GEOTECHNICAL ENGINEERING STUDY
COPELLO DRIVE SUBDIVISION
ASSESSOR PARCEL NUMBER 058-011-026
ANGELS CAMP, CALIFORNIA

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1.0 INTRODUCTION

This report includes the results of a Geotechnical Engineering Study (GES) for the Copello Drive Subdivision Project. The subject site is located at Assessor Parcel Number 058-011-026 in Angels Camp, California. The general location of the site is shown on Figure 1 – Vicinity Map, and Figure 2 – Site Map with Test Pit Locations, Appendix A. Condor Earth (Condor) performed this study at the request of Mr. Scott Behiel for Habitat for Humanity Calaveras. This report was prepared to meet the requirements of 2019 California Building Code (CBC) for Geotechnical Engineering Studies.

2.0 PURPOSE AND SCOPE

This GES was performed to 1) characterize geotechnical conditions; 2) identify geotechnical or geologic conditions that might impact design or construction; 3) provide geotechnical recommendations to mitigate geotechnical constraints; and 4) provide geotechnical criteria for design of the proposed improvements. Condor completed the following work for this GES:

1. Reviewed available maps and documents relevant to the site geology, seismic setting, and geotechnical conditions.
2. Performed field explorations using backhoe test pits.
3. Analyzed the findings from the field exploration to develop geotechnical recommendations for:
   a) General earthwork, including site stripping, subgrade preparation, temporary excavations, permanent slopes, trench backfill, import fill, compaction criteria, and site surface drainage;
   b) Foundation design and construction, including foundation type, allowable bearing capacities, lateral resistance, settlement, and foundation depth;
   c) 2019 CBC seismic design criteria;
   d) Potential geologic and seismic hazards and recommendations for mitigation;
   e) Lateral earth pressures and retaining wall design criteria;
   f) Concrete slabs and exterior flatwork; and
   g) Asphalt and concrete pavements.
4. Prepared this written report summarizing our findings, conclusions and geotechnical recommendations.

3.0 PROJECT DESCRIPTION

Habitat for Humanity Calaveras is considering development of the approximately 17-acre assessor parcel number 058-011-026 in Angels Camp, California for 65 single family residential lots, 42 multifamily units, a recreation area and associated streets and parking. Condor anticipates that the structures will be one- or two-story slab-on-grade, wood or steel-framed.

The elevation of the site is approximately 1,540 feet. Elevations cited in this report and shown on exploratory test pits are estimated from the preliminary site plan. The site was covered with grasses and sparsely spaced native trees at the time of our site exploration.

Site development plans will require engineered fills up to 23 feet thick and cuts of up to 23 feet deep. The planned cuts will require excavation into bedrock to a greater depth than explored in Condor's field investigation. Trenching for utilities may require additional cuts below the general cuts into native bedrock. Please refer to the conclusions section of the report for additional discussion regarding excavations.

4.0 SITE CONDITIONS

Figure 2 shows the existing and proposed topography with other pertinent aspects of the site conditions and preliminary proposed layout of the site improvements. The site is undeveloped and covered with native trees and grasses.

The ground surface generally slopes from the northwest to the southeast. The highest ground is at the northwest and the lowest is at the southeast. The elevation difference across the site is approximately 70 feet. Resistant bedrock outcrops exist in the northwest portion of the site and along the topologic high area in the central western portion of the site.

A series of graded pads with cuts and fills of approximately 4 feet exists in the northwest portion of the site, adjacent to church property. An approximately 5-foot tall earthen berm exists in the southwest portion of the site. The berm was likely created to retain water for use as a stock pond. The upstream side of the berm is filled with sediment.

Surface drainage flows southeast to Cherokee Creek.

5.0 GEOLOGIC AND SEISMIC SETTING

5.1 REGIONAL GEOLOGY

The site is located in the foothills of the central Sierra Nevada. The basement rock of the Sierra Nevada range consists of steeply dipping metamorphic rocks of Paleozoic and Mesozoic age that have been intruded by the Mesozoic age granitic plutons of the Sierra Nevada Batholith. Within Calaveras County, these basement rocks are locally overlain by the eroded remnants of younger, Tertiary age, continental volcanic and sedimentary rock and Quaternary alluvium.

Uplift and westward tilting of the Sierra Nevada range began along the faults flanking its eastern edge. Erosion caused by west-flowing streams incised deep canyons and eroded much of the younger Tertiary rock that overlies the basement rock. Several episodes of glaciation during the last 2 million years have exposed much of the basement rock in the higher Sierra Nevada and generated the extensive deposits of glacial outwash in the Great Central Valley. The geologic processes of tectonic uplift and erosion continue to the present.

5.2 SITE GEOLOGY

The bedrock underlying the site and locally exposed in roadcuts and outcrops belongs to the Western Sierra Nevada metamorphic belt and is mapped as Calaveras Complex Volcanic Rocks (Pzcv) of Paleozoic age and was derived from basaltic and andesitic breccia and tuff that has been moderately to extremely deformed. The estimated distribution of the various rock units in the vicinity site is shown on Figure 3 – Geologic Map. Our field mapping confirmed the onsite bedrock as greenschist beneath a thin mantle of residual soils.

5.3 FAULTING AND REGIONAL SEISMICITY

No active faults are known to cross the site, nor is the site located within an Earthquake Fault Hazard Zone, as established by the Alquist-Priolo Earthquake Fault Zoning Act (Bryant and Hart, 2007), therefore,

ground rupture from faulting is not considered a significant hazard. Geologically recent (late Pleistocene to Holocene) movement has been identified on only eight faults within the Sierra Nevada block. These recent faults include the Poorman Gulch and Rawhide Flat traces of the Melones Fault Zone shown on Figure 4 – Regional Fault Map, approximately 9 miles northwest and 10 miles southeast of the site, respectively.

6.0 SUBSURFACE CONDITIONS

On February 3, 2020, Condor observed the excavation of 12 exploratory test pits (TP-1 through TP-12) to depths ranging from approximately 4.0 to 10.5 feet at the locations shown on Figure 2 – Site Map with Test Pit Locations, Appendix A. The exploratory test pits were excavated by Brad Sutton Trucking, Inc. by use of a CAT 420D backhoe with an 18-inch bucket.

A Condor staff geologist logged the materials encountered at each test pit and selected sample locations representative of site conditions. The subsurface was classified using the Unified Soil Classification System and applicable rock classification system noting color, moisture, weathering, strength, hardness, texture, fabric, composition, and excavation rate. Selected samples were tested for moisture content, dry density, sieve analysis, plasticity index and R-Value at Condor's Soils Laboratory. Chemical tests were performed by our laboratory subcontractor. The test pit logs are provided in Appendix B. Laboratory test reports are provided in Appendix C.

6.1 EARTH MATERIALS

The site is generally characterized as moderately to highly weathered, friable to weak, laminated, moist, light yellowish brown, metamorphic bedrock overlain by a by a 1.0 to 3.5-foot-thick mantle of residual soil that is a soft to stiff, light reddish-brown Sandy Lean Clay to Clayey Sand. Surface conditions were typically soft due to the high moisture content from recent rains. A detailed description of the encountered ground conditions is provided in the test pit logs, Appendix B.

6.2 LOCAL GROUNDWATER CONDITIONS

No groundwater was observed during our field work. However, with seasonal variation in rainfall, seepage in excavations may be encountered during the wet season.

6.3 SEISMIC CONSIDERATIONS

6.3.1 Ground Shaking

Probabilistic values of ground motion corresponding to various levels of seismic hazards are available on-line from professional organizations using the USGS data to retrieve the seismic design data and presents the findings in a report format. The USGS uses a probabilistic model to estimate ground motions corresponding to various levels of seismic hazard. Site soils were classified using the procedures specified in the 2019 CBC, which utilizes ASCE 7-16.

The results for the general seismic analysis using the 2019 CBC for Site Class D (Stiff Soil) are summarized below and provided in Appendix B. The recommended values for design of the proposed structures are:

- Site Class: D
- S_S: 0.358 g (where g is acceleration from gravity)
- S_1: 0.187 g
- S_{MS}: 0.542 g
- S_{M1} 0.416 g

- S_{DS}: 0.361 g
- S_{D1}: 0.277 g

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 GENERAL

Based on our findings, it is our professional opinion that from a geotechnical standpoint for construction of the proposed improvements, the site is suitable to receive the proposed project improvements provided the geotechnical recommendations contained herein are incorporated into the project design. The primary geotechnical considerations from a development standpoint are (1) the presence of resistant bedrock within the planned excavation depths and trenches for foundations and utilities; and (2) the need for processing fill materials derived from bedrock cuts to meet the gradation requirements of engineered fill, and (3), the need to remove existing fills associated with existing graded pads and stock ponds (see Section 4.0).

Specific conclusions and recommendations addressing these geotechnical considerations, as well as general recommendations regarding the geotechnical aspects of design and construction, are presented in the following sections.

7.2 GRADING AND EARTHWORK RECOMMENDATIONS

The grading and site work should be performed in accordance with the 2019 CBC, Title 24, Chapter 33 (Safeguards During Construction), Appendix J (Grading), and Chapter 18 (Soil and Foundations), and with the recommendations of the Geotechnical Engineer-of-Record during construction. Where the recommendations of this report and the cited sections of the CBC are in conflict, the owner should request clarification from the Geotechnical Engineer-of-Record. The recommendations of this report should not be waived without the consent of the Geotechnical Engineer-of-Record for the project. Recommendations for additional work and construction monitoring are contained in later sections of this report.

7.2.1 Site Preparation

Existing fills associated with the previously graded pads and stock pond earthen berm described in Section 4.0 should be overexcavated to weathered bedrock. Overexcavation depths at the previously graded pads and earthen berm are expected to be approximately 4 feet and 6 feet, respectively.

The ground surface in the area of the proposed improvements should be stripped of all vegetation, debris, organic topsoil, or any other unsuitable material or soil. Stripping should extend at least 5 feet beyond the limits of the proposed improvements where possible. Soils containing more than 2 percent organic material by weight over baseline conditions should be considered organic. Roots remaining greater than ½-inch in diameter should be removed by either mechanical means or by hand during grading operations. Actual stripping depths should be determined at the time of grading by the geotechnical engineer or a qualified representative. Site strippings may be stockpiled for later use in landscape areas. Disking may be considered as an alternative to stripping when approved by the Geotechnical Engineer.

7.2.2 Subgrade Preparation

In all areas to receive fill material, the exposed subgrade consisting of native soil or weathered bedrock should be scarified to a depth of 8 inches, uniformly moisture conditioned to between 2 and 4 percentage points above optimum moisture content, and compacted to achieve a minimum relative compaction of 90 percent of the ASTM D1557 maximum dry density. Field density tests should be taken to verify compaction of the prepared subgrade in these areas.

The subgrade conditions exposed in cut bedrock areas will not warrant scarification and recompaction. If highly to moderately weathered bedrock is exposed, we recommend that the exposed surface be thoroughly moisture conditioned and track walked with a dozer to break up the oversize material and provide a workable and dense surface. The Geotechnical Engineer or qualified representative should observe this operation to verify that the oversize material has been properly broken down and the surface is firm and unyielding.

7.2.3 Overexcavation of Cut/Fill Transitions

To reduce the potential for differential settlement below the proposed building pads or other sensitive structures, the cut portion of the cut/fill transition should be overexcavated to provide a minimum of 2 feet of engineered fill below the proposed footings and extending at least 3 feet horizontal beyond.

7.2.4 Engineered Fill Materials

Engineered fill used for the project should be either 1) select import engineered fill, or 2) general on-site materials with less than 2 percent organic content and a maximum particle size of 6 inches. Select import material used for engineered fill should be inorganic, have an R-value of at least 30, a liquid limit less than 30, and plasticity index less than 7. Engineered fill should also meet the following particle-size gradation:

Sieve Opening	Percent Passing, by Dry Weight
6-inch square	100
3/4-inch square	70 minimum
U.S. No. 4	60 minimum
U.S. No. 200	50 maximum

Samples of proposed imported fill material should be submitted to the Laboratory of Record for testing and approved by the Geotechnical Engineer-of-Record prior to being brought to the site. If certified testing has been performed on any proposed imported fill material, the Geotechnical Engineer-of-Record or a qualified professional may approve its use based on the test results.

General on-site engineered fill should be inorganic, contain no rocks greater than 6 inches in least dimension, and be free of deleterious materials. Soils containing more than 2 percent by weight of organic material should be considered organic. Grading contractors should anticipate that processing of the weathered bedrock generated from cuts may be necessary to meet the gradation requirements. Processing could include track-walking the coarse materials to break down the particle size, screening and mechanically crushing the coarse materials, or removing coarse material and replacing the material with import. The required amount of processing and the excavation difficulty will generally increase with increasing depth of cut. Additional discussion regarding excavation is provided in Section 7.2.6

7.2.5 Engineered Fill Placement

Engineered fill should be placed in a series of horizontal layers not exceeding 8 inches in loose thickness, uniformly moisture-conditioned to between 2 and 4 percentage points above optimum moisture content and compacted to achieve a minimum relative compaction of 90 percent of the ASTM D1557 maximum dry density. Where fill depths exceed 10 feet, we recommend that the minimum relative compaction be 95 percent for fill below a depth of 10 feet from finished subgrade. Additional fill lifts should not be placed if the previous lift did not meet the required relative compaction or if soil conditions are not stable. Disking, tilling, and/or blending may be required to uniformly moisture-condition soils used for engineered fill.

7.2.6 Excavations

Construction site safety generally is the sole responsibility of the Contractor who shall also be solely responsible for the means, methods, and sequencing of construction operations. The Contractor should be aware that slope height, slope inclination, or excavation depths (including foundation excavations) should in no case exceed those specified in local, state, and/or federal safety regulations (e.g., OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, or successor regulations). Heavy construction equipment, building materials, excavated soil, and vehicular traffic should not be allowed within a lateral distance equal to one-third the slope height from the top of any excavation. During wet weather, earthen berms or other methods should be used to prevent runoff water from entering all excavations. Runoff water, seepage, and/or groundwater encountered within excavations should be collected and disposed of outside the construction limits.

Open temporary trenches and cuts should be monitored for evidence of incipient instability and should be in compliance with applicable OSHA regulations (California Construction Safety Orders, Title 8). The contractor is responsible for final determination of safe slopes for all temporary cuts and trenches.

The presence of resistant bedrock within the planned excavation depths should be considered when planning site grading. We anticipate that resistant bedrock encountered within the proposed cut areas will generally be rippable with large equipment, without the aid of blasting to a depth of at least 10 feet but may generate over-sized rock. However, in small excavations, such as foundations, impact mechanical excavation (jackhammer) will likely be required.

Resistant rock requiring percussion excavation or blasting is known to occur for developments in the area, particularly for excavations deeper than 5 feet, or narrow utility trenches. If blasting is necessary, Condor recommends that this work be performed by a certified state licensed blaster. If blasting is conducted, water sprays and/or blasting mats should be employed to reduce the potential for any environmental impact or accidents. Over-sized rock may require mechanical treatment to meet the requirements of maximum particle size as discussed in Section 7.2.4.

7.2.7 Temporary and Permanent Slopes

It is our opinion that temporary unbraced cut slopes up to 10 feet high in the weathered rock may be ½H:1V (horizontal to vertical), provided that the rock is not fissured and will remain intact while exposed. If the rock is wet or seepage is encountered, or if the rock is subject to other instability factors, the inclination of the slope should be flattened to maintain safe conditions. The soil mantle exposed by temporary cut slopes should be flattened to no steeper than 1½H to 1V provided there is no evidence of saturation or seepage. Excavation deeper than 4 feet should be reviewed by a competent person at the time of exploration where the excavation cannot be sloped to 1½H:1V or flatter.

Permanent cut slopes in engineered fill should have an inclination no steeper than 2H to 1V (2H:1V). Permanent cut slopes in moderately weathered rock should be made no steeper than 1½H:1V. Permanent cut slopes in competent rock may be made as steep as 1H:1V upon approval of the Geotechnical Engineer, but we recommend avoiding such steepened slopes for planning.

In large part, the stability of cut slopes is due to their location and orientation with respect to the structure of the underlying weathered bedrock. If adverse bedding, joint planes, or other zones of geologic weakness are encountered during earthwork, corrective grading may be required to provide permanent stability. Examples of corrective grading include buttress fills, reconstruction of the slope, or flattening of the slope. If exposed bedding dips steeper than 2H:1V stability problems probably will not pose a significant concern. If bedding planes are flatter, however, the beds would be exposed adversely to the cut and there would be a potential for slope failure, especially if weak clay interbeds are present. Accordingly, an engineering

geologist should observe the initial grading of cut slopes during grading operations. If adverse bedding is discovered, the geologist can recommend a study scope to evaluate the conditions and provide remedial alternatives.

Interceptor drains should be provided along the tops of slopes where the tributary area flowing toward the slope has a drainage path greater than 40 feet, measured horizontally. The interceptor drains should be sloped to a suitable drainage device and disposed off-site well below the toe of the slope. The permanent cut slopes should be inspected periodically for erosion, and if detected, repaired immediately. Interceptor drains should be cleaned before the start of each rainy season, and if necessary, after each rainstorm. To minimize erosion and gulling/rilling, disturbed areas should be planted with erosion-resistant vegetation suited to the area. As an alternative, jute netting or geotextile erosion control mats can be installed per the manufacturer's recommendations.

7.3 UNDERGROUND UTILITY TRENCHES

Unless concrete bedding is required around utilities, pipe bedding should consist of sand with a sand equivalent of at least 30 or the pipe manufacturer's requirements, whichever is more restrictive. The pipe bedding should extend from 6 inches below the invert of the pipe to 1 foot above the crown of the pipe. The pipe bedding material should be compacted to a minimum of 90 percent relative compaction or the manufacturer's recommendations if more stringent.

Trench backfill above the pipe bedding zone should be placed in the same manner as required in Section 7.2.5, Engineered Fill Placement. On-site fill soils and "non-organic" native soils may be used as backfill in trenches above the pipe bedding. Utility trench backfill should be placed in layers not exceeding a loose lift thickness of 8 inches, uniformly moisture conditioned, and compacted to a minimum of 90 percent relative compaction.

Compaction criteria for trench backfill above the bedding zone may be decreased to 85 percent relative compaction in landscape areas at least 5 feet beyond structural improvements, except in areas overlain by pavements, sidewalks, or other hardscapes. In landscape areas overlain by pavements, sidewalks, or other hardscapes, we recommend that the trench backfill be compacted to a minimum of 90 percent relative compaction to within 1 foot of the finished subgrade surface. The upper 1 foot should be compacted to 95 percent relative compaction.

7.4 SUBDRAINS

If seasonal perched groundwater or seeps, or evidence of such conditions are encountered, subdrains should be provided. The design of the subdrains depends on the topography, the specific seepage conditions, and the characteristics of adjacent improvements. Should evidence of wet conditions or seepage be encountered during site grading, we recommend that the geotechnical engineer evaluate the need for subdrainage and, if appropriate, prepare a subdrain design.

7.5 SURFACE DRAINAGE CONTROL

Surface drainage should be designed to prevent ponding and to drain surface water away from foundations, slabs-on-grade, tops of retaining walls, and cut slopes faces. Under no circumstances should concentrated surface water be allowed to run over slope faces. Surface runoff should be directed toward suitable collection or discharge facilities. A positive surface drainage of at least 5 percent should be provided within 10 feet of building foundations and tops of retaining walls. Elsewhere, positive surface drainage of at least 2 percent is recommended to allow for rapid removal of surface water or as recommended by the site development civil engineer. Roof drainage should be directed away from building foundations and retaining

walls where bare ground is exposed. A detailed drainage plan is outside the scope of this report but should be included in the preparation of the grading plans for new construction.

8.0 FOUNDATION RECOMMENDATIONS

8.1 GENERAL FOUNDATION RECOMMENDATIONS

The foundation improvements should be designed and constructed in accordance with the 2019 CBC, Title 24, Chapter 17 (Structural Tests and Special Inspections), Chapter 18 (Soil and Foundations), and all other sections applicable to the proposed structural improvements. Note that the stated preliminary bearing pressures in Section 8.2 are net values, and the weight of concrete in the portion of the foundations that extends below grade can be neglected in proportioning the foundations. Further evaluation of the subsurface may be warranted based on any other specific foundation designs not considered in this report.

8.2 SPREAD FOOTING FOUNDATIONS

Based on this study, we conclude that the proposed structures may be supported by conventional spread footing foundations founded on undisturbed weathered bedrock or engineered fill, provided that the Grading and Earthwork Recommendations in Section 7.2 are adhered to during the design and construction of earthwork and foundation improvements. Based on our current understanding, the foundations will bear in weathered bedrock, or a maximum of 25 feet of engineered fill over bedrock. If conditions deviate from these, our recommendations should be reviewed.

We recommend that a representative of the Geotechnical Engineer-of-Record or a qualified professional civil engineer observe foundation excavations prior to the placing of reinforcing steel. This inspection should be conducted and documented to verify that the bottoms and sides of foundation excavations are level or suitably benched and are free of loose or soft soil, ponded water, and debris. If loose pockets are encountered in the bottom of the foundation excavations, they should be over-excavated, and the base of the excavation should be recompacted or backfilled with lean concrete. It is important that foundation excavations be clean and free of loose or soft soils, water, or other debris at the time concrete is placed.

We recommend that the conventional spread foundations should be designed to support dead loads plus normal duration live loads using an allowable bearing capacity of 3,000 pounds per square foot (psf) for footings with a minimum embedment depth of 12 inches. All footing dimensions should comply with the California Building Code. Continuous and column spread footings should have minimum widths of 15 and 24 inches, respectively, to facilitate hand cleaning. The allowable bearing capacities may be increased by one-third when considering short-term wind and seismic loads.

Total settlement of an individual foundation will vary depending on the compressibility of the material underlying the foundation, the plan dimensions of the foundation and the actual load supported. Based on the anticipated/assumed foundation dimensions and loads, we estimate maximum total and differential foundation settlements should be less than 1- and ½-inch, respectively.

8.2.1 Lateral Resistance

Resistance to lateral loads (including those due to wind or seismic forces) may be determined using the friction between the bottom of concrete foundations and the underlying soil/bedrock and the passive soil pressure acting against the vertical face of the footings. These two modes of resistance can be combined. Sliding resistance to lateral forces may be calculated using a coefficient of friction of 0.35. Passive resistance pressure available in the weathered bedrock or engineered fill may be calculated using an allowable equivalent fluid weight of 350 pounds per cubic foot (pcf), assuming that the ground adjacent to the foundation is level. This allowable value includes a reduction factor of 1.5 to limit the foundation movement required to mobilize the ultimate passive resistance.





Passive resistance contributed by soils within 1 foot of the ground surface should be neglected unless the ground is covered and confined by a slab-on-grade or pavement. To mobilize passive pressure, gaps between the footing and adjacent ground should be completely backfilled using engineered fill, concrete, or lean cement sand slurry with a 28-day unconfined compressive strength of at least 500 pounds per square inch (psi).

9.0 SLABS-ON-GRADE

Concrete slabs should be constructed on a surface prepared as described in Section 7.2. Where dampness of floor slabs is to be minimized, the slabs should be constructed on a minimum 4-inch-thick layer of capillary break material covered with a high-quality vapor retarder. The capillary break material should be free-draining, clean gravel or rock such as No. 4 by ¾-inch pea gravel or permeable aggregate complying with Caltrans Standard Specifications, Section 68, Class 1, Type B. A 2-inch thick protective cover (blotter) of clean sand should be placed over the vapor retarder. The vapor retarder should have a minimum thickness of 15 mils, a permeance as tested before and after mandatory conditioning (ASTM E 1745, Section 7.1.2 – 7.1.5) of less than 0.01 perms [grains/(ft2 · hr · inHg)], and comply with the ASTM E 1745 Class A requirements. Vapor retarders having these properties are commonly referred to as “vapor barriers”. The designer of record may omit the blotter at their discretion when a concrete with a water-cement ratio of 0.45 or less is specified. The vapor retarder should be constructed in accordance with ASTM E 1643-09 using material which meets ASTM E 1745. A licensed copy of ASTM E 1643-11 is included in Appendix E.

Slab surfaces to receive moisture sensitive floor coverings should have considerations for maximum vapor emission levels. Most floor coverings require 3-or 5-pound emission levels for a warranted installation. Emission levels may be controlled by the use of a sub-slab vapor barrier meeting ASTM E 1745 Class A, ASTM E 154-93 resistance to puncture of not less than 3,000 grams and ASTM E 154-93 tensile strength after soaking of not less than 55.5 (MD/TD) average.

Slabs should be cast using concrete with a maximum slump of 4 inches or less. Excessive water content is the major cause of concrete cracking. To reduce concrete shrinkage, a water reducing agent or plasticizer may be utilized in the concrete to increase slump while maintaining an appropriate water/cement ratio. Hot reinforcing steel should be cooled prior to concrete placement to help prevent concrete shrinkage at the bar location. Where there is potential for moisture accumulation under the slab, special consideration should be given to allow gravity drainage of any water that could migrate into the subgrade of the slab or rock cushion.

The project structural engineer should design the slab-on-grade of building structures. The following table provides our recommended interior slab-on-grade alternative in lieu of a Structural Engineer.

SLAB-ON-GRADE RECOMMENDATIONS

Building Pad Subgrade	Minimum Slab Thickness	Minimum Reinforcement
Weathered bedrock or engineered fill moisture conditioned and compacted per Section 7.2.5	4 inches PCC	No. 3 at 18 inches O.C.E.W.

Notes:
a) PCC = Portland Cement Concrete with minimum compressive strength of 3,000 psi, and jointed and reinforced per structural design for shrinkage. Minimum slab thickness may be revised per the design structural engineer.
b) Grading recommendations per Section 7.2 are to be followed.

Exterior concrete slabs should be constructed over 4 inches of Class 2 Aggregate Base over compacted engineered fill prepared as discussed in Section 7.2 and should be reinforced or jointed and scored to limit cracking from shrinkage. At the time of exterior slab construction, reprocessed native material should be moisture conditioned to near the optimum moisture content where imported soil is not supporting the slab.

10.0 RETAINING WALLS

Active earth pressures may be used in design of unrestrained retaining walls where the top of the wall is free to translate or rotate. To develop active earth pressures, the walls should be capable of deflecting by at least 0.004H (where H is the height of the wall). At-rest earth pressures should be used for design of retaining walls where the wall top is restrained such that the deflections required for development of active soil pressures cannot occur or are undesirable. Cantilever walls retaining bedrock or engineered fill may be designed for active or at-rest lateral earth pressures for various backfill slopes using the following equivalent fluid unit weights.

Equivalent Fluid Unit Weight (pcf)

Backfill Slope	Active Conditions	At-Rest Conditions
Level	30	50
3H:1V	35	60
2H:1V	45	70

Where walls will retain the native soil mantle, the lateral earth pressures imposed within the upper 3 feet of the ground surface should be designed for the higher values given below:

Equivalent Fluid Unit Weight (pcf)

Backfill Slope	Active Conditions	At-Rest Conditions
Level	40	60
3H:1V	50	80
2H:1V	70	90

Lateral earth pressures for backfill slopes other than those given above can be estimated by interpolation. The lateral earth pressures should be applied to a plane extending vertically upward from the bottom of the foundation heel to the ground surface.

The lateral earth pressures given above apply where the wall backfill is fully drained, is not subject to traffic or other surcharge loads, and the backfill is not subject to heavy compaction equipment within a distance of one-third the height of the backfill. Lateral surcharge pressures are discussed later in this section.

10.1 SURCHARGE LOADS

If the wall backfill will be subject to traffic loading within a distance of H/2 from the top of the wall (where H is the wall height) the wall should be designed to resist an additional uniform lateral pressure of 65 psf applied to the back of yielding walls (active conditions) or 110 psf applied to the back of non-yielding walls (at-rest conditions). Surcharge loads imposed by greater loads or unusual loads within a distance of H of the back of the wall should be considered on a case-by-case basis.

10.2 BACKFILL DRAINAGE

The above lateral earth pressures are based on fully drained conditions. A drainage system should be constructed on the back side of all retaining walls. The drainage system for backfilled walls should consist

of a 4-inch diameter perforated pipe surrounded by Class 2 permeable material complying with Section 68 of the Caltrans Standard Specifications, latest edition. The section of permeable material should be at least 12 inches wide and should extend up the back of the wall to within about 18 inches of finished grade. The drainage material should be capped with compacted fine-grained soil, soil-cement, or other relatively impermeable material. Perforations in the drainpipe should be ¼-inch in diameter. The perforated pipe should be placed "holes down" near the bottom of the section of permeable material and should discharge by gravity to a suitable outlet. Alternatively, the perforated pipe may be surrounded by clean coarse gravel or drain rock, provided the gravel or rock is completely separated from the surrounding soil by an engineering filter fabric such as Mirafi 140N or similar fabric. If approved by the geotechnical engineer, prefabricated wall drain systems may also be used instead of an aggregate drainage system. If minor seepage or dampness through the concrete walls is objectionable, a water proofing should be applied between the drainage material and the wall. A prefabricated wall drainage system approved by the geotechnical engineer should be used for cast-in-place concrete tie-back retaining walls.

11.0 COROSION POTENTIAL

Chemical tests were performed on a composite sample of soil anticipated to be in contact with foundation improvements. Test results yielded a pH of 6.55, chloride ion concentration reflects none detected, sulfate ion concentration reflects none detected, and soil redox potential of 400-nV.

Resistivity test results of 8,300 ohm-centimeter indicate that the soil is mildly corrosive. A commonly accepted correlation between soil resistivity and corrosivity towards ferrous metals is provided in the following table developed by the National Association of Corrosion Engineers (NACE).

Soil Resistivity	Corrosivity
Less than 500 ohm-cm	Very corrosive
500 to 1,000 ohm-cm	Corrosive
1,000 to 2,000 ohm-cm	Moderately corrosive
2,000 to 10,000 ohm-cm	Mildly corrosive
Over 10,000 ohm-cm	Progressively less corrosive

Appendix C contains the results of the corrosivity tests performed, as well as a brief evaluation letter by our laboratory subcontractor. The brief evaluation provides general recommendations regarding protecting buried metals. If warranted, a corrosion expert should be consulted to develop specific recommendations.

12.0 PAVEMENTS

Pavement sections[1] for anticipated subgrade soils are presented below based on an R-value of 22, current Caltrans design procedures, and traffic indices ranging from 4 to 8. However, if the pavement section is founded on resistant bedrock, the Class 2 Aggregate Base thickness may be reduced to 4.0 inches. The traffic index (TI) is a measure of traffic wheel loading frequency and intensity of anticipated traffic. For comparison, TI's of between 4 and 5 are often suitable for design of automobile parking areas, whereas TI's of between 5 and 6 are commonly used for design of fire truck access lanes and areas subject to channelized flow with light delivery trucks. Traffic lanes that carry routine bus traffic should be designed for higher TI values based on specific conditions. Traffic indices assumed above should be reviewed by the project Owner, Architect, and/or Civil Engineer to evaluate their suitability for this project. Pavement

[1] *Caltrans design procedures for asphalt concrete pavements provide sections in units of inches, rounded up to the nearest ½-inch. Sections provided above include no Gravel Equivalent Safety Factor (per County Engineers Association and the League of California Cities criteria). If required a Gravel Equivalent Safety Factor is required, the pavement sections should be reevaluated.*

sections for other traffic loading should be designed on a case-by-case basis. The use of rigid concrete pavement is favored where trash pick-up or truck traffic necessitates short radius maneuvering and/or heavy metal bin movement on rollers.

RECOMMENDED NEW PAVEMENT SECTIONS ON COMPACTED SOIL AND HIGHLY WEATHERED BEDROCK

Traffic Index (T.I.)	Asphalt Concrete Thickness (inches)	Class 2 Aggregate Base Thickness (inches)
4.0	2.0	6.0
5.0	3.0	7.0
6.0	3.5	9.0
7.0	4.0	12.0
8.0	4.0	15.0

The pavement sections provided above are contingent on the following recommendations being implemented during and following construction.

- The subgrade soils in the upper 12 inches below the finished subgrade elevation should be compacted to achieve a minimum relative compaction of 95 percent of the CAL 216 maximum wet density.
- Trench backfill for culverts, utilities and pipes underlying paved areas should be properly placed and compacted to at least 90 percent relative compaction (ASTM D1557) within one foot of finished subgrade elevation. The upper 12 inches of trench backfill should be compacted to at least 95 percent relative compaction (CAL 216).
- The subgrade soils should be in a stable, non-pumping condition at the time the aggregate base material is placed and compacted.
- Aggregate base and aggregate subbase materials should conform to the specifications stated in Section 25 and 26 of the current Caltrans specifications and be compacted as engineered fill to at least 95 percent relative compaction.
- Asphalt paving materials and placement methods should meet current Caltrans specifications for asphalt concrete.
- Adequate drainage (both surface and subsurface) should be provided such that the subgrade soils and aggregate base materials are not allowed to become continuously wet.
- Concrete curbs separating pavement and landscaped areas should extend at least 2 inches into the subgrade and below the bottom of the adjacent aggregate base to provide a barrier against lateral migration of landscape water or runoff into the pavement section. For better performance, we recommend that subdrains be considered along edges of roads where there are slopes and especially swales that descend towards pavement.
- Periodic maintenance should be performed to repair degraded areas and seal cracks with appropriate filler.

The pavement sections provided above are based on the anticipated subgrade materials following site grading operations. During our site investigation, we observed that the degree of weathering in the bedrock varied based on location and depth. Therefore, we highly recommend that a representative subgrade sample be obtained following site grading activities and R-value testing be performed. If the results of the R-value

testing vary significantly from those assumed, the pavement sections presented above will need to be revised.

Portland Cement Concrete pavements may be constructed directly on engineered fill or on recompacted native soils and weathered bedrock. Concrete pavements that support truck and bus traffic should be a minimum of 8 inches in thickness and should be designed to accommodate temperature expansion/contraction using reinforcement or appropriate joint control. Portland Cement Concrete used for driveways and exterior traffic uses should have a minimum compressive strength of 3,000 psi and should contain entrained air to help prevent freeze damage. A modulus of subgrade reaction, k_v (30-inch circular plate) of 250 psi may be used for design of Portland Cement Concrete pavements.

13.0 ADDITIONAL SERVICES

The geotechnical recommendations and design criteria in this report are sensitive to the location, design details, and any special requirements of the new construction. Condor should review the geotechnical elements of project grading, foundation plans and specifications prior to construction bidding to check that the intent of our recommendations have been incorporated into these project documents. If Condor does not review the geotechnical elements of the plans and specifications, the reviewing geotechnical engineer or qualified professional civil engineer should thoroughly review this report and concur with its conclusions and recommendations or provide alternative recommendations.

Because surface conditions vary across the site, geotechnical recommendations used as a basis for construction contracting are sensitive to the possible need for adjustment in the field. The adjustments are dependent upon conditions revealed during construction that could previously only be assumed based upon site exploration. Since the intent of the recommendations given in this report are best understood by a Condor representative, we recommend that field observations and testing during earthwork and construction be performed by Condor. If Condor does not provide the field observations and testing, the Geotechnical Engineer-of-Record should thoroughly review this report and concur with its conclusions and recommendations or provide alternative recommendations.

A representative of the Geotechnical Engineer-of-Record or a qualified professional civil engineer should be on-site to observe and advise during site preparation, grading and earthwork, paving, and construction of foundations and slabs-on-grade. These observations should be supplemented with periodic density and compaction testing of subgrade and engineered fills to evaluate conformance with the recommendations contained in this report. It is important that foundation excavations be checked after cleaning and immediately prior to concrete placement to verify their suitability.

14.0 LIMITATIONS

The geotechnical conclusions and recommendations presented in this report are based on our findings during our February 3, 2020 field investigations, and are intended for planning, design, and construction of the proposed improvements for Habitat for Humanity Calaveras, Copello Drive Subdivision Project. These conclusions and recommendations may be invalid if:

- The design assumptions change;
- The report is used for another site and/or project;
- The encountered soil or groundwater conditions are different than those anticipated in this report;
- The recommendations contained in this report are not followed; or
- Any other change is implemented that materially alters the project.





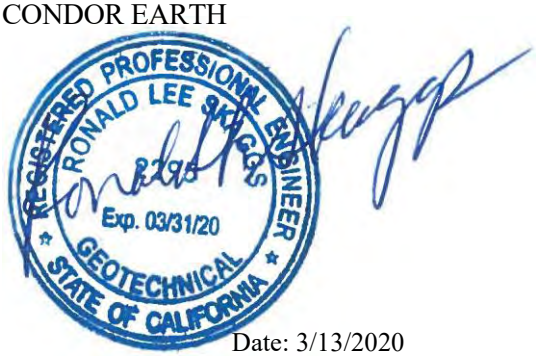
This report was prepared in accordance with the generally accepted standards of geotechnical engineering practice existing in Calaveras County at the time it was written. No other warranty, expressed or implied, is made. It is the owner's responsibility to see that all parties to the project, including the designer, contractors, subcontractors, etc., are made aware of this report in its entirety.

The analyses and recommendations submitted herein are based upon the data obtained during our test pit investigation as shown on Figure 2. Subsurface exploration of any site is necessarily confined to selected locations and conditions may, and often do, vary between and around these locations. Should varied conditions come to light during construction on the project site, additional exploration, testing, or analysis may be required. Any person concerned with this project who observes conditions or features of the site or its surrounding areas that are different from those described in this report, should report them immediately to Condor for evaluation.

It should be noted that changes in the standards of practice in the field of geotechnical engineering, changes in site conditions (such as new excavations or fills), new agency regulations, or modifications to the proposed project are grounds for this report to be professionally reviewed. In light of this, there is a practical limit to the usefulness of this report without critical professional review. It is suggested that 2 years be considered a reasonable time for the usefulness of this report.

We trust this report provides the information required at this time. Please call with any questions.

Respectfully submitted,
CONDOR EARTH



Date: 3/13/2020

Ronald L. Skaggs, GE No. 2295
Vice President, Engineering Services

Chad Borean
Staff Geologist

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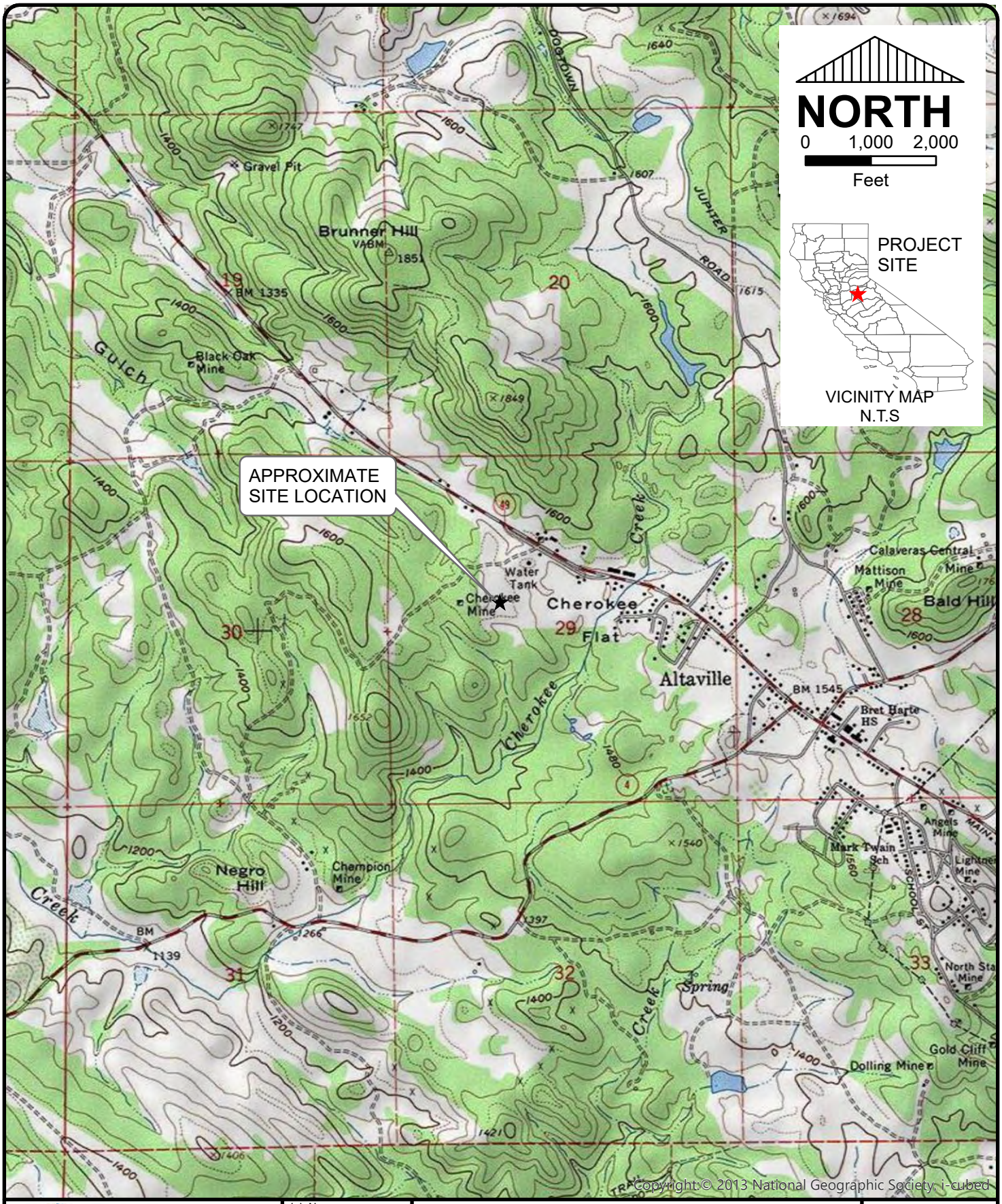
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APPENDIX A
Figures



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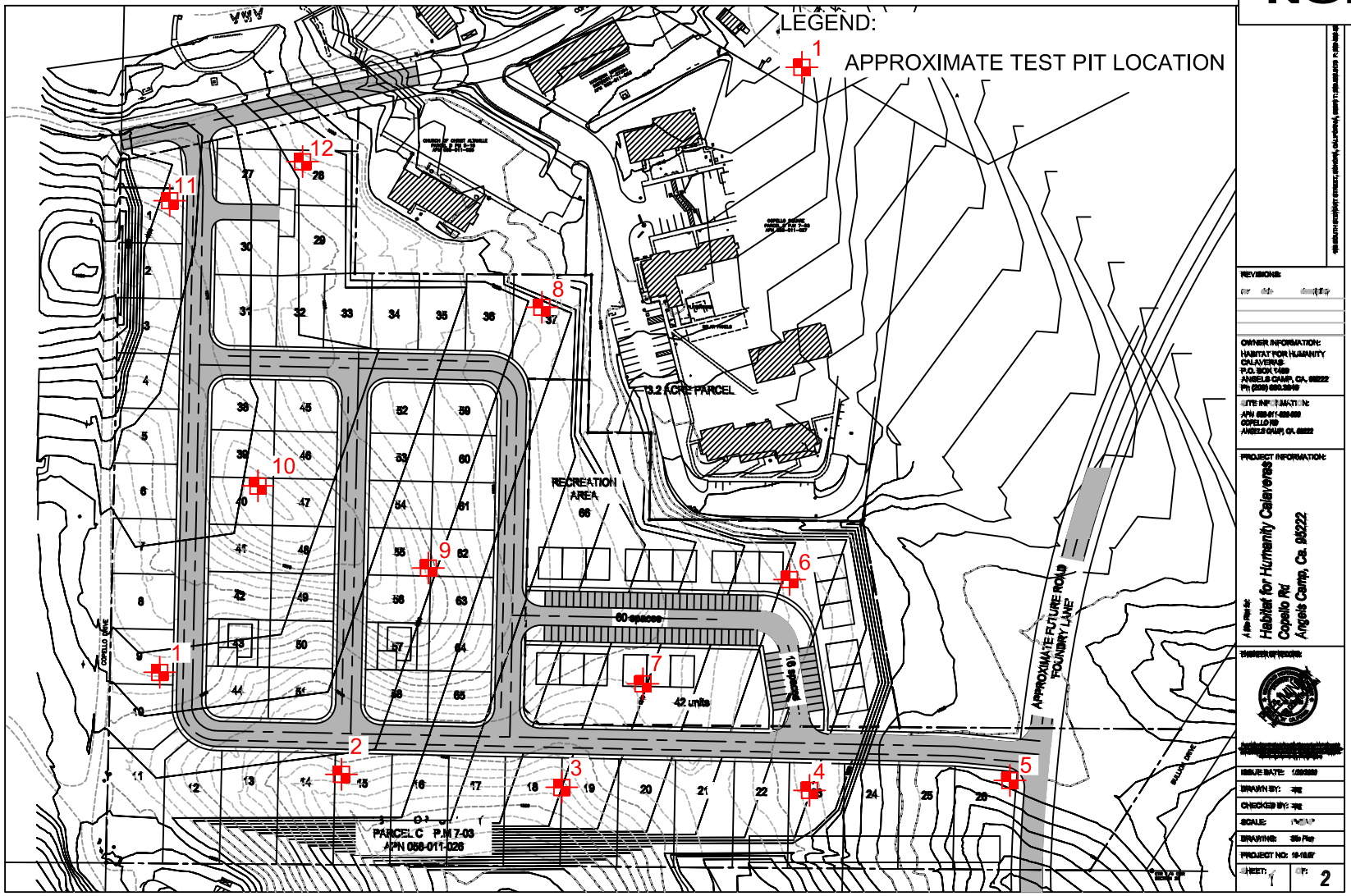
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VICINITY MAP
HABITAT FOR HUMANITY
COPELLO DRIVE SUBDIVISION
ANGELS CAMP, CALIFORNIA

FIGURE 1

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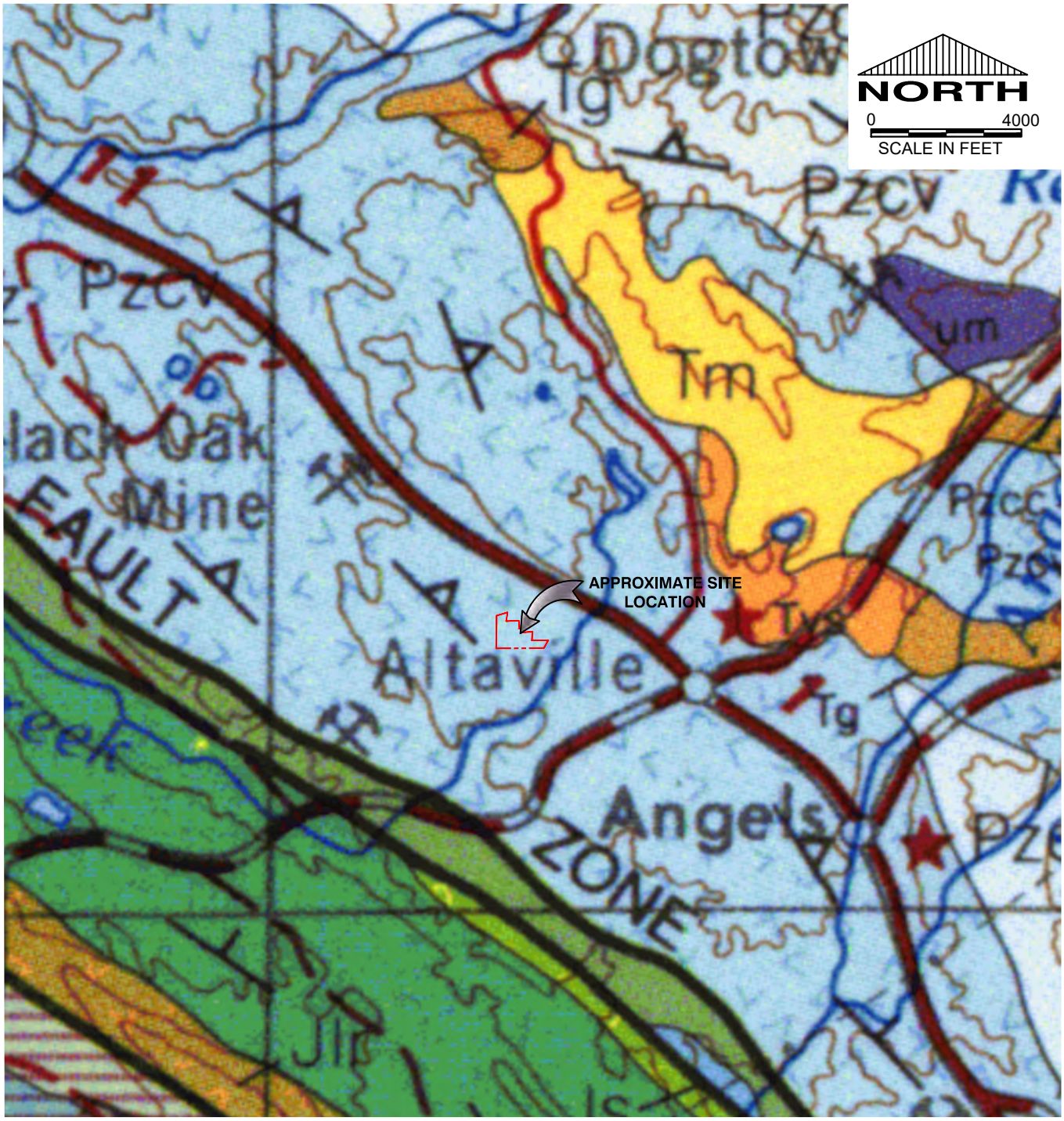
FIGURE 2

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Job No.	
8199	
Date	
03 MAR 2020	
Scale	
N.T.S.	
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JW	CB

SITE MAP WITH TEST PIT LOCATIONS
HABITAT FOR HUMANITY
COPELLO DRIVE SUBDIVISION
ANGELS CAMP, CALIFORNIA

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LEGEND:

Pzcv — Calaveras Complex volcanic rocks

SOURCE: *Wagner, D.L., et al, 1981, Geologic Map of the Sacramento Quadrangle, California, Map No. 1A, Scale 1:250000.*

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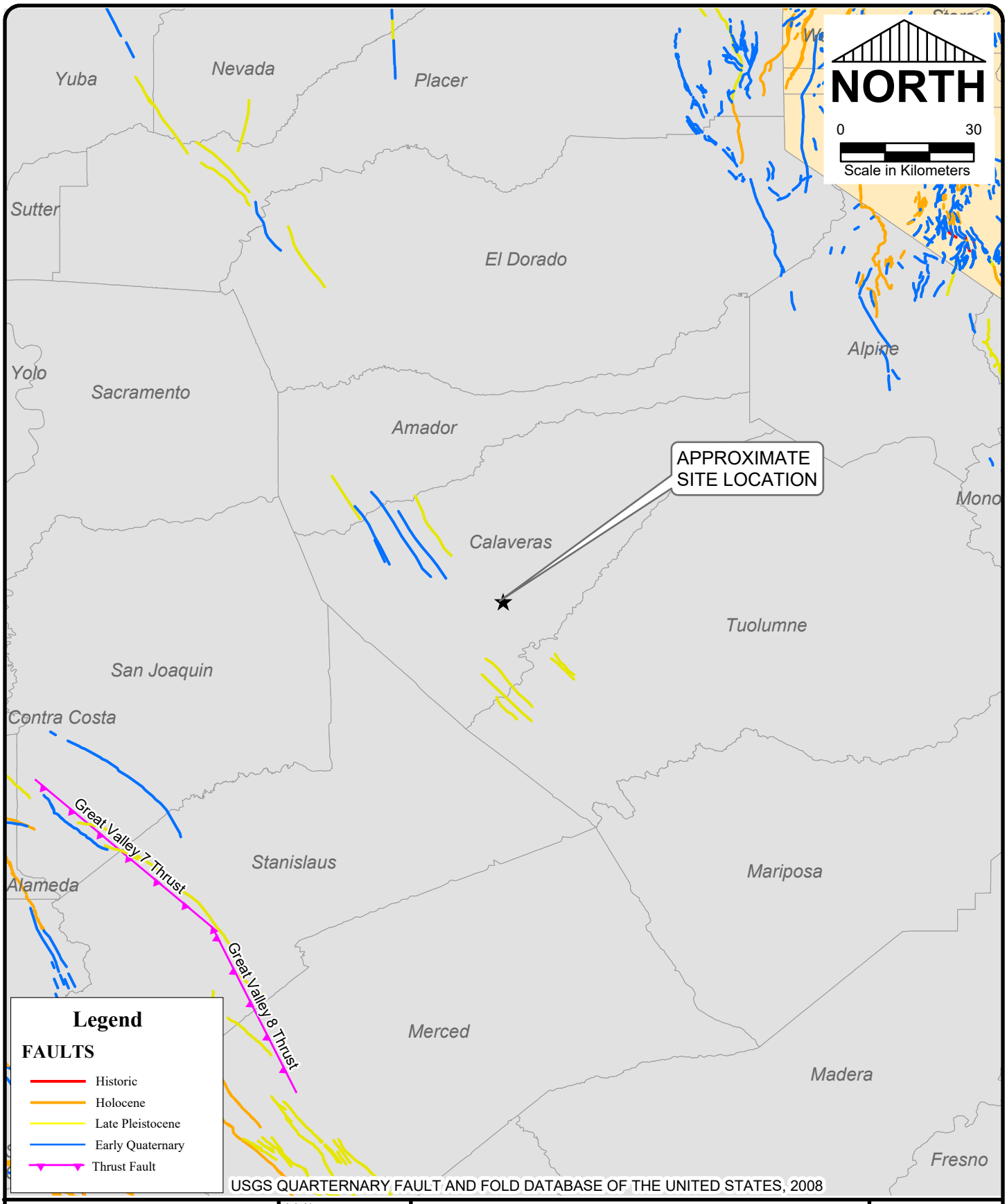
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GEOLOGIC MAP
HABITAT FOR HUMANITY
COPELLO DRIVE SUBDIVISION
ANGELS CAMP, CALIFORNIA

FIGURE 3

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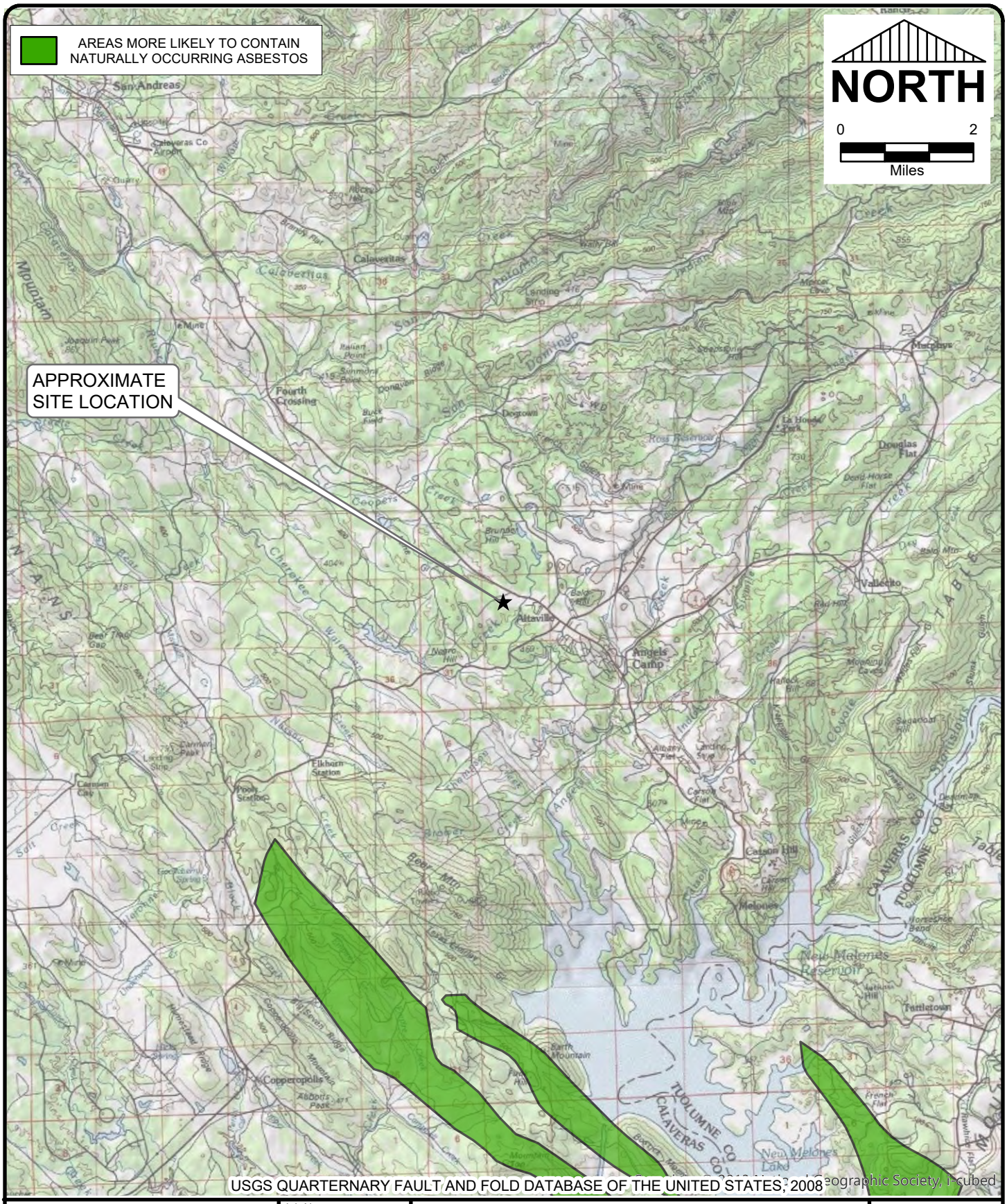
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Date	13 Feb 2020
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REGIONAL FAULT MAP
HABITAT FOR HUMANITY
COPELLO DRIVE SUBDIVISION
ANGELS CAMP, CALIFORNIA

FIGURE
4

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ULTRAMAFIC ROCK MAP
HABITAT FOR HUMANITY
COPELLO DRIVE SUBDIVISION
ANGELS CAMP, CALIFORNIA

FIGURE
5

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APPENDIX B
Test Pit Logs

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• **Engineering** • **Geotechnical** • **Environmental** • **Mapping** •

TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lots 40 – 47
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 1
Total Depth: 7.0'
Date Excavated: 2/3/2020
Elevation: 1,554'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 1.5'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, soft, moist.
1.5' – 7. 0'	RX	Metamorphic bedrock encountered at 1.5', light yellowish brown, highly to moderately weathered, friable to weak, laminated, moist. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 7.0'.

No groundwater encountered; ground surface gently slopes south; test pit oriented northeast-southwest; and test pit backfilled with cuttings and loosely compacted.

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TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lot 14
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 2
Total Depth: 7.0'
Date Excavated: 2/3/2020
Elevation: 1,526'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 2.0'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, soft, moist.
2.0' – 7.0'	RX	Metamorphic bedrock at 2.0', light reddish brown, highly weathered, friable, laminated, moist. At 3.0' becoming light reddish yellow. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 7.0'.

No groundwater encountered; ground surface gently slopes southeast; test pit oriented north-south; and test pit backfilled with cuttings and loosely compacted.

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TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lot 19
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 3
Total Depth: 7.0'
Date Excavated: 2/3/2020
Elevation: 1,522'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 3.0'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, moist, soft becoming firm to stiff with depth PI = 10, 50% Passing No. 200.
3.0' – 5.5'	RX	Metamorphic bedrock at 3.0', yellowish red, highly weathered, friable, laminated, moist. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 5.5'.

No groundwater encountered; ground surface gently slopes southwest; test pit oriented northwest-southeast; liner sample collected at 1.5' below grade; and test pit backfilled with cuttings and loosely compacted.

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TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lot 23
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 4
Total Depth: 4.0'
Date Excavated: 2/3/2020
Elevation: 1,528'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 1.5'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, moist, soft.
1.5' – 4.0'	RX	Metamorphic bedrock at 1.5', pale brown, highly weathered, moderately strong, moderately fractured. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 4.0'.

No groundwater encountered; ground surface gently slopes east; test pit oriented northwest-southeast; and test pit backfilled with cuttings and loosely compacted.

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TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Intersection at Lot 26
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 5
Total Depth: 6.0'
Date Excavated: 2/3/2020
Elevation: 1,516'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 1.5'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, reddish brown, moist, soft.
1.5' – 6.0'	RX	Metamorphic bedrock at 1.5', pale brown, highly weathered, friable, laminated, moist. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 6.0'.

No groundwater encountered; relatively flat ground surface; test pit oriented east-west; bulk sample collected from 0'-1' below grade; and test pit backfilled with cuttings and loosely compacted.

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• **Engineering** • **Geotechnical** • **Environmental** • **Mapping** •

TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Apartments Northeast
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 6
Total Depth: 9.0'
Date Excavated: 2/3/2020
Elevation: 1,530'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 3.5'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, reddish brown, moist, soft becoming firm to stiff with depth.
3.5' – 9.0'	RX	Metamorphic bedrock at 3.5', yellowish red, highly weathered, friable, laminated, moist. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 9.0'.

No groundwater encountered; ground surface gently slopes east; test pit oriented northwest-southeast; liner sample collected at 2.0' below grade; and test pit backfilled with cuttings and loosely compacted.

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TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Apartments Parking
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 7
Total Depth: 6.0'
Date Excavated: 2/3/2020
Elevation: 1,540'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 2.0'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, moist, soft.
2.5' – 6.0'	RX	Metamorphic bedrock at 2.5', yellowish red, highly weathered, friable, laminated, moist. Excavates to Silty Sandy with Gravel and Cobbles.

Notes: Refusal at 6.0'.

No groundwater encountered; ground surface gently slopes east; test pit oriented east-west; bulk sample collected from 2'-6' below grade; and test pit backfilled with cuttings and loosely compacted.

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• **Engineering** • **Geotechnical** • **Environmental** • **Mapping** •

TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lot 37
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 8
Total Depth: 4.5'
Date Excavated: 2/3/2020
Elevation: 1,545'
Logged by: C. Borean

No Photo

LOG	USCS	DESCRIPTION
0 – 1.5'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, moist, soft.
1.5' – 4.5'	RX	Metamorphic bedrock at 1.5', reddish brown, highly weathered, friable, moist. At 4.0' becoming moderately weathered, strong. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 4.5'.

No groundwater encountered; ground surface gently slopes east; test pit oriented east-west; liner sample collected at 1' below grade; and test pit backfilled with cuttings and loosely compacted.

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● **Engineering** ● **Geotechnical** ● **Environmental** ● **Mapping** ●

TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lots 55 – 62
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 9
Total Depth: 10.0'
Date Excavated: 2/3/2020
Elevation: 1,566'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 1.5'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, soft, moist.
1.5' – 10.0'	RX	Metamorphic bedrock at 1.5', yellowish red, highly weathered, friable, laminated, moist. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 10.0'.

No groundwater encountered; ground surface moderately slopes east; test pit oriented east-west; bulk sample collected from 3'-6' below grade; and test pit backfilled with cuttings and loosely compacted.

CONDOR EARTH

21663 Brian Lane, PO Box 3905, Sonora, CA 95370 (209) 532-0361 FAX (209) 532-0773
188 Frank West Circle, Suite I, Stockton, CA 95206 (209) 234-0518 FAX (209) 234-0538
1739 Ashby Road, Suite B, Merced, CA 95347 (209) 388-9601 FAX (209) 388-1778

• **Engineering** • **Geotechnical** • **Environmental** • **Mapping** •

TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lots 40 – 47
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 10
Total Depth: 10.5'
Date Excavated: 2/3/2020
Elevation: 1,578'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 1.5'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, moist, soft.
1.5' – 10.5'	RX	Metamorphic bedrock at 1.5', reddish yellow, highly weathered, friable, laminated, moist. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 10.5'.

No groundwater encountered; relatively flat ground surface; test pit oriented northeast-southwest; bulk sample collected from 5'-8' below grade; and test pit backfilled with cuttings and loosely compacted.

CONDOR EARTH

21663 Brian Lane, PO Box 3905, Sonora, CA 95370 (209) 532-0361 FAX (209) 532-0773
188 Frank West Circle, Suite I, Stockton, CA 95206 (209) 234-0518 FAX (209) 234-0538
1739 Ashby Road, Suite B, Merced, CA 95347 (209) 388-9601 FAX (209) 388-1778

● **Engineering** ● **Geotechnical** ● **Environmental** ● **Mapping** ●

TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lot 1
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 11
Total Depth: 10.0'
Date Excavated: 2/3/2020
Elevation: 1,570'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 1.5'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, reddish brown, soft, moist.
1.5' – 10.0'	RX	Metamorphic bedrock at 1.5', yellowish red, highly weathered, friable, laminated, moist. Excavates to Silty Sand with Gravel and Cobbles.

Notes: Refusal at 10.0'.

No groundwater encountered; ground surface gently slopes northeast; test pit oriented northwest-southeast; bulk sample collected from 5'-8' below grade; and test pit backfilled with cuttings and loosely compacted.

CONDOR EARTH

21663 Brian Lane, PO Box 3905, Sonora, CA 95370 (209) 532-0361 FAX (209) 532-0773
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1739 Ashby Road, Suite B, Merced, CA 95347 (209) 388-9601 FAX (209) 388-1778

• **Engineering** • **Geotechnical** • **Environmental** • **Mapping** •

TEST PIT LOG

Project No: 8199
Client: Habitat for Humanity Calaveras
Project Location: Copello Drive, Angels Camp, California
Test Pit Location: Lot 28
Equipment: CAT 420D Backhoe w/ 18" Bucket

Test Pit No: TP – 12
Total Depth: 5.5'
Date Excavated: 2/3/2020
Elevation: 1,556'
Logged by: C. Borean



LOG	USCS	DESCRIPTION
0 – 2.0'	CL/SC	RESIDUAL SOIL: Sandy Lean Clay to Clayey Sand, dark reddish brown, soft, moist.
2.0' – 5.5'	RX	Metamorphic bedrock at 2.0', yellowish red, highly weathered, friable, moist. At 5' becoming very strong. Excavates to Silty Sand with Gravel and Cobbles

Notes: Refusal at 5.5'.

No groundwater encountered; ground surface gently slopes northeast; test pit oriented northwest-southeast; and test pit backfilled with cuttings and loosely compacted.

APPENDIX C
Laboratory Test Results

California State Certified Laboratory No. 2153

CERCO analytical
1100 Willow Pass Court, Suite A
Concord, CA 94520-1006
925 462 2771 Fax: 925 462 2775
www.cercoanalytical.com

28 February, 2020

Job No. 2002168
Cust. No. 12016

Mr. Eric Carrasco
Condor Earth Technologies, Inc.
P.O. Box 3905
Sonora, CA 95370

Subject: Project No.: 8199
Project Name: Angels Camp-Copello Drive Subd.
Corrosivity Analysis – ASTM Test Methods

Dear Mr. Carrasco:

Pursuant to your request, CERCO Analytical has analyzed the soil sample submitted on February 24, 2020. Based on the analytical results, this brief corrosivity evaluation is enclosed for your consideration.

Based upon the resistivity measurement, the sample is classified as "mildly corrosive". All buried iron, steel, cast iron, ductile iron, galvanized steel and dielectric coated steel or iron should be properly protected against corrosion depending upon the critical nature of the structure. All buried metallic pressure piping such as ductile iron firewater pipelines should be protected against corrosion.

The chloride ion concentration was none detected at detection limit of 15 mg/kg.

The sulfate ion concentration was none detected at a detection limit of 15 mg/kg.

The pH of the soil was 6.55 which does not present corrosion problems for buried iron, steel, mortar-coated steel and reinforced concrete structures.

The redox potential was 400-mV and is indicative of potentially "slightly corrosive" resulting from anaerobic soil conditions.

This corrosivity evaluation is based on general corrosion engineering standards and is non-specific in nature. For specific long-term corrosion control design recommendations or consultation, please call *JDH Corrosion Consultants, Inc. at (925) 927-6630.*

We appreciate the opportunity of working with you on this project. If you have any questions, or if you require further information, please do not hesitate to contact us.

Very truly yours,
CERCO ANALYTICAL, INC.

J. Darby Howard, Jr., P.E.
President

JDH/jdl
Enclosure

California State Certified Laboratory No. 2153

CERCO analytical
1100 Willow Pass Court, Suite A
Concord, CA 94520-1006
925 **462 2771** Fax. 925 **462 2775**
www.cercoanalytical.com

Client: Condor Earth Technologies, Inc.
Client's Project No.: 8199
Client's Project Name: Angels Camp-Copello Drive Subd.
Date Sampled: 19-Feb-20
Date Received: 24-Feb-20
Matrix: Soil
Authorization: Signed Chain of Custody

Date of Report: 28-Feb-2020

Job/Sample No.	Sample I.D.	Redox (mV)	pH	Conductivity (umhos/cm)*	Resistivity (100% Saturation) (ohms-cm)	Sulfide (mg/kg)*	Chloride (mg/kg)*	Sulfate (mg/kg)*
2002168-001	Composite of TP-7 @ 4-6', TP-9 @ 3-6' & TP-10 @ 5-8'	400	6.55	-	8,300	-	N.D.	N.D.

Method:	ASTM D1498	ASTM D4972	ASTM D1125M	ASTM G57	ASTM D4658M	ASTM D4327	ASTM D4327
Reporting Limit:	-	-	10	-	50	15	15
Date Analyzed:	27-Feb-2020	27-Feb-2020	-	26-Feb-2020	-	27-Feb-2020	27-Feb-2020

Cheryl McMillen
Laboratory Director

* Results Reported on "As Received" Basis
N.D. - None Detected

Quality Control Summary - All laboratory quality control parameters were found to be within established limits

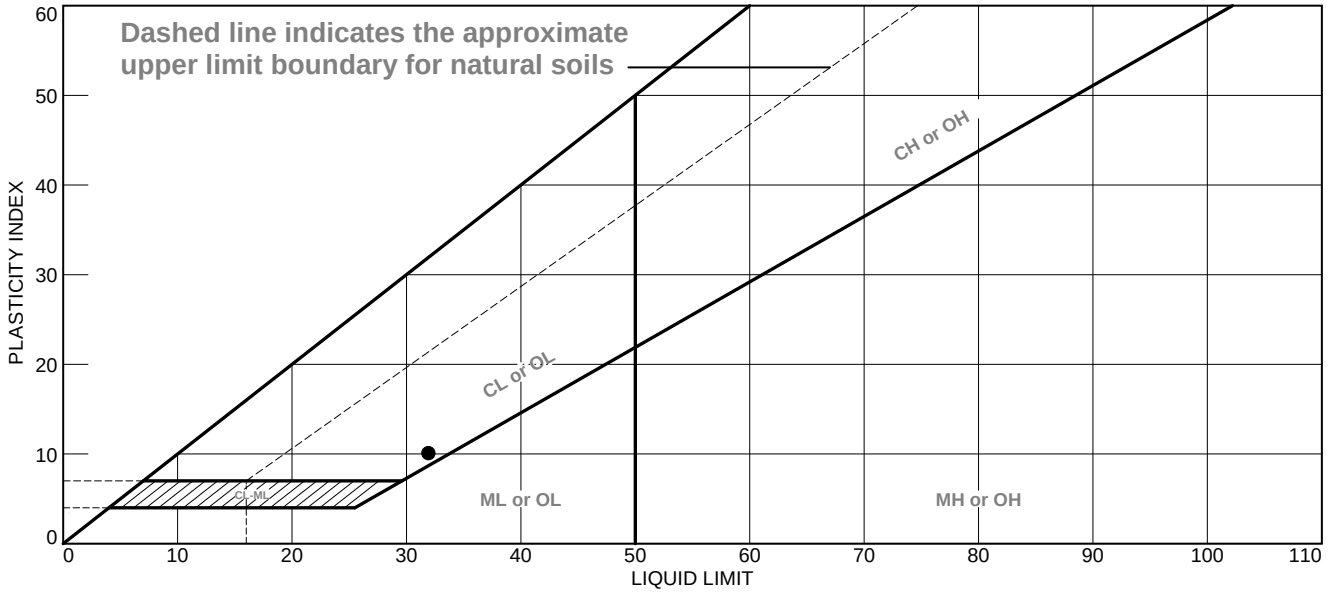
CONDOR EARTH
188 Frank West Circle, Suite I
Stockton CA 95206
Phone 209.234.0518
FAX 209.234.0538
www.condorearth.com

Project #: 8199
Client: Habitat for Humanity Calaveras
Project: Copello Drive Subdivision
Test Date: 2/22/2020
Tested by: E. Carrasco

Natural Dry Density/Unit Weight								
Sample #	TP-3	TP-6	TP-7	TP-8				
Date	2/22/2020	2/22/2020	2/22/2020	2/22/2020				
Depth (ft)	1.5'	2.0'	1.0'	1.0'				
Sleeve Diam. (in)	2.45	2.45	2.45	2.45				
Sleeve Area (sq in)	4.7	4.7	4.7	4.7				
Sample Length (in)	5.8	6.0	5.8	5.8				
Volume (cu.in)	27.3	28.2	27.3	27.3				
Volume(cu ft)	0.016	0.016	0.016	0.016				
Gross wt (grms)	1173.7	893.7	1133.0	1120.6				
Tare wt (grms)	320.9		316.8	316.0				
Soil wt (grms)	852.8	893.7	816.2	804.6				
Soil wt (lbs)	1.9	2.0	1.8	1.8				
Wet density (pcf)	119.2	120.7	114.1	112.4				
Dry Density(pcf)	101.7	100.4	95.8	94.5				

Moisture Content								
Tare #	J		C	F				
Wet wt & Tare (grms)	1173.7	728.0	1133.0	1120.6				
Dry wt & Tare (grms)	1048.4	660.3	1002.2	992.3				
Wt of Water (grms)	125.3	67.7	130.8	128.3				
Wt of Tare (grms)	320.9	326.1	316.8	316.0				
Wt dry Soil (grms)	727.5	334.2	685.4	676.3				
Moisture Content %	17.2	20.3	19.1	19.0				

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Red Sandy Lean Clay	32	22	10	66.5	50.2	CL

Project No. 8199 **Client:** Habitat for Humanity Calaveras

Project: Copello Drive Subdivision

Location: TP-3
Sample Number: PI-1 (TP-3) **Depth:** 1.5'

Remarks:

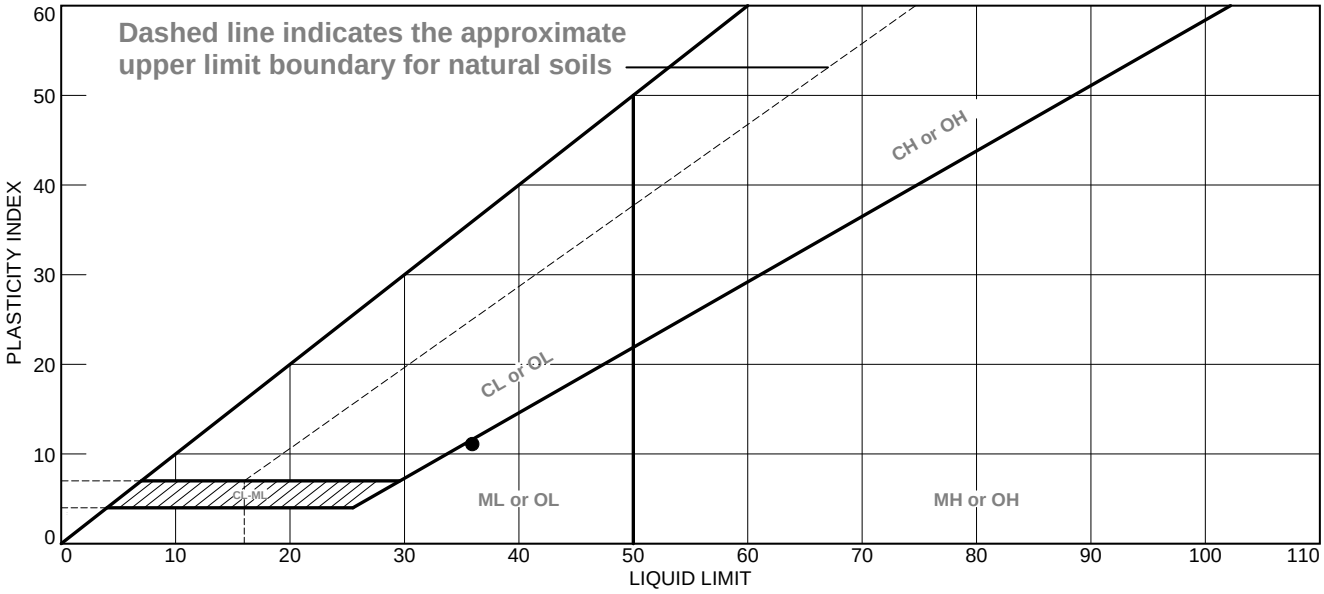
CONDOR EARTH TECHNOLOGIES INC.

Stockton, California

Figure

Tested By: E. Carrasco **Checked By:** R. Skaggs

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Light Brown Silty Sand with Gravel	36	25	11	37.5	24.6	SM

Project No. 8199 **Client:** Habitat for Humanity Calaveras

Project: Copello Drive Subdivision

Location: TP-7, TP-9, TP-10
Sample Number: PI-2 **Depth:** 3'-8'

Remarks:

CONDOR EARTH TECHNOLOGIES INC.

Stockton, California

Figure

Tested By: E. Carrasco **Checked By:** R. Skaggs

CONDOR EARTH TECHNOLOGIES, INC.
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17857 High School Road, Jamestown, CA 95327 (209) 984-4593/4596(f)
www.condorearth.com

Resistance "R" Value Test Report (California Test 301)

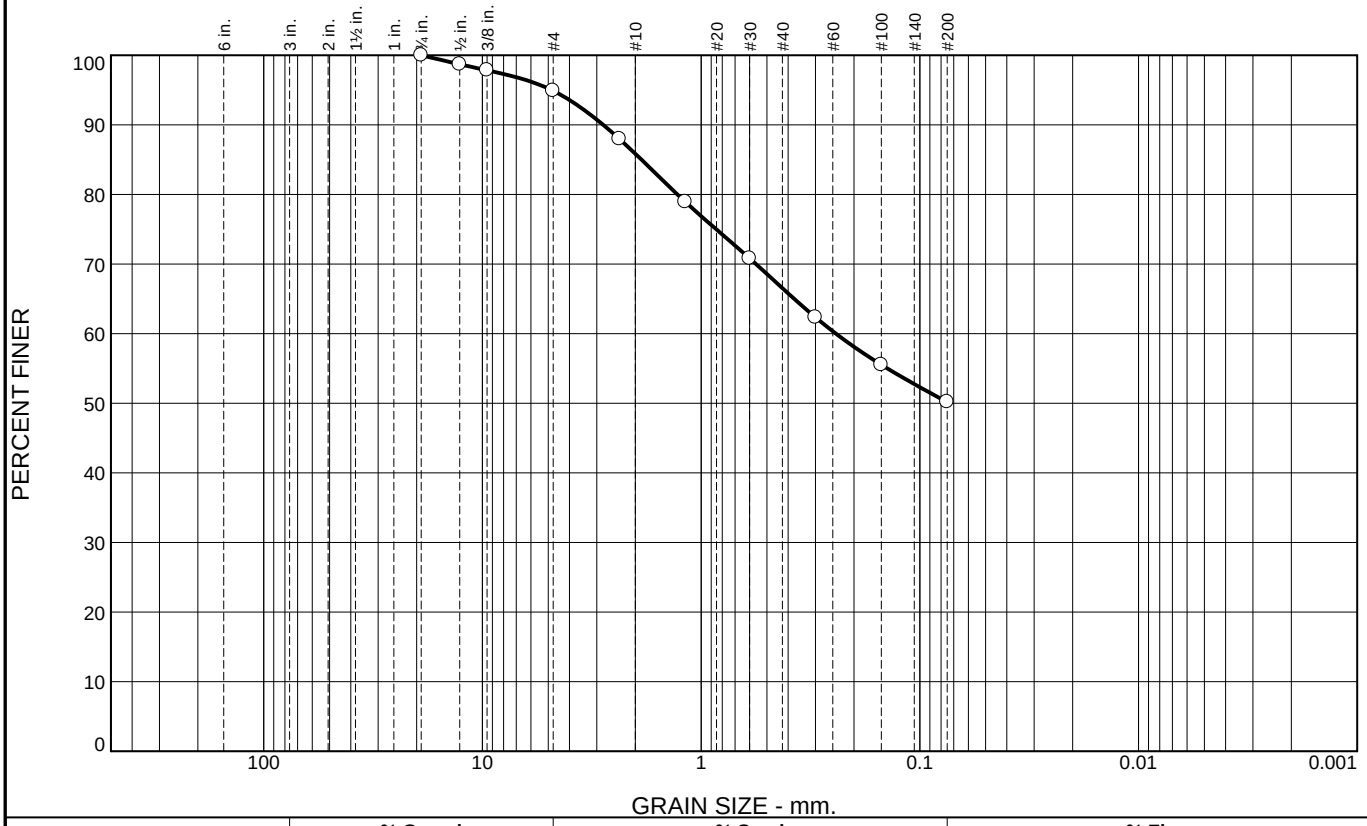
CET Job: 8199

Client: **Habitat for Humanity Calaveras**
Project: **Copello Drive Subdivision**

Sample ID : **RV-1**
Soil Description: **Light Brown Silty Sand with Gravel**
Date Received: **February 20, 2020**
Tested by: **E.Carrasco**
Sample Source: **TP-7, TP-9 and TP-10**
Depth of Sample: **3'-8'**

Specimen Number	1	2	3	4
Exudation Pressure (psi)	346.4	493.1	168.1	-
Expansion Pressure (psf)	47.6	90.9		-
Resistance Value, "R"	28.0	35.0	13.0	-
Moisture Content at Test (%)	15.3	14.3	17.4	-
Dry Density at Test (pcf)	115.9	113.2	112.8	-
Initial Moisture Content (%)	12.8			
R-Value by Exudation Pressure =	**25.0**			
R-Value by Expansion Pressure =	**21.9**	Assumed/Given TI = 4.0		
R-Value Design =	**22.0**			

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.1	9.0	19.4	16.3	50.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	98.7		
3/8"	97.8		
#4	94.9		
#8	88.0		
#16	78.9		
#30	70.8		
#50	62.3		
#100	55.5		
#200	50.2		

* (no specification provided)

Material Description

Red Sandy Lean Clay

Atterberg Limits

PL= 22 LL= 32 PI= 10

Coefficients

D_{90}= 2.8023 D_{85}= 1.8738 D_{60}= 0.2417
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-4(2)

Remarks

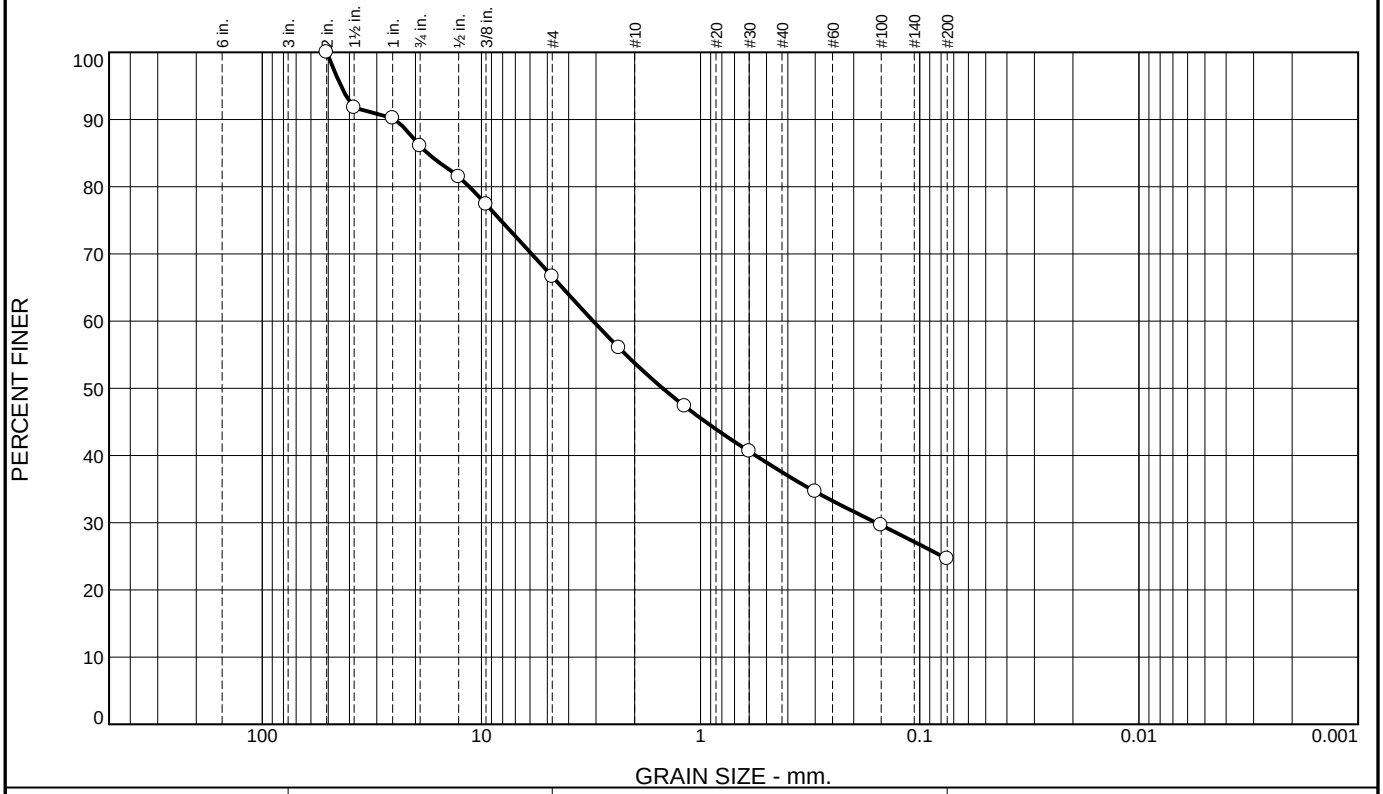
F.M.=1.52

Location: TP-3
Sample Number: SA-1 (TP-3) **Depth:** 1.5' **Date:** 2/28/2020

CONDOR EARTH TECHNOLOGIES, INC.
Stockton, California

Client: Habitat for Humanity Calaveras
Project: Copello Drive Subdivision
Project No: 8199 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	13.9	19.5	12.8	16.3	12.9	24.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2	100.0		
1-1/2"	91.8		
1"	90.2		
3/4"	86.1		
1/2"	81.5		
3/8"	77.4		
#4	66.6		
#8	56.0		
#16	47.3		
#30	40.6		
#50	34.6		
#100	29.6		
#200	24.6		

* (no specification provided)

Material Description

Light Brown Silty Sand with Gravel

Atterberg Limits

PL= 25 LL= 36 PI= 11

Coefficients

D_{90}= 24.8030 D_{85}= 17.6360 D_{60}= 3.0912
D_{50}= 1.4885 D_{30}= 0.1580 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-2-6(0)

Remarks

F.M.=3.70

Location: TP-7, TP-9, TP-10
Sample Number: SA-2 **Depth:** 3'-8' **Date:** 2/28/2020

CONDOR EARTH TECHNOLOGIES, INC.
Stockton, California

Client: Habitat for Humanity Calaveras
Project: Copello Drive Subdivision
Project No: 8199 **Figure**

Tested By: E. Carrasco **Checked By:** R. Skaggs

APPENDIX D
USGS Seismic Design Parameters

Habitat For Humanity

Latitude, Longitude: 38.0849, -120.5719



Date	3/12/2020, 10:39:54 AM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	0.358	MCE_R ground motion. (for 0.2 second period)
S_1	0.187	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.542	Site-modified spectral acceleration value
S_{M1}	0.416	Site-modified spectral acceleration value
S_{DS}	0.361	Numeric seismic design value at 0.2 second SA
S_{D1}	0.277	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	D	Seismic design category
F_a	1.514	Site amplification factor at 0.2 second
F_v	2.227	Site amplification factor at 1.0 second
PGA	0.151	MCE_G peak ground acceleration
F_{PGA}	1.499	Site amplification factor at PGA
PGA_M	0.226	Site modified peak ground acceleration
T_L	12	Long-period transition period in seconds
SsRT	0.358	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	0.369	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.5	Factored deterministic acceleration value. (0.2 second)
S1RT	0.187	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.195	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.6	Factored deterministic acceleration value. (1.0 second)
PGAd	0.5	Factored deterministic acceleration value. (Peak Ground Acceleration)
C_{RS}	0.97	Mapped value of the risk coefficient at short periods
C_{R1}	0.958	Mapped value of the risk coefficient at a period of 1 s

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APPENDIX E
ASTM E1643-18a
ASTM E1745-17

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: E1643 – 18a

Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs[1]

This standard is issued under the fixed designation E1643; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers procedures for selecting, designing, installing, and inspecting flexible, prefabricated sheet membranes in contact with earth or granular fill used as vapor retarders under concrete slabs.

1.2 Conditions subject to frost and either heave or hydrostatic pressure, or both, are beyond the scope of this practice. Vapor retarders are not intended to provide a waterproofing function.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1745 Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

E1993/E1993M Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs

F710 Practice for Preparing Concrete Floors to Receive Resilient Flooring

2.2 *Other Standard:*[3]

ACI 302.2R–06 Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials

3. Significance and Use

3.1 Vapor retarders provide a method of limiting water vapor transmission and capillary transport of water upward through concrete slabs on grade, which can adversely affect floor finishes and interior humidity levels.

3.2 Adverse impacts include adhesion loss, warping, peeling, and unacceptable appearance of resilient flooring; deterioration of adhesives, ripping or separation of seams, and air bubbles or efflorescence beneath seamed, continuous flooring; damage to flat electrical cable systems, buckling of carpet and carpet tiles, offensive odors, growth of fungi, and undesired increases to interior humidity levels.

4. Manufacturer's Recommendations

4.1 Where inconsistencies occur between this practice and the manufacturer's instructions, conform to the manufacturer's instructions for installation of vapor retarder.

5. Material, Design, and Construction

5.1 See ACI 302.2R–06 for material, design, and construction recommendations.

5.2 See Specifications E1745 and E1993/E1993M for vapor retarder specifications.

5.3 *Vapor Retarder Material Selection*—The following criteria should be considered when selecting a vapor retarder material.

5.3.1 Local building code and regulatory requirements.

5.3.1.1 Comply with local building code and regulatory requirements as a minimum consideration.

[1] This practice is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.21 on Serviceability.

Current edition approved Feb. 15, 2018. Published February 2018. Originally approved in 1994. Last previous edition approved in 2018 as E1643-18. DOI: 10.1520/E1643-18A.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331-3439, http://www.concrete.org.

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5.3.2 The water-vapor permeance of the vapor retarder material.

5.3.2.1 The water vapor permeance of the vapor retarder material shall be at such a rate so that adverse impacts to floor finishes and coatings do not occur

5.3.2.2 Refer to X1.6 for discussion on water vapor transmission rate of vapor retarder.

5.3.2.3 The perm rating determined under these criteria shall supersede that in references 5.2 should this value be less than required under references in 5.2.

5.3.3 The types and amounts of deleterious compounds in the soil on the building site.

5.3.3.1 Review building site soil analyses for deleterious materials and compounds and select a vapor retarder material that will withstand exposure to such deleterious materials or compounds.

5.3.4 The tensile strength and puncture resistance of the vapor retarder material.

5.3.4.1 Select a vapor retarder material capable of withstanding potential construction site damage.

5.3.5 The type of base material on which the vapor retarder is to be installed.

5.3.5.1 Select vapor retarder material capable of withstanding tear or puncture damage due to the type, gradation, and texture of the base material to be installed below the material. Prepare base material to minimize risk of puncture, for example, by rolling or compacting.

5.3.6 The expected exposure of the vapor retarder to ultraviolet rays.

5.3.6.1 Assess expected exposure of the vapor retarder material to ultra violet rays and select a material capable of withstanding such exposure and maintain its capability to perform its intended function.

6. Placement

6.1 Level and compact base material.

6.2 Install vapor retarder material with the longest dimension parallel with the direction of concrete pour.

6.3 Face laps away from the expected direction of the concrete pour whenever possible.

6.4 Extend vapor retarder over footings and seal to foundation wall, grade beam, or slab at an elevation consistent with the top of the slab or terminate at impediments such as water stops or dowels. Seal around penetrations such as utilities and columns in order to create a monolithic membrane between the surface of the slab and moisture sources below the slab as well as at the slab perimeter.

6.5 Lap joints minimum 6 in. (150 mm), or as instructed by the manufacturer, and seal laps in accordance with the manufacturer's recommendations.

6.6 Extend vapor retarder over the tops of pile caps and grade beams to a distance acceptable to the structural engineer and terminate as recommended by the manufacturer.

7. Protection

7.1 Take precautions to protect vapor retarder from damage during installation of reinforcing steel, utilities and concrete.

7.2 Use reinforcing bar supports with base sections that minimize the potential for puncture of the vapor retarder.

7.3 Avoid use of stakes driven through the vapor retarder.

7.4 Refer to ACI 302.2R–06 for discussion of aggregate for protection of vapor retarder, including the risks of installing aggregate fill above a vapor retarder that can act as a reservoir for water.

8. Inspection and Repair

8.1 Inspect and mark all areas of damage and insufficient installation of the vapor retarder sufficiently in advance of concrete placement such that deficiencies may be corrected before concrete is placed.

8.2 Repair damaged areas prior to concrete placement with vapor retarder material lapped and sealed minimum of 6 in. (150 mm) beyond damaged area or as instructed by manufacturer.

9. Keywords

9.1 concrete slabs; vapor; vapor retarder

APPENDIX

(Nonmandatory Information)

X1. PRE-DESIGN CONSIDERATIONS

X1.1 *Planning and Organization of Construction*—To avoid ambiguities, redundancies, conflicts, and omissions, plan the organization and coordination of drawings and specifications so that graphic, dimensional, and descriptive information on subgrade, granular base, vapor retarder, and protection course, if any, appears in only one place. Since the relationship of the subgrade (pad) elevation (usually shown on grading plans) to the rest of the building finish floor elevations and finished site grades is a function of the depth of the granular base and protection course, these dimensions should be shown in only one place. For graphic depictions and dimensions of the granular base and the protection course, the architectural drawings are preferred, but structural drawings are sometimes used. Specifications for sub-base conditions should be in the grading section. Specifications for base, vapor retarder, and protection course should be in the section on concrete, but there are advocates of a separate section in Division 7 for the vapor retarder system. Examination and testing of surface

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conditions should be in appropriate finish sections.

X1.2 *Scheduling*—Determine if slab drying will be on the critical path for schedule occupancy. If so, plan measures to reduce drying times, mitigate moisture, or select floor finish materials not subject to damage by moisture.

X1.3 *Geotechnical*—Ensure that the geotechnical survey includes comprehensive and reliable information on subsurface water table levels and the hydrology of geological strata as well as historical data on surface flooding and hydrology. The survey should also include a list of compounds and concentration levels that are deleterious to plastic materials. The geotechnical study should consider not only the past but also the projected change from ongoing or anticipated development patterns. Soils with comparably higher clay contents are particularly troublesome because the relatively high capillary action within the clay allows moisture to rise under the slab.

X1.4 *Civil*—Ensure that site topographic surveys and grading plans accurately and comprehensively establish surface drainage characteristics for the site and surrounding areas.

X1.5 *Landscape and Irrigation*—Most traditional geotechnical studies do not take into account the post-construction change in ground moisture conditions due to introduced planting and irrigation which is a major problem. For example, in California coastal areas, the average annual rainfall is about 18 in. (457 mm). Turf irrigation amounting to 1.3 in. (33 mm) of water per week over the normal seven-month dry season will increase this to nearly 60 in. (1524 mm) with almost no runoff. It is not enough to assume that irrigation will simply duplicate natural conditions encountered during the wet season. The landscape architect, geotechnical engineer, and civil engineer should closely coordinate design recommendations to avoid moisture problems introduced or exacerbated by landscape planting and irrigation. Once a project is completed, effective irrigation management is instrumental not only in water conservation but also in avoiding potential building-related moisture problems.

X1.6 *Water Vapor Permeance of Vapor Retarder*—In order to prevent moisture damage to the slab on grade, floor covering systems and floor coating systems the water vapor permeance of the vapor retarder material shall be such that accumulation of moisture in the slab through the vapor retarder material does not occur. The vapor pressures of the below grade environment and the interior environment shall be calculated and analyzed. For humidity sensitive interior environments, calculate the effect of vapor diffusion through the vapor retarder, slab on grade and, if applicable, the floor covering or coating on the interior humidity levels. Select a vapor retarder material with a water vapor permeance rating that will maintain interior humidity levels within specified tolerances. The water vapor permeance of flooring material or coating shall be obtained, if available. Calculate the amount of moisture entering the slab through the vapor retarder material. Calculate the amount of moisture that can diffuse through the flooring material. Insure that the water vapor permeance of the vapor retarder material does not allow accumulation of moisture within the slab due to water vapor permeance of the flooring material. Analyze soil temperatures with regard to heat flux through the slab on grade as well as interior temperature and RH levels. Determine if conditions exist for a dew point within the slab. If such conditions can potentially exist, analyze the amount of moisture accumulation within the slab versus the drying potential of the slab through its top surface, and if applicable, through the floor covering system to determine if prolonged and detrimental wetting of the slab will occur. If so, incorporate measures to eliminate conditions for a dew point to occur. One such measure is installing an insulation layer directly below the slab and vapor retarder.

X1.7 *Moisture Entrapment Due to Rainfall or Ground Water Intrusion*—Moisture entrapment can occur beneath slabs when the vapor retarder is placed below a fill course or vapor retarder protection layer, and the fill material takes on water from rainfall, saw-cutting, curing, cleaning or other sources. If a fill course or vapor retarder protection layer is used, the extent of moisture entrapment can be reduced by scheduling concrete placements before rainfall and by sealing any entry points for water in the completed slab. If a fill course or vapor retarder protection layer is used, the vapor retarder must be turned up at the perimeter of the slab to protect the fill course from lateral entrance of moisture.

X1.8 Ensure there is no water accumulation on top of the vapor retarder prior to placing of concrete.

X1.9 *Moisture Conditions of Slab*—Following placement of the concrete and acclimatization of the building, comply with Practice F710 and floor covering manufacturer's recommendations for any specified tests for moisture emissions from or moisture content of the slab on grade. Review written report(s) on test results prior to the installation of the floor covering or coating installation. Obtain written approval of acceptable slab conditions from the floor covering manufacturer and project design professional. See also ACI 302.2R–06.

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Designation: E1745 – 17

Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs[1]

This standard is issued under the fixed designation E1745; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers flexible, preformed sheet membrane materials to be used as vapor retarders in contact with soil or granular fill under concrete slabs.

1.1.1 This specification does not cover bituminous vapor retarders. See Specification E1993/E1993M for information on bituminous vapor retarders.

1.2 The specified tests are conducted on new materials and materials that have been conditioned or exposed to simulate potential service conditions.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C168 Terminology Relating to Thermal Insulation

D828 Test Method for Tensile Properties of Paper and Paperboard Using Constant-Rate-of-Elongation Apparatus

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

D1709 Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method

E96/E96M Test Methods for Water Vapor Transmission of Materials

E154/E154M Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

E631 Terminology of Building Constructions

E1643 Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs

E1993/E1993M Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs

F1249 Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, see Terminologies C168 and E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *perm, n*—the time rate of water vapor migration through a material or a construction of one grain per hour, square foot, inch of mercury pressure difference.

3.2.1.1 *Discussion*—If a specification states that a one perm limit is required, the same flow rate will be obtained from the following relationships:

1 perm = 1 grain/h · ft^2 in. · Hg (inch·pound)
= 57.2 10^{-12} kg/(Pa · s · m^2) (SI fundamental units)
= 57.2 ng/(Pa · s · m^2) (SI frequently used)
= 0.66 g/24 h · m^2 · mm Hg (SI has been used but is now obsolete)

3.2.2 *vapor retarder, n*—(formerly vapor barrier) a material or construction that impedes the transmission of water vapor under specified conditions.

3.2.3 *water vapor permeability, n*—a property of material which is water vapor permeance through unit thickness. Since materials that provide resistance to vapor flow are never used in unit thickness, the preferred evaluation of both materials and constructions is the permeance.

3.2.4 *water-vapor permeance, n*—the time rate of water vapor flow through unit area of the known thickness of a flat material or a construction normal to two specific parallel surfaces induced by unit vapor pressure difference between the two surfaces under specific temperature and humidity conditions. See *perm*.

[1] This specification is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.21 on Serviceability.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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4. Classification

4.1 Materials shall be specified to conform to one of these three classes: A, B, or C, or specific requirements shall be specified in one or more of the properties listed in Table 1.

5. Specifying Information

5.1 Specifications for materials shall include the following:

5.1.1 This specification number.

5.1.2 Class A, B, or C, or alternatively, specific performance requirements for each of the properties listed in Table 1.

5.1.3 Performance requirements, if any, for special conditions (see 7.4).

5.1.4 Execution or installation requirements with reference to Practice E1643.

6. Lap Sealing

6.1 The producer shall provide instructions for lap sealing, including minimum width of lap, method of sealing, and either supply or specify suitable products for lap sealing.

7. Properties

7.1 *Permeance*—Material shall conform to the requirements listed in Table 1 under the following conditions: when tested in accordance with Test Methods E154/E154M, Section 7 (based on Test Methods E96/E96M), or Test Method F1249, test temperature shall be 73.4 °F (23 °C) and test humidity shall be 50 ± 2 %.

7.1.1 *Permeance of New Material*—No conditioning.

7.1.2 *Permeance after Wetting, Drying, and Soaking*—Refer to Test Methods E154/E154M, Section 8.

7.1.3 *Permeance after Heat Conditioning*—Refer to Test Methods E154/E154M, Section 11.

7.1.4 *Permeance after Low Temperature Conditioning*—Refer to Test Methods E154/E154M, Section 12.

7.1.5 *Permeance after Soil Organism Exposure*—Refer to Test Methods E154/E154M, Section 13.

7.2 *Tensile Strength of New Material*—Refer to Test Methods E154/E154M, Section 9. (The apparatus shall be that described in either Test Methods D828 or D882.)

7.3 *Resistance to Puncture of New Material*—Refer to Test Methods D1709, Test Method B.

7.4 *Special Conditions*—When specifically required by the buyer, due to special conditions which dictate properties of fire resistivity, prolonged exposure to sunlight, or resistance to deterioration from hydrocarbons, the material shall conform to the following:

7.4.1 *Flame Spread*[3]—Refer to Test Methods E154/E154M, Section 16, as follows:

Class A	0–25
Class B	26–75
Class C	76–200

7.4.2 *Permeance after Soil Poison Petroleum Vehicle Exposure*—Refer to Test Methods E154/E154M, Section 14 (based on Test Methods E96/E96M), or Test Method F1249. Conform to permeance requirements in Table 1.

7.4.3 *Permeance after Exposure to Ultraviolet Light*—Refer to Test Methods E154/E154M, Section 15. Conform to permeance requirements in Table 1.

8. Sampling

8.1 For each complete set of tests, obtain all samples from a single production roll of material. Samples shall be representative of the material being sold to the end user.

9. Certification

9.1 When specified in the purchase order or contract, the purchaser shall be furnished with certification that samples representing each lot have been either tested or inspected as directed in this specification and that requirements have been met.

9.2 Upon the request of the purchaser in the contract or order, the certification of an independent third party (testing laboratory) indicating conformance to the requirements of this specification may be considered.

[3] The classes and values shown are distinct from the performance classes listed in Table 1.

TABLE 1 Properties for Specified Performance Classes[A]

	Class A		Class B		Class C	
	IP Units	SI Units	IP Units	SI Units	IP Units	SI Units
Water vapor permeance (Test Methods E154/E154M, Section 7, or Test Method F1249), max	0.1 perms (0.1 gr/[h·ft^2·in.·Hg])	(6 ng/[s·m^2·Pa])	0.1 perms (0.1 gr/[h·ft^2·in·Hg])	(6 ng/[s·m^2·Pa])	0.1 perms (0.1 gr/[h·ft^2·in.·Hg])	(6 ng/[s·m^2·Pa])
Tensile strength (Test Methods E154/E154M, Section 9),[B] min	45.0 lbf/in.	7.9 kN/m	30.0 lbf/in.	5.3 kN/m	13.6 lbf/in.	2.4 kN/m
Puncture resistance (Test Methods D1709, Test Method B), min	no inch-pound equivalent used	2200 g	no inch-pound equivalent used	1700 g	no inch-pound equivalent used	475 g

[A] Refer to Practice E1643 for assessing suitability of use based on reported perm rating of material.

[B] Tensile strength per unit width for the total sample thickness is used instead of tensile strength per unit area because vapor retarder materials are never used in unit thickness.

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9.3 When specified in the purchase order or contract, the producer or supplier shall furnish a summary of the test procedures listed in Table 1, providing for each test the laboratory that performed or witnessed the test, the date of the most recent test, and the test results.

9.4 When specified in the purchase order or contract, the producer or supplier shall furnish copies of the laboratory reports for each of the tests listed in Table 1.

10. Keywords

10.1 concrete; concrete slab; floor; plastic; vapor retarder

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