PRELIMINARY GEOTECHNICAL INVESTIGATION

SALTON SEA
SPECIES CONSERVATION HABITAT PROJECT
SALTON SEA, CALIFORNIA

Project No. 758.01
September 2, 2011

Prepared by

Hultgren – Tillis Engineers

A California Corporation
Specializing in Geotechnical Engineering

Hultgren-Tillis Engineers

September 2, 2011
Project No. 758.01

Cardno ENTRIX
701 University Avenue, Suite 200
Sacramento, California 95825

Attention: Mr. Paul Wisheropp

Preliminary Geotechnical Investigation
Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Dear Mr. Wisheropp:

We performed a geotechnical investigation for preliminary design of the Species Conservation Habitat Project along the southeast shoreline of the Salton Sea. Our services are part of Cardno ENTRIX Project Number 32676001-5000, Task 5 of the Salton Sea SCH Project. Our task number is HT-DWR-2010-01, dated July 22, 2010. An administrative draft of this report was issued in January 2011. Additional pinhole tests by DWR were completed and transmitted to us on August 4, 2011. The results of our preliminary geotechnical investigation are presented in the attached report.

It was a pleasure working with you on this project and we look forward to working with you during design development and construction. If you have any questions, please call.

Sincerely,

Hultgren – Tillis Engineers

Edwin M. Hultgren
Geotechnical Engineer

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I. INTRODUCTION

This report presents the results of our preliminary geotechnical investigation for the proposed Salton Sea Species Conservation Habitat Project (SCH Project). The preliminary investigation is intended to provide a general characterization of on-site soil conditions and to provide geotechnical engineering criteria for preliminary design. The preliminary design will be the basis for the project description in the environmental impact documents. The findings and conclusions presented in this report are not intended for final design. A more detailed investigation should be conducted for the final berm alignment, berm configurations, borrow sources, and anticipated construction methodologies.

II. PROJECT DESCRIPTION

The SCH Project will be located along the southeast shore of the Salton Sea. A Vicinity Map is presented on Plate 1. The project will consist of creating shallow ponds along the existing shoreline. The ponds will be located on both sides of the mouths of the New River and the Alamo River. The approximate boundaries of the ponds near New River and Alamo River are shown on the Exploration Site Plans, Plates 2 and 3, respectively.

In the area of the New River, the ponds will extend approximately 2.5 miles southwest and 1.5 miles east from the mouth of the river. In the area of the Alamo River, the ponds will extend between 1.5 miles south to about 2 miles northeast of the river mouth. Immediately adjacent to both river mouths, the berms will close off existing bays, and the berms will be approximately 1.5 to 2 miles offshore of the existing levees. Beyond the bays, the seaward-most berms will be approximately 0.5 to 1 mile beyond the existing levees. The seaward berms may need to be constructed in water depths of up to three feet. The total length of seaward berms will be up to approximately 5.5 miles in the vicinity of the New River and approximately 3.5 miles in the Alamo River area. These estimates of berm lengths are preliminary as berm alignments continue to be evaluated.

The water depths within the ponds will typically be 6 feet or less. Ponds will contain water with varying degrees of salinity. Interior berms will subdivide the site into smaller ponds for individual salinity control. The target salinities are 20 parts per thousand (ppt) and 35 ppt. Water for the ponds will come from the New River and the Alamo River. Additional water for mixing various salinities in the ponds will come from the Salton Sea.

III. SCOPE OF SERVICES

For this preliminary investigation, our scope of services included reviewing the existing geotechnical data, exploring subsurface conditions at shallow depths along the berm alignments, assigning laboratory testing to be done by others, characterizing the materials encountered, and performing analyses and developing preliminary geotechnical conclusions and recommendations for constructing berms for the ponds.

IV. PREVIOUS INVESTIGATIONS

Two previous investigations contained geotechnical exploration and testing data.

The September 1972 Federal-State Feasibility Report, Salton Sea Project, California contained a summary of shallow probes drilled between the shoreline and five miles offshore. The thickness of sediment and the material type that refused further penetration are presented on Map 13, “Subaqueous Geology”, in the 1972 report. Map 14, titled “Subaqueous Structure Contours, Top of Foundation” provides bathymetry in 1972 and generalized elevation contours of the top of relatively firm foundation materials.

URS issued a report for the “Preliminary In-Sea Geotechnical Investigation, Salton Sea Restoration Project” in February 2004. One cone penetration test, CPT-13, and one boring, 14, were performed near the SCH Project. Engineering properties in what URS labeled “sea floor deposits” from their exploration across the length of the sea were similar to our findings and conclusions regarding “sea sediments” (the term used in our report) in the SCH Project area.

V. FIELD EXPLORATION

Methods for exploring subsurface conditions were dependent in part on site accessibility. On the playa (beach) above the water's edge, the site conditions were judged too soft to support conventional exploration equipment. This portion of the site was explored by hand augering. The hand auger was a 3.25-inch diameter barrel "Regular Auger" manufactured by AMS, Inc. of American Falls, Idaho. At and beyond the water's edge (within the Sea)[1], vibracore samples were taken from an airboat. Vibracores consisted of 3.0-inch outside diameter (OD) eight feet long Rexane sample liners in a 4.0-inch OD aluminum barrel and cutting shoe. The vibracore barrel was hung from an A-frame extending off the bow of the airboat.

At each exploration location, the in-situ strength was characterized by hand-held vane shear apparatus (Geonor Model H-60). The vanes were 1.0-inch wide (total width) and 2.0-inches long. Vane shear strength measurements were made at 0.5 foot depth intervals on the playa and at 1.0 foot depth intervals beneath the Sea. The vane was advanced between reading depths by pressing the vane further into the formation. In addition to the vane shear measurements taken by continuous advancement of the vane, hand-held vane shear strength measurements were also taken within the hand auger borings at approximately one foot intervals. At each hand auger sample depth, the vane was pressed 6-inches below the bottom of the augered hole. If the vane could not be pressed the full 6-inches below the augered depth, it was recorded on the log as "refused to vane shear penetration". A vane shear strength measurement was made, and the hand auger boring was advanced to the next test depth. Where the soil shear strength exceeded the range of hand-held vane shear apparatus using 1.0-inch wide vanes, the shear strength was reported as "0.68+ tsf" on the logs of borings.

Cuttings from the hand auger borings were placed in one-gallon plastic "freezer" bags, sealed, and marked with the boring number and depth intervals. The filled one-gallon bags were placed in larger 2.5 mil plastic bags, which were also sealed. A cone penetrometer test was conducted adjacent to each of the six hand auger borings. As the portable hand-held static cone penetrometer (Durham Geo Slope Indicator Model S-215) was pushed, the maximum and minimum penetration resistance was recorded for each 0.5 foot of penetration. The penetrometer had a 60 degree cone with a cross-sectioned area of 3.0 square centimeters.

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[1] The term "Sea" used by itself refers to the body of water, a feature within the greater Salton Sea area. "Sea" excludes the exposed playas, which are above the Sea.

The locations of the exploration points are shown on the Exploration Site Plans, Plates 2 and 3. Hand auger locations are noted as “HA” and vibracores locations are noted as “VC” Logs of the hand auger borings and vibracores are presented on Plates 4 through 18. The key to the logs is presented on Plate 19. The hand-held vane shear tests conducted within the hand auger borings are shown on the hand auger logs. The hand-held van shear tests performed adjacent to the vibracores are shown on the logs of the vibracores. In several instances, the hand-held vane shear tests extend deeper than the depths from which material was recovered in the vibracores.

The hand-held vane shear tests performed both adjacent to the hand auger and adjacent to the vibracore locations are summarized on Plate 20. (To better define the individual vane shear test results, the data points are shown vertically offset, in depth, by up to +/- 0.14 foot. The sole purpose of this arbitrary shift is to avoid having one data point masked by another.) Plate 20 is the only location in this report where the hand-held vane shear tests that were made *adjacent to* the hand augers are presented. The hand-held vane shear tests taken *within* the hand auger borings are presented on the logs of borings but are not included in Plate 20. The hand-held vane shear tests taken by continuous advancement of the vane adjacent to the vibracores are both shown on the vibracore logs and are included on Plate 20.

The hand-held cone penetrometer tests taken adjacent to the hand augers are presented on Plates 21 and 22.

VI. LABORATORY TESTING

Samples recovered from the hand augers and vibracores were delivered to the Moore Twining Associates, Inc. laboratory in Fresno, California. Laboratory testing on selected samples from the hand auger borings and vibracores consisted of 46 moisture content tests, 24 sieve analyses, and 18 Atterberg limits. Two bulk samples were collected from the playas near the New and Alamo Rivers (hand auger boring locations HA-1 and HA-4, respectively). Two laboratory compaction tests were performed on each bulk sample. One laboratory compaction test used “modified Proctor” compactive effort (ASTM Test D-1557) and the other “standard Proctor” (ASTM Test D-698).

To evaluate the dispersive characteristics of the on-site soils (sea sediments), six samples were selected for additional laboratory testing. They included the two bulk samples (HA-1 and HA-4) and four vibracore composite samples (VC-11, VC-16, VC-20 and VC-28). For each sample, the following laboratory tests were performed: gradation; Atterberg limits; organic content; crumb test; double hydrometer test; percent sodium in saturation extract; and pinhole test.

All of the laboratory testing was performed by Moore Twining Associates, Inc. except the pinhole tests. The pinhole tests were performed by the Department of Water Resources’ Bryte Soils and Concrete Laboratory in West Sacramento. Initial pinhole tests were performed in December 2010 using distilled water. Additional pinhole tests on the same samples were performed in July 2011 using mixtures of the New River and the Salton Sea waters at 20 and 40 parts per thousand (ppt) total dissolved solids (TDS).

The results of the laboratory testing are presented in Appendix A. A summary of the laboratory test results is presented in Table A-1 in Appendix A. Moisture contents and Atterberg limits are included in the logs of borings on Plates 4 to 18. The range of gradation test results are shown on Plate 23. The results of Atterberg limits tests are summarized on Plates 24 and 25. A plot of in-situ moisture contents and the corresponding Atterberg limit tests is presented on Plate 26. A combined plot of the four compaction tests is presented on Plate 27. The flow rates from the pinhole tests using the different salinity concentrations are summarized on Plate 28.

VII. SITE AND SUBSURFACE CONDITIONS

Several processes have gone into creating the feature now known as the Salton Sea. The Salton Sea basin is a northern extension of the Sea of Cortez, a down-dropped block created as the Pacific Plate moved northwest and the Gulf of California spread opened. The San Andreas Fault system forms a boundary between the low lying Salton Sea basin and the Chocolate Mountains further east. The Southern Salton Sea Seismic Zone lies beneath the Alamo River portion of the SCH Project.

The Salton Sea basin is now isolated from the Sea of Cortez by an enormous alluvial fan created by the Colorado River. In the past, the Colorado River has flowed into the Salton Sea basin to heights well above those experienced in historic times. Upon European man's arrival in the Imperial Valley, the Salton Sea was a dry sink. Beginning in 1900, irrigation canals were constructed from the Colorado River into the Imperial Valley and northern Mexico. In 1905, control of the river was lost at a canal headworks, and the Colorado River flowed uncontrolled into the Salton Sea for one and a half years. The Sea as it is known today was reborn.

Over the subsequent century, the Sea has shrunk, swelled and now is again shrinking, all in response to the extent of irrigation and irrigation practices. Since the flood of 1905 – 1907, much of the site drainage and irrigation tail water has been collected by the New and Alamo Rivers and discharged into the Salton Sea. These waters are fairly high in dissolved solids, about 2 ppt. These rivers also bring suspended sediments. Upon reaching the high salinity of the Salton Sea (currently about 51 ppt), the finer grained sediments (clay size) flocculate and settle out on the floor of the Sea. The coarser grained sediments, including silt and fine sands, settle by normal gravity forces.

The Sea is now receding. On the exposed playa, the sediments are drying, creating a crust strong enough to walk on. However, as one approaches the shoreline, within one to two feet of elevation above the current sea level, the ground remains too soft to walk on in some areas. The surface of the playa is cracked in many areas as the sediments shrink from evaporation. At fairly shallow depths, the sediments remain nearly saturated over much of the playa.

In approximately half of the locations explored within the Sea, the mudline beneath the Sea is very soft and will not support a person wading. Surface grades on the playas and beneath the Sea are generally very flat.

The thicknesses of sea sediments nominally range from 3 to 8 feet in the areas we explored along and adjacent to the southeast shore of the Salton Sea. The thicknesses probably exceed this range in some areas. Most of these sediments likely accumulated within the last sixty years during the Sea's most recent rise above Elevation -240 feet. The sea sediments consist of very soft to medium stiff fat and lean clays, loose clayey and silty sands, and soft to medium stiff silt, but they are predominantly clay. Red-brown lean clay, commonly medium stiff to stiff, was encountered below the sea sediment in many areas.

VIII. DISCUSSION OF FINDINGS

A. General

The most significant geotechnical issues for the project include the low strength of the sea sediments, constructing seaward berms within the Sea, erosion from wave action, the dispersive nature of the sediments, and internal erosion. Compressibility, seepage, and the expansion potential are also significant issues.

In some portions of the currently submerged areas, very flat fill slopes may be needed to safely construct the planned berms. Over a greater portion of the site, moderate fill slopes may be used, but the ground is too weak to support traditional low-ground-pressure track-mounted construction equipment.

Sea sediments, including those beneath the playa, are predominantly fine grained soils. These soils will readily erode when exposed to even light wave action. The soils are dispersive in both fresh and brackish water. If seepage developed through a berm and daylighted on the downstream slope, the dispersive nature of the soils could lead to rapid development of a piping condition and loss of the embankment.

B. Settlement

The embankments for the berm will settle appreciatively during and following construction. To quantify the potential settlement, we performed one dimensional settlement analysis. This assumes that the loaded area is wide relative to the depth of the compressible layer and ignores edge effects. We considered varying thicknesses of new fill, from 2 feet thick to 12 feet thick. The analyses were done for a range of compressible soil depths from 2 feet to 12 feet. For the preliminary design, no undisturbed samples were taken from which to do consolidation testing. To assess potential settlement, we used estimated values of the compression ratio and coefficient of consolidation in our settlement analysis. We assumed that the sea sediments are normally consolidated and that the virgin compression ratio, C_{ce}, equals 0.3[2]. The alluvial soil beneath the sea sediment is over-consolidated relative to the weight of the planned berms and was assumed to be incompressible.

Results of the settlement analyses are summarized on Plate 29.

[2] Tests performed by URS in sea sediments from deeper water areas indicated virgin compression ratios between 0.10 and 0.33.

To estimate how quickly this settlement may occur, we ran analyses that assumed single drainage, meaning that the soils beneath the sea sediments are assumed to be very low in permeability and are considered an impermeable boundary and the soils overlying sea sediments are assumed to be sufficiently permeable to provide unrestricted drainage. Pore water trying to escape the sea sediments under the weight of the fill is assumed to travel vertically to the top of the sediment layer. Lateral drainage is ignored. These are simplifying assumptions. Fill that will be placed to create the berm will be of low permeability and will inhibit drainage at the surface. Some drainage will likely occur into the underlying alluvial formation and some lateral drainage will occur. For the purpose of these analyses, we have assumed that modeling single vertical drainage and ignoring lateral drainage is offset by ignoring the low permeability of the overlying fill.

In estimating the time rate of consolidation, we assumed a coefficient of consolidation (c_v) of 10 feet squared per year. The estimated time to 50 percent consolidation is less than one to two months. The time requirement for 90 percent of the consolidation settlement to occur for varying thicknesses of soft soil sediments are presented in Table 1.

Table 1. Time for 90 Percent Consolidation

Thickness of Compressible Soils (feet)	Time required for 90 percent of Ultimate Settlement (months)
4	3
6	6
8	12
10	18
12	28

The above time rates of settlement as well as the estimated magnitudes of settlement were developed for assumed properties of the sea sediments. The presented results are intended to provide an order of magnitude understanding. Settlement will vary across the site. We estimate that about two-thirds of the site will have magnitudes of settlement less than presented on Plate 29. And we estimate that two-thirds of the site will consolidate faster than indicated on Table 1.

C. Stability

The results of the vane shear tests at the fifteen exploration locations are summarized on Plate 20. In this plot, the vane shear data taken adjacent to hand auger borings on the exposed playa are shown in warm colors (pale yellow, orange, and brown tones). Those vane shear tests taken from the airboat on the Sea or at its shoreline are shown in cool (lavender and blue) colors. On average, the strength of the materials beneath the Sea are considerably weaker than those beneath the playa.

The strength plots shown on Plate 20 as well as the strengths taken within the hand auger borings are measures of peak strength. No residual strength tests were performed for the preliminary investigation. Because the sediments coming out of the New and Alamo Rivers were essentially coming from a fresh water environment and hitting a highly saline body of water, the clayey materials likely have a flocculated structure. Flocculated clays can be highly sensitive, meaning that the residual strength may be much less than the peak strength.

The strength of the foundation soils (sea sediments) will greatly influence the way in which the berms are constructed. Where the shear strength in the foundation soil is consistently greater than 300 pounds per square feet (psf), the foundation soil can support the berm fill with little risk of foundation failure. (We discuss ability of construction equipment to operate on weak foundation soil in a later section.) At strengths lower than 300 psf, the risk of shear failure in the foundation soils needs to be carefully considered.

There are several states of stress that are commonly considered when assessing the stability of a water retention embankment such as the planned berms. The “end of construction” condition assumes that the soils are undrained and that no consolidation (and corresponding strength gain) has occurred in the weak foundation soils. The “steady state seepage” (or “long-term”) condition assumes that the soils are fully consolidated and that the water level in the pond has been in place long enough for the embankment to become saturated up to a stable phreatic surface. “Sudden drawdown” occurs when the pool elevation in the pond is lowered quickly, faster than the embankment soils can drain. “Seismic loading” includes inertial lateral forces from earthquake shaking. Other seismic considerations are liquefaction in cohesionless soil, strength reduction in sensitive cohesive soils, and excessive deformations. The more critical cases for the berms at this site will be the end of construction condition and, for seismic considerations, liquefaction and strength reduction.

To check the capacity of the sea sediments to support fill for the berms, we performed a series of stability analyses for the end of construction condition. We considered three idealized strength profiles, various depths of weak sediments, various thickness of berm fill and four slope inclinations.

For soil parameters, we assumed the densities of fill and underlying sea sediments were 110 and 100 pounds per cubic feet (pcf), respectively. Three models for shear strength for the sea sediment foundation soils were used. To represent what we judge to be the weakest conditions, we assumed an undrained shear strength (S_u) of 100 psf at the mudline, increasing at 10 psf per foot of depth (D) below the mud line. We note this as *S_u=100+10D psf* in our results summary (discussed below). Several vane shear measurements at one foot depth had strengths less than this "weakest" shear strength model. Under almost any method of fill placement, we concluded that this very weak surficial material will be displaced.

To characterize the mid-range of shear strengths in sea sediments beyond the shoreline, we used a shear strength profile of 200 psf at the mudline, increasing at 10 psf per foot of depth *(S_u=200+10D psf)*.

We used one additional strength profile of *S_u=300+10D psf*. This third profile is stronger than most strength measurements taken in the sea sediments beyond the current shoreline, but it was also less than essentially all of the vane shear strength data measured beneath the exposed playa. This strength profile was used as a lower bound strength for sediments beneath the playa.

We ran a suite of stability analyses using Spencers method for soft sea sediment thicknesses of 4, 8, and 12 feet. We evaluated four slope inclinations of 3 horizontal to 1 vertical (3H:1V), 5H:1V, 8H:1V, and 10H:1V. The factor of safety was computed for berm fill thicknesses of between 2 to 12 feet.

The results of stability analyses for the S_u=100+10D psf profile are summarized on Plate 30. Those for the S_u=200+10D psf strength profile are summarized on Plate 31. All of the computed factors of safety were greater than 2.0 for the S_u=300 + 10D psf strength profile and a plot of these results is not presented.

The maximum height of the berm will be eight feet where the exiting grade is six feet below the planned pool elevation. Using the findings of the settlement and stability analyses for the two weaker soil profiles, the computed factors of safety for the end of construction condition for fill thicknesses that will result in an eight feet high berm after consolidation are presented in Table 2.

Table 2. Factor of Safety for Fills That Will Yield an Eight Feet High Berm

Depth of Soft Sea Sediments (ft)	Shear Strength S_u=100+10D psf			Shear Strength S_u=200+10D psf		
	5H:1V Slope	8H:1V Slope	10H:1V Slope	5H:1V Slope	8H:1V Slope	10H:1V Slope
4	1.1	1.6	1.8	2.0	2.9	3.5
8	1.0	1.4	1.6	1.7	2.3	2.5
12	0.9	1.3	1.5	1.6	2.1	2.4

For most projects, the minimum factor of safety for an end of construction condition is commonly required to be at least 1.3. As discussed above, the sea sediments at this site are likely to be highly sensitive and may exhibit considerable strength loss once strained beyond their peak strength. To reduce the risk of overstressing the foundation soil and experiencing a strength reduction, a higher target should be set for the minimum end of construction factor of safety. The selection should be made during final design, when the sensitivity of the sea sediment is more fully assessed. We anticipate that the minimum recommended factor of safety may be on the order of 1.5 or higher.

For the steady state seepage (long term) conditions, we checked two profiles whose end of construction factors of safety were between 1.5 and 2.0. For effective stress parameters, we used an angle of internal friction of 27 degrees and zero cohesion for both the berm embankment and the underlying sea sediments. We assumed a phreatic surface that intercepts the toe of the berm. For eight feet high berms (post settlement), we computed factors of safety for the steady state seepage condition of 1.9 for a 5H:1V slope and 3.2 for a 10H:1V slope.

A pseudo-static stability analyses, using consolidated strengths, was not performed at the conceptual design phase. With long-term static factors of safety of 1.9 to 3.2,

the application of an inertial force to represent seismic loading would indicate a factor of safety still greater than 1.0. However, during a large earthquake, we believe that some reduction in strength is likely within the foundation soils and that the embankment foundation may fail. This is discussed in the following section.

D. Seismic Performance

Sand, silty sand, and sandy silt were encountered at some of the exploration locations. Standard penetration testing was not part of the preliminary geotechnical investigation, so no definitive measure (SPT blow count) is available to classify the density of these cohesionless soils. The recent deposition history of these soils suggest that these are mostly loose deposits. With several seismic sources close by, sandy materials with little to no cohesion are likely to liquefy during a moderately large to large nearby earthquake. Lateral deformation and/or settlement (slumping) is likely to occur if the foundation soils liquefy. Lateral deformation and/or settlement could lead to cracking of the berm, which could in turn lead to increased seepage, internal erosion and a piping failure through the berm. The berm settlement and deformation could also lead to overtopping of the berm.

Seismic shaking may strain the soils beyond their peak strength and the slope may slump. There is a possibility of a fault rupture at the ground surface in the Alamo River area.

A detailed seismic risk analyses was not part of the preliminary geotechnical investigation. The consequences of berm failure are not likely to include property damage beyond that of the ponds, and chance of injury or death from berm failure is low. For the purpose of assessing the economic impact of a seismically-induced berm failure, an annual chance of occurrence of about 2 percent is reasonable. This applies to berms with internal seepage control measures (discussed in later sections) constructed over the sea sediments. If the sea sediments are excavated and the berms are constructed on the underlying alluvium, the risks will be reduced considerably.

E. Plasticity and Expansion Potential

Half of the samples tested for Atterberg limits had a plasticity index (PI) greater than 30. More than two-thirds classify as fat clays. These classification tests indicate that these materials have a high potential for shrinking and swelling with changes in moisture content. During our field investigation, we had judged the materials to be lower plasticity, observing a more silt-like behavior than the classification tests indicate. When comparing the Atterberg limits test results between Plates 24 and 25, we observed that the six bulk and composite samples indicated higher plasticity on average compared to the individual sample tests. The bulk/composite samples were for sample lengths of 3.6 to 5.3 feet. The individual samples from the hand auger borings were shorter, commonly 1.0 to 1.5 foot sample lengths. The vibracore samples lengths commonly were 2.7 feet, though some samples were shorter. We suspect that high plasticity clay layers within the longer stratigraphic samples dominated the sample behavior, masking lower plasticity silts within the longer sample lengths.

As the Sea level falls and the sea sediments become exposed, cracking is observed on the surface of the playa. These cracks extend at least in the range of 1 to 2 feet deep; though no detailed assessment of the depths of the cracks was performed. Water can be seen within some of the cracks. Surface cracking is an indication of the high initial moisture content of the soils as well as the possible expansive character of the soil. Though cracking was observed, the pervasiveness was not as extensive as one would expect from high plasticity soils in a hot arid climate. The networks of cracks that have formed may be in contact with the Sea, keeping the soils wet and inhibiting drying well away from the shoreline.

F. Dispersion

Dispersive clay soils are clays that disaggregate (or deflocculate and lose their cohesion) easily and rapidly in water of low-salt concentration and become susceptible to erosion and piping. Dispersive clay soils can be eroded by slow-moving water, at gradients that would not erode cohesionless fine sands and silts.

Dispersive clay soils cannot be identified by the usual laboratory index tests such as moisture and dry density measurements, grain size distribution or Atterberg limits. Other special laboratory tests (i.e. crumb test, double hydrometer test, percent sodium in saturation extract and pinhole test) were performed as mentioned earlier. Samples for the pinhole tests were compacted to near 95 percent relative compaction using Standard Proctor (ASTM Test D-

698) as the laboratory compaction reference. The moisture content was near optimum. This resulted in a moderately compacted clay. We chose this level of compaction to reflect our belief that higher degrees of compaction may not be readily achievable for the soft site conditions. A summary of the dispersion potential from the various laboratory tests performed for this purpose is shown in Table 3. Each of these samples were logged as gray fat clay (CH). Detailed results of the dispersion tests are included in Appendix A.

Table 3. Summary of Dispersion Potential

Sample	Crumb Test (ATM Test D-6572)	Double Hydrometer Test (ASTM Test D-4221)	Percent Sodium in Saturation Extract (EPA 60103)	Pinhole Test (ASTM Test D-4647)
HA-1	Nondispersive	Nondispersive	Nondispersive	Dispersive
HA-4	Intermediate	Nondispersive	Nondispersive	Dispersive
VC-11	Dispersive	Dispersive	Nondispersive	Dispersive
VC-16	Intermediate	Nondispersive	Nondispersive	Dispersive
VC-20	Nondispersive	Nondispersive	Nondispersive	Dispersive
VC-28	Nondispersive	Nondispersive	Nondispersive	Dispersive

As shown, the results from the individual tests do not agree. Due to the very high total dissolved salts, the correlation with Percent Sodium in Solution Extract and dispersion potential were beyond the range used in the Bureau of Reclamation's chart of percent sodium versus total dissolved salts[3]. The total dissolved salts in saturation extract range from 2,800 to 5,000 milliequivalents per liter. The dispersive potential chart did not extend past 700 milliequivalents per liter. Extrapolation of the chart suggests the non-dispersive classification. The Sodium Absorption Ratio (SAR) ranged between 0.15 to 0.39, also inferring non-dispersive.

[3] "Characteristics and Problems of Dispersive Clay Soils", Publication R-91-09, U.S. Department of Interior, Bureau of Reclamation, Denver Office, Research and Laboratory Service Division, Materials Engineering Branch, October 1991 (Figures 3 and 4).

We considered the pinhole test to be the most reliable test method for dispersion, since it is a direct physical test. Based on these considerations, it appears likely that the on-site soils would have a tendency to disperse in a fresh water environment. The ASTM standard for pinhole test uses distilled water. The tendency toward dispersive erosion in a dispersive clay should depend in part on the chemistry of the water. The dispersion potential is expected to decrease with increasing salinity of the water. The retained water will have 20 ppt to 35 ppt TDS. To access whether the soils would still be dispersive for the planned pond salinities, additional pinhole tests were performed using salt concentrations of 20 and 40 ppt TDS to model the waters in the planned ponds. Though the severity of dispersion potential was generally less for the higher concentrations, the pinhole tests generally indicated that the soils would be dispersive for the planned waters. The dispersion ratings from the pinhole tests using the varying salt concentrations are summarized in Table 4.

Table 4. Summary of Dispersion Ratings for Pinhole Tests for Varying TDS in Water

	Total Dissolved Soils in Water		
Sample	**0 ppt**	**20 ppt**	**40 ppt**
HA-1	D1	D2	ND4
HA-4	D1	ND4	ND4
VC-11	D2	D1	D2
VC-16	D1	D1	D2
VC20	D2	D2	ND4
VC-28	D2	D2	D2

Key:

Pinhole Classification	Dispersive Character
D1	Dispersive
D2	Dispersive
ND4	Intermediate

When dispersive clay soils are used for constructing embankments without filters, piping and erosion may occur. Dispersive piping is usually initiated when water flows into small cracks and fissures caused by desiccation and/or differential settlement, particularly if the soils are placed dry of optimum or not well-compacted. The water that flows through the cracks will remove the disaggregated particles, with the rate of removal increasing as the seepage velocity and size of opening increase.

The risk of a dispersive erosion induced failure is greatest in areas of higher seepage potential, such as in areas with shrinkage cracks, around pipes through the embankments, adjacent to concrete structures, and in poorly-compacted areas. Gullies may also form on embankment slopes, where dispersive clay soils are exposed to rainwater run-off as well as storm driven wave splash within the ponds. Severe dispersive erosion can lead to costly and difficult operation and maintenance and may render a water retention berm inoperable.

G. Seepage

A wide range of permeabilities likely occurs within the sea sediments. In some hand auger holes, no apparent water seeped into the boring as it was drilled. In other hand auger borings where sandy silt layers were encountered, water percolated into the hole during drilling. Permeability in the undisturbed sea sediment is likely anisotropic. One slug test was performed in hand auger boring HA-4. The transmissivity was too low to develop reliable data from the sensors used. For purposes of estimating seepage through the soil matrix, the permeability correlations with material type and gradation presented in Table 5 may be used.

Table 5. Permeability Estimates for Conceptual Design

Material Type	Vertical Permeability cm/sec	Horizontal Permeability cm/sec
Sand	$1x10^{-4}$	$1x10^{-3}$
Silty Sand and Clayey Sand	$1x10^{-5}$	$1x10^{-4}$
Silt	$1x10^{-6}$	$1x10^{-5}$
Clay	$1x10^{-7}$	$1x10^{-6}$

Where shrinkage cracks have developed, structure of the soil will dominate seepage performance. The cracking will need to be considered when estimating seepage and internal erosion potential beneath the embankments. The tendency of the embankments themselves to develop shrinkage cracks will also need to be considered in evaluating seepage risks.

Seepage may occur through and beneath the berms. The fills used to construct the berms will be predominately fine grained soils of low permeability. Factors with the greatest potential for causing adverse seepage through the berms include shrinkage cracking, less-than-rigorous placement and compaction methods, cracking due to settlement, and dispersion potential. By “adverse seepage”, we refer to conditions that could potentially lead to internal erosion within the berm.

On the playa, the sea sediments have dried on the surface and shrinkage cracks extend at least a couple of feet. These cracks could become seepage paths beneath the berm fill. Having a pre-existing cracking pattern coupled with the dispersive character of the soil creates risk of piping beneath the berm. Leakage through these cracks can be limited by constructing a wide, shallow cutoff trench during site preparation, prior to placing berm fill. The intent of the trench is to disrupt the interconnected cracks.

As the Sea level falls, additional shrinkage cracking could occur in the foundation soils if the berms are constructed on the saturated, weak sea sediments. While seepage from the ponds will tend to retard shrinkage cracking, a dispersion-assisted piping failure remains a possibility.

Sand and silty sand within the foundation can be a seepage path beneath the berm. Though some water loss may occur at these locations, the sandy soils would not be dispersive, and the risk is low for a berm failure by under seepage in these soils. An upstream blanket of lower permeability soil may be used to limit seepage through an underlying sand formation. A vertical cutoff trench would be more effective at reducing the magnitude of seepage through an underlying sand layer.

If local seepage is identified once the ponds are containing water, excavating a trench parallel to the berm’s axis and remixing and tamping the soils can be an inexpensive method of disrupting a seepage path and controlling seepage. Some form of cutoff will likely be needed if the berm is to be constructed from soft sea sediments on a soft sea sediment foundation.

The risks of seepage induced failures are greatly reduced if the berms can be constructed of well-compacted fill on stiff alluvial foundation soils.

IX. CONCLUSIONS

A. General

There are several major considerations in assessing what may be the more efficient methods for constructing the berms. Major considerations include:

- Will the berm site be below the water level in the Sea?
- How will the berm be protected from wave erosion by the Sea?
- Will the berm be supported on the existing weak sea sediments or will the sediments be excavated from beneath the planned berm footprint?
- Will soft sea sediments be used to create the berm or will stiffer soils be used?
- Will the berm be sufficiently compacted to control pond seepage or will additional seepage barriers be used?
- How will the berm be protected from wave action within the ponds?

These and other issues are addressed in this section.

B. Berm Embankments

In much of the currently submerged areas, the sea sediments are quite weak. If the berm is be constructed on these sediments, the berm embankments will need to have very flat slopes to avoid failing the ground. In these areas the ground is too weak to support traditional construction equipment. Barge-mounted equipment or special amphibious-mounted equipment will be needed. One method to construct berms in those conditions is to excavate sediment immediately adjacent to the berm's alignment and cast it up on the berm. The berm footprint would be quite wide. The saturated soft berm fill material cannot be effectively compacted. Once the surface of the fill extends more than about one foot above the level of the Sea, the dragline bucket can be dropped on the fill as a means of providing some compactive effort. Repeated discing or ripping the soil with amphibious equipment can reduce the moisture content to a range suitable for compaction. The first lift above the Sea level may need to be compacted by track-walking. Incrementally, subsequent lifts of fill can be more aggressively compacted. A goal of this method for constructing berms would be to not over-stress and fail the weak foundation soils.

The berm fill would be weak, have a high moisture content, and be subject to shrinking and cracking as the fill dries. With a fill poorly compacted and having a high potential for shrinkage cracks, there is risk of seepage developing through the berm. If seepage is observed, it can be remediated by excavating a trench partially down through the center of the berm crest. Within the trench, the excavator bucket can be used to remold the soils at depth. Adding a thick pre-mixed bentonite slurry to the partially excavated trench can aid the remolding process. This technique would be useful for treating local seepage zones. The above scheme is likely the most cost-effective method for constructing some form of berm in these weak foundation areas. However, it may have marginal reliability and have high maintenance costs. If seepage develops over long sections of the berm, a traditional slurry trench cutoff wall or a sheetpile cutoff wall with sealed/grouted interlocks may be needed.

An alternate approach for constructing a berm in submerged areas would be to create a berm using moisture conditioned fill. The stiff fills would be placed by end-dumping from the end of the berm alignment and advancing the berm as additional fill is placed. The fill can either be placed on the soft sediments or the sediments could be excavated to a firm bottom prior to placing the fill. Once the fill surface is above the water, dozing 18-inches to two feet of fill out in front of the tracked equipment and keeping this thickness beneath the tracks may spread the contact pressure enough to support light, low ground pressure equipment.

Soft sediments will not support steeper sloped fills in many areas. The weight of the fill will create a “mudwave” as the displaced sediments are heaved up in front of and/or to the sides of the advancing fill. Creating mudwaves is one form of berm construction in very weak areas. A drawback is that the weak soils are displaced in a non-uniform manner and the final thickness of fill will vary along the berm alignment. Excavating the soft soil prior to placing the fill can develop a more uniform thickness fill. The fill material could be developed by excavating alluvial soils from the higher portions of the site, above the Sea. Whether placed with mudwaves or in areas where soft soil is removed, the fills below the water will not be compacted. As the fill extends above the water surface, the upper lifts of fill can be compacted. However, in the mudwave case, the compacted fill will be dropping in irregular sections as the foundation soil becomes over-stressed from increasing fill thickness. It would be better to avoid mudwaves.

These schemes for building a berm will not be suitable for retaining water without additional seepage control measures. Soil bentonite or sheetpile cutoffs would be needed as part of the initial design.

The above schemes assume that the project site would not be dewatered. If the site was dewatered, the berm could be constructed of compacted alluvial soils founded on the alluvium which underlies the weak sediments. The scheme would involve excavating the sediments down to the underlying alluvial soils. This excavation could be done by hydraulic dredging before the site is dewatered or by dragline or clamshell after site dewatering. A borrow area in alluvial soils would likely be developed in areas where the sea sediment overburden is minimal and the alluvial soil is clayey.

C. Treating Dispersion and Seepage Control

Embankments can be constructed with dispersive clay soils, provided certain precautionary measures are taken. Erosion of dispersive clay soils through embankments can be controlled by properly designed and constructed filters. The filter may be part of a downstream seepage berm. Filter material should be placed around the downstream one-third portion of pipes through the embankments, regardless of whether the soils are dispersive or not. Embankments constructed with dispersive clay soils should be properly compacted; especially if the soils are being placed around pipes, adjacent to concrete structures, at the foundation interface, if no filters are being provided. Achieving a well-compacted embankment on the soft subgrade may not be feasible. Risk of seepage induced failures, including those due to dispersive soils can be reduced somewhat by simply making a wider embankment. Most dispersive clay soils can be rendered non-dispersive by the addition of lime. Lime-modified dispersive clay soils may be considered for portions of the interface with rigid structures such as pipes through the embankments. A cutoff wall to block seepage through the embankments may be considered to lower the risk of piping. The cutoff wall may consist of a soil-bentonite cutoff wall constructed by slurry trench methods and using non-dispersive clay for source fill. Plastic sheetpiling with sealed interlocks could also be used.

Most of these schemes reduce the potential rate of dispersion, but the risk of an eventual piping failure may still remain. If the site can be dewatered, seepage from the ponds can be effectively controlled by constructing a well-compacted clayey alluvium fill on an alluvial

foundation. Sandy zones in the alluvial foundation may need to be excavated or covered with an upstream clayey blanket.

D. Shoreline Protection

There are two shorelines for the ponds. The interior of each pond will have water lapping against the interior face of the berm for the life of the ponds. During construction and during the first several years of operation, the seaward-most berm will be exposed to wave action from the Salton Sea.

For the interior face of the berms, the wave height will be fetch-limited with maximum fetches of about two miles for some ponds. The shallow water depth will also limit the wave height. Berm faces derived from sediment fill sources will be highly erodible. Well-compacted clay fill will be considerably less erodible but will still need protection. Some form of shoreline protection will be needed on the interior faces of the berms. The protective facing will need to extend over the portion of slope face that will be exposed to wave action, including the estimated height of run-up.

The traditional scheme for erosion protection is riprap facing. Riprap would be quarried rock material with an angular to subangular shape. Riprap should be placed on slopes no steeper than 2H:1V. However, steep as opposed to flat slopes will limit the square footage of berm face that needs to be protected with riprap. Placing riprap on slopes flatter than about 3H:1V becomes increasing inefficient with respect to the quantity of riprap needed. Riprap would be placed on a geotextile designed for riprap underlayment. Riprap is the preferred slope protection for the interior faces of the berms.

Soil cement can be used for erosion protection and often is a viable option when riprap is not available. Soil cement consists of mixing portland cement with a locally available source of sand or silty sand. For good quality control, it is preferable to mix the soil cement in a pugmill at a central location within the project site and deliver the soil cement by dump truck to the berm. Soil cement is most efficient when there is little to no clay or organic material in the sands to be treated. Identifying a suitable source of sand within the project site may be a challenge. The vibracores near the mouth of Alamo River (VC-22 and 24) indicated about one foot of silty sand over fat clay and silt. No other surficial sand deposits were identified. These thin layers would be difficult to mine. At present there is no identified readily available source of

sand within the project site for making soil cement. Hauling sand from offsite sources would likely make soil cement more costly than riprap.

Geomembrane facing has been used to line reservoirs. The service life of the linings vary considerably with the type of material used and its resistance to degradation under extended sunlight. A geomembrane would have the smoothest surface of the erosion protection systems addressed here, and for similar slope inclinations would have the highest run-up. A geomembrane system is not expected to be as cost-effective as riprap.

On the outward face of the seaward-most berms, waves from across the 40-mile fetch of the Salton Sea will attack the slope. Unprotected fill will readily erode. The installation of shore protection will be complicated by interfacing with the method selected for berm embankment construction.

Placing riprap can be reasonably efficient to quite inefficient. Some embankment construction methods will have flat slopes or heaved up sediments on the seaward side of the berm. These geometries will be inefficient to armor with riprap. Riprap could be used to create an offshore breakwater, creating a still water pool adjacent to the berm.

Other offshore breakwater systems could be considered, including a floating cable tire system. This system could be relocated further offshore as the Sea level drops.

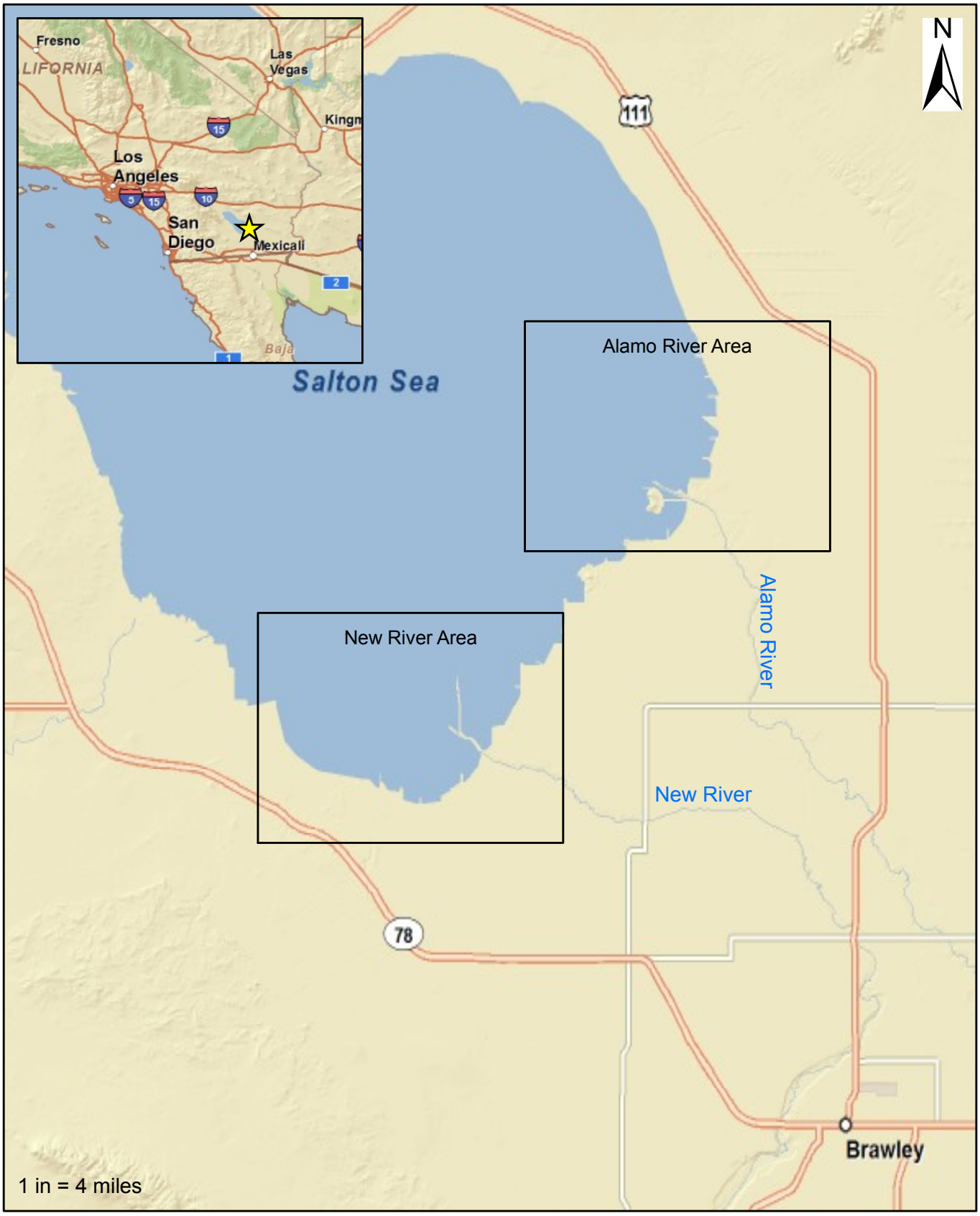
A geomembrane could be used to wrap the face of fill. Though the material may have a limited service life, the period that sea waves may attack the berm would likely be shorter than the service life for many materials. We are not aware of an example of this scheme, suggesting that issues such as how to anchor the geomembrane and how to distribute stresses at anchorage points have not been satisfactorily resolved. Deployment may also be difficult.

A geotube is a large diameter geotextile tube (in the range of 20 to 30 feet in diameter), that is filled by pumping slurried soil into the tube, creating a gravity structure. The more common applications of geotubes include serving as groins to control onshore/offshore and longshore migration of beach sand and as containment structures for fine grained slurries to allow the slurries to drain. The geotube could become the seaward toe of the berm and act as a

sea-wall. A geotube would be compatible with the berm construction method of excavating adjacent sediments and casting them up on the landward side of the geotube. Sand and silty sand are the preferable soil types for filling the geotubes. The material requirements of the sands would not be as strict as those for soil-cement. Material logged as clayey sand in the hand auger borings and vibracores would likely be suitable fill. This material was found in limited locations. Further exploration near the mouths of the New and Alamo Rivers may disclose additional sources of silty sand or sand.

A sheetpile wall buttressed on its landside by cast-up sea sediment fill can be used as a sea-wall. Vinyl sheetpiles would be appropriate. Steel should be avoided in this corrosive environment. A vinyl sheetpile backed by a cast-up buttress would also make for a reliable temporary dike to isolate the project area from the Sea. This will allow dewatering of the project area and construction of the berms in the dry. With the site dewatered, traditional earthwork equipment and embankment construction methods could be used to create a well-compacted berm on a stiff alluvial foundation. This would result in the most reliable berm embankment and water retention system. It is likely the most cost-effective approach when including wave protection from the Sea.

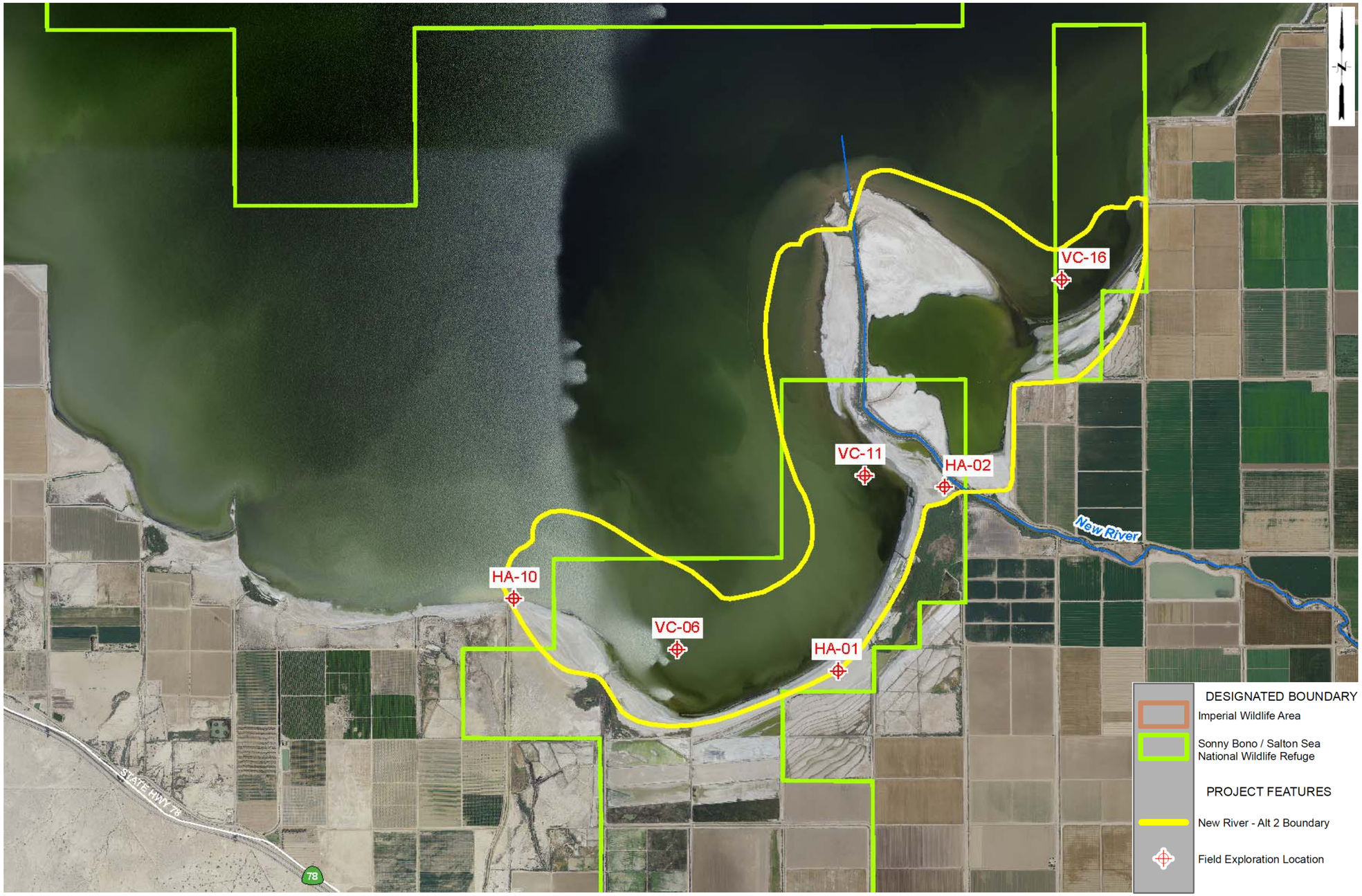
PLATES



Salton Sea
SCH Project
Salton Sea, California

Vicinity Map

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 1



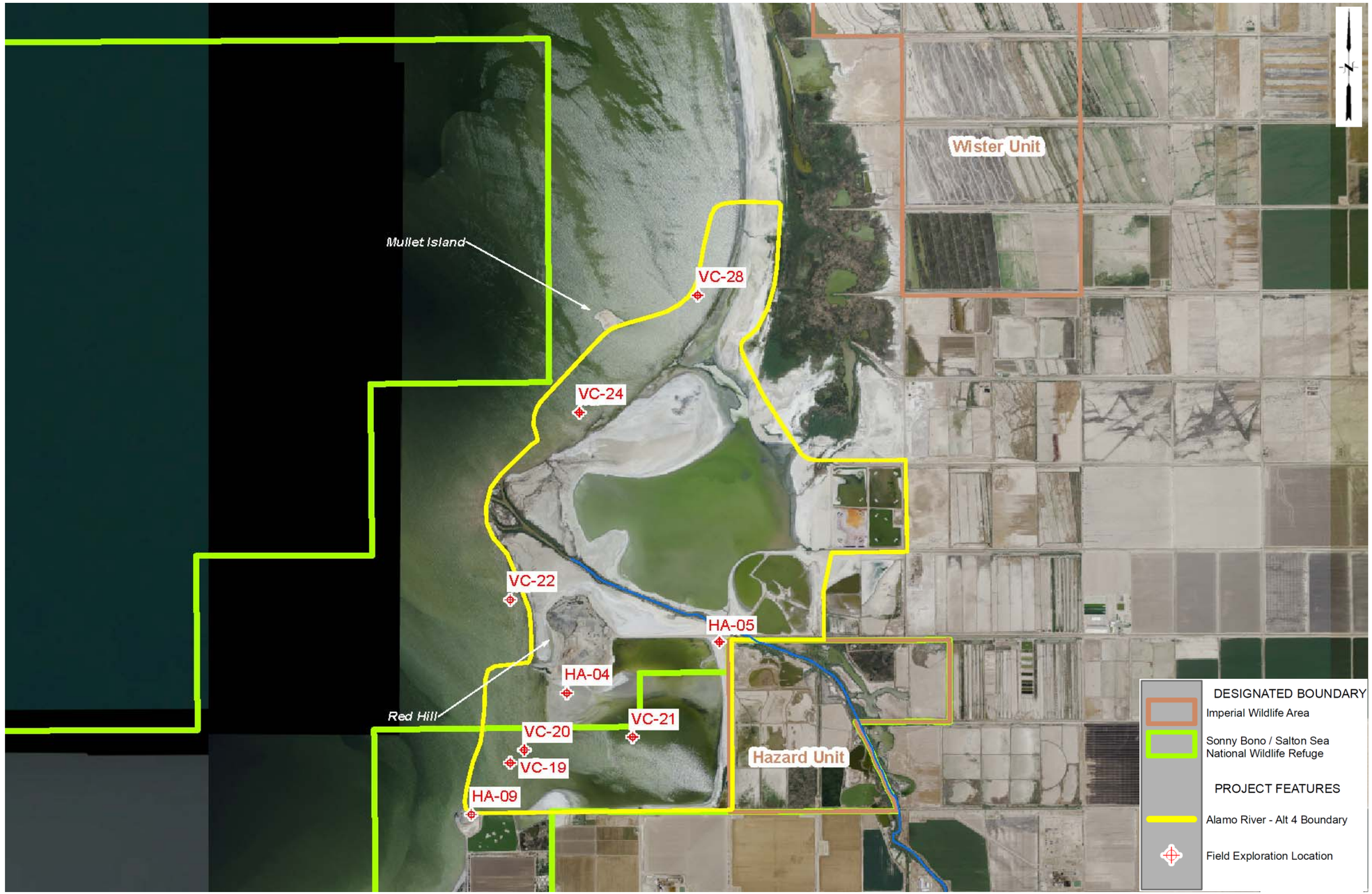
0 2,700 ft

1 inch = 2,700 feet
Approximate Scale

Salton Sea
SCH Project
Salton Sea, California

Exploration Site Plan
New River

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 2



0 2,700 ft

1 inch = 2,700 feet
Approximate Scale

Salton Sea
SCH Project
Salton Sea, California

Exploration Site Plan
Alamo River

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 3

Date : 9/15/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.0949
Longitude : -115.6957

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), olive gray, moist, medium stiff, with occassional sand partings			63*	44*	Full Suite**
	B							45			Sieve
1						Becoming wet	0.33				
				CH		Becoming dark gray					
2						Becoming saturated					
	B						0.33	65			Sieve
3						Lean Clay (CL), gray, saturated, medium stiff					
	B			CL			0.41	35			
						Lean Clay (CL), reddish brown, saturated, stiff					
4											
	B			CL			0.55	22	42	27	Sieve
5											

Bottom of boring at 5 feet
No groundwater encountered during drilling.
Refusal to vane shear penetration at 5.2 feet.
*Atterberg Limits measurements on bulk sample (0 - 3.6 feet).
**Full suite of laboratory tests on bulk sample (0 - 3.6 feet).

Salton Sea
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Salton Sea, California

Log of HA-1
(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 4

Date : 9/16/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.1099
Longitude : -115.6855

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	B					Lean Clay (CL), tan brown, moist, medium stiff to soft, with some shell fragments					
1							0.32	31			
						Becoming dark gray, saturated					
2	B			CL	▽		0.24	45	43	24	Sieve
3							0.21				
	B							54			
4	B			ML		Silt (ML), reddish brown, saturated, medium stiff	0.40	41			

Bottom of boring at 4.3 feet
Groundwater encountered during drilling.
Refusal to cone penetrometer at 4.3 feet.

Salton Sea
SCH Project
Salton Sea, California

Log of HA-2
(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 5

Date : 9/14/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.1939
Longitude : -115.6129

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Silt (ML), mottled olive brown, moist, stiff to medium stiff, low plasticity			56*	36*	Sieve* Full Suite**
1	B			ML				29			
2						Lean Clay (CL), gray, moist, soft to medium stiff, with some fine grained sand, low plasticity	0.22				
	B			CL		Becoming wet, with shell fragments		33			Sieve
3							0.24				
						Fat Clay (CH), dark gray, wet, soft to medium stiff					
4							0.21				
	B				▽			46			Sieve
5				CH							
							0.23				
6	B						0.26	47			
7						Bottom of boring at 7.0 feet	0.24				

Vane shear device used to measure undrained shear strength to a depth of 7.2 feet
Groundwater encountered during drilling.
*Atterberg Limits measurement and sieve analysis on bulk sample (0 - 5.3 feet).
**Full suite of laboratory tests on bulk sample (0 - 5.3 feet).

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Log of HA-4
(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 6

Date : 9/14/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.1981
Longitude : -115.5979

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), mottled olive gray, moist, meduim stiff, trace of organics, rare salt crystals					
1	B							44			
							0.44				
						Becoming moist, thin shell bed at 1.5 feet					
2	B					Sand seams between 1.7 and 2 feet		49	52	28	Sieve
							0.31				
				CH		Becoming dark gray, saturated, soft to medium stiff, organic odor					
3	B					Soft zone between 3 and 3.5 feet	0.21	55			
4						Becoming gray	0.29				
	B							49			
5	B			SM	▽	Silty Sand (SM), dark gray, fine grained, saturated, loose	0.22	20			Sieve

Bottom of boring at 5.3 feet
Groundwater encountered during drilling.
Refusal to cone penetrometer at 5.0 feet.

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Log of HA-5
(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 7

Date : 9/17/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.1836
Longitude : -115.6222

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
1	B			CL		Lean Clay (CL), mottled tan and dark gray, wet, medium stiff to soft, with shell fragments	0.21	44			
2	B			CL		Sandy Lean Clay (CL), wet, medium stiff, organic odor	0.33	44	31	15	Sieve
3	B			SC		Clayey Sand (SC), gray, saturated, medium dense	0.42	29			
4	B			CL		Sandy Lean Clay (CL), gray, saturated, stiff					
				CL		Lean Clay (CL), gray, saturated, stiff	0.68+	33			
5	B			CL		Lean Clay (CL), reddish brown, saturated, stiff	0.68+	31			

Bottom of boring at 5 feet
No groundwater enountered.
Refusal to vane shear penetration at 4.5 feet.
Refusal to cone penetrometer at 6 feet.

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Salton Sea, California

Log of HA-9
(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 8

Date : 9/16/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.1009
Longitude : -115.7263

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	B			ML-CL		Clayey Silt (ML-CL), tan and gray, dry to moist, soft to medium stiff, with sand, abundant shell fragments		25	25	5	Sieve
1						Becoming dark gray to black, saturated	0.29				
					▽	Clayey Sand (SC), tan, saturated, loose to medium dense					
2	B			SC			0.28	21			Sieve
3							0.35				
	B							34			
4						Sandy Lean Clay (CL), reddish brown, saturated, stiff	0.50				
	B			CL				31			
5											

Bottom of boring at 5 feet
Groundwater encountered during drilling.
Refusal to vane shear penetration at 3.3 feet.
Refusal to cone penetrometer at 5.3 feet.

Salton Sea
SCH Project
Salton Sea, California

Log of HA-10
(Page 1 of 1)

Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 9

Date : 9/17/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.0968
Longitude : -115.7109

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
1	V			ML		Silt (ML), gray, saturated, soft to stiff, non plasticplastic, with sand, organic odor	0.12	69	NP	NP	Sieve
2						No recovery below 1.3 feet	0.68+				

Bottom of boring at 2 feet
Water level approximately 2 feet above surface.
Refusal to vane shear penetration at 1.5 feet.

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SCH Project
Salton Sea, California

Log of VC-6
(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 10

Date : 9/17/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.1109
Longitude : -115.6931

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V					Fat Clay (CH), gray, saturated, very soft, organic odor		31	68*	47*	Sieve* Full Suite**
1							0.05				
2	V			CH			0.11	56			
3							0.11				
						No recovery below 3.6 feet					
4							0.14				
5						Bottom of boring at 5.0 feet	0.22				
6							0.36				
7							0.61				
8							0.68+				

Refusal to vane shear penetration at 8.5 feet
Vane Shear device used to measure undrained shear strength to a depth of 8.5 feet.
*Atterberg Limits measurements on bulk sample (0 - 3.6 feet).
**Full suite of laboratory tests on bulk sample (0 - 3.6 feet).

Salton Sea
SCH Project
Salton Sea, California

Log of VC-11
(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 11

Date : 9/17/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.1268
Longitude : -115.6743

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V					Fat Clay (CH), gray, saturated, very soft, organic odor		43	66*	46*	Sieve* Full Suite**
1							0.05				
				CH							
2							0.13				
						Becoming soft					
	V							52			
3						Lean Clay (CL), reddish brown, saturated, soft	0.17				
				CL							
4						No recovery below 4.0 feet	0.12				
5							0.26				
							0.68+				
6											
7											

Bottom of boring at 7.5 feet
Water level approximately 2-feet above surface.
Refusal to vane shear penetration at 5.5 feet.
*Atterberg Limits measurements and sieve analysis on bulk sample (0 - 3.9 feet).
**Full suite of laboratory tests on bulk sample (0 - 3.9 feet).

Salton Sea
SCH Project
Salton Sea, California

Log of VC-16
(Page 1 of 1)

Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 12

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.188
Longitude : -115.6184

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V			ML		Sandy Silt (ML), gray, saturated, medium stiff, organic odor		44	NP	NP	Sieve
1						Silt (ML), gray, saturated, soft to medium stiff, low plasticity	0.28				
2	V			ML			0.17	34			
3							0.39				
4						Fat Clay (CH), gray, saturated, soft to medium stiff, organic odor	0.25		58	37	
5	V			CH			0.29	38			Sieve
6						Becoming stiff at 6 feet	0.68+				
						No recovery below 6.2 feet					
7											

Bottom of boring at 7.5 feet
Water level on the surface.
Refusal to vane shear penetration at 6 feet.

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Salton Sea, California

Log of VC-19
(Page 1 of 1)

Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 13

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.1891
Longitude : -115.617

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), gray, saturated, medium stiff, organic odor			67*	49*	Sieve* Full Suite**
1	V						0.32	29			
2				CH			0.27				
3						Becoming soft	0.19				
	V							39			
4							0.17				
						No recovery below 4.7 feet					
5							0.45				
6							0.68+				

Bottom of boring at 6 feet
Water level approximately 1-foot above surface.
Refusal to vane shear penetration at 6 feet.
*Atterberg Limits measurements and sieve analysis on bulk sample (0 - 4.7 feet).
**Full suite of laboratory tests on bulk sample (0 - 4.7 feet).

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 14

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.1901
Longitude : -115.6065

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), gray, saturated, very soft, organic odor					
1	V						0.04	56			
2							0.07				
				CH							
3							0.11				
	V							53	57	38	Sieve
4						Becoming soft to medium stiff	0.18				
						No recovery below 4.8 feet					
5							0.41				

Bottom of boring at 5.5 feet
Water level on the surface.
Refusal to vane shear penetration at 5.3 feet.

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Salton Sea, California

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(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 15

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.2018
Longitude : -115.6183

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V			SM		Silty Sand (SM), gray, saturated, loose to medium dense, organic odor		33			
1							0.11				
						Fat Clay (CH), gray, saturated, soft, with sand					
2							0.14				
	V			CH				32	60	41	Sieve
3							0.19				
4							0.20				
						No recovery below 4.0 feet					
5							0.20				
6							0.21				
7							0.31				

Bottom of boring at 7 feet
Water level approximately 1-foot above surface.
Refusal to vane shear penetration at 7.2 feet.

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Log of VC-22
(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 16

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.2176
Longitude : -115.6115

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V			SM		Silty Sand (SM), gray, saturated, loose		28	NP	NP	Sieve
1							0.27				
						Silt (ML), gray, saturated, medium stiff to soft, organic odor, non-plastic					
2							0.17				
	V			ML				57			
3							0.18				
4						Lean Clay (CL), gray, saturated, soft, organic odor	0.16				
5	V			CL			0.20	42	26	10	Sieve
6							0.21				
						No recovery below 6.4 feet					
7							0.60				

Bottom of boring at 7.5 feet
Water level approximately 2-inches above surface.
Refusal to vane shear penetration at 7 feet.

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(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 17

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.2274
Longitude : -115.5999

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V					Fat Clay (CH), gray, saturated, very soft, lowplastic, organic odor		48	65*	47*	Sieve* Full Suite**
1							0.10				
	V							45			
2							0.10				
3				CH			0.12				
4							0.11				
	V							64			
5						Becoming soft	0.13				
						No recovery below 5.7 feet					
6							0.14				
7							0.22				

Bottom of boring at 7 feet
Water level approximately 1-foot above surface.
Refusal to vane shear penetration at 7.3 feet.
*Atterberg Limits measurements and sieve analysis on bulk sample (0.4 - 5.7 feet).
**Full suite of laboratory tests on bulk sample (0.4 - 5.7 feet).

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Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 18

MAJOR DIVISIONS				GROUP NAMES
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	**GRAVELS** MORE THAN 50% OF COARSE FRACTION IS RETAINED ON NO. 4 SIEVE	**CLEAN GRAVELS** WITH LESS THAN 5% FINES	GW	WELL GRADED GRAVEL
			GP	POORLY GRADED GRAVEL
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SANDS 50% OR MORE OF COARSE FRACTION PASSES NO. 4 SIEVE	**CLEAN SANDS** WITH LESS THAN 5% FINES	SW	WELL GRADED SAND
			SP	POORLY GRADED SAND
		SANDS WITH OVER 12% FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS 50% OR MORE PASSES NO. 200 SIEVE	**SILTS AND CLAYS** LIQUID LIMIT LESS THAN 50		ML	SILT
			CL	LEAN CLAY
			OL	ORGANIC CLAY, ORGANIC SILT
	SILTS AND CLAYS LIQUID LIMIT 50 OR MORE		MH	ELASTIC SILT
			CH	FAT CLAY
			OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			Pt	PEAT

UNIFIED SOIL CLASSIFICATION SYSTEM- ASTM D 2487

S - SPT

M - 2.5 inch

C - 3.0 inch

T - Shelby Tube

B - Bag

- Water Level at Time of Drilling
- Water Level after Drilling (with date measured)

Consol - Consolidation

Gs - Specific Gravity

LL - Liquid Limit (%)

PI - Plasticity Index (%)

TxUU - Shear Strength (psf) - Unconsolidated Undrained Triaxial Shear

TxCU - Shear Strength (psf) - Consolidated Undrained Triaxial Shear

UC - Compressive Strength (psf) - Unconfined Compression

P - Push

Perm - Permeability

Sieve - Particle Size Analysis

VS - Laboratory Vane Shear (psf)

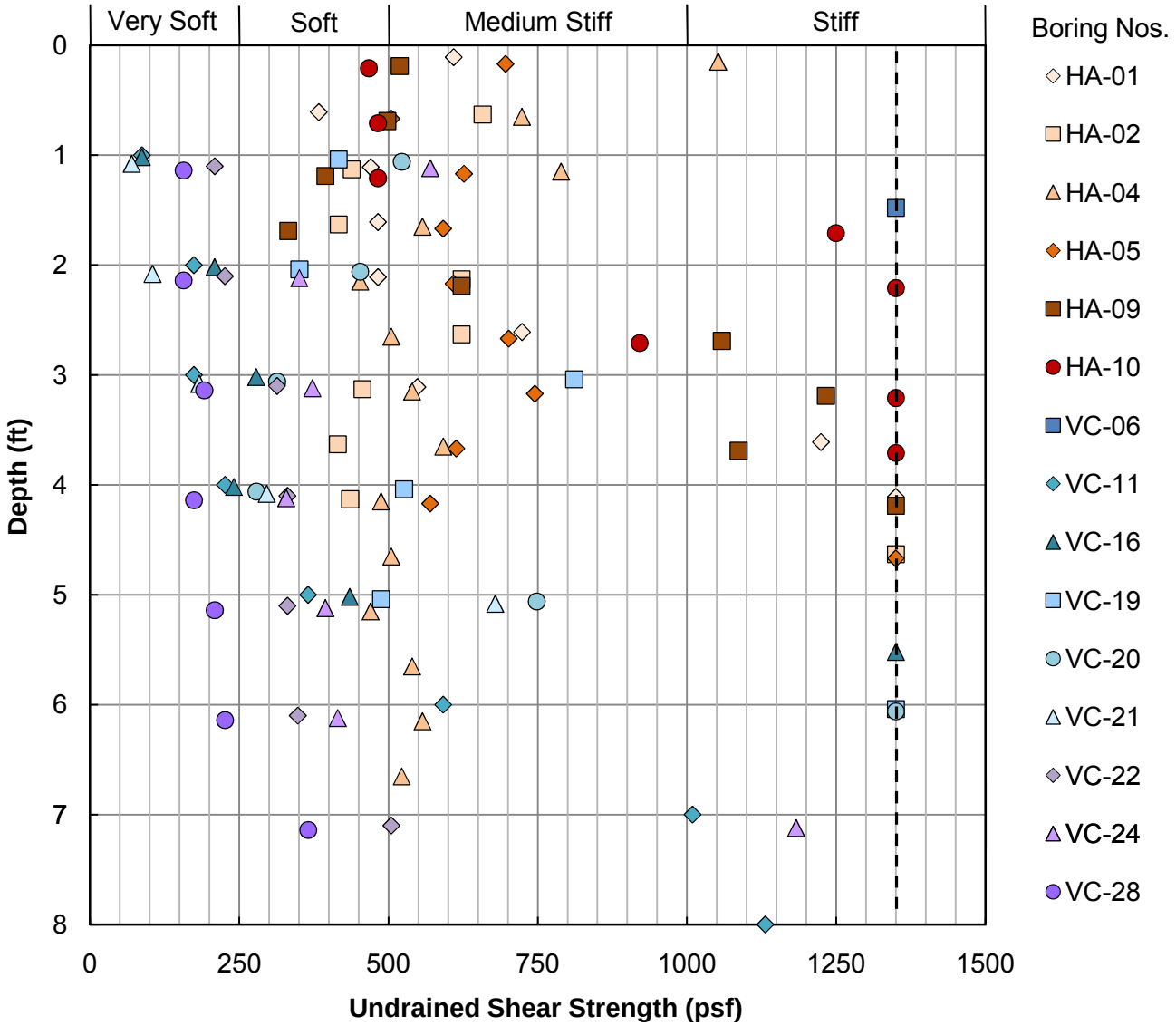
-200 - % Passing No. 200 Sieve

KEY TO TEST DATA

Salton Sea
SCH Project
Salton Sea, California

Soil Classification Chart

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 19



Notes:

1. Undrained shear strength was measured using hand held vane shear device (Model: Geonor H-60) manufactured by Geonor, Inc.
2. Undrained shear strength data shown in the plot above were modified by the Bjerrum's field vane correction factor (μ) in correlation with plastic index (PI).
3. Atterberg limits (LL and PI) measurements were conducted on selected samples only. PI's of soil samples without directly measurements were estimated by soil types accordingly .
4. The Hand Auger (HA) and Vibracore (VC) borings were presented using warm and cool colors, respectively.
5. Data points falling on the vertical dashed gridline indicate the soil samples have an undrained shear strength exceeding 1350 psf (65 kPa), the maximum value for the vane used.

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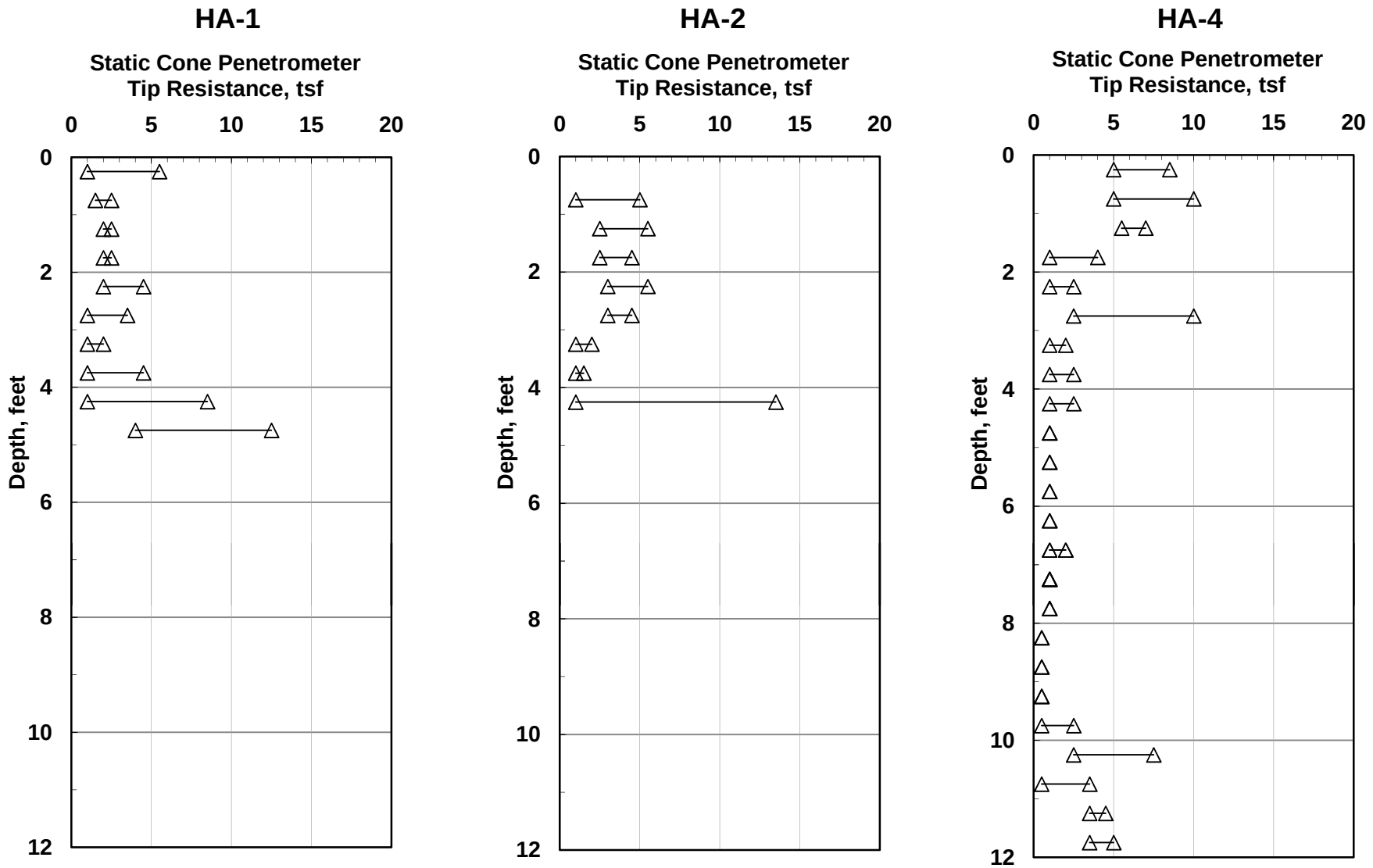
Vane Shear Results

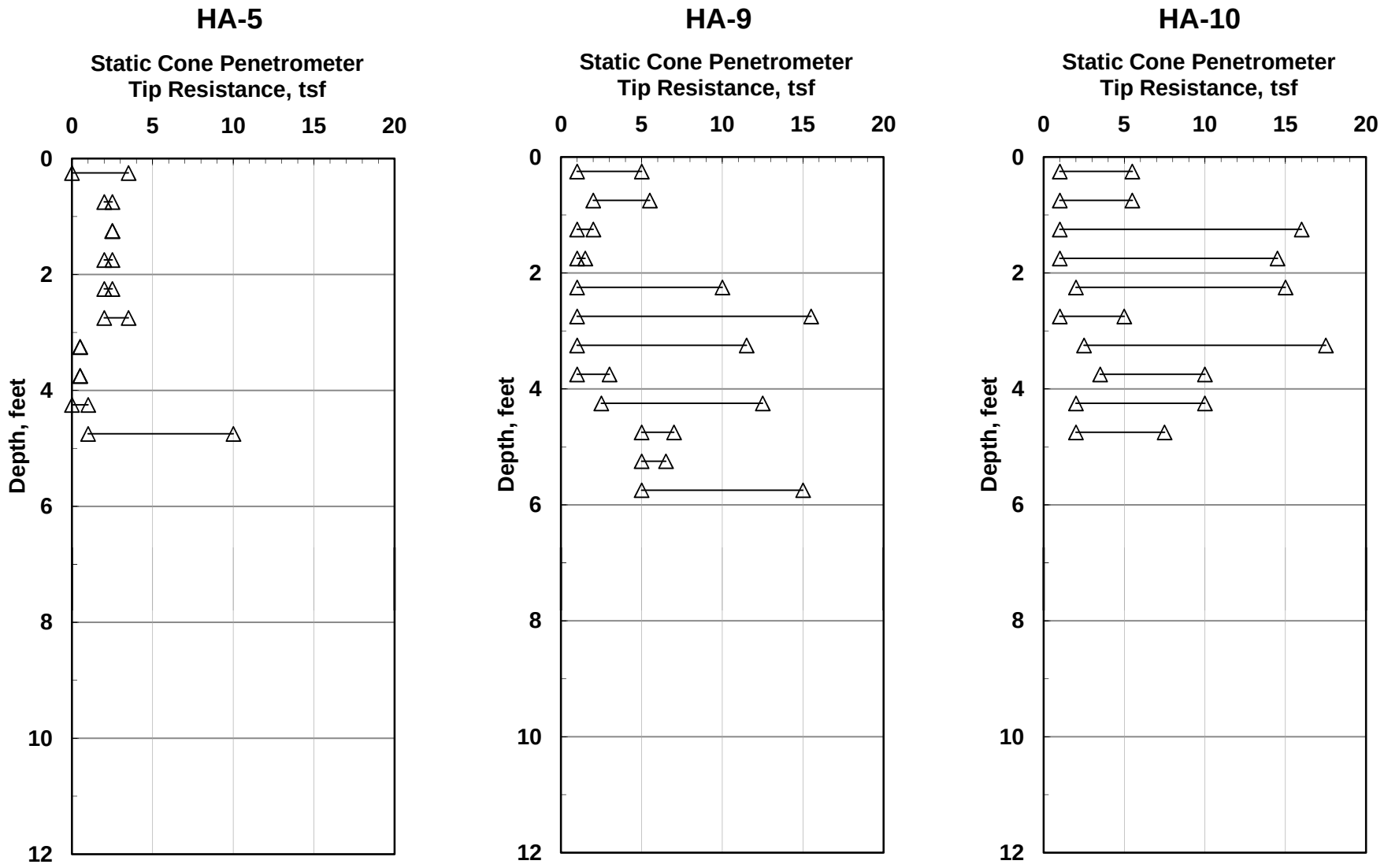
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 20



Note:

1. Portable Static Cone Penetrometer (Durham Geo Slope Indicator Model S-215).
2. Range of penetration resistance (max and min) shown for 0.5 feet intervals.

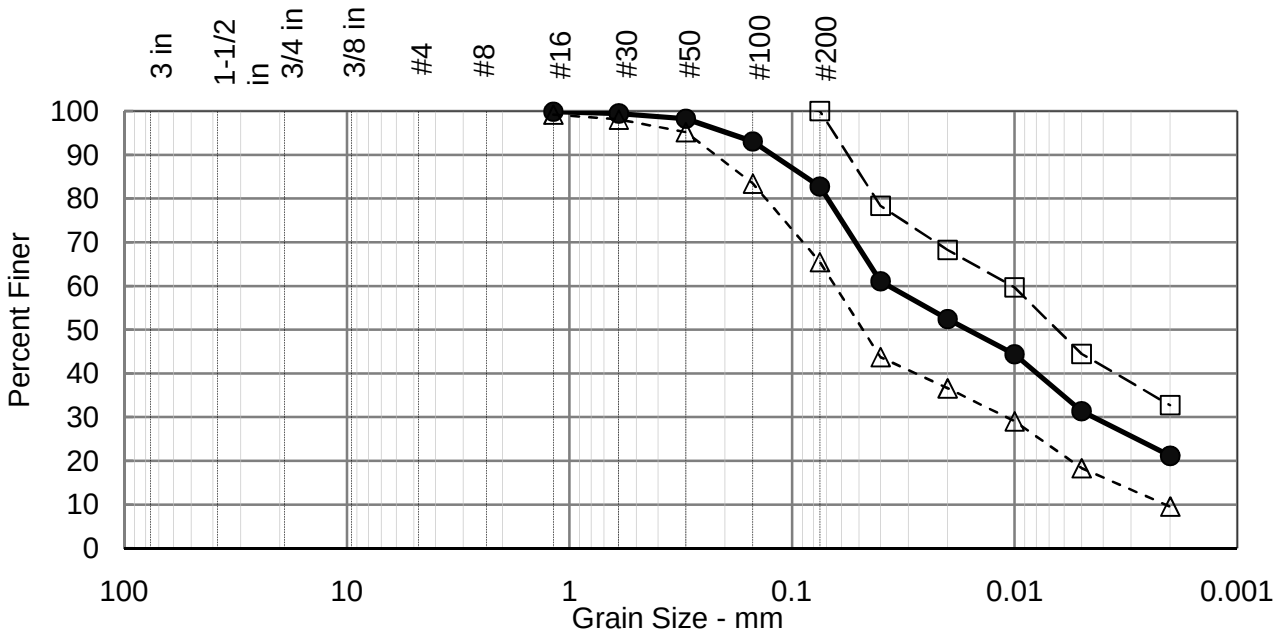
Salton Sea SCH Project Salton Sea, California	**Penetrometer Results**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 21



Note:

1. Portable Static Cone Penetrometer (Durham Geo Slope Indicator Model S-215).
2. Range of penetration resistance (max and min) shown for 0.5 feet intervals.

Salton Sea SCH Project Salton Sea, California	**Penetrometer Results**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 22



Key to Gradation Plots	
□	Mean Plus One Standard Deviation
●	Mean Grain Size of all sea sediment samples tested
△	Mean Minus One Standard Deviation

Grain Size	□	●	△
	Percent Finer		
1.19 mm (#16)	100	100	99
0.595 mm (#30)	100	99	98
0.297 mm (#50)	100	98	95
0.149 mm (#100)	100	93	83
0.074 mm (#200)	100	83	65
0.04 mm	78	61	44
0.02 mm	68	52	37
0.01 mm	60	44	29
0.005 mm	44	31	18
0.002 mm	33	21	10

Note: Includes gradation tests on individual samples from hand auger borings and vibracores and the four vibracore composite samples. Gradation test results for the two bulk samples (HA-1 and HA-4) are not included in this summary.

Salton Sea
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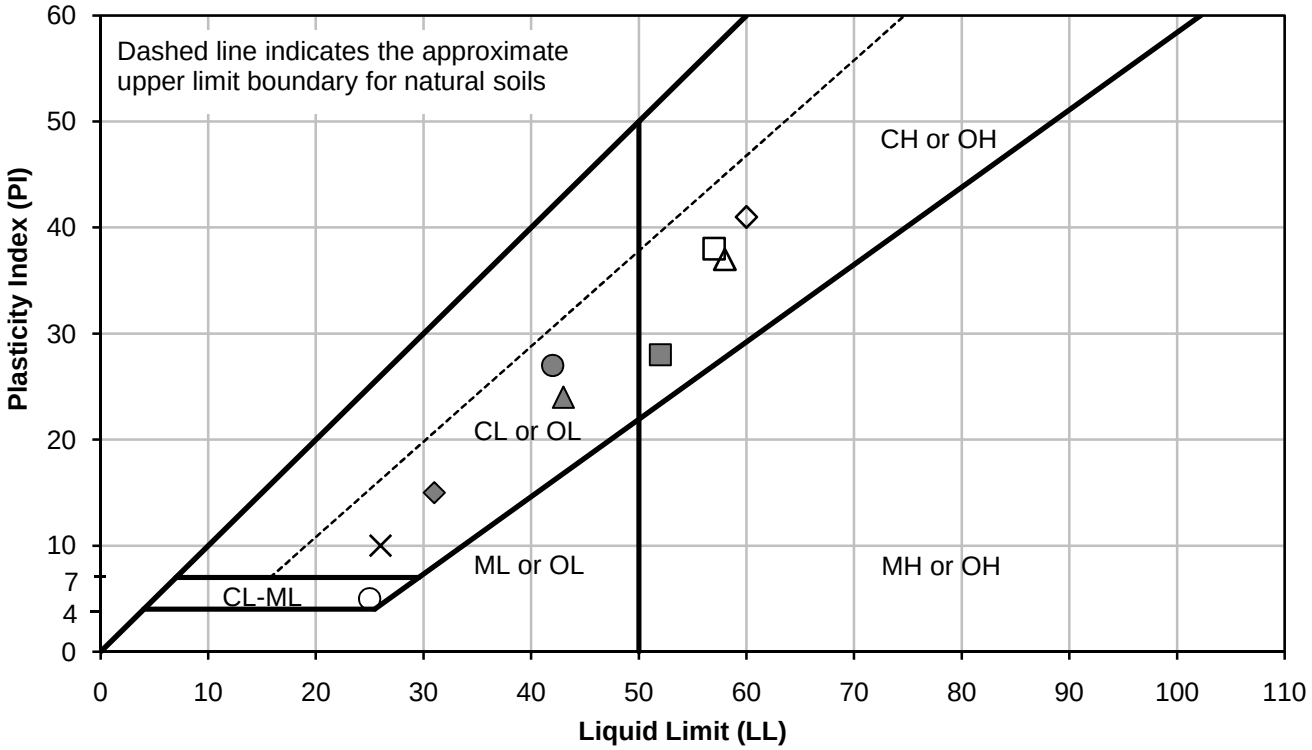
Summary of Sieve Analysis on Sea Sediments

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 23



Symbol	Boring Number	Depth (feet)	Soil Description	LL (%)	PL (%)	PI (%)	Moisture Content
●	HA-1	3.6 - 5.0	Reddish Brown LEAN CLAY	42	15	27	22
▲	HA-2	1.5 - 3.0	Tan Brown LEAN CLAY	43	19	24	45
■	HA-5	1.5 - 2.5	Olive Gray FAT CLAY	52	24	28	49
◆	HA-9	1.5 - 3.0	Dark Gray Sandy LEAN CLAY	31	16	15	44
○	HA-10	0.0 - 1.5	Tan Gray CLAYEY SILT	25	20	5	25
	VC-6	0.0 - 1.3	Gray SILT	NV	NP	NP	69
	VC-19	0.0 - 0.9	Gray Sandy SILT	NV	NP	NP	44
△	VC-19	3.5 - 6.2	Gray FAT CLAY	58	21	37	38
□	VC-21	2.1 - 4.8	Gray FAT CLAY	57	19	38	53
◇	VC-22	1.3 - 4.0	Gray FAT CLAY	60	19	41	32
	VC-24	0.0 - 1.1	Gray Silty SAND	NV	NP	NP	28
×	VC-24	3.7 - 6.4	Gray LEAN CLAY	26	16	10	42

Salton Sea
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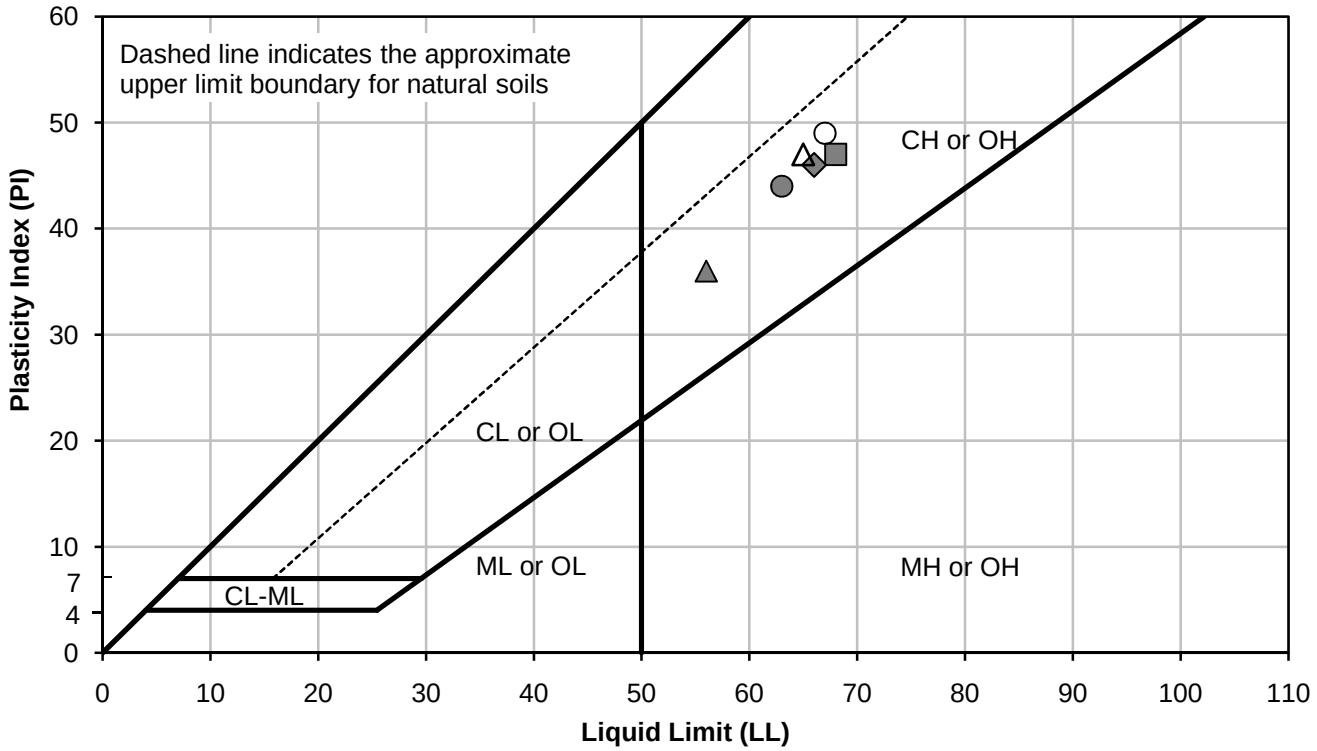
Salton Sea, California

Atterberg Limits on Individual Samples

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 24



Symbol	Boring Number	Depth (feet)	Soil Description	LL (%)	PL (%)	PI (%)	Moisture Content
●	HA-1	0.0 - 3.6	FAT CLAY (Bulk Sample)	63	19	44	
▲	HA-4	0.0 - 5.3	FAT CLAY (Bulk Sample)	56	20	36	
■	VC-11	0.0 -3.6	FAT CLAY (Composite Sample)	68	21	47	
◆	VC-16	0.0 - 3.9	FAT CLAY (Composite Sample)	66	20	46	
○	VC-20	0.0 - 4.7	FAT CLAY (Composite Sample)	67	18	49	
△	VC-28	0.4 - 5.7	FAT CLAY (Composite Sample)	65	18	47	

Salton Sea
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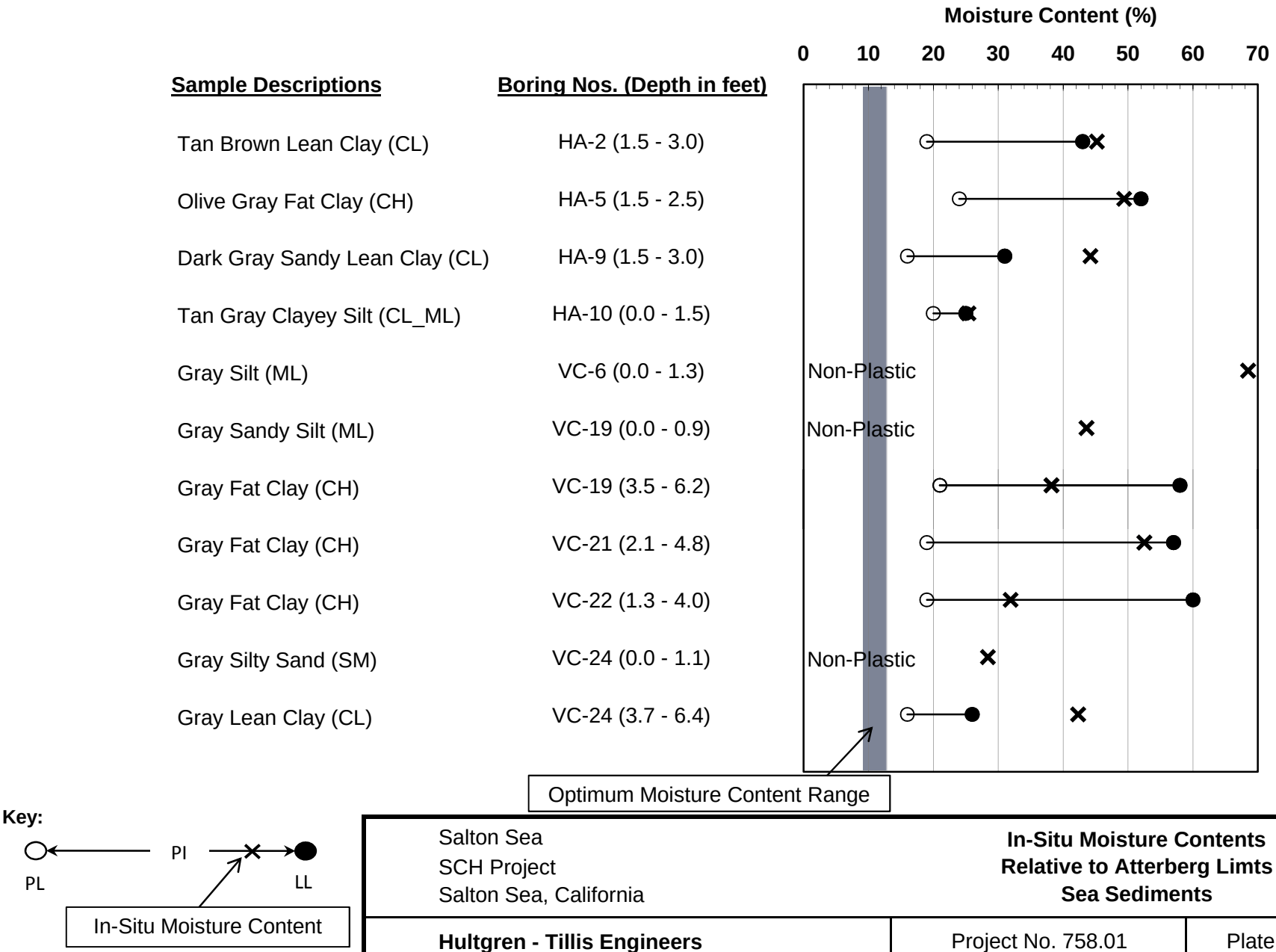
Salton Sea, California

Atterberg Limits on Bulk and Composite Samples

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 25



Salton Sea
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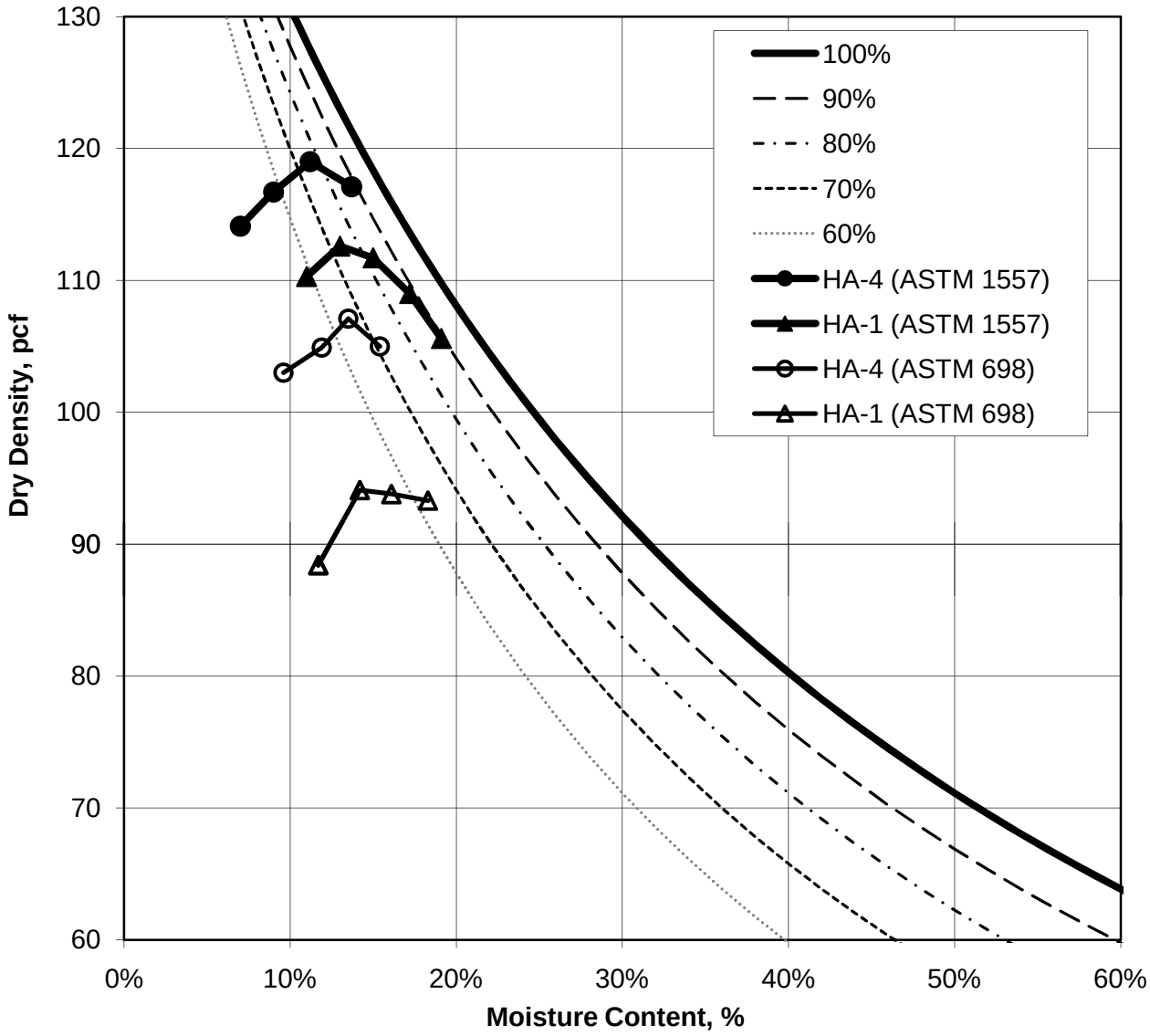
In-Situ Moisture Contents Relative to Atterberg Limts Sea Sediments

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 26

Compaction Test Results
(Saturation Curves Assume Specific Gravity = 2.65)



Salton Sea
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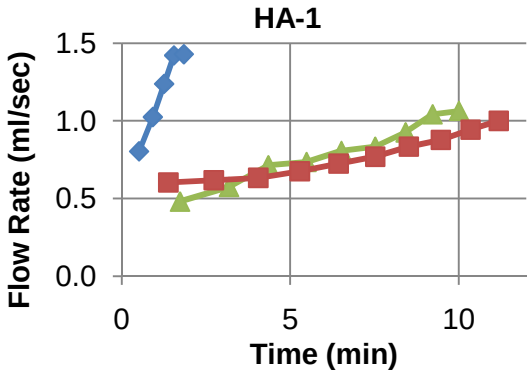
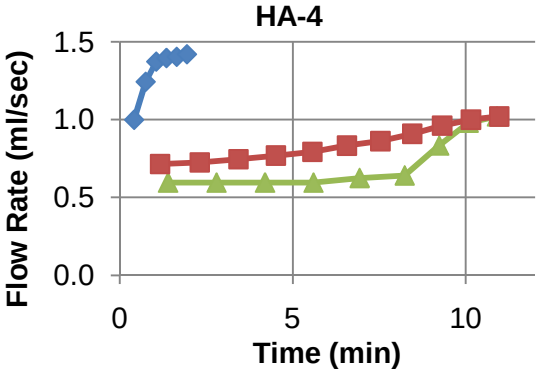
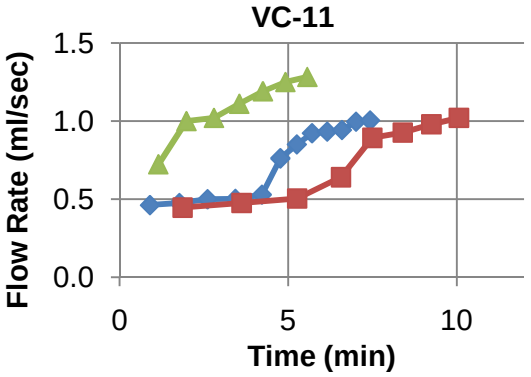
Salton Sea, California

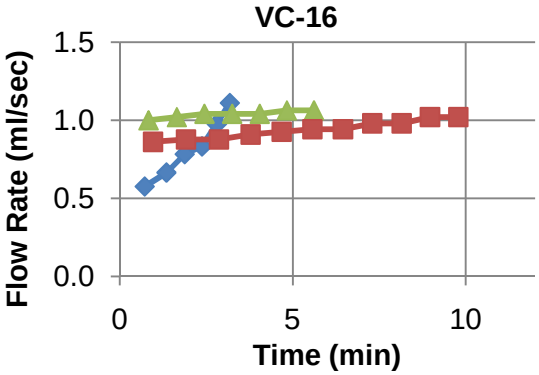
Compaction Test Results

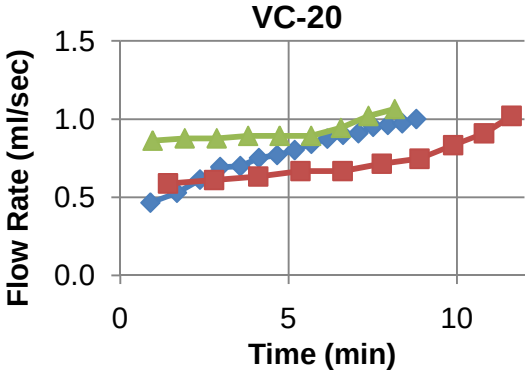
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 27

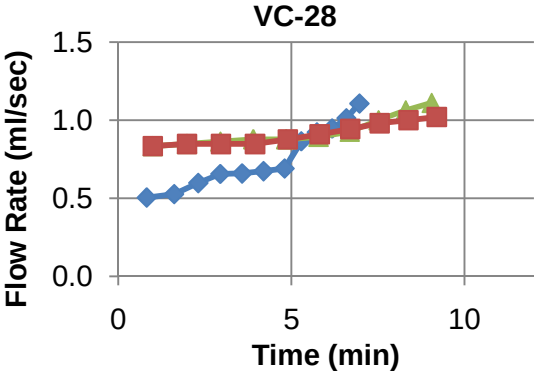




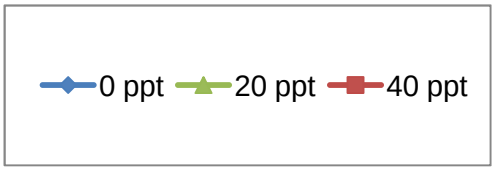








Dispersive classification *D1-Dispersive* applies where the flow rate is above 1.0 ml/sec in the first 5 minutes. Classification *D2-Dispersive* occurs if the rate reaches 1.0 ml/sec in the second 5 minute interval (5 to 10 minutes). Classification *ND4 - Intermediate* occurs if the rate increases to 0.8 ml/sec in the second 5 minute interval. In all cases, the dispersion classification could be made within the first ten minutes of testing with a hydraulic head of the 2-inches.



Salton Sea
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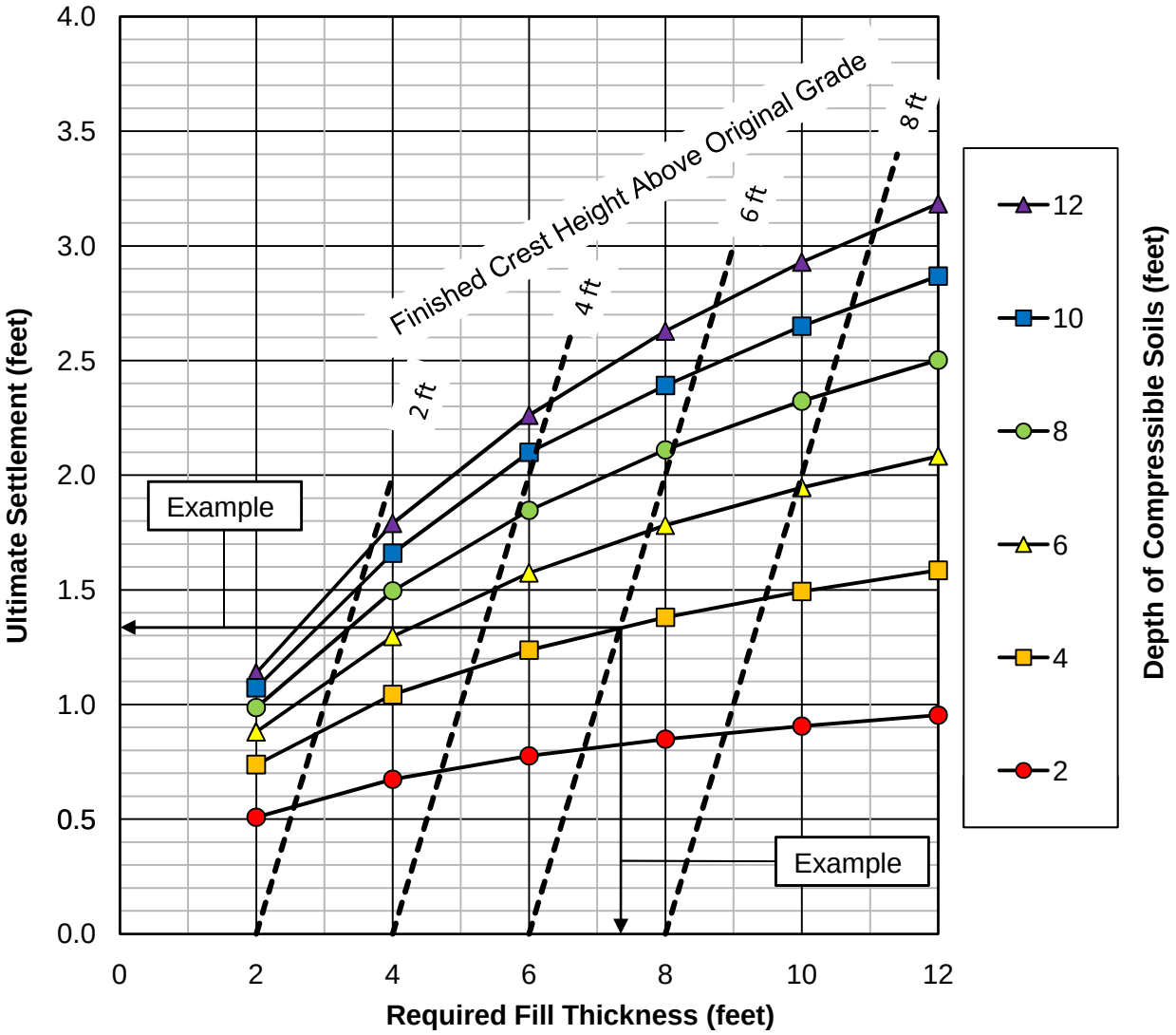
Salton Sea, California

Summary of Pinhole Tests

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 28



Notes:

1. Analyses based on uniform thickness fills placed on top of normally consolidated compressible soils with depths varying from 2 to 12 feet.
2. Analyses assume the ground water table at the top of compressible soils.
3. Analyses assume compressible soils with a coefficient of compressibility (Cce) of 0.3 and an unit weight of 100 pcf, and fills with an unit weight of 110 pcf.
4. To use this plot, select the desired final (post settlement) height of the berm crest above the original grade. From the geotechnical exploration data or by additional probing estimate the depth to the base of the compressible soils below existing grade. From the intersection of the final crest height with the depth of compressible soils, find the estimated ultimate settlement on the vertical axis and the required fill thickness on the horizontal axis. Example: For a final berm height six feet above existing grade in an area where the compressible soils extend four feet below existing grade, the estimated settlement is 1.3 feet (rounded) and the required fill thickness is 7.3 feet.

Salton Sea
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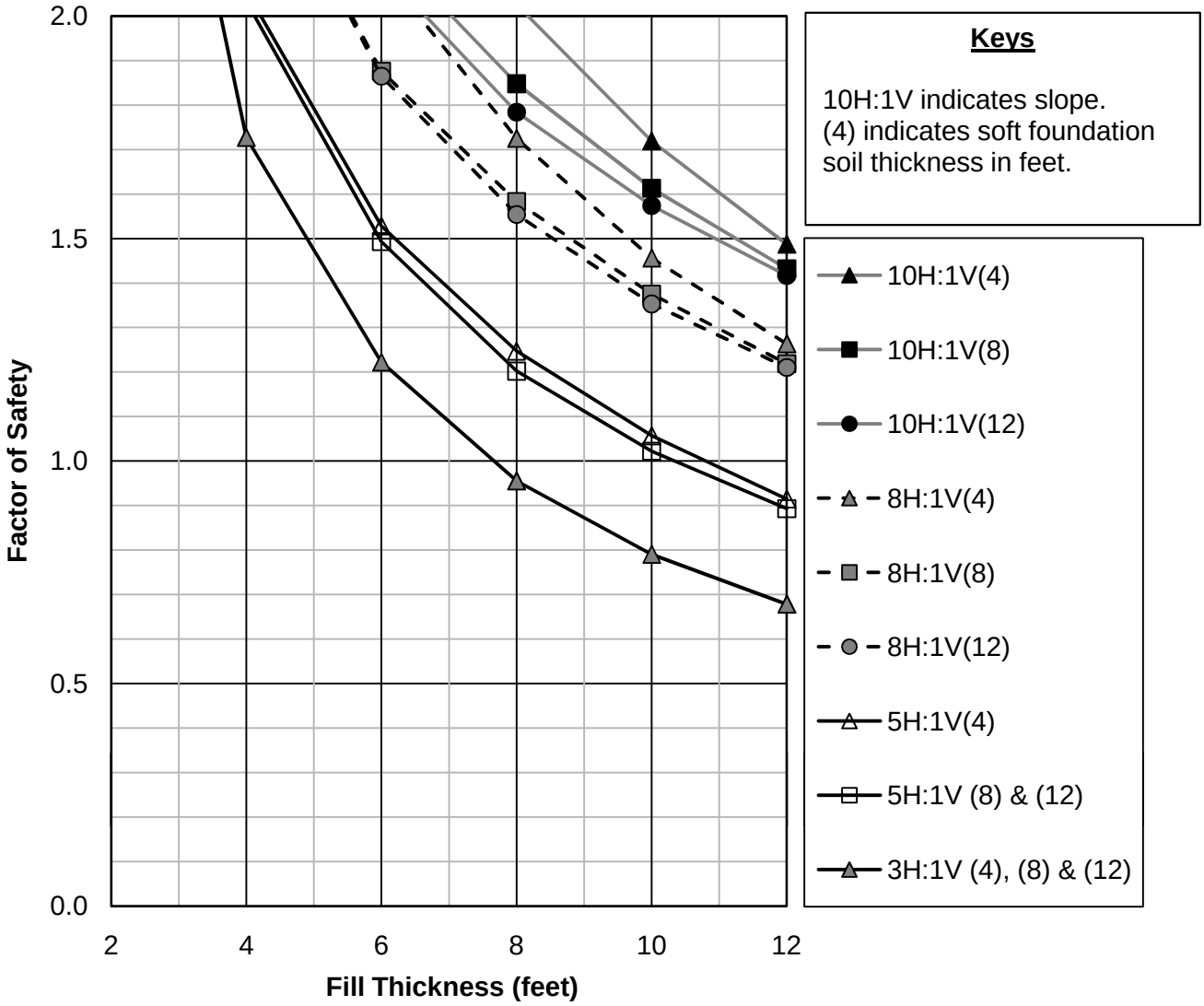
Ultimate Settlement vs Fill Thickness Plot

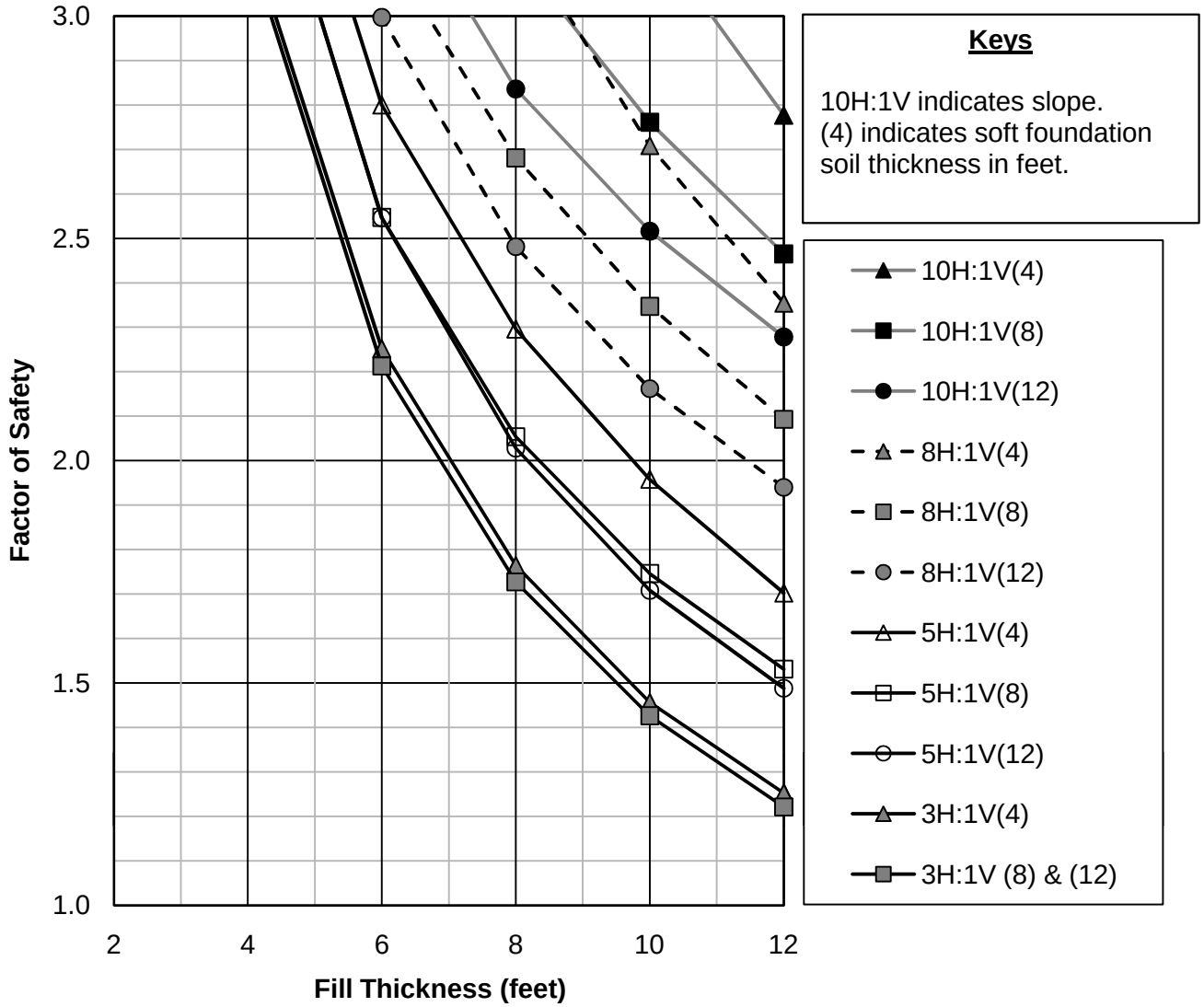
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 29



Notes:

1. Factor of Safety represents the Immediately-After-Construction condition.
2. Analyses assume uniform slopes (3H:1V, 5H:1V, 8H:1V and 10H:1V) with a maximum slope height varying form 2 to 12 feet, constructed on top of soft foundation soils of 4, 8, and 12 feet in thickness.
3. Analyses assume an undrained strength of 100 psf at top of the foundation soils and increase 10 psf per foot of depth (D). Strength Profile (foundation soils): Su = 100+10D (psf).
4. Analyses assume an undrained strength of 100 psf of fill.
5. Analyses assume the ground water table at the top of the foundation soils.

Salton Sea SCH Project Salton Sea, California	**Factor of Safety vs Fill Thickness Plot** **Su = 100 + 10 D (psf)**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 30



Notes:

1. Factor of Safety represents the Immediately-After-Construction condition.
2. Analyses assume uniform slopes (3H:1V, 5H:1V, 8H:1V and 10H:1V) with a maximum slope height varying form 2 to 12 feet, constructed on top of soft foundation soils of 4, 8, and 12 feet in thickness.
3. Analyses assume an undrained strength of 200 psf at top of the foundation soils and increase 10 psf per foot of depth (D). Strength Profile (foundation soils): Su = 200+10D (psf).
4. Analyses assume an undrained strength of 200 psf of fill.
5. Analyses assume the ground water table at the top of the foundation soils.

Salton Sea SCH Project Salton Sea, California	**Factor of Safety vs Fill Thickness Plot** **Su = 200 + 10 D (psf)**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 31

APPENDIX A

Laboratory Test Results

APPENDIX A

TABLE OF CONTENTS

Table A-1 ..... Plate A-1

Tests on Individual Samples ..... Plate A-2
- Moisture Content ..... Plate A-3
- Grain Size Analyses ..... Plate A-6
- Atterberg Limits ..... Plate A-24

Tests on Bulk and Composite Samples ..... Plate A-36
- Compaction Tests ..... Plate A-37
- Grain Size Analyses ..... Plate A-41
- Atterberg Limits ..... Plate A-47
- Chemical Analyses ..... Plate A-53
- Double Hydrometer and Crumb Tests ..... Plate A-61
- Pinhole Tests ..... Plate A-67

Summary of Laboratory Test Results

Table A-1

Boring No.	Depth (ft.)	Unified Soil Classification/ Description	In-situ Moisture Content (%)	Soil Fines Passing No. 200 Sieve (%)	Atterberg Limits			Organic Content (%)	Compaction (Stand.)		Compaction (Mod.)		Anion Fracton				Cation				Double Hydrometer Dispersion (%)	Crumb Test (Grade)	Pinhole Test - Dispersive Classification
					LL	PL	PI		Max Dry Density (pcf)	Optimum Moisture Content (%)	Max Dry Density (pcf)	Optimum Moisture Content (%)	Bromide (mg/kg)	Chloride (mg/kg)	Nitrate (mg/kg)	Nitrite (mg/kg)	Calcium (mg/kg)	Magnesium (mg/kg)	Potassium (mg/kg)	Sodium (mg/kg)			
HA-1	0.0 - 1.5	Olive Gray Fat Clay (CH)	45	94																			
HA-1	1.5 - 3.0	Olive Gray Fat Clay (CH)	65	91																			
HA-1	3.0 - 3.6	Gray Lean Clay (CL)	35																				
HA-1	3.6 - 5.0	Reddish Brown Lean Clay (CL)	22	97	42	15	27																
HA-1	0.0 - 3.6	Bulk Sample		89	63	19	44	Non-Organic	94	15	113	13	ND	29000	ND	ND	62000	11000	5900	18000	11	1 - Nondispersive	D1 - Dispersive
HA-2	0.0 - 1.5	Tan Brown Lean Clay (CL)	31																				
HA-2	1.5 - 3.0	Tan Brown Lean Clay (CL)	45	99	43	19	24																
HA-2	3.0 - 4.0	Dark Gray Lean Clay (CL)	54																				
HA-2	4.0 - 4.3	Reddish Brown Silt (ML)	41																				
HA-4	0.0 - 2.0	Olive Brown Silt (ML)	29																				
HA-4	2.0 - 3.5	Gray Lean Clay (CL)	33	85																			
HA-4	3.5 - 5.3	Dark Gray Fat Clay (CH)	46	93																			
HA-4	5.3 - 7.0	Dark Gray Fat Clay (CH)	47																				
HA-4	0.0 - 5.3	Bulk Sample		75	56	20	36	Non-Organic	107	14	119	11	ND	12000	ND	ND	48000	9000	3700	8500	17	2 - Intermediate	D1 - Dispersive
HA-5	0.0 - 1.5	Olive Gray Fat Clay (CH)	44																				
HA-5	1.5 - 2.5	Olive Gray Fat Clay (CH)	49	94	52	24	28																
HA-5	2.5 - 4.0	Dark Gray Fat Clay (CH)	55																				
HA-5	4.0 - 4.9	Gray Fat Clay (CH)	49																				
HA-5	4.9 - 5.3	Dark Gray Sandy Fat Clay (CH)	20	72																			
HA-9	0.0 - 1.5	Tan & Gray Lean Clay (CL)	44																				
HA-9	1.5 - 3.0	Dark Gray Sandy Lean Clay (CL)	44	62	31	16	15																
HA-9	3.0 - 4.0	Gray Clayey Sand (SC)	29																				
HA-9	4.0 - 4.5	Gray Lean Clay (CL)	33																				
HA-9	4.5 - 4.8	Reddish Brown Lean Clay (CL)	31																				
HA-10	0.0 - 1.5	Tan & Gray Clayey Silt (CL-ML)	25	78	25	20	5																
HA-10	1.5 - 3.0	Tan Clayey Sand (SC)	21	42																			
HA-10	3.0 - 4.0	Tan Sandy Lean Clay (CL)	34																				
HA-10	4.0 - 5.0	Reddish Brown Lean Clay (CL)	31																				
VC-6	0.0 - 1.3	Gray Silt (ML)	69	83	NV	NP	NP																
VC-11	0.0 - 0.8	Gray Fat Clay (CH)	31																				
VC-11	0.8 - 3.6	Gray Fat Clay (CH)	56																				
VC-11	0.0 - 3.6	Bulk Sample		90	68	21	47	Non-Organic					ND	5,500	ND	ND	41,000	8,000	3,700	6,400	61	3 - Dispersive	D2 - Dispersive
VC-16	0.0 - 1.3	Gray Fat Clay (CH)	43																				
VC-16	1.3 - 3.9	Gray Fat Clay (CH) & Reddish Brown Lean Clay (CL)	52																				
VC-16	0.0 - 3.9	Bulk Sample		95	66	20	46	Non-Organic					ND	6,900	ND	ND	36,000	7,500	3,500	6,700	9	2 - Intermediate	D1 - Dispersive
VC-19	0.0 - 0.9	Gray Sandy Silt (ML)	44	64	NV	NP	NP																
VC-19	0.9 - 3.5	Gray Silt (ML)	34																				
VC-19	3.5 - 6.2	Gray Fat Clay (CH)	38	93	58	21	37																
VC-20	0.0 - 2.0	Gray Fat Clay (CH)	29																				
VC-20	2.0 - 4.7	Gray Fat Clay (CH)	39																				
VC-20	0.0 - 4.7	Bulk Sample		89	67	18	49	Non-Organic					ND	4,600	ND	ND	40,000	7,600	2,000	4,600	13	1 - Nondispersive	D2 - Dispersive
VC-21	0.0 - 2.1	Gray Fat Clay (CH)	56																				
VC-21	2.1 - 4.8	Gray Fat Clay (CH)	53	98	57	19	38																
VC-22	0.0 - 1.3	Gray Silty Sand (SM)	33																				
VC-22	1.3 - 4.0	Gray Fat Clay (CH)	32	75	60	19	41																
VC-24	0.0 - 1.1	Gray Silty Sand (SM)	28	40	NV	NP	NP																
VC-24	1.1 - 3.7	Gray Silt (ML)	57																				
VC-24	3.7 - 6.4	Gray Lean Clay (CL)	42	89	26	16	10																
VC-28	0.0 - 0.4	Gray Fat Clay (CH)	48																				
VC-28	0.4 - 3.0	Gray Fat Clay (CH)	45																				
VC-28	3.0 - 5.7	Gray Fat Clay (CH)	64																				
VC-28	0.4 - 5.7	Bulk Sample		98	65	18	47	Non-Organic					ND	8,600	ND	ND	48,000	7,900	3,400	8,400	9	1 - Nondispersive	D2 - Dispersive

Note:

1. "Bulk Sample" indicates that the sample was recovered over a wide depth interval. Several additional hand auger borings were drilled immediately adjacent to the logged boring to recover a large quantity of soil for testing. The depth interval is noted.
2. "Composite sample" indicates that a sample that extends more than one 2.7-feet section of vibracore tubing. The depth interval is noted.
3. Abbreviations - NV: No Value, NP: Non Plastic, ND: Not Detected.

Tests on Individual Samples

DENSITY MOISTURE

PROJECT	Hultgren - Tillis Engineers (Salton Sea)	DATE	10/5/2010
PROJECT NUMBER	60	TECHNICIAN	997

BORING NO.	HA-1				HA-2				HA-4	
DEPTH, ft	0-1.5	1.5-3	3-3.6	3.6-5	0-1.5	1.5-3	3-4	4-4.3	0-2	2-3.5
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	423.1	357.9	400.2	454.4	421.1	465.6	432.3	406.9	609.7	609.4
DRY WT. (g)	291.4	216.7	297.6	371.7	322.6	320.6	281.7	289.6	473.4	457.4
WET DENSITY										
% MOISTURE	**45.2**	**65.2**	**34.5**	**22.2**	**30.5**	**45.2**	**53.5**	**40.5**	**28.8**	**33.2**
DRY DENSITY										

BORING NO.	HA-4		HA-5					HA-9		
DEPTH, ft	3.5-5.3	5.3-7	0-1.5	1.5-2.5	2.5-4	4-4.9	4.9-5.3	0-1.5	1.5-3	3-4
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	522.2	437.7	455.3	599.2	443	410.4	519.3	550.6	441.7	585.9
DRY WT. (g)	357.1	298.3	316.3	401.1	285.8	276.4	433.6	383.6	306.4	453.2
WET DENSITY										
% MOISTURE	**46.2**	**46.7**	**43.9**	**49.4**	**55.0**	**48.5**	**19.8**	**43.5**	**44.2**	**29.3**
DRY DENSITY										

DENSITY MOISTURE

PROJECT Hultgren - Tillis Engineers (Salton Sea) DATE 10/5/2010

PROJECT NUMBER 60 TECHNICIAN 997

BORING NO.	HA-9		HA-10				VC-6C	VC-11B	VC-11C	VC-16B
DEPTH, ft	4-4.5	4.5-4.8	0-1.5	1.5-3	3-4	4-5	0-1.3	0-0.8	0.8-3.6	0-1.3
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	518.9	252.4	578.9	583.5	557.8	562.2	442.2	288.8	471.4	480.9
DRY WT. (g)	389.6	192.2	461.7	483.1	416.5	430.4	262.4	220.9	302.9	336.6
WET DENSITY										
% MOISTURE	**33.2**	**31.3**	**25.4**	**20.8**	**33.9**	**30.6**	**68.5**	**30.7**	**55.6**	**42.9**
**							**14/1.5**	**8.5/0.5**	**33/0**	**13/0.5**

** Length of Solid column/Length of Water Column, Respectively, IN

BORING NO.	VC-16C	VC-19A	VC-19B	VC-19C	VC-20B	VC-20C	VC-21B	VC-21C	VC-22B	VC-22C
DEPTH, ft	1.3-3.9	0-0.9	0.9-3.5	3.5-6.2	0-2	2-4.7	0-2.1	2.1-4.8	0-1.3	1.3-4
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	345.6	220	496.3	325.9	481.7	317.8	523.9	439.8	336.6	482.1
DRY WT. (g)	227.4	153.2	370.1	235.9	374.2	228.7	336.5	288.4	253.3	365.6
WET DENSITY										
% MOISTURE	**52.0**	**43.6**	**34.1**	**38.2**	**28.7**	**39.0**	**55.7**	**52.5**	**32.9**	**31.9**
**	**33/0**	**7.5/0.5**	**32.0**	**33/0**	**21.5/1.0**	**33/0**	**21/2**	**33/0**	**8.5/0**	**31/0.5**

** Length of Solid column/Length of Water Column, Respectively, IN

DENSITY MOISTURE

PROJECT Hultgren - Tillis Engineers (Salton Sea) DATE 10/5/2010

PROJECT NUMBER TECHNICIAN 997

BORING NO.	VC-24A	VC-24B	VC-24C	VC-28A	VC-28B	VC-28C				
DEPTH, ft	0-1.1	1.1-3.7	3.7-6.4	0-0.4	0.4-3	3-5.7				
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	342.7	440	444.7	306.7	488.6	335.9				
DRY WT. (g)	266.9	280.9	312.4	207.3	337.9	205.5				
WET DENSITY										
% MOISTURE	**28.4**	**56.6**	**42.3**	**47.9**	**44.6**	**63.5**				
**	**10/1**	**31/0**	**32/0**	**3/6**	**32/0**	**28.5/0**				

** Length of Solid column/Length of Water Column, Respectively, IN

BORING NO.										
DEPTH, ft										
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)										
DRY WT. (g)										
WET DENSITY										
% MOISTURE										
DRY DENSITY										

Particle Size Distribution Report

% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	1.5	4.9	63.1	30.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	98.9		
#50	97.9		
#100	96.2		
#200	93.6		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0540 D_{60}= 0.0241 D_{50}= 0.0091
D_{30}= 0.0049 D_{15}= 0.0025 D_{10}= 0.0021
C_u= 11.25 C_c= 0.46

Classification

USCS= AASHTO=

Remarks

F.M.=0.07

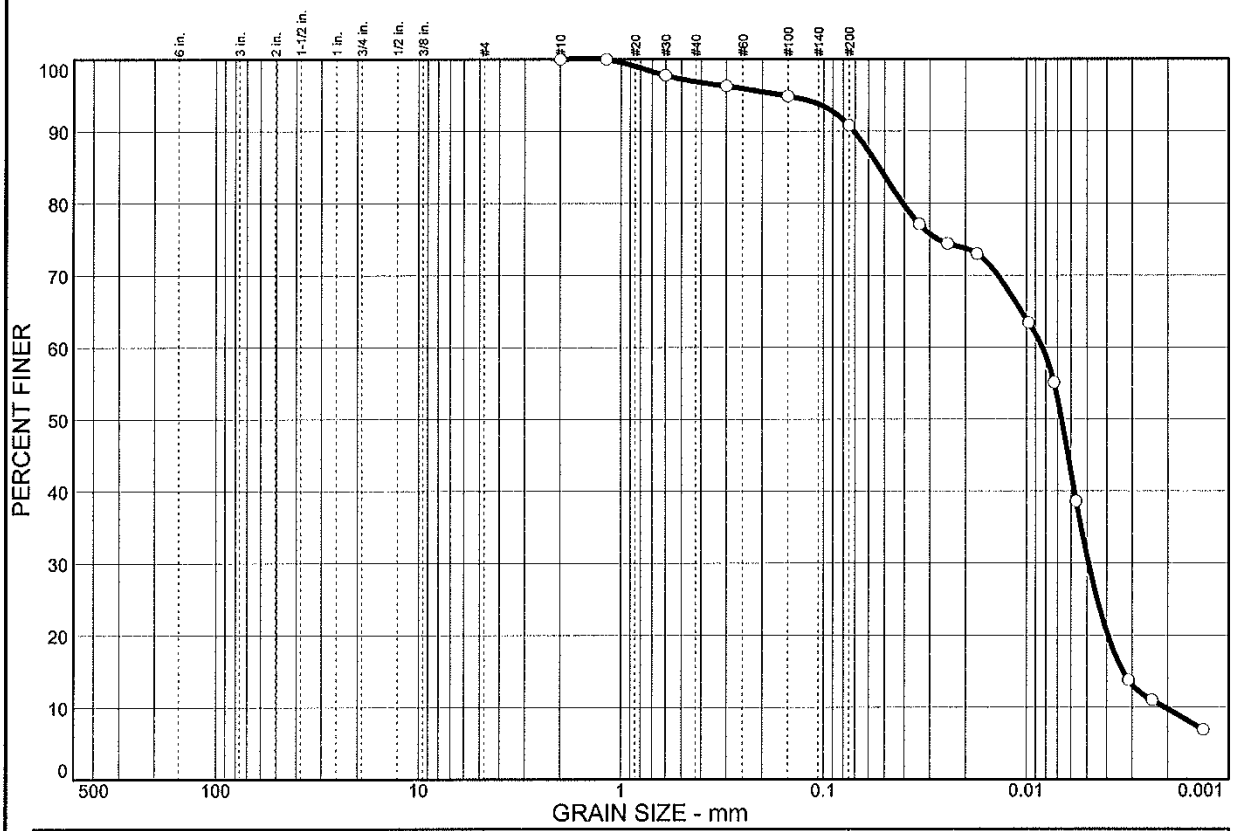
Sample No.: HA-1 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 0-1.5 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	3.1	6.1	59.9	30.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	97.8		
#50	96.3		
#100	94.9		
#200	90.8		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0532 D_{60}= 0.0083 D_{50}= 0.0067
D_{30}= 0.0049 D_{15}= 0.0033 D_{10}= 0.0021
C_u= 4.02 C_c= 1.41

Classification

USCS= AASHTO=

Remarks

F.M.=0.11

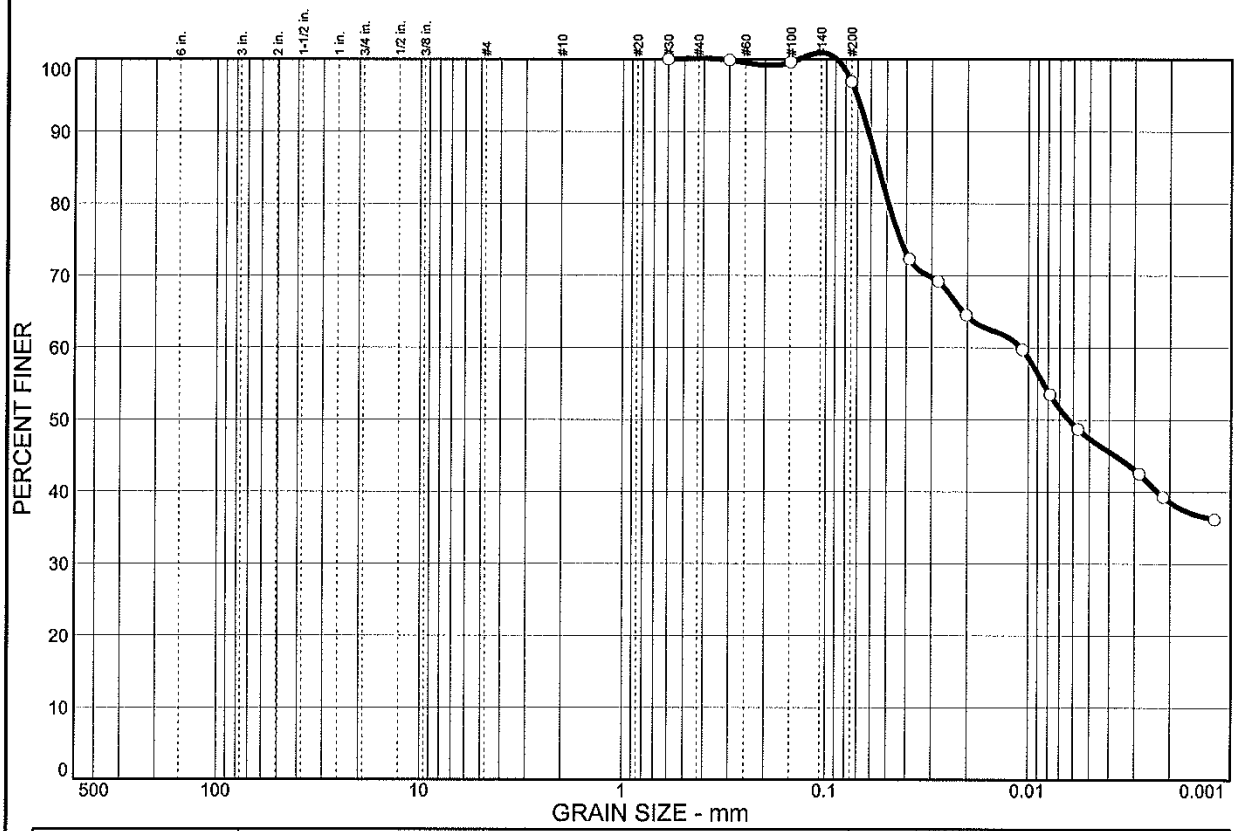
Sample No.: HA-1 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 1.5-3 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0		3.2	49.5	47.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#30	100.0		
#50	99.9		
#100	99.6		
#200	96.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0551 D_{60}= 0.0109 D_{50}= 0.0063
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.00

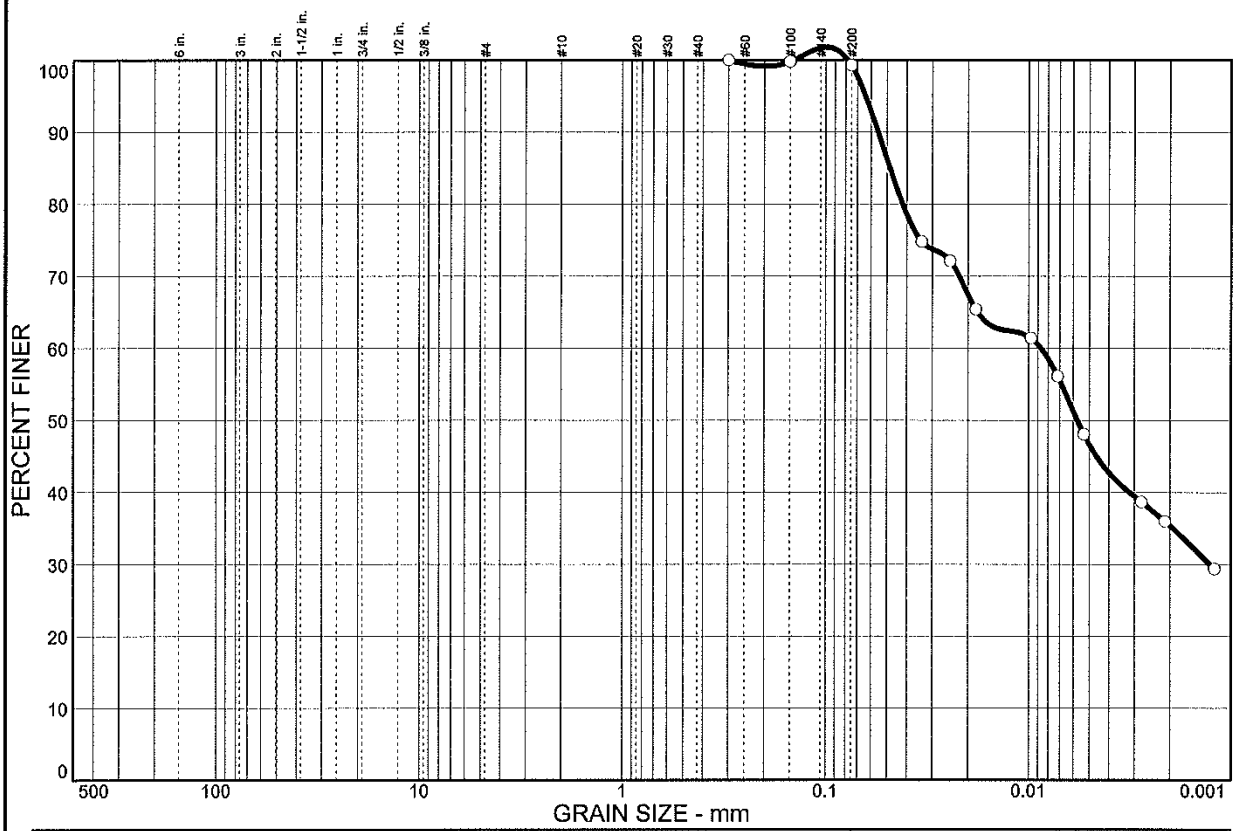
Sample No.: HA-1 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 3.5-5 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.0	0.7	52.6	46.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#50	100.0		
#100	99.8		
#200	99.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= 19 LL= 43 PI= 24

Coefficients

D_{85}= 0.0485 D_{60}= 0.0087 D_{50}= 0.0057
D_{30}= 0.0013 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.00

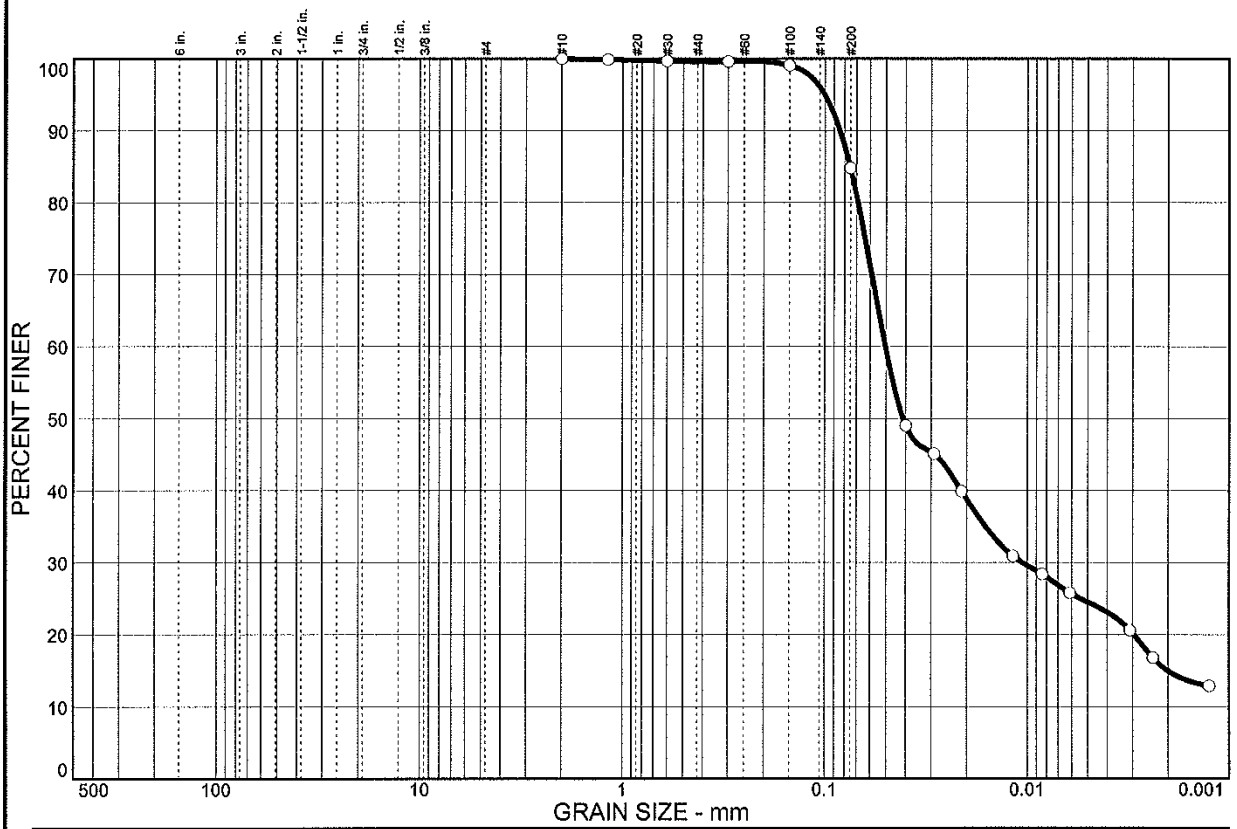
Sample No.: HA-2 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 1.5-3 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.4	14.8	60.3	24.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.7		
#50	99.6		
#100	99.1		
#200	84.8		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0753 D_{60}= 0.0505 D_{50}= 0.0412
D_{30}= 0.0105 D_{15}= 0.0020 D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.02

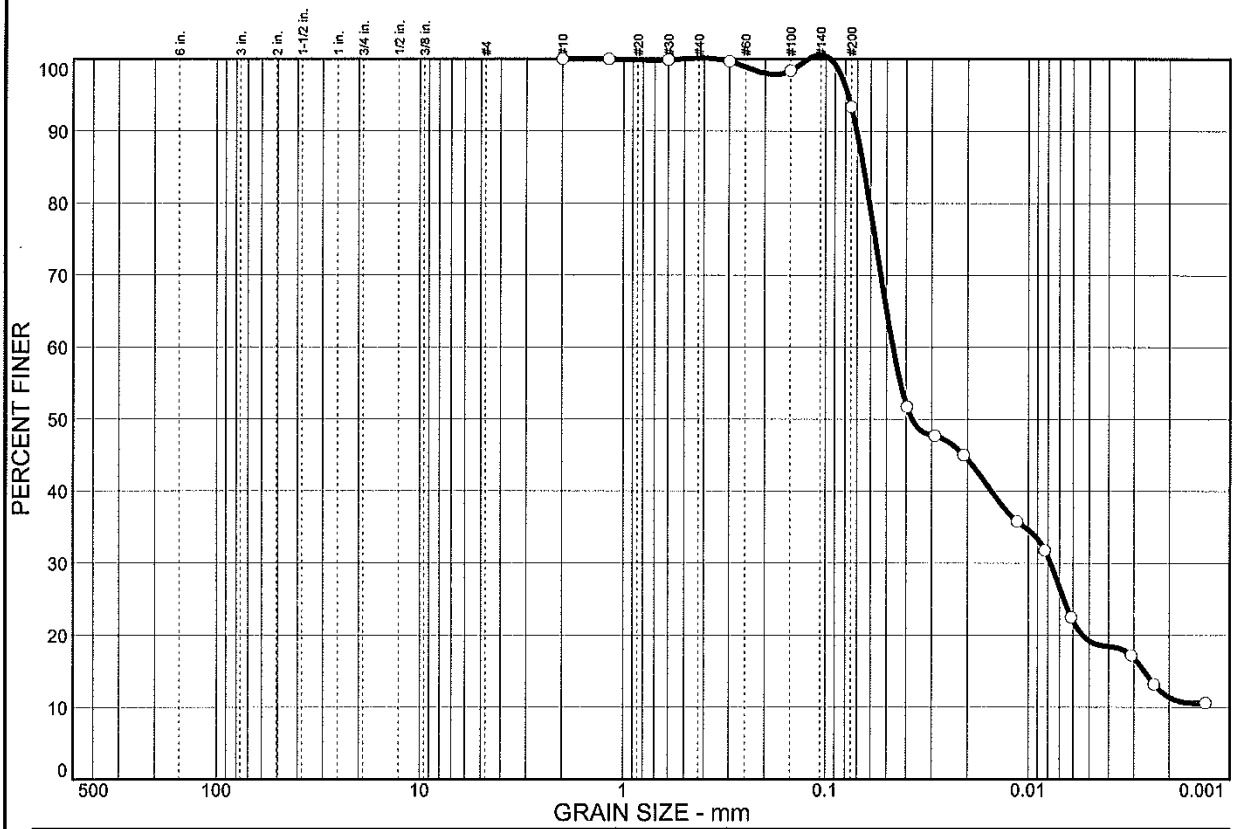
Sample No.: HA-4 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 2-3.5 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0		6.7	74.2	19.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.9		
#50	99.7		
#100	98.4		
#200	93.4		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0652 D_{60}= 0.0465 D_{50}= 0.0374
D_{30}= 0.0078 D_{15}= 0.0027 D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.02

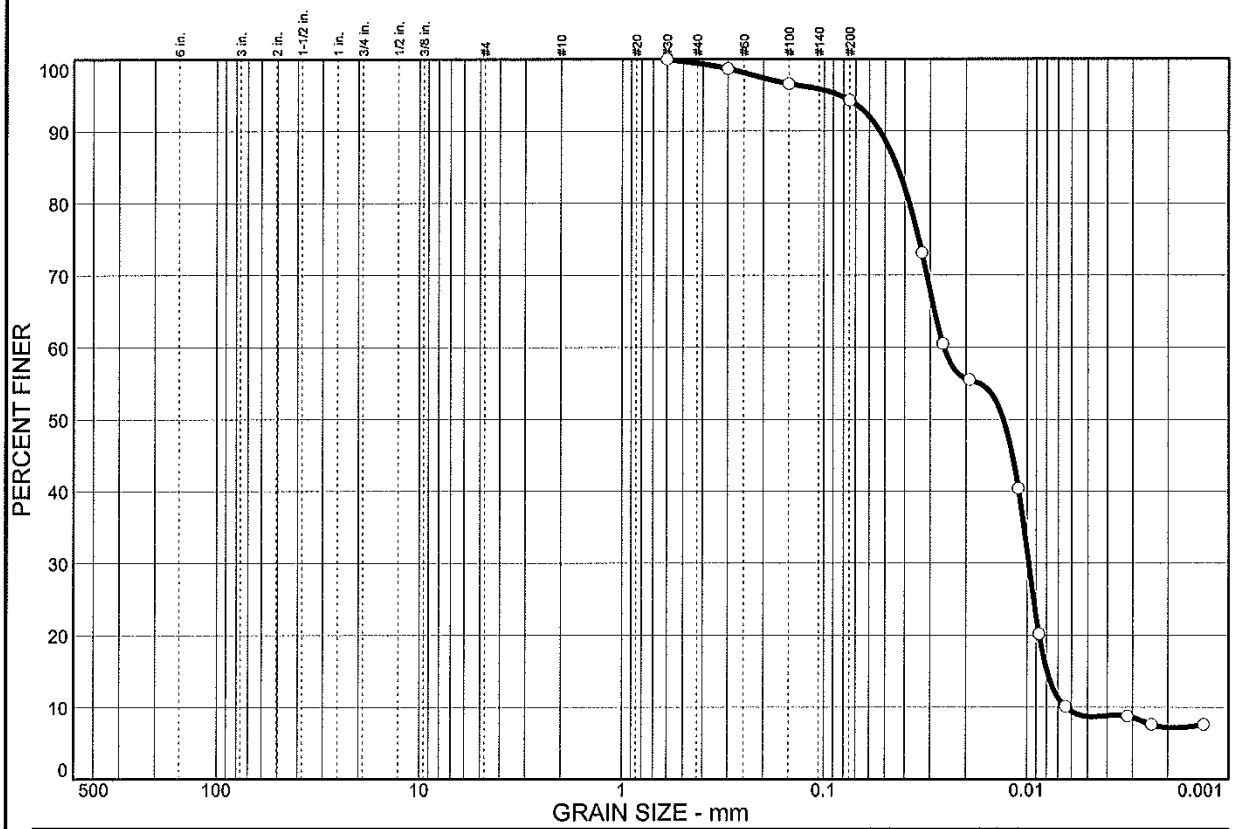
Sample No.: HA-4 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 3.5-5.3 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.5	5.2	85.6	8.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#30	100.0		
#50	98.7		
#100	96.6		
#200	94.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= 24 LL= 52 PI= 28

Coefficients

D_{85}= 0.0436 D_{60}= 0.0256 D_{50}= 0.0131
D_{30}= 0.0098 D_{15}= 0.0079 D_{10}= 0.0064
C_u= 4.02 C_c= 0.59

Classification

USCS= AASHTO=

Remarks

F.M.=0.05

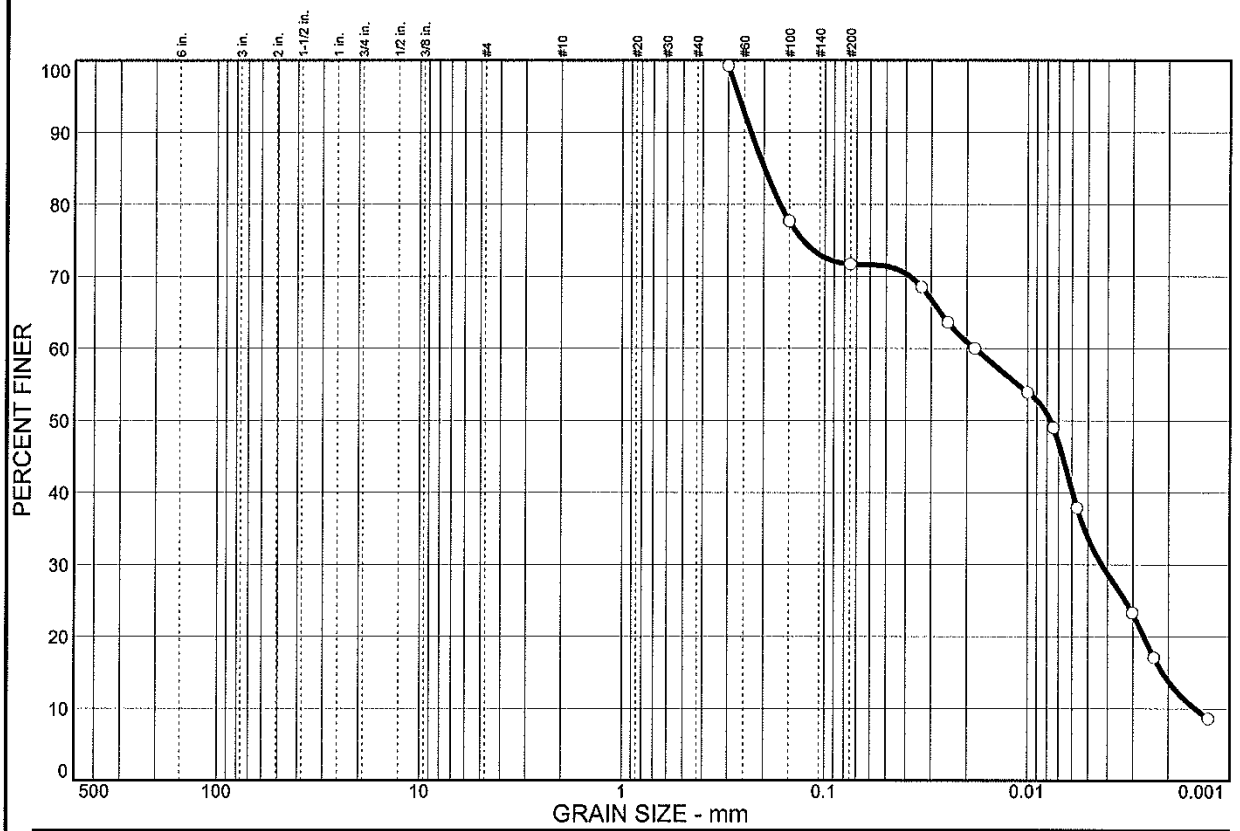
Sample No.: HA-5 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 1.5-2.5 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
						37.9	33.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#50	99.3		
#100	77.7		
#200	71.7		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.198 D_{60}= 0.0183 D_{50}= 0.0077
D_{30}= 0.0043 D_{15}= 0.0021 D_{10}= 0.0015
C_u= 12.33 C_c= 0.67

Classification

USCS= AASHTO=

Remarks

F.M.=0.23

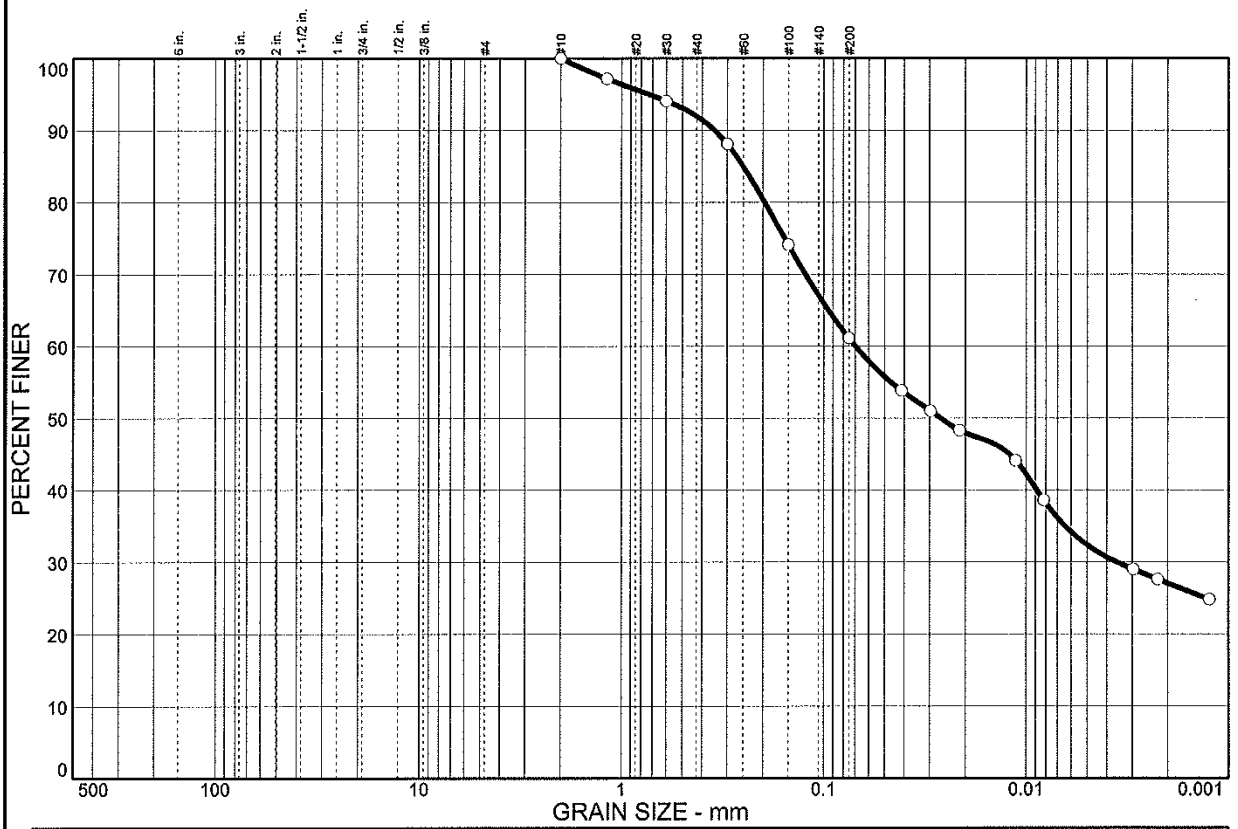
Sample No.: HA-5 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 4.9-5.3 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	8.0	30.9	28.7	32.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	97.2		
#30	94.1		
#50	88.1		
#100	74.1		
#200	61.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= 16 LL= 31 PI= 15

Coefficients

D_{85}= 0.250 D_{60}= 0.0697 D_{50}= 0.0265
D_{30}= 0.0036 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.47

Sample No.: HA-9 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 1.5-3 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report

% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.4	21.2	63.0	15.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.7		
#50	99.0		
#100	95.9		
#200	78.4		

* (no specification provided)

Material Description

*

Atterberg Limits

PL= 20 LL= 25 PI= 5

Coefficients

D_{85}= 0.0841 D_{60}= 0.0597 D_{50}= 0.0530
D_{30}= 0.0205 D_{15}= 0.0045 D_{10}= 0.0023
C_u= 25.70 C_c= 3.03

Classification

USCS= AASHTO=

Remarks

F.M.=0.05

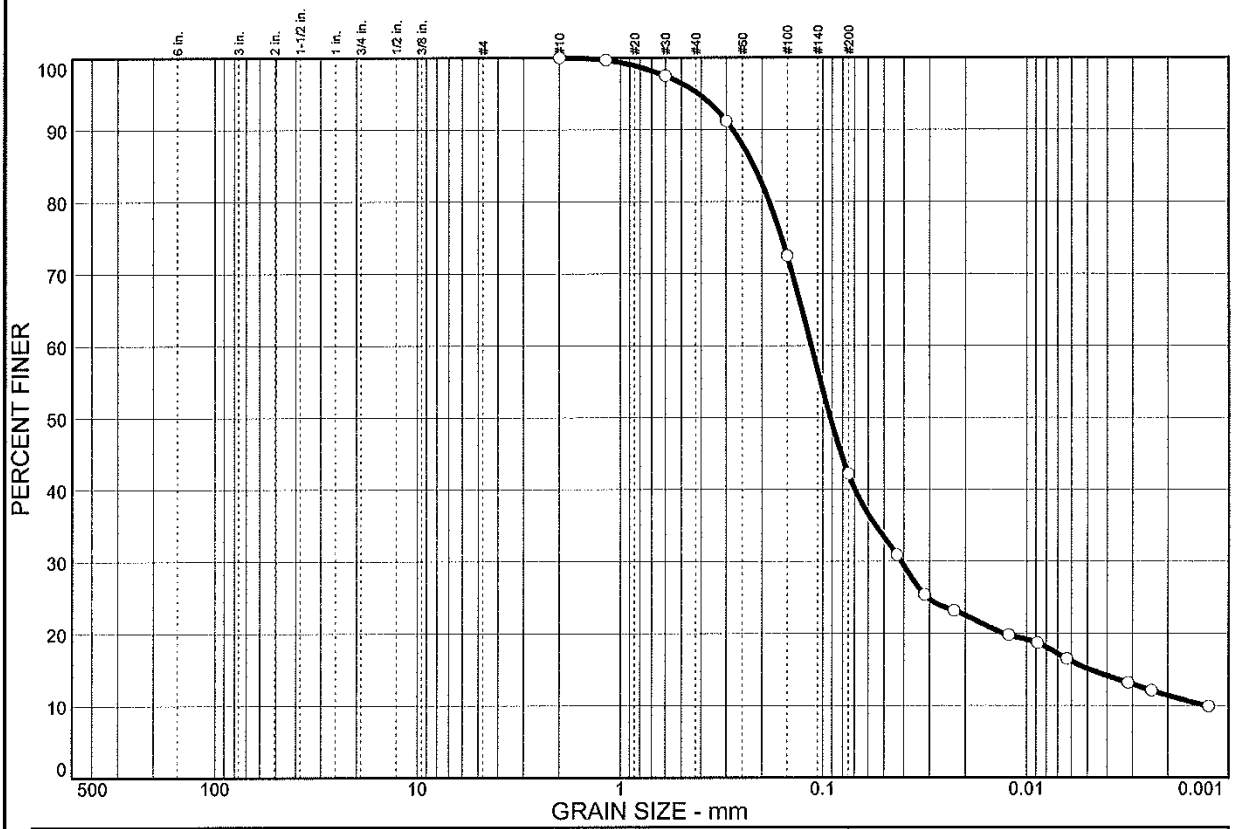
Sample No.: HA-10 **Source of Sample:** **Date:** 10/13/10
Location: **Elev./Depth:** 0-1.5 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	4.7	53.1	27.0	15.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.7		
#30	97.5		
#50	91.2		
#100	72.5		
#200	42.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.220 D_{60}= 0.114 D_{50}= 0.0919
D_{30}= 0.0412 D_{15}= 0.0048 D_{10}= 0.0013
C_u= 87.63 C_c= 11.46

Classification

USCS= AASHTO=

Remarks

F.M.=0.39

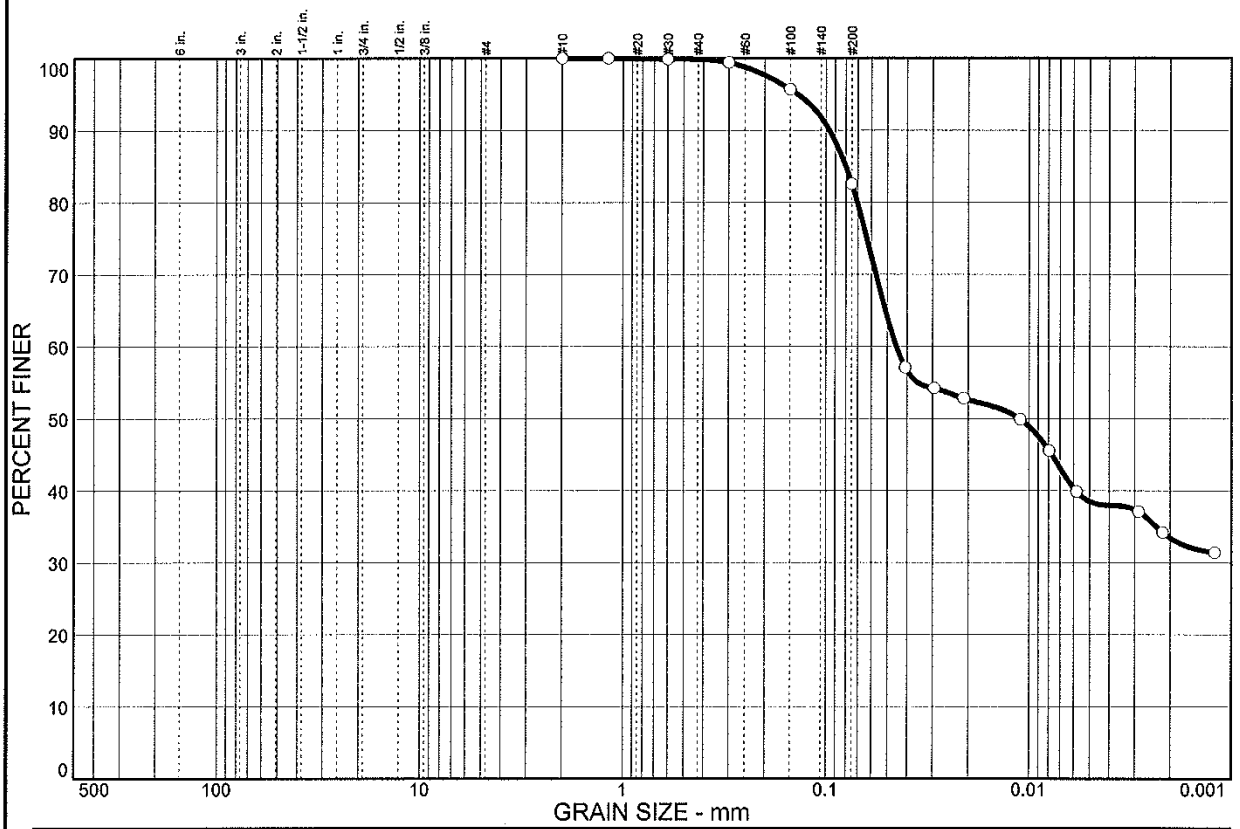
Sample No.: HA-10 **Source of Sample:** **Date:** 12/13/10
Location: **Elev./Depth:** 1.3-3 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.1	17.3	44.1	38.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.9		
#50	99.4		
#100	95.7		
#200	82.6		

* (no specification provided)

Material Description

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.0801 D_{60}= 0.0452 D_{50}= 0.0111
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.05

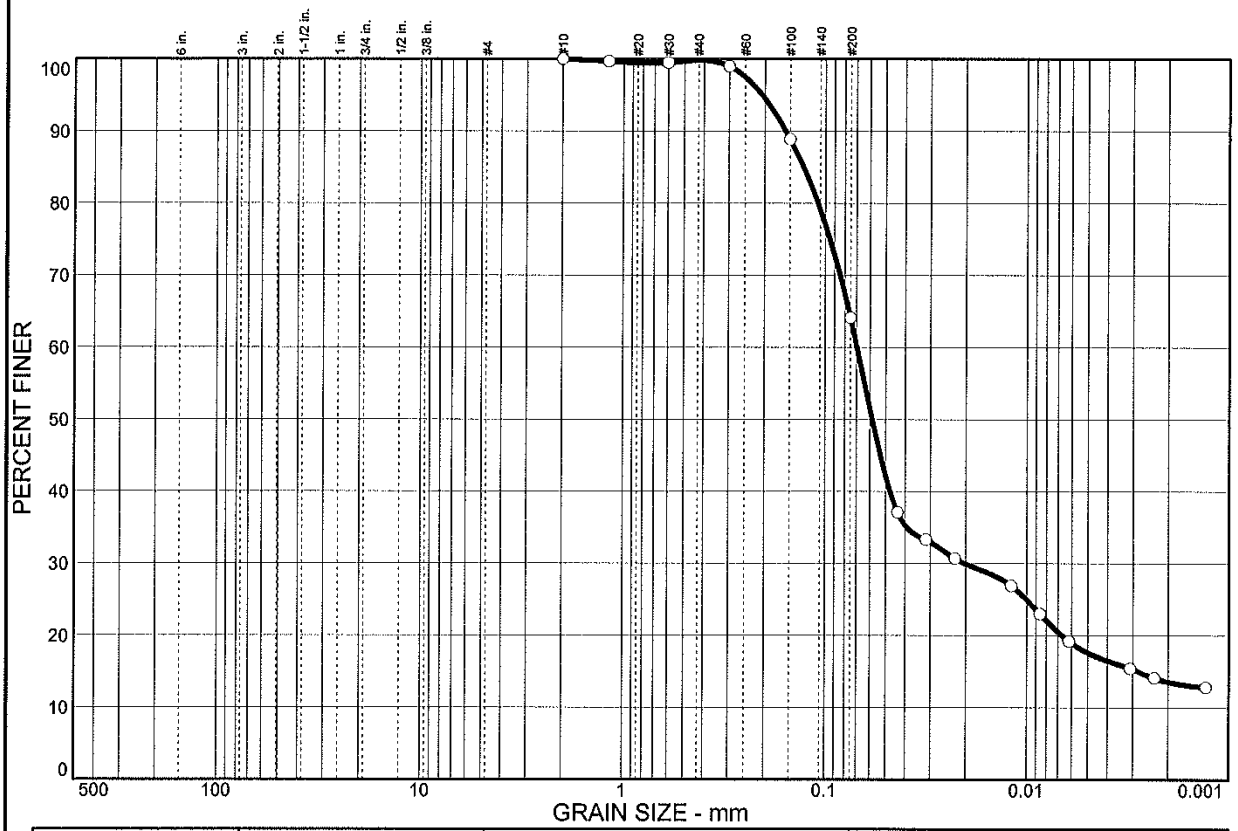
Sample No.: VC-6C **Source of Sample:** **Date:** 10/13/10
Location: **Elev./Depth:** 0-1.3 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	35.7	46.5	17.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.7		
#30	99.5		
#50	99.0		
#100	88.9		
#200	64.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.128 D_{60}= 0.0696 D_{50}= 0.0584
D_{30}= 0.0202 D_{15}= 0.0028 D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.13

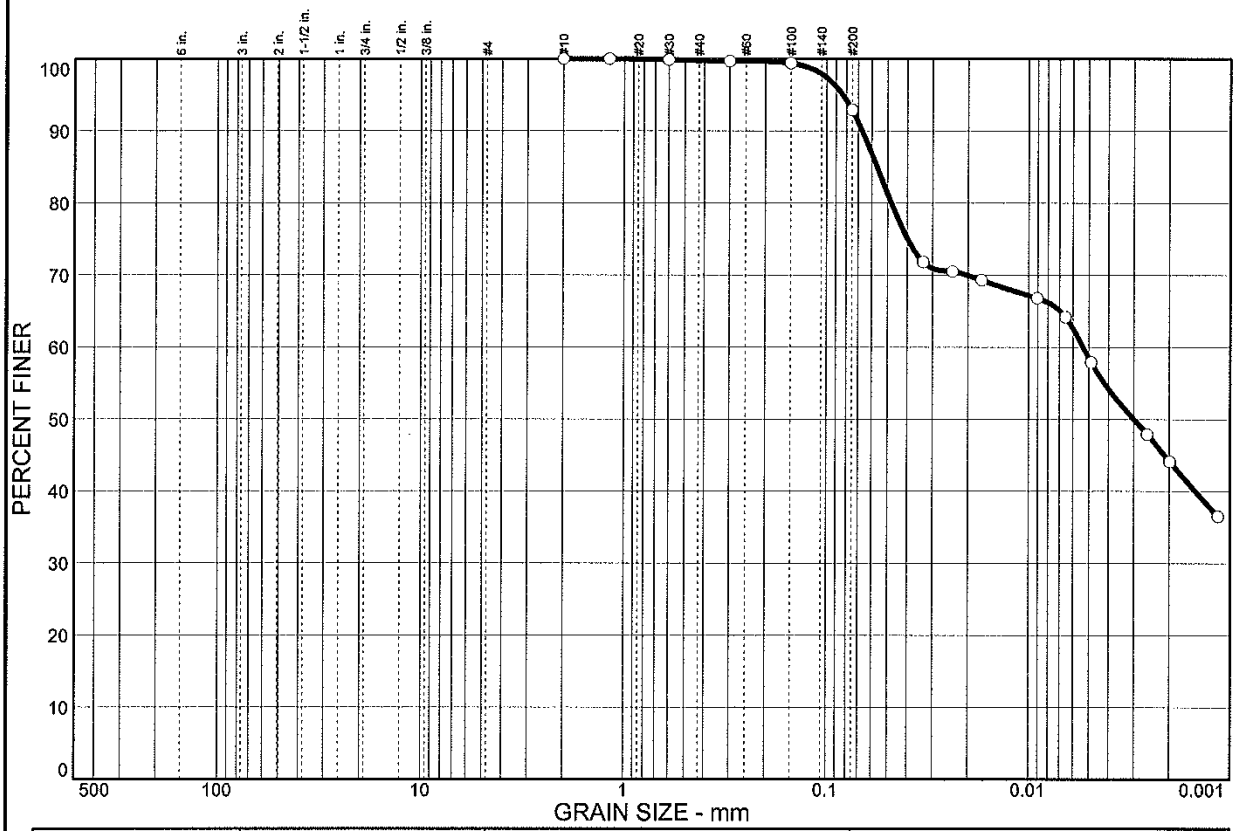
Sample No.: VC-19A **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0-0.9 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	6.9	34.4	58.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.9		
#50	99.7		
#100	99.4		
#200	92.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= 21 LL= 58 PI= 37

Coefficients

D_{85}= 0.0564 D_{60}= 0.0053 D_{50}= 0.0030
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.01

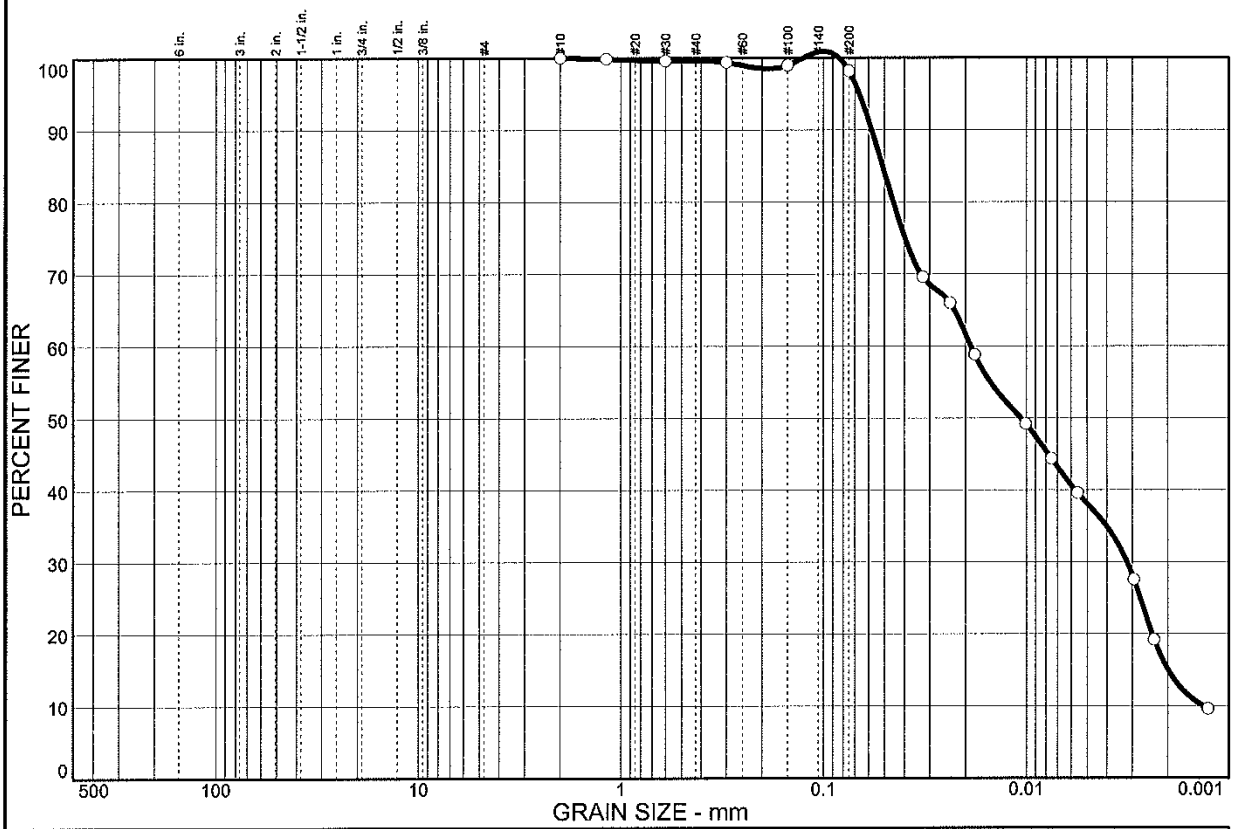
Sample No.: VC-19C **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 3.5-6.2 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.3	1.5	60.1	38.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.6		
#50	99.4		
#100	99.0		
#200	98.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= 19 LL= 57 PI= 38

Coefficients

D_{85}= 0.0512 D_{60}= 0.0188 D_{50}= 0.0106
D_{30}= 0.0032 D_{15}= 0.0020 D_{10}= 0.0013
C_u= 14.06 C_c= 0.40

Classification

USCS= AASHTO=

Remarks

F.M.=0.02

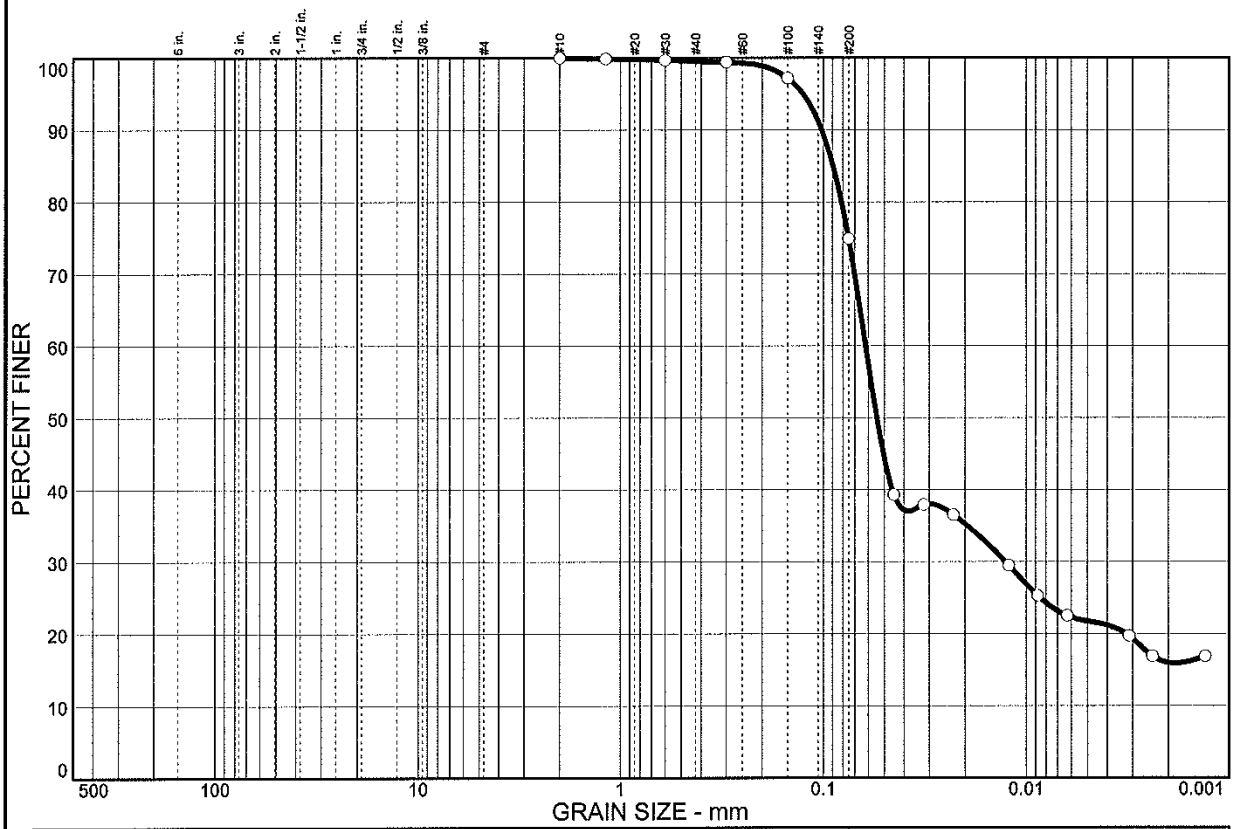
Sample No.: VC-21C **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 2.1-4.8 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.5	24.6	53.2	21.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.7		
#50	99.4		
#100	97.2		
#200	74.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= 19 LL= 60 PI= 41

Coefficients

D_{85}= 0.0896 D_{60}= 0.0619 D_{50}= 0.0545
D_{30}= 0.0126 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.04

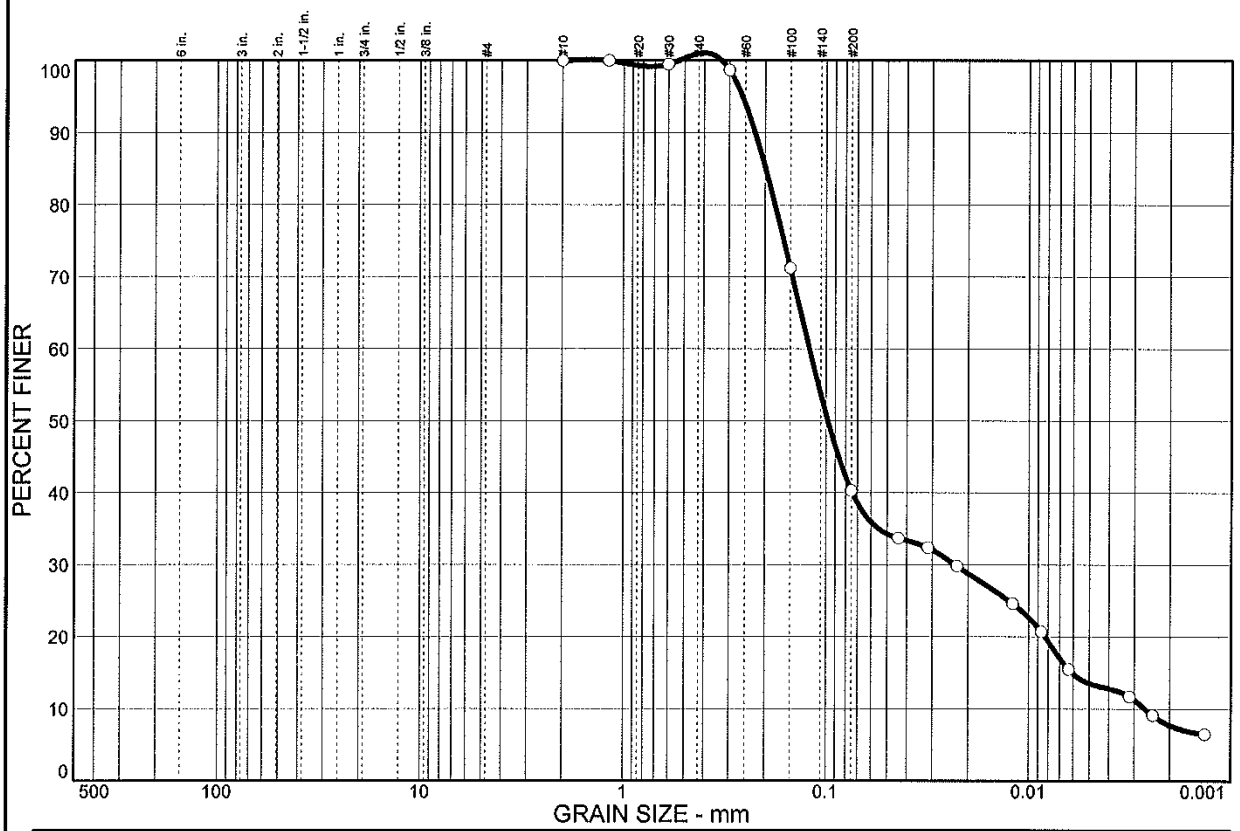
Sample No.: VC-22C **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 1.3-4 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0		60.7	26.7	13.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.5		
#50	98.7		
#100	71.2		
#200	40.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.199 D_{60}= 0.121 D_{50}= 0.0979
D_{30}= 0.0231 D_{15}= 0.0061 D_{10}= 0.0027
C_u= 45.57 C_c= 1.67

Classification

USCS= AASHTO=

Remarks

F.M.=0.31

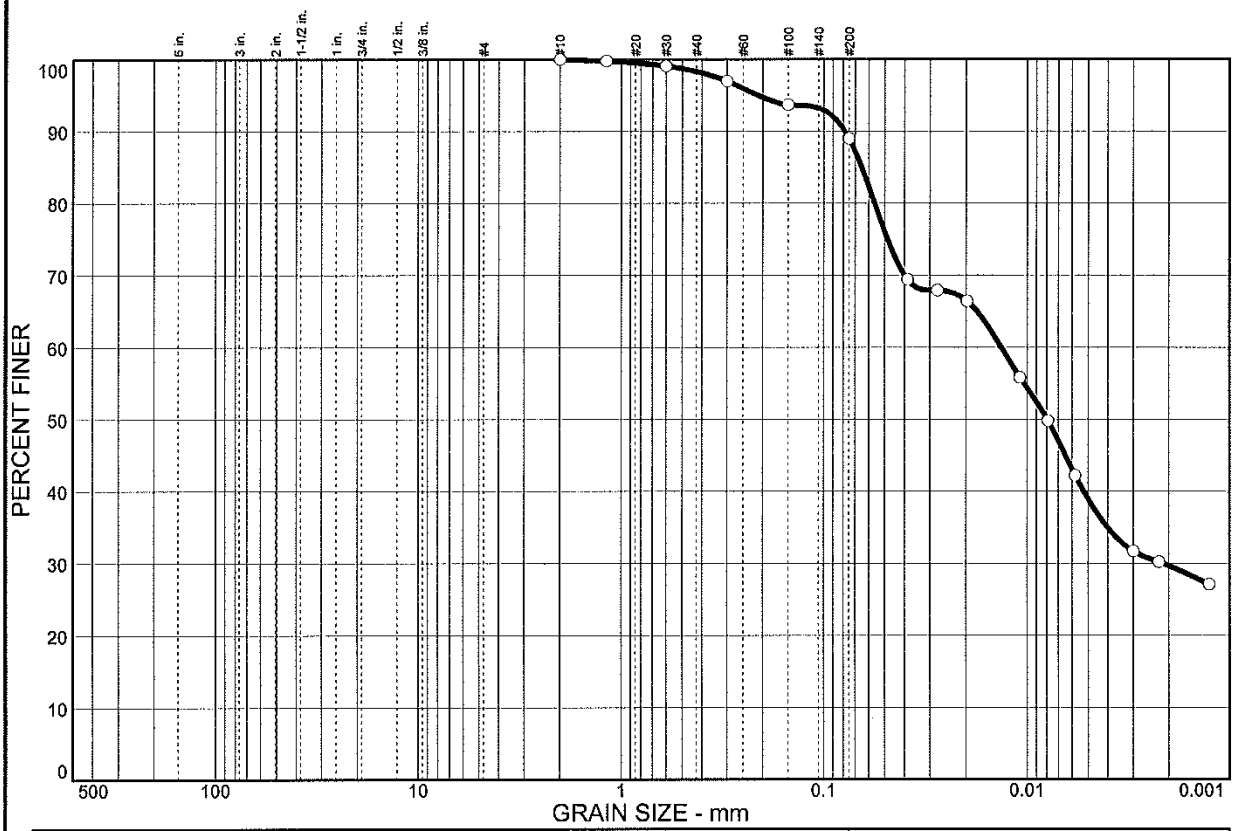
Sample No.: VC-24A **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0-1.1 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	1.7	9.3	50.1	38.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.8		
#30	99.1		
#50	97.0		
#100	93.7		
#200	89.0		

* (no specification provided)

Material Description

Atterberg Limits

PL= 16 LL= 26 PI= 10

Coefficients

D_{85}= 0.0650 D_{60}= 0.0134 D_{50}= 0.0080
D_{30}= 0.0021 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.10

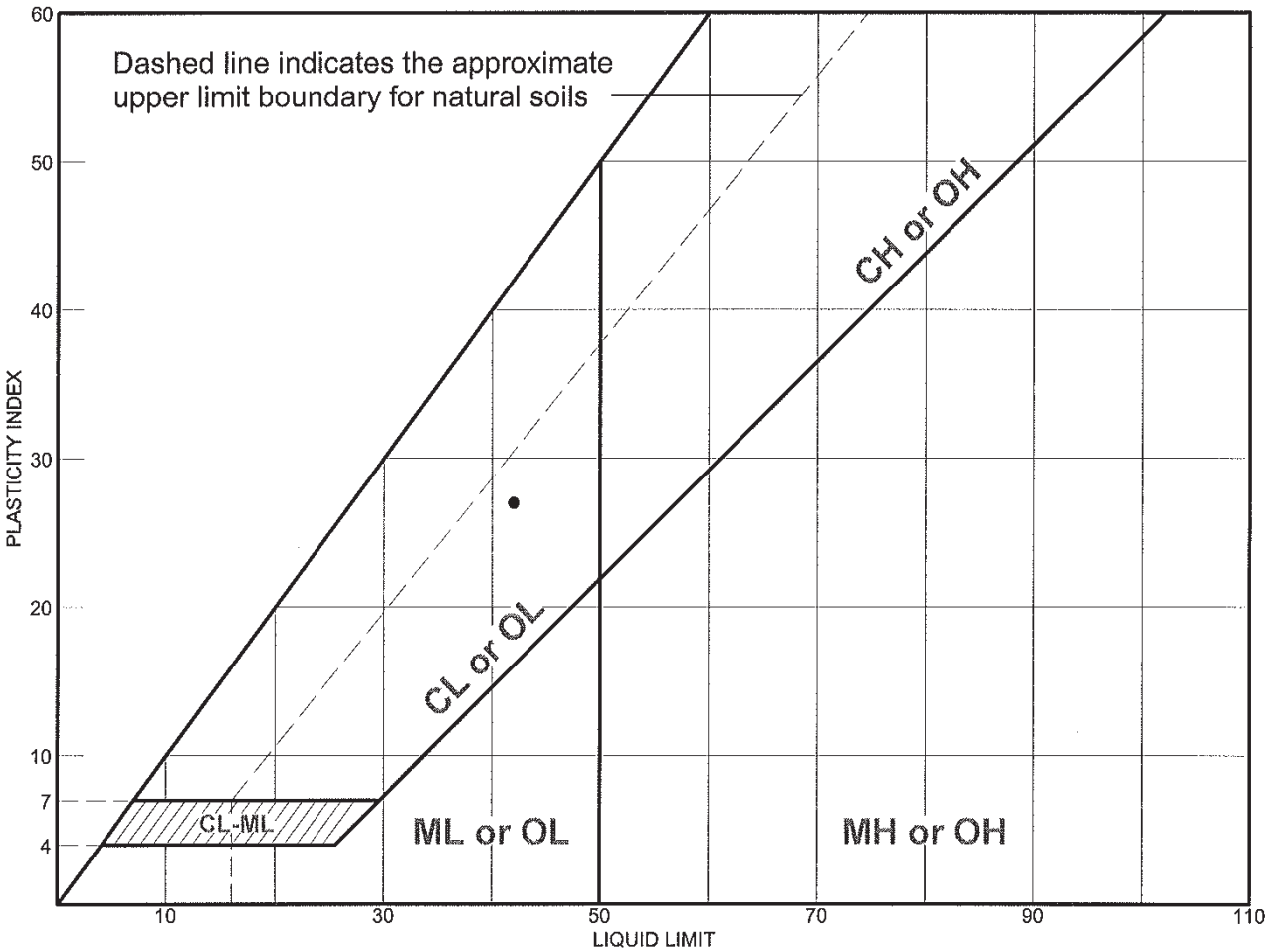
Sample No.: VC-24C **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 3.7-6.4 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		42	15	27			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-1 **Elev./Depth:** 3.6-5 Feet

Remarks:

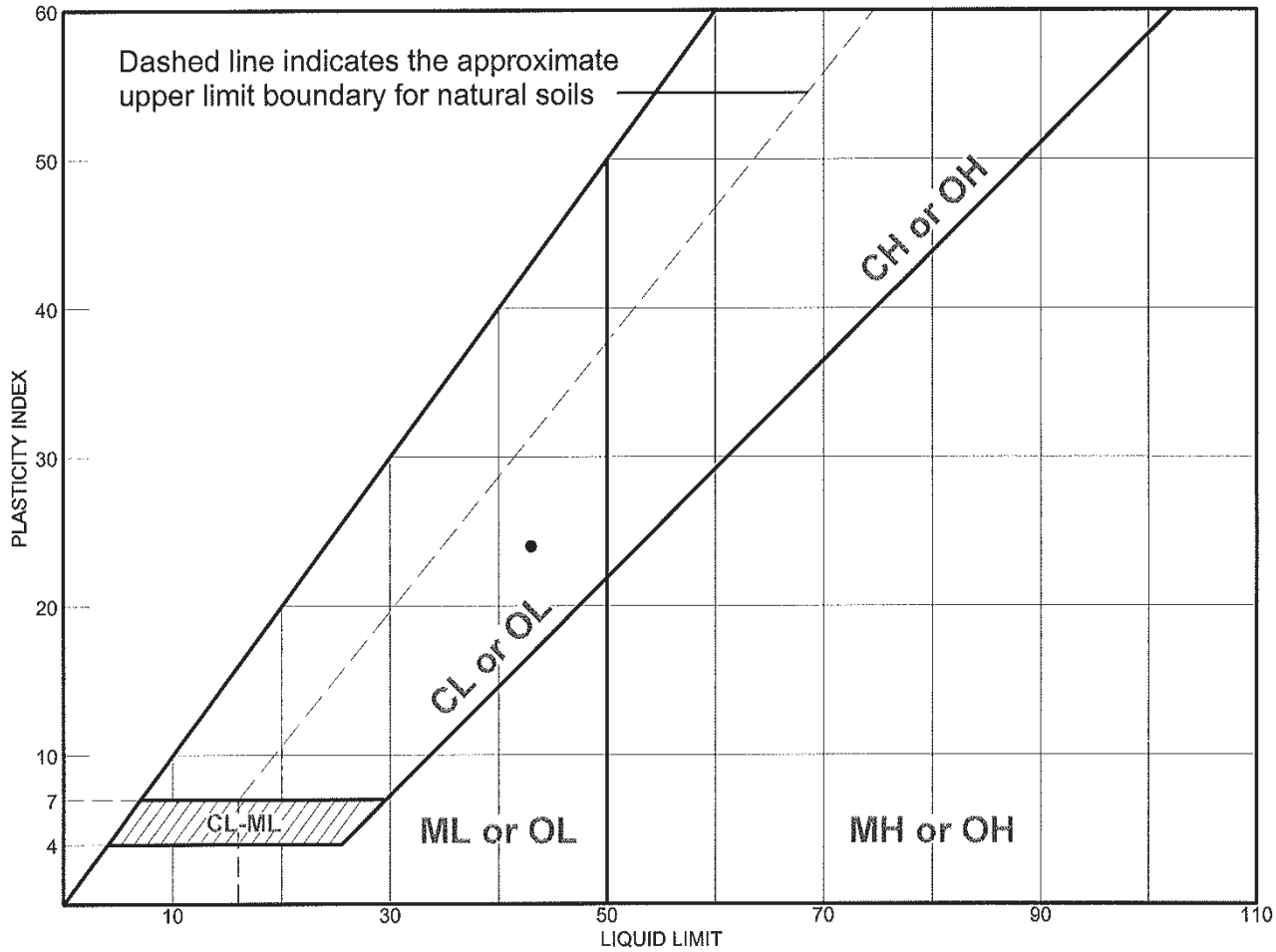
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		43	19	24			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-2 **Elev./Depth:** 1.5-3 Feet

Remarks:

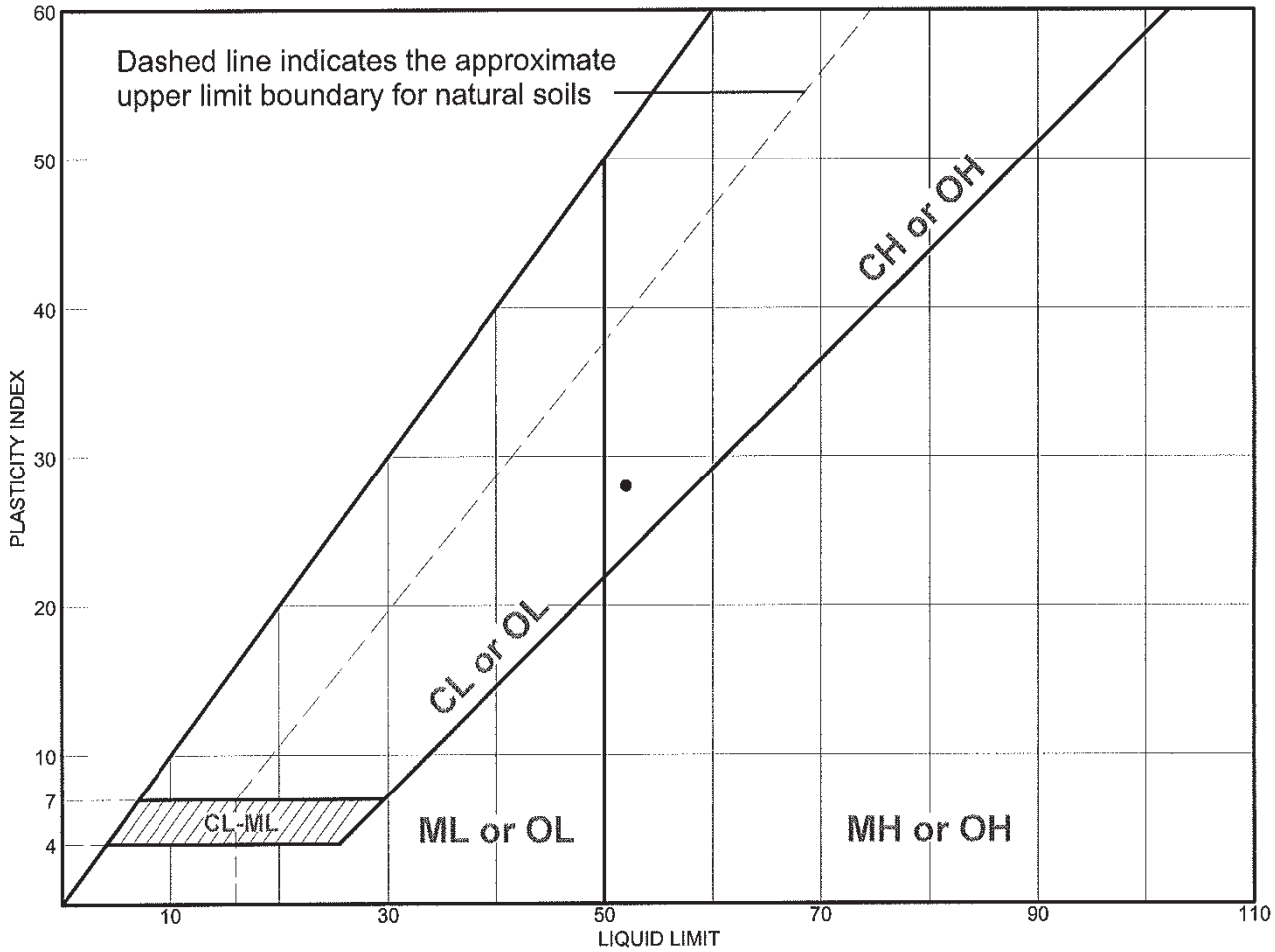
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		52	24	28			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-5 **Elev./Depth:** 1.5-2.5 Feet

Remarks:

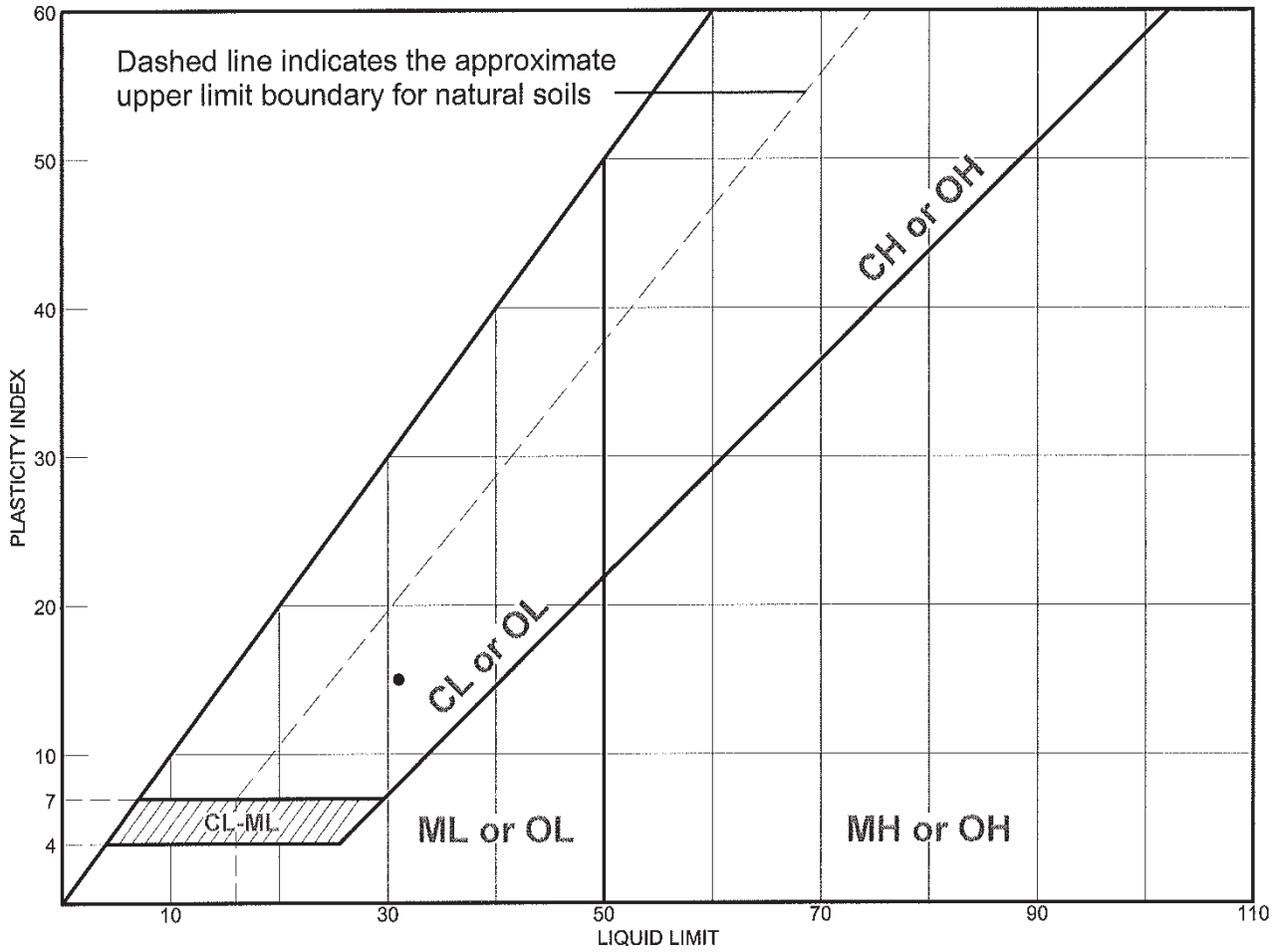
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		31	16	15			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-9 **Elev./Depth:** 1.5-3 Feet

Remarks:

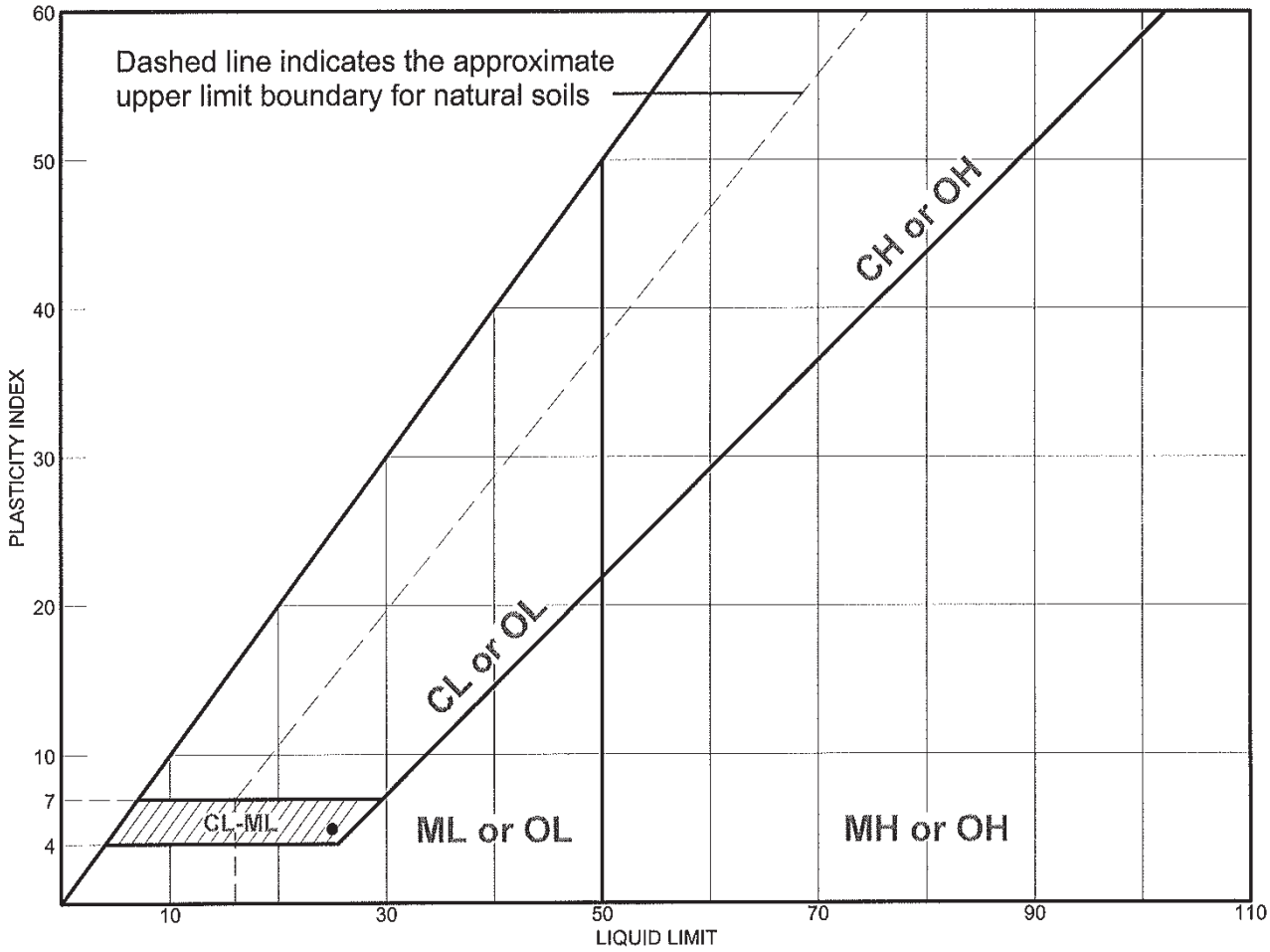
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		25	20	5			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-10 **Elev./Depth:** 0-1.5 Feet

Remarks:

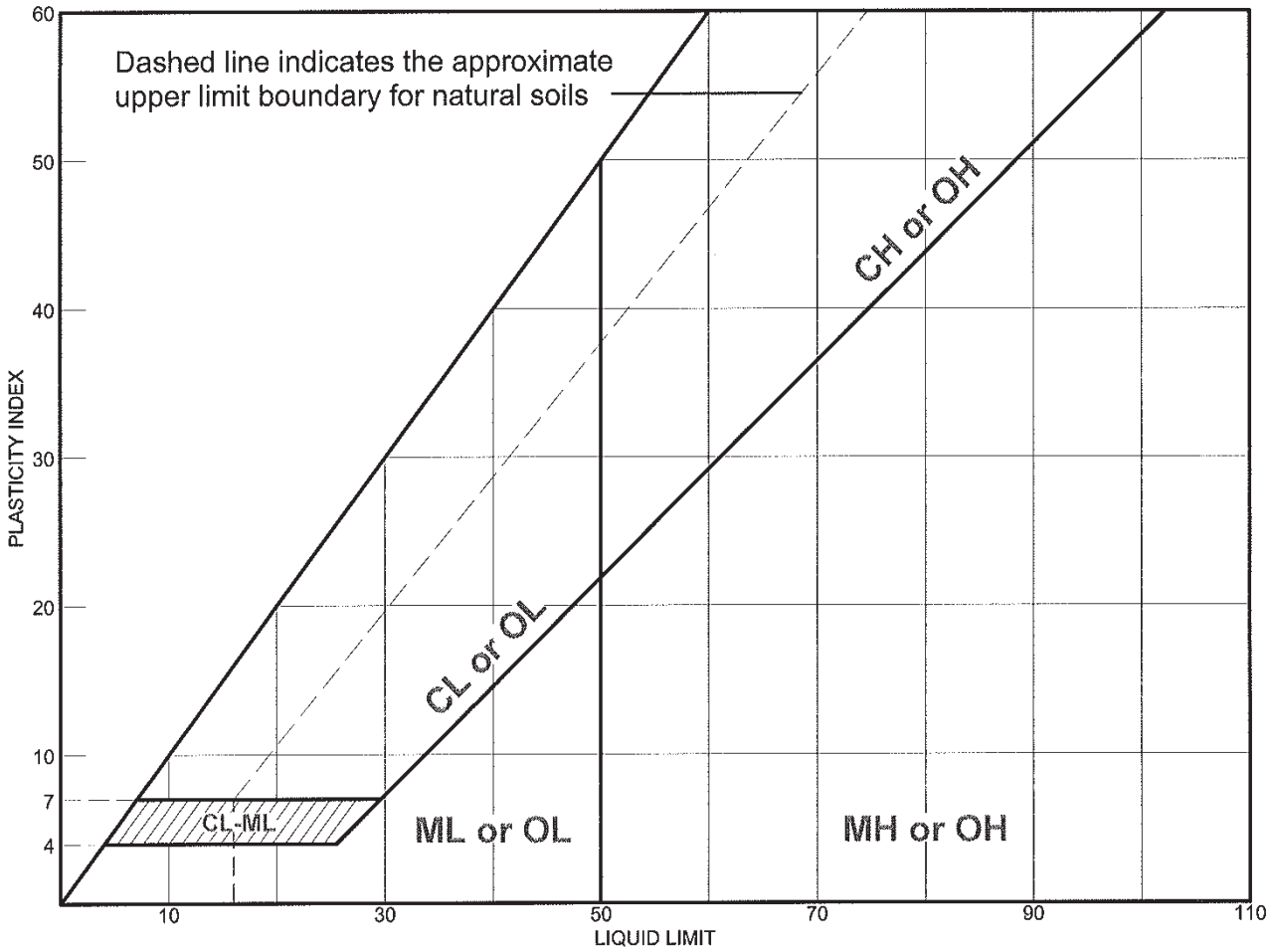
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		NV	NP	NP			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-6C **Elev./Depth:** 0-1.3 Feet

Remarks:

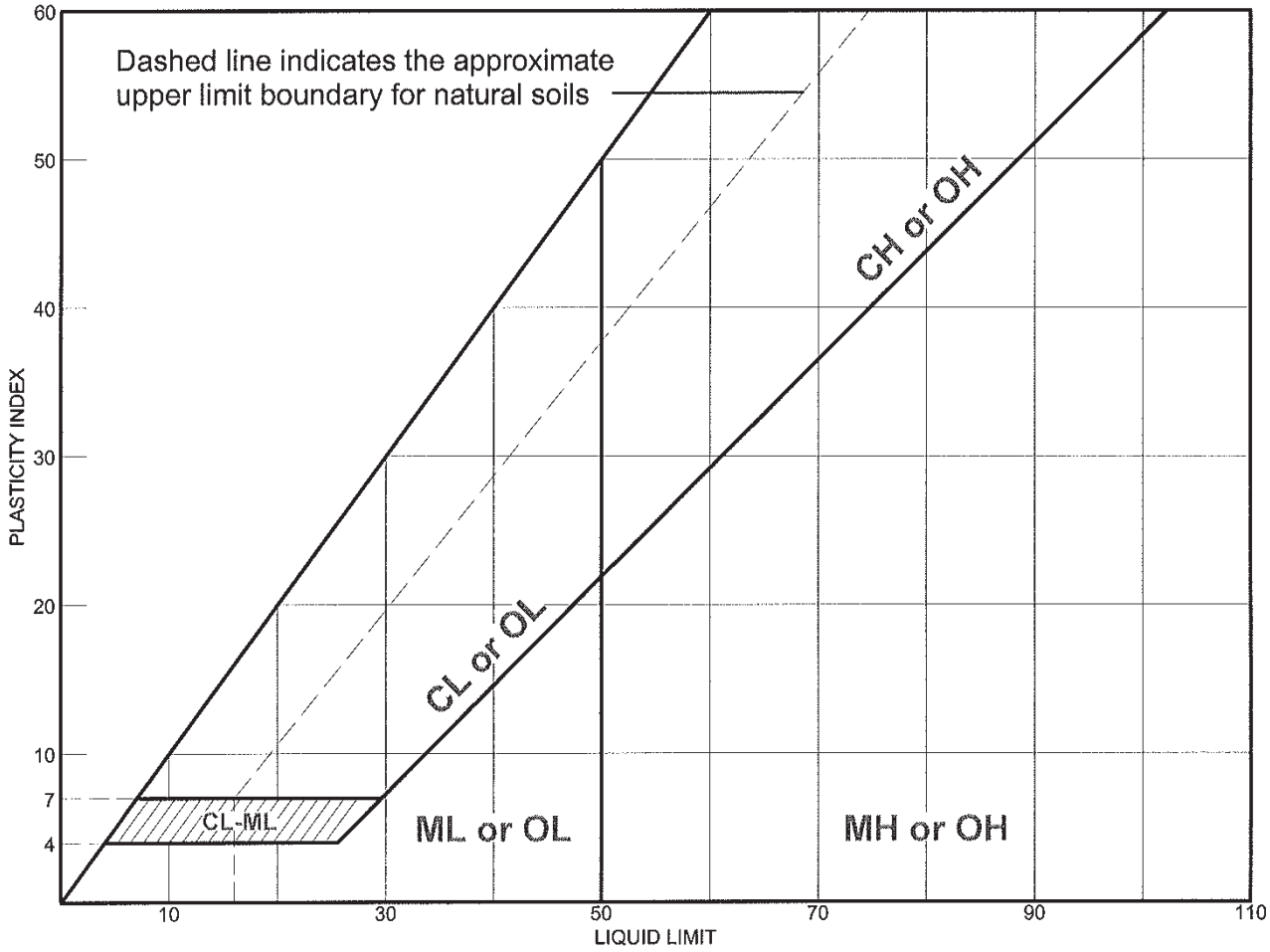
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		NV	NP	NP			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-19A **Elev./Depth:** 0-0.9 Feet

Remarks:

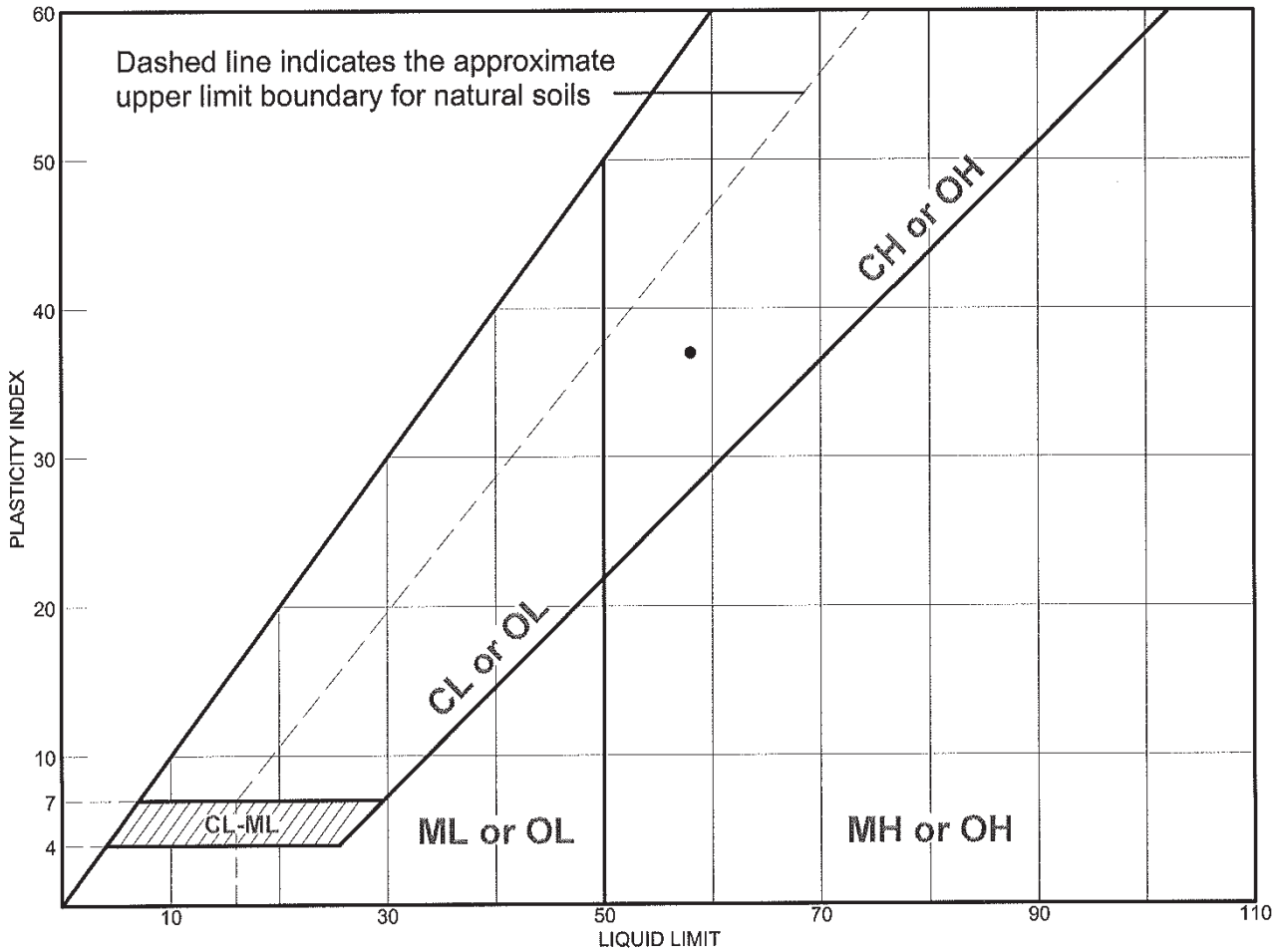
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		58	21	37			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-19C **Elev./Depth:** 3.5-6.2 Feet

Remarks:

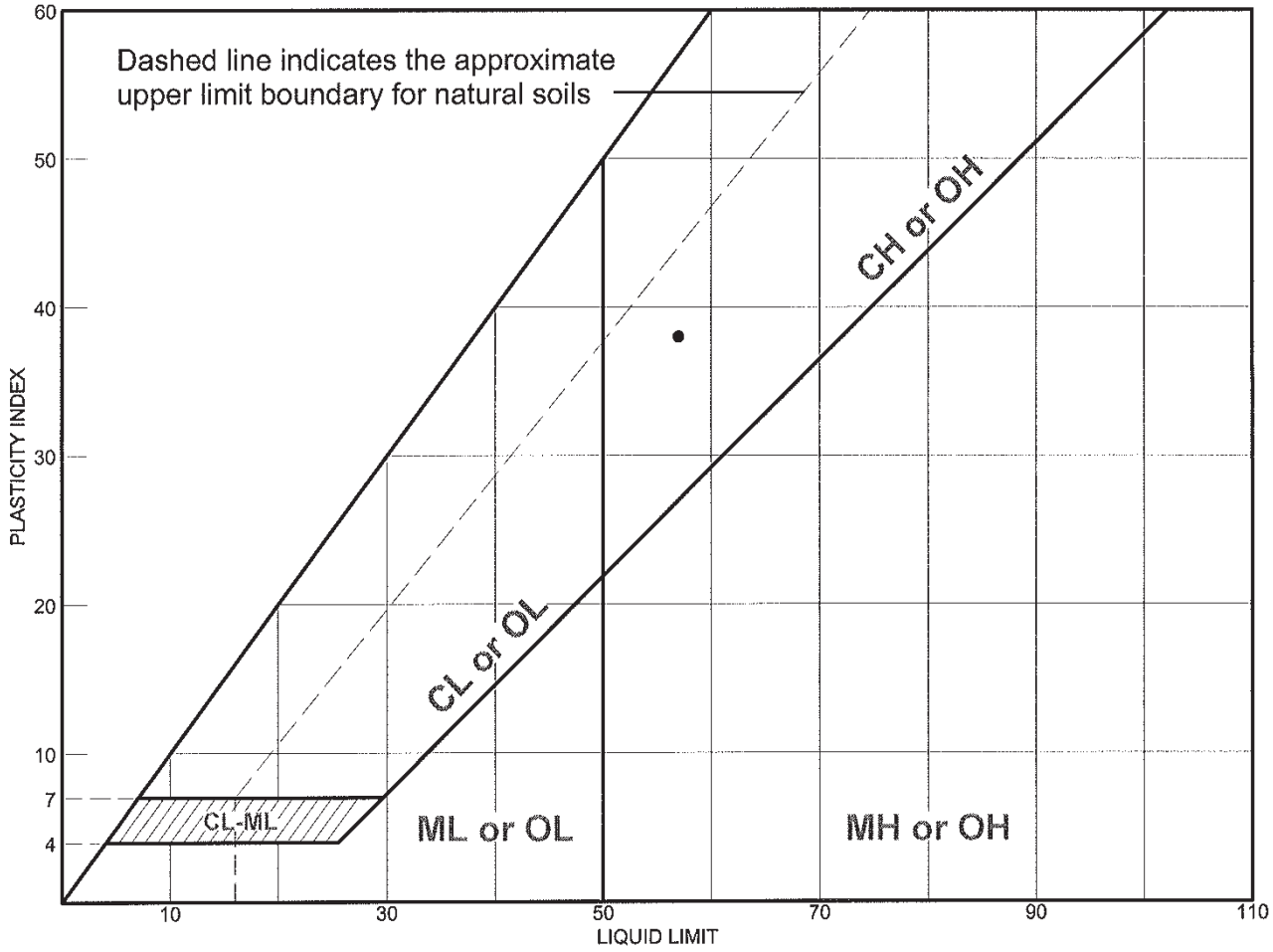
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		57	19	38			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-21C **Elev./Depth:** 2.1-4.8 Feet

Remarks:

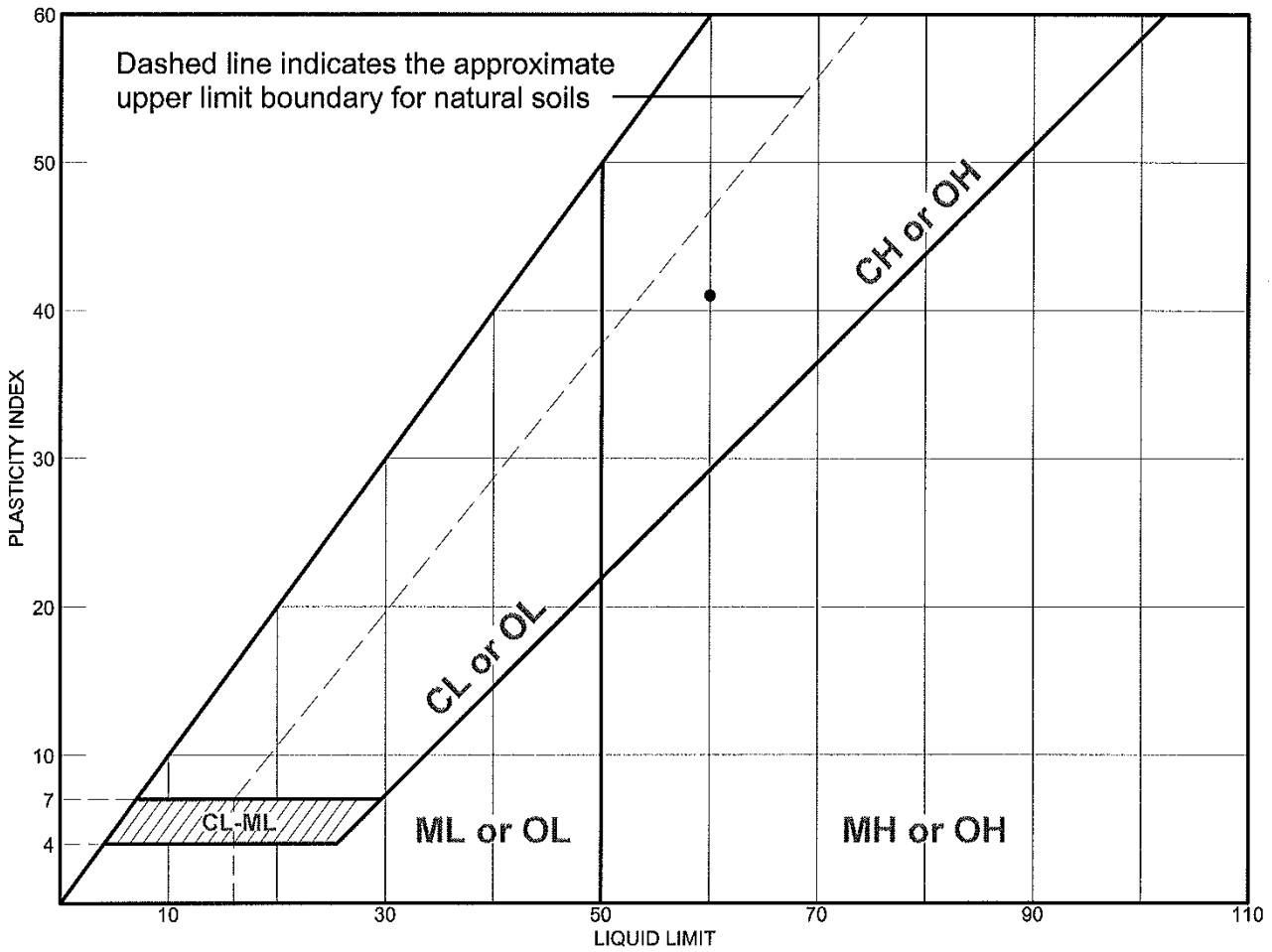
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		60	19	41			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-22C **Elev./Depth:** 1.3-4 Feet

Remarks:

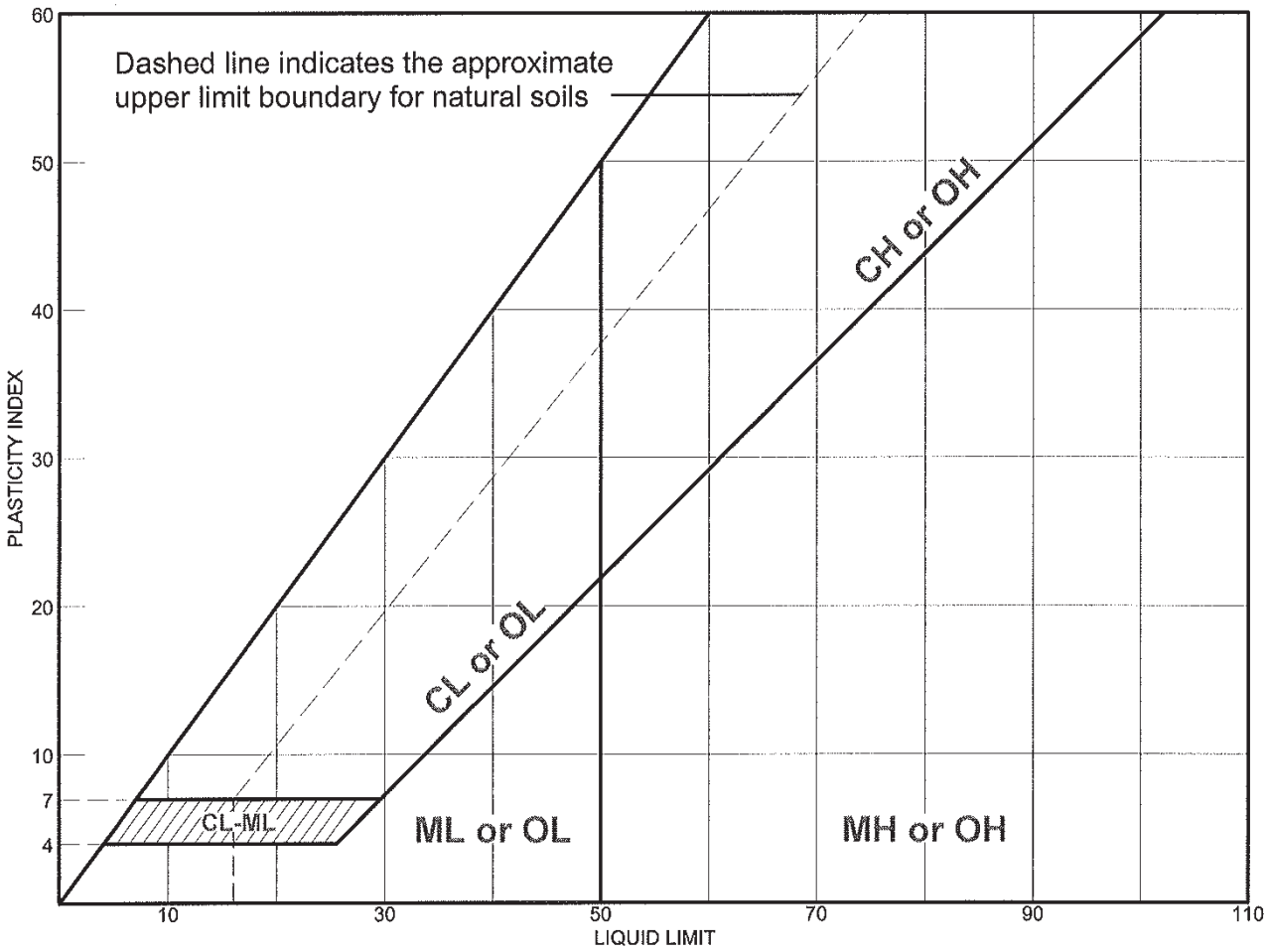
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		NV	NP	NP			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-24A **Elev./Depth:** 0-1.1 Feet

Remarks:

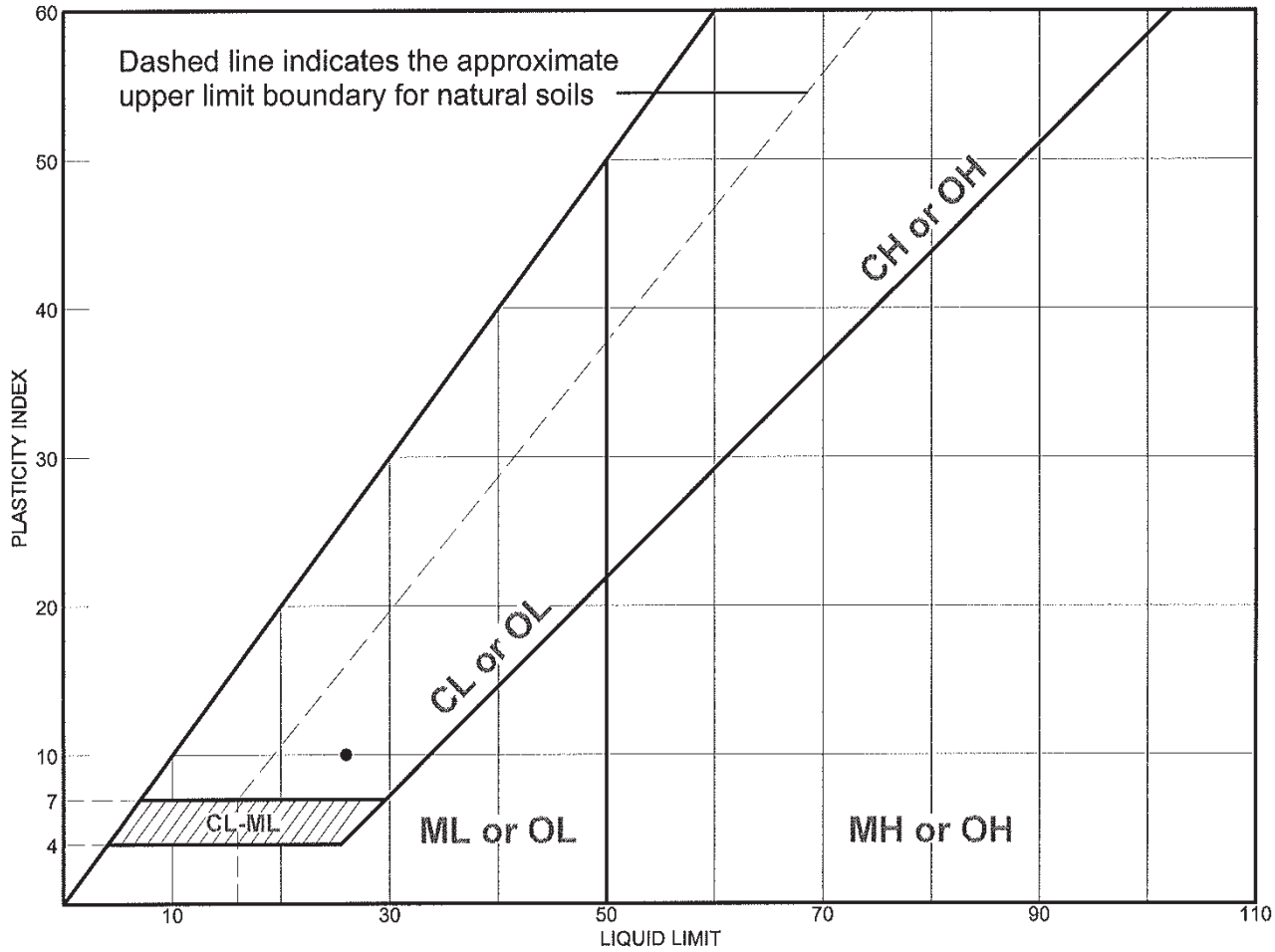
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		26	16	10			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-24C **Elev./Depth:** 3.7-6.4 Feet

Remarks:

●

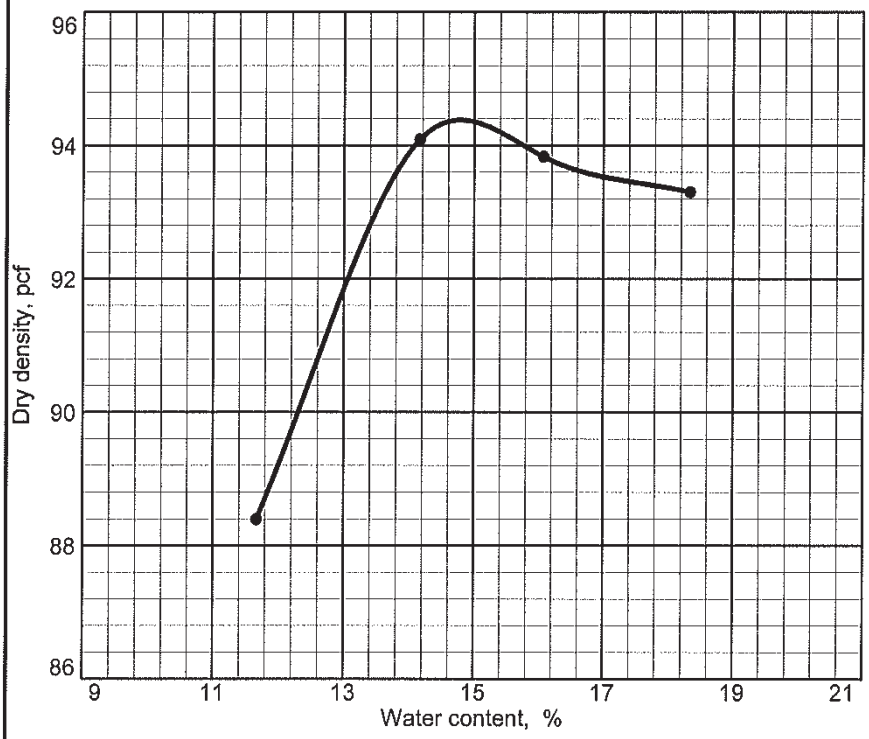
Moore Twining Associates, Inc.

Fresno, CA

Figure

Tests on Bulk and Composite Samples

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 698-07 Procedure A Standard

Hammer Wt.: 5.5 lb.
Hammer Drop: 12 in.
Number of Layers: three
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM		**Sp.G.**	
LL		**PI**	
%>No.4		**%<#200**	
USCS		**AASHTO**	

TESTING DATA

	1	2	3	4	5	6
WM + WS	7.91	7.96	7.62	8.01		
WM	4.33	4.33	4.33	4.33		
WW + T #1	269.30	262.20	285.20	263.30		
WD + T #1	235.90	225.90	255.40	222.50		
TARE #1	0.00	0.00	0.00	0.00		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	14.2	16.1	11.7	18.3		
DRY DENSITY	94.1	93.8	88.4	93.3		

TEST RESULTS

Maximum dry density = 94.4 pcf

Optimum moisture = 14.8 %

Material Description

Project No. 60 **Client:** Hultgren - Tillis Engineers
Project: Salton Sea

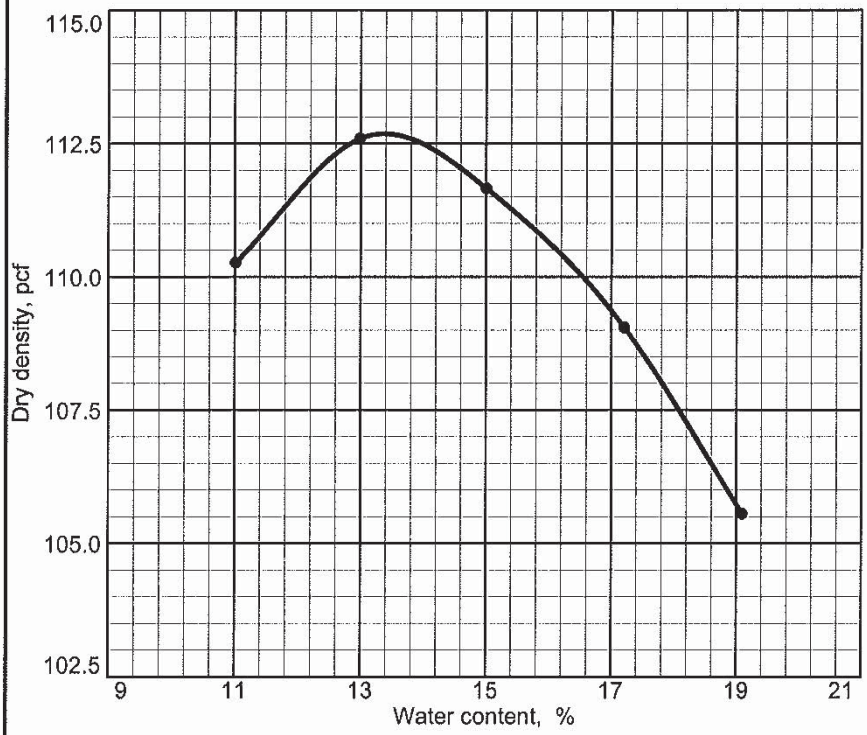
● **Source:** **Sample No.:** HA-1

Remarks:

Moore Twining Associates, Inc.
Fresno, CA

Figure

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 1557-07 Method A Modified

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM		**Sp.G.**	
LL		**PI**	
%>No.4		**%<#200**	
USCS		**AASHTO**	

TESTING DATA

	1	2	3	4	5	6
WM + WS	8.59	8.52	8.61	8.57	8.41	
WM	4.33	4.33	4.33	4.33	4.33	
WW + T #1	506.10	260.70	262.90	253.20	250.00	
WD + T #1	431.80	218.90	228.60	224.10	225.20	
TARE #1	0.00	0.00	0.00	0.00	0.00	
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	17.2	19.1	15.0	13.0	11.0	
DRY DENSITY	109.0	105.6	111.7	112.6	110.3	

TEST RESULTS	**Material Description**
Maximum dry density = 112.7 pcf Optimum moisture = 13.4 %	

Project No. 60 **Client:** Hultgren - Tillis Engineers
Project: Salton Sea

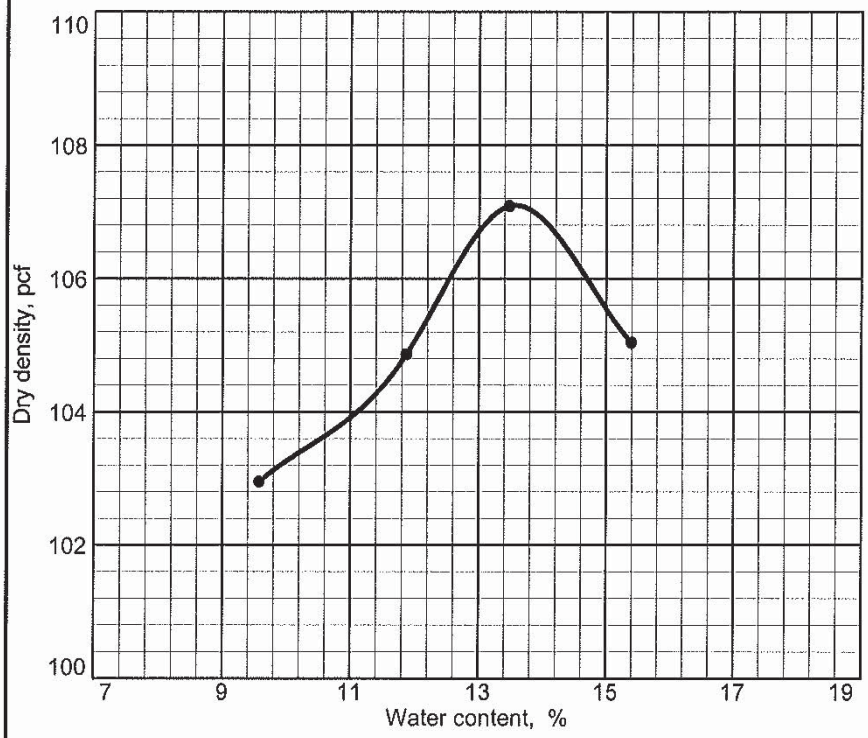
● **Source:** **Sample No.:** HA-1

Remarks:

Moore Twining Associates, Inc.
Fresno, CA

Figure

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 698-07 Procedure A Standard

Hammer Wt.: 5.5 lb.
Hammer Drop: 12 in.
Number of Layers: three
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM		Sp.G.	
LL		PI	
%>No.4		%<#200	
USCS		AASHTO	

TESTING DATA

	1	2	3	4	5	6
WM + WS	8.24	8.38	8.09	8.37		
WM	4.33	4.33	4.33	4.33		
WW + T #1	279.90	274.60	273.50	268.40		
WD + T #1	250.20	242.00	249.60	232.60		
TARE #1	0.00	0.00	0.00	0.00		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	11.9	13.5	9.6	15.4		
DRY DENSITY	104.9	107.1	103.0	105.0		

TEST RESULTS

Maximum dry density = 107.1 pcf

Optimum moisture = 13.6 %

Material Description

Project No. 60 **Client:** Hultgren - Tillis Engineers
Project: Salton Sea

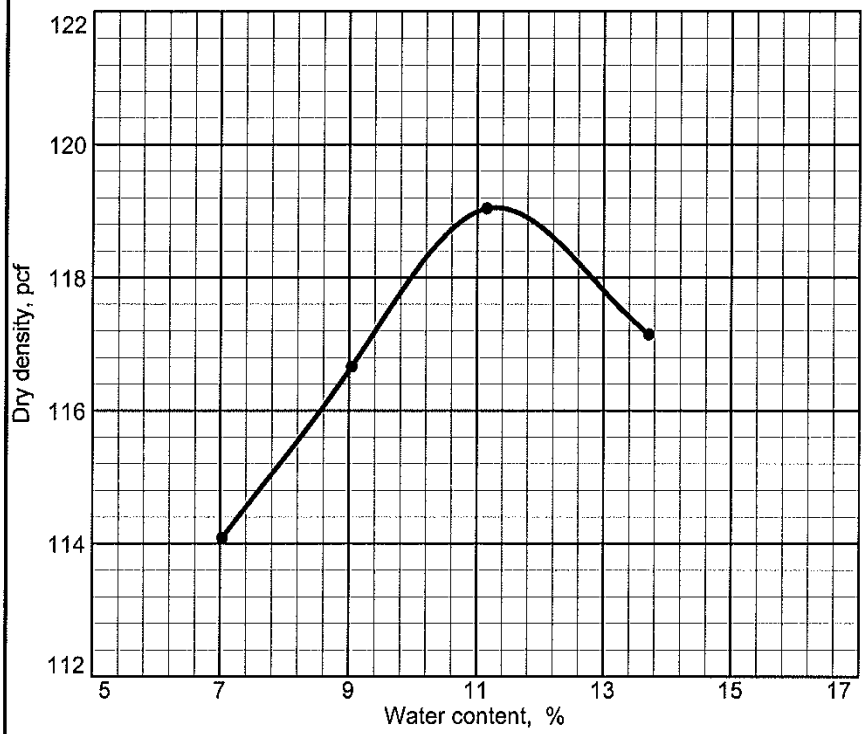
● **Source:** **Sample No.:** HA-4

Remarks:

Moore Twining Associates, Inc.
Fresno, CA

Figure

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 1557-07 Method A Modified

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM		**Sp.G.**	
LL		**PI**	
%>No.4		**%<#200**	
USCS		**AASHTO**	

TESTING DATA

	1	2	3	4	5	6
WM + WS	8.57	8.40	8.74	8.77		
WM	4.33	4.33	4.33	4.33		
WW + T #1	255.70	274.00	266.10	260.40		
WD + T #1	234.50	256.00	239.40	229.00		
TARE #1	0.00	0.00	0.00	0.00		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	9.0	7.0	11.2	13.7		
DRY DENSITY	116.7	114.1	119.0	117.1		

TEST RESULTS

Maximum dry density = 119.1 pcf

Optimum moisture = 11.3 %

Material Description

Project No. 60 **Client:** Hultgren - Tillis Engineers
Project: Salton Sea

● **Source:** **Sample No.:** HA-4

Remarks:

Moore Twining Associates, Inc.
Fresno, CA

Figure

Particle Size Distribution Report

% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	2.1	9.0	60.3	28.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.1		
#30	98.2		
#50	97.2		
#100	94.6		
#200	88.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= 19 LL= 63 PI= 44

Coefficients

D_{85}= 0.0643 D_{60}= 0.0340 D_{50}= 0.0241
D_{30}= 0.0052 D_{15}= 0.0034 D_{10}= 0.0023
C_u= 15.00 C_c= 0.35

Classification

USCS= AASHTO=

Remarks

F.M.=0.11

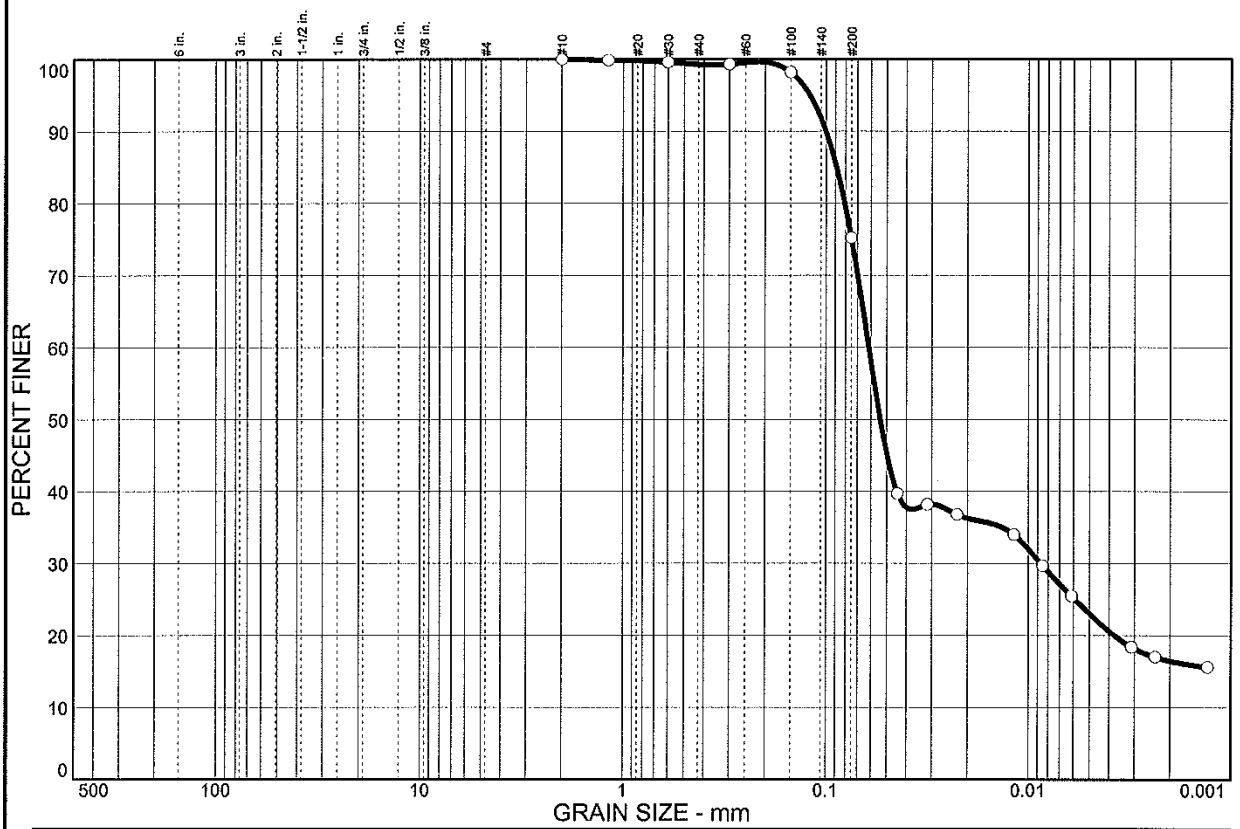
Sample No.: HA-1 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:**

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.7	24.1	52.2	23.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.6		
#50	99.3		
#100	98.2		
#200	75.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= 20 LL= 56 PI= 36

Coefficients

D_{85}= 0.0889 D_{60}= 0.0614 D_{50}= 0.0538
D_{30}= 0.0087 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.03

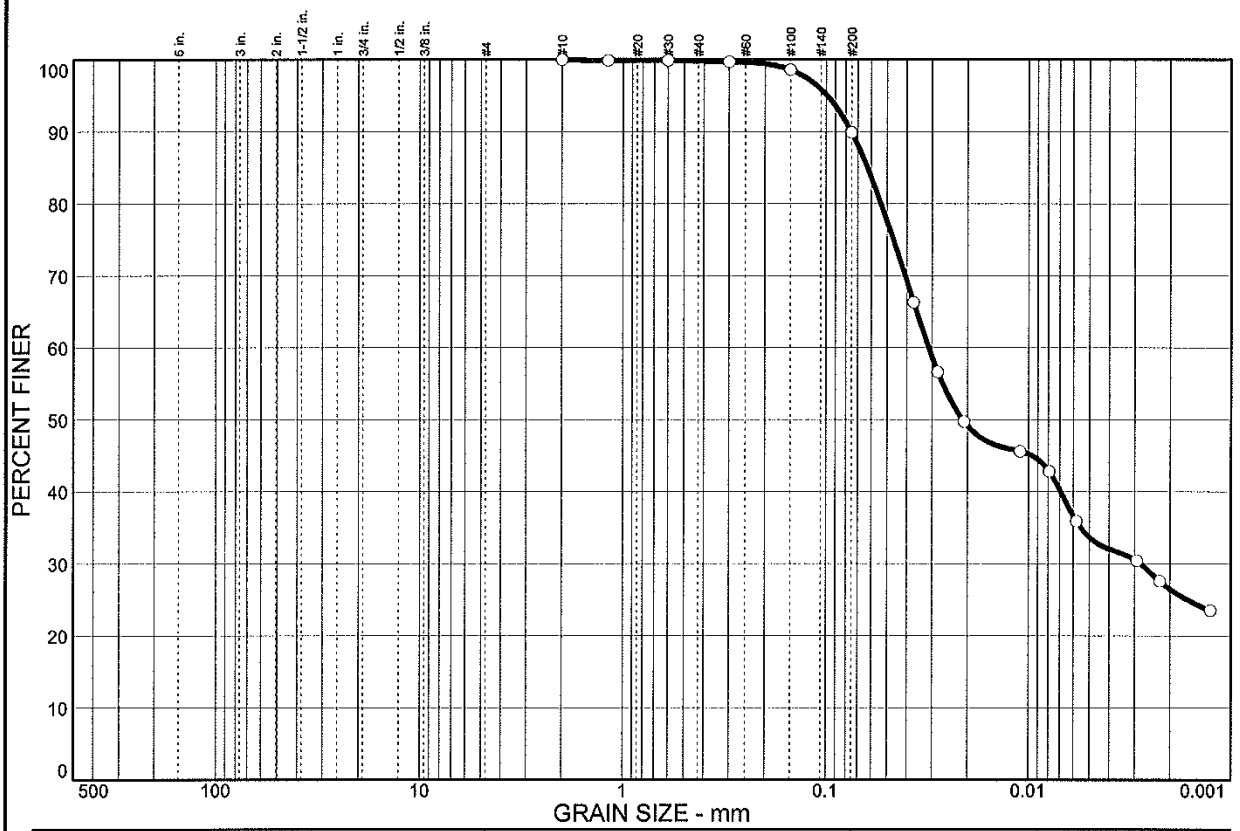
Sample No.: HA-4 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:**

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	9.9	56.2	33.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.9		
#50	99.7		
#100	98.6		
#200	89.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= 21 LL= 68 PI= 47

Coefficients

D_{85}= 0.0627 D_{60}= 0.0311 D_{50}= 0.0211
D_{30}= 0.0028 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.02

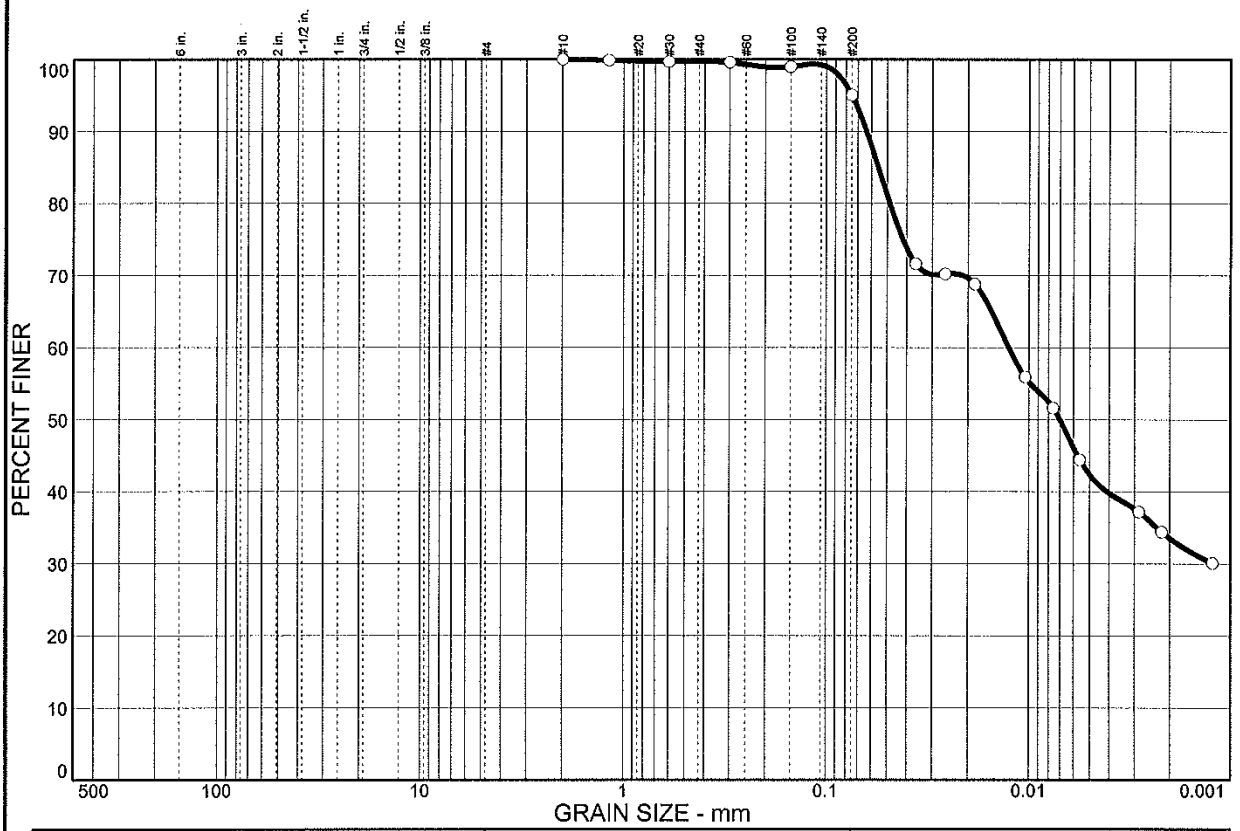
Sample No.: VC-11 (B&C) **Source of Sample:** **Date:** 10/13/10
Location: **Elev./Depth:** 0-3.5 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	4.7	52.7	42.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.7		
#50	99.6		
#100	99.0		
#200	95.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= 20 LL= 66 PI= 46

Coefficients

D_{85}= 0.0554 D_{60}= 0.0126 D_{50}= 0.0070
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.02

Sample No.: VC-16 (B&C) **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0-3.9 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report

% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.4	10.8	58.5	30.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.6		
#50	99.3		
#100	98.0		
#200	88.8		

* (no specification provided)

Material Description

Atterberg Limits

PL= 18 LL= 67 PI= 49

Coefficients

D_{85}= 0.0696 D_{60}= 0.0463 D_{50}= 0.0196
D_{30}= 0.0047 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.03

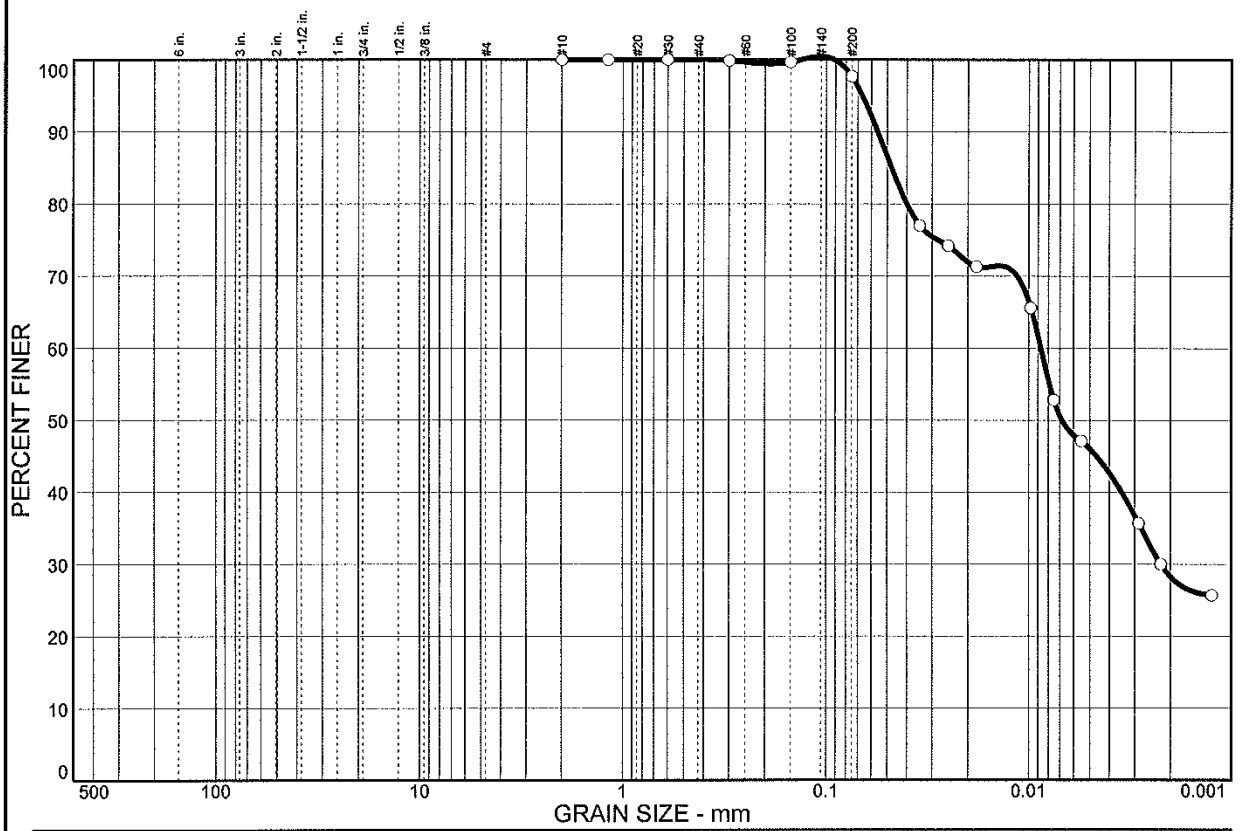
Sample No.: VC-20 (B&C) **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0-4.7 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0		2.3	51.6	46.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	100.0		
#50	99.9		
#100	99.7		
#200	97.7		

* (no specification provided)

Material Description

Atterberg Limits

PL= 18 LL= 65 PI= 47

Coefficients

D_{85}= 0.0476 D_{60}= 0.0087 D_{50}= 0.0068
D_{30}= 0.0022 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.00

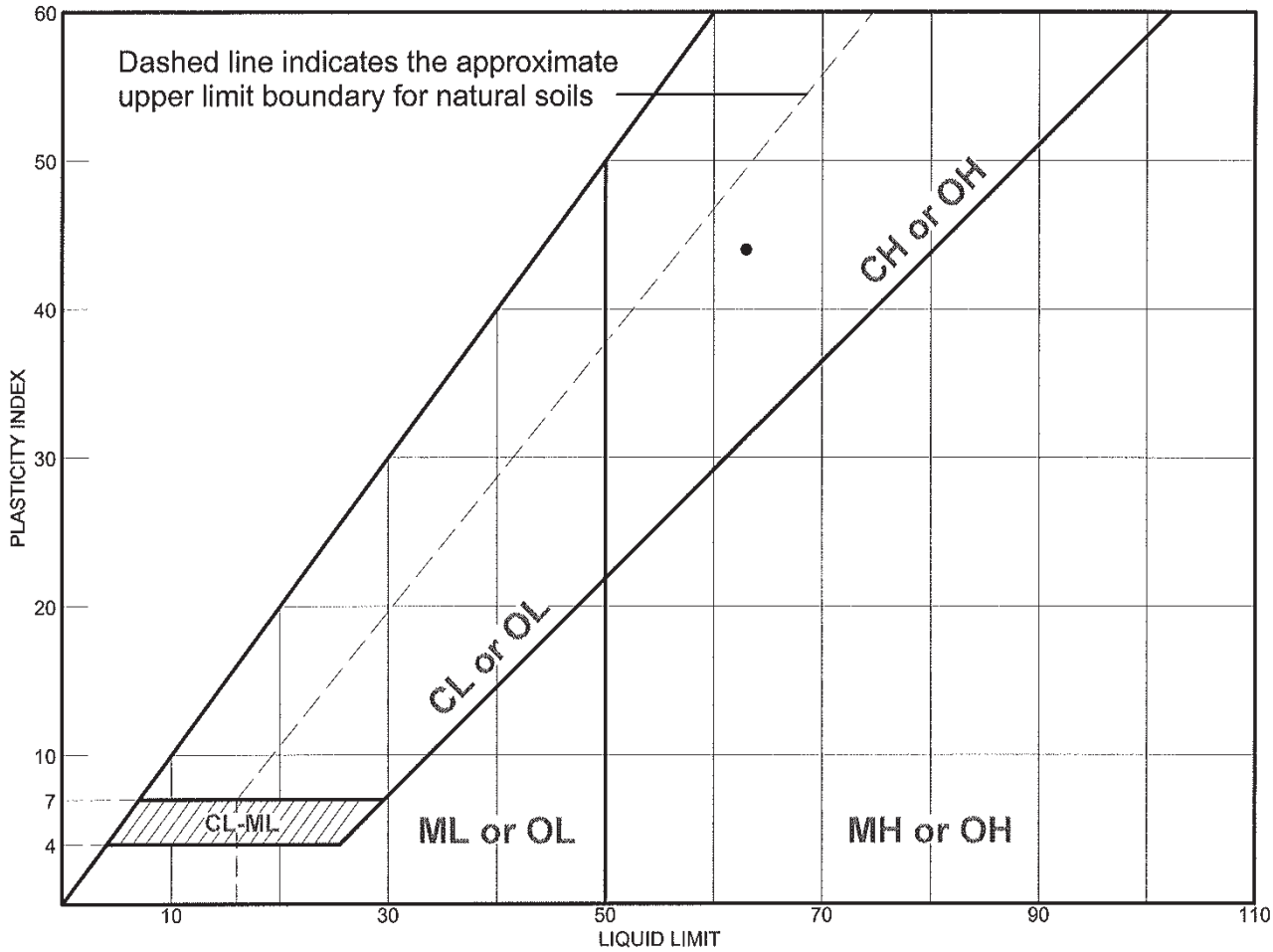
Sample No.: VC-28 (B&C) **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0.4-5.7 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		63	19	44			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-1

Remarks:

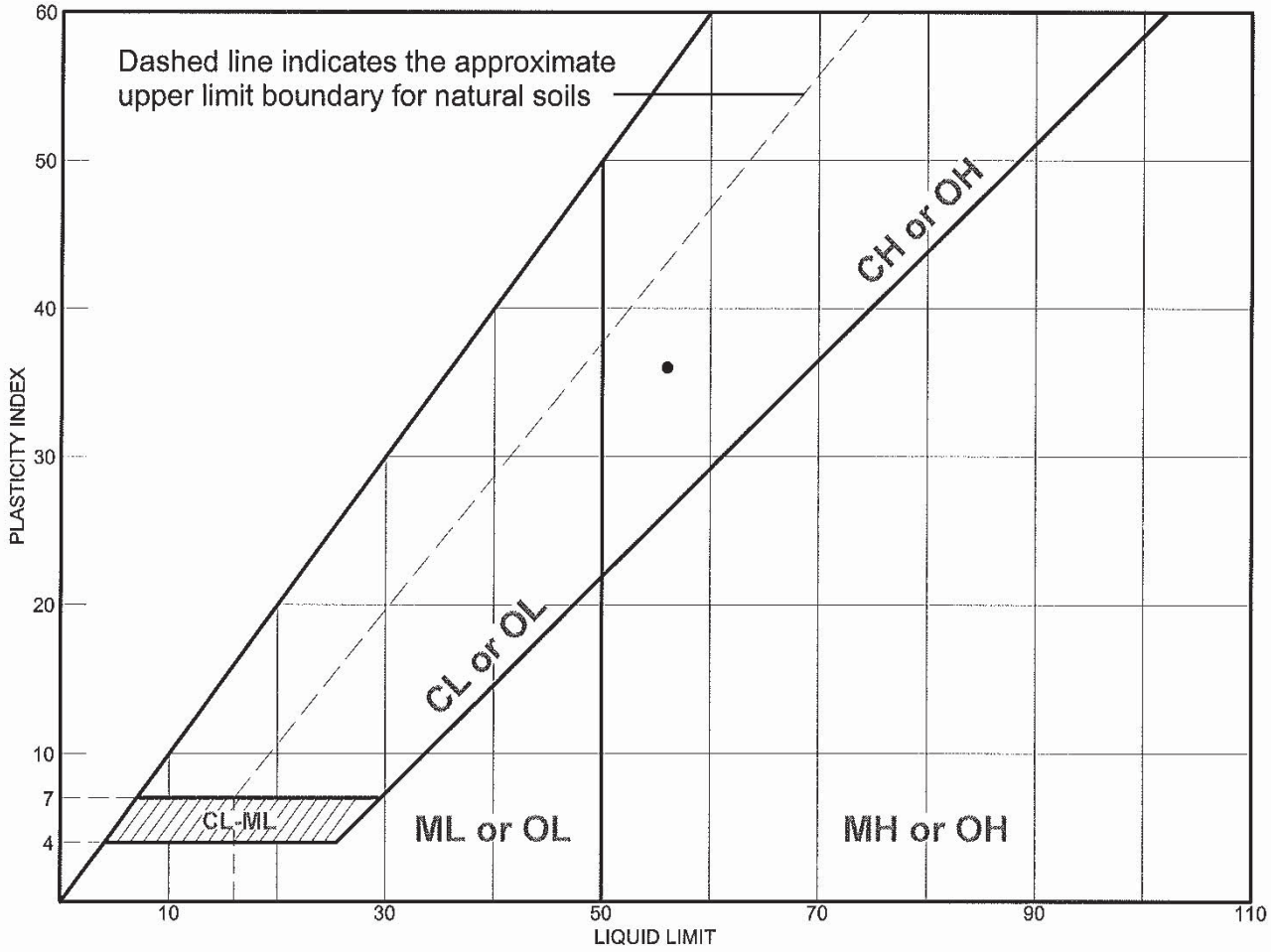
● Material is considered Non-Organic

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		56	20	36			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-4

Remarks:

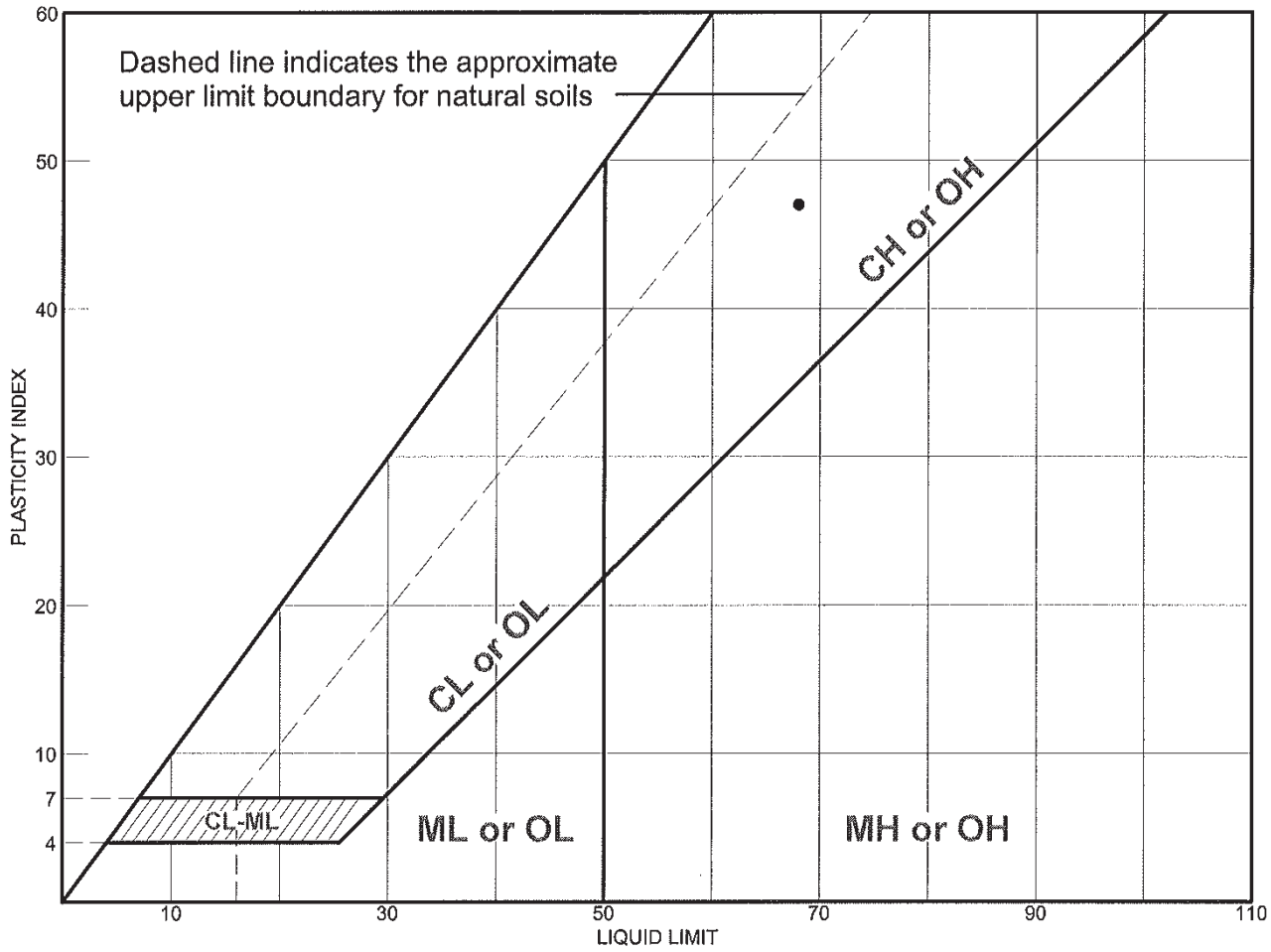
● Material is considered Non-Organic

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		68	21	47			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-11 (B&C) **Elev./Depth:** 0-3.5 Feet

Remarks:

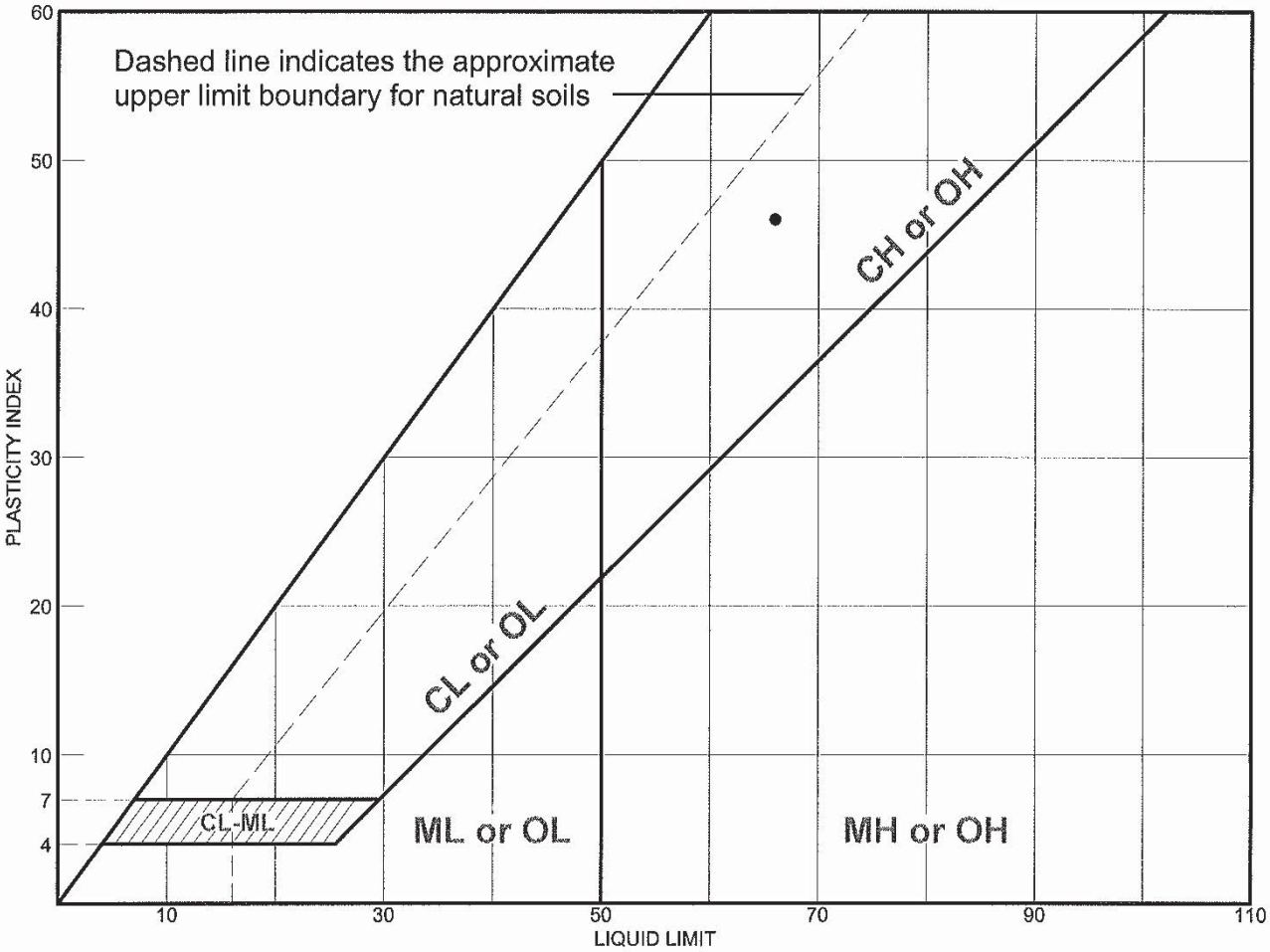
● Material is considered Non-Organic

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		66	20	46			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-16 (B&C) **Elev./Depth:** 0-3.9 Feet

Remarks:

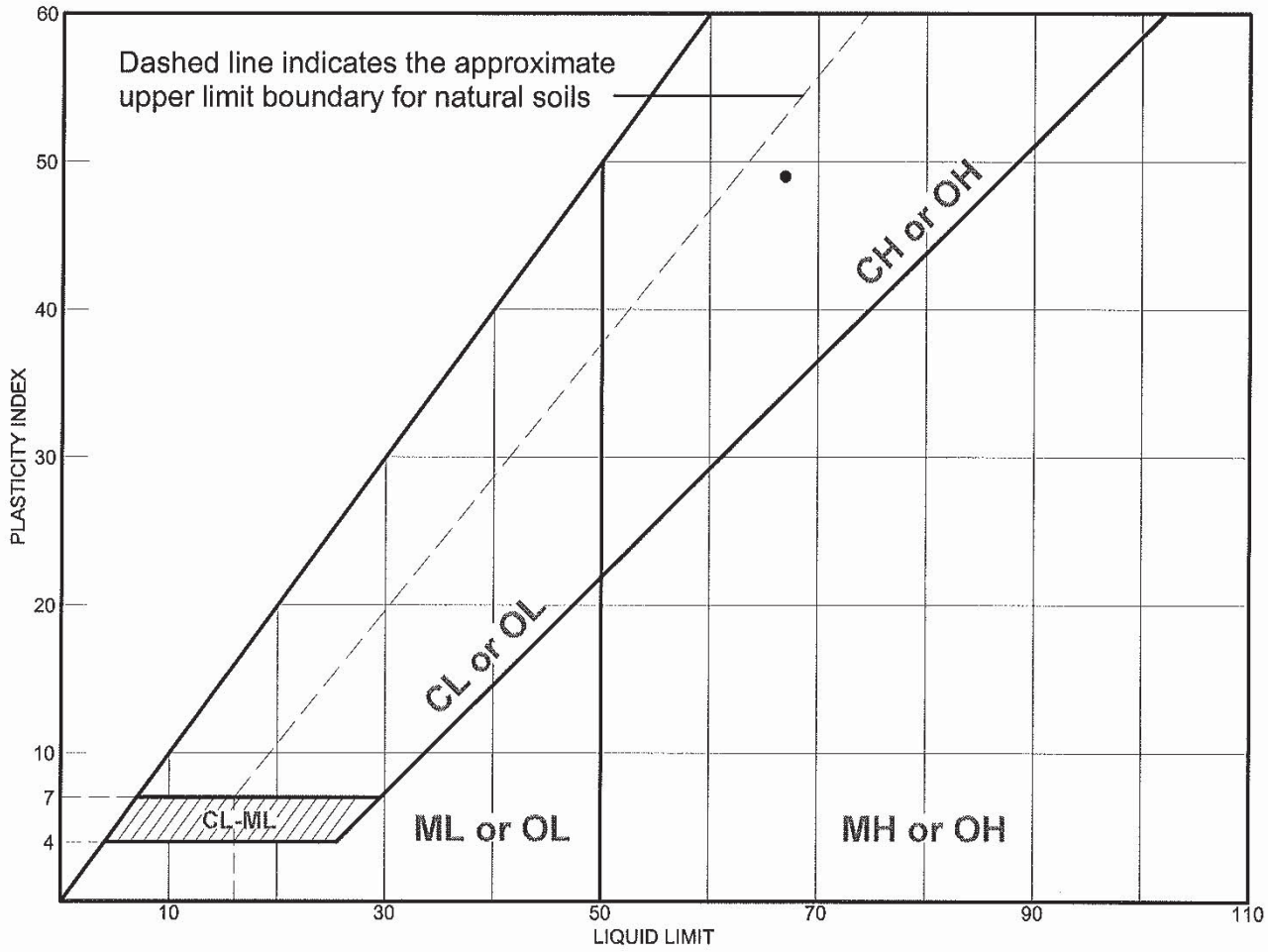
● Material is considered Non-Organic

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		67	18	49			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-20 (B&C)**Elev./Depth:** 0-4.7 Feet

Remarks:

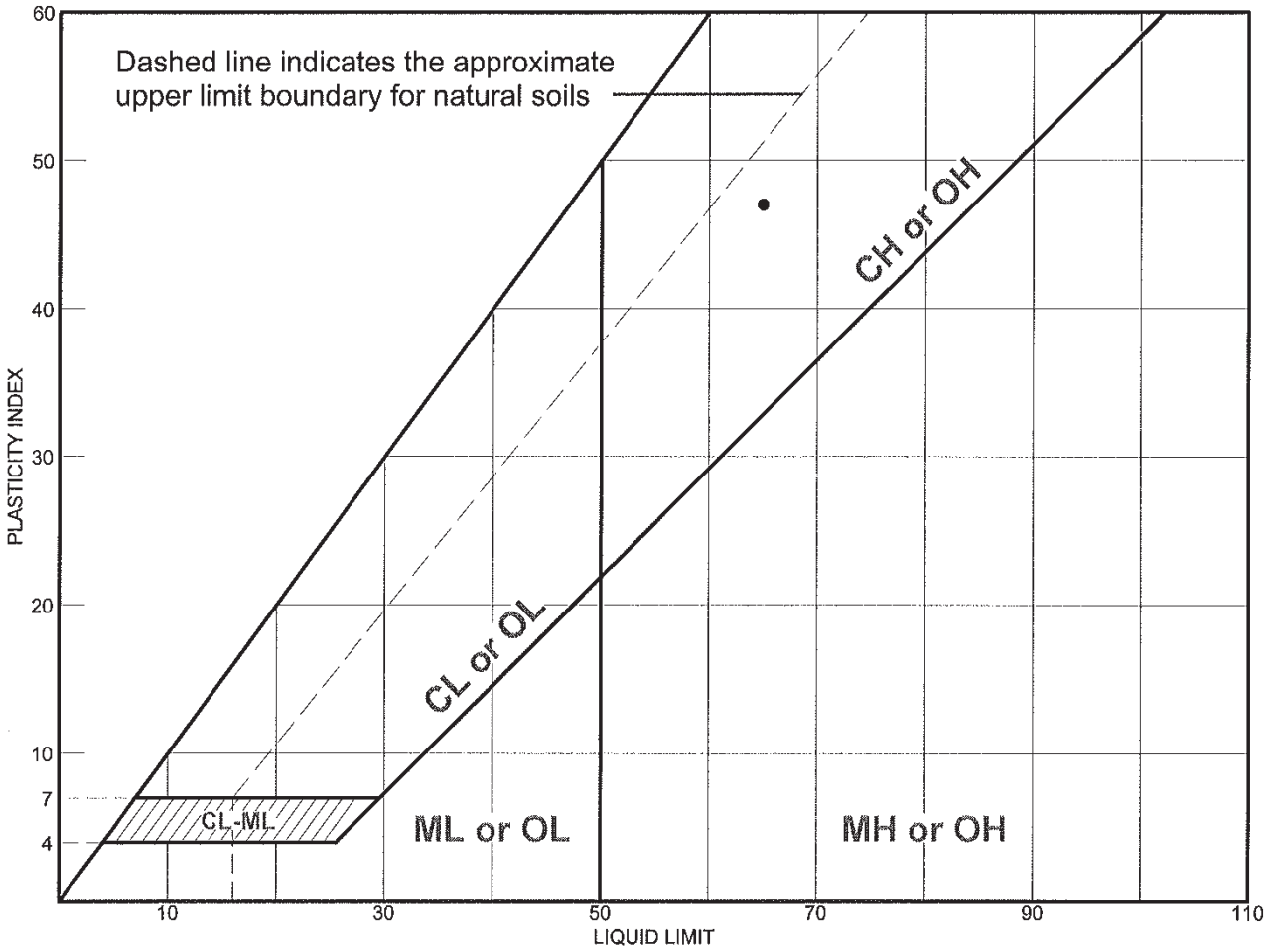
● Material is considered Non-Organic

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		65	18	47			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-28 (B&C) **Elev./Depth:** 0.4-5.7 Feet

Remarks:

● Material is considered Non-Organic

Moore Twining Associates, Inc.

Fresno, CA

Figure

MOORE TWINING
ASSOCIATES, INC.

California ELAP Certificate #1371

2527 Fresno Street
Fresno, CA 93721
(559) 268-7021 Phone
(559) 268-0740 Fax

October 22, 2010

Work Order #: 0I29061

Michael Shwiyhat
MTA Materials Division
2527 Fresno St.
Fresno, CA 93721

RE: Salton Sea Project

Enclosed are the analytical results for samples received by our laboratory on 09/29/10 . For your reference, these analyses have been assigned laboratory work order number 0I29061.

All analyses have been performed according to our laboratory's quality assurance program. All results are intended to be considered in their entirety, Moore Twining Associates, Inc. (MTA) is not responsible for use of less than complete reports. Results apply only to samples analyzed.

If you have any questions, please feel free to contact us at the number listed above.

Sincerely,

Moore Twining Associates, Inc.

for AG

Allen Glover
Director of Analytical Chemistry

MOORE TWINING ASSOCIATES, INC.

California ELAP Certificate # 1371

2527 Fresno Street
Fresno, CA 93721
(559) 268-7021 Phone
(559) 268-0740 Fax

MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
HA1 Bulk Comp.	0I29061-01	Soil	09/29/10 00:00	09/29/10 15:22
HA4 Bulk Comp.	0I29061-02	Soil	09/29/10 00:00	09/29/10 15:22
VC 11 (B+C)	0I29061-03	Soil	09/29/10 00:00	09/29/10 15:22
VC 16 (B+C)	0I29061-04	Soil	09/29/10 00:00	09/29/10 15:22
VC 20 (B+C)	0I29061-05	Soil	09/29/10 00:00	09/29/10 15:22
VC 28 (B+C)	0I29061-06	Soil	09/29/10 00:00	09/29/10 15:22

MOORE TWINING ASSOCIATES, INC.

California ELAP Certificate # 1371

2527 Fresno Street
Fresno, CA 93721
(559) 268-7021 Phone
(559) 268-0740 Fax

MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

HA1 Bulk Comp.

0I29061-01 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	4000	mg/kg	2000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**29000**	4000	mg/kg	2000	T0J1910	10/19/10	10/20/10	EPA 300.0	
LOI (% Organic Matter)	**2.3**	0.10	%	1	T0J1123	10/11/10	10/13/10	ASTM D2974	
Nitrate as NO3	ND	4000	mg/kg	2000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	2000	mg/kg	2000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**62000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**11000**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**5900**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**18000**	200	mg/kg	50	T0J0514	10/05/10	10/12/10	EPA 6010B	

MOORE TWINING ASSOCIATES, INC.

California ELAP Certificate # 1371

2527 Fresno Street
Fresno, CA 93721
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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

HA4 Bulk Comp.

0I29061-02 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	2000	mg/kg	1000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**12000**	2000	mg/kg	1000	T0J1910	10/19/10	10/20/10	EPA 300.0	
LOI (% Organic Matter)	**0.80**	0.10	%	1	T0J1123	10/11/10	10/13/10	ASTM D2974	
Nitrate as NO3	ND	2000	mg/kg	1000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	1000	mg/kg	1000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**48000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**9000**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**3700**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**8500**	80	mg/kg	20	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

VC 11 (B+C)

0I29061-03 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**5500**	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrate as NO3	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	500	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**41000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**8000**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**3700**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**6400**	80	mg/kg	20	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

VC 16 (B+C)

0I29061-04 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**6900**	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrate as NO3	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	500	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**36000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**7500**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**3500**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**6700**	80	mg/kg	20	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

VC 20 (B+C)

0I29061-05 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**4600**	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrate as NO3	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	500	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**40000**	100	mg/kg	10	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**7600**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**2000**	1000	mg/kg	10	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**4600**	40	mg/kg	10	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

VC 28 (B+C)

0I29061-06 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**8600**	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrate as NO3	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	500	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**48000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**7900**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**3400**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**8400**	80	mg/kg	20	T0J0514	10/05/10	10/12/10	EPA 6010B	

Notes and Definitions

RPD	The RPD result exceeded the QC control limits. However, both percent recoveries were acceptable.
QM	The spike recovery for this QC sample is outside of established control limits due to matrix interference.
Q4	The spike recovery was outside of QC acceptance limits for the MS and/or MSD due to analyte concentration at 4 times or greater the spike concentration.
ug/L	micrograms per liter (parts per billion concentration units)
mg/L	milligrams per liter (parts per million concentration units)
mg/kg	milligrams per kilogram (parts per million concentration units)
ND	Analyte NOT DETECTED at or above the reporting limit
RPD	Relative Percent Difference

Quality Control Data Available Upon Request

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/14/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location:	VC-28 @ 0.4-5.7 Feet		
Visual Classification:	Fat Clay		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	70.1	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	97.7	% Passing #200 Sieve	97.7
Hydrometer Reading @ 60 min	37	Hydrometer Reading @ 60 min	1
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	46	% Passing 5-µm(b)	4

$$\textbf{\% Dispersion} = \frac{\textbf{(\% Passing 5-µm(b))}}{\textbf{(\% Passing 5-µm(a))}} * 100 \longrightarrow \frac{4.0\ (100)}{46.0} = 9\%$$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location:	VC-28 @ 0.4-5.7 Feet		
Visual Classification:	Fat Clay		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

Test Results:

Grade: 1 - Nondispersive

(a) % by ASTM D422

(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/14/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location: VC-20 @ 0-4.7 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	73.4	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	88.8	% Passing #200 Sieve	88.8
Hydrometer Reading @ 60 min	27	Hydrometer Reading @ 60 min	1
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	30	% Passing 5-µm(b)	4

$$\textbf{\% Dispersion} = \frac{\textbf{(\% Passing 5-µm(b))}}{\textbf{(\% Passing 5-µm(a))}} * 100 \longrightarrow \frac{4.0\ (100)}{30.0} = 13\%$$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location: VC-20 @ 0-4.7 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

Test Results:
Grade: 1 - Nondispersive

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/14/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location: VC-16 @ 0-3.5 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	69.8	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	95.1	% Passing #200 Sieve	95.1
Hydrometer Reading @ 60 min	35	Hydrometer Reading @ 60 min	1
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	42.5	% Passing 5-µm(b)	4

$$\textbf{\% Dispersion} = \frac{\textbf{(\% Passing 5-µm(b))}}{\textbf{(\% Passing 5-µm(a))}} * 100 \longrightarrow \frac{4.0\ (100)}{42.5} = 9\%$$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location: VC-16 @ 0-3.5 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

Test Results:
Grade: 2 - Intermediate

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/14/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location:	VC-11 @ 0-3.5 Feet		
Visual Classification:	Fat Clay		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	72.4	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	89.9	% Passing #200 Sieve	89.9
Hydrometer Reading @ 60 min	30	Hydrometer Reading @ 60 min	6
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	33	% Passing 5-µm(b)	20

$$\textbf{\% Dispersion} = \frac{\textbf{(\% Passing 5-µm(b))}}{\textbf{(\% Passing 5-µm(a))}} * 100 \longrightarrow \frac{20.0\ (100)}{33.0} = 61\%$$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location:	VC-11 @ 0-3.5 Feet		
Visual Classification:	Fat Clay		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

Test Results:
Grade: 3 - Dispersive

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/12/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location:	HA-4 (Bulk)		
Visual Classification:	Fat Clay W/Sand		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	70.6	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	75.2	% Passing #200 Sieve	75.2
Hydrometer Reading @ 60 min	22	Hydrometer Reading @ 60 min	1
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	23	% Passing 5-µm(b)	4

$$\textbf{\% Dispersion} = \frac{\textbf{(\% Passing 5-µm(b))}}{\textbf{(\% Passing 5-µm(a))}} * 100 \longrightarrow \frac{4.0\ (100)}{23.0} = 17\%$$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location:	HA-4 (Bulk)		
Visual Classification:	Fat Clay W/Sand		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

Test Results:

Grade: 2 - Intermediate

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/12/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location:	HA-1 (Bulk)		
Visual Classification:	Fat Clay		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	77.5	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	88.9	% Passing #200 Sieve	88.9
Hydrometer Reading @ 60 min	30	Hydrometer Reading @ 60 min	1
Temperature, °C	21.3	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	36	% Passing 5-µm(b)	4

$$\textbf{\% Dispersion} = \frac{\textbf{(\% Passing 5-µm(b))}}{\textbf{(\% Passing 5-µm(a))}} * 100 \longrightarrow \frac{4.0\ (100)}{36.0} = 11\%$$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location:	HA-1 (Bulk)		
Visual Classification:	Fat Clay		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

Test Results:

Grade: 1 - Nondispersive

(a) % by ASTM D422
(b) % by ASTM D4221

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OFFICE MEMO

TO: Thang (Vic) Nguyen	**DATE:** December 29, 2010
FROM: Mike Driller	**SUBJECT:** Test Request No. 2010-29: Pin Hole Tests of Salton Sea Restoration Samples

Attached are the results of testing performed under Test Request No. 2010-29, "Pin Hole Tests of Salton Sea Restoration Soil Samples." Soil samples were received at the Bryte Laboratory on October 7, 2010 in six small plastic bags.

Pin Hole Tests were performed according to ASTM Test Designation D 4647 - 06, "Identification and Classification of Dispersive Clay Soils by the Pinhole Test." Results are listed below and on the attached Pin Hole Test Data Sheets.

The Method A procedure was used, and testing consisted of compacting the 38-mm (1.5-in.) long specimens into the pinhole test cylinder on top of the coarse sand and wire screen (see Figure 1). Samples were compacted to the density and moisture contents provided. The test method used distilled water flowing horizontally under a hydraulic head of 50 mm (2 in.) through a 1.0-mm (0.04-in.) diameter hole punched in the soil specimen. Pictures were taken before and after the Pinhole Test are attached.

Pinhole Test Results

The Pin Hole test is a direct, qualitative measurement of the dispersibility and erodibility of clay soils when subjected to water of low-salt concentration. The test is performed by passing water through a small hole punched in a specimen (see Figure 1). Flow from *dispersive* clays will be distinctly dark and the hole through the specimen will enlarge rapidly, with a resultant increase in the flow rate. Flow from slightly to *moderately dispersive* clays will be slightly dark with a constant hole size and flow rate. Flow from *nondispersive* clays will be completely clear with no measureable increase in the hole size. Classifications were determined using criteria from ASTM (see attached) based on the flow rate, turbidity, and hole size at the end of the test.

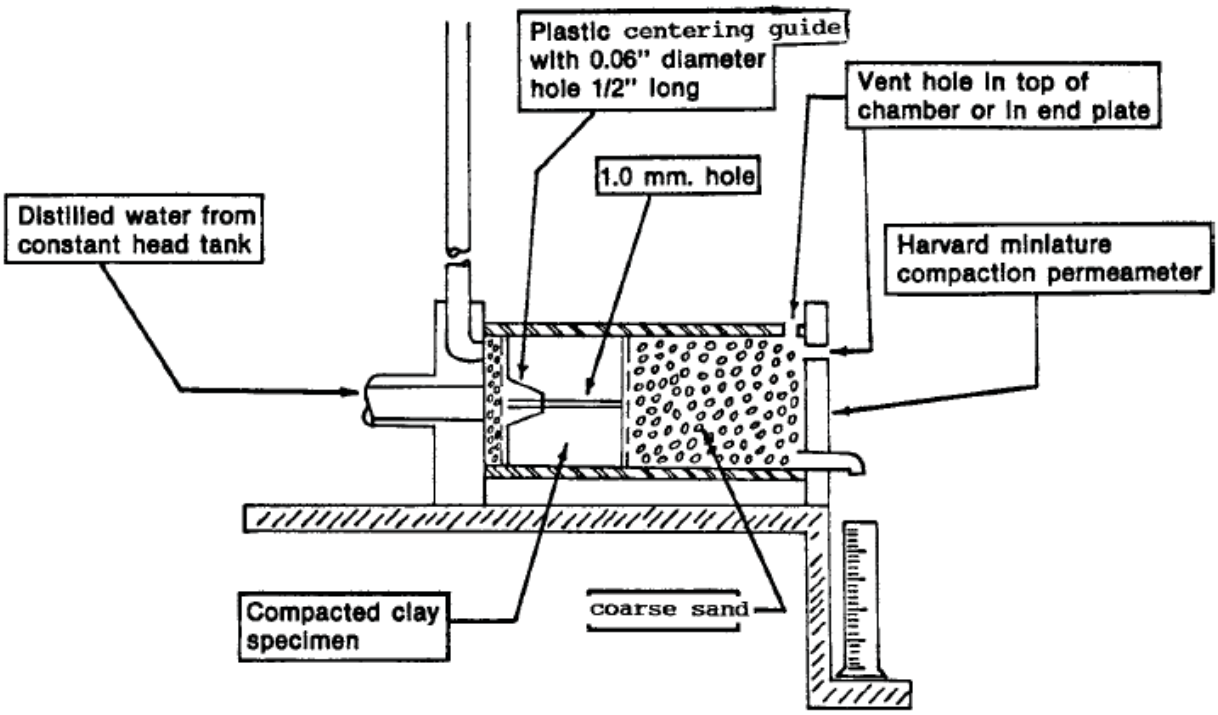


FIG. 1 Schematic Drawing of the Pinhole Test Equipment

Table 1: Results of pinhole tests

Hole No.	Bryte Lab No.	Dry Unit Weight	Moisture Content	Dispersive Classification	Remarks
HA-1	10-528	90 pcf	14.2	D1	Dispersive
HA-4	10-529	101 pcf	11.9	D1	Dispersive
VC-11	10-530	95 pcf	12.9	D2	Dispersive
VC-16	10-531	95 pcf	13.4	D1	Dispersive
VC-20	10-532	95 pcf	13.2	D2	Dispersive
VC-28	10-533	101 pcf	12.3	D2	Dispersive

Please call myself at 916-764-0277 or Doug Najima of my staff at 916-375-6012 if you have any questions.

PIN HOLE TEST DATA

Date: 12/11/2010

Pin Hole Test No. 1

Page: 1

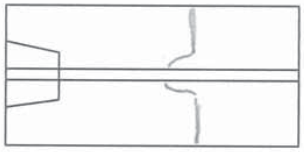
Sample No. 10-528 (HA-1)

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 14.2% @ 90pcf

Distilled water added x (yes) or _____ (no)



Curing time: 24 hrs.

Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
1.33p	2"	25	31.1		x					x		0.80	
	2"	25	24.4		x					x		1.02	
	2"	25	20.2		x					x		1.24	
	2"	25	17.6		x					x		1.42	
1:38p	2"	25	17.5		x					x		1.43	<---stop test.
													Classification of test results:
													Method A: D1, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to 3.58mm hole.
													Soil was air dried and moisturized to
													14.2%.

PIN HOLE TEST DATA

Date: 12/13/2010

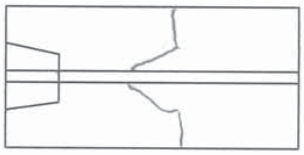
Pin Hole Test No. 2

Page: 1

Sample No. 10-529 (HA-4)

Speciman after test:

Compaction Characteristics good, firm, pliable



Water Content 11.9% @ 101pcf

Distilled water added x (yes) or _____ (no)

Curing time: 48 hrs.

Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
1:00p	2"	25	25	X						x		1.00	
	2"	25	20.1	x						x		1.24	
	2"	25	18.2	x						x		1.37	
	2"	25	17.9	x						x		1.40	
	2"	25	17.8	x						x		1.40	
1.05p	2"	25	17.6	x						x		1.42	<---stop test.
													Classification of test results:
													Method A: D1, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													8.89mm hole.
													Soil was air dried and moisturized to
													11.9%.

PIN HOLE TEST DATA

Date: 12/14/2010

Pin Hole Test No. 3

Page: 1

Sample No. 10-530 (VC-11)

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 12.9% @ 95pcf

Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
1:30p	2"	25	54		x					x		0.46	
	2"	25	52.5		x					x		0.48	
	2"	25	49.9		x					x		0.50	
	2"	25	49.8		x					x		0.50	
	2"	25	47.2		x					x		0.53	
	2"	25	32.8		x					x		0.76	
	2"	25	29.8		x					x		0.76	
	2"	25	27.1		x					x		0.92	
	2"	25	26.8		x					x		0.93	
	2"	25	26.5		x					x		0.94	
	2"	25	25.1		x					x		1.00	
1:41p	2"	25	24.9		x					x		1.004	<--- stop test
													Classification of test results:
													Method A: D2, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													9.5mm hole.
													Soil was air dried and moisturized to
													12.9%.

PIN HOLE TEST DATA

Date: 12/15/2010

Pin Hole Test No. 4

Page: 1

Sample No. 10-531 (VC-16)

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 13.4% @ 95pcf

Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
2:55p	2"	25	43.4		x					x		.058	
	2"	25	37.6		x					x		0.66	
	2"	25	31.9		x					x		0.78	
	2"	25	30.0		x					x		0.83	
	2"	25	25.6		x					x		0.98	
3:00p	2"	25	22.5		x					x		1.11	<--- stop test
													Classification of test results:
													Method A: D1, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													7.061mm hole.
													Soil was air dried and moisturized to
													13.4%.

PIN HOLE TEST DATA

Date: 12/16/2010

Pin Hole Test No. 5

Page: 1

Sample No. 10-532 (VC-20)

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 13.2% @ 95pcf

Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
2:09p	2"	25	53.8		x					x		0.46	
	2"	25	47.3		x					x		0.53	
	2"	25	40.8		x					x		0.61	
	2"	25	36.1		x					x		0.69	
	2"	25	35.8		x					x		0.70	
	2"	25	33.3		x					x		0.75	
	2"	25	32.5		x					x		0.77	
	2"	25	31.2		x					x		0.80	
	2"	25	29.7		x					x		0.84	
	2"	25	28.6		x					x		0.87	
	2"	25	27.8		x					x		0.90	
	2"	25	27.5		x					x		0.91	
	2"	25	26.3		x					x		0.95	
	2"	25	26.0		x					x		0.96	2:20p---stop test.
	2"	25	25.7		x					x		0.97	Classification of test results:
2:20p	2"	25	25.0		x					x		1.00	Method A: D2, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													5.105mm hole.
													Soil was air dried and moisturized to 13.2%.

PIN HOLE TEST DATA

Date: 12/17/2010

Pin Hole Test No. 6

Page: 1

Sample No. 10-533 (VC-28)

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 12.3% @ 101pcf

Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1 trial.

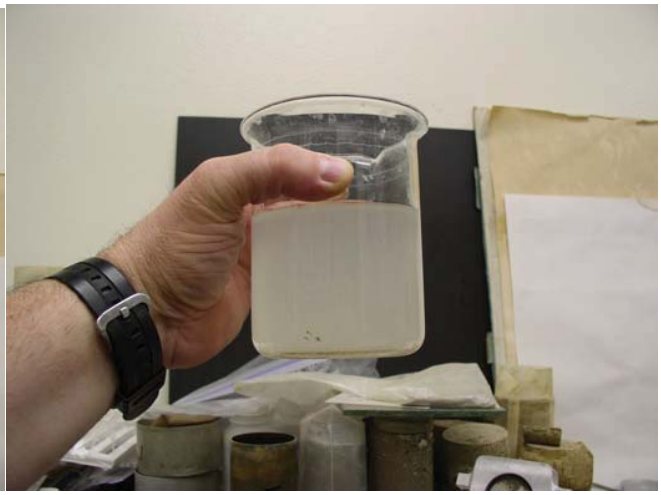
Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
2:06p	2"	25	49.5		x					x		0.51	
	2"	25	47.4		x					x		0.53	
	2"	25	41.8		x					x		0.60	
	2"	25	38.1		x					x		0.66	
	2"	25	37.9		x					x		0.66	
	2"	25	37.1		x					x		0.67	
	2"	25	36.2		x					x		0.69	
	2"	25	28.9		x					x		0.87	
	2"	25	27.1		x					x		0.92	
	2"	25	26.4		x					x		0.95	
	2"	25	24.7		x					x		1.01	
2:16p	2"	25	22.6		x					x		1.11	<--- stop test
													Classification of test results:
													Method A: D2, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													5.029mm hole.
													Soil was air dried and moisturized to 12.3%.

Pinhole Test Pictures

Hole HA-1(Lab No. 10-528):

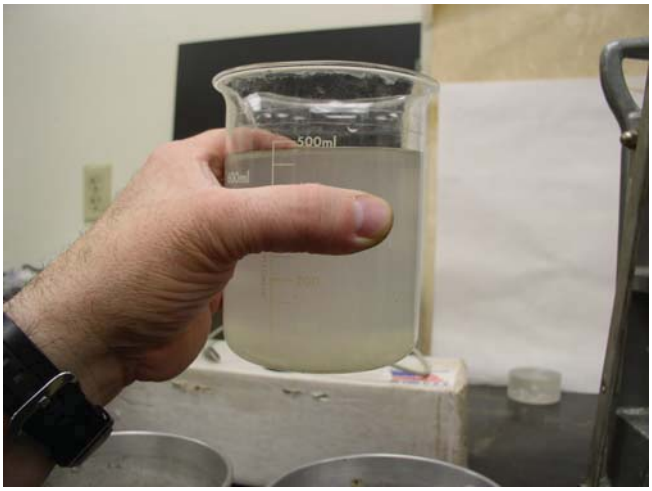
Hole HA-4(Lab No. 10-529):

Hole VC-11(Lab No. 10-530):

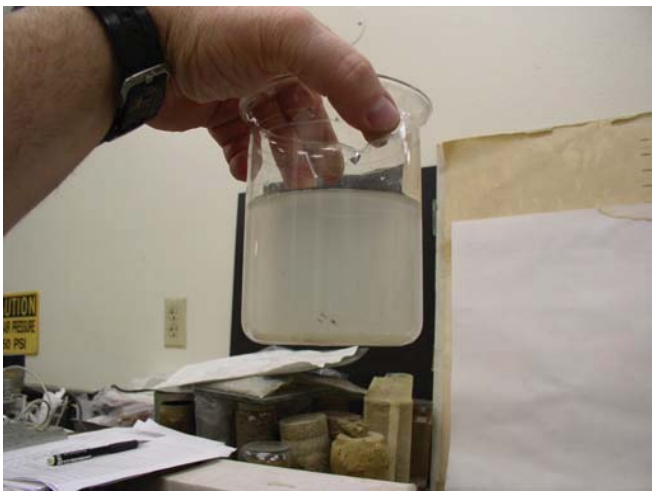


Hole VC-16(Lab No. 10-531):

Hole VC-20(Lab No. 10-532):



Hole VC-28(Lab No. 10-533):



ASTM Criteria for interpreting results.

7. Classification

7.1 The observations of this test method provide the basis for classifying the soil specimen into a category of dispersiveness according to the following general criteria:

7.1.1 *Method A:*

D1, D2—Dispersive clays that fail rapidly under 50-mm (2-in.) head.

ND4, ND3—Slightly to moderately dispersive clays that erode slowly under 50-mm (2-in.) or 180-mm (7-in.) head.

ND2, ND1—Nondispersive clay with very slight to no colloidal erosion under 380-mm (15-in.) or 1020-mm (40-in.) head.

TABLE 1 Criteria for Evaluating Pinhole Test Results[A]

Dispersive Classification[B]	Head, mm	Test time for given head, min.	Final flow rate through specimen, mL/s	Cloudiness of flow at end of test		Hole size after test, mm
				from side	from top	
D1	50	5	1.0–1.4	dark	very dark	≥2.0
D2	50	10	1.0–1.4	moderately dark	dark	>1.5
ND4	50	10	0.8–1.0	slightly dark	moderately dark	≤1.5
ND3	180	5	1.4–2.7	barely visible	slightly dark	≥1.5
	380	5	1.8–3.2			
ND2	1020	5	>3.0	clear	barely	<1.5
ND1	1020	5	≤3.0	perfectly clear	perfectly clear	1.0

OFFICE MEMO

TO: Thang (Vic) Nguyen	**DATE:** August 4, 2011
FROM: Mike Driller	**SUBJECT:** Test Request No. 2011-26: Pin Hole Tests of Salton Sea Restoration Samples w/Different Salinity Samples

Attached are the results of testing performed under Test Request No. 2011-26, "Pin Hole Tests of Salton Sea Restoration Soil Samples with Different Salinity Samples." Original Soil samples were received at the Bryte Laboratory on October 7, 2010 in six small plastic bags and remaining samples were retained for future use. On July 7, 2011 a request was made for two additional pinhole tests on each of the six Salton Sea samples; a total of 12 additional pinhole tests. DWR has already done one pinhole test on each of the six samples using distilled water as the fluid in an earlier report to you dated December 29, 2010. The current task was to repeat the pinhole tests using two different salinity concentrations (20 ppt and 40 ppt total dissolved solids), which model the water in the habitat ponds. The saline water was delivered to the Bryte lab on July 13, 2011, premixed to these two concentrations.

Pin Hole Tests were performed according to ASTM Test Designation D 4647 - 06, "Identification and Classification of Dispersive Clay Soils by the Pinhole Test." Results are listed below and on the attached Pin Hole Test Data Sheets.

The Method A procedure was used, and testing consisted of compacting the 38-mm (1.5-in.) long specimens into the pinhole test cylinder on top of the coarse sand and wire screen (see Figure 1). Samples were compacted to the density and moisture contents provided. The test method used two different salinity concentrations of water (20 ppt and 40 ppt total dissolved solids), flowing horizontally under a hydraulic head of 50 mm (2 in.) through a 1.0-mm (0.04-in.) diameter hole punched in the soil specimen. Pictures were taken before and after the Pinhole Test are attached.

Pinhole Test Results

The Pin Hole test is a direct, qualitative measurement of the dispersibility and erodibility of clay soils when subjected to water of low-salt concentration. The test is performed by passing water through a small hole punched in a specimen (see Figure 1). Flow from *dispersive* clays will be distinctly dark and the hole through the specimen will enlarge rapidly, with a resultant increase in the flow rate. Flow from slightly to *moderately dispersive* clays will be slightly dark with a constant hole size and flow rate. Flow from *nondispersive* clays will be completely clear with no measureable increase in the hole size. Classifications were determined using criteria from ASTM (see attached) based on the flow rate, turbidity, and hole size at the end of the test.

In comparing the new tests using two different salinity concentrations to the tests performed last year using distilled water, all samples were determined to be dispersive regardless of the solution used. The flow rate using the salinity samples was observed to be more varilable than the flow rate using the distilled water; the flow would fluctuate and pick up speed as solids would grab hold and let loose of compacted material. In addition, samples tested using the higher concentration of dissolved solids appeared to produce slightly less dispersive results.

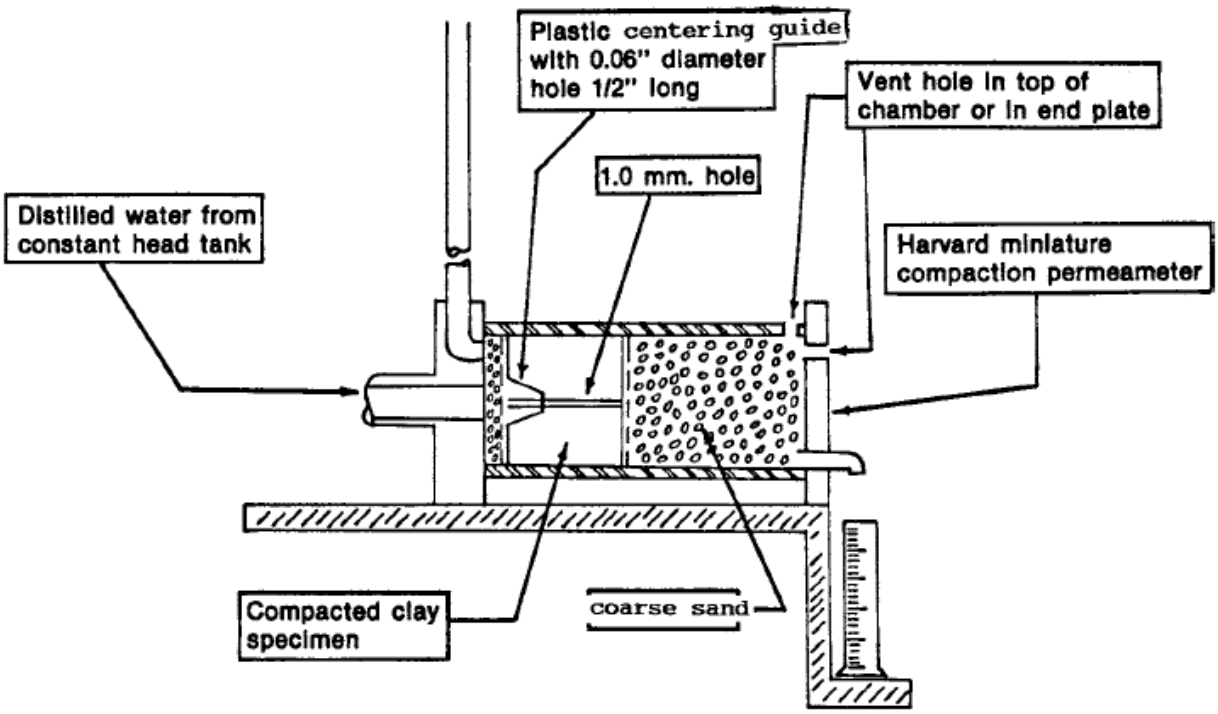


FIG. 1 Schematic Drawing of the Pinhole Test Equipment

Table 1: Results of pinhole tests

Hole No.	Dissolved Solids	Bryte Lab No.	Dry Unit Weight	Moisture Content	Dispersive Classification	Remarks
HA-1	20ppt	10-528	90 pcf	14	D2	Dispersive
HA-4	20ppt	10-529	101 pcf	12	D2	Dispersive
VC-11	20ppt	10-530	95 pcf	13	D1	Dispersive
VC-16	20ppt	10-531	95 pcf	13	D1	Dispersive
VC-20	20ppt	10-532	95 pcf	13	D2	Dispersive
VC-28	20ppt	10-533	101 pcf	12	D2	Dispersive
HA-1	40ppt	10-528	90 pcf	14	D2	Dispersive
HA-4	40ppt	10-529	101 pcf	12	D2	Dispersive
VC-11	40ppt	10-530	95 pcf	13	D2	Dispersive
VC-16	40ppt	10-531	95 pcf	13	D2	Dispersive
VC-20	40ppt	10-532	95 pcf	13	D2	Dispersive
VC-28	40ppt	10-533	101 pcf	12	D2	Dispersive

Please call myself at 916-764-0277 or George Benny of my staff at 916-375-6014 if you have any questions.

PIN HOLE TEST DATA

Date: 07/28/2011

Pin Hole Test No. 1

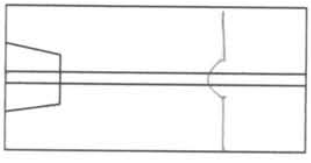
Page: 1

Sample No. 10-528 (HA-1), 20ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 14% @ 90pcf



Distilled water added X (yes) or ____ (no)

Curing time: 24hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
10:59	2"	50	104									0.48	
		50	87									0.57	
		50	70									0.71	
		50	68									0.74	
		50	62									0.81	
		50	60									0.83	
		50	54									0.93	
		50	48									1.04	
11:09		50	47									1.06	<---- stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with
													suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.00mm to
													a 5.37mm hole.
													Soil was air dried and moisturized with
													distilled water to 14%.

PIN HOLE TEST DATA

Date: 07/28/2011

Pin Hole Test No. 2

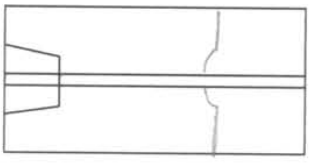
Page: 1

Sample No. 10-529 (HA-4), 20ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 12% @ 101pcf



Distilled water added X (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
12:12	2"	50	84									0.60	
		50	84									0.60	
		50	84									0.60	
		50	84									0.60	
		50	80									0.63	
		50	78									0.64	
		50	60									0.83	
		50	51									0.98	
12:23		50	49									1.02	<--- stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.00mm
													to a 9.71mm hole.
													Soil was air dried and moisturized with
													distilled water to 12%.

PIN HOLE TEST DATA

Date: 07/28/2011

Pin Hole Test No. 3

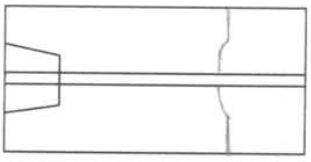
Page: 1

Sample No. 10-530 (VC-11), 20ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 13% @ 95pcf



Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
2:02	2"	50	69									0.72	
		50	50									1.00	
		50	49									1.02	
		50	45									1.11	
		50	42									1.19	
		50	40									1.25	
2:08		50	39									1.28	<--- stop test.
													Classification of test results:
													Method A: D1, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 10.54mm hole.
													Soil was air dried and moisturized with
													distilled water to 13%.

PIN HOLE TEST DATA

Date: 07/29/2011

Pin Hole Test No. 4

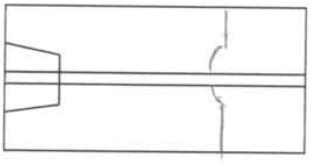
Page: 1

Sample No. 10-531 (VC-16), 20ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 13% @ 95pcf



Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
11:18	2"	50	50									1.00	
		50	49									1.02	
		50	48									1.04	
		50	48									1.04	
		50	48									1.04	
		50	47									1.06	
11:23		50	47									1.06	<--- stop test.
													Classification of test results:
													Method A: D1, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 9.12mm.
													Soil was air dried and moisturized with
													distilled water to 13%.

PIN HOLE TEST DATA

Date: 07/29/2011

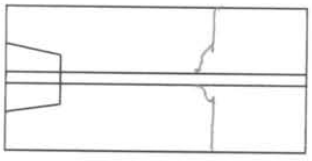
Pin Hole Test No. 5

Page: 1

Sample No. 10-532 (VC-20), 20ppt

Speciman after test:

Compaction Characteristics good, firm, pliable



Water Content 13% @ 95pcf

Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
2:09	2"	50	58									0.86	
		50	57									0.88	
		50	57									0.88	
		50	56									0.89	
		50	56									0.89	
		50	56									0.89	
		50	53									0.94	
		50	49									1.02	
2:18		50	47									1.06	<--- Stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 9.88mm hole.
													Soil was air dried and moisturized with
													distilled water to 13%.

PIN HOLE TEST DATA

Date: 07/29/2011

Pin Hole Test No. 6

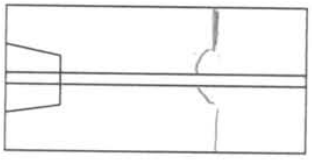
Page: 1

Sample No. 10-533 (VC-28), 20ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 12% @ 101pcf



Distilled water added X (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
2:48	2"	50	60									0.83	
		50	59									0.85	
		50	58									0.86	
		50	57									0.88	
		50	57									0.88	
		50	56									0.89	
		50	54									0.93	
		50	50									1.00	
		50	47									1.06	
2:57		50	45									1.11	<--- Stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 8.05mm hole.
													Soil was air dried and moisturized with
													distilled water to 12%.

PIN HOLE TEST DATA

Date: 08/01/2011

Pin Hole Test No. 7

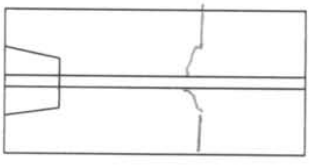
Page: 1

Sample No. 10-528 (HA-1), 40ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 14% @ 90pcf



Distilled water added x (yes) or _____ (no)

Curing time: 40 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
11:20	2"	50	83									0.60	
		50	81									0.62	
		50	79									0.63	
		50	74									0.68	
		50	69									0.72	
		50	65									0.77	
		50	60									0.83	
		50	57									0.88	
		50	53									0.94	
11:31		50	50									1.00	<--- Stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 8.94mm hole.
													Soil was air dried and moisturized
													with distilled water to 14%.

PIN HOLE TEST DATA

Date: 08/01/2011

Pin Hole Test No. 8

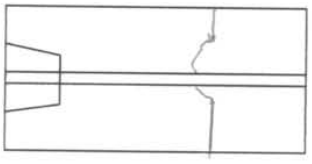
Page: 1

Sample No. 10-529 (HA-4), 40ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 12% @ 101pcf



Distilled water added x (yes) or _____ (no)

Curing time: 40 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
1:37	2"	50	70									0.71	
		50	69									0.72	
		50	67									0.75	
		50	65									0.77	
		50	63									0.79	
		50	60									0.83	
		50	58									0.86	
		50	55									0.91	
		50	52									0.96	
		50	50									1.00	
		50	49									1.02	<--- Stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 8.31mm hole.
													Soil was air dried and moisturized with
													distilled water to 12%.

PIN HOLE TEST DATA

Date: 08/01/2011

Pin Hole Test No. 9

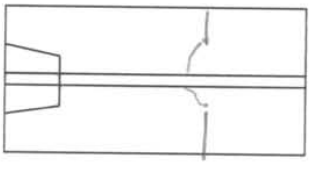
Page: 1

Sample No. 10-530 (VC-11), 40ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 13% @ 95pcf



Distilled water added x (yes) or _____ (no)

Curing time: 40 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
2:16	2"	50	112									0.45	
		50	105									0.48	
		50	99									0.51	
		50	78									0.64	
		50	56									0.89	
		50	54									0.93	
		50	51									0.98	
2:27		50	49									1.02	<--- Stop test.
													Classification of test results.
													Method A: D2, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 8.70mm hole.
													Soil was air dried and moisturized with
													distilled water to 13%.

PIN HOLE TEST DATA

Date: 08/01/2011

Pin Hole Test No. 10

Page: 1

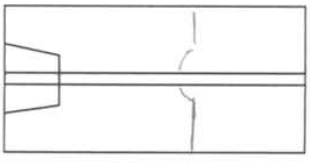
Sample No. 10-531 (VC-16), 40ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 13% @ 95pcf

Distilled water added x (yes) or _____ (no)



Curing time: 40 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
2:59	2"	50	58									0.86	
		50	57									0.88	
		50	57									0.88	
		50	55									0.91	
		50	54									0.93	
		50	53									0.94	
		50	53									0.94	
		50	51									0.98	
		50	51									0.98	
		50	49									1.02	
3:10		50	49									1.02	<--- Stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 7.84mm hole.
													Soil was air dried and moisturized with
													distilled water to 13%.

PIN HOLE TEST DATA

Date: 08/02/2011

Pin Hole Test No. 11

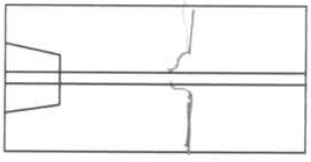
Page: 1

Sample No. 10-532 (VC-20), 40ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 13% @ 90pcf



Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

Flow started on 1st trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
8:54	2"	50	85									0.59	
		50	82									0.61	
		50	79									0.63	
		50	75									0.67	
		50	75									0.67	
		50	70									0.71	
		50	67									0.75	
		50	60									0.83	
		50	55									0.91	
9:05		50	49									1.02	<--- Stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 6.57mm hole.
													Soil was air dried and moisturized with
													distilled water to 13%.

PIN HOLE TEST DATA

Date: 08/02/2011

Pin Hole Test No. 12

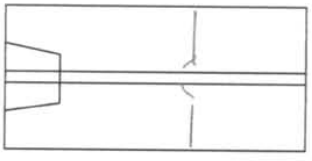
Page: 1

Sample No. 10-533 (VC-28), 40ppt

Speciman after test:

Compaction Characteristics good, firm, pliable

Water Content 12% @ 101pcf



Distilled water added x (yes) or _____ (no)

Curing time: 24 hrs.

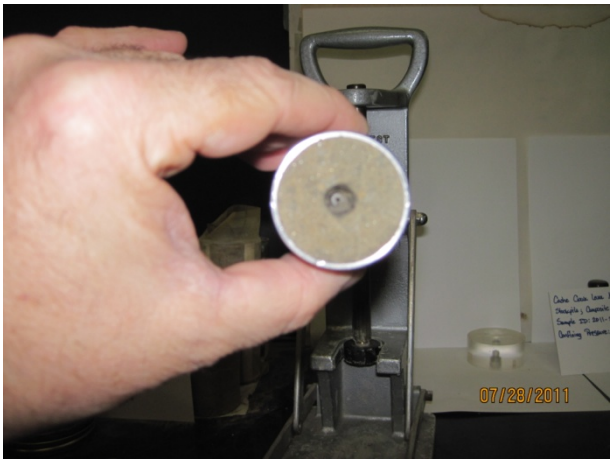
Flow started on 1st trial.

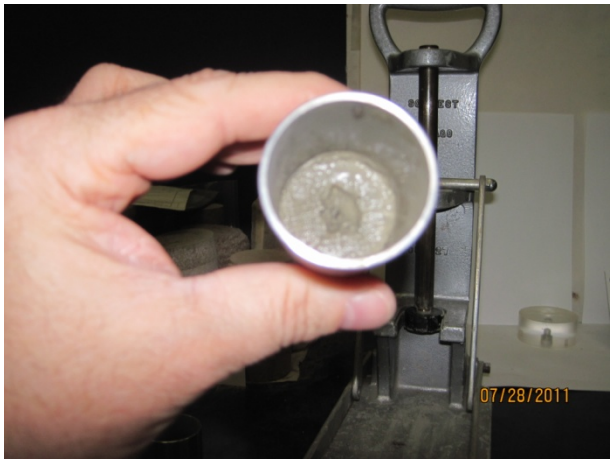
Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
9:44	2"	50	60									0.83	
		50	59									0.85	
		50	59									0.85	
		50	59									0.85	
		50	57									0.88	
		50	55									0.91	
		50	53									0.94	
		50	51									0.98	
		50	50									1.00	
9:55		50	49									1.02	<--- Stop test.
													Classification of test results:
													Method A: D2, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to a 5.77mm hole.
													Soil was air dried and moisturized with
													distilled water to 12%.

Pinhole Test Pictures

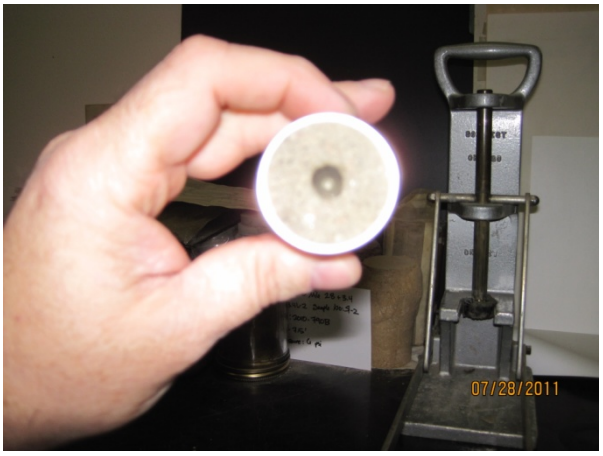
Hole HA-1(Lab No. 10-528); 20ppt:

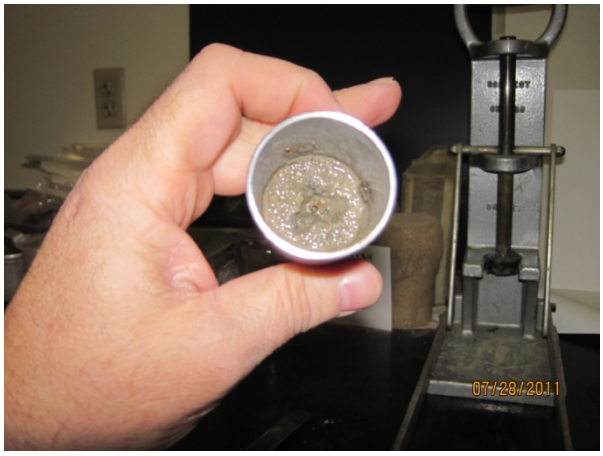
Hole HA-4(Lab No. 10-529); 20ppt:





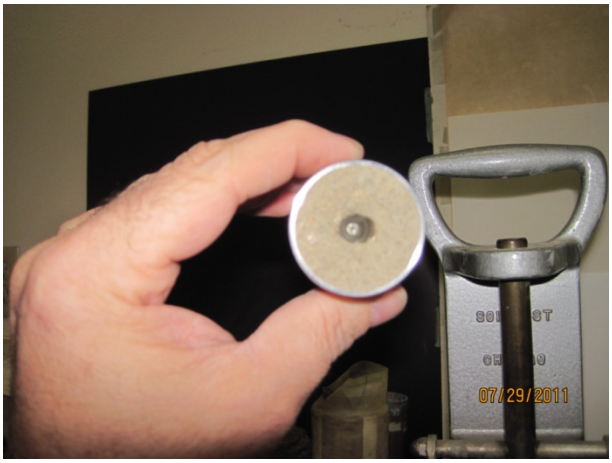
Hole VC-11(Lab No. 10-530); 20ppt:





Hole VC-16(Lab No. 10-531); 20ppt:

Hole VC-20(Lab No. 10-532); 20ppt:



Hole VC-28(Lab No. 10-533); 20ppt:

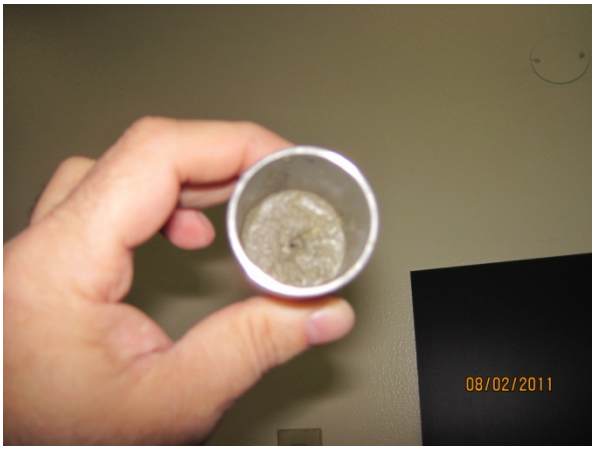
Hole HA-1(Lab No. 10-528); 40ppt:

Hole HA-4(Lab No. 10-529); 40ppt:

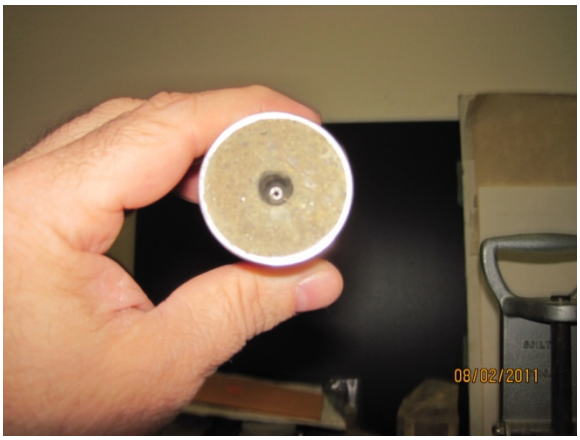
Hole VC-11(Lab No. 10-530); 40ppt:

Hole VC-16(Lab No. 10-531); 40ppt:

Hole VC-20(Lab No. 10-532); 40ppt:



Hole VC-28(Lab No. 10-533); 40ppt:



08/02/2011

08/02/2011

ASTM Criteria for interpreting results.

7. Classification

7.1 The observations of this test method provide the basis for classifying the soil specimen into a category of dispersiveness according to the following general criteria:

7.1.1 *Method A:*

D1, D2—Dispersive clays that fail rapidly under 50-mm (2-in.) head.

ND4, ND3—Slightly to moderately dispersive clays that erode slowly under 50-mm (2-in.) or 180-mm (7-in.) head.

ND2, ND1—Nondispersive clay with very slight to no colloidal erosion under 380-mm (15-in.) or 1020-mm (40-in.) head.

TABLE 1 Criteria for Evaluating Pinhole Test Results[A]

Dispersive Classification[B]	Head, mm	Test time for given head, min.	Final flow rate through specimen, mL/s	Cloudiness of flow at end of test		Hole size after test, mm
				from side	from top	
D1	50	5	1.0–1.4	dark	very dark	≥2.0
D2	50	10	1.0–1.4	moderately dark	dark	>1.5
ND4	50	10	0.8–1.0	slightly dark	moderately dark	≤1.5
ND3	180	5	1.4–2.7	barely visible	slightly dark	≥1.5
	380	5	1.8–3.2			
ND2	1020	5	>3.0	clear	barely	<1.5
ND1	1020	5	≤3.0	perfectly clear	perfectly clear	1.0