South Shore Testing & Environmental

23811 Washington Ave, Suite C110, #112, Murrieta, CA 92562 E-mail: ss.testing@aol.com
Phone: (951) 239-3008 FAX: (951) 239-3122

January 29, 2019

Mr. Steve Galvez
Tierra Nova Consulting, Inc.
31938 Temecula Parkway, Ste A369
Temecula, California 92592

SUBJECT: **REVISED PRELIMINARY GEOTECHNICAL INVESTIGATION**
Proposed Multi-Family Residential Development - MHS-98, LLC
APN Nos.: 913-210-005 to -007, -010 to -013, & -032 to -035
Northeast of Rising Hill Drive and Bahama Way
City of Murrieta, Riverside County, California
Work Order No. 3721801.00R (Revised)

Dear Mr. Galvez:

Pursuant to your authorization, a preliminary geotechnical evaluation was conducted on the subject site in accordance with the 2016 California Building Code, Section 1803.5.11. In accordance with the City of Murrieta "Review Comments", we have revised the referenced report (SS, 2018) to include proposed retaining walls. Attached as **Plate 1**, the **Geotechnical Map** is a reduced image of a 40-scale "Site Plan" indicating the approximate location of the proposed retaining walls, exploration trenches, and pertinent geotechnical information.

Scope of Work

The scope of work performed for this study included the following:

1. Onsite observation and documentation of existing site geometry with respect to the proposed site plan for the proposed multi-family residential development.

2. Advancement of seven (7) exploratory trenches to the total depth explored of 6.0-ft (T-6) below the ground surface (bgs) for sample recovery for laboratory testing and observation of subsurface conditions.

3. Engineering analysis of test results to develop specifications for grading and preliminary foundation design.

4. Research of Geologic literature to develop design specifications for hazards such as seismic shaking and related effects.

5. Preparation of report of findings, including conclusions and recommendations for grading and minimum foundation design.

Introduction

This investigation has been conducted resulting from a 2016 California Building Code Chapter 18 requirement for preliminary geotechnical investigation being conducted for all projects in Seismic Category D. This investigation will address geotechnical conditions existing on the site as they may pertain to the proposed multi-family residential development and associated mass graded pad. It is our understanding that the multi-family residences will be typical one, two, and three-story type V structures. Contained herein also are preliminary recommendations for foundation design for the proposed construction.

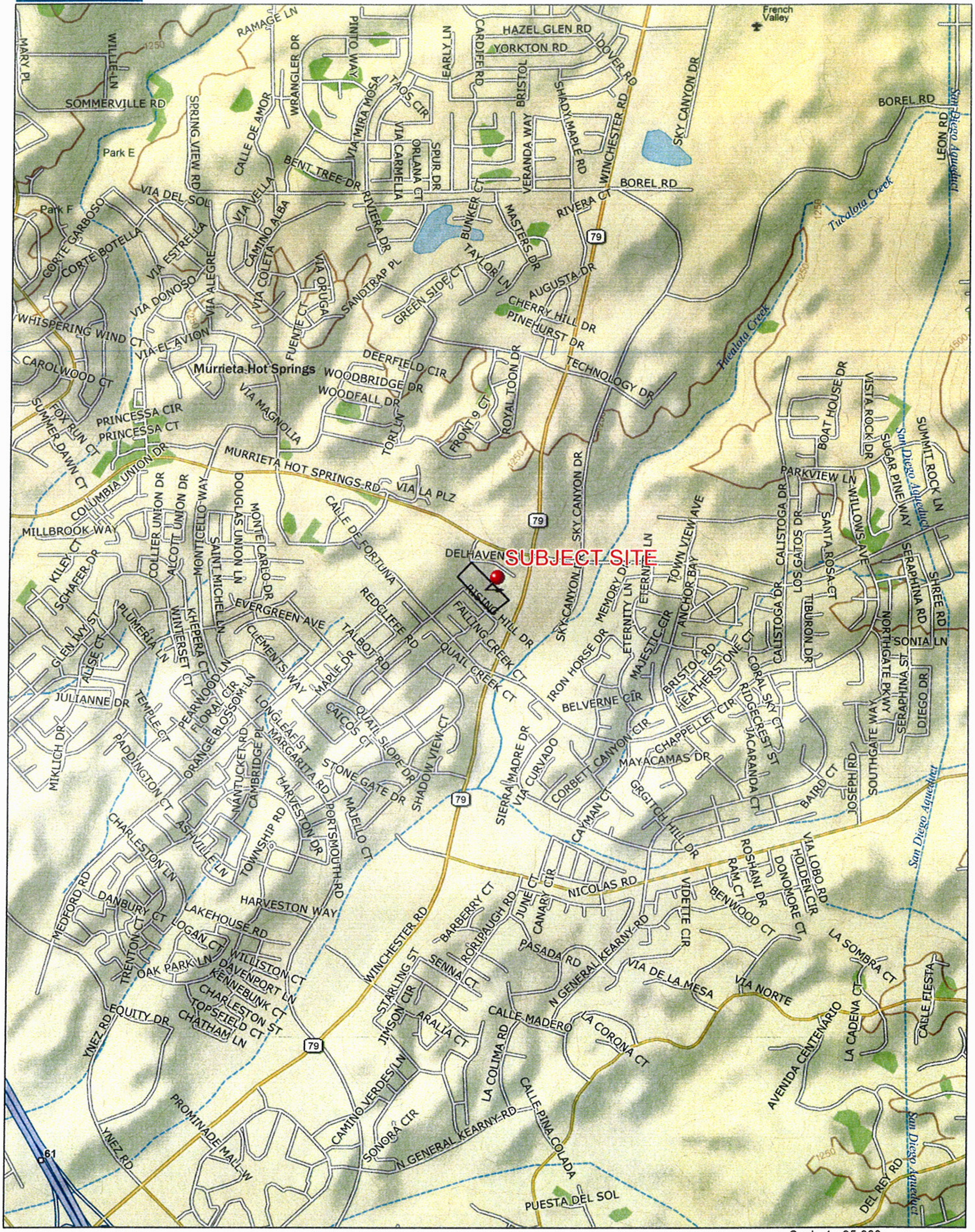
Site Description

The proposed apartments and associated driveways and parking areas will be located across the subject site. The subject site is located north-northwest of Rising Hill Drive in the City of Murrieta, Riverside County, California. The geographical relationships of the site and surrounding area are depicted on our Site Location Map, **Figure 1**.

At the time of our investigation, vegetation on the subject site consists of moderate low growth of chaparral type vegetation and a sparse dry growth of annual weeds and grasses. Man-made development at the subject site is generally limited to numerous undocumented soil stockpiles, several dirt access roads, and partial fencing along southeast portion of the site. Topographically, the subject site consists of low rolling terrain with natural gradients of approximately 8 to 20 percent to the north-northeast. Drainage is accomplished by sheetflow to the north-northeast toward Date Street. Overall relief on the subject site, in the vicinity of proposed development is approximately 50-ft, from above mean sea elevations 1,122 to 1,172.

Proposed Development

The proposed development consists of grading a mass graded flat pad to be used in the future for multi-family residential development across the subject site with access from both Date Street and Bahama Way. Both a "Mass Grading Plan" and "Site Plan" were available for our review, and we anticipate the quantities appear to be balanced. Please refer to **Plate 1**, **Geotechnical Map**, for proposed site geometry and location of the multi-family buildings including 8 apartment buildings, garages, parking and driveway areas, retaining walls, club house, pool-spa, and barbecue area, Topo North America™ 9



Data use subject to license.

TN

MN (11.6°E)

Scale 1 : 25,000

0 600 1200 1800 2400 3000 ft

0 200 400 600 800 1000 m

1" = 2,083.3 ft

FIGURE 1

Foundations are anticipated to consist of continuous spread and isolated column footings to carry structural loads, otherwise typical multi-family residential construction.

Field Work

Field work on the site consisted of review of available literature and observation and logging of seven (7) exploratory trenches advanced with a CAT No. 430 rubber-tired backhoe equipped with an 18-inch bucket. Representative bulk samples of earth materials were obtained for laboratory testing and observing the conditions of the soils on the site. Subsurface exploration of the subject site was performed on January 3, 2018 and the exploratory trench logs are presented in **Appendix B**. The approximate locations of our exploratory trenches are presented on our **Geotechnical Map**, **Plate 1**. Observation and sampling of the exploratory trenches were performed by our field personnel, who logged numerous undocumented fill stockpiles, undifferentiated alluvial/colluvial soils overlying medium dense to dense sedimentary bedrock of the late Pleistocene-age Pauba formation (Morton & Kennedy, 2005). This unit was exposed both at the ground surface and shallow depths and extended to the total depth explored of 6.0-ft bgs (T-1).

Laboratory Testing

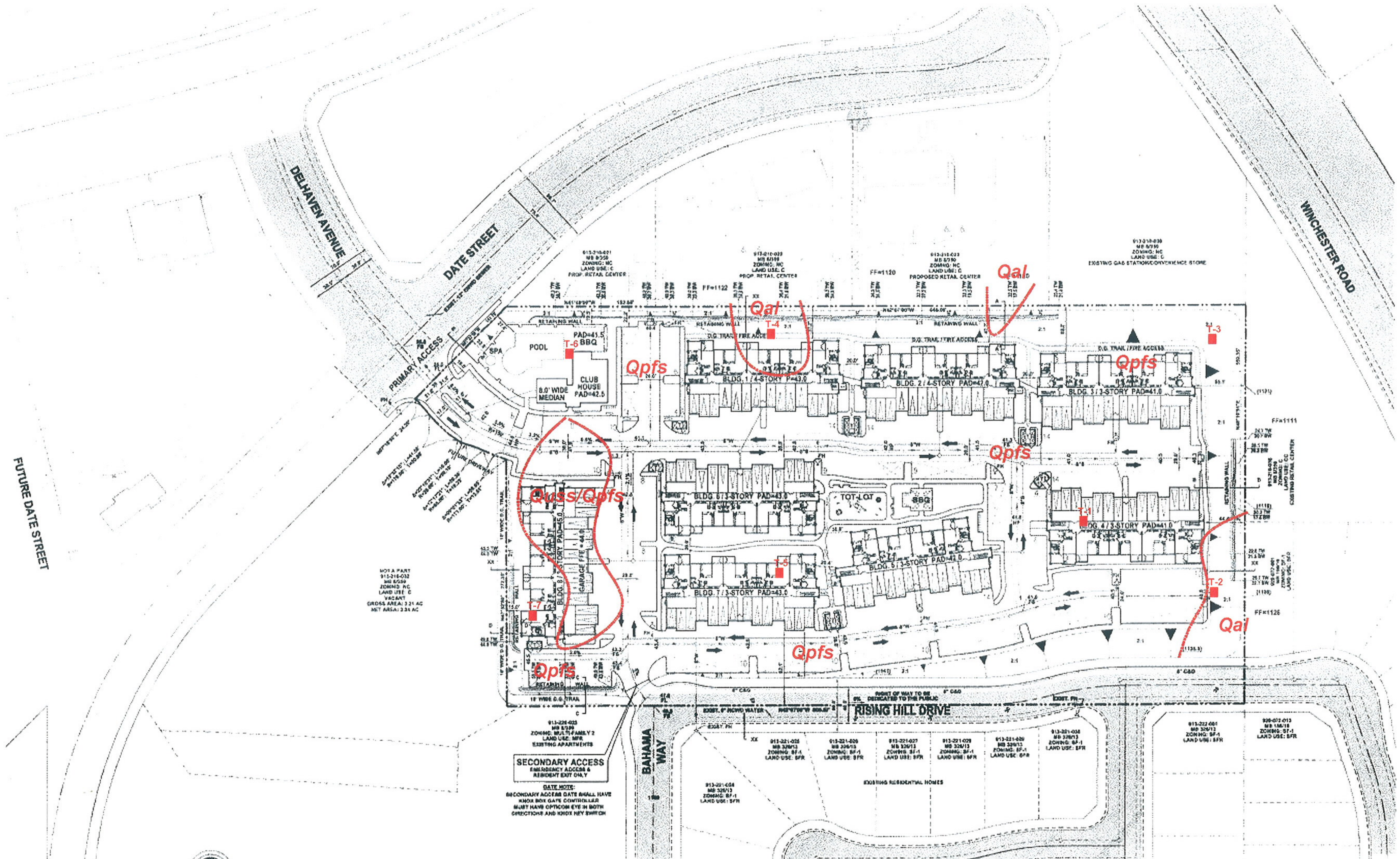
The results of laboratory testing are presented in **Appendix C**. It should be noted test results are preliminary and generally representative for the purposes of demonstrating feasibility of design for proposed construction. Addition testing recommended by this report may result in changes of minimum design requirements.

Subsurface Conditions

The USGS Preliminary Geologic Map of the Murrieta 7.5' Quadrangle (Kennedy & Morton, 2003) indicates the formational earth materials underlying the site to be late Pleistocene age sedimentary units (map symbol Qpfs). A brief description of the geologic units underlying the site that are considered pertinent to proposed development follows:

Undocumented Soil Stockpiles (Map Symbol – Quss)

Onsite undocumented soil stockpiles are generally limited to the westerly portion of the subject site. This unit, for the most part, consists of a dark brown sandy Silt (Unified Soil Classification – ML) that can be described as dry, sandy in part, loose to medium dense with minor construction debris and were generally to motorcycle jumps and track on westerly portion of the site.



NOTES

1. NO EXISTING STRUCTURES (BUILDINGS, WALLS, FENCES, GATES, ETC.) ON THE SUBJECT PROPERTY
2. NO KNOWN EXISTING SUB-SURFACE STRUCTURES ON THE SUBJECT PROPERTY
3. TOT LOT DRAINAGE SHALL BE CAPTURED AND DIRECTED THROUGH DRAIN PIPES TO THE WATER QUALITY SYSTEM DESCRIBED ON SHEET 1

GRAPHIC SCALE

(IN FEET)
1 inch = 40 ft.

SHEET NO. 2 OF 2

SOUTH SHORE TESTING & ENVIRONMENTAL

GEOTECHNICAL MAP

PROPOSED MULTI-FAMILY RESIDENTIAL DEVELOPMENT
APN NOS.: 913-210005 TO -007, -020 TO -003 TO -.035
NORTHEAST OF RISING HILL DR. AND BAHAMA WAY
CITY OF MURRIETA , RIVERSIDE COUNTY, CALIFORNIA

WORK ORDER: 3721801.00R DATE: JAN. 2019 PLATE: 1 OF 1

LEGEND

UNITS

Quss - UNDOCUMENTED SOIL STOCKPILES

Qal - UNDIFFERENTIATED ALLUVIAL/COLLUVIAL SOILS

Qpfs - SEDMENTARY BEDROCK UNITS OF THE PAUBA FORMATION

SYMBOLS

T-7 - APPROXIMATE LOCATION OF EXPLORATORY TRENCHES

- APPROXIMATE LOCATION OF UNIT CONTACTS

Undifferentiated Alluvial/Colluvial Soils (Map Symbol – Qal)

Undifferentiated alluvial/colluvial soils observed overlying the sedimentary bedrock units within the moderately incised drainage courses on the lower elevations of the subject site. This unit consisted of yellow brown silty Sand (SM) that can generally be described as fine to medium grained, moderately graded, dry and loose.

Sedimentary Bedrock (Map Symbol – Qpfs)

Late Pleistocene-age sedimentary bedrock units of the Pauba formation (Kennedy & Morton, 2003) underlie the subject site both at the ground surface and shallow depths throughout the subject site. This unit, for the most part, consisted of a silty Sand (SM) that can be described as dark brown, fine to medium grained, minor coarse, moderately sorted, medium dense to dense, and slightly moist. Detailed descriptions of the onsite units are presented on our exploratory trench logs included in **Appendix B**.

Groundwater

Groundwater was not encountered within our exploratory trenches, which were advanced to a maximum depth of 6.0-ft bgs on the lower elevations of the subject site. The subject site is located at the northerly end of the Santa Gertrudis Groundwater Unit (Rancho Water, 1984). Historic high groundwater in the vicinity of the subject site is anticipated to be at least 50-ft below the ground surface in the vicinity of the subject site (Rancho Water, 1984). Minor fluctuations can and will likely occur in moisture or free water content of the soil owing to rainfall and irrigation over time

Excavation Characteristics

We anticipate that the onsite undocumented soil stockpiles and undifferentiated alluvial/colluvial soils can be excavated with moderate ease to the proposed depths utilizing conventional grading equipment in proper working condition. We anticipate that the sedimentary bedrock can be excavated with moderate difficulty to the proposed depths utilizing conventional grading equipment in proper working condition.

Seismicity

There are no known active of potentially active faults transecting the site, and the site is not located within the presently defined boundaries of either an Alquist-Priolo Earthquake Fault Zone (Hart, 2000) or a County of Riverside fault hazard zone (County of Riverside GIS, 2018).

Active fault zones regional to the site include the Murrieta Hot Springs fault, the Elsinore fault (Glen Ivy segment), the San Jacinto fault (Anza segment), the Newport-Inglewood fault and the San Andreas fault, which are located 0.6-km north, 5.7-kilometers southwest, 30.0-km northeast, 50-km southwest, and 59-km northeast, respectively. The following table lists the known faults that would have the most significant impact on the site:

FAULT	MAXIMUM PROBABLE EARTHQUAKE (MOMENT MAGNITUDE)	SLIP RATE	FAULT TYPE
Elsinore (Glen Ivy Segment) (5.7-km SW)	6.8	5 mm/year	A
San Jacinto (Anza segment) (30.0-km NE)	6.6	12 mm/year	A
San Andreas (Southern Segment) (50.0-km NE)	7.2	25 mm/year	A

2016 California Building Code (CBC) -Seismic Parameters:

Based on the geologic setting and soil conditions encountered, the soils underlying the site are classified as "Site Class C, "Very Dense Soil and Soft Rock", according to the CBC. The seismic parameters according to the CBC are summarized in the USGS Design Maps Summary Report presented in **Appendix E**. The corresponding value for peak ground acceleration from the design response spectrum based on the 2016 CBC seismic parameters is 0.732g.

SEISMIC EFFECTS

Ground Accelerations

The most significant earthquake to affect the property is a 6.8 Richter magnitude earthquake on the Elsinore fault zone (Glen Ivy segment). Based on Section 1803.5.12 of the 2016 California Building Code, peak ground accelerations modified for site class effects (PGA_M) of approximately **0.732g** are possible for the design earthquake. The seismic parameters according to the CBC are summarized in the USGS Design Maps Summary Report presented in **Appendix E**.

Ground Cracks

The risk of surface rupture as a result of active faulting is considered negligible based on the absence of known active faulting on the site (Kennedy & Morton, 2003). Ground cracks can and do appear on sites for a variety of reasons including, but not limited to, strong seismic shaking, imperfections in subsurface strata (either man-made or natural), and the expansive nature of some soils near the ground surface. Therefore, the possibility of minor cracks at the ground surface for the life of the project cannot be fully eliminated.

Landslides

The subject property is in an area low rolling to moderately steep terrain and no landslides have been mapped in the area (Kennedy & Morton, 2003). The subject site is not located in an area of earthquake-induced landslide zones (California Geologic Survey, 2019). The risk of seismically induced landsliding to affect the proposed development is low.

Liquefaction

The site is not within either a State of California (California Geologic Survey, 2018) or County of Riverside designated or mapped liquefaction hazard zone. Therefore, coupled with the absence of shallow groundwater (less than 50-ft bgs) and the medium dense to dense nature of the subsurface sedimentary bedrock units, it is our opinion that liquefaction is not anticipated, and further analysis appears to be unwarranted at this time. Liquefaction potential is negligible.

Seismically Induced Soil Settlement

The proposed footings are anticipated to be founded in medium dense engineered fill overlying medium dense to dense sedimentary bedrock units (Kennedy & Morton, 2003). The settlement potential, under seismic loading conditions for these onsite materials, in our opinion, is low.

Seiches and Tsunami

Considering the location of the site in relation to large bodies of water, seiches and tsunamis are not considered potential hazards of the site.

Rockfall Potential

The subject site is in an area of low rolling and moderately steep terrain that is free of surficial boulder outcroppings. The potential for rockfall is anticipated to be negligible.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

General

The development of the site as proposed is both feasible and safe from a geotechnical standpoint provided that the recommendations contained herein are implemented during design and construction.

1. According to the available "Site Plan" (VSL, 2018), the proposed multi-family residential development will encompass the entire site with access from both Date Street and Bahama Way.

2. Observation of excavations indicates that suitable material for support of fill and/or structures is near the surface on the site. Earth materials on the site are also suitable for use as compacted structural fill.

3. Observation, classification, and testing indicate that the near surface soils have a very low expansion potential (EI = 3 & 8) consisting of low plastic silty Sand (SM) and sandy Silt (ML).

4. Based on our exploratory trenches, sedimentary bedrock units underlie the subject site both at shallow depths and at the ground surface and extended to the total depth explored of 6.0-ft bgs.

RECOMMENDATIONS

Site Grading

General

The Mass Grading Plan (VSL, 2017) indicates that the proposed mass graded multi-family residential pad will be constructed as a cut/fill transition pad. Fill and fill-over-cut slopes will be constructed along the north, east and west boundaries of the subject site and are proposed at a 2:1 (h: v) slope ratio to maximum vertical height of approximately 25-ft. Cut generated from excavation of the cut portion of the pad will likely be utilized as fill for pads and fill slopes.

We anticipate that the subject grading will be a balanced job. Retaining walls are proposed to achieve final grades of the subject site. It is important to note that all imported soils must be observed and approved by the soil engineer prior to use as fill to verify compliance with project specifications and consistency with onsite soils with respect to expansion potential and structural contact pressure.

Site Specific Grading

A representative of this firm shall be present to observe the bottom of all excavations including keyways, overexcavation bottoms, and footing excavations. A representative of this firm shall be present during all fill placement operations to monitor and test as the earth materials are being placed. This observation and testing are intended to assure compliance with the recommendations of this report as well as project specifications as they relate to earthwork construction, City and State ordinances and Table 1705.6 of the 2016 California Building Code.

Where structural fill is to be placed, all loose soils and weathered bedrock at the ground surface shall be removed to competent earth, i.e., sedimentary bedrock. Where proposed structures are underlain by a fill/cut transition they should be overexcavated a minimum of 4-ft below finish grade elevation or a minimum of 2-ft below the deepest footing, whichever is greater. Prior to placement of fill, all fill areas shall be suitably processed by moisture conditioning to near optimum moisture content, then compacted in the upper 6-inches to the minimum compaction requirement prior to placing fill. No structural fill shall be placed within the building area on any ground without first being observed by a representative of the company providing this report and then providing written certification that the ground is competent and prepared to receive fill.

Onsite soils derived from excavations will be suitable for use as structural fill provided, they are free of large rock (6-inches or larger) and organic debris or construction waste. Approved fill material should be placed in 6 to 8-inch loose lifts, brought to optimum moisture content, and compacted to a minimum of 90% of the maximum laboratory dry density, as determined by the ASTM D 1557-12 test method. No rocks larger than 6-inches in diameter should be used as fill material as they inhibit the compaction process. Rocks larger than 6-inches may be removed or crushed and used as fill material. Broken concrete slab shall also be reduced in size to be less than 6-inches in the major direction. Rocks larger than 6-inches that cannot be crushed, organic materials, asphaltic concrete or oil-bearing surface aggregate should be removed from the graded area and in the case of oil-bearing materials, removed and taken to an appropriate dump site that is designed to handle such.

All earthwork should be done in accordance with the specifications contained in **Appendix D**. Additionally, it will be the responsibility of the owner and or the grading contractor to provide this firm with schedule information for grading activities that require observation and testing. It is preferred that we have a minimum of 48 hours of notice for such.

It will also be recommended that at the completion of rough grading, additional testing of engineering characteristics such as expansion potential and ancillary testing should take place to determine final design requirements for foundations, slabs and concrete used.

Slope Construction

Fill slopes constructed at a 2:1 (h: v) slope ratio, to a maximum vertical height of approximately 30-ft, will be surficially and grossly stable if constructed in accordance with the recommendations presented in this report and in **Appendix D** of this report. The 40-scale "Mass Grading Plan" indicate that fill and fill-over cut slopes have been designed at a 2:1 (h:v) slope ratio to maximum vertical height of 25-ft. An approximately 4-ft high cut slopes is planned for the southwest corner of the subject site adjacent to an existing multi-family development. We anticipate that proposed fill slopes will be constructed of earth materials generated from the onsite sedimentary bedrock units. The fill is anticipated to consist of silty Sands (SM) and sandy Silts (ML).

A keyway should be established along the toe of any proposed fill slope. The outside edge of the keyway should be founded a minimum of 2-ft into observed and competent sedimentary units and inclined into the hillside at a minimum 2% gradient for a minimum width of 12'. The keyway excavations should expose sedimentary bedrock units that are free of pinpoint pores and fine roots throughout the bottom area and up a minimum of 2 feet on all sides. Any loose soils or weathered bedrock should be completely removed by benching during rough grade operation.

The importance of proper fill compaction to the face of slope cannot be overemphasized. In order to achieve proper compaction to the slope face, one or more of the four following methods should be employed by the contractor following implementation of typical slope construction guidelines; 1) track walk the slopes at grade, 2) grid roll the slopes, 3) use a combination of sheep foot roller and track walking, and/or 4) overfill the slope 3 to 5-ft laterally and cut it back to grade.

Care should be taken to avoid spillage of loose materials down the face of any slope during grading. Loose fill on the face of the slope will require complete removal prior to shaping and or track walking. Proper seeding and planting of the slopes should follow as soon as practical to inhibit erosion and deterioration of the slope surfaces. Proper moisture control will enhance the long-term stability of the finish slope surface.

Bearing Value and Footing Geometry

A safe allowable bearing value of 2,100 psf for foundations embedded into observed competent granitic bedrock. Continuous footings, for single-story or equivalent structures, should have a minimum width of 12-inches and depth of 12-inches and conform to the minimum criteria of the 2016 CBC for very low expansive soils (EI = 3 and 8).

Continuous footings, for both two or three-story or equivalent structures, should have a minimum width of 15 and 18-inches and depths of 18 and 24-inches, respectively and conform to the minimum criteria of the 2016 CBC. The use of isolated column footings is not discouraged, however, where utilized, should have a minimum embedment of 18-inches below lowest soil grade. The minimum distance of the bottom outside edge of all footings and any slope face shall be 5-ft. All footings should be embedded a minimum of 12-inches into observed competent native materials, regardless of depth below the adjacent ground surface.

Settlement

The bearing value recommended above reflects a total settlement of 0.5-inches and a differential settlement of 0.5-inches within a horizontal distance of 20-ft (L/480). Most of this settlement is expected to occur during construction and as the loads are being applied.

Concrete Slabs

All concrete slabs on grade should be 4 inches thick, minimum. They should be underlain by 2-inches of sand or approved non-expansive onsite materials. Imported or approved onsite materials may be utilized for this purpose. Contractors should be advised that when pouring during hot or windy weather conditions, they should provide large slabs with sufficiently deep weakened plane joints to inhibit the development of irregular or unsightly cracks. Also, 4-inch thick slabs should be jointed in panels not exceeding 8-ft in both directions to augment proper crack direction and development.

Moisture Barrier

When the intrusion of moisture through concrete slabs is objectionable, particularly with interior slabs where flooring is moisture sensitive, a vapor barrier should be installed onto the subgrade prior to the pouring of concrete. It should consist of a minimum 10-mil visqueen, protected from puncture with 2-inches of sand above and 2-inches of sand below. This is considered a minimum recommendation as there are other devices that provide as good as or better moisture protection. The project architect and or structural engineer may recommend alternative devices for moisture protection.

Reinforcement

From a Geotechnical standpoint, continuous footings should be reinforced with a minimum of two number 4 steel bar placed at the top and bottom. In no case, should the content of steel in concrete footings be less than the recommended minimums of the appropriate sections of the A.C.I. standards. Slabs should be reinforced with a minimum of number 3 steel bars placed at the center of thickness at 18-inch centers both ways (CBC 2016).

These are considered minimums and additional requirements may be imposed by other structural engineering design requirements. In addition, at the completion of grading, testing of the near surface soils may indicate that different or more stringent reinforcing schedule minimums may be appropriate. Careful consideration should be given to the recommendations that will be contained in the final report of compaction test results and foundation design requirements.

Concrete

Based on our corrosivity suite testing, Type II Portland cement concrete can be utilized for the subject site. Laboratory analysis results, which are included in **Appendix C**, indicated that the percentage by weight of soluble sulfates were reported as **0.002**, which equates to a **Negligible** sulfate exposure per American Concrete Institute (ACI), 318, Table 4.3.1 (2005). Soluble sulfate content testing should be conducted within the building pad at the completion of rough grading to confirm concentration of sulfite ions within the onsite earth materials.

Corrosivity test results, which are summarized in **Appendix C,** indicated saturated resistivity of 4,700 ohms/cm for the onsite soils, which indicates the onsite soils are moderately corrosive (NACE International, 1984). Results for pH and Chlorides are included in **Appendix C**. South Shore Testing and Environmental does not practice corrosion engineering. If specific information or evaluation relating to the corrosivity of the onsite or any import soil is required, we recommend that a competent corrosion engineer be retained to interpret or provide additional corrosion analysis and mitigation.

Lateral Loads

The bearing value of the soil may be increased by one-third for short duration loading (wind, seismic). Lateral loads may be resisted by passive forces developed along the sides of concrete footings or by friction along the bottom of concrete footings. The value of the passive resistance for level ground may be computed using an equivalent fluid density of 300 pcf for level ground. The total force should not exceed 3,000 psf. A coefficient of friction of .35 may be used for the horizontal soil/concrete interface for resistance of lateral forces. If friction and passive forces are combined, then the passive values should be reduced by one third.

Earthwork Factors

Shrinkage results when a volume of material removed at one density is compacted to a higher density. A shrinkage factor of 8 to 15 percent for the undifferentiated alluvial/colluvial soils should be anticipated when excavating and compacting the undifferentiated alluvial/colluvial soils to an average relative compaction of 92 percent. An increase in relative compaction, or deeper removals, could correspond to an increase in shrinkage values. Subsidence, as a result of ground preparation, may also be anticipated on the order of 0.15 feet, occurring mostly during site construction.

Cut/Fill Transitions

Footings should not span cut to fill soil conditions. Cut-to-fill transitions should be eliminated from building pads where the depth of fill exceeds 6-inches. This should be accomplished by overexcavating the cut portion a minimum of 4-ft below the pad surface or 2-ft below the bottom of the deepest footings, whichever is greater, and replacing the materials as properly compacted fill. Limits of excavation should be verified by the project soils engineer. Recommended depths of overexcavation are as follows:

Depth of Fill on "Fill" Portion	Depth of Overexcavation "Cut" Portion
0 to 6 feet	4.0 feet
> 6 feet	½ Depth of Fill to Maximum Depth of 15 feet

Retaining Wall Parameters

Section 1803.5.12 of the California Building Code, Seismic Category D, indicates this geotechnical report shall provide information for the following: "The determination of dynamic seismic lateral earth pressures on foundation walls and retaining walls supporting more than 6-ft (1.83 m) of backfill height due to design earthquake ground motions." A seismic load of 20H should be used for design for retaining walls having more than 6 feet of backfill.

Table of Retaining Wall Design Pressures

Slope of adjacent ground	Active Pressure	Passive Pressure
LEVEL	35 pcf	250 pcf
2:1	55 pcf	150 pcf

Coefficient of friction 0.35

The pressures in the preceding table are for retaining walls backfilled with non-cohesive (EI ≤ 20), granular materials and provided with drainage devices such as weep holes or subdrains to prevent the build-up of hydrostatic pressures beyond the design values. It is imperative that all retaining wall backfills be compacted to a minimum of 90% relative compaction to achieve their design strength. Failure to provide proper drainage and minimum compaction may result in pressures against the wall that will exceed the design values indicated above. Surface waters should be directed away from retaining wall backfill areas so as not to intrude into the backfill materials. Retaining wall backfill should be constructed in such a way to have granular non-cohesive backfill placed in all but the upper 2-ft. The upper two feet should consist of cohesive materials to minimize the potential for surface waters to infiltrate into the retaining wall backfill system.

Subdrains should be placed at the back of all retaining walls to achieve proper drainage and reduce the possibility of increased hydrostatic pressures. Retaining wall subdrains should consist of a minimum of 1 cubic foot per linear foot of gravel, placed at the heel, and be separated from earth materials by a filter fabric or geotextile designed for that purpose. The gravel should be drained by a minimum 4-inch diameter perforated pipe, sloped at a minimum of 1% toward outlets spaced no more than 50-ft apart. Outlet tubes through or around wall stems should be solid pipe, sloped to drain, and maintained so to be unobstructed by earth, vegetation, or animals.

As an alternate, Mira Drain retaining wall back-drain system may be used where space is limited and the typical drain system is not practical to install. Care should be taken to properly construct or install the drain system per manufacturer's specifications where possible. Also, it is strongly recommended that no surface runoff be allowed to infiltrate into retaining wall back-drains, and that where outlet holes are provided at the toe of the wall, they remain open and free of obstructions.

Oversize Rock

No oversize material was observed within our exploratory trenches or on the ground surface during our subsurface exploration. If any oversize material is to be generated during site development, it should be disposed of off-site, utilized in landscaping, or placed in an approved rock fill in accordance with **Appendix D** of this report.

Utility Trench Backfill

All trench excavations should be conducted in accordance with Cal-OSHA standards as a minimum. The soils encountered within our exploratory trenches are generally classified as Type "C" soil in accordance with the CAL/OSHA (2013) excavation standards. Based upon a soil classification of Type "C", the temporary excavations should not be inclined steeper than 1.5:1 (h: v) for a maximum depth of 20-ft. For temporary excavations, deeper than 20-ft or for conditions that differ from those described for Type "C" in the CAL/OSHA excavation standards, the project geotechnical engineer should be contacted.

Utility trench backfill should be compacted to a minimum of 90 percent of the maximum dry density determined in laboratory testing by the ASTM D 1557-12 test method. It is our opinion that utility trench backfills consisting of onsite or approved sandy soils can best be placed by mechanical compaction to a minimum of 90 percent of the maximum dry density. The upper 1-ft of utility trench excavations located within pavement areas should be compacted to a minimum of 95 percent of the maximum dry density.

Fine Grading and Site Drainage

Fine grading of areas outside of the multi-family residential structures should be accomplished such that positive drainage exists away from all footings in accordance with 2016 CBC and local governing agency requirements. Run-off should be conducted in a non-erosive manner toward approved drainage devices per approved plans. No run-off should be allowed to concentrate and flow over the tops of slopes.

Construction

South Shore Testing & Environmental, or a duly designated representative, should be present during all earthwork construction in accordance with the standard specifications contained at the back of this report, to test and or confirm the conditions encountered during this study. In addition, post earthwork construction monitoring should be conducted at the following stages:

- At the completion of final grading of the building pad so that a finished surface compaction test may be obtained. Moisture content near optimum will necessarily need to be maintained, both to maintain proper compaction and to prevent wind erosion of the pad.

- At the completion of foundation excavations, but prior to the placement of steel and or other construction materials in them. As a requirement of this report, the undersigned must, in writing, certify that the foundations meet the minimum requirements of this report and the building plans for depth and width along with the earth materials being the appropriate moisture content and compaction. Backfilling of over deepened footings with earth materials will not be allowed and must be poured with concrete. Consequential changes and differences may exist throughout the earth materials on the site. It may be possible that certain excavations may have to be deepened slightly if earth materials are found to be loose or weak during these observations.

- Any other pertinent post construction activity where soils are excavated or manipulated or relied upon in any way for the performance of buildings or hardscape features.

Supplemental Recommendations

If at any time during grading or construction on this site, conditions are found to be different than those indicated in this report, it is essential that the soil engineer be notified. The soil engineer reserves the right to modify in any appropriate way the recommendations of this report if site conditions are found to be different than those indicated in this report.

- The earth units exposed at the surface is observed to be medium dense sedimentary bedrock. It is minimally to moderately-erosive. It is dense at shallow depths, on the order of 2-ft and water does percolate moderately into the onsite bedrock units.

- Cuts to 5-ft, or slightly more will stand vertical for normal time periods associated with construction of backcuts for fill slopes or retaining walls. Time periods for unsupported cuts 5-ft or greater vertical should be limited to 60 days in the non-rainy season and 30 days in the rainy season.

Foundation Plan Review

Once foundation plans are finalized, a Foundation Plan Review should be performed to review plans and confirm that the plans are in general conformance with recommendations presented in this report.

Construction Monitoring

Observation and testing by South Shore Testing & Environmental is necessary to verify compliance with recommendations contained in this report and to confirm that the geotechnical conditions encountered are consistent with those encountered. South Shore Testing & Environmental should conduct construction monitoring during any fill placement and subgrade preparation prior to placement of fill or construction materials.

LIMITATIONS

Our investigation was performed using the degree of care and skill ordinarily exercised, under similar circumstances, by reputable Geotechnical Engineers and Geologists practicing in this or similar localities. No other warranty, expressed or implied, is made as to the conclusions and professional advice included in this report.

The report is issued with the understanding that it is used only by the owner and it is the sole responsibility of the owner or their representative to ensure that the information and recommendations contained herein are brought to the attention of the architect, engineer, and appropriate jurisdictional agency for the project and incorporated into the plans; and the necessary steps are taken to see that the contractor and subcontractors carry out such recommendations contained herein during construction and in the field.

The samples taken and used for testing and the observations made are believed representative; however, soil and geologic conditions can vary significantly between test locations. The evaluation or identification of the potential presence of hazardous or corrosive materials was not part of the scope of services provided by **South Shore Testing & Environmental**, or its assigns.

The findings of this report are valid as of the present date. However, changes in the condition of a property can occur with the passage of time, whether due to natural processes or the works of man on this or adjacent properties. In addition, changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and revision as changed conditions are identified.

The firm that performed the geotechnical investigation for this project should be retained to provide testing observation services during construction to maintain continuity of geotechnical interpretation and to check that the recommendations presented herein are implemented during site grading, excavation of foundations and construction of improvements.

If another geotechnical firm is selected to perform the testing and observation services during construction operations, that firm should prepare a letter indicating their intent to assume the responsibilities of project geotechnical engineer of record. Selection of another firm to perform any of the recommended activities or failure to retain the undersigned to perform the recommended activities wholly absolves **South Shore Testing & Environmental**, the undersigned, and its assigns from all liability arising directly or indirectly from any aspects of this project.

We appreciate the opportunity to be of service. Limitations and conditions contained in reference documents are considered in full force and applicable. If you have any questions, please do not hesitate to call our office.

Respectfully submitted,

South Shore Testing & Environmental

John P. Frey
Project Geologist

William C. Hobbs, RCE 42265
Civil Engineer

ATTACHMENTS
Figure 1 - Site Location Map (2,000-scale)
Plate 1 - Geotechnical Map (not-to-scale)
Appendix A - References
Appendix B - Exploratory Trench Logs
Appendix C - Laboratory Test Results
Appendix D – Standards of Grading
Appendix E - USGS Design Maps Summary Report

APPENDIX A

References

REFERENCES

California Building Standards Commission (CBSC), 2016, "2016 California Building Code, California Code of Regulations, Title 24, Part 2, Volume 2 of 2".

California Geologic Survey, Revised 2018, "Earthquake Fault Zones, A Guide for Government Agencies, Property Owners/Developers, and Geoscience Practitioners for Assessing Fault Rupture Hazards in California", Special Publication 42.

California Geologic Survey, 2019, "Earthquake Zones of Required Investigation Murrieta Quadrangle, Earthquake Fault Zones (Released: January 1, 1990) – Seismic Hazard Zones (Released: January 11, 2018)", Scale: 1" = 2,000'.

California Division of Mines & Geology, 1997, "Guidelines for Evaluating and Mitigating Seismic Hazards in California", Special Publication 117.

California Division of Mines & Geology, 1996, "Probabilistic Seismic Hazard Assessment for the State of California", DMG Open File Report 96-08, USGS Open File Report 96-706.

California Geological Survey, 2006, "California Fault Parameters", California Geologic Survey website - Open-file Report 96-08.

City of Murrieta, October 19, 2018, "Review Comments, Case GP-2018-1762, ZC-2018-1762, DP-2018-1761.

Coduto, Don, P., 1994, "Foundation Design Principles and Practice", Prentice Hall, pages 637-655.

County of Riverside GIS Website, 2019.

Department of Water Resources, August 1971, "Water Wells and Springs in the Western Part of the Upper Santa Margarita River Watershed, Riverside and San Diego Counties, California", Bulletin No. 91-20.

Hart, E.W., 2000, "Fault-Rupture Hazard Zones in California", California Division of Mines and Geology Special Publication 42, CD-003 (CD-ROM Version).

Jennings, C.W., 1994, Fault Activity Map of California and Adjacent Areas with Locations and Ages of Recent Volcanic Eruptions, California Division of Mines and Geology, Geologic Data Map No. 6.

Kennedy, M.P. and Morton, D.M., 2003, "Preliminary Geologic Map of the Murrieta 7.5' Quadrangle, Riverside County, California", U.S.G.S. Open-File Report 03-189, Scale: 1" = 2,000'.

Mann, John F. Jr., October 1955, "Geology of a Portion of the Elsinore Fault Zone, California", California Division of Mines, Special Report 43.

REFERENCES (continued)

Morton, D.M., 2004, "Preliminary Digital Geologic Map of the Santa Ana 30' x 60' Quadrangle, Southern California (Version 2.0)", U.S. Geological Survey in Cooperation with the California Geologic Survey, Open-File Report 99-172, Scale: 1"=100,000'.

Rancho California Water District, March 1984, "Water Resources Master Plan".

Rockwell, T.K., Millman, D.E., McElwain, R.S., and Lamar, D.L., 1985, Study of Seismic Activity by Trenching Along the Glen Ivy North Fault, Elsinore Fault Zone, Southern California, Lamar-Merifield Technical Report 85-1.

South Shore Testing & Environmental, February 08, 2018, "Preliminary Geotechnical Investigation, Proposed Multi-Family Residential Development - MHS-98, LLC, APN Nos.: 913-210-005 to -007, -010 to -013, & -032 to -035, Northeast of Rising Hill Drive and Bahama Way, City of Murrieta, Riverside County, California", Work Order No. 3721801.00

Weber, F.H., Jr., 1977, Seismic Hazards Related to Geologic Factors, Elsinore and Chino Fault Zones, Northwestern Riverside County, California, DMG Open File Report, 77-4 L.A., 96 pages.

VSL Engineering, 2018, "Site Plan", Sheet No. 2 of 2, Scale: 1 = 40-ft, Project No. 99-063.

VSL Engineering, 2017, "Mass Grading Plan", Sheet 1 of 1, Scale: 1 = 40-ft, Project No. 99-063.

APPENDIX B

Exploratory Trench Logs

LOGGED BY: JPF	METHOD OF EXCAVATION:CAT # 430 BACKHOE EQUIPPED W/ 18" BUCKET ELEVATION: + 1140	DATE OBSERVED: 1/3/18 LOCATION: SEE GEOTECHNICAL

DEPTH (FEET)	CLASSIFICATION	BLOWS/FOOT	UNDISTURBED SAMPLE	BULK SAMPLE	MOISTURE CONTENT(%)	INPLACE DRY DENSITY (PCF)	TEST PIT NO.__1__ DESCRIPTION	SOIL TEST
				V			**PAUBA FORMATION**	MAXIMUM ENSITY/OPITMUM MOISTURE
				|			SILTY SAND (SM): DARK YELLOW BROWN, FINE TO MEDIUM GRAINED, NUMEROUS	CONTENT, SIEVE ANALYSIS, EXPANSION
				|			PINPOINT PORES TOP 2-FT	INDEX, CORROSIVITY SUITE & REMOLDED
				|			SILTY SAND (SM): YELLOW BROWN, FINE TO CORSE GRAINED, TRACE GRAVEL,	SHEAR
5				Λ			MODERATELYGRADED, DRY, DENSE	INFILTRATION TEST
							TOTAL DEPTH 5.0'	
							NO GROUNDWATER	
							NO CAVING	
10								
15								
20								
25								
30								
35								
40								

JOB NO: 3721801.00	LOG OF TEST PIT	FIGURE: T-1

LOGGED BY: JPF	METHOD OF EXCAVATION:CAT # 430 BACKHOE EQUIPPED W/ 18" BUCKET ELEVATION: ± 1125	DATE OBSERVED: 1/3/18 LOCATION: SEE GEOTECHNICAL

DEPTH (FEET)	CLASSIFICATION	BLOWS/FOOT	UNDISTURBED SAMPLE	BULK SAMPLE	MOISTURE CONTENT(%)	INPLACE DRY DENSITY (PCF)	TEST PIT NO. __2__ DESCRIPTION	SOIL TEST
							UNDIFFERENTIATED ALLUVIUM/COLLUVIUM SILTY SAND (SM): YELLOW BROWN, FINE TO MEDIUM GRAINED, MODERATELY GRADED, DRY, LOOSE	
5							**PAUBA FORMATION** SILTY SAND (SM): DARK BROWN, FINE TO COARSE GRAINED, WELL GRADED, MINOR COBBLES SUBROUNDED TO 3", MINOR PINPOINT PORES IN UPPER 1'	
							TOTAL DEPTH 5.0'	
10								
15								
20								
25								
30								
35								
40								

JOB NO: 3721801.00	LOG OF TEST PIT	FIGURE: T-2

LOGGED BY: JPF	METHOD OF EXCAVATION: CAT # 430 BACKHOE EQUIPPED W/ 18" BUCKET ELEVATION: ± 1126	DATE OBSERVED: 1/3/18 LOCATION: SEE GEOTECHNICAL

DEPTH (FEET)	CLASSIFICATION	BLOWS/FOOT	UNDISTURBED SAMPLE	BULK SAMPLE	MOISTURE CONTENT(%)	INPLACE DRY DENSITY (PCF)	TEST PIT NO.__3__ DESCRIPTION	SOIL TEST
							PAUBA FORMATION SILTY SAND (SM): DARK BROWN, FINE TO MEDIUM GRAINED, MODERATELY SORTED, MINOR COARSE & GRAVEL SIZE, DRY, BECOMING DENSER WITH DEPTH MODERATELY CEMENTED, MINOR PINPOINT PORES TO TOTAL DEPTH	
5							**TOTAL DEPTH 4.0'** **NO GROUNDWATER**	
10								
15								
20								
25								
30								
35								
40								

JOB NO: 3721801.00	LOG OF TEST PIT	FIGURE: T-3

LOGGED BY: JPF	METHOD OF EXCAVATION:CAT # 430 BACKHOE EQUIPPED W/ 18" BUCKET ELEVATION: ± 1125	DATE OBSERVED: 1/3/18 LOCATION: SEE GEOTECHNICAL

DEPTH (FEET)	CLASSIFICATION	BLOWS/FOOT	UNDISTURBED SAMPLE	BULK SAMPLE	MOISTURE CONTENT(%)	INPLACE DRY DENSITY (PCF)	TEST PIT NO.__4__ DESCRIPTION	SOIL TEST
							ALLUVIAL/COLLUVIAL SOILS SILTY SAND (SM): DARK GRAY, FINE TO MEDIUM GRAINED, DRY, LOOSE, NUMEROUS, PINPOINT PORES & FINE ROOTS	
5							**PAUBA FORMATION** SILTY SAND (SM): DARK BROWN, FINE TO MEDIUM GRAINED, MINOR COARSE GRAVEL, STIFF, MEDIUM DENSE, DIFFICULT EXCAVATION	
							TOTAL DEPTH 5.0'	
10								
15								
20								
25								
30								
35								
40								

JOB NO: 3721801.00	LOG OF TEST PIT	FIGURE: T-4

LOGGED BY: JPF	METHOD OF EXCAVATION:CAT # 430 BACKHOE EQUIPPED W/ 18" BUCKET ELEVATION: ± 1172	DATE OBSERVED: 1/3/18 LOCATION: SEE GEOTECHNICAL

DEPTH (FEET)	CLASSIFICATION	BLOWS/FOOT	UNDISTURBED SAMPLE	BULK SAMPLE	MOISTURE CONTENT(%)	INPLACE DRY DENSITY (PCF)	TEST PIT NO.__5__ DESCRIPTION	SOIL TEST
							PAUBA FORMATION SANDY SILT (ML): YELLOW BROWN TO OLIVE BROWN, STIFF, DRY, TRACE OF SAND, MINOR PINPOINT PORES IN UPPER 1'	
5							BECOMING SLIGHTLY MOIST AND DENSER W/ DEPTH	
							TOTAL DEPTH 5.0' **NO GROUNDWATER**	
10								
15								
20								
25								
30								
35								
40								

JOB NO: 3721801.00	LOG OF TEST PIT	FIGURE: T-5

LOGGED BY: JPF	METHOD OF EXCAVATION:CAT # 430 BACKHOE EQUIPPED W/ 18" BUCKET ELEVATION: ± 1146	DATE OBSERVED: 1/3/18 LOCATION: SEE GEOTECHNICAL

DEPTH (FEET)	CLASSIFICATION	BLOWS/FOOT	UNDISTURBED SAMPLE	BULK SAMPLE	MOISTURE CONTENT(%)	INPLACE DRY DENSITY (PCF)	TEST PIT NO.__6__ DESCRIPTION	SOIL TEST
5							**PAUBA FORMATION** SILTY SAND (SM): MEDIUM GRAY, FINE TO COARSE GRAINED, MODERATELY GRADED, DRY, WEAKLY CEMENTED, MEDIUM DENSE, MINOR POROSITY	INFILTRATION TEST
10							**TOTAL DEPTH 6.0'** **NO GROUNDWATER**	
15								
20								
25								
30								
35								
40								

JOB NO: 3721801.00	LOG OF TEST PIT	FIGURE: T-6

LOGGED BY: JPF	METHOD OF EXCAVATION:CAT # 430 BACKHOE EQUIPPED W/ 18" BUCKET ELEVATION: ± 1146	DATE OBSERVED: 1/3/18 LOCATION: SEE GEOTECHNICAL

DEPTH (FEET)	CLASSIFICATION	BLOWS/FOOT	UNDISTURBED SAMPLE	BULK SAMPLE	MOISTURE CONTENT(%)	INPLACE DRY DENSITY (PCF)	TEST PIT NO.__6__ DESCRIPTION	SOIL TEST
5							**PAUBA FORMATION** SILTY SAND (SM): MEDIUM GRAY, FINE TO COARSE GRAINED, MODERATELY GRADED, DRY, WEAKLY CEMENTED, MEDIUM DENSE, MINOR POROSITY	INFILTRATION TEST
10							**TOTAL DEPTH 6.0'** **NO GROUNDWATER**	
15								
20								
25								
30								
35								
40								

JOB NO: 3721801.00	LOG OF TEST PIT	FIGURE: T-6

LOGGED BY: JPF	METHOD OF EXCAVATION:CAT # 430 BACKHOE EQUIPPED W/ 18" BUCKET ELEVATION: ± 1149.5	DATE OBSERVED: 1/3/18 LOCATION: SEE GEOTECHNICAL

DEPTH (FEET)	CLASSIFICATION	BLOWS/FOOT	UNDISTURBED SAMPLE	BULK SAMPLE	MOISTURE CONTENT(%)	INPLACE DRY DENSITY (PCF)	TEST PIT NO.__7__ DESCRIPTION	SOIL TEST
				V | | Λ			**PAUBA FORMATION** SILT (ML): OLIVE BROWN, STIFF, DENSE, MINOR CALCERCOUS VEINLETS	MAXIMUM ENSITY/OPITMUM MOISTURE CONTENT, SIEVE ANALYSIS, EXPANSION INDEX,
5							SAND (SW): ORANGE BROWN, COARSE GRAINED, WEAKLY CEMENTED, SLIGHTLY MOIST, POORLY GRADED	
							TOTAL DEPTH 5.0' **NO GROUNDWATER**	
10								
15								
20								
25								
30								
35								
40								

JOB NO: 3721801.00	LOG OF TEST PIT	FIGURE: T-7

APPENDIX C

Laboratory Test Results

LABORATORY TESTING

A. Classification

Soils were visually classified according to the Unified Soil Classification System. Classification was supplemented by index tests such as maximum density and optimum moisture content.

B. Expansion Index

Expansion index tests were performed on representative samples of the onsite soils remolded and tested under a surcharge of 144 lb/ft^2, in accordance with ASTM D-4829-11. The test results are presented on **Figure C-1, Table I** and a copy of our laboratory test results are presented on **Figures C-2 & C-3.**

C. Maximum Density/Optimum Moisture Content

Maximum density/optimum moisture content relationships were determined for typical samples of the onsite soils. The laboratory standards used were ASTM 1557-Method A. The test results are summarized on **Figure C-1, Table II** and laboratory results are presented on **Figures C-4 & C-5.**

D. Particle Size Determination

Particle size determinations, consisting of mechanical analyses (sieve) were performed on representative samples of the onsite soils in accordance with ASTM D 422-63 and CAL TEST 202. The test results are shown on **Figures C-6 & C-7.**

E. Corrosivity Suite

Corrosivity suite testing including resistivity, soluble sulfate content, pH and chloride content were performed on a representative sample of the onsite soils. The laboratory standards used were CTM 643, CTM 417 & CTM 422. The test results are presented on **Figure C-1, Table III and Figure C-8**.

F. Direct Shear

A remolded direct shear strength test was performed on a representative sample of the onsite undisturbed soils. To simulate possible adverse field conditions, the samples were saturated prior to shearing. A saturating device was used which permitted the samples to absorb moisture while preventing volume change. Test results are graphically displayed on **Figure C-9.**

TABLE I EXPANSION INDEX		
TEST LOCATION	EXPANSION INDEX	EXPANSION POTENTIAL
T-1 @ 0-5 ft	8	Non Expansive
T-7 @ 0-4 ft	3	Non Expansive

TABLE II MAXIMUM DENSITY/OPTIMUM MOISTURE RELATIONSHIP ASTM D 1557		
TEST LOCATION	MAXIMUM DRY DENSITY (pcf)	OPTIMUM MOISTURE (%)
T-1 @ 0-5 ft	126.3	10.3
T-7 @ 0-4 ft	118.0	11.9

TABLE III CORROSIVITY SUITE				
TEST LOCATION	SATURATED RESISTIVITY	pH	CHLORIDE CONTENT	SULFATE CONTENT
T-1 @ 0-5 ft	4,700	6.9	30 ppm	0.002 % by wgt

Figure C-1

S-6 - D - 8

EXPANSION INDEX TEST

Test Method	ASTM D 4829	Job No. 3721801.00	
		Project Tierra	Nova
		Tested By	
		Date Thur Jan 4	2018
Lot #	T1	Checked By	
Depth (ft.)	0-5	Date	
Sample / Lab No.		Tract	

INITIAL CONDITIONS				
INITIAL MOISTURE, W %	8.3			
REMOLDED WET SOIL + TARE	6325			
TARE (g)	198			
WET SOIL, Wt (g)	4345			
DRY SOIL, Ws (g)	4012			
REMOLDED WET DENSITY t t = Wt(.30165) (PCF)	1312			
REMOLDED DRY DENSITY d d = Ws(.30165) (PCF)	1211			
WEIGHT OF WATER Ww Ww = t - d (PCF)	101			
SOLIDS VOLUME, Vs (ft) Vs = d + 168.5	71			**% Saturation 40-60**
VOIDS VOLUME, Vv (ft) Vv = 1 - Vs	29			**Expansion Results**
DEGREE OF SATURATION S S = Ww x 100/62.4 x Vv(%) 1010 18.0	56			Initial Reading 0
Sample Description:				Final Reading 8
				Height Change 8
				Expansion Index 8

C-2

EXPANSION INDEX TEST

0 - 0		Job No. 3721801.00	
		Project Tierra	Nova
Test Method	ASTM D 4829	Tested By	
		Date thur Jan 4	2018
Lot #	T-7	Checked By	
Depth (ft.)	0-4	Date	
Sample / Lab No.		Tract	

INITIAL CONDITIONS			
INITIAL MOISTURE, W %	10.3		
REMOLDED WET SOIL + TARE	6038		
TARE (g)	198		
WET SOIL, Wt (g)	4058		
DRY SOIL, Ws (g)	365.4		
REMOLDED WET DENSITY t t = Wt(.30165) (PCF)	122.5		
REMOLDED DRY DENSITY d d = Ws(.30165) (PCF)	110.3		
WEIGHT OF WATER Ww Ww = t - d (PCF)	12.2		
SOLIDS VOLUME, Vs (ft) Vs = d + 168.5	65		
VOIDS VOLUME, Vv (ft) Vv = 1 - Vs	35		
DEGREE OF SATURATION S S = Ww x 100/62.4 x Vv(%) 1220 21.6	55		

Sample Description:

% Saturation 40-60

Expansion Results

Initial Reading	0
Final Reading	3
Height Change	3
Expansion Index	3

COMPACTION TEST REPORT

Curve No.: 2.60

Project No.: 3721801.00 **Date:** 01/04/18
Project: TIERRA NOVA

Location: T-1
Elev./Depth: 0-5 **Sample No.**
Remarks:

MATERIAL DESCRIPTION

Description: ORANGE BROWN FINE SILTY SAND

Classifications - **USCS:** SM **AASHTO:**
Nat. Moist. = **Sp.G. =** 2.65
Liquid Limit = **Plasticity Index =**
% > No.4 = % **% < No.200 =**

TEST RESULTS	
Maximum dry density =	126.3 pcf
Optimum moisture =	10.3%

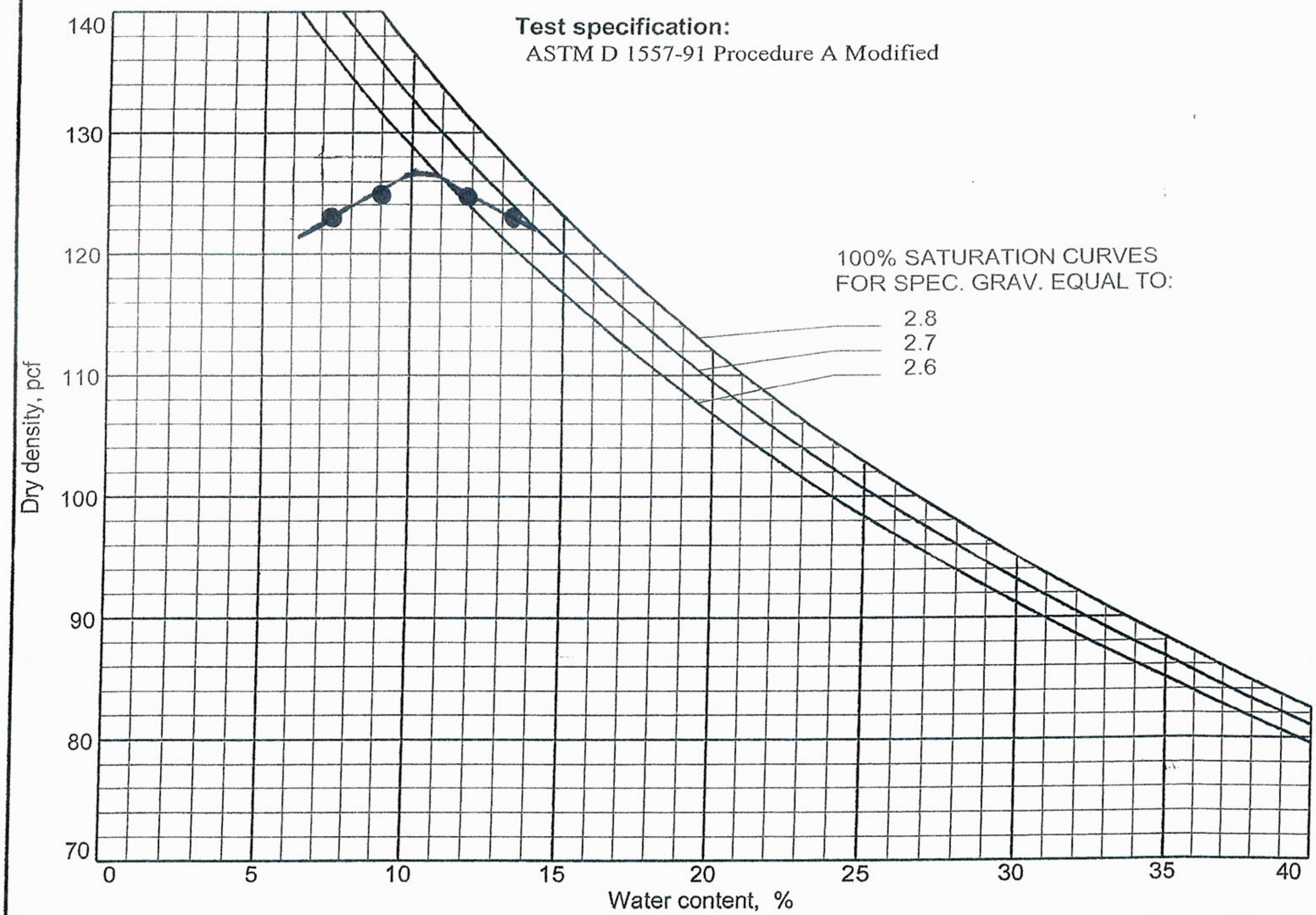


Figure C-4

COMPACTION TEST REPORT

Curve No.: 2.60

Project No.: 3721801.00

Date: 01/05/18

Project: TIERRA NOVA

Location: T-7

Elev./Depth: 0-4

Sample No.

Remarks:

MATERIAL DESCRIPTION

Description: ORANGE BROWN FINE SILTY SAND

Classifications - USCS: SM AASHTO:

Nat. Moist. = Sp.G. = 2.65

Liquid Limit = Plasticity Index =

% > No.4 = % % < No.200 =

TEST RESULTS	
Maximum dry density =	118.0 pcf
Optimum moisture =	11.9%

Test specification:
ASTM D 1557-91 Procedure A Modified

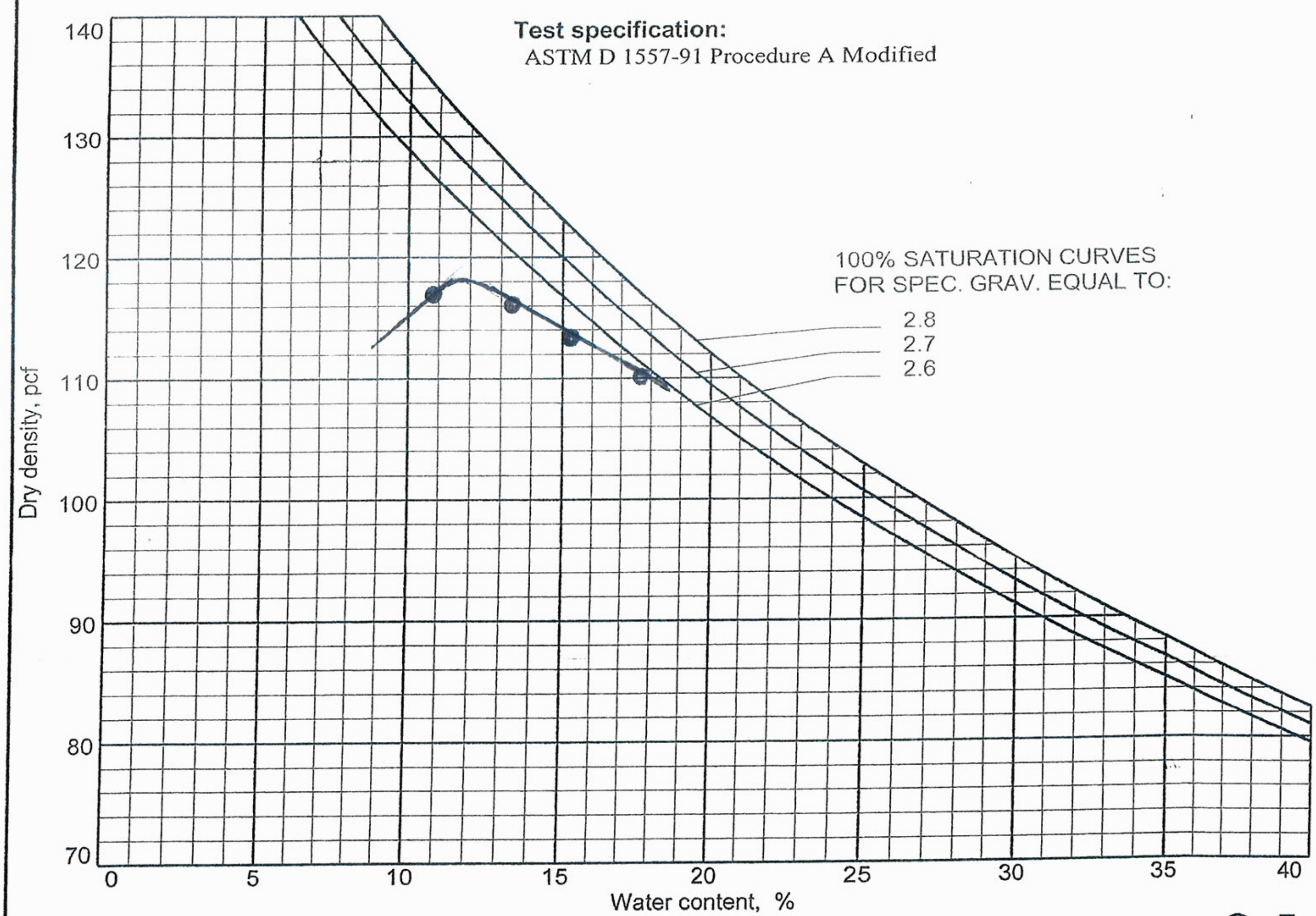
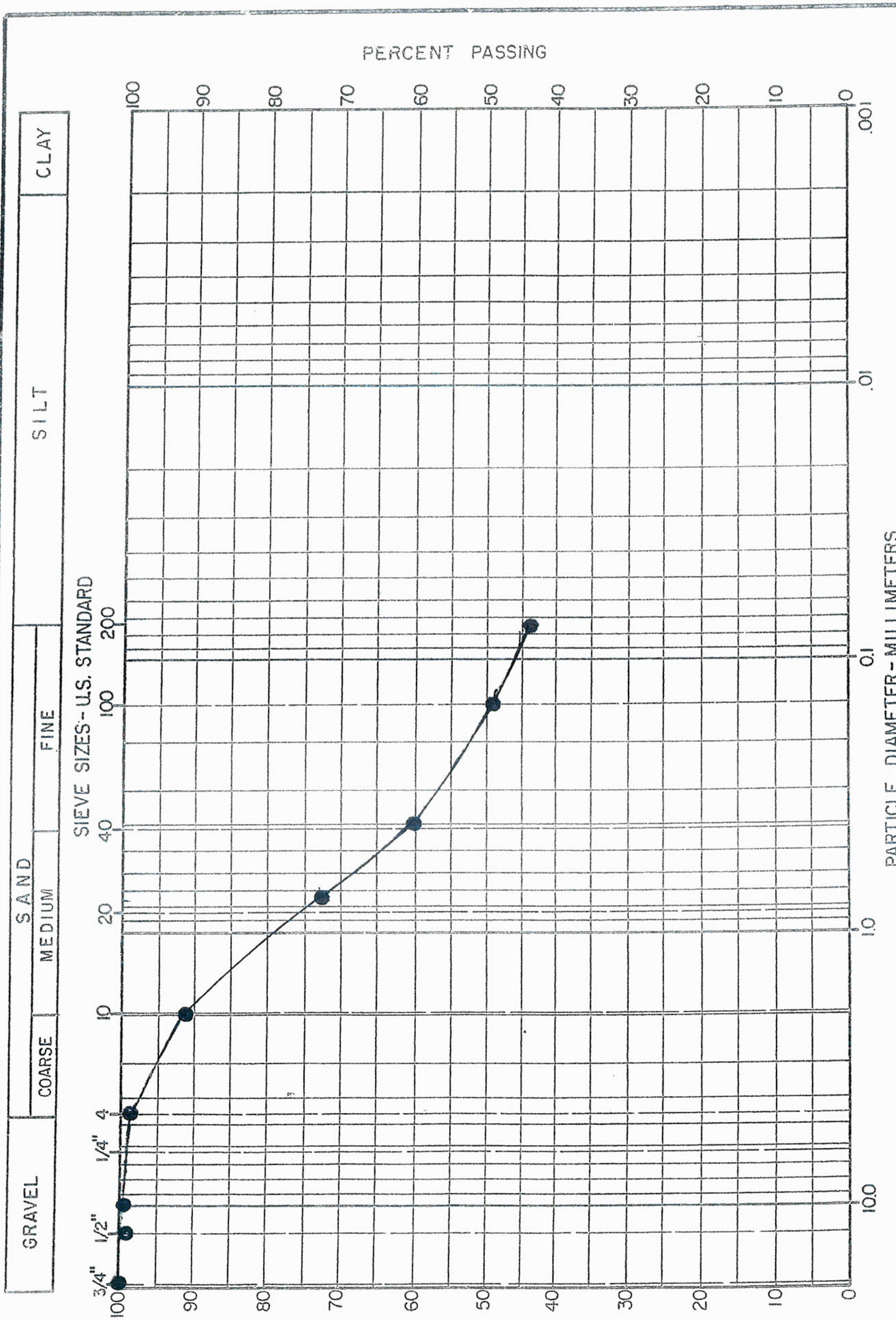


Figure C-5

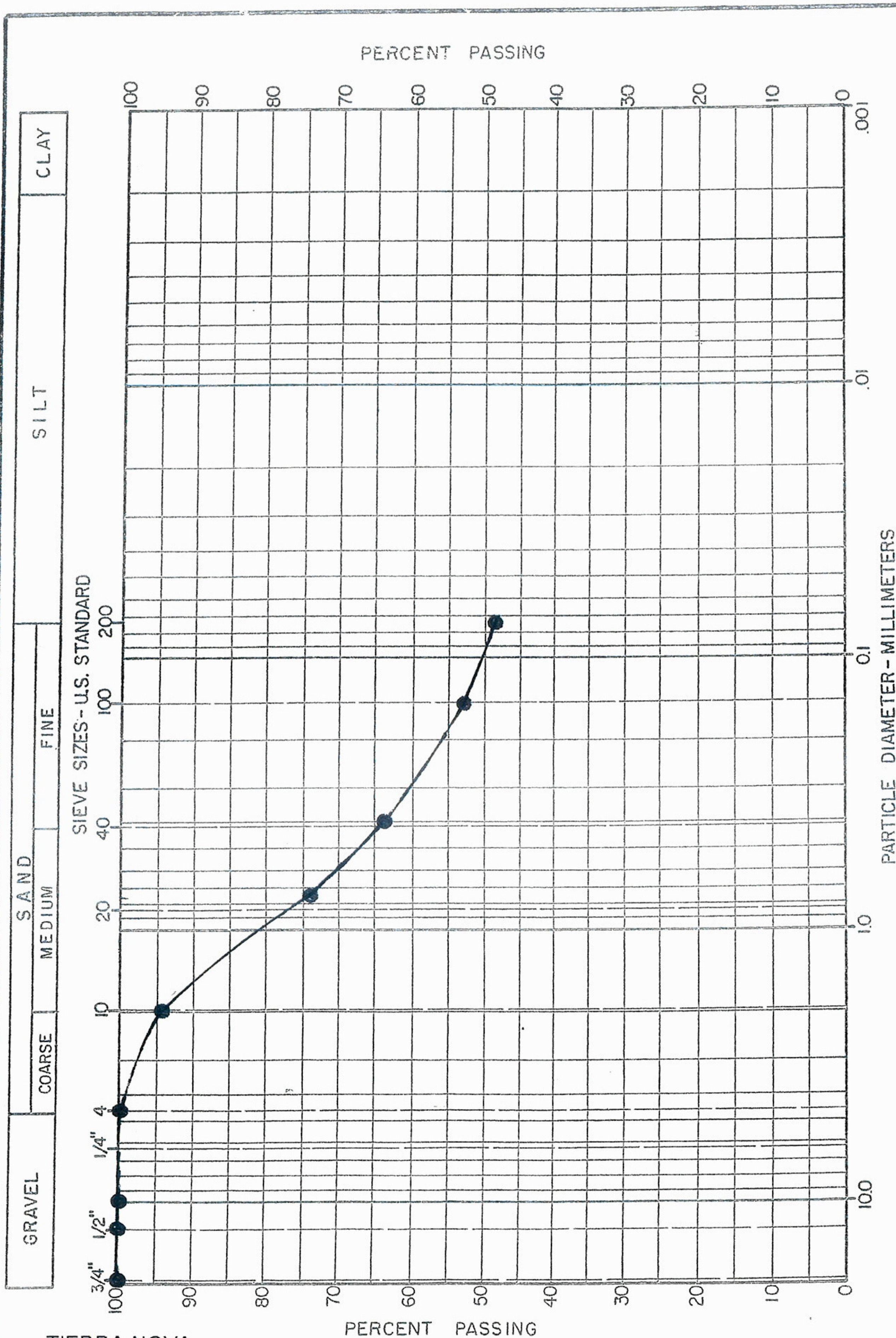
TIERRA NOVA



BORING NO.	DEPTH, FT.	SYMBOL	LIQUID LIMIT	PLASTIC INDEX	CLASSIFICATION
T-7	0-4	SM			ORANGE BROWN FINE SILTY SAND

C-6

JOB NO: 3721801.00	GRAIN SIZE DISTRIBUTION	FIGURE NO:



BORING NO.	DEPTH, FT.	SYMBOL	LIQUID LIMIT	PLASTIC INDEX	CLASSIFICATION
T-1	0-5	SM			ORANGE BROWN FINE SILTY SAND

SoilCor
CORROSION & THERMAL SCIENCES
41765 Hawthorn Street Murrieta, CA 92562
ph (951) 894-2682 • fx (951) 894-2683

Work Order No.: 18A1307
Client: South Shore Testing & Environmental
Project No.: 3721801.00
Project Name: Tierra Nova
Report Date: February 5, 2018

Laboratory Test(s) Results Summary

The subject soil sample was processed in accordance with California Test Method CTM 643 and tested for pH / Minimum Resistivity (CTM 643), Sulfate Content (CTM 417) and Chloride Content (CTM 422). The test results follow:

Sample Identification	pH	Minimum Resistivity (ohm-cm)	Sulfate Content (mg/kg)	Sulfate Content (% by wgt)	Chloride Content (ppm)
Corrosion Bulk	6.9	4,700	20	0.002	30

*ND=No Detection

We appreciate the opportunity to serve you. Please do not hesitate to contact us with any questions or clarifications regarding these results or procedures.

Ahmet K. Kaya, Laboratory Manager

SoilCor
CORROSION & THERMAL SCIENCES
41765 Hawthorn Street
Murrieta, CA 92562
ph (951) 894-2682

DIRECT SHEAR
ASTM D 3080

South Shore Testing & Environmental
Project: 3721801.00 Tierra Nova, Sample ID: Shear Bulk

Soil Description: (SC) Olive Brown, Clayey Fine-Coarse Sand
Displacement Rate: 0.050 in/m Box Gap: 0.025 in Max Data: 126.3 @ 10.3%
Remold Target Data: 90 % = 113.7 pcf 12.3 %Mc(-No.10) 2.65 Gs(assumed)
*As Received Mc: --- Adjusted Mc: --- % **After Shear Mc: --- %

*Existing Gradation for undisturbed specimens, -No.10 fraction for remolded specimens
**Test 1 Specimen (Highest Normal Stress)

☐ Undisturbed
■ Remolded

	Test 1		Test 2		Test 3	
SHEAR RECORD:	Prov. Ring	Vert. Dial	Prov. Ring	Vert. Dial	Prov. Ring	Vert. Dial
Displacement (in): 0.020	138	101	73	100	55	100
0.040	153	101	85	100	64	101
0.060	163	102	83	101	71	103
0.080	174	103	98	102	77	104
0.100	182	103	106	103	80	105
0.120	189	104	113	105	83	106
0.140	196	104	119	107	84	108
0.160	202	105	123	108	85	109
0.180	207	106	125	109	**85**	110
0.200	211	107	125	109	84	112
0.220	214	107	**126**	110	82	112
0.240	215	108	126	110	78	113
0.260	**216**	108	125	111	71	115
0.280	216	109	121	111		
0.300	214	110	117	111		
0.320	207	111	110	111		
0.340	201	112				
0.360	192	112				
0.380						
0.400						
0.420						
0.440						
0.460						
0.480						
0.500						

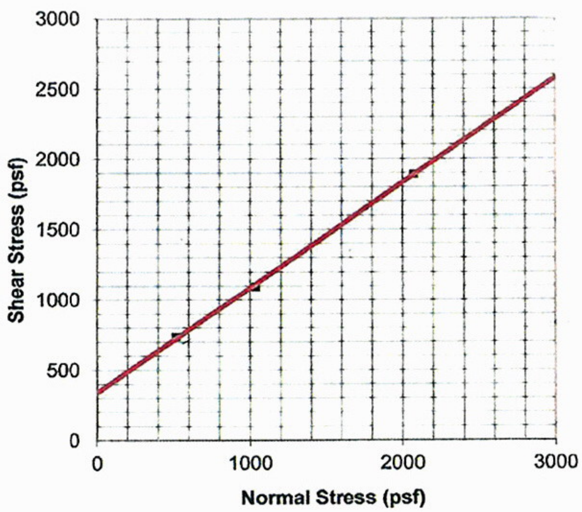
*SHEAR STRESS:	Divisions	Pounds	psf
Test 1:	216	64.48	1892
Test 2:	126	37.35	1096
Test 3:	85	25.13	737

***Ultimate Values**

NORMAL STRESS (psf):	
Test 1:	2070
Test 2:	1035
Test 3:	517

Ø=	**36.8°**
C=	**339psf**

Proving Ring
SN: 6927
Calibrated 30-August-16



Reviewed By: [signature] Date: 2/13/2018

APPENDIX D

Standards of Grading

STANDARD GRADING AND EARTHWORK SPECIFICATIONS

These specifications present **South Shore Testing & Environmental**, standard recommendations for grading and earthwork.

No deviation from these specifications should be permitted unless specifically superseded in the geotechnical report of the project or by written communication signed by the Soils Consultant. Evaluations performed by the Soils Consultant during the course of grading may result in subsequent recommendations which could supersede these specifications or the recommendations of the geotechnical report.

1.0 GENERAL

1.1 The Soils Consultant is the Owner's or Developer's representative on the project. For the purpose of these specifications, observations by the Soils Consultant include observations by the Soils Engineer, Soils Engineer, Engineering Geologist, and others employed by and responsible to the Soils Consultant.

1.2 All clearing, site preparation, or earthwork performed on the project shall be conducted and directed by the Contractor under the allowance or the supervision of the Soils Consultant.

1.3 The Contractor should be responsible for the safety of the project and satisfactory completion of all grading. During grading, the Contractor shall remain accessible.

1.4 Prior to the commencement of grading, the Soils Consultant shall be employed for the purpose of providing field, laboratory, and office services for conformance with the recommendations of the geotechnical report and these specifications. It will be necessary that the Soils Consultant provide adequate testing and observations so that he may provide an opinion as to determine that the work was accomplished as specified. It shall be the responsibility of the Contractor to assist the Soils Consultant and keep him apprised of work schedules and changes so that he may schedule his personnel accordingly.

1.5 It shall be the sole responsibility of the Contractor to provide adequate equipment and methods to accomplish the work in accordance with applicable grading codes, agency ordinances, these specifications, and the approved grading plans. If, in the opinion of the Soils Consultant, unsatisfactory conditions, such as questionable soil, poor moisture condition, inadequate compaction, adverse weather, etc, are resulting in a quality of work less then required in these specifications, the Soils Consultant will be empowered to reject the work and recommend that construction be stopped until the conditions are rectified.

1.6 It is the Contractor's responsibility to provides safe access to the Soils Consultant for testing and/or grading observation purposes. This may require the excavation of the test pits and/or the relocation of grading equipment.

1.7 A final report shall be issued by the Soils Consultant attesting to the Contractor's conformance with these specifications.

2.0 SITE PREPARTION

2.1 All vegetation and deleterious material shall be disposed of off-site. This removal shall be observed by the Soils Consultant and concluded prior to fill placement.

2.2 Soil, Alluvium or bedrock materials determined by the Soils Consultant as being unsuitable for placement in compacted fills shall be removed from the site or used in open areas as determined by the Soils Consultant. Any material incorporated as a part of a compacted fill must be approved by the Soils Consultant prior to fill placement.

2.3 After the ground surface to receive fill has been cleared, it shall be scarified, disced and/or bladed by the Contractor until it is uniform and free from ruts, hollows, hummocks, or other uneven features which may prevent uniform compaction.

The scarified ground surface shall then be brought to optimum moisture, mixed as required, and compacted as specified. If the scarified zone is greater than twelve inches in depth, the excess shall be removed and placed in lifts not to exceed six inches or less.

Prior to placing fill, the ground surface to receive fill shall be observed, tested, and approved by the soils consultant.

2.4 Any underground structures or cavities such as cesspools, cisterns, mining shafts, tunnels, septic tanks, wells, pipe lines, or others are to be removed or treated in a manner prescribed by the Soils Consultant.

2.5 In cut-fill transitions lots and where cut lots are partially in soil, colluvium or unweathered bedrock materials, in order to provide uniform bearing conditions, the bedrock portion of the lot extending a minimum of 5 feet outside of building lines shall be over excavated a minimum of 3 feet and replaced with compacted fill. Greater over excavation could be required as determined by Soils Consultant. Typical details are attached.

3.0 <u>COMPACTED FILLS</u>

3.1 Material to be placed as fill shall be free of organic matter and other deleterious substances, and shall be approved by the Soils Consultant. Soils of poor gradation, expansion, or strength characteristics shall be placed in areas designated by Soils Consultant or shall be mixed with other soils to serve as satisfactory fill material, as directed by the Soils Consultant.

3.2 Rock fragments less than six inches in diameter may be utilized in the fill, provided

- They are not placed or nested in concentrated pockets
- There is sufficient amount of approved soil to surround the rocks
- The distribution of rocks is supervised by the Soils Consultant

3.3 Rocks greater than twelve inches in diameter shall be taken off-site, or placed in accordance with the recommendations of the Soils Consultant, areas designated as suitable for rock disposal (A typical detail for Rock Disposal is attached.)

3.4 Material that is spongy, subject to decay, or otherwise considered unsuitable shall not be used in the compacted fil.

3.5 Representative samples of materials to be utilized as compacted fill shall be analyzed by the laboratory of the Soils Consultant to determine the physical properties. If any material other than that previously tested is encountered during grading, the appropriate analysis of this material shall be conducted by the Soils Consultant before being approved as fill material.

3.6 Material used in the compacting process shall be evenly spread, watered, processed, and compacted in thin lifts not to exceed six inches in thickness to obtain a uniformly dense layer. The fill shall be placed and compacted on a horizontal plane, unless otherwise approved by the Soils Consultant.

3.7 If the moisture content or relative compaction varies from that required by the Soils Consultant, the Contractor shall rework the fill until it has been approved by the Soils Consultant.

3.8 Each layer shall be compacted to at least 90 percent of the maximum density in compliance with the testing method specified by the controlling government agency or ASTM 1557-70, whichever applies.

If compaction to a lesser percentage is authorized by the controlling governmental agency because of a specific land use or expansive soil conditions the area to receive fill compacted to less than 90 percent shall either be delineated on the grading plan and/or appropriate reference made to the area in the geotechnical report.

3.9 All fills shall be keyed and benched through all topsoil, colluvium, alluvium, or creep material, into sound bedrock, or firm material where the slope receiving fill exceeds a ratio of five horizontal to one vertical or in accordance with the recommendations of the Soils Consultant.

3.10 The key for side hill fills shall be a minimum width of 15 feet within bedrock or firm materials, unless otherwise specified in the geotechnical report, (see detail attached.)

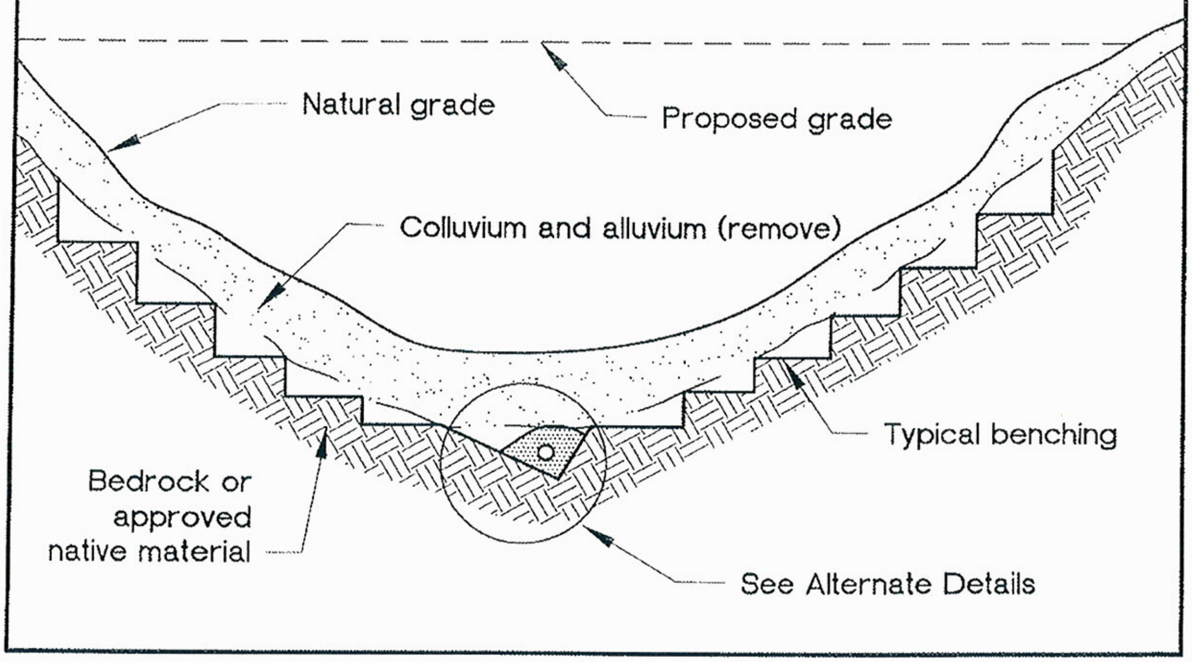
3.11 Sub drainage devices shall be constructed in compliance with the ordinances of the controlling governmental agency, or with the recommendations of the Soils Consultant. (Typical Canyon Subdrain details are attached.)

3.12 The contractor will be required to obtain a minimum relative compaction of at least 90 percent out to the finish slope face of fill slopes, buttresses, and stabilization fills. This may be achieved by either over building the slope and cutting back to the compacted core, or by direct compaction of the slope face with suitable equipment, or by any other procedure, which produces the required compaction approved by the Soils Consultant.

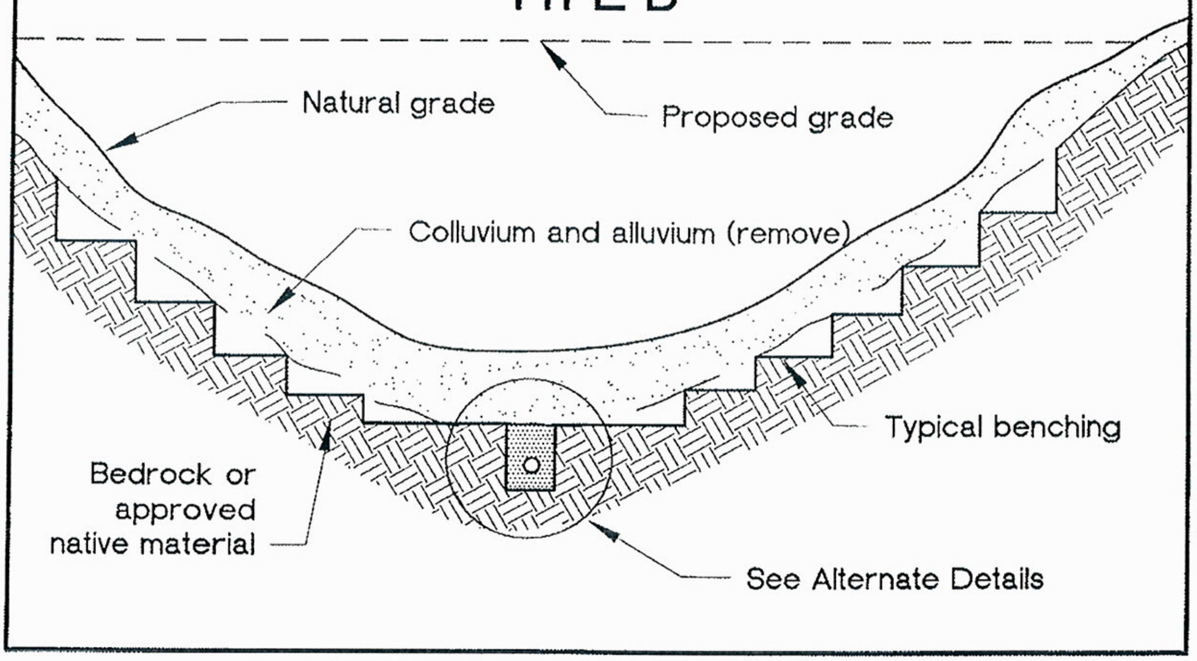
3.13 All fill slopes should be planted or protected from erosion by other methods specified in the Soils report.

3.14 Fill-over-cut slopes shall be properly keyed through topsoil, colluvium or creep material into rock or firm materials and the transition shall be stripped of all soils prior to placing fill (see attached detail.)

TYPE A

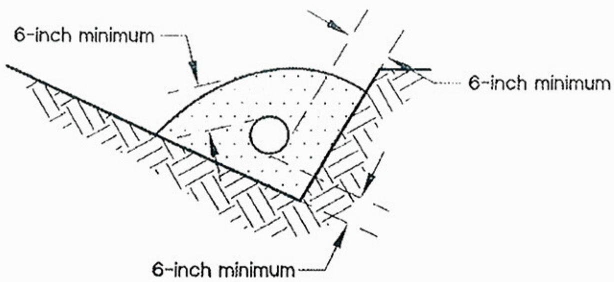


TYPE B

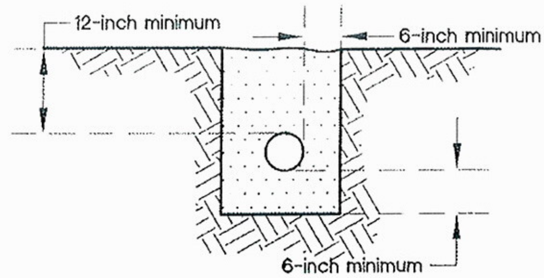


Selection of alternate subdrain details, location, and extent of subdrains should be evaluated by the geotechnical consultant during grading.

SOUTH SHORE TESTING	CANYON SUBDRAIN DETAIL	Plate 1



A-1



B-1

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

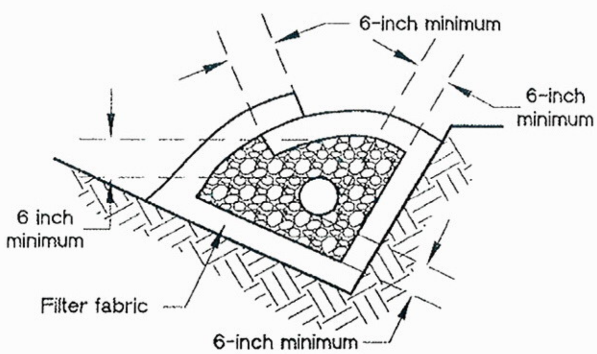
Perforated pipe: 6-inch-diameter ABS or PVC pipe or approved substitute with minimum 8 perforations (¼-inch diameter) per lineal foot in bottom half of pipe (ASTM D-2751, SDR-35, or ASTM D-1527, Schd. 40).

For continuous run in excess of 500 feet, use 8-inch-diameter pipe (ASTM D-3034, SDR-35, or ASTM D-1785, Schd. 40).

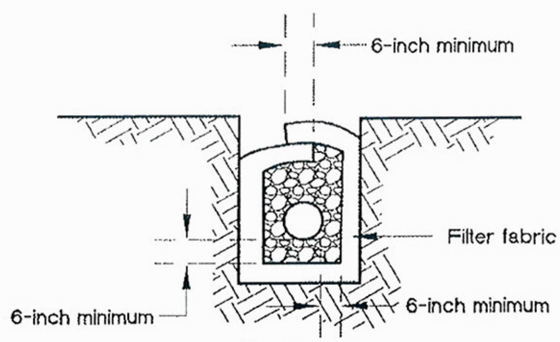
FILTER MATERIAL

Sieve Size	Percent Passing
1 inch	100
¾ inch	90-100
⅜ inch	40-100
No. 4	25-40
No. 8	18-33
No. 30	5-15
No. 50	0-7
No. 200	0-3

ALTERNATE 1: PERFORATED PIPE AND FILTER MATERIAL



A-2

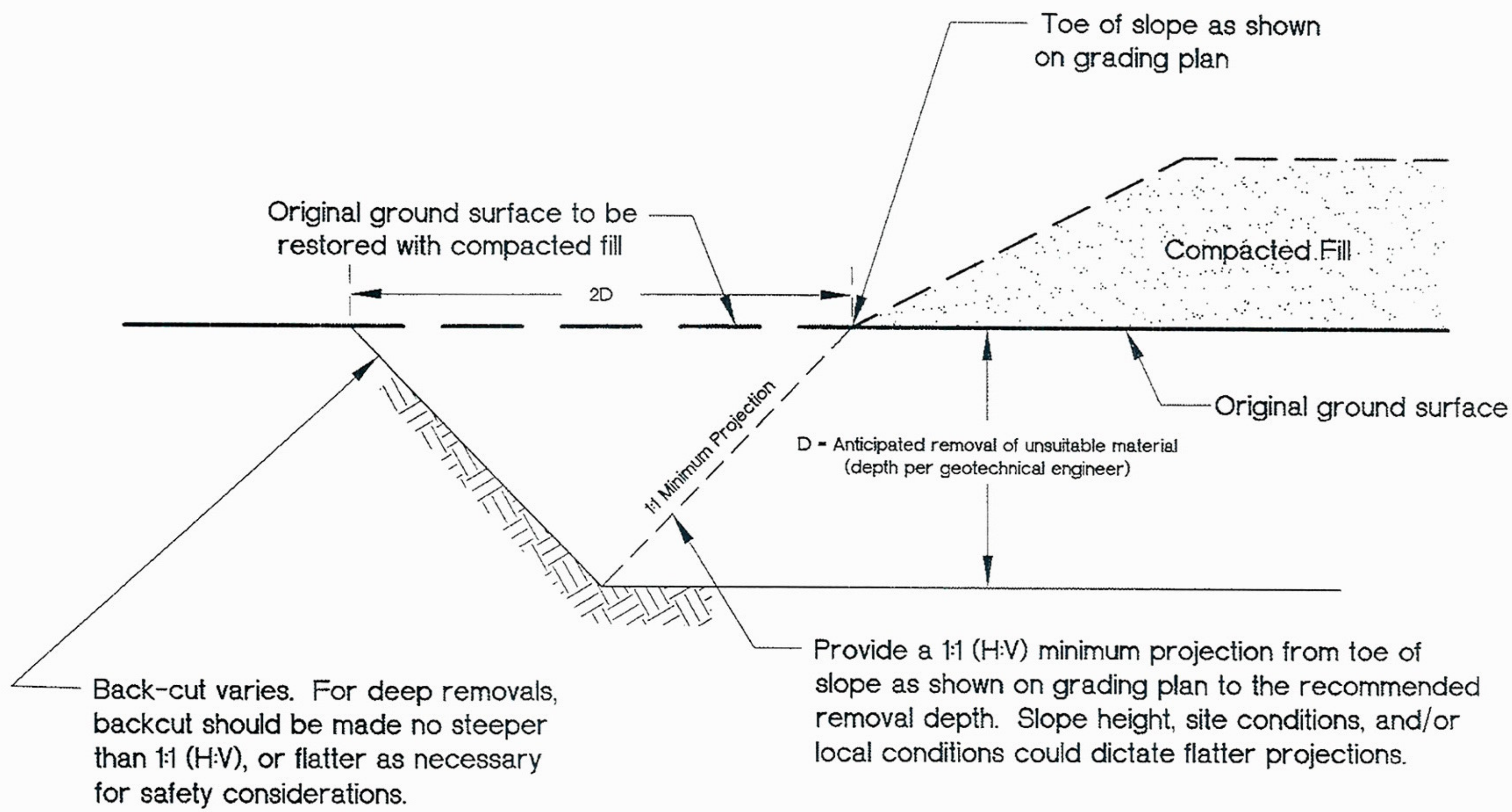


B-2

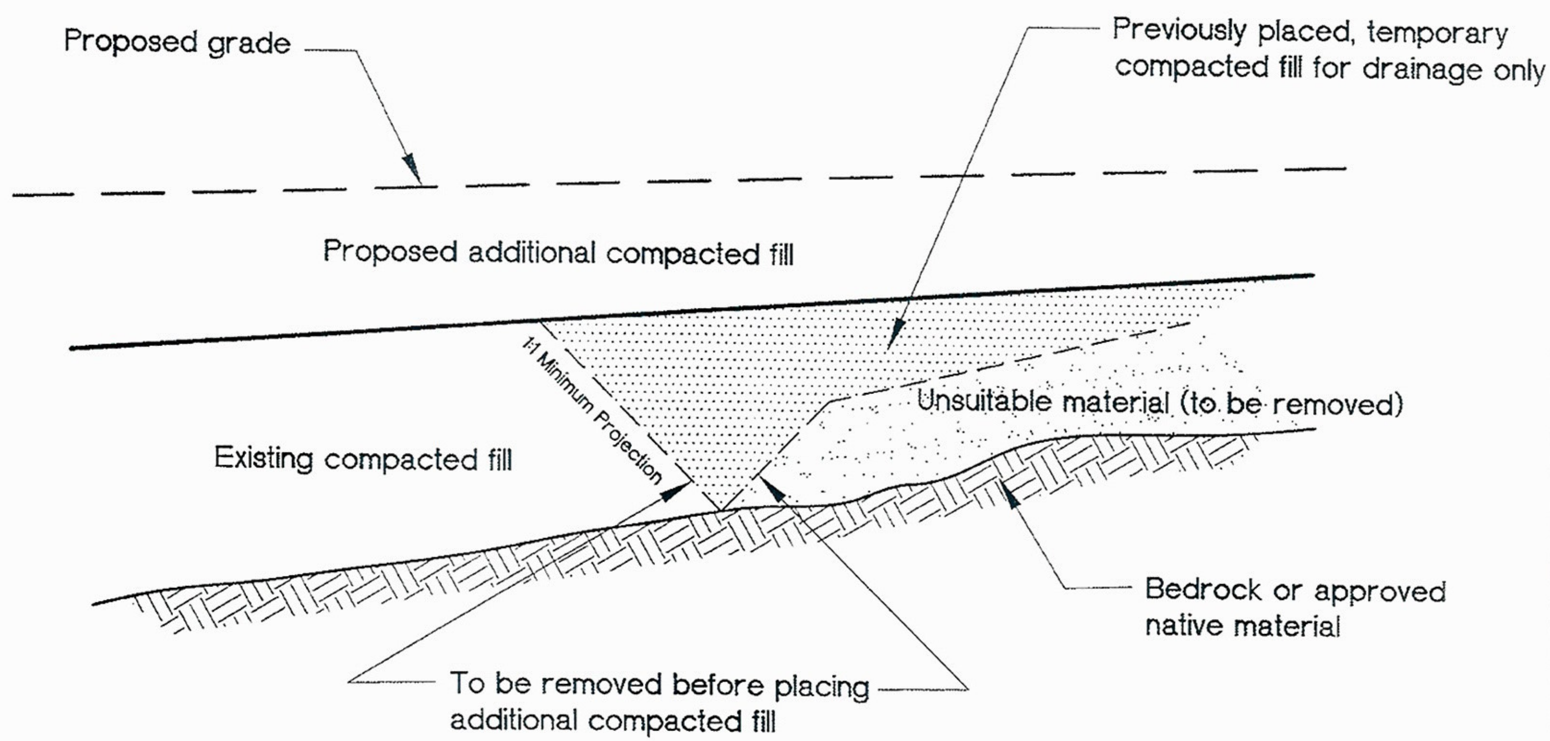
Gravel Material: 9 cubic feet per lineal foot.
Perforated Pipe: See Alternate 1
Gravel: Clean ¾-inch rock or approved substitute.
Filter Fabric: Mirafi 140 or approved substitute.

ALTERNATE 2: PERFORATED PIPE, GRAVEL, AND FILTER FABRIC

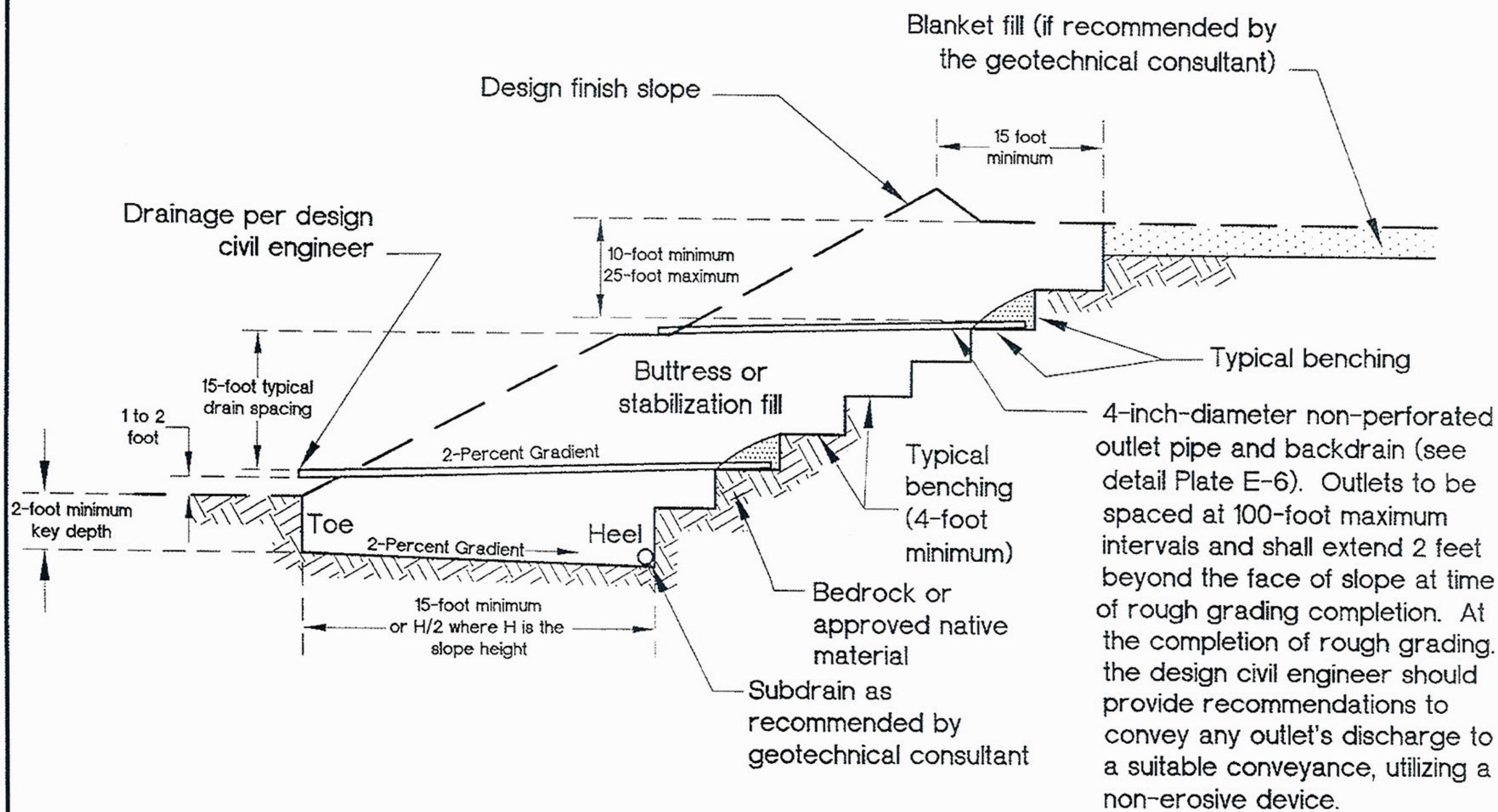
SOUTH SHORE TESTING	CANYON SUBDRAIN ALTERNATE DETAILS	Plate 2



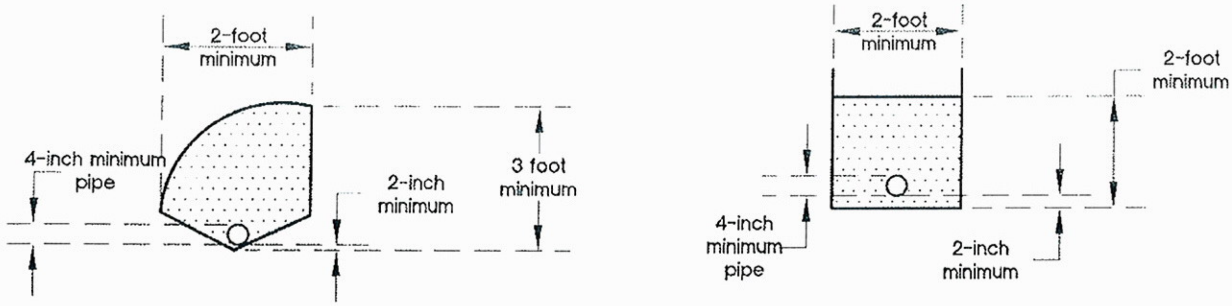
SOUTH SHORE TESTING	FILL SLOPE TOEING OUT ON FLAT ALLUVIATED CANYON DETAIL	PLATE 3



SOUTH SHORE TESTING	REMOVAL ADJACENT TO EXISTING FILL ADJOINING CANYON FILL DETAIL	Plate 4



SOUTH SHORE TESTING	TYPICAL STABILIZATION / BUTTRESS FILL DETAIL	Plate 5



Filter Material: Minimum of 5 cubic feet per lineal foot of pipe or 4 cubic feet per lineal feet of pipe when placed in square cut trench.

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

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

Notes:

1. Trench for outlet pipes to be backfilled and compacted with onsite soil.
2. Backdrains and lateral drains shall be located at elevation of every bench drain. First drain located at elevation just above lower lot grade. Additional drains may be required at the discretion of the geotechnical consultant.

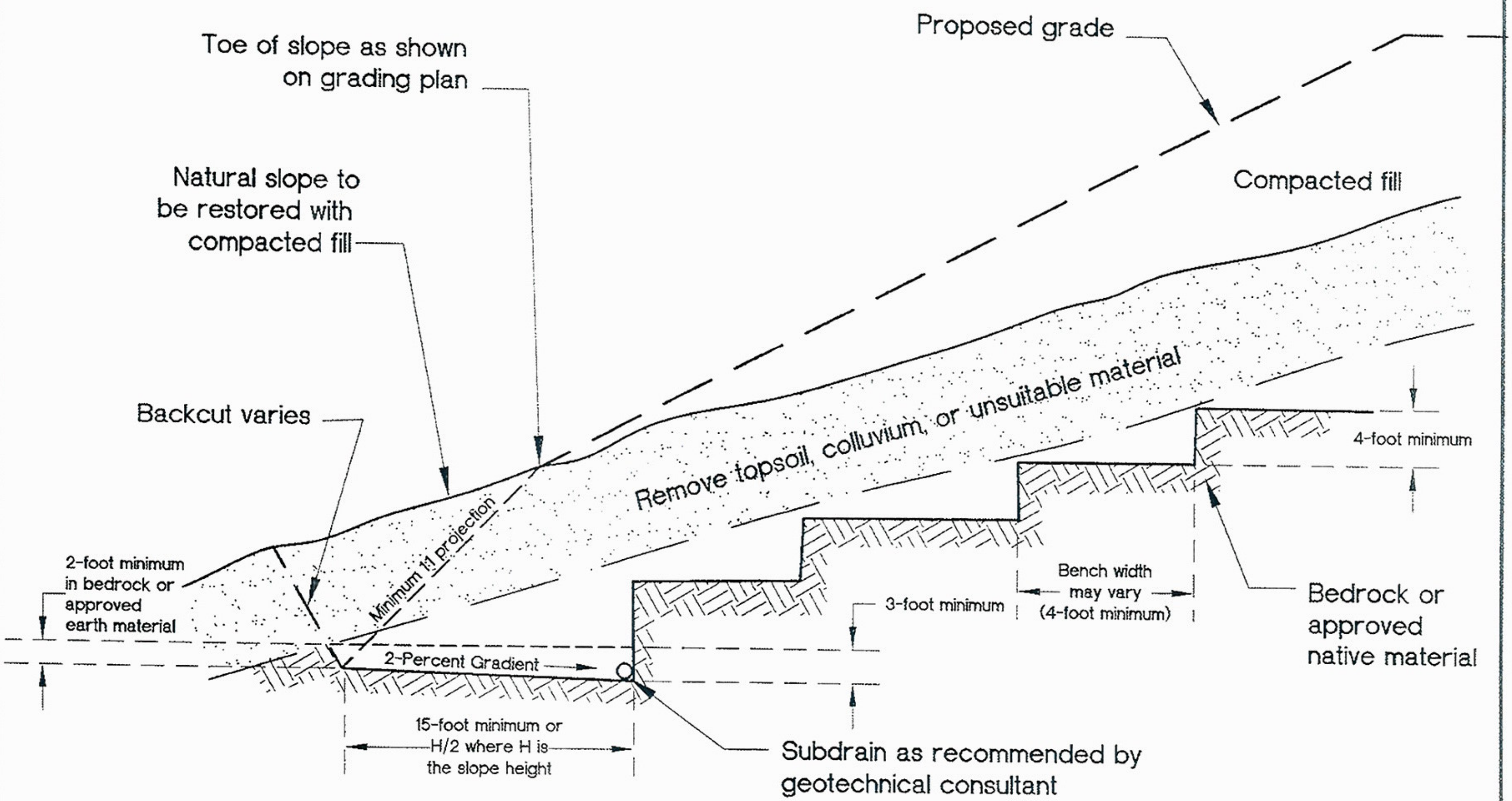
Filter Material shall be of the following specification or an approved equivalent.

Sieve Size	Percent Passing
1 inch	100
¾ inch	90-100
⅜ inch	40-100
No. 4	25-40
No. 8	18-33
No. 30	5-15
No. 50	0-7
No. 200	0-3

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

Sieve Size	Percent Passing
1½ inch	100
No. 4	50
No. 200	8

SOUTH SHORE TESTING	TYPICAL BUTTRESS SUBDRAIN DETAIL	Plate 6

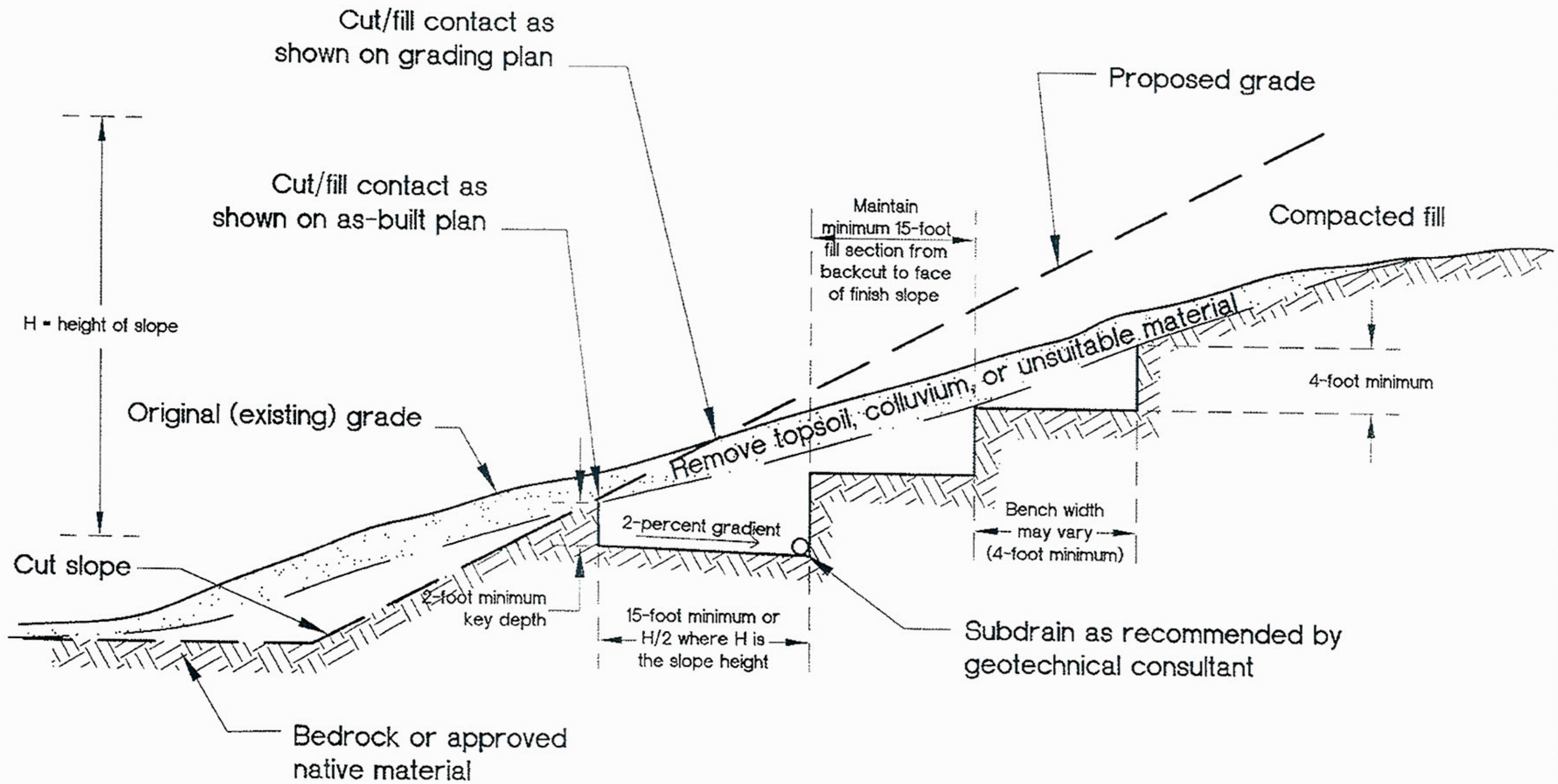


NOTES:

1. Where the natural slope approaches or exceeds the design slope ratio, special recommendations would be provided by the geotechnical consultant.

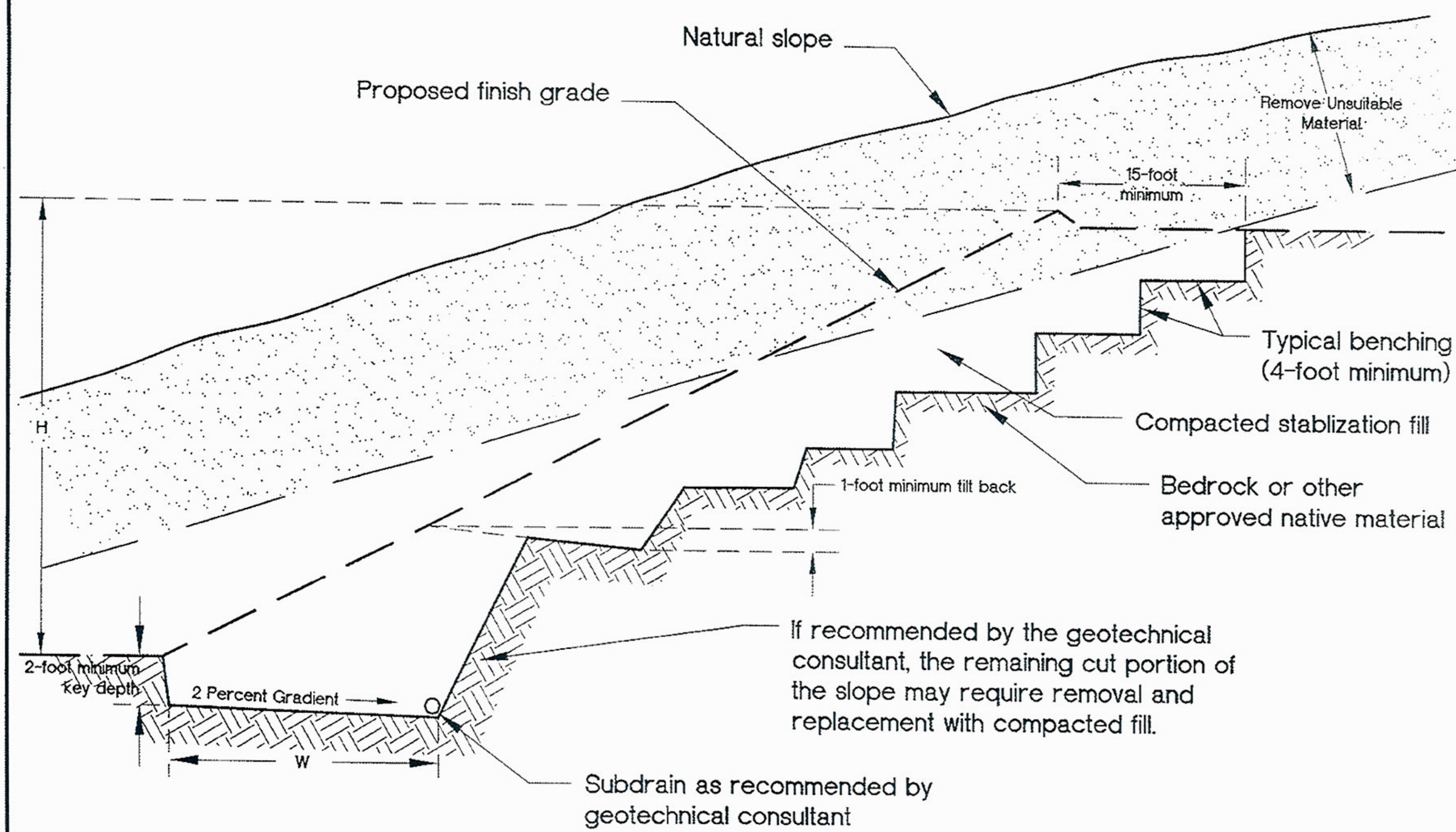
2. The need for and disposition of drains should be evaluated by the geotechnical consultant, based upon exposed conditions.

SOUTH SHORE TESTING	FILL OVER NATURAL (SIDEHILL FILL) DETAIL	Plate 7



NOTE: The cut portion of the slope should be excavated and evaluated by the geotechnical consultant prior to construction of the fill portion.

SOUTH SHORE TESTING	FILL OVER CUT DETAIL	Plate 8

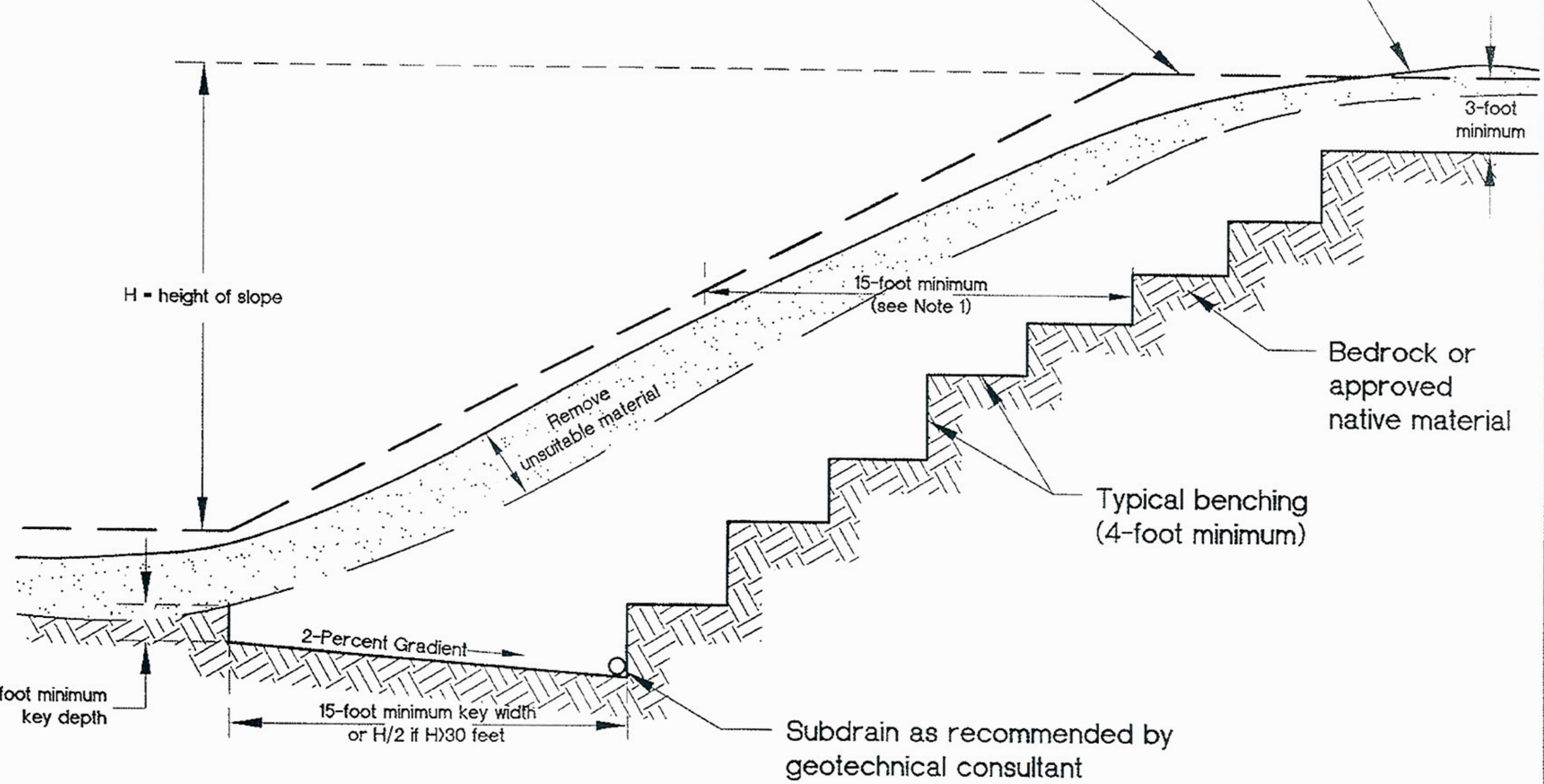


NOTES:

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

2 W shall be equipment width (15 feet) for slope heights less than 25 feet. For slopes greater than 25 feet, W shall be evaluated by the geotechnical consultant. At no time, shall W be less than H/2, where H is the height of the slope.

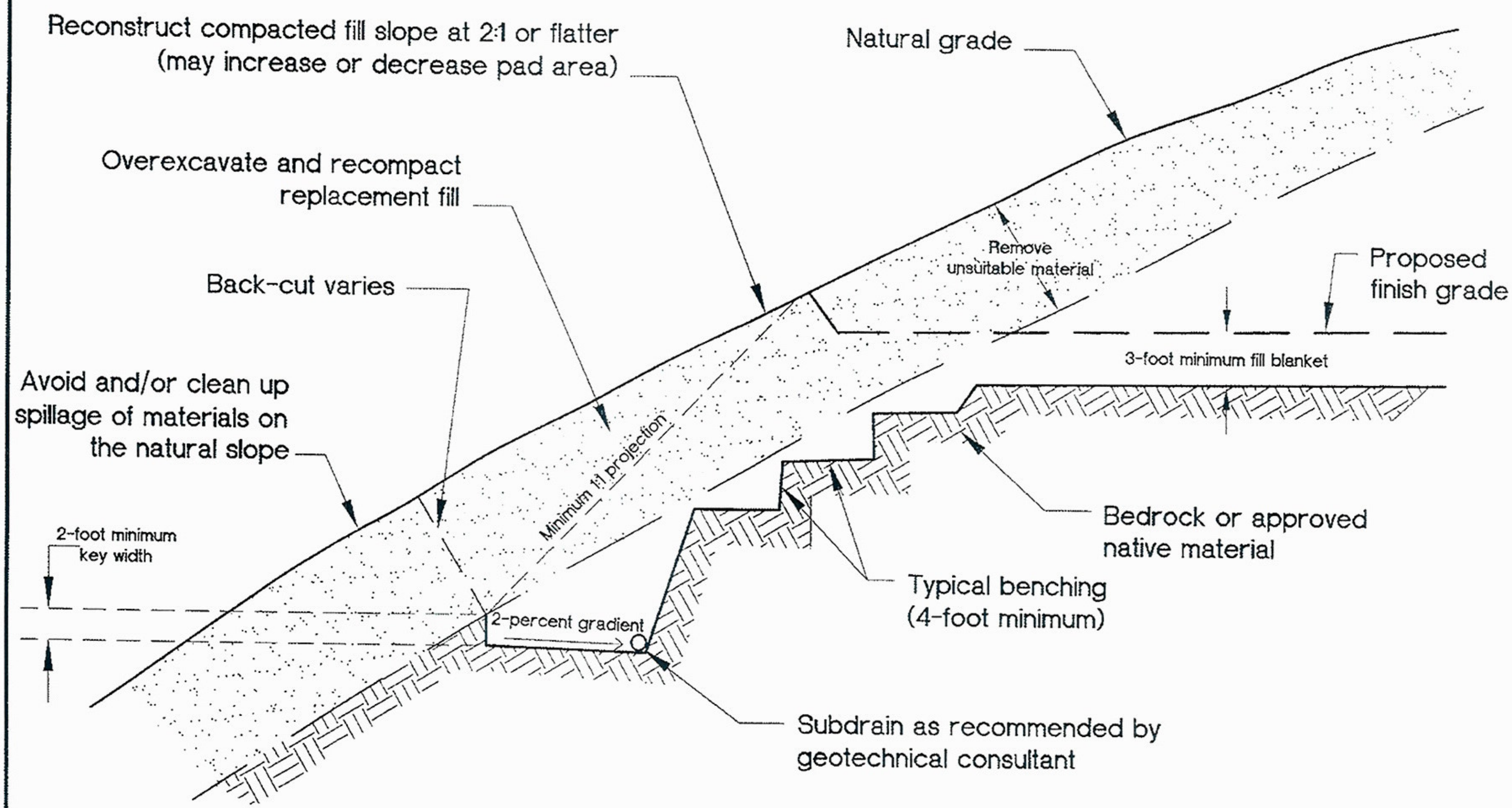
SOUTH SHORE TESTING	STABLIZATION FILL FOR UNSTABLE MATERIAL EXPOSED IN CUT SLOPE DETAIL	Plate 9



NOTES:

1. 15-foot minimum to be maintained from proposed finish slope face to backcut.
2. The need and disposition of drains will be evaluated by the geotechnical consultant based on field conditions.
3. Pad overexcavation and recompaction should be performed if evaluated to be necessary by the geotechnical consultant.

SOUTH SHORE TESTING	SKIN FILL OF NATURAL GROUND DETAIL	Plate 10

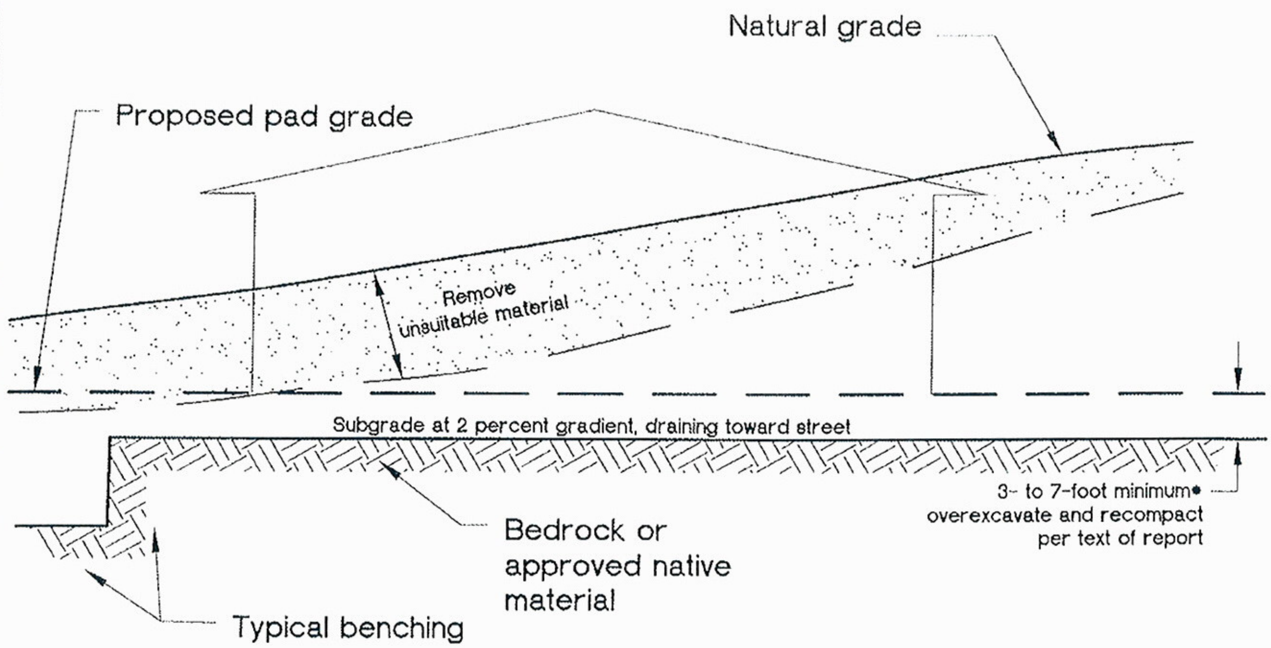


NOTES:

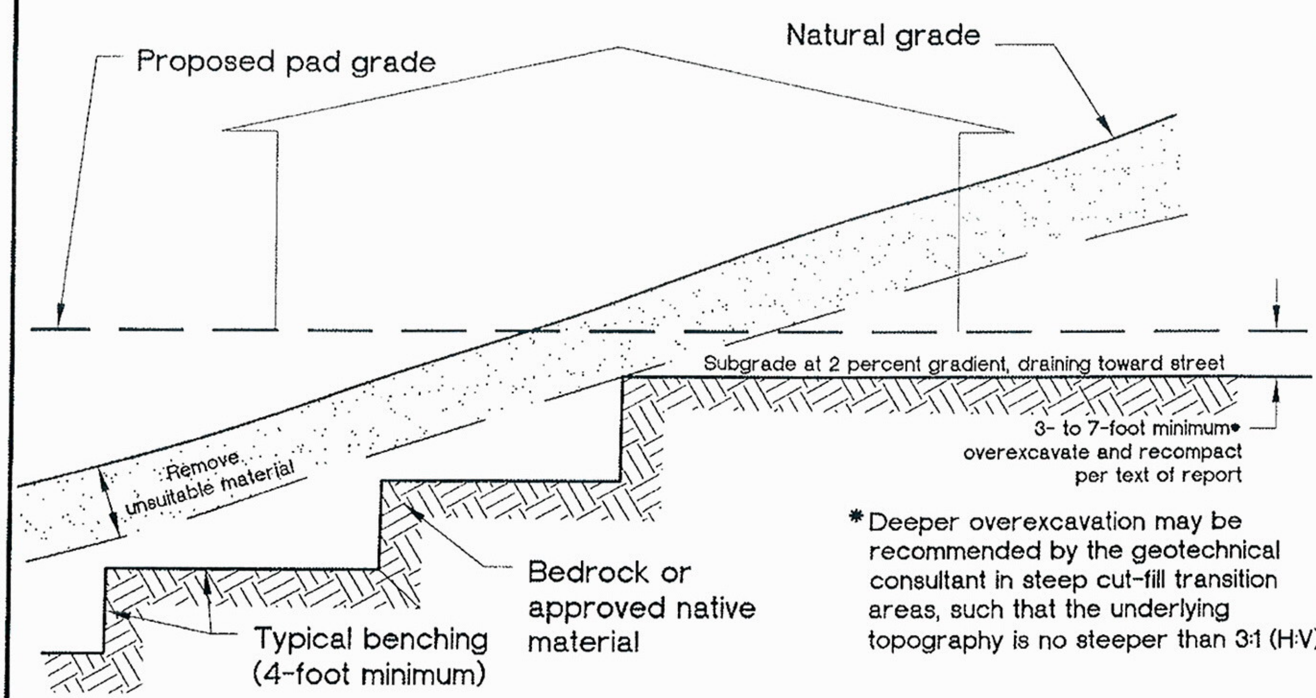
1. Subdrain and key width requirements will be evaluated based on exposed subsurface conditions and thickness of overburden.

2. Pad overexcavation and recompaction should be performed if evaluated necessary by the geotechnical consultant.

SOUTH SHORE TESTING	DAYLIGHT CUT LOT DETAIL	Plate 11



CUT LOT OR MATERIAL-TYPE TRANSITION

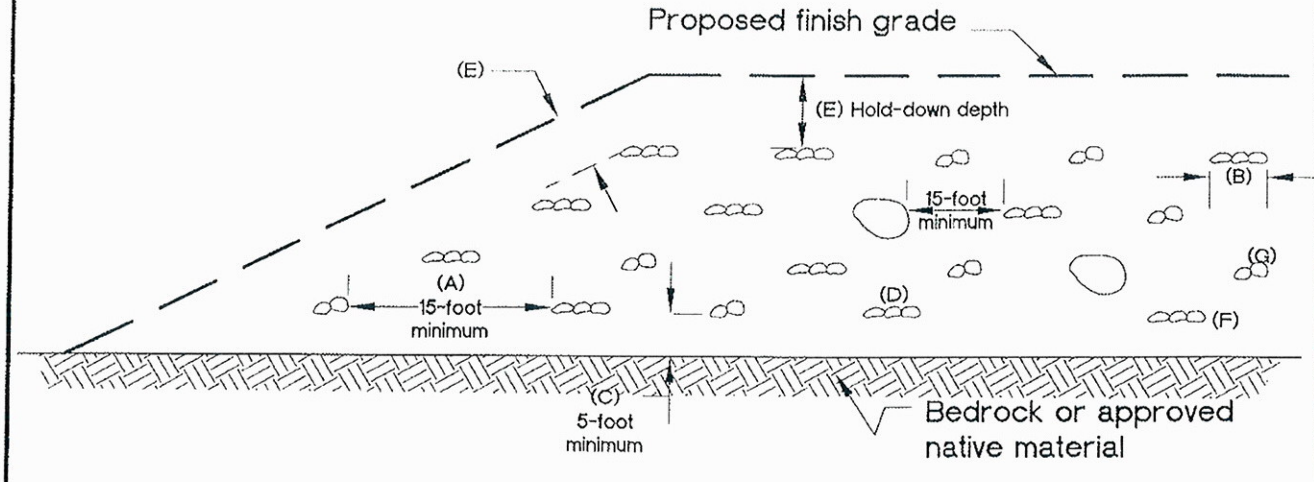


*Deeper overexcavation may be recommended by the geotechnical consultant in steep cut-fill transition areas, such that the underlying topography is no steeper than 3:1 (H:V)

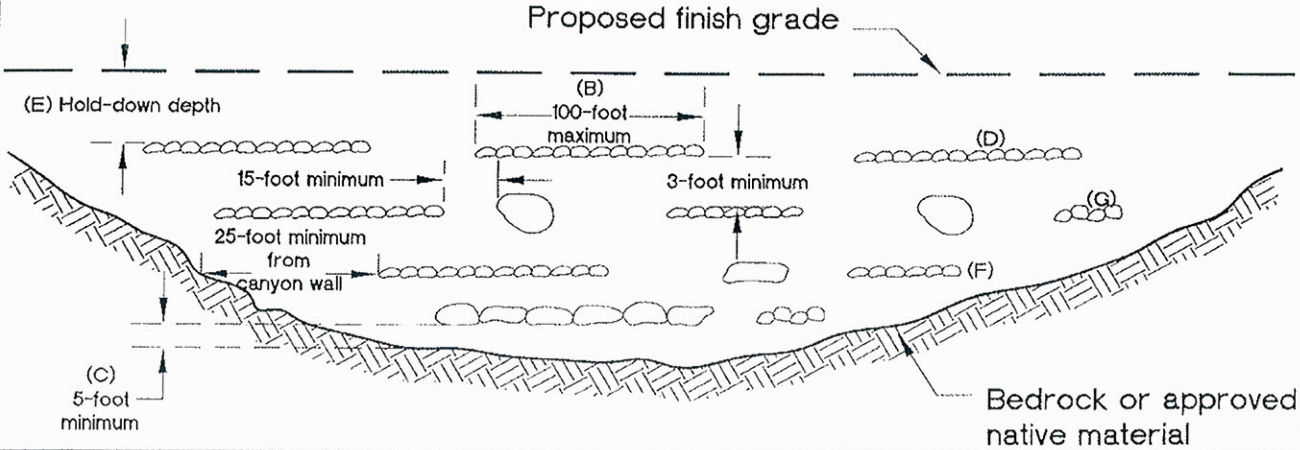
CUT-FILL LOT (DAYLIGHT TRANSITION)

SOUTH SHORE TESTING	TRANSITION LOT DETAILS	Plate 12

VIEW NORMAL TO SLOPE FACE



VIEW PARALLEL TO SLOPE FACE



NOTES:

A. One equipment width or a minimum of 15 feet between rows (or windrows).

B. Height and width may vary depending on rock size and type of equipment. Length of windrow shall be no greater than 100 feet.

C. If approved by the geotechnical consultant, windrows may be placed direclty on competent material or bedrock, provided adequate space is available for compaction.

D. Orientation of windrows may vary but should be as recommended by the geotechnical engineer and/or engineering geologist. Staggering of windrows is not necessary unless recommended.

E. Clear area for utility trenches, foundations, and swimming pools; Hold-down depth as specified in text of report, subject to governing agency approval.

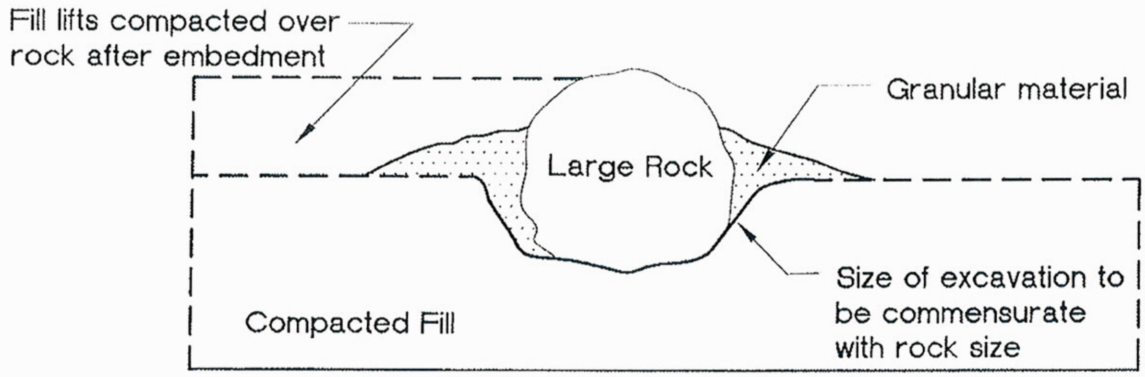
F. All fill over and around rock windrow shall be compacted to at least 90 percent relative compaction or as recommended.

G. After fill between windrows is placed and compacted, with the lift of fill covering windrow, windrow should be proof rolled with a D-9 dozer or equivalent.

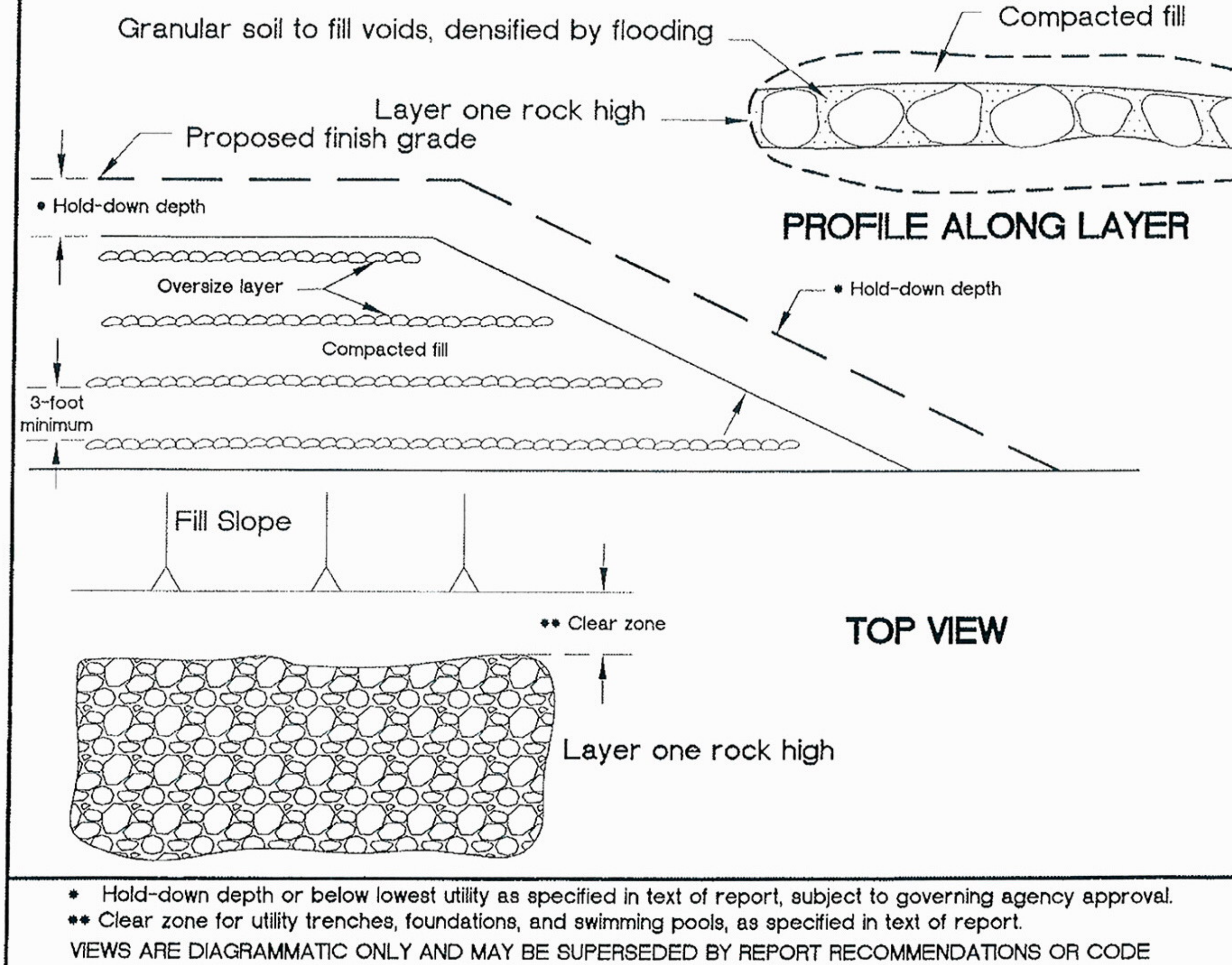
VIEWS ARE DIAGRAMMATIC ONLY AND MAY BE SUPERSEDED BY REPORT RECOMMENDATIONS OR CODE
ROCK SHOULD NOT TOUCH AND VOIDS SHOULD BE COMPLETELY FILLED

SOUTH SHORE TESTING	OVERSIZE ROCK DISPOSAL DETAIL	Plate 13

ROCK DISPOSAL PITS



ROCK DISPOSAL LAYERS



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

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

SOUTH SHORE TESTING	ROCK DISPOSAL DETAIL	Plate 14

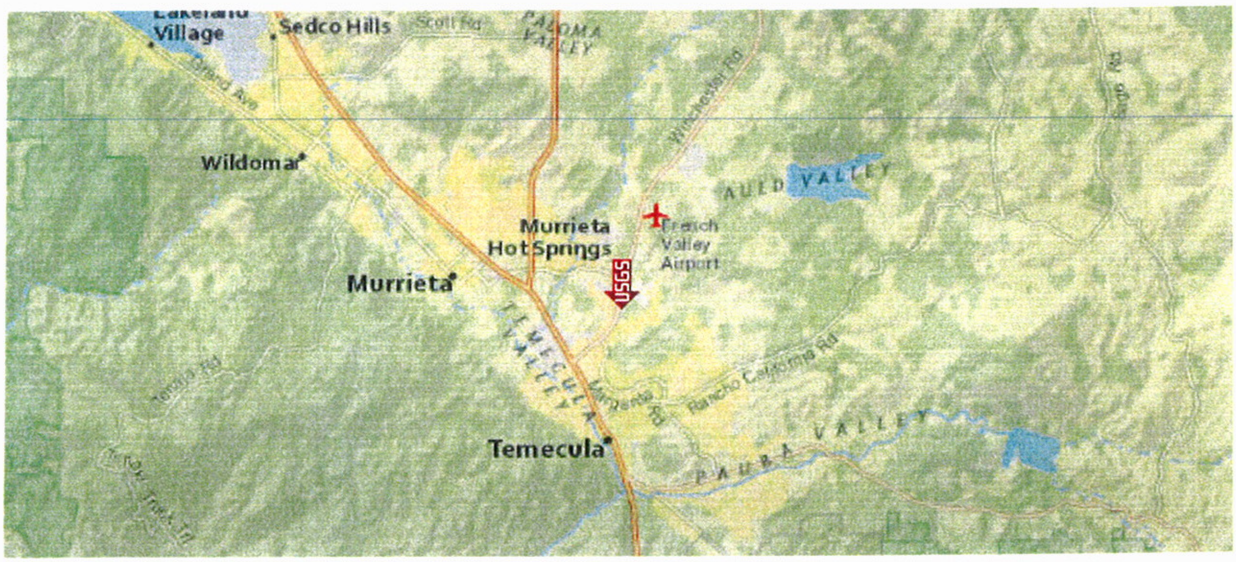
APPENDIX E

USGS Design Maps Summary Report

USGS Design Maps Summary Report

User–Specified Input

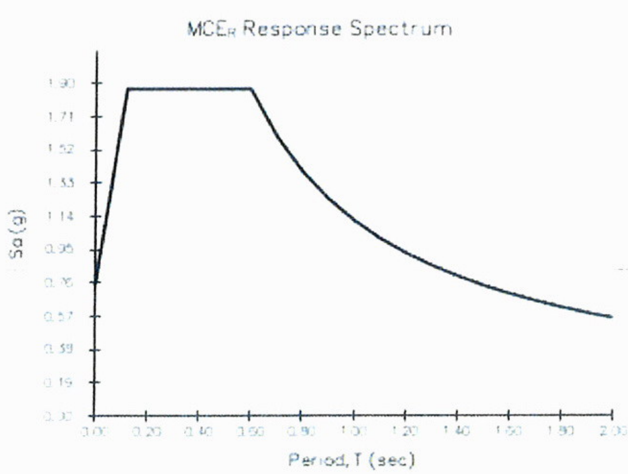
Report Title	Tierra Nova - MHS-98 Wed February 7, 2018 17:39:48 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	33.5512°N, 117.1427°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

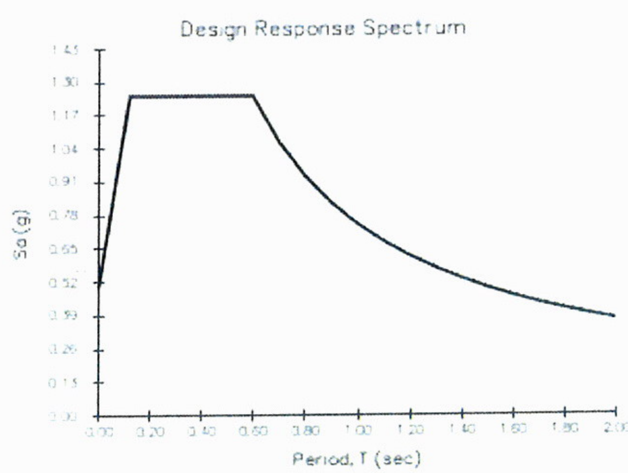


USGS–Provided Output

$S_S =$	1.870 g	$S_{MS} =$	1.870 g	$S_{DS} =$	1.247 g
$S_1 =$	0.745 g	$S_{M1} =$	1.118 g	$S_{D1} =$	0.745 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

USGS Design Maps Detailed Report

ASCE 7-10 Standard (33.5512°N, 117.1427°W)

Site Class D – "Stiff Soil", Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1 [1] $S_S = 1.870$ g

From Figure 22-2 [2] $S_1 = 0.745$ g

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_S$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index $PI > 20$, • Moisture content $w \geq 40\%$, and • Undrained shear strength $\bar{s}_u < 500$ psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 11.4.3 — Site Coefficients and Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Table 11.4-1: Site Coefficient F_a

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight-line interpolation for intermediate values of S_S

For Site Class = D and S_S = 1.870 g, F_a = 1.000

Table 11.4-2: Site Coefficient F_v

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight-line interpolation for intermediate values of S_1

For Site Class = D and S_1 = 0.745 g, F_v = 1.500

Equation (11.4-1): $S_{MS} = F_a S_S = 1.000 \times 1.870 = 1.870$ g

Equation (11.4-2): $S_{M1} = F_v S_1 = 1.500 \times 0.745 = 1.118$ g

Section 11.4.4 — Design Spectral Acceleration Parameters

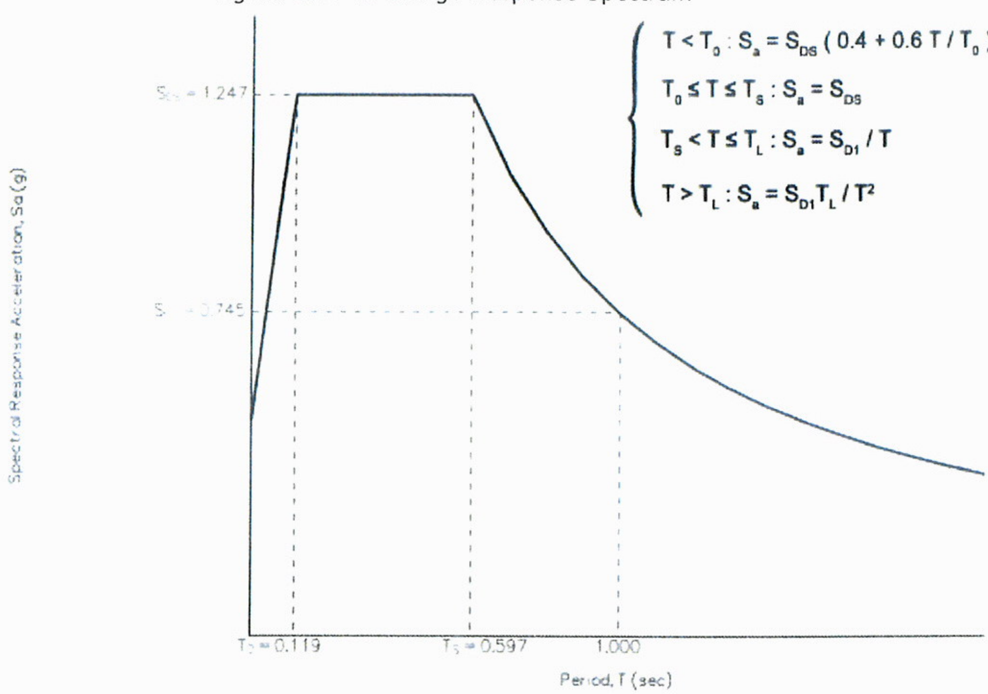
Equation (11.4-3): $S_{DS} = ⅔ S_{MS} = ⅔ \times 1.870 = 1.247$ g

Equation (11.4-4): $S_{D1} = ⅔ S_{M1} = ⅔ \times 1.118 = 0.745$ g

Section 11.4.5 — Design Response Spectrum

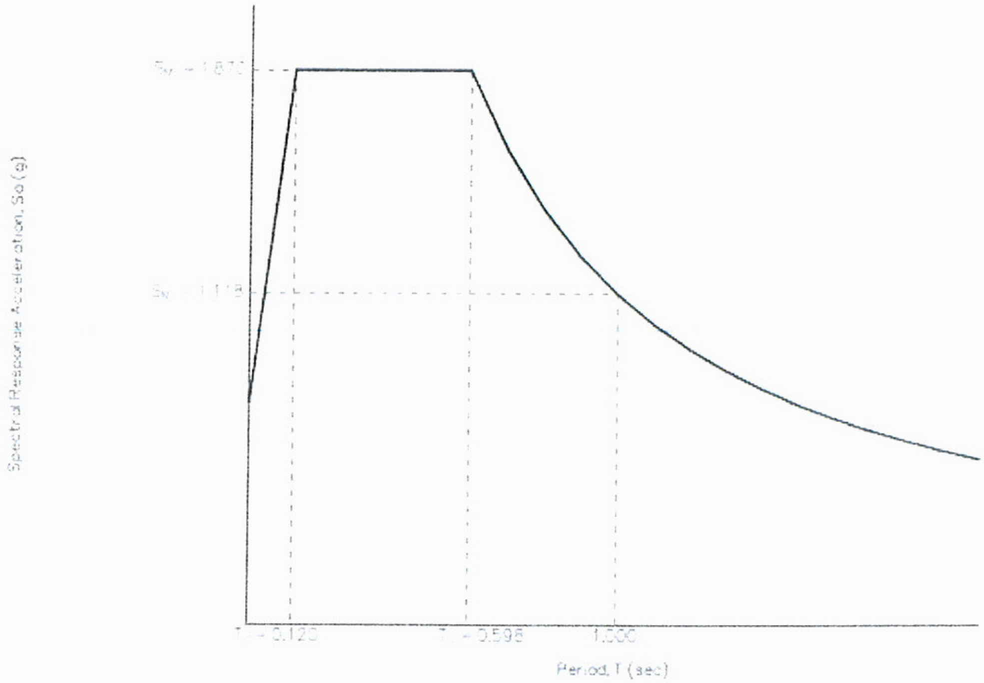
From Figure 22-12 [3] $T_L = 8$ seconds

Figure 11.4-1: Design Response Spectrum



Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum

The MCE_R Response Spectrum is determined by multiplying the design response spectrum above by 1.5.



Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] PGA = 0.732

Equation (11.8-1): $PGA_M = F_{PGA}PGA = 1.000 \times 0.732 = 0.732$ g

Table 11.8-1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	$\boxed{1.0}$
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight-line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.732 g, F_{PGA} = 1.000

Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From Figure 22-17 [5] C_{RS} = 0.947

From Figure 22-18 [6] C_{R1} = 0.933

Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 1.247 g, Seismic Design Category = D

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.745 g, Seismic Design Category = D

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = D

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 22-1*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf