PRELIMINARY GEOTECHNICAL EVALUATION
PROPOSED 5-LOT SUBDIVISION, 2535 IVY ROAD
OCEANSIDE, SAN DIEGO COUNTY, CALIFORNIA
FOR
MAIN STREET PARTNERS, INC.
10 PINEHURST LANE
NEWPORT BEACH, CALIFORNIA 92660

Executive Summary

Based upon our field exploration, geologic, and geotechnical engineering analysis, the proposed development is feasible from a soils engineering and geologic viewpoint, provided that the recommendations presented in the text of this report are properly incorporated into the design and construction of the project. The most significant elements of our study are summarized below:

- In general, the site may be characterized as being mantled by relatively thin sections of localized undocumented artificial fill, and colluvium (topsoil). These earth materials are in turn underlain by Eocene-age sedimentary bedrock belonging to the Santiago Formation.

- Due to their relatively low density, lack of uniformity, and porous nature, all undocumented fill, Quaternary-age colluvium, and any highly weathered bedrock are considered potentially compressible and unsuitable for the support of settlement-sensitive improvements (i.e., residential foundations, concrete slab-on-grade floors, site walls, underground utilities, roadways, exterior hardscape, etc.) and/or engineered fill in their existing state. Based on the available data, the thickness of potentially compressible soils across the site is anticipated to vary between approximately 2 feet and 5½ feet. However, localized thicker sections of...
unsuitable soils cannot be precluded and should be anticipated. Conversely, the underlying unweathered sedimentary bedrock is considered suitable for the support of settlement-sensitive improvements and engineered fill.

- Onsite earth materials are typically anticipated to generate good quality fill material within the near surface, and the presence of oversize materials within the native formation is not anticipated. Localized areas of undocumented fill may contain significant amounts of construction debris, or landscaping/organic debris, that may not be suitable for re-use (see Test Pit Logs TP-1 and TP-5).

- In order to: facilitate future improvements construction; mitigate the potential for water vapor transmission through floor slabs; and provide for the uniform support of structures; transition (cut/fill) lots, cut lots, lots with relatively thin plan fills, and street areas will need to be undercut (overexcavated), then brought to grade with suitable fill soil. Undercut recommendations are presented herein.

- Graded slopes to the gradients and heights indicated herein are generally anticipated to be stable, assuming proper construction, maintenance, and normal climatic conditions.

- Slope stability analyses should be performed on the 40-scale grading plans when wall design is finalized, so that the actual location of any necessary stabilization fills and subdrainage devices can be shown on the grading plans, and wall stability evaluated.

- It should be noted that the 2013 California Building Code ([2013 CBC], California Building Standards Commission [CBSC], 2013) indicates that removals of unsuitable soils be performed across all areas to be graded, under the purview of the grading permit, not just within the influence of the residential structures. Relatively deep removals may also necessitate a special zone of consideration, on perimeter/confining areas. This zone would be approximately equal to the depth of removals, if removals cannot be performed onsite or offsite. In general, any planned improvement located above a 1:1 (horizontal:vertical [h:v]) projection up from the bottom, outboard edge of the remedial grading excavation at the subdivision boundary would be affected by perimeter conditions. On a preliminary basis, any planned settlement-sensitive improvements located within approximately 2 feet to potentially 6 feet from the subdivision boundary would require deepened foundations or additional reinforcement by means of ground improvement or specific structural design. Otherwise these improvements may be subject to distress and a reduced serviceable life span. This will also require proper disclosure to any owners and all interested/affected parties should this condition exist at the conclusion of grading.

- Laboratory testing, including expansion index (E.I.) and Atterberg Limits, performed on samples of the onsite soils, indicates soil expansion potentials ranging from very
low to medium (E.I. range of 0 to 90). Atterberg limits testing performed on representative soil samples indicates a plasticity indices ranging from 12 to 44. As such, some site soils (colluvium, highly weathered bedrock, and formational claystones) are considered detrimentally expansive as defined in Section 1803.5.2 of the 2013 CBC. On a preliminary basis, residential building foundations within the influence of expansive soils should be designed and constructed in accordance with Sections 1808.6.1 or 1808.6.2 of the 2013 CBC. Alternatively, selective grading may be performed.

- Corrosion testing performed on a representative sample of the onsite soils indicates site soils are relatively neutral with respect to soil acidity/alkalinity, severely corrosive to exposed buried metals when saturated, present negligible sulfate exposure to concrete, and are below action levels for chloride exposure. Additional comments may be obtained from a corrosion engineer, depending on the level of protection required, as determined by the project design civil engineer and/or architect.

- Neither the regional groundwater table nor perched water was encountered during our subsurface studies to the depth explored. As such, regional groundwater is not anticipated to significantly affect the planned improvements. Perched water may occur in the future along zones of contrasting permeability and/or density, or seepage may occur along bedrock joints and fractures. This potential should be disclosed to all interested/affected parties.

- Our evaluation indicates there are no known active faults crossing the site and the natural slope upon which the site is located has low susceptibility to deep-seated landslides. Owing to the depth to groundwater and the dense nature of the sedimentary bedrock, the potential for the site to be adversely affected by liquefaction/lateral spreading is considered low. Some of the site soils that exist will be generated during grading are considered erosive (low cohesion). Thus, properly designed and maintained site drainage is necessary in reducing erosion damage to the planned improvements.

- The seismic acceleration values and design parameters provided herein should be considered during the design of the proposed development. The adverse effects of seismic shaking on the structure(s) will likely be wall cracks, some foundation/slab distress, and some seismic settlement. However, it is anticipated that the structure will be repairable in the event of the design seismic event. This potential should be disclosed to any owners and all interested/affected parties.

- Additional adverse geologic features that would preclude project feasibility were not encountered, based on the available data.

- The recommendations presented in this report should be incorporated into the design and construction considerations of the project.
The opportunity to be of service is sincerely appreciated. If you should have any questions, please do not hesitate to contact our office.

Respectfully submitted,

**GeoSoils, Inc.**

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RGC/JPF/DWS/jh

Distribution: (3) Addressee
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PRELIMINARY GEOTECHNICAL EVALUATION
PROPOSED 5-LOT SUBDIVISION, 2535 IVY ROAD
OCEANSIDE, SAN DIEGO COUNTY, CALIFORNIA

SCOPE OF SERVICES

The scope of our services has included the following:

1. Review of readily available published literature, aerial photographs, and maps of the vicinity (see Appendix A), including proprietary in-house geologic/geotechnical reports for other nearby sites.

2. Site reconnaissance mapping and the excavation of nine exploratory test pits with a rubber tire backhoe to evaluate the soil/bedrock profiles, sample representative earth materials, and delineate the horizontal and vertical extent of earth material units (see Appendix B).

3. General areal geologic and seismic hazards evaluation (see Appendix C).

4. Appropriate laboratory testing of relatively undisturbed and representative bulk soil samples collected during our geologic mapping and subsurface exploration program (see text and Appendix D).

5. Analysis of field and laboratory data relative to the proposed development.

6. Appropriate engineering and geologic analyses of data collected, and the preparation of this summary report and accompaniments.

SITE DESCRIPTION AND PROPOSED DEVELOPMENT

The subject site consists of about \( \frac{1}{2} \) acre of existing flat-graded property, that was previously a single-family residential site, in the City of Oceanside, San Diego County, California (see Figure 1). The site appears to be an infill lot, located south of Ivy Road and bounded on the remaining sides by existing residential development. We understand that the site use may have included residential (possibly with a pool), which was apparently razed, and then for greenhouse purposes (the remnants of which, still partially exist). Topographically, the site consists of two relatively flat lying areas located atop a broad, north-south trending ridgeline. The relatively flat areas generally descend in elevation form the northwest to southeast, and are separated by a small, irregular slope, ranging from approximately 7 feet to 10 feet in height. Along the west side of the site, a natural slope descends from the site to adjacent residential property. This slope varies up to approximately 25 feet in height, at gradients on the order of 1.5:1 (h:v), or flatter. Site elevations appear to range from approximately 110 feet Mean Sea Level (MSL) in the south, to approximately 122 feet MSL in the north. Drainage appears to be directed offsite to the southwest and southeast. Vegetation onsite consists of scattered trees, shrubs and grasses.
Based on the grading study, prepared by Buccola Engineering (2013), GSI understands that proposed development includes preparing the site for five (5) new one- or two-story single-family homes, a cul-de-sac off of Ivy Road, retaining walls, hardscape, landscape improvements and underground utility improvements. Cut and fill grading would be required to bring the site to design grade. Maximum fill slope heights (including several 4-foot high retaining walls at the toe of slope) are on the order of about 9 feet. Significant cut slopes are not proposed. Maximum planned cut and fill thicknesses are on the order of 4½ and 7 feet, respectively. Sewage disposal is proposed to be accommodated by utilizing the regional municipal system. Proposed grading and street improvements are shown on Plate 1.

FIELD STUDIES

Site-specific field studies were conducted by GSI during December, 2013, and consisted of reconnaissance geologic mapping, excavating six (6) exploratory test pits with a rubber tire backhoe. The test pits were logged by a representative of this office who collected representative bulk and undisturbed soil samples for appropriate laboratory testing. The logs of the test pits are presented in Appendix B. Site geology, and test pit locations are presented on the Geotechnical Map (see Plate 1), which uses the 40-scale grading study, prepared by Buccola Engineering (Buccola, 2013), as a base.

REGIONAL GEOLOGY

The subject property lies within the coastal plains physiographic region of the Peninsular Ranges Geomorphic Province of southern California. This region consists of dissected, mesa-like terraces that transition inland to rolling hills. The encompassing Peninsular Ranges Geomorphic Province is characterized as elongated mountain ranges and valleys that generally trend northwesterly. This geomorphic province extends from the base of the east-west aligned Santa Monica - San Gabriel Mountains, and continues south into Baja California. The mountain ranges within this province are underlain by basement rocks consisting of pre-Cretaceous metasedimentary rocks, Jurassic metavolcanic rocks, and Cretaceous plutonic (granitic) rocks.

In the southern California region, deposition occurred during the Cretaceous Period and Cenozoic Era in the continental margin of a forearc basin. Sediments, derived from Cretaceous-age plutonic rocks and Jurassic-age volcanic rocks, were deposited during the Tertiary Period (Eocene-age) into the narrow, steep, coastal plain and continental margin of the basin. These rocks have been uplifted, eroded, and deeply incised. During early Pleistocene time, a broad coastal plain was developed from the deposition of marine terrace deposits (currently termed “paralic deposits”). During mid to late Pleistocene time, this plain was uplifted, eroded and incised. Alluvial deposits have since filled the lower valleys, and young marine sediments are currently being deposited/eroded within coastal
and beach areas. Regional geologic mapping by Kennedy and Tan (2005) indicate the site is underlain by Eocene-age sedimentary bedrock.

SITE GEOLOGIC UNITS

General

The geologic units observed and/or encountered at the subject site consist of localized undocumented artificial fill, Quaternary-age colluvium (topsoil), and sedimentary bedrock. A general description of each soil type is presented as follows, from youngest to oldest. The general distribution of geologic units across the site is presented on Plate 1.

Undocumented Artificial Fill (Map Symbol - Afu)

Undocumented artificial fill was observed locally throughout the site, primarily associated with former greenhouse areas and creates a slope embankment through the central portion of the site. Fill generally consists of brown to dark brown, silty sand, and clayey sand, with some construction/landscape debris present locally, and is estimated to be on the order of ±5 feet in thickness. Where encountered, fill in typically damp to moist, loose, porous, and locally desiccated. All undocumented fill is potentially compressible in its existing state and should not be relied upon for the support of settlement-sensitive improvements and/or new planned fill, unless removed, moisture conditioned, and placed as properly compacted fill. The fill appears to vary from non-detrimentally expansive to expansive, based on visual appearance and classification; however, this will need to be verified by testing.

Quaternary Colluvium (Map Symbol - Qcol)

Discontinuous surficial deposits of Quaternary colluvium occur throughout the site as a relatively thin (½ to ±1 foot) layer of soil throughout the site. Where encountered, colluvium consists of reddish brown sandy clay that is typically damp to moist, stiff, and porous. The discontinuous nature of colluvium throughout the site is likely due to previous episodes of grading performed onsite. Colluvium is considered potentially compressible in its existing state. As such, it should not be used for the support of settlement-sensitive improvements and/or new planned fill, unless removed, moisture conditioned, and placed as properly compacted fill. Colluvium is typically plastic and expansive.

Eocene Sedimentary Bedrock - Santiago Formation (Map Symbol - Tsa)

Eocene-age sedimentary bedrock belonging to the Santiago formation underlie the entire site. Where encountered within the test pits, these deposits generally consist of 1-foot thick to 2½-foot thick zone of highly weathered materials consisting of brown to olive brown, clayey sand to sandy clay that is typically moist, medium dense/stiff, and porous.
Below this highly weathered zone, bedrock grades into yellowish brown clayey sandstone (with some minor sandy claystone locally) that is typically moist, and dense/very stiff. Highly weathered bedrock is considered potentially compressible in its existing state. As such, it should not be used for the support of settlement-sensitive improvements and/or new planned fill, unless removed, moisture conditioned, and placed as properly compacted fill.

**Structural Geology**

Bedding within sedimentary bedrock onsite appears to be generally flat lying, to gently sloping to the southwest, on the order of 2 degrees. Significant jointing/fractures were not observed.

**GROUNDWATER**

GSI did not observe evidence of a regional groundwater table nor perched water within our subsurface explorations. Therefore, regional groundwater is not anticipated to significantly affect proposed site development, provided that the recommendations contained in this report are properly incorporated into final design and construction. These observations reflect site conditions at the time of our investigation and do not preclude future changes in local groundwater conditions from excessive irrigation, precipitation, or that were not obvious, at the time of our investigation. Based on site topography, the regional groundwater table is likely at elevations in excess of 50 feet below the lowest site elevation.

Seeps, springs, or other indications of subsurface water were not noted on the subject property during the time of our field investigation. However, perched water seepage may occur locally (as the result of heavy precipitation and/or irrigation, or damaged wet utilities) along zones of contrasting permeabilities/densities (fill/bedrock contacts, sandy/clayey fill lifts, etc.) or along geologic discontinuities (contacts, joints/fractures). This potential should be anticipated and disclosed to all interested/affected parties.

Due to the potential for post-development perched water to manifest near the surface, owing to as-graded permeability/density contrasts, more onerous slab design is necessary for any new slab-on-grade floor (State of California, 2014). Recommendations for reducing the amount of water and/or water vapor through slab-on-grade floors are provided in the “Soil Moisture Considerations” sections of this report.
GEOLOGIC HAZARDS EVALUATION

Mass Wasting/Landslide Susceptibility

Mass wasting refers to the various processes by which earth materials are moved down slope in response to the force of gravity. Examples of these processes include slope creep, surficial failures, and deep-seated landslides. Creep is the slowest form of mass wasting and generally involves the outer 5 to 10 feet of a slope surface. During heavy rains, such as those in El Niño years, creep-affected materials may become saturated, resulting in a more rapid form of downslope movement (i.e., landslides and/or surficial failures).

According to regional landslide susceptibility mapping by Tan and Giffen (1995), the site is located within landslide susceptibility Subarea 3-1 which is characterized as being "generally susceptible" to landsliding. However, geomorphic expressions indicative of past mass wasting events (i.e., scarps and hummocky terrain) were not observed on the property during our field studies nor our review of stereoscopic aerial photographs (United State Department of Agriculture [USDA], 1953). Further, no adverse geologic structures were encountered during our subsurface exploration. Regional geologic maps do not indicate the presence of landslides on the property.

The onsite soils are considered erosive when exposed on unprotected slopes. Therefore, slopes comprised of these materials may be subject to rilling, gullying, sloughing, and surficial slope failures depending on rainfall severity and surface drainage practices. Such risks can be minimized through properly designed, and regularly and periodically maintained surface drainage.

FAULTING AND REGIONAL SEISMICITY

Regional Faults

Our review indicates that there are no known active faults crossing the project and the site is not within an Alquist-Priolo Earthquake Fault Zone (Bryant and Hart, 2007). However, the site is situated in a region subject to periodic earthquakes along active faults.

The Rose Canyon fault, part of the Newport Inglewood - Rose Canyon fault zone, is the closest known active fault to the site (located at a distance of approximately 6.2 miles [9.9 kilometers]) and should have the greatest effect on the site in the form of strong ground shaking, should the design earthquake occur. The location of the Rose Canyon fault and other major faults relative to the site is shown on the “California Fault Map” in Appendix C. The possibility of ground acceleration, or shaking at the site, may be considered as approximately similar to the southern California region as a whole.
Local Faulting

Although active faults lie within a few miles of the site, no active faults were observed to specifically transect the site during the field investigation. Additionally, a review of available regional geologic maps does not indicate the presence of active faults crossing the specific project site.

Seismicity

The acceleration-attenuation relation of Bozorgnia, Campbell, and Niazi (1999) has been incorporated into EQFAULT (Blake, 2000a). EQFAULT is a computer program developed by Thomas F. Blake (2000a), which performs deterministic seismic hazard analyses using digitized California faults as earthquake sources.

The program estimates the closest distance between each fault and a given site. If a fault is found to be within a user-selected radius, the program estimates peak horizontal ground acceleration that may occur at the site from an upper bound event (formerly “maximum credible earthquake”), on that fault. Upper bound refers to the maximum expected ground acceleration produced from a given fault. Site acceleration (g) was computed by a user-selected acceleration-attenuation relation that is contained in EQFAULT. Based on the EQFAULT program, a peak horizontal ground acceleration from an upper bound event on the Rose Canyon fault may be on the order of 0.498g. The computer printouts of pertinent portions of the EQFAULT program are included within Appendix C.

Historical site seismicity was evaluated with the acceleration-attenuation relation of Bozorgnia, Campbell, and Niazi (1999), and the computer program EQSEARCH (Blake, 2000b, updated to December 2012). This program performs a search of the historical earthquake records for magnitude 5.0 to 9.0 seismic events within a 100-kilometer radius, between the years 1800 through June 2013. Based on the selected acceleration-attenuation relationship, a peak horizontal ground acceleration is estimated, which may have affected the site during the specific event listed. Based on the available data and the attenuation relationship used, the estimated maximum (peak) site acceleration during the period 1800 through June 2013 was about 0.21 g. A historic earthquake epicenter map and a seismic recurrence curve are also estimated/generated from the historical data. Computer printouts of the EQSEARCH program are presented in Appendix C.

SEISMIC SHAKING PARAMETERS

Based on the site conditions, the following table summarizes the updated site-specific design criteria obtained from the 2013 CBC (CBSC, 2013), Chapter 16 Structural Design, Section 1613, Earthquake Loads. The computer program “U.S. Seismic Design Maps, provided by the United States Geologic Survey (USGS, 2013) was utilized for design
The short spectral response utilizes a period of 0.2 seconds.

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<th>2013 CBC SEISMIC DESIGN PARAMETERS</th>
<th>VALUE</th>
<th>2013 CBC REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Category</td>
<td>II</td>
<td>Table 1604.5</td>
</tr>
<tr>
<td>Site Class</td>
<td>C</td>
<td>Section 1613.3.2/ASCE 7-10 (p. 203-205)</td>
</tr>
<tr>
<td>Spectral Response - (0.2 sec), S_a</td>
<td>1.109</td>
<td>Section 1613.3.1 Figure 1613.3.1(1)</td>
</tr>
<tr>
<td>Spectral Response - (1 sec), S_i</td>
<td>0.427</td>
<td>Section 1613.3.1 Figure 1613.3.1(2)</td>
</tr>
<tr>
<td>Site Coefficient, F_a</td>
<td>1.0</td>
<td>Table 1613.3.3(1)</td>
</tr>
<tr>
<td>Site Coefficient, F_i</td>
<td>1.373</td>
<td>Table 1613.3.3(2)</td>
</tr>
<tr>
<td>Maximum Considered Earthquake Spectral Response Acceleration (0.2 sec), S_{m0}</td>
<td>1.109</td>
<td>Section 1613.3.3 (Eqn 16-37)</td>
</tr>
<tr>
<td>Maximum Considered Earthquake Spectral Response Acceleration (1 sec), S_{m1}</td>
<td>0.586</td>
<td>Section 1613.3.3 (Eqn 16-38)</td>
</tr>
<tr>
<td>5% Damped Design Spectral Response Acceleration (0.2 sec), S_{d0}</td>
<td>0.740</td>
<td>Section 1613.3.4 (Eqn 16-39)</td>
</tr>
<tr>
<td>5% Damped Design Spectral Response Acceleration (1 sec), S_{d1}</td>
<td>0.391</td>
<td>Section 1613.3.4 (Eqn 16-40)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GENERAL SEISMIC DESIGN PARAMETERS</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to Seismic Source (Rose Canyon fault)</td>
<td>6.2 mi (9.9 km) (1)</td>
</tr>
<tr>
<td>Upper Bound Earthquake (Rose Canyon fault)</td>
<td>M_w = 7.2 (2)</td>
</tr>
<tr>
<td>PGA_{d} (3)(4)</td>
<td>0.43g</td>
</tr>
<tr>
<td>Seismic Design Category (4)</td>
<td>D</td>
</tr>
</tbody>
</table>

(1) - From Blake (2000a)  
(2) - Cao, et al. (2003)  
(3) - ASCE 7 (2010)  
(4) - Probabilistic Vertical Ground Acceleration may be assumed as about 50% of these values.

Conformance to the criteria above for seismic design does not constitute any kind of guarantee or assurance that significant structural damage or ground failure will not occur in the event of a large earthquake. The primary goal of seismic design is to protect life, not to eliminate all damage, since such design may be economically prohibitive. Cumulative effects of seismic events are not addressed in the 2013 CBC (CBSC, 2013) and regular
maintenance and repair following locally significant seismic events (i.e., $M_w 5.5$) will likely be necessary, as is the case in all of southern California.

**SECONDARY SEISMIC HAZARDS**

**Liquefaction/Lateral Spreading**

Liquefaction describes a phenomenon in which cyclic stresses, produced by earthquake-induced ground motion, create excess pore pressures in relatively cohesionless soils. These soils may thereby acquire a high degree of mobility, which can lead to vertical deformation, lateral movement, lurching, sliding, and as a result of seismic loading, volumetric strain and manifestation in surface settlement of loose sediments, sand boils and other damaging lateral deformations. This phenomenon occurs only below the water table, but after liquefaction has developed, it can propagate upward into overlying non-saturated soil as excess pore water dissipates.

One of the primary factors controlling the potential for liquefaction is depth to groundwater. Typically, liquefaction has a relatively low potential at depths greater than 50 feet and is unlikely and/or will produce vertical strains well below 1 percent for depths below 60 feet when relative densities are 40 to 60 percent and effective overburden pressures are two or more atmospheres (i.e., 4,232 pounds per square foot [Seed, 2005]).

The condition of liquefaction has two principal effects. One is the consolidation of loose sediments with resultant settlement of the ground surface. The other effect is lateral sliding. Significant permanent lateral movement generally occurs only when there is significant differential loading, such as fill or natural ground slopes within susceptible materials. No such loading conditions exist at the site.

Liquefaction susceptibility is related to numerous factors and the following five conditions should be concurrently present for liquefaction to occur: 1) sediments must be relatively young in age and not have developed a large amount of cementation; 2) sediments must generally consist of medium- to fine-grained, relatively cohesionless sands; 3) the sediments must have low relative density; 4) free groundwater must be present in the sediment; and 5) the site must experience a seismic event of a sufficient duration and magnitude, to induce straining of soil particles. Only about one of these five necessary, concurrent conditions have the potential to affect the site.

**Seismic Densification**

Seismic densification is a phenomenon that typically occurs in low relative density granular soils (i.e., United States Soil Classification System [USCS] soil types SP, SM, and SC) that are above the groundwater table. These unsaturated granular soils are susceptible if left in the original density (unmitigated), and are generally dry of the optimum moisture content.
(as defined by the ASTM D 1557). During seismic-induced ground shaking, these natural or artificial soils deform under loading and volumetrically strain, potentially resulting in ground surface settlements. Some densification of the adjoining un-mitigated properties may influence improvements at the perimeter of the site. Special setbacks and/or foundations may be utilized if significant structures/improvements are placed close to the perimeter of the site. Our evaluation assumed that the current offsite conditions will not be significantly modified by future grading at the time of the design earthquake, which is a reasonably conservative assumption.

**Summary**

It is the opinion of GSI that the susceptibility of the site to experience damaging deformations from seismically-induced liquefaction and densification is low owing to the dense nature of the bedrock that underlies the site in the near-surface and the depth to the regional water table. In addition, the recommendations for remedial earthwork and foundations would further reduce any significant liquefaction/densification potential. Some seismic densification of the adjoining un-mitigated site(s) may adversely influence planned improvements at the perimeter of the site. However, given the remedial earthwork and foundation recommendations provided herein, the potential for the planned buildings to be affected by significant seismic densification or liquefaction of offsite soils may be considered low.

**Other Geologic/Secondary Seismic Hazards**

The following list includes other geologic/seismic related hazards that have been considered during our evaluation of the site. The hazards listed are considered negligible and/or mitigated as a result of site location, soil characteristics, and typical site development procedures:

- Subsidence
- Surface Rupture
- Ground Lurching or Shallow Ground Rupture
- Sieche
- Tsunami

**SLOPE STABILITY**

Assuming proper surface drainage, regular and periodic care and maintenance, and normal rainfall, permanent graded slopes, constructed from the onsite materials, as recommended herein, are considered grossly and surficially stable. The natural slope, located along the western, and southwestern property line (below Lots 1 and 2) is generally considered grossly stable given the absence of adverse structures and no evidence of historic instability. Site earth materials are also considered erosive. As such,
positive surface drainage practices and vegetative covering should be maintained throughout the life of the project. Temporary slopes for construction are discussed in subsequent sections of our report.

LABORATORY TESTING

Laboratory tests were performed on representative samples of site earth materials collected during our subsurface exploration in order to evaluate their physical characteristics. Test procedures used and results obtained are presented below.

Classification

Soils were visually classified with respect to the Unified Soil Classification System (U.S.C.S.) in general accordance with ASTM D 2487 and D 2488. The soil classifications of the onsite soils are provided on the Test Pit Logs in Appendix B.

Moisture-Density Relations

The field moisture contents and dry unit weights were determined for selected samples in the laboratory. Testing was performed in general accordance with ASTM D 2937 and ASTM D 2216. The dry unit weight was determined in pounds per cubic foot (pcf), and the field moisture content was determined as a percentage of the dry weight. The results of these tests are shown on the Test Pit Logs in Appendix B.

Expansion Index

Representative samples of near-surface site soils were evaluated for expansion potential. Expansion Index (E.I.) testing and expansion potential classification was performed in general accordance with ASTM Standard D 4829, the results of the expansion testing are presented in the following table.

<table>
<thead>
<tr>
<th>SAMPLE LOCATION AND DEPTH (FT)</th>
<th>EXPANSION INDEX</th>
<th>EXPANSION POTENTIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-2 @ 4½</td>
<td>10</td>
<td>Very Low</td>
</tr>
<tr>
<td>TP-4 @ 1-2</td>
<td>69</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Atterberg Limits

Tests were performed on a representative fine-grained soil sample to evaluate its liquid limit, plastic limit, and plasticity index (P.I.) in general accordance with ASTM D 4318-4318.
The test results are presented below and Appendix D. Testing indicates that the tested samples of the onsite soils are high to very highly plastic.

<table>
<thead>
<tr>
<th>SAMPLE LOCATION AND DEPTH (FT)</th>
<th>PLASTIC LIMIT</th>
<th>LIQUID LIMIT</th>
<th>PLASTICITY INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-2 @ 4 1/2</td>
<td>16</td>
<td>28</td>
<td>12</td>
</tr>
<tr>
<td>TP-4 @ 1-2</td>
<td>18</td>
<td>62</td>
<td>44</td>
</tr>
</tbody>
</table>

**Grain-Size Distribution**

An evaluation was performed on a selected representative soil sample in general accordance with ASTM D 422. The grain-size distribution curve is presented in Appendix D.

**Direct Shear**

Shear testing was performed on a representative, relatively undisturbed sample of site soil in general accordance with ASTM Test Method D 3080 in a Direct Shear Machine of the strain control type. The shear test results are presented in the following table and in Appendix D:

<table>
<thead>
<tr>
<th>SAMPLE LOCATION AND DEPTH (FT)</th>
<th>PRIMARY</th>
<th>RESIDUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>COHESION (PSF)</td>
<td>FRICITION ANGLE (DEGREES)</td>
</tr>
<tr>
<td>TP-3 @ 3 1/2 (undisturbed)</td>
<td>779</td>
<td>28</td>
</tr>
</tbody>
</table>

**Saturated Resistivity, pH, and Soluble Sulfates, and Chlorides**

GSI conducted sampling of onsite earth materials for general soil corrosivity and soluble sulfates, and chlorides testing. The testing included evaluation of soil pH, soluble sulfates, chlorides, and saturated resistivity. Test results are presented in the following table:

<table>
<thead>
<tr>
<th>SAMPLE LOCATION AND DEPTH (FT)</th>
<th>pH</th>
<th>SATURATED RESISTIVITY (ohm-cm)</th>
<th>SOLUBLE SULFATES (% by weight)</th>
<th>SOLUBLE CHLORIDES (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-1 @ 2-4</td>
<td>7.54</td>
<td>470</td>
<td>0.0830</td>
<td>118</td>
</tr>
</tbody>
</table>
Corrosion Summary

Laboratory testing indicates that tested samples of the onsite soils are neutral with respect to soil acidity/alkalinity, are severely corrosive to exposed, buried metals when saturated, present negligible (“not applicable” [or class SO] per American Concrete Institute [ACI] 318-08) sulfate exposure to concrete, and are below action levels for chloride exposure (per State of California Department of Transportation, 2003). Reinforced concrete mix design for foundations, slab-on-grade floors, and pavements should minimally conform to “Exposure Class C1” in Table 4.3.1 of ACI 318-08, as concrete would likely be exposed to moisture. It should be noted that GSI does not consult in the field of corrosion engineering. The client and project architect should agree on the level of corrosion protection required for the project and seek consultation from a qualified corrosion consultant.

PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Based on our field exploration, laboratory testing, and geotechnical engineering analysis, it is our opinion that the subject site is suitable for the proposed residential development from a geotechnical engineering and geologic viewpoint, provided that the recommendations presented in the following sections are incorporated into the design and construction phases of site development. The primary geotechnical concerns with respect to the proposed development and improvements are:

- Earth materials characteristics and depth to competent bearing material.
- Potential for construction/landscape debris to be present in some existing fill areas, that may render that fill unsuitable for re-use.
- On-going expansion and corrosion potentials of site soils.
- Permanent and temporary slope stability.
- Erosiveness of site earth materials.
- Potential for perched water during and following site development.
- Perimeter conditions and planned improvements near the subdivision boundary.
- Regional seismic activity.

The recommendations presented herein consider these as well as other aspects of the site. The engineering analyses performed concerning site preparation and the recommendations presented herein have been completed using the information provided and obtained during our field work.

In the event that any significant changes are made to proposed site development, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the recommendations of this report verified or modified in writing by this office. Foundation design parameters are considered preliminary until the foundation design, layout, and structural loads are provided to this office for review.
1. Soil engineering, observation, and testing services should be provided during grading to aid the contractor in removing unsuitable soils and in his effort to compact the fill.

2. Geologic observations should be performed during any grading and foundation construction to verify and/or further evaluate geologic conditions. Although unlikely, if adverse geologic structures are encountered, supplemental recommendations and earthwork may be warranted.

3. Undocumented fill, colluvium, and any highly weathered bedrock is considered unsuitable for the support of the planned settlement-sensitive improvements (i.e., residential structures, walls, underground utilities, and pavements, etc.) and new planned fills. Unsuitable soils within the influence of planned settlement-sensitive improvements and planned fill should be removed to expose suitable bedrock and then be reused as properly engineered fill. Based on the available subsurface data, remedial grading excavations are anticipated to extend to depths of approximately 2 to 5½ feet. However, locally deeper remedial grading excavations cannot be precluded and should be anticipated. It should be noted that local areas of construction/landscape debris in some existing fill areas may render that fill unsuitable for re-use.

4. Expansion Index testing performed on a sample of the onsite soils indicates very low to medium expansive soil conditions (E.I. of 10 to 69), for representative site soils, with higher expansive soils indicated, based on testing indicating a plasticity index (PI) of 44. As such, it is possible that soils with higher expansion potentials may be encountered locally. Thus, in general, surficial deposits of undocumented fill, colluvium, and highly weathered bedrock likely meet the criteria for detrimentally expansive soils, as defined in Section 1803.5.2 of the 2013 CBC, while soils derived from less weathered sedimentary bedrock are less expansive, and may not be considered detrimentally expansive in some areas. On a preliminary basis, residential building foundations within the influence of expansive soils should be designed and constructed in accordance with Sections 1808.6.1 or 1808.6.2 of the 2013 CBC. Foundation systems used for the mitigation of expansive soils typically incorporate the Post-tension Institute (PTI) and Wire Reinforcement Institute (WRI) methodologies. Preliminary recommendations for the design and construction of both conventional, and post-tension (PT) type foundations are included herein. Final foundation design will be provided at the conclusion of grading, based on the E.I. and P.I. of soils exposed near pad grade. The existing fill soils are likely very low to medium in expansion potential, based on visual classification and appearance and are therefore considered potentially detrimentally expansive, on a preliminary basis.

As an alternative to designing and constructing specialized foundation systems to reduce expansive soil effects, earthwork mitigation and/or selective grading may be performed to create a non-detrimentally expansive fill cap (soils derived from
5. Laboratory testing indicates that site soils are neutral with respect to soil acidity/alkalinity and are severely corrosive to exposed buried metals when saturated. Testing also indicates that site soils present negligible (“not applicable” per ACI 318-08) sulfate exposure to concrete and are classified as “C1” for chloride exposure (ACI 318-08). The client and project architect should agree on the level of corrosion protection required for the project and seek consultation from a qualified corrosion consultant as warranted.

6. Earthwork adjacent to property lines will need to consider any perimeter conditions (slopes, walls, adjacent structures, etc.) that may be encountered. On a preliminary basis, significant perimeter conditions may exist in the vicinity of planned retaining walls located along the south and southwest edges of the site. Deepened footings, and structural setbacks may be recommended. This potential appears to be greatest within plan Lots 2 through 5 (see Plate 1). This should be evaluated further during the final grading plan review.

7. Site soils are considered erosive. Surface drainage should be designed to eliminate the potential for concentrated flows. Positive surface drainage away from foundations and tops of slopes is recommended. Temporary erosion control measures should be implemented until vegetative covering is well established. The homeowners and homeowner’s association (if any) will need to maintain proper surface drainage over the life of the project.

8. No evidence of a high regional groundwater table nor perched water was observed during our subsurface exploration within the property. However, due to the nature of site earth materials, there is a potential for perched water to occur both during and following site development. This potential should be disclosed to all interested/affected parties. Should perched water conditions be encountered, this office could provide recommendations for mitigation. Typical mitigation includes subdrainage system, cut-off barriers, etc.

9. The removal and recompaction of potentially compressible soils below a 1:1 (h:v) projection down from the bottom outside of planned settlement-sensitive improvements and fill along the perimeter of the site will be limited due to boundary restrictions. As such, any settlement-sensitive improvement located above a 1:1 (h:v) projection from the bottom outboard edge of the remedial grading excavation at the property line would require deepened foundations below this plane, additional reinforcement, or would retain some potential for distress and therefore, a reduced serviceable life. On a preliminary basis, any planned settlement-sensitive improvements located within approximately 2 to potentially 6 feet from the subdivision boundary would require deepened foundations or
additional reinforcement by means of ground improvement or specific structural design. This should be disclosed to all interested/affected parties.

10. On a preliminary basis, temporary slopes should be constructed in accordance with CAL-OSHA guidelines for Type “B” soils, provided water or seepage is not present. All temporary slopes should be evaluated by the geotechnical consultant, prior to worker entry. Should adverse conditions be identified, the slope may need to be laid back to a flatter gradient or require the use of shoring.

11. The seismicity-acceleration values provided herein should be considered during the design and construction of the proposed development.

12. General Earthwork and Grading Guidelines are provided at the end of this report as Appendix E. Specific recommendations are provided below.

**EARTHWORK CONSTRUCTION RECOMMENDATIONS**

**General**

All earthwork should conform to the guidelines presented in the 2013 CBC (CBSC, 2013), the requirements of the City, County, and the General Earthwork and Grading Guidelines presented in Appendix E, except where specifically superceded in the text of this report. Prior to earthwork, a GSI representative should be present at the preconstruction meeting to provide additional earthwork guidelines, if needed, and review the earthwork schedule. This office should be notified in advance of any fill placement, supplemental re-grading of the site, or backfilling underground utility trenches and retaining walls after rough earthwork has been completed. This includes grading for driveway approaches, driveways, and exterior hardscape.

During earthwork construction, all site preparation and the general grading procedures of the contractor should be observed and the fill selectively tested by a representative(s) of GSI. If unusual or unexpected conditions are exposed in the field, they should be reviewed by this office and, if warranted, modified and/or additional recommendations will be offered. All applicable requirements of local and national construction and general industry safety orders, the Occupational Safety and Health Act (OSHA), and the Construction Safety Act should be met. It is the onsite general contractor’s and individual subcontractors’ responsibility to provide a safe working environment for our field staff who are onsite. GSI does not consult in the area of safety engineering.

**Site Preparation**

All existing improvements, vegetation and deleterious debris should be removed from the site prior to the start of construction if they are located in areas of proposed earthwork. If
an existing pool backfill is present, the backfill shall be removed to suitable formation and properly backfilled.

Any remaining cavities should be observed by the geotechnical consultant. Mitigation of cavities would likely include removing any potentially compressible soils to expose suitable bedrock and then backfilling the excavation with a controlled engineered fill or soils that have been moisture conditioned to optimum moisture content and compacted to at least 90 percent of the laboratory standard (ASTM D 1557).

**Removal and Recompaction of Potentially Compressible Earth Materials**

Potentially compressible undocumented fill, colluvium, and any highly weathered bedrock should be removed to expose suitable sedimentary bedrock. Following removal, these soils should be cleaned of any vegetation and deleterious debris, moisture conditioned to at least optimum moisture, and then be recompacted to at least 90 percent of the laboratory standard (ASTM D 1557). Based on the available data, excavations necessary to remove unsuitable soils are anticipated to range between approximately 2 to 5½ feet. Across the site. The potential to encounter thicker sections of unsuitable soils that require deeper remedial grading excavations than stated above cannot be precluded and should be anticipated. Potentially compressible soils should be removed below a 1:1 (h:v) projection down from the bottom, outboard edge of any settlement-sensitive improvement or limits of planned fill. Remedial grading excavations should be observed by the geotechnical consultant prior to scarification and fill placement. Once observed and approved, the bottom of the remedial grading excavation should be scarified at least 6 to 8 inches, moisture conditioned to at least the soil’s optimum moisture content, and then recompacted to a minimum 90 percent of the laboratory standard (ASTM D 1557).

**Perimeter Conditions**

It should be noted that the 2013 CBC (CBSC, 2013) indicates that the removal of unsuitable soils be performed across all areas to be graded, under the purview of the grading permit, not just within the influence of the residential structures. Relatively deep removals may also necessitate a special zone of consideration, on perimeter/confining areas. This zone would be approximately equal to the depth of removals, if removals cannot be performed onsite or offsite. In general, any planned improvement located above a 1:1 (h:v) projection up from the bottom, outboard edge of the remedial grading excavation at the subdivision boundary would be affected by perimeter conditions. On a preliminary basis, any planned settlement-sensitive improvements located within approximately 2 feet of the subdivision boundary would require deepened foundations or additional reinforcement by means of ground improvement or specific structural design, for perimeter conditions discussed above. Otherwise these improvements may be subject to distress and a reduced serviceable lifespan. This will also require proper disclosure to any owners and all interested/affected parties should this condition exist at the conclusion of grading. The need for remedial measures for support of settlement-sensitive
improvements near the subdivision boundary should be further evaluated at the final grading plan review stage.

Fill Placement

Following scarification of the bottom of the remedial grading excavation, the reused onsite soils and import (if necessary) should be placed in ±6- to ±8-inch lifts, cleaned of vegetation and debris, moisture conditioned, and compacted to achieve a minimum relative compaction of 90 percent of the laboratory standard (ASTM D 1557). In general, moisture conditioning should be such that site soils are placed to at least optimum moisture content, with soils placed within approximately 2 feet of finished grade placed to at least 1.2 times the soils optimum moisture content.

Overexcavation

In order to provide uniform foundation and slab-on-grade floor support, mitigate water vapor transmission potential, and to facilitate improvements construction, it is recommended that building pads (cut pads and transition pads) are overexcavated (undercut) to a depth of at least 3 feet below pad grade or 2 feet below the lowest bottom of the footing elevation (whichever is greater). When removals do not provide for the minimum fill thickness with a given building pad, the building pad shall be overexcavated as described herein.

Overexcavation should be completed across the entire building pad in case the location of the building footprint requires modification after grading. The maximum:minimum fill thickness (subsurface slope) across a lot should not exceed 3:1 (maximum:minimum) and overexcavation is recommended when necessary. The bottom of the overexcavation should be graded such that it slopes away from the residential structure/lot, preferably toward the street. Prior to fill placement, the bottom of the overexcavation should be scarified at least 6 to 8 inches, moisture conditioned to at least the soil’s optimum moisture content, and then recompacted to a minimum 90 percent of the laboratory standard (ASTM D 1557).

OTHER EARTHWORK CRITERIA

Import Soils

If import fill is necessary, a sample of the soil import should be evaluated by this office prior to importing, in order to assure compatibility with the onsite soils and the recommendations presented in this report. If non-manufactured materials are used, environmental documentation for the export site should be provided for GSI review. At least three business days of lead time should be allowed by builders or contractors for proposed import submittals. This lead time will allow for environmental document review,
particle size analysis, laboratory standard, expansion testing, and blended import/native characteristics as deemed necessary. Import soils should be compatible with onsite soils in consideration of soil expansion and corrosion potential. It should be understood that importing higher expansive soils that what is present onsite will result in more onerous foundation design.

**Graded Slope Construction**

Graded fill slopes should be constructed at gradients no steeper than 2:1 (h:v) to the heights indicated on Plate 1, without further analysis. Fill slopes should be properly keyed and benched if constructed along surfaces steeper than 5:1 (h:v). All fill slopes should be compacted to at least 90 percent of the laboratory standard (ASTM D 1557) throughout, including the slope face.

Graded cut slopes should be constructed at gradients no steeper than 2.1:1 (h:v) to heights up to 10 feet, without further evaluation. Any cut slopes should be mapped by a geologist during construction. Although not anticipated at this time, should intersecting planes of joints/fractures daylight the cut slope face, or should undocumented fill, colluvium, or highly weathered bedrock be exposed in cut slopes, remedial grading including stabilization fills or inclining the cut slope to a gradient flatter than the adverse structure may be necessary. The type of remedial grading would be based on the conditions exposed during cut slope construction.

**Stabilization Fills/Slope Drainage**

Stabilization fills are not anticipated at this time. Slope subdrainage may be accommodated by drainage systems for the planned perimeter, toe of slope walls, on a preliminary basis.

**Temporary Slopes**

Temporary slopes for excavations greater than 4 feet but less than 20 feet in overall height should conform to CAL-OSHA and/or OSHA requirements for Type “B” soils, provided water or seepage is not present. Temporary slopes, up to a maximum height of ±20 feet, may be excavated at a 1:1 (h:v) gradient, or flatter, provided groundwater and/or running sands are not exposed. Construction materials or soil stockpiles should not be placed within ‘H’ of any temporary slope where ‘H’ equals the height of the temporary slope. All temporary slopes should be observed by a licensed engineering geologist and/or geotechnical engineer prior to worker entry into the excavation. Based on the exposed field conditions, inclining temporary slopes to flatter gradients or the use of shoring may be necessary if adverse conditions are observed. If temporary slopes conflict with property boundaries, shoring or alternating slot excavations may be necessary. The need for shoring or alternating slot excavations could be further evaluated during the 40-scale grading plan review stage.
Excavation Observation and Monitoring (All Excavations)

When excavations are made adjacent to an existing improvement (i.e., utility, road or building) there is a risk of some damage even if a well designed system of excavation is planned and executed. We recommend, therefore, that a systematic program of observations be made before, during, and after construction to determine the effects (if any) of construction on existing improvements.

We believe that this is necessary for two reasons: First, if excessive movements (i.e., more than ½-inch) are detected early enough, remedial measures can be taken which could possibly prevent serious damage to existing improvements. Second, the responsibility for damage to the existing improvement can be determined more equitably if the cause and extent of the damage can be determined more precisely.

Monitoring should include the measurement of any horizontal and vertical movements of the existing structures/improvements. Locations and type of the monitoring devices should be selected prior to the start of construction. The program of monitoring should be agreed upon between the project team, the site surveyor and the Geotechnical Engineer-of-Record, prior to excavation.

Reference points on existing walls, buildings, and other settlement-sensitive improvements. These points should be placed as low as possible on the wall and building adjacent to the excavation. Exact locations may be dictated by critical points, such as bearing walls or columns for buildings; and surface points on roadways or curbs near the top of the excavation.

For a survey monitoring system, an accuracy of a least 0.01 foot should be required. Reference points should be installed and read initially prior to excavation. The readings should continue until all construction below ground has been completed and the permanent backfill has been brought to final grade.

The frequency of readings will depend upon the results of previous readings and the rate of construction. Weekly readings could be assumed throughout the duration of construction with daily readings during rapid excavation near the bottom of the excavation. The reading should be plotted by the Surveyor and then reviewed by the Geotechnical Engineer. In addition to the monitoring system, it would be prudent for the Geotechnical Engineer and the Contractor to make a complete inspection of the existing structures both before and after construction. The inspection should be directed toward detecting any signs of damage, particularly those caused by settlement. Notes should be made and pictures should be taken where necessary.
Observation

It is recommended that all excavations be observed by the Geologist and/or Geotechnical Engineer. Any fill which is placed should be approved, tested, and verified if used for engineered purposes. Should the observation reveal any unforseen hazard, the Geologist or Geotechnical Engineer will recommend treatment. Please inform GSI at least 24 hours prior to any required site observation.

Earthwork Balance (Shrinkage/Bulking)

The volume change of excavated materials upon compaction as engineered fill is anticipated to vary with material type and location. Based on the available data, the overall earthwork shrinkage and bulking may be approximated by using the following parameters:

- Existing Artificial Fill: 5% to 10% shrinkage
- Colluvium/highly weathered Bedrock: 2% to 5% shrinkage
- Bedrock: 3% shrinkage to 3% bulking

It should be noted that the above factors are estimates only, based on preliminary data. Existing fill and colluvium may achieve higher shrinkage if organics or clay content is higher than anticipated, or if compaction averages more than 92 percent of the laboratory standard (ASTM D 1557). Final earthwork balance factors could vary. In this regard, it is recommended that balance areas be reserved where grades could be adjusted up or down near the completion of grading in order to accommodate any yardage imbalance for the project.

PRELIMINARY RECOMMENDATIONS - FOUNDATIONS

General

Preliminary recommendations for foundation design and construction are provided in the following sections. These preliminary recommendations have been developed from our understanding of the currently planned site development, site observations, subsurface exploration, laboratory testing, and engineering analyses. Foundation design should be re-evaluated at the conclusion of site grading/remedial earthwork for the as-graded soil conditions. Although not anticipated, revisions to these recommendations may be necessary. In the event that the information concerning the proposed development plan is not correct, or any changes in the design, location or loading conditions of the proposed residential structures are made, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report are modified or approved in writing by this office.
The information and recommendations presented in this section are not meant to supercede design by the project structural engineer or civil engineer specializing in structural design. Upon request, GSI could provide additional input/consultation regarding soil parameters, as related to foundation design.

In the following sections, GSI provides preliminary design and construction recommendations for foundations underlain by both non-detrimentally and detrimentally expansive soil conditions. Foundation systems constructed within the influence of detrimentally expansive soils (i.e., E.I. > 20 and PI > 15) will require specific design to resist expansive soil effects per Sections 1808.6.1 or 1808.6.2 of the 2013 CBC.

**Preliminary Foundation Design**

1. The foundation systems should be designed and constructed in accordance with guidelines presented in the 2013 CBC.

2. An allowable bearing value of 2,000 pounds per square foot (psf) may be used for the design of footings that maintain a minimum width of 12 inches and a minimum depth of 12 inches (below the lowest adjacent grade), and are founded entirely into approved engineered fill. This value may be increased by 20 percent for each additional 12 inches in footing depth to a maximum value of 2,500 psf for footings founded into approved engineered fill. This value may be increased by one-third when considering short duration seismic or wind loads. Isolated pad footings should have a minimum dimension of at least 24 inches square and a minimum embedment of 24 inches below the lowest adjacent grade into approved engineered fill. Foundation embedment depth excludes concrete slabs-on-grade, and/or slab underlayment.

3. For foundations deriving passive resistance from approved engineered fill, a passive earth pressure may be computed as an equivalent fluid having a density of 250 pcf, with a maximum earth pressure of 2,500 psf.

4. The upper 6 inches of passive pressure should be neglected if not confined by slabs or pavement.

5. For lateral sliding resistance, a 0.35 coefficient of friction may be utilized for a concrete to soil contact when multiplied by the dead load.

6. When combining passive pressure and frictional resistance, the passive pressure component should be reduced by one-third.

7. All footing setbacks from slopes should comply with Figure 1808.7.1 of the 2013 CBC. GSI recommends a minimum horizontal setback distance of 7 feet as measured from the bottom, outboard edge of the footing to the slope face.
8. Footings for structures adjacent to retaining walls should be deepened so as to extend below a 1:1 projection up from the heel of the retaining wall. Alternatively, the retaining wall may be designed for the applicable surcharge.

PRELIMINARY FOUNDATION CONSTRUCTION RECOMMENDATIONS

Conventional Foundation and Slab-On-Grade Floor Systems

The following recommendations are intended to support foundations and slab-on-grade floor systems underlain by at least 7 feet of non-detrimentally expansive soils (i.e., E.I. < 21 and P.I. < 15). Earthwork mitigation of expansive soils will be required for the use of conventional foundation and slab-on-grade floor systems.

1. Exterior and interior footings should be founded into approved engineered fill at a minimum depth of 12 or 18 inches below the lowest adjacent grade for one- or two-story floor loads, respectively. For one- and two-story floor loads, footing widths should be 12 and 15 inches, respectively. Isolated, exterior column and panel pads, or wall footings, should be at least 24 inches square, and founded at a minimum depth of 24 inches into approved engineered fill. All footings should be minimally reinforced with four No. 4 reinforcing bars, two placed near the top and two placed near the bottom of the footing.

2. All interior and exterior column footings, and perimeter wall footings, should be tied together via grade beams in at least two directions. The grade beam should be at least 12 inches square in cross section, and should be provided with a minimum of one No.4 reinforcing bar at the top, and one No.4 reinforcing bar at the bottom of the grade beam. The base of the reinforced grade beam should be at the same elevation as the adjoining footings.

3. A grade beam, reinforced as previously recommended and at least 12 inches square, should be provided across large (garage) entrances. The base of the reinforced grade beam should be at the same elevation as the adjoining footings.

4. A minimum concrete slab-on-grade thickness of 5 inches is recommended.

5. Concrete slabs should be reinforced with a minimum of No. 3 reinforcement bars placed at 18 inches on center, in two horizontally perpendicular directions (i.e., long axis and short axis).

6. All slab reinforcement should be supported to ensure proper mid-slab height positioning during placement of the concrete. "Hooking" of reinforcement is not an acceptable method of positioning.
7. Slab subgrade pre-soaking is not required for non-detrimentally expansive soil conditions. However, the client should consider pre-wetting the slab subgrade materials to at least the soil’s optimum moisture content to a minimum depth of 12 inches, prior to the placement of the underlayment sand and vapor retarder.

8. Soils generated from footing excavations to be used onsite should be compacted to a minimum relative compaction of 90 percent of the laboratory standard (ASTM D 1557), whether the soils are to be placed inside the foundation perimeter or in the yard/right-of-way areas. This material must not alter positive drainage patterns that direct drainage away from the structural areas and toward the street.

9. Reinforced concrete mix design should conform to “Exposure Class C1” in Table 4.3.1 of ACI-318-08 since concrete would likely be exposed to moisture.

**Post-Tensioned Foundations**

Post-tension (PT) foundations should be used to mitigate the damaging effects of expansive soils on the planned residential foundations and slab-on-grade floors if expansive soil conditions are encountered within 7 feet of finish grade. They may also be used for increased performance of foundations constructed on non-detrimentally expansive soils.

Current laboratory testing indicates that the onsite soils exhibit expansion index values ranging up to 69 with a plasticity index of up to 44. These soils meet the criteria of detrimentally expansive soils as defined in Section 1803.5.2 of the 2013 CBC. Thus, GSI is providing geotechnical parameters for the design of PT foundations within the influence of such soil conditions. In addition, GSI is also providing geotechnical design recommendations for PT foundations within the influence of up to highly expansive soils (E.I. ranging from 90 to 130) in the unlikely event that these soil conditions are encountered.

The PT foundation designer may elect to exceed these minimal recommendations to increase slab stiffness performance. PT design may be either ribbed or mat-type. The latter is also referred to as uniform thickness foundation (UTF). The use of a UTF is an alternative to the traditional ribbed-type. The UTF offers a reduction in grade beams (i.e., that method typically uses a single perimeter grade beam and possible “shovel” footings), but has a thicker slab than the ribbed-type.

The information and recommendations presented in this section are not meant to supercede design by a registered structural engineer or civil engineer qualified to perform post-tensioned design. PT foundations should be designed using sound engineering practice and be in accordance with local and 2013 CBC requirements. Upon request, GSI can provide additional data/consultation regarding soil parameters as related to post-tensioned foundation design.
From a soil expansion/shrinkage standpoint, a common contributing factor to distress of structures using post-tensioned slabs is a "dishing" or "arching" of the slabs. This is caused by the fluctuation of moisture content in the soils below the perimeter of the slab primarily due to onsite and offsite irrigation practices, climatic and seasonal changes, and the presence of expansive soils. When the soil environment surrounding the exterior of the slab has a higher moisture content than the area beneath the slab, moisture tends to migrate inward, underneath the slab edges to a distance beyond the slab edges referred to as the moisture variation distance. When this migration of water occurs, the volume of the soils beneath the slab edges expand and cause the slab edges to lift in response. This is referred to as an edge-lift condition. Conversely, when the outside soil environment is drier, the moisture transfer regime is reversed and the soils underneath the slab edges lose their moisture and shrink. This process leads to dropping of the slab at the edges, which leads to what is commonly referred to as the center lift condition. A well-designed, PT slab having sufficient stiffness and rigidity provides a resistance to excessive bending that results from non-uniform swelling and shrinking slab subgrade soils, particularly within the moisture variation distance, near the slab edges. Other mitigation techniques typically used in conjunction with post-tensioned slabs consist of a combination of specific soil pre-saturation and the construction of a perimeter "cut-off" wall grade beam. Soil pre-saturation consists of moisture conditioning the slab subgrade soils prior to the PT slab construction. This effectively reduces soil moisture migration from the area located outside the building toward the soils underlying the post-tension slab. Perimeter cut-off walls are thickened edges of the concrete slab that impedes both outward and inward soil moisture migration.

**Slab Subgrade Pre-Soaking**

Pre-moistening of the slab subgrade soil is recommended for these soil conditions. The moisture content of the subgrade soils should be equal to or greater than optimum moisture to a depth equivalent to the exterior footing depth in the slab areas (typically 12, 18, and 24 inches for very low to low, medium, and highly expansive soils, respectively). Pre-moistening and/or pre-soaking should be evaluated by the soils engineer 72 hours prior to vapor retarder placement. In summary:

<table>
<thead>
<tr>
<th>EXPANSION INDEX</th>
<th>PAD SOIL MOISTURE</th>
<th>CONSTRUCTION METHOD</th>
<th>SOIL MOISTURE RETENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low (0-20)</td>
<td>Upper 12 inches of pad at or above soil optimum moisture</td>
<td>Wetting and/or reprocessing</td>
<td>Periodically wet or cover with plastic after trenching. Evaluation 72 hours prior to placement of concrete.</td>
</tr>
<tr>
<td>Low (21-50)</td>
<td>Upper 12 inches of pad soil moisture 2 percent over optimum</td>
<td>Wetting and/or reprocessing</td>
<td>Periodically wet or cover with plastic after trenching. Evaluation 72 hours prior to placement of concrete.</td>
</tr>
<tr>
<td>EXPANSION INDEX</td>
<td>PAD SOIL MOISTURE</td>
<td>CONSTRUCTION METHOD</td>
<td>SOIL MOISTURE RETENTION</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------</td>
<td>---------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Medium (51-90)</td>
<td>Upper 18 inches of pad soil moisture 2 percent over optimum or 1.2 times optimum, whichever is greater.</td>
<td>Berm and flood or wetting and reprocessing</td>
<td>Periodically wet or cover with plastic after trenching. Evaluation 72 hours prior to placement of concrete.</td>
</tr>
<tr>
<td>High (91-130)</td>
<td>Upper 24 inches of pad soil moisture 3 percent over optimum or 1.3 times optimum, whichever is greater.</td>
<td>Berm and flood or wetting and reprocessing, and berm and flood.</td>
<td>Periodically wet or cover with plastic after trenching. Evaluation 72 hours prior to placement of concrete.</td>
</tr>
</tbody>
</table>

**Perimeter Cut-Off Walls**

Perimeter cut-off walls should be 12, 18, and 24 inches deep for very low to low, medium, and highly expansive soil conditions, respectively. The cut-off walls may be integrated into the slab design or independent of the slab. The cut-off walls should be a minimum of 6 inches thick. The bottom of the perimeter cut-off wall should be designed to resist tension, using cable or reinforcement per the structural engineer.

**Post-Tensioned Foundation Design**

The following recommendations for design of post-tensioned slabs have been prepared in general compliance with the requirements of the recent Post Tensioning Institute’s (PTI’s) publication titled “Design of Post-Tensioned Slabs on Ground, Third Edition” (PTI, 2004), together with it’s subsequent addendums (PTI, 2008).

**Soil Support Parameters**

The recommendations for soil support parameters have been provided based on the typical soil index properties for soils that are very low to high in expansion potential. The soil index properties are typically the upper bound values based on our experience and practice in the southern California area. The following table presents suggested minimum coefficients to be used in the Post-Tensioning Institute design method.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thornthwaite Moisture Index</td>
<td>~20 inches/year</td>
</tr>
<tr>
<td>Correction Factor for Irrigation</td>
<td>20 inches/year</td>
</tr>
<tr>
<td>Depth to Constant Soil Suction</td>
<td>7 feet</td>
</tr>
<tr>
<td>Constant soil Suction (pf)</td>
<td>3.6</td>
</tr>
<tr>
<td>Moisture Velocity</td>
<td>0.7 inches/month</td>
</tr>
<tr>
<td>Plasticity Index (P.I.)</td>
<td>&lt;15-50</td>
</tr>
</tbody>
</table>
Based on the above, the recommended soil support parameters are tabulated below:

<table>
<thead>
<tr>
<th>DESIGN PARAMETERS</th>
<th>EXPANSION POTENTIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VERY LOW TO LOW</td>
</tr>
<tr>
<td></td>
<td>(E.I. = 0-50)</td>
</tr>
<tr>
<td></td>
<td>MEDIUM</td>
</tr>
<tr>
<td></td>
<td>(E.I. = 51-90)</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
</tr>
<tr>
<td></td>
<td>(E.I. = 91-130)</td>
</tr>
<tr>
<td>( e_m ) center lift</td>
<td>9.0 feet</td>
</tr>
<tr>
<td>( e_m ) edge lift</td>
<td>5.2 feet</td>
</tr>
<tr>
<td>( y_m ) center lift</td>
<td>0.3 inches</td>
</tr>
<tr>
<td>( y_m ) edge lift</td>
<td>0.7 inch</td>
</tr>
<tr>
<td>Bearing Value (^{(1)})</td>
<td>1,000 psf</td>
</tr>
<tr>
<td>Lateral Pressure</td>
<td>250 psf</td>
</tr>
<tr>
<td>Subgrade Modulus (k)</td>
<td>100 pci/inch</td>
</tr>
<tr>
<td>Minimum Perimeter Footing Embedment (^{(2)})</td>
<td>12 inches</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Internal bearing values within the perimeter of the post-tension slab may be increased to 2,000 psf for a minimum embedment of 12 inches, then by 20 percent for each additional foot of embedment to a maximum of 2,500 psf.

\(^{(2)}\) As measured below the lowest adjacent compacted subgrade surface without landscape layer or sand underlayment (interior footings also).

Note: The use of open bottomed or raised planters adjacent to foundations will require more onerous design parameters.

Deepened footings/edges around the slab perimeter must be used to minimize non-uniform surface moisture migration (from an outside source) beneath the slab. An edge depth of 12 inches should be considered a minimum. The bottom of the deepened footing/edge should be designed to resist tension, using cable or reinforcement per the structural engineer.

The parameters are considered minimums and may not be adequate to represent all expansive soils/drainage conditions such as adverse drainage and/or improper landscaping and maintenance. The above parameters are applicable provided the structure has positive drainage that is maintained away from the structure. In addition, no trees with significant root systems are to be planted within 15 feet of the perimeter of foundations. Therefore, it is important that information regarding drainage, site maintenance, trees, settlements, and effects of expansive soils be passed on to future all interested/affected parties. The values tabulated above may not be appropriate to account for possible differential settlement of the slab due to other factors, such as excessive settlements. If a stiffer slab is desired, alternative Post-Tensioning Institute ([PTI] third edition) parameters may be recommended.
Foundation Settlement

Based on the current plan (Plate 1), and provided that the earthwork and foundation recommendations in this report are adhered, foundations bearing on approved engineered fill should also be minimally designed to accommodate a total static settlement of 2 inches and a differential static settlement of 1 inch over a 40-foot horizontal span (angular distortion = 1/480), and up to ½ inch of seismic differential settlement over a 40-foot horizontal span (seismic angular distortion = 1/960).

SOIL MOISTURE TRANSMISSION CONSIDERATIONS

GSI has evaluated the potential for vapor or water transmission through the concrete floor slab, in light of typical floor coverings and improvements. Please note that slab moisture emission rates range from about 2 to 27 lbs/24 hours/1,000 square feet from a typical slab (Kanare, 2005), while floor covering manufacturers generally recommend about 3 lbs/24 hours as an upper limit. The recommendations in this section are not intended to preclude the transmission of water or vapor through the foundation or slabs. Foundation systems and slabs shall not allow water or water vapor to enter into the structure so as to cause damage to another building component or to limit the installation of the type of flooring materials typically used for the particular application (State of California, 2014). These recommendations may be exceeded or supplemented by a water “proofing” specialist, project architect, or structural consultant. Thus, the client will need to evaluate the following in light of a cost vs. benefit analysis (owner expectations and repairs/replacement), along with disclosure to all interested/affected parties. It should also be noted that vapor transmission will occur in new slab-on-grade floors as a result of chemical reactions taking place within the curing concrete. Vapor transmission through concrete floor slabs as a result of concrete curing has the potential to adversely affect sensitive floor coverings depending on the thickness of the concrete floor slab and the duration of time between the placement of concrete, and the floor covering. It is possible that a slab moisture sealant may be needed prior to the placement of sensitive floor coverings if a thick slab-on-grade floor is used and the time frame between concrete and floor covering placement is relatively short.

Considering the E.I. test results presented herein, and known soil conditions in the region, the anticipated typical water vapor transmission rates, floor coverings, and improvements (to be chosen by the Client and/or project architect) that can tolerate vapor transmission rates without significant distress, the following alternatives are provided:

• Concrete slabs including garages should be a minimum of 5 inches thick.

• Concrete slab underlayment should consist of a 10- to 15-mil vapor retarder, or equivalent, with all laps sealed per the 2013 CBC and the manufacturer’s recommendation. The vapor retarder should comply with the ASTM E 1745 -
Class A criteria, and be installed in accordance with ACI 302.1R-04 and ASTM E 1643.

- The 10- to 15-mil vapor retarder (ASTM E 1745 - Class A) shall be installed per the recommendations of the manufacturer, including all penetrations (i.e., pipe, ducting, rebar, etc.).

- Concrete slabs, including the garage areas, shall be underlain by 2 inches of clean, washed sand (SE > 30) above a 10- to 15-mil vapor retarder (ASTM E-1745 - Class A, per Engineering Bulletin 119 [Kanare, 2005]) installed per the recommendations of the manufacturer, including all penetrations (i.e., pipe, ducting, rebar, etc.). The manufacturer shall provide instructions for lap sealing, including minimum width of lap, method of sealing, and either supply or specify suitable products for lap sealing (ASTM E 1745), and per code.

ACI 302.1R-04 (2004) states “If a cushion or sand layer is desired between the vapor retarder and the slab, care must be taken to protect the sand layer from taking on additional water from a source such as rain, curing, cutting, or cleaning. Wet cushion or sand layer has been directly linked in the past to significant lengthening of time required for a slab to reach an acceptable level of dryness for floor covering applications.” Therefore, additional observation and/or testing will be necessary for the cushion or sand layer for moisture content, and relatively uniform thicknesses, prior to the placement of concrete.

- The vapor retarder should be underlain by at least 2 inches of clean, washed sand (SE > 30). The sand should be placed on the prepared subgrade described above.

- Concrete should have a maximum water/cement ratio of 0.50. This does not supercede Table 4.3.1 of Chapter 4 of the ACI (2008) for corrosion or other corrosive requirements. Additional concrete mix design recommendations should be provided by the structural consultant and/or waterproofing specialist. Concrete finishing and workability should be addressed by the structural consultant and a waterproofing specialist.

- Where slab water/cement ratios are as indicated herein, and/or admixtures used, the structural consultant should also make changes to the concrete in the grade beams and footings in kind, so that the concrete used in the foundation and slabs are designed and/or treated for more uniform moisture protection.

- The homeowners should be specifically advised which areas are suitable for tile flooring, vinyl flooring, or other types of water/vapor-sensitive flooring and which are not suitable. In all planned floor areas, flooring shall be installed per the manufactures recommendations.
Additional recommendations regarding water or vapor transmission should be provided by the architect/structural engineer/slab or foundation designer and should be consistent with the specified floor coverings indicated by the architect.

Regardless of the mitigation, some limited moisture/moisture vapor transmission through the slab should be anticipated. Construction crews may require special training for installation of certain product(s), as well as concrete finishing techniques. The use of specialized product(s) should be approved by the slab designer and water-proofing consultant. A technical representative of the flooring contractor should review the slab and moisture retarder plans and provide comment prior to the construction of the foundations or improvements. The vapor retarder contractor should have representatives onsite during the initial installation.

**WALL DESIGN PARAMETERS CONSIDERING EXPANSIVE SOILS**

**Conventional Retaining Walls**

The design parameters provided below assume that either very low expansive soils (typically Class 2 permeable filter material or Class 3 aggregate base) or native onsite materials with an expansion index up to 20 are used to backfill any retaining wall (this latter case would require significant compliance testing). The type of backfill (i.e., select or native), should be specified by the wall designer, and clearly shown on the plans. Building walls, below grade, should be water-proofed. The foundation system for the proposed retaining walls should be designed in accordance with the recommendations presented in this and preceding sections of this report, as appropriate. Retaining wall footings should be embedded a minimum of 18 inches below the lowest adjacent grade (excluding landscape layer, 6 inches [i.e., 24 inches total]) and should be at least 24 inches in width. There should be no increase in bearing for footing width. Planned retaining wall footings near the perimeter of the site will likely need to be deepened into suitable bedrock for adequate vertical and lateral bearing support. Recommendations for the design of specialty walls (i.e., crib, earthstone, geogrid, etc.) can be provided upon request.

**Restrained Walls**

Any retaining walls that will be restrained prior to placing and compacting backfill material or that have re-entrant or male corners, should be designed for an at-rest equivalent fluid pressure (EFP) of 55 pcf and 65 pcf for select and very low to low expansive native backfill, respectively. The design should include any applicable surcharge loading. For areas of male or re-entrant corners, the restrained wall design should extend a minimum distance of twice the height of the wall (2H) laterally from the corner.
Cantilevered Walls

The recommendations presented below are for cantilevered retaining walls up to 10 feet high. Design parameters for walls less than 3 feet in height may be superceded by San Diego Regional Standard design. Active earth pressure may be used for retaining wall design, provided the top of the wall is not restrained from minor deflections. An equivalent fluid pressure approach may be used to compute the horizontal pressure against the wall. Appropriate fluid unit weights are given below for specific slope gradients of the retained material. These do not include other superimposed loading conditions due to traffic, structures, seismic events or adverse geologic conditions. When wall configurations are finalized, the appropriate loading conditions for superimposed loads can be provided upon request.

For preliminary planning purposes, the structural consultant should incorporate the surcharge of traffic on the back of retaining walls. The traffic surcharge may be taken as 100 psf/ft in the upper 5 feet of backfill for light truck and car traffic within “H” feet from the back of the wall, where “H” equals the wall height. This does not include the surcharge of parked vehicles which should be evaluated at a higher surcharge to account for the effects of seismic loading.

<table>
<thead>
<tr>
<th>SURFACE SLOPE OF RETAINED MATERIAL (HORIZONTAL:VERTICAL)</th>
<th>EQUIVALENT FLUID WEIGHT P.C.F. (SELECT BACKFILL) (2)</th>
<th>EQUIVALENT FLUID WEIGHT P.C.F. (APPROVED NATIVE BACKFILL) (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level(1)</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>2 to 1</td>
<td>65</td>
<td>70</td>
</tr>
</tbody>
</table>

(1) Level backfill behind a retaining wall is defined as compacted earth materials, properly drained, without a slope for a distance of 2H behind the wall, where H is the height of the wall.

(2) SE > 30, P.I. < 15, E.I. < 21, and < 10% passing No. 200 sieve.

(3) E.I. = 0 to 20, SE > 25, P.I. < 15, and < 15% passing No. 200 sieve; confirmation testing required, and soils will need to be selectively mined for this purpose.

Seismic Surcharge

For engineered retaining walls that may pose ingress or egress constraints within 6 feet of a structure, GSI recommends that such walls be evaluated for a seismic surcharge (in general accordance with 2013 CBC requirements). The site walls in this category should maintain an overturning Factor-of-Safety (FOS) of approximately 1.25 when the seismic surcharge (increment), is applied. For restrained walls, the seismic surcharge should be applied as a uniform surcharge load from the bottom of the footing (excluding shear keys) to the top of the backfill at the heel of the wall footing. This seismic surcharge pressure (seismic increment) may be taken as 15H where “H” for retained walls is the dimension previously noted as the height of the backfill to the bottom of the footing. The resultant
force should be applied at a distance 0.6 H up from the bottom of the footing. For the evaluation of the seismic surcharge, the bearing pressure may exceed the static value by one-third, considering the transient nature of this surcharge. For cantilevered walls the pressure should be an inverted triangular distribution using 15H. Reference for the seismic surcharge is Section 1802.2 of the 2013 CBC. Please note this is for local wall stability only.

The 15H is derived from a Mononobe-Okabe solution for both restrained cantilever walls. This accounts for the increased lateral pressure due to shakedown or movement of the sand fill soil in the zone of influence from the wall or roughly a 45° - φ/2 plane away from the back of the wall. The 15H seismic surcharge is derived from the formula:

\[ P_h = \frac{3}{8} \cdot a_h \cdot \gamma \cdot H \]

Where:
- \( P_h \) = Seismic increment
- \( a_h \) = Probabilistic horizontal site acceleration with a percentage of “g”
- \( \gamma \) = total unit weight (115 to 125 pcf for site soils @ 90% relative compaction).
- \( H \) = Height of the wall from the bottom of the footing or point of pile fixity.

**Retaining Wall Backfill and Drainage**

Positive drainage must be provided behind all retaining walls in the form of gravel wrapped in geofabric and outlets. A backdrain system is considered necessary for retaining walls that are 2 feet or greater in height. Details 1, 2, and 3, present the backdrainage options discussed below. Backdrains should consist of a 4-inch diameter perforated PVC or ABS pipe encased in either Class 2 permeable filter material or ¼-inch to 1½-inch gravel wrapped in approved filter fabric (Mirafi 140N or equivalent). The drain should flow via gravity to an approved drainage facility. For select backfill, the filter material should extend a minimum of 1 horizontal foot behind the base of the walls and upward at least 1 foot. For native backfill that has up to E.I. = 20, continuous Class 2 permeable drain materials should be used behind the wall. This material should be continuous (i.e., full height) behind the wall, and it should be constructed in accordance with the enclosed Detail 1 (Typical Retaining Wall Backfill and Drainage Detail). For limited access and confined areas, (panel) drainage behind the wall may be constructed in accordance with Detail 2 (Retaining Wall Backfill and Subdrain Detail Geotextile Drain).

Materials with an expansion index (E.I.) potential of greater than 20 should not be used as backfill for retaining walls. For more onerous expansive situations, backfill and drainage beyond the retaining wall should conform with Detail 3 (Retaining Wall And Subdrain Detail Clean Sand Backfill). Retaining wall backfill should be moisture conditioned to 1.1 times the soil’s optimum moisture content, placed in relatively thin lifts, and compacted to at least 90 percent of the laboratory standard (ASTM D 1557).
(1) Waterproofing membrane.

(2) Gravel: Clean, crushed, \( \frac{3}{4} \) to 1\( \frac{1}{2} \) inch.

(3) Filter fabric: Mirafi 140N or approved equivalent.

(4) Pipe: 4-inch-diameter perforated PVC, Schedule 40, or approved alternative with minimum of 1 percent gradient sloped to suitable, approved outlet point (perforations down).

(5) Weep hole: Minimum 2-inch diameter placed at 20-foot centers along the wall and placed 3 inches above finished surface. Design civil engineer to provide drainage at toe of wall. No weep holes for below-grade walls.

(6) Footing: If bench is created behind the footing greater than the footing width, use level fill or cut natural earth materials. An additional "heel" drain will likely be required by geotechnical consultant.
(1) Waterproofing membrane (optional): Liquid boot or approved mastic equivalent.

(2) Drain: MiradRAIN 6000 or J-drain 200 or equivalent for non-waterproofed walls; MiradRAIN 6200 or J-drain 200 or equivalent for waterproofed walls (all perforations down).

(3) Filter fabric: Mirafi 140N or approved equivalent; place fabric flap behind core.

(4) Pipe: 4-inch-diameter perforated PVC, Schedule 40, or approved alternative with minimum of 1 percent gradient to proper outlet point (perforations down).

(5) Weep hole: Minimum 2-inch diameter placed at 20-foot centers along the wall and placed 3 inches above finished surface. Design civil engineer to provide drainage at toe of wall. No weep holes for below-grade walls.

(6) Gravel: Clean, crushed, $\frac{3}{4}$ to 1$\frac{1}{2}$ inch.

(7) Footing: If bench is created behind the footing greater than the footing width, use level fill or cut natural earth materials. An additional "heel" drain will likely be required by geotechnical consultant.
(1) Waterproofing membrane: Liquid boot or approved mastic equivalent.

(2) Gravel: Clean, crushed, 3/4 to 1 1/2 inch.

(3) Filter fabric: Mirafi 140N or approved equivalent.

(4) Pipe: 4-inch-diameter perforated PVC, Schedule 40, or approved alternative with minimum of 1 percent gradient to proper outlet point (perforations down).

(5) Weep hole: Minimum 2-inch diameter placed at 20-foot centers along the wall and placed 3 inches above finished surface. Design civil engineer to provide drainage at toe of wall. No weep holes for below-grade walls.

(6) Clean sand backfill: Must have sand equivalent value (S.E.) of 35 or greater; can be densified by water jetting upon approval by geotechnical engineer.

(7) Footing: If bench is created behind the footing greater than the footing width, use level fill or cut natural earth materials. An additional "heel" drain will likely be required by geotechnical consultant.

(8) Native backfill: If E.I. < 21 and S.E. > 35 then all sand requirements also may not be required and will be reviewed by the geotechnical consultant.
Outlets should consist of a 4-inch diameter solid PVC or ABS pipe spaced no greater than ± 100 feet apart, with a minimum of two outlets, one on each end. The use of weep holes, only, in walls higher than 2 feet, is not recommended. The surface of the backfill should be sealed by pavement or the top 18 inches compacted with native soil (E.I. ≤ 50). Proper surface drainage should also be provided. For additional mitigation, consideration should be given to applying a water-proof membrane to the back of all retaining structures. The use of a waterstop should be considered for all concrete and masonry joints.

Wall/Retaining Wall Footing Transitions

Site walls are anticipated to be founded on footings designed in accordance with the recommendations in this report. Should wall footings transition from cut to fill, the civil designer may specify either:

a) A minimum of a 2-foot overexcavation and recompaction of cut materials for a distance of 2H, from the point of transition.

b) Increase of the amount of reinforcing steel and wall detailing (i.e., expansion joints or crack control joints) such that a angular distortion of 1/360 for a distance of 2H on either side of the transition may be accommodated. Expansion joints should be placed no greater than 20 feet on-center, in accordance with the structural engineer’s/wall designer’s recommendations, regardless of whether or not transition conditions exist. Expansion joints should be sealed with a flexible, non-shrink grout.

c) Embed the footings entirely into native formational material (i.e., deepened footings).

If transitions from cut to fill transect the wall footing alignment at an angle of less than 45 degrees (plan view), then the designer should follow recommendation "a" (above) and until such transition is between 45 and 90 degrees to the wall alignment.

TOP-OF-SLOPE WALLS/FENCES/IMPROVEMENTS AND EXPANSIVE SOILS

Expansive Soils and Slope Creep

Some of the soils at the site are likely to be expansive and therefore, become desiccated when allowed to dry. Such soils are susceptible to surficial slope creep, especially with seasonal changes in moisture content. Typically in southern California, during the hot and dry summer period, these soils become desiccated and shrink, thereby developing surface cracks. The extent and depth of these shrinkage cracks depend on many factors such as the nature and expansivity of the soils, temperature and humidity, and extraction of moisture from surface soils by plants and roots. When seasonal rains occur, water percolates into the cracks and fissures, causing slope surfaces to expand, with a corresponding loss in soil density and shear strength near the slope surface. With the
passage of time and several moisture cycles, the outer 3 to 5 feet of slope materials experience a very slow, but progressive, outward and downward movement, known as slope creep. For slope heights greater than 7 feet, this creep related soil movement will typically impact all rear yard flatwork and other secondary improvements that are located within about 15 feet from the top of slopes, such as swimming pools, concrete flatwork, etc., and in particular top of slope fences/walls. This influence is normally in the form of detrimental settlement, and tilting of the proposed improvements. The dessication/swelling and creep discussed above continues over the life of the improvements, and generally becomes progressively worse. Accordingly, the developer should provide this information to all interested/affected parties.

**Top of Slope Walls/Fences**

Due to the potential for slope creep for slopes higher than about 7 feet, some settlement and tilting of the walls/fence with the corresponding distresses, should be expected. To mitigate the tilting of top of slope walls/fences, we recommend that the walls/fences be constructed on a combination of grade beam and caisson foundations. The grade beam should be at a minimum of 12 inches by 12 inches in cross section, supported by drilled caissons, 12 inches minimum in diameter, placed at a maximum spacing of 6 feet on center, and with a minimum embedment length of 7 feet below the bottom of the grade beam. The strength of the concrete and grout should be evaluated by the structural engineer of record. The proper ASTM tests for the concrete and mortar should be provided along with the slump quantities. The concrete used should be appropriate to mitigate site corrosion, as warranted. The design of the grade beam and caissons should be in accordance with the recommendations of the project structural engineer, and include the utilization of the following geotechnical parameters:

- **Creep Zone:** 5-foot vertical zone below the slope face and projected upward parallel to the slope face.

- **Creep Load:** The creep load projected on the area of the grade beam should be taken as an equivalent fluid approach, having a density of 60 pcf. For the caisson, it should be taken as a uniform 900 pounds per linear foot of caisson’s depth, located above the creep zone.

- **Point of Fixity:** Located a distance of 1.5 times the caisson’s diameter, below the creep zone.

- **Passive Resistance:** Passive earth pressure of 300 psf per foot of depth per foot of caisson diameter, to a maximum value of 4,500 psf may be used to determine caisson depth and spacing, provided that they meet or exceed the minimum requirements stated above. To determine the total lateral resistance, the contribution of the
creep prone zone above the point of fixity, to passive resistance, should be disregarded.

**Allowable Axial Capacity:**

**Shaft capacity:** 350 psf applied below the point of fixity over the surface area of the shaft.

**Tip capacity:** 4,500 psf.

**EXPANSIVE SOILS, DRIVEWAY, FLATWORK, AND OTHER IMPROVEMENTS**

Some of the soil materials on site are likely to be expansive. The effects of expansive soils are cumulative, and typically occur over the lifetime of any improvements. On relatively level areas, when the soils are allowed to dry, the dessication and swelling process tends to cause heaving and distress to flatwork and other improvements. The resulting potential for distress to improvements may be reduced, but not totally eliminated. To that end, it is recommended that the developer should notify all interested/affected parties of this long-term potential for distress. To reduce the likelihood of distress, the following recommendations are presented for all exterior flatwork:

1. The subgrade area for concrete slabs should be compacted to achieve a minimum 90 percent relative compaction, and then be presoaked to 1 to 2 percentage points above (or 110 percent of) the soils’ optimum moisture content, to a depth of 18 inches below subgrade elevation. If very low expansive soils are present, only optimum moisture content, or greater, is required and specific presoaking is not warranted. The moisture content of the subgrade should be proof tested within 72 hours prior to concrete placement.

2. Exterior concrete slabs should be cast over a non-yielding surface, consisting of a 4-inch layer of Class 3 base, crushed rock, gravel, or clean sand (or City of Encinitas minimum, whichever is greater), that should be compacted and level prior to placement of concrete. If very low expansive soils are present, the base, rock, gravel, or sand may be deleted. The layer or subgrade should be wet-down completely prior to placement of concrete, to minimize loss of concrete moisture to the surrounding earth materials.

3. Exterior slabs should be a minimum of 4 inches thick. Driveway slabs and approaches should additionally have a thickened edge (12 inches) adjacent to all landscape areas, to help impede infiltration of landscape water under the slab.

4. The use of transverse and longitudinal control joints are recommended to help control slab cracking due to concrete shrinkage or expansion. Two ways to
mitigate such cracking are: a) add a sufficient amount of reinforcing steel, increasing tensile strength of the slab; and, b) provide an adequate amount of control and/or expansion joints to accommodate anticipated concrete shrinkage and expansion.

In order to reduce the potential for unsightly cracks, slabs should be reinforced at mid-height with a minimum of No. 3 bars placed at 18 inches on center, in each direction. The exterior slabs should be scored or saw cut, \( \frac{1}{2} \) to \( \frac{3}{8} \) inches deep, often enough so that no section is greater than 10 feet by 10 feet. For sidewalks or narrow slabs, control joints should be provided at intervals of every 6 feet. The slabs should be separated from the foundations and sidewalks with expansion joint filler material.

5. No traffic should be allowed upon the newly poured concrete slabs until they have been properly cured to within 75 percent of design strength. Concrete compression strength should be a minimum of 2,500 psi.

6. Driveways, sidewalks, and patio slabs adjacent to the house should be separated from the house with thick expansion joint filler material. In areas directly adjacent to a continuous source of moisture (i.e., irrigation, planters, etc.), all joints should be additionally sealed with flexible mastic.

7. Planters and walls should not be tied to the house.

8. Overhang structures should be supported on the slabs, or structurally designed with continuous footings tied in at least two directions.

9. Any masonry landscape walls that are to be constructed throughout the property should be grouted and articulated in segments no more than 20 feet long. These segments should be keyed or doweled together.

10. Utilities should be enclosed within a closed utilidor (vault) or designed with flexible connections to accommodate differential settlement and expansive soil conditions.

11. Positive site drainage should be maintained at all times. Finish grade on the lots should provide a minimum of 1 to 2 percent fall to the street, as indicated herein. It should be kept in mind that drainage reversals could occur, including post-construction settlement, if relatively flat yard drainage gradients are not periodically maintained by the homeowner or homeowners association.

12. Due to expansive soils, air conditioning (A/C) units should be supported by slabs that are incorporated into the building foundation or constructed on a rigid slab with flexible couplings for plumbing and electrical lines. A/C waste water lines should be drained to a suitable non-erosive outlet.
13. Shrinkage cracks could become excessive if proper finishing and curing practices are not followed. Finishing and curing practices should be performed per the Portland Cement Association Guidelines. Mix design should incorporate rate of curing for climate and time of year, sulfate content of soils, corrosion potential of soils, and fertilizers used on site.

PRELIMINARY ASPHALTIC CONCRETE PAVEMENT DESIGN RECOMMENDATIONS

General

The City of Oceanside may retain the authority to approve the final structural design sections after subgrade elevations and actual resistance values (R-values) have been obtained at the conclusion of earthwork. On a preliminary basis, and for estimation and bidding purposes, the asphaltic concrete pavement section for the planned cul-de-sac street may consist of 3 inches of asphaltic concrete over 8 inches of aggregate base (Caltrans Class II, or equivalent). Final pavement sections should be based on actual R-value testing performed following the backfill of underground utilities in the street right-of-way.

The preliminary pavement section provided is intended as a minimum guideline. If thinner or highly variable pavement sections are constructed, increased maintenance and repair could be expected. If the ADT (average daily traffic) or ADTT (average daily truck traffic) increases beyond that intended, as reflected by the T.I. used for design, increased maintenance and repair could be required for the pavement section. Consideration should be given to the increased potential for distress from overuse of paved street areas by heavy equipment and/or construction related heavy traffic (e.g., concrete trucks, loaded supply trucks, etc.), particularly when the final section is not in place (i.e., topcoat). Best management construction practices should be followed at all times, especially during inclement weather.

PAVEMENT GRADING RECOMMENDATIONS

General

All section changes should be properly transitioned. If adverse conditions are encountered during the preparation of subgrade materials, special construction methods may need to be employed. A GSI representative should be present for the preparation of subgrade, aggregate base, and asphaltic concrete.
Subgrade

Within street and parking areas, all surficial deposits of loose soil material should be removed and recompacted as recommended. After the loose soils are removed, the bottom is to be scarified to a depth of at least 6 inches, moisture conditioned as necessary and compacted to 95 percent of the maximum laboratory density, as determined by ASTM D 1557.

Deleterious material, excessively wet or dry pockets, concentrated zones of oversized rock fragments, and any other unsuitable materials encountered during grading should be removed. The compacted fill material should then be brought to the elevation of the proposed subgrade for the pavement. The subgrade should be proof-rolled in order to promote a uniform firm and unyielding surface. All grading and fill placement should be observed by the project geotechnical consultant.

Aggregate Base

Compaction tests are required for the recommended aggregate base section. Minimum relative compaction required will be 95 percent of the laboratory maximum density as determined by ASTM D 1557. Base aggregate should be in accordance to the “Greenbook” crushed aggregate base rock (minimum R-value=78).

Paving

Prime coat may be omitted if all of the following conditions are met:

1. The asphalt pavement layer is placed within two weeks of completion of aggregate base and/or subbase course.
2. Traffic is not routed over completed base before paving
3. Construction is completed during the dry season of May through October.
4. The aggregate base is kept free of debris prior to placement of asphaltic concrete.

If construction is performed during the wet season of November through April, prime coat may be omitted if no rain occurs between completion of the aggregate base course and paving and the time between completion of aggregate base and paving is reduced to three days, provided the aggregate base is free of loose soil or debris. Where prime coat has been omitted and rain occurs, traffic is routed over the aggregate base course, or paving is delayed, measures shall be taken to restore the aggregate base course, and subgrade to conditions that will meet specifications as directed by the geotechnical consultant.
**Drainage**

Positive drainage should be provided for all surface water to drain towards the area swale, curb and gutter, or to an approved drainage channel. Positive site drainage should be maintained at all times. Water should not be allowed to pond or seep into the ground, such as from behind unprotected curbs, both during and after grading. If planters or landscaping are adjacent to paved areas, measures should be taken to minimize the potential for water to enter the pavement section, such as thickened edges, enclosed planters, etc. Also, best management construction practices should be strictly adhered to at all times to minimize the potential for distress during construction and roadway improvements.

**PCC Cross Gutters**

PCC cross gutters should be designed in accordance with San Diego Regional Standard Drawing (SDRSD) G-12.

**Additional Considerations**

To mitigate perched groundwater, consideration should be given to installation of subgrade separators (cut-offs) between pavement subgrade and landscape areas, although this is not a requirement from a geotechnical standpoint. Cut-offs, if used, should be 6 inches wide and at least 12 inches below the pavement subgrade contact or 12 inches below the crushed aggregate base rock, if utilized.

**ONSITE INFILTRATION-RUNOFF RETENTION SYSTEMS**

**General**

Onsite infiltration-runoff retention systems (OIRRS) may be planned for Best Management Practices (BMP’s) or Low Impact Development (LID) principles for the project. To that end, some guidelines should/must be followed in the planning, design, and construction of such systems. Such facilities, if improperly designed or implemented without consideration of the geotechnical aspects of site conditions, can contribute to flooding, saturation of bearing materials beneath site improvements, slope instability, and possible concentration and contribution of pollutants into the groundwater or storm drain and/or utility trench systems.

A key factor in these systems is the infiltration rate (often referred to as the percolation rate) which can be ascribed to, or determined for, the earth materials within which these systems are installed. Additionally, the infiltration rate of the designed system (which may include gravel, sand, mulch/topsoil, or other amendments, etc.) will need to be considered. The project infiltration testing is very site specific, any changes to the location of the proposed OIRRS and/or estimated size of the OIRRS, may require additional infiltration
testing. GSI anticipates that relatively impermeable earth materials including the bedrock as well as expansive fill soils will be exposed at the conclusion of grading.

Some of the methods which are utilized for onsite infiltration include percolation basins, dry wells, bio-swale/bio-retention, permeable pavers/pavement, infiltration trenches, filter boxes and subsurface infiltration galleries/chambers. Some of these systems are constructed using native and import soils, perforated piping, and filter fabrics while others employ structural components such as stormwater infiltration chambers and filters/ separators. Every site will have characteristics which should lend themselves to one or more of these methods; but, not every site is suitable for OIRRS. In practice, OIRRS are usually initially designed by the project design civil engineer. Selection of methods should include (but should not be limited to) review by licensed professionals including the geotechnical engineer, hydrogeologist, engineering geologist, project civil engineer, landscape architect, environmental professional, and industrial hygienist. Applicable governing agency requirements should be reviewed and included in design considerations.

The following geotechnical guidelines should be considered when designing onsite infiltration-runoff retention systems:

- On a preliminary basis, the onsite soils are considered to fall into Hydrologic Soil Group (HSG) “D” as defined in County of San Diego (2007).

- It is not good engineering practice to allow water to saturate soils, especially near slopes or improvements; however, controlling agencies/authorities are now requiring this for OIRRS purposes on many projects.

- If infiltration is planned, infiltration system design should be based on actual infiltration testing results/data, preferably utilizing double-ring infiltrometer testing (ASTM D 3385) to determine the infiltration rate of the earth materials being contemplated for infiltration.

- Wherever possible, infiltration systems should not be installed within ±50 feet of the tops of slopes steeper than 15 percent or within H/3 from the tops of slopes (where H equals the height of slope).

- Wherever possible, infiltrations systems should not be placed within a distance of H/2 from the toes of slopes (where H equals the height of slope).

- Impermeable liners and subdrains should be used along the bottom of bioretention swales/basins located within the influence of slopes.

- The landscape architect should be notified of the location of the proposed OIRRS. If landscaping is proposed within the OIRRS, consideration should be given to the type of vegetation chosen and their potential effect upon subsurface improvements.
(i.e., some trees/shrubs will have an effect on subsurface improvements with their extensive root systems). Over-watering landscape areas above, or adjacent to, the proposed OIRRS could adversely affect performance of the system.

- Areas adjacent to, or within, the OIRRS that are subject to inundation should be properly protected against scouring, undermining, and erosion, in accordance with the recommendations of the design engineer.

- Seismic shaking may result in the formation of a seiche which could potentially overtop the banks of an OIRRS and result in down-gradient flooding and scour.

- If subsurface infiltration galleries/chambers are proposed, the appropriate size, depth interval, and ultimate placement of the detention/infiltration system should be evaluated by the design engineer, and be of sufficient width/depth to achieve optimum performance, based on the infiltration rates provided. In addition, proper debris filter systems will need to be utilized for the infiltration galleries/chambers. Debris filter systems will need to be self cleaning and periodically and regularly maintained on a regular basis. Provisions for the regular and periodic maintenance of any debris filter system is recommended and this condition should be disclosed to all interested/affected parties.

- Infiltrations systems should not be installed within ±8 feet of building foundations utility trenches, and walls, or a 1:1 (h:v) slope (down and away) from the bottom elements of these improvements. Alternatively, deepened foundations and/or pile/pier supported improvements may be used.

- Infiltrations systems should not be installed adjacent to pavement and/or hardscape improvements. Alternatively, deepened/thickened edges and curbs and/or impermeable liners may be utilized in areas adjoining the OIRRS.

- As with any OIRRS, localized ponding and groundwater seepage should be anticipated. The potential for seepage and/or perched groundwater to occur after site development should be disclosed to all interested/affected parties.

- Installation of infiltrations systems should avoid expansive soils (E.I. ≥51) or soils with a relatively high plasticity index (P.I. > 20).

- Infiltration systems should not be installed where the vertical separation of the groundwater level is less than ±10 feet from the base of the system.

- Where permeable pavements are planned as part of the system, the site Traffic Index (T.I.) should be less than 25,000 Average Daily Traffic (ADT), as recommended in Allen, et al. (2011).
• Infiltration systems should be designed using a suitable factor of safety (FOS) to account for uncertainties in the known infiltration rates (as generally required by the controlling authorities), and reduction in performance over time.

• As with any OIRRS, proper care will need to be provided. Best management practices should be followed at all times, especially during inclement weather. Provisions for the management of any siltation, debris within the OIRRS, and/or overgrown vegetation (including root systems) should be considered. An appropriate inspection schedule will need to adopted and provided to all interested/affected parties.

• Any designed system will require regular and periodic maintenance, which may include rehabilitation and/or complete replacement of the filter media (e.g., sand, gravel, filter fabrics, topsoils, mulch, etc.) or other components utilized in construction, so that the design life exceeds 15 years. Due to the potential for piping and adverse seepage conditions, a burrowing rodent control program should also be implemented onsite.

• All or portions of these systems may be considered attractive nuisances. Thus, consideration of the effects of, or potential for, vandalism should be addressed.

• Newly established vegetation/landscaping (including phreatophytes) may have root systems that will influence the performance of the OIRRS or nearby LID systems.

• The potential for surface flooding, in the case of system blockage, should be evaluated by the design engineer.

• Any proposed utility backfill materials (i.e., inlet/outlet piping and/or other subsurface utilities) located within or near the proposed area of the OIRRS may become saturated. This is due to the potential for piping, water migration, and/or seepage along the utility trench line backfill. If utility trenches cross and/or are proposed near the OIRRS, cut-off walls or other water barriers will need to be installed to mitigate the potential for piping and excess water entering the utility backfill materials. Planned or existing utilities may also be subject to piping of fines into open-graded gravel backfill layers unless separated from overlying or adjoining OIRRS by geotextiles and/or slurry backfill.

• The use of OIRRS above existing utilities that might degrade/corrode with the introduction of water/seepage should be avoided.

• A vector control program may be necessary as stagnant water contained in OIRRS may attract mammals, birds, and insects that carry pathogens.
**DEVELOPMENT CRITERIA**

**Slope Deformation**

Compacted fill slopes designed using customary factors of safety for gross or surficial stability and constructed in general accordance with the design specifications should be expected to undergo some differential vertical heave or settlement in combination with differential lateral movement in the out-of-slope direction, after grading. This post-construction movement occurs in two forms: slope creep, and lateral fill extension (LFE). Slope creep is caused by alternate wetting and drying of the fill soils which results in slow downslope movement. This type of movement is expected to occur throughout the life of the slope, and is anticipated to potentially affect improvements or structures (e.g., separations and/or cracking), placed near the top-of-slope, up to a maximum distance of approximately 15 feet from the top-of-slope, depending on the slope height. This movement generally results in rotation and differential settlement of improvements located within the creep zone. LFE occurs due to deep wetting from irrigation and rainfall on slopes comprised of expansive materials. Although some movement should be expected, long-term movement from this source may be minimized, but not eliminated, by placing the fill throughout the slope region, wet of the fill’s optimum moisture content.

It is generally not practical to attempt to eliminate the effects of either slope creep or LFE. Suitable mitigative measures to reduce the potential of lateral deformation typically include: setback of improvements from the slope faces (per the adopted California Building Code), positive structural separations (i.e., joints) between improvements, and stiffening and deepening of foundations. Expansion joints in walls should be placed no greater than 20 feet on-center, and in accordance with the structural engineer’s recommendations. All of these measures are recommended for design of structures and improvements. The ramifications of the above conditions, and recommendations for mitigation, should be provided to each homeowner and/or any homeowners association.

**Slope Maintenance and Planting**

Water has been shown to weaken the inherent strength of all earth materials. Slope stability is significantly reduced by overly wet conditions. Positive surface drainage away from slopes should be maintained and only the amount of irrigation necessary to sustain plant life should be provided for planted slopes. Over-watering should be avoided as it adversely affects site improvements, and causes perched groundwater conditions. Graded slopes constructed utilizing onsite materials would be erosive. Eroded debris may be minimized and surficial slope stability enhanced by establishing and maintaining a suitable vegetation cover soon after construction. Compaction to the face of fill slopes would tend to minimize short-term erosion until vegetation is established. Plants selected for landscaping should be light weight, deep rooted types that require little water and are capable of surviving the prevailing climate. Jute-type matting or other fibrous covers may aid in allowing the establishment of a sparse plant cover. Utilizing plants other than those
recommended above will increase the potential for perched water, staining, mold, etc., to develop. A rodent control program to prevent burrowing should be implemented. Irrigation of natural (ungraded) slope areas is generally not recommended. These recommendations regarding plant type, irrigation practices, and rodent control should be provided to each homeowner. Over-steepening of slopes should be avoided during building construction activities and landscaping.

**Drainage**

Adequate surface drainage is a very important factor in reducing the likelihood of adverse performance of foundations, hardscape, and slopes. Surface drainage should be sufficient to mitigate ponding of water anywhere on the property, and especially near structures and tops of slopes. Surface drainage should be carefully taken into consideration during fine grading, landscaping, and building construction. Therefore, care should be taken that future landscaping or construction activities do not create adverse drainage conditions. Positive site drainage within the property should be provided and maintained at all times. Drainage should not flow uncontrolled down any descending slope. Water should be directed away from foundations and tops of slopes, and not allowed to pond and/or seep into the ground. In general, site drainage should conform to Section 1804.3 of the 2013 CBC. Consideration should be given to avoiding construction of planters adjacent to structures (buildings, pools, spas, etc.). Building pad drainage should be directed toward the street or other approved area(s). Although not a geotechnical requirement, roof gutters, down spouts, or other appropriate means may be utilized to control roof drainage. Down spouts, or drainage devices should outlet a minimum of 5 feet from structures or into a subsurface drainage system. Areas of seepage may develop due to irrigation or heavy rainfall, and should be anticipated. Minimizing irrigation will lessen this potential. If areas of seepage develop, recommendations for minimizing this effect could be provided upon request.

**Toe of Slope Drains/Toe Drains**

Where significant slopes intersect pad areas, surface drainage down the slope allows for some seepage into the subsurface materials, sometimes creating conditions causing or contributing to perched and/or ponded water. Toe of slope/toe drains may be beneficial in the mitigation of this condition due to surface drainage. The general criteria to be utilized by the design engineer for evaluating the need for this type of drain is as follows:

- Is there a source of irrigation above or on the slope that could contribute to saturation of soil at the base of the slope?

- Are the slopes hard rock and/or impermeable, or relatively permeable, or; do the slopes already have or are they proposed to have subdrains (i.e., stabilization fills, etc.)?

- Are there cut-fill transitions (i.e., fill over bedrock), within the slope?
• Was the lot at the base of the slope overexcavated or is it proposed to be overexcavated? Overexcavated lots located at the base of a slope could accumulate subsurface water along the base of the fill cap.

• Are the slopes north facing? North facing slopes tend to receive less sunlight (less evaporation) relative to south facing slopes and are more exposed to the currently prevailing seasonal storm tracks.

• What is the slope height? It has been our experience that slopes with heights in excess of approximately 10 feet tend to have more problems due to storm runoff and irrigation than slopes of a lesser height.

• Do the slopes “toe out” into a residential lot or a lot where perched or ponded water may adversely impact its proposed use?

Based on these general criteria, the construction of toe drains may be considered by the design engineer along the toe of slopes, or at retaining walls in slopes, descending to the rear of such lots. Following are Detail 4 (Schematic Toe Drain Detail) and Detail 5 (Subdrain Along Retaining Wall Detail). Other drains may be warranted due to unforeseen conditions, homeowner irrigation, or other circumstances. Where drains are constructed during grading, including subdrains, the locations/elevations of such drains should be surveyed, and recorded on the final as-built grading plans by the design engineer. It is recommended that the above be disclosed to all interested parties, including homeowners and any homeowners association.

**Erosion Control**

Onsite earth materials have a moderate to high erosion potential. Consideration should be given to providing hay bales and silt fences for the temporary control of surface water, from a geotechnical viewpoint.

**Landscape Maintenance**

Only the amount of irrigation necessary to sustain plant life should be provided. Over-watering the landscape areas will adversely affect proposed site improvements. We would recommend that any proposed open-bottom planters adjacent to proposed structures be eliminated for a minimum distance of 10 feet. As an alternative, closed-bottom type planters could be utilized. An outlet placed in the bottom of the planter, could be installed to direct drainage away from structures or any exterior concrete flatwork. If planters are constructed adjacent to structures, the sides and bottom of the planter should be provided with a moisture barrier to prevent penetration of irrigation water into the subgrade. Provisions should be made to drain the excess irrigation water from the planters without saturating the subgrade below or adjacent to the planters. Graded slope areas should be planted with drought resistant vegetation. Consideration should be given to the type of vegetation chosen and their potential effect upon surface improvements (i.e.,
1. Soil cap compacted to 90 percent relative compaction.
2. Permeable material may be gravel wrapped in filter fabric (Mirafi 140N or equivalent).
3. 4-inch-diameter, perforated pipe (SDR-35 or equivalent) with perforations down.
4. Pipe to maintain a minimum 1 percent fall.
5. Concrete cut-off wall to be provided at transition to solid outlet pipe.
6. Solid outlet pipe to drain to approved area.
7. Cleanouts are recommended at each property line.
NOTES:
1. Soil cap compacted to 90 percent relative compaction.
2. Permeable material may be gravel wrapped in filter fabric (Mirafi 140N or equivalent).
3. 4-inch-diameter, perforated pipe (SDR-35 or equivalent) with perforations down.
4. Pipe to maintain a minimum 1 percent fall.
5. Concrete cut-off wall to be provided at transition to solid outlet pipe.
6. Solid outlet pipe to drain to approved area.
7. Cleanouts are recommended at each property line.
8. Effort to compact should be applied to drain rock.
some trees will have an effect on concrete flatwork with their extensive root systems). From a geotechnical standpoint leaching is not recommended for establishing landscaping. If the surface soils are processed for the purpose of adding amendments, they should be recompacted to 90 percent minimum relative compaction.

**Gutters and Downspouts**

As previously discussed in the drainage section, the installation of gutters and downspouts should be considered to collect roof water that may otherwise infiltrate the soils adjacent to the structures. If utilized, the downspouts should be drained into PVC collector pipes or other non-erosive devices (e.g., paved swales or ditches; below grade, solid tight-lined PVC pipes; etc.), that will carry the water away from the house, to an appropriate outlet, in accordance with the recommendations of the design civil engineer. Downspouts and gutters are not a requirement; however, from a geotechnical viewpoint, provided that positive drainage is incorporated into project design (as discussed previously).

**Subsurface and Surface Water**

Subsurface and surface water are not anticipated to affect site development, provided that the recommendations contained in this report are incorporated into final design and construction and that prudent surface and subsurface drainage practices are incorporated into the construction plans. Perched groundwater conditions along zones of contrasting permeabilities may not be precluded from occurring in the future due to site irrigation, poor drainage conditions, or damaged utilities, and should be anticipated. Should perched groundwater conditions develop, this office could assess the affected area(s) and provide the appropriate recommendations to mitigate the observed groundwater conditions. Groundwater conditions may change with the introduction of irrigation, rainfall, or other factors.

**Site Improvements**

If in the future, any additional improvements (e.g., pools, spas, etc.) are planned for the site, recommendations concerning the geological or geotechnical aspects of design and construction of said improvements could be provided upon request. Pools and/or spas should not be constructed without specific design and construction recommendations from GSI, and this construction recommendation should be provided to all interested/affected parties. Rock fills may not be suitable for supporting pools/spa. This office should be notified in advance of any fill placement, grading of the site, or trench backfilling after rough grading has been completed. This includes any grading, utility trench and retaining wall backfills, flatwork, etc.

**Tile Flooring**

Tile flooring can crack, reflecting cracks in the concrete slab below the tile, although small cracks in a conventional slab may not be significant. Therefore, the designer should
consider additional steel reinforcement for concrete slabs-on-grade where tile will be placed. The tile installer should consider installation methods that reduce possible cracking of the tile such as slipsheets. Slipsheets or a vinyl crack isolation membrane (approved by the Tile Council of America/Ceramic Tile Institute) are recommended between tile and concrete slabs on grade.

**Additional Grading**

This office should be notified in advance of any fill placement, supplemental regrading of the site, or trench backfilling after rough grading has been completed. This includes completion of grading in the street, driveway approaches, driveways, parking areas, and utility trench and retaining wall backfills.

**Footing Trench Excavation**

All footing excavations should be observed by a representative of this firm subsequent to trenching and prior to concrete form and reinforcement placement. The purpose of the observations is to evaluate that the excavations have been made into the recommended bearing material and to the minimum widths and depths recommended for construction. If loose or compressible materials are exposed within the footing excavation, a deeper footing or removal and recompaition of the subgrade materials would be recommended at that time. Footing trench spoil and any excess soils generated from utility trench excavations should be compacted to a minimum relative compaction of 90 percent, if not removed from the site.

**Trenching/Temporary Construction Backcuts**

Considering the nature of the onsite earth materials, it should be anticipated that caving or sloughing could be a factor in subsurface excavations and trenching. Shoring or excavating the trench walls/backcuts at the angle of repose (typically 25 to 45 degrees [except as specifically superceded within the text of this report]), should be anticipated. All excavations should be observed by an engineering geologist or soil engineer from GSI, prior to workers entering the excavation or trench, and minimally conform to CAL-OSHA, state, and local safety codes. Should adverse conditions exist, appropriate recommendations would be offered at that time. The above recommendations should be provided to any contractors and/or subcontractors, or homeowners, etc., that may perform such work.

**Utility Trench Backfill**

1. All interior utility trench backfill should be brought to at least 2 percent above optimum moisture content and then compacted to obtain a minimum relative compaction of 90 percent of the laboratory standard. As an alternative for shallow (12-inch to 18-inch) under-slab trenches, sand having a sand equivalent value of
30 or greater may be utilized and jetted or flooded into place. Observation, probing and testing should be provided to evaluate the desired results.

2. Exterior trenches adjacent to, and within areas extending below a 1:1 plane projected from the outside bottom edge of the footing, and all trenches beneath hardscape features and in slopes, should be compacted to at least 90 percent of the laboratory standard. Sand backfill, unless excavated from the trench, should not be used in these backfill areas. Compaction testing and observations, along with probing, should be accomplished to evaluate the desired results.

3. All trench excavations should conform to CAL-OSHA, state, and local safety codes.

4. Utilities crossing grade beams, perimeter beams, or footings should either pass below the footing or grade beam utilizing a hardened collar or foam spacer, or pass through the footing or grade beam in accordance with the recommendations of the structural engineer.

**SUMMARY OF RECOMMENDATIONS REGARDING GEOTECHNICAL OBSERVATION AND TESTING**

We recommend that observation and/or testing be performed by GSI at each of the following construction stages:

- During grading/recertification.
- During excavation.
- During placement of subdrains or other subdrainage devices, prior to placing fill and/or backfill.
- After excavation of building footings, retaining wall footings, and free standing walls footings, prior to the placement of reinforcing steel or concrete.
- Prior to pouring any slabs or flatwork, after presoaking/presaturation of building pads and other flatwork subgrade, before the placement of concrete, reinforcing steel, capillary break (i.e., sand, pea-gravel, etc.), or vapor retarders (i.e., visqueen, etc.).
- During retaining wall subdrain installation, prior to backfill placement.
- During placement of backfill for area drain, interior plumbing, utility line trenches, and retaining wall backfill.
• During slope construction/repair.

• When any unusual soil conditions are encountered during any construction operations, subsequent to the issuance of this report.

• When any homeowner improvements, such as flatwork, spas, pools, walls, etc., are constructed, prior to construction.

• A report of geotechnical observation and testing should be provided at the conclusion of each of the above stages, in order to provide concise and clear documentation of site work, and/or to comply with code requirements.

OTHER DESIGN PROFESSIONALS/CONSULTANTS

The design civil engineer, structural engineer, post-tension designer, architect, landscape architect, wall designer, etc., should review the recommendations provided herein, incorporate those recommendations into all their respective plans, and by explicit reference, make this report part of their project plans. This report presents minimum design criteria for the design of slabs, foundations and other elements possibly applicable to the project. These criteria should not be considered as substitutes for actual designs by the structural engineer/designer. Please note that the recommendations contained herein are not intended to preclude the transmission of water or vapor through the slab or foundation. The structural engineer.foundation and/or slab designer should provide recommendations to not allow water or vapor to enter into the structure so as to cause damage to another building component, or so as to limit the installation of the type of flooring materials typically used for the particular application.

The structural engineer/designer should analyze actual soil-structure interaction and consider, as needed, bearing, expansive soil influence, and strength, stiffness and deflections in the various slab, foundation, and other elements in order to develop appropriate, design-specific details. As conditions dictate, it is possible that other influences will also have to be considered. The structural engineer/designer should consider all applicable codes and authoritative sources where needed. If analyses by the structural engineer/designer result in less critical details than are provided herein as minimums, the minimums presented herein should be adopted. It is considered likely that some, more restrictive details will be required.

If the structural engineer/designer has any questions or requires further assistance, they should not hesitate to call or otherwise transmit their requests to GSI. In order to mitigate potential distress, the foundation and/or improvement’s designer should confirm to GSI and the governing agency, in writing, that the proposed foundations and/or improvements can tolerate the amount of differential settlement and/or expansion characteristics and other design criteria specified herein.
PLAN REVIEW

Final project plans (grading, precise grading, foundation, retaining wall, landscaping, etc.), should be reviewed by this office prior to construction, so that construction is in accordance with the conclusions and recommendations of this report. Based on our review, supplemental recommendations and/or further geotechnical studies may be warranted.

LIMITATIONS

The materials encountered on the project site and utilized for our analysis are believed representative of the area; however, soil and bedrock materials vary in character between excavations and natural outcrops or conditions exposed during mass grading. Site conditions may vary due to seasonal changes or other factors.

Inasmuch as our study is based upon our review and engineering analyses and laboratory data, the conclusions and recommendations are professional opinions. These opinions have been derived in accordance with current standards of practice, and no warranty, either express or implied, is given. Standards of practice are subject to change with time. GSI assumes no responsibility or liability for work or testing performed by others, or their inaction; or work performed when GSI is not requested to be onsite, to evaluate if our recommendations have been properly implemented. Use of this report constitutes an agreement and consent by the user to all the limitations outlined above, notwithstanding any other agreements that may be in place. In addition, this report may be subject to review by the controlling authorities. Thus, this report brings to completion our scope of services for this portion of the project. All samples will be disposed of after 30 days, unless specifically requested by the client, in writing.
APPENDIX A

REFERENCES
APPENDIX A

REFERENCES

American Concrete Institute (ACI) Committee 318, 2008, Building code requirements for structural concrete (ACI318-08) and commentary, dated January.


____, 1998, Standard practice for installation of water vapor retarder used in contact with earth or granular fill under concrete slabs, Designation: E 1643-98 (Reapproved 2005).

____, 1997, Standard specification for plastic water vapor retarders used in contact with soil or granular fill under concrete slabs, Designation: E 1745-97 (Reapproved 2004).

American Society of Civil Engineers, 2010, Minimum design loads for buildings and other structures, ASCE Standard ASCE/SEI 7-10.

Blake, Thomas F., 2000a, EQFAULT, A computer program for the estimation of peak horizontal acceleration from 3-D fault sources; Windows 95/98 version.

____, 2000b, EQSEARCH, A computer program for the estimation of peak horizontal acceleration from California historical earthquake catalogs; Updated to December 2011, Windows 95/98 version.


County of San Diego, Department of Planning and Land Use, 2007, Low impact development (LID) handbook, stormwater management strategies, dated December 31.

Hydrologic Solutions, StormChamber™ installation brochure, pgs. 1 through 8, undated.

Jennings, C.W., 1994, Fault activity map of California and adjacent areas: California Division of Mines and Geology, Map Sheet No. 6, scale 1:750,000.


Romanoff, M., 1957, Underground corrosion, originally issued April 1.

Seed, 2005, Evaluation and mitigation of soil liquefaction hazard “evaluation of field data and procedures for evaluating the risk of triggering (or inception) of liquefaction”, in Geotechnical earthquake engineering; short course, San Diego, California, April 8-9.


State of California, 2014, Civil Code, Sections 895 et seq.


_____, 1997, San Luis Rey quadrangle, San Diego County, California, 7.5 minute series, 1:24,000 scale.
APPENDIX B

TEST PIT LOGS
### Unified Soil Classification System

<table>
<thead>
<tr>
<th>Major Divisions</th>
<th>Group Symbols</th>
<th>Typical Names</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coarse-Grained Soils</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 50% retained on No. 200 sieve</td>
<td>GW</td>
<td>Well-graded gravels and gravel-sand mixtures, little or no fines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GP</td>
<td>Poorly graded gravels and gravel-sand mixtures, little or no fines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GM</td>
<td>Silty gravels gravel-sand-silt mixtures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GC</td>
<td>Clayey gravels, gravel-sand-clay mixtures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SW</td>
<td>Well-graded sands and gravelly sands, little or no fines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SP</td>
<td>Poorly graded sands and gravelly sands, little or no fines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>Clayey sands, sand-clay mixtures</td>
<td></td>
</tr>
<tr>
<td><strong>Sands with fines</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SM</td>
<td>Silty sands, sand-silt mixtures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>Clayey sands, sand-clay mixtures</td>
<td></td>
</tr>
<tr>
<td><strong>Fine-Grained Soils</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% or more passes No. 200 sieve</td>
<td>ML</td>
<td>Inorganic silts, very fine sands, rock flour, silty or clayey fine sands</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CL</td>
<td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OL</td>
<td>Organic silts and organic silty clays of low plasticity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MH</td>
<td>Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CH</td>
<td>Inorganic clays of high plasticity, fat clays</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OH</td>
<td>Organic clays of medium to high plasticity</td>
<td></td>
</tr>
<tr>
<td><strong>Highly Organic Soils</strong></td>
<td>PT</td>
<td>Peat, mucic, and other highly organic soils</td>
<td></td>
</tr>
</tbody>
</table>

### Moisture Conditions

<table>
<thead>
<tr>
<th>MOISTURE CONDITIONS</th>
<th>MATERIAL QUANTITY</th>
<th>OTHER SYMBOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>Absence of moisture: dusty, dry to the touch</td>
<td>trace</td>
</tr>
<tr>
<td>Slightly Moist</td>
<td>Below optimum moisture content for compaction</td>
<td>few</td>
</tr>
<tr>
<td>Moist</td>
<td>Near optimum moisture content</td>
<td>little</td>
</tr>
<tr>
<td>Very Moist</td>
<td>Above optimum moisture content</td>
<td>some</td>
</tr>
<tr>
<td>Wet</td>
<td>Visible free water; below water table</td>
<td></td>
</tr>
</tbody>
</table>

### Basic Log Format:

- **Group name**, **Group symbol**, *(grain size)*, **color**, **moisture**, **consistency** or **relative density**. Additional comments: **odor**, presence of **roots**, **mica**, **gypsum**, **coarse grained particles**, etc.

#### Example:

Sand (SP), fine to medium grained, brown, moist, loose, trace silt, little fine gravel, few cobbles up to 4” in size, some hair roots and rootlets.

---

**Plate B-1**
<table>
<thead>
<tr>
<th>TEST PIT NO.</th>
<th>ELEV. (ft.)</th>
<th>DEPTH (ft.)</th>
<th>GROUP SYMBOL</th>
<th>SAMPLE DEPTH (ft.)</th>
<th>MOISTURE (%)</th>
<th>FIELD DRY DENSITY (pcf)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-1</td>
<td></td>
<td>0 - ½</td>
<td>SM</td>
<td>Large Bag @ 0 - 3</td>
<td></td>
<td></td>
<td>UNDOCUMENTED FILL: SILTY SAND, dark brown, moist, loose; few roots.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ - 3</td>
<td>SC</td>
<td></td>
<td></td>
<td></td>
<td>CLAYEY SAND, brown, damp, loose; contains some construction wood and plastic debris, few roots, porous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - 5</td>
<td>CL</td>
<td></td>
<td></td>
<td></td>
<td>HIGHLY WEATHERED SANTIAGO FORMATION: SANDY CLAY, brown, moist, stiff; many open pores to 3 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - 6</td>
<td>SC</td>
<td></td>
<td></td>
<td></td>
<td>SANTIAGO FORMATION: CLAYEY SANDSTONE, yellowish brown, moist, dense; thickly bedded.</td>
</tr>
</tbody>
</table>

Total Depth = 6’
No Groundwater Encountered
Backfilled on 12-24-2013
# LOG OF EXPLORATORY TEST PITS

<table>
<thead>
<tr>
<th>TEST PIT NO.</th>
<th>ELEV. (ft.)</th>
<th>DEPTH (ft.)</th>
<th>GROUP SYMBOL</th>
<th>SAMPLE DEPTH (ft.)</th>
<th>MOISTURE (%)</th>
<th>FIELD DRY DENSITY (pcf)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-2</td>
<td></td>
<td>0 - ½</td>
<td>SM</td>
<td></td>
<td></td>
<td></td>
<td>UNDOCUMENTED FILL: SILTY SAND, dark brown, moist, loose; few rounded cobbles and gravel.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>½ - 3</td>
<td>CL</td>
<td></td>
<td></td>
<td></td>
<td>HIGHLY WEATHERED SANTIAGO FORMATION: SANDY CLAY, mottled brown and olive brown, moist, stiff; porous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - 5</td>
<td>SC</td>
<td>Large Bag @ 4½</td>
<td></td>
<td></td>
<td>SANTIAGO FORMATION: CLAYEY SANDSTONE, mottled light gray olive brown and yellow brown, moist, dense; weak subhorizontal bedding.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total Depth = 5'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No Groundwater Encountered</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Backfilled on 12-24-2013</td>
</tr>
<tr>
<td>TEST PIT NO.</td>
<td>ELEV. (ft.)</td>
<td>DEPTH (ft.)</td>
<td>GROUP SYMBOL</td>
<td>SAMPLE DEPTH (ft.)</td>
<td>MOISTURE (%)</td>
<td>FIELD DRY DENSITY (pcf)</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
<td>--------------</td>
<td>-------------------</td>
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</tr>
<tr>
<td>TP-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 - 1</td>
<td>SM/SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>UNDOCUMENTED FILL</strong>: SILTY SAND with CLAY, dark brown, moist, loose; many roots, westward thickening wedge at west end of test pit.</td>
</tr>
<tr>
<td></td>
<td>0 - 1½</td>
<td>CL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>COLLUVIUM</strong>: SANDY CLAY, red brown, damp, stiff; desiccated, porous, many roots, blocky structure.</td>
</tr>
<tr>
<td></td>
<td>1½ - 2½</td>
<td>CL-SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>HIGHLY WEATHERED SANTIAGO FORMATION</strong>: CLAYEY SAND to SANDY CLAY, brown, moist, medium dense to stiff; porous, few roots.</td>
</tr>
<tr>
<td></td>
<td>2½ - 5</td>
<td>SC</td>
<td>Large Bag @ 3½</td>
<td></td>
<td>8.0</td>
<td>118.4</td>
<td><strong>SANTIAGO FORMATION</strong>: CLAYEY SANDSTONE, yellowish brown, moist, dense; thickly bedded to weak subhorizontal bedding.</td>
</tr>
</tbody>
</table>

Total Depth = 5’
No Groundwater Encountered
Backfilled on 12-24-2013
# LOG OF EXPLORATORY TEST PITS

<table>
<thead>
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<th>TEST PIT NO.</th>
<th>ELEV. (ft.)</th>
<th>DEPTH (ft.)</th>
<th>GROUP SYMBOL</th>
<th>SAMPLE DEPTH (ft.)</th>
<th>MOISTURE (%)</th>
<th>FIELD DRY DENSITY (pcf)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-4</td>
<td></td>
<td>0 - 1</td>
<td>SC</td>
<td></td>
<td></td>
<td></td>
<td>UNDOCUMENTED FILL: CLAYEY SAND and MULCH, dark grayish brown, damp, loose, desiccated and porous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - 2</td>
<td>CL</td>
<td></td>
<td></td>
<td></td>
<td>COLLUVIUM: SANDY CLAY, reddish brown, moist, stiff; porous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - 4</td>
<td>SC</td>
<td></td>
<td></td>
<td></td>
<td>SANTIAGO FORMATION: CLAYEY SANDSTONE, yellowish brown, moist, dense; abrupt smooth basel contact N70°W, 2°SW.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - 6</td>
<td>CL</td>
<td>Large Bag @ 4½</td>
<td></td>
<td></td>
<td>SANDY CLAYSTONE, brown, moist, very stiff.</td>
</tr>
</tbody>
</table>

Total Depth = 6'
No Groundwater Encountered
Backfilled on 12-24-2013
<table>
<thead>
<tr>
<th>TEST PIT NO.</th>
<th>ELEV. (ft.)</th>
<th>DEPTH (ft.)</th>
<th>GROUP SYMBOL</th>
<th>SAMPLE DEPTH (ft.)</th>
<th>MOISTURE (%)</th>
<th>FIELD DRY DENSITY (pcf)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-5</td>
<td>0 - 4</td>
<td>SM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>UNDOCUMENTED FILL:</strong> SILTY SAND, brown, damp, loose; many roots and construction debris (plastic, wood, etc.) in upper 2'.</td>
</tr>
<tr>
<td></td>
<td>4 - 5½</td>
<td>CL/SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>HIGHLY WEATHERED SANTIAGO FORMATION:</strong> CLAYEY SAND to SANDY CLAY, brown, moist, medium dense/stiff; porous.</td>
</tr>
<tr>
<td></td>
<td>5½ - 6</td>
<td>SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>SANTIAGO FORMATION:</strong> CLAYEY SANDSTONE, yellowish brown, moist, dense; weak subhorizontal bedding.</td>
</tr>
</tbody>
</table>

Total Depth = 6'
No Groundwater Encountered
Backfilled on 12-24-2013
# LOG OF EXPLORATORY TEST PITS

<table>
<thead>
<tr>
<th>TEST PIT NO.</th>
<th>ELEV. (ft.)</th>
<th>DEPTH (ft.)</th>
<th>GROUP SYMBOL</th>
<th>SAMPLE DEPTH (ft.)</th>
<th>MOISTURE (%)</th>
<th>FIELD DRY DENSITY (pcf)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-6</td>
<td></td>
<td>0 - 2</td>
<td>SM/SC</td>
<td></td>
<td></td>
<td></td>
<td>UNDOCUMENTED FILL: Mixture of SILTY SAND and CLAYEY SAND, brown, damp, loose; few roots in upper 1 foot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - 3</td>
<td>SM</td>
<td></td>
<td></td>
<td></td>
<td>COLLOUVIUM: SILTY SAND, grayish brown, dry, loose; porous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - 4</td>
<td>CL</td>
<td></td>
<td></td>
<td></td>
<td>HIGHLY WEATHERED SANTIAGO FORMATIONS: SANDY CLAY, brown, damp, stiff; blocky structure relict formational texture.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - 6</td>
<td>SC</td>
<td></td>
<td></td>
<td></td>
<td>SANTIAGO FORMATION: CLAYEY SANDSTONE, yellowish brown, moist, dense.</td>
</tr>
</tbody>
</table>

Total Depth = 6’
No Groundwater Encountered
Backfilled on 12-24-2013
APPENDIX C

SEISMICITY DATA
DETERMINISTIC ESTIMATION OF
PEAK ACCELERATION FROM DIGITIZED FAULTS

JOB NUMBER: 6643
DATE: 01-31-2014

JOB NAME: Ivy Road
CALCULATION NAME: Test Run Analysis
FAULT-DATA-FILE NAME: CDMGFLTE.DAT

SITE COORDINATES:
  SITE LATITUDE:  33.1850
  SITE LONGITUDE:  117.3340

SEARCH RADIUS:  62.4  mi

  UNCERTAINTY (M=Median, S=Sigma): S       Number of Sigmas:  1.0
  DISTANCE MEASURE:  cdist
  SCOND:   1
  Basement Depth:  .01 km  Campbell SSR:  1  Campbell SHR:  0

COMPUTE PEAK HORIZONTAL ACCELERATION

FAULT-DATA FILE USED:  CDMGFLTE.DAT

MINIMUM DEPTH VALUE (km):  3.0
### EQFAULT SUMMARY

---

**DETERMINISTIC SITE PARAMETERS**

---

<table>
<thead>
<tr>
<th>ABBREVIATED FAULT NAME</th>
<th>APPROXIMATE DISTANCE</th>
<th>ESTIMATED MAX. EARTHQUAKE EVENT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mi (km)</td>
<td>MAXIMUM EARTHQUAKE SITE INTENSITY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAG.(Mw)</td>
<td>PEAK ACCEL. g</td>
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<td>PALOS VERDES</td>
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---

*END OF SEARCH-* 18 FAULTS FOUND WITHIN THE SPECIFIED SEARCH RADIUS.

---

The NEWPORT-INGLEWOOD (Offshore) fault is closest to the site. It is about 6.2 miles (9.9 km) away.

LARGEST MAXIMUM-EARTHQUAKE SITE ACCELERATION: 0.4980 g
EARTHQUAKE MAGNITUDES & DISTANCES

Ivy Road

Distance (mi)

Magnitude (M)
ESTIMATION OF PEAK ACCELERATION FROM CALIFORNIA EARTHQUAKE CATALOGS

JOB NUMBER: 6643
DATE: 01-31-2014

JOB NAME: Ivy Road

EARTHQUAKE-CATALOG-FILE NAME: ALLQUAKE.DAT

SITE COORDINATES:
  SITE LATITUDE:  33.1850
  SITE LONGITUDE:  117.3340

SEARCH DATES:
  START DATE:   1800
  END DATE:   2013

SEARCH RADIUS:
  62.4 mi
  100.4 km

UNCERTAINTY (M=Median, S=Sigma): S       Number of Sigmas:  1.0
ASSUMED SOURCE TYPE:  SS [SS=Strike-slip, DS=Reverse-slip, BT=Blind-thrust]
SCOND:   1  Depth Source:  A
  Basement Depth: .01 km      Campbell SSR:  1      Campbell SHR:  0

COMPUTE PEAK HORIZONTAL ACCELERATION

MINIMUM DEPTH VALUE (km):  3.0
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<tr>
<th>FILE CODE</th>
<th>LAT. NORTH</th>
<th>LONG. WEST</th>
<th>DATE</th>
<th>TIME (H M Sec)</th>
<th>DEPTH (km)</th>
<th>MAG.</th>
<th>ACC.</th>
<th>INT.</th>
<th>DISTANCE [mi]</th>
<th>DISTANCE [km]</th>
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<tr>
<td>DMG</td>
<td>33.0000</td>
<td>117.3000</td>
<td>11/22/1800</td>
<td>2130 0.0</td>
<td>0.0</td>
<td>VI</td>
<td>12.9</td>
<td></td>
<td>(20.8)</td>
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<tr>
<td>MGI</td>
<td>33.0000</td>
<td>117.0000</td>
<td>09/21/1856</td>
<td>730 0.0</td>
<td>0.0</td>
<td>V</td>
<td>34.3</td>
<td></td>
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<td>117.1000</td>
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<td>0 0 0.0</td>
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<td>117.8700</td>
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<td>1347 8.2</td>
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<td>(55.3)</td>
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<td>117.4000</td>
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<td></td>
<td>(59.0)</td>
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<tr>
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<td>117.1700</td>
<td>12/00/1856</td>
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<td></td>
<td>(59.2)</td>
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<tr>
<td>T-A</td>
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<td>117.1700</td>
<td>10/21/1862</td>
<td>0 0 0.0</td>
<td>0.0</td>
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<td></td>
<td>(59.2)</td>
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<td>117.1700</td>
<td>05/24/1865</td>
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<td></td>
<td>(59.2)</td>
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<td>53.7</td>
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<td>(86.3)</td>
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</tbody>
</table>
-END OF SEARCH-  45 EARTHQUAKES FOUND WITHIN THE SPECIFIED SEARCH AREA.

TIME PERIOD OF SEARCH:  1800 TO 2013

LENGTH OF SEARCH TIME:  214 years

THE EARTHQUAKE CLOSEST TO THE SITE IS ABOUT 12.9 MILES (20.8 km) AWAY.

LARGEST EARTHQUAKE MAGNITUDE FOUND IN THE SEARCH RADIUS: 7.0

LARGEST EARTHQUAKE SITE ACCELERATION FROM THIS SEARCH: 0.211 g

COEFFICIENTS FOR GUTENBERG & RICHTER RECURRENCE RELATION:
  a-value=  0.940
  b-value=  0.369
  beta-value=  0.851

------------------------------------
TABLE OF MAGNITUDES AND EXCEEDANCES:
------------------------------------

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APPENDIX D

LABORATORY DATA
## Atterberg Limits' Results

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<th>Depth/El</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>Fines</th>
<th>USCS Classification</th>
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<tr>
<td>TP-2</td>
<td>4.5</td>
<td>28</td>
<td>16</td>
<td>12</td>
<td>27</td>
<td>CLAYEY SAND (SC)</td>
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<td>TP-4</td>
<td>1.0</td>
<td>62</td>
<td>18</td>
<td>44</td>
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<td>Sandy Clay</td>
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</table>

**Sample Details**
- **Project:** MAIN STREET
- **Number:** 6643-A-SC
- **Date:** February 2014
- **Plate:** D - 1

**GeoSoils, Inc.**
5741 Palmer Way
Carlsbad, CA 92008
Telephone: (760) 438-3155
Fax: (760) 931-0915

---

**Graph Details**
- **X-axis:** Liquid Limit
- **Y-axis:** Plasticity Index
- **Legend:**
  - CL: Clay
  - CH: Chalk
  - ML: Mudline
  - MH: Mudmass

---

**Note:**
- The graph illustrates the Atterberg limits for the samples collected, showing their classification according to the USCS system.
Note: Sample Innundated Prior To Test
SUMMARY OF LABORATORY TEST DATA

GeoSoils, Inc.
5741 Palmer Way, Suite D
Carlsbad, CA 92010

QCI Project No.: 14-029-01b
Date: January 7, 2014
Summarized by: ABK

Client: Main Street
Project Name: Corrosivity
W.O. 6443-A-SC

<table>
<thead>
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<th>Sample ID</th>
<th>Sample Depth</th>
<th>pH CT-532 (643)</th>
<th>Chloride CT-422 (ppm)</th>
<th>Sulfate CT-417 % By Weight</th>
<th>Resistivity CT-532 (643) (ohm-cm)</th>
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</thead>
<tbody>
<tr>
<td>TR-4</td>
<td>1'-2'</td>
<td>7.54</td>
<td>118</td>
<td>0.0830</td>
<td>470</td>
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APPENDIX E

GENERAL EARTHWORK, GRADING GUIDELINES
AND PRELIMINARY CRITERIA
GENERAL EARTHWORK AND GRADING GUIDELINES

General

These guidelines present general procedures and requirements for earthwork and grading as shown on the approved grading plans, including preparation of areas to be filled, placement of fill, installation of subdrains, excavations, and appurtenant structures or flatwork. The recommendations contained in the geotechnical report are part of these earthwork and grading guidelines and would supercede the provisions contained hereafter in the case of conflict. Evaluations performed by the consultant during the course of grading may result in new or revised recommendations which could supercede these guidelines or the recommendations contained in the geotechnical report. Generalized details follow this text.

The contractor is responsible for the satisfactory completion of all earthwork in accordance with provisions of the project plans and specifications and latest adopted code. In the case of conflict, the most onerous provisions shall prevail. The project geotechnical engineer and engineering geologist (geotechnical consultant), and/or their representatives, should provide observation and testing services, and geotechnical consultation during the duration of the project.

EARTHWORK OBSERVATIONS AND TESTING

Geotechnical Consultant

Prior to the commencement of grading, a qualified geotechnical consultant (soil engineer and engineering geologist) should be employed for the purpose of observing earthwork procedures and testing the fills for general conformance with the recommendations of the geotechnical report(s), the approved grading plans, and applicable grading codes and ordinances.

The geotechnical consultant should provide testing and observation so that an evaluation may be made that the work is being accomplished as specified. It is the responsibility of the contractor to assist the consultants and keep them apprised of anticipated work schedules and changes, so that they may schedule their personnel accordingly.

All remedial removals, clean-outs, prepared ground to receive fill, key excavations, and subdrain installation should be observed and documented by the geotechnical consultant prior to placing any fill. It is the contractor’s responsibility to notify the geotechnical consultant when such areas are ready for observation.

GeoSoils, Inc.
Laboratory and Field Tests

Maximum dry density tests to determine the degree of compaction should be performed in accordance with American Standard Testing Materials test method ASTM designation D-1557. Random or representative field compaction tests should be performed in accordance with test methods ASTM designation D-1556, D-2937 or D-2922, and D-3017, at intervals of approximately ±2 feet of fill height or approximately every 1,000 cubic yards placed. These criteria would vary depending on the soil conditions and the size of the project. The location and frequency of testing would be at the discretion of the geotechnical consultant.

Contractor's Responsibility

All clearing, site preparation, and earthwork performed on the project should be conducted by the contractor, with observation by a geotechnical consultant, and staged approval by the governing agencies, as applicable. It is the contractor's responsibility to prepare the ground surface to receive the fill, to the satisfaction of the geotechnical consultant, and to place, spread, moisture condition, mix, and compact the fill in accordance with the recommendations of the geotechnical consultant. The contractor should also remove all non-earth material considered unsatisfactory by the geotechnical consultant.

Notwithstanding the services provided by the geotechnical consultant, it is the sole responsibility of the contractor to provide adequate equipment and methods to accomplish the earthwork in strict accordance with applicable grading guidelines, latest adopted codes or agency ordinances, geotechnical report(s), and approved grading plans. Sufficient watering apparatus and compaction equipment should be provided by the contractor with due consideration for the fill material, rate of placement, and climatic conditions. If, in the opinion of the geotechnical consultant, unsatisfactory conditions such as questionable weather, excessive oversized rock or deleterious material, insufficient support equipment, etc., are resulting in a quality of work that is not acceptable, the consultant will inform the contractor, and the contractor is expected to rectify the conditions, and if necessary, stop work until conditions are satisfactory.

During construction, the contractor shall properly grade all surfaces to maintain good drainage and prevent ponding of water. The contractor shall take remedial measures to control surface water and to prevent erosion of graded areas until such time as permanent drainage and erosion control measures have been installed.

SITE PREPARATION

All major vegetation, including brush, trees, thick grasses, organic debris, and other deleterious material, should be removed and disposed of off-site. These removals must be concluded prior to placing fill. In-place existing fill, soil, alluvium, colluvium, or rock materials, as evaluated by the geotechnical consultant as being unsuitable, should be removed prior to any fill placement. Depending upon the soil conditions, these materials
may be reused as compacted fills. Any materials incorporated as part of the compacted fills should be approved by the geotechnical consultant.

Any underground structures such as cesspools, cisterns, mining shafts, tunnels, septic tanks, wells, pipelines, or other structures not located prior to grading, are to be removed or treated in a manner recommended by the geotechnical consultant. Soft, dry, spongy, highly fractured, or otherwise unsuitable ground, extending to such a depth that surface processing cannot adequately improve the condition, should be overexcavated down to firm ground and approved by the geotechnical consultant before compaction and filling operations continue. Overexcavated and processed soils, which have been properly mixed and moisture conditioned, should be re-compacted to the minimum relative compaction as specified in these guidelines.

Existing ground, which is determined to be satisfactory for support of the fills, should be scarified (ripped) to a minimum depth of 6 to 8 inches, or as directed by the geotechnical consultant. After the scarified ground is brought to optimum moisture content, or greater and mixed, the materials should be compacted as specified herein. If the scarified zone is greater than 6 to 8 inches in depth, it may be necessary to remove the excess and place the material in lifts restricted to about 6 to 8 inches in compacted thickness.

Existing ground which is not satisfactory to support compacted fill should be overexcavated as required in the geotechnical report, or by the on-site geotechnical consultant. Scarification, disc harrowing, or other acceptable forms of mixing should continue until the soils are broken down and free of large lumps or clods, until the working surface is reasonably uniform and free from ruts, hollows, hummocks, mounds, or other uneven features, which would inhibit compaction as described previously.

Where fills are to be placed on ground with slopes steeper than 5:1 (horizontal to vertical [h:v]), the ground should be stepped or benched. The lowest bench, which will act as a key, should be a minimum of 15 feet wide and should be at least 2 feet deep into firm material, and approved by the geotechnical consultant. In fill-over-cut slope conditions, the recommended minimum width of the lowest bench or key is also 15 feet, with the key founded on firm material, as designated by the geotechnical consultant. As a general rule, unless specifically recommended otherwise by the geotechnical consultant, the minimum width of fill keys should be equal to ½ the height of the slope.

Standard benching is generally 4 feet (minimum) vertically, exposing firm, acceptable material. Benching may be used to remove unsuitable materials, although it is understood that the vertical height of the bench may exceed 4 feet. Pre-stripping may be considered for unsuitable materials in excess of 4 feet in thickness.

All areas to receive fill, including processed areas, removal areas, and the toes of fill benches, should be observed and approved by the geotechnical consultant prior to placement of fill. Fills may then be properly placed and compacted until design grades (elevations) are attained.
COMPACTED FILLS

Any earth materials imported or excavated on the property may be utilized in the fill provided that each material has been evaluated to be suitable by the geotechnical consultant. These materials should be free of roots, tree branches, other organic matter, or other deleterious materials. All unsuitable materials should be removed from the fill as directed by the geotechnical consultant. Soils of poor gradation, undesirable expansion potential, or substandard strength characteristics may be designated by the consultant as unsuitable and may require blending with other soils to serve as a satisfactory fill material.

Fill materials derived from benching operations should be dispersed throughout the fill area and blended with other approved material. Benching operations should not result in the benched material being placed only within a single equipment width away from the fill/bedrock contact.

Oversized materials defined as rock, or other irreducible materials, with a maximum dimension greater than 12 inches, should not be buried or placed in fills unless the location of materials and disposal methods are specifically approved by the geotechnical consultant. Oversized material should be taken offsite, or placed in accordance with recommendations of the geotechnical consultant in areas designated as suitable for rock disposal. GSI anticipates that soils to be utilized as fill material for the subject project may contain some rock. Appropriately, the need for rock disposal may be necessary during grading operations on the site. From a geotechnical standpoint, the depth of any rocks, rock fills, or rock blankets, should be a sufficient distance from finish grade. This depth is generally the same as any overexcavation due to cut-fill transitions in hard rock areas, and generally facilitates the excavation of structural footings and substructures. Should deeper excavations be proposed (i.e., deepened footings, utility trenching, swimming pools, spas, etc.), the developer may consider increasing the hold-down depth of any rocky fills to be placed, as appropriate. In addition, some agencies/jurisdictions mandate a specific hold-down depth for oversize materials placed in fills. The hold-down depth, and potential to encounter oversize rock, both within fills, and occurring in cut or natural areas, would need to be disclosed to all interested/affected parties. Once approved by the governing agency, the hold-down depth for oversized rock (i.e., greater than 12 inches) in fills on this project is provided as 10 feet, unless specified differently in the text of this report. The governing agency may require that these materials need to be deeper, crushed, or reduced to less than 12 inches in maximum dimension, at their discretion.

To facilitate future trenching, rock (or oversized material), should not be placed within the hold-down depth feet from finish grade, the range of foundation excavations, future utilities, or underground construction unless specifically approved by the governing agency, the geotechnical consultant, and/or the developer’s representative.

If import material is required for grading, representative samples of the materials to be utilized as compacted fill should be analyzed in the laboratory by the geotechnical consultant to evaluate it’s physical properties and suitability for use onsite. Such testing should be performed three (3) days prior to importation. If any material other than that
previously tested is encountered during grading, an appropriate analysis of this material should be conducted by the geotechnical consultant as soon as possible.

Approved fill material should be placed in areas prepared to receive fill in near horizontal layers, that when compacted, should not exceed about 6 to 8 inches in thickness. The geotechnical consultant may approve thick lifts if testing indicates the grading procedures are such that adequate compaction is being achieved with lifts of greater thickness. Each layer should be spread evenly and blended to attain uniformity of material and moisture suitable for compaction.

Fill layers at a moisture content less than optimum should be watered and mixed, and wet fill layers should be aerated by scarification, or should be blended with drier material. Moisture conditioning, blending, and mixing of the fill layer should continue until the fill materials have a uniform moisture content at, or above, optimum moisture.

After each layer has been evenly spread, moisture conditioned, and mixed, it should be uniformly compacted to a minimum of 90 percent of the maximum density as evaluated by ASTM test designation D-1557, or as otherwise recommended by the geotechnical consultant. Compaction equipment should be adequately sized and should be specifically designed for soil compaction, or of proven reliability to efficiently achieve the specified degree of compaction.

Where tests indicate that the density of any layer of fill, or portion thereof, is below the required relative compaction, or improper moisture is in evidence, the particular layer or portion shall be re-worked until the required density and/or moisture content has been attained. No additional fill shall be placed in an area until the last placed lift of fill has been tested and found to meet the density and moisture requirements, and is approved by the geotechnical consultant.

In general, per the latest adopted version of the California Building Code (CBC), fill slopes should be designed and constructed at a gradient of 2:1 (h:v), or flatter. Compaction of slopes should be accomplished by over-building a minimum of 3 feet horizontally, and subsequently trimming back to the design slope configuration. Testing shall be performed as the fill is elevated to evaluate compaction as the fill core is being developed. Special efforts may be necessary to attain the specified compaction in the fill slope zone. Final slope shaping should be performed by trimming and removing loose materials with appropriate equipment. A final evaluation of fill slope compaction should be based on observation and/or testing of the finished slope face. Where compacted fill slopes are designed steeper than 2:1 (h:v), prior approval from the governing agency, specific material types, a higher minimum relative compaction, special reinforcement, and special grading procedures will be recommended.

If an alternative to over-building and cutting back the compacted fill slopes is selected, then special effort should be made to achieve the required compaction in the outer 10 feet of each lift of fill by undertaking the following:
1. An extra piece of equipment consisting of a heavy, short-shanked sheepsfoot should be used to roll (horizontal) parallel to the slopes continuously as fill is placed. The sheepsfoot roller should also be used to roll perpendicular to the slopes, and extend out over the slope to provide adequate compaction to the face of the slope.

2. Loose fill should not be spilled out over the face of the slope as each lift is compacted. Any loose fill spilled over a previously completed slope face should be trimmed off or be subject to re-rolling.

3. Field compaction tests will be made in the outer (horizontal) ±2 to ±8 feet of the slope at appropriate vertical intervals, subsequent to compaction operations.

4. After completion of the slope, the slope face should be shaped with a small tractor and then re-rolled with a sheepsfoot to achieve compaction to near the slope face. Subsequent to testing to evaluate compaction, the slopes should be grid-rolled to achieve compaction to the slope face. Final testing should be used to evaluate compaction after grid rolling.

5. Where testing indicates less than adequate compaction, the contractor will be responsible to rip, water, mix, and recompact the slope material as necessary to achieve compaction. Additional testing should be performed to evaluate compaction.

**SUBDRAIN INSTALLATION**

Subdrains should be installed in approved ground in accordance with the approximate alignment and details indicated by the geotechnical consultant. Subdrain locations or materials should not be changed or modified without approval of the geotechnical consultant. The geotechnical consultant may recommend and direct changes in subdrain line, grade, and drain material in the field, pending exposed conditions. The location of constructed subdrains, especially the outlets, should be recorded/surveyed by the project civil engineer. Drainage at the subdrain outlets should be provided by the project civil engineer.

**EXCAVATIONS**

Excavations and cut slopes should be examined during grading by the geotechnical consultant. If directed by the geotechnical consultant, further excavations or overexcavation and refilling of cut areas should be performed, and/or remedial grading of cut slopes should be performed. When fill-over-cut slopes are to be graded, unless otherwise approved, the cut portion of the slope should be observed by the geotechnical consultant prior to placement of materials for construction of the fill portion of the slope.
The geotechnical consultant should observe all cut slopes, and should be notified by the contractor when excavation of cut slopes commence.

If, during the course of grading, unforeseen adverse or potentially adverse geologic conditions are encountered, the geotechnical consultant should investigate, evaluate, and make appropriate recommendations for mitigation of these conditions. The need for cut slope buttressing or stabilizing should be based on in-grading evaluation by the geotechnical consultant, whether anticipated or not.

Unless otherwise specified in geotechnical and geological report(s), no cut slopes should be excavated higher or steeper than that allowed by the ordinances of controlling governmental agencies. Additionally, short-term stability of temporary cut slopes is the contractor’s responsibility.

Erosion control and drainage devices should be designed by the project civil engineer and should be constructed in compliance with the ordinances of the controlling governmental agencies, and/or in accordance with the recommendations of the geotechnical consultant.

**COMPLETION**

Observation, testing, and consultation by the geotechnical consultant should be conducted during the grading operations in order to state an opinion that all cut and fill areas are graded in accordance with the approved project specifications. After completion of grading, and after the geotechnical consultant has finished observations of the work, final reports should be submitted, and may be subject to review by the controlling governmental agencies. No further excavation or filling should be undertaken without prior notification of the geotechnical consultant or approved plans.

All finished cut and fill slopes should be protected from erosion and/or be planted in accordance with the project specifications and/or as recommended by a landscape architect. Such protection and/or planning should be undertaken as soon as practical after completion of grading.

**PRELIMINARY OUTDOOR POOL/SPA DESIGN RECOMMENDATIONS**

The following preliminary recommendations are provided for consideration in pool/spa design and planning. Actual recommendations should be provided by a qualified geotechnical consultant, based on site specific geotechnical conditions, including a subsurface investigation, differential settlement potential, expansive and corrosive soil potential, proximity of the proposed pool/spa to any slopes with regard to slope creep and lateral fill extension, as well as slope setbacks per Code, and geometry of the proposed improvements. Recommendations for pools/spas and/or deck flatwork underlain by expansive soils, or for areas with differential settlement greater than ¼-inch over 40 feet horizontally, will be more onerous than the preliminary recommendations presented below.
The 1:1 (h:v) influence zone of any nearby retaining wall site structures should be delineated on the project civil drawings with the pool/spa. This 1:1 (h:v) zone is defined as a plane up from the lower-most heel of the retaining structure, to the daylight grade of the nearby building pad or slope. If pools/spas or associated pool/spa improvements are constructed within this zone, they should be re-positioned (horizontally or vertically) so that they are supported by earth materials that are outside or below this 1:1 plane. If this is not possible given the area of the building pad, the owner should consider eliminating these improvements or allow for increased potential for lateral/vertical deformations and associated distress that may render these improvements unusable in the future, unless they are periodically repaired and maintained. The conditions and recommendations presented herein should be disclosed to all homeowners and any interested/affected parties.

**General**

1. The equivalent fluid pressure to be used for the pool/spa design should be 60 pounds per cubic foot (pcf) for pool/spa walls with level backfill, and 75 pcf for a 2:1 sloped backfill condition. In addition, backdrains should be provided behind pool/spa walls subjacent to slopes.

2. Passive earth pressure may be computed as an equivalent fluid having a density of 150 pcf, to a maximum lateral earth pressure of 1,000 pounds per square foot (psf).

3. An allowable coefficient of friction between soil and concrete of 0.30 may be used with the dead load forces.

4. When combining passive pressure and frictional resistance, the passive pressure component should be reduced by one-third.

5. Where pools/spas are planned near structures, appropriate surcharge loads need to be incorporated into design and construction by the pool/spa designer. This includes, but is not limited to landscape berms, decorative walls, footings, built-in barbeques, utility poles, etc.

6. All pool/spa walls should be designed as “free standing” and be capable of supporting the water in the pool/spa without soil support. The shape of pool/spa in cross section and plan view may affect the performance of the pool, from a geotechnical standpoint. Pools and spas should also be designed in accordance with the latest adopted Code. Minimally, the bottoms of the pools/spas, should maintain a distance \( H/3 \), where \( H \) is the height of the slope (in feet), from the slope face. This distance should not be less than 7 feet, nor need not be greater than 40 feet.

7. The soil beneath the pool/spa bottom should be uniformly moist with the same stiffness throughout. If a fill/cut transition occurs beneath the pool/spa bottom, the cut portion should be overexcavated to a minimum depth of 48 inches, and
replaced with compacted fill, such that there is a uniform blanket that is a minimum of 48 inches below the pool/spa shell. If very low expansive soil is used for fill, the fill should be placed at a minimum of 95 percent relative compaction, at optimum moisture conditions. This requirement should be 90 percent relative compaction at over optimum moisture if the pool/spa is constructed within or near expansive soils. The potential for grading and/or re-grading of the pool/spa bottom, and attendant potential for shoring and/or slot excavation, needs to be considered during all aspects of pool/spa planning, design, and construction.

8. If the pool/spa is founded entirely in compacted fill placed during rough grading, the deepest portion of the pool/spa should correspond with the thickest fill on the lot.

9. Hydrostatic pressure relief valves should be incorporated into the pool and spa designs. A pool/spa under-drain system is also recommended, with an appropriate outlet for discharge.

10. All fittings and pipe joints, particularly fittings in the side of the pool or spa, should be properly sealed to prevent water from leaking into the adjacent soils materials, and be fitted with slip or expandible joints between connections transecting varying soil conditions.

11. An elastic expansion joint (flexible waterproof sealant) should be installed to prevent water from seeping into the soil at all deck joints.

12. A reinforced grade beam should be placed around skimmer inlets to provide support and mitigate cracking around the skimmer face.

13. In order to reduce unsightly cracking, deck slabs should minimally be 4 inches thick, and reinforced with No. 3 reinforcing bars at 18 inches on-center. All slab reinforcement should be supported to ensure proper mid-slab positioning during the placement of concrete. Wire mesh reinforcing is specifically not recommended. Deck slabs should not be tied to the pool/spa structure. Pre-moistening and/or pre-soaking of the slab subgrade is recommended, to a depth of 12 inches (optimum moisture content), or 18 inches (120 percent of the soil’s optimum moisture content, or 3 percent over optimum moisture content, whichever is greater), for very low to low, and medium expansive soils, respectively. This moisture content should be maintained in the subgrade soils during concrete placement to promote uniform curing of the concrete and minimize the development of unsightly shrinkage cracks. Slab underlayment should consist of a 1- to 2-inch leveling course of sand (S.E. >30) and a minimum of 4 to 6 inches of Class 2 base compacted to 90 percent. Deck slabs within the H/3 zone, where H is the height of the slope (in feet), will have an increased potential for distress relative to other areas outside of the H/3 zone. If distress is undesirable, improvements, deck slabs or flatwork should not be constructed closer than H/3 or 7 feet (whichever is greater) from the slope face, in order to reduce, but not eliminate, this potential.
14. Pool/spa bottom or deck slabs should be founded entirely on competent bedrock, or properly compacted fill. Fill should be compacted to achieve a minimum 90 percent relative compaction, as discussed above. Prior to pouring concrete, subgrade soils below the pool/spa decking should be thoroughly watered to achieve a moisture content that is at least 2 percent above optimum moisture content, to a depth of at least 18 inches below the bottom of slabs. This moisture content should be maintained in the subgrade soils during concrete placement to promote uniform curing of the concrete and minimize the development of unsightly shrinkage cracks.

15. In order to reduce unsightly cracking, the outer edges of pool/spa decking to be bordered by landscaping, and the edges immediately adjacent to the pool/spa, should be underlain by an 8-inch wide concrete cutoff shoulder (thickened edge) extending to a depth of at least 12 inches below the bottoms of the slabs to mitigate excessive infiltration of water under the pool/spa deck. These thickened edges should be reinforced with two No. 4 bars, one at the top and one at the bottom. Deck slabs may be minimally reinforced with No. 3 reinforcing bars placed at 18 inches on-center, in both directions. All slab reinforcement should be supported on chairs to ensure proper mid-slab positioning during the placement of concrete.

16. Surface and shrinkage cracking of the finish slab may be reduced if a low slump and water-cement ratio are maintained during concrete placement. Concrete utilized should have a minimum compressive strength of 4,000 psi. Excessive water added to concrete prior to placement is likely to cause shrinkage cracking, and should be avoided. Some concrete shrinkage cracking, however, is unavoidable.

17. Joint and sawcut locations for the pool/spa deck should be determined by the design engineer and/or contractor. However, spacings should not exceed 6 feet on center.

18. Considering the nature of the onsite earth materials, it should be anticipated that caving or sloughing could be a factor in subsurface excavations and trenching. Shoring or excavating the trench walls/backcuts at the angle of repose (typically 25 to 45 degrees), should be anticipated. All excavations should be observed by a representative of the geotechnical consultant, including the project geologist and/or geotechnical engineer, prior to workers entering the excavation or trench, and minimally conform to Cal/OSHA (“Type C” soils may be assumed), state, and local safety codes. Should adverse conditions exist, appropriate recommendations should be offered at that time by the geotechnical consultant. GSI does not consult in the area of safety engineering and the safety of the construction crew is the responsibility of the pool/spa builder.

19. It is imperative that adequate provisions for surface drainage are incorporated by the homeowners into their overall improvement scheme. Ponding water, ground saturation and flow over slope faces, are all situations which must be avoided to enhance long-term performance of the pool/spa and associated improvements, and reduce the likelihood of distress.
20. Regardless of the methods employed, once the pool/spa is filled with water, should it be emptied, there exists some potential that if emptied, significant distress may occur. Accordingly, once filled, the pool/spa should not be emptied unless evaluated by the geotechnical consultant and the pool/spa builder.

21. For pools/spas built within (all or part) of the Code setback and/or geotechnical setback, as indicated in the site geotechnical documents, special foundations are recommended to mitigate the affects of creep, lateral fill extension, expansive soils and settlement on the proposed pool/spa. Most municipalities or County reviewers do not consider these effects in pool/spa plan approvals. As such, where pools/spas are proposed on 20 feet or more of fill, medium or highly expansive soils, or rock fill with limited “cap soils” and built within Code setbacks, or within the influence of the creep zone, or lateral fill extension, the following should be considered during design and construction:

OPTION A: Shallow foundations with or without overexcavation of the pool/spa “shell,” such that the pool/spa is surrounded by 5 feet of very low to low expansive soils (without irreducible particles greater that 6 inches), and the pool/spa walls closer to the slope(s) are designed to be free standing. GSI recommends a pool/spa under-drain or blanket system (see attached Typical Pool/Spa Detail). The pool/spa builders and owner in this optional construction technique should be generally satisfied with pool/spa performance under this scenario; however, some settlement, tilting, cracking, and leakage of the pool/spa is likely over the life of the project.

OPTION B: Pier supported pool/spa foundations with or without overexcavation of the pool/spa shell such that the pool/spa is surrounded by 5 feet of very low to low expansive soils (without irreducible particles greater than 6 inches), and the pool/spa walls closer to the slope(s) are designed to be free standing. The need for a pool/spa under-drain system may be installed for leak detection purposes. Piers that support the pool/spa should be a minimum of 12 inches in diameter and at a spacing to provide vertical and lateral support of the pool/spa, in accordance with the pool/spa designers recommendations current applicable Codes. The pool/spa builder and owner in this second scenario construction technique should be more satisfied with pool/spa performance. This construction will reduce settlement and creep effects on the pool/spa; however, it will not eliminate these potentials, nor make the pool/spa “leak-free.”

22. The temperature of the water lines for spas and pools may affect the corrosion properties of site soils, thus, a corrosion specialist should be retained to review all spa and pool plans, and provide mitigative recommendations, as warranted. Concrete mix design should be reviewed by a qualified corrosion consultant and materials engineer.
23. All pool/spa utility trenches should be compacted to 90 percent of the laboratory standard, under the full-time observation and testing of a qualified geotechnical consultant. Utility trench bottoms should be sloped away from the primary structure on the property (typically the residence).

24. Pool and spa utility lines should not cross the primary structure’s utility lines (i.e., not stacked, or sharing of trenches, etc.).

25. The pool/spa or associated utilities should not intercept, interrupt, or otherwise adversely impact any area drain, roof drain, or other drainage conveyances. If it is necessary to modify, move, or disrupt existing area drains, subdrains, or tightlines, then the design civil engineer should be consulted, and mitigative measures provided. Such measures should be further reviewed and approved by the geotechnical consultant, prior to proceeding with any further construction.

26. The geotechnical consultant should review and approve all aspects of pool/spa and flatwork design prior to construction. A design civil engineer should review all aspects of such design, including drainage and setback conditions. Prior to acceptance of the pool/spa construction, the project builder, geotechnical consultant and civil designer should evaluate the performance of the area drains and other site drainage pipes, following pool/spa construction.

27. All aspects of construction should be reviewed and approved by the geotechnical consultant, including during excavation, prior to the placement of any additional fill, prior to the placement of any reinforcement or pouring of any concrete.

28. Any changes in design or location of the pool/spa should be reviewed and approved by the geotechnical and design civil engineer prior to construction. Field adjustments should not be allowed until written approval of the proposed field changes are obtained from the geotechnical and design civil engineer.

29. Disclosure should be made to homeowners and builders, contractors, and any interested/affected parties, that pools/spas built within about 15 feet of the top of a slope, and/or H/3, where H is the height of the slope (in feet), will experience some movement or tilting. While the pool/spa shell or coping may not necessarily crack, the levelness of the pool/spa will likely tilt toward the slope, and may not be esthetically pleasing. The same is true with decking, flatwork and other improvements in this zone.

30. Failure to adhere to the above recommendations will significantly increase the potential for distress to the pool/spa, flatwork, etc.

31. Local seismicity and/or the design earthquake will cause some distress to the pool/spa and decking or flatwork, possibly including total functional and economic loss.
32. The information and recommendations discussed above should be provided to any contractors and/or subcontractors, or homeowners, interested/affected parties, etc., that may perform or may be affected by such work.

**JOB SAFETY**

**General**

At GSI, getting the job done safely is of primary concern. The following is the company's safety considerations for use by all employees on multi-employer construction sites. On-ground personnel are at highest risk of injury, and possible fatality, on grading and construction projects. GSI recognizes that construction activities will vary on each site, and that site safety is the prime responsibility of the contractor; however, everyone must be safety conscious and responsible at all times. To achieve our goal of avoiding accidents, cooperation between the client, the contractor, and GSI personnel must be maintained.

In an effort to minimize risks associated with geotechnical testing and observation, the following precautions are to be implemented for the safety of field personnel on grading and construction projects:

**Safety Meetings:** GSI field personnel are directed to attend contractor’s regularly scheduled and documented safety meetings.

**Safety Vests:** Safety vests are provided for, and are to be worn by GSI personnel, at all times, when they are working in the field.

**Safety Flags:** Two safety flags are provided to GSI field technicians; one is to be affixed to the vehicle when on site, the other is to be placed atop the spoil pile on all test pits.

**Flashing Lights:** All vehicles stationary in the grading area shall use rotating or flashing amber beacons, or strobe lights, on the vehicle during all field testing. While operating a vehicle in the grading area, the emergency flasher on the vehicle shall be activated.

In the event that the contractor's representative observes any of our personnel not following the above, we request that it be brought to the attention of our office.

**Test Pits Location, Orientation, and Clearance**

The technician is responsible for selecting test pit locations. A primary concern should be the technician’s safety. Efforts will be made to coordinate locations with the grading contractor’s authorized representative, and to select locations following or behind the established traffic pattern, preferably outside of current traffic. The contractor’s authorized representative (supervisor, grade checker, dump man, operator, etc.) should direct
excavation of the pit and safety during the test period. Of paramount concern should be
the soil technician’s safety, and obtaining enough tests to represent the fill.

Test pits should be excavated so that the spoil pile is placed away from oncoming traffic,
whenever possible. The technician's vehicle is to be placed next to the test pit, opposite
the spoil pile. This necessitates the fill be maintained in a driveable condition. Alternatively, the contractor may wish to park a piece of equipment in front of the test
holes, particularly in small fill areas or those with limited access.

A zone of non-encroachment should be established for all test pits. No grading equipment
should enter this zone during the testing procedure. The zone should extend
approximately 50 feet outward from the center of the test pit. This zone is established for
safety and to avoid excessive ground vibration, which typically decreases test results.

When taking slope tests, the technician should park the vehicle directly above or below the
test location. If this is not possible, a prominent flag should be placed at the top of the
slope. The contractor's representative should effectively keep all equipment at a safe
operational distance (e.g., 50 feet) away from the slope during this testing.

The technician is directed to withdraw from the active portion of the fill as soon as possible
following testing. The technician's vehicle should be parked at the perimeter of the fill in
a highly visible location, well away from the equipment traffic pattern. The contractor
should inform our personnel of all changes to haul roads, cut and fill areas or other factors
that may affect site access and site safety.

In the event that the technician’s safety is jeopardized or compromised as a result of the
contractor’s failure to comply with any of the above, the technician is required, by company
policy, to immediately withdraw and notify his/her supervisor. The grading contractor’s
representative will be contacted in an effort to affect a solution. However, in the interim,
no further testing will be performed until the situation is rectified. Any fill placed can be
considered unacceptable and subject to reprocessing, recompaction, or removal.

In the event that the soil technician does not comply with the above or other established
safety guidelines, we request that the contractor bring this to the technician’s attention and
notify this office. Effective communication and coordination between the contractor’s
representative and the soil technician is strongly encouraged in order to implement the
above safety plan.

**Trench and Vertical Excavation**

It is the contractor's responsibility to provide safe access into trenches where compaction
testing is needed. Our personnel are directed not to enter any excavation or vertical cut
which: 1) is 5 feet or deeper unless shored or laid back; 2) displays any evidence of
instability, has any loose rock or other debris which could fall into the trench; or 3) displays
any other evidence of any unsafe conditions regardless of depth.
All trench excavations or vertical cuts in excess of 5 feet deep, which any person enters, should be shored or laid back. Trench access should be provided in accordance with Cal/OSHA and/or state and local standards. Our personnel are directed not to enter any trench by being lowered or “riding down” on the equipment.

If the contractor fails to provide safe access to trenches for compaction testing, our company policy requires that the soil technician withdraw and notify his/her supervisor. The contractor’s representative will be contacted in an effort to affect a solution. All backfill not tested due to safety concerns or other reasons could be subject to reprocessing and/or removal.

If GSI personnel become aware of anyone working beneath an unsafe trench wall or vertical excavation, we have a legal obligation to put the contractor and owner/developer on notice to immediately correct the situation. If corrective steps are not taken, GSI then has an obligation to notify Cal/OSHA and/or the proper controlling authorities.
Selection of alternate subdrain details, location, and extent of subdrains should be evaluated by the geotechnical consultant during grading.
ALTERNATE 1: PERFORATED PIPE AND FILTER MATERIAL

Filter material: Minimum volume of 9 cubic feet per lineal foot of pipe.

Perforated pipe: 6-inch-diameter ABS or PVC pipe or approved substitute with minimum 8 perforations (⅜-inch diameter) per lineal foot in bottom half of pipe (ASTM D-2751, SDR-35, or ASTM D-1527, Schd. 40).

For continuous run in excess of 500 feet, use 8-inch-diameter pipe (ASTM D-3034, SDR-35, or ASTM D-1765, Schd. 40).

FILTER MATERIAL

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
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<tr>
<td>1 inch</td>
<td>100</td>
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<tr>
<td>¾ inch</td>
<td>90-100</td>
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<tr>
<td>⅜ inch</td>
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<td>No. 4</td>
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<td>No. 8</td>
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<td>No. 30</td>
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<td>No. 50</td>
<td>0-7</td>
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<td>No. 200</td>
<td>0-3</td>
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</table>

ALTERNATE 2: PERFORATED PIPE, GRAVEL, AND FILTER FABRIC

Gravel Material: 9 cubic feet per lineal foot.
Perforated Pipe: See Alternate 1
Gravel: Clean ¾-inch rock or approved substitute.
Filter Fabric: Mirafi 140 or approved substitute.
Back-cut varies. For deep removals, backcut should be made no steeper than 1:1 (H:V), or flatter as necessary for safety considerations.

Provide a 1:1 (H:V) minimum projection from toe of slope as shown on grading plan to the recommended removal depth. Slope height, site conditions, and/or local conditions could dictate flatter projections.
Proposed grade

Previously placed, temporary compacted fill for drainage only

Proposed additional compacted fill

Existing compacted fill

Unsuitable material (to be removed)

Bedrock or approved native material

To be removed before placing additional compacted fill
Design finish slope

15-foot minimum
25-foot maximum

10-foot minimum

Blanket fill (if recommended by
the geotechnical consultant)

Drainage per design
civil engineer

15-foot typical
drain spacing

1 to 2
foot

2-foot minimum
key depth

2-foot minimum

Toe

Heel

2-Percent Gradient

2-Percent Gradient

Buttress or
stabilization fill

Typical benching
(4-foot minimum)

Subdrain as
recommended by
geotechnical consultant

Bedrock or
approved native
material

4-inch-diameter non-perforated
outlet pipe and backdrain (see
detail Plate E-6). Outlets to be
spaced at 100-foot maximum
intervals and shall extend 2 feet
beyond the face of slope at time
of rough grading completion. At
the completion of rough grading,
the design civil engineer should
provide recommendations to
convey any outlet's discharge to
a suitable conveyance, utilizing a
non-erosive device.
Filter Material: Minimum of 5 cubic feet per lineal foot of pipe or 4 cubic feet per lineal feet of pipe when placed in square cut trench.

Alternative in Lieu of Filter Material: Gravel may be encased in approved filter fabric. Filter fabric shall be Mirafi 140 or equivalent. Filter fabric shall be lapped a minimum of 12 inches in all joints.

Minimum 4-Inch-Diameter Pipe: ABS-ASTM D-2751, SDR 35; or ASTM D-1527 Schedule 40, PVC-ASTM D-3034, SDR 35; or ASTM D-1785 Schedule 40 with a crushing strength of 1,000 pounds minimum, and a minimum of 8 uniformly-spaced perforations per foot of pipe. Must be installed with perforations down at bottom of pipe. Provide cap at upstream end of pipe. Slope at 2 percent to outlet pipe. Outlet pipe to be connected to subdrain pipe with tee or elbow.

Notes: 1. Trench for outlet pipes to be backfilled and compacted with onsite soil.

2. Backdrains and lateral drains shall be located at elevation of every bench drain. First drain located at elevation just above lower lot grade. Additional drains may be required at the discretion of the geotechnical consultant.

Filter Material shall be of the following specification or an approved equivalent. Gravel shall be of the following specification or an approved equivalent.

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<thead>
<tr>
<th>Sieve Size</th>
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<tbody>
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<td>1½ inch</td>
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<tr>
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<tr>
<td>½ inch</td>
<td>40-100</td>
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</tbody>
</table>
NOTES:
1. Where the natural slope approaches or exceeds the design slope ratio, special recommendations would be provided by the geotechnical consultant.

2. The need for and disposition of drains should be evaluated by the geotechnical consultant, based upon exposed conditions.
NOTES:

1. Subdrains may be required as specified by the geotechnical consultant.

2. W shall be equipment width (15 feet) for slope heights less than 25 feet. For slopes greater than 25 feet, W shall be evaluated by the geotechnical consultant. At no time, shall W be less than H/2, where H is the height of the slope.
NOTES:  
1. 15-foot minimum to be maintained from proposed finish slope face to backcut.
2. The need and disposition of drains will be evaluated by the geotechnical consultant based on field conditions.
3. Pad overexcavation and recompaction should be performed if evaluated to be necessary by the geotechnical consultant.
Reconstruct compacted fill slope at 2:1 or flatter
(may increase or decrease pad area)

Overexcavate and recompack replacement fill

Back-cut varies

Avoid and/or clean up spillage of materials on the natural slope

Natural grade

Remove unsuitable material

Proposed finish grade

3-foot minimum fill blanket

Bedrock or approved native material

Typical benching
(4-foot minimum)

Subdrain as recommended by geotechnical consultant

NOTES:
1. Subdrain and key width requirements will be evaluated based on exposed subsurface conditions and thickness of overburden.

2. Pad overexcavation and recompacktion should be performed if evaluated necessary by the geotechnical consultant.
CUT LOT OR MATERIAL-TYPE TRANSITION

CUT-FILL LOT (DAYLIGHT TRANSITION)

*Deeper overexcavation may be recommended by the geotechnical consultant in steep cut-fill transition areas, such that the underlying topography is no steeper than 31 (H-V)
NOTES:
A. One equipment width or a minimum of 15 feet between rows (or windrows).
B. Height and width may vary depending on rock size and type of equipment. Length of windrow shall be no greater than 100 feet.
C. If approved by the geotechnical consultant, windrows may be placed directly on competent material or bedrock, provided adequate space is available for compaction.
D. Orientation of windrows may vary but should be as recommended by the geotechnical engineer and/or engineering geologist. Staggering of windrows is not necessary unless recommended.
E. Clear area for utility trenches, foundations, and swimming pools: Hold-down depth as specified in text of report, subject to governing agency approval.
F. All fill over and around rock windrow shall be compacted to at least 90 percent relative compaction or as recommended.
G. After fill between windrows is placed and compacted, with the lift of fill covering windrow, windrow should be proof rolled with a D-9 dozer or equivalent.

VIEWS ARE DIAGRAMMATIC ONLY AND MAY BE SUPERSEDED BY REPORT RECOMMENDATIONS OR CODE ROCK SHOULD NOT TOUCH AND VOIDS SHOULD BE COMPLETELY FILLED
ROCK DISPOSAL PITS

- Fill lifts compacted over rock after embedment
- Granular material
- Large Rock
- Size of excavation to be commensurate with rock size
- Compacted Fill

ROCK DISPOSAL LAYERS

- Granular soil to fill voids, densified by flooding
- Layer one rock high
- Proposed finish grade
- Hold-down depth
- Oversize layer
- Compacted fill
- 3-foot minimum
- Fill Slope
- Clear zone
- Layer one rock high
- Hold-down depth

PROFILE ALONG LAYER

TOP VIEW

- Hold-down depth or below lowest utility as specified in text of report, subject to governing agency approval.
- Clear zone for utility trenches, foundations, and swimming pools, as specified in text of report.

VIEWS ARE DIAGRAMMATIC ONLY AND MAY BE SUPERSEDED BY REPORT RECOMMENDATIONS OR CODE. ROCK SHOULD NOT TOUCH AND VOIDS SHOULD BE COMPLETELY FILLED IN.

GeoSoils Inc.

ROCK DISPOSAL DETAIL

Plate E-14
METHOD 1

METHOD 2

METHOD 3

METHOD 4

NOT TO SCALE
Gabion impact or diversion wall should be constructed at the base of the ascending slope subject to rock fall. Walls need to be constructed with high segments that sustain impact and mitigate potential for overtopping, and low segment that provides channelization of sediments and debris to desired depositional area for subsequent clean-out. Additional subdrain may be recommended by geotechnical consultant.
NOTES:
1. 6-inch-thick, clean gravel (\(\frac{3}{4}\) to \(\frac{1}{2}\) inch) sub-base encapsulated in Mirafi 140N or equivalent, underlain by a 15-mil vapor retarder, with 4-inch-diameter perforated pipe longitudinal connected to 4-inch-diameter perforated pipe transverse. Connect transverse pipe to 4-inch-diameter nonperforated pipe at low point and outlet or to sump pump area.
2. Pools on fills thicker than 20 feet should be constructed on deep foundations; otherwise, distress (tilting, cracking, etc.) should be expected.
3. Design does not apply to infinity-edge pools/spas.
2-foot x 2-foot x \( \frac{3}{4} \)-inch steel plate

Standard \( \frac{3}{4} \)-inch pipe nipple welded to top of plate

\( \frac{3}{4} \)-inch x 5-foot galvanized pipe, standard pipe threads top and bottom; extensions threaded on both ends and added in 5-foot increments

3-inch schedule 40 PVC pipe sleeve, add in 5-foot increments with glue joints

Proposed finish grade

5 feet

5 feet

5 feet

2 feet

1 foot

Bottom of cleanout

Provide a minimum 1-foot bedding of compacted sand

NOTES:

1. Locations of settlement plates should be clearly marked and readily visible (red flagged) to equipment operators.

2. Contractor should maintain clearance of a 5-foot radius of plate base and within 5 feet (vertical) for heavy equipment. Fill within clearance area should be hand compacted to project specifications or compacted by alternative approved method by the geotechnical consultant (in writing, prior to construction).

3. After 5 feet (vertical) of fill is in place, contractor should maintain a 5-foot radius equipment clearance from riser.

4. Place and mechanically hand compact initial 2 feet of fill prior to establishing the initial reading.

5. In the event of damage to the settlement plate or extension resulting from equipment operating within the specified clearance area, contractor should immediately notify the geotechnical consultant and should be responsible for restoring the settlement plates to working order.

6. An alternate design and method of installation may be provided at the discretion of the geotechnical consultant.
Finish grade

3/8-inch-diameter X 6-inch-long carriage bolt or equivalent

6-inch diameter X 3 1/2-inch-long hole

Concrete backfill
SIDE VIEW

Spoil pile
Test pit

TOP VIEW

Flag
Spoil pile
Test pit
Flag
Light
Vehicle

50 feet
50 feet
100 feet