City of Trinidad

ASBS Stormwater Improvement Project
Geotechnical Analysis

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CITY OF TRINIDAD GEOTECHNICAL EVALUATION REPORT
TRINIDAD, CALIFORNIA

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Table of contents

1. Introduction 1
   - 1.1 Project Area 1
   - 1.2 Project Objectives 2
   - 1.3 Scope and limitations 2
2. Field Investigations 3
   - 2.1 Geologic Setting 3
   - 2.2 Bedrock, Seep, and Spring Mapping 4
   - 2.3 Soil Borings 4
   - 2.4 Groundwater Monitoring Wells 6
   - 2.5 Soil Boring and Monitoring Well Survey 7
   - 2.6 Groundwater Monitoring 7
   - 2.7 Geophysical Investigation 9
3. Geotechnical Investigation Results 9
   - 3.1 Hydrogeologic Setting 9
   - 3.2 Physical Properties of the Marine Terrace Aquifer and Franciscan Bedrock 10
4. Conclusions and Recommendations 17
   - 4.1 Recommendations 18
   - 4.2 Next Steps 18
5. References 19

Table index

Table 1 Soil Boings SB-1 through SB-18 Completion Data 6

Table 2 Soil Borings Completed as Monitoring Wells 7

Table 3 Groundwater Elevation in Monitoring Wells 8

Table 4 Particle Size Distribution and Estimated Hydraulic Conductivity (K_s) 14

Figure index

Figure A-1. Vicinity Map City of Trinidad

Figure A-2. Site Map, Geophysical Transect, Boring and Monitoring Well Locations

Figure A-3. Bedrock Surface Model

Figure A-4. Springs, Seeps, and Bedrock Outcrops

Figure A-5. Groundwater Flow Direction and Hydraulic Gradient (Wet Season)

Figure A-6. Groundwater Flow Direction and Hydraulic Gradient (Dry Season)

Figure A-7. Project Area Conceptual Cross Sections A-A' through G-G'

Figure A-8. Lithology Cross Sections A-A', B-B', C-C', and D-D'

Figure A-9. Lithology Cross Sections E-E', F'F', G-G', and H-H'

Figure A-10. Estimated Hydraulic Conductivity

Appendices

Appendix A – Figures

Appendix B – HCDEH Boring and Monitoring Well Installation Permit

Appendix C – Boring Logs

Appendix D – Monitoring Well Construction Diagrams

Appendix E – GHD Standard Operating Procedures

Appendix F – Depth to Water Measurements Field Forms

Appendix G – Spectrum Geophysical Report

Appendix H – Sieve Analysis Laboratory Data Sheets

GEOLOGIC TERMS

Bedding
The arrangement of igneous, metamorphic, and sedimentary rock in layers.

Biogenic Rock (as used to define ribbon chert)
An organic rock produced directly by the physiological activities of organisms, for example, coral reefs and coal.

Blueschist
A metavolcanic rock that forms by metamorphism of basalt. The blue color of the rock comes from the presence of the mineral glaucophane.

Chert
A hard, dense sedimentary rock consisting of interlocking crystals of quartz less than 30 micrometers in diameter.

Clastic
Pertaining to a rock or sediment composed principally of fragments derived from pre-existing rocks or minerals and transported some distance from their place of origin.

Competent
A bed or stratum that is able to withstand the pressure of folding without flowage or change in original thickness. Competent strata form parallel folds.

Deformation
A general term for the process of folding, faulting, shearing, compression, or extension of rocks as a result of various earth forces.

Dip (Dipping)
The angle that a stratum or any planar feature makes with the horizontal, measured perpendicular to the strike and in the vertical plane.

Facies
The aspect, appearance, and characteristics of a rock unit, usually reflecting the conditions of origin.

Fault Plane
A fault surface that is more or less situated in a plane.

Feldspar
A group of abundant rock-forming minerals of the general formula MAl $(Al,Si)_3O_8$, where M can be potassium, sodium, calcium, barium, rubidium, strontium or iron. Feldspars are the most widespread of any mineral group and constitute 60 percent of the earth's crust.

Ferromagnesian
Containing iron or magnesium.

Footwall
The mass of rock beneath a fault; especially the wall rock beneath an inclined fault.

Fluvial
Of or pertaining to rivers, produced by the action of a stream or river.

Gradient
Degree of inclination of steepness of slope of the groundwater surface. It may be expressed as a ratio (of vertical to horizontal), fraction, percent, or angle.

Graywacke
An old term now generally applied to a dark gray firmly indurated coarse-grained sandstone that consists of poorly sorted angular to subangular grains of quartz and and feldspar.

Hanging Wall
The overlying side of a fault; especially the wall rock above an inclined fault.

Igneous
Said of a rock or mineral that solidified from molten or partially molten material.

Indurated
Said of a rock or soil hardened or consolidated by pressure, cementation, or heat.

Mafic
Said of igneous rock composed chiefly of dark, ferromagnesian minerals.

Marine terrace
A wave-cut platform that has been exposed by uplift along a seacoast or by lowering of sea level.

Matrix
The finer-grained material enclosing the larger grains in sediment or sedimentary rock.

Mélange
A mappable body of rock that includes fragments and blocks of all sizes, both exotic and native, embedded in a fragmented and generally sheared matrix.

Metamorphic rock
Any rock derived from pre-existing rocks by mineralogical, chemical, and/or structural changes, especially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment, generally at depth in the earth's crust.

Normal fault
A fault in which the hanging wall appears to have moved downward relative to the footwall. The angle of dip is usually 45 to 90 degrees (°).

Outcrop
The part of a geologic formation or structure that appears at the surface of the earth; also, bedrock that is covered by surficial deposits.

Paleo-(as used to describe a channel [Paleochannel])
A combining form meaning old or ancient, for example paleoclimate. This term is used in this report to describe an old channel identified in the project area subsurface.

Paleoseismic
Pertaining to an old earthquake or earth vibration.

Pleistocene
An epoch of the Quaternary period. It began two (2) to three (3) million years ago and lasted until the start of the Holocene (approximately 8,000 years ago).

Plutonic Rock
A rock formed at considerable depth by crystallization of magma and/or by chemical alteration.

Poorly graded
An engineering term pertaining to a soil or sediment in which all the particles are of about the same size or in which a continuous distribution of particle sizes from the coarsest to the finest are lacking.

Poorly Sorted
Said of clastic sediment or rock that consists of particles of many sizes mixed together in an unsystematic manner so that no one size class predominates.

Quartz
Crystalline silica, an important rock-forming mineral, SiO_2.

Quaternary
The second period of the Cenozoic era. It began two (2) to three 93) million years ago and extends to the present.

Ribbon rock
A rock characterized by a succession of thin layers of differing composition or color.

Sea Stack
An isolated, pillarlike rocky island, detached from a headland by wave erosion.

Scarp
A line of cliffs produced by faulting or erosion.

Sedimentary Rock
A layered rock resulting from the consolidation of sediment.

Shear
A deformation resulting from stresses that cause contiguous parts of a body to slide relative to each other in a direction parallel to their plane of contact. In geological literature the term refers almost invariably to strain rather than to stress. It is also used to refer to the surfaces and zones of failure by shear, and to surfaces along which differential movement has taken place.

Strain
Change in shape or volume of a body as a result of stress.

Stress
In a solid, the force per unit area, acting on any surface within it, and variously expressed as pounds or tons per square inch.

Strike

The direction taken by a structural surface (e.g. a bedding or fault plane), as it intersects the horizontal.

Thrust Fault

A fault with a dip of 45 degrees or less over much of its extent on which the hanging wall appears to have moved upward relative to the footwall. Horizontal compression rather than vertical displacement is its characteristic feature.

Ultramafic

Said of an igneous rock composed chiefly of mafic minerals.

Unconformable (Unconformably)

Strata that do not succeed the underlying rocks in immediate order of age or in parallel position; especially younger strata that do not have the same dip and strike as the underlying rocks. Also, said of the contact between unconformable rocks.

Wave-cut platform

A gently sloping surface produced by wave erosion, extending far into the sea or lake from the base of the wave-cut cliff.

Well graded

An engineering term pertaining to soil or sediment with a continuous distribution of particle sizes from coarsest to finest.

*Unless otherwise noted, definitions are from “Dictionary of Geological Terms, 3rd Edition.

ABBREVIATIONS

ASBS	Area of Special Biological Significance
ASTM	American Society for Testing and Materials
bgs	below ground surface
BMPs	Best Management Practices
DTW	Depth-to-groundwater
HCDEH	Humboldt County Division of Environmental Health
Ks	saturated hydraulic conductivity
LID	Low Impact Development
LiDAR	Light Detection and Ranging
ML	silt
msl	mean sea level
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
PSD	particle size distribution
PVC	polyvinyl chloride
SOP	Standard Operating Procedure
SM	Silty Sand
SP	Poorly graded sand
SW	Well graded sand
TOC	Top of casing

1. Introduction

The City of Trinidad (the City) is undertaking the Trinidad ASBS Stormwater Improvement Project (the Project) to make improvements to the municipal stormwater drainage system. The City's existing stormwater system was constructed in the early 1970's. The system discharges to a single 32-inch stormwater outfall (TRI032), which discharges just south of the boat launch at Trinidad Head to Trinidad Bay, as shown on Figure A-1, in Appendix A. The current system is designed to carry runoff to the outfall and does not incorporate modern retention, treatment or infiltration features.

Trinidad Bay is designated as an Area of Special Biological Significance (ASBS). It is one of 34 ASBS ocean areas monitored and maintained for water quality by the State Water Resources Control Board. ASBS cover much of the length of California's coastal waters. They support an unusual variety of aquatic life, and often host unique individual species. Trindad Bay was designated as an ASBS in part because of the fluctuating presence of bull kelp (*Nereocystis luetkeana*), which are considered biologically significant in providing an ecological base for fish and invertebrate habitats by supplying food and shelter. All ASBS may be adversely affected by polluted stormwater discharges, which could damage their unique ecoysystems.

The long term goal of the City in implementing the stormwater improvement project is to protect the ASBS by making improvements to the stormwater drainage system including implementation of Low Impact Development Best Management Practices (LID/BMPs) to capture, treat, and infiltrate stormwater runoff from rainfall events.

1.1 Project Area

The project is generally located within the City limits of Trinidad, Humboldt County, California and is shown on Figures A-1 and A-2. The City of Trinidad is located in rural northern California, approximately 25 miles from the county seat of Eureka and 300 miles from San Francisco. The community has a population of approximately 1,000 people with approximately 350 living within the City limits.

The project area is encompassed by Mill Creek in the north, Highway 101 and Parker Creek in the east, Trinidad Head to the southwest, and the Pacific Ocean on the west and south. The project encompasses portions of three watersheds: Mill Creek, the City of Trinidad, and Parker Creek. Currently, stormwater that accumulates in the northern portions of the City, drain into Mill Creek, which discharges near Trinidad State Beach approximately 500 feet north of the ASBS. The City of Trinidad watershed encompasses most of the City, the surrounding coastal bluffs, and Trinidad Head. Parker Creek drains a small portion of the eastern edge of the City. The City's stormwater system collects much of the precipitation that accumulates on the many paved and impermeable surfaces in the City and discharges it directly to the ASBS through discharge TRI032.

The City of Trinidad does not have a wastewater system and all residences and businesses use on-site wastewater treatment systems, also referred to as septic systems. The majority of the City of Trinidad Watershed is developed. Mill Creek is slightly less populated and is heavily forested in the upper watershed, as is Parker Creek. Highway 101 cuts across the north end of town and generally marks the transition from urban landscape to forested areas. The western and southern boundaries of the project area are bounded by coastal bluff with relatively steep slopes down to the ocean.

1.2 Project Objectives

The objective of this geotechnical evaluation is to gather information to support a groundwater model of the City of Trinidad, which will be used in the design of Stormwater LID/BMPs to help protect the Trinidad ASBS. The final groundwater model will be used to inform the design of LID/BMPs in considerations of the existing septic systems and the coastal bluffs.

To meet the objectives of the Project, this geotechnical evaluation includes the following information for the future project groundwater model:

- Characterization of the bounding hydrologic features including creeks, seeps and springs, the ocean, and coastal bluffs
- Characterization of the marine terrace aquifer and Franciscan bedrock, including saturated hydraulic conductivity
- Characterization of the flow of water into and through the marine terrace aquifer, including groundwater flow, gradient, and direction.

1.3 Scope and limitations

This report: has been prepared by GHD for City of Trinidad and may only be used and relied on by City of Trinidad and the SWRCB for the purpose agreed between GHD and the City of Trinidad as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than City of Trinidad arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

GHD has prepared this report on the basis of information provided by City of Trinidad and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based in part on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Field Investigations

As a first step for this project, a literature review of relevant information was conducted, and documents reviewed are included in the reference section at the end of this report. This literature review was used in the development of the geologic setting for this project which is presented below. The geologic setting is followed by a discussion of the completion of soil borings, installation of monitoring wells, mapping of springs and seeps, and geophysical investigation. Appendix I includes definitions of geologic terms and abbreviations.

2.1 Geologic Setting

The project area is underlain by Franciscan Bedrock. The Franciscan Complex is a late Mesozoic complex of rocks composed of highly sheared oceanic sediments that were deformed above the oceanic plate (which is sliding underneath western North America) (Aalto, 1982). These Franciscan rocks comprise the competent rocks of resistant headlands and sea stacks along the Trinidad coast and consist of greywacke, sandstone, marine sandstones, biogenic ribbon chert, limestone, greenstone, ultramafic and mafic plutonic rocks, and bluechist-facies metamorphic rocks (Aalto, 1976). The lesser constituents exist as blocks, or mixtures of blocks, ranging on a scale from centimeters to kilometers in length along the northern California coast within mélange units.

The Franciscan Formation is unconformably overlain by Pleistocene marine terraces along the Trinidad coast, within the project area, and up to several miles inland. The presence of stair-stepping, progressively older (and higher in elevation) marine terraces inland is a result of the ongoing deformation of the northern California coast along thrust faults, which account for most of the uplift. In the project area, a series of three terraces were previously mapped as follows: (Rust, 1982, Stephens, 1982); Trinidad Low marine terrace (approximately 40,000 years old), located closest to Trinidad Head, the Luffenholtz marine terrace (approximately 60,000 years old) and the Patrick's Point terrace (approximately 83,000 years old). According to the map produced by Rust (1982), the City was built on the Patrick's Point terrace. Additionally, the Trinidad Low marine terrace and/or the Luffenholtz marine terrace unconformably overlies an older (approximately 370,000 years old) marine terrace, marked with a paleosol (buried soil) at the contact (Stephens, 1982, Rust, 1982). These marine terraces can be generally described as thin to massive intervals of fine to coarse beach sands (mixed with various quantities of silt) containing local stringers of beach and fluvial gravel.

The project area is complicated by ongoing faulting of the Franciscan Complex rocks and the younger overlying marine terrace sediments. The close proximity of the offshore Cascadia Subduction Zone has resulted in crustal shortening and onshore tectonic deformation. At least two faults exist within the project area and have been mapped and trenched for paleoseismic information (by others); the Anderson Ranch (also called the Trinidad Fault) and the Trinidad Head Fault. The Anderson Ranch fault is located at the eastern boundary of the project area. The rise in land north of the Chevron Station (at the intersection of Scenic Drive and Main Street) is the fault line scarp of the Anderson Ranch Fault. The Trinidad Head Fault is northwest/southeast trending and mapped in the low elevation notch between Trinidad Head and the slope that rises toward Trinidad from the beach. According to Rust (1982), the Trinidad Head fault is interpreted as northeast-dipping. However, later interpretation by K.R. Aalto (2009), observed this fault to be a southwest-dipping normal fault.

Additionally, mass movements, including but not limited to debris flows, hillslope creep, and slumps, commonly occur along the coast north and south of the project area where more competent mélange blocks are relatively small and the surrounding matrix materials are dominant. The majority of the coast (north of Trinidad to Patrick's Point and south to Moonstone Beach), have been found to be extremely susceptible to small and large scale erosion (Aalto, 1977, Aalto, 2009, Rust, 1982) within the less competent mélange matrix. Identification of the general type and condition of the underlying Franciscan Complex mélange is critical to planning and engineering on the northern Californian coastline. However, as seen in Trinidad, the marine terrace margin is generally found to be more stable when overlying massive beachfront sandstone and greenstone units that buffer the high energy ocean waves. Nestled between these competent rocks that form much of the seastacks and headlands are sandy coves and beaches.

2.2 Bedrock, Seep, and Spring Mapping

On January 25, 2012, GHD's project geologist conducted a preliminary seep/spring and bedrock mapping survey of the cliffs, bluffs, gulleys, and slopes to the north, west, and south of the project area. A portion of the southern cliff area includes the Tsauri Village Site, part of the ancestral lands of the Yurok Tribe, which contains irreplaceable cultural resources significant to the Yurok People. For this reason, the portion of field mapping within the Tsurai Village Area in the southern portion of the project area, was conducted with Joe Lundgren of the Tsurai Ancestral Society. Mr. Lundgren provided key current and historical information on seep and spring locations.

The identified locations of seeps, springs, and bedrock outcrops were approximately placed on high resolution satellite imagery (see Figure A-4), and generally agree with historical mapping (Rust, 1982). Seeps and springs were generally observed at the bedrock/marine terrace interface on the exposed bluffs, gulleys, and slopes to the north, west, and south of the project area. It was noted that the seeps and springs were very noticeable when surveyed at the end of the dry season, indicating there is year round flow. This was confirmed in the Tsauri Village area via communications with Mr. Lundgren. The bedrock and seep/spring observations were used in conjunction with the depth to bedrock observations in borings and geophysical data in order to estimate bedrock elevations in the areas where bedrock could not be physically observed.

2.3 Soil Borings

Prior to conducting soil borings and installation of monitoring wells, approvals were obtained and preliminary reconnaissance of the project area was conducted. A drilling permit was obtained from the Humboldt County Department of Environmental Health (HCDEH), a copy of which is included in Appendix B. The proposed location of each boring was marked with white paint and Underground Service Alert was notified at least 48 hours prior to subsurface investigation to mark the locations of subsurface utilities. The HCDEH and the City of Trinidad were notified in advance of scheduled drilling and sampling activities and information on the subsurface investigation was made available to the public. The borings were observed by Ruby Rollins, a cultural monitor with Trinidad Rancheria's Tribal Historic Preservation Office. Ms. Rollins did not note any items of cultural or historical significance with the soil cuttings of the borings

In January and February 2012, GHD oversaw Clear Heart Drilling Inc. of Santa Rosa, California, during the drilling of 18 soil borings (SB-1 through SB-18). The borings were drilled using a truck-mounted drill rig fitted with 8-inch diameter hollow stem augers. As the borings were located in areas with numerous subsurface utilities, each location was hand augered prior to drilling to a depth of approximately 5 feet below ground surface (bgs). The soil borings (SB-1 through SB-18) were

drilled to varying total depths based on the depth of the encountered bedrock surface. The location of the soil borings are shown on Figure A-2. Boring logs are included in Appendix C.

Soil samples were collected using either a 2-inch split-spoon sampler continuously, or at 5-foot intervals. The soil profile was classified and entered on a field boring log using the American Society for Testing and Materials, (ASTM Visual Manual Procedure D 2488 09a) and Munsell Soil Color Charts. Observations on lithology, moisture, consistency/density, plasticity, first encountered groundwater estimates, oxidation and mottling, and sample depths were noted on the boring logs as appropriate. Representative samples of the subsurface materials were retained and labeled for sieve analysis and stratigraphic reference from each boring location.

Franciscan Complex bedrock was encountered in borings SB-1 through SB-18. Each boring was generally terminated within a foot or less into bedrock surface. Where possible, a bedrock sample was collected from the cutting shoe of the soil sampler. In some borings, approximately 1 to 2 feet of weathered bedrock was encountered above the competent bedrock surface.

The field geologist identified the type of bedrock encountered, which is interpreted here as a block of Franciscan Complex mélange marine sandstone and shale rocks previously mapped/identified by Aalto and others. These rocks ranged from having no obvious deformation to being highly sheared. Laboratory analysis was not completed on the bedrock samples to determine the degree of competency or shear strength properties.

Table 1 presents the boring location, total depth of exploration for each borehole, depth to competent bedrock, and the type of bedrock encountered.

Table 1 Soil Boings SB-1 through SB-18 Completion Data

Boring	Completed Depth (feet bgs)	Depth to Bedrock (feet bgs)	Bedrock Type	Ground Elevation (msl)
SB-1	39	39	Siltstone	171
SB-2	34	34	Siltstone	153
SB-3	43	43	Graywacke/Sandstone	171
SB-4	55	53	Graywacke	176
SB-5	58	58	Sandstone	172
SB-6	60	58	Highly Sheared Siltstone	178
SB-7	66.5	62.5	Hard Siltstone	178
SB-8	50.5	50	Mudstone	177
SB-9	40.5	40.5	Siltstone	173
SB-10	43.5	43	Sandstone/Graywacke	172
SB-11	63	63	Sandstone	178
SB-12	61.5	61.5	Sandstone	179
SB-13	39.5	39.5	Highly Sheared Siltstone	94
SB-14	22	10	Highly Sheared Siltstone	140
SB-15	23	23	Sandstone	171
SB-16	29	29	Sandstone	29
SB-17	51.5	51	Siltstone	120
SB-18	70	70	Sandstone	175

2.4 Groundwater Monitoring Wells

Nine groundwater monitoring wells (MW-1 through MW-9) were installed throughout the project area using existing borings drilled during this investigation. The locations of the monitoring wells are identified on Figure A-2. Table 2 identifies the soil boring locations which were converted into the 9 monitoring wells installed.

Monitoring wells MW-1 through MW-9 were constructed of two-inch diameter blank polyvinyl chloride (PVC) well casing from the surface down to the slotted screen intervals. The factory-slotted well screens (0.010-inch) were placed at 10 to 20 foot intervals and depth to the top of the screens ranges from approximately 19 feet to 50 feet bgs in the monitoring wells. A uniform filter pack of Cemex #2/12 washed silica sand was placed around the well screens from a minimum of 2 feet above the slotted screens to the bottom of the wells. A 2-foot thick seal of hydrated bentonite pellets was placed over the filter pack, then a surface/sanitary seal of cement was placed to within 1 foot of the surface and finished with one foot of concrete. The top of each well casing was cut at approximately 2-inches below the well vault grade.

Table 2 Soil Borings Completed as Monitoring Wells

Soil Boring	Corresponding Monitoring Well	Total Depth (feet bgs)	TOC Elevation (msl)	Screened Interval	
				(bgs)	(msl)
SB-16	MW-1	29	28.26	19-29	9 to -1
SB-13	MW-2	39	93.46	29-39	64 to 54
SB-17	MW-3	51.5	118.99	41.5-51.5	77 to 67
SB-1	MW-4	39	170.98	29-39	142 to 132
SB-10	MW-5	43	171.62	33-43	139 to 129
SB-2	MW-6	34	152.73	24-34	129 to 119
SB-4	MW-7	55	175.33	45-55	130 to 120
SB-8	MW-8	49	176.72	29-49	148 to 128
SB-18	MW-9	70	174.23	50-70	134 to 104

The new monitoring wells are protected by flush-mounted traffic rated vaults set in concrete, expandable well plugs, and a lock. The top of the traffic vaults are set slightly above the adjacent surface grade with a gently sloping concrete rim to avoid ponding water during the winter months. The horizontal location and top-of-casing (TOC) elevation of each new monitoring well were surveyed as describedbelow. Monitoring well construction diagrams are included in Appendix D.

2.5 Soil Boring and Monitoring Well Survey

Horizontal soil boring and monitoring well locations and ground surface and TOC elevations were surveyed on March 23, 2012, by Phil Gutierez, a licensed surveyor, to facilitate calculations for groundwater flow direction and gradient. Ground surface and TOC elevations were surveyed to the nearest 0.01 foot mean sea level (msl) relative to the North American Vertical Datum of 1988 (NAVD88). Horizontal soil boring and monitoring well locations were surveyed relative to State Plane Coordinate System and in degrees latitude/longitude to 7 decimal places relative to the North American Datum of 1983 (NAD83).

2.6 Groundwater Monitoring

The depth-to-groundwater (DTW) was measured in each of the 9 monitoring wells (MW-1 through MW-9) on March 12, 2012, April 2, 2012, June 28, 2012 and September 20, 2012 per GHD standard operating procedures (SOPs). GHD SOPs are included as Appendix E. The final DTW measurement at each monitoring well was recorded after groundwater levels had equilibrated to atmospheric pressure for at least 15 minutes. Measurements were obtained using an electronic water level meter. DTW measurements for the 4 gauging events are presented on Table 3, below. DTW measurement field forms are included as Appendix F.

Table 3 Groundwater Elevation in Monitoring Wells

Well	Date	Groundwater Elevation (feet MSL)	Top of Casing (feet MSL)	Depth to Water (feet below TOC)
MW-1	3/12/12	11.27	28.26	16.99
	4/2/12	13.84	28.26	14.42
	6/28/12	10.52	28.26	17.74
	9/20/12	8.74	28.26	19.52
MW-2	3/12/12	64.11	93.46	29.35
	4/2/12	65.60	93.46	27.86
	6/28/12	66.13	93.46	27.33
	9/20/12	63.40	93.46	30.06
MW-3	3/12/12	78.37	118.99	40.62
	4/2/12	79.98	118.99	39.01
	6/28/12	78.48	118.99	40.51
	9/20/12	76.11	118.99	42.88
MW-4	3/12/12	136.38	170.98	34.60
	4/2/12	137.16	170.98	33.82
	6/28/12	136.10	170.98	34.88
	9/20/12	134.54	170.98	36.44
MW-5	3/12/12	133.40	171.62	38.22
	4/2/12	133.93	171.62	37.69
	6/28/12	134.62	171.62	37.00
	9/20/12	132.51	171.62	39.11
MW-6	3/12/12	134.48	152.73	18.25
	4/2/12	136.38	152.73	16.35
	6/28/12	135.83	152.73	16.90
	9/20/12	134.04	152.73	18.69
MW-7	3/12/12	134.98	175.33	40.35
	4/2/12	135.42	175.33	39.91
	6/28/12	137.57	175.33	37.76
	9/20/12	135.82	175.33	39.51
MW-8	3/12/12	132.51	176.72	44.21
	4/2/12	133.04	176.72	43.68
	6/28/12	134.91	176.72	41.81
	9/20/12	143.52	176.72	33.20
MW-9	3/12/12	120.35	174.23	53.88
	4/2/12	118.10	174.23	56.13
	6/28/12	118.68	174.23	55.55
	9/20/12	117.71	174.23	56.52

2.7 Geophysical Investigation

Spectrum Geophysics, a subconsultant to GHD, conducted a geophysical investigation from August 8 to August 17, 2012 in the project area to further define the subsurface including location of bedrock surface and marine terrace materials. Geophysical methods were used for the purpose of delineating detailed geologic stratigraphy and structure and to augment existing boring and well information within the project area. During this investigation, four linear transects, shown on Figure A-2, were established, and both seismic reflection and electrical resistivity data were collected along each transect. A discussion of the methods, field procedures, and data processing is presented in the full Geophysical Report, included as Appendix G.

3. Geotechnical Investigation Results

This section presents the results and interpretations of the field data collected and discussed in Section 2. First, the physical boundaries of the aquifer are discussed, which include the two area creeks, ocean, coastal bluffs, and watersheds. Next, the composition of the subsurface is presented, including the uplifted marine terrace deposits and underlying Franciscan bedrock. Lastly, the groundwater flow and direction is presented. This is followed by a conclusions and recommendations section, which summarizes the key report finding and recommendations for additional data collection and analysis during the next phases of the project.

3.1 Hydrogeologic Setting

The aerial extent of the aquifer below the project area is relatively small, bounded to the north and east by Mill and Parker Creeks, respectively, and to the west and south by the Pacific Ocean. The term aquifer is used here as a general term for a water bearing formation of unconsolidated sediments, that could theoretically yield useable water to a well or spring. The aquifer is not currently used for extraction purposes, due to its low storage capacity, relatively shallow depth and proximity to the residential septic systems. The top of the aquifer is considered unconfined (the groundwater rises and declines freely within the unsaturated/saturated zone) and the bottom of the aquifer is confined by the underlying bedrock surface that impedes the vertical migration of infiltrating surface water and then directs the majority of groundwater horizontally through the pore spaces of the marine terrace sand. The aquifer is comprised of primarily one connected hydraulic unit. While there are localized variations in the composition, it is primarily comprised of sand on top of bedrock. Groundwater input to the aquifer is limited by the incised creek drainages and coastal bluffs.

The zone of infiltration is approximately 15 to 55 feet below the surface of the project area (depending on how deep bedrock is encountered). This zone is characterized by grey, brown, and red mottling (leopard spot colorings in hand specimen) and red oxidation bands due to the repeated cycle of infiltrating water and the precipitation of iron oxides. The vertical migration of water in the upper 5 feet underlying the project area is assumed to be relatively slower, due to the higher silt content observed in undisturbed areas, and the compaction of imported fill materials to build houses and roads in the disturbed areas.

Below the upper silty/compacted/disturbed zone is up to 70 feet of silty sand, poorly graded fine to medium-grained sand, and well graded sand. The vertical and horizontal flow (hydraulic conductivity) is generally thought to increase due to the reduced silt content, increased porosity (space between soil gains), and loose consistency of the sand. Despite the presence of relatively

thin (less than 2 feet thick) silt layers, which can impede flow, in a few project area borings, the vertical migration of infiltrating water is likely not significantly reduced because the lateral extent of the silt layers is discontinuous. Additionally, there are thin localized layers of well graded, well rounded, sandy gravel. Like the silt layers, the gravel layers were discontinuous, and not expected to have a significant effect on the overall vertical and horizontal groundwater migration.

Bedrock underlying the marine terrace sand serves as the principle confining layer to the vertical migration of infiltrating water in the project area. This is due to the Franciscan Complex mélange rocks encountered at the bottom of the borings and observed surrounding the project area being composed of massive sandstone, siltstone greywacke, and mudstone units. The massive bedrock units are considerably more competent and durable than unconsolidated marine sand, and relatively impermeable. Thus, when groundwater reaches the bedrock surface it flows horizontally down gradient toward the ocean (south and west) and towards the creek systems (north and east).

Thus, accurately incorporating septic system inputs to the marine terrace aquifer in the groundwater model will be important, as it has the potential to be a large contributor to groundwater flow, especially in the summer. Each of the properties within the City discharges wastewater to individual septic systems. The volume of water introduced into the subsurface is referred to as the septic loading rate. The septic loading rate will be developed based on water use records for a one year period. The water use will be modified to account for consumptive use and outdoor irrigation. A generalized loading rate for residential properties will be developed. This generalized residential loading rate removes the variability due to changes in residential occupancy. Larger businesses will be modeled individually. Based on a preliminary analysis of water use, it is estimated that total septic loading to the project area is between 19,000 gallons and 25,000 gallons per day.

3.1.1 Marine Terrace Outlets

There are several outlets for groundwater to leave the aquifer, which include seeps and springs, creeks, and the ocean. The creeks intercept the groundwater table to the north and east as previously discussed and act as a divide to preventing water movement into the City aquifer from other watersheds and also act as a drain allowing movement of water generally from the City watershed to the creeks. The Ocean acts as the final outlet, receiving water from the creeks, seeps and springs, and the groundwater aquifer.

Where encountered, seeps and springs were generally found to be at the bedrock/marine terrace contact along the north, west, and south bluffs surrounding the project area. In general, seeps, or clusters of seeps, were more prevalent on the low point of bedrock cliff slopes containing paleochannels, pervasive jointing, and sheared bedrock, and areas with active and historical marine terrace slope failures. Larger clusters of springs and seeps were observed on the beachfront bluffs in the northwest and southeastern portion of the project area. The observed seeps ranged from a trickle of water flow (less than approximately 1/4 gallon per minute) around the north and west boundaries of the project area, to that of an open garden hose (greater than approximately 5 gallons per minute) on the southern boundary bluffs below Trinity Street, Ocean Avenue, and Wagner Street within the Tsurai Village Site. Figure A-4, shows approximate seep locations.

3.2 Physical Properties of the Marine Terrace Aquifer and Franciscan Bedrock

The previous section discussed the general hydrogeologic characteristics of the project area. This section provides more detail on of the physical properties of the marine terrace aquifer and Franciscan bedrock.

3.2.1 Marine Terrace Aquifer

The description of the marine terrace stratigraphy is taken from the sediment types identified on project area boring logs obtained during this study (SB-1 through SB-18). Boring and trench logs from previous consultants (Busch Geotechnical Consultants [BGC], LACO, Taber Consultants [Taber], California Department of Transportation [Caltrans], GHD, and Oscar Larson Associates [OLA]) were also reviewed and discussed via personal communication (BGC, 2012).

Stratigraphy of the upper five (5) feet to the surface in the project area has been described from boring logs (using the ASTM D2488-09a) as loose to compact disturbed and mixed fill materials of imported river gravel, sand, and silt. Where undisturbed, the upper five (5) feet is generally loose to compact organic-rich silt (ML), silt with fine sand, or fine silty sandy (SM).

Underlying the upper fill and silty sand layer, the majority of the subsurface materials encountered were generally dominated by loose, poorly graded, fine and medium-grained sand (SP) down to bedrock (up to 70' thick, see Table 4 below). Lesser quantities of coarse grained sand were observed within well graded sand (SW) intervals ranging from approximately one (1) foot to 20 feet thick. The SW units were found overlying bedrock in 14 of the 18 borings, and often contained highly oxidized fines (silt and clay) and precipitates on grains. A thin (approximately ½ foot to 2 feet) interval of well graded and well-rounded gravel was encountered within a few borings, at depths ranging from approximately 13 feet to 20 feet bgs, and were generally bounded above, and below, by poorly graded sand.

Sieve results (Appendix H, and further discussed in Section 3.2.2) of well graded sand (SW) sand samples indicate the majority of those units are dominated by fine to medium grained sand. Additionally, sediment units described as silty sand (SM), after sieving were also found to be generally dominated by fine sand. Therefore, as discussed further in the conclusions and recommendations, the groundwater in the project area should be modeled to reflect unconsolidated marine sand (fine to medium-grain size) with relatively high porosity (approximately 25 to 50%).

Marine Terrace Surfaces

A conceptual model of the marine terrace surfaces was created from the boring log data, the bedrock surface model, and the LiDAR surface model. Upper and lower surfaces of the marine terrace were created using elevations from the bedrock surface model (Figure A-3) and LiDAR surface model (Figure A-4) respectively. The marine terrace stratigraphy was generally interpreted using boring log data and is shown in the Conceptual Cross Sections A-A' through H-H' (Figures A-7 through A-9).

Marine Terrace Stratigraphy

The stratigraphy of the project area marine terrace sediments form one primary water bearing unit and, as described in detail above, are generally interpreted in conceptual cross sections of the project area (Figure A-7). Eight conceptual cross sections, A-A' through H-H', were developed to convey general trends in the bedrock surface, basic stratigraphy, and groundwater elevations (Figure A-8 and Figure A-9). Soil boring logs, from this and previous studies, indicated that the marine terrace sediments in the project area are generally comprised of thin (generally 2-5 feet and up to 10 feet thick) silt (ML) and fine silty sand (SM) layers at the near surface (where undisturbed), with poorly graded fine and medium-grained sand (SP), and well graded sand (SW) intervals, of varying thickness down to bedrock. A particle size (sieve) analysis of selected samples was performed, and is described below. The results of the sieve analysis are presented in tabular form in Appendix H.

The northern California coast has a relatively high energy near shore erosional and depositional environment, perpetual daily tidal swings, and historical sea elevation variations due to climate change and tectonic uplift. Therefore, stratigraphy of the marine terrace is often observed to be laterally discontinuous, pinching, interbedded, and unconformable on a lateral scale of hundreds of feet. This process is indicated, for example in conceptual cross section A-A', where the well graded sand and gravel layers observed below the surface in boring SB-4/MW-7 are underlain by a poorly graded sand to the bottom and overlying bedrock. These same stratigraphic layers were observed in an inverted orientation approximately 500 feet west in boring SB-3.

Groundwater elevations observed during the construction of the borings and measured in the monitoring wells during subsequent monitoring events are also indicated in the conceptual cross sections A-A' through H-H' (Figures A-8 and A-9) , therefore, the apparent groundwater flow direction and saturated thickness can again be generally interpreted.

3.2.2 Estimated Hydraulic Conductivity

Hydraulic conductivity is an important parameter in predicting water movement through porous media like the marine terrace formations found on the northern California coast. Saturated hydraulic conductivity (K_s, the ability of a fully water saturated porous material to transmit water though its pore spaces) can be estimated from the particle size distribution (PSD) of the marine terrace materials. Investigators from 1892 (Hazen) to the present (Freeze and Cherry [1979], Shepard [1989], Alyamani and Sen [1993], and Salarashayeri, et. al. [2012]) have related and estimated hydraulic conductivity to PSD.

Particle Size Analysis

A mechanical sieve analysis was performed by GHD on 18 representative samples collected from the borings in the project area using the ASTM Standard Test Method for Particle-Size Analysis of Soils (ASTM D422-63[2007]). The boring logs which depict the vertical stratigraphy and depth of samples are presented in Appendix C. Since sand is the dominant material underlying the project area above bedrock, samples described in the field as poorly graded sand, well graded sand, and silty sand, were chosen to be sieved. 6 sieve sizes (Numbers 10, 16, 30, 50, 100, and 200) were used to separate the various particle sizes. Further separation of particle size through sedimentation processes was not completed on the material which passed the Number 200 sieve, as the materials that passed through the smallest sieve (number 200) were assumed to be dominated by silt with minor quantities clay. Material retained on the largest sieve (number 10) was identified as coarse sand.

Estimated Hydraulic Conductivity Evaluation

Using the distribution expressions D_{10}, D_{50}, and D_{60} (where 10%, 50%, and 60%, respectively, of the sample's mass is smaller than the corresponding diameter), K_s can be expressed in meters per day. Equations for K_s have been generated using D_{10} (Hazen 1892), and extended with power regression analysis (Shepard, 1989), and from multiple linear regressions (also using D_{50} and D_{60}) and statistically compared to observed values of K_s of sand (Salarashayeri, et. al., 2012). Studies have shown (Hazen, 1892, Alyamani and Sen, 1993, and Salarashayeri, et. al., 2012) that the relatively finer zone of PSD (D_{10}) plays a more significant role in estimating/ calculating K_s using PSD data. For the purposes of this investigation 10 equations were identified to calculate K_s, from Salarashayeri, et. al.,(2012) to establish a range of potential values. By utilizing the mean D_{10}, D_{50}, and D_{60} of the samples collected as the effective parameters, the range of K_s values for the marine terrace sediments in the project area was calculated.

Fine and medium-grained sand were the bulk of the materials retained in the test samples sieved. The range of K_s values for each sample is shown in Table 4, with a low of 11 and a high of 26. These values are similar to those of other investigators calculations (Alyamani and Sen, 1993), and are planned to be used for the future project area model calibration for the lower portion of the marine terrace.

As discussed previously, the shallower sediments have higher silt content in undisturbed areas and in disturbed areas fill soil and compaction have occurred to allow for construction of roads and buildings. Thus, the K_s value near the surface from 0 to approximately 3 to 10 feet bgs is recommended to be 1 to 2 orders of magnitude slower than the ~12 to ~26 meters per day for the lower portion of the marine terrace. The spatial distribution of the sieve analysis results is presented in Figure A-10. Particular attention should be paid to the level of disturbance (grading and compaction from road and house building activities) and depth of silt and/or silty sand encountered at specific locations for proposed surface infiltration designs. Previous studies in the project area (OLA, 1977) estimating vertical hydraulic conductivity from samples collected less than 10 feet bgs (Using a repacked falling head method of estimation instead), have indicated values much less than 1 meter per day (m/day).

Despite the pervasive deformation observed (fractures, faults, and folds) here and by others of the Franciscan Complex mélange rocks, the overall hydraulic conductivity of the bedrock is probably much slower (centimeters per day at most) than the overlying marine terrace sand (tens of meters per day).

Therefore, assumptions of the project area subsurface hydrology are that the majority of the downward vertical migration of water through the marine terrace sand is fast, and stops upon contact with bedrock. After the vertical migration of infiltrating water collects on the bedrock-marine terrace contact surface, it flows horizontally down gradient toward the ocean (south and west) and towards the creek systems (north and east). Although considered here to be insignificant at this time for the sake of the project area conceptual model of subsurface hydrology, there may be localized areas within the fractured bedrock allowing for further vertical migration of unknown quantities of groundwater.

Table 4 Particle Size Distribution and Estimated Hydraulic Conductivity (K_s)

			Particle Size (µm) & Soil Type[1]						K_s (m/day)[2]										K_s (m/day)	
Soil Unit	Soil Boring	Sample Depth (ft bgs)	D10	D10 Soil Type	D50	D50 Soil Type	D60	D60 Soil Type	EQ 7	EQ 8	EQ 9	EQ 10	EQ 11	EQ 12	EQ 13	EQ 14	EQ 15	EQ 16	Min	Max
ML	SB-5	30	43	Silt	150	Fine Sand	182	Fine Sand	11.6	17.3	16.9	16.4	21.0	20.9	12.0	12.0	18.1	12.0	12	21
SM	SB-8	4	162		253		275		18.8	18.6	17.9	19.4	21.3	21.1	23.5	24.3	18.8	24.1	18	24
SM	SB-12	5	150	Fine Sand	279	Fine Sand	330	Fine Sand	18.1	18.5	17.8	18.9	21.4	21.2	21.5	22.0	19.3	21.9	18	22
SM	SB-15	6	152		262		290		18.2	18.5	17.8	19.0	21.3	21.1	22.1	22.9	18.9	22.7	18	23
SM	SB-17	30-32	161		464		577		18.7	18.6	17.9	19.3	22.3	22.1	18.9	19.3	21.4	19.1	18	22
SM	SB-18	10-12	151		249		274		18.1	18.5	17.8	18.9	21.3	21.1	22.3	23.0	18.8	22.9	18	23
		Average	155		301		349		18.4	18.5	17.8	19.1	21.5	21.3	21.6	22.3	19.4	22.2	18	22
SP	SB-3	20-22	139		239		262		17.4	18.4	17.7	18.5	21.3	21.1	21.1	21.8	18.7	21.6	17	22
SP	SB-8	35	128	Fine Sand	229	Fine Sand	250	Fine Sand	16.8	18.2	17.6	18.2	21.2	21.0	20.1	20.8	18.6	20.6	17	21
SP	SB-10	26	80		155		185		13.8	17.7	17.2	16.9	21.1	20.9	16.0	16.1	18.2	16.2	14	21
SP	SB-13	20-22	78		150		215		13.7	17.7	17.2	16.9	21.0	21.0	15.9	15.5	18.5	15.9	14	21
		Average	106		193		228		15.4	18.0	17.4	17.5	21.1	21.0	18.3	18.5	18.5	18.6	15	21
SW	SB-1	35-37	179		912		1084		19.8	18.8	18.0	20.0	26.3	25.3	11.6	13.4	25.3	11.9	12	26
SW	SB-2	25	189		823		924		20.4	18.9	18.1	20.5	25.3	24.1	14.5	17.0	23.9	15.4	15	25
SW	SB-4	45-47	121		276		368		16.3	18.2	17.6	17.9	21.4	21.3	18.2	18.0	19.7	18.2	16	21
SW	SB-5	55-57	270	Fine Sand	864	Medium Sand	959	Medium Sand	25.4	19.7	18.8	25.0	25.8	24.3	23.0	25.9	24.2	24.2	19	26
SW	SB-6	50-52	131		272		330		16.9	18.3	17.6	18.3	21.4	21.2	19.5	19.8	19.3	19.8	17	21
SW	SB-11	60-62	158		643		890		18.6	18.6	17.9	19.2	23.6	23.8	14.8	14.0	24.1	14.2	14	24
SW	SB-16	20-22	130		328		394		16.8	18.3	17.6	18.2	21.6	21.4	18.2	18.7	19.8	18.5	17	22
SW	SB-18	60-61	166		755		949		19.0	18.6	17.9	19.5	24.6	24.2	13.3	14.0	24.4	13.3	13	25
		Average	168		609		737		19.2	18.7	17.9	19.6	23.3	22.9	16.6	17.6	22.6	17.0	17	23

[1] USDA classification of particle size for soil separates (soil types)

[2] K_s estimated using Equations 7 thru 16 from A.F. Salarashayeri and M. Siosemarde (2012)

3.2.3 Franciscan Bed Rock

A model of the bedrock surface (See Figure A-3) was created from depth to bedrock information collected from the drilling of 18 soil borings, geophysical transects (seismic reflection and electrical resistivity) conducted for this investigation, field observations from this and previous studies, and a Light Detection And Ranging (LiDAR) surface model.

Bedrock elevations from soil borings (See Appendix C) and geophysical transects (presented in Appendix G) were used to interpolate the bedrock surface throughout the project area. Observed bedrock elevations from soil borings and interpreted elevations from geophysical transects were used to estimate bedrock elevations between soil borings. Locations of exposed bedrock and bedrock boundaries such as the adjacent creeks and beach were used to establish boundaries and elevations. These model boundaries included the coastal bluffs to the west and south, and the creeks to the north (Mill Creek) and east (Parker Creek).

The seep/ spring observations were, in some cases, used as an indicator marker of the bedrock/marine terrace contact at locations where bedrock was not physically observed (covered in landslide materials, debris, etc.). Physically observed bedrock exposures were approximately located and placed on a LiDAR field map and those horizontal locations and corresponding vertical elevations were then estimated. Bedrock elevation data were then entered into Rockworks, an industry standard software program used for subsurface data visualization, and the bedrock surface was then developed. Based on the developed bedrock surface, as shown in Figure A-3, a bedrock ridge which divides the groundwater basin exists in the vicinity of main street and beneath the school. The bedrock surface is also shown on the cross sections previously discussed.

Figures A-3 and A-4 present observations of the bedrock surface as interpreted from geophysical data and depth to bedrock encountered during subsurface investigation, respectively, within the project area.

3.2.4 Groundwater Gradient and Flow Direction

Groundwater moves quickly through sandy aquifers with low amounts of fines. In the marine terrace aquifer below the City of Trinidad, where there are no groundwater extraction wells, groundwater flow direction is primarily influenced by the contour and slope of the confining bedrock layer, which is shown in Figure A-3. The gradient and flow direction may also be assessed using measured groundwater levels from the monitoring wells.

Using simple multi-linear regressions, groundwater flow directions and gradient were calculated using the data collected from monitoring wells MW-1 through MW-9, and show similar flow patterns to those anticipated from the bedrock surface. The measured groundwater level data is presented in Appendix F. An overall flow direction was also calculated using the 9 wellsHowever, due to the site vertical boundary conditions (topographic differences of the marine terrace and the vertical geometry of the monitoring wells relative to each other and variable bedrock elevations), and the various lateral boundary conditions to the north (Mill Creek), east (Parker Creek), south (cliffs and beach), and west (cliffs and beach), groups of 3 and 4 nearest monitoring wells were used to estimate groundwater gradient and flow direction within each of those locales (cells). Individual cells and groundwater flow direction maps for March 2012 and September 2012 are presented as Figures A-5 and A-6 (Appendix A), respectively.

From groundwater elevations collected in March, April, June, and September of 2012, groundwater below the northern half of the City generally flows (inferred in the northwest portion from subsurface topography) to the north-northwest towards Mill Creek at a calculated hydraulic gradient up to 0.012 feet per foot (ft/ft). Below the southern half of the City, groundwater generally flows to the south and southwest with a hydraulic gradient up to 0.12 ft/ft. In the western portion of the City, groundwater flows to the west-southwest at a gradient up to 0.087 ft/ft. In the southeastern portion of the City groundwater flows general south with a hydraulic gradient of 0.030 ft/ft. Groundwater flow directions and gradient did not significantly change between the Spring and Fall. Further support for groundwater flow directions are presented in Figure A-5 and Figure A-6 for wet and dry seasons respectively.

Groundwater Flow and Gradient

The direction of groundwater flow and gradient below the project area is believed to be controlled by the bedrock surface and the volume of infiltrating water. The direction of groundwater flow and the hydraulic gradient was calculated from the groundwater monitoring well network constructed during this investigation. Looking at the modeled bedrock surface, one can now reasonably estimate and independently verify the groundwater flow direction in the project area by using the basic concept that groundwater will flow from areas of higher elevation to areas of lower elevation.

The bedrock surface varies in elevation throughout the project area and shows ridges and valleys that are thought to control the overall groundwater flow and gradient. As shown in Figure A-3, there is a bedrock surface high at approximately 120 feet msl, running southwest to northest through the center of Trinidad. Groundwater north of this surface is flows toward Mill Creek or along seeps on Trinidad's bluffs to the northwest. Groundwater to the south of the central bedrock surface is thought to flow in a southerly direction eventually daylighting as seeps and springs along Trindad's southern bluffs. Figure A-3 also shows an area of higher bedrock, at approximately 150 feet msl in the southern portion of the project area. This area of higher bedrock is thought to direct groundwater around either side in troughs to the east and west of it on the southern bluffs. This is supported by geophysical evidence and the fact that boring SB-15 did not have groundwater or moisture at the bedrock marine terrace contact.

Field observations of groundwater seeps (Figure A-4) generally agree with estimated groundwater flow patterns created by the bedrock surface. Groundwater directed north daylights through seeps along the north-northwest portion of the project area at Mill Creek and along the western bluff. Groundwater directed south generally daylights through seeps along the southern bluffs.

4. Conclusions and Recommendations

This geotechnical evaluation was completed to better understand subsurface conditions below the City of Trinidad. The focus of the evaluation was to determine existing groundwater flow patterns and physical properties of the marine terrace aquifer to aid in the design of an effective stormwater treatment system which minimizes impacts to septic systems and the surrounding environment and natural resources.

This geotechnical evaluation consisted of:

- Reviewing previous studies and reports
- Drilling 18 soil borings, which extended from the surface to bedrock
- Installing groundwater monitoring wells in 9 of the soil borings
- Monitoring of groundwater elevation for 4 events
- Surveying and mapping of major surface features, geological features, and identified groundwater seeps and springs
- Conducting seismic reflection and electrical resistivity tomography along 4 transects

Based on the evaluation, it was found that the site is comprised of two predominant geologic formations; the overlaying marine terrace (sand) and a confining Franciscan bedrock layer. The bedrock surface is considered to be a larger block of competent Franciscan Complex mélange material ranging from approximately 15 to 70 feet below ground surface.

The marine terrace aquifer is an isolated unit above the bedrock dominated by poorly to well graded fine to medium-grained beach sand. The marine terrace aquifer ranges from 15 to 70 feet thick, with local discontinuous thin layers of silt and gravel. The estimated saturated hydraulic conductivity of the marine terrace below approximately 5 to 10 feet bgs, ranges from 11 to 26 meters per day. The upper 5 to 10 feet of the marine terrace typically has a higher percentage of fine grains, and thus the saturated hydraulic conductivity for this layer should be one to two orders of magnitude slower than the deeper sediments.

Groundwater flow into the marine terrace aquifer is constrained by natural drainages (creeks) to the north and the east and the ocean to the west and south. Groundwater flow direction and gradient appear to be controlled by the shape and slope of the bedrock surface. Water entering the aquifer either from upgradient marine terrace sediments, precipitation, or septic systems quickly migrates vertically until it reaches the confining bedrock layer, as evidenced by the groundwater level monitoring discussed in the results section. Groundwater flows from the bedrock ridges to the troughs, along the sloping bedrock surface, and out the bedrock/marine terrace interface at the exposed bluffs to the northwest and south, Mill Creek to the north, and Parker Creek to the east. Generally, the groundwater flow paths extend radially from a point in the northern segment of Trinity Street with the bulk of the aquifer collecting and flowing south within the two north-south trending troughs. Groundwater flow patterns are shown graphically in Figures A-5 and A-6.

Near Main Street and Highway 101 the underlying bedrock slopes to Mill Creek limiting the groundwater contributions to flow along this boundary. Water also enters the system via infiltration of precipitation and infiltration of septic discharge. Groundwater recharge from the creeks likely does not occur as the creek beds are incised and lower than the surrounding bedrock.

4.1 Recommendations

Representative infiltration tests should be conducted for potential locations of LID/ BMPs in the upper 5 to 10 feet of the marine terrace, where grading and compaction from road and other infrastructure and development has likely reduced the hydraulic conductivity compared to lower undisturbed portions of the marine terrace deposits.

With numerous groundwater seeps that exhibit continual flow out of the marine terrace aquifer and limited dry weather inputs, recharge of the aquifer from anthropogenic sources (septic systems, leaking water lines, irrigation, etc.) will be further evaluated during groundwater modeling and design processes.

4.2 Next Steps

The next step in the City's ASBS Stormwater Improvement Project will be to use the data from this geotechnical evaluation to develop a groundwater model. The groundwater model will be used to further delineate groundwater flow paths, quantify groundwater flow velocities and directions, and evaluate the impacts of potential stormwater LID/ BMPs on groundwater patterns in the marine terrace aquifer.

Based upon the preliminary groundwater flow characteristics developed in this geotechnical evaluation, there appear to be two potential primary locations for stormwater infiltration that could meet project objectives: the north side of Main Street near Stagecoach Road and the southwest between the Trinidad Head and the City. These locations will be further evaluated along with other potential infiltration sites during the future modeling/ design analysis.

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Appendices

Appendix A – Figures

Figure A-1. Vicinity Map City of Trinidad

Figure A-2. Site Map, Geophysical Transect, Boring and Monitoring Well Locations

Figure A-3. Bedrock Surface Model

Figure A-4. Springs, Seeps, and Bedrock Outcrops

Figure A-5. Groundwater Flow Direction and Hydraulic Gradient (Wet Season)

Figure A-6. Groundwater Flow Direction and Hydraulic Gradient (Dry Season)

Figure A-7. Project Area Conceptual Cross Sections A-A' through G-G'

Figure A-8. Lithology Cross Sections A-A', B-B', C-C', and D-D'

Figure A-9. Lithology Cross Sections E-E', F'F', G-G', and H-H'

Figure A-10. Estimated Hydraulic Conductivity

Humboldt County

Counties

Watershed Boundary

Area of Special Biological Significance (ASBS)

Project Area Boundary

Paper Size ANSI A

0 250 500 750 1,000

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Vicinity Map
City of Trinidad

Job Number	1016311005
Revision	1
Date	26 Oct 2012

Figure A-1

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Data source: StreetMapUSA, Roads, Boundaries, 2010. Bing Aerials, Aerial Imagery, 2012. City of Trinidad, Area of Special Biological Significance, 2011. Humboldt County, Watersheds, 2011. Created by:bvivyan

Paper Size 11" x 17" (ANSI B)

0 100 200 300 400 500 600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

Soil Boring

Monitoring Well

Preexisting Monitoring Well

Project Area Boundary

Geophysical Transect
(Seismic Reflection & Electrical Resistivity)

GHD

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Site Map, Geophysical Transect, Boring, and Monitoring Well Locations

Figure A-2

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Figures\FA-2_Site_Map.mxd

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Data source: Bing, Aerial Maps, 2012. GHD Inc., Field Points, 2012. Created by:bvivyan

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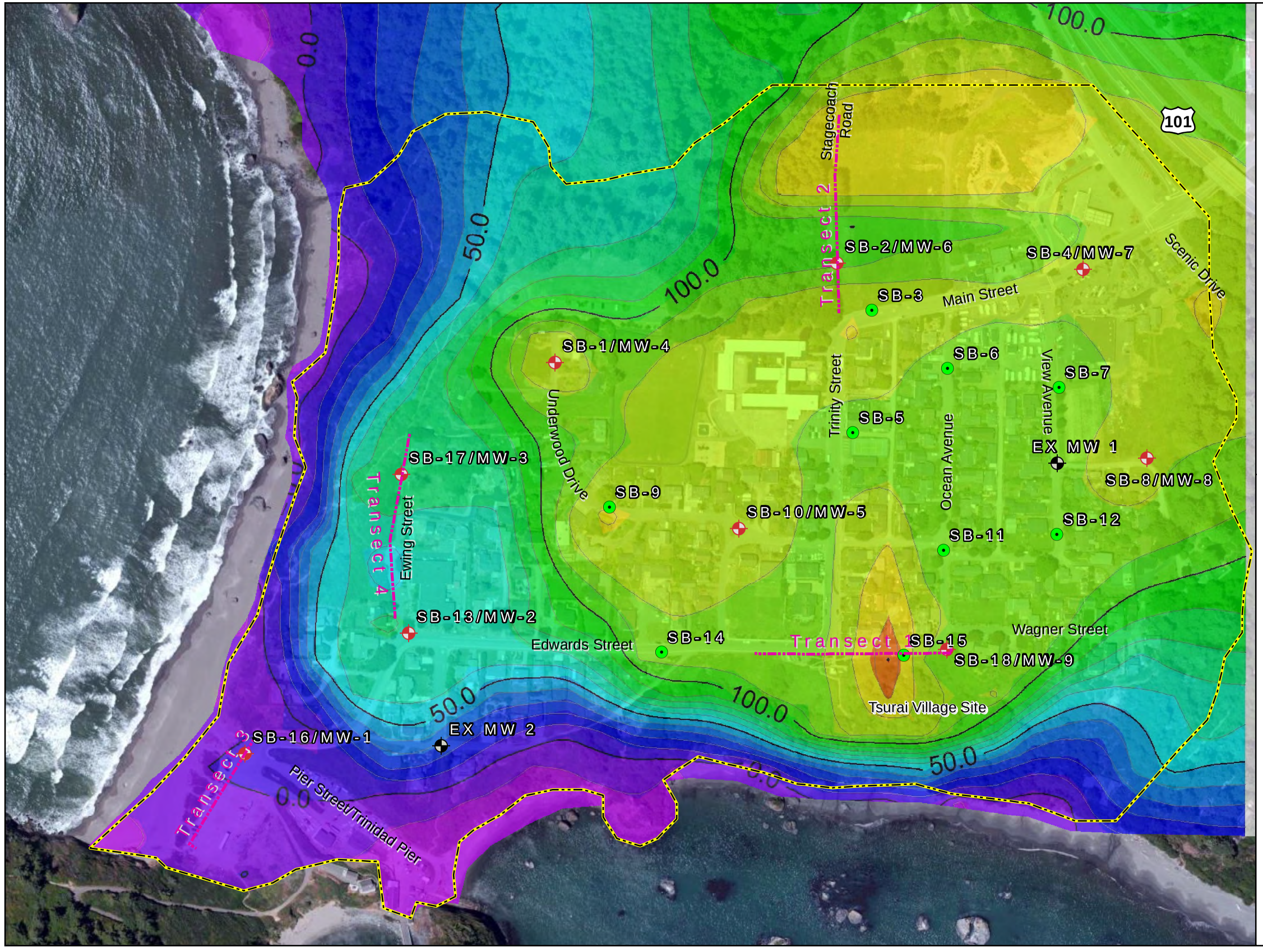

Bedrock Elevation (ft msl)

160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0

Note: Bedrock contours are based upon field observations, soil borings, and geotechnical studies within the study area. Some coastal features outside of the primary areas of concern, where they will not impact groundwater flow paths, may not be representative.

Paper Size 11" x 17" (ANSI B)

0 100 200 300 400 500 600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

Soil Boring

Monitoring Well

Preexisting Monitoring Well

Project Area Boundary

Geophysical Transect
(Seismic Reflection & Electrical Resistivity)

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Bedrock Surface Model

Figure A-3

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Data source: Bing, Aerial Maps, 2012. GHD Inc., Field Points, 2012. GHD Inc., Rockworks Bedrock Surface, 2012. Created by:bvivyan

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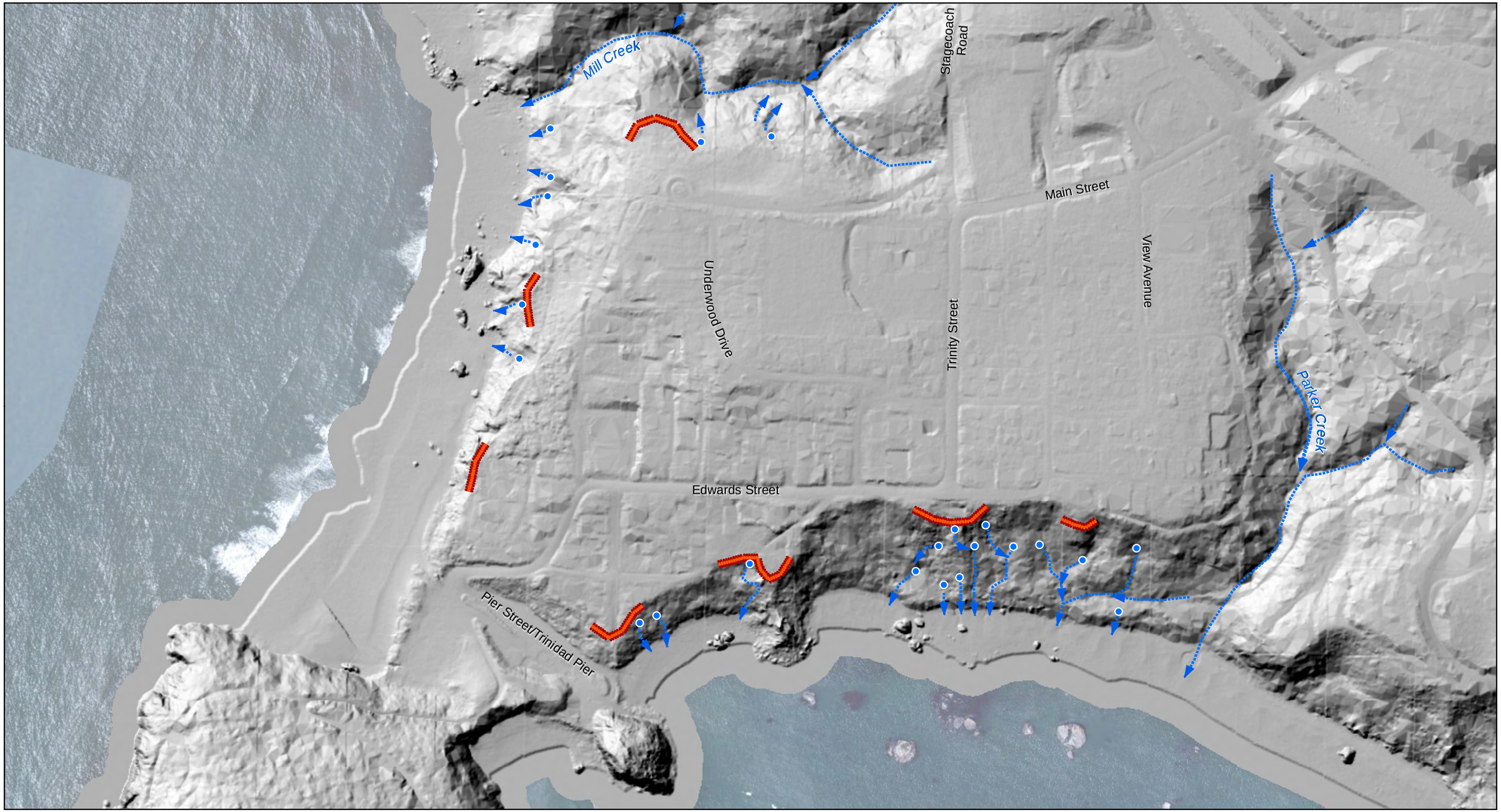

Paper Size 11" x 17" (ANSI B)

0 100 200 300 400 500 600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

Seep

Flow Path

Exposed/Evidence of Bedrock Outcrop

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Springs, Seeps, and Bedrock Outcrops

Figure A-4

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Figures\FA-4_Springs_Seeps.mxd

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Data source: NOAA, CA Coastal Conservancy Coastal Lidar Project, 2012. GHD Inc., Field Points, 2012. Created by:bvivyan

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0 100 200 300 400 500 600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

Soil Boring

Monitoring Well

Preexisting Monitoring Well

Groundwater Cells

Calculated groundwater flow direction (Azimuth) and hydraulic gradient in feet per foot (ft/ft). Size of the arrow is relative to gradient magnitude.

Inferred groundwater gradient. Where azimuth or hydraulic gradient are not indicated, Groundwater flow direction has been inferred from the bedrock model (See Figure A-3).

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Groundwater Flow Direction and Hydraulic Gradient (Wet Season)

Figure A-5

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Figures\FA-5_GW_Flow_March.mxd

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Data source: Bing, Aerial Maps, 2012. GHD Inc., Field Points, 2012. GHD Inc., Groundwater Gradient, 2012. Created by:bvivyan

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Paper Size 11" x 17" (ANSI B)

0 100 200 300 400 500 600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

Soil Boring
Monitoring Well
Preexisting Monitoring Well
Groundwater Cells

Calculated groundwater flow direction (Azimuth) and hydraulic gradient in feet per foot (ft/ft). Size of the arrow is relative to gradient magnitude.

Inferred groundwater gradient. Where azimuth or hydraulic gradient are not indicated, Groundwater flow direction has been inferred from the bedrock model (See Figure A-3).

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Groundwater Flow Direction and Hydraulic Gradient (Dry Season)

Figure A-6

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Data source: Bing, Aerial Maps, 2012. GHD Inc., Field Points, 2012. GHD Inc., Groundwater Gradient, 2012. Created by:bvivyan

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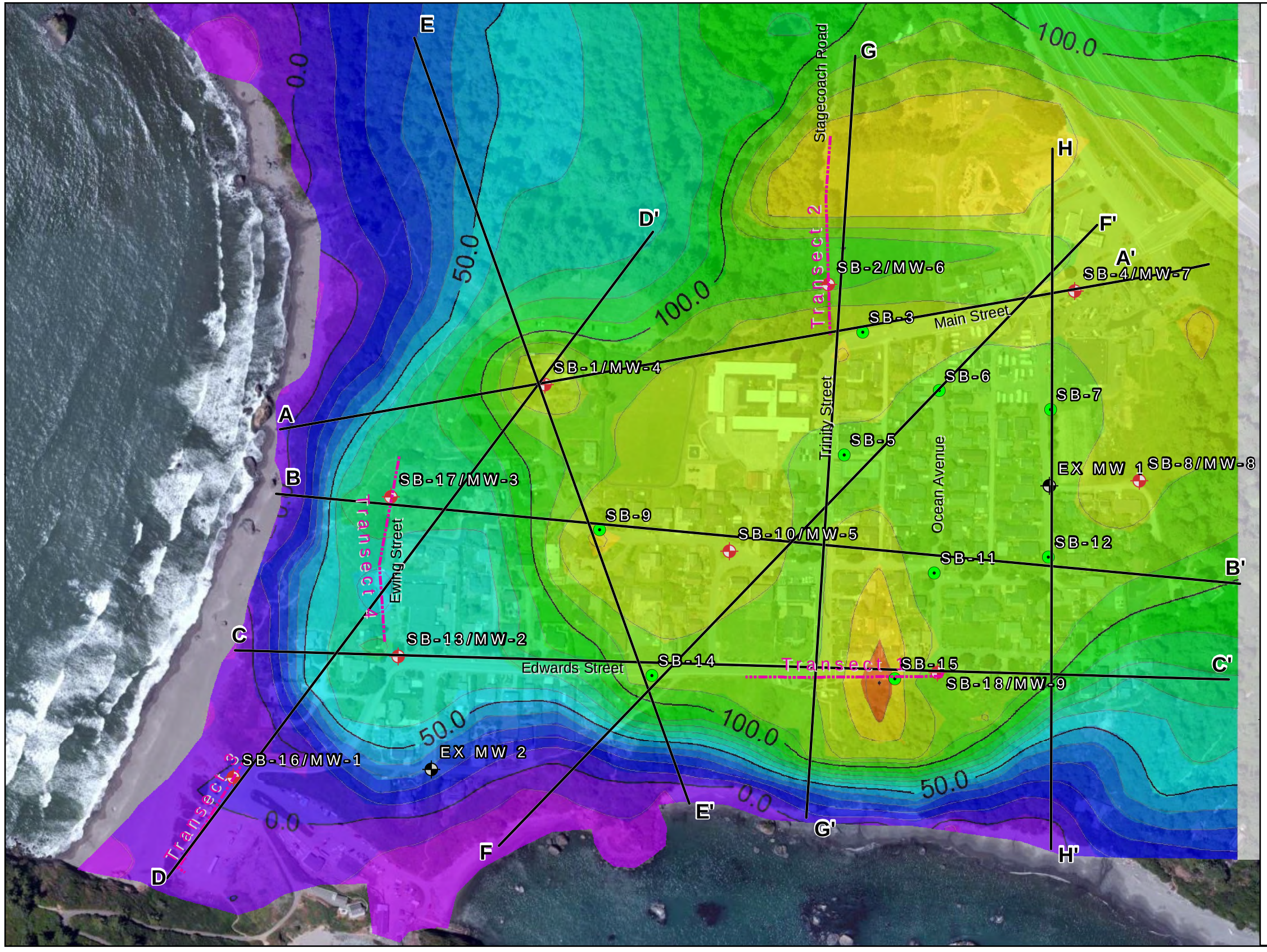

Bedrock Elevation (ft msl)

160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0

Note: Bedrock contours are based upon field observations, soil borings, and geotechnical studies within the study area. Some coastal features outside of the primary areas of concern, where they will not impact groundwater flow paths, may not be representative.

Paper Size 11" x 17" (ANSI B)

0 100 200 300 400 500 600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

Soil Boring

Monitoring Well

Preexisting Monitoring Well

Cross Section

Geophysical Transect
(Seismic Reflection & Electrical Resistivity)

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Project Area Conceptual
Cross Sections A-A' through G-G'

Figure A-7

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Data source: Bing, Aerial Maps, 2012. GHD Inc., Field Points, 2012. GHD Inc., Rockworks Bedrock Surface, 2012 Created by:bvivyan

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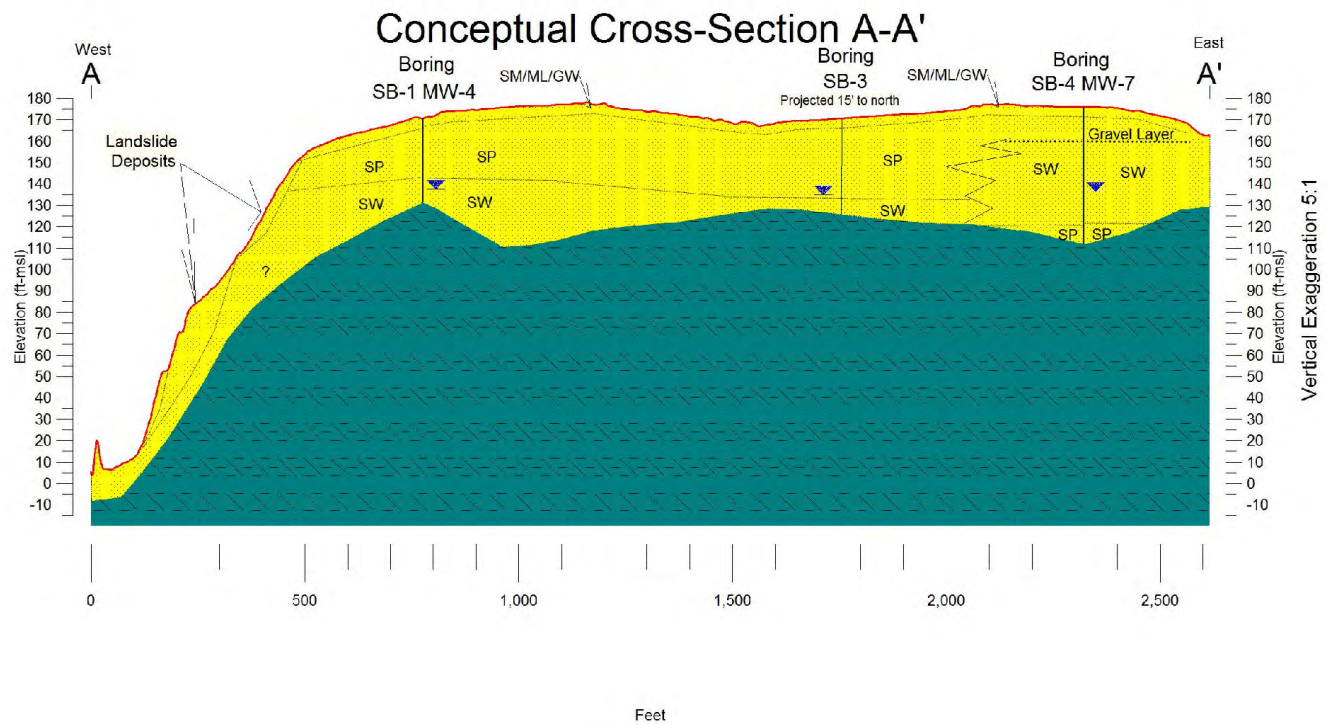

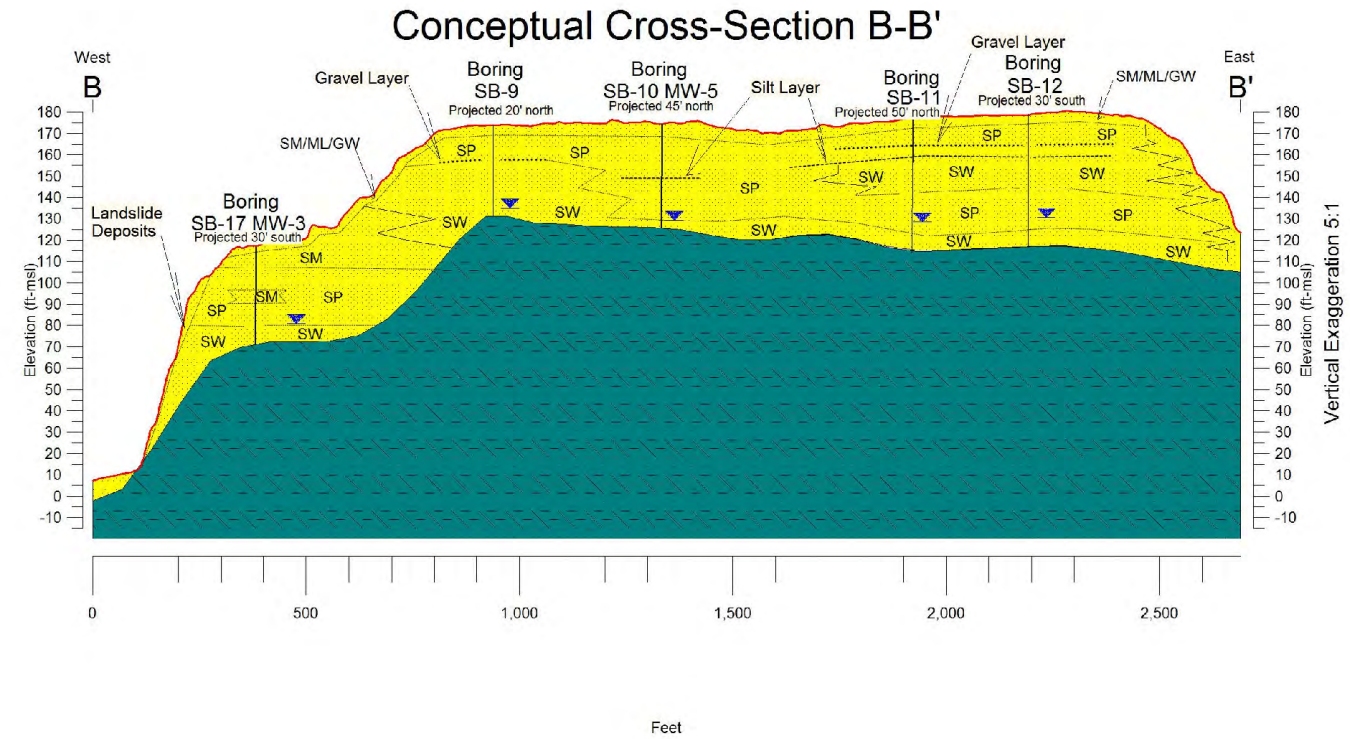

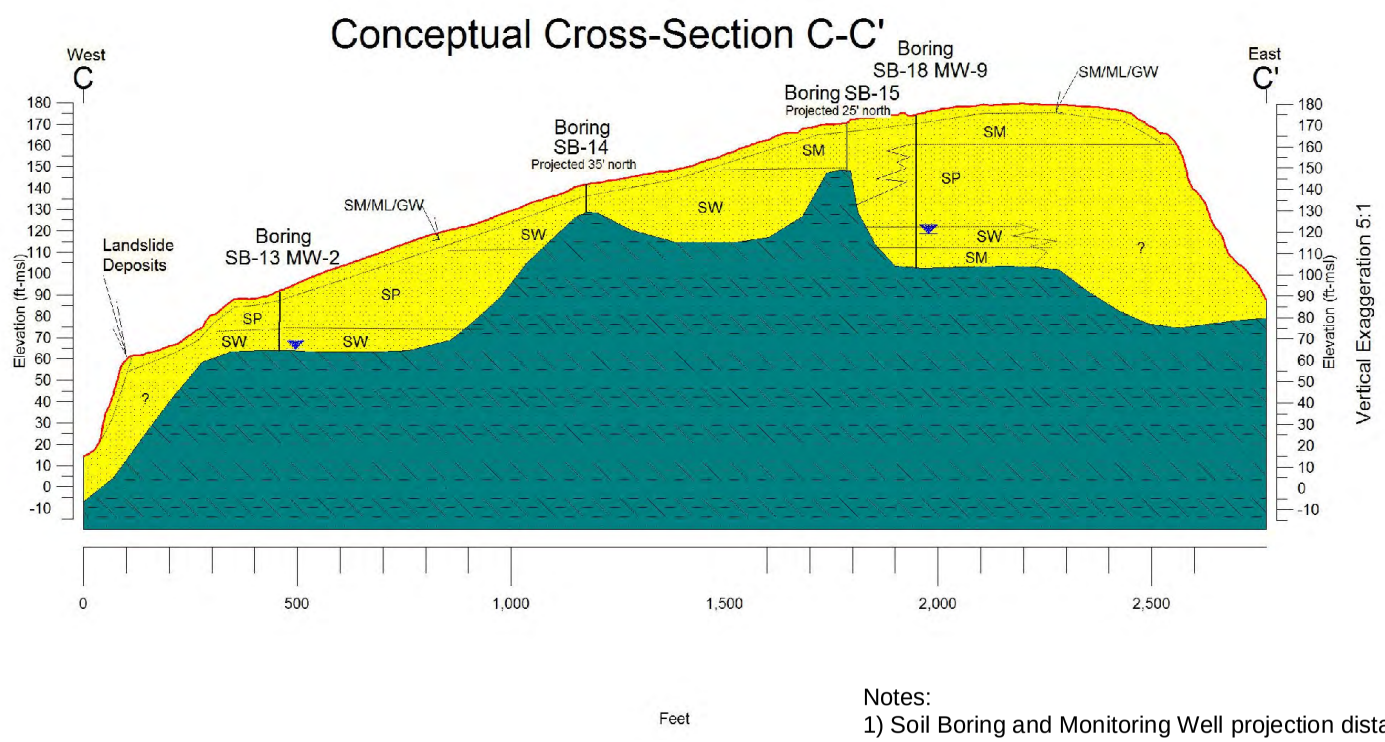

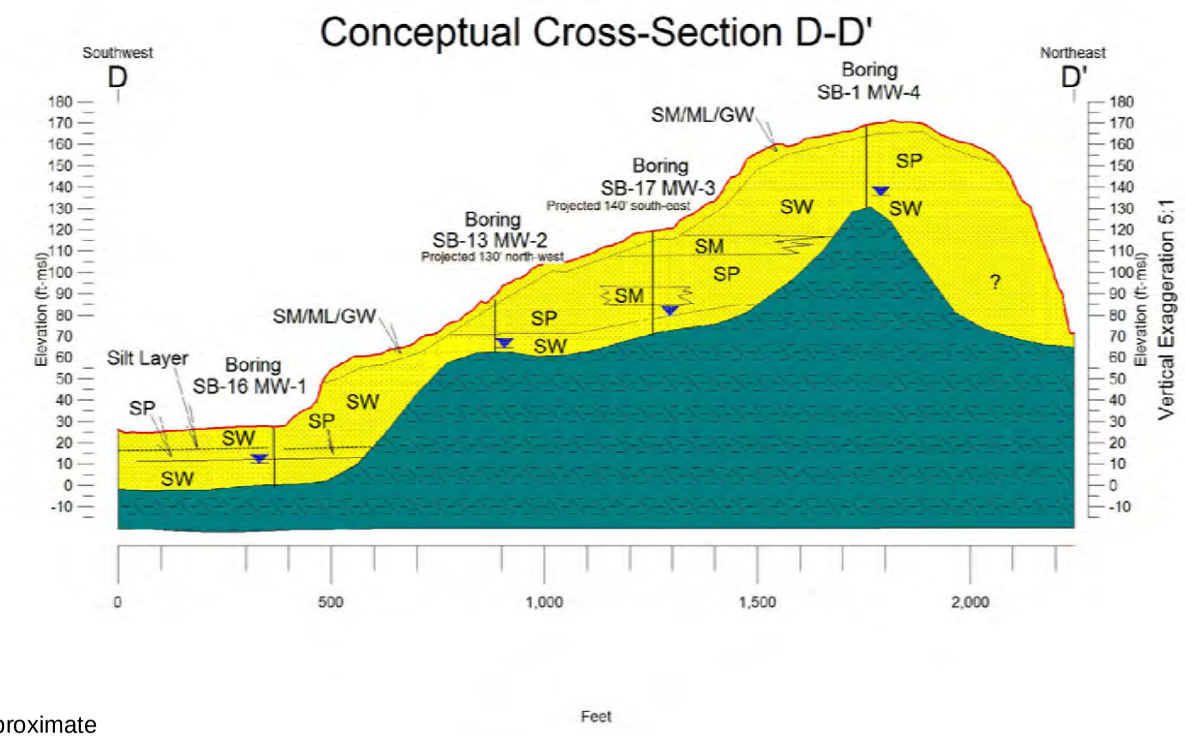

Notes:
1) Soil Boring and Monitoring Well projection distances are approximate
2) Groundwater elevations shown in soil borings indicated first encountered groundwater during drilling.
3) Groundwater elevations shown in monitoring wells indicate average observed groundwater elevations.

Paper Size 11" x 17" (ANSI B)

*Note
See Cross Sections for Scale

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

*Note
See Cross Sections for Orientation

Marine Terrace
Franciscan
Facies/Stratigraphic Change

SP	Poorly Graded Sand
SW	Well Graded Sand
SM/ML/GW	Silty Sand, Silt or Fill Material
?	Unknown

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Conceptual Cross Sections
A-A', B-B', C-C', D-D'

Figure A-8

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Figures\FA-8_Cross_Sections_A-D.mxd

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Data source: GHD Inc., Rockworks Stratigraphy Profiles, 2012. Created by:bvivyan

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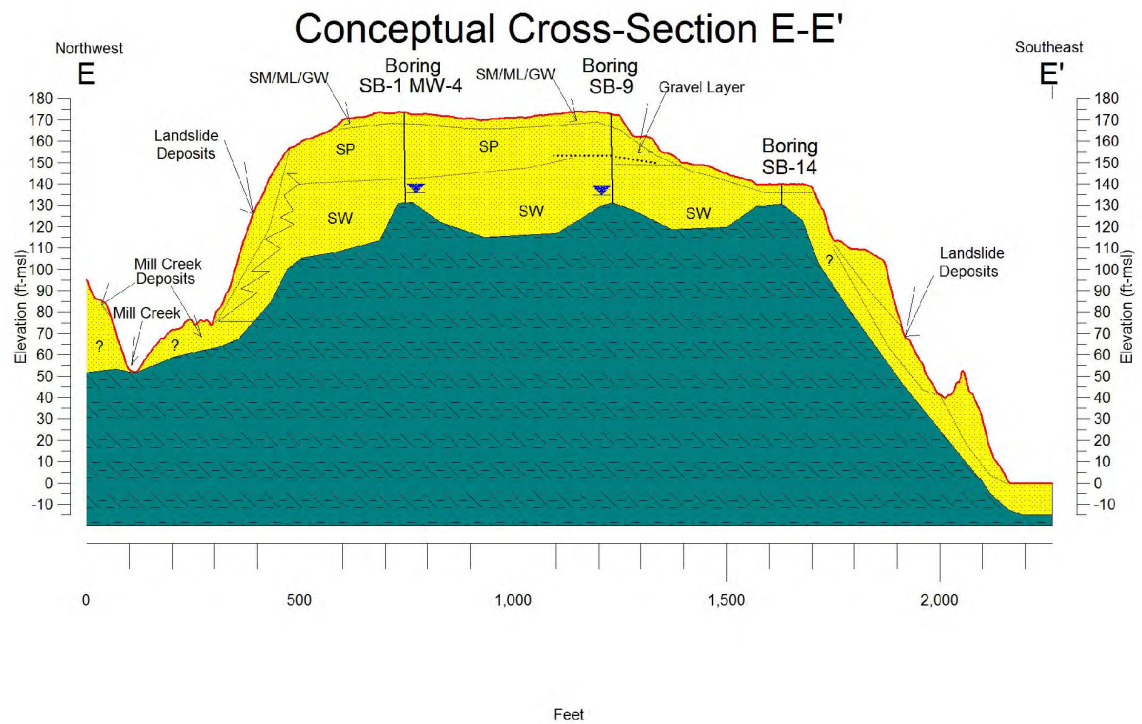

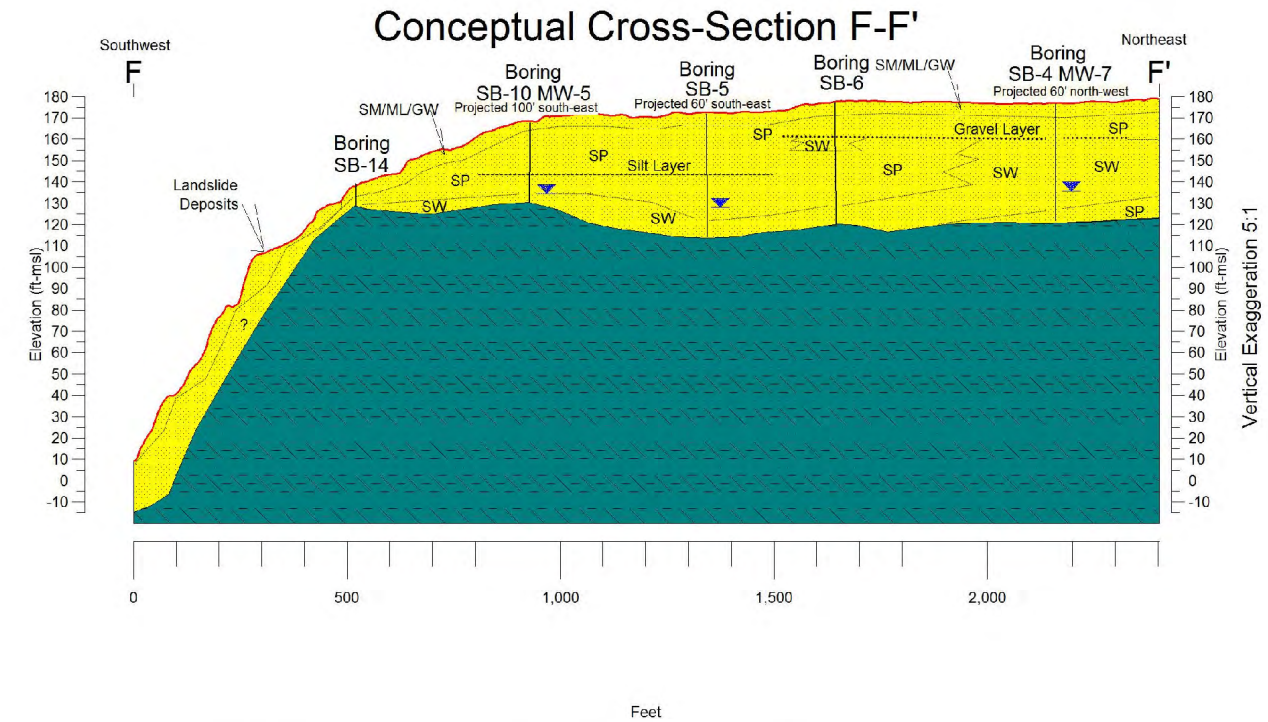

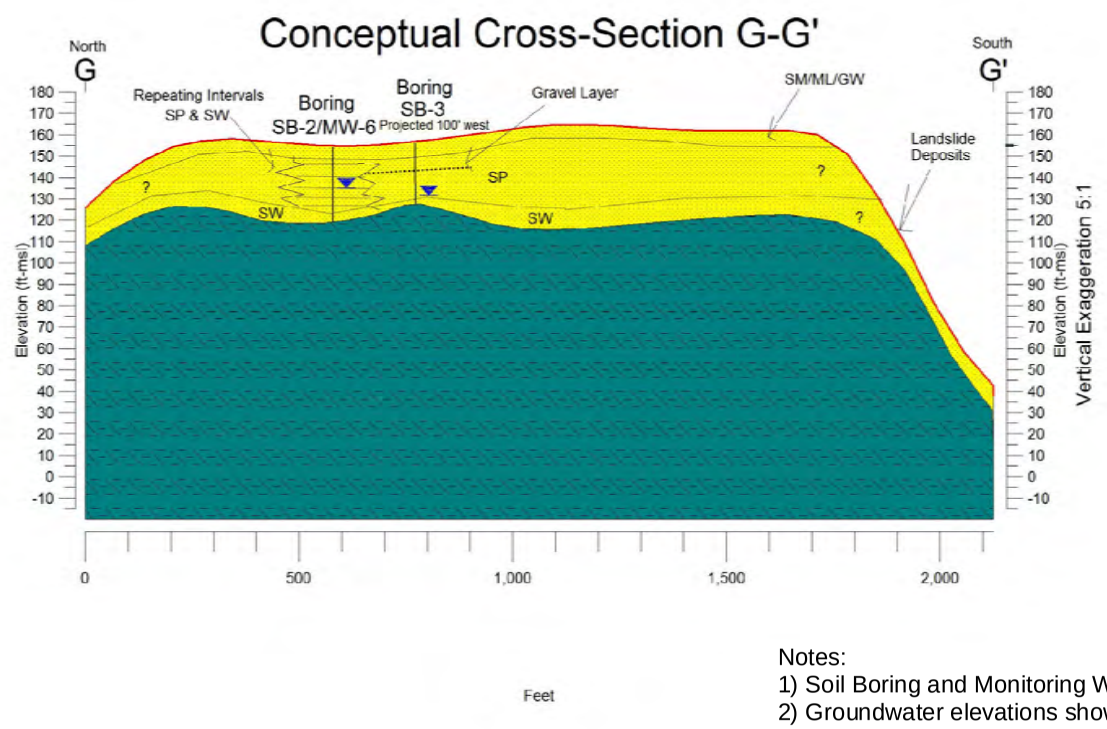

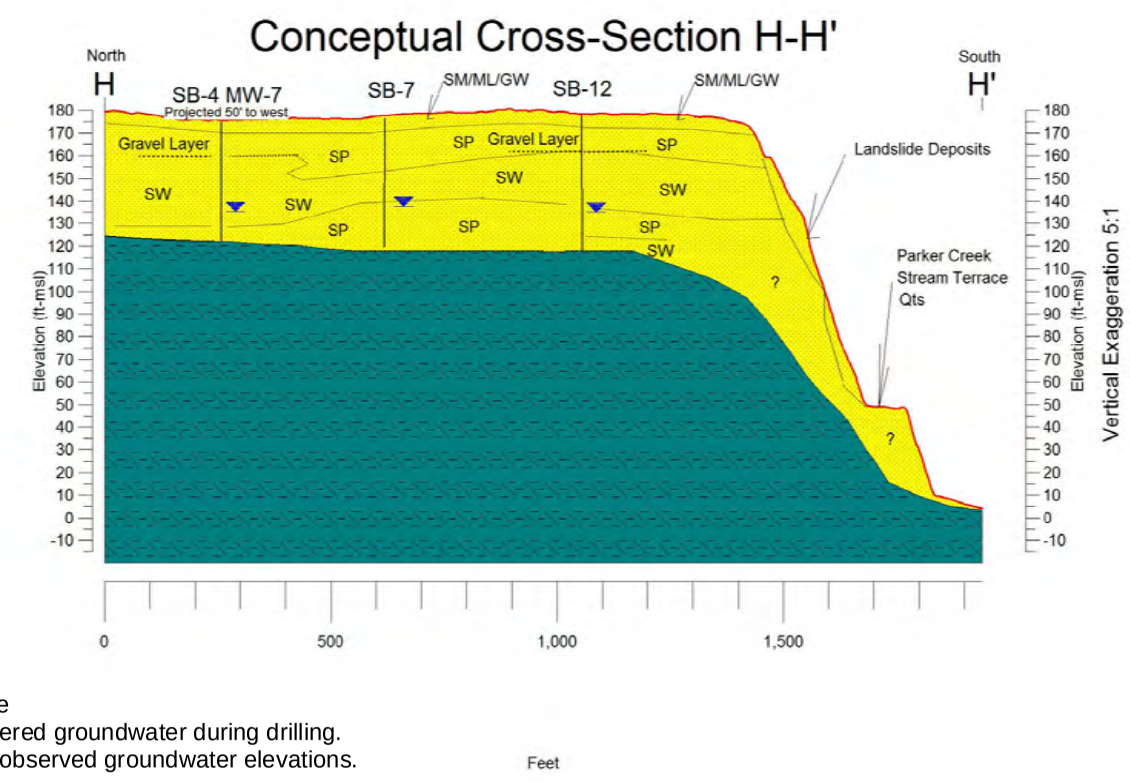

Notes:
1) Soil Boring and Monitoring Well projection distances are approximate
2) Groundwater elevations shown in soil borings indicated first encountered groundwater during drilling.
3) Groundwater elevations shown in monitoring wells indicate average observed groundwater elevations.

Paper Size 11" x 17" (ANSI B)

*Note
See Cross Sections for Scale

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

*Note
See Cross Sections for Orientation

Marine Terrace
Franciscan
Facies/Stratigraphic Change

SP	Poorly Graded Sand
SW	Well Graded Sand
SM/ML/GW	Silty Sand, Silt or Fill Material
?	Unknown

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Cross Sections
E-E', F-F', G-G', H-H'

Figure A-9

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Figures\FA-9_Cross_Sections_E-H.mxd

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Data source: GHD Inc., Rockworks Stratigraphy Profiles, 2012. Created by:bvivyan

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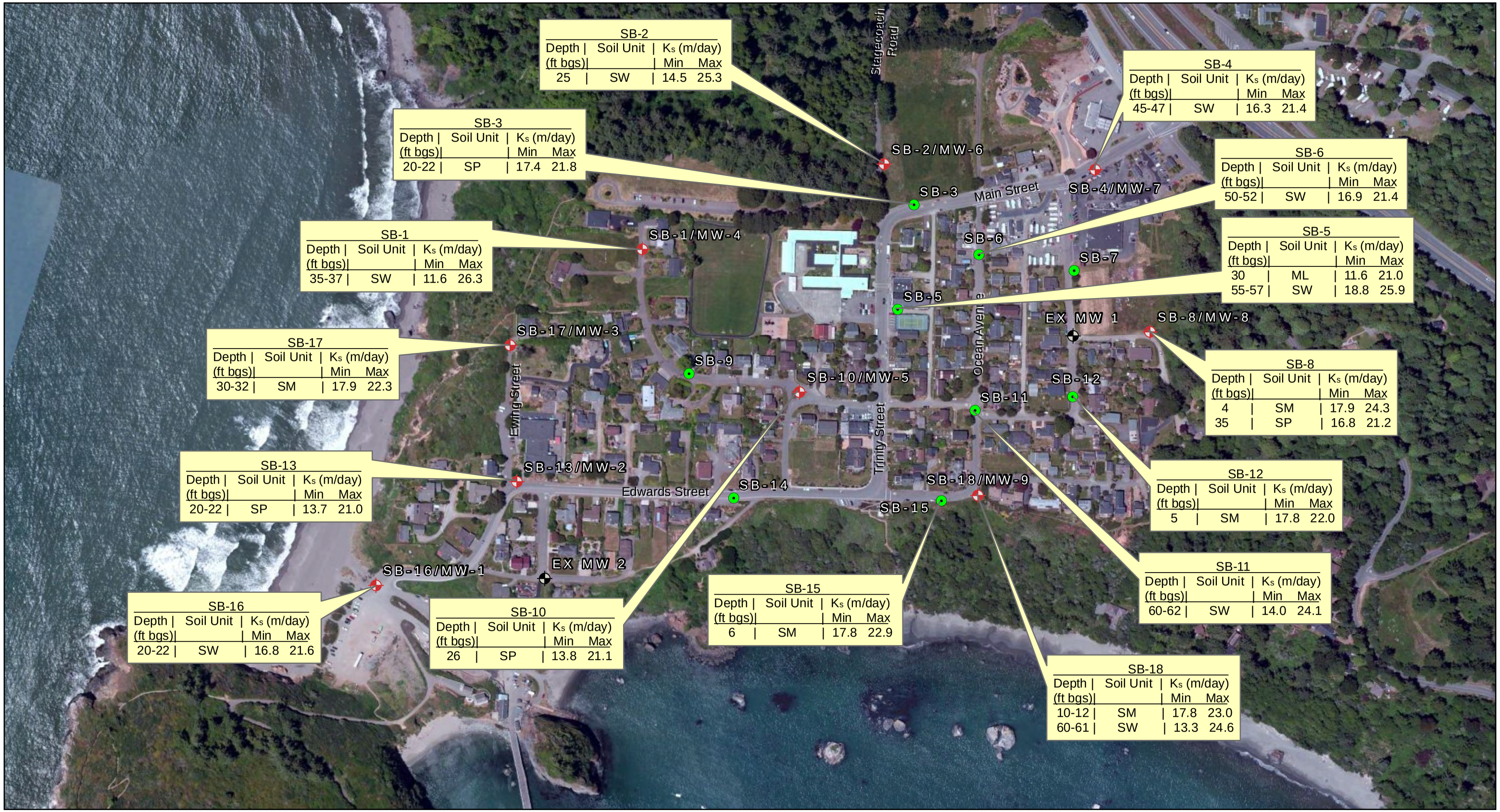

SB-2

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
25	SW	14.5	25.3

SB-3

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
20-22	SP	17.4	21.8

SB-4

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
45-47	SW	16.3	21.4

SB-6

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
50-52	SW	16.9	21.4

SB-1

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
35-37	SW	11.6	26.3

SB-5

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
30	ML	11.6	21.0
55-57	SW	18.8	25.9

SB-17

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
30-32	SM	17.9	22.3

SB-8

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
4	SM	17.9	24.3
35	SP	16.8	21.2

SB-13

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
20-22	SP	13.7	21.0

SB-12

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
5	SM	17.8	22.0

SB-11

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
60-62	SW	14.0	24.1

SB-16

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
20-22	SW	16.8	21.6

SB-10

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
26	SP	13.8	21.1

SB-15

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
6	SM	17.8	22.9

SB-18

Depth (ft bgs)	Soil Unit	Ks (m/day) Min	Ks (m/day) Max
10-12	SM	17.8	23.0
60-61	SW	13.3	24.6

Paper Size 11" x 17" (ANSI B)

0 100 200 300 400 500 600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

N

Soil Boring

Monitoring Well

Preexisting Monitoring Well

ML - Silt
SM - Silty Sand
SP - Poorly Graded Sand
SW - Well Graded Sand

K_s - Hydraulic Conductivity
bgs - below ground surface

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	26 Oct 2012

Estimated
Hydraulic Conductivity

Figure A-10

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Data source: Bing, Aerial Maps, 2012. GHD Inc., Field Points, 2012. GHD Inc., Soil Hydraulic Conductivity, 2012. Created by:bvivyan

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Appendix B – HCDEH Boring and Monitoring Well Installation Permit

RECEIVED

JAN - 4 2012

HUMBOLDT COUNTY DIVISION of ENVIRONMENTAL HEALTH - HAZARDOUS MATERIALS UNIT
WELL and BORING PERMIT APPLICATION

1

Facility ID # COT **Permit #** COT 01042012

Facility Name: CITY OF TRINIDAD

Site Address: CITY LIMITS

Site Owner: CITY OF TRINIDAD **Telephone:** (707) 677-0223

Address: 409 TRINITY STREET, PO BOX 390 **AP#:** 042-061-018

RP Name: SAME, CONTACT REBECCA PRICE-HALL **Telephone:** (707) 677-3759

Address:

Consultant: WINZLER & KELLY / GHD **Telephone:** (707) 443-8326

Address: 718 3RD ST. EUREKA, CA, RYAN CRAWFORD **Reg.#/Type:** PG#8744

Driller: Clear Heart Drilling, INC **Telephone:** 707-568-6095

Address: 555 W. College Ave. Suite B, Santa Rosa 95401 **C-57 Lic.#:** 780357

# On-site				# Off-site			
Wells	8	Borings	17	Wells		Borings	

Activity: ☒ Construct ☐ Destroy ☐ Repair/Modify **Electrode Type:**

Well Type: ☒ Monitoring Well ☐ Injection Well ☐ Vapor Extraction ☒ Geologic Boring
☐ Extraction Well ☐ Piezometer ☐ Vapor Point ☐ Soil Gas Survey
☐ Vadose Well ☐ Cathodic Protection ☐ Direct Push Boring ☐ Temporary Well Point

Investigation Type: ☒ Site Assessment ☐ Disposal Practice ☐ UST ☒ Other*
☐ Surface Contamination ☐ Surface Impoundment ☐ AST
*Specify: STORMWATER IMPROVEMENT DESIGN

Investigation Phase: ☒ Initial ☐ Subsequent ☐ Remediation ☐ Closure

Suspected Contaminants: NA

Disposal/Containment for Soil Cuttings: 55-GAL DOT DRUMS/ROLL OUT BINS

Disposal/Containment for Rinsate: 55-GAL DOT DRUMS

Disposal/Containment for Development Water: 55-GAL DOT DRUMS

Permits will not be processed with out the following information:

- ☒ Scaled Construction Detail
- ☒ Detailed Site Plan
- ☐ Lead Agency Approval Letter
- ☐ Off Site Well Requirements:
  - ☐ Legal Right of Entry
  - ☐ Off Site Address/Location
  - ☐ Encroachment Permit
  - ☐ Coastal Zone Permit
- ☒ Appropriate Fees
- ☐ Copy of Workplan (if not on file at HCDEH)

Proposed Work Date: 1-9-2012

rev. 6/98

HUMBOLDT COUNTY DIVISION of ENVIRONMENTAL HEALTH - HAZARDOUS MATERIALS UNIT
WELL and BORING PERMIT APPLICATION

Facility ID # COT **Permit #** COT 01042012

I hereby agree to comply with all laws, ordinances and regulations of the county of Humboldt and State of California pertaining to water well construction. I will contact the Humboldt County Hazardous Materials Unit at (707) 445-6215 five (5) working days prior to commencing this work. I will furnish to the County of Humboldt, Division of Environmental Health, and the owner a legible copy of the State Water Well Completion Report (form DWR 188) within fifteen (15) days after completion of work to obtain final approval of the well(s). I acknowledge that the application will become a permit ONLY after site approval by the Local Implementing Agency (HCDEH, NCRWQCB, DTSC, EPA). I understand this permit is not transferable and expires one hundred twenty (120) days from the date of issuance.

Certificates of Insurance:

☒ A currently effective General Liability Certificate of Insurance is on file with this office, endorsed to include the Humboldt County Division of Environmental Health as additional named insured.

☒ A currently effective Worker's Compensation Certificate of Insurance is on file with this office, endorsed to include the Humboldt County Division of Environmental Health as additional named insured.

Jerri White — 12/16/2011

Signature of Well Driller - no proxies - original signature only in blue ink — Date

- **Well identification number and type must be affixed to exterior surface of security structure.**
- **The applicant is responsible for notifying Underground Services Alert at least 48 hours prior to the scheduled work date.**
- **A State of California Department of Water resources Well Completion Report (Form DWR 1-88) must be filed within 15 days of completion of work for all well completions and destructions.**
- **A licensed California C-57 Well Driller is required for all wells and direct push work.**

FOR OFFICE USE ONLY

Permit Approval: Norman Crawford **Date:** 1-5-2012

✓ 916

Fee: $1108.00 **Date:** 1/4/12 **Receipt:** 250886 SR0000297

IN0004198

Initial Inspection: _____ **Date:** _____

Final Inspection: _____ **Date:** _____

Appendix C – Boring Logs

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-1

DATE BEGAN: 1/12/12

DRILLER: CLEARHEART **DATE FINISHED:** 1/13/12 **FIELD GEOLOGIST:** R. CRAWFORD

C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 36.65' ▽ **INITIAL DEPTH TO GW:** 36' ▽

DRILLING METHOD: HSA **DRILLING EQUIP:** 5' SOLID FLIGHT **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	SAMPLE NOTES ~~WELL CONSTRUCTION~~
		↓ GRASS					
	0	COARSE GRAVEL/SAND/SILT FILL GRAVEL UP TO 6"		MOIST	LOOSE	GW	HAND AUGER TO 5' BGS
	1	SILT WITH SAND (85,15,0) FINE GRAINED SAND, DARK YELLOWISH BROWN, NON-PLASTIC.	10YR 4/6	MOIST	FIRM	ML	
	2	SILTY SAND (20,80,0) FINE GRAINED SAND, LIGHT YELLOWISH BROWN	10YR 6/4	MOIST	LOOSE	SM	
	3	MOTTLING FROM 4-6' BGS					
	4	POORLY GRADED SAND W/SILT (10,90,0) FINE GRAINED SAND, LIGHT YELLOWISH BROWN.	10YR 6/4	MOIST	LOOSE	SP-SM	FROM CUTTING
	5	FINES REDUCED AT DEPTH					
	6	STRONG ORANGE BANDED/OXIDIZED LAYERS 10.5'-18.5' BGS		MOIST			SAMPLE 100%
	7	1" THICK ROUNDED GRAVEL LENSE UP TO 1/2" DIAMETER					
	8	16'-17' OXIDIZED LAYERS WITH CHARCOAL					SAMPLE 100%
	9	4" THICK ROUNDED GRAVEL LAYER, 1/2" DIA.					
	10	WELL GRADED SAND (5,95,0) FINE TO COARSE SAND, SUB-ROUNDED, LIGHT BROWNISH GRAY, STRONG OXIDIZED LAYER AT 22' BGS 1/2" THICK.	10YR 6/2	MOIST	LOOSE	SW	SAMPLE 100%
	11	POORLY GRADED SAND (1,99,0) FINE SAND, LIGHT BROWNISH GRAY.	10YR 6/2	MOIST	MED. DENSE	SP	

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** CONT. SB-1

DATE BEGAN: 1/12/12

DRILLER: CLEARHEART **DATE FINISHED:** 1/13/12 **FIELD GEOLOGIST:** R. CRAWFORD

C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 36' ▽ **INITIAL DEPTH TO GW:** 36' ▽

DRILLING METHOD: HSA **DRILLING EQUIP:** 5' CORE BARREL, 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
		CONT. SP, SAME AS ABOVE						
-25	25							SAMPLE 100% LAST CORE BARREL, TOO SLOW
-26	26							
-27	27	WELL GRADED SAND (1,99,0) FINE TO COARSE SUBROUNDED TO SUBANGULAR SAND. OVERLYING CONTACT AT 27' AND AT 29' MARKED WITH STRONG OXIDIZED LAYER ½" THICK.	SAME	MOIST	MED. DENSE	SW		
-28	28							
-29	29							
1/12/12 -30	30							
-31	31							DRILL OUT
1/13/12 -32	32							
-33	33							
-34	34							SWITCH TO 2' SAMPLER
-35	35		SAME	MOIST	LOOSE		3 3 4 11	90% SAMPLE
-36	36	▽						
-37	37							
-38	38	RIG STARTED RATTLING @ 37' BGS						
-39	39	BEDROCK @ 39'					17 21 50 -	75% SAMPLE FOR 5"
-40	40							
-41	41	BOH = 39' 0845 1/13/12						
-42	42							
-43	43							
-44	44							
-45	45							
-46	46							
-47	47							
-48	48							
-49	49							
-50	50							

SOIL BORING AND WELL LOG

PROJECT NO: 0W631005 **PROJECT NAME:** TRINIDAD ABBS **BORING NUMBER:** SB-2
DATE BEGAN: 1/13/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/17/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 19.90' ▽ **INITIAL DEPTH TO GW:** 19' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 5' CORE BARREL **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
0	0	↓ GRASSY GRAVEL/SAND/SILT FILL		MOIST	LOOSE	GW	HAND AUGER TO 5' BGS
-5	5	POORLY GRADED SAND (5,95,0) FINE GRAINED SAND, LIGHT YELLOWISH BROWN.	10YR 6/4	MOIST	LOOSE	SP	DRILL TO 10' DESC. FROM CUTTINGS
-10	10						100% SAMPLE
-13	13	WELL GRADED SAND (5,95,0) FINE TO COARSE GRAINED SAND, SUB-ROUNDED TO SUBANGULAR, YELLOWISH BROWN. STRONG OXIDIZED LAYER @ 15' BGS. 15.5'-18' FINE SAND STRINGERS UP TO 3" THICK.	10YR 5/6	MOIST	LOOSE	SW	
							100% SAMPLE
		DISCRETE OXIDIZED CONTACT @ 19'					▽
-19	19	POORLY GRADED SAND (1,99,0) FINE SAND, LIGHT BROWNISH GRAY. ½" THICK OXIDATION LAYER @ 21' BGS	10YR 6/2	WET	MED. DENSE	SP	▼
							80% SAMPLE
-22	22	WELL GRADED SAND (5,95,0) FINE TO COARSE SAND, SUB ROUNDED TO SUBANGULAR. 24.5'-25' VERY STRONG OXIDATION LAYER	SAME	WET	LOOSE	SW	
-25	25						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-2
DATE BEGAN: 1/13/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/17/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** ~20' **INITIAL DEPTH TO GW:** 19
DRILLING METHOD: HSA **DRILLING EQUIP:** 5' CORE BARREL, 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
		CONT. SW AS ABOVE					
-25	25	OXIDATION LAYER ½" THICK @ 26' BGS	SAME	WET	LOOSE	SW	90% SAMPLE
-26	26						
-27	27						
-28	28						
-29	29						
-30	30	POORLY GRADED SAND (1,99,0) FINE SAND LAYER.	SAME	WET	LOOSE	SP	
-31	31	WELL GRADED SAND (1,99,0) FINE TO COARSE SAND	SAME	WET	LOOSE	SW	SAMPLE TO 33', SWITCH TO 2' SAMPLER
-32	32						
-33	33						
-34	34	STRONGLY OXIDIZED 3" ROUNDED GRAVEL LAYER					
-35	35	WEATHERED SILTSTONE BEDROCK					
-36	36						
-37	37	BOH = 34' 1305					
-38	38	1/1					
-39	39						
-40	40						
-41	41						
-42	42						
-43	43						
-44	44						
-45	45						
-46	46						
-47	47						
-48	48						
-49	49						
-50	50						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-3

DATE BEGAN: 1/16/12 **DATE FINISHED:** 1/16/12 **FIELD GEOLOGIST:** R. CRAWFORD

DRILLER: CLEARHEART **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

C57 License #: 780357

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 39' ▽ **INITIAL DEPTH TO GW:** 38' ▽

DRILLING METHOD: HSA **DRILLING EQUIP:** 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl) / DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	Blows	WELL CONSTRUCTION
0–1	ASPHALT 3" ROADBASE GRAVEL FILL TO 3' BGS		DRY	LOOSE	GW		HAND AUGER TO 5' BGS
1–5	SILT WITH SAND (75,25,0) FINE SAND, DARK YELLOWISH BROWN NON PLASTIC.	10YR 4/6	DRY	SOFT	ML		
5–9	SILTY SAND (20, 80, 0) FINE SAND LIGHT YELLOWISH BROWN.	10YR 6/4	DRY	LOOSE	SM		DRILL TO 10' BGS
9–15	POORLY GRADED SAND (5,95,0) FINE SAND, LIGHT YELLOWISH BROWN GRAVEL LENSE 1" THICK, ROUNDED @ 10.5' STRONG OXIDIZED LAYER ½" THICK @ 11' GRADATIONAL INCREASE IN MEDIUM SAND 12-13.5', GRADATIONAL DECREASE IN MEDIUM SAND 13.5-15'.	SAME	DRY	LOOSE-MED DENSE	SP	5 5 7 11 7 11 13 13	SAMPLE 100%
15–20							DRILL TO 20' BGS
20–25	SAME AS ABOVE, COLOR CHANGE LIGHT BROWNISH GRAY	10YR 6/2	DRY	LOOSE		6 6 7 9	SAMPLE 100%

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-3
DATE BEGAN: 1/16/12
DRILLER: CLEARHEART DATE FINISHED: 1/16/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 760357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 39' ▽ INITIAL DEPTH TO GW: 38' ▽
DRILLING METHOD: HSA DRILLING EQUIP: 5', 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
		SAME AS ABOVE				SP		DRILL TO 30' BGS
-30	30	@ 31' STRONG OXIDIZED LAYER ½" THICK, DIPPING ~ 35°	SAME	DRY	MED DENSE		8, 11, 17, 19	SAMPLE 100%
-35	35	GRADATION INCREASE IN SILT CONTENT 32'-38'						DRILL TO 40' BGS ▽
-38	38	WELL GRADED SAND (5,95,0) FINE TO COARSE SAND, SUBROUNDED TO SUBANGULAR, GRAYISH BROWN.	10YR 5/2	WET	LOOSE	SW		▽
-40	40						3, 3, 5, 10	SAMPLE 100%
-43	43	GRAYWACKE/SANDSTONE BEDROCK @ 43' BGS					50, –, –	
-47	47	BOH = 43' 1445 1/16/12						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-4
DATE BEGAN: 1/17/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/17/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 44' ▽ **INITIAL DEPTH TO GW:** 43 ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** CORE BARREL, 5' **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
	0–1	GRAVEL/SAND/SILT FILL TO 4' BGS		DRY		GW	HAND AUGER TO 5' BGS
	4–5	SILTY SAND (20,80,0) FINE SAND, LIGHT YELLOWISH BROWN	10YR 6/4	DRY	LOOSE	SM	
	5–9	FINES REDUCING AT DEPTH					DRILL TO 10' BGS
	9–10	POORLY GRADED SAND (5,95,0)	SAME	DRY	LOOSE	SP	
	10–15	FINE SAND COLOR CHANGE TO PALE BROWN STRONG 1" THICK OXIDIZED LAYER AT 12' BGS, FEW ROUNDED GRAVEL UP TO 3/4" DIAMETER.	10YR 6/3	DRY	LOOSE		SAMPLE 100%
	15–16	WELL GRADED SAND (5,95,0) FINE TO COARSE SUBANG-SUBROUNDED SAND, LIGHT BRN GRAY.	10YR 6/2	DRY	LOOSE	SW	SAMPLE 100%
	16–17	POORLY GRADED SAND (5,95,0) FINE SAND	SAME	DRY	LOOSE	SP	
	17–18	WELL GRADED GRAVEL (0,5,95) FINE TO COARSE SAND, STRONGLY OXIDIZED, WELL ROUNDED	10YR 4/6	DRY	LOOSE	GW	
	18–20	POORLY GRADED SAND (1,95,0) FINE SAND LIGHT YELLOWISH BROWN	10YR 6/4	DRY	LOOSE	SP	
	20–23						SAMPLE 100%
	23–25	WELL GRADED SAND (1,99,0) FINE TO COARSE SUBANGULAR TO SUBROUNDED SAND, LIGHT BROWNISH GRAY, STRONG OXIDIZED LAYER AT 24' BGS	10YR 6/2	DRY	LOOSE	SW	

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-4
DATE BEGAN: 1/17/12
DRILLER: CLEARITERRY DATE FINISHED: 1/17/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 44' ▽ INITIAL DEPTH TO GW: 43 ▽
DRILLING METHOD: HSA DRILLING EQUIP: 5, 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	↓ BLOWS	WELL CONSTRUCTION
-25	25					SW		
-26	26	STRONG OXIDIZED LAYER @ 26' BGS						SAMPLE 100%
-27	27							
-28	28	POORLY GRADED SAND (1,99,0) FINE SAND, LIGHT YELLOWISH BROWN	10YR 6/4	DRY	LOOSE	SP		
-29	29							
-30	30							
-31	31	WELL GRADED SAND (1,99,0) FINE TO COARSE SUBANG-SUBROUNDED SAND. 1/2" THICK OXIDIZED LAYER AT 33' BGS.	SAME	DRY	LOOSE	SW		SAMPLE 100%
-32	32							
-33	33							
-34	34							
-35	35		SAME	DRY	LOOSE			
-36	36							SAMPLE 60%
-37	37	STRONG OXIDIZED LAYER AT 37' BGS, TRACE COARSE GRAVEL UP TO 3/4" DIA.						
-38	38							STOPPED @ 38' DRILL TO 40
-39	39							
-40	40		SAME	DRY	MED.-DENSE		9	2' SAMPLER
-41	41	STRONG OXIDIZED LAYER AT 41' BGS 3/4" THICK DIPPING ~20°					7	100%
-42	42						11	
-43	43	COARSENING AT DEPTH			▽		15	
-44	44				▽			
-45	45	45-47' STRONGLY OXIDIZED, TRACE ROUNDED GRAVEL, HEAVING AT 47'					9	100%
-46	46						13	SAMPLE
-47	47	POORLY GRADED SAND (1,99,0) FINE SAND, DARK YELLOWISH BROWN	10YR 4/6	WET	MED.-DENSE	SP	17	
-48	48						21	
-49	49							
-50	50							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-4
DATE BEGAN: 1/17/12
DRILLER: CLEARWATER **DATE FINISHED:** 1/17/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 44' ▽ **INITIAL DEPTH TO GW:** 43' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 5', 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
-50	50		SAME	WET	LOOSE	SP	HEAVING SAND
-51	51						
-52	52						
-53	53	DRILL 2' INTO BEDROCK					
-54	54						
-55	55	BUILD WELL TO 55' BGS					
-56	56						
-57	57						
-58	58	BOH=55' 1410 1/17/12					
-59	59						
-60	60						
-61	61						
-62	62						
-63	63						
-64	64						
-65	65						
-66	66						
-67	67						
-68	68						
-69	69						
-70	70						
-71	71						
-72	72						
-73	73						
-74	74						
-75	75						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-5

DATE BEGAN: 1/18/12 DATE FINISHED: 1/18/12 FIELD GEOLOGIST: R. CRAWFORD

DRILLER: CLEARHEART NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA

C57 License #: 780357

SURFACE ELEVATION: NA STABLE DEPTH TO GW: ~44 ▽ INITIAL DEPTH TO GW: 43' ▽

DRILLING METHOD: HSA DRILLING EQUIP: 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
	0–1	GRAVEL/SAND/SILT FILL TO 3' BGS		DRY	LOOSE	GW		HAND AUGER TO 5' BGS
	3–5	SILT WITH SAND (75,25,0) FINE SAND, DARK YELLOWISH BROWN NON-PLASTIC.	10YR 4/6	DRY	SOFT	ML		
	6–9	SILTY SAND (25,75,0) FINE SAND, LIGHT YELLOWISH BROWN	10YR 6/4	DRY	LOOSE	SM		DRILL TO 10'
	9–13	POORLY GRADED SAND (5,95,0) FINE SAND. MOTTLING/OXIDATION TO 13'	10YR 6/4	DRY	LOOSE	SP	5 5 7 9	SAMPLE 100%
	13–14	COARSE ROUNDED GRAVEL LENSE UP TO 1" DIA.				GW		
	14–15	POORLY GRADED SAND (5,95,0) FINE SAND.	SAME	DRY	LOOSE	SP		DRILL TO 20'
	18–20	COLOR CHANGE TO LIGHT BROWNISH GRAY.	10YR 6/2	DRY			5 8 11 13	SAMPLE 100%

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-5
DATE BEGAN: 1/18/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/18/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 44' ▽ **INITIAL DEPTH TO GW:** 43' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 5,2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
-25	25					SP	7 11 13 17	SAMPLE 100%
-26	26							
-27	27							
-28	28	ABRUPT CONTACT						
-29	29	SILT (95,5,0) FINE SAND	SAME	MOIST	FIRM-HARD	ML		
-30	30	NON-PLASTIC.					17 21	SAMPLE 90%
-31	31	POORLY GRADED SAND (5,95,0)	SAME	DRY	MED-DENSE	SP	23 27	
-32	32	FINE SAND.						
-33	33							
-34	34							
-35	35							DRILL TO 40' BGS
-36	36							
-37	37							
-38	38							
-39	39	4" SILT LENSE, NON-PLASTIC						
-40	40						7 8 11 15	
-41	41							
-42	42							
-43	43			WET				▽ ▼
-44	44							DRILL TO 55' BGS
-45	45							
-46	46							
-47	47							
-48	48							
-49	49							
-50	50							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-5
DATE BEGAN: 1/18/12
DRILLER: CLEARHEART DATE FINISHED: 1/18/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 44' ▽ INITIAL DEPTH TO GW: 43' ▽
DRILLING METHOD: HSA DRILLING EQUIP: 5', 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	↓ Blows	WELL CONSTRUCTION
-50	50					SP		
-51	51	DRILL RIG RATTLED AT 52'						
-52	52	WELL GRADED SAND (5,95,0)	SAME	WET	LOOSE	SW		
-53	53	FINE TO COARSE SUBANG -						
-54	54	SUBROUNDED SAND						
-55	55						7 8 7 11	SAMPLE 100%
-56	56							
-57	57							
-58	58							
-59	59	BEDROCK					50 = = =	FOR 2"
-60	60							
-61	61	BOH = 58' 1105 1/18/12						
-62	62							
-63	63							
-64	64							
-65	65							
-66	66							
-67	67							
-68	68							
-69	69							
-70	70							
-71	71							
-72	72							
-73	73							
-74	74							
-75	75							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-6

DATE BEGAN: 1/19/12

DRILLER: CLEARHEART **DATE FINISHED:** 1/19/12 **FIELD GEOLOGIST:** R. CRAWFORD

C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** NONE **▽ INITIAL DEPTH TO GW:** NONE ▽

DRILLING METHOD: HSA **DRILLING EQUIP:** 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	↓ BLOWS	WELL CONSTRUCTION
	0	ASPHALT 3"						
	1	GRAVEL/SAND/SILT FILL TO 3'		DRY	LOOSE	GW		HAND AUGER TO 5'
	3	SILT WITH SAND (75,25,0) FINE SAND, LIGHT YELLOWISH BROWN, NON-PLASTIC.	10YR 4/6	DRY	LOOSE	ML		
	5	SILTY SAND (25,75,0) FINE SAND.	SAME	DRY	LOOSE	SM		DRILL TO 10'
	9	POORLY GRADED SAND (5,95,0) FINE SAND, STRONGLY OXIDIZED 10-12'	SAME	DRY	LOOSE	SP	5 7 6 10	SAMPLE 100%
	15	RIG RATTLED, GRAVEL IN CUTTINGS						DRILL TO 20'
	18	WELL GRADED GRAVEL (5,10,85) FINE TO COARSE SAND, WELL ROUNDED FINE TO COARSE GRAVEL UP TO 1" DIA.	SAME	DRY	LOOSE	GW		
	20	WELL GRADED SAND (5,95,0) FINE TO COARSE SUBANG-SUBROUNDED SAND, LIGHT BROWNISH GRAY.	10YR 6/2	DRY	LOOSE	SW	5 7 7 9	SAMPLE 100%

SOIL BORING AND WELL LOG

PROJECT NO: 010631/005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-6
DATE BEGAN: 1/19/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/19/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** NONE ▽ **INITIAL DEPTH TO GW:** NONE ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 5', 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	↓ BLOWS	WELL CONSTRUCTION
-25	25					SW		DRILL TO 30' BGS
-26	26							
-27	27							
-28	28	POORLY GRADED SAND (5,95,0)	10YR 6/6	DRY	MED-DENSE	SP		
-29	29	FINE SAND, LIGHT YELLOWISH BROWN.						
-30	30		SAME	DRY	SAME		11 13 17 21	SAMPLE 100%
-31	31							
-32	32							
-33	33							
-34	34							
-35	35							DRILL TO 40' BGS
-36	36							
-37	37							
-38	38							
-39	39							
-40	40						13 15 17 22	SAMPLE 100%
-41	41							
-42	42							
-43	43							
-44	44							
-45	45							DRILL TO 50' BGS
-46	46	RIG RATTLED						
-47	47	WELL GRADED SAND (5,95,0)	10YR 6/6	MOIST	LOOSE	SW		
-48	48	FINE TO COARSE SUBANG -						
-49	49	SUBROUNDED SAND, BROWNISH YELLOW						
-50	50							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-6
DATE BEGAN: 1/19/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/19/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** NONE ▽ **INITIAL DEPTH TO GW:** NONE ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 5', 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
-50	50							
-51	51	STRONG OXIDIZED LAYER @ 51'	SAME	MOIST	LOOSE		10 11 11 13	SAMPLE 90%
-52	52							
-53	53							
-54	54							
-55	55							DRILL TO 60'
-56	56							
-57	57							
-58	58	HIGHLY SHEARED SILTSTONE BEDROCK						
-59	59							
-60	60							
-61	61	BOH = 60' 1540 1/19/12						
-62	62							
-63	63							
-64	64	NO GROUNDWATER ENCOUNTERED						
-65	65	POSSIBLY @ 46' BGS						
-66	66							
-67	67							
-68	68							
-69	69							
-70	70							
-71	71							
-72	72							
-73	73							
-74	74							
-75	75							

SOIL BORING AND WELL LOG

PROJECT NO: 010631005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-7
DATE BEGAN: 1/9/12
DRILLER: CLEARHEART DATE FINISHED: 1/10/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: ~40' ▽ INITIAL DEPTH TO GW: 39' ▽
DRILLING METHOD: HSA DRILLING EQUIP: 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	Blows	WELL CONSTRUCTION
		↓ GRASS						
0	0	GRAVEL/SAND/SILT FILL TO 3'		MOIST	LOOSE	GW		HAND AUGER TO 5'
-3	3	SANDY SILT (55,45,0) FINE SAND, DARK YELLOWISH BROWN, NON-PLASTIC.	10YR 4/6	MOIST	FIRM	ML		
-5	5	SILTY SAND (15,85,0) FINE SAND, LIGHT YELLOWISH BROWN.	10YR 6/4	MOIST	LOOSE	SM	3 3 4 6	SAMPLE 100%
-9	9	POORLY GRADED SAND WITH SILT (10,90,0) FINE SAND, STRONG 1/2" THICK OXIDIZED INTERVALS OF SAND.	SAME	DRY	MED.-DENSE	SP-SM	7 12 14 18	SAMPLE 100%
-14	14	POORLY GRADED SAND (5,95,0) FINE SAND, PALE BROWN 6" FINE GRAVEL LENSE, UP TO 3/4" DIA., ROUNDED.	10YR 6/3	DRY	MED.-DENSE	SP	13 15 19 22	SAMPLE 100%
-19	19	WELL GRADED SAND (1,99,0) FINE TO COARSE SAND, SUBANG-SUBROUNDED, GRAYISH BROWN	10YR 5/2	DRY	LOOSE	SW	6 7 20 12	SAMPLE 100%
-24	24	4" STIFF SILT LAYER						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-7

DATE BEGAN: 1/9/12 **DATE FINISHED:** 1/10/12 **FIELD GEOLOGIST:** R. CRAWFORD

DRILLER: CLEARHEART **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

C57 License #: 780357

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 40' **INITIAL DEPTH TO GW:** 39'

DRILLING METHOD: HSA **DRILLING EQUIP:** 5', 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	Blows	WELL CONSTRUCTION
-25	25	WELL GRADED SAND (1,99,0) FINE TO COARSE SAND, SUBANG - SUBROUNDED, GRAYISH BROWN.	10YR 5/2	DRY	LOOSE	SW	10 17 9 17	SAMPLE 100%
-26	26							
-27	27	SANDY SILT (70,30,0) FINE TO COARSE SAND, DARK YELLOWISH BROWN, NON-PLASTIC	10YR 4/6	MOIST	HARD	ML		SILT IN CUTTINGS
-28	28							
-29	29							
-30	30	WELL GRADED SAND (5,95,0) FINE TO COARSE SAND, SUBANG-SUBROUND, DARK GRAYISH BROWN, TRACE FINE ROUNDED GRAVEL < 1/4" DIA.	10YR 4/2	DRY	MED-DENSE	SW	9 13 17 21	SAMPLE 80%
-31	31							
-32	32							
-33	33	SANDY SILT (60,35,5) FINE TO COARSE SAND, TRACE ANGULAR GRAVEL, NON-PLASTIC	10YR 5/4	DRY	HARD	ML		
-34	34							
-35	35	POORLY GRADED SAND (5,95,0) FINE SAND, BROWN. STRONG OXIDIZED LAYER AT 36'.	10YR 5/3	DRY	LOOSE	SP	12 16 19 21	SAMPLE 100%
-36	36							
-37	37							
-38	38							
-39	39			WET				▽
-40	40	SAME AS ABOVE			LOOSE		4 7 7 10	SAMPLE 100% ▼
-41	41							
-42	42							
-43	43							
-44	44							
-45	45	47.5-49.5' SILICIOUS CEMENTED SAND			DENSE		15 - - - -	FOR 4" 20% SAMPLE
-46	46							
-47	47							
-48	48							
-49	49							
-50	50							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-7
DATE BEGAN: 1/9/12
DRILLER: CLEARHEART DATE FINISHED: 1/10/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 40' ▼ INITIAL DEPTH TO GW: 39' ▽
DRILLING METHOD: HSA DRILLING EQUIP: 5', 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
-50	50					SP	DRILL TO 66.5' BGS
-51	51						
-52	52						
-53	53	53.5-57' SILICIOS CEMENTED SAND					
-54	54						
-55	55						
-56	56						
-57	57						
-58	58						
-59	59						
-60	60						
-61	61	WEATHERED BEDROCK					0% SAMPLE
-62	62	HARD SILTSTONE BEDROCK					
-63	63						DRILL 3' INTO BEDROCK
-64	64						
-65	65						
-66	66	BOH = 66.5' 0905 1/10/12					
-67	67						
-68	68						
-69	69						
-70	70						
-71	71						
-72	72						
-73	73						
-74	74						
-75	75						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASRS **BORING NUMBER:** SB-8

DATE BEGAN: 1/11/12

DRILLER: CLEARHEART **DATE FINISHED:** 1/11/12 **FIELD GEOLOGIST:** R. CRAWFORD

C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

SURFACE ELEVATION: **STABLE DEPTH TO GW:** 45.5' ▽ **INITIAL DEPTH TO GW:** 45.5' ▽

DRILLING METHOD: HSA **DRILLING EQUIP:** 5' CORE BARREL **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
		↓ GRASS					
0	0	SILT (99,1,0) FINE SAND, DARK BROWN, LOW PLASTICITY.	10YR 3/3	WET	SOFT	ML	HAND AUGER TO 5' BGS
-1	1	SANDY SILT (60,40,0) FINE SAND DARK YELLOWISH BROWN NON-PLASTIC	10YR 4/6	MOIST	FIRM	ML	
-2	2	SILTY SAND (20,80,0) FINE SAND LIGHT YELLOWISH BROWN.	10YR 6/4	MOIST	LOOSE	SM	
-3	3						
-4	4						
-5	5	½" THICK ALTERNATING LAYERS OF ORANGE, YELLOW, BROWN OXIDES, FROM 6-8' BGS					
-6	6						
-7	7						50% SAMPLE
-8	8	WELL GRADED SAND WITH SILT (10,90,0) FINE TO MEDIUM SAND, SUBROUNDED TO SUBANGULAR, LIGHT YELLOWISH BROWN	10YR 6/4	MOIST	LOOSE	SW-SM	
-9	9						
-10	10	ABRUPT OVERLYING CONTACT. COLOR CHANGE AT 11' BGS YELLOWISH BROWN.	10YR 5/6	DRY	LOOSE		100% SAMPLE
-11	11						
-12	12	POORLY GRADED SAND (5,95,0) FINE SAND, PALE BROWN.	10YR 6/3	DRY	LOOSE	SP	
-13	13						
-14	14						
-15	15						100% SAMPLE
-16	16	TRACE COARSE SAND, COARSENING AT DEPTH GRADATIONAL CONTACT					
-17	17						
-18	18						
-19	19	WELL GRADED SAND (1,99,0) FINE TO COARSE SAND, SUBROUNDED TO SUBANGULAR, LIGHT GRAYISH BROWN.	10YR 6/2	DRY	LOOSE	SW	
-20	20						100% SAMPLE
-21	21						
-22	22						
-23	23						
-24	24						
-25	25						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-8

DATE BEGAN: 1/11/12 DATE FINISHED: 1/11/12 FIELD GEOLOGIST: R. CRAWFORD

DRILLER: CLEARHEART NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA

C57 License #: 780357

SURFACE ELEVATION: NA STABLE DEPTH TO GW: 45.5' ▽ INITIAL DEPTH TO GW: 45.5' ▽

DRILLING METHOD: HSA DRILLING EQUIP: 5', 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	Blows	WELL CONSTRUCTION
-25	25	SAME AS ABOVE		DRY	LOOSE	SW		100% SAMPLE
-26	26							
-27	27	STRONG 3/4" THICK OXIDIZED LAYER						
-28	28							
-29	29	FEW COARSE GRAVEL, UP TO 2" DIA.						
-30	30							
-31	31	POORLY GRADED SAND (1,99,0)						90% SAMPLE
-32	32	FINE SAND, LIGHT GRAYISH BROWN.	10YR 6/2	DRY	MED-DENSE	SP		
-33	33							
-34	34							
-35	35	COLOR CHANGE TO GRAYISH BROWN	10YR 5/2				11 14 14 15	2' SAMPLER 100%
-36	36							
-37	37							
-38	38							
-39	39							
-40	40							
-41	41	WELL GRADED SAND (1,99,0)	10YR 5/2	MOIST	MED-DENSE	SW	13 17 39 31	100% SAMPLE
-42	42	FINE TO MEDIUM SAND, GRAYISH BROWN.						
-43	43							
-44	44							
-45	45			WET	DENSE	▽	15 14 15 32	100% SAMPLE
-46	46							
-47	47							
-48	48	WEATHERED BEDROCK						
-49	49	MUDSTONE BEDROCK 50' BGS						
-50	50						52	

BOH = 50.5 1/11/12 1305

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-9

DATE BEGAN: 1/12/12

DRILLER: CLEARHEART **DATE FINISHED:** 1/12/12 **FIELD GEOLOGIST:** R. CRAWFORD

C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** ~38' ▽ **INITIAL DEPTH TO GW:** 39' ▽

DRILLING METHOD: HSA **DRILLING EQUIP:** 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
0	0	✓ GRASS GRAVEL/SAND/SILT FILL				GW		HAND AUGER, TO 5' BGS
-1	1							
-2	2	SILT WITH SAND (85,15,0) FINE SAND DARK YELLOWISH BROWN, NON-PLASTIC.	10YR 4/6	MOIST	FIRM	ML		
-3	3	SILTY SAND (20,80,0) FINE SAND LIGHT YELLOWISH BROWN	10YR 6/4	MOIST	LOOSE	SM		
-4	4							
-5	5	MOTTLING AT 5'-12'						
-6	6	POORLY GRADED SAND WITH SILT (10,90,0) FINE SAND, LIGHT YELLOWISH BROWN				SP		DRILL TO 10' BGS
-7	7							
-8	8							
-9	9							
-10	10	WOODY DEBRIS/ROOTS					2 3 4	SAMPLE 80%
-11	11							
-12	12							
-13	13							
-14	14							
-15	15							DRILL TO 20' BGS
-16	16							
-17	17	RIG RATTLED AT 17.5'						
-18	18	WELL GRADED GRAVEL WITH SILT AND SAND (10,35,55) WELL ROUNDED FINE TO COARSE GRAVEL	10YR 6/2	DRY	LOOSE	GW-GM		
-19	19							
-20	20	UP TO 1" DIA., FINE TO COARSE SAND, LIGHT BROWNISH GRAY.					4 6 11 12	SAMPLE 80%
-21	21		10YR 2/2			PALEOSOL		
-22	22	WELL GRADED SAND (5,95,0) FINE TO COARSE SAND, LIGHT BROWNISH GRAY.	10YR 6/2	DRY	LOOSE	SW		
-23	23	ABRUPT OVERLYING CONTACT 2" THICK, VERY DARK BROWN ORGANIC LAYER,						
-24	24							
-25	25	SAND SUBROUNDED TO SUBANGULAR.						

SOIL BORING AND WELL LOG

PROJECT NO: 010631005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-9
DATE BEGAN: 1/12/12
DRILLER: CLEARHEART DATE FINISHED: 1/12/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780352 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 38 ▼ INITIAL DEPTH TO GW: 39 ▽
DRILLING METHOD: HSA DRILLING EQUIP: 5', 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl) / DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	Blows	WELL CONSTRUCTION
-25 25	CONT. SW				SW		DRILL TO 30' BGS
-26 26							
-27 27							
-28 28							
-29 29							
-30 30			DRY	LOOSE		7 7 8 10	
-31 31							
-32 32							
-33 33							
-34 34	SAME AS ABOVE, PARTIALLY						
-35 35	CEMENTED (SILICIOUS?) ZONE	SAME	DRY	VERY DENSE		50	10% SAMPLE
-36 36	35'-40.5' BGS.						
-37 37							
-38 38				▼			
-39 39			WET	▽			
-40 40							
-41 41	40.5 SILTSTONE BEDROCK						
-42 42	1/12/12 BOH=40.5'						
-43 43	1130						
-44 44							
-45 45							
-46 46							
-47 47							
-48 48							
-49 49							
-50 50							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-10

DATE BEGAN: 1/11/12

DRILLER: CLEARHEART **DATE FINISHED:** 1/12/12 **FIELD GEOLOGIST:** R. CRAWFORD

C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 40.25' ▽ **INITIAL DEPTH TO GW:** 38' ▽

DRILLING METHOD: HSA **DRILLING EQUIP:** 2' SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
		✓ GRASS						
0	0	GRAVEL/SAND/SILT FILL		MOIST	LOOSE	GW		HAND AUGER, TO 5' BGS
-1	1							
-2	2	SILT WITH SAND (85,15,0) FINE SAND, NON-PLASTIC, DARK YELLOW BROWN	10YR 4/6	MOIST	FIRM	ML		
-3	3	GRADATIONAL CONTACT						
-4	4	SILTY SAND (20,80,0) FINE SAND	10YR 6/4	MOIST	LOOSE	SM		
-5	5	LIGHT YELLOWISH BROWN						
-6	6	POORLY GRADED SAND WITH SILT (10,90,0) FINE SAND, LIGHT YELLOWISH BROWN, ORANGE OXIDIZED LAYER AND MOTTLING 7-12', AT 12' ABRUPT CHANGE IN COLOR (DARK YELLOWISH				SP-SM	3 3 4 5	SAMPLE 100%
-7	7							
-8	8		10YR 4/6	DRY	LOOSE			
-9	9							
-10	10	BROWN) MARKED BY STRONG 1/2" OXIDIZED LAYER AT 12'.					4 4 4 5	SAMPLE 100%
-11	11							
-12	12	POORLY GRADED SAND (5,95,0) FINE SAND, PALE BROWN.	10YR 4/6 10YR 6/3	DRY DRY	LOOSE LOOSE	SP		
-13	13							
-14	14							
-15	15							DRILL TO 20' BGS
-16	16							
-17	17							
-18	18							
-19	19							
-20	20							
-21	21	RIG RATTLED AT 23' DISCRETE CONTACT					10 12 17 16	SAMPLE 100%
-22	22							
-23	23	SILT (99,1,0) FINE SAND, GRAYISH BROWN, LOW PLASTICITY.	10YR 5/2	DRY		ML		
-24	24							
-25	25							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-10

DATE BEGAN: 1/11/12

DRILLER: CLEARHEART DATE FINISHED: 1/12/12 FIELD GEOLOGIST: R. CRAWFORD

C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA

SURFACE ELEVATION: NA STABLE DEPTH TO GW: 40.25' ▽ INITIAL DEPTH TO GW: 38' ▽

DRILLING METHOD: HSA DRILLING EQUIP: 5', 2' SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	Blows	WELL CONSTRUCTION
-25	25	DISCRET CONTACT AT 26'				ML	7	SAMPLE
-26	26	POORLY GRADED SAND (1,99,0)	10YR 6/2	DRY	MED. DENSE	SP	13	80%
-27	27	FINE SAND, LIGHT BROWNISH					17	
-28	28	GRAY.					21	
-29	29							
-30	30						11	SAMPLE
-31	31	STRONG OXIDIZED LAYER AT 31'					15	90%
-32	32	1/2" THICK.					21	
-33	33						32	
-34	34							
-35	35							DRILL
-36	36							TO
-37	37							40'
-38	38	SAND COARSENING		WET		▽		BGS
-39	39							
-40	40	GRADATIONAL CONTACT				▽		
-41	41	WELL GRADED SAND (5,95,0)	SAME	WET	MED-DENSE	SW	7	
-42	42	FINE TO COARSE SAND, SUB-					11	
-43	43	ROUNDED TO SUB-ANGULAR.					14	
-44	44	RIG RATTLED HARD AT 43'					21	50+
-45	45	SANDSTONE/GRAYWACKE BEDROCK						
-46	46	BOH = 43.5						
-47	47	1/12/12						
-48	48							
-49	49							
-50	50							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-11
DATE BEGAN: 1/19/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/19/12 **FIELD GEOLOGIST:** R CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 49' **▽ INITIAL DEPTH TO GW:** 49' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 2' CORE SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl) / DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	↓ BLOWS	WELL CONSTRUCTION
0	ASPHALT 3"						
-1	GRAVEL/SAND/SILT FILL TO 3' BGS				GW		HAND AUGER TO 5' BGS
-2							
-3	SILTY SAND (15, 85, 0) FINE SAND, LIGHT YELLOWISH BROWN.	10YR 6/4	DRY	LOOSE	SM		
-4							
-5							DRILL TO 10' BGS
-6							
-7							
-8							
-9	POORLY GRADED SAND (5, 95, 0)	10YR 6/4	DRY	LOOSE	SP		
-10	FINE SAND, LIGHT YELLOWISH BROWN.					5	SAMPLE 100%
-11	STRONG OXIDIZED 1/2" LAYERS @ 10.5' & 11.5'					7	
-12						7	
-13						11	
-14	WELL GRADED GRAVEL WITH SAND (5, 15, 85) FINE TO COARSE SAND, SUBROUNDED	SAME	DRY	LOOSE	GW		
-15	GRAVEL UP TO 1" DIAMETER	SAME	DRY	LOOSE	SP		DRILL TO 20' BGS
-16	POORLY GRADED SAND (5, 95, 0) FINE SAND.						
-17							
-18	6" SILT LAYER				ML		
-19	WELL GRADED SAND (5, 95, 0)	10YR 6/3	DRY	LOOSE-MED-DENSE	SP SW		
-20	FINE TO COARSE SUBROUNDED TO SUBANGULAR SAND, PALE BROWN.					7	SAMPLE 100%
-21						11	
-22						13	
-23						19	
-24							
-25							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-11
DATE BEGAN: 1/19/12
DRILLER: CLEARHEART DATE FINISHED: 1/19/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 49' ▽ INITIAL DEPTH TO GW: 49' ▽
DRILLING METHOD: HSA DRILLING EQUIP: 2' CORE SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
-25	25	CONT. SW	SAME	DRY		SW	DRILL TO 30' BGS
-26	26						
-27	27						
-28	28						
-29	29						
-30	30						7 9 11 10 SAMPLE 100%
-31	31	SAND FINING AT DEPTH					
-32	32						
-33	33						
-34	34						
-35	35						DRILL TO 40' BGS
-36	36						
-37	37						
-38	38	POORLY GRADED SAND (5,95,0) FINE SAND, LIGHT YELLOWISH BROWN				SP	* RIG RATTLED @ 38' BGS, SO ASSUME STRAT CHANGE
-39	39						
-40	40						12 17 19 23
-41	41						
-42	42						
-43	43						
-44	44						
-45	45						DRILL TO 50' BGS
-46	46						
-47	47						
-48	48						
-49	49					▽	
-50	50						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-11
DATE BEGAN: 1/19/12
DRILLER: CLEARHEART DATE FINISHED: 1/19/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 49' ▽ INITIAL DEPTH TO GW: 49' ▽
DRILLING METHOD: HSA DRILLING EQUIP: 2' CORE SAMPLER TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
-50	50	CONT. SP	SAME	DRY	MED DENSE	SP	13 15 21 26	
-51	51							
-52	52							
-53	53							
-54	54							
-55	55						DRILL TO 60' BGS	
-56	56							
-57	57							
-58	58	WELL GRADED SAND (5,95,0) FINE TO COARSE SUBROUNDED TO SUBANGULAR SAND, BROWN. STRONG OXIDIZED LAYER FROM 59-61' AS BRIGHT ORANGE/RED.	10YR 5/3	WET	LOOSE	SW		
-59	59							
-60	60						10 11 14 17	
-61	61							
-62	62							
-63	63							
-64	64	BOH = 63' 1/19/12 1105 SANDSTONE				BEDROCK		
-65	65							
-66	66							
-67	67							
-68	68							
-69	69							
-70	70							
-71	71							
-72	72							
-73	73							
-74	74							
-75	75							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-12
DATE BEGAN: 1/10/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/10/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 48' ▽ **INITIAL DEPTH TO GW:** 48' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 2' CORE SAMPLER 8" AUGERS **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
	0	GRAVEL FILL TO 2' BGS				GW		HAND AUGER TO 5' BGS
	2	SANDY SILT (60,40,0) FINE SAND, LOW PLASTICITY, DARK YELLOWISH BROWN.	10YR 4/6	MOIST	FIRM	ML		
	5	SILTY SAND (15,85,0) FINE SAND LIGHT YELLOWISH BROWN.	10YR 6/4	MOIST	LOOSE	SM		DRILL TO 10' BGS
	9	POORLY GRADED SAND (5,95,0) FINE SAND, LIGHT YELLOWISH BROWN.	10YR 6/4	MOIST	LOOSE	SP	11 6 9 13	SAMPLE 90%
	13	WELL GRADED GRAVEL WITH SAND (5,25,70) FINE TO COARSE SAND, FINE ROUNDED GRAVEL UP TO 3/4", GRAY.	10YR 6/1	MOIST	LOOSE	GW		
	15	POORLY GRADED SAND (5,95,0) FINE SAND, PALE BROWN.	10YR 6/3	DRY	FIRM	SP		DRILL TO 20' BGS
	17	SILT WITH SAND (80,20,0) LOW PLASTICITY, PALE BROWN				ML		
	19	WELL GRADED SAND (1,99,0) FINE TO MEDIUM, SUBROUND TO SUBANGULAR SAND, FEW COARSE SAND, PALE BROWN	10YR 6/3	DRY	LOOSE	SW	6 9 10 12	SAMPLE 60%
	23	COARSENING AT DEPTH						

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-12
DATE BEGAN: 1/10/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/10/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 48' ▽ **INITIAL DEPTH TO GW:** 48' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 2' CORE SAMPLER 8" AUGERS **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
	25	CONT. SW				SW		DRILL TO 30' BGS
	29	FINE TO COARSE SAND	SAME	DRY	MED-DENSE			
	30						10 9 9 12	SAMPLE 100%
	35		SAME	SAME	SAME		6 9 13 15	SAMPLE 100%
	40		SAME	SAME	SAME			DRILL TO 45' BGS
	43	POORLY GRADED SAND (1,99,0) FINE SAND, BROWN. ORANGE	10YR5/3	DRY	MED. DENSE	SP		
	45	MOTTLING 45-47'. STRONG OXIDIZED LAYER AT 46.5' (IDENTICLE TO THAT OF SB-7)					14 19 21 32	SAMPLE 100%
	47			WET		▽		

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ABBS **BORING NUMBER:** SB-12
DATE BEGAN: 1/10/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/10/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 48' ▽ **INITIAL DEPTH TO GW:** 48' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 2' CORE SAMPLER 8" AUGERS **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	← BLOWS	WELL CONSTRUCTION
-50	50	CONT. SP	SAME	WET	SAME	SP		DRILL TO 55' BGS
-51	51							
-52	52							
-53	53							
-54	54	WELL GRADED SAND (5,95,0)	10YR 5/3	WET	DENSE TO VERY DENSE	SW		
-55	55	FINE TO COARSE, SUBROUNDED TO SUBANGULAR SAND, BROWN.					15 29 30 32	
-56	56							
-57	57							
-58	58							
-59	59							
-60	60						10 11 13	
-61	61							
-62	62	SANDSTONE BEDROCK DISCRETE CONTACT WITH RED OXIDATION						
-63	63							
-64	64							
-65	65	BOH = 61.5' BGS 1/10/12 1530						
-66	66							
-67	67							
-68	68							
-69	69							
-70	70							
-71	71							
-72	72							
-73	73							
-74	74							
-75	75							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-13
DATE BEGAN: 1/20/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/20/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 30' ▽ **INITIAL DEPTH TO GW:** 30' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 2' CORE SAMPLER 8" AUGERS **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS ↓	WELL CONSTRUCTION
	0	ASPHALT 4"						
	1	GRAVEL/SAND/SILT FILL TO 4.5' BGS				GW		HAND AUGER TO 5' BGS
	5	POORLY GRADED SAND (1,99,0) FINE SAND, LIGHT BROWNISH GRAY	10YR 6/2	DRY	LOOSE	SP		DRILL TO 10' BGS
	10	ORANGE MOTTLING 10.5-11.5' BGS	SAME	SAME	SAME		5 7 11 17	SAMPLE 100%
	15		SAME	SAME	SAME			DRILL TO 20' BGS
	20	COLOR CHANGE TO LIGHT YELLOWISH BROWN	10YR 6/4	MOIST	LOOSE		7 7 10 15	SAMPLE 100%
	25							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-13
DATE BEGAN: 1/20/12
DRILLER: CLEARHEART DATE FINISHED: 1/20/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 30' ▽ INITIAL DEPTH TO GW: 30' ▽
DRILLING METHOD: HSA DRILLING EQUIP: 2' CORE SAMPLER 8" AUGERS TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
-25	25	CONT. SP				SP		DRILL TO 30' BGS
-26	26							
-27	27	WELL GRADED SAND WITH SILT (10,90,0) FINE TO COARSE, SUB-ROUNDED TO SUBANGULAR SAND, DARK YELLOWISH BROWN.	10YR 4/6	MOIST	LOOSE	SW-SM		
-28	28							
-29	29							
-30	30	BLACK OXIDIZED 1/4" LAYER AT 31' BGS					7 11 13 17	SAMPLE 100%
-31	31							
-32	32							
-33	33							
-34	34							
-35	35		SAME	WET	LOOSE			DRILL TO 39'
-36	36							
-37	37							
-38	38							
-39	39						50	
-40	40	HIGHLY SHEARED SILTSTONE BEDROCK @ 39.5'						
-41	41							
-42	42							
-43	43	BOH = 39.5' 1/20/12 1045						
-44	44							
-45	45							
-46	46							
-47	47							
-48	48							
-49	49							
-50	50							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-14
DATE BEGAN: 1/23/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/23/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** **EASTING/LONGITUDE:**

SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** NA **INITIAL DEPTH TO GW:** NA
DRILLING METHOD: HSA **DRILLING EQUIP:** 2' CORE SAMPLER 8" AUGERS **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	← BLOWS	WELL CONSTRUCTION
	0	ASPHALT 4"						
	1	GRAVEL/SAND/SILT FILL TO 3.5' BGS				GW		HAND AUGER TO 5' BGS
	2							
	3							
	4	WELL GRADED SAND (1,99,0) FINE TO COARSE SUBROUNDED TO SUBANGULAR SAND, PALE BROWN.	10YR 6/3	DRY	LOOSE	SW		
	5							DRILL TO 10
	6							
	7							
	8							
	9			MOIST				
	10	HIGHLY SHEARED SILTSTONE BED ROCK		DRY			7 21 27 30	SAMPLE 100%
	11							
	12							
	13							
	14							
	15							DRILL TO 20' BGS
	16							
	17							
	18							
	19							
	20						11 17 22 24	
	21							
	22							
	23	BOH = 22' 1/23/12 1515						
	24							
	25							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-15
DATE BEGAN: 1/23/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/23/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** NA **INITIAL DEPTH TO GW:** NA
DRILLING METHOD: HSA **DRILLING EQUIP:** 2' CORE SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
0	0	ASPHALT 4"						
-1	1	GRAVEL/SAND/SILT FILL TO 3.5' BGS.				GW		HAND AUGER TO 5' BGS
-2	2							
-3	3							
-4	4	SILT WITH SAND (75,25,0) FINE SAND, LOW PLASTICITY, YELLOWISH BROWN.	10YR 5/6	DRY	SOFT	ML		
-5	5							
-6	6	SILTY SAND (15,85,0) FINE SAND, LIGHT YELLOWISH BROWN.	10YR 6/4	DRY	LOOSE	SM		DRILL TO 10' BGS
-7	7							
-8	8							
-9	9							
-10	10							
-11	11	ORANGE MOTTLING AT 11' BGS	SAME	DRY	LOOSE		2 2 3 5	SAMPLE 100%
-12	12							
-13	13	FINE, ROUNDED, GRAVEL LAYER (2")						
-14	14							
-15	15							DRILL TO 20' BGS
-16	16							
-17	17							
-18	18							
-19	19							
-20	20	COLOR CHANGE TO PALE BROWN	10YR 6/3	DRY	LOOSE		4 5 5 6	
-21	21							
-22	22							
-23	23	SANDSTONE BEDROCK				BEDROCK	50 BLOWS FOR 5"	
-24	24	BOH = 23'						
-25	25							

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 **PROJECT NAME:** TRINIDAD ASBS **BORING NUMBER:** SB-16
DATE BEGAN: 1/18/12
DRILLER: CLEARHEART **DATE FINISHED:** 1/18/12 **FIELD GEOLOGIST:** R. CRAWFORD
C57 License #: 780357 **NORTHING/LATITUDE:** NA **EASTING/LONGITUDE:** NA
SURFACE ELEVATION: NA **STABLE DEPTH TO GW:** 15.5' ▽ **INITIAL DEPTH TO GW:** 15.5' ▽
DRILLING METHOD: HSA **DRILLING EQUIP:** 5' CORE BARREL, 2' CORE SAMPLER **TOC ELEVATION:** NA

ELEVATION (ft.-msl) / DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	BLOWS	WELL CONSTRUCTION
0–1	ASPHALT 3" GRAVEL/SAND/SILT FILL TO 3' BGS	–	MOIST	LOOSE	GW		HAND AUGER TO 5' BGS
1–5	WELL GRADED SAND (1,99,0) FINE TO MEDIUM SAND, LIGHT BROWNISH GRAY.	10YR 6/2	MOIST	LOOSE	SW		DRILL TO 10' BGS
5–10							
10–13	SILT (99,1,0) TRACE FINE SAND, LOW PLASTICITY, DARK BROWN. DISCRETE CONTACT WITH OVERLYING SAND, CHARCOAL.	10YR 3/3	MOIST	SOFT-FIRM	ML	4 5 5 6 5 7 9 11	SAMPLE 100% FOR 2'
13–15	POORLY GRADED SAND (1,99,0) FINE SAND, LIGHT BROWNISH GRAY.	10YR 6/2	MOIST	LOOSE	SP		SAMPLE 100% FOR 2'
15–20			WET		▽		DRILL TO 20' BGS
20–25	WELL GRADED SAND (5,95,0) FINE TO COARSE, SUBROUNDED TO SUBANGULAR SAND, LIGHT BROWNISH GRAY MATRIX SILT IS BRIGHT ORANGE	10YR 6/2	WET	LOOSE	SW	5 6 5 7	SAMPLE 100%

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-16
DATE BEGAN: 1/18/12
DRILLER: CLEARHEART DATE FINISHED: 1/18/12 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 15.5 ▽ INITIAL DEPTH TO GW: 15.5 ▽
DRILLING METHOD: HSA DRILLING EQUIP: 2' AND 5' CORE SAMPLERS TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
	25	CONT. SW	SAME	SAME	SAME	SW	DRILL TO 29' BGS
	29	SANDSTONE BEDROCK					
	30	BOH = 29' 1/18/12 1415					

Drafted ~~1/9/2012~~ 1/18/12

 WINZLER & KELLY

SOIL BORING AND WELL LOG

PROJECT NO: 0106311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-17
DATE BEGAN: 1/24/2012
DRILLER: CLEARHEART DATE FINISHED: 2/1/2012 FIELD GEOLOGIST: R. CRAWFORD
C57 License #: 780357 NORTHING/LATITUDE: NA EASTING/LONGITUDE: NA
SURFACE ELEVATION: NA STABLE DEPTH TO GW: 45.9' bgs ▼ INITIAL DEPTH TO GW: 45' bgs ▽
DRILLING METHOD: HSA DRILLING EQUIP: CORE BARREL, 5' TOC ELEVATION: NA

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
		ASPHALT 3"					
	0	GRAVEL/SAND/SILT FILL TO 3"				GW	HAND AUGER TO 5' BGS
	1						
	2						
	3	SANDY SILT (50,50,0) FINE GRAIN SAND, LIGHT YELLOWISH BROWN, NON PLASTIC	10YR 6/4	MOIST	FIRM	ML	
	4						
	5	SILTY SAND (20,80,0) FINE GRAIN SAND, LIGHT YELLOWISH BROWN	10YR 6/4	DRY	LOOSE	SM	DRILL TO 10' BGS
	6						
	7						
	8						
	9						
	10						SAMPLE 100%
	11						
	12	POORLY GRADED SAND (5, 95,0) FINE GRAIN SAND, LIGHT BROWN GRAY	10YR 6/2	DRY	LOOSE	SP	
	13						
	14	MOTTLING (DARK REDDISH BROWN, 5YR 3/3) AT 14' bgs					
	15						SAMPLE 100%
	16						
	17						
	18						
	19	MOTTLING (DARK REDDISH BROWN, 5YR 3/3) AT 19' bgs					
	20						
	21						SAMPLE 100%
	22						
	23	COARSE SAND (SEMI ROUND TO SEMI ANGULAR) (APPROX. 4" THICK), OXIDIZED					
	24	DRILL RIG BROKE AT APPROX. 25' bgs					
	25						

SOIL BORING AND WELL LOG

PROJECT NO: 01063111105 PROJECT NAME: TRINIDAD ABBS BORING NUMBER: SB-17

DATE BEGAN: 1/24/12 BY R. CRAWFORD (GHD)

DRILLER: CLEARHEART DATE FINISHED: 2/1/2012 FIELD GEOLOGIST: A. GROVER

C57 License #: 780359 NORTHING/LATITUDE: NOT SURVEYED EASTING/LONGITUDE: NOT SURVEYED

SURFACE ELEVATION: STABLE DEPTH TO GW: N/A ▽ INITIAL DEPTH TO GW: 45' bgs

DRILLING METHOD: HOLLOW STEM AUGER DRILLING EQUIP: 2' SAMPLER TOC ELEVATION:

ELEVATION (ft.-msl) / DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
	* TOOK OVER LOGGING SOILS/OVERSIGHT FOR R. CRAWFORD. CONTINED DRILLING AT 25' bgs ON 2/1/12					
-25 / 25	POORLY GRADED SAND (5,95,0), FINE-GRAINED SAND, LIGHT BROWN GRAY	10YR 6/2	MOIST	LOOSE	SP 10, 10, 12, 13 (BLOW COUNTS)	SAMPLE FROM 25' TO 27' bgs RECOVERY = 90% DRILL TO 30' bgs
-30 / 30	SILTY SAND (20,80,0), FINE GRAINED SAND, LIGHT BROWN GRAY MOTTLING (5YR 3/3, DARK REDDISH BROWN) ↓ SLIGHTLY COARSER	10YR 6/2	MOIST	LOOSE ↓ MEDIUM DENSE	SM 10, 10, 12, 13	SAMPLE 30'-32' bgs RECOVERY = 90% DRILL TO 35' bgs
-35 / 35	POORLY GRADED SAND (5,95,0), FINE GRAINED SAND, LIGHT BROWN GRAY COARSENS ~ 39'-39.5' bgs	10YR 6/2	MOIST	LOOSE	SP 4, 6, 8, 8	SAMPLE 35'-37' bgs RECOVERY = 80% DRILL TO 40' bgs
-40 / 40	WELL GRADED SAND (10,90,0) FINE TO MEDIUM GRAINED SAND, LIGHT YELLOW BROWN	10YR 6/4	DRY	MEDIUM DENSE	SW 8, 11, 15, 21	SAMPLE 40'-42' bgs RECOVERY = 90% DRILL TO 45' bgs
-45 / 45 ▽	WELL GRADED SAND (5,90,5), FINE TO COARSE SAND, SUBROUNDED, <3/8" GRAVEL	10YR 3/3	WET → SATURATED	LOOSE	SW 10, 8, 8, 7	SAMPLE 45'-47' bgs RECOVERY = 30% DRILL TO 50' bgs
-50 / 50						

SOIL BORING AND WELL LOG

PROJECT NO: 01D0311005 PROJECT NAME: TRINIDAD ASSS BORING NUMBER: SB-17

DATE BEGAN: 1/24/2012

DRILLER: CLEAR HEART DATE FINISHED: 2/1/2012 FIELD GEOLOGIST: A. GROWER

C57 License #: 780359 NORTHING/LATITUDE: NOT SURVEYED EASTING/LONGITUDE: NOT SURVEYED

SURFACE ELEVATION: STABLE DEPTH TO GW: 45.9 ▽ INITIAL DEPTH TO GW: 45' bgs

DRILLING METHOD: HSA DRILLING EQUIP: 2' SAMPLER TOC ELEVATION:

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
-50	50	WELL GRADED SAND (0, 90, 10) FINE TO COARSE SAND, SUBROUND, <3/8" GRAVEL, DARK BROWN BEDROCK ENCOUNTERED AT 51' bgs. TOTAL DEPTH OF SB-17 = 51.5' bgs	10YR 3/3	MOIST	LOOSE	SW aa ID SD	SAMPLE 50'-52' bgs RECOVERY = 100%
-51	51						
-52	52						
-53	53						
-54	54						
-55	55						
-56	56						
-57	57						
-58	58						
-59	59						
-60	60						
-61	61						
-62	62						
-63	63						
-64	64						
-65	65						
-66	66						
-67	67						
-68	68						
-69	69						
-70	70						
-71	71						
-72	72						
-73	73						
-74	74						
-75	75						

SOIL BORING AND WELL LOG

PROJECT NO: 0100311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-18
DATE BEGAN: 2/1/2012
DRILLER: CLEARHEART DATE FINISHED: 2/2/2012 FIELD GEOLOGIST: A GOWER
C57 License #: 780357 NORTHING/LATITUDE: NOT SURVEYED EASTING/LONGITUDE: NOT SURVEYED

SURFACE ELEVATION: STABLE DEPTH TO GW: 58.14' bgs ▽ INITIAL DEPTH TO GW: 58' bgs
DRILLING METHOD: HSA DRILLING EQUIP: 2' SAMPLER TOC ELEVATION:

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
		ASPHALT ~4"					
0–-1	0–1	SILT/GRAVEL/SAND FILL (35,30,15), FINE SAND, VERY DARK BROWN	10YR 3/2	MOIST	LOOSE	GW	HAND AUGER FROM APPROXIMATELY 0.5' TO 5' bgs
-2–-3	2–3	SILTY SAND (15,85,0), FINE SAND, VERY DARK BROWN	10YR 3/2	MOIST	LOOSE	SM	
-4–-5	4–5	COLOR CHANGE TO 10YR 5/6 (YELLOWISH BROWN) AT APPROX. 4' bgs					SAMPLES 1-7' bgs RECOVERY = 90%
-6–-8	5–8	YELLOW BROWN	10YR 5/6	MOIST	LOOSE	2 2 2 3 W → BLOW COUNTS	DRILL TO 10' bgs
-9–-10	9–10	DARK BROWN	10YR 3/3	MOIST	LOOSE	3 3 2 3 3	SAMPLE 10'-12' bgs RECOVERY = 75% DRILL TO 15' bgs
-11–-13	11–13	MOTTLING AT 11' bgs (5YR 3/3, DARK REDDISH BROWN) GRAVEL LENS AT APPROXIMATELY 13.5'-14.25' bgs					
-14–-15	14–15	POORLY GRADED SAND (5,95,0) FINE SAND, LIGHT YELLOWISH BROWN	2.5Y 6/4	MOIST	LOOSE ↓ MEDIUM DENSE	SP 8 9 7 8	SAMPLE 15'-17' bgs RECOVERY = 90% DRILL TO 20' bgs
-16–-18	16–18	MOTTLING AT 16' bgs (5YR 3/3, DARK REDDISH BROWN)					
-19–-20	19–20	LIGHT BROWNISH GRAY	10YR 6/2	MOIST	MEDIUM DENSE	10 10 12 14	SAMPLE 20'-22' bgs RECOVERY = 90% DRILL TO 25' bgs
-21–-25	21–25	COARSENS FROM ~23'-24.5' bgs					

SOIL BORING AND WELL LOG

PROJECT NO: 01012311005 PROJECT NAME: TRINIDAD ASBS BORING NUMBER: SB-18
DATE BEGAN: 2/1/2012
DRILLER: CLEARHEART DATE FINISHED: 2/2/2012 FIELD GEOLOGIST: A GOWER
C57 License #: 780357 NORTHING/LATITUDE: NOT SURVEYED EASTING/LONGITUDE: NOT SURVEYED

SURFACE ELEVATION: STABLE DEPTH TO GW: 58.4' bgs ∇ INITIAL DEPTH TO GW: 58' bgs
DRILLING METHOD: HSA DRILLING EQUIP: 2" SAMPLER * SWITCHED TO 18" ON 2/2/2012 TOC ELEVATION:

ELEVATION (ft.-msl) / DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
-25 / 25	LIGHT BRONNISH GRAY	10YR 6/2	DRY → MOIST	MEDIUM DENSE TO DENSE	SP 11 10 23 30	SAMPLE 25'-27' bgs RECOVERY = 80% DRILL TO 30' bgs
-26 / 26						
-27 / 27						
-28 / 28	COARSENS @ 28.25'; NO COLOR CHANGE					
-29 / 29						
-30 / 30	* SOME COARSER-GRAINED SAND AT TOP OF SAMPLER.		DRY → MOIST	MEDIUM DENSE	21 21 17	SAMPLE 30'-32' bgs RECOVERY = 90% DRILL TO 35' bgs * DRILL RIG BROKE DOWN. HIT @ 35' bgs ON 2/1/2012
-31 / 31						
-32 / 32						
-33 / 33						
-34 / 34						
-35 / 35	POORLY GRADED SAND (10, 90, 0), FINE GRAINED SAND, BROWN	10YR 4/3	MOIST	LOOSE → MEDIUM DENSE	SP 6 8 10	* 2/2/2012 RESUME DRILLING WITH A NEW RIG. 18" SAMPLER SAMPLE 35'-36.5' bgs DRILL TO 40' bgs
-36 / 35						
-37 / 37						
-38 / 38						
-39 / 39						
-40 / 40	POORLY GRADED SAND (5, 95, 0), FINE GRAINED SAND, BROWN	10YR 4/3	DRY → MOIST	LOOSE	11 9 9	SAMPLE 40'-41.5' bgs RECOVERY = 80% DRILL TO 45' bgs
-41 / 41						
-42 / 42						
-43 / 43						
-44 / 44						
-45 / 45			DRY → MOIST	LOOSE → MEDIUM DENSE	10 9 12	SAMPLE 45'-46.5' bgs RECOVERY = 75% DRILL TO 50' bgs
-46 / 46						
-47 / 47						
-48 / 48						
-49 / 49						
-50 / 50						

SOIL BORING AND WELL LOG

PROJECT NO: 0100311005 PROJECT NAME: TRINIDAD MSBS BORING NUMBER: SB18

DATE BEGAN: 2/1/2012

DRILLER: CLEARHEART DATE FINISHED: 2/2/2012 FIELD GEOLOGIST: A. GROWER

C57 License #: 780357 NORTHING/LATITUDE: NOT SURVEYED EASTING/LONGITUDE: NOT SURVEYED

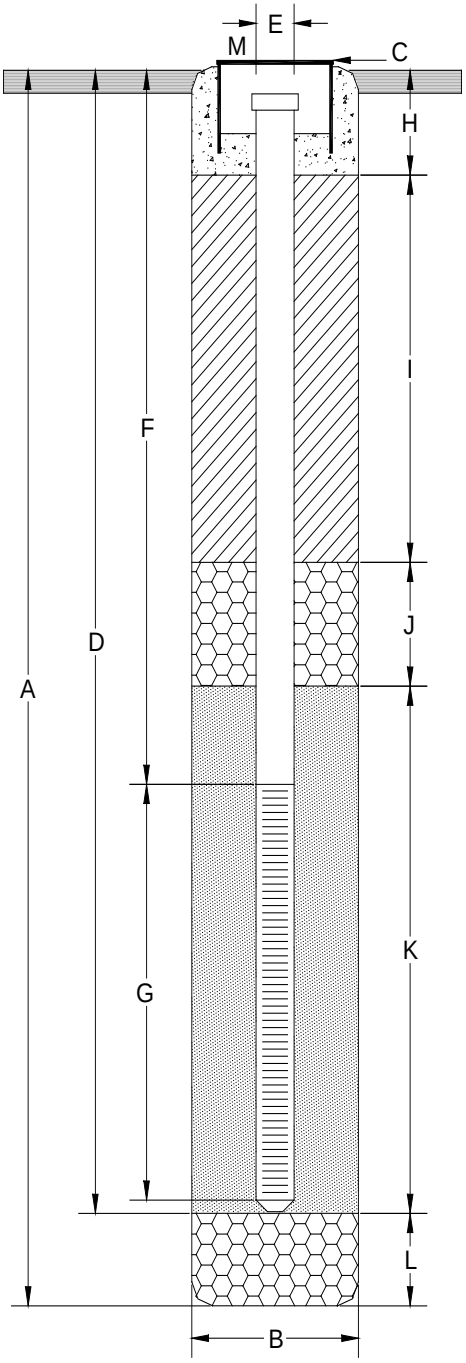
SURFACE ELEVATION: STABLE DEPTH TO GW: 58.4' bgs ▼ INITIAL DEPTH TO GW: 58' bgs

DRILLING METHOD: HSA DRILLING EQUIP: 18" STAINLESS TOC ELEVATION:

ELEVATION (ft.-msl)	DEPTH (ft.)	SOIL DESCRIPTION ASTM Soil Name - Percentages (0,0,0), fines, sand, gravel; grain size, plasticity, roundness, interpretation; other.	COLOR (MUNSELL)	MOISTURE	CONSISTENCY	SOIL PROFILE	WELL CONSTRUCTION
-50	50	POORLY GRADED SAND (10, 90, 0), FINE GRAINED SAND, LIGHT OLIVE BROWN	2.5Y 5/3	DRY → SLIGHTLY MOIST	MEDIUM DENSE	SP 10 12 14	SAMPLE 50'-51.5' bgs RECOVERY = 90% DRILL TO 55' bgs
-55	55	POORLY GRADED SAND (5, 95, 0), FINE GRAINED SAND, LIGHT OLIVE BROWN SATURATED AT 58' bgs	2.5Y 5/3	MOIST	LOOSE	SP 8 10 12 ▽	SAMPLE 55'-56.5' bgs RECOVERY = 60% DRILL TO 60' bgs
-60	60	WELL GRADED SAND (5, 95, 0) FINE TO COARSE SAND, SUBROUND TO SUBANGULAR, LIGHT OLIVE BROWN	2.5Y 5/3	SAT-URATED	MEDIUM DENSE	SW 9 10 14	SAMPLE 60'-61.5' bgs RECOVERY = 70% DRILL TO 65' bgs
-65	65	66'-66.5' SILTY SAND, (20, 80, 0) FINE SAND, DUSKY RED	10R 3/3			SOBR 3" SM	SAMPLE 65'-66.5' bgs RECOVERY = 50% DRILL TO 70' bgs
-70	70	BEDROCK ENCOUNTERED AT 70' bgs TOTAL DEPTH OF SB18 = 70' bgs				SD PAL 3" SD PAL 3"	SAMPLE 70'-71' bgs RECOVERY = 15%
-71	71						
-72	72						
-73	73						
-74	74						
-75	75						

Appendix D – Monitoring Well Construction Diagrams

MW-1 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 29 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 28.26 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 29 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 19 ft.

G Perforated Length 10 ft.
Perforated interval from 19-29 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material Concrete

I Backfill from 1 up to 14 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 14-17 feet bgs

K Sand Pack minimum of 2 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 17 to 29 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

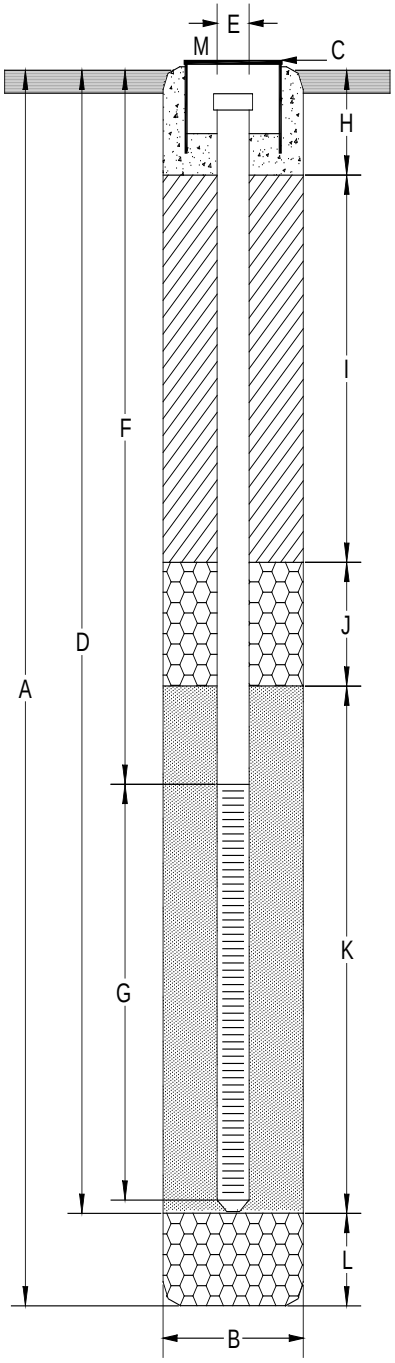
718 Third Street
Eureka, CA 95501 (707) 443-8326

Well No.

City of Trinidad ASBS Project **MW-1**

JOB NUMBER	REVIEWED BY	DATE	
106311005	P.Sullivan	18-Jan-12	**Monitoring Well Construction Details**

MW-2 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 39 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 93.46 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 39 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 29 ft.

G Perforated Length 10 ft.
Perforated interval from 29-39 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material concrete

I Backfill from 1 up to 24 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 24 to 27 feet bgs

K Sand Pack minimum of 2 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 27 to 39 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

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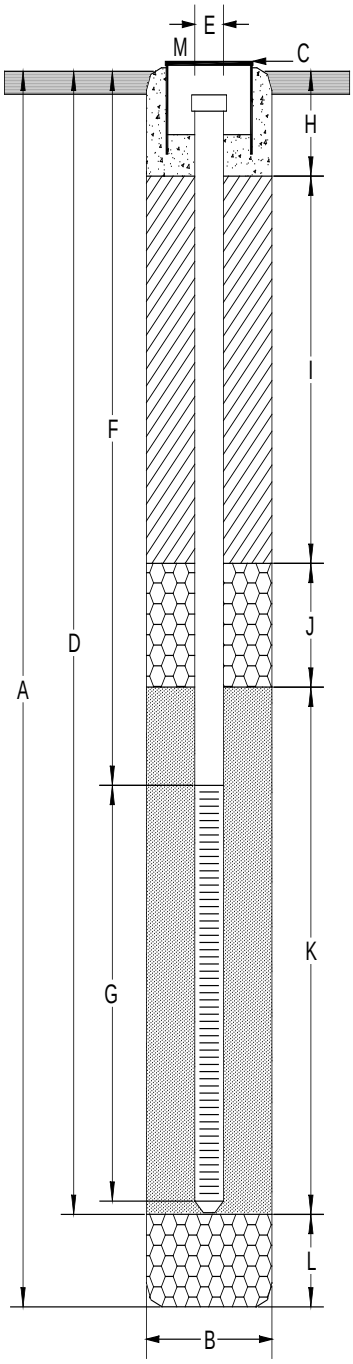
Eureka, CA 95501 (707) 443-8326

Well No.

City of Trinidad ASBS Project **MW-2**

JOB NUMBER	REVIEWED BY	DATE	
106311005	P.Sullivan	20-Jan-12	**Monitoring Well Construction Details**

MW-3 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 51.5 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 118.99 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 51.5 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 41.5 ft.

G Perforated Length 10 ft.
Perforated interval from 41.5-51.5 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material concrete

I Backfill from 1 up to 36.5 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 36.5 to 39.5 feet bgs

K Sand Pack minimum of 2 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 39.5 to 51.5 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

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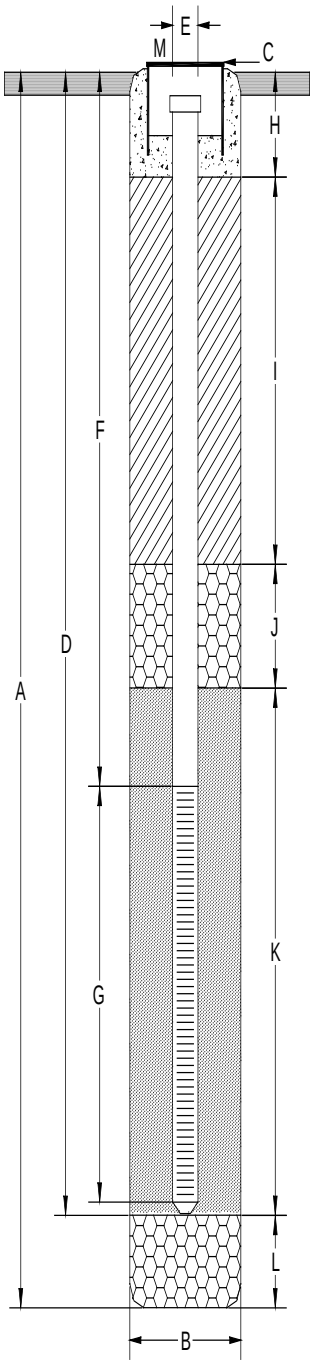
Well No.

City of Trinidad ASBS Project **MW-3**

JOB NUMBER	REVIEWED BY	DATE	
106311005	P.Sullivan	1-Feb-12	**Monitoring Well Construction Details**

MW-4 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 39 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 170.98 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 39 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 29 ft.

G Perforated Length 10 ft.
Perforated interval from 29-39 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material concrete

I Backfill from 1 up to 24 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 24-27 feet bgs

K Sand Pack minimum of 1 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 27 to 39 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

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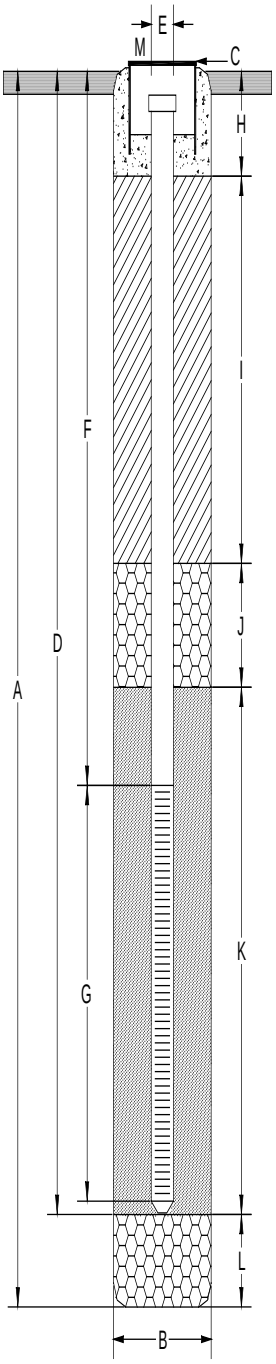
Well No.

City of Trinidad ASBS Project **MW-4**

JOB NUMBER	REVIEWED BY DATE	
106311005	P.Sullivan 12-Jan-12	**Monitoring Well Construction Details**

MW-5 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 43 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 171.62 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 43 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 33 ft.

G Perforated Length 10 ft.
Perforated interval from 33-43 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material concrete

I Backfill from 1 up to 22 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 22-28 feet bgs

K Sand Pack minimum of 2 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 28-43 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

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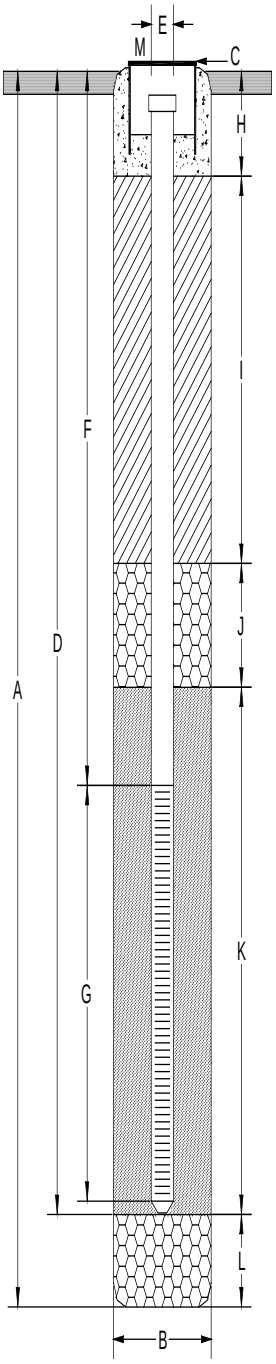
Well No.

City of Trinidad ASBS Project **MW-5**

JOB NUMBER	REVIEWED BY	DATE	
106311005	P.Sullivan	12-Jan-12	**Monitoring Well Construction Details**

MW-6 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 34 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 152.73 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 34 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 24 ft.

G Perforated Length 10 ft.
Perforated interval from 24-34 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material concrete

I Backfill from 1 up to 19 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 19 to 22 feet bgs

K Sand Pack minimum of 2 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 22-34 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

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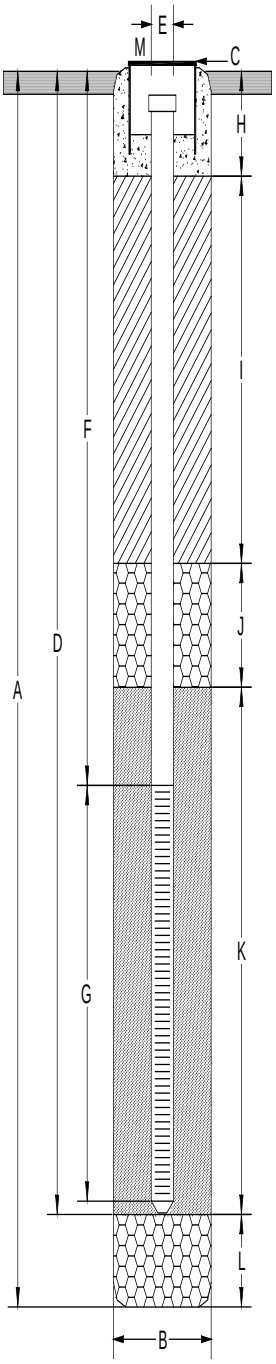
Well No.

City of Trinidad ASBS Project **MW-6**

JOB NUMBER	REVIEWED BY	DATE	
106311005	P.Sullivan	17-Jan-12	**Monitoring Well Construction Details**

MW-7 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 55 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 175.33 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 55 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 45 ft.

G Perforated Length 10 ft.
Perforated interval from 45-55 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material concrete

I Backfill from 1 up to 40 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 40 to 43 feet bgs

K Sand Pack minimum of 2 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 43-55 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

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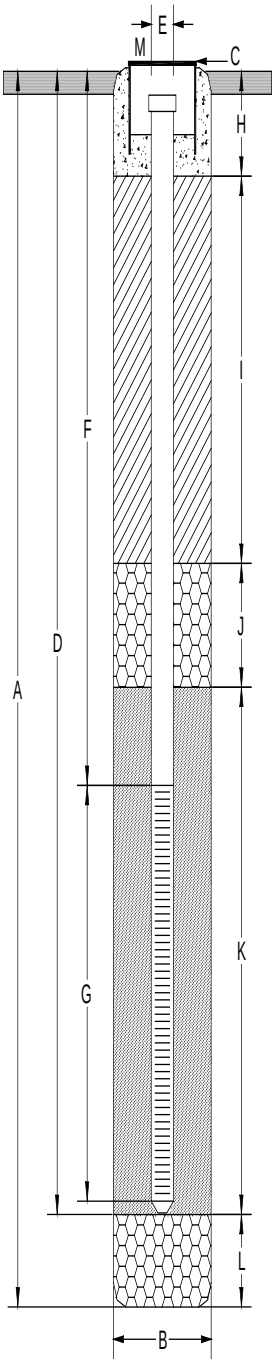
Well No.

City of Trinidad ASBS Project **MW-7**

JOB NUMBER	REVIEWED BY	DATE	
106311005	P.Sullivan	17-Jan-12	**Monitoring Well Construction Details**

MW-8 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 49 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 176.72 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 49 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 29 ft.

G Perforated Length 20 ft.
Perforated interval from 29-49 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material concrete

I Backfill from 1 up to 25 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 25 to 28 feet bgs

K Sand Pack minimum of 2 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 28-49 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

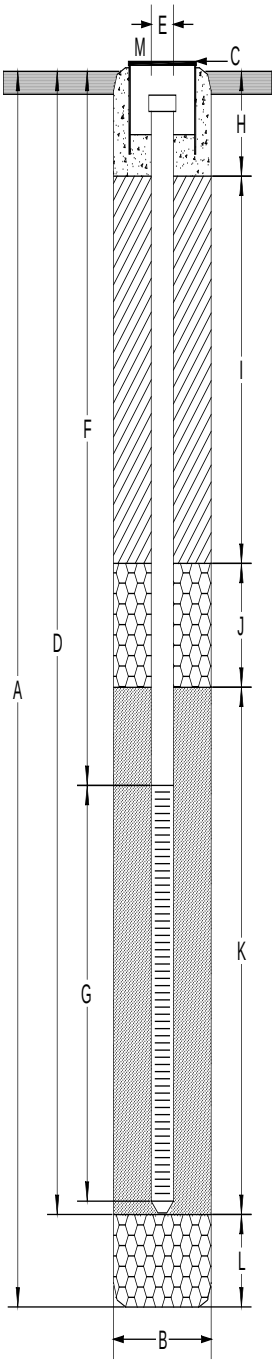
718 Third Street
Eureka, CA 95501 (707) 443-8326

Well No.

City of Trinidad ASBS Project **MW-8**

JOB NUMBER	REVIEWED BY	DATE	
106311005	P.Sullivan	11-Jan-12	**Monitoring Well Construction Details**

MW-9 MONITORING WELL CONSTRUCTION DETAILS



A Total Depth of Boring 70 ft.

B Diameter of Boring 8 in.
Drilling Method hollow stem auger

C Top of Box Elevation 174.23 ft.
☐ Referenced to Mean Sea Level
☒ Referenced to Project-Datum

D Casing Length 70 ft.
Material schedule 40 PVC

E Casing Diameter 2 in.

F Depth to Top Perforations 50 ft.

G Perforated Length 20 ft.
Perforated interval from 50-70 ft bgs
Perforation Size 0.010 in.

H Surface Seal from 0 to 1 ft.
Seal Material concrete

I Backfill from 1 up to 45 ft.
Seal Material neat cement

J Seal will be a minimum of 2 ft thick
Seal Material hydrated bentonite from 45 to 48 feet bgs

K Sand Pack minimum of 2 ft above screen to the bottom
Pack Material Cemex # 2/12 sand from 48 to 70 feet bgs

L Bottom Seal N/A ft.
Seal Material N/A

M Traffic-rated, water-resistant, steel well box
Locking expandable well plug with lock

Note: Depths measured from initial ground surface.

GHD
718 Third Street
Eureka, CA 95501 (707) 443-8326

Well No.

City of Trinidad ASBS Project **MW-9**

JOB NUMBER	REVIEWED BY	DATE	
106311005	P.Sullivan	3-Feb-12	**Monitoring Well Construction Details**

Appendix E – GHD Standard Operating Procedures

WINZLER & KELLY

STANDARD OPERATING PROCEDURES
GROUNDWATER LEVEL MEASUREMENTS

1.0 OBJECTIVE

To establish accepted procedures for measuring the depth to groundwater in monitoring wells and piezometers.

1.1 Background

Groundwater level measurements are required to determine the groundwater gradient or flow direction. These Standard Operating Procedures (SOPs) establish the procedures for measuring depth to.

1.2 Personnel Required and Responsibilities

Project Manager: The Project Manager (PM) is responsible for ensuring that field personnel have been trained in these procedures and for verifying that water level have been collected in compliance with this SOP.

Field Technician: The Field Technician is responsible for complying with this SOP, and the equilibrated water level in the monitoring well.

2.0 EQUIPMENT REQUIRED

- Tape measure
- Water Level Data Form/pencil
- Watch
- Disposable gloves
- Distilled water
- Alconox soap
- Containers to hold rinsate water
- Site Safety Plan and Hospital Map
- Keys to wells
- Tools to open wells

3.0 PROCEDURE

After reviewing the Site Safety Plan and determining the type and concentrations of contaminants that may be present on site, the field personnel will don the proper level of personal protection prior to opening monitoring wells.

Open monitoring wells to be measured and remove locks and expandable caps. Allow wells to equilibrate to atmospheric pressure for a minimum of 15 minutes. Record time and visual observations regarding well access, condition, security, etc., on water level data sheet.

3.1 Procedure for electronic water-level meter

- Decontaminate probe with potable water and Alconox mix. Rinse with distilled or deionized water.
- Lower probe into the well and record the depth to.
- Groundwater elevation shall be calculated as follows:
- GW Elevation = (TOC) - (depth to water).
- TOC indicates top of casing elevation as surveyed.

WINZLER & KELLY

STANDARD OPERATING PROCEDURES
for
MONITORING WELL INSTALLATION IN THE UNCONFINED AQUIFER

1. Objective

To provide an accepted method for the installation of monitoring wells in the unconfined aquifer for sites impacted with chemical contaminants.

2. Background

Monitoring wells are installed in accordance with the California Well Standards (Bulletin 74-90) and the appropriate lead agency guidelines.

Careful consideration should be given to the specific gravity of the contaminants of concern and screening the upper or lower portion of the aquifer.

Except where otherwise required, W&K only utilize disposable polyethylene bailers to collect groundwater samples.

3. Personnel Required and Responsibilities

Professional Geologist: A Professional Geologist (PG) is responsible for ensuring that the monitoring well is properly installed and oversee the logging of the monitoring well and for ensuring that field personnel have been trained in the use of this procedure.

Staff Geologist: A staff geologist (SG) has 0.5 to 5 years experience logging borings and installing monitoring wells. The SG is responsible for complying with the procedure, installing the well, collection of samples, containerization of samples, and documentation. The SG will call into the PG with proposed well construction, soils and contaminant data to obtain approval prior to well installation.

4. Equipment Required

- Level D Safety Equipment
- Boring Log form / Munsell Soil Charts
- Sample containers - provided by the laboratory
- En Core® Sampler Set and sample containers
- Sample labels/Indelible marker
- Disposal gloves
- Ice chest with ice
- Unified Soil Classification System Guide

5. Procedure

- Prior to drilling the monitoring well boring Winzler & Kelly will obtain all required permits. A Site-Specific Safety Plan detailing site hazards, site safety, and control will be prepared prior to any field work. At least 48 hours prior to drilling Underground Services Alert (USA) will be notified of the planned work.

- Prior to installing a monitoring well, log the boring and sample according to Winzler & Kelly's Standard Operating Procedures for *Soil and Water Sampling from a Boring.*

- Use a PID during the drilling and sampling activities to screen for the presence of Volatile Organic Compounds (VOCs).

- Use a hollow-stem rotary auger drill rig set up with a 9-inch auger to complete the well drilling and to assist in the well installation.

- Extend the well borings at least 10 feet into the aquifer under investigation. At a minimum, obtain soil samples by driving an 18- or 24-inch long split spoon sampler continuously for the first well and at 5-foot intervals for the other wells. Retain one 6-inch sample tube from each 5-foot interval for possible submittal to the analytical laboratory. Collect soil samples at the soil-water interface, at notable changes in lithology, and in areas of observed chemical contaminant impact.

- For the laboratory analysis of <u>non-VOCs</u>, obtain soil samples in clean brass tubes during the drilling as part of the monitoring well installation process. Cap the 6-inch tube of soil selected for laboratory analysis with aluminum foil or Teflon tape and plastic caps; label and store samples in a cooler, on ice. Transport the soil samples to a state-certified analytical laboratory under chain-of-custody documentation. Handle soil samples that will be selected for laboratory analysis in accordance with Winzler & Kelly's Standard Operating Procedures for *Soil and Water Sampling from a Boring*.

- For the laboratory analysis of <u>VOCs</u>, soil samples will be collected with a split spoon sampler or direct-push sample barrel that is not lined with any sleeves. Soil will be scraped away using a clean trowel or other device to get to the interior of the sample. As per EPA Method 5035, a new disposable En Core® Sampler will be in the En Core® handle. Three clean En Core® sample tubes will be driven into the soil and filled completely to avoid air space. The En Core® sample tube will be retracted from the soil and capped with the locking cap, and inserted in the provided envelope. Each envelope will be labeled with the job number, the sample identification, date and time of collection, the sampler's name, and the analyses required. Each set of three En Core® samples will then be placed in an ice chest (chilled to 4°C) until delivered to a state-certified laboratory under strict chain-of-custody documentation, where they will weigh and preserve each sample within 48-hours of collection.

A fourth sample will be collected for laboratory screening, by driving a pre-cleaned container, such as a glass jar or a brass tube into the soil, capping it with Teflon or aluminum sheeting, and tight-fitting plastic caps.

A clean set of En Core® samplers and brass tube will then be driven into the soil until each are completely full.

- Classify soil types and log under the Unified Soil Classification System using the ASTM Visual Manual Procedure (D 2488-84) and Munsell Soil Color Charts. Field screen the soil headspace within a sealed sample bag, using a portable Organic Vapor Meter. Winzler & Kelly uses a photo-ionization detector (PID) to assess relative concentrations of volatile constituents in the soil samples, and also to monitor the breathing zone.

- Include the lithology, moisture, density, colors and depth sample identification, PID measurements and well construction details on the boring logs as appropriate. Include the boring logs generated from the field activities in the Report of Investigation.

- If a clay layer is encountered, perform continuous sampling to assess its thickness. A clay aquitard shall not be penetrated more than 3 feet. If cross contamination of aquifers is possible, use conductor casings and packers, as appropriate to maintain groundwater quality.

- Depending on the season during the drilling activities (high water table season or low water table season), the screened interval should be placed to allow for fluctuations in the water table. The screened casing should be placed about 5-feet above the anticipated high water table, and should extend a maximum of 15 feet below the water table.

- The last page of this SOP illustrates the Typical Monitoring Well Construction Detail.

- Use two-inch diameter schedule 40-PVC, flush-threaded well screen and install through the hollow-stem augers. If the soils are stiff enough to open hole the boring, then make sure centralizers are installed on the outside of the casing every 10-feet.

- Slowly install a uniform filter pack from the bottom of each boring to a depth of 6 inches and preferably 1-foot above the top of the well screen. This step is imperative because if the sand is poured too quickly, it may bridge. The bridging can also cause the well casing to move upward. If this happens and the well bridge cannot be broken, remove the well casing and auger out all the sand and reinstall.

- Use a clean, weighted tape measure to ensure proper placement of the sand and that sand always stays in the auger. This prevents any possible cave ins.

- Use Lonestar #2/16, or #2/12 Monterey sand or equivalent with a 0.010-inch slot or 0.020-inch slot screen. The screen size is dependent on the lithology. If the saturated soil consists of coarser material, then 0.020-inch slot with #3 Lonestar Sand (or equivalent) should be used.

- Place a minimum 1-foot thick seal of **hydrated** bentonite pellets over the filter pack. Grout the remainder of the boring with a cement/bentonite slurry not exceeding 5 percent bentonite to 1 foot below the ground surface. The top of the PVC casing will be approximately 2 inches below grade. Slide slip cap over the top of the casing.

- Place empty Lonestar sandbags around the casing to ensure no clods of dirt fall into the boring until ready to place the surface seal.

- Protect the wells by 8-inch minimum to a 12-inch maximum, flush-mounted traffic boxes set in concrete, with locking well caps. The top of the traffic boxes will be set above grade with a gently sloping concrete rim. The monitoring well identification number should be scribed into the concrete rim before it completely sets.

- Refer to other SOPs for development and sampling the wells.

- A depth to water measurement should be collected after the sample is collected. The measurement and time shall be documented in the logbook.

- Upon completion of the well installation, each well will be closed and secured by replacing the well cap, securing the lock and bolting down the lid of the flush-mounted traffic box. Ensure the box does not sink in the wet concrete.

- Properly drum or dispose of used gloves and any other PPE gear, after each use.

Explanation for Winzler & Kelly Boring Logs

Coarse Grained Soils (more than half of soil > No. 200 sieve)	Gravels (More than half of coarse fraction > no. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Sandy gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-silt mixtures
	Sands (More than half 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	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
Fine Grained Soils (more than half of soil < No. 200 sieve)	Silts and Clays LL = < 50	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays LL = > 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic silts of high plasticity, fat clays
		OH	Organic clays of high plasticity, organic silty clays, organic silts
Highly Organic Soils		Pt	Peat and other highly organic soils

Grain Size Chart

Classification	Range of Grain Sizes	
	U.S. Standard Sieve Size	Grain Size In Millimeters
Boulders	Above 12"	Above 305
Cobbles	12" to 3"	305 to 76.2
Gravel	3" to No. 4	76.2 to 7.76
coarse	3" to 3/4"	76.2 to 4.76
fine	3/4"to No.4	19.1 to 4.76
Sand	No. 4 to No. 200	4.76 to 0.074
coarse	No.4 to No. 10	4.76 to 2.00
medium	No. 10 to No. 40	2.00 to 0.420
fine	No. 40 to No. 200	0.420 to 0.074
Silt and Clay	Below No. 200	Below 0.074

Relative Density (SPT)

SANDS AND GRAVELS	BLOWS/FOOT
VERY LOOSE	0 – 4
LOOSE	4 – 10
MEDIUM DENSE	10 – 30
DENSE	32 – 50
VERY DENSE	OVER 50

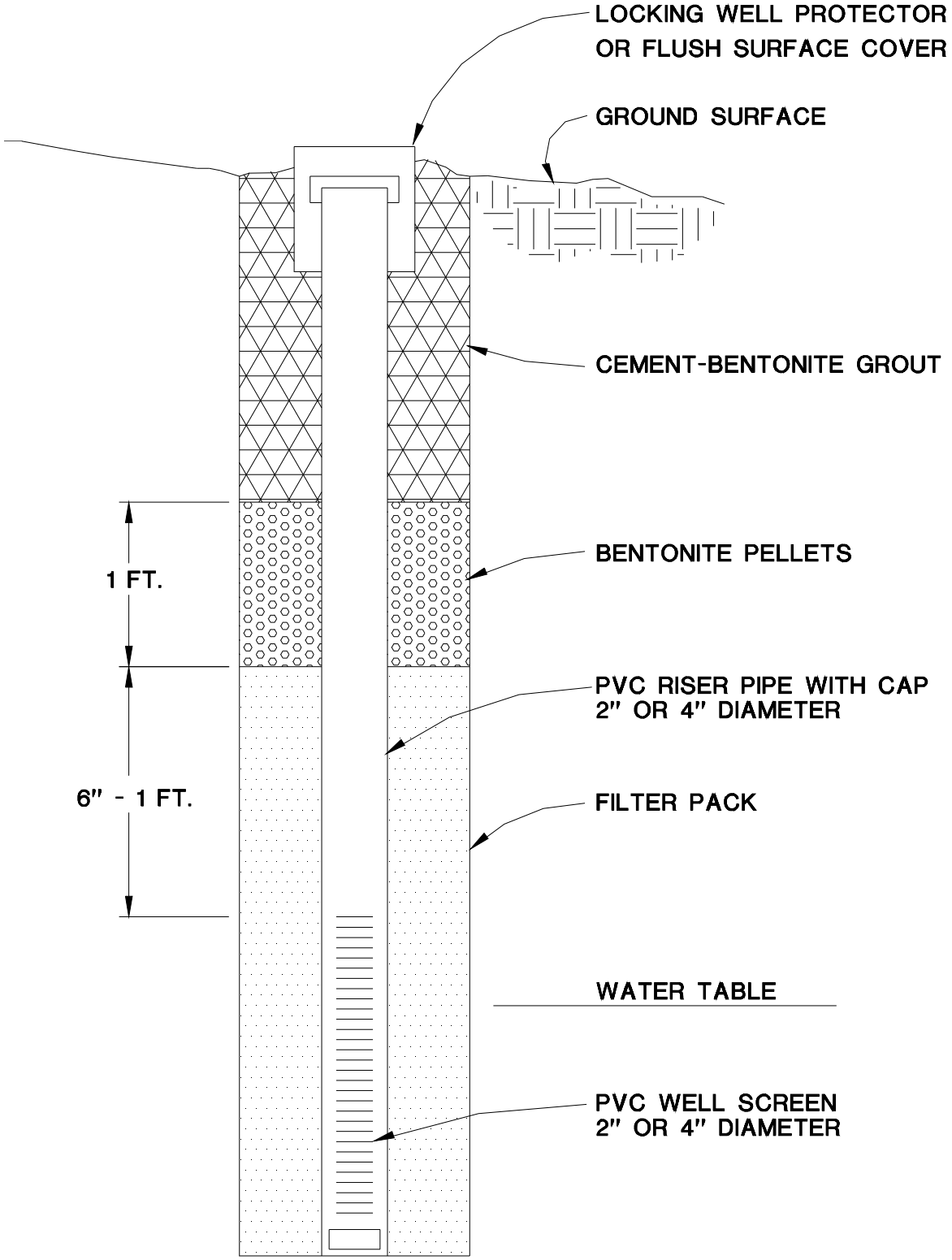
Consistency (SPT)

SILTS AND CLAYS	BLOWS/FOOT
VERY SOFT	0 – 2
SOFT	2 – 4
MEDIUM STIFF	4 – 8
STIFF	8 – 16
VERY STIFF	16 – 22
HARD	OVER 32

▽ **Initial water level measured during drilling (date in italics)**

▼ **Static water level measured after well development (date in italics)**

× **Depths where soil samples were recovered**



TYPICAL MONITORING WELL CONSTRUCTION DIAGRAM

NOT TO SCALE

WINZLER & KELLY

STANDARD OPERATING PROCEDURES
for
SOIL BORING INSTALLATION

1.0 Objective

To establish procedures for sampling soil and water from using a hand auger or direct push tools to install soil borings.

2.0 Background

During subsurface investigations it is necessary to obtain discrete soil and water samples from below the ground surface. This SOP establishes the procedures for collecting soil and groundwater samples from borings using hand tools on projects requiring near-surface data.

3.0 Personnel Required and Responsibilities

Project Manager: The Project Manager (PM) is responsible for ensuring that field personnel have been trained in the use of these procedures and for verifying that drilling water and soil sampling activities are performed in compliance with this SOP.

Project Scientist: The responsible professional in charge of the field work must determine the exact location and depth of each boring, and decide on the sampling interval. The project scientist must collect samples; prepare them for transport to the laboratory, and record lithologic and other observations. The Project Scientist is responsible for complying with this SOP.

4.0 Equipment Required

- Hand auger kit or direct push boring tools
- Core drill and power supply if boring to be installed through hard surface
- Split spoon sampler or direct push sample barrel
- Brass or stainless steel sample liners and plastic end caps
- Soil sampling jars
- Aluminum foil or Teflon sheeting
- Decontamination equipment
- Containers for decontamination rinseate
- Disposable gloves
- Sample labels
- Field guide for logging boreholes
- Munsell color charts
- Putty knife
- Boring logs
- Photoionization detector (PID)
- Ice/ice chest

- Sealable plastic storage bags
- Indelible marker that will not transfer volatile compounds to sampling container.

5.0 Procedure

Borings will be installed using hand augers, or small diameter pushrods. Borings will extend to the groundwater surface or deeper as specified by the project requirements. Typically, soil samples will be obtained either continuously, or at a minimum of 5-foot intervals for lithologic logging, on site field screening, and potential chemical analyses. Additional soil samples will be obtained at any notable changes in lithology and at any obvious areas of contamination.

- Soil samples will be collected in a hand auger, split spoon sampler or direct-push sample barrel lined with clean brass or stainless steel sleeves. A six-inch interval of the sample will be capped with aluminum foil or Teflon sheeting and plastic end caps, labeled, wrapped in a plastic storage bag and stored in a cooler, on ice. Sample numbers and depths will be noted on the boring logs.
- The remaining sample will be used for color and soil type classification using the Unified Soil Classification System and Munsell color charts. A portion of each sample will be field-screened with a photo-ionization detector. Results of classification and field screening will be recorded on the boring logs.
- Sample equipment will be decontaminated in an Alconox detergent solution and rinsed in deionized or tap water between sampling intervals.
- If a hydropunch sampler is to be used to collect water samples, borings will terminate at the groundwater surface. A hydropunch-type groundwater sampling device will be lowered into the hollow stem augers or the drive casing, and driven three to four feet into the aquifer. Groundwater will be allowed to flow into the hydropunch.
- If a hydropunch type sampler is not used, the boring will be extended 3 to 5 feet into the aquifer. The augers or drive casing will be pulled back to allow for water to enter the boring. If caving of the bore hole occurs, temporary PVC casing may be lowered into the drive casing or hollow stem augers prior to retraction of the drive casing.
- Groundwater will be sampled using a small diameter stainless steel or disposable polyethylene bailer.
- Groundwater samples will be transferred from the bailer to appropriate size/type containers with the appropriate preservatives, as required by the project needs. Precautions will be taken to avoid capturing air bubbles in the samples. Sample containers will be labeled, wrapped in plastic bags and stored in a cooler, on ice. The water samples will be transported to a State-certified laboratory for the appropriate chemical analyses.
- Soil borings will be closed by filling to 6 inches below the surface with bentonite or a cement/bentonite grout mixture, not exceeding 5% bentonite.

Appendix F – Depth to Water Measurements Field Forms

GHD Inc.

WATER LEVEL MEASUREMENT DATA SHEET

PROJECT NAME: TRINIDAD ASBS PH 1 TODAY'S DATE: 03/12/12
PROJECT NUMBER: 0106311005.11005 FIELD PERSONNEL: KEITH KORBIN

WELL NUMBER	OPEN WELL	INITIAL WATER LEVEL		FINAL WATER LEVEL		COMMENTS
	Time	Time	Depth to Water (ft. bgs.)	~~TOTAL Time~~ WELL	~~Depth to Water~~ (ft. bgs.)	
MW-7	1525	1620	40.35'		54.22'	
MW-8	1530	1628	44.21'		48.92'	
MW-9	1536	1639	53.88'		70.11'	
MW-1	1541	1649	16.99'		27.86'	
MW-3	1548	1705	40.62'		50.98'	
MW-2	1553	1712	29.35'		38.72'	
MW-5	1559	1721	38.22'		42.53'	
MW-4	1606	1732	34.60'		38.93'	
MW-6	1612	1747	18.25'		33.90'	
ON SITE @ 1515						
OFF SITE @ 1803						
ALL WELL CASES MARKED WITH "NOTCH" @ NORTH						
ALL WELL CAPS & COVERS SECURE						

Weather Conditions Today: VERY WINDY, CLOUDY, SPRINKLES

GHD Inc.

WATER LEVEL MEASUREMENT DATA SHEET

PROJECT NAME: TRINIDAD ASBS PH. I TODAY'S DATE: 04/02/12
PROJECT NUMBER: 0106311005.11005 FIELD PERSONNEL: KEITH KORBIN

WELL NUMBER	OPEN WELL	INITIAL WATER LEVEL		FINAL WATER LEVEL		COMMENTS
	Time	Time	Depth to Water (ft. bgs.)	TOTAL ~~Time~~ WELL	Depth ~~to Water~~ (ft. bgs.)	
MW-7	0902	1011	39.91'	54.22'		
MW-8	0912	1026	43.68'	48.93'		
MW-9	0918	1038	56.13'	70.11'		
MW-1	0925	1052	14.42'	28.77'		
MW-3	0930	1103	39.01'	50.95'		
MW-2	0935	1116	27.86'	38.65'		
MW-5	0942	1131	37.69'	42.53'		
MW-4	0947	1142	33.82'	38.93'		
MW-6	0953	1157	16.35'	33.97'		
ON SITE @ 0845						
OFF SITE @ 1210						
* ALL WELLS: CLEANED CAPS, VAULT/BOXES, & STAMPED I.D. MARKINGS ON COVERS						

Weather Conditions Today: CALM, MOSTLY CLOUDY

GHD Inc.

WATER LEVEL MEASUREMENT DATA SHEET

PROJECT NAME: TRINIDAD ASBS PH 1 TODAY'S DATE: 06/28/12
PROJECT NUMBER: 0163110005.11005 FIELD PERSONNEL: KEITH KORBIN

WELL NUMBER	OPEN WELL	INITIAL WATER LEVEL		~~FINAL WATER LEVEL~~ TOTAL WELL DEPTH		COMMENTS
	Time	Time	Depth to Water (ft. bgs.)	Time	Depth to Water (ft. bgs.)	
MW-7	0931	1030	37.76'		54.10'	
MW-8	0936	1057	41.81'		48.92'	
MW-9	0948	1110	55.55'		70.00'	
MW-1	0957	1120	17.74'		28.77'	
MW-3	1002	1130	40.51'		50.95'	
MW-2	0954	1137	27.33'		38.24'	
MW-5	1015	1152	37.00'		42.54'	
MW-4	1017	1159	34.88'		38.94'	
MW-6	1021	1206	16.90'		33.90'	
EX-1	1010 *	1143	9.90'		15.52'	
EX-2	0944*	1047	DRY		34.49'	
	* BOX FULL OF WATER					
	DEPART EKA		0845			
	ON-SITE @		0915			
	OFF-SITE @		1215			
	LUNCH →		1227			
	ARRIVE EKA		1253			

Weather Conditions Today: CLEAR, DRY, WARM, SOME CLOUDS LIGHT BREEZE

GHD Inc.

WATER LEVEL MEASUREMENT DATA SHEET

PROJECT NAME: TRINIDAD ASBS PH 1 TODAY'S DATE: 9/20/12
PROJECT NUMBER: 0106311005.11005 FIELD PERSONNEL: KEITH KORBIN

WELL NUMBER	OPEN WELL	INITIAL WATER LEVEL		~~FINAL WATER LEVEL~~		COMMENTS
	Time	Time	Depth to Water (ft. bgs.)	TOTAL WELL ~~Time~~ DEPTH	Depth to Water (ft. bgs.)	
MW-7	1322	1414	39.51'	54.10'		ALLEN SCREWS CLOGGED W/ DEBRIS
MW-8	1332	1441	33.20'	48.93'		IRREGULAR SOUNDING ON DEPTH PROBE*
MW-9	1336	1449	56.52'	70.00'		
MW-1	1343	1503	19.52'	28.76'		WASHED SAND AWAY W/ DI WATER
MW-3	1352	1519	42.88'	50.98'		
MW-2	1355	1526	30.06'	38.02'		≈ 12" MVO/SILT @ BOTTOM OF WELL
MW-5	1358	1536	39.11'	42.54'		
MW-4	1401	1543	36.44'	38.95'		
MW-6	1405	1551	18.69'	33.96'		
EX-1	1348	1510	11.36'	14.52'		
EX-2	1328	1424	DRY	34.48'		
	DEPART:	1245				
	ONSITE:	1315				
	OFFSITE:	1558				
	EUREKA:	1625				
	* SEVERAL ATTEMPTS TO DETERMINE DTW. WHITE GRANULATED MATERIAL OBSERVED ON PROBE.					

Weather Conditions Today: OVERCAST, MILD, LIGHT BREEZE

Appendix G – Spectrum Geophysical Report

SPECTRUM

GEOPHYSICS

2727 S. Croddy Way, Unit I
Santa Ana, CA 92704

www.spectrum-geophysics.com

REPORT OF GEOPHYSICAL INVESTIGATION
Trinidad, California

Prepared by:

SPECTRUM GEOPHYSICS
2727 S. Croddy Way
Unit I
Santa Ana, California 92704

Submitted to:

GHD
718 Third Street
Eureka, California 95501

October 16, 2012

Report of Geophysical Investigation
Trinidad, California

October 16, 2012

Laura Cathcart-Dodge
Professional Geophysicist No. 1017
Vice President
Spectrum Geophysics

Table of Contents

1.0 INTRODUCTION 1
2.0 EQUIPMENT AND METHODS 1
2.1 Electrical Resistivity Method 1
2.2 Seismic Reflection Method 2
3.0 FIELD PROCEDURES 2
3.1 Electrical Resistivity Procedures 2
3.2 Seismic Reflection Procedures 2
4.0 DATA PROCESSING 3
4.1 Electrical Resistivity 3
4.2 Seismic Reflection 3
5.0 INTERPRETATION 5
5.1 Electrical Resistivity 5
5.2 Seismic Reflection 6
6.0 RESULTS 6
6.1 Line 1 7
6.1.1 Electrical Resistivity 7
6.1.2 Seismic Reflection 7
6.2 Line 2 8
6.2.1 Electrical Resistivity 8
6.2.2 Seismic Reflection 8
6.3 Line 3 9
6.3.1 Electrical Resistivity 9
6.3.2 Seismic Reflection 9
6.4 Line 4 10
6.4.1 Electrical Resistivity 10
6.4.2 Seismic Reflection 10
7.0 LIMITATIONS 10
7.1 Electrical Resistivity 10
7.2 Seismic Reflection 11
8.0 REFERENCES 13

LIST OF FIGURES

FIGURE	TITLE
1	Site Map: Geophysical Transect, Boring and Monitoring Well Locations
2	Electrical Resistivity Profile – Line 1
3	Sesimic Profile 1 – Edwards St

LIST OF FIGURES (cont.)

4	Electrical Resistivity Profile – Line 2
5	Seismic Profile 2 – Stagecoach Rd
6	Electrical Resistivity Profile – Line 3
7	Seismic Profile 3 - Beach
8	Electrical Resistivity Profile – Line 4
9	Seismic Profile 4 – Ewing St

1.0 INTRODUCTION

Spectrum Geophysics conducted a geophysical investigation from August 8 to August 17, 2012 in the city of Trinidad, California (hereinafter referred to as the Site). This investigation was conducted to assist in the design and implementation of a stormwater management system for the city. Geophysical methods were used for the purpose of delineating detailed geologic stratigraphy and structure, and to augment existing boring and well information at the Site. During this investigation, four linear transects (referred to as Lines 1 through 4) were established, and both seismic reflection and electrical resistivity data were collected along each transect (Figure 1).

A discussion of the equipment used during this investigation is presented in Section 2.0, the field procedures are presented in Section 3.0, data processing is presented in Section 4.0, data interpretation is presented in Section 5.0, results are presented in Section 6.0 and limitations are discussed in Section 7.0.

2.0 EQUIPMENT AND METHODS

Electrical resistivity field equipment consisted of the Advanced Geosciences SuperSting R8/IP system (SuperSting), steel electrodes and associated cabling. The Advanced Geosciences EarthImager® software package (AGI, 2010) was used to process the resistivity data. Seismic reflection field equipment consisted of a 72-channel Geometrics Stratavisor NZ-II or laptop using Geometrics Seismodule Controller software and 24-bit seismic data recording, 40-Hz vertical geophones, geophone cables and accessories. A 20-lb sledgehammer was used as the seismic p-wave source on Lines 1, 2 and 4. A Geometrics PRS-1 "Urban Seismic" swept impact source was used on Line 3 as the ground conditions for this source were ideal along Line 3. The Vista 11.0® Software package was used to process the seismic reflection data. A discussion of the p-wave seismic reflection procedures may be found in Section 3.2.

2.1 Electrical Resistivity Method

Electrical resistivity data collection along Line 3

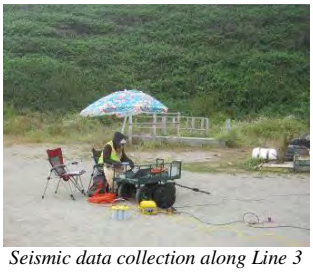
The electrical resistivity method was used at the Site in order to assist in the identification of contrasting lithology, such as may occur at the marine terrace sediments/Franciscan Complex interface, as well as at the sheared Franciscan matrix contact with buried exotic blocks within it. Electrical resistivity is a surface method whereby a DC circuit is established in the ground via cables and electrodes, and the ground acts as the resistor to complete the circuit. During a resistivity survey, a known amount of current is introduced into the ground through two electrodes, called current electrodes. This current then travels through the ground and the electrical potential is measured by 2 other electrodes some distance from the current electrodes. Ohm's Law (V=IR) is then used to calculate the apparent resistivity of the ground through which the current has traveled. The SuperSting is a powerful resistivity system that allows automated acquisition of electrical resistivity data. Because it is automated it is quite efficient and relatively easy to use in the field. During a SuperSting survey, many apparent resistivity measurements are made for a suite of electrode pair separations, and these apparent resistivity values are plotted on a two-dimensional diagram (location of measurement vs. depth). The result is a 2D subsurface image that contains both sounding and profiling data. The automated resistivity data acquisition provided by the SuperSting allows for a tremendous amount of data to be acquired relatively quickly at very high-resolution capability. Once the data have been acquired for a given transect, they can be downloaded to a field computer and subsequently viewed, color-contoured, and interpreted for features of interest. There are several different arrays that can be used to collect the data; during this investigation both Schlumberger and dipole-dipole arrays were used. Electrical resistivity data are typically displayed in 2D sections or profiles where they supply lateral and vertical electrical resistivity information about materials directly below a given transect (much like a road cut).

DC resistivity data provide high quality, high resolution imaging of subsurface layers where there is a contrast in electrical resistivity across a vertical or horizontal boundary. Since most minerals are insulators, electrical current flow through a material is primarily electrolytic and takes place through pore spaces, along grain boundaries and through fractures. Because the electrical resistivity of a material correlates well with grain size (and generally increases with increasing grain size) this method can be used quite effectively to distinguish sands, silts and clays as well as their bedrock counterparts of sandstone, siltstone and shale. Based on this ability, resistivity data were used not only to identify lateral and vertical contacts between marine terrace deposits or fill lateral (which were highly resistive) and Franciscan bedrock (which was generally less resistive), but also to identify more subtle lithology

variation *within* the Franciscan Complex (i.e. sand versus shale versus siltstone or, even buried resistive exotic blocks beneath the sheared siltstone) at the Site.

2.2 Seismic Reflection Method

The seismic reflection method was used to delineate the subsurface structure and stratigraphy at the Site. For each line of acquisition, the seismic reflection data were tied to GHD borings and wells in order to trace key reflectors and confining layers through the subsurface to assist GHD in identifying the geologic controls on the flow of groundwater through the subsurface.


Seismic data collection along Line 3

Seismic reflection profiling is a surface method that uses the reflective properties of acoustic waves to obtain highly detailed images of subsurface layers and bedding planes to significant depths. The seismic reflection method has a long history with the oil industry where seismic sections are interpreted for subsurface structural features such as anticlines, faults, unconformities and other sources of oil traps. More recently, seismic reflection methods have been used for environmental and engineering investigations to delineate faults, aquifers, aquitards or other subsurface features of interest.

3.0 FIELD PROCEDURES

Four transects were selected for seismic reflection profiles and coincident electrical resistivity profiles. Line 1 followed Edwards Street from west of Trinity Street heading east past the Memorial Lighthouse, and borehole SB-15 and ended at the intersection with Ocean Avenue and well SB-18/MW-9. Line 2 followed Stagecoach Road starting at Main Street and proceeded north for 385 feet. Line 3 ran northeast across the beach parking lot on the isthmus between Trinidad and Trinidad Head at the west end of Edwards Street and ended near well SB-16/MW-1. Line 4 ran north-south along Ewing Street, beginning at the junction with Edwards Street near well SB-13/MW-2 and continued northward for 385 feet and crossed well SB-17/MW-3.

The electrical resistivity transects were established in the same footprint as the seismic transects, but where possible the resistivity transects were extended to a length of 525 feet or greater as follows: Line 1 resistivity was extended 158 feet west of seismic Station 0, Line 2 resistivity was extended 166 feet north of seismic Station 385, and Line 4 resistivity was extended 140 feet north of seismic Station 385. Line 3 resistivity was extended 65 feet northeast of seismic Station 285. Field procedures for each of the methods are discussed below.

3.1 Electrical Resistivity Procedures

Prior to DC electrical resistivity data acquisition, the geophysics crew used a survey chain to establish the four electrical resistivity transects at the Site. Each line consisted of a linear array of electrodes spaced 4 meters apart. Once the stakes were established in the ground at each electrode location, the resistivity cable with passive electrodes was then attached to each stake with a rubber band to form the electrical circuit. Once this was done, the SuperSting cable was connected across the entire array of electrodes, recommended manufacturer system tests were conducted, and contact resistance tests were run on the electrodes to ensure good coupling between the electrodes and the ground, a necessary procedure to obtain accurate results. During this procedure, the soil at the base of the stakes was watered with a saltwater solution at each electrode location in order to lower the contact resistance. During this project, no electrode was accepted with a contact resistance higher than 1.5 kOhm. Once the contact resistance test had passed the requirements, DC resistivity data were then collected along each line using a linear array of multiple electrodes with both Schlumberger and dipole-dipole geometries. For each measurement on each line two readings were taken to allow a determination of data repeatability.

Once the data were acquired for each line, they were downloaded to a field computer, reviewed for quality and saved in a raw data file. Elevations were surveyed at each electrode station along each transect by the Spectrum crew using a surveyor's tripod and a stadia rod; these elevations were then referenced to Station 0 on each line (where Station 0 was assigned a relative elevation of 0 and subsequently tied to absolute elevations).

3.2 Seismic Reflection Procedures

Each seismic profile consisted of seventy-two 40-Hz geophones that were placed at a nominal group interval of 5-feet, with 10-feet spacing at the ends of lines 1, 2, and 4 to extend the length of these lines. In order to maximize fold all 72 channels were held live during shooting. Offset of geophones along line 4 was necessary due to a jog in

the pavement. Orthogonal arrays consisting of 6 to 11 elements were established at one end of lines 1, 2, and 3 to enable better focusing of seismic energy for accurate measurement of seismic wave velocities at greater source-to-receiver offsets.

"Whacker" in action

Prior to collecting data the Spectrum crew used a survey chain to establish the seismic lines, where each transect was marked at 5-foot intervals for its entire length. Once the lines and stations were marked and prior to field acquisition, a walkaway noise test was performed, during which different sweeps with the Urban Seismic source "whacker" were tested and compared with hammer-source impacts, and different geophone arrays were compared in order to optimally cancel ground roll. Other parameters tested were acquisition parameters such as sample rate, record length, and high and low cut filters. The hammer source was used for most of the survey after tests showed the soft soil did not enable good coupling of the "whacker" source energy into the ground (the "whacker" would compact the soil as it was design to do). For line 3 along the beach where the ground was hard, the whacker was successful in providing good SNR to image significant depths (>100 feet) in the subsurface.

Once the optimal acquisition parameters were determined for each line, seismic data acquisition followed. Seismic data were collected using a linear CMP configuration with a near-offset of 2.5 feet and nominal geophone and shot intervals of 5 feet, with additional long offsets for subsequent refraction interpretation. As previously stated, all 72 channels were kept live at all times. Such data provided nominal 36-fold data. Geophone stations were surveyed in elevation to the nearest 0.1 foot by the Spectrum crew.

4.0 DATA PROCESSING

4.1 Electrical Resistivity

The EarthImager 2D® software package (AGI, 2010) was used to interpret the data acquired with the SuperSting. First, the raw resistivity data file is entered into the program, where the data file is read; this raw data file contains information such as electrode spacing, length of transect, number of repeat measurements per electrode, and type of resistivity array. Once the data are read into EarthImager® they are reviewed for indication of erroneous or noisy data using several different interactive displays, such as plots of actual injected current, measured voltage, repeat error (which is a measure of repeatability for a given measurement) and raw resistivity associated with each measurement. Each of these displays allows the user to remove undesired or noisy data points and to save the new data file.

Once appropriate editing of a given data file was carried out, topography information was supplied to the program and the data were then sorted into finite element blocks where each block was assigned an initial resistivity value. A forward modeling algorithm that uses a non-linear least squares optimization technique was then used to first calculate apparent resistivity values that would be measured with the given array type for the starting model. The *calculated* apparent resistivity values were then compared with the *measured* apparent resistivity values, and the difference between the two used to adjust the model block values to produce a model that has a lower root-mean-square (RMS) error fit to the measured section. The program then advances through a series of iterations until an acceptable error level is reached or the model fails to improve.

The final product of the processing was a color-contoured *model section* that represents the subsurface materials along a given transect, where the final fitting error between the *calculated* pseudosection generated from the final model section and the *actual* measured pseudosection is represented as the RMS (root mean square) in percent. EarthImager also allows the user to create a customized master color scale for the resistivity values encountered at a given Site, so that resistivity values in each model section can be correlated from transect to transect and the same color (darkest blue, for instance) represents the same resistivity
value range (2 to 4 Ohm-m for example) from transect to transect.

4.2 Seismic Reflection

The seismic reflection data collected during this investigation was processed with the VISTA 11.0® software package. Special care was taken with the processing of these seismic reflection data. The hammer is an impulsive source that produces a seismic wavelet with most of the energy near the beginning of the waveform – known as a minimum-phase wavelet. In contrast, because the whacker uses a number of randomly induced ground impacts over an extended time (about 60 seconds), correlation of the recorded seismic wave energy with the source signal (recorded on the nearest geophone) produces a symmetrical waveform – known as a zero-phase wavelet. Typically,

minimum-phase source reflection data are deconvolved to produce zero-phase wavelets; however, for the shallow reflection targets of this project, inadequate SNR in the raw data (weak reflections and strong ground roll) precluded effective use of pre-stack deconvolution. The hammer data were processed without deconvolution, but fortunately the impulsive nature of the hammer strikes produces a relatively sharp "spike" that contains sufficient bandwidth for high-resolution subsurface imaging. For this survey, the bandwidth used in the final stacked and migrated data was from 40 Hz to 360 Hz.

The combination of the short receiver and shot spacing enabled acquisition of high fold for reflection seismic data processing, and substantial redundancy for refraction data analysis. The maximum fold for the reflection seismic profiles was generally about 40 (4000%). Thus, forty traces were stacked (summed) to improve the signal-to-noise ratio (SNR) for reflected acoustic waves. The fold tapers off to one (single-fold) at both ends of the lines.

The major source of acoustic noise that obscures the reflected wave energy is source-generated, i.e., the same source used to create acoustic waves for reflection from subsurface geological layers also creates coherent wave energy traveling in other directions – away from the vertical. In particular, surface waves including ground roll and airblast propagate at slow wave velocities (~560 ft/sec ground roll and 1120 ft/sec airblast). For the 5-ft shot and receiver spacing, the spatial Nyquist frequency for ground roll is about 112 Hz so that simple low-cut filtering will not allow sufficient bandwidth for stacking unaliased reflection energy. Consequently, the seismic reflection data processing required use of a mute to eliminate the slow airblast and ground roll surface wave energy. For the shallow reflections of interest, the refracted wave energy (wide-angle reflections) also must be muted out so that only the short offset seismic traces are stacked at the shallowest depths (two-way travel times less than about 50-75 msec). The actual fold for the shallow reflections is reduced accordingly (~8-16). At the shallowest levels, some ground roll may be present, so in-line receiver arrays were used in the processing to attenuate this ground roll further. Where possible, wide source arrays were used to increase the directivity of the acoustic energy in the vertical direction and attenuate the surface wave energy.

Seismic velocity structure must be determined for removal of normal-move-out (NMO) before stacking and for migration of the final stacked data. Shot and receiver geometry were setup in the seismic trace headers including horizontal positions and relative elevations. The vertical datum was set at a level near or slightly above the highest shot or geophone elevation along the profile. Velocity analysis to determine the subsurface velocity structure was performed on the seismic traces after correcting for the relative elevation differences between source and receiver positions. Based on refraction analysis of linear moveout on shot records and preliminary stacking velocity analysis for reflections, a weathering velocity (near-surface alluvium) of 1800 ft/sec was used for the elevation "statics" correction. Due to the complex character of the subsurface geology, with high velocity Franciscan bedrock including sea stacks or fault blocks buried by low velocity Late Quaternary and Holocene alluvium, few coherent reflections could be identified in the raw shot records. The pre-processing including array forming enhanced some reflections, in particular the bedrock reflection and possibly the top of the water table where seismic velocities jumped from around 800 ft/sec to about 5000 ft/sec due to water saturation.

The final processing steps included NMO correction, stacking, and migration (frequency-wavenumber, FK) to produce the seismic image for interpretation. A constant velocity of 1880 ft/sec was used for the migration as this represented a reasonable average velocity of the shallow alluvium. More detailed velocity structure could be used for migration, but significant effort in developing an accurate velocity model is required and the simple constant velocity model provides a good image of the alluvium above the bedrock and water table. For the shallow depths involved, errors in depths to significant reflection horizons is minor compared to the smearing of reflection horizons by 3-D effects (sideswipe) and limited bandwidth. In addition, due to the slow velocities in the dry alluvium, some spatial aliasing is apparent, especially where the geophone and shot spacing exceeded the nominal 5 feet. This aliasing appears as a "checkerboard" pattern in the seismic image, most noticeable near the ends of the profiles where the longer geophone spacing was used. Notwithstanding, the strong low-frequency component of the significant reflection horizons stands out to allow interpretation across the profile and into these areas.

Once processed, subsurface reflection seismic sections were interpreted for key reflectors and subsurface features of interest. During this stage, the velocity analysis results and ties with key boreholes and wells were used to ensure a match between geologic/hydrogeologic interfaces and seismic reflectors. The final product of the seismic processing was a 2D seismic section for each line with labeled key reflectors and interpreted features of interest.

5.0 INTERPRETATION

5.1 Electrical Resistivity

The final model section for a given transect (the image in the resistivity profiles) contains the inverted resistivity distribution which best represents the actual lateral and vertical variation of earth resistivity beneath the ground surface along that transect, which is the final result of the iterative inversion process. It is from the model sections that inferences were made regarding depth to bedrock, structural features, and interpreted seastacks. Each transect had at least one tie point where GHD borings or wells intersected it. Careful review of the boring logs for these tie points was completed in order to allow correlation of resistivity values with known lithology.

During generation of the best-fit model resistivity section, the EarthImager® program creates a standard color scheme that represents the range in resistivity of the calculated model section, where the lowest resistivity values (in this case 2 to 4 Ohm-meters) are assigned a dark blue color and the highest resistivity values are assigned a red color. In order to facilitate discussion of resistivity values and to compare and contrast between transects, this standard color scheme was modified and used to create one standard color scheme (colors ranging from dark blue to green to gold to brown to dark red and resistivity values ranging from 2 to 5000 Ohm-meters) for all of the model sections generated for this project. Interpretations of the resistivity values were made by plotting known lithologies on the model sections at the appropriate tie location and determining what corresponding range of resistivity values was indicated. Depths to Franciscan bedrock were plotted for each boring location and a close-as-possible depth match was made to tie points by adjusting the depth factor in Earth Imager.

In order to identify the overlying terrace deposits/Franciscan bedrock interface using the electrical resistivity model sections, experience at similar sites was used. Given that the nature of bedrock in this area is the Franciscan Complex which generally consists of a sheared siltstone, mudstone or sandstone the interpretation of depth to bedrock on a given transect was made by identifying the depth at which an obvious decrease in resistivity occurred in the sections, where generally the resistivity of overlying soils was 1000 to 3000 Ohm-meters (dark brown to red colors in the model sections) and the top of the Franciscan was 460 Ohm-meters (olive green color) where the contact was a sandstone and 200 Ohm-meters or less (gold to grey colors) where the contact was a sheared siltstone. Interpretations of buried seastacks were made based on the assumption that these features would primarily be associated with abrupt changes in the topography of the bedrock surface. A brief discussion of results on a line by line basis may be found in Section 6.0.

A breakdown of resistivity values and the materials that these values could be associated with may be found below.

Resistivity

- Resistivity values ranging from 2 to 9 Ohm-meters (dark blue to deep blue to light blue) are considered very low resistivity values that may be associated with Franciscan mudstone or highly weathered and sheared siltstone

- Resistivity values ranging from 10 to 97 Ohm-meters (green to dark green to yellow green to grey) are considered low to moderate resistivity values that may be associated with weathered Franciscan greywacke, where values approaching 97 Ohm-meters have greater amounts of silt and lesser amounts of clay type material in the matrix

- Resistivity values ranging from 100 to 312 Ohm-meters (gold to yellow) are considered moderate resistivity values that may be associated with well to poorly graded sands in the terrace deposits or with Franciscan siltstone or sandstone where values approaching 312 Ohm-meters have greater amounts of sand and lesser amounts of silt in the matrix

- Resistivity values ranging from 313 to 460 Ohm-meters (olive green color) are considered moderately high resistivity values that may be associated with terrace deposits or with the top of Franciscan bedrock where the bedrock consists of sandstone or sheared siltstone

- Resistivity values ranging from 460 to 678 Ohm-meters (light brown) are considered high resistivity values that may be associated with sands in the terrace deposits or with the top of Franciscan bedrock where this contact consists of a sandstone or siltstone

- Resistivity values ranging from 679 to 5000 Ohm-meters (dark brown to orange to red colors) are considered high to very high resistivity values that may be associated with coarse grained terrace sands where values approaching 3000 to 5000 Ohm-meters are very coarse grained and many have higher amounts of gravel in the matrix

5.2 Seismic Reflection

Seismic interpretation requires understanding that the seismic profile represents a seismic wavefield image of the subsurface geology – the seismic profile is not a direct geologic cross-section but an interpreter with geological knowledge must pick what are real stratigraphic and structural features in the subsurface. For the hammer data, which involve minimum-phase wavelets, horizon picks should fall at the beginning of a waveform, or at the zero crossing between positive and negative wave peaks. Because the lines are short, the seismic image is presented as a wiggle trace overlying a variable density background with color representing amplitude and polarity of the waveforms. Most geological strata are relatively flat-lying near the surface for young sediments, especially on the sub-horizontal surfaces represented by erosional marine terraces as exist in Trinidad and elsewhere in the coastal areas of California. As observed on the beach, there may be sea stacks of widely varying sizes, and there may be boulders scattered on the former beach or erosional terrace surface. Channels eroded into the wave-cut terrace, composed of Franciscan bedrock, are also likely to be present – these may have been cut by ancient streams after the terrace was uplifted by tectonic activity, or the channels may be related to coastal streams active when the terrace was cut. In the tectonically-active area of northern California, where the Cascadia Subduction Zone produces major earthquakes with large coastal uplift, shallow faulting is expected. Faults are identified by systematic offset of the sub-horizontal reflections in the seismic profile.

The final migrated seismic profiles were prepared as Depth sections using the velocity model described above. The datum elevation at the zero depth line is identified at the upper right of each profile. The vertical scale on the left side of each seismic profile shows the elevation relative to Mean Sea Level (MSL), whereas the scale on the right side shows the depth below the datum (vertical reference level) used for seismic processing. The horizontal scale at the top of each profile shows the station distance (feet) and the CMP number derived from processing. The station values correlate with those used in the electrical resistivity profiles.

Borehole and well data from the area were plotted on the seismic profiles at the appropriate scale and location to correlate geological horizons in the borehole logs to prominent reflections apparent in the seismic image. The most prominent reflection horizon is the top of the Franciscan bedrock identified by the purple lines on the seismic profiles. The seismic character of this reflection is at the zero crossing below a strong positive (black) reflector above an equally strong negative (red) reflector. The reflections below the bedrock interface appear broader due to lower frequency content (attenuation of high frequencies with depth and high seismic velocities that produce longer wavelengths for the set frequency bandwidth. The bedrock surface is irregular for all of the profiles due to tectonic and erosional processes. In some areas prominent reflectors appear to sag into deeper layers. These are interpreted as buried channels (paleochannels) associated with sub-aerial streams cut during sea level lowstands and filled by subsequent sea level rise.

Immediately above the bedrock surface, alluvial strata consisting of coarse sands, gravels, cobbles and possibly boulders and weathered bedrock exist as a lag deposit and produce the variably-colored reflectors at the base of the strong positive waveform. This coarse layer was identified in several of the borehole/well logs (e.g., SB-2/MW-6). Multiple bands of positive and negative reflection energy are apparent in the seismic profiles above the bedrock interface. These are interpreted to represent multiple layers of fine sands, silty-sands, silts and possibly clay that are also recognized in well logs. Two prominent horizons have been interpreted (yellow and green). The shallow yellow horizon follows the zero crossing below the uppermost strong positive reflector and above another strong negative reflector. The green horizon is interpreted at the top of the strong positive reflector above the bedrock surface – this horizon appears to follow the top of the groundwater based on the well logs.

6.0 RESULTS

The electrical resistivity model sections for Lines 1, 2, 3 and 4 are presented in Figures 2, 4, 6 and 8, respectively. The seismic reflection profiles for Lines 1, 2, 3 and 4 are presented in Figures 3, 5, 7 and 9, respectively. A discussion of results on a line by line basis is contained below.

6.1 Line 1

6.1.1 Electrical Resistivity

In Figure 2, the colors represent values of electrical resistivity in Ohm-meters. The numbers along the horizontal axis at the top of each model section represent distances along the transect in units of feet. The numbers along the vertical axis of each section represent elevation in MSL – feet.

The model section in Figure 2 contains the inverted resistivity distribution which best represents the actual lateral and vertical variation of earth resistivity beneath the ground surface along Line 1, which is the final result of the iterative inversion process. It is from this model section that interpretations were made regarding the depth to Franciscan bedrock and the locations of buried seastacks. The ties for top of sandstone bedrock for GHD boring SB-15 and GHD well MW-9 are indicated in Figure 2. Review of the boring logs for these tie points was done in order to correlate resistivity values with known lithology.

The resistivity data collected along Line 1 were mostly of high quality, although the effects of the utilities near the Memorial Lighthouse and at the east end of Line 1 needed to be removed from the raw pseudosections before a valid inversion of the data could be run. Both Schlumberger and dipole-dipole data sections were reviewed, and ultimately it was decided that a merged data set containing both the Schlumberger and the dipole-dipole data collected provided the highest confidence in an inversion result that was representative of the subsurface. Therefore, bedrock interpretations were made from the inversion results of this merged file.

The elevation of the top of bedrock along Line 1 was interpreted based on a decrease in resistivity from 678 - 1000 Ohm-meters (light brown to brown) to 460 Ohm-meters (olive green color) in the model section. Based on this, the bedrock surface appears to be relatively flat between at least Station 40 to Station 140, where the elevation of the top of bedrock ranges from 111 to 105 feet MSL. At approximately Station 150 the elevation of top of competent bedrock drops to about 83 feet MSL; a sub-vertical fracture in bedrock that may continue to elevation 65 MSL is interpreted at Station 150. Continuing to the east the bedrock surface rises back to elevation 118 feet MSL between Stations 200 and 250. A paleochannel is interpreted between Stations 250 and 310: a bedrock low is indicated between Stations 280 and 295, where the bedrock elevation drops to between 106 and 107 feet MSL. At about Station 300 there is a sharp (10-foot) rise in the bedrock surface, where it continues to rise eastward between Stations 310 and 380, where it peaks at elevation 150 MSL, just 19 feet below ground surface. A buried seastack is interpreted between Stations 310 and at least 390; the boring tie with SB-15 at Station 400 indicates that bedrock is still high at this location (23 feet to hard sandstone bedrock); although the resistivity-interpreted top of bedrock contour indicates a sharp drop in bedrock elevation to 110 feet MSL at Station 400. Regardless, east of Station 400 the bedrock surface continues to drop to a low of 101 feet MSL at Station 425. Another rise in bedrock occurs between Stations 440 and 470, where the bedrock surface peaks at elevation 127 feet MSL; thereafter it appears to drop back down to at least elevation 120 feet MSL at Station 485. East of Station 485 the electrical resistivity solution is not well constrained because there is a lack of data at depth; however, the model section does indicate a possible east-dipping fracture in bedrock in the depth range of the water table at MW-9 between Stations 490 and 500.

6.1.2 Seismic Reflection

The seismic reflection profile for Line 1 is presented in Figure 3. A prominent bedrock uplift or sea stack is interpreted along the central part of Line 1. This feature corresponds to the shallow bedrock (23 feet depth) encountered in SB-15 and the deeper (70 feet) channel (?) at the east end of the profile sampled by SB-18/MW-9. . This shallow feature appears to continue east along the profile beneath SB-15, where hard sandstone was encountered, and gets deeper until truncated and offset by a fault inferred near Station 484'. The bedrock interface is interpreted to drop down about 40 feet across a normal-separation fault. This drop in bedrock elevation is located about 100 feet east of the interpreted drop on the electrical resistivity profile. Farther east, near Station 510' basement is observed to rise on the electrical resistivity data. The high electrical resistivity apparent in the area where basement remains shallow in the seismic and borehole data may result from a change in bedrock composition. The broad concave-downward reflector (black) above the bedrock interface appears to be repeated about 20-ft deeper, that suggests a multiple reflection consistent with the hard (strongly reflective) bedrock-alluvium interface.

The groundwater interface interpreted as the green horizon is deep (about 110-ft MSL) on the east and west ends of the profile and absent in the middle above the sea stack. Shallow layers in the alluvium above bedrock appear to

correlate with strongly oxidized layers in the borehole. The thicker alluvial section above bedrock at the east end where SB-18/MW-9 is located may represent a channel fill sequence above a fault-controlled trough. Further analysis is needed on this complex profile. Further analysis is needed on this complex profile.

6.2 Line 2

6.2.1 Electrical Resistivity

The model electrical resistivity section for Line 2 is presented in Figure 4. The raw resistivity data collected along Line 2 were somewhat noisy; although the effects of the utilities at the junction of Main and Stagecoach were readily observed in the dipole-dipole data and removed. Several inversions were attempted with both the dipole-dipole and Schlumberger data and a general comment for this area is that the subsurface is highly complex along Line 2, with several fault zones and at least one paleochannel indicated (Figure 4). After much comparison and numerous attempts to match the resistivity results to the reflection interpretations, it was decided that a merged data set of both Schlumberger and dipole-dipole data would provide the highest resolution of the complex features along Line 2. Final interpretations of bedrock and structural features were made from inversion of this combined data file.

The resistivity profile for Line 2 exhibits many areas of sharply contrasting resistivity, indicating complex geology and tectonics on this line. The bedrock tie for MW-6 was good, where top of weathered siltstone bedrock is marked by a drop in resistivity from 1000 Ohm-meters (dark brown) to a resistivity value between 460 and 678 Ohm-meters (light brown). Interpretations along Line 2 were made based on a review of the multitude of inversions that were run on the data: individual Schlumberger, individual dipole-dipole, and the combined data.

A possible high-angle fault is indicated at Station 40 on Line 2; because the data are not well resolved south of Station 40 and no bedrock surface is indicated, the extent of this fault cannot be determined. Between Stations 40 and 92, the bedrock surface slopes to the north from 138 feet MSL to 129.5 feet MSL. Immediately north of Station 92 the bedrock surface drops 40 feet: a south-dipping thrust fault is indicated between Station 93 and 127, where the bedrock elevation ranges from 82 feet MSL at Station 100 to a low point of 79 MSL at Station 106. At Station 111 bedrock takes a sharp rise to 103 feet MSL, where it continues to rise to 119 feet MSL at the well tie with MW-6. The bedrock elevation rises to a high of 121 feet MSL at Station 145, whereupon it slopes down to 111 feet MSL at Station 176. A north-dipping normal fault is indicated at Station 176, where the bedrock drops at least 10 feet on the downthrown block. A thrust-fault-controlled, sediment-filled paleochannel is interpreted between Stations 176 and 270 where the bedrock surface at the bottom of the channel at Station 223 is approximately 63 feet MSL. The bedrock surface rises at least 30 feet from Station 267 to Station 268, where the bedrock elevation is 96 feet MSL. North of the paleochannel bedrock continues to rise to a high of 136 feet MSL at Station 335. A north-dipping fault is indicated between Stations 338 and 348, where the bedrock elevation drops to 130 feet MSL. North of this the bedrock surface is relatively flat until Station 375, where it takes a sharp rise to a high of 141 feet MSL at Station 392. An infilled fissure is indicated between Stations 392 and 418, where bedrock drops to a low of 121 feet MSL at Station 410. The bedrock surface then slopes from 142 feet MSL at Station 418 to 129 feet MSL at Station 448. A fault zone is interpreted between Stations 448 and at least 510: this fault zone is bounded on the south by a vertical fault at Station 448, interpreted based on a sharp increase in resistivity and a drop in bedrock elevation to 125 feet MSL by Station 455. Bedrock takes a sharp rise to 136 feet MSL at Station 478, and then continues to rise to at least 146 feet MSL by Station 505. The bedrock surface is not well resolved north of Station 505, although it appears to continue to rise north of this.

6.2.2 Seismic Reflection

The seismic reflection profile for Line 2 is presented in Figure 5. A 250-300-ft wide sag apparent on Line 2 is interpreted to represent the buried valley cut into bedrock that has been partially filled, but still exists in the modern topography. The bedrock structure appears to consist of at least three fault-bounded blocks. The southern block is high with elevation reaching about 140-ft MSL near Station 40' and appears to be relatively horizontal or slightly warped upward at the bedrock interface. The central block is lower with elevation down to about 120-ft MSL and shows a slight sag toward the middle near Station 140'. The northern block is tilted down to the south with elevation change from about 120-ft MSL rising to about 140-ft MSL near Station 330'.

Major faults appear to control the location of the valley, cutting through the bedrock and into the deeper alluvium. A small south-dipping thrust fault appears to cut through borehole SB-2/MW-6 at a depth of 37-40 ft (elevation 127-130 ft). This fault may intersect the steep normal-separation fault between Stations 60' and 70' forming a "flower structure" often associated with strike-slip fault zones. Normal separation is apparent on the northern fault, which

lies within about 500 feet of the Trinidad fault. This may be a fault splay that accommodates some component of strike-slip as these faults evolve from subduction-induced thrusting into right-slip associated with the northward-migrating Mendocino Triple Junction and the San Andreas fault system. The southern fault may also exhibit normal separation, but the aliased data to the south obscure the offset character.

Within the shallow alluvium on Line 2, the groundwater interface (green horizon) follows the broad sag at the basement interface and topographic valley, except for a vertical offset of about 5-6 ft at the thrust fault near SB-2/MW-6. Reflection sequences of several thin layers appear in the alluvium above the groundwater interface, which may represent interfingering and overlapping sediment sequences resulting from migrating channels within the valley fill. There may be buried paleosols that formed during various sea level lowstands during the progressive tectonic uplift of the coastal terrace, too. The yellow horizon follows one of the more continuous shallow layers, which may be offset by the thrust fault, indicating Late Quaternary faulting. Aliasing obscures the details of the stratigraphy and structure on the two ends of the profile, although another fault may exist near Station 350' at the north end where the reflectors appear to flatten.

6.3 Line 3

6.3.1 Electrical Resistivity

The model resistivity section for Line 3 is presented in Figure 6. The resistivity data collected along Line 3 were of extremely high quality; there were no effects from utilities or other subsurface interferences in the data. Both Schlumberger and dipole-dipole data sections were reviewed, and while the model sections were similar it was decided that a merged data set containing both the Schlumberger and the dipole-dipole data collected provided the highest resolution of subtle features both at the bedrock surface and within the Franciscan bedrock. Therefore, bedrock interpretations were made from the inversion results of this merged data file.

The elevation of the top of bedrock along Line 3 was interpreted based on a decrease in resistivity from 150 - 200 Ohm-meters (gold color) to between 66 and 97 Ohm-meters (grey color) in the model section. Based on this, the bedrock surface appears to be relatively flat between at least Station 80 and Station 200, where the elevation of the top of bedrock ranges from 3 and 5 feet MSL. At the southwest end of the line a drop in the bedrock surface is indicated and although it is not well resolved there may be a high-angle fault at Station 49, where apparent termination of layers within the Franciscan is evident. To the northeast there appears to be a drop in the bedrock surface from Station 200 (5 feet MSL) to Station 240 (-4 feet MSL); a high angle fault is interpreted at Station 218, as indicated in Figure 6. The bedrock surface appears to rise again between Stations 260 and at least 313, where the bedrock elevation is approximately 3 feet MSL. A fault is interpreted at Station 313 based on a termination of the 66 to 97 Ohm-meter (grey) layer. Although the type of fault is not well resolved it may be a low-angle thrust fault as the elevation of bedrock drops approximately 3 feet at the tie to well MW-1.

6.3.2 Seismic Reflection

The seismic reflection profile for Line 3 is presented in Figure 7. Line 3 was acquired using the "Whacker" source, so that the reflection data consist of zero-phase wavelets. The horizon "picks" follow the peaks or troughs of the strong reflection energy rather than the zero crossings used for minimum phase data. In general, the subsurface structure appears relatively simple and flat-lying compared to the other profiles. A small channel (25-30-ft wide), possibly controlled by some high-angle faulting at the northeast end of the profile is interpreted (near Stations 250'-275'). In addition, a prominent low-angle fault, possibly related to ancient subduction structure, is inferred within the Franciscan bedrock. This feature may be oblique to the profile so that the true dip is steeper – the reflections that align with this feature appear to cut across the relatively horizontal layers, typical of offline reflections (side-swipe). Two faults with steep dip appear on the northeast end of the profile, near Stations 220' and 270'. The northeast splay appears to steepen with dip to intersect the other faults at about elevation -90-ft MSL.

The reflectors in the shallow alluvium includes the inferred groundwater interface, which appears to dip into the paleochannel at the northeast end of the profile. There appears to be a thicker alluvial section at the southwest end of the profile, which may be related to mass wasting and landsliding from the adjacent Trinidad Head highland. The shallow yellow horizon is relatively flat, with a slight upwarp at the south end and a possible bulge above the northeast paleochannel deposit. The latter feature may result from differential compaction above a more coarse-grained channel fill between fine-grained sands and silts or older paralic (coastal shelf) deposits.

6.4 Line 4

6.4.1 Electrical Resistivity

The model resistivity section for Line 4 is presented in Figure 8. The resistivity data collected along Line 4 were generally of good quality and there is a high degree of confidence in the interpretation of top of Franciscan bedrock. As in Line 3, both Schlumberger and dipole-dipole data sections were reviewed, and while the model sections were similar it was decided that a merged data set containing both the Schlumberger and the dipole-dipole data collected provided the highest resolution of subtle features both at the bedrock surface and within the Franciscan bedrock. Therefore, bedrock interpretations were made from the inversion results of this merged data file.

Based on the tie with well MW-3, the elevation of the top of bedrock along Line 4 was interpreted based on a decrease in resistivity from 460 - 678 Ohm-meters (light brown) to between 312 and 460 Ohm-meters (olive green color) in the model section. The bedrock elevation at Station 45 is 64 feet MSL; continuing to the north the bedrock surface slopes down to about Station 100 where the bedrock elevation is 54 feet MSL. A paleochannel is interpreted between Stations 100 and 160, where a bedrock low of 42 feet MSL is apparent at Station 131. The bedrock surface takes a gradual rise from Station 160 (57 feet MSL) to Station 200 (63 feet MSL), whereupon it slopes down to the north to a low point of 56 feet MSL at Station 228. A zone of high-angle faulting is interpreted between Stations 237 and 278, where the bedrock surface rises to a high of 73.5 feet MSL at Station 278. Between Stations 280 and 375 the bedrock surface drops from 73 feet MSL to a low point 60 feet MSL. North of Station 280 the bedrock surface rises to a high of 70 feet MSL at Station 425. Although it is not well resolved a north-dipping fault is interpreted at about Station 474, where the bedrock surface north of Station 474 takes a sharp rise from 73 feet MSL to at least 86 feet MSL at Station 490.

6.4.2 Seismic Reflection

The seismic reflection profile for Line 4 is presented in Figure 9. A prominent paleochannel appears just below the ground surface near the middle of line 4 (Stations 180'-230'). The shallow layers on the southern half of the profile are relatively thin, whereas a thicker sequence appears north of the channel. The thicker sequence may be related to landsliding in the area. At depth, a set of three downward convergent faults are interpreted, which may provide structural control for the channel location. The fault pattern resembles "flower" structure (Harding, 1985), which may indicate a component of strike-slip, especially considering the lack of systematic vertical separation across the zone. The bedrock surface is gently undulating from about 50-ft to 70-ft MSL across the profile. The fault zone between Stations 170' and 260' creates greater disruption of the bedrock surface, although there may be deeper paleochannels that further complicate this interface.

The inferred groundwater interface (green horizon) lies generally parallel to the bedrock surface except for a small bulge above another small possible paleochannel near Station 90' at about 66-ft MSL. The shallow horizon (yellow) is interpreted to form the base of the main channel near the middle of the profile. This layer is relatively smooth and gently-dipping to the south rising from 85-ft to about 94-ft MSL at the south edge of the channel. To the north of the channel, the shallow layer appears to be arched upward to about 105-ft MSL and then drops into a second small paleochannel near Stations 320' to 350'.

7.0 LIMITATIONS

7.1 Electrical Resistivity

In general the electrical resistivity data collected during this project were of very high quality. Although there was some interference from utilities along Lines 1 and 2, every effort to remove these effects from the data was made. The merged Schlumberger and dipole-dipole data sets allowed for extremely high resolution and high sensitivity to the lateral and vertical contrasts in resistivity at the Site. In terms of being able to distinguish the top of bedrock contact from the overlying terrace deposits electrical resistivity is considered a success as in almost every case a drop in resistivity was observed at the bedrock contact.

The sources of error in the resistivity method to detect the top of bedrock contact come in to play where the resistivity of the actual Franciscan material varies, in addition to whether it is a weathered or sheared contact or a competent contact on any given transect. Because of the variable nature (e.g. sandstone vs. siltstone vs. mudstone) of the Franciscan Complex at the Site and the sensitivity of the resistivity method to grain size the resistivity value

of the bedrock contact also changed depending on which portion of the Site the data were acquired on – as was evident based on the resistivity value used to assign the top of bedrock between say Line 1 and Line 3. One key assumption was that top of Franciscan bedrock was essentially the same resistivity value or range of values for any given line. Ultimately the assignment of top of bedrock contact from resistivity values was made based on well or boring ties as well as experience; however, because of this limitation the top of bedrock contact may be in error by as much as 5 feet along these lines. The lateral boundaries of features of interest may also be in error somewhat; although every effort was made to minimize this error during the iterative inversion process. Generally the lateral resolution of the resistivity method is ½ the electrode spacing in the upper third of the section: in this case that corresponds to +/- 2 meters (6.6 feet) for defined features such as faults and paleochannels. One exception to this case occurred along Line 1 at the tie to boring SB-15: the boring indicated sandstone bedrock 23 feet below ground surface at this location, corresponding to a bedrock elevation of 148 feet. The electrical resistivity data do not indicate a "bedrock" resistivity value (i.e. 460 Ohm-meters or less) in this location; however, the location of SB-15 is just east of a prominent seastack, and it may be that the resistivity finite element mesh is not fine enough to accurately depict the changes occurring where there is a sharp vertical boundary in the bedrock surface. Alternatively, there is a high resistivity value indicated at the bedrock tie for SB-15 and boring log indicated hard sandstone in this location: 678 to 1000 Ohm-meters is not at all outside of the range for a sandstone.

The lateral resolution can be considered somewhat higher in the near surface because electrical resistivity interpretations were cross-checked with seismic reflection interpretations. As is common in the electrical resistivity method the vertical resolution decreases significantly in the bottom third of the section, and where the depth to bedrock approaches 70 feet or more the actual elevation may be in error by 10 feet or more. Finally, the resistivity method is limited on either end of each profile because of the taper-off effect of the data points, so that in areas where the bedrock was expected to be deeper than the data were capable of measuring the resistivity method was not able to detect it.

7.2 Seismic Reflection

Seismic reflection profiles provide an image of the acoustic (p-waves) wavefield reflected from subsurface geology. Data are recorded in two-way travel time and must be converted to depth using the appropriate seismic velocity versus depth information. Multichannel seismic reflection profiling using the common-depth-point method (CDP) obtains an estimate of the seismic velocity structure with the shot and multichannel receiver (geophone) arrays. A constant velocity of 1800 ft/sec was used to migrate the seismic data to an appropriate depth based on the velocity analysis performed during seismic data processing. This velocity represents a reasonable average for the dry alluvium, but is lower than the velocity below the water table and the velocity of competent bedrock. The borehole data available for this survey showed good correlation with the seismic profiles. The depth to Franciscan bedrock appears to be within about 5-ft of the measured depth. The interpreted depth to the top of the water table deviates from that observed in the boreholes, but this may result from seasonal fluctuations. Depths to features below the bedrock/alluvium interface are poorly constrained due to lack of good velocity data from the CDP processing. Bedrock velocity structure may be obtained from detailed analysis of the seismic data using refraction methods – the dense array of seismic data acquired are appropriate for such analysis with sufficient time and budget.

The seismic survey is two-dimensional (2-D) based on data acquisition along a linear transect. In areas of complex geology, three-dimensional structure produces seismic reflections from the side of the profile as well as from directly below the transect. The seismic profile is complicated by reflections arriving from the side (side-swipe) that overlap and obscure the reflections from directly below that are the objectives for interpretation. Furthermore, for non-horizontal layers, the seismic reflections arrive at the receiver (geophone) array at off-vertical angles so that the depth inferred using a seismic velocity estimate for flat layers misplaces the true depth (and horizontal position) of the reflection layer. Exploration seismology for the petroleum industry has shifted to 3-D seismic data profiling to address these issues. Although the cost rises dramatically for 3-D seismic, the improvement in subsurface geological interpretation leads to greater drilling success that translates into major cost savings (and return on the investment).

Time and budget limited the acquisition footprint and array size (only 72 channels) for the seismic survey. The group interval (spacing between geophones) varied from 5-ft to 10-ft, which resulted in a spatial Nyquist frequency of about 110 Hz for the very low seismic velocities in the alluvium. This produces aliasing in the data during processing, which appears as the "checkerboard" pattern on the ends of the seismic profiles where the geophone spacing was larger (10-ft). Resolution of subsurface features is reduced by low-pass filtering to remove the aliased frequencies, so that a compromise was made to provide reasonable resolution while allowing some aliasing to occur. Low frequency seismic reflections can be followed through the areas where data are aliased, but lateral resolution and interpretation confidence is reduced in these areas located near the ends of the profiles.

RECOMMENDATION:

A more thorough seismic refraction analysis, especially on key transects (#1, #2), should provide a more accurate seismic velocity structure within alluvium and upper bedrock material. The refraction analysis will also provide an independent estimate of the depth to bedrock that may add confidence to the seismic reflection and electrical resistivity profile interpretations. The improved seismic velocity data may be used to re-migrate the seismic reflection data and obtain more accurate depth converted seismic profiles. Finally, some 3-D subsurface information may be obtained by using the offset geophone arrays at the ends of profiles 1, 2, and 3 for 3-D processing as a narrow 3-D swath profile.

8.0 REFERENCES

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Paper Size 11" x 17" (ANSI B)

0 100 200 300 400 500 600

Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

O

! Soil Boring

A Monitoring Well

A Preexisting Monitoring Well

Transect

City of Trinidad
Trinidad ASBS Stormwater Phase 1

Job Number	0106311005
Revision	A
Date	15 Oct 2012

Site Map, Geophysical Transect, Boring and Monitoring Well Locations

Figure 1

G:\01063 City of Trinidad\01063-11-005 Trinidad ASBS Stormwater Ph1\08-GIS\Maps\Working\F1_Site_Map_Spectrum.mxd

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Data source: Bing, Aerial Maps, 2012. GHD Inc., Field Points, 2012. Created by:rscrow

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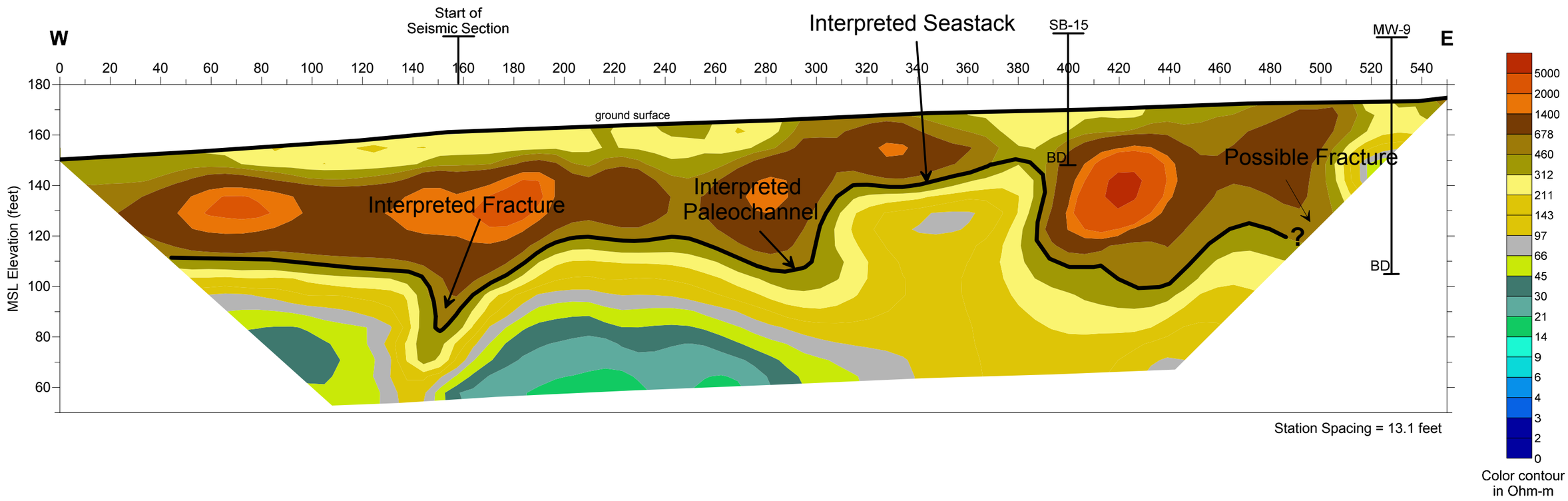
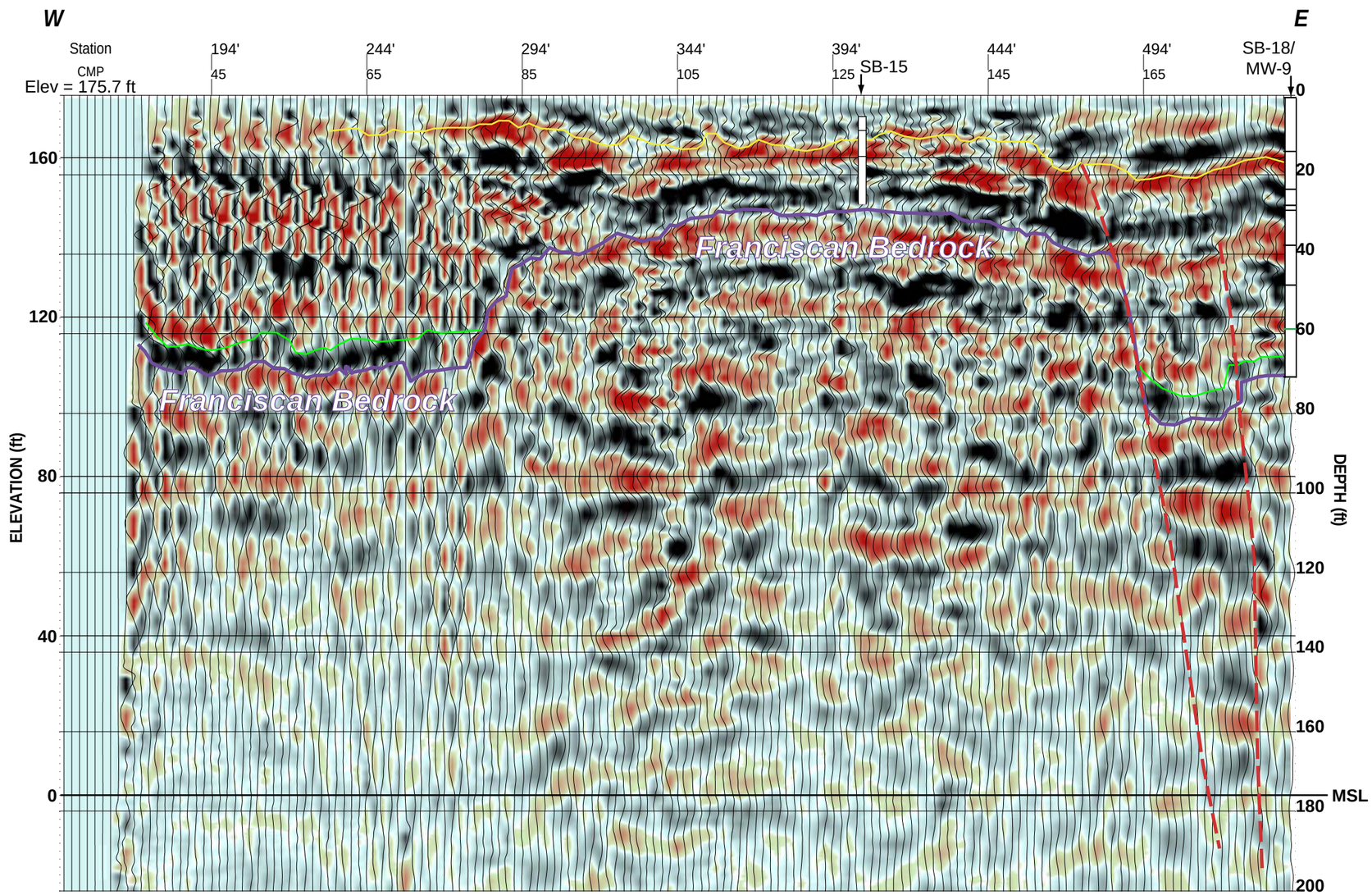


BD Boring Bedrock Elevation

Interpreted Top of Bedrock

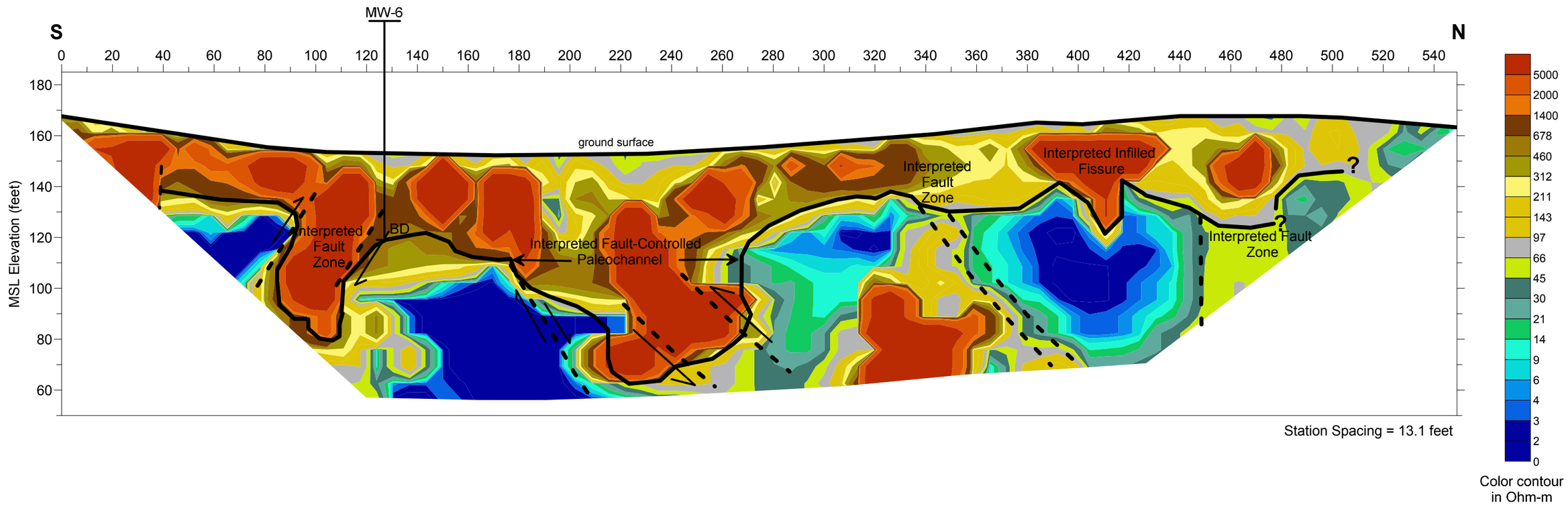
SPECTRUM GEOPHYSICS "Revealing The Subsurface"	**Electrical Resistivity Profile - Line 1**			FIGURE NUMBER **2**
	PROJECT: Geophysical Investigation Trinidad, CA			
2727 Croddy Way, Unit I Santa Ana, CA 92704 (714) 435-1073 www.spectrum-geophysics.com	PREPARED FOR: GHD Eureka, California			PROJECT NUMBER 1208081L
	SCALE: 1 inch = 40 feet	FIGURE BY: BAU	REVIEWED BY: LCD	DATE 10/10/12



Edwards Street

TRN-01 FKmig Depth 1880fps EnsMix StakVmix [Test2D] Page 1 Mon Sep 24 17:01:51 2012

Geophysical Investigation Trinidad, California	
Figure 3	Seismic Profile 1 - Edwards St
Legg Geophysical, Inc. Huntington Beach, CA	VERSION 1.0 15 October 2012



BD Boring Bedrock Elevation

Interpreted Top Of Bedrock

SPECTRUM GEOPHYSICS "Revealing The Subsurface"

2727 Croddy Way, Unit I
Santa Ana, CA 92704
(714) 435-1073 www.spectrum-geophysics.com

Electrical Resistivity Profile - Line 2

PROJECT: Geophysical Investigation, Trinidad, CA

PREPARED FOR: GHD, Eureka, California

SCALE	FIGURE BY	REVIEWED BY	DATE
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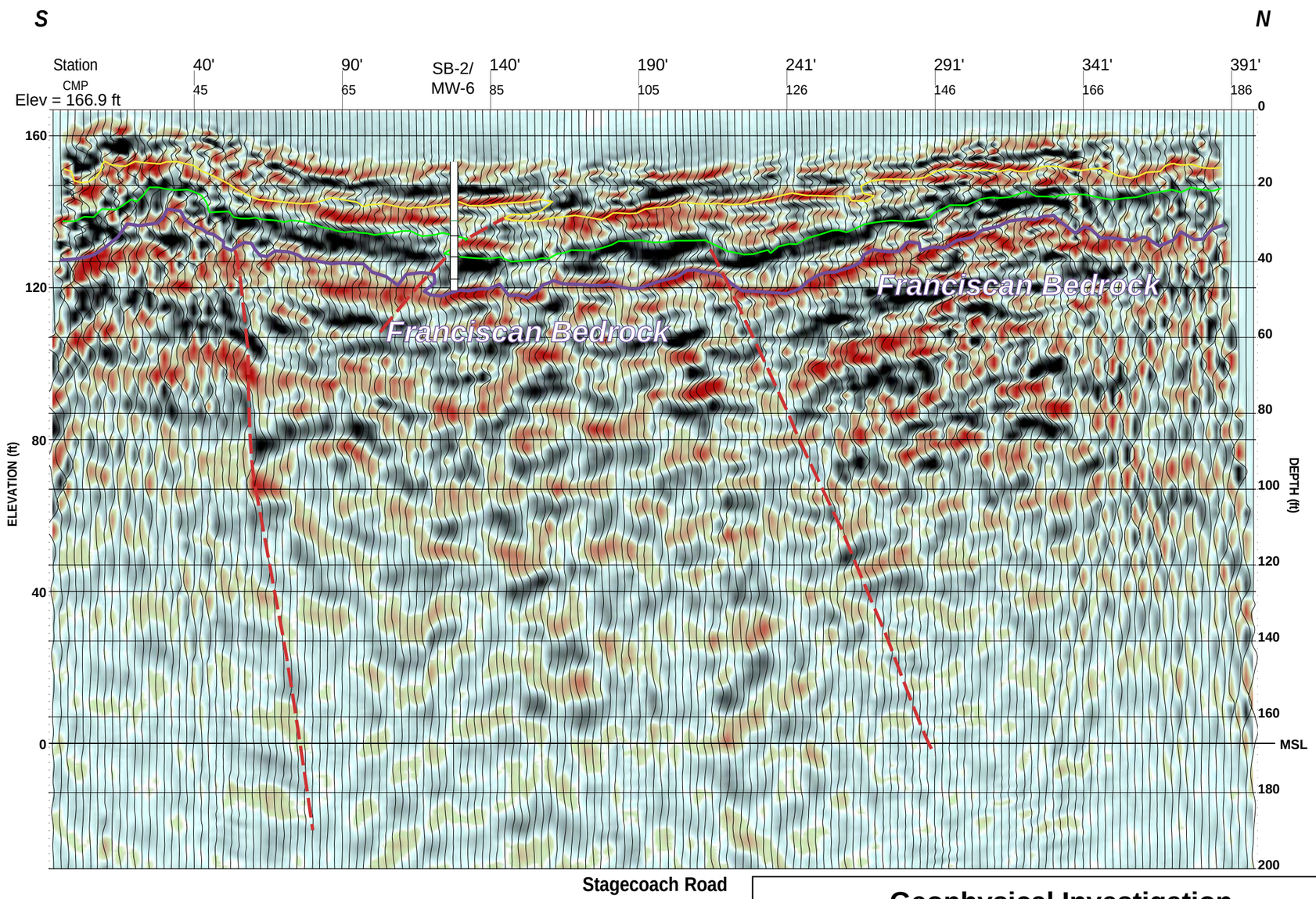
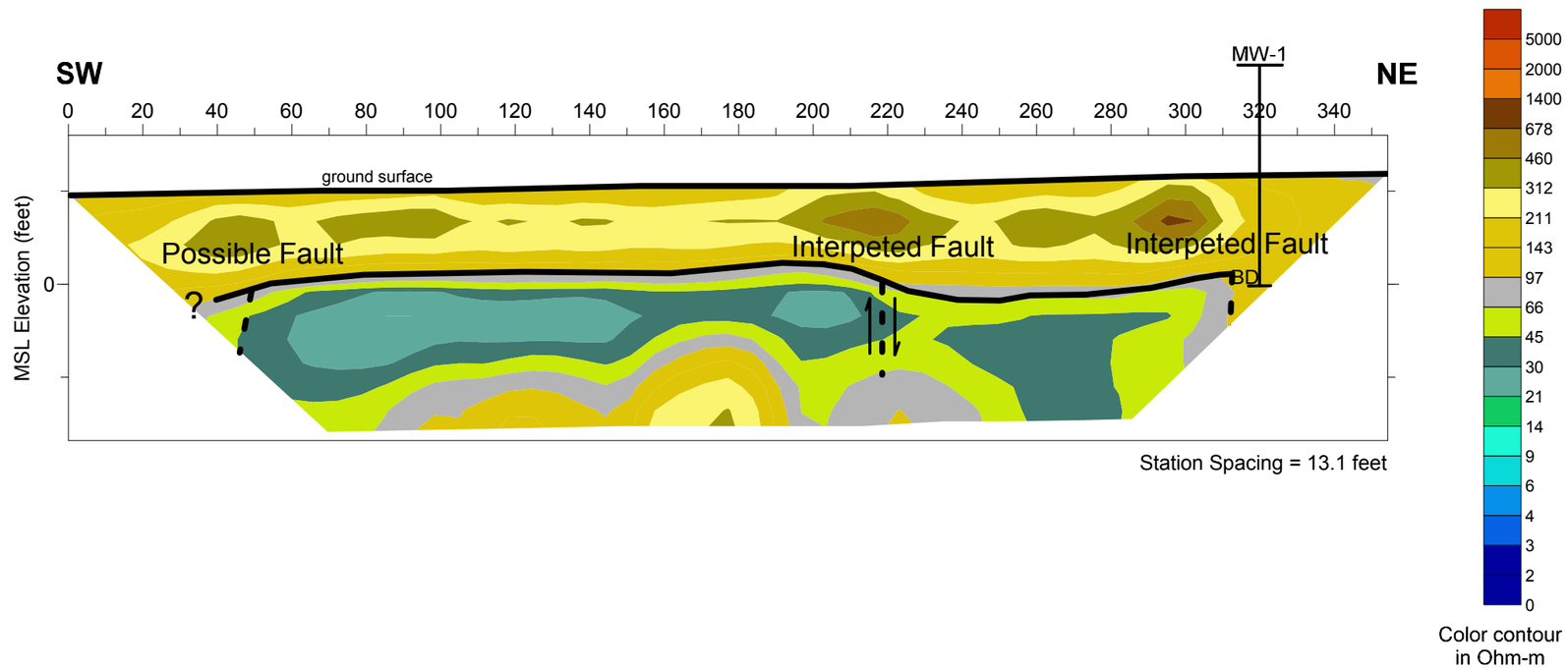
FIGURE NUMBER: 4

PROJECT NUMBER: 1208081L



TRN-02 FKmig Depth 1800fps EnsMix StakVmix [TRN02] Page 1 Fri Sep 21 14:13:37 2012

Geophysical Investigation Trinidad, California	
Figure 5	Seismic Profile 2 - Stagecoach Rd
Legg Geophysical, Inc. Huntington Beach, CA	VERSION 1.0 15 October 2012



BD Boring Bedrock Elevation

Interpreted Top of Bedrock

SPECTRUM GEOPHYSICS "Revealing The Subsurface"
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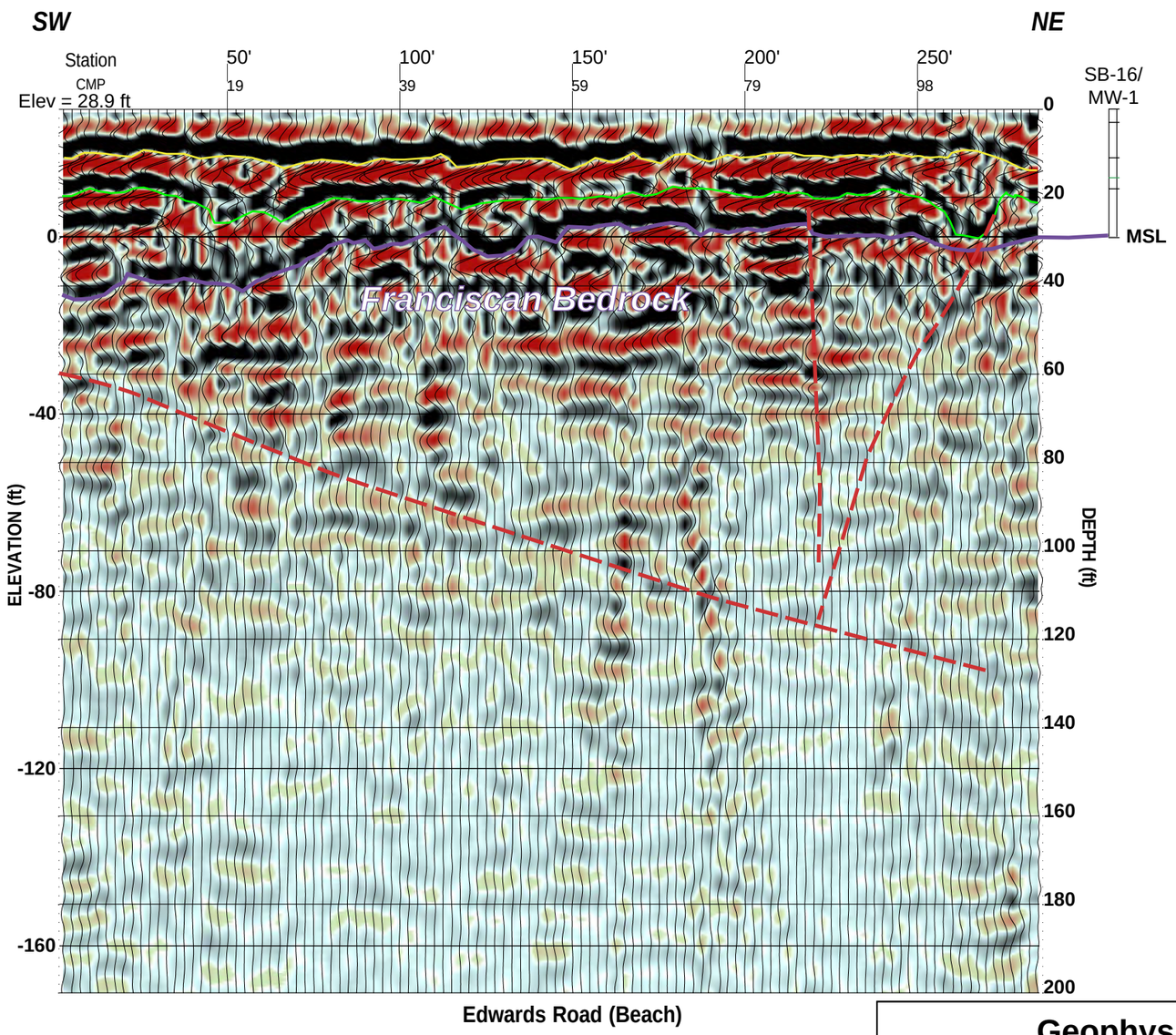
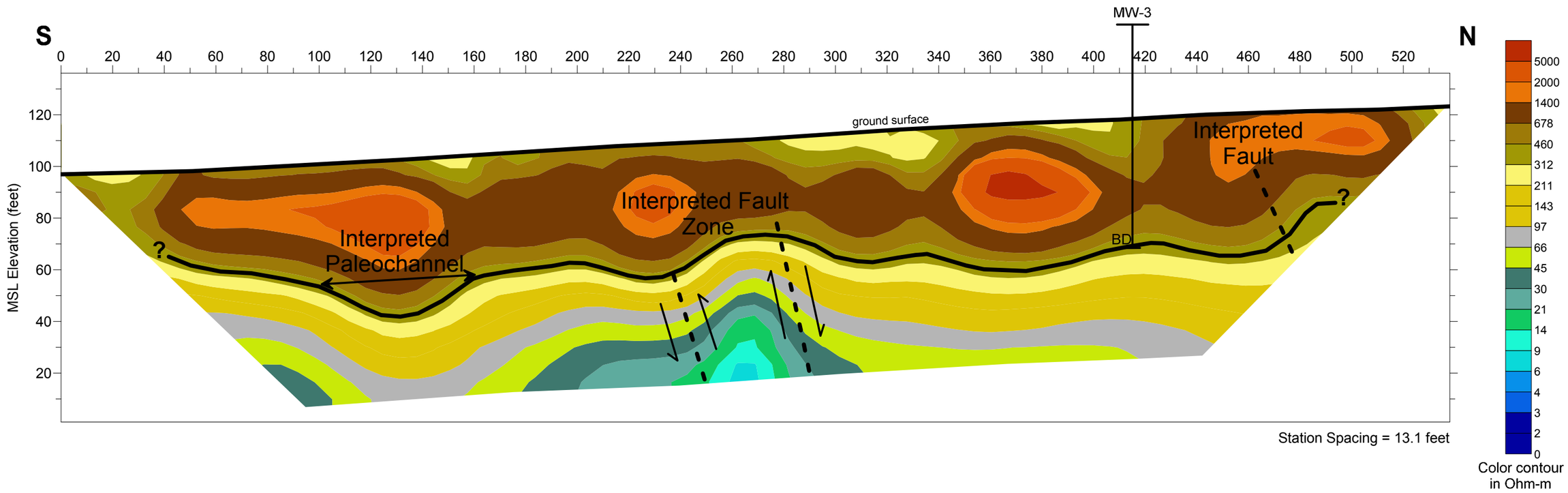
Santa Ana, CA 92704
(714) 435-1073 www.spectrum-geophysics.com

Electrical Resistivity Profile - Line 3			FIGURE NUMBER **6**
PROJECT: Geophysical Investigation, Trinidad, CA			
PREPARED FOR: GHD, Eureka, California			PROJECT NUMBER 1208081L
SCALE: 1 inch = 40 feet	FIGURE BY: BAU	REVIEWED BY: LCD	DATE: 10/10/12



FKmig v1880 DEPTH EnsMixStakV5Mix Float5ft [TRN03] Page 1 Thu Sep 27 16:40:53 2012

Geophysical Investigation Trinidad, California	
Figure 7	Seismic Profile 3 - Beach
Legg Geophysical, Inc. Huntington Beach, CA	VERSION 1.0 15 October 2012



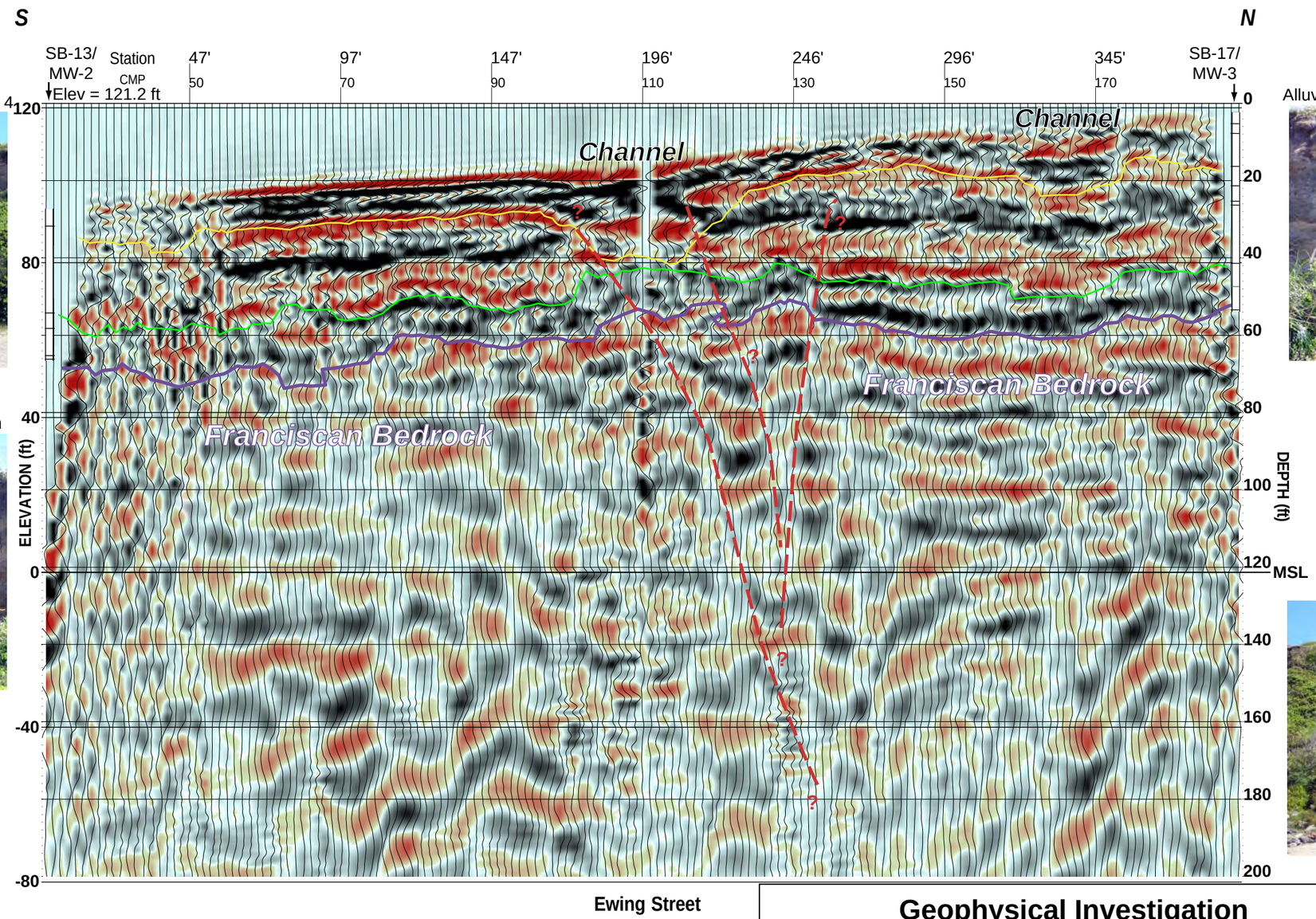
BD Boring Bedrock Elevation

Interpreted Top of Bedrock

SPECTRUM GEOPHYSICS "Revealing The Subsurface"	**Electrical Resistivity Profile - Line 4**			FIGURE NUMBER **8**
	PROJECT: Geophysical Investigation, Trinidad, CA			
2727 Croddy Way, Unit I, Santa Ana, CA 92704	PREPARED FOR: GHD, Eureka, California			PROJECT NUMBER 1208081L
(714) 435-1073 www.spectrum-geophysics.com	SCALE: 1 inch = 40 feet	FIGURE BY: BAU	REVIEWED BY: LCD	DATE 10/10/12

Alluvium with channels in seacliff west of Line 4

Close-up view of "paleochannels" in alluvium



Alluvium with channels in seacliff west of Line 4

Landslide on beach west of Line 4

TRN-04 FKmig Depth 1880fps Mix StakVmix [TRN04] Page 1 Mon Sep 24 12:51:28 2012

Geophysical Investigation Trinidad, California	
Figure 9	Seismic Profile 4 - Ewing St
Legg Geophysical, Inc. Huntington Beach, CA	Version 1.0 15 October 2012

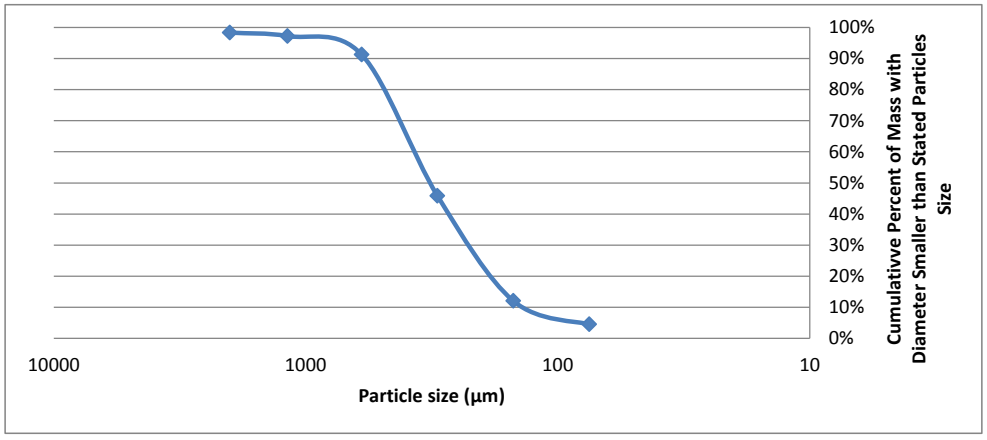
Appendix H – Sieve Analysis Laboratory Data Sheets

Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-16 (20-22 feet bgs)	Soil Description:	
Sample Wt. (dry):	358.9 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	5.9	2%	353	98%	
16	1180	4.0	3%	349	97%	
30	600	21.4	9%	327.6	91%	
50	300	163.2	54%	164.4	46%	
100	150	121.3	88%	43.1	12%	
200	75	27.0	96%	16.1	4%	

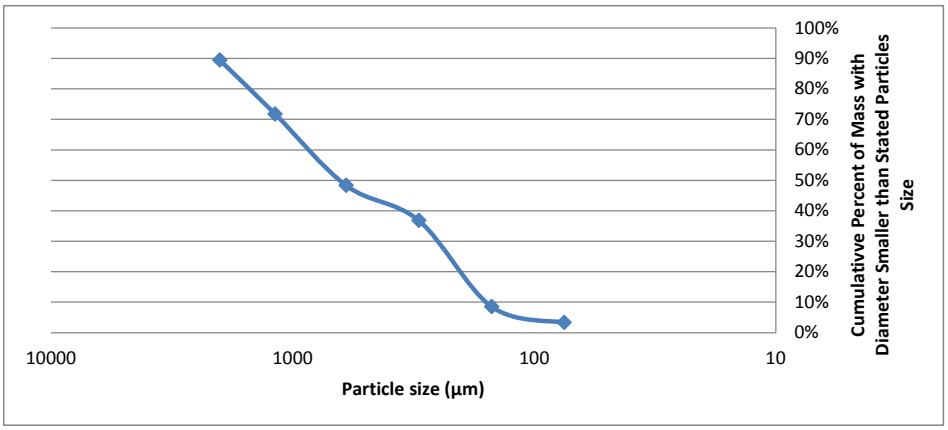


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-11 (60-62 feet bgs)	Soil Description:	
Sample Wt. (dry):	628.0 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	66.4	11%	561.6	89%	
16	1180	111.1	28%	450.5	72%	
30	600	147.3	52%	303.2	48%	
50	300	72.3	63%	230.9	37%	
100	150	177.5	91%	53.4	9%	
200	75	32.5	97%	20.9	3%	

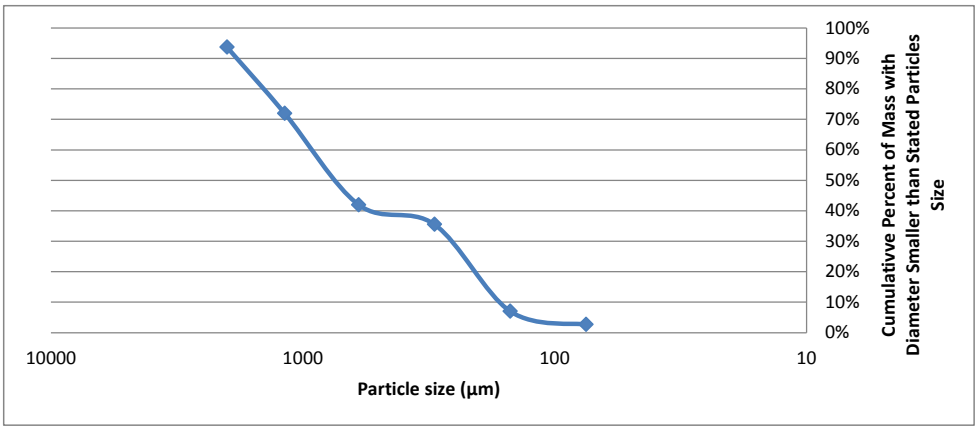


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-18 (60-61 feet bgs)	Soil Description:	
Sample Wt. (dry):	328.2 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	20.8	6%	307.44	94%	
16	1180	71.3	28%	236.14	72%	
30	600	98.4	58%	137.74	42%	
50	300	21.2	64%	116.54	36%	
100	150	93.6	93%	22.94	7%	
200	75	14.1	97%	8.84	3%	

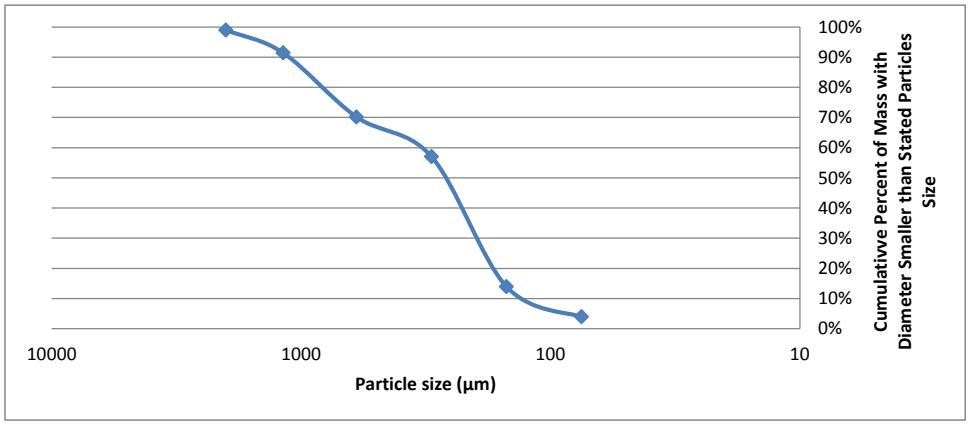


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-4 (45-47 feet bgs)	Soil Description:	
Sample Wt. (dry):	178.5 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	1.8	1%	176.7	99%	
16	1180	13.5	9%	163.2	91%	
30	600	37.9	30%	125.3	70%	
50	300	23.5	43%	101.8	57%	
100	150	77	86%	24.8	14%	
200	75	17.8	96%	7	4%	

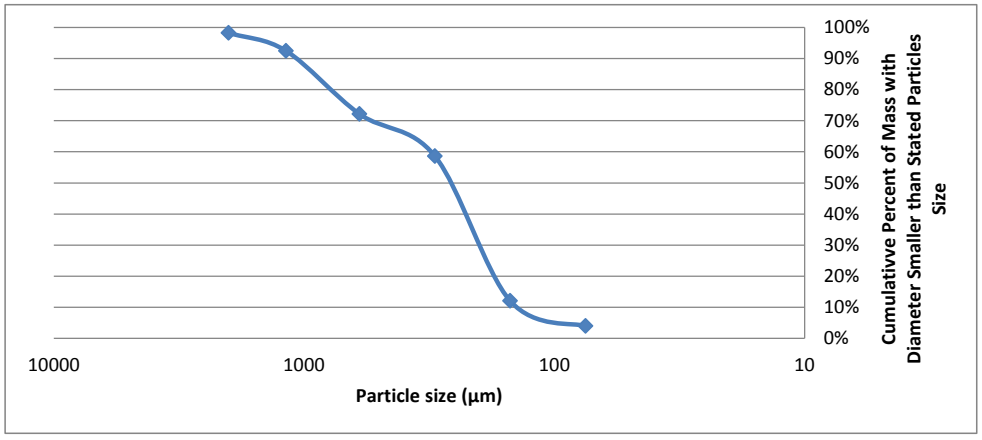


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-6 (50-52 feet bgs)	Soil Description:	
Sample Wt. (dry):	543.2 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	9.35	2%	533.85	98%	
16	1180	31.44	8%	502.41	92%	
30	600	110.45	28%	391.96	72%	
50	300	73.5	41%	318.46	59%	
100	150	253.3	88%	65.16	12%	
200	75	43.7	96%	21.46	4%	

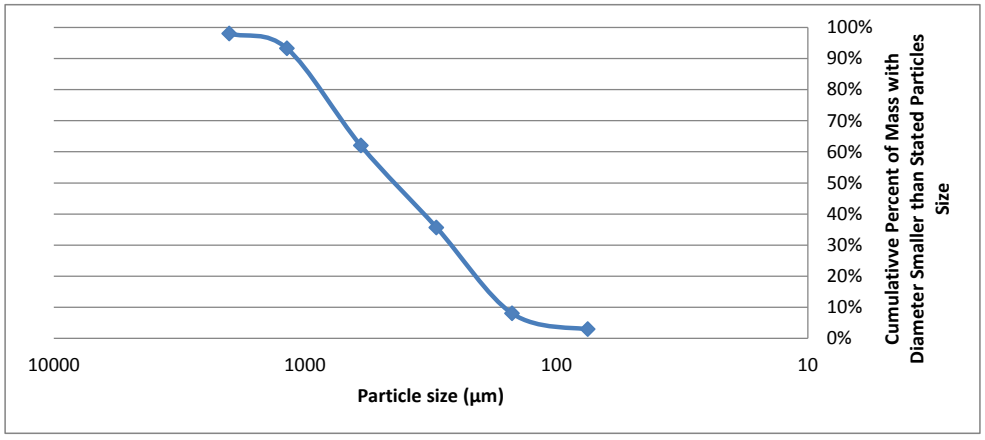


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-17 (30-32 feet bgs)	Soil Description:	
Sample Wt. (dry):	661.0 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	12.9	2%	648.1	98%	
16	1180	31.8	7%	616.3	93%	
30	600	206.6	38%	409.7	62%	
50	300	174.2	64%	235.5	36%	
100	150	182.7	92%	52.8	8%	
200	75	33.8	97%	19	3%	

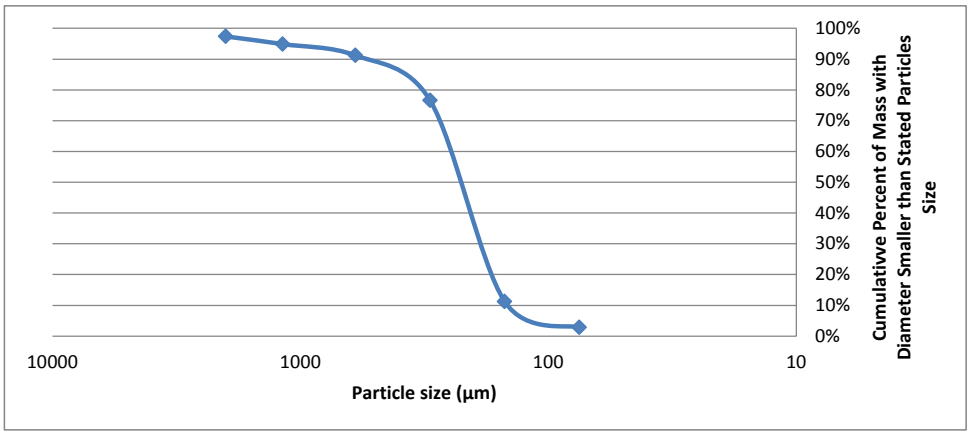


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-3 (20-22 feet bgs)	Soil Description:	
Sample Wt. (dry):	507.6 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	13.3	3%	494.3	97%	
16	1180	12.6	5%	481.7	95%	
30	600	18.7	9%	463	91%	
50	300	74.1	23%	388.9	77%	
100	150	331.8	89%	57.1	11%	
200	75	42.7	97%	14.4	3%	

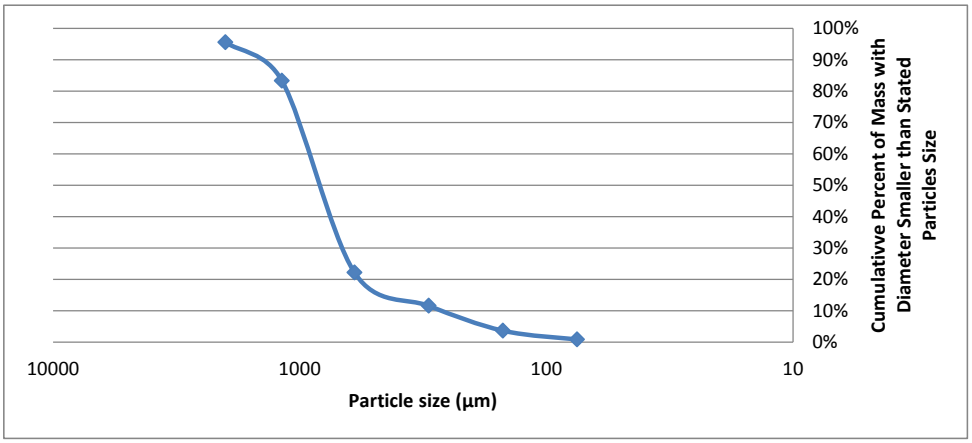


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-5 (55-57 feet bgs)	Soil Description:	
Sample Wt. (dry):	478.7 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	21.3	4%	457.4	96%	
16	1180	58.8	17%	398.6	83%	
30	600	292.4	78%	106.2	22%	
50	300	50.7	88%	55.5	12%	
100	150	38	96%	17.5	4%	
200	75	13.3	99%	4.2	1%	

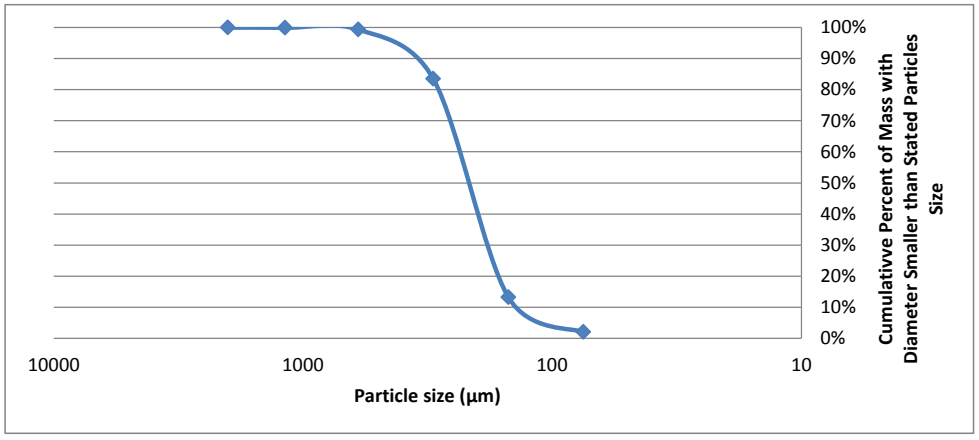


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-8 (35 feet bgs)	Soil Description:	
Sample Wt. (dry):	791.6 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	0.3	0%	791.3	100%	
16	1180	0.4	0%	790.9	100%	
30	600	4.4	1%	786.5	99%	
50	300	125.7	17%	660.8	83%	
100	150	556.1	87%	104.7	13%	
200	75	88.8	98%	15.9	2%	

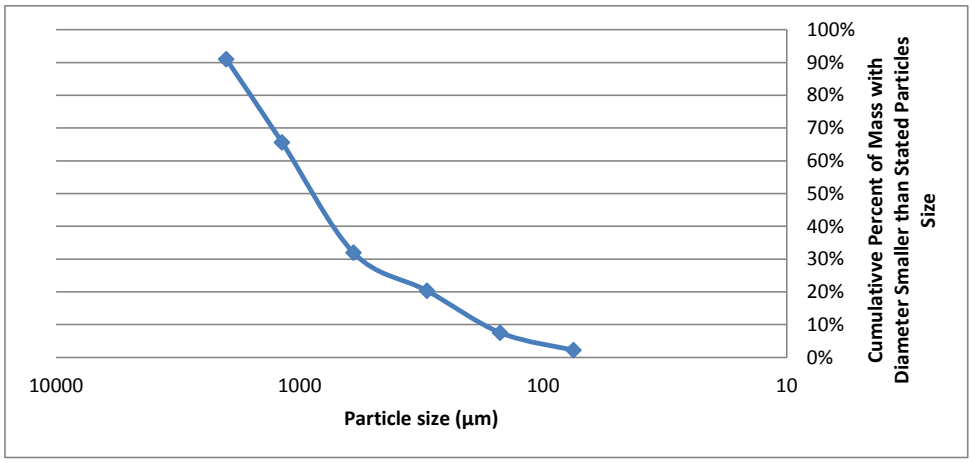


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-1 (35-37 feet bgs)	Soil Description:	
Sample Wt. (dry):	561.2 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	50.5	9%	510.7	91%	
16	1180	142.7	34%	368	66%	
30	600	188.88	68%	179.12	32%	
50	300	64.9	80%	114.22	20%	
100	150	71.9	92%	42.32	8%	
200	75	29.8	98%	12.52	2%	

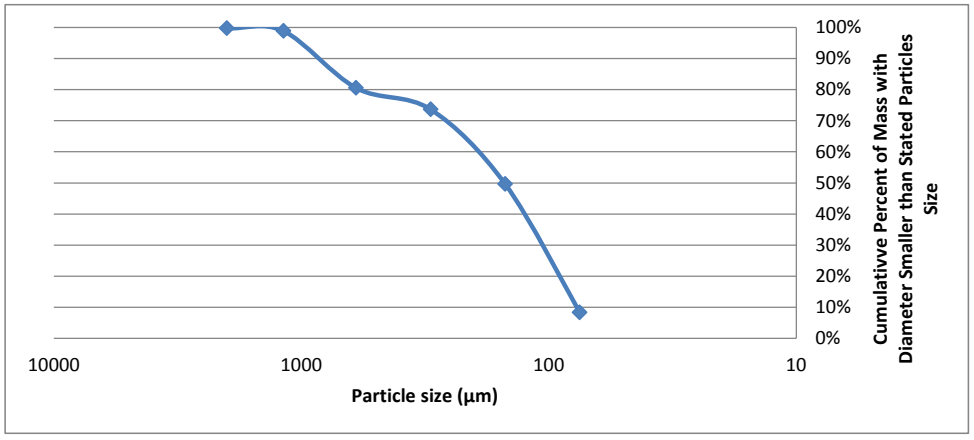


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-13 (20-22 feet bgs)	Soil Description:	
Sample Wt. (dry):	561.2 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	1.5	0%	559.7	100%	
16	1180	4.9	1%	554.8	99%	
30	600	102.8	19%	452	81%	
50	300	38.8	26%	413.2	74%	
100	150	134.7	50%	278.5	50%	
200	75	231.7	92%	46.8	8%	

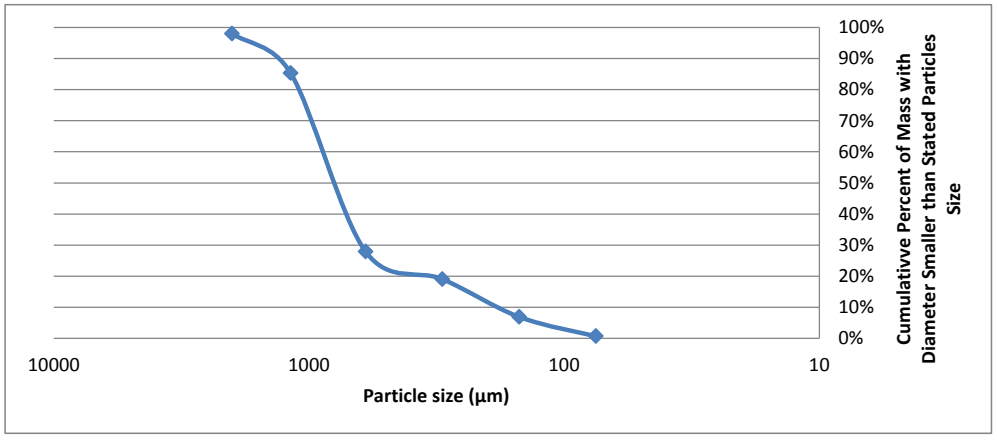


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-2 (25 feet bgs)	Soil Description:	
Sample Wt. (dry):	646.6 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	12.8	2%	633.8	98%	
16	1180	81.9	15%	551.9	85%	
30	600	371.5	72%	180.4	28%	
50	300	57.3	81%	123.1	19%	
100	150	78.7	93%	44.4	7%	
200	75	40.1	99%	4.3	1%	

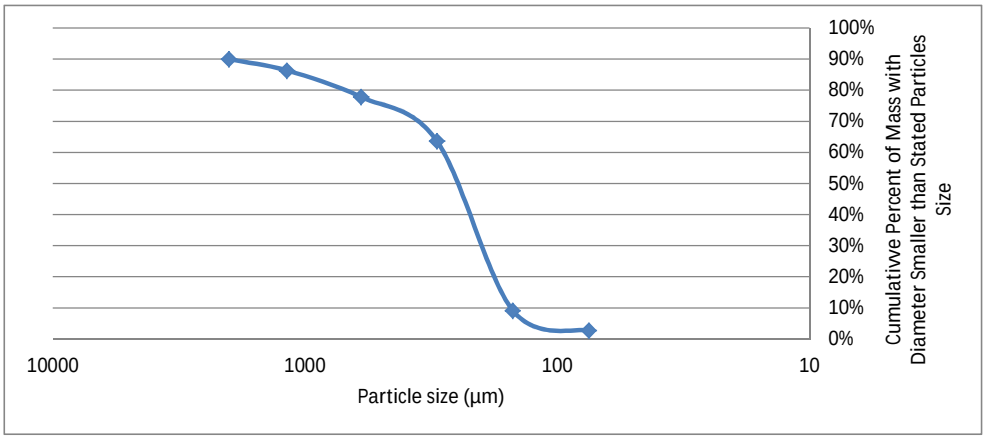


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-15 (5.5 feet bgs)	Soil Description:	
Sample Wt. (dry):	380.4 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	38.17	10%	342.21	90%	
16	1180	13.8	14%	328.41	86%	
30	600	32.3	22%	296.11	78%	
50	300	54.0	36%	242.11	64%	
100	150	207.2	91%	34.91	9%	
200	75	24.6	97%	10.31	3%	

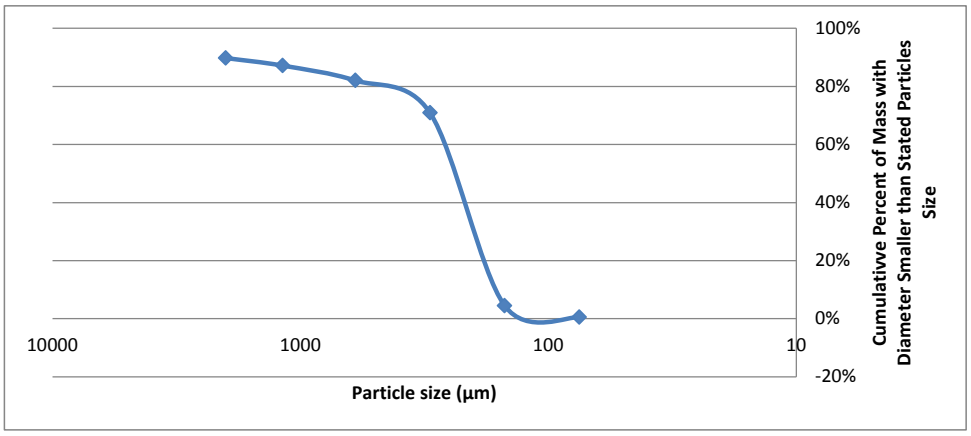


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-8 (4 feet bgs)	Soil Description:	
Sample Wt. (dry):	583.3 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	59.6	10%	523.7	90%	
16	1180	15.2	13%	508.5	87%	
30	600	30	18%	478.5	82%	
50	300	64.9	29%	413.6	71%	
100	150	387.4	96%	26.2	4%	
200	75	23.3	100%	2.9	0%	

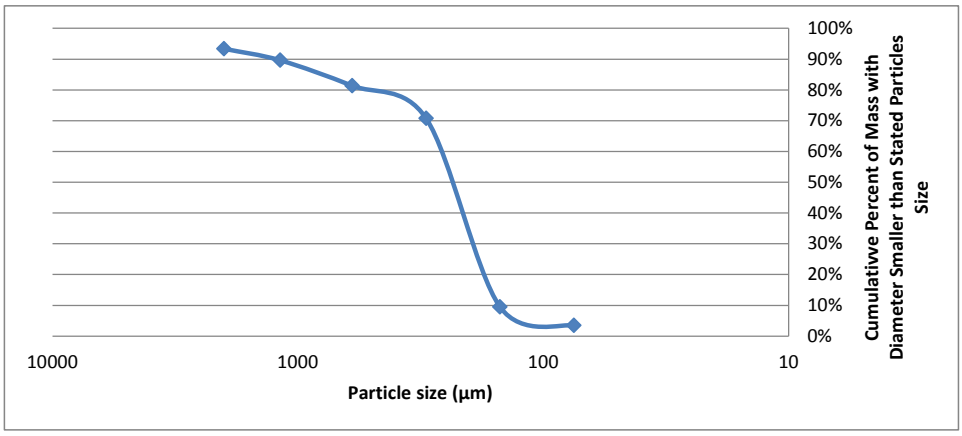


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-18 (10-12 feet bgs)	Soil Description:	
Sample Wt. (dry):	420.1 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	27.8	7%	392.3	93%	
16	1180	15.8	10%	376.5	90%	
30	600	34.8	19%	341.7	81%	
50	300	44.5	29%	297.2	71%	
100	150	257.3	91%	39.9	9%	
200	75	25.5	97%	14.4	3%	

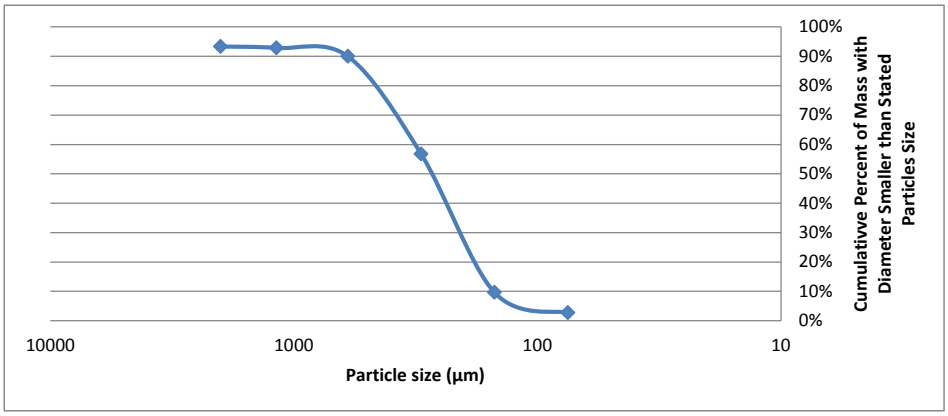


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	9/26/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-12 (5 feet bgs)	Soil Description:	
Sample Wt. (dry):	689.7 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	45.8	7%	643.9	93%	
16	1180	3.6	7%	640.3	93%	
30	600	19.7	10%	620.6	90%	
50	300	229.4	43%	391.2	57%	
100	150	324.8	90%	66.4	10%	
200	75	47.4	97%	19	3%	

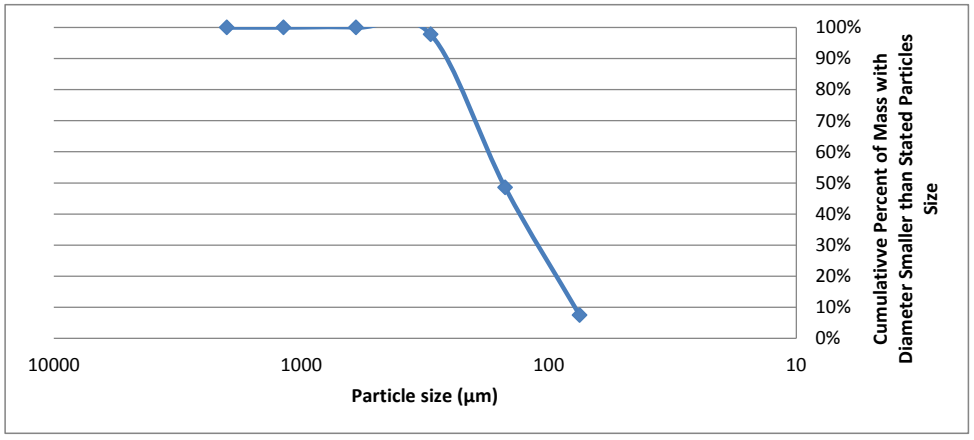


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	10/1/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-10 (26 feet bgs)	Soil Description:	
Sample Wt. (dry):	75.9 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	0	0%	75.92	100%	
16	1180	0.0	0%	75.92	100%	
30	600	0	0%	75.92	100%	
50	300	1.7	2%	74.22	98%	
100	150	37.4	52%	36.82	48%	
200	75	31.2	93%	5.62	7%	

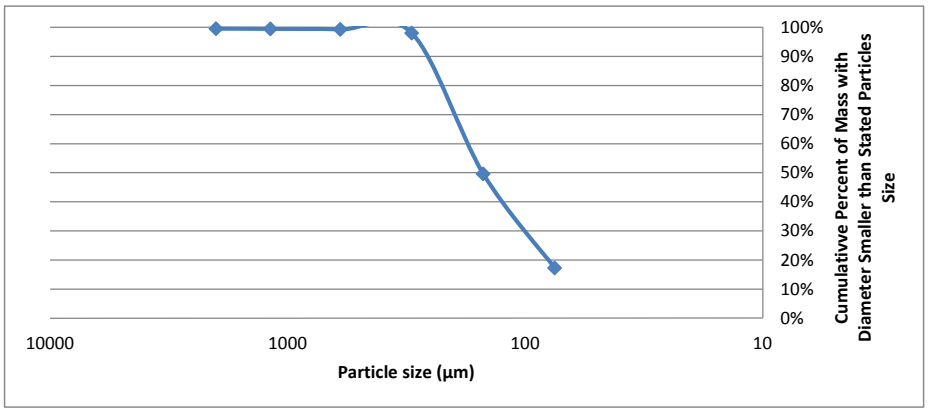


Sieve Analysis Test -ASTM C117 and C136

Job Name:	Trinidad ASBS		
Project Location:	Trinidad, California		
Job Number:	106311005	Date:	10/1/2012
AP#:		Tested By:	Anna Gower

Sample #:	SB-5 (30 feet bgs)	Soil Description:	
Sample Wt. (dry):	238.5 grams	Sample Location:	

Sieve Size	Particle Size (µm)	Grams Retained	Cumulative % Retained	Grams Passing	Cumulative % Passing	Comments
10	2000	1.04	0%	237.46	100%	
16	1180	0.2	1%	237.26	99%	
30	600	0.4	1%	236.86	99%	
50	300	3.1	2%	233.75	98%	
100	150	115.4	50%	118.35	50%	
200	75	77.2	83%	41.15	17%	



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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	Ryan Crawford and Patrick Sullivan	Rebecca Crow		Steve Allen		10/26/12

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