Geotechnical Engineering Report

Discovery Bay Community Center Swimming Pool
Discovery Bay, Contra Costa County, California
January 30, 2019
Terracon Project No. ND185167

Prepared for:
Town of Discovery Bay
Discovery Bay, California

Prepared by:
Terracon Consultants, Inc.
Concord, California
January 30, 2019

Town of Discovery Bay
1800 Willow Lake Road
Discovery Bay, California 94505

Attn: Mr. Mike Davies
P: (925) 634 1131
E: mdavies@todb.ca.gov

Re: Geotechnical Engineering Report
Discovery Bay Community Center Swimming Pool
1601 Discovery Bay Boulevard
Discovery Bay, Contra Costa County, California
Terracon Project No. ND185167

Dear Mr. Davies:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PND185167 dated November 29, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of a new swimming pool and foundations for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.

Hoda Alinasababoli, E.I.T.
Staff Geotechnical Engineer

Noah T. Smith, P.E., G.E.
Principal

[Signature]
REPORT TOPICS

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Note: This report was originally delivered in a web-based format. Orange Bold text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the GeoReport logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
PHOTOGRAPHY LOG
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SUPPORTING INFORMATION

Note: Refer to each individual Attachment for a listing of contents.
### REPORT SUMMARY

<table>
<thead>
<tr>
<th>Topic</th>
<th>Overview Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Description</strong></td>
<td>The project will consist of the demolition of the existing 3-lane irregular shaped swimming pool and construction of a 6-lane L-shaped swimming pool that is 3.5 to 7 feet deep. Development will also include new decking and an expansion to the existing swimming pool mechanical room which is a single-story structure.</td>
</tr>
<tr>
<td><strong>Geotechnical Characterization</strong></td>
<td>Subgrade soil conditions generally consist of 3 to 4 feet of sand and clay fill underlain by medium stiff to stiff lean clay with variable amounts of sand and interbedded layers of very loose to medium dense sand with variable amounts of clay to the maximum explored depth of 26½ below the existing ground surface (bgs). Similar lithology was encountered in the CPT soundings to a depth of 45 feet bgs beyond which was predominantly clay to a depth of 100 feet bgs. Groundwater was encountered in the borings at depths ranging from 7 to 8 feet bgs while drilling. Groundwater was also encountered in CPT soundings ranging from 9 to 13 feet bgs. Dewatering could be required for construction of the new pool and excavations and should be planned for during construction.</td>
</tr>
<tr>
<td><strong>Earthwork</strong></td>
<td>The existing pool will be demolished to accommodate the proposed improvements. Up to 7 feet of cuts and fills are anticipated associated with construction of the new pool and backfill of the existing pool in some areas. Surface clays are moderately to highly plastic and are sensitive to moisture variation. Grading should be conducted in accordance with the Earthwork section of this report.</td>
</tr>
<tr>
<td><strong>Swimming Pool</strong></td>
<td>The swimming pool may be constructed utilizing conventional in-ground construction. We have assumed the pool shells will extend approximately 3½ to 7 feet deep. The swimming pool shell should extend through all fill and bear into firm native medium stiff to stiff sandy lean clay. Pool areas where over-excavation may be required due to the presence of fill or where the new pool shell may be shallower than the existing pool shell may be backfilled with a 2 sack lean concrete mix or ¾ inch clean crushed gravel wrapped in a geotextile fabric and compacted by vibratory methods as needed.</td>
</tr>
<tr>
<td><strong>Shallow Foundations</strong></td>
<td>The mechanical room expansion may be supported by a Shallow Foundation spread footing system provided the footings extend a minimum 18 inches bgs and are underlain by a minimum 18 inches of LVC that extends to firm native soil. Allowable bearing pressure = 1,500 psf Expected settlements: &lt; 1-inch total, &lt; ½ inch differential</td>
</tr>
<tr>
<td><strong>Floor Slabs</strong></td>
<td>The upper 18 inches of subgrade below slabs should consist of Low Volume Change (LVC) material to help protect the slabs from the swelling pressure of the surface moderate to high volume change soils.</td>
</tr>
<tr>
<td><strong>General Comments</strong></td>
<td>This section contains important information about the limitations of this geotechnical engineering report.</td>
</tr>
</tbody>
</table>

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.  
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.
INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed swimming pool and mechanical room expansion to be located at 1601 Discovery Bay Boulevard in Discovery Bay, Contra Costa County, California. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Foundation design and construction
- Groundwater conditions
- Seismic site classification per 2016 CBC
- Site preparation and earthwork
- Liquefaction analysis
- Swimming pool design and construction
- Soil corrosivity

The geotechnical engineering Scope of Services for this project included the advancement of three test borings to depths ranging from approximately 21½ to 26½ feet below existing site grades (bgs). Additionally, two Cone Penetration Test (CPT) soundings were advanced to a depth of 100½ feet bgs.

Maps showing the site and boring locations are shown in the Site Location and Exploration Plan sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs as separate graphs in the Exploration Results section.

SITE CONDITIONS

The following description of site conditions was derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parcel Information</td>
<td>The project is located at 1601 Discovery Bay Boulevard in Discovery Bay,</td>
</tr>
<tr>
<td></td>
<td>Contra Costa County, California. 37.9026°N 121.6010°W See Site Location.</td>
</tr>
</tbody>
</table>
Geotechnical Engineering Report
Discovery Bay Community Center Swimming Pool
Discovery Bay, Contra Costa County, California
January 30, 2019 ■ Terracon Project No. ND185167

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Improvements</td>
<td>The site is developed with an existing community center, tennis courts,</td>
</tr>
<tr>
<td></td>
<td>swimming pool, mechanical room, hardscape, landscaping, and paved</td>
</tr>
<tr>
<td></td>
<td>parking lot.</td>
</tr>
<tr>
<td>Current Ground Cover</td>
<td>Concrete hardscape, grass, and pavement.</td>
</tr>
<tr>
<td>Existing Topography (from Google Earth</td>
<td>The project site is relatively flat with an approximate elevation of 5</td>
</tr>
<tr>
<td>Pro)</td>
<td>feet above mean sea level (MSL).</td>
</tr>
<tr>
<td>Geology</td>
<td>Geologic maps indicate subsurface conditions consist of Holocene age</td>
</tr>
<tr>
<td></td>
<td>alluvial fan deposits. The surface conditions encountered in our borings</td>
</tr>
<tr>
<td></td>
<td>and CPTs were consistent with the mapped geology.</td>
</tr>
</tbody>
</table>

We also collected photographs at the time of our field exploration program. Representative photos are provided in our Photography Log.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Provided</td>
<td>A description of the proposed improvements was provided to Terracon by</td>
</tr>
<tr>
<td></td>
<td>Mike Davies with the Town of Discovery Bay via email</td>
</tr>
<tr>
<td>Project Description</td>
<td>The project will consist of the demolition of the existing 3-lane irregular</td>
</tr>
<tr>
<td></td>
<td>shaped swimming pool and construction of a 6-lane L-shaped swimming pool.</td>
</tr>
<tr>
<td></td>
<td>Development will also include new decking and an expansion to the swimming</td>
</tr>
<tr>
<td></td>
<td>pool mechanical room.</td>
</tr>
<tr>
<td>Proposed Structures</td>
<td>The project will include (1) 6-lane L-shaped swimming pool approximately</td>
</tr>
<tr>
<td></td>
<td>3.5 to 7 feet deep and an expansion to the single-story, wood frame,</td>
</tr>
<tr>
<td></td>
<td>mechanical room building.</td>
</tr>
<tr>
<td>Finished Floor Elevation</td>
<td>Unknown</td>
</tr>
<tr>
<td>Grading</td>
<td>Up to 7 feet of cuts and fills are anticipated associated with construction</td>
</tr>
<tr>
<td></td>
<td>of the new pool and backfill of the existing pool in some areas.</td>
</tr>
<tr>
<td>Estimated Start of Construction</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

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GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the Exploration Results section and the GeoModel can be found in the Figures section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

<table>
<thead>
<tr>
<th>Model Layer</th>
<th>Layer Name</th>
<th>General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fill</td>
<td>Medium stiff to stiff sandy lean clay and lean clay with sand and medium dense sand.</td>
</tr>
<tr>
<td>2</td>
<td>Lean Clay</td>
<td>Medium stiff to stiff sandy lean clay.</td>
</tr>
<tr>
<td>3</td>
<td>Poorly Graded Sand</td>
<td>Very loose to medium dense poorly graded sand and poorly graded sand with clay.</td>
</tr>
</tbody>
</table>

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Pore pressure dissipation tests were also performed in the CPTs to help determine groundwater levels. The water levels observed in the boreholes and CPTs can be found on the boring/CPT logs in Exploration Results and are summarized below.

<table>
<thead>
<tr>
<th>Boring/CPT Number</th>
<th>Approximate Depth to Groundwater while Drilling (feet)</th>
<th>Approximate Depth to Groundwater after Drilling (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>B2 and B3</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>CPT1</td>
<td>13</td>
<td>N/A</td>
</tr>
<tr>
<td>CPT2</td>
<td>9</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1. Below ground surface

Since the borings were backfilled relatively soon after completion, the water levels summarized above are not stable groundwater levels. Due to the low permeability of the soils encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole and CPT. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.
Groundwater level fluctuations occur due to tide, seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings and CPTs were performed. Therefore, groundwater levels during construction or at other times in the life of the structures may be higher or lower than the levels indicated on the boring/CPT logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

**Dewatering should be considered and planned for in proposed excavations.** The depth of dewatering below the bottom of excavations should be determined by the contractor/and or designer. Pump tests for dewatering were not included in the scope of work for this report. However, Terracon can perform pump tests for an additional fee if desired.

**GEOTECHNICAL OVERVIEW**

The subject site has several geotechnical considerations that will affect the construction and performance of the proposed swimming pool, mechanical room expansion, and hardscape. The following geotechnical considerations have been identified at the subject site:

- Moderately to Highly Plastic Soil Considerations
- Existing Undocumented Fill Considerations
- Swimming Pool Considerations

**Moderately to Highly Plastic Soil Considerations**

The surficial soils across the project site are generally moderately to highly plastic (expansive). Additional areas of localized moderately to highly plastic clays may be present where borings/CPTs were not performed.

These plastic clays are prone to volume change with variations in moisture which may lead to excessive shrinking and swelling of foundations and hardscapes. In order to address the effects of the moderate to high volume change soils, we recommend floor slabs and exterior hardscapes be underlain by a minimum 18 inches of low volume change (LVC) material and foundations extend to a minimum depth of 18 inches bgs and be underlain by a minimum 18 inches of LVC. Using an LVC zone as recommended in this report may not eliminate all future subgrade volume change and resultant slab and foundation movements. However, the procedures outlined herein should help to reduce the potential for subgrade volume changes.

This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in the slabs and mechanical room expansion should be anticipated. The severity of cracking and other
(cosmetic) damage such as uneven slabs will likely increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction such as utilizing deep foundations. We would be pleased to discuss other construction alternatives with you upon request.

Existing Undocumented Fill Considerations

Approximately 3 to 4 feet of fill consisting of sandy lean clay, lean clay with sand, and sand was encountered in our borings. Compaction records for the fill could not be obtained or reviewed to confirm the fill was placed under controlled conditions. The density/consistency of the fill encountered in our borings varied from medium stiff to stiff and loose to dense. Such undocumented fill conditions can result in differential settlement and damage to proposed structures relying on the fill for structural support. As a result, the undocumented fill is not suitable to support the proposed swimming pool or mechanical room expansion. The swimming pool should extend through all fill and derive support from the underlying firm native medium stiff to stiff sandy lean clay. The mechanical room expansion footings should extend a minimum 18 inches bgs and be underlain by a minimum 18 inches of LVC extending down to firm native soil.

While the undocumented fill is not suitable to support the proposed swimming pool and building expansion, the fill should be adequate to support proposed slabs and hardscapes provided Earthwork is conducted per the recommendations provided herein. The fill below slab and hardscape areas should be over-excavated to a depth of 18 inches and the resulting subgrade should be scarified to a minimum depth of 12 inches, moisture conditioned, and compacted per the recommendations in the Earthwork section of this report. Following compaction of the subgrade, the over-excavated areas should be backfilled with compacted LVC structural fill.

Even with the recommended earthwork procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the undocumented fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing all the existing undocumented fill but can be reduced by following the recommendations contained in this report. To take advantage of the cost benefit of not removing the entire amount of undocumented fill, the owner must be willing to accept the risk associated with building over the undocumented fill following the recommended reworking of the material.

Swimming Pool Considerations

The pool may be constructed using a conventional pool shell provided the pool extends through all fill and bears into the underlying firm naïve medium stiff to stiff sandy lean clay. We have assumed the new pool depths will extend from 3½ up to 7 feet bgs. Terracon should be contacted to provide additional recommendations, if needed, if this is not the case.
Due to the presence of shallow groundwater, the pool should be underlain by a 6-inch thick layer of 3/4-inch clean gravel underlain by Mirafi 140N filter fabric or Caltrans Class II permeable material. A 4-inch diameter perforated Schedule 40 PVC or ABS pipe should be installed in the gravel at the deepest point. The perforated pipe should slope at a 2 percent minimum grade to a tight line at the edge of the pool that carries the drainage to an existing drainage system or to an observation well where water can be removed by pumping. A hydrostatic pressure relief system should be installed at the deepest point of the pool.

The General Comments section provides an understanding of the report limitations.

EARTHWORK

We anticipate grading for this project may consist of cuts and fills up to 7 feet mainly associated with backfill of the existing pool and construction of the new pool. If greater cuts and fills are required, Terracon should be contacted to provide supplemental recommendations. We understand site grades will remain at the current elevation. If site grades will be elevated, Terracon should be contacted to provide additional recommendations as elevating the site grades may generate additional settlement of the site. Earthwork will include demolition of existing pool, clearing and grubbing, excavations and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria as necessary to render the site in the state considered in our geotechnical engineering evaluation for the swimming pool, foundations and slabs.

Site Preparation

Prior to placing fill, all existing debris, debris generated from demolition of the existing pool shells and hardscape, underground utilities, existing vegetation and root mat, debris, and any otherwise unsuitable material should be removed. Complete stripping of the topsoil should be performed in the proposed pool and mechanical room expansion areas.

If possible, the subgrade should be proof-rolled with an adequately loaded vehicle such as a fully loaded tandem axle dump truck. The proof-rolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proof-roll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed or modified by stabilizing as noted in the following section Soil Stabilization. Excessively wet or dry material should either be removed, or moisture conditioned and recompacted. Exposed surfaces should be free of mounds and depressions which could prevent uniform compaction.
Subgrade Preparation

After clearing any required cuts should be made. Any fill below the swimming pool and foundation areas should be over-excavated to firm native soil. Terracon should be present during over-excavation to verify all fill has been removed in the excavation. If needed, a geotextile fabric may be used as a separator between the native soil and engineered fill. Once any required cuts and over-excavations have been made, and prior to placing any fill, the subgrade soil should be scarified and compacted. Scarification is not required in the bottom of the pool excavation. The depth of scarification of subgrade soils and moisture conditioning of the subgrade is highly dependent on the time of year of construction and the site conditions that exist immediately prior to construction. If construction occurs during the winter or spring, when the subgrade soils are typically already in a moist condition, scarification and compaction may only be 12 inches. If construction occurs during the summer or fall when the subgrade soils have been allowed to dry out deeper, the depth of scarification and moisture conditioning may be as much as 18 inches. Due to shallow groundwater, the subgrade soil at over-excavated depths is likely to be in an elevated moisture condition and compaction will likely require some drying before it can be compacted. A representative from Terracon should be present to observe the exposed subgrade and specify the depth of scarification and moisture conditioning required.

Following scarification and compaction of the subgrade, the footing excavations may be backfilled with compacted LVC structural fill and the swimming pool may be backfilled with a 2 sack lean concrete mix or ¾ inch clean crushed gravel wrapped in geotextile fabric and compacted by vibratory methods as needed.

The moisture content and compaction of subgrade soils should be maintained until poo/foundation/slab construction. Care should be taken to prevent wetting or drying of the bearing materials during construction.

Soil Stabilization

Methods of subgrade improvement, as described below, could include scarification, moisture conditioning and recompaclion, and removal of unstable materials and replacement with granular fill (with or without geosynthetics). The appropriate method of improvement, if required, would be dependent on factors such as schedule, weather, the size of the area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm seasons and dry periods would help to reduce the amount of subgrade stabilization required.

If the exposed subgrade is unstable during proof rolling operations, it could be stabilized using one of the methods outlined below.

- **Scarification and Compaction** – It may be feasible to scarify, dry, and compact the exposed soils. The success of this procedure would depend primarily upon favorable weather and...
sufficient time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot, if the unstable soil is at or near groundwater levels, or if construction is performed during a period of wet or cool weather when drying is difficult.

Aggregate Base – The use of Caltrans Class II aggregate base is the most common procedure to improve subgrade stability. Typical undercut depths would be expected to range from about 6 to 18 inches below finished subgrade elevation with this procedure. The use of high modulus geotextiles (i.e., engineering fabric or geogrid) could also be considered after underground work such as utility construction is completed. Prior to placing the fabric or geogrid, we recommend that all below-grade construction, such as utility line installation, be completed to avoid damaging the fabric or geogrid. Equipment should not be operated above the fabric or geogrid until one full lift of aggregate base is placed above it. The maximum particle size of granular material placed over geotextile fabric or geogrid should meet the manufacturer’s specifications.

Further evaluation of the need and recommendations for subgrade stabilization can be provided during construction as the geotechnical conditions are exposed.

Existing Undocumented Fill

As noted in Geotechnical Characterization, 3 to 4 feet of fill was encountered in our borings. Compaction records for the fill could not be obtained or reviewed to confirm the fill was placed under controlled conditions. The fill is considered undocumented as we have no records to indicate the degree of control that was performed during placement. Support of floor slabs and hardscapes on or above existing undocumented fill soils is discussed in this report.

The density/consistency of the undocumented fill encountered in our borings varied from medium stiff to stiff and loose to medium dense. Such undocumented fill conditions can result in differential settlement and damage to proposed structures relying on the undocumented fill for structural support. As a result, the undocumented fill is not suitable to support the proposed swimming pool and mechanical room expansion. While the undocumented fill is not suitable to support the proposed pool and mechanical room expansion, the fill should be adequate to support proposed floor slabs and exterior hardscapes provided Earthwork is conducted per the recommendations provided herein. If the owner elects to construct floor slabs and hardscapes on the existing undocumented fill, the following protocol should be followed. The fill below floor slabs and hardscape areas should be over-excavated to a depth of 18 inches and the resulting subgrade should be scarified to a minimum depth of 12 inches, moisture conditioned, and compacted per the recommendations in the Earthwork section of this report. Following compaction of the subgrade, the over-excavated areas may be backfilled with compacted LVC structural fill.
Even with the recommended earthwork procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the undocumented fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing all the existing undocumented fill but can be reduced by following the recommendations contained in this report. To take advantage of the cost benefit of not removing the entire amount of undocumented fill, the owner must be willing to accept the risk associated with building over the undocumented fill following the recommended reworking of the material.

**Fill Material Types**

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 5 feet of structures, pavements or constructed slopes. General fill is material used to achieve grade outside of these areas. Earthen materials used for structural and general fill should meet the following material property requirements:

<table>
<thead>
<tr>
<th>Fill Type</th>
<th>USCS Classification</th>
<th>Acceptable Location for Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lean Clay</td>
<td>CL (LL&lt;40)</td>
<td>All locations and elevations, except as LVC material unless material explicitly meets LVC requirements.</td>
</tr>
<tr>
<td>Moderate Plasticity Material</td>
<td>CL (50&gt;LL≥40 or 30&gt;PI≥25)</td>
<td>General fill locations</td>
</tr>
<tr>
<td>Well-graded Granular</td>
<td>GM, GC, SP, SW, SM</td>
<td>All structural and general fill locations and elevations</td>
</tr>
<tr>
<td>Low Volume Change (LVC) Material</td>
<td>CL (LL&lt;30 &amp; PI&lt;10) or Well-graded Granular Material</td>
<td>All structural and general fill locations and elevations</td>
</tr>
<tr>
<td>On-site Soils</td>
<td>CL, SP</td>
<td>As indicated above</td>
</tr>
</tbody>
</table>

1. Compacted structural fill should consist of approved materials that are free of organic matter and debris. A sample of each material type should be submitted to Terracon for evaluation at least 2 weeks prior to construction.
2. Delineation of moderate to highly plastic clays should be performed in the field by a qualified geotechnical engineer or their representative and could require additional laboratory testing.
3. Caltrans Class II aggregate base may be used for this material.
4. Low plasticity cohesive soil or granular soil having low plasticity fines. Material should be approved by the geotechnical engineer.
5. This material should be removed and recompacted if used as an engineered or structural fill as described in section Fill Compaction Requirements.
Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

<table>
<thead>
<tr>
<th>Item</th>
<th>Structural Fill</th>
<th>General Fill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Lift Thickness</td>
<td>8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used.</td>
<td>Same as Structural fill</td>
</tr>
<tr>
<td></td>
<td>4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used.</td>
<td></td>
</tr>
<tr>
<td>Minimum Compaction Requirements</td>
<td>95% of max. below foundations and floor slabs, for fills deeper than 5 feet, and for aggregate base. 90% of max above foundations and below exterior hardscape.</td>
<td>95% of max. for fills deeper than 5 feet. 90% of max. all other locations.</td>
</tr>
<tr>
<td>Water Content Range</td>
<td>Low plasticity cohesive: +1% to +3% above optimum. High plasticity cohesive: +2% to +4% above optimum. Granular: -2% to +2% of optimum.</td>
<td>As required to achieve min. compaction requirements.</td>
</tr>
</tbody>
</table>

1. Maximum density and optimum water content as determined by the Modified Proctor test (ASTM D 1557).
2. Reduced lift thicknesses are recommended in confined areas (e.g., utility trenches, foundation excavations, and foundation backfill) and when hand-operated compaction equipment is used.
3. We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved. This procedure is intended for soils with 30 percent or less material larger than ¾ inch. Accordingly, we recommend full time proof roll observation be performed instead of moisture density testing for materials containing more than 30 percent aggregate retained on the ¾-inch sieve.
4. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proof rolled.

Utility Trench Backfill

Depending on the planned depth of utilities, groundwater and/or soft soil conditions may be encountered in the bottom of the planned trench excavations and should be planned for. If the soils are unworkable, the contractor may utilize dry crushed rock or clean granular fill material placed over a geotextile such as Mirafi RS580i or equivalent to stabilize wet subgrade materials in the bottom of the excavation prior to backfill. If further soil stabilization is needed, Terracon should be consulted to evaluate the situation as needed.

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of cementitious flowable fill or cohesive fill in non-pavement areas to reduce the infiltration and conveyance of surface water through the trench backfill. Attempts should also be made to limit the amount of fines migration.
into the clean granular material. Fines migration into clean granular fill may result in unanticipated localized settlements over a period of time. To help limit the amount of fines migration, Terracon recommends the use of a geotextile fabric that is designed to prevent fines migration in areas of contact between clean granular material and fine-grained soils. Terracon also recommends that clean granular fill be tracked or tamped in place where possible to limit the amount of future densification which may cause localized settlements over time.

Utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building and the expansion. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for structural fill stated previously in this report.

**Grading and Drainage**

All grades must provide effective drainage away from the improvements during and after construction and should be maintained throughout the life of the structures. Water retained next to the improvements can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential slab and/or foundation/pool shell movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building.

Exposed ground should be sloped and maintained at a minimum 5 percent away from the building for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping, final grades should be verified to document effective drainage has been achieved. Grades around the structures should also be periodically inspected and adjusted as necessary as part of the structures’ maintenance program. Where paving or flatwork abuts the structures a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Planters or bio-swales located within 10 feet of the improvements should be self-contained or lined with an impermeable membrane to prevent water from accessing subgrade soils. Sprinkler mains and spray heads should be located a minimum of 5 feet away from the pool and building lines.

Trees or other vegetation whose root systems have the ability to remove excessive moisture from the subgrade and foundation soils should not be planted next to the structures. Trees and
shrubbery should be kept away from the exterior of the structures a distance at least equal to their expected mature height.

Earthwork Construction Considerations

Shallow excavations for the proposed structures are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of floor and exterior slabs. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over, or adjacent to, construction areas should be removed. If the subgrade desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted, prior to slab construction.

The groundwater table could affect over-excavation efforts, especially for over-excavation and replacement of lower strength soils. A temporary dewatering system consisting of sumps with pumps could be necessary to achieve the recommended depth of over-excavation for required excavations. **Dewatering should be anticipated and planned for in proposed excavations. The depth of dewatering below the bottom of excavations should be determined by the contractor and/or designer.** Pump tests for dewatering were not included in the scope of work for this report. However, Terracon can perform pump tests for an additional fee, if desired.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local, and/or state regulations. Stockpiles of soil, construction materials, and construction equipment should not be placed near trenches or excavations.

We recommend that the earthwork portion of this project be completed during extended periods of dry weather if possible. If earthwork is completed during the wet season (typically November through April) it may be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork operations may require additional mitigation measures beyond that which would be expected during the drier summer and fall months. This could include ground stabilization utilizing chemical treatment of the subgrade, diversion of surface runoff around exposed soils, and draining of ponded water on the site. Once subgrades are established, it may be necessary to protect the exposed subgrade soils from construction traffic.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.
Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of concrete debris, vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 1,000 square feet of compacted fill. One density and water content test per lift should be performed for every 20 linear feet of compacted utility trench backfill.

In areas of pool and foundation excavations and slabs, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. In the event that unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer’s evaluation of subsurface conditions, including assessing variations and associated design changes.
SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in Earthwork, the mechanical room expansion can be supported by spread footings designed per following design parameters.

Design Parameters – Compressive Loads

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Net Allowable Bearing pressure 1, 2</td>
<td>1,500 psf</td>
</tr>
<tr>
<td>Required Bearing Stratum</td>
<td>Minimum 18 inches of LVC material over firm native soil</td>
</tr>
<tr>
<td>Minimum Foundation Width</td>
<td>12 inches</td>
</tr>
<tr>
<td>Maximum Foundation Width</td>
<td>30 inches</td>
</tr>
<tr>
<td>Ultimate Passive Resistance 3,7 (equivalent fluid pressures)</td>
<td>300 pcf</td>
</tr>
<tr>
<td>Ultimate Coefficient of Sliding Friction 4,7</td>
<td>0.35</td>
</tr>
<tr>
<td>Minimum Embedment below Finished Grade 5</td>
<td>18 inches</td>
</tr>
<tr>
<td>Estimated Total Settlement from Structural Loads 1,8</td>
<td>Less than about 1 inch</td>
</tr>
<tr>
<td>Estimated Differential Settlement 4, 6,8</td>
<td>About 1/2 of total settlement</td>
</tr>
</tbody>
</table>

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.

2. Values provided are for maximum loads noted in Project Description.

3. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face.

4. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.

5. Embedment necessary to minimize the effects of seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.

6. Differential settlements are as measured over a span of 40 feet.

7. Passive pressure and sliding friction may be combined to resist sliding provided the passive pressure is reduced by 50 percent.

8. Estimated settlements are for static loading only and do not include settlements due to dynamic loading such as seismically induced liquefaction.
Construction Adjacent to Existing Building

Differential settlement between the mechanical room expansion and the existing building is expected to approach the magnitude of the total settlement of the addition. Expansion joints should be provided between the existing building and the proposed expansion to accommodate differential movements between the structures. Underground piping between the two structures should be designed with flexible couplings and utility knockouts in foundation walls should be oversized, so minor deflections in alignment do not result in breakage or distress. Care should be taken during excavation adjacent to existing foundations, to avoid disturbing existing foundation bearing soils.

New footings should bear at or near the bearing elevation of immediately adjacent existing foundations. Depending upon their locations and current loads on the existing footings, footings for the new expansion could cause settlement of adjacent walls. To reduce this concern and risk, clear distances at least equal to the new footing widths should be maintained between the expansion’s footings and footings supporting the existing building.

Foundation Construction Considerations

As noted in Earthwork, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

To ensure foundations have adequate support, special care should be taken when footings are located adjacent to trenches. The bottom of such footings should be at least 1 foot below an imaginary plane with an inclination of 1.5 horizontal to 1.0 vertical extending upward from the nearest edge of adjacent trenches.

If unsuitable bearing soils are encountered at the base of the planned footing excavations, the excavations should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below.
Over-excavation for structural fill placement below footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation, with structural fill placed, as recommended in the Earthwork section.
POOL RECOMMENDATIONS

The pool shell may be constructed as a conventional pool shell provided the pool extends through all fill and bears into the underlying native medium stiff to stiff sandy lean clay. We have assumed the new pool depths will be 3½ to 7 feet. Areas where over-excavation may be required due to the presence of fill or where the new pool shell may be shallower than the existing pool shell may be backfilled with a 2 sack lean concrete mix or ¾ inch clean crushed gravel wrapped in a geotextile fabric and compacted by vibratory methods as needed. Terracon should be contacted to provide additional recommendations, if this is not the case.

Pool walls should be designed for both retaining and free-standing conditions. Pool walls should be designed to resist a lateral earth pressure of 60 pounds per cubic foot (pcf) equivalent fluid pressure for walls with flat backfill. Pool walls should also be designed to resist an outward fluid pressure of 63 pcf.

The pool should be underlain by a 6-inch thick layer of 3/4-inch clean gravel underlain by Mirafi 140N filter fabric or Caltrans Class II permeable material. A 4-inch diameter perforated Schedule 40 PVC or ABS pipe should be installed in the gravel at the deepest point. The perforated pipe should slope at a 2 percent minimum grade to a tight line at the edge of the pool that carries the drainage to an existing drainage system or to an observation well where water can be removed by pumping. A hydrostatic pressure relief system should be installed at the deepest point of the pool.

Expansive soils within the pool excavation should be maintained at an elevated moisture content during construction.

Additional geotechnical design considerations for the swimming pool and items that may affect the future geotechnical stability of the pool system are listed below.

- **Isolate pool shell** – The proposed pool should be isolated from any source that could cause additional settlement of the pool. Foundations from buildings and other structures related to the pool should be kept a minimum distance equal to the depth of the pool from the pool’s edge to reduce the effect of the foundation on the pool shell. Additionally, pool decks should not be tied into the pool shell.

- **Avoid fill material below the pool** – Fill material placed below the pools is to be avoided due to the potential for excessive differential settlements within the fill material. This includes documented fills that have been placed correctly.
Avoid surcharge loading on pool shell – The addition of surcharge loads on the pool shells either during construction or after construction should be avoided to limit the possibility of damaging the pool walls.

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7-10.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016 California Building Code Site Classification (CBC)</td>
<td>F⁴</td>
</tr>
<tr>
<td>Site Latitude</td>
<td>37.9026°N</td>
</tr>
<tr>
<td>Site Longitude</td>
<td>121.6010°W</td>
</tr>
<tr>
<td>Sₘ, Spectral Acceleration for a Short Period</td>
<td>1.378g</td>
</tr>
<tr>
<td>S₁, Spectral Acceleration for a 1-Second Period</td>
<td>0.467g</td>
</tr>
<tr>
<td>Fₘ, Site Coefficient</td>
<td>0.9</td>
</tr>
<tr>
<td>Fᵥ, Site Coefficient (1-second period)</td>
<td>2.4</td>
</tr>
<tr>
<td>Sₛₛ, Spectral Acceleration for a Short Period</td>
<td>0.827g</td>
</tr>
<tr>
<td>Sₛₛ¹, Spectral Acceleration for a 1-Second Period</td>
<td>0.748g</td>
</tr>
</tbody>
</table>

2. The 2016 California Building Code (CBC) requires a site soil profile determination extending a depth of 100 feet for seismic site classification. Two CPTs were extended to a maximum depth of approximately 100½ feet bgs.
3. These values were obtained using online seismic design maps and tools provided by the USGS (http://earthquake.usgs.gov/hazards/designmaps/).
4. This site qualifies as a site class F due to the presence of liquefiable soils. A site class E was used to develop the listed seismic design parameters due to the static in-situ soil conditions encountered in our CPTs. Structures may use the listed design parameters provided they have a period of 0.5s or less. Should the anticipated structures have a period greater than 0.5s, a site-specific ground motion analysis should be conducted to develop seismic design parameters. Terracon is qualified to perform such an analysis.

Faulting and Estimated Ground Motions

The site is located in the San Francisco Bay Area of California, which is a relatively high seismicity region. The type and magnitude of seismic hazards affecting the site are dependent on the distance to causative faults, the intensity, and the magnitude of the seismic event. The following table indicates the distance of the fault zones and the associated maximum credible earthquake...
that can be produced by nearby seismic events, as calculated using the USGS Unified Hazard Tool. Segments of the Mount Diablo Thrust, which is located approximately 10 kilometers from the site, are considered to have the most significant effect at the site from a design standpoint.

<table>
<thead>
<tr>
<th>Fault Name</th>
<th>Approximate Contribution (%)</th>
<th>Approximate Distance to Site (kilometers)</th>
<th>Maximum Credible Earthquake (MCE) Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Diablo Thrust: bFault.ch</td>
<td>7.56</td>
<td>23.46</td>
<td>6.59</td>
</tr>
<tr>
<td>Great Valley 7: bFault.ch</td>
<td>4.84</td>
<td>21.08</td>
<td>6.71</td>
</tr>
<tr>
<td>PointSourceFinite: -121.601, 37.907: CAmapper.21.ch.in (opt)</td>
<td>4.70</td>
<td>4.98</td>
<td>5.61</td>
</tr>
</tbody>
</table>

Based on the ASCE 7-10 Standard, the peak ground acceleration (PGA\textsubscript{M}) at the subject site is approximately 0.434g. Based on the USGS 2008 interactive deaggregations, the PGA at the subject site for a 2% probability of exceedance in 50 years (return period of 2475 years) is expected to be about 0.551g. The site is not located within an Alquist-Priolo Earthquake Fault Zone based on our review of the State Fault Hazard Maps.\(^1\)

**LIQUEFACTION**

Liquefaction is a mode of ground failure that results from the generation of high pore water pressures during earthquake ground shaking, causing loss of shear strength. Liquefaction is typically a hazard where loose sandy soils or low plasticity fine grained soils exist below groundwater. The California Geologic Survey (CGS) has designated certain areas within California as potential liquefaction hazard zones. These are areas considered at a risk of liquefaction-related ground failure during a seismic event, based upon mapped surficial deposits and the presence of a relatively shallow water table. The project site and surrounding area is located within an area designated as having a high susceptibility to liquefaction. Therefore, a liquefaction analysis was performed to determine the liquefaction induced settlement.

Groundwater was observed in our borings at the time of field exploration at depths varying from 7 to 8 feet bgs. Additionally, water was encountered in the CPT soundings at depths varying from 9 to 13 feet bgs.

A liquefaction analysis was performed in general accordance with California Geologic Survey Special Publication 117. The liquefaction study utilized the software “CLiq” by GeoLogismiki Geotechnical Software. This analysis was based on the soil data from the CPT soundings. A Peak Ground Acceleration (PGA) of 0.434g and a mean magnitude of 6.35 for the project site was used. A groundwater level of 5 feet bgs was used in our analysis. Analysis were performed on data obtained from CPT1 and CPT 2. CPT calculations were assessed using the Idriss & Boulanger (2008), Moss et al. (2006), and Boulanger & Idriss (2014) methods.

A liquefaction potential analysis was calculated from a depth of 5 to 65 feet below the ground surface. Based on the analysis, liquefiable layers most susceptible to liquefaction potential were encountered between the depths of approximately 15 to 45 feet bgs. Due to the lithology consisting predominantly of clayey soils with thin sand layers, we believe the probability for liquefaction to occur is low with minor liquefaction manifestation to occur at the surface. However, based on our review of the calculations by the various methods, the anticipated potential total liquefaction-induced settlement is on the order of 3/4 to 1 ½ inches. Actual settlement could vary by a factor of 2. The differential liquefaction-induced settlement may be about 3/4 inch. Since the project site and surrounding area is relatively level ground, the potential for lateral spreading is considered to be low.

Based on our experience, swimming pools perform relatively well during a liquefaction event. However, some cracking and differential settlement could occur requiring repair and releveling of the pool. If the risk of some potential repair is not acceptable for the swimming pool, the effects of liquefaction settlement can be mitigated by supporting the proposed structures on Deep Foundations that derive support below the soils prone to these conditions. If supporting the pool on Deep Foundations is desired, Terracon can provide additional recommendations for the design of such a foundation system.

We anticipate a brief loss of shear strength during a significant seismic event where liquefaction may occur. The bearing strength and vertical and lateral stiffness of the subsurface soils will be reduced to the residual shear strength of the liquefiable layer, causing the anticipated settlement noted above.

Accurate evaluation of the effects of liquefaction-induced instability requires accurate estimation of the shear strength of the liquefied soils. Terracon should be consulted to evaluate the subsurface conditions and foundation capacities after a significant event where liquefaction has occurred.
FLOOR SLABS

We understand that the mechanical room expansion will be constructed with a concrete slab-on-grade floor. The surficial soils are comprised of moderately to highly plasticity lean clay with variable amounts of sand exhibiting the potential for volume change with changes in moisture. Changes in water content could cause the subgrade soils to shrink and swell damaging the slabs. In order to help mitigate the effects of the moderately to highly plastic soils on the building slab we recommend an 18-inch, low volume change (LVC) zone be constructed beneath the at-grade slab.

Using an 18 inch, LVC zone as recommended in this report may not eliminate all future subgrade volume change and resultant slab movements. However, the procedures outlined herein should help to reduce the potential for subgrade volume change. LVC fill should meet the specifications and be placed and compacted as recommended in Earthwork section of this report.

Due to the potential for significant moisture fluctuations of subgrade material beneath floor slabs supported at-grade, the Geotechnical Engineer should evaluate the material within 12 inches of the bottom of the LVC zone immediately prior to placement of additional fill or floor slabs. Soils below the specified water contents within this zone should be moisture conditioned or replaced with structural fill as stated in our Earthwork section.

Even with the recommended earthwork procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the existing undocumented fill in slab or hardscape areas will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing all the existing undocumented fill but can be reduced by following the recommendations contained in this report. To take advantage of the cost benefit of not removing the entire amount of undocumented fill, the owner must be willing to accept the risk associated with building over the undocumented fill following the recommended reworking of the material.
Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure.

**Floor Slab Design Parameters**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Slab Support 1</td>
<td>At least 18 inches of low volume change (LVC) material as described for structural fill in the Fill Material Types section</td>
</tr>
<tr>
<td>Estimated Modulus of Subgrade Reaction 2</td>
<td>80 pounds per square inch per inch (psi/in)</td>
</tr>
<tr>
<td>Capillary Break Layer Thickness 3, 4</td>
<td>Minimum 4 inches of free-draining (less than 6% passing the U.S. No. 200 sieve) crushed aggregate compacted to at least 95% of ASTM D 698</td>
</tr>
</tbody>
</table>

1. Floor slabs should be structurally independent of building foundations or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in Earthwork, and the floor slab support as noted in this table.
3. Free-draining granular material should have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.
4. These granular materials are in addition to the LVC zone.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder,
the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks should be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Floor Slab Construction Considerations

Finished subgrade within and for at least 10 feet beyond the floor slab should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until the floor slab is constructed. If the subgrade should become damaged or desiccated prior to construction of the floor slab, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should approve the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Exterior Hardscape

The near surface soils in our borings consisted of 3 to 4 feet of medium stiff to stiff and loose to medium dense undocumented fill. We anticipate hardscape constructed at the site will be lightly loaded. Subsequently, we believe the fill should provide sufficient support for the hardscape. However, we recommend the subgrade soil below hardscape be over-excavated to a minimum depth of 18 inches and replaced with compacted LVC structural fill per the recommendations provided in this report.

Exterior hardscape, exterior architectural features, and utilities founded on, or in backfill may experience some movement due to the volume change of the backfill. To reduce the potential for damage caused by movement, we recommend:

- Slabs be underlain by a minimum 18 inches of compacted LVC material as indicated
- Minimizing moisture increases in the backfill;
- Controlling moisture-density during placement of backfill;
n Using designs which allow vertical movement between the exterior features and adjoining structural elements;
n Placing effective control joints on relatively close centers.
n Ensure clay subgrade soils are in a moist condition prior to slab construction.
n Reinforce exterior slabs and flatwork with a minimum No. 4 bars at 12 inches on center.
n Maintain slabs structurally independent from the swimming pool shell.

**CORROSIVITY**

The table below lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, and pH testing. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

<table>
<thead>
<tr>
<th>Boring</th>
<th>Sample Depth (feet)</th>
<th>Soil Description</th>
<th>Soluble Sulfate (ppm)</th>
<th>Soluble Chloride (ppm)</th>
<th>Electrical Resistivity (Ω-cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-2</td>
<td>2½</td>
<td>Sandy lean clay</td>
<td>286</td>
<td>623</td>
<td>475</td>
<td>8.46</td>
</tr>
</tbody>
</table>

These test results are provided to assist in determining the type and degree of corrosion protection that may be required for the project. We recommend that a certified corrosion engineer determine the need for corrosion protection and design appropriate protective measures.

**Resistivity**

The resistivity test results indicate that the sample tested exhibit a very high corrosive potential to buried metal pipes. Evaluation of the test results is based upon the guidelines of J.F. Palmer, “Soil Resistivity Measurements and Analysis”, Materials Performance, Volume 13, January 1974. The following table outlines the guidelines for soil resistivity for corrosion potential.

<table>
<thead>
<tr>
<th>Soil Resistivity (ohm-cm)</th>
<th>Corrosion Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1,000</td>
<td>Very High</td>
</tr>
<tr>
<td>1,000 to 2,000</td>
<td>High</td>
</tr>
<tr>
<td>2,000 to 5,000</td>
<td>Moderate</td>
</tr>
<tr>
<td>&gt; 5,000</td>
<td>Mild</td>
</tr>
</tbody>
</table>
Sulfates

The sulfate test results indicate that the soil from boring B2 classify as Class S1 according to Table 19.3.1.1 of ACI 318-14. This indicates that the sulfate severity is moderate when considering corrosion to concrete. Based on the sulfate content test results, ACI 318-14, Section 19.3 requires the use of Type II cement, a maximum water/cement ratio of 0.50, and a minimum compressive strength of 4,000 psi. For further information, see ACI 318-14, Section 19.3.

Laboratory pH

Data suggests the soil pH should not be the dominant soil variable affecting soil corrosion if the soil has a pH in the 5 to 8 range. Based on our laboratory pH test, the soil sample tested has a pH value of 8.46. The pH of the sample is above the recommended range, and therefore should be considered when determining soil corrosion potential.

GENERAL COMMENTS

As the project progresses, we address assumptions by incorporating information provided by the design team, if any. Revised project information that reflects actual conditions important to our services is reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and
are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing. This report should not be considered valid and used after 3 years without written permission from Terracon.
FIGURES

Contents:
GeoModel
This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

### Model Layer

<table>
<thead>
<tr>
<th>Model Layer</th>
<th>Layer Name</th>
<th>General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fill</td>
<td>Medium stiff to stiff sandy lean clay and lean clay with sand and medium dense sand</td>
</tr>
<tr>
<td>2</td>
<td>Lean Clay</td>
<td>Medium stiff to stiff sandy lean clay</td>
</tr>
<tr>
<td>3</td>
<td>Poorly Graded Sand</td>
<td>Very loose to medium dense poorly graded sand and poorly graded sand with clay</td>
</tr>
</tbody>
</table>

### LEGEND

- Sandy Lean Clay
- Poorly-graded Sand with Clay
- Poorly-graded Sand
- Lean Clay with Sand

### Soil Behavior Type (SBT)

- 1 Sensitive, fine grained
- 2 Organic soils - clay
- 3 Clay - silty clay to clay
- 4 Silt mixtures - clayey silt to silty clay
- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravelly sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff fine grained

### NOTES:

Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time. Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.
EXPLORATION AND TESTING PROCEDURES

Field Exploration

<table>
<thead>
<tr>
<th>Number of Borings/CPT</th>
<th>Boring Depth/CPT (feet)</th>
<th>Planned Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>21½ to 26½</td>
<td>Planned pool area</td>
</tr>
<tr>
<td>2</td>
<td>100½</td>
<td>Planned pool area</td>
</tr>
</tbody>
</table>

**Boring/CPT Layout and Elevations:** The boring/CPT layout was performed by Terracon. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±20 feet) and approximate elevations were estimated using Google Earth Pro. If more precise boring/CPT locations and elevations are desired, we recommend borings/CPTs be surveyed.

**Subsurface Exploration Procedures:** We advanced the borings with a Superman Portable drill rig using continuous flight, solid stem augers. Two samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. Soil sampling was performed using split-barrel sampling. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon or 2.5-inch outer diameter Modified California split-barrel sampling spoon were driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. The values provided on our boring logs are uncorrected. Additionally, we observed and recorded groundwater levels during drilling and sampling. Per the requirements of the local health department and for safety purposes, all borings/CPTs were backfilled with grout after their completion.

For the cone penetrometer testing, the CPT rig hydraulically pushes an instrumented cone through the soil while nearly continuous readings are recorded to a portable computer. The cone is equipped with electronic load cells to measure tip resistance and sleeve resistance and a pressure transducer to measure the generated ambient pore pressure. The face of the cone has an apex angle of 60° and an area of 15 cm². Digital Data representing the tip resistance, friction resistance, pore water pressure, and probe inclination angle are recorded about every 2 centimeters while advancing through the ground at a rate between 1½ and 2½ centimeters per second. These measurements are correlated to various soil properties used for geotechnical design. No soil samples are gathered through this subsurface investigation technique. CPT testing was conducted in general accordance with ASTM D5778 “Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils.”
The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

**Laboratory Testing**

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D1140 Standard Test Method for Determining the Amount of Material Finer than No. 200 Sieve by Soil Washing

The laboratory testing program often included examination of soil samples by an engineer. Based on the material’s texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.
PHOTOGRAPHY LOG

Photo 1 – Northwest side of the pool (facing southeast)

Photo 2 – Southeast side of the pool (facing west)
Photo 3 – Southeast side of the pool (facing northwest)

Photo 4 – West side of the pool (facing east)
SITE LOCATION AND EXPLORATION PLANS

Contents:
Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.
SITE LOCATION
Discovery Bay Community Center Swimming Pool ■ Discovery Bay, Contra Costa County, California
January 30, 2019 ■ Terracon Project No. ND185167

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES
MAP PROVIDED BY MICROSOFT BING MAPS
EXPLORATION RESULTS

Contents:

Boring Logs (B-1 through B-3)
CPT Logs (CPT 1 and CPT 2)
Atterberg Limits
Corrosivity

Note: All attachments are one page unless noted above.
# BORING LOG NO. B1

**PROJECT:** Discovery Bay Community Center Swimming Pool  
**SITE:** 1601 Discovery Bay Boulevard  
**CLIENT:** Town of Discovery Bay  
**Location:** Discovery Bay, CA

### WATER LEVEL OBSERVATIONS

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER LEVEL OBSERVATIONS</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>$1$</td>
<td>With drilling</td>
</tr>
</tbody>
</table>

### FIELD TEST RESULTS

<table>
<thead>
<tr>
<th>Observation</th>
<th>FIELD TEST RESULTS</th>
<th>LABORATORY HP</th>
<th>WATER CONTENT (%)</th>
<th>DRY UNITWEIGHT (pcf)</th>
<th>ATTERBERG LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$5-9-9$</td>
<td>$5-9-9$</td>
<td>$1.5$</td>
<td>$25$</td>
<td>$94$</td>
<td>$N=13$</td>
</tr>
<tr>
<td>$2-2-2$</td>
<td>$2-2-2$</td>
<td>$1.5$</td>
<td>$26$</td>
<td>$91$</td>
<td>$N=13$</td>
</tr>
<tr>
<td>$3-2-8$</td>
<td>$3-2-8$</td>
<td>$1.5$</td>
<td>$29$</td>
<td>$84$</td>
<td>$N=13$</td>
</tr>
<tr>
<td>$3-3-5$</td>
<td>$3-3-5$</td>
<td>$28$</td>
<td>$27-17-10$</td>
<td>$67$</td>
<td>$N=18$</td>
</tr>
<tr>
<td>$7-8-10$</td>
<td>$7-8-10$</td>
<td>$19$</td>
<td>$N=18$</td>
<td>$N=13$</td>
<td>$N=13$</td>
</tr>
<tr>
<td>$5-5-8$</td>
<td>$5-5-8$</td>
<td>$24$</td>
<td>$N=13$</td>
<td>$N=13$</td>
<td>$N=13$</td>
</tr>
</tbody>
</table>

### GEOLOGICAL DATA

**Model Layer**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Location</th>
<th>Depth (ft)</th>
<th>Elevation (ft)</th>
<th>Sample Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1$</td>
<td>FILL - SANDY LEAN CLAY (CL)</td>
<td>$3.0$</td>
<td>$2+/-$</td>
<td>$5-9-9$</td>
<td>$1.5$</td>
</tr>
<tr>
<td>$2$</td>
<td>POORLY GRADED SAND (SP)</td>
<td>$6.0$</td>
<td>$-13+/-$</td>
<td>$2-2-2$</td>
<td>$1.5$</td>
</tr>
<tr>
<td>$3$</td>
<td>SANDY LEAN CLAY (CL)</td>
<td>$18.0$</td>
<td>$-13+/-$</td>
<td>$3-2-8$</td>
<td>$1.5$</td>
</tr>
<tr>
<td>$3$</td>
<td>POORLY GRADED SAND (SP)</td>
<td>$23.0$</td>
<td>$-18+/-$</td>
<td>$3-3-5$</td>
<td>$28$</td>
</tr>
<tr>
<td>$2$</td>
<td>SANDY LEAN CLAY (CL)</td>
<td>$26.5$</td>
<td>$-21.5+/-$</td>
<td>$7-8-10$</td>
<td>$19$</td>
</tr>
</tbody>
</table>

### Advancement Method:

- 4" Solid Stem Auger

### Abandonment Method:

- Boring backfilled with cement-bentonite grout upon completion.

### Notes:

- Boring Started: 01-03-2019
- Boring Completed: 01-03-2019
- Drill Rig: Superman
- Driller: Calgeo
- Project No.: ND185167

---

*This boring log is not valid if separated from original report.*
### BORING LOG NO. B2

**PROJECT:** Discovery Bay Community Center Swimming Pool  
**SITE:** 1601 Discovery Bay Boulevard  
**CLIENT:** Town of Discovery Bay, Discovery Bay, CA

<table>
<thead>
<tr>
<th>MODEL LAYER</th>
<th>GRAPHIC LOG</th>
<th>LOCATION</th>
<th>DEPTH (FL)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>FIELD TEST RESULTS</th>
<th>LABORATORY HP (tsf)</th>
<th>WATER CONTENT (%)</th>
<th>DRY UNIT WEIGHT (pcf)</th>
<th>PERCENT FINES</th>
<th>ATTERBERG LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FILL - LEAN CLAY WITH SAND (CL), fine grained, brown, medium stiff to stiff</td>
<td>1.5</td>
<td>0-2</td>
<td>4-6</td>
<td>1.5 (HP)</td>
<td>28</td>
<td>89</td>
<td>40-18-22</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SANDY LEAN CLAY (CL), fine grained, brown to dark brown, medium stiff to stiff</td>
<td>1.0</td>
<td>0-2</td>
<td>2-2</td>
<td>1.0 (HP)</td>
<td>26</td>
<td>88</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>POORLY GRADED SAND WITH CLAY (SP), fine to medium grained, brown, loose</td>
<td>1.0</td>
<td>0-2</td>
<td>4-5</td>
<td>1.0 (HP)</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**WATER LEVEL OBSERVATIONS**

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>FIELD TEST RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.0</td>
<td>2-3-4 N=7</td>
</tr>
<tr>
<td>25.0</td>
<td>2-3-6 N=9</td>
</tr>
</tbody>
</table>

**Notes:**

- Advancement Method: 4" Solid Stem Auger
- Abandonment Method: Boring backfilled with cement-bentonite grout upon completion.
- Stratification lines are approximate. In-situ, the transition may be gradual.
- Hammer Type: Rope and Cathead

**Project No.: ND185167**  
**Drill Rig: Superman**  
**Driller: Calgeo**  
**Boring Started: 01-03-2019**  
**Boring Completed: 01-03-2019**  
**5075 Commercial Cir, Ste E** Concord, CA  
**See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (if any). See Supporting Information for explanation of symbols and abbreviations.**
### Water Level Observations

<table>
<thead>
<tr>
<th>Depth (Ft.)</th>
<th>Field Test Results</th>
<th>Laboratory HP (tsf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5+/−</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Stratification Lines
- Stratification lines are approximate. In-situ, the transition may be gradual.

### Advancement Method
- 4" Solid Stem Auger

### Abandonment Method
- Boring backfilled with cement-bentonite grout upon completion.

### Notes
- Project No.: ND185167
- Drill Rig: Superman
- Driller: Calgeo
- Boring Started: 01-03-2019
- Boring Completed: 01-03-2019
- 5075 Commercial Cir, Ste E Concord, CA
CPT LOG NO.  CPT-01

PROJECT: Discovery Bay Community Center Swimming Pool

CLIENT: Town of Discovery Bay

Discovery Bay, CA

TEST LOCATION: See Exploration Plan

Approx. Surface Elev: 5 ft +/-
Latitude: 37.90230449°
Longitude: -121.6009789°

SITE: 1601 Discovery Bay Boulevard

Discovery Bay, CA

WATER LEVEL OBSERVATION

13 ft estimated water depth
(used in normalizations and correlations; See Supporting Information)

CPT Terminated at 100.6 Feet

Dead weight of rig used as reaction force.

CPT sensor calibration reports available upon request.

---

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

---

Terracon
5075 Commercial Cir, Ste E
Concord, CA

CPT Started: 1/3/2019
Rig: CPT

CPT Completed: 1/3/2019
Operator: Middle Earth
Project No.: ND185167
**SITE:** 1601 Discovery Bay Boulevard
Discovery Bay, CA

**PROJECT:** Discovery Bay Community Center
Swimming Pool

**CLIENT:** Town of Discovery Bay
Discovery Bay, CA

**TEST LOCATION:** See Exploration Plan

**WATER LEVEL OBSERVATION**

- 9 ft estimated water depth

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

---

**Material Description**

- 1. Sensitive, fine grained
- 2. Organic soils - clay
- 3. Clay - silty clay to clay
- 4. Silt mixtures - clayey silt to silty clay
- 5. Sand mixtures - silty sand to sandy silt
- 6. Sands - clean sand to silty sand
- 7. Gravelly sand to dense sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

---

**CPT Terminated at 100.9 Feet**

---

**Dead weight of rig used as reaction force.**

CPT sensor calibration reports available upon request.

---

**Supporting Information**

- 0.1
- 0.8
- 1.7
- 2.6
- 3.5
- 4.4
- 5.3
- 6.2
- 7.1

---

**Hydrostatic Pressure**

- Normalized CPT
- Soil Behavior Type

---

**Sleeve Friction, f_s**

- 1.6
- 3.2
- 4.8
- 6.4

---

**Tip Resistance, q_t**

- 100
- 200
- 300
- 400

---

**Depth (ft)**

- 0
- 5
- 10
- 15
- 20
- 30
- 40

---

**Approx. Elev. (ft)**

- 50
- 55
- 60
- 65
- 70
- 75
- 80
- 85
- 90
- 95

---

**WATER LEVEL OBSERVATION**

- See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

---

**Approx. Surface Elev: 5 ft +/-**

- Latitude: 37.90273527°
- Longitude: -121.6009888°

---

**1/30/19**
ATTERBERG LIMITS RESULTS
ASTM D4318

<table>
<thead>
<tr>
<th>Boring ID</th>
<th>Depth</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>Fines</th>
<th>USCS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>15 - 16.5</td>
<td>27</td>
<td>17</td>
<td>10</td>
<td>67</td>
<td>CL</td>
<td>SANDY LEAN CLAY</td>
</tr>
<tr>
<td>B2</td>
<td>2.5 - 4</td>
<td>40</td>
<td>18</td>
<td>22</td>
<td>76</td>
<td>CL</td>
<td>LEAN CLAY with SAND</td>
</tr>
</tbody>
</table>

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS ND185167 DISCOVERY BAY COMMUNITY CENTER SWIMMING POOL TERRACON DATATEMPLATE.GDT 1/15/19
Results of Corrosion Analysis

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>B2-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location</td>
<td>B2</td>
</tr>
<tr>
<td>Sample Depth (ft.)</td>
<td>2.5-4.0</td>
</tr>
<tr>
<td>pH Analysis, ASTM G 51</td>
<td>8.46</td>
</tr>
<tr>
<td>Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)</td>
<td>286</td>
</tr>
<tr>
<td>Sulfides, AWWA 4500-S D, (mg/kg)</td>
<td>Nil</td>
</tr>
<tr>
<td>Chlorides, ASTM D 512, (mg/kg)</td>
<td>623</td>
</tr>
<tr>
<td>Red-Ox, AWWA 2580, (mV)</td>
<td>+687</td>
</tr>
<tr>
<td>Total Salts, AWWA 2520 B, (mg/kg)</td>
<td>3892</td>
</tr>
<tr>
<td>Resistivity, ASTM G 57, (ohm-cm)</td>
<td>475</td>
</tr>
</tbody>
</table>

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

Analyzed By: Trisha Campo
Chemist
SUPPORTING INFORMATION

Contents:

General Notes
CPT General Notes
Unified Soil Classification System
Liquefaction Analysis Results

Note: All attachments are one page unless noted above.
Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

**Soil classification** is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

**STRENGTH TERMS**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>0 - 3</td>
<td>0 - 6</td>
<td>Very Soft</td>
<td>less than 0.25</td>
<td>0 - 1</td>
</tr>
<tr>
<td>Loose</td>
<td>4 - 9</td>
<td>7 - 18</td>
<td>Soft</td>
<td>0.25 to 0.50</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>10 - 29</td>
<td>19 - 58</td>
<td>Medium Stiff</td>
<td>0.50 to 1.00</td>
<td>4 - 8</td>
</tr>
<tr>
<td>Dense</td>
<td>30 - 50</td>
<td>59 - 98</td>
<td>Stiff</td>
<td>1.00 to 2.00</td>
<td>8 - 15</td>
</tr>
<tr>
<td>Very Dense</td>
<td>&gt; 50</td>
<td>&gt; 99</td>
<td>Very Stiff</td>
<td>2.00 to 4.00</td>
<td>15 - 30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hard</td>
<td>&gt; 4.00</td>
</tr>
</tbody>
</table>

**CONSISTENCY OF FINE-GRAINED SOILS**

Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance.

<table>
<thead>
<tr>
<th>Description Term (Consistency)</th>
<th>Standard Penetration or N-Value Blows/Ft.</th>
<th>Ring Sampler Blows/Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>&gt; 4.00</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

**RELATIVE DENSITY OF COARSE-GRAINED SOILS**

Density determined by Standard Penetration Resistance.

<table>
<thead>
<tr>
<th>Descriptive Term (Density)</th>
<th>Standard Penetration or N-Value Blows/Ft.</th>
<th>Ring Sampler Blows/Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>0 - 3</td>
<td>0 - 6</td>
</tr>
<tr>
<td>Loose</td>
<td>4 - 9</td>
<td>7 - 18</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>10 - 29</td>
<td>19 - 58</td>
</tr>
<tr>
<td>Dense</td>
<td>30 - 50</td>
<td>59 - 98</td>
</tr>
<tr>
<td>Very Dense</td>
<td>&gt; 50</td>
<td>&gt; 99</td>
</tr>
</tbody>
</table>

**RELATIVE DENSITY OF SAND AND GRAVEL**

Percent of Dry Weight

<table>
<thead>
<tr>
<th>Descriptive Term(s) of other constituents</th>
<th>Percent of Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt;15</td>
</tr>
<tr>
<td>With</td>
<td>15 - 29</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>

**RELATIVE PROPORTIONS OF FINES**

Percent of Dry Weight

<table>
<thead>
<tr>
<th>Descriptive Term(s) of other constituents</th>
<th>Percent of Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt;5</td>
</tr>
<tr>
<td>With</td>
<td>5 - 12</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt;12</td>
</tr>
</tbody>
</table>

**GRAIN SIZE TERMINOLOGY**

<table>
<thead>
<tr>
<th>Major Component of Sample</th>
<th>Particle Size</th>
<th>Term</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulders</td>
<td>Over 12 in. (300 mm)</td>
<td>Non-plastic</td>
<td>0</td>
</tr>
<tr>
<td>Cobble</td>
<td>12 in. to 3 in. (300mm to 75mm)</td>
<td>Low</td>
<td>1 - 10</td>
</tr>
<tr>
<td>Gravel</td>
<td>3 in. to #4 sieve (75mm to 4.75 mm)</td>
<td>Medium</td>
<td>11 - 30</td>
</tr>
<tr>
<td>Sand</td>
<td>#4 to #200 sieve (4.75mm to 0.075mm)</td>
<td>High</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>Silt or Clay</td>
<td>Passing #200 sieve (0.075mm)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DESCRIPTION OF MEASUREMENTS AND CALIBRATIONS

To be reported per ASTM D5778:

- Uncorrected Tip Resistance, \( q_t \)
- Measured force acting on the cone divided by the cone’s projected area

- Corrected Tip Resistance, \( q_c \)
- Cone resistance corrected for porewater and net area ratio effects
  \[ q_c = q_t \times \frac{a_t}{a} \]

Where \( a \) is the net area ratio, a lab calibration of the cone typically between 0.70 and 0.85

- Pore Pressure, \( u \)
- Pore pressure measured during penetration
  \[ u = \frac{F_s}{\pi \times 10^{6} \times \frac{2I}{3N}} \]

- Sensitivity, \( S \)
  \[ S = (q_c - q_s(N_s/N)) \times (1/f_t) \]

- Effective Friction Angle, \( \phi' \)
  \[ \phi' = (1 - \tan(0.373 \times q_c/q_s)) + 0.29 \]

- Over Consolidation Ratio, OCR
  \[ OCR (1) = 0.25(q_t)^{0.5} \]
  \[ OCR (2) = 0.33(q_t) \]

- Undrained Shear Strength, \( S_u \)
  \[ S_u = q_c \times \sigma_v' N_u \]
  \( N_u \) is a soil-specific factor (shown on SPT plot)

- Small Strain Shear Modulus, \( G_s \)
  \[ G_s(1) = 0.15 \times 10^{6} (1/21) \]
  \[ G_s(2) = 0.015 \times 10^{6} (1/21) \]

REFERENCES


Mayne, P.W., (2013), "Geotechnical Site Exploration in the Year 2013," Georgia Institute of Technology, Atlanta, GA.


REPORTED PARAMETERS

CPT logs as provided, at a minimum, report the data as required by ASTM D5778 and ASTM D7400 (if applicable). This minimum data include \( q_t \), \( I_c \), and \( u \). Other correlated parameters may also be provided. These other correlated parameters are interpretations of the measured data based upon published and reliable references, but they do not necessarily represent the actual values that would be derived from direct testing to determine the various parameters. To this end, more than one correlation to a given parameter may be provided. The following chart illustrates estimates of reliability associated with correlated parameters based upon the literature referenced below.

RELATIVE RELIABILITY OF CPT CORRELATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>High Reliability</th>
<th>Low Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permeability, ( k )</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Constrained Modulus, ( M )</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Unit Weight, ( \gamma )</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Effective Friction Angle, ( \phi' )</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Sensitivity, ( S )</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Undrained Shear Strength, ( S_u )</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Relative Density, ( D_r )</td>
<td>Over Consolidation Ratio, OCR</td>
<td>Sand</td>
</tr>
<tr>
<td>Small Strain Modulus, ( G_s ), and Elastic Modulus, ( E_s )</td>
<td>Low Reliability</td>
<td>High Reliability</td>
</tr>
</tbody>
</table>

WATER LEVEL

The groundwater level at the CPT location is used to normalize the measurements for vertical overburden pressures and as a result influences the normalized soil behavior type classification and correlated soil parameters. The water level may either be "measured" or "estimated:"

- Measured - Depth to water directly measured in the field
- Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions

While groundwater levels displayed as "measured" more accurately represent site conditions at the time of testing than those "estimated," in either case the groundwater should be further defined prior to construction as groundwater level variations will occur over time.

CONE PENETRATION SOIL BEHAVIOR TYPE

The estimated stratigraphic profiles included in the CPT logs are based on relationships between corrected tip resistance \( (q_t) \), friction resistance \( (f_s) \), and porewater pressure \( (u) \). The normalized friction ratio \( (F_r) \) is used to classify the soil behavior type.

Typically, silts and clays have high \( F_r \) values and generate large excess penetration porewater pressures; sands have lower \( F_r \)'s and do not generate excess penetration porewater pressures. The adjacent graph (Robertson et al.) presents the soil behavior type correlation used for the logs. This normalized SBT chart, generally considered the most reliable, does not use pore pressure to determine SBT due to its lack of repeatability on onshore CPTs.

REFERENCES
### Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests

<table>
<thead>
<tr>
<th>Group Symbol</th>
<th>Group Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>Well-graded gravel</td>
</tr>
<tr>
<td>GP</td>
<td>Poorly graded gravel</td>
</tr>
<tr>
<td>GM</td>
<td>Silty gravel</td>
</tr>
<tr>
<td>GC</td>
<td>Clayey gravel</td>
</tr>
<tr>
<td>SW</td>
<td>Well-graded sand</td>
</tr>
<tr>
<td>SP</td>
<td>Poorly graded sand</td>
</tr>
<tr>
<td>SM</td>
<td>Silty sand</td>
</tr>
<tr>
<td>SC</td>
<td>Clayey sand</td>
</tr>
<tr>
<td>CL</td>
<td>Lean clay</td>
</tr>
<tr>
<td>ML</td>
<td>Silt</td>
</tr>
<tr>
<td>OL</td>
<td>Organic clay</td>
</tr>
<tr>
<td>CH</td>
<td>Elastic silt</td>
</tr>
<tr>
<td>OH</td>
<td>Organic silt</td>
</tr>
<tr>
<td>PT</td>
<td>Peat</td>
</tr>
</tbody>
</table>

**Coarse-Grained Soils:** More than 50% retained on No. 200 sieve

- **Gravels:** More than 50% of coarse fraction retained on No. 4 sieve
- **Clean Gravels:** Less than 5% fines
- **Gravels with Fines:** More than 12% fines
- **Sands:** 50% or more of coarse fraction passes No. 4 sieve
- **Clean Sands:** Less than 5% fines
- **Sands with Fines:** More than 12% fines

**Fine-Grained Soils:** 50% or more passes the No. 200 sieve

- **Inorganic:**
  - PI > 7 and plots on or above “A” line
  - PI ≤ 4 or plots below “A” line
- **Organic:**
  - Liquid limit - oven
  - Liquid limit - not dried

- **Sils and Clays:**
  - Liquid limit less than 50
- **Sils and Clays:**
  - Liquid limit 50 or more
- **Highly organic soils:**
  - Primarily organic matter, dark in color, and organic odor

---

For classification of fine-grained soils and fine-grained fraction of coarse-grained soils:

- **Equation of “A” - line**
  - Horizontal at PI=4 to LL=25.5, then PI=0.73 (LL-20)
  - Vertical at LL=16 to PI=7, then PI=0.9 (LL-8)
- **Equation of “U” - line**
  - CH or OH
  - MH or OH
:: CPT main liquefaction parameters details ::

<table>
<thead>
<tr>
<th>CPT Name</th>
<th>Earthquake Mag.</th>
<th>Earthquake Accel.</th>
<th>GWT in situ (ft)</th>
<th>GWT earthq. (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPT-01</td>
<td>6.35</td>
<td>0.43</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>CPT-02</td>
<td>6.35</td>
<td>0.43</td>
<td>5.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Overall Parametric Assessment Method
Overlay Intermediate Results

- Norm. cone resistance
- SBTn Index
- Apparent fines content
- "Fines" adjustment
- Corrected norm. cone resistance

Project: Overlay Intermediate Results

Terracon Consultants, Inc.
5075 Commercial Circle, Suite E
Concord, CA 94520
www.terracon.com

CLiq v.2.0.6.89 - CPT Liquefaction Assessment Software - Report created on: 1/30/2019, 7:35:50 AM
Project file: N:\Projects\2018\ND185167\Working Files\Calculations-Analyses\Liquefaction Cliq - Discovery Bay.clq
Overlay Strength Loss Plots

- Norm. cone resistance
- Residual strength correction
- Corrected norm. cone resistance
- SBTn Index
- Liquefied Su/Sig'v