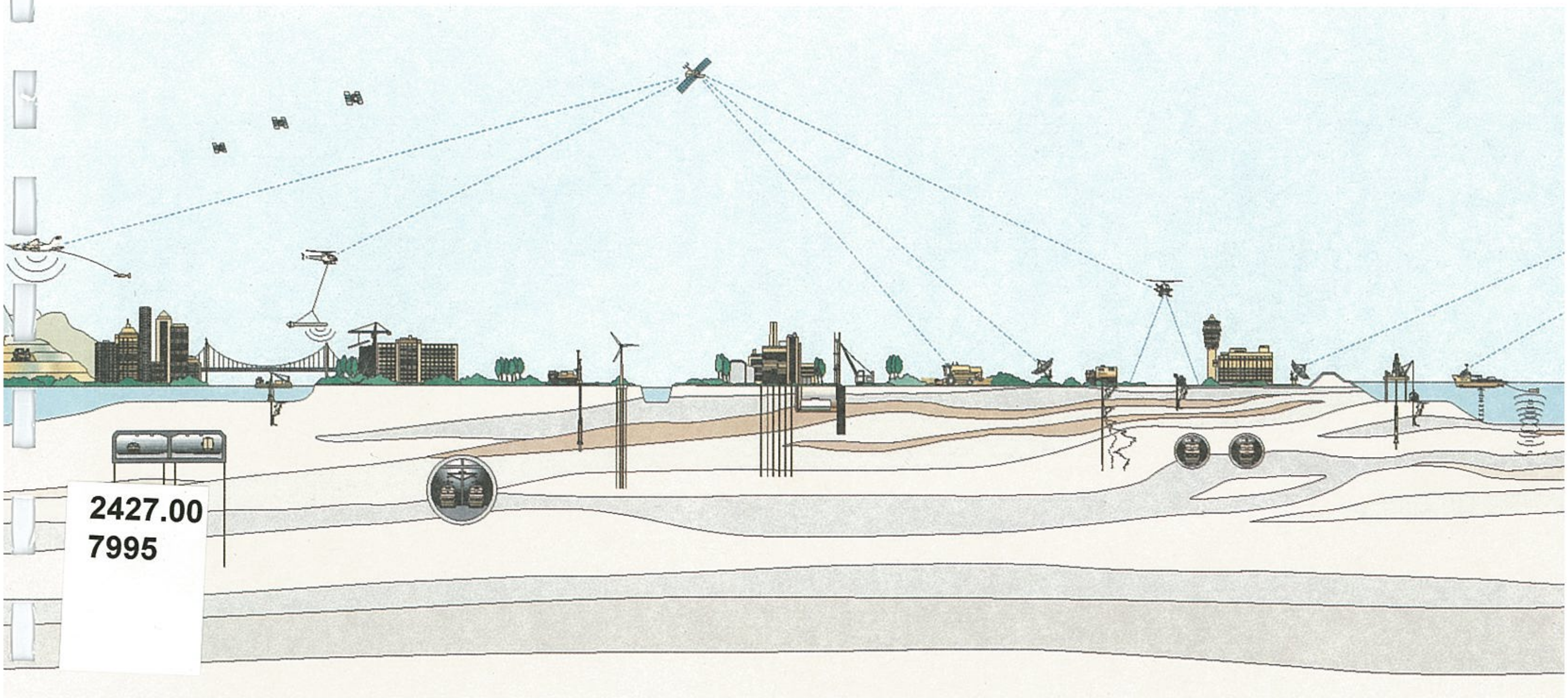
FUGRO WEST, INC.

GEOTECHNICAL STUDY
TWIN LAKES EMERGENCY WATER SUPPLY PIPELINE
LAS VIRGENES MUNICIPAL WATER DISTRICT
CHATSWORTH, CALIFORNIA

Prepared for:
Boyle Engineering Corporation

October 2007
Fugro Job No. 3044.064



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October 12, 2007
Project No. 3044.064

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Attention: Mr. Dan Ellison, P.E.

Subject: Geotechnical Study, Twin Lakes Emergency Water Supply Pipeline, Las Virgenes Municipal Water District, Chatsworth, California

Dear Mr. Ellison:

Fugro is pleased to present this geotechnical study report for Las Virgenes Municipal Water District's (LVMWD) Twin Lakes Emergency Water Supply Pipeline Project. The project area is located along the northwestern edge of the San Fernando Valley in Chatsworth, California. The project is part of the permanent backup water supply system for the Twin Lakes area and Chatsworth Park South during the times when the Metropolitan Water District Southern California's feeder is out of service. The proposed project consists of construction of three segments of pipeline using cut-and-cover construction methods. The northern terminus of the pipeline project is the Twin Lakes Pump Station. The southern terminus of the proposed project is the existing LVMWD 30-inch-diameter pipeline in Valley Circle Boulevard.

The results of our study, as described in this report, include descriptions of our field exploration and laboratory testing programs, interpretation of subsurface conditions, and recommendations for the geotechnical design and construction of the project.

The work was performed in general accordance with our proposal dated November 15, 2006, and authorized by the Professional Services Agreement signed March 23, 2007. We appreciate the opportunity to provide geotechnical services on this project. Please call if you have any questions or need additional information.

Sincerely,

FUGRO WEST, INC.

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1.0 INTRODUCTION

1.1 PROJECT AND SITE DESCRIPTION

The project area is located along the northwestern edge of the San Fernando Valley in Chatsworth, California, as indicated on Plate 1 - Vicinity Map. The proposed pipeline alignment is shown on Plate 2 - Site Map.

The pipeline project is to be a part of the permanent backup water supply system for the Twin Lakes area and Chatsworth Park South during the times when the Metropolitan Water District, Southern California (MWDSC) feeder is out of service.

The proposed project consists of construction of three segments of pipeline using cut-and-cover construction methods. From north to south, the three segments include:

- 730 lineal feet of 10-inch-diameter steel pipeline between the Twin Lakes pump station and the meter vault;
- 200 lineal feet of 12-inch-diameter steel pipeline between the meter vault and the Los Angeles City, Chatsworth Park South facility; and
- About 2,900 lineal feet of 14-inch-diameter steel pipeline between the meter vault and the existing Las Virgenes Municipal Water District (LVMWD) 30-inch-diameter pipeline in Valley Circle Boulevard, the southern terminus.

The 10-inch diameter, 12-inch diameter and the northern 70 percent of the 14-inch-diameter pipelines are located within Chatsworth Park South. The southern 30 percent of the 14-inch diameter pipeline will be beneath Devonshire Street.

As noted above, the pipeline segments will probably be steel; however, an alternate for PVC also may be presented. The pipelines will have at least 3-1/2 feet of cover, implying a trench depth of about 4-1/2 to 5 feet. The line pressure will be less than 100 pounds per square inch (psi).

1.2 WORK PERFORMED

The work performed for this study consisted of permitting, field exploration, laboratory testing, geotechnical evaluation, and reporting. The work was performed in general accordance with our proposal dated November 15, 2006, and authorized by the Professional Services Agreement signed March 23, 2007. Project design plans were not available at the time of field exploration.

1.2.1 Permitting

Fugro obtained encroachment permits from the City of Los Angeles Parks Department and the City of Los Angeles Public Works Department. Fugro coordinated with the City of Los

Angeles Parks Department representatives and with Chatsworth Park South staff. For the work on Devonshire Street, Fugro coordinated with the City of Los Angeles Department of Public Works Inspector and submitted a traffic control plan in accordance with the City of Los Angeles criteria. Traffic control consisted of a left turn lane closure.

Exploration locations were marked prior to notifying Underground Service Alert (USA). The site was visited prior to the drill date to confirm that all subscribing USA members had marked underground utilities. Additional calls were made to USA members in order to have all lines marked. Fugro coordinated with the MWDSC field representative so that he could be present (per his request) during the drilling of Boring No. DH-2 located near MWDSC facilities. Los Angeles City Park Department representatives were present, to verify irrigation line clearance, during drilling of Boring Nos. DH-2, DH-4, and DH-5, which are located in the grass areas of the park.

1.2.2 Field Exploration

Fugro advanced five hollow-stem-auger drill holes in the vicinity of the proposed alignments as follows:

- Boring No. DH-1 was advanced on Devonshire Street to a depth of about 13.9 feet, 50 feet east of the intersection with Larwin Avenue. This drill hole was back filled with a sand cement mixture, and capped with colored concrete.
- Boring No. DH-2 was advanced to a depth of about 16.5 feet, 36 feet south of the meter vault.
- Boring No. DH-3 was advanced to a depth of about 16.5 feet, 25 feet south of the Twin Lakes Pump Station entrance gate.
- Boring No. DH-4 was advanced to a depth of about 14.6 feet, 17 feet southeast of the southwest corner of the Chatsworth Park South main parking area. The purpose of this drill hole was to evaluate subsurface conditions in the vicinity of the Crimson Oil pipeline crossing.
- Boring No. DH-5 was advanced to a depth of about 16.3 feet, approximately 30 feet north of the "large boulder," at the toe of slope. The purpose of the drill hole was to evaluate the potential for shallow bedrock to be encountered during excavation of the pipeline trench, and to evaluate the excavatability of the bedrock based on drilling conditions.

Boring locations are shown on Plate 2. Logs of the borings are presented in Appendix A - Subsurface Exploration.

1.2.3 Laboratory Testing

Laboratory testing was performed on selected earth materials sampled in the drill holes to estimate engineering parameters of the materials. The testing program was based on the findings from the field exploration and included moisture/density measurements, grain-size analyses, direct shear tests, limited chemical testing (pH, resistivity, sulfates, chlorides), and sand equivalent. The test results are presented in Appendix B - Laboratory Testing.

1.2.4 Geotechnical Evaluation and Reporting

Geotechnical evaluations of the field and laboratory data were performed to provide geotechnical design criteria for the proposed pipelines. The following geotechnical information and design criteria have been included in this report:

- Summary of soil and groundwater conditions;
- Discussion of seismic setting and potential geohazards;
- Geotechnical pipeline and thrust block design criteria;
- Excavation and trenching conditions of soil/rock units; and
- Suitability of onsite soil for use as fill and select fill material.

This geotechnical report was prepared to present the findings, conclusions, and recommendations developed for this study.

2.0 FINDINGS

2.1 SITE CONDITIONS

The project site is located along the western margin of the fairly flat-lying, alluvial San Fernando Valley plain and the east side of the Santa Susana Mountains, about 0.7 mile south of Santa Susana Pass, in Los Angeles County. The United States Geologic Survey (USGS) topographic map of the area (USGS, 1969) and the topographic map provided by Boyle Engineering Corporation indicate that elevations (El.) along the proposed alignments vary from a high of about +995 feet to a low of about +940 feet above mean sea level (MSL), with the ground surface generally sloping gently to the southeast.

The northern end of the project area, the Twin Lakes Pump Station, is in the bottom of a south draining canyon at an El. of about +995 feet. The alignment follows the tree-brush-grass lined pump station dirt access road for about 300 feet in a southwesterly direction. The access road intersects a northwest - southeast oriented dirt road at a "T" intersection. The alignment follows the northwest-southeast dirt road in a southeasterly direction for about 500 feet, along the northern edge of an alluvial valley. The northwest-southeast oriented road is about 20 to 25 feet south of the toe of a steep, about 125-foot high, ascending slope. Well-indurated sandstone of the Chatsworth Formation is exposed in the ascending slope.

The alignment crosses the manicured lawn and tree covered valley floor of Chatsworth Park South for about 600 feet in a southerly direction, gently descending from an El. of +974 feet to an El. of +965 feet in the middle of the alluvial canyon bottom, then ascending to an El. of +969 feet near the southwest corner of the main parking lot of Chatsworth Park South.

The middle third of the alignment traverses the park in a general southeasterly direction for about 1,300 feet from the southwestern corner of the parking lot to the entrance gate of

Chatsworth Park South. The middle third of the alignment is generally along the southern edge of the alluvial valley, roughly 50 feet north of the southwesterly ascending, moderate to steeply inclined, slope. The park entrance gate is at the west end of Devonshire Street, which is at an El. of +942 feet, and which roughly marks the boundary between the Santa Susana Mountains and the alluvial basin known as the San Fernando Valley.

The southern 800 feet of the alignment is beneath a roughly two-block stretch of the gentle southwesterly descending grade of Devonshire Street. Devonshire Street is about 85-feet wide and has a raised center divider. The southern terminus of the alignment is beneath Valley Circle Boulevard, and has a road surface El. of +940 feet.

2.2 GEOLOGIC CONDITIONS

2.2.1 Regional Setting

The proposed pipelines are located within the Transverse Ranges geologic/geomorphic province of California. The province is characterized by east-west-trending mountain ranges composed of sedimentary and volcanic rocks ranging in age from Cretaceous to Recent. Major east-trending folds, reverse faults, and left-lateral strike-slip faults reflect regional north-south compression and are characteristic of the Transverse Ranges. Regional geologic conditions, as mapped by Dibblee (1992a and 1992b), are presented on Plate 3 - Regional Geologic Map.

The site is located about 0.4 miles south of an unnamed fault, 1.9 miles south of the south branch of the Simi fault, 2.6 miles south of the north branch of the Simi fault, 3.1 miles south of the Santa Susana fault zone. The project site is located in the seismically active southern California area. The site is likely to be subjected to strong earthquake ground motion during the lifetime of the project.

2.2.2 Local Setting

The pipe alignment is located west of Chatsworth Peak in the Simi hills, about 4,000 feet south of Santa Susanna Pass and the Santa Susanna Mountains, and along the northeastern boundary between the Simi hills and the San Fernando Valley. There are two un-named southwest-northeast trending faults located about 2,700 and 4,200 feet north of the alignment. As mapped by Dibblee (1992a), the earth materials exposed at the site consist of a mixture of fine- to coarse-grained alluvium and bedrock of the Chatsworth Formation as suggested on Plate 3.

About 650 feet of the alignment will be underlain by dense older alluvium or hard, thick-bedded sandstone of the Chatsworth Formation. Sandstone beds in the vicinity of the alignment dip 10 to 16 degrees to the northwest and valley and floodplain deposits generally capped by artificial fill underlie the remaining 2,250 feet of the alignment. The alluvium generally consists of gravel, sand and clay.

2.3 EARTH MATERIALS

Earth materials encountered in the bore holes advanced for this study to the depths explored generally consisted of artificial fill, alluvium, older alluvium and bedrock of the Chatsworth Formation. Generalized descriptions of the various earth materials encountered in the explorations are provided below.

2.3.1 Artificial Fill (af)

Artificial fill (af) materials were encountered in Boring Nos. DH-1, DH-2, DH-4 and DH-5 to depths of about 4, 0.5, 12 and 7.8 feet, respectively. Artificial fill materials at DH-1 consisted of road base underlain by clayey sand. Artificial fill materials at DH-3 consisted of imported poorly graded gravel. Artificial fill materials at DH-4 and DH-5 consisted of loose to medium dense silty sand and clayey sand.

The southern portion of the alignment is along Devonshire Street, and in or along the park entrance road. Roadway surfaces consist of asphaltic concrete. Road base was encountered and should be anticipated beneath Devonshire Street. No boreholes were advanced in the park roadways so the presence and thickness of road base is not known.

2.3.2 Alluvium (Qa)

Alluvium was encountered in Boring Nos. DH-1, DH-4 and DH-5, beneath artificial fill materials. Alluvium is exposed at the surface in drill hole DH-2. The granular alluvium consisted of medium dense to dense poorly graded sand, silty sand, sandy silt and clayey sand. Cohesive alluvial sediments consisted of stiff sandy clay. The color of the alluvium was generally dark grayish brown to varying shades of olive brown and yellowish brown.

2.3.3 Older Alluvium (Qoal)

Older alluvium was encountered in DH-3 below the roadway base materials. Older alluvium consisted of yellowish brown to light olive brown, very stiff sandy clay and brown medium dense to dense clayey sand.

2.3.4 Chatsworth Formation (Tcs)

Sandstone of the Chatsworth Formation is exposed in the steeply ascending canyon slopes and was encountered in Boring No. DH-5 at a depth of about 10 feet in the project area. As described by Dibblee (1992a and b), the Chatsworth Formation is light gray to light brown, hard thick bedded sandstone; locally gritty with minor thin layers of micaceous siltstone. Highly weathered sandstone of the Chatsworth Formation, encountered in Boring No. DH-5, varied from brown to light olive brown to yellowish brown in color. Although dense, the weathered sandstine was excavated with the drill rig. Unweathered Chatsworth Formation sandstone was not encountered in any of the bore holes excavated for this study.

2.4 GROUNDWATER

Groundwater was encountered at a depth of 7.5 feet (about El. + 933 feet) in Boring No. DH-1. Groundwater was not encountered in DH-2 through DH-5, to the maximum depth explored of 16.5 feet.

Perched groundwater may occur above materials of low permeability, such as fine-grained silt or clay lenses, which could exist within the project area. In addition, fractures in bedrock could act as conduits to groundwater flow. Therefore, shallow groundwater and groundwater seepage could potentially be present along any portion of the pipeline alignment.

2.5 ENGINEERING PROPERTIES OF SELECTED EARTH MATERIALS

Laboratory tests were performed on selected samples recovered from our field exploration program to characterize the engineering properties of the soils at the locations explored. The results of the laboratory tests are presented in Appendix B.

2.5.1 Blow Count Data

Field blowcounts for fill and alluvial soil materials sampled in the drill holes using the automatic trip hammer ranged from about 6 to 62 blows per foot (bpf). The high value of 62 measured in DH-5 at about 3 feet was probably due to a cobble. Two values of 50 blows per 5 inches measured in DH-1 at 13.5 feet and in DH-5 at 9.5 feet are probably due to the presence of hard gravel and proximity to the weathered Chatsworth sandstone, respectively. A more typical value for alluvium is in the range of 12 to 40 bpf. Field blowcounts for fill, encountered in DH-4, range from 6 to 16 bpf.

Two field blowcount values measured in the highly weathered Chatsworth sandstone ranged were 46 and 59 bpf.

2.5.2 Soil Unit Weight

In-place soil dry density measurements for selected soil samples ranged from about 103 to 122 pcf. Moisture contents ranged from 5 to 20 percent. Total unit weights ranged from about 108 to 133 pcf.

2.5.3 Grain Size

Measured fines contents for granular materials ranged from 36 to 49 percent, with one value of 9 percent.

2.5.4 Sand Equivalent

A sand equivalent (SE) test of 18 was measured on a selected sample of onsite granular soil recovered from Boring No. DH-1 at a depth of 10 feet.

2.6 POTENTIAL VARIATION OF SUBSURFACE MATERIALS

Borings excavated for this study were spaced about 500 to 800 feet apart along the proposed pipeline alignment (Plate 2). There is a potential for variation in the consistency, densities, and strength/hardness of the materials. There is also potential for oversized materials (greater than 8 inches in diameter), perched water, zones of poorly consolidated soils, or other conditions not indicated in the boring logs. If significant variation in the geologic conditions is observed during grading, we recommend that the geotechnical engineer, in conjunction with the project designer, evaluate the impact of those variations on the project design.

2.7 GEOHAZARDS AND SEISMICITY

2.7.1 Fault Rupture Potential/Ground Shaking

The proposed pipeline route does not lie within nor cross an Alquist-Priolo fault rupture hazard zone. Based on our data review, no known faults traverse or trend toward the pipeline alignment. Therefore, the potential for ground rupture to occur along the alignment is considered to be low.

The project site is located within a seismically active area of southern California and the potential exists for strong ground motion to affect the project during the design lifetime. The site is proximal to a number of faults that are considered active or potentially active including the Santa Susana, Sierra Madre, Holser and Oak Ridge faults as summarized in Table 1. The Santa Susana fault zone, located about 4.3 miles to the north of the project area (Blake, 1998), has not yet been evaluated for zoning purposes. However, the portion of the Santa Susana fault zone located about 4.6 miles northeast of the site has been zoned as active by the State of California (California Department of Mines and Geology [CDMG], 1976).

Table 1. Active and Potentially Active Faults

Fault	Distance (miles)	Maximum Earthquake Magnitude (Mw)
Santa Susana	4.3	6.6
Sierra Madre (San Fernando)	8.4	6.7
Holser	8.6	6.5
Oak Ridge (Onshore)	9.3	6.9
Simi - Santa Rosa	10.6	6.7
Verdgo	11.2	6.7
San Gabriel	12.0	7.0
Malibu Coast	13.5	6.7
San Cayetano	14.7	6.8
Anacapa - Dume	14.9	7.3
Hollywood	15.0	6.5
Santa Monica	15.0	6.6
San Andreas - 1857 Rupture	30.2	7.8

Probabilistic seismic hazard studies by the California Division of Mines and Geology (CDMG, 2001) indicates that the project area could experience horizontal ground accelerations (10 percent probability of exceedance in 50 years, i.e, a 475-year return period) in the range of about 0.68 g to 0.73 g for alluvial conditions.

2.7.2 Liquefaction

CDMG (2001) has identified the alluvium as susceptible to potential liquefaction. Historic high groundwater levels suggested in CDMG (2001) are generally about 10- to 30-feet below ground surface along the proposed alignment. Groundwater was encountered at a depth of 7.5 feet in Boring No. DH-1 near the southern end of the alignment. Shallow groundwater is a factor contributing to the potential for liquefaction.

Liquefaction is described as the sudden loss of soil strength because of a rapid increase in soil pore water pressures due to cyclic loading during a seismic event. In order for liquefaction to occur, three general geotechnical characteristics must be present: 1) groundwater must be present within the potentially liquefiable zone; 2) the potentially liquefiable soil must be granular and the grain size distribution should fall within a relatively specific range; and 3) the potentially liquefiable soil must be of low to moderate relative density. If those criteria are met and strong ground motion occurs, then those soils may liquefy, depending upon the intensity and cyclic nature of the strong ground motion. Liquefaction that produces surface effects generally occurs in the upper 40 to 50 feet of the soil column, although the phenomenon can occur deeper than 100 feet.

Earth materials encountered in the exploration performed for this study included loose to medium dense granular fill and alluvial deposits. Groundwater was present at a depth of 7.5 feet in DH-1, located in the southern portion of the alignment.

Portions of the pipeline alignment underlain by young granular alluvium, where shallow groundwater is present, may be potentially liquefiable, resulting in liquefaction-related settlement or lateral deformation. Liquefaction would not affect those pipeline areas underlain by dense older alluvium and bedrock materials.

2.7.3 Landsliding/Slope Instability

Dibblee (1992a) and the CDMG (2001) Landslide Inventory do not identify landslide deposits in the vicinity of the proposed route. The pipeline alignment traverses flat to gently sloping terrain. A portion of the proposed alignments are proximal to relatively steep slopes in the area of the meter vault and the boulder outcrop; however, because the slopes are composed of hard sandstone resistant to weathering, the potential for slope instability and landsliding to impact the pipeline project is considered low. There is, however, a potential for rocks/ boulders to land on the alignment due to weathering processes and seismic shaking, during the lifetime of the project.

2.7.4 Seiches/Tsunamis/Flooding

The project site is located in fairly flat-lying canyon bottoms, and near the edge of an alluvial flood plane at about 950 feet above sea level. There are no land-locked bodies of water proximal to the site. The proposed alignment does not cross any stream or flood control channels. The alignment does cross a seasonal creek (USGS, 1969). Based on site elevation, topography, and proximity to land-locked bodies of water, the potential for seiches, tsunamis, and flooding to affect the site and damage project elements is low.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 TRENCHES AND EXCAVATIONS

3.1.1 Excavation Conditions

Earth materials encountered in the bore holes excavated for this study consisted primarily of granular soils with lesser amounts of cohesive soils deposited in an alluvial environment. Bore holes were excavated using a truck-mounted CME-75 hollow-stem-auger drill rig equipped with 8-inch-diameter hollow-stem augers. Based on our observations during drilling, we anticipate that conventional heavy-duty earth moving equipment in good working order should be capable of excavating fill and alluvial earth materials encountered along the proposed pipeline alignments. Bedrock excavation, if encountered, may require special excavation techniques such hoe-rams.

3.1.2 Dewatering

Groundwater was encountered at DH-1 at a depth of 7.5-feet below ground surface. The groundwater depth recorded during drilling does not necessarily indicate seasonal perched or static groundwater levels, which may be higher. Although groundwater was not encountered above anticipated excavation depths, the potential exists for elevated groundwater conditions or perched water to be encountered during excavations for the pipeline and other construction activities.

If groundwater is encountered, sumping and pumping of free water from open excavations may not be adequate to maintain excavations in a dry and stable condition. Dewatering systems should be designed, installed, and operated by an experienced company specializing in groundwater dewatering systems, and should be capable of lowering the groundwater surface to a level below the required depth of excavation. Groundwater levels should be maintained at least 3-feet below any point on the excavated surface (defined by the elevation of any overexcavated surface), and should provide excavation sidewalls free of groundwater seepage.

Dewatering systems may encounter difficulty performing efficiently because of the interbedded nature of the sand and clay layers present in the subsurface and possibly from perched water conditions. Before implementing a dewatering system, we recommend that a dewatering test program be conducted to evaluate the feasibility and efficiency of the proposed dewatering system. Dewatering operations may require permitting in accordance with the National Pollutant Discharge Elimination System (NPDES) regulations and possibly other local permits.

3.1.3 Temporary Excavations and Shoring

Either temporary slopes and shoring and bracing of the trench sidewalls will be required. At a minimum, all temporary excavations should be designed in accordance with OSHA regulations. The contractor should be responsible for the design and implementation of shoring systems and safe working conditions.

Unconsolidated sand with varying amounts of sand, silt, and clay were encountered in the bore holes and sloughing of those materials could occur unless the trench walls are shored or shielded.

As guidance for design, the onsite soils appear to meet the OSHA criteria for Type C Soils provided the materials are properly dewatered. Temporary excavations should be monitored for stability during construction and be modified if necessary.

From our experience, we anticipate that potential shoring methods could consist of cantilevered or braced/tied-back sheet pilling or cantilevered or braced soldier beam and lagging systems. Lateral pressures considered applicable for the design will depend on the type of shoring system selected by the contractor (braced/unbraced) and whether the site is appropriately dewatered or not.

3.1.4 Existing Utilities/Pipelines

Trenches should be excavated no closer than a 1 horizontal:1 vertical (1h:1v) projection up from the bottom of the excavation in areas where an existing utility/pipeline parallels or subparallels the trench excavation. The minimum clear distance between an existing utility and the trench should be evaluated by the contractor. We recommend that existing utility/pipelines be supported/protected or that the trench be shored to prevent loss of lateral support for existing utility/pipelines when: 1) the trench is closer than a 1h:1v projection to the existing utility, 2) the stability of the existing utility is in question, or 3) there is a potential for sloughing of the trench sidewalls adjacent to the existing utility.

3.2 PIPELINE DESIGN

Compacted fill materials for the proposed pipeline will consist of pipe zone materials and trench backfill materials. The following subsections describe each of those materials. The recommendations for characteristics and placement of those materials are largely derived from the "Greenbook" (2006), Section 306. Las Virgenes Municipal Water District (LVMD) has standard details that will probably be used for pipeline construction. Consideration should be given to modify the LVMWD details where recommendations presented herein are more restrictive than the LVMWD details.

3.2.1 Pipe Zone Materials

Pipe zone materials are defined, herein, as those select earth materials used as pipeline bedding and shading. The pipe zone materials should extend from at least 6-inches below the pipe to 12-inches above the crown. The pipe zone materials also should extend at least 24 inches out from the sides of the pipeline. Pipe zone materials should consist of clean sand or crushed angular gravel with a minimum SE of 30 to facilitate placement and achieve uniform support for the improvements. Gravel should conform to the gradation for three-quarter-inch, crushed rock in Table 200-1.2, of the "Greenbook" (2006).

On the basis of our observations, the soils encountered during subsurface exploration for the project appear unlikely to comply with the recommendations presented above for pipe zone backfill materials. Selected soil samples from the bore holes advanced along the pipeline alignment have fines contents typically in excess of about 35 percent and a single SE result was 18. Some onsite soil may satisfy the requirements for pipe zone material. However, the potential quantity of those materials is unknown and it will be difficult to identify and segregate those materials. Therefore, in our opinion, most (if not all), of the pipe zone backfill materials will likely need to be imported to the project site.

Pipe zone materials should be properly placed and mechanically compacted in order to achieve a minimum of 90 percent relative compaction as determined by standard test method ASTM D1557. Sand backfill should be placed in loose lift thicknesses no greater than 8 inches and mechanically compacted with a vibratory compactor. If crushed gravel is used as bedding material, the gravel bedding should be placed in loose lift thicknesses no greater than 8 inches and should be mechanically compacted using a minimum of three passes of a vibrating mechanical compactor. The trench width should be sufficient to allow compaction equipment to operate between the pipe spring line and trench wall. Jetting or flooding of pipe zone materials should not be allowed.

3.2.2 Trench Backfill Materials

Trench backfill materials are defined herein, as those materials placed above the pipe zone. Onsite soils should be suitable for use as trench backfill. Trench backfill should be spread in loose lifts not to exceed 8 inches in thickness, moisture conditioned to within 2 percent of optimum moisture content and compacted to 90 percent of the maximum dry density as determined from ASTM D1557. The upper 1 foot of the subgrade beneath paved areas should be compacted to 95 percent of the maximum dry density ASTM D1557. Particles larger than 6 inches in maximum dimension should be excluded.

3.2.3 External Pipeline Loads

External loads on the pipes will consist of loads due to the overlying earth materials, loads due to construction activities, and loads related to traffic, agricultural operations, or other post-construction land uses. We recommend that the pipes be designed to resist the imposed loads with a factor of safety and an amount of deflection, as recommended by the pipeline manufacturer.

Loads on the pipe due to the overlying soil will be dependent upon the depth of placement, the type and method of backfill, the type of pipe, the configuration of the trench, and whether or not any fill will be placed above the ground surface. The pipe may be subject to surcharge pressures due to construction activities and traffic. Those surcharge pressures should be considered in the design of the pipe.

3.2.4 Thrust Resistance

Thrust resistance will be provided using thrust blocks, most likely designed in accordance with LVMWD standard thrust block details. Those details are based on an ultimate lateral bearing of 1,500 psf in conjunction with factors of safety ranging from 2 to 4 depending on pipe diameter. Based on conversations with Mr. Dan Ellison, the LVMWD standard thrust block details have worked reasonably well.

However, we recommend that thrust block design be checked using an ultimate lateral pressure estimated using an equivalent fluid weight of 300 pcf up to an ultimate value of 2,000 pounds per square foot (psf) for bearing directly against undisturbed native soils. The estimated lateral displacement needed to develop the ultimate passive pressure for a 5-foot high thrust-block is about 1/2 inch (about 1 percent of the block height). Lateral bearing should be neglected from the ground surface to a depth of 1 foot below the lowest adjacent grade.

3.2.5 Corrosivity

Two samples were selected for corrosivity testing and the results are summarized in Table 2.

Table 2. Summary of Chemical Test Results

Drill Hole	Material Description	Resistivity (OHMS-cm)	pH	Chloride (ppm)	Sulfate (percent)
DH-1 at 4-6 ft	Alluvium - Sandy SILT (ML)to Silty SAND (SM)	8300	7.7	<42	0.0057
DH-2 at 0-5 ft	Alluvium - Silty SAND (SM) to Clayey SAND (SC)	9800	8.5	<33	0.0086

Measured chloride and sulfate values suggest that the tested soil is not corrosive to concrete per Table 19-A-4 of the 1997 UBC. A corrosion engineer should review the resistivity and other chemical results to assess what corrosion measures are needed.

3.3 FIELD OBSERVATION AND TESTING

The construction process is an integral part of the design with respect to geotechnical aspects of a project. Some of the conclusions and recommendations presented herein are based on assumptions made during our geotechnical studies and evaluations. To verify or disprove those assumptions, a representative of our firm should be present during construction to observe subsurface geotechnical conditions as they are exposed. Therefore, we recommend that Fugro be retained during grading and construction of the proposed pipeline to observe compliance with the design concepts and geotechnical recommendations, and to allow design changes in the event that subsurface conditions or methods of construction differ from those anticipated. Our representative should test and/or observe all excavations, fill and backfill placement and compaction, and the construction of all foundation systems. In addition, in geologically sensitive areas, an engineering geologist from our firm should observe and map exposures to verify the presence or absence of geohazards.

4.0 LIMITATIONS

This report has been prepared for the exclusive use of Boyle Engineering Corporation and their agents for specific application to the TLPSP. In our opinion, the findings, conclusions, professional opinions, and recommendations presented herein were prepared in accordance with generally accepted geotechnical engineering practice of the project region.

Although information contained in this report may be of use for other purposes, it may not contain sufficient information for other parties or uses. If any changes are made to the project as described in this report, the conclusions and recommendations in this report shall not be considered valid unless the changes are reviewed and the conclusions and recommendations of this report are modified or validated in writing by Fugro.

In performing our professional services, in our opinion, we have used generally accepted geologic and geotechnical engineering principles and have applied that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers currently practicing in this or similar localities. No other warranty, express or implied, is made as to the professional advice included in this report.

We recommend that Fugro be provided the opportunity to review and comment on the project design plans and specifications in order that geotechnical recommendations may be properly integrated and implemented.

The scope of our services presented in this report did not include any environmental site assessment for the presence or absence of hazardous/toxic/biological materials in the soil, groundwater, or surface water, presence or absence of any environmentally sensitive areas, endangered or candidate wildlife or vegetation, wetland, or culturally significant zones within the project area. Any statements or lack of statements regarding odors noted or unusual or suspicious items or conditions observed during this study are strictly for descriptive purposes and are not intended to convey engineering judgment regarding potential hazardous/toxic assessment.

We thank you for providing us the opportunity to perform this geotechnical study. The attachments that complete this report are listed in the Table of Contents.

5.0 REFERENCES

Blake, T.F. (1998), UBCSEIS, A computer Program for the Estimation of Uniform Building Code Coefficients Using 3-D Fault Sources: Thousand Oaks, California.

California Division of Mines and Geology (CDMG) (2001), Seismic Hazard Zone Report for the Oat Mountain 7.5-Minute Quadrangle, Los Angeles County, California: Seismic Hazard Zone Report 005.

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Dibblee, T.W., Jr. (1992a), Geologic Map of the Oat Mountain and Canoga Park (North ½) Quadrangles, Los Angeles County, California: The Dibblee Geological Foundation, Map # DF-36, 1:24000.

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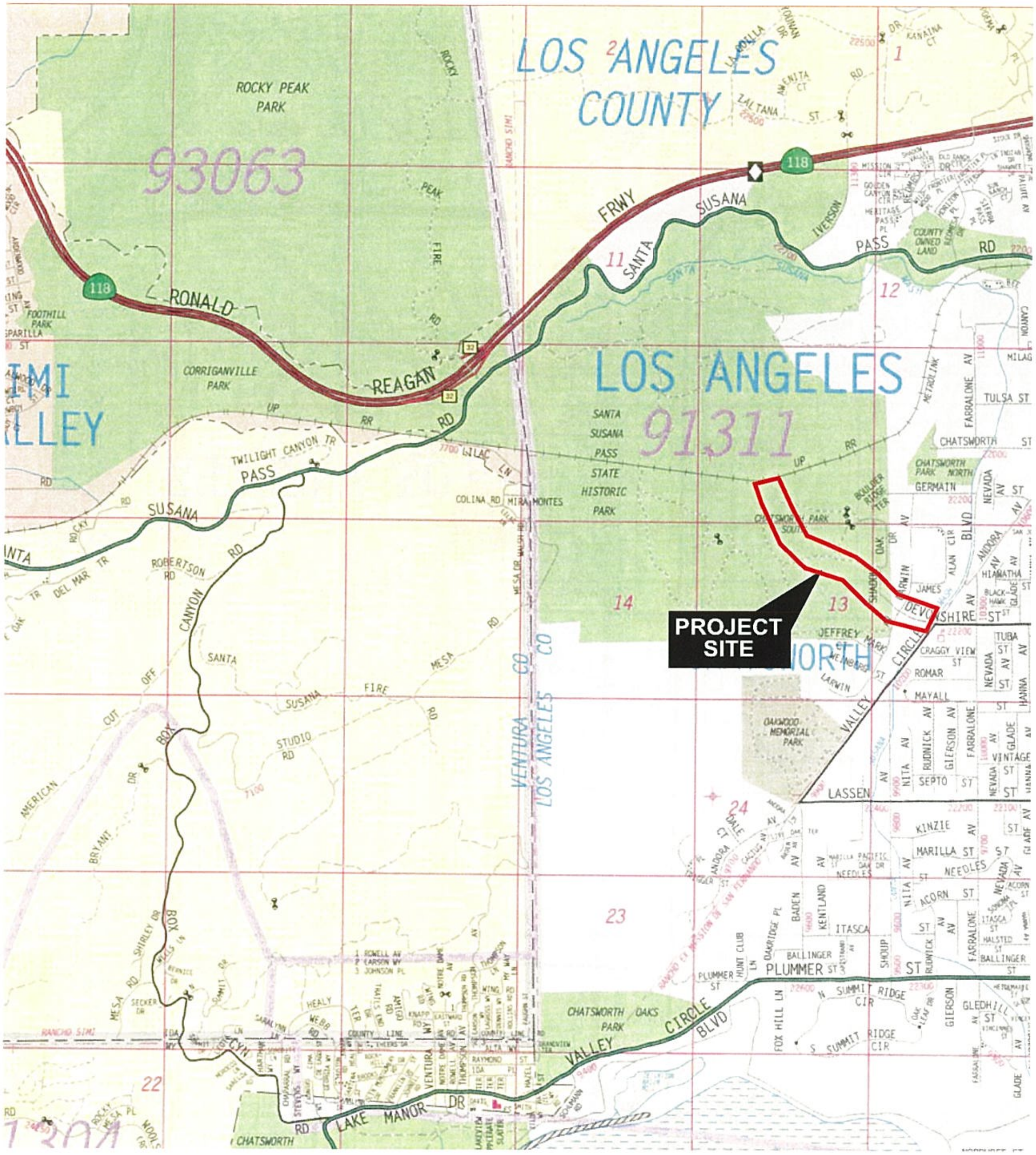
Fugro West, Inc. (2006), Geology Report, LVMWD Twin Lakes Pump Station Emergency Supply Pipeline, Chatsworth, California: unpublished consulting report prepared for Boyle Engineering Corporation, FWI Job No. 3044.054, April 28.

Greenbook (2006), "Standard Specifications for Public Works Construction", BNI Building News, BNI Publications, Inc.

Uniform Building Code (1997), International Conference of Building Officials, May.

United States Geological Survey (USGS) (1969), Oat Mountain Quadrangle, California- Los Angeles County, 7.5 Minute Series (Topographic): 1:24000.

PLATES



Base map source: Thomas Guide 2001(Los Angeles and Ventura Counties), p. 499.

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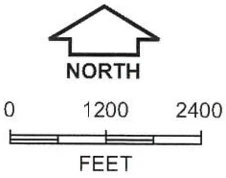
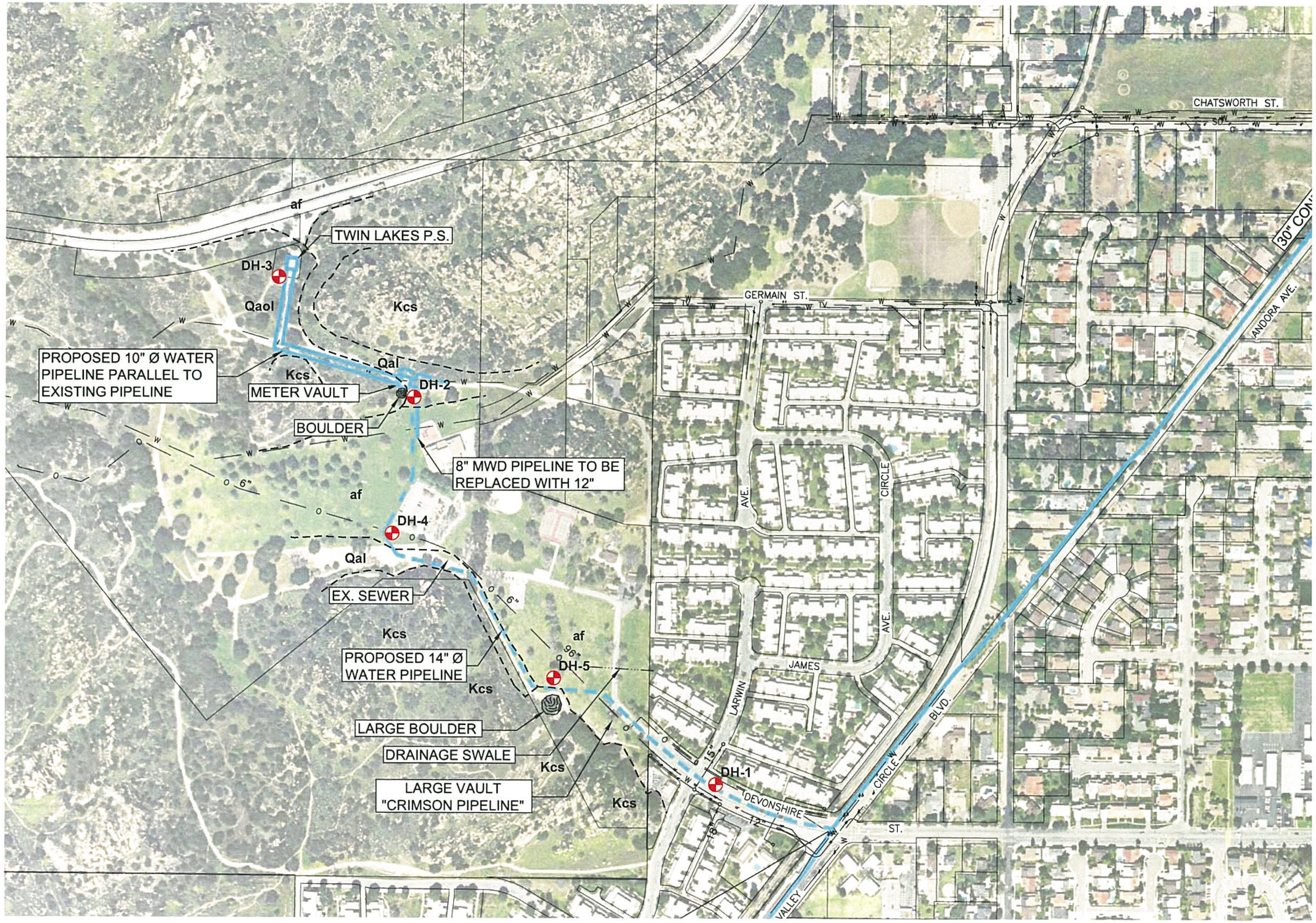


VICINITY MAP
Twin Lakes Pump Station Emergency Water Supply Pipeline
Chatsworth, California

PLATE 1

FUGRO



Base map source: \Ventura\LVMWD\exhibit-1.pdf; ftp.boyleengineering.com.

LEGEND

● DH-1	Approximate drill hole location
▬▬	Existing pipe
▬ ▬ ▬	Proposed pipe
—— W ——	Existing Utilities
af	Artificial fill
Qal	Alluvium
Qoal	Older Alluvium
Kcs	Chatsworth Formation
- - - - - -	Geologic Contact, dashed where approximate

NORTH

0 400 800
FEET

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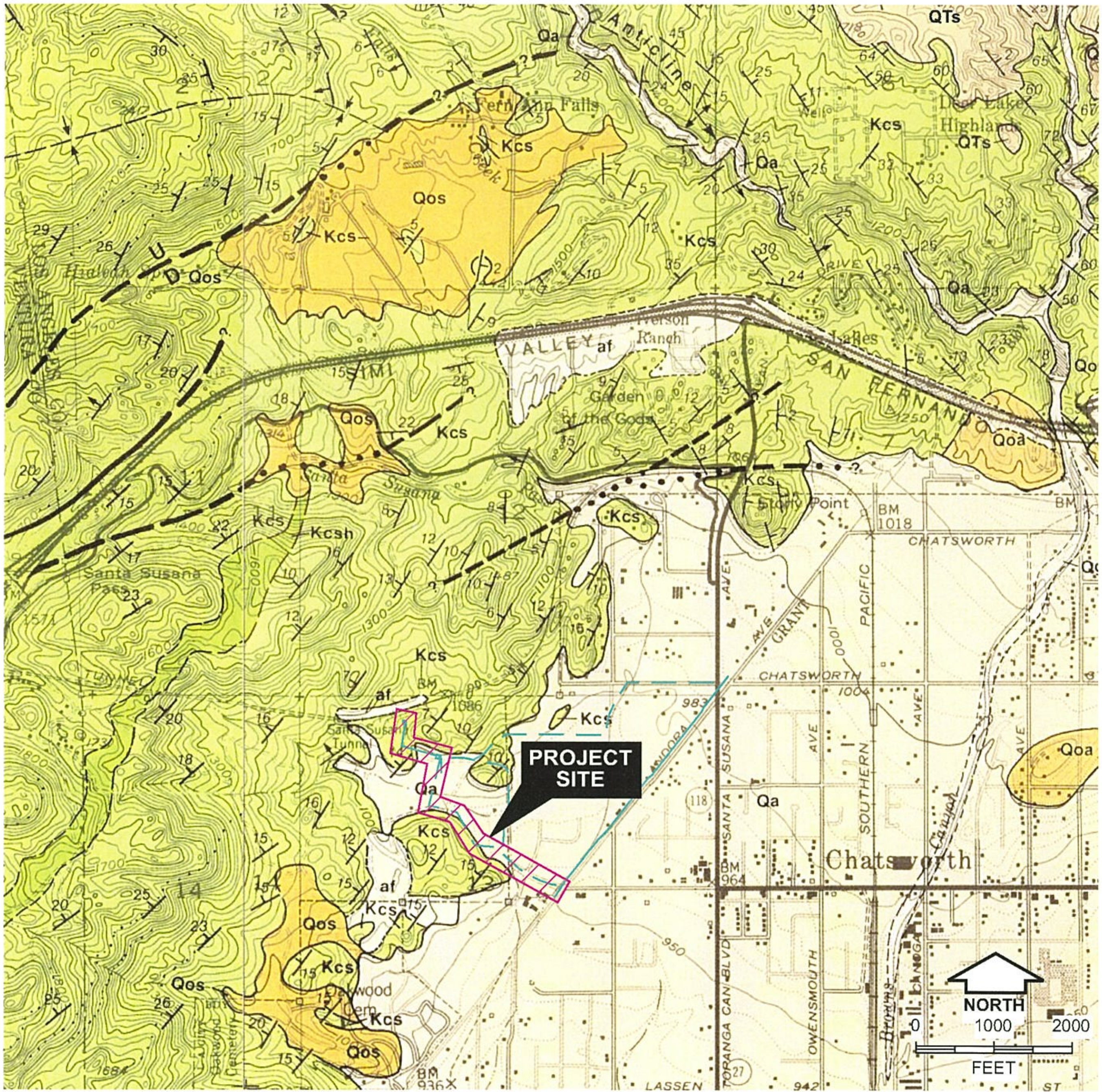
SITE MAP
Twin Lakes Pump Station
Emergency Water Supply Pipeline
Chatsworth, California

PLATE 2



Base map sources: Dibblee, 1992a and 1992b.

LEGEND

af	Artificial fill
Qa	Alluvial gravel, sand and clay
Qos	Older sandy alluvium
QTs	Saugus Formation
Kcsh	Chatsworth Formation, gray micaceous shale and siltstone
Kcs	Chatsworth Formation, light gray to light brown, hard, thick bedded sandstone

Formation contact

Member contact

Contact between surficial sediments

Anticline, dashed where approximate, arrow on axis indicates direction of plunge

Syncline, dashed where approximate, arrow on axis indicates direction of plunge

U
D

Fault, dashed where indefinite or inferred, dotted where concealed, queried where existence is doubtful, relative vertical movement shown by U/D (U = upthrown side, D = downthrown side)

Strike and dip of beds:

24	inclined
	inclined (approximate)

Sandstone marker bed

REGIONAL GEOLOGIC MAP
Twin Lakes Pump Station Emergency Water Supply Pipeline
Chatsworth, California

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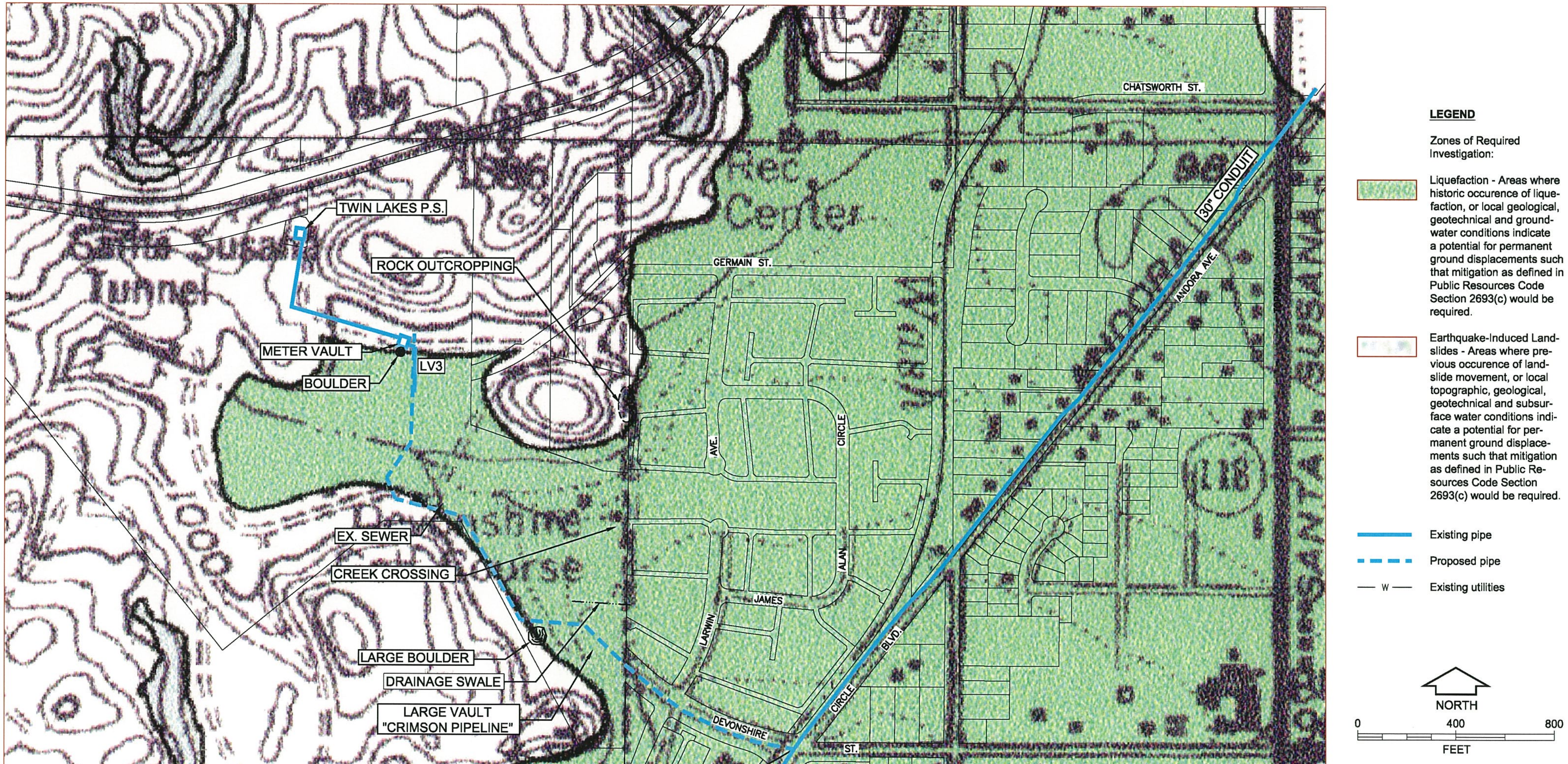

LEGEND

Zones of Required Investigation:

🟩 Liquefaction - Areas where historic occurence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

▨ Earthquake-Induced Landslides - Areas where previous occurence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

Existing pipe

Proposed pipe

— W — Existing utilities

HAZARD ZONES MAP
Twin Lakes Pump Station
Emergency Water Supply Pipeline
Chatsworth, California

Sources:
1. Exhibit 1, Emergency Supply; Las Virgenes Municipal Water District, Twin Lakes Pump Station; Figure 1 (Boyle Engineering Corporation, 11-22-05).
2. Seismic Hazard Zones Map, Oat Mountain Quadrangle CDMG (1998).

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APPENDIX A
SUBSURFACE EXPLORATION

APPENDIX A
SUBSURFACE EXPLORATION

Introduction

The contents of this appendix should be integrated with the geotechnical engineering study of which it is a part. Data contained in this appendix should not be used in whole or in part as a sole source for information or recommendations regarding the subject site.

Hollow-Stem-Auger Borings

The subsurface exploration program for the proposed project consisted of the excavation of five 8-inch-diameter hollow-stem-auger borings, located as shown on Plate 2. The borings were excavated on May 15, 2007 using a truck-mounted CME-75 drill rig supplied by WDC Exploration and Wells, of Montclair, California. The borings extended to depths between about 14 and 16.5 feet.

Exploration locations were determined by tape measurements from various references on the site. Their location should be considered accurate only to the degree implied by the method used.

Samples were obtained using a 2-3/8-inch-inside-diameter, 3-inch-outside-diameter Modified California and 1-3/8-inch-inside-diameter, 2-inch-outside-diameter, Standard Penetration Test samplers. The samplers were driven with a 140-pound CME automatic trip hammer.

Boring logs, presented as Plates A-1 through A-5, describe the earth materials encountered, sampling methods used, and field and laboratory tests performed. The logs also show the location, boring number, dates of start and completion, and the names of the logger and drilling subcontractor. A Fugro field geologist logged the borings in general accordance with ASTM D2488 for visual soil classification. Boundaries between soil types shown on the logs are approximate because the transition between different soil layers may be gradual and may change with time. A key to the logs is presented on Plate A-6.

LOCATION: Devonshire St. westbound left turn lane at Larwin Ave., 49.5 feet E. of light post in center divider and 5 ft N. of curb face.

SURFACE EL: 941 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf
						ARTIFICIAL FILL (af) Asphaltic Concrete: 8 in.							
940						Road Base/ Silty GRAVEL with sand (GM) to Silty SAND with abundant gravel (SM): gray, slightly moist, angular							
	2		1										
938			2		(26)	Clayey SAND (SC): medium dense, very dark brown, moist, very fine to medium grained with scattered gravel	130	115	13	49			
	4		3			**ALLUVIUM (Qal)** Sandy SILT (ML) to Silty SAND (SM): light yellowish brown to olive brown, moist, mottled to laminated							
936													
	6		4		23	Poorly-graded SAND with silt and gravel (SP-SM): medium dense to dense, light olive brown, moist, predominantly medium to coarse grained, with trace gravel			9	9			
934					▼	- wet below 7.5 feet							
	8												
932			5		(33)	- brown, predominantly coarse grained with trace to scattered gravel	133	115	16				
	10		6										
930													
	12												
928			7		50/5"	- sampler removal difficult, sand in auger (flowing sand). Gravel in sample.			17				
	14												
926													
	16												
924													
	18												
922													

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

COMPLETION DEPTH: 13.9 ft
DEPTH TO WATER: 7.5 ft
BACKFILLED WITH: Sand cement slurry with concrete surface patch
DRILLING DATE: May 15, 2007

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLED BY: WDC Exploration & Wells
LOGGED BY: K Riedel, C.E.G.
CHECKED BY: C D Prentice

LOG OF BORING NO. DH-1

Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

PLATE A-1

LOCATION: Approx. 345 ft N of NW corner of main parking lot, 36 ft S of SE corner of MWD vault, 38 ft S. of SW corner of MWD vault, 19 ft S. of dirt road.
SURFACE EL: 975 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf
			1 2		6	**ALLUVIUM (Qal)** Silty SAND (SM) to Clayey SAND (SC): loose, very dark grayish brown - brown with trace organics below 0.5 feet			13				
974													
	2												
972			3		(16)		124	111	12	41			
	4												
970						Clayey SAND (SC): medium dense, dark yellowish brown, moist, fine grained							
	6		4 5		12				12	37			
968													
	8												
966			6		20	- olive brown below 9 feet			12				
	10												
964													
	12		7		(32)	Sandy Lean CLAY (CL) to Clayey SAND (SC): very stiff / medium dense, dark yellowish brown and light olive brown, moist, mottled	130	114	14				
962													
	14												
960			8		18				16				
	16												
958													
	18												
956													

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

COMPLETION DEPTH: 16.5 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: May 15, 2007

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLED BY: WDC Exploration & Wells
LOGGED BY: K Riedel, C.E.G.
CHECKED BY: C D Prentice

LOG OF BORING NO. DH-2

Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

PLATE A-2

LOCATION: S. of Twin Lakes Pump Station, 24.8 ft S of SW side of entrance gate, 36.5 ft SW of SE side of entrance gate

SURFACE EL: 996 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf
			1 2		20	**ARTIFICIAL FILL (af)** Base/Poorly-graded GRAVEL (GP): gray, slightly moist, angular **OLDER ALLUVIUM (Qoal)** Sandy CLAY (CL): very stiff, brown, moist			7				
994	2												
			3		(44)		122	113	8				
992	4												
990	6		4 5		39	Clayey SAND (SC): medium dense to dense, yellowish brown, moist, predominantly fine grained			7	45			
988	8												
			6		(38)	- light olive brown	108	103	6				
986	10												
984	12		7		26				7	45			
982	14												
			8		(51)	- mottled texture, porous, with trace roots.							
980	16												
978	18												

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

COMPLETION DEPTH: 16.5 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: May 15, 2007

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLED BY: WDC Exploration & Wells
LOGGED BY: K Riedel, C.E.G.
CHECKED BY: C D Prentice

LOG OF BORING NO. DH-3

Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

LOCATION: 17 ft S. of SW corner of main parking lot (5 ft E. along S edge of lot and 16.1 ft S perpendicular to edge of pavement)

SURFACE EL: 969 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf
			1 2		12	**ARTIFICIAL FILL (af)** Silty SAND (SM) to Clayey SAND (SC): loose to medium dense, dark brown, moist, fine to medium grained			6				
968													
	2												
966			3		(16)		133	119	11	37			
	4												
964													
	6		4		6	- very dark grayish brown, predominantly very fine to fine grained			13				
962													
	8												
960			5		(9)		124	111	12	36			
	10												
958													
	12		6 7		13	**ALLUVIUM (Qal)** Sandy CLAY (CL): stiff, dark yellowish brown, moist, predominantly fine to medium grained			16				
956													
	14												
954			8		(15)		132	109	20				p 2.6
	16					- very moist at 16.2 feet							
952													
	18												
950													

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

COMPLETION DEPTH: 16.3 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: May 15, 2007

DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLED BY: WDC Exploration & Wells
LOGGED BY: K Riedel, C.E.G.
CHECKED BY: C D Prentice

LOG OF BORING NO. DH-4

Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

PLATE A-4

LOCATION: Located at toe of slope below boulder outcrop, approximately 217 feet W of first bend in entrance road.

SURFACE EL: 957 ft +/- (rel. MSL datum)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOW COUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf
			1 2		9	**ARTIFICIAL FILL (af)** Silty SAND (SM) to Clayey SAND (SC): loose to medium dense, dark yellowish brown, moist, with trace cobbles.			5				
956													
	2												
954			3		(62)		131	122	8	43			
						- claystone cobble at 3.5 feet							
	4												
952													
	6		4		14				14				
950													
	8					**ALLUVIUM (Qal)** Clayey SAND (SC): dense, yellowish brown, moist, mottled color and texture, porous with scattered root tubes							
948			5		(50/5")		128	110	16				
	10					**CHATSWORTH FORMATION (Kcs)** Highly weathered SANDSTONE (Rx): brown to light olive brown, moist - yellowish brown							
946			6										
	12		7		59				11				
944													
	14		8		46	- greenish gray 1/4 in rim around root tube.			15				
942													
	16												
940													
	18												
938													

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

COMPLETION DEPTH: 14.6 ft
DEPTH TO WATER: Not Encountered
BACKFILLED WITH: Cuttings
DRILLING DATE: May 15, 2007

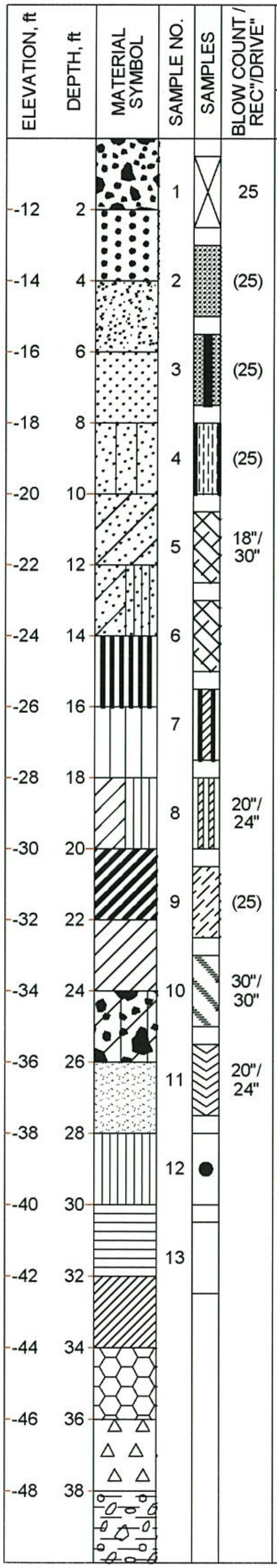
DRILLING METHOD: 8-inch-dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLED BY: WDC Exploration & Wells
LOGGED BY: K Riedel, C.E.G.
CHECKED BY: C D Prentice

LOG OF BORING NO. DH-5

Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

LOCATION: The drill hole location referencing local landmarks or coordinates

SURFACE EL: Using local, MSL, MLLW or other datum



MATERIAL DESCRIPTION

COARSE GRAINED
- Well graded GRAVEL (GW)
- Poorly graded GRAVEL (GP)
- Well graded SAND (SW)
- Poorly graded SAND (SP)
- Silty SAND (SM)
- Clayey SAND (SC)
- Silty, Clayey SAND (SC-SM)

FINE GRAINED
- Elastic SILT (MH)
- SILT (ML)
- Silty CLAY (CL-ML)
- Fat CLAY (CH)
- Lean CLAY (CL)

ROCK
- CONGLOMERATE
- SANDSTONE
- SILTSTONE
- MUDSTONE
- CLAYSTONE
- BASALT
- ANDESITE BRECCIA

Paving and/or Base Materials

General Notes

Soil Texture Symbol

Sloped line in symbol column indicates transitional boundary

Samplers and sampler dimensions (unless otherwise noted in report text) are as follows:

Symbol for:

1	SPT Sampler, driven 1-3/8" ID, 2" OD
2	CA Liner Sampler, driven 2-3/8" ID, 3" OD
3	CA Liner Sampler, disturbed 2-3/8" ID, 3" OD
4	Thin-walled Tube, pushed 2-7/8" ID, 3" OD
5	Bulk Bag Sample (from cuttings)
6	CA Liner Sampler, Bagged
7	Hand Auger Sample
8	CME Core Sample
9	Pitcher Sample
10	Lexan Sample
11	Vibracore Sample
12	No Sample Recovered
13	Sonic Soil Core Sample

Sampler Driving Resistance

Number of blows with 140 lb. hammer, falling 30" to drive sampler 1 ft. after seating sampler 6"; for example,

Blows/ft	Description
25	25 blows drove sampler 12" after initial 6" of seating
86/11"	After driving sampler the initial 6" of seating, 36 blows drove sampler through the second 6" interval, and 50 blows drove the sampler 5" into the third interval
50/6"	50 blows drove sampler 6" after initial 6" of seating
Ref/3"	50 blows drove sampler 3" during initial 6" seating interval

Blow counts for California Liner Sampler shown in ( )

Length of sample symbol approximates recovery length

Classification of Soils per ASTM D2487 or D2488

Geologic Formation noted in bold font at the top of interpreted interval

Strength Legend

Q = Unconfined Compression
u = Unconsolidated Undrained Triaxial
t = Torvane
p = Pocket Penetrometer
m = Miniature Vane

Water Level Symbols

⊻	Initial or perched water level
▼	Final ground water level
∿	Seepages encountered

Rock Quality Designation (RQD) is the sum of recovered core pieces greater than 4 inches divided by the length of the cored interval.

KEY TO TERMS & SYMBOLS USED ON LOGS

PLATE A-6

APPENDIX B
LABORATORY TESTING

APPENDIX B
LABORATORY TESTING

Introduction

The contents of this appendix shall be integrated with the geotechnical engineering study of which it is a part. The data contained in this appendix shall not be used in whole or in part as a sole source for information or recommendations regarding the subject site.

Laboratory Analysis

Laboratory tests were performed on selected driven ring or Standard Penetration Test (SPT) and bulk soil samples to estimate engineering characteristics of the various earth materials encountered. Testing was performed in general accordance with ASTM Standards for Soil Testing, latest revision. The results of the laboratory analyses are summarized on Plate B-1 - Summary of Laboratory Test Results.

Laboratory Moisture and Density Determinations

Moisture content and dry density determinations were performed on selected driven ring samples collected to evaluate the natural water content and dry density of the various soils encountered in accordance with ASTM D2937. In addition, moisture contents were determined on selected SPT or bulk samples in accordance with ASTM D2216. The results are presented on Plate B-1 and on the respective drill-hole logs (Appendix A).

Grain Size Distribution

One grain size distribution was determined for a selected soil sample in accordance with standard test method ASTM D422. Tests also were performed to determine the amount of material in soils finer than the No. 200 sieve in accordance with ASTM test method D1140. The grain-size curve is presented on Plate B-2 - Grain Size Curves. The results of percent passing No. 200 Sieve are shown on Plate B-1 and on the respective drill-hole logs.

Direct Shear Tests

Three sets of single stage direct shear tests were performed on selected driven ring samples to evaluate the shear strength of earth materials. The tests were performed in accordance with standard test method ASTM D-3080. Summary plots of the direct shear data are presented on Plates B-3a through B-3 - Direct Shear Test Results.

Soil Chemistry Tests/Corrosion Tests

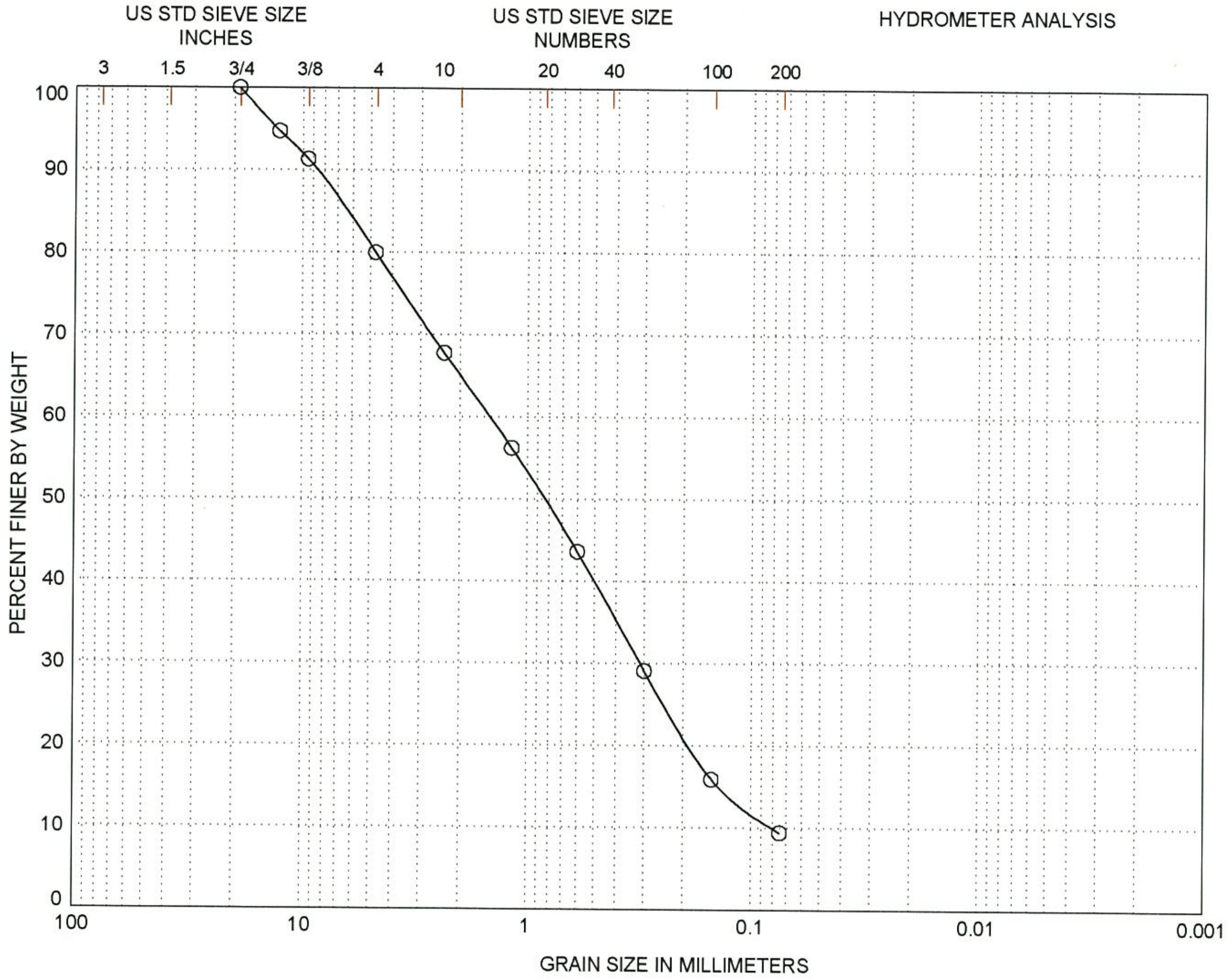
Soil chemistry tests were performed on selected samples to evaluate resistivity, pH, sulfate, and chloride. Testing was performed by LA Testing Laboratories, in Los Alamitos, California. The results of the soil chemistry tests are summarized on Plate B-1 and Plate B-4.

Sand Equivalent Tests

One sand equivalent test was performed on selected materials to estimate the sand equivalency in general accordance with ASTM D2419. The result of that test is presented on Plate B-1.

DRILL HOLE	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	ATTERBERG LIMITS		COMPACTION TEST		DIRECT SHEAR		COMPRESSIVE STRENGTH TESTS		CORROSIVITY TESTS				R-VALUE	EXPANSION INDEX	SAND EQUIVALENT (SE)	SPECIFIC GRAVITY
								LL	PI	MAX DD pcf	OPT MC %	C ksf	PHI deg	Qu, ksf	S_u (Cell Prs.) ksf	R	pH	Cl	So_4 (%)				
DH-1	3.0	2	Silty SAND (SM)	130	115	13	49					0.2	31										
DH-1	6.0	4	Poorly-graded SAND with silt and gravel (SP-SM)			9	9																
DH-1	9.0	5	Poorly-graded SAND (SP)	133	115	16																	
DH-1	10.1	6	Silty SAND with gravel (SM)																			18	
DH-1	13.0	7	Poorly-graded SAND (SP)			17																	
DH-2	0.0	2	Sandy Fat CLAY (CH)			13																	
DH-2	3.0	3	Clayey SAND (SC)	124	111	12	41					0.2	33										
DH-2	6.0	4	Silty SAND (SM)			12	37																
DH-2	9.0	6	Silty SAND (SM)			12																	
DH-2	12.0	7	Clayey SAND (SC)	130	114	14																	
DH-2	15.0	8	Clayey SAND (SC)			16																	
DH-3	0.5	2	Fat CLAY (CH)			7																	
DH-3	3.0	3	Clayey SAND (SC)	122	113	8																	
DH-3	6.0	4	Clayey SAND (SC)			7	45																
DH-3	9.0	6	Silty SAND (SM)	108	103	6																	
DH-3	12.0	7	Silty SAND (SM)			7	45																
DH-4	0.0	2	Silty SAND (SM)			6																	
DH-4	3.0	3	Silty SAND (SM)	133	119	11	37																
DH-4	6.0	4	Clayey SAND (SC)			13																	
DH-4	9.0	5	Clayey SAND (SC)	124	111	12	36					0.1	36										
DH-4	12.0	6	Clayey SAND (SC)			16																	
DH-4	15.0	8	Lean CLAY (CL)	132	109	20																	
DH-5	0.0	1	Silty SAND (SM)			5																	
DH-5	3.0	3	Clayey SAND (SC)	131	122	8	43																
DH-5	6.0	4	Clayey SAND (SC)			14																	
DH-5	9.0	5	Clayey SAND (SC)	128	110	16																	
DH-5	12.0	7	SAND with silt (SP-SM)			11																	
DH-5	14.0	8	Clayey SAND (SC)			15																	

SUMMARY OF LABORATORY TEST RESULTS
Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

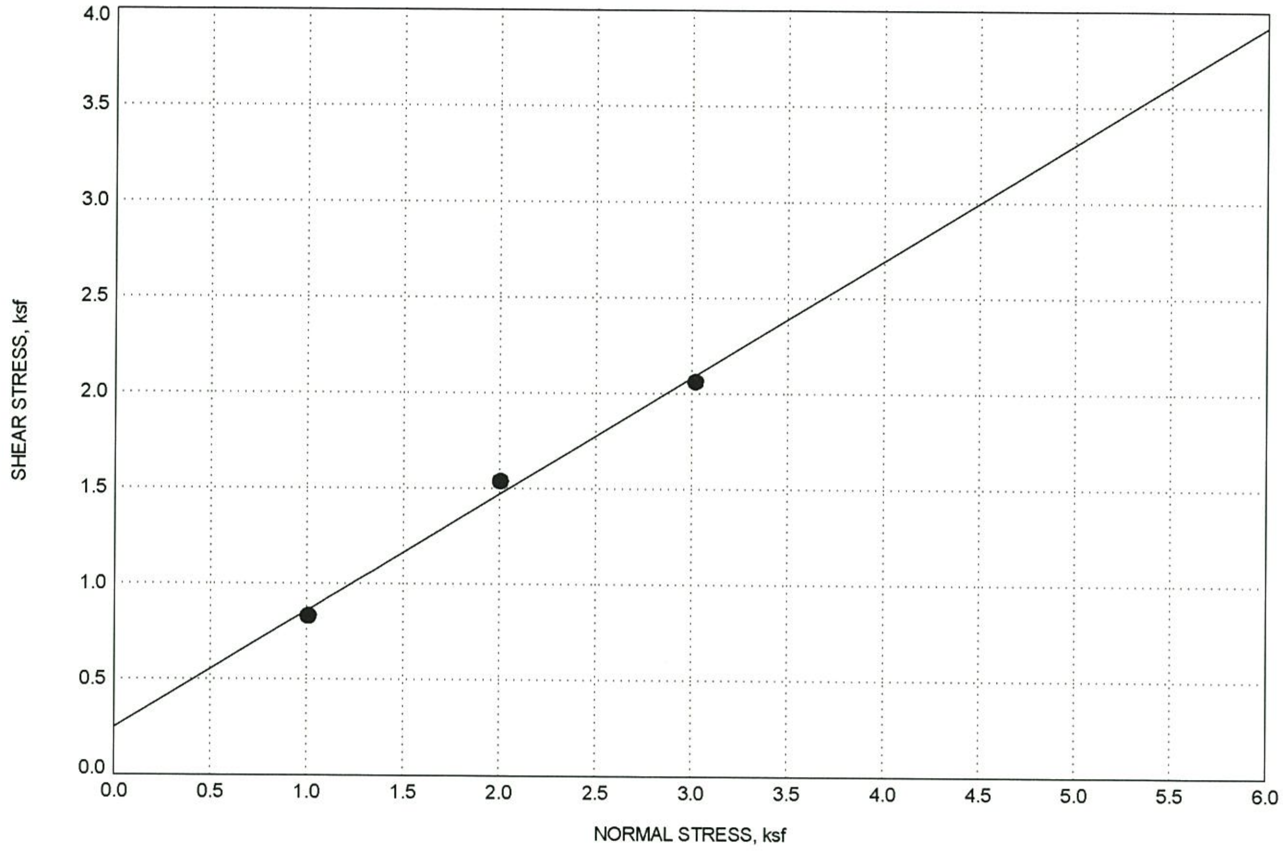


GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

LEGEND			CLASSIFICATION	Cc	Cu
	(location)	(depth,ft)			
○	DH-1	6.0	Poorly-graded SAND with silt and gravel (SP-SM)	0.8	18.6

GRAIN SIZE CURVES
Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

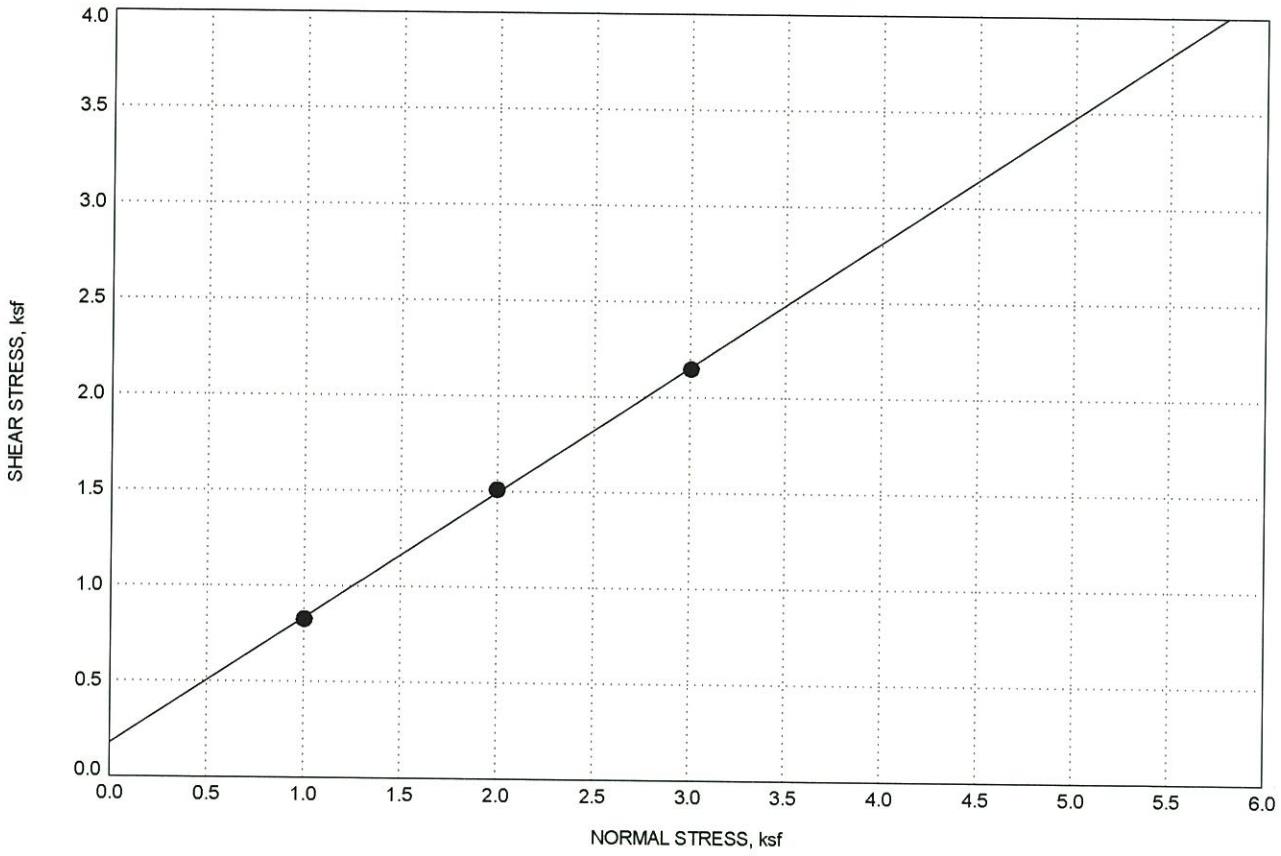
PLATE B-2



COHESION, ksf	0.2
ANGLE OF INTERNAL FRICTION, deg	31
LOCATION	DH-1
DEPTH, ft	3
MOISTURE CONTENT, %	13
UNIT DRY WEIGHT, pcf	113
MATERIAL DESCRIPTION	Silty SAND (SM)
SAMPLE CONDITION	Ring Sample

DIRECT SHEAR TEST RESULTS
Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

PLATE B-3a

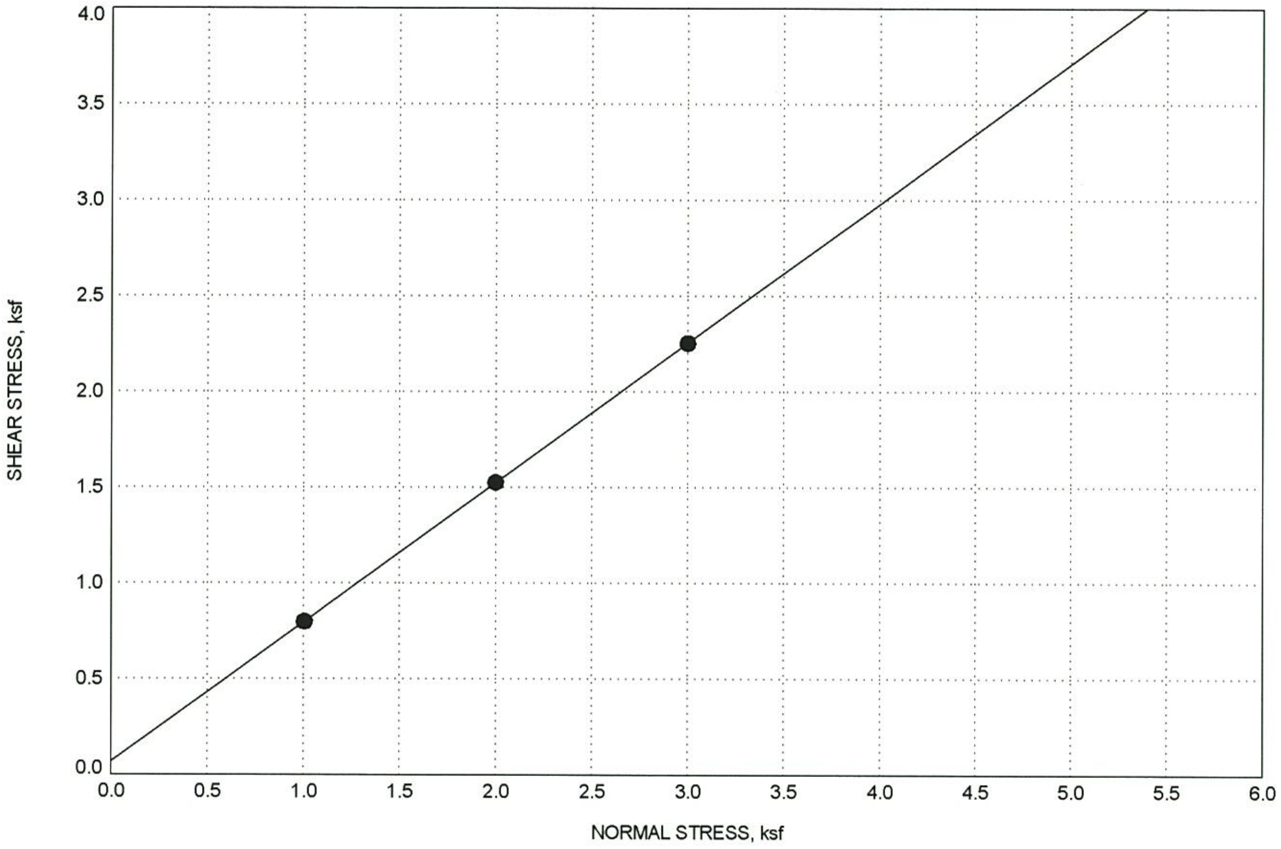


COHESION, ksf	0.2
ANGLE OF INTERNAL FRICTION, deg	33
LOCATION	DH-2
DEPTH, ft	3
MOISTURE CONTENT, %	12
UNIT DRY WEIGHT, pcf	106
MATERIAL DESCRIPTION	Clayey SAND (SC)
SAMPLE CONDITION	Ring Sample

DIRECT SHEAR TEST RESULTS

Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

PLATE B-3b



COHESION, ksf	0.1
ANGLE OF INTERNAL FRICTION, deg	36
LOCATION	DH-4
DEPTH, ft	9
MOISTURE CONTENT, %	12
UNIT DRY WEIGHT, pcf	110
MATERIAL DESCRIPTION	Clayey SAND (SC)
SAMPLE CONDITION	Ring Sample

DIRECT SHEAR TEST RESULTS

Twin Lakes Emergency Water Supply Pipeline
Chatsworth, California

LA Testing
10772 Noel Street, Los Alamitos, CA 90720

Order ID: 330703473

Attn: Ed Sullivan
Fugro West Inc.
4820 McGrath Street
Ventura, CA 93003
Fax: 805-650-7010
Phone: 805-650-7000
Project: **3044.064/3189**

Customer ID: 32FUW145
Customer PO: 3044.064/3189
Date Received: 05/22/07
LA Testing Order: 330703473

Report Date: 6/6/07

Date Analyzed: 6/2/07

Fugro via CTM-643M, CTM-417M, EPA 300.0M

Sample ID	pH	Chloride (ppm)	Sulfate (wt %)	Final Resistivity (ohms-cm)
DH-1	7.7	<42	0.0057	8300
DH-2	8.5	<33	0.0086	9800

Note: Samples were not blank corrected. This report relates only to the samples reported above.

JSL/MNH
Analysts

Michael Chapman
Michael Chapman
Or other approved signatory

AIHA Accredited - Laboratory ID #101650
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