GEOTECHNICAL EXPLORATION

6 MG WATER STORAGE RESERVOIR PROJECT

PITTSBURG, CALIFORNIA

SUBMITTED

TO

CAMP DRESSER & MCKEE INC.

WALNUT CREEK, CALIFORNIA

PREPARED

BY

ENGEO INCORPORATED

PROJECT NO. 2494-M2

DECEMBER 31, 1997

ENGEO
INCORPORATED

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

Project No.
2494-M2

December 31, 1997

Mr. Jon Toyoda
Camp Dresser & McKee Inc.
One Walnut Creek Center
100 Pringle Avenue, Suite 300
Walnut Creek, CA 94596

Subject: 6MG Water Storage Reservoir Project
Pittsburg, California

GEOTECHNICAL EXPLORATION

Dear Mr. Toyoda:

With your authorization, we conducted a Geotechnical Exploration for the City of Pittsburg 6MG Water Storage Reservoir Project in Pittsburg, California.

The accompanying report contains our exploration data, conclusions, and recommendations for grading, foundation design and final development of the project. It is our opinion that the water storage reservoir project is feasible from a geotechnical standpoint provided that the recommendations of this report are implemented.

We are pleased to be of service to you on this project and will continue to consult with you and your design team as project planning progresses.

Very truly yours,

ENGEO INCORPORATED

REGISTERED PROFESSIONAL ... JEAN E. MEURIS

Jean Meuris
JM/jf/gex
Attachments

Reviewed by:

Donald Bruggers

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INTRODUCTION

Purpose and Scope

The purpose of this geotechnical report is to provide recommendations regarding foundation design criteria, grading, and site drainage for construction of the proposed 6MG Water Storage Reservoir project.

The scope of our services included a review of available literature, geologic maps, and previous geotechnical reports pertinent to the site; exploratory drilling and sampling; laboratory testing of borehole sampling materials; analysis of collected geotechnical data; reporting our findings and providing our geotechnical recommendations.

This report was prepared for the exclusive use of CDM and their design team consultants. In the event that any changes are made in the character, design or layout of the project, the conclusions and recommendations contained in this report should be reviewed by our office to determine if modifications to the report are necessary. This document may not be reproduced in whole or in part by any means whatsoever, nor may it be quoted or excerpted without the express written consent of ENGEO Incorporated.

Site Location and Description

The project site is located at the south end of the Pittsburg Water Treatment Plant, off Olympia Drive in Pittsburg, California as shown on the Site Location Map, Figure 1. It is occupied by a 6MG reservoir, currently in use, but scheduled for replacement by the proposed reservoir system.

The original site topography consisted of the lower terminal section of a ridgeline with its crest sloping down in a near south to north direction from about elevation 192 feet mean sea level (msl) at the water treatment plant south boundary to about elevation 182 feet at the north edge of the existing 6MG reservoir and elevation at the rear of the treatment plant. The existing reservoir was constructed by excavating the ridge down to accommodate a finished center of tank floor elevation of 173.5 feet. Filling was done on the sides of the ridge line to support the sloped sides of the 6MG reservoir. The top of berm at the periphery of the 6MG reservoir is at about elevation 190 feet.

Proposed Construction

It is proposed to replace the 6MG reservoir currently in use by two post-tensioned concrete tanks, a smaller tank with a 1MG capacity and a larger tank with a 5MG capacity. The smaller tank will be built in front of the existing reservoir, as shown on Figure 2. This will require shoring the existing berm while the 6MG reservoir remains in operation. The existing reservoir will be removed and replaced by the 5MG tank once the 1MG tank has been completed and put into service. The 5MG tank will be located within the limits of the 6MG reservoir as shown in Figure 2.

Both reservoirs will have a bottom elevation at about 170 feet. The smaller tank will be 86 feet in diameter and the larger one will be 170 feet in diameter. It is our understanding that both reservoirs will have a peak roof elevation of 198.8 feet. A significant amount of filling will be required, mostly on the west side of the 5MG tank, to backfill the excess excavation remaining from the removal of the existing 6MG reservoir. A permanent unsupported slope will be graded between the two tanks to replace the temporary shoring.

GEOLOGIC CONDITIONS

Site Geology

The geology of the existing and proposed tank site was mapped by Dibblee (1980) as part of regional mapping of the Honker Bay Quadrangle. The project site is mapped as Tertiary-age sedimentary bedrock described as weakly indurated pebble conglomerate, sandstone and claystone referred to at the Tehama formation (Dibblee, 1980). Recent bedrock mapping by Crane (1995a) also shows the site is underlain by Tertiary age Tehama bedrock described as non-marine clays, silts, sands, tuffaceous sands and gravels. Crane (1995a) does not map any faults underlying the immediate vicinity of the tank site.

No landslides were mapped by Nilsen (1975) on, or affecting the property.

Faulting and Seismicity

The project site is located in a region that contains numerous active earthquake faults. No known faults are mapped at the property. The nearest State of California zoned active[1] faults are the Concord and Greenville faults, located about 7 miles west and 10 miles to the south,respectively. The closest mapped fault is the East Kirker Pass fault, mapped about 2,000 feet to the northeast (Crane, 1995a). This fault is considered inactive.

The Coast Ranges – Sierran Block (CRSB) boundary is mapped approximately 8 miles east of the property. This boundary is considered a seismically active thrust fault; however, since the fault does not extend to the ground surface, it is not zoned by the State of California. The CRSB is considered capable of generating the highest ground shaking at the site, up to 0.33g, for a maximum

[1] An active fault is defined by the State Mining and Geology Board as one that has had surface displacement within Holocene time (about the last 10,000 years) (Hart, 1992). The State of California has prepared maps designating zones for special studies that contain these active earthquake faults.

probable event, according to attenuation relationships by Idriss (1994). However, the recurrence interval for the boundary is believed longer than for the closer strike-slip faults.

Because of the presence of active faults in the region, the Pittsburg area is seismically active. Numerous small earthquakes occur every year in the region, and large (>M7) earthquakes have been recorded and can be expected to occur in the future. Table I lists distances to known active and potentially active faults located within 50 miles (80 km) of the subject site and summarizes their estimated earthquake magnitudes and ground shaking potentials. Figure 4 shows the approximate locations of these faults and significant historic earthquakes recorded within the San Francisco region.

Site Soils

The United States Department of Agriculture (1977) has mapped the soils at the Pittsburg Water Treatment Plant as the Altamont Series clay, which is classified as having a moderate to high plasticity, a high shrink-swell potential and high corrosivity toward uncoated steel.

Field Exploration

Exploratory Test Borings. The field exploration for this study was conducted in December 1997. Four test borings were drilled on the parcel at the approximate locations shown in Figure 2. The borings were approximately located by pacing from existing features. The elevations for the borings were estimated from maps provided by CDM.

A truck-mounted drill rig with continuous 6-inch-diameter flight augers was used to drill the borings to a maximum depth of 30 feet. Our field representative logged the borings and took samples during drilling for soil identification and laboratory testing using a 3-inch O.D. California-type split-spoon sampler fitted with 6-inch-long brass liners. A 2-inch O.D. Standard Penetration Test (SPT) split-spoon sampler was used in more dense granular materials.

The penetration of the samplers into the native materials was field recorded as the number of blows needed by the 140-pound hammer with a 30-inch drop to advance the sampler 18 inches in 6-inch increments. The blow counts observed when using the 3-inch sampler have been converted to Standard Penetration Test (SPT) values using published blow count conversion factors (Seed et al, 1985). The standard penetration test, used predominantly for cohesionless materials, is made with a 2-inch-diameter split-spoon sampler. SPT results on the boring logs are the number of blows required for the last one-foot penetration.

The field logs were used to develop the report borelogs (Figures 5 through 8). The logs depict subsurface conditions within the borings for the date of drilling; however, subsurface conditions may vary with time. All boreholes were backfilled with cement slurry in accordance with Contra Costa County standard procedures on the day of drilling.

Laboratory Testing

Soil samples recovered during borehole drilling were selected for laboratory testing to determine the following soil characteristics:

Characteristic	Test Method	Location of Results Within this Report
Natural Unit Weights	ASTM D-2216	Boring Logs
Natural Moisture Contents	ASTM D-2216	Boring Logs
Atterberg Limits	ASTM D-4318	Figure 9
Shear Strength	ASTM D-3080	Figures 10 through 12

Natural unit weights and moisture contents are presented on the borelogs (Figures 5 through 8). The results for the Atterberg Limits and shear testing are presented in Figures 9 through 12.

Subsurface Stratigraphy

In general, the native soil materials encountered in the borings consist of interlayered silty clay, sandy clay clayey sand, silty sand and gravelly sand. The thicker deposits of clay were encountered in the borings located on the west and east sides of the original ridge line (Borings 1 and 4).

Very dense silty and gravelly sands were encountered below a depth of about 11 to 14 feet in Boring 2 located on the north side of the existing reservoir. Very dense sands were encountered at a depth of about 8 feet below ground surface in the area of the proposed 1MG tank. Bedrock, consisting of highly weathered sandstone was encountered at a depth of 20 feet, in Boring 1, at the top of slope, on the north-west side of the existing reservoir.

Atterberg Limits were determined on samples of site silty and sandy clays. Plasticity Indices of 22 and 31 were determined for the sandy and silty clays respectively. These indices are indications of moderately high to high swell potentials.

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Ground Water

No free ground water was encountered in any of the boreholes during drilling. A well casing was installed in Boring 4 to monitor ground water levels after the end of drilling. Ground water was measured several days after the end of drilling at a depth of approximately 17 feet below the ground surface; this corresponds to about elevation 157 feet, about 13 feet below the proposed tank bottom.

DISCUSSION AND CONCLUSIONS

Seismic Hazards

Seismic hazards can generally be classified as primary and secondary. The primary effect is ground rupture also called surface faulting. The common secondary seismic hazards include ground shaking, lurch cracking, soil liquefaction, lateral spreading, landslides, tsunamis and seiches.

Since there are no known active faults crossing the site and the site is not within an Alquist-Priolo Special Study Zone, the likelihood of ground rupture is considered remote. We would anticipate that an earthquake of moderate to high magnitude generated on any known fault in the Greater Bay Area Region would cause considerable ground shaking at the site, similar to that which has been previously experienced.

Ground Shaking. An earthquake of moderate to high magnitude generated within the San Francisco Bay Region could cause considerable ground shaking at the site, similar to that which has occurred in the past. To mitigate the shaking effects, all structures should be designed using sound engineering judgment and as a minimum, the latest Uniform Building Code (UBC) requirements. We recommend using Soil Profile S_B (UBC 1997; Table 16-J) in seismic design.

Seismic design provisions of current building codes generally prescribe minimum lateral forces, applied statically to structures, combined with the gravity forces of dead and live loads. The prescribed lateral forces are generally considered to be substantially smaller than the equivalent forces that would be associated with a major earthquake. Conformance to the current building code recommendations does not constitute any kind of guarantee that significant structural damage would not occur in the event of a maximum credible earthquake; however, it is reasonable to expect that a well-designed and well-constructed structure will not collapse or cause loss of life in a major earthquake.

Ground Accelerations. Ground shaking at a particular site resulting from an earthquake can be estimated from relationships between ground acceleration, earthquake magnitude and distance from the causative fault.

For this study, a probabilistic seismic hazard evaluation has been conducted. In this analysis, the computer program EZ-FRISK (Risk Engineering, Inc., 1997) was used to model the seismic setting of the region. This model can account for uncertainty relating to:

- Earthquake magnitude
- Rupture length
- Location of rupture
- Maximum possible earthquake magnitude
- Attenuation relationship

The program calculates, by summation from earthquake sources, the total average annual expected number of occurrences of an acceleration greater than each of several specified values. Once the annual probability is obtained, the probability of the level of ground acceleration being exceeded over a specified time period can be calculated by the following equation:

$$P = 1 - e^{-pT}$$

in which P is the probability of the level of ground acceleration being exceeded in T years, p is the annual probability of exceedance and e is the Napierian constant 2.718···.

The peak horizontal ground accelerations calculated from the probabilistic seismic hazard evaluation are presented on Figure 13 where the average return period on the ordinate is the inverse of the annual probability of exceedance (p). Attenuation relationships developed by Abrahamson and Silva (1995) were used in our analysis. Using the relationship depicted on Figure 13, the probability of exceedance for various accelerations can be calculated for a 50-year design life using the above equation. This calculation has been made with the results presented on Figure 14. A horizontal ground acceleration of 0.45g is predicted to have a 10 percent probability of exceedance for a 50-year design life.

Spectral Accelerations. A probabilistic seismic analysis was also performed using the computer program EZ-FRISK to develop uniform hazard spectra. This procedure is similar to that described above but for various values of undamped natural period. The program was used to compute uniform probability design spectra at 5 percent damping using spectral-ordinate attenuation relations. Ratios to 5 percent damped spectral values were used to develop spectral accelerations for ½, 2, and 10 percent damping (Abrahamson, 1995). The spectra were developed for a uniform hazard corresponding to a 10 percent probability of exceedance in 50 years. The spectral accelerations for the four damping values are presented on Figure 15.

Liquefaction. Liquefaction is a phenomenon in which saturated cohesionless soils are subject to a temporary but essentially total loss of shear strength because of pore pressure build-up under the reversing cyclic shear stresses associated with earthquakes. As a result, these soils are temporarily transformed into a liquid state.

Based on our analyses, the granular soil encountered in our borings in the tank areas is not considered potentially liquefiable due to either high density, high fines content or lack of groundwater. Hence, liquefaction at this site is considered unlikely during earthquake ground shaking.

Densification due to Earthquake Shaking. It was determined during drilling that the soils encountered below a depth of about 10 feet below ground surface are in a dense state. Therefore, densification induced by earthquake shaking is not expected for these soils. Where necessary, shallower soils will be removed and recompacted. This is addressed later in this report.

Lateral Spreading. Lateral spreading is horizontal movement of soil on top of liquefied granular or sandy soils induced by strong seismic shaking. Lateral spreading can cause severe cracking and differential displacement of the ground surface. Areas most susceptible to lateral spreading are unengineered man-made fill and loose cohesionless alluvial deposits along streams and channels. In our opinion, lateral spreading is unlikely at this site because there were no soils encountered that would be considered susceptible to liquefaction.

Expansive Soils

The clayey soils at the site display a moderate to high Plasticity Index which is an indication of high potential for shrink-swell behavior. Expansive soils shrink and swell as a result of moisture change which can cause heaving and cracking of slabs-on-grade. Such soils should be removed from the tank subgrade areas and, if necessary, replaced by site sands or select low swell potential import fill.

Conclusions

Based on our explorations, we conclude that the proposed water reservoir project is feasible from a geotechnical standpoint, provided that the recommendations included in this report are incorporated in the design and construction of the project, along with other sound engineering practices. We expect that some of these recommendations may have to be supplemented, particularly in the area of the 5MG tank, as construction proceeds, and more detailed subsurface site features are exposed.

As mentioned earlier, it is our understanding that project development will be conducted in four phases. The first phase will include grading followed by construction of the 1MG tank. Once the 1MG tank has been put into service, the second phase will be initiated by demolition of the existing 6MG tank. The third phase will include subgrade grading and construction of the new 5GM tank. The fourth phase of construction will consist of backfilling around the 5MG tank to the desired grades.

RECOMMENDATIONS

General

The recommendations for grading contained in this report are of a general nature since formal grading plans were not available at the time of this writing. It is expected that much of the grading will include:

1. Subexcavation and replacement of the appropriate soils in the 1MG tank area to complete the tank building pad.
2. Some subexcavation and reworking of existing soils in the 5MG tank area.
3. Backfill around the 5MG tank to achieve design finish grades.

We recommend that the Grading Plans for the project be developed in coordination with ENGEO in order to mitigate known adverse soil conditions.

Before contract bidding, the final grading plans should be reviewed by ENGEO.

Grading operations including demolition need full-time observation by the Geotechnical Engineer's field representative and they should meet the requirements of the "Guide Earthwork Specifications" included in the appendix. ENGEO should be notified a minimum of 48 hours prior to grading in order to coordinate its schedule with the grading contractor. ENGEO should be notified a minimum of 48 hours prior to grading in order to coordinate its schedule with the grading contractor.

Ponding of storm water is not allowed at the site and particularly on the building pads during work stoppage for rainy weather. Before the grading is halted by rain, positive slopes should be provided to carry the surface runoff water in a controlled manner.

Site Grading

The pad subgrade for both tanks will be at elevation 170 feet. In order to achieve this design requirement in the selected location of the 1MG tank, as much as 4 to 6 feet of filling will be required in the north section of the tank site. In the southern section of the 1MG tank site, as much as 10 to 12 feet of cutting will be required below natural ground surface. In addition, in this area, cutting will extend to the fill supporting the existing 6MG reservoir. This cutting will require temporary support so as not to affect the performance of the existing reservoir which must remain in use until the completion of the 1MG tank.

In the 5MG tank area, 3.5 to 4 feet of subexcavation will be required. As presently located, the 5MG tank area is encroaching onto the north-east sloped side of the existing reservoir by as much as 12 feet; this will require additional subexcavation into the existing fill.

Any site development should commence with the appropriate removal of vegetation, removal of debris, and the excavation and removal of buried structures including utilities. Underground structures, which could act as water traps or could deteriorate, should be removed from the project areas as needed.

All debris, loose soil, or soft compressible materials in any location to be graded, should be removed as necessary for project requirements. The actual depths of removal of these materials should be determined by the Geotechnical Engineer or his/her qualified representative in the field at the time of grading.

In order to provide a tank pad with uniform subgrade conditions, we recommend excavating the entire 1MG tank area proper by an estimated depth of 8 feet below existing natural grades as is shown in Figure 16. The purpose of this excavation is to remove all clays and looser sands from the tank area down to firm materials. The actual depth of excavation should be confirmed during construction.

From the borelog data available, we expect most of the 5MG tank excavation to be in dense sands, except perhaps near its eastern boundary; some subexcavation of looser soils may be necessary in this area. This will have to be confirmed during construction.

Subject to approval by the Landscape Architect, strippings and organically contaminated soils can be used in landscape areas. Otherwise, such soils should be removed from the project site. Any topsoil which will be retained for future use in landscape areas should be stockpiled in areas where it will not interfere with grading operations.

All excavations from demolition and stripping below design grades should be cleaned to a firm undisturbed soil surface as determined by the Geotechnical Engineer. This surface should then be scarified to a depth of at least 12 inches, moisture conditioned and backfilled with compacted engineered fill. The requirements for backfill materials and placement operations should be the same as for engineered fill.

No loose or uncontrolled backfilling of depressions resulting from demolition and stripping are permitted.

The requirements for backfill material quality, placement and compaction are the same as for engineered filling. These requirements are formulated in a subsequent section of this report.

Graded Slopes

According to the preliminary grading concepts known by the time of this writing, the only new graded slopes will be a low fill slope on the north side of the 1MG tank and a 20-foot cut slope between the two proposed tanks. For the long term stability of the improvements and to minimize maintenance, we recommend that graded slopes be constructed as much as possible at slope gradient not exceeding 3 horizontal to 1 vertical or flatter. Steeper gradients will be required locally between the two tanks, however, they should not be steeper than 2:1 (horizontal:vertical). All fill slopes should be adequately keyed into firm natural materials unaffected by shrinkage cracks.

Selection of Materials

With the exception of organically contaminated soil containing more than 2 percent organics, the site soils and excavated rock are selectively suitable for use as engineered fill. Every effort should be made to use only low swell potential soils to construct the tank building pads. Site clays can be used in the fill area outside the perimeter of the 1MG tank and selectively as backfill in the open excavation on the southwest side of the 5MG tank where the removal of the existing tank will have left a significant open area.

It is expected that import materials will be necessary to complete the proposed grading. Import materials should conform to Section 2.02B in Part I of the Guide Contract Specifications and must be approved by the Geotechnical Engineer. A sample of such material should be submitted to the Geotechnical Engineer for evaluation prior to being brought on the site. This material should be used selectively to prepare the tank pads.

Placement of Fill

The soils in areas to receive fill should be scarified, moisture conditioned and recompacted prior to placing the initial lift of fill.

All fills should be placed in thin lifts. The lift thickness should not exceed the depth of penetration of the compaction equipment used.

The following compaction control requirements are generally applied to all fills:

Test Procedures:	ASTM D-1557.
Required Moisture Content:	Not less than 3 percent above optimum moisture content for clay soils, not less than optimum moisture for sands.
Minimum Relative Compaction:	Not less than 90 percent.

Foundation Design

It is our understanding that the tank walls will be supported on peripheral ring foundations, and that the roofs will be supported additionally by isolated interior spread footings.

Geotechnical design criteria for use in footing sizing are as follows:

Minimum depth of footing embedment:	24 inches below subgrade along perimeter.
Maximum allowable footing pressure:	3500 psf dead-plus-live loads in firm soil. 4500 psf for total loads including wind or seismic loads.

We expect foundation settlements not to exceed ¼ to ½ inch under the influence of the above loads.

Footing trenches should not be allowed to desiccate prior to pouring concrete, and they should also be cleared of all loose soil prior to pouring concrete.

The foundation plans should be reviewed by a Geotechnical Engineer when they become available to check for conformance with these recommendations.

Tank Pad Subdrainage

The tank pads should include underdrain systems whose purpose will be to rapidly carry away accidental water leakage and surface seepage, should it occur. The underdrains should be at least 12 inches wide and at least 8 inches deep. The underdrain gravel should be Class 2 Permeable material as specified in the Standard Specifications of the State of California Division of Highways. The underdrains should be protected against siltation by filter fabric. All underdrains should discharge into a single concrete structure where their performance may easily be observed and monitored.

The concrete should be underlain by a tough vaporproof membrane at least 10 mils thick to minimize moisture condensation under the slabs. The Structural Engineer should be consulted on the advisability of using a 2-inch-thick sand cushion under slabs for concrete curing purposes and to separate the concrete from the vapor barrier.

Subgrade Chemical Testing

The USDA estimates that the Altamont soil series has high corrosivity. Because of this, we recommend chemical testing of the subgrade soils after completion of the building pads in order to determine what type of cement should be used in the concrete, and if special protection of concrete reinforcement and metal utility lines will be required. Your Structural Engineer should be consulted on this matter and make the appropriate determinations with respect to type of cement to be used and reinforcement steel protective coating to be considered if any.

Slab-On-Grade Construction

Care must be exercised to attain a near-saturation condition of the subgrade before concrete is placed. If slab construction follows site grading by an extended period, slab subgrade soils may become desiccated and may need to be presoaked prior to pouring concrete. The amount of presoaking required will depend upon the degree of desiccation which will in turn be dependent upon the time of construction. Following placement of gravel beneath the slabs, we recommend that the subgrade soils again be extensively moistened. If inadequate premoistening occurs, slab heave may be experienced. Moisture requirements should be determined by the Geotechnical Engineer during construction.

The tank slabs-on-grade should be designed specifically for their intended loading requirements.

It is an accepted practice to provide a 6-inch-thick layer of clean, crushed rock or gravel under the slabs-on-grade. The gravel may be placed directly upon compacted native material. Slab subgrades should be rolled smooth prior to slab construction to provide a uniformly dense, non-yielding surface.

The Structural Engineer should be consulted on the advisability of using a 2-inch-thick sand cushion below the slab to improve concrete curing and minimize shrinkage.

Concrete shrinkage should be expected. In order to control the resultant cracking of the concrete, we recommend that contraction joints be provided. Joint spacing should be determined as recommended in the ACI publication ACI 302.1R-89 and provided with water stops.

In our experience, welded wire mesh may not be effective in reinforcing slabs as it may be difficult to maintain it in the proper location during concrete pouring. Because of this, we recommend that more rigid network of reinforcing bars each way. The actual slab reinforcement should be designed by the Structural Engineer.

Secondary Slabs-on-Grade

This section provides guidelines for secondary slabs such exterior slabs, walkways, and steps in addition to the applicable recommendations of the preceding section.

Exterior slabs-on-grade may undergo some movement as moderately expansive soils shrink and swell with changes in moisture. We therefore recommend that all exterior slabs-on-grade be constructed structurally independent from all other construction. This allows the slabs to move with minimum distress to the slabs and adjacent foundations.

Exterior slabs should be constructed with thickened edges extending at least 6 inches into compacted soil to minimize water infiltration under them.

Retaining Structures

The temporary shoring for the 1MG tank excavation should be designed to support the lateral loads which will be imposed by the existing reservoir fill. Design lateral load diagrams are provided in Figure 17. Passive pressures acting on soldier piles may be assumed as 250 pcf applied to one and one-half times the diameter of the soldier pile pier foundation. If a soil anchor shoring system is used, a bond stress of 1000 psf may be used between anchor and soil. The shoring system should be designed by the shoring contractor's Structural Engineer.

The 5MG tank should be designed to resist lateral loads and downdrag which may be applied to it by the proposed backfill. Lateral load design diagrams are provided in Figure 17. A downdrag value of $15H_l$ psf, where H_l is the height of backfill against the tank, should be applied to the wall of the 5MG tank, neglecting the top 3 feet of embankment.

An equivalent fluid pressure of 250 pcf may be used in passive resistance against tank walls and foundations. However, because of the limited lateral extent of the embankment located between the 1MG and 5MG tanks, passive resistance in this area should not be considered above elevation 180 feet. A friction factor of 0.4 may be used between site soil and tank floor and foundation in the design of both tanks. This friction factor may be increased to 0.45 provided that the tank subgrade include a layer of compacted predominantly granular material extending from subgrade levels to a depth of at least 12 inches below bottom of tank footings.

Utility vaults may be designed using an at-rest equivalent fluid pressure of 65 pcf.

Appropriate safety factors against overturning and sliding should be incorporated into the design calculations.

The 5MG tank wall should be provided with drainage facilities to prevent the buildup of hydrostatic pressures behind it. Wall drainage may be provided using a 4-inch-diameter perforated pipe embedded in Class 2 permeable material (Guide Contract Specification, Part I, Section 2.05B), or free-draining gravel surrounded by synthetic filter fabric. The width of the drain blanket should be at least 12 inches. The drain blanket should extend to about one foot below the finished grades. As an alternative, prefabricated synthetic wall drain panels can be used. The upper two feet of wall backfill should consist of site clayey soils. Subdrainage should be collected by perforated pipes and directed to an outlet approved by the Civil Engineer. Synthetic filter fabric should meet the minimum requirement as listed in the Guide Contract Specifications.

All backfill should be placed in accordance with recommendations provided above for engineered fill. Light equipment should be used during backfill compaction to minimize possible overstressing of the walls.

Preliminary Pavement Design

All access road subgrades should be scarified to a depth of 12 inches below finished subgrade elevation, moisture conditioned to 3 percent above optimum, and recompacted to at least 90 percent relative compaction and in accordance with city or county requirements. Sand subgrades should be compacted above optimum at a relative compaction of at least 95 percent. Aggregate baserock materials should meet current Caltrans specifications for Class 2 aggregate baserock, and should be compacted to at least 95 percent of maximum dry density.

Based on the soil conditions encountered in our borings, we have assumed an R-value of 5 for the clayey subgrade condition in calculating pavement sections. A Traffic Index of 5 was assumed, this does not allow for concentrated heavy truck type traffic.

The following preliminary pavement section has been determined for a Traffic Index of 5 and an assumed R-value of 5 according to methods contained in Topic 608 of Highway Design Manual by Caltrans.

ALTERNATIVE	I	II
Asphaltic Concrete	3.0"	3.0"
Aggregate Base Class 2 Material R=78 minimum	10.0"	6.0"
Aggregate Subbase R=50 minimum	--	4.0"

The above pavement section is provided for estimating only. The actual subgrade material should be tested for R-value. The Traffic Index should be confirmed by the Civil Engineer.

Pavement construction and all materials should conform to the specifications and requirements of the Standard Specifications by the Division of Highways, Department of Public Works, State of California, latest edition, City of Pittsburg requirements and the following minimum requirements.

- Subgrade soils should be in a stable, non-pumping condition at the time aggregate baserock materials are placed and compacted.
- Adequate provisions must be made such that the subgrade soils and aggregate baserock materials are not allowed to become saturated.
- All concrete curbs separating pavement and irrigated landscaped areas should extend into the subgrade and below the bottom of adjacent aggregate baserock materials.

Surface Drainage

All areas must be positively graded at all times to provide for rapid removal of surface water runoff away from tank foundation systems and to prevent ponding of water around the tanks at any time during or after construction. Ponded water will cause undesirable soil swell and loss of strength. Area drains may be needed to comply with these requirements in some instances.

As a minimum requirement, finished grades should have slopes of at least 3 to 5 percent within 7 feet from the tank walls at right angles to them to allow surface water to drain positively away from the subject structures. All surface water should be collected and discharged into the storm drain system.

All lots should be protected against the surface run-off from adjacent uphill property; your Civil Engineer should be consulted on this matter.

No water should be allowed to discharge in a concentrated manner over downslopes as this could cause erosion and possibly weaken the soil mantle to the point of causing it to slough downhill

Requirements for Landscaping Irrigation

The geotechnical foundation design parameters contained in this report have considered the swelling potential of site soils. However, it is important to recognize that swell in excess of that anticipated is possible under adverse drainage conditions. Therefore, planted areas should be avoided immediately adjacent to the proposed tanks and related improvements. The use of plants that require very little moisture is recommended.

Sprinkler systems should not be installed where they may cause ponding or saturation of foundation soils within 3 feet from walls and paving. Such ponding or saturation could result in undesirable soil swell, loss of compaction and bearing capacity.

Irrigation of landscaped areas should be strictly limited to that necessary to sustain vegetation. Excessive irrigation could result in saturating, weakening, and possible swelling of foundation soils. The Landscape Architect and grounds maintenance crews should be informed of the surface drainage and irrigation requirements included in this report.

Utilities

It is recommended that utility trench backfilling be done under the observation of a Geotechnical Engineer. Pipe zone backfill (i.e. material beneath and immediately surrounding the pipe) may consist of a well-graded import or native material less than ¾-inch in maximum dimension compacted in accordance with recommendations provided above for engineered fill. Trench zone backfill (i.e. material placed between the pipe zone backfill and the ground surface) may consist of native soil compacted in accordance with recommendations for engineered fill.

Where import material is used for pipe zone backfill, we recommend it consist of fine- to medium-grained sand or a well-graded mixture of sand and gravel and that this material not be used within 2 feet of finish grades. In general, uniformly-graded gravel should not be used for pipe or trench zone backfill due to the potential for migration of: (1) soil into the relatively large void spaces present in this type of material, and (2) water movement along trenches backfilled with this type of material. All utility trenches entering tank perimeters and paved areas must be provided with an impervious seal. The impervious plug should extend at least 4 feet to either side of the crossing. This is to prevent surface water percolation into the sands under foundations and pavements where such water would remain trapped in a perched condition, allowing subgrade soils to loose strength and where applicable, clays to develop their full expansion potential.

Care should be exercised where utility trenches are located beside foundation areas. Utility trenches constructed parallel to foundations should be located entirely above a plane extending down from the lower edge of the footing at an angle of 45 degrees. Utility companies and Landscape Architects should be made aware of this information.

All trench backfill should be compacted using approved techniques to a minimum of 90 percent compaction.

Utility trenches in areas to be paved should be constructed in accordance with City of Pittsburg requirements. Compaction of native trench backfill by jetting should not be allowed at this site.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

This report is issued with the understanding that it is the responsibility of the owner to transmit the information and recommendations of this report to developers, contractors, buyers, architects, engineers, and designers for the project so that the necessary steps can be taken by the contractors and subcontractors to carry out such recommendations in the field. The conclusions and recommendations contained in this report are solely professional opinions.

The professional staff of ENGEO Incorporated strives to perform its services in a proper and professional manner with reasonable care and competence but is not infallible. There are risks of earth movement and property damages inherent in land development. We are unable to eliminate all risks or provide insurance; therefore, we are unable to guarantee or warrant the results of our work.

This report is based upon field and other conditions discovered at the time of preparation of ENGEO's work. This document must not be subject to unauthorized reuse, that is, reuse without written authorization of ENGEO. Such authorization is essential because it requires ENGEO to evaluate the document's applicability given new circumstances, not the least of which is passage of time. Actual field or other conditions will necessitate clarifications, adjustments, modifications or other changes to ENGEO's work. Therefore, ENGEO must be engaged to prepare the necessary clarifications, adjustments, modifications or other changes before construction activities commence or further activity proceeds. If ENGEO's scope of services does not include on-site construction observation, or if other persons or entities are retained to provide such services, ENGEO cannot be held responsible for any or all claims, including, but not limited to claims arising from or resulting from the performance of such services by other persons or entities, and any or all claims arising from or resulting from clarifications, adjustments, modifications, discrepancies or other changes necessary to reflect changed field or other conditions.

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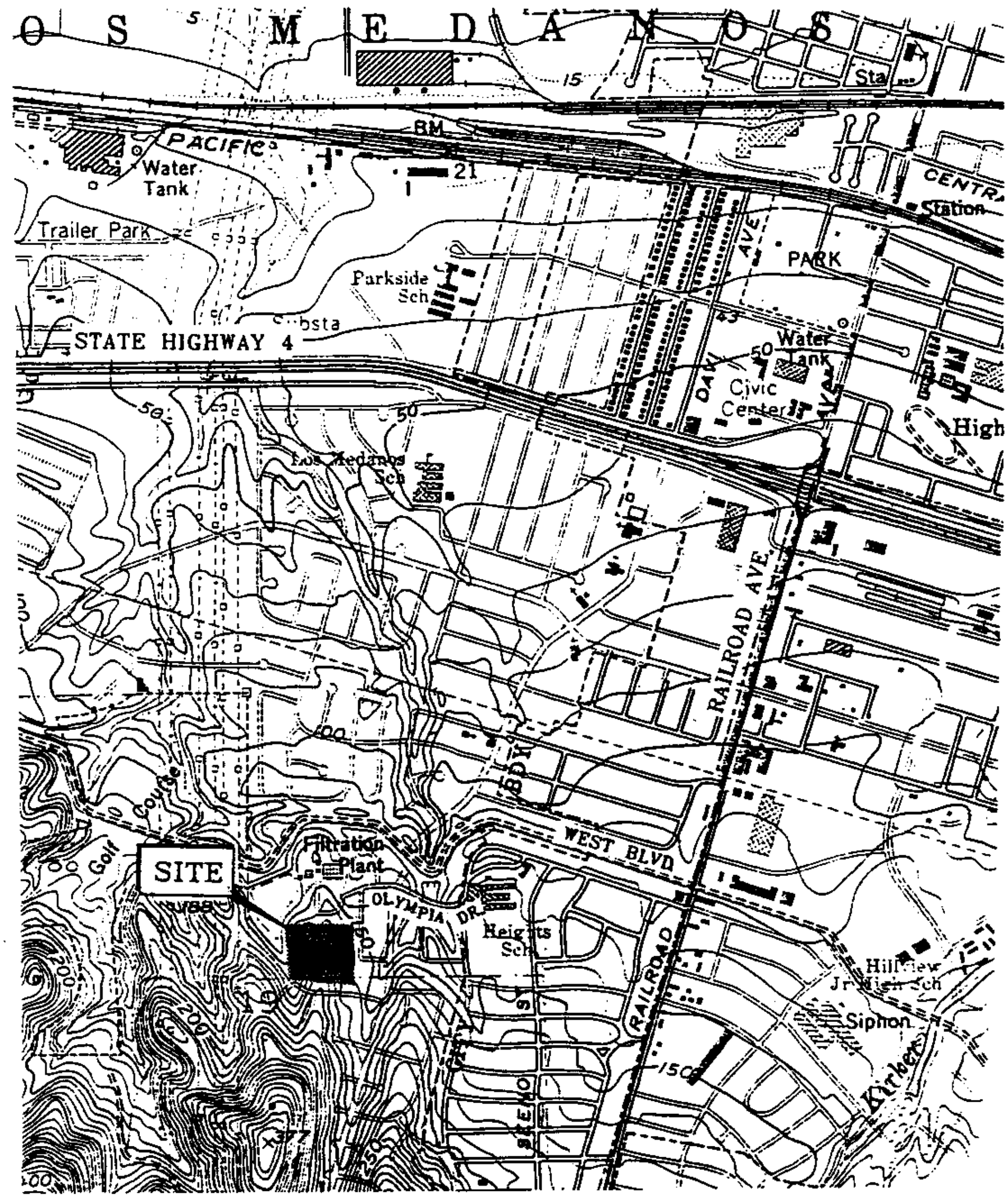
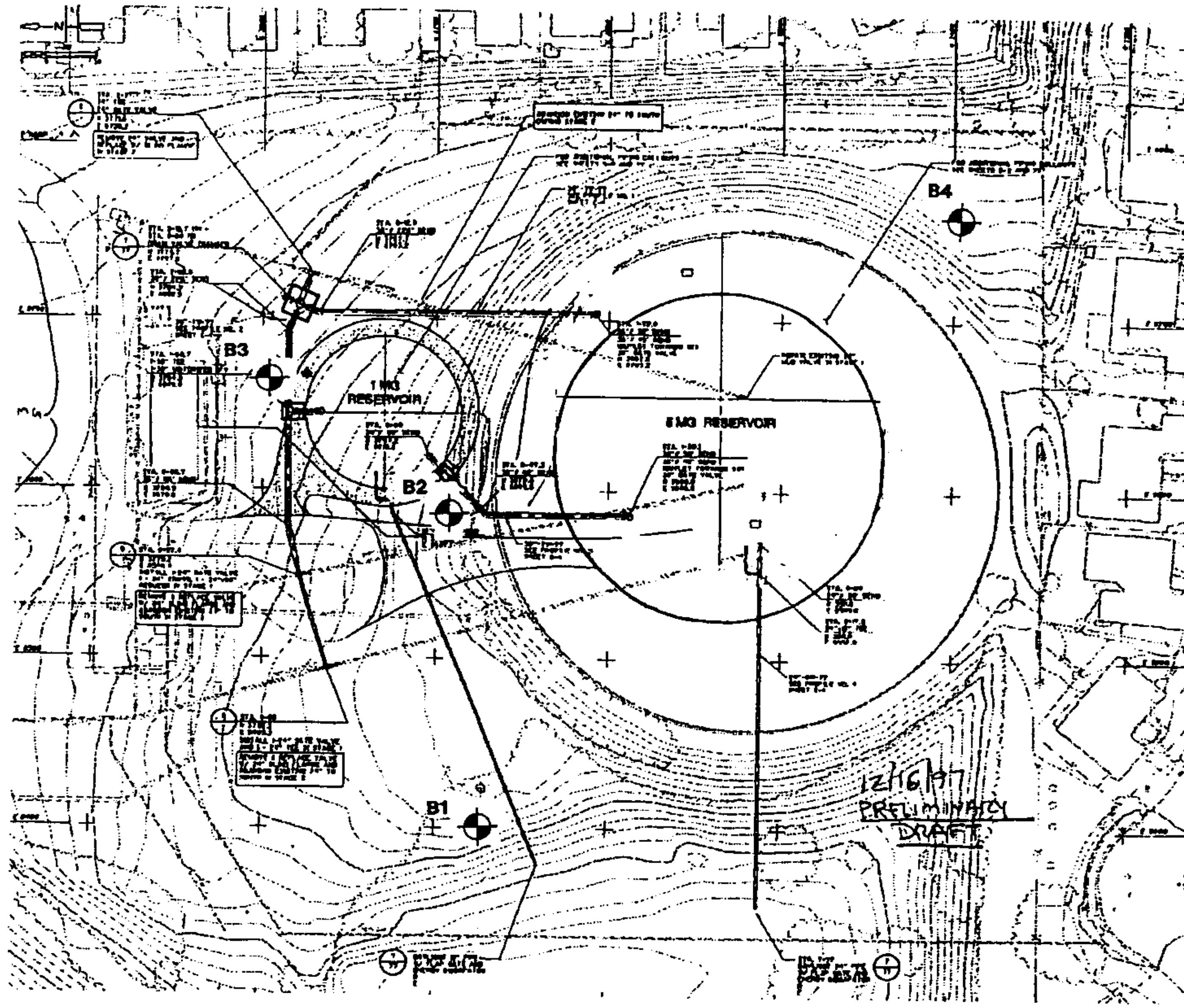
APPENDIX



SOURCE: USGS

ENGEO INCORPORATED	SITE LOCATION MAP 6 MG WATER STORAGE RESERVOIR PROJECT PITTSBURG, CALIFORNIA	PROJECT NO.: 2494-M2 DATE: DECEMBER 1997 DRAWN BY: CB / CHECKED BY: JM	FIGURE NO. 1



EXPLANATION

B4 APPROXIMATE BOREHOLE LOCATION

N

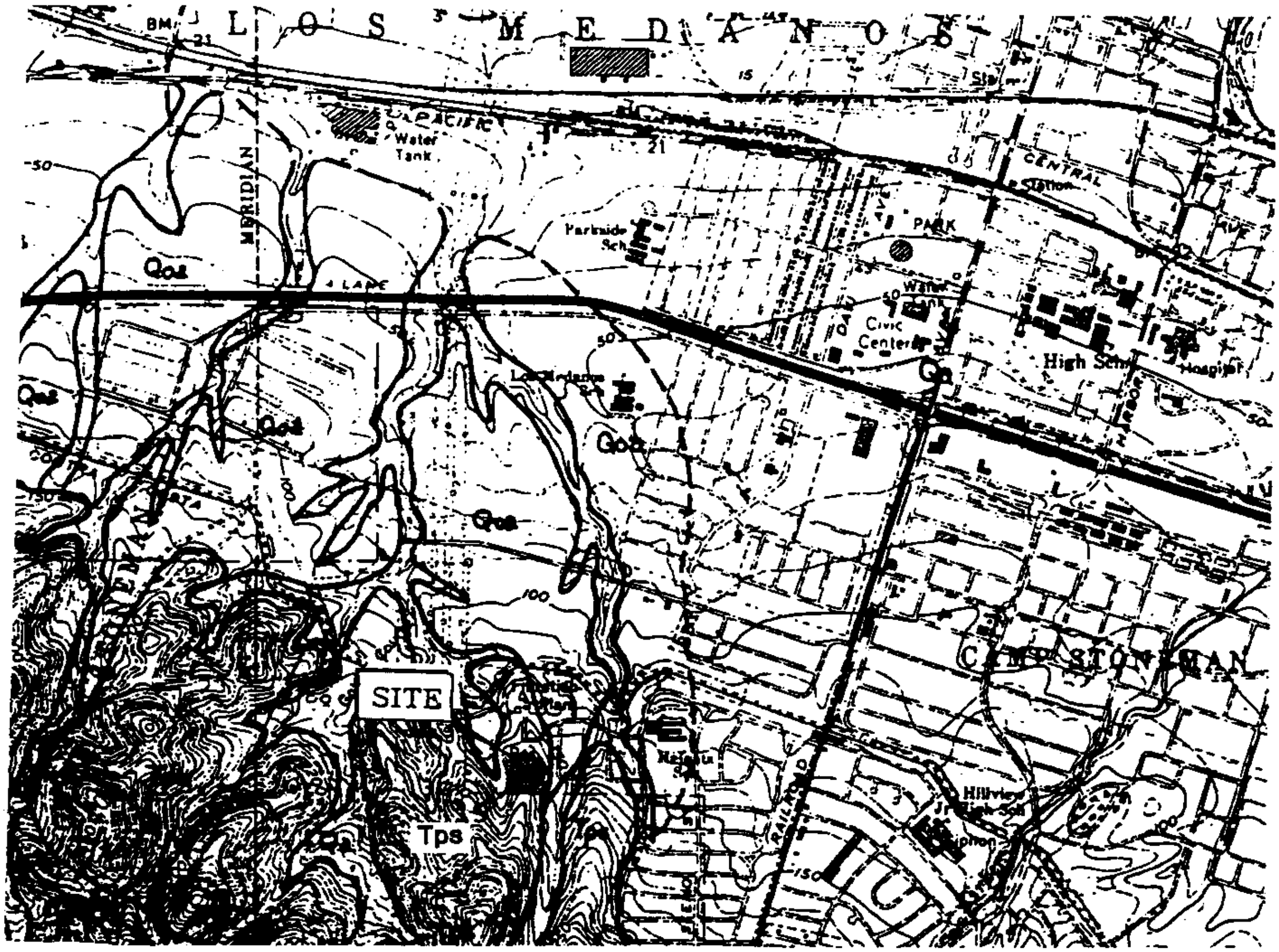
0 FEET 100
0 METERS 50

SOURCE: CAMP DRESSER & MCKEE

ENGEO INCORPORATED

SITE PLAN AND BORHOLE LOCATIONS
6 MG WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

PROJECT NO.: 2494-M2		FIGURE NO.
DATE: DECEMBER 1997		2
DRAWN BY: CB	CHECKED BY: JM	



SOURCE: DIBBLEE, 1980

0 MILE .5
0 KILOMETER 1

EXPLANATION

———— - - - - BEDROCK CONTACT–DASHED WHERE GRADATIONAL OR APPROXIMATELY LOCATED

STRIKE AND DIP OF STRATA

VERTICAL

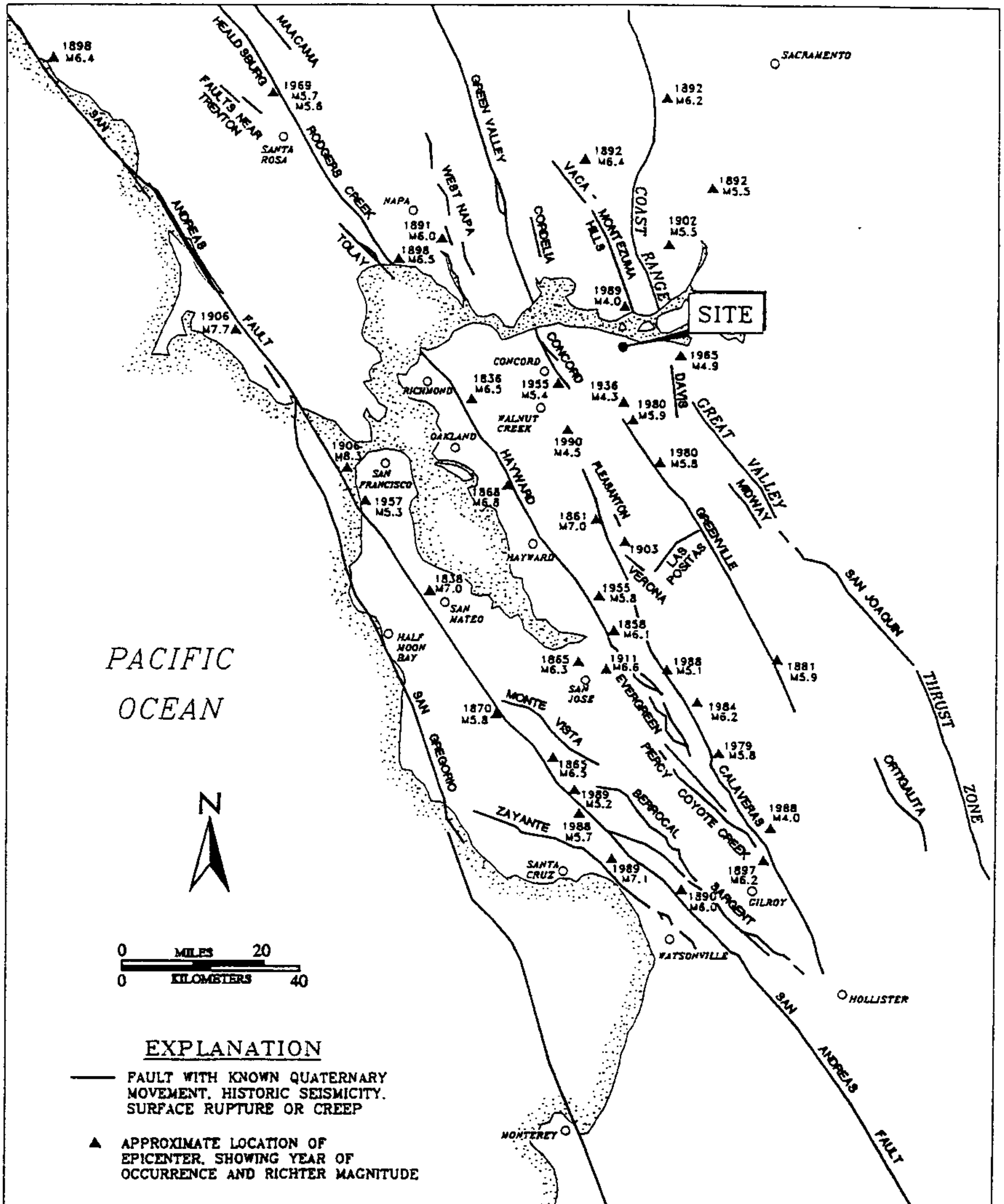
Qa ALLUVIUM

Qoa OLDER ALLUVIUM

Tps WEAKLY INDURATED CLAY, SAND AND PEBBLE GRAVEL.

N

ENGEO INCORPORATED	SITE GEOLOGY MAP 6 MG WATER STORAGE RESERVOIR PROJECT PITTSBURG, CALIFORNIA	PROJECT NO.: 2494-M2 DATE: DECEMBER 1997 DRAWN BY: LB CHECKED BY: JH	FIGURE NO. 3



ENGEO INCORPORATED	REGIONAL FAULTING AND SEISMICITY 6 MG WATER STORAGE RESERVOIR PROJECT PITTSBURG, CALIFORNIA	PROJECT NO.: 2494-M2 DATE: DECEMBER 1997 DRAWN BY: LB CHECKED BY: JM	FIGURE NO. 4

DATE OF BORING: December 3, 1997

SURFACE ELEVATION: Approx. 172.0 feet (52.4 meters)

DEPTH (FEET)	DEPTH (METERS)	SAMPLE NUMBER	DESCRIPTION	N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER	qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX.	IN PLACE DRY UNIT WEIGHT (PCF)	IN PLACE MOIST. CONTENT % DRY WEIGHT
0			Sparse grass over dark yellowish brown silty sandy CLAY with trace subrounded gravel, moist. (Fill)				
	1	1-1	Dark grayish brown silty CLAY with fine sand and trace subrounded fine gravel, some dark reddish brown, rare asphalt chunks, slightly moist. PI = 31	9*		101.7	12.6
5	2		Yellowish brown silty SAND, rare fine gravel.				
		1-2	Grayish brown sandy silty CLAY, rare, fine subrounded gravel, trace amounts of angular cobble, slightly moist, very stiff.	16*		116.2	8.3
10	3, 4	1-3	Yellowish brown clayey fine SAND, rare fine subrounded gravel, some carbonate, slightly moist, very dense.	38*/5"		111.5	16.0
15	5	1-4	Light yellowish brown sandy silty CLAY, some carbonates, rare fine mica, moist, very hard.	61*		107.3	14.2
20	6, 7	1-5	Light yellowish brown, clayey fine highly weathered SANDSTONE, trace carbonate, moist, very dense.	48*		106.7	18.7
25	8	1-6	Light yellowish brown clayey fine highly weathered SANDSTONE, abundant carbonate, moist, dense.	39*		101.2	20.1
30	9	1-7		70			
			Bottom of boring at approximately 30 feet. Ground water not encountered.				

MET 2494B 1/2/98

ENGEO INCORPORATED

PITTSBURG 6 MG
WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

BORING NO.: B1

DATE: January 1998

PROJECT NO.: 2494-M2

CHECKED BY: JM

FIGURE NO. 5

DATE OF BORING: December 3, 1997

SURFACE ELEVATION: Approx. 180.0 feet (54.9 meters)

DEPTH (FEET)	DEPTH (METERS)	SAMPLE NUMBER	LOG, LOCATION AND TYPE OF SAMPLE	DESCRIPTION	N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER	qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX.	IN PLACE DRY UNIT WEIGHT (PCF)	IN PLACE MOIST. CONTENT % DRY WEIGHT
0				Sparse native grass over dark yellowish brown silty sandy CLAY, trace subrounded gravel, moist. (Fill)				
	1			Dark grayish brown sandy CLAY, trace rootlets, trace fine gravel, slightly moist.				
5		2-1		Yellowish brown silty clayey fine SAND, trace subrounded gravel, some carbonate, slightly moist, very stiff.	22*		100.8	16.0
	2							
10	3	2-2		Yellowish brown silty clayey fine SAND, trace fine subrounded gravel, some carbonate, slightly moist, very dense. Elevation approximately 170 feet.	31*/6"		112.1	15.7
15	4	2-3		Yellowish brown SAND, with silt, rare fine subrounded gravel, slightly moist, very dense.	51*		101.3	6.9
	5			Grayish brown SAND, some silt, rare fine subrounded gravel, slightly moist, dense.				
20	6	2-4			57			
25	7	2-5		Grayish brown to olive brown fine gravelly SAND, some silty, slightly moist, very dense.	71			
	8							
30	9	2-6		Yellowish brown with olive brown fine gravelly SAND, some silt moist and iron oxide, very dense.	66			
				Bottom of boring at approximately 29.5 feet. Ground water not encountered.				

ENGEO INCORPORATED

PITTSBURG 6 MG
WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

BORING NO.: B2

DATE: January 1998

PROJECT NO.: 2494-M2

CHECKED BY JM

FIGURE NO. 6

MET 2494B 1/2/98

DATE OF BORING: December 3, 1997

SURFACE ELEVATION: Approx. 165.0 feet (50.3 meters)

DEPTH (FEET)	DEPTH (METERS)	SAMPLE NUMBER	DESCRIPTION	N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER	qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX.	IN PLACE DRY UNIT WEIGHT (PCF)	IN PLACE MOIST. CONTENT % DRY WEIGHT
0			Sparse native grass over grayish brown silty CLAY, some fine gravel and cobbles, moist.				
	1	3-1	Yellowish brown silty fine SAND, rare fine subrounded gravel, slightly moist, medium dense.	20*		96.8	8.9
5	2						
	3	3-2	Grayish brown with yellowish brown silty clayey fine SAND, some angular to subangular gravel and cobbles, slightly moist, very dense.	52*	4.5+*	120.1	4.1
10	4	3-3	Yellowish brown silty clayey fine SAND, rare fine subrounded gravel, slightly moist, dense.	32*	4.5+*	104.8	11.4
15	5	3-4	Yellowish brown with olive brown SAND with fine subrounded gravel, moist, very dense.	38*/4"			
		3-5		67			
			Bottom of boring at approximately 18 feet. Ground water not encountered.				
20	6						
	7						
25	8						
30	9						

MET 2494B 1/2/98

ENGEO
INCORPORATED

PITTSBURG 6 MG
WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

BORING NO.: B3

DATE: January 1998

PROJECT NO.: 2494-M2

CHECKED BY: JM

FIGURE NO. 7

DATE OF BORING: December 3, 1997

SURFACE ELEVATION: Approx. 174.0 feet (53.0 meters)

DEPTH (FEET)	DEPTH (METERS)	SAMPLE NUMBER	DESCRIPTION	N S.P.T. BLOWS/FT *MODIFIED FOR 3" O.D. SAMPLER	qu UNCON. COMP. STRENGTH (TSF) *FIELD PENET. APPROX.	IN PLACE DRY UNIT WEIGHT (PCF)	IN PLACE MOIST. CONTENT % DRY WEIGHT
0			Sparse native grass over yellowish brown and grayish brown silty sandy CLAY, rare fine subrounded gravel, very moist.				
	1						
		4-1		24*			
5			Dark yellowish brown with dark grayish brown silty fine sandy CLAY, some carbonates and iron oxide, rare fine subrounded gravel, moist, very stiff.				
		4-2		28*			
	2						
		4-3	Dark brown and dark grayish brown silty CLAY, some fine sand, moist.	19	4.25*		
		4-4	(Cobble)	31*/5"			18.0
10	3	4-5	Yellowish brown sandy silty CLAY, abundant carbonates, some iron oxide, rare fine subrounded gravel, slightly moist, hard.	70	4.5+*	115.0	14.1
	4		Yellowish brown silty CLAY with fine sand, abundant carbonates, slightly moist, hard. PI = 22				
		4-6		90	4.5+*	114.0	16.7
15							
	5		Ground water level.				
		4-7	No recovery - (Cobble)	70/6"			
		4-8		66/5"			
20	6	4-9		66/33"			
			Refusal at approximately 20 feet. (onto schist like material)				
	7						
25							
	8						
	9						
30							

MET 2494B 1/2/98

ENGEO INCORPORATED

PITTSBURG 6 MG
WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

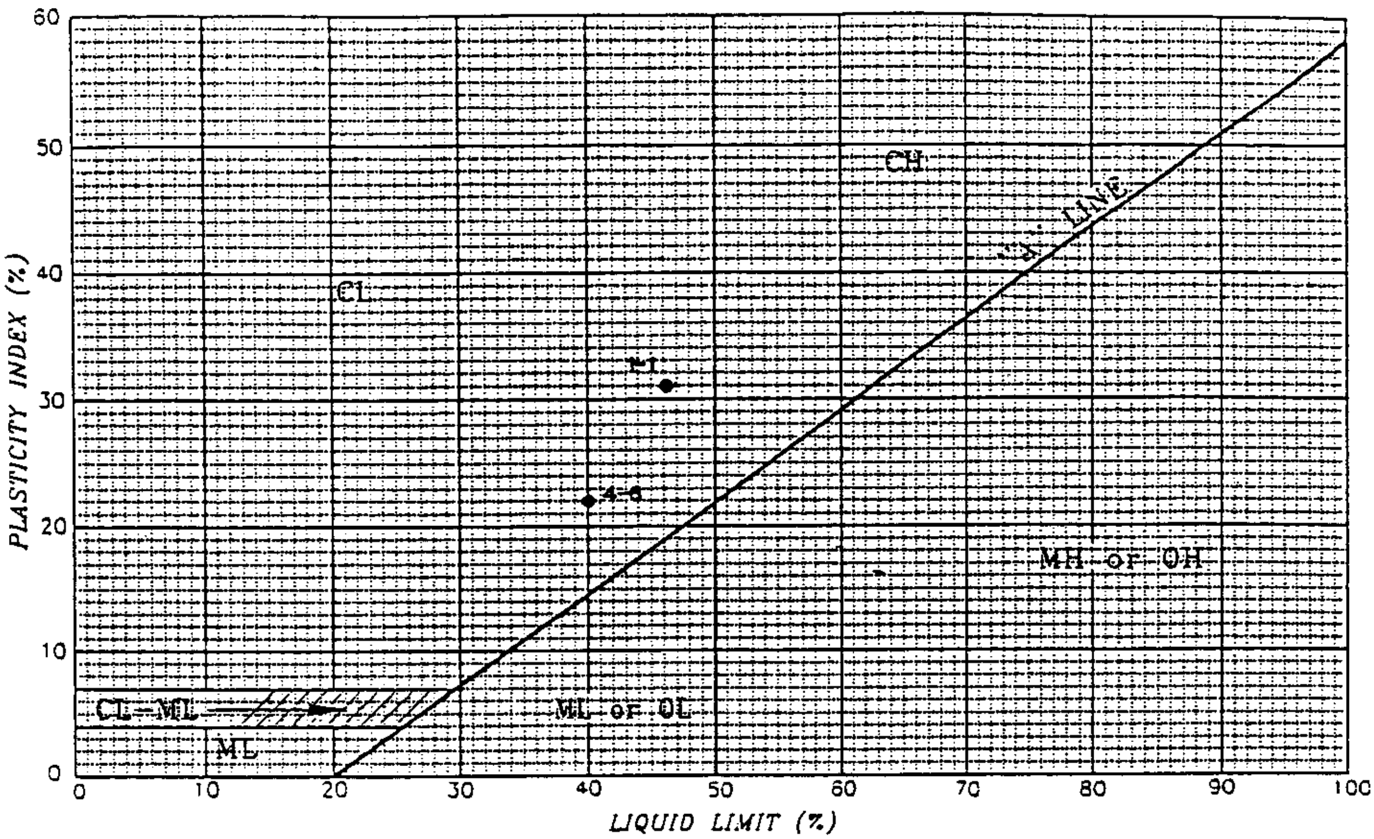
BORING NO.: B4

DATE: January 1998

PROJECT NO.: 2494-M2

CHECKED BY: JM

FIGURE NO. 8



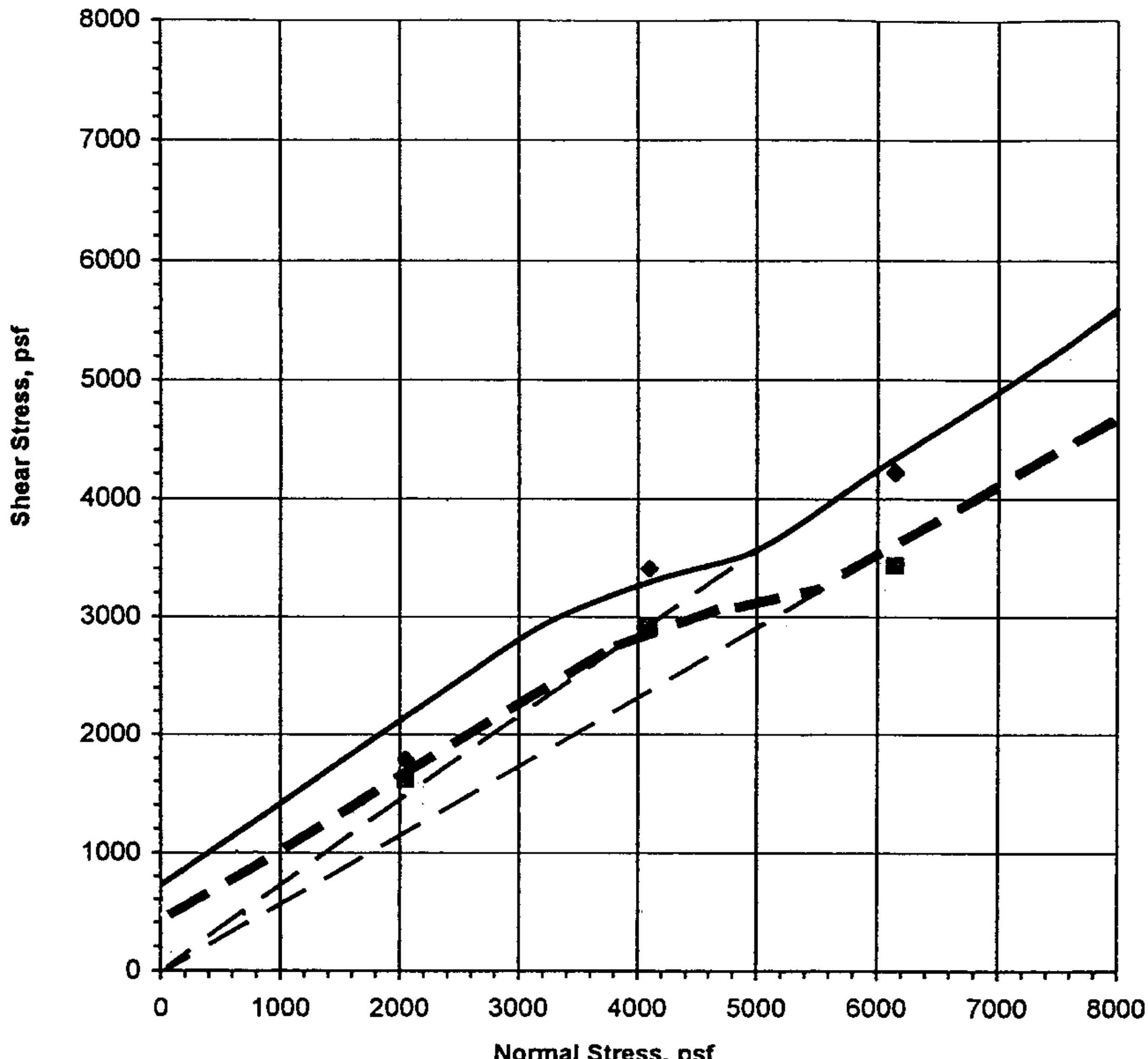
NO.	SAMPLE DEPTH IN FEET (METERS)	NATURAL WATER CONTENT (%)	ATTERBERG LIMITS			PERCENT PASSING NO. 200 SIEVE	UNIFIED SOIL CLASSIFICATION SYMBOL
			LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)		
1-1	--	--	46	15	31	--	CL
4-6	--	--	40	18	22	--	CL

ENGEO INCORPORATED

PLASTICITY CHART
6 MG WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

PROJECT NO.: 2494-M2
DATE: DECEMBER 1997
DRAWN BY: CB | CHECKED BY: JH

FIGURE NO. 9

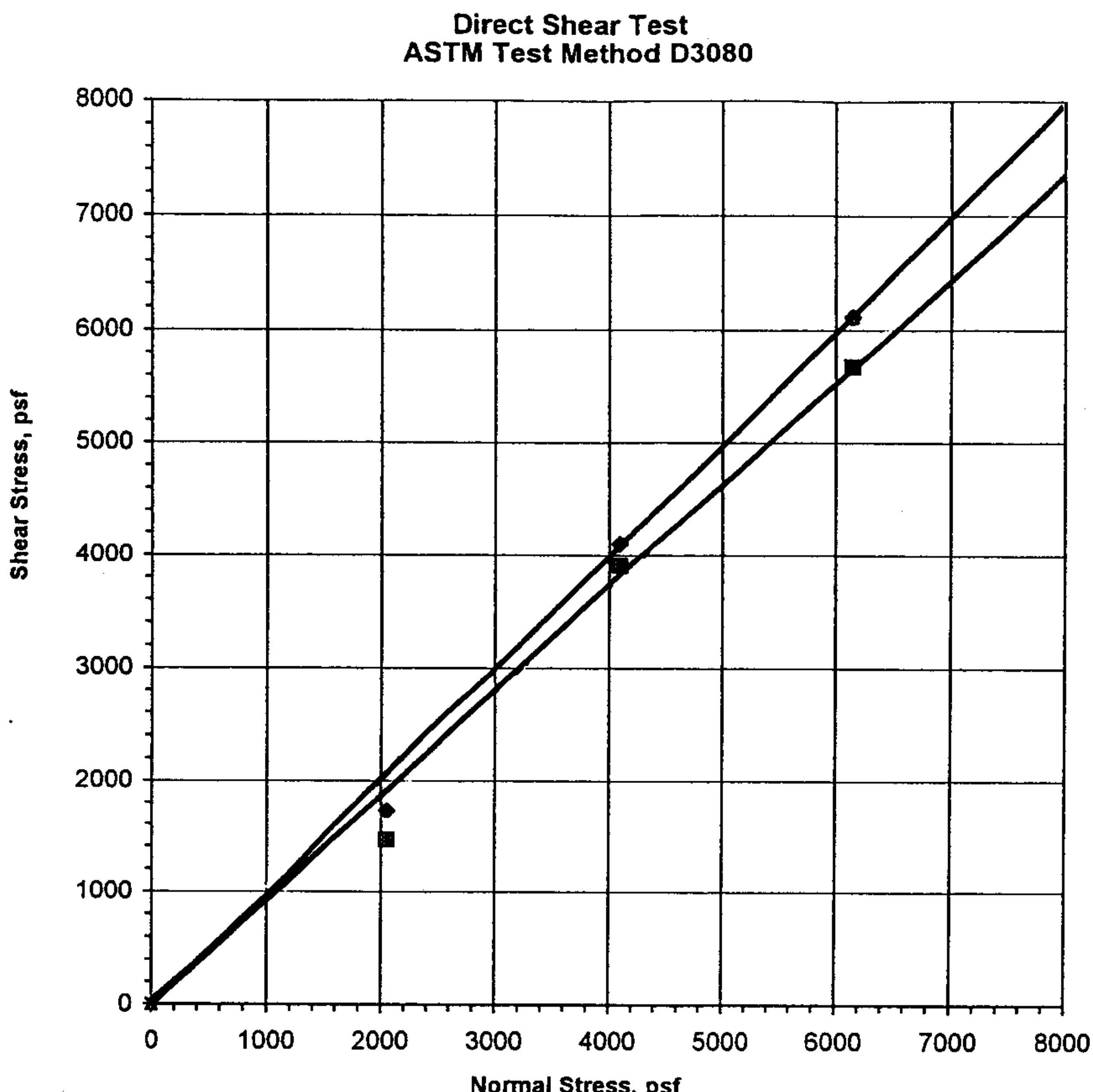


	FRICTION ANGLE	COHESION	
Peak	30.6 degrees	600	psf
Softened	23.9 degrees	500	psf

Dry Density:	99.6 pcf
Moisture Content:	18.5 %
USCS Classification:	SM
Shear Type:	CD
Shear Rate:	Slow

SAMPLE NO.: 1-4

ENGEO INCORPORATED	DIRECT SHEAR TEST ASTM D 3080 6 MG WATER STORAGE RESERVOIR PROJECT PITTSBURG, CALIFORNIA	PROJECT NO.: 2494-M2 DATE: DECEMBER 1997 DRAWN BY: CB CHECKED BY: JM	FIGURE NO. 10



	FRICTION ANGLE	COHESION
Peak	44.8 degrees	--- psf
Softened	42.7 degrees	--- psf

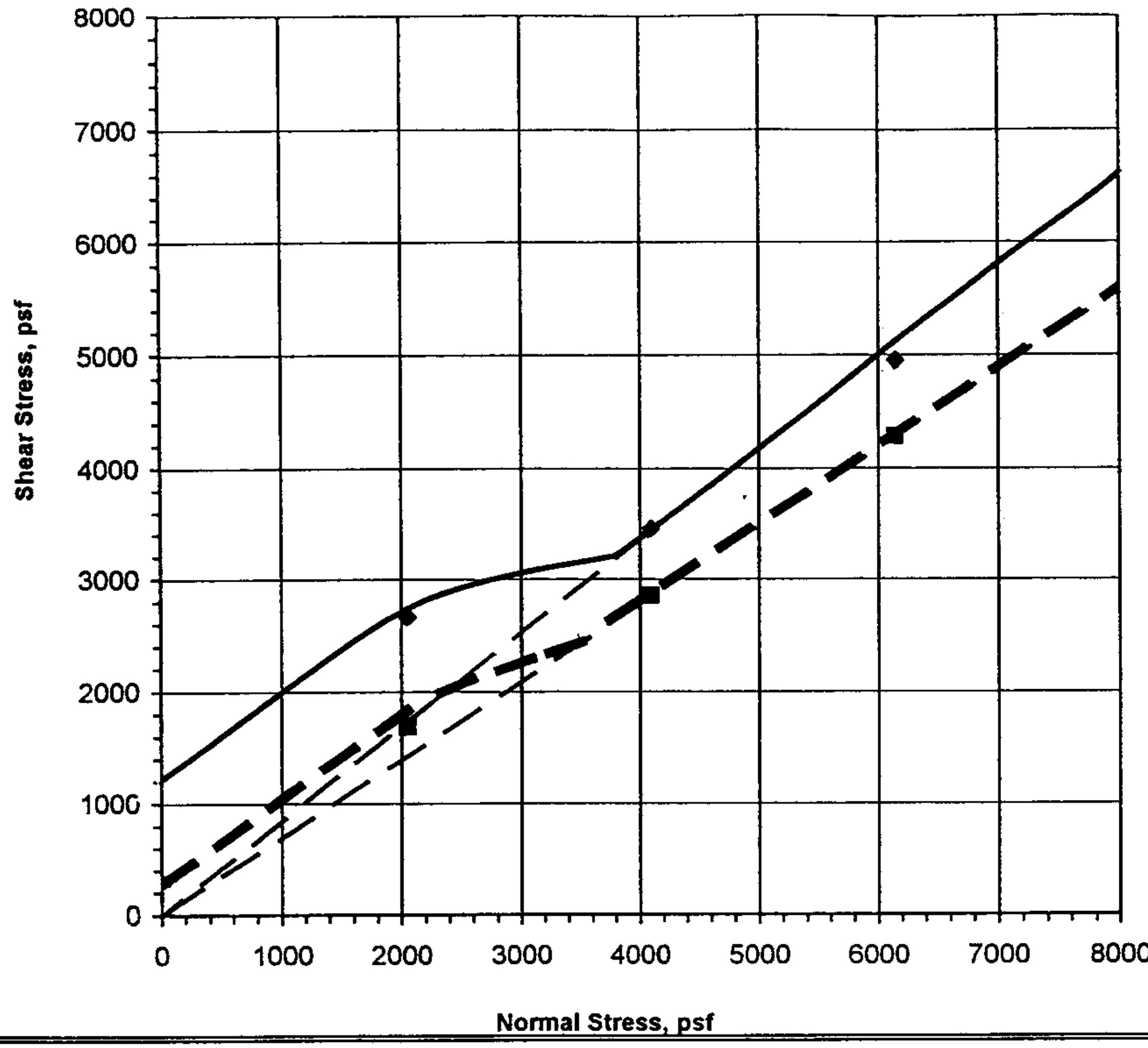
Dry Density:	96.5 pcf
Moisture Content:	21.2 %
USCS Classification:	SC-SM
Shear Type:	CD
Shear Rate:	Slow

SAMPLE NO.: 2-1

ENGEO INCORPORATED

DIRECT SHEAR TEST ASTM D 3080
6 MG WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

PROJECT NO.: 2494-M2
DATE: DECEMBER 1997
DRAWN BY: LB
CHECKED BY: JM
FIGURE NO. 11



	FRICTION ANGLE	COHESION	
Peak	38.9 degrees	1000	psf
Softened	34.9 degrees	300	psf

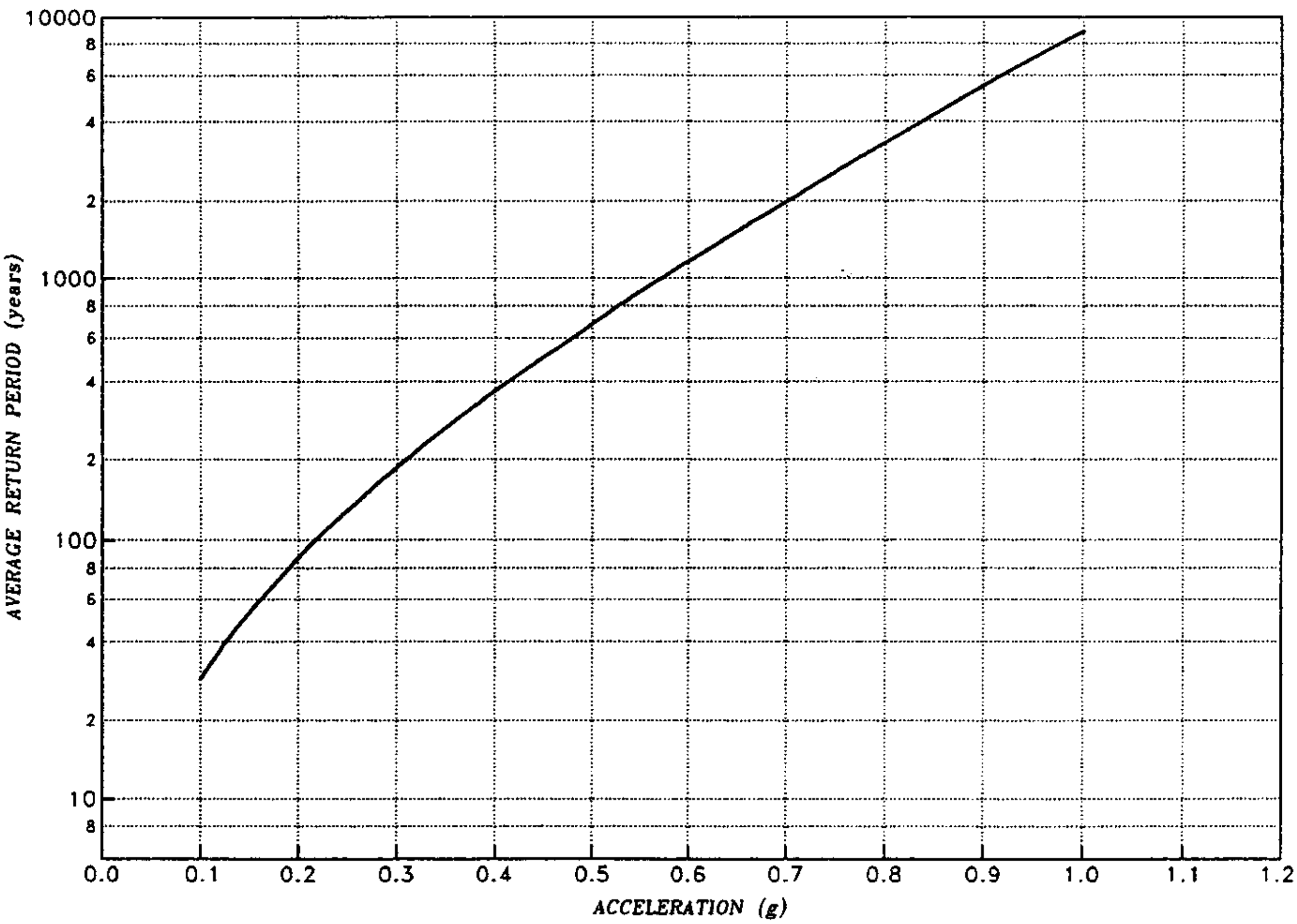
Dry Density:	112.1 pcf
Moisture Content:	15.7 %
USCS Classification:	SM
Shear Type:	CD
Shear Rate:	Slow

SAMPLE NO.: 2-2

ENGEO INCORPORATED

DIRECT SHEAR TEST ASTM D 3080
6 MG WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

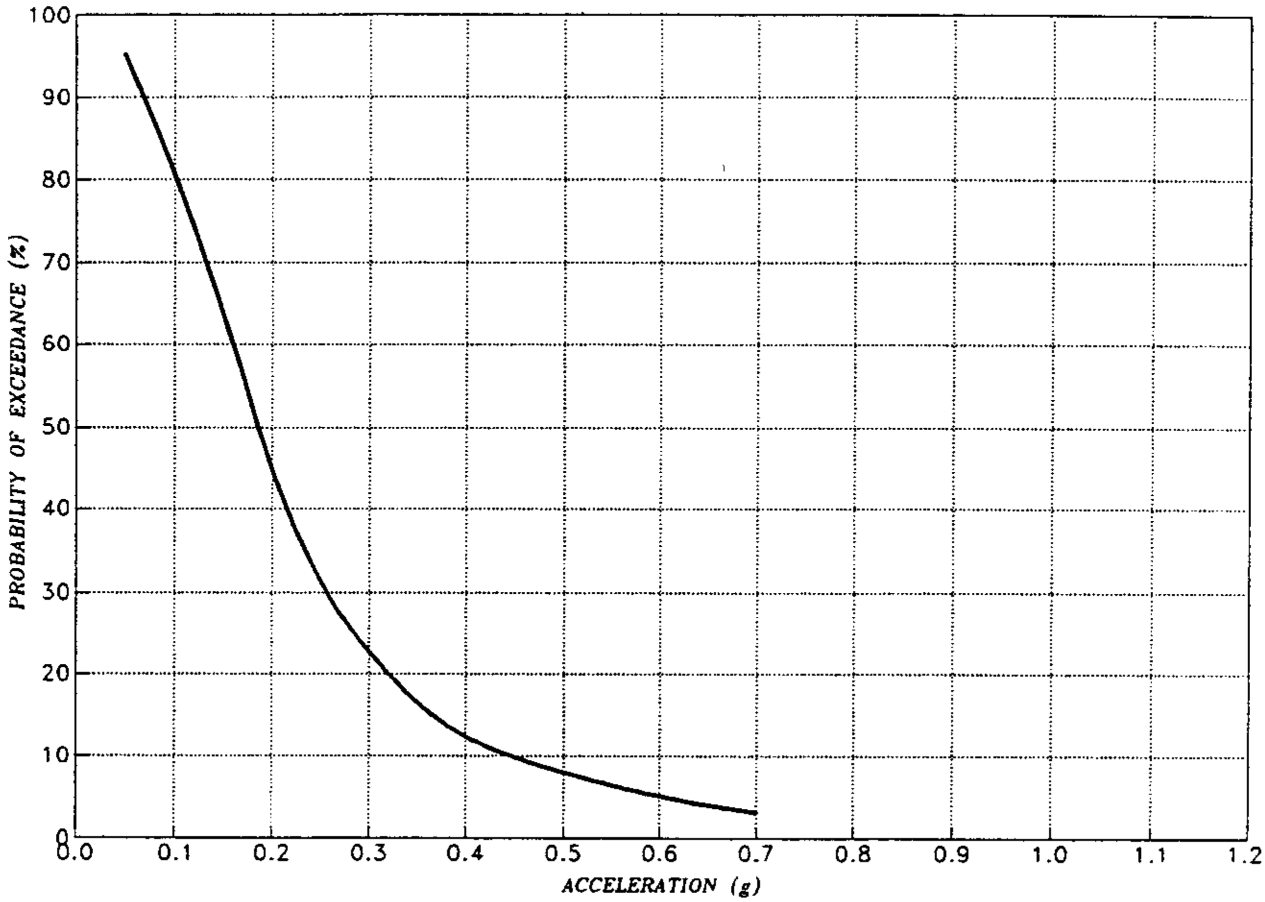
PROJECT NO.: 2494-M2
DATE: DECEMBER 1997
DRAWN BY: LB CHECKED BY: JM
FIGURE NO. 12



AVERAGE RETURN PERIOD vs. ACCELERATION
6 MG WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

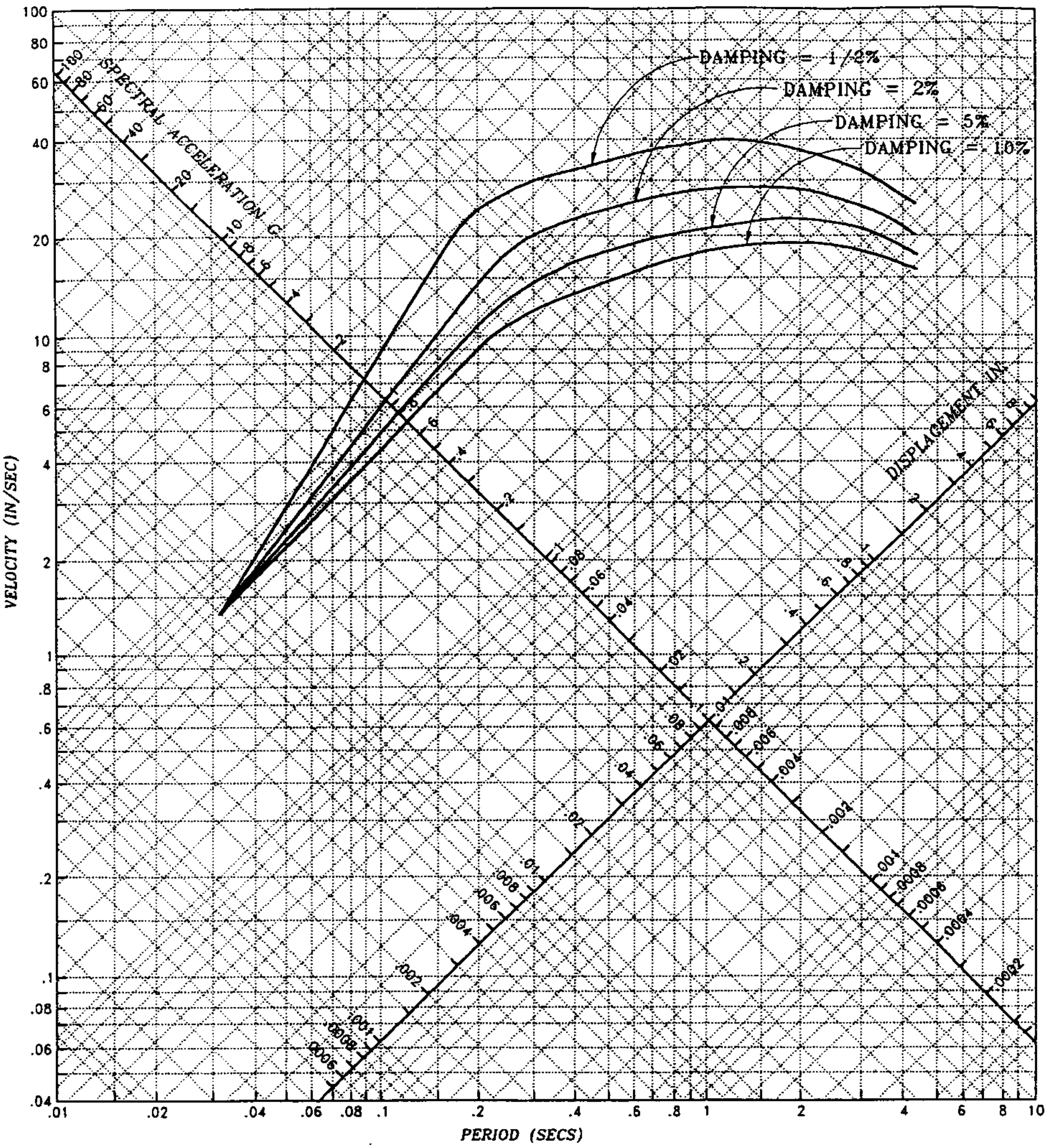
ENGEO INCORPORATED

PROJECT NO.: 2494-M2	FIGURE NO. 13
DATE: DECEMBER 1997	
DRAWN BY: [illegible] CHECKED BY: JM	



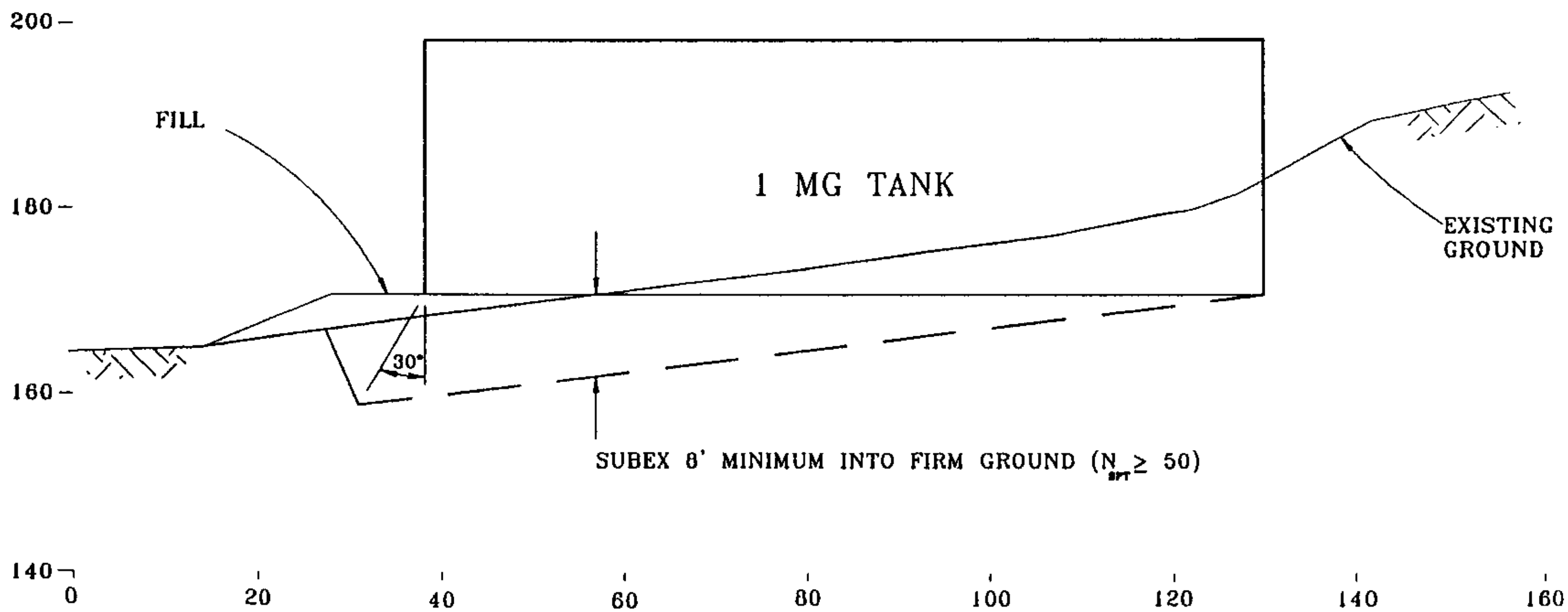
EXPOSURE PERIOD: 50 YEARS

ENGEO INCORPORATED	PROBABILITY OF EXCEEDANCE vs. ACCELERATION 6 MG WATER STORAGE RESERVOIR PROJECT PITTSBURG, CALIFORNIA	PROJECT NO.: 2494-M2 DATE: DECEMBER 1997 DRAWN BY: B CHECKED BY: JM	FIGURE NO. 14



RESPONSE SPECTRA FOR VARIOUS DAMPING VALUES FOR GROUND SHAKING WITH 10% PROBABILITY OF EXCEEDANCE IN 50 YEARS.

ENGEO INCORPORATED	RESPONSE SPECTRA 6 MG WATER STORAGE RESERVOIR PROJECT PITTSBURG, CALIFORNIA	PROJECT NO.: 2494-M2 DATE: DECEMBER 1997 DRAWN BY: JB CHECKED BY: JM	FIGURE NO. 15



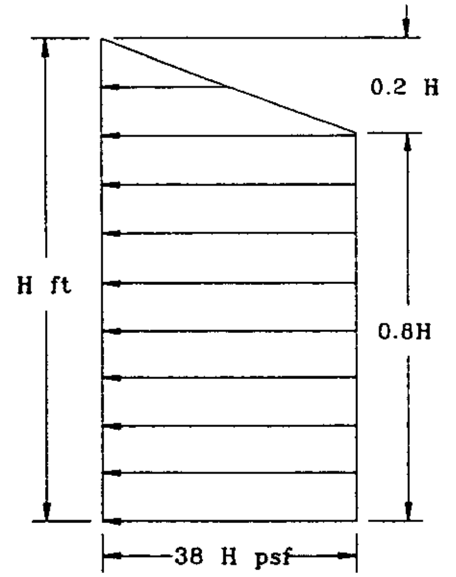
ENGEO INCORPORATED

1 MG TANK
6 MG WATER STORAGE RESERVOIR PROJECT
PITTSBURG, CALIFORNIA

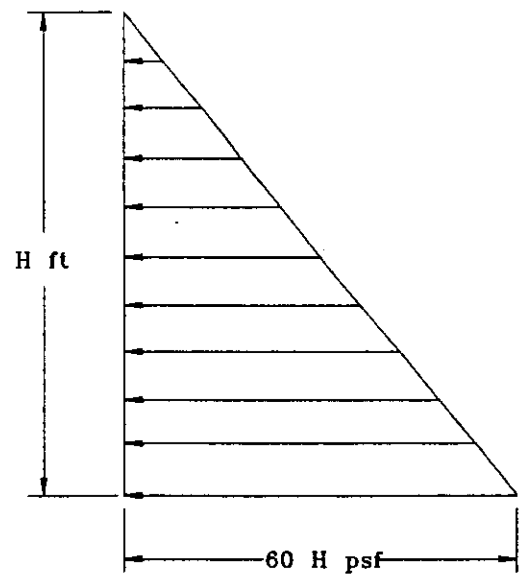
JOB NO.: 2494-M2	
DATE: DECEMBER 1997	
DRAWN BY: CB	CHECKED BY: JM

FIGURE NO. 16

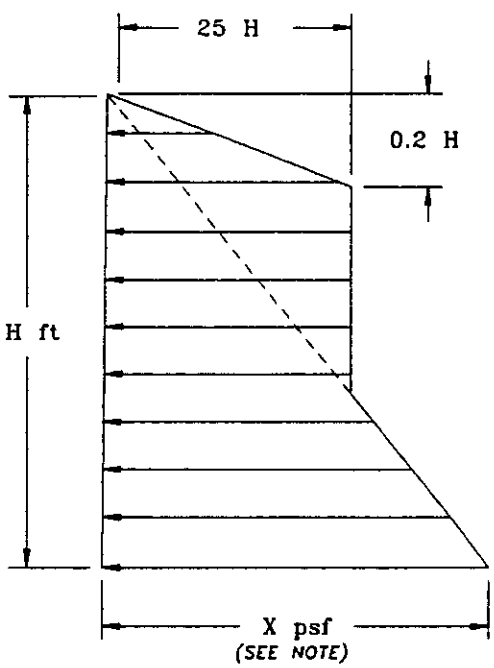
SHORING DESIGN DIAGRAMS



BRACED OR ANCHORED
SHORING SYSTEM

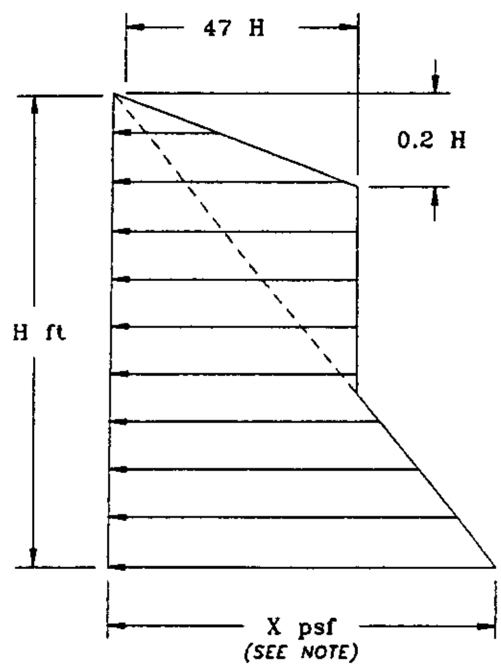


SOLDIER PILE SYSTEM



TANK WALL DESIGN DIAGRAM
STATIC LOAD CONDITION

X=40H FLEXIBLE WALL
X=60H RIGID WALL



TANK WALL DESIGN DIAGRAM
STATIC & SEISMIC LOAD CONDITION

X=75H FLEXIBLE WALL
X=95H RIGID WALL

ENGEO INCORPORATED	PRELIMINARY RETAINING WALL DESIGN CRITERIA 6 MG WATER STORAGE RESERVOIR PROJECT PITTSBURG, CALIFORNIA	PROJECT NO.: 2494-M2 DATE: DECEMBER 1997 DRAWN BY: LB CHECKED BY: JM	FIGURE NO. 17

TABLE I

REGIONAL ACTIVE FAULTS

FAULT NAME	Approx. Distance mi (km)	Max. Credible Event			Max. Probable Event		
		Max. Cred. Mag.	Peak Site Acc. g	Site Intens MM	Max. Prob. Mag.	Peak Site Acc. g	Site Intens MM
CALAVERAS	14 (23)	7.50	0.238	IX	6.50	0.149	VIII
COAST RANGES-SIERRAN BLOCK	8 (13)	8.00	0.491	X	6.70	0.329	IX
CONCORD	7 (12)	6.70	0.276	IX	6.50	0.256	IX
CORDELIA	17 (28)	6.70	0.137	VIII	4.25	0.018	IV
GREEN VALLEY	11 (17)	7.00	0.241	IX	6.00	0.119	VII
GREENVILLE	10 (16)	7.30	0.289	IX	5.75	0.110	VII
HAYWARD	21 (34)	7.50	0.173	VIII	7.00	0.133	VIII
HEALDSBURG - RODGERS CREEK	31 (49)	7.00	0.089	VII	7.00	0.089	VII
LAS POSITAS	27 (43)	6.30	0.062	VI	4.50	0.012	III
MAACAMA	55 (89)	7.60	0.071	VI	6.50	0.027	V
PALO COLORADO-SAN GREGORIO	43 (69)	7.70	0.099	VII	6.75	0.049	VI
SAN ANDREAS (Northern)	40 (64)	8.00	0.128	VIII	7.25	0.079	VII
SARGENT	60 (96)	7.00	0.039	V	5.25	0.006	II
WEST NAPA	23 (37)	6.50	0.089	VII	5.00	0.024	V
ZAMORA	49 (78)	6.50	0.039	V	4.75	0.006	II

15 FAULTS FOUND WITHIN THE SPECIFIED SEARCH RADIUS.

THE ANTIOCH FAULT IS CLOSEST TO THE SITE.
IT IS ABOUT 7.5 MILES AWAY.

LARGEST MAXIMUM-CREDIBLE SITE ACCELERATION: 0.491 g

LARGEST MAXIMUM-PROBABLE SITE ACCELERATION: 0.329 g

SITE COORDINATES:
LATITUDE: 38.0067 N
LONGITUDE: 121.904 W

ATTENUATION RELATION: IDRISS (1994) – HORIZ. – ROCK/STIFF SOIL

GUIDE CONTRACT SPECIFICATIONS

PART I - EARTHWORK

PREFACE

These specifications are intended as a guide for the earthwork performed at the subject development project. If there is a conflict between these specifications (including the recommendations of the geotechnical report) and agency or code requirements, it should be brought to the attention of ENGEO and Owner prior to contract bidding.

PART 1 - GENERAL

1.01 WORK COVERED

A. Grading, excavating, filling and backfilling, including trenching and backfilling for utilities as necessary to complete the Project as indicated on the Drawings.

B. Subsurface drainage as indicated on the Drawings.

1.02 CODES AND STANDARDS

A. Excavating, trenching, filling, backfilling, and grading work shall meet the applicable requirements of the Uniform Building Code and the standards and ordinances of state and local governing authorities.

1.03 SUBSURFACE SOIL CONDITIONS

A. The Owners' Geotechnical Exploration report is available for inspection by bidder or Contractor. The Contractor shall refer to the findings and recommendations of the Geotechnical Exploration report in planning and executing his work.

1.04 DEFINITIONS

A. Fill: All soil, rock, or soil-rock materials placed to raise the grades of the site or to backfill excavations.

B. Backfill: All soil, rock or soil-rock material used to fill excavations and trenches.

C. On-Site Material: Soil and/or rock material which is obtained from the site.

D. Imported Material: Soil and/or rock material which is brought to the site from off-site areas.

E. Select Material: On-site and/or imported material which is approved by ENGEO as a specific-purpose fill.

F. Engineered Fill: Fill upon which ENGEO has made sufficient observations and tests to confirm that the fill has been placed and compacted in accordance with specifications and requirements.

G. Degree of Compaction or Relative Compaction: The ratio, expressed as a percentage, of the in-place dry density of the fill and backfill material as compacted in the field to the maximum dry density of the same material as determined by ASTM D-1557 or California 216 compaction test method.

H. Optimum Moisture: Water content, percentage by dry weight, corresponding to the maximum dry density as determined by ASTM D-1557.

I. ENGEO: The project geotechnical engineering consulting firm, its employees or its designated representatives.

J. Drawings: All documents, approved for construction, which describe the Work.

1.05 OBSERVATION AND TESTING

A. All site preparation, cutting and shaping, excavating, filling, and backfilling shall be carried out under the observation of ENGEO, employed and paid for by the Owners. ENGEO will perform appropriate field and laboratory tests to evaluate the suitability of fill material, the proper moisture content for compaction, and the degree of compaction achieved. Any fill that does not meet the specification requirements shall be removed and/or reworked until the requirements are satisfied.

B. Cutting and shaping, excavating, conditioning, filling, and compacting procedures require approval of ENGEO as they are performed. Any work found unsatisfactory or any work disturbed by subsequent operations before approval is granted shall be corrected in an approved manner as recommended by ENGEO.

C. Tests for compaction will be made in accordance with test procedures outlined in ASTM D-1557, as applicable. Field testing of soils or compacted fill shall conform with the applicable requirements of ASTM D-2922.

D. All authorized observation and testing will be paid for by the Owners.

1.06 SITE CONDITIONS

A. Excavating, filling, backfilling, and grading work shall not be performed during unfavorable weather conditions. When the work is interrupted by rain, excavating, filling, backfilling, and grading work shall not be resumed until the site and soil conditions are suitable.

B. Contractor shall take the necessary measures to prevent erosion of freshly filled, backfilled, and graded areas until such time as permanent drainage and erosion control measures have been installed.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall furnish all materials, tools, equipment, facilities, and services as required for performing the required excavating, filling, backfilling, and grading work, and trenching and backfilling for utilities.

2.02 SOIL MATERIALS

A. Fill

1. Material to be used for engineered fill and backfill shall be free from organic matter and other deleterious substances, and of such quality that it will compact thoroughly without excessive voids when watered and rolled. Excavated on-site material will be considered suitable for engineered fill and backfill if it contains no more than 3 percent organic matter, is free of debris and other deleterious substances and conforms to the requirements specified above. Rocks of maximum dimension in excess of two-thirds of the lift thickness shall be removed from any fill material to the satisfaction of ENGEO.

2. Excavated earth material which is suitable for engineered fill or backfill, as determined by ENGEO, shall be conditioned for reuse and properly stockpiled as required for later filling and backfilling operations. Conditioning shall consist of spreading material in layers not to exceed 8 inches and raking free of debris and rubble. Rocks and aggregate exceeding the allowed largest dimension, and deleterious material shall be removed from the site and disposed off site in a legal manner.

3. ENGEO shall be notified at least 48 hours prior to the start of filling and backfilling operations so that it may evaluate samples of the material intended for use as fill and backfill. All materials to be used for filling and backfilling require the approval of ENGEO.

B. Import Material: Where conditions require the importation of fill material, the material shall be an inert, nonexpansive soil or soil-rock material free of organic matter and meeting the following requirements unless otherwise approved by ENGEO.

Gradation (ASTM D-421):	Sieve Size	Percent Passing
	2-inch	100
	#200	15 - 70
Plasticity (ASTM D-4318):	Liquid Limit	Plasticity Index
	< 30	< 12
Swell Potential (ASTM D-4546B): (at optimum moisture)	Percent Heave	Swell Pressure
	< 2 percent	< 300 psf
Resistance Value (ASTM D-2844):	Minimum 25	
Organic Content (ASTM D-2974):	Less than 2 percent	

A sample of the proposed import material should be submitted to ENGEO for evaluation prior to delivery at the site.

2.03 SAND

A. Sand for sand cushion under slabs and for bedding of pipe in utility trenches shall be a clean and graded, washed sand, all passing a No. 4 U. S. Standard Sieve, and generally conforming to ASTM C33 for fine aggregate.

2.04 AGGREGATE DRAINAGE FILL

A. Aggregate drainage fill under concrete slabs and paving shall consist of broken stone, crushed or uncrushed gravel, clean quarry waste, or a combination thereof. The aggregate shall be free from fines, vegetable matter, loam, volcanic tuff, and other deleterious substances. It shall be of such quality that the absorption of water in a saturated surface dry condition does not exceed 3 percent of the oven dry weight of the samples.

B. Aggregate drainage fill shall be of such size that the percentage composition by dry weight as determined by laboratory sieves (U. S. Series) will conform to the following grading:

Sieve Size	Percentage Passing Sieve
1½-inches	100
1-inch	90 - 100
#4	0 - 5

2.05 SUBDRAINS

A. Perforated subdrain pipe of the required diameter shall be installed as shown on the drawings. The pipe(s) shall also conform to these specifications unless otherwise specified by ENGEO in the field.

Subdrain pipe shall be manufactured in accordance with one of the following requirements:

Design depths less than 30 feet

- Perforated ABS Solid Wall SDR 35 (ASTM D-2751)
- Perforated PVC Solid Wall SDR 35 (ASTM D-3034)
- Perforated PVC A-2000 (ASTM F949)
- Perforated Corrugated HDPE double-wall (AASHTO M-252 or M-294, Caltrans Type S, 50 psi minimum stiffness)

Design depths less than 50 feet

- Perforated PVC SDR 23.5 Solid Wall (ASTM D-3034)
- Perforated Sch. 40 PVC Solid Wall (ASTM-1785)
- Perforated ABS SDR 23.5 Solid Wall (ASTM D-2751)
- Perforated ABS DWV/Sch. 40 (ASTM D-2661 and D-1527)
- Perforated Corrugated HDPE double-wall (AASHTO M-252 or M-294, Caltrans Type S, 70 psi minimum stiffness)

Design depths less than 70 feet

- Perforated ABS Solid Wall SDR 15.3 (ASTM D-2751)
- Perforated Sch. 80 PVC (ASTM D-1785)
- Perforated Corrugated Aluminum (ASTM B-745)

B. Permeable Material (Class 2): Class 2 permeable material for filling trenches under, around, and over subdrains, behind building and retaining walls, and for pervious blankets shall consist of clean, coarse sand and gravel or crushed stone, conforming to the following grading requirements:

Sieve Size	Percentage Passing Sieve
1-inch	100
¾-inch	90 - 100
⅜-inch	40 - 100
#4	25 - 40
#8	18 - 33
#30	5 - 15
#50	0 - 7
#200	0 - 3

C. Filter Fabric: All filter fabric shall meet the following Minimum Average Roll Values unless otherwise specified by ENGEO.

Grab Strength (ASTM D-4632)..180 lbs
Mass Per Unit Area (ASTM D-4751).................................6 oz/yd^2
Apparent Opening Size (ASTM D-4751)...........................70-100 U.S. Std. Sieve
Flow Rate (ASTM D-4491)..80 gal/min/ft^2
Puncture Strength (ASTM D-4833)...................................80 lbs

D. Vapor Barrier: Vapor barriers shall consist of PVC, LDPE or HDPE impermeable sheeting at least 10 mils thick.

2.06 PERMEABLE MATERIAL (Class 1; Type A)

A. Class 1 permeable material to be used in conjunction with filter fabric for backfilling of subdrain excavations shall conform to the following grading requirements:

Sieve Size	Percentage Passing Sieve
¾-inch	100
½-inch	95 - 100
⅜-inch	70 - 100
#4	0 - 55
#8	0 - 10
#200	0 - 3

PART 3 - EXECUTION

3.01 STAKING AND GRADES

A. Contractor shall lay out all his work, establish all necessary markers, bench marks, grading stakes, and other stakes as required to achieve design grades.

3.02 EXISTING UTILITIES

A. Contractor shall verify the location and depth (elevation) of all existing utilities and services before performing any excavation work.

3.03 EXCAVATION

A. Contractor shall perform excavating as indicated and required for concrete footings, drilled piers, foundations, floor slabs, concrete walks, and site leveling and grading, and provide shoring, bracing, underpinning, cribbing, pumping, and planking as required. The bottoms of excavations shall be firm undisturbed earth, clean and free from loose material, debris, and foreign matter.

B. Excavations shall be kept free from water at all times. Adequate dewatering equipment shall be maintained at the site to handle emergency situations until concrete or backfill is placed.

C. Unauthorized excavations for footings shall be filled with concrete to required elevations, unless other methods of filling are authorized by ENGEO.

D. Excavated earth material which is suitable for engineered fill or backfill, as determined by ENGEO, shall be conditioned for reuse and properly stockpiled for later filling and backfilling operations as specified under Section 2.02, "Soil Materials."

E. Abandoned sewers, piping, and other utilities encountered during excavating shall be removed and the resulting excavations shall be backfilled with engineered fill as required by ENGEO.

F. Any active utility lines encountered shall be reported immediately to the Owner's Representative and authorities involved. The Owner and proper authorities shall be permitted free access to take the measures deemed necessary to repair, relocate, or remove the obstruction as determined by the responsible authority or Owner's Representative.

3.04 SUBGRADE PREPARATION

A. All brush and other rubbish, as well as trees and root systems not marked for saving, shall be removed from the site and legally disposed of.

B. Any existing structures, foundations, underground storage tanks, or debris must be removed from the site prior to any building, grading, or fill operations. Septic tanks, including all drain fields and other lines, if encountered, must be totally removed. The resulting depressions shall be properly prepared and filled to the satisfaction of ENGEO.

C. Vegetation and organic topsoil shall be removed from the surface upon which the fill is to be placed and either removed and legally disposed of or stockpiled for later use in approved landscape areas. The surface shall then be scarified to a depth of at least eight inches until the surface is free from ruts, hummocks, or other uneven features which would tend to prevent uniform compaction by the equipment to be used.

D. After the foundation for the fill has been cleared and scarified, it shall be made uniform and free from large clods. The proper moisture content must be obtained by adding water or aerating. The foundation for the fill shall be compacted at the proper moisture content to a relative compaction as specified herein.

3.05 ENGINEERED FILL

A. Select Material: Fill material shall be "Select" or "Imported Material" as previously specified.

B. Placing and Compacting: Engineered fill shall be constructed by approved and accepted methods. Fill material shall be spread in uniform lifts not exceeding 8 inches in uncompacted thickness. Each layer shall be spread evenly, and thoroughly blade-mixed to obtain uniformity of material. Fill material which does not contain sufficient moisture as specified by ENGEO shall be sprinkled with water; if it contains excess moisture it shall be aerated or blended with drier material to achieve the proper water content. Select material and water shall then be thoroughly mixed before being compacted.

C. Unless otherwise specified in the Geotechnical Exploration report, each layer of spread select material shall be compacted to at least 90 percent relative compaction at a moisture content of at least three percent above the optimum moisture content. Minimum compaction in all keyways shall be a minimum of 95 percent with a minimum moisture content of at least 1 percent above optimum.

D. Unless otherwise specified in the Geotechnical Exploration report or otherwise required by the local authorities the upper 6 inches of engineered fill in areas to receive pavement shall be compacted to at least 95 percent relative compaction.

E. Testing and Observation of Fill: The work shall consist of field observation and testing to determine that each layer has been compacted to the required density and that the required moisture is being obtained. Any layer or portion of a layer that does not attain the compaction required shall be reworked until the required density is obtained.

F. Compaction: Compaction shall be by sheepsfoot rollers, multiple-wheel steel or pneumatic-tired rollers or other types of acceptable compaction equipment. Rollers shall be of such design that they will be able to compact the fill to the specified compaction. Rolling shall be accomplished while the fill material is within the specified moisture content range. Rolling of each layer must be continuous so that the required compaction may be obtained uniformly throughout each layer.

G. Fill slopes shall be constructed by overfilling the design slopes and later cutting back the slopes to the design grades. No loose soil will be permitted on the faces of the finished slopes.

H. Strippings and topsoil shall be stockpiled as approved by Owner, then placed in accordance with ENGEO's recommendations to a minimum thickness of 6 inches over exposed open space cut slopes which are 3:1 or flatter, and track walked to the satisfaction of ENGEO.

I. Final Prepared Subgrade: Finish blading and smoothing shall be performed as necessary to produce the required density, with a uniform surface, smooth and true to grade.

3.06 BACKFILLING

A. Backfill shall not be placed against footings, building walls, or other structures until approved by ENGEO.

B. Backfill material shall be Select Material as specified for engineered fill.

C. Backfill shall be placed in 6-inch layers, leveled, rammed, and tamped in place. Each layer shall be compacted with suitable compaction equipment to 90 percent relative compaction at a moisture content of at least 3 percent above optimum.

3.07 TRENCHING AND BACKFILLING FOR UTILITIES

A. Trenching:

1. Trenching shall include the removal of material and obstructions, the installation and removal of sheeting and bracing and the control of water as necessary to provide the required utilities and services.

2. Trenches shall be excavated to the lines, grades, and dimensions indicated on the Drawings. Maximum allowable trench width shall be the outside diameter of the pipe plus 24 inches, inclusive of any trench bracing.

3. When the trench bottom is a soft or unstable material as determined by ENGEO, it shall be made firm and solid by removing said unstable material to a sufficient depth and replacing it with on-site material compacted to 90 percent minimum relative compaction.

4. Where water is encountered in the trench, the contractor must provide materials necessary to drain the water and stabilize the bed.

B. Backfilling:

1. Trenches must be backfilled within 2 days of excavation to minimize desiccation.

2. Bedding material shall be sand and shall not extend more than 6 inches above any utility lines.

3. Backfill material shall be select material.

4. Trenches shall be backfilled as indicated or required and compacted with suitable equipment to 90 percent minimum relative compaction at the required moisture content.

3.08 SUBDRAINS

A. Trenches for subdrain pipe shall be excavated to a minimum width equal to the outside diameter of the pipe plus at least 12 inches and to a depth of approximately 2 inches below the grade established for the invert of the pipe, or as indicated on the Drawings.

B. The space below the pipe invert shall be filled with a layer of Class 2 permeable material, upon which the pipe shall be laid with perforations down. Sections shall be joined as recommended by the pipe manufacturer.

C. Rocks, bricks, broken concrete, or other hard material shall not be used to give intermediate support to pipes. Large stones or other hard objects shall not be left in contact with the pipes.

D. Excavations for subdrains shall be filled as required to fill voids and prevent settlement without damaging the subdrain pipe. Alternatively, excavations for subdrains may be filled with Class 1 permeable material (as defined in Section 2.06) wrapped in Filter Fabric (as defined in Section 2.05).

3.09 AGGREGATE DRAINAGE FILL

A. ENGEO shall approve finished subgrades before aggregate drainage fill is installed.

B. Pipes, drains, conduits, and any other mechanical or electrical installations shall be in place before any aggregate drainage fill is placed. Backfill at walls to elevation of drainage fill shall be in place and compacted.

C. Aggregate drainage fill under slabs and concrete paving shall be the minimum uniform thickness after compaction of dimensions indicated on Drawings. Where not indicated, minimum thickness after compaction shall be 4 inches.

D. Aggregate drainage fill shall be rolled to form a well-compacted bed.

E. The finished aggregate drainage fill must be observed and approved by ENGEO before proceeding with any subsequent construction over the compacted base or fill.

3.10 SAND CUSHION

A. A sand cushion shall be placed over the vapor barrier membrane under concrete slabs on grade. Sand cushion shall be placed in uniform thickness as indicated on the Drawings. Where not indicated, the thickness shall be 2 inches.

3.11 FINISH GRADING

A. All areas must be finish graded to elevations and grades indicated on the Drawings. In areas to receive topsoil and landscape planting, finish grading shall be performed to a uniform 6 inches below the grades and elevations indicated on the Drawings, and brought to final grade with topsoil.

3.12 DISPOSAL OF WASTE MATERIALS

A. Excess earth materials and debris shall be removed from the site and disposed of in a legal manner. Location of dump site and length of haul are the Contractor's responsibility.

PART II - GEOGRID SOIL REINFORCEMENT

1. DESCRIPTION:

   Work shall consist of furnishing geogrid soil reinforcement for use in construction of reinforced soil slopes and retention systems.

2. GEOGRID MATERIAL:

   2.1 The specific geogrid material shall be preapproved by ENGEO.

   2.2 The geogrid shall be a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil or rock. The geogrid structure shall be dimensionally stable and able to retain its geometry under construction stresses and shall have high resistance to damage during construction, to ultraviolet degradation, and to all forms of chemical and biological degradation encountered in the soil being reinforced.

   2.3 The geogrids shall have an Allowable Strength (T_a) and Pullout Resistance, for the soil type(s) indicated, as listed in Table I.

   2.4 Certifications: The Contractor shall submit a manufacturer's certification that the geogrids supplied meet the respective index criteria set when geogrid was approved by ENGEO, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Contractor will supply test data from an ENGEO-approved laboratory to support the certified values submitted.

3. CONSTRUCTION:

   3.1 Delivery, Storage, and Handling: Contractor shall check the geogrid upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geogrid shall be protected from temperatures greater than 140 °F, mud, dirt, dust, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the geogrid will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be repaired by placing a patch over the damaged area. Any geogrid damaged during storage or installation shall be replaced by the Contractor at no additional cost to the owner.

3.2 On-Site Representative: Geogrid material suppliers shall provide a qualified and experienced representative on site at the initiation of the project, for a minimum of three days, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criterion will apply to construction of the initial slope only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Geogrid reinforcement may be joined with mechanical connections or overlaps as recommended and approved by the Manufacturer. Joints shall not be placed within 6 feet of the slope face, within 4 feet below top of slope, nor horizontally or vertically adjacent to another joint.

3.4 Geogrid Placement: The geogrid reinforcement shall be installed in accordance with the manufacturer's recommendations. The geogrid reinforcement shall be placed within the layers of the compacted soil as shown on the plans or as directed.

The geogrid reinforcement shall be placed in continuous longitudinal strips in the direction of main reinforcement. However, if the Contractor is unable to complete a required length with a single continuous length of geogrid, a joint may be made with the Manufacturer's approval. Only one joint per length of geogrid shall be allowed. This joint shall be made for the full width of the strip by using a similar material with similar strength. Joints in geogrid reinforcement shall be pulled and held taut during fill placement.

Adjacent strips, in the case of 100 percent coverage in plan view, need not be overlapped. The minimum horizontal coverage is 50 percent, with horizontal spacings between reinforcement no greater than 40 inches. Horizontal coverage of less than 100 percent shall not be allowed unless specifically detailed in the construction drawings.

Adjacent rolls of geogrid reinforcement shall be overlapped or mechanically connected where exposed in a wrap around face system, as applicable.

The Contractor may place only that amount of geogrid reinforcement required for immediately pending work to prevent undue damage. After a layer of geogrid reinforcement has been placed, the next succeeding layer of soil shall be placed and compacted as appropriate. After the specified soil layer has been placed, the next geogrid reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geogrid reinforcement and soil.

Geogrid reinforcement shall be placed to lay flat and pulled tight prior to backfilling. After a layer of geogrid reinforcement has been placed, suitable means, such as pins or small piles of soil, shall be used to hold the geogrid reinforcement in position until the subsequent soil layer can be placed.

Under no circumstances shall a track-type vehicle be allowed on the geogrid reinforcement before at least six inches of soil have been placed. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and the geogrid reinforcement. If approved by the Manufacturer, rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds, less than 10 mph. Sudden braking and sharp turning shall be avoided.

During construction, the surface of the fill should be kept approximately horizontal. Geogrid reinforcement shall be placed directly on the compacted horizontal fill surface. Geogrid reinforcements are to be placed within three inches of the design elevations and extend the length as shown on the elevation view unless otherwise directed by ENGEO. Correct orientation of the geogrid reinforcement shall be verified by ENGEO.

Table I
Allowable Geogrid Strength
With Various Soil Types
For Geosynthetic Reinforcement In
Mechanically Stabilized Earth Slopes

(Geogrid Pullout Resistance and Allowable Strengths vary with reinforced backfill used due to soil anchorage and site damage factors. Guidelines are provided below.)

SOIL TYPE	MINIMUM ALLOWABLE STRENGTH, T_a (lb/ft)*		
	GEOGRID Type I	GEOGRID Type II	GEOGRID Type III
A. Gravels, sandy gravels, and gravel-sand-silt mixtures (GW, GP, GC, GM & SP)**	2400	4800	7200
B. Well graded sands, gravelly sands, and sand-silt mixtures (SW & SM)**	2000	4000	6000
C. Silts, very fine sands, clayey sands and clayey silts (SC & ML)**	1000	2000	3000
D. Gravelly clays, sandy clays, silty clays, and lean clays (CL)**	1600	3200	4800

* All partial Factors of Safety for reduction of design strength are included in listed values. Additional factors of safety may be required to further reduce these design strengths based on site conditions.

** Unified Soil Classifications.

PART III - GEOTEXTILE SOIL REINFORCEMENT

1. DESCRIPTION:

Work shall consist of furnishing geotextile soil reinforcement for use in construction of reinforced soil slopes.

2. GEOTEXTILE MATERIAL:

2.1 The specific geotextile material and supplier shall be preapproved by ENGEO.

2.2 The geotextile shall have a high tensile modulus and shall have high resistance to damage during construction, to ultraviolet degradation, and to all forms of chemical and biological degradation encountered in the soil being reinforced.

2.3 The geotextiles shall have an Allowable Strength (T_a) and Pullout Resistance, for the soil type(s) indicated as listed in Table II.

2.4 Certification: The Contractor shall submit a manufacturer's certification that the geotextiles supplied meet the respective index criteria set when geotextile was approved by ENGEO, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Contractor will supply the data from an ENGEO-approved laboratory to support the certified values submitted.

3. CONSTRUCTION:

3.1 Delivery, Storage and Handling: Contractor shall check the geotextile upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geotextile shall be protected from temperatures greater than 140 °F, mud, dirt, dust, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the geotextile will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be repaired by placing a patch over the damaged area. Any geotextile damaged during storage or installation shall be replaced by the Contractor at no additional cost to the owner.

3.2 On-Site Representative: Geotextile material suppliers shall provide a qualified and experienced representative on site at the initiation of the project, for a minimum of three days, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criterion will apply to construction of the initial slope only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Geotextile Placement: The geotextile reinforcement shall be installed in accordance with the manufacturer's recommendations. The geotextile reinforcement shall be placed within the layers of the compacted soil as shown on the plans or as directed.

The geotextile reinforcement shall be placed in continuous longitudinal strips in the direction of main reinforcement. Joints shall not be used with geotextiles.

Adjacent strips, in the case of 100 percent coverage in plan view, need not be overlapped. The minimum horizontal coverage is 50 percent, with horizontal spacings between reinforcement no greater than 40 inches. Horizontal coverage of less than 100 percent shall not be allowed unless specifically detailed in the construction drawings.

Adjacent rolls of geotextile reinforcement shall be overlapped or mechanically connected where exposed in a wrap around face system, as applicable.

The Contractor may place only that amount of geotextile reinforcement required for immediately pending work to prevent undue damage. After a layer of geotextile reinforcement has been placed, the succeeding layer of soil shall be placed and compacted as appropriate. After the specified soil layer has been placed, the next geotextile reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geotextile reinforcement and soil.

Geosynthetic reinforcement shall be placed to lay flat and be pulled tight prior to backfilling. After a layer of geotextile reinforcement has been placed, suitable means, such as pins or small piles of soil, shall be used to hold the geotextile reinforcement in position until the subsequent soil layer can be placed.

Under no circumstances shall a track-type vehicle be allowed on the geotextile reinforcement before at least six inches of soil has been placed. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and the geotextile reinforcement. If approved by the Manufacturer, rubber-tired equipment may pass over the geotextile reinforcement as slow speeds, less than 10 mph. Sudden braking and sharp turning shall be avoided.

During construction, the surface of the fill should be kept approximately horizontal. Geotextile reinforcement shall be placed directly on the compacted horizontal fill surface. Geotextile reinforcements are to be placed within three inches of the design elevations and extend the length as shown on the elevation view unless otherwise directed by

ENGEO. Correct orientation of the geotextile reinforcement shall be verified by ENGEO.

Table II
Allowable Geotextile Strength
With Various Soil Types
For Geosynthetic Reinforcement In
Mechanically Stabilized Earth Slopes

(Geotextile Pullout Resistance and Allowable Strengths vary with reinforced backfill used due to soil anchorage and site damage factors. Guidelines are provided below.)

SOIL TYPE	MINIMUM ALLOWABLE STRENGTH, T_a (lb/ft)*		
	GEOTEXTILE Type I	GEOTEXTILE Type II	GEOTEXTILE Type III
A. Gravels, sandy gravels, and gravel-sand-silt mixtures (GW, GP, GC, GM & SP)**	2400	4800	7200
B. Well graded sands, gravelly sands, and sand-silt mixtures (SW & SM)**	2000	4000	6000
C. Silts, very fine sands, clayey sands and clayey silts (SC & ML)**	1000	2000	3000
D. Gravelly clays, sandy clays, silty clays, and lean clays (CL)**	1600	3200	4800

* All partial Factors of Safety for reduction of design strength are included in listed values. Additional factors of safety may be required to further reduce these design strengths based on site conditions.

** Unified Soil Classifications.

PART IV - EROSION CONTROL MAT OR BLANKET

1. DESCRIPTION:

Work shall consist of furnishing and placing a synthetic erosion control mat and/or degradable erosion control blanket for slope face protection and lining of runoff channels.

2. EROSION CONTROL MATERIALS:

2.1 The specific erosion control material and supplier shall be preapproved by ENGEO.

2.2 Certification: The Contractor shall submit a manufacturer's certification that the erosion mat/blanket supplied meets the criteria specified when the material was approved by ENGEO. The manufacturer's certification shall include a submittal package of documented test results that confirm the property values. In case of a dispute over validity of values, the Contractor will supply property test data from an ENGEO-approved laboratory, to support the certified values submitted. Minimum average roll values, per ASTM D 4759, shall be used for conformance determinations.

3. CONSTRUCTION:

3.1 Delivery, Storage, and Handling: Contractor shall check the erosion control material upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the erosion mat shall be protected from temperatures greater than 140 °F, mud, dirt, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the erosion mat/blanket shall be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be removed by cutting OUT a section of the mat. The remaining ends should be overlapped and secured with ground anchors. Any erosion mat/blanket damaged during storage or installation shall be replaced by the Contractor at no additional cost to the Owner.

3.2 On-Site Representative: Erosion control material suppliers shall provide a qualified and experienced representative on site, for a minimum of one day, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criteria will apply to construction of the initial slope only. The representative shall be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Placement: The erosion control material shall be placed and anchored on a smooth graded, firm surface approved by the Engineer. Anchoring terminal ends of the erosion control material shall be accomplished through use of key trenches. The material in the trenches shall be anchored to the soil on maximum 1½ foot centers. Topsoil, if required by construction drawings, placed over final grade prior to installation of the erosion control material shall be limited to a depth not exceeding 3 inches.

3.4 Erosion control material shall be anchored, overlapped, and otherwise constructed to ensure performance until vegetation is well established. Anchors shall be as designated on the construction drawings, with a minimum of 12 inches length, and shall be spaced as designated on the construction drawings, with a maximum spacing of 4 feet.

3.5 Soil Filling: If noted on the construction drawings, the erosion control mat shall be filled with a fine grained topsoil, as recommended by the manufacturer. Soil shall be lightly raked or brushed on/into the mat to fill the mat voids or to a maximum depth of 1 inch.

PART V - GEOSYNTHETIC DRAINAGE COMPOSITE

1. DESCRIPTION:

Work shall consist of furnishing and placing a geosynthetic drainage system as a subsurface drainage medium for reinforced soil slopes.

2. DRAINAGE COMPOSITE MATERIALS:

2.1 The specific drainage composite material and supplier shall be preapproved by ENGEO.

2.2 The drain shall be of composite construction consisting of a supporting structure or drainage core material surrounded by a geotextile. The geotextile shall encapsulate the drainage core and prevent random soil intrusion into the drainage structure. The drainage core material shall consist of a three dimensional polymeric material with a structure that permits flow along the core laterally. The core structure shall also be constructed to permit flow regardless of the water inlet surface. The drainage core shall provide support to the geotextile. The fabric shall meet the minimum property requirements for filter fabric listed in Section 2.05C of the Guide Earthwork Specifications.

2.3 A geotextile flap shall be provided along all drainage core edges. This flap shall be of sufficient width for sealing the geotextile to the adjacent drainage structure edge to prevent soil intrusion into the structure during and after installation. The geotextile shall cover the full length of the core.

2.4 The geocomposite core shall be furnished with an approved method of constructing and connecting with outlet pipes or weepholes as shown on the plans. Any fittings shall allow entry of water from the core but prevent intrusion of backfill material into the core material.

2.5 Certification and Acceptance: The Contractor shall submit a manufacturer's certification that the geosynthetic drainage composite meets the design properties and respective index criteria measured in full accordance with all test methods and standards specified. The manufacturer's certification shall include a submittal package of documented test results that confirm the design values. In case of dispute over validity of design values, the Contractor will supply design property test data from an ENGEO-approved laboratory, to support the certified values submitted. Minimum average roll values, per ASTM D 4759, shall be used for determining conformance.

3. CONSTRUCTION:

3.1 Delivery, Storage, and Handling: Contractor shall check the geosynthetic drainage composite upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geosynthetic drainage composite shall be protected from temperatures greater than 140 °F, mud, dirt, and debris. Manufacturer's recommendations in regards to protection from direct sunlight must also be followed. At the time of installation, the geosynthetic drainage composite shall be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be removed or repaired. Any geosynthetic drainage composite damaged during storage or installation shall be replaced by the Contractor at no additional cost to the Owner.

3.2 On-Site Representative: Geosynthetic drainage composite material suppliers shall provide a qualified and experienced representative on site, for a minimum of one half day, to assist the Contractor and ENGEO personnel at the start of construction with directions on the use of drainage composite. If there is more than one application on a project, this criterion will apply to construction of the initial application only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining applications.

3.3 Placement: The soil surface against which the geosynthetic drainage composite is to be placed shall be free of debris and inordinate irregularities that will prevent intimate contact between the soil surface and the drain.

3.4 Seams: Edge seams shall be formed by utilizing the flap of the geotextile extending from the geocomposite's edge and lapping over the top of the fabric of the adjacent course. The fabric flap shall be securely fastened to the adjacent fabric by means of plastic tape or non-water-soluble construction adhesive, as recommended by the supplier. Where vertical splices are necessary at the end of a geocomposite roll or panel, an 8-inch-wide continuous strip of geotextile may be placed, centering over the seam and continuously fastened on both sides with plastic tape or non-water-soluble construction adhesive. As an alternative, rolls of geocomposite drain material may be joined together by turning back the fabric at the roll edges and interlocking the cuspidations approximately 2 inches. For overlapping in this manner, the fabric shall be lapped and tightly taped beyond the seam with tape or adhesive. Interlocking of the core shall always be made with the upstream edge on top in the direction of water flow. To prevent soil intrusion, all exposed edges of the geocomposite drainage core edge must be covered. Alternatively, a 12-inch-wide strip of fabric may be utilized in the same manner, fastening it to the exposed fabric 8 inches in from the edge and folding the remaining flap over the core edge.

3.5 Soil Fill Placement: Structural backfill shall be placed immediately over the geocomposite drain. Care shall be taken during the backfill operation not to damage the geotextile surface of the drain. Care shall also be taken to avoid excessive settlement of the backfill material. The geocomposite drain, once installed, shall not be exposed for more than seven days prior to backfilling.