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SAN BERNARDINO COUNTY

CALICO PHASE 2 ADVANCE WASTEWATER TREATMENT PROJECT

FOR

CALICO GHOST TOWN REGIONAL PARK
YERMO, CALIFORNIA
PROJECT NO.: 30.30.0074

WARNING

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SECTION H

GEOTECHNICAL REPORT

CALICO PHASE 2 ADVANCED WASTEWATER TREATMENT PROJECT

FOR

CALICO GHOST TOWN REGIONAL PARK
YERMO, CALIFORNIA

PROJECT NO.: 30.30.0074

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October 16, 2020

Mr. Brian P. Knoll, PE
Albert A Webb Associates
3788 McCray Street
Riverside, CA 92056

Geotechnical Report
Proposed Calico WWTP Upgrades
Calico, California
LCI Report No.: LP20154

Dear Mr. Knoll:

This geotechnical report is provided for design and construction of the proposed upgrades to the Calico WWTP facility located at the southwest corner of Cemetery Road and Ghost Town Road south of the ghost town of Calico, County of San Bernardino, California. Our geotechnical investigation was conducted in response to your request for our services. The enclosed report describes our soil engineering investigation and present our professional opinions regarding geotechnical conditions at the site to be considered in the design and construction of the project.

The findings of this study indicate the site is underlain by dense to very dense sand and silty sand. The near surface soils are expected to be non-expansive. Groundwater was not encountered to a depth of 31.5 feet during the time of exploration.

Severe sulfate levels were not encountered at the soil samples tested for this investigation. A minimum of 2,500 psi concrete of Type II Portland Cement with a maximum water/cement ratio of 0.60 (by weight).

We did not encounter soil conditions that would preclude implementation of the proposed project provided the recommendations contained in this report are implemented in the design and construction of this project. Our findings, recommendations, and application options are related ***only through reading the full report***, and are best evaluated with the active participation of the engineer of record who developed them.

We appreciate the opportunity to provide our findings and professional opinions regarding geotechnical conditions at the site. If you have any questions or comments regarding our findings, please call our office at (760) 360-0665.

Respectfully Submitted,
LandMark Consultants, Inc.

Greg M. Chandra, P.E., M.ASCE
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
GREG M. CHANDRA
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CIVIL
STATE OF CALIFORNIA

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Section 1
INTRODUCTION

1.1 Project Description

This report presents the findings of our geotechnical investigation for the proposed upgrades to the Calico WWTP facility located at the southwest corner of Cemetery Road and Ghost Town Road south of the ghost town of Calico, County of San Bernardino, California (See Vicinity Map, Plate A-1). The proposed upgrades will consist of packaged equipment placed on concrete slab-on-grade pads with pre-engineered shade canopies. There is a potential for below grade structures which may be founded at 10 to 15 feet below ground surface. Sludge drying beds are also planned for the project. A site plan for the proposed development was not provided by your office.

1.2 Purpose and Scope of Work

The purpose of this geotechnical study was to investigate the upper 31.5 feet of subsurface soil within the project site for evaluation of physical/engineering properties. From the subsequent field and laboratory data, professional opinions were developed and are provided in this report regarding geotechnical conditions at this site and the effect on design and construction. The scope of our services consisted of the following:

< Field exploration and in-situ testing of the site soils at selected locations and depths.
< Laboratory testing for physical and/or chemical properties of selected samples.
< Review of the available literature and publications pertaining to local geology, faulting, and seismicity.
< Engineering analysis and evaluation of the data collected.
< Preparation of this report presenting our findings, professional opinions, and recommendations for the geotechnical aspects of project design and construction.

This report addresses the following geotechnical issues:

< Subsurface soil and groundwater conditions
< Site geology, regional faulting and seismicity, near source factors, and site seismic accelerations
< Aggressive soil conditions to metals and concrete

Professional opinions with regard to the above issues are presented for the following:

< Site grading and earthwork
< Building pad and foundation subgrade preparation
< Allowable soil bearing pressures and expected settlements
< Concrete slabs-on-grade
< Lateral earth pressures
< Excavation conditions and buried utility installations
< Mitigation of the potential effects of salt concentrations in native soil to concrete mixes and steel reinforcement
< Seismic design parameters

Our scope of work for this report did not include an evaluation of the site for the presence of environmentally hazardous materials or conditions.

1.3 Authorization

Mr. Brian P. Knoll of Albert A Webb Associates provided authorization by written agreement to proceed with our work on September 9, 2020.

Section 2
METHODS OF INVESTIGATION

2.1 Field Exploration

Subsurface exploration was performed on September 21, 2020 using 2R Drilling of Ontario, California to advance one (1) boring to depth of 31.5feet below existing ground surface. The boring was advanced with a truck-mounted, CME 75 drill rig using 8-inch diameter, hollow-stem, continuous-flight augers. The approximate boring location was established in the field and plotted on the site map by sighting to discernable site features. The boring location is shown on the Site and Exploration Plan (Plate A-2).

A staff engineer observed the drilling operations and maintained a log of the soil encountered and sampling depths, visually classified the soil encountered during drilling in accordance with the Unified Soil Classification System, and obtained drive tube and bulk samples of the subsurface materials at selected intervals. Relatively undisturbed soil samples were retrieved using a 2-inch outside diameter (OD) split-spoon sampler. The samples were obtained by driving the sampler ahead of the auger tip at selected depths. The drill rig was equipped with a 140-pound CME automatic hammer with a 30-inch drop for conducting Standard Penetration Tests (SPT) in accordance with ASTM D1586. The number of blows required to drive the samplers the last 12 inches of an 18 inch drive length into the soil is recorded on the boring logs as "blows per foot". Blow counts (N values) reported on the boring logs represent the field blow counts. No corrections have been applied for effects of overburden pressure, automatic hammer drive energy, drill rod lengths, liners, and sampler diameter.

After logging and sampling the soil, the exploratory borings were backfilled with the excavated material. The backfill was loosely placed and was not compacted to the requirements specified for engineered fill.

The subsurface log is presented on Plate B-1 in Appendix B. A key to the log symbols is presented on Plate B-2. The stratification lines shown on the subsurface log represent the approximate boundaries between the various strata. However, the transition from one stratum to another may be gradual over some range of depth.

2.2 Laboratory Testing

Laboratory tests were conducted on selected bulk and relatively undisturbed soil samples to aid in classification and evaluation of selected engineering properties of the site soils. The tests were conducted in general conformance to the procedures of the American Society for Testing and Materials (ASTM) or other standardized methods as referenced below. The laboratory testing program consisted of the following tests:

< Particle Size Analyses (ASTM D422)
< Unit Dry Densities (ASTM D2937)
< Moisture Contents (ASTM D2216)
< Moisture-Density Relationship (ASTM D1557)
< Chemical Analyses (soluble sulfates & chlorides, pH, and resistivity) (Caltrans Methods)

The laboratory test results are presented on the subsurface logs (Appendix B) and on Plates C-1 through C-3 in Appendix C.

Engineering parameters of soil strength, compressibility and relative density utilized for developing design criteria provided within this report were either extrapolated from correlations with the data obtained from the field and laboratory testing program.

Section 3
DISCUSSION

3.1 Site Conditions

The project site is triangular shaped in plan view, is relatively flat-lying and covered with scattered desert vegetation. The project site is located at the southwest corner of Cemetery Road and Ghost Town Road south of the ghost town of Calico, California. The project site is located between existing percolation ponds and Ghost Town Road. Earthen drainage diversion berms surround the site.

The project site lies at an elevation of approximately 2125 feet above mean sea level (AMSL) in the Mojave Desert region of the California high desert. Annual rainfall in this arid region is less than 4 inches per year with four months of average summertime temperatures above 100 °F. Winter temperatures are mild, seldom reaching freezing.

3.2 Geologic Setting

The site is located in the Mojave Desert region of the California high desert. The Mojave Desert occupies about 25,000 miles^2 (65,000 km^2) of southeastern California. It is landlocked, enclosed on the southwest by the San Andreas Fault and the Transverse Ranges, on the north and northwest by the Garlock Fault, the Tehachapi Mountains and the Basin Ranges. The Nevada state line and the Colorado River form the arbitrary eastern boundary, although the province actually extends into southern Nevada. The San Bernardino-Riverside county line is designated as the southern boundary (Norris & Webb, 1976).

The desert itself is a Cenozoic feature, formed as early as the Oligocene presumably from movements related to the San Andreas and Garlock Faults. Prior to the development of the Garlock Fault, the Mojave was part of the Basin Ranges and shares Basin Range geologic history possibly through the Miocene. Today the region is dominated by broad alleviated basins that are mostly aggrading surfaces receiving nonmarine continental deposits from adjacent uplands. The alluvial deposits buried the older topography which was more mountainous. The highest general elevation of the Mojave Desert approaches 4,000 feet (1,200 m) along a northeastern axis from Cajon Pass to Barstow.

Alluvial cover thins to the east, and pediment - often with thick regolith - occupies much of the surface. The Mojave area contains Paleozoic and lower Mesozoic rocks, although Triassic and Jurassic marine sediments are scarce (Norris & Webb, 1976). The Mojave block is approximately bounded by the San Andreas and Garlock Faults. The western Mojave Desert is broken by major faults that primarily parallel the San Andreas and seems to be truncated by the Garlock. Many faults occur in the eastern Mojave, but since most of this area is underlain by rather uniform granitic rocks, the faults are difficult to map. Some faults are known positively, but many can only be inferred (Norris & Webb, 1976).

3.3 Subsurface Soil

Subsurface soils encountered during the field exploration conducted on September 21, 2020 consist of dense to very dense sand (SP-SM) overlying silty sand (SM) to a depth of 31.5 feet, the maximum depth of exploration. The near surface soils are non-expansive in nature. The subsurface log (Plate B-1) depicts the stratigraphic relationships of the various soil types.

3.4 Groundwater

Groundwater was not encountered during the time of exploration. There is uncertainty in the accuracy of short-term water level measurements, particularly in fine-grained soil. Groundwater levels may fluctuate with precipitation, irrigation of adjacent properties, drainage, and site grading. The groundwater level noted should not be interpreted to represent an accurate or permanent condition. Based on the regional topography, groundwater flow is assumed to be generally towards the south within the site area. Flow directions may vary locally in the vicinity of the site.

3.5 Faulting

The project site is located in the seismically active Mojave Desert region of the California with numerous mapped faults of the San Andreas Fault System traversing the region. We have performed a computer-aided search of known faults or seismic zones that lie within a 67-mile radius of the project site (Table 1).

A fault map illustrating known active faults relative to the site is presented on Figure 1, *Regional Fault Map*. Figure 2 shows the project site in relation to local faults. The criterion for fault classification adopted by the California Geological Survey defines Earthquake Fault Zones along active or potentially active faults. An active fault is one that has ruptured during Holocene time (roughly within the last 11,000 years). A fault that has ruptured during the last 1.8 million years (Quaternary time), but has not been proven by direct evidence to have not moved within Holocene time is considered to be potentially active. A fault that has not moved during Quaternary time is considered to be inactive.

Review of the current Alquist-Priolo Earthquake Fault Zone maps (CGS, 2000a) indicates that the nearest mapped AP Earthquake Fault Zone is the Calico-Hidalgo fault located approximately5.0 miles southeast of the project site. The Calico-Hidalgo fault has been mapped to within approximately 0.3 miles of the project site, but this portion of the fault zone in not currently included in the AP fault maps.

3.6 General Ground Motion Analysis

The project site is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. Ground motions are dependent primarily on the earthquake magnitude and distance to the seismogenic (rupture) zone. Acceleration magnitudes also are dependent upon attenuation by rock and soil deposits, direction of rupture and type of fault; therefore, ground motions may vary considerably in the same general area.

<u>2019 CBC General Ground Motion Parameters:</u> The California Building Code (CBC) requires that a site-specific ground motion hazard analysis be performed in accordance with ASCE 7-16 Section 11.4.8 for structures on Site Class D and E sites with S_1 greater than or equal to 0.2 and Site Class E sites with S_s greater than or equal to 1.0. ***This project site has been classified as Site Class C and, which would not require a site-specific ground motion hazard analysis.***

The 2019 CBC general ground motion parameters are based on the Risk-Targeted Maximum Considered Earthquake (MCE_R). The Structural Engineers Association of California (SEAOC) and Office of Statewide Health Planning and Development (OSHPD) Seismic Design Maps Web Application (SEAOC, 2020) was used to obtain the site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters. Design spectral response acceleration parameters are defined as the earthquake ground motions that are two-thirds (2/3) of the corresponding MCE_R ground motions. The Maximum Considered Earthquake Geometric Mean (MCE_G) peak ground acceleration adjusted for soil site class effects (PGA_M) value to be used for liquefaction and seismic settlement analysis in accordance with 2019 CBC Section 1803A.5.12 ($PGA_M = F_{PGA}$*PGA) is estimated at 0.93g for the project site. ***Design earthquake ground motion parameters are provided in Table 2.***

3.7 Seismic and Other Hazards

► **Groundshaking.** The primary seismic hazard at the project site is the potential for strong groundshaking during earthquakes along the Calico-Hidalgo fault.

► **Surface Rupture.** The project site does not lie within a State of California, Alquist-Priolo Earthquake Fault Zone. Surface fault rupture is considered to be unlikely at the project site because of the well-delineated fault lines through the Mojave Desert region of the California high desert as shown on USGS and CDMG maps. However, because of the high tectonic activity and deep alluvium of the region, we cannot preclude the potential for surface rupture on undiscovered or new faults that may underlie the site.

► **Liquefaction.** Liquefaction is unlikely to be a potential hazard at the site, due to groundwater deeper than 50 feet (the maximum depth that liquefaction is known to occur).

<u>Other Secondary Hazards.</u>

► **Landsliding.** The hazard of landsliding is unlikely due to the regional planar topography. No ancient landslides are shown on geologic maps of the region and no indications of landslides were observed during our site investigation.

► **Volcanic hazards.** The site is not located in proximity to any known volcanically active area and the risk of volcanic hazards is considered very low.

► **Tsunamis, sieches, and flooding.** The site does not lie near any large bodies of water, so the threat of tsunami, sieches, or other seismically-induced flooding is unlikely.

► **Expansive soil.** The near surface soils at the site consist of sands which are non-expansive.

Section 4
RECOMMENDATIONS

4.1 Site Preparation

Clearing and Grubbing: All surface improvements, debris or vegetation including grass, brush, and weeds on the site at the time of construction should be removed from the construction area. Root balls should be completely excavated. Organic stripping should be hauled from the site and not used as fill. *Any trash, construction debris, concrete slabs, old pavement, landfill, and buried obstructions such as old foundations and utility lines exposed during rough grading should be traced to the limits of the foreign material by the grading contractor and removed under our supervision.* Any excavations resulting from site clearing should be dish-shaped to the lowest depth of disturbance and backfilled under the observation of the geotechnical engineer's representative.

Below Grade Structures Site Preparation: The existing soil within the below grade structure foundation areas should be over-excavated to 12 inches below the bottom of the proposed foundation elevation extending 2 feet beyond the perimeter walls. The exposed soils should be uniformly moisture conditioned to a depth of 8 inches to a minimum of 2% above optimum moisture and re-compacted to at least 90% of ASTM D1557 maximum density. Native sand soils may be used for the engineered pad and excavation backfill by placing in 6-inch maximum lifts, uniformly moisture conditioning to a minimum of 2% above optimum moisture and re-compacting to at least 90% of ASTM D1557 maximum density.

Small Building/Equipment Pad Subgrade Preparation (Shallow Foundations): The exposed surface soil within the small building and equipment mat foundation areas such as a generator or pumps should be over-excavated to 12 inches below the bottom of the mat foundations to 2 feet beyond the edges of the foundation. Exposed subgrade should be scarified to a depth of 12 inches, uniformly moisture conditioned to a minimum of 2% above optimum moisture content, and recompacted to a minimum of 90% of the maximum density determined in accordance with ASTM D1557 methods.

In areas other than the structures which are to receive fill and/or concrete pavement, the ground surface should be over-excavated to a depth of 12 inches below the existing grade, uniformly moisture conditioned to a minimum of 2% over optimum moisture, and re-compacted to at least 90% of ASTM D1557 maximum density.

The on-site soils are suitable for use as compacted fill and utility trench backfill. Imported fill soil (if required) should similar to onsite soil or non/less expansive, granular soil meeting the USCS classifications of SM, SP, ML with a maximum rock size of 3 inches. ***The geotechnical engineer should approve imported fill soil sources before hauling material to the site***.

Native and imported materials should be placed in lifts no greater than 8 inches in loose thickness, uniformly moisture conditioned to a minimum of 2% over optimum moisture, and re-compacted to at least 90% of ASTM D1557 maximum density.

Observation and Density Testing: All site preparation and fill placement should be continuously observed and tested by a representative of a qualified geotechnical engineering firm. Full-time observation services during the excavation and scarification process is necessary to detect undesirable materials or conditions and soft areas that may be encountered in the construction area. The geotechnical firm that provides observation and testing during construction shall assume the responsibility of "***geotechnical engineer of record***" and, as such, shall perform additional tests and investigation as necessary to satisfy themselves as to the site conditions and the recommendations for site development.

4.2 Bedding and Backfill of Pipeline

Bedding provides lateral and bearing support to the pipe. The bedding and the backfill and their densification should conform to the "*Standard Specifications for Public Works Construction*" Sections 306-1.2.1 and 306-1.3.1 through 306-1.3.5 or other acceptable standard methods. Backfill within roadway (if any) should be over-excavated to a depth of 12 inches below the existing grade, uniformly moisture conditioned to a minimum of 2% over optimum moisture, and re-compacted to at least 90% of ASTM D1557 maximum density.

Pipe Support: It is assumed that pipeline depths at most locations will vary from 3 to 5 feet below ground surface. At these depths, the soils are predominantly sands and silts. For pipes bedded on the native soils, a modulus of Soil Reaction (E') of 1,000 psi may be used to estimate initial pipe deflection calculation. Earth dead loads may be assumed to be approximately 125 pounds per cubic foot.

4.3 Foundations and Settlements

The below ground structures may be designed for an allowable soil bearing pressure of 2,500 pounds per square foot (psf) at the base of the structure. Footings and small equipment foundations which are embedded a minimum of 18 inches into native soil may be designed for an allowable bearing pressure of 2,000 psf. It is suggested that a rigid mat be used for structures placed over below ground structure backfill. Horizontal sliding can be resisted with passive earth pressure equivalent to 300 pounds per cubic foot (pcf) of fluid pressure and a coefficient of friction of 0.35.

<u>Small Equipment Flat Plate Structural Mats</u>: Structural concrete mat foundations may be designed using an allowable soil bearing pressure of 2,000 psf when the foundation is supported on 12 inches of compacted native soil. The allowable soil pressure may be increased by one-third for short term loads induced by winds or seismic events. The structural mat shall have a double mat of steel and a minimum thickness of 10 inches. Structural mats may be designed for a modulus of subgrade reaction (Ks) of 250 pci. An allowable friction coefficient of 0.35 may also be used at the base of the mat to resist lateral sliding.

Resistance to horizontal loads will be developed by passive earth pressure on the sides of footings and frictional resistance developed along the base of footings. Passive resistance to lateral earth pressure may be calculated using an equivalent fluid pressure of 300 pcf to resist lateral loadings. An allowable friction coefficient of 0.35 may also be used at the base of the footings to resist lateral sliding.

4.4 Concrete Mixes and Corrosivity

Selected chemical analyses for corrosivity were conducted on bulk samples of the near surface soil from the project site (Plate C-2). The native soils have low levels of sulfate ion concentrations (670 ppm) and moderate chloride ion concentrations (250 ppm). Resistivity determinations on the soil indicate severe potential for metal loss because of electrochemical corrosion processes.

A minimum of 4,000 psi concrete of Type II/V Portland Cement with a maximum water-cement ration of 0.50 (by weight) should be placed in contact with native soil on this project (sitework including hardscape and foundations).

A minimum concrete cover of three (3) inches is recommended around steel reinforcing or embedded components (anchor bolts, hold-downs, etc.) exposed to native soil or landscape water (to 18 inches above grade). The concrete should also be thoroughly vibrated during placement.

Landmark does not practice corrosion engineering. We recommend that a qualified corrosion engineer evaluate the corrosion potential on metal construction materials and concrete at the site.

4.5 Excavations for Sewer Lift Station

All site excavations to 4 feet should conform to Cal/OSHA requirements for Type C soil. The contractor is solely responsible for the safety of workers entering trenches. Temporary excavations with depths of 4 feet or less may be cut nearly vertical for short duration. Excavations deeper than 4 feet will require shoring or slope inclinations in conformance to CAL/OSHA regulations for Type C soil.

Due to encountered sand soils, the use of a shoring system should be planned. Since no groundwater is expected to be encountered in the excavation (approximately 15 feet in depth), the use of a dewatering system of the excavation is not required.

All discussions in this section regarding stable excavation slopes assumes minimal equipment vibration and adequate setback of excavated material and construction equipment from the top of the excavation. We recommended that the minimum setback distance be equal to the depth of excavation and at least 10 feet from the crown of the slope. If excavated materials are stockpiled adjacent to the excavation, the weight of the material should be considered as a surcharge load for slope stability.

The responsibility for any excavation and the selection and performance of an appropriate shoring system is the contractor's responsibility. The contractor is cautioned to evaluate soil moisture and groundwater conditions at the time of bidding. This report should be made available to the general contractors for theirs initial assessment of the site conditions. However, it is the contractor's own risk to interpret the information contained in this report.

4.6 Lateral Earth Pressures

Earth retaining structures, such as retaining walls, should be designed to resist the soil pressure imposed by the retained soil mass. Walls with granular drained backfill may be designed for an assumed static earth pressure equivalent to that exerted by a fluid weighing 45 pcf for unrestrained (active) conditions (able to rotate 0.1% of wall height), and 60 sand pcf for restrained (at-rest) conditions. These values should be verified at the actual wall locations during construction.

When applicable (Seismic Design Category D, E or F), retaining wall structures where the backfill is greater than 6 feet high shall be designed in addition to the static loading (active or at-rest condition) with an additional seismic lateral pressure increasing linearly with depth and the resultant acting as a point load at 0.4H above the base of the wall. The term H is the height of the backfill against a retaining wall in feet. The seismic load increment, shall be determined using the following equations for different wall type and backfill conditions:

Basement (restrained) walls with level backfill: $\Delta K_{ae} = \frac{1}{2}\gamma H^2(0.68\ PGA_M/g)$

Cantilever (unrestrained) wall with level backfill: $\Delta K_{ae} = \frac{1}{2}\gamma H^2(0.42\ PGA_M/g)$

Cantilever (unrestrained) wall with sloping backfill*: $\Delta K_{ae} = \frac{1}{2}\gamma H^2(0.70\ PGA_M/g)$

*Applicable for sloping backfill that is no steeper than 2:1 (horizontal:vertical).

Where:

ΔK_{ae} = Seismic Lateral Force (plf) based on seismic pressure
γ = 115 pcf
A PGA_M value of 0.93g has been determined for the project site.
H = Height of retained soil (ft)

Surcharge loads should be considered if loads are applied within a zone between the face of the wall and a plane projected behind the wall 45 degrees upward from the base of the wall. The increase in lateral earth pressure acting uniformly against the back of the wall should be taken as 50% of the surcharge load within this zone. Areas of the retaining wall subjected to traffic loads should be designed for a uniform surcharge load equivalent to two feet of native soil.

Walls should be provided with backdrains to reduce the potential for the buildup of hydrostatic pressure. The drainage system should consist of a composite HDPE drainage panel or a 2-foot wide zone of free draining crushed rock placed adjacent to the wall and extending 2/3 the height of the wall. The gravel should be completely enclosed in an approved filter fabric to separate the gravel and backfill soil. A perforated pipe should be placed perforations down at the base of the permeable material at least six inches below finished floor elevations. The pipe should be sloped to drain to an appropriate outlet that is protected against erosion. Walls should be properly waterproofed. The project geotechnical engineer should approve any alternative drain system.

4.7 Seismic Design

This site is located in the seismically active southern California area and the site structures are subject to strong ground shaking due to potential fault movements along the Calico-Hidalgo fault. Engineered design and earthquake-resistant construction are the common solutions to increase safety and development of seismic areas. Designs should comply with the latest edition of the CBC for Site Class D using the seismic coefficients given in Section 3.6 of this report.

Section 5
LIMITATIONS AND ADDITIONAL SERVICES

5.1 Limitations

The recommendations and conclusions within this report are based on current information regarding the proposed upgrades to the Calico WWTP facility located at the southwest corner of Cemetery Road and Ghost Town Road south of the ghost town of Calico, County of San Bernardino, California. The conclusions and recommendations of this report are invalid if:

< Structural loads change from those stated or the structures are relocated.
< The Additional Services section of this report is not followed.
< This report is used for adjacent or other property.
< Changes of grade or groundwater occur between the issuance of this report and construction other than those anticipated in this report.
< Any other change that materially alters the project from that proposed at the time this report was prepared.

Findings and recommendations in this report are based on selected points of field exploration, geologic literature, laboratory testing, and our understanding of the proposed project. Our analysis of data and recommendations presented herein are based on the assumption that soil conditions do not vary significantly from those found at specific exploratory locations. Variations in soil conditions can exist between and beyond the exploration points or groundwater elevations may change. If detected, these conditions may require additional studies, consultation, and possible design revisions.

This report contains information that may be useful in the preparation of contract specifications. However, the report is not worded is such a manner that we recommend its use as a construction specification document without proper modification. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

This report was prepared according to the generally accepted *geotechnical engineering standards of practice* that existed in San Bernardino County at the time the report was prepared. No express or implied warranties are made in connection with our services. This report should be considered invalid for periods after two years from the report date without a review of the validity of the findings and recommendations by our firm, because of potential changes in the Geotechnical Engineering Standards of Practice.

The client has responsibility to see that all parties to the project including, designer, contractor, and subcontractor are made aware of this entire report. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

5.2 Additional Services

We recommend that Landmark Consultants, Inc. be retained as the geotechnical consultant to provide the tests and observations services during construction. If ***LandMark Consultants, Inc.*** does not provide such services then *the geotechnical engineering firm providing such tests and observations shall become the geotechnical engineer of record and assume responsibility for the project.*

The recommendations presented in this report are based on the assumption that:

- Consultation during development of design and construction documents to check that the geotechnical recommendations are appropriate for the proposed project and that the geotechnical recommendations are properly interpreted and incorporated into the documents.
- Landmark Consultants will have the opportunity to review and comment on the plans and specifications for the project prior to the issuance of such for bidding.
- Continuous observation, inspection, and testing by the geotechnical consultant of record during site clearing, grading, excavation, placement of fills, building pad and subgrade preparation, and backfilling of utility trenches.
- Observation of foundation excavations and reinforcing steel before concrete placement.
- Other consultation as necessary during design and construction.

We emphasize our review of the project plans and specifications to check for compatibility with our recommendations and conclusions. Additional information concerning the scope and cost of these services can be obtained from our office.

TABLES

Table 1
Summary of Characteristics of Closest Known Active Faults

Fault Name	Approximate Distance (miles)	Approximate Distance (km)	Maximum Moment Magnitude (Mw)	Fault Length (km)	Slip Rate (mm/yr)
Calico-Hidalgo	0.3	0.6	7.3	95 ± 10	0.6 ± 0.4
Landers	10.6	16.9	7.3	83 ± 8	0.6 ± 0.4
Lenwood - Lockhart - Old Woman Springs	11.9	19.0	7.5	145 ± 15	0.6 ± 0.4
Pisgah Mtn. - Mesquite Lake	22.3	35.6	7.3	89 ± 9	0.6 ± 0.4
Helendale - S. Lockhart	26.7	42.7	7.3	97 ± 10	0.6 ± 0.4
Johnson Valley (northern)	28.0	44.7	6.7	35 ± 4	0.6 ± 0.4
Garlock - East	32.6	52.2	7.5	156 ± 16	7 ± 2
S. Emerson - Copper Mtn.	33.9	54.3	7	54 ± 5	0.6 ± 0.4
North Frontal Fault Zone - Western	37.5	60.0	7.2	51 ± 5	1 ± 0.5
North Frontal Fault Zone - Eastern	41.8	66.9	6.7	27 ± 3	0.5 ± 0.3
Owl Lake	46.2	73.9	6.5	25 ± 3	2 ± 1
Cleghorn	49.7	79.5	6.5	25 ± 3	3 ± 2
San Andreas - San Bernardino (South)	57.2	91.6	7.4	103 ± 10	30 ± 7
San Andreas - Mojave	57.5	92.0	7.1	39 ± 4	3 ± 3
San Jacinto - San Bernardino	59.5	95.2	6.7	36 ± 4	12 ± 6
Pinto Mtn.	60.7	97.1	7.2	74 ± 7	2.5 ± 2
Garlock - West	60.7	97.2	7.3	98 ± 10	6 ± 3
Cucamonga	61.5	98.4	6.9	28 ± 3	5 ± 2
Morongo *	61.7	98.7			
Burnt Mtn.	62.1	99.4	6.5	21 ± 2	0.6 ± 0.4
Eureka Peak	62.9	100.6	6.4	19 ± 2	0.6 ± 0.4
San Jacinto - San Jacinto Valley	67.0	107.2	6.9	43 ± 4	12 ± 6

* Note: Faults not included in CGS database.

Table 2

2019 California Building Code (CBC) and ASCE 7-16 Seismic Parameters

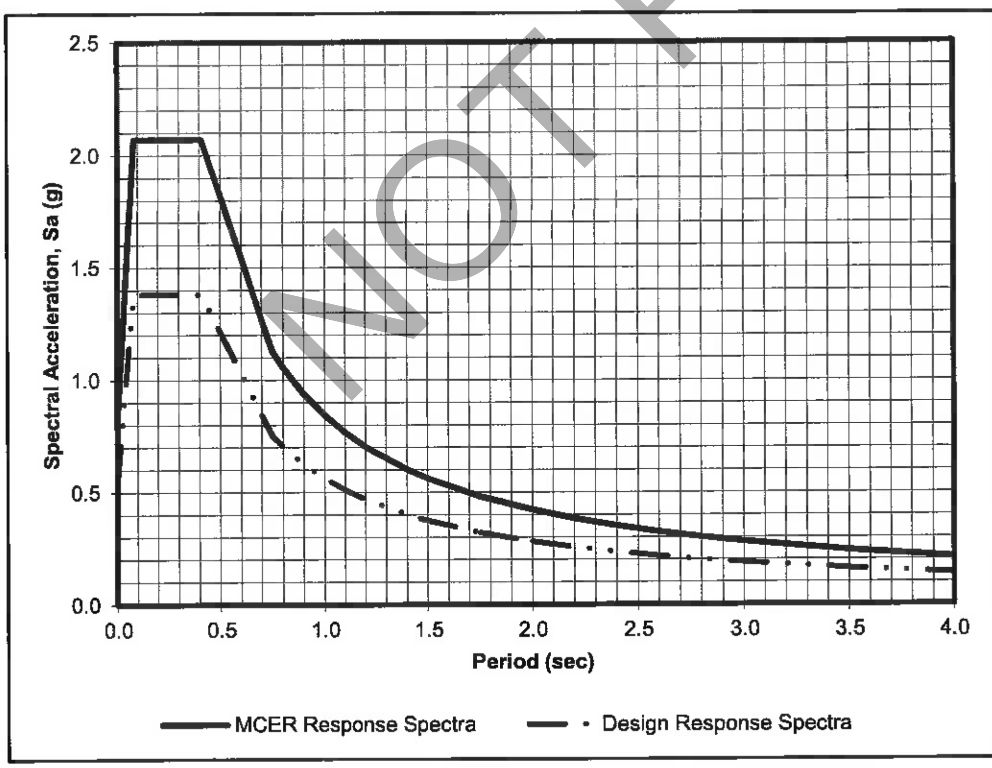
			ASCE 7-16 Reference
Soil Site Class:	C		Table 20.3-1
Latitude:	34.9411	N	
Longitude:	-116.8682	W	
Risk Category:	III		
Seismic Design Category:	D		

Maximum Considered Earthquake (MCE) Ground Motion

Mapped MCE_R Short Period Spectral Response	S_s	1.726 g	ASCE Figure 22-1	
Mapped MCE_R 1 second Spectral Response	S_1	0.598 g	ASCE Figure 22-2	
Short Period (0.2 s) Site Coefficient	F_a	1.20	ASCE Table 11.4-1	
Long Period (1.0 s) Site Coefficient	F_v	1.41	ASCE Table 11.4-2	
MCE_R Spectral Response Acceleration Parameter (0.2 s)	S_{MS}	2.071 g	$= Fa * S_s$	ASCE Equation 11.4-1
MCE_R Spectral Response Acceleration Parameter (1.0 s)	S_{M1}	0.843 g	$= Fv * S_1$	ASCE Equation 11.4-2

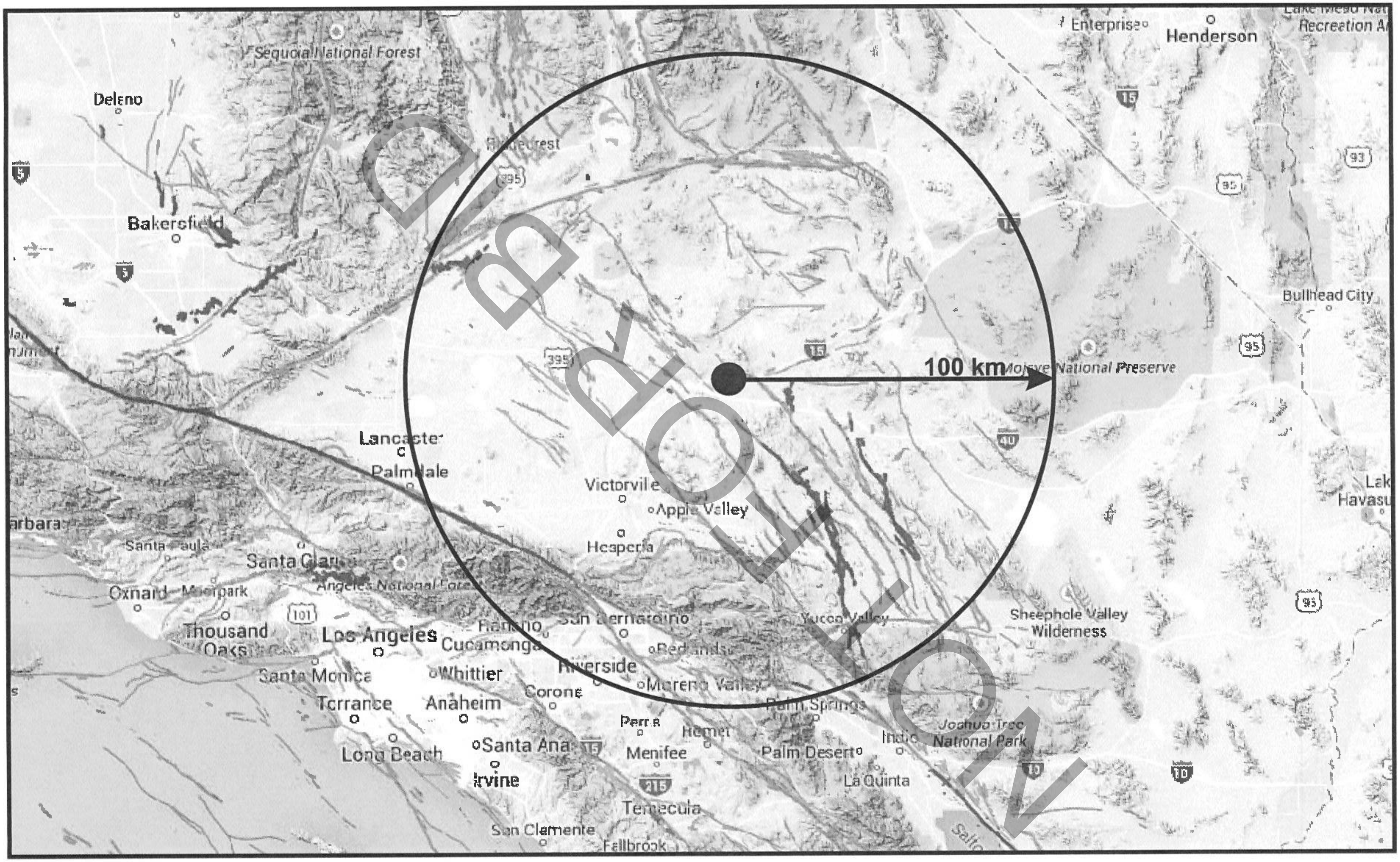
Design Earthquake Ground Motion

Design Spectral Response Acceleration Parameter (0.2 s)	S_{DS}	1.381 g	$= 2/3*S_{MS}$	ASCE Equation 11.4-3
Design Spectral Response Acceleration Parameter (1.0 s)	S_{D1}	0.562 g	$= 2/3*S_{M1}$	ASCE Equation 11.4-4
Risk Coefficient at Short Periods (less than 0.2 s)	C_{RS}	0.887		ASCE Figure 22-17
Risk Coefficient at Long Periods (greater than 1.0 s)	C_{R1}	0.885		ASCE Figure 22-18
	T_L	8.00 sec		ASCE Figure 22-12
	T_O	0.08 sec	$=0.2*S_{D1}/S_{DS}$	
	T_S	0.41 sec	$=S_{D1}/S_{DS}$	
Peak Ground Acceleration	PGA_M	0.93 g		ASCE Equation 11.8-1



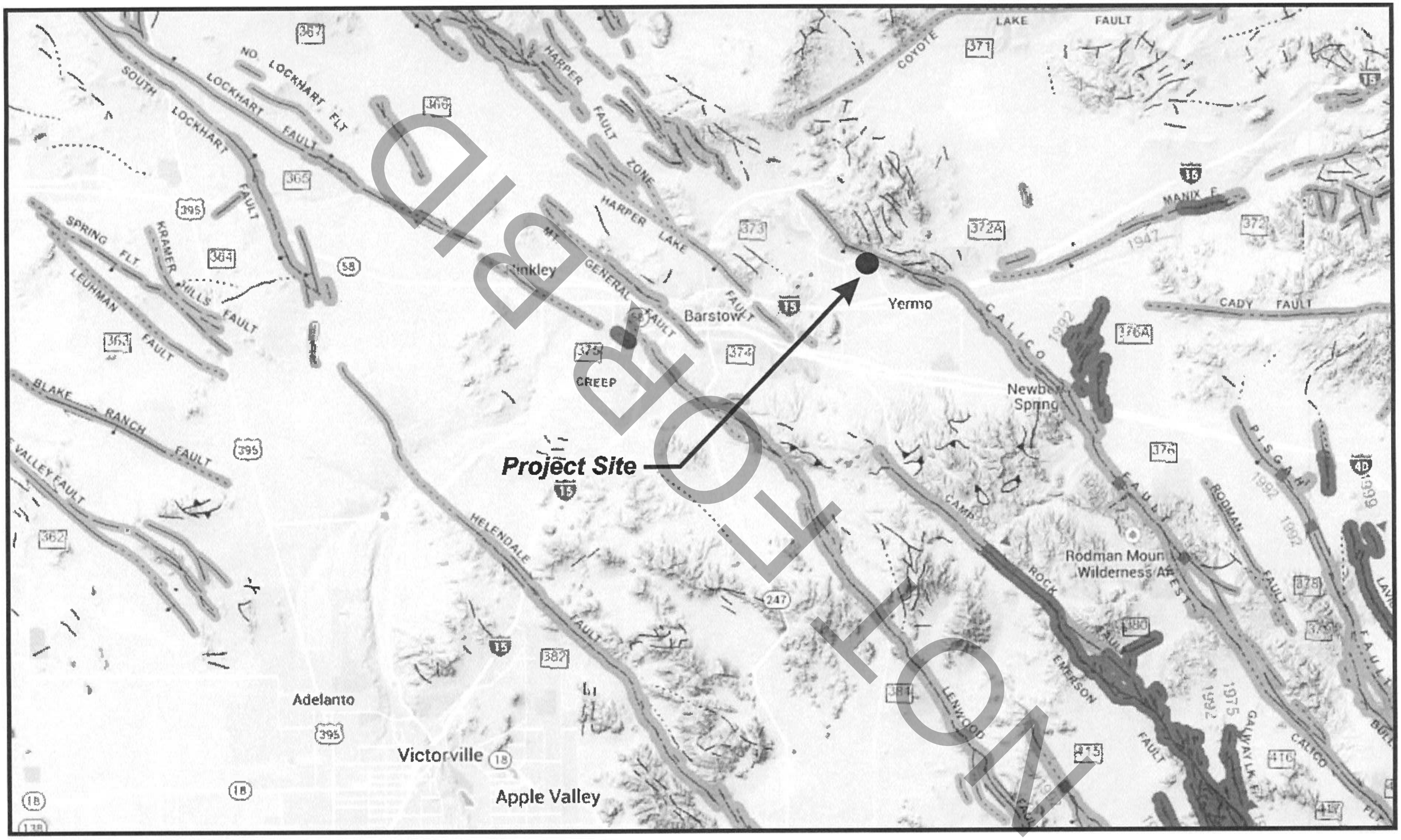
Period T (sec)	Sa (g)	MCE_R Sa (g)
0.00	0.55	0.83
0.08	1.38	2.07
0.41	1.38	2.07
0.75	0.75	1.12
0.80	0.70	1.05
0.90	0.62	0.94
1.00	0.56	0.84
1.10	0.51	0.77
1.20	0.47	0.70
1.20	0.47	0.70
1.40	0.40	0.60
1.50	0.37	0.56
1.75	0.32	0.48
2.00	0.28	0.42
2.20	0.26	0.38
2.40	0.23	0.35
2.60	0.22	0.32
2.80	0.20	0.30
3.00	0.19	0.28
3.50	0.16	0.24
4.00	0.14	0.21

FIGURES



Source: California Geological Survey 2010 Fault Activity Map of California
http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html#

LANDMARK Geo-Engineers and Geologists Project No.: LP20154	Regional Fault Map	Figure 1



Source: California Geological Survey 2010 Fault Activity Map of California
http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html#

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Map of Local Faults

Figure 2

No triangle by date indicates an intermediate point along fault break.

Fault that exhibits fault creep slippage. Hachures indicate linear extent of fault creep. Annotation (cr with leader) indicates representative locations where fault creep has been observed and recorded.

Square on fault indicates where fault creep slippage has occured that has been triggered by an earthqu on some other fault. Date of causative earthquake indicated. Squares to right and left of date indicate ter nal points between which triggered creep slippage has occurred (creep either continuous or intermitt between these end points).

Holocene fault displacement (during past 11,700 years) without historic record. Geomorphic evidence Holocene faulting includes sag ponds, scarps showing little erosion, or the following features in Holoc age deposits: offset stream courses, linear scarps, shutter ridges, and triangular faceted spurs. Rece of faulting offshore is based on the interpreted age of the youngest strata displaced by faulting.

Late Quaternary fault displacement (during past 700,000 years). Geomorphic evidence similar to t described for Holocene faults except features are less distinct. Faulting may be younger, but lack younger overlying deposits precludes more accurate age classification.

Quaternary fault (age undifferentiated). Most faults of this category show evidence of displacement so time during the past 1.6 million years; possible exceptions are faults which displace rocks of undiffere ated Plio-Pleistocene age. Unnumbered Quaternary faults were based on Fault Map of California, 19 See Bulletin 201, Appendix D for source data.

Pre-Quaternary fault (older that 1.6 million years) or fault without recognized Quaternary displacement. Some faults are shown in this category because the source of mapping used was of reconnaissnce nature, or was not done with the object of dating fault displacements. Faults in this category are not necessarily inactive.

ADDITIONAL FAULT SYMBOLS

Bar and ball on downthrown side (relative or apparent).

Arrows along fault indicate relative or apparent direction of lateral movement.

Arrow on fault indicates direction of dip.

Low angle fault (barbs on upper plate). Fault surface generally dips less than 45° but locally may have b subsequently steepened. On offshore faults, barbs simply indicate a reverse fault regardless of steepn of dip.

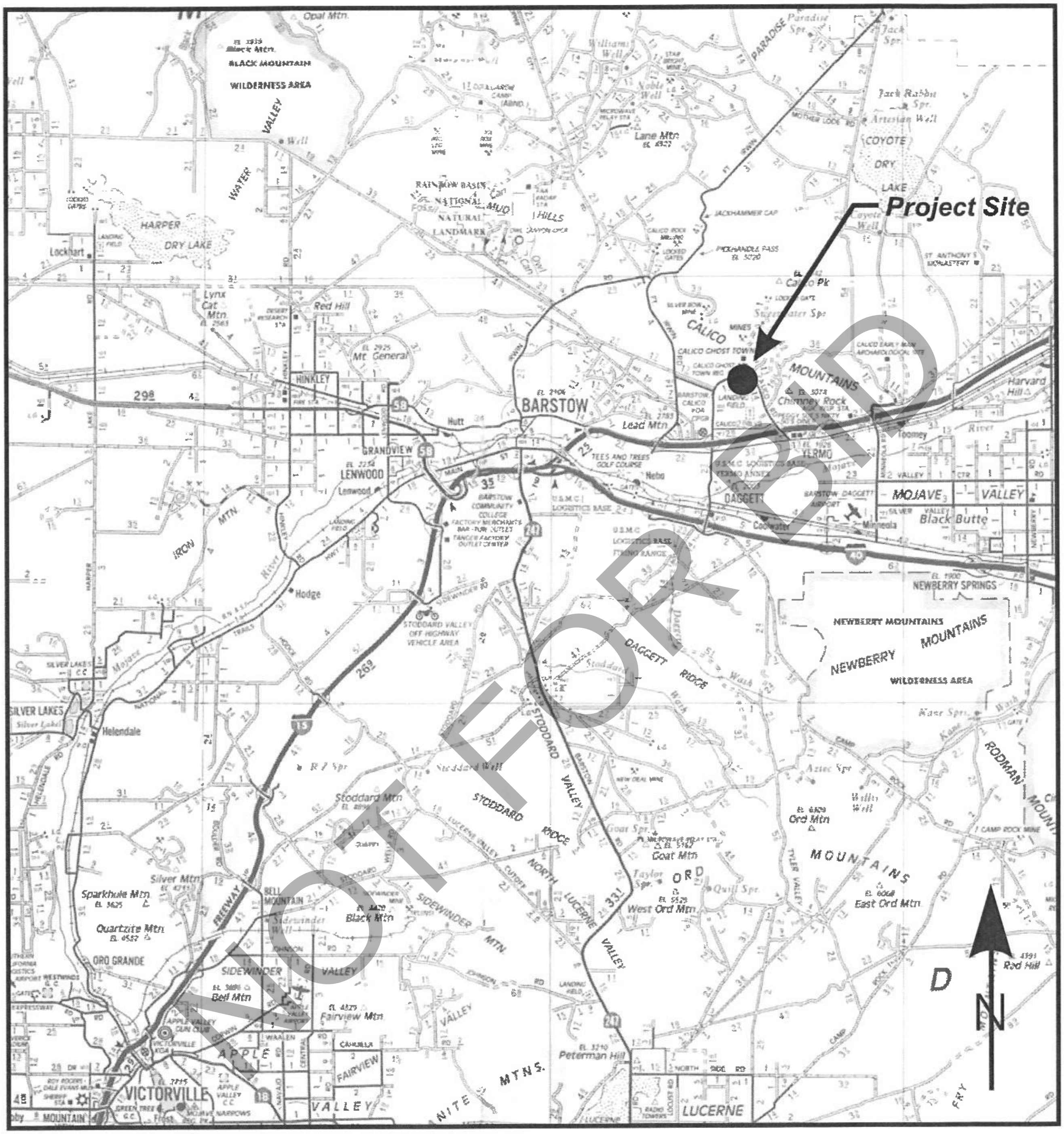
OTHER SYMBOLS

Numbers refer to annotations listed in the appendices of the accompanying report. Annotations include f name, age of fault displacement, and pertinent references including Earthquake Fault Zone maps whe fault has been zoned by the Alquist-Priolo Earthquake Fault Zoning Act. This Act requires the State Ge gist to delineate zones to encompass faults with Holocene displacement.

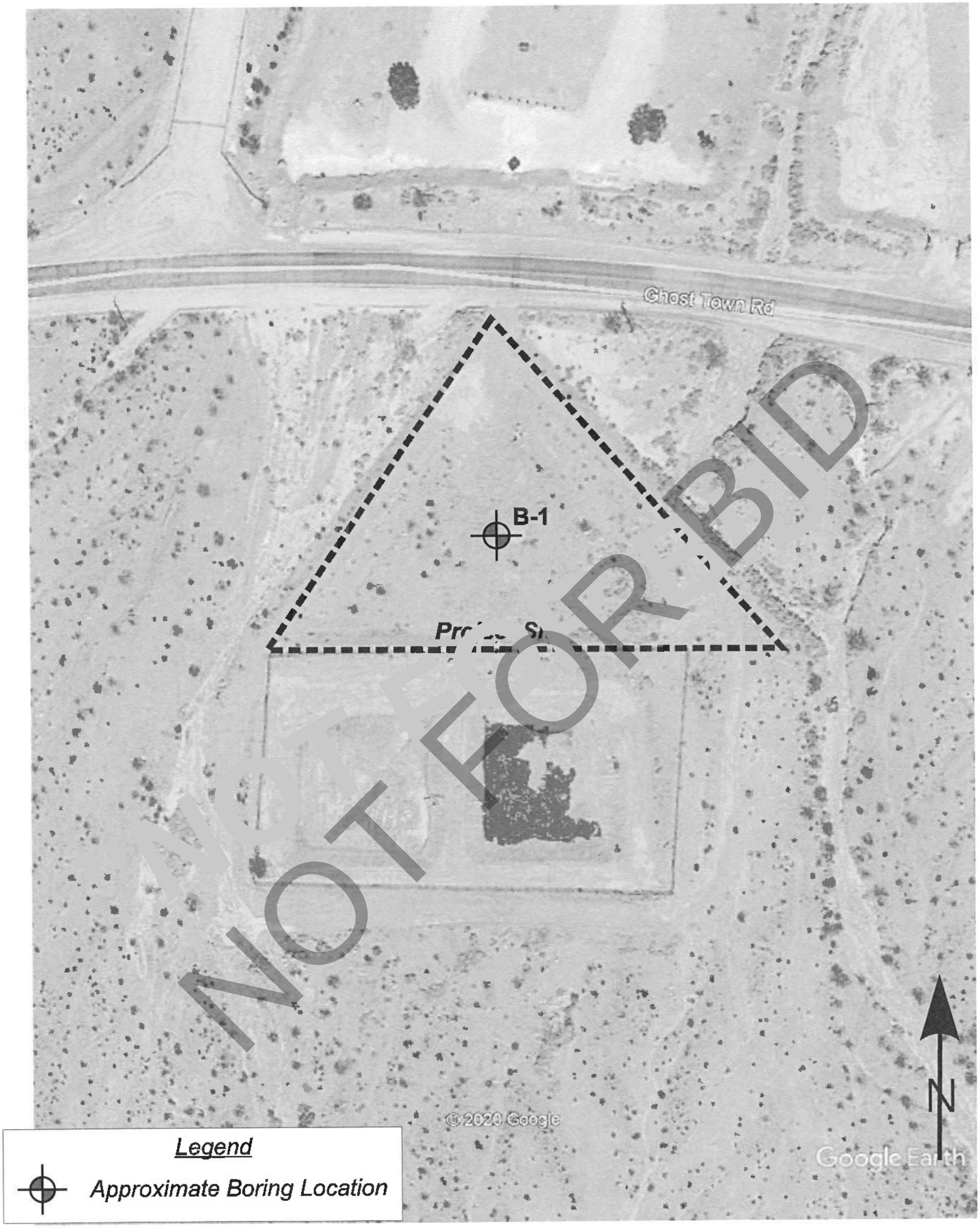
Structural discontinuity (offshore) separating differing Neogene structural domains. May indicate disco nuities between basement rocks.

Brawley Seismic Zone, a linear zone of seismicity locally up to 10 km wide associated with the releas step between the Imperial and San Andreas faults.

APPENDIX A



LANDMARK Geo-Engineers and Geologists **Project No.: LP20154**	**Vicinity Map**	**Plate A-1**



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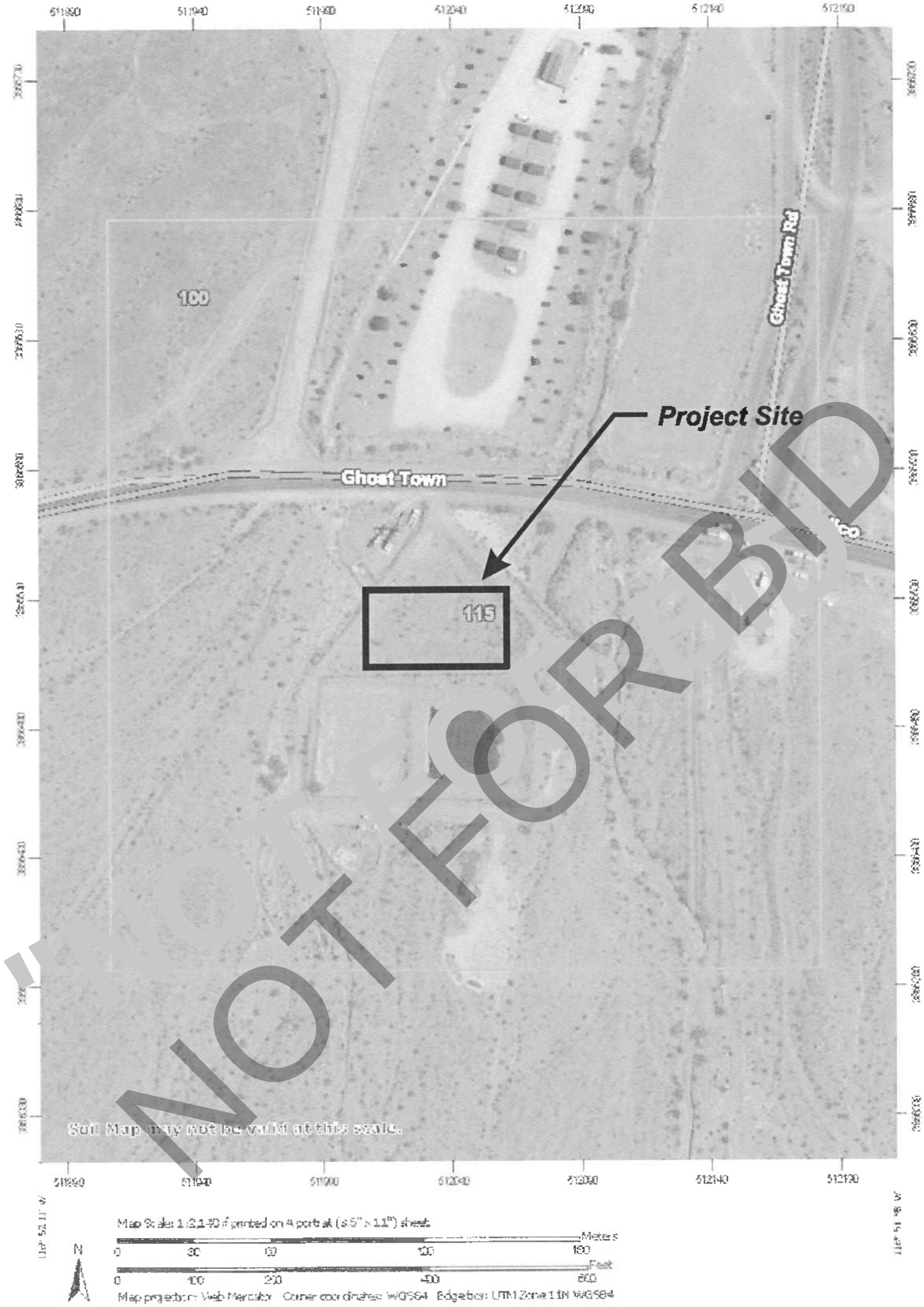
Site Map

Plate
A-2



Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

10/9/2020
Page 1 of 3

LANDMARK Geo-Engineers and Geologists

Project No.: LP20154

USDA Soil Conservation Soil Service Map

Plate A-3

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Bernardino County, California, Mojave River Area
Survey Area Data: Version 12, May 27, 2020

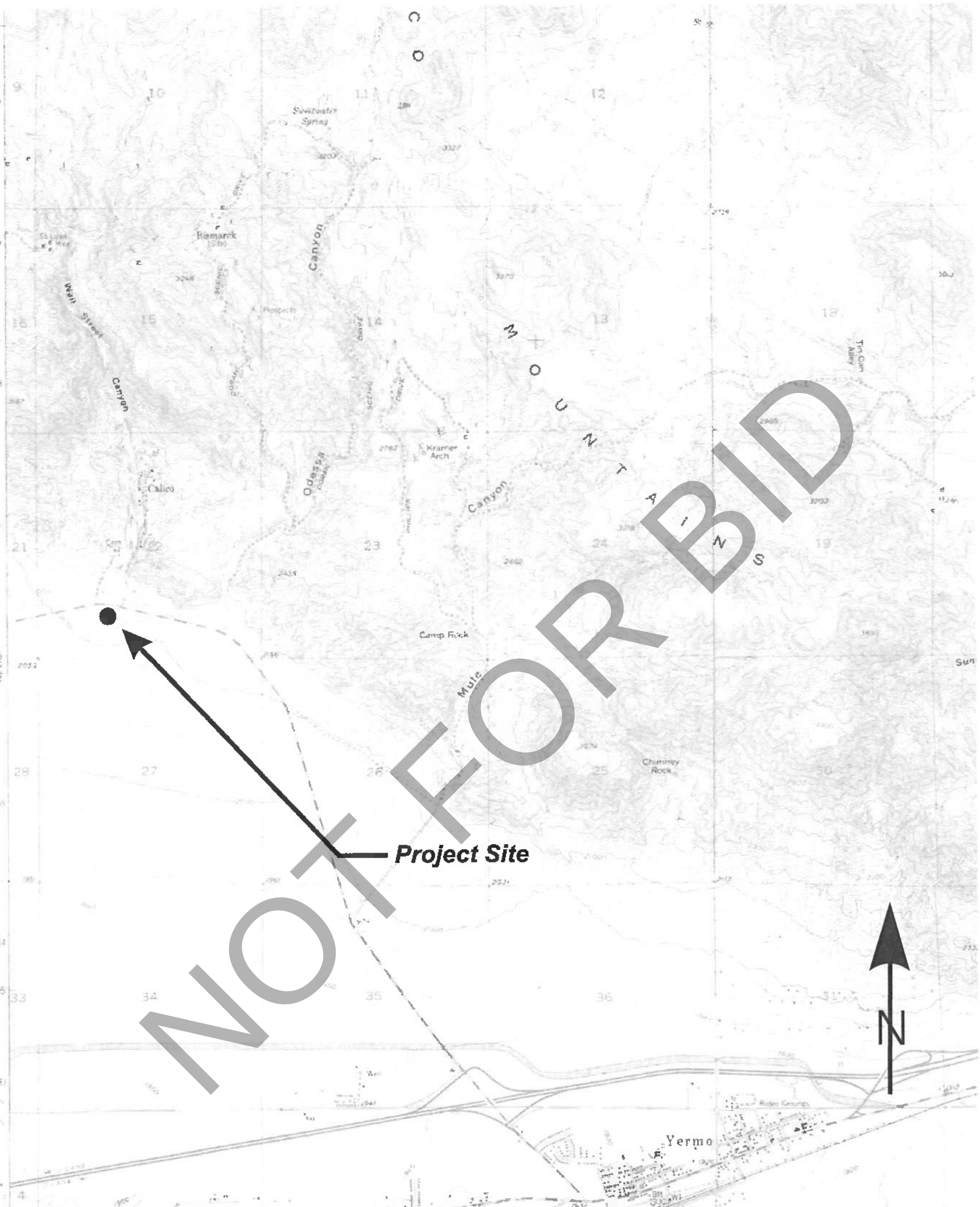
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 26, 2019—Jul 8, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

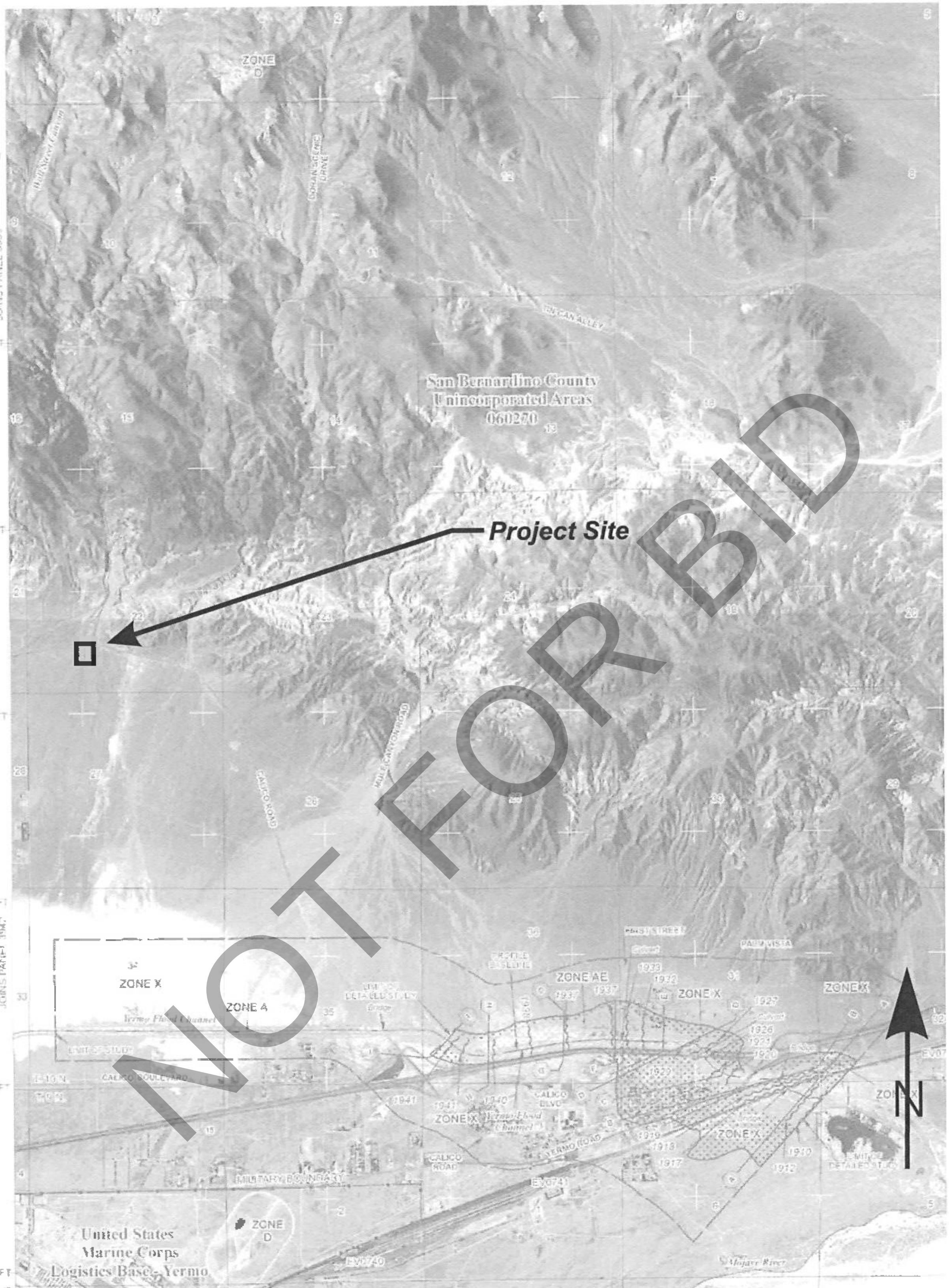
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
100	ARIZO GRAVELLY LOAMY SAND, 2 TO 9 PERCENT SLOPES	1.1	5.6%
115	CAJON GRAVELLY SAND, 2 TO 15 PERCENT SLOPES	18.7	94.4%
Totals for Area of Interest		**19.8**	**100.0%**



Yermo Quadrangle
California - San Bernardino Co.
7.5 Minute Series

Site Coordinates
Lat: 34.9411 N
Long: -116.8682 W

LANDMARK Geo-Engineers and Geologists **Project No.: LP20154**	USGS U.S. Department of the Interior U.S. Gelogical Survey **Topographic Map**	**Plate** **A-4**



Reference: Federal Emergency Management Agency (FEMA)
San Bernardino County Community Panel Number 06071C3975H

LANDMARK Geo-Engineers and Geologists Project No.: LP20154	Flood Insurance Rate Map (FIRM)	Plate A-5

APPENDIX B

LOG OF BORING No. B-1

SHEET 1 OF 1

DEPTH	SAMPLE	USCS CLASS.	BLOW COUNT	POCKET PEN. (tsf)	DESCRIPTION OF MATERIAL	DRY DENSITY (pcf)	MOISTURE CONTENT (% dry wt.)	OTHER TESTS
0–5		SP-SM			SAND (SP-SM): Brown, dry, very dense, fine to coarse grained, with some gravel			Passing #200 = 8.8%
5			88		no recovery			
10			50/2"			77.5	2.0	Passing #200 = 6.8%
15			50/6"			71.4	2.6	
20		SM	95/11"		SILTY SAND (SM): Brown, dry, very dense, fine to coarse grained, with some gravel		3.2	Passing #200 = 13.4%
25			69				3.0	
30			50/6"				3.2	Passing #200 = 14.3%
35–60					Total Depth = 31.5' Groundwater not encountered at time of drilling Backfilled with excavated soil			

NOT FOR BID

DATE DRILLED: 9/21/20 | TOTAL DEPTH: 31.5 Feet | DEPTH TO WATER: NA

LOGGED BY: J. Lorenzana | TYPE OF BIT: Hollow Stem Auger | DIAMETER: 8 in.

SURFACE ELEVATION: 3410 ft. | HAMMER WT.: 140 lbs. | DROP: 30 in.

PROJECT NO. LP20154

LANDMARK Geo-Engineers and Geologists

PLATE B-1

DEFINITION OF TERMS

PRIMARY DIVISIONS			SYMBOLS	SECONDARY DIVISIONS
Coarse grained soils More than half of material is larger that No. 200 sieve	Gravels — More than half of coarse fraction is larger than No. 4 sieve	Clean gravels (less than 5% fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, or gravel-sand mixtures, little or no fines
		Gravel with fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	Sands — More than half of coarse fraction is smaller than No. 4 sieve	Clean sands (less than 5% fines)	SW	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands or gravelly sands, little or no fines
		Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
Fine grained soils More than half of material is smaller than No. 200 sieve	Silts and clays — Liquid limit is less than 50%		ML	Inorganic silts, clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravely, sandy, or lean clays
			OL	Organic silts and organic clays of low plasticity
	Silts and clays — Liquid limit is more than 50%		MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
Highly organic soils			PT	Peat and other highly organic soils

GRAIN SIZES

Silts and Clays	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

200 40 10 4 3/4" 3" 12"

US Standard Series Sieve — Clear Square Openings

Sands, Gravels, etc.	Blows/ft. *
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Over 50

Clays & Plastic Silts	Strength **	Blows/ft. *
Very Soft	0-0.25	0-2
Soft	0.25-0.5	2-4
Firm	0.5-1.0	4-8
Stiff	1.0-2.0	8-16
Very Stiff	2.0-4.0	16-32
Hard	Over 4.0	Over 32

* Number of blows of 140 lb. hammer falling 30 inches to drive a 2 inch O.D. (1 3/8 in. I.D.) split spoon (ASTM D1586).

** Unconfined compressive strength in tons/s.f. as determined by laboratory testing or approximated by the Standard Penetration Test (ASTM D1586), Pocket Penetrometer, Torvane, or visual observation.

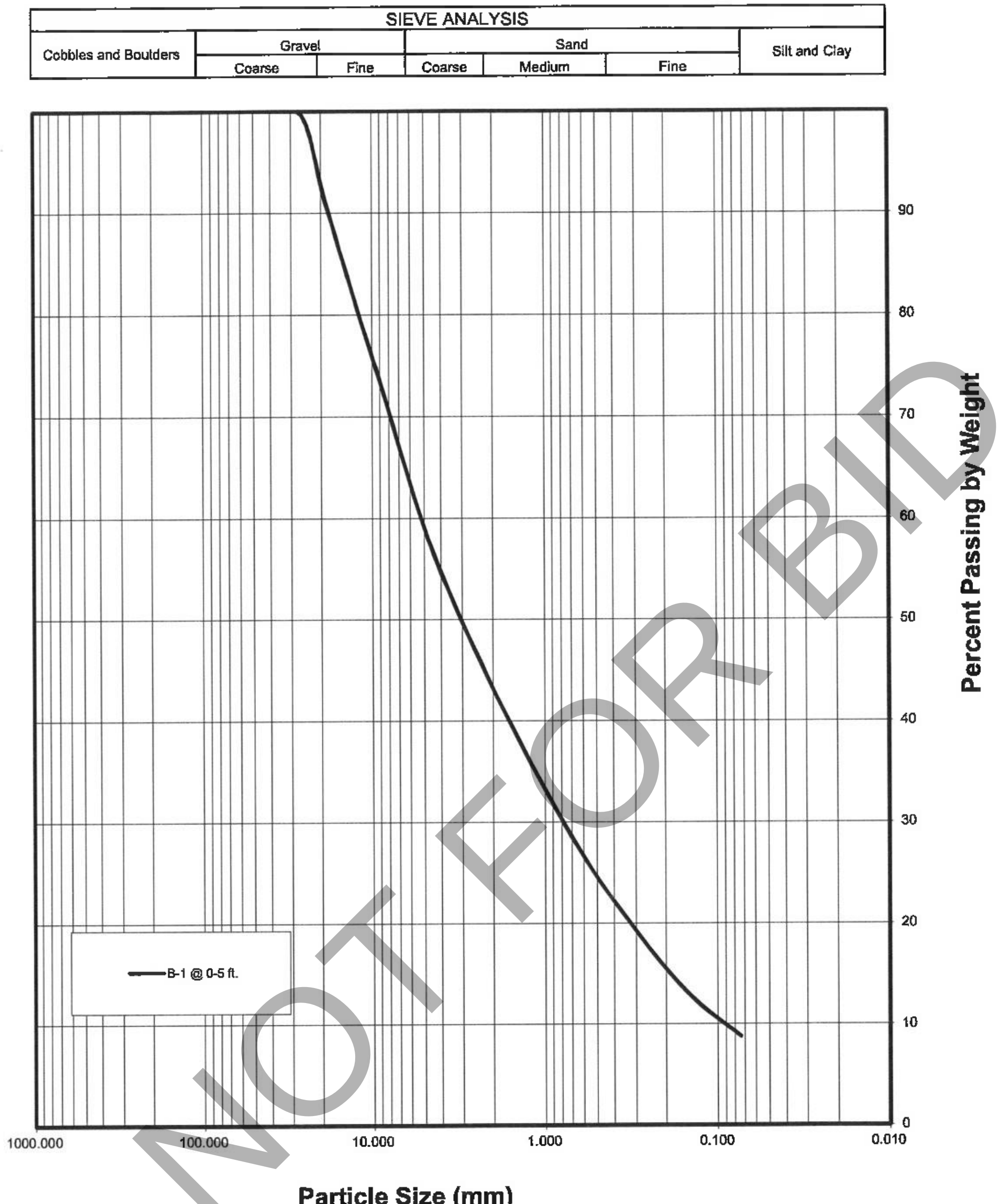
Type of Samples:

Ring Sample — Standard Penetration Test — Shelby Tube — Bulk (Bag) Sample

Drilling Notes:

1. Sampling and Blow Counts
   Ring Sampler - Number of blows per foot of a 140 lb. hammer falling 30 inches.
   Standard Penetration Test - Number of blows per foot.
   Shelby Tube - Three (3) inch nominal diameter tube hydraulically pushed.
2. P. P. = Pocket Penetrometer (tons/s.f.).
3. NR = No recovery.
4. GWT = Ground Water Table observed @ specified time.

APPENDIX C



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Project No.: LP20154

Grain Size Analysis

Plate C-1

LANDMARK CONSULTANTS, INC.

CLIENT: Webb Associates
PROJECT: Calico WWTP Upgrades - Barstow, CA
JOB No.: LP20154
DATE: 10/08/20

CHEMICAL ANALYSIS

		Caltrans Method
Boring:	B-1	
Sample Depth, ft:	0-3	
pH:	7.5	643
Electrical Conductivity (mmhos):	--	424
Resistivity (ohm-cm):	1,300	643
Chloride (Cl), ppm:	250	422
Sulfate (SO4), ppm:	670	417

General Guidelines for Soil Corrosivity

Material Affected	Chemical Agent	Amount in Soil (ppm)	Degree of Corrosivity
Concrete	Soluble Sulfates	0 - 1,000	Low
		1,000 - 2,000	Moderate
		2,000 - 20,000	Severe
		> 20,000	Very Severe
Normal Grade Steel	Soluble Chlorides	0 - 200	Low
		200 - 700	Moderate
		700 - 1,500	Severe
		> 1,500	Very Severe
Normal Grade Steel	Resistivity	1 - 1,000	Very Severe
		1,000 - 2,000	Severe
		2,000 - 10,000	Moderate
		> 10,000	Low

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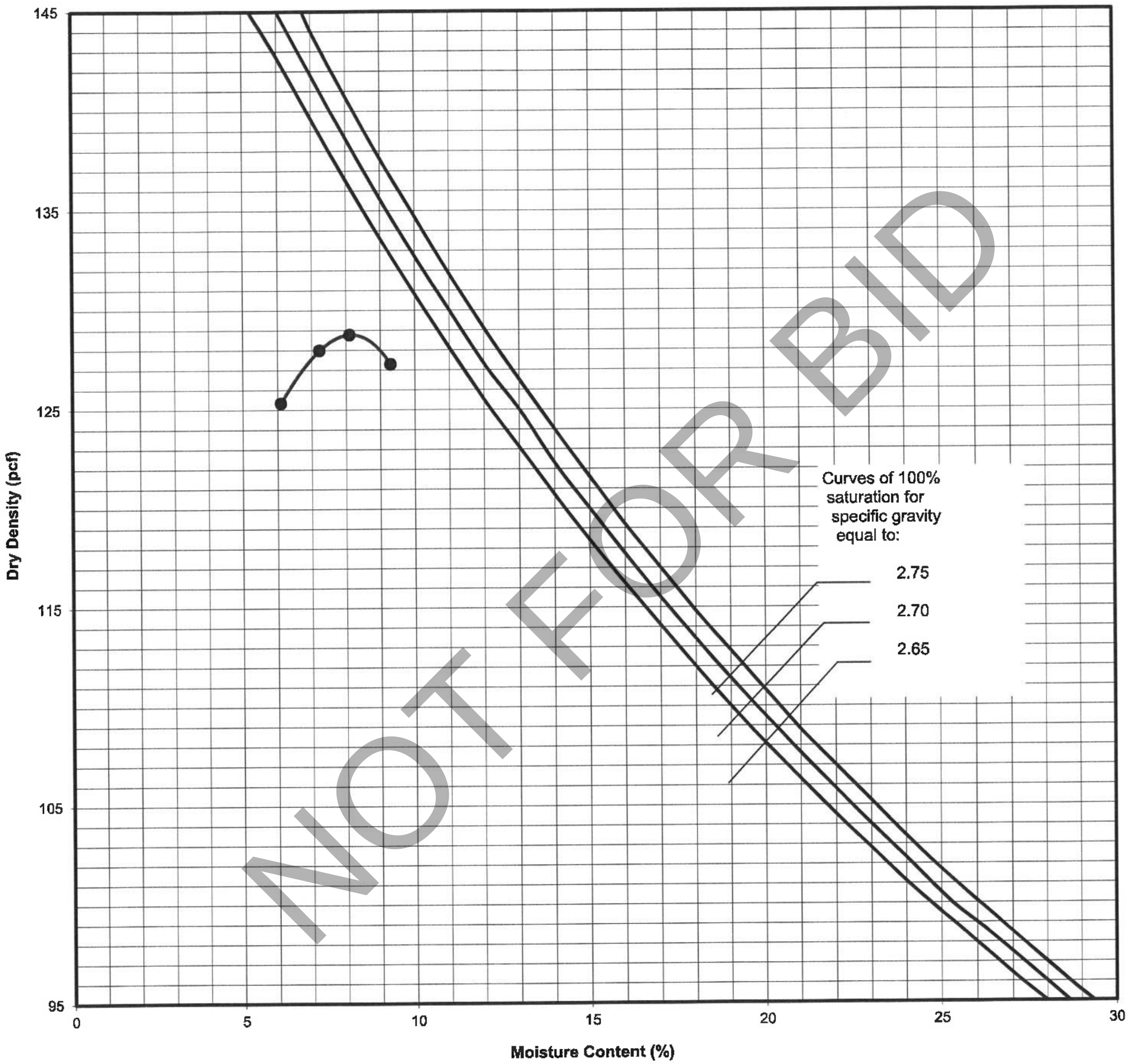
Project No.: LP20154

Selected Chemical Test Results

Plate C-2

Client:	A. Webb & Associates	**Soil Description:**	Brown Sand w/ Gravel
Project:	EQ Basin @ Calico WWTP	**Sample Location:**	B-1 @ 0-3 ft.
Project No.:	LP20154	**Test Method:**	ASTM D-1557 B
Date:	9/23/2020	**Maximum Dry Density (pcf):**	**128.8**
Lab. No.:	N/A	**Optimum Moisture Content (%):**	**8.1**



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Moisture Density Relationship

Plate C-3