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Geotechnical Report

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The Altum Group
73-710 Fred Waring Drive, Suite 219
Palm Desert, California 92260

Geotechnical Engineering Feasibility Report
Proposed Glamis Specific Plan Project
State Highway 78 and the Union Pacific Railroad
Glamis, Imperial County, California

August 29, 2019

File No.: 303235-001
Doc. No.: 19-08-705

Earth Systems
79-811 Country Club Drive, Suite B | Bermuda Dunes, CA 92203 | Ph: 760.345.1588 | www.earthsystems.com

August 29, 2019

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The Altum Group
73-710 Fred Waring Drive, Suite 219
Palm Desert, California 92260

Attention: Mr. Taku Shiozaki

Project: **Proposed Glamis Specific Plan Project**
State Highway 78 and the Union Pacific Railroad
Glamis, Imperial County, California

Subject: **Geotechnical Engineering Feasibility Report**

Earth Systems Pacific is pleased to submit this geotechnical feasibility report for the proposed Glamis Specific Plan Project, totaling approximately 141 acres. We understand that a design-level recommendation report is not required at this time. A feasibility level report has fewer exploration locations and more general recommendations about site development considering that the exact plan for the site area is not yet developed. Once plans are developed, site-specific design-level exploration and reporting should be performed.

We understand the proposed development is located at six APNs: 039-310-022, 039-310-023, 039-310-026, 039-310-027, 039-310-029, and 039-310-030 within Imperial County, California. This report completes our scope of services in accordance with our agreement BER-19-4-002, authorization date June 5, 2019. Other services may be required, such as design-level reports once structure locations are decided. More field exploration, reporting, consultation, plan review, construction testing, inspection, and grading observation, are additional services and will be billed according to our Fee Schedule in effect at the time services are provided when such services are requested. Unless requested in writing, the client is responsible for distributing this report to the appropriate governing agency or other members of the design team.

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

Respectfully submitted,
EARTH SYSTEMS PACIFIC

No. 60302
Exp. 6/30/2020
CIVIL

No. 1174
CERTIFIED ENGINEERING GEOLOGIST

Anthony Colarossi
Project Engineer
CE 60302

Mark S. Spykerman
Principal Engineering Geologist
EG 1174

SER/ac/cgj/klp/mss

Distribution: 4/The Altum Group
1/Mr. Taku Shiozaki (taku.shiozaki@thealtumgroup.com)
1/Ms. Tonya Carnevale (carnevale@thealtumgroup.com)
1/BER File

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Glamis, Imperial County, California

Section 1
INTRODUCTION

1.1 Project Description

This geotechnical feasibility report has been prepared for the proposed Glamis Specific Plan. The Glamis Specific Plan is intended to accommodate recreation-supporting land uses including retail and service commercial, motel accommodations, recreational vehicle and mobile home parks, and community facilities. A conceptual layout prepared by The Altum Group and provided to us on December 3, 2019 is included with this report. Although dated August 29, 2019, this report was held such that a conceptual plan could be included.

Actual structure types and locations are not available at this time. This report is feasibility in nature in order to better guide the project forward from a geotechnical perspective until structure locations and scope are developed and actual location-specific geotechnical reports are authorized and prepared. We assume the project will use one to two story masonry, wood-framed or metal stud construction founded on shallow permanent foundations, and that there will be no below grade basement levels. Anticipated loads are assumed will be less than 100 kips for isolated spread footings and 4.0 kip/ft for continuous footings. Preliminary grading and foundation plans were not available at the time this proposal was prepared. We assume that proposed finish grades will likely be within approximately five feet of existing site grades.

As the basis for the foundation recommendations, all loading is assumed to be dead plus actual live load. No preliminary design loading was provided by the structural engineer. If actual structural loading exceeds these assumed values, we will need to reevaluate the given recommendations. In addition, the geotechnical engineer of record should evaluate structural plans for additive pressures from closely spaced footings and differential settlements between nearby heavily and lightly loaded footings.

1.2 Site Description

The project is located approximately 27 miles east of the city of Brawley at the intersection of State Highway 78 and the Union Pacific Railroad in Imperial County, California, see Figure 1 below, and Plate 1 in Appendix A. The legal addresses of the project site are Accessor Parcel Numbers (APN): 039-310-022, 039-310-023, 039-310-026, 039-310-027, 039-310-029, and 039-310-030, and its combined area is approximately 141 acres. The latitude and longitude of the local Glamis Store, somewhat central to the project area, is approximately 32.99594°N and 115.07267°W.

Based on a USGS topographic (USGS, 1968), the project is located between contour elevations 300 and 360 feet above Mean Sea Level (MSL); grades dip towards the west-southwest. Based on a google image (Google, 2019), the project area is generally flat. The site appears to have past use and demolition performed, see Section 3.2 for aerial photo research. The project area is mostly bare of vegetation.

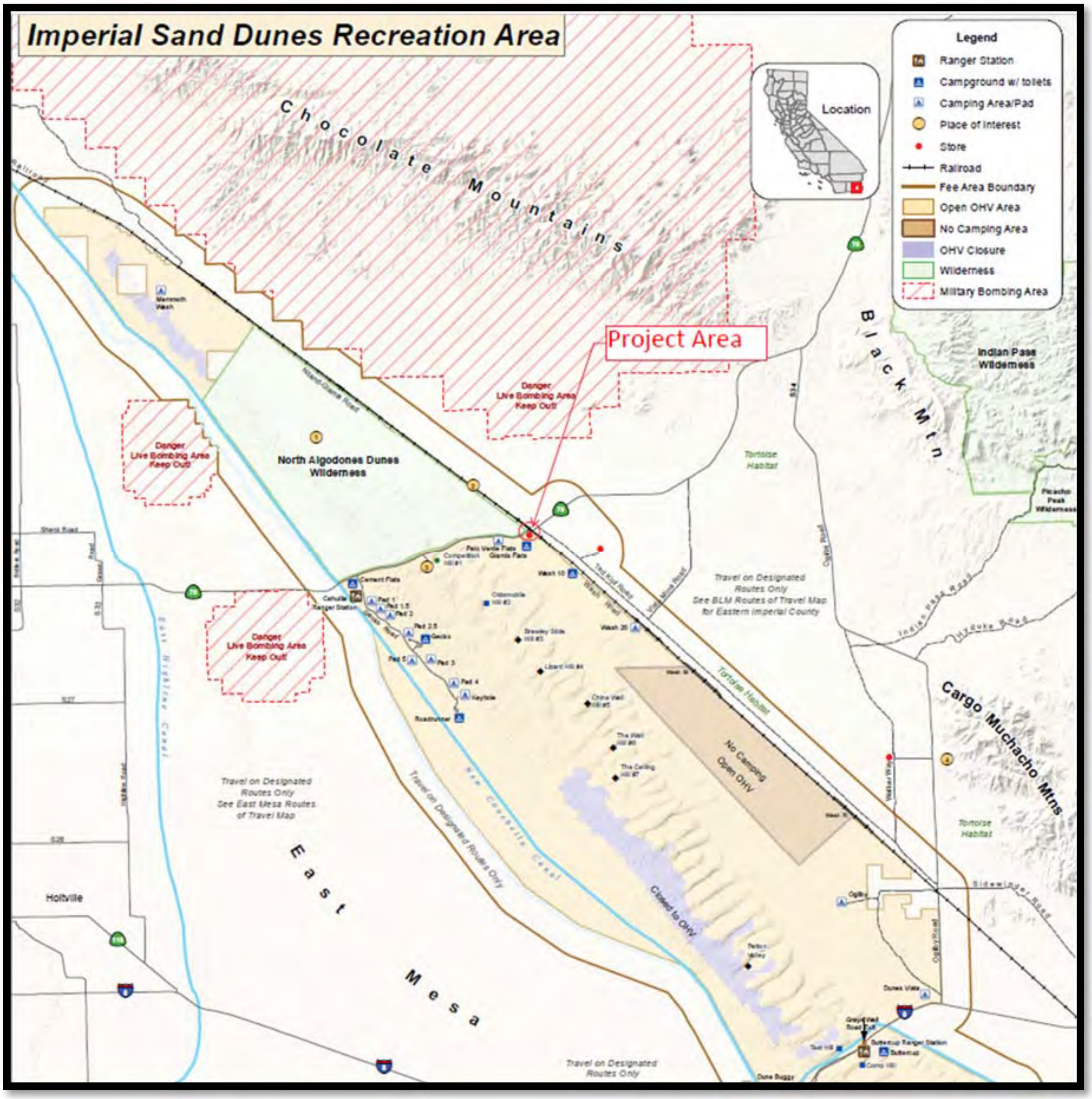


Figure 1 Imperial Sand Dunes Recreation Area

1.3 Scope of Services

The scope of services provided by Earth Systems consisted of the following:

1. A visual site assessment was made by our representative regarding surficial observed site conditions. In addition, we reviewed our files and select published literature pertinent to the site vicinity. We marked our proposed boring locations and had them cleared through Underground Service Alert (USA).

2. Near-surface soil conditions were explored by means of approximately 21 exploratory borings using truck-mounted drilling rig equipment with hollow-stem augers. The borings extended to depths of approximately 20 to 50 feet below the existing ground surface. The borings were backfilled with soil derived from the auger cuttings. The exposed soil profiles were observed relative to soil and groundwater (not encountered) conditions. Samples of the surface and subsurface materials were collected at various intervals, logged by our representative, and returned to our laboratory.
3. Near-surface soil conditions were also explored by means of approximately 7 test pits that were excavated using a backhoe equipped with a 24-inch-wide bucket. The test pits extended to a maximum depth of approximately 8 feet below the ground surface. The test pits were backfilled with soil derived from the excavation. Compaction was not performed. The exposed soil profiles were observed relative to soil and groundwater (not encountered) conditions. Samples of the surface and subsurface materials were collected at various intervals, logged by our representative, and returned to our laboratory.
4. Laboratory tests were performed on selected samples to evaluate the physical characteristics of the materials encountered during our field exploration. Laboratory testing included moisture content, dry unit weight, maximum density/optimum moisture content, sieve analysis, consolidation/collapse potential, and Expansion Index. Testing was performed in general accordance with American Society for Testing and Materials [ASTM] or appropriate test procedure. Selected samples will also be tested for a screening level of corrosion potential (pH, electrical resistivity, water-soluble sulfates, and water-soluble chlorides). Earth Systems does not practice corrosion engineering; however, these test results may be used by a qualified engineer in designing an appropriate corrosion control plan for the project. The tests selected and the frequency of testing may be modified and will be based on the subsurface conditions actually encountered.
5. We conducted a feasibility level engineering analysis of the data generated from this commission and prepared a written report presenting our findings and feasibility level recommendations related to the following:
    - A description of the proposed project including a site plan showing the approximate boring locations.
    - A description of the surface and subsurface site conditions including groundwater conditions, as encountered in our field exploration (if applicable).
    - A description of the site geologic setting and possible associated geology-related hazards, including a liquefaction, subsidence, and seismic settlement analysis.
    - A discussion of regional geology and site seismicity.
    - A description of local and regional active faults, their distances from the site, their potential for future earthquakes.
    - A discussion of other geologic hazards such as ground shaking, landslides, flooding, and tsunamis.
    - A discussion of site conditions, including the geotechnical feasibility suitability of the site for the general type of construction proposed.

- A seismic analysis including recommendations for geotechnical feasibility level seismic design coefficients in accordance with the 2016 CBC.
- Recommendations for imported fill (if required) for use in compacted fills.
- Feasibility level recommendations for foundation design including parameters for shallow foundations and building pad and subgrade preparation.
- Preliminary recommendations for the mitigation of seismic induced settlement.
- Recommendations for lateral earth pressures (active, at-rest, and passive) for below grade structures and retaining walls, including drainage requirements, coefficients of friction and seismic earth pressures.
- General feasibility recommendations for site grading and earthwork, and fill compaction specifications.
- Discussion of anticipated excavation conditions, including preliminary shrinkage and/or bulking.
- Recommendations for underground utility trench backfill and import soils.
- Recommendations for stability of temporary trench excavations.
- Recommendations for slabs-on-grade (building slabs and walkways), including recommendations for reducing the potential for moisture transmission through interior slabs.
- Recommendations for collapsible or expansive soils (if applicable).
- Asphalt concrete pavement and Portland cement concrete preliminary recommendations for onsite driveways and parking areas, using assumed Traffic Indices.
- A discussion of the corrosion potential of the near-surface soils encountered during our field exploration.
- An appendix, which will include a summary of the field exploration and laboratory testing program.

- Services that investigate or detect the presence of moisture, mold, or any biological contaminants in or around any structure, or any service that was designed or intended to prevent or lower the risk of the occurrence of the amplification of the same, were not provided. Mold is ubiquitous to the environment with mold amplification occurring when building materials are impacted by moisture. Site conditions are outside of Earth Systems control, and mold amplification will probably occur, or even continue to occur, in the presence of moisture. As such, Earth Systems cannot be held responsible for the occurrence or recurrence of mold amplification.

- Services that investigate or detect water quality in or around any structure, or any service that was designed or intended to determine water quality, were not provided.

Section 2
METHODS OF EXPLORATION AND TESTING

2.1 Field Exploration

Exploratory Borings

Twenty-one exploratory borings were drilled to depths ranging from 21½ to 51½ feet below the existing ground surface to observe soil profiles and obtain samples for laboratory testing. The borings were drilled on June 18, 19 and 21, 2019, using either an approximate 6 or 8-inch outside diameter hollow-stem auger. Augers were powered by a Mobile B-61 truck-mounted rubber tired drill rig. The boring locations are shown on the Boring Location Map, Plate 2, in Appendix A. The locations shown are approximate, established by pacing and line-of-sight bearings from adjacent landmarks and consumer grade GPS coordinates (+/- 15 feet).

A representative from Earth Systems maintained a log of the subsurface conditions encountered and obtained samples for visual observation, classification and laboratory testing. Subsurface conditions encountered in the borings were categorized and logged in general accordance with the Unified Soil Classification System [USCS] and ASTM D 2487 and 2488 (current edition). Our typical sampling interval within the borings was approximately every 2½ to 5 feet to the full depth explored; however, sampling intervals were adjusted depending on the materials encountered onsite. Samples were obtained within the test borings using a Standard Penetration [SPT] sampler (ASTM D 1586) and a Modified California [MC] ring sampler (ASTM D 3550 similar to ASTM D 1586). The SPT sampler has an approximate 2-inch outside diameter and an approximate 1.38-inch inside diameter. The MC sampler has an approximate 3-inch outside diameter and an approximate 2.4-inch inside diameter.

Both the ring and SPT samplers were mounted on drill rod and driven using a rig-mounted 140-pound automatic hammer falling for a height of 30 inches. The number of blows necessary to drive either a SPT sampler or a MC type ring sampler within the borings was recorded.

Design parameters provided by Earth Systems in this report have considered an estimated 72% hammer efficiency based on data provided by the drilling subcontractor. The number of blows necessary to drive either a SPT sampler or a MC type ring sampler within the borings was recorded. Since the MC sampler was used in our field exploration to collect ring samples, the N-values using the California sampler can be roughly correlated to SPT N-values using a conversion factor that may vary from about 0.5 to 0.7. In general, a conversion factor of approximately 0.63 from a study at the Port of Los Angeles (Zueger and McNeilan, 1998 per SP 117A) is considered satisfactory. A value of 0.63 was applied in our calculations for this project.

Bulk samples of the soil materials were obtained from the drill auger cuttings, representing a mixture of soils encountered at the depths noted. Following drilling, sampling, and logging the borings were backfilled with native cuttings and tamped upon completion. Our field exploration was provided under the direction of a registered Geotechnical Engineer from our firm.

The final logs of the borings represent our interpretation of the contents of the field logs and the results of laboratory testing performed on the samples obtained during the subsurface exploration. The final logs are included in Appendix A of this report. The stratification lines represent the approximate boundaries between soil types, although the transitions may be gradual. In reviewing the logs and legend, the reader should recognize the legend is intended as a guideline only, and there are a number of conditions that may influence the soil characteristics observed during drilling. These include, but are not limited to, the presence of cobbles or boulders, cementation, variations in soil moisture, presence of groundwater, and other factors.

The boring logs present field blowcounts per 6 inches of driven embedment (or portion thereof) for a total driven depth attempted of 18 inches. The blowcounts on the logs are uncorrected (i.e. not corrected for overburden, sampling, etc.). Consequently, the user must correct the blowcounts per standard methodology if they are to be used for design and exercise judgment in interpreting soil characteristics, possibly resulting in soil descriptions that vary somewhat from the legend.

Test Pits

Seven exploratory test pits were excavated using a mechanical backhoe with a 24-inch bucket to a maximum depth of eight feet below existing surface. The test pits were excavated for soil classification purposes. The pits were excavated June 20, 2019. The test pit locations are shown on Plate 2 in Appendix A. The locations shown are approximate, established by pacing and line-of-sight bearings from adjacent landmarks and survey stakes.

A representative from Earth Systems maintained a log of the subsurface conditions encountered and obtained samples for visual observation, classification and laboratory testing. Subsurface conditions encountered in the test pits were categorized and logged in general accordance with the Unified Soil Classification System [USCS] and ASTM D 2487 and 2488 (current edition). Our typical sampling interval within the pits was at the locations of soil change. Samples were obtained within the test pits using a standard shovel collecting from the sides of the test pits and undisturbed block samples.

2.2 Laboratory Testing

Samples were reviewed along with field logs to select those that would be analyzed further. Test results are presented in graphic and tabular form in Appendix B of this report. The tests were conducted in general accordance with the procedures of the American Society for Testing and Materials [ASTM] or other standardized methods as referenced below. Our testing program consisted of the following:

- Density and Moisture Content of select samples of the site soils (ASTM D 2937 & 2216).
- Maximum dry density tests to evaluate the moisture-density relationship of typical soils encountered (ASTM D 1557).
- Particle Size Analysis to classify and evaluate soil composition. The gradation characteristics of selected samples were made by sieve analysis procedures (ASTM D 6913).
- Expansion Index (EI) test to evaluate the expansive nature of the soil. The samples were surcharged under 144 pounds per square foot at moisture content of near 50%

saturation. The samples were then submerged in water for 24 hours and the amount of expansion recorded with a dial indicator (ASTM D 4829).

- Consolidation/Collapse Potential to evaluate the compressibility and hydroconsolidation (collapse) potential of the soil upon wetting (ASTM D 5333).
- Chemical Analyses (Soluble Sulfates and Chlorides (ASTM D 4327), pH (ASTM D 1293), and Electrical Resistivity/Conductivity (ASTM D 1125) to evaluate the potential for adverse effects of the soil on concrete and steel.
- R-Value to evaluate pavement support characteristics (CTM 301)

Section 3
DISCUSSION

3.1 Geologic Setting

Regional Geology: The site lies within the Imperial Valley, a part of the Colorado Desert geomorphic province (see Plate 3). A significant feature within the Colorado Desert geomorphic province is the Salton Trough, a large northwest-trending structural depression that extends approximately 180 miles from the San Gorgonio Pass to the Gulf of California. Much of this depression in the area of the Salton Sea is below sea level.

The Imperial Valley forms the southerly part of the Salton Trough and exhibits a thick sequence of Miocene to Holocene sedimentary deposits. Mountains bounding the Imperial Valley include the Chocolate Mountains to the northeast, the Santa Rosa Mountains to the west, and associated mountain ranges to the southwest, including the Vallecito, Pinyon, Inkopah, and Jacumba Mountains. These mountains expose primarily Precambrian metamorphic and Mesozoic granitic rocks, with some Tertiary sedimentary deposits and volcanics. Other geologic/geomorphic features in the southern Imperial Valley area include the Salton Sea, Sand Hills (Algodones Dunes), East Mesa, West Mesa, and Borrego Badlands. Within the immediate site area, native geologic lithologic units consist of a mix of younger (Holocene) dune sand and alluvium, and Pleistocene alluvial fan (fanglomerates) deposits associated with the western flank of the Chocolate Mountains.

The San Andreas fault zone within the Imperial Valley consists of the San Andreas fault trending along the northeast shore of the Salton Sea which transitions to the southeast into the Brawley Seismic Zone and Imperial fault (Plate 4). Other significant active faults associated with the San Andreas rift zone, west of the Salton Sea, include the extensions and traces of the Elsinore and San Jacinto fault zones. No major active (last 11,700 years) faults are in the immediate vicinity of the site. The San Andreas fault and associated subsidiary faults are considered the primary sources for seismic ground shaking with approximately 15 recognized active faults within 70 miles of Glamis.

Local Geology: The project site is located slightly northeast of the Sand Hills and is located within a mapped area of borderline sedimentary deposit called Pleistocene nonmarine (Qc) and alluvium (Qal), which are associated with deposits from the southwestern flanks of the Chocolate Mountains. Immediately east are the Sand Hills, which is mapped as “Dune Sand” associated with wind-blown deposits. Artificial fill associated with various areas of the project, including building pads, graded parking areas, elevated roadways, railroad beds/right-of-way, and drainage control berms are present. The fills are considered uncompacted and locally contain debris and aggregate base.

Native soils consist of thin deposits of dune sand overlying Quaternary younger and older alluvial deposits. Fills are a mix of locally derived materials. Within the project limits, the thickness of the true dune sand is generally less than two feet thick. Fills vary in thickness, being the thickest for roadways and flood control berms (+10 feet).

There are no active faults currently mapped within the project limits. The nearest mapped faults are the in-active and buried Sand Hills fault, located approximately one mile southwest of the site and several Quaternary faults about 9 miles west of the property (see Regional Fault Map, Plate 4). Several in-active faults within the Chocolate Mountains are located several miles northwest of the site. The nearest mapped active fault zone is the Brawley seismic zone, located approximately 24 miles west of the site, and the Imperial fault located approximately 27 miles west-southwest of the property.

Site Soil Conditions: The field exploration indicates that site soils consist generally of poorly and well graded sand, poorly and well graded sand with silt, silty sand, silty-clayey-sand and poorly graded gravels to the maximum depth of exploration of 51½ feet below the ground surface. These soils have designations of SP, SW, SP-SM, SW-SM, SM, SC-SM, and GP soil types and were classified according to the Unified Soil Classification System. Cobbles and boulders may be present at depth and were noted based on drilling operations. Refusal was not encountered however high blow counts were encountered at shallow depths ranging between 5 and 20 feet below the ground surface (bgs) or greater. Dune sand deposits are relatively thin (<2’) across the site. Fills are considered undocumented and for the most part are probably poorly compact. Clay zones could exist.

The site lies within an area of high potential for wind and water erosion. Fine particulate matter (PM10) can create an air quality hazard if dust is blowing. Watering the surface, planting grass or landscaping, or placing hardscape normally mitigates this hazard.

The boring and trench logs provided in Appendix A include more detailed descriptions of the soils encountered. Site soils are classified as Type C in accordance with Cal OSHA.

3.2 Aerial Image Reconnaissance

Earth Systems reviewed past aerial photographs of the project area. The dates ranged from 1996 to 2018. A summary of our findings is presented below.

- June 1996; the well-known Glamis store is shown along with some improvements or parking use in the northeast portion of the project. Possible structure in the northeast portion;
- April 2004; grading improvements occur on the southwest portion of the site adjacent to the Glamis Store;
- October 2006; possible erosion channels in the middle of the project and south of the Glamis store. Large square object near the northwest portion of the project. Significant use (probably parking) on the southeast portion of the project;
- February 2008; grading and rectangular object observed south of the Glamis Store.
- April 2016; large rectangular object in the southwest portion of the project area.

3.3 Groundwater

This section will discuss both current and past groundwater levels at or near the project site. For this report, we used information dated back to 1979 to use as historic information. Also, this section provides a brief discussion of the moisture contents of the soils found during the exploration and the ability of storm water retention facilities to produce a perched water table.

Recent Exploration Information: Free groundwater was not encountered in borings or test pits during our explorations conducted on January of 2019. Boring depths exceeded 50 feet from the ground surface. Moisture contents observations of the soils indicate the soils are dry to moist.

Perched Water Table: By definition, perched ground water conditions were not observed during our exploration. Observations did not indicate "wet" soils meaning free water was noted on the soil. Impermeable type soils (generally clay) were not found at depths ranging from the ground surface to 50 feet bgs. Moisture contents performed in the lab indicated values between 1 percent and 9 percent, which indicates degrees of saturation less than approximately 50 percent.

Nearby Well Information

We researched the California Department of Water Resources groundwater database and found one well very close to the project. Station Well No. 13S18E33A001S is within one of the project site's APN, APN 039-310-026. The well reading information is provided in Figure 2 below.

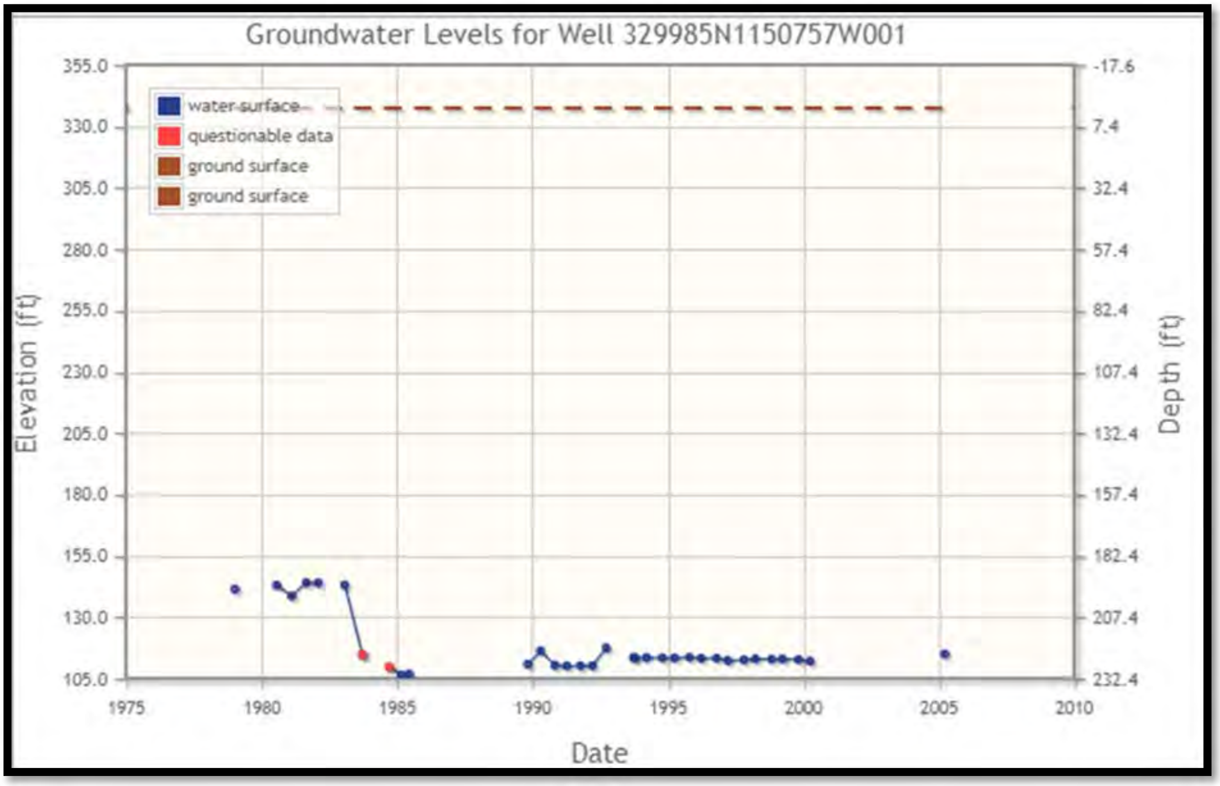


Figure 2 Groundwater Information from Nearby Well

The graph indicates the well readings dropped significantly sometime before 1985 and stayed in generally consistent till 2005. From the tabled data in the State database, the depth the water was approximately 196 feet on 1/10/1979 and 222 feet on 3/24/2005, a difference of 26 feet.

Estimated Project Groundwater Depth

Based on the information provided above, it is anticipated that the current depth of groundwater below the projects surface is over 100 feet. Groundwater levels may fluctuate with precipitation, irrigation, drainage, regional pumping from wells, site grading, and nearby faults.

3.4 Collapse/Consolidation Potential

Collapsible soil deposits generally exist in regions of moisture deficiency. Collapsible soils are generally defined as soils having potential to suddenly decrease in volume upon increase in moisture content even without an increase in external loads. Soils susceptible to collapse include loess, weakly cemented sands and silts where the cementing agent is soluble (e.g. soluble gypsum, halite), valley alluvial deposits within semi-arid to arid climate, and certain granite residual soils above the groundwater table.

In arid climatic regions, granular soils may have a potential to collapse upon wetting. Collapse (hydroconsolidation) may occur when the soluble cements (carbonates) in the soil matrix dissolve, or particles are lubricated causing the soil to densify from its loose configuration from deposition.

The degree of collapse of a soil can be defined by the Collapse Potential [CP] value, which is expressed as a percent of collapse of the total sample using the Collapse Potential Test (ASTM Standard Test Method D 5333). Based on the Naval Facilities Engineering Command (NAVFAC) Design Manual 7.1, the severity of collapse potential is commonly evaluated by the following Table 1, Collapse Potential Values.

Table 1
Collapse Potential Values

Collapse Potential Value	Severity of Problem
0-1%	No Problem
1-5%	Moderate Problem
5-10%	Trouble
10-20%	Severe Trouble
> 20%	Very Severe Trouble

The project site is located in a geologic environment where the potential for collapsible soil exists. For alluvial deposits without cementation, studies suggest some sites with densities above 103 pcf are “not likely to collapse” and N_{60} Values > 10 do not fit into the category of “Likely Collapsible” (Lommler, C. J. and Bandini). In addition, soils with greater than 85 percent relative compaction are compact and not likely to settle, especially after initial inundation. Earth Systems provides key items of interest that supports Earth Systems recommendations regarding collapse settlement determined for this site:

1. Soils are granular in nature and cementation was observed or apparent upon chemical testing

2. Pinhole voids were observed in the field or lab samples.
3. High blow-counts during the exploration were noted, as well as disturbed samples due to high blow counts.
4. High dry densities (Estimated compaction equal or greater than 85%) of the soils located below the over-excavation zone are assumed to have a low potential for collapse.
5. The soils can have a high gravel content; however the soil matrix portion can be susceptible to collapse including differential collapse where gravel content may be higher in differing site areas.
6. Boring B-11 was found to exhibit the worst case for collapsible soils.

The results of eight (8) collapse potential tests were performed on selected single ring samples from different depths and locations and indicated a range of collapse potential on the order of 1.3 to 4.7 percent at an applied vertical stress of 2,000 psf. Additional testing involving maximum density testing along with larger volume in-situ density determination was used to further evaluate the potential of collapse based on larger samples. Based on the larger sample size, the range of collapse potential ranged between on the order of 1.1 to 4.0 percent at an applied vertical stress of 2,000 psf.

Our collapse settlement analysis used an estimated active wetting depth of approximately 15 feet below the existing surface. Based on the analysis and the active wetting depth, the collapse potential zone now ranged between 1.5 percent and 2.7 percent. Earth Systems notes that the potential for collapse is “Moderate” and we evaluated samples within the active wetting zone having a value of 1 to 2.7 percent. Boring B-11 was determined to exhibit the worst case for collapse and was used for settlement analysis due to collapse.

Three estimates of collapse settlement based on three possible grading recommendations are presented: Pavement Recommendations, Building Pad Four Foot Over-excavation, and Building Pad Six Foot Over-Excavation. Please note that collapse settlement is based on the worst case for the samples collected, from boring B-11. The three settlements for the worst-case scenario for the locations tested are provided in the table below:

Table 2

Estimated Settlement due to Hydro Collapse

Grading Recommendation	**General Collapse Settlement (inches)****
Pavement Area*	1
4 Feet Over-Excavation *	⅝
6 Feet Over-Excavation	½

*--Assuming 2 ksf overburden exists during inundation

**--Localized areas where direct water is applied could be significantly greater. These settlements are based upon the limited samples obtained in the site area. Increased water introduction into the site through drywells, infiltrating structures or leach fields/seepage pits could increase the collapse potential and related settlement. Site and structure specific exploration and testing with specific recommendations should be provided via a design-level geotechnical report at each site once plans are developed.

3.5 Expansive Soils

Expansive soils are characterized by their ability to undergo significant volume change (shrink or swell) due to variations in moisture content. Changes in soil moisture content can result from rainfall, landscape irrigation, utility leakage, roof drainage, perched groundwater, drought, or other factors, and may cause unacceptable settlement or heave of structures, concrete slabs supported-on-grade, or pavements supported over these materials. Depending on the extent and location below finished subgrade, expansive soils can have a detrimental effect on structures. Based on our visual observations, site soils were observed to be granular however clayey zones could be present. As such, the Expansion Index of the onsite soils is anticipated to be "very low" for granular soils, and if encountered, could be medium to high for clayey soils as defined by ASTM D 4829. Samples of building pad soils should be observed or tested during grading to confirm or modify these findings.

3.6 Corrosivity

Three samples of the near-surface blended soil and one in situ sample from a depth of 10 feet within the site area were tested for potential to corrosion of concrete and ferrous metals. The tests were conducted in general accordance with the ASTM test methods to evaluate pH, resistivity, and water-soluble sulfate and chloride content. The test results are presented in Appendix B. These tests should be considered as only an indicator of corrosivity for the samples tested. Other earth materials found on site may be more, less, or of a similar corrosive nature. Water-soluble sulfates in soil can react adversely with concrete. ACI 318 provides the relationship between corrosivity to concrete and sulfate concentration, presented in the table below:

Table 3
Sulfate Corrosion Correlations

Water-Soluble Sulfate in Soil (ppm)	Corrosivity to Concrete
0-1,000	Negligible
1,000 – 2,000	Moderate
2,000 – 20,000	Severe
Over 20,000	Very Severe

In general, the lower the pH (the more acidic the environment), the higher the soil corrosivity will be with respect to ferrous structures and utilities. As soil pH increases above 7 (the neutral value), the soil is increasingly more alkaline and less corrosive to buried steel structures, due to protective surface films, which form on steel in high pH environments. A pH between 5 and 8.5 is generally considered relatively passive from a corrosion standpoint. High chloride levels tend to reduce soil resistivity and break down otherwise protective surface deposits, which can result in corrosion of buried steel or reinforced concrete structures. Soil resistivity is a measure of how easily electrical current flows through soils and is the most influential factor. Based on the findings of studies presented in ASTM STP 1013 titled "Effects of Soil Characteristics on

Corrosion" (February, 1989), the approximate relationship between soil resistivity and soil corrosivity was developed as shown in Table 4.

Table 4
Resistivity Corrosion Correlations

Soil Resistivity (Ohm-cm)	Corrosivity to Ferrous Metals
0 to 900	Very Severely Corrosive
900 to 2,300	Severely Corrosive
2,300 to 5,000	Moderately Corrosive
5,000 to 10,000	Mildly Corrosive
10,000 to >100,000	Very Mildly Corrosive

Four samples recovered from our field sampling were tested for pH, Resistivity, Chlorides, and Sulfate Content. Test results (presented in Appendix B) and shown below in Table 5 shows pH values ranging from 7.9 to 8.6, chloride contents from 17 ppm to 808 ppm, sulfate contents from 11 ppm to 348 ppm, and resistivities from 520 Ohm-cm to 6,400 Ohm-cm. Although Earth Systems does not practice corrosion engineering, the corrosion values from the soil tested are normally considered as being "Mildly to Very Severely Corrosive" to buried metals and as possessing a "Negligible" exposure to sulfate attack for concrete as defined in American Concrete Institute (ACI) 318, Section 4.3.

Table 5
Corrosivity Chemical Test Results

Location Boring/Depth	pH	Chloride (ppm)	Sulfate (ppm)	Corrosivity to Concrete	Resistivity Saturated (ohm-cm)	Corrosivity to Ferrous Metals
B2 / 0-5ft	8.3	22	26	Negligible	4,800	Moderately
B13 / 0-5ft	7.9	79	11	Negligible	3,160	Moderately
B18 / 0-5ft	8.2	17	21	Negligible	6,400	Mildly
B19 / 10ft	8.6	808	348	Negligible	520	Very Severely

The above values can potentially change based on several factors, such as importing soil from another job site and the quality of construction water used during grading and subsequent landscape irrigation. As such, an engineer competent in corrosion mitigation should review these results and design corrosion protection appropriately. Additionally, we recommend an engineer competent in corrosion analysis evaluate the results presented in Appendix B in relation to other constituents that may be of concern such as chlorides, nitrates, ammonium, etc.

3.7 Geologic Hazards

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

3.7.1 Seismic Hazards

Seismic Sources: Approximately 15 active faults or seismic zones lie within 70 miles of the project site. The primary seismic hazard to the site is strong ground shaking from earthquakes along regional faults including the Brawley and Imperial faults. The Brawley segment of the San Andreas fault is located approximately 24 miles west of the site. The Imperial segment of the San Andreas fault is located approximately 27 miles west of the site.

Surface Fault Rupture: The project site does not lie within a currently delineated State of California, *Alquist-Priolo* Earthquake Fault Zone (CGS, 2018). Well-delineated fault lines cross through this region as shown on California Geological Survey [CGS] maps (Jennings, 2010); however, no active faults are mapped in the immediate vicinity of the site. Therefore, active fault rupture is unlikely to occur at the project site. While fault rupture would most likely occur along previously established fault traces, future fault rupture could occur at other locations. Aerial photographs from 1961 to 2016 were reviewed and no naturally occurring lineaments were observed within or adjacent to the site. Anthropic lineal features associated with drainage control are common in the site vicinity.

Historic Seismicity: The site is located within a very active seismic area in southern California where large numbers of earthquakes are recorded each year. Approximately 31 magnitude 5.5 or greater earthquakes have occurred within 60 miles of the site since 1852. Significant local Imperial Valley earthquakes have included the 1940 Imperial Valley (6.9), 1942 Fish Creek Mountains (6.6), 1968 Borrego Mountain (6.6), 1979 Imperial (6.4), 1987 Elmore Ranch and Superstition Hills (6.6), and 2010 Baja (7.2) earthquakes, see Table A-2 in the Appendix. Most of the historic earthquakes have occurred along segments of the San Jacinto fault or Brawley seismic zone which produces very regular ground shaking of low (magnitude 1) to higher magnitude as described above. Ground shaking which may be tolerable from a structural design perspective, can have psychological effects that need to be understood by buyers and users of the site.

Seismic Risk: While accurate earthquake predictions are not possible, various agencies have conducted statistical risk analyses. In 2013, the California Geological Survey [CGS] and the United States Geological Survey [USGS] presented new earthquake forecasts for California (USGS UCERF3). We have used these maps in our evaluation of the seismic risk at the site. The recent Working Group of California Earthquake Probabilities (WGCEP, 2014) estimated a 35 to 41 percent conditional probability that a magnitude 6.7 to 7.0 or greater earthquake may occur in 30 years (2014 as base year) along the nearby Coachella segment of the San Andreas fault, 37 to 45 percent for the Brawley seismic zone, 30 to 41 percent for the Imperial fault, and about 5 to 7 percent for the San Jacinto (Superstition Hills section) fault. The revised estimate for an 8+ magnitude earthquake along the local San Andreas fault is about 7%.

The primary seismic risk at the site is a potential earthquake along the Brawley seismic zone and San Andreas, San Jacinto, and Imperial faults that are northwest and west of Glamis. Geologists believe that the San Andreas fault has characteristic earthquakes that result from rupture of each fault segment. The estimated characteristic earthquake is magnitude 8.1 for a multi-segment San

Andreas rupture event. The San Jacinto fault is historically be one of the most active faults in southern California, especially in the southern Imperial Valley and San Jacinto Valley. Multi-segment magnitudes for a San Jacinto fault rupture is approximately 7.9.

3.7.2 Secondary Hazards

Secondary seismic hazards related to ground shaking include soil liquefaction, ground subsidence, tsunamis, flooding, slope instability, erosion and seiches. The site is far inland, so the hazard from tsunamis is non-existent. The site is relatively flat so the hazard from slope instability is not considered a significant issue for this site, except in the near vicinity of dune fields located offsite.

Seiches: A small water storage tank and basin are located approximately 4 miles northeast and upgradient of the project, associated with mining activities. In the event of tank rupture or basin failure due to seiching, there is a remote possibility of some flooding within the defined drainages of the alluvial fan, although it appears, that any runoff would trend southerly of the project, depending on localized drainage courses and man-made modifications to drainage paths.

Soil Liquefaction and Lateral Spreading: Liquefaction is the loss of soil strength from sudden shock (usually earthquake shaking), causing the soil to become a fluid mass. Liquefaction describes a phenomenon in which saturated soil loses shear strength and deforms as a result of increased pore water pressure induced by strong ground shaking during an earthquake. Dissipation of the excess pore pressures will produce volume changes within the liquefied soil layer, which can cause settlement. Shear strength reduction combined with inertial forces from the ground motion may also result in lateral migration (lateral spreading). Factors known to influence liquefaction include soil type, structure, grain size, relative density, confining pressure, depth to groundwater (typically occurs in the upper 50 feet), and the intensity and duration of ground shaking. Soils most susceptible to liquefaction are saturated, loose sandy soils and low plasticity clay and silt. The results of our analyses indicate that groundwater depth is more than 50 feet below the ground surface and therefore liquefaction potential is low.

Dry Seismic Settlement: The amount of dry seismic settlement is dependent on relative density of the soil, ground motion, and earthquake duration. In accordance with current CGS policy (Earth Systems discussion with Jennifer Thornburg, CGS May 2014), we used a site peak ground acceleration of ⅔ $PGA_{M,}$ where PGA_M was found to be 0.39 and an earthquake magnitude of 7.9. Based upon methods presented by Tokimatsu and Seed (1987), the potential for seismically induced dry settlement of soils above the groundwater table and the full soil column heights ranging between 7.5 feet and 50 feet bgs was calculated for all borings. Earth Systems found the largest settlement was less than ⅛ inch due to dry seismic forces found at boring B-11, which had a maximum depth of 50 feet. Although the 50-foot deep boring had the largest settlement, the highest differential settlement occurred for the 25 feet bgs borings (B-15 and B-28). The highest differential settlements was found less than ⅛ inch.

Due to the general uniformity of the soils encountered, seismic settlement is expected to occur on an areal basis and as such per Special Publication 117 (2008), the calculated differential settlement (after Section 5.1 mitigation) between all borings is estimated to be less than ¼ inch.

<u>Ground Subsidence</u>: Based on research of nearby State-monitored groundwater wells, elevations of groundwater and the well ground surface has been generally stable for the last 20 years. Figure 2 in this report indicates the groundwater has deviated approximately 26 feet between 1979 and 2005. As areal subsidence typically occurs on a regional basis and with a large fluctuation of groundwater levels, the effects of subsidence on structures within the site should have a low potential. Based on a USGS web site (https://ca.water.usgs.gov/land_subsidence/california-subsidence-areas.html), the project area is not located within an area of land subsidence in California.

<u>Flooding</u>: The project site lies within two designated FEMA Flood Zones: A and X (see Figure 4) Zone "A" is defined as "Without Base Flood Elevation" and Zone "X" is defined as "Areas of 0.2% annual chance floodplain; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas of less than 1 square mile; and areas protected by levees from 1% annual chance flood." These zones are defined on FEMA Map Number 06025C1125C and 06025C1475C both effective 9/26/2008. The project site is in an area where sheet and concentrated flow and erosion could occur. Appropriate project design by the civil engineer, construction, and maintenance can minimize the sheet flooding potential.

From Section 3.2 of this report, please be aware the 2006 google photo shows what looks like natural storm channel erosion (dry stream beds) present in the middle of the project and south of the Glamis store. Therefore, uncontrolled concentrated flows may exist at or near the project site and debris flow may occur.

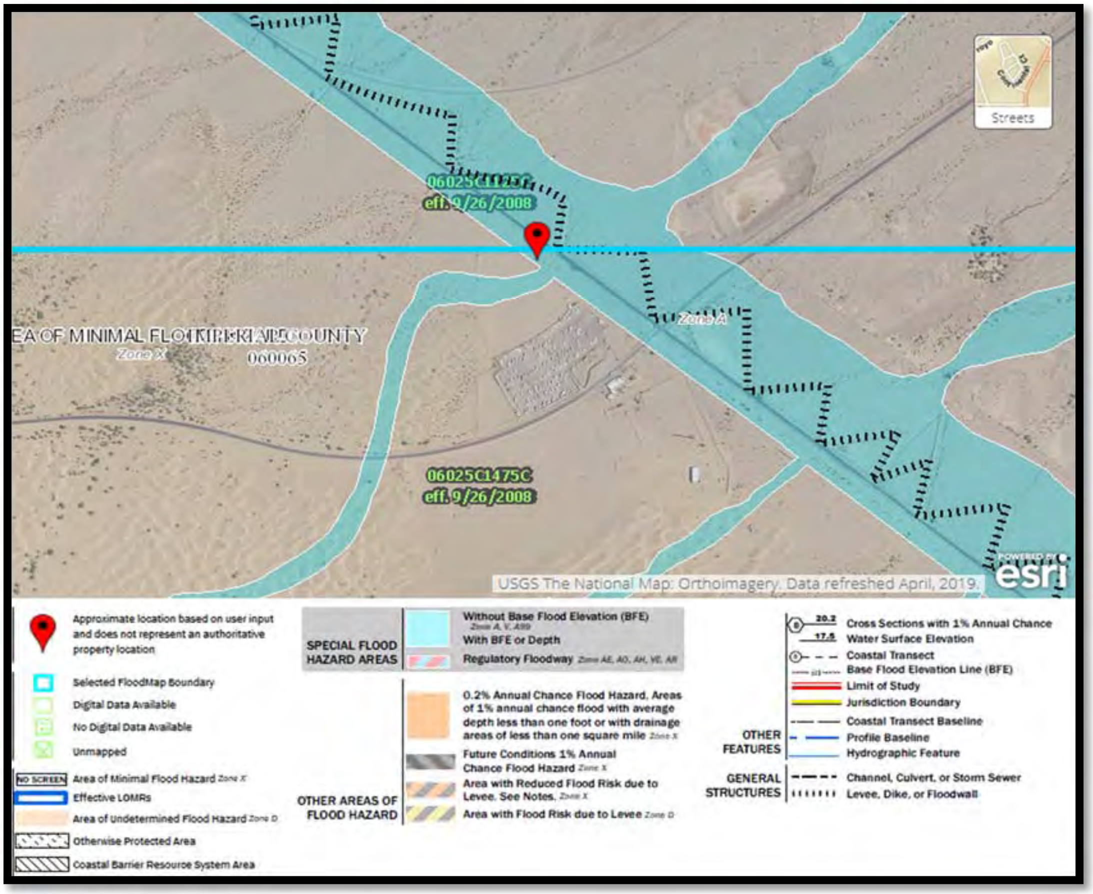


Figure 3 Zone A Flood Boundary

Section 4
CONCLUSIONS

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

General:

- Based on the limited exploration associated with a feasibility study, from a geotechnical feasibility level perspective, the sites are generally suitable for the proposed development as described within, provided further design-level studies are performed to quantify actual design parameters and hazards. Design-level reports will supersede recommendations within. Additionally, site-specific design recommendations may differ from recommendations presented within if differing conditions are found.

Geotechnical Constraints and Mitigation:

- The primary geologic hazard is severe ground shaking from earthquakes originating on regional faults. A major earthquake above magnitude 7 originating on the local segments of the San Andreas, San Jacinto, and Imperial faults, the Brawley seismic zones or other nearby fault zones would be the critical sources for seismic event that may affect the site within the design life of the proposed development. Engineered design and earthquake-resistant construction increase safety and allow development of seismic areas.

- The underlying geologic condition for seismic design is Site Class D. A qualified professional should design any permanent structure constructed on the site. The minimum seismic design should comply with the 2016 edition of the California Building Code.

- The site is about 24 miles from an active seismic source as defined in the California Geological Survey. A qualified professional should design any permanent structure constructed on the site. The minimum seismic design should comply with the 2016 or 2019 edition of the California Building Code.

- The soils are susceptible to wind and water erosion. Preventative measures to reduce seasonal flooding and erosion should be incorporated into site grading plans. Dust control should also be implemented during construction. Site grading should be in strict compliance with the requirements of the South Coast Air Quality Management District [SCAQMD].

- The soils tested have a low to moderate potential for collapse. Preventative measures to reduce collapse should be incorporated into site grading plans. Storm drainage should flow away from foundations per the minimum building code regulations and water conduits should be repaired immediately or the design should follow the potential for maximum collapse not based on an active water depth as assumed in this report. Water introduction into the subsurface should be kept well away from planned structures and improved areas.

- Other geologic hazards, including fault rupture, liquefaction, seismically induced flooding, and lateral spreading are considered low.

- Site soils are generally very low in Expansion Index, but clayey zones could exist that could affect foundation design and grading recommendations. Grading recommendations within require blending of site soils to achieve a “very low” expansion fill soil for support of structures, flatwork, and pavement.

- Site soils are potentially “Very Severely Corrosive” to buried metallic elements and “Negligible” for sulfate exposure. See Section 3.6 for further information. Site soils should be reviewed by an engineer competent in corrosion evaluation.

- Currently the project area is not located within an area of land subsidence in California as described by the USGS. Groundwater overdraft does not appear to be changing significantly. It is important to emphasize increased pumping and continued groundwater pumping may lead to increased subsidence related settlement which is impossible to predict given the current level of information. If differential pumping occurs, subsidence and the damaging effects of differential settlement can occur.

- Site soils are non-uniform and are generally in a loose to very dense condition. Undocumented fill is present. Overexcavation and recompaction is required to reduce the potential for settlement by providing a compacted fill mat below foundations in order to better distribute loading.

- Site soils were generally dry to moist. The addition of significant water for compaction moisture conditioning will likely be required.

Section 5
RECOMMENDATIONS

The recommendations in the following are feasibility level only. More detailed recommendations should be provided in a design-level geotechnical report. The recommendations in the following should not be used for construction unless verified by a design-level report performed by Earth Systems.

5.1 Site Development – General Grading

A representative of Earth Systems should observe site clearing, grading, and the bottoms of excavations before placing fill. Local variations in soil conditions may warrant increasing the depth of recompaction and overexcavation.

Proper geotechnical observation and testing during construction is imperative to allow the geotechnical engineer the opportunity to verify assumptions made during the design process, to verify our geotechnical recommendations from future design-level studies have been properly interpreted and implemented during construction and is required by the 2016 California Building Code. Observation of fill placement by the Geotechnical Engineer of Record should be in conformance with Section 17 of the 2016 California Building Code. California Building Code requires full time observation by the geotechnical consultant during site grading (fill placement). Additionally, the California Building Code requires the testing agency to be employed by the project owner or representative (i.e. architect) to avoid a conflict of interest if employed by the contractor.

Clearing and Grubbing: At the start of site grading, existing vegetation, pavement, septic systems, irrigation systems, undocumented fill, construction debris, foundations, structures, trash, and underground utilities should be removed from the proposed building pad and improvement areas. Onsite soil with deleterious material may be reused if the deleterious material can be removed. Oversize material, trash, debris, vegetation (greater than 1% organic content), etc. should be removed before use as engineered fill.

Undocumented fill, and buried utilities may be located in the vicinity of proposed structures and within other areas of the project site. All buried structures which are removed should have the resultant excavation backfilled with soil compacted as engineered fill described herein or with a minimum 2-sack sand slurry approved by the project geotechnical engineer. Abandoned utilities should be removed entirely, or pressure-filled with concrete or grout and be capped. Abandoned buried utilities structures, or foundations should not extend under building limits.

After stripping and grubbing operations, areas to receive fill should be stripped of loose or soft earth materials until a firm subgrade is exposed, as evaluated by the geotechnical engineer or geologist. Before the placement of fill or after cut, the existing surface soils within the building pads and improvement areas should be over-excavated as follows:

Pad Preparation: Due to the non-uniform and variable low-density of shallow soils and hydro collapse potential, the existing soils within the building pad and foundation areas should be over-excavated a minimum of six feet below existing or finished grade, or four feet below the bottom of the foundation, whichever is lower. The exposed subgrade bottom should be observed and tested by the geotechnical engineer or their representative to verify an in-place density of the subgrade is at or greater than 85% relative compaction per ASTM D 1557 or soils are firm (as determined by the geotechnical engineer). Deeper over-excavation may be recommended if the required in-place density is not achieved or soils are not firm.

Once the subgrade is attained and approved, the surface should be scarified an additional 12 inches, moisture conditioned to near 3% over optimum for an additional 2 feet depth below the scarification to near optimum moisture and recompacted to a minimum of 90% relative compaction per ASTM D 1557. On the bottom of the overexcavation a layer of geogrid such as Terrafix BX3000, or Tensar TX160 should be placed and overlapped at least 3 feet. Placement should be as per the manufacturer's recommendation. Moisture conditioned, compacted engineered fill should then be placed to finished grade in maximum 8-inch thick loose lifts, and be compacted to at least 90% relative compaction prior to the placement of subsequent lifts. The over-excavation should extend for at least 10 feet beyond the outer edge of the building pad and include all exterior footings or slabs, where possible, and include any overhead canopy/or covered walkway and patio areas.

Pad Preparation in High Risk Flood Hazard Areas: Pad preparation in flood hazard areas should follow pad preparation as state previously except for changes note in this section. Fill used to support or protect a structure shall be compacted to at least 95 percent of its maximum modified Proctor density. Structural fill, including side slopes, shall be protected from scouring and erosion under flood conditions up to and including the design flood, (ASCE, 2000, page 9).

Over-excavation depth shall be the minimum stated above or as set forth per the foundation depth described above.

Auxiliary Structures Subgrade Preparation: Auxiliary structures such as CMU/CIP garden or fence walls, trash enclosure, equipment pads, or retaining walls, and slabs-on-grade for support of structures/skids should have the foundation subgrade prepared similar to the building pad recommendations given above depending on their location. The lateral extent of the over-excavation needs only to extend 2 feet beyond the face of the footing. Moisture conditioned, compacted engineered fill should then be placed to finished grade as described above.

Pavement Area Preparation: In street, drive, and permanent parking areas, the exposed subgrade should be over-excavated, scarified, moisture conditioned, and compacted to at least 90% relative compaction (ASTM D 1557) for a depth of 3 feet below existing grade or finish grade (whichever is deeper). The bottom of the overexcavation should be scarified 12 inches and moisture conditioned for an additional depth of 2 feet to near 3% over optimum moisture. Engineered fill should then be moisture conditioned, placed in suitable lifts, and compacted to a minimum of 90% relative compaction to finish grade as described above, with the upper 1 foot compacted to at least 95% relative compaction. Compacted fill should be placed to finish subgrade elevation. Compaction should be verified by testing.

All over-excavations should extend to a depth where the project geologist, engineer or his representative has deemed the exposed soils as being suitable for receiving compacted fill. The materials exposed at the bottom of excavations should be observed by a geotechnical engineer or geologist from our office before the placement of any compacted fill soils to verify all old fill is removed. Additional removals may be required as a result of observation and/or testing of the exposed subgrade after the required over-excavation.

Subgrade Preparation: In areas to receive fill not supporting structures or lightly loaded hardscape (i.e. no vehicle traffic), the subgrade should be overexcavated; moisture conditioned, and compacted to at least 90% relative compaction (ASTM D 1557) for a depth of 1½ feet below existing or finished subgrade, whichever is lower. Compaction should be verified by testing.

Engineered Fill Soils: The native soil (SM, SC, SC-SM, SP-SM, SW-SM, SW, and SP) is suitable for use as engineered fill and utility trench backfill, provided they are free of significant organic or deleterious matter. The native soil and any import should be placed in maximum 8-inch lifts (loose) and compacted to at least 90 percent relative compaction (ASTM D 1557) near its optimum moisture content prior to the placement of subsequent lifts. Soils having low plasticity or designated Clayey Sand (SC) should have their moisture content approximately 2 to 4 percent above optimum moisture content during compaction. Within pavement areas, the upper 12 inches of subgrade should be compacted to a at least 95 percent relative compaction (ASTM D 1557). Compaction should be verified by testing. Rocks larger than 6 inches in greatest dimension should be removed from fill or backfill material.

Within areas to receive foundations and slabs-on-grade the fill should be “very low” in Expansion Index. Expansive soils which are identified should be removed and replaced with low permeability soils which are “very low” in expansion potential or blended with lesser expansive soils to achieve a “very low” expansion fill. Soils which are found to have an Expansive Index greater than “very low” will require differing foundation recommendations for each specific building location which could require redesign.

Imported fill soils (if needed) should be very low in Expansion Index (ASTM D 4829) granular soils meeting the Unified Soil Classification System (USCS) classifications of SM, SP-SM, or SW-SM with a maximum rock size of 3 inches and 5 to 35-percent passing the No. 200 sieve (unless otherwise approved by the geotechnical engineer).

A program of compaction testing, including frequency and method of test, should be developed by the project geotechnical engineer at the time of grading. Acceptable methods of test may include Nuclear methods such as those outlined in ASTM D 6938 (Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods), alternative methods may include methods outlined in ASTM D 1556 (Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method), or correlated hand probing.

Engineered Fill Soils in High Risk Flood Hazard Areas: Engineered fill in flood hazard areas should follow the recommendations stated in the Section above “Engineered Fill Soils” except for changed noted in this section. Structural fill should only be used in flood hazard areas not susceptible to high velocity wave action and other forces capable of eroding the fill. Structural fill used for foundation support and protection should be properly designed, constructed and protected. Guidance on the protection of earth slopes to resist erosion from wave action and/or high flow velocities is available in several U.S. Army Corps of Engineers' publications (U.S. Army Corps of Engineers, 1978, 1984, and 1994).

For low flood velocities (5 ft/s, or less) adjacent to structural fills, fill and slope protection is normally achieved with vegetation or velocity dissipation devices. Calculations showing the slope protection should be performed. Protection against moderate flood velocities (5-8 ft/s) will require the use of stone or other rip-rap (12 inches or greater dimension) materials. Use of structural fill for flow velocities greater than 8 ft/s may not be feasible. The use of piers, posts, columns, or piles may be a more appropriate choice. For geotechnical design requirements for pier, posts, columns, or piles, please contact Earth Systems for additional information. Earth Systems should review precise and structural foundation plans for geotechnical conformance.

Shrinkage and Oversize Losses: Based upon a 95 percent confidence level using 24 in-place soil densities in the upper five feet of soil, three maximum density curves, assuming an average 93% compaction for fill placement, we calculate the shrinkage limits between 1 and 10 percent with a mean shrinkage of 7 percent. One standard deviation from the mean is 5 percent (Negative shrinkage is bulking).

Fugitive Dust: Site soils are generally dry and have a high potential for wind erosion. General requirements for dust control include:

- Utilize continuous to semi-continuous moisture conditioning of disturbed surfaces, including graded areas and haul roads.
- Use best management practices during construction to minimize dust generation, including reduced speeds for vehicular traffic across unpaved areas.
- Terminate dust generating activities when wind speeds exceed 20 mph and employ high-wind dust mitigation protocols during high wind events.
- Use track out devices to eliminate generation of dust onto paved access roads.
- Pave or use gravel surfaces on haul roads.
- Use chemical binders or palliatives on exposed surfaces to maintain surface crusts.
- Cover exposed stock piles.
- Minimize areas of soil disturbance by phased construction practices to avoid large expanses of disturbed land at any given time.

The proposed site lies within an area of high potential for wind erosion. The site soils have a fine-grained component of their composition. As such, exposed soil surfaces may be subject to disturbed fine particulate matter (PM10) which can create airborne dust if the soil surface or roadways are not maintained. During construction, watering the soil surface can reduce airborne dust. Alternatively, a dust control palliative may be spray applied to the soil surface to act as a tackifier which contains loose soil particles. Palliatives must be reapplied periodically as they weather and degrade.

Further guidance for dust palliatives can be found in reviewing the United States Department of Agriculture publication Dust Palliative Selection and Application Guide, Document No. 9977-1207-SDTDC. Soil data related to dust palliative selection is provided in the Guide's Table 3 as shown in Figure 4 below. Earth Systems performed several classification tests on the soil. Plastic Index (PI) are in general less than 3 and fines content vary but are in general between 7 and 30 percent; however, some soils have been classified as clean sands, which have a fines content between 0 and 5 percent. Final observations and possible testing of the disturbed area needing protection should be performed for greater accuracy.

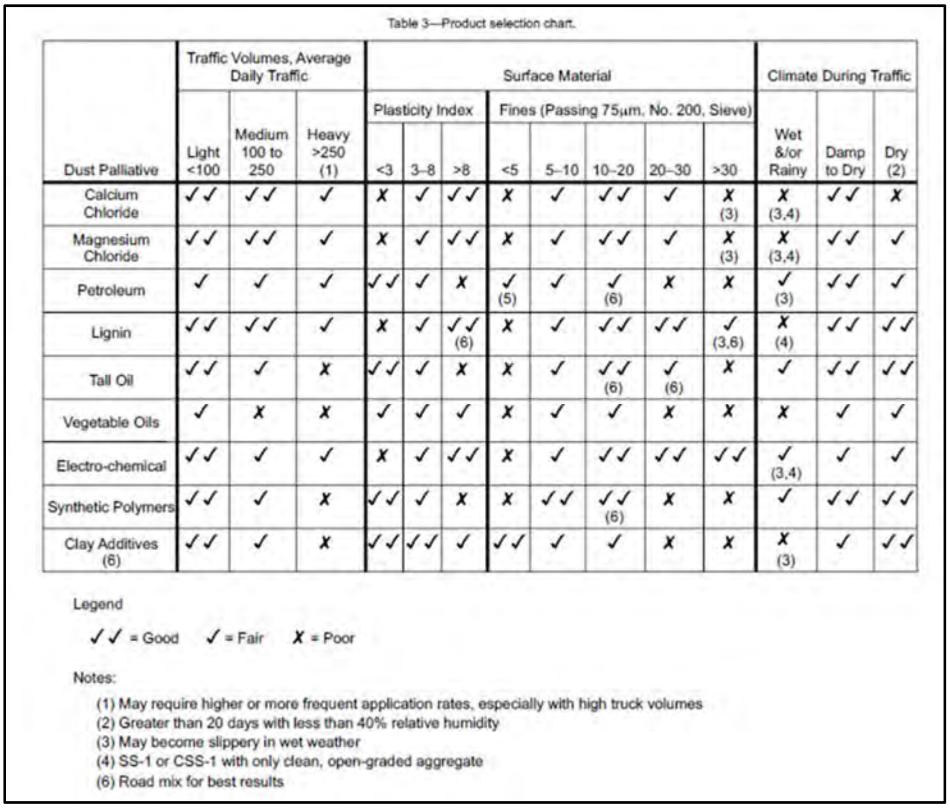


Table 3—Product selection chart.

Dust Palliative	Traffic Volumes, Average Daily Traffic			Surface Material								Climate During Traffic		
				Plasticity Index			Fines (Passing 75µm, No. 200, Sieve)							
	Light <100	Medium 100 to 250	Heavy >250 (1)	<3	3–8	>8	<5	5–10	10–20	20–30	>30	Wet &/or Rainy	Damp to Dry	Dry (2)
Calcium Chloride	✓✓	✓✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓	✗ (3)	✗ (3,4)	✓✓	✗
Magnesium Chloride	✓✓	✓✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓	✗ (3)	✗ (3,4)	✓✓	✓
Petroleum	✓	✓	✓	✓✓	✓	✗	✓ (5)	✓	✓ (6)	✗	✗	✓ (3)	✓✓	✓
Lignin	✓✓	✓✓	✓	✗	✓	✓✓ (6)	✗	✓	✓✓	✓✓	✓ (3,6)	✗ (4)	✓✓	✓✓
Tall Oil	✓✓	✓	✗	✓✓	✓	✗	✗	✓	✓✓ (6)	✓ (6)	✗	✓	✓✓	✓✓
Vegetable Oils	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗	✗	✓	✓
Electro-chemical	✓✓	✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓✓	✓✓	✓ (3,4)	✓	✓
Synthetic Polymers	✓✓	✓	✗	✓✓	✓	✗	✗	✓✓	✓✓ (6)	✗	✗	✓	✓✓	✓✓
Clay Additives (6)	✓✓	✓	✗	✓✓	✓✓	✓	✓✓	✓	✓	✗	✗	✗ (3)	✓	✓✓

Legend

✓✓ = Good ✓ = Fair ✗ = Poor

Notes:

(1) May require higher or more frequent application rates, especially with high truck volumes
(2) Greater than 20 days with less than 40% relative humidity
(3) May become slippery in wet weather
(4) SS-1 or CSS-1 with only clean, open-graded aggregate
(6) Road mix for best results

Figure 4 Excerpt from United States Department of Agriculture (Table 3)

5.2 Excavations

Excavations should be made in accordance with OSHA requirements. Using the OSHA standards and general soil information obtained from the field exploration, classification of the near surface on-site soils will likely be characterized as Type C. Actual classification of site-specific soil type per OSHA specifications as they pertain to trench safety should be based on real-time observations and determinations of exposed soils by the contractor's Competent Person (as defined by OSHA) during grading and trenching operations.

Our site exploration and knowledge of the general area indicates there is a high potential for caving and slaking of site excavations (overexcavation areas, utilities, footings, etc.). Gravels were common in the explorations and cobbles noted during drilling operation. Where excavations over 4 feet deep are planned lateral bracing or appropriate cut slopes of 1½:1 (horizontal/vertical) should be provided. No surcharge loads from stockpiled soils or construction materials should be allowed within a horizontal distance measured from the top of the excavation slope and equal to the depth of the excavation.

Excavations which parallel structures, pavements, or other flatwork, should be planned so that they do not extend into a plane having a downward slope of 1.5:1 (horizontal: vertical) from the bottom edge of the footings, pavements, or flatwork. Shoring or other excavation techniques may be required where these recommendations cannot be satisfied due to space limitations or foundation layout. Where overexcavation will be performed adjacent to existing structures, ABC slot cutting techniques may be used. The width of the slot cuts will depend on the soils encountered at the point of excavation (slot cut widths are generally no greater than 5 to 8 feet and excavated in an alternating A then B, then C pattern to minimize disturbance and undermining to the existing foundations).

Shoring: Shoring may be required where soil conditions, space or other restrictions do not allow a sloped excavation. A braced or cantilevered shoring system may be used.

A temporary cantilevered shoring system should be designed to resist an active earth pressure equivalent to a fluid weighing 50 pounds per cubic foot (pcf). Braced or restrained excavations above the groundwater table should be designed to resist a uniform horizontal equivalent soil pressure of 65 pounds per cubic foot (pcf). The values provided above assume a level ground surface adjacent to the top of the shoring and do not include a factor of safety.

Fifty percent of an areal surcharge placed adjacent to the shoring may be assumed to act as a uniform horizontal pressure against the shoring. Special cases such as combinations of slopes and shoring or other surcharge loads may require an increase in the design values recommended above. These conditions should be evaluated by the project geotechnical engineer on a case-by-case basis.

Cantilevered shoring must extend to a sufficient depth below the excavation bottom to provide the required lateral resistance. We recommend required embedment depths be determined using methods for evaluating sheet pile walls and based on the principles of force and moment equilibrium. For this method, the allowable passive pressure against shoring, which extends below the level of excavation, may be assumed to be equivalent to a fluid weighing 270 pcf. Additionally, we recommend a factor of safety of at least 1.2 be applied to the calculated embedment depth and passive pressure be limited to 2,000 psf.

The contractor should be responsible for the structural design and safety of all temporary shoring systems. The contractor should carefully review the boring logs in this report, and perform their own assessment of potential construction difficulties, and methods should be selected accordingly. The method of excavation and support is ultimately left to the contractor.

A representative from our firm should be present during all site demolition, and clearing and grading operations to monitor site conditions; substantiate proper use of materials; evaluate compaction operations; and verify the recommendations contained herein are met.

5.3 Utility Trenches

Backfill of utilities within roads or public right-of-ways should be placed in conformance with the requirements of the governing agency (water district, public works department, etc.). Utility trench backfill within private property should be placed in conformance with the provisions of this report. Backfill operations should be observed and tested to monitor compliance with these recommendations.

Trench Width and Vertical Loads on Pipelines: Vertical loads to the pipeline are highly dependent upon the geometry of the trench. In general, the narrower the trench is at the top of the pipe/conduit with respect to the diameter of the conduit, the less vertical load is applied to the conduit. This is because as the trench backfill and bedding compress or consolidate over time, the weight of the soil mass is partially offset by the frictional resistance along the trench sidewalls. In addition, the type of bedding supporting the pipeline affects the bearing strength of the conduit. This is accounted by a load factor that is multiplied to the design strength of the conduit. The pipe manufacturer recommendations for trench installation and maximum width should be followed to reduce the potential for overloading the pipe due to excess backfill load.

Pipe Subgrade and Bedding: Pipeline subgrade should be compacted to a minimum of 90% relative compaction (ASTM D 1557) or be in a firm condition as evaluated by the geotechnical engineer or his representative for a depth of 6 inches below any bedding. Bedding material shall consist of sand 100 percent passing a No. 4 sieve and less than 5 percent fines (passing a No. 200 sieve) and a sand equivalent of 30 or more if jetted and a fines content no greater than 15 percent with a sand equivalent of 30 or more if mechanically compacted, or as approved by the project inspector and geotechnical engineer. The unprocessed native soils are not typical of that used for bedding and import will be required if needed. Bedding should be compacted to at least 90% relative compaction or firm (less than 3” insertion of a ½“ probe under typical 200 lb weight).

Pipe-Zone, Trench–Zone, Trench Backfill and Compaction: Backfill of utilities should be placed in conformance with the requirements of the specifications. Backfill of utilities within roads or public right-of-ways should be placed in conformance with the requirements of the governing agency (water district, public works department, etc.).

Pipe zone backfill material (the pipe area from the bedding to 12 inches above the top of pipe) may consist of native soils screened to a ¾” maximum particle size or import sand (as described above for bedding) as dictated by the pipe designer or manufacturer. The pipe zone backfill material should be placed in maximum 8-inch lifts (loose) and compacted near its optimum moisture content. Pipe zone backfill should be compacted to a minimum of 90% relative compaction (ASTM D 1557) or to a firm condition as evaluated by the geotechnical engineer or his representative. Compaction should be assured in the pipe haunches.

The native soil is suitable for use as trench zone and street zone (and manholes) backfill (from the top of pipe zone up to finished grade), provided it is free of significant organic or deleterious matter and oversize materials. This backfill shall contain no particles larger than 3 inches in greatest dimension. The final backfill material should be placed in maximum 8-inch lifts (loose) and compacted to at least 90% relative compaction (ASTM D 1557) near its optimum moisture content for the trench zone and 95% for the street zone (upper 12 inches) where below pavement. Compaction should be verified by testing.

Backfill materials should be brought up at substantially the same rate on both sides of the pipe or conduit. Reduction of the lift thickness may be necessary to achieve the above recommended compaction. Care should be taken to not overstress the piping during compaction operations. Mechanical compaction is recommended; ponding or jetting is not recommended.

Alternatively, if the utility cannot accommodate the increased stress, or if compaction is difficult, we recommend the pipe be encased by at least 1 foot of 1-sack cement-sand slurry (at least 1 foot as measured from the top of pipe). Backfill operations should be observed and tested to monitor compliance with these recommendations.

In general, coarse-grained sand and/or gap graded gravel (i.e. ¾-inch rock or pea-gravel, etc.) should not be used for pipe or trench zone backfill due to the potential for soil migration into the relatively large void spaces present in this type of material and water seepage along trenches backfilled with coarse-grained sand and/or gravel. Water seepage or soil migration will cause settlement of the overlying soils. Rock backfill where permitted should be wrapped in filter fabric such as Mirafi 140N where there is contact with native or other fill soils.

Compaction should be verified by testing. Backfill operations should be observed and tested to monitor compliance with these recommendations. Trench backfill compacted per these requirements can be expected to settle 0.1 to 0.3 percent of the trench depth. This can cause an elevation difference between backfilled trenches and the surrounding soil or pavement. Increased relative compaction can reduce settlement if the potentials presented are not acceptable. The geotechnical engineer should be consulted on a case-by-case basis to provide further recommendations to reduce the settlement potential.

5.4 Slope Construction

Slopes are not generally proposed for this project; however, minor slopes (less than 5 feet in height) may be constructed. Site soils are highly susceptible to erosion. Compacted fill slopes protected against erosion (per approved methods such as significant planting, facing (concrete, soil cement, or similar), or erosion blankets, etc.) should be constructed at 2:1 (horizontal: vertical) or flatter inclinations. Unprotected slopes with exposed native soils at the surface should be expected to require repair after heavy nuisance or storm runoff occurs due to significant erosion. The above slope recommendations may change pending a more in-depth geotechnical evaluation once design plans are developed. Slopes used as nuisance or storm drainage channel slopes which should be no steeper than 3:1.

Compacted fill should be placed at near optimum moisture content and compacted to a minimum 90 percent of the maximum dry unit weight, as measured in relation to ASTM D 1557 test procedures. The exposed face of any cut or fill slope (upper 12 inches) should have a minimum relative density of 90 percent of the maximum dry unit weight, as measured in relation to ASTM D 1557 test procedures, and be compacted at near optimum moisture content. Due to the highly erodible site soils, slope faces should be protected with facing or rip-rap to reduce the erosion potential, or be maintained on a regular basis when erosion occurs.

5.4.1 Surficial Slope Failures

Site soils are highly susceptible to erosion from wind and water sources. All slopes will be exposed to weathering, resulting in decomposition of surficial earth materials, thus potentially reducing shear strength properties of the surficial soils. In addition, these slopes become increasingly susceptible to rodent burrowing. As these slopes deteriorate, they can be expected to become susceptible to surficial instability such as soil slumps, erosion, soil creep, and debris flows. Development areas immediately adjacent to ascending or descending slopes should address future surficial sloughing of soil material and erosion. Such measures may include debris fences, slope facing, catchment areas or walls, diversion ditches or berms, soil planting, velocity reducers or other techniques to contain soil material away from developed areas and reduce erosion. Additionally, foundations should be set back at least 5 feet from the edge of slope or as per the 2016 CBC, whichever is greater. See also Section 5.1 for erosion mitigation recommendations.

Operation and maintenance inspections should be done after a significant rainfall event and on a time-based criteria (annually or less) to evaluate distress such as erosion, slope condition, rodent infestation burrows, etc. Inspections should be recorded and photographs taken to document current conditions. The repair procedure should outline a plan for fixing and maintaining surficial slope failures, erosional areas, gullies, animal burrows, etc. Repair methods could consist of excavating and infilling with compacted soil erosional features, track walking the slope faces with heavy equipment, as determined by the type and size of repair. These repairs should be performed in a prompt manner after their occurrence. Slope inclinations should be maintained and a maintenance program should include identifying areas where slopes begin to steepen. Where future maintenance is not possible, slopes should be faced to reduce the erosion and degradation potential.

Slope faces are highly erodible even if compacted and will gradually erode and move down slope presenting maintenance issues and debris deposited in drainage devices and flatwork areas. The minimum material necessary to support landscaping should be specified by the landscape consultant (typically less than 6 inches).

5.5 Shallow Foundations

In our professional opinion, foundations for the structures proposed (as presented within) could be supported on shallow foundations bearing in properly prepared and compacted soils placed as recommended in Section 5.1. The following recommendations are based on “very low” expansion category soils in the upper 6 feet of subgrade. Soils which are found to be more expansive than a “very low” Expansion Index will require differing foundation requirements which should be provided on a case by case basis.

Footing design of widths, depths, and reinforcing are the responsibility of the Structural Engineer, considering the structural loading and the geotechnical feasibility level parameters given in this report. The recommended minimum footing depth below lowest adjacent grade should be maintained (lowest grade within 2 feet laterally as measured from the foundation bottom). Earth Systems should be retained to observe foundation excavations before placement of reinforcing steel or concrete. Loose soil or construction debris should be removed from footing excavations before placement of concrete. *All footing excavations should be probed for uniformity. Soft or loose zones should be excavated and recompacted to finish foundation bottom subgrade. The bottom of all foundations should be tested to confirm a minimum of 90% relative compaction (ASTM D 1557).*

Slope Setback for Foundations: Earth Systems recommends a minimum setback distance of 5 feet. The 2016 California Building Code provides setback distances for foundations along slopes. Setback distances are measured differently for foundations located above the slope and those located below the slope. For foundations located at the top of the slope, the measurement is taken horizontally from the outside face of the foundation footing to the face of the slope. For foundations located below the slope, the horizontal distance is measured from the face of the structure to the top of the slope. For pools and slopes steeper than 1(H):1(V), please contact Earth System for these setbacks with submittal of detailed information using plan form.

Conventional Spread Foundations: Allowable soil bearing pressures are given below for foundations bearing on recompacted soils as described in Section 5.1. Allowable bearing pressures are net (weight of footing and soil surcharge may be neglected).

- Continuous Wall foundations, 12-inch minimum width and 4-feet maximum width and minimum 18 inches below grade:
  1500 psf for dead plus design live loads

- Pad foundations, 2 x 2 foot minimum and approximately 7 x 7 foot maximum in plan and 24 inches below grade:
  2000 psf for dead plus design live loads

A one-third (⅓) increase in the allowable bearing pressure may be used when calculating resistance to wind or seismic loads as bearing is controlled by tolerable long-term settlement. The allowable bearing values indicated are based on the anticipated maximum loads of 100 kips for isolated spread footings (7’x7’ maximum) and 4 kip/ft for continuous footings. If the anticipated loads exceed these values, the geotechnical engineer must reevaluate the allowable bearing values as the allowable bearing was controlled by the allowable settlement such that total settlement due to static and collapse provides a distortion angle equal or greater than 1:480.

The spacing between any large spread footings should be evaluated by the geotechnical engineer during the plan review stage to confirm or modify the settlement estimates and bearing capacity due to large footings and the influences from adjacent footings. A preliminary analysis suggests spacing the footings (adjacent edge to adjacent edge) a lateral distance from one another of the width of the largest footing from any adjacent footing, such that influence effects are minor.

Maximum foundation sizes given above are based on settlement due to Dead + Sustained Live loads. Transient loads such as earthquake or wind loads are not subject to the stated size limitations; however, the allowable bearing pressure (including ⅓ increase) should be followed considering the relevant foundation sizes given above.

An average modulus of subgrade reaction, k, of 200 pounds per cubic inch (pci) can be used to design lightly loaded footings and slabs founded upon compacted fill. Other foundations such as mat slabs, will require the use of differing modulus of subgrade reaction values than used for lightly loaded slabs.

Minimum Foundation Reinforcement: Minimum reinforcement should be provided by the structural engineer to accommodate the settlement potentials presented within. Minimum reinforcement for continuous wall footings should be four, No. 4 steel reinforcing bars, two placed near the top and two placed near the bottom of the footing. This reinforcing is not intended to supersede any structural requirements provided by the structural engineer.

5.5.1 Estimated Settlements for Foundations

Estimated Settlements for Shallow Foundations: We estimated a total settlement of approximately ⅝ inch based on static loading. Collapse settlement was estimated in Section 3.2 and was found to be approximately ½ inch based on grading recommendation of Section 5.1 (6ft existing and 2ft below footing). Differential settlement from the combination of static and collapse settlement condition is estimated to be less than ¾ inch. As such, considering the differential settlement for the settlement condition (static loading, seismic and collapse) applied over a typical foundation distance of 40 feet, the angular distortion is considered 1:480 which meets the typical allowable of 1:480, which is normally defined as a tolerable level for typical buildings with standard foundations.

Earth Systems should review the foundation plan to review and analyze the actual distortion angles. The structural engineer should submit the plans and column and wall loading for review and analysis.

5.6 Seismic Coefficients

This site may be subject to severe ground shaking due to potential fault movements along regional faults. The site soils are not subject to liquefaction induced bearing failure. As such, the *minimum* seismic design should comply with the 2016 edition of the CBC using the seismic coefficients given in the list below.

Seismic parameters are based upon computation by American Society of Civil Engineers (ASCE) hazard map database, which developed a web interface that uses the USGS web services and retrieve the seismic design data and presents it in a report format. This website does not perform any calculations to the table values. The web site can be located at: https://asce7hazardtool.online and Earth Systems entered the site on July 29, 2019.

2016 CBC (ASCE 7-10 w/ July 2013 errata) Seismic Parameters

Site Location:	32.99677°N/115.07081°W (approximate central site location)
Site Class:	D

Maximum Considered Earthquake [MCE] Ground Motion

Short Period Spectral Response S_s:	0.974 g
1 second Spectral Response, S_1:	0.358 g

Design Earthquake Ground Motion

Short Period Spectral Response, S_{DS}	0.721 g
1 second Spectral Response, S_{D1}	0.402 g
PGA_M	0.39 g

The intent of the CBC lateral force requirements are to provide a structural design that will resist collapse to provide reasonable life safety from a major earthquake, but may experience some structural and nonstructural damage. A fundamental tenet of seismic design is inelastic yielding is allowed to adapt to the seismic demand on the structure. In other words, *damage is allowed*. The CBC lateral force requirements should be considered a *minimum* design. The owner and the designer may evaluate the level of risk and performance that is acceptable. Performance based criteria could be set in the design. The design engineer should exercise special care so that all components of the design are fully met with attention to providing a continuous load path. An adequate quality assurance and control program is urged during project construction to verify the design plans and good construction practices are followed. This is especially important for sites lying close to major seismic sources. Design peak horizontal ground accelerations are estimated to be above 0.4 g. Vertical accelerations are typically 1/3 to 2/3 of the horizontal acceleration but can equal or exceed horizontal accelerations depending upon underlying geologic conditions and basin effects.

Depending upon the extent of structural and geotechnical design of exterior flatwork, walls, utilities, roadways, and other similar site improvements, some damage due to seismic events will occur. We recommend a standard statement for purchasers of the property and within title reports that seismic induced damage may occur. Note that all of southern California in general is in earthquake country. Site developments in southern California are typically not designed to mitigate anticipated seismic events without some damage. In fact, the Building Code is intended to provide Life-Safety performance, not complete damage-free design. In other words, some damage from earthquakes in the form of structural damage, settlement, cracking, and disruption of utilities is expected and that repair after an earthquake event will likely be required. It is not the current standard of care for site developers to fully mitigate all anticipated earthquake induced hazards. It is incumbent on the developer to advise the end-users of the project of the anticipated hazards in the form of disclosure statements during the initial and subsequent purchase processes.

According to literature from Robert W. Day, doors and windows may stick at distortion angles between 1:240 and 1:175. In this situation, a human being could be put in a life-threatening situation. Therefore, Earth Systems recommends the maximum distortion angle using all the settlement conditions including seismic settlements be 1:240. For all settlement conditions excluding seismic settlement, the structure’s maximum distortion angle should be the typical required 1/480.

5.7 Slabs

Subgrade: Concrete slabs-on-grade and flatwork should be supported by compacted soil placed in accordance with Section 5.1 of this report.

Vapor Retarder: In areas of moisture-sensitive floor coverings, coatings, adhesives, underlayment, goods or equipment stored in direct contact with the top of the slab, bare slabs, humidity controlled environments, or climate-controlled cooled environments, an appropriate vapor retarder that maintains a permeance of 0.01 perms or less after ASTM E1745's mandatory conditioning tests should be installed to reduce moisture transmission from the subgrade soil to the slab. For these areas, a vapor retarder (Stego wrap 15-mil thickness or equal) should underlie the floor slabs. If a Class A vapor retarder (ASTM E 1745) is specified, the retarder can be placed directly on non-expansive soil, and be covered with a minimum 2 inches of clean sand.

Clean sand is defined as well or poorly-graded sand (ASTM D 2488) of which less than 5 percent passes the No. 200 sieve and all the material passes a No. 4 sieve. The site soils do not fulfill the criteria to be considered clean sand. Alternatively, the slab designer may consider the use of other vapor retarder systems that are recommended by the American Concrete Institute.

Low-slump concrete should be used to help reduce the potential for concrete shrinkage. The effectiveness of the membrane is dependent upon its quality, the method of overlapping, its protection during construction, the successful sealing of the membrane around utility lines, and sealing the membrane at perimeter terminations and of all penetrations. Capillary breaks, if any, beneath slabs should consist of a minimum of at least four inches of permeable base material (Caltrans) with the following specified gradation.

Table 6

Percent Passing Sieve Size

Sieve Size	Percent Passing
1 inch	100
¾ Inch	90-100
3/8 Inch	40-100
#4	25-40
#8	18-33
#30	5-15
#50	0-7
#200	0-3

Where vapor retarders are placed directly on a gravel capillary break, they should be a minimum of 15 mil thickness. Where concrete is placed directly on the vapor retarder "plastic", proper curing techniques are essential to minimizing the potential of slab edge curl and shrinkage cracking. The edges of slabs can curl upward because of differential shrinkage when the top of the slab dries to lower moisture content than the bottom of the slab. Curling and cracking are caused by the difference in drying shrinkage between the top and bottom of the slab. Curling and cracking can be exacerbated by hot weather, or dry condition concrete placement, even with proper curing techniques.

The following minimum slab recommendations are intended to address geotechnical feasibility level concerns such as potential variations of the subgrade and are not to be construed as superseding any structural design. A design engineer should be retained to provide building specific systems to handle subgrade moisture to ensure compliance with SB800 with regards to moisture and moisture vapor.

Slab Thickness and Reinforcement: Slab thickness and reinforcement of slabs-on-grade are contingent on the recommendations of the structural engineer or architect. Based upon our findings, a modulus of subgrade reaction of approximately 200 pounds per cubic inch can be used in concrete lightly loaded (not mat) slab design for the expected compacted subgrade. Mat slab design will require differing modulus values.

Concrete slabs and flatwork should be a minimum of 5 inches thick (actual, not nominal). If heavily loaded flatwork is proposed (forklift drive areas, heavy racking, etc.), the actual thickness should be designed by the structural engineer utilizing techniques of the American Concrete Institute (ACI) and may be greater than 4 inches in thickness. We suggest the concrete slabs be reinforced with a minimum of No. 3 rebar at 18-inch centers, both horizontal directions, placed at slab mid-height to better resist cracking related offset. Concrete floor slabs may either be monolithically placed with the foundations or doweled (No. 4 bar embedded at least 40 bar diameters) after footing placement. The thickness, location, and reinforcing given are not intended to supersede any structural or corrosion requirements provided by the structural engineer. The project architect or concrete inspector should continually observe all reinforcing steel in slabs during placement of concrete to check for proper location within the slab. These slab recommendations are based on the shallow surface soils having an Expansive Index of “Very Low”, and prior to placement of concrete, the subgrade is presaturated and compacted as recommended within.

Sidewalks: For sidewalks, 6x6 10/10 welded wire fabric or No. 3 rebar at 18 inches on center may be used. Sidewalks should be at least four inches in actual thickness. A minimum concrete gap of three (3) inches should be provided around the steel reinforcing fabric and the edge of the formwork. Reinforcing steel should be placed at mid-height within the sidewalk and placed upon centralizers rather than lifted into place during placement. Flat sheets should be used instead of rolls, as rolls do not allow for accurate locating of the fabric at mid height of the slab. Where the reinforcing steel does not have adequate cover, it will corrode and can fracture the cured concrete and produce unsightly rust discoloration when exposed to the corrosive site soils and landscape water. Fabric should be overlapped at least six inches at joints. Control joints should be provided in all concrete slabs-on-grade at a maximum spacing of approximately four to six feet. All joints should form approximately square patterns to reduce the potential for randomly oriented, contraction cracks. Contraction joints in the slabs should be tooled at the time of the pour or saw cut (¼ of slab depth (1 inch for a 4-inch slab)) within eight hours of concrete placement. Construction (cold) joints should consist of thickened butt joints with one-half inch dowels at 18 inches on center or a thickened keyed-joint to resist vertical deflection at the joint.

Slab-On-Grade Control Joints: Control joints should be provided in all regular concrete slabs-on-grade at a maximum spacing of 24 to 36 times the slab thickness as recommended by American Concrete Institute [ACI] guidelines. All joints should form approximately square patterns to reduce the potential for randomly oriented shrinkage cracks. Control joints in the slabs should be tooled at the time of the concrete placement or saw cut (¼ of slab depth) as soon as practical but not more than 8 hours from concrete placement, or just after the initial set if concrete is exposed to sunny or hot climatic conditions.

Construction (cold) joints should consist of thickened butt joints with ½-inch dowels at 18 inches on center embedded per ACI or a thickened keyed-joint to resist vertical deflection at the joint. All control joints in exterior flatwork should be sealed to reduce the potential of moisture or foreign material intrusion. These procedures will reduce the potential for randomly oriented cracks, but may not prevent them from occurring.

Curing and Quality Control: The contractor should take precautions to reduce the potential of curling and cracking of slabs in this arid desert region using proper batching, placement, and curing methods. Curing is highly affected by temperature, wind, and humidity.

Quality control procedures should be used, including trial batch mix designs, batch plant inspection, and on-site special inspection and testing. Curing should be in accordance with ACI recommendations contained in ACI 211, 304, 305, 308, 309, and 318. Additionally, the concrete should be vibrated during placement. Concrete should be wet cured for at least 7 days with burlap or plastic and not allowed to dry out to minimize surface cracking.

5.8 Retaining Walls and Lateral Earth Pressures

Retaining Walls:

- Retaining walls should be designed for an active soil pressure equivalent to a fluid density of 40 pcf. The active lateral earth pressures are for horizontal (level) backfills using the on-site native soils on walls free to rotate at least 0.1 percent of the wall height. Walls, which are restrained against movement or rotation at the top, should be designed for an at-rest equivalent fluid pressure of 60 pcf. The lateral earth pressure values presented are for level backfill and are provided for walls backfilled with drainage materials and existing on-site soils. Walls retaining sloping backfill or other conditions should be evaluated on a case-by-case basis by the geotechnical engineer.
- In addition to the active or at rest soil pressure, the proposed wall structures (where not excepted) should be designed to include forces from dynamic (seismic) earth pressure. Dynamic pressures are additive to active and at-rest earth pressure and should be considered as 5 pcf for flexible walls, and 10 pcf for rigid walls. Seismic pressures are based on PGA_M (see Section 5.5) and the near fault location of the site.
- Retaining wall foundations should be placed upon compacted fill described in Section 5.1.
- A backdrain or an equivalent system of backfill drainage should be incorporated into the wall design, whereby the collected water is conveyed to an approved point of discharge. Design should be in accordance with the 2016 California Building Code. Drain rock (1 cubic foot per foot) should be wrapped in filter fabric such as Mirafi 140N as a minimum.

Backfill immediately behind the retaining structure should be a free-draining granular. Waterproofing should be according to the designer's specifications. Water should not be allowed to pond or infiltrate near the top of the wall. To accomplish this, the final backfill grade should divert water away from retaining walls.

- Compaction on the retained side of the wall within a horizontal distance equal to one wall height (to a maximum of six feet) should be performed by hand-operated or other lightweight compaction equipment (90% compaction relative to ASTM D 1557 at near optimum moisture content). This is intended to reduce potential locked-in lateral pressures caused by compaction with heavy grading equipment or dislodging modular block type walls.
- The above recommended values do not include compaction or truck-induced wall pressures. Care must be taken during the compaction operation not to overstress the wall. Heavy construction equipment should be maintained a distance of at least six feet away from the walls while the backfill soils are placed. Upward sloping backfill or surcharge loads from nearby footings can create larger lateral pressures. Should any walls be considered for retaining sloped backfill or placed next to foundations, our office should be contacted for recommended design parameters. Surcharge loads should be considered if they exist within a zone between the face of the wall and a plane projected 45 degrees upward from the base of the wall. The increase in lateral earth pressure should be taken as 50% of the surcharge load within this zone. Retaining walls subjected to traffic loads should include a uniform surcharge load equivalent of 240 psf for auto and 450 psf for truck traffic located at least three feet from the wall back edge. Retaining walls should be designed with a minimum factor of safety of 1.5.

<u>Frictional and Lateral Coefficients</u>:

- Resistance to lateral loads (including those due to wind or seismic forces) may be provided by frictional resistance between the bottom of concrete foundations and the underlying soil, and by passive soil pressure against the foundations. An allowable coefficient of friction of 0.30 may be used between cast-in-place concrete foundations and slabs and the underlying soil. An allowable coefficient of friction of 0.25 may be used between pre-cast or formed concrete foundations and slabs and the underlying soil
- Allowable passive pressure may be taken as equivalent to the pressure exerted by a fluid weighing 275 pounds per cubic foot (pcf). Vertical uplift resistance may consider a soil unit weight of 105 pounds per cubic foot. The upper one foot of soil should not be considered when calculating passive pressure unless confined by overlying asphalt concrete pavement or Portland cement concrete slab. The soils pressures presented have considered onsite fill soils. Testing or observation should be performed during grading by the soils engineer or his representative to confirm or revise the presented values.
- Passive resistance for thrust blocks bearing against firm natural soil or properly compacted backfill can be calculated using an equivalent fluid pressure of 275 pcf. The maximum passive resistance should not exceed 2,000 psf.

- Construction employing poles or posts (i.e. lamp posts) may utilize design methods presented in Section 1807.3 of the CBC for sand (SM) material class for lateral and axial resistance.
- The passive resistance of the subsurface soils will diminish or be non-existent if trench sidewalls slough, cave, or are over widened during or following excavations. If this condition is encountered, our firm should be notified to review the condition and provide remedial recommendations, if warranted.

5.9 Site Drainage, Infiltration, and Maintenance

Positive drainage in native soils should be maintained away from the structures (5 percent for 10 feet minimum) to prevent ponding and subsequent saturation of the foundation soils. Gutters and downspouts in conjunction with a 1 to 2% paved or hardscape grade should be considered as a means to convey water away from foundations if increased fall is not provided.

Drainage should be maintained for all areas. Water should not pond on or near paved areas or foundations. The following recommendations are provided in regard to site drainage and structure performance:

- In no instance should water be allowed to flow or pond against structures, slabs or foundations or flow over unprotected slope faces. Adequate provisions should be employed to control and limit moisture changes in the subgrade beneath foundations or structures to reduce the potential for soil saturation and erosion. Landscape borders should not act as traps for water within landscape areas. Potential sources of water such as piping, drains, broken sprinklers, etc., should be frequently examined for leakage or plugging. Any such leakage or plugging should be immediately repaired.
- It is highly recommended landscape irrigation or other sources of water be collected and conducted to an approved drainage device. Landscaping and drainage grades should be lowered and sloped such that water drains to appropriate collection and disposal areas. All runoff water should be controlled, collected, and drained into proper drain outlets. Control methods may include curbing, ribbon gutters, 'V' ditches, or other suitable containment and redirection devices.
- Drywells, seepage pits, leach fields, washout areas, showers, condensate lines, infiltrating structures, or similar measures which infiltrate water into the subgrade soil should be located or drain at least 75 feet away from structures or improvements where excessive settlement is a concern.
- Maintenance of drainage systems and infiltration structures (basins) can be the most critical element in determining the success of a design. They must be protected and maintained from sediment-laden water both during and after construction to prevent clogging of the surficial soils and any filter medium. The potential for clogging can be reduced by pre-treating structure inflow through the installation of maintainable forebays, biofilters, or sedimentation chambers. In addition, sediment, leaves, and debris must be removed from inlets and traps and basin bottoms on a regular basis, and basin bottoms must have silt soils removed periodically from the bottom.

- The drainage pattern should be established at the time of final grading and maintained throughout the life of the project. Additionally, drainage structures should be maintained (including the de-clogging of piping, basin bottom scarification and removal, etc.) throughout their design life. Maintenance of these structures should be incorporated into the facility operation and maintenance manual. Structural performance is dependent on many drainage-related factors such as landscaping, irrigation, lateral drainage patterns and other improvements.

5.10 Streets, Driveways and Parking Areas

Preliminary pavement structural sections for associated drive areas including recommendations for standard asphalt concrete, and Portland cement concrete are provided below.

Pavement Area Preparation: In street, drive, and parking areas, the exposed subgrade should be overexcavated as recommended in Section 5.1, moisture conditioned, and compacted. Compaction should be verified by testing. Aggregate base should be compacted to a minimum 95% relative compaction (ASTM D 1557).

Automobile Traffic and Parking Areas: Pavement sections presented in the following Table for automobile type traffic areas with typical highway type tires and are based on a tested R-value and current Caltrans design procedures. Traffic Indices (TI) of 5 and 7 were used to facilitate the design of asphalt concrete pavements for parking and main drives. The TI's assumed below should be reviewed by the project Civil Engineer to evaluate the suitability for this project. All design should be based upon an appropriately selected Traffic Index. Changes in the traffic indices will affect the corresponding pavement section.

Table 7

Preliminary Flexible Pavement Section Recommendations
Onsite/Interior Automobile Drive Areas

R-Value of Subgrade Soils – Greater than 60 (tested) Design Method – CALTRANS

Traffic Index (Assumed)	**Pavement Use**	**Flexible Pavements**	
		Asphaltic Asphalt-Concrete Thickness (inches)	**Aggregate Aggregate Base Thickness (inches)**
5	Parking Areas	3.0	4.0
7	Drive Areas	4.0	4.0

The presented Traffic Indices should be confirmed by the project civil engineer. Changes to the Traffic Index will result in a differing pavement section required.

Conventional, rigid pavements, i.e. Portland cement concrete (PCC) pavements, can be used in areas subject to relatively high static wheel loads and/or heavy vehicle loading and unloading and turning areas (i.e. truck/bus lanes). The pavement section below is based upon the American Concrete Institute (ACI) *Guide for Construction of Concrete Parking Lots, ACI 330R*, and the assumptions outlined below.

Table 8

Preliminary Portland Cement Concrete Pavement Sections

Areas	Minimum Pavement PCC Thickness (inches)	Minimum 28-Day Flexural Strength (psi)	Concrete-Compressive Strength (psi)
Truck Access or Loading/Unloading Areas (Traffic Category D, ADTT =700)	7.0*	550	3,650

Modulus of Subgrade Reaction drive area fill, k = 200 pci

*Concrete Pavement may be placed directly on the compacted subgrade (minimum 95% relative compaction ASTM D 1557)

Should the actual traffic category vary from those assumed and listed above, these sections should be modified. All above recommended preliminary pavement sections are contingent on the following recommendations being implemented during construction:

- Pavement should be placed upon compacted fill processed as described in Section 5.1. The upper 12 inches of subgrade soils beneath the asphalt concrete and conventional PCC pavement section should be compacted to a minimum of 95 percent relative compaction (ASTM D 1557).
- Subgrade soils and aggregate base should be in a stable, non-pumping condition at the time of placement and compaction. Exposed subgrades should be proof-rolled to verify the absence of soft or unstable zones.
- Aggregate base materials should be compacted at near optimum moisture content to at least 95 percent relative compaction (ASTM D 1557) and should conform to Caltrans Class II criteria. Compaction efforts should include proof-rolling of the aggregate base with heavy compaction-specific equipment (i.e. drum rollers).
- All concrete curbs separating pavement from landscaped areas should extend at least 6 inches into the subgrade soils to reduce the potential for movement of moisture into the aggregate base layer (this reduces the risk of pavement failures due to subsurface water originating from landscaped areas).
- Asphaltic concrete should be ½-in. or ¾-in. grading and compacted to a minimum of 95% of the 75-blow Marshall density (ASTM D 1559) or equivalent.
- Portland cement concrete pavements should be constructed with transverse joints at maximum spacing of 12 feet. A thickened edge should be used where possible and, as a minimum, where concrete pavements abut asphalt pavements. The thickened edge should be 1.2 times the thickness of the pavement (8.4 inches for a 7-inch pavement), and should taper back to the pavement thickness over a horizontal distance on the order of 3 feet.
- All longitudinal or transverse control joints should be constructed by hand forming or placing pre-molded filler such as "zip strips." Expansion joints should be used to isolate fixed objects abutting or within the pavement area.

The expansion joint should extend the full depth of the PCC pavement. Joints should run continuously and extend through integral curbs and thickened edges. We recommend joint layout be adjusted to coincide with the corners of objects and structures. In addition, the following is recommended for concrete pavements:

1. Slope pavement at least ½ percent to provide drainage;
2. Provide rough surface texture for traction;
3. Cure PCC concrete with curing compound or keep continuously moist for a minimum of seven days;
4. Keep all traffic off concrete until PCC compressive strength exceeds 2,000 pounds per square inch (truck traffic should be limited until the concrete meets the design strength (3,650 psi); and
5. Consideration should be given to having PCC construction joints keyed or using slip dowels on 24-inch centers to strengthen control and construction joints. Dowels placed within dowel baskets should be incorporated into the concrete at each saw-cut control joint (i.e. dowel baskets and dowels are set in place before placement of concrete).

- Portland cement concrete placement and curing should, at a minimum, be in accordance with the American Concrete Institute [ACI] recommendations contained in ACI 211, 304, 305, 308, 309, and 318.
- Within the structural pavement section areas, positive drainage (both surface and subsurface) should be provided. In no instance should water be allowed to pond on the pavement. Roadway performance depends greatly on how well runoff water drains from the site. This drainage should be maintained both during construction and over the entire life of the project.
- Proper methods, such as hot-sealing or caulking, should be employed to limit water or sand infiltration into concrete joints and the pavement base course and/or subgrade at construction/expansion joints and/or between existing and reconstructed asphalt concrete sections (if any). Water or sand infiltration could lead to premature pavement failure, or “walking” slabs from thermal loading.
- To reduce the potential for detrimental settlement, excess soil material, and/or fill material removed during any footing or utility trench excavation, should not be spread or placed over compacted finished grade soils unless subsequently compacted to at least 95 percent of the maximum dry unit weight, as evaluated by ASTM D 1557 test procedure, at near optimum moisture content, if placed under areas designated for pavement.
- Where new roadways will be installed against existing roadways, the repaired asphalt concrete pavement section should be designed and constructed to have at least the pavement and aggregate base section as the original pavement section thickness (for both AC and base) or upon the newly calculated pavement sections presented within, whichever is greater.

The appropriate pavement design section depends primarily on the shear strength of the subgrade soil exposed after grading and anticipated traffic over the useful life of the pavement.

R-value testing or observation of subgrade soils should be performed during grading to verify and/or modify the preliminary pavement sections presented within this report. Pavement designs assume heavy construction traffic will not be allowed on base cap or finished pavement sections.

Section 6
LIMITATIONS AND ADDITIONAL SERVICES

6.1 Uniformity of Conditions and Limitations

Our evaluation of subsurface conditions at the site has considered subgrade soil and groundwater conditions present at the time of our study. The influence(s) of post-construction changes to these conditions such as introduction or removal of water into or from the subsurface will likely influence future performance of the proposed project. The magnitude of the introduction or removal, and the effect on the surface and subsurface soils is currently unknown.

It should be recognized that definition and evaluation of subsurface conditions are difficult. Judgments leading to conclusions and recommendations are generally made with incomplete knowledge of the subsurface conditions due to the limitation of data from field studies. The availability and broadening of knowledge and professional standards applicable to engineering services are continually evolving. As such, our services are intended to provide the Client with a source of professional advice, opinions and recommendations based on the information available as applicable to the project location and scope. Recommendations contained in this report are based on our field observations and subsurface explorations, select published documents (referenced), and our present knowledge of the proposed construction. If the scope of the proposed construction changes from that described in this report, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed, and the conclusions of this report are modified or approved in writing by Earth Systems.

Final grading and foundation plans were not available for our review before the preparation of this report, and therefore, the recommendations presented within may change pending a review of grading and foundation plans or proposed site use as this report is considered Feasibility Level. Recommendations presented in this report should not be extrapolated to other areas or be used for other projects without our prior review. This report is not valid for final site or structure design as it is feasibility only. Design-level report(s) should be prepared once plans are developed.

Findings of this report are valid as of the issued date of the report and are strictly for the client. Changes in conditions of a property can occur with passage of time, whether they are from natural processes or works of man, on this or adjoining properties. In addition, changes in applicable standards occur, whether they result from legislation or broadening of knowledge. Accordingly, findings of this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and should not be relied upon after a period of one year. Land use, site conditions (both on site and off site) or other factors may change over time, and additional work may be required with the passage of time.

If during construction or further exploration, soil conditions are encountered which differ from those described herein, we should be notified immediately in order that a review may be made and any supplemental recommendations provided. In such an event, the contractor should promptly notify the owner so that Earth Systems geotechnical engineer can be contacted to confirm those conditions. We recommend the contractor describe the nature and extent of the differing conditions in writing and that the construction contract include provisions for dealing with differing conditions. Contingency funds should be reserved for potential problems during earthwork and foundation construction.

This report is issued with the understanding that the owner or the owner's representative has the responsibility to bring the information and recommendations contained herein to the attention of the architect and engineers for the project so that they are reviewed for applicability and conformance to the current design and incorporated into the plans for the project. Earth Systems has striven to provide our services in accordance with generally accepted geotechnical engineering practices in this locality at this time. No warranty or guarantee, express or implied, is made. This report was prepared for the exclusive use of the Client and the Client's authorized agents.

Demolition, grading and compaction operations should be performed in conjunction with observation and testing. The recommendations provided in this report are based on the assumption that design-level reports will be prepared and Earth Systems will be retained to provide observation during the construction phase to evaluate our recommendations in relation to the apparent site conditions at that time. If we are not accorded this observation or if design-level reports are not prepared, Earth Systems assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, the Client must obtain written approval from Earth Systems engineer that such changes do not affect our recommendations. Failure to do so will vitiate Earth Systems recommendations. These services will be performed on a time and expense basis in accordance with our agreed upon fee schedule once we are authorized and contracted to proceed. Maintaining Earth Systems as the geotechnical consultant from beginning to end of the project will provide continuity of services. *The geotechnical engineering firm providing tests and observations shall assume the responsibility of Geotechnical Engineer of Record.*

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

6.2 Additional Services

This report is based on the assumption that an adequate program of client consultation, design reports, construction monitoring, and testing will be performed during the final design and construction phases to check compliance with these recommendations. Maintaining Earth System as the geotechnical consultant from beginning to end of the project will provide continuity of services. Proper geotechnical observation and testing during construction is imperative to allow the geotechnical engineer the opportunity to verify assumptions made during the design process and to verify that our geotechnical recommendations have been properly interpreted and implemented during construction and is required by the 2016 California Building Code. Therefore, we recommend that Earth Systems be retained during the construction of the proposed improvements to provide testing and observe compliance with the design concepts and geotechnical recommendations, and to allow design changes in the event that subsurface conditions or methods of construction differ from those assumed while completing our previous study. Additionally, the California Building Codes requires the testing agency to be employed by the project owner or representative (i.e. architect) to avoid a conflict of interest if employed by the contractor.

Construction monitoring and testing would be additional services provided by our firm. The costs of these services are not included in our present fee arrangements, but can be obtained from our office. The recommended review, tests, and observations include, but are not necessarily limited to, the following:

- Consultation during the final design stages of the project.
- Preparation of design-level reports.
- A review of the building and grading plans to observe that recommendations of our report have been properly implemented into the design.
- Observation and testing during site preparation, grading, and placement of engineered fill and Special Inspection as required by CBC Sections or local grading ordinances.
- Consultation as needed during construction.

-o0o-

Appendices as cited are attached and complete this report.

REFERENCES

Al Atik, L., and Sitar, N., 2010, Seismic Earth Pressures on Cantilever Retaining Structures, Journal of Geotechnical and Geoenvironmental Engineering, ASCE.

American Concrete Institute (1992) "Guide for Design and Construction of Concrete Parking Lots (ACI 330R.01) (Reapproved 1997)."

American Concrete Institute (2014) "Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)."

American Society of Civil Engineers [ASCE], 2000, Flood Resistant Design and Construction, Structural Engineering Institute, American Society of Engineers, SEI/ASCE 24-98, 2000, paperback, 58 pages.

American Society of Civil Engineers [ASCE], 2010, Minimum Design Loads for Buildings and Other Structures, ASCE 7-10.

American Society for Testing Materials, 1989, STP 1013, Effects of Soil Characteristics on Corrosion (February, 1989).

Boulanger, R. W., and Idriss, I. M., 2006, Liquefaction susceptibility criteria for silts and clays, J. Geotechnical and Geoenvironmental Eng., ASCE 132 (11), 1413-1426.

Bowles, J.E., 1988, Foundation Analysis and Design, Fourth Edition, McGraw-Hill Book Company.

California Geological Survey-SP117A, 2008, Guidelines for Evaluating and Mitigating Seismic Hazards in California.

California Geological Survey [CGS], 1992, Geologic Map of California, Salton Sea Sheet, Olaf P Jenkins Edition, scale 1:250,000.

California Geological Survey, 2008, Ground Motion Interpolator: https://www.conservation.ca.gov/cgs/ground-motion-interpolator.

California Geological Survey, 2018, Earthquake Fault Zones, Special Publication 42, revise 2018.

County of Imperial, 2019, Geographic Information Services (GIS), Imperial County Assessor's Office, https://geoviewer.io/maps?t=2cf2cfe02f0240cb8e8f2aaedb86cc9f.

County of Imperial, Seismic and Public Safety Element, Planning/Building Department.

Dept. of the Navy, 1986, NAVFAC DM 7.01: Soil Mechanics, Naval Facilities Engineering Command, Alexandria, Virginia.

Dept. of the Navy, 1986, NAVFAC DM 7.02: Foundations and Earth Structures, Naval Facilities Engineering Command, Alexandria, Virginia.

FEMA, 2019, Map Service Center website http*:// msc.fema.gov/*

Field, E.H., Biasi, G.P., Bird, P., Dawson, T.E., Felzer, K.R., Jackson, D.D., Johnson, K.M., Jordan, T.H., Madden, C., Michael, A.J., Milner, K.R., Page, M.T., Parsons, T., Powers, P.M., Shaw, B.E., Thatcher, W.R., Weldon, R.J., II, and Zeng, Y., 2013, Uniform California earthquake rupture forecast, version 3 (UCERF3)—The time-independent model: U.S. Geological Survey Open-File Report 2013–1165, 97 p., California Geological Survey Special Report 228, and Southern California Earthquake Center Publication 1792, http://pubs.usgs.gov/of/2013/1165/.

Google Earth, 2019, Aerial Photograph Library, 1996-2018

Historic Aerials, 2019, Viewer website: https://www.historicaerials.com/viewer.

Hunt, Roy E., 1984, Geotechnical Engineering Practice, McGraw-Hill Book Company.

International Code Council [ICC], 2016, California Building Code, 2016 Edition.

Jennings, C.W, 2010, Fault Activity Map of California: California Geologic Survey, Geological Data Map No. 6, scale 1:750,000.

Southern California Earthquake Center (S.C.E.C.), 1999, Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California: available at web site: http://www.scecdc.scec.org.

Tokimatsu, K, and Seed, H.B., 1987, Evaluation of Settlements in Sands Due To Earthquake Shaking, ASCE, Journal of Geotechnical Engineering, Vol. 113, No. 8, August 1987.

United States Geologic Survey, 2015, Design Maps website: http://ehp3-earthquake.wr.usgs.gov/designmaps/.

U.S. Army Corps of Engineers. 1978. Design and Construction of Levees, Engineer Manual EM 1110-2-1913, Washington D.C.

U.S. Army Corps of Engineers. 1984. Shore Protection Manual, Washington, D.C.

U.S. Army Corps of Engineers. 1994. Earth and Rock-Fill Dams, Engineer Manual EM 1110-2-2300, Washington D.C.

Youd, T.L., and Idriss, I.M., 2001, Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 127, No. 10, October 2001.

APPENDIX A

LEGEND

⬚ Approximate Site Boundary

Approximate Scale: 1" = 1 Mile

0 1 Mile 2 Miles

N

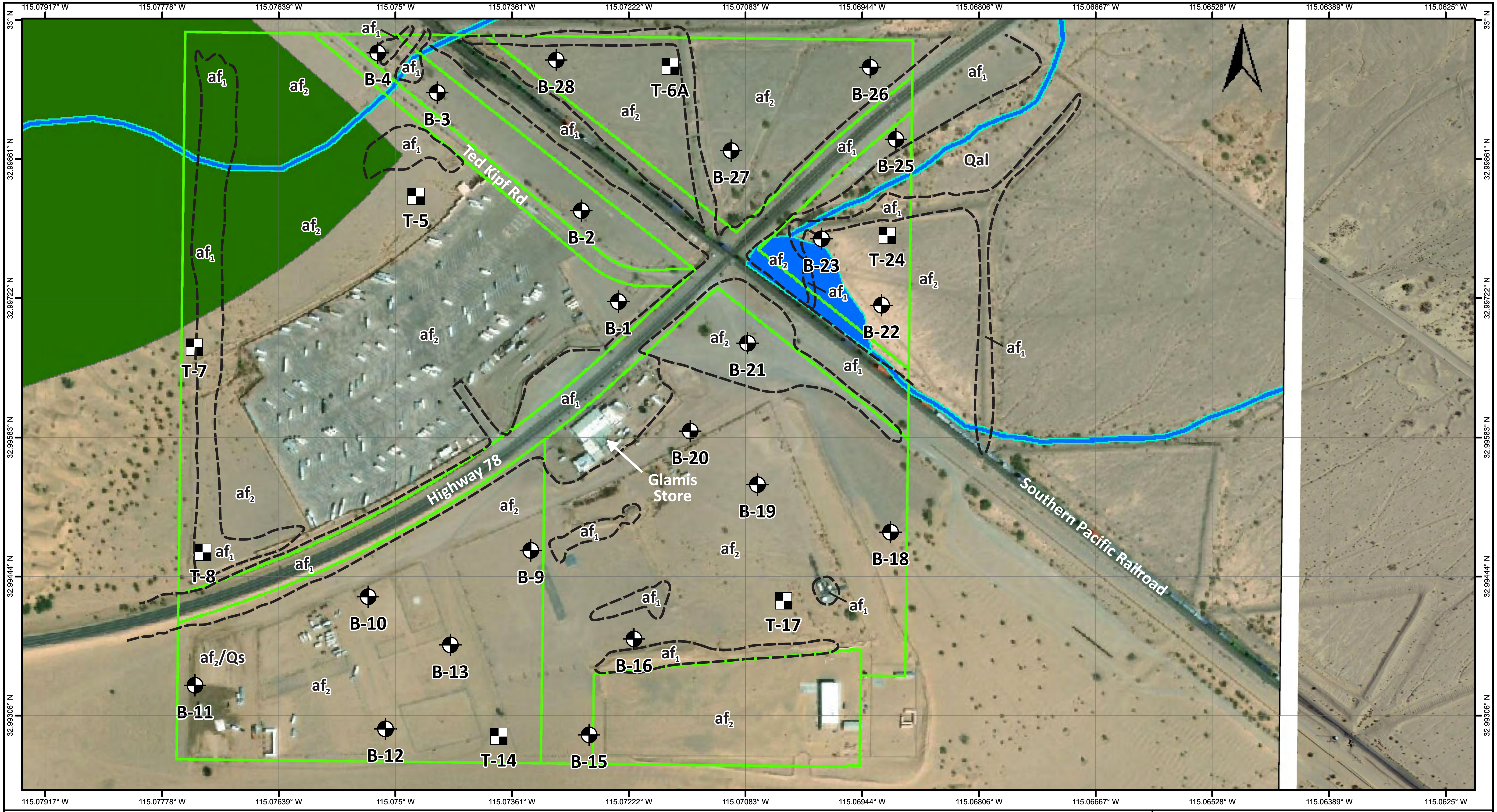
Reference: Google Earth satellite image dated with USGS topographic map overlay.

Plate 1
Site Vicinity Map

Proposed Glamis Specific Plan Project
Highway 78 & Ted Kipf Road
Glamis, Imperial County, California

Earth Systems

8/29/2019	File No.: 303235-001



LEGEND

af$_1$	Artificial Fill - Roadway & Berms
af$_2$	Artificial Fill - Disturbed Surface w/Minor Fill Thickness (<2-3')
Qs	Quaternary Younger Alluvium
Qal	Quaternary Dune Sand
⊕	Approximate Boring Locations
▚	Approximate Test Pit Locations
—	Approximate Project Boundary
🟦	CA Wetlands South
🟩	North Algodones Dunes Wilderness

0 155 310 620 930 1,240 1,550 Feet

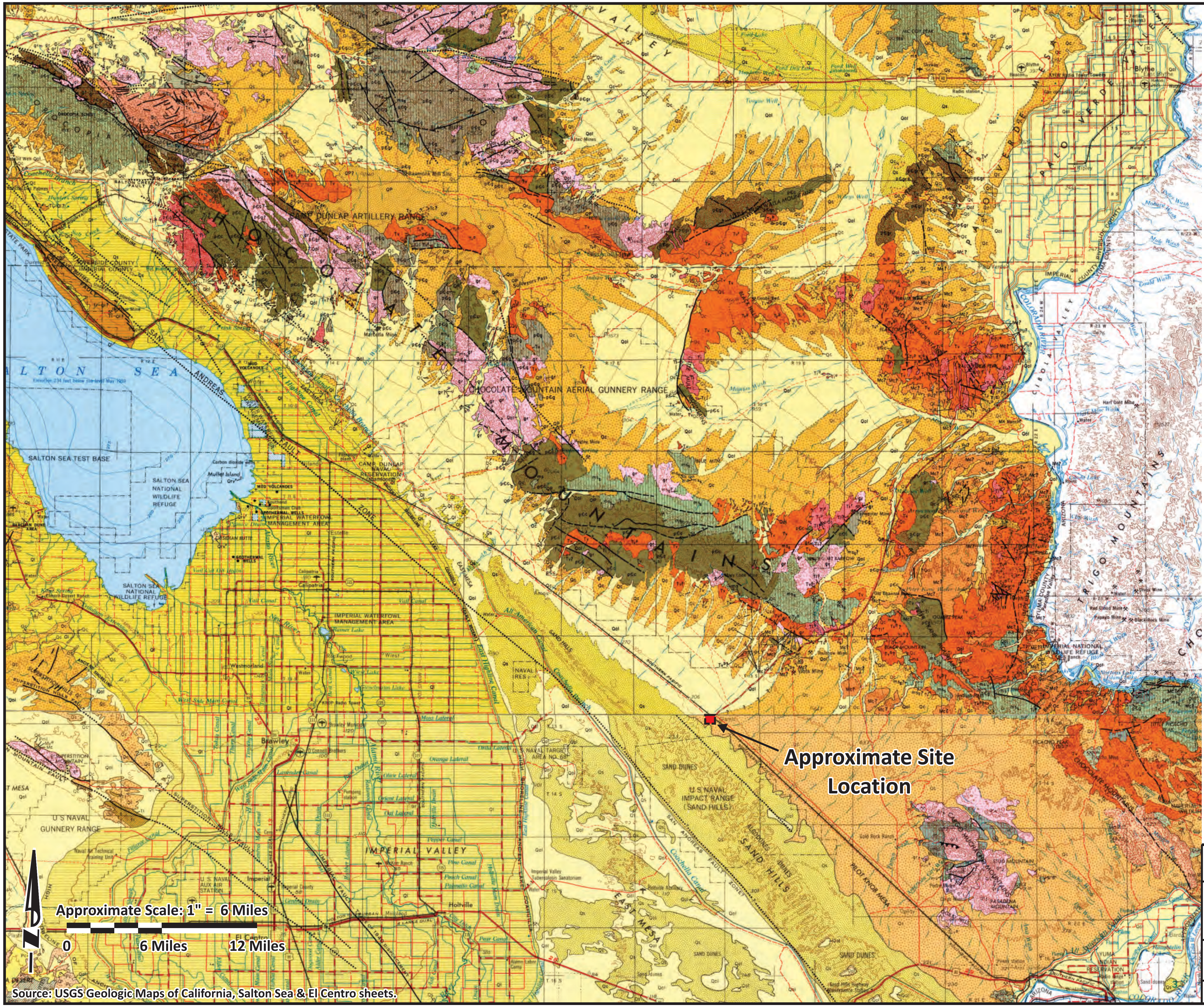
Plate 2
Exploration Location & Local Geologic Map

Proposed Glamis Specific Plan Project
Highway 78 & Ted Kipf Road
Glamis, Imperial County, California

Earth Systems

8/29/2019

File No.: 303235-001



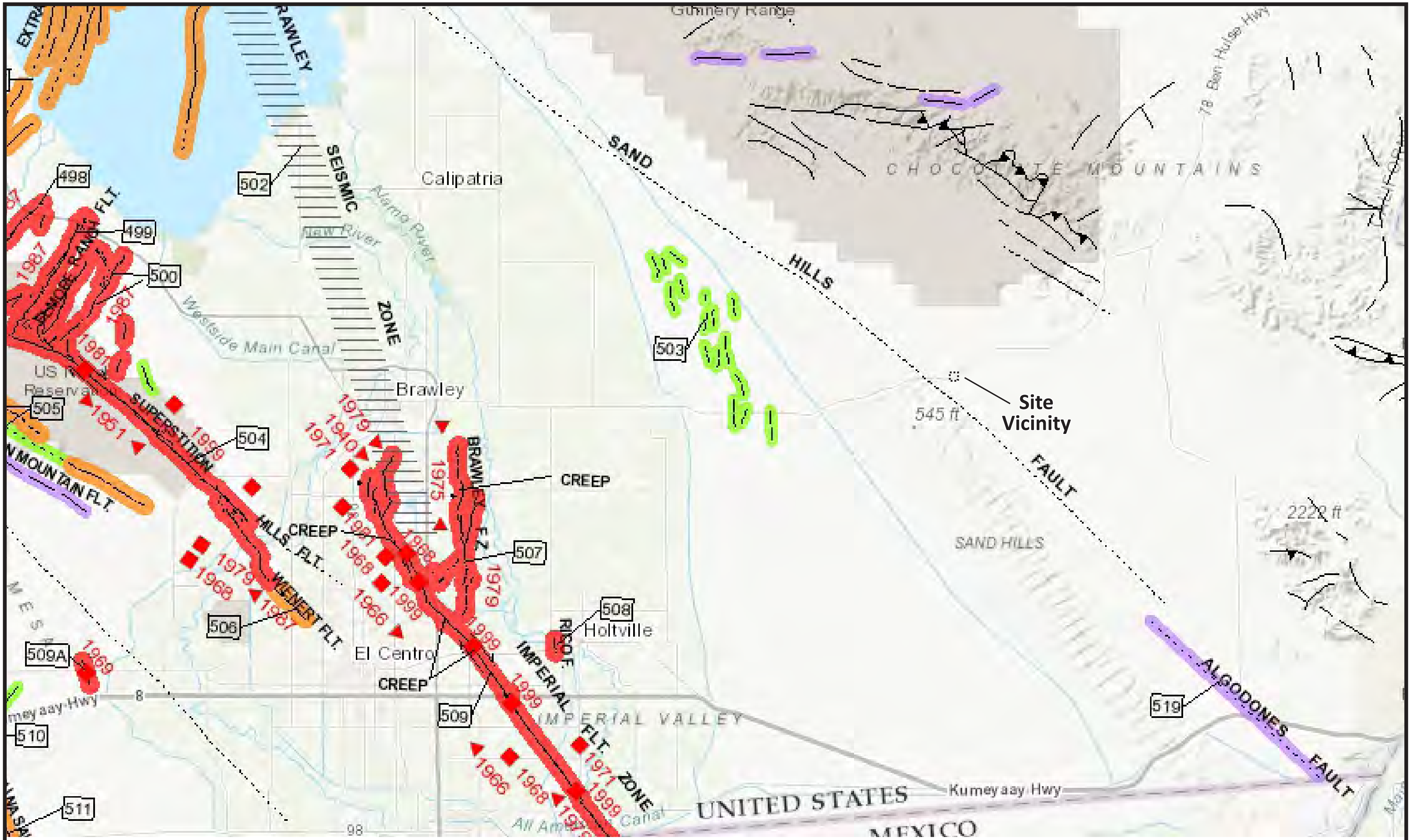
Source: USGS Geologic Maps of California, Salton Sea & El Centro sheets.

Plate 3
Regional Geologic Map

Proposed Glamis Specific Plan Project
Highway 78 & Ted Kipf Road
Glamis, Imperial County, California

Earth Systems

8/29/2019	File No.: 303235-001



Source: CGS Data Map Series, Fault Activity Map of California.

LEGEND

🟥 Fault along which historic (last 200 years) displacement has occurred.

🟧 Fault along which Holocene (last 11,700 years) displacement, has occurred.

🟩 Fault along which Late Quaternary (past 700,000 years) displacement has occurred.

🟪 Fault along which Quaternary (past 1.6 million years) displacement has occurred.

N

Plate 4
Regional Fault Map

Proposed Glamis Specific Plan Project
Highway 78 & Ted Kipf Road
Glamis, Imperial County, California

Earth Systems

8/29/2019

File No.: 303235-001

The Altum Group

Exhibit 8

GLAMIS SPECIFIC PLAN

CONCEPTUAL SITE PLAN

0 125 250 500 750 1,000 Feet

1 INCH = 100 FEET

Table A-1
Fault Parameters

Fault Section Name	**Distance** (miles)	(km)	Avg Dip Angle (deg.)	Avg Dip Direction (deg.)	Avg Rake (deg.)	Trace Length (km)	Fault Type	**Mean Mag**	Mean Return Interval (years)	Slip Rate (mm/yr)
Brawley (Seismic Zone), alt 2	23.8	38.4	90	250	na	61	B'	**7.0**		
Imperial	26.9	43.3	82	55	180	46	A	**6.8**	89	20
Brawley (Seismic Zone), alt 1	28.8	46.3	90	250	na	60	B'	**7.0**		
Superstition Hills	33.1	53.3	90	220	180	36	A	**7.4**	199	4
San Jacinto (Superstition Mtn)	37.2	59.8	90	210	180	26	B'	**6.6**		
Superstition Mountain	37.3	60.1	37	37	37	37	B	**7.0**		0.1
Elmore Ranch	37.5	60.3	90	310	0	29	B	**6.6**		1
Cerro Prieto	39.4	63.5	90	221	na	84	B'	**7.2**		
San Andreas (Coachella) rev	44.4	71.4	90	224	180	69	A	**7.2**	69	20
Laguna Salada	48.9	78.7	90	41	180	99	A	**6.8**	89	3.5
San Jacinto (Borrego)	50.5	81.3	90	223	180	34	A	**7.0**	146	4
Canada David (Detachment)	51.2	82.4	37	255	na	37	B'	**7.1**		
Elsinore (Coyote Mountain)	56.3	90.6	82	35	180	39	A	**7.1**	322	3
San Jacinto (Clark) rev	62.1	99.9	90	214	180	47	A	**7.6**	211	14
San Jacinto (Coyote Creek)	67.2	108.1	90	223	180	43	A	**7.3**	259	4
Blue Cut	68.0	109.5	90	177	na	79	B'	**7.1**		
Earthquake Valley (So Extension)	72.4	116.6	90	204	180	9	B'	**6.3**		
Elsinore (Julian)	74.5	119.9	84	36	180	75	A	**7.6**	725	3
Earthquake Valley	77.8	125.2	90	217	180	20	B	**6.7**		2
San Andreas (San Gorgonio Pass-Garnet HIll)	87.1	140.1	58	20	180	56	A	**7.6**	219	10
San Andreas, (North Branch, Mill Creek)	87.1	140.1	76	204	180	106	A	**7.5**	110	17
Earthquake Valley (No Extension)	88.6	142.5	90	221	180	33	B'	**6.9**		
San Jacinto (Anza) rev	90.0	144.8	90	216	180	46	A	**7.6**	151	18
Pinto Mtn	91.6	147.4	90	175	0	74	B	**7.2**		2.5
Pisgah-Bullion Mtn-Mesquite Lk	95.3	153.4	90	60	180	88	B	**7.3**		0.8
Joshua Tree (Seismicity)	95.9	154.3	90	271	na	17	B'	**6.5**		
Eureka Peak	98.9	159.2	90	75	180	19	B	**6.6**		0.6
Burnt Mtn	99.9	160.7	67	265	180	21	B	**6.7**		0.6
Calico-Hidalgo	102.3	164.6	90	52	180	117	B	**7.4**		1.8
So Emerson-Copper Mtn	102.4	164.8	90	51	180	54	B	**7.0**		0.6
Ludlow	109.9	176.9	90	239	na	70	B'	**7.0**		
Mission Creek	110.9	178.5	65	5	180	31	B'	**6.9**		
Landers	112.1	180.5	90	60	180	95	B	**7.4**		0.6
Elsinore (Temecula) rev	114.5	184.2	90	230	180	40	A	**7.4**	431	5
San Jacinto (San Jacinto Valley, stepover)	117.9	189.8	90	224	180	24	A	**7.4**	199	9
San Jacinto (Anza, stepover)	117.9	189.8	90	224	180	25	A	**7.6**	151	9
San Jacinto (Stepovers Combined)	117.9	189.8	90	229	180	25	B'	**6.7**		
San Gorgonio Pass	118.0	189.9	60	11	na	29	B'	**6.9**		
San Andreas (San Bernardino S)	120.7	194.2	90	210	180	43	A	**7.6**	150	16
Johnson Valley (No)	120.9	194.6	90	51	180	35	B	**6.8**		0.6

Reference: USGS OFR 2007-1437 (CGS SP 203)

Based on Site Coordinates of 32.99677 Latitude, -115.07081 Longitude

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

Site Coordinates: 32.996 N 115.073 W

Table A-2

Historic Earthquakes in Vicinity of Project Site, M > 5.5

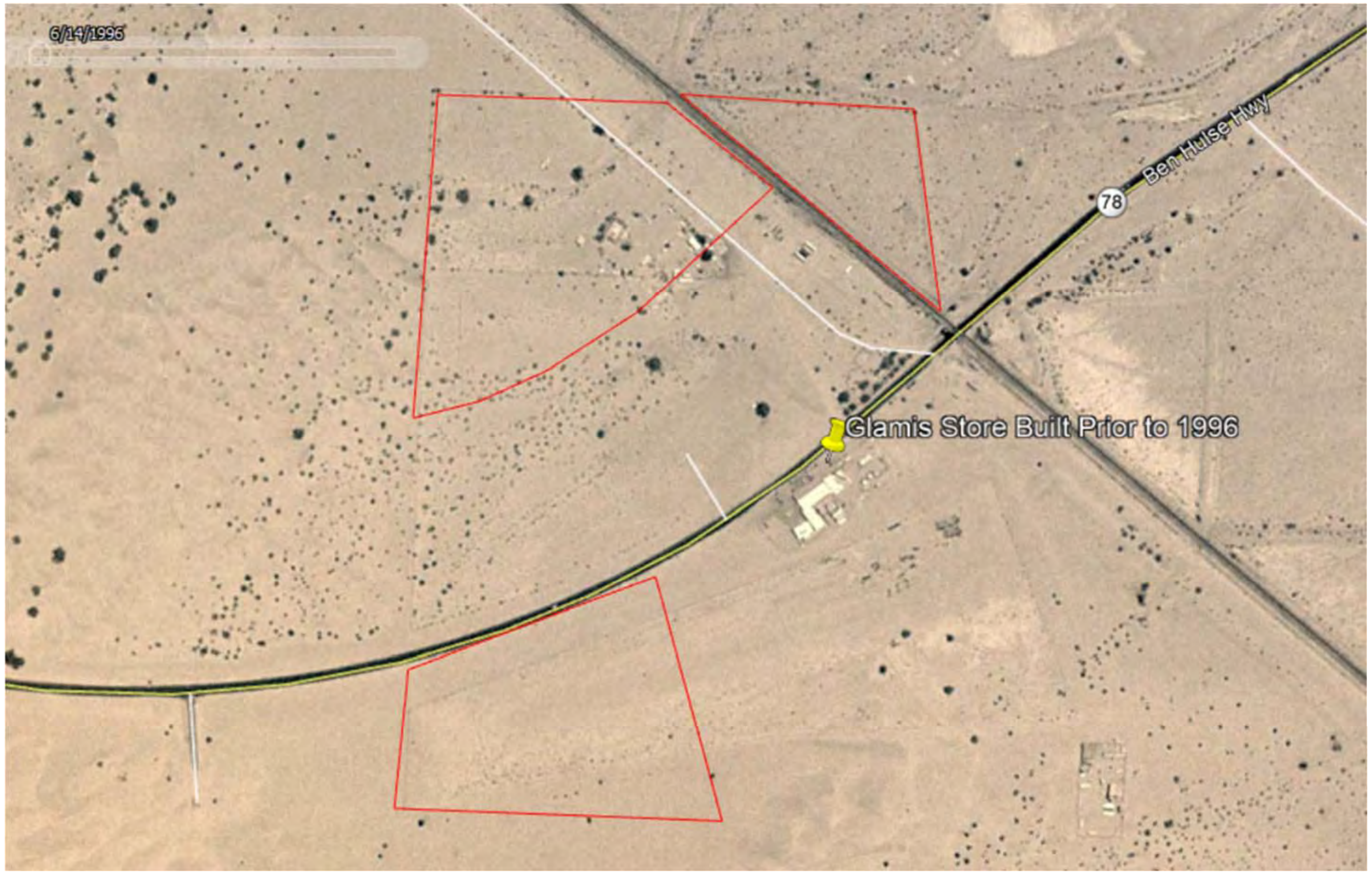
Event Name	*Day*	*Year*	*Epicenter Latitude (Degrees)*	*Epicenter Longitude (Degrees)*	*Distance from Site (mi)*	*Reported Magnitudes* M_W	M_S	M_L	M_I	Estimated Site PGA (g)
	05/03	1872	33.00	115.00	4				5.8	0.25
	05/28	1917	32.80	115.30	19				5.5	0.06
Imperial Valley	04/19	1906	32.90	115.50	26	**6.2**	6.2		5.8	0.07
Brawley Aftershock	10/15	1979	32.98	115.55	28			5.8		0.05
Imperial Valley	06/23	1915	32.80	115.50	28		5.9		5.6	0.05
Imperial Valley	06/23	1915	32.80	115.50	28	**6.0**	6.0		5.6	0.05
	07/29	1950	33.12	115.57	30			5.5		0.04
Imperial Valley	10/15	1979	32.61	115.32	30	**6.5**	6.8	6.6	6.0	0.07
El Centro	05/19	1940	32.73	115.50	31	**7.0**	7.2	6.2	7.0	0.10
Westmorland	04/26	1981	33.10	115.63	33	**5.9**	6.0	5.6		0.04
Fort Yuma	11/29	1852	32.50	115.00	34	**7.0**			7.0	0.09
	06/14	1953	32.95	115.72	37			5.5		0.03
	01/24	1951	32.98	115.73	38			5.6		0.03
	10/22	1942	33.23	115.72	41			5.5		0.03
Elmore Ranch	11/23	1987	33.08	115.78	41	**5.9**	6.2	5.8		0.03
	11/15	1875	32.50	115.50	42	**6.2**			6.2	0.04
North San Jacinto	11/07	1923	32.50	115.50	42				5.5	0.02
	01/01	1927	32.50	115.50	42			5.5		0.02
	01/01	1927	32.50	115.50	42			5.8		0.03
Superstition Hills	11/24	1987	33.01	115.84	44	**6.5**	6.6	6.0		0.05
Laguna Salada	02/24	1892	32.55	115.63	45	**7.0**			7.0	0.06
	02/01	1954	32.30	115.30	50			5.6		0.02
Victoria	06/09	1980	32.20	115.08	55	**6.4**	6.4	6.1		0.02
Laguna Salada	12/30	1934	32.25	115.50	57	**6.4**		6.5		0.03
Fish Creek Mountain	10/21	1942	33.05	116.08	59	**6.6**		6.5	6.3	0.03
Fish Creek Mountain	10/21	1942	33.05	116.08	59	**6.6**		6.5	6.3	0.04
Borrego Mountain	04/09	1968	33.19	116.13	63	**6.5**	6.8	6.8	6.3	0.03
	08/15	1945	33.22	116.13	63			5.7		0.02
	12/01	1958	32.25	115.75	65			5.8		0.02
	05/28	1892	33.20	116.20	67	**6.5**			6.3	0.03
Arroyo Salada	03/19	1954	33.28	116.18	67	**6.4**		6.2	6.2	0.03

Notes:

1.) Earthquake information primarily from Ellsworth (1990) in USGS Professional Paper 1515

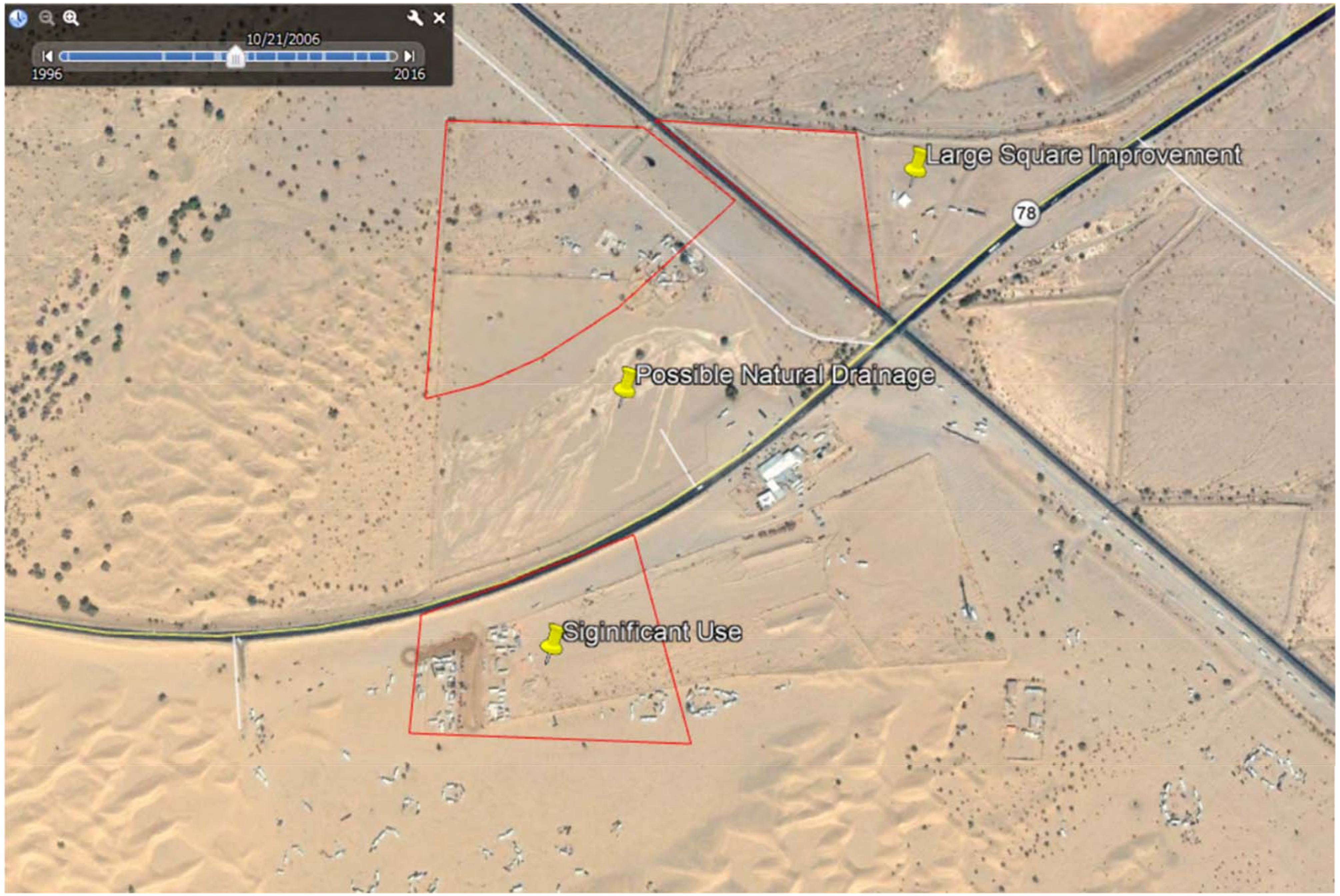
2.) Magnitude Scales: M_W - moment magntude, M_L - Local (Richter) magnitude,
M_S - surface wave magnitude, M_I - estimated from felt area intensity.

3.) Before 1932, Epicenters of earthquakes are approximate, indicated to nearest 0.5 to 0.1 degree.



Aerial 1   June 1996

Aerial 2   April 2004 (Grading)



Aerial 3   October 2006

Aerial 4   August 2007

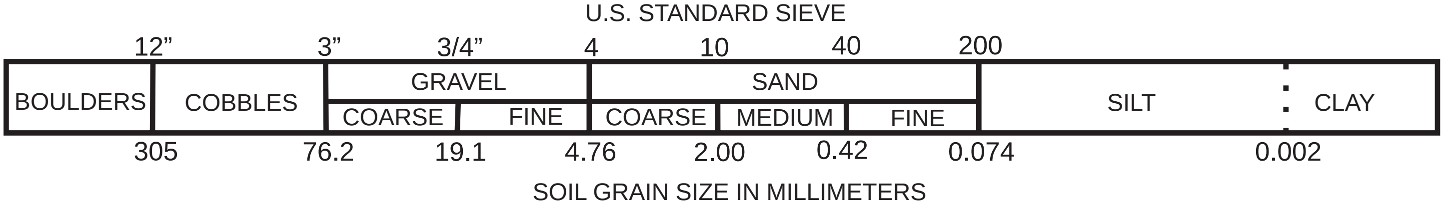
Aerial 5   February 2008

Aerial 6 June 2016

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on ASTM Designations D 2487 and D 2488 (Unified Soil Classification System). Information on each boring log is a compilation of subsurface conditions obtained from the field as well as from laboratory testing of selected samples. The indicated boundaries between strata on the boring logs are approximate only and may be transitional.

SOIL GRAIN SIZE



RELATIVE DENSITY OF GRANULAR SOILS (GRAVELS, SANDS, AND NON-PLASTIC SILTS)

Very Loose	*N=0-4	RD=0-30	Easily push a 1/2-inch reinforcing rod by hand
Loose	N=5-10	RD=30-50	Push a 1/2-inch reinforcing rod by hand
Medium Dense	N=11-30	RD=50-70	Easily drive a 1/2-inch reinforcing rod with hammer
Dense	N=31-50	RD=70-90	Drive a 1/2-inch reinforcing rod 1 foot with difficulty by a hammer
Very Dense	N>50	RD=90-100	Drive a 1/2-inch reinforcing rod a few inches with hammer

*N=Blows per foot in the Standard Penetration Test at 60% theoretical energy. For the 3-inch diameter Modified California sampler,140-pound weight, multiply the blow count by 0.63 (about 2/3) to estimate N. If automatic hammer is used, multiply a factor of 1.3 to 1.5 to estimate N. RD=Relative Density (%). C=Undrained shear strength (cohesion).

CONSISTENCY OF COHESIVE SOILS (CLAY OR CLAYEY SOILS)

Very Soft	*N=0-1	*C=0-250 psf	Squeezes between fingers
Soft	N=2-4	C=250-500 psf	Easily molded by finger pressure
Medium Stiff	N=5-8	C=500-1000 psf	Molded by strong finger pressure
Stiff	N=9-15	C=1000-2000 psf	Dented by strong finger pressure
Very Stiff	N=16-30	C=2000-4000 psf	Dented slightly by finger pressure
Hard	N>30	C>4000	Dented slightly by a pencil point or thumbnail

MOISTURE DENSITY

Moisture Condition:	An observational term; dry, damp, moist, wet, saturated.
Moisture Content:	The weight of water in a sample divided by the weight of dry soil in the soil sample expressed as a percentage.
Dry Density:	The pounds of dry soil in a cubic foot.

MOISTURE CONDITION

Dry.....................Absence of moisture, dusty, dry to the touch
Damp................Slight indication of moisture
Moist.................Color change with short period of air exposure (granular soil)
Below optimum moisture content (cohesive soil)
Wet....................High degree of saturation by visual and touch (granular soil)
Above optimum moisture content (cohesive soil)
Saturated..........Free surface water

RELATIVE PROPORTIONS

Trace.............minor amount (<5%)
with/some......significant amount
modifier/and...sufficient amount to influence material behavior (Typically >30%)

PLASTICITY

DESCRIPTION	FIELD TEST
Nonplastic	A 1/8 in. (3-mm) thread cannot be rolled at any moisture content.
Low	The thread can barely be rolled.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit.
High	The thread can be rerolled several times after reaching the plastic limit.

LOG KEY SYMBOLS

▮	Bulk, Bag or Grab Sample
◧	Standard Penetration Split Spoon Sampler (2” outside diameter)
▮	Modified California Sampler (3” outside diameter)
◪	No Recovery

GROUNDWATER LEVEL

▼	Water Level (measured or after drilling)
▽	Water Level (during drilling)

Terms and Symbols Used on Boring Logs

Earth Systems

MAJOR DIVISIONS			GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More than 50% of material is larger than No. 200 sieve size	**GRAVEL AND GRAVELLY SOILS** More than 50% of coarse fraction retained on No. 4 sieve	**CLEAN GRAVELS**	░	**GW**	Well-graded gravels, gravel-sand mixtures, little or no fines
			▓	**GP**	Poorly-graded gravels, gravel-sand mixtures. Little or no fines
		GRAVELS WITH FINES	▥	**GM**	Silty gravels, gravel-sand-silt mixtures
			▩	**GC**	Clayey gravels, gravel-sand-clay mixtures
	SAND AND SANDY SOILS More than 50% of coarse fraction passing No. 4 sieve	**CLEAN SAND (Little or no fines)**	░	**SW**	Well-graded sands, gravelly sands, little or no fines
			░	**SP**	Poorly-graded sands, gravelly sands, little or no fines
		SAND WITH FINES (appreciable amount of fines)	▥	**SM**	Silty sands, sand-silt mixtures
			▨	**SC**	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size	**SILTS AND CLAYS**	**LIQUID LIMIT LESS THAN 50**	▥	**ML**	Inorganic silts and very fine sands, rock flour, silty low clayey fine sands or clayey silts with slight plasticity
			▨	**CL**	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			▥	**OL**	Organic silts and organic silty clays of low plasticity
		LIQUID LIMIT GREATER THAN 50	▥	**MH**	Inorganic silty, micaceous, or diatomaceous fine sand or silty soils
			▨	**CH**	Inorganic clays of high plasticity, fat clays
			▨	**OH**	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			▒	**PT**	Peat, humus, swamp soils with high organic contents
VARIOUS SOILS AND MAN MADE MATERIALS			▦		Fill Materials
MAN MADE MATERIALS			■		Asphalt and concrete

Soil Classification System

Earth Systems

Earth Systems

1680 Illinois Avenue, Suite 20, Perris, CA 92571
Phone (951) 928-9799

Boring No. B-1

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 19, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

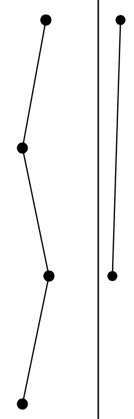
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0						SM			SILTY SAND WITH GRAVEL: yellow brown, loose, dry, fine to coarse grained sand, fine gravel, Fill
						SM			SILTY SAND WITH GRAVEL: yellow brown, loose, dry, fine to coarse grained sand, fine gravel, Qa
5			■	31,50/5"			122	2	very dense at 4 feet
10			■	50/6"		SW			WELL GRADED SAND: reddish brown, very dense, dry, fine to coarse grained sand, trace fine gravel and silt, calcium carbonate lenses, Qoa
15			■	35,50/5"		SW	114	2	WELL GRADED SAND WITH GRAVEL: reddish brown, very dense, dry, fine to coarse grained sand, fine gravel, calcium carbonate cementation
20			▨	50/6"					no recovery

Graphic Trend
Blow Count Dry Density



Depth (Ft.): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60

Boring completed at 20-1/2 feet
No groundwater encountered
Backfill with cuttings

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1680 Illinois Avenue, Suite 20, Perris, CA 92571
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Boring No. **B-2**
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 19, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

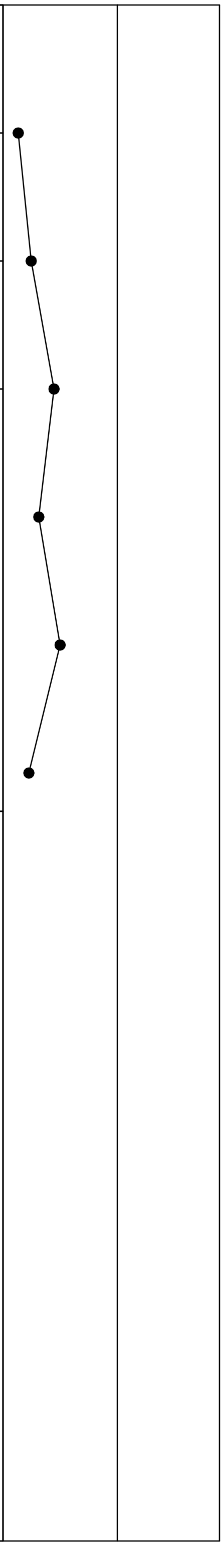
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0	■				▨	SC-SM			SILTY CLAYEY SAND WITH GRAVEL: brown, medium dense, damp, fine to medium grained sand, trace silt, fine gravel, Fill
5		◨		11,10,10	▨	SC-SM			SILTY CLAYEY SAND WITH GRAVEL: brown, medium dense, damp, fine to medium grained sand, trace silt, fine gravel, Qa
10		◨		25,15,22	▨	SC			CLAYEY SAND: reddish brown to white, dense, dry, fine to medium grained sand, low plasticity, calcium carbonate lenses, Qoa
15		◨		21,33,34	▨	SM			SILTY SAND: light reddish brown, very dense, dry, fine to coarse grained sand, some fine gravel
20		◨		18,20,27	▨				
25		◨		25,32,43	▨				orange brown, trace fine gravel, trace calcium carbonate
30		◨		21,17,17	▨				
35									
40									
45									
50									
55										Boring completed at 31-1/2 feet No groundwater encountered Backfill with cuttings
60									

Graphic Trend
Blow Count Dry Density



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Boring No. **B-3**
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

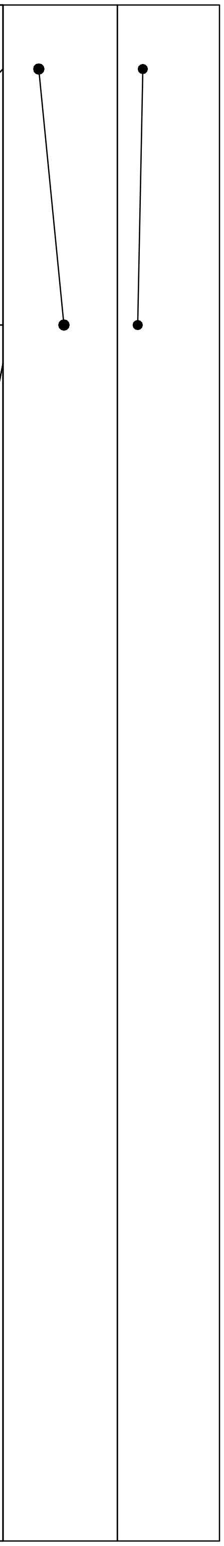
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0						SM			SILTY SAND WITH GRAVEL: brown, loose, dry, fine to coarse grained sand, fine gravel, Fill
			■	4,19,28		SM	125	2	SILTY SAND WITH GRAVEL: brown, dense, damp, fine to coarse grained sand, Qa
			■	24,30,50		SC	120	3	WELL GRADED CLAYEY SAND: reddish brown, very dense, damp, fine to coarse grained sand, slight plasticity, calcium carbonate lenses, Qoa

Graphic Trend
Blow Count Dry Density



Boring completed at 14 feet
No groundwater encountered
Backfill with cuttings

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1680 Illinois Avenue, Suite 20, Perris, CA 92571
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Boring No. B-4
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

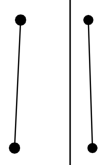
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0	■				⁙	SP-SM			POORLY GRADED SAND WITH SILT: reddish brown, loose, damp, fine to coarse grained sand, trace fine gravel, Fill
					⁙	SP-SM			
5			■	35.50/5"	⁙		118	4	POORLY GRADED SAND WITH SILT: reddish brown, dense, damp, fine to coarse grained sand, trace fine gravel, Qa
10			■	20,27,50	▨	SP	122	4	POORLY GRADED SAND: grey to brown, very dense, damp, fine to coarse grained sand, some fine gravel, Qoa

Graphic Trend
Blow Count Dry Density



Boring completed at 11-1/2 feet
No groundwater encountered
Backfill with cuttings

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Boring No. B-9
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

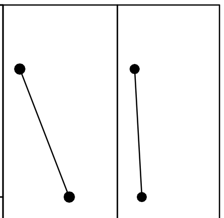
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0						SM			SILTY SAND: grey brown, loose, damp, fine to coarse grained sand, Fill
			■	8,9,13			117	4	medium dense
5									
			■	28,37,50/5"		SW-SM	124	4	WELL GRADED SAND WITH SILT: reddish brown, very dense, damp, fine to coarse grained sand, calcium carbonate lenses, alternating layers with silty sand, Qoa
10									
15									
20									
25									
30									
35									
40									
45									
50									
55									Boring completed at 9 feet No groundwater encountered Backfill with cuttings
60									

Graphic Trend
Blow Count Dry Density



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Boring No. B-10
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

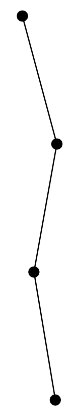
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type: Bulk	Sample Type: SPT	Sample Type: MOD Calif.	Penetration Resistance (Blows/6")	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0					SM			SILTY SAND: reddish brown, medium dense, dry, fine to medium grained sand, trace calcium carbonate stringers, Fill
5			■	8,20,31	SM	118	3	SILTY SAND: reddish brown, damp, dense, fine to medium grained sand, Qoa
10			■	23,46,50/6"	SW			POORLY GRADED SAND WITH GRAVEL: reddish brown, very dense, damp, fine to coarse grained sand, trace silt, fine gravel trace clay, calcium carbonate streaking
15			■	16,50/6"				
20			■	44,50/5"	SC			CLAYEY SAND: reddish brown, very dense, damp, fine to coarse grained sand, calcium carbonate, low placticity

Graphic Trend
Blow Count Dry Density



Boring completed at 21 feet
No groundwater encountered
Backfill with cuttings

Boring No. B-11

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 18, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

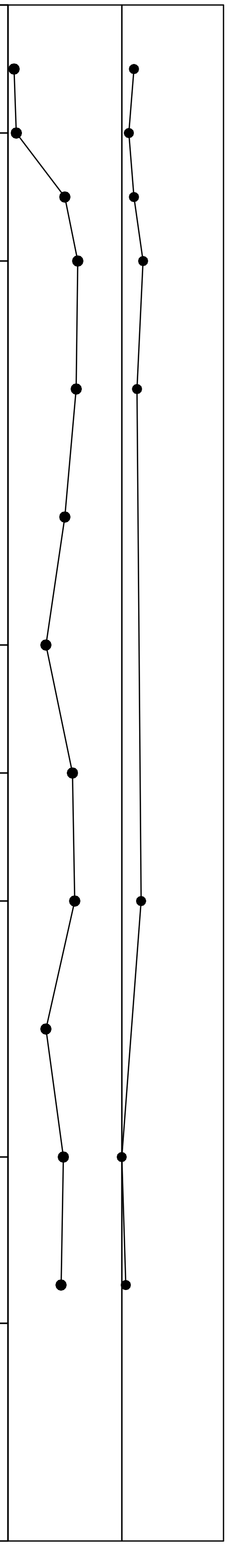
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type	Penetration Resistance (Blows/6")	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0	Bulk		SM			SILTY SAND: yellow brown, loose, dry, fine to medium grained sand, trace fine gravel, Fill
	MOD Calif.	4,5,7		112	2	
5	MOD Calif.	4,8,10	SP-SM	107	3	SAND WITH SILT: yellow brown, dense, damp, fine grained sand, some cementation, Qa
	MOD Calif.	13,29,46		112	9	moist
10	MOD Calif.	26,42,50	SW-SM	121	2	WELL GRADED SAND WITH SILT AND GRAVEL: brown, very dense, dry, fine to coarse grained sand, fine gravel, Qoa
15	MOD Calif.	19,40,50		115	3	damp
20	MOD Calif.	12,25,50/5"		104	2	
25	MOD Calif.	50/6"	SM	---	5	SILTY SAND: brown, dry, very dense, fine to medium grained sand
30	MOD Calif.	35,50/6"	SM	107	2	SILTY SAND: light brown, very dense, dry, fine grained sand
35	MOD Calif.	32,38,50/5"	SM	119	2	SILTY SAND: grey brown, very dense, dry, fine to coarse grained sand, some fine gravel
40	MOD Calif.	50/3"		---	3	some cobble/coarse
45	MOD Calif.	23,50/6"	SM	---	3	SILTY SAND: yellow brown, very dense, damp, fine grained sand
50	MOD Calif.	20,50/6"		---	2	dry
55						Boring completed at 51-1/2 feet No groundwater encountered Backfill with cuttings
60						

Graphic Trend
Blow Count Dry Density



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Boring No. B-12	Drilling Date: June 21, 2019
Project Name: Glamis Specific Plan	Drilling Method: Mobile B-61 w/autohammer
Project Number 303235-001	Drill Type: 8" HSA
Boring Location: Plate 2	Logged By: R. Howe

Page 1 of 1

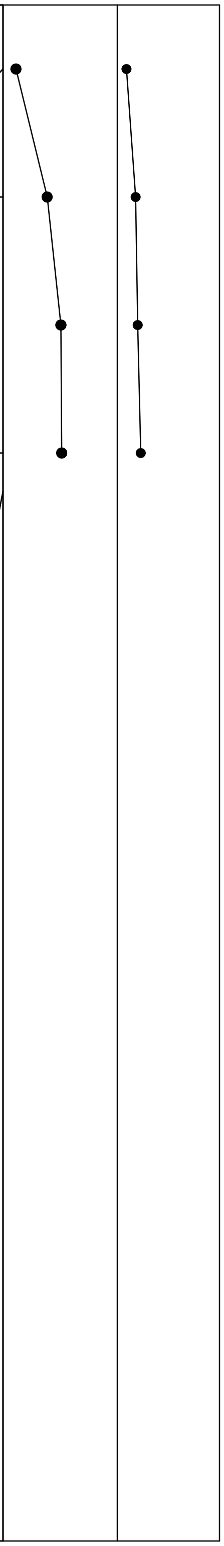
Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
						SW-SM			WELL GRADED SAND WITH SILT: brown, loose, damp, fine to coarse grained sand, Fill
			■	8,8,9		SW-SM	109	3	WELL GRADED SAND WITH SILT: brown, loose, damp, fine to coarse grained sand, calicum carbonate lenses, Qa
			■	17,24,34		SC	118	3	CLAYEY SAND: reddish brown, dense, damp, fine grained sand, low to medium plasticity, calcium carbonate lenses, Qoa
			■	26,50/6"			120	6	very dense, fine to medium grained sand
			■	13,27,50		SW-SM	123	3	WELL GRADED SAND WITH SILT: grey brown, dense, damp, fine to coarse grained sand, trace fine gravel

Boring completed at 19-1/2 feet
No groundwater encountered
Backfill with cuttings

Graphic Trend
Blow Count Dry Density



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Boring No. B-13
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count	Graphic Trend Dry Density
0	■				░	SM			SILTY SAND: brown, medium dense, damp, fine to medium grained sand, some fine gravel, Fill		
5			■	8,10,23	░	SW	118	3	WELL GRADED SAND WITH GRAVEL: reddish brown, medium dense, damp, fine to coarse grained sand, calcium carbonate stringers and lenses, Qa		●
10			■	20,40,50/4"	░		118	3	clayey sand lenses at 10 feet, Qoa		●
15											
20											
25											
30											
35											
40											
45											
50											
55									Boring completed at 11-1/2 feet No groundwater encountered Backfill with cuttings		
60											

Earth Systems

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Boring No. B-15

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

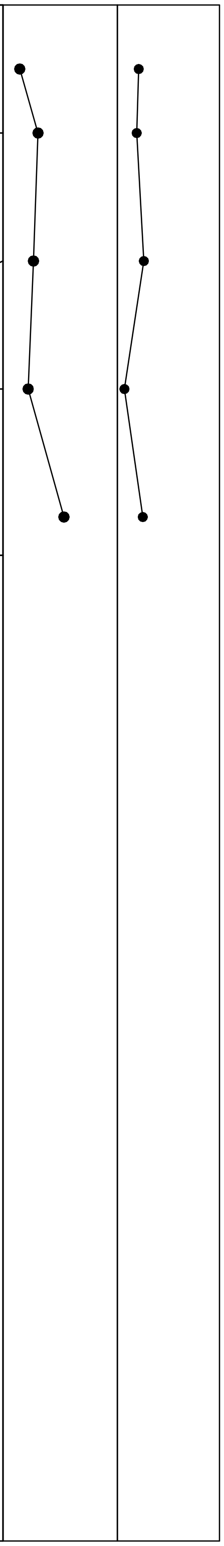
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0						SP-SM			POORLY GRADED SAND WITH SILT: brown, loose, damp, fine to medium grained sand, trace fine gravel, Fill
			■	8,11,11			121	3	
5			■	8,18,28		SP-SM	119	2	POORLY GRADED SAND WITH SILT AND GRAVEL: reddish brown, medium dense, dry, fine to medium grained sand, fine gravel, trace clay, trace calcium carbonate lenses, Qa
10			■	20,20,20		SM	126	3	SILTY SAND: red brown, medium dense, damp, fine to medium grained sand, low plasticity, calcium carbonate lenses, Qoa
15			■	16,16,17		SM	107	3	SILTY SAND WITH GRAVEL: reddish brown, medium dense, damp, fine to coarse grained sand, fine gravel, some cementation
20			■	20,30,50			125	6	minor calcium carbonate lenses, trace clay, slight plasticity very dense
55									Boring completed at 21-1/2 feet No groundwater encountered Backfill with cuttings

Graphic Trend
Blow Count Dry Density



Boring No. B-16

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

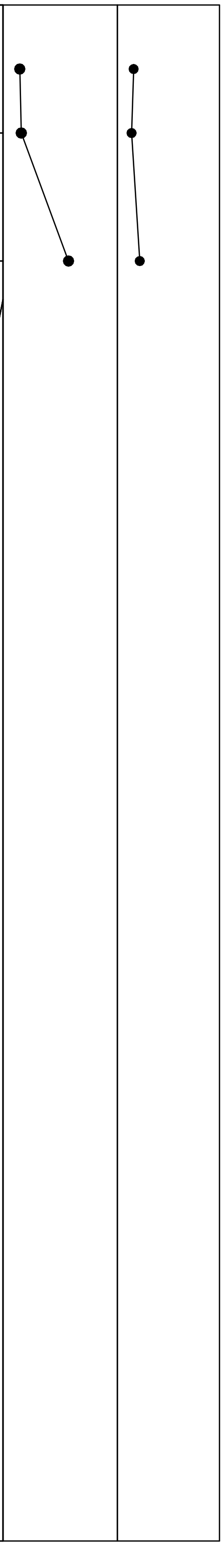
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0	■				SP-SM			POORLY GRADED SAND WITH SILT: brown, dry, loose, fine grained sand, Fill/Qs
			■	7,9,13		116	2	medium dense, trace medium gravel
5			■	6,7,17	SW	114	3	WELL GRADED SAND: grey brown, medium dense, damp, fine to coarse grained sand, some calcium carbonate cementation
10			■	20,36,50/6"	SP-SM	122	5	POORLY GRADED SAND WITH SILT: reddish brown, very dense, damp, fine to medium grained sand, trace calcium carbonate cementation, Qoa

Graphic Trend
Blow Count Dry Density



Boring completed at 11-1/2 feet
No groundwater encountered
Backfill with cuttings

Earth Systems

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Boring No. B-18
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 6" HSA
Logged By: R. Howe

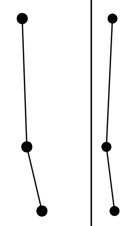
Description of Units

Page 1 of 1

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0–4.5	Bulk			SP-SM			POORLY GRADED SAND WITH SILT AND GRAVEL: brown, medium dense, damp, fine to coarse grained sand, fine gravel, Qs
2.5	MOD Calif.	12,24,33			121	4	dense at 2-1/2 feet
7.5	MOD Calif.	17,30,35		SM	115	4	SILTY SAND: reddish brown to white, damp, dense, fine to medium grained sand, calcium carbonate lenses, Qoa
10	MOD Calif.	21,35,50/4"		SW	123	3	WELL GRADED SAND: brown to reddish, very dense, damp, fine to coarse grained sand, trace calcium carbonate, trace clay, coarse gravel in sample tip

Graphic Trend
Blow Count Dry Density



Boring completed at 11-1/2 feet
No groundwater encountered
Backfill with cuttings

Boring No. B-19

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 6" HSA
Logged By: R. Howe

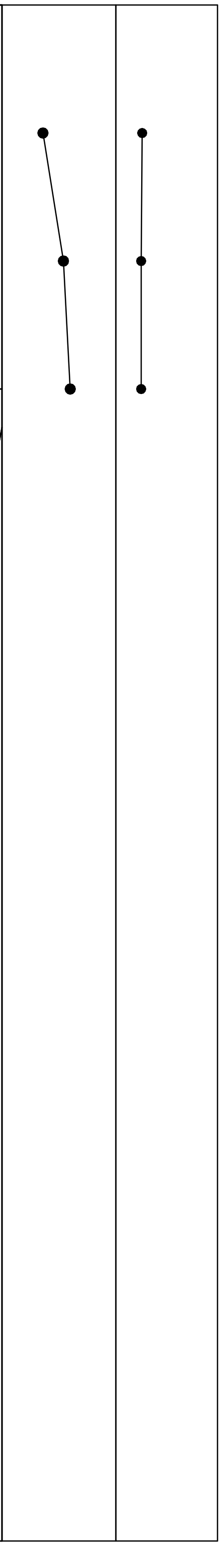
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0					▨	SC-SM			SILTY CLAYEY SAND WITH GRAVEL: red brown to white, loose, damp, fine to coarse grained sand, fine to coarse gravel, calcium carbonate cementation, low plasticity, upper 1 to 2 feet disturbed, Qa
5			■	17,27,27			126	6	dense, Qoa
10			■	23,35,46			125	7	very dense, moist, fine to medium grained sand, fine gravel
15			■	33,40,50/5"	▨	SP	125	8	POORLY GRADED SAND: reddish brown, very dense, moist, fine to medium grained sand, calcium carbonate lenses cementation, trace clay lenses, slight plasticity
20									
25									
30									
35									
40									
45									
50									
55									Boring completed at 16-1/2 feet No groundwater encountered Backfill with cuttings
60									

Graphic Trend
Blow Count Dry Density



Boring No. B-20
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 6" HSA
Logged By: R. Howe

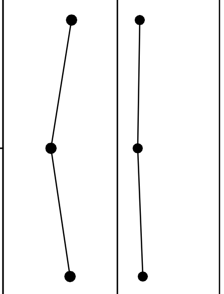
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0						SP-SM			POORLY GRADED SAND WITH SILT: reddish brown, medium dense, damp, fine to medium grained sand, minor calcium carbonate lenses, trace clay, upper 1 to 2 feet disturbed, Fill
5			■	22,40,50/6"			122	4	very dense, Qoa
10			■	10,14,49		SW	120	4	WELL GRADED SAND WITH GRAVEL: brown, dense, damp, fine to coarse grained sand, fine gravel, calcium carbonate lenses
15			■	27,38,50/5"			125	4	very dense, calcium carbonate lenses
20									
25									
30									
35									
40									
45									
50									
55									Boring completed at 16-1/2 feet No groundwater encountered Backfill with cuttings
60									

Graphic Trend
Blow Count Dry Density



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Boring No. B-21

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 21, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 6" HSA
Logged By: R. Howe

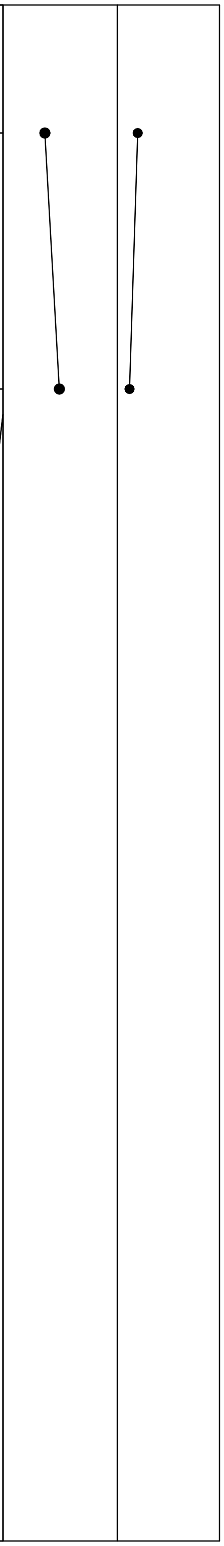
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0					SM			SILTY SAND: red brown, medium dense, damp, fine to coarse grained sand, slight plasticity, Fill
5			■	18,27,28	SW	120	4	WELL GRADED SAND WITH GRAVEL: grey, very dense, damp, fine to coarse grained sand, fine gravel, Qa
15			■	24,50/6"	SC-SM	112	7	SILTY-CLAYEY SAND: red brown to white, very dense, moist, fine to medium grained sand, calcium carbonate layers and lenses, some fine gravel, low plasticity, Qoa

Graphic Trend
Blow Count Dry Density



Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60

Boring completed at 16 feet
No groundwater encountered
Backfill with cuttings

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Boring No. B-22

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 19, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 6" HSA
Logged By: R. Howe

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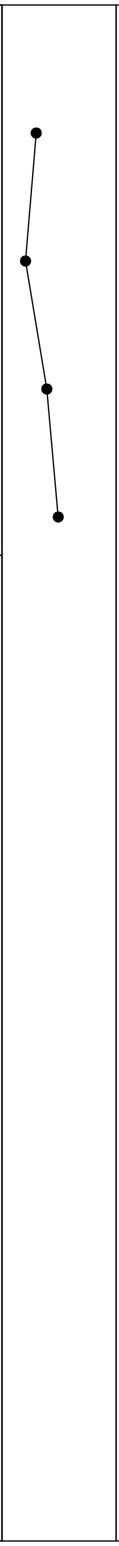
Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count	Graphic Trend Dry Density
0					▒	SW			WELL GRADED SAND WITH GRAVEL: reddish brown, dense, dry, fine to coarse grained sand, fine gravel, upper 1 to 2 feet disturbed, af		
5		◧		21,22,23	▒				Qoa	●	
10		◧		18,16,15	▒				increasing gravel, trace calcium carbonate lenses	●	
15		◧		19,31,28	▒					●	
20		◧		14,29,25	▒				reddish to greyish brown, very dense, damp	●	
55									Boring completed at 21-1/2 feet No groundwater encountered Backfill with cuttings		



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Boring No. B-23

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 19, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 6" HSA
Logged By: R. Howe

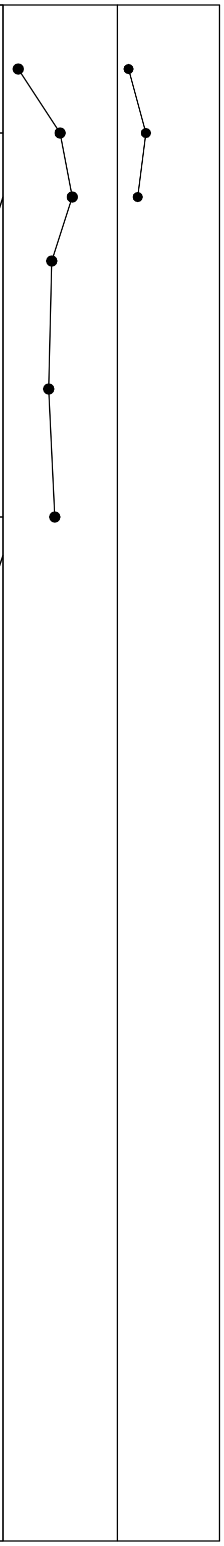
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0	■					SW			WELL GRADED SAND WITH GRAVEL: brown, loose, dry, fine to coarse grained sand, trace silt, Fill
	■		■	6,8,12			111	1	
5			■	7,25,50/5"		GP	128	3	POORLY GRADED GRAVEL WITH SAND: grey to brown, very dense, damp, fine to medium grained sand, fine gravel, cementation in sample tip, Qoa
			■	41,50/6"		SW	120	4	
10		◧		19,38,26					WELL GRADED SAND WITH GRAVEL: reddish brown, very dense, damp, fine to coarse grained sand, fine to coarse gravel
15		◧		24,38,22					SC lenses interbedded, low plasticity
20		◧		23,27,41		SW			WELL GRADED SAND: reddish brown, very dense, dry, fine to coarse grained sand
25									
30									
35									
40									
45									
50									
55									Boring completed at 21-1/2 feet No groundwater encountered Backfill with cuttings
60									

Graphic Trend
Blow Count Dry Density



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Boring No. B-25

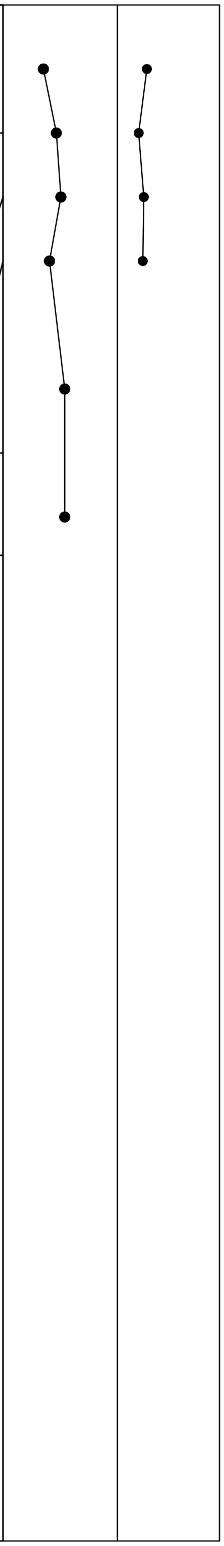
Project Name: Glamis Specific Plan	Drilling Date: June 19, 2019
Project Number 303235-001	Drilling Method: Mobile B-61 w/autohammer
Boring Location: Plate 2	Drill Type: 6" HSA
	Logged By: R. Howe

Page 1 of 1

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0					░	SW			WELL GRADED SAND WITH GRAVEL: reddish brown, medium dense, damp, fine to coarse grained sand, fine gravel, trace silt, Fill, damp at 2 feet
			■	15,22,31	░		129	5	
					░				Qoa below 2 feet
5			■	23,34,36	▒	SP	121	5	POORLY GRADED SAND: reddish brown to white, dense, damp, fine grained sand, calcium carbonate lenses, some cementation
			■	23,35,41	▨	SC	126	7	CLAYEY SAND: dense, moist, fine grained sand, trace fine gravel, low plasticity, some cementation
10			■	23,31,30	▦	SM	125	5	SILTY SAND: reddish brown, dense, damp, fine to coarse grained sand, trace fine gravel
15		◧		31,50/5"	▦		---	7	clayey sand lenses, very dense, calcium carbonate stringers
					░	SW-SM			SAND WTIH SILT: reddish brown, damp, fine to coarse grained sand, some fine gravel
20		◧		31,50/5"	░		---	4	

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Graphic Trend
Blow Count Dry Density



Boring completed at 21 feet
No groundwater encountered
Backfill with cuttings

Boring No. B-26
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 18, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

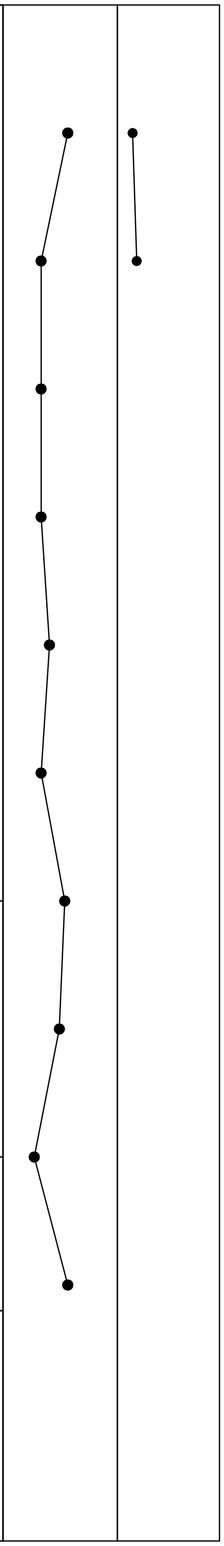
Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0	■				SP-SM			POORLY GRADED SAND WITH SILT: reddish brown, medium dense, damp, fine to coarse grained sand, Qa, upper 1 to 2 feet disturbed
5			■	35,50/5'		115	4	very dense, Qoa
10			■	50/6"		119	4	gravelly
15			■	50/6"		---	4	
20			■	50/5"		---	3	
25		■		20,31,30				increase in silt, SM lenses
30		■		50/6"				
35		■		26,31,50/5"	SM			SILTY SAND: reddish brown, very dense, damp, fine grained sand, trace fine to coarse gravel
40		■		24,50/6"				1 inch layer of gravelly sand
45		■		11,15,26	SP-SM			POORLY GRADED SAND WITH SILT: reddish brown, very dense, damp, fine to coarse grained sand
50		■		35,50/5"				
55								Boring completed at 51-1/2 feet No groundwater encountered Backfill with cuttings
60								

Graphic Trend
Blow Count Dry Density



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Boring No. **B-27**
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 19, 2019
Drilling Method: Mobile B-61 w/autohammer
Drill Type: 8" HSA
Logged By: R. Howe

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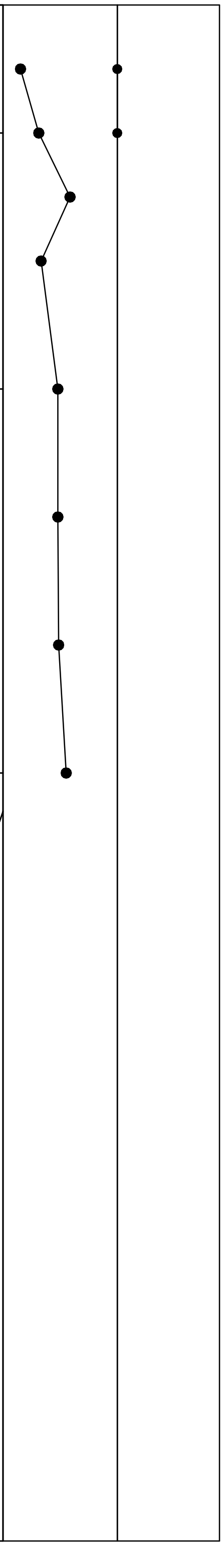
Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type			Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
	Bulk	SPT	MOD Calif.						
0						SW			WELL GRADED SAND WITH GRAVEL: reddish brown, loose, damp, fine to coarse grained sand, trace silt, Qa, upper 1 to 2 feet disturbed
			■	4,8,15			110	3	
5			■	7,23,24		GP	116	2	POORLY GRADED GRAVEL WITH SAND: reddish brown to grey, medium dense, dry, fine to coarse grained sand, fine gravel
			■	38,50/4"			---	3	
10			▨	50/6"					no recovery, very dense, Qoa
15		◧		35,38,34		SP-SM			POORLY GRADED SAND WITH SILT AND GRAVEL: reddish brown, very dense, damp, fine to coarse grained sand, fine gravel
20		◧		22,50/6"					
25		◧		26,34,39					increasing coarse gravel
30		◧		16,33,50/5"		SM			SILTY SAND: brown, very dense, damp, fine grained sand, trace fine to coarse gravel
35									
40									
45									
50									
55									Boring completed at 31-1/2 feet No groundwater encountered Backfill with cuttings
60									

Graphic Trend
Blow Count Dry Density



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Boring No. B-28

Project Name: Glamis Specific Plan	Drilling Date: June 19, 2019
Project Number 303235-001	Drilling Method: Mobile B-61 w/autohammer
Boring Location: Plate 2	Drill Type: 8" HSA
	Logged By: R. Howe

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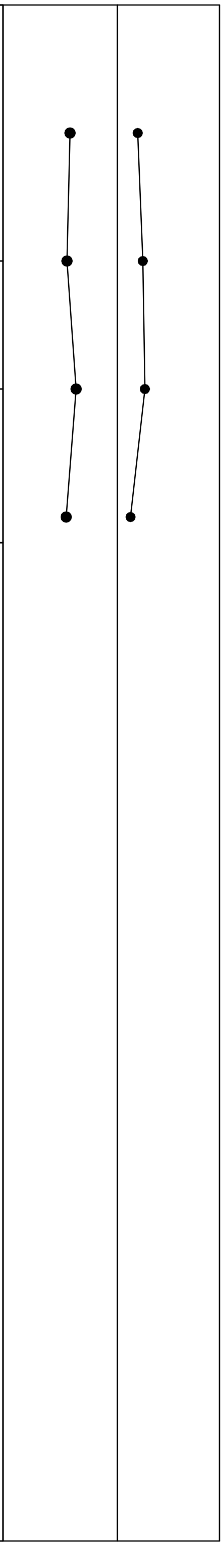
Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units
0	■					SW			WELL GRADED SAND WITH GRAVEL: reddish brown, medium dense, damp, fine to coarse grained sand, fine gravel, upper 1 to 2 feet disturbed, af
5			■	24,38,50/5"			120	4	very dense, Qoa
10			■	34,50/5"		GP	125	4	POORLY GRADED GRAVEL WITH SAND: grey to brown, very dense, damp, fine gravel, fine to coarse grained sand, trace silt
15			■	33,46,50		SW	127	5	WELL GRADED SAND WITH GRAVEL: white to reddish brown, very dense, damp, fien to coarse grained sand, fine gravel, calcium carbonate, caliche, gravel sized fragments of calcium carbonate
20			■	33,50/5"			113	3	

Graphic Trend



Boring completed at 21 feet
No groundwater encountered
Backfill with cuttings

Earth Systems

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Boring No. **T-5**
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 20, 2019
Drilling Method: Backhoe
Drill Type: 18" Bucket
Logged By: R. Howe

Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	SPT	MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count	Dry Density
0					⁘	SW			WELL GRADED SAND WITH GRAVEL: brown, dense, dry, fine to coarse grained sand, fine to coarse gravel, cementation, calcium carbonate lenses, upper 1 foot fill, Qa below that		
5			■		⁘						
10											
15											
20											
25											
30											
35											
40											
45											
50											
55									Trenching completed at 8 feet No groundwater encountered Backfill with cuttings		
60											

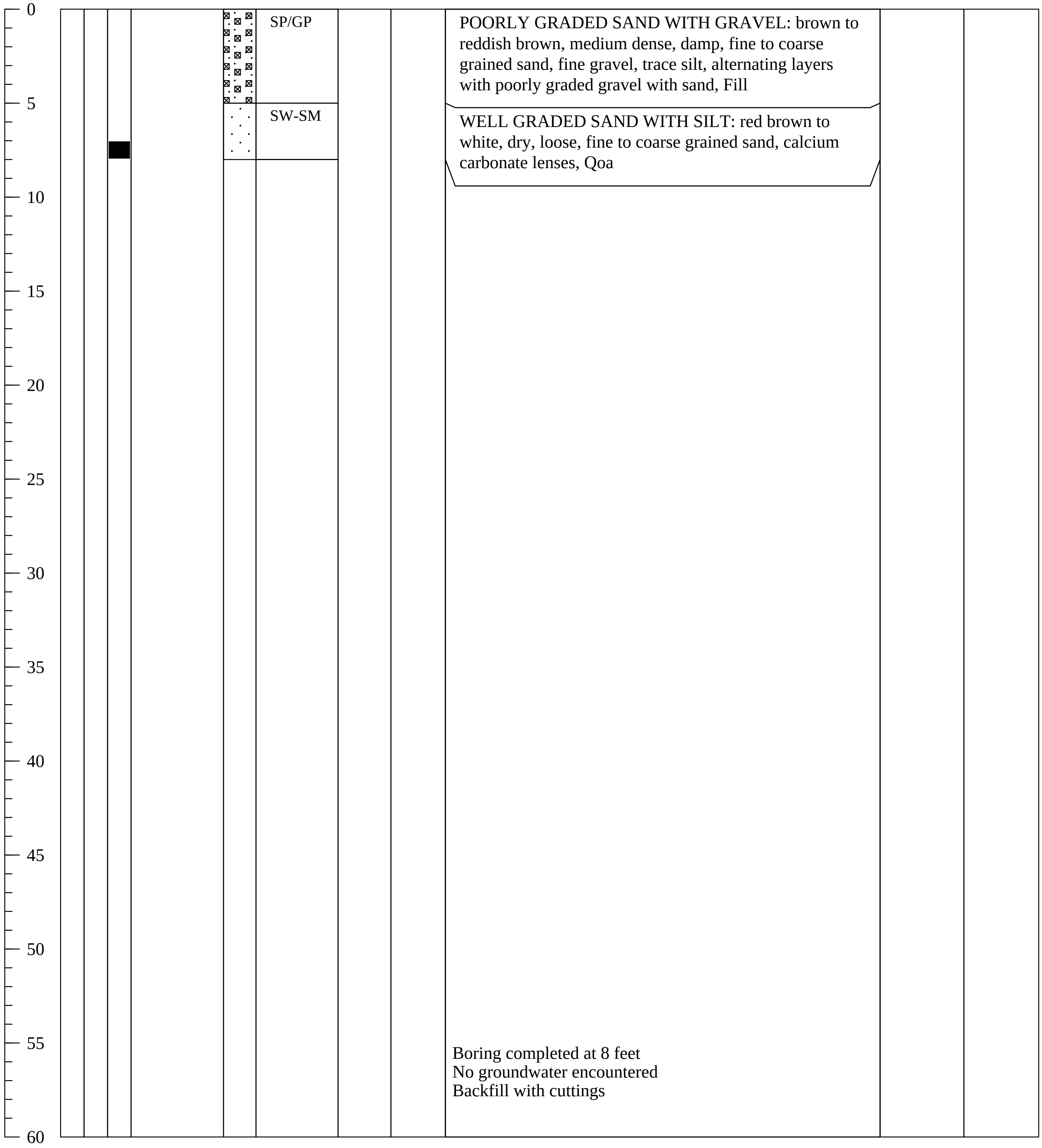
Boring No. **T-6A**
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 20, 2019
Drilling Method: Backhoe
Drill Type: 18" Bucket
Logged By: R. Howe

Depth (Ft.)	Sample Type Bulk SPT MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count Dry Density

Page 1 of 1

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.



POORLY GRADED SAND WITH GRAVEL: brown to reddish brown, medium dense, damp, fine to coarse grained sand, fine gravel, trace silt, alternating layers with poorly graded gravel with sand, Fill

WELL GRADED SAND WITH SILT: red brown to white, dry, loose, fine to coarse grained sand, calcium carbonate lenses, Qoa

Boring completed at 8 feet
No groundwater encountered
Backfill with cuttings

Earth Systems

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Boring No. T-17	Drilling Date: June 20, 2019
Project Name: Glamis Specific Plan	Drilling Method: Back Hoe
Project Number 303235-001	Drill Type: 18" Bucket
Boring Location: Plate 2	Logged By: R. Howe

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Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count	Graphic Trend Dry Density
0		◧ ◧				SP SW			POORLY GRADED SAND: light brown, loose, dry, fine to coarse grained sand, some silt, Fill		
5		◧							WELL GRADED SAND WITH GRAVEL: brown, loose, damp, fine to coarse grained sand, fine gravel, Qa cementation calcium carbonate lenses		
10											
15											
20											
25											
30											
35											
40											
45											
50											
55									Boring completed at 8 feet No groundwater encountered Backfill with cuttings		
60											

Earth Systems

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Boring No. T-8

Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 20, 2019
Drilling Method: Backhoe
Drill Type: 18" Bucket
Logged By: R. Howe

Page 1 of 1

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count	Graphic Trend Dry Density
0					▒	GP/SW-SM			POORLY GRADED GRAVEL WITH SAND: reddish brown, damp, fine to coarse grained sand, fine gravel, alternating layers with well graded sand with gravel, Fill		
5		◧			∴	SP-SM			POORLY GRADED SAND WITH SILT: yellow brown, dry, loose, fine grained sand, trace fine gravel, Qs		
10											
15											
20											
25											
30											
35											
40											
45											
50											
55									Trenching completed at 8 feet No groundwater encountered Backfill with cuttings		
60											

Earth Systems

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Boring No. **T-14**
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 20, 2019
Drilling Method: Backhoe
Drill Type: 18" Bucket
Logged By: R. Howe

Page 1 of 1

Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count	Graphic Trend Dry Density
0						GP			POORLY GRADED GRAVEL WITH SAND: brown to grey, damp, fine to coarse grained sand, fine gravel, alternating layers with well graded sand with gravel, Fill		
5			■			SW-SM			SAND WITH SILT AND GRAVEL: reddish brown, dry, very dense, fine to coarse grained sand, fine gravel, calcium carbonate, hard digging, cementation, Qoa		

Trenching completed at 8 feet
No groundwater encountered
Backfill with cuttings

Earth Systems

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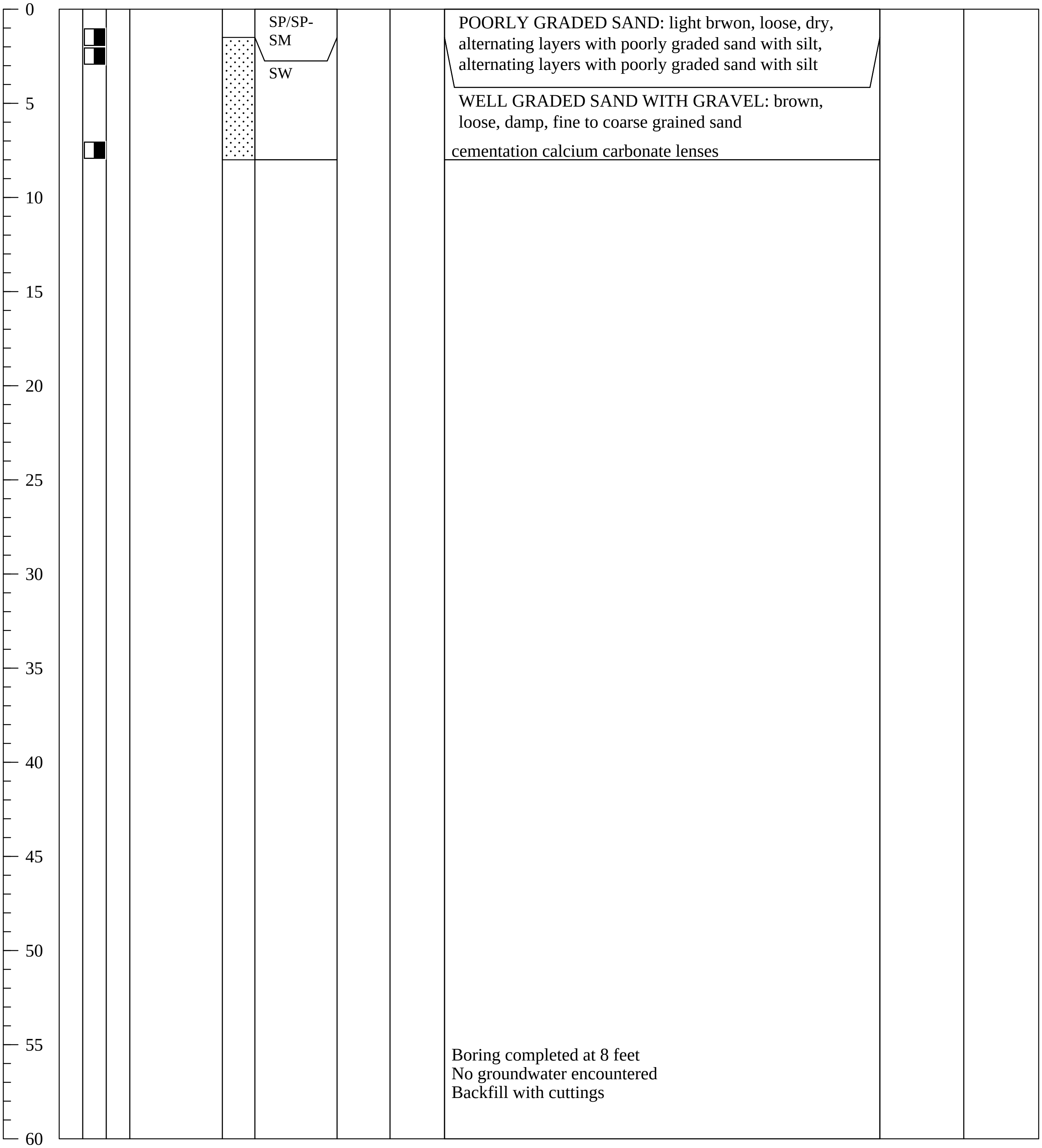
Boring No. T-17
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 20, 2019
Drilling Method: Back Hoe
Drill Type: 18" Bucket
Logged By: R. Howe

Depth (Ft.)	Sample Type Bulk SPT MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count Dry Density

Page 1 of 1

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.



POORLY GRADED SAND: light brwon, loose, dry, alternating layers with poorly graded sand with silt, alternating layers with poorly graded sand with silt

WELL GRADED SAND WITH GRAVEL: brown, loose, damp, fine to coarse grained sand

cementation calcium carbonate lenses

Boring completed at 8 feet
No groundwater encountered
Backfill with cuttings

Boring No. **T-24**
Project Name: Glamis Specific Plan
Project Number 303235-001
Boring Location: Plate 2

Drilling Date: June 20, 2019
Drilling Method: Backhoe
Drill Type: 18" Bucket
Logged By: R. Howe

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Description of Units

Note: The stratification lines shown represent the approximate boundary between soil and/or rock types and the transition may be gradational.

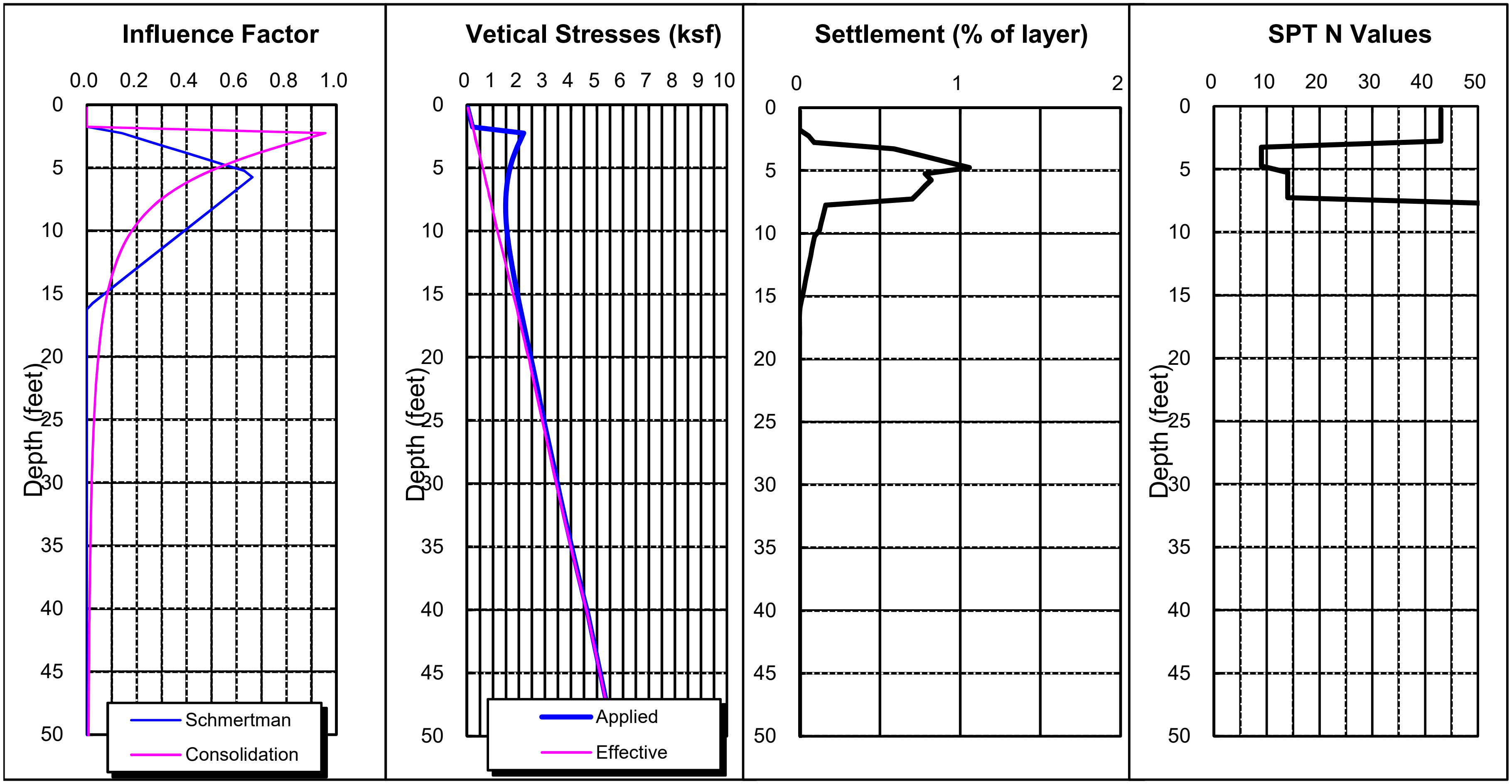
Depth (Ft.)	Sample Type Bulk	Sample Type SPT	Sample Type MOD Calif.	Penetration Resistance (Blows/6")	Symbol	USCS	Dry Density (pcf)	Moisture Content (%)	Description of Units	Graphic Trend Blow Count	Graphic Trend Dry Density
0					░	GP/SW-SM			POORLY GRADED GRAVEL: brown to red brown, damp, fine to coarse grained sand, fine gravel, alternating layers with well graded sand with silt, Fill		
5			■		· · ·	SW-SM			WELL GRADED SAND WITH SILT: brown to white, dense, dry, fine to coarse grained sand, calcium carbonate lenses, Qa		
10											
15											
20											
25											
30											
35											
40											
45											
50											
55									Trenching completed at 8 feet No groundwater encountered Backfill with cuttings		
60											

EARTH SYSTEMS SOUTHWEST - SETTLEMENT ANALYSES

Glamis

303235-001

Width, ft: 7.1 Length, ft: 7.1 Net pressure, ksf: 2.00 **Settlement, inches: 0.5**



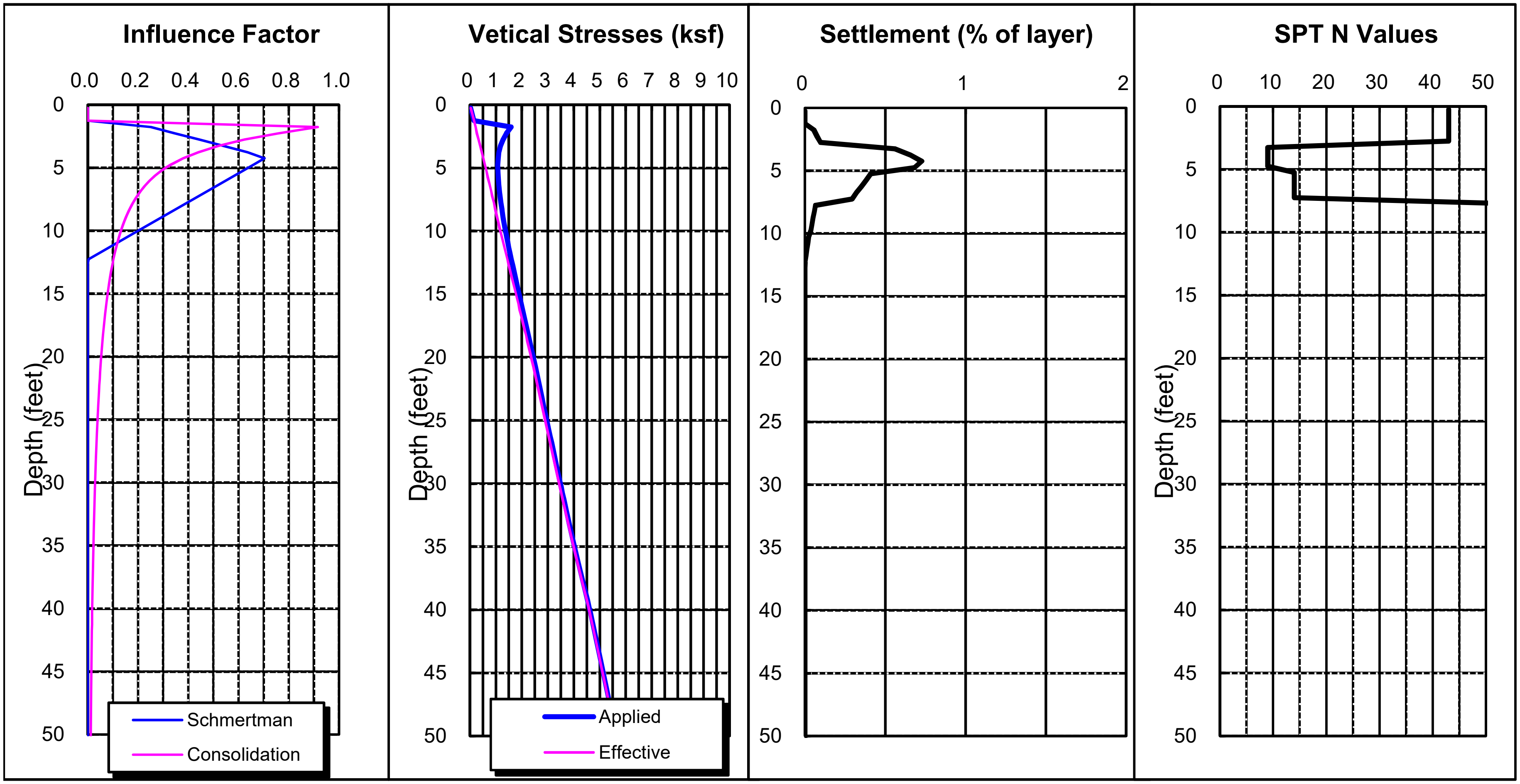
Load, Q: 100 kips Embedment, feet: 2.0 **Boring: 11**

EARTH SYSTEMS SOUTHWEST - SETTLEMENT ANALYSES

Glamis

303235-001

Width, ft: 2.7 Length, ft: 40.0 Net pressure, ksf: 1.50 **Settlement, inches: 0.3**



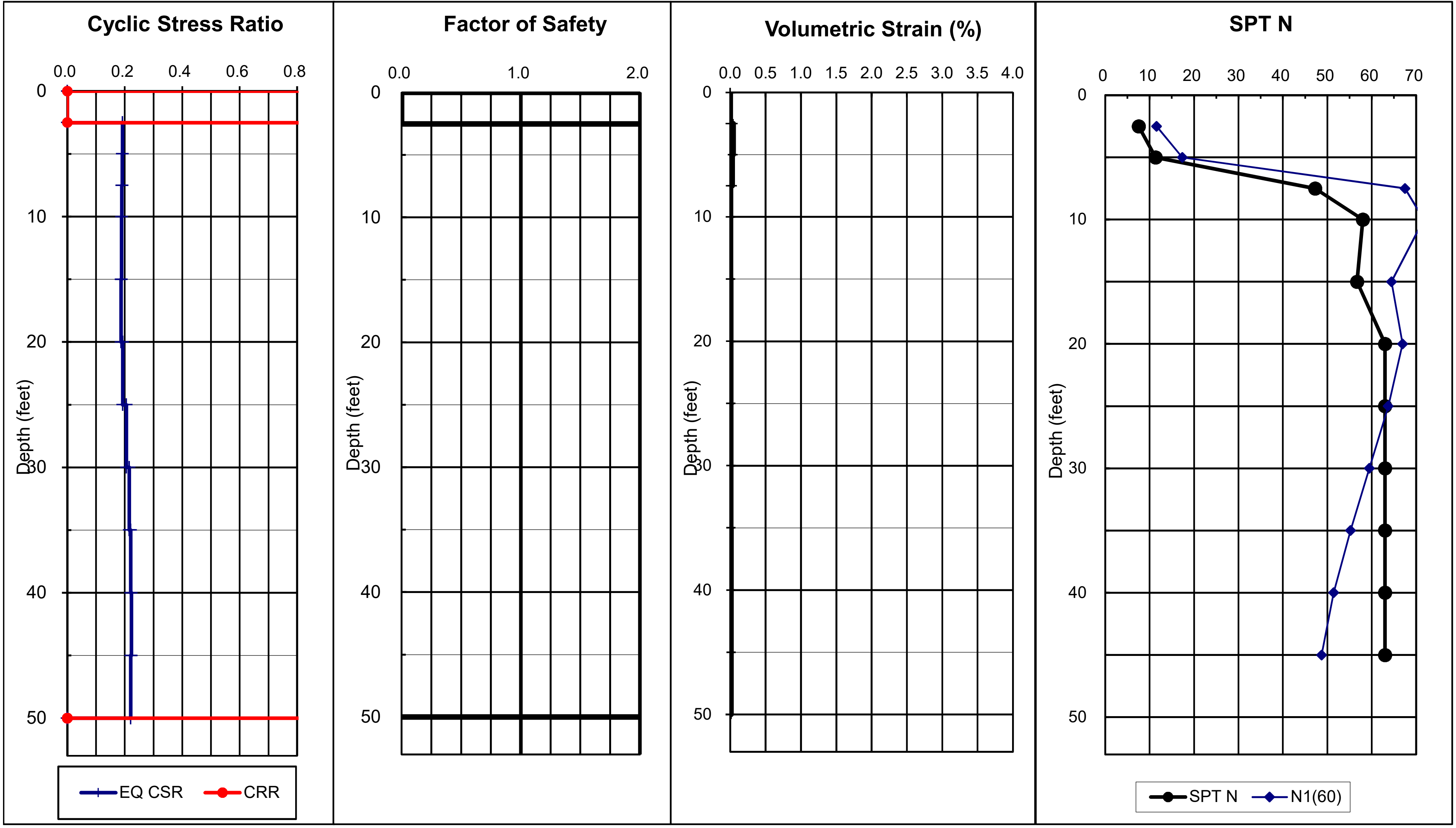
Load, Q: 4 kpf Embedment, feet: 1.5 **Boring: 11**

EARTH SYSTEMS - EVALUATION OF LIQUEFACTION POTENTIAL AND INDUCED SUBSIDENCE

Proposed Glamis Specific Plan Project **Project No: 303235-001** 1996/1998 NCEER Method

Ground Compaction Remediated to 3 foot depth

Boring: 11 **Earthquake Magnitude: 7.9** **PGA, g: 0.26** **Calc GWT (feet): 100**



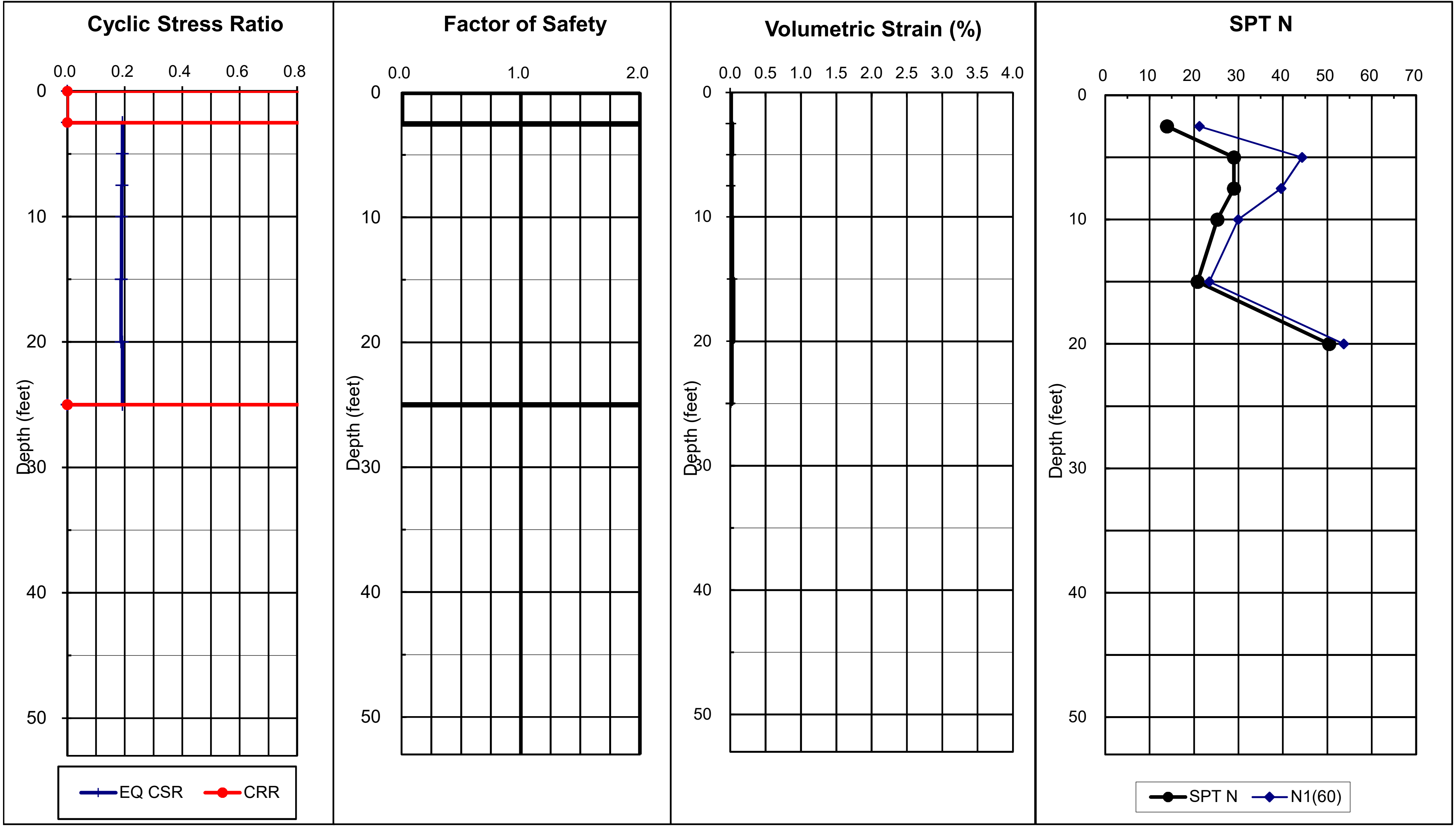
Total Thickness of Liquefiable Layers: 0.0 feet **Estimated Total Ground Subsidence: 0.1 inches**

EARTH SYSTEMS - EVALUATION OF LIQUEFACTION POTENTIAL AND INDUCED SUBSIDENCE

Proposed Glamis Specific Plan Project **Project No: 303235-001** 1996/1998 NCEER Method

Ground Compaction Remediated to 3 foot depth

Boring: 15 **Earthquake Magnitude: 7.9** **PGA, g: 0.26** **Calc GWT (feet): 100**



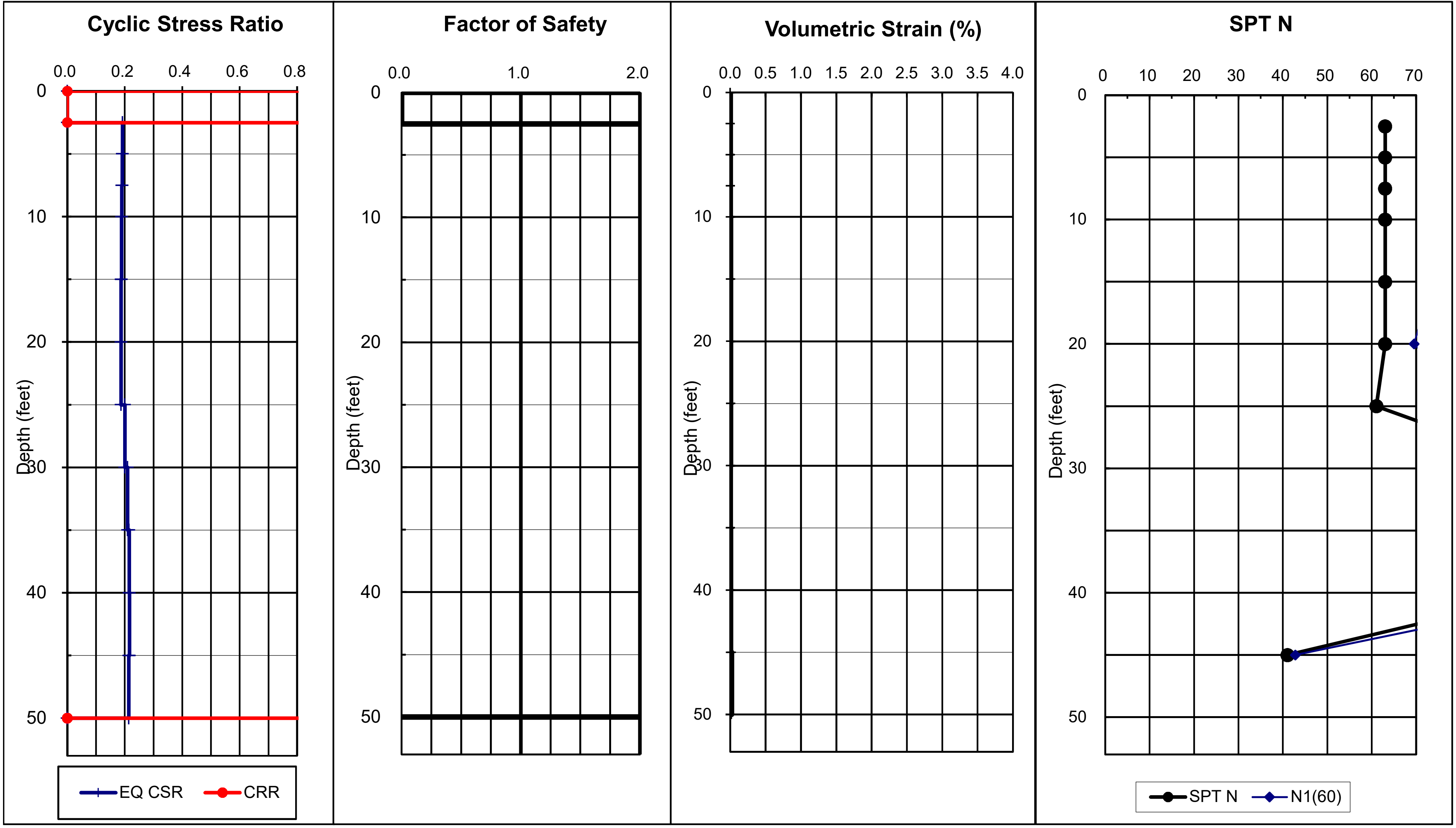
Total Thickness of Liquefiable Layers: 0.0 feet **Estimated Total Ground Subsidence: 0.1 inches**

EARTH SYSTEMS - EVALUATION OF LIQUEFACTION POTENTIAL AND INDUCED SUBSIDENCE

Proposed Glamis Specific Plan Project **Project No: 303235-001** 1996/1998 NCEER Method

Ground Compaction Remediated to 3 foot depth

Boring: 26 **Earthquake Magnitude: 7.9** **PGA, g: 0.26** **Calc GWT (feet): 100**



Total Thickness of Liquefiable Layers: 0.0 feet

Estimated Total Ground Subsidence: 0.0 inches

Boring No. 11 | **Project and Number** Proposed Glamis Spec 303235-001

ESSW Field Staff R. Howe

Drilling Company Calpac

Drilling Method B-61 HAS **HSA Inner Diameter** 8"

Site Latitude (North) Decimal Degrees 32.9934

Site Longitude (West) Decimal Degrees -115.0774

27.40

Date Drilled
6/18/2019

Hammer Weight (lbs)
140

Hammer Drop (inches)
30

Hammer Efficiency (E_M)
72

Borehole Correction (Cb)*
1
*inside diameter of Hollow Stem Auger

Sampler Correction Mod Cal to SPT
0.63

Sampler Liner Correction (Cs)
1.2 Applied if SPT Sampler Used
1.0 Applied if Cal Sampler Used

Rod Length Above Ground (ft)
3

Depth to Estimate Vs Over (ft)*
100
*Caltrans Estimation Method

***N_{sub} Value Desired For Column 6**
70
*Only Used for Calculating Nsub otherwise not used by program (i.e.N50, N70, N80, etc)

	Equipment variable	Typical Correction (%/100)
Energy ratio (Skempton, 1986)	Donut Hammer	0.50 to 1.00
	Safety Hammer	0.70 to 1.20
	Automatic-Trip Donut-type Hammer	0.80 to 1.30

→ Hammer energy as related to the standard 60% delivered energy, i.e. a 72% hammer has and energy ratio of 1.2, i.e. (72/60=1.2)

Calculation Results

Ave. SPT N60HE-value (blows/ft)
34
(Based on Upper 50 feet)

Ave. Shear Wave Velocity (ft/sec)
1015
(Based on Upper 50 feet)

Soil Profile Type (Site Class)
D
(Based on Upper 50 feet)

Ave. Friction Angle (degrees)
38
(Based on Upper 50 feet)

Estimated Shear Wave Velocity **
Based on Depth Less than 100' ft
1003 (ft/sec Upper 100 feet)

Soil Profile Type (Site Class)**
D
Based on
Ave. Shear Wave Velocity (ft/sec)
306 (m/sec Upper 100 feet)

Ave. Field SPT N-value (blows/ft)
28.6
(Based on Upper 50 feet)

Ave. Field SPT N-value (blows/ft)
46.6
(Based on Upper 100 feet)

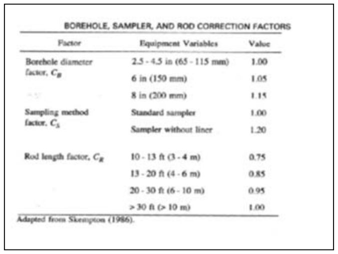
Soil Profile Type (Site Class)**
D
Based on
Ave. Field Blow Count
47 (Upper 100 feet)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bottom of Layer Depth (ft)	**Blow Count*****	**Type of Sampler**	**d_i (feet)**	**N_{60} (blows/ft)**	**N70 (blows/ft)**	**N_{60HE} (blows/ft)**	**V_{si**} (m/sec)**	**V_{si} (ft/sec)**	**Φ_i (degrees)**	**d_i/N_{60HEi}**	**d_i/V_{si}**	**d_i/Φ_i**	**Consistency if Coarse Grained (Based on ASTM and Corrected for N60)**	**Consistency if Fine Grained (Based on ASTM and Corrected for N60)**
2.5	8	c	2.5	4.54	3.89	6.05	169.37	555.53	27.40	0.41336	0.00450	0.091251	Loose	Firm
5.0	12	c	2.5	6.80	5.83	9.07	190.50	624.85	28.86	0.27557	0.00400	0.086615	Loose	Firm
7.5	18	c	2.5	10.21	8.75	13.61	214.27	702.81	30.51	0.18372	0.00356	0.081942	Medium Dense	Stiff
10.0	75	c	2.5	42.53	36.45	56.70	324.12	1063.11	38.07	0.04409	0.00235	0.065672	Dense	Hard
15.0	92	c	5.0	59.12	50.67	69.55	343.90	1128.00	39.42	0.07189	0.00443	0.126829	Very Dense	Hard
20.0	90	c	5.0	64.64	55.40	68.04	341.72	1120.83	39.27	0.07349	0.00446	0.127312	Very Dense	Hard
25.0	100	c	5.0	71.82	61.56	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
30.0	100	c	5.0	75.60	64.80	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
35.0	100	c	5.0	75.60	64.80	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
40.0	100	c	5.0	75.60	64.80	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
45.0	100	c	5.0	75.60	64.80	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
50.0	100	c	5.0	75.60	64.80	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
		Total:	50.0	"d" Feet				Total:		1.45894	0.04926	1.329633		

**Used When Boring Depths are less than 100 feet to estimate Shear Wave Velocity over 100 feet. Caltrans Geotechnical Services Design Manual, Version 1.0, August 2009 using N60HE corrected only for Hammer Energy (Empirical Calculation)

*** Uncorrected blowcount not to exceed 100 blows as entry per CBC

Consistency classification based upon ASCE 1996



BOREHOLE, SAMPLER, AND ROD CORRECTION FACTORS

Factor	Equipment Variables	Value
Borehole diameter factor, C_B	2.5 - 4.5 in (65 - 115 mm)	1.00
	6 in (150 mm)	1.05
	8 in (200 mm)	1.15
Sampling method factor, C_S	Standard sampler	1.00
	Sampler without liner	1.20
Rod length factor, C_R	10 - 13 ft (3 - 4 m)	0.75
	13 - 20 ft (4 - 6 m)	0.85
	20 - 30 ft (6 - 10 m)	0.95
	> 30 ft (> 10 m)	1.00

Adapted from Skempton (1986).

Spreadsheet Version 2.6, 2019: Prepared by Kevin L. Paul, PE, GE

Boring No.	26	**Project and Number**	Proposed Glamis Spec	303235-001
		ESSW Field Staff	R. Howe	
		Drilling Company	Calpac	
		Drilling Method	B-61 HAS	**HSA Inner Diameter** 8"
		Site Latitude (North)	**Decimal Degrees** 32.9995	
		Site Longitude (West)	**Decimal Degrees** -115.0593	

33.65

Date Drilled	6/18/2019
Hammer Weight (lbs)	140
Hammer Drop (inches)	30
Hammer Efficiency (E_M)	72
Borehole Correction (Cb)*	1

*inside diameter of Hollow Stem Auger

Sampler Correction Mod Cal to SPT	0.63

Sampler Liner Correction (Cs)
1.2 Applied if SPT Sampler Used
1.0 Applied if Cal Sampler Used

Rod Length Above Ground (ft)	3
Depth to Estimate Vs Over (ft)*	100

*Caltrans Estimation Method

***N_{sub} Value Desired For Column 6**	70

*Only Used for Calculating Nsub
otherwise not used by program
(i.e.N_{50}, N_{70}, N_{80}, etc)

Calculation Results
Ave. SPT N_{60HE}-value (blows/ft)
73
(Based on Upper 50 feet)
Ave. Shear Wave Velocity (ft/sec)
1162
(Based on Upper 50 feet)
Soil Profile Type (Site Class)
D
(Based on Upper 50 feet)
Ave. Friction Angle (degrees)
40
(Based on Upper 50 feet)
Estimated Shear Wave Velocity ** **Based on Depth Less than 100' ft**
1151 (ft/sec Upper 100 feet)
Soil Profile Type (Site Class)**
D **Based on** **Ave. Shear Wave Velocity (ft/sec)** **351 (m/sec Upper 100 feet)**
Ave. Field SPT N-value (blows/ft)
60.6
(Based on Upper 50 feet)
Ave. Field SPT N-value (blows/ft)
66.3
(Based on Upper 100 feet)

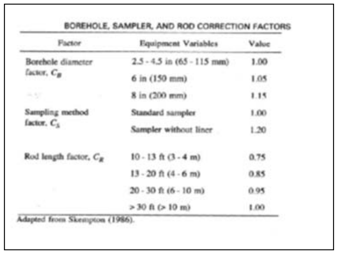
Soil Profile Type (Site Class)**
Check Rock Type for Either A, B, or C **Based on** **Ave. Field Blow Count** **66 (Upper 100 feet)**

	Equipment variable	Typical Correction (%/100)
Energy ratio (Skempton, 1986)	Donut Hammer	0.50 to 1.00
	Safety Hammer	0.70 to 1.20
	Automatic-Trip Donut-type Hammer	0.80 to 1.30

→ Hammer energy as related to the standard 60% delivered energy, i.e. a 72% hammer has and energy ratio of 1.2, i.e. (72/60=1.2)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bottom of Layer Depth (ft)	**Blow Count*****	**Type of Sampler**	**d_i (feet)**	**N_{60} (blows/ft)**	**N70 (blows/ft)**	**N_{60HE} (blows/ft)**	**V_{si**} (m/sec)**	**V_{si} (ft/sec)**	**Φ_i (degrees)**	**d_i/N_{60HEi}**	**d_i/V_{si}**	**d_i/Φ_i**	**Consistency if Coarse Grained (Based on ASTM and Corrected for N60)**	**Consistency if Fine Grained (Based on ASTM and Corrected for N60)**
2.5	35	c	2.5	19.85	17.01	26.46	259.85	852.30	33.65	0.09448	0.00293	0.074285	Medium Dense	Very Stiff
5.0	100	c	2.5	56.70	48.60	75.60	352.32	1155.61	40.00	0.03307	0.00216	0.062501	Very Dense	Hard
7.5	100	c	2.5	56.70	48.60	75.60	352.32	1155.61	40.00	0.03307	0.00216	0.062501	Very Dense	Hard
10.0	100	c	2.5	56.70	48.60	75.60	352.32	1155.61	40.00	0.03307	0.00216	0.062501	Very Dense	Hard
15.0	100	c	5.0	64.26	55.08	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
20.0	100	c	5.0	71.82	61.56	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
25.0	100	c	5.0	71.82	61.56	75.60	352.32	1155.61	40.00	0.06614	0.00433	0.125002	Very Dense	Hard
30.0	61	s	5.0	87.84	75.29	73.20	349.04	1144.85	39.77	0.06831	0.00437	0.125708	Very Dense	Hard
35.0	100	s	5.0	144.00	123.43	120.00	402.84	1321.30	43.45	0.04167	0.00378	0.115062	Very Dense	Hard
40.0	100	s	5.0	144.00	123.43	120.00	402.84	1321.30	43.45	0.04167	0.00378	0.115062	Very Dense	Hard
45.0	100	s	5.0	144.00	123.43	120.00	402.84	1321.30	43.45	0.04167	0.00378	0.115062	Very Dense	Hard
50.0	41	s	5.0	59.04	50.61	49.20	311.05	1020.26	37.17	0.10163	0.00490	0.134508	Very Dense	Hard
		Total:	50.0	"d" Feet				Total:		0.68703	0.04302	1.242194		

**Used When Boring Depths are less than 100 feet to estimate Shear Wave Velocity over 100 feet. Caltrans Geotechnical Services Design Manual, Version 1.0, August 2009
using N60HE corrected only for Hammer Energy (Empirical Calculation)
*** Uncorrected blowcount not to exceed 100 blows as entry per CBC
Consistency classification based upon ASCE 1996



BOREHOLE, SAMPLER, AND ROD CORRECTION FACTORS

Factor	Equipment Variables	Value
Borehole diameter factor, C_B	2.5 - 4.5 in (65 - 115 mm)	1.00
	6 in (150 mm)	1.05
	8 in (200 mm)	1.15
Sampling method factor, C_S	Standard sampler	1.00
	Sampler without liner	1.20
Rod length factor, C_R	10 - 13 ft (3 - 4 m)	0.75
	13 - 20 ft (4 - 6 m)	0.85
	20 - 30 ft (6 - 10 m)	0.95
	> 30 ft (> 10 m)	1.00

Adapted from Skempton (1986).

Spreadsheet Version 2.6, 2019: Prepared by Kevin L. Paul, PE, GE

APPENDIX B

Laboratory Test Results

File No.: 303235-001 August 29, 2019

Lab No.: 19-073

UNIT DENSITIES AND MOISTURE CONTENT ASTM D2937 & D2216

Job Name: Glamis Plan

Sample Location	Depth (feet)	Unit Dry Density (pcf)	Moisture Content (%)	USCS Group Symbol
B1	5	122	2	SM
B1	15	114	2	SW
B3	2.5	125	2	SM
B3	12.5	120	3	SC
B4	5	118	4	SP-SM
B4	10	122	4	SP
B9	2.5	117	4	SM
B9	7.5	124	4	SW-SM
B10	5	118	3	SM
B11	2.5	112	2	SM
B11	5	107	3	SP-SM
B11	7.5	112	9	SM
B11	10	121	2	SW-SM
B11	15	115	3	SW-SM
B11	20	104	2	SW-SM
B11	25	---	5	SM
B11	30	107	2	SM
B11	35	119	2	SM
B11	40	---	3	SM
B11	45	---	3	SM
B11	50	---	2	SM
B12	2.5	109	3	SW-SM
B12	7.5	118	3	SC
B12	12.5	120	6	SC
B12	17.5	123	3	SW-SM

File No.: 303235-001 August 29, 2019

Lab No.: 19-073

UNIT DENSITIES AND MOISTURE CONTENT ASTM D2937 & D2216

Job Name: Glamis Plan

Sample Location	Depth (feet)	Unit Dry Density (pcf)	Moisture Content (%)	USCS Group Symbol
B13	5	118	3	SW
B13	10	118	3	SW
B15	2.5	121	3	SP-SM
B15	5	119	2	SP-SM
B15	10	126	3	SM
B15	15	107	3	SM
B15	20	125	6	SM
B16	2.5	116	2	SP-SM
B16	5	114	3	SW
B16	10	122	5	SP-SM
B18	2.5	121	4	SP-SM
B18	7.5	115	4	SM
B18	10	123	3	SW
B19	5	126	6	SC-SM
B19	10	125	7	SC-SM
B19	15	125	8	SP
B20	5	122	4	SP-SM
B20	10	120	4	SW
B20	15	125	4	SW
B21	5	120	4	SW
B21	15	112	7	SC-SM
B23	2.5	111	1	SW
B23	5	128	3	GP
B23	7.5	120	4	SW

File No.: 303235-001 August 29, 2019

Lab No.: 19-073

UNIT DENSITIES AND MOISTURE CONTENT ASTM D2937 & D2216

Job Name: Glamis Plan

Sample Location	Depth (feet)	Unit Dry Density (pcf)	Moisture Content (%)	USCS Group Symbol
B25	2.5	129	5	SW
B25	5	121	5	SP
B25	7.5	126	7	SC
B25	10	125	5	SM
B25	15	---	7	SM
B25	20	---	4	SW-SM
B26	5	115	4	SP-SM
B26	10	119	4	SP-SM
B26	15	---	4	SP-SM
B26	20	---	3	SP-SM
B27	2.5	110	3	SW
B27	5	116	2	GP
B27	7.5	---	3	GP
B28	5	120	4	SW
B28	10	125	4	GP
B28	15	127	5	SW
B28	20	113	3	SW

File No.: 303235-001 August 29, 2019
Lab No.: 19-073

PLASTICITY INDEX

ASTM D 4318

Job Name: Glamis Plan
Sample ID: B11 @ 25 feet
Soil Description: Well Graded Sand w/Silt and Gravel (SW-SM)

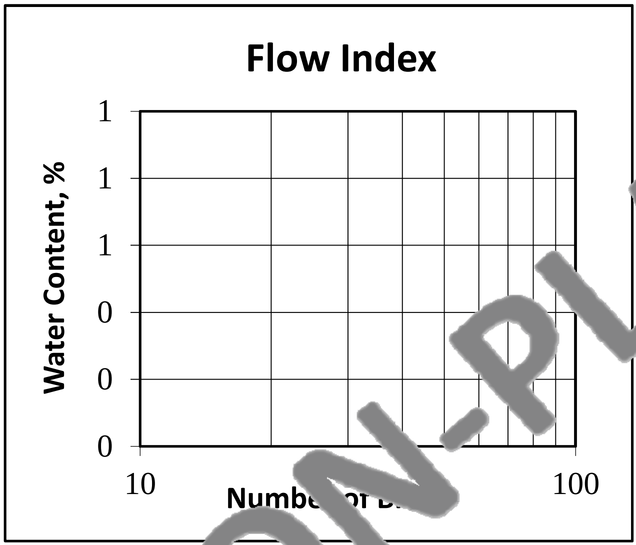
DATA SUMMARY

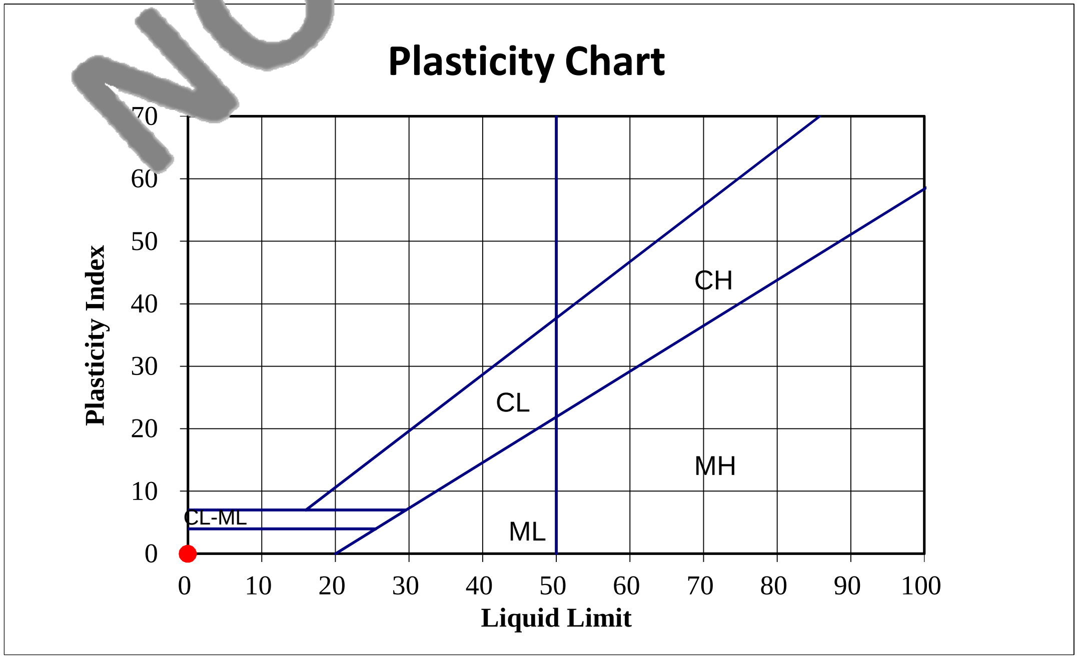
Number of Blows:	0	0	0
Water Content, %	#DIV/0!	#DIV/0!	

TEST RESULTS

LIQUID LIMIT	**#DIV/0!**
PLASTIC LIMIT	**#DIV/0!**
PLASTICITY INDEX	**#DIV/0!**

NON-PLASTIC





File No.: 303235-001
Lab No.: 19-073

August 29, 2019

PLASTICITY INDEX

ASTM D 4318

Job Name: Glamis Plan
Sample ID: B26 @ 25 feet
Soil Description: Poorly Graded Sand w/Silt (SP-SM)

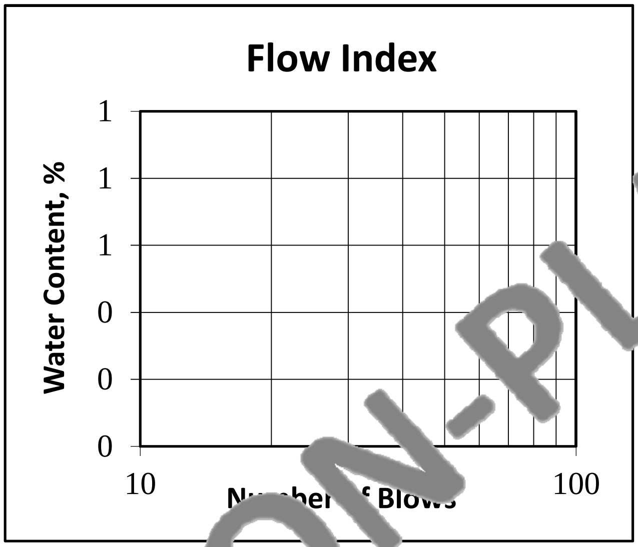
DATA SUMMARY

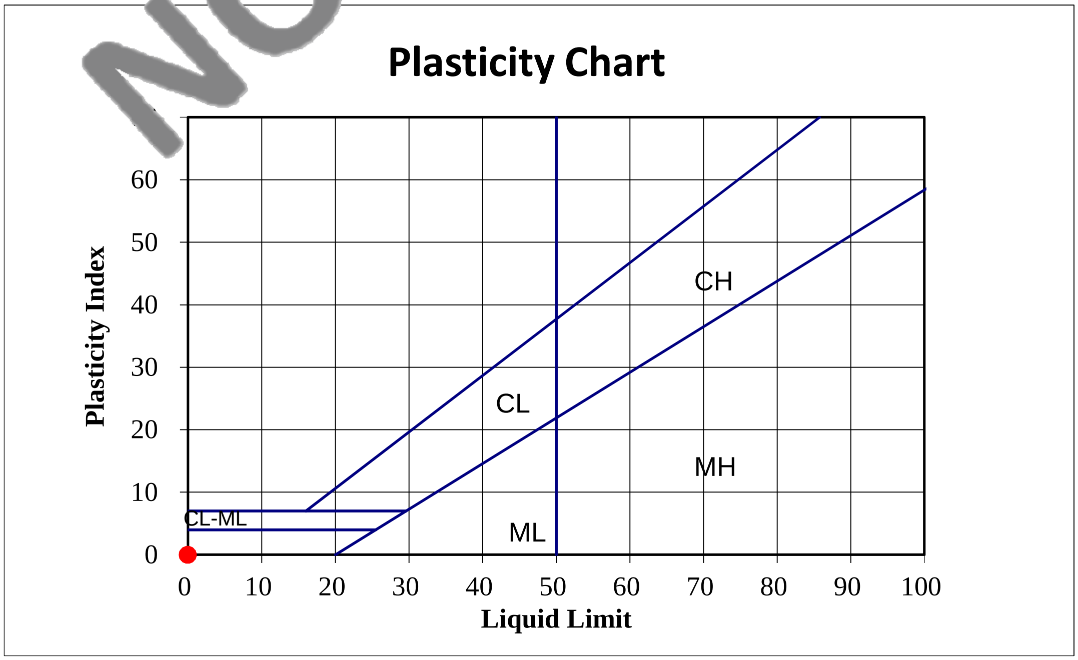
Number of Blows:	0	0	0
Water Content, %	#DIV/0!	#DIV/0!	

TEST RESULTS

LIQUID LIMIT	**#DIV/0!**
PLASTIC LIMIT	**#DIV/0!**
PLASTICITY INDEX	**#DIV/0!**

NON-PLASTIC



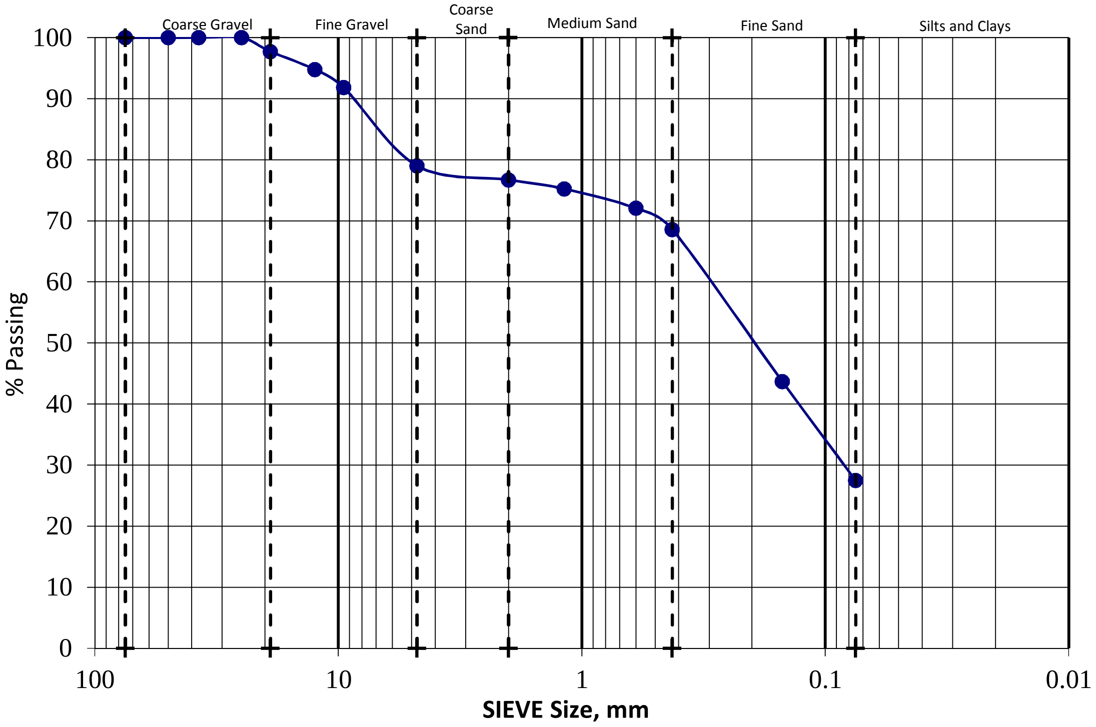


File No.: 303235-001 August 29, 2019
Lab No.: 19-073

SIEVE ANALYSIS ASTM D6913

Job Name: Glamis Plan
Sample ID: B2 @ 0-5 feet
Description: Silty Clayey Sand w/Gravel (SC-SM)

Sieve Size	% Passing
3"	100
2"	100
1-1/2"	100
1"	100
3/4"	98
1/2"	95
3/8"	92
#4	79
#10	77
#16	75
#30	72
#40	69
#100	44
#200	27.5



% Coarse Gravel:	2	% Coarse Sand:	2			
% Fine Gravel:	19	% Medium Sand:	8	Cu:	NA	
		% Fine Sand:	41	Cc:	NA	Gradation
% Total Gravel	21	% Total Sand	52	% Fines:	27.5	NA

EARTH SYSTEMS PACIFIC

File No.: 303235-001 August 29, 2019

Lab No.: 19-073

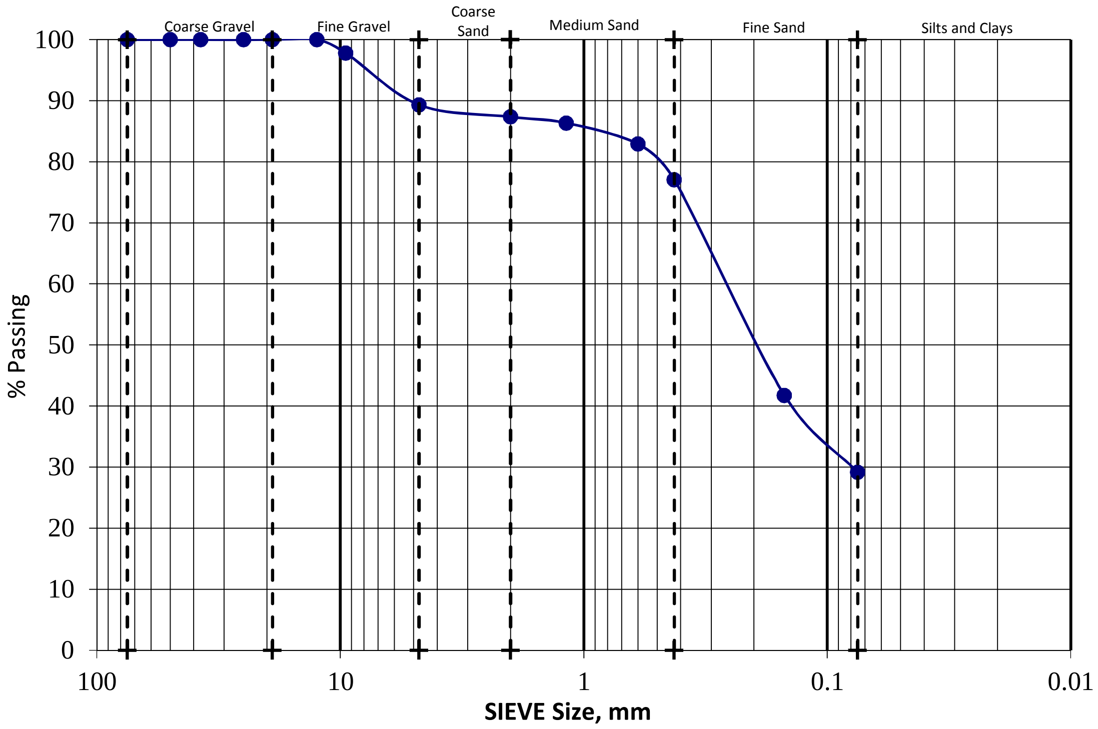
SIEVE ANALYSIS ASTM D6913

Job Name: Glamis Plan

Sample ID: B13 @ 0-5 feet

Description: Silty Sand (SM)

Sieve Size	% Passing
3"	100
2"	100
1-1/2"	100
1"	100
3/4"	100
1/2"	100
3/8"	98
#4	89
#10	87
#16	86
#30	83
#40	77
#100	42
#200	29.1



% Coarse Gravel:	0	% Coarse Sand:	2				
% Fine Gravel:	11	% Medium Sand:	10	Cu:	NA		
		% Fine Sand:	48	Cc:	NA	Gradation	
% Total Gravel	11	% Total Sand	60	% Fines:	29.1	NA	

File No.: 303235-001 August 29, 2019

Lab No.: 19-073

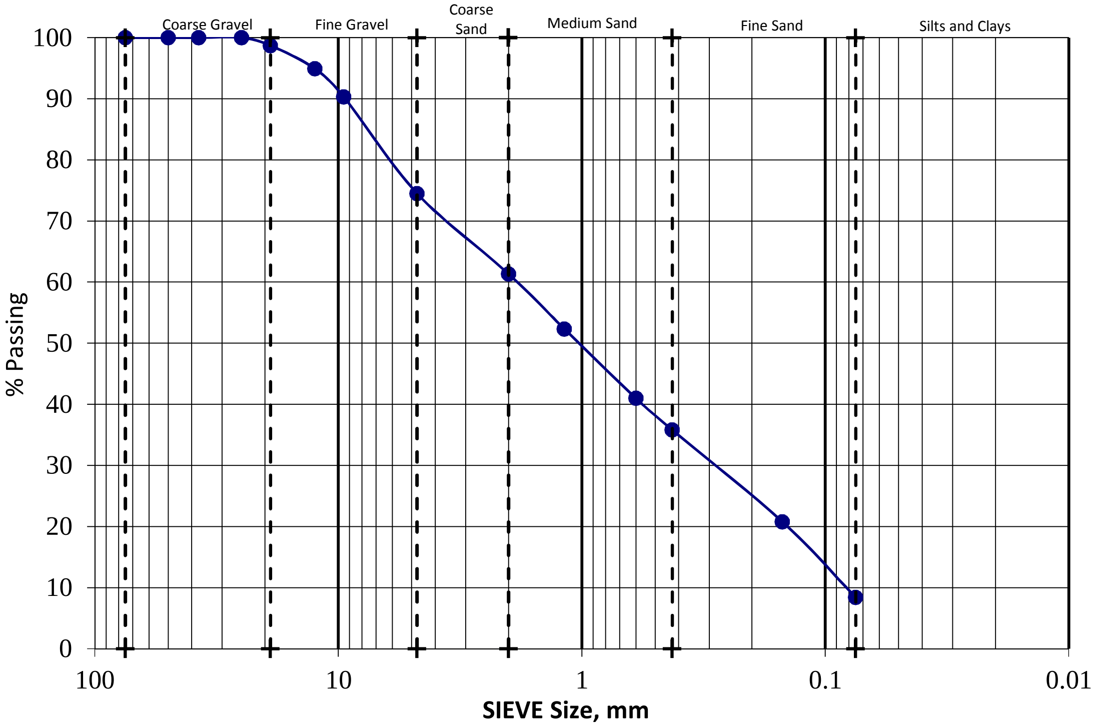
SIEVE ANALYSIS ASTM D6913

Job Name: Glamis Plan

Sample ID: B18 @ 0-5 feet

Description: Poorly Graded Sand w/Gravel (SP-SM)

Sieve Size	% Passing
3"	100
2"	100
1-1/2"	100
1"	100
3/4"	99
1/2"	95
3/8"	90
#4	74
#10	61
#16	52
#30	41
#40	36
#100	21
#200	8.4



% Coarse Gravel: 1	% Coarse Sand:	13				
% Fine Gravel: 24	% Medium Sand:	26	Cu:	22.54		
	% Fine Sand:	27	Cc:	0.533	Gradation	
% Total Gravel 26	% Total Sand	66	% Fines:	8.4	Poorly Graded	

File No.: 303235-001 August 29, 2019

Job Name: Glamis Plan

Lab Number: 19-073

AMOUNT PASSING NO. 200 SIEVE

ASTM D 1140

Sample Location	Depth (feet)	Fines Content (%)	USCS Group Symbol	Soaking Time (min)
B2	5	7.5	SC-SM	10
B2	10	20.7	SC	10
B2	15	18.5	SM	10
B2	20	13.3	SM	10
B2	25	16.4	SM	10
B2	30	15.6	SM	10
B11	25	16.4	SM	10
B26	25	12.2	SM	10

File No.: 303235-001
Lab No.: 19-073

August 29, 2019

CONSOLIDATION TEST

ASTM D 2435 & D 5333

Glamis Plan
B11 @ 5 feet

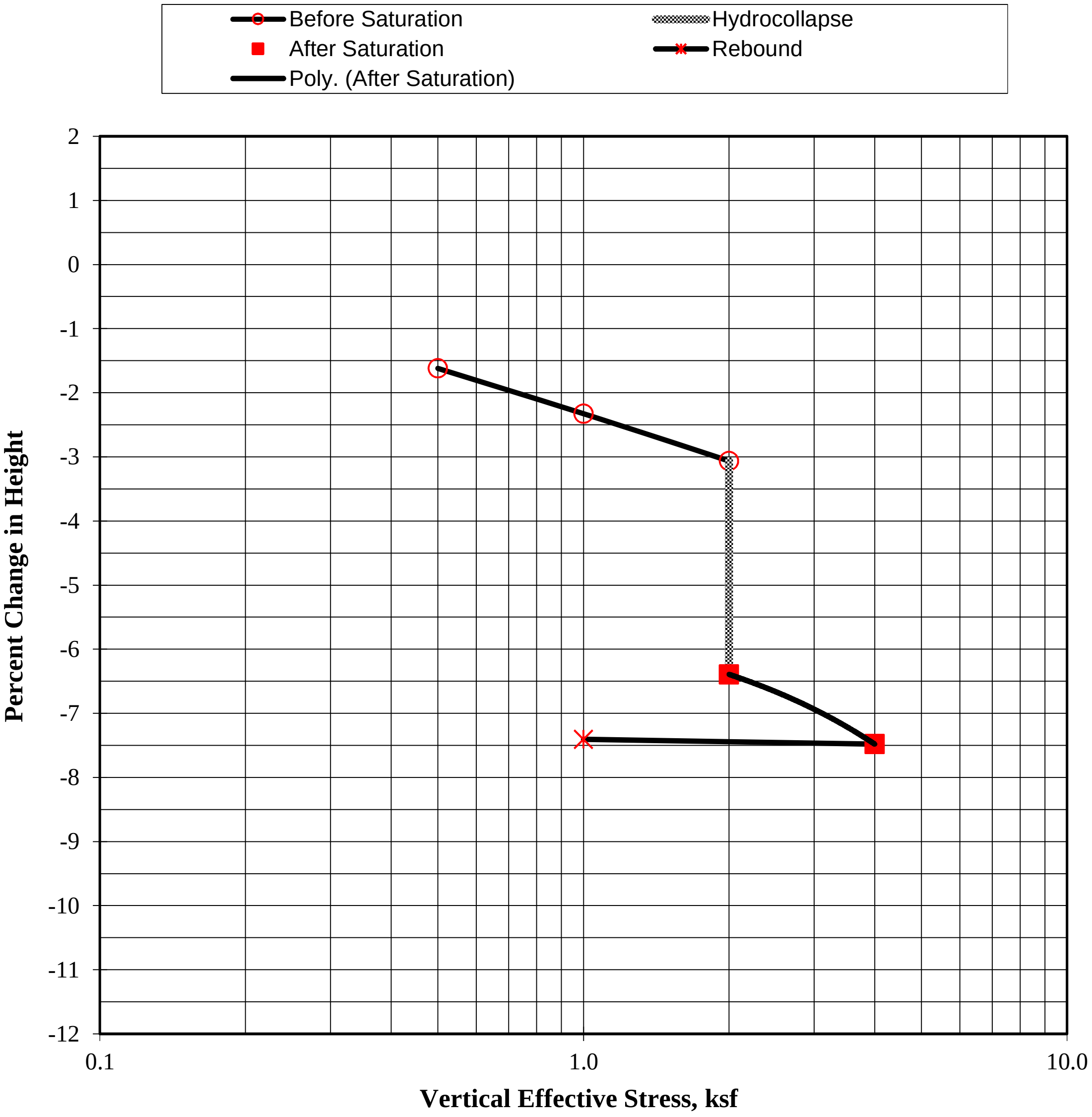
Sand w/Silt (SP-SM)

Ring Sample

Initial Dry Density: 105.1 pcf
Initial Moisture: 4.6%
Specific Gravity: 2.67
Initial Void Ratio: 0.586

Hydrocollapse: 3.3% @ 2.0 ksf

% Change in Height vs Normal Pressure Diagram



File No.: 303235-001
Lab No.: 19-073

August 29, 2019

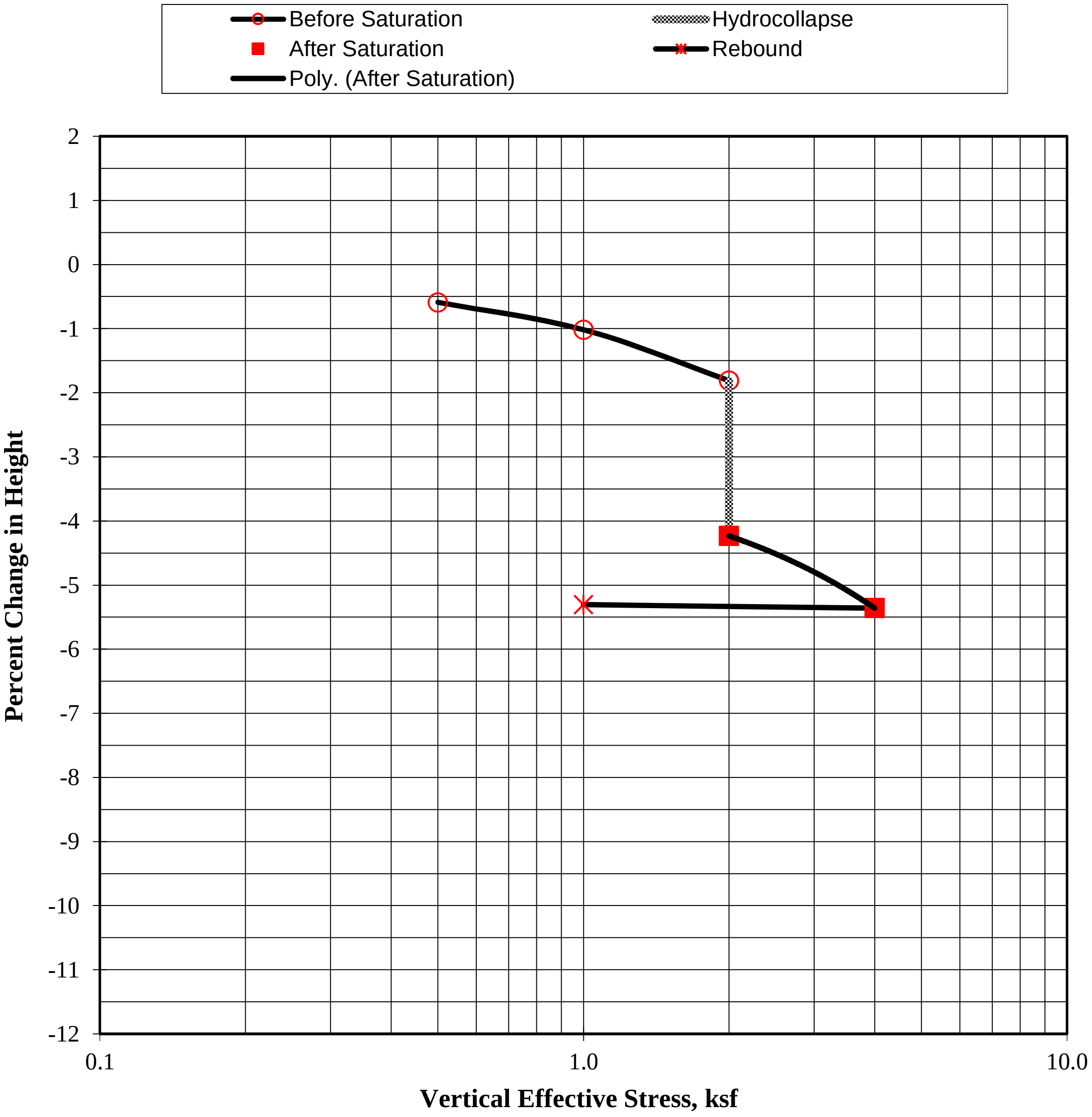
CONSOLIDATION TEST **ASTM D 2435 & D 5333**

Glamis Plan
B11 @ 10 feet
Well Graded Sand w/Silt and
Gravel (SW-SM)
Ring Sample

Initial Dry Density: 107.0 pcf
Initial Moisture: 3.3%
Specific Gravity: 2.67
Initial Void Ratio: 0.367

Hydrocollapse: 2.4% @ 2.0 ksf

% Change in Height vs Normal Pressure Diagram



File No.: 303235-001
Lab No.: 19-073

August 29, 2019

CONSOLIDATION TEST

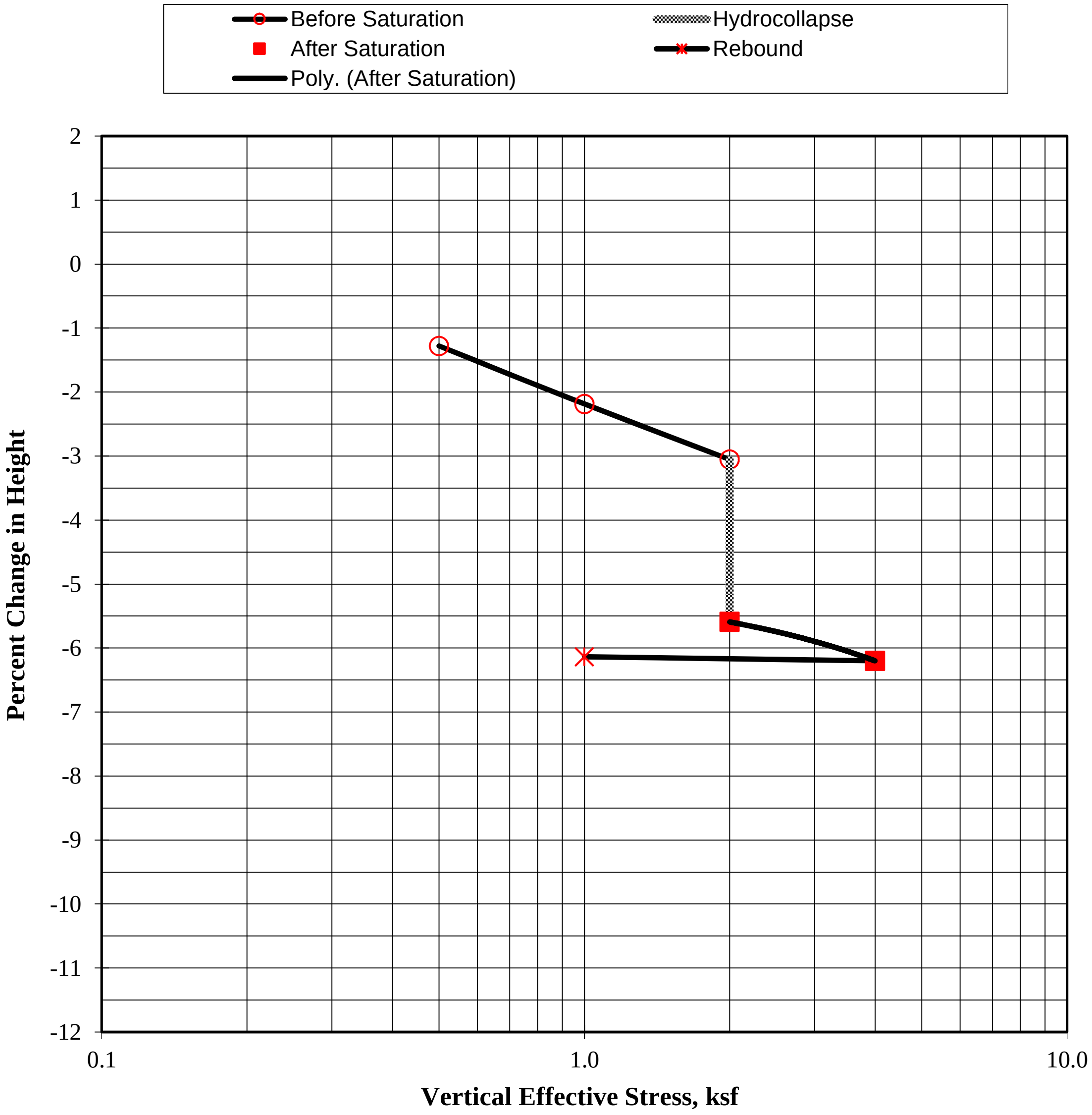
ASTM D 2435 & D 5333

Glamis Plan
B11 @ 15 feet
Well Graded Sand w/Silt and
Gravel (SW-SM)
Ring Sample

Initial Dry Density: 107.0 pcf
Initial Moisture: 7.8%
Specific Gravity: 2.67
Initial Void Ratio: 0.489

Hydrocollapse: 2.5% @ 2.0 ksf

% Change in Height vs Normal Pressure Diagram



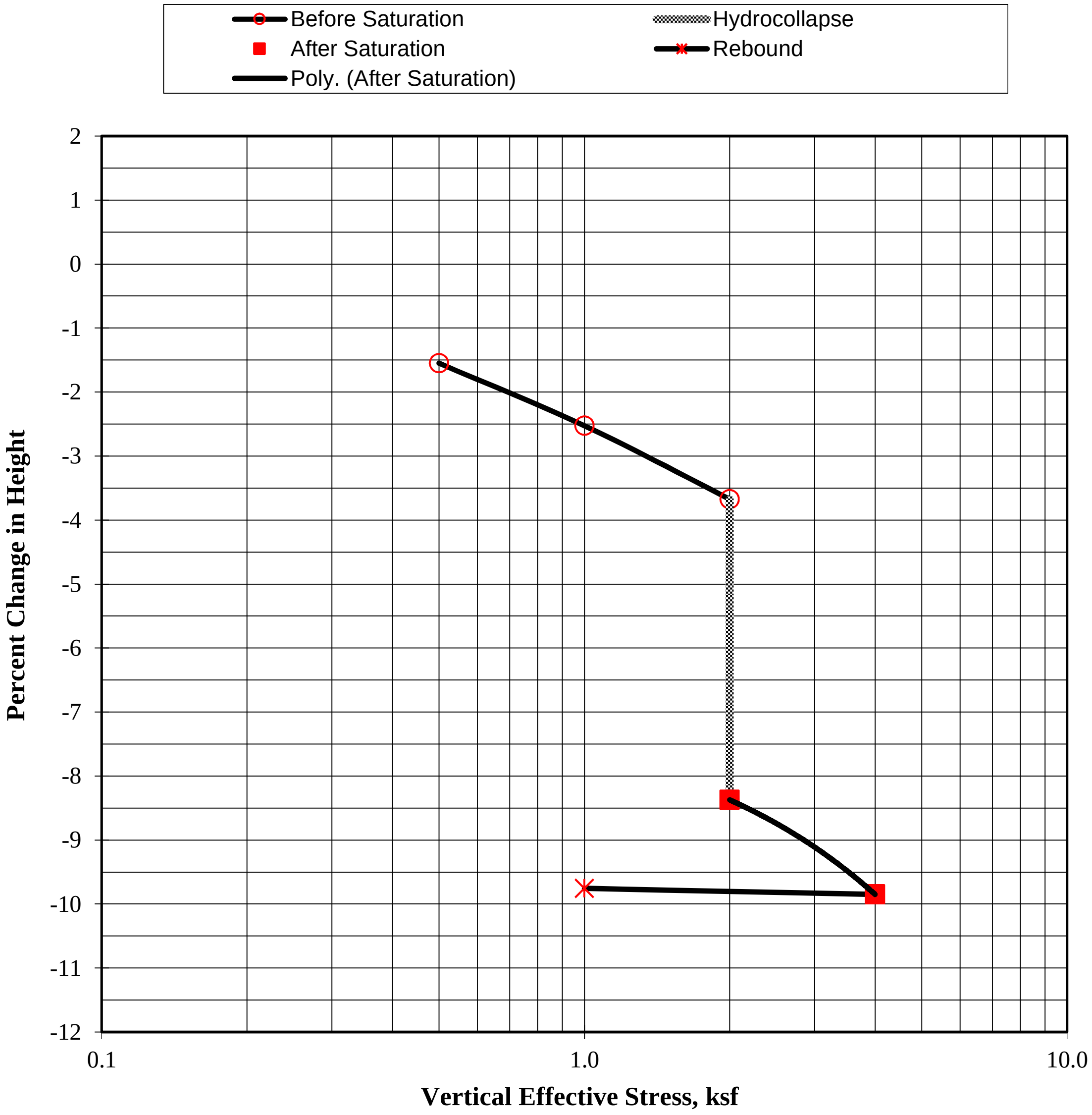
File No.: 303235-001 August 29, 2019
Lab No.: 19-073

CONSOLIDATION TEST ASTM D 2435 & D 5333

Glamis Plan	Initial Dry Density: 99.8 pcf
B11 @ 20 feet	Initial Moisture: 7.0%
Well Graded Sand w/Silt and Gravel (SW-SM)	Specific Gravity: 2.67
Ring Sample	Initial Void Ratio: 0.670
Sample disturbed	Hydrocollapse: 4.7% @ 2.0 ksf

Test run for low density vs. wetting collapse evaluation

% Change in Height vs Normal Pressure Diagram



File No.: 303235-001
Lab No.: 19-073

August 29, 2019

CONSOLIDATION TEST **ASTM D 2435 & D 5333**

Glamis Plan
B13 @ 5 feet

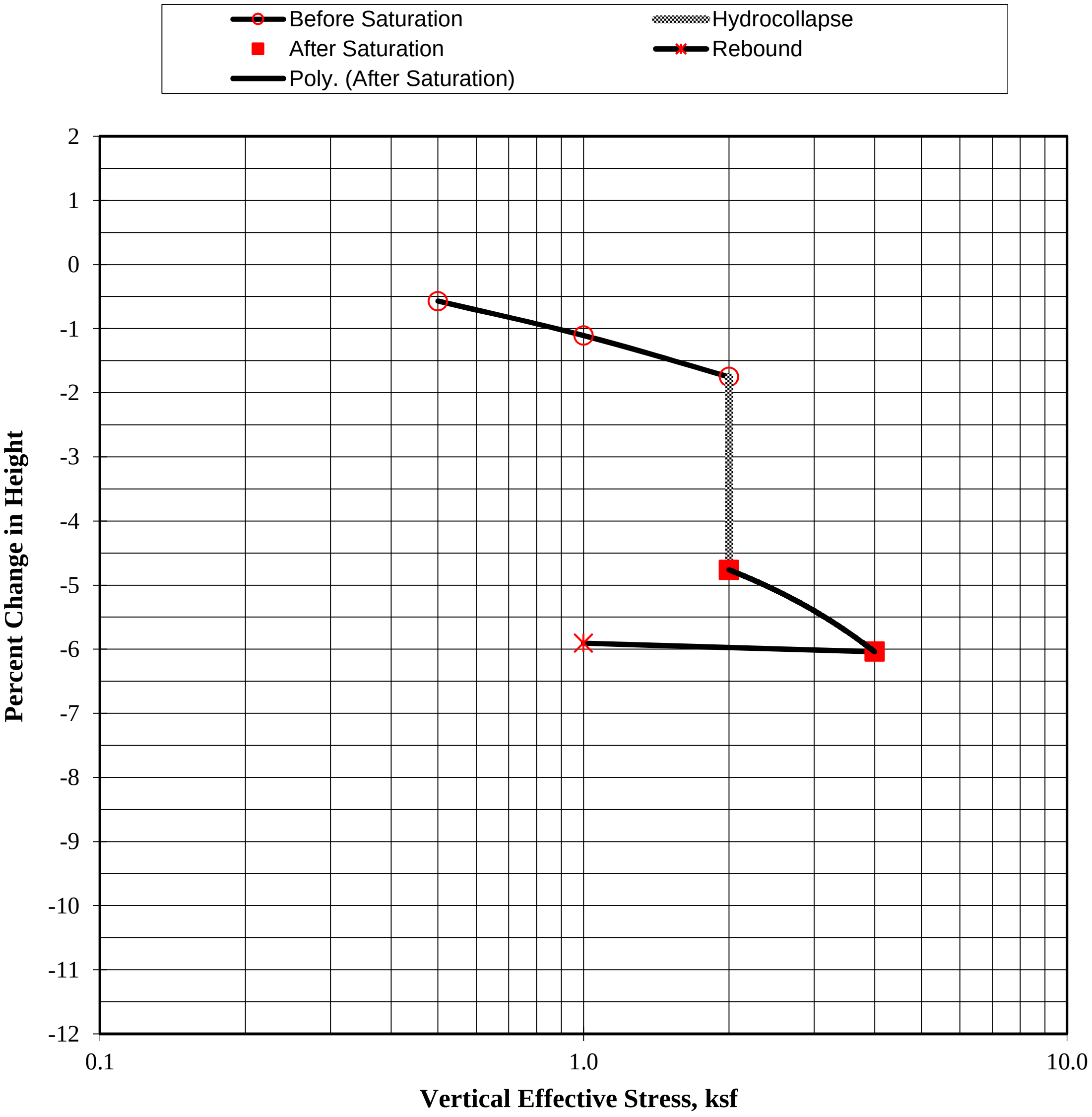
Well Graded Sand w/Gravel (SW)

Ring Sample

Initial Dry Density:	105.0 pcf
Initial Moisture:	4.8%
Specific Gravity:	2.67
Initial Void Ratio:	0.417

Hydrocollapse: 3.0% @ 2.0 ksf

% Change in Height vs Normal Pressure Diagram



File No.: 303235-001 August 29, 2019
Lab No.: 19-073

CONSOLIDATION TEST ASTM D 2435 & D 5333

Glamis Plan
B15 @ 10 feet

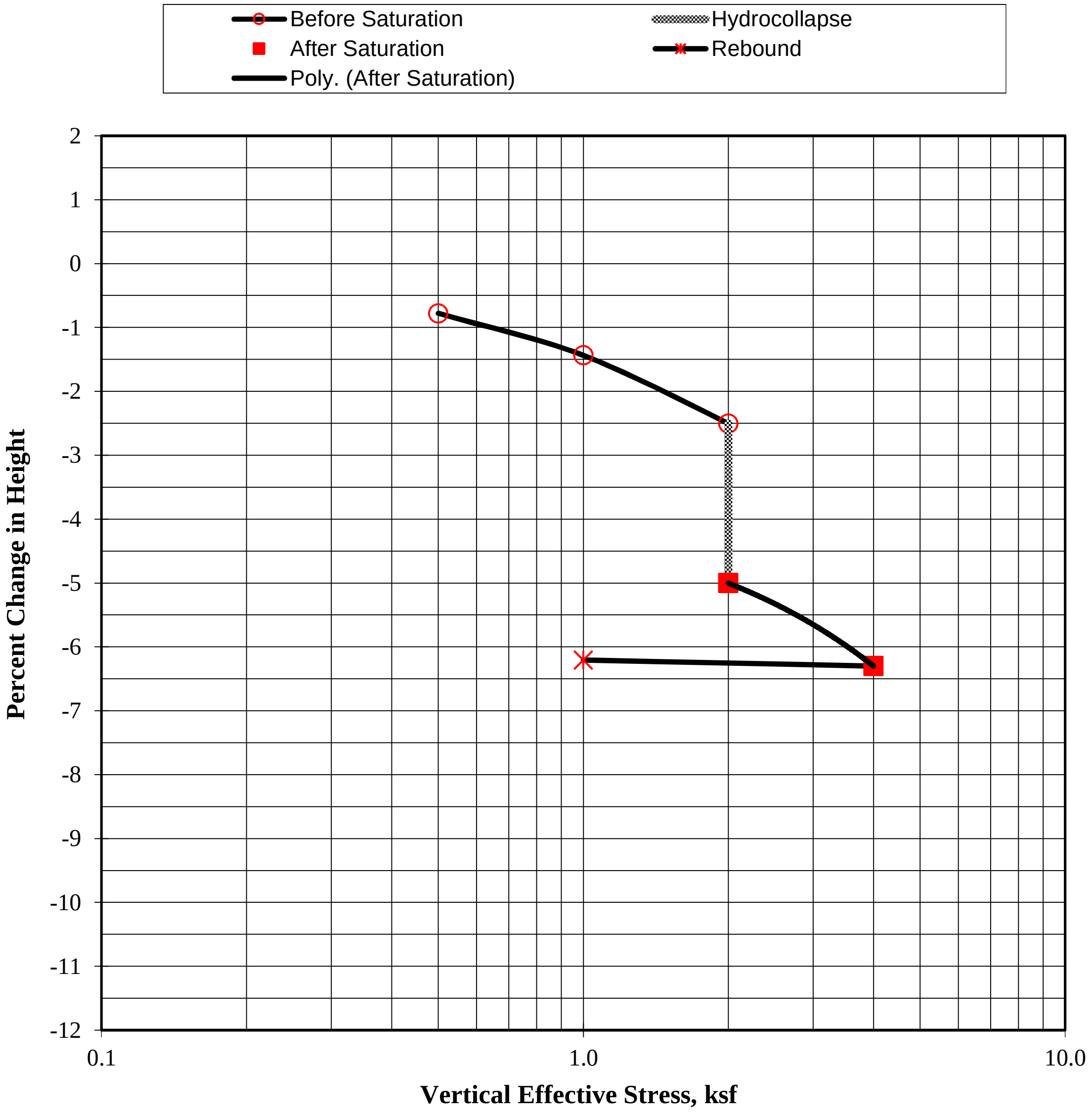
Silty Sand (SM)

Ring Sample

Initial Dry Density: 107.0 pcf
Initial Moisture: 6.5%
Specific Gravity: 2.67
Initial Void Ratio: 0.326

Hydrocollapse: 2.5% @ 2.0 ksf

% Change in Height vs Normal Pressure Diagram



File No.: 303235-001
Lab No.: 19-073

August 29, 2019

CONSOLIDATION TEST

ASTM D 2435 & D 5333

Glamis Plan
B15 @ 15 feet

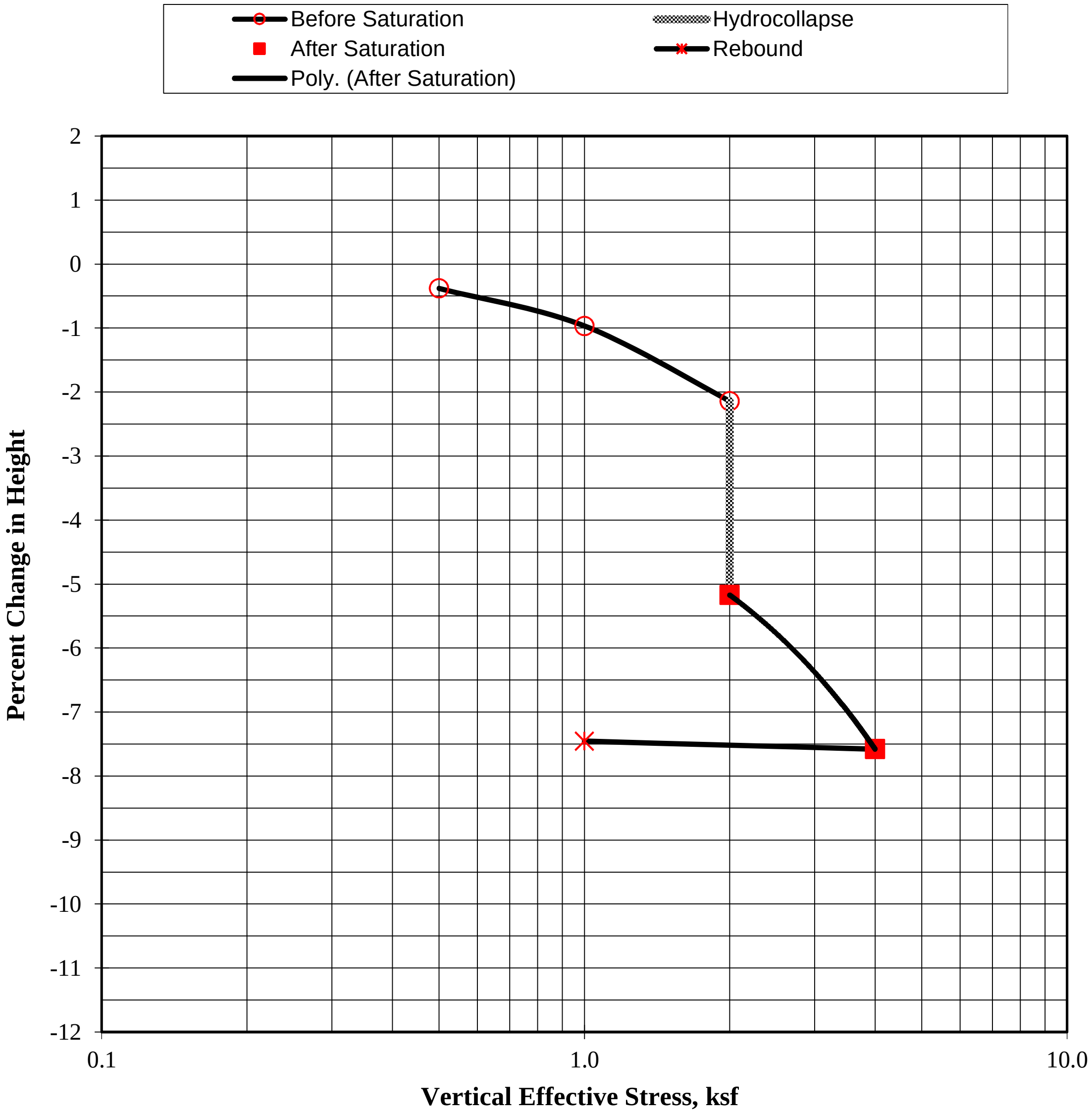
Well Graded Sand w/Gravel (SW)

Ring Sample

Initial Dry Density: 102.9 pcf
Initial Moisture: 6.5%
Specific Gravity: 2.67
Initial Void Ratio: 0.621

Hydrocollapse: 3.0% @ 2.0 ksf

% Change in Height vs Normal Pressure Diagram



File No.: 303235-001
Lab No.: 19-073

August 29, 2019

CONSOLIDATION TEST

ASTM D 2435 & D 5333

Glamis Plan
B16 @ 5 feet

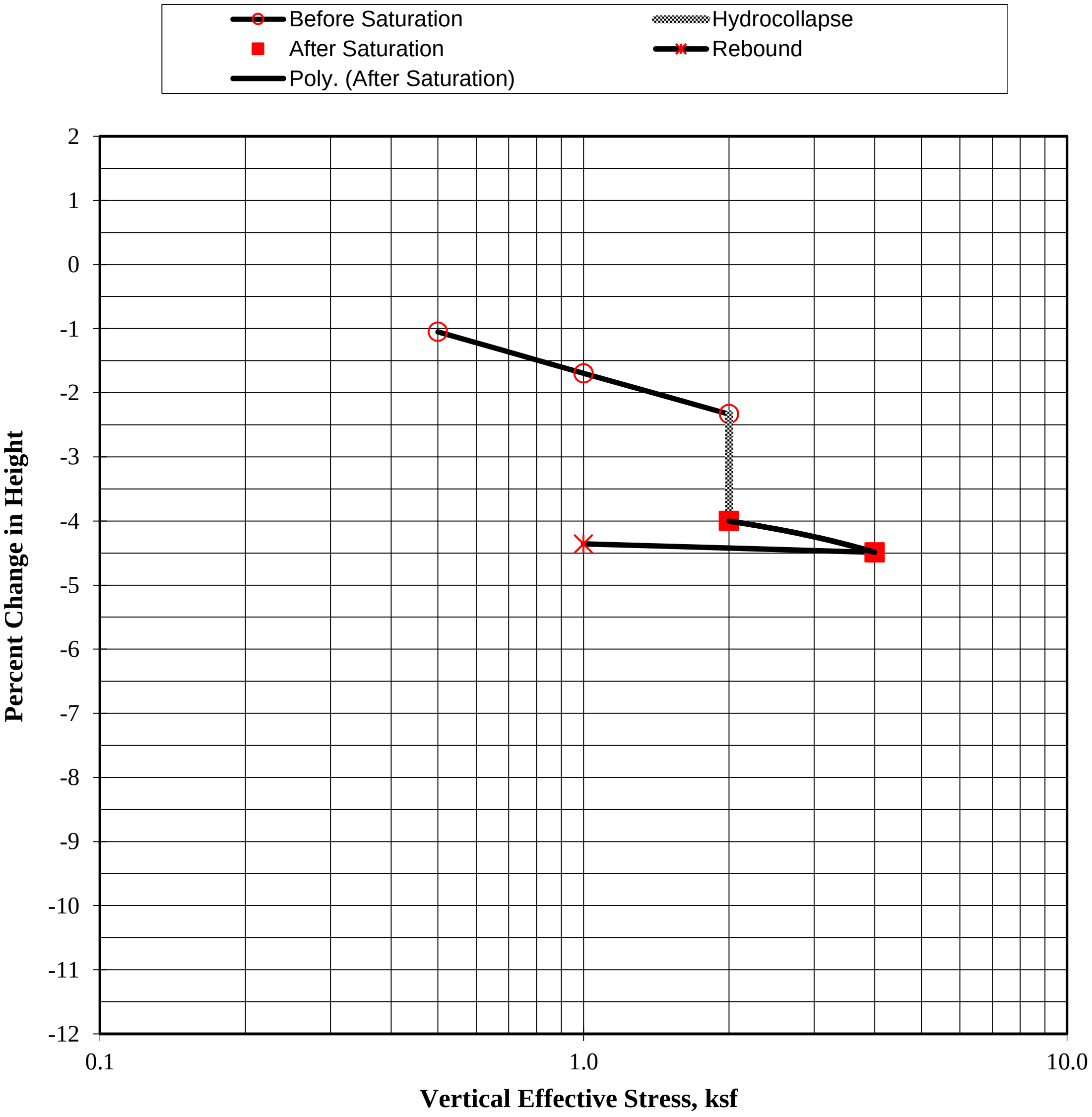
Well Graded Sand (SW)

Ring Sample

Initial Dry Density: 110.0 pcf
Initial Moisture: 2.4%
Specific Gravity: 2.67
Initial Void Ratio: 0.634

Hydrocollapse: 1.7% @ 2.0 ksf

% Change in Height vs Normal Pressure Diagram



File No.: 303235-001
Lab No.: 19-073

August 29, 2019

CONSOLIDATION TEST

ASTM D 2435 & D 5333

Glamis Plan
B27 @ 5 feet

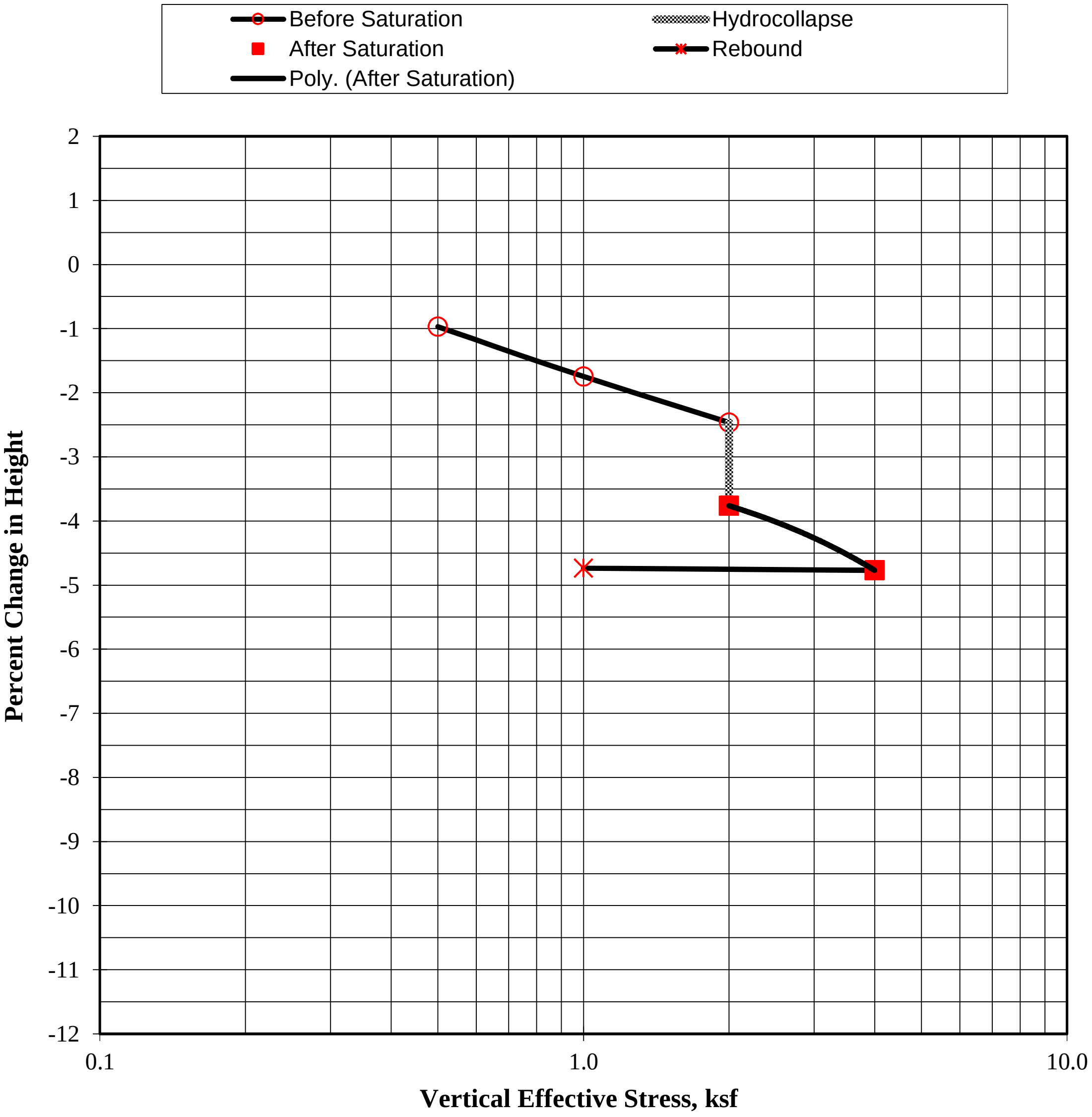
Poorly Graded Gravel w/Sand (GW)

Ring Sample

Initial Dry Density: 114.5 pcf
Initial Moisture: 3.3%
Specific Gravity: 2.67
Initial Void Ratio: 0.337

Hydrocollapse: 1.3% @ 2.0 ksf

% Change in Height vs Normal Pressure Diagram



File No.: 303235-001
Lab No.: 19-073

August 29, 2019

EXPANSION INDEX **ASTM D-4829**

Job Name: Glamis Plan
Sample ID: B2 @ 0-5 feet
Soil Description: Silty Clayey Sand w/Gravel (SC-SM)

Initial Moisture, %:	8.9
Initial Compacted Dry Density, pcf:	114.0
Initial Saturation, %:	51
Final Moisture, %:	16.7
Volumetric Swell, %:	0.7

Expansion Index, EI: **7** **Very Low**

EI	ASTM Classification
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

File No.: 303235-001 August 29, 2019
Lab No.: 19-073

EXPANSION INDEX **ASTM D-4829**

Job Name: Glamis Plan
Sample ID: B4 @ 0-5 feet
Soil Description: Poorly Graded Sand w/Silt (SP-SM)

Initial Moisture, %:	9.7
Initial Compacted Dry Density, pcf:	109.2
Initial Saturation, %:	49
Final Moisture, %:	27.6
Volumetric Swell, %:	-1.1

Expansion Index, EI: 0 Very Low

EI	ASTM Classification
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

File No.: 303235-001 August 29, 2019
Lab No.: 19-073

EXPANSION INDEX **ASTM D-4829**

Job Name: Glamis Plan
Sample ID: B4 @ 5 feet
Soil Description: Poorly Graded Sand w/Silt (SP-SM)

Initial Moisture, %:	8.7
Initial Compacted Dry Density, pcf:	114.3
Initial Saturation, %:	50
Final Moisture, %:	20.9
Volumetric Swell, %:	0.0

Expansion Index, EI: 0 Very Low

EI	ASTM Classification
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

File No.: 303235-001 August 29, 2019
Lab No.: 19-073

EXPANSION INDEX **ASTM D-4829**

Job Name: Glamis Plan
Sample ID: B15 @ 5 feet
Soil Description: Poorly Graded Sand w/Silt and Gravel (SP-SM)

Initial Moisture, %:	9.1
Initial Compacted Dry Density, pcf:	114.3
Initial Saturation, %:	52
Final Moisture, %:	14.1
Volumetric Swell, %:	-0.9

Expansion Index, EI: 0 Very Low

EI	ASTM Classification
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

File No.: 303235-001 August 29, 2019
Lab No.: 19-073

EXPANSION INDEX **ASTM D-4829**

Job Name: Glamis Plan
Sample ID: B19 @ 5 feet
Soil Description: Silty Clayey Sand w/Gravel (SC-SM)

Initial Moisture, %:	8.2
Initial Compacted Dry Density, pcf:	116.0
Initial Saturation, %:	49
Final Moisture, %:	24.9
Volumetric Swell, %:	0.8

Expansion Index, EI: **8** **Very Low**

EI	ASTM Classification
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

File No.: 303235-001 August 29, 2019
Lab No.: 19-073

EXPANSION INDEX **ASTM D-4829**

Job Name: Glamis Plan
Sample ID: B13 @ 0-5 feet
Soil Description: Silty Sand (SM)

Initial Moisture, %:	9.7
Initial Compacted Dry Density, pcf:	109.7
Initial Saturation, %:	49
Final Moisture, %:	16.3
Volumetric Swell, %:	-0.3

Expansion Index, EI: **0** **Very Low**

EI	ASTM Classification
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

File No.: 303235-001 August 29, 2019
Lab No.: 19-073

EXPANSION INDEX **ASTM D-4829**

Job Name: Glamis Plan
Sample ID: B15 @ 10 feet
Soil Description: Silty Sand (SM)

Initial Moisture, %:	8.5
Initial Compacted Dry Density, pcf:	114.4
Initial Saturation, %:	49
Final Moisture, %:	25.5
Volumetric Swell, %:	-1.6

Expansion Index, EI: 0 Very Low

EI	ASTM Classification
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

File No.: 303235-001 August 29, 2019

Lab No.: 19-073

MAXIMUM DRY DENSITY / OPTIMUM MOISTURE

ASTM D 1557 (Modified)

Job Name: Glamis Plan

Sample ID: 1

Location: B2 @ 0-5 feet

Description: Silty Clayey F-M Sand w/Gravel (SC-SM)

Procedure Used: A

Preparation Method: Moist

Rammer Type: Mechanical

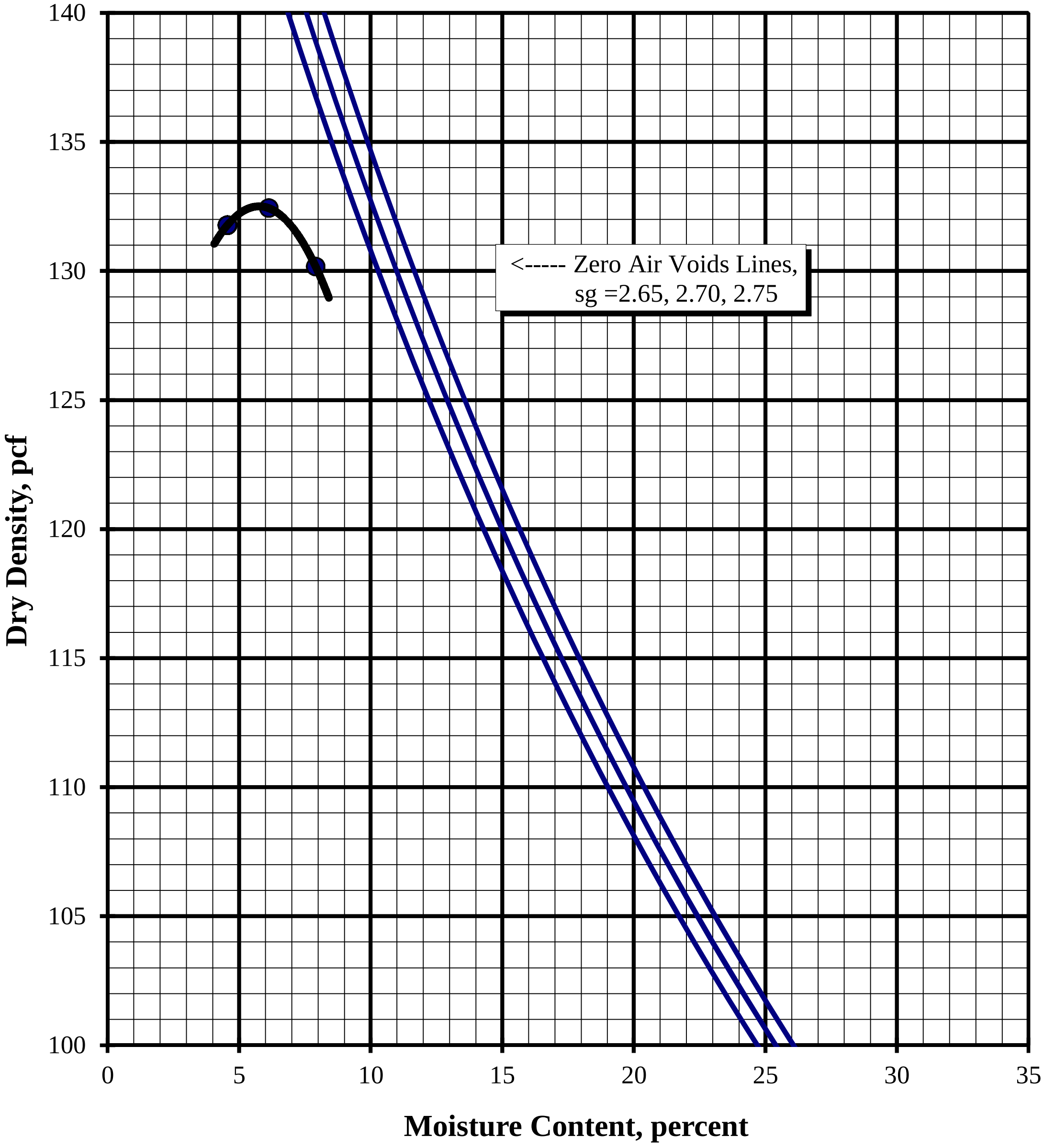
Lab Number: 19-073

Maximum Dry Density: 132.5 pcf

Optimum Moisture: 5.9%

Corrected for Oversize (ASTM D4718)

Sieve Size	% Retained (Cumulative)
3/4"	2.3
3/8"	8.2
#4	21.0



File No.: 303235-001 August 29, 2019

Lab No.: 19-073

MAXIMUM DRY DENSITY / OPTIMUM MOISTURE

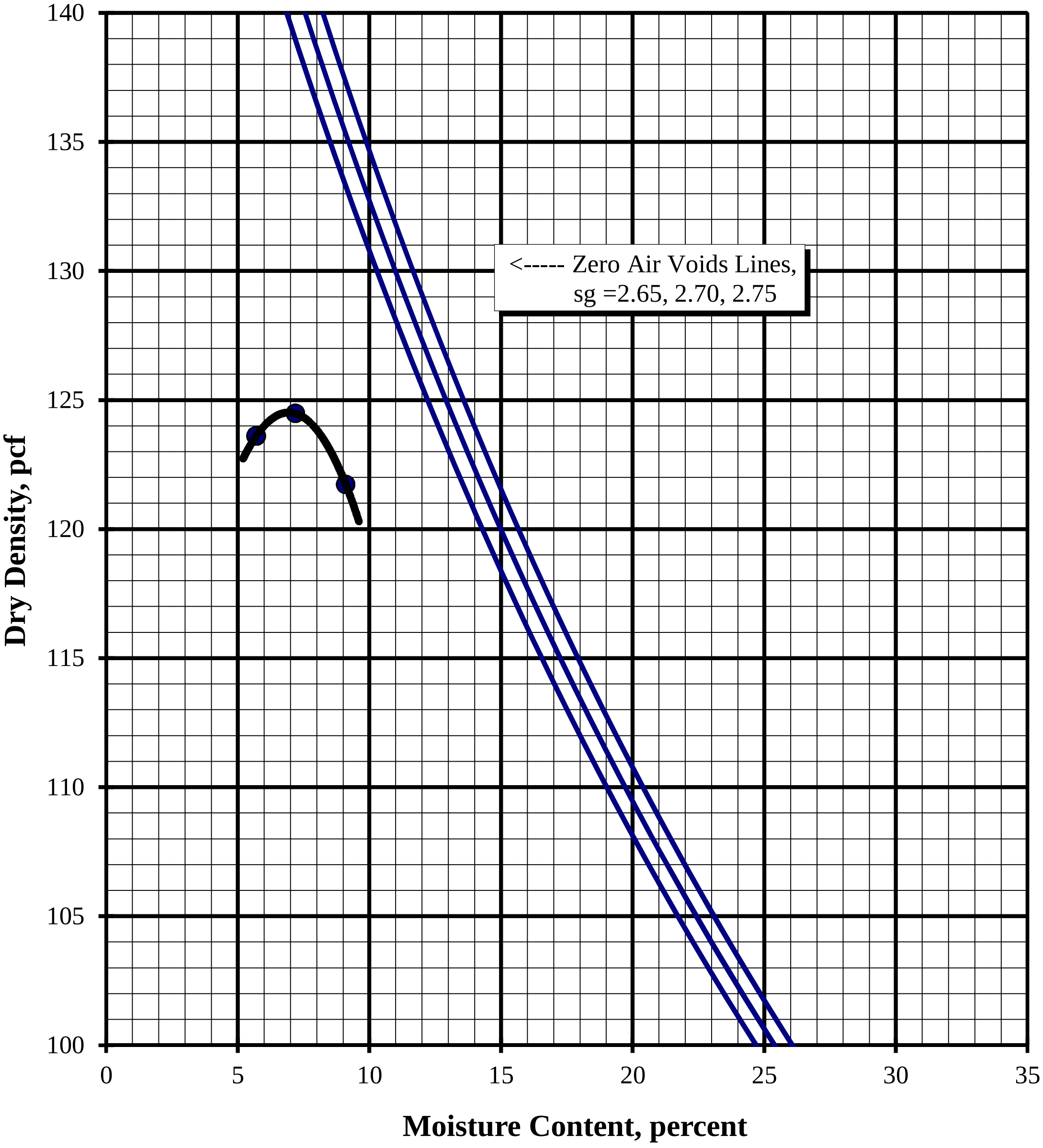
ASTM D 1557 (Modified)

Job Name: Glamis Plan
Sample ID: 2
Location: B13 @ 0-5 feet
Description: Silty F-M Sand (SM)

Procedure Used: A
Preparation Method: Moist
Rammer Type: Mechanical
Lab Number: 19-073

Maximum Dry Density: **124.5 pcf**
Optimum Moisture: **7.1%**
Corrected for Oversize (ASTM D4718)

Sieve Size	% Retained (Cumulative)
3/4"	0.0
3/8"	2.2
#4	10.7



File No.: 303235-001 August 29, 2019

Lab No.: 19-073

MAXIMUM DRY DENSITY / OPTIMUM MOISTURE

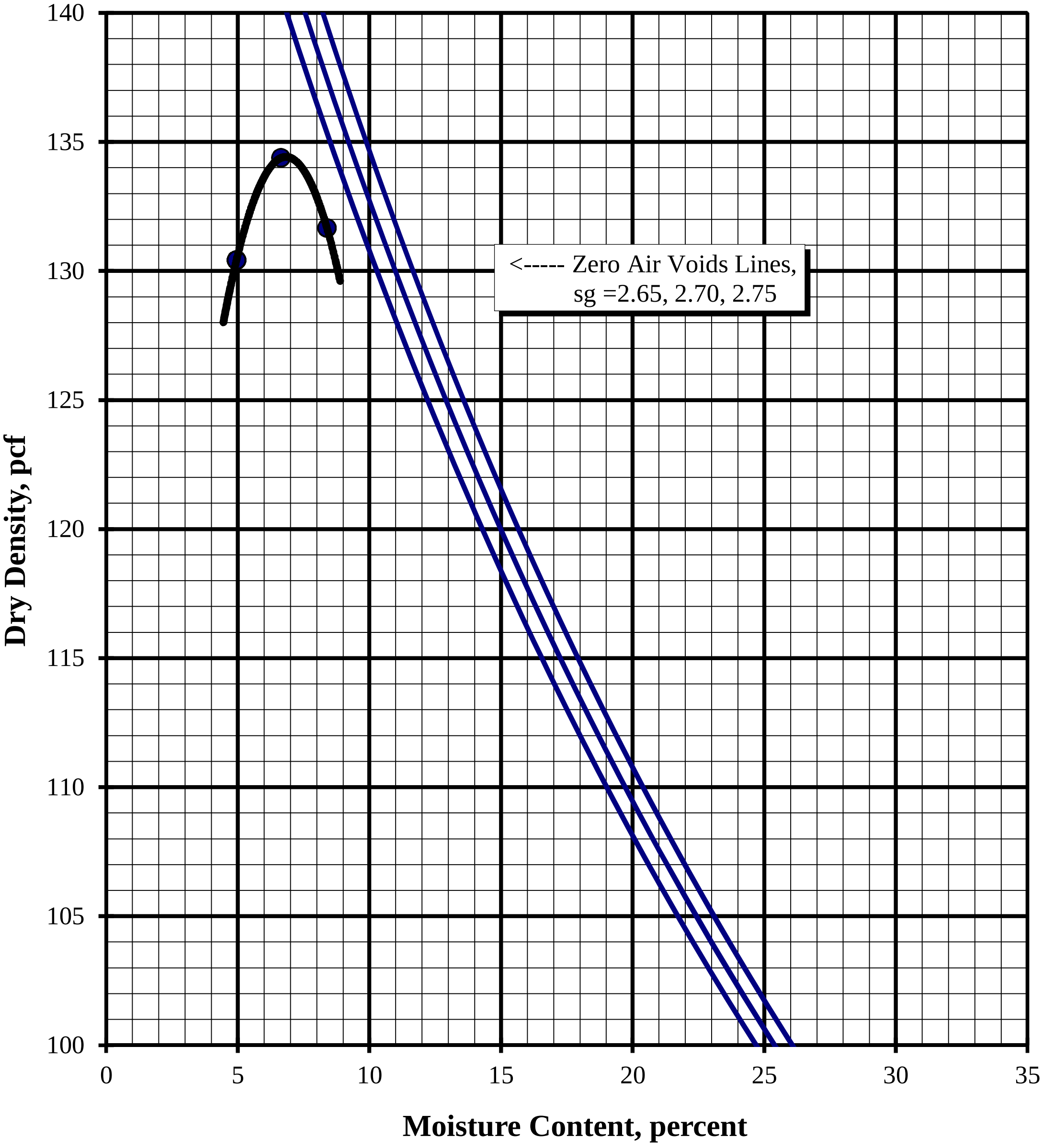
ASTM D 1557 (Modified)

Job Name: Glamis Plan
Sample ID: 3
Location: B18 @ 0-5 feet
Description: Poorly Graded F-C Sand w/Silt and Gravel (SP-SM)

Procedure Used: B
Preparation Method: Moist
Rammer Type: Mechanical
Lab Number: 19-073

Maximum Dry Density: **134.5 pcf**
Optimum Moisture: **7%**
Corrected for Oversize (ASTM D4718)

Sieve Size	% Retained (Cumulative)
3/4"	1.3
3/8"	9.7
#4	25.5



File No.: 303235-001 August 29, 2019

Lab No.: 19-073

SOIL CHEMICAL ANALYSES

Job Name: Glamis Plan

Job No.: 303235-001

Sample ID:	B2	B13	B18	B19
Sample Location:	0-5	0-5	0-5	10
Resistivity (Units)				
as-received (ohm-cm)	12,400	68,000	180,000	22,800
saturated (ohm-cm)	4,800	3,160	6,400	520
pH	8.3	7.9	8.2	8.6
Electrical Conductivity (mS/cm)	0.09	0.11	0.07	0.81
Chemical Analyses				
Cations				
calcium Ca^{2+} (mg/kg)	72	62	75	25
magnesium Mg^{2+} (mg/kg)	1.6	1.4	2.7	3.2
sodium Na^{1+} (mg/kg)	61	85	34	884
potassium K^{1+} (mg/kg)	18	18	21	21
Anions				
carbonate CO_3^{2-} (mg/kg)	17	14	ND	78
bicarbonate HCO_3^{1-}(mg/kg)	125	110	204	104
fluoride F^{1-} (mg/kg)	1.4	ND	ND	7.5
chloride Cl^{1-} (mg/kg)	22	79	17	808
sulfate SO_4^{2-} (mg/kg)	26	11	21	348
phosphate PO_4^{3-} (mg/kg)	ND	ND	ND	ND
Other Tests				
ammonium NH_4^{1+} (mg/kg)	ND	ND	ND	ND
nitrate NO_3^{1-} (mg/kg)	29	21	13	29
sulfide S^{2-} (qual)	na	na	na	na
Redox (mV)	na	na	na	na

Note: Tests performed by Subcontract Laboratory:
HDR Engineering, Inc.
431 West Baseline Road
Calremont, California 91711 Tel: (909) 962-5485

mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed
T.O.P. = top of pipe

Resistivity per ASTM G187, Cations per ASTM D6919, Anions per ASTM D4327, and Alkalinity per APHA 2320-B. Electrical conductivity in millisiemens/cm and chemical analyses were made on a 1:5 soil-to-water extract.

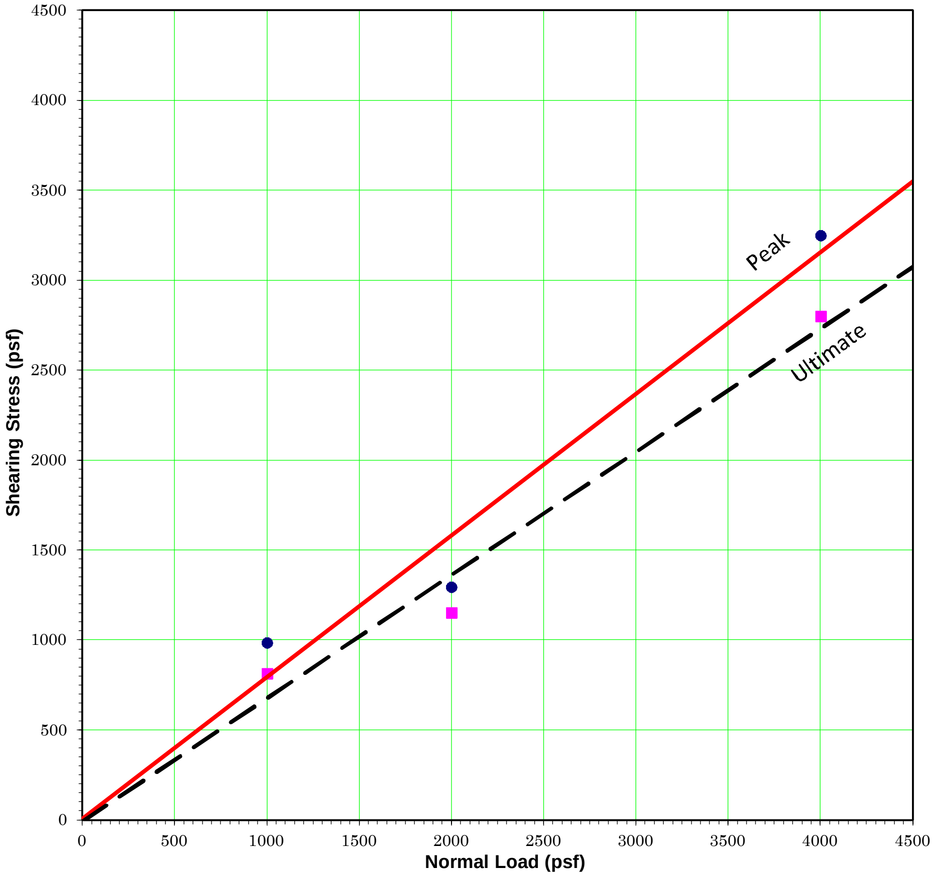
General Guidelines for Soil Corrosivity

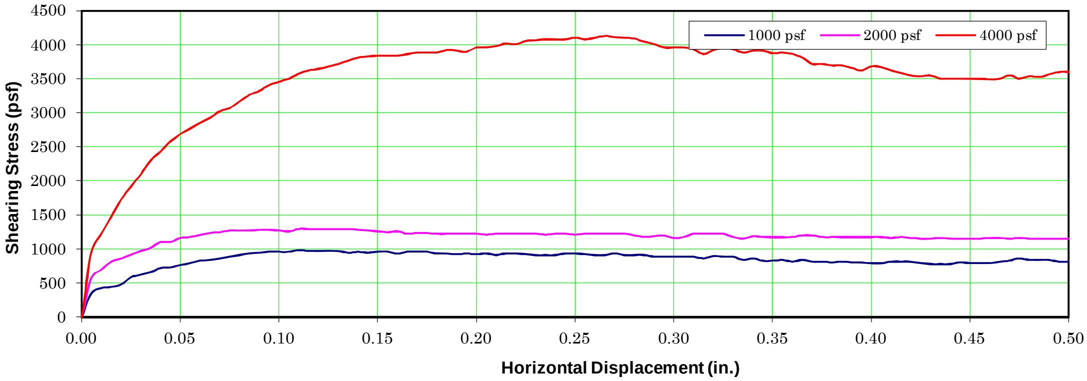
Chemical Agent	Amount in Soil	Degree of Corrosivity
Soluble Sulfates[1]	0 -1,000 mg/Kg (ppm) [0-.1%]	Low
	1,000 - 2,000 mg/Kg (ppm) [0.1-0.2%]	Moderate
	2,000 - 20,000 mg/Kg (ppm) [0.2-2.0%]	Severe
	> 20,000 mg/Kg (ppm) [>2.0%]	Very Severe
Resistivity[2] (Saturated)	0- 900 ohm-cm	Very Severely Corrosive
	900 to 2,300 ohm-cm	Severely Corrosive
	2,300 to 5,000 ohm-cm	Moderately Corrosive
	5,000-10,000 ohm-cm	Mildly Corrosive
	10,000+ ohm-cm	Progressively Less Corrosive

1 - General corrosivity to concrete elements. American Concrete Institute (ACI) Water Soluble Sulfate in Soil by Weight, ACI 318, Tables 4.2.2 - Exposure Conditions and Table 4.3.1 - Requirements for Concrete Exposed to Sulfate-Containing Solutions. *It is recommended that concrete be proportioned in accordance with the requirements of the two ACI tables listed above (4.2.2 and 4.3.1). The current ACI should be referred to for further information.*

2 - General corrosivity to metallic elements (iron, steel, etc.). Although no standard has been developed and accepted by corrosion engineering organizations, it is generally agreed that the classification shown above, or other similar classifications, reflect soil corrosivity. Source: Corrosionsource.com. The classification presented is excerpted from ASTM STP 1013 titled "Effects of Soil Characteristics on Corrosion" (February, 1989)

3 - Earth Systems does not practice corrosion engineering. Results should be reviewed by an engineer competent in corrosion evaluation, especially in regard to nitrites and ammonium.





DIRECT SHEAR DATA*

Sample Location: B16 @ 2 1/2 feet

Material: Poorly Graded Sand w/Silt (SP-SM)

Dry Density (pcf): 115.8

	Initial	Final
Moisture Content (%):	1.6	14.8
Saturation (%):	10	100
	Peak	Ultimate
ϕ Angle of Friction (degrees):	38	34
c Cohesive Strength (psf):	0	0

Test Type: Peak and Ulitimate

Shear Rate (in/min): 0.007

* Test Method: ASTM D-3080

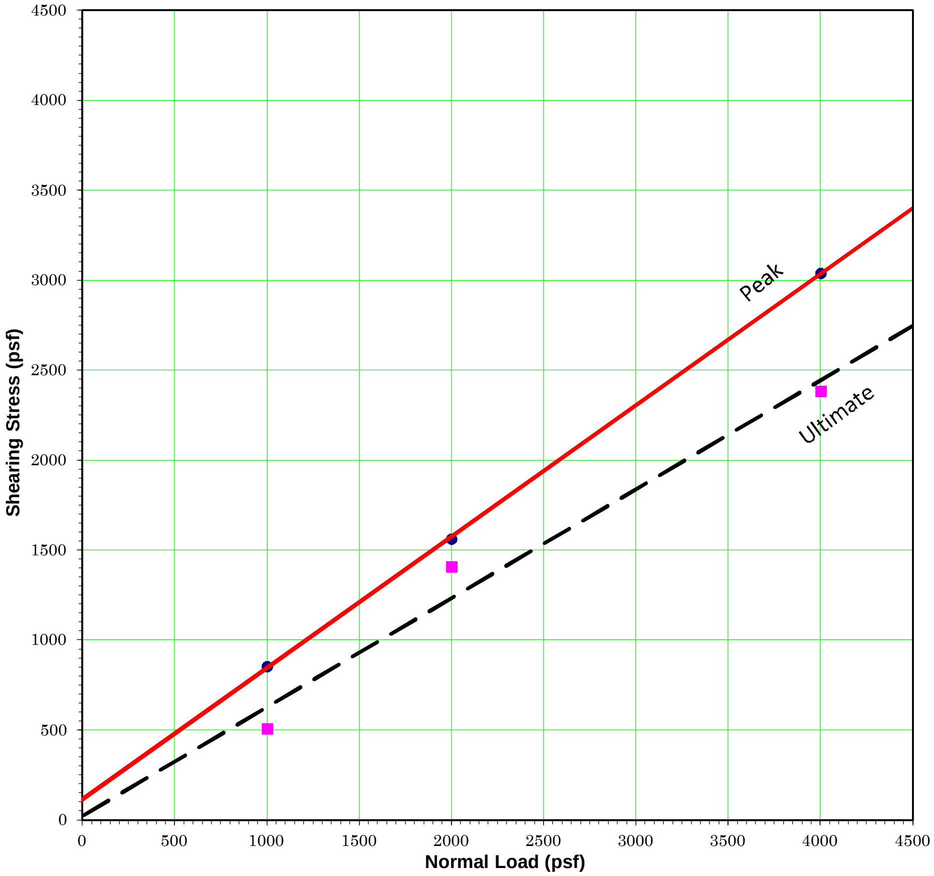
DIRECT SHEAR TEST

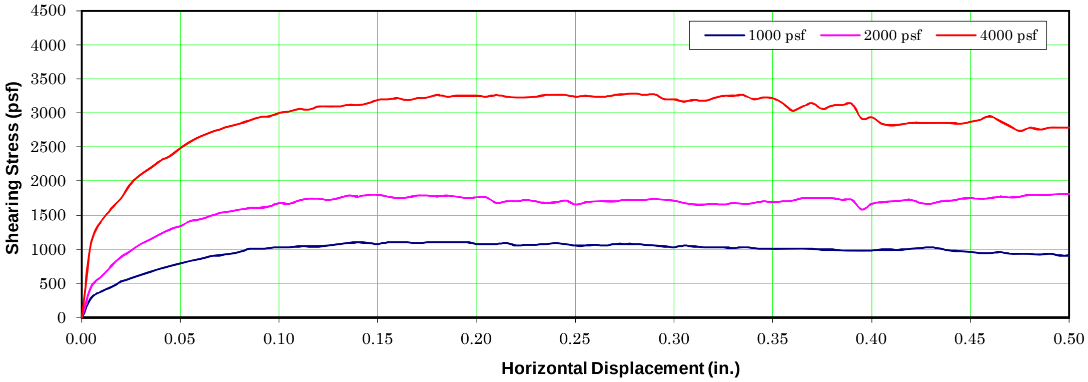
Glamis Plan

Glamis, California

Earth Systems Pacific

8/29/2019 303235-001





DIRECT SHEAR DATA*

Sample Location: B23 @ 2 1/2 feet

Material: Well Graded Sand w/Gravel (SW)

Dry Density (pcf): 111.4

	Initial	Final
Moisture Content (%):	1.2	13.9
Saturation (%):	6	100
	Peak	Ultimate
ϕ Angle of Friction (degrees):	36	31
c Cohesive Strength (psf):	110	20

Test Type: Peak and Ulitimate

Shear Rate (in/min): 0.007

* Test Method: ASTM D-3080

DIRECT SHEAR TEST

Glamis Plan

Glamis, California

Earth Systems Pacific

8/29/2019 | 303235-001

R-VALUE TEST DATA

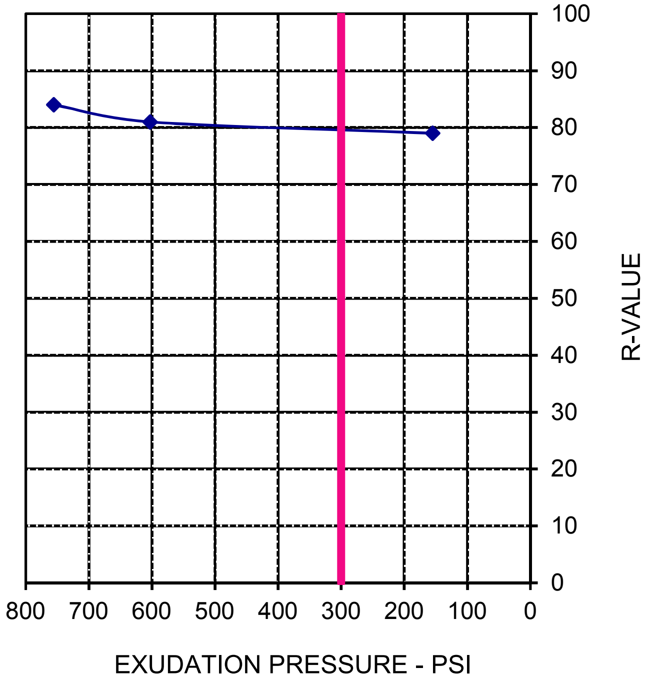
ASTM D2844

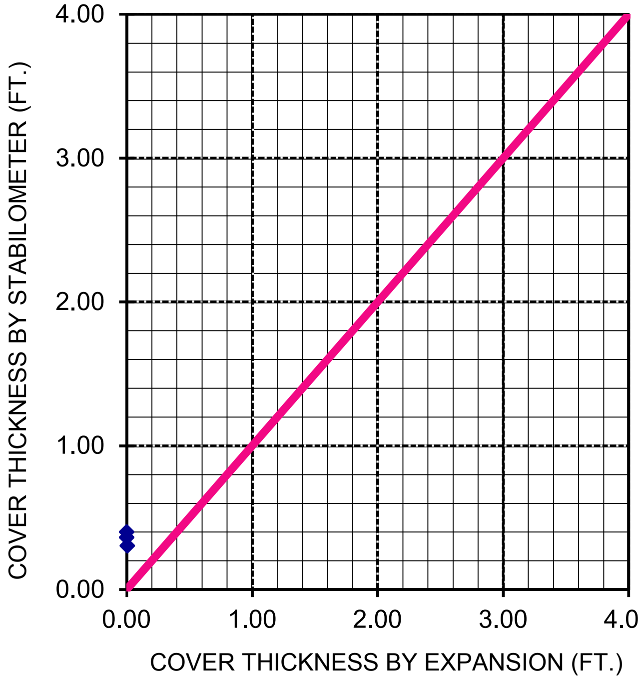
Project Name: Glamis Specific Plan
Project Number: 303235-001
Boring No.: B2
Sample Type: -
Depth (ft.): 0-5
Location: N/A
Soil Description: Silty Clayey Sand w/gravel

Tested By: ST Date: 07/13/19
Computed By: KM Date: 07/15/19
Checked By: AP Date: 07/18/19

Mold Number	A	C	B	
Water Added, g	31	35	41	
Compact Moisture(%)	7.6	8.0	8.5	
Compaction Gage Pressure, psi	350	350	350	
Exudation Pressure, psi	756	603	155	
Sample Height, Inches	2.4	2.4	2.4	
Gross Weight Mold, g	3044	3048	3047	
Tare Weight Mold, g	1967	1968	1969	
Net Sample Weight, g	1078	1080	1078	
Expansion, inchesx10^{-4}	1	0	0	
Stability 2,000 (160 psi)	8/15	10/18	11/20	
Turns Displacement	4.32	4.44	4.46	
R-Value Uncorrected	85	82	80	
R-Value Corrected	84	81	79	
Dry Density, pcf	126.5	126.3	125.4	
Traffic Index	8.0	8.0	8.0	
G.E. by Stability	0.31	0.36	0.40	
G.E. by Expansion	0.00	0.00	0.00	

R-VALUE	By Exudation:	80
	By Expansion:	*N/A
	At Equilibrium: (by Exudation)	80
Remarks	Gf = 1.34, and 3.8 % Retained on the ¾" *Not Applicable	





R-VALUE TEST DATA

ASTM D2844

Project Name: Glamis Specific Plan
Project Number: 303235-001
Boring No.: B13
Sample Type: -
Depth (ft.): 0-5
Location: N/A
Soil Description: Silty Sand

Tested By: ST Date: 07/13/19
Computed By: KM Date: 07/15/19
Checked By: AP Date: 07/18/19

Mold Number	R6	R8	R7	
Water Added, g	82	90	102	
Compact Moisture(%)	9.5	10.3	11.4	
Compaction Gage Pressure, psi	350	350	350	
Exudation Pressure, psi	660	358	162	
Sample Height, Inches	2.6	2.6	2.6	
Gross Weight Mold, g	3134	3145	3147	
Tare Weight Mold, g	2011	2015	2010	
Net Sample Weight, g	1123	1130	1137	
Expansion, inchesx10^{-4}	0	0	0	
Stability 2,000 (160 psi)	10/20	13/24	15/28	
Turns Displacement	4.94	5.24	5.32	
R-Value Uncorrected	78	73	69	
R-Value Corrected	79	75	71	
Dry Density, pcf	119.6	119.3	118.9	
Traffic Index	8.0	8.0	8.0	
G.E. by Stability	0.40	0.48	0.55	
G.E. by Expansion	0.00	0.00	0.00	

R-VALUE	By Exudation:	74
	By Expansion:	*N/A
	At Equilibrium: (by Exudation)	74
Remarks	Gf = 1.34, and 0.0 % Retained on the ¾" *Not Applicable