Geologic Hazard Evaluation and Geotechnical Engineering Report

Proposed Food Waste Digester Project
On a Portion of the "Crowley Property"
Hilfiker Lane
Eureka, California
APNs 019-271-004 and 019-331-002

Prepared for:

Humboldt Waste Management Authority

Consulting Engineers & Geologists, Inc.

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Abbreviations and Acronyms

km	kilometer
psf	pounds per square inch
AAAS	American Association for the Advancement of Science
AAPG	American Association of Petroleum Geologists
APN	Assessor's Parcel Number
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing Materials-International
CBC	California Building Code
CPT	Cone Penetration Test
CPT-#	Cone Penetration Test-number
CSZ	Cascadia Subduction Zone
FEMA	Federal Emergency Management Agency
HWMA	Humboldt Waste Management Authority
M-#	Magnitude number
MRfz	Mad River fault zone
M_W	Moment Magnitude
NR	No Reference
SHN	SHN Consulting Engineers & Geologists, Inc.
USGS	United States Geological Survey

1.0 Introduction

This report presents the results of the geologic hazards and geotechnical engineering investigation conducted by SHN Consulting Engineers & Geologists, Inc. (SHN) for a proposed food waste digester facility on Hilfiker Lane north of the existing wastewater treatment plant in Eureka, California (Figure 1). This work was conducted on behalf of Humboldt Waste Management Authority (HWMA).

The subject site occupies the southern part of City of Eureka-owned land known as the "Crowley property." The Crowley property consists of eight parcels encompassing about 25 acres along the Humboldt Bay shoreline. The proposed digester facility would occupy portions of a 6.1-acre parcel (Assessor's Parcel Number [APN] 019-271-004) and a 1.12-acre parcel (APN 019-331-002). The project site is bordered on the north side by the Eureka Fire Department's training site, to the west by Hilfiker Lane, to the south by the City of Eureka's Elk River Wastewater Treatment Plant, and to the east by railroad tracks and industrial/commercial businesses. Latitude and longitude of the subject property is 40.77° N and 124.211° W, respectively.

1.1 Proposed Project

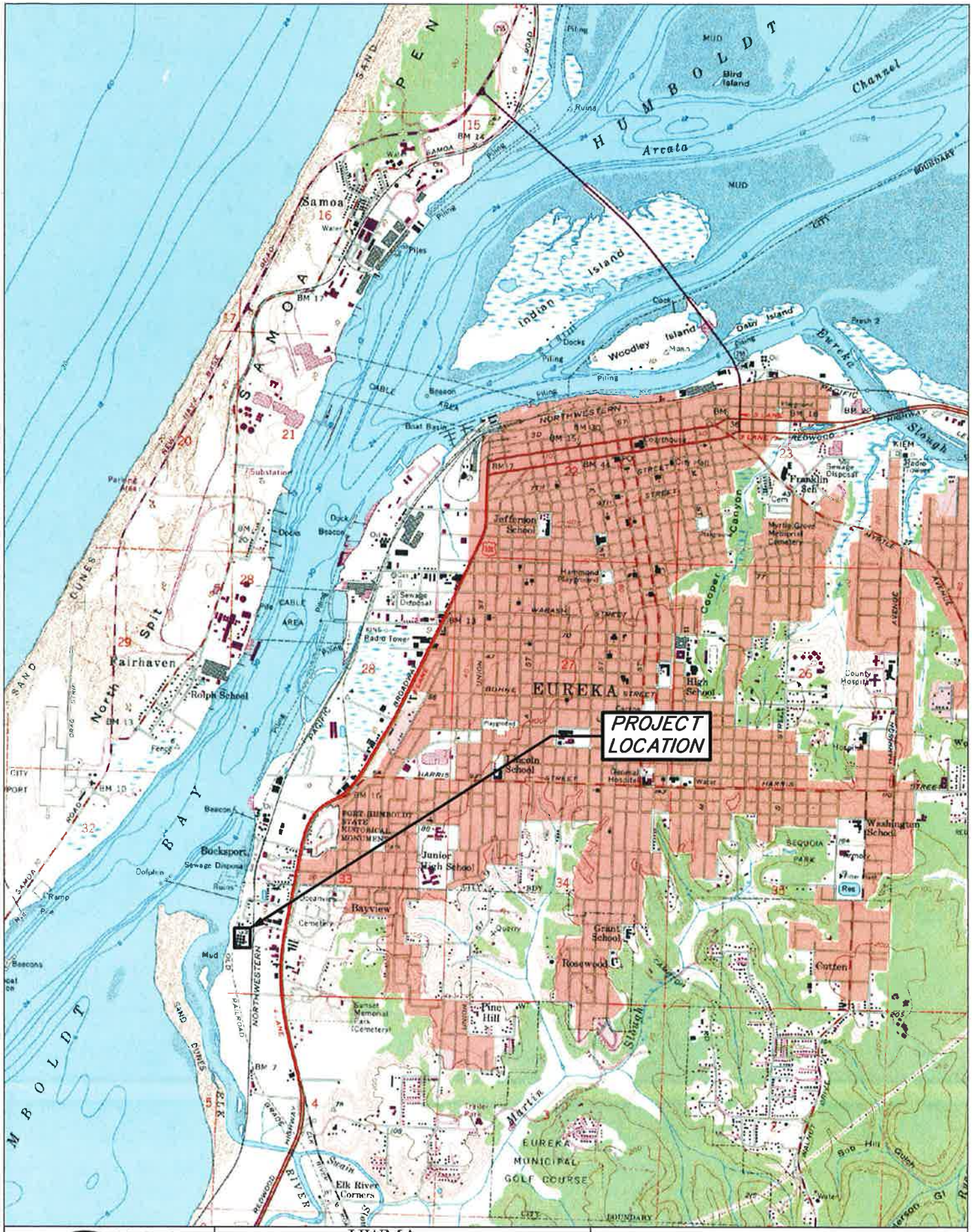
It is our understanding that the site is being considered for development of an anaerobic digester facility for the purposes of developing a regional food waste diversion program in Humboldt County. Our understanding of the project is based on a project description (Planwest/ Ourevolution Energy, 2011a) that outlines project objectives and describes the general elements of a food waste digester facility. The environmental impacts related to the project were described in an initial study/mitigated negative declaration (Planwest/Ourevolution Energy, 2011b).

At the time of our investigation, project plans were conceptual, and individual elements of the facility had not been designed. Facility layout was not known, and will presumably be subject to a design process at a later date. Based on the initial project description, we understand a typical "food waste digester facility" to contain the following structural elements:

- **Pre-processing Facility Building.** As currently conceived, this approximately 80-foot X 80-foot steel-frame structure would house pre-processing equipment and a reinforced concrete tipping floor. A 6-foot high concrete stem wall would serve as a "push wall" to facilitate the ability of heavy equipment (presumably, front-end loaders, or similar) to maneuver the food waste. Pre-processing equipment in this structure would include screens and magnetic, density, and/or turbo separators.
- **Digester Tanks.** Anaerobic digester tanks will be a primary element of the facility. As currently conceived, up to 5 tanks (each with a volume of 4,600 cubic feet) will be constructed. The tanks are likely to be plumbed in a single row (parallel plumbed) to provide maximal operational flexibility.
- **Ancillary Equipment.** Additional facility improvements would include a variety of pumps, a heating system, biogas generation and conveyance systems, and treatment facilities for the residual material remaining following the digestion process.

1.2 Purpose and Scope of Services

This report presents the results of our preliminary investigation at the site. The primary focus of the investigation is to inform HWMA as to the feasibility of developing the site, and if feasible, the magnitude of the geotechnical challenge in completing the development. The investigation is intended to provide HWMA with findings, conclusions, and recommendations related to geologic



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SHN Consulting Engineers & Geologists, Inc.	HWMA Food Waste Digester Geotech Eureka, California	Project Location SHN 012046
	July 2012	Figure1_Project_Location	Figure 1

hazard and soils engineering aspects of project design and construction. This report is somewhat generic at this phase, as the facility has not been designed and most "design-level" information has yet to be developed. We anticipate that additional, focused geotechnical engineering will need to be completed once a specific plan with verified structural loading is available. Our investigation was performed to evaluate the surface and subsurface conditions at the site in order to develop preliminary geotechnical criteria for design and construction of the proposed project such that it will not contribute or be subject to substantial risk associated with the geologic environment of the site. Specifically, the scope of our services consisted of the following:

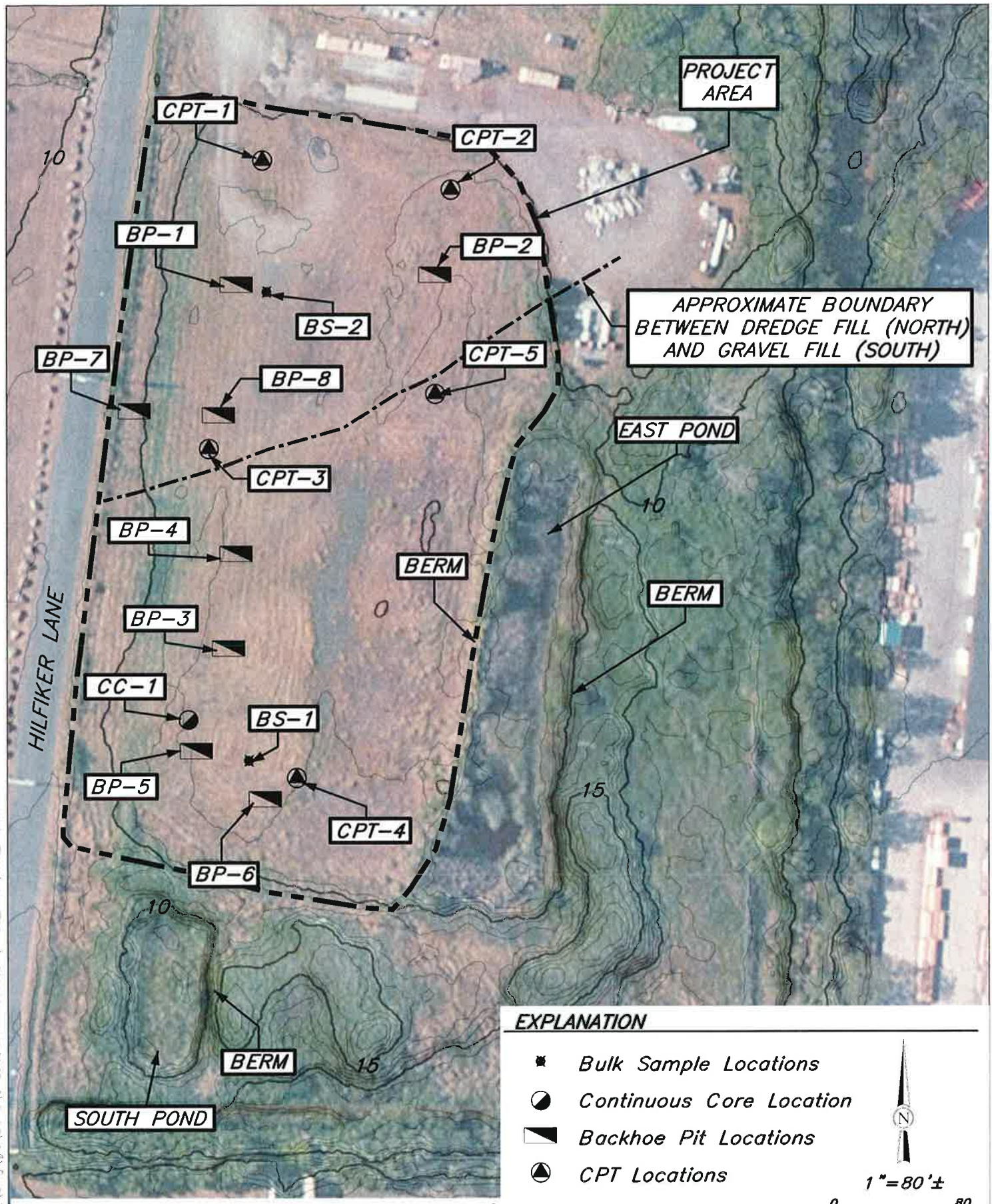
1. Review pertinent published and unpublished geologic references and project documents.
2. Provide an assessment of the deep soil profile using five Cone Penetration Test (CPT) borings (locations shown on Figure 2).
3. Assess the shallow soil profile and thickness of fill through the excavation, logging, and sampling of eight exploratory backhoe test pits in the vicinity of the proposed project (locations shown on Figure 2).
4. Perform laboratory testing on representative soil samples collected during our subsurface exploration.
5. Develop geotechnical recommendations for site preparation and grading, compaction requirements for fill and backfill, site drainage, generalized foundation design criteria (design-level criteria can not be developed until more is known about the type and loading associated with proposed improvements), and subgrade preparation for concrete slab-on-grade floors.
6. Produce this report outlining our findings including CPT and exploratory test pit logs, laboratory test data, assessment of liquefaction potential, seismic design criteria, and our conclusions and recommendations.

The recommendations contained in this report are subject to the limitations presented herein. Attention is directed to the "Construction Phase Monitoring" and "Closure and Limitations" sections of this report.

1.3 Site Conditions

The subject property occupies low-elevation, relatively flat ground along the shore of Humboldt Bay. Elevation of the site averages about 9 feet, but a berm in the eastern part of the property has a crest elevation of about 15 feet, and a closed basin in the southern part of the site has a floor elevation of about 5 feet. The property is currently undeveloped, but portions of the site have been used in the past as a bulk fuel storage facility (from the 1950s to 1989). Remnants of this prior use (and subsequent City of Eureka use) include concrete pads, debris piles, and various ponds and berms.

Review of available historical aerial photographs (included in the project initial study), indicate that the bulk fuel storage facility first appears in 1954 photography. The initially improved portion of the site (the northern end of the subject site) was relatively small, and was initially occupied by 11 relatively small tanks (approximate locations shown on Figure 3). According to environmental remediation documentation acquired from the California Regional Water Quality Control Board, North Coast Region these initial 11 tanks included eight, 5,000-barrel (210,000-gallon, assuming a "barrel" equals 42 gallons of petroleum) tanks; three, 8,000-barrel (336,000-gallon) tanks; and a single, 10,000-barrel (420,000-gallon) tank. In 1979, the southern part of the site was cleared, and six additional tanks were added to the south end of the tank complex (see Figure 3). These were



EXPLANATION

- Bulk Sample Locations
- Continuous Core Location
- Backhoe Pit Locations
- CPT Locations

N

1"=80'±

0 80

Feet

CONTOUR INTERVAL = 1 FOOT, IMAGE SOURCE: BING, 2011 HILLSHADE AND CONTOURS GENERATED FROM 1 FOOT LIDAR (CA COASTAL CONSERVANCY, COASTAL LIDAR PROJECT, 2009-2011)

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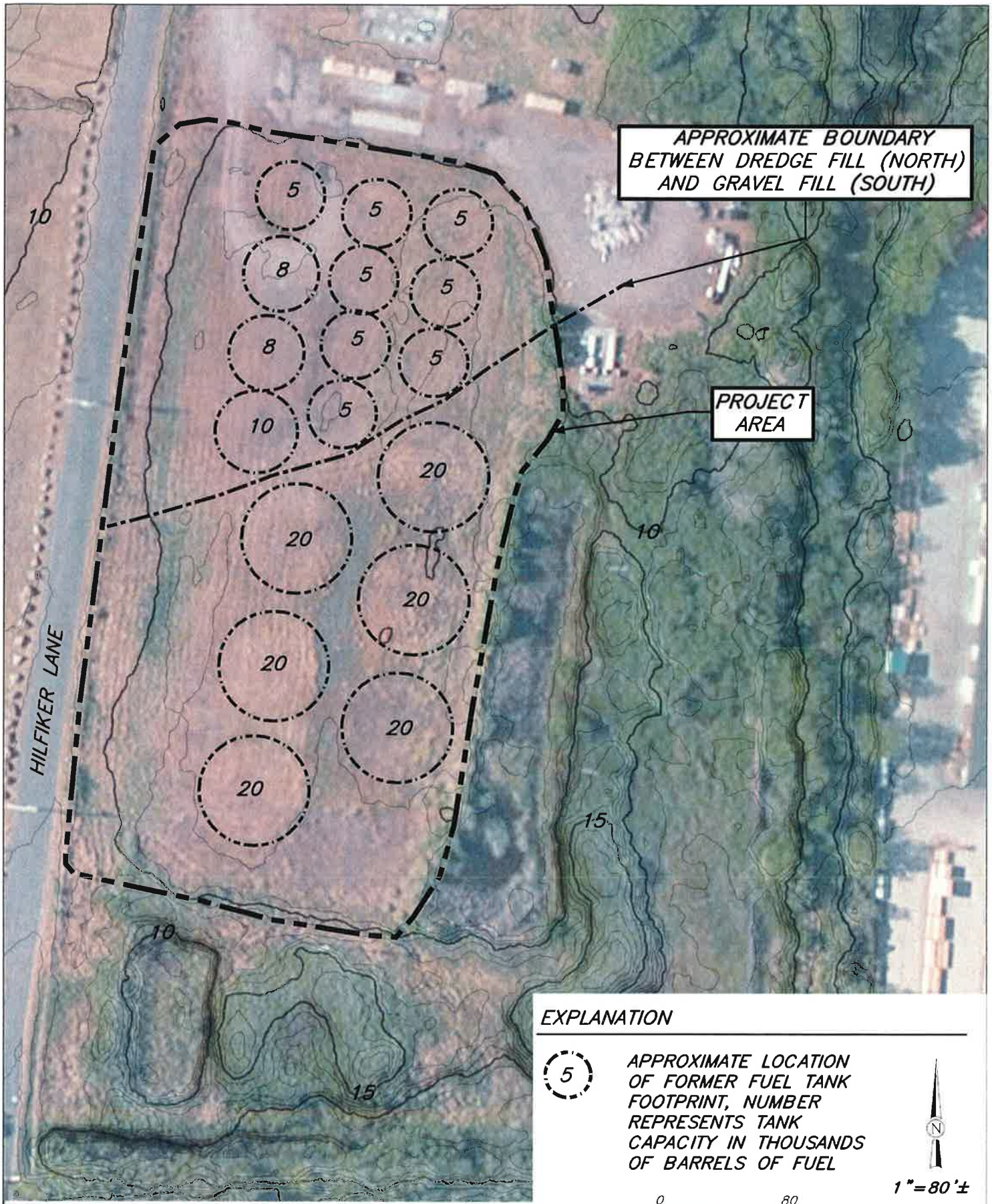
SHN Consulting Engineers & Geologists, Inc.	HWMA Food Waste Digester Geotech Eureka, California	Site Map SHN 012046
	July 2012 Site_Plan	Figure 2



EXPLANATION

5 — APPROXIMATE LOCATION OF FORMER FUEL TANK FOOTPRINT, NUMBER REPRESENTS TANK CAPACITY IN THOUSANDS OF BARRELS OF FUEL

N

1" = 80'±

0 80
Feet

CONTOUR INTERVAL = 1 FOOT, IMAGE SOURCE: BING, 2011; HILLSHADE AND CONTOURS GENERATED FROM 1 FOOT LIDAR (CA COASTAL CONSERRVANCY LIDAR PROJECT, 2009–2011)

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SHN Consulting Engineers & Geologists, Inc.	HWMA Food Waste Digester Geotech Eureka, California	Approximate Locations of Former Fuel Tank Footprints SHN 012046
	July 2012	Figure3_Tank_Locations	Figure 3

reportedly 20,000-barrel (840,000-gallon) tanks. After expansion of the tank farm in 1979, a berm was constructed around the facility to contain storm runoff and route it to a series of drainage ditches and holding ponds. Portions of the berm and ponds are evident at the site today, but are outside the portion of the parcels proposed for development of the digester facility. Much of the southern and eastern part of the subject property has been identified as "wetland."

2.0 Geologic Setting

The site is located along the margin of Humboldt Bay, near the mouth of Elk River. The Humboldt Bay region occupies a complex geologic environment characterized by very high rates of active tectonic deformation and seismicity. The location and morphology of Humboldt Bay is largely a result of tectonic processes. Humboldt Bay consists of two principal basins (Arcata Bay and South Bay), which are connected across the bay mouth. Each of the principal basins is associated with a tectonic syncline (for example, crustal down-warp), and represents a filled paleo-river valley. The oceanward side of Humboldt Bay is formed by the Samoa Peninsula (that is, the north spit) and the south spit. These spits are underlain by the same subsurface materials as areas east of the bay (for example, Hookton Formation and Wildcat Group sediments, described below), suggesting the bay occupies an erosional valley, and that the spits are remnants of a once-continuous surface that extended to the east.

Basement rock beneath Humboldt Bay is the Paleocene-Eocene Yager terrane, a part of the Coastal belt of the Franciscan Complex (Blake et al., 1985; Clarke, 1992). The Franciscan Complex is a regional bedrock unit that consists of a series of "terranes," discrete blocks of highly deformed oceanic crust that have been welded to the western margin of the North American plate over the past 140 million years. The Yager terrane consists of as much as 9,840 feet (3,000 meters) of well-indurated marine mudstone and thin-bedded siltstone.

Basement rock in the Humboldt Bay region is unconformably overlain by a late Miocene to middle Pleistocene age sequence of primarily marine deposits referred to as the Wildcat Group (Ogle, 1953). The marine portion of the Wildcat Group includes some 6,235 to 8,200 feet (1,900 to 2,500 meters) of mudstone and lesser amounts of sandstone that were deposited in a deep coastal basin (for example, the Eel River basin). Gradationally overlying the marine portion of the Wildcat Group are 2,625 to 3,280 feet (800 to 1,000 meters) of nonmarine sandstone and conglomerate, which represent the uppermost part of the Wildcat depositional sequence. The Wildcat Group is truncated at its top by an unconformity of middle Pleistocene age, and is overlain by coastal plain and fluvial deposits of middle to late Pleistocene age. In the Eureka area, these middle and late Pleistocene deposits were initially referred to as the Hookton Formation by Ogle (1953).

Beneath Humboldt Bay, and along its margins, Hookton Formation sediments are overlain by late Holocene age (that is, younger than about 5-6,000 years old) bay muds and associated littoral and estuarine deposits. Near alluvial sources at the fringes of the bay, bay muds are intermixed with terrestrial alluvial deposits; this appears to be the case at the subject site, which is located near the mouth of the Elk River. These youthful, generally unconsolidated deposits vary in thickness and composition around the bay, often exhibiting large amounts of lateral variation over very small distances. Bay deposits typically consist of silty clays or clayey silts (that is, bay muds) interbedded with clean sand lenses and beds.

2.1 Tectonic Setting

Northwestern California is located in a complex tectonic region dominated by northeast-southwest compression associated with collision of the Gorda and North American tectonic plates. The Gorda plate is being actively subducted beneath North America north of Cape Mendocino, along the

southern part of what is commonly referred to as the Cascadia Subduction Zone (CSZ). This plate convergence has resulted in a broad fold and thrust belt along the western edge of the accretionary margin of the North American plate. In the Humboldt Bay region, this fold-and-thrust belt is manifested as a series of northwest-trending, southeast-vergent thrust faults, including the Little Salmon fault and faults that comprise the Mad River fault zone (MRfz). These faults are active and are capable of generating moderate- to large-magnitude earthquakes.

The proposed facility site is located in the hanging wall of the nearby Little Salmon fault, which projects across the mouth of Humboldt Bay just west of the site. The Little Salmon fault appears to be the most active fault in the Humboldt Bay region, and is capable of generating very large earthquakes. The Little Salmon fault is a northwest-trending, southwest-vergent reverse fault (that is, the northeast side of the fault slides up and over the southwest side of the fault along a northeast-dipping fault plane); therefore, the fault dips northeastward, beneath the site). Offset relations within the upper Wildcat Group suggest vertical separation exceeds 5,900 feet (1,800 meters), representing about 4.4 miles (7 kilometers [km]) of dip-slip motion on the Little Salmon fault since the Quaternary (that is, in the past 700,000 to 1 million years). Paleoseismic studies of the Little Salmon fault indicate that the fault deforms late Holocene sediments at the southern end of Humboldt Bay (Clarke and Carver, 1992). Estimates of the amount of fault slip for individual earthquakes along the fault range from 15 to 23 feet (4.5 to 7 meters). Radiocarbon dating suggests that earthquakes have occurred on the Little Salmon fault about 300, 800, and 1,600 years ago. Average slip rate for the Little Salmon fault for the past 6,000 years is between 6 and 10 millimeters per year. Based on currently available fault parameters, the maximum magnitude earthquake for the Little Salmon fault is thought to be about 7.3 (Geomatrix Consultants, 1994).

2.2 Seismic Setting

Northwestern California is the most seismically active region in the continental United States. More than 60 earthquakes have produced discernable damage in the region since the mid-1800s (Dengler et al., 1992).

Other than the Little Salmon fault, there are 6 other potential sources for strong seismic shaking:

1. **The Gorda Plate.** Gorda Plate earthquakes account for the majority of historical seismicity. These earthquakes occur primarily offshore along left-lateral faults, and are generated by the internal deformation within the plate as it moves toward the subduction zone. Significant historical Gorda Plate earthquakes have ranged in magnitude from M5 to M7.5. The November 8, 1980, earthquake (M7.2) and the more recent January 9, 2010 (M6.5) were both generated on left-lateral faults within the Gorda Plate.
2. **The Mendocino Fault.** The Mendocino fault is the second most frequent source of earthquakes in the region. The fault represents the plate boundary between the Gorda and Pacific plates, and typically generates right lateral strike-slip displacement. Historical Mendocino fault events have ranged in magnitude from M5 to M7.5. The September 1, 1994, M7.2 event west of Petrolia was generated along the Mendocino Fault.
3. **The Mendocino Triple Junction.** The Mendocino triple junction was identified as a separate seismic source only after the August 17, 1991, M6.0 earthquake. Events associated with the triple junction are shallow onshore earthquakes that appear to range in magnitude from about M5 to M6. Raised Holocene terraces near Cape Mendocino suggest larger events are possible in this region.

4. **The northern end of the San Andreas Fault.** Northern San Andreas fault events are rare, but can be very large. The northern San Andreas fault is a right lateral strike-slip fault that represents the plate boundary between the Pacific and North American plates. The fault extends through the Point Delgada region and terminates in the Mendocino triple junction region. The 1906 San Francisco earthquake (M8.3) caused the most significant damage in the north coast region, with the possible exception of the 1992 Petrolia earthquake.

5. **The North American Plate.** Earthquakes originating within the North American plate can be anticipated from a number of intraplate sources, including the MRfz and Little Salmon fault. The MRfz is located at the northern end of Humboldt Bay, and is entirely north of the site. There has been no large magnitude earthquakes associated with faults within the North American plate, although the December 21, 1954, magnitude 6.5 event may have occurred in the MRfz. Damaging North American plate earthquakes are expected to range from magnitude 6.5 to 8.

6. **The Cascadia Subduction Zone.** The CSZ represents the most significant potential seismic source in the north coast region. A great subduction event has the potential to rupture up to 200 km or more, beginning off the coast from Cape Mendocino and extending north to British Columbia. CSZ events may be up to M9.5, and could be associated with extensive tsunami inundation in low-lying coastal areas. The April 25, 1992, Petrolia earthquake (M7.1) appears to be the only documented historical earthquake involving slip along the subduction zone, but this event was confined to the southernmost portion of the fault. Paleoseismic studies along the subduction zone suggest that great earthquakes are generated along the zone every 300 to 500 years. The last large subduction earthquake occurred in 1700. A great subduction earthquake would generate long duration, very strong ground shaking throughout the Pacific Northwest.

3.0 Field Investigation and Laboratory Testing

We completed our geotechnical field investigation at the site on March 19, 2012. Our site investigation included the advancement of five CPT, extraction of a continuous soil core, and excavation of 8 backhoe test pits (Figure 2). The locations of CPT soundings and backhoe test pits were distributed as evenly as possible around the site; however, we could not investigate areas within 50 feet of mapped wetlands, so our ability to investigate portions of the eastern and southeastern parts of the site was limited.

Soils encountered within the test pits were logged in general accordance with the Unified Soil Classification System and representative soil samples were collected using a 2.5 inch thin-walled tube sampler (test pit logs are included as Appendix A). Bulk samples of shallow site soils were collected in 5-gallon buckets from two locations for R-value testing, which is essential for the design of flexible pavements.

The CPT soundings provide a relatively continuous profile of the soils underlying the site to a depth of approximately 26 to 30 feet below grade. CPT involves pushing an instrumented probe ("cone") into the subsurface. The tip of the cone records the tip resistance (q_c), sleeve friction (f_s), and pore pressure (u2). No soil samples are recovered from CPT soundings. The parameters measured by the cone are used to derive a "soil behavior type" displayed on the left side of the CPT logs in Appendix B. Soil behavior type is a description of how the measured soil behaves, and should not be confused with actual soil type, as would be logged in a boring.

Logs of the test pit exposures are included as Appendix A. The computer print-outs from the CPT soundings are provided in Appendix B. The results of our laboratory (R-value) testing are provided in Appendix C.

4.0 Soil and Groundwater Conditions

Subsurface exploration indicates that the site is underlain by a consistent stratigraphy, consisting of 6 to 7 feet of uncontrolled fill material overlying 5 to 13 feet of native Holocene-age bay margin sediment. The bay margin deposits, in turn, overlie Pleistocene age Hookton Formation sediments, which exist to the depth explored. The transition from estuarine/alluvial sediment to the older, denser Hookton Formation occurs at depths ranging from about 12 feet, to as deep as 20 feet below ground surface (generally deeper beneath the southern end of the site).

The fill materials at the site are distinctly different in the northern and southern parts of the site, and appear to reflect the placement of different materials, at different times, due to the two-stage development of the tank farm described above (see Figures 2 and 3). In the northern part of the site (encompassing the locations of test pits 1, 2, 7, and 8, and CPT-1 and -2), the fill materials consist of loose, poorly graded sand. These materials were notable for their inability to hold up in the sidewall of a test pit (sands flowed freely into the excavation). Based on the texture of these materials, and our experience with similar materials at other sites around Humboldt Bay, we infer these materials to be dredge spoils mined from the bay by hydraulic dredging. Based on their distribution, it appears these low-quality fill soils supported the 11 initial (5,000- to 10,000-barrel) fuel tanks at the site. In the southern part of the site (including the areas of test pits 3, 4, 5, and 6), the fill materials consist of tight, compact sandy gravel. These materials were difficult to penetrate (the anchors of the CPT truck pulled out while trying to advance the cone), and easily maintained a vertical test pit sidewall. The material appears similar to standard "river-run" fill typically imported to sites throughout the area as structural fill. Based on their distribution, and assessment of aerial photographs, this fill is inferred to have been placed to support the six larger (20,000-barrel) tanks that were installed in 1979.

Bay margin deposits at the site consist of estuarine and alluvial sediments, often referred to around Humboldt Bay as "bay mud." At the project site, the bay margin sediments primarily consist of granular sediments (silty sand, poorly graded sand) with shells and plant fragments. Near the south end of the site, some interlayered clay and peaty mud was encountered. The bay margin sediments at this site are sandier than we have encountered elsewhere around the bay (which tend toward finer grained "muds"), which likely reflects the proximity to the mouth of the Elk River. The sandy bay margin deposits were described in the field as medium dense; they demonstrated moderate penetration resistance during cone penetration testing (N_{60} values of 10 to 20).

Hookton Formation sediments beneath the site (inferred from CPT logs) are dense sand, silty sand, and gravelly sand associated with very high penetration resistance values.

Groundwater was encountered in test pits throughout the low-elevation site at between 2.25 and 6.75 feet. As our field investigation was completed in March, it appears we observed typically shallow groundwater conditions, as would be expected on a low-lying site near the bay margin. Groundwater levels can be expected to fluctuate seasonally, based on the degree of recent precipitation, and is likely to be tidally-influenced as well.

5.0 Geologic Hazards

5.1 Slope Stability

The project site is situated on relatively flat-lying ground, well away from any significant slopes and we, therefore, consider the slope stability hazard associated with the proposed project to be negligible.

5.2 Seismic Hazards

As discussed in Section 2.2, the project site is situated within a seismically active area. Seismic hazards identified within the region include strong ground shaking, surface fault rupture, and seismically induced ground deformation (liquefaction, lateral spread, settlement, and slope failure). These hazards are discussed below as they relate to the project.

5.2.1 Ground Shaking

Strong ground shaking associated with earthquakes on the many seismic sources within the area (see Section 2.2 above) should be anticipated within the design life of the structure. The structure should be designed to withstand strong ground shaking. We provide seismic design parameters in Section 7.1, below.

5.2.2 Surface Fault Rupture

The project site is not located within an Alquist-Priolo Earthquake Fault Hazard Zone. The project site is located just northeast of the nearest active fault, the Little Salmon fault. The Little Salmon fault is a northwest-trending reverse fault that passes beneath the community of Fields Landing, south of Eureka, and projects across the entrance to Humboldt Bay. The fault zone is not well-located beneath the bay, but appears to be about 1.5 miles southwest of the site. As the Little Salmon fault is a southwest-vergent thrust fault, it dips northeastward beneath the site. The site lies about 2,000 feet northeast of the inferred trace of the "North Spit fault." The North Spit fault is an unconfirmed, poorly understood fault that has been mapped based on offshore seismic profiles; it has never been confirmed on land.

Based on the absence of previously identified active faults crossing the site, and the lack of geomorphic evidence of previously unmapped faults, it appears the hazard associated with surface rupture at the project site is negligible.

5.2.3 Seismically-Induced Ground Deformation

Liquefaction is described as the sudden loss of soil shear strength due to a rapid increase of soil pore water pressures caused by cyclic loading from a seismic event. The adverse effects of liquefaction include local and regional ground settlement, ground cracking and expulsion of water and sand, the partial or complete loss of bearing and confining forces used to support loads, amplification of seismic shaking, and lateral spreading. Lateral spreading is defined as lateral earth movement of liquefied soils, or competent strata riding on a liquefied soil layer, downslope toward an unsupported slope face (such as, a creek bank or an inclined slope face). In general, lateral spreading has been observed on low- to moderate-gradient slopes, but has been noted on slopes inclined as flat as one degree. In order for liquefaction to occur, the following are needed:

- granular soils (sand, silty sand, sandy silt, and some gravels),
- a low density of the granular soils (usually associated with young geologic age), and
- a high groundwater table.

From a geologic standpoint, these conditions are most likely to occur in latest Holocene age deposits, especially those less than a thousand years old, in stream channels, floodplains, river deltas, lakes, and low wave energy beaches.

Liquefaction and other seismically-induced ground deformation have been documented around Humboldt Bay during several historical earthquakes (Youd and Hoose, 1978). Specifically, the strong shaking effects associated with large earthquakes in 1906 (great San Francisco quake), and 1954 included extensive damage in Fields Landing and in unconsolidated sediments along much of the bay margin where alluvial sources enter the bay. The nearest documented seismically-induced ground deformation was documented at Broadway and Hawthorne streets, where a long 12-inch wide, 5-foot deep fissure formed in 1954 (probably at the edge of the "reclaimed" fill area that extends west of Broadway Street); this site is about 1.7 miles northeast of the project site.

Based on the geologic setting of the site, the nature (age, texture, and consistency) of earth materials underlying it, and our experience at similar sites around the bay, it appears there would ordinarily be a low to moderate potential for liquefaction and other seismically-induced ground failures during all but the largest earthquakes. Under long-duration strong ground shaking associated with the rare, great earthquake (CSZ event, for example), the potential for liquefaction would increase to a moderate to high potential. The materials most susceptible to liquefaction are the 5- to 13-foot thick section of Holocene age bay margin deposits that underlie on-site fill materials. The deeper Hookton Formation sediments are too old and too dense to be subject to liquefaction. However, based on the relatively thin zone of liquefiable sediment, and the history of surcharge loading related to past use as a tank farm, we find that the overall liquefaction potential at the site has likely been significantly reduced due to densification of the materials beneath the individual tanks. This will be especially true directly beneath the footprints of the larger (20,000-barrel) tanks at the southern end of the site.

The risks associated with liquefaction can be reduced through appropriate foundation design. In liquefaction events, a lesser degree of differential foundation settlement, and less damage to buildings, has been observed to be associated with continuous foundation systems or mat foundations, where individual foundations are structurally tied or restrained from settling markedly on their own (Liu and Dobry, 1997). Consequently, our recommendations include provisions for using relatively strong, well-connected foundation systems for building elements to reduce risk of abrupt differential settlement.

Building code criteria include provisions for some structural damage in major seismic events, but not to the point of building collapse. For example, recent building codes have been based on the following criteria:

> *Structures should be able to 1) resist a minor level of earthquake motion without damage; 2) resist a moderate level of earthquake ground motions without structural damage, but possibly experience some nonstructural damage; and 3) resist a major level of earthquake ground motion having an intensity equal to the strongest either experienced or forecast for the building site, without collapse, but possibly with some structural as well as nonstructural damage. (Kramer, 1996).*

The foundation and slab-on-grade recommendations presented below assume the acceptance of some degree of risk of adverse effects resulting from relatively rare, very strong, upper bound seismic events, as discussed above. No very strong earthquakes (for example M_W greater than 7.5) have occurred in the last 150 years. The behavior of these soil deposits during strong ground motion has not been observed since the advent of European settlement in this part of the continent.

The recurrence interval for very strong earthquake events originating on the CSZ is 300 to 500 years. As discussed in Section 2.2, above, evidence suggests the last major subduction zone quake occurred on January 27, 1700.

5.3 Flooding

The site is located at an elevation of approximately 9 feet above mean sea level. According to the Federal Emergency Management Agency (FEMA) panel 060062006C, revised by FEMA June 17, 1986, the subject property is located in Zone C, which is considered an area with minimal flooding hazard.

5.4 Tsunami Hazard

The site is located within the mapped Tsunami Inundation Area on the Tsunami Inundation Map for Emergency Planning (State of California, 2009). Tsunami waves that might impact the site may be generated by a variety of local or distant sources. The site's location inside Humboldt Bay complicates the assessment of inundation potential, as the impacts in the bay will be directly relative to the degree to which the north and south spits are overtopped. Based on available inundation models, it is unlikely that significant overtopping of the spits would occur from a tsunami derived from a distant source. In that case (as has been observed historically), the area inside Humboldt Bay is subject to swift currents from tsunami waves entering the harbor entrance, but no inundation. In the event of a great Cascadia subduction earthquake, however, the region may be subjected to significant tsunami inundation that may include a relatively large degree of overtopping of both the north and south spits. Under this scenario, bayfront sites, including the project site, would be subject to a significant inundation potential.

6.0 Discussion and Conclusions

Based on the results of our field and laboratory investigations, it is our opinion that the project site can be developed as proposed, provided that our recommendations are followed, and that noted conditions and risks are acknowledged.

The proposed project is situated in an area that has been identified as subject to several seismic hazards, including strong seismic shaking, liquefaction, and tsunami inundation. These hazards are not unique to the project site, but rather are shared by much of the low-lying areas surrounding the bay. Where feasible, we provide recommendations that should reduce the effects of the seismic hazards on the improvements; however, it is not considered practical or economically feasible to eliminate the risks altogether. Further, it is our understanding that HWMA would prefer to use a shallow foundation system. Our recommendations are tendered on the assumption that some risk associated with these hazards is accepted.

The primary geotechnical site considerations are the soft/loose soil conditions relative to the bay margin sediments underlying the site, the potential for liquefaction of isolated soil intervals, and the presence of unsuitable fill underlying portions of the site. Consequently recommendations presented below include provisions for locating specific structures over former fuel tank footprints, using relatively strong, well-connected foundation systems for building elements and in places, the removal and replacement of poor fill materials.

The liquefaction hazard at the project site has likely been reduced in areas previously occupied by large fuel tanks due to consolidation of the supporting sediment. However, some liquefaction potential remains, especially in the event of a very large, long duration seismic event. Differential

foundation settlement could occur, resulting in structural distress. However, light steel-frame structures built to code standards are not likely to collapse in strong seismic events, and thus are likely to meet the building-code criteria cited above under relatively rare, high-magnitude seismic events.

The soft soil conditions identified in the bay margin sediments at depths ranging from about 7 feet (base of fill) to 19 feet in our subsurface investigation present a settlement hazard to the proposed improvements. The risk of settlement is greatest where heavy structural loads (column loads) are applied or where moderate to heavy loads are applied over relatively wide areas (tank pads). The risk of differential settlement exists where there are wide variations in the loads applied by the improvements. The settlement potential, however, is likely reduced in areas that previously supported fuel tanks. **Due to the surcharge loading provided by the former fuel tanks, we recommend that the proposed facility be laid out such that structures with the greatest loads, as well as the digester tanks, are situated directly over the former tank footprints in the southern part of the site.** In addition, we provide recommendations for the design and construction of foundation systems that apply a reduced bearing pressure and are well-reinforced to minimize the risk of differential settlement.

The fill materials in the northern part of the site are of poor quality, and are not suitable as bearing material for structures in their existing condition. Assuming that major structural elements of the facility are located in the southern part of the site, it is feasible to remove/replace the upper part of the material; install a reinforced gravel blanket and cover with structural fill; and use this area for light structures, parking, or other non-critical functions.

7.0 Recommendations

We understand that it is desired to construct the new facility on conventional shallow foundations and without ground improvement or excessive grading. New structures on both the northern and southern portions of the site will be supported on existing fill. The fill on the southern portion has greater shear strength and less compressibility than fill on the northern portion. For deeper sediments underlying the fill, the degree of compressibility is dependent on the recent stress history. Where soils have been subjected to static loading in the past, where tanks or other structures were supported, the amount of additional settlement due to new structures is expected to be minimal. However, in areas between former tanks, these soils are subject to increased compressibility where no load existed previously. The implication of these conditions is that differential settlement may be significant where new structures span previously loaded ground and areas where no load existed in the past. Therefore, the best mitigation is to locate new structures over areas previously occupied by loads equal to or greater than the proposed loading.

7.1 Seismic Design

We recommend that the proposed structures (building and tanks) be designed and built to withstand strong seismic shaking. The minimum standard for construction of the structures should be in accordance with the latest edition of the California Building Code (CBC) for the most seismically active areas.

The 2010 CBC requires the following information for seismic design. Based on our knowledge of subsurface and geologic conditions, we estimate a Site Class D for the project. Based on the site class and the latitude and longitude, we calculated the design spectral response acceleration parameters S_S, S_1, F_a, F_v, S_{MS}, S_{M1}, S_{DS}, and S_{D1} using the United States Geological Survey (USGS)

seismic calculator software, "Seismic Hazard Curves, Response Parameters, Design Parameters: Seismic Hazard Curves, and Uniform Hazard Response Spectra," v. 5.1.0, dated February 10, 2011. Calculated values are presented in Table 1.

Table 1 Seismic Design Criteria Hilfiker Lane, Eureka, CA	
Latitude	40.76955
Longitude	-124.1954
Site Class	D
S_S	2.569
S_1	0.985
F_a	1.00
F_v	1.50
S_{MS}	2.569
S_{M1}	1.478
S_{DS}	1.712
S_{D1}	0.985
Occupancy Category	II
Seismic Design Category	E

7.2 Site Preparation and Grading

Because the project design is still conceptual, a grading plan was not available at the time of our reporting. Based on the flat-lying topography of the project site, we do not expect significant cuts or fills and that structures will be situated within 2 feet of existing grade.

7.2.1 Northern Portion of the Site

The northern portion of the site is underlain by what we infer to be dredged spoils. However, in the past, this fill supported small tanks having relatively low contact pressures (the actual pressure of the tank and contents on the ground surface). Without knowing if the tanks settled uniformly and where the tanks were located, at least the upper 3 feet of existing fill should be improved by excavation and replacement or reuse as compacted fill. We assume that only relatively light new structures will be located in this area.

The following sections provide recommendations for fill placement and compaction requirements as necessary to achieve a building or tank pad grade.

Identification of Existing Utilities: If appropriate, notify Underground Service Alert (1-800-642-2444) prior to commencing site work, and use this location service and other methods to avoid injury or risk to life from underground and overhead utilities, and to avoid damaging them. We encountered no utilities during the planning or execution of our investigation.

Stripping Organic Material and Topsoil: Unsuitable organic matter and topsoil should be stripped to expose dredged spoil fill. Topsoil and organic soil may be stockpiled for reuse in landscape areas but should not be used within structural fill. Unsuitable fill may be used in non-structural areas where there is no traffic loading.

Existing Fill Over-excavation: We encountered 6 to 7 feet of fill consisting of dredged spoil over the northern portion of the site. However, we recommend that at least 3 feet of this fill be excavated to be replaced with structural fill having improved engineering properties. This material may be stockpiled for incorporation into structural fill or as a subgrade surface for paved parking and truck traffic.

Observation of Exposed Subgrade Surfaces: Exposed surfaces resulting from over-excavation of the upper 3 feet of dredged fill should be observed by the geotechnical engineer to determine appropriate action. Due to the nature of this material and possible differences in consistency due to previous site use, this evaluation is essential. The geotechnical engineer may recommend that remaining unsuitable soils, such as overly weak, compressible, or disturbed soils, be additionally excavated. This evaluation may include in-place soil density testing, as well as proofrolling.

Placement of Reinforced Gravel Mattress: An angular gravel or crushed rock mattress at least 12 inches thick should be placed over the excavated and approved fill surface. Reinforcement at the

base of this rock mattress should consist of a high modulus synthetic geogrid that extends at least 5 feet beyond the outer extent of any proposed structure. The geogrid should be biaxial and be manufactured of polyester, which is less prone to creep under sustained loading. The geogrid should be placed on top of the exposed dredged spoil surface and then covered with 12 inches of crushed rock or gravel, placed in two lifts. Compaction of the gravel mattress should be performed after the second lift is placed. The gravel mattress should be covered with a woven 6-oz per square yard geotextile that is typically used for road stabilization, such as Mirafi 600X or equivalent manufacture. This geotextile should be placed before additional filling resumes.

Structural Fill: Structural fill should be placed to design grades and compacted to a minimum of 90 percent of the maximum relative dry density as determined by the current American Society for Testing Materials-International (ASTM) D1557 test method. Structural fill may consist of the existing excavated dredged spoil or imported granular soil (a durable, sand and gravel mixture, containing little or no clay and silt, no organic material or debris, and no individual particles over three inches across such as river-run gravel or base rock). A contractor may discover that imported granular soil should be relatively easy to moisture condition and compact compared to reusing existing dredged spoils. Structural fill should extend horizontally beyond the exterior footing perimeters a distance of 5 feet, measured at the bottom of the excavation.

7.2.2 Southern Portion of the Site

The existing gravel fill within the upper 6 or 7 feet was found to be competent. It is likely that this gravel fill was placed over the entire surface for the tank farm, without regard to where tanks were to be located. Accordingly, we consider this gravel fill to be relatively incompressible. However, the underlying bay margin sediments are compressible, as are the same sediments underlying the northern portion of the site. We expect that heavier structures and loads will be imposed on soils in the southern portion of the site. To minimize differential settlement where tanks were previously located and where no loading occurred (between tanks), those original tank locations should be identified.

The following sections provide recommendations for site preparation requirements as necessary to achieve a building or tank pad grade.

Identification of Existing Utilities: If appropriate, notify Underground Service Alert (1-800-642-2444) prior to commencing site work, and use this location service and other methods to avoid injury or risk to life from underground and overhead utilities, and to avoid damaging them. We encountered no utilities during the planning or execution of our investigation.

Stripping Organic Material and Topsoil: Unsuitable organic matter and topsoil should be stripped to expose gravel fill. Topsoil and organic soil may be stockpiled for reuse in landscape areas.

Identification of Original Tank Locations: We encountered 6 to 7 feet of fill consisting of competent gravel fill over the southern portion of the site. This fill is to remain in place. It cannot be readily determined where tanks were previously located based on the consistency of the fill. However, the underlying bay sediment is expected to exhibit differences in density and consistency where tanks previously consolidated the sediment and where there was no loading influence on the soil. As such, it will be necessary to verify where the previous tanks were located to avoid undesirable differential settlement. As an initial step, the former tank locations should be located using triangulation (based on historical aerial photographs of the site) and survey. Second, CPT should be used to verify site conditions in the estimated former tank footprints at locations where proposed structures will be re-occupying the former tank sites. Because of the high density of the

fill, it will be necessary to pre-drill through the fill in order to advance the CPT through the bay sediments. Once the facility layout is determined, an appropriate distribution (grid?) of CPT test points should be developed.

Structural Fill: If site grade is raised, structural fill should be placed to design grades and compacted to a minimum of 90 percent of the maximum relative dry density as determined by the current ASTM D1557 test method. Structural fill should consist of imported granular soil (a durable, sand and gravel mixture, containing little or no clay and silt, no organic material or debris, and no individual particles over three inches across) such as river-run gravel or base rock, similar to the material the exists presently. Structural fill should extend horizontally beyond the exterior footing perimeters a distance of five feet.

7.3 Foundations

7.3.1 Building Foundations

Where practicable, conventional shallow foundations supported on structural fill should be proportioned to exert a relatively low contact pressure. We recommend an allowable bearing pressure of 1,500 pounds per square foot (psf) for structures located over the northern portion of the site. For conventional foundations in the southern portion of the site, an allowable bearing pressure of 2,500 psf should be used. These values may be increased by one-third to accommodate temporary durations of loading including seismic loads. Foundations should be supported on structural fill and established a minimum of 18 inches below the lowest adjacent grade. The above values may be conservative. By reducing the contact pressure, the intent is to also reduce stress influence on the underlying soils, to minimize the effects of static total and differential settlement.

Once structural details are finalized, we will analyze foundations for total and differential settlement. Until the engineering properties of the subsoils are known, specifically the bay margin sediment underlying existing fill, any estimates of settlement are premature.

7.3.2 Tank Foundations

The tanks may be supported on grade consisting of existing gravel fill. Alternately, tanks may be supported on a concrete mat. The advantage of the existing gravel fill is that it acts as a mat and the influence of the stress due to a fully loaded tank is extended to the underlying soft bay sediment in a relatively uniform distribution.

We assume that large tanks will be supported on a concrete ringwall. Large tanks should be located in the southern portion of the site and, if at all possible, over a footprint previously occupied by an older tank. A concrete ringwall may be proportioned using an allowable bearing pressure of 2,500 psf and should extend at least 24 inches below the lowest grade. Once the tank dimensions are determined, a more sophisticated analytical procedure should be undertaken to determine total and differential settlement.

7.4 Slab-on-Grade

Where floor slabs are located within the southern portion of the site, all concrete slabs should be underlain by at least 4 inches of crushed rock that acts as a capillary break and provides a uniform surface to construct the slab. Where a reinforced floor to accommodate heavy traffic loads is designed, the slab should be underlain by at least 8 inches of crushed rock. We assume no moisture-sensitive floor coverings are planned.

Within the northern portion of the site, concrete slabs-on-grade should be supported on 6 inches of crushed rock over structural fill. A slab that supports heavy traffic loads should be underlain by 10 inches of crushed rock.

7.5 Construction Phase Monitoring

In order to assess construction conformance with the intent of our recommendations, it is important that a representative of our firm monitor the following tasks:

1. Site stripping, including removal of topsoil and organic matter, existing improvements, and any uncontrolled existing fill soils
2. Excavation and replacement of existing fill
3. Construction of the reinforced gravel mattress over the northern portion of the site
4. Placement of structural fill
5. Determining the locations of previous tanks
6. Foundation excavations

This construction phase monitoring is important because it provides the owner and SHN the opportunity to verify anticipated site conditions, and recommend appropriate changes in design or construction procedures if site conditions encountered during construction vary from those described in this report. It also allows SHN to recommend appropriate changes in design or construction procedures if construction methods adversely affect the competence of on-site soils to support the structural improvements.

8.0 Closure and Limitations

The analyses, conclusions, and recommendations contained in this preliminary report are based on site conditions that we observed at the time of our investigation, data from our subsurface explorations and laboratory tests, our current understanding of proposed project elements, and on our experience with similar projects in similar geotechnical environments. We have assumed that the information obtained from our limited subsurface explorations is representative of subsurface conditions across the site.

We recommend that a representative of our firm confirm site conditions during the construction phase. If subsurface conditions differ significantly from those disclosed by our investigation, we should be given the opportunity to re-evaluate the applicability of our conclusions and recommendations. Some alteration of recommendations may be appropriate.

If there is a substantial lapse of time between the submission of our preliminary report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, we should review our report to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse. This report is applicable only to the project and site studied. We assume that when design details become more formalized, then our design recommendations can be refined. The conclusions and recommendations presented in this report are professional opinions derived in accordance with current standards of professional practice. Our recommendations are tended on the assumption that design of the improvements will conform to their intent. No warranty, express or implied, exists on the information presented in this report.

The field and laboratory work was conducted to investigate the site characteristics specifically addressed by this report. Assumptions about other site characteristics (such as, hazardous materials contamination, or environmentally sensitive or culturally significant areas) should not be made from this report.

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Appendix A

Test Pit Logs

CONSULTING ENGINEERS
& GEOLOGISTS

BORING LOG KEY

SAMPLE TYPES

- DISTURBED SAMPLE (BULK)
- HAND DRIVEN TUBE SAMPLE
- 1.4" I.D. STANDARD PENETRATION TEST SAMPLE (SPT)
- 2.5" I.D. MODIFIED CALIFORNIA SAMPLE (SOLID WHERE RETAINED)
- CORE BARREL SAMPLE (NOT RETAINED)
- CORE BARREL SAMPLE (RETAINED)

SYMBOLS

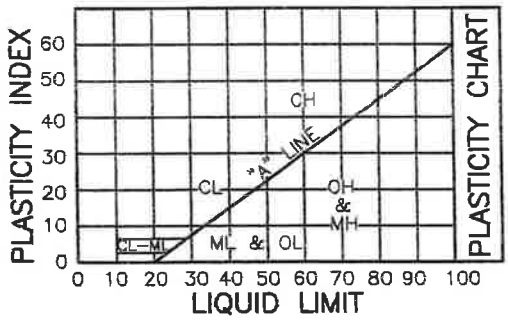
- INITIAL WATER LEVEL
- STABILIZED WATER LEVEL
- GRADATIONAL CONTACT
- WELL DEFINED CONTACT
- SS — SPLIT SPOON

CONSULTING ENGINEERS
& GEOLOGISTS

METHOD OF SOIL CLASSIFICATION

MAJOR DIVISIONS		SYMBOLS	TYPICAL NAMES	
COARSE GRAINED SOILS (MORE THAN 1/2 OF SOIL >NO. 200 SIEVE SIZE)	GRAVELS (MORE THAN 1/2 OF COARSE FRACTION > NO.4 SIEVE SIZE)	GW	WELL GRADED GRAVELS OR GRAVEL–SAND MIXTURES, LITTLE OR NO FINES	CLASSIFICATION CHART
		GP	POORLY GRADED GRAVELS OR GRAVEL–SAND MIXTURES, LITTLE OR NO FINES	
		GM	SILTY GRAVELS, GRAVEL–SAND–SILT MIXTURES	
		GC	CLAYEY GRAVELS, GRAVEL–SAND–CLAY MIXTURES	
	SANDS (MORE THAN 1/2 OF COARSE FRACTION < NO.4 SIEVE SIZE)	SW	WELL GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES	
		SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES	
		SM	SILTY SANDS, SAND–SILT MIXTURES	
		SC	CLAYEY SANDS, SAND–CLAY MIXTURES	
FINE GRAINED SOILS (MORE THAN 1/2 OF SOIL <NO. 200 SIEVE SIZE)	SILTS & CLAYS LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	
		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	
	SILTS & CLAYS LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	
		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
		OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTY CLAYS, ORGANIC SILTS	
HIGHLY ORGANIC SOILS		PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	

CLASSIFICATION	U.S. STANDARD SIEVE SIZE	
BOULDERS	ABOVE 12"	GRAIN SIZE CHART
COBBLES	12" TO 3"	
GRAVEL	3" TO NO. 4	
COARSE	3" TO 3/4"	
FINE	3/4" TO NO. 4	
SAND	NO. 4 TO NO. 200	
COARSE	NO. 4 TO NO. 10	
MEDIUM	NO. 10 TO NO. 40	
FINE	NO. 40 TO NO. 200	
SILT & CLAY	BELOW NO. 200	



CONSISTENCY OF FINE GRAINED SOILS		DENSITY OF COARSE GRAINED SOILS	
CLASSIFICATION	COHESION (PSF)	CLASSIFICATION	STANDARD PENETRATION (BLOW COUNT)
VERY SOFT	0–250	VERY LOOSE	0–4
SOFT	250–500	LOOSE	4–10
MEDIUM STIFF	500–1000	MEDIUM	10–30
STIFF	1000–2000	DENSE	30–50
VERY STIFF	2000–4000	VERY DENSE	50+
HARD	4000+		

MOISTURE CLASSIFICATIONS
DRY
DAMP
MOIST
WET

BASED ON UNIFIED SOILS CLASSIFICATION SYSTEM

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Backhoe
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF TEST PIT: 7.25 Feet
SAMPLER TYPE: 2.5" O.D. brass tube

TEST PIT NUMBER
BP-1

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	U.C. (psf) by P.P.	% Passing 200	REMARKS
0.0			GM		SANDY GRAVEL; Brownish-gray, medium dense, wet, abundant roots. (Fill)						Ground surface saturation
-1.0			SP		POORLY GRADED SAND; Brownish-gray, medium dense, wet. (Fill)						Massive side-wall collapse below a depth of 1.5 feet.
-2.0		■									
-3.0	▽										
-4.0											
-5.0											
-6.0											
-7.0			SM		SILTY SAND; Bluish-gray, medium dense, wet, coarse sand and shell fragments. (Alluvium)						
-8.0					Excavation terminated at a depth of 7.25 feet. Groundwater encountered at a depth of 3.25 feet.						
-9.0											
-10.0											
-11.0											
-12.0											
-13.0											
-14.0											
-15.0											

The log and data presented are a simplification of actual conditions encountered at the time of excavation at the excavated location. Subsurface conditions may differ at other locations and with the passage of time.

SOIL LOG

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Backhoe
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF TEST PIT: 9.5 Feet
SAMPLER TYPE: 2.5" O.D. brass tube

TEST PIT NUMBER
BP-2

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	U.C. (psf) by P.P.	% Passing 200	REMARKS
0.0			GM		SANDY GRAVEL; Gray, loose to medium dense, saturated. (Fill)						
-1.0			SP		POORLY GRADED SAND; Bluish-gray, wet to saturated, medium dense, some woody debris. (Fill)						
-2.0											Sample attempted from 2 to 2.5 feet-No Recovery
-3.0											
-4.0											
-5.0											
-6.0											
-7.0											
-8.0			SP		POORLY GRADED SAND; Bluish-gray, wet to saturated, medium dense, shell fragments. (Alluvium)						
-9.0											
-10.0					Excavation terminated at a depth of 9.5 feet. Groundwater encountered at a depth of 3.75 feet.						
-11.0											
-12.0											
-13.0											
-14.0											
-15.0											

The log and data presented are a simplification of actual conditions encountered at the time of excavation at the excavated location. Subsurface conditions may differ at other locations and with the passage of time.

SOIL LOG

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812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Backhoe
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF TEST PIT: 13 Feet
SAMPLER TYPE: 2.5" O.D. brass tube

TEST PIT NUMBER
BP-3

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	U.C. (psf) by P.P.	% Passing 200	REMARKS
0.0			GM		SANDY GRAVEL; Gray, moist to wet, medium dense, contains coarse rounded gravel and cobble. (Fill)						
-1.0											
-2.0											
-3.0		■	SP-SM		POORLY GRADED SAND with SILT; Bluish-gray, wet, medium dense, contains lenses of coarse rounded gravel. (Fill)						
-4.0											
-5.0			SM		SILTY SAND with GRAVEL; Bluish-gray, wet, medium dense, coarse sand and gravel. (Fill)						
-6.0											
-7.0			SP-SM		POORLY GRADED SAND with SILT; Bluish-gray, wet, medium dense, shell fragments. (Alluvium)						
-8.0											
-9.0											
-10.0											
-11.0											
-12.0			SM		SILTY SAND; Bluish-gray, wet, medium dense, shell fragments, plant fragements, coarse sand and fine gravel. (Alluvium)						
-13.0											
-14.0					Excavation terminated at a depth of 13 feet. Groundwater encountered at a depth of 6.75 feet.						
-15.0											

The log and data presented are a simplification of actual conditions encountered at the time of excavation at the excavated location. Subsurface conditions may differ at other locations and with the passage of time.

SOIL LOG

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Backhoe
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF TEST PIT: 11.5 Feet
SAMPLER TYPE: 2.5" O.D. brass tube

TEST PIT NUMBER
BP-4

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	U.C. (psf) by P.P.	% Passing 200	REMARKS
0.0			GM		SANDY GRAVEL; Brownish-gray, moist, medum dense, coarse rounded gravel. (Fill)						
-1.0											
-2.0											
-3.0		■									
-4.0											
-5.0											
-6.0			SM		SAND with GRAVEL; Bluish-gray, wet, medium dense. (Alluvium)						Sidewalls holding vertically
			SM		SILTY SAND; Bluish-gray, wet, medium dense, shell fragments. (Alluvium)						
-7.0											
-8.0											
-9.0					Grades brownish-gray; contains plant material and medium to coarse grain sand						
-10.0											
-11.0											
-12.0					Excavation terminated at a depth of 11.5 feet. Groundwater encountered a depth of 6.0 feet.						
-13.0											
-14.0											
-15.0											

The log and data presented are a simplification of actual conditions encountered at the time of excavation at the excavated location. Subsurface conditions may differ at other locations and with the passage of time.

SOIL LOG

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Backhoe
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF TEST PIT: 8.5 Feet
SAMPLER TYPE: 2.5" O.D. brass tube

TEST PIT NUMBER
BP-5

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	U.C. (psf) by P.P.	% Passing 200	REMARKS
0.0			GM		SANDY GRAVEL; Brownish-gray, wet, medium dense to dense, contains construction waste. (Fill)						Difficulty digging
-1.0											
-2.0											
-3.0					Grades bluish-gray						
-4.0											
-5.0											
-6.0 ▽			SM		SAND with GRAVEL; Bluish-gray, wet, medium dense. (Alluvium)						water pouring out of sidewall
-7.0			SM		SILTY SAND; Bluish-gray, wet, medium dense, shell fragments. (Alluvium)						
-8.0											
-9.0											
-10.0											
-11.0											
-12.0											
-13.0											
-14.0											
-15.0											

The log and data presented are a simplification of actual conditions encountered at the time of excavation at the excavated location. Subsurface conditions may differ at other locations and with the passage of time.

SOIL LOG

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Backhoe
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF TEST PIT: 7.5 Feet
SAMPLER TYPE: 2.5" O.D. brass tube

TEST PIT NUMBER
BP-6

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	U.C. (psf) by P.P.	% Passing 200	REMARKS
0.0			GM		SANDY GRAVEL; Brownish-gray, moist, medium dense, coarse sand and rounded gravel, construction waste. (Fill)						
-1.0											
-2.0											
-3.0					Grades bluish-gray						
-4.0		■									
-5.0											
-6.0			SM		SAND with GRAVEL; Bluish-gray, wet, medium dense, shell fragments, coase sand and gravel. (Alluvium)						
-7.0			SM		SILTY SAND; Bluish-gray, wet, medium dense, shell fragments. (Alluvium)						
-8.0					Excavation terminated at a depth of 7.5 feet. Groundwater encountered at a depth of 6.0 feet.						
-9.0											
-10.0											
-11.0											
-12.0											
-13.0											
-14.0											
-15.0											

The log and data presented are a simplification of actual conditions encountered at the time of excavation at the excavated location. Subsurface conditions may differ at other locations and with the passage of time.

SOIL LOG

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Backhoe
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF TEST PIT: 6.5
SAMPLER TYPE: 2.5" O.D. brass tube

TEST PIT NUMBER
BP-7

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	U.C. (psf) by P.P.	% Passing 200	REMARKS
0.0			SM		SILTY SAND; Brown, moist, loose to medium dense, abundant roots. (Fill)						
-1.0			SP-SM		POORLY GRADED SAND with SILT; Brown, moist, medium dense (Fill)						
-2.0											
-3.0											
-4.0											
-5.0	▽				observed roots						Major side-wall collapse
-6.0					Grades bluish-gray						
-7.0					Excavation terminated at a depth of 6.5 feet. Groundwater encountered at a depth of 5.0 feet.						
-8.0											
-9.0											
-10.0											
-11.0											
-12.0											
-13.0											
-14.0											
-15.0											

The log and data presented are a simplification of actual conditions encountered at the time of excavation at the excavated location. Subsurface conditions may differ at other locations and with the passage of time.

SOIL LOG

Consulting Engineers & Geologists, Inc.
812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Backhoe
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF TEST PIT: 4.0 Feet
SAMPLER TYPE: 2.5" O.D. brass tube

TEST PIT NUMBER
BP-8

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	U.C. (psf) by P.P.	% Passing 200	REMARKS
0.0			GM		SANDY GRAVEL; Brownish-gray, moist, medium dense. (Fill)						
-1.0											
-2.0			SM		SILTY SAND; Brownish-gray, moist, medium dense. (Fill)						
-3.0											Sample attempted from 2.5 to 3 feet - No recovery
-4.0					Grades bluish-gray						
-5.0					Excavation terminated at a depth of 4.0 feet. Groundwater encountered at a depth of 2.25 feet.						
-6.0											
-7.0											
-8.0											
-9.0											
-10.0											
-11.0											
-12.0											
-13.0											
-14.0											
-15.0											

The log and data presented are a simplification of actual conditions encountered at the time of excavation at the excavated location. Subsurface conditions may differ at other locations and with the passage of time.

SOIL LOG

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: HWMA Food Digester Geotech
LOCATION: Crowley Property
GROUND SURFACE ELEVATION: 7 Feet MSL (Google Earth)
EXCAVATION METHOD: Direct Push
LOGGED BY: PRS

JOB NUMBER: 012046
DATE DRILLED: 3/19/12
TOTAL DEPTH OF BORING: 30 Feet
SAMPLER TYPE: Continuous Core

CONTINUOUS CORE
CC-1

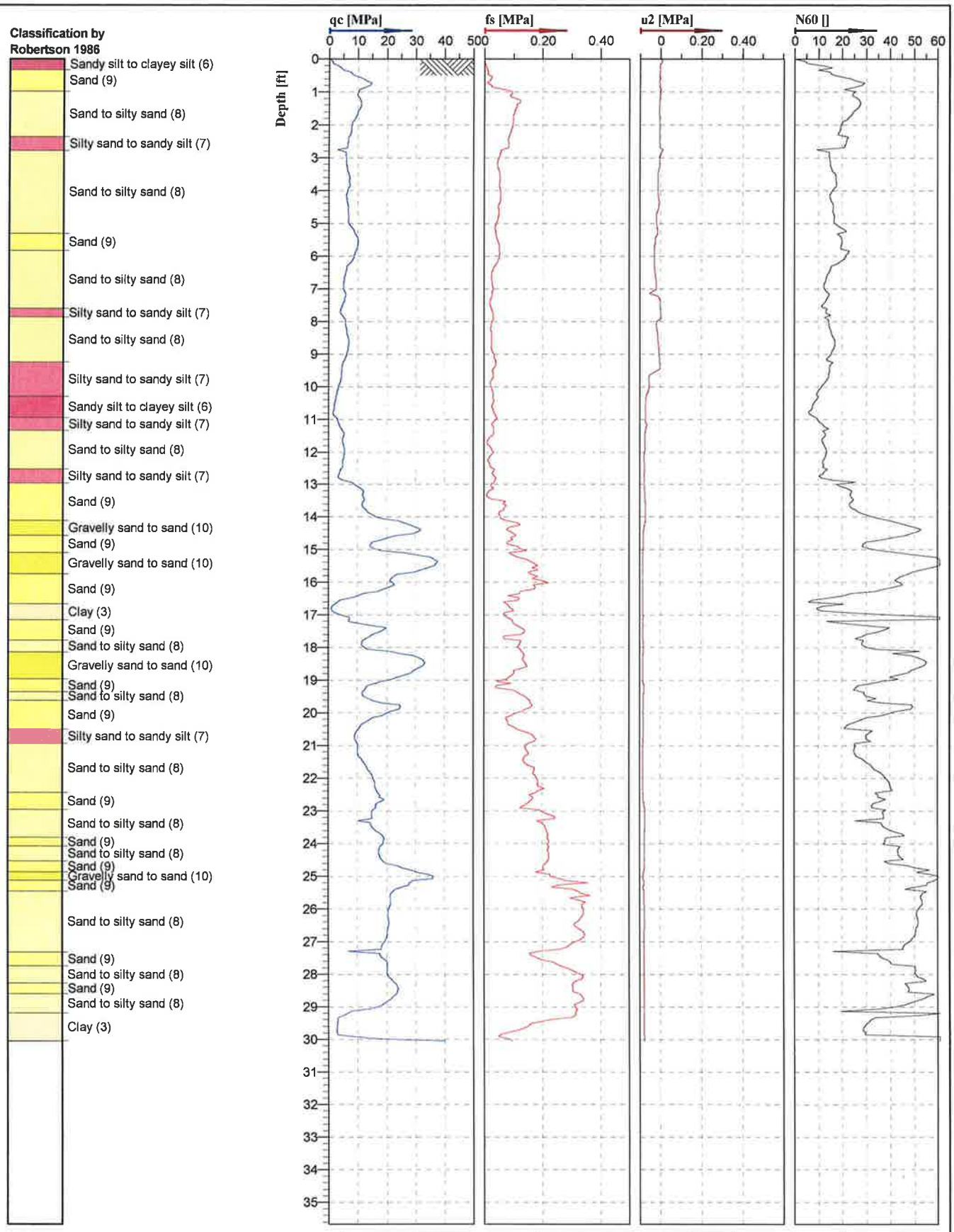
DEPTH (FT)	Lab Sample	% Recovery	USCS	PROFILE	SOIL DESCRIPTION (ASTM D 2488)	% Moisture	Atterburg Limits: Liquid Limit	Atterburg Limits: Plastic Index	U.C. (psf) by P.P.*	% Passing 200	REMARKS
-10.0											No Samples Taken to 10 Feet
-11.0		80	SP-SM		POORLY GRADED SAND with SILT; Black, wet, medium dense, shell fragments.						
-12.0			SM		SILTY SAND; Black, wet, medium dense, shell fragments						
-13.0			CL								
-14.0		100	OL		CLAY; Very dark gray, moist to wet, stiff to medium stiff.						
-15.0					ORGANIC SILT; Dark brown, wet, medium stiff, contains silt and peat, alternating zones of coarse plant fragments.						
-16.0			SM-ML								
-17.0			SP-SM		SILTY SAND/SANDY SILT; Black, moist to wet, medium stiff/medium dense.						
-18.0		100			POORLY GRADED SAND with SILT; Very dark gray, wet, medium dense, alternating zones of saturation.						
-19.0											
-20.0			SM		SILTY SAND; Dark grayish-brown, saturated, meduim dense, contains lenses of coarse sand and well rounded fine gravel, alternating zones of saturation.						
-21.0		100									
-22.0											
-23.0											
-24.0											
-25.0		100									
-26.0											
-27.0											
-28.0		100									
-29.0											
-30.0					Continuous core terminated at a depth of 30 feet.						
-31.0											

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

CONTINUOUS CORE LOG

Appendix B

Cone Penetration Test Logs

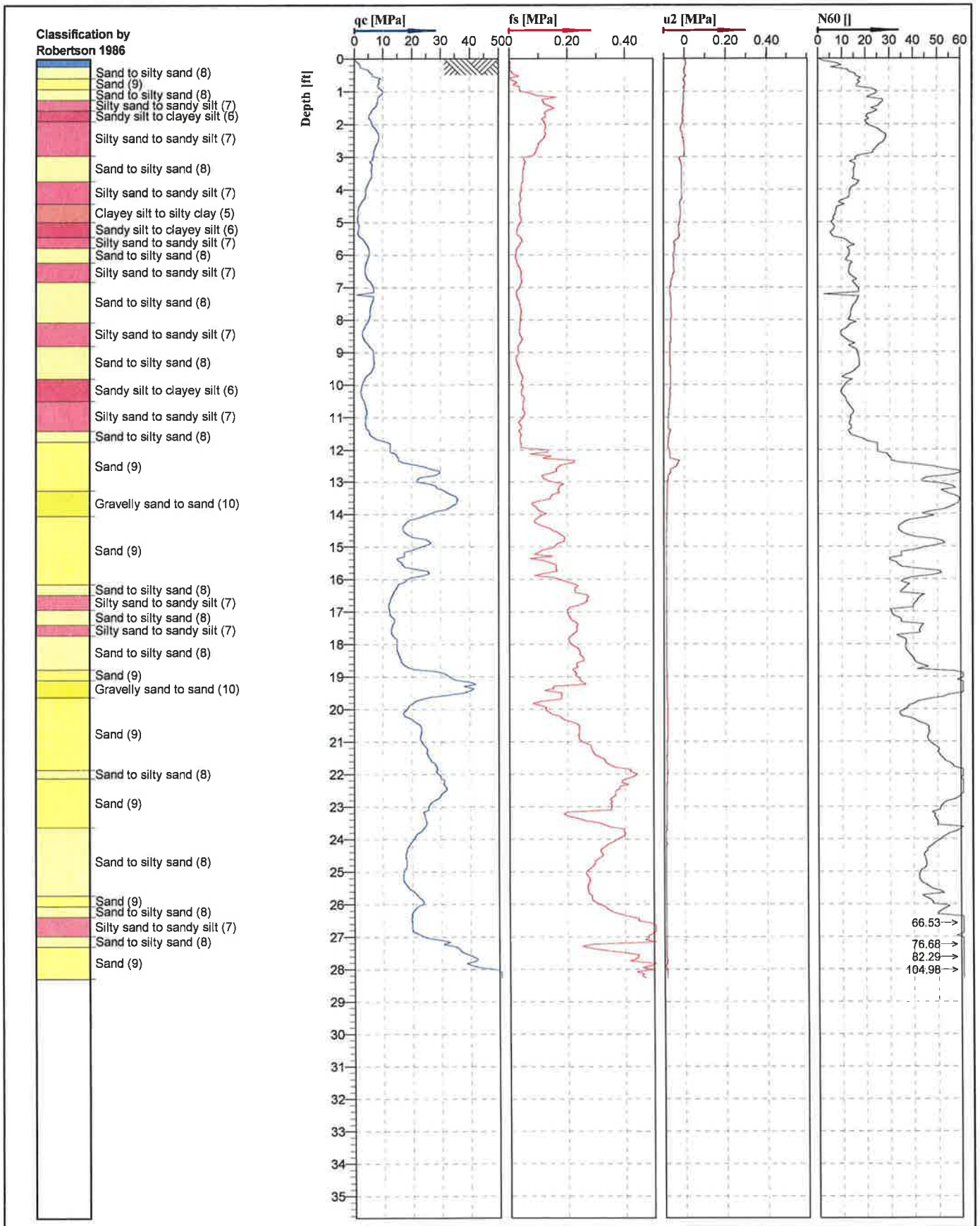


FISCH DRILLING

U2

Cone No: 3335
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Eureka, Ca	Position: X: 0.00 ft, Y: 0.00 ft	Ground level: 0.00	Test no: CPT1
Project ID: G3849	Client: SHN	Date: 3/19/2012	Scale: 1 : 50
Project: HWMA		Page: 1/1	Fig:
		File: SHN HWMAcpt1.CPT	

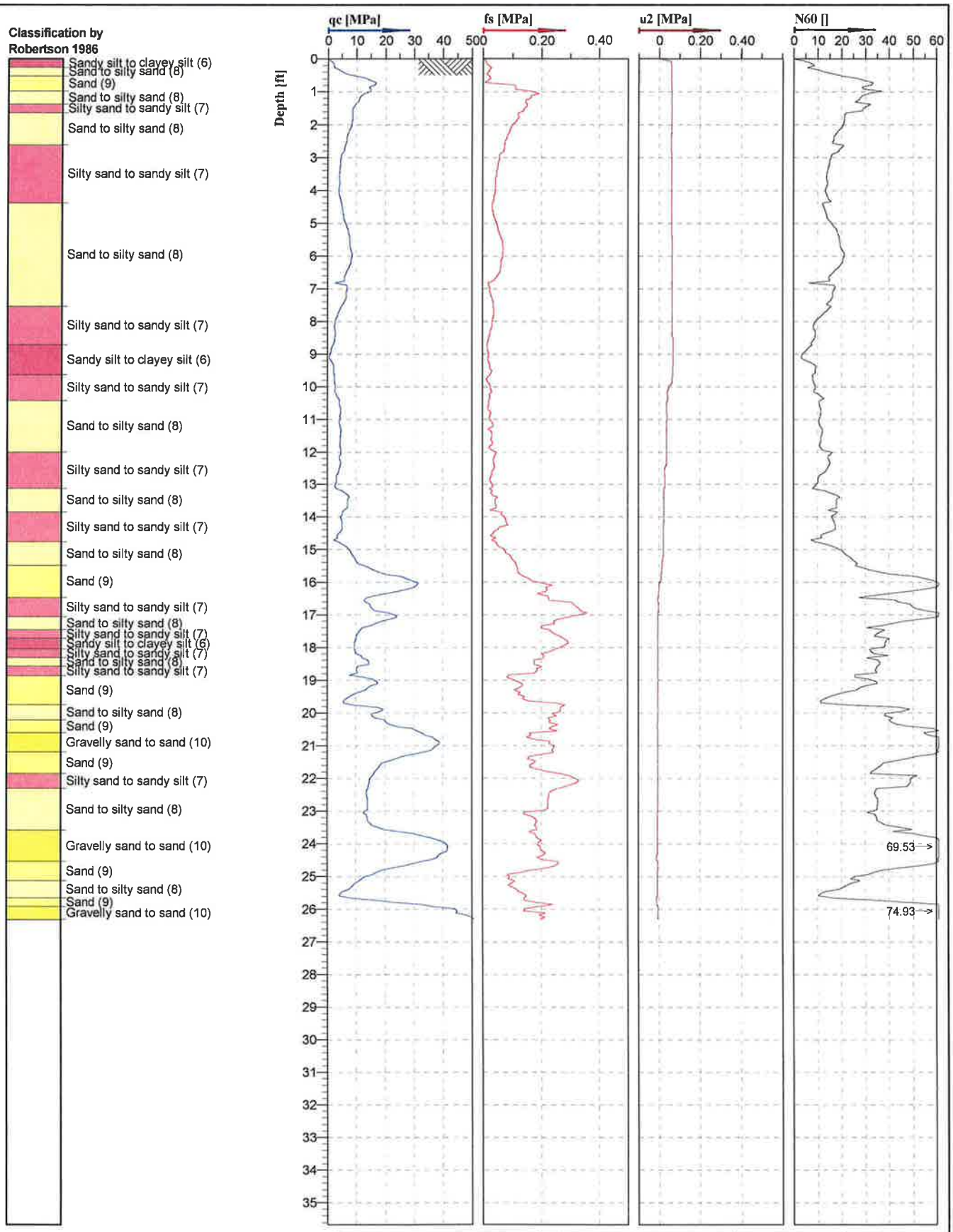


FISCH DRILLING

U2

Cone No: 3335
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Eureka, Ca	Position: X: 0.00 ft, Y: 0.00 ft	Ground level: 0.00	Test no: CPT2
Project ID: G3849	Client: SHN	Date: 3/19/2012	Scale: 1 : 50
Project: HWMA		Page: 1/1	Fig:
		File: SHN HWMA cpt2.CPT	

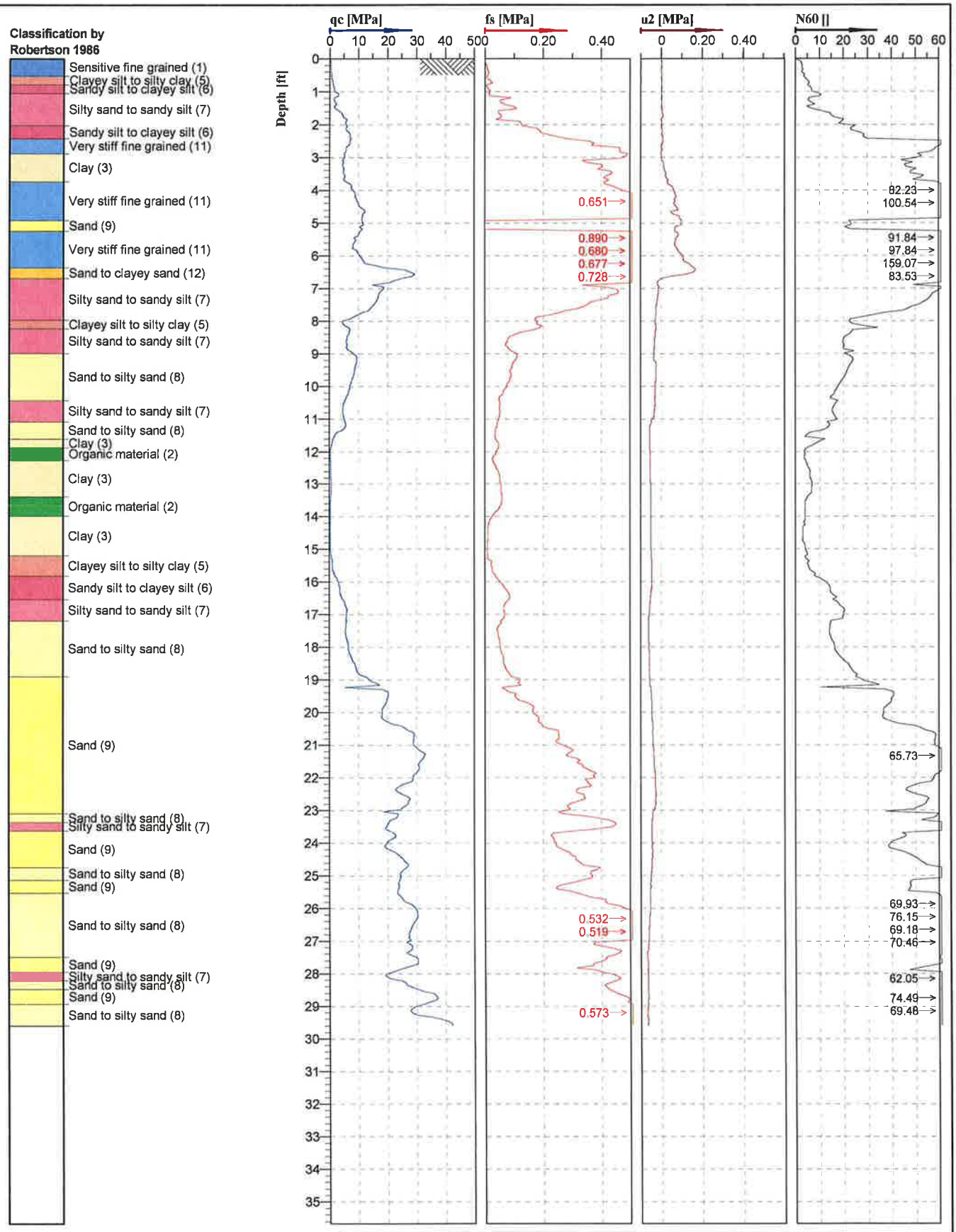


FISCH DRILLING

U2

Cone No: 3335
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Eureka, Ca	Position: X: 0.00 ft, Y: 0.00 ft	Ground level: 0.00	Test no: CPT3
Project ID: G3894	Client: SHN	Date: 3/19/2012	Scale: 1 : 50
Project: HWMA		Page: 1/1	Fig:
		File: SHN HWMA cpt3.CPT	

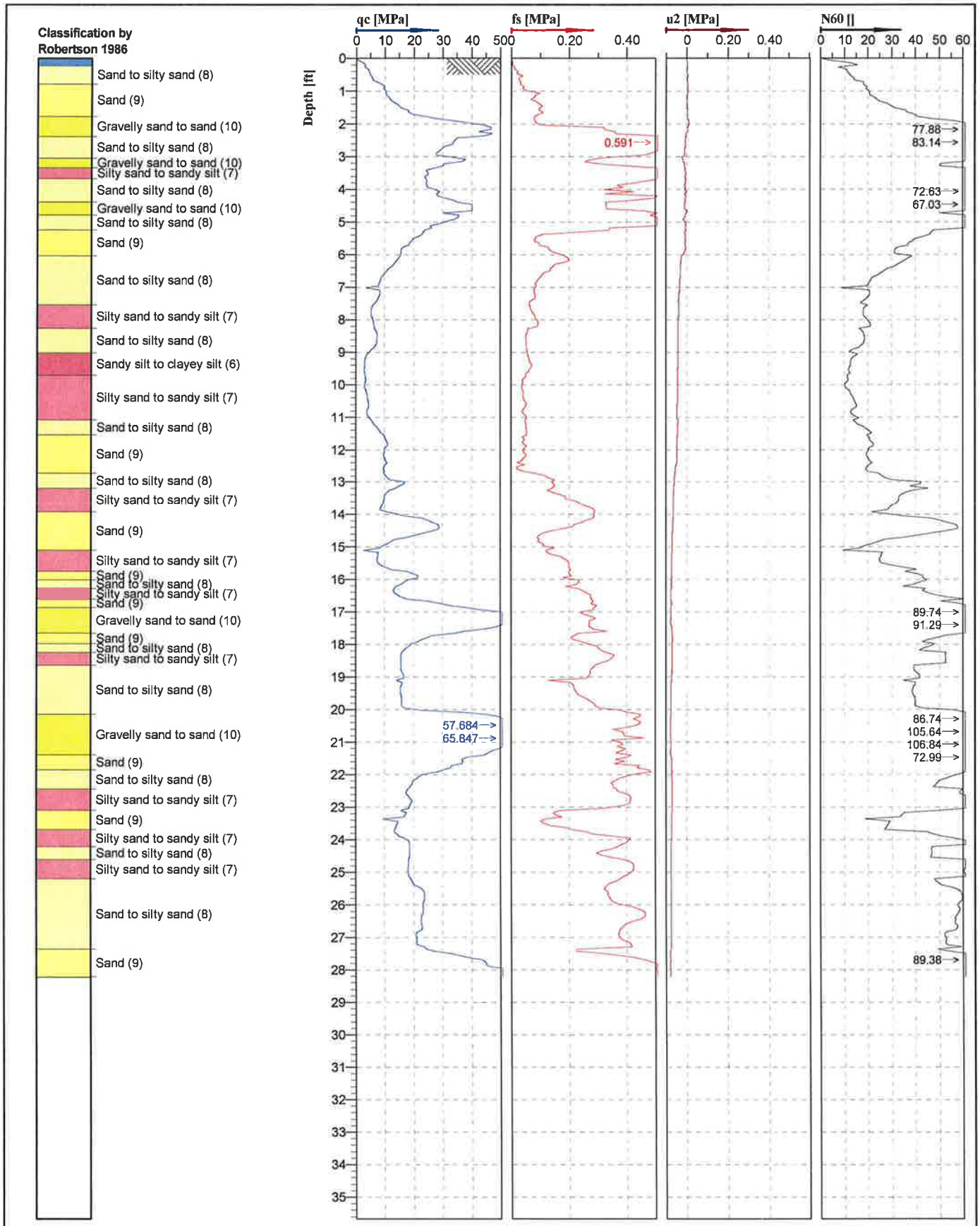


FISCH DRILLING

U2

Cone No: 3335
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Eureka, Ca	Position: X: 0.00 ft, Y: 0.00 ft	Ground level: 0.00	Test no: CPT4
Project ID: G3849	Client: SHN	Date: 3/19/2012	Scale: 1 : 50
Project: HWMA		Page: 1/1	Fig:
First 7' preprobed large river run gravel		File: SHN HWMA cpt4.CPT	



Location:	Position:	Ground level:	Test no:
Eureka, Ca	X: 0.00 ft, Y: 0.00 ft	0.00	CPT5
Project ID: G3849	Client: SHN	Date: 3/19/2012	Scale: 1 : 50
Project: HWMA		Page: 1/1	Fig:
		File: SHN HWMA cpt5.CPT	

FISCH DRILLING

U2

Cone No: 3335
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Appendix C

Laboratory Test Data Sheets

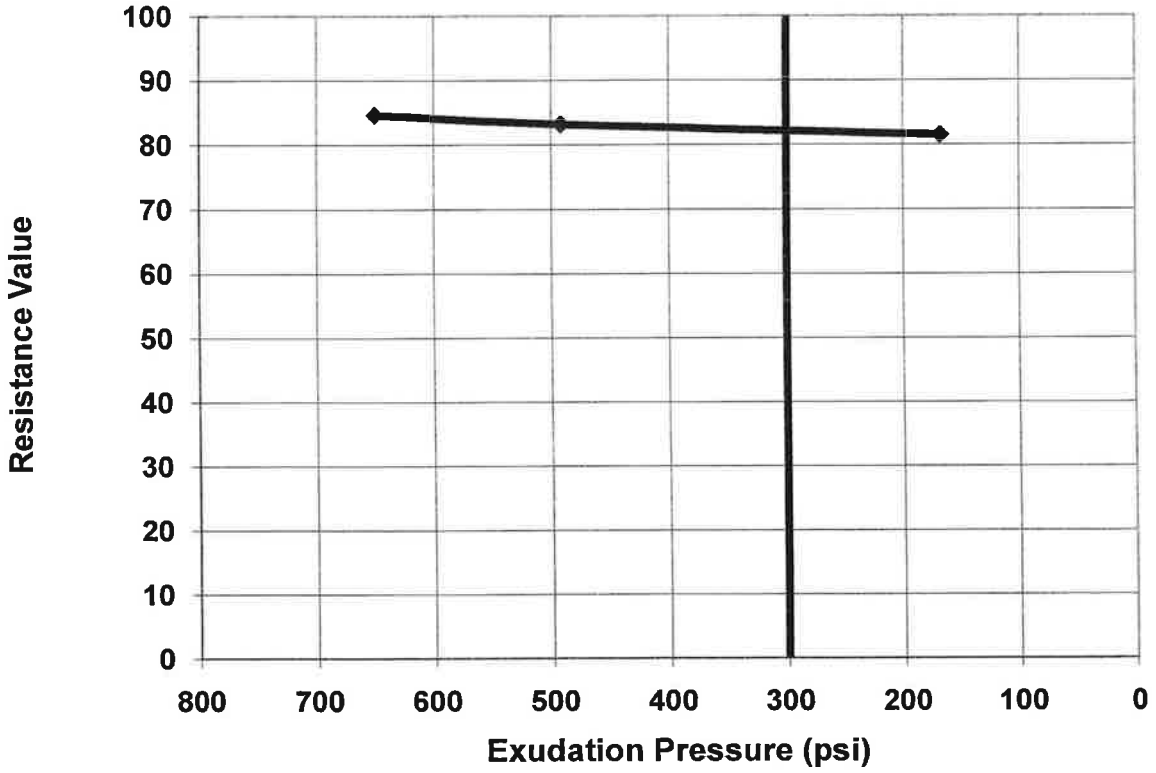
Resistance, R-Value

Caltrans Method 301

Project :	Food Digester	**Project No. :**	012046
Client :	HWMA	**Sampled By :**	PRS
Sample Location :	BS-1	**Test Date :**	4/17/12
Sample Description :	BS-1 @ 0-1'	**Sample Number :**	12-313

Test Specimen	1	2	3
Moisture Content (%)	6.4	6.6	6.5
Dry Density (pcf)	132.8	131.9	132.4
Expansion Pressure (psf)	0.0	0.0	0.0
Exudation Pressure (psi)	650	492	168
Resistance Value	85	83	82

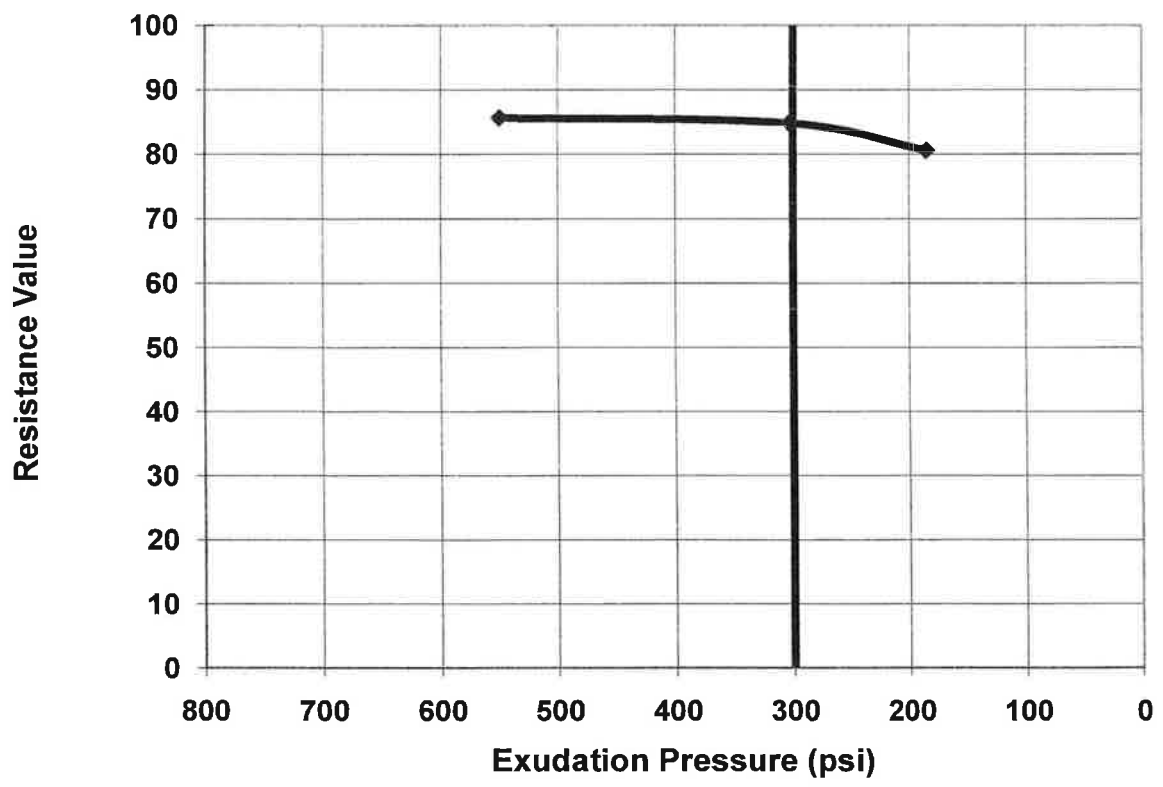
R Value at 300 psi Exudation Pressure: **82**



Resistance, R-Value

Caltrans Method 301

Project :	Food Digester	**Project No. :**	012046
Client :	HWMA	**Sampled By :**	PRS
Sample Location :	BS-2	**Test Date :**	4/17/12
Sample Description :	BS-2 @ 0-1'	**Sample Number :**	12-314

Test Specimen	1	2	3
Moisture Content (%)	7.1	6.8	6.9
Dry Density (pcf)	139.1	138.8	138.2
Expansion Pressure (psf)	0.0	0.0	0.0
Exudation Pressure (psi)	185	303	550
Resistance Value	81	85	86

R Value at 300 psi Exudation Pressure: **85**