GEOTECHNICAL INVESTIGATION

SALTON SEA
SPECIES CONSERVATION HABITAT PROJECT
SALTON SEA, CALIFORNIA

Project No. 758.01
April 7, 2014

Prepared by

Hultgren – Tillis Engineers

A California Corporation
Specializing in Geotechnical Engineering

Hultgren-Tillis Engineers

April 7, 2014
Project No. 758.01

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

Attention: Mr. Paul Wisheropp

Geotechnical Investigation
Species Conservation Habitat Project
Salton Sea, California

Dear Mr. Wisheropp:

We performed geotechnical investigations for design of the Salton Sea Species Conservation Habitat Project (SCH Project) in the New River area at the Salton Sea in Imperial County, California. Our services are part of Cardno ENTRIX Project Number 32676001 of the SCH Project.

The results of the geotechnical investigations are presented in the attached report.

We previously performed a geotechnical investigation for preliminary design of the SCH Project along the southeast shoreline of the Salton Sea, including the New River and the Alamo River sites. We issued a preliminary geotechnical report dated September 2, 2011. Our current report supercedes the preliminary report.

We previously issued a design memorandum of geotechnical parameters for preliminary design of the pump stations on July 25, 2013, and a design memorandum for pump stations on October 21, 2013. The design parameters and recommendations in this report supersede those presented in the July 25, 2013 and the October 21, 2013 design memoranda.

It was a pleasure working with you on this project. If you have any questions, please call.

Sincerely,

Hultgren – Tillis Engineers

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I. INTRODUCTION

This report presents the results of our geotechnical investigation for the Salton Sea Species Conservation Habitat Project (SCH Project) in Imperial County, California. The SCH Project is intended to serve as a proof of concept for the restoration of shallow water habitat that currently supports fish and wildlife dependent upon the Salton Sea. This habitat is being lost due to salinity increases and the declining Sea[1] elevation. The project will consist of creating shallow ponds for shorebird habitat near the mouth of the New River along the southern shore of the Salton Sea. A Vicinity Map is presented on Plate 1. The approximate boundaries of the ponds are shown on the Exploration Site Plans, Plates 2 and 3.

Two habitat ponds will be created on the east side of the New River in the New River's delta area. The ponds are named New Delta West and New Delta East. A third habitat pond, New South, may be created on the west side of the New River, depending on the available construction funds.

The combination of the two ponds on the east side of the New River (New Delta West and New Delta East) will be bounded on the west and south by a new berm paralleling the existing New River east bank levee. The existing Imperial Irrigation District (IID) levees on the southeast side of the New Delta East pond will be used as part of the containment berm. New northern berms for these two ponds will close off an existing bay.

A maximum pool elevation of -228 feet was selected early in the planning process to not be higher than the recent high Sea stands in the 1980's and 1990's. The elevation datum for the project is NGVD1929.

The initial project concept included seaward berms that extend out to Elevation -234 feet contour within the Sea. The level of the Sea has been dropping about 0.5 foot per year for the last seven years, and the Sea's annual winter to summer variation has been between 1 and 1.5 feet per year. The maximum Sea level is expected to be below Elevation -232 feet during construction of the SCH Project. At Elevation -234 feet contour, the seaward berms would be constructed in up to 2 feet of water. Due to the incremented costs associated with constructing the berms within the Sea, the planned berm alignments for the New Delta West and New Delta

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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.

East ponds were pulled upslope, out of the Sea. The berms will be constructed above water on the playa (beach).

The water depths within the ponds will typically be 2 to 3 feet, with the deepest areas being in channels about 6 feet deep. The ponds will contain water with varying degrees of salinity. The target salinities are 20 parts per thousand (ppt) and 35 ppt. Water for the ponds will be pumped from the New River and the Salton Sea, then blended to achieve the desired salinities.

The ponds will include low loafing islands, small habitat islands, and large habitat islands. The loafing islands will be up to 2 feet above the design water elevation within the ponds. The large habitat islands will be up to 20 feet above the pond level.

Improvements will include the existing New River east bank levee in areas where the existing levee is narrow and/or low. These improvements are not intended to meet a specific flood control standard, but rather are intended to provide protection consistent with the levels of risk being accepted for other elements of the project. Other portions of the New River east bank levee will not be improved.

The pumping facilities which are part of the SCH Project include a saline water pump station and a fresh water pump station. The New River Pump Station supplying the fresh water[2] will be located at the southern end of the SCH Project's planned inner berm on the east bank of the New River. The pump station will have a cast-in-place wetwell with an intake pipe passing beneath the New River east bank levee into the New River. The portion of the pond containment berm extending south from the New River Pump Station will be upgraded to an all-weather service road.

The Saline Water Pump Station will be on a pile-supported pier extending into an excavated intake basin. The Saline Water Pump Station will be located adjacent to an existing IID levee, approximately 2,500 feet north of the western end of Young Road. A Saline Water Channel will be cut out into the Sea to maintain the connection between the intake basin and the Sea as the Sea level drops.

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[2] The "fresh water" from the New River has about 2 ppt dissolved solids and is not suitable for human contact.

Our scope of services included reviewing existing geotechnical data, exploring subsurface conditions, performing laboratory tests characterizing the materials encountered, performing engineering analyses, and developing geotechnical conclusions and recommendations for containment berms, habitat islands, pump stations, and the Saline Water Channel.

II. FIELD EXPLORATION AND LABORATORY TESTING

A. Previous Investigations

Three previous investigations that contained geotechnical exploration and testing data were performed near or at the site, including (1) the April 1974 Federal-State Feasibility Report, Salton Sea Project, (2) the 2004 “Preliminary In-Sea Geotechnical Investigation, Salton Sea Restoration Project” by URS, and (3) the 2011 “Preliminary Geotechnical Investigation of the Salton Sea Species Conservation Habitat Project” by Hultgren – Tillis Engineers.

The April 1974 Federal-State Feasibility Report, Salton Sea Project, 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 were presented on Map 13, “Subaqueous Geology”, in the 1974 report. Map 14, titled “Subaqueous Structure Contours, Top of Foundation” provided bathymetry in 1972 and generalized elevation contours of the top of relatively firm foundation materials. Selected data from the 1974 investigation are presented in Appendix H.

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 (Boring Number 14) were performed near the SCH Project New River site. 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. Selected data from the 2004 investigation are presented in Appendix H.

Hultgren – Tillis Engineers issued a geotechnical report for preliminary design of the Salton Sea SCH Project in January 2011. The exploration for the 2011 preliminary investigation was done in September 2010. Subsurface data included three hand auger borings (1HA, 2HA, and 10HA) and three vibracores (6VC, 11VC, and 16VC) in or near the New River site (the project site), and three hand auger borings and six vibracores in the Alamo River area. The preliminary investigation was intended to provide a general characterization of on-site soil conditions and to provide geotechnical engineering criteria for preliminary design. The preliminary design was the basis for the project description in the environmental impact documents. Logs of these borings and vibracores are presented in Appendix F, Plates F-3 through F-17. The soil descriptions shown in the boring and vibracores are presented in general accordance with the Unified Soil Classification System (USCS) presented on Plate F-18. The approximate locations of the exploration are presented on Plates F-1 and F-2. The locations of hand auger borings and vibracores within the New River area are also shown on the current project's Exploration Site Plans, Plates 2 and 3.

B. Current Investigations

For the current investigation (2014 Geotechnical Investigation), four phases of exploration were performed. Twelve (12) hand augers and thirty (30) vibracores were performed in October 2011 in the general area of potential berm alignments and within potential borrow areas at the New River project site. In addition, a hand-held vane shear apparatus and a portable static cone penetrometer were used to provide additional subsurface characterization between hand auger and vibracore locations. During a November 2011 site reconnaissance, additional vane shear probing was performed immediately east of the New River and along the water’s edge in the northern area (approximately Elevation -232 feet). In September 2013, one boring was drilled at each of the two pump station locations. During a December 2013 site reconnaissance, additional hand augers and vane shear probing were performed in four areas, including (1) a low lying saddle area (approximately Elevation -231 feet) to the northeast of the inner bay; (2) a potential borrow area immediately to the east of New River; (3) a low lying area between New River and the inner bay, north of an existing IID weir structure; and (4) the planned all-weather service access road on the south end of the project area.

The exploration locations are presented on the Exploration Site Plans, Plates 2 and 3. The coordinates of the exploration locations are shown on the logs of borings and vibracores. The logs of borings and vibracores are presented in Appendix A, Plates A-1 through A-59. The soil descriptions shown in the borings and vibracore logs are presented in general accordance with the USCS presented on Plate A-60.

Methods used for exploring subsurface conditions were dependent in part on-site accessibility. On the playa above the water’s edge, the site conditions were judged too soft in many areas 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.

Cuttings from the hand auger borings were placed in one-gallon re-sealable plastic “freezer” bags, sealed, and marked with the boring number and depth interval. The one-gallon samples bag were placed in larger 2.5 mil plastic “trash compactor” bags, which were also sealed.

A cone penetrometer test was conducted adjacent to eight of the twelve 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. The cone tip resistance was computed using size correction factors provided by the manufacturer.

At and beyond the water’s edge (within the Sea), vibracore samples were taken from an airboat. Vibracores consisted of 3.5-inch outside diameter (O.D.), 3.0-inch inside diameter (I.D.), ten feet long PVC sample tubes, and utilized a vibratory hammer to advance the sample tubes into the underlying soil formations. The vibracore tubing was hung from an A-frame extending off the bow of the airboat. In many locations, the vibracores met refusal and were not advanced for the full length of the tube.

At each vibracore location, the in-situ strength was characterized by the hand-held vane shear apparatus (Geonor Model H-60). The vanes were 1.0-inch wide (total width) and 2.0-inches long. Smaller vanes with dimensions of 0.79-inch wide and 1.58-inches long were used occasionally where stiff soils were encountered. A manufacturer's recommended correction factor appropriate for the vane size was applied. Beneath the Sea, vane shear strength measurements were generally made at 1.64 feet (0.5 meter) depth intervals and were made off the side of the airboat within a few feet of the vibracore location. The vane was advanced between reading depths by pressing the vane further into the formation.

Hand-held vane shear strength measurements were also taken within the hand auger borings at approximately 0.5 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 “refusal to vane shear penetration”. After a vane shear strength measurement was made, the augered hole was advanced to the next test depth.

Where the soil shear strength exceeded the torque range of the hand-held vane shear apparatus, the shear strength was reported with a “>” (greater than symbol) in front of the limiting strength on the logs of hand auger borings and vibracores.

Two correction factors were applied to the vane field strength measurements for shaft friction and plasticity. Where the vanes were advanced between reading depths by pressing the vane further into the formation, friction along the shaft was corrected by considering torque lost to shaft friction above the vanes. The shaft friction was assumed to be directly proportional to the shear strength in the materials that the shaft is in. To compute the friction, the adhesion around the shaft above the vanes is calculated by multiplying the shear strength of materials by an adhesion factor. The net torque applied to the vanes was calculated by subtracting the torque lost to shaft friction from the total torque measured. The net torque was used to compute shear strength. Field strength measurements were also corrected for plasticity. We used plasticity correction factors ranging from 0.75 to 1.0. Plasticity of soils was not available at each reading depth. Plasticity was assumed using our engineering judgment on soil types and field strength measurements.

Between hand auger borings and vibracores, the subsurface conditions were assessed using the vane shear apparatus or the static cone penetrometer to measure the in-situ vane shear strength or cone tip resistance. No soil sampling or logging was done at these supplemental locations. Only the in-situ vane shear strength or penetration resistance measurements were recorded.

Two borings were drilled for the planned pump stations on September 18 and 19, 2013 using a track-mounted, hollow-stem drill rig. The two borings (numbered 112HS and 113HS) were drilled to depths below existing grade of 76.5 to 66.5 feet, respectively. Boring 112HS was drilled from the top of the existing IID levee nearest the planned Saline Water Pump Station location. Boring 113HS was drilled at the New River Pump Station location, on an access road adjacent to the toe of the existing east bank levee along the New River.

The locations of the exploration points are shown on the Exploration Site Plans, Plates 2 and 3. Each location has a unique number, continued from the 2011 Preliminary Geotechnical Investigation by Hultgren – Tillis Engineers. In the preliminary investigation, the exploration location numbers were preceded by letters indicating the type of exploration. We have restructured the labeling system to put the descriptive letters after the location number. Hand auger locations are noted as “HA” and vibracore locations are noted as “VC”. The “HS” indicates that a boring was drilled using hollow-stem equipment. Vane shear strength and/or cone penetration resistance was measured at each hand auger and vibracore location. At locations where no sampling was done, the symbol “VS” indicates that only supplemental vane shear strength data was collected. Similarly, static cone penetrometer locations are noted as “P”. Logs of borings and vibracores and the key to the logs are presented in Appendix A. The hand-held vane shear tests conducted within the hand auger borings are shown on the hand auger logs. The hand-held vane 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.

Vane shear data is also plotted in strength versus depth format for each exploration location in Appendix B, Plates B-1 through B-67. A summary of the vane strength data sorted by site elevation and depth below grade is presented on Plate 7. This distribution is discussed further in the Foundation Strength and Berm Geometry section of this report. The hand-held cone penetrometer tests taken adjacent to the hand augers are presented in Appendix C, Plates C-1 through C-13.

C. Laboratory Testing

1. General

Laboratory testing was performed for both the previous Preliminary Investigation and for the current investigation. The testing is described in the following two sections.

2. Testing For January 2011 Preliminary Investigation Report

Samples recovered from the hand augers and vibracores in September 2010 for the preliminary investigation 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 1HA and 4HA, respectively). Two laboratory compaction tests were performed on each bulk sample. One laboratory compaction test was performed using “Modified Proctor” compactive effort (ASTM D1557) and the other “Standard Proctor” (ASTM D698).

To evaluate the dispersive characteristics of the on-site soils (sea sediments), six samples were selected for additional laboratory testing as part of the preliminary investigation. They included the two bulk samples (1HA and 4HA) and four vibracore composite samples (11VC, 16VC, 20VC, and 28VC). 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 for the preliminary investigation 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 ppt total dissolved solids (TDS).

The results of the laboratory testing from the preliminary investigation are presented in Appendix G. A summary of the laboratory test results is presented on Plate G-1 in Appendix G. The range of gradation test results are shown on Plate G-2. Moisture contents and the results of Atterberg limits tests are summarized on Plates G-3 and G-4. A plot of in-situ moisture contents and the corresponding Atterberg limit tests is presented on Plate G-5. A combined plot of the four compaction tests is presented on Plate G-6. The flow rates from the pinhole tests using the different salinity concentrations are summarized on Plate G-7.

3. Testing For The Current Geotechnical Investigation

The laboratory testing consisted of moisture content, Atterberg limits, sieve analysis, triaxial unconsolidated-undrained strength tests (TxUU), a total petroleum hydrocarbons (TPH) test, and corrosivity. Samples were delivered to the Hultgren – Tillis Engineers office in Concord, California. Vibracore tubes were cut into short sections, split in half, and logged by our engineering geologist. Vibracore tubes were re-sealed after logging. Selected soil samples from the borings and vibracores were delivered to Cooper Testing Laboratory in Palo Alto, California for soil mechanics testing. All of the laboratory tests were performed by Cooper Testing Laboratory except a TPH test that was performed by McCampbell

Analytical Inc. in Pittsburg, California and the corrosivity analysis that was performed by CERCO Analytical in Concord, California.

Hydrocarbon odor was detected by our geologist while logging vibracore soil samples in our Concord office. Ten vibracore locations were found with the odor of hydrocarbons (see Plate 5). One selected soil sample (Vibracore 41VC at depths of 4.3 to 4.9 feet) was delivered to the McCampbell Analytical Inc. laboratory for a TPH scan test. Hydrocarbons were not detected during the 2011 preliminary investigation and were not anticipated in our geotechnical exploration. The soil sample for the TPH scan test was not handled in a manner according to required chain-of-custody methods. Hydrocarbon odor was much stronger when samples were first exposed than later when samples were prepared for testing. The degree to which volatilization of hydrocarbons may have occurred prior to testing is unknown.

The results of the laboratory testing are presented in Appendix D. A summary of the laboratory test results is presented on Plate D-1. The moisture content results for the hand augers, vibracores, and hollow-stem auger borings are presented on Plates D-2 through D-12. The moisture content, dry density, and Atterberg limits are also presented on the individual logs of the hand auger borings, vibracores, and hollow-stem auger borings. The sieve analysis results for the hand augers and vibracores are presented on Plates D-13 through D-17. The sieve analysis results for the two pump station borings are presented on Plates D-18 through D-20. The results of Atterberg limits tests for the hand augers and vibracores are summarized on Plates D-21 and D-22. The results of Atterberg limits tests for the two pump station borings are summarized on Plate D-23. The TxUU results are presented on Plate D-24. The TPH scan test results are presented on Plates D-25 through D-34. The corrosivity analysis result is presented on Plates D-35 and D-36.

III. SURFACE AND SUBSURFACE CONDITIONS

A. General

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 open. 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 an area near the mouth of the Alamo River, northeast of the New River site.

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 northern Mexico and the Imperial Valley. In 1905, control of the river was lost at a canal headwork, 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 and tend to be concentrated near the river mouths.

B. New Delta Ponds

1. Surface Conditions

The grades within the New Delta East and New Delta West ponds are generally very flat. The ground surface ranges from Elevations -232 feet to -228 feet with the exception of the areas immediately adjacent to existing levees where the ground elevation ranges from Elevations -227 feet to -222 feet. In the central portion of the New Delta East and

New Delta West ponds, the ground is low relative to the surrounding areas, forming a bay. Within the bay, the ground elevation is between Elevations -232 feet to -231 feet and inundated with water depths of one to two feet. The water in the bay did not directly connect to the Sea. Until the fall of 2013 when the weir was permanently closed, the bay received water through a weir structure on New River. Trees and brush grow on the New River levees. A few large dead trees are located within the bay and some aquatic grasses exist in the bay. Much of the playa is devoid of vegetation. Salt cedar trees occur in thick stands where irrigation return water still charges onto the playa. The ground surface along the sea shoreline slopes down toward the Sea with an inclination of approximately 200H:1V (horizontal to vertical) or flatter. The slope of the mudline commonly becomes flatter below Elevation -235 feet in the Sea.

For the western site (the New South pond), the site is bordered by New River to the east, the Sea to the west, and open playa to the north and south. Similar to the eastern site, the grade is generally flat and the ground surface is in the range of Elevations -234 feet to -228 feet with the exception of higher areas immediately adjacent to and including the existing New River west bank levee. The western site is smaller and narrower compared to the eastern site. The Sea water's edge is approximately 1,000 to 2,000 feet from the New River axis. The Elevation -234 feet contour is approximately 1,500 to 3,000 feet from the New River axis. The ground surface along the shoreline slopes down toward the Sea and the slope of the mudline becomes flatter below Elevation -235 feet in the Sea.

With the Sea receding, sediments are drying on the exposed playa, 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. In approximately one fourth of the locations explored within the Sea and the bay, the mudline beneath the water is very soft and will not support a person wading.

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 the areas of Elevation -230 feet or higher, a crust of about 2 feet thick was generally encountered during our exploration. The crust was dry to moist and strong enough to temporarily support light weight, low ground pressure (LGP) vehicles, such as an all-terrain-vehicle (ATV).

2. Subsurface Conditions

As discussed previously, existing ground surface was judged not strong enough to support conventional exploration equipment. Hand augering and vibracores were utilized during our explorations in both 2010 and 2011. The explorations were limited to depths of 10 feet or less below the mudline or existing ground. A map showing the elevation of the bottom of very soft (undrained strength less than 250 pounds per square foot (psf)) sea sediment is presented on Plate 4.

Soil conditions of interest in the project area along the berm alignments and in the potential borrow areas include three general soil units: (1) Recent Sea Sediment, (2) Sand/Silty Sand, and (3) Holocene Lacustrine Deposits. These soil units are summarized below.

(a) <u>Recent Sea Sediments</u>

The recent sea sediments were up to 8 feet thick in the areas that we explored in and near New River. The thickness may exceed 8 feet in some areas. These sediments likely accumulated within the last 60 years during the Sea's most recent rise above Elevation -240 feet. The sea sediments consist of very soft to medium stiff clays, loose clayey and silty sands, and soft to medium stiff silts, but they are predominantly clays. Thicker layers of sea sediments (approximately 6 to 8 feet) were generally found along the northeastern portion, along the middle portion of the western side, and within the bay of the project site.

(b) <u>Sand/Silty Sand</u>

The sea sediment and sand/silty sand units are both very young materials and are mainly differentiated by the rate at which they settled out into the Sea.

The sand/silty sand unit is an alluvial fan deposit from New River. These materials have been accumulating since the current New River began to reform sometime after the end of the 1905 – 1907 flood event.

The sand/silty sand at shallow depths were mainly encountered in the northern end of the site, on both sides of the mouth of New River within 1,000 to 2,000 feet from the river axis.

Many of the sand deposits on the west side of the New River are cleaner (contain less silt) than those on the east side of the river. We suspect that these cleaner sands may have been re-sorted by wave action causing a re-suspension of silts that were carried to deeper water. Differences in wind exposure and wave action, flatness of the playa, and/or less silt migration once re-suspended likely contributed to the sands commonly retaining a higher silt content in the sands on the east side of New River.

We conclude that the sands are predominantly loose and susceptible to liquefaction during a strong earthquake. Though many of the sand samples within the vibracore samples appear to be medium dense, these samples may have been densified during vibratory sampling. We have chosen to describe these samples as loose.

(c) <u>1905 – 1907 Flood Alluvium and Holocene Lacustrine Deposits</u>

Reddish brown clay, silt and clayey sand, commonly medium stiff to stiff, was encountered below the sea sediment in many areas. These materials were predominately encountered in the southeastern portion of the site and dips below the depth of our shallow exploration for the balance of the site. The source of these materials may be a combination of Colorado River deltaic deposits and sea sediments from former higher stands of the Sea pre-dating the 1905 – 1907 Sea filling. These materials are oxidized as indicated by their colors and are slightly to moderately over-consolidated. The plasticity index of the silts and clays immediately below the sea sediments are between 12 and 29, indicating a moderate expansion potential. Fat clay was found below the leaner clays and silts. Though only found in our deeper borings, it is likely part of a lacustrine deposit that was found in earlier regional exploration by others.

The above descriptions of soil and groundwater conditions summarize observations at the exploration locations. Conditions vary across the site.

C. Pump Stations

1. Saline Water Pump Station

The Saline Water Pump Station site is currently submerged beneath the Sea. Bathymetric surveys are reported to have been done by others, but we have not reviewed this information. Very soft sea sediment likely covers the site. While the thickness of the sea sediment is not known, a 1947 aerial photograph indicates that the pump station site had been previously farmed. The current elevation for the farmed field southeast of the existing levee is near Elevation -235 feet. Assuming an elevation drop between fields of about 4 to 5 feet, this suggests that the top of the previously farmed ground at the Saline Water Pump Station location is near Elevations -239 feet to -240 feet. The Sea is currently near Elevation -233 feet and the sediment is not exposed, suggesting that the thickness of the sediment is less than about 6 feet in the region of the Saline Water Pump Station and access pier. The 1947 aerial photograph suggests that irrigation ditches were located along the edge of the now submerged field. The sea sediments are likely thicker at these locations.

The boring at the Saline Water Pump Station site (112HS) was drilled from the crest of the existing levee near Elevation -222 feet. The soils are interbedded silts, sands and clays. The following is a summary of the idealized stratigraphy, which we used in assigning engineering properties to the soils. The upper 18 feet of soil is stiff to very stiff clay with some medium dense silt and sand. Between Elevations -240 feet to -255 feet, the soils are typically medium stiff, consisting mostly of silt. A stiff to very stiff fat clay layer was encountered between Elevations -255 feet to -265 feet. The clay is underlain by 15 feet of predominately medium stiff to stiff silt to Elevation -280 feet. Below that depth, extending down to bottom of the boring near Elevation -298 feet, the soils are predominately medium dense sand with interbedded silt and clay.

2. New River Pump Station

The New River Pump Station site is currently an unimproved dirt access road that parallels the New River levee. Neither the access road nor levee are believed to be engineered structures; that is, fills for these features were not likely placed and compacted to standards of practice for similar structures that provide access to or protect significant improvements. Plans indicate that the existing New River channel slopes are inclined at about 2.5H:1V to 2.8H:1V.

Boring 113HS was drilled from Elevation -226 feet at the New River Pump Station site. The upper 7 feet is interbedded stiff clay and medium dense silty sand. Below Elevation -233 feet, the soil is predominately loose sandy silt and silty sand down to near Elevation -246 feet. Below that depth, the soil is predominately stiff to very stiff fat clay down to Elevation -277 feet. From Elevation -227 feet to the bottom of the boring near Elevation -292 feet, the soil was medium stiff to very stiff sandy silt.

D. New River East Bank Levee

1. Surface Conditions

The survey of the crest indicates that the centerline of the New River east bank levee within the project site varies from Elevations -218.5 feet to -224 feet. The levee crest width varies from 18 to 34 feet. The levee crest is covered with loose dirt. An existing IID weir structure that was used to feed water into the bay encroaches on the levee near River Station 60. Other encroachments include trees and bushes located on or near the existing levee. The New River east bank levee is generally higher than the west bank levee except the stretches from River Stations 2 to 19, 32 to 37, 39 to 44, 58 to 61, 63 to 63, and 69 to 72.

The interior ground surface near the levee varies from about Elevations -227 feet to -228 feet. The land-side slopes are generally flatter than 2.5H:1V. The land-side levee slope and toe is covered by vegetation that consists of brush and trees. Limited topographic data suggests that the river-side slope is generally flatter than 2.5H:1V.

The river stage in the past 2 years ranged from about Elevations -227 feet to -231 feet.

2. Subsurface Conditions

No subsurface data is available along the New River east bank except Boring 113HS. The subsurface conditions encountered at the location of the planned New River Pump Station (Boring 113HS) are described earlier in this report.

IV. DISCUSSION AND CONCLUSIONS

A. General

The most significant geotechnical issues for the project include: (1) the low strength of the sea sediment and its impact on both site accessibility and foundation support for the containment berms; (2) constructing berms within the Sea and protecting the berms from erosion by wave action; (3) potential seepage losses; (4) seepage induced internal erosion (piping); and (5) seismic reliability.

Initially, one of the proof of concept goals for the SCH Project was to identify an economical methodology for constructing pond containment berms in the Sea. Considerable effort went into evaluating schemes to construct the berms in 1 to 2 feet of water over weak foundation soils. No economical system was identified. To achieve reasonable pond acreage within the funding limits, the berms were located on the playa, with the lowest toe of the perimeter berm being above Elevation -231 feet, at least one foot above the Sea. This berm relocation eliminated the need for exterior shoreline protection from waves, both for the temporary during-construction phase and during a several year period before the sea level recedes below the berm toe. The methods described for use on the current SCH Project may be considered in the future for other sites in the New River delta as the Sea drops and candidate pond areas become fully exposed above the Sea.

The containment berms will be constructed on very weak soils, which are typically not used to support engineered structures. A more traditional method for constructing water retention structures at such sites would be to excavate the weak soils to an underlying firm foundation material and then build either a compacted earth embankment or a reinforced concrete containment wall. Another approach could be to create a pond lined with geomembrane, which can limit the risk on a seepage induced failure. Placing broad berms by hydraulically dredging in sandy areas is another method that we considered for development of containment berms. These more traditional methodologies could not be accomplished within the funding limits. Hence, we strove to develop methods of constructing an earthen berm on the weak soils.

Issues associated with constructing low containment berms over weak foundation soils include:

1. Supporting construction equipment;
2. Supporting fill loads;
3. Existing cracking in foundations soils;
4. Potential for future cracking;
5. Highly erodible silts with little to no plasticity;
6. Being prepared to address seepage as it occurs; and
7. Seismic risks, including liquefaction induced lateral spreading.

The risk of water loss through shrinkage cracking is a major factor to overcome if extensive ponds are to be constructed on the Sea's playa. The schemes developed herein begin with minimal efforts in the form of an inspection trench backfilled with low permeability material. Additional remedial efforts in the form of deeper clay cut soil-attapulgite off trenches or vinyl sheetpiles may be needed. These are all part of the demonstration project.

Due to funding limitations, the containment berms are not being designed and constructed to the level of reliability or safety that is normally used for engineered structures. The berm designs were developed with the intent that they would not create a risk of injury or death to persons beyond normal risks. However, these berms would have a greater risk of economic and functional failure than traditional engineered water retention structures. The project owners need to understand and accept this risk prior to proceeding with construction.

Some improvement will be made to limited sections of the New River levee. We believe that the New River levee has a high risk of failure during peak flow events. During such events, personnel should be kept out of the SCH site. No attempts at flood fighting should be made so as to not put flood fighters in harm's way.

B. Site Accessibility

Site accessibility was a major factor in our selection of the type of exploration equipment to be used at this site. This issue will only be magnified for the contractor constructing the improvements. In areas where fine-grained sea sediments were below the water level at the time of our exploration, these materials were frequently too weak to support a person wading. This condition existed within the bay immediately east of the New River and in areas distant from the mouth of New River. More recently, the replenishment water from the New River has been cut off from the bay. The drying is expected to improve access conditions for men and equipment. In the vicinity of (close to) the mouth of the New River, sand or silty sand lies on the Sea floor. Our personnel could walk on these materials. For much of the emergent land within the footprint of the planned ponds, we could travel the site on ATVs. We did not attempt to run the ATVs on wet, fine-grained sediments (silts and clays) near the edges of the Sea or bay. Our judgment was that we would likely get the ATV stuck. We walked carefully in these areas, avoiding portions of these areas where footing support was becoming tenuous.

On the exposed playa, sediments are drying, creating a crust strong enough to walk on. A two feet (or greater) thick crust was generally encountered during exploration where the ground elevation is at approximately Elevation -230 feet or higher. The crust was dry to moist and firm enough to readily support an ATV. There were a few car or pick-up truck tire tracks across some of these areas. Though the contractor will need to make his own judgment on the suitability of these areas to support his equipment, we believe this crust will support lightweight LGP equipment.

As one approaches the shoreline adjacent to these crust areas and is within about two feet of elevation above the lower annual Sea level, it is our opinion that the ground remains too soft to support most LGP equipment. For the purpose of developing our opinions regarding constructability at this site, we concluded that the ground is too weak to reliably support traditional LGP track-mounted construction equipment over much of the site. One method of improving site access would be to place a working pad over the existing weak areas to spread loads and reduce contact pressure limitations on LGP construction equipment. Increased work pad thickness can be constructed to support trucks and other rubber-tired equipment. Using a hand vane, we attempted to characterize the variations of strength versus depth at numerous locations across the site. The contractor may wish to consider similar methods to rate the capability of the soils to support his equipment.

We considered the use of water-born equipment to construct the berms. In this approach, a barge-mounted crane excavates a borrow ditch in front of itself using a clamshell bucket, casting the excavated material to the side to create the berm. To maintain stability of the cast-up embankment, wide stability berms or very flat slopes will be needed in the weaker sediment areas. While use of a barge-mounted clamshell or drag line may seem like promising construction equipment, we found that the flatness of the slopes (or width of stability berms) made the required reach to be excessive in the weaker ground areas. The weak character of the excavated sediments also affects the integrity of the core section of the berms. Excessively wet material, such as clay soil with high plasticity, will form large shrinkage cracks upon drying. This material would need to be reworked to create a water retention structure.

Floating hydraulic dredges could be used to mine the coarser grained materials (sands), pumping the materials to the berm alignments. Accessibility considerations include handling the discharge pipe. Sites to launch floating equipment within the Salton Sea are becoming more limited as the Sea level drops. The contractor may need to construct a launching facility specific to his needs.

Currently, access to the Sea is limited to shallow ramps that serve airboats and similar shallow draft watercraft. This access may soon be lost as the Sea continues to recede. Initial concepts for the Saline Water Pump Station included constructing a pump station within the Sea. Besides the high capital cost to construct the offshore pump station and associated power feed and delivery pipe, continued access to these features would be costly as the Sea level drops.

C. Shoreline Protection

1. General

There originally were two shorelines for the ponds: the interior and exterior faces of the berms. The interior of each pond will have water lapping at the toe or against the interior face of the berm for the life of the ponds. The wave height within the ponds will be fetch-limited, with maximum fetches of about one mile.

As we discussed earlier, the seaward-most berm originally would have been exposed to wave action from the Sea during construction and during the first several years of operation. To avoid this, the currently proposed berm alignments are at or above Elevation -231 feet, which is 1 foot above the current Sea level, Elevation -232 feet. Some earlier pond configurations called for constructing berms in the Sea with water depths of up to 2 feet. For the exterior 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. If the berms were constructed above the Sea level, the shoreline protection will be limited to the interior faces of the berms. The mitigation measures for both interior and exterior berm faces are discussed in the next two sections.

2. Interior Faces of the Berms

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. Within the ponds, maximum fetch will be about one mile for some directions within the ponds, less for others. Wave heights for 40 and 60 miles per hour (mph) sustained wind speeds over a one mile fetch were checked. For water depths of one feet and three feet, the significant wave heights (H_s) are estimated to be 0.8 and 1.3 feet, respectively, for a 40 mph sustained wind and 0.8 and 2.1 feet for a 60 mph sustained wind.

Several erosion control measures could be suitable for use within the ponds. These include riprap, sacrificial beaches, soil cement, geomembrane facing, and small seawalls.

The more traditional scheme for erosion protection is riprap facing. Riprap would be quarried rock material with an angular to subangular shape. Steep as opposed to flat slopes will limit the square footage of berm face that needs to be protected with riprap. Riprap should be placed on slopes no steeper than 2H:1V. Placing riprap on slopes flatter than about 3H:1V becomes increasing inefficient with respect to the quantity of riprap needed. A riprap thickness equivalent to two rock layers would be appropriate. Riprap would be placed on a geotextile designed for riprap underlayment. Riprap is one of the preferred slope protection schemes for the interior faces of the berms. For a 3 foot water depth, 40-pound rock is needed for a 40 mph wind and 170-pound rock would be needed for a 60 mph wind on a 2H:1V slope. For a one foot water depth, 10-pound rock is needed on a 2H:1V slope.

A beach slope could be created that is nearly stable under expected wave conditions within the ponds. These beach slopes can be used for erosion protection in lieu of hardening the interior slope. Because some material migration is expected, the beach should be considered a “sacrificial beach”. The existing beach slopes on the edge of the Sea to the northeast and west sides of New River have average inclinations between 0.5 and 1 percent. Wave energy within the ponds will be much less than those against the existing beaches. A sacrificial beach with a slope of 30H:1V or flatter could be used as erosion protection. A sacrificial beach needs to be constructed with considerable material above the design pool elevation to allow for material migration during a wind-driven wave event. A sacrificial beach consisting predominantly of sand would be needed. Sand that was found near the mouth of New River could be a potential borrow source. Hydraulic dredging and placement could be used to construct a sacrificial beach. Settlement from the consolidation of the underlying sea sediment should be considered in the design. A sacrificial beach could be a preferred scheme for some locations. Slopes that are not facing prevailing winds or seasonal high winds and that have short fetches are the preferred locations for sacrificial beach slopes. Additional sand will be needed to occasionally replenish the beach slopes.

Soil cement can be used for erosion protection and often is a viable option when riprap is not available. This should be considered a back-up preferred scheme. Soil cement consists of mixing Portland cement with a locally available source of sand or silty sand having less than 15 percent by weight passing a No. 200 sieve. 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. The vibracores and hand auger borings near the mouth of New River indicated sand or silty sand was encountered at shallow depths in these areas. Clean sand that was found directly on the surface on the west side of New River would be the most suitable for soil cement. For water depths of one foot and three feet and 40 mph sustained winds, run-ups of 1.7 and 2.2 feet above still water are estimated for the highest two percent waves on a smooth soil cement surface inclined at 3H:1V. For a 5H:1V slope, the run-ups would be 1.0 and 1.3 feet, respectively. For 60 mph sustained winds, run-ups of 3.0 and 4.9 feet are estimated on 3H:1V slopes in water depths of one and three feet, respectively. For 5H:1V slopes and 60 mph sustained winds, run-ups would be 1.2 and 2.0 feet.

Geomembrane facing has been used to line some reservoirs. The service lives 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 the "preferred" schemes.

3. Exterior Face of the Seaward-Most Berms

The current plan is to build the berms above the level of the Sea, so as to not need to protect against wave erosion on the exterior of the berms. The following discussion describes considerations that were addressed before moving the berms from the Sea.

On the exterior face of the seaward-most berms within the Sea, waves from across the long, north-south fetch of the Sea will attack the slope. Unprotected fill would readily erode and some temporary protection would be needed. The exterior shore protection would only need to resist wave action for the few years that the Sea remains high enough to reach the exterior toe of the berms. The installation of shore protection on the outside face of the berm would be complicated by access limitations and interfacing with the method selected for berm embankment construction.

Several erosion control schemes could be considered for the exterior sides of the berms. These include geotubes, riprap, and sand bags. A geomembrane wrapped face and a sheetpile wall were also considered.

A geotube is a large diameter geotextile tube (up to 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 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 seawall. 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 sand, silty sand, and clayey sand in the hand auger borings and vibracores would likely be suitable fill. This material was found predominantly near the mouth of New River. Conceptual design using geotubes is discussed later in this report. Three conceptual configurations in which geotubes could be used to construct the berms are discussed. Geotubes are the preferred scheme for temporary protection of the outside face of the berm where it is exposed to the Sea.

Riprap would provide effective shore protection. It would be a preferred choice if it were not for the difficulty in delivering the rock to the seaward edge of the berm fill.

Offshore breakwater systems could be considered, including a floating cabled 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 sheetpile wall buttressed on its landside by cast-up sea sediment fill can be used as a seawall. Potentially, sheetpiles could be installed from a shallow draft barge. Steel sheetpiles would be appropriate. Although the high salinity and corrosive environment would have adverse impacts on steel, the Sea is receding, and the sheetpiles would be exposed to the Sea for a limited time. Steel sheetpiles that have a relatively high stiffness would have less lateral deformation and have less chance of damage during installation compared to vinyl or fiberglass sheetpiles.

4. Saline Water Channel and Intake Basin

The south side of the intake basin adjacent to the pier structure and below the existing IID levee will need to be protected by riprap. The slope adjacent to the boat ramp in the intake basin will also need to be protected. Other than protecting excavated slopes adjacent to these improvements, it was acknowledged that the side slopes for the saline water channel and intake basin will be eroded by waves. Much of the dislodged material will end up in the channel. Maintenance dredging will be required as the Sea level drops.

D. Foundation Strength and Berm Geometry

The low strength of the sea sediments in many areas will limit the geometry of the berms. For those portions of the site where the existing ground surface is above Elevation -231 feet, over 90 percent of the shear strength measurements taken using the hand vane were greater than 300 psf. Almost the opposite is true in the lower elevations of the site near the existing shoreline, beneath the Sea, and within the existing bay. Where the existing ground surface is below Elevation -231 feet, approximately half of the hand vane tests in sea sediments within 6 feet of the ground surface indicated shear strengths of 250 psf or less.

These generalizations of foundation conditions are based on frequency distributions of vane shear strengths summarized on Plate 7. To develop these distributions, the site was divided into four existing ground surface elevation groupings (*elevation terrains*):

- Elevations -227 feet to -229 feet (High-Ground) – This zone covers much of the area where recent deltaic sands, silty sands, and non-plastic sandy silts have been deposited, most notably on the east side of New River, near its mouth.

- Elevations -229 feet to -231 feet (Mid-Ground) – This zone covers the saddle across the north end of the bay and the transitions from High-Ground to existing shoreline areas.

- Elevations -231 feet to -233 feet (Existing Shoreline) – From June 2011 to June 2012, the Sea level ranged between Elevations -231.0 feet to -232.3 feet, with a seasonal variation of about one foot. The Sea has been receding at an annual rate of about 0.5 foot per year. Our October 2011 subsurface exploration occurred at the annual nadir (low point), with the Sea at Elevation -232.3 feet. The Sea was at Elevation -231.9 feet during our exploration in September 2010.

- Elevations -233 feet to -235 feet (Offshore Alignment) – This zone is beneath the current Sea and includes the originally planned seaward alignment of the berm at contour Elevation -234 feet.

For each of these four elevation terrains, the available strength data was grouped into two feet thick depth intervals. The percentage of vane shear strength tests having less strength for a selected value was plotted, forming a frequency distribution curve (see Plate 7). While this strength zoning based on existing ground elevation cannot be used indiscriminately, it does provide a general framework for anticipating where the weaker materials are more likely to be. With the margin of safety for the berm geometry closely tied to the shear strength of the foundation soils, additional shear strength testing immediately beneath the berm alignment will be needed during construction.

For stability considerations, if the lowest average shear strength in the foundation material is greater than 300 psf, the berms can be constructed with 3H:1V side slopes. Sketches at the various berm side slope configuration are presented in Plates 12 through 15. Within the highest terrain (High-Ground), the strengths were nearly all (>95 percent occurrence) at or above 300 psf. 3H:1V side slopes can likely be used throughout the High-Ground area. Where the minimum shear strengths are less than 300 psf, the minimum slope geometry can be taken from Table 1.

Table 1: Minimum Undrained Shear Strength for Berm Side Slopes

Design Height Above Existing Grade	**Minimum Undrained Shear Strength (psf)**		
	10H:1V	**6H:1V**	**3H:1V**
2	100	130	150
3	110	150	180
4	120	170	210
5	140	190	250
6	160	220	300

Note: The minimum shear strengths presented in the above table were derived from the design charts on Plates 8 through 11 using 8 feet as the depth to the base of the soft sediment. For the design height above existing grade in the above table, an additional margin of safety was applied by using a height of the berm of 2 feet higher than design height when entering the design charts to select a minimum strength. For example for a design height of 4 feet, a berm height of 6 feet was used in the design charts.

Using the shear strength distribution from Plate 7, coupled with engineering judgment, one can expect that within the Mid-Ground terrain interval between -229 to -231 feet, about 40 percent of the perimeter berm alignment can be constructed with a 3H:1V slope, about 30 percent at 6H:1V, 10 percent at 10H:1V, with the remaining 20 percent needing wide stability berms.

In about half of the area covered by the two lower terrains (near the existing shoreline or beneath the Sea or bay), 10H:1V side slopes or berms buttressed by wide stability berms can be used to support berm embankments that extend up to Elevation -226 feet, including an overbuild allowance for settlement. The other half of these lower areas is too weak to reliably support a traditional embankment berm and may be more efficiently constructed using displacement methods, which are discussed later.

The containment berm will consist of three sections, a core berm, an upstream stability berm and a downstream seepage berm. The core berm is defined as the area beneath the berm crest and 3H:1V slopes extending down from the berm crest to the prepared subgrade. The 3H:1V slopes will be buried beneath the upstream stability berm where needed and downstream seepage berm. In addition to foundation stability issues, a seepage berm will have a 10H:1V slope against the downstream (outboard) face of the core berm limiting internal soil erosion (piping) through the fill. The seepage berm is discussed further in a later section.

E. Fill Materials

Fill will be needed to construct the berms. The most economical source of fill would be to borrow material from the playa immediately adjacent to the berm alignment (local borrow). Local borrow could be excavated beyond setback distance (clear zone) between the borrow area and the toe of the berm. Fill may also be generated from other locations within the project site (on-site borrow) and transported to the berm area.

Three on-site material types were considered for berm fill. The lean clay and silt that underlies the sea sediments is well suited for constructing water retention embankments. Unfortunately, it lies beneath several feet (4 feet or more) of sea sediment. The extent of overburden to be excavated to access the clay/silt makes this material an uneconomical source.

The sand/silty sand deposits in the New River delta are a readily available fill source. These materials can either be mechanically excavated and hauled to the berm alignment or excavated by a suction or cutterhead dredge and hydraulically transported to the berm alignment. With proper attention to relative grain sizes, the sand/silty sand can be used for a downstream seepage berm for seepage control (discussed later).

Sea sediments that have dried on the playa may also be used for berm fill. In most areas, these sediments still have moisture contents that are considerably higher than the optimum for compaction. Scarifying and discing will likely be needed before compacting fine-grained sea sediment in the core berm. Where used in a buttressing slope (stability berm), the sea sediments from playa crust areas may be considered for use without moisture conditioning. The dispersive character of the sea sediments is discussed in Appendix E.

Hydrocarbons were found at ten vibracore locations (see Plate 5). Though the concentrations of petroleum hydrocarbons are expected to be below thresholds that would preclude excavating and re-handling of these materials, further investigation may be needed to further characterize these materials prior to construction.

Imported materials will be needed for this project. Depending on the quality of service road desired for the top of the berm, a ¾-inch aggregate base material may be imported to create a gravel road.

Some form of hardening will likely be needed for at least some portions of the berm's interior face. Riprap can be imported from a commercial quarry.

Soil cement could also be used for erosion protection. Portland cement would need to be imported to the site. The cement would be mixed with on-site sand/silty sand to create soil cement for facing the interior slopes of the berms. Water from the nearby IID irrigation ditches could be used to mix soil cement. Erosion protection is discussed in greater detail in an earlier section of this report.

Controlled low strength material (CLSM) could be used to backfill around the outlet pipelines in trenches. Pipelines and weirs are discussed later in this report.

Graded sand filter and gravel drainage materials will be needed at the two perimeter water control structures (outlets).

F. Berm Settlement

The berms will settle appreciatively during and following construction. One dimensional settlement analysis was used to estimate the potential settlement. This assumes that the loaded area is wide relative to the depth of the compressible layer and ignores edge effects. The sea sediments were assumed to be normally consolidated. The alluvial soil beneath the sea sediments was assumed to be over-consolidated relative to the weight of the planned berms, and its minor contribution to the total settlement was ignored.

No consolidation testing was done for the SCH Project. Compression ratio (C_{ce}) and coefficient of consolidation (C_v) values were estimated based on experience with other normally consolidated sediments. A virgin compression ratio, C_{ce}, of 0.30 was selected for the sea sediments. This value was within the range of consolidation test results performed by URS (2004) in sea sediments from deeper water areas beneath the Sea. A C_v of 10 feet squared per year was used in our analysis for berm settlement. This is likely near a lower bound estimate and much of the sea sediment was judged to have higher C_v values. This means that settlement is more likely to occur faster than we calculated, as opposed to slower than we calculated. A C_v of 20 feet squared per year was used at the locations of the tall habitat islands. Settlement of the tall habitat islands is discussed in a separate section.

To estimate how quickly this settlement may occur, various drainage path conditions and thicknesses of compressible sea sediments were used. There is a moderate correlation between existing site elevations and thickness of highly compressible sea sediments. In general, single drainage and sea sediment thicknesses of 6 to 8 feet were used in the analyses for berm settlement where existing ground elevation is lower than Elevation -230 feet. Double drainage and sea sediment thicknesses of 3 to 5 feet were used in the analyses for the high ground areas where existing ground is at Elevation -230 feet or higher. Lateral drainage was ignored. These simplifying assumptions were judged to yield reasonable and probably conservative estimates of the magnitude and time rate of settlement.

We performed the settlement analysis for berms constructed in different ground elevation terrains. The berms were assumed to have a minimum final subgrade of Elevation -226 feet before placement of aggregate base on the berm crest. Results of the settlement analysis, tempered by engineering judgment, are summarized in Plate 6.

The estimated time to 50 percent consolidation is less than 6 months and in some cases less than a month. The time to 90 percent consolidation for the varying thicknesses of soft sea sediments is estimated to generally be less than 2 years and in some cases less than 2 or 3 months. The time rates for consolidation are very difficult to predict due to the heterogeneous nature of the soils and presence of sand layers.

G. Stability of Berms

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 and the phreatic surface become stable. "Rapid drawdown" occurs when the pool elevation in the pond is lowered quickly, faster than the embankment soils can drain. For embankment consisting mainly of fine-grained soils such as clay or silt, drawdown of the pool elevation greater than one foot per day (1 ft/day) would be considered as rapid drawdown. "Seismic loading" includes inertial lateral forces from earthquake shaking. Other seismic considerations include liquefaction in cohesionless soil, strength reduction in sensitive cohesive soils, and deformations. The more critical cases for the berms at this site will be the end-of-construction condition and liquefaction and strength reduction from a seismic event.

The undrained strength of the foundation soils (sea sediments) will greatly influence the way the berms are constructed. Where the shear strength in the foundation soil is consistently greater than 300 psf, the foundation soil should support the berm fill with low risk of foundation failure under static loading. At shear strengths lower than 300 psf, the risk of shear failure in the foundation soil increases and needs to be carefully considered.

The results of the vane shear tests performed beneath the different elevation terrains within the project site are summarized on Plate 7. On average, the strength of the materials beneath the Sea and bay are considerably weaker than those beneath the playa. The strength plots shown on Plate 7 are measures of peak undrained shear strength. No residual strength tests were performed. Because New River sediments were coming from a fresh water environment and mixing with a highly saline body of water, the clayey sea sediment 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. Liquidity indices (see Plate 17) were greater than 1.0 for most sea sediment samples. Over-stressing such foundation soils can result in rapid large displacement failures with little to no hint that a failure is about to occur.

To check the capability of the sea sediments to support fill for the berms, a series of stability analyses for the end-of-construction condition were performed. The assessment considered various thicknesses of berm fill, four slope inclinations, and various depths of weak sediments. A factor of safety of 1.5 was chosen for the during-construction and immediately following construction loading condition. The results of the stability analyses are presented on

Plates 8 through 11. These charts present the undrained shear strength required to achieve a computed factor of safety of 1.5 for fill loads only. These same charts also represent the undrained shear strength needed to achieve a computed factor of safety of 1.3 for fill loads plus a 125 psf surcharge on the berm crest, which provide an allowance for moderate construction equipment traffic.

In the above analyses, the site fill was assumed to have a moist density of 115 pounds per cubic feet (pcf). The fill was assumed to have the same strength as the underlying foundation soils. These simplifying assumptions permitted use of stability charts developed by Taylor and modified by Janbu and others. The method of incorporating surcharge pressures in the analyses was modified slightly from the influence charts as presented in Design Manual 7.01, Figure 4, (Page 7.1-321, September 1986) by Naval Facilities Engineering Command.

When using the stability analysis charts on Plates 8 through 11, one needs to first estimate the settlement that may occur and add it to the total height of the berm above the existing grade. This settlement estimate may be made using Plate 6. Then using the appropriate plot for that total berm height from Plates 8 through 11, the required slope inclinations can be assessed for various foundation shear strengths.

For example, assume that the existing site is at Elevation -231 feet and that the thickness of soft sediments is 6 feet. The design berm crest elevation (post settlement) is Elevation -226 feet. The design berm height (post settlement) is 5 feet above the original grade. From Plate 6, a total fill thickness of 6.2 feet is predicted. The total berm height to be used in the stability charts is 6.2 feet. From the stability charts, for berm heights of 6 feet and 7 feet and a depth to base of soft sediment of 6 feet, shear strengths of 170 psf and 190 psf, respectively, are needed for 3H:1V slopes and 130 psf and 145 psf are needed for 6H:1V slopes. Interpolating and rounding for a 6.2 feet high berm indicates that a 175 psf shear strength is needed in the foundation soils for a 3H:1V slope, and 135 psf is needed for a 6H:1V slope. In this manner, the settlement and stability charts can be used for selecting berm geometries, depending on the strength of the foundation soils. Site specific selection of appropriate berm geometries will require measuring the shear strength of the foundation soils at frequent intervals.

Applying the above procedure to the shear strengths of the four elevation terrains (see Plate 7) indicates that, in general, 3H:1V slopes can be used where the existing site is above Elevation -229 feet. Similarly, 3H:1V or 6H:1V slopes can be used in about two-thirds of the area where the existing site elevation is between Elevations -229 feet and -231 feet as discussed earlier in the Foundation Strength and Berm Geometry section.

For the steady state seepage (long-term) conditions, three upstream (inboard) slope profiles were checked: a 4 feet high 3H:1V waterside slope, a 6 feet high 6H:1V waterside slope, and an 8 feet high 10H:1V waterside slope. Typical cross-sections are presented on Plates 12 through 15, Design Geometries A through C. For the downstream (outboard) slope on each of these three profiles, a 3H:1V slope was used for the upper 1½ feet of slope height with a 10H:1V slope used for the balance of the downstream slope. This flat downstream slope will act as a seepage berm, discussed in a separate section. For effective stress parameters, an angle of internal friction of 27 degrees and zero cohesion was used for both the berm embankment and the underlying sea sediments. The water surface in the pond was modeled at two feet below the berm crest. The phreatic surface was modeled as a straight line from the edge of the pond on the upstream slope to the toe of the 10H:1V downstream slope. Computed factors of safety for steady state seepage are summarized in Table 2, Factors of Safety for End-Of-Construction, Long-Term Seepage and Rapid Drawdown Conditions. The computed steady state factors of safety are in an acceptable range in our opinion.

Table 2: Factors of Safety of Stability
End-Of-Construction, Long-Term Seepage and Rapid Drawdown Conditions

Design Geometry	Pond-Side Slope (horizontal to vertical)	Ground Elevation (feet)	Thickness of Sea Sediments (feet)	Factors of Safety		
				End-Of-Construction[1]	Long-Term	Rapid Draw-Down
A	3H:1V	-230	6	1.5	1.8	1.2
B	6H:1V	-232	8	1.5	3.4	1.8
C	10H:1V	-234	8	1.5	5.0	1.9

Note:
(1). Undrained strengths used in the end-of-construction cases (with a factor of safety 1.5) for Design Geometries A, B and C are 155, 170, and 135 psf, respectively.

Table 3: Factors of Safety of Stability
Pseudo-Static Condition[1]

Design Geometry	Pond-Side Slope (horizontal to vertical)	Ground Elevation (feet)	Thickness of Sea Sediments (feet)	Factors of Safety – Pseudo-Static [2]	
				Upstream (Inboard)	Downstream (Outboard)
A	3H:1V	-230	6	1.7	1.5
B	6H:1V	-232	8	1.4	1.3
C	10H:1V	-234	8	1.3	1.2

Note:
(1). In each pseudo-static case, a horizontally seismic load of 0.15g is applied in the analysis.
(2). Greater of the undrained strengths used in the end-of-construction cases or the strengths calculated using a S_u (undrained strength) / P_o'(effective overburden pressure) ratio of 0.3 are used in the pseudo-static stability analysis. No strength reduction due to sensitivity of the on-site sea sediments or strength increase due to short term loading is used in our analysis.

A pseudo-static stability analyses, using consolidated strengths, was performed using a 0.15g horizontal inertial force to represent seismic loading. The consolidated undrained strength was modeled using S_u/P_o' ratio of 0.3, where S_u is the consolidated undrained strength and P_o' is the effective overburden pressure. A minimum undrained strength of 400 psf was applied to berm fill. The results of the pseudo-static analyses are summarized in Table 3. Although the computed factors of safety are in an acceptable range, during a large earthquake substantial reduction in strength is likely to occur where loose cohesionless sand exists within the foundation soils. If liquefaction occurs, the embankment foundation is at risk of failing. This is discussed later in this report.

Rapid drawdown analyses were performed for the three upstream (inboard) profiles described above. The effective strength envelope used an internal friction angle of 27 degrees and a zero cohesion intercept. Undrained shear strengths ranged from 135 to 170 psf. The results of the rapid drawdown analyses are presented in Table 2. The computed factors of safety for rapid drawdown are in an acceptable range in our opinion.

H. Seismic Performance of Berms

Sand, silty sand, and sandy silt were encountered at some of the exploration locations. Standard penetration testing was not performed during our investigations except for the two soil borings drilled at the planned pump stations, 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 major seismic sources close by, sandy materials with little to no cohesion are likely to liquefy during a large nearby earthquake. Some 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 lead to a piping failure through the berm. Berm settlement and deformation could also lead to overtopping of the berm.

The pseudo-static analyses indicate slope stability factors of safety of 1.2 or higher. However, seismic shaking during a large earthquake may strain the sensitive clayey soils with high liquidity indices beyond their peak strength. Considerable loss of strength may occur, potentially resulting in lateral deformation, slumping of the berm crest, and a breach of the berm.

We believe that the consequences of berm failure are not likely to include significant property damage beyond that of the ponds, and chance of injury or death from berm failure is very low. For this reason, a more detailed seismic risk analyses was not warranted in our opinion.

For the purpose of assessing the economic impact of a seismically-induced berm failure, we judge that an annual chance of occurrence may be about 2 percent.

Seismic performance of the planned pump stations and associated facilities are discussed later in the Pump Stations section.

I. Shrinkage and Expansion Potential

The Atterberg limits in the sea sediments commonly show a liquid limit above 40, with a maximum liquid limit measured at 86. The in-situ moisture contents are commonly above the liquid limit in the sea sediment. These trends can be seen on Plate 17, in which the in-situ moisture content is plotted relative to Atterberg limits. Materials with liquidity indices significantly above 1.0 (in-situ moisture content exceeds the liquid limits) can transform into a thick slurry of very low shear strength upon remolding. This characterization (thick slurry) reinforces the importance of not over-stressing the foundation soils during berm construction.

The high in-situ moisture contents also indicate that a great deal of shrinkage will occur when these high plasticity clay soils dry. As the Sea level falls and the sea sediments become exposed, cracking is observed on the surface of the playa. We estimate that these cracks extend at least 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. 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. These cracks could become potential seepage paths beneath the planned berms, adversely affecting the ponds ability to hold water, and posing a risk of internal erosion (piping). Although the weight of the berms will compress the surface soils and close some of the cracks, it is not expected to completely eliminate the cracks nor considerably reduce the internal erosion potential. When sea sediments that have a dispersive character are used for constructing berms without filters, piping may occur. Characteristics and problems of dispersive sea sediments are discussed in the Appendix E.

J. Seepage Control Measures

Two major risks associated with seepage through and beneath containment berms include increased make-up water requirements and risk of internal erosion (piping) that could lead to a breach. Seepage can occur through the more permeable materials (sand) and along cracks. We address the permeable materials first, followed by risks associated with cracking in the foundation soils.

To assess whether a cutoff was warranted to limit the quantity of seepage through permeable foundation materials, estimates were made of horizontal seepage losses through the berm and its immediate foundation. The analyses considered sandy zones extending 6 feet below existing grade. This is to represent an average depth to the first aquitard, recognizing that the thicknesses may be greater in some areas and less in others. This model is not intended to address potential seepage losses through shrinkage cracks or through the bottom of the ponds. Losses recorded on other large ponds in the region and monitoring the dropping water in the bay may be used to assess the total infiltration losses from the ponds.

Vertical permeability values for sand and silty sand were estimated using the Kozeny-Carman relationship. Ratios of vertical to horizontal permeability values of 0.25 and 0.10 were used, that is, the horizontal permeability values were assumed to be four and ten times of the vertical permeability values. Vertical permeability values of 3 x 10^{-3} cm/sec and 3 x 10^{-4} cm/sec were used for sand and silty sand, respectively. The permeability values for the remaining materials were estimated based on available data with similar soil conditions and common correlations to material type and gradation. For purposes of estimating seepage through the berm and the foundation soils, the permeability values presented in Table 4 were used in our analyses.

Table 4: Permeability Estimates for Conceptual Design

Material Type	Vertical Permeability cm/sec	Horizontal Permeability cm/sec
Sand (SP)	$3x10^{-3}$	$1.2x10^{-2}$
Silty Sand (SM)	$3x10^{-4}$	$3x10^{-3}$
Recent Sea Sediment	$3x10^{-6}$	$3x10^{-5}$
Holocene Lacustrine Deposits	$3x10^{-6}$	$3x10^{-5}$

Several variations of materials for berm and berm foundations were analyzed. We used the computer program SEEP/W as well as hand drawn flownets and simplifying models. The seepage loss laterally through the berms and shallow foundation soils are estimated to average about 0.02 gallons per minute (gpm) per foot of containment berm alignment. Extrapolating this estimate to 23,000 feet of perimeter berm and a pond area of 640 acres indicates that an annual water loss of about 14-inches in the ponds might be attributed to lateral flow through the berm and its shallow foundation soils.

In discussion with the design team, we judged this value to be small relative to the combination of evaporation losses, the balance of the infiltration beneath the pond, and the desire to cycle the pond volume several times per year. We concluded that no special treatment of the sandy soils within the foundation or the berm was warranted for the purpose of controlling the quantity of seepage losses. Again, the above evaluation did not consider seepage through existing shrinkage cracks.

Existing cracking was observed on the surface on several sections of the planned berm alignment. The cracking is due to the material settling out in a very loose state at high moisture content. As the site was dried from the sun, the soils lose moisture content, shrink, and create the cracking pattern. The cracks interconnect, creating a potential seepage path that could extend beneath the berm. In the areas where the shrinkage cracks have occurred, the material is primarily an erodible non-plastic silt or dispersive clay. Seepage through the cracks could transport some of this material causing internal erosion which eventually could lead to a breach of the berm. Common methods for controlling seepage include cutting off the seepage upstream of the berm or collecting the water in a filter material on the downstream side. We believe for this site a combination of these two methods would be appropriate.

On the upstream side, an inspection trench backfilled with low permeability soil could be used for disrupting the continuity of the seepage path. The inspection trench would be excavated through the existing subgrade down to below the base of the shrinkage cracks, if encountered. The excavation would then be backfilled with a compacted lean clay. The clay will need to be moisture conditioned to a stiffness that allows it be remolded. Some experimentation in the field will be needed to determine this stiffness.

One method for excavating and backfilling an inspection trench could be by using two excavators, one doing the excavation and the second following it with a wheel roller compacting the clay backfill. The owner's representative would follow right behind the first excavator, checking for the presence and depth of cracks. A separate piece of equipment such as a loader or another excavator may be needed to place the fill between the two excavators. The length of open trench should be kept fairly short, probably less than about 100 feet. Equipment should be kept back from the side of the open trench to minimize the risk of additional load causing the trench to collapse.

In addition to the inspection trench, three other cutoff methods were considered for possible use: a geomembrane, a vertical cutoff trench, and a sheetpile wall.

The geomembrane would need to be installed as the berm is constructed. The lower end of the geomembrane would be placed in a trench excavated to below the depth of shrinkage cracking, the same depth that an inspection trench would be excavated. The geomembrane would be placed against the downstream face of the trench and subsequent berm fill. Stability concerns during the various stages of fill placement coupled with the difficulty of staging the fill made this option less attractive than other cutoff approaches.

The inspection trench and geomembrane approaches to a seepage cutoff would only be applicable as part of initial construction. Both the slurry trench and sheetpile walls are suitable for remedial action.

A vertical cutoff trench would extend through the berm fill and into the foundation soils. The vertical cutoff trench excavation will likely need to be laterally supported by slurry trench methods. Attapulgite clay in lieu of bentonite clay would be needed for the slurry due to the saline environment. Even with the use of attapulgite, only fresh water from IID canals should be used in making the slurry. The vertical cutoff trench would be backfilled with a low slump soil-attapulgite mixture. Whether or not it is used for initial construction, the vertical cutoff trench should be considered for maintenance and emergency response. It could take a more simplified form during an emergency.

Once the ponds are containing water, if local seepage is identified and is judged to be putting the berm at immediate risk of failure, a simplified (and less reliable) form of a vertical cutoff wall could be made. This would consist of partially excavating a trench on the berm crest, parallel to the berm axis, adding pre-mixed attapulgite-water slurry, then excavating deeper, keeping the soil within the trench. The excavator bucket would be used to remix the soils within the trench. This can be an inexpensive method to immediately disrupt a seepage path and control seepage.

An interlocking sheetpile wall, coupled with the use of an interlock sealant, could be driven from the berm crest to create a cutoff wall. The sheetpile wall can be used as part of the initial design or as a remedial measure. Sheetpiles are well-suited for controlling seepage in areas where displacement fill methods are used to construct the berm. Displacement methods are most likely to be used within the existing bay for the berm that will separate the two ponds. The very nature of how a displacement embankment is constructed puts it at higher risk of a piping failure than a methodically compacted embankment. The interior displacement berm can be tested by initially filling one pond and observing seepage on the dry-side face. If it appears the displacement berm is not performing well or if a breach occurs, a sheetpile wall may be placed down the axis of the displacement berm. The sheetpiles would likely need to be in the range of about 20 feet long to penetrate into the medium stiff to stiff alluvium beneath the weak sea sediments. Non-corroding sheetpile material, such as vinyl, would be needed. The interlocks should be treated with a sealant prior to driving.

Erosion of silts and dispersive clay soils through embankments can be controlled by a downstream seepage berm that will act as a filter. A downstream seepage berm with a 10H:1V slope consisting of sandy soils is a preferred method to reduce risk of piping for most of the berm alignment. The seepage berm would consist of sand excavated from on-site sources. By selective grading, sand sources can be found on-site that are already at a gradation that will capture the erodible material, minimizing the risk for a progressive failure. The primary design factors for the seepage berm are (1) that it function as a graded filter relative to the fill that makes up the upstream portion of the berm and (2) that it be more permeable than the upstream fill material. The seepage berm will need to have a flat slope to contain the phreatic surface within the berm. A 10H:1V slope is being used for design and is expected to be generally suitable. The computed exit gradients are small and the toe of the 10H:1V slope should be stable. However, once the pond is filled, if seepage exiting within the 10H:1V slope were observed along with some movement of the sand materials, some additional sand fill would be needed near the toe of the seepage berm. Locally, geotextile wrapped around a clean sand may be used at the toe of the seepage berm to control particle movement.

K. Existing IID Levee

An existing IID levee borders the project site to the east. This segment of the IID levee appears to be in fair condition and will be used as part of the berm embankment of the New Delta East pond. The existing levee is about 8 to 12 feet tall (with crest elevation at -222 feet) and has a crest width of about 25 feet. The levee slopes are inclined at about 1.5H:1V or flatter on both sides. The levee crest is currently used as an access road. Other than a widening at the corner to increase the turning radius, we understand no improvements will be performed for this levee reach.

L. Existing New River Levees

The east bank of the New River borders the site on the west and south. The New River east bank levee appears to be in poor condition. Deep pot holes and very loose surfaces were observed during our site visits in 2011 and 2013. A portion of the levee to the south of the project failed in 2012.

While the levee of the east bank is typically higher than on the west bank, in some stretches the reverse is true. To reduce the risk of the New River breaching the east levee, the low areas are being raised and some of the higher sections on the west bank levee will be lowered. For those sections where the east bank levee crest is to be raised, the downstream (landside) slope will be excavated and a new levee slope will be constructed of low permeability core fill. The existing material excavated will be re-purposed elsewhere on the project. The slope re-construction will be limited to keeping 4 feet back from the upstream (riverside) slope and not excavating below the river stage at the time of the work.

The proposed New River east bank berm improvements will reduce the risk of overtopping and reduce the risk of through-seepage exiting on the downstream (landside) slope face. Underseepage will still occur and the seismic reliability remains low. Risks at unimproved sections will remain unchanged.

M. Water Control Structures and Pipelines

Pool levels in the ponds will be maintained at Elevation -228 feet. Water control structures (WCS) consisting of weirs and pipelines will be constructed to control pool levels. The weirs and pipes will be sized to pass the design rainfall event concurrent with design pumping capacities from the New River and Saline Water Pump Stations.

Supply pipelines from the mixing box into the two ponds will cross the berms with the pipes placed at least 0.5 feet above the planned pool elevation of Elevation -228 feet. Outlet pipes of the WCS will be placed in trenches with the bottoms of the pipes at or below Elevation -234 feet. The pipes need to be designed to counter-act buoyancy uplift of the empty pipes.

Settlement beneath the pipelines and weirs would occur when the underlying soils consolidate under the loading from berm fills and/or weir structures. To minimize settlements, the locations of weirs and pipeline crossings could be sited in high ground areas where less thickness of fill for raising grade would be needed. To further reduce the potential of settlement, the sites of the WCS and outlet pipes can be pre-loaded by constructing the berm embankments plus several feet of surcharge fill to pre-consolidate the ground. A temporary horizontal drain installed within the planned pipeline and WCS footprint would aid in accelerating the consolidation. With the horizontal drain, consolidation settlement is expected to be complete or nearly complete within 4 months. If sea sediments are thicker than 6 feet, the surcharge fills may need to be in place longer. If surcharge fills greater than 4 feet thick are used, they may need to be placed in stages to avoid overstressing the foundation soils. The thickness of sea sediments will need to be checked at the WCS locations.

Once consolidation is complete, the WCS and outlet pipes can be installed. A benched excavation would reduce the risk of tension cracks forming through berms when excavating for the outlet pipeline.

Poorly compacted fill beneath the haunch of a pipe can become a seepage path that could lead to internal erosion and an eventual piping failure of the berm. To reduce the potential of internal erosion, CLSM can be used to backfill beneath and around the outlet pipelines where proper compaction is difficult to achieve. The CLSM needs to be used for outlet pipeline backfill from the weir on the upstream side to the far side of the berm crest. Downstream (outboard) of the core berm, a graded sand filter is needed to retain soil particles if a concentrated seepage path develops.

The WCS located in the planned inner berm between the two ponds could have differential water head in either direction. At this location, CLSM needs to be used to backfill beneath, around and above the pipe for its entire length. If groundwater is encountered during excavation, shoring and/or dewatering will be needed.

The intake pipeline from New River will be installed between a bulkhead wall / intake structure on the New River levee slope and a wetwell on the land-side of the New River levee. The bulkhead, wetwell, and pipeline excavations will need to be shored by sheetpiles. The seepage gradient between the ponds and the New River will reverse direction, depending on the stage in the river. With the pad elevation around the New River intake sump near the same elevation as the New River berm crest, a seepage induced failure from the river toward the ponds at this wide embankment location is not likely. As the New River drops in future years, the seepage gradient toward the river has potential to lead to a loss of ground from internal erosion. The two-thirds of the intake pipe length closest to the sump needs to be bedded and backfilled in CLSM to restrict seepage. The one-third closest to the intake headwall in the New River needs to be bedded in a sand filter to capture seepage with minimal fines migration.

N. Habitat Islands

Several habitat islands for bird nesting and loafing will be constructed within the ponds. The main concerns for siting the habitat islands will be accessibility for construction equipment and the strength of the underlying sediments to support the islands. The habitat islands need to be located where land-based equipment can access the site, provided doing so also meets other habitat protection criteria. It would also be desirable to site the habitat islands where the existing ground is high. Constructing the habitat islands in the high areas will minimize the quantity of fill needed and reduce the risk of instability of the fills.

If the habitat islands are sited in high areas that would be accessible by light-weight LGP equipment, the islands could be constructed using surface materials from the adjacent playa. Hydraulic sand fills pumped by dredge equipment from the on-site borrow could also be used for construction of the islands. The range of construction methods for the islands will likely be the same as those for berm construction discussed earlier in this report.

The size of the habitat islands will vary from about 1/3 acre or less to 2 acres. The height of the islands would vary from 3 feet (for loafing islands) to 21 feet (for tall or large islands) above existing grade.

Tall habitat islands will be constructed in the high-ground area at existing Elevation -229 feet or higher. No deep subsurface exploration was done for the large islands. Assessments of stability and settlement are based on shallow hand auger borings and interpretation of the geomorphic processes that created the current site condition. Stability analysis for the end-of-construction condition was performed for the tall islands. Initial undrained strength of 300 psf and thicknesses of 6 to 9 feet were assumed for the foundation soils / sea sediments. The soil model with the 6 feet thick sea sediment zone was assumed to be double drained. The soil model with the 9 feet thick layer was assumed to drain on the top, with impeded drainage below the layer. A drainage path of 6 feet was used for the second model. The alluvial soil underlying the sea sediments were assumed to be stiff. Limiting slip surfaces were assumed to only occur at or above the top of the alluvium.

To achieve a minimum stability factor of safety of 1.5, an initial fill no more than 10 feet thick with a slope of 3H:1V can be placed initially. In our analysis, we assumed that additional (or a second stage) fill will be placed at least 6 months after placing the initial fill. To estimate strength gain of the foundation soils over time under the initial fill loading, a C_v of 20 feet squared per year was used. For the first soil model (Model 1), consolidation would be essentially complete within 6 months. Using the second model (Model 2), only about 50 percent of the excess pore pressure from the initial fill will have dissipated from the center portion of the weak foundation soils within 6 months of placing the fill. A S_u/p (undrained strength over effective overburden pressure) ratio of 0.3 was used to estimate the undrained strength of the foundation soils. To take advantage of strength gain from the fill loading, we assumed the fill to be placed in the second stage of filling (after 6 months) was stockpiled on the face of the initial fill. This will aid in strengthening the weak foundation soil.

We analyzed different island slope configurations using Soil Models 1 and 2 for tall habitat islands with the same island footprint, including terraced slopes (see Plate 19). Soil Model 2 was used in the screening. The results were discussed with the project team, and a 2-stage, wide single terrace configuration was selected. The computed factor of safety of the selected configuration is greater than 1.5 using Soil Model 1 and 1.3 using Soil Model 2. We conclude that the islands can be raised to a maximum of 21 feet above initial grade (to a crest at Elevation -208 feet where existing grade is Elevation -229 feet). The configuration and associated factors of safety were accepted by the design team. The islands need to be constructed in two stages with material for the second stage fill temporarily stockpiled against the face of the initial fill. The temporary stockpile will surcharge the ground beneath the toe of the final slope. As the surcharge is removed for reuse the upper fill, the final slope below the terrace would be cut at 2H:1V. This steep lower slope is needed to balance the weight of the second stage fill. The setback distance for the second stage fill (or terrace width) will need to be at least 26 feet, measured from the top of the 2H:1V cut slope below the terrace to the toe of the upper slope. The upper portion of the islands need to be constructed using a minimum 2H:1V slope and a maximum crest width of 10 feet. The crest can be wider only if the crest elevation is lower than Elevation -208 feet.

Settlement of about 1 foot may occur in 6 months after the initial fill. A total settlement of up to 2 feet (including the initial settlement of 1 foot) is expected after completion of construction of the tall islands to a crest at Elevation -208 feet. The crest should not be overfilled to allow for settlement.

Habitat channels (with the channel bottom at Elevation -234 feet) will be dredged or excavated near the slope toe of the tall islands. To avoid the adverse impact on the stability of the islands, a minimum channel setback distance (clear zone) of 30 feet, measured from the top of channel slope to the toe of the islands' slopes will be needed. If the channels are to be excavated before the second stage of filling (at least 6 months after initial filling), the setback distances need to be measured from the toe of the temporary surcharge fill.

O. Pump Stations

1. Saline Water Pump Station

The Saline Water Pump Station will be located on a pile-supported pier within an excavated intake basin at the current edge of the Sea. Piles for the Saline Water Pump Station pier can develop axial capacity by skin friction in the soils beneath the base of the intake basin excavation. The pier will be high above the excavated mudline, and batter piles will likely be needed to control lateral movements and resist lateral forces. Soil parameters for assessing axial compression and tension and lateral capacity through pile bending are provided in the Recommendations section.

The loose, non-plastic silt and sandy silt that will be exposed in the intake basin slope cut may liquefy during a large earthquake. This could result in large lateral displacements in the submerged cut slope, potentially leading to failure of the pier structure. For the balance of the SCH Project, the consensus has been that the project would accept this type of risk. If SCH facilities were damaged during a large earthquake, the judgment has been that it would be more cost effective to plan to reconstruct earthquake damaged areas than to reduce that risk by strengthening the entire project. Stability of the cut slope at the saline intake pier likely falls into that same category of risk taking. Making slopes earthquake resistant can be expensive and, if done, would probably be limited to an area that is beneath and a few feet beyond the footprint of the pier. If a decision was made to reduce the risk of slope movement, the soils beneath the pier could be improved using compaction piles, deep soil mixing, jet grouting, or other techniques. The most efficient method would likely be installing additional piles at the same time that the pier foundation piles are being installed but the additional piles would be for slope strengthening only.

2. New River Pump Station

The New River Pump Station includes a bulkhead wall sited near the existing toe of the New River channel slope, a wetwell between the New River levee and the SCH ponds that will house the pumps, and a buried horizontal pipeline extending from the face of the bulkhead back to the wetwell. The existing New River channel slope is inclined at near 2.5H:1V. Steepening the slope would increase the risk of slumping and should be avoided. Slopes along the New River channel have a high risk of failing by liquefaction during a large earthquake. The depth zone most susceptible to liquefaction at the New River Pump Station site extends down to near Elevation -244 feet, with very stiff clays found beginning two feet deeper. In the event of a liquefaction induced ground failure, the distressed zone may extend back to the planned pump station location. As with the Saline Water Pump Station, the risk of distress at the New River Pump Station can be reduced by ground improvement, such as deep soil mixing, jet grouting, or compaction piles.

The New River pumps will discharge into a distribution box that also receives water from the Saline Water Pump Station. The bulkhead, pipeline and wetwell excavation will need to be shored by sheetpiles to isolate the excavation from New River (and from groundwater). Though there remains some deeper zones of potential liquefaction, removing and replacing the weaker soils above Elevation -246 feet with well-compacted soil would greatly reduce risks of ground movement during an earthquake. If the weak soils are not removed from beneath the bulkhead, the bulkhead would need to be supported on pile foundations. The toe of the bulkhead will need to be protected from scour, which could cause loss of lateral support to the bulkhead and undermine the pipeline. Sheetpiles driven to protect the excavation may be left in place to provide the needed scour protection.

The New River wetwell will be supported on a deep mat foundation. The distribution box will be supported on a shallow mat foundation. To reduce the impact of differential settlement, the wetwell and distribution box need to be two independent structures. While there may be no new loading to cause settlement, the potential for 1-inch of differential settlement between the two structures should be considered in design. To minimize potential pipe stress due to differential settlement, the two structures could be located many feet from each other.

A crane with a long reach will be needed to install sheetpiles and foundation piles at the toe of the New River channel slope. Crane outriggers will need to be setback a safe distance from the top of the loose sand channel slope, or piles may be driven to support the outriggers. One alternate configuration for the New River Pump Station could include mounting the pumps on a pile-supported pier in New River, similar to that used for the Saline Water Pump Station. Another alternate configuration could include placing the wetwell at the location of the bulkhead, limiting the deep excavation to the in-stream wetwell. The wetwell would be accessed by a pile-supported pier which would also support the discharge pipeline.

3. Seismic Design Parameters for Pump Stations

No known active faults pass beneath the two pump station sites, and we conclude that the risk of fault rupture is low. The predominant seismic hazards for this site are liquefaction and strong groundshaking. As discussed above, the project is not currently being designed to prevent widespread liquefaction, which may occur at both pump station sites. Ground failure may occur. Regardless of liquefaction risks, the pump stations should be designed to accommodate groundshaking in accordance with existing codes.

In assessing the appropriate Site Class, the risk of liquefaction itself does not trigger a Site Class F determination. If a structures fundamental period of vibration is less than 0.5 second, the Site Class can be determined based on stiffness of the soils within the upper 100 feet. We assume that the pump station structures will have short periods and that this exception applies. Using the stiffness screening in the upper 100 feet, we believe that both pump station sites are borderline sites in this regard. The weighted average shear strengths are greater than 1,000 psf in the lower portions of both sites (beneath the intake basin at the Saline Water Channel site and beneath the toe of the New River channel slope). The weighted average shear strengths are lower than 1,000 psf near or behind the top of the slopes. We conclude that Site Class D should be used for facilities within the intake basin (including the pier) at the Saline Water Pump Station site and for facilities on or at the base of the New River channel slope. We conclude that Site Class E is appropriate outside the intake basin at the Saline Water Pump Station site and outside the New River channel at the New River Pump Station site.

The mapped seismic acceleration parameters S_S and S_1 in Table 5 are calculated based on ASCE 7-10 and using the USGS website calculator.

Table 5: Mapped Seismic Acceleration Parameters S_s and S_1

Pump Station	Latitude	Longitude	S_s	S_1
Saline Water	33.13975	-115.66633	1.526	0.600
New River	33.11436	-115.68810	1.516	0.600

P. Saline Water Channel

Several pieces of data exist offshore which may be used to assess the slopes and dredging conditions along the Saline Water Channel alignment. These include a 1947 aerial photograph, a 1974 a joint state and federal feasibility investigation for the Salton Sea Project, a 2004 In-Sea geotechnical investigation by URS, recent (January 2011) bathymetry by Scripps Institution of Oceanography, and October 2011 vibracores near the Alamo River and New River conceptual SCH sites, and a 2013 geotechnical investigation boring (Boring 112HS) for the Saline Water Pump Station. We believe that the elevations in each of these investigations refer to NGVD1929, the same used for the SCH Project.

The 1947 aerial photograph (Plate 20) shows the shoreline of the Sea approximately one mile offshore of the current shoreline. At that time, the Sea level was approximately Elevation -241 feet.

A series of 1972 probings, several borings and bathymetry were done by a joint state and federal investigation dated 1974. Two summary maps of the data are presented on Maps 13 and 14 (Appendix H). Some of the individual probe data on Map 13 is difficult to read. However, contours of the top of firm material are shown on Map 14, summarizing the probe data. The Map 14 contours are shown overlaying the Saline Water Channel alignment on Plate 21.

In 2004 URS conducted an In-Sea investigation. One boring (Boring 14) and two cone penetration tests (CPT-13 and CPT-15) were drilled on a line parallel with the Saline Water Channel alignment, but about 2.5 to 3 miles to the east. Boring 14 from that investigation was drilled at a distance from the existing shoreline about equal to that of the proposed seaward end of the Saline Water Channel. The mudline was at approximate Elevation -250 feet. The log of Boring 14 indicates 8 feet of soft to very soft silt and lean clay with one recorded shear strength of 200 psf. This material overlies soft to medium stiff clays and silts and loose to medium dense very fine silty sand from Elevations -258 feet to -293 feet. At a depth of 43 feet (Elevation -293 feet), very stiff fat clay was encountered. CPT-15 was located further offshore near mudline Elevation -270 feet and encountered very low tip resistances. CPT-13 was conducted south of Boring 14, approximately opposite the mid-section of a planned Saline Water Channel (but 2.5 miles east). Tip resistances in the range of 10 to 24 tons per square foot were recorded in the upper 7 feet. If very soft sea sediments similar to those described below from the vibracores had been encountered, the tip resistance would have been negligible. The data from CPT-13 data suggests that very soft sea sediments are absent from that location. There remains a possibility that sea sediments were present at a higher elevation but were so soft as to not be detected.

The mudline at our 2011 vibracores locations were between Elevations -232 feet to -234 feet. Sea sediments were up to 8 feet thick. Sea sediments at many of the vibracore locations had low shear strengths as measured by a hand operated vane shear device. The vane shear strengths are summarized on Plate 24.

We drilled a boring from the top of the levee near the planned Saline Water Pump Station in 2013. Assuming the original ground prior to construction of the levee was near Elevation -238 feet, the boring indicates approximately 18 feet of loose sandy silt and soft to medium stiff silt and clay. These materials are judged to be similar to those identified below Elevation -271 feet in CPT-13 and between Elevations -271 feet to -293 feet in Boring 14. Below Elevation -256 feet in Boring 112HS, stiff to very stiff fat clay was encountered.

The most recent (2011) bathymetry was by Scripps Institution of Oceanography. The bathymetry in the area of the Saline Water Channel is shown on Plate 22. The two bathymetry maps (1972 and Scripps) are shown overlaying each other on Plate 23. Bathymetry profiles for both the 1972 and more recent Scripps survey along the planned Saline Water Channel alignment, together with the 1972 top of firm material, are presented on Plate 25. Along the Saline Water Channel alignment within about 8,000 feet of the existing shoreline, the bathymetry suggests that the mudline was generally 2 to 3 feet higher in 1972 than it was in 2011 as measured by the Scripps survey.

One possibility for the differences in mudline elevations may be differing accuracies and/or precisions of the methods used. Another possibility is that the very weak sediments noted in 1972 may have been resuspended by the cyclical loading during large wind-driven wave events. If the former is true, we would characterize the site using the thickness of very soft sediments as measured by the 1974 study. Assuming that the Scripps bathymetry is more accurate, we would apply the depth of the very soft sediment below the Scripps mudline. If the latter explanation is true, we would conclude that most of the soft sediments have been eroded form the Saline Water Channel alignment out to about 5,000 feet offshore. Beyond that distance, the 1972 probes indicate that the soft sediments become thicker.

We propose that three models be considered for both design and bidding the Saline Water Channel. The three models would include: (A) only minor thicknesses of soft sea sediment out to about 5,000 feet offshore, then becoming progressively thicker further offshore; (B) an average soft sediment thickness of 2 feet out to about 5,000 feet offshore then becoming progressively thicker; and (C) an average soft sediment thickness of 5 feet out to about 7,000 feet offshore then becoming progressively thicker. These three models are shown on Plates 26 through 28. On each of these plates, we show the 1972 bathymetry and depth to firm material for reference.

Upon award of the construction contract, one of the dredging contractor’s first tasks would be to confirm depth, thickness, and strength of the materials along the Saline Water Channel alignment.

Q. Geotube Applications

Geotubes may be suitable for select applications. Geotubes would have the same bearing capacity limitations as steep-sided fills. Geotubes would not be able to stand alone and work as water retention structure in the weak areas of the project site. A geotube of limited height can be used as shoreline protection for berms constructed in the submerged areas or at the seashore (approximately Elevation -232 feet). A stand-alone geotube can be considered where the existing ground is strong enough to support the geotube without a stability berm.

On-site sources of sand and silty sand fill from the northwestern corner of the site are suitable for filling the geotubes. These materials are also suitable for constructing berms by hydraulic filling. If berm fill is to be placed hydraulically, geotubes could be used as containment structures to control outwash/sedimentation from hydraulic filling if direct discharge to the Sea is not allowed. Three conceptual designs of geotube applications are discussed below and are shown on Plates 29 through 31. They include a geotube on higher ground, a geotube at the shoreline, and a geotube seawall in two feet of water.

The high ground geotube berm configuration on Plate 29 (assume about Elevation -230 feet) is suitable for use in terrains where the ground is strong enough to use 6H:1V slopes, as described in earlier sections. Fill will be placed by hydraulic filling. This design configuration consists of a 30 foot wide geotube covered with one foot fill, a 6H:1V slope on the pond side and a 10H:1V seepage berm on the sea-ward side. Erosion protection is required for the pond side slope. The geotube will need to be covered by at least one foot of fill to protect it from traffic and sunlight.

The geotube at the shoreline configuration (Plate 30) is similar to the one above except that the existing ground surface is about 2 feet lower. The geotube would be filled to a final (post settlement) height of not more than three feet above the existing grade.

The geotube seawall in two feet of water configuration (Plate 31) is applicable to those terrains that could support 10H:1V slopes as described earlier in this report. Fill would be placed by hydraulic filling. This design configuration consists of a berm core with a 3H:1V slope for the upper 1½ feet of slope height and a 10H:1V slope to the geotube for the balance of the downstream slope. The upstream slope would be 10H:1V based on the earlier criteria.

The construction sequence would likely be: (1) lay out the first geotube for a design width of approximately 30 feet; (2) place and fill the geotube to a maximum thickness of about 5 feet (but not more than 3 feet above the water surface); (3) place sandy fill hydraulically behind the geotube and across the full width of the berm; (4) place and fill a second geotube (approximately 15 feet wide) to about 5 feet above the level of the Sea to complete the shoreline protection, and (5) place additional hydraulic fill in the pond side and shape to the final berm configuration.

R. Displacement Method

As described earlier in this report, in about half of the area covered by the two lower terrains (near the existing shoreline or beneath the Sea or bay), the ground may be too soft/weak to construct the berm using uniform slopes. The berm can be constructed using "displacement method".

Where soft sea sediments will not support fill loads, the weight of the fill will create a "mudwave" as the displaced sediment are heaved up in front of and/or to the sides of the advancing fill. Intentionally creating mudwaves, also known as "displacement method", 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. The fill material could be developed by excavating clay soils from the higher portions of the site, above the Sea. Fills placed below the water cannot be compacted. As the fill extends above the water surface, the upper lifts of fill can be compacted. However, the compacted fill will be dropping in irregular sections as the foundation soil becomes over-stressed from increasing fill thickness. To create a factor of safety, the compacted fill needs to be placed four feet or higher above the design berm Elevation -226 feet. This four foot overbuild would provide surcharge to consolidate the underlying soils and reduce potential of settlement of the berms. This overbuild needs to remain in place for a minimum of 4 months, and can either be removed for use as a borrow source for maintaining the berms or be pushed laterally to make a wider berm.

This scheme for building a berm will not be suitable for retaining water without additional seepage control measures. A vertical cutoff wall or a sheetpile wall would be needed as part of the initial design.

S. Test Fill Strips

The borrow sources are stratified and varying mixtures of materials will be used. We concluded that a method specification would be appropriate for quality control when placing and compacting fill. Test fill strips are needed to develop the methods that will be the basis for acceptance for core berm fills.

Some portions of the site have weak subgrade conditions that may not directly support construction equipment. Test sections are needed to allow the contractor to check his procedure for operating equipment and placing material in these weak areas. Methods for placing and compacting fills for core berms on weak subgrade need to be developed.

Weak soils are expected in the bottom and sides of many sections of the inspection trench. Procedures for conditioning lean clay fill material for use in backfilling inspection trenches and procedures for placing and compacting the lean clay fills on the weak foundation soils need to be developed.

After checking the shear strength of weak sea sediment materials beneath the planned core berm alignment, additional strength testing will need to be done to identify test fill strip sites that are representative of the weaker areas. Test fill strips do not need to be located near a berm alignment, but if they are, they will need to be sited such that the fills for the test fill strips will not impact the permanent work.

V. RECOMMENDATIONS

A. Geometry of Berms, Islands, and Channels

1. Containment Berms

The pond containment berm configurations should be designed to account for existing ground elevations and subsurface conditions (i.e. thicknesses and strengths of sea sediments). The shear strength of the foundation materials beneath the containment berm centerline should be checked prior to selection of berm geometry. The testing locations should be spaced no greater than 200 feet along the berm alignments. Closer spacing may be needed in the weaker areas. Tests should be performed using a hand held vane shear device. A Geonor Model H-60 is an acceptable testing device. Vane shear strength measurements should be corrected for shaft friction and plasticity of the soil. Tests should be taken at 1 foot or closer depth intervals. Tests do not need to be performed in sand. Provided the tests indicate corrected shear strengths greater than 300 psf, the depth of testing may terminate at 6 feet. If lower strengths are measured, testing should continue to the bottom of the weak soils. The horizontal coordinates or stationing and ground surface elevations should be recorded for each testing location. In deciding which berm geometry to use, the shear strength used in the selection of berm geometry should not be higher than the average of the three lowest corrected measurements at a location.

The minimum side slope inclinations for the containment berms should be taken from Table 1 on page 26. A slope of 2H:1V or flatter could be used if the underlying sea sediments are removed and the berms are founded on the alluvium.

Containment berms should consist of two or three fill zones: a core berm, a seepage berm and, in weaker ground areas, a stability berm. The core berm should have 3H:1V slopes extending down from the finished crest. Seepage berms should abut the downstream (outboard) face of the core berms and be sloped no steeper than 10H:1V. Stability berms, if needed, should abut the upstream (inboard) face of the core berm and be included as determined from Table 1.

The core berm should be designed to have a minimum crest width of 12 feet at the top of the aggregate base plus the width of shore protection, as needed. The minimum crest subgrade elevation of the core berm prior to placing the aggregate base as a road surface should be Elevation -226 feet after completion of settlement. To allow for settlement after completion of grading, the subgrade elevation immediately prior to placing the aggregate base should not be less than presented in Column 6 (Minimum Finish Crest Subgrade Elevation 6 Months After Initial Fill) on Plate 6. For the access road to the maintenance pad / New River Pump Station, the minimum crest elevation should be at Elevation -225 feet or higher after completion of settlement.

2. Habitat Islands

Tall habitat islands should be constructed in the high-ground areas where existing grades are at Elevation -229 feet or higher. The tall islands should be built in 2 stages (minimum) with a minimum waiting period of 6 months between stages. The initial fill thickness should be limited to 10 feet. The fill to be placed in the second stage should be stockpiled against the face of the initial fill (see Plate 19) with a 3H:1V or flatter exterior slope for the stockpiled material. Upon removal of the stockpiled material for the second stage fill, a 2H:1V finish slope should be cut at the perimeter of the first stage fill. The second stage fill should be placed no closer than 26 feet from the top of the 2H:1V slope cut in the perimeter of the first stage fill when the lateral surcharge is removed. The upper portion of the tall habitat islands should be constructed using a 2H:1V slope and a maximum crest width of 10 feet. The crest elevation should be at Elevation -208 feet or lower. Except for the tall habitat islands, a 3H:1V slope or flatter should be used for other types of habitat islands, including the small habitat islands and the low loafing islands.

3. Habitat Channels

Habitat channels within the ponds should have cut slopes of 5H:1V or flatter. That habitat channels should not be cut deeper than 6 feet below the adjacent pond bottom. The top of the channel slopes should be setback a minimum distance of 30 feet from the toes of the berm or island slopes.

4. Saline Water Channel and Intake Basin

Soft sea sediments should be removed beneath and 50 feet laterally beyond the sides of the planned pier at the Saline Water Pump Station site. Sea sediments should also be removed beneath and 20 feet laterally beyond the boat ramp. The slope for the intake basin should be cut at 3H:1V or flatter. Slopes on the sides of the boat ramp should be cut at 3H:1V or flatter.

Slopes for the Salton Sea saline water channel should be cut at 2H:1V or flatter.

5. Existing New River Levee

For those sections where the New River east bank levee crest is to be raised, the downstream (inboard) slope should be excavated and a new berm slope should be constructed of core fill. The slope re-construction should be limited to keeping 4 feet back from the upstream slope and not excavating below an elevation 2 feet above the river stage at the time of the work (see Plate 18). Deeper excavation should only be made upon approval of the owner's representative.

B. Earthwork

1. Fill Materials

Common fill should be material from on-site excavations, free of debris, and containing no rocks, concrete fragments or hard soil lumps greater than 4-inches in maximum dimension. Common fill should consist of material with Unified Soil Classification System (USCS) types CL, CH, ML, MH, SP, SW, SM, SC, GP, GW, GM, GC or mixtures thereof. Common fill should be used for stability berms, temporary staging areas, large and small habitat islands, loafing bars, and those portions of new road embankments more than 3 feet below finish subgrade and not retaining water. Common fill is referred to a *stability fill* in the project specifications.

Core fill should consist of low permeability material, free of debris, derived from on-site excavations. Core fill should consist of material with USCS types CL, ML, SC or SM or mixtures thereof. The SC or SM materials should have a liquid limit less than 50 and at least 30 percent passing a No. 200 (0.074 mm) sieve. Core fill should be used for the core berm and for the existing New River berm improvements.

Lean clay fill should consist of material free of debris and derived either from on-site excavations or from approved off-site borrow sources. Lean clay fill should be a USCS type CL with a PI of at least 15 but not greater than 30. Lean clay fill should be used to backfill inspection trenches. When sources of lean clay fill are identified in borrow areas, they should be set aside for use as inspection trench backfill.

Sand fill should consist of material from on-site excavations, free of debris, with no rocks or concrete fragments greater than 4-inches in maximum dimension. Sand fill should be USCS material types SP, SW, SM or SC. Sand fill should be used for sacrificial erosion control slopes and for the upper several inches of fill on habitat islands.

Seepage fill should meet the requirements of sand fill and, in addition, should have no more than 15 percent passing a No. 200 sieve. Seepage fill should be used for the seepage berms. When sources of seepage fill are identified in borrow areas, they should be set aside for use in seepage berms.

Sand filter and gravel drain should satisfy Caltrans quality requirements for Permeable Material in Section 68-1.025, have a Durability Index of no less than 40 and satisfy the following gradation requirements.

Table 6: Sand Filter Material

Sieve Size	Percentage Passing
No. 4	100
No. 8	80 – 100
No. 16	35 – 80
No. 30	10 – 45
No. 50	0 – 12
No. 100	0 – 5

Table 7: Gravel Drain Material

Sieve Size	Percentage Passing
1 inch	100
3/4 inch	90 – 100
3/8 inch	35 – 65
No. 4	5 – 25
No. 8	0 – 10
No. 16	0 – 5

Sand filter and gravel drain materials should be used to backfill the downstream portion of the WCS outlet pipes.

CLSM should conform to Caltrans Standard Specification for Controlled

Low Strength Material. CLSM should have a compressive strength at 28 days of at least 60 psi. CLSM should be used to bed and backfill the upstream portion of the WCS outlet pipes and the connecting pipe between the two ponds.

Aggregate base should meet the requirements for Caltrans 3/4-inch maximum Class 2 aggregate base per Standard Specifications Section 26-1.02A. Aggregate base should be used for the final wearing course of all-weather roads.

Imported riprap should meet requirements for Rock Slope Protection per Caltrans Standard Specifications Section 72-2. Minimum riprap sizes should be selected based on expected wind exposures.

Geotextile should conform to Caltrans Standard Specification Section 88-1.04 for Rock Slope Protection Fabric for non-woven Type B material.

Vertical cutoff trench backfill should consist of core fill mixed with an attapulgite-water slurry and supplemented with additional attapulgite as needed to achieve a slump of between 2- to 6-inches as measured by a concrete slump test. This material would be used for backfilling in a slurry-filled trench as a remedial measure to control seepage.

At least seven calendar days prior to importing fill, the contractor should submit samples of import fill to the owner's representatives office together with the results of laboratory test data verifying the suitability of the material. The source of the import borrow area should be identified and owner's representative should be given unrestricted access to visit the import borrow area prior to and during importing operations.

2. Test Fill Strips

Test fill strips should be made to develop method specifications for placing and compacting core fill, to develop methods for conditioning lean clays and for placing them as a low permeability backfill in inspection trenches, and to confirm material handling and placement methods over weak sea sediment areas.

Sites for test fill strips should be located at least 30 feet clear of permanent improvements. Soft subgrade sites should be chosen to represent the more challenging portions of the planned containment berm alignment.

(a) Core Berm Test Fill Strips

The core berms should be compacted to at least 95 percent relative compaction, using Standard Proctor (ASTM D698) for the laboratory reference curves. The moisture content should be within 1 percent below and 3 percent above the optimum moisture content prior to compacting. Method specifications should be used to control the placement quality of the core berm fill. Prior to placing fill on the berm alignment, test fill strips should be made to verify that the moisture conditioning, material handling, lift thicknesses, type and size of compaction equipment, and the number of compaction coverages are appropriate for achieving the required compaction. The test fills should be performed on both firm and yielding (pumping) subgrades.

At least three different core berm fill materials should be tested at the test fill strips: lean clay (CL), non-plastic silt (ML), and silty sand (SM) having at least 30 percent passing a No. 200 sieve. Prior to constructing the test fill strips, laboratory testing should be performed on each of the proposed fill materials, consisting of gradation analyses including hydrometer, Atterberg limits, and compaction including both Standard Proctor and Modified Proctor. Only the Standard Proctor compaction curve should be used to report relative compaction. At least four lifts should be placed and compacted for each combination of material type, moisture content, lift thickness, type and weight of compactor, and number of compaction coverages. At least 3 field compaction tests should be performed on each of the four lifts. An independent engineering and testing firm should observe and test the fills. Each of the variants described above should be recorded along with observations of pumping, rutting, and/or cracking. Trial test strips should be performed until a methodology is developed that consistently meets or exceeds the recommended degree of compaction. Results of the test fill strip tests along with a description of the contractor's proposed methods for consistently achieving the required compaction should be sent to the project geotechnical engineer. The geotechnical engineer should review the results and the contractor's proposed methods. The geotechnical engineer should recommend to the owner's representative whether the contractor's proposed methods should be accepted for the method specification.

(b) Inspection Trench Test Strips

The final methods for preparing, placing, and compacting lean clay fill for the inspection trench should be developed as part of the test fill strips. The lean clay fill materials for backfilling the inspection trench should be moisture conditioned in the borrow area prior to hauling to the test fill strip site and placing in the trench. The lean clay fill should be kneadable and moldable. Several moisture contents and stiffnesses should be prepared, with the more malleable material placed in the trench first, followed by increasing stiffer lifts. The lean clay fill should be compacted to the point that the air voids are essentially gone and the fill is saturated. Pumping (deflection) at these moisture contents is expected. No specific degree of compaction beyond that described above need be achieved for the lean clay fill backfill for inspection trenches in soft ground areas. The project geotechnical engineer should observe and approve the contractor's proposed methods for backfilling inspection trenches in soft ground areas prior to their use beneath the berm alignment.

3. Seepage Control

(a) Inspection Trench

The alignment of the inspection trench should approximately follow the alignment of the upstream (inboard) hinge point for the core berm. Many of the areas where the inspection trench will need to be excavated may be too soft to directly support the excavation equipment. To provide suitable support for the excavation equipment, the first two to three feet of embankment berm fill may need to be placed prior to excavating the inspection trench. The inspection trench should be excavated for a minimum width of 3 feet. The trench should be excavated to below the base of the cracking. In addition to an obvious open crack, the cracking can be identified by small vertical seep zones or thin vertical sheens on the sides of the excavation. Picking at the trench wall with an adze can aid in identifying shrinkage cracks. Personnel will need to enter the trench to inspect for cracks. Worker protection that would still allow inspection for cracks should be provided. The inspection trench should be backfilled with lean clay fill using the methods developed in the test strips.

At three WCS locations where temporary horizontal drains will be installed, the inspection trench should be excavated prior to installing the temporary horizontal drains.

(b) **Seepage Berm**

Seepage berms should consist of seepage fill. Seepage berms should be placed against the downstream (outboard) face of the core berms and should extend up to at least Elevation -227.5 feet, plus a settlement allowance estimated from Plate 6. The seepage berms should have a minimum slope of 10H:1V or flatter extending down to existing grade. The seepage fill should be placed in lifts and track-walked with sufficient compaction effort to support construction equipment.

(c) **Vertical Cutoff Trench**

The vertical cutoff trench should be excavated from the berm crest as near the upstream (inboard) slope as practical. The slurry trench method should be used to retain the sides of the trench while excavating a vertical cutoff trench. The slurry should be an attapulgite-water mixture and should be assessed in a test section outside of the containment berms. The viscosity and density of the slurry should be designed to be capable of temporarily holding the excavation without causing sloughing of the trench wall or cracks in the berm. The trench should extend from the berm crest to several feet below the depth of the suspected shrinkage cracking or other suspected seepage conduit. The trench should be a minimum of 2 feet wide. Due to the narrow width of the crest, vertical cutoff trench backfill materials should be prepared at another on-site location and transported to the trench. The vertical cutoff trench backfill should be placed to Elevation -227.5 feet. Aggregate base should be placed and compacted above the trench backfill.

4. Foundation Preparation

The site should be cleared, and debris should be removed. Surface grasses and brush, if any, should be stripped to sufficient depth to remove vegetation and soil containing roots from beneath the footprint of the berm and its stability berms. Stripped and grubbed materials should be removed from the berm site and should not be used as berm fill.

If sea sediments are fully excavated from beneath the planned berm, the excavated subgrade beneath the berm embankment should be proof rolled prior to receiving fill.

In sea sediment areas where the site subgrade is not pumping, areas to be filled should be scarified to a depth of at least 6-inches and recompacted. Scarification is not required where weak sea sediment exists at or near the ground surface and the existing grade is too weak to create a base for compacting. The scarified soil should be moisture conditioned to at least optimum moisture content and compacted with a sheepsfoot compactor to the same method requirements as the core fill.

5. Placing and Compacting Fill

Prior to hauling to the berm, Core fill should be conditioned to a moisture content suitable for compaction prior to placing the material on the berm embankment. Water available locally from the nearby IID irrigation ditches should be used to moisture condition the fill. The fill should be placed in lifts 8-inches or less in loose thickness. Thinner lifts may be required, depending on the results of the test fill strips. Each lift should be methodically compacted using the equipment and number of coverages determined from the test fill strips, but not less than 4 coverages. A sheepsfoot or equivalent kneading compaction equipment that was used and approved as part of the test fill strips should be used for compacting core fill. After compaction, the fill should not be allowed to dry out. This may require periodic sprinkling. Compacted fill that has dried should be scarified, remoisture conditioned, and recompacted prior to receiving additional fill.

The lower lifts of fill near the water level may deflect (pump) under equipment loads. Mild pumping will be accepted provided the recommended compaction is achieved. If the fill surface is pumping more than 4-inches, alternative methods should be employed to place and compact fill until a more stable site surface is achieved. Such methods may include using lighter compaction equipment with correspondingly thinner lift thickness to achieve the required compaction. These methods should be developed as part of the test fill strips. If methods have not been previously approved as part of the test fill strip process, additional compaction testing should be done to confirm that the procedure(s) are effective in achieving 95 percent relative compaction per ASTM D698.

Core fill should be placed parallel to the longitudinal axis of the berm. Ramps for material haulers and other construction traffic accessing the core berm embankment should be routed at angles less than 30 degrees to the core berm axis and should be disbursed to avoid overly compacted zones (hard spots) within the core berm embankment.

Fill used for staging areas and for the New River and saline pump station areas should be compacted to at least 95 percent relative compaction for ASTM D698. Fill for tall habitat islands should be compacted to at least 90 percent relative compaction per Standard Proctor. The degree of compaction should be established by test sections for the various types of fills. These test sections may be done within the various features and incorporated into the final embankments. Results of the test sections should be the basis of method specifications for placing and compacting these materials.

ASTM test D1557 (Modified Proctor) should be used to establish the reference values for computing optimum moisture content and relative compaction for road subgrades and aggregate base. The upper 6-inches of core fill on the containment berms will be a road subgrade and should be compacted to at least 95 percent relative compaction per Modified Proctor and rolled to provide a smooth, non-yielding surface. Aggregate base should be placed in thin lifts no greater than 6-inches in loose thickness and in a manner that avoids segregation, moisture conditioned as necessary, and compacted to at least 95 percent relative compaction per Modified Proctor.

6. Erosion Protection

Erosion protection should be provided on the upstream (inboard) slopes within the ponds against the wave action, including the core berm slopes and stability berms. Two erosion protection measures for these slopes are presented as the following:

(a) Sacrificial Beach

Sacrificial beaches, if any, for erosion protection of slopes within the ponds should have a slope of 30H:1V or flatter. Sacrificial beaches should be maintained at least 2 feet above the design pool elevation (to Elevation -226 feet) extending down to one foot below the design pool elevation (Elevation -229 feet) after completion of settlement.

(b) Riprap

Riprap should be placed from 2 feet below to at least 2 feet above the design pool elevation (see Plate 16). Riprap should have of a five foot wide base and a two rock layer minimum thickness perpendicular to its face. Geotextile should be placed beneath riprap.

7. Water Control Structures (WCS) and Pipeline

Prior to placing fill for berms at the Water Control Structure and outlet pipeline locations, the site preparation and inspection trench should be accomplished. A temporary horizontal drain should then be installed within the planned pipeline footprint. The trench for the temporary drain should be at least 6-inches wide. The bottom of the drain should be between Elevations -233 to -234 feet, and it should slope toward the pond. The horizontal drain should extend from 50 feet downstream (outboard) of the core berm crest to 10 feet upstream (inboard) of the water control structure. A perforated subdrain pipe should be placed at the bottom of the drain trench and the trench backfilled with Seepage Fill. The pond end of the drain should connect to a temporary sump to allow collected water to flow to the surface or to be baled or pumped down.

Once the temporary horizontal drain is installed, the berm should be constructed. At the planned WCS and outlet pipeline alignments, the site should be preloaded by placing 4 feet of temporary surcharge fill above the design elevation of the berm and surrounding ground. The 4 feet thick surcharge should extend at least 10 feet beyond the footprint of structures and/or the axis of pipelines crossing the berm, then sloping down using a 10H:1V slope (see Plate 32). The surcharge should be in place for at least 4 months.

After the 4 month consolidation period, the fill surcharge should be removed, and the pipe trench should be excavated. The excavation should be benched at one foot above the planned top of pipe. The upper slope should be cut at 2H:1V or flatter. The bench should be at least 15 feet wide between the upper and lower excavation slopes. Below the bench, the pipe trench should be excavated at 1H:1V to 6-inches below the bottom of the pipe and one foot wider than the pipe. The temporary horizontal drain should be removed in its entirety as part of this excavation.

Groundwater, if encountered, should be drawndown to below the bottom of the trench excavation. If loose or unsuitable materials are encountered at the planned bottom of trench excavation, they should be compacted or overexcavated to expose undisturbed soil and replaced with CLSM.

CLSM should be used to backfill around the outlet pipelines of the WCS from the weir to the far (outboard) side of the berm crest. The CLSM should extend to at least 1 foot above the pipe. The pipe should be sheltered from the sun on the morning of the CLSM pour and should be kept shaded until the pipe is completely covered by CLSM. Sand filter material should be used to backfill around and to at least 1 foot above the outlet pipe beneath and beyond the downstream (outboard) seepage berm. The filter sand should be placed and compacted in lifts 8-inches or less in thickness under the full-time observation of the owner's representative. For the WCS located at the planned inner berm, CLSM should be used to backfill around and above the pipe for the entire pipe length.

Riprap should be placed in front of the weirs and outlet pipes.

At the New River Pump Station, the pipe connected between the river bulkhead and the intake structure should be backfilled with CLSM around and to at least 1 foot above the pipe for the entire pipe length.

Supply pipelines should be designed to cross the berms with the pipes placed at least 0.5 feet above the planned pool of Elevation -228 feet.

8. New River Pump Station

In areas where shallow foundations are planned, the site should be excavated down to a level that is at least 2 feet below the base of the new foundations and extending at least 5 feet outside the foundation's perimeter. The excavated subgrade should be compacted to a depth of at least 6-inches to at least 95 percent relative compaction, using ASTM D698 as the maximum density reference. If loose or soft materials are encountered at the planned bottom of the excavation such that the recommended subgrade compaction cannot be achieved, the loose or soft soil should be excavated an additional one foot and backfilled with clean crushed aggregate, compacted using a vibratory compactor and covered by a layer of geogrid. The excavation beneath shallow foundations should be backfilled with Caltrans Class 2 aggregate base placed in 6-inch lifts. The aggregate base should be compacted to at least 90 percent relative compaction (per ASTM Test D1557). The total thickness of aggregate base beneath shallow foundations should be at least 2 feet. The balance of the site grading should conform to the grading recommendations in this report.

C. Pile Foundations

1. Axial Pile Capacity

Piles should be designed to gain support for axial compression loads and tension forces from skin friction. Ignore end bearing support for preliminary calculations of pile lengths. The axial pile capacities for the two pump station sites should be calculated as described below.

At the Saline Water Pump Station, we modeled the subsurface soils as non-plastic silt with a buoyant unit weight of 56 pcf and a friction angle, Φ, of 28 degrees. We recommend that a skin friction value of 15 psf per foot of depth below mudline be used to estimate the ultimate pile capacity in compression. To resist tension forces, we recommend using 10 psf per foot of depth below mudline. Using these values, the ultimate friction in compression is 150 psf at a depth of 10 feet below the base of the excavated basin and 300 psf at a depth of 20 feet. Ultimate tension resistance is computed as two-thirds of the compression capacity. For a 7-inch tip timber pile increasing in diameter at 1-inch in 10 feet, a pile driven 30 feet below mudline would have an ultimate capacity of about 14,500 pounds. The ultimate tension capacity of the same pile would be about 9,700 pounds. A factor of safety of 2 should be used for working loads including wave forces. A factor of safety of 1.5 may be used when considering transient loads including wind or seismic forces.

At the New River Pump Station, we modeled the subsurface soils between Elevations -236 feet to -246 feet as non-plastic silt with a buoyant unit weight of 56 pcf and a friction angle, Φ, of 28 degrees. In this elevation range, we recommend using an ultimate skin friction value of 15 psf/ft of depth for compressive loads and 10 psf/ft for tension forces. In the stiff to very stiff clay below Elevation -246 feet, we recommend using an ultimate adhesion value of 1,000 psf to a maximum depth elevation of -277 feet. To resist tension forces in the clay layer, we recommend using two-thirds of the compressive resistance (or 670 psf). Factors of safety should be used with these ultimate values, as described in the previous paragraph. For a 7-inch tip timber pile increasing in diameter at 1-inch in 10 feet, a pile driven 30 feet below Elevation -236 feet (to Elevation -266 feet), would have an ultimate compressive capacity of about 49,000 pounds. The ultimate tension capacity of the same pile would be about 33,700 pounds.

2. Lateral Pile Resistance

To assess lateral pile resistance, the geotechnical parameters presented in Tables 8 and 9 should be used with the computer program LPILE Plus Version 5 or similar programs to internally compute p-y curves. The “Soil Type” names are those used in LPILE to describe the built-in soil p-y curves. The zero values are used to trigger default values within the LPILE program. We selected the “Soft Clay” and “Stiff Clay” models to characterize many of the soils logged as silt in the borings. The “Sand” model was selected where interbedded silty sand and silts were logged.

Table 8: LPILE Soil Parameters at Saline Water Pump Station

Elevation (feet)	Soil Type	Effective Unit Weight (lbs/in^3)	Undrained Cohesion, c (lbs/in^2)	Friction Angle, Φ (deg)	Strain Factor, E50	p-y Modulus, k (lbs/in^3)
-230 to -237	Stiff Clay with Free Water	0.033	6.94	-	0	0
-237 to -256	Soft Clay	0.033	3.47	-	0	-
-256 to -280	Stiff Clay without Free Water	0.033	6.94	-	0	-
-280 and below	Sand	0.033	-	32	-	0

Table 9: LPILE Soil Parameters at New River Pump Station

Elevation (feet)	Soil Type	Effective Unit Weight (lbs/in^3)	Undrained Cohesion, c (lbs/in^2)	Friction Angle, Φ (deg)	Strain Factor, E50	p-y Modulus, k (lbs/in^3)
-226 to -246	Sand	0.033	-	30	-	0
-246 to -277	Stiff Clay without Free Water	0.033	13.89	-	0	-
-277 to -292	Sand	0.033	-	34	-	0

D. Footing and Mat Foundations

Spread footing and mat foundations at the New River Pump Station should be founded at least 12-inches below the lowest adjacent finished grade. Footings should be sized using allowable bearing pressures of 1,000 psf for dead loads, 1,500 psf for dead plus live loads and 2,000 psf for total loads including wind or seismic forces. These bearing pressures are net of imbedded foundation weight.

Resistance to lateral loads can be developed by friction at the base of footings and passive pressures acting against the vertical faces of below-grade foundation elements. Frictional resistance on the base of the foundation elements should be calculated using a frictional coefficient of 0.35 multiplied by the vertical dead load. An equivalent fluid pressure of 360 pcf should be used to calculate passive resistance above the water surface. An equivalent fluid pressure of 180 pcf (exclusive of hydrostatic pressure) can be used for passive resistance below the water surface. Lateral resistance values do not include a factor of safety.

Wetwells should be checked for uplift resistance.

E. Lateral Earth Pressures on Wetwells

For walls that are restrained at the top, we recommend that the below grade walls, including wetwells, be designed for an equivalent fluid pressure of 95 pcf, which includes hydrostatic forces. This value does not include an allowance for surcharge loads or earthquake pressures. To account for increased loading due to seismic forces, an additional pressure of 10H psf (rectangular distribution) should be added to the pressure given above, where H is the height of the wall in feet.

F. Sheetpiles

Sheetpiles may be used to shore the planned excavation(s) for the bulkhead wall, intake pipe and wetwell at the New River Pump Station site. The soil parameters presented in Table 10 are for the soil conditions encountered at boring 113HS. These soil parameters do not include factors of safety. The conditions may vary laterally, especially toward the New River channel due to past scour and deposition. The contractor's engineer should consider surface loadings behind the wall, differential water levels and potential lateral variation of soil conditions when designing a sheetpile wall.

Table 10: Preliminary Soil Parameters for Sheetpiling

Elevation (feet)	Soil Type	Total Unit Weight (pcf)	Buoyant Unit Weight (pcf)	Undrained Cohesion, c (psf)	Friction Angle, Φ (deg)
-226 to -233	Fill	120	58	500	0
-233 to -246	Sand / Silt	120	58	0	30
-246 to -277	Clay	120	58	2000	0
-277 to -292	Silt	120	58	0	34

G. Service During Construction

Prior to construction, the geotechnical engineer of record should review project foundation and grading plans and specifications for conformance with the intent of the recommendations in this report. During construction the geotechnical engineer should review Test Fill Strip results and review the contractor's proposed method specifications for placing and compacting Core Berm Fill and for backfilling the Inspection Trench with lean clay fill.

Additional site specific characterization should be done when the contract is awarded. The contractor’s geotechnical engineer or engineering geologist should check the strength and depth of sea sediments along the final berm alignment. The contractor should characterize the soil conditions along the planned Saline Water Channel.

If conditions are encountered during construction that are not consistent with those described herein, the geotechnical engineer of record should be contacted to review the recommendations in this report and provide alternatives, if appropriate.

REFERENCES

REFERENCES

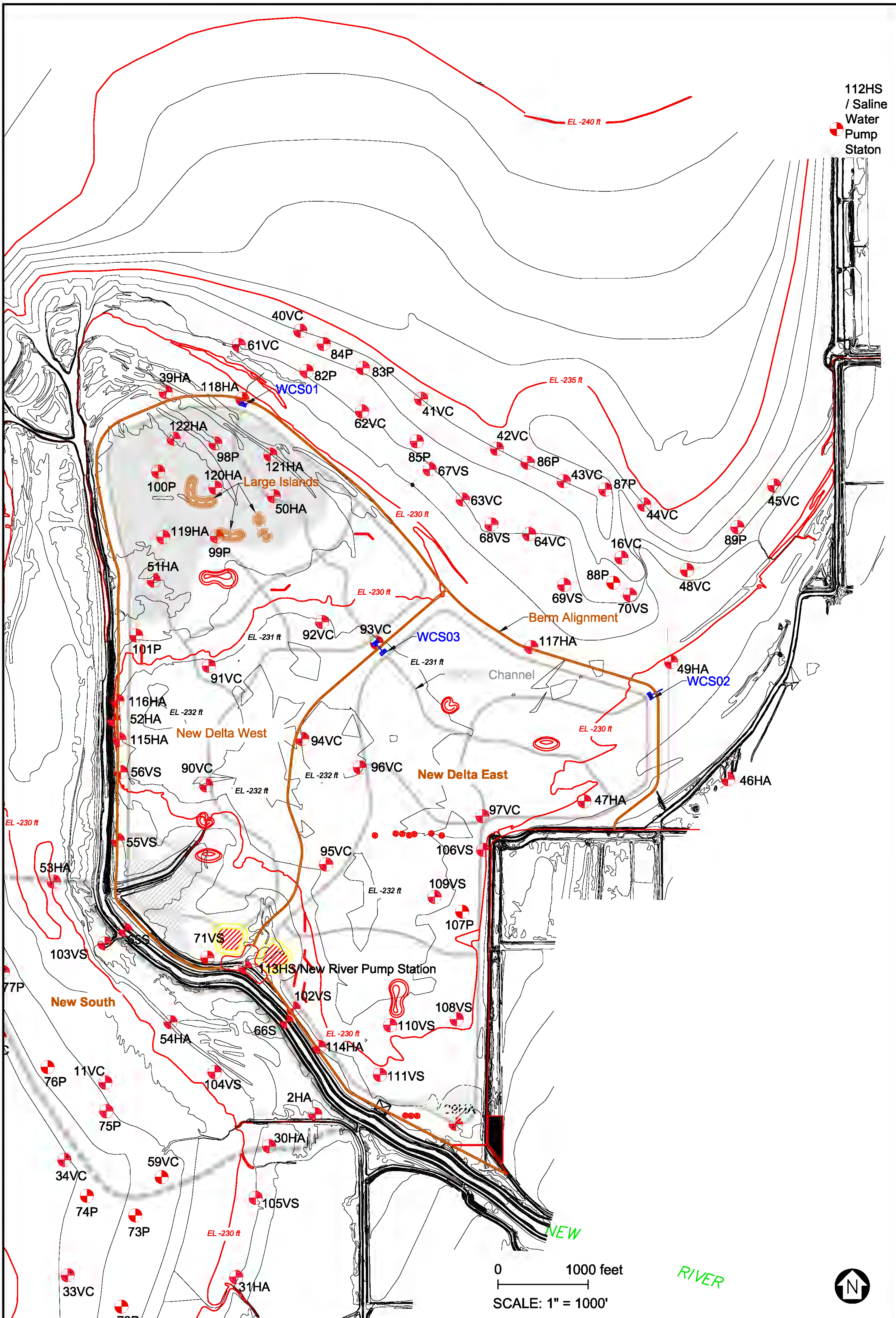
Hultgren – Tillis Engineers. 2011. Preliminary Geotechnical Investigation, Salton Sea, Species Conservation Habitat Project, Salton Sea, California, September 2, 2011

United States Department of The Interior and The Resources Agency of California. 1974. Salton Sea Project, Federal-State Feasibility Report, April 1974

URS. 2004. Preliminary In-Sea Geotechnical Investigation, Salton Sea Restoration Project, Riverside and Imperial Counties, California, February 27, 2004

PLATES

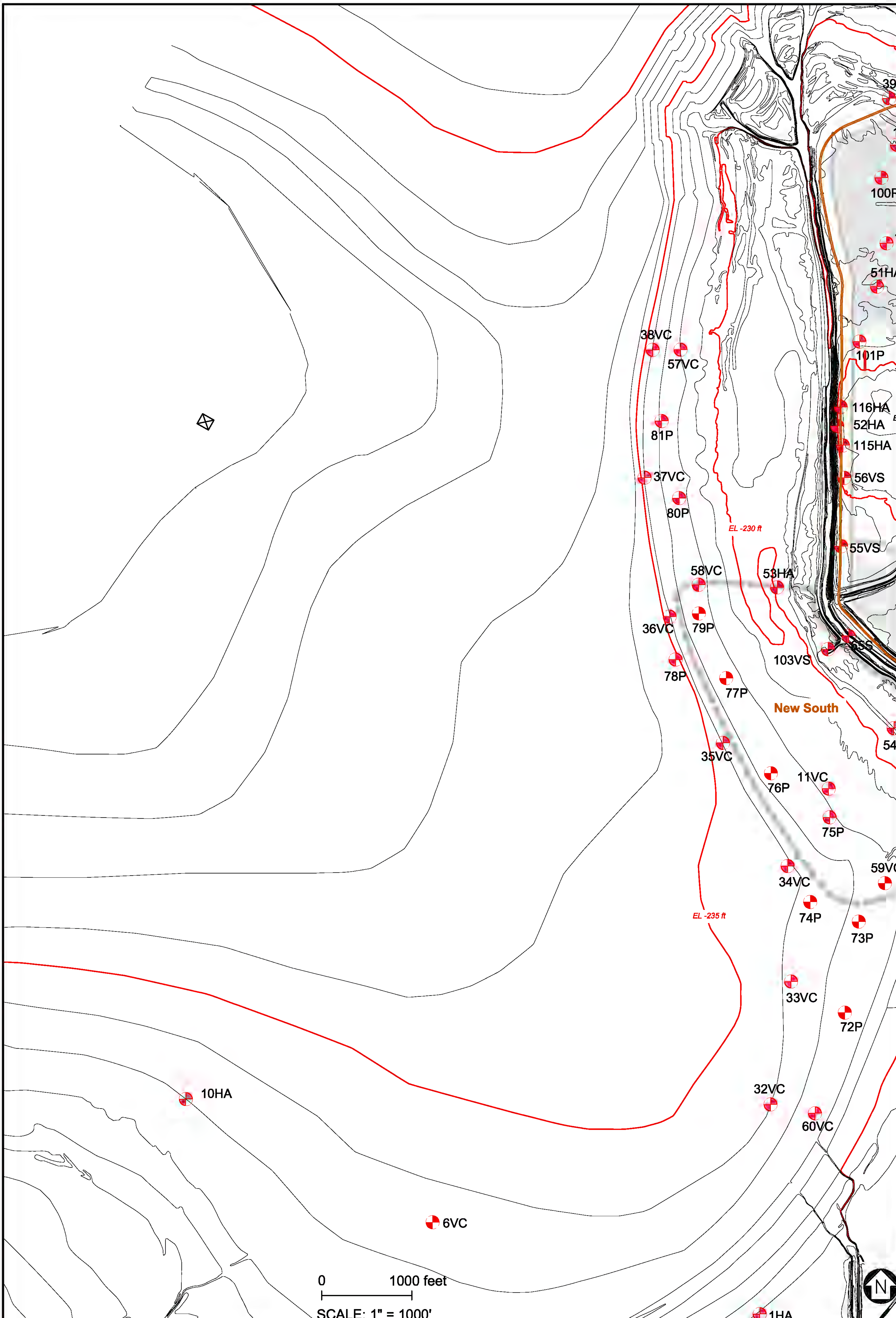
Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vicinity Map**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 1



KEY TO EXPLORATION

HA=Hand Auger
VC=Vibracore
VS=Vane Shear
P=Probe
S=Sounding
HS=Hollow-Stem

Salton Sea Species Conservation Habitat Project Salton Sea, California		**Exploration Site Plan 1**
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 2



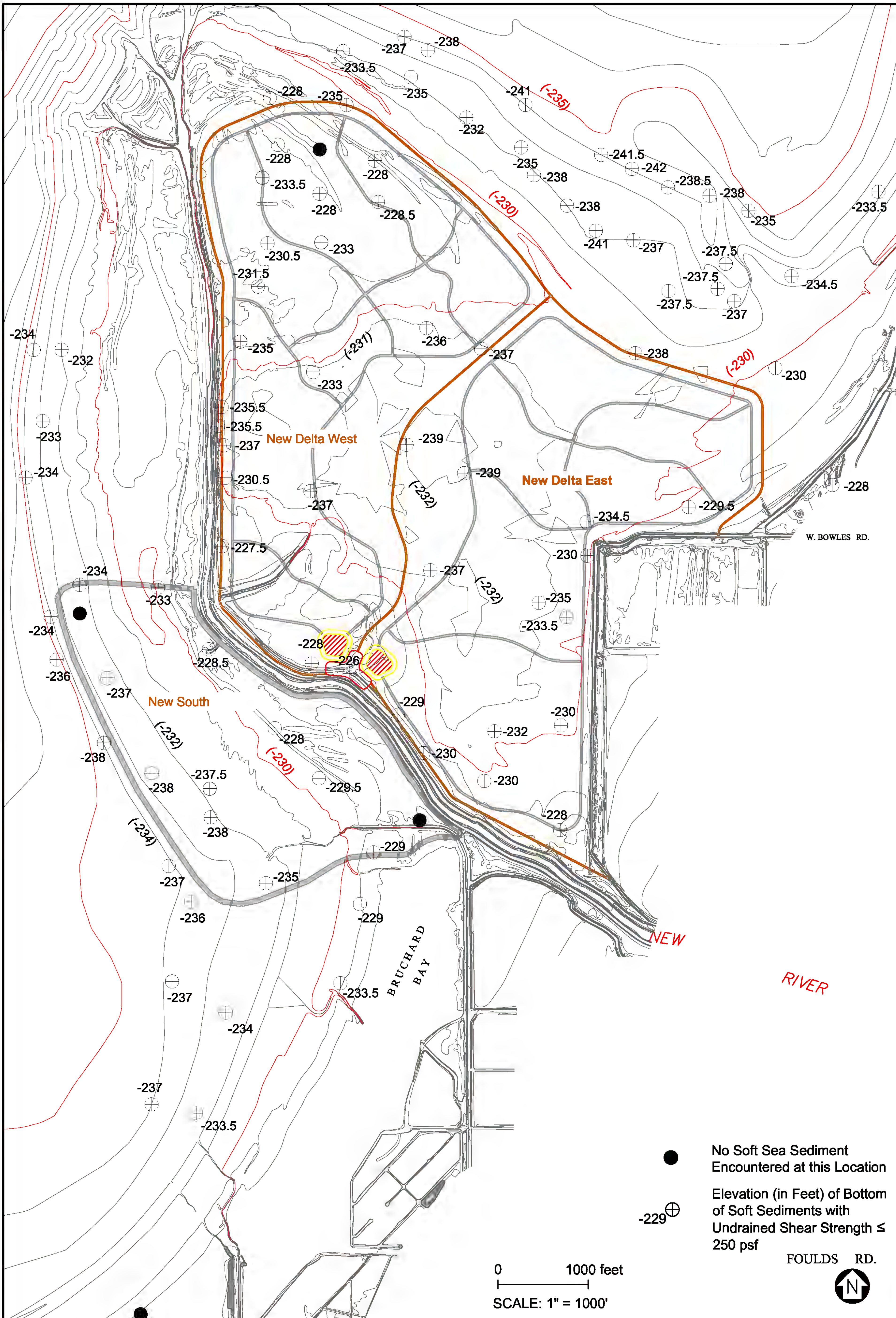
KEY TO EXPLORATION

HA=Hand Auger P=Probe
VC=Vibracore S=Sounding
VS=Vane Shear HS=Hollow-Stem

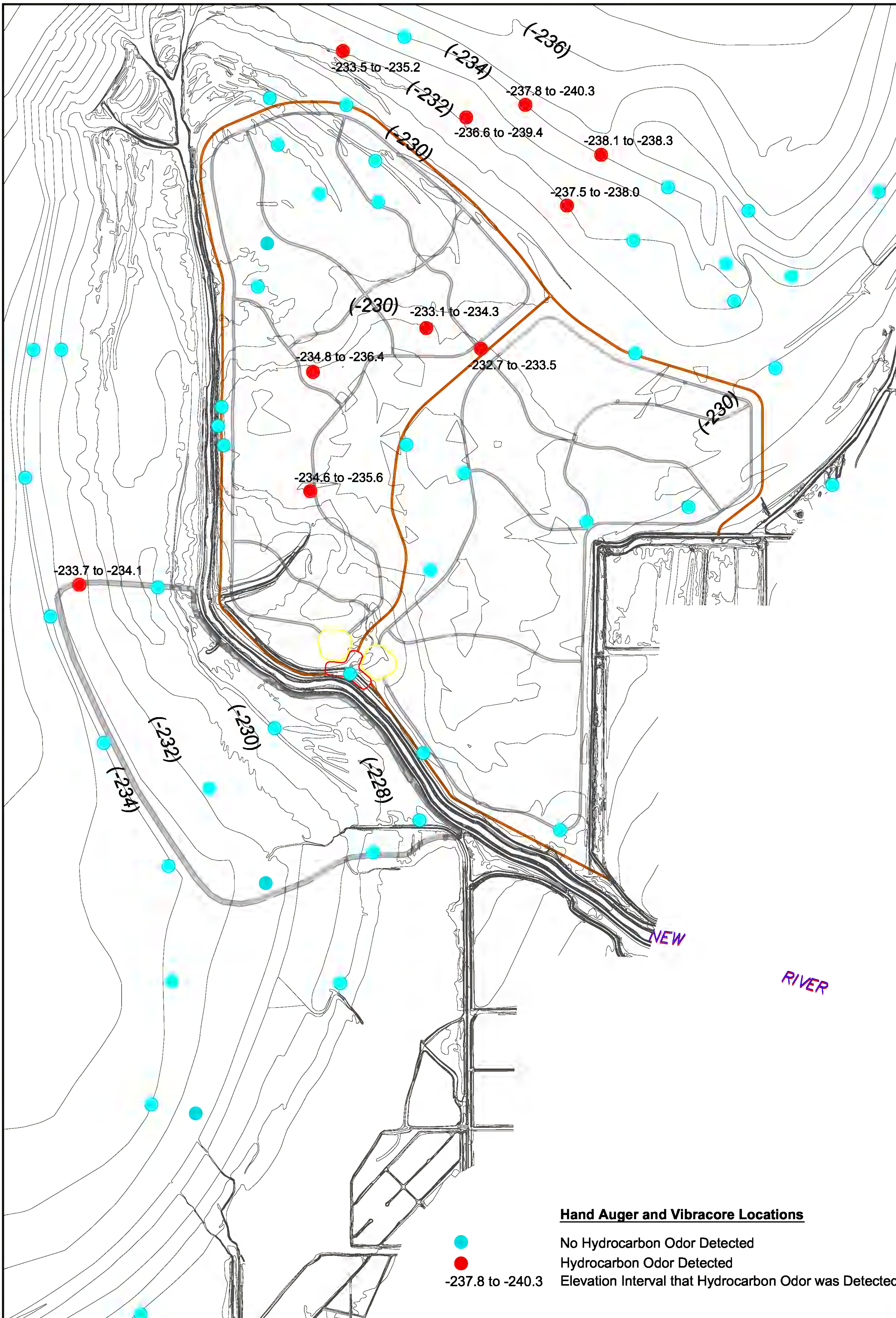
Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Exploration Site Plan 2

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



Salton Sea Species Conservation Habitat Project Salton Sea, California	**Elevation of Bottom of Sea Sediments with Undrained Strength ≤ 250 psf**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 4



0 1000 feet

SCALE: 1" = 1000'

N

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Hydrocarbon Odor Detection in Hand Augers and Vibracores

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

Estimates of settlement were made for the range of existing site grades, Column 1, using the parameters described in report section IV-F, Berm Settlement. To estimate the thickness of fill needed, a finish berm crest subgrade elevation of -226 feet after both consolidation settlement and incidental compaction was used. The results of the consolidation settlement analysis, buffered by judgment, are summarized in Column 2. Incidental compaction settlement of 0.1 foot was assumed for LGP earthmoving equipment operating on the existing subgrade. Once the fill has been placed, additional incidental compaction settlement will occur from laden truck traffic. An additional settlement allowance of 0.3 foot was used to account for post-grading compaction.

The total estimated thickness of fill will be the neat height of the fill (Elevation -226 minus the Existing Ground Elevation) plus the consolidation settlement and the 0.4 foot incidental compaction settlement allowance. The estimated total thickness of fill is presented in Column 3.

Some consolidation settlement will occur during the grading operation. This portion of the consolidation settlement is commonly referred to as "immediate settlement". Estimates of the magnitude of immediate settlement are shown in Column 4.

When setting grade stakes to control grading operations, allowance for that portion of the consolidation settlement yet to occur plus a post-grading incidental compaction allowance (we chose 0.3 feet) should be considered. Suggested elevations for initial grade stakes are shown in Column 5 .

After the initial berm fill has been in place for at least 6 months, the subgrade elevation should be checked. Those areas where the elevation is below that which will allow for at least 50 percent of the total estimated consolidation settlement should be raised to accommodate potential on-going settlement. The finish crest subgrade elevations (prior to placing Aggregate Base) allowing for one half of the estimated consolidation settlement are shown in Column 6.

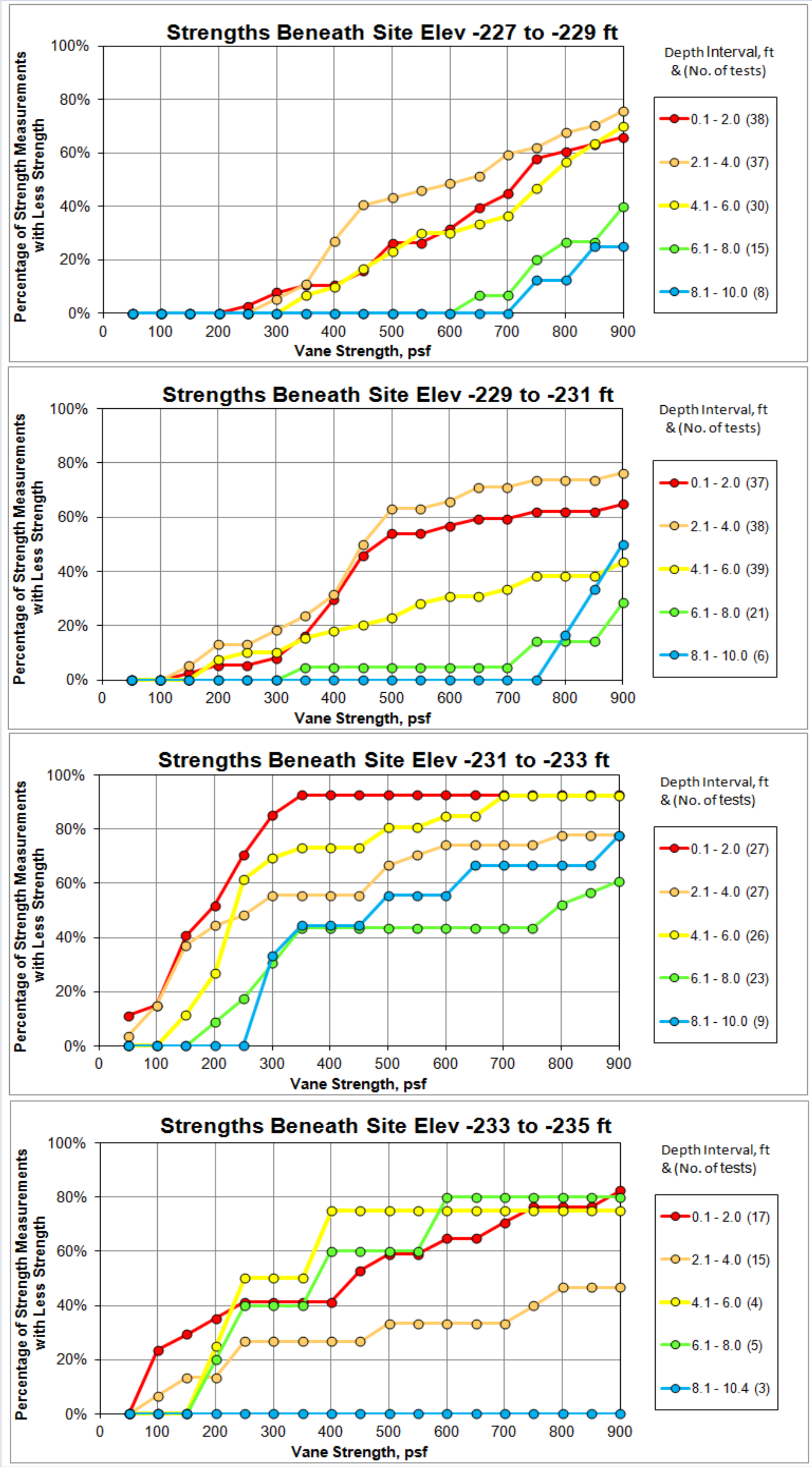
(1) Existing Ground Elevation	**(2) Total Estimated Settlement due to Consolidation**	**(3) Total Fill Thickness**	**(4) Assumed Immediate Consolidation Settlement (during initial grading)**	**(5) Suggested Initial Finish Crest Subgrade Elevation (for grade stakes)**	**(6) Minimum Finish Crest Subgrade Elevation 6-Months After Initial Fill**
-229	0.4	3.8	0.1	-225.4	-225.8
-230	0.6	5.0	0.1	-225.2	-225.7
-231	0.8	6.2	0.2	-225.0	-225.6
-232	1.2	7.8	0.3	-224.8	-225.4
-233	1.8	9.2	0.3	-224.3	-225.1

(All units in feet)

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Settlement of Berm Design Finished Subgrade at Elevation -226 Feet

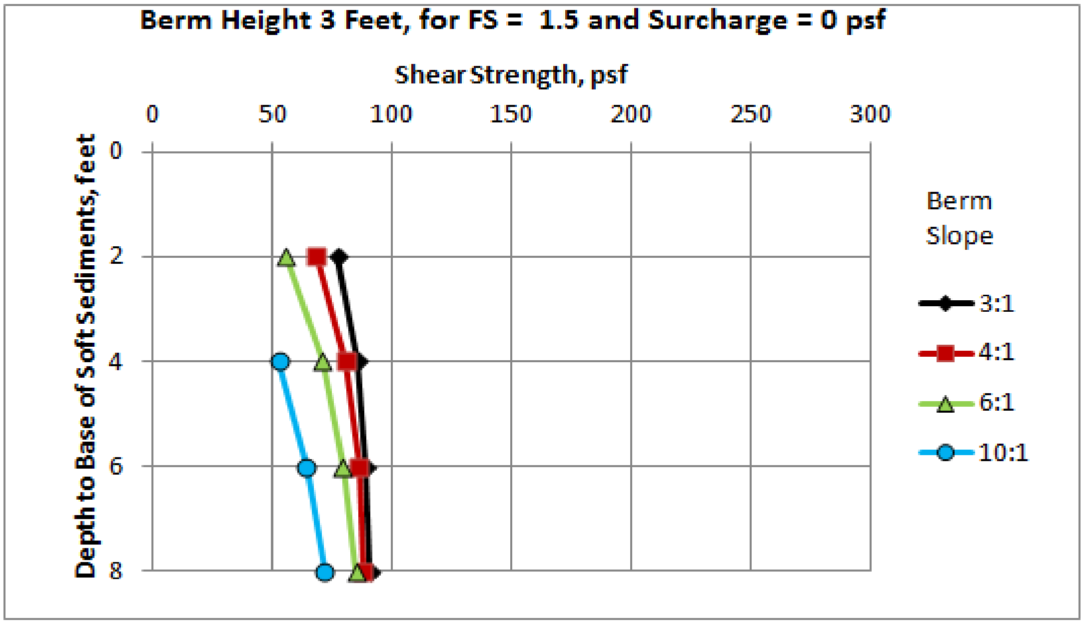
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 6

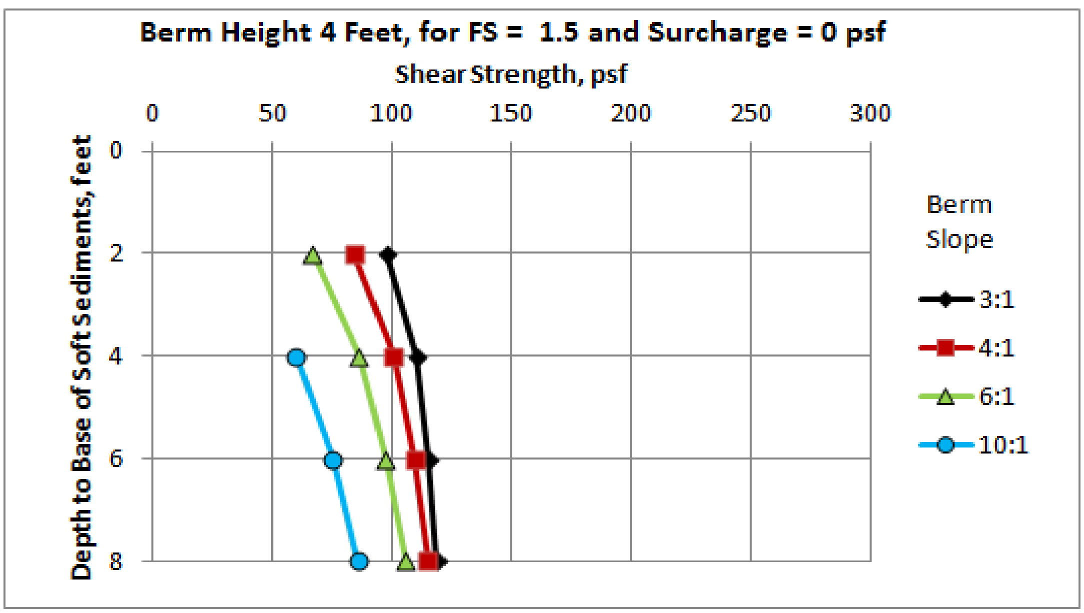


Salton Sea
Species Conservation Habitat Project
Salton Sea, California

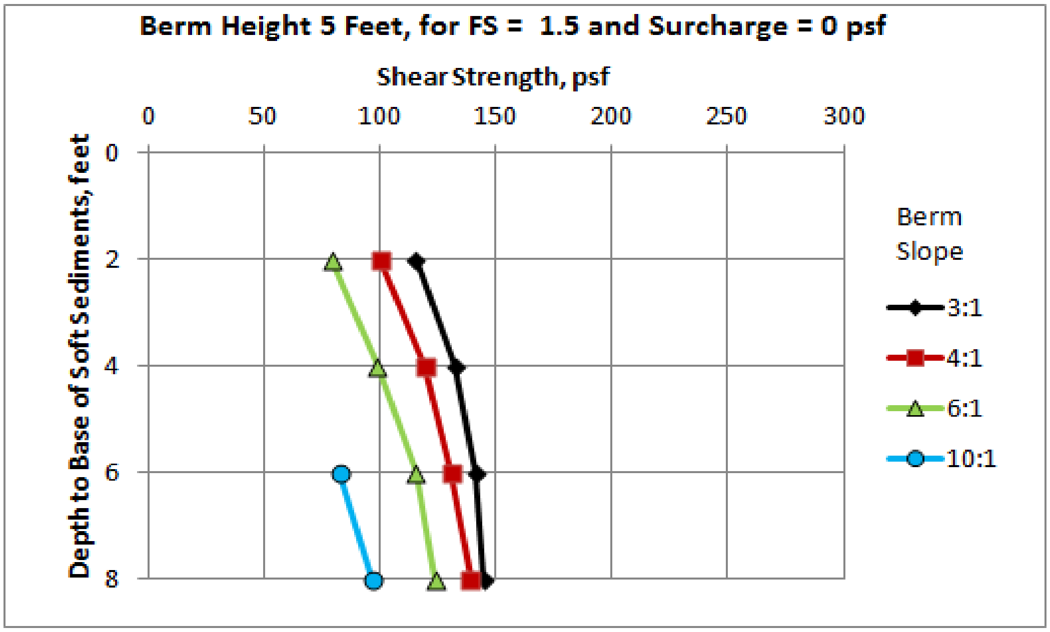
Shear Strength Plots of Four Elevation Terrains

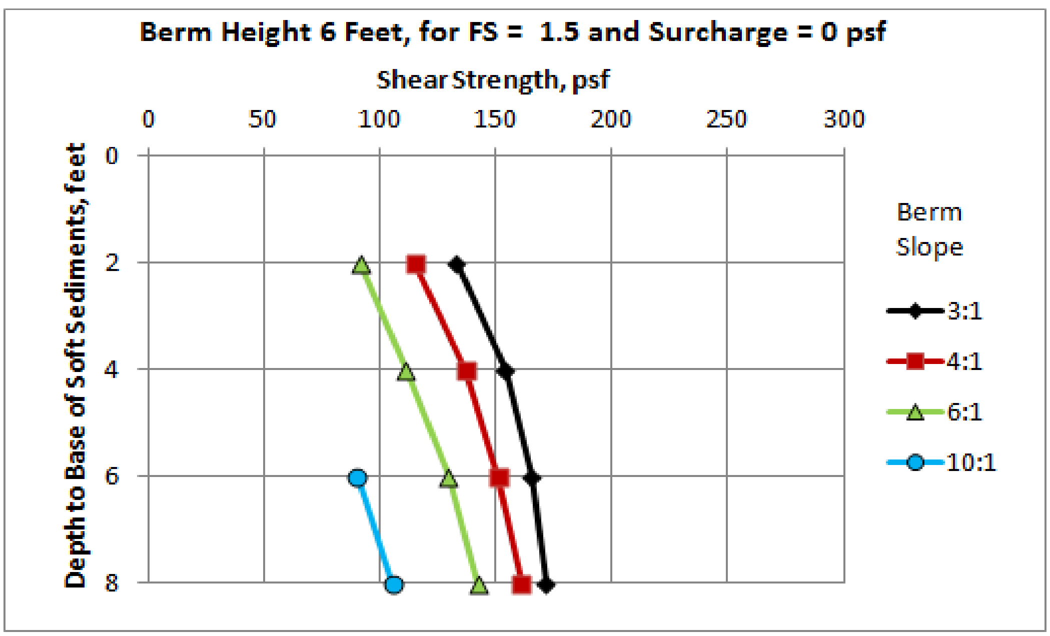
Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 7





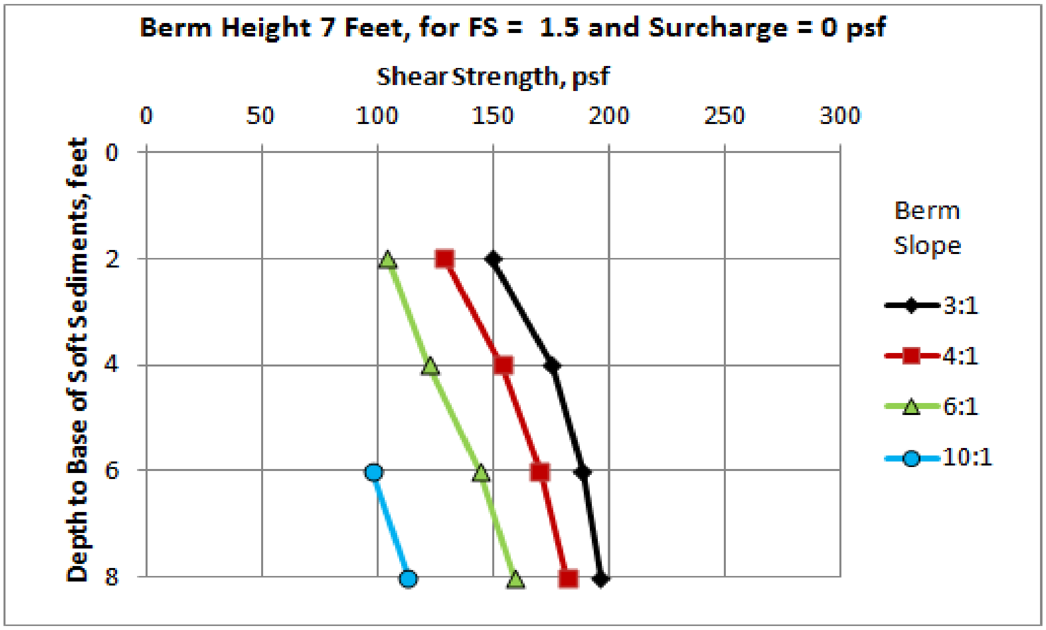
Salton Sea Species Conservation Habitat Project Salton Sea, California	**Design Charts for Berm Heights of 3 and 4 feet**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 8

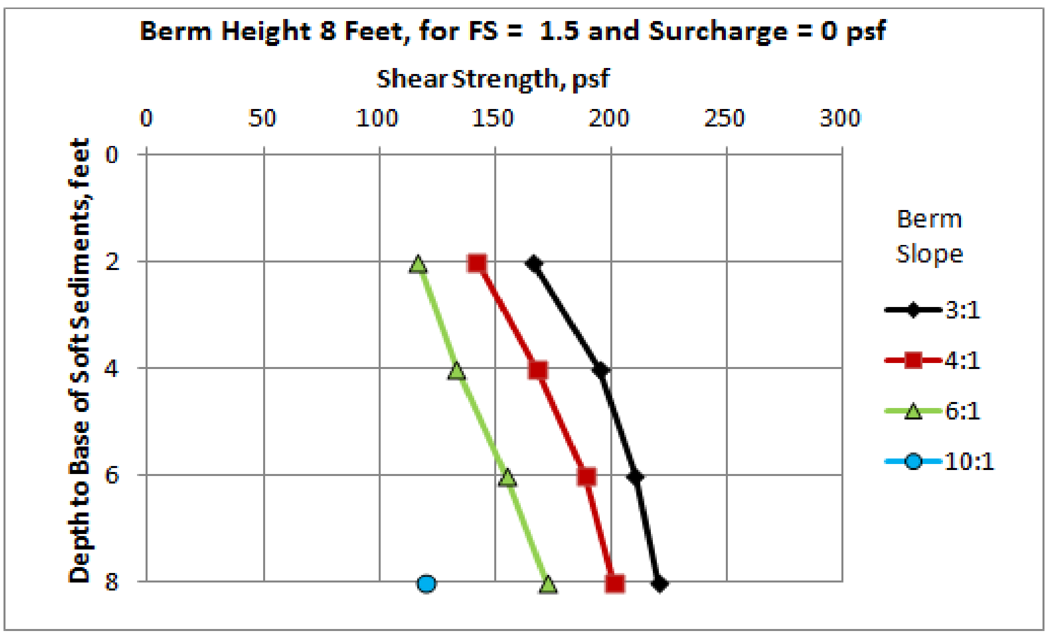




Salton Sea Species Conservation Habitat Project Salton Sea, California	**Design Charts for Berm Heights of 5 and 6 feet**

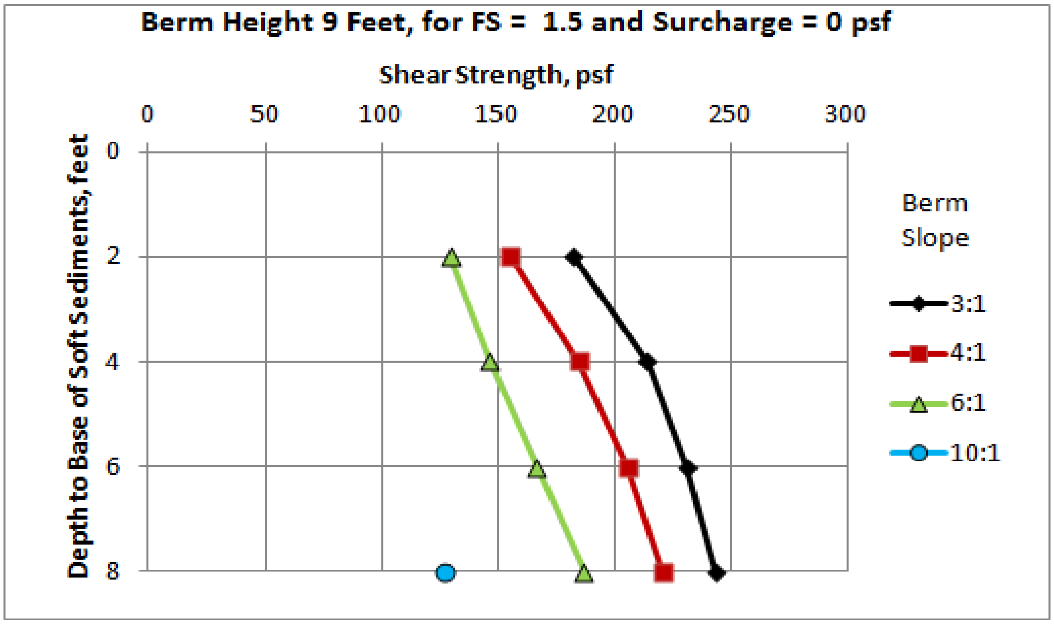
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 9

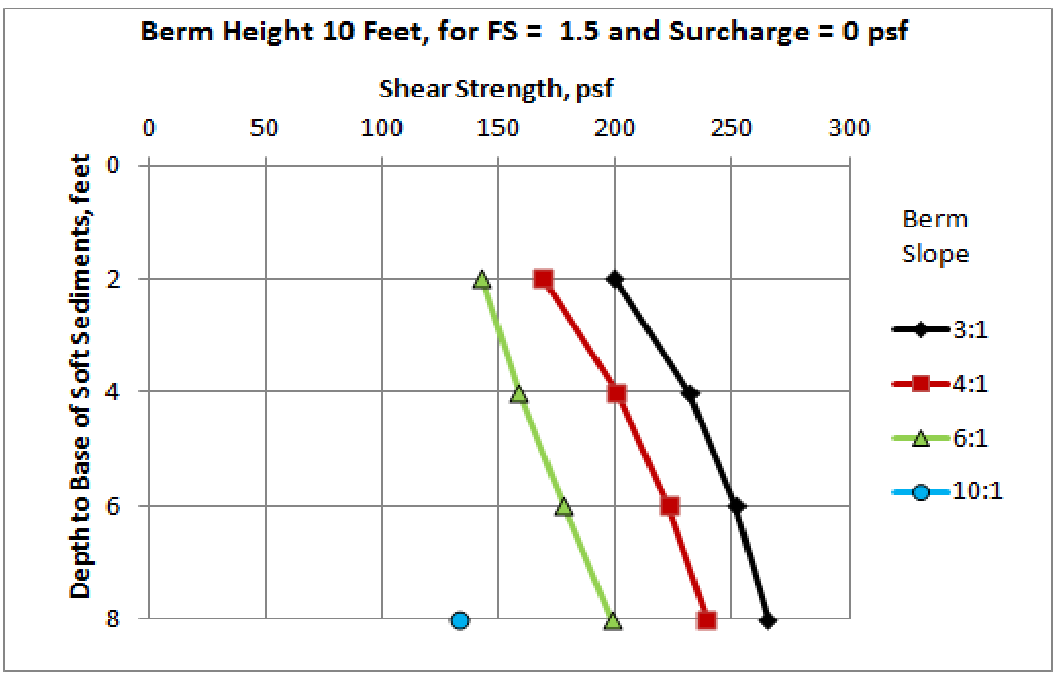




Salton Sea Species Conservation Habitat Project Salton Sea, California	**Design Charts for Berm Heights of 7 and 8 feet**

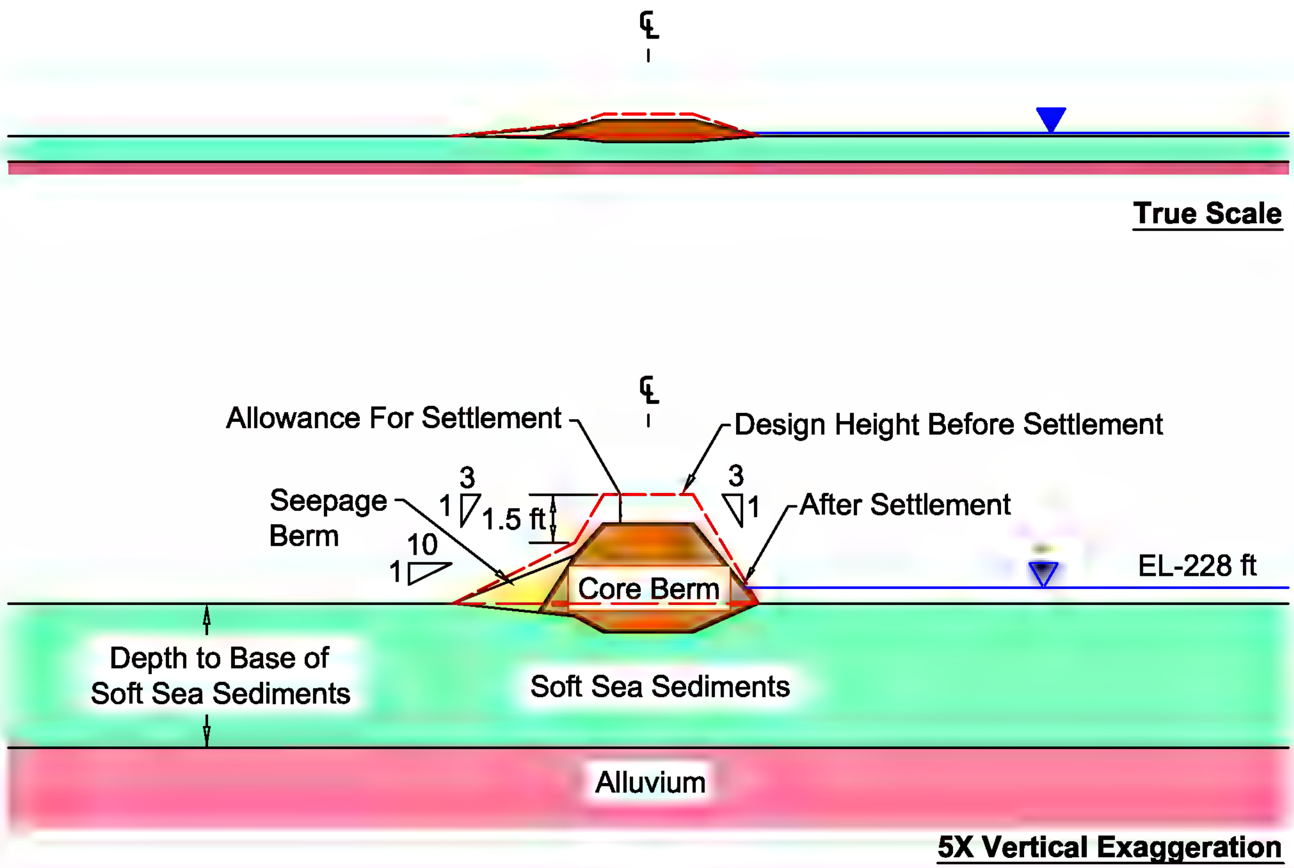
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 10





Salton Sea Species Conservation Habitat Project Salton Sea, California	**Design Charts for Berm Heights of 9 and 10 feet**

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

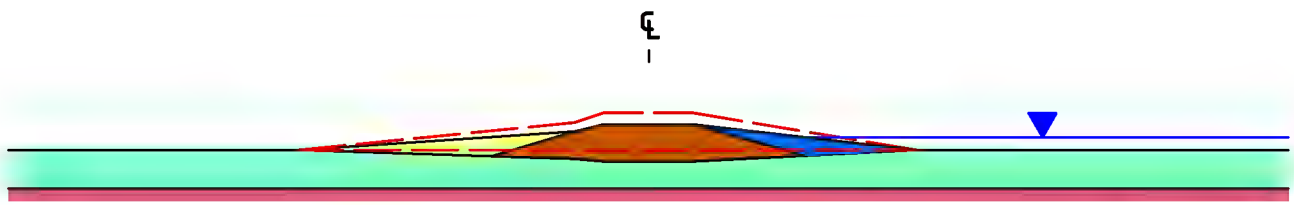


HORIZONTAL SCALE

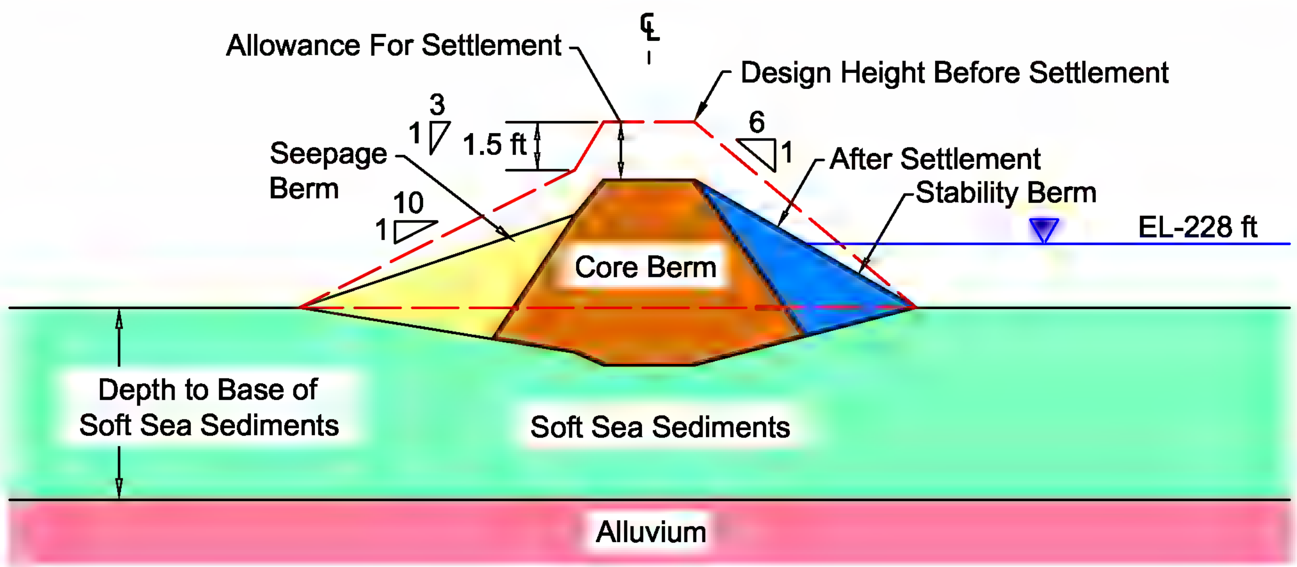
0 30 feet

1 inch = 30 feet

Salton Sea Species Conservation Habitat Project Salton Sea, California		**Design Geometry A**
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 12



True Scale



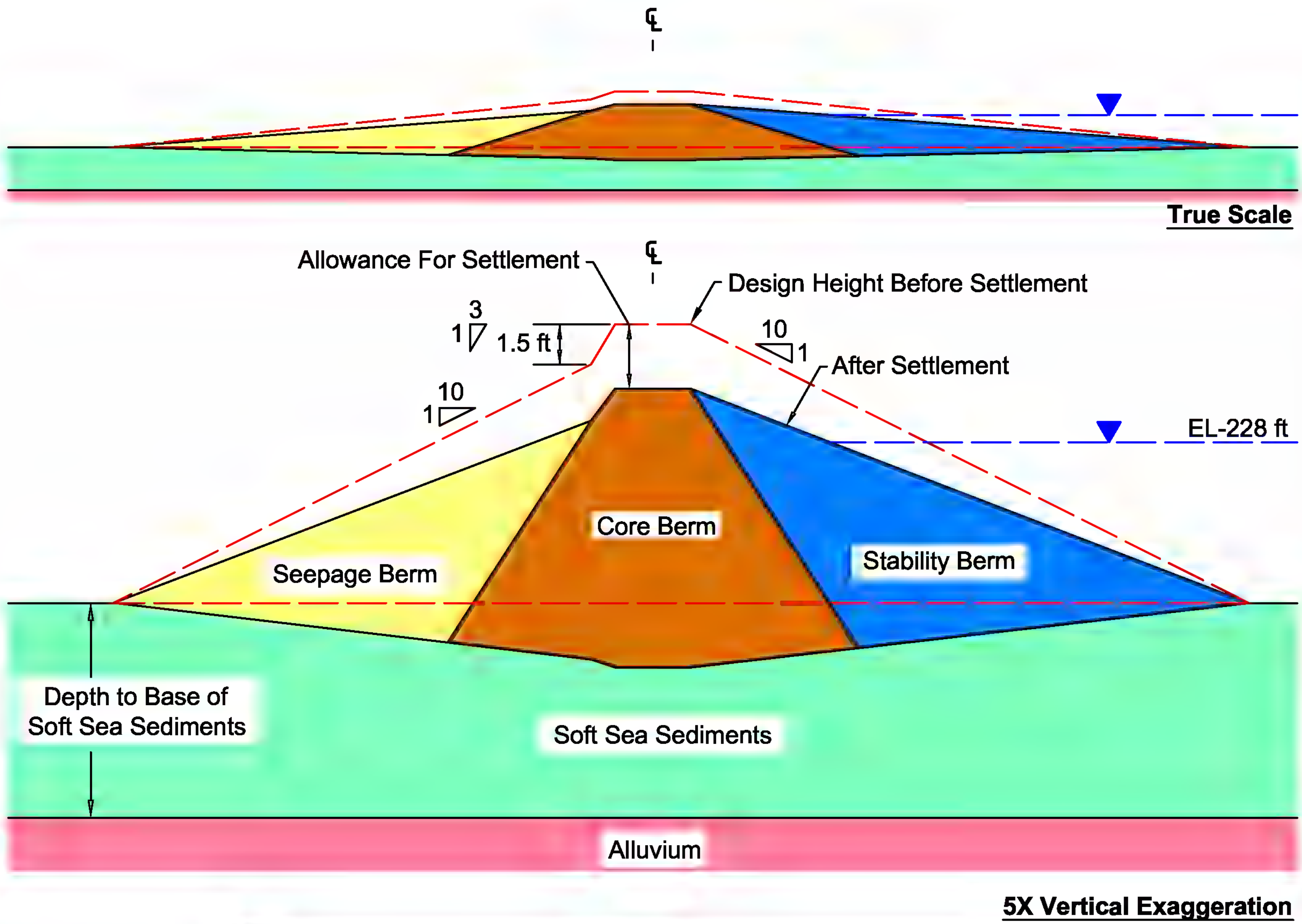
5X Vertical Exaggeration

HORIZONTAL SCALE

0 30 feet

1 inch = 30 feet

Salton Sea Species Conservation Habitat Project Salton Sea, California		**Design Geometry B**
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 13

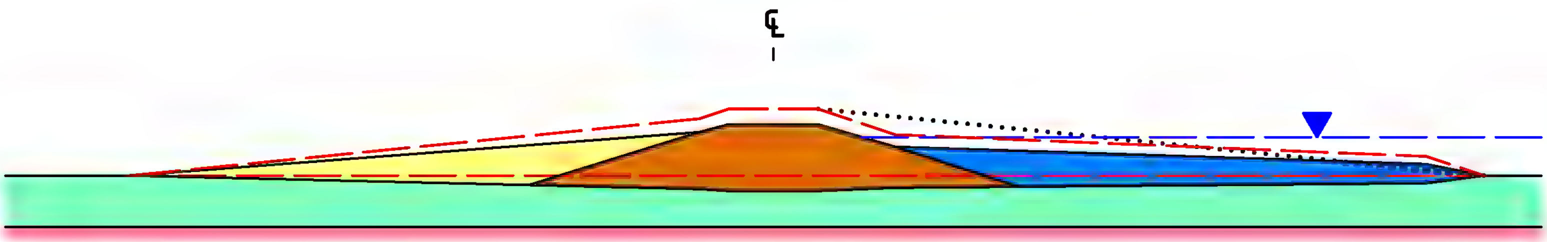


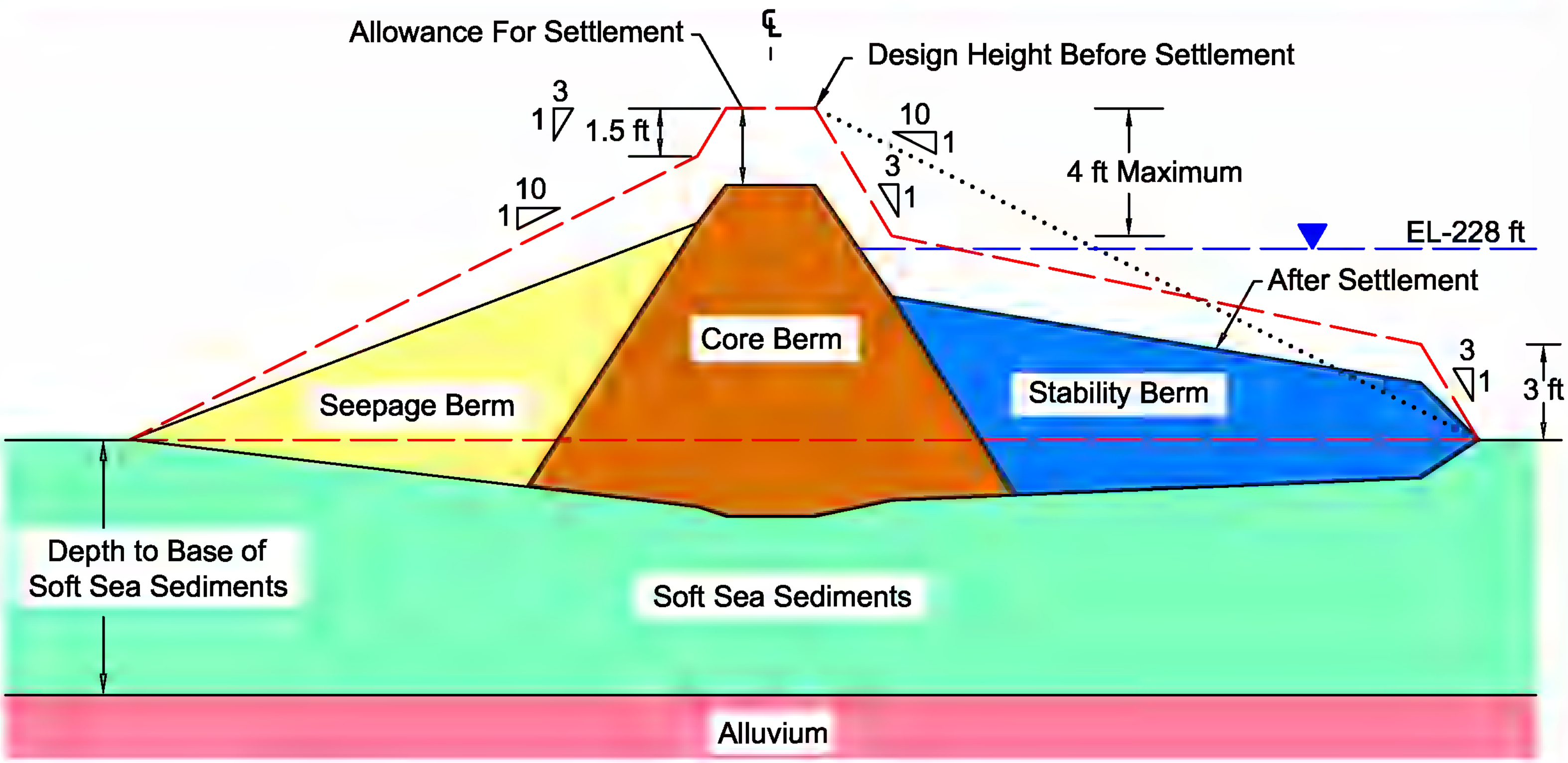
HORIZONTAL SCALE
0 30 feet
1 inch = 30 feet

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Design Geometry C

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



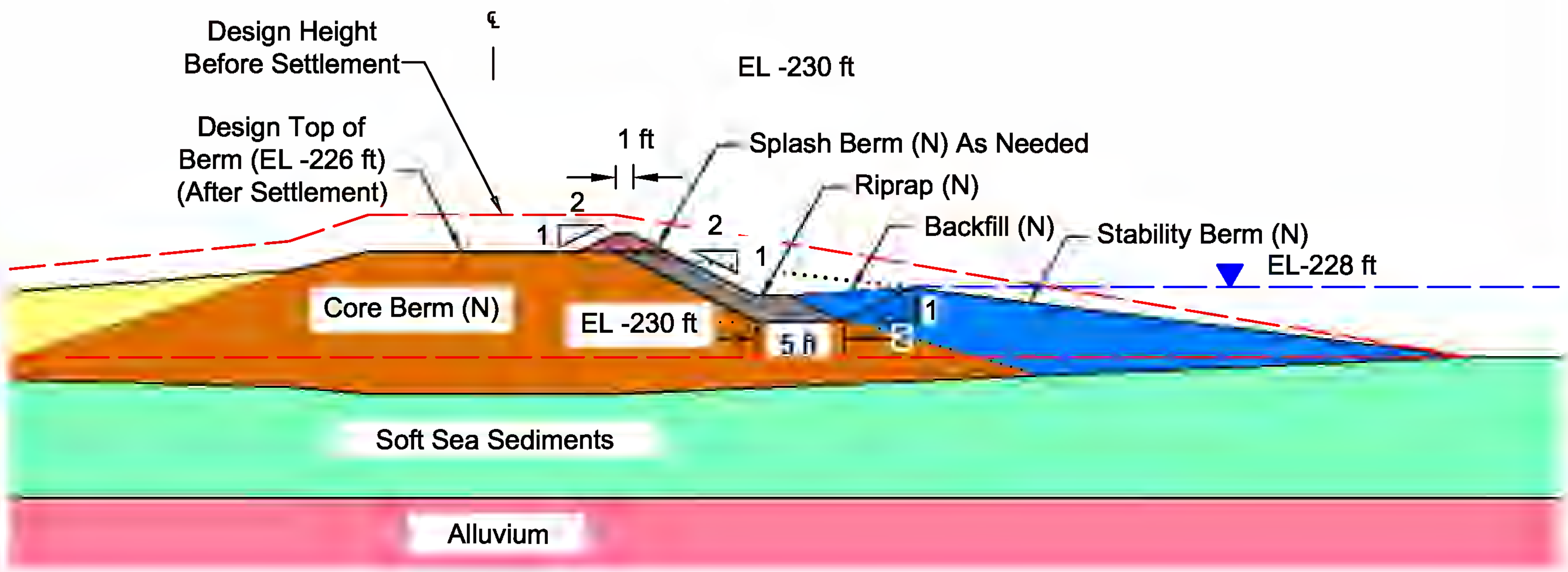


HORIZONTAL SCALE
0 30 feet
1 inch = 30 feet

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Design Geometry C
(Broken Slopes)

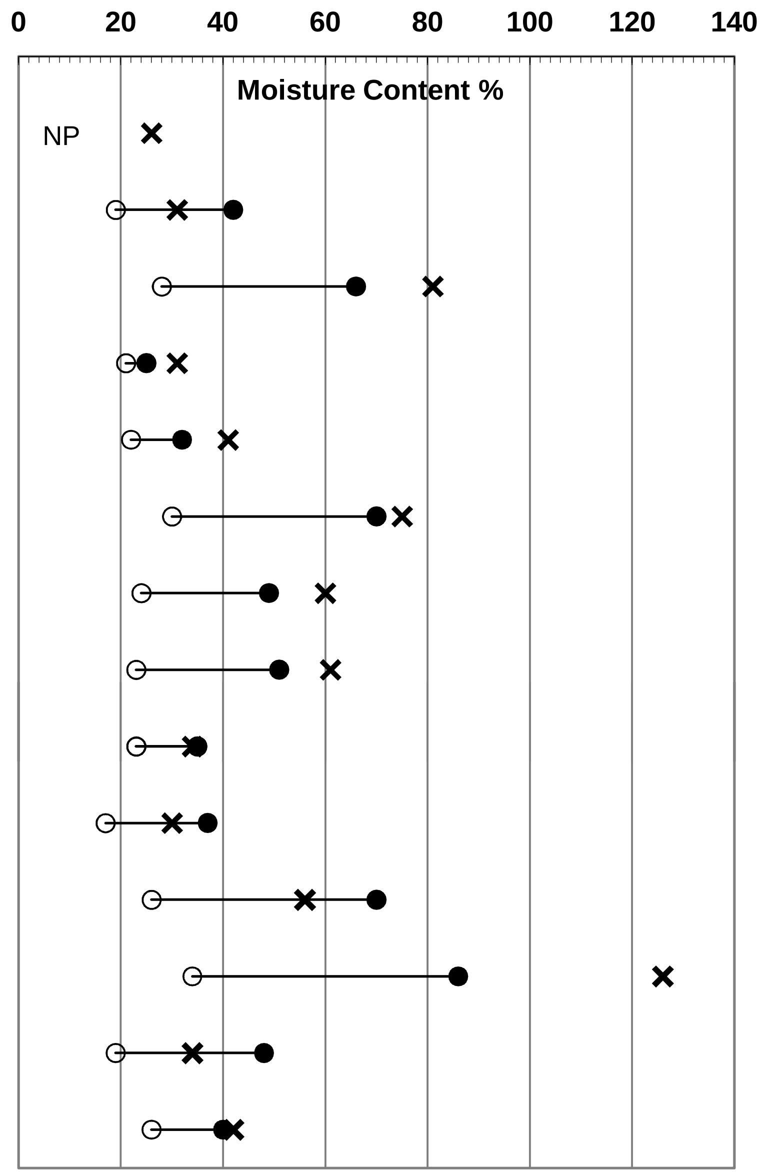
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 15



NOT TO SCALE

Salton Sea Species Conservation Habitat Project Salton Sea, California		**Details of Riprap**
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 16

Sample Descriptions	Boring Nos. (Depth in feet)	Liquidity Index
Gray Fat Clay (CH)	31HA (2.0 - 2.5)	0.50
Reddish Brown Lean Clay (CL)	32VC (1.5 - 1.8)	0.52
Olive Gray Fat Clay (CH)	34VC (1.0 - 1.2)	1.39
Olive Brown Sandy Silt (ML)	35VC (3.5 - 4.0)	2.50
Olive Brownish Gray Lean Clay (CL)	40VC (3.0 - 3.5)	1.90
Black Fat Clay (CH)	41VC (5.0 - 5.5)	1.13
Olive Gray Lean Clay (CL)	43VC (1.0 - 1.5)	1.44
Olive Gray Fat Clay (CH)	44VC (1.2 - 1.4)	1.36
Reddish Brown Lean Clay (CL)	47HA (6.0 - 6.5)	0.92
Reddish Brown Lean Clay (CL)	51HA (0.0 - 0.5)	0.43
Olive Brown to Gray Fat Clay (CH)	59VC (3.0 - 4.0)	0.67
Olive Gray Fat Clay (CH)	94VC (1.0 - 2.0)	1.77
Reddish Brown Lean Clay (CL)	95VC (4.0 - 5.0)	0.52
Olive Gray Silt (ML)	97VC (1.0 - 2.0)	1.14



Key:

NP= Non-Plastic

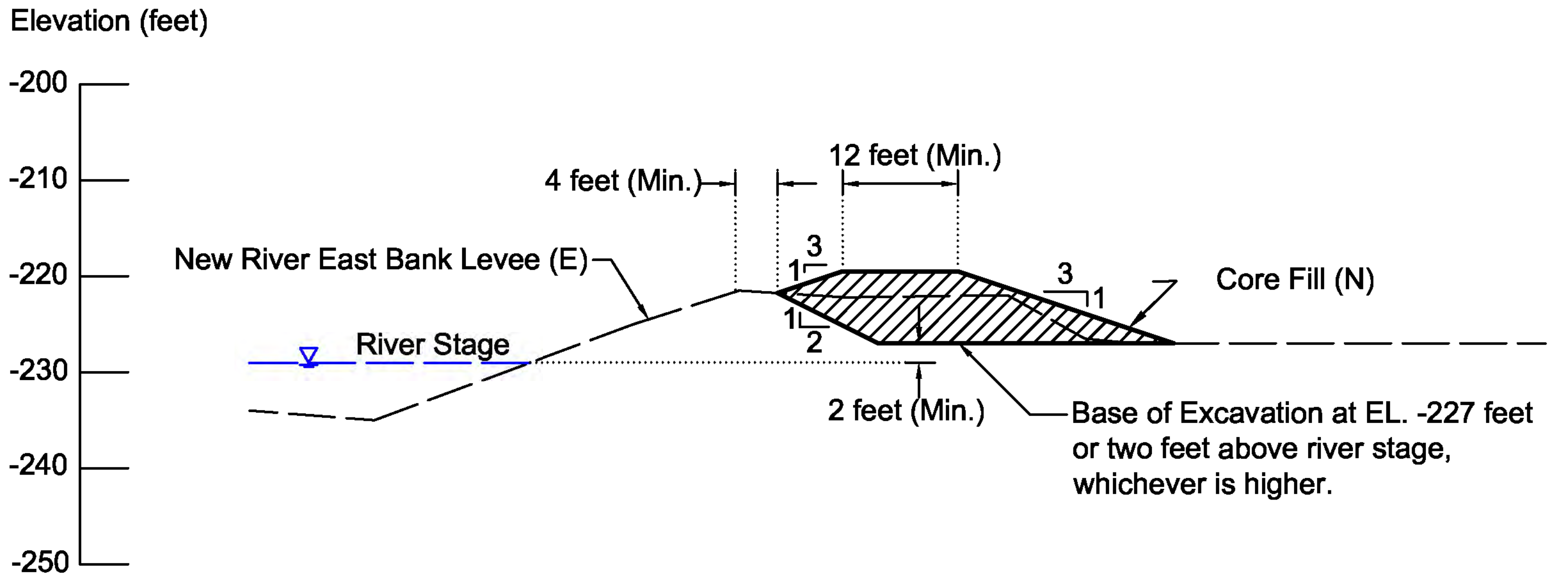
PL PI LL

In-Situ Moisture Content

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

In-Situ Moisture Contents Relative to Atterberg Limits

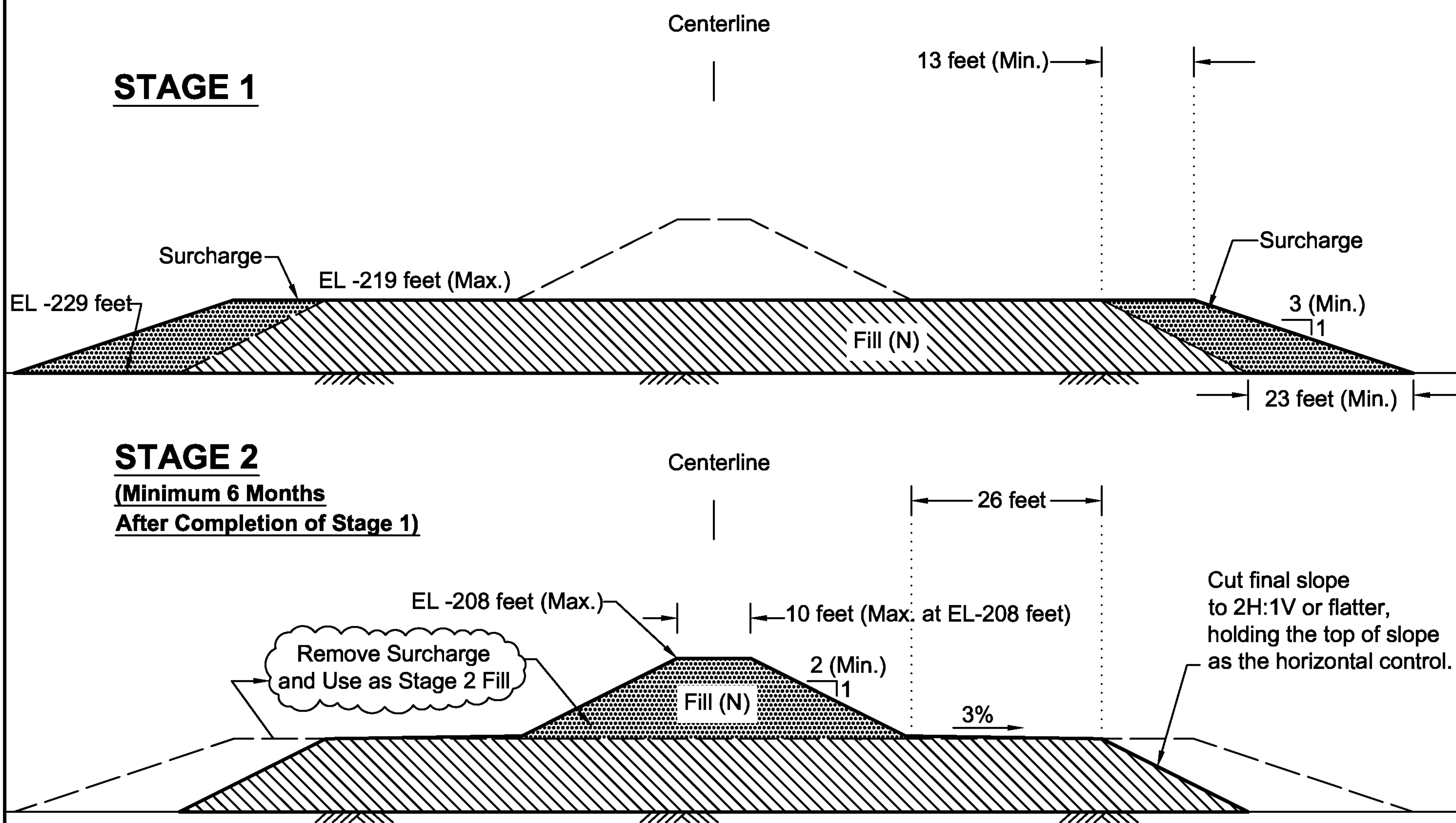
Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 17



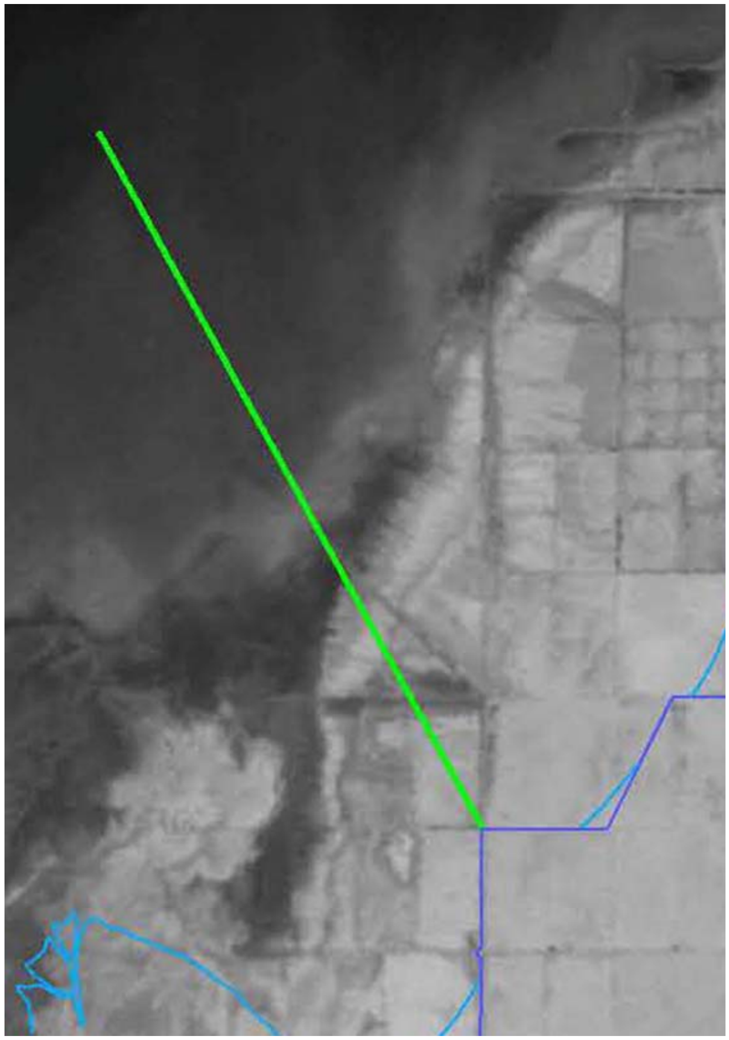
Notes:

1. Cut backside of existing New River east bank levee at 2H:1V (Min.).
2. Base of the excavation should be at Elevation -227 feet or 2 feet above the river stage, whichever is higher.
3. Scarify and compact subgrade to 95% relative compaction as determined by ASTM D698, Standard Proctor Test.
4. Place and compact fill (*"Core Fill"*) against existing levee. Moisture condition and compact to 95% relative compaction as determined by ASTM D698, Standard Proctor Test.
5. Material excavated from existing levee shall not be reused.
6. Reliable forcasting of river stage is needed prior to cutting into existing levee.

SCALE 1 inch = 20 feet	Salton Sea Species Conservation Habitat Project Salton Sea, California	**Typical Design Configuration** **New River East Bank Levee**	
	Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 18

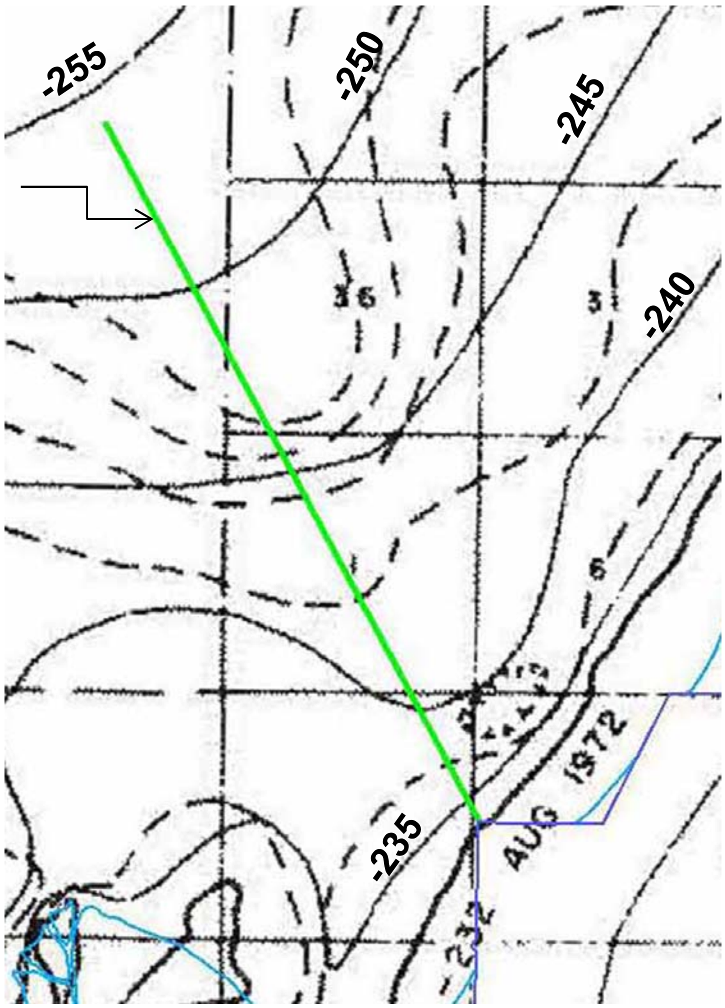


SCALE 0 — 20 feet 1 inch = 20 feet	Salton Sea Species Conservation Habitat Project Salton Sea, California	**Typical Configuration** **Tall Habitat Islands**
	Hultgren - Tillis Engineers	Project No. 758.01 — Plate No. 19



1 inch = 4000 feet

Salton Sea Species Conservation Habitat Project Salton Sea, California	**1947 Aerial Photo at Saline Channel**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 20



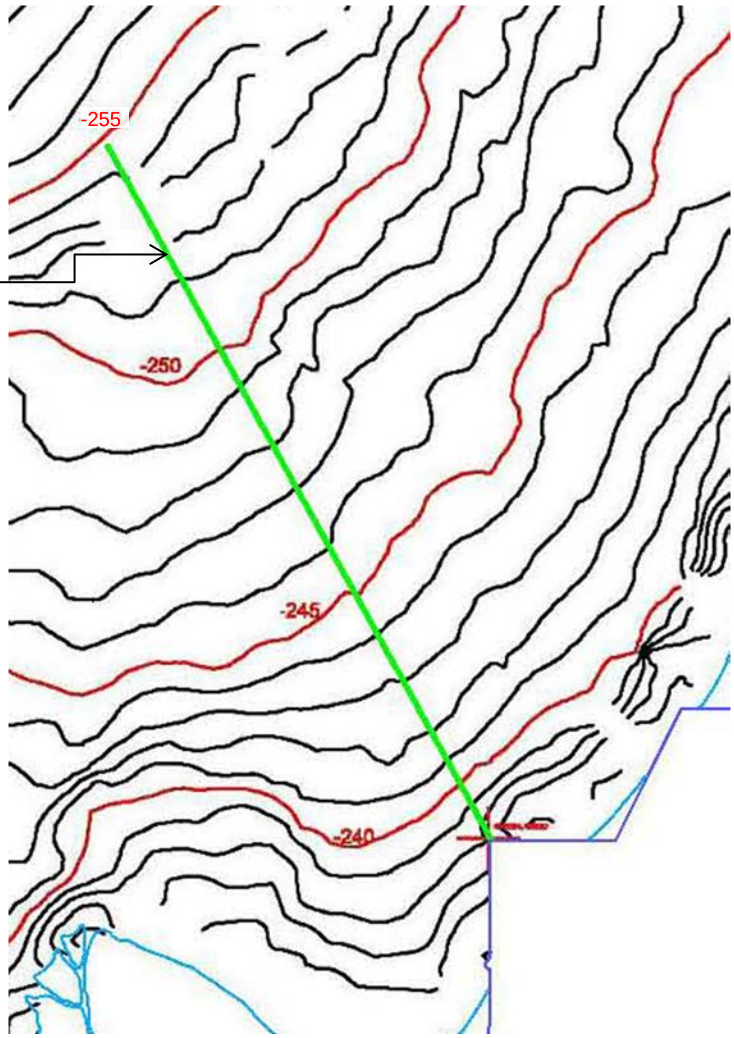
Source: United States Department of The Interior and The Resources Agency of California. 1974. Salton Sea Project, Federal-State Feasibility Report , April 1974.

1 inch = 4000 feet

Salton Sea Species Conservation Habitat Project Salton Sea, California	**1972 Bathymetry at Saline Channel**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 21

Saline Channel (N)

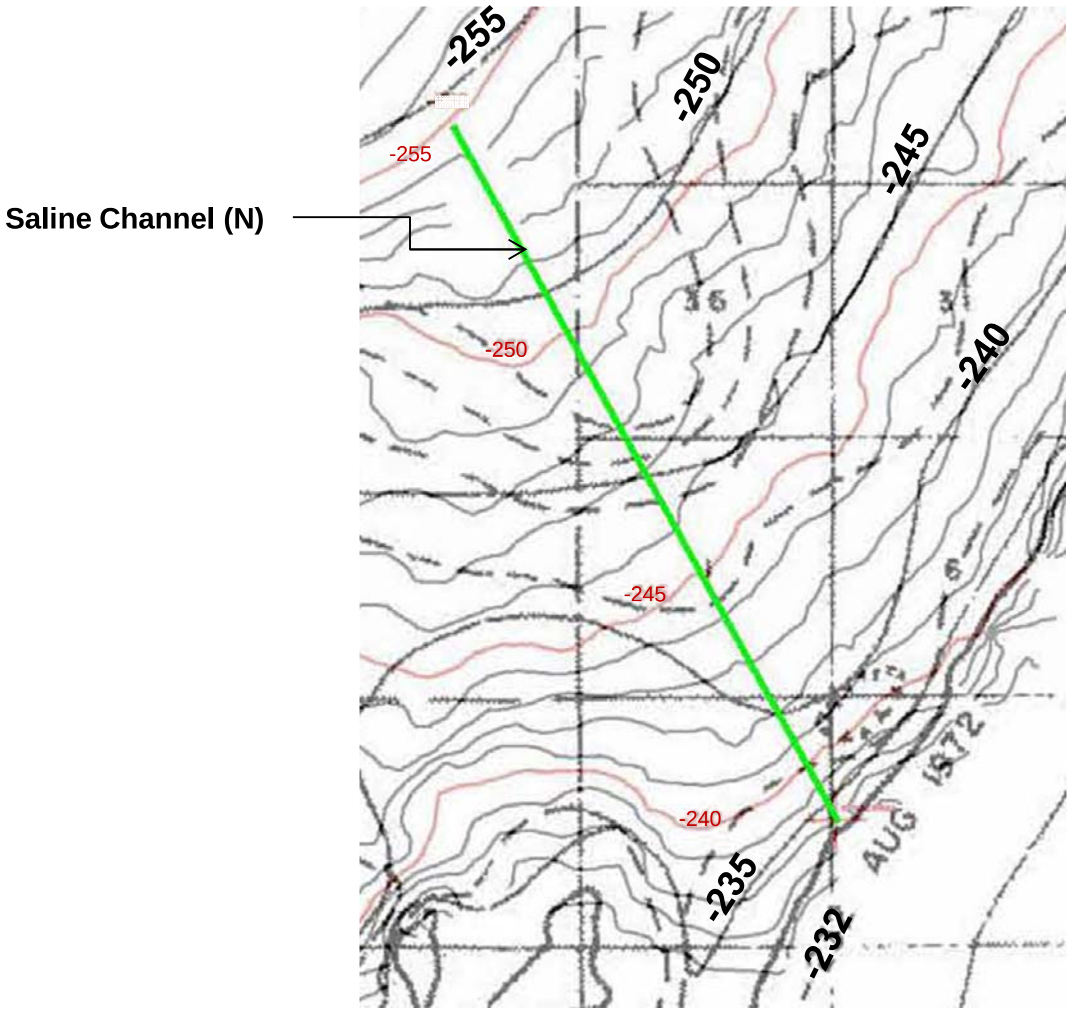


1 inch = 4000 feet

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Scripps (2011) Bathymetry at Saline Channel

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 22

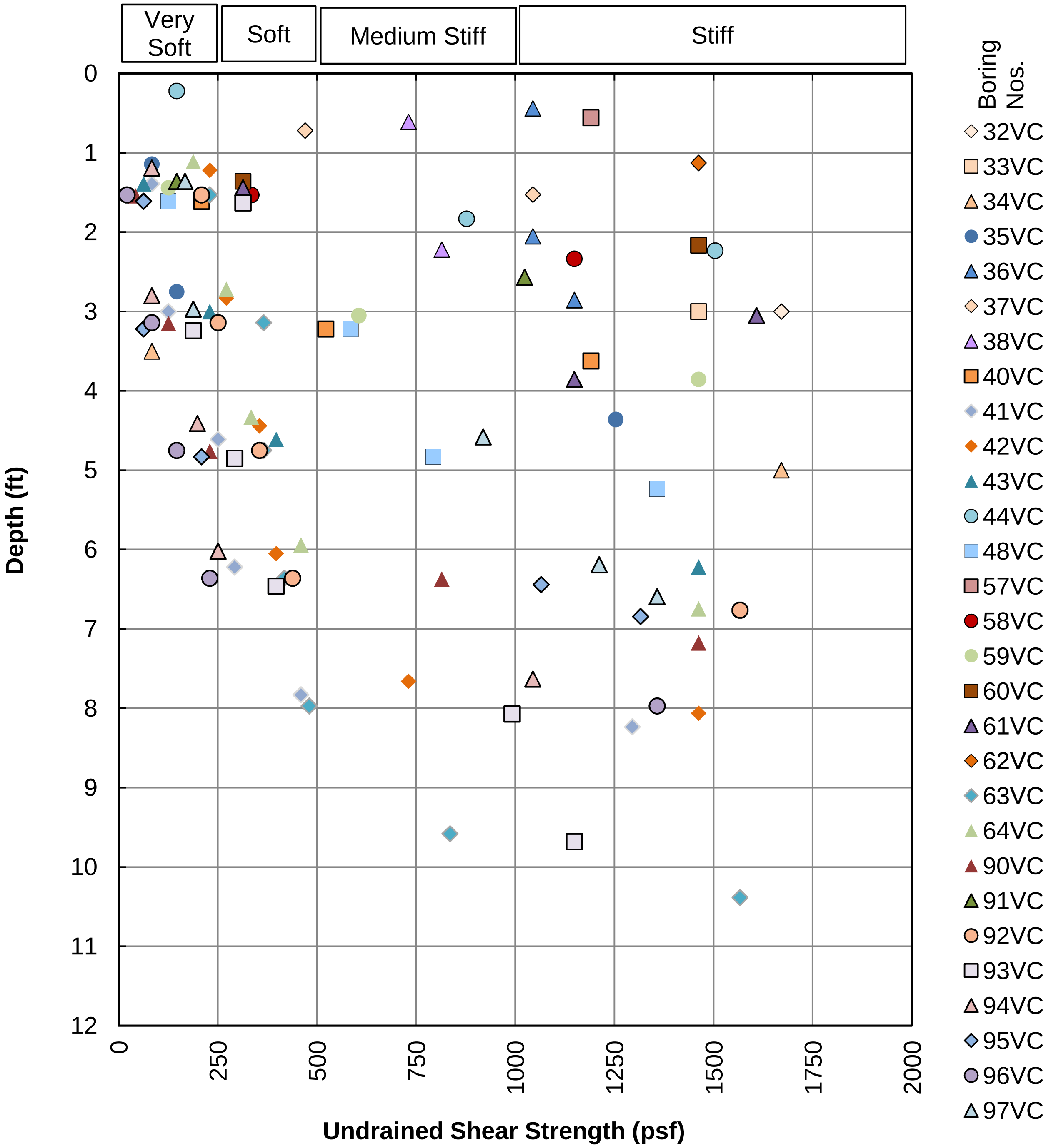


1 inch = 4000 feet

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Comparison of 1972 Bathymetry and 2011 Scripps

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

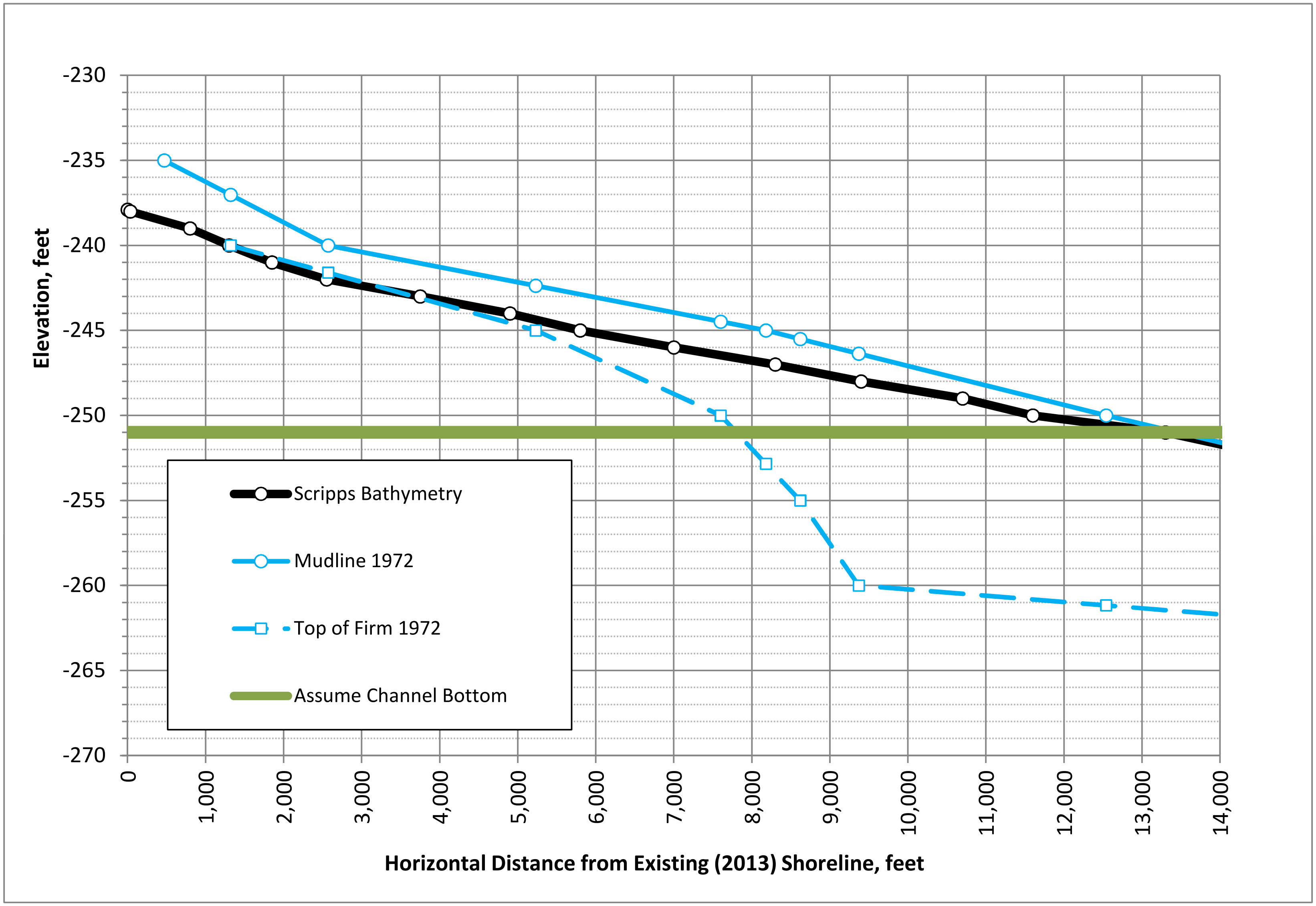


Notes:

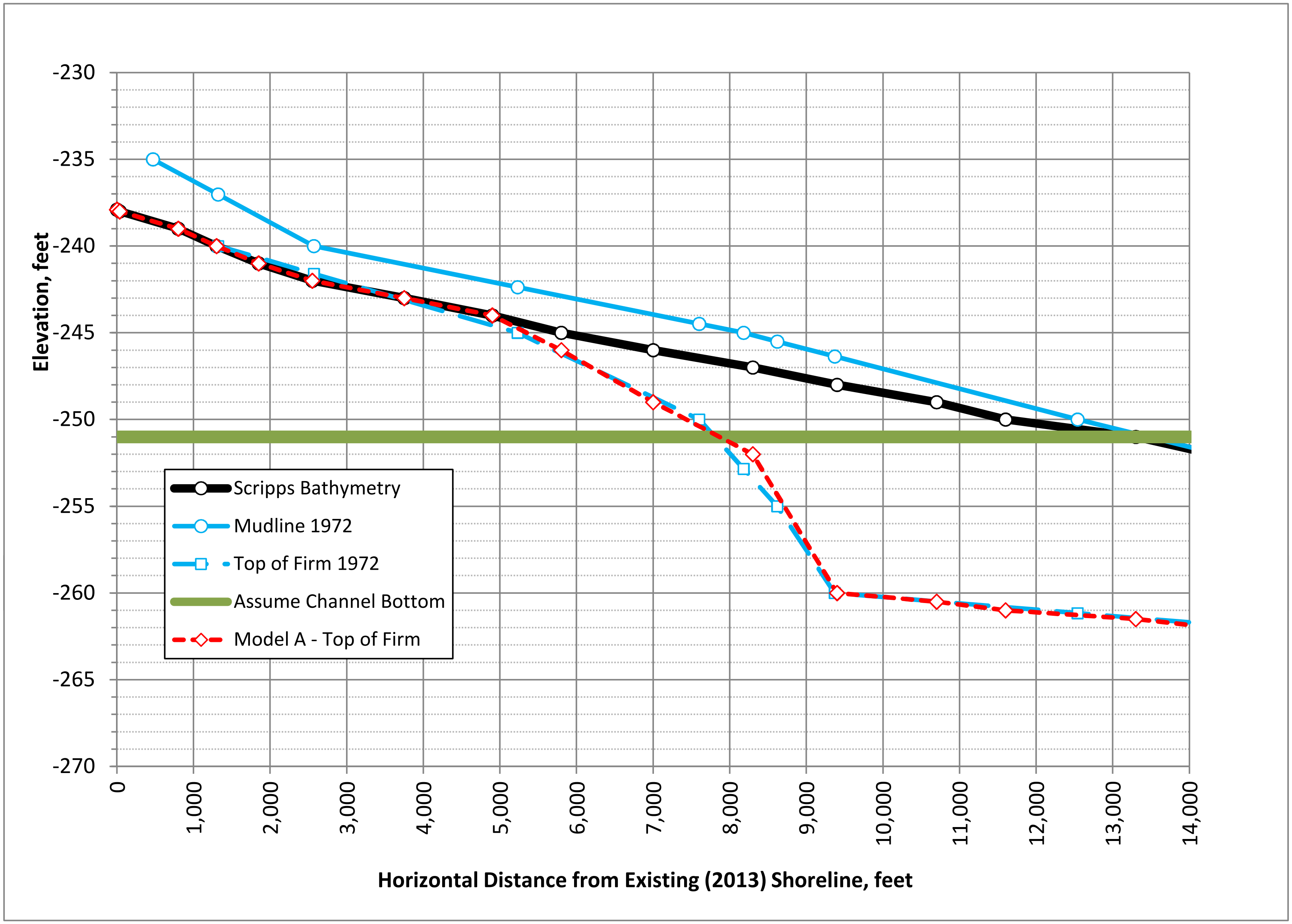
1. Undrained shear strength was measured using hand held vane shear device (Model: Geonor H-60) manufactured by Geonor, Inc.(before shaft friction corrections)

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Results at Vibracores**

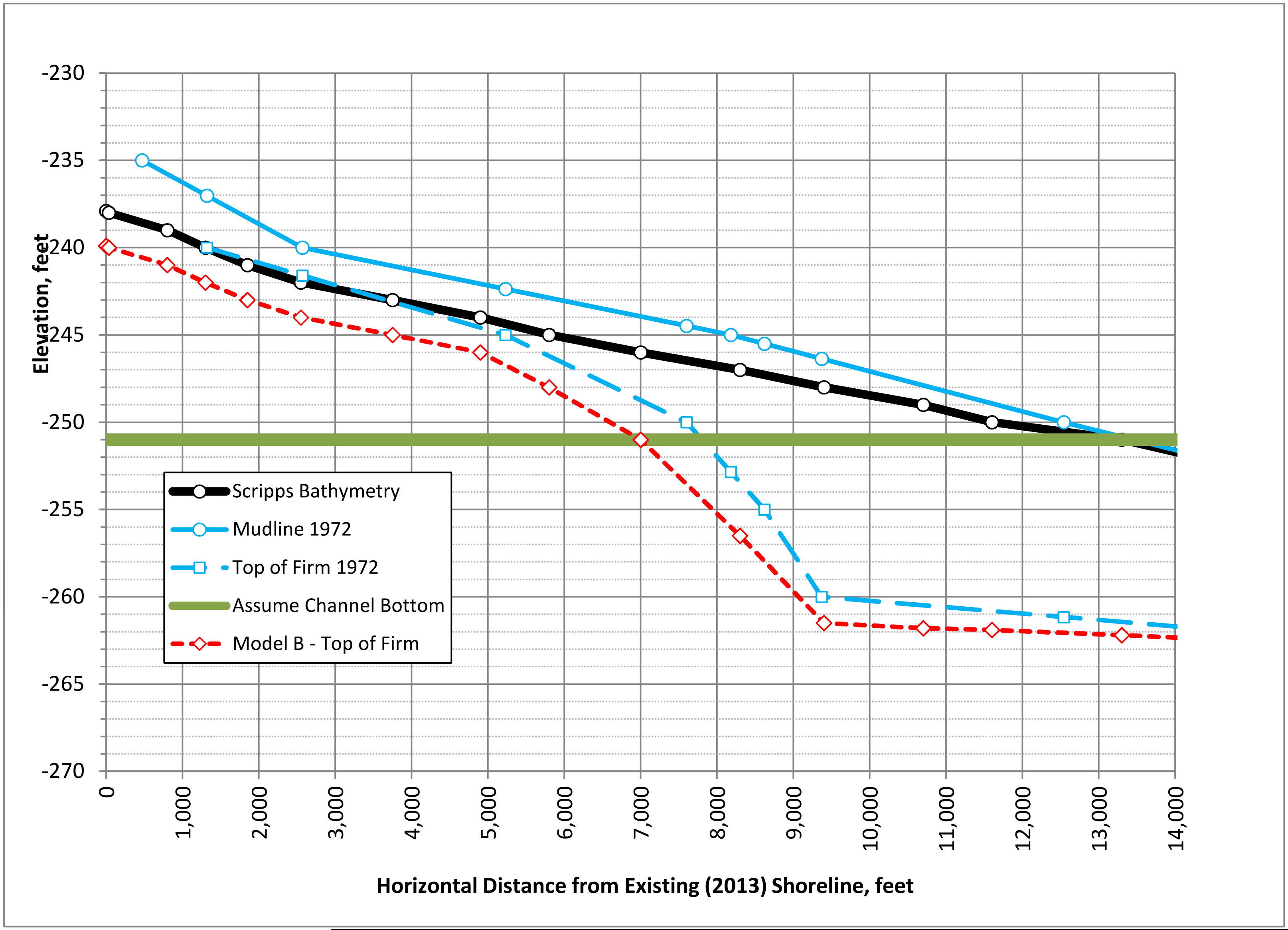
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 24



Salton Sea Species Conservation Habitat Project Salton Sea, California		**1972 Bathymetry and Probes Compared to Scripps Bathymetry**
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 25

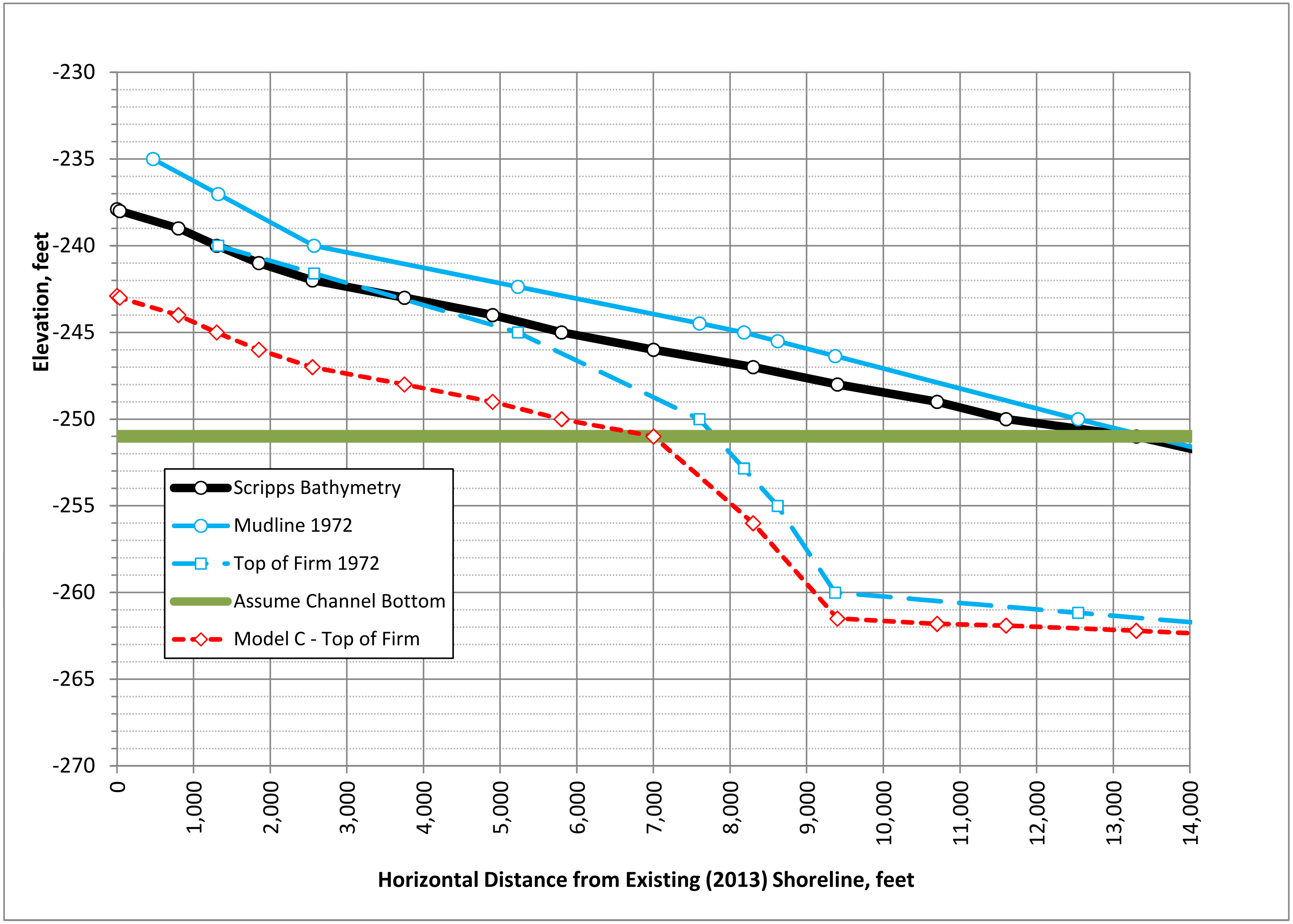


Salton Sea Species Conservation Habitat Project Salton Sea, California	**Model "A" for Top of Firm Material**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 26



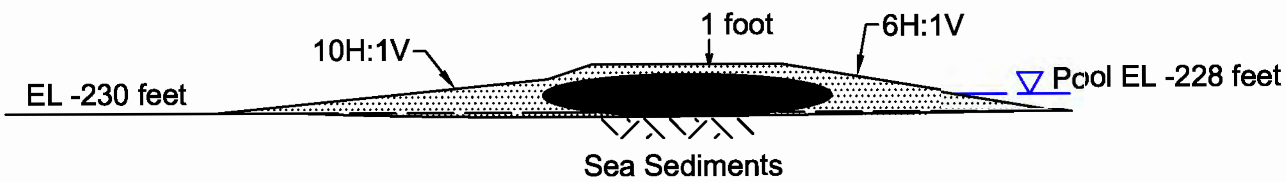
Salton Sea Species Conservation Habitat Project Salton Sea, California	**Model "B" for Top of Firm Material**

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



Salton Sea Species Conservation Habitat Project Salton Sea, California	**Model "C" for Top of Firm Material**

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



Notes:

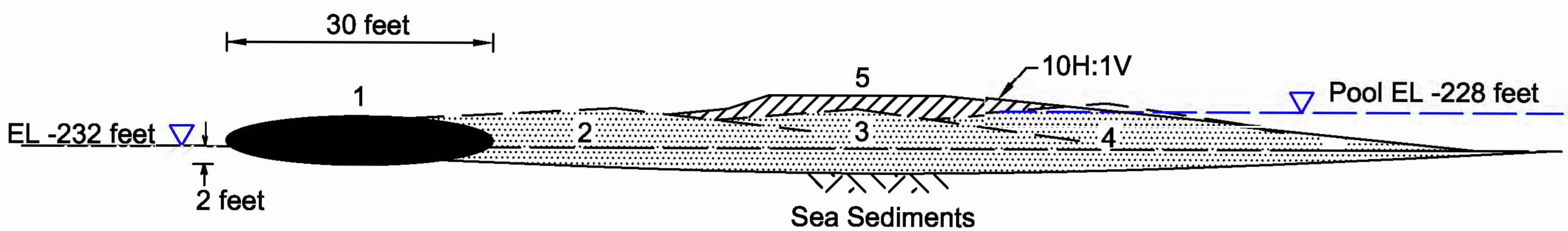
1. Place and fill a geotube. Assume 30 feet wide footprint, displacing only a little with a total height 4 feet to EL -226 feet. The geotube will settle further.
2. Place sea-side seepage berm at 10:1.
3. Place pond-side fill at 6:1 and cover geotube with 1 feet of fill to protect from traffic and sunlight.
4. Provide erosion protection on the pond-side slope.

SCALE
0 20 feet
1 inch = 20 feet

Salton Sea
Species Conservation Hapitat Project
Salton Sea, California

Geotube Application On Higher Ground

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



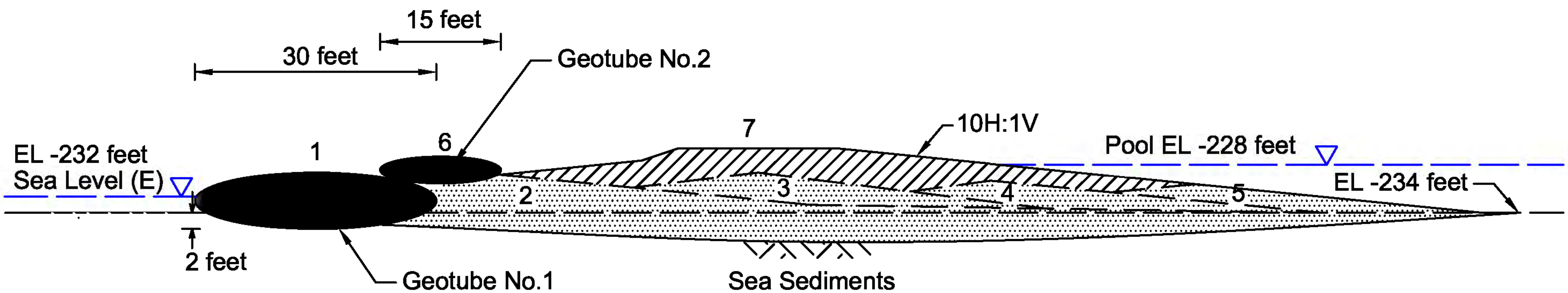
Notes:

1. Place and fill a geotube. Assume 30 feet wide footprint, displacing 2 feet into sea sediment with a total height 5 feet to EL -229 feet (3 feet above the existing sea level). The geotube will settle further.

2- 4. Place sandy fill hydraulically behind the geotube. Shape to planar berm.

5. Place additional hydraulic fill and shape to the final design configuration.

SCALE 0 20 feet 1 inch = 20 feet	Salton Sea Species Conservation Habitat Project Salton Sea, California	**Geotube Application At Shoreline**
	Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. 30



Notes:

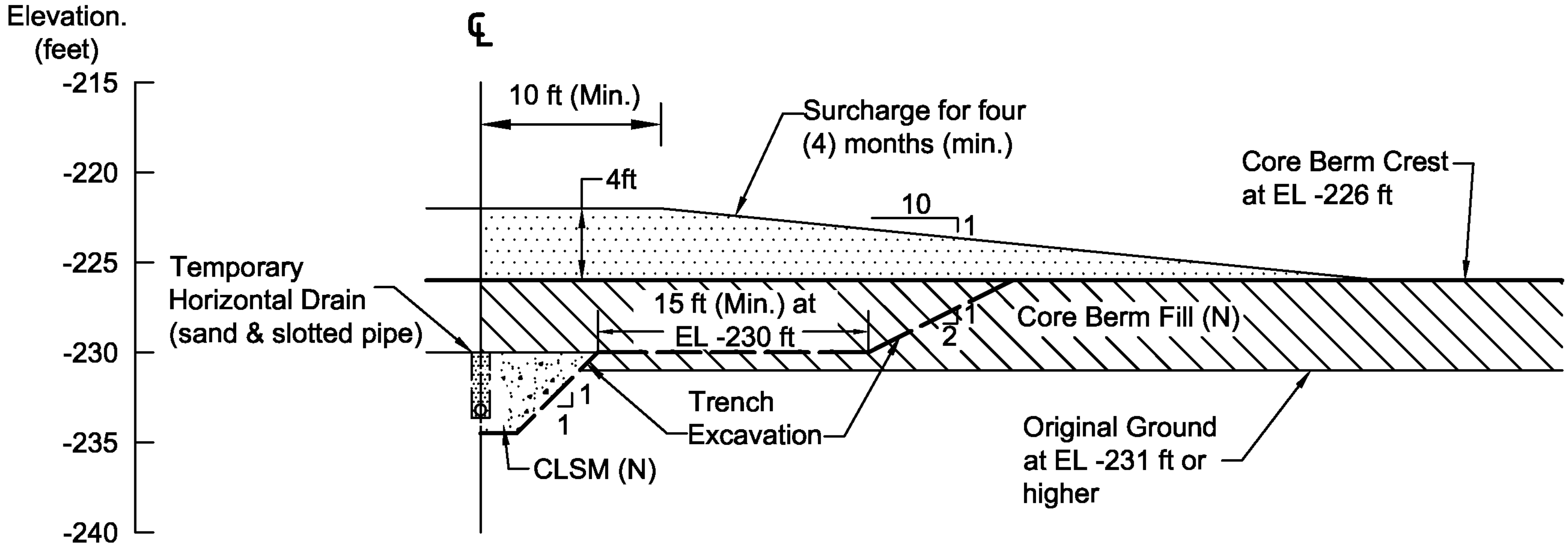
1. Place and fill a geotube (Geotube No.1). Assume approximately 30 ft wide footprint, displacing approximately 2 feet into sea sediment, with a total height of approximatley 6 ft to EL -230 (2 ft above existing sea level). The geotube will settle further.

2-5. Place sandy fill hydraulically behind Geotube No.1 and across full width of the berm.

6. Place and fill second geotube (Geotube No.2) with a total height of 2 to 3 feet (about 5 feet above the existing Sea level) to complete temporary shoreline protection. Up to this point, large seas would run up over Geotube No.1, but most sand fill would be protected.

7. Place additional hydraulic fill in the center area. Shape to final design configuration.

SCALE 0 20 feet 1 inch = 20 feet	Salton Sea Species Conservation Habitat Project Salton Sea, California	**Geotube Application In Two Feet Water**	
	Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 31



Note:
1. Temporary horizontal drain should be installed before placement of new core berm fill and surcharge.
2. Drain should be removed when excavating WCS pipe trench.
3. WCS pipe should be backfilled with CLSM beneath the core berm and with graded filters downstream of the core berm

SCALE 0 10 feet 1 inch = 10 feet	Salton Sea Species Conservation Habitat Project Salton Sea, California	**Surcharge and Horizontal Drain along the WCS pipeline**
	Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. 32

APPENDIX A

APPENDIX A

LOGS OF HAND AUGER BORINGS AND VIBRACORES

2011-2013 EXPLORATION OF NEW RIVER SITE

TABLE OF CONTENTS

Date	:	10/13/2011
Drilling Method	:	Hand Auger
Elevation (Feet)	:	-228
Latitude	:	33.10958
Longitude	:	115.68041

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
				SP-SM		Poorly-Graded Sand (SP-SM), brown, dry, dense, with silt					
	B						0.65				Sieve
1						becoming moist	0.65				
	B						0.34				
				ML		Sandy Silt (ML), reddish brown, moist, medium stiff					
2							0.36				
							0.37				
				ML		Silt (ML), reddish brown, moist to wet, medium stiff					
3							0.49				
	B						0.54	27			
4				SM	∇	Silty Sand (SM), reddish brown, wet, dense	0.22				
						10/13/2011	0.57				
	B						0.61	26	NP	NP	
5				ML		Sandy Silt (ML), reddish brown, saturated, medium stiff					
							0.24				
6							0.36				
							0.45				
7							0.32				
							0.43				
8				ML		Silt (ML), reddish brown, saturated, medium stiff	0.36				
							0.36				
9							0.47				
							0.41				
	B					becoming stiff	0.65				
10											

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/13/2011 Drilling Method : Hand Auger Elevation (Feet) : -228 Latitude : 33.10958 Longitude : 115.68041 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Bottom of boring at 10 feet Groundwater encountered during drilling at 4.5 feet					

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 2 of 2)

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

Date : 10/13/2011
Drilling Method : Hand Auger
Elevation (Feet) : -228.7
Latitude : 33.10892
Longitude : 115.68718

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), gray, dry to moist, medium stiff to stiff, with sand	0.33				
1	B						0.50				
							0.50				
2	B			ML			0.46				
							0.65				
3	B						0.50				
							0.44				
4	B						0.35				
							0.36				
5	B					Lean Clay (CL), reddish brown, moist, medium stiff to stiff	0.40				
							0.46	32			
6	B						0.65				
				CL			0.65	33			
7	B						0.82				
							0.73				
8	B					Silt (ML), reddish brown, moist to wet, stiff to very stiff	0.63				
							0.71				
9				ML			0.71				
							1.10				

Bottom of boring at 9.5 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

Log of 30HA
(Page 1 of 1)

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

Date : 10/13/2011
Drilling Method : Hand Auger
Elevation (Feet) : -229.2
Latitude : 33.10495
Longitude : 115.6884

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), brown, dry to moist, medium stiff to stiff, with sand					
	B			ML							
1							0.25				
							0.57				
2	B					Fat Clay (CH), gray, moist, medium stiff	0.46		56	28	
							1.23	42			
3				CH			0.22				
						becoming light gray and soft	0.22				
4	B					Lean Clay (CL), reddish brown, moist, stiff to very stiff	0.22				
							0.65				
5				CL			0.65				
							1.28	36			
6	B					Silt (ML), reddish brown, moist to wet, stiff	0.61				
							0.84				
7				ML	∇	10/13/2011	0.47				
	B						0.78				
8						Lean Clay (CL), reddish brown, saturated, stiff to very stiff	0.63				
				CH			1.19				
9							0.35				

Bottom of boring at 9 feet
Groundwater encountered during drilling at 7 feet

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

Log of 31HA
(Page 1 of 1)

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

Date : 10/11/2011
Drilling Method : Vibracore
Elevation (Feet) : -234
Latitude : 33.10126
Longitude : 115.69528

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
				CH		Fat Clay (CH), gray, saturated, soft					
				ML		Sandy Silt (ML), dark gray, saturated, soft to medium stiff					
				CH		Fat Clay (CH), gray, saturated, medium stiff, silty					
1	V			CL		Lean Clay (CL), reddish brown, wet, stiff, trace sand		31	42	23	
2											
						Bottom of boring at 2.4 feet					
3							0.84				

Vane Shear device used to measure undrained shear strength to a depth of 3.2 feet
Refusal to vane shear penetration at 3.2 feet.
Water level approximately 2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Date : 10/11/2011
Drilling Method : Vibracore
Elevation (Feet) : -233.8
Latitude : 33.10503
Longitude : 115.6945

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			CH		Fat Clay (CH), dark gray, saturated, soft becoming gray					
1								87			
						becoming olive gray					
2				CH		Fat Clay (CH), reddish brown, saturated, stiff, silty					
3						Bottom of boring at 2.8 feet	0.73				

Vane Shear device used to measure undrained shear strength to a depth of 3.2 feet
Refusal to vane shear penetration at 3.2 feet.
Water level approximately 2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Date : 10/11/2011
Drilling Method : Vibracore
Elevation (Feet) : -234
Latitude : 33.10855
Longitude : 115.6946

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), dark gray, saturated, loose					
1				CH		Fat Clay (CH), olive gray, saturated, soft, with few wood chips	0.04	81	66	38	
2						becoming olive gray, with fish bones					
3				CH		Silty Fat Clay (CH), reddish brown, wet, stiff	0.70 0.82	26			

Bottom of boring at 3.5 feet
Water level approximately 2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date : 10/11/2011
Drilling Method : Vibracore
Elevation (Feet) : -233.9
Latitude : 33.11231
Longitude : 115.69689

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			CH		Fat Clay (CH), dark gray, saturated, soft, with 1-inch silty sand layer on the surface					
1, 2, 3				CH		Fat Clay (CH), olive gray, saturated, soft, with few fish bones	0.04, 0.06	91			
				ML		Sandy Silt (ML), olive brown, saturated, medium stiff		31	25	4	
4				SM		Silty Sand (SM), olive brown, saturated, loose	0.60				
5				CH		Fat Clay (CH), olive gray, saturated, soft, silty					

Bottom of boring at 5.4 feet
Refusal to vane shear penetration at 5.8 feet.
Water level approximately 2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Depth in Feet	Samples Type/ Recovery	Blow Count	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
					Date : 10/11/2011 Drilling Method : Vibracore Elevation (Feet) : -234 Latitude : 33.11616 Longitude : 115.6988					
					Poorly-Graded Sand (SP), dark gray, wet, loose, with shell debris	0.52				
1										
										Sieve
2			SP		with interbedded clay and silt layers between 2 and 4 feet	0.46				
	V						57			
3						0.48				
4					Well-Graded Sand (SW), brown, wet, loose		26			
			SW							
5										

Bottom of boring at 5.2 feet
Refusal to vane shear penetration at 3.4 feet.
Water level approximately 1.2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/11/2011 Drilling Method : Vibracore Elevation (Feet) : -234 Latitude : 33.1204 Longitude : 115.69971 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V			CH		Fat Clay (CH), dark gray, saturated, soft					
1				SP		Poorly-Graded Sand (SP), dark gray, wet, loose, with shell debris	0.24				Sieve
						Bottom of boring at 1.3 feet	0.51				
2											

Vane Shear device used to measure undrained shear strength to a depth of 2 feet
Refusal to vane shear penetration at 2 feet.
Water level approximately 2.5 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/11/2011 Drilling Method : Vibracore Elevation (Feet) : -234 Latitude : 33.12429 Longitude : 115.69939 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
1				SW		Well-Graded Sand (SW), dark gray, wet, loose, with shell debris	0.37				
2	V										
3				SW		Well-Graded Sand (SW), olive gray, wet, loose	0.36	22			

Bottom of boring at 3.8 feet
Water level approximately 1 foot above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

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			CL		Sandy Lean Clay (CL), brown, moist, soft	0.22				
1	B			SC		Clayey Sand (SC), brown, moist, medium dense	0.46				
	B B			ML		Silt (ML), brown, moist, medium stiff, with sand	0.42	28			
2 3	B			SM		Silty Sand (SM), gray, fine grained sand, moist, medium dense, with black clay lens	0.28 0.58 0.44				Sieve
4	B			ML		Silt (ML), black gray, wet, medium stiff, with sand and mica	0.58 0.34	29			
5	B			SP		Poorly-Graded Sand (SP), gray, fine grained sand, medium dense, with silt	0.42				

Date : 10/12/2011
Drilling Method : Hand Auger
Elevation (Feet) : -228
Latitude : 33.13192
Longitude : 115.69078

Bottom of boring at 5 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/25/2011 Drilling Method : Vibracore Elevation (Feet) : -234 Latitude : 33.13377 Longitude : 115.68589 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V			SP		Poorly-Graded Sand (SP), dark gray, wet, loose Gray 1/2-inch clay bed, soft, saturated					Sieve
1				CH		Sandy Fat Clay (CH), gray, saturated, soft, with thin sand layers	0.09	70			
2											
3				CL		Lean Clay (CL), olive brown to olive gray, saturated, soft to medium stiff, with fish bones	0.25 0.58	41	32	9	
4				SW-SM		Well-Graded Sand (SW-SM), olive brown, wet, loose, with silt					
5											
6											

Bottom of boring at 6.3 feet
Refusal to vane shear penetration at 3.8 feet.
Water level approximately 1.6 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Date : 10/25/2011
Drilling Method : Vibracore
Elevation (Feet) : -234
Latitude : 33.13168
Longitude : 115.68154

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
				SM		Silty Sand (SM), dark gray, saturated, loose, with thin beds of soft clay					
1				CH		Fat Clay (CH), dark gray, saturated, very soft, with numerous shells					
				SM		Silty Sand (SM), gray, saturated, loose	0.04				
2 3	V			CH		Fat Clay (CH), gray, saturated, very soft, with shells	0.05	78			
4 5 6				CH		Fat Clay (CH), black, saturated, soft, with petroleum odor	0.10 0.10	75	70	40	
7				CH		Fat Clay (CH), olive gray, saturated, soft		85			
8						Bottom of boring at 7.5 feet	0.19 0.60				

Vane Shear device used to measure undrained shear strength to a depth of 8.2 feet
Refusal to vane shear penetration at 8.2 feet.
Water level approximately 1.8 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Date : 10/25/2011
Drilling Method : Vibracore
Elevation (Feet) : -234
Latitude : 33.13014
Longitude : 115.67879

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
0–1	V			SM		Silty Sand (SM), dark gray, saturated, loose, with shell debris					Sieve
1–2				CL		Sandy Lean Clay (CL), olive gray, saturated, very soft, with thin gray sand layers	0.12				
2–2.75				CL		Sandy Lean Clay (CL), olive gray, saturated, soft to medium stiff, very thin interbedded silty sand layers		48			
2.75–4				CH		Fat Clay (CH), olive gray, saturated, soft, with shell debris	0.11				
4–4.25				CH		Fat Clay (CH), black, saturated, soft, with petroleum odor					
4.25–6.8				CH		Fat Clay (CH), olive gray, saturated, soft, laminated	0.11				
							0.13	71			
6.8						Bottom of boring at 6.8 feet					
							0.13				
8							0.30				

Vane Shear device used to measure undrained shear strength to a depth of 8.1 feet
Refusal to vane shear penetration at 8.1 feet.
Water level approximately 2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/25/2011 Drilling Method : Vibracore Elevation (Feet) : -234 Latitude : 33.12914 Longitude : 115.67638 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
0	V			CL		Sandy Lean Clay (CL), olive gray, saturated, soft, with shells					
				CL		Lean Clay (CL), olive gray, saturated, very soft, with rare shells and fish bones					
1							0.03	60	49	25	
2											
3				SM		Silty Sand (SM), olive gray, saturated, loose, laminated	0.11				
				CH		Fat Clay (CH), olive gray, saturated, soft, with scattered fish and shell debris					
4								46			
						Bottom of boring at 4.5 feet	0.18				
5											
6							0.60				

Vane Shear device used to measure undrained shear strength to a depth of 6.2 feet
Refusal to vane shear penetration at 6.2 feet.
Water level approximately 1.8 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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(Page 1 of 1)

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/25/2011 Drilling Method : Vibracore Elevation (Feet) : -233.4 Latitude : 33.12841 Longitude : 115.67347 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
				CH		Fat Clay (CH), dark gray, saturated, soft, with scattered shell debris, locally sandy	0.06				
1	V			CH		Fat Clay (CH), olive gray, saturated, soft		61	51	28	
2				ML		Silt (ML), reddish brown, saturated, medium stiff becomes sandy, stiff	0.43 0.65	29			

Bottom of boring at 2.8 feet
Refusal to vane shear penetration at 2.2 feet.
Water level approximately 3 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/25/2011 Drilling Method : Vibracore Elevation (Feet) : -234 Latitude : 33.12897 Longitude : 115.66875 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
				CL		Sandy Lean Clay (CL), dark gray, saturated, soft to medium stiff, with interbedded silty sand		36			
1							0.16				
				ML		Sandy Silt (ML), gray to dark gray, saturated, medium stiff					
2	V					Sandy Silt (ML), reddish brown, medium stiff	0.40				
3				ML							
4								29			

Bottom of boring at 4.3 feet
Refusal to vane shear penetration at 2.5 feet.
Water level approximately 0.3 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date : 10/11/2011
Drilling Method : Vibracore
Elevation (Feet) : -228.1
Latitude : 33.12004
Longitude : 115.67049

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
						Lean Clay (CL), reddish brown, dry to moist, stiff to medium stiff					
	B						0.65				
1				CL			0.65				
							0.65				
2							0.36				
	B					Silt (ML), reddish brown, moist to wet, medium stiff, with sand	0.40	30			
3							0.42				
							0.39				
4						with some plasticity	0.35				
	B			ML			0.39	27			
5							0.44				
	B					increasing plasticity	0.48				
6							0.45				
							0.40				

Bottom of boring at 6.5 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date : 10/11/2011
Drilling Method : Vibracore
Elevation (Feet) : -229.7
Latitude : 33.11939
Longitude : 115.67569

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
				ML		Silt (ML), brown, dry to moist, medium stiff	0.30				
	B										
1						Fat Clay (CH), tan gray, moist, soft					
	B										
2							0.21				
				CH							
3	B						0.23	53			
4	B					Lean Clay (CL), reddish brown, moist, medium stiff to stiff	0.52				
	B										
5							0.29				
					∇	10/11/2011					
6							0.75				
	B						0.58	34	35	12	
7				CL			0.35				
							0.45				
8							0.46				
	B										
9											
							0.69				
10											

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/11/2011 Drilling Method : Vibracore Elevation (Feet) : -229.7 Latitude : 33.11939 Longitude : 115.67569 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
				CL		Lean Clay (CL), reddish brown, moist, medium stiff to stiff					
11						Bottom of boring at 11 feet Groundwater encountered during drilling at 5.5 feet					

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-21

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/25/2011 Drilling Method : Vibracore Elevation (Feet) : 231.5 Latitude : 33.12641 Longitude : 115.67192 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), dark gray, saturated, very soft					
1				CH		1-inch seam of gray silty sand		47			
							0.06				
						1-inch seam of gray silty sand					
2	V					Sandy Silt (ML), reddish brown, saturated, medium stiff					
3				ML			0.29				
											Sieve
4								31			
						Bottom of boring at 4.5 feet	0.35				
5							0.60				

Vane Shear device used to measure undrained shear strength to a depth of 5.2 feet
Refusal to vane shear penetration at 5.2 feet.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers	Project No. 758.01	Plate No. A-22

Date : 10/11/2011
Drilling Method : Hand Auger
Elevation (Feet) : -229.9
Latitude : 33.12362
Longitude : 115.67252

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), brown, dry to moist, soft					
	B			CH			0.21				
1	B					Elastic Silt (MH), gray, moist to wet, very soft to soft, with organic odor and black matters	0.19				
							0.18				
2	B						0.17	37			
				MH			0.15				
3	B				▽	10/11/2011	0.21				
							0.20				
4	B					Fat Clay (CH), brown, moist, medium stiff to stiff	0.22				
							0.56				
5	B						0.54	27			
							0.54				
6							0.46				
				CH			0.46				
7	B						0.46				
							0.55				
8	B										
9	B										

Bottom of boring at 9.5 feet
Groundwater encountered during drilling at 3 feet

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date : 10/12/2011
Drilling Method : Vibracore
Elevation (Feet) : -228.5
Latitude : 33.12875
Longitude : 115.68688

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		Silt (ML), brown, moist, medium stiff, with sand and some plasticity	0.38	24			
1	B			SM		Silty Sand (SM), brown, very fine grained sand, dry to moist, loose	0.54				
							0.39				
2	B			SM		Silty Sand (SM), gray, moist, medium dense	0.45				
							0.65				
3	B						0.52				
				CH		Fat Clay (CH), black, moist, soft, with interbedded sand lens	0.22	58			
4	B			CH		Sandy Fat Clay (CH), gray, wet, soft, with organics, wood branches approximately 0.25-inch in diameter	0.17				
	B						0.57				
5				SM		Silty Sand (SM), reddish brown, wet, medium dense	0.58				
							0.39				
6											

Bottom of boring at 6 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date : 10/12/2011
Drilling Method : Hand Auger
Elevation (Feet) : -228
Latitude : 33.12618
Longitude : 115.69125

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			CL		Lean Clay (CL), reddish brown, moist, medium stiff	0.36	30	37	21	
1	B			ML		Sandy Silt (ML), reddish brown, moist, stiff to medium stiff	0.32				
							0.65				
2	B					becoming wet	0.37				
	B			CH		Fat Clay (CH), black and gray, wet, soft	0.29				
3						shells, organic odor	0.17				
				CH		Fat Clay (CH), tan, wet, soft, with organic matters and shells	0.21	89			
4	B						0.20				
				CL		Lean Clay (CL), reddish brown, wet, medium stiff	0.26				
5	B				▽	10/12/2011	0.33				
	B						0.37				
6				SM		Silty Sand (SM), reddish brown, fine grained sand, saturated, medium dense to dense	0.65				
7						becoming gray					
				ML		Sandy Silt (ML), gray, saturated, medium stiff					Sieve
8	B										
9	B										

Bottom of boring at 9 feet
Groundwater encountered during drilling at 5 feet

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date	:	10/12/2011	
Drilling Method	:	Vibracore	
Elevation (Feet)	:	-229.3	
Latitude	:	33.12194	
Longitude	:	115.69273	

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			CH		Fat Clay (CH), greenish gray, dry to moist, stiff to medium stiff	0.45				
1						Fat Clay (CH), grayish gray, soft to very soft, with black organic matter, organic odor	0.29				
	B						0.19				
2							0.07				
							0.07				
3							0.07				
				CH			0.09				
4					▽	10/12/2011	0.08				
							0.10	86			
5							0.10				
							0.11				
6							0.09				
	B			SM		Silty Sand (SM), gray, wet, medium dense to dense	0.52				
7	B			ML		Sandy Silt (ML), reddish brown, saturated, stiff	0.64				
8	B			SM		Silty Sand (SM), reddish brown, saturated, medium dense to dense	0.65				
							0.64				

Bottom of boring at 8.5 feet
Groundwater encountered at 4 feet

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date : 10/14/2011
Drilling Method : Hand Auger
Elevation (Feet) : -229.8
Latitude : 33.11703
Longitude : 115.69493

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
				CH		Fat Clay (CH), reddish brown, moist, soft to medium stiff	0.20	30			
	B										
1						Fat Clay (CH), gray, moist, soft to medium stiff, with wood chips	0.24				
							0.18				
2	B			CH			0.22				
							0.23	37			
3	B					Silty Sand (SM), gray, wet to saturated, medium dense	0.15				
							0.65				
4	B				▽	becoming brown 10/14/2011	0.55				
							0.65				
5				SM			0.47				Sieve
							0.52				
6	B						0.65				
							0.65				
7											

Bottom of boring at 7 feet
Groundwater encountered during drilling at 4 feet

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date	: 10/14/2011
Drilling Method	: Vibracore
Elevation (Feet)	: -228.1
Latitude	: 33.11273
Longitude	: 115.69073

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			SP-SM		Poorly-Graded Sand with Silt (SP-SM), gray and brown, dry, loose	0.49				
1	B			CH		Fat Clay (CH), gray, wet, medium stiff to soft	0.33				
							0.24				
2							0.14				
							0.14				
3	B			CH		Fat Clay (CH), black, saturated, soft	0.14	86			
							0.19				
4	B			CH		Fat Clay (CH), gray, saturated, soft to medium stiff	0.22				
	B			CH		Fat Clay (CH), reddish brown, saturated, medium stiff	0.24				
5							0.34				
	B						0.42				
6							0.22				
				SM		Silty Sand (SM), reddish brown, saturated, medium dense to dense	0.65				
7							0.38				
	B						0.52				
8	B						0.65				
9											

Bottom of boring at 9 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date	:	10/27/2011
Drilling Method	:	Vibracore
Elevation (Feet)	:	-232
Latitude	:	33.12429
Longitude	:	115.69838

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
						Poorly-Graded Sand (SP-SM), olive gray, wet, loose, with silt and shells					
							0.60				
1				SP-SM							
											Sieve
						with abundant shell debris					
2				CH		Fat Clay (CH), dark gray, saturated, soft					
						Poorly-Graded Sand (SP-SM), olive gray, wet, loose, with silt and shell debris					
3	V										
						1/2-inch thick fat clay, dark gray					
4						becoming grayish brown, with scattered shell debris					
				SP-SM							
5											
6											
								26			

Bottom of boring at 6.8 feet
Vane Shear device used to measure undrained shear strength to a depth of 0.6 feet
Refusal to vane shear penetration at 0.6 feet.
Water level approximatly 0.25 feet above surface

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Date	: 10/27/2011
Drilling Method	: Vibracore
Elevation (Feet)	: -232.3
Latitude	: 33.1171
Longitude	: 115.69777

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
0–1	V			SP		Poorly-Graded Sand (SP), dark gray, wet, loose, with shell debris					
1–1.75				CH		Fat Clay (CH), dark olive gray, saturated, soft	0.14	51			
1.75–2.2				CH		Fat Clay (CH), dark olive and black, saturated, soft, with petroleum odor					
2.2–3				CH		Fat Clay (CH), olive gray, saturated, soft to medium stiff	0.48				
3–4.25				SP		Poorly-Graded Sand (SP), brownish gray, wet, loose, with shell debris and tace silt					Sieve
4.25–5				ML		Silt (ML), olive brown, wet, medium stiff					
5–5.25				SP		Poorly-Graded Sand (SP), olive brown, wet, loose, with trace silt					
5.25–5.8				SM		Silty Sand (SM), brown, wet, loose					
5.8–6.45				SP		Poorly-Graded Sand (SP), brown, wet, loose					
6.45–7				CL		Lean Clay (CL), olive brown, wet, medium stiff, with charcoal					

Bottom of boring at 7 feet
Refusal to vane shear penetration at 2.3 feet.
Water level approximately 0.1 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-30

Date	: 10/27/2011
Drilling Method	: Vibracore
Elevation (Feet)	: -232.4
Latitude	: 33.10801
Longitude	: 115.69108

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
				CH		Fat Clay (CH), dark gray, saturated, very soft					
				ML		Sandy Silt (ML), dark gray, saturated, very soft					
1						Fat Clay (CH), dark gray, saturated, very soft, with plant debris		80			
	V			CH			0.06				
2											
				OH		Peat (Pt), olive brown, saturated, soft					
3						Fat Clay (CH), olive brown to gray, wet to saturated, medium stiff to stiff, with some plant debris	0.25	56	70	44	
				CH							
4							0.55				

Bottom of boring at 4.5 feet
Refusal to vane shear penetration at 3.9 feet.
Water level approximately 0.2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/27/2011 Drilling Method : Vibracore Elevation (Feet) : -232.4 Latitude : 33.10101 Longitude : 115.69366 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
1	V			CH		Fat Clay (CH), dark gray, saturated, soft, with sandy zones		92			
2				CH		Fat Clay (CH), gray, saturated, soft	0.14				
				CH		Fat Clay (CH), reddish brown, wet, stiff	0.55	35			

Bottom of boring at 2.6 feet
Refusal to vane shear penetration at 2.2 feet
Water level approximately 0.25 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-32

Date : 10/27/2011
Drilling Method : Vibracore
Elevation (Feet) : -232
Latitude : 33.13335
Longitude : 115.68813

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
0–0.75	V			CH		Fat Clay (CH), dark gray, saturated, soft					
0.75–1.5				SP		Poorly-Graded Sand (SP), dark gray, wet, loose, slightly silty					
1.5–3.2				CH		Fat Clay (CH), dark gray, saturated, soft, locally sandy, slight petroleum odor	0.14	51			
3.2–4.25				SP		Poorly-Graded Sand (SP), dark gray, wet, loose, locally silty	0.65 0.51				
4.25–4.5				SM		Silty Sand (SM), olive gray, saturated, loose, with shell debris					
4.5–5.75				SP		Poorly-Graded Sand (SP), olive gray, wet, loose					
5.75–6.3				SM		Silty Sand (SM), olive gray, wet, loose becoming brown		27			

Bottom of boring at 6.3 feet
Water level approximately 0.2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-33

Date : 10/27/2011
Drilling Method : Vibracore
Elevation (Feet) : -232.1
Latitude : 33.1313
Longitude : 115.68367

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			SP		Poorly-Graded Sand (SP), dark gray, wet, loose					
1				SM		Silty Sand (SM), olive gray, saturated, loose					
2, 3				SP-SM		Poorly-Graded Sand (SP-SM), dark gray, wet, loose, with silt and shell debris	0.65				Sieve
4				CH		Fat Clay (CH), olive gray, saturated, soft		56			
5, 6, 7				CH		Fat Clay (CH), mottled black and olive brown, saturated, soft to medium stiff, with strong petroleum odor					
8				CH		Fat Clay (CH), olive brown, saturated, medium stiff, with scattered shell debris		71			

Bottom of boring at 8.6 feet
Refusal to vane shear penetration at 1.1 feet.
Water level approximately 0.1 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-34

Date : 10/27/2011
Drilling Method : Vibracore
Elevation (Feet) : -232
Latitude : 33.12859
Longitude : 115.68003

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
				SP		Poorly-Graded Sand (SP), dark gray, saturated, loose					
				CH		Fat Clay (CH), dark gray, saturated, soft					
1											
				SP		Poorly-Graded Sand (SP), dark gray, wet to saturated, loose	0.12				
2						Fat Clay (CH), olive gray, saturated, soft					
3				CH			0.15				
4				SP		Poorly-Graded Sand (SP), olive gray, saturated, loose					
	V										
				CH		Fat Clay (CH), olive gray, saturated, soft	0.13				
5											
				CH		Fat Clay (CH), mottled olive gray and black, saturated, soft, with petroleum odor					
6						Fat Clay (CH), olive gray, saturated, soft					
							0.13				
7				CH							
8							0.14	78			
						Bottom of boring at 8.5					
9											
							0.32				
10											

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-35

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/27/2011 Drilling Method : Vibracore Elevation (Feet) : -232 Latitude : 33.12859 Longitude : 115.68003 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
							0.55				
						Vane Shear device used to measure undrained shear strength to a depth of 10.4 feet Water level approximately 0.1 feet above surface.					

Date	: 10/27/2011
Drilling Method	: Vibracore
Elevation (Feet)	: -232
Latitude	: 33.12755
Longitude	: 115.67764

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
				SP		Poorly-Graded Sand (SP), dark gray, saturated, loose, with shell debris					
1				CH		Fat Clay (CH), dark gray, saturated, very soft	0.08				
				SM		Silty Sand (SM), dark gray, saturated, loose					
				CH		Fat Clay (CH), dark gray, saturated, loose					
2				SM		Silty Sand (SM), dark gray, saturated, very soft		61			
						Fat Clay (CH), olive gray, saturated, soft, with shell debris	0.11				
3											
4	V			CH			0.12				
5								83			
6							0.16				
						Fat Clay (CH), olive brown, wet to saturated, medium stiff to stiff	0.55				
7				CH							

Bottom of boring at 7.6 feet
Refusal to vane shear penetration at 6.7 feet.
Water level approximately 0.5 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-37

Date : 10/27/2011
Drilling Method : Vibracore
Elevation (Feet) : -231.9
Latitude : 33.11994
Longitude : 115.68939

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			CH		Fat Clay (CH), dark gray, saturated, very soft					
1, 2				CH		Fat Clay (CH), olive gray, saturated, very soft, with rare shell debris	0.02	85			
3				CH		Fat Clay (CH), mottled olive gray to black, saturated, very soft, with petroleum odor	0.05				
4				CH		Fat Clay (CH), olive gray, saturated, very soft		71			
5				ML		Sandy Silt (ML), olive gray, saturated, very soft, with charcoal fragments	0.11				
				SM		Silty Sand (SM), brown, saturated, loose					
6				SP		Poorly-Graded Sand (SP), brown, saturated, loose	0.39				
7						Bottom of boring at 7 feet	0.60				

Vane Shear device used to measure undrained shear strength to a depth of 7.2 feet
Water level approximately 0.2 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers	Project No. 758.01	Plate No. A-38

Date : 10/27/2011
Drilling Method : Vibracore
Elevation (Feet) : -231.4
Latitude : 33.12357
Longitude : 115.68927

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			CH		Fat Clay (CH), olive gray, saturated, soft, with shell debris					
1				SM		Silty Sand (SM), olive gray, wet, loose					
2, 3				SP		Poorly-Graded Sand (SP), dark gray, wet, loose	0.08 0.51	25			Sieve
4				CH		Fat Clay (CH), black, saturated, soft to medium stiff, with scattered plant debris and petroleum odor					
5, 6				CH		Fat Clay (CH), olive brown, saturated, medium stiff, with scattered shell debris		29			

Bottom of boring at 6.6 feet
Refusal to vane shear penetration at 2.6 feet.
Water level approximately 0.25 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-39

Date	: 10/27/2011
Drilling Method	: Vibracore
Elevation (Feet)	: -231.2
Latitude	: 33.12489
Longitude	: 115.68516

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				CH		Fat Clay (CH), olive gray, saturated, very soft, with shell debris	0.09	64			
2				CH		Fat Clay (CH), black, saturated, very soft, with petroleum odor					
3						Fat Clay (CH), olive gray, saturated, soft, with scattered shell debris	0.10				
4	V										
5				CH			0.13	78			
6						Silty Sand (SM), reddish brown, wet, loose	0.17				
7				SM			0.60				Sieve
8											

Bottom of boring at 8 feet
Refusal to vane shear penetration at 6.8 feet.
Water level approximately at 0.1 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-40

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
						Date : 10/27/2011 Drilling Method : Vibracore Elevation (Feet) : -231.1 Latitude : 33.12425 Longitude : 115.68318					
0–1.5	V			CH		Fat Clay (CH), olive gray, saturated, soft, with shell debris					
1.5–2.5				CH		Fat Clay (CH), mottled olive gray and black, saturated, soft, with petroleum odor	0.14				
2.5–6.5				CH		Fat Clay (CH), olive gray, saturated, soft, with scattered shell debris	0.06 0.10 0.13	84 76			
6.5–6.8				SM		Silty Sand (SM), olive gray, wet, loose					
6.8						Bottom of boring at 6.8 feet	0.43 0.45				

Vane Shear device used to measure undrained shear strength to a depth of 9.7 feet

Salton Sea
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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-41

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 10/27/2011 Drilling Method : Vibracore Elevation (Feet) : -231.1 Latitude : 33.12425 Longitude : 115.68318 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Refusal to vane shear penetration at 9.7 feet. Water level approximately at 0.1 feet above surface.					

Salton Sea
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Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-42

Date : 10/27/2011
Drilling Method : Vibracore
Elevation (Feet) : -232
Latitude : 33.12134
Longitude : 115.6859

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, saturated, very soft, with scattered organic debris and shell debris					
1				CH			0.04	126	86	53	
2				SM		Silty Sand (SM), olive gray, saturated, loose					
	V					Fat Clay (CH), olive gray, saturated, very soft to soft, with scattered shell debris	0.03				
3											
4				CH							
							0.08				
5								109			
						Bottom of boring at 5.5 feet					
6							0.13				
7											
							0.49				

Vane Shear device used to measure undrained shear strength to a depth of 7.6 feet
Refusal to vane shear penetration at 7.6 feet.
Water level approximately at 0.4 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-43

Date	: 10/27/2011
Drilling Method	: Vibracore
Elevation (Feet)	: -231.8
Latitude	: 33.11751
Longitude	: 115.68506

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, saturated, very soft					
1											
				CH			0.03				
2								94			
3	V						0.03				
4						Lean Clay (CL), reddish brown, wet, very soft to soft, with some plant debris					
5				CL			0.10	34	48	29	
6						Bottom of boring at 5.8 feet					
							0.51				
							0.62				

Vane Shear device used to measure undrained shear strength to a depth of 6.8 feet
Refusal to vane shear penetration at 6.8 feet.
Water level approximately at ground surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-44

Date : 10/27/2011
Drilling Method : Vibracore
Elevation (Feet) : -232
Latitude : 33.12046
Longitude : 115.68382

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
0	V			CH		Fat Clay (CH), olive gray, saturated, very soft					
1											
2							0.01	98			
3						with abundant shells	0.04				
4											
4.5				SM		Silty Sand (SM), olive gray, saturated, loose	0.07				
5											
5.25				CH		Fat Clay (CH), reddish brown, saturated, medium stiff, with abundant wood debris		39			
5.8						Bottom of boring at 5.8 feet					
6							0.09				
7											
8							0.65				

Vane Shear device used to measure undrained shear strength to a depth of 8 feet
Water level approximately at 0.1 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers	Project No. 758.01	Plate No. A-45

Date : 10/27/2011
Drilling Method : Vibracore
Elevation (Feet) : -230.6
Latitude : 33.11896
Longitude : 115.67939

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			CH		Fat Clay (CH), black, saturated, soft					
1				ML		Silt (ML), olive gray, saturated, soft	0.09	42	40	14	
2											
3							0.09				
				SM		Silty Sand (SM), gray, saturated, loose					
4				ML		Sandy Silt (ML), reddish brown, wet, medium stiff		31			Sieve
						Bottom of boring at 4.5 feet	0.44				
5											
6							0.53				
							0.55				

Vane Shear device used to measure undrained shear strength to a depth of 6.6 feet
Refusal to vane shear penetration at 6.6 feet.
Water level approximately at 0.3 feet above surface.

Salton Sea
Species Conservation Habitat Porject
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-46

Date : 9/18/2013
Drilling Method : Hollow-Stem Auger
Elevation (Feet) : -222
Northing (Feet) : 33.13982
Easting (Feet) : -115.66642

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	M	29		ML		Silt with Sand (ML), brown, moist, very stiff, (fill)		4.5			
5	M	22						4.5	17	110	LL=33 PI=15
				SP		Poorly-Graded Sand (SP), brown, fine grained sand, moist, medium dense, (fill)					
	M	11		CL		Lean Clay (CL), reddish brown, moist, very stiff to stiff	0.5	3.5 1.5			Sieve
10	M	9					0.7	1.5	26	94	
15	M	10						2.5	26	98	Sieve
				ML		Silt (ML), brown, moist, stiff					
				ML		Sandy Silt (ML), brown, saturated, medium stiff					
20	M	9									Sieve LL=NP PI=NP
				CL		Lean Clay (CL), brown, saturated, soft to medium stiff					
25	M	3					0.2		35	87	TxUU=410
				ML		Silt with Sand (ML), brown, saturated, soft to medium stiff					
30	S	4									Sieve LL=NP PI=NP
				CH		Fat Clay with Sand (CH), brown, saturated, stiff to very stiff					
35	M	10					0.4	2.0 2.5	26	96	LL=70 PI=50
40	M	5				Stiff	0.5				
				ML		Silt with Sand (ML), reddish brown, saturated, medium stiff to stiff					

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-47

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/18/2013 Drilling Method : Hollow-Stem Auger Elevation (Feet) : -222 Northing (Feet) : 33.13982 Easting (Feet) : -115.66642 Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	M	7					0.5 0.3	2.0	28	95	TxUU=878
50	M	5		ML		Medium stiff	0.3 0.2				
55	M	3		CH		Fat Clay (CH), brown, saturated, stiff	0.8	1.5 2.5			
				SM		Silty Sand (SM), brown, fine grained sand, saturated, medium dense					
60	M	11		ML		Sandy Silt (ML), brown, saturated, medium stiff to stiff	0.3				
				SM		Silty Sand (SM), brown, fine grained sand, saturated, loose					
65	M	7		ML		Silt (ML), brown, saturated, medium stiff to stiff	0.3	1.0	28	95	Sieve
				CL		Lean Clay (CL), brown, saturated, very stiff					
70	M	11		SM		Silty Sand (SM), brown, fine grained sand, saturated, loose		2.5			
75	M	9									

Bottom of boring at 76.5 feet.
Groundwater obsured by adding water into the borehole during drilling

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-48

Date	:	9/19/2013
Drilling Method	:	Hollow-Stem Auger
Elevation (Feet)	:	-226
Northing (Feet)	:	33.11433
Easting (Feet)	:	-115.68801

Depth in Feet	Samples Type/ Recovery	Blow Count	USCS	Water Levels	Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	M	23	CL		Sandy Lean Clay (CL), brown, moist, stiff		2.5			
			SM		Silty Sand (SM), light brown, fine grained sand, moist, medium dense, (fill)					
			CL		Lean Clay (CL), brown, moist, stiff, (fill)					
5	M	11	SM		Silty Sand (SM), brown, fine grained sand, moist, medium dense, (fill)					
	M	6	CL		Sandy Lean Clay (CL), brown, medium stiff to stiff, (fill)	0.3	1.0	25	98	Sieve
10	S	5	ML		Sandy Silt (ML), brown, saturated, medium stiff					
15	S	4	SM		Silty Sand (SM), light brown, fine grained sand, saturated, very loose					Sieve LL=NP PI=NP
			ML		Sandy Silt (ML), light brown, saturated, soft					
			CL		Lean Clay with Sand (CL), brown, saturated, soft to medium stiff					
20	M	7	CH		Fat Clay (CH), brown, saturated, very stiff	0.5	3.5			
25	M	12					3.8	30	91	LL=79 PI=59
30	M	14					2.5			
			SM		Silty Sand (SM), brown, fine grained sand, saturated, medium dense					
35	S	7	CH		Fat Clay (CH), brown, saturated, medium stiff to very stiff		1.0 1.8			
40	M	17	CH		Very stiff		3.5 3.0			

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-49

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/19/2013 Drilling Method : Hollow-Stem Auger Elevation (Feet) : -226 Northing (Feet) : 33.11433 Easting (Feet) : -115.68801 Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	M	11		CH		Stiff	0.6	2.0			
50	M	5				Medium stiff to stiff	0.2 0.5	1.2			
						Sandy Silt (ML), brown, saturated, medium stiff to very stiff					
55	M	9									
60	M	46/11		ML					22	103	Sieve
65	M	34/5									

Bottom of boring at 65.9 feet.
Groundwater obscured by adding water into borehole during drilling

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-50

Date : 12/16/2013
Drilling Method : Hand Auger
Elevation (Feet) : -228
Latitude : 38.11195
Longitude : -115.68535

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
				CL-ML		Silty Clay (CL-ML), gray, wet, medium stiff					
1							0.30				
2					▽	12/16/2013 Soft	0.14				
3				ML		Silt (ML), black, saturated, very soft to soft	0.16				
4				ML		Sandy Silt (ML), saturated, medium stiff	0.28				

Bottom of boring at 4.5 feet
Groundwater encountered at 2 feet during augering.

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-51

Date : 12/16/2013
Drilling Method : Hand Auger
Elevation (Feet) : -231
Latitude : 33.12135
Longitude : -115.69252

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
0–3				CL-ML	▽ (2)	Silty Clay (CL-ML), gray, moist, very soft to soft 12/16/2013	0.11 0.22				
3–4.5				ML		Silt (ML), black, saturated, very soft	0.10 0.13				
4.5–6.25				ML		Silt (ML), gray, saturated, very soft, with fish bones	0.11				
6.25–6.7				ML		Sandy Silt (ML), red brown, saturated, medium stiff	0.42				

Bottom of boring at 6.7 feet
Refusal to vane shear penetration at 6.7 feet.
Groundwater encountered at 2 feet during augering.

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-52

Date : 12/16/2013
Drilling Method : Hand Auger
Elevation (Feet) : -231
Latitude : 33.12252
Longitude : -115.69259

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
				ML		Silt (ML), gray, saturated, very soft					
							0.09				
1											
							0.04				
							0.05				
2											
							0.08				
							0.07				
3											
							0.08				
							0.08				
4											
							0.09				
							0.21				
5						Soft					
							0.20				
							0.51				
				ML		Silt (ML), red brown, saturated, medium stiff					
6											
						Stiff					

Bottom of boring at 6.7 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-53

Date : 12/16/2013
Drilling Method : Hand Auger
Elevation (Feet) : -231
Latitude : 33.12409
Longitude : -115.67759

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
				ML		Silt (ML), gray, moist, medium stiff to soft, non-plastic, with trace sand					
1							0.38				
							0.49				
				ML	▽	12/16/2013	0.23				
2						Silt (ML), dark gray, saturated, soft	0.23				
3							0.21				
							0.19				
				ML		Silt (ML), black, saturated, soft	0.18				
4				ML		Silt (ML), dark gray, saturated, soft	0.16				
5							0.15				
							0.17				
6							0.16				
							0.22				
7							0.13				
							0.12				
				CH		Fat Clay (CH), red brown, medium stiff to stiff	0.22				
8						Bottom of boring at 8 feet	0.56				

Vane shear device used to measure undrained shear strength to a depth of 8.3 feet
Groundwater encountered at 1.7 feet during augering.

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-54

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
0–1				SM		Silty Sand (SM), brown, moist, loose					
1–4				SM		Silty Sand (SM), moist, loose	0.44 0.66 0.68				
4–5				MH		Elastic Silt (MH), black, saturated, very soft to soft, with bones	0.17				
5–7.75				CL-ML		Silty Clay (CL-ML), gray, saturated, soft Medium stiff, with bones	0.14 020 0.30				
7.75–8				ML		Sandy Silt (ML), soft	0.20				

Date : 12/16/2013
Drilling Method : Hand Auger
Elevation (Feet) : -230
Latitude : 33.1317
Longitude : -115.68807

Bottom of boring at 8 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-55

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
						Date : 12/17/2013 Drilling Method : Hand Auger Elevation (Feet) : -228 Latitude : 33.1275 Longitude : -115.6909					
0–1.25				SM		Silty Sand (SM), fine grained sand, loose					
				ML		Silt (ML), brown, moist, soft to medium stiff					
				ML		Silt (ML), gray, moist, stiff to medium stiff					
2–4.75				MH		Elastic Silt (MH), black, moist, soft	0.14 0.17 0.16 0.19 0.16 0.17				
5				SM		Silty Sand (SM), gray, saturated, loose	0.53				
				ML		Sandy Silt (ML), gray, saturated, medium stiff					
6				SM		Silty Sand (SM), gray, saturated, medium stiff					
				SP-SM		Poorly-Graded Sand with Silt (SP-SM), gray, saturated, loose					
7				ML		Sandy Silt (ML), gray, saturated, medium stiff					

Bottom of boring at 7 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-56

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 12/17/2013 Drilling Method : Hand Auger Elevation (Feet) : -228 Latitude : 33.129 Longitude : -115.689 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
0–2				ML		Silt (ML), red brown, moist, medium stiff, non-plastic					
2				SM		Silty Sand (SM), brown, loose, with fish bones					
				ML		Sandy Silt (ML), orange brown, soft to medium stiff					
				ML		Silt (ML), gray, saturated, soft					
3				SM		Silty Sand (SM), saturated, loose, with shells					
4				ML		Silt (ML), gray, saturated, soft	022 0.20				
5–7				SM		Silty Sand (SM), gray, saturated, loose					

Bottom of boring at 7 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-57

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 12/17/2013 Drilling Method : Hand Auger Elevation (Feet) : -228 Latitude : 33.13 Longitude : -115.687 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
				SM		Silty Sand (SM), brown, moist, loose					
1											
2				SM		Silty Sand (SM), gray, saturated, loose					
3											
4											
5											
6											
7				ML		Silt (ML), gray, saturated, soft	0.19 0.19				
8											

Bottom of boring at 8 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-58

Date	:	12/17/2013
Drilling Method	:	Hand Auger
Elevation (Feet)	:	-228
Latitude	:	33.1305
Longitude	:	-115.6905

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				ML		Silt (ML), orange brown, dry to moist, medium stiff					
2				SP		Poorly-Graded Sand (SP), moist, loose					
3				ML		Silt (ML), black, moist, medium stiff	0.26				
4				ML		Sandy Silt (ML), soft to medium stiff, silty sand					
5, 6				ML		Silt (ML), gray, soft, with shells	0.19				
7				ML		Sandy Silt (ML), gray, saturated, soft to medium stiff	0.24 0.52				
8, 9						Bottom of boring at 8 feet	0.19 0.43 0.36				

Vane shear device used to measure undrained shear strength to a depth of 9 feet
No groundwater encountered

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-59

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	▽	- Water Level at Time of Drilling	P	- Push
		▼	- Water Level after Drilling (with date measured)	Perm	- Permeability
M	- 2.5 inch	Consol	- Consolidation	Sieve	- Particle Size Analysis
		Gs	- Specific Gravity	VS	- Laboratory Vane Shear (psf)
C	- 3.0 inch	LL	- Liquid Limit (%)	-200	- % Passing No. 200 Sieve
		PI	- Plasticity Index (%)		
T	- Shelby Tube	TxUU	- Shear Strength (psf) - Unconsolidated Undrained Triaxial Shear		
		TxCU	- Shear Strength (psf) - Consolidated Undrained Triaxial Shear		
B	- Bag	UC	- Compressive Strength (psf) - Unconfined Compression		

KEY TO TEST DATA

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Soil Classification Chart

Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. A-60

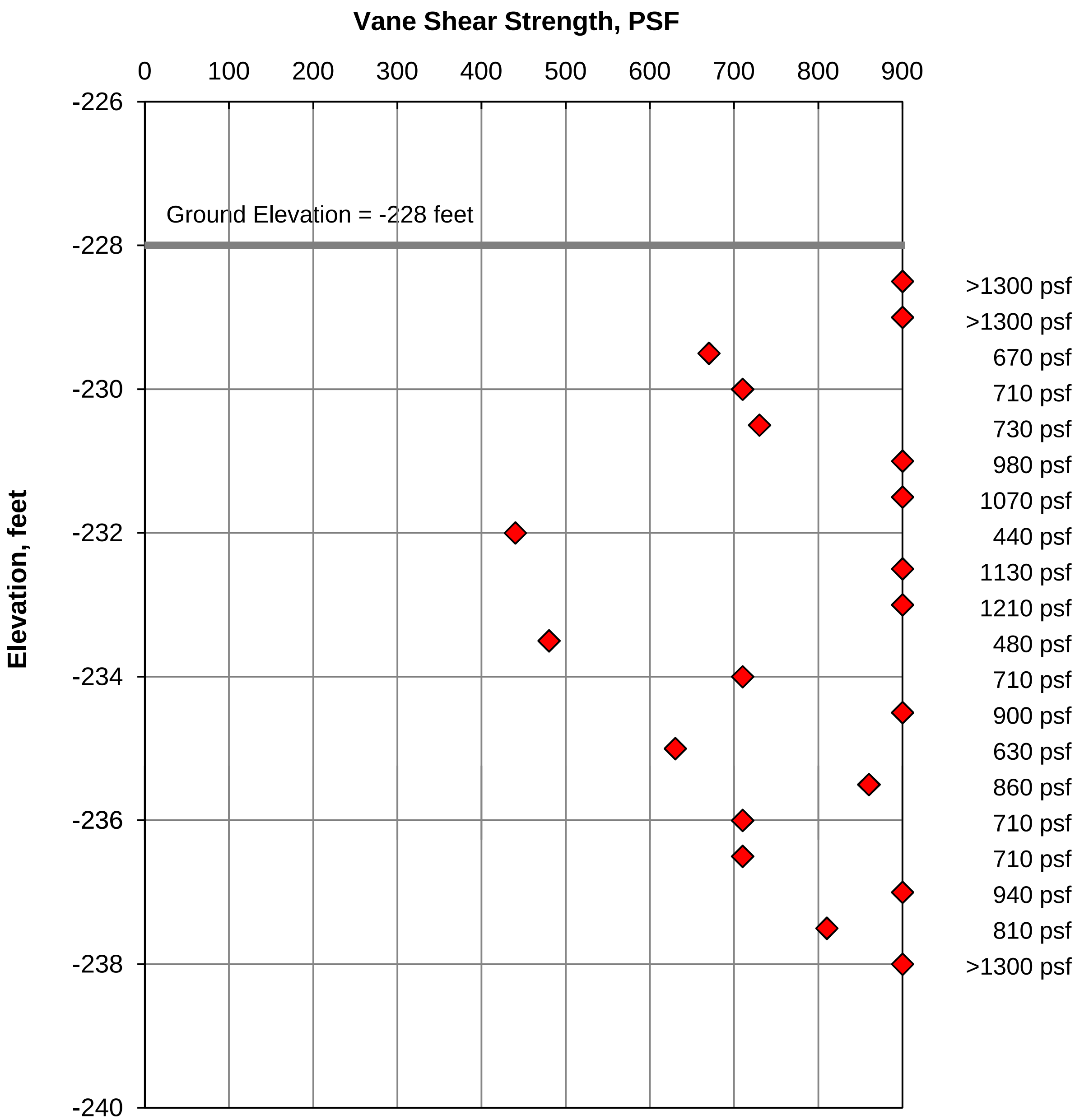
APPENDIX B

APPENDIX B

VANE SHEAR RESULTS

2011-2013 EXPLORATION OF NEW RIVER SITE

TABLE OF CONTENTS



Notes:

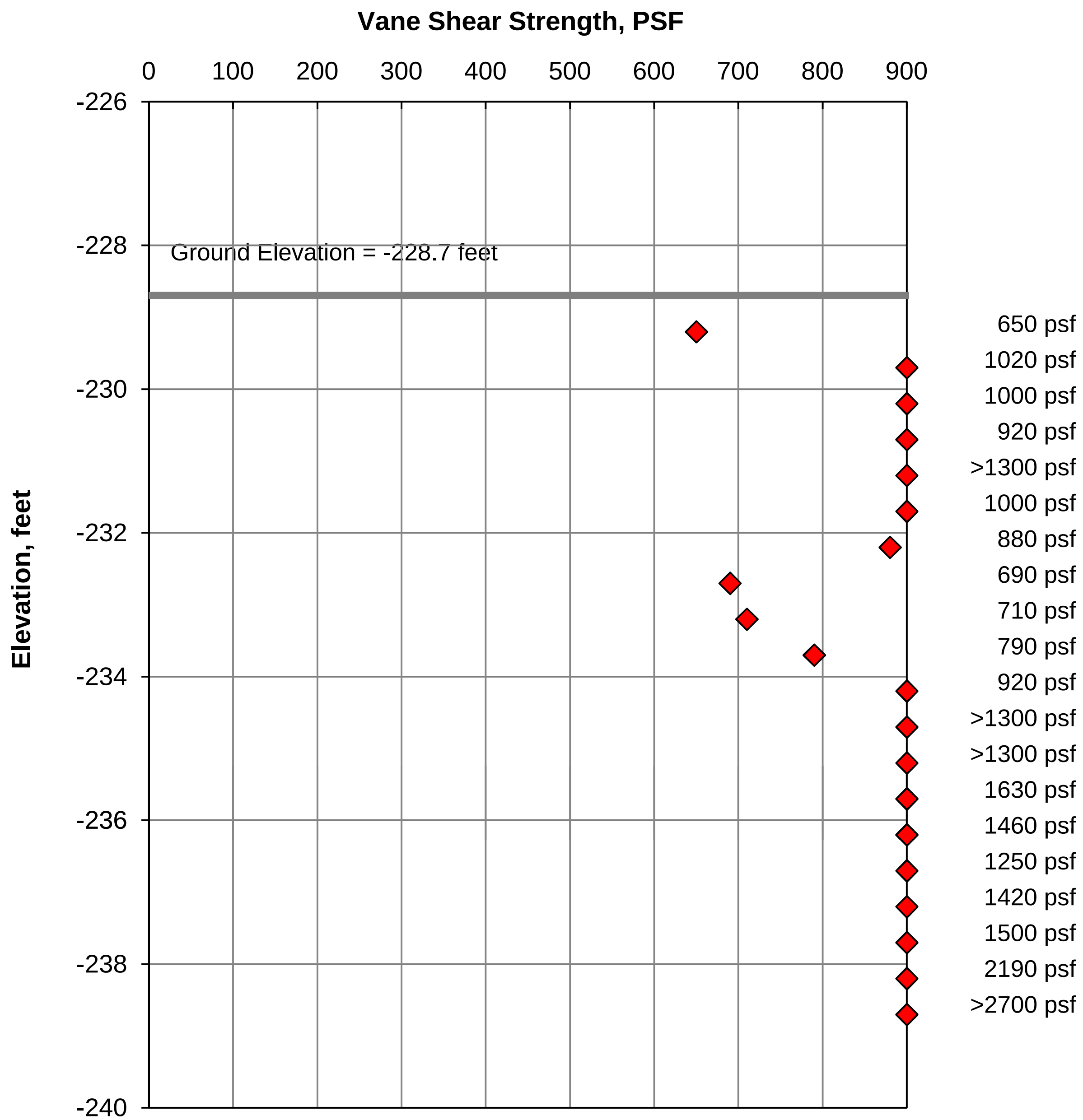
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 29HA**

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



Notes:

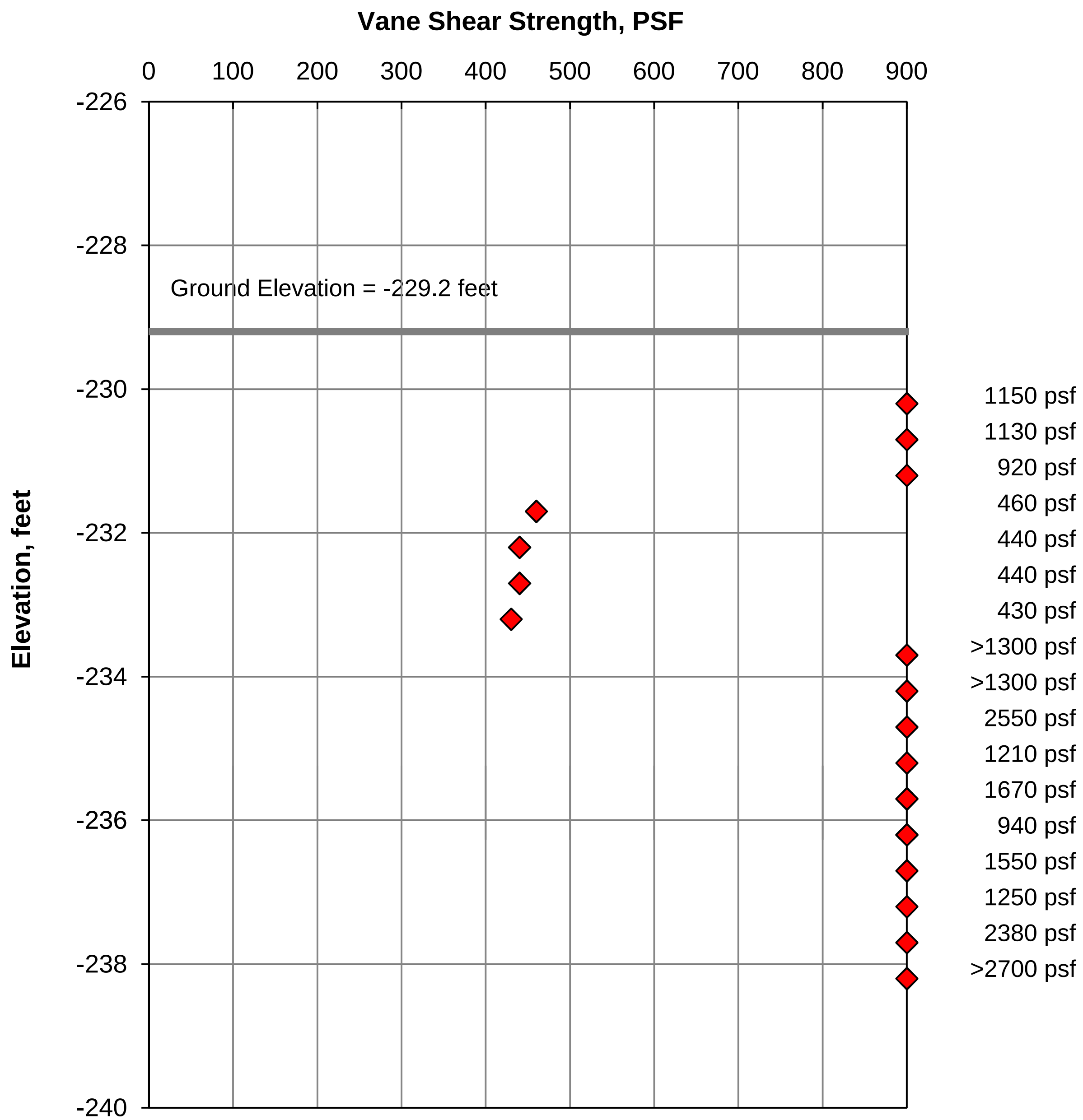
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 30HA**

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



Notes:

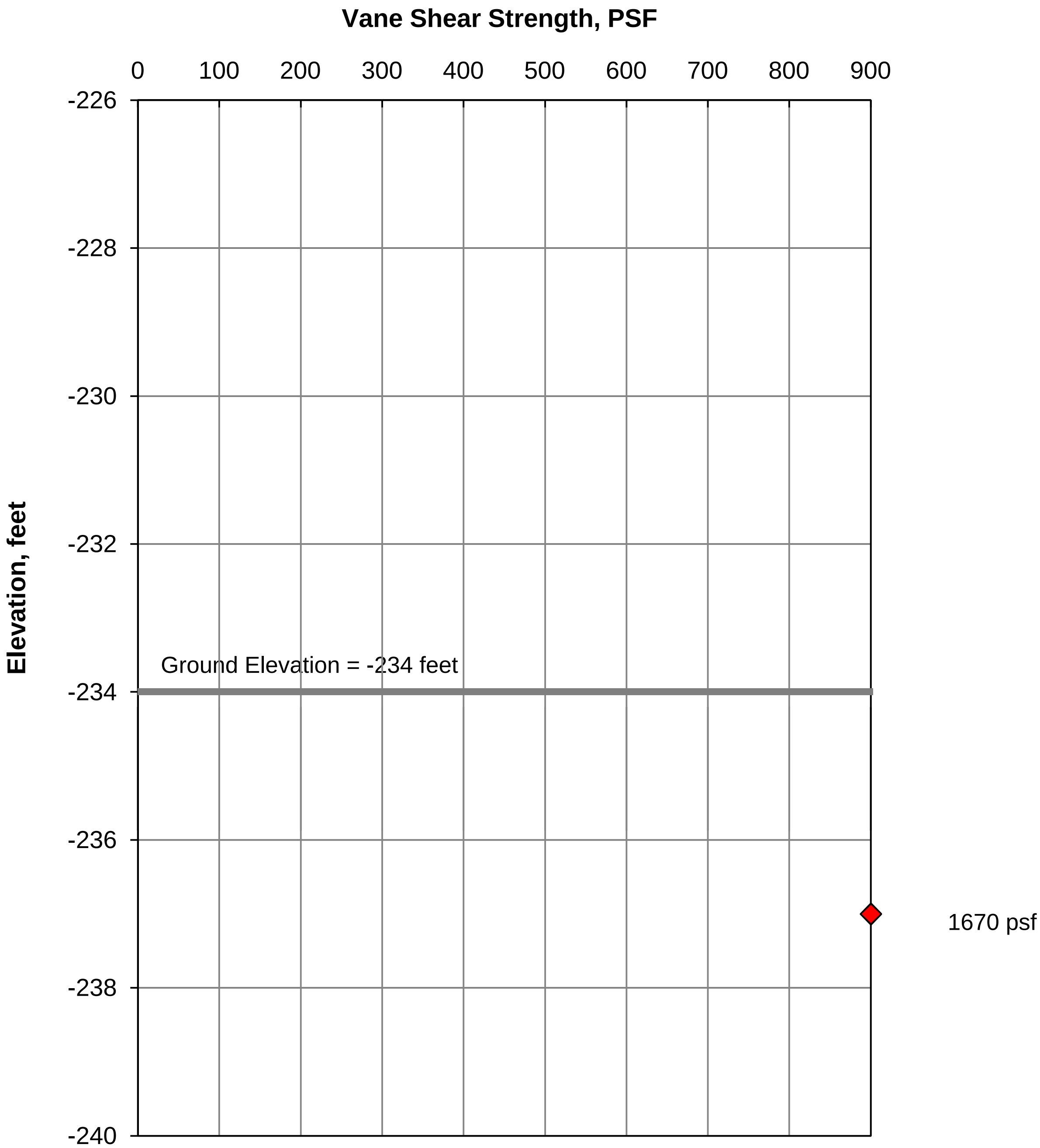
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 31HA**

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



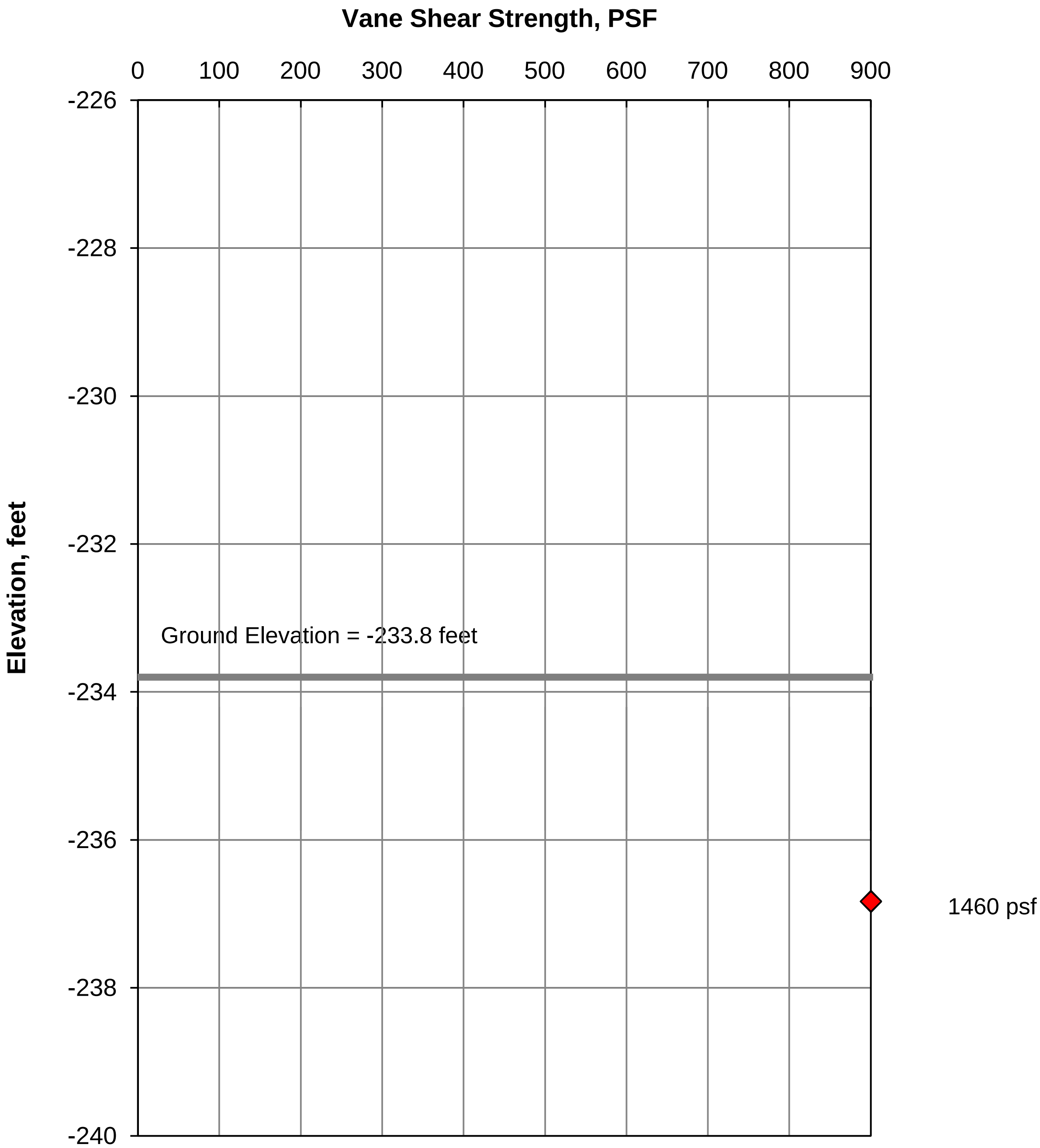
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 32VC**
Hultgren - Tillis Engineers	Project No. 758.01 Plate No. B-4



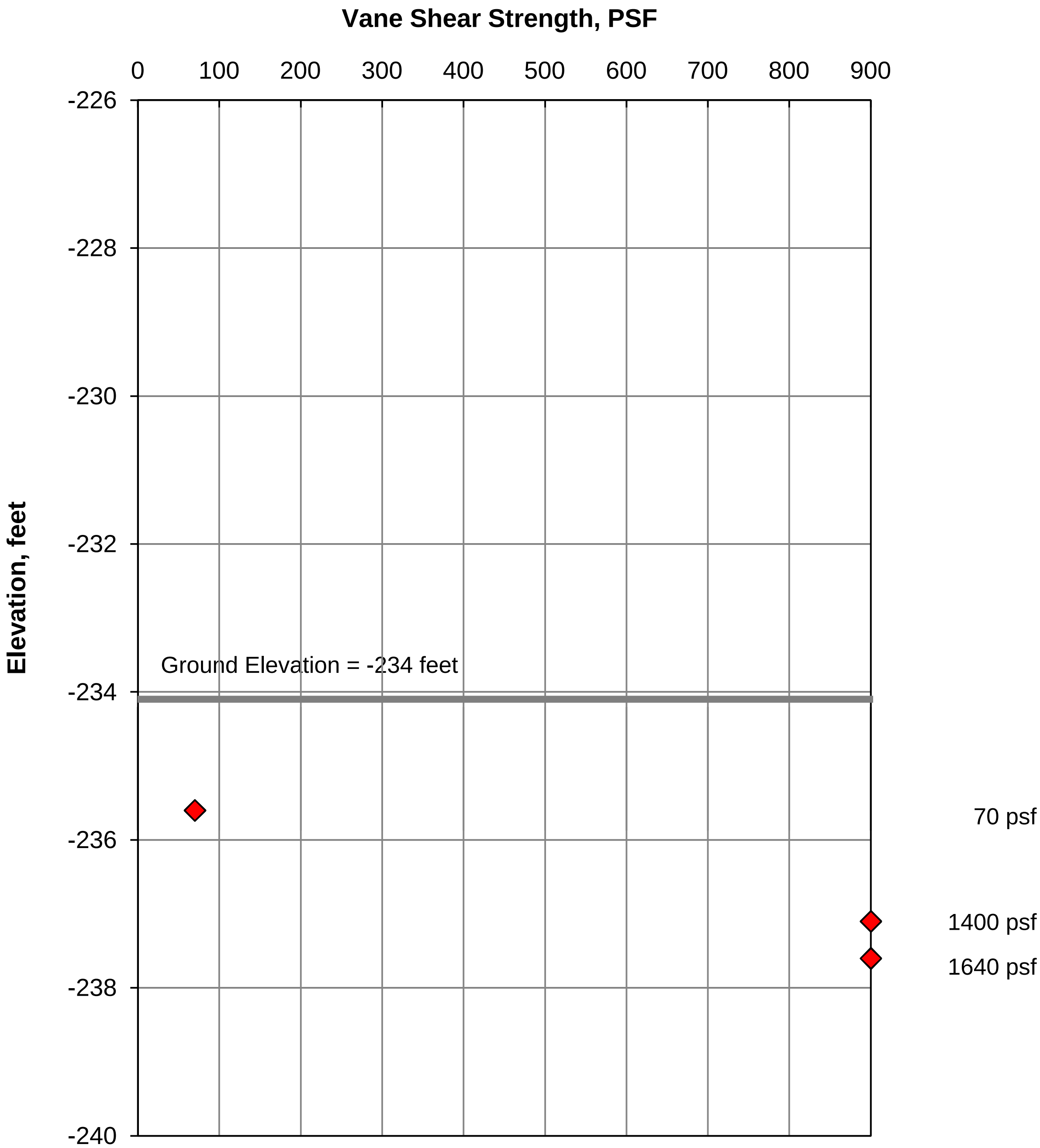
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength Exploration Point 33VC**
Hultgren - Tillis Engineers	Project No. 758.01 | Plate No. B-5



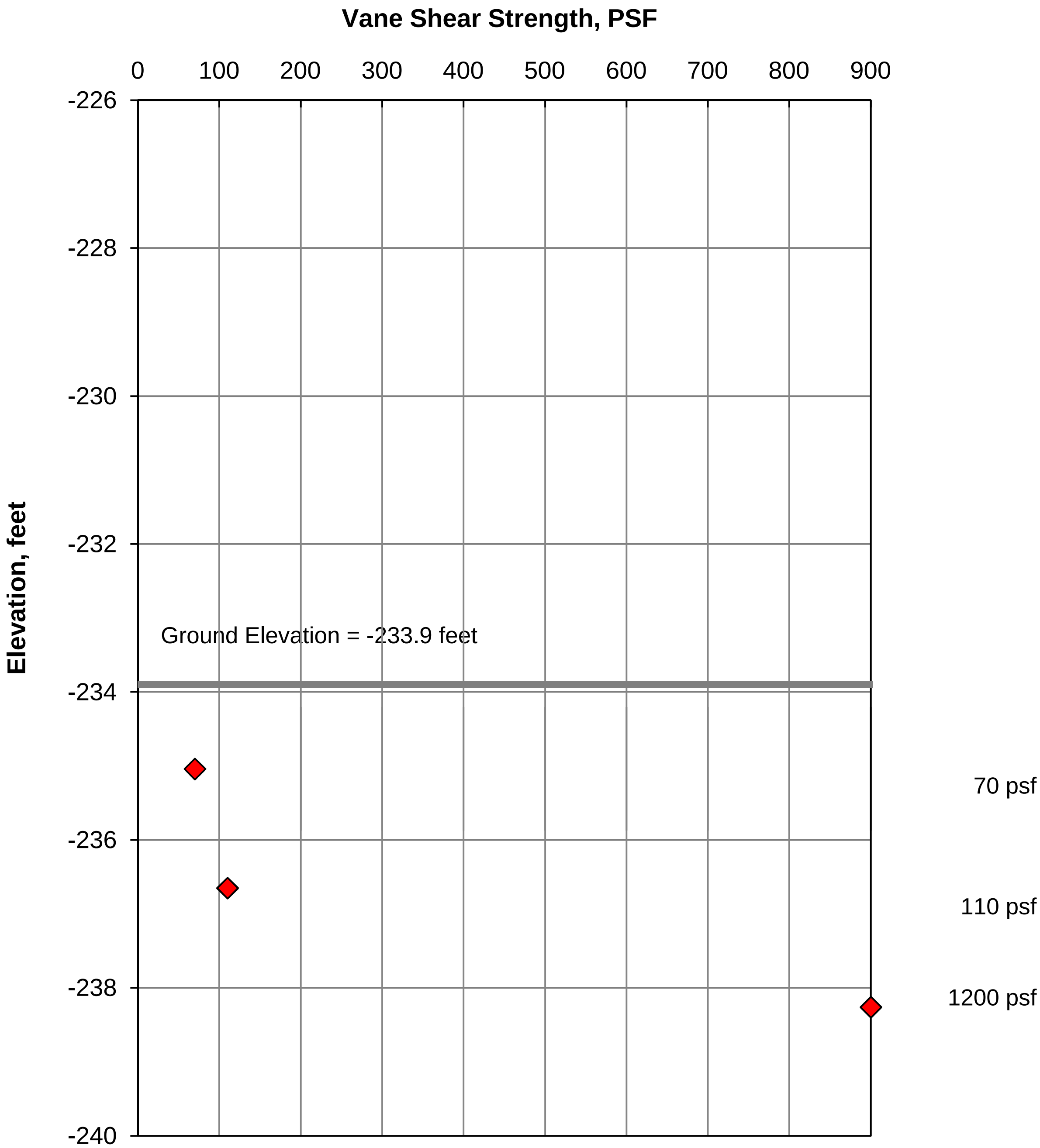
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 34VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-6



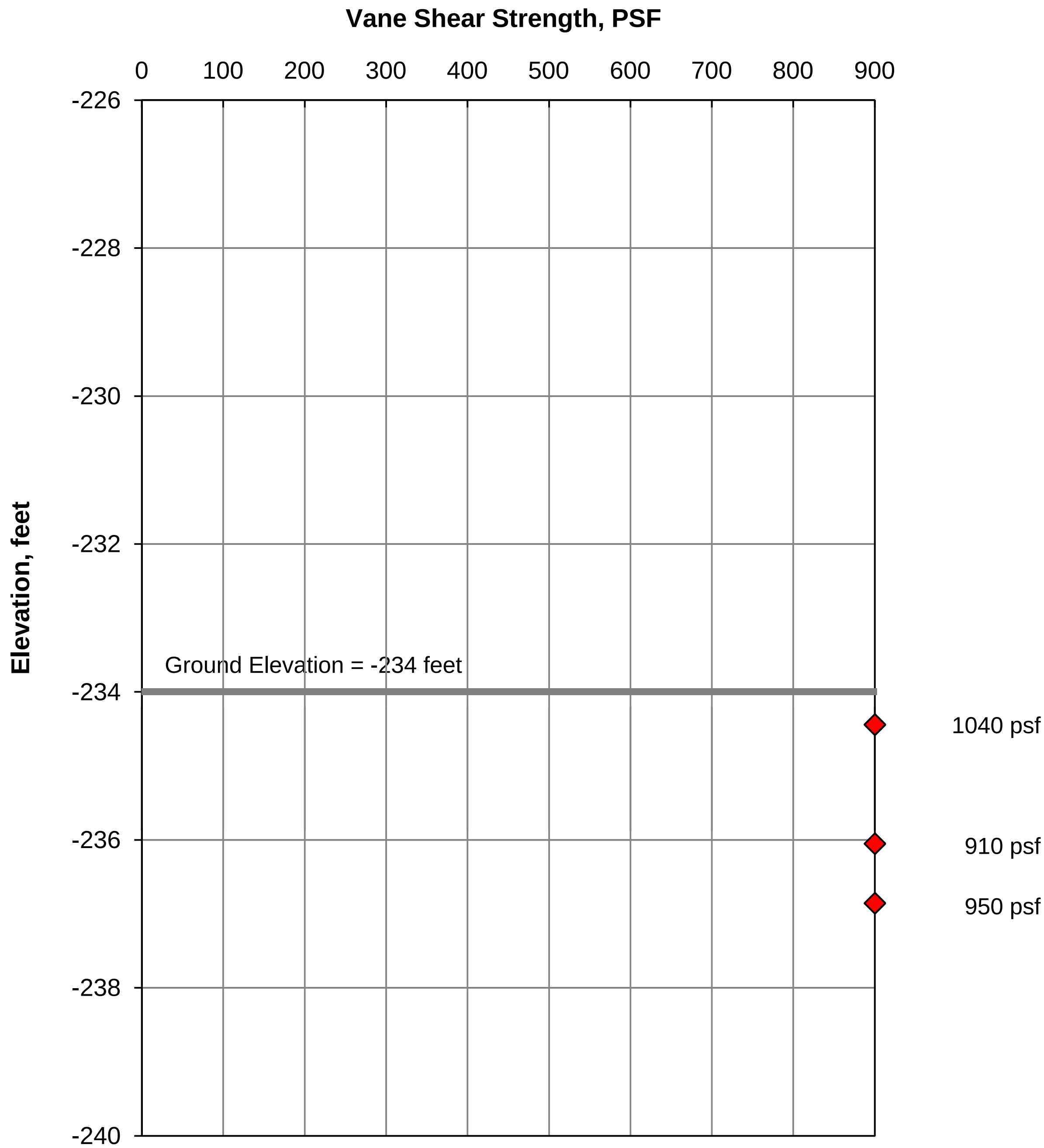
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 35VC**
Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. B-7



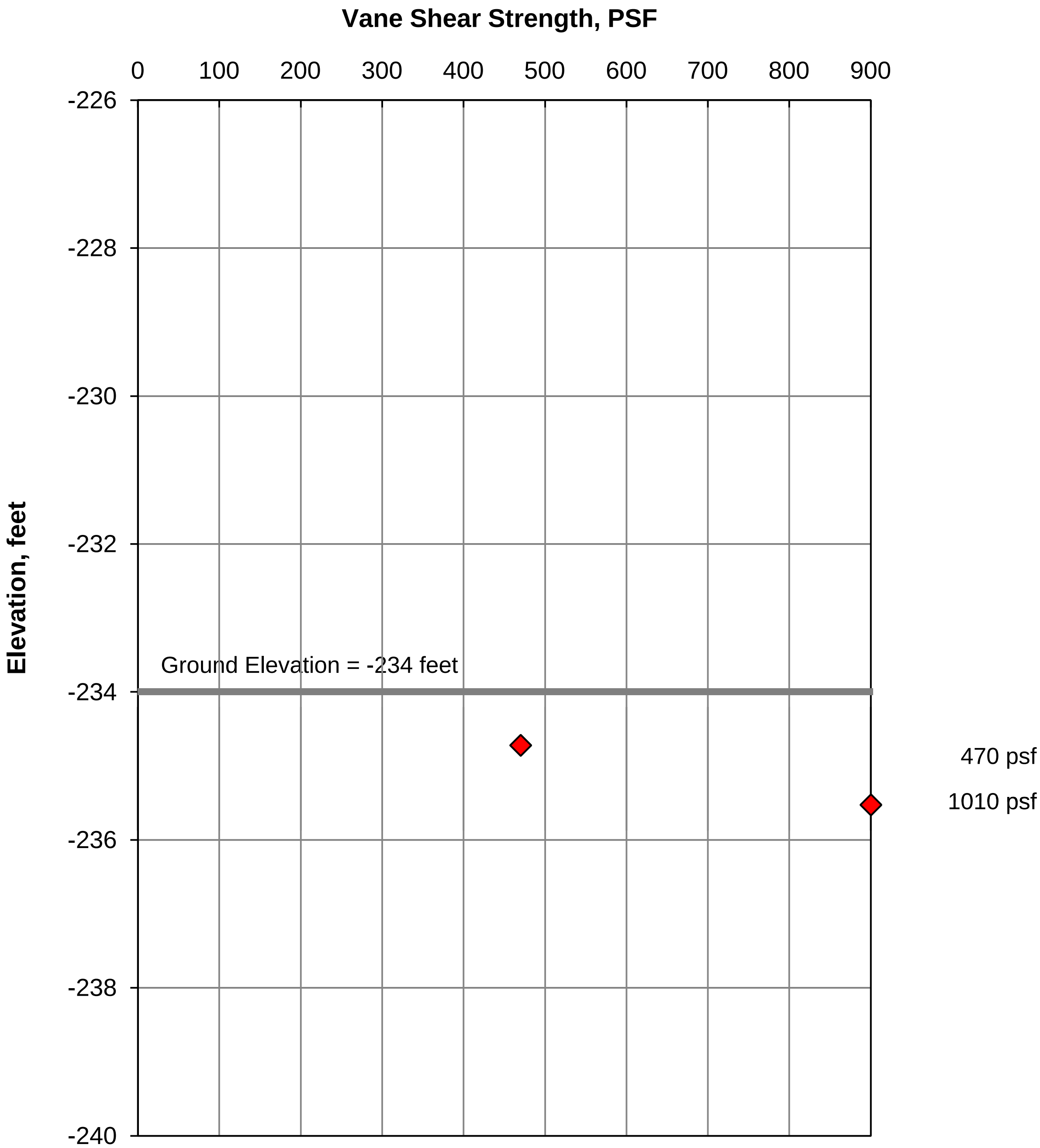
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 36VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-8



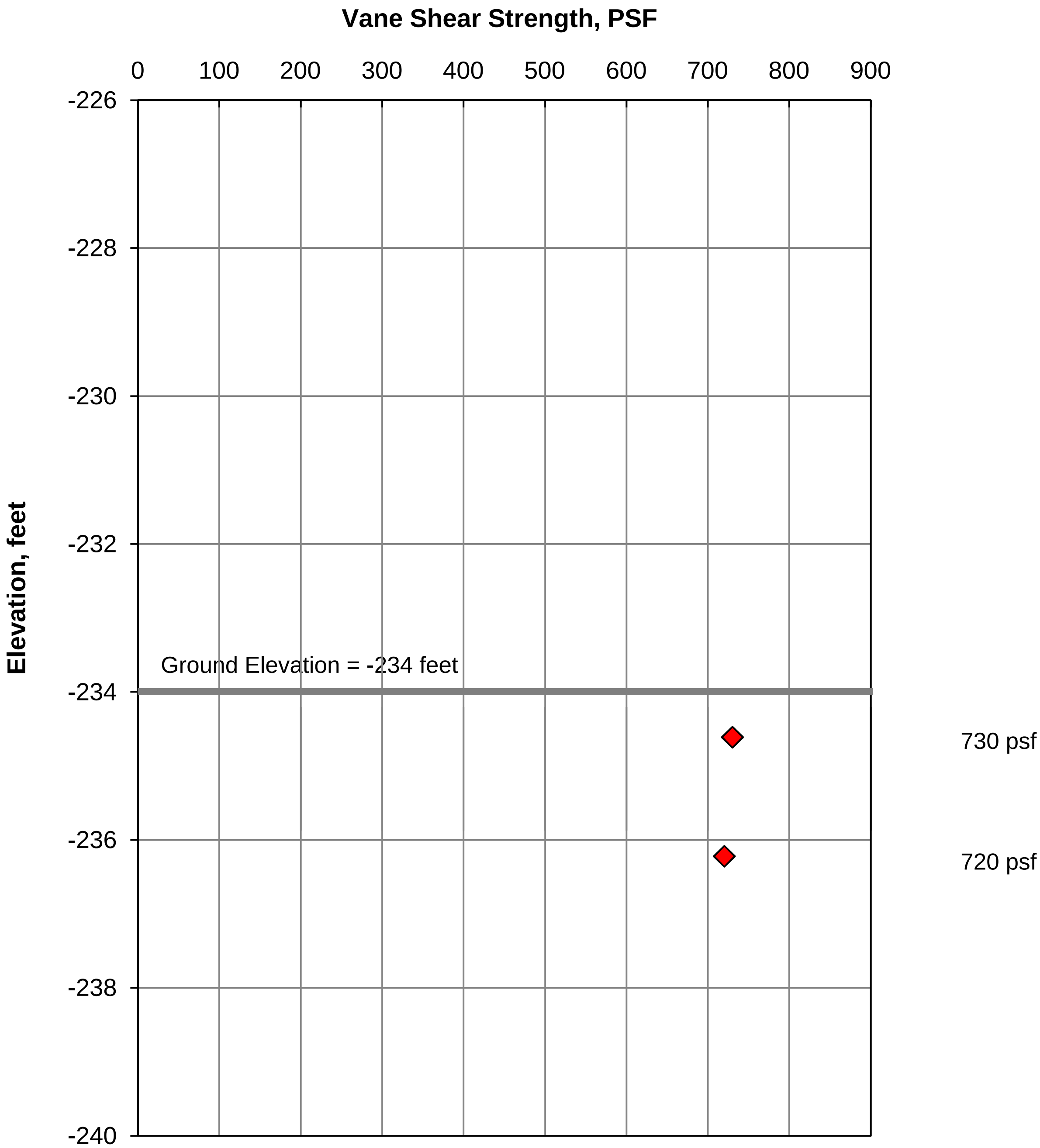
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength Exploration Point 37VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-9



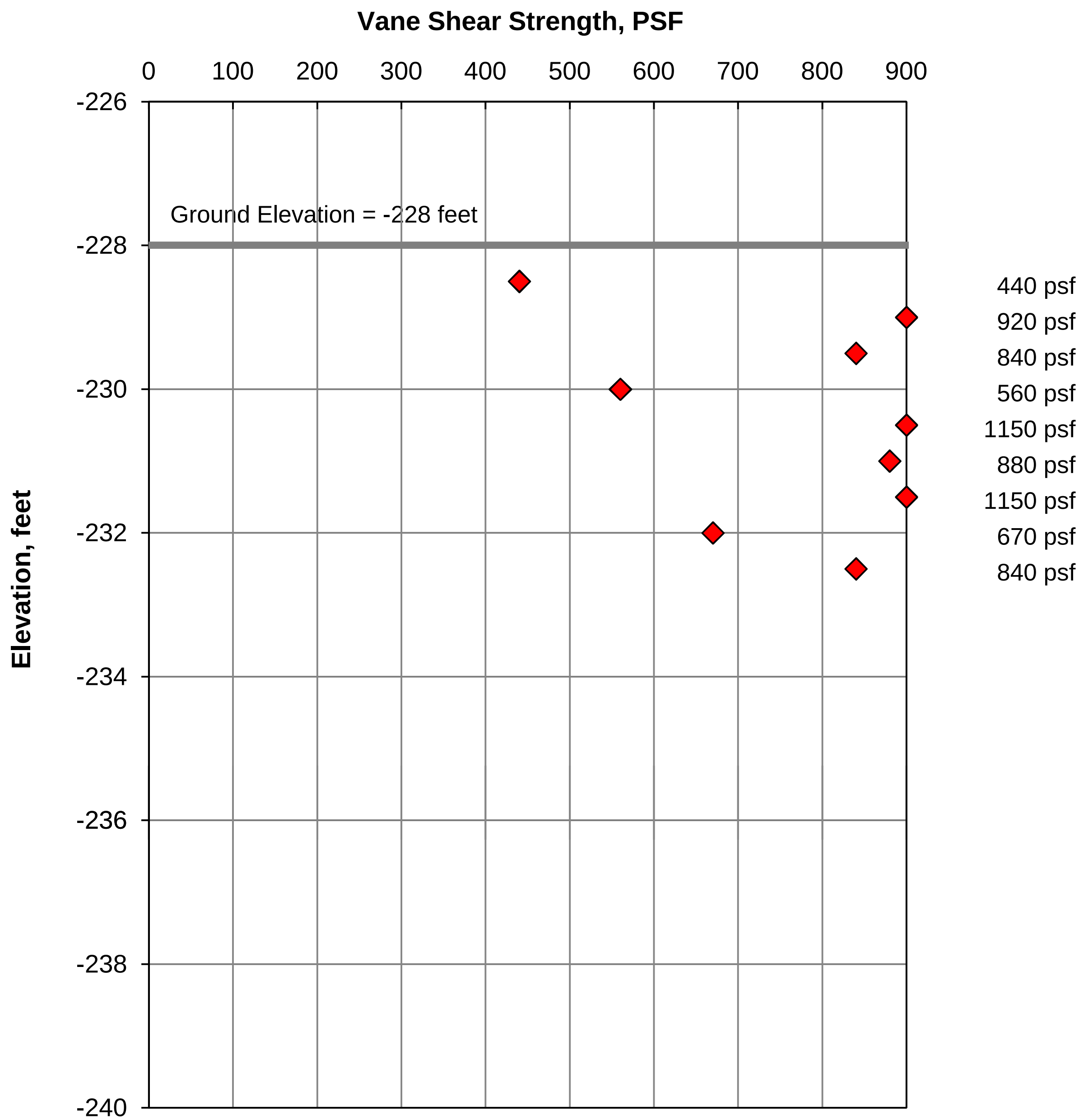
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 38VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-10



Notes:

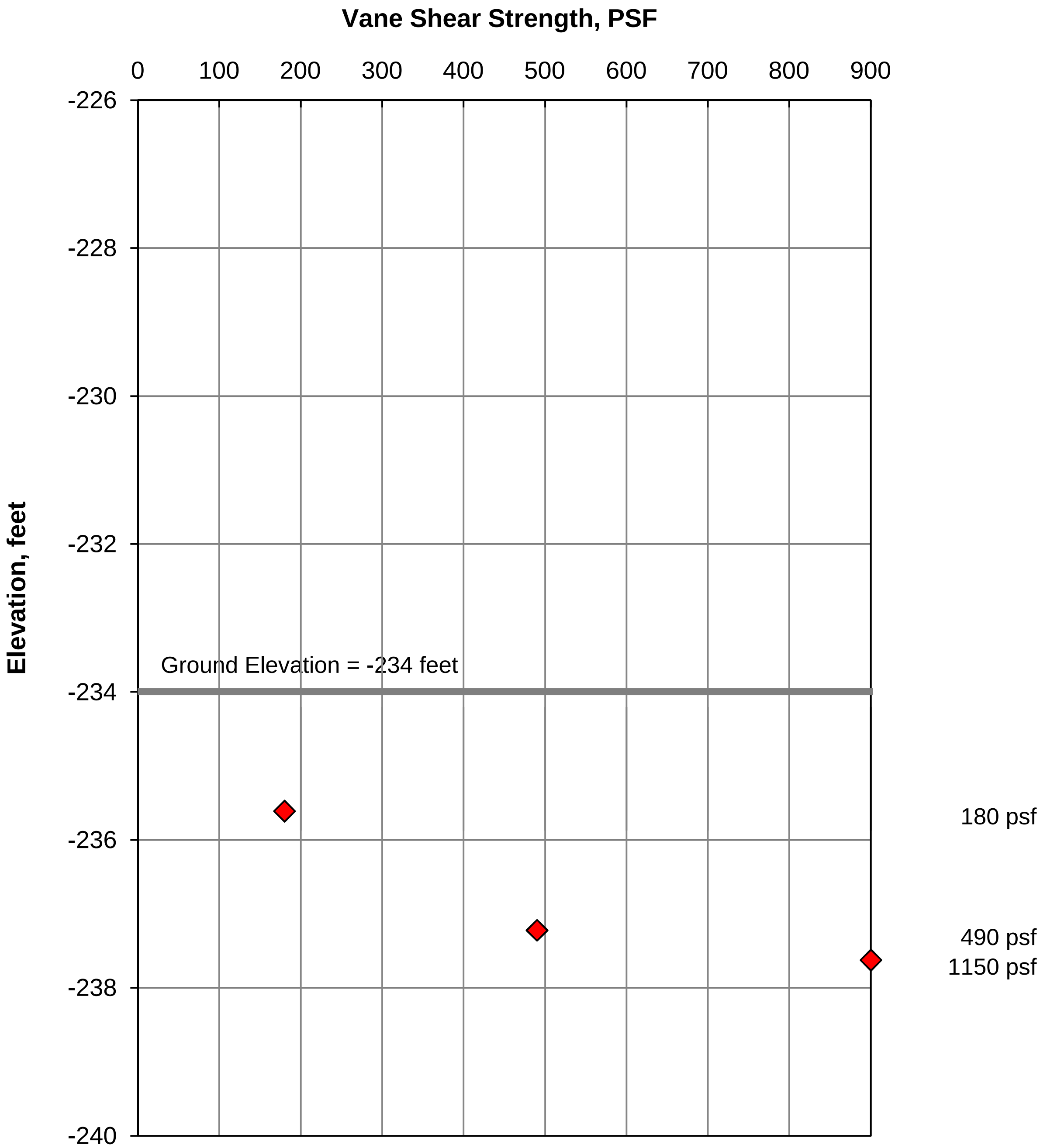
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 39HA**

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



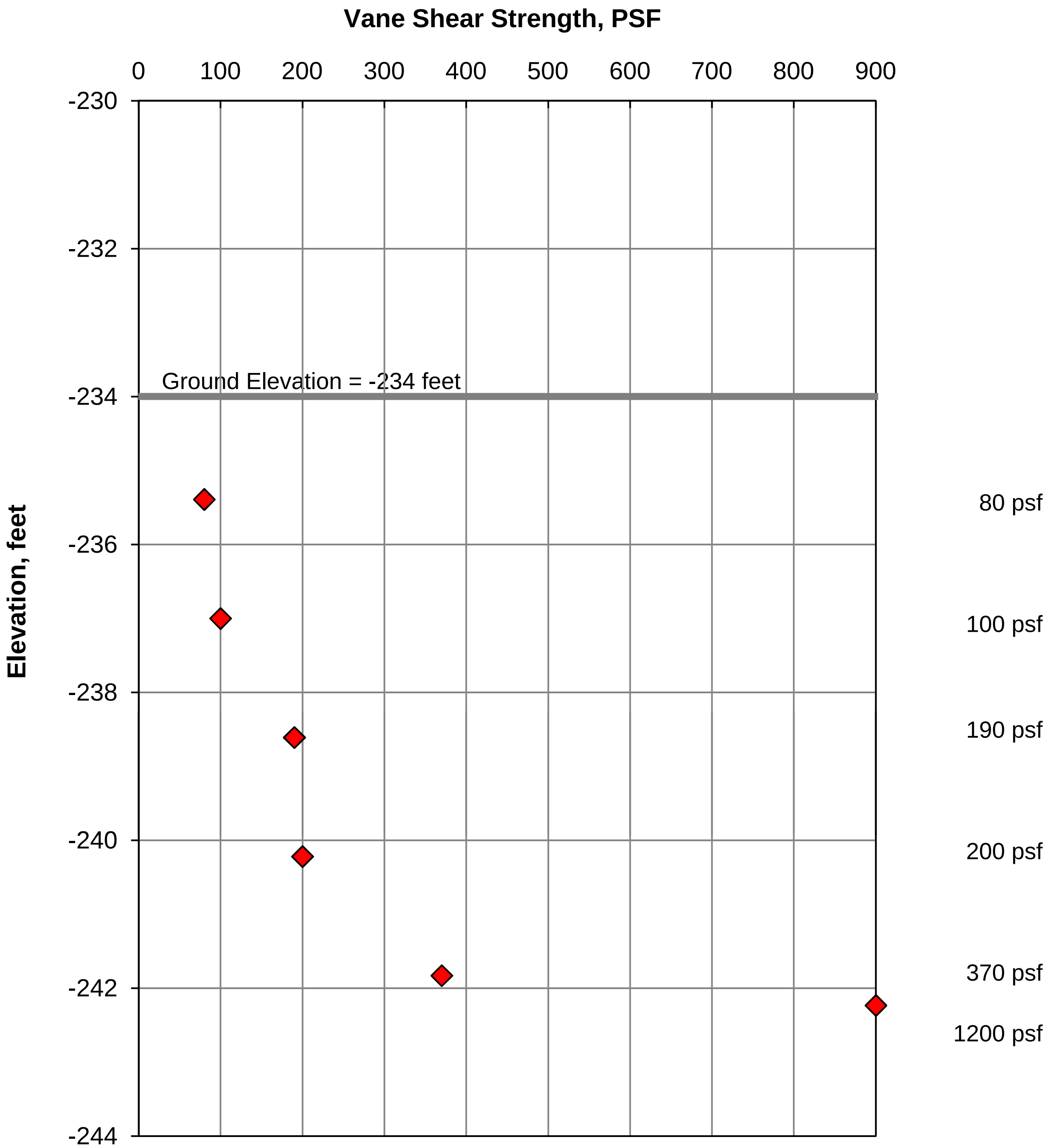
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength Exploration Point 40VC**
Hultgren - Tillis Engineers	Project No. 758.01 — Plate No. B-12



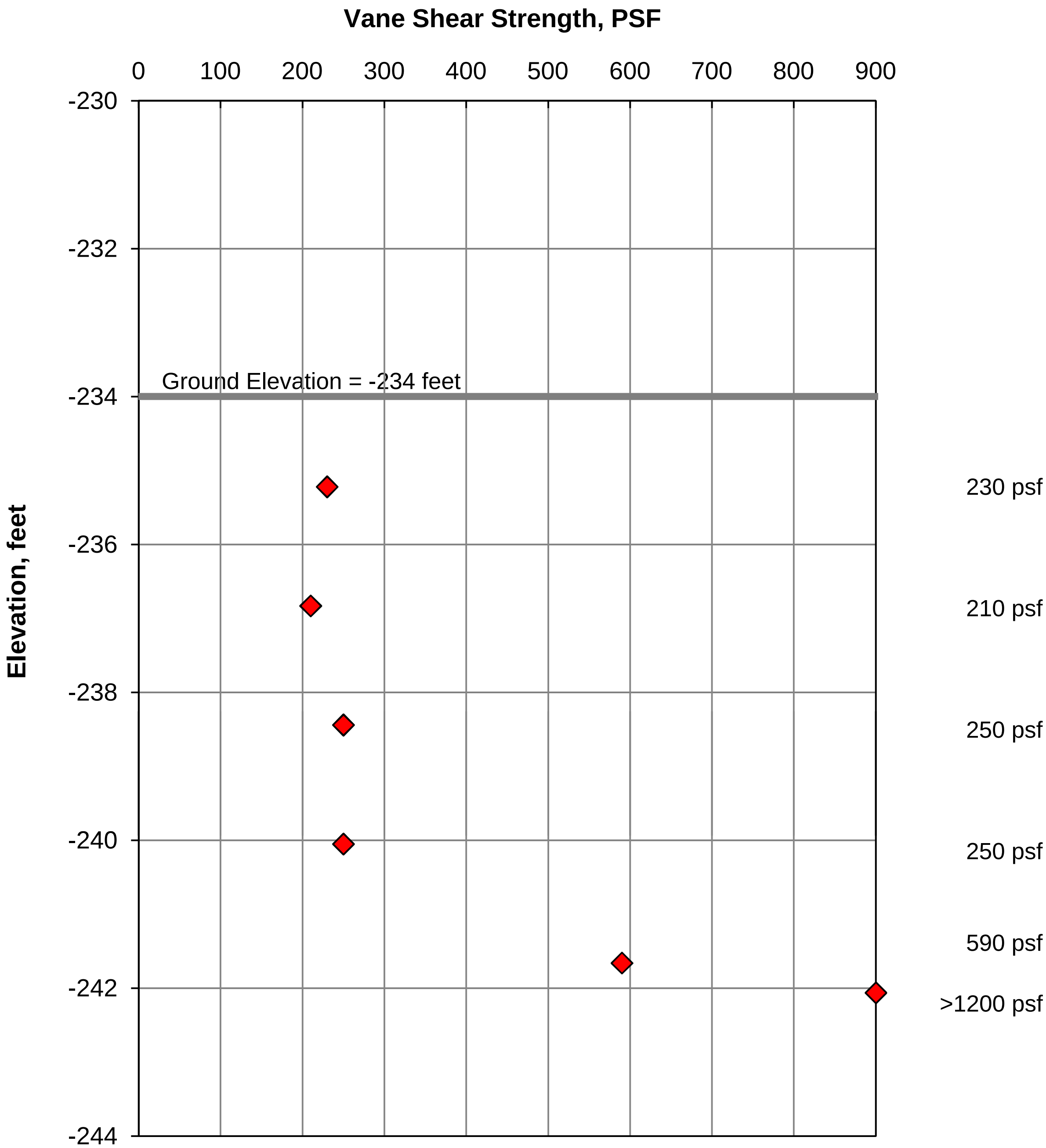
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 41VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-13



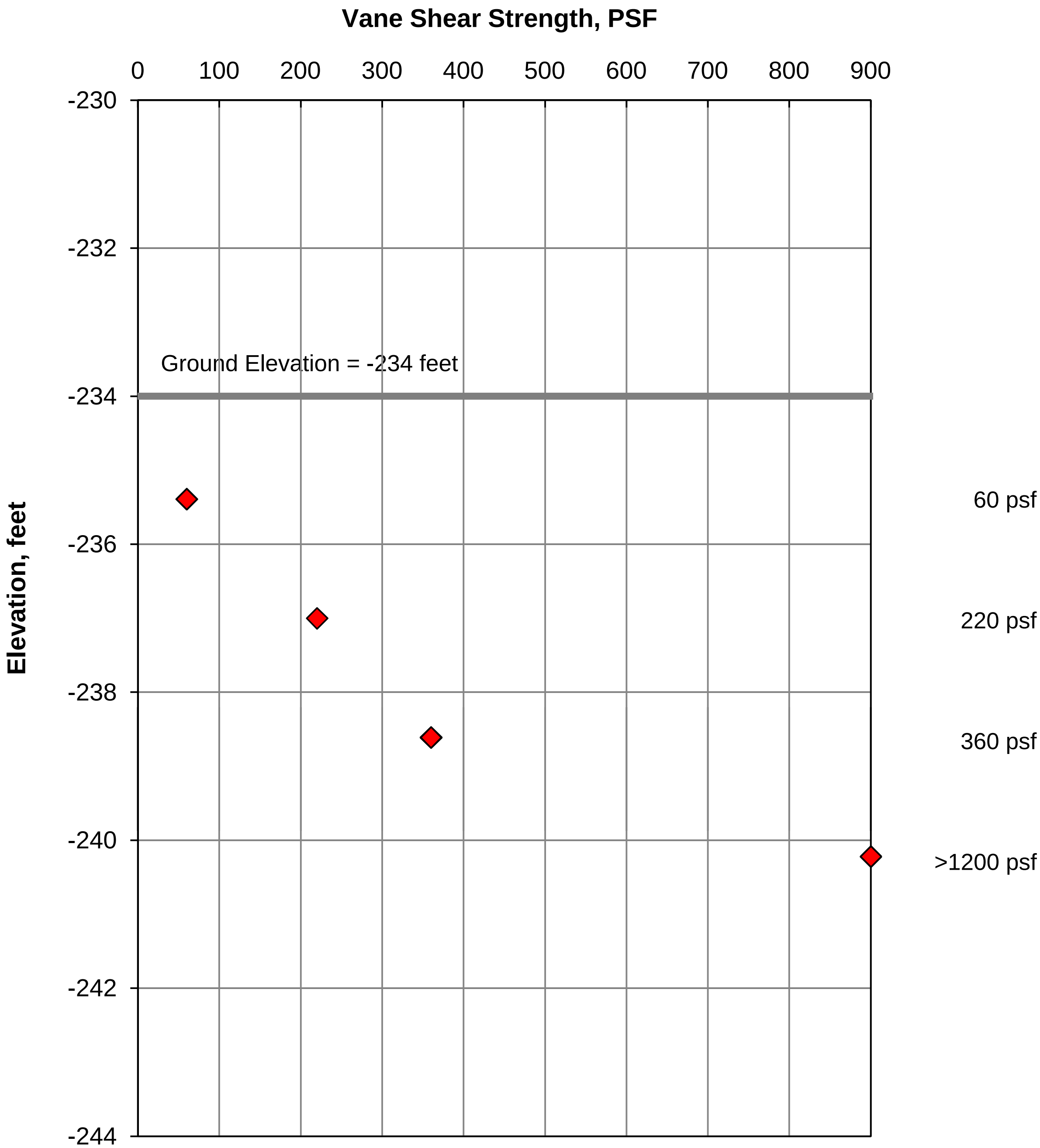
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength Exploration Point 42VC**
Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. B-14



Notes:

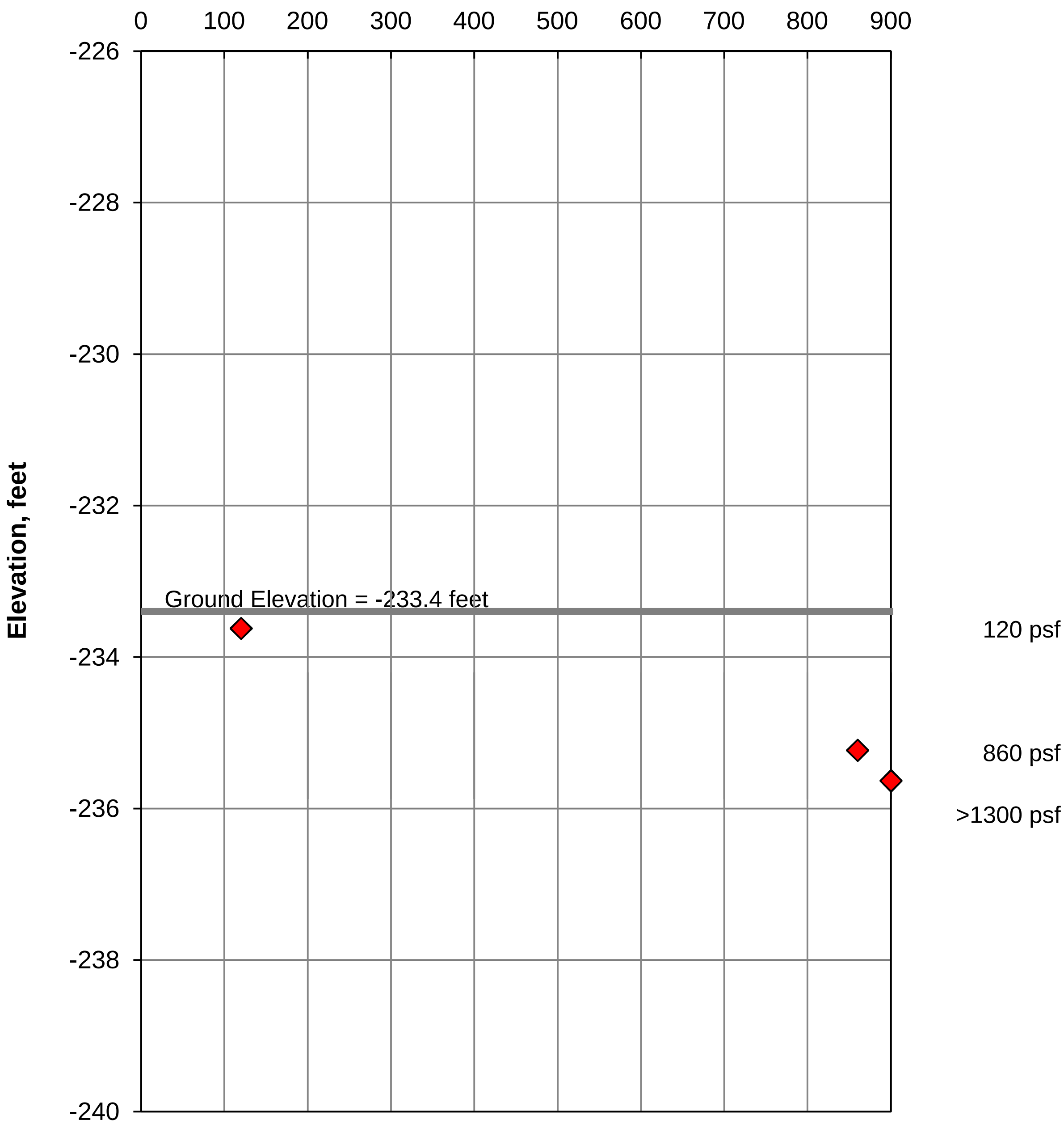
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 43VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-15

Vane Shear Strength, PSF



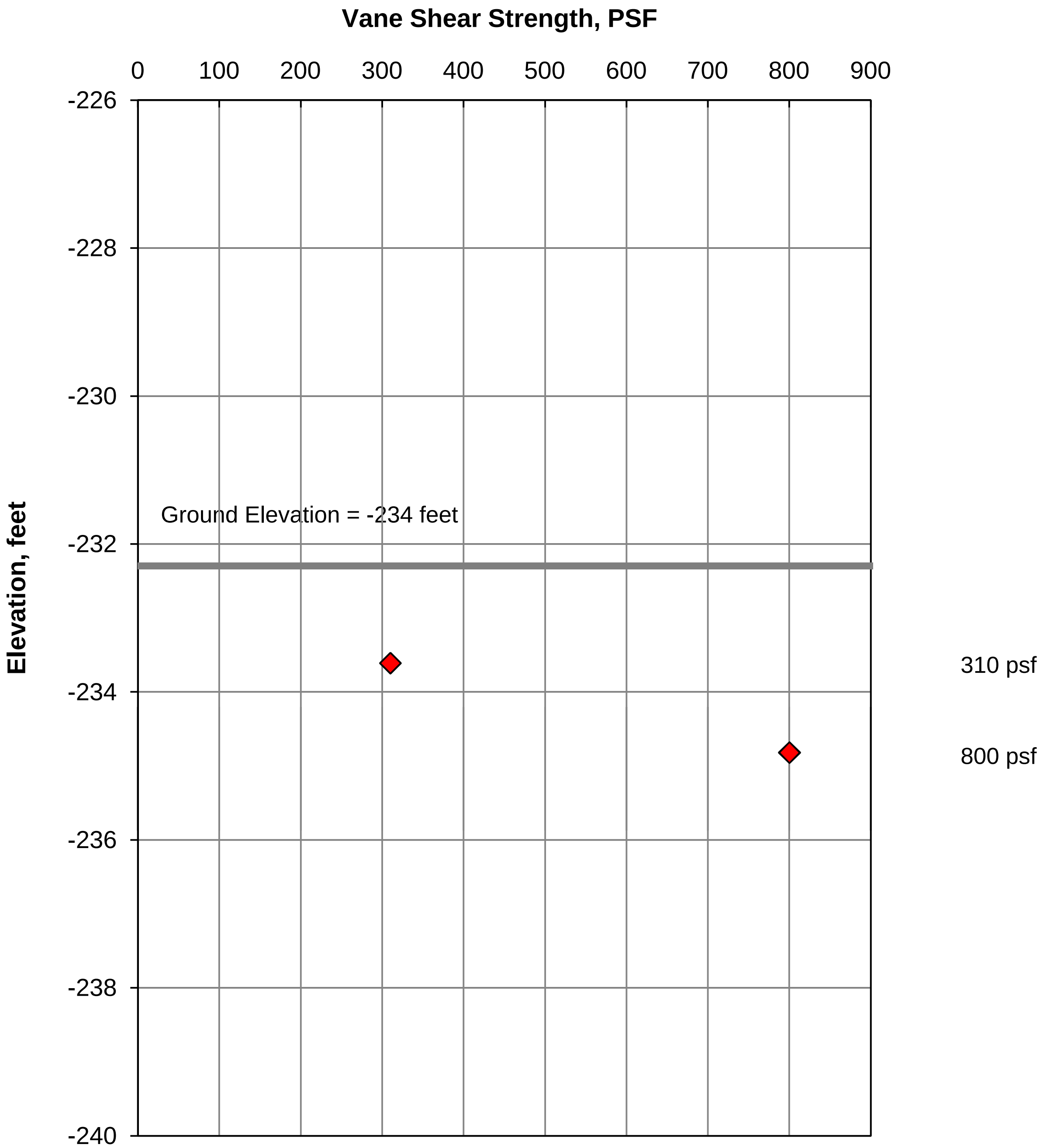
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 44VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-16



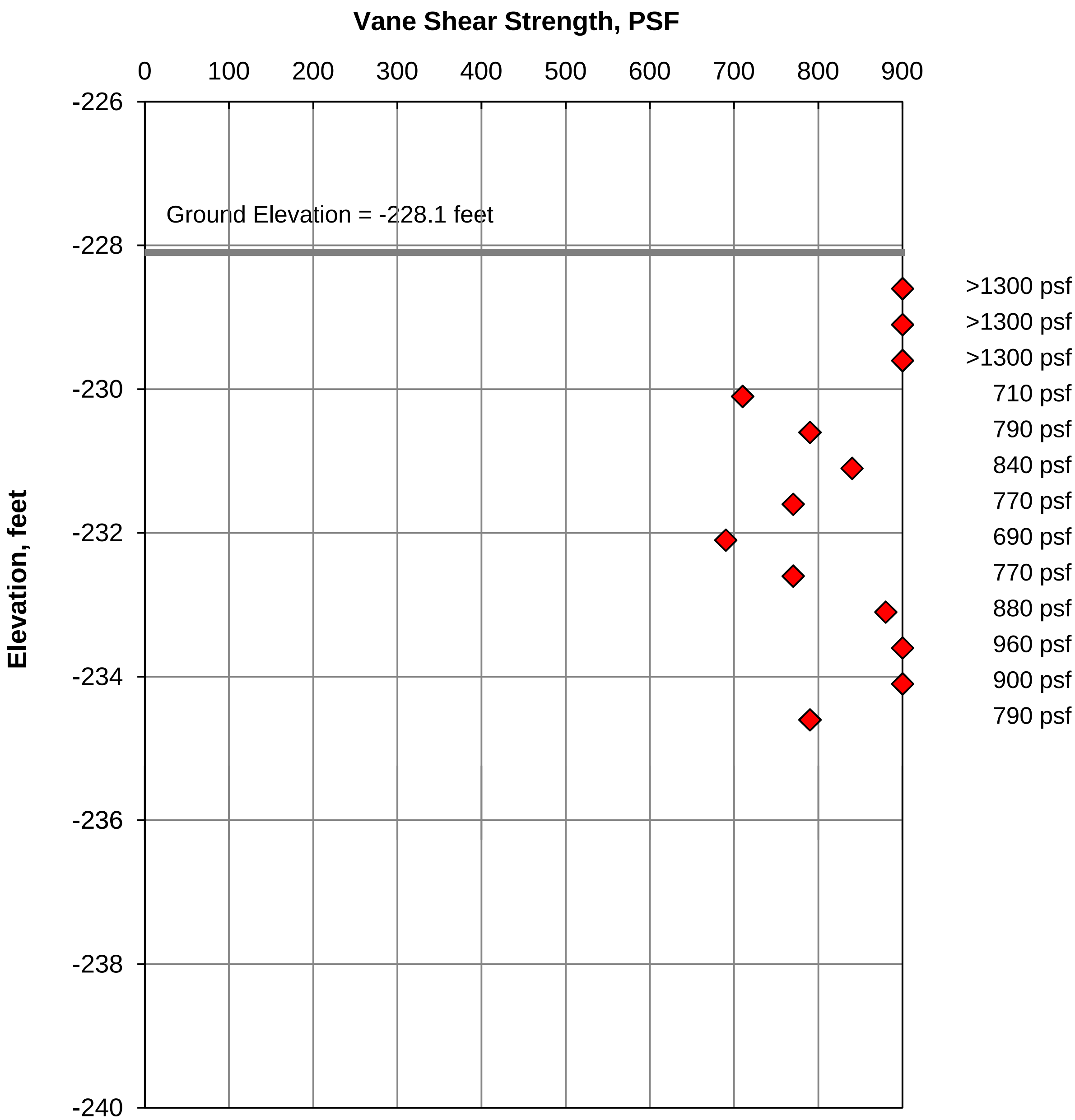
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength Exploration Point 45VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-17



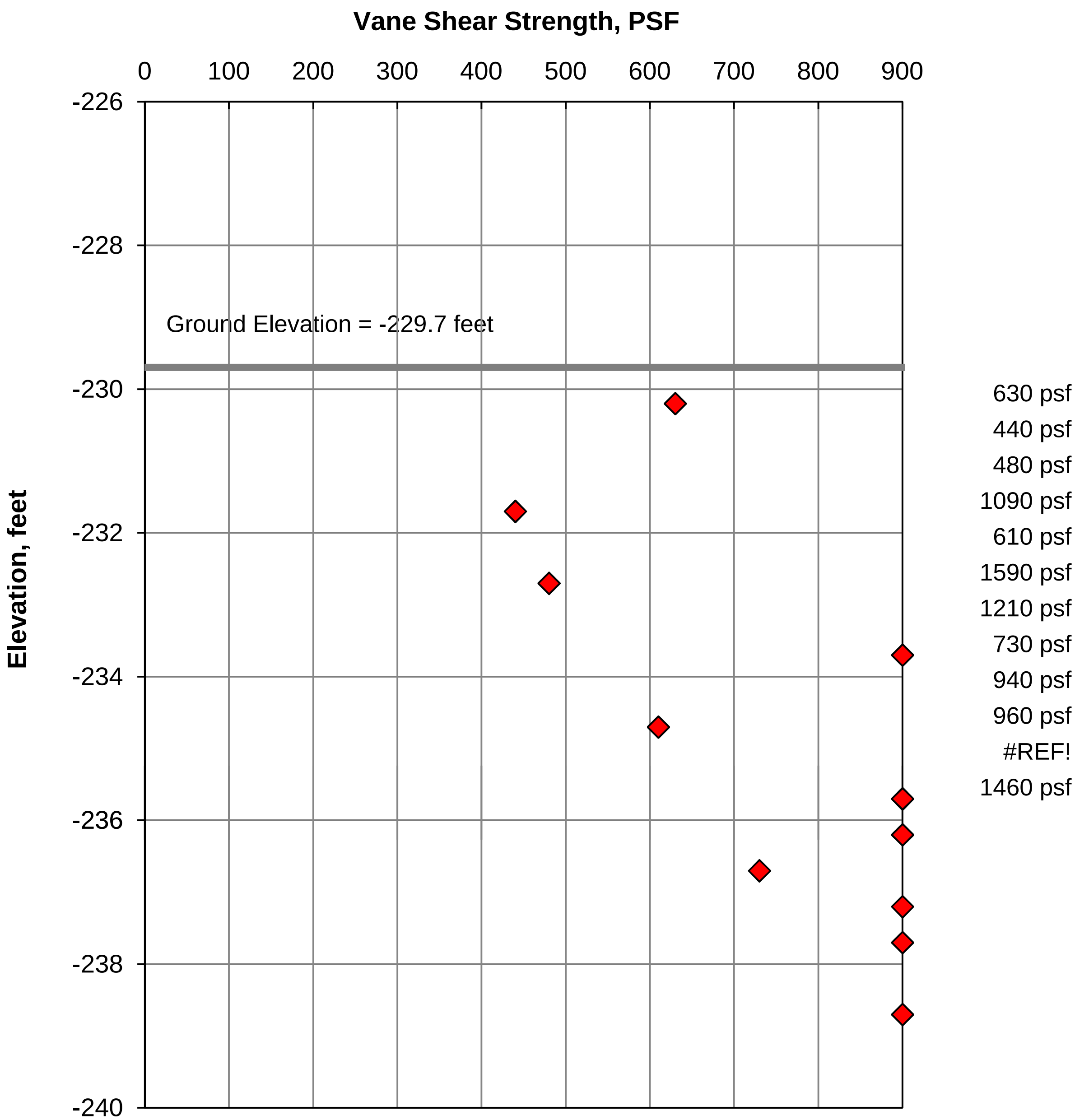
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California		**Vane Shear Strength** **Exploration Point 46HA**
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-18



Notes:

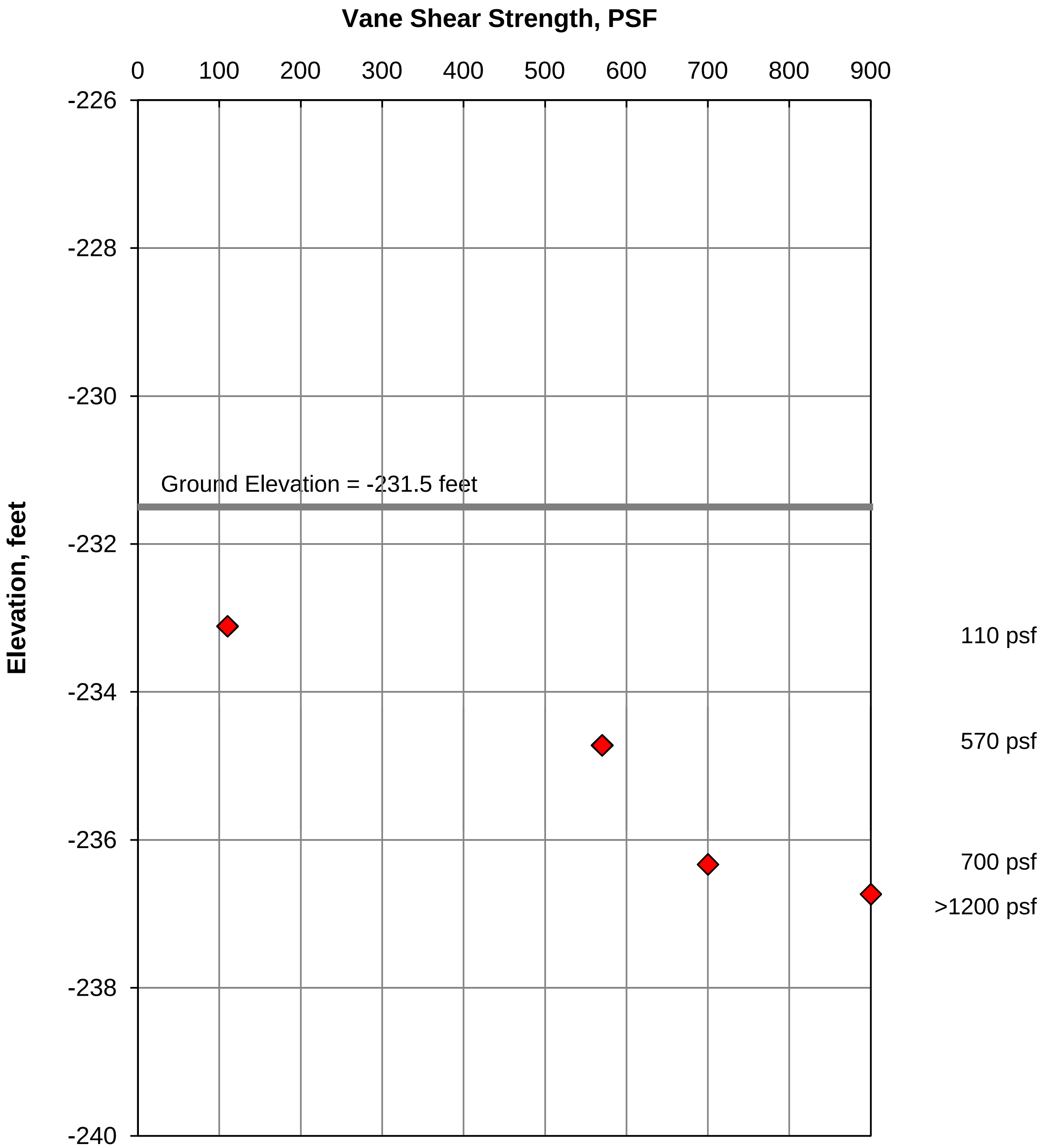
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 47HA**

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



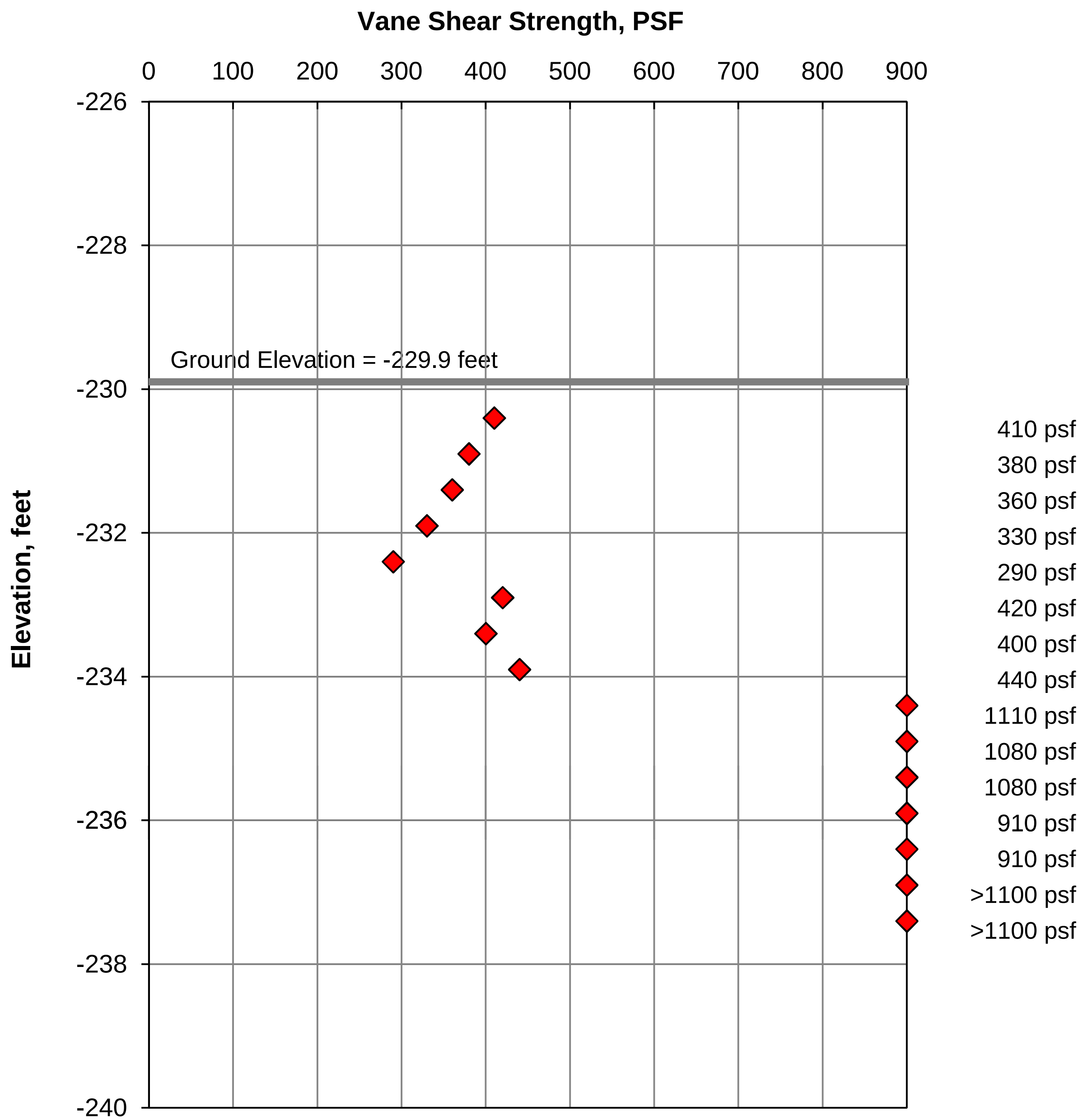
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 48VC**
Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. B-20



Notes:

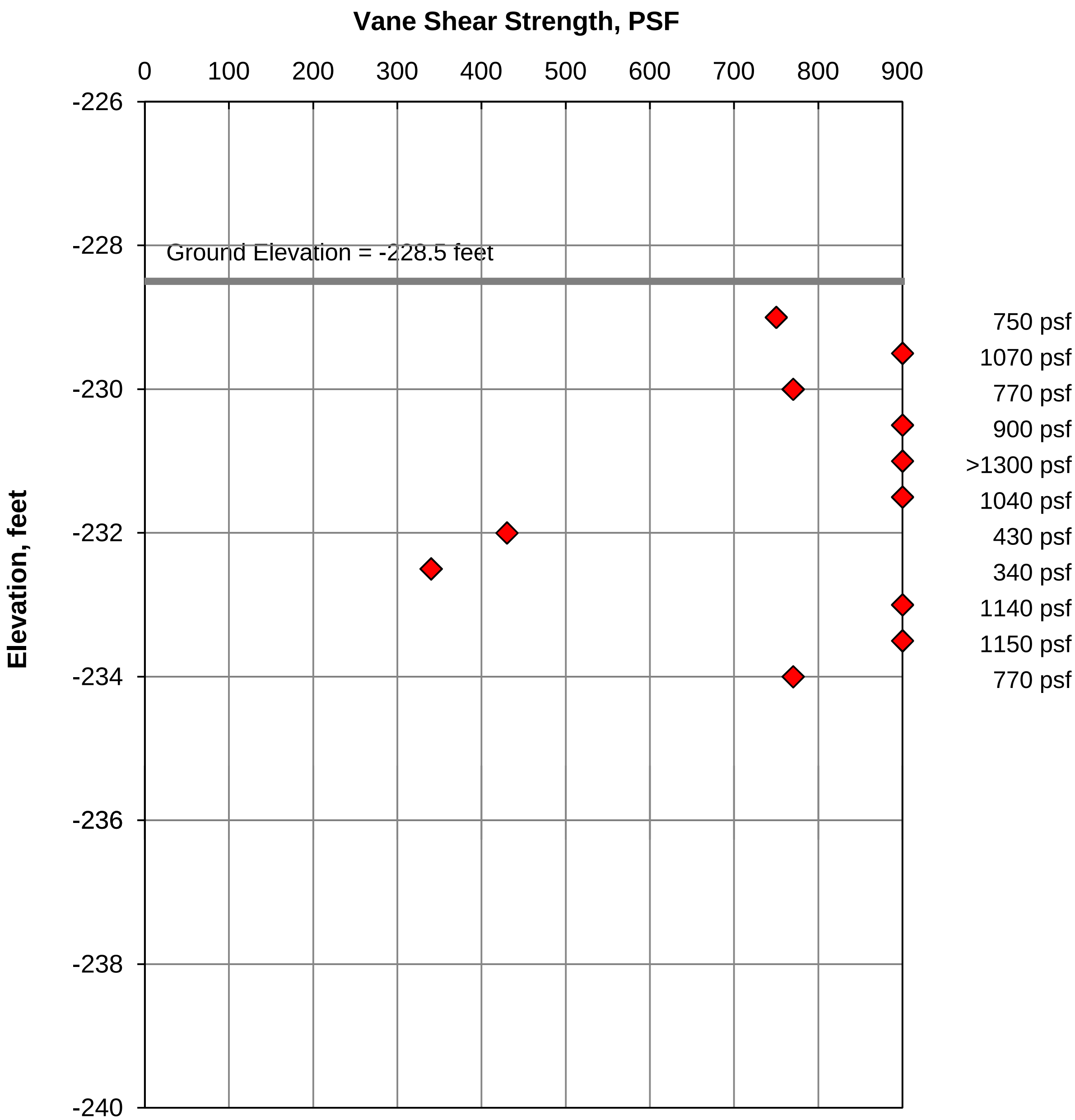
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 49HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-21



Notes:

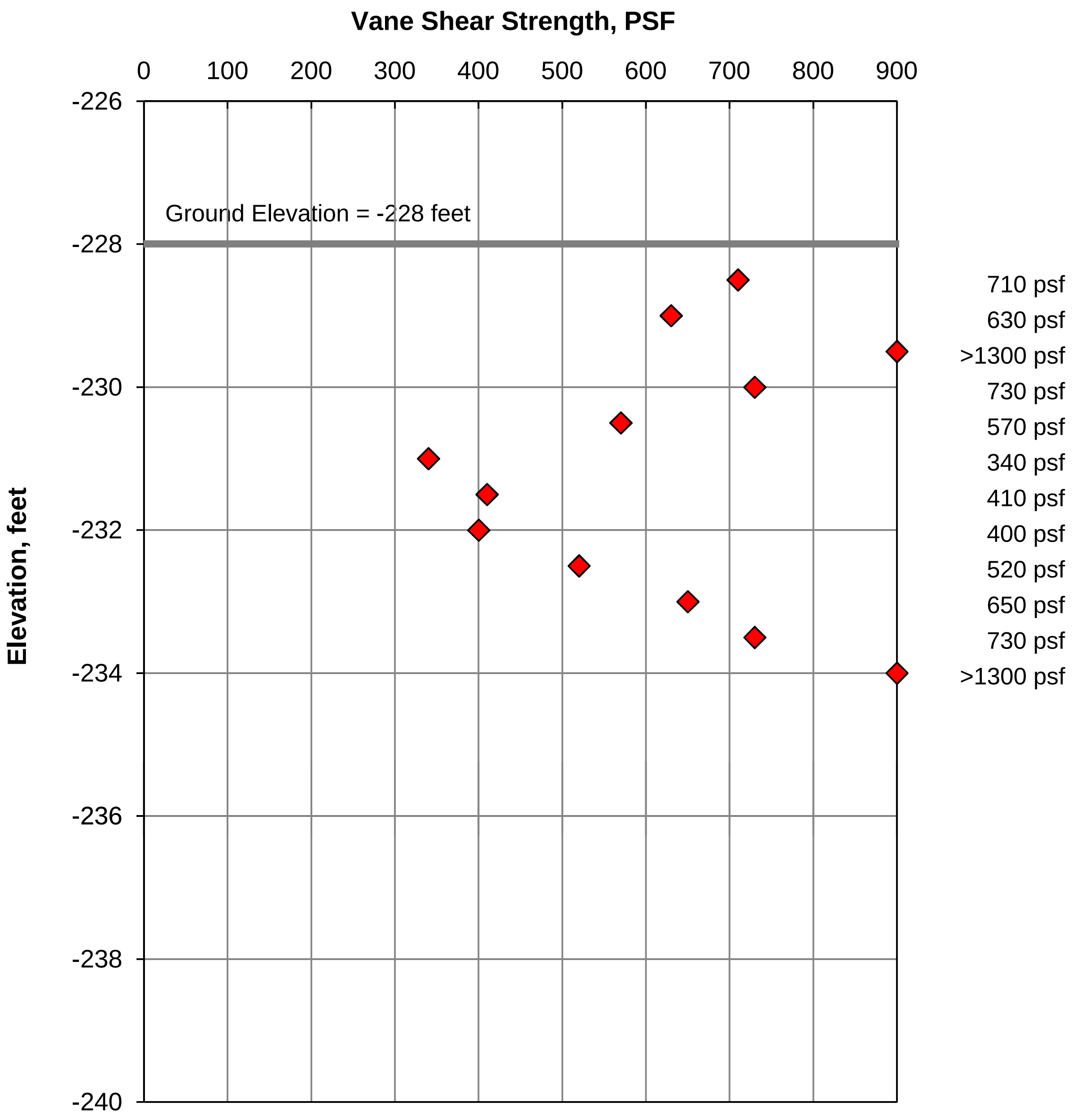
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 50HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-22



Notes:

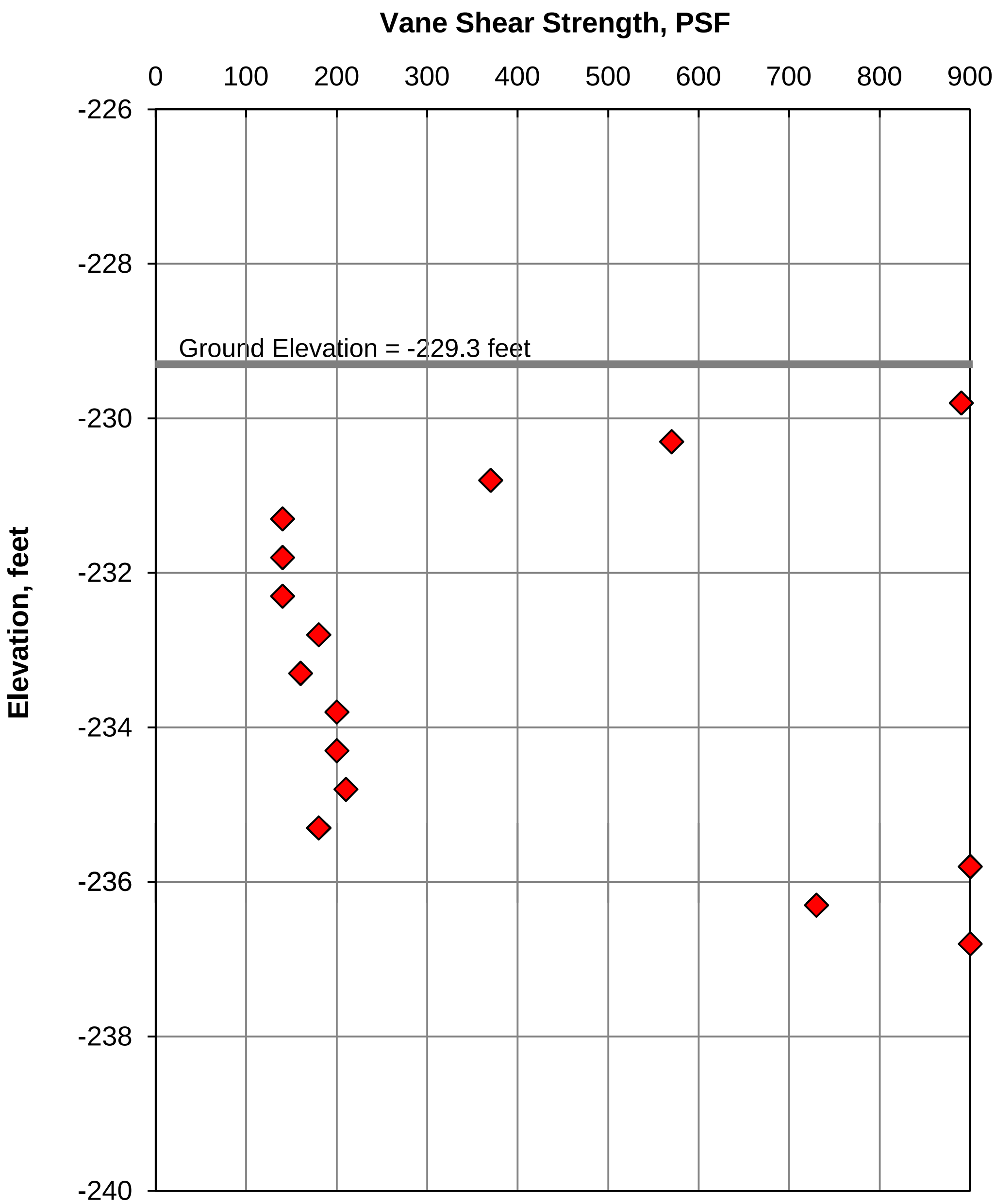
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 51HA**

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



890 psf
570 psf
370 psf
140 psf
140 psf
140 psf
180 psf
160 psf
200 psf
200 psf
210 psf
180 psf
1040 psf
730 psf
>1300 psf

Notes:

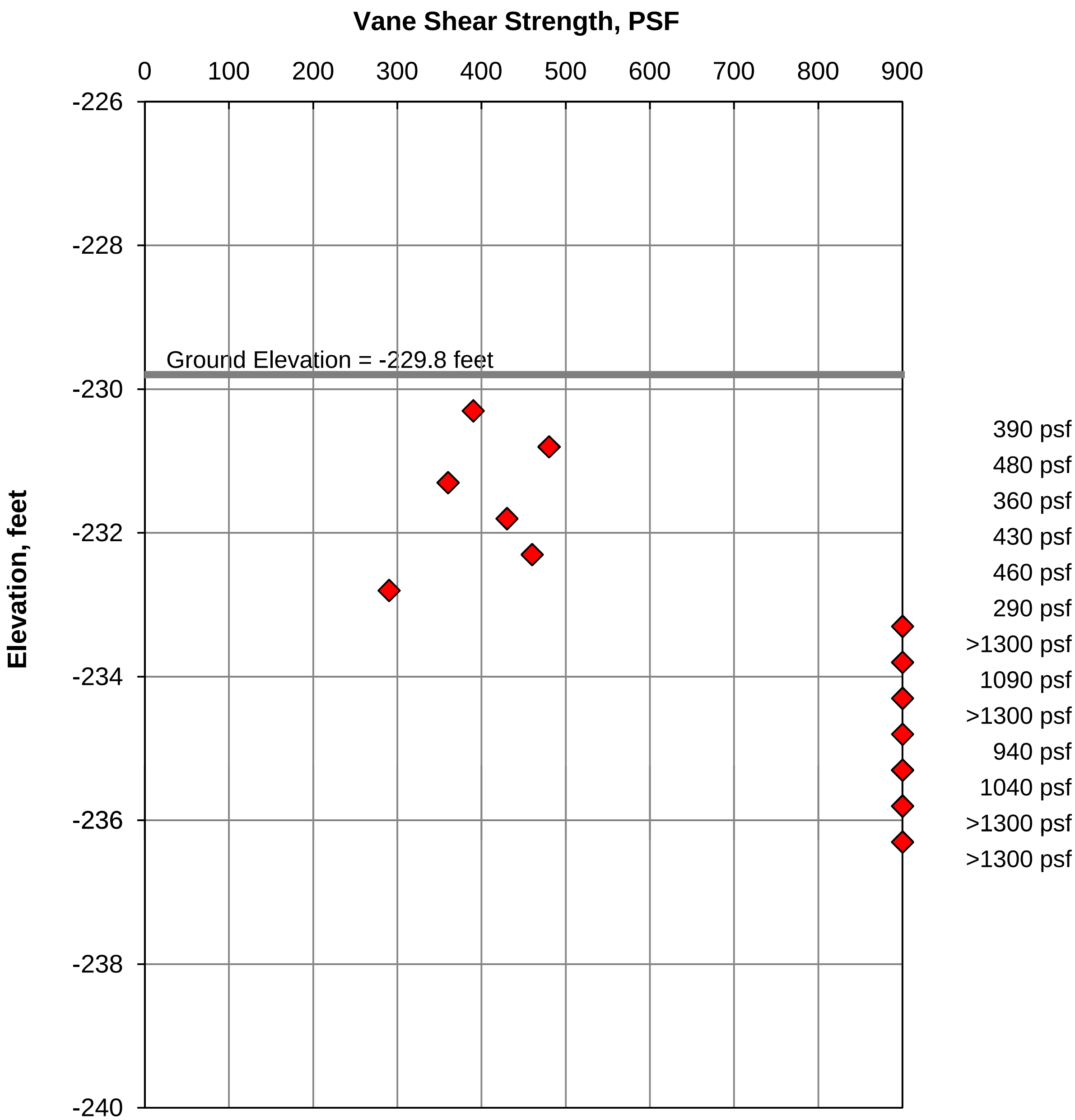
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 52HA**

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



Notes:

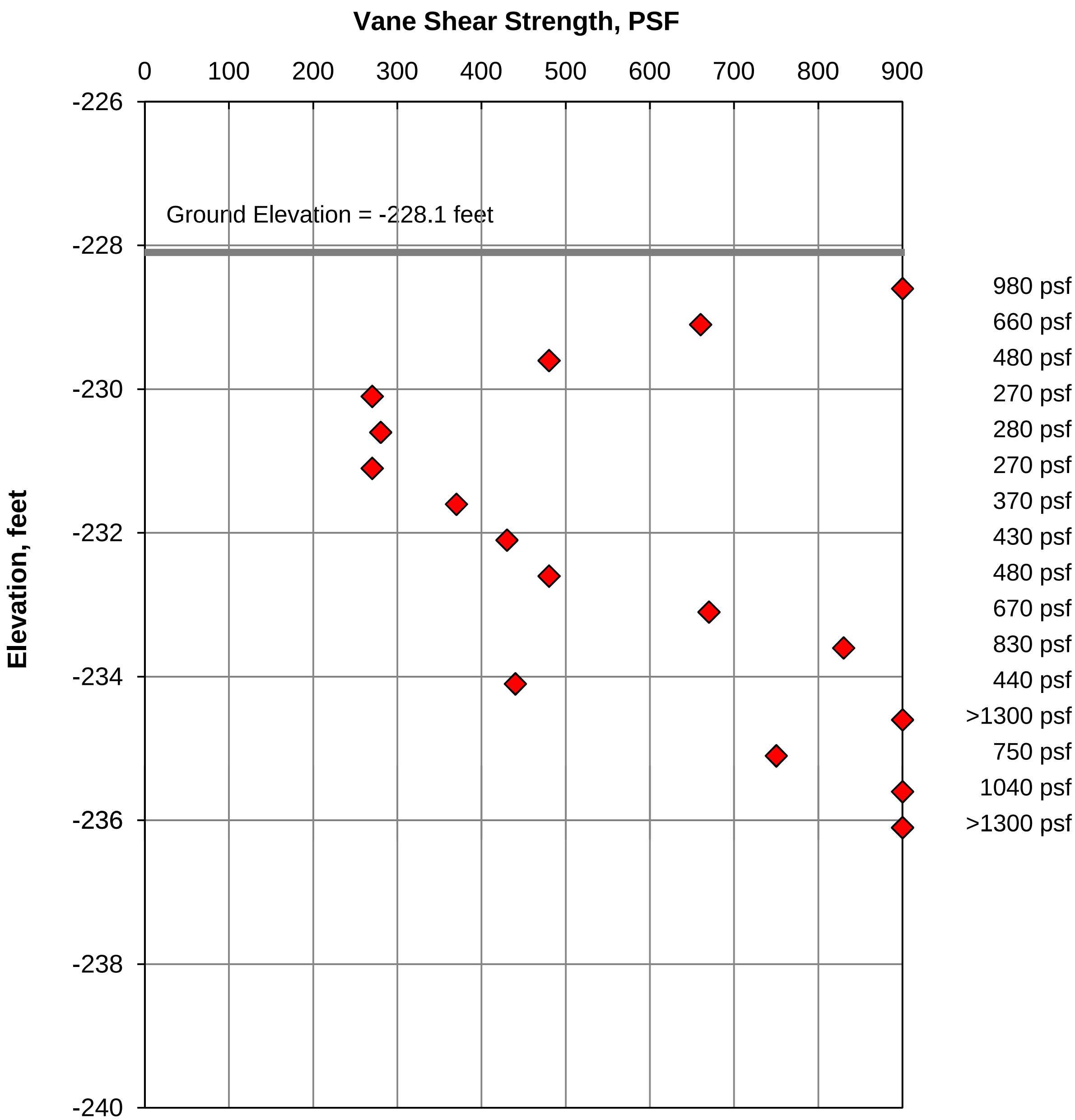
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 53HA**

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



Notes:

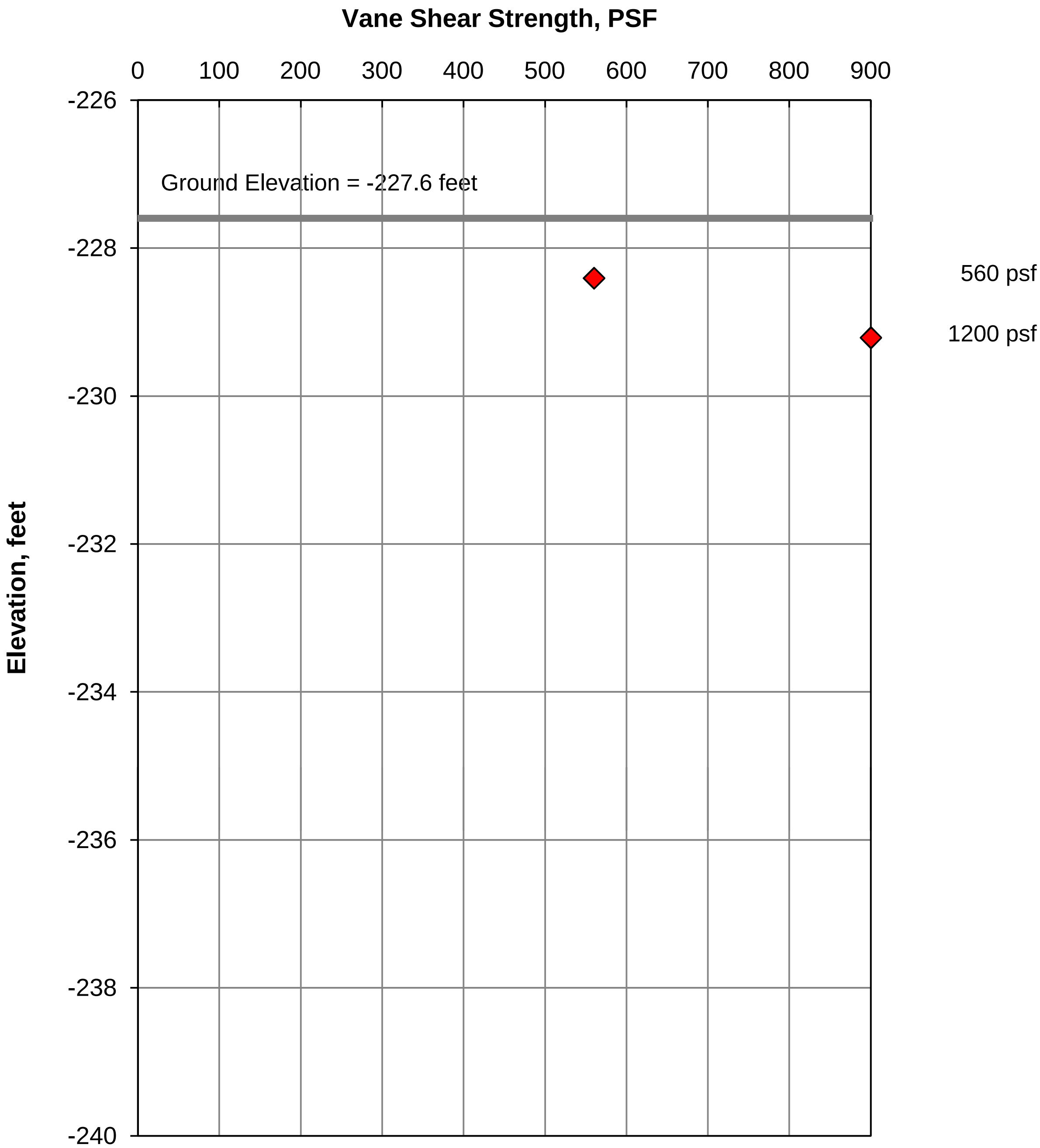
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength Exploration Point 54HA**

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



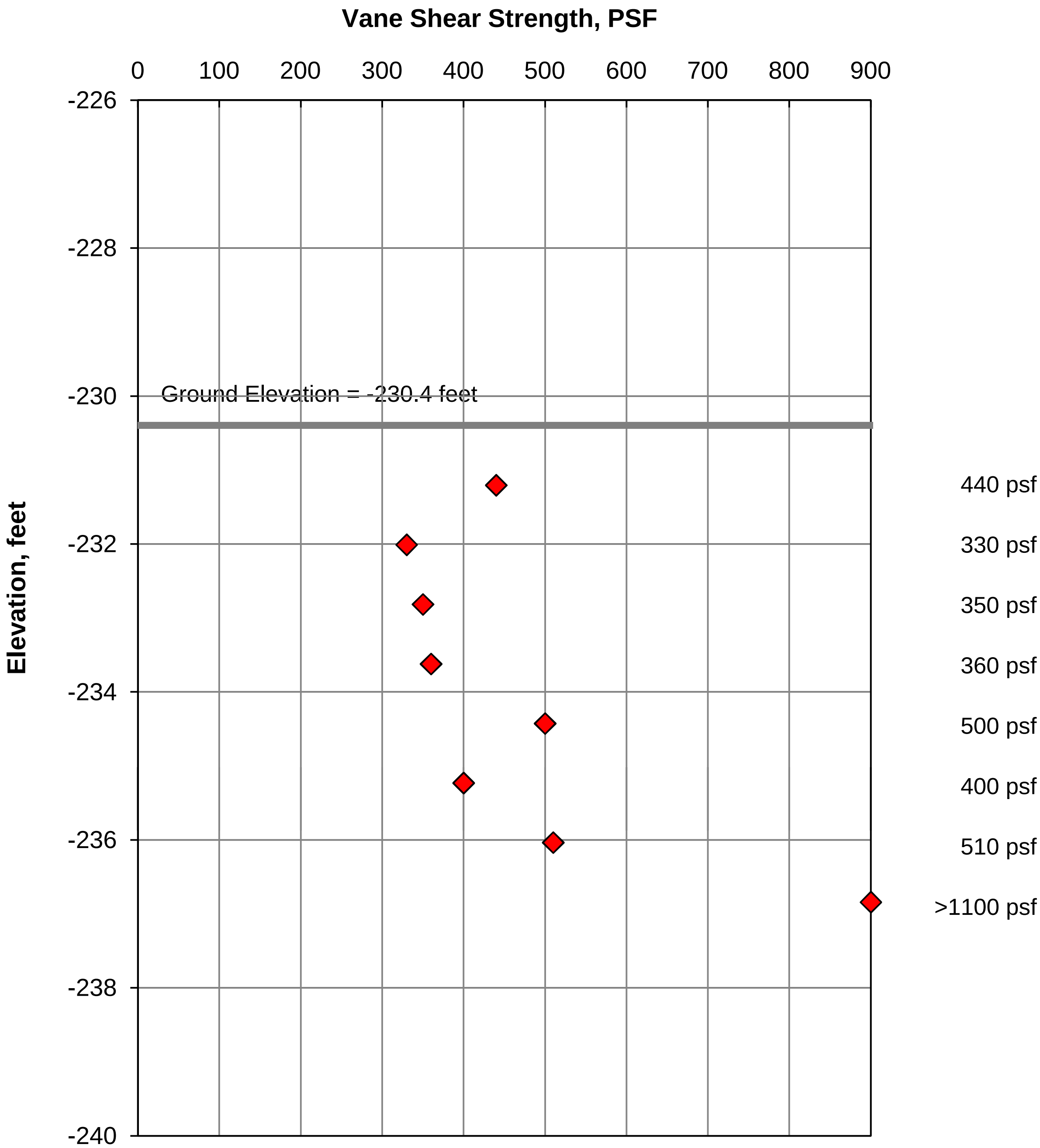
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 55VS**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-27



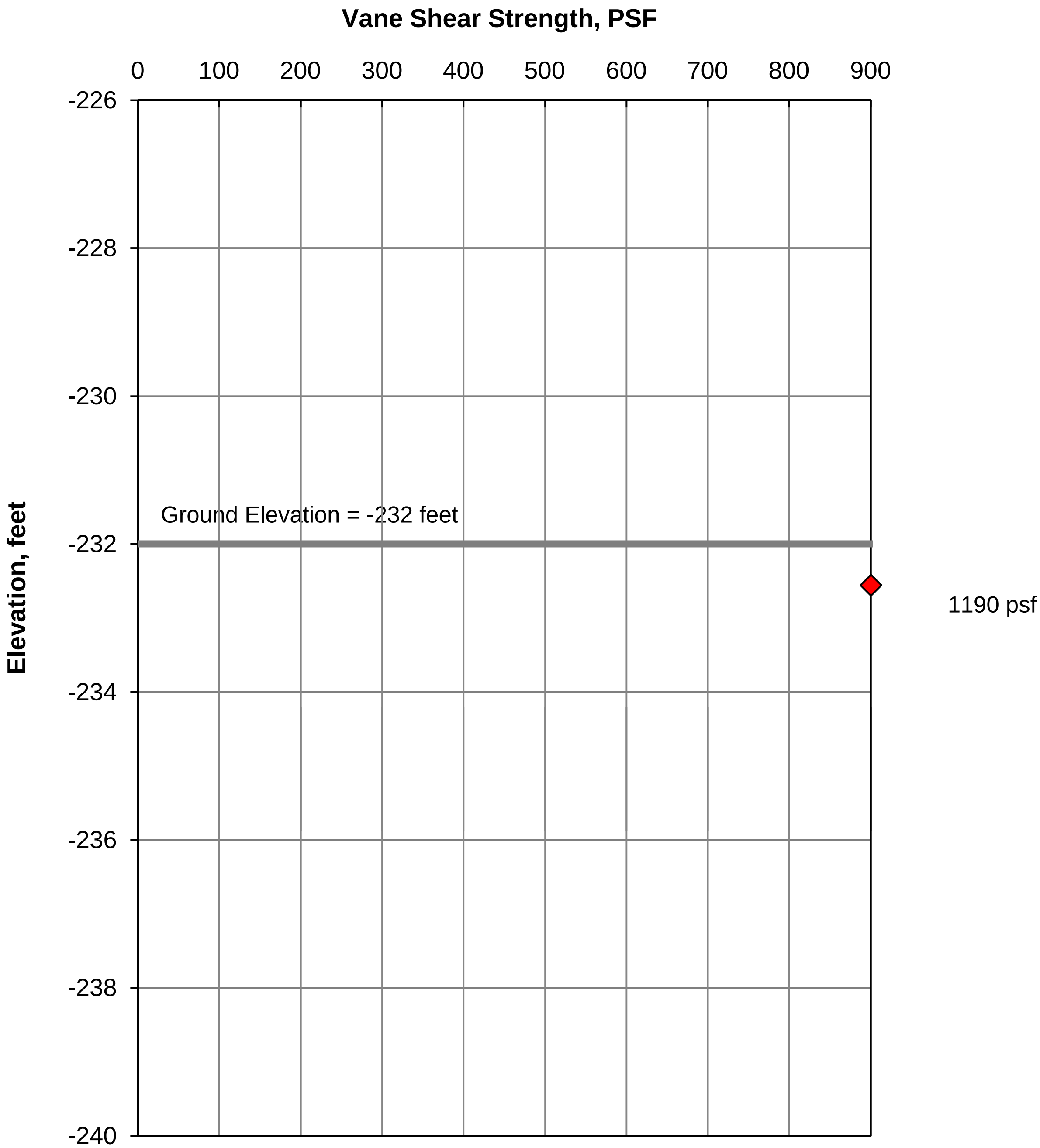
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 56VS**
Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. B-28



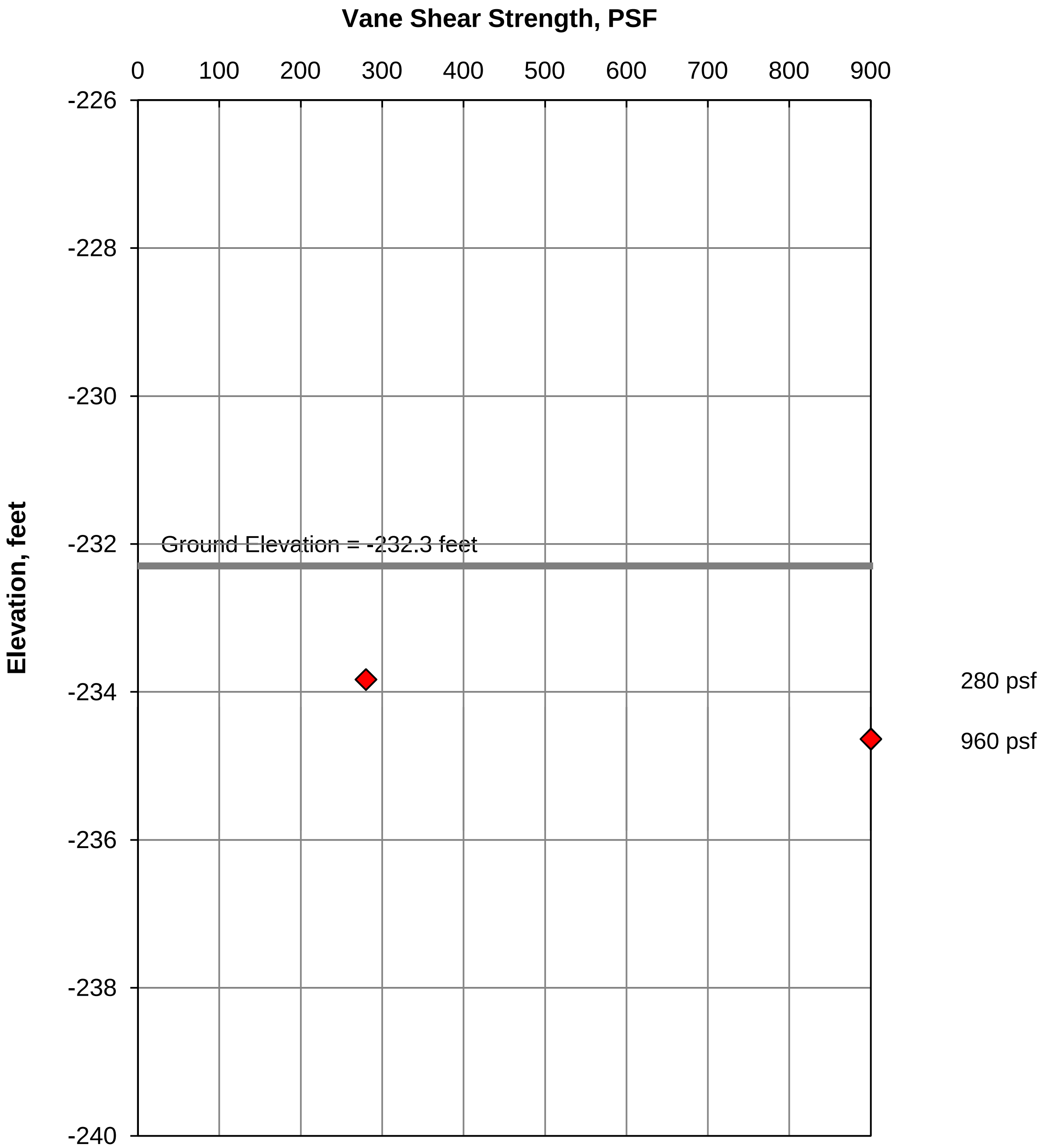
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 57VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-29



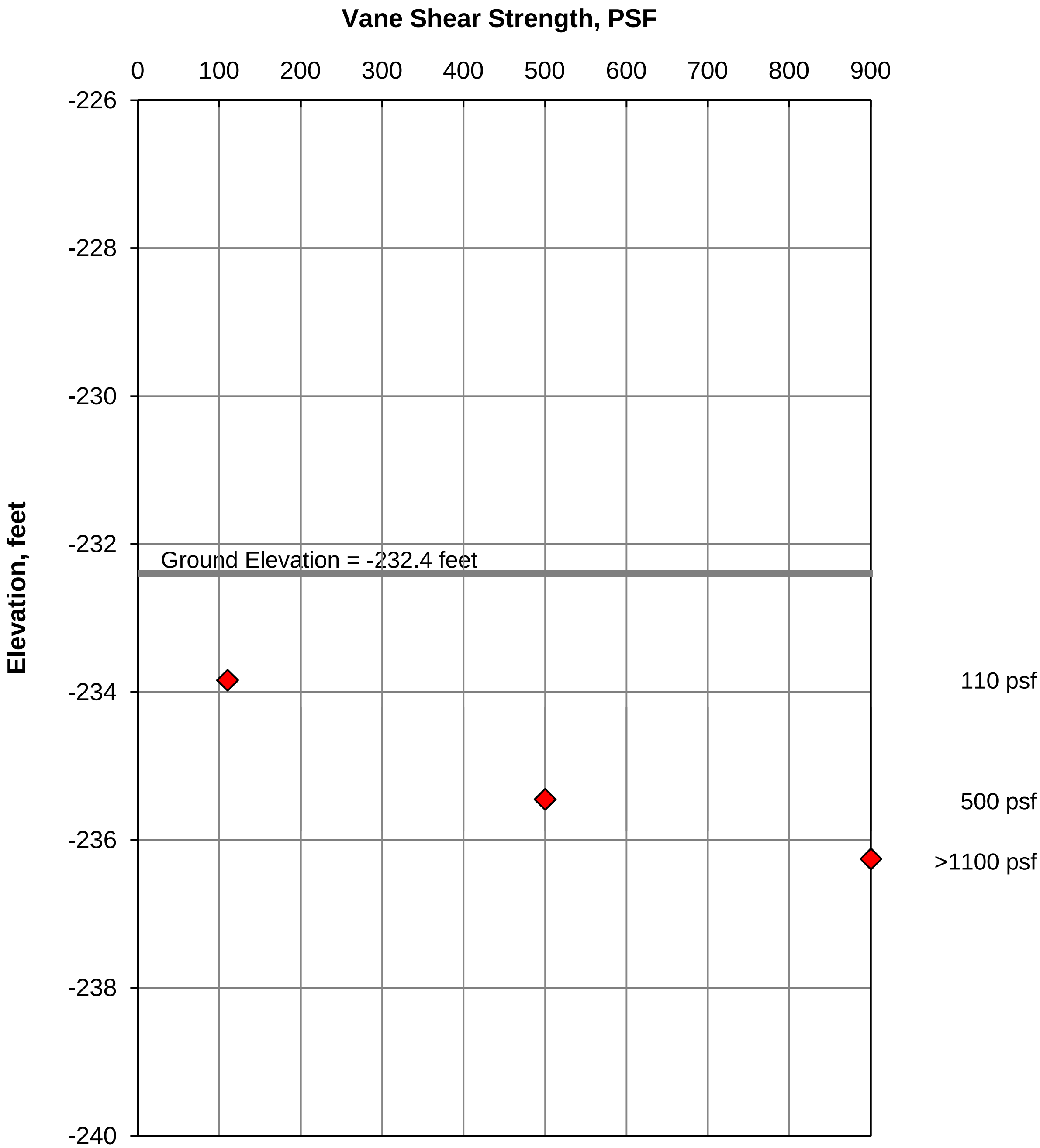
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 58VC**
Hultgren - Tillis Engineers	Project No. 758.01 — Plate No. B-30



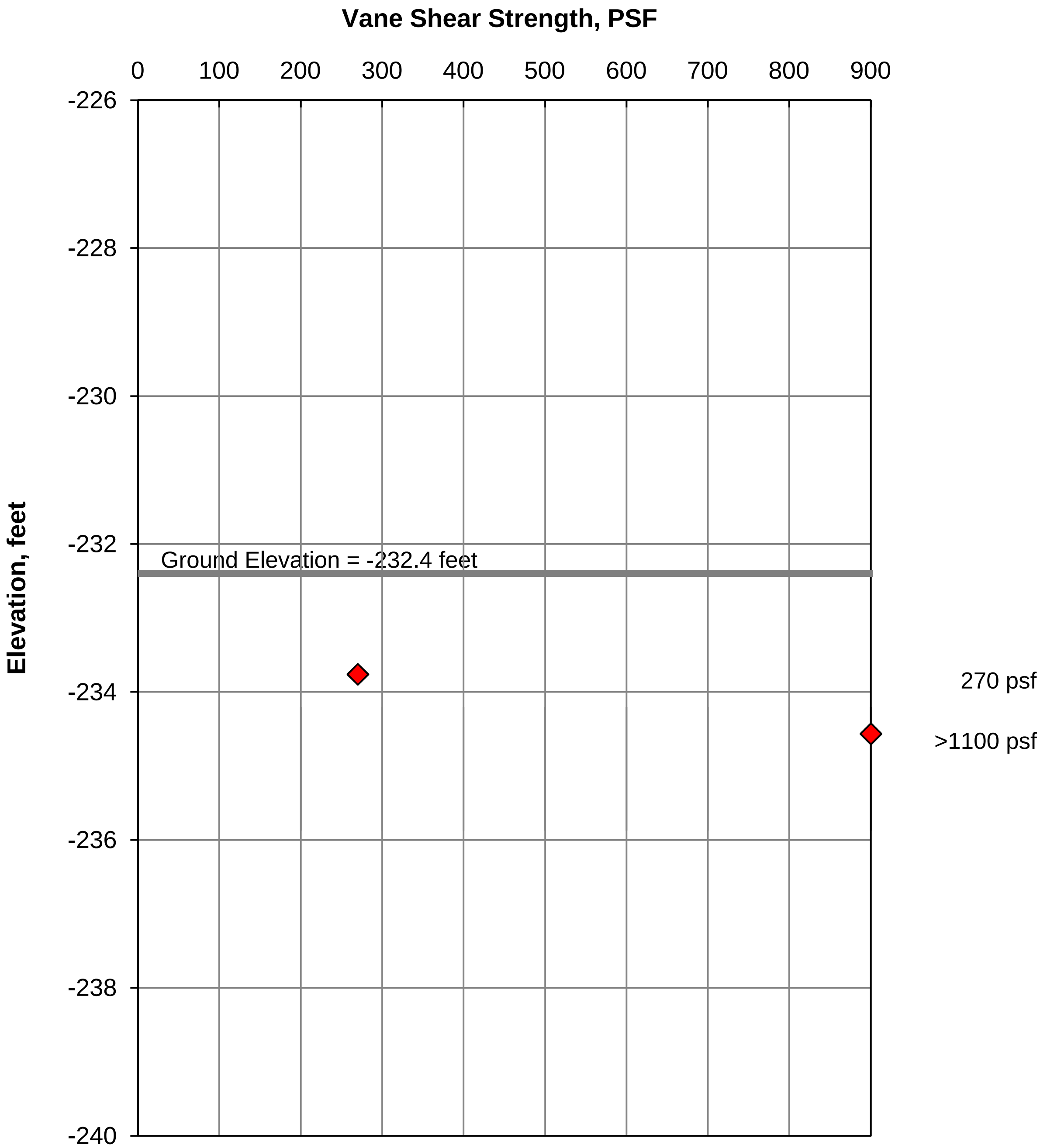
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 59VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-31



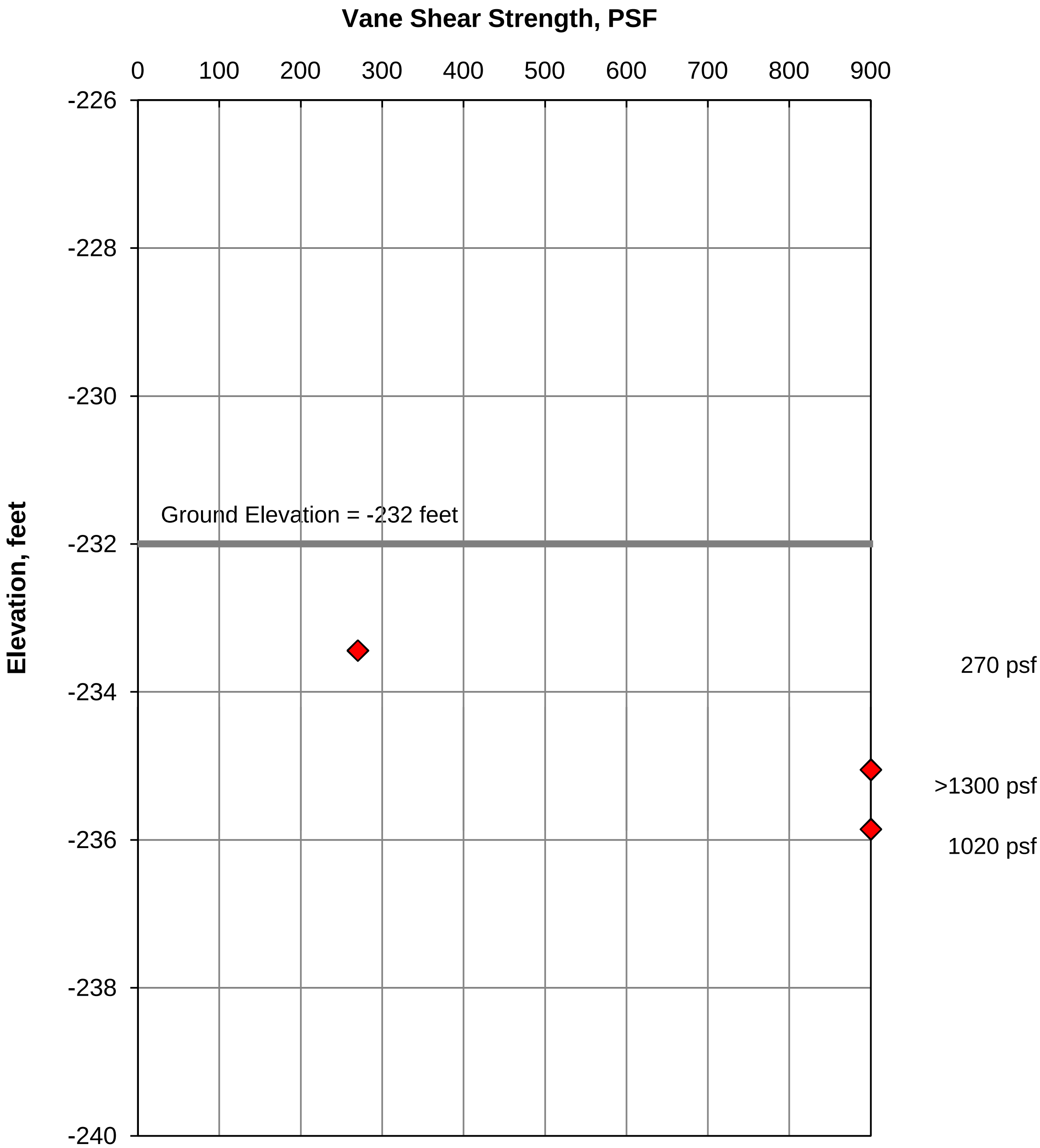
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 60VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-32



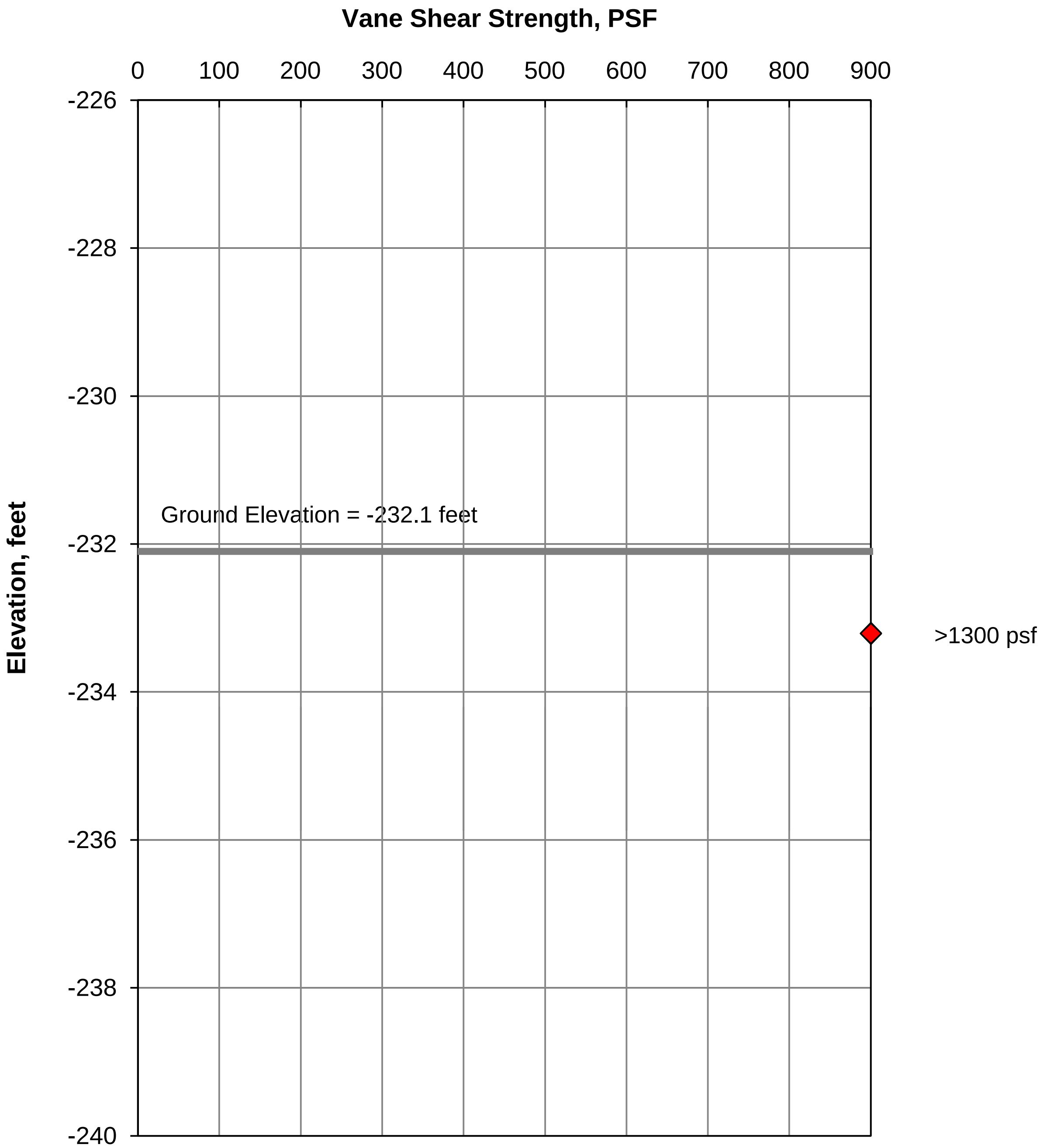
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 61VC**
Hultgren - Tillis Engineers	Project No. 758.01 | Plate No. B-33



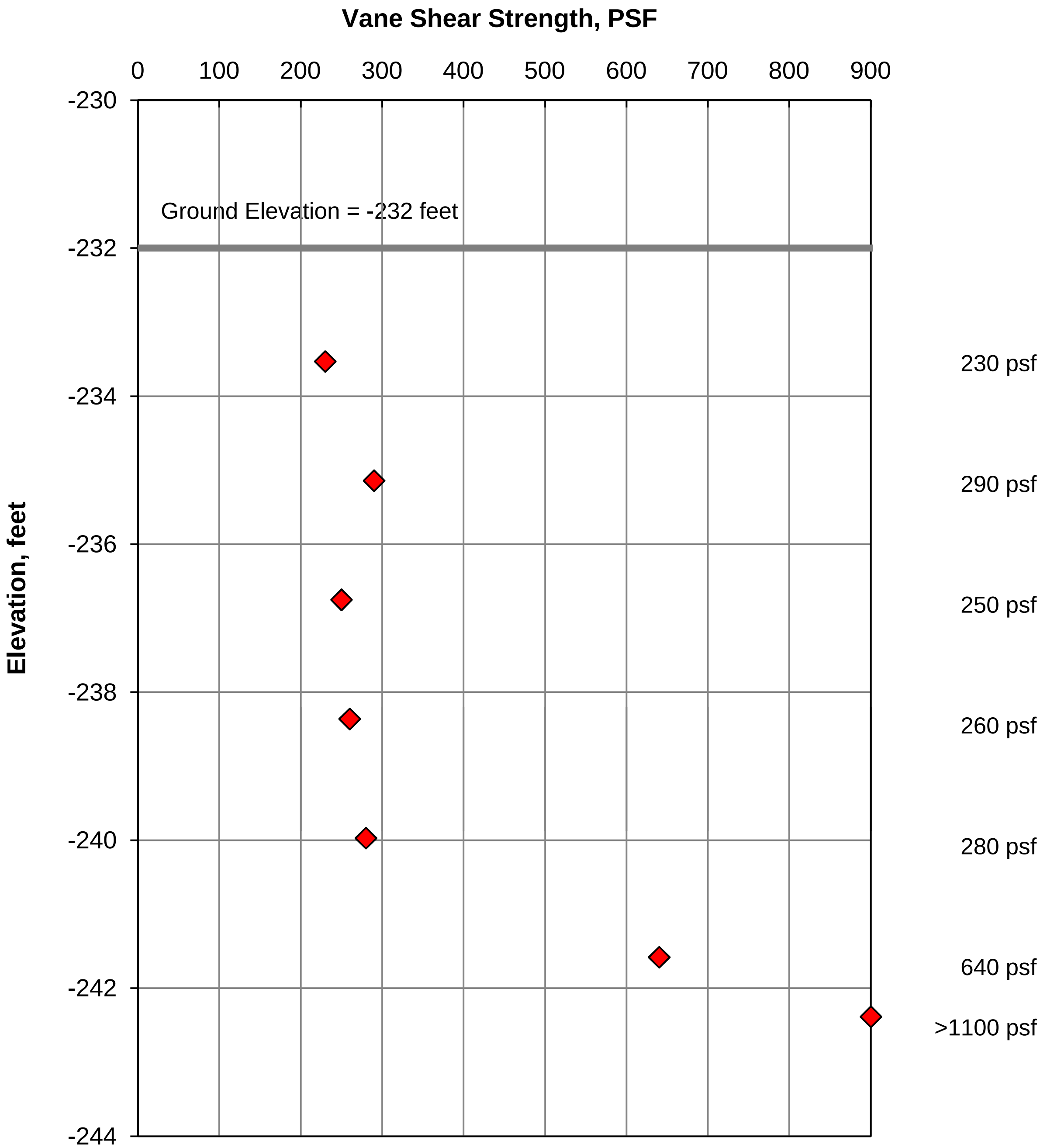
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 62VC**
Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. B-34



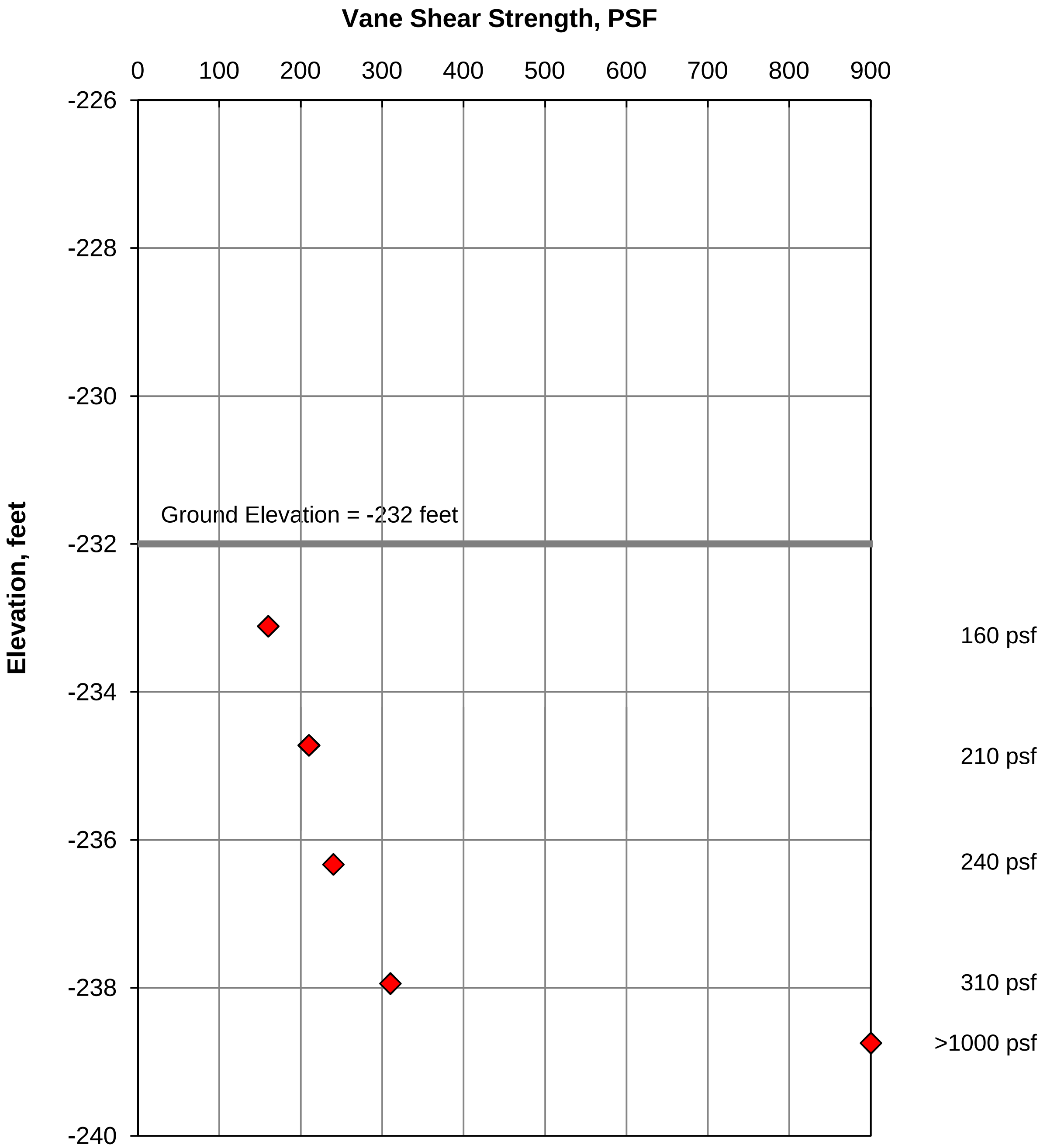
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 63VC**
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-35



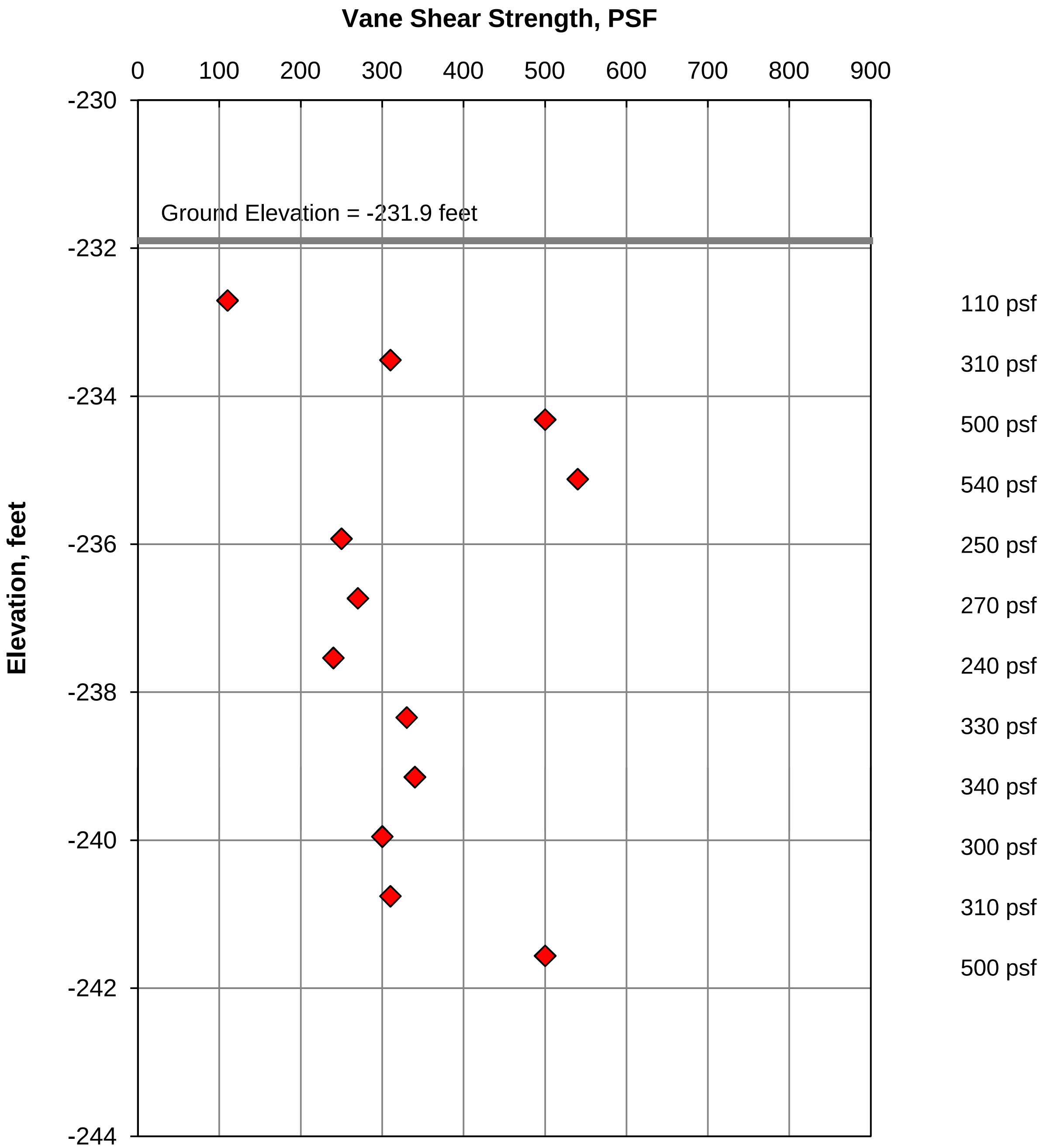
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 64VC**
Hultgren - Tillis Engineers	Project No. 758.01 | Plate No. B-36



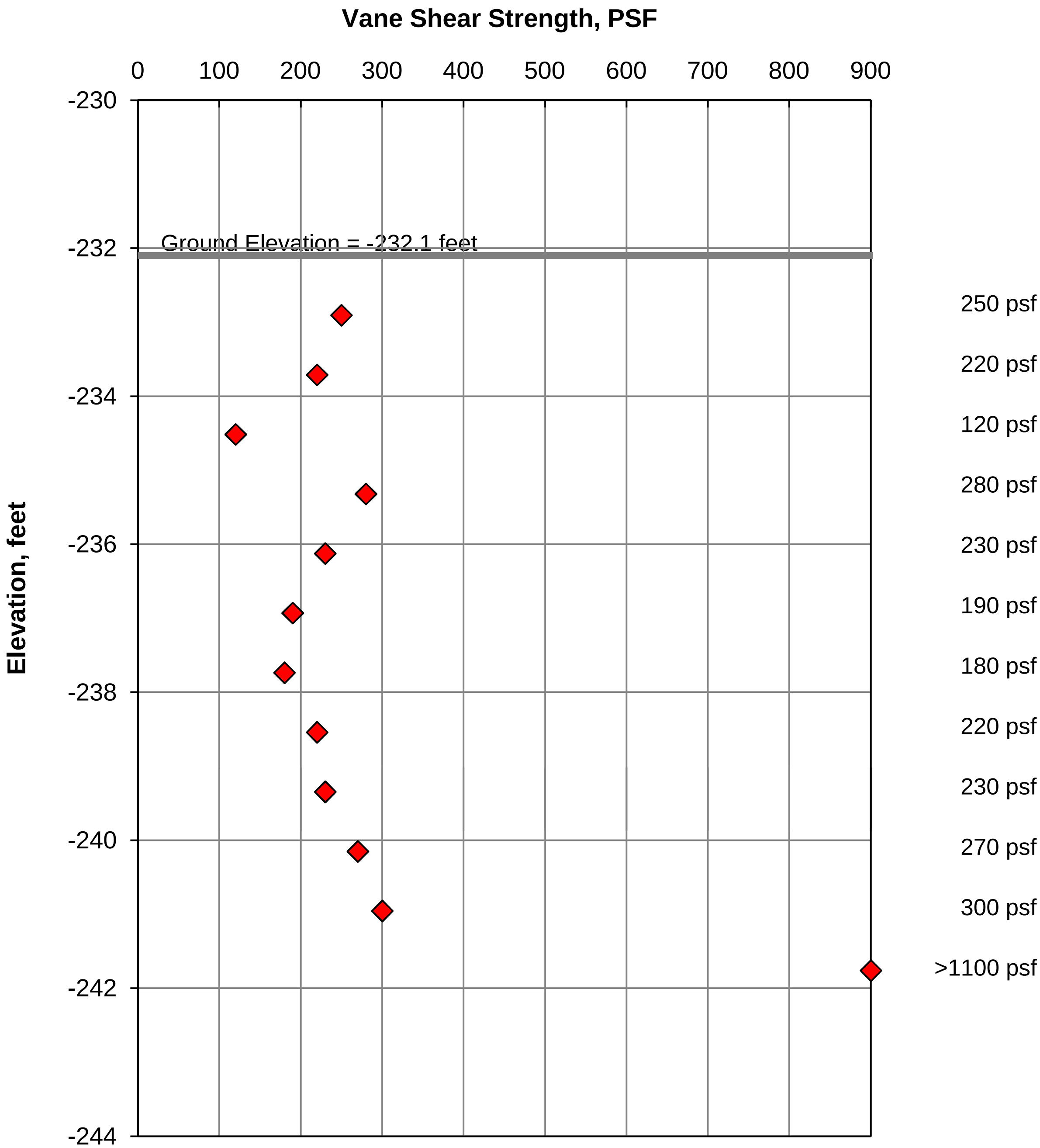
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 67VS**
Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. B-37



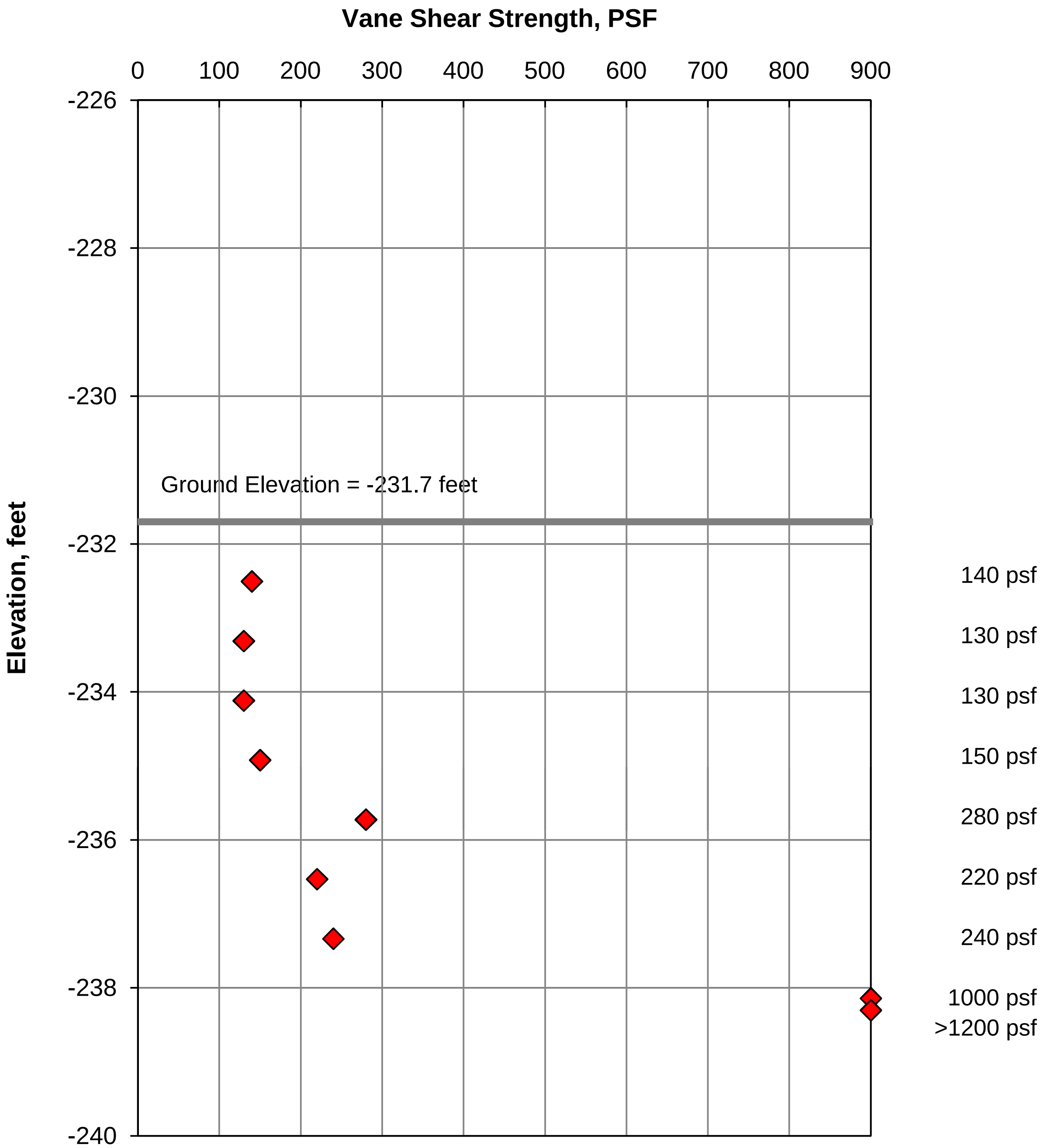
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 68VS**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-38



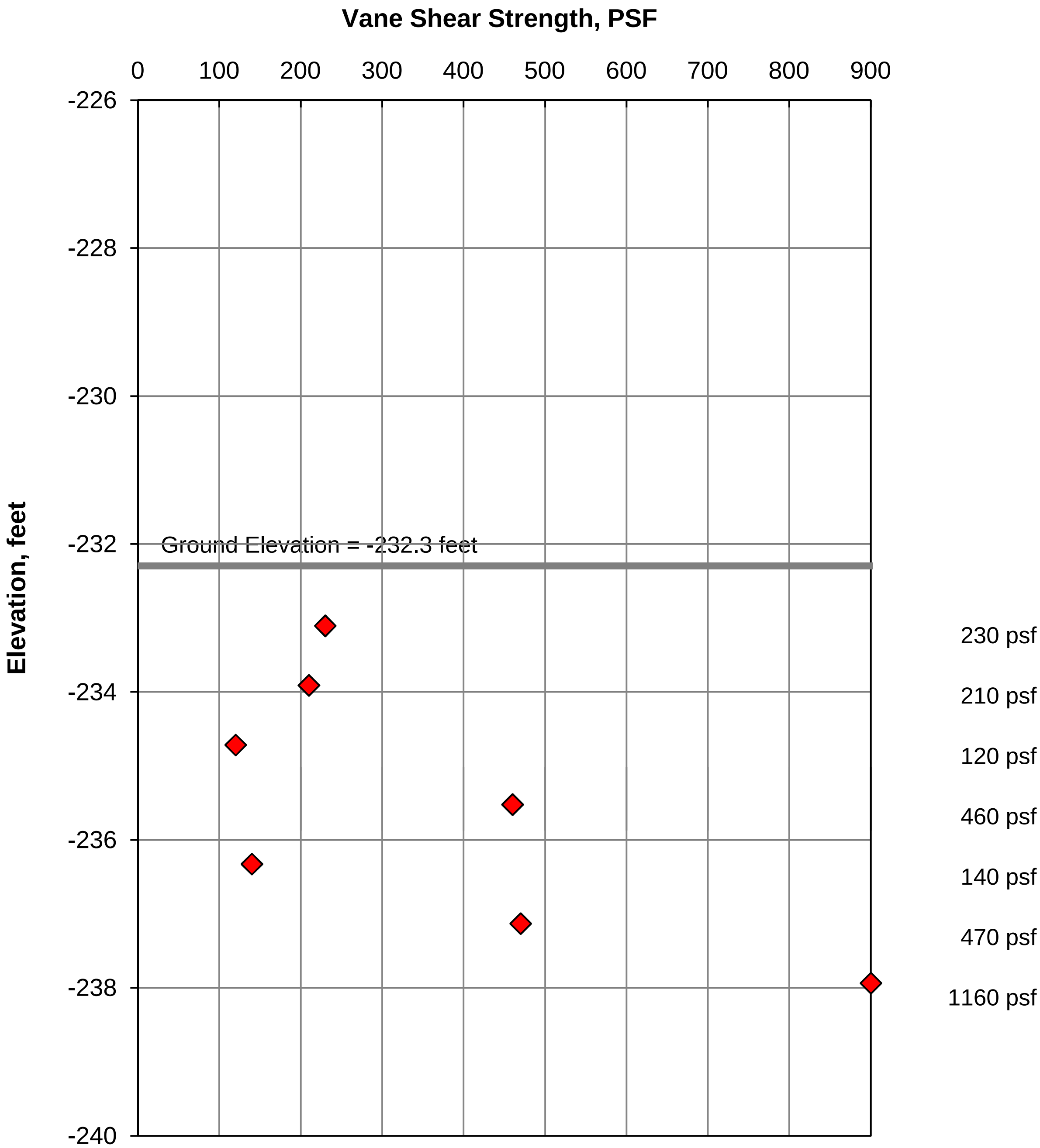
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 69VS**
Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. B-39



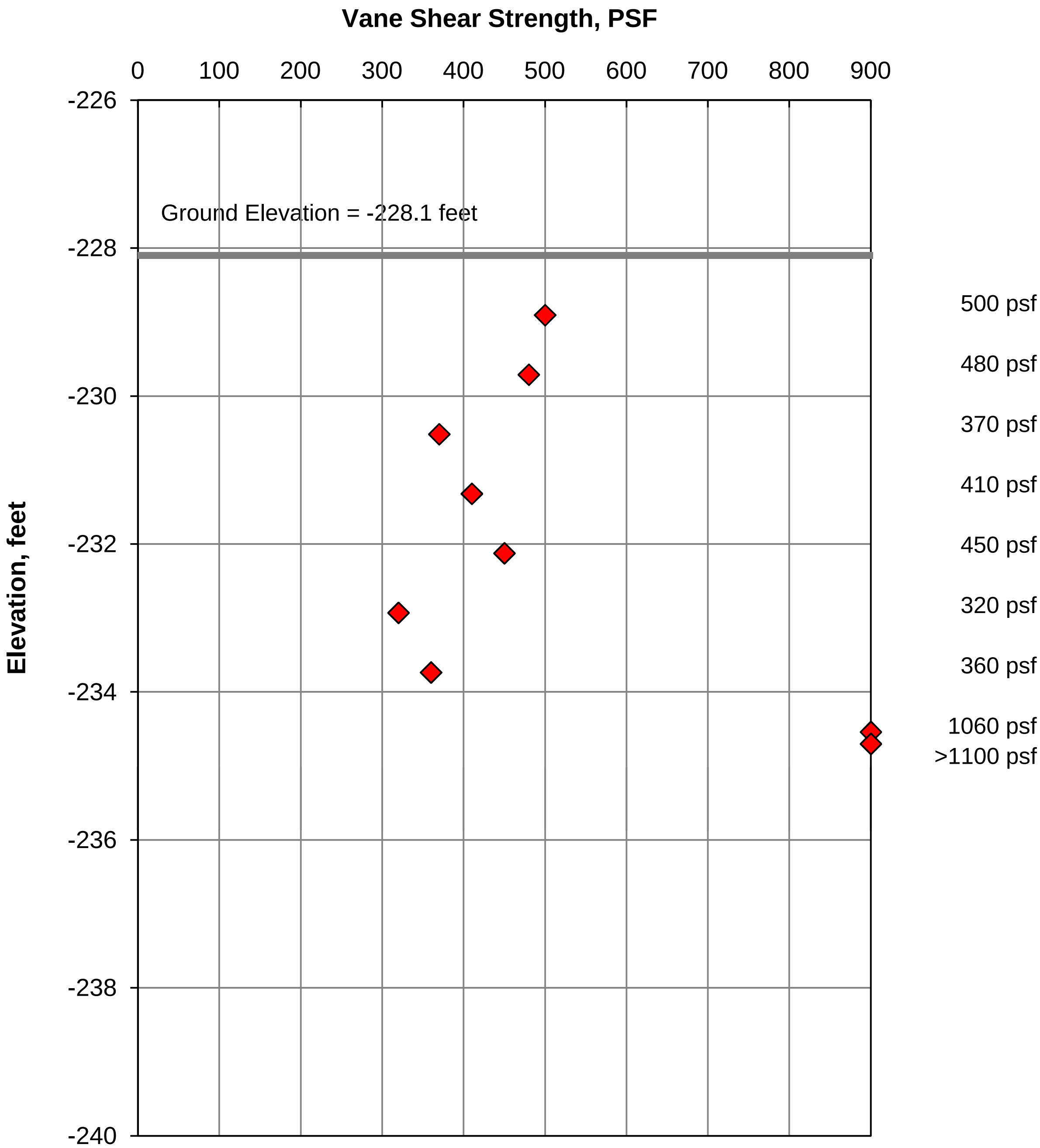
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength Exploration Point 70VS**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-40



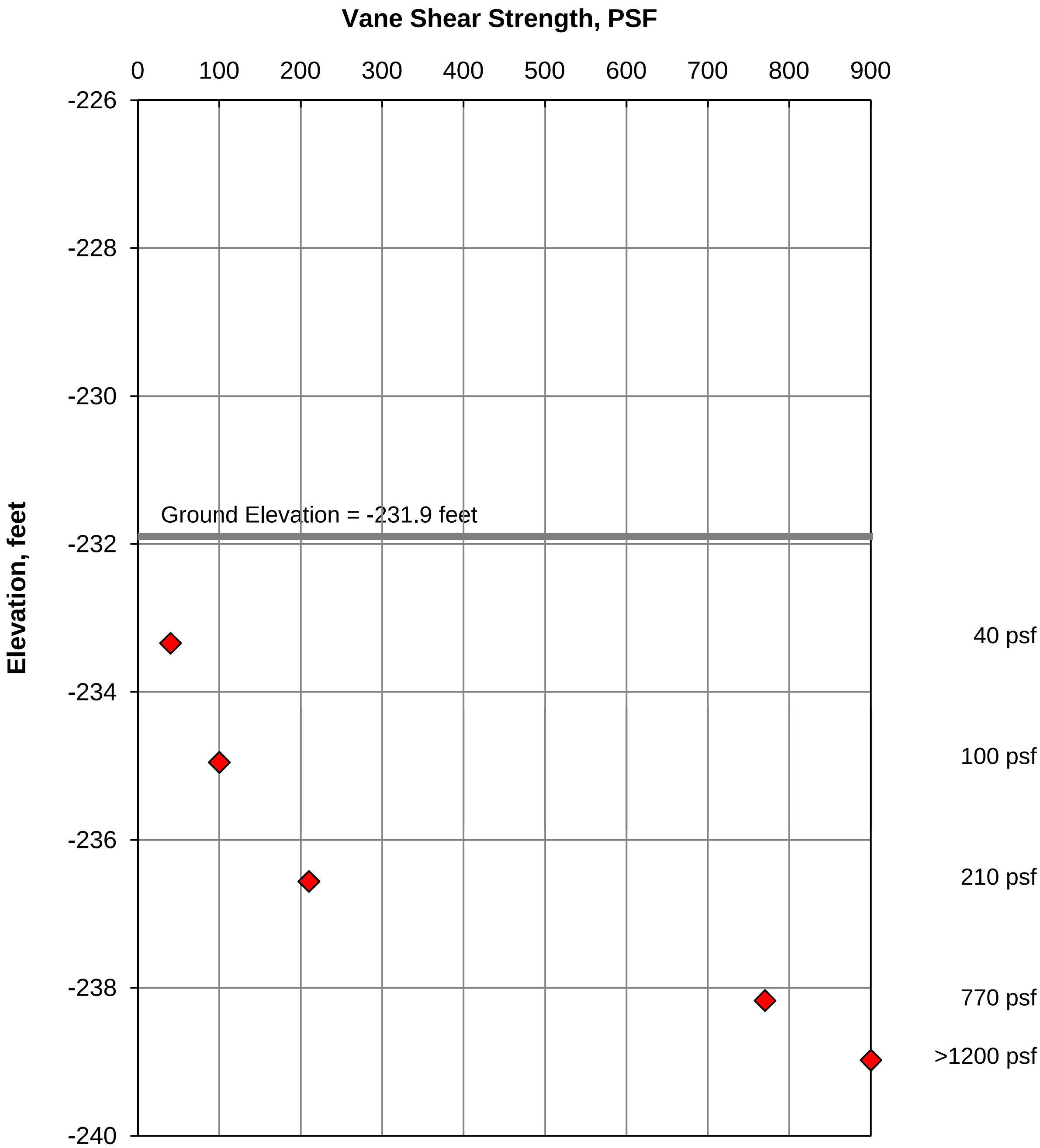
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 71VS**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-41



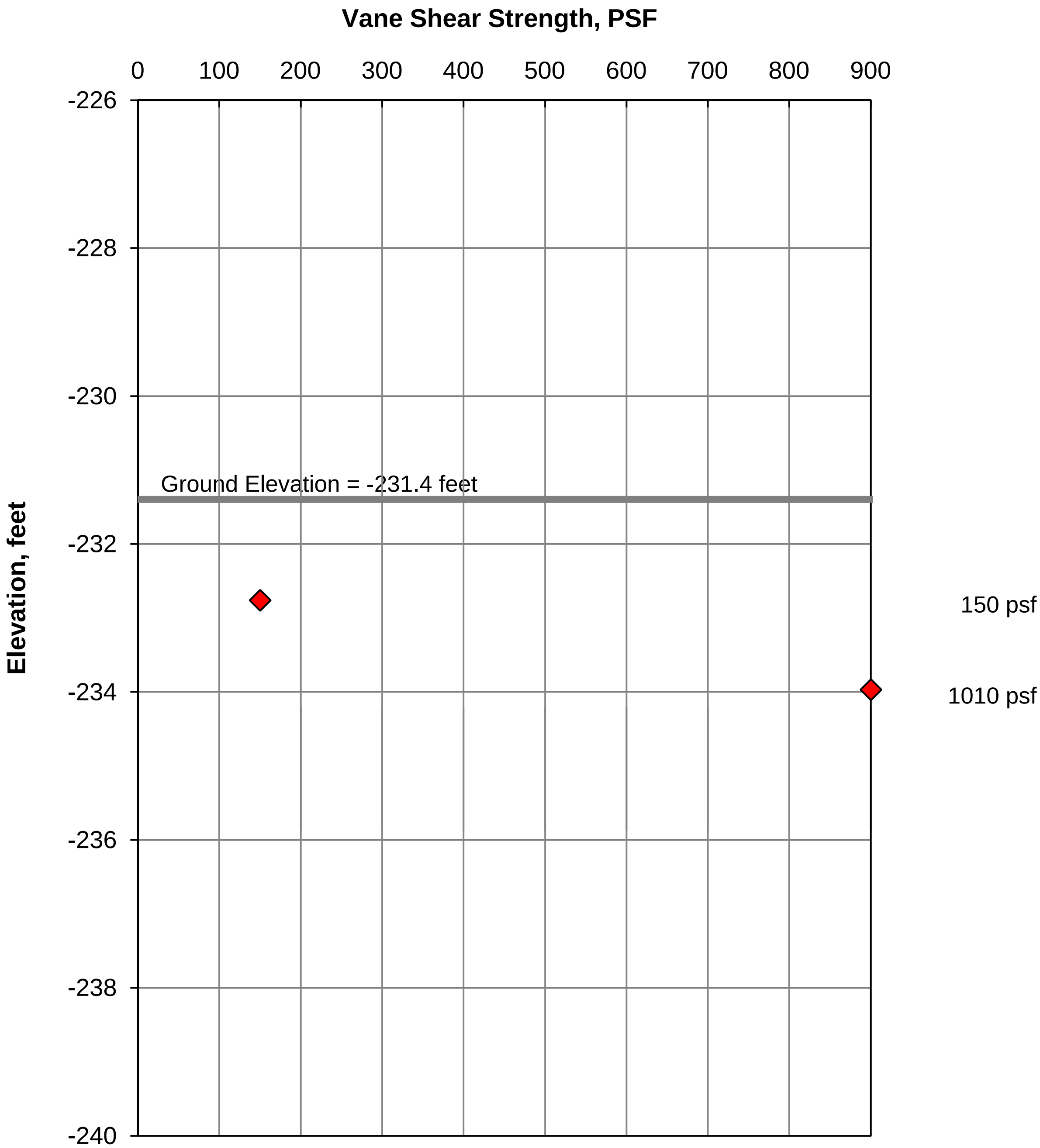
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 90VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-42



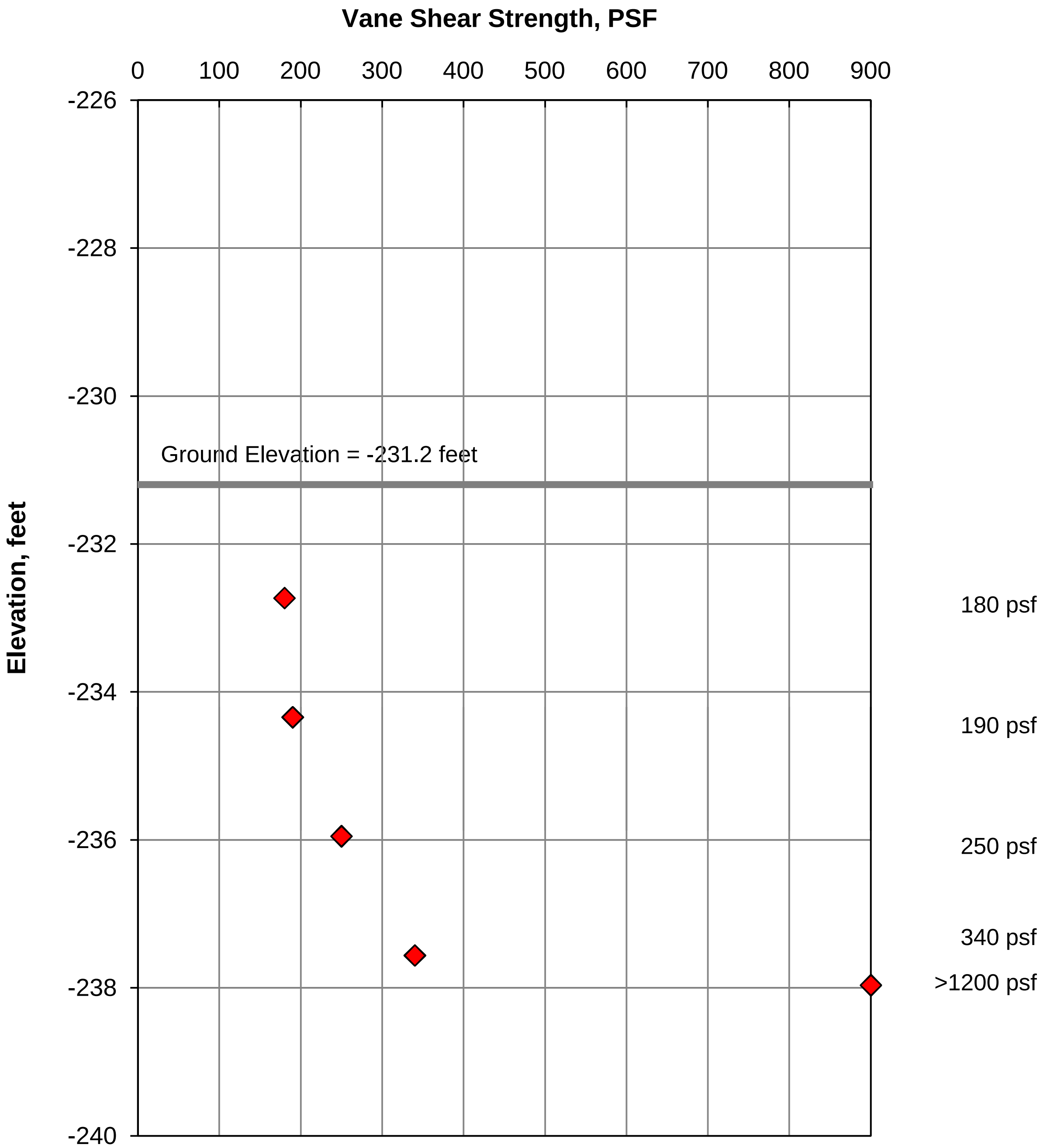
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 91VC**
Hultgren - Tillis Engineers	Project No. 758.01 — Plate No. B-43



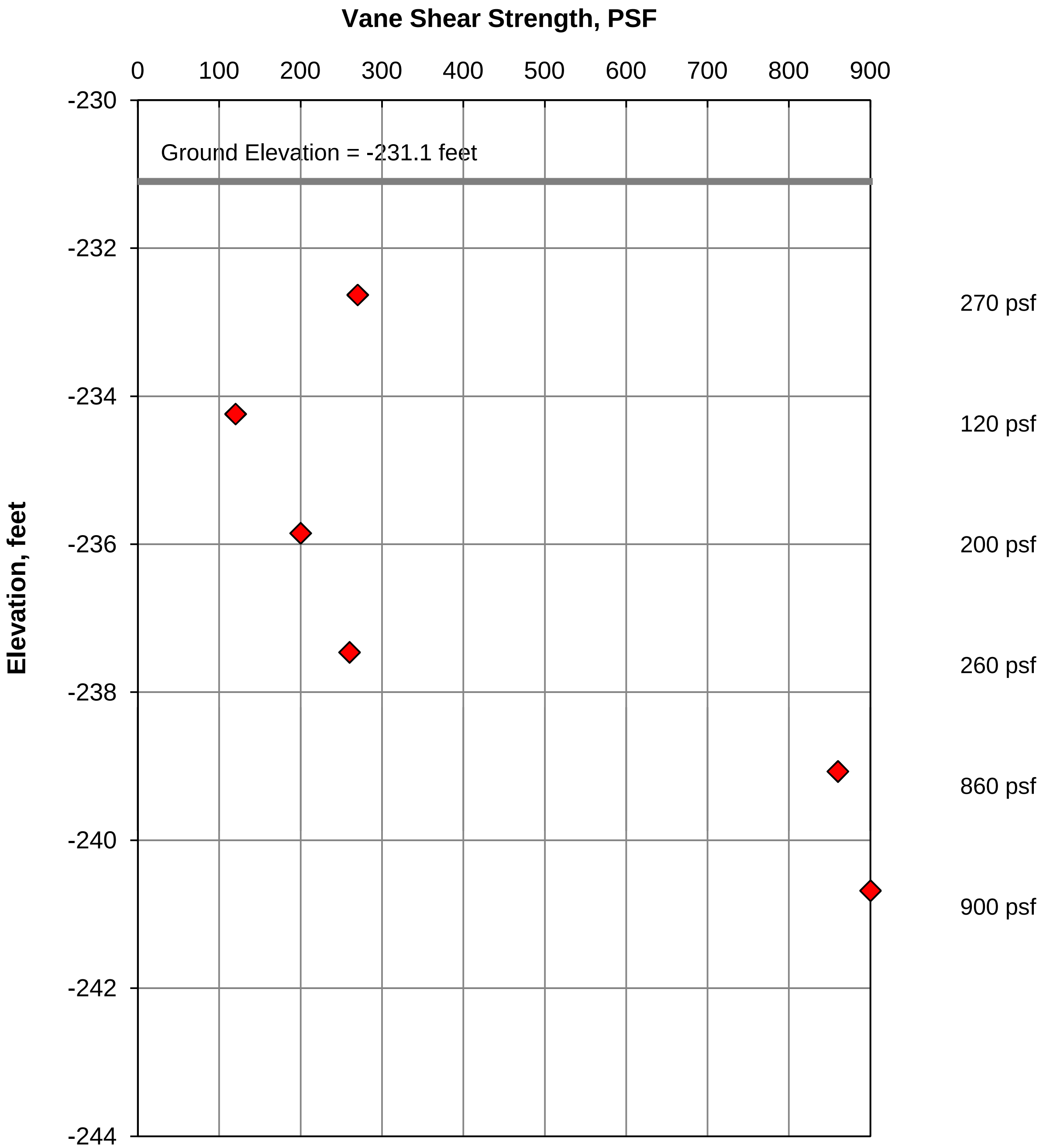
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 92VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-44



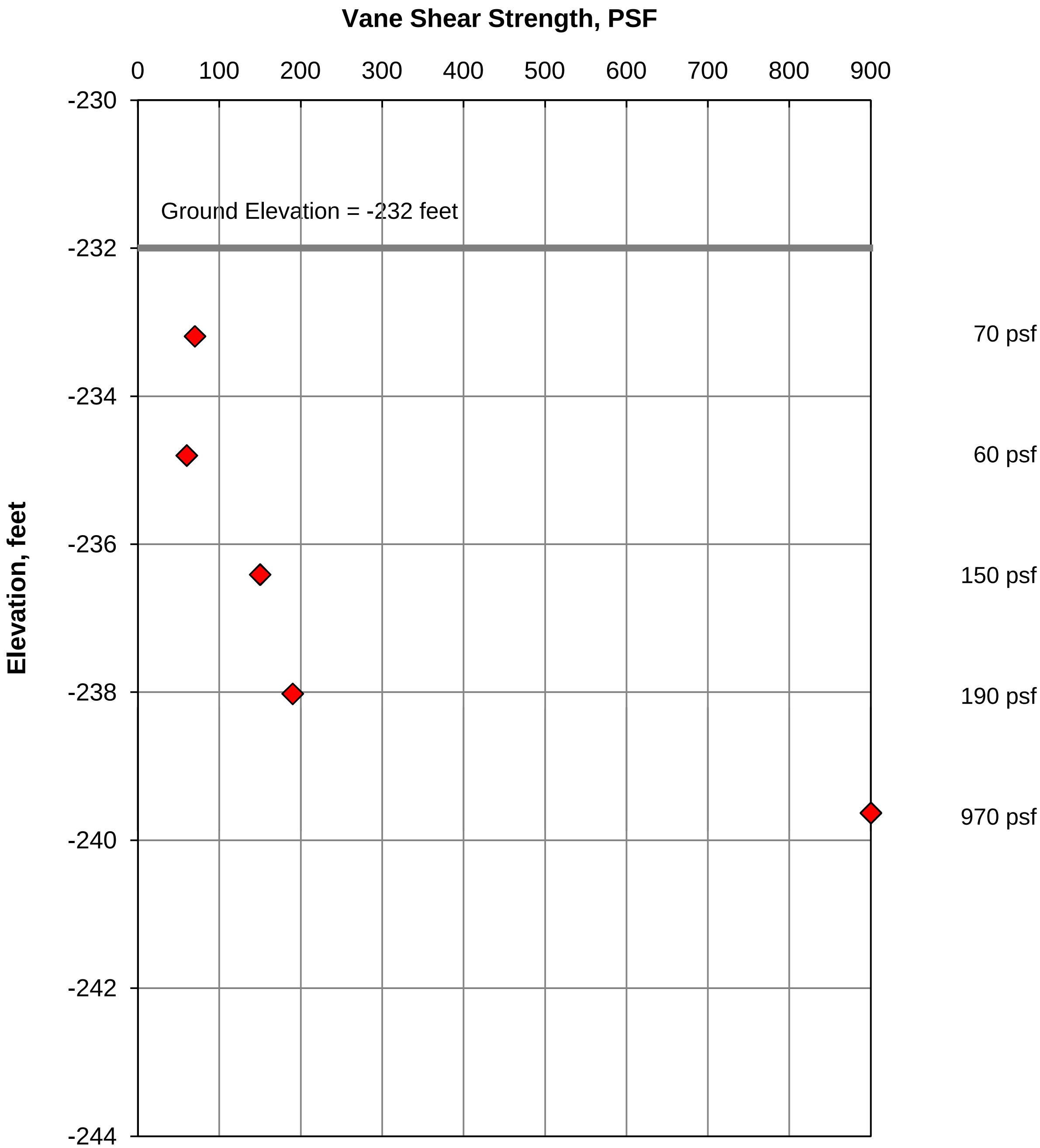
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 93VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-45



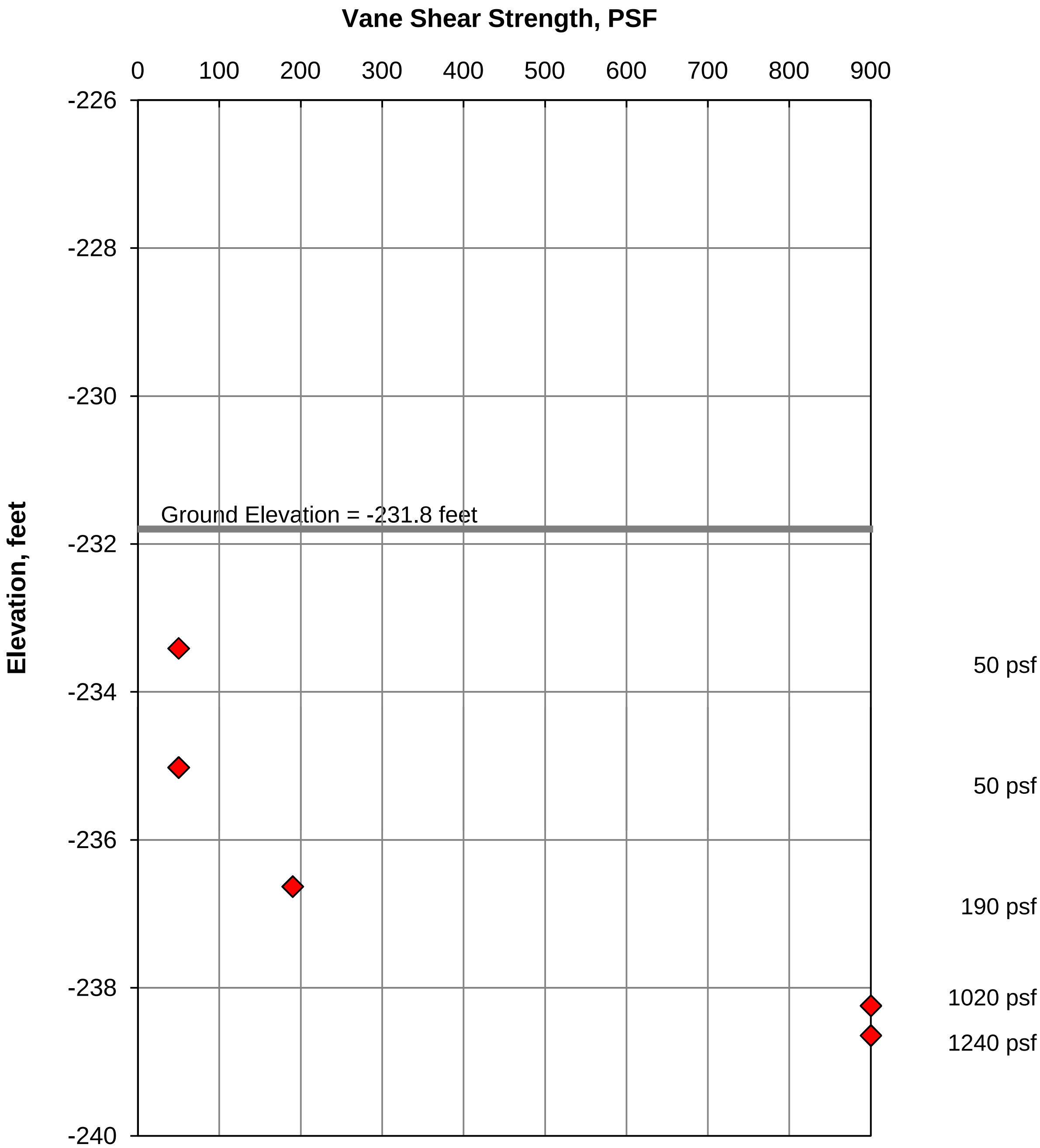
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 94VC**
Hultgren - Tillis Engineers	Project No. 758.01 | Plate No. B-46



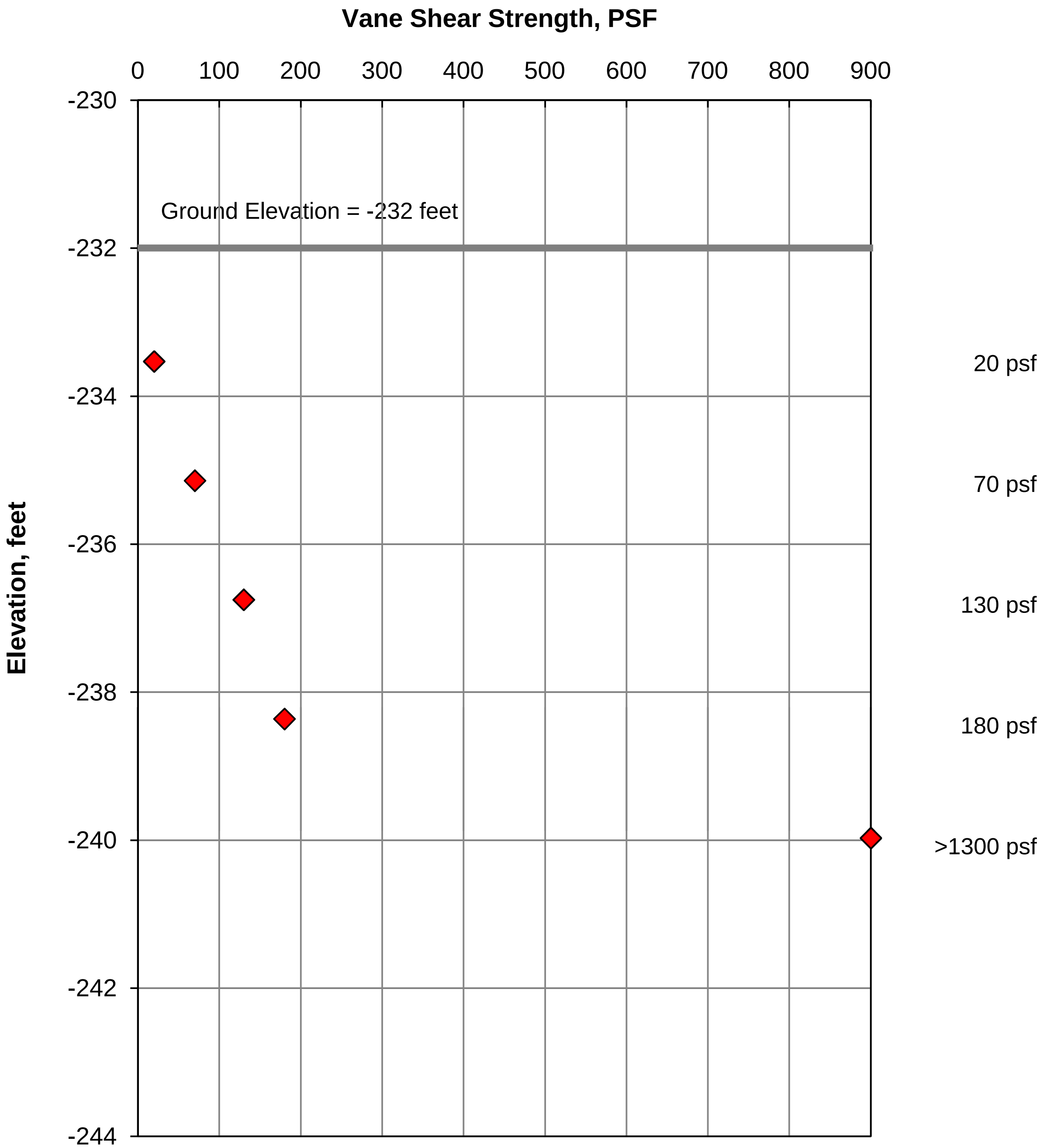
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 95VC**
Hultgren - Tillis Engineers	Project No. 758.01 Plate No. B-47



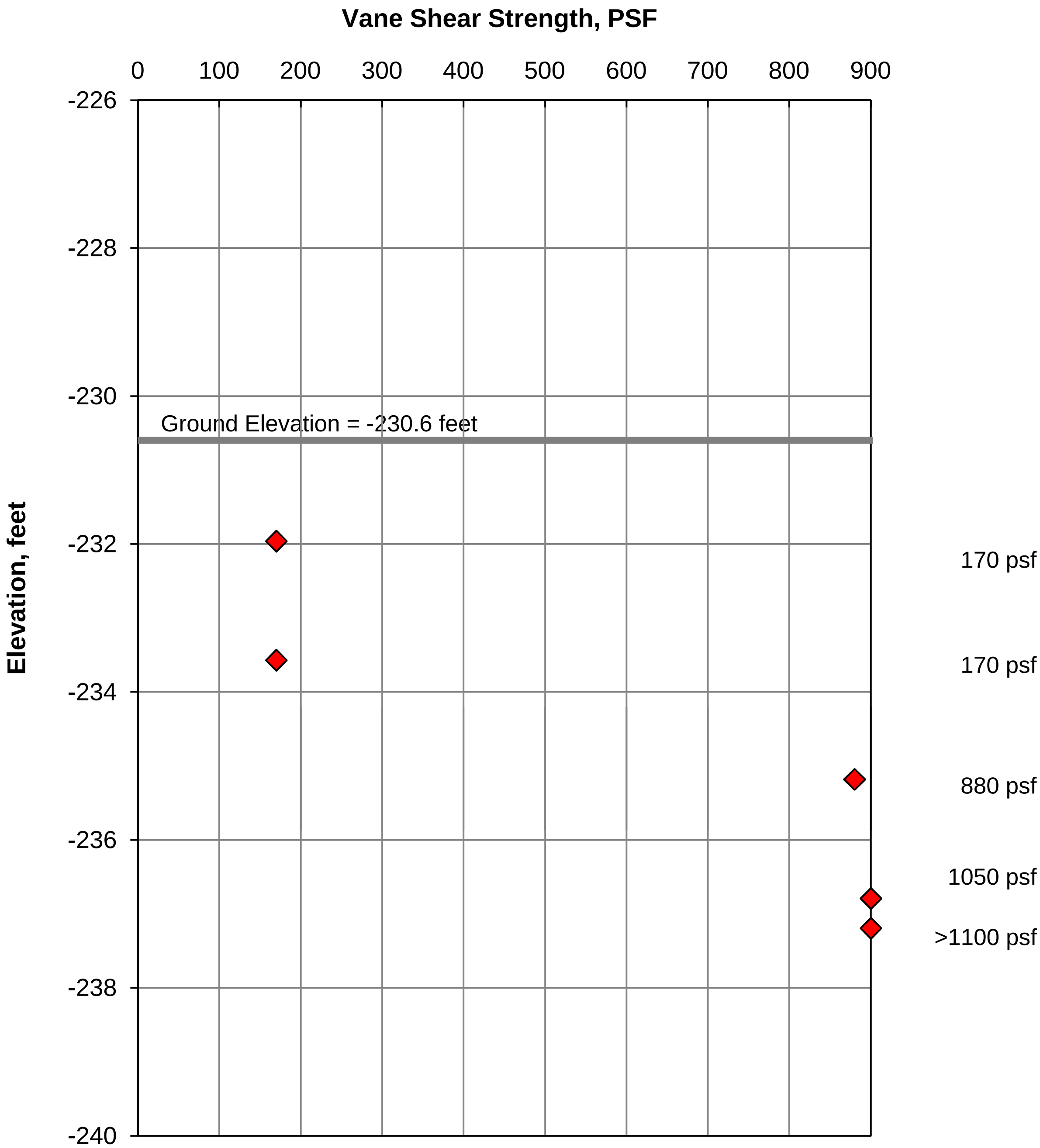
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 96VC**
Hultgren - Tillis Engineers	Project No. 758.01 | Plate No. B-48



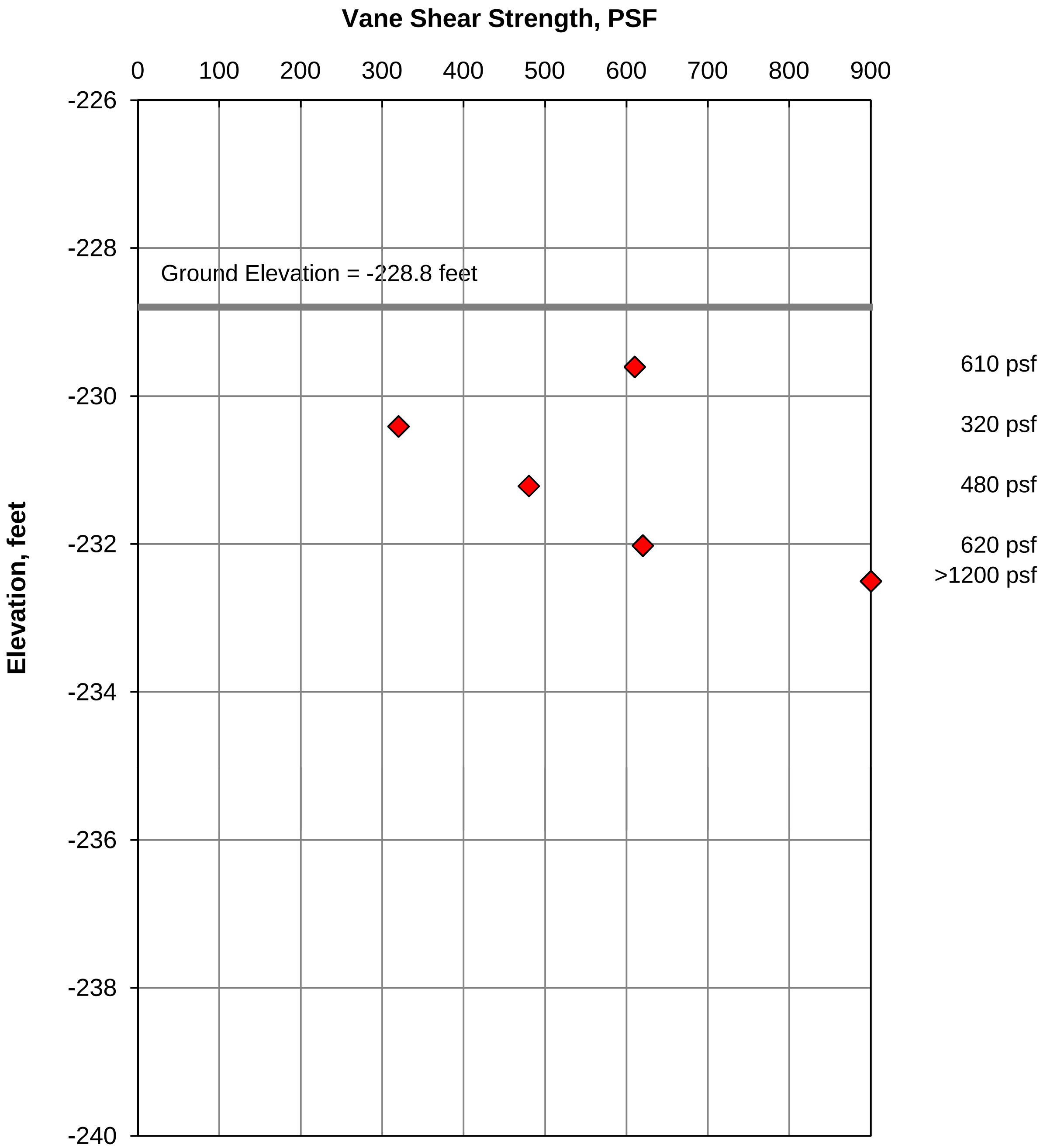
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 97VC**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-49



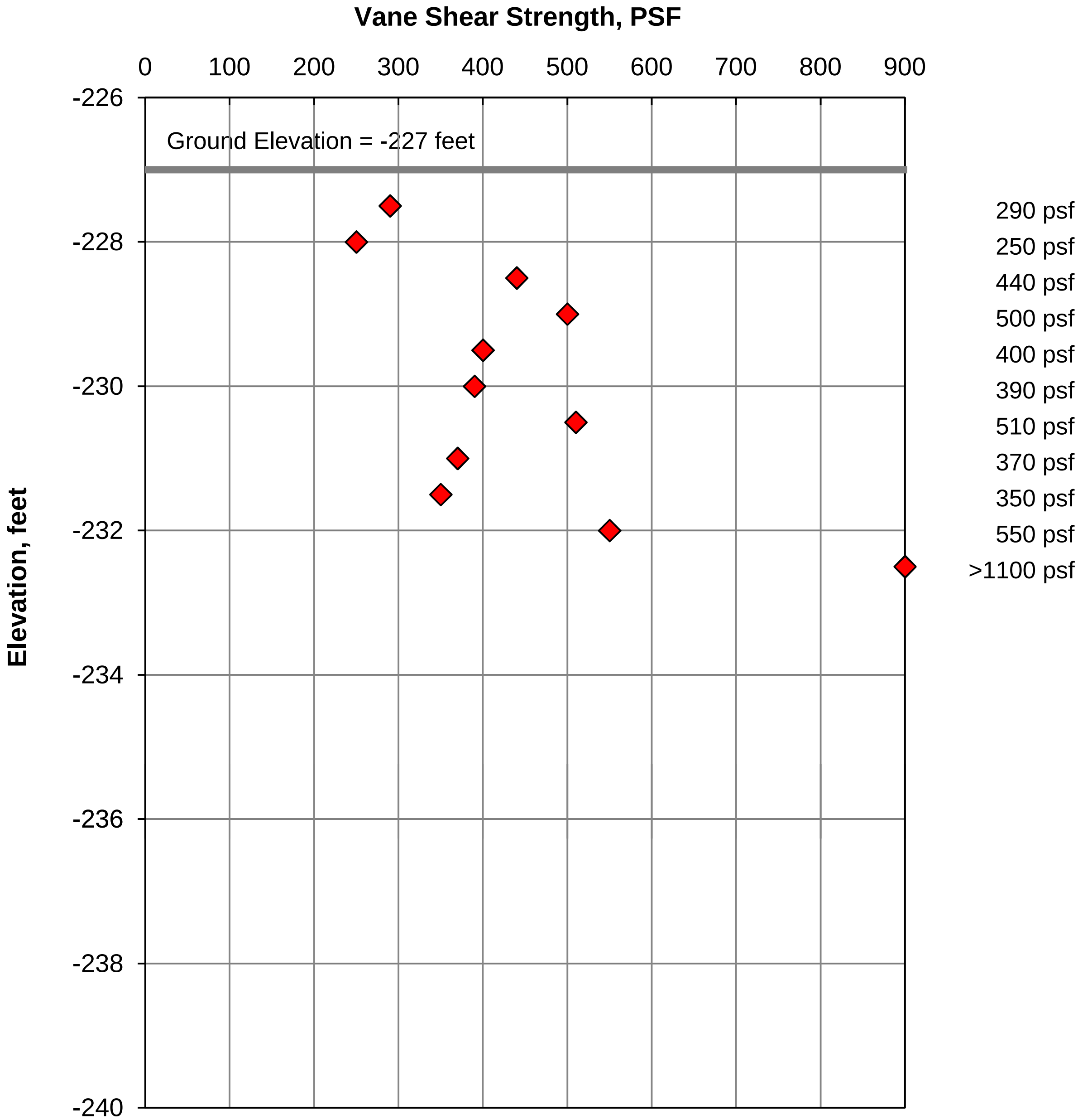
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 102VS**
Hultgren - Tillis Engineers	Project No. 758.01 | Plate No. B-50



Notes:

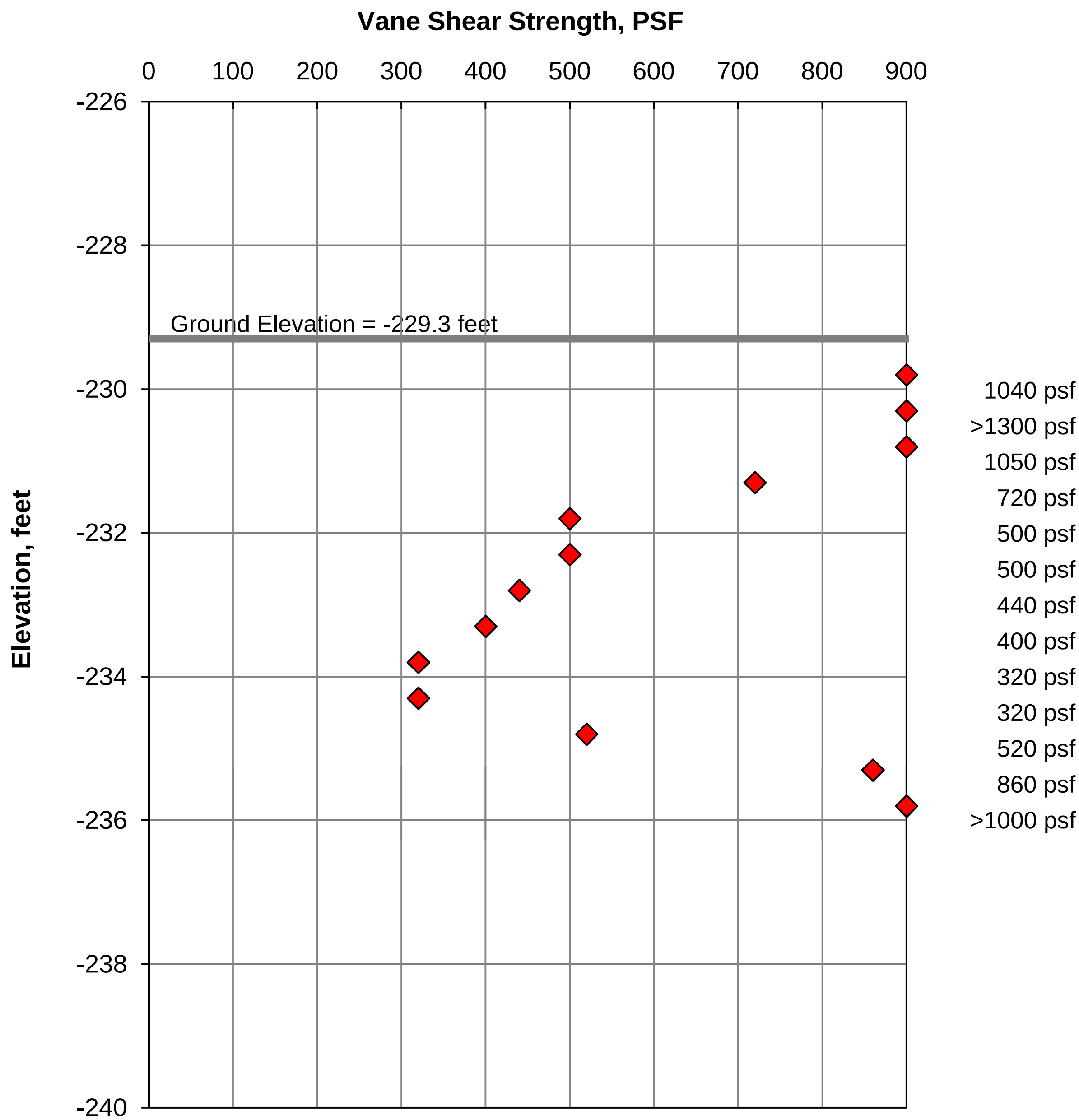
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 103VS**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-51



Notes:

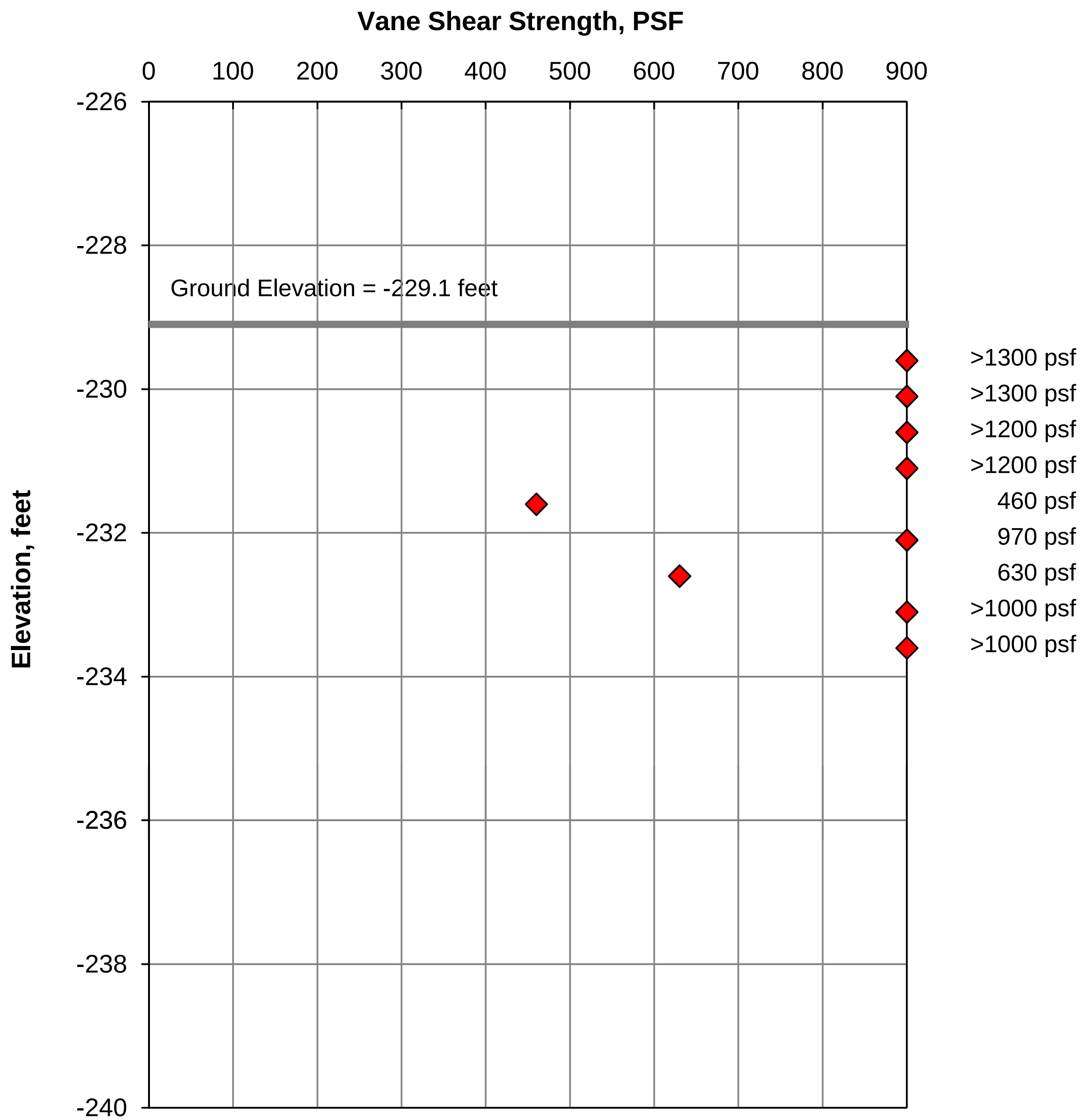
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 104VS**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-52



Notes:

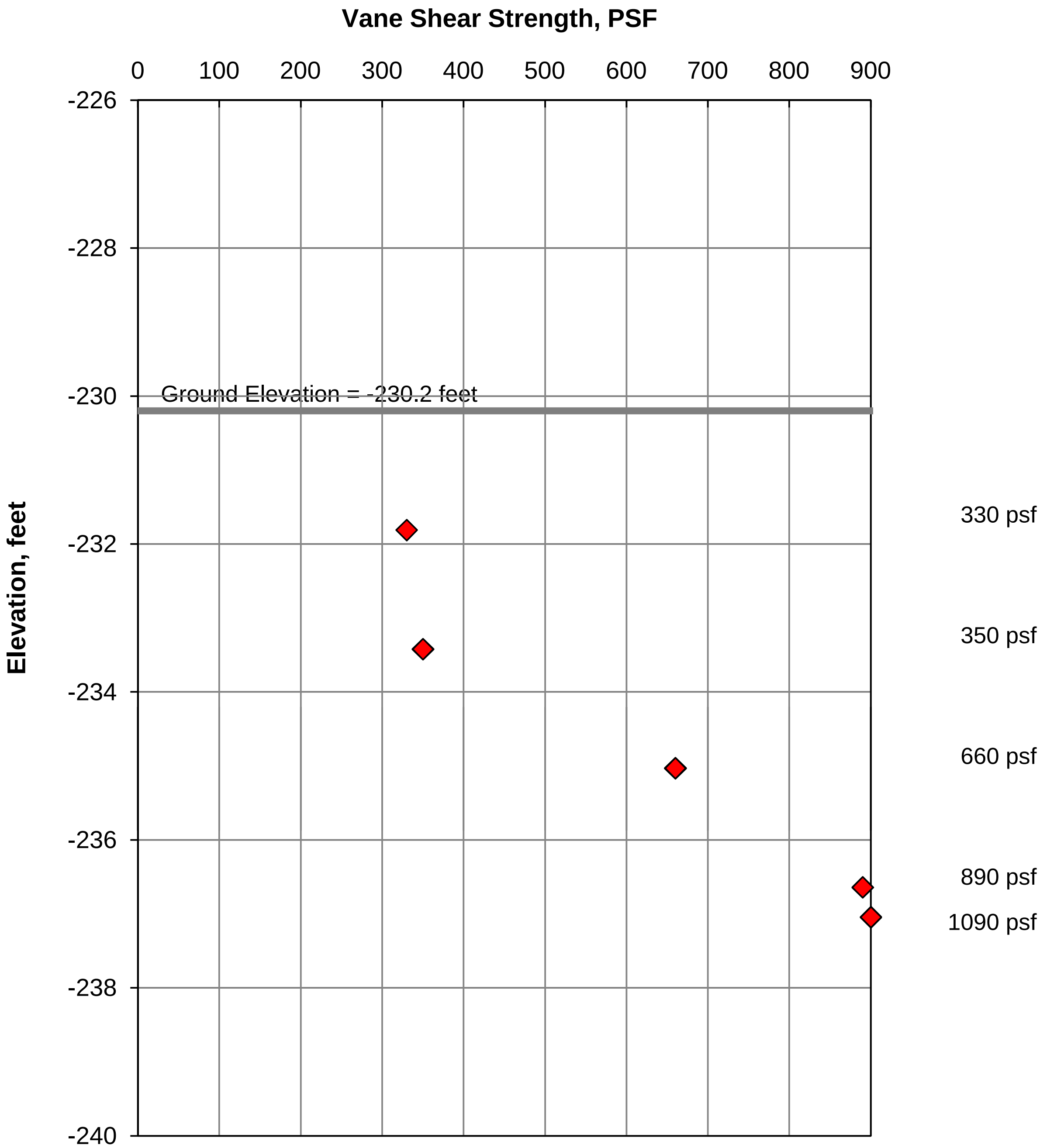
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 105VS**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-53



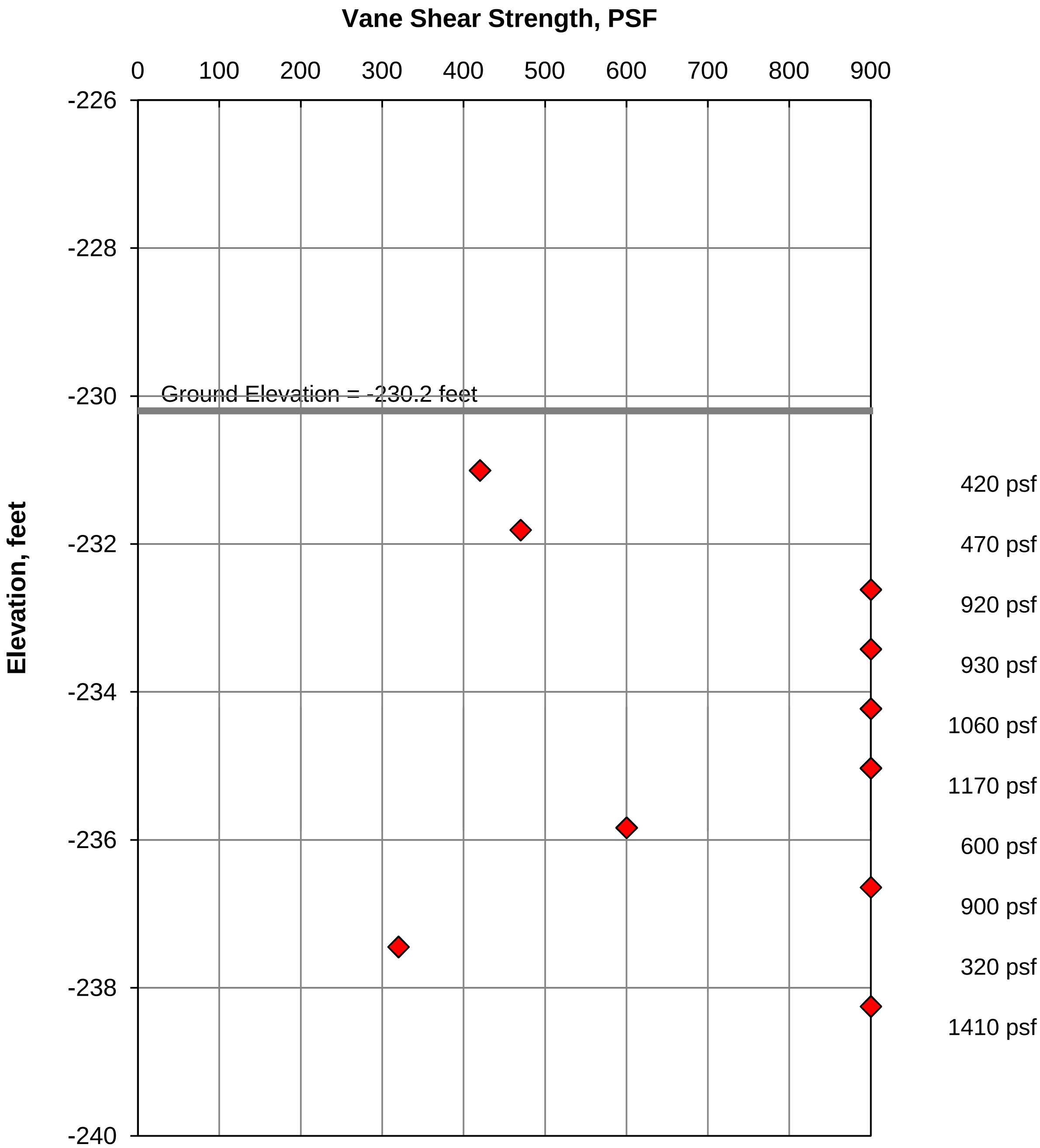
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 106VS**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-54



Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 108VS**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-55

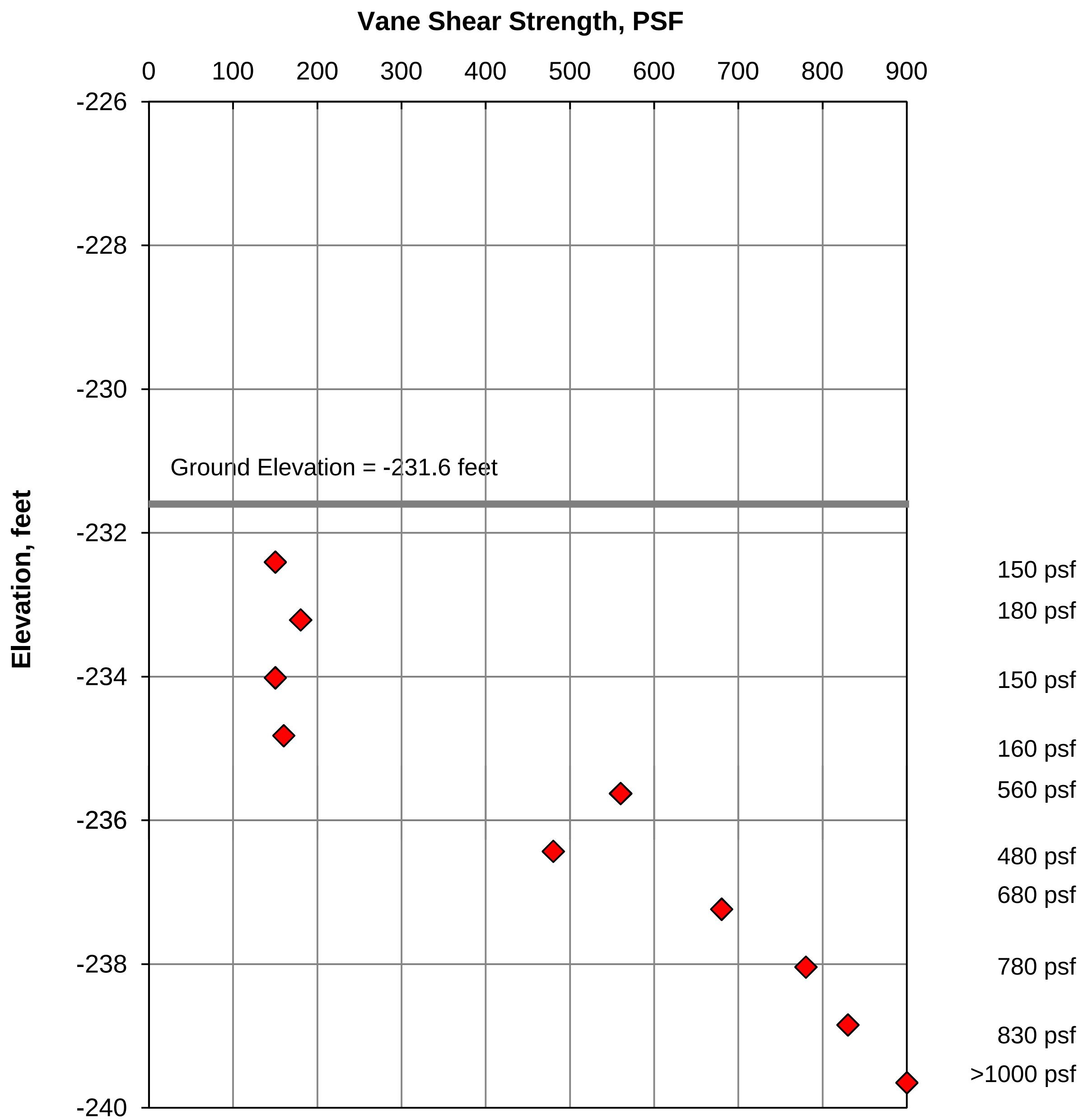


Plate No. B-

Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 109VS**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-56

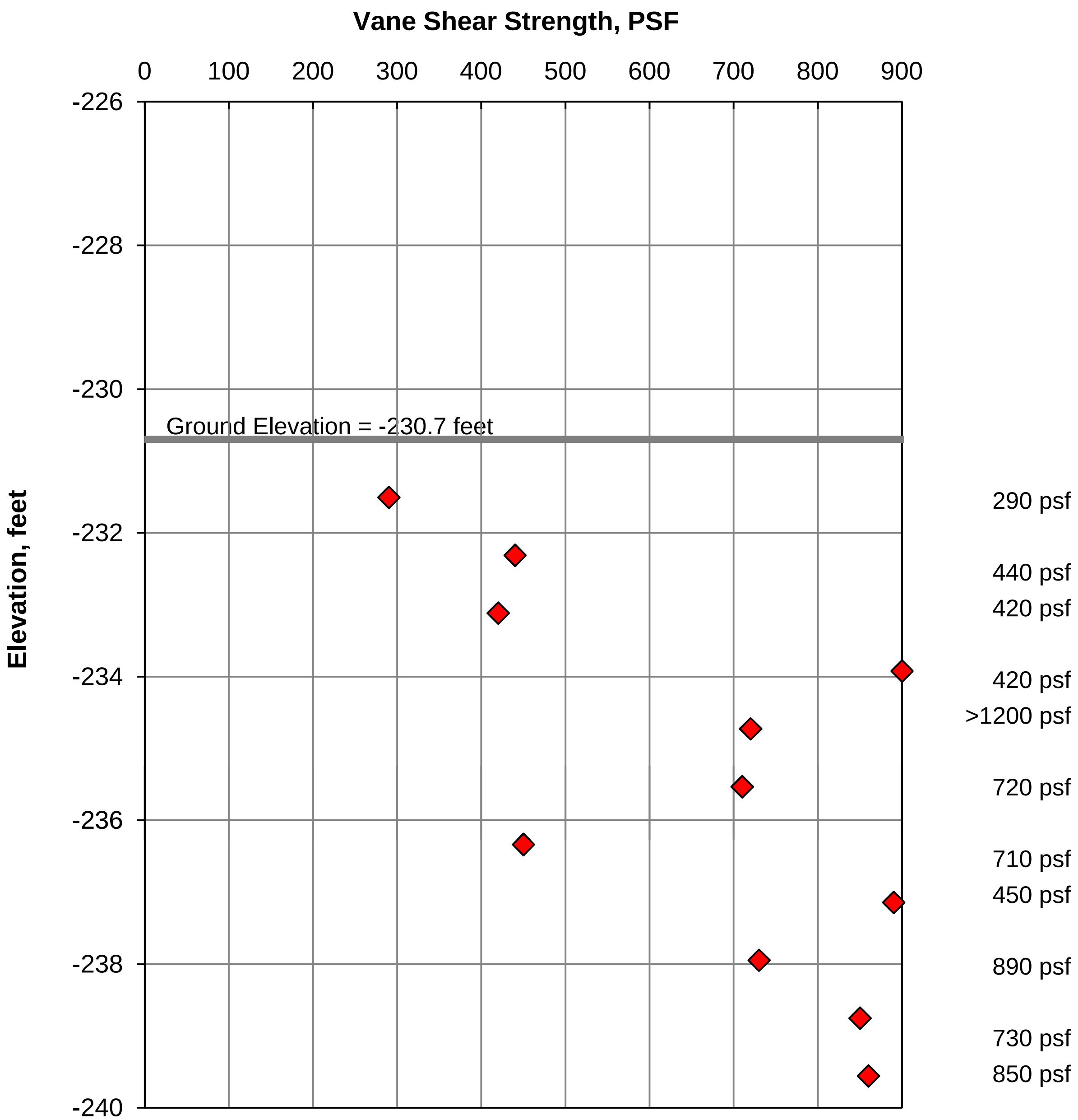


Plate No. B-

Notes:

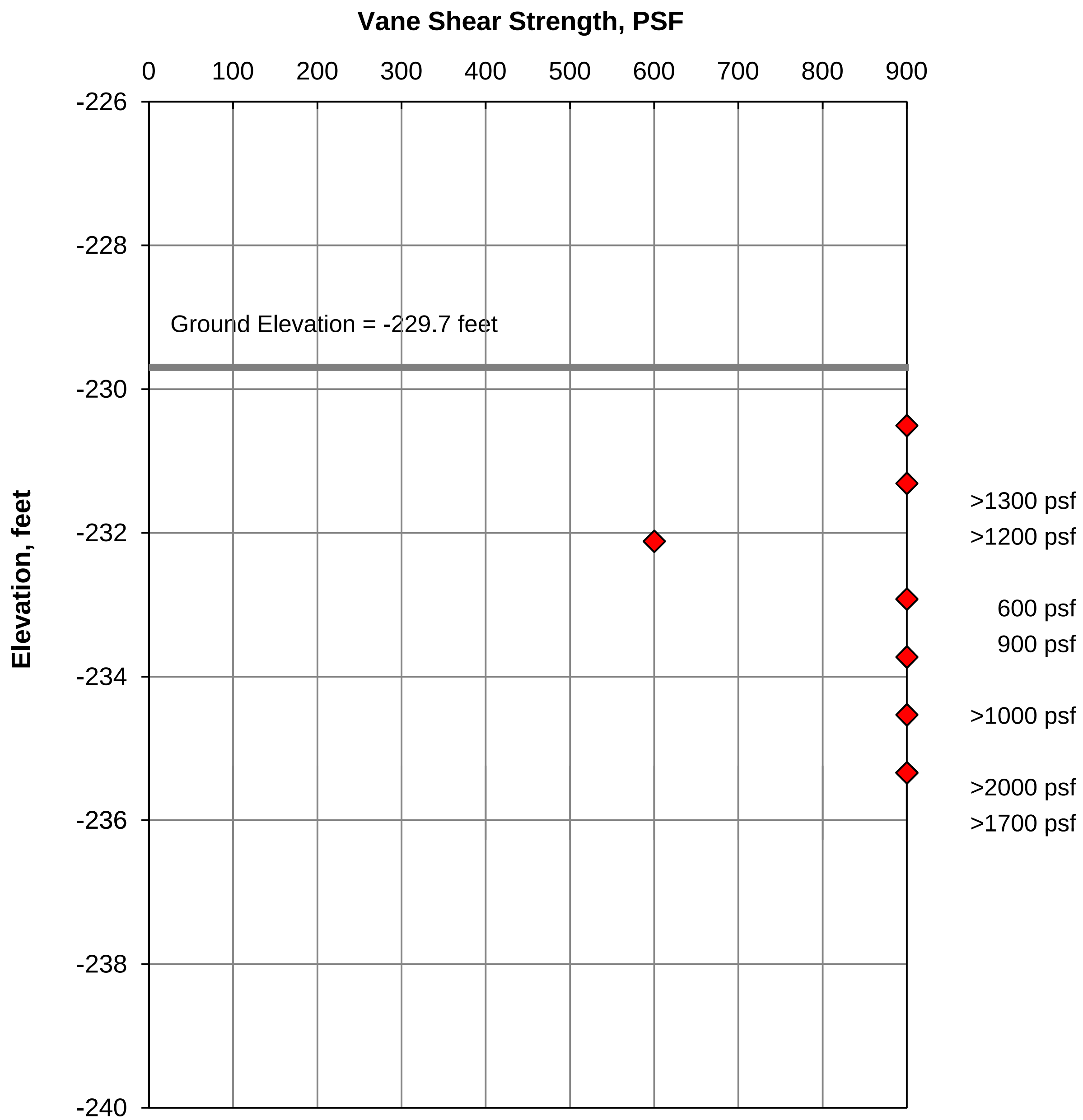
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 110VS**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-57



Notes:

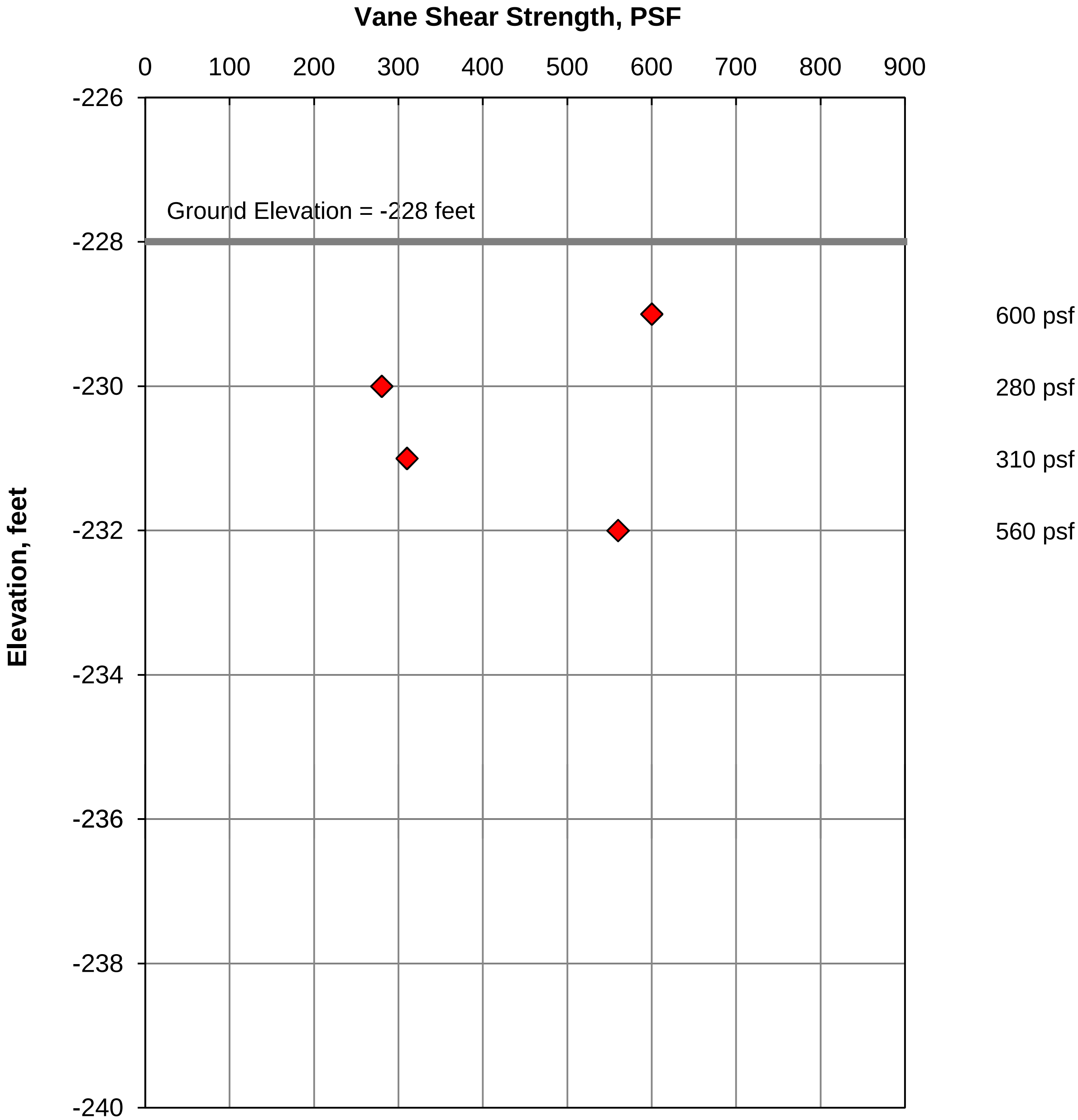
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 111VS**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-58



Notes:

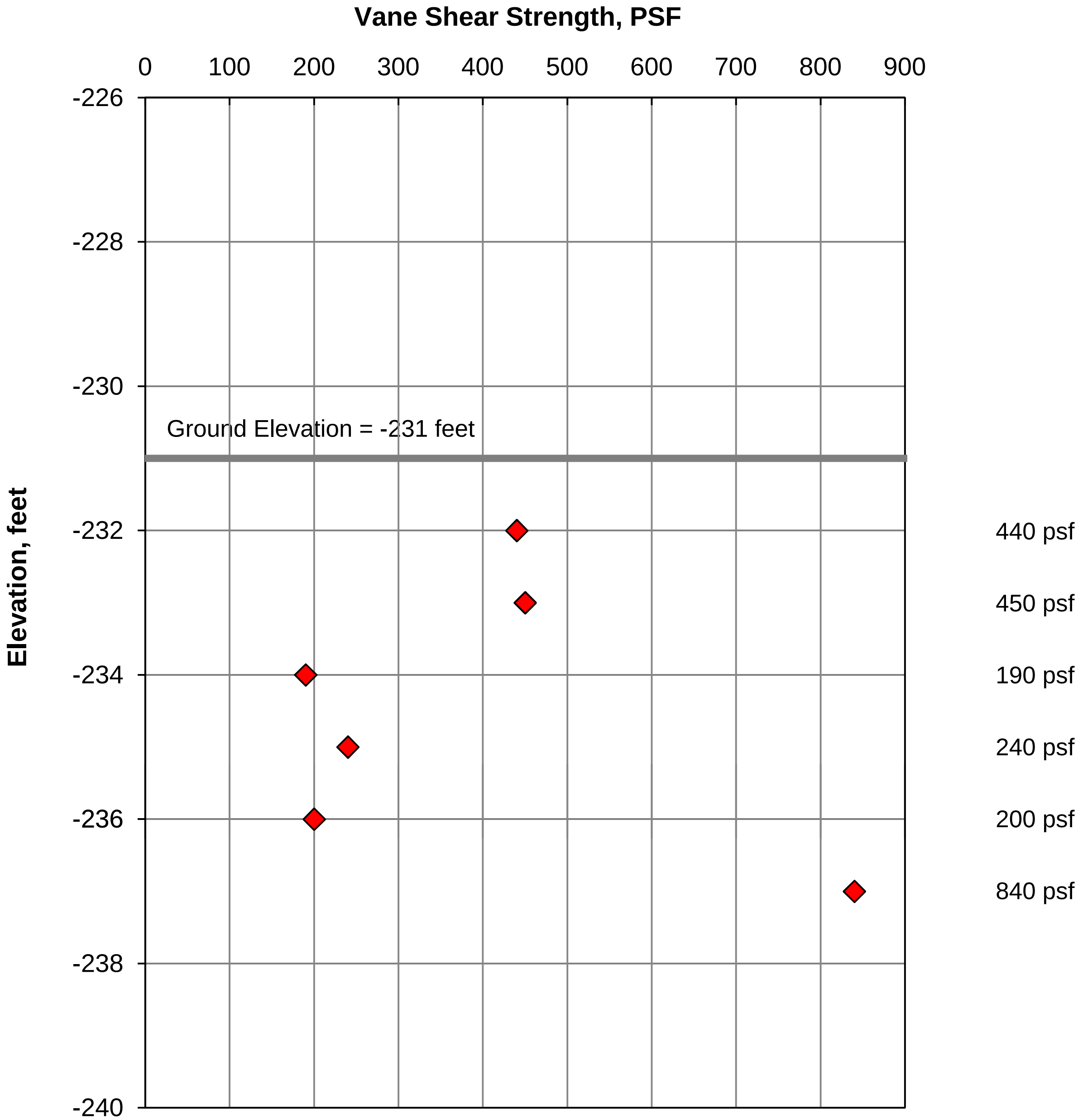
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 114HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-59



Notes:

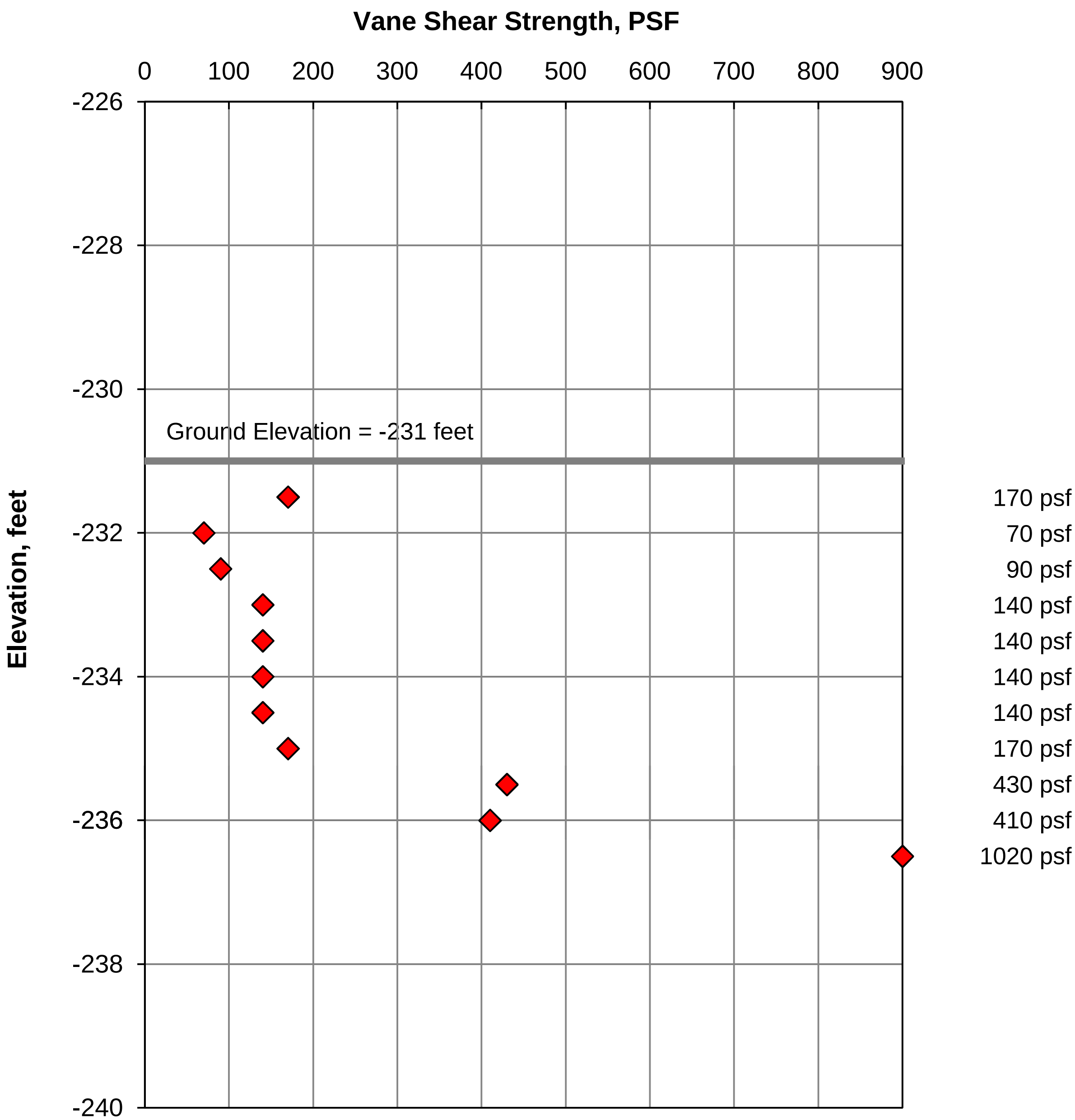
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 115HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-60



Notes:

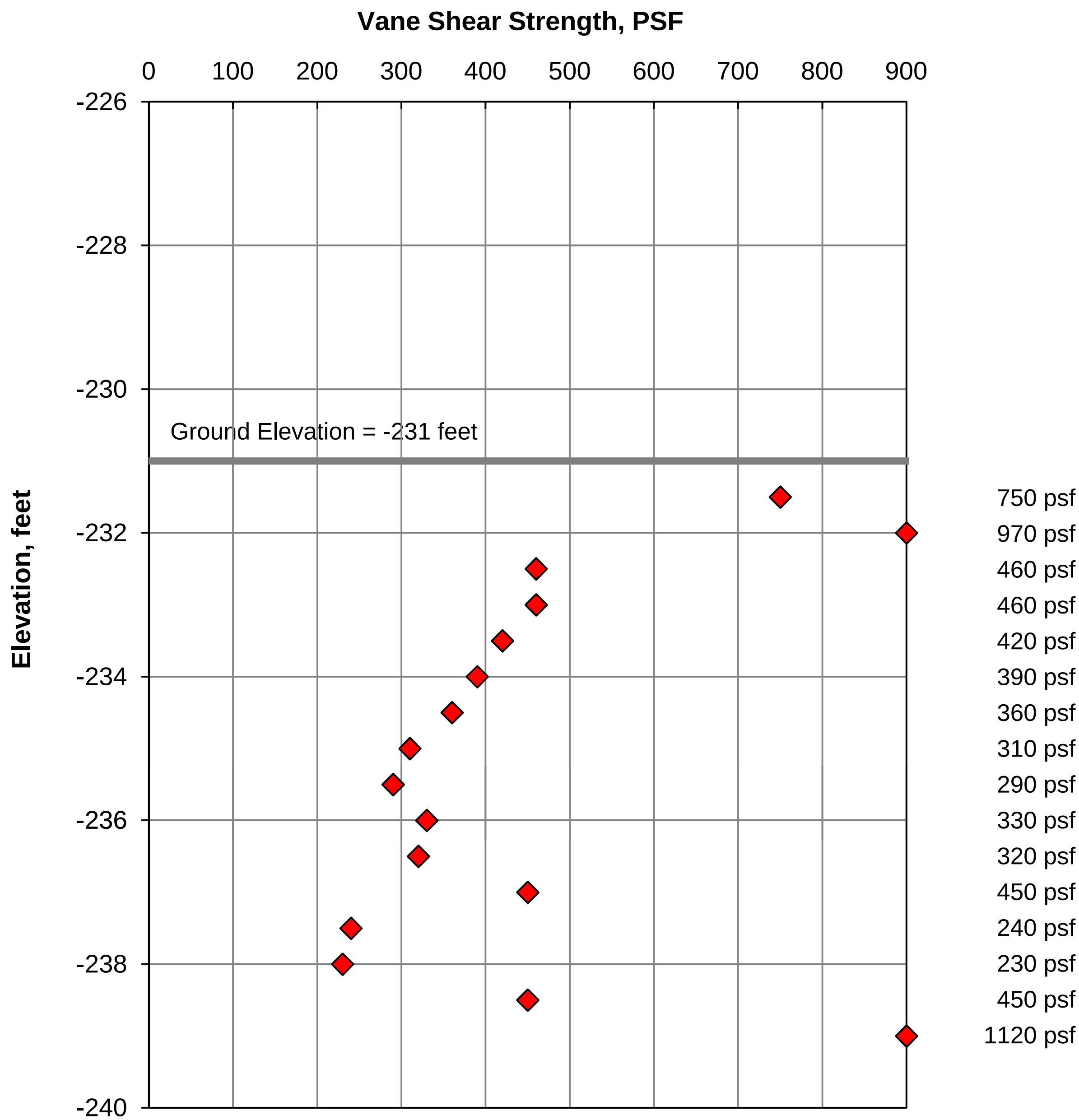
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 116HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-61



Notes:

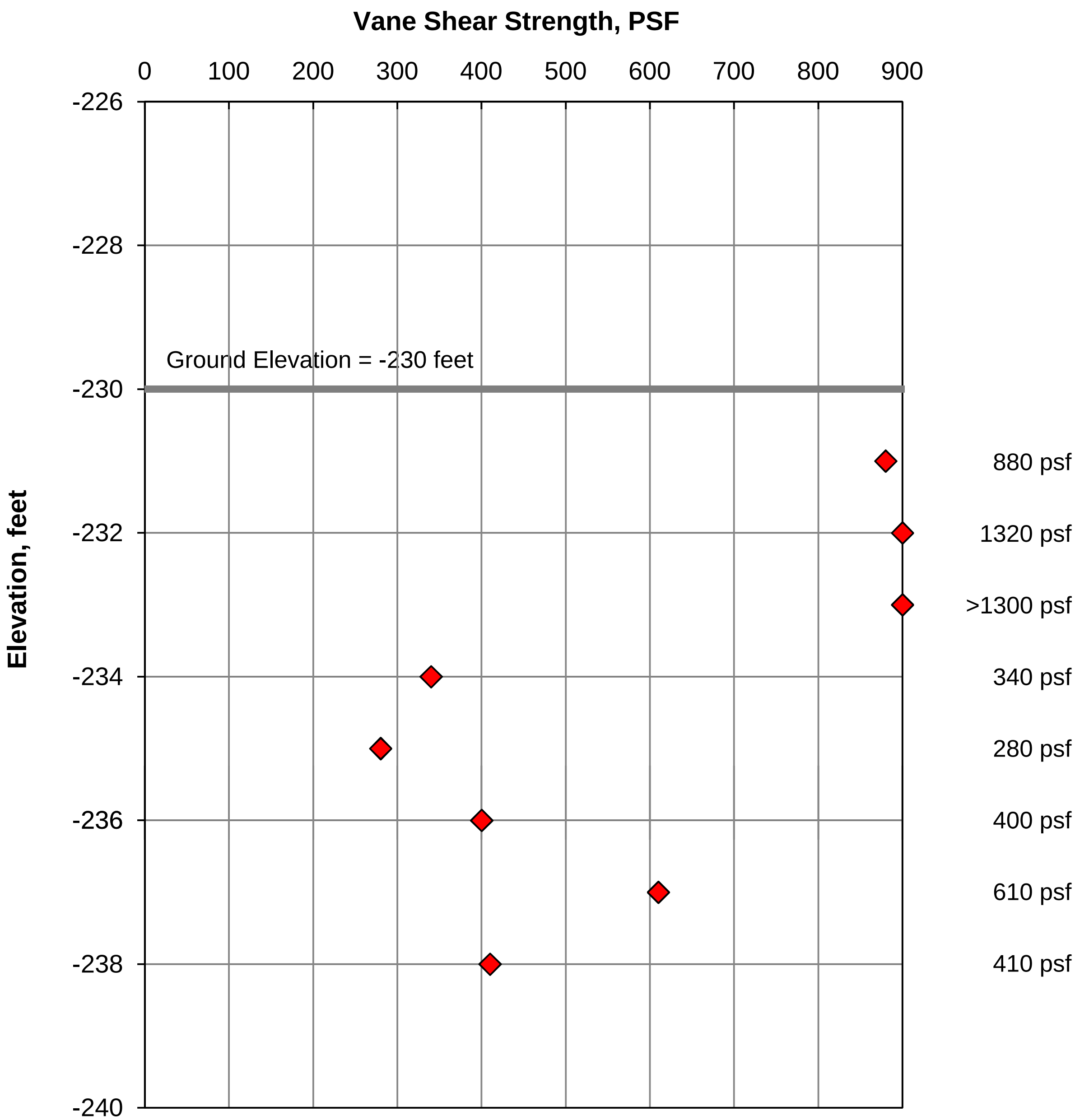
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength Exploration Point 117HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-62



Notes:

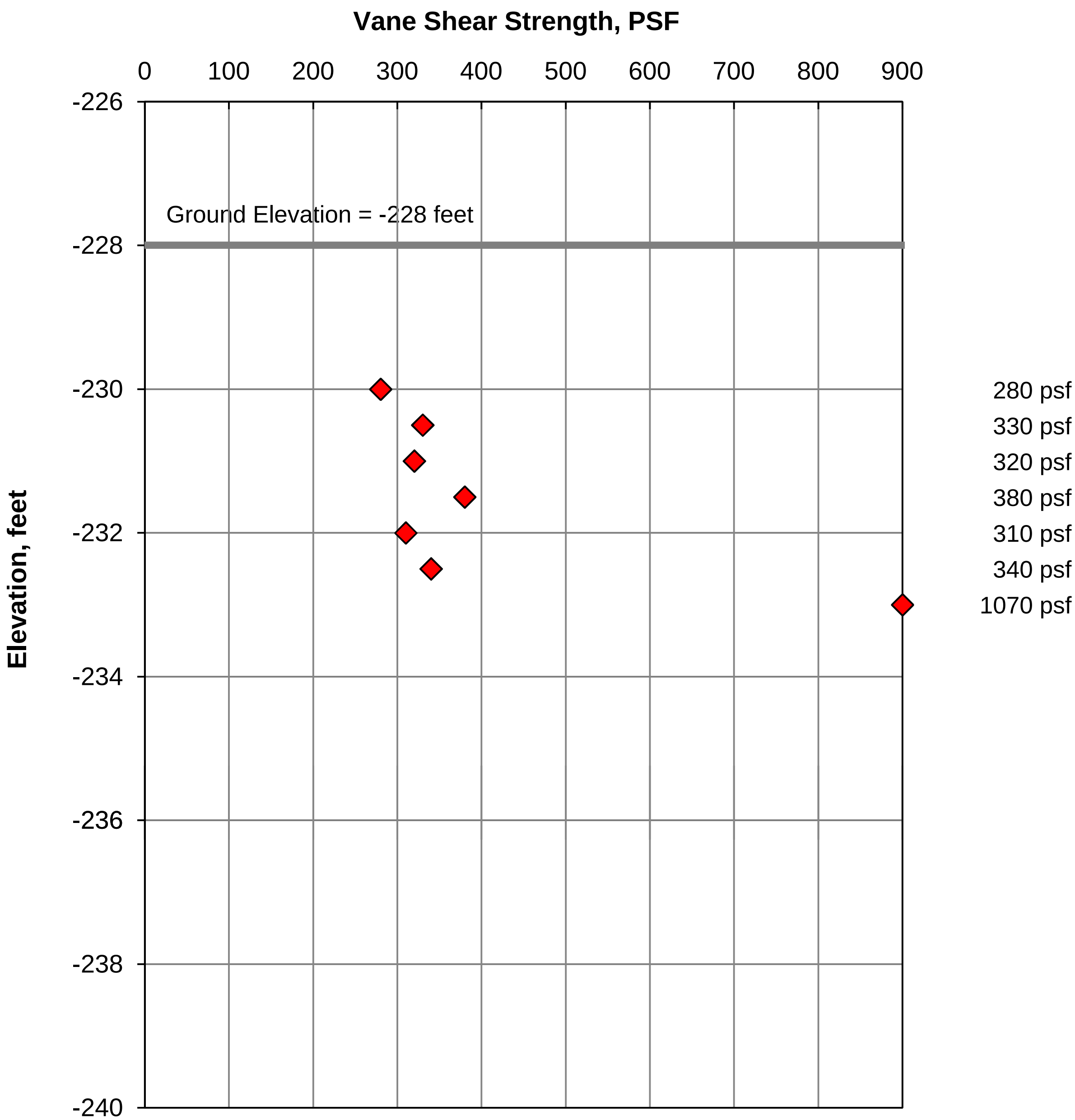
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 118HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-63



Notes:

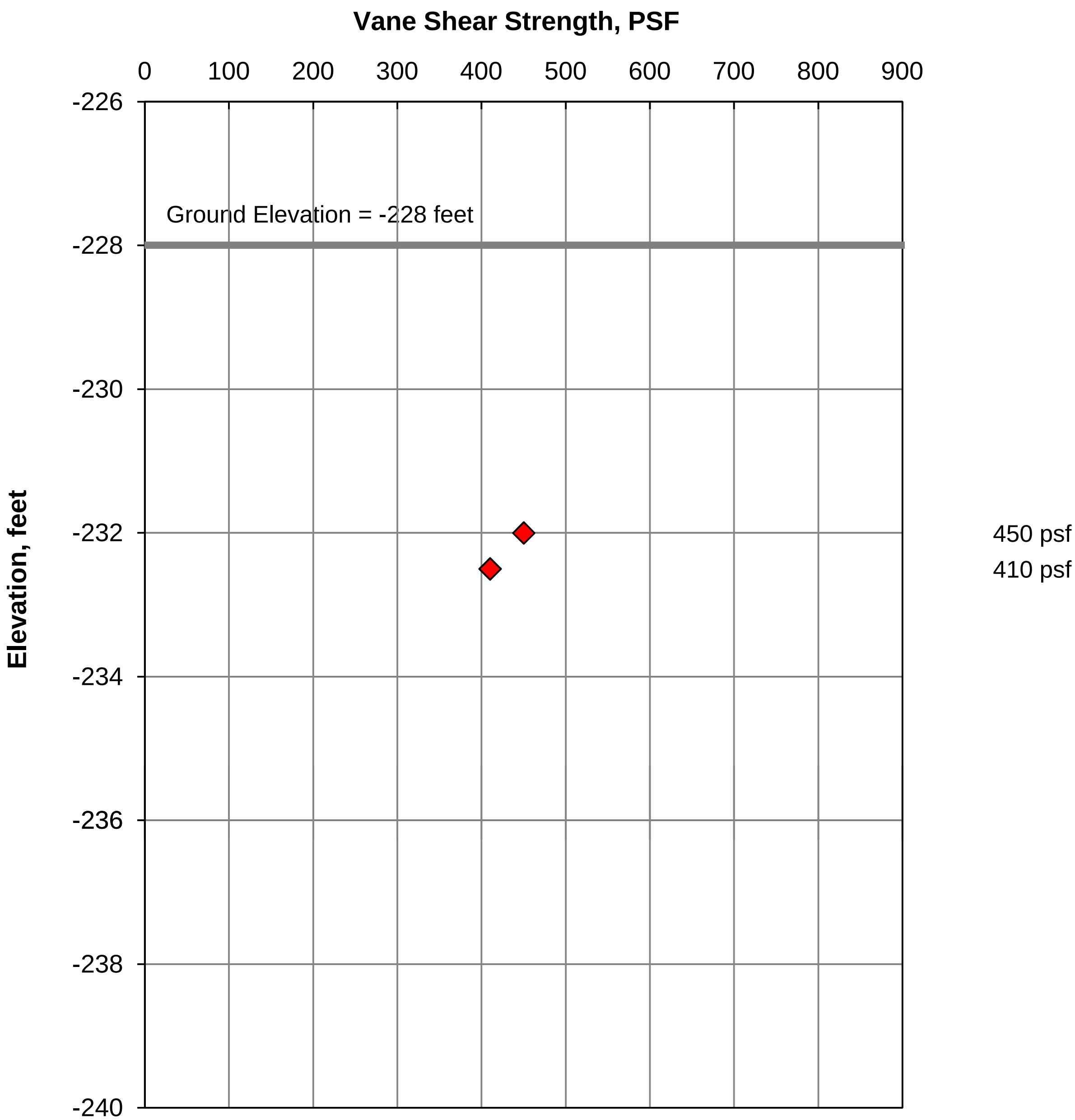
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 119HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-64



Notes:

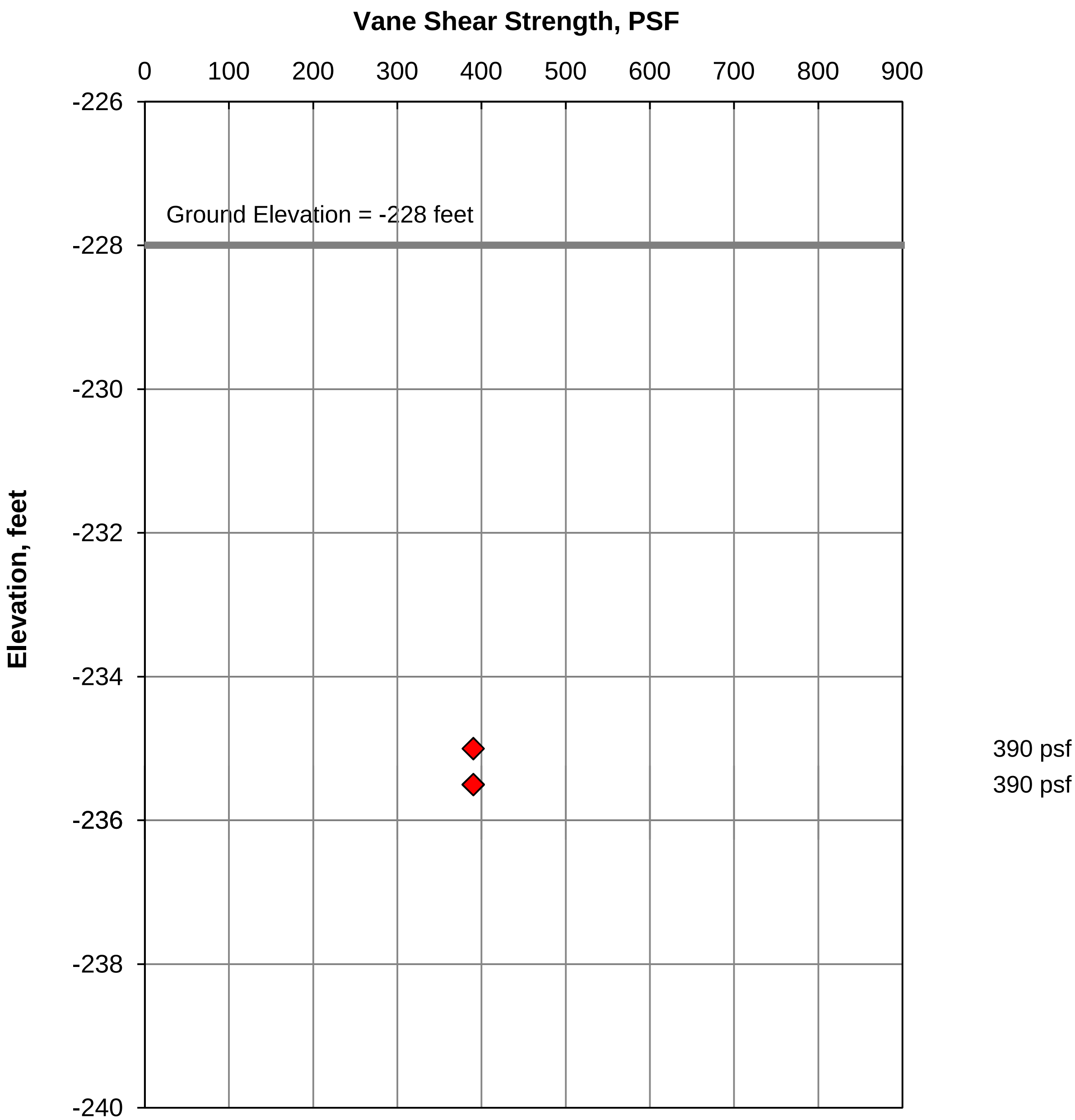
(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 120HA**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-65



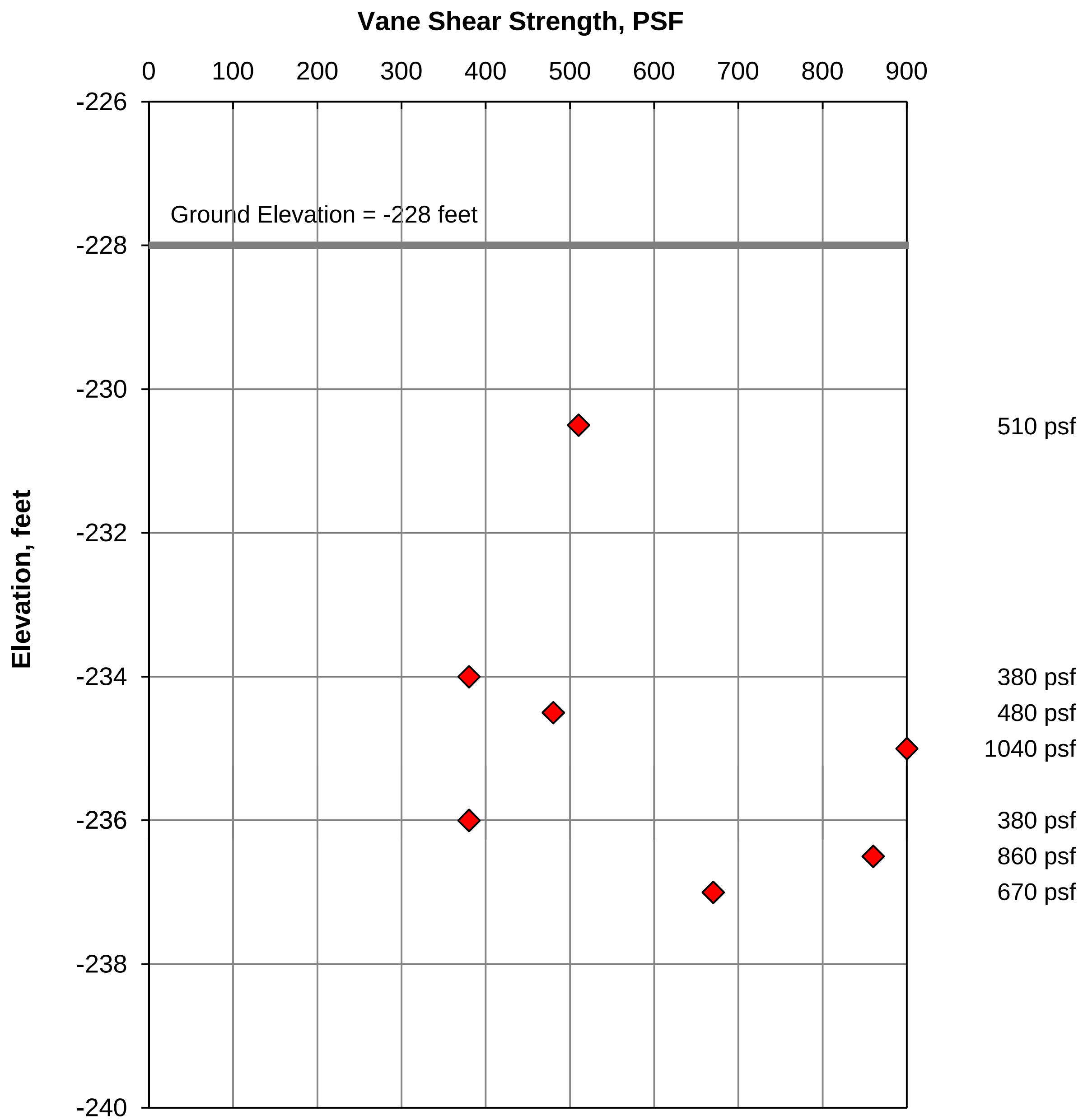
Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 121HA**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-66



Notes:

(1) Vane shear strength data was collected using a Geonor model H-60 hand-held vane shear device. Data was corrected for shaft friction and plasticity as described in the report text.

(2) Strengths in excess of 900 psf are plotted as 900 psf.

(3) Numerical values of plotted data are shown to right of plot. Where strengths are shown with a " >" symbol, the field reading exceeded the torque range for the vane size used.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Vane Shear Strength** **Exploration Point 122HA**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. B-67

APPENDIX C

APPENDIX C

CONE PENETROMETER TEST RESULTS

2011 EXPLORATION OF NEW RIVER SITE

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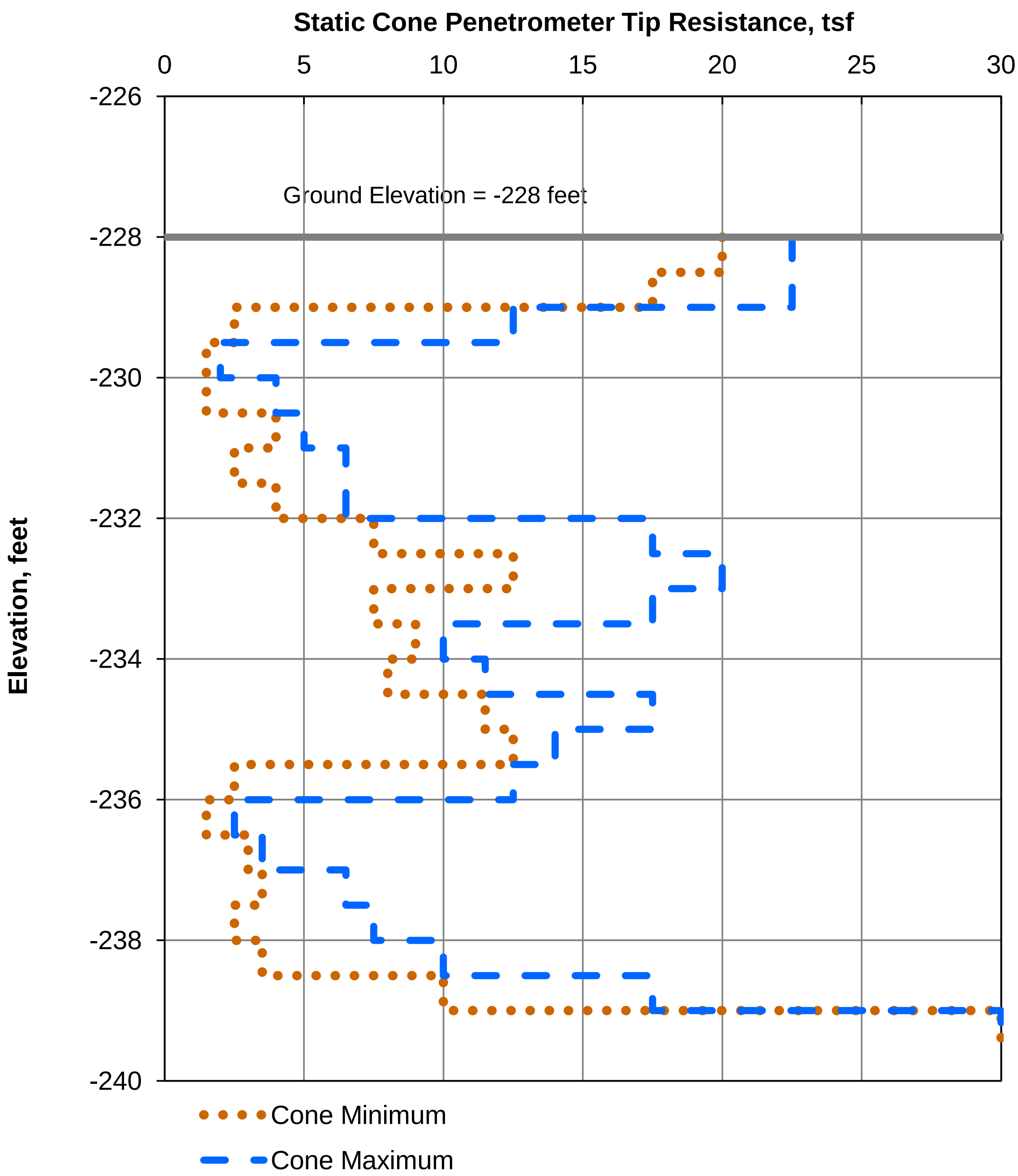


Notes:

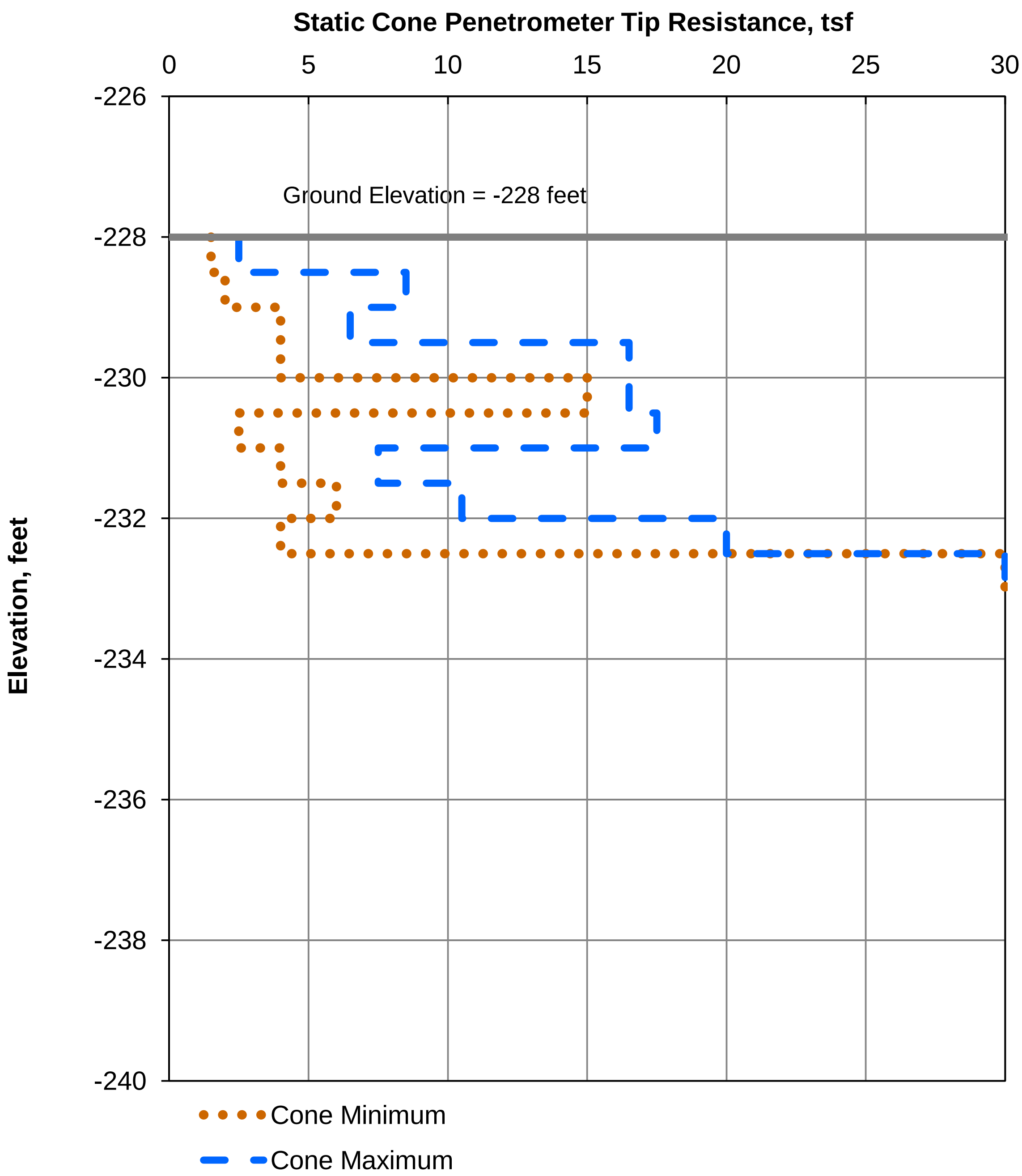
(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 29HA**

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



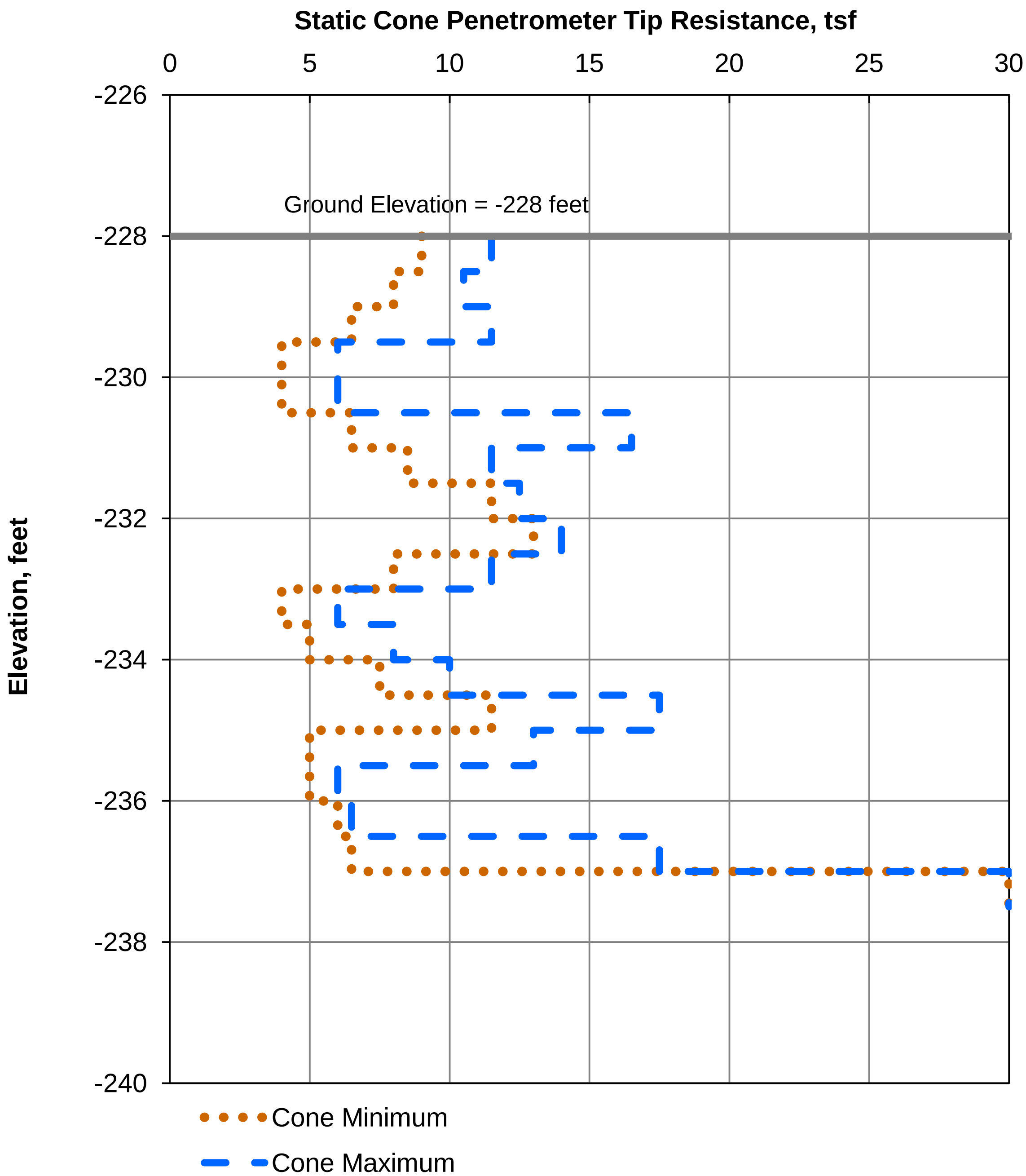
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer** **Exploration Point 39HA**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-2



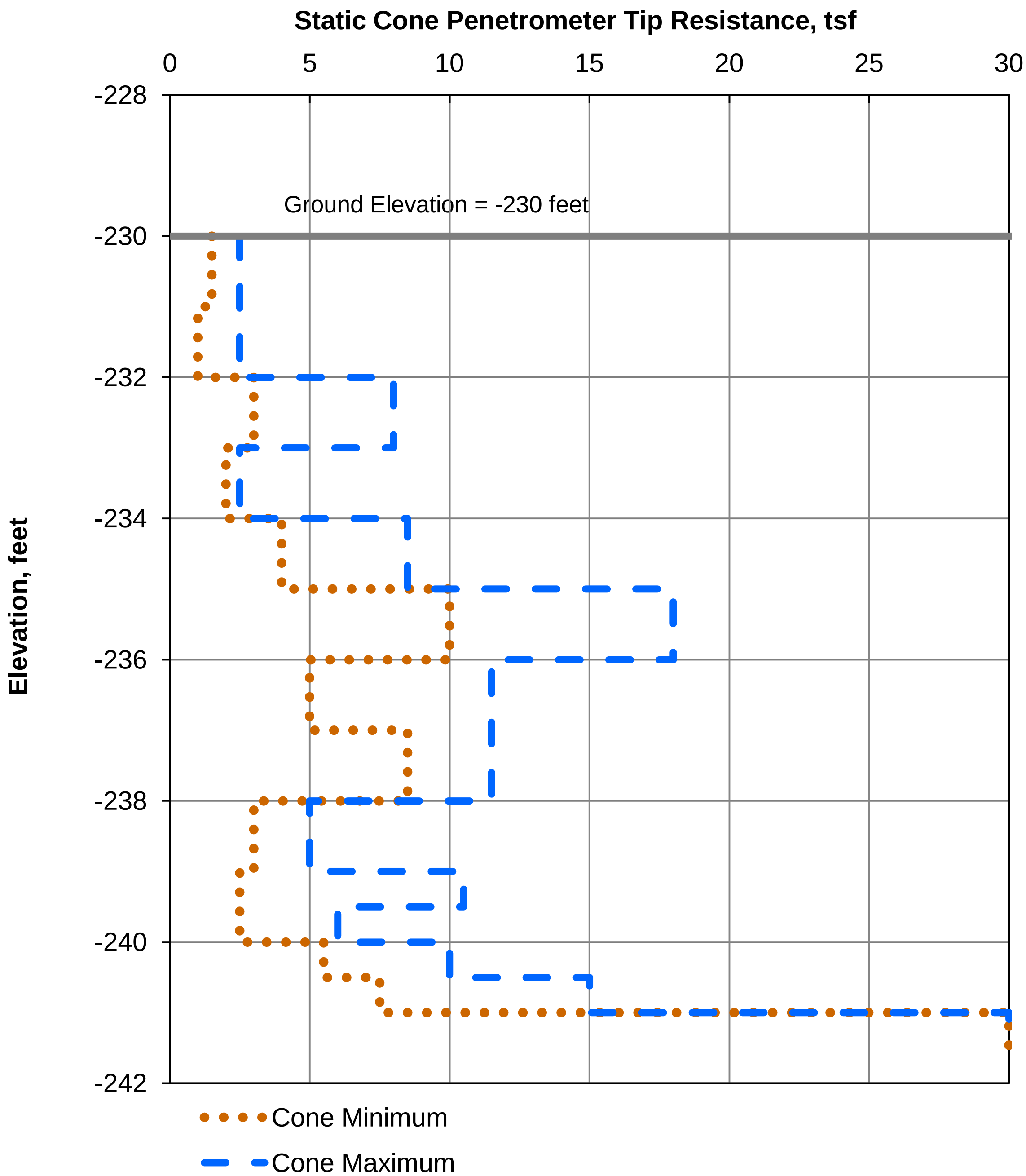
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer** **Exploration Point 46HA**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-3



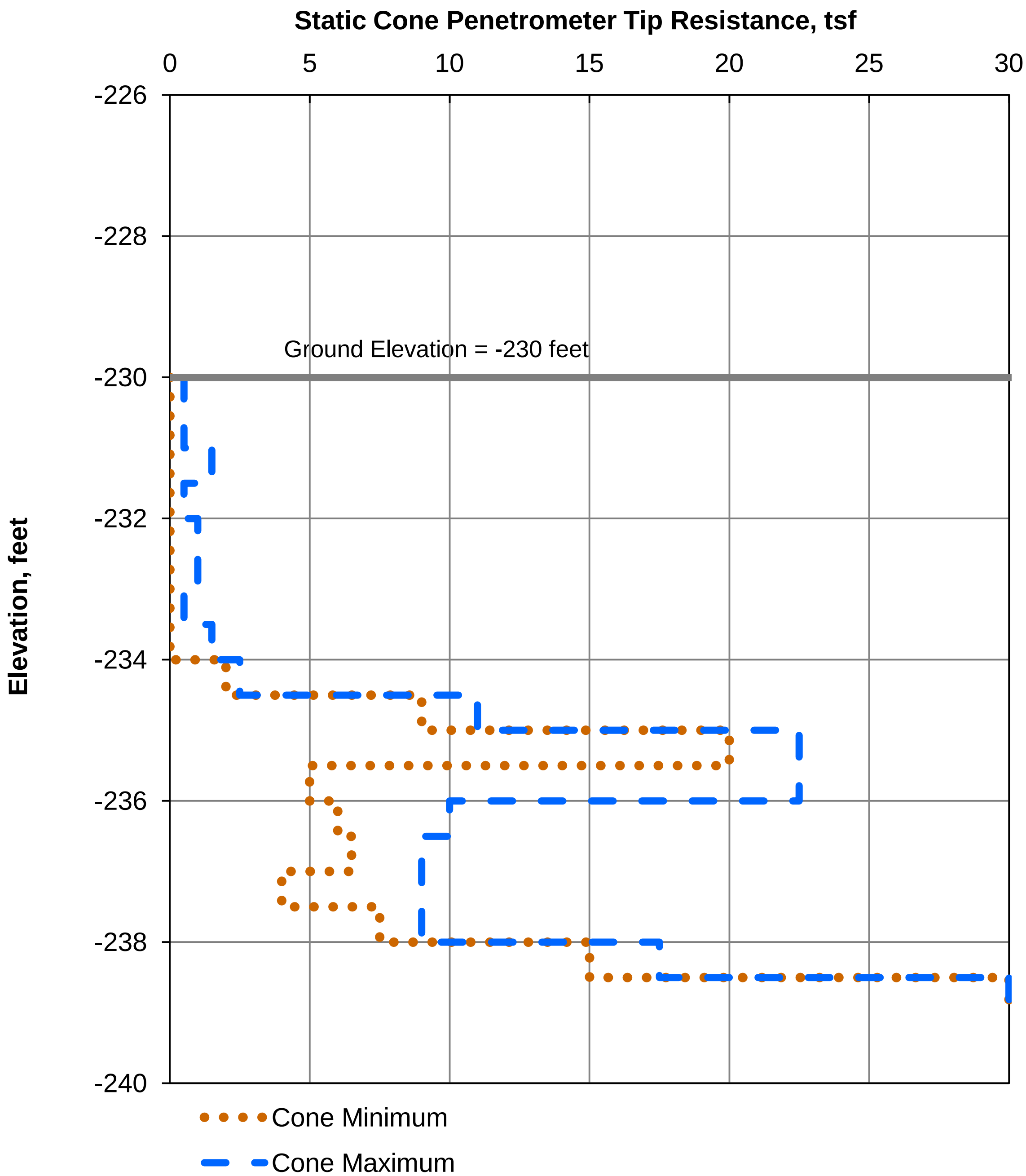
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer** **Exploration Point 47HA**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-4



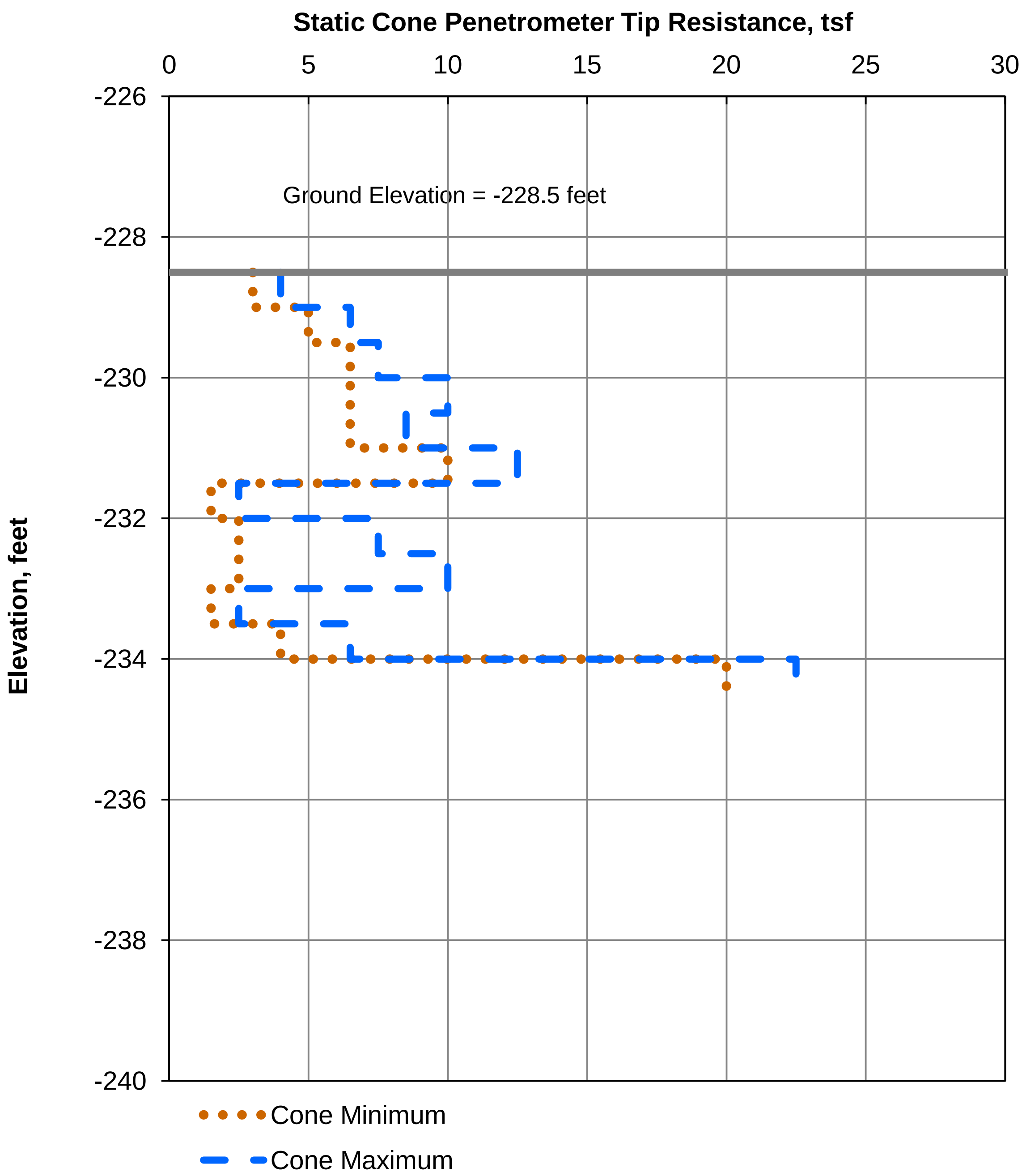
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 49HA**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-5



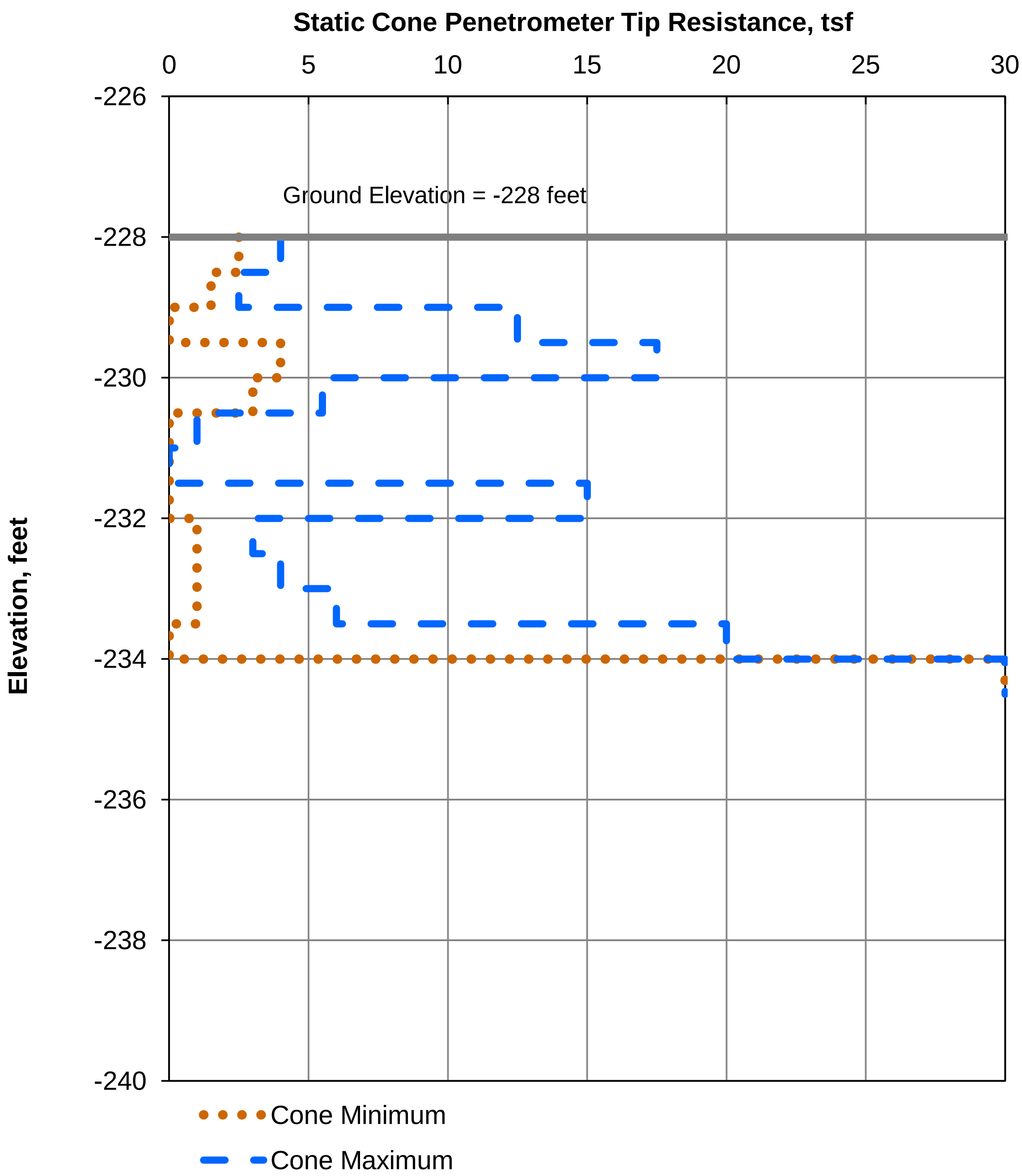
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 50HA**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-6



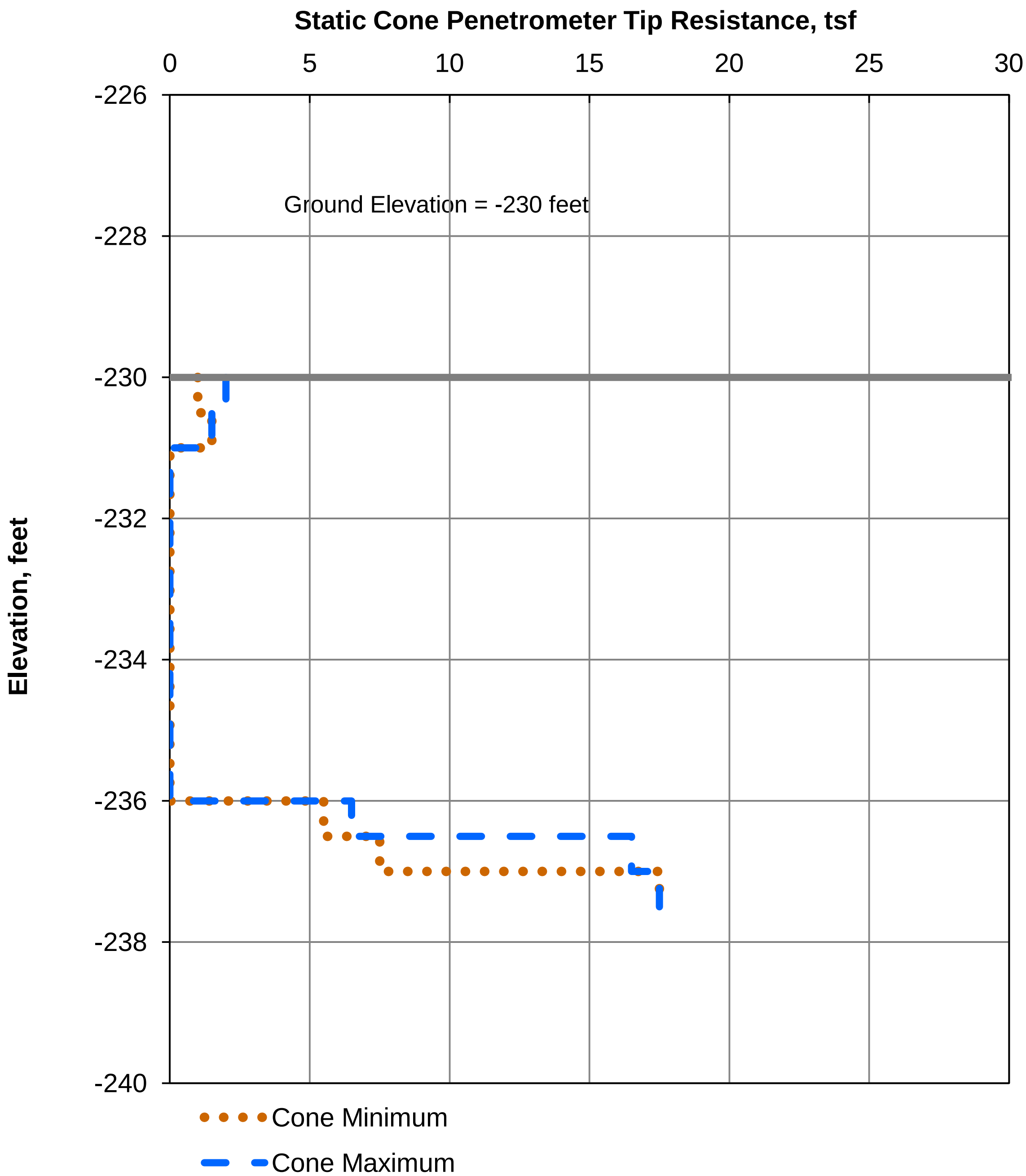
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 51HA**
Hultgren - Tillis Engineers	Project No. 758.01 / Plate No. C-7



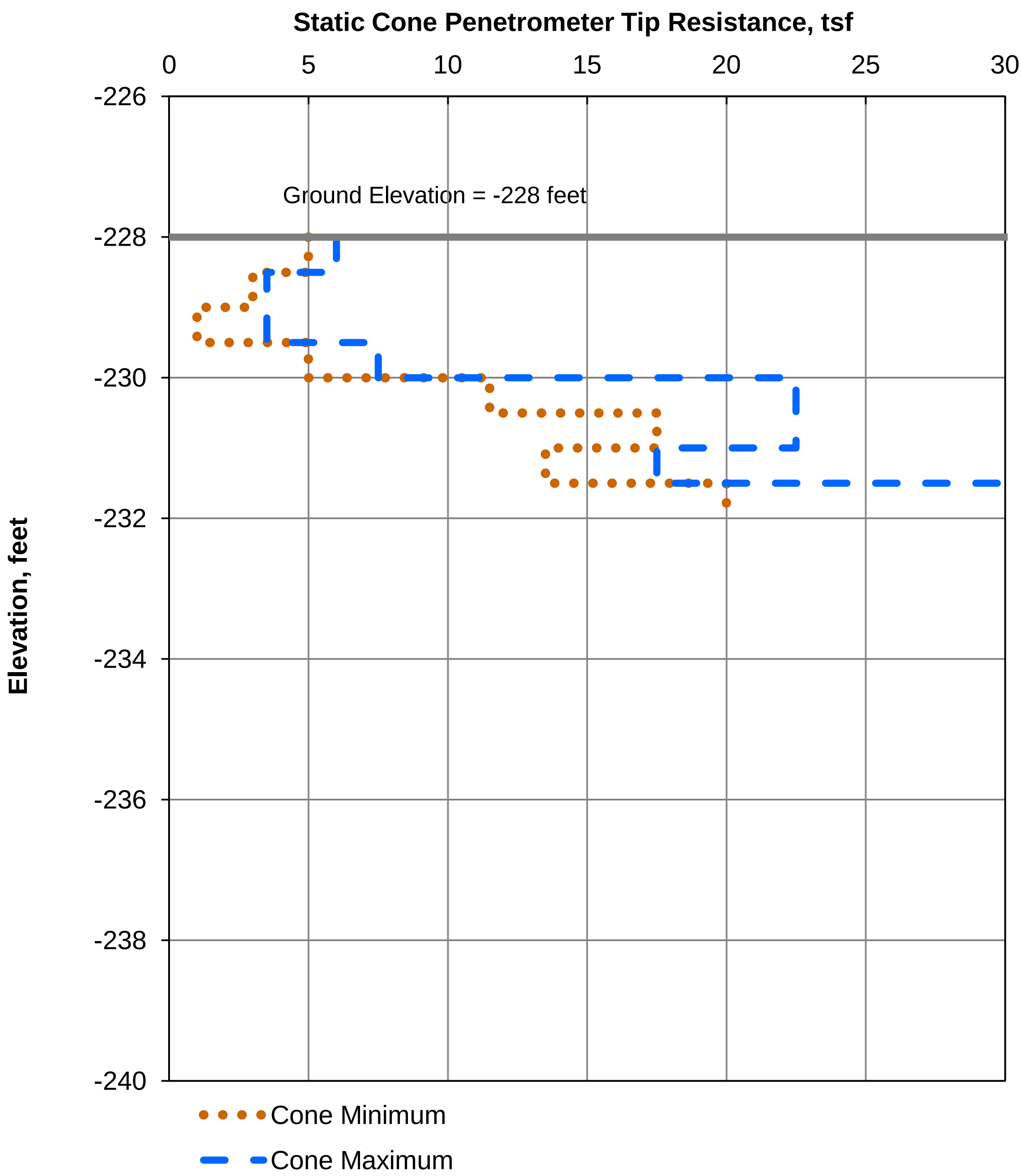
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 52HA**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-8



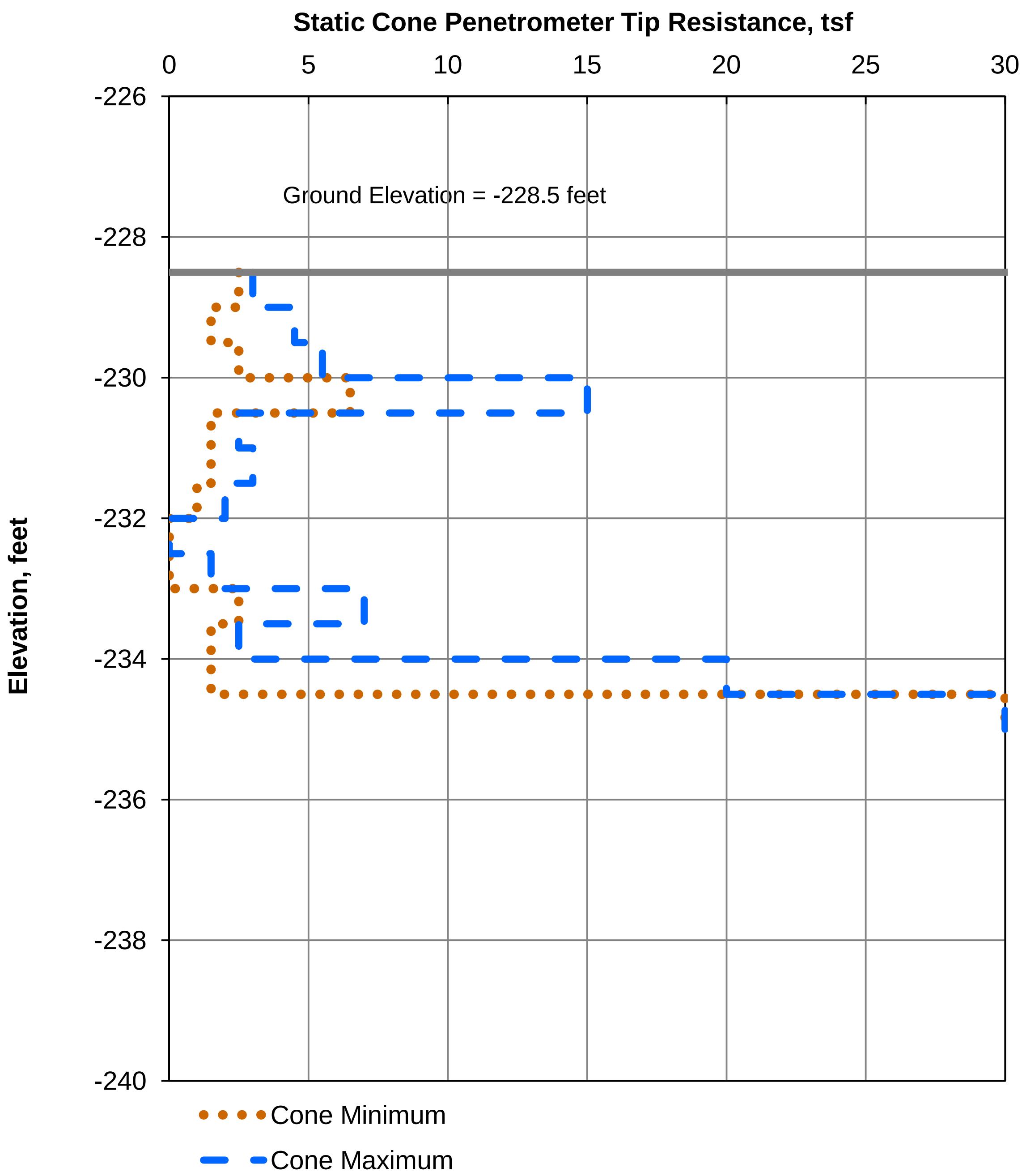
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 98P**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-9



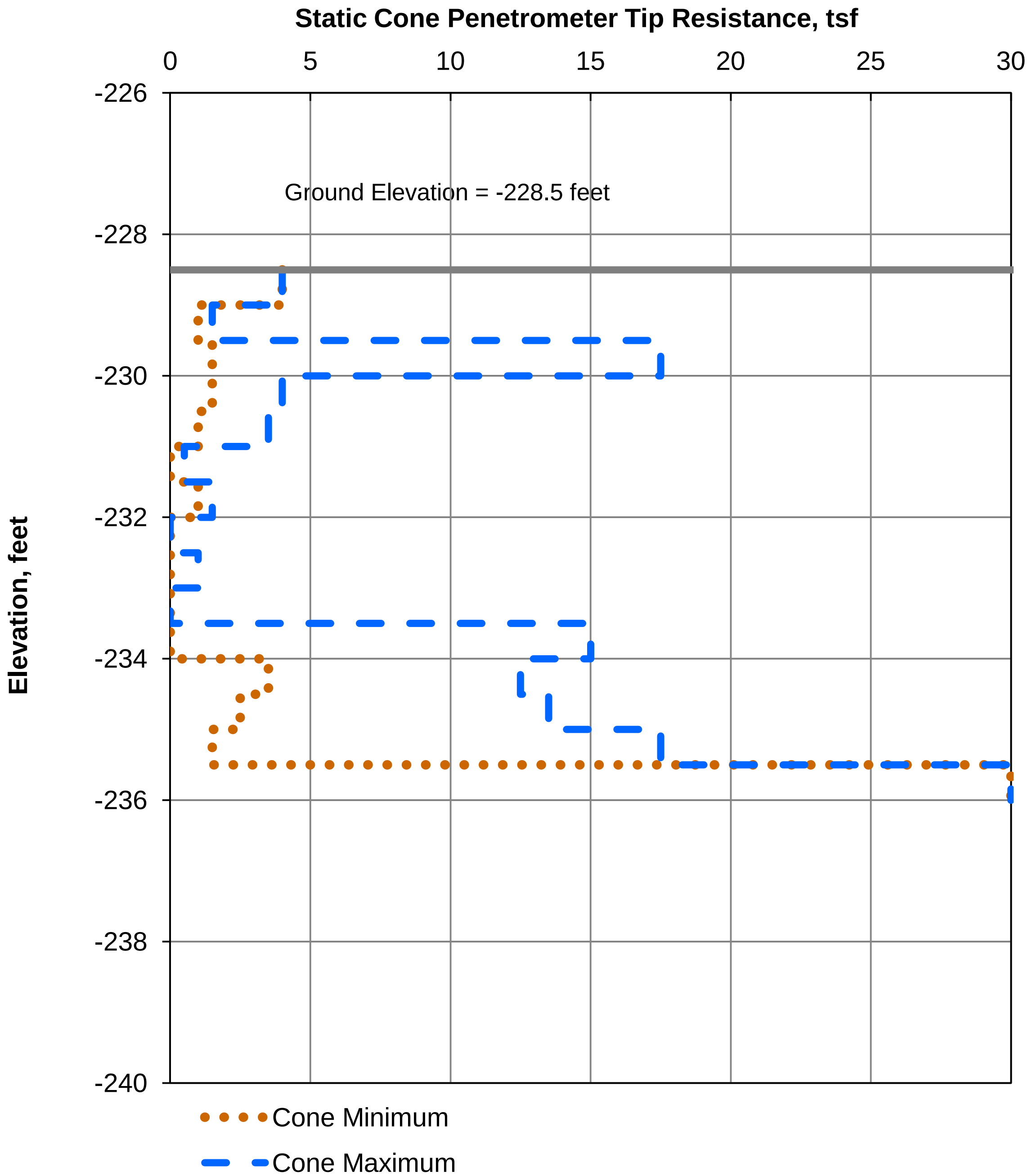
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 99P**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-10



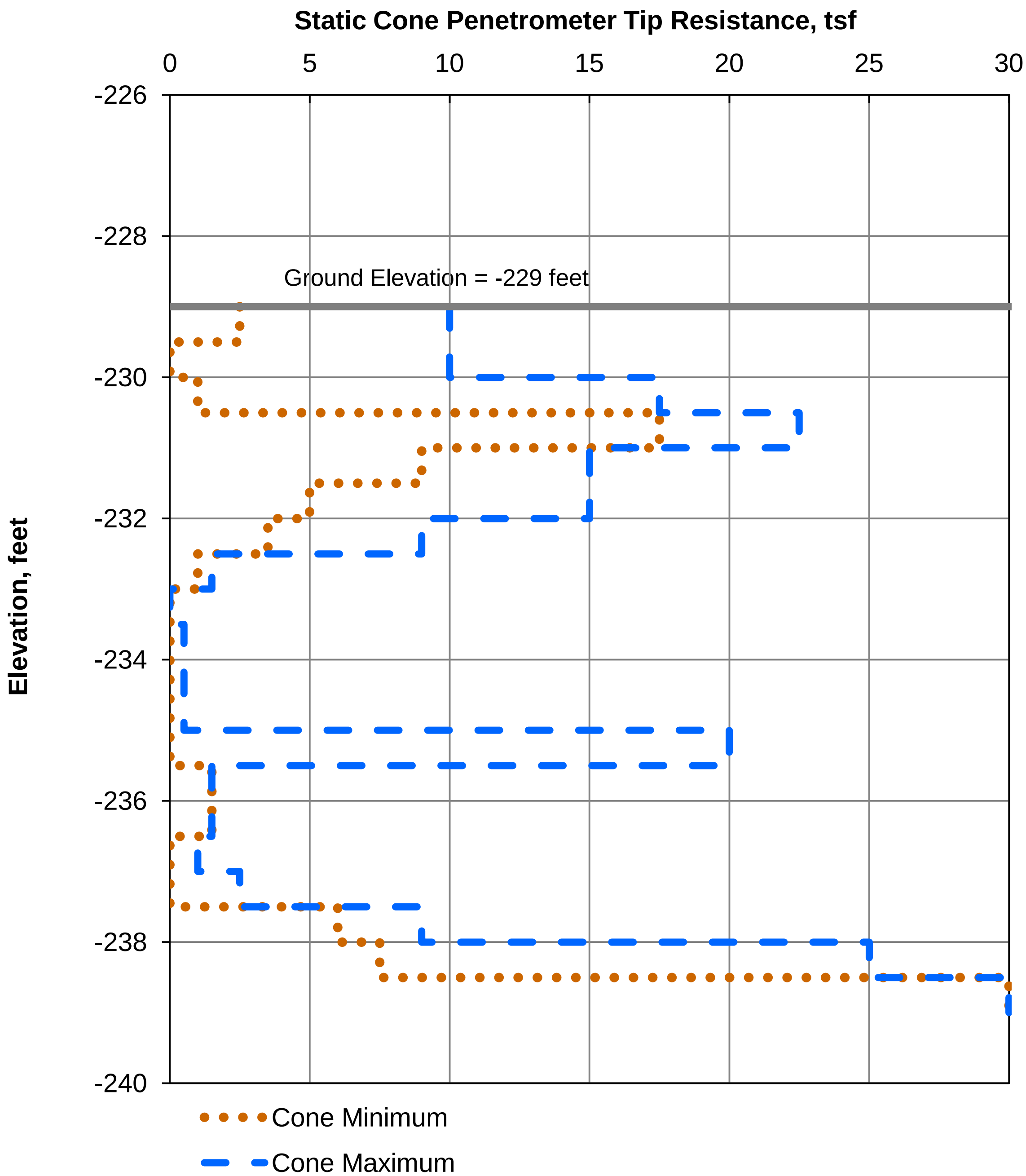
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 100P**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-11



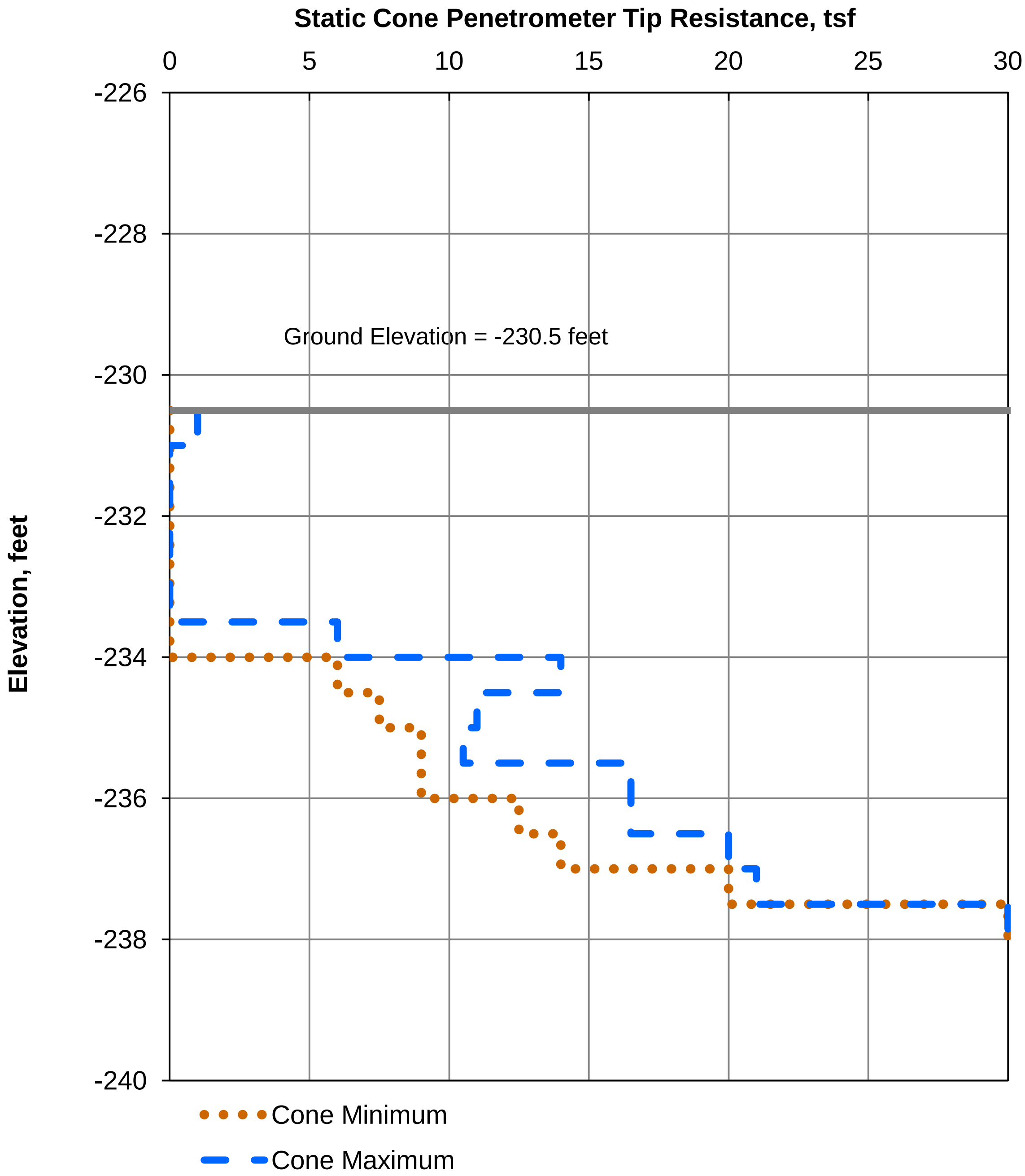
Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer Exploration Point 101P**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-12



Notes:

(1) Penetration resistance was measured with a hand-pushed Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214)

(2) Plot presents maximum and minimum penetration resistances over various depth intervals.

(3) Penetration resistances in excess of 30 tsf or refusal are plotted at 30 tsf.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Static Cone Pentrometer** **Exploration Point 107P**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. C-13

APPENDIX D

APPENDIX D

LABORATORY TEST RESULTS

2011-2013 EXPLORATION OF NEW RIVER SITE

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Table D-1. Summary of Laboratory Test Results

Boring No.	Depth (ft.)	Unified Soil Classification/ Description	In-situ Moisture Content (%)	Soil Fines Passing No. 200 Sieve (%)	Atterberg Limits		
					LL	PL	PI
29HA	0.5 - 1.0	Gray Poorly Graded Sand (SP)		5			
29HA	3.0 - 3.5	Reddish Brown Silt (ML)	27				
29HA	4.5 - 5.0	Reddish Brown Silty Sand (SM)	26		NP	NP	
30HA	5.0 - 5.5	Reddish Brown Lean Clay (CL)	32				
30HA	6.0 - 6.5	Reddish Brown Lean Clay (CL)	33				
31HA	2.0 - 2.5	Gray Fat Clay (CH)	42		56	28	28
31HA	5.5 - 6.0	Reddish Brown Lean Clay (CL)	36				
32VC	1.5 - 1.8	Reddish Brown Lean Clay (CL)	31		42	19	23
33VC	1.0 - 2.0	Dark Gray Fat Clay (CH)	87				
34VC	1.0 - 1.2	Olive Gray Fat Clay (CH)	81		66	28	38
34VC	2.5 - 3.0	Reddish Brown Silty Fat Clay (CH)	26				
35VC	1.0 - 3.2	Olive Gray Fat Clay (CH)	91				
35VC	3.5 - 4.0	Olive Brown Sandy Silt (ML)	31		25	21	4
36VC	0.0 - 4.0	Dark Gray Poorly Graded Sand (SP)	57	5			
36VC	4.0 - 5.2	Brown Well Graded Sand (SW)	26				
37VC	0.5 - 1.0	Dark Gray Poorly Graded Sand (SP)		30			
38VC	2.0 - 3.8	Olive Gray Well Graded Sand (SW)	22				
39HA	1.0 - 1.75	Brown Silt (ML)	28				
39HA	2.5 - 3.0	Gray Silty Sand (SM)		19			
39HA	3.5 - 4.5	Black Gray Silt (ML)	29				
40VC	0.0 - 1.0	Dark Gray Poorly Graded Sand (SP)		3			
40VC	1.0 - 2.5	Sandy Fat Clay (CH)	70				
40VC	3.0 - 3.5	Olive Brownish Lean Clay (CL)	41		32	22	9
41VC	2.0 - 3.0	Gray Fat Clay (CH)	78				
41VC	5.0 - 5.5	Black Fat Clay (CH)	75		70	30	40
41VC	7.0 - 7.5	Olive Gray Fat Clay (CH)	85				
42VC	0.0 - 1.0	Dark Gray Silty Sand (SM)		13			
42VC	2.0 - 2.5	Olive Gray Sandy Lean Clay (CL)	48				
42VC	6.0 - 6.8	Olive Gray Fat Clay (CH)	71				
43VC	1.0 - 1.5	Olive Gray Lean Clay (CL)	60		49	24	25
43VC	4.0 - 4.5	Olive Gray Fat Clay (CH)	46				
44VC	1.2 - 1.4	Dark Gray Fat Clay (CH)	61		51	23	28
44VC	2.0 - 2.8	Reddish Brown Silt (ML)	29				
45VC	0.5 - 1.0	Dark Gray Sandy Lean Clay (CL)	36				
45VC	4.0 - 4.3	Reddish Brown Sandy Silt (ML)	29				
46HA	2.0 - 2.5	Reddish Brown Silt (ML)	30				
46HA	4.0 - 4.5	Reddish Brown Silt (ML)	27				
47HA	3.0 - 3.5	Tan Gray Fat Clay (CH)	53				
47HA	6.0 - 6.5	Reddish Brown Lean Clay (CL)	34		35	23	12
48VC	1.0 - 2.0	Dark Gray Fat Clay (CH)	47				
48VC	3.0 - 4.0	Reddish Brown Sandy Silt (ML)		98			
48VC	4.0 - 4.5	Reddish Brown Sandy Silt (ML)	31				
49HA	2.0 - 2.5	Gray Elastic Silt (MH)	37				
49HA	5.0 - 5.5	Brown Fat Clay (CH)	27				
50HA	0.5 - 1.0	Brown Silt (ML)	24				
50HA	3.0 - 3.5	Black Fat Clay (CH)	58				
51HA	0.0 - 0.5	Reddish Brown Lean Clay (CL)	30		37	17	21

Boring No.	Depth (ft.)	Unified Soil Classification/ Description	In-situ Moisture Content (%)	Soil Fines Passing No. 200 Sieve	Atterberg Limits		
					LL	PL	PI
51HA	3.2 - 4.5	Tan Fat Clay (CH)	89				
51HA	7.5 - 8.0	Gray Sandy Silt (ML)		57			
52HA	4.0 - 5.0	Grayish Gray Fat Clay (CH)	86				
53HA	0.5 - 1.0	Reddish Brown Fat Clay (CH)	30				
53HA	5.5 - 6.0	Gray Silty Sand (SM)		19			
54HA	3.0 - 3.5	Black Fat Clay (CH)	86				
57VC	1.0 - 2.0	Olive Gray Poorly Graded Sand (SP-SM)		8			
57VC	6.0 - 6.8	Olive Gray Poorly Graded Sand (SP-SM)	26				
58VC	1.0 - 2.0	Dark Olive Gray Fat Clay (CH)	51				
58VC	3.0 - 4.0	Brownish Gray Poorly Graded Sand (SP)		3			
59VC	1.0 - 2.0	Dark Gray Fat Clay (CH)	80				
59VC	3.0 - 4.0	Olive Brown to Gray Fat Clay (CH)	56		70	27	44
60VC	1.2 - 2.0	Gray Fat Clay (CH)	92				
60VC	2.0 - 2.6	Reddish Brown Fat Clay (CH)	35				
61VC	2.0 - 2.5	Dark Gray Fat Clay (CH)	51				
61VC	5.7 - 6.3	Olive Gray Silty Sand (SM)	27				
62VC	2.0 - 3.0	Dark Gray Poorly Graded Sand with Silt (SP-SM)		6			
62VC	3.5 - 4.5	Olive Gray Fat Clay (CH)	56				
62VC	8.0 - 8.6	Olive Brown Fat Clay (CH)	71				
63VC	8.0 - 8.5	Olive Gray Fat Clay (CH)	78				
64VC	2.0 - 3.0	Olive Gray Fat Clay (CH)	61				
64VC	5.0 - 6.0	Olive Gray Fat Clay (CH)	83				
90VC	1.0 - 2.0	Olive Gray Fat Clay (CH)	85				
90VC	4.0 - 4.5	Olive Gray Fat Clay (CH)	71				
91VC	1.5 - 2.0	Dark Gray Poorly Graded Sand (SP)	25				
91VC	2.0 - 3.0	Dark Gray Poorly Graded Sand (SP)		5			
91VC	6.0 - 6.6	Olive Brown Fat Clay (CH)	29				
92VC	1.0 - 2.0	Olive Gray Fat Clay (CH)	64				
92VC	5.0 - 6.0	Olive Gray Fat Clay (CH)	78				
92VC	7.0 - 8.0	Reddish Brown Silty Sand (SM)		15			
93VC	3.5 - 4.0	Olive Gray Fat Clay (CH)	84				
93VC	4.5 - 5.0	Olive Gray Fat Clay (CH)	76				
94VC	1.0 - 2.0	Olive Gray Fat Clay (CH)	126		86	34	53
94VC	5.0 - 5.5	Olive Gray Fat Clay (CH)	109				
95VC	2.0 - 3.0	Olive Gray Fat Clay (CH)	94				
95VC	4.0 - 5.0	Reddish Brown Lean Clay (CL)	34		48	19	29
96VC	3.0 - 4.0	Olive Gray Fat Clay (CH)	98				
96VC	5.5 - 6.0	Reddish Brown Fat Clay (CH)	39				
97VC	1.0 - 2.0	Olive Gray Silt (ML)	42		40	26	14
97VC	3.8 - 4.4	Reddish Brown Sandy Silt (ML)	31	95			
112HS	4.5 - 5.0	Dark Brown Lean Clay With Sand	17		33	18	15
112HS	21.0 - 21.5	Reddish Gray Sandy Silt (ML)				NP	NP
112HS	30.5 - 31.0	Reddish Gray Silt with Sand			20	22	NP
112HS	36.0 - 36.5	Brown Fat Clay (CH)	26		70	20	50
113HS	15.0 - 16.0	Brown Sility Sand (SM)				NP	NP
113HS	26.0 - 26.5	Brown Fat Clay (CH)	119		79	20	59

Note: 1. Abbreviations - NV: No Value, NP: Non Plastic, ND: Not Detected.

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No: 212-108a **Project No.** 758.01 **By:** RU
Client: Hultgren-Tillis Engineers **Date:** 11/11/11
Project Name: Salton Sea SCH Project **Remarks:**

Boring:	29HA	29HA	29HA	30HA	30HA	31HA	31HA	32VC
Sample:								
Depth, ft:	3-3.5	4.5-5	6-7	5-5.5	6-6.5	2-2.5	5.5-6	0.5-1
Visual Description:	Dusky Red Silty SAND (slightly plastic)	Strong Brown Silty SAND	*Sample Missing*	Dusky Red CLAY	Reddish Brown CLAY	Greenish Black Fat CLAY	Reddish Brown CLAY	*Sample Missing*
Actual G_s								
Assumed G_s								
Moisture, %	27.4	25.5		32.2	32.7	42.1	35.5	
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.ρb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont,Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Moisture Content

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

Moisture-Density-Porosity Report

Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108b	Project No.	758.01	By:	RU
Client:	Hultgren-Tillis Engineers	Date:	11/11/11		
Project Name:	Salton Sea SCH Project	Remarks:			

Boring:	32VC	33VC	34VC	34VC	35VC	35VC	36VC	36VC
Sample:								
Depth, ft:	1.5-1.8	1-1.2	1-1.2	3.2-3.4	1.5-1.7	3.5-4	2-2.2	4.3-4.5
Visual Description:	Strong Brown Lean CLAY	Dark Greenish Gray CLAY	Bluish Black Fat CLAY	Reddish Brown CLAY	Dark Greenish Gray CLAY	Strong Brown Silty, Clayey SAND	Greenish Black CLAY	Weak Red Silty SAND
Actual G_s								
Assumed G_s								
Moisture, %	30.6	87.2	81.1	25.5	91.4	30.9	56.9	26.2
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.ρb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont,Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Testing performed by Cooper Testing Laboratory

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108c	**Project No.**	758.01	**By:**	RU
Client:	Hultgren-Tillis Engineers	**Date:**	11/11/11		
Project Name:	Salton Sea SCH Project	**Remarks:**			

Boring:	38VC	39HA	39HA	40VC	40VC	41VC	41VC	41VC
Sample:								
Depth, ft:	3-3.2	1-1.5	3.5-4	1.9-2.1	3-3.5	2.4-2.6	5-5.5	7.5-7.7
Visual Description:	Dark Gray Silty SAND	Dark Yellowish Brown Silty SAND (slightly plastic)	Black Silty SAND (very plastic)	Black CLAY, trace sand	Very Dark Greenish Gray Lean CLAY	Very Dark Greenish Gray CLAY	Black Fat CLAY	Very Dark Greenish Gray CLAY
Actual G_s								
Assumed G_s								
Moisture, %	21.8	28.2	29.2	70.4	40.8	77.7	74.8	85.0
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.ρb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont, Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Testing performed by Cooper Testing Laboratory

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108d	Project No.	758.01	By: RU
Client:	Hultgren-Tillis Engineers	Date:	11/11/11	
Project Name:	Salton Sea SCH Progect	Remarks:		

Boring:	42VC	42VC	43VC	43VC	44VC	44VC	45VC	45VC
Sample:								
Depth, ft:	2-2.2	6.4-6.6	1-1.5	4-4.2	1.2-1.4	2.2-2.4	0.7-0.9	3.6-3.8
Visual Description:	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray Lean CLAY, trace sand	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray Fat CLAY, trace sand	Dusky Red CLAY	Very Dark Greenish Gray Silty SAND (slightly plastic)	Reddish Brown CLAY
Actual G_s								
Assumed G_s								
Moisture, %	48.4	70.5	60.0	46.4	60.8	28.7	36.2	28.8
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.ρb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont,Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Moisture Content

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

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108e	Project No.	758.01	By: RU
Client:	Hultgren-Tillis Engineers	Date:	11/11/11	
Project Name:	Salton Sea SCH Project	Remarks:		

Boring:	46VC	46VC	47HA	47HA	48VC	48VC	49HA	49HA
Sample:								
Depth, ft:	2-2.5	4-4.5	3-3.5	6-6.5	1.1-1.3	4.1-4.3	2-2.5	5-5.5
Visual Description:	Reddish Brown Sandy SILT	Reddish Brown Silty SAND	Very Dark Greenish Gray CLAY	Strong Brown Lean CLAY	Very Dark Greenish Gray CLAY	Reddish Brown Sandy SILT	Very Dark Greenish Gray Silty SAND near Sandy SILT	Reddish Brown Sandy SILT near Silty SAND
Actual G_s								
Assumed G_s								
Moisture, %	29.8	26.6	52.9	34.1	47.4	30.6	37.1	27.0
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.ρb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont, Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Testing performed by Cooper Testing Laboratory

Moisture-Density-Porosity Report

Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108f	**Project No.**	758.01	**By:**	RU
Client:	Hultgren-Tillis Engineers	**Date:**	11/11/11		
Project Name:	Salton Sea SCH Project	**Remarks:**			

Boring:	50HA	50HA	51HA	51HA	52HA	52HA	53HA	53HA
Sample:								
Depth, ft:	0.5-1	3-3.5	0-0.5	3-3.5	0-1	4-5	0.5-1	2-2.5
Visual Description:	Weak Red Silty SAND	Black CLAY	Strong Brown Lean CLAY w/ Sand	Very Dark Greenish Gray CLAY, trace Gravel & organics	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Weak Red CLAY, trace SAND	Very Dark Greenish Gray CLAY
Actual G_s								
Assumed G_s								
Moisture, %	24.2	58.0	30.0	88.9	58.1	86.2	30.1	36.9
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.ρb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont, Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Testing performed by Cooper Testing Laboratory

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108g	Project No.	758.01	By:	RU
Client:	Hultgren-Tillis Engineers	Date:	11/11/11		
Project Name:	Salton Sea SCH Project	Remarks:			

Boring:	54HA	57VC	58VC	59VC	59VC	60VC	60VC	61VC
Sample:								
Depth, ft:	3-3.5	7.1-7.3	1.5-1.7	1.1-1.3	3-4	1-1.2	2.2-2.4	5.8-6
Visual Description:	Black CLAY	Dusky Red Silty SAND (slightly plastic)	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Dark Bluish Gray Fat CLAY, trace organics	Very Dark Greenish Gray CLAY	Dusky Red CLAY	Dusky Red Silty SAND (slightly plastic)
Actual G_s								
Assumed G_s								
Moisture, %	85.9	26.1	51.3	80.4	56.0	91.8	34.8	27.2
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.pb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont, Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Moisture Content

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108h	Project No.	758.01	By:	RU
Client:	Hultgren-Tillis Engineers	Date:	11/11/11		
Project Name:	Salton Sea SCH Project	Remarks:			

Boring:	61VC	62VC	62VC	63VC	63VC	64VC	64VC	90VC
Sample:								
Depth, ft:	2.3-2.5	3.7-3.9	8.4-8.6	2.3-2.5	8-8.2	2.5-2.7	5.4-5.6	1.8-2
Visual Description:	Black CLAY	Very Dark Greenish Gray CLAY	Greenish Gray CLAY	Very Dark Greenish Gray CLAY w/ Sand	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY
Actual G_s								
Assumed G_s								
Moisture, %	50.6	56.4	70.8	63.6	77.5	60.6	83.0	84.9
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.ρb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont,Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

COOPER TESTING LABORATORY

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Moisture Content

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

COOPER TESTING LABORATORY

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108i	Project No.	758.01	By: RU
Client:	Hultgren-Tillis Engineers	Date:	11/11/11	
Project Name:	Salton Sea SCH Project	Remarks:		

Boring:	90VC	91VC	91VC	92VC	92VC	93VC	93VC	94VC
Sample:								
Depth, ft:	4-4.2	1.6-1.8	6.2-6.4	1.6-1.8	5.4-5.6	3.6-3.8	5.1-5.3	1-2
Visual Description:	Dark Greenish Gray CLAY	Dark Reddish Gray Silty SAND	Dark Reddish Gray Silty SAND	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray Fat CLAY, trace organics
Actual G_s								
Assumed G_s								
Moisture, %	71.1	24.9	29.4	63.6	78.3	84.0	76.0	125.8
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.pb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont, Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

COOPER TESTING LABORATORY

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Moisture Content

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

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-108j	Project No.	758.01	By:	RU
Client:	Hultgren-Tillis Engineers	Date:	11/11/11		
Project Name:	Salton Sea SCH Project	Remarks:			

Boring:	94VC	95VC	95VC	96VC	96VC	97VC	97VC	97VC
Sample:								
Depth, ft:	5-5.2	2.4-2.6	4-5	1.9-2.1	5.3-5.5	1.4-1.5	4-4.3	1-2
Visual Description:	Very Dark Greenish Gray CLAY	Very Dark Greenish Gray CLAY	Dusky Red Lean CLAY	Very Dark Greenish Gray CLAY	Dusky Red CLAY	Very Dark Greenish Gray CLAY w/ Sand	Dusky Red CLAY	Very Dark Bluish Gray SILT
Actual G_s								
Assumed G_s								
Moisture, %	108.7	94.2	33.7	97.9	38.8	41.5	30.9	49.7
Wet Unit wt, pcf								
Dry Unit wt, pcf								
Dry Bulk Dens.pb, (g/cc)								
Saturation, %								
Total Porosity, %								
Volumetric Water Cont, Θw								
Volumetric Air Cont., Θa								
Void Ratio								
Series	1	2	3	4	5	6	7	8

Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

COOPER TESTING LABORATORY

Testing performed by Cooper Testing Laboratory

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D 2937)

CTL Job No:	212-122	**Project No.**	758.01	**By:**	RU
Client:	Hultgren-Tillis Engineers	**Date:**	10/10/13		
Project Name:	Salton Sea SCH Project-Pump Stations				

Boring:	112HS	112HS	112HS	112HS	112HS	113HS	113HS	113HS
Sample:								
Depth, ft:	4.5-5	10.5-11	16-16.5	36-36.5	66-66.5	8-8.5	26-26.5	60-60.5
Visual Description:	Reddish Gray Lean CLAY w/ Sand	Brown CLAY	Reddish Gray SILT (slightly plastic)	Brown Fat CLAY	Brown Sandy SILT	Brown Sandy SILT	Brown Fat CLAY	Brown Sandy SILT
Actual G_s								
Assumed G_s	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
Moisture, %	16.5	26.2	26.3	26.0	27.9	24.7	30.1	22.0
Wet Unit wt, pcf	127.7	118.4	124.3	120.7	122.0	122.5	118.7	125.6
Dry Unit wt, pcf	109.7	93.8	98.4	95.8	95.4	98.3	91.2	103.0
Dry Bulk Dens.pb, (g/cc)	1.76	1.50	1.58	1.53	1.53	1.57	1.46	1.65
Saturation, %	82.7	88.6	99.5	92.2	98.1	93.0	95.7	93.0
Total Porosity, %	35.0	44.4	41.7	43.2	43.4	41.7	45.9	39.0
Volumetric Water Cont, Θw	28.9	39.4	41.5	39.8	42.6	38.8	43.9	36.3
Volumetric Air Cont., Θa	6.1	5.0	0.2	3.4	0.8	2.9	2.0	2.7
Void Ratio	0.54	0.80	0.72	0.76	0.77	0.72	0.85	0.64
Series	1	2	3	4	5	6	7	8

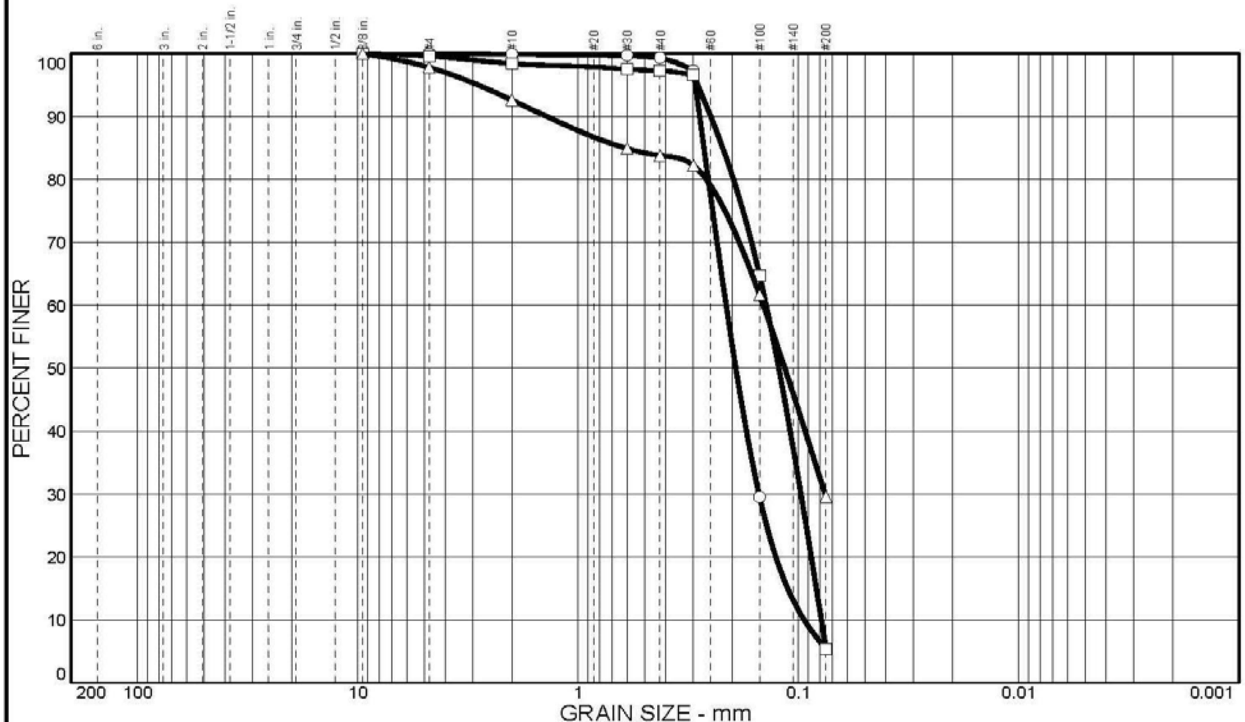
Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.

The Zero Air-Voids curves represent the dry density at 100% saturation for each value of specific gravity

COOPER TESTING LABORATORY

Testing performed by Cooper Testing Laboratory

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			94.7	5.3					
□		0.4	94.2	5.4					
△		2.2	68.3	29.5		SM			

SIEVE inches size	PERCENT FINER ○	□	△
3/8"		100.0	100.0

	GRAIN SIZE ○	□	△
D_{60}	0.213	0.140	0.144
D_{30}	0.151	0.0975	0.0758
D_{10}	0.0943	0.0787	

	COEFFICIENTS ○	□	△
C_c	1.14	0.86	
C_u	2.26	1.78	

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	99.6	97.8
#10	99.9	98.4	92.6
#30	99.7	97.5	84.9
#40	99.3	97.3	83.8
#50	97.3	96.6	82.2
#100	29.5	64.7	61.6
#200	5.3	5.4	29.5

SOIL DESCRIPTION

○ Gray Poorly Graded SAND w/ Silt

□ Dark Gray Poorly Graded SAND w/ Silt

△ Dark Gray Clayey SAND

REMARKS:

○

□

△

○ Source: 29HA Elev./Depth: 0.5-1'

□ Source: 36VC Elev./Depth: 1-2'

△ Source: 37VC Elev./Depth: 0.5-1'

COOPER TESTING LABORATORY

Client: Hultgren-Tillis Engineers

Project: Salton Sea SCH Project - 758.01

Project No.: 212-108 Figure

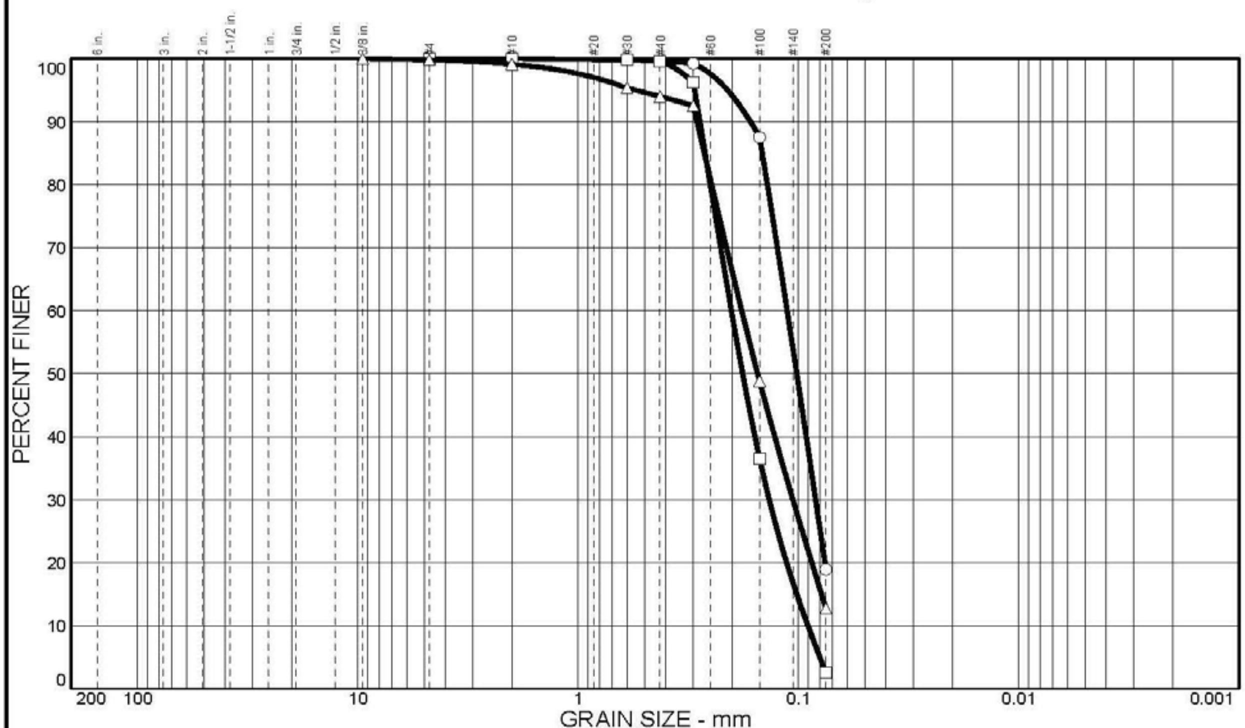
Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Sieve Analysis

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

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			81.1	18.9					
□			97.5	2.5					
△		0.2	87.1	12.7					

SIEVE inches size	PERCENT FINER ○	□	△
3/8"			100.0
	GRAIN SIZE		
D_{60}	0.113	0.202	0.181
D_{30}	0.0836	0.136	0.106
D_{10}		0.0906	
	COEFFICIENTS		
C_c		1.01	
C_u		2.23	

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	100.0	99.8
#10	100.0	100.0	99.1
#30	99.8	99.8	95.3
#40	99.6	99.6	94.0
#50	99.2	96.2	92.5
#100	87.5	36.5	48.8
#200	18.9	2.5	12.7

SOIL DESCRIPTION
○ Dark Gray Silty SAND
□ Dark Gray Silty SAND
△ Very Dark Gray Silty SAND

REMARKS:
○
□
△

○ Source: 39HA Elev./Depth: 2.5-3'
□ Source: 40VC Elev./Depth: 0-1'
△ Source: 42VC Elev./Depth: 0-1'

COOPER TESTING LABORATORY

Client: Hultgren-Tillis Engineers
Project: Salton Sea SCH Project - 758.01
Project No.: 212-108 Figure

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Sieve Analysis

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

Particle Size Distribution Report

	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			1.6	98.4					
□			43.2	56.8					
△			80.6	19.4					

SIEVE inches size	PERCENT FINER ○	□	△

	GRAIN SIZE ○	□	△
D_{60}		0.0814	0.115
D_{30}			0.0833
D_{10}			

	COEFFICIENTS ○	□	△
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	100.0	100.0
#10	99.9	99.9	100.0
#30	99.8	99.7	99.9
#40	99.8	99.2	99.9
#50	99.7	97.0	99.4
#100	99.5	82.0	79.4
#200	98.4	56.8	19.4

SOIL DESCRIPTION

○ Dusky Red SILT (slightly plastic)

□ Very Dark Gray Sandy SILT (slightly plastic)

△ Dark Brown Silty SAND

REMARKS:

○

□

△

○ Source: 48VC — Elev./Depth: 3-4'

□ Source: 51HA — Elev./Depth: 7.5-8'

△ Source: 53HA — Elev./Depth: 5.5-6'

COOPER TESTING LABORATORY

Client: Hultgren-Tillis Engineers

Project: Salton Sea SCH Project - 758.01

Project No.: 212-108 Figure

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Sieve Analysis

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

Particle Size Distribution Report

	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.1	92.1	7.8					
□			97.3	2.7					
△			94.3	5.7					

SIEVE inches size	PERCENT FINER ○	□	△
3/8"	100.0		

	GRAIN SIZE ○	□	△
D_{60}	0.122	0.212	0.206
D_{30}	0.0911	0.163	0.141
D_{10}	0.0764	0.124	0.0870

	COEFFICIENTS ○	□	△
C_c	0.89	1.02	1.10
C_u	1.59	1.72	2.37

SIEVE number size	PERCENT FINER ○	□	△
#4	99.9		100.0
#10	99.4	100.0	99.7
#30	98.8	99.8	99.0
#40	98.7	98.7	98.5
#50	98.5	92.5	97.1
#100	76.4	22.1	34.1
#200	7.8	2.7	5.7

SOIL DESCRIPTION

○ Dark Gray Poorly Graded SAND w/ Silt

□ Dark Gray Poorly Graded SAND

△ Dark Gray Poorly Graded SAND w/ Silt

REMARKS:

○

□

△

○ Source: 57VC Elev./Depth: 1-2'

□ Source: 58VC Elev./Depth: 3-4'

△ Source: 62VC Elev./Depth: 2-3'

COOPER TESTING LABORATORY

Client: Hultgren-Tillis Engineers

Project: Salton Sea SCH Project - 758.01

Project No.: 212-108 Figure

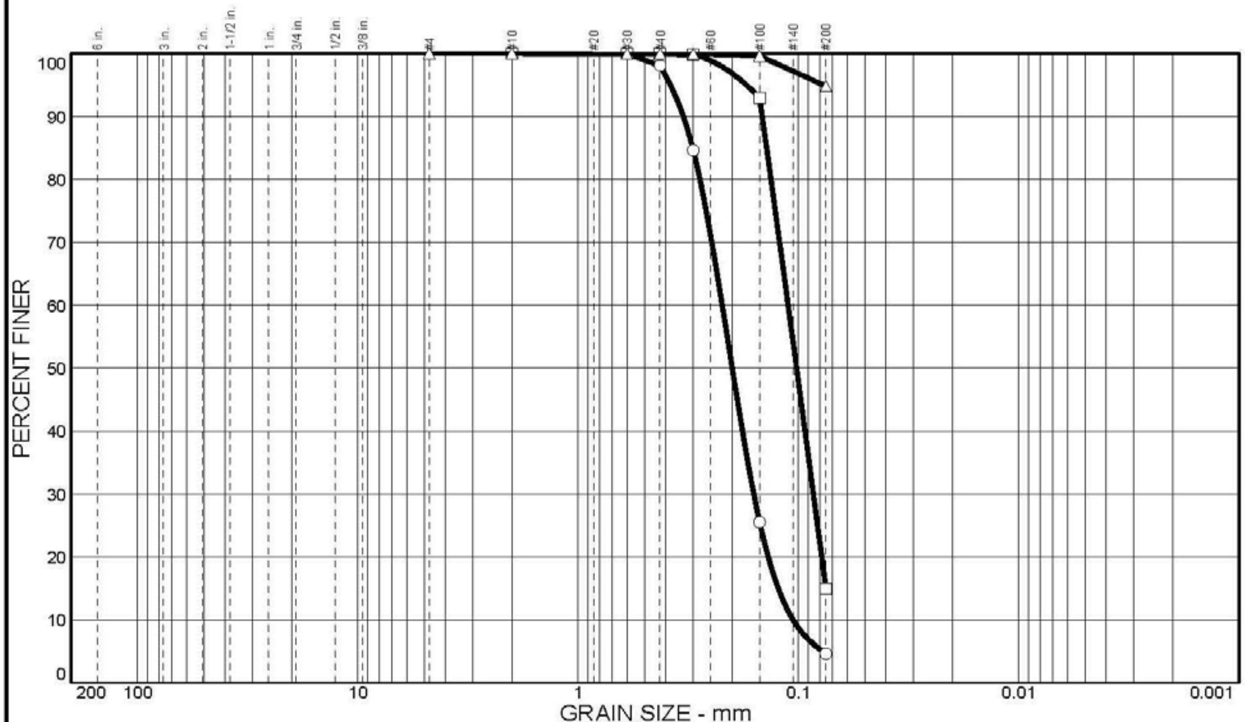
Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Sieve Analysis

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

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			95.4	4.6					
□			85.1	14.9					
△			5.2	94.8					

SIEVE inches size	PERCENT FINER ○	□	△

	GRAIN SIZE ○	□	△
D_{60}	0.222	0.111	
D_{30}	0.159	0.0856	
D_{10}	0.106		

	COEFFICIENTS ○	□	△
C_c	1.08		
C_u	2.10		

SIEVE number size	PERCENT FINER ○	□	△
#4			100.0
#10	100.0	100.0	100.0
#30	99.9	99.9	99.9
#40	98.1	99.9	99.9
#50	84.6	99.8	99.9
#100	25.5	92.9	99.6
#200	4.6	14.9	94.8

SOIL DESCRIPTION

○ Dark Gray Poorly Graded SAND

□ Strong Brown Silty SAND

△ Strong Brown SILT (slightly plastic)

REMARKS:

○

□

△

○ Source: 91VC Elev./Depth: 2-3'

□ Source: 92VC Elev./Depth: 7-8'

△ Source: 97VC Elev./Depth: 3.8-4.4'

COOPER TESTING LABORATORY

Client: Hultgren-Tillis Engineers

Project: Salton Sea SCH Project - 758.01

Project No.: 212-108 Figure

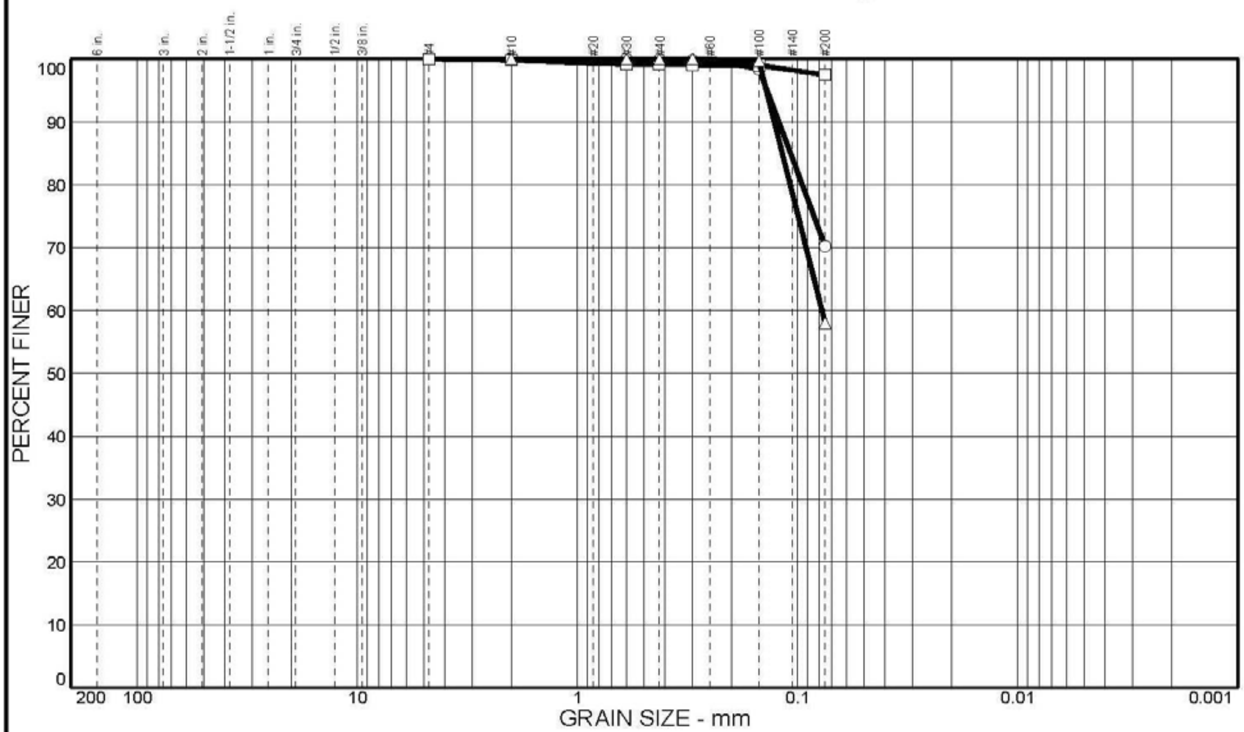
Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Sieve Analysis

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

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			29.8	70.2		ML		21.9	20.3
□			2.5	97.5		ML			
△			42.0	58.0					

SIEVE inches size	PERCENT FINER ○	□	△
GRAIN SIZE			
D_{60}			0.0775
D_{30}			
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	100.0	
#10	100.0	99.8	100.0
#30	100.0	99.2	100.0
#40	99.9	99.2	100.0
#50	99.8	99.1	100.0
#100	98.4	99.0	99.7
#200	70.2	97.5	58.0

SOIL DESCRIPTION

○ Reddish Gray SILT w/ Sand

□ Brown SILT

△ Brown Sandy SILT

REMARKS:

○

□

△

○ Source: 112HS Elev./Depth: 30.5-31'

□ Source: 112HS Elev./Depth: 66-66.5'

△ Source: 113HS Elev./Depth: 8-8.5'

COOPER TESTING LABORATORY

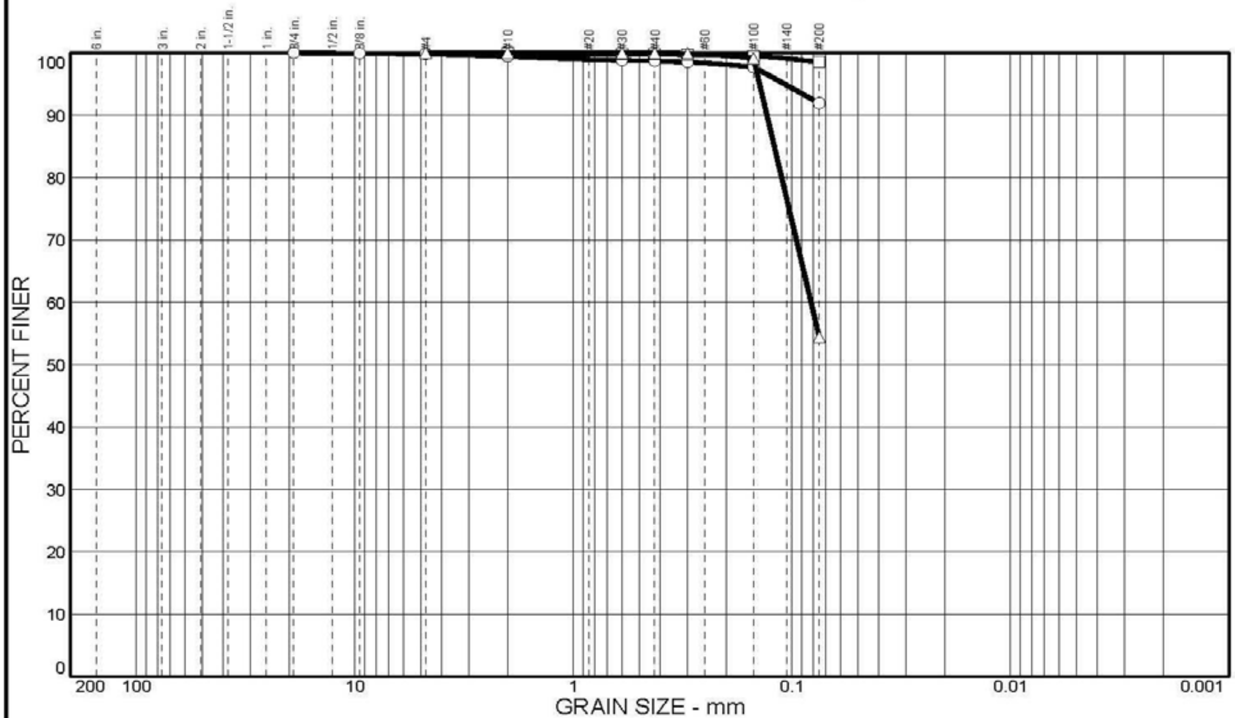
Client: Hultgren-Tillis Engineers

Project: Salton Sea SCH Project-Pump Stations - 758.01

Project No.: 212-122 Figure

Testing performed by Cooper Testing Laboratory

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.2	7.9	91.9					
□			1.5	98.5					
△			45.6	54.4		ML		NP	

SIEVE inches size	PERCENT FINER ○	□	△
3/4"	100.0		
3/8"	99.9		
GRAIN SIZE			
D_{60}			0.0818
D_{30}			
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	99.8		100.0
#10	99.4	100.0	100.0
#30	98.8	99.8	100.0
#40	98.7	99.8	100.0
#50	98.5	99.7	99.9
#100	97.7	99.5	99.1
#200	91.9	98.5	54.4

SOIL DESCRIPTION

○ Reddish Gray CLAY

□ Reddish Gray SILT (slightly plastic)

△ Reddish Gray Sandy SILT

REMARKS:

○

□

△

○ Source: 112HS Elev./Depth: 7.5-8'

□ Source: 112HS Elev./Depth: 16-16.5'

△ Source: 112HS Elev./Depth: 21-21.5'

COOPER TESTING LABORATORY

Client: Hultgren-Tillis Engineers

Project: Salton Sea SCH Project-Pump Stations - 758.01

Project No.: 212-122 Figure

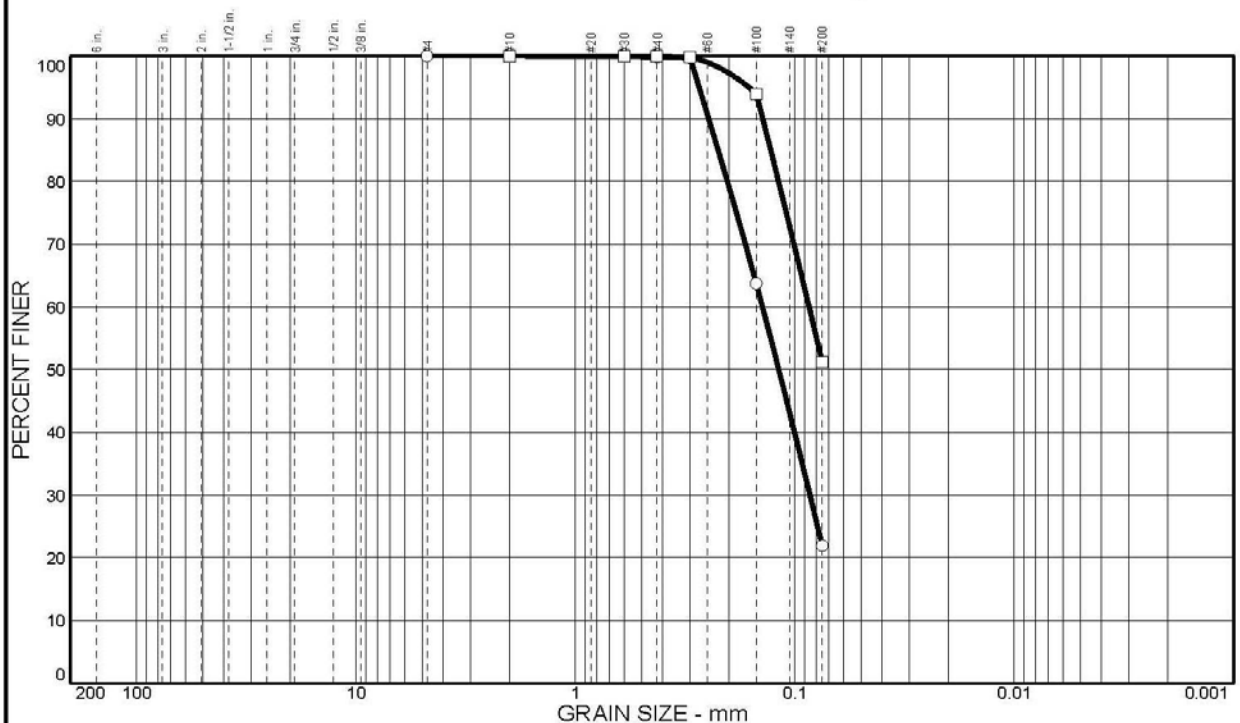
Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Sieve Analysis

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

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			78.1	21.9		SM		NP	
□			48.8	51.2					

SIEVE inches size	PERCENT FINER ○	□	
	GRAIN SIZE		
D_{60}	0.141	0.0862	
D_{30}	0.0854		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	
#4	100.0		
#10	100.0	100.0	
#30	99.9	100.0	
#40	99.8	100.0	
#50	99.7	99.8	
#100	63.7	94.0	
#200	21.9	51.2	

SOIL DESCRIPTION
○ Brown Silty SAND

□ Brown Sandy SILT

REMARKS:
○

□

○ Source: 113HS Elev./Depth: 15-16'
□ Source: 113HS Elev./Depth: 60-60.5'

COOPER TESTING LABORATORY

Client: Hultgren-Tillis Engineers
Project: Salton Sea SCH Project-Pump Stations - 758.01

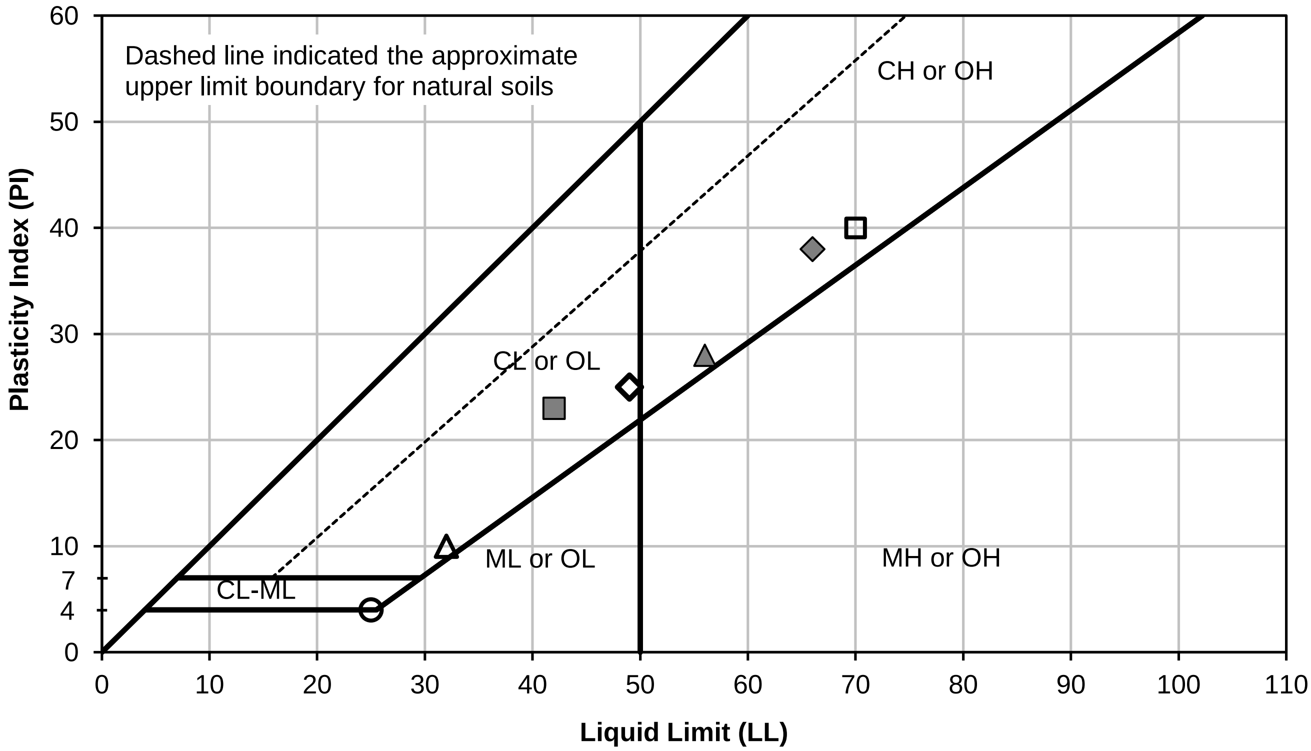
Project No.: 212-122 Figure

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Sieve Analysis

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



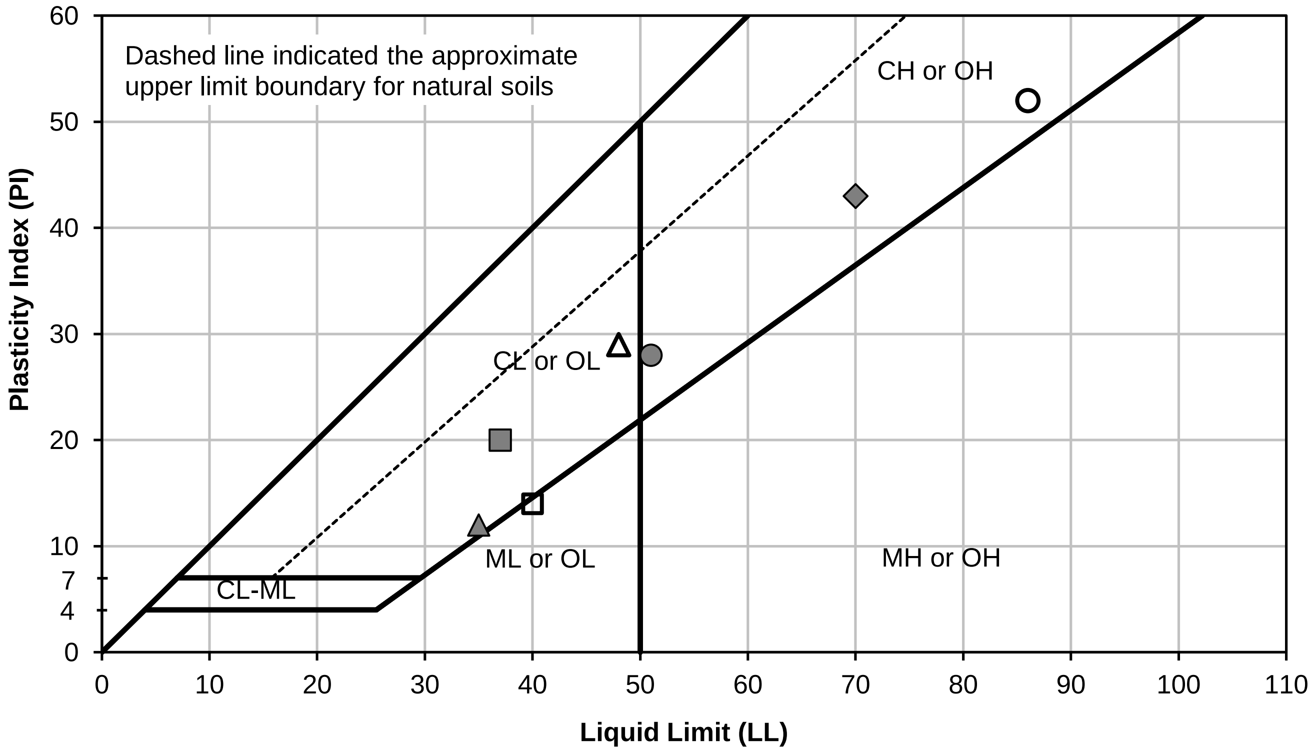
Symbol	Boring Number	Depth (feet)	Soil Description	LL (%)	PL (%)	PI (%)	Moisture Content (%)
●	29HA	4.5-5	Reddish Brown Silty SAND		NP	NP	
▲	31HA	2-2.5	Gray Fat CLAY	56	28	28	42
■	32VC	1.5-1.8	Reddish Brown Lean CLAY	42	19	23	31
◆	34VC	1-1.2	Olive Gray Fat CLAY	66	28	38	81
○	35VC	3.5-4	Olive Brown Sandy SILT	25	21	4	31
△	40VC	3-3.5	Olive Brownish Gray Lean CLAY	32	22	10	41
□	41VC	5-5.5	Black Fat CLAY	70	30	40	75
◇	43VC	1-1.5	Olive Gray Lean CLAY	49	24	25	60

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Atterberg Limits

Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. D-21



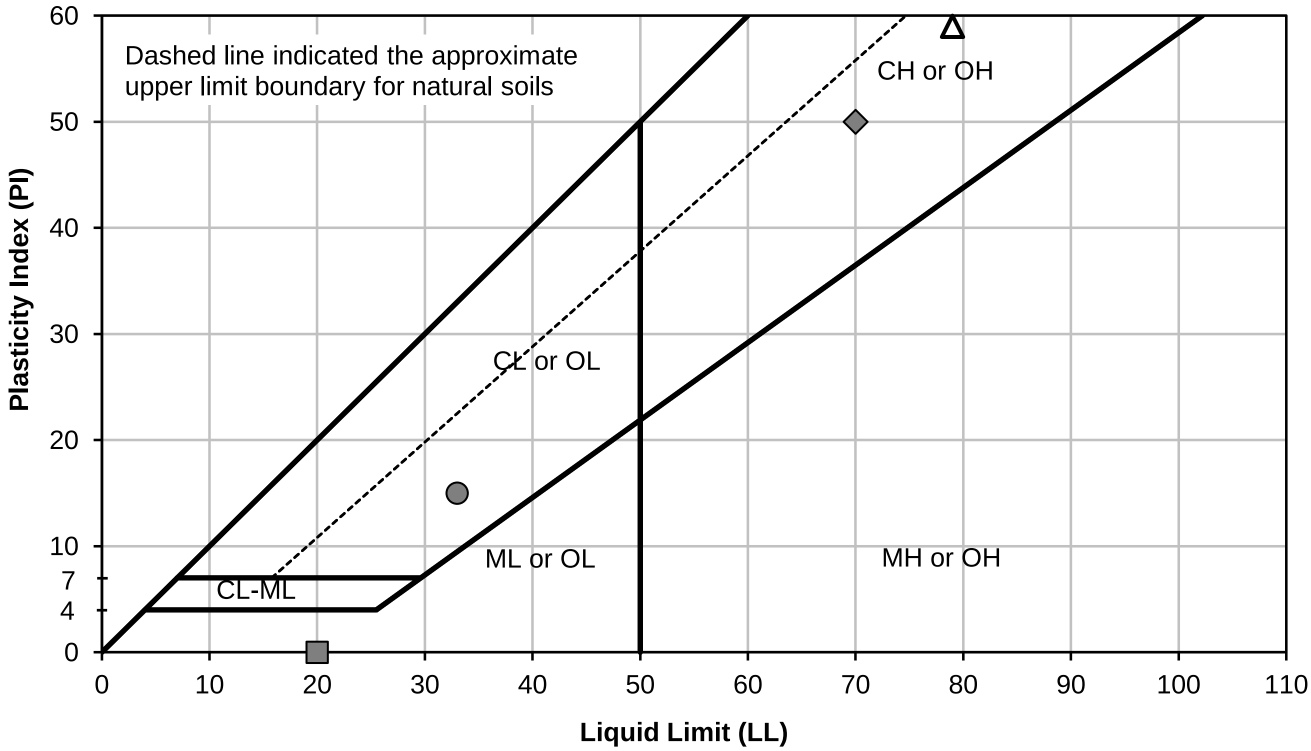
Symbol	Boring Number	Depth (feet)	Soil Description	LL (%)	PL (%)	PI (%)	Moisture Content (%)
●	44VC	1.2-1.4	Olive Gray Fat CLAY	51	23	28	61
▲	47HA	6-6.5	Reddish Brown Lean CLAY	35	23	12	34
■	51HA	0-0.5	Reddish Brown Lean CLAY	37	17	20	30
◆	59VC	3-4	Olive Brown to Gray Fat CLAY	70	27	43	56
○	94VC	1-2	Olive Gray Fat CLAY	86	34	52	126
△	95VC	4-5	Reddish Brown Lean CLAY	48	19	29	34
□	97VC	1-2	Olive Gray SILT	40	26	14	42

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Atterberg Limits

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. D-22



Symbol	Boring Number	Depth (feet)	Soil Description	LL (%)	PL (%)	PI (%)	Moisture Content (%)
●	112HS	4.5-5	Dark Bown Lean CLAY with Sand	33	18	15	17
▲	112HS	21-21.5	Reddish Gray Sandy SILT		NP	NP	
■	112HS	30.5-31	Reddish Gray SILT with Sand	20	22	NP	
◆	112HS	36-36.5	Brown Fat CLAY	70	20	50	26
○	113HS	15-16	Brown Silty Sand		NP	NP	
△	113HS	26-26.5	Brown Fat CLAY	79	20	59	119

Testing performed by Cooper Testing Laboratory

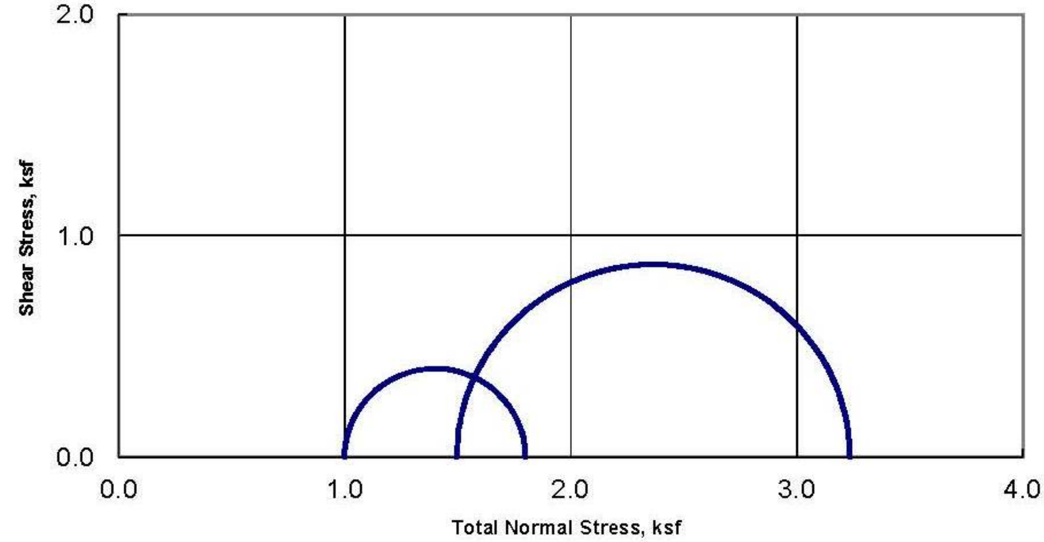
Salton Sea
Species Conservation Habitat Project
Salton Sea, California

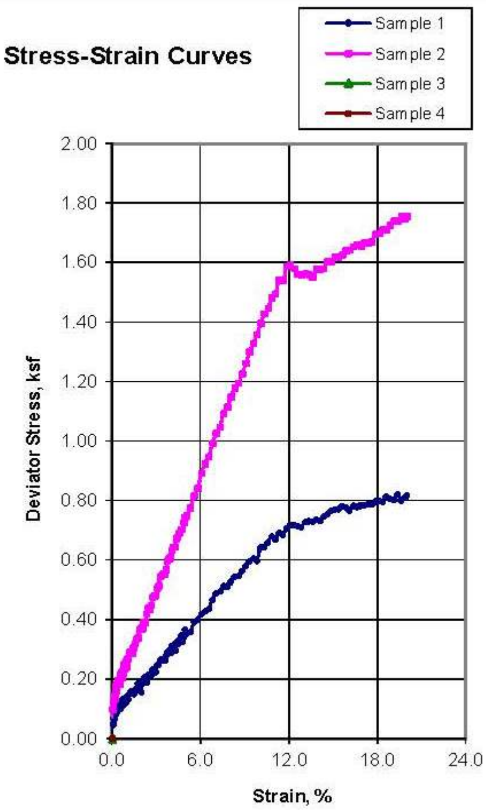
Atterberg Limits

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

COOPER TESTING LABORATORY

Unconsolidated-Undrained Triaxial Test
ASTM D-2850





Sample Data				
	1	2	3	4
Moisture %	34.8	27.7		
Dry Den,pcf	86.8	95.4		
Void Ratio	0.942	0.767		
Saturation %	99.8	97.4		
Height in	4.99	4.98		
Diameter in	2.42	2.42		
Cell psi	6.9	10.4		
Strain %	19.30	19.60		
Deviator, ksf	0.821	1.757		
Rate %/min	1.00	1.00		
in/min	0.050	0.050		
Job No.:	212-122			
Client:	Hultgren-Tillis Engineers			
Project:	Salton Sea SCH Project-Pump Stations - 758.01			
Boring:	112HS	112HS		
Sample:				
Depth ft:	25-25.5	46-46.5		

Visual Soil Description	
Sample #	
1	Reddish Gray SILT w/ Sand (slightly plastic)
2	Reddish Gray SILT w/ Sand (slightly plastic)
3	
4	

Remarks:

Testing performed by Cooper Testing Laboratory

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Unconsolidated-Undrained Triaxial Test

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

McCampbell Analytical, Inc.
"When Quality Counts"

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Toll Free Telephone: (877) 252-9262 / Fax: (925) 252-9269
http://www.mccampbell.com / E-mail: main@mccampbell.com

Analytical Report

Hultgren-Tillis Engineers 2221 Commerce Avenue, Suite A-1 Concord, CA 94520	Client Project ID: #758.01; Salton Sea SCH PROJ	Date Sampled: 10/28/11 Date Received: 10/28/11
	Client Contact: Ed Hultgren	Date Reported: 11/04/11
	Client P.O.:	Date Completed: 11/04/11

WorkOrder: 1110886

November 04, 2011

Dear Ed:

Enclosed within are:

1) The results of the **1** analyzed sample from your project: **#758.01; Salton Sea SCH PROJ,**
2) A QC report for the above sample,
3) A copy of the chain of custody, and
4) An invoice for analytical services.

All analyses were completed satisfactorily and all QC samples were found to be within our control limits.

If you have any questions or concerns, please feel free to give me a call. Thank you for choosing McCampbell Analytical Laboratories for your analytical needs.

Best regards,

Angela Rydelius
Laboratory Manager
McCampbell Analytical, Inc.

The analytical results relate only to the items tested.

Plate No. D-25

TO: McCAMPBELL 1110886 925 685-6300

Hultgren - Tillis Engineers

TEST REQUEST

Project Name: SALTON SEA SCH PROJ
Project No.: 758.01
Date Requested: 10/28/11
Requested By: ED HULTGREN
Due Date: ROUTINE

Boring / Test Pit No.	Depth (ft)	Sample Diameter	Test Requested: Moisture Only	Moisture / Density	Atterberg Limits	-200 Wash	Sieve with Hydrometer	Sieve Only	Test Performed: Moisture Only	Moisture / Density	Atterberg Limits	-200 Wash	Sieve with Hydrometer	Sieve Only	Instructions
41VC	4.3-4.9														TPH MULTISCAN TPH w/ SILICA GEL CLEANUP

ICE/t° 7.2
GOOD CONDITION ____ APPROPRIATE
HEAD SPACE ABSENT ____ CONTAINERS ____
DECHLORINATED IN LAB ____ PRESERVED IN LAB ____
VOAS | O & G | METALS | OTHER
PRESERVATION ____

	Total Requested						Total Completed					

Special Instructions: GROUND TEMP AT SITE IS ABOUT 80°F. SAMPLE WAS NOT KEPT ON ICE.

* Sample Sealed WITH Electrical Tape. a.V 10/28/11 MAI

NOTE – WE SUSPECT THIS IS ORGANIC MATERIAL, BUT PRESENTED AS A HYDROCARBON ODOR WHEN OPENING SAMPLE TUBE.

Note: Please return Test Request form to Admin after completion of tests

Lab Test Request-HTE.XLS

☐Ajera

Plate No. D-26

rel [signature] rec: M. [signature] 10/28/11 4:40PM

McCampbell Analytical, Inc.

1534 Willow Pass Rd
Pittsburg, CA 94565-1701
(925) 252-9262

CHAIN-OF-CUSTODY RECORD

WorkOrder: 1110886 **ClientCode: HTC**

☐ WaterTrax ☐ WriteOn ☐ EDF ☐ Excel ☐ Fax ☑ Email ☐ HardCopy ☐ ThirdParty ☐ J-flag

Report to:
Ed Hultgren
Hultgren-Tillis Engineers
2221 Commerce Avenue, Suite A-1
Concord, CA 94520
(925) 685-6300 FAX: (925) 685-6768

Email: edhultgren@hultgrentillis.com
cc:
PO:
ProjectNo: #758.01; Salton Sea SCH PROJ

Bill to:
Chris Muller
Hultrgren-Tillis Engineers
2221 Commerce Avenue, Suite A-1
Concord, CA 94520

Requested TAT: **5 days**

Date Received: **10/28/2011**
Date Printed: **10/28/2011**

Lab ID	Client ID	Matrix	Collection Date	Hold	Requested Tests (See legend below) 1	2	3	4	5	6	7	8	9	10	11	12
1110886-001	41 VC 4.3-4.9	Soil	10/28/2011	☐	A	A										

Test Legend:

1	TPH(DMO)_S	2	TPH(DMO)WSG_S	3		4		5	
6		7		8		9		10	
11		12							

The following SampID: 001A contains testgroup.

Prepared by: Ana Venegas

Comments:

NOTE: Soil samples are discarded 60 days after results are reported unless other arrangements are made (Water samples are 30 days).
Hazardous samples will be returned to client or disposed of at client expense.

Plate No. D-27

McCampbell Analytical, Inc.
"When Quality Counts"
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http://www.mccampbell.com / E-mail: main@mccampbell.com

Sample Receipt Checklist

Client Name: **Hultrgren-Tillis Engineers** Date and Time Received: **10/28/2011 4:55:36 PM**

Project Name: **#758.01; Salton Sea SCH PROJ** Checklist completed and reviewed by: Ana Venegas

WorkOrder N°: **1110886** Matrix: Soil Carrier: Client Drop-In

Chain of Custody (COC) Information

	Yes	No	
Chain of custody present?	✔	☐	
Chain of custody signed when relinquished and received?	✔	☐	
Chain of custody agrees with sample labels?	✔	☐	
Sample IDs noted by Client on COC?	✔	☐	
Date and Time of collection noted by Client on COC?	✔	☐	
Sampler's name noted on COC?	☐	✔	

Sample Receipt Information

	Yes	No	NA
Custody seals intact on shipping container/cooler?	☐	☐	✔
Shipping container/cooler in good condition?	✔	☐	
Samples in proper containers/bottles?	✔	☐	
Sample containers intact?	✔	☐	
Sufficient sample volume for indicated test?	✔	☐	

Sample Preservation and Hold Time (HT) Information

	Yes	No	Other
All samples received within holding time?	✔	☐	
Container/Temp Blank temperature	Cooler Temp: 7.2°C		NA ☐
Water - VOA vials have zero headspace / no bubbles?	☐	☐	No VOA vials submitted ✔
Sample labels checked for correct preservation?	✔	☐	
Metal - pH acceptable upon receipt (pH<2)?	☐	☐	NA ✔
Samples Received on Ice?	✔	☐	

(Ice Type: WET ICE)

** NOTE: If the "No" box is checked, see comments below.*

Client contacted: Date contacted: Contacted by:

Comments:

Plate No. D-28

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Hultgren-Tillis Engineers 2221 Commerce Avenue, Suite A-1	Client Project ID: #758.01; Salton Sea SCH PROJ	Date Sampled: 10/28/11 Date Received: 10/28/11
	Client Contact: Ed Hultgren	Date Extracted 10/28/11
Concord, CA 94520	Client P.O.:	Date Analyzed 11/02/11

Gasoline Range (C6-C12) Volatile Hydrocarbons as Gasoline *

Extraction method: SW5030B   Analytical methods: SW8015Bm   Work Order: 1110886

Lab ID	Client ID	Matrix	TPH(g)	DF	% SS	Comments
001A	41 VC 4.3-4.9	S	2.3	1	84	d7

Reporting Limit for DF =1; ND means not detected at or above the reporting limit			
	W	NA	NA
	S	1.0	mg/Kg

* water and vapor samples are reported in µg/L, soil/sludge/solid samples in mg/kg, wipe samples in µg/wipe, product/oil/non-aqueous liquid samples and all TCLP & SPLP extracts in mg/L.

cluttered chromatogram; sample peak coelutes w/surrogate peak; low surrogate recovery due to matrix interference; %SS = Percent Recovery of Surrogate Standard; DF = Dilution Factor

The following descriptions of the TPH chromatogram are cursory in nature and McCampbell Analytical is not responsible for their interpretation:
d7) strongly aged gasoline or diesel range compounds are significant in the TPH(g) chromatogram

DHS ELAP Certification 1644   Angela Rydelius, Lab Manager

Plate No. D-29

McCampbell Analytical, Inc.
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http://www.mccampbell.com / E-mail: main@mccampbell.com

Hultgren-Tillis Engineers 2221 Commerce Avenue, Suite A-1 Concord, CA 94520	Client Project ID: #758.01; Salton Sea SCH PROJ	Date Sampled: 10/28/11 Date Received: 10/28/11
	Client Contact: Ed Hultgren	Date Extracted: 10/28/11
	Client P.O.:	Date Analyzed: 11/04/11

Total Extractable Petroleum Hydrocarbons*

Extraction method: SW3550B   Analytical methods: SW8015B   Work Order: 1110886

Lab ID	Client ID	Matrix	TPH-Diesel (C10-C23)	TPH-Motor Oil (C18-C36)	DF	% SS	Comments
1110886-001A	41 VC 4.3-4.9	S	16	44	1	84	e7,e2

Reporting Limit for DF =1; ND means not detected at or above the reporting limit				
	W	NA	NA	ug/L
	S	1.0	5.0	mg/Kg

* water samples are reported in µg/L, wipe samples in µg/wipe, soil/solid/sludge samples in mg/kg, product/oil/non-aqueous liquid samples in mg/L, and all DISTLC / STLC / SPLP / TCLP extracts are reported in µg/L.

cluttered chromatogram resulting in coeluted surrogate and sample peaks, or; surrogate peak is on elevated baseline, or; surrogate has been diminished by dilution of original extract; %SS = Percent Recovery of Surrogate Standard; DF = Dilution Factor

The following descriptions of the TPH chromatogram are cursory in nature and McCampbell Analytical is not responsible for their interpretation:
e2) diesel range compounds are significant; no recognizable pattern
e7) oil range compounds are significant

DHS ELAP Certification 1644

Angela Rydelius, Lab Manager

Plate No. D-30

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http://www.mccampbell.com / E-mail: main@mccampbell.com

Hultgren-Tillis Engineers	Client Project ID: #758.01; Salton Sea SCH PROJ	Date Sampled: 10/28/11
2221 Commerce Avenue, Suite A-1		Date Received: 10/28/11
	Client Contact: Ed Hultgren	Date Extracted: 10/28/11
Concord, CA 94520	Client P.O.:	Date Analyzed: 11/04/11

Total Extractable Petroleum Hydrocarbons with Silica Gel Clean-Up*

Extraction method: SW3550B/3630C   Analytical methods: SW8015B   Work Order: 1110886

Lab ID	Client ID	Matrix	TPH-Diesel (C10-C23)	TPH-Motor Oil (C18-C36)	DF	% SS	Comments
1110886-001A	41 VC 4.3-4.9	S	19	31	1	101	e7,e2

Reporting Limit for DF =1; ND means not detected at or above the reporting limit				
	W	NA	NA	ug/L
	S	1.0	5.0	mg/Kg

* water samples are reported in µg/L, wipe samples in µg/wipe, soil/solid/sludge samples in mg/kg, product/oil/non-aqueous liquid samples in mg/L, and all DISTLC / STLC / SPLP / TCLP extracts are reported in µg/L.

cluttered chromatogram resulting in coeluted surrogate and sample peaks, or; surrogate peak is on elevated baseline, or; surrogate has been diminished by dilution of original extract.

%SS = Percent Recovery of Surrogate Standard. DF = Dilution Factor

The following descriptions of the TPH chromatogram are cursory in nature and McCampbell Analytical is not responsible for their interpretation:
e2) diesel range compounds are significant; no recognizable pattern
e7) oil range compounds are significant

DHS ELAP Certification 1644

Angela Rydelius, Lab Manager

Plate No. D-31

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QC SUMMARY REPORT FOR SW8021B/8015Bm

W.O. Sample Matrix: Soil | QC Matrix: Soil | BatchID: 62274 | WorkOrder: 1110886

EPA Method: SW8015Bm | **Extraction: SW5030B** | **Spiked Sample ID: 1110857-002A**

Analyte	Sample	Spiked	MS	MSD	MS-MSD	LCS	LCSD	LCS-LCSD	Acceptance Criteria (%)			
	mg/Kg	mg/Kg	% Rec.	% Rec.	% RPD	% Rec.	% Rec.	% RPD	MS / MSD	RPD	LCS/LCSD	RPD
TPH(btex)£	ND	0.60	94.6	92.7	1.99	92.5	93.4	1.02	70 - 130	20	70 - 130	20
MTBE	ND	0.10	110	117	6.20	115	110	4.72	70 - 130	20	70 - 130	20
Benzene	ND	0.10	100	103	3.20	107	105	1.92	70 - 130	20	70 - 130	20
Toluene	ND	0.10	88.3	91.7	3.74	92.9	92.1	0.841	70 - 130	20	70 - 130	20
Ethylbenzene	ND	0.10	90.5	94.5	4.28	94.6	93.5	1.10	70 - 130	20	70 - 130	20
Xylenes	ND	0.30	102	107	4.98	106	105	1.14	70 - 130	20	70 - 130	20
%SS:	112	0.10	86	86	0	86	92	6.57	70 - 130	20	70 - 130	20

All target compounds in the Method Blank of this extraction batch were ND less than the method RL with the following exceptions:
NONE

BATCH 62274 SUMMARY

Lab ID	Date Sampled	Date Extracted	Date Analyzed	Lab ID	Date Sampled	Date Extracted	Date Analyzed
1110886-001A	10/28/11	10/28/11	11/02/11 10:07 PM				

MS = Matrix Spike; MSD = Matrix Spike Duplicate; LCS = Laboratory Control Sample; LCSD = Laboratory Control Sample Duplicate; RPD = Relative Percent Deviation.

% Recovery = 100 * (MS-Sample) / (Amount Spiked); RPD = 100 * (MS - MSD) / ((MS + MSD) / 2).

MS / MSD spike recoveries and / or %RPD may fall outside of laboratory acceptance criteria due to one or more of the following reasons: a) the sample is inhomogenous AND contains significant concentrations of analyte relative to the amount spiked, or b) the spiked sample's matrix interferes with the spike recovery.

£ TPH(btex) = sum of BTEX areas from the FID.

cluttered chromatogram; sample peak coelutes with surrogate peak.

N/A = not enough sample to perform matrix spike and matrix spike duplicate.

NR = matrix interference and/or analyte concentration in sample exceeds spike amount for soil matrix or exceeds 2x spike amount for water matrix or sample diluted due to high matrix or analyte content.

DHS ELAP Certification 1644

QA/QC Officer

Plate No. D-32

McCampbell Analytical, Inc.
"When Quality Counts"
1534 Willow Pass Road, Pittsburg, CA 94565-1701
Toll Free Telephone: (877) 252-9262 / Fax: (925) 252-9269
http://www.mccampbell.com / E-mail: main@mccampbell.com

QC SUMMARY REPORT FOR SW8015B

W.O. Sample Matrix: Soil | QC Matrix: Soil | BatchID: 62310 | WorkOrder: 1110886

EPA Method: SW8015B | **Extraction: SW3550B/3630C** | **Spiked Sample ID: 1110880-002A**

Analyte	Sample	Spiked	MS	MSD	MS-MSD	LCS	LCSD	LCS-LCSD	Acceptance Criteria (%)			
	mg/Kg	mg/Kg	% Rec.	% Rec.	% RPD	% Rec.	% Rec.	% RPD	MS / MSD	RPD	LCS/LCSD	RPD
TPH-Diesel (C10-C23)	60	40	NR	NR	NR	115	105	9.64	70 - 130	30	70 - 130	30
%SS:	94	25	96	105	9.53	75	98	27.5	70 - 130	30	70 - 130	30

All target compounds in the Method Blank of this extraction batch were ND less than the method RL with the following exceptions:
NONE

BATCH 62310 SUMMARY

Lab ID	Date Sampled	Date Extracted	Date Analyzed	Lab ID	Date Sampled	Date Extracted	Date Analyzed
1110886-001A	10/28/11	10/28/11	11/04/11 4:28 AM				

MS = Matrix Spike; MSD = Matrix Spike Duplicate; LCS = Laboratory Control Sample; LCSD = Laboratory Control Sample Duplicate; RPD = Relative Percent Deviation.

% Recovery = 100 * (MS-Sample) / (Amount Spiked); RPD = 100 * (MS - MSD) / ((MS + MSD) / 2).

MS / MSD spike recoveries and / or %RPD may fall outside of laboratory acceptance criteria due to one or more of the following reasons: a) the sample is inhomogenous AND contains significant concentrations of analyte relative to the amount spiked, or b) the spiked sample's matrix interferes with the spike recovery.

N/A = not enough sample to perform matrix spike and matrix spike duplicate.

NR = analyte concentration in sample exceeds spike amount for soil matrix or exceeds 2x spike amount for water matrix or sample diluted due to high matrix or analyte content.

DHS ELAP Certification 1644

QA/QC Officer

Plate No. D-33

McCampbell Analytical, Inc.
"When Quality Counts"

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QC SUMMARY REPORT FOR SW8015B

W.O. Sample Matrix: Soil | QC Matrix: Soil | BatchID: 62313 | WorkOrder: 1110886

EPA Method: SW8015B | **Extraction: SW3550B** | **Spiked Sample ID: 1110904-003A**

Analyte	Sample	Spiked	MS	MSD	MS-MSD	LCS	LCSD	LCS-LCSD	Acceptance Criteria (%)			
	mg/Kg	mg/Kg	% Rec.	% Rec.	% RPD	% Rec.	% Rec.	% RPD	MS / MSD	RPD	LCS/LCSD	RPD
TPH-Diesel (C10-C23)	1.5	40	133, F1	133, F1	0	121	121	0	70 - 130	30	70 - 130	30
%SS:	118	25	119	119	0	105	105	0	70 - 130	30	70 - 130	30

All target compounds in the Method Blank of this extraction batch were ND less than the method RL with the following exceptions:
NONE

F1 = MS / MSD outside of acceptance criteria. LCS - LCSD validate prep batch.

BATCH 62313 SUMMARY

Lab ID	Date Sampled	Date Extracted	Date Analyzed	Lab ID	Date Sampled	Date Extracted	Date Analyzed
1110886-001A	10/28/11	10/28/11	11/04/11 3:10 PM				

MS = Matrix Spike; MSD = Matrix Spike Duplicate; LCS = Laboratory Control Sample; LCSD = Laboratory Control Sample Duplicate; RPD = Relative Percent Deviation.

% Recovery = 100 * (MS-Sample) / (Amount Spiked); RPD = 100 * (MS - MSD) / ((MS + MSD) / 2).

MS / MSD spike recoveries and / or %RPD may fall outside of laboratory acceptance criteria due to one or more of the following reasons: a) the sample is inhomogenous AND contains significant concentrations of analyte relative to the amount spiked, or b) the spiked sample's matrix interferes with the spike recovery.

N/A = not enough sample to perform matrix spike and matrix spike duplicate.

NR = analyte concentration in sample exceeds spike amount for soil matrix or exceeds 2x spike amount for water matrix or sample diluted due to high matrix or analyte content.

DHS ELAP Certification 1644 | QA/QC Officer

Plate No. D-34

California State Certified Laboratory No. 2153

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

15 October, 2013

Job No.1310022
Cust. No.11451

RECEIVED

OCT 17 2013

Hultgren - Tillis Engineers

Mr. W. Rick Chen
Hultgren-Tillis Engineers
4085 Nelson Avenue, Suite A
Concord, CA 94520-1257

Subject: Project No.: 758.01
Project Name: Salton Sea SCH Project
Corrosivity Analysis – ASTM Test Methods

Dear Mr. Chen:

Pursuant to your request, CERCO Analytical has analyzed the soil sample submitted on October 02, 2013. Based on the analytical results, this brief corrosivity evaluation is enclosed for your consideration.

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

The chloride ion concentration is 2,200 mg/kg and is determined to be sufficient to attack steel embedded in a concrete mortar coating. Chloride ion concentrations greater than 300 mg/kg are considered corrosive to embedded reinforcing steel; and, as such, the concrete mix design shall be adjusted accordingly by a qualified corrosion engineer.

The sulfate ion concentration is 1,300 mg/kg and is determined to be sufficient to damage reinforced concrete structures and cement mortar-coated steel at these locations. Therefore, concrete that comes into contact with this soil should use sulfate resistant cement such as Type II, in accordance with the California Building Code requirements with a maximum water-to-cement ratio of 0.50.

The sulfide ion concentration reflects none detected with a detection limit of 50 mg/kg.

The pH of the soil is 8.30, which does not present corrosion problems for buried iron, steel, mortar-coated steel and reinforced concrete structures.

The redox potential is 450-mV, which is indicative of aerobic soil conditions.

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

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

Very truly yours,
CERCO ANALYTICAL, INC.

Cheryl McMillen for

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

JDH/jdl
Enclosure

California State Certified Laboratory No. 2153

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

Client: Hultgren-Tillis Engineers
Client's Project No.: 758.01
Client's Project Name: Salton Sea SCH Project
Date Sampled: 19-Sep-13
Date Received: 2-Oct-13
Matrix: Soil
Authorization: Signed Chain of Custody

Date of Report: 15-Oct-2013

Job/Sample No.	Sample I.D.	Redox (mV)	pH	Conductivity (umhos/cm)*	Resistivity (100% Saturation) (ohms-cm)	Sulfide (mg/kg)*	Chloride (mg/kg)*	Sulfate (mg/kg)*
1310022-001	113HS @ 5-5.5	450	8.30	-	150	N.D.	2,200 (1)	1,300

	Redox	pH	Conductivity	Resistivity	Sulfide	Chloride	Sulfate
Method:	ASTM D1498	ASTM D4972	ASTM D1125M	ASTM G57	ASTM D4658M	ASTM D4327	ASTM D4327
Detection Limit:	-	-	10	-	50	150	15
Date Analyzed:	8-Oct-2013	8-Oct-2013		9-Oct-2013	14-Oct-2013	8-Oct-2013	7-Oct-2013

Cheryl McMillen
Laboratory Director

* Results Reported on "As Received" Basis
N.D. - None Detected
(1) Detection limit is elevated to 75 mg/kg due to dilution

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

APPENDIX E

APPENDIX E
DISPERSION

E-1. Dispersion

The laboratory tests of dispersive character of clay soils were performed during the 2010 exploration. The 2010 exploration covered both the New River and the Alamo River sites. No additional laboratory tests (such as crumb test, double hydrometer test, percent sodium in saturation extract and pinhole test) were performed on soil samples collected during the 2011 exploration for characterizing sea sediments (clay soils).

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 D698) as the laboratory compaction reference. The moisture content was near optimum. This resulted in a moderately compacted clay compared to the one compacted using Modified Proctor (ASTM D1557). 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 indicated by the various laboratory tests performed for this purpose is shown in Table E-1. Each of these samples was logged as gray fat clay (CH). Detailed results of the dispersion tests are included in Appendix G.

Table E-1. Summary of Dispersion Potential

Sample	Crumb Test (ASTM D6572)	Double Hydrometer Test (ASTM D4221)	Percent Sodium in Saturation Extract (EPA 60103)	Pinhole Test (ASTM D4647)
1HA	Nondispersive	Nondispersive	Nondispersive	Dispersive
4HA	Intermediate	Nondispersive	Nondispersive	Dispersive
11VC	Dispersive	Dispersive	Nondispersive	Dispersive

Table E-1. Summary of Dispersion Potential (continued)

Sample	Crumb Test (ASTM D6572)	Double Hydrometer Test (ASTM D4221)	Percent Sodium in Saturation Extract (EPA 60103)	Pinhole Test (ASTM D4647)
16VC	Intermediate	Nondispersive	Nondispersive	Dispersive
20VC	Nondispersive	Nondispersive	Nondispersive	Dispersive
28VC	Nondispersive	Nondispersive	Nondispersive	Dispersive

As shown in Table E-1, 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 (BuRec's) chart of percent sodium versus total dissolved salts[1]. The total dissolved salts in saturation extract in the samples tested ranged from 2,800 to 5,000 milliequivalents per liter. The BuRec's dispersive potential chart does not extend past 700 milliequivalents per liter. Extrapolation of the chart suggests non-dispersive classifications. The Sodium Absorption Ratio (SAR) in the samples tested ranged between 0.15 to 0.39, also inferring non-dispersive.

The pinhole test results indicate that the on-site sea sediments 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 in the planned ponds will have 20 ppt to 35 ppt TDS. To assess 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 E-2.

---

1. "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).

Table E-2. Summary of Dispersion Ratings for Pinhole Tests for Varying TDS in Water

	Total Dissolved Soils in Water		
Sample	**0 ppt**	**20 ppt**	**40 ppt**
1HA	D1	D2	ND4
4HA	D1	ND4	ND4
11VC	D2	D1	D2
16VC	D1	D1	D2
20VC	D2	D2	ND4
28VC	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. Methods of avoiding erosion/piping are discussed in the seepage control section.

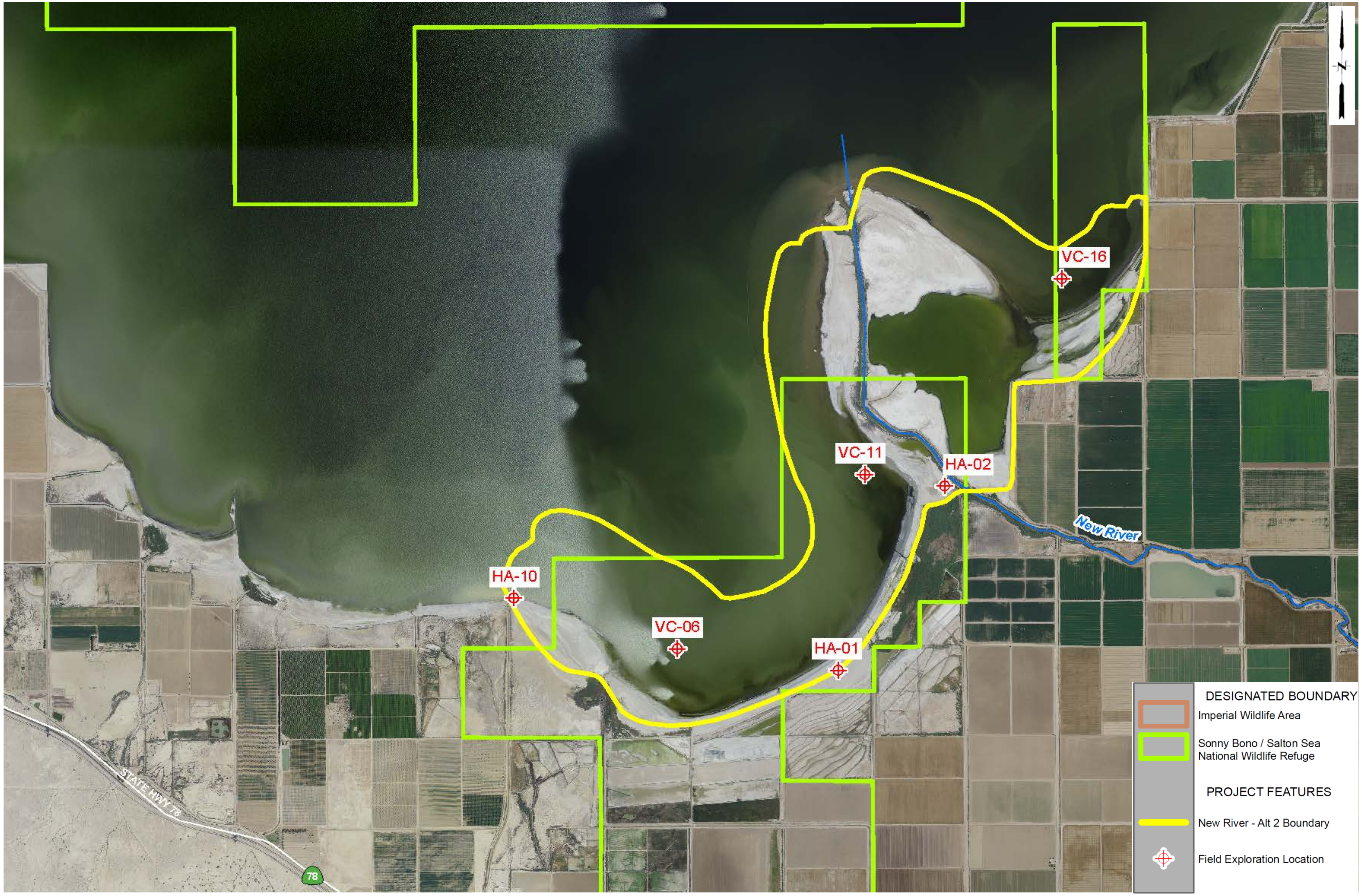
APPENDIX F

APPENDIX F

LOGS OF HAND AUGER BORINGS AND VIBRACORES

2010 EXPLORATION OF NEW RIVER AND ALAMO RIVER SITES

TABLE OF CONTENTS

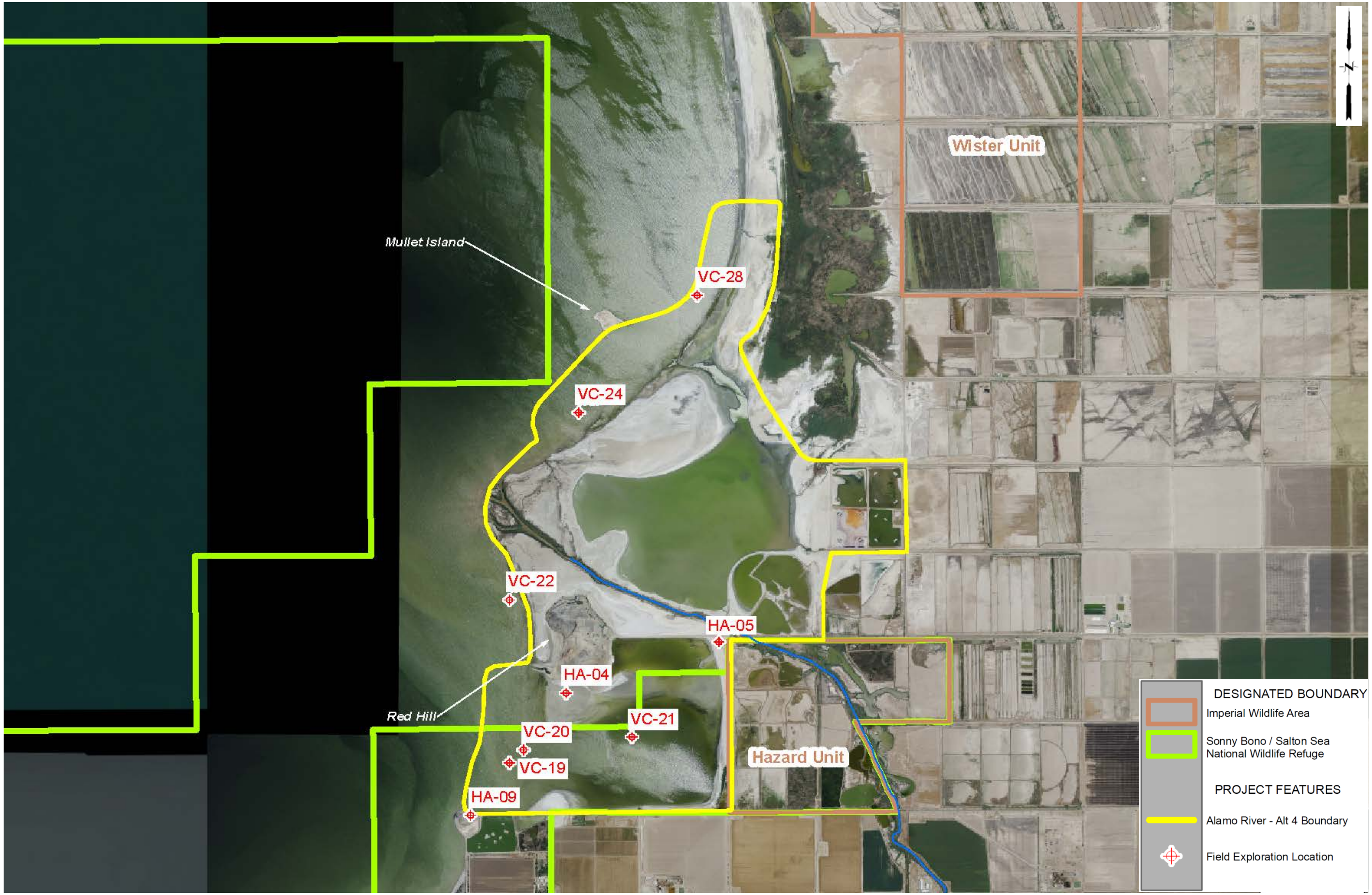


0 2,700 ft

1 inch = 2,700 feet
Approximate Scale

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Exploration Site Plan** **New River**

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



0 2,700 ft

1 inch = 2,700 feet
Approximate Scale

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Exploration Site Plan** **Alamo River**

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/15/2010 Drilling Method : Hand Auger Elevation (Feet) : Latitude : 33.0949 Longitude : -115.6957 Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
						Fat Clay (CH), olive gray, moist, medium stiff, with occassional sand partings					Full Suite**
	B								45		Sieve
						Becoming wet					
				CH		Becoming dark gray					
						Becoming saturated					
	B								65		Sieve
	B			CL		Lean Clay (CL), gray, saturated, medium stiff			35		
						Lean Clay (CL), reddish brown, saturated, stiff					
	B			CL					22		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
Species Conservation Habitat Project
Salton Sea, California

Log of 1HA
(Page 1 of 1)

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

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	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
						Lean Clay (CL), tan brown, moist, medium stiff to soft, with some shell fragments					
	B										
1									31		
						Becoming dark gray, saturated					
2				CL	∇						
	B								45		Sieve
3											
	B								54		
4	B			ML		Silt (ML), reddish brown, saturated, medium stiff			41		

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

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Log of 2HA
(Page 1 of 1)

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

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	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
						Silt (ML), mottled olive brown, moist, stiff to medium stiff, low plasticity					Sieve* Full Suite**
	B			ML					29		
						Lean Clay (CL), gray, moist, soft to medium stiff, with some fine grained sand, low plasticity					
	B			CL		Becoming wet, with shell fragments			33		Sieve
						Fat Clay (CH), dark gray, wet, soft to medium stiff					
	B				▽				46		Sieve
5				CH							
	B								47		
						Bottom of boring at 7.0 feet					

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).

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Log of 4HA
(Page 1 of 1)

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

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	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
				CH		Fat Clay (CH), mottled olive gray, moist, meduim stiff, trace of organics, rare salt crystals					
	B								44		
						Becoming moist, thin shell bed at 1.5 feet					
	B					Sand seams between 1.7 and 2 feet			49		Sieve
						Becoming dark gray, saturated, soft to medium stiff, organic odor					
	B					Soft zone between 3 and 3.5 feet			55		
						Becoming gray					
	B								49		
5	B			SM	▽	Silty Sand (SM), dark gray, fine grained sand, saturated, loose			20		Sieve

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

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	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	B			CL		Lean Clay (CL), mottled tan and dark gray, wet, medium stiff to soft, with shell fragments			44		
	B			CL		Sandy Lean Clay (CL), wet, medium stiff, organic odor			44		Sieve
	B			SC		Clayey Sand (SC), gray, saturated, medium dense			29		
				CL		Sandy Lean Clay (CL), gray, saturated, stiff					
	B			CL		Lean Clay (CL), gray, saturated, stiff			33		
5	B			CL		Lean Clay (CL), reddish brown, saturated, stiff			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.

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Log of 9HA
(Page 1 of 1)

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

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	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	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		Sieve
					▽	Becoming dark gray to black, saturated					
	B			SC		Clayey Sand (SC), tan, saturated, loose to medium dense			21		Sieve
	B								34		
	B			CL		Sandy Lean Clay (CL), reddish brown, saturated, stiff			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.

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	V			ML		Silt (ML), gray, saturated, soft to stiff, non plasticplastic, with sand, organic odor			69		Sieve
1											
						No recovery below 1.3 feet					
2											

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

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

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Log of 6VC
(Page 1 of 1)

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/17/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.1109 Longitude : -115.6931 Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	V			CH		Fat Clay (CH), gray, saturated, very soft, organic odor			31		Sieve* Full Suite**
	V								56		
						No recovery below 3.6 feet					
5						Bottom of boring at 5.0 feet					

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
Species Conservation Habitat Project
Salton Sea, California

Log of 11VC
(Page 1 of 1)

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

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	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	V			CH		Fat Clay (CH), gray, saturated, very soft, organic odor			43		Sieve* Full Suite**
	V					Becoming soft			52		
				CL		Lean Clay (CL), reddish brown, saturated, soft					
5						No recovery below 4.0 feet					

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).

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/14/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.188 Longitude : -115.6184 Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	V			ML		Sandy Silt (ML), gray, saturated, medium stiff, organic odor			44		Sieve
	V			ML		Silt (ML), gray, saturated, soft to medium stiff, low plasticity			34		
5	V			CH		Fat Clay (CH), gray, saturated, soft to medium stiff, organic odor Becoming stiff at 6 feet			38		Sieve
						No recovery below 6.2 feet					

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

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/14/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.1891 Longitude : -115.617 Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
				CH		Fat Clay (CH), gray, saturated, medium stiff, organic odor					Sieve* Full Suite**
	V								29		
						Becoming soft					
	V								39		
5						No recovery below 4.7 feet					

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).

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/14/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.1901 Longitude : -115.6065 Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
				CH		Fat Clay (CH), gray, saturated, very soft, organic odor					
	V								56		
	V								53		Sieve
						Becoming soft to medium stiff					
5						No recovery below 4.8 feet					

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

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/14/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.2018 Longitude : -115.6183 Material Description	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	V			SM		Silty Sand (SM), gray, saturated, loose to medium dense, organic odor			33		
	V			CH		Fat Clay (CH), gray, saturated, soft, with sand			32		Sieve
5						No recovery below 4.0 feet					

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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(Page 1 of 1)

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

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	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	V			SM		Silty Sand (SM), gray, saturated, loose			28		Sieve
	V			ML		Silt (ML), gray, saturated, medium stiff to soft, organic odor, non-plastic			57		
5	V			CL		Lean Clay (CL), gray, saturated, soft, organic odor			42		Sieve
						No recovery below 6.4 feet					

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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Log of 24VC
(Page 1 of 1)

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

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	Torvane (tsf)	Pocket Pen (tsf)	Moisture Content (%)	Dry Density (pcf)	Other Laboratory Tests
	V			CH		Fat Clay (CH), gray, saturated, very soft, lowplastic, organic odor			48		Sieve* Full Suite**
	V								45		
	V								64		
5						Becoming soft					
						No recovery below 5.7 feet					

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. F-17

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		- Water Level at Time of Drilling	P	- Push
			- Water Level after Drilling (with date measured)	Perm	- Permeability
M	- 2.5 inch	Consol	- Consolidation	Sieve	- Particle Size Analysis
		Gs	- Specific Gravity	VS	- Laboratory Vane Shear (psf)
C	- 3.0 inch	LL	- Liquid Limit (%)	-200	- % Passing No. 200 Sieve
		PI	- Plasticity Index (%)		
T	- Shelby Tube	TxUU	- Shear Strength (psf) - Unconsolidated Undrained Triaxial Shear		
		TxCU	- Shear Strength (psf) - Consolidated Undrained Triaxial Shear		
B	- Bag	UC	- Compressive Strength (psf) - Unconfined Compression		

KEY TO TEST DATA

Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Soil Classification Chart

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

APPENDIX G

APPENDIX G

LABORATORY TEST RESULTS

2010 EXPLORATION OF NEW RIVER

AND ALAMO RIVER SITES

TABLE OF CONTENTS

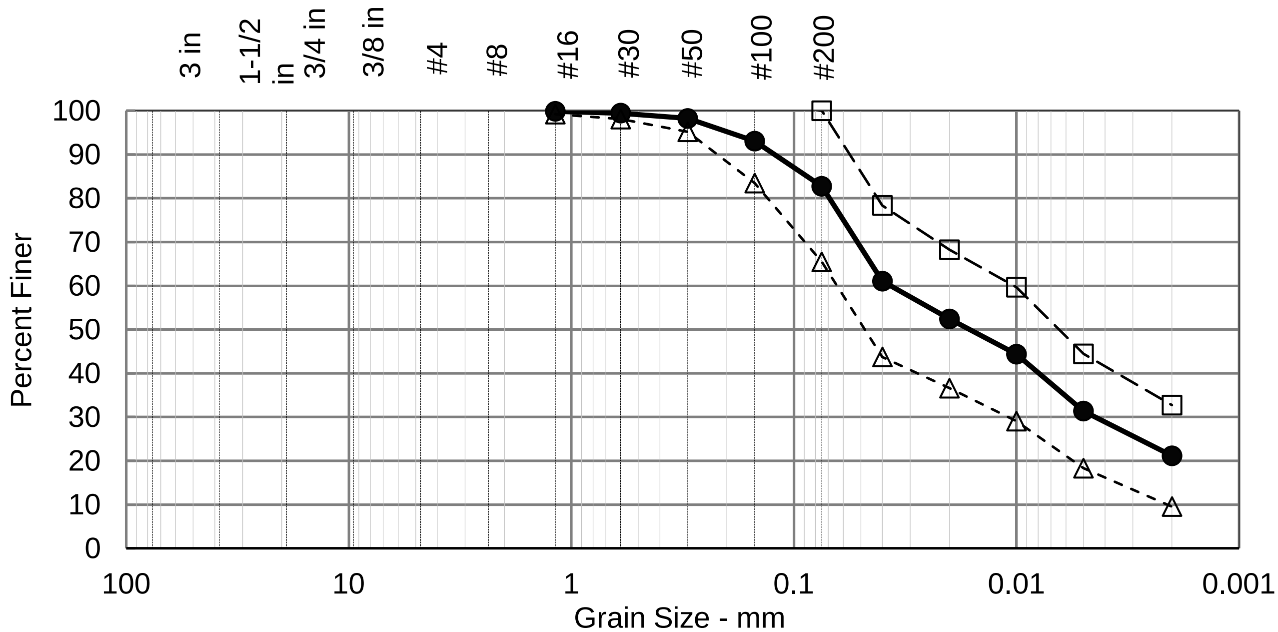
Summary of Laboratory Test Results

Table G-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.



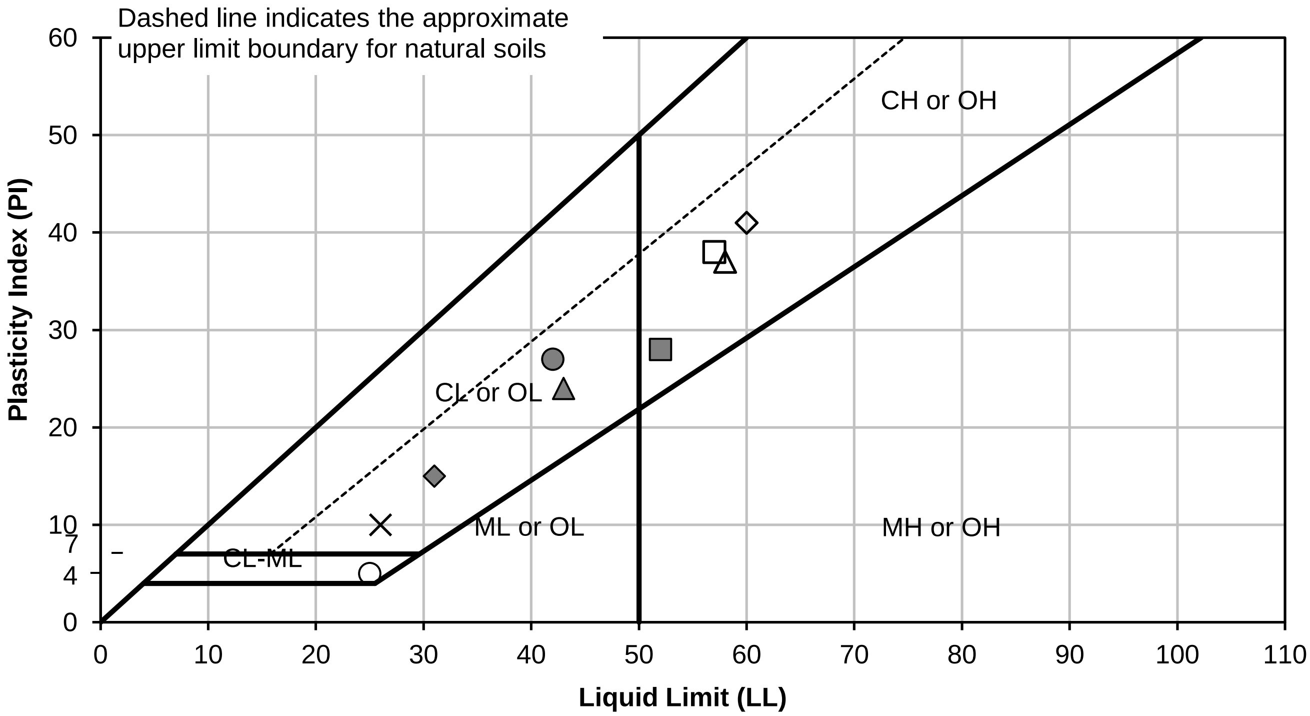
Key to Gradation Plots	
□	Mean Plus One Standard Deviation
●	Mean Grain Size of all sea sediment samples tested
△	Mean Minus One Standard Deviation

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 (1HA and 4HA) are not included in this summary.

Salton Sea Species Conservation Habitat Project Salton Sea, California	**Summary of Sieve Analysis on Sea Sediments**

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



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

Salton Sea
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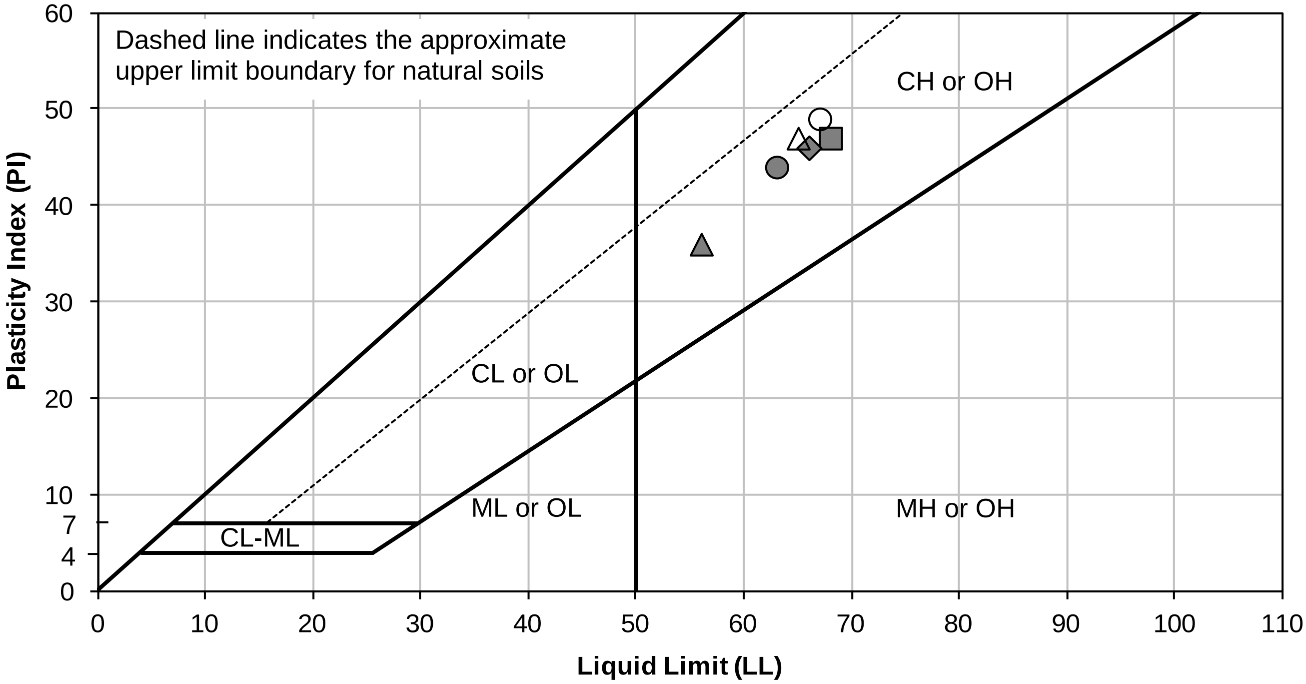
Atterberg Limits on Individual Samples

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



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

Salton Sea
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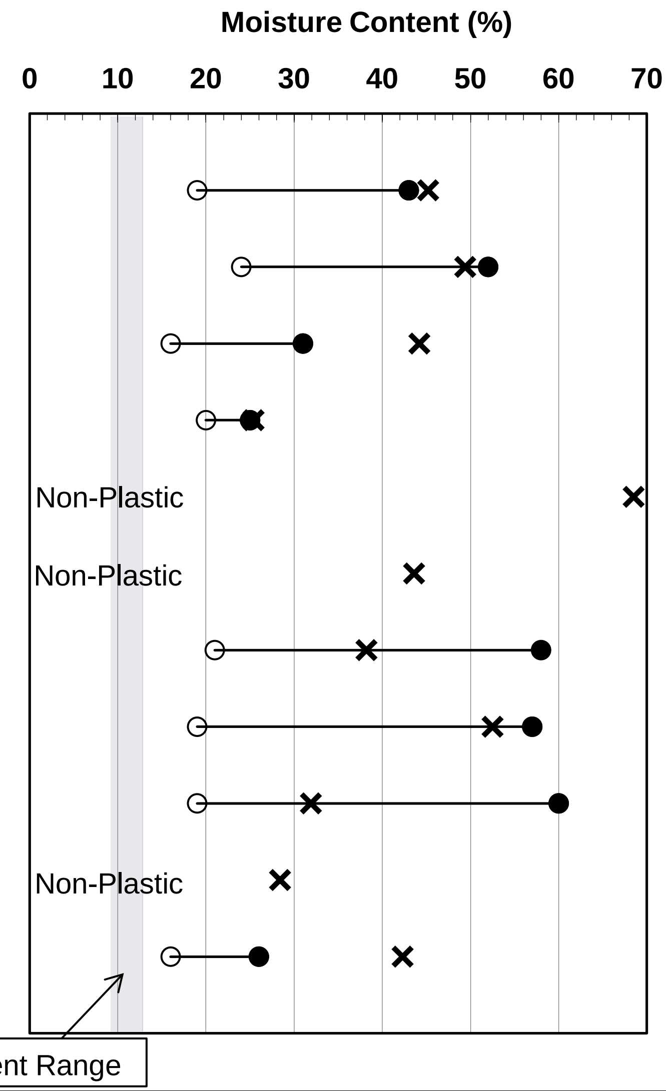
Atterberg Limits on Bulk and Composite Samples

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

Sample Descriptions	Boring Nos. (Depth in feet)
Tan Brown Lean Clay (CL)	2HA (1.5 - 3.0)
Olive Gray Fat Clay (CH)	5HA (1.5 - 2.5)
Dark Gray Sandy Lean Clay (CL)	9HA (1.5 - 3.0)
Tan Gray Clayey Silt (CL_ML)	10HA (0.0 - 1.5)
Gray Silt (ML)	6VC (0.0 - 1.3)
Gray Sandy Silt (ML)	19VC (0.0 - 0.9)
Gray Fat Clay (CH)	19VC (3.5 - 6.2)
Gray Fat Clay (CH)	21VC (2.1 - 4.8)
Gray Fat Clay (CH)	22VC (1.3 - 4.0)
Gray Silty Sand (SM)	24VC (0.0 - 1.1)
Gray Lean Clay (CL)	24VC (3.7 - 6.4)



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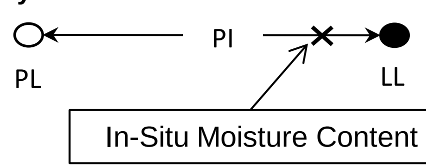
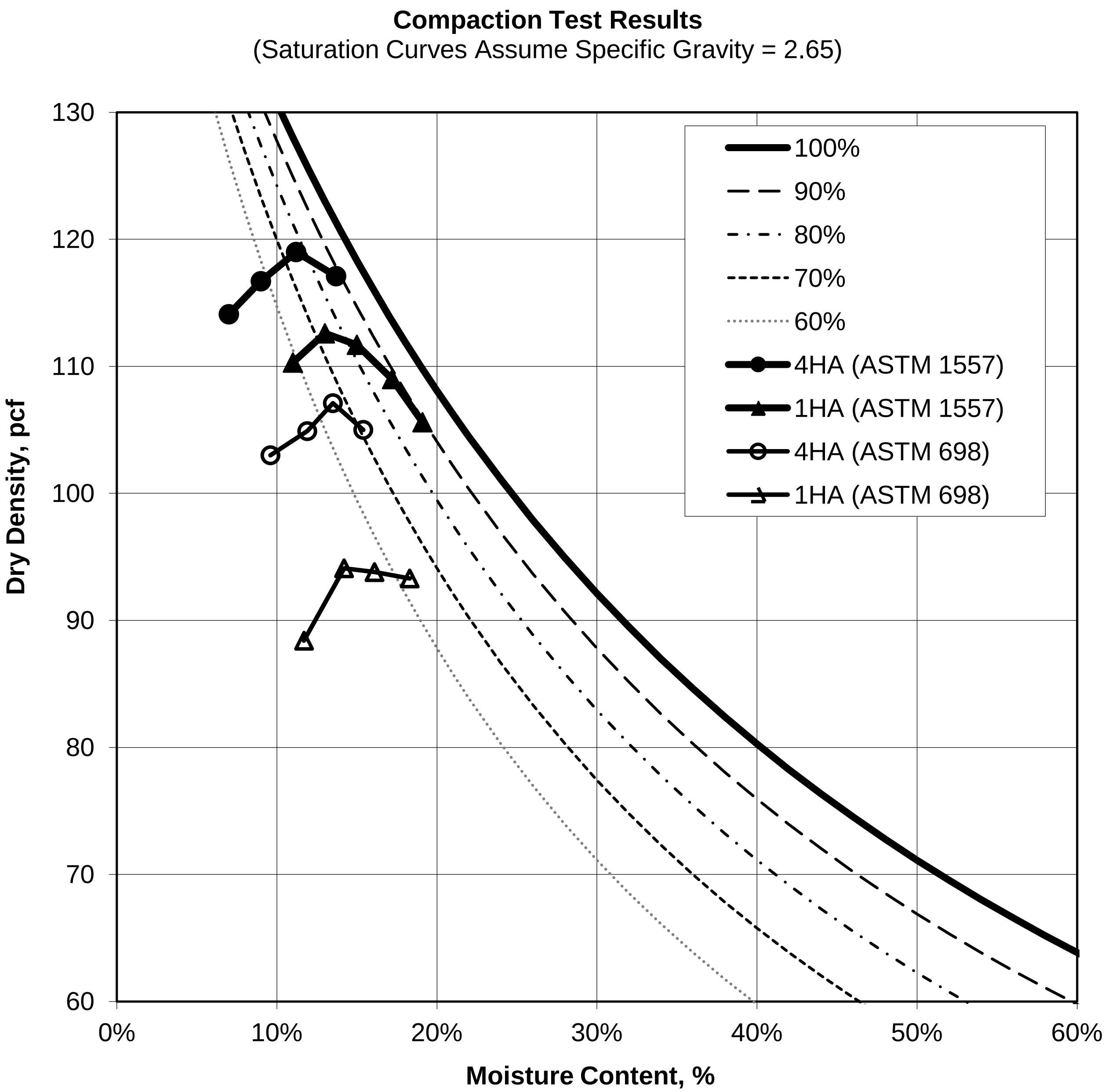


Salton Sea
Species Conservation Habitat Project
Salton Sea, California

In-Situ Moisture Contents Relative to Atterberg Limts

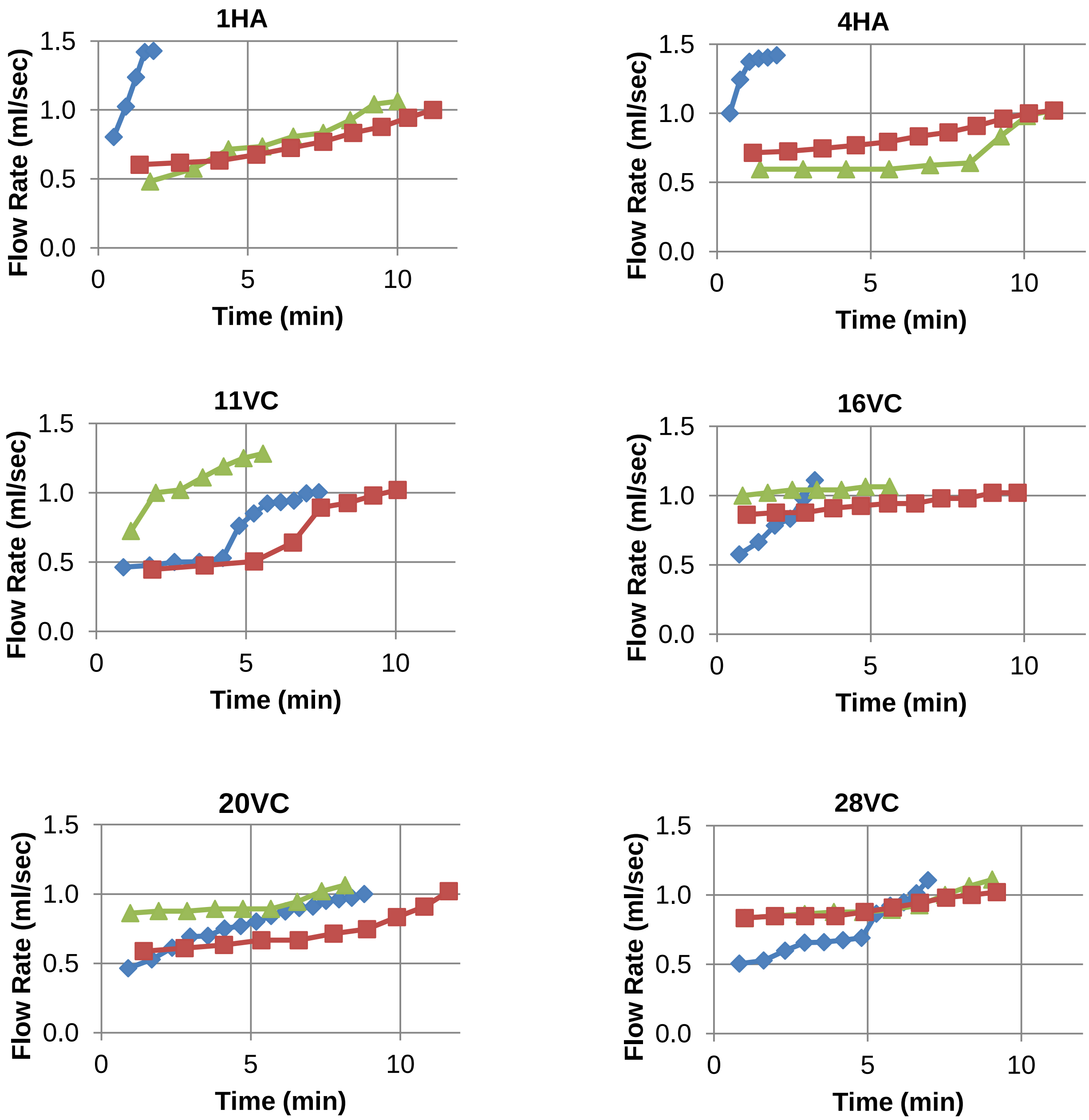
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. G-5



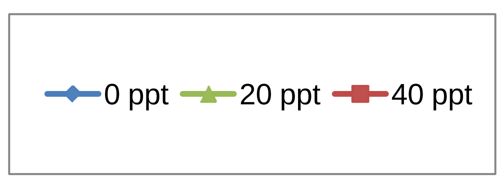
Salton Sea
Species Conservation Habitat Project
Salton Sea, California

Compaction Test Results

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

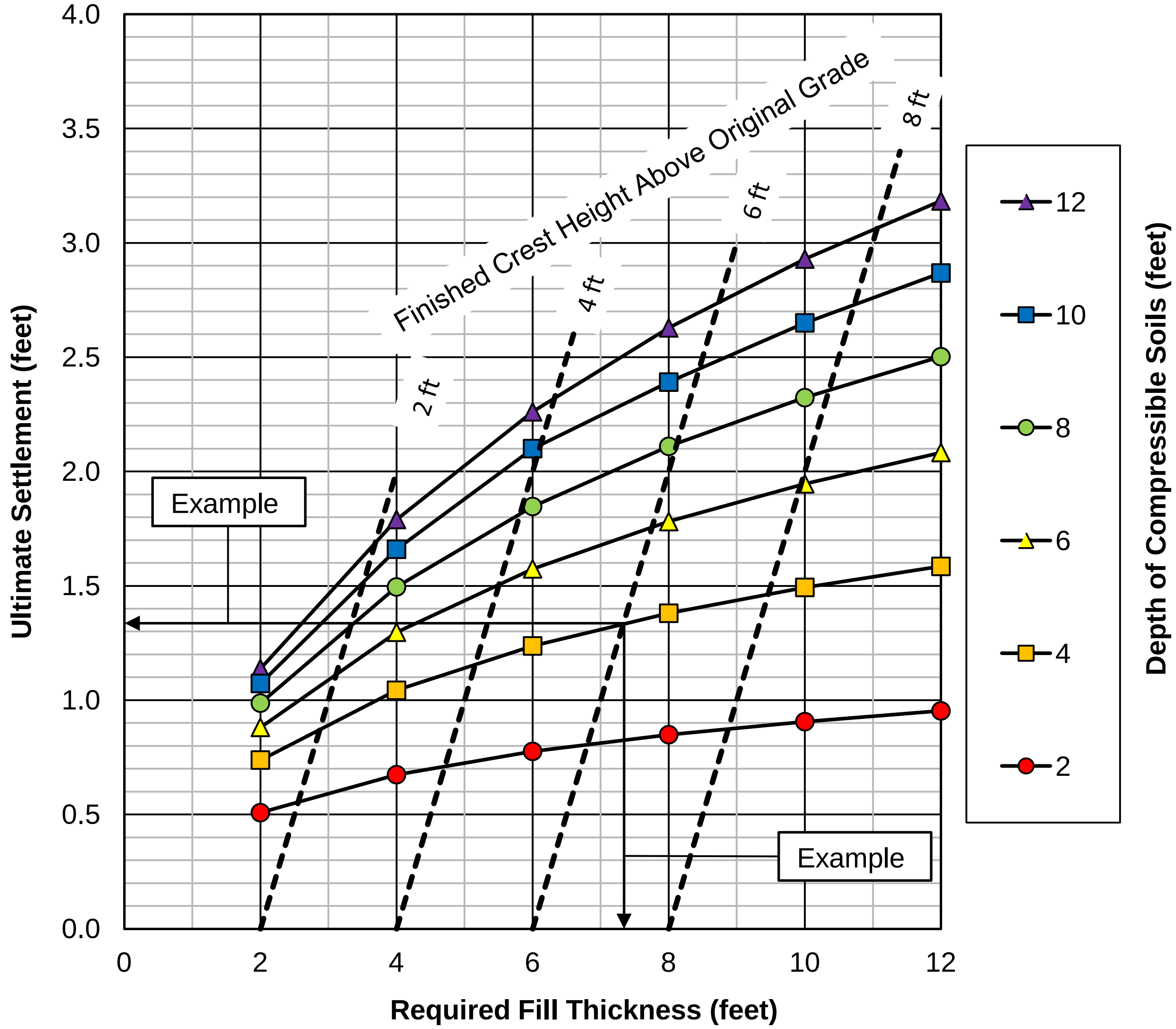


Dispersive classification *D1-Dispersive* applies where the flow rate is above 1.0 ml/sec in the first 5 minutes. Classification *D2-Dispersive* occurs if the rate reaches 1.0 ml/sec in the second 5 minute interval (5 to 10 minutes). Classification *ND4 - Intermediate* occurs if the rate increases to 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 Species Conservation Habitat Project Salton Sea, California	**Summary of Pinhole Tests**

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

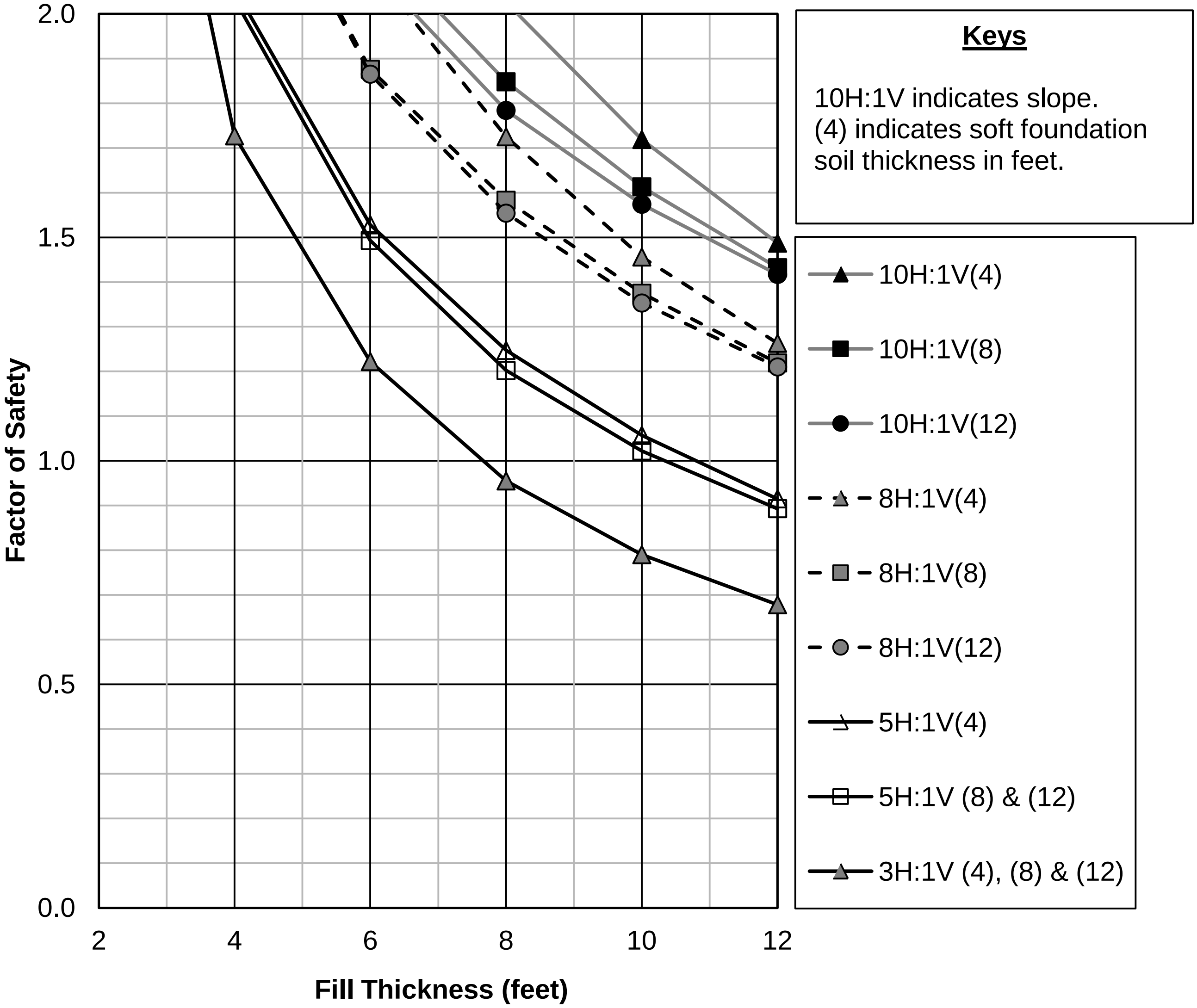


Notes:

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 Species Conservation Habitat Project Salton Sea, California	**Ultimate Settlement vs Fill Thickness Plot**

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

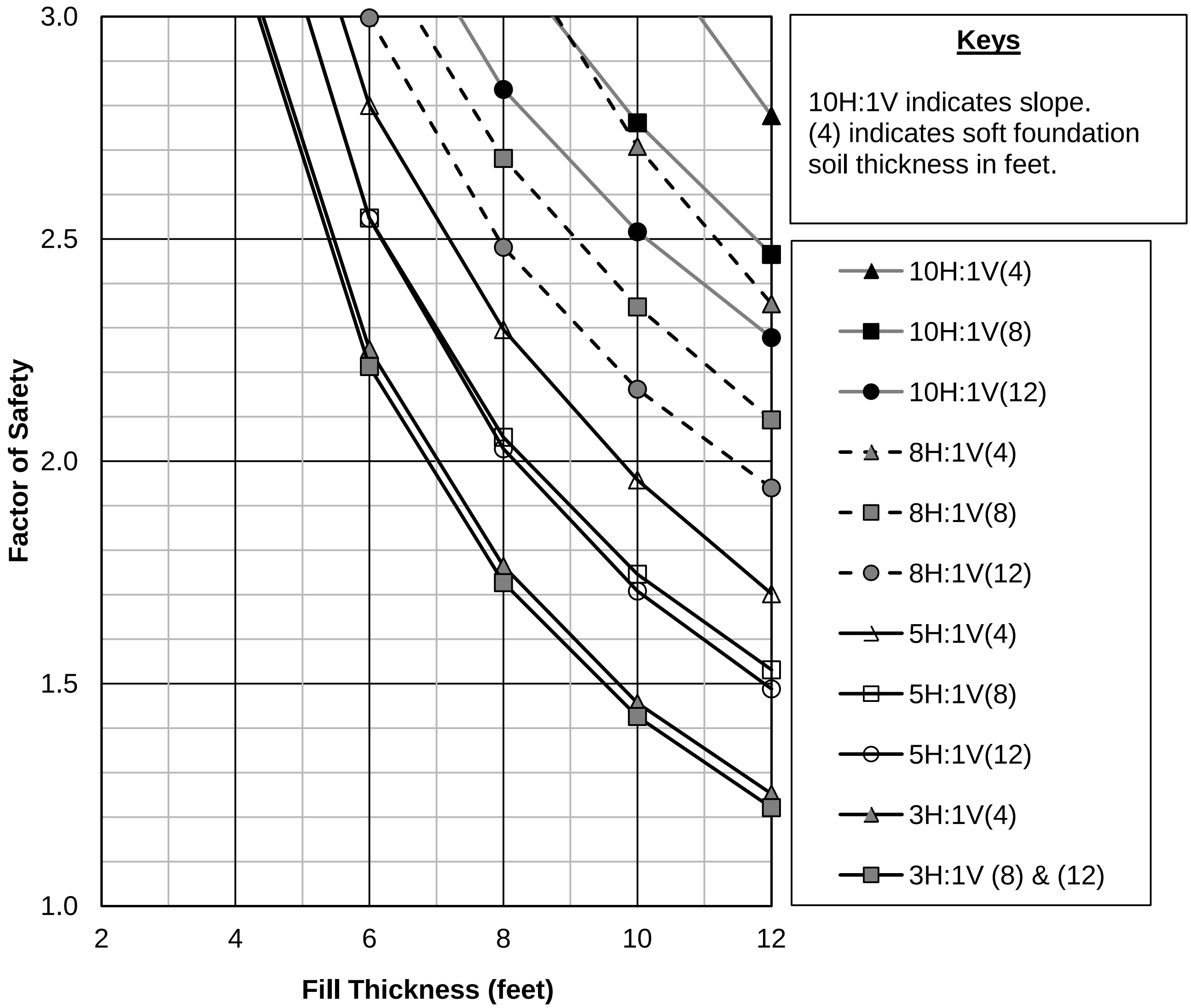


Notes:

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 Species Conservation Habitat 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. G-9



Notes:

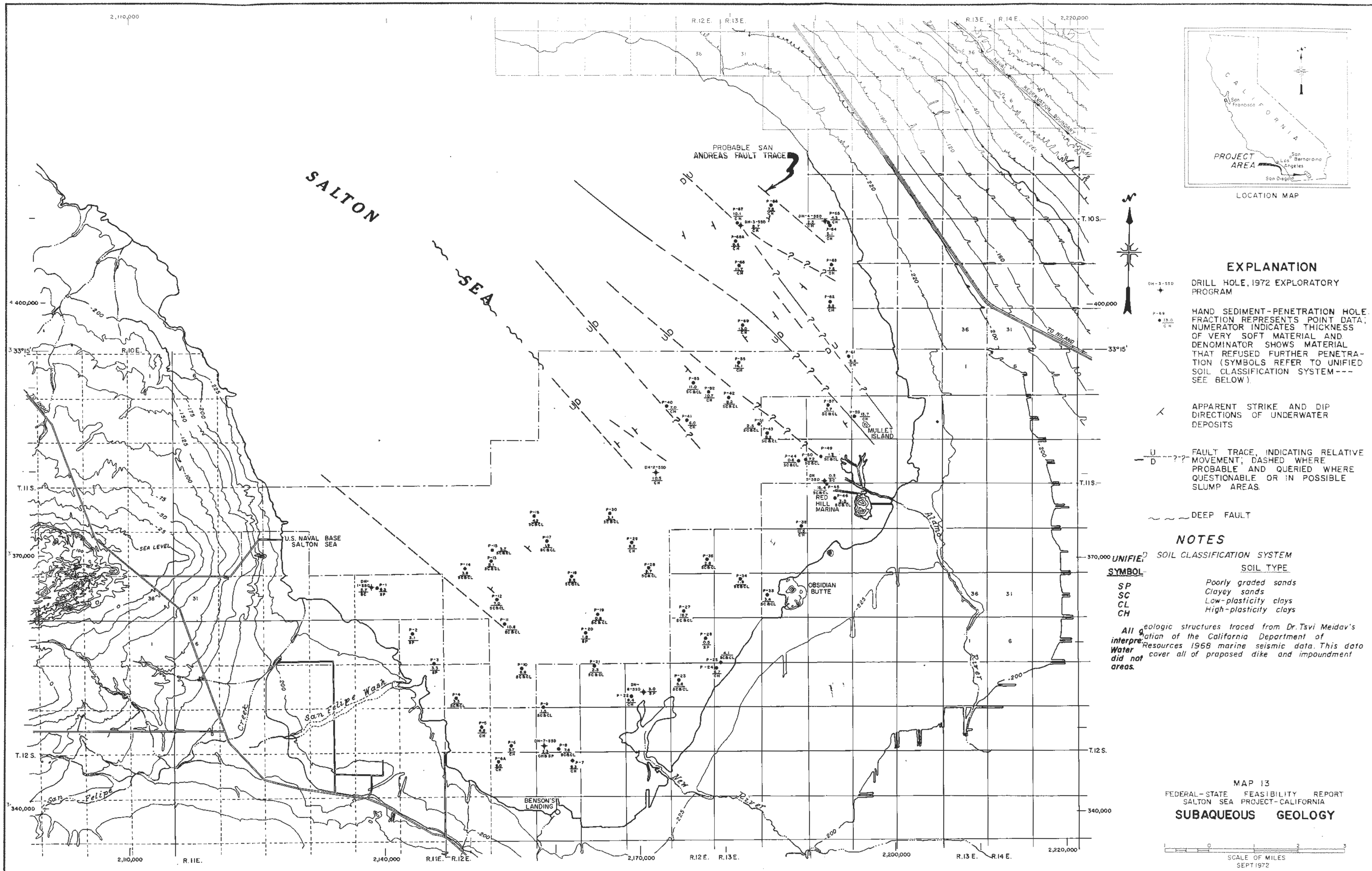
1. Factor of Safety represents the Immediately-After-Construction condition.
2. Analyses assume uniform slopes (3H:1V, 5H:1V, 8H:1V and 10H:1V) with a maximum slope height varying form 2 to 12 feet, constructed on top of soft foundation soils of 4, 8, and 12 feet in thickness.
3. Analyses assume an undrained 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 Species Conservation Habitat 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. G-10

APPENDIX H

APPENDIX H
EXISTING SUBSURFACE DATA
1974 SALTON SEA FEDERAL-STATE FEASIBILITY REPORT



Interior - Reclamation, B.C., Nev. 5-74

DRAWING NO. 1169-326-41

Plate No. H-1

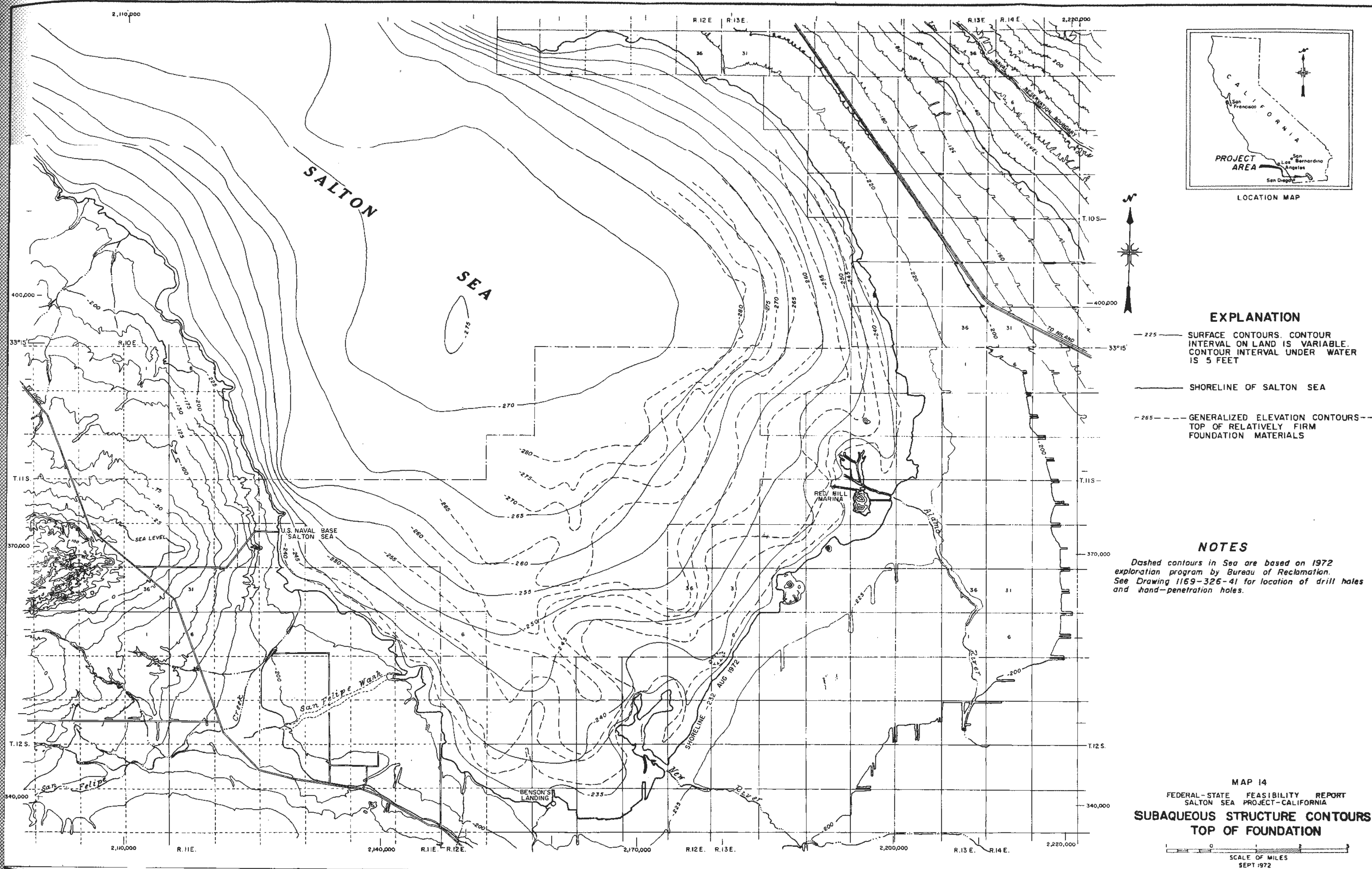

SALTON SEA
LOCATION MAP
CALIFORNIA
PROJECT AREA
San Francisco
Los Angeles
San Bernardino
San Diego
EXPLANATION
— 225 — SURFACE CONTOURS. CONTOUR INTERVAL ON LAND IS VARIABLE. CONTOUR INTERVAL UNDER WATER IS 5 FEET
SHORELINE OF SALTON SEA
— 265 — — — GENERALIZED ELEVATION CONTOURS-- TOP OF RELATIVELY FIRM FOUNDATION MATERIALS
NOTES
Dashed contours in Sea are based on 1972 exploration program by Bureau of Reclamation. See Drawing 1169-326-41 for location of drill holes and hand-penetration holes.
MAP 14
FEDERAL-STATE FEASIBILITY REPORT
SALTON SEA PROJECT-CALIFORNIA
SUBAQUEOUS STRUCTURE CONTOURS
TOP OF FOUNDATION
SCALE OF MILES
SEPT 1972
DRAWING NO. 1169-326-99
U.S. NAVAL BASE SALTON SEA
RED HILL MARINA
BENSON'S LANDING
SHORELINE -232 AUG 1972
San Felipe Wash
San Felipe Creek
New River
Alamo River
TO NILAND
NAVAL RESERVATION BOUNDARY
SEA LEVEL
T.10 S.
T.11 S.
T.12 S.
R.10 E.
R.11 E.
R.12 E.
R.13 E.
R.14 E.
33°15'
2,110,000
2,140,000
2,170,000
2,200,000
2,220,000
400,000
370,000
340,000

Plate No. H-2

Plate No. H-3

GEOLOGIC LOG OF LAKE BOTTOM DRILL HOLE NO. 2 SSD . . .

FEATURE . . SALTON SEA DIKE . . . . PROJECT . . . SALTON SEA . . . . STATE . . . CALIFORNIA . . . .

LOCATION . . . . COORDINATES . N 380,059.69 . . E 2,171,686.69 . . LAKE BOTTOM ELEVATION . -256.5' . . . . . .

BEGUN . 8/15/72 . . . . . FINISHED . 8/16/72 . . . . DRILLERS State of Calif. Drill Crew. DEPTH OF WATER . . 24.5 . . . . .

LOGGED BY . E. E. Komie, G. P. Ewoldt . . . . COMPILED BY . . G. P. Ewoldt . . . .

NOTES	TYPE OF TEST OR HOLE	PENETRATION TESTS: STANDARD BLOWS (10 20 30 40 50 60)	TEST DATA: TW BLOWS/FOOT	TEST DATA: PR BLOWS/FOOT	TEST DATA: RECOVERY	CORE RECOVERY (%)	DEPTH (FEET)	ELEV. (FEET)	TEST SAMPLES	CLASSIFICATION AND PHYSICAL CONDITION
SITE South end of the Salton Sea. **PURPOSE** To determine foundation conditions for the proposed dike.										0.0 – 18.2 FAT CLAY: High plasticity with scattered organic material, very soft, gray to brown (CH).
EQUIPMENT Acker Nx8, hydraulic feed rotary drill mounted on barge.	TW		H/3.0		3.0	100	10			
	PR			2/1.0	1.0					
PROCEDURE Barge location slightly different on second day of drilling but both sites within 200 yds. of designated location.	W									
	TW		20/2.0		2.0	100		-274.7		18.2 – 35.5 CLAYEY SAND: Fine to medium sand, micaceous, with about 20% low plasticity fines, firm, brown (SC).
Sounded lake bottom.	PR			9/1.0	0.5		20			
Took modified PR test by placing apparatus and hammer on bottom. Penetrometer sank 10.5' under its own weight. Drove to 12.0' with 9 blows.	W									
Moved barge a few feet and advanced hole by taking Shelby samples and standard penetration tests with interspersed washed intervals.	TW		18/2.0		2.0	100				
	PR			11/1.0	1.0		30			
	W							-292.0		35.5 – 40.0 FAT CLAY High plasticity, soft to firm, brown with gray-green mottling. (CH).
	TW		20/3.0		3.0	100				
	PR			9/1.0	1.0		40	296.5		
							50			

Thin-wall drive sampler advanced by blows of 140 lb hammer dropped 30", except advanced by hydraulic pressure where indicated by H.

EXPLANATION

MP = Modified penetration test
PR = Standard field penetration test
C = Core barrel
Rb = Rockbit
Dr = Drive sampler
TW = Thin-walled drive sampler
W = Washing or jetting
Ss = Sediment sampler
Ts = Thief sampler

Plate No. H-4

GEOLOGIC LOG OF LAKE BOTTOM DRILL HOLE NO. 5SSD

FEATURE: SALTON SEA DIKE
PROJECT: SALTON SEA
STATE: CALIFORNIA
LOCATION:
COORDINATES: N 379,019.06 E 2,191,452.19
LAKE BOTTOM ELEVATION: -237.1
BEGUN: 8/22/72
FINISHED: 8/22/72
DRILLERS: State of Calif. Drill Crew
DEPTH OF WATER: 5.1
LOGGED BY: R. H. Raymond
COMPILED BY:

NOTES

SITE
South end of the Salton Sea.

PURPOSE
To determine foundation conditions for the proposed dike.

EQUIPMENT
Acker Nx 8, Hydraulic feed, rotary drill mounted on barge.

PROCEDURE
1. Sounded lake bottom.
2. Attemped Ss 0.0'-2.5' with no recovery.
3. Moved barge and conducted Modified P. R. 0.0'-0.7' free fall, 0.7'-1.7' 15 blows.
4. Moved barge again, and took Shelby samples and penetration resistance tests with interspersed washed or washed or rock-bitted intervals in the lower portion of the hole.

TEST DATA

Type of test or hole	Penetration tests (standard blows)	TW blows/foot	PR blows/foot	Recovery	Core recovery (%)	Elev. (feet)
TW	MP	H/2.8		1.5	54	-237.9
TW		21/2.8		2.0	71	
TW		37/2.8		2.45	88	-243.1
PR	•		5/1.0	1.0		
TW		25/2.8		2.6	93.	-247.4
TW		45/2.8		2.35	84	
PR	•		17/1.0	1.0		
Rb						-257.0
TW		47/1.5		1.5	100	
PR	•		21/1.0	1.0		
W						
PR	•		17/1.0	1.0		242.0

Depth scale (feet): 10, 20, 30, 40, 50. Standard blows scale: 10 20 30 40 50 60.

CLASSIFICATION AND PHYSICAL CONDITION

0.0 – 0.8 **CLAYEY SAND**: About 70% fine sand, micaceous, 30% clay, very soft, gray (SC).

0.8 – 6.0 **CLAYEY SAND**: About 70% fine sand, micaceous, and 30% high plasticity fines, firm, brown (SC).

8.0 – 10.3 **POORLY GRADED SAND to SILTY SAND**: Fine sand, micaceous, clean to 10% silt, firm, brown (SP-SM).

10.3 – 19.9 **FAT CLAY**: High plasticity, firm, brown (CH).

19.9 – 40.0 **POORLY GRADED SAND**: Clean, fine sand, micaceous, lower 0.9' clayey sand, firm, brown (SP).

Thin-wall drive sampler advanced by blows of 140 lb hammer dropped 30", except advanced by hydraulic pressure where indicated by H.

EXPLANATION

MP = Modified penetration test
PR = Standard field penetration test
C = Core barrel
Rb = Rockbit
Dr = Drive sampler
TW = Thin-walled drive sampler
W = Washing or jetting
Ss = Sediment sampler
Ts = Thief sampler

GEOLOGIC LOG OF LAKE BOTTOM DRILL HOLE NO. 6 SSD

FEATURE: SALTON SEA DIKE PROJECT: SALTON SEA STATE: CALIFORNIA
LOCATION: COORDINATES: N 354,177.19 E 2,170,263.44 LAKE BOTTOM ELEVATION: -238.5
BEGUN: 8/24/72 FINISHED: 8/24/72 DRILLERS: Calif. State Drill Crew DEPTH OF WATER: 6.5
LOGGED BY: R. H. Raymond COMPILED BY:

NOTES

SITE
South end of the Salton Sea.

PURPOSE
To determine foundation conditions for the proposed dike.

EQUIPMENT
Acker Nx 8, hydraulic feed, rotary drill mounted on barge.

PROCEDURE
Sounded lake bottom and conducted modified PR test by setting apparatus including hammer on bottom. Penetrometer sank to 0.2' under its own weight. Drove 0.2 to 1.2' with 7 blows.
Moved a few feet and advanced hole by taking Shelby samples and standard PR tests with interspersed washed intervals.

TEST DATA

Type of test or hole	TW blows/foot	PR blows/foot	Recovery	Core recovery (%)	Elev. (feet)
TW	23/2.8		2.4	85	
					-241.5
TW	15/2.8		1.9	68	
PR		5/1.0	1.0		-244.9
TW	20/2.8		1.6	56	
PR		5/1.0	0.8		
TW	9/2.8		1.3	46	
PR		2/1.0	1.0		-254.0
W					
TW	66/2.0		1.6	78	
PR		15/1.0			
W					
PR		22/1.0	1.0		
TW	56/2.0		1.7	83	-270.2

Penetration tests: MP; standard blows 10 20 30 40 50 60. Depth (feet): 10, 20, 30, 40, 50.

CLASSIFICATION AND PHYSICAL CONDITION

0.0 – 3.0 **POORLY GRADED SAND**: Clean fine grained, micaceous, very soft, gray (SP).

3.0 – 6.4 **POORLY GRADED SAND**: Clean fine grained, micaceous, soft to firm, brown (SP).

6.4 – 15.5 **FAT CLAY**: High plasticity, upper 0.5' sandy, soft to firm, brown (CH).

15.5 – 31.7 **Interbedded CLAYEY SAND, FAT CLAY, POORLY GRADED SAND, LEAN CLAY and SILTY SAND.**
Layers or lenses a few inches to a few feet thick of high to low plasticity clay, silty sand and sand and various mixtures; soft to 19.7, firm to hard below, brown (SC, SM, CH, CL).

Thin-wall drive sampler advanced by blows of 140 lb hammer dropped 30", except advanced by hydraulic pressure where indicated by H.

EXPLANATION

MP = Modified penetration test
PR = Standard field penetration test
C = Core barrel
Rb = Rockbit
Dr = Drive sampler
TW = Thin-walled drive sampler
W = Washing or jetting
Ss = Sediment sampler
Ts = Thief sampler

Plate No. H-6

GEOLOGIC LOG OF LAKE BOTTOM DRILL HOLE NO. 7 SSD

FEATURE: SALTON SEA DIKE — PROJECT: SALTON SEA — STATE: CALIFORNIA

LOCATION: — COORDINATES: N 347,567.69 E 2,158,581.81 — LAKE BOTTOM ELEVATION: -243.5

BEGUN: 8/23/72 — FINISHED: 8/23/72 — DRILLERS: State of Calif Drill Crew — DEPTH OF WATER: 11.5'

LOGGED BY: R. H. Raymond — COMPILED BY:

NOTES

SITE
South end of the Salton Sea.

PURPOSE
To determine foundation conditions for the proposed dike.

EQUIPMENT
Acker Nx 8, hydraulic feed, rotary drill mounted on barge.

PROCEDURE
1. Sounded lake bottom.
2. Conducted modified PR test: 2.3' free fall; 12 blows to 33', 6 blows to 4.3', 11 blows to 5.3'.
3. Moved barge a few feet and took Shelby samples and penetration resistance tests with interspersed washed intervals in the lower portion of the hole.

Test data

Type of test or hole	TW blows/foot	PR blows/foot	Recovery	Core recovery (%)
TW	H / 2.0		1.5	75
TW	6 / 2.8		2.6	92
PR		12 / 1.0	1.0	
TW	24 / 2.8		1.7	61
TW	59 / 2.0		1.4	70
PR		34 / 1.0	1.0	
TW	68 / 1.5		1.3	87
W				
PR		57 / 1.0	1.0	
W				
PR		23 / 1.0	1.0	
TW	61 / 2.0		0.0	0
TW	75 / 2.0		1.25	62

Penetration tests — Standard blows: 10 20 30 40 50 60 (MP)

Depth (feet): 10, 20, 30, 40, 50

Elev. (feet): -244.5, -255.7, 274.6

CLASSIFICATION AND PHYSICAL CONDITION

0.0 – 1.0 <u>FAT CLAY</u>: High plasticity, very soft, gray (CH).

1.0 – 12.2 <u>Interbedded FAT CLAY, SANDY CLAY and POORLY GRADED SAND</u>. Layers or lenses a few to several inches thick of high plasticity clay and clean fine sand and various mixtures of the two; soft to hard, brown (CH, SP).

12.2 – 31.1 <u>POORLY GRADED SAND</u>: Fine grained, clean except lower 1.5' with 30% plastic fines firm to hard, brown (SP).

Thin-wall drive sampler advanced by blows of 140 lb hammer dropped 30", except advanced by hydraulic pressure where indicated by H.

EXPLANATION

MP = Modified penetration test
PR = Standard field penetration test
C = Core barrel
Rb = Rockbit
Dr = Drive sampler
TW = Thin-walled drive sampler
W = Washing or jetting
Ss = Sediment sampler
Ts = Thief sampler

HAND SEDIMENT - PENETRATION DATA SUMMARY SHEET
AUGUST 1972 INVESTIGATION PROGRAM
Salton Sea Project, California

Hole No.	Coordinates North	Coordinates East	Water Depth	Elev. Top of Sediment	Elev. Bottom of Sediment	Sediment* Thickness	Sum of Thickness of Sediment & Water Depth
P-1	366,199.13	2,138,199.31	15.0	-247.0	-253.3	6.3	21.3
P-2	360,578.94	2,142,933.63	12.5	-244.5	-247.6	3.1	15.6
P-3	357,487.13	2,145,517.56	8.0	-240.0	-243.5	3.5	11.5
P-4	353,091.06	2,148,169.81	9.8	-241.8	-245.1	3.3	13.1
P-5	349,961.19	2,151,191.50	9.5	-241.5	-246.0	4.5	14.0
P-6	345,704.69	2,153,157.25	10.5	-242.5	-248.2	5.7	16.2
P-6A	347,616.13	2,154,678.94	7.5	-239.5	-246.0	6.5	14.0
P-7	345,768.13	2,161,780.25	8.7	-240.7	-247.0	6.3	15.0
P-8	347,173.13	2,160,216.25	10.5	-242.5	-250.3	7.8	18.3
P-9	352,213.94	2,158,448.50	12.5	-244.5	-246.0	1.5	14.0
P-10	356,922.31	2,155,883.94	14.8	-246.8	-253.7	6.9	21.7
P-11	362,074.25	2,153,859.25	21.4	-253.4	-261.6	8.2	32.0
P-12	364,972.44	2,152,957.56	23.3	-255.3	-262.3	7.0	30.3
P-13	369,546.81	2,152,191.25	29.6	-261.6	-266.7	5.1	34.7
P-14	368,565.69	2,149,214.56	26.7	-258.7	-262.5	3.8	30.5
P-15	370,740.31	2,152,384.19	30.7	-262.7	-266.4	3.7	34.4
P-16	374,650.63	2,157,157.94	33.8	-265.8	-270.7	4.9	38.7
P-17	371,721.94	2,158,649.88	31.5	-263.5	-265.4	1.9	33.4
P-18	367,678.06	2,161,602.25	26.0	-258.0	-266.8	8.8	34.8
P-19	363,240.19	2,164,828.13	15.2	-247.2	-248.0	0.8	16.0
P-20	361,084.63	2,163,398.56	12.4	-244.4	-246.2	1.8	14.2
P-21	357,320.38	2,164,476.69	10.3	-242.3	-244.6	2.3	12.6
P-22	353,723.50	2,168,864.00	9.2	-241.2	-250.6	9.4	18.6
P-23	355,452.38	2,174,769.44	4.0	-236.0	-241.6	5.6	9.6

* "Sediment" includes Fat Clay deposited from the present Salton Sea, and underlying saturated older lacustrine deposits. All would be displaced by dike embankment.

Hole No.	Coordinates North	Coordinates East	Water Depth	Elev. Top of Sediment	Elev. Bottom of Sediment	Sediment* Thickness	Sum of Thickness of Sediment & Water Depth
P-24	357,065.44	2,178,896.94	7.8	-239.8	-246.5	6.7	14.5
P-25	357,753.94	2,179,365.81	7.7	-239.7	-243.8	4.1	11.8
P-26	360,305.88	2,177,569.94	11.1	-243.1	-243.6	0.5	11.6
P-27	363,597.81	2,174,915.44	15.3	-247.3	-263.0	15.7	31.0
P-28	368,779.13	2,170,837.25	22.0	-254.0	-263.7	9.7	31.7
P-29	371,689.19	2,168,796.63	25.6	-257.6	-263.8	6.2	31.8
P-30	375,215.63	2,166,271.19	30.5	-262.5	-265.6	3.1	33.6
P-31	Water too shallow for boat						
P-32	Water too shallow for boat						
P-33	365,564.81	2,184,799.25	4.6	-236.6	-240.0	3.4	8.0
P-34	367,403.56	2,181,611.69	11.1	-243.1	-245.0	1.9	13.0
P-35	369,731.19	2,177,782.13	15.8	-247.8	-250.6	2.8	18.6
P-38	373,586.06	2,188,813.00	9.5	-241.5	-253.0	11.5	21.0
P-39	(Unable to locate)		28.2	-260.2	-267.2	7.0	35.2
P-40	388,011.75	2,172,909.38	36.0	-268.0	-275.0	7.0	43.0
P-41	386,212.19	2,175,327.56	30.0	-262.0	-268.0	6.0	36.0
P-42	389,028.31	2,180,142.81	23.0	-255.0	-263.2	8.2	31.2
P-43	384,796.31	2,184,768.81	14.8	-246.8	-255.0	8.2	23.0
P-44	381,526.81	2,188,504.94	13.4	-245.4	-246.0	0.6	14.0
P-45	378,776.19	2,191,720.56	4.5	-236.5	-251.9	15.4	19.9
P-46	376,959.00	2,192,815.56	3.5	-235.5	-239.0	3.5	7.0
P-47	Water too shallow for boat						
P-48	Water too shallow for boat						
P-49	382,000.31	2,191,181.81	7.3	-239.3	-247.9	8.6	1.3
P-50	381,822.50	2,189,286.19	10.8	-242.8	-250.0	7.2	18.0
P-51	385,857.38	2,183,597.50	17.0	-249.0	-251.5	2.5	19.5
P-52	389,700.56	2,177,843.31	30.8	-262.8	-273.5	10.7	41.5
P-53	390,781.75	2,176,045.94	36.0	-268.0	-279.0	11.0	47.0

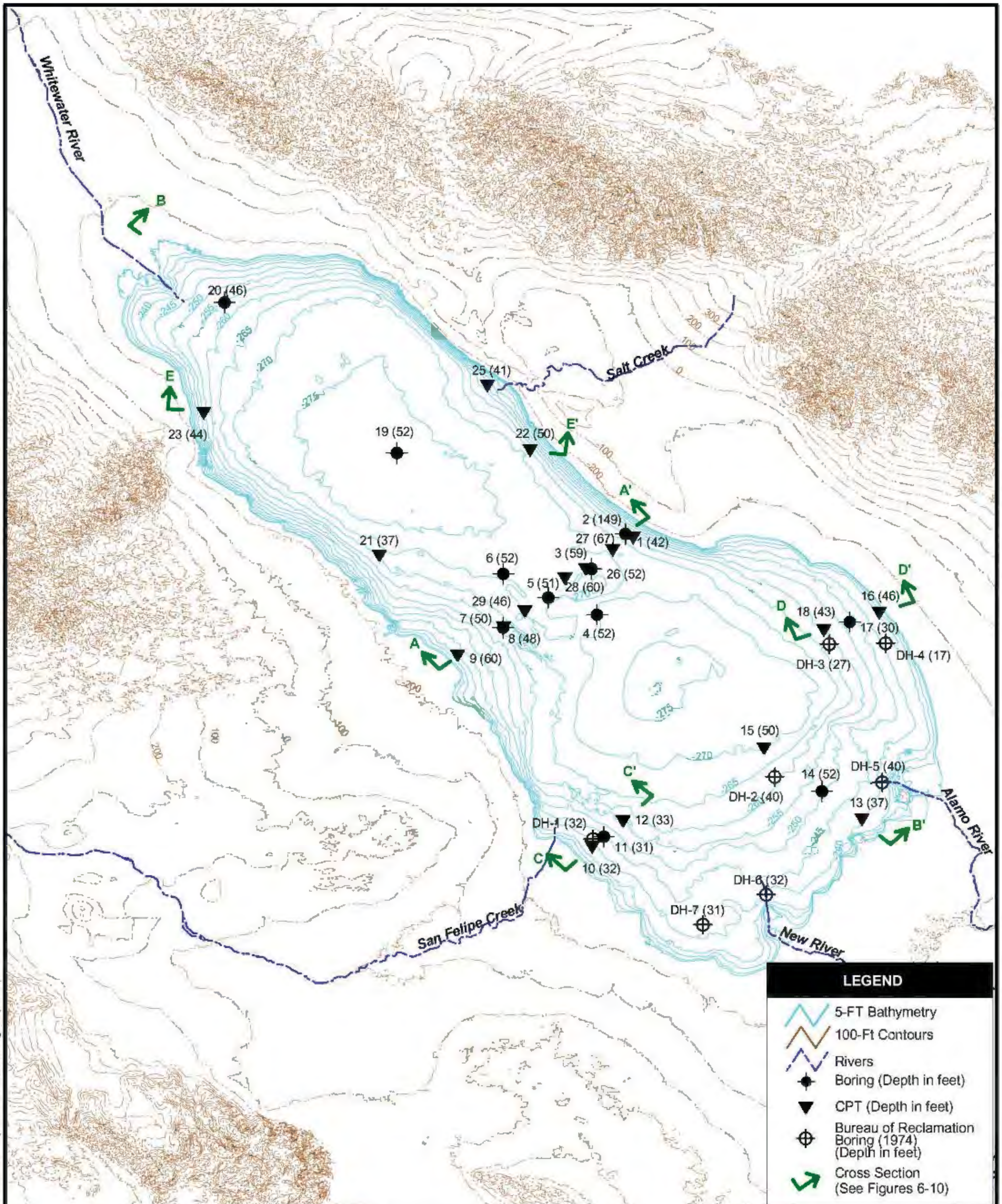
* "Sediment" includes Fat Clay deposited from the present Salton Sea, and underlying saturated older lacustrine deposits. All would be displaced by dike embankment.

Hole No.	Coordinates North	Coordinates East	Water Depth	Elev. Top of Sediment	Elev. Bottom of Sediment	Sediment* Thickness	Sum of Thickness of Sediment & Water Depth
P-55	394,194.13	2,181,363.06	29.4	-261.4	-275.5	14.1	43.5
P-57	388,079.69	2,192,845.44	10.3	-242.3	-248.0	5.7	16.0
P-59	386,725.69	2,195,010.94	7.8	-239.8	-253.5	13.7	21.5
P-60	Water too shallow for boat						
P-61	393,971.38	2,194,229.63	13.0	-245.0	-251.6	6.6	19.6
P-62	400,127.88	2,192,058.38	14.8	-246.8	-255.0	8.2	23.0
P-63	404,689.56	2,192,127.19	11.8	-243.8	-251.4	7.6	19.4
P-64	409,381.81	2,192,039.06	8.4	-240.4	-245.5	5.1	13.5
P-65	409,497.94	2,191,976.31	6.2	-238.2	-242.5	4.3	10.5
P-66	411,629.56	2,185,115.00	19.2	-251.2	-259.0	7.8	27.0
P-67	409,260.75	2,181,542.00	25.5	-257.5	-267.6	10.1	35.6
P-68	407,460.44	2,180,848.69	30.6	-262.6	-274.3	11.7	42.3
P-68A	404,594.50	2,181,293.38	28.6	-260.6	-270.0	9.4	38.0
P-69	397,634.19	2,181,756.63	33.0	-265.0	-278.0	13.0	46.0

* "Sediment" includes Fat Clay deposited from the present Salton Sea, and underlying saturated older lacustrine deposits. All would be displaced by dike embankment.

Note: 62 sites tested
5 too shallow for boat.

Sea elevation varied from -231.8' to -232.0'. Elevations computed from elevation -232.0'.



N

SOURCE: University of Redlands.
COORDINATE SYSTEM: Geographic North American Datum, 1983, Decimal Degrees.

PLAN OF EXPLORATIONS
SALTON SEA RESTORATION PROJECT

URS

3 0 3 6 Miles

SCALE: 1:360,000

CHECKED BY: AJ	DATE: 2-24-04	FIG. NO:
PM: LDH	PROJ. NO: 27663042.00005	2

G:\gis\projects\1577\27663042\aprs\actual_borings-cpts.apr

Project:	**Salton Sea Restoration**
Project Location:	**Salton Sea, California**
Project Number:	**27663042.00002**

Key to Log of Exploration

Sheet 1 of 1

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pct	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10

COLUMN DESCRIPTIONS

1 Elevation: Elevation in feet referenced to mean sea level (MSL) or site datum.

2 Depth: Depth in feet below the ground surface.

3 Sample Type: Type of soil sample collected at depth interval shown; sampler symbols are explained below

4 Sample Number: Sample identification number. Unnumbered sample indicates no sample recovery.

5 Sampling Resistance: Number of blows required to advance driven sampler 12 inches beyond first 6-inch interval, or distance noted, using a 140-lb hammer with a 30-inch drop.

6 Graphic Log: Graphic depiction of subsurface material encountered; typical symbols are explained below.

7 Material Description: Description of material encountered; may include relative density/consistency, moisture, color (Munsell classification), particle size; tecture, weathering, and strength of formation material (USCS classification in parentheses).

8 Water Content: Water content of soil sample measured in laboratory, expressed as percentage of dry weight of

9 Dry Unit Weight: Dry density of soil sample measured in laboratory, in pounds per cubic foot.

10 Remarks and Other Tests: Comments and observations regarding drilling or sampling made by driller or field personnel. Other field and laboratory test results, using the following abbreviations:

LL(63): Liquid Limit (test result in percent)
PI(28): Plasticity Index (test result in percent)
WA(91): Wash Analysis (percent passing #200 sieve)
SA(94): Sieve Analysis (percent passing #200 sieve)
UU(1000): Unconsolidated Undrained Strength Test (shear strength in psf)
SG(2.77): Specific Gravity (test result)
CON: Consolidation Test
CORR: Corrosivity Tests
ICU: Isotropically Consolidated Undrained Triaxial Compression Test
PIN: Pinhole Dispersion Test

TYPICAL MATERIAL GRAPHIC SYMBOLS

GRAVEL (GW)
Well graded SAND (SW)
Poorly graded SAND (SP)
Silty SAND (SM)
Clayey SAND (SC)
Clayey SILT (ML)
CLAY (CL)
CLAY to SILT (CL/ML)
SILT (ML)
Fat clays (CH)
SAND to CLAY (SC/CL)
SAND to SILT (SM/ML)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Sack or Bag sample
Standard Penetration sampler (SPT)
Core sample
Modified California sampler
Shelby Tube sampler
Acetate sleeves

OTHER GRAPHIC SYMBOLS

First water encountered at time of drilling and sampling (ATD)
Water level measured at specified time after completion of drilling and sampling
Inferred or gradational contact between strata

GENERAL NOTES

1. Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.

2. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

Figure A-1

URS

Project:	Salton Sea Restoration	**Log of Boring 14**
Project Location:	Salton Sea, California	Sheet 1 of 2
Project Number:	27663042.00002	

Date(s) Drilled	10/10/03	Logged By	A. Greene	Checked By	A. Greene
Drilling Method	Tricone bit with rotary drilling	Drill Bit Size/Type	3.25"	Total Depth of Borehole	51.5' below mudline
Drill Rig Type	Mobile Sea 80-14	Drilling Contractor	Gregg Drilling	Approximate Surface Elevation	-250' below sea level
Elevation of Sea Surface	-227' below sea level	Sampling Method(s)	Shelby/SPT	Hammer Data	140 lbs/30" drop
Borehole Backfill	Native	Location	N33.20150/W115.66085		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pct	REMARKS AND OTHER TESTS
-250	0		14-1			LACUSTRINE DEPOSITS Very soft to wet, brown to dark brown (7.5 YR-4/2) to 10 YR-4/3), lean SILT with trace fine sand (ML) to lean CLAY (CL)	33	73	SA(93)
-255	5		14-2				39 30	83 90	LL(32), PI(12) UU(200), CON, PIN
-260	10		14-3			ALLUVIAL DEPOSITS Soft to loose, wet, brown to dark brown (7.5 YR-4/4), silty very fine SAND (SM) to SILT with fine sand (ML)	28	95	SA(54)
-265	15		14-4			LACUSTRINE DEPOSITS Soft to medium stiff, wet, brown (7.5 YR-4/2), lean CLAY with trace sand (CL) ...decrease in sand, becomes interbedded lean clay with thin layers of fine sandy silt to silty fine sand	35	84	LL(36), PI(19) UU(300), SG(2.73)
-270	20		14-5	16		...20.5'-21', silty fine sand lense (SM)	35		WA(95)
						ALLUVIAL DEPOSITS Medium dense, wet, brown (7.5 YR-4/2), silty fine to very fine SAND (SM) with interbedded layers of SILT with fine sand (ML)			
-275	25		14-6						
			14-6a	14			22		WA(30)
-280	30		14-7	13			28		SA(54)
-285	35		14-8	14			26		WA(54)

Figure A-8

URS

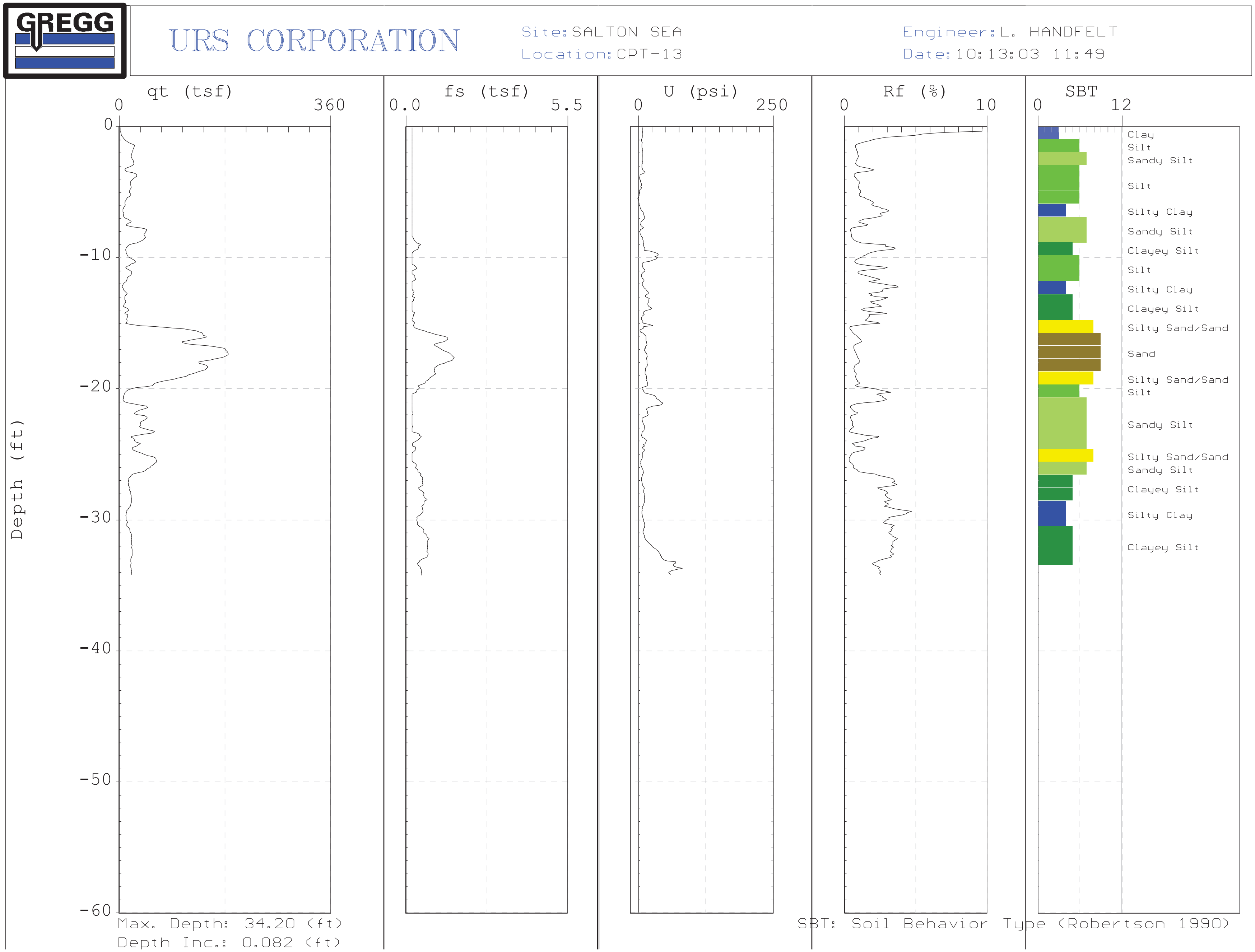
Project: Salton Sea Restoration Project Location: Salton Sea, California Project Number: 27663042.00002	**Log of Boring 14** Sheet 2 of 2

Date(s) Drilled	10/10/03	Logged By	A. Greene	Checked By	A. Greene
Drilling Method	Tricone bit with rotary drilling	Drill Bit Size/Type	3.25"	Total Depth of Borehole	51.5' below mudline
Drill Rig Type	Mobile Sea 80-14	Drilling Contractor	Gregg Drilling	Approximate Surface Elevation	-250' below sea level
Elevation of Sea Surface	-227' below sea level	Sampling Method(s)	Shelby/SPT	Hammer Data	140 lbs/30" drop
Borehole Backfill	Native	Location	N33.20150/W115.66085		

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	Blows per foot	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Density, pct	REMARKS AND OTHER TESTS
-290	40		14-9				27		WA(29)
						LACUSTRINE DEPOSITS Very stiff, moist, brown (7.5 YR-4/2), fat CLAY (CH)			
-295	45		14-10				41		LL(65), PI(42)
						Medium dense, moist, brown (7.5-4/2), silty fine SAND (SM)			
-300	50		14-11				26	97	SA(41)
						Bottom of boring at 51.5 feet below mudline (75 feet below sea surface)			
-305	55								

Figure A-8

URS

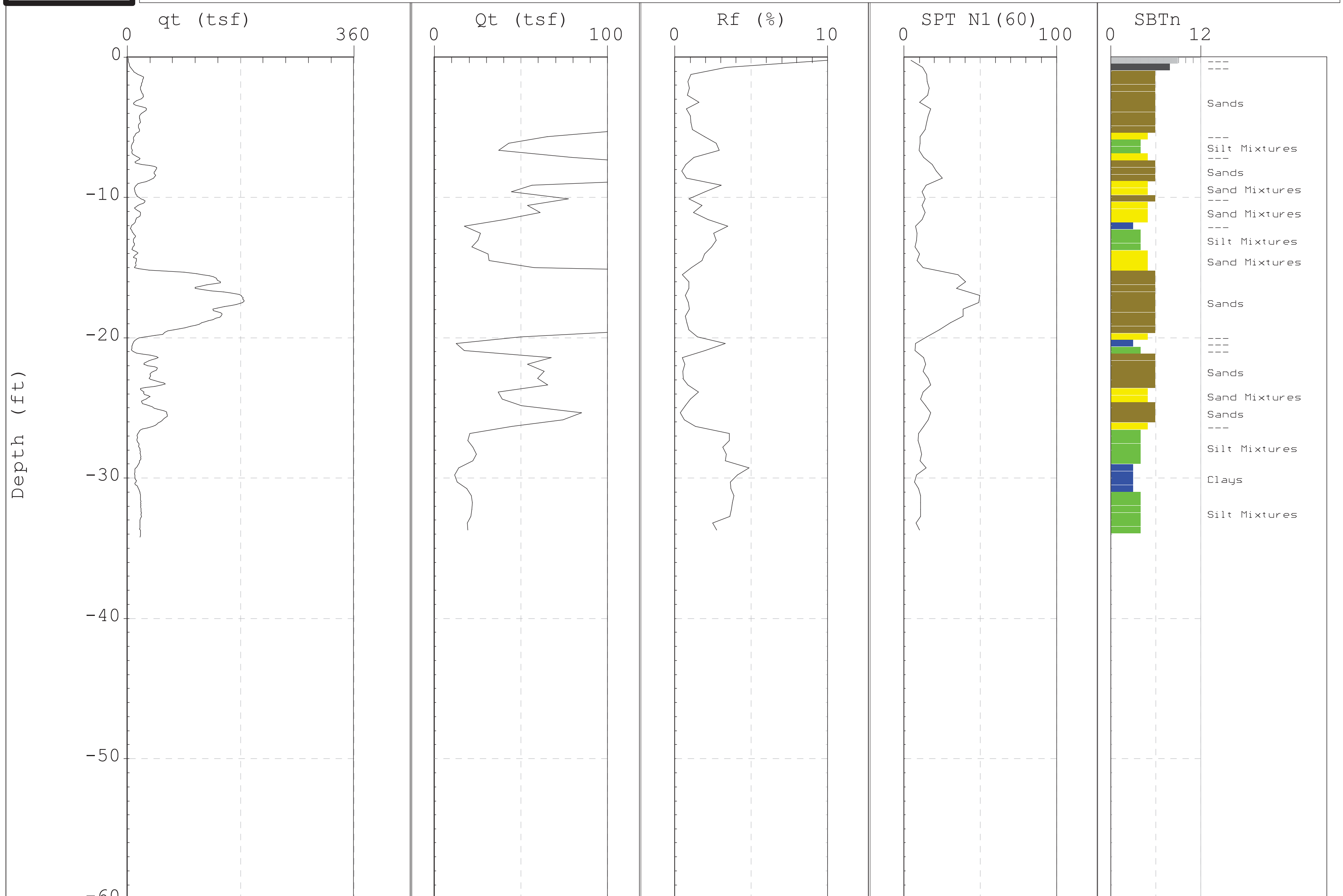


URS CORPORATION
Site: SALTON SEA
Location: CPT-13
Engineer: L. HANDFELT
Date: 10:13:03 11:49
Depth (ft)
qt (tsf)
0
360
fs (tsf)
0.0
5.5
U (psi)
0
250
Rf (%)
0
10
SBT
0
12
0
-10
-20
-30
-40
-50
-60
Clay
Silt
Sandy Silt
Silt
Silty Clay
Sandy Silt
Clayey Silt
Silt
Silty Clay
Clayey Silt
Silty Sand/Sand
Sand
Silty Sand/Sand
Silt
Sandy Silt
Silty Sand/Sand
Sandy Silt
Clayey Silt
Silty Clay
Clayey Silt
Max. Depth: 34.20 (ft)
Depth Inc.: 0.082 (ft)
SBT: Soil Behavior Type (Robertson 1990)

URS CORPORATION

Site: SALTON SEA
Location: CPT-13

Engineer: L. HANDFELT
Date: 10:13:03 11:49



Max. Depth: 34.20 (ft)
Depth Inc.: 0.082 (ft)

SBT: Soil Behavior Type (Robertson 1990)

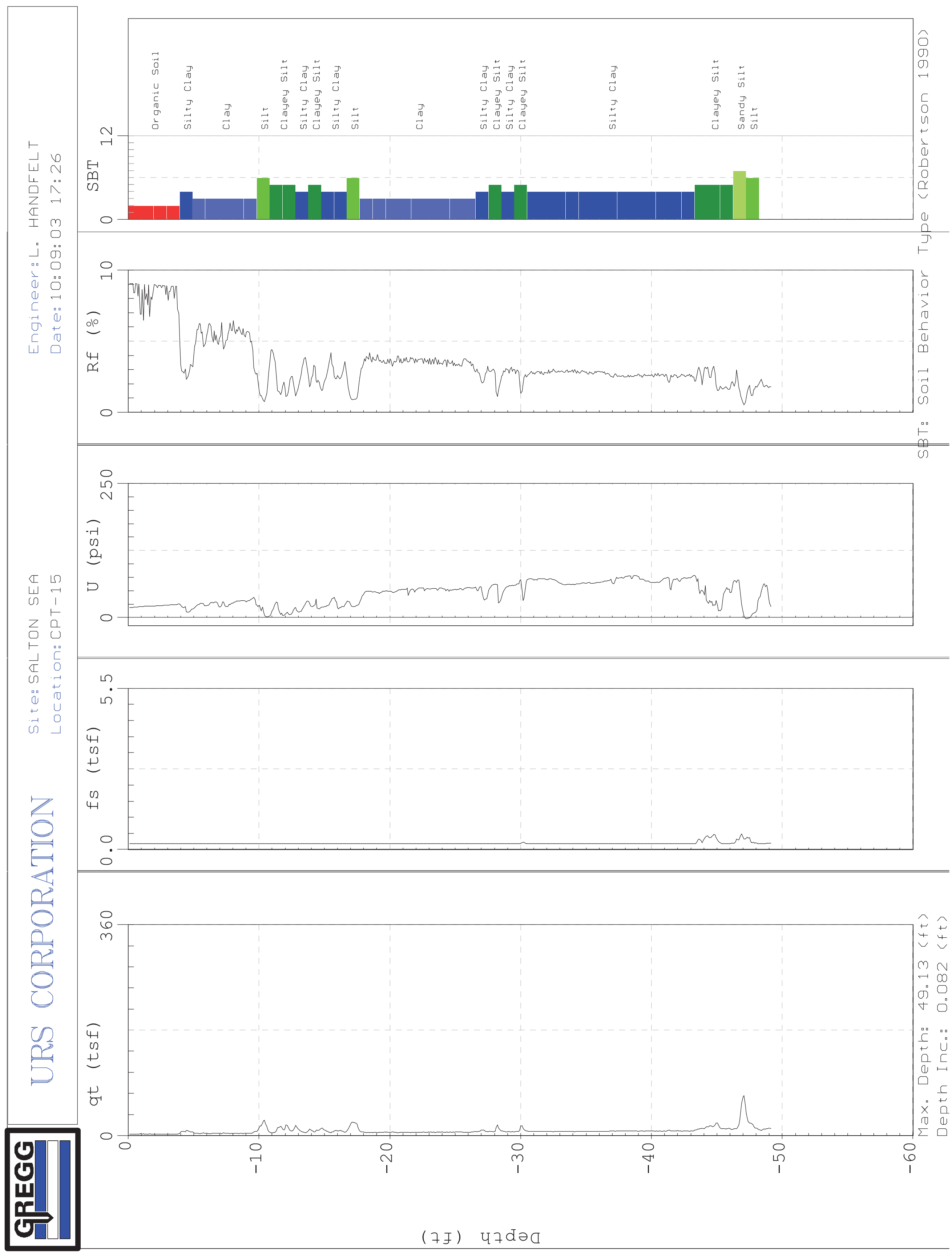

URS CORPORATION
Site: SALTON SEA
Location: CPT-15
Engineer: L. HANDFELT
Date: 10:09:03 17:26
GREGG
qt (tsf)
fs (tsf)
U (psi)
Rf (%)
SBT
Depth (ft)
Organic Soil
Silty Clay
Clay
Silt
Clayey Silt
Sandy Silt
SBT: Soil Behavior Type (Robertson 1990)
Max. Depth: 49.13 (ft)
Depth Inc.: 0.082 (ft)

Plate No. H-16

URS CORPORATION

Site: SALTON SEA
Location: CPT-15

Engineer: L. HANDFELT
Date: 10:09:03 17:26