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August 14, 2024

Darren Diess
P. O. BOX 2266
Lake Arrowhead, CA 92352

Project No.: 1669-01
Report No.: 1

Subject: **Update Report of Geotechnical/Geologic Study, Proposed Boat Storage Buildings, 32864 Hilltop Boulevard, Arrowbear Lake, CA 92314.**

References: 1. Hilltop Geotechnical, Inc. December 19, 2007, *Report of Preliminary Geotechnical Study, Proposed Hilltop Storage Facility, Located on Northwest Side of State Highway 18 between Powers Lane and Deep Creek Drive in Arrowbear Area of San Bernardino County, California, Project No.: 688-A07.1, Report No.: 1.*

2. Robert Kubicek Architects & Associates, *site plan, On The Mountain Boat & The Boat Yard, 32864 Hilltop Blvd., Arrowbear Lake, CA 92314, SP1.0, project #: 23101.*

Mr. Diess,

Pursuant to your request, Hilltop Geotechnical, Inc. (HGI) have reviewed the preliminary geotechnical investigation report (Reference No. 1) and update site plan (Reference No. 2).

Based on our site visit conducted on August 12, 2024, the site conditions have no significant changes within the proposed project area compared to the site conditions at the time the preliminary geotechnical study report was prepared by HGI. Per update site plan provided by the property owner (Reference No. 2), the proposed development has slightly been changed. The recommendations presented in the geotechnical report (Reference No. 1) are still applicable to the presently proposed development with some modifications presented in this update report. The updated recommendations are presented in the report below and supersede the recommendations presented in the geotechnical report (Reference No. 1).

The findings of this study indicate that the proposed development at the subject site is feasible provided the recommendations presented in the update report are incorporated into the project design and implemented during the project construction.

If you have any questions after reviewing the findings and recommendations contained in the attached report, please do not hesitate to contact this office. This opportunity to be of professional service is sincerely appreciated.

Respectfully Submitted,
HILLTOP GEOTECHNICAL, INC.

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Principal Engineer/Geologist

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1. UPDATED GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

GENERAL

In our opinion, the proposed boat storage buildings are feasible from a geotechnical engineering point of view provided the geotechnical recommendations presented in this report are followed. The main concerns from a geotechnical standpoint are the presence of artificial fill and relatively loose alluvium below the proposed buildings and parking areas.

The average in-situ moisture contents and in-situ dry densities of the upper 3.0 to 4.0 feet of the near-surface alluvial materials on the subject site suggests that the soils have an average relative compaction of less than 85 percent.

The field observations indicate that up to approximately 0.5 to 1.0 foot of material present on the subject site was an undocumented fill material. The artificial fills on the site are also considered loose and compressible. The man-made fills are not considered suitable for the support of structural fills, foundations, slab-on-grade floor slabs, hardscape, and/or pavement.

Field observations also indicate that some of the near-surface alluvial soils on the subject site were visually slightly porous to porous. These deposits extended to depths of approximately 3.0 to 9.0 feet below the existing ground surfaces at several of the exploratory excavation locations. Typically, porous, collapsible soils are formed in dry desert regions, such as the project site, where alluvial materials are rapidly deposited in lenses and layers and rapid evaporation of the water takes place. Moisture sensitive, collapsible soils generally consist of silty sands which exhibit high dry strengths, low in-situ dry densities, and low moisture contents. The high dry strength is caused by silt and clay particles and natural cementation by calcium carbonates which are left in the soil matrix during the evaporation process. However, upon future saturation of the soil strata by prolonged periods of landscape irrigation (such as happens on developed lots), the soils lose their apparent dry strength, collapse of the soil structure occurs, and settlement takes place.

Some of the near-surface alluvial soils present on the subject site exhibit an expansion potential. If precautions are not taken during the design and construction of the project, the on-site expansive soil could cause heaving and distress to the structures, hardscape, and pavement if they should become saturated in the future.

Therefore, some remedial grading consisting of removals and replacement will have to be performed within loose, compressible, artificial fill and porous, near-surface alluvium in proposed structural fills, structures, exterior hardscapes, and/or pavement.

The actual conditions of the near surface supporting material across the site may vary. The nature and extent of variations of the surface and subsurface conditions between the exploratory excavations may not become evident until construction. If variations of the material become evident during construction of the proposed development, **HGI** should be notified so that the project Geotechnical / Geologic Consultant can reevaluate the characteristics of the material and the conclusions and recommendations of this report, and, if needed, revise the conclusions and recommendations presented herein.

Preliminary recommendations for site grading, foundation design, slab support, pavement design, slope maintenance, etc., are presented in the subsequent paragraphs.

SITE PREPARATION RECOMMENDATIONS

General

The grading recommendations presented in this report are intended for: 1) the rework of unsuitable, near-surface, fill and alluvial earth materials to create engineered building pads and satisfactory support for exterior hardscape (i.e., sidewalks, curb / gutters, etc.) and pavement; and 2) the use of a foundation system and concrete slabs cast on-grade designed to resist the expansion potential of the near-surface on-site soils.

If hardscape and pavement subgrade soils are prepared at the time of grading of the building sites, and the improvements are not constructed immediately, additional observations and testing of the subgrade soil will have to be performed to locate areas which may have been damaged by construction traffic, construction activities, and/or seasonal wetting and drying. Additional observations and testing should be performed before placing aggregate base material, asphaltic concrete, and/or Portland Cement concrete in those areas.

The following recommendations may need to be modified and/or supplemented during grading as field conditions dictate. The grading should be performed in accordance with the current California Building Code presented and the recommendations in this report. We recommend that **HGI**, as the Geotechnical Engineer / Geologist of Record, be retained by the owner of the proposed project to observe the excavation and grading operations, foundation preparation, and test the compacted fill and utility trench backfill. A pregrading conference should be held at the site with the owner, contractor, County of San Bernardino representative, Civil Engineer, and Geotechnical / Geologic Consultant in attendance. Special grading procedures and/or concerns can be addressed at that time.

Earthwork observation services allow the testing of only a small percentage of the fill placed at the site. Contractual arrangements with the grading contractor by the project owner should contain the provision that he is responsible for excavating, placing, and compacting fill in accordance with the recommendations presented in this report and the approved project grading plans and specifications. Observation by the project Geotechnical / Geologic Consultant and/or his representatives during grading should not relieve the grading contractor of his responsibility to perform the work in accordance with the recommendations presented in this report and the approved project plans and specifications.

The following recommendations may need to be modified and/or supplemented during grading as field conditions require.

Clearing and Grubbing

Debris, grasses, weeds, brush, trees, and other deleterious materials should be removed from the proposed buildings, exterior hardscape and pavement areas and areas to receive structural fill before grading is performed. Any organic material and miscellaneous / demolition debris should be legally disposed of offsite. Any topsoil or highly organic surface soils encountered should be stripped and stockpiled for use on finished grades in landscape areas or exported from the site. Disking or mixing organic material into the soils proposed to be used as structural fill should not be permitted. Man-made objects encountered (i.e., septic tanks, leach lines, irrigation systems, underground utilities, old foundations, etc.) should be over excavated, exported from the site, and legally disposed of offsite. Cesspools or seepage pits, if encountered (none were encountered during this study), should be abandoned, and capped according to directions and supervision of San Bernardino County Department of Health, the State of California, and/or the appropriate governmental agency procedures which has jurisdiction over them before fill and/or pavement is placed over the area. If no procedures are required by the Health Department or if the following recommendations are more stringent, the cesspool or seepage pit should be pumped free of any liquid and filled with a low strength sand cement slurry to an elevation 5.0 feet below the final site grade in the area. The upper 5.0 feet of the cesspool or seepage pit should be excavated; and the area should be backfilled with a properly compacted fill material. The location of the cesspool or seepage pit should be surveyed and plotted on the final 'As-Graded' plan prepared by the project Civil Engineer. Trees and their roots should be completely removed, ensuring that 95 percent or more of the root systems are extracted. Wells, if encountered, should be abandoned, and capped according to directions and supervision of San Bernardino County Department of Health, the State of California, and/or the appropriate governmental agency procedures which has jurisdiction over the well before fill and/or pavement is placed over the area.

Excavation Characteristics

Excavation and trenching within the subject property to the depths anticipated for the proposed development are anticipated to be relatively easy in the near-surface undocumented fills, alluvial, and highly weathered bedrock materials on the subject site and should be accomplished with conventional earth-moving equipment since the backhoe was able to penetrate to the indicated depths. Materials were not encountered or are anticipated that would require heavy ripping or blasting to excavate. It is anticipated that a small amount of oversized rock material (i.e., 3 inches in greatest dimension) will be generated during the removal and replacement process within the alluvial materials which will require special handling during the development of the site.

In general, the bedrock will be excavated with varying degrees of difficulty. Based upon available exposures in the exploratory trenches, much of the underlying, near-surface bedrock should be excavated with moderate difficulty. Difficult to very difficult ripping with the likelihood of blasting may be encountered in deeper excavations, due to the nature and character of the bedrock (i.e., differential weathering, residual boulders, intrusive dikes, etc.).

Oversized rock materials are anticipated to be generated during the grading. Such materials will likely require special handling methods during site development.

Suitability of on-Site Materials as Fill

In general, the on-site earth materials present below any topsoil and/or highly organic materials are considered satisfactory for reuse as fill. Fill materials should be free of significant amounts of organic materials and/or debris and should not contain rocks or clumps greater than 3 inches in maximum dimension. It is noted that the in-situ moisture content of the near-surface fill and alluvial soils on the subject site at the time this field study was performed was below the optimum moisture content for the on-site materials and that moisture will have to be added to the on-site soils if the soils are to be used as compacted fill material soon.

Removal and Recompaction

Uncontrolled or undocumented fills and/or unsuitable, disturbed near-surface alluvial soil in proposed areas which will support structural fills, structures (i.e., buildings, decorative block walls, retaining walls, trash enclosure walls, etc.), exterior hardscape (i.e., sidewalks, patios, curb / gutters, etc.), fill slopes, and pavement should be prepared in accordance with the following recommendations for grading in such areas. If over excavation of undocumented fill and/or unsuitable, disturbed near-surface alluvial soil is elected not to be performed in hardscape, curb / gutter, pavement, and decorative block wall or fence areas, penetration of irrigation water with time may cause some settlement and distress to the improvements in those areas. The cost of the additional grading versus the risk of distress and cost of repairs to the structures needs to be evaluated by the project owner.

- The near-surface undocumented fill soils and the unsuitable, porous, near-surface alluvial materials on the site are recommended to be over excavated and recompacted. Based upon our exploratory excavations and laboratory test results, we anticipate that the over excavation will extend to a depth of approximately 5.0 feet below existing ground surface in the areas which will receive structural fill, building structures, retaining walls, trash enclosure walls, and decorative concrete block walls. Moreover, the depth of the over excavation within the perimeter of the proposed structures should be at a uniform elevation throughout the limits of the structures. It is noted that fill placed to construct slopes and/or support sidewalks, patios, retaining walls, block walls, driveways, and pavement is considered as structural fill.

- Where a cut / fill transition zone extends through a proposed building pad area, a compacted mat of fill will have to be constructed under the building area to prevent differential settlement between the two (2) dissimilar materials. This mat should be constructed by over excavating the materials in the cut portion of the pad to a distance outside the proposed building limits of 5.0 feet or to the depth of the over excavation below the finish pad grade, whichever is greater. The over excavation should extend to a depth of 5.0 feet below the pad elevation or to a minimum depth of 0.5 times the depth of the deepest fill within the building pad, whichever is greater.

- In total cut building pads for proposed structures, over excavation and recompaction are recommended to be performed to a depth of 5.0 feet below the proposed cut pad elevation and to a lateral distance of 5.0 feet outside the perimeter of the structure. This will provide a uniformly compacted building pad for support of the structure and remove oversize materials within the anticipated depths of foundations and underground utilities.

- In the proposed exterior hardscape (i.e., sidewalks, patio slabs, etc.), and pavement areas where structural fill will not be placed or cuts are proposed, the existing near-surface soils need only be processed to a depth of 6.0 to 12 inches below existing site grades or proposed subgrade elevation, whichever is deeper unless old, undocumented fill materials are encountered at exposed grades. If undocumented fills are encountered, they will need to be over excavated and properly compacted fill replaced to achieve proposed grades.

  Due to the porous nature of some of the near-surface alluvial soils on the subject site, if over excavation and replacement is not performed under the exterior concrete slabs, hardscape, pavement, curb / gutters, etc., there is a risk of settlement and vertical differential movement if the subgrade soils are allowed to become saturated. Therefore, proper drainage should be established away from such improvements and minimal precipitation or irrigation water allowed to percolate into the soils adjacent to the exterior concrete hardscape, pavement, curbs / gutters, etc.

- Additional over excavation will need to be performed in areas where the exposed subgrade cannot be properly processed and recompacted per the following recommendations presented in this section of this report.

- If wet, unstable soil is encountered at the over excavation depth, additional over excavation and a 0.75-to-1.0-inch gravel worked into the soil may be required to establish a firm working base for the placement of fill. As an alternative, a mud coat (i.e., sand /cement slurry) consisting of a minimum of 2.0 sacks of cement per cubic yard of sand may be placed over the soft subgrade and allowed to cure overnight. This will establish a firm working base for the placement of fill.

- The limits of over excavation for the building pads should extend to 5.0 feet or to the depth of the over excavation beneath the finish pad grade for the structure, whichever is greater, beyond the structure perimeter or footing edges. The limits of over excavation for fill slopes should extend to 4.0 feet beyond the toe of the slope or to the depth of the over excavation beneath the toe of the slope, whichever is greater. The limits of over excavation for the decorative concrete block perimeter wall footings and/or retaining wall footings should extend to 4.0 feet beyond the footing edges or to the depth of the over excavation beneath the footing grade, whichever is greater. The limits of processing or over excavation for exterior hardscape, curb / gutter, and pavement areas should extend to 2.0 feet beyond the edge of the exterior hardscape, curb / gutter, or pavement, or to the depth of the over excavation beneath the finish subgrade elevation, whichever is greater.

  In areas where over excavation cannot be performed to the required distance beyond the foundations, (i.e., perimeter project block walls, retaining walls, etc.) along property lines, the foundations should be deepened to extend through the loose fill and near-surface, porous alluvial soils and be founded to a minimum depth of 1.0 foot into the firm underlying material (i.e., approximately 5.0 feet or greater below existing site grades).

- Where the exploratory backhoe trenches are located within the limits of the proposed over excavations for the proposed structural fills, structures, decorative walls, trash enclosure walls, retaining walls, exterior hardscape, and/or pavement areas, the trenches should be over excavated to the width and depth of the trench.

- It is noted that localized areas, once exposed, may warrant additional over excavation for the removal of existing undocumented fills, porous, moisture sensitive alluvial soils, and subsurface obstructions and/or debris which may be associated with the past usage of the site. Actual depths of removals and the competency of the exposed over excavation bottoms should be determined by the project Geotechnical / Geologic Consultant and/or his representative during grading operations at the time they are exposed and before scarification and recompaction or the placement of fill.

- The exposed over excavation bottom surfaces should be scarified to a depth of 6.0 to 12 inches, brought to optimum moisture content to 3.0 percent within optimum moisture content, and compacted to 90 percent or greater relative compaction before placement of fill. Maximum dry density and optimum moisture content for compacted materials should be determined according to current ASTM D1557 procedures. The scarification and recompaction of the exposed over excavation bottoms in bedrock materials may be deleted upon approval by the project Geotechnical / Geologic Consultant, and/or his representative. The scarification and recompaction of the exposed over excavation bottoms in alluvial materials may be deleted upon approval by the project Geotechnical / Geologic Consultant, and/or his representative when in-place density test results in the undisturbed alluvial materials indicate a relative compaction of 90 percent or greater.

Import Material

Imported fill should not be more expansive in nature than the existing on-site material as determined by current ASTM D4829 procedures and have strength parameters equivalent to or greater than the on-site soils. Imported fill material should be approved by the project Geotechnical / Geologic Consultant prior to it being brought on-site.

Fill Placement Requirements

Fill material, whether on-site material or import, should be approved by the project Geotechnical / Geologic Consultant and/or his representative before placement. Fill material should be free from vegetation, organic material, debris, and oversize material (i.e., 3 inches in maximum dimension). Approved fill material should be placed in horizontal lifts not exceeding 6.0 to 12 inches in compacted thickness or in thicknesses the grading contractor can demonstrate that he can achieve adequate compaction and watered or aerated to obtain optimum moisture content to 3.0 percent above optimum moisture content. Each lift should be spread evenly and should be thoroughly mixed to ensure uniformity of soil moisture. Fill soils should be compacted to 90 percent or greater relative compaction. Maximum dry density and optimum moisture content for compacted materials should be determined in accordance with current ASTM D1557 procedures.

Compaction Equipment

It is anticipated that the compaction equipment to be used for the project will include a combination of rubber-tired, track-mounted, sheepsfoot, and/or vibratory rollers to achieve compaction. Compaction by rubber-tired or track-mounted equipment, by itself, may not be sufficient. Adequate water trucks, water pulls, and/or other appropriate equipment should be available to provide sufficient moisture and dust control. The actual selection of equipment and compaction procedures are the responsibility of the contractor performing the work and should be such that uniform compaction of the fill is achieved.

Shrinkage, Bulking, and Subsidence

There will be a material loss due to the clearing and grubbing operations. The following values are exclusive of losses due to clearing, grubbing, tree root removal, or the removal of other subsurface features and may vary due to differing conditions within the project boundaries and the limitations of this study.

Volumetric shrinkage of the fill materials and near-surface alluvium on the subject site that are excavated and replaced as controlled, compacted fill should be anticipated. It is estimated that the average shrinkage of the near-surface soils within the upper 5.0 feet of the site which will be removed and replaced will be approximately 8.0 to 14 percent, based on fill volumes when compacted to 90 to 95 percent of maximum dry density for the soil type based on current ASTM D1557 procedures. For example, an 8.0 percent shrinkage factor would mean that it would take 1.08 cubic yards of excavated material to make 1.0 cubic yard of compacted fill at 90 percent relative compaction. A higher relative compaction would mean a larger shrinkage value. Any oversize rock removal and export will also result in additional shrinkage.

A subsidence factor (loss of elevation due to compaction of existing fill and/or alluvial soils in-place) of 0.07 to 0.12 foot per foot of compacted soil should be used in areas where the existing soils are compacted in-place to 90 to 95 percent relative compaction and to a depth of 12 inches.

Subsidence of the site due to settlement from the placement of less than 5.0 feet of fill (not including the depth of over excavation and replacement) during the planned grading operation is expected to be minimal.

Although the above values are only approximate, they represent the recommended estimate of some of the respective factors to be used to calculate lost volume that will occur during grading.

Abandonment of Existing Underground Lines

Abandonment of existing underground irrigation, utility, or pipelines, if present within the zone of construction, should be performed by either excavating the lines and filling in the excavations with documented, properly compacted fill or by filling the lines with a low strength sand / aggregate / cement slurry mixture. Filled lines should not be permitted closer than 3.0 feet below the bottom of proposed footings and/or concrete slabs on-grade. The lines should be cut off at 5.0 feet or greater from the area of construction. The ends of the lines should be plugged with 5.0 feet or more of concrete exhibiting minimal shrinkage characteristics to prevent water or fluid migration into or from the lines. Capping of the lines may also be needed if the lines are subject to line pressures. The slurry should consist of a fluid, workable mixture of sand, aggregate, cement, and water. Plugs should be placed at the ends of the line prior to filling with the slurry mixture. Cement should be Portland cement conforming to current ASTM C150 specifications. Water used for the slurry mixture should be free of oil, salts, and other impurities which would have an adverse effect on the quality of the slurry. Aggregate, if used in the slurry, mixture should meet the following gradation or a suitable equivalent:

SIEVE SIZE	PERCENT PASSING
1.5"	100
1.0"	80-100
3/4"	60-100
3/8"	50-100
No. 4	40-80
No. 100	10-40

The sand, aggregate, cement, and water should be proportioned either by weight or by volume. Each cubic yard of slurry should not contain less than 188 pounds (2.0 sacks) of cement. Water content should be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed. The slurry should be placed within 1.0 hour of mixing. The contractor should take precautions so that voids within the line to be abandoned are completely filled with slurry.

Local ordinances relative to abandonment of underground irrigation, utility, or pipelines, if more restrictive, supersede the above recommendations.

Over-Size Rock Disposal

Any over-size rock material with measurements of 12 inches or greater in maximum dimension will have to be properly disposed of offsite since it is anticipated that there will not be any deep fills to be placed in which to properly dispose of the over-size material as part of the site development.

Slope Setbacks

Cut and fill slope setbacks from the permit boundary lines should be in accordance with Appendix 'J,' Section J108, 'Setbacks,' of the 2022 CBC or current San Bernardino County, California grading ordinances, whichever is more stringent.

Fill Slopes

Finish fill slopes should not be inclined steeper than 2H:1V (Horizontal to Vertical). Fill slope surfaces should be compacted to 90 percent relative compaction to the face of the finished slope. Overexcavation beneath proposed fill slopes should be performed in accordance with the recommendations presented in previous sections of this report. Fill slopes should be constructed in a skillful manner so that they are positioned at the design orientations and slope ratio. Achieving a uniform slope surface by subsequent thin wedge filling should be avoided. Add-on correction to a fill slope should be conducted under the observation and recommendations of the project Geotechnical / Geologic

Consultant. The proposed add-on correction procedures should be submitted in writing by the contractor before commencement of corrective grading and reviewed by the project Geotechnical / Geologic Consultant. Compacted fill slopes should be back rolled with appropriate equipment for the type of soil being used during fill placement at intervals not exceeding 4.0 feet in vertical height. As an alternative to the bankrolling of the fill slopes, over-filling of the slopes will be considered acceptable and preferred. The fill slope should be constructed by over-filling with compacted fill to 3.0 feet or greater horizontally, and then trimmed back to expose the dense inner core of the slope surface. Fill slopes steeper than 3H:1V are moderately susceptible to erosion due to the low cohesion parameters of the soils.

Cut Slopes

Finish cut slopes in alluvium should not be inclined steeper than 2H:1V (Horizontal to Vertical). The cut slopes should be observed by the project Geotechnical / Geologic Consultant and/or his representative during grading to provide supplemental recommendations for stability of slopes, if needed. Cut slopes that face in the same direction as the prevailing natural slope will require top of cut paved interceptor swales. Cut slopes steeper than 3H:1V are moderately susceptible to erosion due to the low cohesion parameters of the soils.

Loose Material on Slope Face

The grading contractor should be made aware to take care to avoid spillage of loose material down the face of slopes during grading and during drainage terrace and down drain construction. Fine grading operations for benches and down drains should not deposit loose trimmed soils on the finished slope surfaces.

Slope Creep

Proposed slopes are planned to be stable under normal conditions and moderate earthquakes. However, movement due to creep effects of improvements located near the tops of existing slopes and/or proposed fill and cut slopes must be considered. Due to moisture variations and natural gravity forces, the soils on the face of a slope tend to move downward and outward with time. Past experience has indicated that there is a zone which ranges back from the top of the slope edge that may experience movement. This zone varies from approximately 5.0 feet to 15 to 20 feet depending on the type of soil the slope is composed of, the height of the slope, the inclination of the slope, moisture conditions, etc. The movement tends to be greatest at the top of the slope near the slope edge. Improvements within the creep zone should be designed and constructed to accommodate the anticipated movements. The movements may vary from a fraction of an inch to several inches and are dependent on the slope height, soil type, distance from the slope edge, and other factors.

Slope Protection

Permanent slope maintenance and protection measures as presented in the subsequent ‘Slope Maintenance and Protection Recommendations’ section of this report should be initiated as soon as practicable after completion of cut and/or fill slope construction. Fill slopes and cut slopes in alluvium materials steeper than 3H:1V (Horizontal to Vertical) are moderately susceptible to erosion due to the low cohesion parameters of the soils. The plant mix, method of application, and maintenance requirements are subject to the approval of a registered Landscape Architect or other qualified landscape professional. Construction delays, climate or weather conditions, and plant growth rates may be such that additional short-term non-plant erosion management measures may be needed. Examples would include matting, netting, plastic sheets, deep staking (5.0 feet or deeper), etc.

Protection of Work

During the grading process and prior to the completion of construction of permanent drainage controls, it is the responsibility of the grading contractor to provide good drainage and prevent ponding of water and damage to the in progress or finished work on the site and/or to adjoining properties.

Observation and Testing

During grading, observation and testing should be conducted by the project Geotechnical / Geologic Consultant and/or his representatives to verify that the grading is being performed according to the recommendations presented in this report. The project Geotechnical / Geologic Consultant and/or his representative should observe the over excavation bottoms and the placement of fill and should take tests to verify the moisture content, density, uniformity, and degree of compaction obtained. The contractor should notify the project Geotechnical / Geologic Consultant when cleanout and/or over excavation bottoms are ready for observation and prior to scarification and recompaction. Where testing demonstrates insufficient density, additional compaction effort, with the adjustment of the moisture content when needed, should be applied until retesting shows that satisfactory relative compaction has been obtained. The results of observations and testing services should be presented in a formal 'Grading Report' following completion of the grading operations. Grading operations undertaken at the site without the project Geotechnical / Geologic Consultant and/or his representative present may result in exclusions of the affected areas from the grading report for the project. The presence of the project Geotechnical / Geologic Consultant and/or his representative will be for the purpose of providing observations and field testing and will not include supervision or directing of the actual work of the contractor or the contractor's employees or agents. Neither the presence and/or the non-presence of the project Geotechnical / Geologic Consultant and/or his field representative nor the field observations and testing will excuse the contractor for defects discovered in the contractor's work. If **HGI** does not perform the observation and testing of the earthwork for the project and is replaced as Geotechnical / Geologic Consultant of record for the project, the work on the project should be stopped until the replacement Geotechnical / Geologic Consultant has reviewed the previous reports and work performed for the project, agreed in writing to accept the recommendations and prior work performed by **HGI** for the subject project, or has performed their own studies and submitted their revised recommendations.

Soil Expansion Potential

The preliminary expansion potential of the on-site soils is discussed in the subsequent foundation and floor slab recommendation sections of this report. Upon completion of grading for the building pad areas, near-surface samples should be obtained for expansion potential testing to verify the preliminary expansion test results and the foundation and slab-on-grade recommendations presented in this report.

Soil Corrosion Potential

The preliminary corrosion potential of the on-site soil is discussed in the subsequent corrosion recommendation sections of this report. Upon completion of grading for the building pad areas, near-surface samples should be obtained for corrosion potential testing to verify the preliminary chemical test results and the recommendations presented in this report for protection of concrete which come in direct contact with the on-site soils and to present recommendations for protection of bare metal, if desired, which come in direct contact with the on-site soils.

SEISMIC COEFFICIENTS

Based on our field investigation, the 2022 California Building Code (CBC), and

ASCE/SEI 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16), the site could be designated as **Site Class C** per Table 20.3-1 of ASCE 7-16. The occupancy risk category can be designated as II. Other required seismic design parameters can be obtained from Section 1613 of the 2022 CBC or could be obtained from the California Structural Engineers Association website: ***https://seismicmaps.org/*** below by entering the address of the project site (34.2099152, -117.0867135), the computer outputs are summarized in the following table:

Spectral Response Accelerations S_{MS} and S_{M1}	
S_s = 1.5g, S_{MS} = Fa x Ss	S_1 = 0.6g, S_{M1} = Fv x S_1
Site Class C: Fa = 1.2, Fv = 1.4	
Period (Sec.)	Sa (g)
0.2	1.8 (S_{MS}, Site Class C)
1.0	0.84 (S_{M1}, Site Class C)

Design Spectral Response Accelerations S_{DS} and S_{D1}	
S_{DS} = 2/3 x S_{MS}	S_{D1} = 2/3 x S_{M1}
PGA=0.626g, F_{PGA}=1.2, PGA_M=0.752g	
Period (Sec.)	Sa(g)
0.2	1.2 (S_{DS}, Site Class C)
1.0	0.56 (S_{D1}, Site Class C)
Seismic Design Category: D	

PRELIMINARY FOUNDATION DESIGN RECOMMENDATIONS

General

The foundation recommendations presented in this report are considered preliminary since the type of structures, the ground floor level elevations, the structural loads, etc. were not known at the time of this report.

The recommendations presented in the subsequent paragraphs for foundation design and construction are based on geotechnical characteristics and expansive soil conditions for the supporting soils and should not preclude more restrictive structural requirements. Per 2022 CBC, foundations for structures resting on soils with an Expansion Index greater than 20 require special design considerations or such other engineering design based on geotechnical recommendations as approved by the building official. Foundations for proposed building structures could consist of a 'Slab-on-Ground Foundation' system based on the **Wire Reinforcement Institute, Inc.** procedures or a 'Post-Tension Slab-on-Ground' system based on the **Post Tensioning Institute**. However, since foundations in the Arrowbear area of San Bernardino County, California must be deepened due to frost penetration in the winter months, it may also be feasible to use a foundation system which is deepened to a depth below where volume changes occur in the soils due to wetting and drying with pre-saturation under the floor slabs for the subject structures.

Recommendations for a deepened foundation system and pre-saturation under the floor slabs are presented in the following sections. The project Structural Engineer may design a 'Slab-on-Ground Foundation' system based on the **Wire Reinforcement Institute, Inc.** procedures or a 'Post-Tension Slab-on-Ground' system based on the **Post Tensioning Institute** as an alternative to deepened conventional reinforced concrete foundations and cast-on-grade concrete floor slabs. Geotechnical parameters for the design of a 'Slab-on-Ground Foundation' system or a 'Post-Tension Slab-on-Ground' system can be submitted upon request, if needed.

The foundations for proposed decorative block walls, retaining walls, etc. may consist of conventional continuous footings which are deepened to a depth below where volume changes occur in the soils due to wetting and drying or be isolated from the expansive soils.

The Structural Engineer for the project should determine the actual foundation type and footing width, depth, and reinforcing to resist design vertical, horizontal, and uplift forces under static and seismic conditions. Reinforcement recommendations presented in this report are considered the minimum for the soil conditions present on the site and are not intended to supersede the design of the project Structural Engineer or the criteria of the governing agencies for the project.

Due to the freeze / thaw conditions during the winter months in the project area, air entrained concrete should be utilized for concrete exposed to these conditions.

Deepened Conventional Foundations

Foundation Size: Continuous footings should have a minimum width of 12 inches for 1-story structure and a minimum width of 15 inches for 2-story structures. Footings supporting a roof only should be as required for supporting one (1) floor. Continuous footings should be continuously reinforced with a minimum of two (2) No. 4 steel reinforcing bars located near the top and two (2) No. 4 steel reinforcing bars located near the bottom of the footings to minimize the effects of slight differential movements which may occur due to minor variations in the engineering characteristics or seasonal moisture change in the supporting soils. Column footings should have a width of 18 inches by 18 inches or greater and be suitably reinforced, based on structural requirements. The continuous footings should extend across doorway and garage entrances and should be founded at the same depths and reinforced the same as the adjacent footings.

Depth of Embedment: Exterior footings should extend to a depth of 24 inches or greater below lowest adjacent finish grade due to the expansive characteristics of the near-surface alluvial soils. Frost is also considered a design factor for foundations in the Arrowbear area of San Bernardino County, California. The recommended depth of embedment will also be below anticipated frost depths in the project area since there will not be any significant frost penetration in the winter months.

Footing Setback: Embedment of footings on or near existing or planned slopes should be determined by a setback distance measured from the bottom outside edge of the footing to the slope face in accordance with the 2022 CBC or the current San Bernardino County, California Building Codes, whichever is greater.

Foundations for the proposed structure and/or retaining walls on slopes that are steeper than 10H:1V (Horizontal to Vertical) (10 percent slope) should be designed in accordance with the 2022 CBC. The top surface of the footings should be level or should be stepped so that both the top and bottom of such foundations are in accordance with the provisions in the 2022 CBC. The stepped foundation should be suitably reinforced and designed by a qualified Civil or Structural Engineer.

The fine-grained soils overlying the natural slopes on the subject site are prone to downslope creep. The rate of creep is a function of the length and steepness of the slope, the moisture content of the soils, the depth of creep prone soils, and the degree and care and maintenance of the slope. Slope creep is activated by wetting of the soil mantle. In addition, the presence of burrowing animals can reduce the integrity of the soil and increase the downslope creep.

Bearing Capacity: Provided the recommendations for site earthwork and for footing width and depth of embedment are incorporated into the project design and construction, the allowable bearing value for design of continuous and column footings for the total dead plus frequently-applied live loads is 2,000 pounds per square foot (psf) for footings that are 12 inches in width and a depth of embedment of 12 inches or greater below lowest adjacent finish grade for footings founded in undisturbed, documented, properly, compacted fill material.

For eccentrically loaded footings and/or overturning moments, the resultant force should be in the middle one-third of the footing and the average bearing value across the footing should not exceed the recommended allowable bearing value. The allowable bearing values have a factor of safety of 3.0 or greater and may be increased by 33.3 percent for short durations of live and/or dynamic loading such as wind or seismic forces.

Settlement: Footings designed according to the recommended bearing value for continuous and column footings, the assumed maximum wall and column loads, and founded in undisturbed, properly compacted fill material are not expected to exceed a total settlement of 1.0 inch or a differential settlement of 0.25 inch between similarly sized and loaded footings.

Lateral Capacity

Resistance to lateral loads can be provided by a combination of friction acting at the base of the foundation and passive earth pressure on the sides of the footings and stem walls. Foundation design parameters, based on undisturbed, documented, properly compacted fill or undisturbed, in-situ alluvium for resistance to static lateral dead forces are as follows:

Allowable Lateral Bearing Pressure

(Equivalent Fluid Pressure), Passive Case:

Undisturbed, Documented, Compacted Fill - 150 pcf

Undisturbed Alluvial Soil - 150 pcf

* Pounds per Square foot per Foot of Depth (pcf).

Allowable Lateral Sliding Coefficient of
Friction Between Soil and Concrete:

Undisturbed, Documented, Compacted Fill - 0.25

Undisturbed Alluvial Soil - 0.25

The above values are allowable design values and have safety factors of 2.0 or greater incorporated into them and may be used in combination without reduction in evaluating the resistance to lateral loads. The recommended lateral resistance assumes a horizontal surface for the soil mass extending to 10 feet or greater from the face of the footing, or three (3) times the height of the surface generating passive pressure, whichever is greater. The allowable values may be increased by 33.3 percent for short durations of live and/or dynamic loading, such as wind or seismic forces. For the calculation of the allowable lateral bearing pressure (passive earth resistance), the upper 1.0 foot of material should be neglected unless confined by a concrete slab or pavement. The largest recommended allowable lateral bearing pressure (passive earth resistance) is 15 times the recommended design value for the appropriate class of material.

Final Foundation Design Recommendations

Final foundation recommendations should be made upon completion of grading and be included in the 'Report of Grading' prepared by the Geotechnical / Geologic Consultant for the project.

Foundation Excavations

Foundation excavations should be observed by the project Geotechnical / Geologic Consultant and/or his representative prior to placement of forms, reinforcing steel, or placement of concrete for the purpose of verification of the recommendations presented in this report and for compliance with the project plans and specifications. The foundation excavations should be trimmed neat, level, and square. Any loose or sloughed material and debris should be removed from the foundation excavations prior to placement of reinforcing steel and removed again prior to the placement of concrete. Soils removed from the foundation excavations should not be placed in slab-on-grade areas unless compacted to 90 percent or greater relative compaction. The maximum dry density and optimum moisture content for the soil should be determined in accordance with current ASTM D1557 procedures.

SLAB-ON-GRADE FLOOR RECOMMENDATIONS

The recommendations for concrete slabs on-grade, both interior and exterior, excluding Portland Cement Concrete (PCC) pavement, based on geotechnical characteristics and expansive conditions for the supporting soils. The expansion potential of the slab subgrade areas should be verified at the completion of grading of the building pad areas. Concrete slabs should be designed to minimize cracking as a result of shrinkage. Joints (isolation, contraction, and construction) should be placed in accordance with the American Concrete Institute (ACI) or Portland Cement Association (PCA) guidelines. Special precautions should be taken during placement and curing of concrete slabs. Excessive slump (high water / cement ratio) of the concrete and/or improper curing procedures used during either hot or cold weather conditions could result in excessive shrinkage, cracking, or curling in the slabs. It is recommended that concrete proportioning, placement, and curing be performed in accordance with ACI recommendations and procedures.

Commercial and/or industrial slabs should be designed by the project Structural Engineer in accordance with Portland Cement Association (PCA) or other approved design procedures for the actual loads and uses proposed.

Interior floor Slabs with a Deepened Conventional Foundation System

Interior concrete slabs-on-grade should be 4.0 inches or greater in thickness and be underlain by 4.0 inches or greater (does not include the 1.0 to 2.0 inches of sand above a vapor barrier) of clean coarse sand, gravel, or other approved granular material with an Expansion Index (EI) = 0 and a Sand Equivalent (SE) value of 30 or greater placed on properly prepared subgrade per the ‘Earthwork

Recommendations' section of this report. The granular layer should be compacted to 90 percent or greater of maximum dry density as determined by current ASTM D1557 procedures. The concrete for the floor slab should have a compressive strength of 2,500 psi or greater at 28 days. Slab reinforcement should consist of a minimum of No. 3 reinforcing bars placed 18 inches on center in both directions, or an equivalent substitute. The reinforcing should be placed at mid-depth to 1.5 inches below the top surface of the slab to minimize cracking. The reinforcing should be tied into the adjacent footing stem wall. The concrete section, reinforcing steel, and/or design concrete compressive strength should be increased appropriately for anticipated excessive or concentrated floor loads. A Modulus of Subgrade Reaction (k_s) of 200 pounds per square inch per inch of deflection is recommended for the design of structural slabs cast on grade for excessive floor loads.

Subgrade soils should be moisture conditioned to 120 percent of optimum moisture content to a depth of 18 inches or greater immediately before placing the sand or gravel material, the vapor barrier, or pouring concrete.

If a vapor barrier / moisture retarder is used under the floor slab and it is placed on well graded crushed gravel material, it is recommended that a 1.0-inch-thick layer of sand or other approved granular material be placed beneath the vapor barrier / moisture retarder to prevent punctures from angular gravel fragments and projections. If open graded gravel (capillary break) is placed beneath the vapor barrier or retarder, the gravel should be 6.0 inches or greater in thickness. If open graded gravel is used, a separation fabric such as Mirafi 140N series or an equivalent substitute should be used in-leu of a sand cushion to protect the vapor barrier / moisture retarder from punctures.

Subgrade soils should be moisture conditioned to optimum moisture content to 3.0 percent above optimum moisture content to a depth of 12 inches and proof compacted to 90 percent or greater relative compaction based on current ASTM D1557 procedures immediately before placing the gravel material, the moisture barrier, or pouring concrete.

Vapor Barrier / Moisture Retarder Recommendations

In areas where moisture sensitive floor coverings are anticipated over the floor slab, the use of a vapor barrier / moisture retarder beneath the slab should be considered. The use or non-use of a vapor barrier / moisture retarder, the thickness of the vapor barrier / moisture retarder, the use of a granular layer over the vapor barrier / moisture retarder, the thickness of the granular materials, the type of granular material, etc. should be determined by the Structural Engineer who is designing the floor slab in conjunction with the Architect who is specifying the use and the type of floor coverings to be placed over the floor slab. The vapor barrier / moisture retarder recommendations provided by the supplier of the flooring materials should also be incorporated into the project plans.

EXTERIOR CONCRETE FLATWORK

Due to the freeze / thaw conditions during the winter months in the project area, air entrained concrete should be considered for use in concrete exposed to these conditions.

Due to the expansion potential of some of the near-surface on-site soils, exterior slabs-on-grade will experience seasonal vertical movement and cracking. There are several alternatives for minimizing or mitigating the impacts of expansive soils beneath exterior flatwork. Recommendations to reduce the distress to concrete flatwork include moisture conditioning the subgrade soils, using non-expansive fill, and providing adequate construction and control joints in the concrete. It should be noted that localized cracking, vertical movement, and distress could still occur.

- The minimum recommendation for concrete flatwork constructed on expansive soils is to properly prepare the clayey soils prior to placing concrete. This is typically achieved by scarifying, moisture conditioning, and re-compacting the subgrade soil. The subgrade soils should be moisture conditioned to a depth of 18 inches or greater and to 120 percent or greater of the optimum moisture content for the supporting soils as determined by current ASTM D1557 procedures. The subgrade soils should be compacted using moderate compaction effort to a relative compaction of 87 to 92 percent relative compaction. If the near-surface subgrade soils had previously been compacted and tested, the subgrade soils could possibly be moisture conditioned by gradually wetting the soil, depending on the time of the year the flatwork construction occurs. This procedure should not include flooding or excessively wetting of the soil, which would likely result in soft, unstable subgrade conditions, and possible delays in the construction while waiting for the soils to dry out. In general, the subgrade soils should be firm and non-yielding prior to constructing the flatwork.
- The replacement of expansive soils with non-expansive soils, aggregate base, crushed rock, gravel, sand, etc, in localized areas under exterior flatwork should be avoided unless the materials are provided with a positive drainage system which will prevent a "bathtub" type situation. If non-expansive soils, aggregate base, crushed rock, gravel, sand, etc, are used under the exterior flatwork, the materials should be proof compacted to 90 percent or greater relative compaction based on ASTM D1557 procedures. The subgrade soils under the non-expansive soils, aggregate base, crushed rock, gravel, sand, etc., should be prepared in accordance with the recommendations in the above bulleted paragraph.

- Use of maximum control joint spacing of no more than 8.0 feet in each direction and a construction joint spacing of 10 to 12 feet should be used in the design of flatwork on expansive soils. Construction joints that abut the foundations or garage slab should include a felt strip, or approved equivalent, which extends the full depth of the exterior slab. This will help to reduce the potential for permanent vertical offset between the slabs due to friction between the concrete edges. It is recommended that exterior slabs be isolated from adjacent foundations.

If the subgrade soils are allowed to become saturated, there is a risk of heaving and vertical differential movement of the exterior concrete hardscape, sidewalks, curbs / gutters, etc. Therefore, proper drainage should be established away from such improvements and minimal precipitation or irrigation water allowed to percolate into the soils adjacent to and/or under the exterior concrete flatwork or hardscape, curbs / gutters, etc.

RETAINING WALL RECOMMENDATIONS

Retaining walls may be needed to achieve finish grades for the proposed building pads, driveways, parking areas, and/or landscape areas. Due to the freeze / thaw conditions in the during the winter months in the project area, air entrained concrete should be utilized for concrete exposed to these conditions. Retaining walls should be designed in accordance with the recommendations in the following sections. If earth reinforced walls, crib wall, keystone walls, etc. are used for the development of the subject site, the design requirement of the proprietary wall system should supersede the following recommendations if there are any conflicts.

Static Lateral Earth Pressures

Retaining walls backfilled with non-expansive granular soil (i.e., Expansion Index (EI) = 0 or Unified Soil Classifications of SP, SW, SM, GP, GW, and GM) within a zone extending upward and away from the heel of the footing at a slope of 0.5H:1V (Horizontal to Vertical) or flatter for level backfill behind the wall can be designed to resist static lateral earth pressures equivalent to those recommended in the following table:

CONDITION	LEVEL BACKFILL AND SOIL CLASSIFICATION*		
	SP, SW, GP, GW	GM	SM
Active	30 pcf**	40 pcf	45 pcf
At-Rest	60 pcf	60 pcf	60 pcf
*	Per table 1610.1, ‘ Soil lateral Load,’ in the 2022 CBC.		
**	Equivalent fluid Pressure, pounds per square foot per foot of depth (pcf).		

The on-site clayey, expansive soils should not be used as backfill for retaining walls. The designer of the retaining wall should specify the type of backfill material to be used in the active / at-rest zone behind the wall. Walls that are free to deflect 0.001 radian at the top should be designed for the above-recommended active condition. Walls that are not capable of this movement should be assumed rigid and designed for the at-rest condition. The above values assume well-drained backfill and that a buildup of hydrostatic pressure will not occur. Surcharge loads, dead and/or live (i.e., construction loads, etc.), acting on the backfill within a horizontal distance behind the wall, equivalent to or less than the vertical height of the wall, should also be considered in the design. Uniform surcharge pressures should be applied as an additional uniform (rectangular) pressure distribution. The lateral earth pressure coefficient for a uniform vertical surcharge load behind the wall is 0.50. Seismic and wind loads should also be added to the design loads on the walls.

DYNAMIC (SEISMIC) EARTH PRESSURE

The increase in lateral earth pressure on any retaining wall higher than six feet from earthquake loading may be estimated using the Mononobe-Okabe method as described by Seed and Whitman (1970). Based on the theory, the total active pressure can be divided into static and dynamic components. The total earth active pressure could be divided into static and dynamic components. For the proposed project, lateral earth seismic increment as equivalent fluid pressure can be taken as:

$$\gamma_{seismic} = 3/4 * K_h * \gamma_s = 3/4 * 0.25 * 120 = 22.5 \text{ pcf (level backfill)}$$

$$= 30 \text{ pcf (3:1 backfill)}$$

$$= 32.5 \text{ pcf (2:1 backfill)}$$

Where, $K_h = 1/2 x 2/3 x PGAm$, PGAm=0.752g,

γ_s=120 pcf

Seismic loading shall be distributed as an inverted triangle from top to bottom of retained earth. The centroid of the dynamic lateral force increase shall be applied at a distance of 2/3H above the base of the wall, where H represents retained earth height. To estimate the total (static and dynamic) lateral forces, the dynamic lateral force increase may be added to the active pressure. For dynamic conditions, the safety factor for sliding and overturning may be reduced to 1.1.

Foundation Design

Retaining wall footings should be founded to the same depths below lowest adjacent finished grade and offsets from the face of slopes, and into undisturbed, observed and tested, compacted fill, or firm, competent, undisturbed, alluvial soil as recommended in the previous sections of this report for a deepened foundation system. The foundations may be designed for the same average allowable bearing value across the footing (as long as the resultant force is located in the middle one-third of the footing), and with the same allowable static and seismic allowable lateral bearing pressure, allowable passive earth pressure, and allowable sliding resistance as recommended in the 'Foundation Design Recommendations' section of this report. When using the allowable lateral pressure and allowable lateral sliding resistance, a factor of safety of 1.0 may be used. If ultimate values are used for design, an approximate factor of safety (i.e., 1.5) should be achieved.

Subdrain

A subdrain system should be constructed behind, and at the base of retaining walls to allow drainage and to prevent the buildup of excessive hydrostatic pressures. The subdrain system should be designed by the project Civil Engineer. The use of water-stops, impermeable barriers, or other damp proofing or waterproofing methods should be considered for any walls where moisture migration through the wall is considered critical to the performance and/or appearance of the walls. A waterproofing consultant should be retained to provide specific waterproofing recommendations for the project.

Typical subdrains may include weep holes with a continuous free draining gravel gallery, perforated pipe surrounded by free draining filter rock, or another approved system. The option of providing an ungrouted, open coarse of block at the bottom of a retaining wall is not a recommended drainage option since the openings are so often covered by landscape soil, hardscape, and or pavement. Gravel galleries and/or filter rock, if not designed and graded for the on-site and/or import materials, should be enclosed in a geotextile fabric such as Mirafi 140N series or an equivalent substitute, to prevent infiltration of fine soil particles into the subdrain and clogging of the system. Before placement of the fabric, the top of the footing should be cleared of loose soil materials, large stones, and/or other debris. Any large depressions or holes should be filled with a concrete slurry or a suitable equivalent to permit close contact of the fabric with the surrounding surface. The fabric should be placed smoothly without folds or excessive wrinkles. Successive sheets of the fabric should be placed with an overlap of 24 inches or more in the direction of the flow of the water in the pipe with the upstream layer overlapping the downstream layer. The fabric should be folded over the top of the free draining granular material producing an overlap of 12 inches or more. The perforated pipes should be Schedule 40 or stronger and 4.0 inches or greater in diameter. Perforations may be either bored 0.25-inch diameter holes or 0.1875-inch (3/16-inch) wide slots placed on the bottom one-third of the pipe perimeter. If the pipe is bored, a minimum of 10 holes per linear foot should be uniformly placed along the pipe. If slots are used, they should not exceed 2.0 inches in length and should not be closer than 2.0 inches on center along the length of the pipe. The total length of the slots should not be less than 50 percent of the pipe length and should be uniformly spaced along the length of the pipe. Pipe perforations should be placed downward. Gravel filters should have a volume of 3.0 cubic feet or greater per linear foot of pipe. Subdrains should maintain a positive flow gradient and have outlets that drain in a non-erosive manner.

Prefabricated drainage products such as ‘Miradrain’ or a suitable equivalent may also be used for the purpose of providing drainage behind retaining walls when installed in accordance with the manufacturer’s recommendations.

Backfill

Backfill directly behind retaining walls (if backfill width is less than 3.0 feet) may consist of 0.5- to 0.75-inch diameter, rounded to subrounded gravel with less than 5.0 percent passing the 0.5-inch sieve enclosed in a geotextile fabric such as Mirafi 140N series, or an equivalent substitute, or a clean sand (Sand Equivalent Value greater than 50) water jetted into place to obtain compaction. If water jetting is used, the subdrain system should be in place. Even if water jetting is used, the sand should be densified to 90 percent or greater relative compaction. If the specified density is not obtained by water jetting, mechanical methods will have to be used. If other types of soil or gravel are used for backfilling, mechanical compaction methods will have to be used to obtain a relative compaction of 90 percent or greater of maximum dry density. Backfill directly behind retaining walls should not be compacted by wheel, track, or other rolling by heavy construction equipment unless the wall is designed for the surcharge loading. If gravel, clean sand, or other imported backfill is used behind retaining walls in unpaved areas, the upper 12 to 18 inches of backfill should consist of typical on-site material compacted to 90 percent or greater relative compaction to prevent the influx of surface run-off into the granular backfill and into the subdrain system. Maximum dry density and optimum moisture content for backfill materials should be determined according to current ASTM D1557 procedures.

V-Drain Design

A V-drain should be constructed directly behind retaining walls which have a sloping backfill to intercept surface water and drain it from the back of the wall. The V-drain should be designed and constructed in accordance with the current typical standards of San Bernardino County, California. The V-drain should direct water from the back of the wall to an adequate down drain and discharge it in a non-erosive manner.

Observation and Testing

During retaining wall construction, observation and testing should be conducted by the project Geotechnical / Geologic Consultant and/or his representatives to verify that the work is being performed according to the recommendations presented in this report.

The foundation excavations should be observed by the project Geotechnical / Geologic Consultant and/or his representative prior to placement of forms, reinforcing steel, or placement of concrete for the purpose of verification of the recommendations presented in this report and for compliance with the project plans and specifications. The foundation excavations should be trimmed neat, level, and square. Any loose or sloughed material and debris should be removed from the foundation excavations prior to placement of reinforcing steel and removed again prior to the placement of concrete.

The placement and construction of the subdrain system behind the retaining walls should be observed by the project Geotechnical / Geologic Consultant and/or his representatives to verify that the work is being performed according to the recommendations presented in this report.

During backfill of the retaining walls, observation and testing should be conducted by the project Geotechnical / Geologic Consultant and/or his representatives to verify that the backfilling is being performed according to the recommendations presented in this report. The project Geotechnical / Geologic Consultant and/or his representative should observe the placement of fill and should take tests to verify the moisture content, density, uniformity, and degree of compaction obtained. Where testing demonstrates insufficient density, additional compaction effort, with the adjustment of the moisture content when needed, should be applied until retesting shows that satisfactory relative compaction has been obtained. The results of observations and testing services should be presented in a formal report following completion of the construction operations. Retaining wall backfill operations undertaken at the site without the project Geotechnical / Geologic Consultant and/or his representative present may result in exclusions of the affected areas from the final report for the project.

The presence of the project Geotechnical / Geologic Consultant and/or his representative will be for the purpose of providing observations and field testing and will not include supervision or directing of the actual work of the contractor or the contractor's employees or agents. Neither the presence and/or the non-presence of the project Geotechnical / Geologic Consultant and/or his field representative nor the field observations and testing will excuse the contractor for defects discovered in the contractor's work.

CORROSION POTENTIAL EVALUATION

The recommendations for corrosion protection should be verified at the completion of grading of the building pads on the subject site. Bulk samples of the near surface on-site soils were obtained during the field study which was performed for this report to evaluate the potential for soil corrosivity.

Concrete Corrosion

A preliminary test on a sample of near-surface on-site soil material suggests a soluble sulfate concentration of 0.0 to 0.001 percent. Soils with a water-soluble sulfate (SO_4) concentration are within exposure category S0 based on ACI 318-19 Tables 19.3.1.1 and 19.3.2.1. Cement Type I or II can be used in concrete.

SLOPE STABILITY EVALUATION

Since anticipated cut and fill slopes for the development of the site are not anticipated to exceed 10 feet in vertical height and will not be steeper than 2H:1V (Horizontal to Vertical), a formal slope stability analysis was not performed as part of this study. The proposed cut and fill slopes should be constructed at an inclination of 2H:1V or flatter. It is anticipated that the proposed cut slopes will expose alluvial material. It is anticipated that the proposed fill slopes will be constructed of the materials obtained from the proposed cuts for the development of the subject site and will be composed of the alluvial materials which are present on the subject site. It is the opinion of this firm that the proposed cut and fill slopes will be grossly and surficially stable as designed. However, the compacted fill and exposed cut materials will be vulnerable to erosion if precautions as recommended in the 'Slope Maintenance and Protection' section of this report are not implemented as soon as practicable after completion of grading.

PRELIMINARY PAVEMENT RECOMMENDATIONS

The following are preliminary recommendations for the structural pavement section for the proposed parking areas, driveway areas, and open storage areas for the subject development. The Hot Mix Asphalt (HMA) pavement sections have been determined in general accordance with current **CALTRANS** design procedures and are based on an assumed Traffic Index (TI) and an assumed R-Value of at least 30 based on past experience in the vicinity of the site and visual textural classification of the on-site soil and/or import materials which are anticipated to be at subgrade elevation. Portland Cement Concrete (PCC) pavement sections are based on equivalent structural numbers as the recommended HMA pavement section. The preliminary recommendations for the pavement sections should consist of the following:

RECOMMENDED PAVEMENT SECTIONS		
Site Area	**Traffic Index**	**Pavement Section**
Driveway and Parking Areas for Autos and Light Weight Vehicles Only.	≤5.0	3.0" Asphaltic Concrete (A.C.) over 5.9" Aggregate Base (A.B.) or 5.3" PCC @ 2,500 psi over properly prepared subgrade.
Driveway and Parking Areas for Heavy Weight Trucks, RV's, etc.	≤6.5	4.1" A.C. over 8.3" A.B. or 7.4" PCC @ 2,500 psi over properly prepared subgrade.

It is noted that the County of San Bernardino, California minimum pavement sections may override the above pavement recommendations without prior County review and approval.

Asphalt concrete pavement materials should be as specified in the current **CALTRANS** Standard Specifications or an equivalent substitute. Aggregate base should conform to Class 2 (37.5-mm {1-1/2"} Maximum or 19-mm {3/4"} Maximum) material as specified in the current **CALTRANS** Standard Specifications, or an equivalent substitute. Portland Cement Concrete sections are based on a compressive strength of 2,500 psi or greater at 28 days for the concrete. Higher strength design for the concrete can permit thinner pavement sections. A lower strength design for the concrete will require thicker pavement sections. Joints (longitudinal, transverse, construction, and expansion), jointing arrangement, joint type, pavement, and/or joint reinforcing, as well as drainage, crowning, finishing, and curing of PCC pavement should be in accordance with current Portland Cement Association (PCA) recommendations.

The subgrade soil, including utility trench backfill, should be compacted to 90 percent or greater relative compaction to a depth of 1.0 foot or greater below finish subgrade elevation. The aggregate base material should be compacted to 95 percent or greater relative compaction. If asphaltic concrete and/or PCC pavement is placed directly on subgrade, the upper 6.0 inches of the subgrade should be compacted to 95 percent or greater relative compaction. Maximum dry density and optimum moisture content for subgrade and aggregate base materials should be determined according to current ASTM D1557 procedures. The asphalt concrete pavement should be densified to 95 percent or greater of the density obtained by current California Test 304 and 308 procedures (Hveem compacted laboratory samples).

Special consideration should also be given to areas where truck traffic will negotiate small radius turns and/or to areas utilized by solid tired forklifts or other material handling equipment. HMA concrete pavement in these areas should utilize stiffer emulsions or the areas should be paved with Portland Cement concrete. Where HMA pavement abuts concrete aprons, drives, walks, or curb and gutter sections, a thickened edge transition zone is recommended for the HMA section to minimize the effects of impact loading as vehicles transition from PCC paving to HMA paving. This thickened edge should consist of an increased thickness of 2.0 inches for parking areas and 4.0 inches for areas of heavy truck usage. This thickened edge should extend to 3.0 feet or greater from the edge of pavement and then gradually taper back to the design pavement thickness. If pavement subgrade soils are prepared at the time of grading of the building site and the areas are not paved immediately, additional observations and testing will have to be performed before placing aggregate base material, asphaltic concrete, or PCC pavement to locate areas that may have been damaged by construction traffic, construction activities, and/or seasonal wetting and drying. In the proposed pavement areas, soil samples should be obtained at the time the subgrade is graded for R-Value testing according to current California Test 301 procedures to verify the pavement design recommendations.

Because the full design thickness of the asphalt concrete is frequently not placed prior to construction traffic being allowed to use the pavement in a development or the parking lots, rutting and pavement failures can occur prior to project completion. To reduce this occurrence, it is recommended that either the full-design pavement section be placed prior to use by the construction traffic, or a higher Traffic Index (TI) be specified where construction traffic will use the pavement.

Surface water infiltration beneath pavements could significantly reduce the pavement design life. To limit the need for additional long-term maintenance of the pavement or pre-mature failure, it would be beneficial to protect at-grade pavements from landscape water infiltration by means of a concrete cutoff wall, deepened curbs, or equivalent. Pavement cut-off barriers should be considered where pavement areas are located downslope of any landscape areas that are to be irrigated. The cut-off barrier should extend to a depth of at least 4.0 inches below the pavement section aggregate base material.

Due to the porous nature of the near-surface alluvial soils on the subject site, if over excavation and replacement is not performed under the pavement areas, there is a risk of settlement and vertical differential movement of the pavement, curbs / gutters, etc. if the subgrade soils are allowed to become saturated. Therefore, proper drainage should be established away from such improvements and minimal precipitation or irrigation water allowed to percolate into the soils adjacent to the pavement, curbs / gutters, etc.

The longevity and performance of pavements utilizing aggregate base material for support is dependent upon the quality of the material. **CALTRANS** specifications do not specifically exclude the use of material other than a natural, crushed rock and rock dust for Class 2 Aggregate Base material as the Standard Specifications for Public Works Construction, Section 200-2.2, does for Crushed Aggregate Base material. Often, reclaimed Portland Cement concrete and Hot Mix Asphalt concrete are crushed and graded to produce a Class 2 Aggregate Base material per **CALTRANS** gradation specifications. Bricks, concrete masonry units, tile, glass, ceramics, porcelain, wood, plastic, metal, etc. are not an acceptable reclaimed material for use in a Class 2 Aggregate Base material per the **CALTRANS** specifications. However, gradation is not the only quality guidelines for aggregate base material. If a reclaimed material is proposed for use on the project as a Class 2 Aggregate Base, the reclaimed materials should not exceed 50 percent of the total volume of the aggregate used. The aggregate base material should also be tested for the following quality requirements per the current, appropriate **CALTRANS** procedures:

TEST	TEST METHOD NO.	QUALITY REQUIREMENT	
		OPERATING RANGE	CONTRACT COMPLIANCE
Resistance (R-Value)	Calif. Test 301	--	78 Min.
Sand Equivalent	Calif. Test 217	25 Min.	22 Min.
Durability Index	Calif. Test 229	--	35 Min.

If a reclaimed material or a pit run aggregate is proposed for use on the project as a 'Greenbook' Crushed Miscellaneous Base, the materials should be tested for the following quality requirements, per the current 'Greenbook,' 2021 Edition, and appropriate procedures as well as the required gradation and other requirements:

TEST	TEST METHOD NO.	QUALITY REQUIREMENT
Resistance (R-Value)	Calif. Test 301	78 Minimum[1]
Sand Equivalent	Calif. Test 217	35 Minimum
Percent Wear[2] 100 Revolutions 500 Revolutions	ASTM C131	15 Maximum 52 Maximum
Gravel Particles[3], (%)	Calif. Test 202	15 Maximum

1. R-Value requirement may be waived if Sand Equivalent is 40 or more.
2. The percentage wear requirements may be waived if the material has a minimum Durability Index of 40 in accordance with CALTRANS Test Method 229.
3. Gravel is defined as particles with no more than one (1) fractured face.

A 'Greenbook' Crushed Miscellaneous Base may contain broken or crushed asphalt concrete or Portland Cement concrete and may contain crushed aggregate base or other rock materials. The Crushed Miscellaneous Base may contain no more than 3.0 percent brick retained on # 4 sieve by dry weight of the total sample.

Samples of the proposed aggregate base using reclaimed material should be sampled from the manufacturer's stockpiles prior to delivery to the project. The samples should be obtained at a time as near the delivery to the project as possible but would allow enough time to complete the testing and report the results before delivery to the site. Samples should again be obtained and tested for quality compliance from the materials delivered to the project. In addition, per the current **CALTRANS** Standard Specifications, "No single aggregate grading or Sand Equivalent test shall represent more than 500 cubic yards or one (1) day production, whichever is less."

Concrete gutters should be provided at flow lines in paved areas. Pavements should be sloped to permit rapid and unimpaired flow of runoff water. In addition, paved areas should be protected from moisture migration and ponding from adjacent water sources. Saturation of aggregate base and/or subgrade materials could result in pavement failure and/or premature maintenance. The gutter material and construction methods should conform to the current standards of San Bernardino County, California.

POST-GRADING CRITERIA

Soils generated from the excavation of foundations, utility trenches, etc., to be used on-site, should be moisture conditioned to optimum moisture content to 3.0 percent within optimum moisture content and compacted to 90 percent or greater of the maximum dry density for the material type as determined by current

ASTM D1557 procedures when it is to be placed under floor slabs, under hardscape areas, and/or in paved areas. The placement of the excess material should not alter positive drainage away from structures and/or off the lot and should not change the distance from the weep screed on the structure to the finished adjacent soil grade per the 'Finish Surface Drainage Recommendations' presented in a subsequent section of this report, the project plans, and/or the 2022 CBC.

SLOPE MAINTENANCE AND PROTECTION RECOMMENDATIONS

Although the design and construction of slopes are planned to create slopes that possess stability against mass rotational failure, surficial slumping, creep, and pop-outs, certain factors are beyond the influence of the project Geotechnical / Geologic Consultant. Soil slopes are subject to some erosion when subjected to sustained water application. To reduce long term erosion, the following recommendations for slope protection and maintenance should be considered when planning, designing, and implementing slope erosion methods:

- Surface water should not be allowed to flow over the on-site natural or proposed man-made slopes other than incidental rainfall and irrigation. Alterations of manufactured or natural slopes, terraces, top of slope berms, and/or pad gradients should not be allowed that will prevent pad and roof run-off from the structures from being expediently directed to approved disposal areas and away from the tops of slopes.

- Surface drainage should be positively maintained and directed to the street or storm drain system in a non-erosive manner.

- Top of slope berms should be constructed and compacted as part of finish grading of the property and should be maintained by the property owner.

The recommended drainage patterns should be established at the time of finish grading and maintained throughout the life of the proposed development. Concentrated surface waters entering the property from off-site sources should be collected and directed to a permanent drainage system.

- The property owner is responsible for the maintenance and cleaning of the interceptor ditches, drainage terraces, down drains and other drainage devices that have been installed to promote slope stability.

- It is recommended that slopes be planted with light-weight ground cover, shrubs and trees that possess deep (5.0 feet or greater), dense root structures that require minimal irrigation (drought resistance). It should be the responsibility of the Landscape Architect or other suitably qualified individual to provide such plants initially and of the [property] [individual lot] owner[s] to maintain such planting. Alteration of the planting scheme is at the property owner's risk.

- If automatic sprinkler systems are installed their use should be adjusted to account for natural rainfall.

- The property owner should establish a program for the elimination of burrowing animals. This should be an on-going program to protect slope stability.

- The property owner should observe the lot drainage during heavy precipitation periods as this is often when trouble occurs. Problems such as gullying or ponding should be corrected as soon as practicable.

- High moisture content in slope soils is a major factor in slope erosion and slope failures. Therefore, precautions should be taken to minimize soil saturation. Leakage from waterlines, irrigation systems, etc. or bypassing of clogged drains should be promptly repaired.

The above guidelines are provided to mitigate slope maintenance and protection problems. The above guidelines are general maintenance and design procedures but may be superseded under the specific direction of a Licensed Landscape Architect or other suitably qualified individual.

UTILITY TRENCH RECOMMENDATIONS

Utility trenches within the zone of influence of foundations or under building floor slabs, exterior hardscape, and/or pavement areas should be backfilled with documented, compacted soil. Utility trenches within the building pad and extending to 5.0 feet beyond the building exterior footings should be backfilled with on-site or similar soil. Where interior or exterior utility trenches are proposed to pass beneath or parallel to building, retaining wall, and/or decorative concrete block perimeter wall footings, the bottom of the trench should not be located below a 1H:1H (Horizontal to Vertical) plane projected downward from the outside bottom edge of the adjacent footing unless the utility lines are designed for the footing surcharge loads.

It is recommended that utility trench excavations be designed and constructed in accordance with current OSHA regulations. These regulations provide trench sloping and shoring design parameters for trenches up to 20 feet in vertical depth based on a description and field verification of the soil types encountered. Trenches over 20 feet in vertical depth should be designed by the Contractor's Engineer based on site specific geotechnical analyses. For planning purposes, we recommend that the following OSHA soil type designations and temporary slope inclinations be used:

EARTH MATERIAL	OSHA SOIL TYPE*	TEMPORARY SLOPE INCLINATION (H:V)**
Undocumented Fill	C	1.5:1
Compacted Fill	C	1.5:1
Alluvium	C	1.5:1
Weathered Bedrock	B	1:1
Granitic Formation	A	3/4:1

*Type 'A': Cohesive soils and weathered bedrock with an unconfined compressive strength of 1.5 tsf or greater.
Type 'B': Cohesive soils with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf.
Type 'C': Cohesive soils with an unconfined compressive strength of 0.5 tsf or less: or Granular soils including sands, gravels, loamy, clayey, or silty sands, etc.
** Steepest allowable slopes for excavations less than 20 feet in vertical height. Slopes for excavations greater than 20 feet in vertical height should be designed by a Registered Professional Engineer with experience in Geotechnical Consulting and Soil Mechanics.

The classification for granitic rock is to be assumed as Type 'A' for planning purposes. Upon making and observing the excavations, it may be upgraded to a "Stable Rock" classification. However, caution should be exercised, as this designation is based on the rock performance as opposed to a material description. A Type 'A' classification should be used if the rock is decomposed, or if joints or fractures daylight into the sidewalls of the trench. Upon making the excavations, the soil rock classifications and excavation performance should be confirmed in the field by a competent person as defined in the current OSHA regulations.

Excavations of less than 5.0 feet in depth may also be subject to collapse due to water, vibrations, previously disturbed soils, or other factors and may require protection for workers such as temporary slopes, shoring, or a shielding protective system. The excavations should be observed by a qualified, competent person (as defined in the current OSHA regulations) looking for signs of potential cave-ins on a daily basis before start of work, as needed throughout the work shifts, and after every rainstorm or other hazard-increasing occurrence.

Surcharge loads (i.e., spoil piles, earthmoving equipment, trucks, etc.,) should not be allowed within 1.5 times the vertical depth of the excavation. Excavations should be initially observed by the project Geotechnical / Geologic Consultant and/or his representative to verify the recommendations presented or to make additional recommendations to maintain stability and safety. Moisture variations, differences in the cohesive or cementation characteristics, or changes in the coarseness of the deposits may require slope flattening or, conversely, permit steepening upon review and appropriate testing by the project Geotechnical / Geologic Consultant and/or his representative. The excavations should be observed by a qualified, competent person (as defined in the current OSHA regulations) looking for signs of potential problems on a daily basis before start of work, as needed throughout the work shifts, and after every rainstorm or other hazard-increasing occurrence. Deep utility trenches may experience caving which will require special considerations to stabilize the walls and expedite trenching operations. Surface drainage should be controlled along the top of the construction slopes to preclude erosion of the slope face. If excavations are to be left open for long periods, the slopes should be sprayed with a protective compound and/or covered to minimize drying out, raveling, and/or erosion of the slopes.

Trench backfilling material should be placed in a lift thickness appropriate for the type of backfilling material and compaction equipment used. Backfilling material should be brought to optimum moisture content to 3.0 percent above optimum moisture content and compacted to 90 percent or greater relative compaction by mechanical means. Jetting or flooding of the backfill material will **not** be considered a satisfactory method for compaction. Maximum dry density and optimum moisture content for backfill material should be determined according to current ASTM D1557 procedures.

FINISH SURFACE DRAINAGE RECOMMENDATIONS

Positive drainage should be established away from the tops of slopes, the exterior walls of structures, the back of retaining walls, trash enclosure walls, decorative concrete block walls, etc. Finish surface gradients in unpaved areas should be provided next to tops of slopes and buildings to guide surface water away from foundations, hardscape, pavement, and from flowing over the tops of slopes. The surface water should be directed toward adequate drainage facilities. Ponding of surface water should not be allowed next to structures or on pavements. Design criteria for finish lot drainage away from structures and off the property should be determined by the project Structural Engineer designing the foundations and slabs in conjunction with the project Civil Engineer designing the precise grading for lot drainage, respectively, in accordance with the 2022 CBC and/or the current San Bernardino County, California building codes and the soil types and expansion characteristics for the soils contained in this report. Finished landscaped and hardscape or pavement grades adjacent to the proposed structures should maintain a vertical distance below the bottom elevation of the weep screed per the 2022 CBC and/or the current San Bernardino County building codes. Landscape plants with high water needs and trees should be planted at a distance away from the structure equivalent to or greater than the width of the canopy of the mature tree or 6.0 feet, whichever is greater. Downspouts from roof drains should discharge to a permanent all-weather surface which slopes away from the structure. Downspouts from roof drains should not discharge into planter areas immediately adjacent to the building unless there is positive drainage out of the planter and away from the structure in accordance with the recommendations of the project foundation and slab designer and/or the project Civil Engineer designing the precise grades for the lot drainage.

PLANTER RECOMMENDATIONS

Planters around the perimeter of the structures should be designed so that adequate drainage is maintained, and minimal irrigation water is allowed to percolate into the soils underlying the buildings. This should include enclosed or trapped planter areas that are created as a result of sidewalks. Planters with solid bottoms, independent of the underlying soil, are recommended within 6.0 feet from the buildings. The planters should drain directly onto surrounding paved areas or into a designed subdrain system. If planters are raised above the surrounding finished grades or are placed against the building structure, the interior walls of the planter should be waterproofed.

2. LIMITATIONS

REVIEW, OBSERVATION, AND TESTING

The recommendations presented in this report are contingent upon review of final plans and specifications for the project by **HGI**. The project Geotechnical / Geologic Consultant should review and verify in writing the compliance of the final grading plan and the final foundation plans with the recommendations presented in this report.

It is recommended that **HGI** be retained to provide continuous Geotechnical / Geologic Consulting services during the earthwork operations (i.e., rough grading, utility trench backfill, subgrade preparation for slabs-on-grade and pavement areas, finish grading, etc.) and foundation installation process. This is to observe compliance with the design concepts, specifications, and recommendations and to allow for design changes if subsurface conditions differ from those anticipated prior to start of construction. If **HGI** is replaced as Geotechnical / Geologic Consultant of record for the project, the work on the project should be stopped until the replacement Geotechnical / Geologic Consultant has reviewed the previous reports and work performed for the project, agreed in writing to accept the recommendations and prior work performed by **HGI** for the subject project, or has submitted their revised recommendations.

UNIFORMITY OF CONDITIONS

The recommendations and opinions expressed in this report reflect our understanding of the project requirements based on an evaluation of subsurface earth material conditions encountered at the subsurface exploration locations and the assumption that earth material conditions do not deviate appreciably from those encountered. It should be recognized that the performance of the foundations may be influenced by undisclosed or unforeseen variations in earth material conditions that may occur in intermediate and unexplored areas. Any unusual conditions not covered in this report that may be encountered during site development should be brought to the attention of **HGI** so that we may make modifications, if necessary.

CHANGE IN SCOPE

HGI should be advised of any changes in the project scope of proposed site grading so that it may be determined if recommendations contained herein are valid. This should be verified in writing or modified by a written addendum.

TIME LIMITATIONS

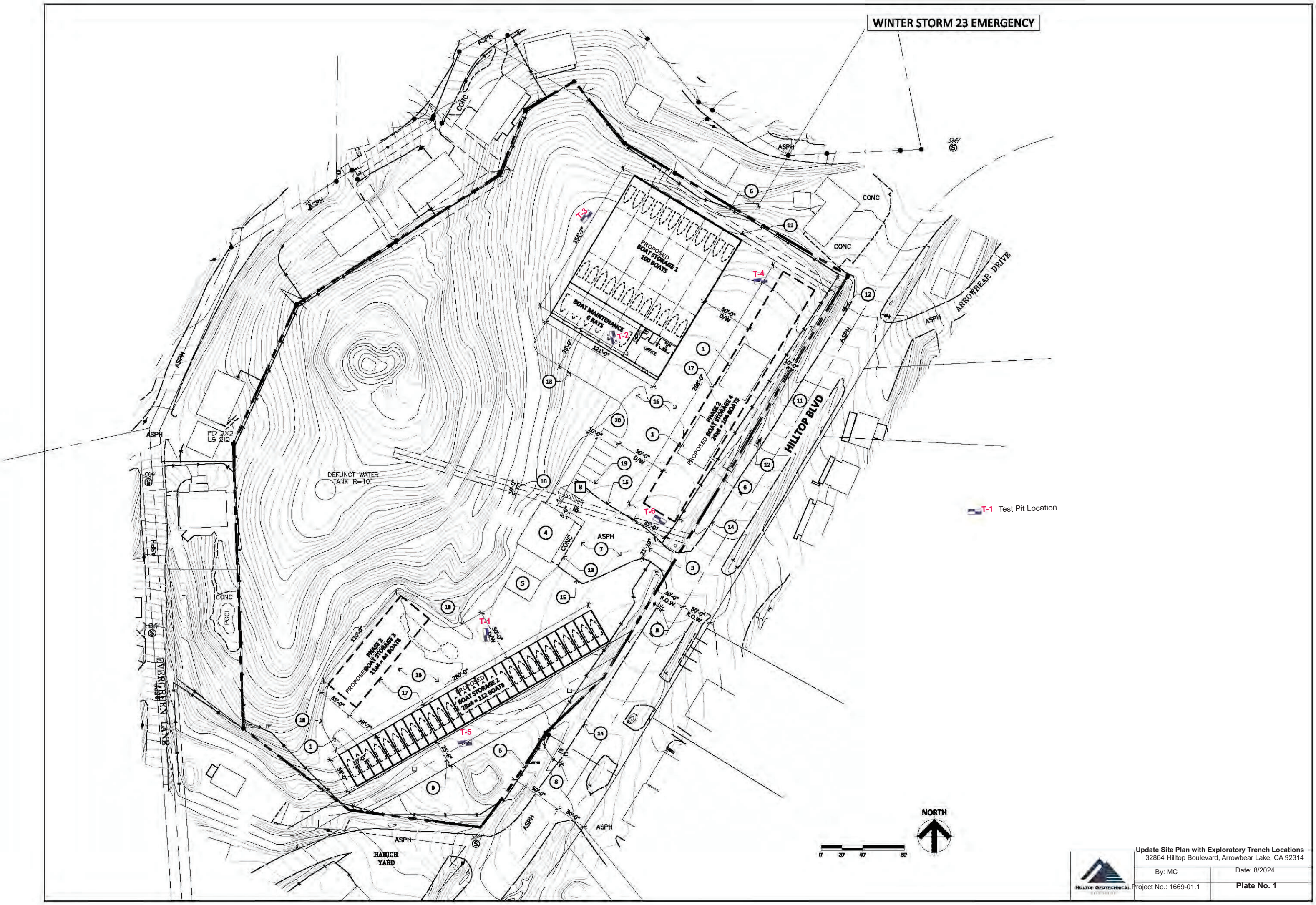
The findings of this report are valid as of this date. Changes in the condition of a property can, however, occur with the passage of time, whether they be due to natural processes or the work of man on this or adjacent properties. In addition, changes in the State-of-the-Art and/or government codes may occur. Due to such changes, the findings of this report may be invalidated wholly or in part by changes beyond our control. Therefore, this report should not be relied upon after a period of two (2) years without a review by **HGI** verifying the validity of the conclusions and recommendations.

PROFESSIONAL STANDARD

In the performance of our professional services, we comply with the standard of care and skill ordinarily exercised under similar circumstances by members of the geologic / geotechnical professions currently practicing under similar conditions and in the same locality. The client recognizes that subsurface conditions may vary from those encountered at the locations where our surveys and exploratory excavations were made, and that our data, interpretations, and recommendations are based solely on information obtained by us. We will be responsible for those data, interpretations, and recommendations, but should not be responsible for interpretations by others of the information presented and/or developed. Our services consist of professional consultation and observation only, and other warranties, expressed or implied, are not made or intended in connection with work performed by **HGI** or by the proposal for consulting or other services or by the furnishing of oral or written reports or findings.

CLIENT'S RESPONSIBILITY

It is the responsibility of the client and/or the client's representatives to ensure that information and recommendations contained herein are brought to the attention of the Engineers and Architect for the project and incorporated into project plans and specifications. It is further their responsibility to take measures so that the contractor and his subcontractors carry out such recommendations during construction.



Update Site Plan with Exploratory Trench Locations
32864 Hilltop Boulevard, Arrowbear Lake, CA 92314

By: MC	Date: 8/2024
Project No.: 1669-01.1	**Plate No. 1**

HILLTOP GEOTECHNICAL

ATTACHMENT A

Preliminary Geotechnical Investigation Report

by Hilltop Geotechnical, Inc.

REPORT OF GEOTECHNICAL / GEOLOGIC STUDY PROPOSED HILLTOP STORAGE FACILITY LOCATED ON NORTHWEST SIDE OF STATE HIGHWAY 18 BETWEEN POWERS LANE AND DEEP CREEK DRIVE IN THE ARROWBEAR AREA OF SAN BERNARDINO COUNTY, CALIFORNIA

PROJECT NO.: 688-A07.1
REPORT NO.: 1

DECEMBER 19, 2007

SUBMITTED TO:

HILLTOP STORAGE, LLC
P.O. BOX 770
RUNNING SPRINGS, CA 92382

PREPARED BY:

HILLTOP GEOTECHNICAL, INC.
786 SOUTH GIFFORD AVENUE
SAN BERNARDINO, CA 92408

HILLTOP GEOTECHNICAL
INCORPORATED

786 S. GIFFORD AVENUE • SAN BERNARDINO • CALIFORNIA 92408
hilltopg@hgeotech.com • FAX 909-890-9055 • **909-890-9079**

December 19, 2007

Hilltop Storage, LLC
P.O. Box 770
Running Springs, CA 92382

Project No.: 688-A07
Report No.: 1

Attention: Mr. Steve Aguirre

Subject: **Report of Geotechnical / Geologic Study, Proposed Hilltop Storage Facility, Located on Northwest Side of State Highway 18, Between Powers Lane and Deep Creek Drive in the Arrowbear Area of San Bernardino County, California.**

References:

1. FAXed Portions of an Unauthored, Undated, Untitled *Site Plan*.
2. Technical References - See Appendix 'C.'

Gentlemen:

According to your request, we have completed a geotechnical / geologic study for the design and construction of the proposed Hilltop Storage Facility. We are presenting, herein, our findings and recommendations.

The findings of this study indicate that the project site is suitable for the proposed development provided the recommendations presented in the attached report are complied with and incorporated into the design and construction of the project.

If you have any questions after reviewing the findings and recommendations contained in the attached report, please do not hesitate to contact this office. This opportunity to be of professional service is sincerely appreciated.

Respectfully submitted,

HILLTOP GEOTECHNICAL, INC.

Mark Hulett, CEG No. 1623
President

REGISTERED PROFESSIONAL ENGINEER
DONALD L. CURRAN
No. GE254
Exp: 3/31/09
GEOTECHNICAL
STATE OF CALIFORNIA

Donald L. Curran, GE No. 254
Senior Engineer
Date Signed: 12-19-07

RG/SS/MH/DLC/em

Distribution: (3) Addressee
(1) **S.L. Pleasant & Associates**
Attn: Mr. Steve Pleasant
3272 North "E" Street
San Bernardino, CA 92405

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REPORT OF
GEOTECHNICAL / GEOLOGIC STUDY
PROPOSED HILLTOP STORAGE FACILITY
LOCATED ON NORTHWEST SIDE OF STATE
HIGHWAY 18 BETWEEN POWERS LANE
AND DEEP CREEK DRIVE IN THE
ARROWBEAR AREA OF
SAN BERNARDINO COUNTY, CALIFORNIA

PROJECT NO.: 688-A07
REPORT NO.: 1

DECEMBER 19, 2007

INTRODUCTION

AUTHORIZATION

This report presents results of the geotechnical / geologic study conducted on the subject site for the proposed Hilltop Storage Facility to be located on northwest side of State Highway 18, between Powers Lane and Deep Creek Drive in the Arrowbear Area of San Bernardino County, California. The general location of the subject site is indicated on the 'Site Location Plan,' Figure No. 1.

Authorization to perform this study was in the form of a signed proposal from **Hilltop Geotechnical, Inc.** (Geotechnical / Geologic Consultant) to Mr. Steve Aguirre of **Hilltop Storage, LLC** (Client) c/o **S.L. Pleasant & Associates**, dated September 21, 2007, Proposal Number: P07171.

PURPOSE AND SCOPE OF STUDY

The scope of work performed for this study was designed to determine and evaluate the surface and subsurface conditions of the subject site with respect to

Reference: **U.S. Department of the Interior, Geological Survey**, 1967, Photorevised 1988, *Keller Peak Quadrangle, California - San Bernardino County, California,* 7.5-Minute Series (Topographic), Scale 1:24,000.

HILLTOP GEOTECHNICAL INCORPORATED	SITE LOCATION MAP	
	By: RG	Date: 12/07
	Project No.: 688-A07.1	Figure No.: 1

geotechnical characteristics, including potential geologic hazards that may effect the development of the site, and to provide geotechnical recommendations and criteria for use in the design and construction of the proposed development. The scope of work included the following:

- Review of locally and easily available published and unpublished soils, geologic, and seismologic reports and data for the area (see References in Appendix 'C'), flood hazard maps, well data, etc. to ascertain soils, geologic, and hydrologic conditions of the area.
- Telephone conversations with the client and/or representatives of the client.
- Site reconnaissance.
- Subsurface exploration by means of backhoe trenches to characterize earth material, geologic, and groundwater conditions that could influence the proposed development.
- Sampling of on-site earth materials from the exploratory excavations.
- Laboratory testing of selected earth material samples considered representative of the subsurface conditions to determine the engineering properties and characteristics.
- Define the general geology of the subject site and evaluate potential geologic hazards which would have an effect on the proposed site development.
- Determine seismic classification of the site to meet the requirements of the 2007 California Building Code (CBC), effective on January 1, 2008.
- Engineering analysis of field and laboratory data to provide a basis for geotechnical and geologic conclusions and recommendations regarding site grading and foundation, floor slab, retaining wall, pavement, etc. design parameters.
- Preparation of this report to present the geotechnical and geologic conclusions and recommendations for the proposed site development.

This report presents our conclusions and/or recommendations regarding:

- The geologic setting of the site.
- Potential geologic hazards (including landslides, seismicity, faulting, liquefaction potential, etc.)
- General subsurface earth conditions.
- Presence and effect of expansive, collapsible, and compressible soils.
- Groundwater conditions within the depth of our subsurface study.
- Excavation characteristics of the on-site earth materials.
- Characteristics and compaction requirements of proposed fill and backfill materials.
- Recommendations and guide specifications for earthwork.
- Seismic design coefficients for structural design purposes.
- Types and depths of foundations.
- Allowable bearing pressure and lateral resistance for foundations.
- Estimated total and differential settlements.
- Corrosion potential evaluation for concrete in direct contact with the on-site soils.
- Utility trench excavation and backfill recommendations.
- Slope maintenance and protection recommendations.
- Preliminary pavement recommendations.

The scope of work performed for this report did not include any testing of soil or groundwater for environmental purposes, an environmental assessment of the property, or opinions relating to the possibility of surface or subsurface contamination by hazardous or toxic substances. In addition, evaluation of on-site private sewage disposal systems for the proposed development was not part of this study.

This study was prepared for the exclusive use of **Hilltop Storage, LLC** and their consultants for specific application to the development of the proposed project in accordance with generally accepted standards of the geotechnical and geologic professions and generally accepted geotechnical (soil and foundation) engineering principles and practices at the time this report was prepared. Other warranties, implied or expressed, are not made. Although reasonable effort has been made to obtain information regarding geotechnical / geologic and subsurface conditions of the site, limitations exist with respect to knowledge of unknown regional or localized off-site conditions which may have an impact at the site. The conclusions and recommendations presented in this report are valid as of the date of this report. However, changes in conditions of a property can occur with passage of time, whether they are due to natural processes or to works of man on this and/or adjacent properties.

If conditions are observed or information becomes available during the design and construction process which are not reflected in this report, **Hilltop Geotechnical, Inc.**, as Geotechnical / Geologic Consultant of record for the project, should be notified so that supplemental evaluations can be performed and conclusions and recommendations presented in this report can be modified or verified in writing as necessary. Changes in applicable or appropriate standards of care in the geologic / geotechnical professions occur, whether they result from legislation or the broadening of knowledge and experience. Accordingly, the conclusions and recommendations presented in this report may be invalidated, wholly or in part, by changes outside the influence of the project Geotechnical / Geologic Consultant which occur in the future.

PREVIOUS SITE STUDIES

No previous geotechnical and/or geological studies for the subject site are known to have been performed or were made available for review at the time of this study, if any had been performed.

PROJECT DESCRIPTION / PROPOSED DEVELOPMENT

As part of our study, we have discussed the project with Mr. Steve Pleasant of **S.L. Pleasant & Associates**, a representative of the client. We also have been provided with the Reference No. 1 'Site Plan' noted on the first page of the cover letter for this report.

The Reference No.1 'Site Plan' indicates the subject property will be developed with a storage facility which will consist of several structures with paved parking areas, driveways, and open storage areas. The proposed structures were indicated to be approximately 6,465, 7,525, 8,400, and 21,300 square feet in size. The proposed buildings are expected to be 1- and/or 2-story structures consisting of wood trusses on wood heams and steel columns with wood or steel studs, and veneered wall construction or of concrete masonry construction. It is assumed that light to moderate loads will be imposed on the foundations. The foundation loads are not anticipated to exceed 3,500 pounds per lineal foot (plf) for continuous footings and 25 kips for column footings. The ground level floors for the proposed structures will consist of a concrete slab cast on compacted subgrade. Finish floor elevation for the structures had not been furnished at the time of our study. It is anticipated that there will be cuts and fills of less than 10 feet to achieve finish site grades for the project. Cut and fill slopes are also anticipated to be required for the development of the site. The cut and fill slopes are anticipated to be less than 10 feet in vertical height and have a 2H:1V (Horizontal to Vertical) slope inclination. Subterranean construction is not anticipated for the proposed structures. The site will also be developed with accompanying asphaltic concrete (AC) and/or Portland Cement concrete (PCC) driveway and parking areas, PCC curbs and gutters, decorative concrete block perimeter walls, and a trash enclosure. Storm drain lines, sewer lines, water lines, dry utility lines (i.e., phone, electric, gas, etc.) will also be constructed as part of the proposed project.

The above project description and assumptions were used as the basis for the field exploration, laboratory testing program, the engineering analysis, and the conclusions and recommendations presented in this report. **Hilltop Geotechnical, Inc.** should be notified if structures, foundation loads, grading, and/or details other than those represented herein are proposed for final development of the site so a review can be performed, a supplemental evaluation made, and revised recommendations submitted, if required.

FIELD EXPLORATION AND LABORATORY TESTING

The field study performed for this report included a visual and geologic reconnaissance of existing surface conditions of the subject site and surrounding area. A study of the property's subsurface condition was performed to evaluate underlying earth strata and the presence of groundwater. Surface and subsurface conditions were explored on November 27, 2007.

The subsurface exploration consisted of excavating six (6) exploratory backhoe trenches on the subject property. The approximate locations of the exploratory excavations are shown on the 'Exploratory Excavation Location Plan,' Plate No. 1, presented Appendix 'A.' The exploratory excavations were observed and logged by a representative of **Hilltop Geotechnical, Inc.** The results are presented on the 'Subsurface Exploration Log,' Plate Nos. 3 through 8, presented in Appendix 'A.' A more detailed explanation of the field study which was performed for this report is presented in Appendix 'A.'

Representative bulk samples of on-site earth materials were collected during the field exploration and returned to the laboratory for testing. Laboratory tests were conducted to evaluate the index and engineering properties of on-site earth materials and included moisture content tests, an expansion index test, soluble sulfate tests, a sieve analysis tests, an Atterberg Limits test, and a maximum dry density / optimum moisture content relationship test. A more detailed explanation of laboratory tests performed for this study and test results are presented in Appendix 'A.'

FINDINGS

SITE DESCRIPTION

The subject property comprises approximately 5.88 acres and was irregular in shape. The subject property is located in the Arrowbear area of San Bernardino County, California. The subject property is situated on the northwest corner of the intersection of Highway 18 and Powers Lane, in the southeast quadrant of the southeast quadrant of Section 33 Township 2 North, Range 2 West of the San Bernardino Principle Meridian, Latitude: 34.2029° North, Longitude: 117.0868° West.

The subject property is bounded by the Highway 18 to the southeast, commercial property to the northeast, and by residential properties to the northwest and southwest, as shown on the Reference No. 1 'Site Plan' noted on the first page of the cover letter for this report.

The legal description for the subject property is as follows:

APN No.: 0328-165-16

Per the Reference No. 1 'Site Plan', the immediate area of the subject site was located on the eastern portion of a small hill. Much of the area to the east and south of the hill has been graded flat to accommodate the previous commercial application of the property. The northern portion of the property, which appears to have undergone very little grading, has a shallow, downward inclination toward the southeast at an average gradient of approximately 5.0 percent. The hillside adjacent to the largest proposed structure has an average gradient of approximately 30 percent. The southeastern portion of the site contains the abandoned alignment for Powers Lane. This area is located at an elevation 15 to 20 feet lower than most of the project area. Total on-site relief in the area of the proposed project was approximately 50 feet. On-site drainage was accomplished by sheetflow toward the southeast and south.

At the time the field exploration was made, the surface of the site was firm and the excavation equipment did not experience difficulty moving around on the site.

At the time of the field study, buildings were present on the site. Utilities consisting of electric, telephone, gas, sewer, water, as well as other unknown underground and overhead lines, were observed to be present on and adjacent to the site. Due to the ages of the structures and the locations on the site, it is anticipated that cisterns, leach lines, and septic tanks also may still be present on the site.

Miscellaneous debris and refuse, dumped piles of soil, and stacks of cut timber were observed at various locations throughout the subject property at the time the field study was performed.

At the time of the field study, vegetation across the site was light to moderate and generally consisted of seasonal native grasses, weeds, forbs, brush, and undergrowth. A moderate growth of trees was located on the hill and in the northern portion of the site.

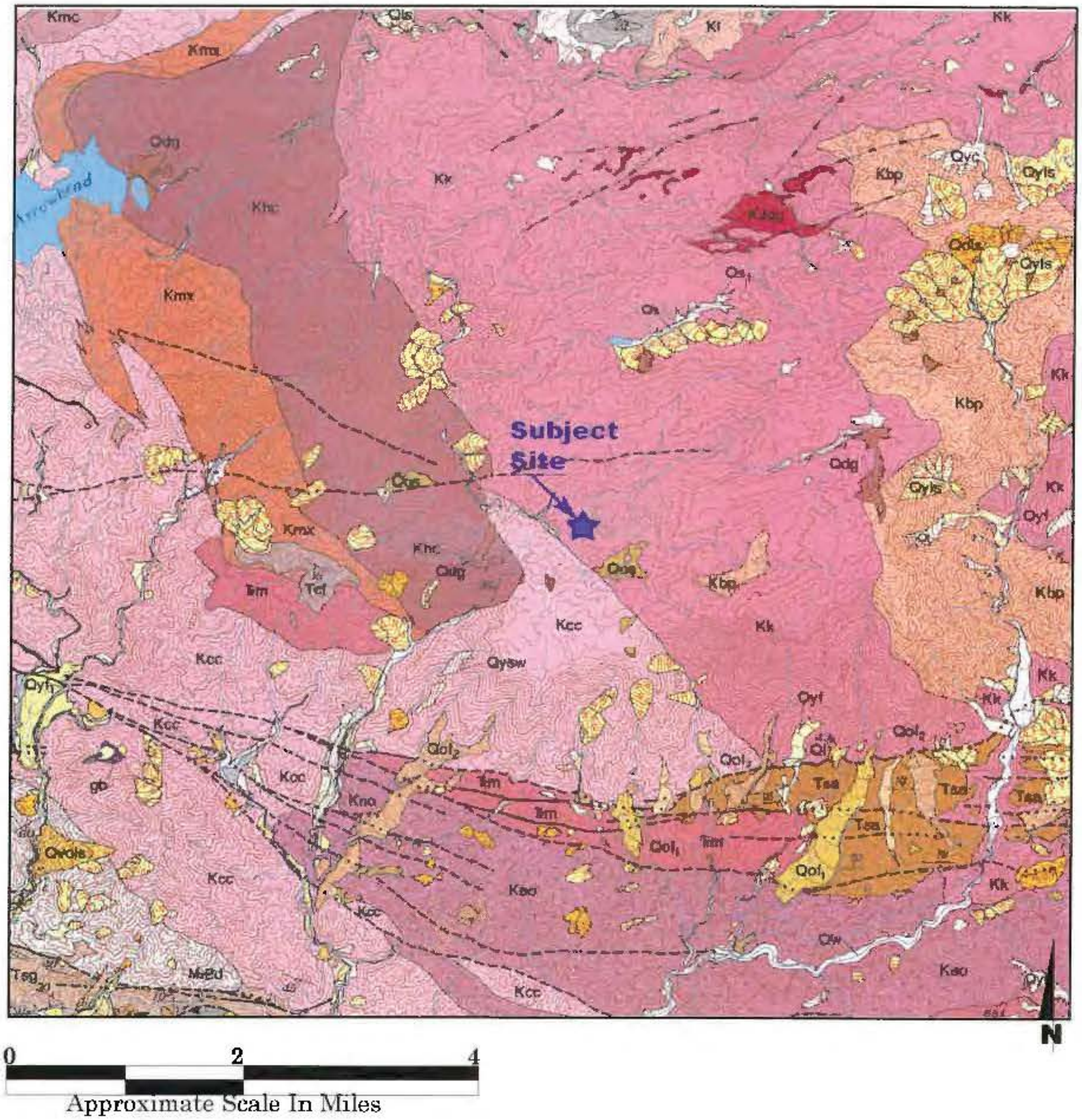
ENGINEERING GEOLOGIC ANALYSIS

Regional Geologic Setting

The San Bernardino Mountains, the San Gabriel Mountains, and other ranges to the west and east of the subject site are portions of the Transverse Ranges Province, a nearly 300-mile-long belt of folded, faulted, and uplifted rocks of diverse lithologies. The east-west orientation of the Transverse Ranges markedly contrasts with the generally northwest-trending, structural grain of surrounding areas in southern California. The presence and orientation of these ranges are generally attributed to north-south directed compressional forces and crustal shortening related to complications within the geometry of the San Andreas transform fault system. These complications are reflected in the kinematics of faults that bound virtually all sides of the San Bernardino Mountains block, faults that include right- and left-lateral strike-slip, and normal and reverse dip-slip displacements.

Basement rocks in the San Bernardino Mountains are similar to those observed in the Mojave Desert areas to the north and consist of Triassic through Cretaceous granitoid rocks of various compositions that have intruded prebatholithic orthogneiss (Proterozoic) and Late Proterozoic to Paleozoic metasedimentary rocks. The layered metasedimentary units consist of quartzites, marbles, pelitic schists, and gneisses and are stratigraphic equivalents to marine sedimentary rocks that are widespread in the eastern Mojave and Great Basin regions. Deformed and undeformed suites of Mesozoic plutonic rocks predominate in the western San Bernardino Mountains. Least-common rock types around the margins of the range include banded and layered Mesozoic metasediments and several Tertiary sedimentary units, usually located within fault-bounded slivers and blocks. The general geology in the area of the subject site is shown on the 'Regional Geology Map,' Figure Nos. 2a and 2b.

The San Andreas fault zone is the dominant structural element in the central Transverse Ranges. Extending over 650 miles from the Gulf of California to the vicinity of Cape Mendocino in northwestern California, the San Andreas fault zone often comprises a strip up to several miles wide of subparallel, branching, and anastamosing fault strands. The fault zone accommodates mostly right-lateral, strike-slip displacements, with small vertical components locally significant in some areas. Current understanding of California tectonics indicates that the fault can be divided into several discrete segments along its length, based upon differing geologic and seismic characteristics. Each discrete segment appears to react to tectonic stress more or less independently from the others, and to have its own characteristic large earthquake with differing maximum magnitude potential and recurrence interval. The San Bernardino segment lies coincident to the southern edge of the San Bernardino Mountains.



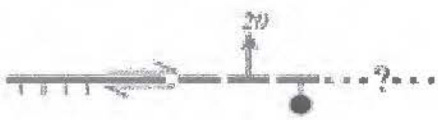
Reference: **United States Department of the Interior, Geological Survey,** 2003, Morton, D.M., and Miller, F.K., Jr., *Preliminary Geologic Map of the San Bernardino 30′ x 60′ Quadrangle, California,* U.S.G.S. Open File Report 03-293, Digital Version 1.0, Sheet 1 of 5, Scale 1:100,000.

HILLTOP GEOTECHNICAL INCORPORATED	REGIONAL GEOLOGY MAP	
	By: RG	Date: 12/07
	Project No.: 688-A07.1	Figure No.: 2a

Legend for Geologic Symbols and Units

Separates geologic-map units. Solid where meets map-accuracy standard; dashed where may not meet map-accuracy standard; dotted where concealed

Contact—Separates terraced alluvial units where younger alluvial unit is incised into older alluvial unit; hachures at base of slope, point toward topographically lower surface. Solid where meets map-accuracy standard; dashed where may not meet map-accuracy standard



Fault—Solid where meets map-accuracy standard; dashed where may not meet map accuracy standard. Dotted where concealed by mapped covering unit; queried where existence uncertain. Hachures indicate scarp, with hachures on downdropped block. Paired arrows indicate relative movement; single arrow indicates direction and amount of fault-plane dip. Bar and ball on down-thrown block.

Qls | Qls - Young landslide deposits (Late Holocene).

Qyf | Qyf - Young alluvial fan deposits, unconsolidated sands and gravels (Holocene and Pleistocene).

Qos | Qos - Old surficial deposits (Late to Middle Pleistocene).

Kcc | Kcc - Monzogranite of City Creek (Cretaceous).

Kk | Kk - Monzogranite of Keller Peak (Cretaceous).

Kbp | Kbp - Monzogranite of Butler Peak (Cretaceous).

Khc | Khc - Granodiorite of Hook Creek (Cretaceous).

Reference: **U.S. Department of the Interior, Geological Survey**, 2003, Morton, D.M., and Miller, F.K., *Preliminary Geologic Map of the San Bernardino 30' x 60' Quadrangle, California*, U.S.G.S. Open-File Report 03-293, Digital Version 1.0, Sheet 2 of 5 .

HILLTOP GEOTECHNICAL INCORPORATED	REGIONAL GEOLOGY MAP	
	By: RG	Date: 12/07
	Project No.: 688-A07.1	Figure No.: 2b

Locally, the subject property lies on an old erosion surface that generally predates the uplift of the San Bernardino Mountains. The site is underlain by older alluvial materials and deeply weathered, crystalline basement rock.

Local Subsurface Conditions

Earth Materials Description: Presented as follows are brief descriptions of the earth materials encountered in the exploratory excavations. More detailed descriptions of encountered earth materials are presented on the 'Subsurface Exploration Log,' Plate Nos. 3 through 8, presented in Appendix 'A.' The earth material strata, as shown on the logs, represent conditions at the actual exploratory excavation locations. Other variations may occur beyond and/or between the excavations. Lines of demarcation between earth materials on the logs represented the approximate boundary between the material types; however, the transition may be gradual.

The earth materials encountered on the subject site during the field exploration were identified as man-made fill (af), Older Alluvium (Qoa), and deeply weathered, Cretaceous granitoid rock that has been classified as monzogranite of Keller Peak (Kk).

The fill material was encountered in the flatter, central portion of the subject site and consisted of slightly silty to silty fine to coarse sands with a trace gravel and aggregate base materials. Some of the fill material contained traces of wood and debris.

The alluvium was encountered in all of the exploratory trenches and consisted of silty fine to coarse sands with varying amounts of gravel and cobbles (SM), clayey fine to coarse sand with a trace gravel and a trace silt (SC), and slightly silty fine to fine to coarse sands with varying amounts of gravel (SP/SM). The alluvium was light brown, brown, dark brown, orange, orange-brown, orange-gray, or gray in color and moist. Locally, the alluvium extended to depths in excess of 13 feet below existing ground surfaces at the excavation locations on the subject site. The upper several feet of the alluvium was visually slightly porous to porous. A subtle and gradual coarsening of the materials with depth was generally noted.

The deeply weathered Cretaceous monzogranite bedrock was encountered in only one (1) excavation, but it can be expected to underlie the entire site at depth and should be expected to be found during grading. The weathered bedrock was found at a depth of 7.5 feet below the existing ground surface in Trench No. T-5 at the time the field study was performed for this report. Bedrock was not encountered in any of the other trenches. The bedrock material broke down into a fine to coarse sand with a trace silt (SP). The weathered bedrock was orange-gray in color and moist.

Groundwater: Groundwater was encountered at a depth of 7.0 and 9.0 feet below the existing ground surface at the location of exploratory trenches T-5 and T-6, respectively, at the time the field study was performed for this report.

The remnants of at least one (1) water well was observed on the subject site during the field study. It is not known how long ago this well had been abandoned and no groundwater information was available for the well.

As weathered rock underlies the entire subject property, some perched groundwater located above the interface between weathered, permeable rock and underlying, less weathered, impermeable material was encountered and more may be evident during years or seasons of higher precipitation. Excavations during grading should be inspected for evidence of shallow groundwater flow that could impact the subject project.

Surface Water: Surface water was not observed on the subject site at the time the field study was performed for this report.

Site Variations: Based on results of our subsurface exploration and experience, variations in the continuity and nature of surface and subsurface conditions should be anticipated. Due to uncertainty involved in the nature and depositional characteristics of earth materials at the site, care should be exercised in extrapolating or interpolating subsurface conditions between and beyond the exploratory excavation locations.

Groundwater observations were made in the exploratory excavations at times and under conditions stated on the trench logs. These data have been reviewed and interpretations made in the text in other sections of this report. However, it should be noted that fluctuations in levels of groundwater, springs, and/or perched water may occur due to variations in precipitation, temperature, and other factors.

Faulting and Regional Seismicity

The site is situated in an area of active and potentially active faults, as is most of metropolitan southern California. Active faults present a variety of potential risks to structures, the most common of which are strong ground shaking, dynamic densification, liquefaction, mass wasting, and surface rupture at the fault plane. Generally speaking, the following four (4) factors are the principal determinants of seismic risk at a given location:

- Distance to seismogenically capable faults.

- The maximum or "characteristic" magnitude earthquake for a capable fault.
- Seismic recurrence interval, in turn related to tectonic slip rates.
- Nature of earth materials underlying the site.

Surface rupture represents the primary potential hazard to structures built on an active fault zone. Reviews of official maps delineating State of California earthquake fault zones (**California Department of Conservation, Division of Mines and Geology**, Effective July 1, 1974, *State of California Special Studies Zones, Keller Peak Quadrangle, Official Map*, Scale 1:24,000) indicated the site is not located within a zone of mandatory study for active faulting. Additionally, no known active faults trend toward the subject property.

The North Frontal fault (Western Segment) is within approximately 8.0 kilometers to the northwest of the site. To the southwest, the San Andreas fault (San Bernardino Segment) passes within approximately 10.0 kilometers of the subject site. The Cleghorn fault passes within approximately 13.5 kilometers to the west of the of the site. To the southwest, the San Jacinto fault (San Jacinto Valley Segment) passes within approximately 25.4 kilometers of the site. Accordingly, the potential for surface fault rupture on this site is considered to be very low.

Ground shaking is judged to be the primary hazard most likely to affect the site, based upon proximity to four (4) regionally significant active faults: the North Frontal fault, the San Andreas fault, the Cleghorn fault, and the San Jacinto fault. Other significant fault zones and several zones in the high desert area are located at distances exceeding 25 kilometers from the site. Greater distances, lower slip rates, and lesser maximum magnitudes indicate much lower risk to the site from the latter fault zones than the three (3) closest faults and the regionally significant

San Andreas fault. Characteristics of the major active fault zones selected for inclusion in analysis of strong ground shaking are listed in the following table:

Fault Zone	Distance from Site (km)[1]	Fault Length (km)[2]	Slip Rate (mm/yr)[2]	Reference Earthquake (M_{max})[2]	Fault Type[2]
North Frontal (Western Segment)	8.0	51	1.0	7.2	B
San Andreas (San Bernardino Segment)	10.0	103	24.0	7.5	A
Cleghorn	13.5	25	3.0	6.5	B
San Jacinto (San Jacinto Valley Segment)	25.4	43	12.0	6.9	A

1. **Blake, Thomas F.**, 2000, *Preliminary Fault-Data for EQFault, EQSearch and FriskSP* and **Blake, Thomas, F.**, *Computer Services and Software, Users Manuals, FriskSP v. 4.00, EQSearch v. 3.00, and EQFault v. 3.00.*
2. **California Department of Conservation, Division of Mines and Geology**, 1996 (Appendix A - Revised 2002), *Probabilistic Seismic Hazard Assessment for the State of California*, DMG Open-File Report 96-08.

Deterministic analyses of the hazard of ground shaking at the site were considered for reference earthquakes on each of the regional faults listed above. The North Frontal fault (Western Segment) is the closest thrust fault associated with uplift of the Transverse Ranges and is modeled as a 7.2 moment-magnitude source with reverse-slip (45 S) displacement. For the San Andreas fault (San Bernardino Segment), the modeled event is a single-segment event, producing a 100-percent, right-lateral, strike-slip, moment-magnitude 7.5 earthquake. The Cleghorn fault is a single-segment, moment-magnitude 6.5 event with 100-percent, left-lateral, strike-slip displacement. The assigned reference earthquake for the San Jacinto fault (San Jacinto Valley Segment) is a 6.9 event with 100-percent, right-lateral, strike-slip displacement.

Probabilistic seismic hazard maps and data files jointly prepared by the **California Geological Survey (CGS)** and the **U.S. Geological Survey (USGS)** assign a 10-percent likelihood that horizontal ground acceleration of approximately 0.519g will occur at this site within the next 50 years. This data was available at the **CGS** 'Probabilistic Seismic Hazards Mapping Ground Motion Page' (http://www.conservation.ca.gov/cgs/rghm/pshamap/pshamain.asp). The probabilistic hazard maps were calculated for alluvial / bedrock sites such as the subject property. Actual shaking intensities at the site from any seismic source may be substantially higher or lower than estimated for a given earthquake magnitude, due to complex and unpredictable effects from variables such as:

- Near-source directivity effects.
- Direction, length, and mechanism of fault rupture (strike-slip, normal, reverse).
- Depth and consistency of unconsolidated sediments.
- Topography.
- Geologic structure underlying the site.
- Seismic wave reflection, refraction, and interference.

Secondary Seismic Hazards

Secondary hazards include induced landsliding or mass wasting, liquefaction, flooding (from ruptured tanks and reservoirs, surface oscillations in larger lakes, or seismic sea waves), and subsidence as a result of soil densification. Landsliding and liquefaction susceptibility maps have been prepared for much of coastal Los Angeles and Orange County, California by the **DMG**. However, this area of San Bernardino County, California is not presently scheduled for mapping by the State.

As of the date of this report, the site has not been identified or excluded from a State-delineated zone of mandatory study for either landsliding or liquefaction.

Landslide: The subject site is located within a designated area as having a low to medium landslide susceptibility per **San Bernardino County Planning Department**, *San Bernardino County Land Use Plan, GENERAL PLAN, Geologic Hazard Overlays*, Sheet FH24 C Keller Peak, Plot Date: 05/30/2007, 11:43 AM, Scale 1:14,400 (http://www.co.san-bernardino.ca.us/landuseservices/general...), shows the subject property to lie within an area of low to moderate susceptibility to landslides, as shown on Figure No. 3, 'Landslide and Liquefaction Susceptibility Map.'

Due to the moderate gradients and moderate relief of the site and adjacent hillsides, on-site landsliding or debris flows sourced from higher elevations should not be considered to be a geologic constraint at this site. Field reconnaissance did not disclose the presence of older, existing landslides within or near the subject property.

Liquefaction: Liquefaction is a phenomenon in which cohesionless, saturated, fine-grained sand and sandy silt soils lose shear strength due to groundshaking.

The subject site not is located within a designated area as having a liquefaction potential per **San Bernardino County Planning Department**, *San Bernardino County Land Use Plan, GENERAL PLAN, Geologic Hazard Overlays*, Sheet FH24 C Keller Peak, Plot Date: 05/30/2007, 11:43 AM, Scale 1:14,400 (http://www.co.san-bernardino.ca.us/landuseservices/general...), Figure No. 3, 'Landslide and Liquefaction Susceptibility Map.'

Generalized Liquefaction Susceptibility

- Low
- Medium
- High

Generalized Landslide Susceptibility

- Low to moderate
- Moderate to high
- Mapped, Existing Landslide
- Rockfall/Debris-Flow Hazard Area (Forest Falls Only)

Earthquake Fault Zones

- Earthquake Fault Zone Boundary
- County Designated Fault Zones

Reference: San Bernardino County Land Use Plan, GENERAL PLAN, Geologic Hazard Overlays, Sheet FH24 C Keller Peak (http://www.co.san-bernardino.co.us/landuseservices/...).

HILLTOP GEOTECHNICAL INCORPORATED	LANDSLIDE AND LIQUEFACTION SUSCEPTIBILITY MAP	
	By: SS	Date: 12/07
	Project No.: 688-A07.1	Figure No.: 3

It is our opinion that liquefaction potential at the subject site is very low due to a shallow depth to bedrock.

Seismically Induced Subsidence: Loose sandy soils subjected to moderate to strong groundshaking can experience settlement. Experience from the Northridge Earthquake indicates that structural distress can result from such seismic settlement. Based upon the results of this study, the subject site is underlain at a shallow depth by bedrock material that should not be prone to a significant degree of seismic settlement. Where applicable, near-surface, alluvial soils and undocumented fills should be removed and recompacted to uniform high densities to mitigate both settlement and consolidation potentials.

Seiching: Seiching involves an enclosed body of water oscillating due to groundshaking, usually following an earthquake. Lakes and water towers are typical bodies of water affected by seiching. However, the site does not appear to be within the influence of large bodies of water and, as such, seiching should not be considered a hazard in the area.

Tsunamis: Because of the inland geographic location of the site, tsunamis are not considered a hazard.

Lurching: Lurching is a phenomena in which ground cracking and/or secondary faulting occurs as a result of groundshaking. Generally, lurching primarily occurs in the immediate vicinity of faulting or within typical building setback zones or "No Human Occupancy" zones. No evidence of faulting was encountered on the site and although the potential for lurching cannot be entirely ruled out, the likelihood for lurching to impact the site is considered to be low.

OTHER GEOLOGIC HAZARDS

Flooding

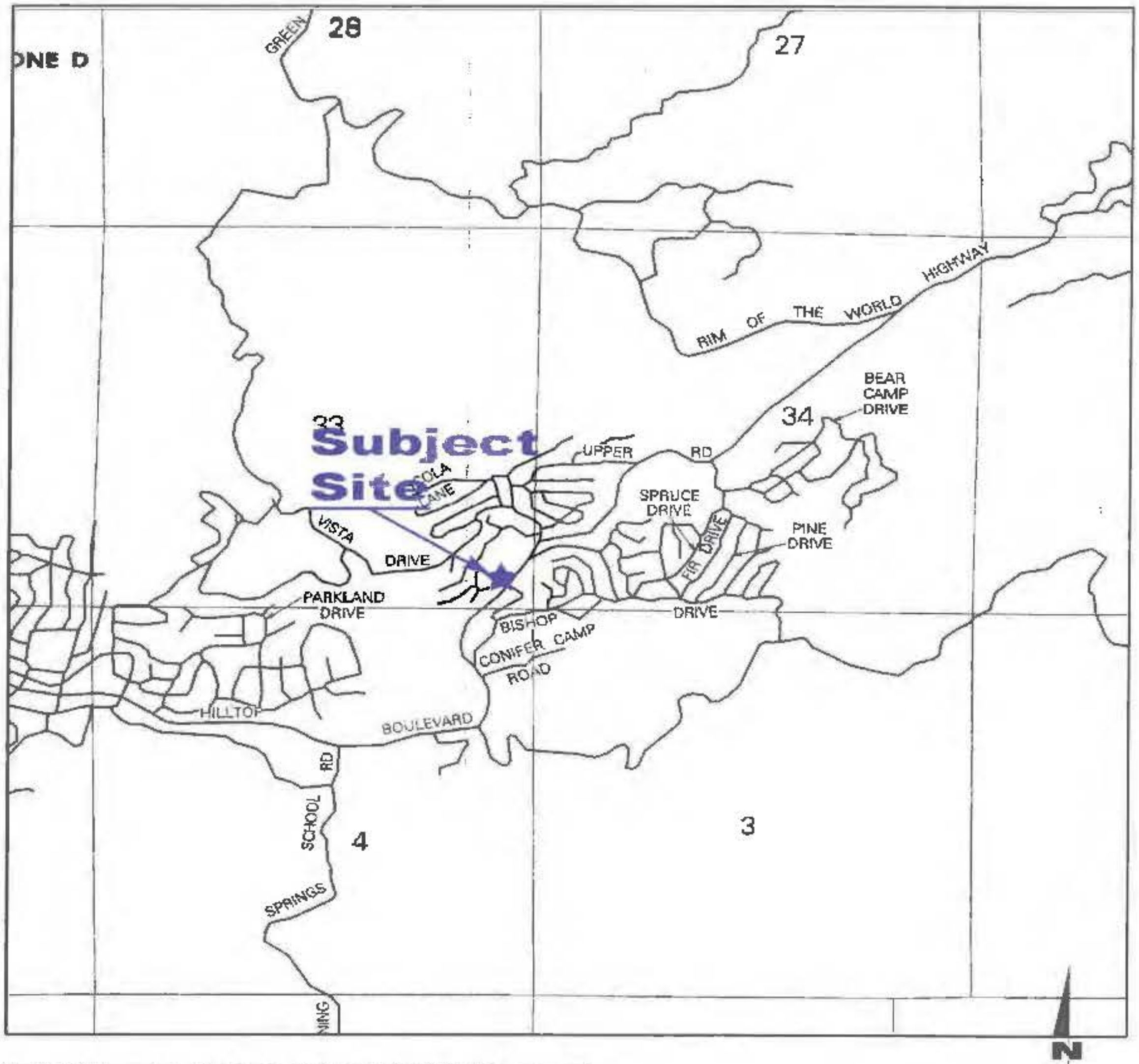
The subject site is not located within a flood-prone area, as designated by the **San Bernardino County Planning Department**, *San Bernardino County Land Use Plan, GENERAL PLAN, Geologic Hazard Overlays*, Sheet FH24 B Keller Peak. Plot Date: 05/30/2007, 11:43 AM, Scale 1:14,400 (http://www.co.san-bernardino.ca.us/landuseservices/general...).

Flood Insurance Rate Maps (FIRM) were compiled by the **Federal Emergency Management Agency (FEMA)** for the Flood Insurance Program and are available for most areas within the United States. The attached 'Flood Hazard Map,' Figure No. 4, is based on FIRMs provided by **FEMA** and is specific to the area around the subject site. The 'Flood Hazard Map' indicates that the site is not located within a 100-year flood zone. In addition, the subject site is located on a hillside above any significant drainage channels. Therefore, flooding is not considered to be a constraint at this location.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

The conclusions and recommendations presented in this report are preliminary since a grading plan, finish floor elevations, types of structures, structural loads, etc. were not available and are, in part, based on information provided to this firm, the results of the field and laboratory data obtained from six (6) exploratory excavations located on the subject property, experience gained from work conducted by this firm on projects within the general vicinity of the subject site, the project description and assumptions presented in the 'Project Description /



Not to Scale

LEGEND

SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

ZONE A No base flood elevations determined.

ZONE AE Base flood elevations determined.

OTHER AREAS

ZONE X Areas determined to be outside 500-year floodplain.

ZONE D Areas in which flood hazards are undetermined.

Reference: **FEMA Flood Insurance Rate Map**, Effective March 18, 1996, *Map 06071C 8000 F*, Site specific information obtained through FEMA website, Map Service Center, http://msc.fema.gov/.

HILLTOP GEOTECHNICAL INCORPORATED	FLOOD HAZARD MAP	
	By: RG	Date: 12/07
	Project No.: 688-A07.1	Figure No.: 4

Proposed Development' section of this report, engineering analyses, and professional judgement. Based on a review of the field and laboratory data and the engineering analysis, the proposed development is feasible from a geotechnical / geologic standpoint and that the subject property can be developed without adverse impact onto or from adjoining properties providing the recommendations contained within this report are adhered to during project design and construction.

The average in-situ moisture contents and in-situ dry densities of the upper 3.0 to 4.0 feet of the near-surface alluvial materials on the subject site suggests that the soils have an average relative compaction of less than 85 percent.

The field observations indicate that up to approximately 0.5 to 1.0 foot of material present on the subject site was an undocumented fill material. The artificial fills on the site are also considered loose and compressible. The man-made fills are not considered suitable for the support of structural fills, foundations, slab-on-grade floor slabs, hardscape, and/or pavement.

Field observations also indicate that some of the near-surface alluvial soils on the subject site were visually slightly porous to porous. These deposits extended to depths of approximately 3.0 to 9.0 feet below the existing ground surfaces at several of the exploratory excavation locations. Typically, porous, collapsible soils are formed in dry desert regions, such as the project site, where alluvial materials are rapidly deposited in lenses and layers and rapid evaporation of the water takes place. Moisture sensitive, collapsible soils generally consist of silty sands which exhibit high dry strengths, low in-situ dry densities, and low moisture contents. The high dry strength is caused by silt and clay particles and natural cementation by calcium carbonates which are left in the soil matrix during the evaporation process. However, upon future saturation of the soil strata by prolonged periods of landscape irrigation (such as happens on developed lots), the soils lose their apparent dry strength, collapse of the soil structure occurs, and settlement takes place.

Some of the near-surface alluvial soils present on the subject site exhibit an expansion potential in accordance with the criteria presented in Section 1802.3.2, 'Expansive Soils,' in the 2007 California Building Code (CBC). If precautions are not taken during the design and construction of the project, the on-site expansive soils could cause heaving and distress to the structures, hardscape, and pavement if they should become saturated in the future.

Therefore, some remedial grading consisting of removals and replacement will have to be performed within loose, compressible, artificial fill and porous, near-surface alluvium in the area of proposed structural fills, structures, exterior hardscapes, and/or pavement.

The actual conditions of the near-surface supporting material across the site may vary. The nature and extent of variations of the surface and subsurface conditions between the exploratory excavations may not become evident until construction. If variations of the material become evident during construction of the proposed development, **Hilltop Geotechnical, Inc.** should be notified so that the project Geotechnical / Geologic Consultant can reevaluate the characteristics of the material and the conclusions and recommendations of this report, and, if needed, make revisions to the conclusions and recommendations presented herein.

Preliminary recommendations for site grading, foundation design, slab support, pavement design, slope maintenance, etc., are presented in the subsequent paragraphs.

SITE PREPARATION RECOMMENDATIONS

General

The grading recommendations presented in this report are intended for: 1) the rework of unsuitable, near-surface, fill and alluvial earth materials to create engineered building pads and satisfactory support for exterior hardscape (i.e., sidewalks, curb / gutters, etc.) and pavement; and 2) the use of a foundation system and concrete slabs cast on-grade designed to resist the expansion potential of the near-surface on-site soils.

If hardscape and pavement subgrade soils are prepared at the time of grading of the building sites, and the improvements are not constructed immediately, additional observations and testing of the subgrade soil will have to be performed to locate areas which may have been damaged by construction traffic, construction activities, and/or seasonal wetting and drying. The additional observations and testing should be performed before placing aggregate hase material, asphaltic concrete, and/or Portland Cement concrete in those areas.

The following recommendations may need to be modified and/or supplemented during grading as field conditions dictate. Typical 'Grading Specifications' are presented in Appendix 'B' for reference. The special site preparation recommendations presented in the following sections will supersede those in the 'Grading Specifications' presented in Appendix 'B' if there is any conflict.

The grading should be performed in accordance with the recommendations presented in this report. We recommend that **Hilltop Geotechnical, Inc.**, as the Geotechnical Engineer / Geologist of Record, be retained by the owner of the proposed project to observe the excavation and grading operations, foundation preparation, and test the compacted fill and utility trench backfill. A pregrading conference should be held at the site with the owner, contractor, County of San Bernardino representative, Civil Engineer, and Geotechnical / Geologic Consultant in attendance. Special grading procedures and/or concerns can be addressed at that time.

Earthwork observation services allow the testing of only a small percentage of the fill placed at the site. Contractual arrangements with the grading contractor by the project owner should contain the provision that he is responsible for excavating, placing, and compacting fill in accordance with the recommendations presented in this report and the approved project grading plans and specifications. Observation by the project Geotechnical / Geologic Consultant and/or his representatives during grading should not relieve the grading contractor of his responsibility to perform the work in accordance with the recommendations presented in this report and the approved project plans and specifications.

The following recommendations may need to be modified and/or supplemented during grading as field conditions require.

Final Grading Plan Review

The project Civil Engineer should review this report, incorporate critical information on to the grading plan and/or reference this geotechnical / geologic study, by Company Name, Project No., Report No., and report date, on the grading plan. Final grading plans should be reviewed by **Hilltop Geotechnical, Inc.** when they become available to address the suitability of our grading recommendations with respect to the proposed improvements.

Clearing and Grubbing

Debris, grasses, weeds, brush, trees, and other deleterious materials should be removed from the proposed building, exterior hardscape and pavement areas and areas to receive structural fill before grading is performed. Any organic material and miscellaneous / demolition debris should be legally disposed of off site. Any topsoil or highly organic surface soils encountered should be stripped and stockpiled for use on finished grades in landscape areas or exported from the site. Disking or mixing of organic material into the soils proposed to be used as structural fill should not be permitted. Man-made objects encountered (i.e., septic tanks, leach lines, irrigation systems, underground utilities, old foundations, etc.) should be overexcavated, exported from the site, and legally disposed of off site. Cesspools or seepage pits, if encountered (none were encountered during this study), should be abandoned and capped according to directions and supervision of San Bernardino County Department of Health, the State of California, and/or the appropriate governmental agency procedures which has jurisdiction over them before fill and/or pavement is placed over the area. If no procedures are required by the Health Department or if the following recommendations are more stringent, the cesspool or seepage pit should be pumped free of any liquid and filled with a low strength sand cement slurry to an elevation 5.0 feet below the final site grade in the area. The upper 5.0 feet of the cesspool or seepage pit should be excavated and the area backfilled with a properly compacted fill material. The location of the cesspool or seepage pit should be surveyed and plotted on the final 'As-Graded' plan prepared by the project Civil Engineer. Trees and their roots should be completely removed, ensuring that 95 percent or more of the root systems are extracted. Wells, if encountered, should be abandoned and capped according to directions and supervision of San Bernardino County Department of Health, the State of California, and/or the appropriate governmental agency procedures which has jurisdiction over the well before fill and/or pavement is placed over the area.

Excavation Characteristics

Excavation and trenching within the subject property to the depths anticipated for the proposed development is anticipated to be relatively easy in the near-surface undocumented fills, alluvial, and highly weathered bedrock materials on the subject site and should be accomplished with conventional earth-moving equipment since the backhoe was able to penetrate to the indicated depths. Materials were not encountered or are anticipated that would require heavy ripping or blasting to excavate. It is anticipated that a small amount of oversized rock material (i.e., 12 inches in greatest dimension) will be generated during the removal and replacement process within the alluvial materials which will require special handling during the development of the site.

In general, the bedrock will excavate with varying degrees of difficulty. Based upon available exposures in the exploratory trenches, much of the underlying, near-surface bedrock should excavate with moderate difficulty. Difficult to very difficult ripping with the likelihood of blasting may be encountered in deeper excavations, due to the nature and character of the bedrock (i.e., differential weathering, residual boulders, intrusive dikes, etc.).

Oversized rock materials are anticipated to be generated during the grading. Such materials will likely require special handling methods during site development.

Suitability of On-Site Materials as Fill

In general, the on-site earth materials present below any topsoil and/or highly organic materials are considered satisfactory for reuse as fill. Fill materials should be free of significant amounts of organic materials and/or debris and should not contain rocks or clumps greater than 12 inches in maximum dimension. It is noted that the in-situ moisture content of the near-surface fill and alluvial soils on the subject site at the time this field study was performed was below the optimum moisture content for the on-site materials and that moisture will have to be added to the on-site soils if the soils are to be used as compacted fill material in the near future.

Removal and Recompaction

Uncontrolled or undocumented fills and/or unsuitable, disturbed near-surface alluvial soil in proposed areas which will support structural fills, structures (i.e., buildings, decorative block walls, retaining walls, trash enclosure walls, etc.), exterior hardscape (i.e., sidewalks, patios, curb / gutters, etc.), fill slopes, and pavement should be prepared in accordance with the following recommendations for grading in such areas. If overexcavation of undocumented fill and/or unsuitable, disturbed near-surface alluvial soil is elected not to be performed in hardscape, curb / gutter, pavement, and decorative block wall or fence areas, penetration of irrigation water with time may cause some settlement and distress to the improvements in those areas. The cost of the additional grading verses the risk of distress and cost of repairs to the structures needs to be evaluated by the project owner.

- The near-surface undocumented fill soils and the unsuitable, porous, near-surface alluvial materials on the site are recommended to be overexcavated and recompacted. Based upon our exploratory excavations and laboratory test results, we anticipate that the overexcavation will extend to a depth of approximately 5.0 feet below existing ground surface in the areas which will receive structural fill, building structures, retaining walls, trash enclosure walls, and decorative concrete block walls. Moreover, the depth of the overexcavation within the perimeter of the proposed structures should be to a uniform elevation throughout the limits of the structures. It is noted that fill placed to construct slopes and/or support sidewalks, patios, retaining walls, block walls, driveways, and pavement are considered to be structural fill.

- Where a cut / fill transition zone extends through a proposed building pad area, a compacted mat of fill will have to be constructed under the building area to prevent differential settlement between the two (2) dissimilar materials. This mat should be constructed by overexcavating the materials in the cut portion of the pad to a distance outside the proposed building limits of 5.0 feet or to the depth of the overexcavation below the finish pad grade, whichever is greater. The overexcavation should extend to a depth of 5.0 feet below the pad elevation or to a minimum depth of 0.5 times the depth of the deepest fill within the building pad, whichever is greater.

- In total cut building pads for proposed structures, overexcavation and recompaction is recommended to be performed to a depth of 5.0 feet below the proposed cut pad elevation and to a lateral distance of 5.0 feet outside the perimeter of the structure. This will provide a uniformly compacted building pad for support of the structure and remove oversize materials within the anticipated depths of foundations and underground utilities.

- In the proposed exterior hardscape (i.e., sidewalks, patio slabs, etc.), and pavement areas where structural fill will not be placed or cuts are proposed, the existing near-surface soils need only be processed to a depth of 6.0 to12 inches below existing site grades or proposed subgrade elevation, whichever is deeper unless old, undocumented fill materials are encountered at exposed grades. If undocumented fills are encountered, they will need to he overexcavated and properly compacted fill replaced to achieve proposed grades.

  Due to the porous nature of some of the near-surface alluvial soils on the subject site, if overexcavation and replacement is not performed under the exterior concrete slabs, hardscape, pavement, curb / gutters, etc,, there is a risk of settlement and vertical differential movement if the subgrade soils are allowed to become saturated. Therefore, proper drainage should be established away from such improvements and minimal precipitation or irrigation water allowed to percolate into the soils adjacent to the exterior concrete hardscape, pavement, curbs / gutters, etc.

- Additional overexcavation will need to be performed in areas where the exposed subgrade can not be properly processed and recompacted per the following recommendations presented in this section of this report.

  If wet, unstable soil is encountered at the overexcavation depth, additional overexcavation and a 0.75 to 1.0 inch gravel worked into the soil may be required to establish a firm working base for the placement of fill. As an alternative, a mud coat (i.e., sand /cement slurry) consisting of a minimum of 2.0 sacks of cement per cubic yard of sand may be placed over the soft subgrade and allowed to cure overnight. This will establish a firm working base for the placement of fill.

- The limits of overexcavation for the building pads should extend to a distance of 5.0 feet or to the depth of the overexcavation beneath the finish pad grade for the structure, whichever is greater, beyond the structure perimeter or footing edges. The limits of overexcavation for fill slopes should extend to a distance of 4.0 feet beyond the toe of the slope or to the depth of the overexcavation beneath the toe of the slope, whichever is greater. The limits of overexcavation for the decorative concrete block perimeter wall footings and/or retaining wall footings should extend to a distance of 4.0 feet beyond the footing edges or to the depth of the overexcavation beneath the footing grade, whichever is greater. The limits of processing or overexcavation for exterior hardscape, curb / gutter, and pavement areas should extend to a distance of 2.0 feet beyond the edge of the exterior hardscape, curb / gutter, or pavement, or to the depth of the overexcavation beneath the finish subgrade elevation, whichever is greater.

  In areas where overexcavation can not be performed to the required distance beyond the foundations, (i.e., perimeter project block walls, retaining walls, etc.) along property lines, the foundations should be deepened to extend through the loose fill and near-surface, porous alluvial soils and be founded to a minimum depth of 1.0 foot into the firm underlying material (i.e., approximately 5.0 feet or greater below existing site grades).

- Where the exploratory backhoe trenches are located within the limits of the proposed overexcavations for the proposed structural fills, structures, decorative walls, trash enclosure walls, retaining walls, exterior hardscape, and/or pavement areas, the trenches should be overexcavated to the width and depth of the trench.

- It is noted that localized areas, once exposed, may warrant additional overexcavation for the removal of existing undocumented fills, porous, moisture sensitive alluvial soils, and subsurface obstructions and/or debris which may be associated with the past usage of the site. Actual depths of removals and the competency of the exposed overexcavation bottoms should be determined by the project Geotechnical / Geologic Consultant and/or his representative during grading operations at the time they are exposed and before scarification and recompaction or the placement of fill.

- The exposed overexcavation bottom surfaces should be scarified to a depth of 6.0 to 12 inches, brought to optimum moisture content to 3.0 percent above optimum moisture content, and compacted to 90 percent or greater relative compaction before placement of fill. Maximum dry density and optimum moisture content for compacted materials should be determined according to current ASTM D1557 procedures. The scarification and recompaction of the exposed overexcavation bottoms in bedrock materials may be deleted upon approval by the project Geotechnical / Geologic Consultant, and/or his representative. The scarification and recompaction of the exposed overexcavation bottoms in alluvial materials may be deleted upon approval by the project Geotechnical / Geologic Consultant, and/or his representative when in-place density test results in the undisturbed alluvial materials indicate a relative compaction of 90 percent or greater.

Import Material

Import fill should not be more expansive in nature than the existing on-site material as determined by current ASTM D4829 procedures and have strength parameters equivalent to or greater than the on-site soils. Import fill material should be approved by the project Geotechnical / Geologic Consultant prior to it being brought on-site.

Fill Placement Requirements

Fill material, whether on-site material or import, should be approved by the project Geotechnical / Geologic Consultant and/or his representative before placement. Fill material should be free from vegetation, organic material, debris, and oversize material (i.e., 12 inches in maximum dimension). Approved fill material should be placed in horizontal lifts not exceeding 6.0 to 12 inches in compacted thickness or in thicknesses the grading contractor can demonstrate that he can achieve adequate compaction and watered or aerated to obtain optimum moisture content to 3.0 percent above optimum moisture content. Each lift should be spread evenly and should be thoroughly mixed to ensure uniformity of soil moisture. Fill soils should be compacted to 90 percent or greater relative compaction. Maximum dry density and optimum moisture content for compacted materials should be determined in accordance with current ASTM D1557 procedures.

Compaction Equipment

It is anticipated that the compaction equipment to be used for the project will include a combination of rubber-tired, track-mounted, sheepsfoot, and/or vibratory rollers to achieve compaction. Compaction by rubber-tired or track-mounted equipment, by itself, may not be sufficient. Adequate water trucks, water pulls, and/or other appropriate equipment should be available to provide sufficient moisture and dust control. The actual selection of equipment and compaction procedures are the responsibility of the contractor performing the work and should be such that uniform compaction of the fill is achieved.

Shrinkage, Bulking, and Subsidence

There will be a material loss due to the clearing and grubbing operations. The following values are exclusive of losses due to clearing, grubbing, tree root removal, or the removal of other suhsurface features and may very due to differing conditions within the project boundaries and the limitations of this study.

Volumetric shrinkage of the fill materials and near-surface alluvium on the subject site that are excavated and replaced as controlled, compacted fill should be anticipated. It is estimated that the average shrinkage of the near-surface soils within the upper 5.0 feet of the site which will be removed and replaced will be approximately 8.0 to 14 percent, based on fill volumes when compacted to 90 to 95 percent of maximum dry density for the soil type based on current ASTM D1557 procedures. For example, a 8.0 percent shrinkage factor would mean that it would take 1.08 cubic yards of excavated material to make 1.0 cubic yard of compacted fill at 90 percent relative compaction. A higher relative compaction would mean a larger shrinkage value. Any oversize rock removal and export will also result in additional shrinkage.

A subsidence factor (loss of elevation due to compaction of existing fill and/or alluvial soils in-place) of 0.07 to 0.12 foot per foot of compacted soil should be used in areas where the existing soils are compacted in-place to 90 to 95 percent relative compaction and to a depth of 12 inches.

Subsidence of the site due to settlement from the placement of less than 5.0 feet of fill (not including the depth of overexcavation and replacement) during the planned grading operation is expected to be minimal.

Although the above values are only approximate, they represent the recommended estimate of some of the respective factors to be used to calculate lost volume that will occur during grading.

Abandonment of Existing Underground Lines

Abandonment of existing underground irrigation, utility, or pipelines, if present within the zone of construction, should be performed by either excavating the lines and filling in the excavations with documented, properly compacted fill or by filling the lines with a low strength sand / aggregate / cement slurry mixture. Filled lines should not be permitted closer than 3.0 feet below the bottom of proposed footings and/or concrete slabs on-grade. The lines should be cut off at a distance of 5.0 feet or greater from the area of construction. The ends of the lines should be plugged with 5.0 feet or more of concrete exhibiting minimal shrinkage characteristics to prevent water or fluid migration into or from the lines. Capping of the lines may also be needed if the lines are subject to line pressures. The slurry should consist of a fluid, workable mixture of sand, aggregate, cement, and water. Plugs should be placed at the ends of the line prior to filling with the slurry mixture. Cement should be Portland cement conforming to current ASTM C150 specifications. Water used for the slurry mixture should be free of oil, salts, and other impurities which would have an adverse effect on the quality of the slurry. Aggregate, if used in the slurry, mixture should meet the following gradation or a suitable equivalent:

SIEVE SIZE	PERCENT PASSING
1.5"	100
1.0"	80-100
3/4"	60-100
3/8"	50-100
No. 4	40-80
No. 100	10-40

The sand, aggregate, cement, and water should be proportioned either by weight or by volume. Each cubic yard of slurry should not contain less than 188 pounds (2.0 sacks) of cement. Water content should be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed. The slurry should be placed within 1.0 hour of mixing. The contractor should take precautions so that voids within the line to be abandoned are completely filled with slurry.

Local ordinances relative to abandonment of underground irrigation, utility, or pipelines, if more restrictive, supersede the above recommendations.

Over-Size Rock Disposal

Any over-size rock material with measurements of 12 inches or greater in maximum dimension will have to be properly disposed of off site since it is anticipated that there will not be any deep fills to be placed in which to properly dispose of the over-size material as part of the site development.

Slope Setbacks

Cut and fill slope setbacks from the permit boundary lines should be in accordance with Appendix 'J', Section J108, 'Setbacks,' of the 2007 CBC or current San Bernardino County, California grading ordinances, whichever is more stringent.

Fill Slopes

Finish fill slopes should not be inclined steeper than 2H:1V (Horizontal to Vertical). Fill slope surfaces should be compacted to 90 percent relative compaction to the face of the finished slope. Overexcavation beneath proposed fill slopes should be performed in accordance with the recommendations presented in previous sections of this report. Fill slopes should be constructed in a skillful manner so that they are positioned at the design orientations and slope ratio. Achieving a uniform slope surface by subsequent thin wedge filling should be avoided. Add-on correction to a fill slope should be conducted under the observation and recommendations of the project Geotechnical / Geologic Consultant. The proposed add-on correction procedures should be submitted in writing by the contractor before commencement of corrective grading and reviewed by the project Geotechnical / Geologic Consultant. Compacted fill slopes should be backrolled with appropriate equipment for the type of soil being used during fill placement at intervals not exceeding 4.0 feet in vertical height. As an alternative to the bankrolling of the fill slopes, over-filling of the slopes will be considered acceptable and preferred. The fill slope should be constructed by over-filling with compacted fill to a distance of 3.0 feet or greater horizontally, and then trimmed back to expose the dense inner core of the slope surface. Fill slopes steeper than 3H:1V are moderately susceptible to erosion due to the low cohesion parameters of the soils.

Cut Slopes

Finish cut slopes in alluvium should not be inclined steeper than 2H:1V (Horizontal to Vertical). The cut slopes should be observed by the project Geotechnical / Geologic Consultant and/or his representative during grading to provide supplemental recommendations for stability of slopes, if needed. Cut slopes that face in the same direction as the prevailing natural slope will require top of cut paved interceptor swales. Cut slopes steeper than 3H:1V are moderately susceptible to erosion due to the low cohesion parameters of the soils.

Loose Material on Slope Face

The grading contractor should be made aware to take care to avoid spillage of loose material down the face of slopes during grading and during drainage terrace and downdrain construction. Fine grading operations for benches and downdrains should not deposit loose trimmed soils on the finished slope surfaces.

Slope Creep

Proposed slopes are planned to be stable under normal conditions and moderate earthquakes. However, movement due to creep effects of improvements located near the tops of existing slopes and/or proposed fill and cut slopes must be considered. Due to moisture variations and natural gravity forces, the soils on the face of a slope tend to move downward and outward with time. Past experience has indicated that there is a zone which ranges back from the top of the slope edge that may experience movement. This zone varies from approximately 5.0 feet to

15 to 20 feet depending on the type of soil the slope is composed of, the height of the slope, the inclination of the slope, moisture conditions, etc. The movement tends to be greatest at the top of the slope near the slope edge. Improvements within the creep zone should be designed and constructed to accommodate the anticipated movements. The movements may very from a fraction of an inch to several inches and is dependent on the slope height, soil type, distance from the slope edge, and other factors.

Slope Protection

Permanent slope maintenance and protection measures as presented in the subsequent 'Slope Maintenance and Protection Recommendations' section of this report should be initiated as soon as practicable after completion of cut and/or fill slope construction. Fill slopes and cut slopes in alluvium materials steeper than 3H:1V (Horizontal to Vertical) are moderately susceptible to erosion due to the low cohesion parameters of the soils. The plant mix, method of application, and maintenance requirements are subject to the approval of a registered Landscape Architect or other qualified landscape professional. Construction delays, climate or weather conditions, and plant growth rates may be such that additional short-term non-plant erosion management measures may be needed. Examples would include matting, netting, plastic sheets, deep staking (5.0 feet or deeper), etc.

Protection of Work

During the grading process and prior to the completion of construction of permanent drainage controls, it is the responsibility of the grading contractor to provide good drainage and prevent ponding of water and damage to the in progress or finished work on the site and/or to adjoining properties.

Observation and Testing

During grading, observation and testing should be conducted by the project Geotechnical / Geologic Consultant and/or his representatives to verify that the grading is being performed according to the recommendations presented in this report. The project Geotechnical / Geologic Consultant and/or his representative should observe the overexcavation bottoms and the placement of fill and should take tests to verify the moisture content, density, uniformity and degree of compaction obtained. The contractor should notify the project Geotechnical / Geologic Consultant when cleanout and/or overexcavation bottoms are ready for observation and prior to scarification and recompaction. Where testing demonstrates insufficient density, additional compaction effort, with the adjustment of the moisture content when needed, should be applied until retesting shows that satisfactory relative compaction has been obtained. The results of observations and testing services should be presented in a formal 'Grading Report' following completion of the grading operations. Grading operations undertaken at the site without the project Geotechnical / Geologic Consultant and/or his representative present may result in exclusions of the affected areas from the grading report for the project. The presence of the project Geotechnical / Geologic Consultant and/or his representative will be for the purpose of providing observations and field testing and will not include supervision or directing of the actual work of the contractor or the contractor's employees or agents. Neither the presence and/or the non-presence of the project Geotechnical / Geologic Consultant and/or his field representative nor the field observations and testing will excuse the contractor for defects discovered in the contractor's work. If **Hilltop Geotechnical, Inc.** does not perform the observation and testing of the earthwork for the project and is replaced as Geotechnical / Geologic Consultant of record for the project, the work on the project should be stopped until the replacement Geotechnical / Geologic Consultant has reviewed the previous reports and work performed for the project, agreed in writing to accept the recommendations and prior work performed by **Hilltop Geotechnical, Inc.** for the subject project, or has performed their own studies and submitted their revised recommendations.

Soil Expansion Potential

The preliminary expansion potential of the on-site soils is discussed in the subsequent foundation and floor slab recommendation sections of this report. Upon completion of grading for the building pad areas, near-surface samples should be obtained for expansion potential testing to verify the preliminary expansion test results and the foundation and slab-on-grade recommendations presented in this report.

Soil Corrosion Potential

The preliminary corrosion potential of the on-site soils is discussed in the subsequent corrosion recommendation sections of this report. Upon completion of grading for the building pad areas, near-surface samples should be obtained for corrosion potential testing to verify the preliminary chemical test results and the recommendations presented in this report for protection of concrete which come in direct contact with the on-site soils and to present recommendations for protection of bare metal, if desired, which come in direct contact with the on-site soils.

2007 CBC SEISMIC DESIGN CRITERIA

Per the **California Building Standards Commission**, *2007 California Building Code* (CBC), California Code of Regulations, Title 24, Part 2, Volume 1 and 2, the followings coefficients and factors relevant to seismic mitigation and design for new construction include:

- **Site Class Types**
  Categorizing the upper 30 meters (±100 ft.) of earth materials into one of the site class types A, B, C, D, E, and F that are based on average shear wave velocities, Standard Penetration Test blow counts, or undrained shear strength.

- **Mapped, Maximum Considered Earthquake (MSC), 5.0 Percent Damped, Spectral Response Acceleration Parameters at Short Period (0.2 Second) and at 1-Second Period**
  Mapped, Maximum Considered Earthquake (MSC), 5.0 percent damped, spectral response acceleration parameters at short period and at 1-second, S_s and S_1 for Site Class 'B' are determined from Java Ground Motion Parameter Calculator - Version 5.0.7 available at the USGS web site (http://earthquake.usgs.gov/research/hazmaps/design/).

- **Site Coefficients**
  Short period site coefficient (0.2 second period), F_a and long-period site coefficient (1.0 second period), F_v are based on 'Site Class Type' and the 'Mapped Spectral Response Acceleration at Short Period (0.2 Second) and at 1-Second period' S_s and S_1.

Based on our understanding of local geologic conditions, the 'Site Class' judged applicable to this site is S_C, with a 'Soil Profile Name' of 'Very Dense Soil and Soft Rock' per Table 1613.5.2, 'Site Class Definitions,' in the 2007 CBC with an average Shear Wave Velocity of 1,200 to 2,500 feet/second (ft./s) in the upper 100 feet (30.48 m) of the site.

The following table presents supplemental coefficients and factors relevant to seismic design for new construction built according to the 2007 CBC.

SEISMIC DESIGN CRITERIA	
Site Location	Latitude: 34.2099° North Longitude: 117.0868° West
Site Class[1]	C
Mapped, Maximum Considered Earthquake (MSC), 5.0 Percent Damped, Spectral Response Acceleration Parameter at Short Period (0,2 Sec.) (S_s)[2] for Site Class B.	1.500
Mapped, Maximum Considered Earthquake (MSC), 5.0 Percent Damped, Spectral Response Acceleration Parameter at 1-Second (S_1)[2] for Site Class B.	0.600
Site Coefficients (F_a)[2] for Site Class.	1.0
Site Coefficients (F_v)[2] for Site Class.	1.3
The MSC, 5.0 Percent Damped, Spectral Response Acceleration Parameter at Short Periods (0,2 Second) Adjusted for Site Class Effects (S_{MS})	1.500
The MSC, 5.0 Percent Damped, Spectral Response Acceleration Parameter at 1-Second Adjusted for Site Class Effects (S_{M1})	0.780
Design, 5.0 Percent Damped, Spectral Response Acceleration Parameter at Short Period (0.2 Second) (S_{DS}) for Site Class.	1.000
Design, 5.0 Percent Damped, Spectral Response Acceleration Parameter at 1-Second (S_{D1}) for Site Class.	0.520

1. **California Building Standards Commission**, *2007, California Building Code*, California Code of Regulations, Title 24, Part 2, Volume 2 of 2, Table 1613.5.2, 'Site Class Definitions.'
2. Java Ground Motion Parameter Calculator - Version 5.0.7 available at USGS web site (http://earthquake.usgs.gov/research/hazmaps/design/).

PRELIMINARY FOUNDATION DESIGN RECOMMENDATIONS

General

The foundation recommendations presented in this report are considered preliminary since the type of structures, the ground floor level elevations, the structural loads, etc. were not known at the time of this report.

The recommendations presented in the subsequent paragraphs for foundation design and construction are based on geotechnical characteristics and expansive soil conditions for the supporting soils as defined in Section 1802.3.2, 'Expansive Soils,' in the 2007 CBC and should not preclude more restrictive structural requirements. Per Section 1805.8, 'Design for Expansive Soil,' in the 2007 CBC, foundations for structures resting on soils with an Expansion Index greater than 20 require special design considerations or such other engineering design based on geotechnical recommendations as approved by the building official. Foundations for proposed building structures could consist of a 'Slab-on-Ground Foundation' system based on the **Wire Reinforcement Institute, Inc.** procedures or a 'Post-Tension Slab-on-Ground' system based on the **Post Tensioning Institute.** However, since foundations in the Arrowbear area of San Bernardino County, California have to be deepened due to frost penetration in the winter months, it may also be feasible to use a foundation system which is deepened to a depth below where volume changes occur in the soils due to wetting and drying with presaturation under the floor slabs for the suhject structures.

Recommendations for a deepened foundation system and presaturation under the floor slabs are presented in the following sections. The project Structural Engineer may design a 'Slab-on-Ground Foundation' system based on the **Wire Reinforcement Institute, Inc.** procedures or a 'Post-Tension Slab-on-Ground' system based on the **Post Tensioning Institute** as an alternative to deepened conventional reinforced concrete foundations and cast-on-grade concrete floor slabs. Geotechnical parameters for the design of a 'Slab-on-Ground Foundation' system or a 'Post-Tension Slab-on-Ground' system can be submitted upon request, if needed.

The foundations for proposed decorative block walls, retaining walls, etc. may consist of conventional continuous footings which are deepened to a depth below where volume changes occur in the soils due to wetting and drying or be isolated from the expansive soils.

The Structural Engineer for the project should determine the actual foundation type and footing width, depth, and reinforcing to resist design vertical, horizontal, and uplift forces under static and seismic conditions. Reinforcement recommendations presented in this report are considered the minimum for the soil conditions present on the site and are not intended to supersede the design of the project Structural Engineer or the criteria of the governing agencies for the project.

Due to the freeze / thaw conditions during the winter months in the project area, air entrained concrete should be utilized for concrete exposed to these conditions.

Deepened Conventional Foundations

Foundation Size: Continuous footings should have a width of 12 inches or greater for 1- and 2-story structures in accordance with Table 1805.4.2, 'Footings Supporting Walls of Light Frame Construction,' in the 2007 CBC. Footings supporting a roof only shall be as required for supporting one (1) floor. Continuous footings should be continuously reinforced with a minimum of two (2) No. 4 steel reinforcing bars located near the top and two (2) No. 4 steel reinforcing bars located near the bottom of the footings to minimize the effects of slight differential movements which may occur due to minor variations in the engineering characteristics or seasonal moisture change in the supporting soils. Column footings should have a width of 18 inches by 18 inches or greater and be suitably reinforced, based on structural requirements. The continuous footings should extend across doorway and garage entrances and should be founded at the same depths and reinforced the same as the adjacent footings.

Depth of Embedment: Exterior footings should extend to a depth of 24 inches or greater below lowest adjacent finish grade due to the expansive characteristics of the near-surface alluvial soils. Frost is also considered a design factor for foundations in the Arrowbear area of San Bernardino County, California. The recommended depth of embedment will also be below anticipated frost depths in the project area, since there will not be any significant frost penetration in the winter months.

Footing Setback: Embedment of footings on or near existing or planned slopes should be determined by a setback distance measured from the bottom outside edge of the footing to the slope face in accordance with Section 1805.3, 'Footing on or Adjacent to Slopes,' in the 2007 CBC or the current San Bernardino County, California building codes, whichever is greater.

Foundations for the proposed structure and/or retaining walls on slopes that are steeper than 10H:1V (Horizontal to Vertical) (10 percent slope) should be designed in accordance with the provisions of Section 1805.1, 'General,' in the 2007 CBC. The top surface of the footings should be level or should be stepped so that both the top and bottom of such foundations are in accordance with the provisions in Section 1805.1 in the 2007 CBC. The stepped foundation should be suitably reinforced and designed by a qualified Civil or Structural Engineer.

The fine grained soils overlying the natural slopes on the subject site are prone to downslope creep. The rate of creep is a function of the length and steepness of the slope, the moisture content of the soils, the depth of creep prone soils, and the degree and care and maintenance of the slope. Slope creep is activated by wetting of the soil mantle. In addition, the presence of burrowing animals can reduce the integrity of the soils and increase the downslope creep.

Bearing Capacity: Provided the recommendations for site earthwork and for footing width and depth of embedment are incorporated into the project design and construction, the allowable bearing value for design of continuous and column footings for the total dead plus frequently-applied live loads is 2,000 pounds per square foot (psf) for footings that are 12 inches in width and a depth of embedment of 12 inches or greater below lowest adjacent finish grade in accordance with Table 1804.2, 'Allowable Foundation and Lateral Pressure,' in the 2007 CBC for footings founded in undisturbed, documented, properly, compacted fill material (Class 4 Material). For eccentrically loaded footings and/or overturning moments, the resultant force should be in the middle one-third of the footing and the average bearing value across the footing should not exceed the recommended allowable bearing value. The allowable bearing values have a factor of safety of 3.0 or greater and may be increased by 33.3 percent for short durations of live and/or dynamic loading such as wind or seismic forces.

Settlement: Footings designed according to the recommended bearing value for continuous and column footings, the assumed maximum wall and column loads, and founded in undisturbed, properly compacted fill material are not expected to exceed a total settlement of 1.0 inch or a differential settlement of 0.25 inch between similarly sized and loaded footings.

Lateral Capacity

Resistance to lateral loads can be provided by a combination of friction acting at the base of the foundation and passive earth pressure on the sides of the footings and stem walls. Foundation design parameters, based on undisturbed, documented, properly compacted fill or undisturbed, in-situ alluvium (Class 4 materials) for resistance to static lateral dead forces per Table 1804.2, 'Allowable Foundation and Lateral Pressure,' in the 2007 CBC,' are as follows:

Allowable Lateral Bearing Pressure
(Equivalent Fluid Pressure), Passive Case:

Undisturbed, Documented, Compacted Fill - 150 pcf
Undisturbed Alluvial Soil - 150 pcf
* Pounds per Square foot per Foot of Depth (pcf).

Allowable Lateral Sliding Coefficient of Friction Between Soil and Concrete:

Undisturbed, Documented, Compacted Fill - 0.25
Undisturbed Alluvial Soil - 0.25

The above values are allowable design values and have safety factors of 2.0 or greater incorporated into them and may be used in combination without reduction in evaluating the resistance to lateral loads. The recommended lateral resistance assumes a horizontal surface for the soil mass extending to a distance of 10 feet or greater from the face of the footing, or three (3) times the height of the surface generating passive pressure, whichever is greater. The allowable values may be increased by 33.3 percent for short durations of live and/or dynamic loading, such as wind or seismic forces. For the calculation of the allowable lateral bearing pressure (passive earth resistance), the upper 1.0 foot of material should be neglected unless confined by a concrete slab or pavement. The largest recommended allowable lateral bearing pressure (passive earth resistance) is 15 times the recommended design value for the appropriate class of material.

Interim Foundation Plan Review

It is recommended that **Hilltop Geotechnical, Inc.** review the foundation plans for the structures as they become available. The purpose of this review is to determine if these plans have been prepared in accordance with the recommendations contained in this report. This review will also provide us an opportunity to submit additional recommendations as conditions warrant.

Final Foundation Design Recommendations

Final foundation recommendations should be made upon completion of grading and be included in the 'Report of Grading' prepared by the Geotechnical / Geologic Consultant for the project.

Foundation Excavations

Foundation excavations should be observed by the project Geotechnical / Geologic Consultant and/or his representative prior to placement of forms, reinforcing steel, or placement of concrete for the purpose of verification of the recommendations presented in this report and for compliance with the project plans and specifications. The foundation excavations should be trimmed neat, level, and square. Any loose or sloughed material and debris should be removed from the foundation excavations prior to placement of reinforcing steel and removed again prior to the placement of concrete. Soils removed from the foundation excavations should not be placed in slab-on-grade areas unless compacted to 90 percent or greater relative compaction. The maximum dry density and optimum moisture content for the soil should be determined in accordance with current ASTM D1557 procedures.

to 90 percent or greater of maximum dry density as determined by current ASTM D1557 procedures. The concrete for the floor slab should have a compressive strength of 2,500 psi or greater at 28 days. Slab reinforcement should consist of a minimum of No. 3 reinforcing bars placed 18 inches on center in both directions, or an equivalent substitute. The reinforcing should be placed at mid-depth to 1.5 inches below the top surface of the slab to minimize cracking. The reinforcing should be tied into the adjacent footing stemwalls. The concrete section, reinforcing steel, and/or design concrete compressive strength should he increased appropriately for anticipated excessive or concentrated floor loads. A Modulus of Subgrade Reaction (k_s) of 200 pounds per square inch per inch of deflection is recommended for the design of structural slabs cast on grade for excessive floor loads.

Suhgrade soils should be moisture conditioned to 130 percent of optimum moisture content to a depth of 18 inches or greater immediately before placing the sand or gravel material, the vapor barrier, or pouring concrete.

If a vapor barrier / moisture retarder is used under the floor slab and it is placed on well graded crushed gravel material, it is recommended that a 1.0 inch thick layer of sand or other approved granular material be placed beneath the vapor barrier / moisture retarder to prevent punctures from angular gravel fragments and projections. If open graded gravel (capillary break) is placed beneath the vapor barrier or retarder, the gravel should be a 6.0 inches or greater in thickness. If open graded gravel is used, a separation fabric such as Mirafi 140N series or an equivalent substitute should be used in-leu of a sand cushion to protect the vapor barrier / moisture retarder from punctures.

Subgrade soils should be moisture conditioned to optimum moisture content to 3.0 percent above optimum moisture content to a depth of 12 inches and proof compacted to 90 percent or greater relative compaction based on current ASTM D1557 procedures immediately before placing the gravel material, the moisture barrier, or pouring concrete.

Vapor Barrier / Moisture Retarder Recommendations

In areas where moisture sensitive floor coverings are anticipated over the floor slab, the use of a vapor barrier / moisture retarder beneath the slab should be considered. The use or non-use of a vapor barrier / moisture retarder, the thickness of the vapor barrier / moisture retarder, the use of a granular layer over the vapor barrier / moisture retarder, the thickness of the granular materials, the type of granular material, etc. should be determined by the Structural Engineer who is designing the floor slab in conjunction with the Architect who is specifying the use and the type of floor coverings to be placed over the floor slab. The vapor barrier / moisture retarder recommendations provided by the supplier of the flooring materials should also be incorporated into the project plans.

EXTERIOR CONCRETE FLATWORK

Due to the freeze / thaw conditions during the winter months in the project area, air entrained concrete should be considered for use in concrete exposed to these conditions.

Due to the expansion potential of some of the near-surface on-site soils, exterior slabs-on-grade will experience seasonal vertical movement and cracking. There are several alternatives for minimizing or mitigating the impacts of expansive soils beneath exterior flatwork. Recommendations to reduce the distress to concrete flatwork include moisture conditioning the subgrade soils, using non-expansive fill, and providing adequate construction and control joints in the concrete. It should be noted that localized cracking, vertical movement. and distress could still occur.

- The minimum recommendations for concrete flatwork constructed on expansive soils is to properly prepare the clayey soils prior to placing concrete. This is typically achieved by scarifying, moisture conditioning, and re-compacting the subgrade soil. The subgrade soils should be moisture conditioned to a depth of 18 inches or greater and to 130 percent or greater of the optimum moisture content for the supporting soils as determined by current ASTM D1557 procedures. The subgrade soils should be compacted using moderate compaction effort to a relative compaction of 87 to 92 percent relative compaction. If the near-surface subgrade soils had previously been compacted and tested, the subgrade soils could possibly be moisture conditioned by gradually wetting the soil, depending on the time of the year the flatwork construction occurs. This procedure should not include flooding or excessively wetting of the soil, which would likely result in soft, unstable subgrade conditions, and possible delays in the construction while waiting for the soils to dry out. In general, the subgrade soils should be firm and non-yielding prior to constructing the flatwork.

- The replacement of expansive soils with non-expansive soils, aggregate base, crushed rock, gravel, sand, etc, in localized areas under exterior flatwork should be avoided unless the materials are provided with a positive drainage system which will prevent a "bathtub" type situation. If non-expansive soils, aggregate base, crushed rock, gravel, sand, etc, are used under the exterior flatwork, the materials should be proof compacted to 90 percent or greater relative compaction based on ASTM D1557 procedures. The subgrade soils under the non-expansive soils, aggregate base, crushed rock, gravel, sand, etc, should be prepared in accordance with the recommendations in the above bulleted paragraph.

- Use of maximum control joint spacing of no more than 8.0 feet in each direction and a construction joint spacing of 10 to 12 feet should be used in the design of flatwork on expansive soils. Construction joints that abut the foundations or garage slab should include a felt strip, or approved equivalent, that extends the full depth of the exterior slab. This will help to reduce the potential for permanent vertical offset between the slabs due friction between the concrete edges. It is recommended that exterior slabs be isolated from adjacent foundations.

If the subgrade soils are allowed to become saturated, there is a risk of heaving and vertical differential movement of the exterior concrete hardscape, sidewalks, curbs / gutters, etc. Therefore, proper drainage should be established away from such improvements and minimal precipitation or irrigation water allowed to percolate into the soils adjacent to and/or under the exterior concrete flatwork or hardscape, curbs / gutters, etc.

RETAINING WALL RECOMMENDATIONS

Retaining walls may be needed to achieve finish grades for the proposed building pads, driveways, parking areas, and/or landscape areas. Due to the freeze / thaw conditions in the during the winter months in the project area, air entrained concrete should be utilized for concrete exposed to these conditions. Retaining walls should be designed in accordance with the recommendations in the following sections. If earth reinforced walls, crib wall, keystone walls, etc. are used for the development of the subject site, the design requirement of the proprietary wall system should supercede the following recommendations if there are any conflicts.

Static Lateral Earth Pressures

Retaining walls backfilled with non-expansive granular soil (i.e., Expansion Index (EI) = 0 or Unified Soil Classifications of SP, SW, SM, GP, GW, and GM) within a zone extending upward and away from the heel of the footing at a slope of 0.5H:1V (Horizontal to Vertical) or flatter for level backfill behind the wall can be designed to resist static lateral earth pressures equivalent to those recommended in the following table:

CONDITION	LEVEL BACKFILL AND SOIL CLASSIFICATION*		
	SP, SW, GP, GW	GM	SM
Active	30 pcf**	40 pcf	45 pcf
At-Rest	60 pcf	60 pcf	60 pcf

* Per table 1610.1, 'Soil lateral Load,' in the 2007 CBC.
** Equivalent fluid Pressure, pounds per square foot per foot of depth (pcf).

The on-site clayey, expansive soils should not be used as backfill for retaining walls. The designer of the retaining wall should specify the type of backfill material to be used in the active / at-rest zone behind the wall. Walls that are free to deflect 0.001 radian at the top should be designed for the above-recommended active condition. Walls that are not capable of this movement should be assumed rigid and designed for the at-rest condition. The above values assume well-drained backfill and that a buildup of hydrostatic pressure will not occur. Surcharge loads, dead and/or live (i.e., construction loads, etc.), acting on the backfill within a horizontal distance behind the wall, equivalent to or less than the vertical height of the wall, should also be considered in the design. Uniform surcharge pressures should be applied as an additional uniform (rectangular) pressure distribution. The lateral earth pressure coefficient for a uniform vertical surcharge load behind the wall is 0.50. Seismic and wind loads should also be added to the design loads on the walls.

Foundation Design

Retaining wall footings should be founded to the same depths below lowest adjacent finished grade and offsets from the face of slopes, and into undisturbed, observed and tested, compacted fill, or firm, competent, undisturbed, alluvial soil as recommended in the previous sections of this report for a deepened foundation system. The foundations may be designed for the same average allowable bearing value across the footing (as long as the resultant force is located in the middle one-third of the footing), and with the same allowable static and seismic allowable lateral bearing pressure, allowable passive earth pressure, and allowable sliding resistance as recommended in the 'Foundation Design Recommendations' section of this report. When using the allowable lateral pressure and allowable lateral sliding resistance, a factor of safety of 1.0 may be used. If ultimate values are used for design, an approximate factor of safety (i.e., 1.5) should be achieved.

Subdrain

A subdrain system should be constructed behind, and at the base of retaining walls to allow drainage and to prevent the buildup of excessive hydrostatic pressures. The subdrain system should be designed by the project Civil Engineer. The use of water-stops, impermeable barriers, or other dampproofing or waterproofing methods should be considered for any walls where moisture migration through the wall is considered critical to the performance and/or appearance of the walls. A waterproofing consultant should be retained to provide specific waterproofing recommendations for the project.

Typical subdrains may include weep holes with a continuous free draining gravel gallery, perforated pipe surrounded by free draining filter rock, or another approved system. The option of providing an ungrouted, open coarse of block at the bottom of a retaining wall is not a recommended drainage option since the openings are so often covered by landscape soil, hardscape, and or pavement. Gravel galleries and/or filter rock, if not designed and graded for the on-site and/or import materials, should be enclosed in a geotextile fabric such as Mirafi 140N series or an equivalent substitute, to prevent infiltration of fine soil particles into the subdrain and clogging of the system. Before placement of the fabric, the top of the footing should be cleared of loose soil materials, large stones, and/or other debris. Any large depressions or holes should be filled with a concrete slurry or a suitable equivalent to permit close contact of the fabric with the surrounding surface. The fabric should be placed smoothly without folds or excessive wrinkles. Successive sheets of the fabric should be placed with an overlap of 24 inches or more in the direction of the flow of the water in the pipe with the upstream layer overlapping the downstream layer. The fabric should be folded over the top of the free draining granular material producing an overlap of 12 inches or more. The perforated pipes should be Schedule 40 or stronger and 4.0 inches or greater in diameter. Perforations may be either bored 0.25-inch diameter holes or 0.1875-inch (3/16-inch) wide slots placed on the bottom one-third of the pipe perimeter. If the pipe is bored, a minimum of 10 holes per linear foot should be uniformly placed along the pipe. If slots are used, they should not exceed 2.0 inches in length and should not be closer than 2.0 inches on center along the length of the pipe. The total length of the slots should not be less than 50 percent of the pipe length and should be uniformly spaced along the length of the pipe. Pipe perforations should be placed downward. Gravel filters should have a volume of 3.0 cubic feet or greater per linear foot of pipe. Subdrains should maintain a positive flow gradient and have outlets that drain in a non-erosive manner.

Prefabricated drainage products such as 'Miradrain' or a suitable equivalent may also be used for the purpose of providing drainage behind retaining walls when installed in accordance with the manufacturers recommendations.

Backfill

Backfill directly behind retaining walls (if backfill width is less than 3.0 feet) may consist of 0.5- to 0.75-inch diameter, rounded to subrounded gravel with less than

5.0 percent passing the 0.5 inch sieve enclosed in a geotextile fabric such as Mirafi 140N series, or an equivalent substitute, or a clean sand (Sand Equivalent Value greater than 50) water jetted into place to obtain compaction. If water jetting is used, the subdrain system should be in place. Even if water jetting is used, the sand should he densified to 90 percent or greater relative compaction. If the specified density is not obtained by water jetting, mechanical methods will have to be used. If other types of soil or gravel are used for backfill, mechanical compaction methods will have to be used to obtain a relative compaction of 90 percent or greater of maximum dry density. Backfill directly behind retaining walls should not be compacted by wheel, track or other rolling by heavy construction equipment unless the wall is designed for the surcharge loading. If gravel, clean sand, or other imported backfill is used behind retaining walls in unpaved areas, the upper 12 to 18 inches of backfill should consist of typical on-site material compacted to 90 percent or greater relative compaction to prevent the influx of surface run-off into the granular backfill and into the subdrain system. Maximum dry density and optimum moisture content for backfill materials should be determined according to current ASTM D1557 procedures.

V-Drain Design

A V-drain should be constructed directly behind retaining walls which have a sloping backfill to intercept surface water and drain it from the back of the wall. The V-drain should be designed and constructed in accordance with the current typical standards of San Bernardino County, California. The V-drain should direct water from the back of the wall to an adequate down drain and discharge it in a non-erosive manner.

Observation and Testing

During retaining wall construction, observation and testing should be conducted by the project Geotechnical / Geologic Consultant and/or his representatives to verify that the work is being performed according to the recommendations presented in this report.

The foundation excavations should he observed by the project Geotechnical / Geologic Consultant and/or his representative prior to placement of forms, reinforcing steel, or placement of concrete for the purpose of verification of the recommendations presented in this report and for compliance with the project plans and specifications. The foundation excavations should be trimmed neat, level, and square. Any loose or sloughed material and debris should be removed from the foundation excavations prior to placement of reinforcing steel and removed again prior to the placement of concrete.

The placement and construction of the subdrain system behind the retaining walls should be observed by the project Geotechnical / Geologic Consultant and/or his representatives to verify that the work is being performed according to the recommendations presented in this report.

During backfill of the retaining walls, observation and testing should be conducted by the project Geotechnical / Geologic Consultant and/or his representatives to verify that the backfilling is being performed according to the recommendations presented in this report. The project Geotechnical / Geologic Consultant and/or his representative should observe the placement of fill and should take tests to verify the moisture content, density, uniformity and degree of compaction obtained. Where testing demonstrates insufficient density, additional compaction effort, with the adjustment of the moisture content when needed, should be applied until retesting shows that satisfactory relative compaction has been obtained. The results of observations and testing services should be presented in a formal report following completion of the construction operations. Retaining wall backfill operations undertaken at the site without the project Geotechnical / Geologic Consultant and/or his representative present may result in exclusions of the affected areas from the final report for the project.

The presence of the project Geotechnical / Geologic Consultant and/or his representative will be for the purpose of providing observations and field testing and will not include supervision or directing of the actual work of the contractor or the contractor's employees or agents. Neither the presence and/or the non-presence of the project Geotechnical / Geologic Consultant and/or his field representative nor the field observations and testing will excuse the contractor for defects discovered in the contractor's work.

CORROSION POTENTIAL EVALUATION

The recommendations for corrosion protection should be verified at the completion of grading of the building pads on the subject site. Bulk samples of the near surface on-site soils were obtained during the field study which was performed for this report to evaluate the potential for soil corrosivity. Results from the tests are included in the 'Summary of Laboratory Test Results' presented in Appendix 'A.'

Concrete Corrosion

A preliminary test on a sample of near-surface on-site soil material suggests a soluble sulfate concentration of 0.0 to 0.001 percent. Soils with a water soluble sulfate (SO_4) concentration in the range of 0.0 to 0.10 percent are considered to have a 'Negligible' sulfate exposure to concrete which comes in direct contact with the on-site soil as defined in Table 4.3.1, 'Requirements for Concrete Exposed to

Sulfate-Containing Solutions,' in **American Concrete Institute (ACI)** 318, Section 4.3. The referenced **ACI** Table should be used to determine the type cement, the maximum water cement ratio, and the minium compressive strength to be used for normal weight concrete which comes in direct contact with the on-site soils (i.e., foundations, floor slabs, driveway slabs, sidewalks, patios, curbs / gutters, etc.). A lower water / cement ratio or higher compressive strength may be requested for design of concrete for water tightness or for protection against corrosion of embedded metallic items or freezing and thawing per Sections 1904.2.1 through 1904.2.3 in the 2007 CBC, if applicable.

Experience in the southern California area has shown that even though the soils do not contain levels of soluble sulfate which would require the use of sulfate resistant cement, maximum water cement ratios, or minimum compressive strength for concrete, concrete corrosion and erosion problems still occur. These problems are the result of concentrations of soluble sulfate, chloride, and other salts and/or acids present in groundwater, irrigation water, rain water, and potable water sources, and in fertilizers or soil amendments used to promote plant growth (i.e., some domestic water sources contain levels of soluble sulfate which would be a moderate sulfate exposure to concrete which comes in contact with it). Therefore, it may be wise to use a concrete designed for a moderate exposure to sulfate per the criteria presented in Table 4.3.1, 'Requirements for Concrete Exposed to Sulfate-Containing Solutions,' in **ACI** 318, Section 4.3 that comes into contact with surface run-off or other sources of water. Higher strength, lower water / cement ratio, and denser concrete may also be effective in reducing the potential for evaporation to occur and preventing damage due to salt or acid exposure. The use of sulfate resistant concrete for non-structural elements (i.e., driveway slabs, sidewalks, patios, curbs / gutters, etc.), is considered to be a value / risk assessment and decision to be made by the project owner / developer.

Metallic Corrosion

The life of buried metals depends on type of material, thickness, and construction details. Tests were not performed as part of this study to evaluate the potential for corrosion of bare metal in direct contact with the on-site soils. If corrosion protection of metals in direct contact with the on-site soils is considered to be a design issue, tests should be performed at the completion of the grading for the building pads and/or an engineer specializing in corrosion should be consulted regarding the potential damage due to corrosion. The corrosion engineer should recommend appropriate types of piping and/or protective measures where needed.

SLOPE STABILITY EVALUATION

Since anticipated cut and fill slopes for the development of the site are not anticipated to exceed 10 feet in vertical height and will not he steeper than 2H:1V (Horizontal to Vertical), a formal slope stability analysis was not performed as part of this study. The proposed cut and fill slopes should be constructed at an inclination of 2H:1V or flatter. It is anticipated that the proposed cut slopes will expose alluvial material. It is anticipated that the proposed fill slopes will be constructed of the materials obtained from the proposed cuts for the development of the subject site and will be composed of the alluvial materials which are present on the subject site. It is the opinion of this firm that the proposed cut and fill slopes will be grossly and surficially stable as designed. However, the compacted fill and exposed cut materials will be vulnerable to erosion if precautions as recommended in the 'Slope Maintenance and Protection' section of this report are not implemented as soon as practicable after completion of grading.

PRELIMINARY PAVEMENT RECOMMENDATIONS

The following are preliminary recommendations for the structural pavement section for the proposed parking areas, driveway areas, and open storage areas for the subject development. The Hot Mix Asphalt (HMA) pavement sections have been determined in general accordance with current **CALTRANS** design procedures and are based on an assumed Traffic Index (TI) and an assumed R-Value of at least 30 based on past experience in the vicinity of the site and visual textural classification of the on-site soil and/or import materials which are anticipated to be at subgrade elevation. Portland Cement Concrete (PCC) pavement sections are based on equivalent structural numbers as the recommended HMA pavement section. The preliminary recommendations for the pavement sections should consist of the following:

RECOMMENDED PAVEMENT SECTIONS		
Site Area	**Traffic Index**	**Pavement Section**
Driveway and Parking Areas for Autos and Light Weight Vehicles Only.	≤5.0	3.0" Asphaltic Concrete (A.C.) over 5.9" Aggregate Base (A.B.) or 5.3" PCC @ 2,500 psi over properly prepared subgrade.
Driveway and Parking Areas for Heavy Weight Trucks, RV's, etc.	≤6.5	4.1" A.C. over 8.3" A.B. or 7.4" PCC @ 2,500 psi over properly prepared subgrade.

It is noted that the County of San Bernardino, California minimum pavement sections may override the above pavement recommendations without prior County review and approval.

Asphalt concrete pavement materials should be as specified in Section 39, 'Asphaltic Concrete,' in the current **CALTRANS** Standard Specifications or an equivalent substitute. Aggregate base should conform to Class 2 (37.5-mm {1-1/2"}

Maximum or 19-mm {3/4"} Maximum) material as specified in Section 26-1.02A, 'Class 2 Aggregate Base,' in the current **CALTRANS** Standard Specifications, or an equivalent substitute. Portland Cement Concrete sections are based on a compressive strength of 2,500 psi or greater at 28 days for the concrete. Higher strength design for the concrete can permit thinner pavement sections. Lower strength design for the concrete will require thicker pavement sections. Joints (longitudinal, transverse, construction, and expansion), jointing arrangement, joint type, pavement and/or joint reinforcing, as well as drainage, crowning, finishing and curing of PCC pavement should be in accordance with current Portland Cement Association (PCA) recommendations.

The subgrade soil, including utility trench backfill, should be compacted to 90 percent or greater relative compaction to a depth of 1.0 foot or greater below finish subgrade elevation. The aggregate base material should be compacted to 95 percent or greater relative compaction. If asphaltic concrete and/or PCC pavement is placed directly on subgrade, the upper 6.0 inches of the subgrade should be compacted to 95 percent or greater relative compaction. Maximum dry density and optimum moisture content for subgrade and aggregate base materials should be determined according to current ASTM D1557 procedures. The asphalt concrete pavement should be densified to 95 percent or greater of the density obtained by current California Test 304 and 308 procedures (Hveem compacted laboratory samples).

Special consideration should also be given to areas where truck traffic will negotiate small radius turns and/or in areas utilized by solid tired forklifts or other material handling equipment. HMA concrete pavement in these areas should utilize stiffer emulsions or the areas should be paved with Portland Cement concrete. Where HMA pavement abuts concrete aprons, drives, walks, or curb and gutter sections, a thickened edge transition zone is recommended for the HMA section to minimize the effects of impact loading as vehicles transition from PCC paving to HMA paving. This thickened edge should consist of an increased thickness of 2.0 inches for parking areas and 4.0 inches for areas of heavy truck usage. This thickened edge should extend to a distance of 3.0 feet or greater from the edge of pavement and then gradually taper back to the design pavement thickness. If pavement subgrade soils are prepared at the time of grading of the building site and the areas are not paved immediately, additional observations and testing will have to be performed before placing aggregate base material, asphaltic concrete, or PCC pavement to locate areas that may have been damaged by construction traffic, construction activities, and/or seasonal wetting and drying. In the proposed pavement areas, soil samples should be obtained at the time the subgrade is graded for R-Value testing according to current California Test 301 procedures to verify the pavement design recommendations.

Because the full design thickness of the asphalt concrete is frequently not placed prior to construction traffic being allowed to use the pavement in a development or the parking lots, rutting and pavement failures can occur prior to project completion. To reduce this occurrence, it is recommended that either the full-design pavement section be placed prior to use by the construction traffic, or a higher Traffic Index (TI) be specified where construction traffic will use the pavement.

Surface water infiltration beneath pavements could significantly reduce the pavement design life. To limit the need for additional long-term maintenance of the pavement or pre-mature failure, it would be beneficial to protect at-grade pavements from landscape water infiltration by means of a concrete cutoff wall, deepened curbs, or equivalent. Pavement cut-off barriers should be considered where pavement areas are located downslope of any landscape areas that are to be irrigated. The cut-off barrier should extend to a depth of at least 4.0 inches below the pavement section aggregate base material.

Due to the porous nature of the near-surface alluvial soils on the subject site, if overexcavation and replacement is not performed under the pavement areas, there is a risk of settlement and vertical differential movement of the pavement, curbs / gutters, etc. if the subgrade soils are allowed to become saturated. Therefore, proper drainage should be established away from such improvements and minimal precipitation or irrigation water allowed to percolate into the soils adjacent to the pavement, curbs / gutters, etc.

The longevity and performance of pavements utilizing aggregate base material for support is dependent upon the quality of the material. **CALTRANS** specifications do not specifically exclude the use of material other than a natural, crushed rock and rock dust for Class 2 Aggregate Base material as the Standard Specifications for Public Works Construction, Section 200-2.2, does for Crushed Aggregate Base material. Often times, reclaimed Portland Cement concrete and Hot Mix Asphalt concrete are crushed and graded to produce a Class 2 Aggregate Base material per **CALTRANS** gradation specifications. Bricks, concrete masonry units, tile, glass, ceramics, porcelain, wood, plastic, metal, etc. are not an acceptable reclaimed material for use in a Class 2 Aggregate Base material per the **CALTRANS** specifications. However, gradation is not the only quality guidelines for aggregate base material. If a reclaimed material is proposed for use on the project as a Class 2 Aggregate Base, the reclaimed materials should not exceed 50 percent of the total volume of the aggregate used. The aggregate base material should also be tested for the following quality requirements per the current, appropriate **CALTRANS** procedures:

TEST	TEST METHOD NO.	QUALITY REQUIREMENT	
		OPERATING RANGE	CONTRACT COMPLIANCE
Resistance (R-Value)	Calif. Test 301	--	78 Min.
Sand Equivalent	Calif. Test 217	25 Min.	22 Min.
Durability Index	Calif. Test 229	--	35 Min.

If a reclaimed material or a pit run aggregate is proposed for use on the project as a 'Greenbook' Crushed Miscellaneous Base, the materials should be tested for the following quality requirements, per the current 'Greenbook,' 2006 Edition with the 2007 Supplements, and appropriate procedures as well as the required gradation and other requirements:

TEST	TEST METHOD NO.	QUALITY REQUIREMENT
Resistance (R-Value)	Calif. Test 301	78 Minimum[1]
Sand Equivalent	Calif. Test 217	35 Minimum
Percent Wear[2] 100 Revolutions 500 Revolutions	ASTM C131	 15 Maximum 52 Maximum
Gravel Particles[3], (%)	Calif. Test 202	15 Maximum

1. R-Value requirement may be waived if Sand Equivalent is 40 or more.
2. The percentage wear requirements may be waived if the material has a minimum Durability Index of 40 in accordance with CALTRANS Test Method 229.
3. Gravel is defined as particles with no more than one (1) fractured face.

A 'Greenbook' Crushed Miscellaneous Base may contain broken or crushed asphalt concrete or Portland Cement concrete and may contain crushed aggregate base or other rock materials. The Crushed Miscellaneous Base may contain no more than 3.0 percent brick retained on the # 4 sieve by dry weight of the total sample.

Samples of the proposed aggregate base using reclaimed material should be sampled from the manufacturer's stockpiles prior to delivery to the project. The samples should be obtained at a time as near the delivery to the project as possible but would allow enough time to complete the testing and report the results before delivery to the site. Samples should again be obtained and tested for quality compliance from the materials delivered to the project. In addition, per the current **CALTRANS** Standard Specifications, "No single aggregate grading or Sand Equivalent test shall represent more than 500 cubic yards or one (1) days production, whichever is less."

Concrete gutters should be provided at flow lines in paved areas. Pavements should be sloped to permit rapid and unimpaired flow of runoff water. In addition, paved areas should be protected from moisture migration and ponding from adjacent water sources. Saturation of aggregate base and/or subgrade materials could result in pavement failure and/or premature maintenance. The gutter material and construction methods should conform to the current standards of San Bernardino County, California.

POST-GRADING CRITERIA

Soils generated from the excavation of foundations, utility trenches, etc., to be used on-site, should be moisture conditioned to optimum moisture content to 3.0 percent above optimum moisture content and compacted to 90 percent or greater of the maximum dry density for the material type as determined by current ASTM D1557 procedures when it is to be placed under floor slabs, under hardscape areas, and/or in paved areas. The placement of the excess material should not alter positive drainage away from structures and/or off the lot and should not change the distance from the weep screed on the structure to the finished adjacent soil grade per the 'Finish Surface Drainage Recommendations' presented in a subsequent section of this report, the project plans, and/or the 2007 CBC.

SLOPE MAINTENANCE AND PROTECTION RECOMMENDATIONS

Although the design and construction of slopes are planned to create slopes that possess stability against mass rotational failure, surficial slumping, creep, and pop-outs, certain factors are beyond the influence of the project Geotechnical / Geologic Consultant. Soil slopes are subject to some erosion when subjected to sustained water application. To reduce long term erosion, the following recommendations for slope protection and maintenance should be considered when planning, designing, and implementing slope erosion methods:

- Surface water should not be allowed to flow over the on-site natural or proposed man-made slopes other than incidental rainfall and irrigation. Alterations of manufactured or natural slopes, terraces, top of slope berms, and/or pad gradients should not be allowed that will prevent pad and roof run-off from the structures from being expediently directed to approved disposal areas and away from the tops of slopes.
- Surface drainage should be positively maintained and directed to the street or storm drain system in a non-erosive manner.
- Top of slope berms should be constructed and compacted as part of finish grading of the property and should be maintained by the property owner. The recommended drainage patterns should be established at the time of finish grading and maintained throughout the life of the proposed development.

- Concentrated surface waters entering the property from off-site sources should be collected and directed to a permanent drainage system.

- The property owner is responsible for the maintenance and cleaning of the interceptor ditches, drainage terraces, downdrains and other drainage devices that have been installed to promote slope stability.

- It is recommended that slopes be planted with light-weight ground cover, shrubs and trees that possess deep (5.0 feet or greater), dense root structures that require minimal of irrigation (drought resistance). It should be the responsibility of the Landscape Architect or other suitably qualified individual to provide such plants initially and of the [property] [individual lot] owner[s] to maintain such planting. Alteration of the planting scheme is at the property owner's risk.

- If automatic sprinkler systems are installed their use should be adjusted to account for natural rainfall.

- The property owner should establish a program for the elimination of burrowing animals. This should be an on-going program to protect slope stability.

- The property owner should observe the lot drainage during heavy precipitation periods as this is often when trouble occurs. Problems such as gullying or ponding should be corrected as soon as practicable.

- High moisture content in slope soils is a major factor in slope erosion and slope failures. Therefore, precautions should be taken to minimize soil saturation. Leakage from waterlines, irrigation systems, etc. or bypassing of clogged drains should be promptly repaired.

The above guidelines are provided to mitigate slope maintenance and protection problems. The above guidelines are general maintenance and design procedures but may be superseded under specific direction of a Licensed Landscape Architect or other suitably qualified individual.

UTILITY TRENCH RECOMMENDATIONS

Utility trenches within the zone of influence of foundations or under building floor slabs, exterior hardscape, and/or pavement areas should be backfilled with documented, compacted soil. Utility trenches within the building pad and extending to a distance of 5.0 feet beyond the building exterior footings should be backfilled with on-site or similar soil. Where interior or exterior utility trenches are proposed to pass beneath or parallel to building, retaining wall, and/or decorative concrete block perimeter wall footings, the bottom of the trench should not be located below a 1H:1H (Horizontal to Vertical) plane projected downward from the outside bottom edge of the adjacent footing unless the utility lines are designed for the footing surcharge loads.

It is recommended that utility trench excavations be designed and constructed in accordance with current OSHA regulations. These regulations provide trench sloping and shoring design parameters for trenches up to 20 feet in vertical depth based on a description and field verification of the soil types encountered. Trenches over 20 feet in vertical depth should be designed by the Contractor's Engineer based on site specific geotechnical analyses. For planning purposes, we recommend that the following OSHA soil type designations and temporary slope inclinations be used:

EARTH MATERIAL	OSHA SOIL TYPE*	TEMPORARY SLOPE INCLINATION (H:V)**
Undocumented Fill	C	1.5:1
Compacted Fill	C	1.5:1
Alluvium	C	1.5:1

EARTH MATERIAL	OSHA SOIL TYPE*	TEMPORARY SLOPE INCLINATION (H:V)**
Weathered Bedrock	B	1:1
Granitic Formation	A	3/4:1

* Type 'A': Cohesive soils and weathered bedrock with an unconfined compressive strength of 1.5 tsf or greater.
Type 'B': Cohesive soils with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf.
Type 'C': Cohesive soils with an unconfined compressive strength of 0.5 tsf or less: or Granular soils including sands, gravels, loamy, clayey or silty sands, etc.

** Steepest allowable slopes for excavations less than 20 feet in vertical height. Slopes for excavations greater than 20 feet in vertical height should be designed by a Registered Professional Engineer with experience in Geotechnical Consulting and Soil Mechanics.

The classification for granitic rock is to be assumed as Type 'A' for planning purposes. Upon making and observing the excavations, it may be upgraded to a "Stable Rock" classification. However, caution should be exercised, as this designation is based on the rock performance as opposed to a material description. A Type 'A' classification should be used if the rock is decomposed, or if joints or fractures daylight into the sidewalls of the trench. Upon making the excavations, the soil rock classifications and excavation performance should be confirmed in the field by a competent person as defined in the current OSHA regulations.

Excavations of less than 5.0 feet in depth may also be subject to collapse due to water, vibrations, previously disturbed soils, or other factors and may require protection for workers such as temporary slopes, shoring, or a shielding protective system. The excavations should be observed by a qualified, competent person (as defined in the current OSHA regulations) looking for signs of potential cave-ins on a daily basis before start of work, as needed throughout the work shifts, and after every rainstorm or other hazard-increasing occurrence.

Surcharge loads (i.e., spoil piles, earthmoving equipment, trucks, etc,) should not be allowed within 1.5 times the vertical depth of the excavation. Excavations should be initially observed by the project Geotechnical / Geologic Consultant and/or his representative to verify the recommendations presented or to make additional recommendations to maintain stability and safety. Moisture variations, differences in the cohesive or cementation characteristics, or changes in the coarseness of the deposits may require slope flattening or, conversely, permit steepening upon review and appropriate testing by the project Geotechnical / Geologic Consultant and/or his representative. The excavations should be observed by a qualified, competent person (as defined in the current OSHA regulations) looking for signs of potential problems on a daily basis before start of work, as needed throughout the work shifts, and after every rainstorm or other hazard-increasing occurrence. Deep utility trenches may experience caving which will require special considerations to stabilize the walls and expedite trenching operations. Surface drainage should be controlled along the top of the construction slopes to preclude erosion of the slope face. If excavations are to be left open for long periods, the slopes should be sprayed with a protective compound and/or covered to minimize drying out, raveling, and/or erosion of the slopes.

Trench backfill material should be placed in a lift thickness appropriate for the type of backfill material and compaction equipment used. Backfill material should be brought to optimum moisture content to 3.0 percent above optimum moisture content and compacted to 90 percent or greater relative compaction by mechanical means. Jetting or flooding of the backfill material will <u>not</u> be considered a satisfactory method for compaction. Maximum dry density and optimum moisture content for backfill material should be determined according to current ASTM D1557 procedures.

FINISH SURFACE DRAINAGE RECOMMENDATIONS

Positive drainage should be established away from the tops of slopes, the exterior walls of structures, the back of retaining walls, trash enclosure walls, decorative concrete block walls, etc. Finish surface gradients in unpaved areas should be provided next to tops of slopes and buildings to guide surface water away from foundations, hardscape, pavement, and from flowing over the tops of slopes. The surface water should be directed toward adequate drainage facilities. Ponding of surface water should not be allowed next to structures or on pavements. Design criteria for finish lot drainage away from structures and off the property should be determined by the project Structural Engineer designing the foundations and slabs in conjunction with the project Civil Engineer designing the precise grading for lot drainage, respectively, in accordance with the 2007 CBC and/or the current San Bernardino County, California building codes and the soil types and expansion characteristics for the soils contained in this report. Finished landscaped and hardscape or pavement grades adjacent to the proposed structures should maintain a vertical distance below the bottom elevation of the weep screed per the 2007 CBC and/or the current San Bernardino County building codes. Landscape plants with high water needs and trees should be planted at a distance away from the structure equivalent to or greater than the width of the canopy of the mature tree or 6.0 feet, whichever is greater. Downspouts from roof drains should discharge to a permanent all-weather surface which slopes away from the structure. Downspouts from roof drains should not discharge into planter areas immediately adjacent to the building unless there is positive drainage out of the planter and away from the structure in accordance with the recommendations of the project foundation and slab designer and/or the project Civil Engineer designing the precise grades for the lot drainage.

PLANTER RECOMMENDATIONS

Planters around the perimeter of the structures should be designed so that adequate drainage is maintained and minimal irrigation water is allowed to percolate into the soils underling the buildings. This should include enclosed or trapped planter areas that are created as a result of sidewalks. Planters with solid bottoms, independent of the underlying soil, are recommended within a distance of 6.0 feet from the buildings. The planters should drain directly onto surrounding paved areas or into a designed subdrain system. If planters are raised above the surrounding finished grades or are placed against the building structure, the interior walls of the planter should be waterproofed.

LIMITATIONS

REVIEW, OBSERVATION, AND TESTING

The recommendations presented in this report are contingent upon review of final plans and specifications for the project by **Hilltop Geotechnical, Inc.** The project Geotechnical / Geologic Consultant should review and verify in writing the compliance of the final grading plan and the final foundation plans with the recommendations presented in this report.

It is recommended that **Hilltop Geotechnical, Inc.** be retained to provide continuous Geotechnical / Geologic Consulting services during the earthwork operations (i.e., rough grading, utility trench backfill, subgrade preparation for slabs-on-grade and pavement areas, finish grading, etc.) and foundation installation process. This is to observe compliance with the design concepts, specifications and recommendations and to allow for design changes in the event that subsurface conditions differ from those anticipated prior to start of construction. If **Hilltop Geotechnical, Inc.** is replaced as Geotechnical / Geologic Consultant of record for the project, the work on the project should be stopped until the replacement Geotechnical / Geologic Consultant has reviewed the previous reports and work performed for the project, agreed in writing to accept the recommendations and prior work performed by **Hilltop Geotechnical, Inc.** for the subject project, or has submitted their revised recommendations.

UNIFORMITY OF CONDITIONS

The recommendations and opinions expressed in this report reflect our understanding of the project requirements based on an evaluation of subsurface soil conditions encountered at the subsurface exploration locations and the assumption that soil conditions do not deviate appreciably from those encountered. It should be recognized that the performance of the foundations may be influenced by undisclosed or unforeseen variations in soil conditions that may occur in intermediate and unexplored areas. Any unusual conditions not covered in this report that may be encountered during site development should be brought to the attention of the **Hilltop Geotechnical, Inc.** so that we may make modifications, if necessary.

CHANGE IN SCOPE

Hilltop Geotechnical, Inc. should be advised of any changes in the project scope of proposed site grading so that it may be determined if recommendations contained herein are valid. This should be verified in writing or modified by a written addendum.

TIME LIMITATIONS

The findings of this report are valid as of this date. Changes in the condition of a property can, however, occur with the passage of time, whether they be due to natural processes or the work of man on this or adjacent properties. In addition, changes in the State-of-the-Art and/or government codes may occur. Due to such changes, the findings of this report may be invalidated wholly or in part by changes beyond our control. Therefore, this report should not be relied upon after a period of two (2) years without a review by **Hilltop Geotechnical, Inc.** verifying the validity of the conclusions and recommendations.

PROFESSIONAL STANDARD

In the performance of our professional services, we comply with the standard of care and skill ordinarily exercised under similar circumstances by members of the geologic / geotechnical profession currently practicing under similar conditions and in the same locality. The client recognizes that subsurface conditions may vary from those encountered at the locations where our surveys and exploratory excavations are made, and that our data, interpretations, and recommendations are based solely on information obtained by us. We will be responsible for those data, interpretations, and recommendations, but should not be responsible for interpretations by others of the information developed. Our services consist of professional consultation and observation only, and other warranties, expressed or implied, are not made or intended in connection with work performed by **Hilltop**

Geotechnical, Inc. or by the proposal for consulting or other services or by the furnishing of oral or written reports or findings.

CLIENT'S RESPONSIBILITY

It is the responsibility of the client and/or the client's representatives to ensure that information and recommendations contained herein are brought to the attention of the Engineers and Architect for the project and incorporated into project plans and specifications. It is further their responsibility to take measures so that the contractor and his subcontractors carry out such recommendations during construction.

APPENDIX A

FIELD EXPLORATION

The field study performed for this report included a visual geologic reconnaissance of existing surface conditions of the subject site and surrounding area. Site observations were conducted on November 27, 2007 by a representative of **Hilltop Geotechnical, Inc.**

A study of the property's subsurface condition was performed to evaluate underlying earth strata and the presence of groundwater. Six (6) exploratory backhoe excavations were performed on the subject site on November 27, 2007. Locations of the exploratory excavations were determined in the field by pacing and sighting from the adjacent existing streets, adjacent structures, and topographic features as shown on the Reference No. 1 'Site Plan' noted on the first page of the cover letter for this report. Approximate locations of the exploratory excavations are denoted on the 'Exploratory Excavation Location Plan,' Plate No. 1, presented in this Appendix. Approximate elevations of the exploratory excavations were determined by interpolation to the closest 1.0 foot from a 1.0 foot contour interval topographic plot of the site (Reference No. 1). Locations and elevations of the exploratory excavations should be considered accurate only to the degree implied by the method used in determining them.

The exploratory trenches were excavated by using a rubber tired, tractor-mounted backhoe. The depths explored in the trenches were approximately 12 to 13 feet below the existing land surface at the excavation locations. Bulk samples were obtained from cuttings developed during the backhoe excavation process and represent the soils within the depth indicated. In-place dry density and moisture content tests were also performed at various depths in the backhoe exploratory excavations. The tests were performed in general accordance with current nuclear testing procedures ASTM D2922 and D3017, respectively. The dry density and moisture content test results are presented on the'Subsurface Exploration Log.' Plate Nos. 3 through 8, presented in this Appendix.

Groundwater observations were made during, and at the completion of the excavation process and are noted on the 'Subsurface Exploration Log' presented in this Appendix, if encountered.

The exploratory excavations were logged by a representative of **Hilltop Geotechnical, Inc.** for earth materials and subsurface conditions encountered. Soil materials encountered in the exploratory excavations were visually described in the field in general accordance with the current Unified Soils Classification System (USCS), ASTM D2488, visual-manual procedures, as illustrated on the attached, simplified 'Subsurface Exploration Legend,' Plate No. 2, presented in this Appendix. The visual textural description, color of the soil at natural moisture content, apparent moisture condition of the soils, and apparent relative density or consistency of the soils, etc., were recorded on the field logs. The field log for each excavation contains factual information and interpretation of earth conditions between samples. The 'Subsurface Exploration Logs' presented in this Appendix represent our interpretation of the field log contents and results of laboratory observations and tests performed on samples obtained in the field from the exploratory excavations.

The exploratory backhoe excavations were backfilled with excavated earth materials and with reasonable effort to restore the areas to their initial condition before leaving the site, but were not compacted to a relative compaction of 90 percent or greater. Recompaction of the exploratory backhoe excavation backfill, if located within proposed structural fill, building, hardscape, and/or pavement areas, should be addressed during site grading operations. In an area as small and deep as a backhoe excavation, consolidation and subsidence of backfill soil may result in time, causing a depression of the excavation areas. The client is advised to observe exploratory excavation areas periodically and, when needed, backfill noted depressions.

LABORATORY TESTING PROGRAM

Laboratory tests were performed on selected, bulk samples obtained from exploratory excavations during the field study. Tests were performed in general accordance with generally accepted American Society for Testing and Materials (ASTM), State of California - Department of Transportation (CALTRANS), Uniform Building Code (UBC), Environmental Protection Agency (EPA) or other suitable test methods or procedures. The remaining samples obtained during the field study will be discarded 30 days after the date of this report. This office should be notified immediately if retention of samples will be needed beyond 30 days. A brief description of the tests performed is presented below:

CLASSIFICATION

The field classification of soil materials encountered in the exploratory excavations was verified in the laboratory in general accordance with the current Unified Soils Classification System, ASTM D2488, 'Standard Practice for Determination and Identification of Soils (Visual-Manual Procedures).' The final classification is shown on the 'Subsurface Exploration Log,' Plate Nos. 3 through 8, presented in this Appendix.

IN-SITU MOISTURE CONTENT

The in-situ moisture contents were determined in general accordance with current ASTM D2216 (Moisture Content) procedures for selected undisturbed samples obtained. This information was an aid to classification and permitted recognition of variations in material consistency with depth. The moisture content is determined as a percentage of the oven dry weight of the soil. Test results are shown on the 'Subsurface Exploration Log,' Plate Nos. 3 through 8, presented in this Appendix.

EXPANSION TEST

A laboratory expansion test was performed on a sample of near-surface earth material in general accordance with the current ASTM D4829 procedures. In this testing procedure, a remolded sample is compacted in two (2) layers in a 4-inch inside diameter mold to a total compacted thickness of approximately 1.0 inch by using a 5.5-pound weight dropping 12 inches and with 15 blows per layer. The sample should be compacted at a saturation between 41 and 59 percent. After remolding, the sample is confined under a pressure of 144 pounds per square foot (psf) and allowed to soak for 24 hours. The resulting volume change due to the increase in moisture content within the sample is recorded and the Expansion Index (EI) calculated. The test results are summarized in the 'Summary of Laboratory Test Results,' Plate No. 9, presented in this Appendix.

SOLUBLE SULFATE TEST

The concentration of soluble sulfate was determined on selected samples of near-surface soil materials in general accordance with current EPA 300.0 procedures. The test results are summarized in the 'Summary of Laboratory Test Results,' Plate No. 9, presented in this Appendix.

SIEVE ANALYSIS

The percent by weight finer than a No. 200 sieve (silt and clay content) was determined for a selected sample of earth material in general accordance with current ASTM D1140 procedures. The test is performed by taking a known weight of an oven dry sample of soil material, washing it over a No. 200 sieve, and oven drying the soil retained on the No. 200 sieve. The dry weight of soil material retained on the No. 200 sieve is measured and the resulting percentage retained is calculated based on the original total dry soil sample weight. The percent passing the No. 200 sieve is determined by subtracting the percent retained from

100. The test results are summarized in the 'Summary of Laboratory Test Results,' Plate No. 10, presented in this Appendix.

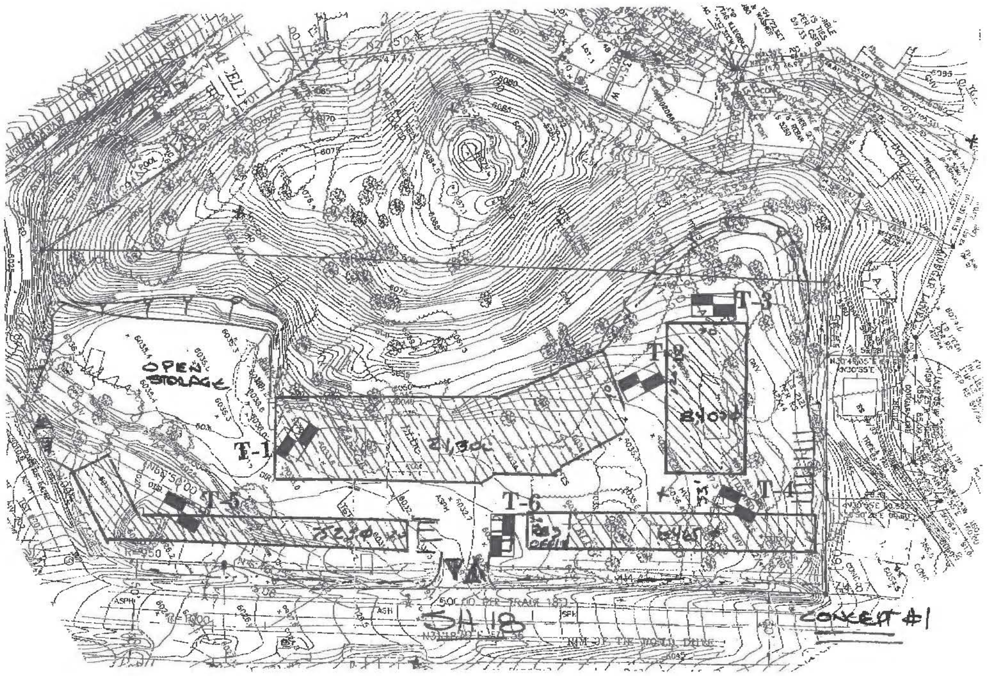
ATTERBERG LIMITS

The Atterberg Limits (Liquid Limit and Plastic Limit) of a selected sample of earth materials was determined in general accordance with current ASTM D4318 procedures. The Liquid Limit of a soil material is defined as the moisture content at which a sample of soil placed in a standard liquid limit cup and cut by a groove 11-mm wide at the top, 2-mm wide at the bottom, and 8-mm deep will flow together at the base of the groove for a distance of 13-mm (0.5 inch) when subjected to 25 shocks from the cup being dropped 10-mm in a standard Liquid Limit apparatus at a rate of two (2) blows per second. The Plastic Limit of a soil material is defined as the moisture content at which a sample of soil can not be deformed by rolling into 1/8 inch diameter threads without crumbling. The Plasticity Index for the soil is equivalent to the Liquid Limit minus the Plastic Limit. The test results are summarized in the 'Summary of Laboratory Test Results,' Plate No. 10, presented in this Appendix.

MAXIMUM DRY DENSITY / OPTIMUM MOISTURE CONTENT RELATIONSHIP TEST

A maximum dry density / optimum moisture content relationship determination was performed on a sample of near-surface earth material in general accordance with current ASTM D1557 procedures using a 4-inch diameter mold. Samples were prepared at various moisture contents and compacted in five (5) layers using a 10-pound weight dropping 18 inches and with 25 blows per layer. A plot of the compacted dry density versus the moisture content of the specimens was constructed and the maximum dry density and optimum moisture content determined from the plot. The test results are summarized in the 'Maximum Dry

Density / Optimum Moisture Content Relationship Test Results,' Plate No. 11, presented in this Appendix.



LEGEND

T-6 Approximate Location of Exploratory Excavation.

Not to Scale

Reference: FAXed Portions of an Unauthored, Undated, Untitled, *Site Plan*.

HILLTOP GEOTECHNICAL INCORPORATED	EXPLORATORY EXCAVATION LOCATION PLAN	
	By: SS	Date: 12/07
	Project No.: 688-A07.1	Plate No.: 1

SUBSURFACE EXPLORATION LEGEND

UNIFIED SOIL CLASSIFICATION SYSTEM
Visual-Manual Procedure (ASTM D2488)

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
Coarse-Grained Soils* More than 50 % Retained on No. 200 Sieve	Gravels 50 % or more of Coarse Fraction Retained on No. 4 Sieve	Clean Gravels	GW	Well Graded Gravels and Gravel-Sand Mixtures, Little or no Fines
			GP	Poorly Graded Gravels and Gravel-Sand Mixtures, Little or no Fines
		Gravels with Fines	GM	Silty Gravels, Gravel-Sand-Silt Mixtures**
			GC	Clayey Gravel, Gravel-Sand-Clay Mixtures**
	Sands More than 50 % of Coarse Fraction Passes No. 4 Sieve	Clean Sands	SW	Well Graded Sands and Gravely Sands, Little or no Fines
			SP	Poorly Graded Sands and Gravelly Sands, Little or no Fines
		Sands with Fines	SM	Silty Sands, Sand-Silt Mixtures**
			SC	Clayey Sands, Sand-Clay Mixtures**
Fine Grained Soils* 50 % or more Passes No. 200 Sieve	Silts and Clays Liquid Limits 50 % or less		ML	Inorganic Silts, Sandy Silts, Rock Flour
			CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
			OL	Organic Silts and Organic silty Clays of Low Plasticity
	Silts and Clays Liquid Limits Greater than 50 %		MH	Inorganic Silts, Micaceous or Diatomaceous silts, Plastic Silts
			CH	Inorganic Clays of High Plasticity, Fat Clays
			OH	Organic Clays of Medium to High Plasticity
Highly Organic Soils			PT	Peat, Muck, or Other Highly Organic Soils

CONSISTENCY / RELATIVE DENSITY

CRITERIA

Reference: 'Foundation Engineering', Peck, Hansen, Thornburn, 2nd Edition.

Standard Penetration Test
Granular Soils

Penetration Resistance, N, (Blows / Foot)	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium
30 - 50	Dense
> 50	Very Dense

Standard Penetration Test
Cohesive Soils

Penetration Resistance, N, (Blows / Foot)	Consistency	Unconfined Compressive Strength, (Tons / Sq. Ft.)
< 2	Very Soft	< 0.25
2 - 4	Soft	0.25 - 0.5
4 - 8	Medium Stiff	0.5 - 1.0
8 - 15	Stiff	1.0 - 2.0
15 - 30	Very Stiff	2.0 - 4.0
> 30	Hard	> 4.0

* Based on material passing the 3-inch sieve.

** More than 12% passing the No. 200 sieve; 5% to 12% passing No. 200 sieve requires use of duel symbols (i.e., SP-SM., GP-GM, SP-SC, GP-GC, etc.); Border line classifications are designated as CH/CI, GM/SM, SP/SW, etc.

U.S. Standard Sieve Size		12"	3"	3/4"	#4	#10	#40	#200
Unified Soil Classification Designation	Boulders	Cobbles	Gravel		Sand			Silt and Clay
			Coarse	Fine	Coarse	Medium	Fine	

Moisture Condition

Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp but no visible moisture.
Wet	Visible free water, usually below the water table.

Material Quantity

Trace	< 5 %
Slightly	5 - 12%
Little	12 - 25%
Some	25 - 50 %

Other Symbols

C - Core Sample
S - SPT Sample
B - Bulk Sample
CK - Chunk Sample
R - Ring Sample
N - Nuclear Gauge Test
∇ - Water Table

PLATE NO. 2

SUBSURFACE EXPLORATION LOG
TRENCH NO. T-1

HILLTOP GEOTECHNICAL INCORPORATED

Project Name: Hilltop Storage
Project No.: 688-A07.1 Date: 11/27/2007 Logged By: RG
Equipment Used : Rubber tired, tractor-mounted backhoe Elevation: ± 6034

Depth (ft.)	Sample Type	Penetration Resistance	Soil Classification	Dry Density (lb/ft3)	Moisture Content (%)	Lithology	Groundwater	Description
			SP-SM			af		FILL:
1	N		SC	103.3	10.4	Qoa		Slightly silty fine to coarse sand, trace gravel; Light gray; Moist.
2	B							OLDER ALLUVIUM: Clayey fine to medium sand, trace gravel, trace silt; Orange-gray; Moist.
3	N			111.9	14.0			
4	B		SP/SM					Slightly silty fine to coarse sand, a little gravel, trace clay; Gray; Moist.
5								
6								
7								
8								
9								
10								Trace cobbles.
11								
12								
13								Bottom of trench at 13.0 feet. No groundwater encountered. Trench backfilled with excavated material.
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

B - Bulk Sample N - Nuclear Gauge Test CK - Chunk Sample

HILLTOP GEOTECHNICAL
INCORPORATED

SUBSURFACE EXPLORATION LOG
TRENCH NO. T-2

Project Name: Hilltop Storage
Project No.: 688-A07.1 Date: 11/27/2007 Logged By: RG
Equipment Used : Rubber tired, tractor-mounted backhoe Elevation: ± 6038

Depth (ft.)	Sample Type	Penetration Resistance	Soil Classification	Dry Density (lb/ft3)	Moisture Content (%)	Lithology	Groundwater	Description
0			GP			af		FILL: Sandy gravel, trace silt (aggregate base); Gray.
			SP/SM			Qoa		OLDER ALLUVIUM: Slightly silty fine to coarse sand, trace to little gravel; Slightly porous to depth of 3.0 feet; Light orange-gray; Moist.
1	N			102.3	3.7			
2	B							
3	N			92.0	5.0			
4								
5								
6								
7								
8								
9								
10			SM					Silty fine to coarse sand, little to some gravel, trace cobbles; Orange-gray; Moist.
11								
12								
13								Bottom of trench at 13.0 feet. No groundwater encountered. Trench backfilled with excavated material.
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

B - Bulk Sample N - Nuclear Gauge Test CK - Chunk Sample

Plate No. 4

SUBSURFACE EXPLORATION LOG
TRENCH NO. T-3

HILLTOP GEOTECHNICAL INCORPORATED

Project Name: Hilltop Storage
Project No.: 688-A07.1 Date: 11/27/2007 Logged By: RG
Equipment Used : Rubber tired, tractor-mounted backhoe Elevation: ± 6043

Depth (ft.)	Sample Type	Penetration Resistance	Soil Classification	Dry Density (lb/ft3)	Moisture Content (%)	Lithology	Groundwater	Description
0–1			SM			Qoa		OLDER ALLUVIUM: Silty fine to coarse sand, trace gravel, trace organics; Brown.
1–2	N		SC	96.9	3.5			Clayey fine to coarse sand, trace gravel; Brown-gray; Moist.
2–10	N		SP/SM	102.9	4.8			Slightly silty fine to coarse sand, little gravel, trace cobbles; Orange-gray; Moist.
10–13			SP					Fine to coarse sand, little gravel, trace cobbles; Light orange-gray; Moist.
13								Bottom of trench at 13.0 feet. No groundwater encountered. Trench backfilled with excavated material.

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

B - Bulk Sample N - Nuclear Gauge Test CK - Chunk Sample

Plate No. 5

SUBSURFACE EXPLORATION LOG
TRENCH NO. T-4

HILLTOP GEOTECHNICAL INCORPORATED

Project Name: Hilltop Storage
Project No.: 688-A07.1 Date: 11/27/2007 Logged By: RG
Equipment Used : Rubber tired, tractor-mounted backhoe Elevation: ± 6039

Depth (ft.)	Sample Type	Penetration Resistance	Soil Classification	Dry Density (lb/ft3)	Moisture Content (%)	Lithology	Groundwater	Description
			SC			Qoa		OLDER ALLUVIUM: Clayey fine to coarse sand, trace gravel; Porous; Light gray; Moist.
1								
2	N			98.1	3.8			
3	N			102.2	5.0			
4			SP/SM					Slightly silty fine to coarse sand, trace gravel; Slightly porous; Light orange-brown; Moist.
5								
6								
7								
8								
9			SM					Silty fine to coarse sand, trace gravel, trace clay; Orange; Moist.
10								
11								
12								
13								Bottom of trench at 12.5 feet. No groundwater encountered. Trench backfilled with excavated material.
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

B - Bulk Sample N - Nuclear Gauge Test CK - Chunk Sample

SUBSURFACE EXPLORATION LOG
TRENCH NO. T-5

HILLTOP GEOTECHNICAL INCORPORATED

Project Name: Hilltop Storage
Project No.: 688-A07.1 Date: 11/27/2007 Logged By: RG
Equipment Used : Rubber tired, tractor-mounted backhoe Elevation: ± 6021

Depth (ft.)	Sample Type	Penetration Resistance	Soil Classification	Dry Density (lb/ft3)	Moisture Content (%)	Lithology	Groundwater	Description
0–1			SM			af		FILL: Silty fine to coarse sand with gravel, bricks, cable, debris and roots to 4 feet; Very porous; Light brown; Moist.
1	N			102.0	8.6			
2	B							
3	N			108.7	9.8			
4								
5			SM					Silty fine to coarse sand; Slightly porous; Brown; Moist.
6							▽	
7						Kgr		HIGHLY WEATHERED GRANITE: Breaks down into fine to coarse sand, trace silt (SP); Orange-gray; Wet.
8–11								
12								Bottom of trench at 12.0 feet. Groundwater encountered at 7.0 feet. Trench backfilled with excavated material.
13–25								

B - Bulk Sample N - Nuclear Gauge Test CK - Chunk Sample

SUBSURFACE EXPLORATION LOG
TRENCH NO. T-6

HILLTOP GEOTECHNICAL INCORPORATED

Project Name: Hilltop Storage
Project No.: 688-A07.1 Date: 11/27/2007 Logged By: RG
Equipment Used : Rubber tired, tractor-mounted backhoe Elevation: ± 6033

Depth (ft.)	Sample Type	Penetration Resistance	Soil Classification	Dry Density (lb/ft3)	Moisture Content (%)	Lithology	Groundwater	Description
0			SM			af		FILL: Silty fine to coarse sand, trace gravel, wood and debris, roots to a depth of approximately 4.0 feet; Dark brown; Moist.
2	N			106.0	7.3			
2			SP/SM			Qoa		OLDER ALLUVIUM: Slightly silty fine to coarse sand, trace gravel; Brown-gray; Moist.
3	N			99.1	10.5			
8			SM				▽	Silty fine to medium sand, trace gravel, trace clay; Orange-gray; Wet.
12								Bottom of trench at 12.0 feet. Groundwater encountered at 9.0 feet. Trench backfilled with excavated material.

B - Bulk Sample N - Nuclear Gauge Test CK - Chunk Sample

SUMMARY OF LABORATORY TEST RESULTS

EXPANSION INDEX TEST RESULTS (ASTM D4829 Test Method)

SAMPLE NO.	MOISTURE CONTENT PRIOR TO TEST (%)	DRY DENSITY PRIOR TO TEST (pcf)	SATURATION PRIOR TO TEST (%)*	MOISTURE CONTENT AFTER TEST (%)	EXPANSION INDEX	EXPANSION POTENTIAL **
T-1, 1.0'-3.0'	10.5	111.8	55.9	20.1	51	Expansive

* Assumes a 2.70 Specific Gravity for the soil.
** As defined in Section 1802.3.2, 'Expansive Soils,' in the 2007 California Building Code (CBC).

SOLUBLE SULFATE TEST RESULTS (EPA 300.0 Test Procedure)

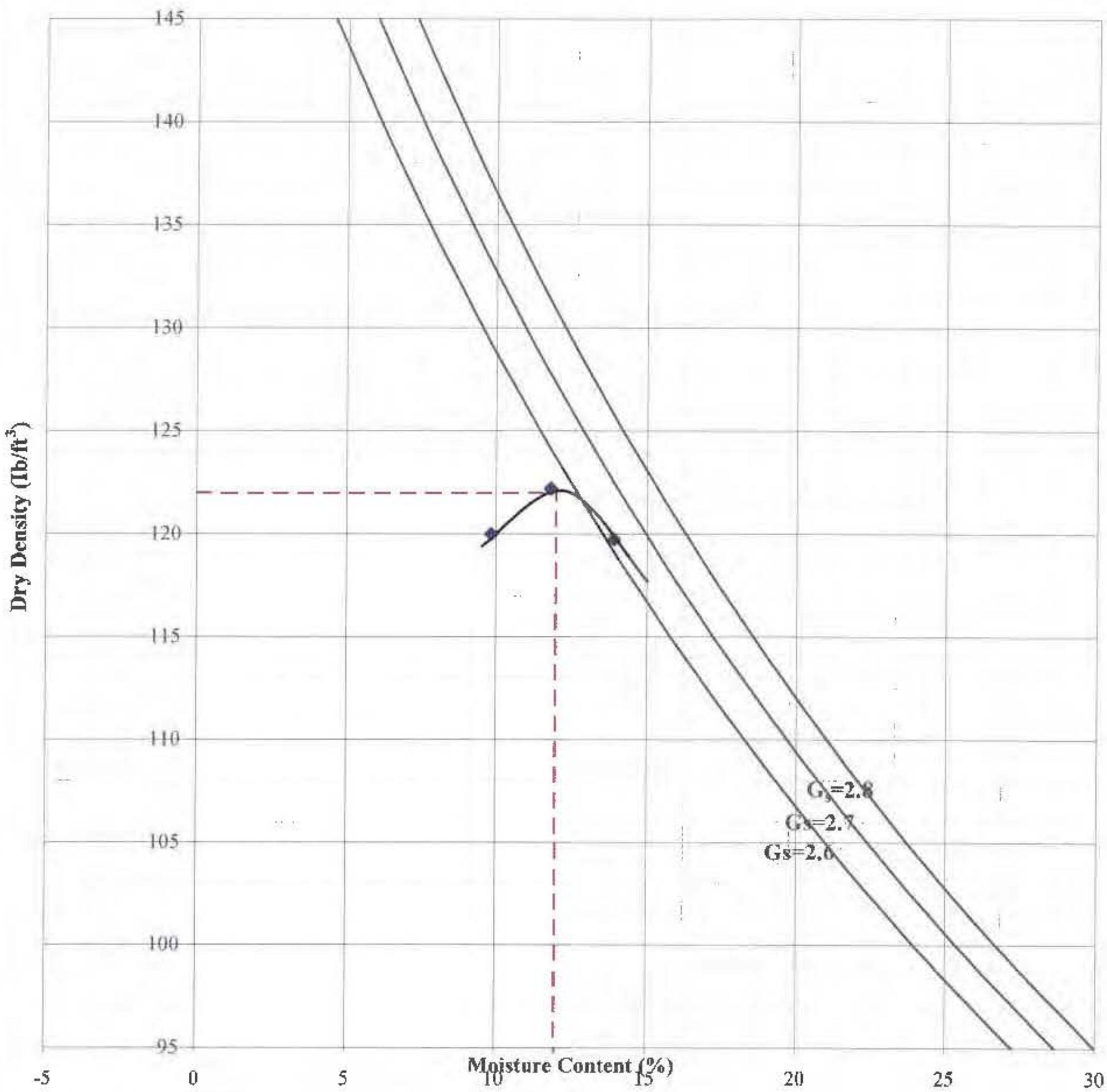
SAMPLE	SOIL DESCRIPTION	SOLUBLE SULFATE (%)	SULFATE EXPOSURE[1]
T-1, 1.0'-3.0'	Orange -gray clayey fine to coarse sand, trace gravel, trace silt (SC)	0.001	Negligible
T-2, 1.0'-3.0'	Slightly silty fine to coarse sand, trace to a little gravel (SP/SM)	ND[2]	Negligible

1. As defined in Table 4.3.1, 'Requirements for Concrete Exposed to Sulfate-Containing Solutions,' in **American Concrete Institute (ACI)** 318, Section 4.3.
2. ND - None Detected.

SUMMARY OF LABORATORY TEST RESULTS

PERCENT PASSING #200 SIEVE TEST RESULTS (ASTM D1140 Test Method)		
SAMPLE	**SOIL DESCRIPTION**	**PERCENT PASSING #200 SIEVE**
T-1, 1.0'-3.0'	Orange -gray clayey fine to coarse sand, trace gravel, trace silt (SC)	35

ATTERBERG LIMITS TEST RESULTS (ASTM D4318 Test Method)				
SAMPLE	**SOIL DESCRIPTION**	**LIQUID LIMIT (%)**	**PLASTIC LIMIT (%)**	**PLASTICITY INDEX**
T-1, 1.0'-3.0'	Orange -gray clayey fine to coarse sand, trace gravel, trace silt (SC)	35	21	14



Maximum Dry Density (lb/ft^3)	122.0
Optimum Moisture Content (%)	12.0
Procedure	A

HILLTOP GEOTECHNICAL INCORPORATED

MAXIMUM DRY DENSITY / OPTIMUM MOISTURE CONTENT RELATIONSHIP TEST RESULTS

SAMPLE: T-1, 1.0'-3.0'			
SOIL DESCRIPTION:	Orange-gray clayey fine to medium sand, trace gravel, trace silt (SC)		
BY:	DLC	DATE:	12/07
JOB NO.:	688-A07.1	PLATE NO.	11

APPENDIX B

REPORT OF
GEOTECHNICAL / GEOLOGIC STUDY
PROPOSED HILLTOP STORAGE FACILITY
LOCATED ON NORTHWEST SIDE OF STATE
HIGHWAY 18 BETWEEN POWERS LANE
AND DEEP CREEK DRIVE IN THE
ARROWBEAR AREA OF
SAN BERNARDINO COUNTY, CALIFORNIA

PROJECT NO.: 688-A07
REPORT NO.: 1

DECEMBER 19, 2007

GRADING SPECIFICATIONS

GENERAL PROVISIONS

General Intent

The intent of these specifications is to establish procedures for clearing, compacting natural ground, preparing areas to be filled, and placing and compacting fill soils to the lines and grades shown on the accepted plans. The recommendations contained in the 'Site Preparation Recommendations' section of the geotechnical / geologic study report are a part of the Recommended Grading Specifications and should supersede the provisions contained hereinafter in the case of conflict. These specifications should only be used in conjunction with the geotechnical / geologic report for which they are a part. Deviation from these specifications will not be allowed, except where specified in the geotechnical / geologic report or in other written communication signed by **Hilltop Geotechnical, Inc.**

Observation and Testing

Hilltop Geotechnical, Inc. should be retained as the project Geotechnical / Geologic Consultant to observe and test the earthwork in accordance with these specifications. It is advised that the project Geotechnical / Geologic Consultant or his representative provide adequate observations so that he may provide an opinion as to whether the work was or was not accomplished as specified. Therefore, it should be the responsibility of the contractor to assist the project Geotechnical / Geologic Consultant and to keep him apprized of work schedules, changes, and new information and data so that he may provide these opinions. In the event that any unusual conditions not covered by the special provisions or preliminary geotechnical / geologic report are encountered during the grading operations, the project Geotechnical / Geologic Consultant should be contacted for further recommendations.

If in the opinion of the project Geotechnical / Geologic Consultant, substandard conditions are encountered, such as: questionable or unsuitable soil, unacceptable moisture content, inadequate compaction, adverse weather, etc., construction would be stopped until the conditions are remedied or corrected or he should recommend rejection of this work.

Test methods used to determine the degree of compaction should be performed in accordance with the following current American Society for Testing and Materials (ASTM) test methods:

Maximum Dry Density / Optimum Moisture Content - ASTM D1557.
Density of Soil In-Place - ASTM D1556 or ASTM D2922.

Dry densities should be expressed in terms of Relative Compaction as determined by the foregoing ASTM testing procedures.

Preparation of Areas to Receive Fill

The vegetation, brush and debris derived from clearing operations should be removed, and legally disposed of. Areas disturbed by site grading should be left in a neat and finished appearance, free from unsightly debris.

After clearing or benching, the natural ground in areas to be filled should be scarified to a depth of 6.0 inches or the minimum degree of compaction as set forth in the Special Provisions or the recommendation contained in the preliminary geotechnical / geologic report. Loose soils in excess of 6.0 inches in thickness should be removed to firm natural ground which should be determined by the project Geotechnical / Geologic Consultant and/or his representative.

When the slope of the natural ground receiving fill exceeds 20 percent (5 horizontal units to 1 vertical unit), the original ground should be stepped or benched. Benches should be cut to a firm competent soil condition. The key at the toe of slope should be at least 15 feet wide or 1.5 times the equipment width, whichever is greater, and should be sloped back into the hillside at a gradient of not less that 2.0 percent. The other benches should be at least 10 feet wide. The horizontal portion of each bench should be compacted prior to receiving fill as previously specified for compacted natural ground. Vertical separations between benches should be at least 4.0 feet. Ground slopes flatter than 20 percent should be benched when advised by the project Geotechnical Consultant and/or Engineering Geologist.

Any abandoned structures encountered during grading operations should be totally removed. Underground utilities to be abandoned beneath any proposed structure and/or surface improvement should be removed from within 10 feet of the structure or improvement and be properly capped off. The resulting depressions from the above described procedures should be backfilled with acceptable soil that is compacted to the requirements of the project Geotechnical / Geologic Consultant. This includes, but is not limited to, septic tanks, fuel tanks, sewer lines or leach lines, storm drains, and water lines. Any buried structures or utilities not to be abandoned should be brought to the attention of the project Geotechnical / Geologic Consultant, so that he may determine if any special recommendation will be necessary.

All water wells which will be abandoned should be abandoned and capped according to directions and supervision of the County Department of Health, the State of California, and/or the appropriate governmental agency procedures which has jurisdiction over the well before fill and/or pavement is placed over the area.

Fill Material

Materials to be placed in the fill should be approved by the project Geotechnical / Geologic Consultant and should be free of vegetable matter and other deleterious substances. Granular soil should contain sufficient fine material to fill the voids. The definition and disposition of oversized rocks, expansive and/or detrimental soils are covered in the geotechnical / geologic report or special provisions. Expansive soils, soils of poor gradation, or soils with low strength characteristics may be thoroughly mixed with other soils to provide satisfactory fill material, but only with the explicit consent of the project Geotechnical / Geologic Consultant. Any import material should be approved by the project Geotechnical / Geologic Consultant before being brought to the site.

Placing and Compaction of Fill

Approved fill material should be placed in areas prepared to receive fill in layers not to exceed 6.0 to 8.0 inches in compacted thickness. Each layer should have a uniform moisture content in the range that will allow the compaction effort to be efficiently applied to achieve the specified degree of compaction. Each layer should be uniformly compacted to a minimum specified degree of compaction with equipment of adequate size to economically compact the layer. Compaction equipment should either be specifically designed for soil compaction or of proven reliability. The minimum degree of compaction to be achieved is specified in either the Special Provisions or the recommendations contained in the preliminary geotechnical / geologic report.

When the structural fill material includes rocks, rocks will not be allowed to nest and the voids should be carefully filled with soil such that the minimum degree of compaction recommended in the Special Provisions or the recommendations contained in the geotechnical / geologic report is achieved. The maximum size and spacing of rock permitted in structural fills and in non-structural fills is discussed in the geotechnical / geologic report, when applicable.

Field observation and compaction tests to evaluate the degree of compaction of the fill will be taken by the project Geotechnical / Geologic Consultant or his representative. The location and frequency of the tests should be at the Project Geotechnical / Geologic Consultant's discretion. When the compaction test indicates that a particular layer is less than the recommended degree of compaction, the layer should be reworked to the satisfaction of the project Geotechnical / Geologic Consultant and until the desired relative compaction has been obtained.

Fill slopes should be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction by sheepsfoot rollers should be at vertical intervals of not greater than 4.0 feet. In addition, fill slopes at ratios of two (2) horizontal to one (1) vertical or flatter, should be gridrolled or trackwalked. Steeper fill slopes, which have been approved by the governing agency, should be over-built and cut-back to finish contours after the slope has been constructed. Slope compaction operations should result in fill material which have been approved by the governing agency having a relative compaction of at least 90 percent of maximum dry density or that specified in the Special Provisions section of this specification. The compaction operation of the slopes should be continued until the project Geotechnical / Geologic Consultant is of the opinion that the slopes will be stable in regards to surficial stability.

Slope tests will be made by the project Geotechnical / Geologic Consultant during construction of the slopes to determine if the recommended compaction is being achieved. Where failing tests occur or other field problems arise, the Contractor will be notified that day of such conditions by written communication from the project Geotechnical / Geologic Consultant or his representative in the form of a daily field report.

If the method of achieving the recommended slope compaction selected by the Contractor fails to produce the recommended results, the Contractor should rework or rebuild such slopes until the recommended degree of compaction is obtained, without additional cost to the Owner or project Geotechnical / Geologic Consultant.

Cut Slopes

The project Engineering Geologist should observe cut slopes excavated in rock or lithified formational material during the grading operations at intervals determined at his discretion. If any conditions not anticipated in the preliminary geotechnical / geologic report such as perched water, seepage, lenticular or confined strata of a potentially adverse nature, unfavorably inclined bedding, joints or fault planes are encountered during grading, these conditions should be analyzed by the project Engineering Geologist and Geotechnical / Geologic Consultant to determine if mitigating measures are necessary.

Unless otherwise specified in the geotechnical / geologic report, cut slopes should not be excavated higher or steeper than that allowed by the ordinances of the controlling governmental agency.

Engineering Observation

Field observation by the project Geotechnical / Geologic Consultant and/or his representative should be made during the filling and compacting operations so that he can express his opinion regarding the conformance of the grading with acceptable standards of practice. The presence of the project Geotechnical / Geologic Consultant or his representative for the observation and testing should not release the Grading Contractor from his duty to compact the fill material to the specified degree of compaction.

Season Limits

Fill should not be placed during unfavorable weather conditions. When work is interrupted by heavy rain, filling operations should not be resumed until the proper moisture content and density of the fill materials can be achieved. Damaged site conditions resulting from weather or acts of God should be repaired before acceptance of work.

SPECIAL PROVISIONS

The minimum degree of compaction to be obtained in compacting natural ground, in the compacted fill, and in the compacted backfill should be at least 90 percent.

Detrimentally expansive soil is defined as soil having an Expansion Index of 21 or greater as determined by Uniform Building Code Standard Procedure 18-2 or ASTM D4829 Test Method.

Oversized material is defined as rocks or lumps over 12 inches in greatest dimension.

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