs along the Dominion and Cat Canyon Roads. The risk for slope failure exists to a lesser extent along Graciosa Road. In general, slopes along the pipeline route are expected to be moderately to highly stable.

EXPANSIVE SOILS

Based on USDA soil survey data, the proposed pipeline alignment is generally underlain by sand and loamy sand, which is not anticipated to have a high shrink-swell potential. According to the HMP (2012), expansive soils present a minor threat to limited portions of the County and no historical problems with expansive soils have been previously identified within this area. However, the presence or absence of expansive soils should be verified by the sampling and testing of on-site earth materials as part of a site-specific geotechnical study.

SUBSIDENCE

Land subsidence is primarily caused by removal of fluids through oil and gas production, groundwater extraction (regional lowering of deeper aquifers, not localized dewatering-induced settlement), compaction of clays and organic layers, and tectonic activity. Subsidence generally occurs fairly uniformly with changes occurring gradually over relatively long distances. After reviewing the HMP (2012) subsidence is not anticipated to pose a hazard because the soils in Santa Barbara County are mostly hard, present a minor threat, and there is no historical record of this hazard in the region. It is Padre's opinion that the potential for damage due to subsidence is low. However, the site-specific geotechnical study should further address the potential for land subsidence to affect the Project site.

FLOOD HAZARD

The Project site is located on varying terrain. According to the Federal Emergency Management Agency (FEMA) Map, Community Panel Nos. 06083C0455G, 06083C0452G, 06083C0456G, 06083C0460G, 06083C0485G, and 06083C0480G dated December 3, 2012, the majority of the Project site is mapped as being located outside of a flood zone designation. However, at the intersections of Clark Avenue and Orcutt Road and Grasiosa Road (Stations 175+00 to 225+00), the proposed pipeline crosses two mapped Flood Zones: A and X. Additionally, the entire length of the proposed pipeline route along Cat Canyon Road from the intersection of Palmer Road to the gate of the Aera Central Processing Facility (Stations 625+00 to 741+23) is mapped as Flood Zone A. Flood Zone A is defined as a special flood hazard area subject to inundation by the 1% annual chance flood with no base flood elevations having been determined. Flood Zone X is defined as areas determined to have 0.2% annual chance of flood; areas of 1% annual chance of flood with average depths of less than one foot or with drainage areas less than one square mile; and areas protected by levees from 1% annual chance of flooding (FEMA, 2012).

DAM INUNDATION

Catastrophic failure of dams is rare and is most likely to occur following significant seismic events. Inundation due to dam failure is considered likely in the event that the dam should fail. The Twitchell Reservoir and Dam are located approximately eight miles northeast of the Project site on the Cuyama River. The Twitchell Reservoir and Dam were constructed in the early 1950s for flood control and ground water recharge purposes. Twitchell Dam is located on the Cuyama River, upstream of where the confluence of the Cuyama and Sisquoc Rivers form the Santa Maria River. The reservoir receives runoff water from approximately 1,135 square miles of Cuyama River watershed, northeast of the Santa Maria River. The dam has a storage capacity of approximately 257,000 acre-feet of water. The dam is used as a seasonal water collection system and water is released on a regularly scheduled basis to recharge the Santa Maria Valley groundwater basin. According to the HMP, in the event the Twitchell Dam were to fail, the proposed alignment would not be impacted by dam inundation and is not included in the mapped inundation zone due to the natural topography of the hillsides separating the Project site and the inundation zone (HMP, 2012). No other dams were identified within the study area.

TSUNAMI AND SEICHE

Tsunamis are long-period sea waves generated by earthquakes or submarine landslides, while seiches are oscillations in large bodies of water such as lakes or reservoirs caused by earthquakes or landslides. The Project site is located approximately 10 miles inland from the Pacific Ocean and separated from the ocean by a natural topographic barrier of the rolling hillsides. Based on Padre's review of the CSB OEM tsunami inundation maps for the proposed Project area, the proposed pipeline route is shown outside of the mapped inundation zone. It is Padre's opinion that the Project site is not at risk for tsunami inundation and the hazard is low. CSB OEM does not address the possibility of seiches in the Project area. As previously mentioned under the dam failure discussion, Twitchell Dam is the nearest reservoir of significant size to the Project site. Although the 2012 HMP does not include seiche inundation maps, it can be inferred that the inundation path of a seiche would be similar and less extensive than that of the inundation zone created by the failure of Twitchell Dam. Therefore, it is Padre's opinion that the potential for a seiche to affect the Project site is low. No other reservoirs were identified within the study area.

NATURALLY OCCURRING ASBESTOS

Asbestos is a naturally occurring silicate mineral of the amphibole group that has historically been utilized for a variety of purposes including fireproofing due to its fibrous nature which allowed it to be woven into cloth and formed into various types of construction material. The mineral generally occurs in association with ultramafic rocks (igneous and metamorphic rocks with high iron and magnesium contents) and is a known carcinogen. According to the Geologic Maps of the Orcutt and Sisquoc Quadrangles by Thomas W. Dibblee (1989 and 1994), the nearest exposure of potentially asbestos-bearing ultramafic rocks is located a distance greater than 10 miles from the proposed pipeline alignment. Based on the distance of the proposed alignment from the nearest mapped exposure, it is Padre's opinion that the potential for exposure to naturally occurring asbestos materials at the Project site is low.

RADON GAS POTENTIAL

Radon is a colorless, odorless, tasteless, and radioactive gas that is produced as a natural decay product of uranium. Because of its radioactivity, studies have shown that at elevated concentrations there is a link between radon and lung cancer. Persons living in a building with elevated radon concentrations may have an increased risk of contracting lung cancer over a period of years.

Sections 307 and 309 of the Indoor Radon Abatement Act of 1988 (IRAA) directed the United States Environmental Protection Agency (U.S. EPA) to list and identify areas of the United States with the potential for elevated indoor radon levels. The U.S. EPA's Map of Radon Zones assigns each of the 3,141 counties in the U.S. to one of three zones based on radon potential:

- Zone 1 counties have a predicted average indoor radon screening level greater than four pCi/L (pico curies per liter) (red zones);
- Zone 2 counties have a predicted average indoor radon screening level between two and four pCi/L (orange zones); and
- Zone 3 counties have a predicted average indoor radon screening level less than two pCi/L (yellow zones).

According to the U.S. EPA Map of Radon Zones, the Project site is located within Zone 1 of the U.S. EPA's Map of Radon Zones. The potential for radon gas to affect the Project will be limited to enclosed structures (like manholes or valve vaults) along the proposed alignment.

VOLCANIC ACTIVITY

Volcanic eruptions have occurred in the western United States in historic times, most notably the Mt. Lassen, California, eruptions of 1914 to 1917 and Mt. St. Helens, Washington, in 1980. Currently, the USGS is monitoring an area of potential volcanic activity near Mammoth Lakes/Long Valley, California, which lies approximately 385 miles northeast of the Project site. Mount Lassen and Mount Shasta are located northwest of the Project site approximately 494 and 526 miles, respectively. Based on the distance of the Project site from these volcanic areas, the potential for a volcanic eruption to affect the Project site is considered low.

CONCLUSIONS

The Project site is not located within the boundaries of an Alquist-Priolo Earthquake Fault Zone at this time, and no active faults are known to traverse the Project site. However, the Casmalia fault is considered by the California Geological Survey to be potentially active and intersects the proposed pipeline approximately at Station 75+00.

The findings in this report identified liquefaction and seismically induced settlement as potential geohazards that cannot be quantified and mitigated, if necessary, without a site-specific geotechnical study. A site-specific geotechnical study is typically performed for a project once

preliminary design (site development plan) has been completed. The geotechnical study will consist of a number of exploration locations (drill holes, cone penetration test soundings, or other methods) along the proposed alignment. Soil samples are collected and tested in the laboratory and the results of field and laboratory data are used by the geotechnical engineer to develop earthwork recommendations for the proposed pipeline design and construction. The potential geohazards identified in this report (if found to be present at locations along the proposed alignment) can typically be mitigated through ground improvement methods, if necessary.

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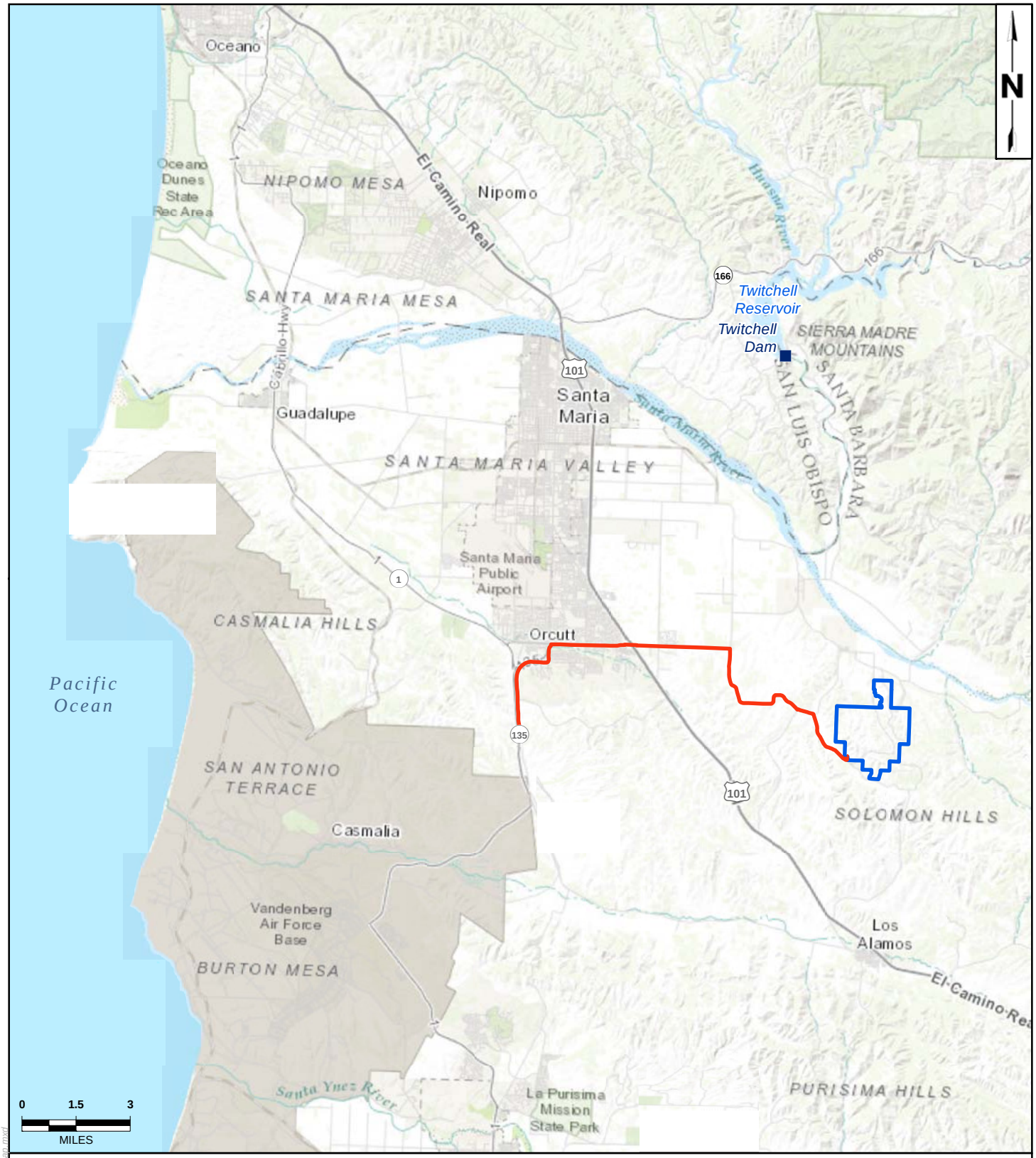
PLATES



LEGEND:

- Twitchell Dam
- Proposed Common Carrier Natural Gas Pipeline Route
- Aera Energy LLC Property Boundary

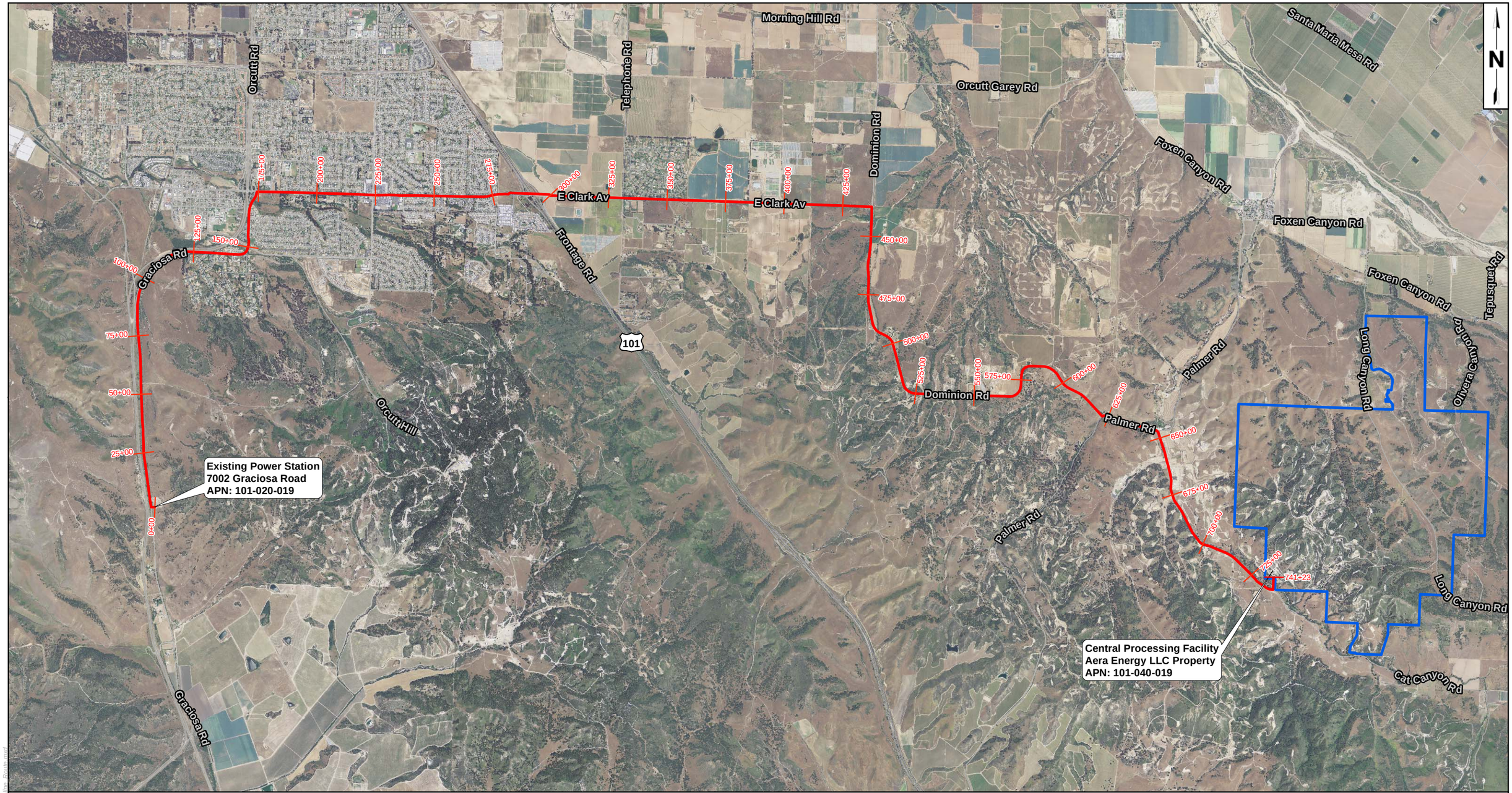
MAP EXTENT:

Source: Esri Online Basemap, SPEC Services
Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
Notes: This map was created for informational and display purposes only

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

PROJECT NAME: EAST CAT CANYON OIL FIELD REDEVELOPMENT PROJECT GEOHAZARD REPORT	SITE LOCATION MAP	PLATE 1
PROJECT NUMBER: 1002-0455 / DATE: May 2017		

East Cat Canyon\Geohazard Rpt\Fig 1_SiteLocMap.mxd

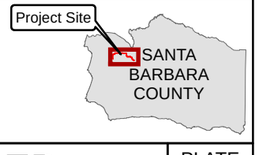


LEGEND:

Proposed Common Carrier Natural Gas Pipeline Route with Padre Estimated Station Numbering (50+00)

Aera Energy LLC Property Boundary

MAP EXTENT:



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Sources:
SPEC Services, DPSI 2013

Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet

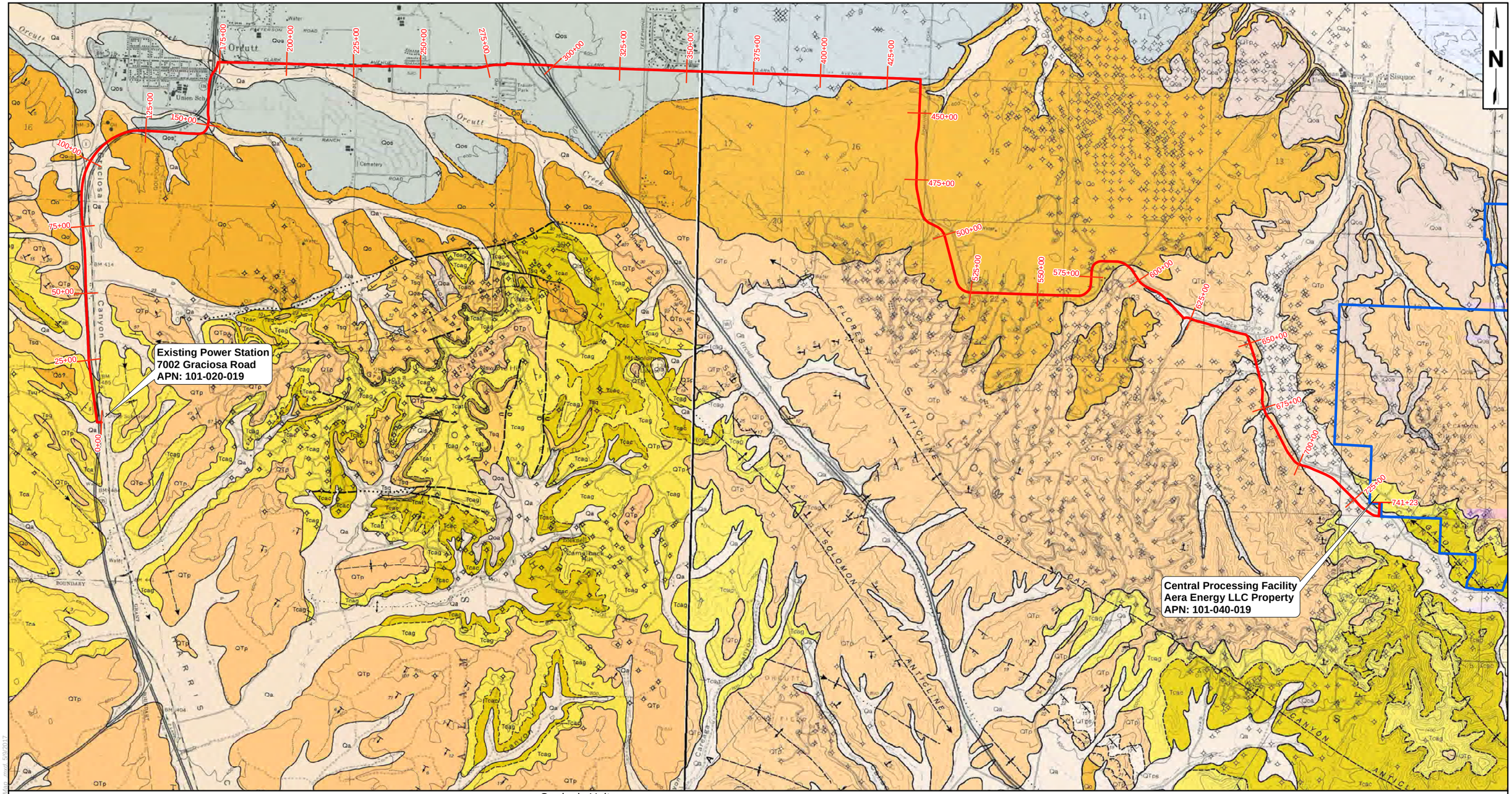
Notes:
1) This map was created for informational and display purposes only.

PROJECT NAME:	EAST CAT CANYON OIL FIELD REDEVELOPMENT PROJECT GEOHAZARD REPORT
PROJECT NUMBER:	1002-0455
DATE:	May 2017

PROPOSED PIPELINE ROUTE

PLATE 2

East Cat Canyon\Geohazard_Rpt\Fi_2_Prop_Pipeline_Route.mxd



LEGEND:

Proposed Common Carrier Natural Gas Pipeline Route with Padre Estimated Station Numbering (50+00)

Aera Energy LLC Property Boundary

Geologic Units:

- Qa Gravel and Sand of Sisquoc River
- Qg Alluvial Gravel
- Qls Landslide Debris
- Qoa Older Alluvial Gravel and Sand
- Qos Older Wind-Deposited Sand
- Qo Older Orcutt Sand
- QTp(s) Paso Robles Formation
- Tcag Careaga Sandstone, Graciosa Member
- Tcac Careaga Sandstone, Cebada Member
- Tca Undifferentiated Careaga Sandstone
- Tf Foxen Claystone
- Tsqd Sisquoc Formation (Surface)
- Tsq(s) Sisquoc Formation (Subsurface), Massive
- Tm Monterey Shale

MAP EXTENT:

0 3,500 7,000 FEET

Sources:
Dibblees, T.W, Geologic Map of the Casmalia and Orcutt Quadrangles, Santa Barbara County, California; Santa Barbara Museum of Natural History, 1989.
Dibblees, T.W, Geologic Map of the Sisquoc Quadrangle, Santa Barbara County, California; Santa Barbara Museum of Natural History, 1994.

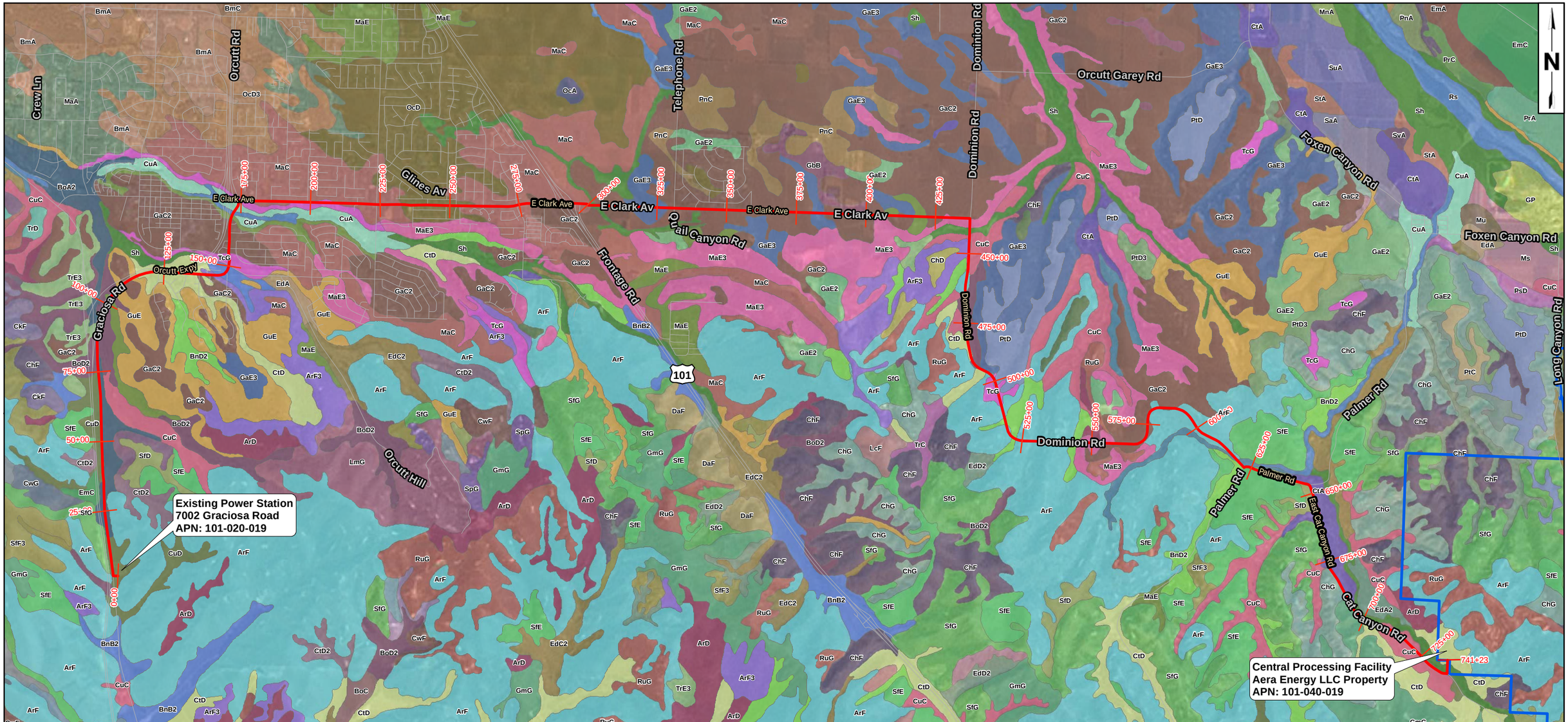
SPEC Services, DPSI 2013

Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet

Notes:
1) This map was created for informational and display purposes only.

PROJECT NAME: EAST CAT CANYON OIL FIELD REDEVELOPMENT PROJECT GEOHAZARD REPORT		GEOLOGY MAP	PLATE
PROJECT NUMBER: 1002-0455	DATE: May 2017		3

East Cat Canyon\Geohazard Rpt\Pl. 3 Geology4.dwg, mwf, 5/9/2017



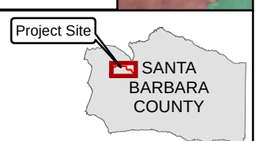
Key to Soils that Intersect the Proposed Pipeline:

- Arnold Sand, 15 To 45 Percent Slopes (ArF)
- Arnold Sand (ArD)
- Arnold sand, 9 to 45 percent slopes, severely eroded (ArF3)
- Betteravia loamy sand, dark variant, 0 to 5 percent slopes, eroded (BnB2)
- Betteravia loamy sand, dark variant, 5 to 15 percent slopes, eroded (BnD2)
- Botella loam, 0 to 2 percent slopes, eroded (BoA2)
- Botella loam, 2 to 15 percent slopes, eroded (BoD2)
- Corralitos loamy sand, 0 to 2 percent slopes (CuA)
- Corralitos loamy sand, 2 to 9 percent slopes (CuC)
- Corralitos loamy sand, 9 to 15 percent slopes (CuD)
- Corralitos sand, 0 to 2 percent slopes (CtA)
- Corralitos sand, 2 to 15 percent slopes (CtD)
- Crow Hill Loam (CwG3)
- Elder Loam, 2 To 9 Percent Slopes (EmC)
- Garey sandy loam, 2 to 9 percent slopes, eroded (GaC2)
- Garey sandy loam, 5 to 30 percent slopes, severely eroded (GaE3)
- Gaviota sandy loam, 30 to 75 percent slopes, MLRA 15 (GmG)
- Gullied land (GuE)
- Marina sand, 2 to 9 percent slopes (MaC)
- Marina sand, 9 to 30 percent slopes (MaE)
- Marina sand, 9 to 30 percent slopes, severely eroded (MaE3)
- Oceano sand, 2 to 15 percent slopes (OcD)
- Positas fine sandy loam, 9 to 15 percent slopes (PtD)
- Riverwash (Rs)
- San Andreas-Tierra complex, 15 to 30 percent slopes (SfE)
- San Andreas-Tierra complex, 5 to 15 percent slopes (SfD)
- Sandy alluvial land (Sh)
- Terrace escarpments, loamy (TdF)
- Terrace escarpments, sandy (TcG)
- Tierra Loam, 2 To 9 Percent Slopes (TrC)

LEGEND:

- Proposed Common Carrier Natural Gas Pipeline Route with Padre Estimated Station Numbering (50+00)
- Aera Energy LLC Property Boundary
- Road

MAP EXTENT:



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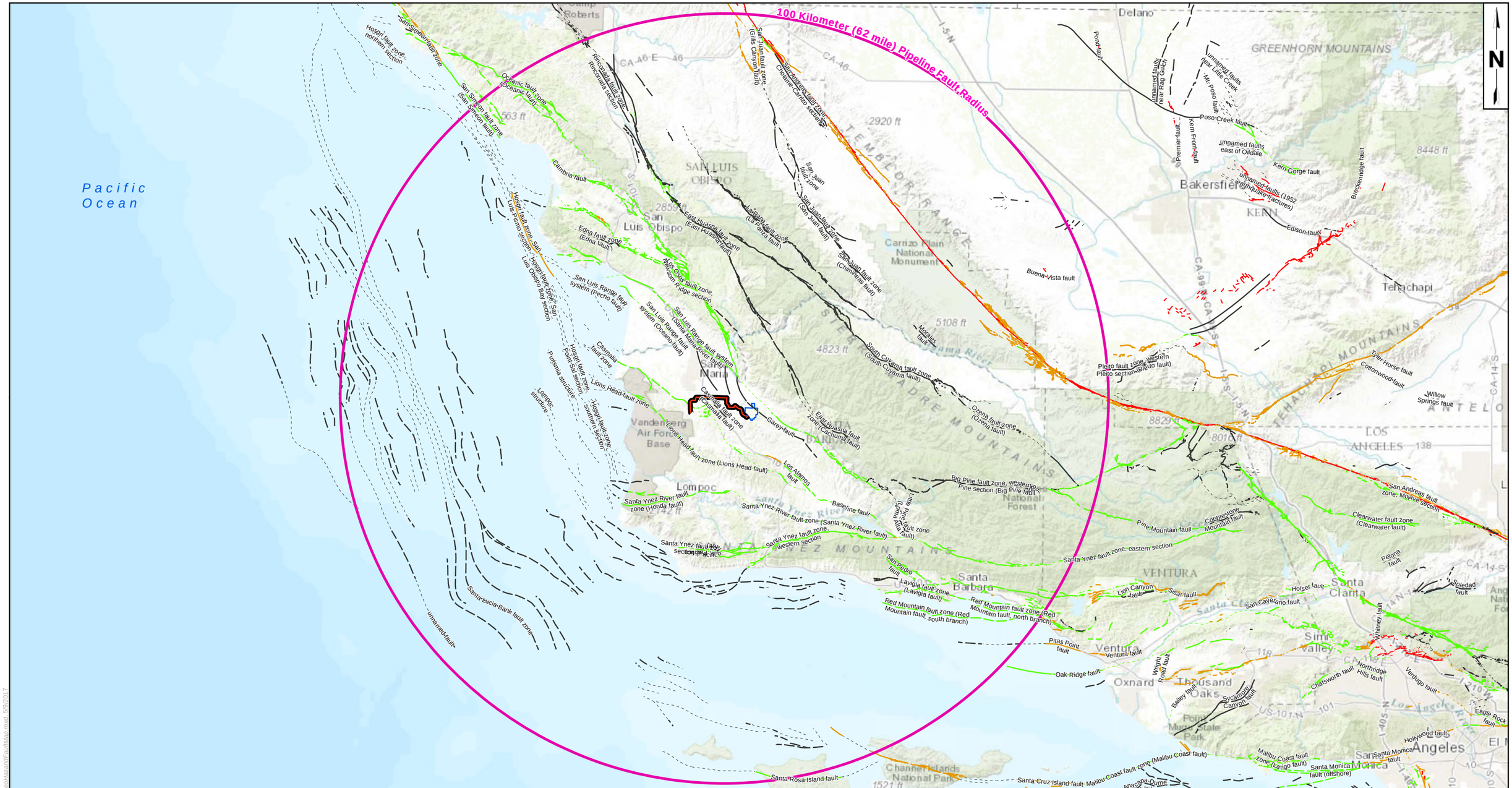
Sources:
SPEC Services, DSPI 2013.
Service Layer Credits: Copyright:© 2013 ESRI, i-cubed, GeoEye
United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), April 2017 (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx)

Notes:
1) This map was created for informational and display purposes only.

Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet

PROJECT NAME: EAST CAT CANYON OIL FIELD REDEVELOPMENT PROJECT GEOHAZARD REPORT	SOIL SURVEY MAP	PLATE 4
PROJECT NUMBER: 1002-0455 / DATE: May 2017		

East Cat Canyon Geohazard_Rpt\01_4_SoilSurveyMap.mxd



LEGEND:

- Proposed Common Carrier Natural Gas Pipeline Route
- Aera Energy LLC Property Boundary
- 100 Kilometer (62 mile) Pipeline Fault Radius

Quaternary Faults (age in years, fault type)

- <1,600,000, Well Constrained
- <1,600,000, Inferred
- <1,600,000, Moderately Constrained
- <130,000, Well Constrained
- <130,000, Inferred
- <130,000, Moderately Constrained
- <15,000, Well Constrained
- <15,000, Inferred
- <15,000, Moderately Constrained
- <150, Inferred
- <150, Moderately Constrained
- <150, Well Constrained

MAP EXTENT:

0 80,000 160,000
FEET

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
SPEC Services, DPSI 2013.

Notes:
1) This map was created for informational and display purposes only.

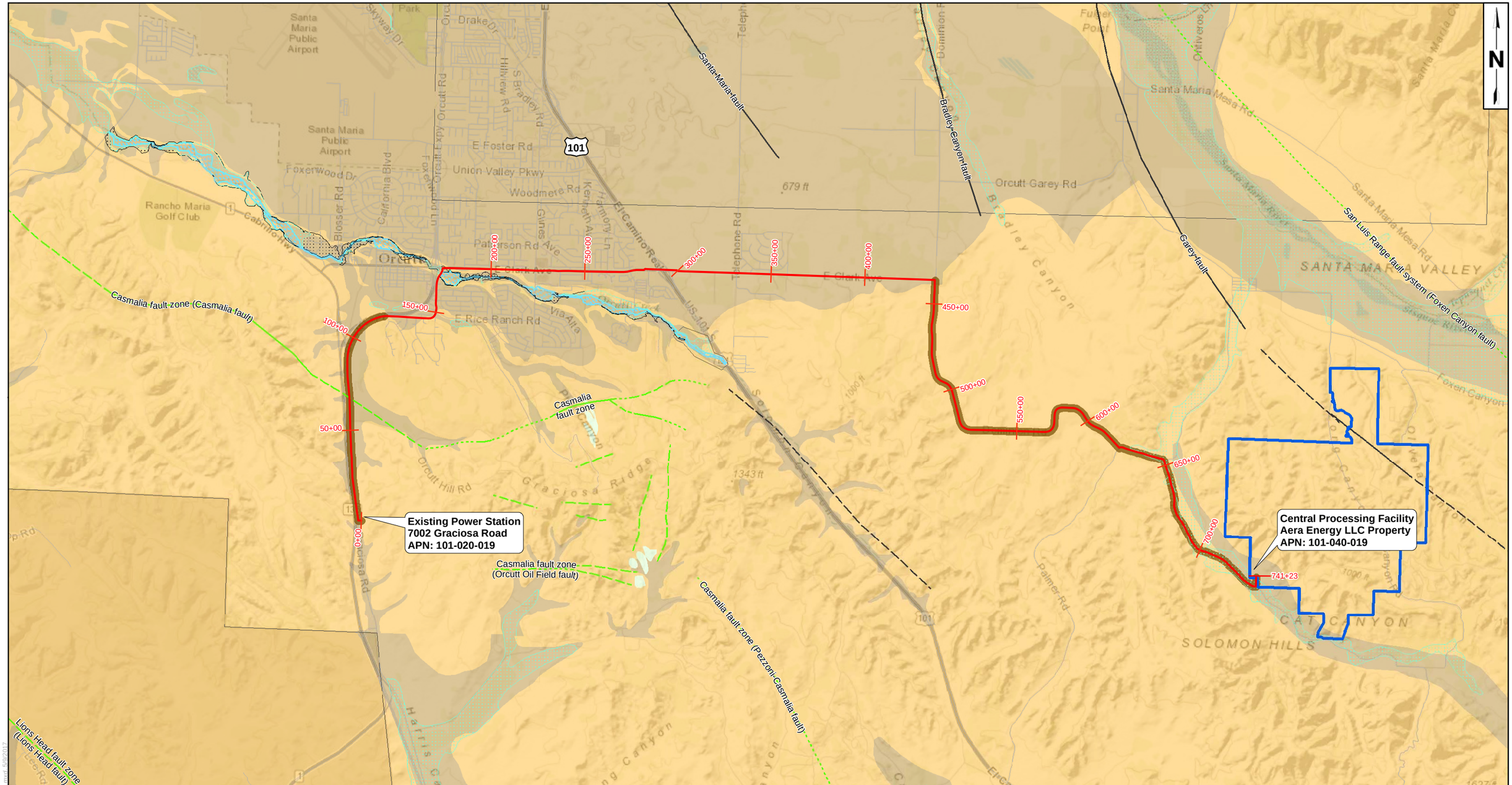
Coordinate System:
NAD 1983 StatePlane California V FIPS 0405 Feet

PROJECT NAME:	EAST CAT CANYON OIL FIELD REDEVELOPMENT PROJECT GEOHAZARD REPORT
PROJECT NUMBER:	1002-0455
DATE:	May 2017

REGIONAL FAULT MAP

PLATE 5

East Cat Canyon\Geohazard_Rpt\Pl-5_RegionalGeoHazardFaultMap.mxd, 5/9/2017



LEGEND:

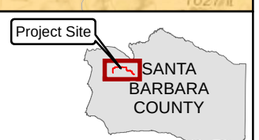
- Proposed Common Carrier Natural Gas Pipeline Route with Padre Estimated Station Numbering (50+00)
- Aera Energy LLC Property Boundary
- Zone of Potential Landslide Along Pipeline Route
- Road

Quaternary Faults
- <1,600,000, Inferred
- <1,600,000, Moderately Constrained
- <130,000, Inferred
- <130,000, Moderately Constrained
- <130,000, Well Constrained

FEMA FIRM Map Flood Zone Hazards
- Areas in which flood hazards are undetermined, but possible (Zones X and D)
- Areas of 0.2% chance of flood; areas of 1% chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas projected by levees from 1% annual flood
- Floodway Areas in Zone
- Special Flood Hazard Areas Subject to Inundation by the 1% Annual Chance Flood (Zones A, AE, AH, AO, and VE)

Groundwater Liquefaction Rating
- Severity Class = 1 (Low); Maximum probable variation in severity = +1
- Severity Class = 1 (Low); Maximum probable variation in severity = 0
- Severity Class = 2 (Moderate); Maximum probable variation in severity = +/-1

MAP EXTENT:



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Sources:
SPEC Services, DPSI 2013.
Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
State of California, 2009, Tsunami Inundation Map for Emergency Planning, Sisquoc and Orcutt Quadrangles, Santa Barbara County; produced by California Emergency Management Agency, California Geological Survey, and University of Southern California – Tsunami Research Center; dated 2017, mapped at 1:24,000 scale.

Notes:
1) This map was created for informational and display purposes only.

Coordinate System:
NAD 1983 StatePlane California V FIPS 0405 Feet

PROJECT NAME: EAST CAT CANYON OIL FIELD REDEVELOPMENT PROJECT GEOHAZARD REPORT		GEOLOGIC HAZARD MAP	PLATE 6
PROJECT NUMBER: 1002-0455	DATE: May 2017		

East Cat Canyon\Geohazard_Rpt\Pl_6_GeohazMap.mxd, 5/9/2017