MONTEREY PENINSULA WATER SUPPLY PROJECT

Hydrogeologic Investigation Work Plan

PREPARED FOR:
California American Water
RBF Consulting

December 18, 2013

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CONTENTS

FIGURES, TABLE AND APPENDIX

FIGURES

TABLES

APPENDIX

MONTEREY PENINSULA WATER SUPPLY PROJECT
HYDROGEOLOGIC INVESTIGATION WORK PLAN

1.0 GENERAL

1.1 Structure of the Work Plan and Attachments

Until recently limited data has been available to characterize the subsurface hydrogeologic conditions in the project area. The process adopted in this workplan consists of on-going steps of data collection and analysis. Each step of data collection is to be followed by refinement of the North Marina Ground Water Model, which is the tool being developed to evaluate the short and long-term hydrogeologic impacts in the project area from operation of The Monterey Peninsula Water Supply Project (MPWSP). Each step of data gathering will be preceded by a technical memorandum describing the proposed work and desired outcomes and documented by a technical memorandum describing the methods of data collection, findings and recommendations, and the results of the model refinements.

The MPWSP Hydrogeologic Investigation Work Plan (HWP) is the main working document for all exploratory, testing and modeling work including:

- Exploratory Boreholes
- Test Slant Well and Two Monitoring Wells
- Long-Term Test Slant Well Monitoring Well System
- Full Scale Slant Well Feedwater Supply to the Desalination Plant
- Ground Water Modeling

As such, the HWP is a “living document” which will be modified as appropriate as the project progresses. The physical structure of the HWP is as follows:

- Main Document - Hydrogeologic Investigation Work Plan
- Attachment 1 - Technical Specifications – Exploratory Boreholes
- Attachment 2 - Technical Specifications – Test Slant Well and Two Monitoring Wells
- Attachment 3 - Technical Specifications – Long-Term Test Slant Well Monitoring Well Installation and Program
- Attachment 4 - Technical Specifications – Full Scale Slant Well Field

A companion document to the work plan will be the Hydrogeologic Investigation Report (HIR) and will include all exploratory and testing activities as well as progressive model refinements and impacts. This document will include the following:

- Main Document - Hydrogeologic Investigation
- Attachment 1 - Technical Memorandum (TM 1) - Summary of Results - Exploratory Boreholes
- Attachment 2 - Technical Memorandum (TM 2) - Summary of Results – Test Slant Wells and Two Monitoring Wells
- Attachment 3 - Technical Memorandum (TM 3) - Summary of Results - Full-Scale Test Slant Well Monitoring Well Installation and Program
- Attachment 4 - Technical Memorandum (TM 4) - Refined Ground Water Model Results Following Exploratory Boreholes, Monitoring Wells, Test Slant Well, and Full Scale System

As of this writing, the structure of the work plan and Hydrogeologic Investigation Report (HIR) is still preliminary and subject to review by the Hydrogeologists Working Group (HWG) and others.

1.2 Monterey Regional Water Supply Project Background

California American Water Company (Cal Am) is planning to increase sustainability of their water supply portfolio to meet the long-term needs of their customers on the Monterey Peninsula. The plan includes construction of a seawater intake system and either a 6.4 million gallon per day (MGD) or 9.6 MGD desalination plant. The proposed project is known as the "Monterey Peninsula Water Supply Project (MPWSP). The Monterey Regional Water Supply Project intends to meet Cal Am's long-term regional water demands, improve ground water quality in the seawater-intruded Salinas Basin, and expand agricultural water deliveries.

As part of the MPWSP, Cal Am will evaluate several different alternatives to supply ocean water, or highly brackish ground water, to the new desalination plant:

1. Install a shallow, slant well intake system at the CEMEX property that produces ocean water from the underlying Dune Sand Aquifer;
2. Install a shallow, slant well intake system in the vicinity of Moss Landing, Potrero Road, Sandholdt Pier that produces ocean water from underlying aquifers;

This project will evaluate the feasibility of providing a feedwater supply to the proposed desalination plant using a slant well intake system located either at the CEMEX facility or in the vicinity of Moss Landing.

The investigation will evaluate the feasibility of extracting seawater from beneath the ocean floor using slant-drilled wells constructed in the aquifers that directly underlie the ocean floor. A key component of the project alternative at the CEMEX facility is to provide an intake system that can supply both saline water and brackish water from the shallow Dune Sand Aquifer. In the vicinity of the project at the CEMEX facility the shallow Dune Sand Aquifer may directly overlie the 180-Foot Aquifer or may be separated from the 180-Foot Aquifer by low permeability material of the hydrostratigraphic unit designated as the Salinas Valley Aquitard or other confining units.

GEOSCIENCE has developed the North Marina Groundwater Model (NMGWM) that covers the region in the current project. The NMGWM has been used to evaluate several proposed projects in the region. The model was developed using computer codes of MODFLOW and MT3DMS in 2008. More recent work (2013) has included updating the model layers using additional geologic data. However, a considerable amount of new data will be generated from the field investigations resulting from this work. The additional data from this study will be used to update and refine the NMGWM. The updated NMGWM will then be an effective tool for simulating ground water conditions and impacts of the proposed project. It was initially planned to update the NMGWM after installation and testing of the test slant well and monitoring wells. The Peer review group identified as the Hydrogeology Working Group for the project recommended drilling of exploratory borings to evaluate the subsurface conditions prior to test slant well construction.

1.3 Project Location

The general location of the potential project areas at the CEMEX facility and the Moss Landing vicinity are shown in Figure 1-1. Site maps for the two potential slant well intake areas in the vicinity of Moss Landing and at the CEMEX facility are shown in Figures 1-2 and 1-3.

1.4 Project Goals

The purpose of this work plan is to describe the recommended work tasks needed to evaluate the feasibility of using a slant well intake system located either at the CEMEX facility or in the vicinity of Moss Landing. In addition to establishing the feasibility of construction a slant well intake, the project goals include a hydrogeologic investigation to collect additional data on hydrogeology and water quality needed to refine and update the NMGWM. Once the model is updated, it will be used to evaluate project impacts to ground water levels and ground water quality in the region. The five main goals of this study are summarized as follows:

1. Conduct borings in vicinity of the CEMEX facility, and in the vicinity of Moss Landing, Monterey Dunes Way, Potrero Rd, and Sandholdt Road to verify the aquifer thickness and water quality in these areas;

2. Design, construct, and operate a test slant well and monitoring wells to obtain data to facilitate the design of the full-scale feedwater supply intake system for the desalination plant;
3. Obtain the necessary data to update the geologic and hydrogeologic conceptual model of the project area and update the NMGWM;
4. Using the NMGWM, determine the capacity of the Dune Sand Aquifer to supply the required project feedwater supply volumes, and;
5. Determine the Impacts of MRWSP operation on the local and regional aquifer systems and habitat.

Project goals are discussed in more detail in the following sections.

1.4.1 Conduct Borings in the Vicinity of the CEMEX facility and Moss Landing to Verify Aquifer Thickness and Water Quality

The purpose of the proposed exploratory borings is to investigate the vertical extent and the character of the dune sand in both the CEMEX area and the Moss Landing area. Determining the lithologic character of the dune sand, potential aquifer characteristics, and the nature of the contact with underlying units are one of the main goals for the exploratory borings.

1.4.2 Design, Construct, and Operate Test Slant Well and Monitoring Wells to Obtain Data to Facilitate the Full Scale Design

Through design construction, and testing of a test slant well, lithologic and aquifer parameter data will be obtained that will form the basis for design of the full-scale slant well intake system. The data from this investigation will determine the number of wells required to meet the required feedwater supply, the length and diameter of the slant well casings, the slant well angle below the horizontal, and the azimuth of each slant well in the wellfield.

1.4.3 Obtain the Necessary Data to Update the Hydrogeologic Conceptual Model and North Marina Ground Water Model

The field work proposed in this work plan will collect the subsurface geologic and hydrogeologic data necessary to:

1. Evaluate the horizontal and vertical extent of the Dune Sand Aquifer in the project area, and;
2. Calculate hydraulic parameters and provide an evaluation of the aquifer sustainable yield to meet project needs.

Monitoring well installation and short and long-term aquifer testing using the proposed test slant well will result in understanding baseline water quality in the Dune Sand Aquifer as well as the potential water quality changes resulting from project pumping. The following sections discuss the key investigative targets for the hydrostratigraphic units beneath the project area.

1.4.3.1 Dune Sand Aquifer

Existing data (Kenedy-Jenks, 2004) indicates that the Dune Sand Aquifer is present from ground surface to an elevation of -160 ft above mean sea level (amsl). The Dune Sand Aquifer has been described as a silty, fine to medium or fine to coarse grained quartz sand with occasional paleosols (soil horizons) distributed vertically in the unit. Recent dune sand extends along the shoreline of Monterey Bay from the southern end of the Bay, northward to Moss Landing, and is only absent in the vicinity of the mouth of the Salinas River (USGS Open File Report 02-373). Recent dune deposits extend landward to approximately 0.1 to 0.5 miles inland.

Recent Dune Sand Deposits

A geologic unit, designated as older Dune Sand, is also present in project area. Older Dune sand deposits are much more extensive in the project area south of the Salinas River Valley, extending inland as far as the East Garrison of former Fort Ord (approximately 5 miles inland). However, north of Salinas River, the older dune sand is limited in extent and crops out in small non-contiguous areas. Further north, nearing the Watsonville area older Dune Sand deposits are again extensive, occupying much of the coastal areas. It is likely that the recent dune sand rests over fluvial deposits (which form a shallow perched aquifer) in the area where the Salinas River Valley meets the ocean. However, to the south of the Salinas River Valley, near the community of Marina and Fort Ord, the recent dune sand likely directly overlies older dune sand deposits. The combined dune sand deposits reach 250-ft depths in the vicinity of Fort Ord (HLA, 2001).

1.4.3.2 180-Foot Aquifer

Aquifers in the Salinas Valley Groundwater Basin have been named for the average depth at which they occur. The "180-Foot Aquifer" lies at an approximate depth of 50 to 250 ft and has a thickness of 50 to 150 ft (Green, 1970). The 180-Foot Aquifer may correlate in part with older portions of Quaternary terrace deposits or the upper Aromas Red Sands and is associated with deposition from the Salinas River. The 180-Foot Aquifer underlies a blue clay confining layer known as the Salinas Aquitard (DWR, 2003). Although, a variety of previous geologic studies (DWR 1973, and USGS, 2003) indicate that the

180-Foot Aquifer is present in the project area. A key investigative target is to verify whether the 180-ft Aquifer is present in the project areas and if present, determine the depth and elevation of the top and bottom of the 180-Foot Aquifer and the lithologic character of the unit in the project area. Three borings recently drilled at the CEMEX site are along a line perpendicular to the shoreline (see Figure 3-4). Initial results from exploratory drilling indicate that the SVA is not present beneath the Dune Sand deposits at the CEMEX project site. Field pore water samples indicate that both the Dune Sand Aquifer and the underlying aquifer contain saline water. The aquifer material which lies beneath the Dune Sand Aquifer is at least hydrostratigraphically equivalent to the 180-Foot Aquifer, but may not share the same depositional origin.

1.4.3.3 Salinas Valley Aquitard

The Salinas Valley Aquitard (SVA) varies in thickness from 25 ft to more than 100 ft thick near Nashua Road, 5 miles west of Salinas (DWR, 1973, Montgomery Watson, 1994). According to HLA (HLA, 2001), the SVA pinches out to the east beneath the former Fort Ord. Aquitard materials encountered beneath Fort Ord may or may not be an extension of the aquitard which is present beneath the Salinas Valley and overlying the 180-ft Aquifer. According to DWR, zones of discontinuous aquifers and aquitards approximately 10 to 70 ft thick underlie the 180-Foot Aquifer (DWR, 1973).

The full-scale slant wells are planned to extract seawater only from the Dune Sand Aquifer. Therefore, a key goal for the current study is to determine whether the SVA is present beneath the Dune Sand Aquifer at the CEMEX project site, effectively isolating the Dune Sand Aquifer from the underlying 180-Foot Aquifer offshore. Initial borings drilled recently (October/November, 2013) drilled at the CEMEX site Indicate that the SVA is not present beneath the CEMEX site. Two additional borings will be drilled in the near future to confirm this finding.

1.4.4 Use the Updated North Marina Ground Water Model to Determine the Capacity of the Dune Sand Aquifer to Supply the Required Project Feedwater Volumes

The exploratory boring information will provide data needed to determine the thickness and extent of the Dune Sand Aquifer, and will provide hydraulic conductivity data for model input. The model layers representing the Dune Sand Aquifer, Salinas Valley Aquitard, and 180-Foot Aquifer will be refined using the new data. The updated model will then be used to determine the capacity of the Dune Sand Aquifer to yield water to wells, acting as a conduit to the project extraction wells, for ocean water leaking through the seafloor into the aquifer. The updated model will simulate the movement of water through the Dune Sand Aquifer based on the operational scenarios of the MPWSP.

1.4.5 Evaluate Impacts of MPWSP operation on the Local and Regional Aquifer Systems and Habitat

The NMGWM will be updated using the new data from exploratory borings, monitoring well data, and test slant well testing. The updated model will then be used to evaluate future basin conditions in response to operation of the MPWSP.

1.4.5.1 Changes in the Seawater Intrusion Front

The main sources of seawater intruding potable aquifers are subsea outcrops of the 180-Foot and 400-Foot Aquifers on the bottom of Monterey Bay, discovered by the U.S. Geological Survey in 1970. There are also areas of active erosion along the south wall of the Monterey Submarine Canyon where the outcrops are located, representing new entrances for seawater intrusion (DWR, 1973; Green, 1970). Natural (historical) ground water gradients were oceanward, keeping seawater in the subsea portion of the freshwater aquifers offshore as freshwater flowed towards subsea outcrops as ground water elevations inland were higher than the ground water elevations at the coast. Historical inland pumping lowered the ground water elevations inland relative to the shoreline resulting in well documented landward movement of seawater in freshwater aquifers (seawater intrusion). The extent of seawater intrusion has been monitored. The rate of movement of the seawater intrusion front has slowed as mitigation has included a reduction of aquifer pumping replaced by the use of surface water. The updated NMGWM will be used to assess the impact of the MPWSP on the existing distribution of seawater intrusion front.

1.4.5.2 Impacts to Inland Ground Water

Ground water in the inland portion of the freshwater is used extensively for potable, agricultural, and commercial uses. Therefore, the project seawater intake wells will target extraction of seawater from the ocean floor via the Dune Sand Aquifer. Although the well screens will be located completely offshore, it is anticipated that influence of the wells will extend towards the shore. Water level and water quality data will be collected from monitoring wells in the Dune Sand Aquifer, 180-Foot Aquifer, and 400-Foot Aquifer during short-term (one week) and long-term (18 months) aquifer testing using the test slant well. The data will then be used to update NMGWM and will allow a more accurate analysis of the impacts on water levels and water quality to inland ground water.

1.4.5.3 Impacts to Riparian Habitat

Impacts on the existing riparian habitat will be evaluated using the updated NMGWM to determine the effect of shallow ground water on surface water levels and surface water quality within the influence of the full-scale slant wells used for desalination feedwater supply.

1.4.5.4 Provide Technical Basis for a Plan to Avoid Detrimental Impacts to Ground Water Users and Protect Beneficial Uses in the Basin

The updated NMGWM will be used to develop the operational criteria of the MPWSP that will protect the existing established beneficial uses of the 180-Foot Aquifer and avoid negative impacts to the current users relying on the ground water basin.

2.0 PRINCIPAL TASKS

This section provides an overview of the principal tasks that will be carried out to complete the hydrogeologic investigation for the Monterey Peninsula Water Supply Project (MPWSP). Principal tasks proposed for the MPWSP hydrogeologic investigation are summarized as follows:

1. Compile and review existing data on the geology both onshore and offshore, hydrogeology, surface water and ground water quality, and on effects of climate change and coastal erosion;
2. Based on a review of the existing data, establish the data gaps and propose procedures to fill in data gaps;
3. Develop a conceptual hydrogeologic model;
4. Perform initial modeling and testing to characterize aquifers and aquitards in the MPWSP vicinity;
5. Establish final location and design for test slant well and two monitoring wells;
6. Construct test slant well and two monitoring wells;
7. Refine the hydrogeologic model using information from new boreholes, and the test slant well and monitoring wells from short-term pump testing;
8. Locate and Construct long-term monitoring wells;
9. Perform long-term pump test on slant well, and;
10. Evaluate the future impacts to ground water and surface water in the region resulting from the MPWSP.

The ten principal tasks proposed for the MPWSP hydrologic investigation are discussed in detail in the following sections.

2.1 Review Existing Data

GEOSCIENCE has been involved in on-going data collection for the Monterey Bay area for various proposed projects in the region. The GEOSCIENCE in-house database contains historical water quality and water level data. Historical hydrologic and hydrogeologic studies conducted in the area by the California Department of Water Resources, United States Geological Survey, by various consultants, and University studies will be reviewed. In addition, lithologic logs from wells and borings will also be included in the review.

Pertinent hydrogeologic information collected in data review will then be used to develop a conceptual hydrogeologic model of the project area. The conceptual hydrogeologic model will provide a preliminary understanding of the areal and vertical distribution of hydrostratigraphic units such as the Dune Sand Aquifer, Perched A Aquifer, Salinas Valley Aquitard, and the 180-Foot Aquifer. The conceptual hydrogeologic model will also provide a preliminary evaluation the water quality conditions within the various aquifer units in the project area. The data will be used to construct hydrogeologic cross-sections to depict the relationships of the hydrostratigraphic units both in the vertical dimension and in areal extent.

2.1.1 Existing Reports

Existing geologic and hydrogeologic reports in the Monterey Bay area have been previously compiled by GEOSCIENCE are shown in the table below:

Table 2-1. Previously Reviewed Technical Reports

REPORT REFERENCE	REPORT REFERENCE
California Department of Public Works, Water Resources Division, 1946. Salinas Basin Investigation, Bulletin 52.	Harding Lawson Associates, 1994. Final Basewide Remedial Investigation/Feasibility Study (RI/FS), Fort Ord, California, Volume II, Remedial Investigation Basewide Hydrogeologic Characterization, Appendixes, Appendix D: Ford Ord Groundwater Model
California Department of Water Resources, 1969. Geology of the Lower Portion of the Salinas Valley Ground Water Basin. Office Report, Central District Office.	Harding Lawson Associates, 2001. Final Report: Hydrogeologic Investigation of the Salinas Valley Basin in the Vicinity of Fort Ord and Marina Salinas Valley, California.
California Department of Water Resources, 1973. Lower Salinas Valley Seawater Intrusion Investigation.	Hornberger, Michelle I, 1991. Paleoenvironment of Elkhorn Slough and Surrounding Wetland Habitats: a geological study using an ecological approach. San Jose State Master's Thesis
California Department of Water Resources, 1977. North Monterey Water Resources Investigation. Prepared pursuant to cooperative agreement between Department of Water Resources and Monterey County Flood Control and Water Conservation District, March 23, 1977.	Kennedy-Jenks Consultants, 2004. Hydrostratigraphic Analysis of the Northern Salinas Valley.

California Department of Water Resources (DWR), 2003. California's Groundwater - Bulletin 118, Update 2003. Dated October, 1, 2003.	Montgomery Watson, 1994. Salinas River Basin Water Resources Management Plan Task 1.09 Salinas Valley Groundwater Flow and Quality Model Report. Prepared for Monterey County Water Resources Agency. Dated February 1994.
CDM, 2004. Monterey Peninsula Water Management District Sand City Desalination Project Feasibility Study Executive Summary. Dated March 25, 2004.	Montgomery Watson, 1997. Final Report – Salinas Valley Integrated Ground Water and Surface Model Update. Prepared for Monterey County Water Resources Agency. Dated May 1997.
Coastal Groundwater Consulting, 2012. Natural Isotope Tracer Study Test Slant Well Phase 3 Extending Pumping Test, South Orange County Desalination Project, prepared for Metropolitan Water District of Orange County.	RBF Consulting, 2012. Contingency Planning for the Monterey Peninsula Water Supply Project. Prepared for California American Water.

Dupre. William R, 1975. Quaternary History of the Watsonville Lowlands North Central Monterey Bay Region, California. Stanford University Ph.D. dissertation	Reading, H.G. editor, 1978. Sedimentary Environments-Processes, Facies, and Stratigraphy. Third edition. Published by Blackwell Science.
Durbin, T.J, G.W. Kapple, and J.R. Freckleton, 1978. Two Dimensional and Three Dimentional Digital Flow Models of the Salinas Valley Ground-Water Basin, California. United States Geological Survey Water-Resources Investigations 78-113.	Tinsley, John C, III, 1975. Quaternary Geology of Northern Salinas Valley, Monterey County, California. Stanford University Ph.D. dissertation
Eittreim, S. L.; Anima, R. J.; Stevenson, A. J., 2002. Seafloor Geology of the Monterey Bay Area Continental Shelf. Marine Geology, 181: 3 – 34.	Schwartz, David L., Henry T. Mullins, and Daniel F. Belknap, 1985. Holocene Geologic History of a Transform Margin Estuary: Elkhorn Slough, Central California. Estuarine, Coastal and Shelf Science, vol. 22, pp. 285-302, 1986.
Feeney and Rosenberg, 2002. "Deep Aquifer Investigation – Hydrogeologic Data Inventory, Review, Interpretation and Implications (TECHNICAL REVIEW DRAFT)", Dated 23 Sep-02.	Stall, Gardner, and Dunne, 1991. Feasibility Study Seawater Intake Wells, Marina County Water District Wastewater Treatment Facility, Marina, California, prepared fro the Marina County Water District
Fugro West, Inc., 1995. Volume I Hydrogeologic Study Seawater Intake/Brine Disposal System, Marina, California prepared for Marina Coast Water District.	Stall, Gardner, and Dunne, 1992. Feasibility Study Saline ground Water Intake System, Monterey Sand Company Site, Marina, California, California prepared for the Monterey Penninsula Water Management District
Fugro West, Inc., 1996. Marina Coast Water District Seawater Desalination Project: Establishment of Monitoring Well Network.	United States Geological Survey, 1983. Ground Water in North Monterey County, California, 1980. U.S.G.S. Water-Resources Investigations Report 83-4023. Prepared in cooperation with

	the Monterey County Flood Control and Water Conservation District. Dated July 1983.
Fugro West, Inc., 1996. Marina Coast Water District Seawater Desalination Project: Initiation of Inland Groundwater Monitoring.	United States Geological Survey, 1988. Reconnaissance High-resolution Geophysical Survey of the Monterey Bay, California, Inner Shelf--Implications for Sand Resources. Chin, J. L.; Wolf, S. C., USGS Open-File Report: 88-410.
Fugro West, Inc., 1996. Summary of Operations Construction and testing of Seawater Intake Well and Brine Injection Well prepared for marina Coast Water District	United States Geological Survey, 2002. Seafloor Rocks and Sediments of the Continental Shelf from Monterey Bay to Point Sur, California by Eittreim, S.L., Anima, R.J., Stevenson, A.J., and Wong, F.L. USGS Miscellaneous Field Studies Map-2345.
GEOSCIENCE Support Services, Inc., 2004. Feasibility of Using HDD Wells to Supply Water for the Coastal Water Project Desalination Plant at Moss Landing. Prepared for RBF Consulting / California American Water, August 3, 2004	United States Geological Survey, 2002. Geohydrology of a Deep-Aquifer System Monitoring Well Site in Marina, Monterey County, California. Water Resources Investigation Report 02-4003.
GEOSCIENCE Support Services, Inc., 2005. Feasibility of Using HDD Wells for Water Supply and Brine Discharge for the Coastal Water Project Desalination Plant, North Marina Site.	United States Geological Survey, 2003. Geohydrologic Framework of Recharge and Seawater Intrusion in the Pajaro Valley, Santa Cruz and Monterey Counties, California. U.S.G.S. Water-Resources Investigations Report 03-4096.
GEOSCIENCE Support Services, Inc., 2008. North Marina Groundwater Model Evaluation of Potential Projects.	United States Geological Survey, Hapke C., Reid, D., 2006. National Assessment of Shoreline Change: A GIS Compilation of Vector Shorelines and Associated Shoreline Change Data for the Sandy Shorelines of the California Coast, Open File Report-1251, 2006.
GEOSCIENCE Support Services, Inc., 2010. Summary of Historical Erosion Rates in the Vicinity of the Marina Coast Water District Office - Marina State Beach, Marina California.	United States Geological Survey, Hapke C., Reid, D., 2006. National Assessment of Shoreline Change: A GIS Compilation of Vector Shorelines and Associated Shoreline Change Data for the Sandy Shorelines of the California Coast, Open File Report-1251, 2006.
Greene, Gary H., 1970. Geology of Southern Monterey Bay and its Relationship to Ground Water Basin and Sea Water Intrusion. U.S. Geologic Survey Open-File Report.	United States Geological Survey, Hapke C., Reid, D., 2007. National Assessment of Shoreline Change Part 4: Historical Cliff Retreat along the California Coast, Open File Report-1133, 2007.

Greene, Gary H, 1977. Geology of the Monterey Bay Region. U.S. Geologic Survey Open-File Report 77-718.	United States Geological Survey, Hapke C., Reid, D., and Borrelli, M., 2007 revised 2008. National Assessment of Shoreline Change: A GIS Compilation of Vector Cliff Edge and Associated Cliff Erosion Data for the California Coast, Open File Report-1112, 2008.
Greene, Gary H, 1990. Regional Tectonics and Structural Evolution of the Monterey Bay Region, Central California. Geology and Tectonics of the Central California Coast Region, San Francisco to Monterey. Pacific Section of the American Association of Petroleum Geologists.	United States Geological Survey, 2009. Map of the Rinconada and Reliz Fault Zones, Salinas River Valley, California. Scientific Investigations Report 3059.
Greene, Gary H, et al, 1991. Offshore and onshore liquefaction at Moss Landing spit, central California-result of the October 17, 1989 Loma Prieta earthquake-Geology, v19 p. 945-949, September 1991	Wong, F. L.; Eittreim, S. L., 2001. Continental Shelf GIS for the Monterey Bay National Marine Sanctuary. USGS Open-File Report 01-179.
Grossman, E. E.; Eittreim, S. L.; Field, M. E.; Wong, F. L., 2006. Shallow Stratigraphy and Sedimentation History During High-frequency Sea-level Changes on the Central California Shelf. Continental Shelf Research, 26: 1217 – 1239.	Water Resources and Information Management Engineering, Inc. (WRIME), 2003. Deep Aquifer Investigative Study. Prepared for the Marina Coast Water District.

The most recent published geologic cross-sections in the vicinity of the project area were prepared for the Monterey County Water Resources Agency by Kennedy/Jenks Consultants. These cross-sections depict subsurface conditions across the southern Salinas Valley at a horizontal scale of 1inch = 1,500 ft and a vertical scale of 1 inch = 150 ft.

These existing cross-sections will be updated with additional subsurface data developed since the cross-sections were constructed in 2007, and will be used to update the ground water model.

2.1.2 Geology and Stratigraphy

Older geologic maps from the 1970's are available that show the onshore and offshore area of Monterey Bay and the description and distribution of stratigraphic units in the area. More recently, the California Geological Survey published a report in 2002 titled: "Geologic Map of the Monterey 30'x60' Quadrangle and Adjacent Areas". Geologic maps are available at scales ranging from 1:100,000 to 1:24,000. These maps will form the basis for the current conceptual model of the geologic and hydrogeologic conditions at the project site. Site specific knowledge of the geologic and hydrogeologic conditions is necessary to accurately assess potential short- and long-term impacts from operation of the MRWSP. GIS files for recently (since approximately 2000) published maps are available and will be used in preparation of project maps.

2.1.3 Driller's Logs, Geophysical Borehole Logs and Well Test Data

Driller's logs, geophysical borehole logs, and pumping test data for the project area and vicinity have and will be compiled to form a comprehensive database of subsurface conditions in the project area. The data collected from the various phases of the project will uploaded to a share site for review by the project team.

2.1.4 Offshore Geology

Distribution of geologic units including outcrops of the 180-Foot Aquifer and the 400-Foot Aquifer in the area offshore in Monterey Bay were published by the United States Geological Survey (USGS) in the 1970's. This USGS report was based on interpretation of geophysical data. More recently, distribution of geologic units on the seafloor was published by the USGS in 2000.

In addition to published offshore geology, the exploratory boring, monitoring well construction, and test well construction Tasks proposed in this Work Plan will provide additional information on subsurface geologic conditions. It is anticipated that additional information on subsurface aquifers will be established to a lower elevation of -310 ft above mean sea level (amsl), and to a distance of approximately 540 feet offshore. It is anticipated that full extent of both the Dune Sand Aquifer and 180-Foot Aquifer will be penetrated during field investigations involving both exploratory borehole drilling and monitoring well construction.

2.1.5 Ground Water Quantity and Quality

This investigation will evaluate the short-term and long-term water quality of ground water pumped from the Dune Sand Aquifer. Initial data collection will include collection of ground water samples from discrete zones during exploratory drilling for initial characterization of the water quality of discreet aquifer units. Additional water quality data from the project site aquifer units will be collected in subsequent phases and during the long-term pumping test. Data that will be used to evaluate the available quantity of ground water, including the salinity of the water extracted from the Dune Sand Aquifer, will be collected from the monitoring wells and from operation of a test slant well described in this Work Plan.

Determination of the quantity of ground water available from aquifers will be based upon the long-term natural and artificial recharge to the aquifers, and the extent of current and projected pumping from the aquifer. The goal of the MPWSP is to extract seawater (i.e., groundwater) from the offshore portion of the Dune Sand Aquifer by inducing downward leakage of ocean water through the seafloor without impacting inland aquifers.

2.1.6 Surface Water

The Pacific Ocean will provide the source of surface water to the MPWSP through leakage into the Dune Sand Aquifer that will be pumped from extraction wells. This dynamic will be tested through the field investigation. Ocean water salinity data from regional sampling points will be collected and reviewed for this task. Potential future sea level rise in the project area is under current study by ESA.

2.1.7 Climate Change and Coastal Erosion

An evaluation of coastal erosion and climate change is being prepared ESA for the proposed full scale slant well locations as part of the EIR preparation.

2.2 Identification of Data Gaps, Methods and Procedures to Close Data Gaps

Review and analysis of existing data will provide information on the thickness and distribution and hydrostratigraphic units in the project vicinity, especially along the shoreline where feedwater supply facilities are planned. The methods and procedures described herein are intended to allow collection of the necessary data to fill data gaps for project planning. If additional data gaps become apparent, methods and procedures to fill the data gaps will be prepared and submitted to the client and technical advisory committee for review and approval.

2.3 Develop Initial Hydrogeologic Conceptual Model

An initial conceptual plan was developed from the review and analysis of existing data during preparation of the North Marina Ground Water Model (NMGWM) in 2008. The conceptual model provides a description of the geologic and hydrogeologic conditions in the project area. For this project, the conceptual model consists of horizontal and vertical distribution and lithologic character of the Dune Sand Aquifer, the 180-Foot Aquifer, the Salinas Valley Aquitard, and the Salinas Valley Perched Aquifer. The conceptual model includes unconfined, semi-confined, and confined ground water surfaces, and distribution of water quality in the units. Additional data collection and review of available data to the date of this work plan has allowed preliminary updating of the model layers. However, during the preparation of the preliminary update, it was agreed that additional data should be collected to provide site specific hydrogeologic data for the NMGWM. After completion of exploratory borings in the Moss Landing and CEMEX project areas a Technical Memorandum (TM-1) will be prepared presenting the results of the drilling and presenting a proposed initial conceptual model of the hydrogeologic conditions in the project area. The proposed conceptual model and recommended model refinements will be discussed with the technical advisory committees prior to implementation into the model. The conceptual model will then be used to refine the NMGWM, as appropriate. As additional data is collected from subsequent phases of the project additional model refinement, may be implemented.

2.4 Perform Initial Testing and Modeling to Characterize Aquifers and Aquitards in MPWSP Vicinity

New site specific data collected during the exploratory borehole phase of the field investigations will be used to prepare an initial update to the NMGWM. Additional model updates will be prepared as new data is collected during subsequent phases of the field investigations. Initial testing and modeling to characterize the aquifers and aquitards in the vicinity of the MPWSP will be conducted to determine aquifer responses to the operation of the MPWSP with subsurface intakes simulated at the proposed project locations.

2.5 Exploratory Borehole Drilling

The exploratory borehole drilling phase of the field investigation includes drilling, logging, and testing 14 boreholes within the project area. Five (5) boreholes are planned for the CEMEX site, and eight (8) additional boreholes are planned for the area around Moss Landing. Drilling is planned in four packages, with timing based on obtaining environmental clearances and permits. A description of the proposed exploratory borehole phase of the field investigation is presented in Section 3 of this work plan. The technical specifications for the exploratory boreholes are presented in Attachment 1 of this work plan. As of this writing, five boreholes have been completed as a part of this Phase. Two borings have been completed in the Moss Landing area and three borings have been completed at CEMEX. “Attachment 1 - Technical Memorandum (TM 1) - Summary of Results - Exploratory Boreholes,” will be prepared after completion of the borings

2.5.1 Drill and Test Sonic Boreholes – Package 1 – Monterey Dunes Way, Potrero Road, and Sandholdt Road

In addition to the CEMEX area, the area in the vicinity of Moss Landing is under consideration as a potential alternate site for the slant well intake system. Package 1 will include an exploratory boring at the The Monterey Dunes Way parking area of Salinas State Beach (Borehole MDW-1), the Potrero Road parking area of the Salinas River State Beach (Borehole PR-1) and an exploratory borehole at the Sandholdt Road parking area of the Salinas River State Beach (Borehole ML-1).

The boreholes have a targeted depth of 200 ft below ground surface (bgs). The purpose for drilling the boreholes is to determine the depth, thickness, and character of the Dune Sand Aquifer and/or Perched Aquifer, and the depth, thickness, and character of the Salinas Valley Aquitard. The boreholes will be used to determine the depth to the top of the 180-Foot Aquifer at these locations. The locations of the boreholes that will be drilled as part of Package 1 are shown on Figures 3-0, 3-1, 3-2, 3-3, and 3-4.

2.5.2 Drill and Test Sonic Boreholes at CEMEX Site – Package 2 – CX-B1, CX-B2, CX-B3

The second package of boreholes will investigate the subsurface conditions at the CEMEX site. Three boreholes are located along a line perpendicular to the shoreline and along an existing access road and will be drilled to a maximum depth of 350 ft bgs. The locations of Package 2 boreholes are shown on Figures 3-1 and 3-4. The purpose of these exploratory boreholes is to determine the depth, thickness, and character of the Dune Sand Aquifer, determine the depth, thickness, and character of the Salinas Valley Aquitard, if present beneath the CEMEX site, and determine the depth, thickness and character of the 180-Foot Aquifer at this location.

2.5.3 Drill and Test Sonic Boreholes in Package 3 – Moss Landing Harbor Area

Package 3 will include six (5) additional exploratory boreholes in the Moss Landing Harbor area. The location of Package 3 boreholes (ML-2, ML-3, ML-4, ML-5, and ML-6) are shown on Figures 3-1 and 3-5, and have a targeted depth of 200 ft bgs. The purpose of these boreholes is to determine the depth, thickness, and character of the Dune Sand Aquifer and/or Perched Aquifer, and the depth, thickness, and character of the Salinas Valley Aquitard. The boreholes will be used to determine the depth to the top of the 180-Foot Aquifer at these locations. A technical memorandum documenting the results of the exploratory borehole drilling and testing will be prepared a presented as Attachment 1 of the Hydrogeologic Investigation Report (HIR).

2.5.4 Drill and Test Sonic Boreholes in Package 4 – CEMEX CX-C1, CX-C2, and CX-B4

The fourth package of borings will seek to investigate the vertical and horizontal distribution of hydrostratigraphic units parallel to the shoreline on the CEMEX property and further inland. The boreholes will be drilled to a maximum depth of 350 ft bgs. The location of Package 4 boreholes are shown on Figures 3-1 and 3-4. The purpose of these exploratory boreholes is to:

1. Determine the depth, thickness, character, and water quality of the Dune Sand Aquifer;
2. Determine the depth, thickness, and character of the Salinas Valley Aquitard if present , and;
3. Determine the depth, thickness,character, and water quality of the 180-Foot Aquifer or it's hydrostratigraphic equivalent at this location.

2.5.5 Refine North Marina Conceptual Model Based on Borehole Data

The exploratory boreholes will be used to obtain information on the lithologic and hydraulic character of hydrostratigraphic units and the vertical and horizontal distribution of the units. In addition water quality data will be obtained from both the Dune Sand Aquifer and the 180-Foot Aquifer or its equivalent. The data gathered will be used to update the hydrogeologic conceptual model and to update the NMGWM. The model layers will be refined using the site-specific depth and thickness information of the hydrostratigraphic units. The hydraulic properties of the units obtained from the field work and the water quality data will be used for model input. The NMGWM will be used to re-evaluate the MPWSP operational impacts, review proposed monitoring well locations, and to check for data gaps. A description of the process to update the model and the proposed model scenarios for evaluation of the MRWSP are provided in Section 8 of this report.

2.5.6 Additional Borehole Locations Based on Refined Model Runs

The model runs from the updated NMGWM will be evaluated to determine:

1. If additional subsurface data is needed to fill gaps in the conceptual model;
2. To assess the optimal location for placement of monitoring wells, and;
3. To allow verification of model-predicted results, both in terms of ground water levels and ground water quality.

2.6 Construct Test Slant Well and Two Monitoring Wells

The second phase of field investigation will include construction of a test slant well and two monitoring wells in the CEMEX area. The tentative location of the proposed test slant well and monitoring wells are shown on Figures 4-1 and 5-1. The initial two monitoring wells are designated as MW-1 and MW-2. Each monitoring wells location will consist of three monitoring wells screened in the Dune Sand Aquifer, the 180-ft aquifer or its equivalent, and the 400-ft Aquifer..

2.6.1 Final Refinements on Slant Well Location, Angle below Horizontal, Azimuth Angle, Total Length and Casing and Screen Intervals

The results of the updated model will be used to refine, if warranted, the proposed location and construction details of the test slant well and monitoring wells. These refinements may include modification to:

1. The angle (below horizontal) of the slant well;

2. The azimuth angle at the insertion point (entry point) of the test slant well;
3. The total length of the test slant well, and;
4. The proposed casing and screen intervals.

The preliminary test slant well design is based on the current conceptual model of hydrogeologic conditions, and is discussed in Section 5 of this work plan. Technical specifications for the test slant well will be prepared for client and Hydrogeology working group for review and approval, and will included as Attachment 2 to this work plan.

2.6.2 Construct Two Monitoring Wells

The tentative locations of the proposed monitoring wells are shown on Figure 4-1. The final locations of the monitoring wells will be based upon the data collected from the exploratory borings and the initial analysis completed using the updated NMGWM. Each monitoring well location will be a cluster of three monitoring wells. Well screens will be constructed in the Dune Sand Aquifer (upper aquifer), the 180-ft Aquifer or equivalent hydrostratigraphic unit (middle aquifer) and the 400-ft Aquifer (deeper aquifer). In addition, each monitoring well cluster of will include a monitoring well constructed to allow test pumping of the of the middle aquifer to evaluate the response in both the upper and deeper aquifers on site. The monitoring wells will be used to collect baseline water quality from the underlying aquifers, and collect data during the long-term slant well pumping test. Data collection and analysis will allow evaluation of site specific water level and water quality responses to pumping—both at the slant well and inland.

Monitoring well construction is discussed in Section 4 of this work plan. Technical specifications for the monitoring wells will be prepared after analysis of the data from the exploratory boreholes and modeling results, and will be included as Attachment 2 to this work plan. Technical memorandum documenting monitoring well completion, and providing field data and baseline water quality data collected from the monitoring wells will be prepared and presented as Attachment 2 (TM 2) of the Hydrogeologic Investigation Report (HIR).

2.7 Perform Short- Pumping Tests on Test Slant Well

Pumping tests on the test slant well will be performed in two phases. The initial phase of pumping will include tests that will be run immediately following construction and development of the test slant well, and will provide initial aquifer parameters for the Dune Sand Aquifer and the 180-Foot Aquifer or equivalent hydrostratigraphic unit. Testing will include pumping the Dune Sand Aquifer separately from the 180-Foot Aquifer using inflatable packers. The nearby monitoring wells will be used as observation wells during the pumping tests, and will be used to collect both water level and water quality data. Separately pumping and monitoring the Dune Sand Aquifer from underlying aquifers will allow determination of the unique hydraulic parameters, water quality changes, and aquifer response inland of the test slant well in the Dune Sand Aquifer from that of the underlying aquifers.

A second phase of pumping (see Section 2.10) will include a long-term (18-month) pumping test. During this period water level and water quality data will be collected from the test slant well and from nearby monitoring wells that are screened in the Dune Sand Aquifer, the 180-Foot Aquifer, and the 400-Foot Aquifer. A detailed description of both the short-term and long-term pumping tests is provided in Section 5.17.

2.7.1 Baseline Monitoring of Water Levels and Water Quality in Test Slant Well and Two Monitoring Wells

Baseline water level and water quality monitoring will commence after installation of the test slant well and two monitoring wells, but prior to conducting the long-term aquifer test. The baseline data will be used as model input for a second update of the NMGWM. A discussion of the baseline monitoring, including instrumentation, data collection frequency, recommended analytes, and quality assurance quality control is discussed in Section 7 of this work plan. A sampling and analysis plan (SAP) for the project is provided as Appendix A to this work plan.

2.7.2 Analyze Well and Aquifer Test Data

An initial analysis of test slant well performance and aquifer parameters will be prepared and submitted as a part of the test slant well completion report (Attachment 3 of the GIR). The data analysis will be used as model input to the updated NMGWM in preparation of the predictive scenarios prior to conducting the long-term pumping test.

Based on slant well performance, the aquifer parameters will be re-evaluated quarterly and at the end of the long-term pumping tests. The methodology for evaluating well performance and aquifer parameters is discussed in Section 5.20.

2.8 Refine North Marina Conceptual Model Based on Test Slant Well Lithologic and Pumping Test Data

After completion of the short-term pumping test for the test slant well, the NMGWM will be updated and validated against field data collected during the investigation and testing phases of this project. The updated model will be used to provide an initial evaluation of the long-term impacts from the MPWSP proposed full-scale project pumping and to refine the locations if necessary, for the long-term test pumping monitoring well system.

2.9 Construct Five Additional Monitoring Wells for Long-Term Aquifer Testing

The tentative locations of the proposed long-term test pumping monitoring wells are also shown on Figure 4-1 and 5-1. The long-term test pumping monitoring wells, are identified on the figures as monitoring well clusters MW-3 through MW-7. Table 4-2 in Section 4 provides an overview of proposed monitoring well design. The final locations of the monitoring wells will be based upon the data collected from the exploratory borings. The results of the test slant well and monitoring well pumping test, and the initial analysis completed using the updated NMGWM. The monitoring wells will be used to collect baseline water quality from the underlying aquifers, and collect data during the long-term slant well pumping test. Data collection and analysis will allow evaluation of site specific water level and water quality responses to pumping—both at the slant well and inland.

Monitoring well construction is discussed in Section 4 of this work plan. Technical specifications for the monitoring wells will be prepared after analysis of the data from the exploratory boreholes and modeling results, and will be included as an addendum to Attachment 2 to this work plan. Technical memorandum documenting monitoring well completion, and providing field data and baseline water quality data collected from the monitoring wells will be prepared and presented as Attachment 3 (TM 3) of the Hydrogeologic Investigation Report (HIR).

2.10 Monitoring of Water Levels and Water Quality in Test Slant Well and Monitoring Wells during Long-Term Aquifer Testing

Long-term aquifer testing will be conducted as a third phase of the MPWSP hydrogeologic investigation. Monitoring of water levels and water quality in the test slant well and monitoring wells will be conducted during long-term aquifer testing. Water level and water quality monitoring will performed in accordance with the SAP. Water level and conductivity data will be downloaded monthly. Water quality sampling will be conducted quarterly. Water level and water quality data will be reviewed quarterly, and will be compared against the predictions obtained from the NMGWM under the modeling scenarios prepared prior to the long-term pumping test. If appropriate, the NMGWM will be refined using the quarterly data, and then re-run to update water level and water quality predictions for project impacts.

2.11 Evaluate Future Impacts from the MPWSP, Changes in the Seawater Intrusion Front, Amount of Recharge to Feedwater Supply Wells from Ocean and Freshwater Sources, Impacts to Inland Ground Water and Near-Shore Riparian Habitat

A final feasibility modeling report will be prepared, which will present the results of MPWSP impacts on local and regional ground water. Modeling will be carried out to determine the response of inland ground water levels over the anticipated project period, and the anticipated contribution of freshwater, if any, from onshore sources. Proposed final modeling scenarios will be submitted for review and approval to the client and technical advisory committee

It is likely that MPWSP will result in a positive impact to the existing conditions of seawater intrusion. The final feasibility modeling report will evaluate anticipated impacts on seawater intrusion in view of existing and proposed regional water management plans, as well as under MRPWSP project conditions. The technical memorandum (TM) will include an evaluation of the response of near-shore shallow ground water levels, which in turn can be used by the project biologist to assess the potential impacts to near-shore riparian habitat.

The predictive scenarios prepared for the final feasibility modeling report will form the baseline to monitor the full-scale project as the full-scale slant wells are brought online.

2.12 Periodic Technical Memoranda, Preliminary and Final Project Reports

- We anticipate that the following Technical Memoranda (attachments or progress portions of the Hydrogeologic Investigation Report – HIR) will be prepared during the course of the hydrogeologic investigation:
- TM 1: Summary of Results – Exploratory Boreholes
- TM 2: Summary of Results – Slant Well and Two Monitoring Wells
- TM 3: Summary of Results – Long-Term Test Slant Well Monitoring Well Installation and Program
- TM 4: Refined Ground Water Model Results Following Exploratory Boreholes, Monitoring Wells, Test Slant Well, and Full Scale System

Draft and final versions of the documents will be submitted to the client and HWG for review and comment.

3.0 DRILLING AND TESTING EXPLORATORY BOREHOLES

3.1 Sonic Drilling Method

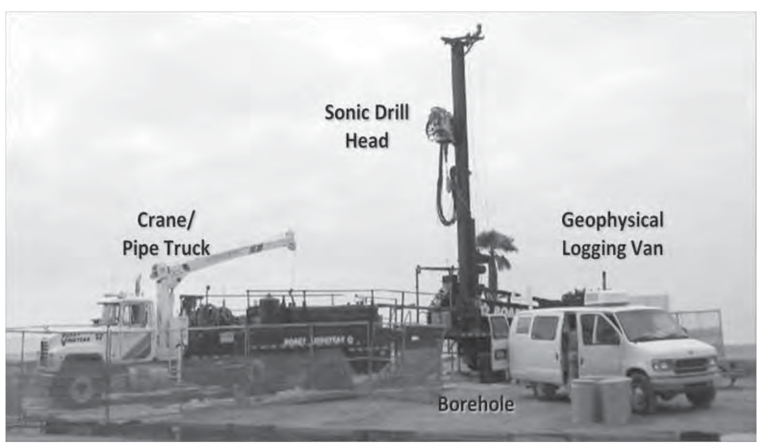
The sonic drilling method will be used for the exploratory boreholes. Sonic drilling allows collection of relatively undisturbed borehole lithologic samples and does not require the use of drilling mud or other additives. If borehole conditions require (e.g., swelling clays) a small amount of potable water can be injected to lubricate the drill bit and prevent excessive sticking of the drill pipe.

Sonic drilling involves generating high-speed vibrations of 50 to 150 cycles per second through a hydraulically operated oscillator located within the drill head. The drill head is attached directly to flush threaded drill casing, enabling the vibrations to be passed down to the drill bit. The drill bit causes the subsurface materials to displace and fracture to allow penetration of the drill bit. As the drill bit is advanced, additional vibrations cause soil and rock particles to move away from the drill casing, permitting fast penetration rates. A flush-threaded temporary casing stabilizes and holds the borehole open as the bit and core barrel is advanced. The sonic drilling method is a very fast and clean drilling method, providing a high level of control regarding the definition and preservation of the subsurface lithologic materials.

GEOSCIENCE has prepared detailed technical specifications for exploratory borehole drilling that will be used as a guidance document for the contractor during work in the field. The technical specifications for exploratory borehole drilling are included as Attachment 1 of this Work Plan.

Drilling

Sonic drilling will produce continuous core samples that are minimally disturbed from both unconsolidated and consolidated formations. Additionally, California modified split spoon samples and standard penetration tests (SPT) will be conducted at specified depths during the drilling process. Sonic drilling is often used in the environmental drilling industry because it is a "dry" drilling method that does not require the addition of water, air, or additives to the borehole. Sonic drilling does not

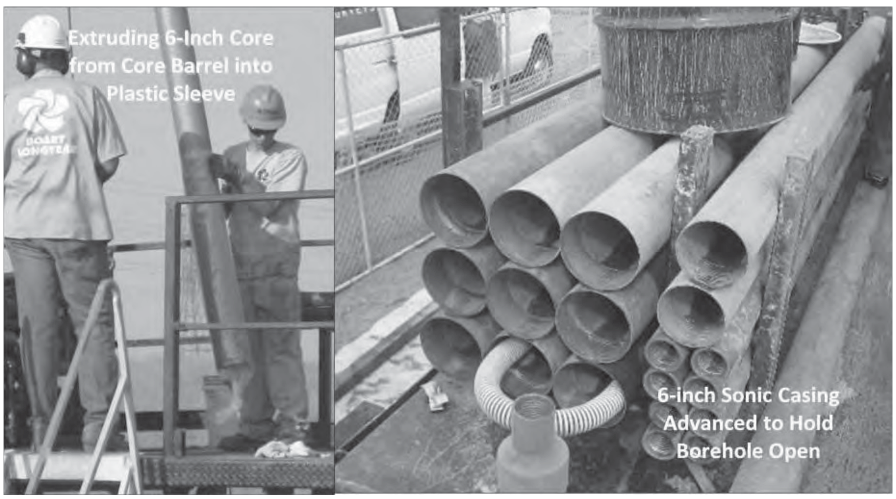


Sonic Drilling Rig and Support Equipment

require drilling fluid or other additives, and generates relatively few drill cuttings, and is considered the best method to use when drilling environmentally sensitivity areas.

Core Sampling

An inner casing (i.e., the core barrel attached to small-diameter drill rods) is vibrated ahead of the outer casing to collect undisturbed formation materials as the core sample. With each 5-ft advance of the casing, the core barrel is extracted and is brought to the surface to retrieve the core, which is then extruded into several heavy plastic sleeves measuring approximately 2.5 ft in length.



Standard specifications that will be used for sonic borehole drilling are listed in the table below:

Table 3-1. Applicable Standards for Testing and Logging of Exploratory Boreholes

Standard No.	Title
ASTM D1586-11	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D3550-01(2007)	Standard Practice for Thick Wall, Ring Lined, Split Barrel, Drive Sampling of Soils
ASTM D5434-12	Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock
ASTM D2488-09a	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D5753-05(2010)	Standard Guide for Planning and Conducting Borehole Geophysical Logging
ASTM D6274-10	Standard Guide for Conducting Borehole Geophysical Logging-Gamma
ASTM D6726-01(2007)	Standard Guide for Conducting Borehole Geophysical Logging – Electromagnetic Induction
American Water Works Association (AWWA)	Standard for Water Wells (AWWA A100-06), or latest revision

Standard No.	Title
California Department of Water Resources (DWR)	*Standards for Water Wells (pertaining to Exploratory Borings):* Part III, Section 19 B. Water Well Standards: (Bulletin 74-81) and California Well Standards (Bulletin 74-90), or latest revision

3.1.1 Location, Access and Permits

Using the sonic drilling method, the Contractor shall drill exploratory borings at the locations shown in the attached figures (see Figure 3-1). The Monterey Dunes Way, Potrero Road, Sandholdt Road, and Moss Landing sites are accessible using existing paved roadways, or are immediately adjacent to paved surfaces and are accessible using standard truck-mounted equipment. Surface conditions in the CEMEX area consist of loose sand, and therefore, it is anticipated that the use of full-sized all-terrain or track-mounted drilling and support equipment will be required.

Environmental clearance and access for each site will be provided by the Project Engineer and Owner. The Contractor will be required to hold all other necessary certificates and licenses required by law for the work. The Contractor will be required to comply with all federal, state and local laws, ordinances, or rules and regulations relating to the work and shall have a valid State of California C-57 Water Well Drilling Contractor License. Additionally, the Contractor will be required to provide a Monterey County Health Department permit for each borehole that is drilled and destroyed.

3.1.2 Borehole Depths and Sampling

Exploratory boreholes are needed to determine the thickness of aquifer sediments and aquifer permeability in areas that have not yet been characterized. This information is necessary to update the ground water model that will be used to locate future subsurface slant well intakes for the pilot study and full-scale desalination project.

Sampling and testing will include:

- Lithologic descriptions of formation materials encountered;
- Mechanical grading analyses to determine aquifer characteristics, and design filter packs;
- California modified split spoon samples to test vertical and horizontal permeability determination;
- Depth to ground water measurements; and
- Depth-specific ground water sampling through zone testing of discrete zones or field conductivity measurements of pore water to allow an initial assessment of water quality beneath the site.
- Geophysical logging including fluid resistivity and borehole temperature logs to allow determination of the depth of discrete aquifer units.

3.1.3 CEMEX Area

It is planned that a total of five (6) exploratory boreholes will be drilled in the CEMEX area. Four (4) of these boreholes are planned to be drilled along the CEMEX haul road and access road in a direction generally perpendicular to the shoreline. Two (2) boreholes will be drilled in an approximate north and south direction from the seaward most, boring (see (CX-B1) on Figure 3-1 and 3-4) within the active mining area.

Each borehole will be drilled using the sonic drilling method to anticipated maximum depths between 300 ft to 350 feet below ground surface. In addition to obtaining lithologic information to further characterize aquifers in the area, mechanical grading analyses will be performed on selected core intervals. After review of the lithologic log and geophysical logs, samples will be collected from core that represents the aquifer materials. Split spoon samples will be collected from each borehole for the purpose of testing for vertical permeability. Finally, depth to ground water measurements and depth-specific ground water samples will be collected from each borehole to determine ground water elevation and water quality beneath the site.

3.1.4 Monterey Dunes Way, Potrero, and Sandholdt Road Beach Parking Areas

It is planned that three (3) exploratory boreholes will be drilled, one each at Monterey Dunes Way, Potrero Road and Sandholdt Road parking areas of Salinas State beach (see Figures 3-0, 3-1, 3-2 and 3-3) to a depth of 200 ft bgs.

3.1.5 Moss Landing Harbor Area

It is recommended that six (5) additional exploratory boreholes are drilled, throughout the Moss Landing Harbor area (see Figure 3-0 and 3-4). These exploratory boreholes will be drilled to an anticipated depth of 200 ft bgs.

3.1.6 Removal of Drill Cuttings and Waste Water

Drill Cuttings

Drill cuttings (i.e., excess borehole materials) from the northern sites (i.e., Potrero Road, Sandholdt Road, Sandholdt Pier and Moss Landing Harbor areas) will be removed and disposed at the nearby Monterey Regional Water Management District facility located at 14201 Del Monte Blvd, Marina, California. Drill cuttings from the CEMEX area boreholes will be spread and leveled at each site prior to demobilization. Minimal cuttings will be produced as most of the material will be core that is retained in plastic sleeves.

Waste Water

Water generated during isolated aquifer zone testing and drilling will be temporarily contained in a portable container such as a trailer mounted tank or water truck, and will be transported to an approved offsite location for discharge to either the local sewer system, or to land. Due to the volume of ground water generated during pumping isolated zones at 10 to 20 gpm, disposal to the local sewer system, if available, would be the preferred alternative.

For the CEMEX sites, it is currently planned to discharge water during isolated aquifer zone testing directly to the ground by sprinkling or spreading along the CEMEX haul road for dust control. If this method of disposal is utilized, the Contractor will provide a water truck that is capable of hauling at least 1,800 gallons of water, and that is equipped with a pump and sprayer bar.

For the Monterey Dunes Way, Potrero Road, Sandholdt Road, and Moss Landing Harbor sites, permission to discharge water generated to a nearby sewer manhole, or other approved discharge location, will be obtained. If this method of disposal is utilized, the Contractor will provide a water truck that is capable of containing at least 1,800 gallons of water for hauling.

If acceptable, the Owner and Project Engineer will obtain permission to discharge low flow rates (i.e., 10 to 20 gpm) directly to the local sewer system in the Moss Landing area.

3.2 Detailed Description of Sonic Drilling Equipment and Testing Tasks

3.2.1 Schedule

The work schedule for drilling operations will be 6 AM to 6 PM daily to expedite the field work. The drilling contractor will schedule personnel to work ten (10) days on, with four (4) days off per work cycle. No construction work will be conducted on major holidays without prior permission from the Owner. It is estimated that drilling and testing of each 200 ft borehole will require 3 to 4 days, and each 350 ft borehole will require 5 to 6 days.

All boreholes will be drilled using a 6-inch diameter drill casing, which will provide a 4-inch diameter core. Upon completion of drilling to total depth, a temporary 4-inch PVC casing will be installed to enable geophysical logging in the open borehole before zones are selected for isolated aquifer zone testing.

Inspection during drilling and testing will be conducted on a full-time, 12-hour working day basis from 6 AM to 6 PM during borehole drilling and testing activities. A field geohydrologist will be onsite at all times during drilling for lithologic logging of the samples retrieved from of each borehole, and during testing to ensure that the proper protocols and procedures are being adhered to.

3.2.2 Number of Workers and Support Vehicles

Exploratory borehole drilling and testing operations will require four drilling contractor personnel, which will include a field supervisor, driller, and two assistants. One supervising geohydrologist will also be onsite at all times. Geophysical borehole logging will be conducted by two subcontracted personnel, assisted by the drilling crew, and will be witnessed by the supervising geohydrologist. Destruction of the boreholes will be undertaken by the four-person drilling crew, and will be overseen by the supervising geologist.

The onsite drilling equipment will consist of the following:

- 25-ton sonic drilling rig (either truck- or track-mounted),
- 25-ton drill pipe truck- or track-vehicle equipped with a water tank,
- 2.5-ton four-wheel drive forklift,
- 1-cubic yard dump bins,
- 5-ton service truck with miscellaneous equipment and fuel tank,
- 1,800 gallon water truck, and
- Sound barriers (when required).

The supervising geohydrologist will have a four-wheel drive pickup truck.

Equipment temporarily stored at each 80 ft x 120 ft fenced staging area may include:

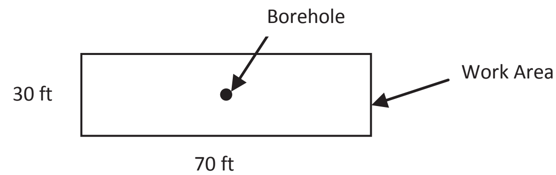
- Roll off box for soils containment,
- Extra sonic drill pipe or specialty tooling,
- Pallets with Portland cement, bentonite pellets, and filter pack ,
- Field sanitation,
- Generator,
- Switchbox and submersible test pumps,
- Air compressor,
- 4 in. PVC screen,
- Forklift, and
- Drilling rig and support truck during days off.

3.2.3 Mobilization and Site Set-Up

The supervising geohydrologist will inspect the contractor's equipment during mobilization and set up at the first site of each group of boreholes to ensure that it meets the specification requirements, is in good operating order, and is adequate to perform the work.

3.2.4 Drilling Footprint – Sonic Drilling Rig

The footprint required for the drilling operations is an area measuring approximately 30 ft wide by 70 ft long (2,100 square feet) with the drilling rig and pipe truck positioned end-to-end to provide adequate working space.



General Equipment Layout for Exploratory Boreholes

Fences or additional security measures will not be required around the drilling equipment when working onsite. Cores that are collected will be removed to an offsite storage area on a daily basis.

3.2.5 Drilling and Logging of Boreholes

GEOSCIENCE will provide field inspection services during exploratory borehole drilling that will encompass collection and preservation of continuous cores from each borehole (4-inch to 6-inch diameter core), obtain detailed photographs of each core, witnessing geophysical borehole logging, testing, and borehole destruction.

3.2.5.1 Continuous Core Sampling

Each approximately 2.5-ft section of core sample will be classified according to the Unified Soil Classification System (USCS) Visual Method. A lithologic log will be prepared for each borehole, with photographs taken of each core sample. The generalized borehole lithology will be presented in the summary report with detailed lithologic classifications presented in an attached appendix to the report.

Borehole Core Sample and Plastic Sleeve

Representative intervals from the core samples will be sieved and grain size distribution charts will be provided to visually present the sieve data. Based on the sieve data, estimates of permeability will be made using the Hazen approximation.

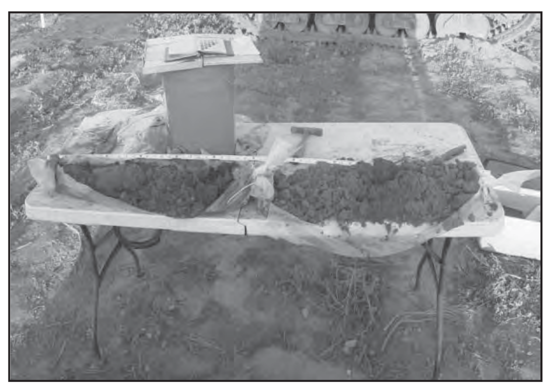
The drilling process will produce 4-inch to 6-inch diameter borehole cores over a 10-ft core run. The core is will then be extruded into plastic sleeves up to 3 feet in length. The core samples will be preliminarily logged and photographed before being transported to a central storage facility at the end of each working day. A more detailed lithologic log will be completed at the storage area.

3.2.5.2 Split Spoon Sampling

Split spoon samples will be collected at specified depths from each borehole to obtain undisturbed samples of the formation materials for the purpose of estimating both vertical and horizontal hydraulic conductivity using a laboratory permeameter. Samples will be collected from the Dune Sand Aquifer, the Salinas Aquitard or other low permeability lithologic units, and the 180-Foot Aquifer.

The split spoon sampler will hold three to four thin-walled metal (i.e., brass or stainless steel) sleeves measuring approximately 6 inches in length and 2.5 inches in diameter. The sampler will be attached to small diameter drill rod that will be pushed through 18- to 24-inches of undisturbed formation material ahead of the drilling bit. Each time the split spoon sampler is retrieved, the sampling sleeves will be removed and the exposed ends will be covered with Teflon® sheets, before being covered with plastic caps and taped to preserve the sample for further testing. Using indelible ink, each sleeve will be marked with the project name, borehole name, sample depth and number, and the date. The sleeves containing the in-situ samples that will be used to measure permeability will be shipped to a laboratory for permeameter testing, with an accompanying chain of custody form that is complete and signed. The chain of custody form will be placed in a one gallon zip lock bag and sealed to prevent damage in transit.

3.2.5.3 Lithologic Logging, Unified Soil Classification System (USCS)



Core Samples Being Logged in the Field

Each soil sample and core section recovered will be described in general accordance with ASTM D2488-09A, which is based on the Unified Soils Classification System (USCS). Descriptions will generally includes soil type, grain size and an estimated percentage of the coarse-grained and fine-grained portions, plasticity of the fines, color and moisture.

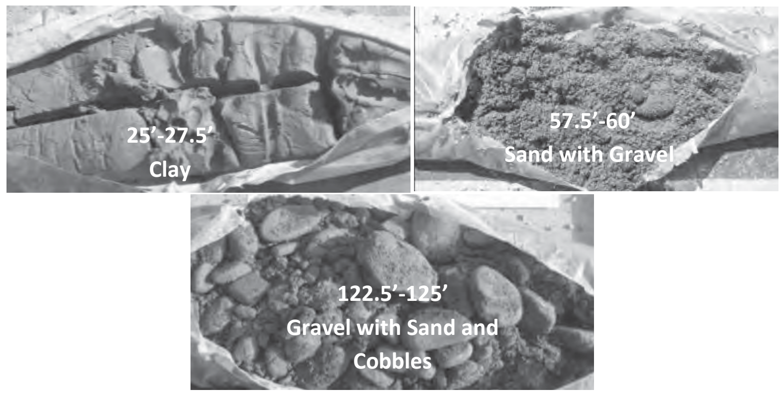
In poorly-indurated materials with high silt content, vibrations imparted by the sonic drill head may cause some expansion of the core sample. Should this occur, an estimation of the amount of expansion will be made.

A detailed lithologic description for each borehole will be prepared primarily in the field, with refinements to the descriptions completed prior to reporting. Lithologic descriptions will include soil type, sample information for the driven samples (California modified method), and the core sections.

The soils recovered from the drive sampler will be described by observation of visible materials at the ends of each sleeve. The soil descriptions for the core will be described in increments of one-tenth of a foot.

3.2.5.4 Photographs of Core, Preservation and Storage

Following logging and photographing at each borehole site, the cores will be re-wrapped and taped before being transported to sample storage area. At the sample storage area, a thorough inspection will be made of each sample, and borehole depth intervals will be selected for mechanical grading analysis and other testing.



Examples of Sonic Core Samples

3.2.5.5 Water Level Measurement and Water Quality Sampling during Drilling

An electric wireline water level indicator will be used to measure depth to ground water during borehole advancement and during the isolated aquifer zone testing. All measurements from each borehole will be recorded from a ground-level reference point. The date, time, reference point will be recorded for each depth-to-water measurement. Water level data will be included in the summary report that will be prepared for the initial hydrogeological investigation phase of the project.

To determine the vertical variation in water quality, water quality samples will be collected from each borehole following drilling and geophysical borehole logging. Isolated aquifer zone testing will be performed by constructing a temporary well within the borehole (see Figure 3-6). A 4-inch diameter PVC screen and casing will be placed in the borehole, and an engineered filter pack and bentonite seal will be installed to complete the isolation process. Prior to developing the zone, the hole will be flooded with potable water and the bentonite seal will be allowed to fully hydrate. Isolated zone development will consist of first airlifting to verify the seal integrity prior to installing a submersible pump. A submersible pump will be then used to completely purge the zone. Each zone will be pumped at 10 to 20 gpm, which will develop the zone and reduce turbidity levels. Low turbidity levels will minimize the interference from suspended sediment in samples collected for water quality analysis.

Two zones will be selected for isolated zone testing for the borings in the Moss Landing area. Up to five zones will be selected for obtaining water quality samples from CEMEX borings CX-C1, CX-C2, and CX-B4.

The additional zones will aid in understanding water quality differences between the Upper Dune Sand Aquifer and the middle 180-ft Aquifer.

The isolated aquifer sampling method does not involve complex construction methods, which lowers the cost of the work. Once the required water samples and water level measurements have been collected, the submersible pump and screen section will be removed and the borehole will be destroyed.

Field water quality parameters that will be measured during pumping (in addition to discharge rate and water level) will include pH, conductivity, resistivity, temperature, salinity, oxidation reduction potential (ORP), and dissolved oxygen. Field measurements will be made using a using an YSI 556, or equivalent, multi-parameter analyzer with probes installed in a flow-through cell. Silt Density Index (SDI) measurements will be performed in the field for each aquifer interval tested.

The anticipated suite of water quality analysis for each of the boreholes is shown in the following table:

Table 3-2. Water Quality Analyses for Exploratory Boreholes

Constituent	Units	Method Reporting Limit	Method
Physical Properties			
Color	Color Units	3.0	SM 2120B/EPA 110.2
Odor	T.O.N.		EPA 140.1
Oxidation-Reduction Potential (Field)	mV	-	Field Meter - Myron L 6PII
pH (Lab)	Units	0.10	SM 4500 H+B
pH (Field)	Units	-	Field Meter - YSI Pro Plus
Turbidity (Laboratory)	NTU	0.20	EPA 180.1/SM 2130B
Turbidity (Field)	NTU	-	Field Meter - Hach 2100P
Temperature (Field)	°C	-	Field Meter - YSI Pro Plus
Dissolved Oxygen (Field)	mg/L	-	Field Meter - YSI Pro Plus
Silt Density Index (Field)	-	-	ASTM D4189-07
Threshold Odor Number	T.O.N.	1.0	EPA 140.1/SM 2150
Total Dissolved Solids (Lab)	mg/L	10	SM 2540 C
Total Dissolved Solids (Field)	mg/L	-	Field Meter - YSI Pro Plus
Specific Conductance (Lab)	µmhos/cm	1	SM 2510 B
Specific Conductance (Field)	µS/cm	-	Field Meter - YSI Pro Plus
General Minerals			
Total Cations	meq/L	-	Calculation
Total Anions	meq/L	-	Calculation
Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B

Constituent	Units	Method Reporting Limit	Method
Bicarbonate Alkalinity as HCO_3	mg/L	3	SM 2320 B
Carbonate Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Hydroxide Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Total Hardness as $CaCO_3$	mg/L	3	Calculation
Aluminum	µg/L	1	EPA 200.7
Arsenic	µg/L	1	EPA 200.7 / EPA 200.8
Barium, Dissolved	µg/L	0.01	EPA 200.7
Boron, Dissolved	µg/L	0.5	EPA 200.8
Bromide, Dissolved	mg/L	0.1	EPA 326.0
Calcium, Dissolved	mg/L	1	EPA 200.7
Chloride, Dissolved	mg/L	1	EPA 300.0
Copper, Total	µg/L	50	EPA 200.7
Fluoride, Dissolved	mg/L	0.10	EPA 300.0 / SM 4500 FC
Iodide, Dissolved	mg/L	0.1	USGS I-2371 / EPA 9056A
Iron, Dissolved	µg/L	100	EPA 200.7 / EPA 200.8
Iron, Total	µg/L	100	EPA 200.7 / EPA 200.8
Lithium	µg/L	10	EPA 200.7 / EPA 6010B
Magnesium, Dissolved	mg/L	1	EPA 200.7
Manganese, Dissolved	µg/L	20	EPA 200.7 / EPA 200.8
Manganese, Total	µg/L	20	EPA 200.7 / EPA 200.8
MBAS	mg/L	0.050	SM 5540 C / EPA 200.8
Nitrogen, Nitrate as NO_3	mg/L	1	EPA 353.2 / EPA 300.0
Nitrogen, Nitrite, Dissolved	mg/L as N	1	SM 4500 NO_2B
Nitrogen, NO_2 + NO_3	mg/L as N	1	EPA 300.0
Nitrogen, Ammonia, Dissolved	mg/L as N	0.1	SM 4500 NH_3H / EPA 350.1
Nitrogen, Ammonia + Organic, Diss. (TKN)	mg/L as N	0.1	EPA 351.2
Phosphorus, Dissolved	mg/L as P	0.01	EPA 365.3
Phosphorus, ortho, Dissolved	mg/L as P	0.01	EPA 365.3
Potassium, Dissolved	mg/L	1	EPA 200.7
Silica, Dissolved	mg/L	1	SM 4500 SiE
Sodium, Dissolved	mg/L	1	EPA 200.7
Strontium, Dissolved	mg/L	0.1	EPA 200.7 / EPA 200.8
Sulfate as SO_4, dissolved	mg/L	0.5	EPA 300.0
Zinc, Total	µg/L	50	EPA 200.7
Radiology / Age Dating Methods			
Delta-Deuterium	δ^2H	-	TC/EA/IRMS
Delta Oxygen-18	$\delta^{18}O$	-	TC/EA/IRMS
Tritium	TU	-	-
Tritium, prec. est.	TU	-	-

Constituent	Units	Method Reporting Limit	Method
Volatile Organic Compounds			
VOCs plus Oxygenates (MTBE)	µg/L	varies	EPA 524.2
EPA Organic Methods			
EDB and DBCP	µg/L	varies	EPA 504.1
Chlorinated Pesticides & PCB's as DCP	µg/L	varies	EPA 508
Chlorinated Acid Herbicides	µg/L	varies	EPA 515
Nitrogen & Phosphorus Pesticides DEHP, DEHA, Benzo(a)Pyrene	µg/L	varies	EPA 525
Carbamates	µg/L	varies	EPA 531.1
Glyphosate	µg/L	varies	EPA 547
Endothall	µg/L	varies	EPA 548.1
Diquat	µg/L	varies	EPA 549.1
Dioxin (2,3,7,8 TCDD)	µg/L	varies	EPA 1613

NTU = Nephelometric Turbidity Units
mg = Milligram
µS = MicroSiemens

Water quality samples collected during zone testing will be delivered to a certified laboratory to perform the required water quality analyses. The results of all water quality analyses will be provided in a technical memorandum (TM 1) at the completion of this phase of the project.

3.2.5.6 Water Quality Sampling Protocol

Water quality samples will be collected from the discharge during each isolated aquifer zone test. Sample for laboratory analysis will be collected directly into the appropriate sampling container, which has been prepared per analytical method requirements and supplied by the laboratory. Samples collected for dissolved metals will be field-filtered from the pump discharge line using a 0.45-micron filter prior to collection in laboratory-prepared sampling containers.

A stainless steel submersible pump installed on flush-threaded PVC column pipe will be used to extract the samples. The sampling pump will be set at just above the top of the screened interval to maximize available drawdown, and will be pumped at an average rate of 10 to 50 gpm.

Sampling for Water Quality Analysis

3.2.5.7 Geophysical Borehole Logs

Geophysical borehole logs will be run on each of the boreholes and as a minimum, the suite of logs will consist of:

- Dual Induction,
- Temperature,
- Fluid Resistivity, and
- Gamma Ray.

Once each borehole has been drilled to its designated total depth, the core barrel will be removed and a 4-inch diameter PVC screen will be installed within the borehole prior to removing the outer sonic casing. The 4-inch PVC screen will ensure that the borehole will remain open during logging, however, it is typical to experience some sand infiltration through the slotted screen during removal of the sonic drill casing.

Geophysical borehole logs will be run inside the temporary PVC screen throughout the total depth of each borehole. Results of the geophysical borehole logging, as well as lithologic descriptions, and analysis of samples and cores, will then be used to delineate the aquifer systems in the CEMEX, Potrero Road, and Moss Landing areas. After collection, copies of each geophysical borehole log will be uploaded to the project share site for review by the HWG and will be included in TM 1.

3.2.5.7.1 Dual Induction Log

Dual induction logs (DIL) are used to determine resistivity of formation materials by measuring conductivity adjacent to the induction tool.[1] The induction tool focuses alternating electromagnetic currents into the formation, with medium and deep measurements determined by transmitter/receiver spacing. The DIL is comprised of six (6) separate measurements:

- **RILM** - Resistivity, Induction Log Medium
- **RILD** - Resistivity, Induction Log Deep
- **CILM** - Conductivity, Induction Log Medium
- **CILD** - Conductivity, Induction Log Deep
- **GR** - Gamma Ray

Induction logs can be run within PVC-cased boreholes, but are not run in steel casings as the steel will interfere with the electrical current. Gamma ray (GR) logs are typically used to aid in lithologic

[1] Conductivity is measured as mho/m and is the reverse of resistivity.

identification.

3.2.5.7.2 Temperature Log

Temperature logs measure absolute temperature of fluid within a borehole. A calculated differential measurement is also provided with the log, which allows detection of vertical fluid movement within borehole, including fluid entry and exit points. These logs can detect very small temperature anomalies, and can be run in any type of fluid in either cased or uncased holes.

3.2.5.7.3 Gamma Ray Log

Gamma ray logs measure naturally occurring gamma radiation that is emitted from formation material surrounding the borehole. Gamma rays are the result of electromagnetic radiation release from elements with unstable nuclei as they decay to a more stable state. The most common source of gamma radiation is potassium-40 (K40), uranium-238 (U238), uranium-235 (U235), and thorium-232 (Th232). Clay-bearing materials commonly emit relatively high gamma radiation due to weathering of potassium-bearing minerals such as potassium feldspar and other mica-bearing rocks.

3.2.5.7.4 Fluid Resistivity Log

Fluid resistivity logs measure the resistivity of borehole fluid (in units of ohm-m) and provides a calculated differential curve. This log is used for correlation of temperature measurements and is used to assist in locating incoming high TDS water, layering effects of different waters within a wellbore, and to differentiate between waters from various contributing aquifer zones.

3.2.6 Analysis of Data

Analysis of data will include:

- Borehole lithology,
- Mechanical grading analysis,
- Vertical permeability,
- Geophysical borehole logs,
- Isolated aquifer zone tests, and
- Results of water quality analysis.

Based on the data analysis of the aforementioned data, well screen depth will be established for the monitoring wells, the test slant well, and for the full-scale project intake wells.

A table will be provided that summarizes the mechanical grading analysis and hydraulic conductivity estimates for the samples collected from each borehole. The table will include depth interval, lithology, geologic formation, conductivity direction, and the average hydraulic conductivity value for each sample interval. Soil types listed will be based upon the results of the mechanical grading analyses, and may not represent the complete lithologic interval from which they were taken if the lithologic units are found to be bedded and gradational.

3.2.6.1 Mechanical Grading Analyses of Selected Formation Intervals

Approximately five (5) samples per borehole will be selected from the core samples and will be analyzed in GEOSCIENCE's laboratory for grain-size.

Mechanical grain size analyses (i.e., grading analysis) will be performed on selected samples collected from the sonic boreholes for the purpose of determining grain size distribution curves of borehole materials, and subsequent estimates of hydraulic conductivity. Samples will be sieved using U.S. Standard sieves with mesh sizes ranging from 0.0740 mm (0.0029 in.) to 9.525 mm (0.375 in.).

3.2.6.2 Determination of Porosity

In-situ samples collected from the boreholes will be submitted to the soils laboratory for a determination of porosity using methods described in American Petroleum Institute’s (API) Recommended Practice 40 (API RP40). A maximum of three samples per borehole will be submitted for laboratory porosity determination

3.2.6.3 Estimates of Hydraulic Conductivity (e.g., Based on Hazen, Kozeny-Carman, and Krumbein-Monk)

Multiple estimates of hydraulic conductivity will be made, including approximations using mechanical grading analysis properties and vertical permeability from laboratory analysis of relatively undisturbed soil samples. The Hazen Approximation, Krumbein-Monk, and Kozeny-Carman methods will be used to estimate hydraulic conductivity from grain size distribution curves of the soil samples collected.

Hazen Approximation

Hazen’s approximation is an empirical equation that estimates hydraulic conductivity to be proportional to the square of the effective grain size, which is expressed as:

$$K = C (d_{10})^2$$

where:

K	=	Hydraulic conductivity (cm/s)
C	=	Hazen's constant, approximately 1 (dimensionless)
d_{10}	=	Grain size in mm for which 10% of the particle pass by weight

The method is applicable to sands where the effective grain size (d_{10}) is between approximately 0.1 and 0.3 mm. Hazen's approximation was originally determined for uniformly graded sands, but it can provide rough but useful estimates for most soils in the fine-grained sand to gravel range (Freeze and Cherry, 1979[2]).

Krumbein-Monk

Krumbein and Monk, 1942[3] described hydraulic conductivity (using units of darcies) for unconsolidated sands with a log-normal grain size distribution. Using this description, they used a semi empirical equation assuming forty percent porosity, which is expressed as:

$$K = (\rho_\omega g)/\mu \cdot [\phi^3/(1-\phi^2)] \quad (d_m{}^2)/180$$

where:

K	=	Hydraulic conductivity (cm/s)
ρ_ω	=	Fluid density (kg/m^3 of ft/s^3), assumed to be the average temperature of groundwater (22 degrees Celsius)
d_m	=	Particle diameter or characteristic length of a given material (m or ft)
ϕ	=	Porosity
μ	=	Dynamic viscosity (Pa-s pr lbs-s/ft^2), also assumed to be the average temperature of groundwater (22 degrees Celsius)
g	=	Gravitational constant (m/s^2 or ft/s^2)

2 Freeze, R.A. and Cherry, J.A., 1979. Groundwater. Upper Saddle River, New York, Prentice Hall, Inc.

3 Krumbein, W.C. and Monk, D.C., 1942. Permeability as a function of the size parameters of unconsolidated sands. Transactions of the American Institute of Mining, Metallurgical and Petroleum Engineers, Littleton, Colorado.

Kozeny-Carman

One of the most widely used equations for determining hydraulic conductivity from characteristic lengths is the Kozeny-Carman Equation. Kozeny proposed in 1927, which was later modified by Carman in 1956[4], a method for determining hydraulic conductivity from the following:

$$K = (760 d_w^2)\exp(-1.31\sigma_\psi)$$

where:

K	=	Hydraulic conductivity (cm/s)
d_w	=	Geometric mean particle diameter by weight (mm or in.)
σ_ψ	=	Standard Deviation of the y distribution function (mm or in.)

Soil samples will be collected in the boreholes and will be submitted to a geotechnical laboratory such as AP Engineering & Testing, Inc. for analysis of physical properties, including vertical permeability (i.e., hydraulic conductivity) for both the Dune Sand Aquifer and the 180-Foot Aquifer.

Hydraulic conductivity values will be converted from centimeters per second (cm/s) to ft per day (ft/day) for reporting purposes.

3.3 Borehole Location Survey

Each completed exploratory borehole will be surveyed by a California licensed land surveyor. The elevation and spatial location of each borehole will be surveyed relative to an established benchmark. Horizontal and vertical accuracy will be established in accordance with a second order Class I survey standard (1: 50,000).

3.4 Borehole Destruction

Borehole destruction will take place immediately after isolated aquifer testing. The temporary casing will be removed and each exploratory borehole will be destroyed by filling with neat cement, or by backfilling with native materials in strict accordance with the requirements of the Monterey County Health Department and DWR Bulletins 74-81 and 74-90. Aquitards encountered between the Dune Sand Aquifer and the 180-Foot Aquifer, or shallower, will be sealed using neat cement grout.

4 Carman, P.C., 1956. Flow of Gases through Porous Media, Butterworths Scientific Publications, London.

To prevent material bridging during placement, all materials used for borehole destruction shall be placed through a tremie pipe, or by other means. All material used for borehole destruction will be clean and free of any contaminants.

3.5 Technical Memorandum 1 (TM 1) – Summary or Results – Exploratory Boreholes

A Technical Memorandum (TM 1) will be prepared at the completion of exploratory borehole drilling and testing. TM 1 will include the following:

- Horizontal and vertical distribution of aquifer units,
- A description of the subsurface conditions and stratigraphy; subsurface material characteristics and properties; groundwater levels and water-quality data; and boring logs,
- Daily field notes,
- Geophysical borehole logs,
- Results of isolated aquifer zone testing,
- Figures, maps and photographs showing site locations and conditions,
- Borehole destruction details,
- Results of mechanical grading analysis, including Hazen Approximation, Krumbein-Monk, and Kozeny-Carman hydraulic conductivity data,
- Results of vertical permeameter testing,
- Recommendations for monitoring well locations and construction details,
- Analytical reports showing ground water quality results; and
- All other pertinent data, recommendations, and conclusions, and
- Recommendations for monitoring well locations and construction details.

GEOSCIENCE will submit five (5) copies of the draft technical memorandum to the client and technical advisory committee. After a review and comment period, GEOSCIENCE will incorporate appropriate revisions and submit five (5) copies of the technical memorandum (TM 1) for exploratory borehole drilling and testing.

4.0 MONITORING WELL CONSTRUCTION AND TESTING – CEMEX AREA

4.1 Overview

Monitoring wells will be constructed in the vicinity of the Test Slant Well at the CEMEX facility to provide information on hydrology and water quality. Monitoring wells will be contructed in two phases. Two monitoring well clusters (MW-1S,1M,1D and MW-2S, 2M, 2D) will be constructed at the time the test slant well is contructed to be used for monitoring during the initial one-week test slant well pumping test. A second set of monitoring well clusters (clusters at MW-3 through MW-7) will be constructed after installation and initial testing of the test slant well to be used for the long-term (18-month) test slant well pumping test. The locations of the monitoring wells clusters for both the short-term and long-term testing are shown on Figure 4-1. The estimated depths and screen lengths are listed on Table 4-2. The depth and screen intervals will be further refined after analysis of recently collected data in the final depths will be determined in the field after drilling and logging of the pilot borehole. The monitoring wells will drilled using the Sonic Drilling method and will be completed in the various underlying aquifers at the site. At the CEMEX site, it is anticipated that monitoring wells will be completed in the Dune Sand Aquifer, 180-Foot Aquifer, and 400-Foot Aquifer.

Each monitoring well will be constructed in a separate borehole (i.e., one screen interval per well) to ensure proper sealing and separation between aquifers, and to ensure that representative aquifer sampling is being achieved. At various depths, split spoon samples of formation material will be collected from each borehole for permeameter testing.

Screen intervals will be provided in the monitoring well technical specifications (Attachment 2) that will be prepared for each monitoring well. Screened intervals will be based on the results of exploratory borehole drilling and will be included in the summary report that will be provided upon completion of exploratory borehole drilling.

The methodology for sonic exploratory borehole drilling and testing is described in Section 3.1 of this work plan. In addition to the standards that apply to exploratory borehole drilling, the following additional standards will be used for monitoring well construction, development and testing:

Table 4-1. Applicable Standards for Monitoring Well Construction Materials and Testing

Standard No.	Title
D6914-04(2010)	Standard Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices.
F480-06be1	Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in

Standard No.	Title
	Standard Dimension Ratios (SDR), SCH 40 and SCH 80.
D1785-06	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
D5092-90(1995)e1	Practice for Design and Installation of Ground Water Observations Wells in Aquifers.
D4050-96(2008	Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems
D5521-05	Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers.
American Water Works Association (AWWA)	Standard for Water Wells (AWWA A100-06), or latest revision.
California Department of Water Resources (DWR)	*Standards for Water Wells (pertaining to Exploratory Borings):* Part III, Section 19 B. California Department of Water Resources (DWR) Water Well Standards: State of California (Bulletin 74-81) and California Well Standards (Bulletin 74-90), or latest revision.

Once each borehole has been drilled and tested, the borehole will be enlarged and a 4-inch diameter single completion PVC monitoring well will be constructed.

4.2 Locations, Access, and Permits

The sonic drilling method will be used to drill and construct monitoring wells. The preliminary monitoring well locations are shown in Figure 4-1 along with the exploratory borehole locations. The monitoring wells will be located along the CEMEX plant access road, the CEMEX haul road, and adjacent beach areas. The final monitoring well locations will be determined following the results of exploratory borehole drilling and testing. Recommendations for the final monitoring well locations will be provided in Technical Memorandum 1 (TM 1) "Summary of Results – Exploratory Boreholes."

Surface conditions in the CEMEX area consist of loose sand, and therefore, it is anticipated that the use of full-sized all-terrain or tracked drilling and support equipment will be required.

Environmental clearances and access for the monitoring well sites will be provided by the Project Engineer and Owner prior to mobilization. Monitoring wells will be located in areas approved by CEMEX so as not to impede site operations.

The Contractor will be required to hold all other necessary certificates and licenses required by law for the work. The Contractor will be required to comply with all federal, state and local laws, ordinances, or rules and regulations relating to the work and shall have a valid State of California C-57 Water Well Drilling Contractor License. Additionally, the Contractor will be required to provide a Monterey County Health Department permit for each borehole that is drilled and completed as a monitoring well.

4.3 Schedule

The work schedule for drilling operations will be 6 AM to 6 PM daily to expedite the field work. The drilling contractor will schedule personnel to work ten (10) days on, with four (4) days off per two-week work cycle. Construction work will not be conducted on major holidays without prior permission from the Owner. It is estimated that drilling and construction of each monitoring well up to 200 ft deep will require 4 to 5 days, each well up to 350 ft deep will require 6 to 7 days, and each well up to 450 ft deep will require 8 to 9 days to complete.

Inspection during drilling and testing will be conducted on a full-time, 12-hour working day basis from 6 AM to 6 PM during drilling, construction, and development activities. A field geohydrologist will be onsite at all times during drilling for lithologic logging of the samples retrieved from of each borehole, and during construction and testing to ensure that the proper protocols and procedures are being followed.

4.4 Proposed Number of Monitoring Wells and Depths (Dune Sand, 180-Foot and 400-Foot Aquifers)

It is proposed that seven (7) sets of monitoring wells are constructed at the locations shown in Figure 4-1. Monitoring wells will be constructed in two phases. Monitoring Well clusters MW-1 and MW-2 will be constructed along with the Test Slant Well and will be used for short term pump testing of the test slant well. The cluster will include one monitoring test well constructed in the 180-ft Aquifer (middle aquifer). Monitoring wells MW-3 through MW-7 will constructed in a second phase of monitoring well construction after short-term pump testing and refinement of the ground water model. Final locations will be based on the ground water modeling. The second phase wells will become the long-term pump test monitoring system and will used for long-term monitoring of prject water quality. The tentative monitoring well locations and preliminary designs are shown on the next page.

Table 4-2. Proposed Monitoring Well Design

Monitoring Well No.	Location Relative to Test Slant Well	Targeted Aquifer	Approximate Distance from Test Slant Well [ft]	Estimated Monitoring Well Depth [ft bgs]	Estimated Screen Interval [ft]
MW-1S	Southeast of the Test Slant Well Entry Point	Dune Sand	100	160	40
MW-1M		180-Foot		320	120
MW-1D		400-Foot		450	50
MW-2S	Inland of Test Slant Well Entry Point	Dune Sand	550	160	40
MW-2M		180-Foot		320	120
MW-2D		400-Foot		450	50
MW-3S	North of Test Slant Well Entry Point	Dune Sand	325	160	40
MW-3M		180-Foot		320	120
MW-4S	South of Test Slant Well Entry Point	Dune Sand	225	160	40
MW-4M		180-Foot		320	120
MW-5S	Inland of Test Slant Well Entry Point	Dune Sand	1,150	160	40
MW-5M		180-Foot		320	120
MW-6S	Inland of Test Slant Well Entry Point	Dune Sand	2,000	160	40
MW-6M		180-Foot		320	120
MW-6D		400-Foot		450	50
MW-7S	Inland of Test Slant Well Entry Point	Dune Sand	3,700 ft from Test Slant Well	160	40
MW-7M		180-Foot		320	120

The proposed monitoring wells will be screened primarily in the Dune Sand aquifer and 180-Foot aquifer. Three wells are planned to be screened in the upper portion of the 400-Foot Aquifer. The monitoring wells in the 400-Foot Aquifer (deeper aquifer) are shown on Figures 4-1 and 5-1 and are designated with a "D" (i.e. MW-1D). Figure 4-2 shows the location of the first phase monitoring wells to be used for the short-term pump test and Figure 4-3 shows the second phase full monitoring system to be used for the Long-term pumping test and long-term monitoring.

4.5 Clustered Monitoring Well Design and Construction

4.5.1 Drilling and Logging Process

Field inspection services during monitoring well borehole drilling will encompass inspection during drilling and continuous coring of each borehole including:

1. Split spoon sampling;
2. Lithologic descriptions;
3. Photographing the cores;
4. Geophysical borehole logging, and;
5. Testing as described in Section 3.2.5 of this Work Plan, with the addition of oversight during monitoring well construction and development.

Isolated aquifer zone testing is not planned for the monitoring wells as verification of water quality. Water levels will be available from each aquifer following completion and sampling of the monitoring wells.

4.5.2 Total Depths, Casing, and Screen Intervals

The proposed monitoring well final depths and screen intervals will be recommended based on lithology and geophysical borehole logging from both the exploratory boreholes and monitoring well boreholes.

At this time, it is estimated that the depth of monitoring wells completed in the Dune Sand Aquifer will be approximately 160 to 190 ft with 40-ft long screen intervals. Monitoring wells completed in the 180-Foot Aquifer or equivalent hydrostratigrpahic unit (middle aquifer) may be approximately 320 to 350 ft deep with approximately 120 ft long screen intervals. The monitoring well that is completed in the 400-Foot Aquifer (deeper aquifer) will be approximately 450 ft deep, and will have a 50-ft screen interval located within the upper portion of the aquifer.

4.5.3 Lithologic Logging, Unified Soil Classification System (USCS)

Each soil sample and core section collected will be described in general accordance with ASTM D2488-09A, which is based on the Unified Soils Classification System (USCS) as described in Section 3.2.5.3 of this Work Plan.

Core Preservations and Storage

Following logging and photographing at each borehole site, the cores will be re-wrapped and placed a wooden core box before being transported to the area designated for storage. At the storage area the core can be available for a more in-depth inspection by the HWG participants.

4.5.4 Monitoring Well Drilling and Logging

Geophysical borehole logs will be measured only in the deepest borehole of each monitoring well group (i.e., the borehole penetrating either the 180-Foot or 400-Foot aquifers).

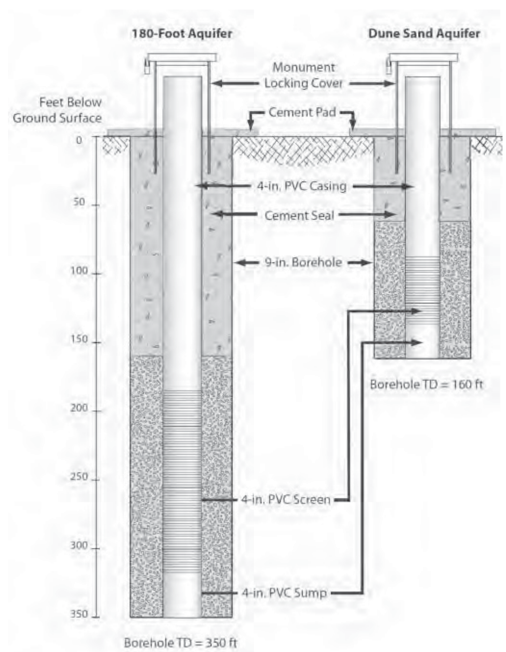
As with the exploratory boreholes, the suite of geophysical logs will consist of:

- Dual Induction,
- Temperature,
- Fluid Resistivity, and
- Natural Gamma Ray.

The procedure for conducting geophysical borehole logging in each initial borehole for monitoring wells is described in Section 3.2.5.7 of this Work Plan.

4.5.5 Monitoring Well Casing and Screen Materials, Slot Size, Filter Pack, and Seals

Following drilling, core sampling, and geophysical borehole logging, the initial 6-inch diameter borehole will then be enlarged to total depth using a 9-inch diameter sonic casing to over-drill the initial 6-inch borehole. The lengths and depths of each well screen will be determined in the field based on the lithology observed in the cores and on the geophysical logs. A conceptual diagram for monitoring well construction is shown on the schematic to the right and Figure 4-4 provides a conceptual monitoring well design. When the targeted total depth is reached, the monitoring well will be constructed by placing a 5-ft sump below the screen, and installing the prescribed amount of well screen and blank casing. All materials that are used for well construction shall be new, clean, and plastic-wrapped flush-threaded schedule 40 or schedule 80 PVC materials. PVC wall thickness will depend on the depth of the monitoring well.



Conceptual Drawing of Monitoring Well Construction

It is planned that screens with 0.050-inch horizontal machine-cut openings and a filter pack with a gradation matching CEMEX Lapis Lustre #3 silica sand[5] will be installed in the monitoring wells. The final slot size and filter pack gradation will be based on mechanical grading analysis results from both the exploratory borehole and initial borehole samples. The filter pack gradation and slot size will be modified as necessary for actual conditions encountered in the field. The filter pack will be placed from the bottom of the borehole to a minimum level of 40 ft above the top of the screen. All filter pack materials used will be delivered to the site in clean, unbroken 50 lb bags.

A minimum 3-ft sand layer, consisting of fine 60-mesh sand, will be placed above the filter pack to prevent wet cement from infiltrating into the top of the filter pack. The filter pack will be placed in the annular space after the casing and screen are placed to the specified depths. Due to the potential for high salinity ground water, a bentonite seal will not be used. Instead, each well casing will be sealed using neat cement grout. Additionally, the annular area of the upper portion of each well will also be sealed with neat cement in accordance with the State of California Department of Water Resources Bulletin 74-81 and 74-90, and Monterey County Health Department requirements.

4.5.6 Monitoring/Test Well Construction Casing and Screen Materials Slot Size, Filter Pack, and Seals

A monitoring/test well that will be used for performing a 48 hour pumping test will be constructed for the monitoring well constructed to monitor the middle aquifer. The purpose of the monitoring/test well is to allow pumping of the middle aquifer and monitor the effect of pumping on the upper Dune Sand Aquifer, deeper 400-ft Aquifer.

The borehole will be approximately 12 inches in diameter to accommodate the casing and screen. The screen will be installed within the aquifer interval from approximately 320 to 350 feet below ground surface (placement will depend upon actual lithology. The geophysical log from the deeper boring will be used to determine the actual depth of screen for the well. The well casing will consist of 8-inch diameter, schedule 80 PVC well casing with mechanical slots. The screen slots size will be determined from mechanical grading analyses that will be performed on the samples collected during borehole drilling. The upper 320 feet of well casing will consist of blank well casing. A bentonite seal will be placed from the top of the filter pack to a depth of 50-ft below ground surface followed by a fifty foot-cement annular seal placed from a depth of 50-ft below to ground surface. A conceptual diagram for Monitoring/Test well construction is shown on Figure 4-5.

5 CEMEX Lapis Lustre #3 Silica Sand has an 8 x 20 gradation.

4.5.7 Cuttings and Waste Water Disposal

There are no known contamination issues at the project site in the vicinity of the proposed monitoring wells. Therefore, it is assumed that soil cuttings and water generated during drilling, construction, development, and testing will remain on site. All Best Management Practices (BMPs) will be utilized to ensure that all waste products are contained and controlled so that run off does not occur. The Contractor will use one cubic yard dump bins and a four-wheel-drive forklift to transfer cuttings from the drill site to where they will be spread on the ground and leveled.

Sonic Drilling Rig with BMPs in Place

All fluids generated during drilling and development will be temporarily contained and discharged as regulated by the California Regional Water Quality Control Board (RWQCB) Central Coast Region per the attached Statewide General Waste Discharge Requirements for Discharges to Land with a Low Threat to Water Quality, Order No. 2003-0003-DWQ. Wastewater produced during development pumping will be contained and discharged into a water truck or trailer-mounted tank. It is planned that waste water produced during drilling and development will be discharged to a water truck or a trailer-mounted tank for spreading on the ground in an area designated by the Project Engineer and Owner.

4.5.8 Wellhead Completion

Well casings will be secured by capping with an expandable and lockable well seal. Monument-style, steel protective covers with concrete well pads will be installed over each well. The well monument covers will be secured with keyed-alike locks. The well pads will gently slope away from the covers to prevent water from pooling around the monitoring well (see Figure 4-3).

Monument Well Cover and Concrete Pad

4.5.9 Monitoring Well Development

After allowing sufficient time for the cement seal to set, the monitoring wells will be developed to clean and consolidate the artificial filter pack near-well zone. Proper development will ensure full communication with the aquifer within the screened interval. Proper monitoring well development will also ensure that samples collected for water quality analyses will have low turbidity.

4.5.9.1 Initial Development – Airlifting and Swabbing

Monitoring wells will be initially developed using a small pump-hoist rig using bailing and airlifting. Initially, a small-diameter bailer will be run to the bottom of each well to remove any residual filter pack remaining from well construction.

Pump Hoist Rig Used for Monitoring Well Development

Once the residual filter pack has been removed, the 4-inch diameter monitoring wells will be initially developed by airlifting. Airlifting will consist of cleaning the 4-inch diameter screen with a swabbing tool and airlift system to isolate 5- to 10- foot intervals of screen to fully clean and consolidate the filter pack. The swabbing tool will be slowly moved up and down throughout the screened interval while airlifting until the fluids removed have low sand, sediment, and turbidity.

It is estimated that the maximum well flow rate during airlifting will be 10 to 20 gallons per minute for the 4-inch monitoring wells and approximately 30 to 60 gpm for the monitoring/test wells.

4.5.9.2 Final Development – Pumping and Surging

Once the screen has been satisfactorily cleaned, and turbidity is reduced, a submersible test pump will be installed in the monitoring wells to perform final well development by pumping. Final development will be accomplished by aggressively pumping and surging the well until fluids removed are effectively free of sand and sediment, and have very low turbidity values.

It is estimated that the maximum flow rate during final development will be 20 to 30 gallons per minute for the 4-inch monitoring wells and 100 to 200 gpm for the 8-inch monitoring/test wells. Water level measurements will be collected during final development pumping.

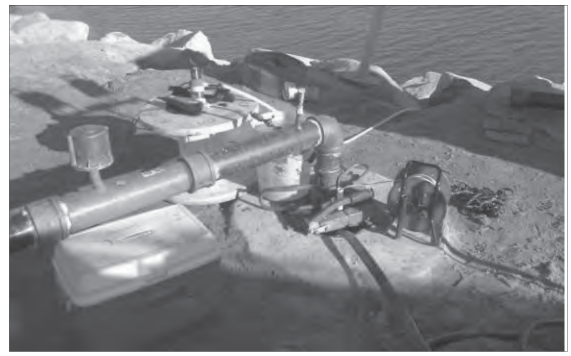
4.5.10 Water Level Measurement

An electric wireline water level indicator will be used to measure depth to ground water during borehole advancement and during the isolated aquifer zone testing. Water level measurements from each borehole will be recorded and will include date, time, reference point, and field measurement. Water level data will be presented in the summary report (i.e., TM 2) that will be prepared at the completion of the monitoring well construction phase of the project.

4.5.11 Measurement of Field Parameters - Conductivity, pH, ORP, Temperature, Dissolved Oxygen, Sand, Turbidity, Silt Density Index

Field water quality parameters that will be collected during development pumping include:

1. Conductivity
2. Resistivity
3. pH,
4. Oxidation reduction potential (ORP),
5. Temperature,
6. Dissolved oxygen,
7. Sand content,
8. Turbidity, and
9. Silt Density Index (SDI).



Monitoring Water Levels and Field Parameters

Field water quality measurements will be taken using a YSI 556 multi-parameter analyzer equipped with a flow-through cell.

4.5.12 Water Quality Sampling

At the conclusion of final development, water quality samples will be collected from the discharge of the monitoring well. The water quality analytical work will provide a baseline characterization of the ground water quality of the Dune Sand aquifer, 180-Foot aquifer and 400-Foot aquifer. These baseline water quality measurements will serve as a basis for comparing long-term water quality changes.

Water quality samples will be submitted to a State certified laboratory for general mineral and general physical analysis, as well as analysis for VOCs, pesticides, and herbicides. The anticipated suite of water quality analysis for each of the boreholes is shown in the following table:

Table 4-3. Water Quality Analyses for Monitoring Wells

Constituent	Units	Method Reporting Limit	Method
Physical Properties			
Color	Color Units	3.0	SM 2120B/EPA 110.2
Odor	T.O.N.		EPA 140.1
Oxidation-Reduction Potential (Field)	mV	-	Field Meter - Myron L 6PII
pH (Lab)	Units	0.10	SM 4500 H+B

Constituent	Units	Method Reporting Limit	Method
pH (Field)	Units	-	Field Meter - YSI Pro Plus
Turbidity (Laboratory)	NTU	0.20	EPA 180.1/SM 2130B
Turbidity (Field)	NTU	-	Field Meter - Hach 2100P
Temperature (Field)	°C	-	Field Meter - YSI Pro Plus
Dissolved Oxygen (Field)	mg/L	-	Field Meter - YSI Pro Plus
Silt Density Index (Field)	-	-	ASTM D4189-07
Threshold Odor Number	T.O.N.	1.0	EPA 140.1/SM 2150
Total Dissolved Solids (Lab)	mg/L	10	SM 2540 C
Total Dissolved Solids (Field)	mg/L	-	Field Meter - YSI Pro Plus
Specific Conductance (Lab)	µmhos/cm	1	SM 2510 B
Specific Conductance (Field)	µS/cm	-	Field Meter - YSI Pro Plus
General Minerals			
Total Cations	meq/L	-	Calculation
Total Anions	meq/L	-	Calculation
Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Bicarbonate Alkalinity as HCO_3	mg/L	3	SM 2320 B
Carbonate Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Hydroxide Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Total Hardness as $CaCO_3$	mg/L	3	Calculation
Aluminum	µg/L	1	EPA 200.7
Arsenic	µg/L	1	EPA 200.7 / EPA 200.8
Barium, Dissolved	µg/L	0.01	EPA 200.7
Boron, Dissolved	µg/L	0.5	EPA 200.8
Bromide, Dissolved	mg/L	0.1	EPA 326.0
Calcium, Dissolved	mg/L	1	EPA 200.7
Chloride, Dissolved	mg/L	1	EPA 300.0
Copper, Total	µg/L	50	EPA 200.7
Fluoride, Dissolved	mg/L	0.10	EPA 300.0 / SM 4500 FC
Iodide, Dissolved	mg/L	0.1	USGS I-2371 / EPA 9056A
Iron, Dissolved	µg/L	100	EPA 200.7 / EPA 200.8
Iron, Total	µg/L	100	EPA 200.7 / EPA 200.8
Lithium	µg/L	10	EPA 200.7 / EPA 6010B
Magnesium, Dissolved	mg/L	1	EPA 200.7
Manganese, Dissolved	µg/L	20	EPA 200.7 / EPA 200.8
Manganese, Total	µg/L	20	EPA 200.7 / EPA 200.8
MBAS	mg/L	0.050	SM 5540 C / EPA 200.8
Nitrogen, Nitrate as NO_3	mg/L	1	EPA 353.2 / EPA 300.0
Nitrogen, Nitrite, Dissolved	mg/L as N	1	SM 4500 NO_2B
Nitrogen, NO_2 + NO_3	mg/L as N	1	EPA 300.0
Nitrogen, Ammonia, Dissolved	mg/L as N	0.1	SM 4500 NH_3H / EPA 350.1

Constituent	Units	Method Reporting Limit	Method
Nitrogen, Ammonia + Organic, Diss. (TKN)	mg/L as N	0.1	EPA 351.2
Phosphorus, Dissolved	mg/L as P	0.01	EPA 365.3
Phosphorus, ortho, Dissolved	mg/L as P	0.01	EPA 365.3
Potassium, Dissolved	mg/L	1	EPA 200.7
Silica, Dissolved	mg/L	1	SM 4500 SiE
Sodium, Dissolved	mg/L	1	EPA 200.7
Strontium, Dissolved	mg/L	0.1	EPA 200.7 / EPA 200.8
Sulfate as SO_4, dissolved	mg/L	0.5	EPA 300.0
Zinc, Total	µg/L	50	EPA 200.7
Radiology / Age Dating Methods			
Delta-Deuterium	$\delta^{2}H$	-	TC/EA/IRMS
Delta Oxygen-18	$\delta^{18}O$	-	TC/EA/IRMS
Tritium	TU	-	-
Tritium, prec. est.	TU	-	-
Volatile Organic Compounds			
VOCs plus Oxygenates (MTBE)	µg/L	varies	EPA 524.2
EPA Organic Methods			
EDB and DBCP	µg/L	varies	EPA 504.1
Chlorinated Pesticides & PCB's as DCP	µg/L	varies	EPA 508
Chlorinated Acid Herbicides	µg/L	varies	EPA 515
Nitrogen & Phosphorus Pesticides DEHP, DEHA, Benzo(a)Pyrene	µg/L	varies	EPA 525
Carbamates	µg/L	varies	EPA 531.1
Glyphosate	µg/L	varies	EPA 547
Endothall	µg/L	varies	EPA 548.1
Diquat	µg/L	varies	EPA 549.1
Dioxin (2,3,7,8 TCDD)	µg/L	varies	EPA 1613

4.5.12.1 Water Quality Sampling Protocol

Water quality samples will be collected from the discharge during final development of each monitoring well per the Sampling and Analysis Plan (SAP) provided in Appendix A. Samples collected for metals will be first field-filtered using a 0.45-micron filter and then collected into acidified containers per the method requirements.

A stainless steel submersible pump installed on flush-threaded PVC column pipe will be used collect water quality samples. The test pump will be set just above the top of each screened interval to maximize available drawdown, so that each monitoring well will be pumped at a rate of approximately 20 to 30 gpm.

4.5.12.2 Estimates of Hydraulic Conductivity

Approximately five (5) samples per borehole will be selected from the continuous core samples collected during initial borehole drilling (i.e., prior to reaming the boreholes for monitoring well construction). These samples will then be analyzed in GEOSCIENCE's laboratory for mechanical grain-size analysis to determine grain size distribution curves of borehole materials, and subsequent estimates of hydraulic conductivity. Samples will be sieved using U.S. standard sieves with mesh sizes ranging from 0.0740 mm (0.0029 in.) to 9.525 mm (0.375 in.).

Analyses will be performed to determine hydraulic conductivity as described in Section 3.2.6 Analysis of Data and Section 5.15 Mechanical Grading Analysis of Selected Formation Intervals of this Work Plan.

4.5.13 Long-Term Data Acquisition

The monitoring wells will be equipped with transducers to allow collection of long-term water level data and electrical conductivity data. Data collected by the transducers will be downloaded quarterly for a period of up to two years. On a quarterly basis, after the data are downloaded, the monitoring wells will be purged by pumping and a ground water sample will be collected for laboratory analysis. Additional details regarding instrumentation for long-term data acquisition is contained in Section 7.2 Instrumentation of Wells of this Work Plan.

Seasonal Influences on Water Quality will be evaluated by review of periodic water quality sampling results from the monitoring wells. The purpose is to determine whether there may be an effect from seasonal rainfall and runoff, and if potential changes due to inland groundwater production impacts aquifer water quality in the vicinity of the project. This information will be included as input data for updating the North Marina Ground Water Model (NMGWM).

4.5.14 Monitoring Well Location Surveys

The location of each of the borehole and monitoring well locations will be surveyed by a California licensed land surveyor. The survey will include horizontal spatial location and the elevation of top of casing, top of monument, and the well pad relative to an established benchmark. The surveyed points will be marked on the well casing, monument cover and well pad.

All benchmarks will be established and surveyed by a California licensed land surveyor. Horizontal and vertical accuracy will be established in accordance with a second order Class I survey standard (1: 50,000).

Upon completion of the survey, the depth to water within each monitoring well will be measured and recorded to the nearest hundredth of a foot[6] referencing the measuring point on the well casing and top of well pad (i.e., ground surface). This data will be used to prepare ground water contour maps.

4.5.15 Borehole Destruction (if Necessary)

If needed, borehole destruction will be accomplished by positive placement of neat cement grout. The grout will be pumped through the sonic drill pipe from the bottom of the borehole to ground surface as the sonic drill casing is extracted. Vibrations will be applied to the drill pipe as necessary during extraction to ensure the elimination of voids during borehole destruction.

4.5.16 Summary Report

At the conclusion of monitoring well construction, GEOSCIENCE will prepare and provide the client and technical advisor with a draft technical memorandum (TM 2) summarizing work performed during the field investigations as well as findings and recommendations where appropriate. The report will include:

- A description of lithology encountered during drilling;
- Daily field notes;
- Geophysical borehole logs;
- Figures and maps showing site locations and conditions;
- Monitoring well construction details with as-built drawings of completed wells;
- Monitoring well development and testing details;
- Results of mechanical grading analysis;
- Results of permeameter testing;
- Estimates for hydraulic conductivity and expected production capacity for production wells in the area;
- Analytical reports showing ground water quality results; and
- All other pertinent data, recommendations, and conclusions.

GEOSCIENCE will submit five (5) copies of the draft technical memorandum to the client and technical advisory committee. After a review and comment period, GEOSCIENCE will incorporate appropriate

[6] Pressure and conductivity dataloggers will be installed in each monitoring well. See Section 4.5.13.

revisions and submit five (5) copies of the technical memorandum (TM 2) for monitoring well construction, testing and analysis.

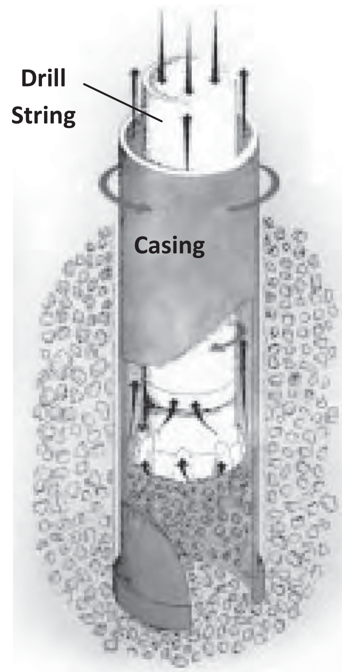
5.0 TEST SLANT WELL CONSTRUCTION AND TESTING – DUAL ROTARY DRILLING METHOD

5.1 Overview of Dual Rotary Drilling Method

The dual rotary drilling method is proposed for drilling and construction of the test slant well that is to be located at the CEMEX property (see Figure 5-1).

The dual rotary drilling method allows the borehole to be drilled at shallow angles (i.e., less than 25 degrees below horizontal) in loose alluvial materials without the use of drilling fluids other than water. Dual rotary drilling advances a temporary outer casing that stabilizes the borehole as an internal rotating drill string removes formation materials using reverse circulation. The mix of lithologic materials and water is discharged to a series of tanks for settling and cleaning. Clean fluids are then re-circulated back to the borehole to complete the loop through the closed system.

Drilling and well construction is accomplished by temporarily casing the borehole as it is advanced. Once the targeted depth is reached, well casing and screen are installed within the temporary drill casing. The temporary outer casing is removed as the filter pack and seals are installed.



Dual Rotary Drilling Method

GEOSCIENCE will prepare detailed technical specifications for test slant well drilling, construction, development, and testing that will be used as a guidance document for the contractor during work in the field. The technical specifications will be included as Attachment 3 of the Work Plan. Screened intervals will be based on the results of exploratory borehole drilling, and monitoring well construction.

Dual Rotary Drilling

The dual rotary method uses a lower rotational driving unit to advance temporary casing[7] through unconsolidated alluvial materials such as sand, gravel, and boulders. Dual rotary drilling units are very powerful, having very high pullback to weight ratios. The high pullback power is very useful when extracting the temporary drill casing from the borehole under difficult downhole conditions
An upper (or top) rotary head will be used to simultaneously drive a "dual-wall" drill string[8] as the lower drive advances the temporary casing. The dual wall drill string that will be used for this work will have a 10.75-inch outside diameter (OD) and a 6-inch diameter inner pipe string. A roller cone rock bit will be

7 Up to 40-inch diameter casing may be advanced.

8 Referring to the fact that the drill string consists of two sizes of pipe (an inner string and an outer string) that are rotated and advanced simultaneously when drilling.

attached to the bottom of the dual wall drill string to break up large diameter formation materials while advancing the borehole.

Compressed air is forced down the annulus between the outer and inner drill strings. Jets, or vents, placed within the inner drill string above the drill bit cause formation materials (drill cuttings) and water to be pushed to the surface through the interior of the inner drill string. The cuttings are then discharged at the surface through a flexible hose to a cyclone separator that is located over a roll off box. Solid cuttings removed from the borehole remain in the roll off box, while fluids are pumped off to settling tanks for recirculation to the borehole during drilling.

The two driving units (upper and lower units) are able to work independently of one another in raising and lowering the temporary drill casing, as well as rotating the dual-wall drill string. Each drive unit may operate at a different rotational speed as down hole conditions dictate. The lower drive can also rotate the casing in either direction because the temporary drill casing has welded rather than threaded connections. Pull down, pullback, and clockwise and counter-clockwise rotational forces are effectively transmitted to the casing through hydraulically-operated jaws on the lower rotary unit.

A carbide studded casing shoe is welded to the leading edge of each string of temporary drill casing, allowing the casing to be advanced through cobbles without being deformed. Each diameter of temporary drill casing may be advanced 250 to 300 ft ahead of the preceding casing diameter. For the 1,000 ft test slant well, four casing diameters will be required, ranging from 30-inches to 24-inches in diameter.

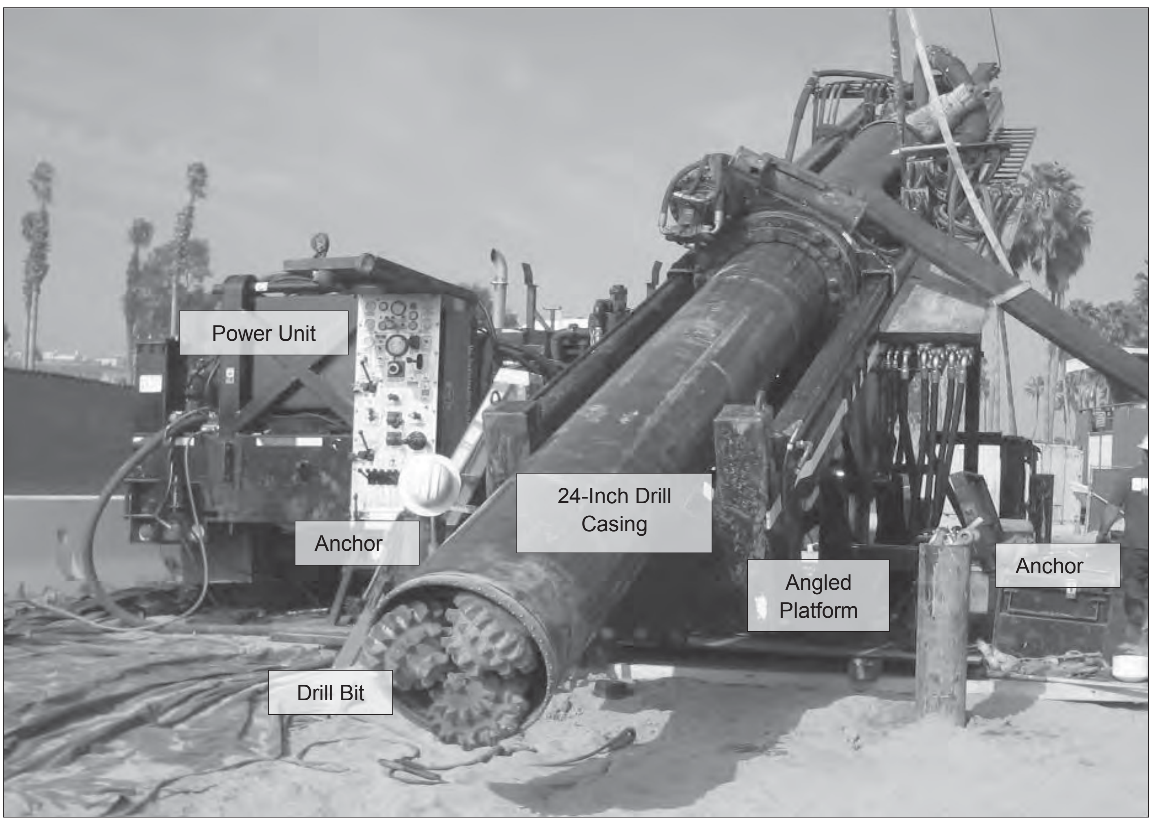
Casing Shoe Being Welded to Temporary Drill Casing

Once the total depth of the borehole has been reached, well screen and casing will be installed within the temporary drill casing. Filter pack and seals are placed around the well screen and casing as the temporary drill casing is gradually pulled up from around the well casing and screen.

In addition to applicable standards mentioned in Section 3 and 4, the following standards will also apply to test slant well construction and testing:

Table 5-1. Applicable Standards for Test Slant Well Construction and Testing

Standard No.	Title
D4050-96(2008)	Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems
American Water Works Association (AWWA)	Standard for Water Wells (AWWA A100-06), or latest revision
California Department of Water Resources (DWR)	*Standards for Water Wells (pertaining to Exploratory Borings):* Part III, Section 19 B. California Department of Water Resources (DWR) Water Well Standards: State of California (Bulletin 74-81) and California Well Standards (Bulletin 74-90), or latest revision



5.2 Location, Site Access, and Permits

The final location of the test slant well will be approved by CEMEX so as to avoid interfering with operations. Due to the location of the test slant well in the proximity of the beach and presence of loose sand, the drilling rig and support vehicles may require all-wheel drive vehicles, or placement of landing mats or similar devices to facilitate movement of heavy equipment.

The final angle for the test slant will be based on the results of both the exploratory borehole and monitoring well construction projects. A conceptual geologic cross section through the area based on current information is shown on Figure 5-2. The geologic cross section will be updated as additional information is obtained.

The test slant well is currently planned to be located at the western terminus of the CEMEX haul road, approximately 260 ft east of the high tide line (see Figure 5-1). The final test slant well location will be dependent on the results of exploratory borehole drilling and monitoring well installation.

The Contractor will be required to obtain all necessary certificates and licenses required by law for the work, including:

- Monterey County Health Department Well Construction Permit; and
- State of California C-57 Water Well Drilling Contractor License.

The Contractor will be required to comply with all federal, state and local laws, ordinances, or rules and regulations relating to the work.

The appropriate environmental clearances and permitting for this project will be obtained by the project environmental team.

5.3 Final Siting With Consideration to Coastal Erosion and Climate Change

An evaluation of coastal erosion and climate change is being prepared by others for the proposed full scale slant well locations as part of the EIR preparation. The coastal erosion analysis will be used for the location and design of the full-scale slant well wellfield that will serve as the desalination plant intake.

5.4 Protection of Native Plants and Wildlife

Drilling activities will not be allowed to damage native plants and existing vegetation outside the specified construction and staging areas. Additionally, drilling operations will be performed in a manner that will comply with local noise level restrictions, and that will minimize disturbance to endangered species (i.e., Western Snowy Plover) and the public.

The Contractor will use Best Industry/Management Practices (BMPs) for the protection of the well site during construction activities, and will take whatever measures are necessary to ensure that activities do not impact surrounding areas.

5.5 Water Source

The Owner and Project Engineer will assist the Contractor with obtaining a water source that is suitable for drilling and well construction purposes. The Contractor will be responsible for providing and maintaining the water supply connection(s) required for drilling and construction. For public safety, and to avoid impacting CEMEX operations, all water pipelines, hoses, and other utilities installed by the Contractor shall be covered or buried where pathways or roadways are crossed.

5.6 Schedule

The proposed work schedule for drilling operations is planned to take place seven days per week during daylight hours only. Work crews will be rotated in a schedule that will make the work as continuous as possible. If it becomes necessary to compress the time required for project completion to as short a schedule as possible, the feasibility and acceptability of nighttime work may be investigated.

The work schedule for dual rotary drilling operations and test slant well construction will be from 6 AM to 6 PM daily. The drilling contractor will schedule personnel to work ten (10) days on and four (4) days off per two-week work cycle. Construction work will not be conducted on major holidays without prior permission from the Owner. It is estimated that a total of approximately 180 working days will be required for the drilling, construction, development, and initial testing of the test slant well. This length of time does not include the long-term (18-month) aquifer test.

Inspection during drilling, well construction, development and testing will be conducted on a full-time, 12-hour working day basis from 6 AM to 6 PM. A field geohydrologist will be onsite at all times during drilling for lithologic logging of the samples retrieved from the borehole, during well construction and during initial testing to ensure that proper protocols and procedures are followed.

5.7 Number of Workers

Test slant well drilling will require a four-person crew, which will include a field supervisor, a driller and two assistants. One to two supervising geohydrologists will be onsite to inspect drilling, construction, development and testing operations. It is anticipated that the Project Engineer and Owner may also periodically visit the site.

5.8 Equipment

The following equipment will need to be located at or near the wellhead during test slant well drilling and construction:

Table 5-2. Approximate Equipment Dimensions and Weights

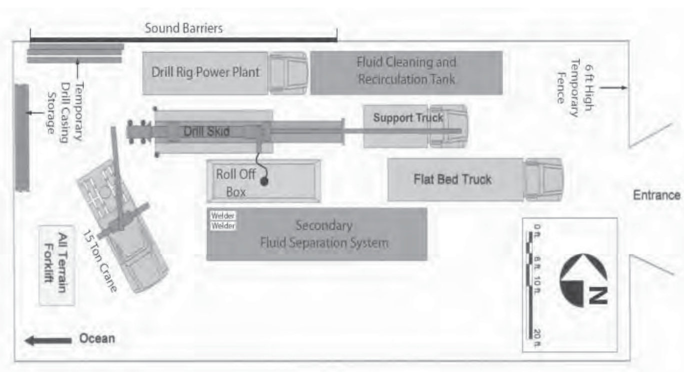
Equipment	Approx. Dimensions [ft]	Approx. Weight [lbs]
DR-24HD Drilling Rig Skid and Mast	10 x 34	75,000
DR-24HD Drilling Rig Power Unit	9 x 40	
Utility Truck	8 x 24	30,000
15-Ton Truck-Mounted Crane	36 x 8, plus 10' outriggers	50,000
4 x 4 Crew Truck	8 x 20	15,000
Baker Tank (Empty)	40 x 8 x12	40,000
Centrifugal Pump (trailer mounted)	8 x 6	5,000
Onsite Storage for Drill Casing/Rods	24 x 10	50,000
Storage Trailer	48 x 8	10,000
ATV Forklift	8 x 20	30,000
Roll Off Box (Empty)	8 x 25	4,000

The 15-ton truck-mounted crane will travel between the beach test well site and staging area on a daily basis to move required equipment on and offsite. In addition, the geohydrologist will have a four-wheel-drive pickup truck that will be used to transport lithologic samples collected from the drilling rig to a storage area located off the beach.

5.9 Drilling Equipment Footprint

The test slant well is planned to be drilled at a 20°-angle below horizontal. To accomplish this, the drilling contractor will use an angled drilling platform (i.e., cradle) to support the drilling rig mast at the desired angle of 20°. The angled drilling platform can be adjusted to any required drill angle.

The footprint required for drilling operations is an area measuring approximately 60 ft wide by 130 ft long (7,800 square feet), and will be oriented in approximately an East-West direction.



Dual Rotary Drilling Site Footprint

To minimize the drilling footprint, a nearby staging area will be used to store support equipment and materials.

5.10 Dual Rotary Drilling Method – Telescopic Construction

Drilling the test slant well will involve advancing the borehole in progressive 250-ft stages (see Figure 5-3). Each stage will use a progressively smaller temporary drill casing diameter (telescoping downward) for a final casing length of 1,000 feet. At an angle of 20° below horizontal, the total vertical depth of the borehole will be approximately 342 ft bgs at its western terminus beneath the ocean.

5.10.1 Mobilization, Anchor Installation and Site Set-Up

Temporary 6-ft high construction fencing will be installed around the work site and the off-site staging area. The staging area will need to be at least 80 ft x 100 ft to store the needed support equipment and construction materials.

To accommodate forces exerted when drilling (i.e., pulling down on the drill casing) and when removing casing (i.e., pulling back on the casing), a number of anchors will be installed at both the front and the back of the drill skid.[9] The anchors will consist of six (6), 8 5/8-inch OD casings set in boreholes drilled to 20 ft bgs. Two anchors will be installed at the back of the rig (i.e., adjacent to the entry point) for use during drilling, and four anchors will be installed at the front of the rig for use during casing removal.

To prevent spilled fluids from leaving the work site, K-rails (i.e., Jersey barriers) will be placed along the perimeter of the work site within the chain-link fencing. Heavy duty 3-ply plastic will be draped over the K-rails and across the entire site, creating a contained, plastic-lined work area. Additionally, 6-mil[10] thick plastic sheeting will be placed under all stationary equipment, and containment berms placed around the perimeter of each plastic sheet. Plastic sheets will be replaced when torn, or when heavily soiled.

A 1-in thick steel plate will be laid in the center of the site to serve as a solid base when depositing the roll-off box.

Sound barriers will be constructed adjacent to the air compressor and power unit to mitigate noise generated by the equipment.

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9 The top drive of the DR-24HD is capable of 84,000 lbs of pullback and 25,900 lbs of pulldown force, while the lower drive is capable of 117,000 lbs of pullback and 42,000 lbs of pulldown force.

10 1 mil equals 1/1,000 inch.

5.10.2 Dual Rotary Borehole Drilling and Logging

GEOSCIENCE will provide field inspection services during test slant well drilling to collect, log, and preserve lithologic samples, to supervise site activities, and to collect information during drilling, well construction, well development, and pump testing.

5.10.3 Installation of Temporary Casing during Drilling

The borehole for the test slant well will be drilled by the dual rotary drilling method using telescoping temporary casings ranging from 30 inches to 24 inches in diameter to the approximate depths shown in the following table and Figure 5-3.

Table 5-3. Test Slant Well Proposed Borehole Diameters and Depths

Diameter of Temporary Drill Casing [OD, in.]	Lineal Length of Each Diameter [ft]	Vertical Depth [ft bgs]
30	+ 0 - 250	+ 0 - 86
28	+ 3 - 500	+ 1- 171
26	+ 5 - 750	+ 2- 257
24	+ 7 – 1,000	+ 3- 342

The first string of casing will be 30 inches in diameter and will be drilled to 250 lineal feet. A second string consisting of 28 inch diameter casing will be set within the 30 inch casing before being advanced to a depth of 500 lineal feet. Within the 28-inch and 30-inch diameter casings, a third string of 26-inch diameter casing will be installed and advanced to 750 lineal feet. The final borehole will be 24 inches in diameter and will be advanced to 1,000 lineal ft.

During casing advancement, the sections will be attached onsite by welding. To avoid disruption of CEMEX operations, drill casing sections and other materials required for each day's work will be transported from the staging area to the wellsite at the start of each day to reduce traffic along the CEMEX haul road. A truck-mounted 15-ton crane will be onsite at all times to lift and place drill casing and drill pipe sections as the borehole is advanced, and to install casing and screen sections during well construction.

5.11 Fluids Control during Drilling

During the drilling process, fluids generated will be discharged to an onsite baffled Baker tank to remove suspended materials. Fluids will be returned to the borehole on a continuous basis during drilling.

Excess fluids will be discharged to the nearby Monterey Regional Water Pollution Control Agency (MRWPCA) ocean outfall.

All fluids that are generated during initial development of the test slant well by airlifting and swabbing, will be discharged to an onsite tank. Clear water in the tank will be decanted and pumped to the ocean outfall in a manner consistent with permit requirements. If water being discharged does not meet MRWPCA outfall requirements, fluids will be further treated or will be removed (using vacuum trucks) and disposed at an acceptable location.

Water produced from the test slant well during final development, aquifer pumping tests, and long-term pumping will be discharged to the MRWPCA ocean outfall located along the south side of the CEMEX haul road.

Fluids discharged to the MRWPCA outfall will be monitored by the contractor and supervising geohydrologist on a continual basis. In addition, the alignment of the conveyance pipeline will be continually monitored during discharges to guard against leakage and pipeline failure. Upon approach of major storms, discharges will be temporary halted if it is determined the outfall cannot accommodate additional water generated by pumping the test slant well.

5.12 Logging Lithologic Samples

During the drilling process, lithologic samples will be collected at 5-foot depth intervals from the cyclone separator, and will be placed in heavy duty one-gallon Ziploc®-type plastic bags. The Ziploc bags will be properly labeled and samples will be identified as to material type and potential as a productive aquifer by visually logging them in the field using the Unified Soil Classification System (USCS).

5.13 Geophysical Borehole Logging – Gamma Ray

Gamma ray logs may be successfully run in steel-cased boreholes. During drilling, a gamma ray log may be run within the temporarily cased borehole to determine if clay-bearing zones occur beneath the ocean west of the test slant well.

Gamma ray logs are used to measure naturally occurring gamma radiation that is emitted from formation material surrounding the borehole, and are the result of the release of electromagnetic radiation from elements with unstable nuclei. The most common source of gamma radiation is potassium-40 (K40), uranium-238 (U238), uranium-235 (U235), and thorium-232 (Th232). Clay-bearing materials commonly emit relatively high gamma radiation due to weathering of potassium-bearing minerals such as potassium feldspar and other mica-bearing rocks.

5.14 Specific Coring and/or Water Quality Testing During Drilling

As the borehole for the test slant well is advanced, split spoon samples may be collected for the purpose of estimating hydraulic conductivity. Samples may be collected by pushing a California modified split spoon sampler into formation materials found at the bottom of the borehole using the rotary head on the drilling rig.

5.15 Mechanical Grading Analyses of Selected Formation Intervals

Grab samples will be collected from the cyclone separator as formation materials and fluids are discharged from the borehole during drilling. These samples will be analyzed in GEOSCIENCE's soils laboratory for grain-size distribution, and will be compared to samples collected from equivalent depths in vertical boreholes. The resulting information will be used to determine stratigraphic continuity of marker beds beneath the ocean in the potential area where full scale project slant wells may be located.

Mechanical grain size analyses (i.e., sieve analysis) will be performed on selected samples for the purpose of determining grain size distribution curves of borehole materials, and subsequent estimates of hydraulic conductivity. Samples will be sieved using U.S. standard sieves with mesh sizes ranging from 0.0740 mm (0.0029 in.) to 9.525 mm (0.375 in.).

5.16 Slant Well Design

Final well design, including screen intervals, screen slot size, filter pack gradation, and seals will be based on the results of exploratory borehole drilling and monitoring well construction to the west. The design may be modified if it is found that offshore geology differs from lithologic observations made during the two phases of vertical sonic borehole drilling.

Based on current geology, it is planned that a section of blank casing will be installed within the screened interval from approximately 500 to 550 lineal ft to allow isolation of the Dune Sand Aquifer from the 180-Foot Aquifer during testing.

Well materials (casing, screen, centralizers, and tremie guides) are recommended to be manufactured using 2507 Super Duplex stainless steel material. The chemical composition of 2507 Super Duplex stainless steel is shown in the following table:

Table 5-4. Chemical Composition of 2507 Super Duplex Stainless Steel

Stainless Steel Grade	ASTM / UNS No.	C	Cr	Ni	Mo	N	Mn	P	S	Si	Fe
2507	S32750	0.0%	25.0%	7.0%	4.0%	0.27%	0.50%	0.030%	0.001%	0.30%	Balance

Source: Outokumpu. Type Outokumpu 2507 UNS S32750.

The pitting resistance equivalent for Type 2507 Super Duplex stainless steel is 42, and is considered generally immune to pitting.

A commonly used version of the pitting resistance equivalent (PREN) formula[11] as provided by the British Stainless Steel Association is:

PREN = Cr + 3.3Mo + 16N

The percentages of Cr, Mo, and N from the preceding table would be used to calculate the PREN.

Well casing and ful-flo louvered well screens manufactured by Roscoe Moss Company are recommended. Roscoe Moss well casing and screen complies with American Society for Testing Materials (ASTM) Specification A790 for longitudinally-welded casing and screen, and ASTM A928 for spirally-welded casing and screen.

5.16.1 Casing and Screen Materials, Slot Size and Filter Pack

Highly corrosion resistant 14 ¾-inch outside diameter (OD), 5/16-inch (0.3125-inch) wall thickness ful-flo louvered well screen, and 14 ¾-inch, 5/16-inch wall thickness blank casing is planned for the test slant well. The proposed screen intervals will be located in two sections; from 200 to 500 lineal ft, and from 550 to 1,000 lineal ft (see Figure 5-4). A blank section of casing will be located from 500 to 550 lineal ft, within an aquitard unit, if such unit exists in an offshore location in the vicinity of the test slant well. The section of blank casing will be used to for setting the inflatable packers during testing of the Dune Sand and 180-Foot Aquifers. With this well design, the targeted design pumping rate of 2,250 gpm will be attainable based on thickness and permeability of materials within the Dune Sand Aquifer.

11 Pitting resistance equivalent numbers (PREN) are a theoretical way of comparing the pitting corrosion resistance of various types of stainless steels, based on their chemical compositions. Some formulas weigh nitrogen more, with factors of 27 or 30, but as the actual nitrogen levels are quite modest in most stainless steels, this does not have a dramatic effect on ranking. Tungsten is also included in the molybdenum-rating factor to acknowledge its effect on pitting resistance in the tungsten bearing super-duplex types (1.4501). A modified formula is then used:

PREN = Cr + 3.3 (Mo +0.5W) + 16N (http://www.bssa.org.uk/topics.php?article=111).

Longitudinal welds in the casing and screen will be factory passivated to remove slag and restore the protective oxide layer. All field welds will also be passivated during well construction to restore the oxide layer and protect the heat affected zones against corrosion.

5.16.2 Filter Pack Design

Formation grab samples will be collected during slant well drilling for mechanical grading analysis and comparison to equivalent materials logged during exploratory borehole and monitoring well drilling. Based on results of mechanical grading analyses, the filter pack will be designed with a pack to aquifer ratio of between 4 and 20. The design will also consider Terzaghi's criteria for the movement of fines through the filter pack and the permeability of the aquifer and filter pack. The design of the filter pack, slot size and location of the screened interval will be based on the results of exploratory borehole and monitoring well drilling, lithologic descriptions, geophysical logs, mechanical grain size analysis, and isolated aquifer zone testing of the exploratory boreholes.

5.17 Well Construction

Prior to installation, the well casings, well screen, and filter pack will be inspected for compliance with the well design specifications.

During well construction, sections of screen and casing will be circumferentially welded together in two passes. The rod selected for welding must be suitable for joining 2507 Super Duplex stainless steel. Centralizers and tremie guides will be added as the casing and screen is installed. All field welds will be passivated using an acid solution and brushing, and then rinsed with fresh water.

2507 Super Duplex Stainless Steel Casing and Screen

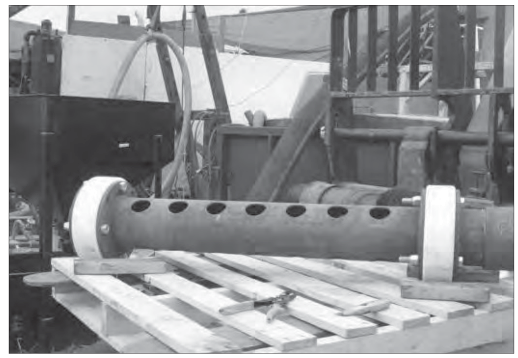
Once the casing and screen has been installed, an engineered filter pack will be placed into the annulus of the borehole to encapsulate the well screen. The filter pack will be placed by slowly pumping filter pack with water through multiple tremie pipes that terminate within the annular space. The temporary casing will be slowly removed, keeping the level of filter pack 5 to 10 ft above the bottom of the temporary casing. This prevents "bridging" (i.e. entraining native material) or forming voids within the filter pack. The cement grout seal will be placed in a similar manner.

As the filter pack and cement seal are being installed, the volume of material placed will be tracked against the calculated volume to ensure that voids have not formed, and that bridging has not occurred within the annular space.

5.18 Initial Development - Airlifting and Swabbing

Initial development of the test slant well will consist of simultaneously airlifting and swabbing the screened interval to consolidate and clean the filter pack and near-well zone.

To ensure maximum compaction of filter pack within the annular space, a swabbing tool with packers spaced 5 ft apart will be installed inside the 14 ¾-inch OD ful-flo louvered well screen. A 20 ft interval of well screen will be mechanically swabbed and airlifted following placement of filter pack. A large quantity of water will be added on a continuous basis to the inside of the casing to assist in moving the filter pack downward, and to add hydrostatic pressure to the formation to prevent formation sand from disrupting the filter pack.



Swabbing Tool for Initial Development

A submersible test pump will be used for final well development and will be installed with an inflatable straddle packer assembly to isolate and test the two screened intervals. The straddle packers will be placed above and below the pump intake located within the blank section between the screened intervals.

By inflating the lower packer and deflating the upper packer, the Dune Sand Aquifer (located above the pump intake) will be isolated and pumped separately from the lower screen (located below the pump intake). In this manner, aquifer parameters and water quality samples are measured only in the Dune Sand Aquifer. Likewise, the upper packer will be inflated and the lower packer will be deflated to isolate and pump only from the lower screen so that aquifer parameters and water quality samples are measured only in the 180-Foot Aquifer.

5.19 Final Development - Pumping and Surging

A submersible test pump powered by a diesel generator will be used for final well development. The final development pump will be installed in the test slant well to an approximate depth of 530 lineal ft (181 vertical ft) using a standard pump hoist with the mast laid down, or crane. The test pump will be designed to produce approximately 3,400 gpm and will exceed the design capacity by 50%. The test pump will provide approximately 100 ft of total dynamic head to accommodate the required lift plus pipeline losses.

5.20 Well and Aquifer Testing

Purpose

The purpose of pumping tests is to obtain accurate hydrologic field data, which, when substituted into an equation or set of equations, will yield estimates of well and aquifer properties. As certain assumptions have been used to derive these equations, it is important to observe or control these factors during the test. These assumptions and conditions are:

Final Development and Testing of Test Slant Well

- The aquifer material is assumed to consist of porous media, with flow velocities being laminar and obeying Darcy's law;
- The aquifer is considered to be homogeneous, isotropic, of infinite aerial extent, and of constant thickness throughout;
- Water is released from (or added to) internal aquifer storage instantaneously upon change in water level;
- Storage does not occur in the semi-confining layers of leaky aquifers;
- The storage in the well is negligible;
- The pumping well penetrates the entire aquifer and receives water from the entire thickness by horizontal flow, and;
- The slope of the water table or piezometric surface is assumed to be flat during the test with no natural (or other) recharge occurring, which would affect test results.

The pumping rate is assumed constant during the entire time period of pumping during a constant-rate test, and constant during each discharge step in a variable-rate test.

Water Level Measurement during Slant Well Testing

Methodology

Following completion of development pumping, step drawdown and constant rate pumping tests will be conducted. A 48-hour constant rate pumping test will be conducted separately on the Dune Sand Aquifer and the 180-Foot Aquifer in the Test Slant Well and separately in the monitoring/test wells.

In addition to water level and flow rate measurements, the sand content, silt density index, pH, conductivity, oxidation-reduction potential (ORP), temperature, dissolved oxygen and, turbidity will be closely monitored during test pumping. Field data will be recorded on field water quality parameter and pumping test forms shown on tables included in the SAP (see Appendix A).

Field procedures for testing will follow American Society for Testing and Materials (ASTM, 2008, Standard Test Method D 4050).

Water levels and conductivity in nearby monitoring wells that are screened in the Dune Sand, 180-Foot, and 400-Foot aquifers will be measured at 5-minute intervals using pressure transducers and conductivity probes during the slant well pumping tests.

Pump startup times, pump shutdown times, and all interim measurements will be recorded with reasonable accuracy (± 0.5 minutes). Irregular events, such as pump failure and restart that occur during the pumping test will be noted and their time recorded. If the pumping test is interrupted due to malfunction, the pumping test will be restarted after water level recovery.
The time interval between depth to water measurements may vary between acceptable limits. The limits in the following table are recommendations for the measurement intervals after the pump startup, change in discharge rate, or end of test:

Table 5-5. Minimum Measurement Intervals during Pumping Tests

Time After Beginning of Each New Discharge Rate, or Step [minutes]	Recommended Measurement Interval [minutes]
1 - 10	2
10 - 30	5
30 - 60	10
60 - 120	15
120 – 1,440	30
1,440 - end of test	60

5.20.1 Step Drawdown Testing

The purpose of the step drawdown test is to determine formation losses, well losses, and well efficiency. Time drawdown measurements will be made to determine specific capacity and well efficiency relationships necessary to calculate the optimal production rate and pump design for the long-term pumping test. Typically, three to four rates are selected for step drawdown testing, starting at the lowest rate, and progressing to the highest.

The range of discharge rates will be within a maximum of 3,400 gpm, or the maximum capacity of the well, as directed by the supervising geohydrologist.

Pumping will continue at each rate for a sufficient length of time to bring about a stable (or predictable) water level trend, as determined by a semi-logarithmic plot of the pumping level versus time. The total duration of the step drawdown test will be no more than eight (8) hours in duration.

Step drawdown data will include the pump discharge rate (in gallons per minute), the static water level depth (in feet), and the drawdown (i.e., change in pumping water level from "static" water level conditions, in feet). An example of a step drawdown test data plot is shown in Figure 5-5. Data from the step drawdown plot will be used to generate the following:

- A specific capacity diagram showing formation loss and well loss curves for the range of discharge rates tested.
- A well efficiency diagram for the range of discharge rates tested.
- Recommended production pumping rate, total dynamic head and depth of pump setting.

Step drawdown testing is planned for both the Dune Sand Aquifer and the 180-Foot Aquifer.

5.20.2 Constant Rate Test

To predict long-term drawdown effects, constant rate pumping tests will be performed for a period of five (5) days (i.e., 120 hours) at the design discharge rate, or as otherwise specified by the supervising geohydrologist. The constant rate tests will provide accurate information on the transmissivity and storativity aquifer parameters. A constant rate test will be performed on each aquifer, which will be isolated using inflatable packers during testing. An example of a constant rate pump test is shown in Figure 5-6.

Inflatable Packer Used to Isolate Screen Intervals

During long-term pumping of the test slant well, it is important that the Upper CEMEX Well remain off to remove interference issues. To replace lost production, up to 400 gallons per minute may be diverted from the discharge of the test slant well.

Prior to starting the constant rate test, manual depth to water measurements will be collected to verify proper operation of installed transducers will be verified. Nearby monitoring wells and non-pumping

irrigation wells (if available) will also be monitored to obtain interference and distance drawdown data during the test.
The constant rate pumping test will be conducted only after recovery from the step drawdown test is complete (or exhibits a predictable trend when residual drawdown versus time is plotted on a semi-logarithmic scale).

Depth to water during testing will be measured by means of an electric wire-line sounder and by use of transducers equipped with dataloggers. Immediately following completion of the constant rate pumping test, the covering water levels will be measured for a minimum of four (4) hours, or as determined by the supervising geohydrologist.

Water quality samples will be collected by the geohydrologist at the end of the constant rate pumping test, and will be submitted to Cal Am's laboratory for analysis of general mineral and physical properties, VOCs, herbicides, pesticides and dioxin.

5.21 Instrumentation and Data Collection

Prior to initiation of aquifer testing, transducers equipped with conductivity sensors and connected to dataloggers will be installed in the pumping well and monitoring wells to allow continuous monitoring of ground water levels and conductivity during the pumping tests, and during the recovery period. Transducers will remain in the monitoring wells after aquifer testing to allow evaluation of seasonal variation in ground water levels and quality over time.

5.21.1 Water Levels in Pumping and Non-Pumping Wells

Where available and if accessible, water level measurements will be collected during pumping tests using transducers that will be installed in nearby non-pumping observation wells that are screened in the Dune Sand or 180-Foot Aquifers. Data collected will be analyzed to quantify interference and to determine aquifer transmissivity and storativity values.

5.21.2 Measurement of Field Parameters during Pumping (Conductivity, pH, ORP, Temperature, Dissolved Oxygen, Turbidity, Silt Density Index, Sand Content)

In addition to discharge rate and water level, pH, conductivity, resistivity, temperature, salinity, oxidation reduction potential (ORP), and dissolved oxygen will be measured in the field during pump testing. These measurements will be taken using a YSI 556, or equivalent, multi-parameter instrument equipped with a flow-through cell. Silt density index (SDI) measurements will be measured in the field at the beginning, middle, and end of each pumping test. Field parameters will be frequently recorded during testing on the forms included in the SAP (see Appendix A).

5.22 Analysis of Well and Aquifer Parameters

Aquifer parameters will be calculated from the test slant well following construction, and following long-term testing to determine if there is a decline in well efficiency over time. In order to collect the required information, step drawdown testing will be performed following the long-term test. Analyses of pumping test data will be performed using both Jacob's straight-line method and Hantush's Inflection Point method.[12]

Incorporating data from the nearby monitoring wells will allow calculation of a distance drawdown plot end of the five-day constant rate pumping test. This will provide a check of storativity, transmissivity, and well efficiency.

A summary of the aquifer parameters measured during the step and constant rate pumping tests will be presented in a comparative table showing transmissivity, storativity, and leakance.

5.22.1 Step Drawdown Pumping Test

The purpose of the step drawdown test is to determine formation losses, well losses, and well efficiency, all of which are necessary in determining the design of the permanent pump and associated equipment. In an actively pumping well, the total drawdown in the well is composed of both laminar and turbulent head loss components. Laminar losses generally occur away from the borehole (where approach velocities are low), while turbulent losses are confined to the area in and around the immediate vicinity of the well screen and within the well borehole.

The total drawdown in a pumping well may be expressed as:

$$s_w = BQ + CQ^2 \quad \text{“Drawdown In a Pumping Well”} \qquad (1)$$

where:

s_w = Total drawdown measured in the well, [ft]

B = Formation or aquifer loss coefficient, [ft/gpm]

Q = Discharge rate of the well, [gpm]

C = Well loss coefficient, [ft/gpm^2]

12 The typical "S"-shaped time drawdown curves reflect leakage.

The first and second terms in equation (1) are referred to as formation, or aquifer loss[13] (BQ) and well loss[14] (CQ^2), respectively. Formation (i.e. aquifer) loss and well loss coefficients are determined from the step drawdown test. The test procedure involves pumping the well at multiple (at least three) discharge rates with each "step" being a fraction of the maximum discharge. Analysis of the step drawdown data requires plotting the "specific drawdown" (s_w/Q) for each step against discharge rate. The formation loss coefficient (B) is the y-intercept of the best-fit straight line through the specific drawdown data points. The slope of the line is equal to the well loss coefficient (C).

Well Efficiency (E) is defined as the ratio of the formation (i.e. aquifer) loss component (BQ) to the total drawdown measured in the well (s_w) and is expressed as a percent (Roscoe Moss, 1990[15]):

$$E = 100\frac{BQ}{s_w} = \frac{100}{1 + CQ/B} \qquad \text{"Well Efficiency"} \qquad (2)$$

where:

E = Well Efficiency, [percent]

B = Formation or aquifer loss coefficient, [ft/gpm]

Q = Discharge rate of the well, [gpm]

s_w = Total drawdown measured in the well, [ft]

C = Well loss coefficient, [ft/gpm^2]

5.22.2 Constant Rate Test

Calculation of aquifer parameters from pumping test data is based on analytical solutions of the basic differential equation of ground water flow that can be derived from fundamental laws of physics. One of the most widely used solutions of this equation for non-steady radial flow to wells is the "Theis Equation"[16]:

13 Aquifer loss is the head loss measured at the interface between the aquifer and the filter pack. The magnitude of the aquifer loss can be found from consideration of radial flow into the well and can be calculated, for example, using Jacob's equation.

14 Well losses are turbulent flow losses which are head losses associated with the entrance of water into and through the well screen as well as those losses incurred as the flow moves axially towards the pump intake. These losses vary as the square of the velocity.

15 Roscoe Moss Company. 1990. Handbook of Ground Water Development. New York: J. Wiley & Sons.

16 Theis, C.V., 1935. The Relation between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage. American Geophysics Union Transfer, 16th Annual Meeting.

$$s(r,t) = \frac{114.6Q}{T} W(u) \qquad \text{"Theis Equation"} \qquad (3)$$

where:

s(r,t) = Drawdown in the vicinity of an artesian well, [ft]

r = Distance from pumping well, [ft]

Q = Discharge rate of pumping well, [gpm]

T = Transmissivity of aquifer, [gpd/ft]

W(u) = "Well function of Theis"

u = $1.87 \times r^2 \times S / (T \times t)$

5.22.2.1 Jacob's Straight-Line (Modified Theis Non-Equilibrium) Method

According to Jacob (1950[17]), for small values of "u" (u < 0.05), the Theis equation may be approximated by Jacob's equation:

$$s(r,t) = \frac{264Q}{T} \log\left(\frac{0.3\ Tt}{r^2\ S}\right) \qquad \text{"Jacob's Equation"} \qquad (4)$$

where:

T = Transmissivity of aquifer, [gpd/ft]

S = Storativity, [fraction]

t = Time after pumping started, [days]

Jacob's Equation is valid for use for most hydrogeologic problems of practical interest, is easier to use than the Theis equation, and involves a simple graphical procedure to calculate transmissivity and storativity. This method is summarized in ASTM D4105-96, "Standard Test Method for (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Modified Theis Nonequilibrium Method" (ASTM, 2008).

Transmissivity (T, in gpd/ft) is defined as the rate of flow (gallons per day) moving through the entire saturated thickness of an aquifer having a width of 1 mi under a hydraulic gradient of 1 ft per mile. T can be calculated as:

[17] Jacob, C.E., 1950. Engineering Hydraulics. J. Wiley and Sons, New York.

$$T = \frac{264Q}{\Delta s} \qquad (5)$$

where:

T	= Transmissivity of aquifer, [gpd/ft]
Q	= Pumping rate, [gpm]
Δs	= Change in drawdown over one log cycle of time, [ft]

Storativity (S) is defined as the amount of water released or added to storage through a vertical column of the aquifer having a unit cross-sectional area, due to a unit amount of decline or increase in average hydraulic Head. S can be calculated as:

$$S = \frac{0.3Tt_0}{r^2} \qquad (6)$$

where:

S	= Storativity, [fraction]
T	= Transmissivity, [gpd/ft]
t_0	= Time at the zero-drawdown intercept, [days]
r	= Radial distance from the pumping well, [ft]

5.22.3 Analysis for Boundary Effects and Leakage Conditions

Analyses of test data will include evaluation of boundary conditions and leakage effects. Conventional methods include Hantush's inflection point method and distance to boundaries (Roscoe Moss, 1990).

5.22.4 Correction for Tidal Influences

Water level data collected during pumping tests show variations that are the result of both pumping and natural fluctuations. To separate the signal caused by pumping from background or environmental noise, the data will be analyzed using SeriesSEE developed by the United Stated Geological Survey (USGS). This program models ground water levels using environmental data, pumping rates and Theis transforms. Changes in water level caused by natural fluctuations, and pumping induced changes are modeled concurrently and are compared to measured values. Differences are minimized using a non-linear estimation technique.

Using the concurrent modeling approach to estimating drawdown allows less data to be collected before the start of pumping. Previous techniques had required a static period as much as three times longer than the period of time spent pumping to provide reliable modeled pumping water levels. However, non-pumping data is still required for calibration, and non-pumping water levels should be frequently and accurately recorded.

5.22.5 Water Quality Samples

Water quality samples will be collected from the discharge of the pumping well on a daily basis during all pumping tests, and on a monthly basis during long-term testing. Water quality samples with completed chain of custody forms and will be submitted to Cal Am's water quality laboratory for analysis of general mineral and physical properties, VOCs, herbicides, pesticides and dioxin. A list of the general mineral and physical constituents is listed in Table 5-6. The water quality analytical work will provide a baseline characterization of the ground water quality of the aquifer in the offshore area for comparison for long-term water quality changes.

5.22.5.1 Laboratory Analyses and Chains of Custody

Water quality samples will be collected from the discharge during testing of the test slant well per the Sampling and Analysis Plan (SAP) provided in Appendix A. Water quality samples will be submitted to a State certified laboratory for general mineral and general physical analysis, as well as analysis for VOCs, pesticides, and herbicides. Samples will be handled under chain-of-custody protocol and will be delivered to the laboratory within 24 hours after collection. Samples will be analyzed by the methods listed in Table 5-6 for each constituent.

5.22.5.2 Analytes to be Measured

The anticipated initial suite of water quality analyses for the test slant well is shown in the following table:

Table 5-6. Water Quality Analyses for Test Slant Well

Constituent	Units	Method Reporting Limit	Method
Physical Properties			
Color	Color Units	3.0	SM 2120B/EPA 110.2
Odor	T.O.N.		EPA 140.1
Oxidation-Reduction Potential (Field)	mV	-	Field Meter - Myron L 6PII
pH (Lab)	Units	0.10	SM 4500 H+B
pH (Field)	Units	-	Field Meter - YSI Pro Plus

Constituent	Units	Method Reporting Limit	Method
Turbidity (Laboratory)	NTU	0.20	EPA 180.1/SM 2130B
Turbidity (Field)	NTU	-	Field Meter - Hach 2100P
Temperature (Field)	°C	-	Field Meter - YSI Pro Plus
Dissolved Oxygen (Field)	mg/L	-	Field Meter - YSI Pro Plus
Silt Density Index (Field)	-	-	ASTM D4189-07
Threshold Odor Number	T.O.N.	1.0	EPA 140.1/SM 2150
Total Dissolved Solids (Lab)	mg/L	10	SM 2540 C
Total Dissolved Solids (Field)	mg/L	-	Field Meter - YSI Pro Plus
Specific Conductance (Lab)	µmhos/cm	1	SM 2510 B
Specific Conductance (Field)	µS/cm	-	Field Meter - YSI Pro Plus
General Minerals			
Total Cations	meq/L	-	Calculation
Total Anions	meq/L	-	Calculation
Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Bicarbonate Alkalinity as HCO_3	mg/L	3	SM 2320 B
Carbonate Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Hydroxide Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Total Hardness as $CaCO_3$	mg/L	3	Calculation
Aluminum	µg/L	1	EPA 200.7
Arsenic	µg/L	1	EPA 200.7 / EPA 200.8
Barium, Dissolved	µg/L	0.01	EPA 200.7
Boron, Dissolved	µg/L	0.5	EPA 200.8
Bromide, Dissolved	mg/L	0.1	EPA 326.0
Calcium, Dissolved	mg/L	1	EPA 200.7
Chloride, Dissolved	mg/L	1	EPA 300.0
Copper, Total	µg/L	50	EPA 200.7
Fluoride, Dissolved	mg/L	0.10	EPA 300.0 / SM 4500 FC
Iodide, Dissolved	mg/L	0.1	USGS I-2371 / EPA 9056A
Iron, Dissolved	µg/L	100	EPA 200.7 / EPA 200.8
Iron, Total	µg/L	100	EPA 200.7 / EPA 200.8
Lithium	µg/L	10	EPA 200.7 / EPA 6010B
Magnesium, Dissolved	mg/L	1	EPA 200.7
Manganese, Dissolved	µg/L	20	EPA 200.7 / EPA 200.8
Manganese, Total	µg/L	20	EPA 200.7 / EPA 200.8
MBAS	mg/L	0.050	SM 5540 C / EPA 200.8
Nitrogen, Nitrate as NO_3	mg/L	1	EPA 353.2 / EPA 300.0
Nitrogen, Nitrite, Dissolved	mg/L as N	1	SM 4500 NO_2B
Nitrogen, $NO_2 + NO_3$	mg/L as N	1	EPA 300.0
Nitrogen, Ammonia, Dissolved	mg/L as N	0.1	SM 4500 NH_3H / EPA 350.1
Nitrogen, Ammonia + Organic, Diss. (TKN)	mg/L as N	0.1	EPA 351.2

Constituent	Units	Method Reporting Limit	Method
Phosphorus, Dissolved	mg/L as P	0.01	EPA 365.3
Phosphorus, ortho, Dissolved	mg/L as P	0.01	EPA 365.3
Potassium, Dissolved	mg/L	1	EPA 200.7
Silica, Dissolved	mg/L	1	SM 4500 SiE
Sodium, Dissolved	mg/L	1	EPA 200.7
Strontium, Dissolved	mg/L	0.1	EPA 200.7 / EPA 200.8
Sulfate as SO_4, dissolved	mg/L	0.5	EPA 300.0
Zinc, Total	µg/L	50	EPA 200.7
Radiology / Age Dating Methods			
Delta-Deuterium	δ^2H	-	TC/EA/IRMS
Delta Oxygen-18	$\delta^{18}O$	-	TC/EA/IRMS
Tritium	TU	-	-
Tritium, prec. est.	TU	-	-
Volatile Organic Compounds			
VOCs plus Oxygenates (MTBE)	µg/L	varies	EPA 524.2
EPA Organic Methods			
EDB and DBCP	µg/L	varies	EPA 504.1
Chlorinated Pesticides & PCB's as DCP	µg/L	varies	EPA 508
Chlorinated Acid Herbicides	µg/L	varies	EPA 515
Nitrogen & Phosphorus Pesticides DEHP, DEHA, Benzo(a)Pyrene	µg/L	varies	EPA 525
Carbamates	µg/L	varies	EPA 531.1
Glyphosate	µg/L	varies	EPA 547
Endothall	µg/L	varies	EPA 548.1
Diquat	µg/L	varies	EPA 549.1
Dioxin (2,3,7,8 TCDD)	µg/L	varies	EPA 1613

5.22.5.3 Sampling Frequency

During the pumping test, the slant test well (pumping well) and monitoring wells will be equipped with transducers and dataloggers to continuously measure water level and electrical conductivity. The transducers will remain in the wells after the end of the pumping test. Data collected by the transducers will be downloaded on a quarterly basis (beginning three months after the end of the pumping test), for a period of two years. After the data is downloaded each quarter, the monitoring wells will be purged by pumping and a ground water sample will be collected and analyzed for general mineral and physical properties, VOCs, herbicides, pesticides, and dioxin.

The purpose of the long-term water level monitoring and water quality sampling is to determine if there are seasonal or annual variations in source water quality due to potential changes in precipitation or upstream ground water production. This information will be subsequently used to provide input data to further refine the North Marina Ground Water Model.

5.23 Disposal of Wastewater to MRWPCA Outfall

Water produced during development and testing will be discharged to the nearby Monterey Regional Water Pollution Control Agency (MRWPCA) ocean outfall, or as otherwise approved. Water produced during development will be discharged to the first baffled compartment of the Baker tank. From there it will settle out fines and flow into the center compartment. The center compartment will contain a "pick-up pump" that will push discharged water through a volumetric cyclone separator and discharge into a third Baker tank compartment. From the third compartment, water will then be pumped into a sand separator before being discharged to the ocean outfall. Discharges to the MRWPCA ocean outfall, or the Pacific Ocean, shall not exceed five million gallons per day.

5.24 Well Plumbness and Alignment (Verticality Survey)

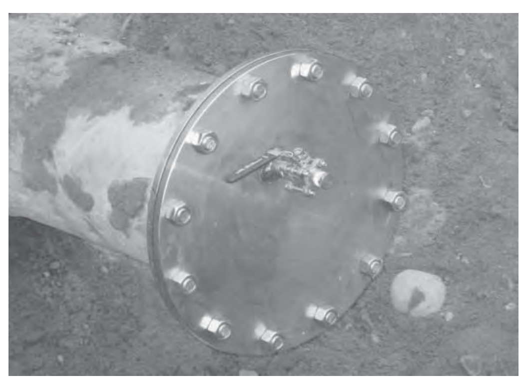
Prior to the installation of the pump for the 18-month pumping test, the well should be surveyed for plumbness and alignment. Because 2507 Super Duplex stainless steel can cause magnetic interference, the survey must be conducted with a gyroscopic tool. The survey will provide deviation from vertical distance and direction data at a minimum of 10 ft intervals. The survey will provide enough data to locate the casing in three dimensional space; it should include azimuth, dip angle, and position information.

5.25 Video Survey of Test Slant Well

A downhole video survey with side scan capability will be run in the test slant well to inspect and record the post-construction condition of the well.

5.25.1 Test Slant Well Location Survey

The location of the test slant well will be surveyed by a California licensed land surveyor. Horizontal and vertical accuracy will be established in accordance with a second order Class I survey standard (1: 50,000). The survey will include horizontal spatial location and the elevation of top of casing relative to an established benchmark. The surveyed points will be marked on the well casing.



Test Slant Well Prior to Burial

Upon completion of the survey, the depth to water within the test slant well will be measured and recorded to the nearest hundredth of a foot[18] referencing the measuring point on the well casing to ground surface. This data will be used to prepare ground water contour maps.

5.26 Wellhead Completion, Demobilization, and Site Restoration

All drilling and testing equipment, including the drilling rig anchors, will be removed from the well site.

Restored Beach Surface

All water supply, distribution, and disposal piping will be removed as directed, and the site will be restored to pre-construction conditions. Due to location on the CEMEX access road, the top of the test well casing will be cut and capped at a depth of 3 feet below ground surface (bgs) so that there are no permanent obstructions created. Final work at the site will involve the removal of the K-rails, landing mats, and security fencing. The site will be cleaned, smoothed, and raked so that all traces of the drilling operations are removed.

5.27 Summary Report – Test Slant Well Construction and Testing

At the conclusion of the test slant well construction and testing, GEOSCIENCE will prepare and provide the client and technical advisor with a draft technical memorandum (TM 3) summarizing work performed during the field investigations as well as findings and recommendations where appropriate. The report will include:

- A description of lithology encountered during drilling;
- Daily field notes;
- Geophysical borehole logs;
- Figures and maps showing site locations and conditions;
- Test slant well construction details with as-built drawings of completed wells;
- Test slant well development and testing details;
- Results of mechanical grading analysis;
- Results of permeameter testing;

[18] Pressure and conductivity dataloggers will be installed in each monitoring well. See Section 4.3.13.

- Pumping test analyses including interference;
- Estimates for hydraulic conductivity and expected production capacity for production wells in the area;
- Analytical reports showing ground water quality results, and;
- All other pertinent data, recommendations, and conclusions.

GEOSCIENCE will submit five (5) copies of the draft technical memorandum to the client and technical advisory committee. After a review and comment period, GEOSCIENCE will incorporate appropriate revisions and submit five (5) copies of the technical memorandum (TM 3) Summary of Results – Full-Scale Test Slant Well Monitoring Well Installation and Program

6.0 PUBLIC SAFETY AND DRILLING CONTRACTOR TERMS AND CONDITIONS (FOR EXPLORATORY BOREHOLES, MONITORING WELL CONSTRUCTION, AND TEST SLANT WELL CONSTRUCTION AND TESTING)

6.1 Overview

The conditions that are described in this section apply to exploratory borehole drilling, monitoring well construction, and slant well construction at the CEMEX area sites and Moss Landing, Potrero Road, Sandholdt Road, and Sandholdt Pier sites.

The work site will be underlain by a heavy-duty plastic liner, which will be changed when necessary due to wear and tear from driving equipment over it. Empty 55-gallon drums and absorbent materials will be kept on site at all times for immediate availability if needed to contain all spills, potential waste and vehicle drippings. Following are a list of terms and conditions for the proposed drilling operations that were developed in collaboration with representatives from MWDOC and California State Parks.

6.2 Pre-Construction Meetings

Prior to any phase of field work or drilling operations, a pre-construction meeting will be held that will include key representatives and field personnel from the following groups: Cal Am, RBF Consulting, GEOSCIENCE, Drilling Contractor, and environmental compliance personnel. The pre-construction meeting will be used to review each plan of work and technical specifications, as well as site rules, safety considerations, and environmental commitments.

Sites for the exploratory boreholes, monitoring wells and test slant well will be visited in the field at the time of the respective pre-construction meeting.

6.3 Safety Fencing

For security purposes and to delineate work spaces, a temporary chain-link fence at least 6 ft in height with a 24-ft wide gate will enclose staging areas and the test slant well work site.

6.4 Staging Areas

To keep drilling footprints on the beach and in public areas to a minimum, nearby staging areas will be established for temporary storage of support equipment. Track-mounted support vehicles will travel between the drilling site and staging area on a daily basis to move required equipment on- and offsite.

Temporary chain-link construction fencing will be installed around the staging area. Staging areas will be of sufficient size to store support equipment and well construction materials. The minimum required staging area is 80 ft x 100 ft.

Mobilization of drilling equipment for the test slant well may require as many as nine trailer loads of equipment. The initial mobilization of equipment will be from the contractor's yard to the designated staging area. Only one tractor (i.e., semi-truck) will remain in the staging area for use in moving the larger pieces of equipment. The remaining tractors used for transportation of the support equipment to the project area will leave the area immediately after delivering their respective loads of equipment to the staging area.

6.5 Informational Signage

Cal Am and RBF will prepare signage that will be posted at the site of each phase of drilling. The sign will explain the project and provide a Cal Am or RBF contact number where public inquiries may be made. At the CEMEX site, the sign will be visible from the beach. Paper fliers will not be available due to the propensity for informational fliers to become litter.

6.6 Schedule of Drilling Operations

The proposed work schedule for drilling operations will be daily from 6 AM to 6 PM for each phase of the drilling work described in Sections 3, 4 and 5 of this Work Plan. During exploratory borehole drilling and monitoring well construction, the drilling contractor will schedule personnel to work ten (10) days on, with four (4) days off per two-week work cycle. Work will not take place on major holidays without prior approval from Cal Am and RBF.

The proposed work schedule for each phase of drilling is planned to take place seven days per week during daylight hours only. The contractor shall establish rotating crews to make the work as continuous as possible. During test slant well drilling, if it becomes necessary to compress the time required for project completion, the feasibility and acceptability of nighttime work may be investigated.

Inspection during drilling, well construction, development and testing will be conducted on a full-time, 12-hour working day basis from 6 AM to 6 PM. A field geohydrologist will be onsite at all times during drilling for lithologic logging of the samples retrieved from the borehole, during well construction, and during testing to ensure that proper protocols and procedures are followed.

Table 6-1. Estimated Number of Working Days

Drilling Phase	Drilling Sites	Estimated Number of Working Days
Exploratory Boreholes	Potrero Road, Sandholdt Road, and Sandholdt Pier	12
	CEMEX Area – CX-B1, CX-B2,CX-B3, CX-B4	40
	Moss Landing Area – ML-A3 to ML-A8	20
	CEMEX Area – CX-C1 andCX-C2	20
Monitoring Wells	CEMEX Area	160
Test Slant Well	CEMEX Area	180

As time is of the essence, all work is scheduled to take place over as short a time frame as possible. Efforts will be made to complete the work earlier if possible.

6.7 Onsite Biologist and Other Environmental Monitors

The Contractor will not disturb designated environmentally sensitive areas. Prior to construction activities, a qualified biologist shall conduct an Employee Education Program for the construction crew and onsite geohydrologist. The program should take place on the project site and include the following:

1. A review of the project boundaries including staging areas and access routes;
2. The special-status species that may be present, their habitat, and proper identification;
3. The specific mitigation measures that will be incorporated into the construction effort;
4. The general provisions and protections afforded by the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (DFG), and;
5. The proper procedures if a special-status animal is encountered within the project site.

Additionally, a biologist will be present during equipment set up and will define the work areas to avoid state or federally listed species.

6.8 Snowy Plover and Other Endangered Species

Activities are not allowed that may jeopardize the continued existence of, or may destroy or adversely modify critical habitat, or threatened or endangered species, or a species proposed for such designation, as identified under the Federal Endangered Species Act (ESA).

Drilling activities on or adjacent to the beach (i.e., exploratory boreholes CX-B1, and potentially boreholes CX-C1, CX-C2 and CX-C3) shall avoid the nesting season (March 1st to September 30th) for Western Snowy Plover. All drilling and construction activities planned for near plover habitat will be restricted to between October 1st and February 28th. During the non-nesting season plovers may be seen foraging within the kelp line that forms at the high tide line, and, if observed, will not be approached.

Monitoring for potential beach nesting areas will be conducted during drilling activities to assess impacts on nesting or wintering wildlife (i.e., particularly the Western Snowy Plover), however, such monitoring is not included in GEOSCIENCE's current scope of work.

6.9 Preservation of Vegetation

Drilling equipment will not occupy ground with native vegetation unless specifically authorized to do so. All work will take place on previously disturbed ground, and will be restricted to within or on the shoulder of existing CEMEX access roads.

No construction activities will be allowed to occur outside specified areas. No removal of native vegetation is authorized for this project.

6.10 Burial of Test Slant Well

Following the five day constant rate tests, the test slant wellhead will be buried. The wellhead area will be returned to preconstruction activity conditions as described in Section 5.26 of this work plan.

6.11 Impacts to CEMEX Operations

Impacts to CEMEX operations will be avoided. During slant well drilling and construction, to avoid disruption of CEMEX operations, drill casing sections and other materials required for each day's work will be transported from the staging area to the wellsite at the start of each day to reduce traffic along the CEMEX haul road. CEMEX will be consulted prior to commencement of construction activities occurring in the CEMEX area to provide advance notice of activities and to schedule activities to limit impact on CEMEX operations.

6.12 Noise Mitigations Measures

Drilling operations shall be performed in a manner that will avoid unnecessary noise generation and will minimize disturbance to special status species (e.g., Western Snowy Plover), the public in general, as well as persons living and working nearby.

The Contractor will be required to provide submittal data regarding their noise mitigation measures. The submittal information will be approved by the Owner and Project Engineer prior to mobilization. The measures used for noise suppression may include (but are not limited to) the following:

- Equipping all internal combustion engines with critical residential silencers (mufflers);
- Placing insulated barriers around the working site to dampen rig engine and/or drill head noise, and;
- Conducting operations in the most effective manner to minimize noise, while allowing Contractor to work in a timely and economic manner.

As directed by the biologist, the Contractor shall provide visual and sound attenuation for sensitive species on the beach such as the Western Snowy Plover.

6.13 Air Emission Controls

Air quality permits may be required for temporary emissions from diesel powered equipment necessary for drilling, construction, and testing activities.

6.14 Water Source/Temporary Hoses/Pipelines

The Owner and Project Engineer will assist the Contractor in obtaining a water source from either fire hydrants located near each site, or more centrally located water filling stations. These locations will be shown to the Contractor prior to start of work. It shall be the Contractor's responsibility to provide and maintain, at his own expense, all water supply connections used during construction. All connections must be at approved locations and maintained in an approved manner. Use of fire hydrants will require installation of a backflow preventer to avoid cross-connection contamination and a meter to quantify water use. Prior to final acceptance of any phase of drilling, all temporary water connections and piping installed by the Contractor shall be removed and the site restored to the satisfaction of the Owner and Project Engineer.

The Contractor will be responsible for providing and maintaining water supply connections required for drilling and construction. For public safety, and to avoid impacting CEMEX operations, all water pipelines, hoses and other utilities installed by the Contractor shall be covered or buried where pathways or roadways are crossed.

At the CEMEX facility, water may be obtained from the nearby Upper CEMEX Well. A water source may only be needed at the initial start of drilling and will not be needed once the static ground water level is reached. Water obtained by the Contractor from CEMEX will not be allowed to impact CEMEX activities.

At the end of the work, all temporary water connections and piping installed by the Contractor shall be removed and the site restored to the satisfaction of CEMEX.

6.15 Drill Cuttings and Drilling Waste Disposal

Due to environmental and aesthetic concerns regarding the beach sites and the proximity of the Pacific Ocean, drilling activities shall be conducted in such a way as to prevent the introduction of pollutants to the beach or ocean during drilling. Accordingly, any equipment and/or materials brought to the project area must be managed in accordance with the following procedures:

- Drip pans will be used to catch leaks and residual material in hoses and spigots under all stationary equipment. The drip pans will be checked daily and emptied as needed by reusing the substance or disposing of it properly at the Contractor's expense.

- Hazardous materials spills will be contained immediately using sand, dirt, and/or absorbent materials. Such spills will be cleaned up promptly along with the contaminant material and will be disposed of properly at the Contractor's expense.

- Storage of all oils, solvents, cleaners and other liquid materials shall be within secondary containment. The area should be covered, as necessary, to prevent storm water accumulation in the containment.

- Bentonite, cement and any other powdered product shall be stored on pallets and away from any drainage path. The storage area should be covered and protected, if necessary, to prevent pollution runoff by wind or storm water.

- Chemicals, bagged material, or drums shall be stored on pallets within secondary containment.

Waste products generated during the drilling/construction work must be managed in accordance with the following procedures:

- Containerized waste will not be allowed to overflow. Any waste that requires storage in containers shall be removed from the project area on a regular basis and disposed of at an approved facility at the Contractor's expense.

- Cleaning of the drilling rig, cement/bentonite mixtures, tremie pipe and any other equipment shall be conducted within a fully contained area or outside the project area and only in an approved place.

- Waste bentonite or cement must be removed from the project area prior to completion of the work.

The use and maintenance of drilling rigs and support vehicles shall be in accordance with the following procedures:

- Fueling of vehicles and equipment will be performed at designated areas only. During fueling operations, drip pans will be used to catch leaks. "Topping off" of fuel tanks is not allowed.

- Drip pans will be used during maintenance activities to catch any leaks.

- Daily inspections of drilling rigs and support vehicles and equipment will be made to check for leaks. Any leaks detected shall be fixed immediately.

- All Contractor employees and subcontractors shall be educated in the proper handling and storage of construction materials used during the project.

- Small spills shall be soaked up using absorbent materials and disposed of properly at the Contractor's expense. Washing down of spills is not allowed.
- Steam cleaning of the drilling rig and support equipment must be done is designated areas. The cleaning area shall be bermed, or otherwise contained, to prevent runoff to storm drains. All wastewater generated from cleaning equipment must be containerized and disposed of at the Contractor's expense. Any soap used during cleaning must be phosphate-free and biodegradable.

During dual rotary drilling, rubber seals will be located between the casing, swivel, and drilling rods to prevent leakage and contain all cuttings and fluids within the closed circulation system of the drilling unit. Cuttings will be directed from the discharge swivel to a sampling cyclone through a large diameter flexible hose.

All drill cuttings will be spread onsite and GEOSCIENCE personnel will ensure that Boart complies with all Best Management Practices (BMPs) to contain and control any kind of run-off from each drilling site

6.16 Health and Safety Plan

A copy of the Contractor's Health and Safety Plan will be included as an appendix to the technical specifications that will be prepared for each phase of the field work.

6.17 Spill Prevention and Response Plan

Prior to the commencement of drilling operations, a containment area will be constructed to enclose the drill rig and other equipment to minimize the potential for releasing fuel, hydraulic fluid, or water from drilling operations to the surrounding environment. A temporary chain-link fence that is at least 6 ft high with a locked 16-ft width gate will surround the entire drilling work site (approximately 130 ft x 60 ft). K-rails (a.k.a. "Jersey barriers") will be placed within the perimeter of the fenced work area, and the site will be underlain by heavy-duty (3-ply) plastic sheeting that extends up and over the K-rails and will completely cover the area under and adjacent to the drilling rig and support equipment. Additionally, absorbent materials will be maintained on site during work operations as part of a spill prevention plan (see Attachment A) to immediately clean up any spills that may occur. Used absorbent materials will be disposed in a proper manner at an approved offsite location.

It is estimated that drilling operations will require the use of 200 to 300 gallons of diesel fuel daily. Fuel will be delivered by bulk truck to the site daily and will be handled in accordance with a fuel containment plan. No fuel or oil products, other than that which is in equipment fuel tanks, will be stored onsite.

A copy of the Contractor's Spill Prevention and Response Plan will be included as an appendix to the technical specifications that will be prepared for each phase of the field work.

7.0 LONG-TERM MONITORING

A ground water monitoring network will be developed to:

- Assess and continually evaluate the hydrogeologic technical aspects of the project;
- Evaluate potential impacts to critical inland water resources, and;
- Assess the movement of ocean water into the test slant well.

The monitoring network will include the test slant well and monitoring wells constructed at the CEMEX site as part of this work plan as well as other existing wells (i.e., existing CEMEX wells) in the project vicinity. The final proposed network of monitoring wells will be submitted to Cal Am and the Hydrogeologists Working Group (HWG) for review and approval prior to initiating the long-term aquifer pumping test.

After establishing the monitoring well network, each well will be equipped with water level transducers and conductivity transmitters that will continually log information. During the approximate 6-month construction and testing period required for the test slant well, ground water level and conductivity data will be collected from the monitoring wells. Water level and conductivity data measured in the monitoring wells will be downloaded on a quarterly basis. Water quality sample will be collected quarterly from each monitoring well when Level and conductivity data is downloaded.

7.1 Wellhead and Borehole Surveys – Elevation and Coordinates

Surveyed elevations for the exploratory borings, monitoring wells, test slant well, and any additional wells deemed appropriate to be included in the monitoring network will be obtained as part of the field investigation. The ground surface at each completed exploratory borehole will be surveyed by a California licensed land surveyor. Surveyed elevations will be obtained at each monitoring well at the top of the well casing, the top of the monument cover, and at the top of the monitoring well concrete pad. Surveyed elevations will be obtained for the test slant well at the upper and lower edge of the surface exposure of the well casing.

All elevations and locations will be surveyed relative to a benchmark surveyed and established by a California licensed land surveyor. Horizontal and vertical accuracy will be established in accordance with a second order Class I survey standard (1: 50,000).

7.2 Instrumentation of Wells

GEOSCIENCE personnel will install level transducers and conductivity sensors connected to a stand-alone data logging system in each of the monitoring wells. Level transducers and conductivity sensors will collect long-term water level and water quality data in each monitoring well. The level transducers will consist of Solinst® Levelogger® Model 3001 devices or equivalent. Level transducers will be installed in each monitoring well and the test slant well and in private wells if permission is granted and the appropriate access port for the equipment is available.

A Solinst® Barologger® will be installed in one of monitoring wells on site, which will be used to normalize for atmospheric barometric variation. Using Solinst® normalization software, data collected from Barologger® transducer will be used to normalize ground water level data collected in the other monitoring wells. The monitoring well for the Barologger® will be selected once the final monitoring well locations have been selected.

7.3 Monitoring Well Network

7.3.1 Frequency and Schedule of Water Level Measurements of Monitoring Wells

Seasonal and other temporal variations in source water quality will be evaluated by measuring water level and water quality data over an approximate 30-month period. The 30-month period includes an approximate 6-month period after monitoring well installation and before installation of the test slant well, an 18-month period for the long-term slant well test, and an additional 6-month period after completion of the long-term slant well test. Level and conductivity data will be downloaded from monitoring wells on a quarterly basis when ground water samples are collected.

Sample Bottles for Water Quality Analysis

For quality control, water levels will be recorded in each of the monitoring wells using a wire-line sounder at the time of transducer installation, during water quality sampling, and at any other time the well is accessed. Water levels will be recorded to the nearest 0.01 ft.

7.3.2 Frequency and Schedule of Water Quality Sampling of Monitoring Wells

Each quarter, when water level and conductivity data are downloaded, the monitoring wells will be purged using a submersible pump, and water quality samples will be collected and analyzed. Ground water sampling will be conducted over an approximate 30-month period. Ground water sampling will occur during the ~6-month slant well construction, during the 18-month, long-term slant well operation, and for a 6-month period following completion of the long-term slant well operation.

Prior to collecting ground water samples, wells will first be purged in accordance with the SAP prepared for this study, and as described in Section 4 of this work plan.

Field water quality parameters that will be measured include pH, conductivity, temperature, salinity, oxidation reduction potential (ORP), and dissolved oxygen. Field measurements will be made using a YSI 556, or equivalent, multi-parameter instrument equipped with a flow-through sample cell. Analytical methods used for parameters that will be measured in the field are listed in Table 7-1.

Total and dissolved iron and manganese will be measured by field filtering samples directly into an acidified container immediately upon collection. A second sample will be collected directly into an acidified container without filtering. This method will provide a reliable and accurate means to determine the amount of dissolved and particulate iron and manganese, which has implications for desalting plant design.

Field parameters will be recorded during testing on the forms included in the SAP (see Appendix A). The stabilization of field conductivity and turbidity measurements will be used to determine when the well has been sufficiently purged and a representative native ground water sample can then be collected.

Water quality samples will be collected from the discharge of the slant well on a daily basis during the short-term pumping tests. Samples will be submitted to a California-certified water quality laboratory for analysis of general mineral and physical properties. A list of the general mineral and physical constituents and analytical methods is listed in Table 7-1. After the first two quarters of sampling, the suite of analytes will be reviewed to determine if all the analytes are required for future sampling, or if other analytes should be added. Recommendations will be provided to the client and the HWG for review and approval prior to the third quarter sampling. The water quality analytical work will allow on-going evaluation of potential water quality changes occurring in the aquifer systems onshore during the project period. Water quality information will provide the data needed to updated and validate the NMGWM in the project area.

Table 7-1. Water Quality Analyses for Quarterly Sampling
Monitoring Wells and Test Slant Well

Constituent	Units	Method Reporting Limit	Method
Physical Properties			
Color	Color Units	3.0	SM 2120B/EPA 110.2
Odor	T.O.N.		EPA 140.1
Oxidation-Reduction Potential (Field)	mV	-	Field Meter - Myron L 6PII
pH (Lab)	Units	0.10	SM 4500 H+B
pH (Field)	Units	-	Field Meter - YSI Pro Plus
Turbidity (Laboratory)	NTU	0.20	EPA 180.1/SM 2130B
Turbidity (Field)	NTU	-	Field Meter - Hach 2100P
Temperature (Field)	°C	-	Field Meter - YSI Pro Plus
Dissolved Oxygen (Field)	mg/L	-	Field Meter - YSI Pro Plus

Constituent	Units	Method Reporting Limit	Method
Silt Density Index (Field)	-	-	ASTM D4189-07
Threshold Odor Number	T.O.N.	1.0	EPA 140.1/SM 2150
Total Dissolved Solids (Lab)	mg/L	10	SM 2540 C
Total Dissolved Solids (Field)	mg/L	-	Field Meter - YSI Pro Plus
Specific Conductance (Lab)	µmhos/cm	1	SM 2510 B
Specific Conductance (Field)	µS/cm	-	Field Meter - YSI Pro Plus
General Minerals			
Total Cations	meq/L	-	Calculation
Total Anions	meq/L	-	Calculation
Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Bicarbonate Alkalinity as HCO_3	mg/L	3	SM 2320 B
Carbonate Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Hydroxide Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Total Hardness as $CaCO_3$	mg/L	3	Calculation
Aluminum	µg/L	1	EPA 200.7
Arsenic	µg/L	1	EPA 200.7 / EPA 200.8
Barium, Dissolved	µg/L	0.01	EPA 200.7
Boron, Dissolved	µg/L	0.5	EPA 200.8
Bromide, Dissolved	mg/L	0.1	EPA 326.0
Calcium, Dissolved	mg/L	1	EPA 200.7
Chloride, Dissolved	mg/L	1	EPA 300.0
Copper, Total	µg/L	50	EPA 200.7
Fluoride, Dissolved	mg/L	0.10	EPA 300.0 / SM 4500 FC
Iodide, Dissolved	mg/L	0.1	USGS I-2371 / EPA 9056A
Iron, Dissolved	µg/L	100	EPA 200.7 / EPA 200.8
Iron, Total	µg/L	100	EPA 200.7 / EPA 200.8
Lithium	µg/L	10	EPA 200.7 / EPA 6010B
Magnesium, Dissolved	mg/L	1	EPA 200.7
Manganese, Dissolved	µg/L	20	EPA 200.7 / EPA 200.8
Manganese, Total	µg/L	20	EPA 200.7 / EPA 200.8
MBAS	mg/L	0.050	SM 5540 C / EPA 200.8
Nitrogen, Nitrate as NO_3	mg/L	1	EPA 353.2 / EPA 300.0
Nitrogen, Nitrite, Dissolved	mg/L as N	1	SM 4500 NO_2B
Nitrogen, $NO_2 + NO_3$	mg/L as N	1	EPA 300.0
Nitrogen, Ammonia, Dissolved	mg/L as N	0.1	SM 4500 NH_3H / EPA 350.1
Nitrogen, Ammonia + Organic, Diss. (TKN)	mg/L as N	0.1	EPA 351.2
Phosphorus, Dissolved	mg/L as P	0.01	EPA 365.3
Phosphorus, ortho, Dissolved	mg/L as P	0.01	EPA 365.3
Potassium, Dissolved	mg/L	1	EPA 200.7

Constituent	Units	Method Reporting Limit	Method
Silica, Dissolved	mg/L	1	SM 4500 SiE
Sodium, Dissolved	mg/L	1	EPA 200.7
Strontium, Dissolved	mg/L	0.1	EPA 200.7 / EPA 200.8
Sulfate as SO_4, dissolved	mg/L	0.5	EPA 300.0
Zinc, Total	µg/L	50	EPA 200.7
Radiology / Age Dating Methods			
Delta-Deuterium	δ^2H	-	TC/EA/IRMS
Delta Oxygen-18	$\delta^{18}O$	-	TC/EA/IRMS
Tritium	TU	-	-
Tritium, prec. est.	TU	-	-
Volatile Organic Compounds			
VOCs plus Oxygenates (MTBE)	µg/L	varies	EPA 524.2
EPA Organic Methods			
EDB and DBCP	µg/L	varies	EPA 504.1
Chlorinated Pesticides & PCB's as DCP	µg/L	varies	EPA 508
Chlorinated Acid Herbicides	µg/L	varies	EPA 515
Nitrogen & Phosphorus Pesticides DEHP, DEHA, Benzo(a)Pyrene	µg/L	varies	EPA 525
Carbamates	µg/L	varies	EPA 531.1
Glyphosate	µg/L	varies	EPA 547
Endothall	µg/L	varies	EPA 548.1
Diquat	µg/L	varies	EPA 549.1
Dioxin (2,3,7,8 TCDD)	µg/L	varies	EPA 1613

7.3.3 Monitoring of Nearby Existing Irrigation or Other Wells

The Upper CEMEX Well, and potentially the Lower CEMEX Well, will be included in the monitoring network. Due to the close proximity of the Upper CEMEX well to the new monitoring wells, only level and conductivity measurements are recommended for this well. Ground water sampling and analysis is not recommended for the Upper CEMEX well as the pumping required for sampling may cause interference.

The Lower CEMEX Well may be screened in the Dune Sand Aquifer only. Information regarding the construction of the Lower CEMEX Well has not been available. It is recommended that the Lower CEMEX Well is included in the monitoring well network, but only if a downhole video log can be conducted to determine well depth and the location of screened intervals. If the Lower CEMEX Well is included in the monitoring network, it will only be necessary to collect transducer data due to the proximity to the new monitoring wells.

If appropriate, additional nearby wells will be recommended for inclusion in the monitoring network prior to initiating the long-term aquifer test. The location of the wells will be selected to fill potential data gaps identified from review of existing data and predictive modeling work to be completed before the long-term aquifer test. To consider adding a well to the monitoring network, well construction details will be needed to first determine which aquifer(s) are penetrated. The list of wells and rationale for inclusion in the monitoring network will be submitted to the client and HWG for review and comment. Permission to install a transducer in the well, and the ability to access the well on a quarterly basis, will be required before including any well. GEOSCIENCE will prepare a letter to be sent to the well owner that outlines the proposed work that to be conducted at the selected well, and time frame for the work. It is assumed that Cal Am will initiate contact with the owners of the selected wells, and will obtain the necessary permission to access the wells.

7.4 Test Slant Well

After installation of the test slant well, baseline water quality data will be collected (see Section 5) and the test slant well will be equipped with a level transducer and conductivity transmitter. Data will be recorded by a stand-alone datalogger during the step-drawdown, constant rate, and recovery tests. The instruments will remain in the test slant well from the time of installation to at least six months after the conclusion of the 18-month test.

7.4.1 Frequency and Schedule of Water Level Measurements of Test Slant Well

Water level measurements will be collected from the wellhead datalogger once the transducer and conductivity transmitter is installed in the test slant well. Data collection will be synchronized with data collection from the monitoring wells. Data from the dataloggers will be downloaded quarterly when ground water quality samples are collected. Data collection will continue for a period of six months after completion of the 18-month aquifer test to obtain additional data on aquifer conditions.

7.4.2 Frequency and Schedule of Water Quality Sampling of Test Slant Well

Samples will be collected from the pumping well on a daily basis during the step tests and five day constant rate tests. After the start of the 18-month slant well test, the test slant well will be sampled on a quarterly basis.

Field water quality parameters including pH, conductivity, SDI, temperature, salinity, ORP, and dissolved oxygen, will be measured before and during all samplings. Samples will be collected only after parameters have stabilized as described in the SAP. Field parameters will be recorded during testing on the field forms included in the SAP.

Water quality samples will be collected from the discharge of the pumping well on a daily basis during all pumping tests. These samples will be submitted to a California-certified water quality laboratory for analysis of general mineral and physical properties. A list of the general mineral and physical constituents is listed in Table 7-1. The water quality analytical work will allow on-going evaluation potential water quality changes in the offshore portion of the Dune Sand Aquifer.

7.5 Laboratory Analyses and Chains of Custody

All samples will be submitted to the a California-certified laboratory under chain-of-custody protocol within 24 hours of collection (i.e., same day, if possible, due to the actual time of day the sample is collected). Analytical methods used for parameters measured in the field and laboratory is listed in Table 7-1. As part of the analytical method, the laboratory will be required to run QA/QC per the method requirements and provide a QA/QC report for each analytical method.

8.0 NORTH MARINA GROUND WATER MODEL UPDATE AND REFINEMENT

The North Marina Ground Water Model (NMGWM) is a detailed hydrologic model with cell size of 200 ft by 200 ft covering an area of approximately 149 square miles (see Figure 8-1). It was developed by GEOSCIENCE in 2008 from the regional-scale Salinas Valley Integrated Groundwater and Surface Water Model (SVIGSM) using the aquifer parameters, recharge and discharge terms, and boundary conditions in the North Marina area. The model codes are MODFLOW and MT3DMS; additional modeling will be through the use of SEAWAT[19]. The combined modeling effort will simulate the response of the aquifers under various pumping scenarios. The NMGWM will be updated and refined to simulate ground water flow patterns in order to determine the Project's effect on the existing basin overdraft and seawater intrusion. The planned model updates and refined predictions are summarized in the Table 8-1 below:

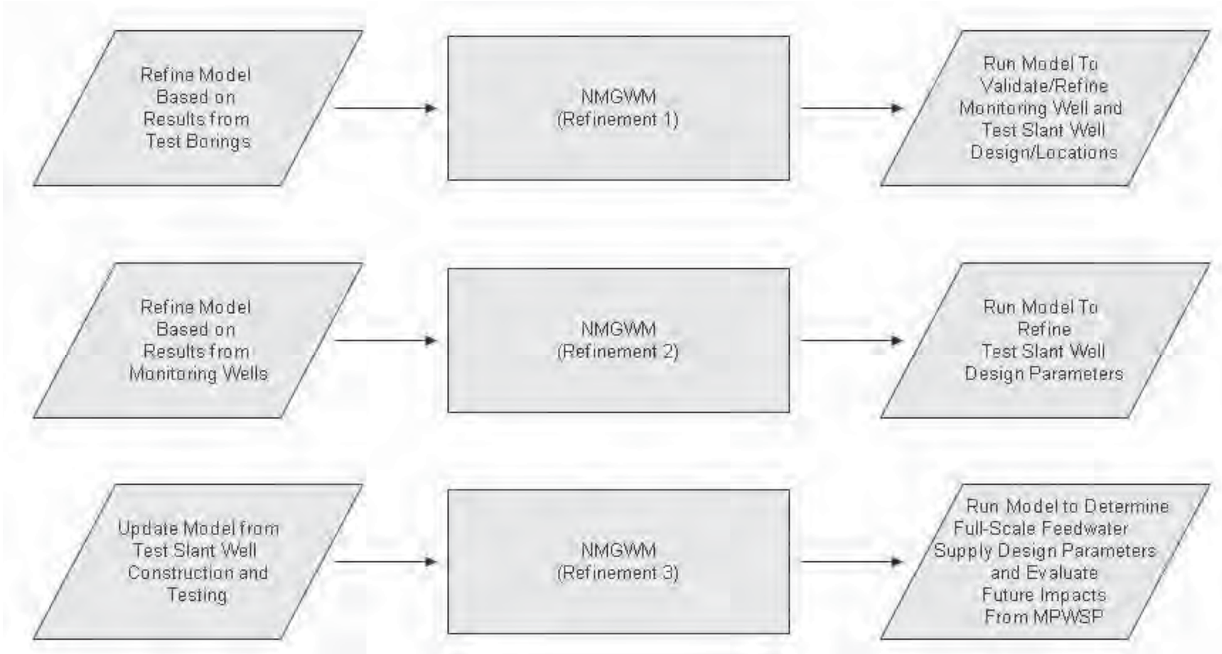
Table 8-1. Planned NMWGM Updates and Refinements

Updated Model Component	Source of Information for Update	Purpose of Predictive Model Run
Model Layer Areal Extent, Thickness, and Hydraulic Properties	Exploratory Boreholes at Potrero/Sandholdt Roads, CEMEX, and Moss Landing Harbor Sites	Check for Data Gaps, Refine/Verify Monitoring Well Locations, and Verification of Model-Predicted Results in Terms of Ground Water Levels and Quality
Ground Water Quality of Dune Sand Aquifer and 180-Foot Aquifer	Exploratory Boreholes at Potrero/Sandholdt Roads, CEMEX, and Moss Landing Harbor Sites	Check for Data Gaps, Refine/Verify Monitoring Well Locations, and Verification of Model-Predicted Results in Terms of Ground Water Levels and Quality
Ground Water Quality of Dune Sand Aquifer, 180-Foot Aquifer and 400-Foot Aquifer	Monitoring Wells at the CEMEX Site	Refine/Verify Locations of Project Slant Wells, Determine Need for Additional Exploratory Boreholes and/or Monitoring Wells, Further Verification of Model-Predicted Results in Terms of Ground Water Levels and Quality
Model Layer Hydraulic Properties	Short- and Long-Term Test Slant Well Pumping Test Data	Evaluate Long-Term Impacts from Full-Scale MPWSP

Figure 8-2 below shows a flow chart of the proposed NMGWM updates, sources of data used for model updates, and the resulting scenarios, which will be run after the model has been updated.

19 SEAWAT is a three-dimensional, variable-density ground water flow model coupled with multi-species solute and heat transport.

Figure 8-2. Flow Chart of Proposed NMWGM Updates and Refinements



8.1 Refine North Marina Conceptual Model Based on Test Borings, Monitoring Well Data and Test Slant Well Lithologic and Pumping Test Data

Aquifer parameter data collected from the hydrogeologic investigations in this work will be used to refine and update the NMGWM. These model updates will provide an accurate and defendable tool for evaluating project impacts to ground water levels and ground water quality in the region.

8.1.1 Refine Model Layer Elevations/Thickness/Areal Extent

The Project area consists of multiple aquifer systems extending offshore, which are separated in places by geologic units of essentially non-water bearing deposits (referred to as aquitards; e.g., Salinas Valley Aquitard). As previously mentioned, the 2008 NMWGM relied primarily on the existing model layers prepared for the SVIGSM. Previous studies were reviewed by GEOSCIENCE to confirm the model layers with respect to the hydrogeology, and the relationship of the subsea aquifers in relation to the seafloor.

Although the aquifer relationships in the model is consistent with previous work by others[20], the recent focus on the best aquifer to pump for the project feedwater supply in has shifted from the 180-Foot

[20] Previous work to map the extent of hydrostratigraphic units within the basin includes Harding Lawson Associates (1994 and 2001), U.S. Geologic Survey (2002), and Kennedy/Jenks (2004).

Aquifer to the overlying Dune Sand Aquifer. GEOSCIENCE has added an additional model layer for the Dune Sand Aquifer. The addition of the new model layer for the Dune Sand Aquifer was based on the review and extension of existing geologic cross-sections, creation of new geologic cross-sections, and evaluation of recent aquifer parameter information for the area. The areal extent and thickness of other model layers were also refined using the same aforementioned information.

Based on the revised conceptual model, the current NMWGM consists of the following seven model layers:

- Layer 1: Only active beneath the ocean and is assumed to be 1 foot thick[21];
- Layer 2: Dune Sand Aquifer;
- Layer 3: Salinas Valley Aquitard (if present);
- Layer 4: 180-Foot Aquifer;
- Layer 5: 400-Foot Aquifer;
- Layer 6: Aquitard, and;
- Layer 7: Deep Aquifer.

To further refine the model, GEOSCIENCE will update and revise the layer elevations, areal extent and thickness as additional data is collected during the hydrogeologic investigation. These revisions will be performed in subsequent phases using lithologic data, water quality data, and data from borehole geophysical surveys. The data will be used to refine geologic cross-sections and contours of model layers.

8.1.2 Refine Aquifer Parameters

The principal model aquifer parameters are:

- Horizontal and vertical hydraulic conductivity;
- Specific storativity;
- Specific yield, and;
- Leakance.

These aquifer parameters will be refined and appropriately distributed throughout the model extent and layers based on the data collected from the hydrogeologic investigations described in this work plan. Hydraulic conductivity, storativity and leakance will be refined based on results of the long-term pumping test conducted in the CEMEX test slant well. For areas without pumping test data, initial

[21] The sole purpose of Model Layer 1 is to allow vertical leakage from the ocean into the underlying aquifers.

hydraulic conductivity values will estimated based on lithology from the exploratory boreholes. Specific yield will be based on the updated SVIGSM.

8.2 Refine Boundary Conditions from Regional SVIGSM

Luhdorff & Scalmanini, Consulting Engineers is currently in the process of refining the SVIGSM, including boundary conditions within the confines of the conceptualized Salinas Valley Groundwater Basin. This revision includes added work to evaluate conditions in the alternate Project location on Potrero Road during model calibration. Since the Potrero Road alterative Project area is approximately 1.5 miles from the edge of the SVIGSM domain, additional groundwater level data along the model edge will be obtained and reviewed to verify the boundary conditions. GEOSCIENCE will prepare additional model input data for existing and new wells, ground water recharge, and general-head update. The NMGWM will then be recalibrated using the updated output files from the SVIGSM.

8.3 Incorporate Sea Level Rise

The refined NMGWM will incorporate sea level rise resulting from climate change. GEOSCIENCE will adjust the constant head (i.e., Pacific Ocean) values based on the estimated rise in sea level as provided by Environmental Science Associates. A sensitivity analysis will be developed to assess the potential for sea level rise to impact the boundary conditions input into the SEAWAT model from the SVIGWM.

8.4 Recalibrate Model Based on Existing and Recent Borehole and Test Data

Once the NMGWM refinement and recalibration of the SVIGSM is completed, a calibration run will be made for the NMGWM. The calibration run will cover the period from October 1945 to 2014[22] with a monthly stress period. The model calibration will be conducted in general accordance with the ASTM D5490-93 "Standard Guide for Comparing Ground-Water Flow Model Simulations to Site-Specific Information", ASTM D5981-96 "Standard Guide for Calibrating a Ground-Water Flow Model Application" and "Guidelines for Evaluating Ground-Water Flow Models"[23].

The calibration method for the NMGWM will be an industry standard "history matching" technique. In this method, a transient calibration period based on the data obtained from the SVIGSM and hydrogeologic investigation will be used. The transient model calibration will be simulated with a

[22] Based on the current Project schedule, pumping test data from the CEMEX test slant well is anticipated to be available for model input in 2014.

[23] U.S. Geological Survey, Scientific Investigations Report 2004-5038-Version 1.01, by Thomas E. Reilly and Arlen W. Harbaugh.

monthly stress period.[24] The model calibration will mainly focus on matching the available water quality the Dune Sand Aquifer and matching the seawater intrusion front in the 180-Foot Aquifer and 400-Foot Aquifer over time. The calibration process will consist of adjusting the hydraulic parameters (hydraulic conductivity, specific storativity, specific yield, and leakance), boundary conditions, and/or initial model conditions within reasonable ranges to obtain a match between the observed and simulated water levels and total dissolved solids (TDS) concentrations.

8.4.1 Water Level Data

Ground water level data from wells within the Project area, including those constructed for the hydrogeologic investigation, will be input into the NMGWM and used to extend the calibration period to 2014. The calibration process will use water level measurements from calibration target wells within the Project area, and will match model-generated head levels to measured values.

8.4.2 Water Quality Data

TDS concentration data collected from wells within the Project area, including those constructed for the hydrogeologic investigation, will be input into the NMGWM and used to extend the calibration period to 2014. The calibration process will use TDS values from calibration target wells within the Project area, and will match model-generated concentrations to measured values.

8.4.3 Model Calibration Results

Hydrographs of model-generated water levels will be prepared and used to compare to measured levels in the calibration target wells that are screened in the Dune Sand Aquifer, 180-Foot Aquifer, 400-Foot Aquifer, and Deep Aquifer. The agreement between model-generated water levels and measured water levels will be used to provide a graphic representation of calibration results. A histogram of water level residuals (i.e., measured levels less model-generated levels) will also be prepared.

To evaluate results of the solute transport model calibration, the model-generated seawater intrusion front for the 180-Foot Aquifer and 400-Foot Aquifer will be plotted and compared to the observed seawater intrusion front. Verification of the model-generated migration rate of the seawater intrusion front with the rate estimated from observed data will be performed.

[24] Stress period is the time length used to change model parameters such as ground water pumping and stream recharge.

8.4.4 Evaluate Future Impacts from the MPWSP

Once the NMGWM has been successfully calibrated, it will be used to evaluate project impacts to ground water levels and ground water quality in the region. Predictive scenarios will be developed based upon a further understanding of the extent and properties of the hydrostratigrahic units gained from the hydrogeologic investigation and in consideration of project goals. Evaluation of potential project impacts for specific terms is discussed in the following sections.

8.4.4.1 Changes in Seawater Intrusion Front

The amount of seawater intrusion into the project area as a result of the various project scenarios will be determined. Plots of the 500-mg/L chloride limit of the seawater intrusion in the 180-Foot and 400-Foot Aquifers at selected times over the model predictive period will be prepared. This information will then be used to determine how each Project scenario impacts the intrusion rate compared to baseline conditions (No Project).

8.4.4.2 Amount of Recharge to Feedwater Supply Wells from both Ocean and Inland Water Sources

Model-calculated TDS concentrations throughout the predictive period will be used to estimate the amount of seawater[25] contribution to the Project feedwater supply wells. Fluctuations in TDS concentration over time in the Project wells will be evaluated for response to varying hydrologic conditions (i.e., normal, dry and wet years).

8.4.4.3 Determination of Impacts to Inland Ground Water Supplies

Results of predictive scenarios for Project conditions will determine the timing and quantity of reduced pumping for the inland wells, which may be impacted by the MPWSP. The degree of seawater intrusion into inland wells as result of the various Project scenario productions will be determined by plotting TDS concentration over time in selected inland wells. A TDS concentration of greater than 500 mg/L chloride represents seawater intrusion into a freshwater aquifer.

8.4.4.4 Determination of Impacts to Riparian Habitat

Model-calculated ground water levels in the Dune Sand Aquifer will be used to determine the potential impacts to riparian habitat from the Project scenarios. Hydrographs of water level elevations in Project

[25] Seawater will be assumed to equal a TDS concentration of 35,000 mg/L.

target wells throughout the predictive period will be compared to a pre-determined minimum water level threshold for riparian habitat protection.

8.4.5 Provide Technical Basis for a Plan that Avoids Adverse Impacts to Ground Water Users and Protects Beneficial Uses in the Basin

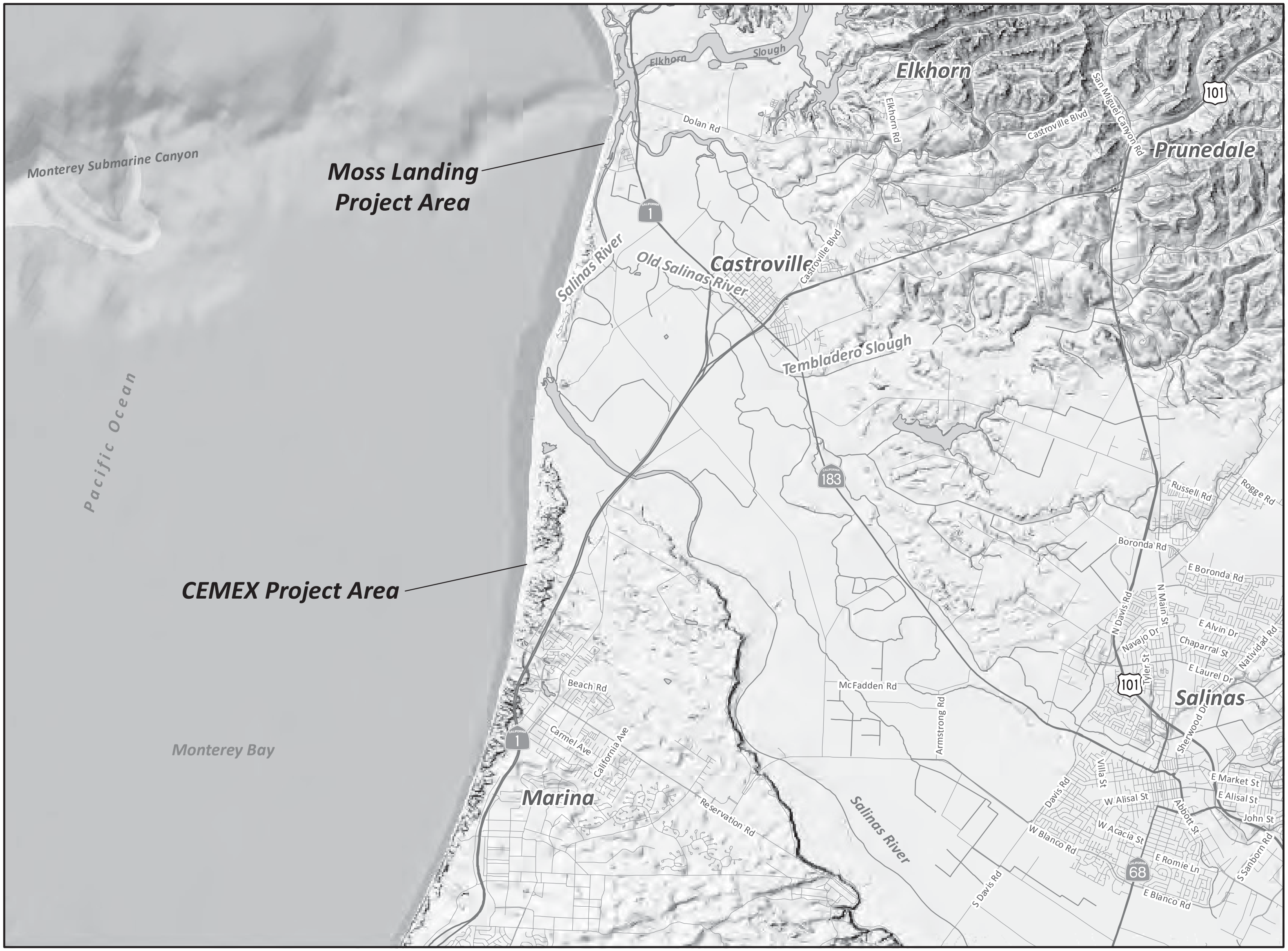
GEOSCIENCE will provide technical input and assist the MPWSP Hydrogeologist Working Group with the evaluation of additional studies needed to determine potential methods for replenishment of fresh water extracted by the project. In order to fulfill the State Water Resources Control Board's recommendation, these studies will form the basis for a plan that avoids adverse impacts to ground water users and protects beneficial uses in the Basin.

FIGURES

CALIFORNIA AMERICAN WATER/RBF CONSULTING

MONTEREY PENINSULA WATER SUPPLY PROJECT
HYDROGEOLOGIC INVESTIGATION WORK PLAN

GENERAL
PROJECT LOCATION



DRAFT

18-Dec-13

Prepared by: DWB. Map Projection: State Plane 1983, Zone IV.

GEOSCIENCE
GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

Figure 1-1

GIS_proj/mcwsp_cal_am//rbf_workplan_7-13/1_Fig_1-1_gen_loc_8x11_12-13.mxd

CALIFORNIA AMERICAN WATER/RBF CONSULTING

MONTEREY PENINSULA WATER SUPPLY PROJECT
HYDROGEOLOGIC INVESTIGATION WORK PLAN

MOSS LANDING
PROJECT AREA

DRAFT

18-Dec-13

Prepared by: DWB. Map Projection: State Plane 1983, Zone IV.

NORTH

0 250 500 1,000 Feet

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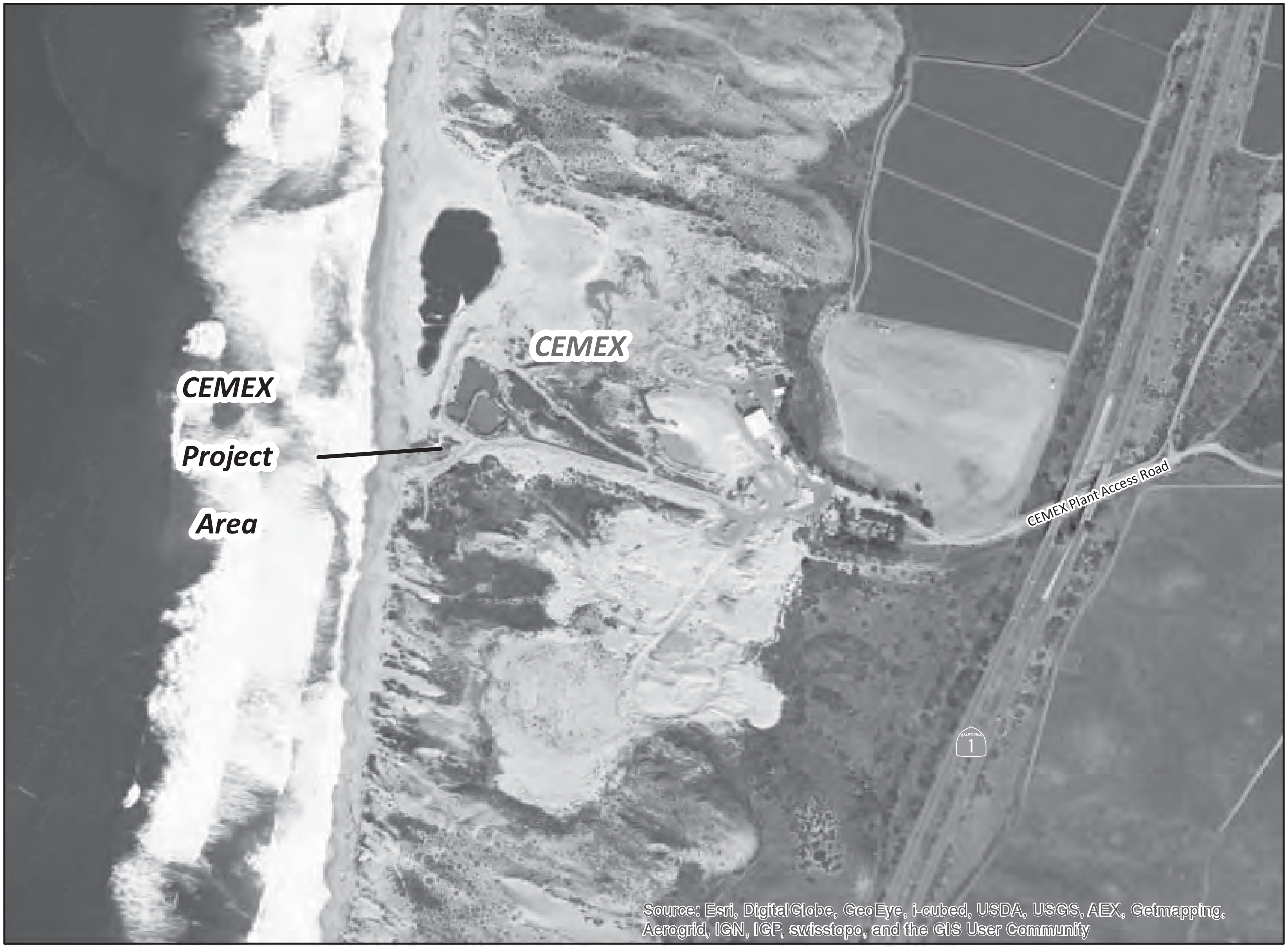
Figure 1-2

GIS_proj/mcwsp_cal_am//rbf_workplan_7-13/1_Fig_1-2_MossLanding_detail_8x11_12-13.mxd

CALIFORNIA AMERICAN WATER/RBF CONSULTING

MONTEREY PENINSULA WATER SUPPLY PROJECT
HYDROGEOLOGIC INVESTIGATION WORK PLAN

CEMEX PROJECT AREA



DRAFT

NORTH
0 250 500 1,000 Feet

18-Dec-13

Prepared by: DWB. Map Projection: State Plane 1983, Zone IV.

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Figure 1-3

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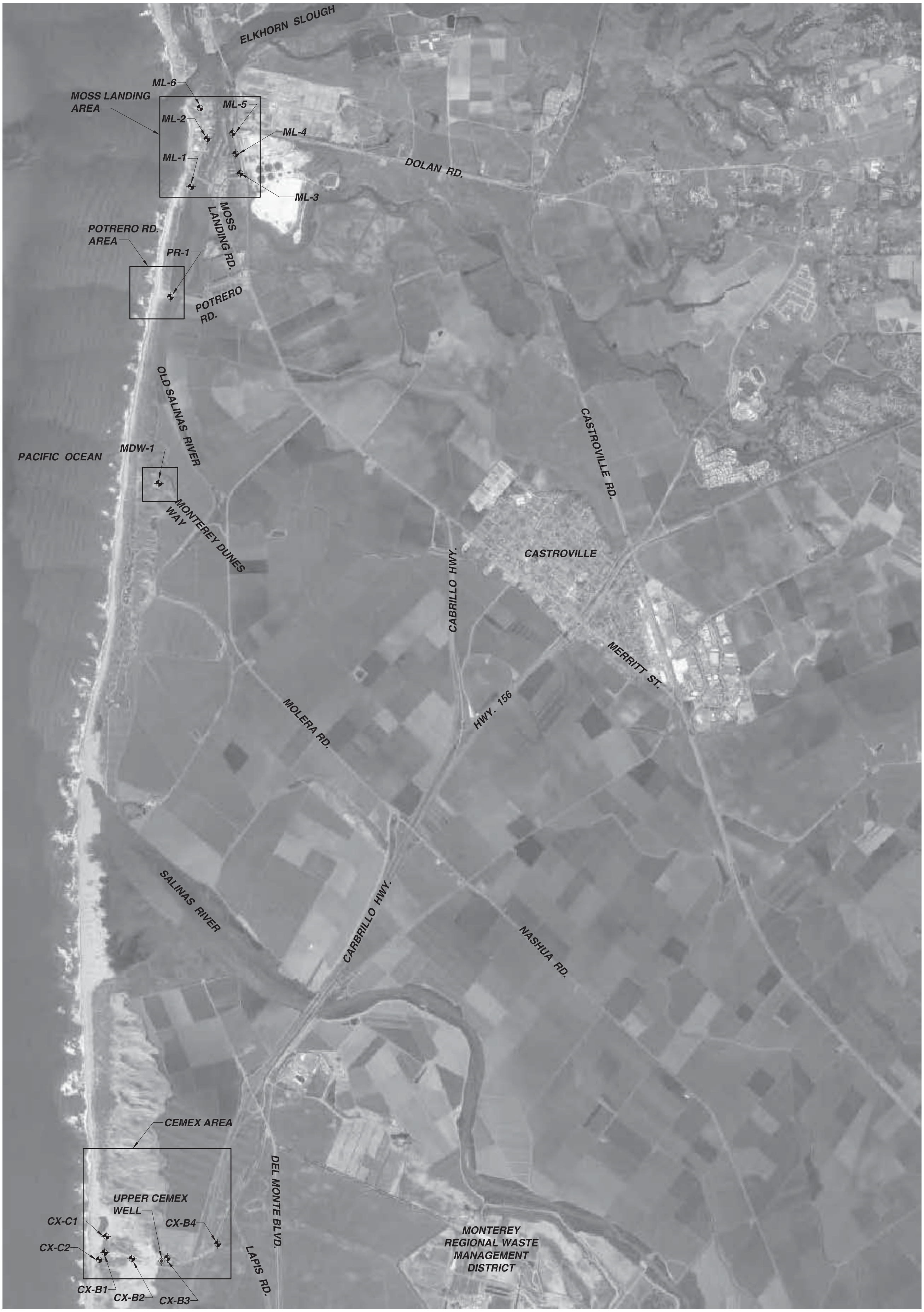

GENERAL NOTES:

1. LOCATION OF EXISTING FACILITIES SHOWN ON THIS MAP IS APPROXIMATE AND INTENDED FOR PURPOSES OF BIDDING. CONTRACTOR IS RESPONSIBLE FOR VERIFYING ACTUAL LOCATION PRIOR TO CONSTRUCTION.

PROPOSED EXPLORATORY BORING LOCATIONS

EXISTING WELLS

NORTH

0 1000 2000 3000

APPROXIMATE HORIZONTAL SCALE (FEET)

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MONTEREY PENINSULA WATER SUPPLY PROJECT

HYDROGEOLOGIC INVESTIGATION WORK PLAN

GENERAL LOCATION OF MOSS LANDING, POTRERO RD, AND CEMEX AREAS

Rev.	Date	By	Description
1			
2			
3			
4			

Date: 02-AUG-13

Designed: MDW

Checked: DEW

File: MSL-CLAM-3-0.dwg

FIGURE

3-0

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"SETTING THE STANDARD IN WATER WELL DESIGN SINCE 1978"

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MONTEREY PENINSULA WATER SUPPLY PROJECT	Date: 18-DEC-13	FIGURE
HYDROGEOLOGIC INVESTIGATION WORKPLAN	Designed: MDW	3-1
	Checked: DEW	
DETAILED SITE MAP - MONTEREY DUNES WAY PARKING LOTS	File: MSL-CLAM-3-1.dwg	

LEGEND:

PROPOSED EXPLORATORY BORING LOCATION

NORTH

0 50 100

APPROXIMATE HORIZONTAL SCALE (FEET)

GEOSCIENCE "SETTING THE STANDARD IN WATER WELL DESIGN SINCE 1978" 909.451.6650 | gssiwater.com			FIGURE
	MONTEREY PENINSULA WATER SUPPLY PROJECT	Date: 18-DEC-13	3-2
	HYDROGEOLOGIC INVESTIGATION WORKPLAN	Designed: MDW	
		Checked: DEW	
	DETAILED SITE MAP - PARKING AREA AT POTRERO RD	File: MSL-CLAM-3-2.dwg	

LEGEND:

PROPOSED EXPLORATORY BORING LOCATION

NORTH

0 50 100

APPROXIMATE HORIZONTAL SCALE (FEET)

GEOSCIENCE

"SETTING THE STANDARD IN WATER WELL DESIGN SINCE 1978"

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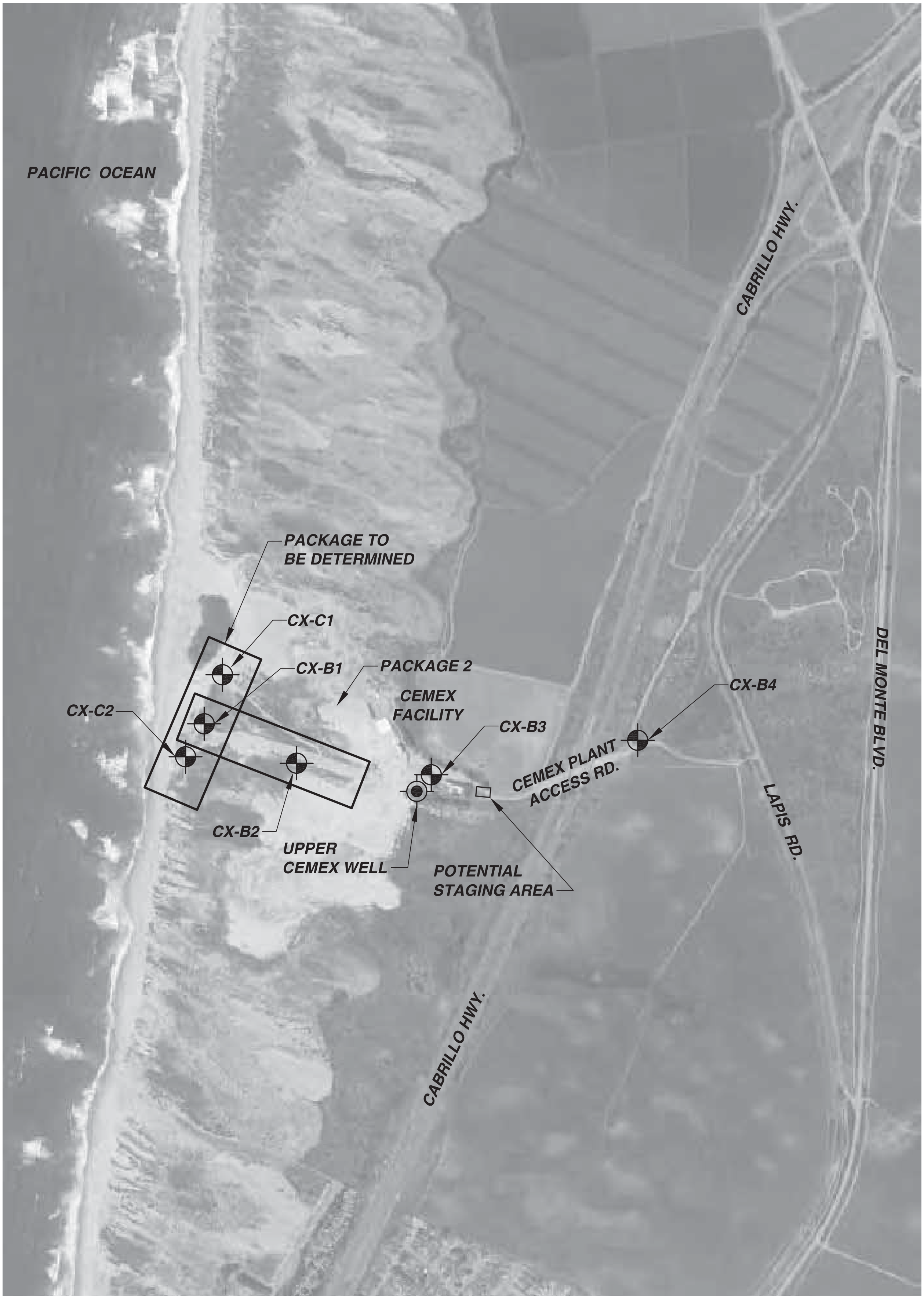
MONTEREY PENINSULA WATER SUPPLY PROJECT	Date: 18-DEC-13	FIGURE
HYDROGEOLOGIC INVESTIGATION WORKPLAN	Designed: MDW	3-3
	Checked: DEW	
DETAILED SITE MAP - PARKING AREA AT SANDHOLDT ROAD	File: MSL-CLAM-3-3.dwg	



LEGEND:

PROPOSED EXPLORATORY BORING LOCATIONS

UPPER CEMEX WELL

NORTH

0 800 1600

APPROXIMATE HORIZONTAL SCALE (FEET)

GEOSCIENCE

"SETTING THE STANDARD IN WATER WELL DESIGN SINCE 1978"

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MONTEREY PENINSULA WATER SUPPLY PROJECT	Date: 18-DEC-13	FIGURE
HYDROGEOLOGIC INVESTIGATION WORKPLAN	Designed: MDW	3-4
	Checked: DEW	
PROPOSED CEMEX AREA BOREHOLES	File: MSL-CLAM-3-4.dwg	

LEGEND:

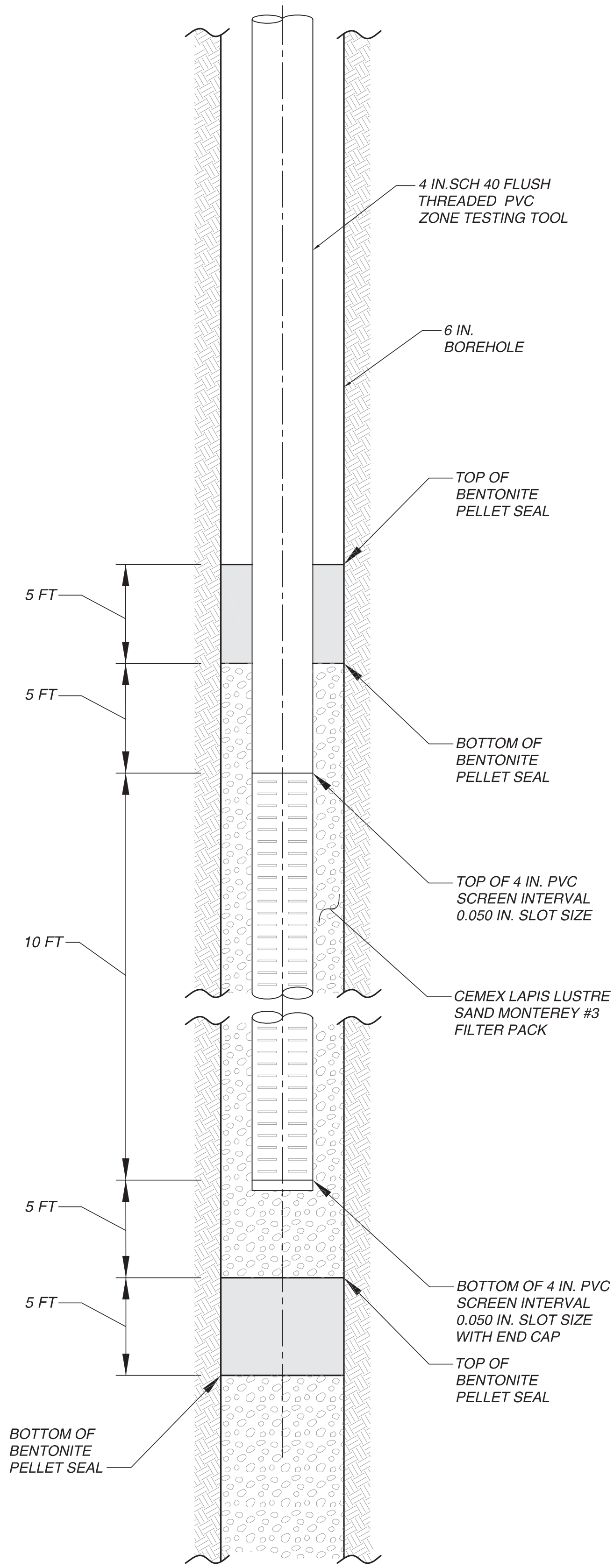
PROPOSED EXPLORATORY BORING LOCATIONS

NORTH

0 200 400

APPROXIMATE HORIZONTAL SCALE (FEET)

GEOSCIENCE "SETTING THE STANDARD IN WATER WELL DESIGN SINCE 1978" 909.451.6650 | gssiwater.com	MONTEREY PENINSULA WATER SUPPLY PROJECT	Date: 18-DEC-13	FIGURE
	HYDROGEOLOGIC INVESTIGATION WORKPLAN	Designed: MDW	3-5
		Checked: DEW	
	DETAILED SITE MAP - MOSS LANDING HARBOR AREA	File: MSL-CLAM-3-5.dwg	



PROFILE
NOT TO SCALE

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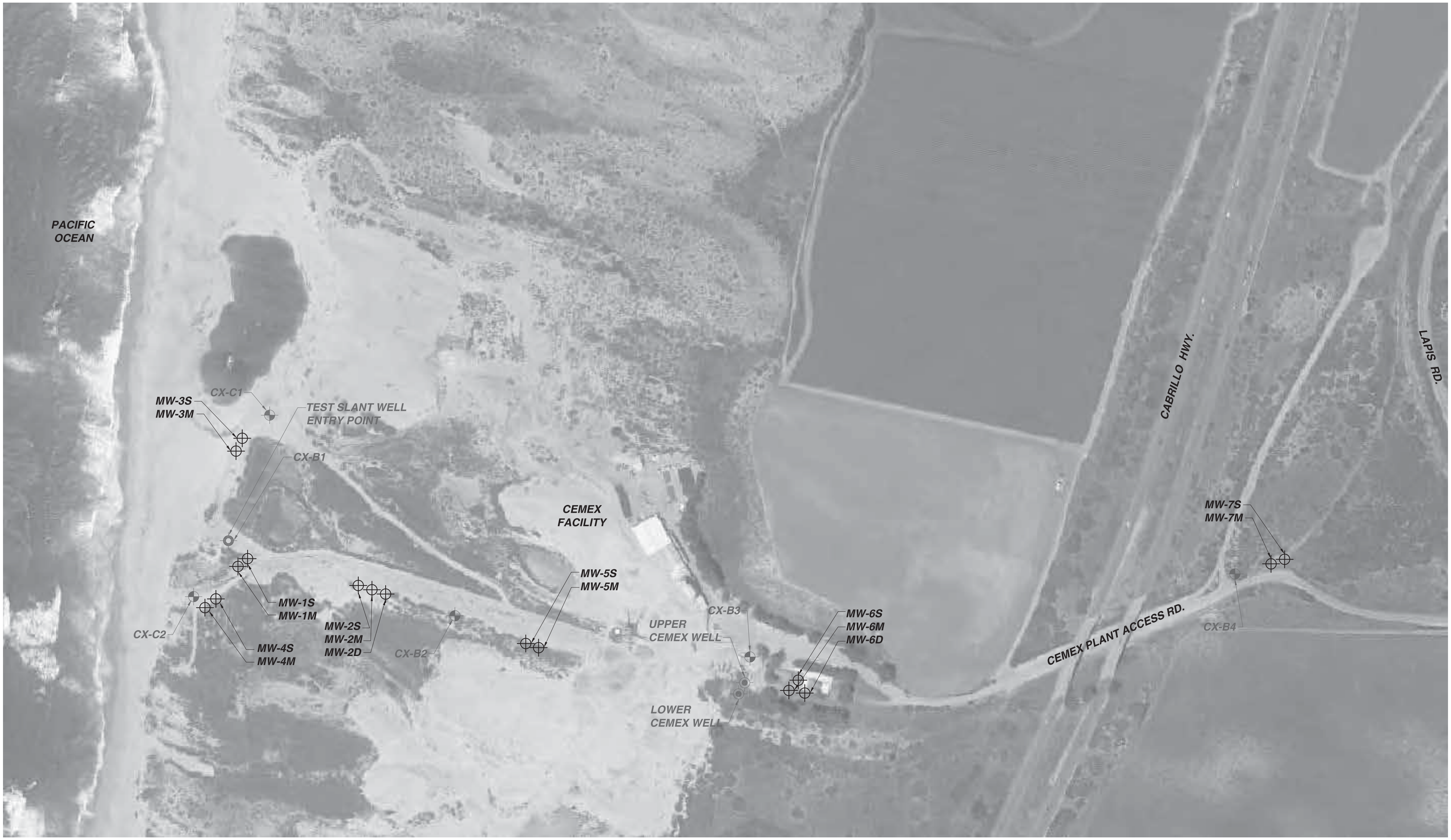
MONTEREY PENINSULA WATER SUPPLY PROJECT	Date: 18-DEC-13	FIGURE
HYDROGEOLOGIC INVESTIGATION WORKPLAN	Designed: MDW	3-6
	Checked: DEW	
DETAILED DRAWING - ISOLATED AQUIFER ZONE TESTING	File: MSL-CLAM-3-6.dwg	



LEGEND:

- PROPOSED EXPLORATORY BORING LOCATIONS
- EXISTING CEMEX WELL
- PROPOSED TEST SLANT WELL
- PROPOSED MONITORING WELLS

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PROJECT GEOHYDROLOGIST NO. DATE

MONTEREY PENINSULA WATER SUPPLY PROJECT

HYDROGEOLOGIC INVESTIGATION WORK PLAN

PROPOSED CEMEX MONITORING WELL LOCATIONS

Rev.	Date	By	Description
1			
2			
3			
4			

Date: 18-DEC-13
Designed: ---
Checked: ---
File: MSL-CLAM-04-1.dwg

FIGURE
4-1

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PROJECT GEOHYDROLOGIST NO. DATE

PROPOSED CEMEX AREA MONITORING WELL LOCATIONS - PHASE 1 WELLS (SHORT-TERM TESTING)

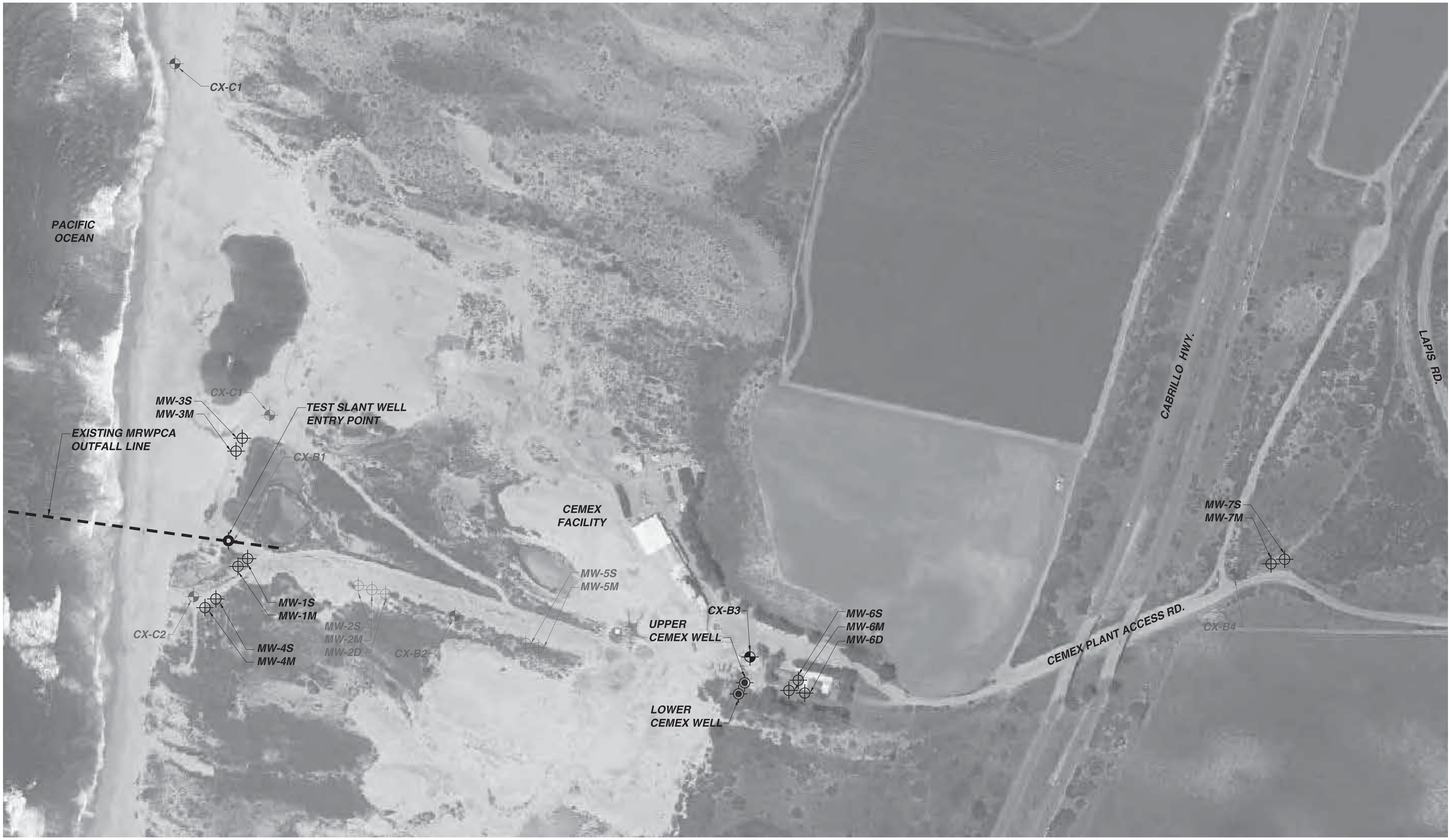
HYDROGEOLOGIC INVESTIGATION WORKPLAN

PREPARED FOR: CALIFORNIA AMERICAN WATER / RBF CONSULTING

Rev.	Date	By	Description
1			
2			
3			
4			

Date: 18-DEC-13
Designed: ---
Checked: ---
File: MSL-CLAM-04-2.dwg

FIGURE
4-2



LEGEND:

- PROPOSED EXPLORATORY BORING LOCATIONS
- EXISTING CEMEX WELL
- PROPOSED TEST SLANT WELL
- PROPOSED MONITORING WELLS

NORTH
0 100 200 300
APPROXIMATE HORIZONTAL SCALE (FEET)

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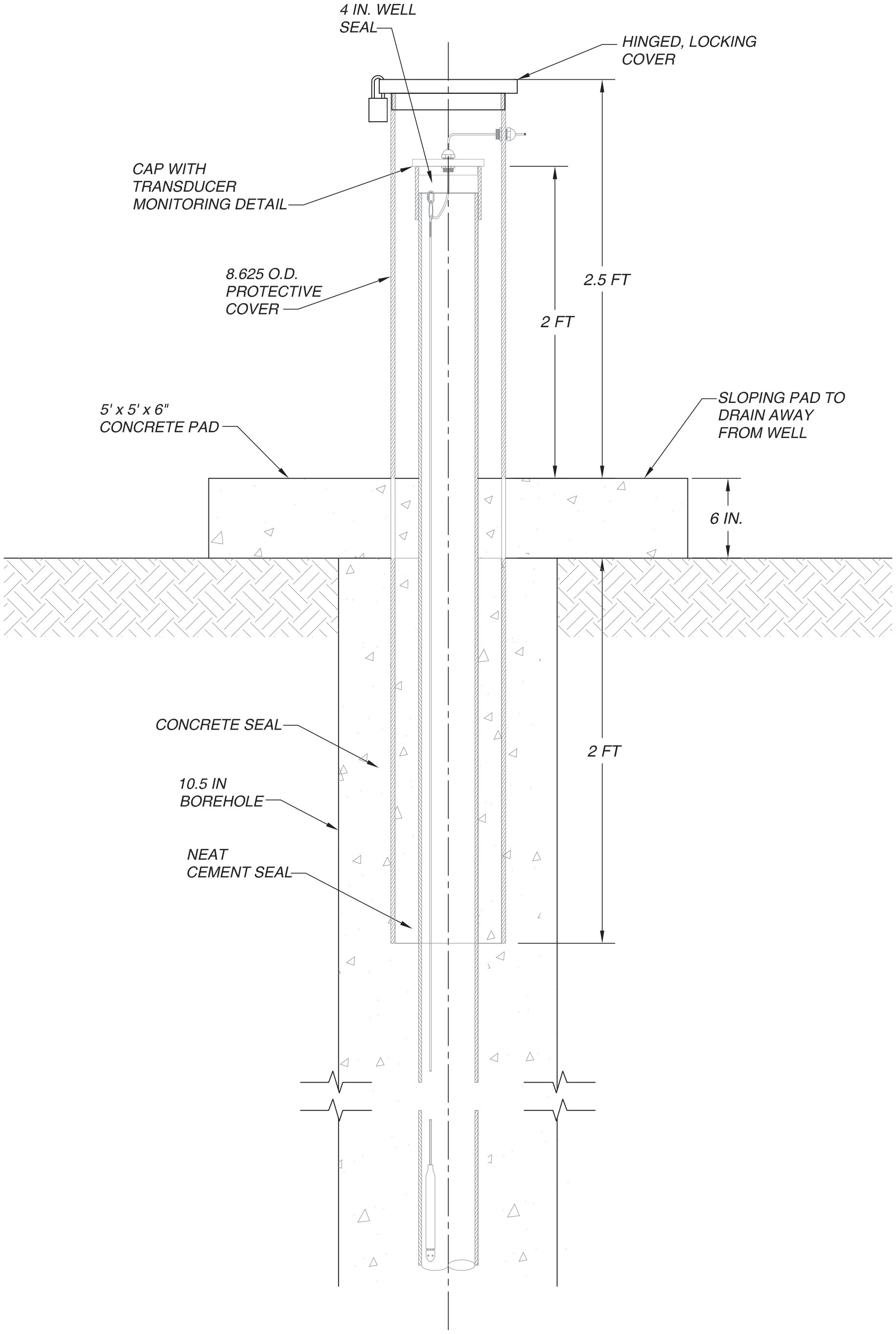
PROJECT GEOHYDROLOGIST	NO.	DATE

PROPOSED CEMEX AREA MONITORING WELL LOCATIONS - PHASE 2 WELLS (LONG-TERM TESTING)
HYDROGEOLOGIC INVESTIGATION WORKPLAN
PREPARED FOR: CALIFORNIA AMERICAN WATER/RBF CONSULTING

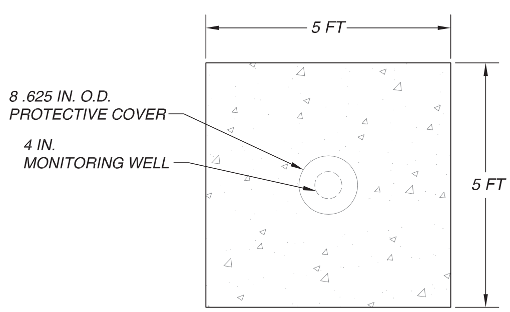
Rev.	Date	By	Description
1			
2			
3			
4			

Date: 18-DEC-13
Designed: ---
Checked: ---
File: MSL-CLAM-04-3.dwg

FIGURE
4-3



PROFILE
NOT TO SCALE



PLAN
NOT TO SCALE

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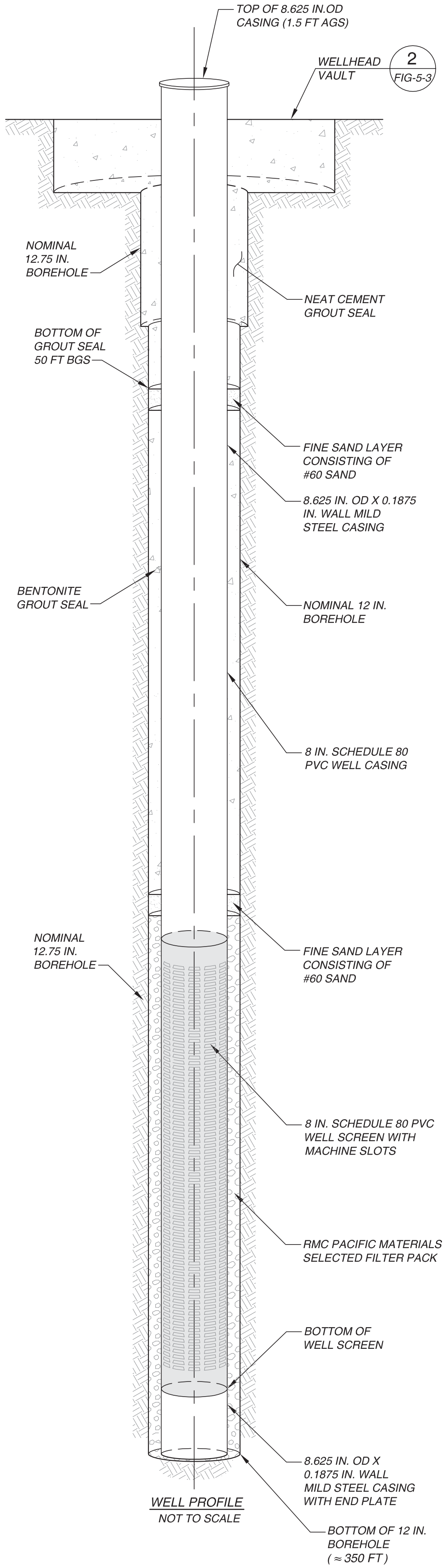
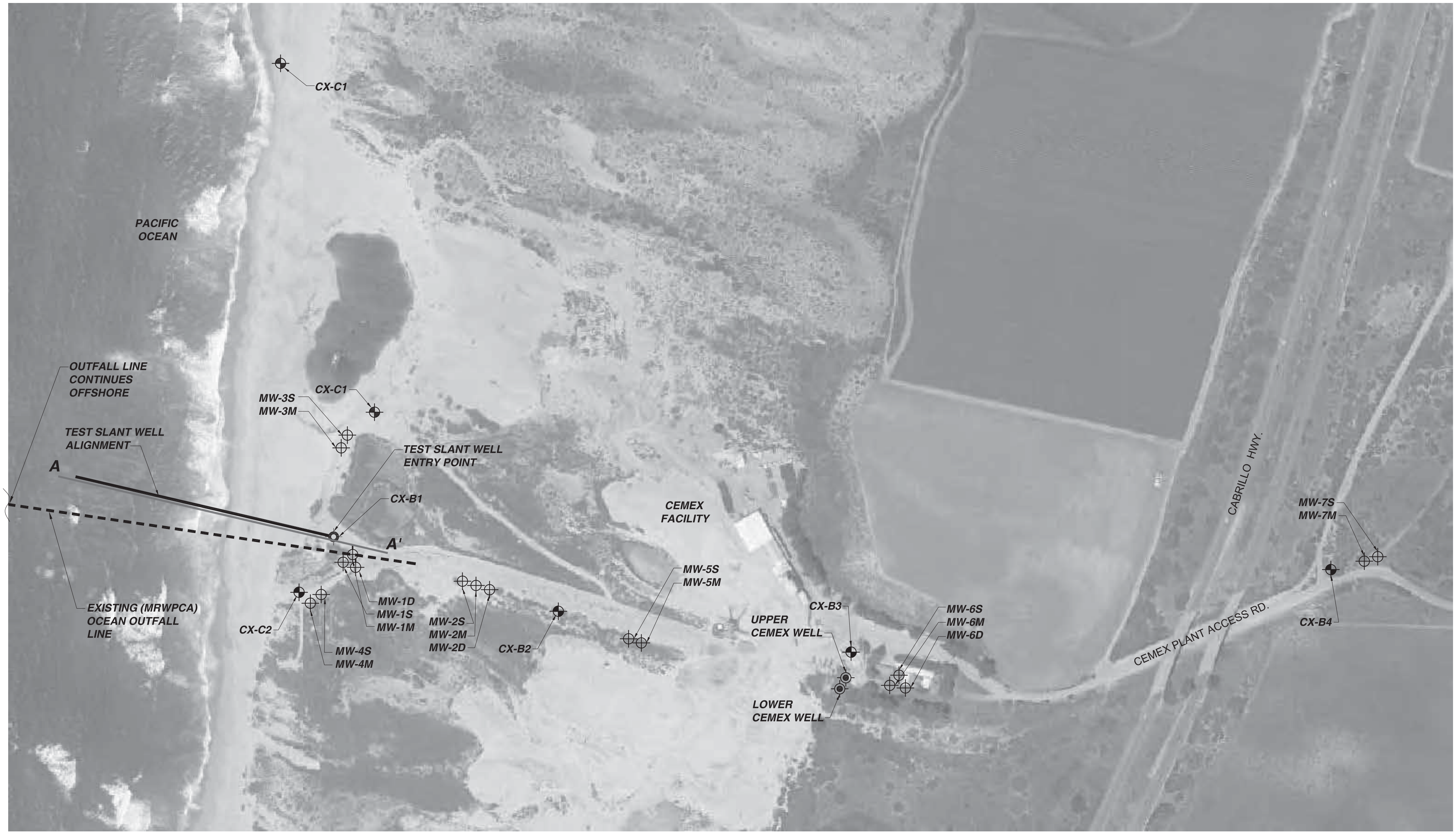
MONTEREY PENINSULA WATER SUPPLY PROJECT	Date: 18-DEC-13	FIGURE
HYDROGEOLOGIC INVESTIGATION WORKPLAN	Designed: MDW	4-4
	Checked: DEW	
MONITORING WELL WELLHEAD DETAIL - MONUMENT COVER AND WELL PAD	File: MSL-CLAM-04-4.dwg	



WELL PROFILE
NOT TO SCALE

GEOSCIENCE "setting the standard in water well design since 1978" 909.451.6650 | gssiwater.com	CALIFORNIA AMERICAN WATER	Date: 12-SEP-13	CLIENT: MONTEREY PENINSULA WATER SUPPLY PROJECT	FIGURE
		Drawn: MDN	PROJECT: HYDROGEOLOGIC INVESTIGATION WORKPLAN	4-5
		Checked: DEW		
		Approved:	CONCEPTUAL MONITORING TEST WELL DESIGN	



LEGEND:

- PROPOSED EXPLORATORY BORING LOCATIONS
- EXISTING CEMEX WELL
- PROPOSED TEST SLANT WELL
- PROPOSED MONITORING WELLS

LEGEND:

A——A' CROSS SECTION LINE (SEE FIGURE 5-2)

NORTH
0 100 200 300
APPROXIMATE HORIZONTAL SCALE (FEET)

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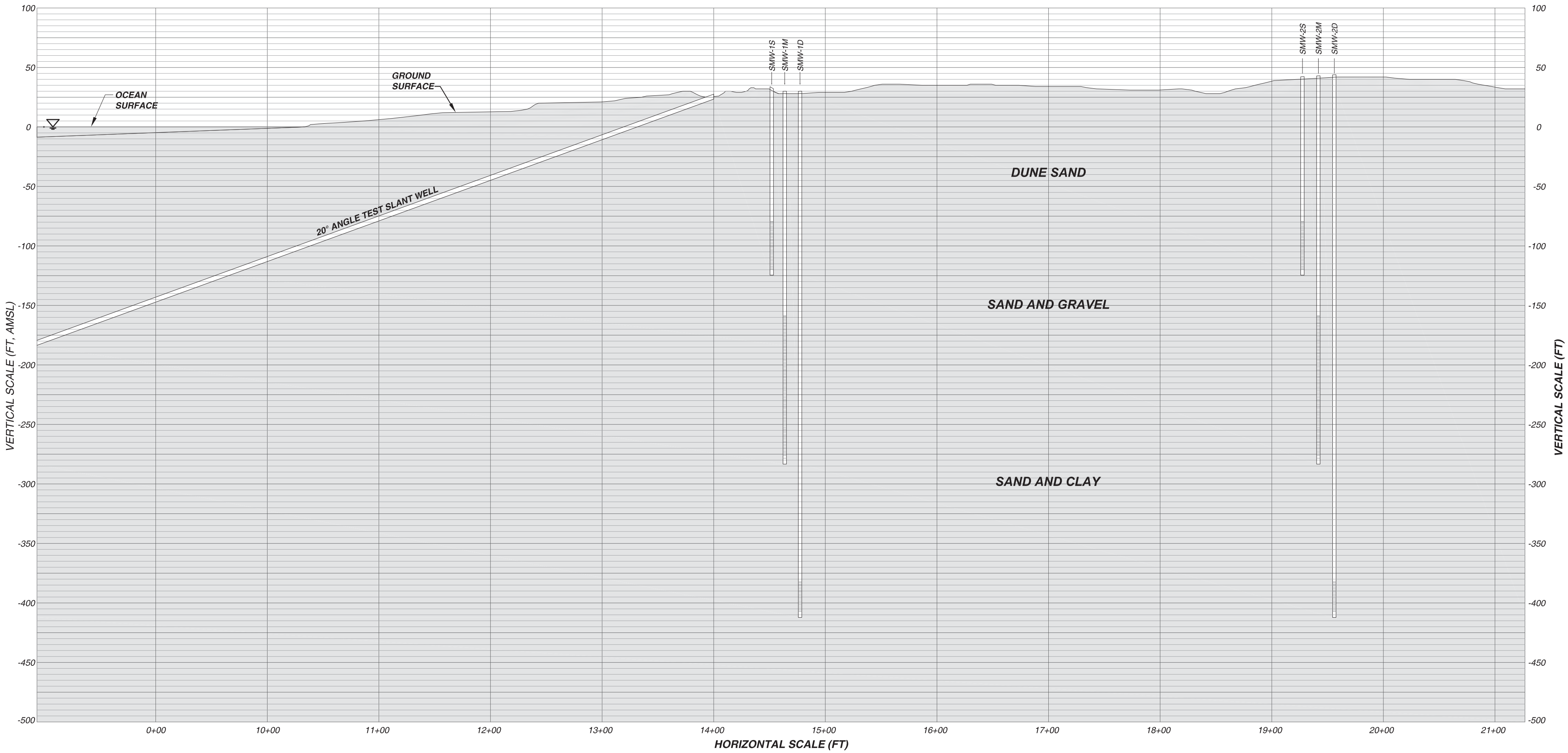
PROJECT GEOHYDROLOGIST NO. DATE

MONTEREY PENINSULA WATER SUPPLY PROJECT
HYDROGEOLOGIC INVESTIGATION WORK PLAN
LOCATION OF TEST SLANT WELL

Rev.	Date	By	Description
1			
2			
3			
4			

Date: 18-DEC-13
Designed: ---
Checked: ---
File: MSL-CLAM-5-1.dwg

FIGURE
5-1



GENERAL NOTES:

1. FINAL DEPTHS OF MONITORING WELL SCREENS AND IDENTIFICATION OF AQUIFERS WILL BE BASED ON EXPLORATORY BOREHOLES.

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PROJECT GEOHYDROLOGIST NO. DATE

MONTEREY PENINSULA WATER SUPPLY PROJECT

HYDROGEOLOGIC INVESTIGATION WORK PLAN

GEOLOGICAL CROSS SECTION THROUGH TEST SLANT WELL AND MONITORING WELLS

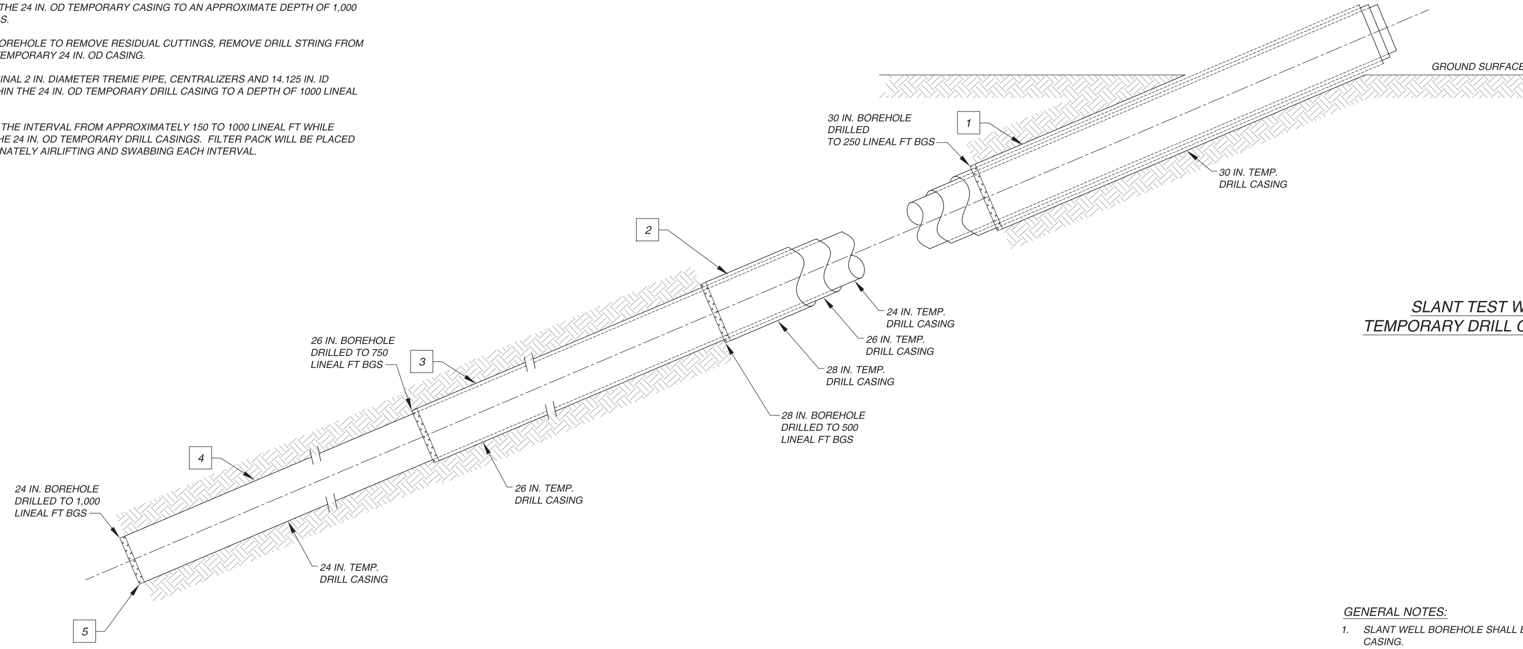
Rev.	Date	By	Description
1			
2			
3			
4			

Date: 18-DEC-13
Designed: ---
Checked: ---
File: MSL-CLAM-5-2.dwg

FIGURE 5-2

DRAWING NOTES - SLANT WELL CONSTRUCTION:

1. DRILL TEMPORARY 30 IN. OD CASING TO A DEPTH OF 250 LINEAL FT BGS.
2. SET TEMPORARY 28 IN. CASING TO THE BOTTOM OF THE 30 IN. CASING, AND ADVANCE BY DRILLING THE 28 IN. OD TEMPORARY CASING TO AN APPROXIMATE DEPTH OF 500 LINEAL FT BGS.
3. SET TEMPORARY 26 IN. CASING TO THE BOTTOM OF THE 28 IN. CASING, AND ADVANCE BY DRILLING THE 26 IN. OD TEMPORARY CASING TO AN APPROXIMATE DEPTH OF 750 LINEAL FT BGS.
4. SET TEMPORARY 24 IN. CASING TO THE BOTTOM OF THE 26 IN. CASING, AND ADVANCE BY DRILLING THE 24 IN. OD TEMPORARY CASING TO AN APPROXIMATE DEPTH OF 1,000 LINEAL FT BGS.
5. FLUSH THE BOREHOLE TO REMOVE RESIDUAL CUTTINGS, REMOVE DRILL STRING FROM WITHIN THE TEMPORARY 24 IN. OD CASING.
6. INSTALL NOMINAL 2 IN. DIAMETER TREMIE PIPE, CENTRALIZERS AND 14.125 IN. ID SCREEN WITHIN THE 24 IN. OD TEMPORARY DRILL CASING TO A DEPTH OF 1000 LINEAL FT BGS.
7. FILTER PACK THE INTERVAL FROM APPROXIMATELY 150 TO 1000 LINEAL FT WHILE REMOVING THE 24 IN. OD TEMPORARY DRILL CASINGS. FILTER PACK WILL BE PLACED WHILE ALTERNATELY AIRLIFTING AND SWABBING EACH INTERVAL.



SLANT TEST WELL BOREHOLE TEMPORARY DRILL CASING INSTALLATION

GENERAL NOTES:

1. SLANT WELL BOREHOLE SHALL BE SUPPORTED DURING DRILLING USING TEMPORARY CASING.
2. CASING LENGTHS SHOWN REPRESENT MINIMUM DISTANCES AT A GIVEN BOREHOLE DIAMETER.
3. THE BOTTOM OF EACH BOREHOLE CASING STRING SHALL HAVE A TUNGSTEN - CARBIDE GUIDE SHOE. WHICH PERMITS CASING TO BE REMOVED WITH A MINIMUM CHANCE OF BINDING.
4. TEMPORARY BOREHOLE SUPPORT CASING SHALL BE FIELD WELDED IN A MANNER, WHICH ENSURES THE INTEGRITY OF THE CASING STRING AND MINIMIZES BINDING DURING INSTALLATION OR REMOVAL.
5. THE CONTRACTOR SHALL BEGIN PLACING ALL REQUIRED MATERIALS IN THE WELL BORE WITHOUT LEAVING SUBSTANTIAL PORTIONS OF THE WELL BORE UNSUPPORTED.
6. 14.125 IN. I.D. WELL CASING AND SCREEN SHALL BE PLACED IN THE SLANT WELL USING DRILL PIPE AND SETTING SUB ATTACHED TO THE TOP OF THE 12 IN. WELL SCREEN.
7. THE CONTRACTOR SHALL ENSURE COMPLETE PLACEMENT OF THE ARTIFICIAL FILTER PACK IN THE SLANT WELL ANNULUS AND SHALL APPROVE METHODS FOR PACK PLACEMENT WITH THE GEOHYDROLOGIST.
8. DURING DRILLING OF EACH BOREHOLE, LITHOLOGIC SAMPLES SHALL BE COLLECTED AS DIRECTED FOR SIEVE ANALYSIS TO VERIFY THE FILTER PACK GRADATION AND SLOT SIZE SELECTION.

ABBREVIATIONS LIST:

AGS ABOVE GROUND SURFACE
BGS BELOW GROUND SURFACE
CON. CONNECTION
I.D. INSIDE DIAMETER
O.D. OUTSIDE DIAMETER

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PROJECT GEOHYDROLOGIST NO. DATE

MONTEREY PENINSULA WATER SUPPLY PROJECT
HYDROGEOLOGIC INVESTIGATION WORK PLAN
TEST SLANT WELL CONSTRUCTION DESIGN

Rev.	Date	By	Description
1			
2			
3			
4			

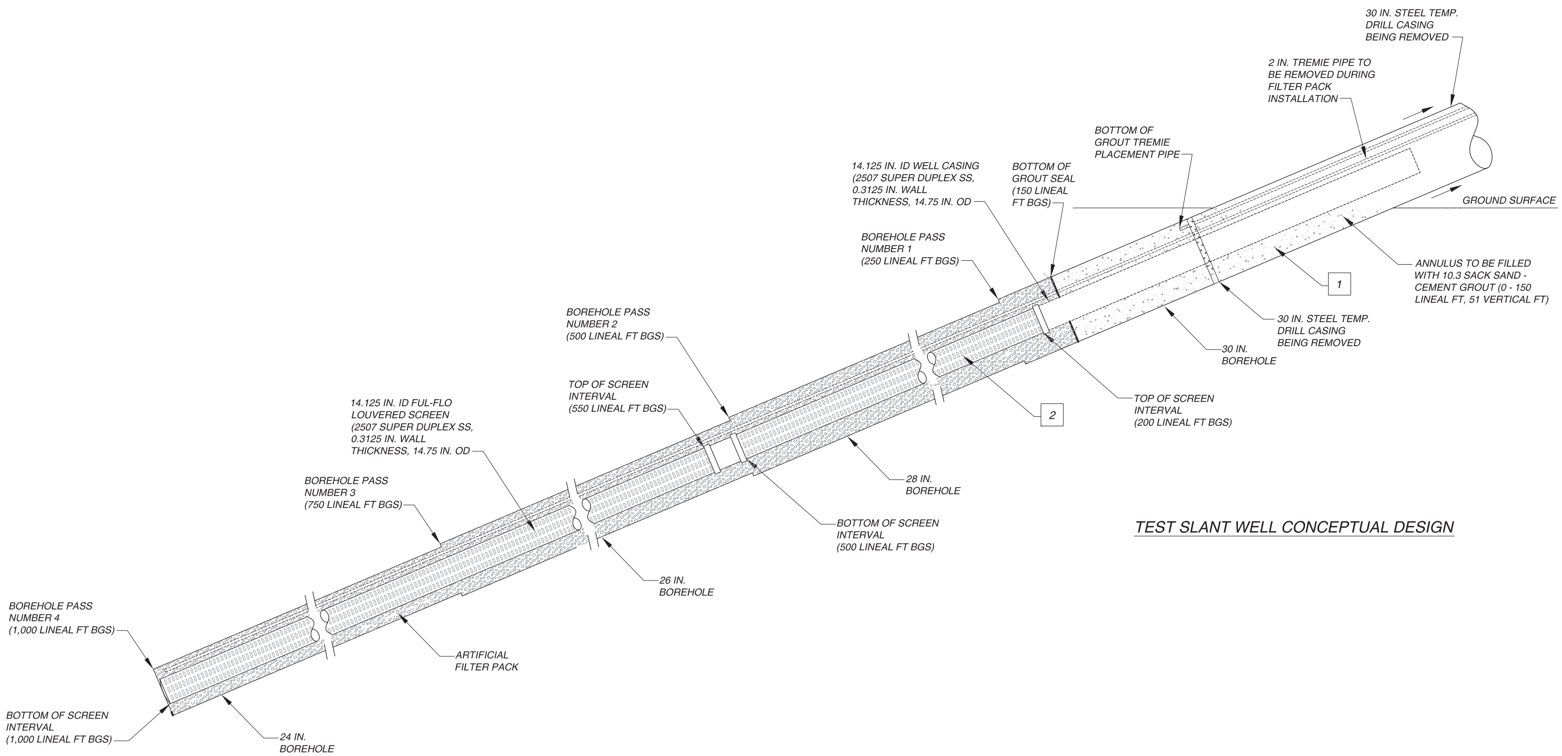
Date: 18-DEC-13
Designed: ---
Checked: ---
File: MSL-CLAM-5-3.dwg

FIGURE 5-3

DRAWING NOTES - SLANT WELL CONSTRUCTION:

1. INSTALL 10.3 SACK SAND-CEMENT GROUT (PUMPED THROUGH A TREMIE) BETWEEN THE 14.75 IN. OD WELL CASING AND THE 30 IN. CASING (FROM 0 TO 150 FT), WHILE REMOVING THE 30 IN. OD TEMPORARY DRILL CASING FROM THE BOREHOLE.

2. DEVELOP ENTIRE SCREEN INTERVAL (FROM 1000 TO 200 FT) BY AIRLIFTING AND SWABBING, WHILE TAGGING AND TOPPING OFF FILTER PACK IN ANNULAR SPACE AS NECESSARY.



TEST SLANT WELL CONCEPTUAL DESIGN

ABBREVIATIONS LIST:

AGS ABOVE GROUND SURFACE
BGS BELOW GROUND SURFACE
CON. CONNECTION
I.D. INSIDE DIAMETER
O.D. OUTSIDE DIAMETER

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PROJECT GEOHYDROLOGIST NO. DATE

MONTEREY PENINSULA WATER SUPPLY PROJECT
HYDROGEOLOGIC INVESTIGATION WORK PLAN
CONCEPTUAL TEST SLANT WELL DESIGN

Rev.	Date	By	Description
1			
2			
3			
4			

Date: 18-DEC-13
Designed: ---
Checked: ---
File: MSL-CLAM-5-4.dwg

FIGURE 5-4

Example of Step Drawdown Pumping Test Plot

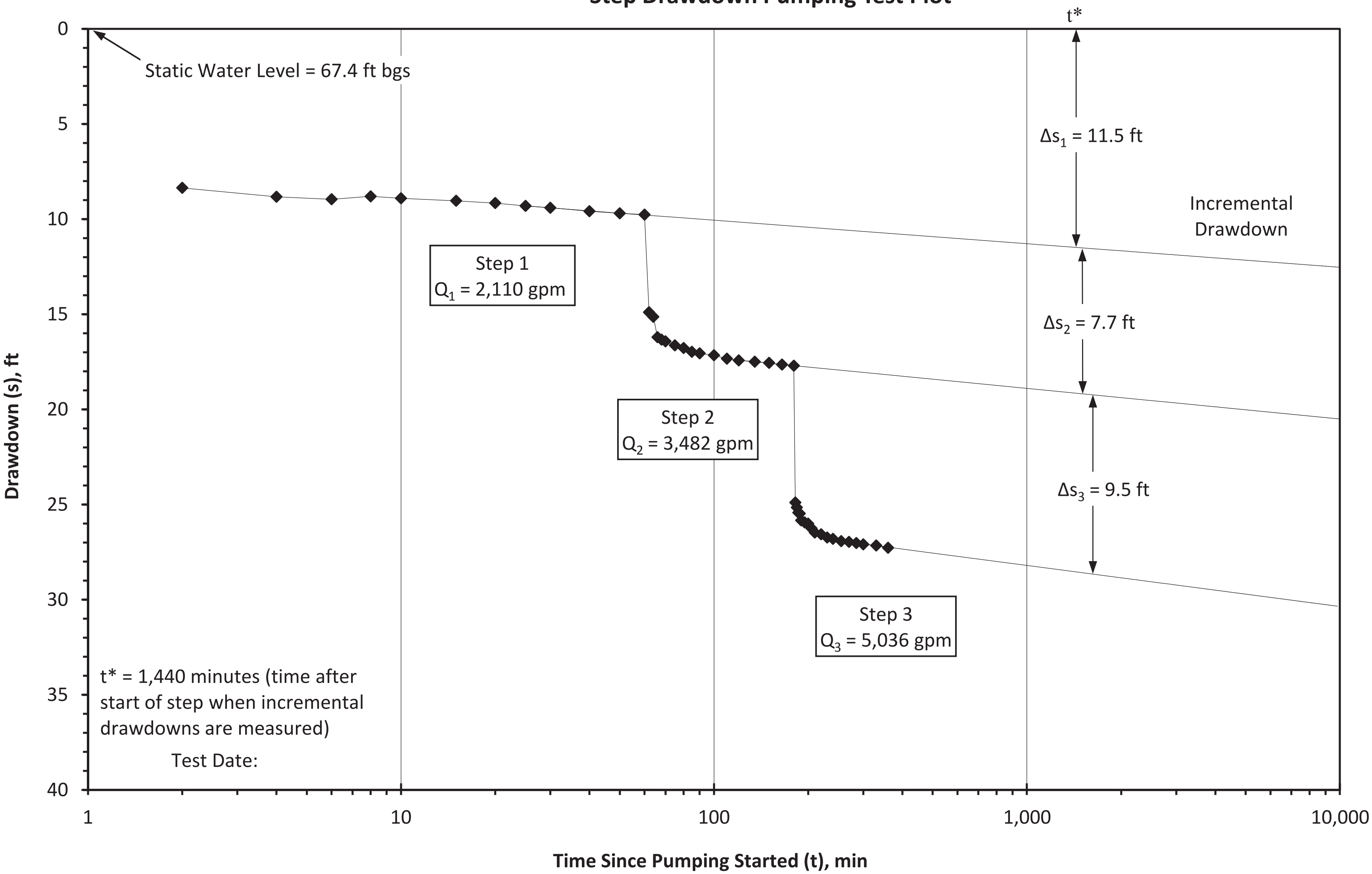


Figure 5-5

Example of Constant Rate Pumping Test Data Plot

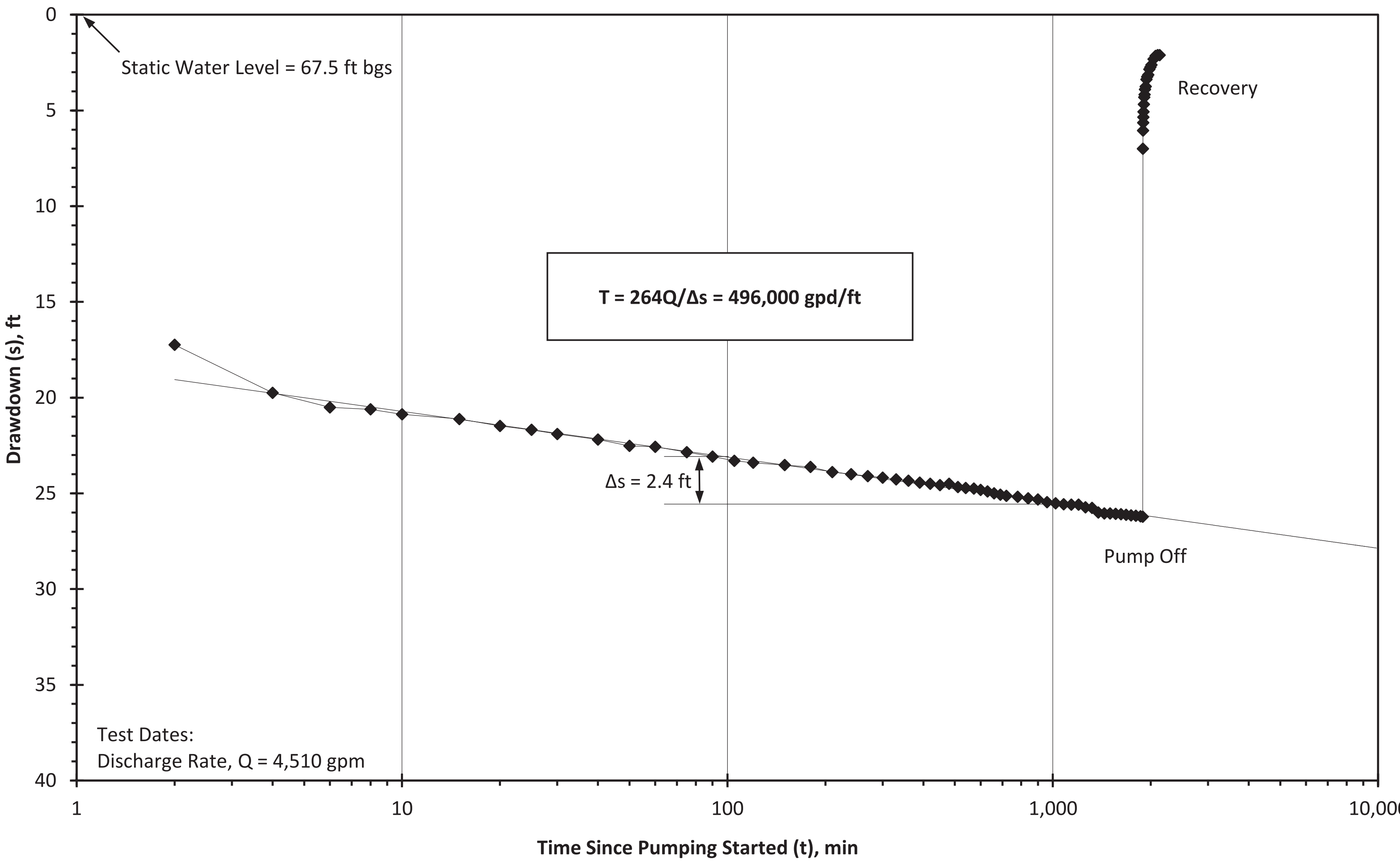
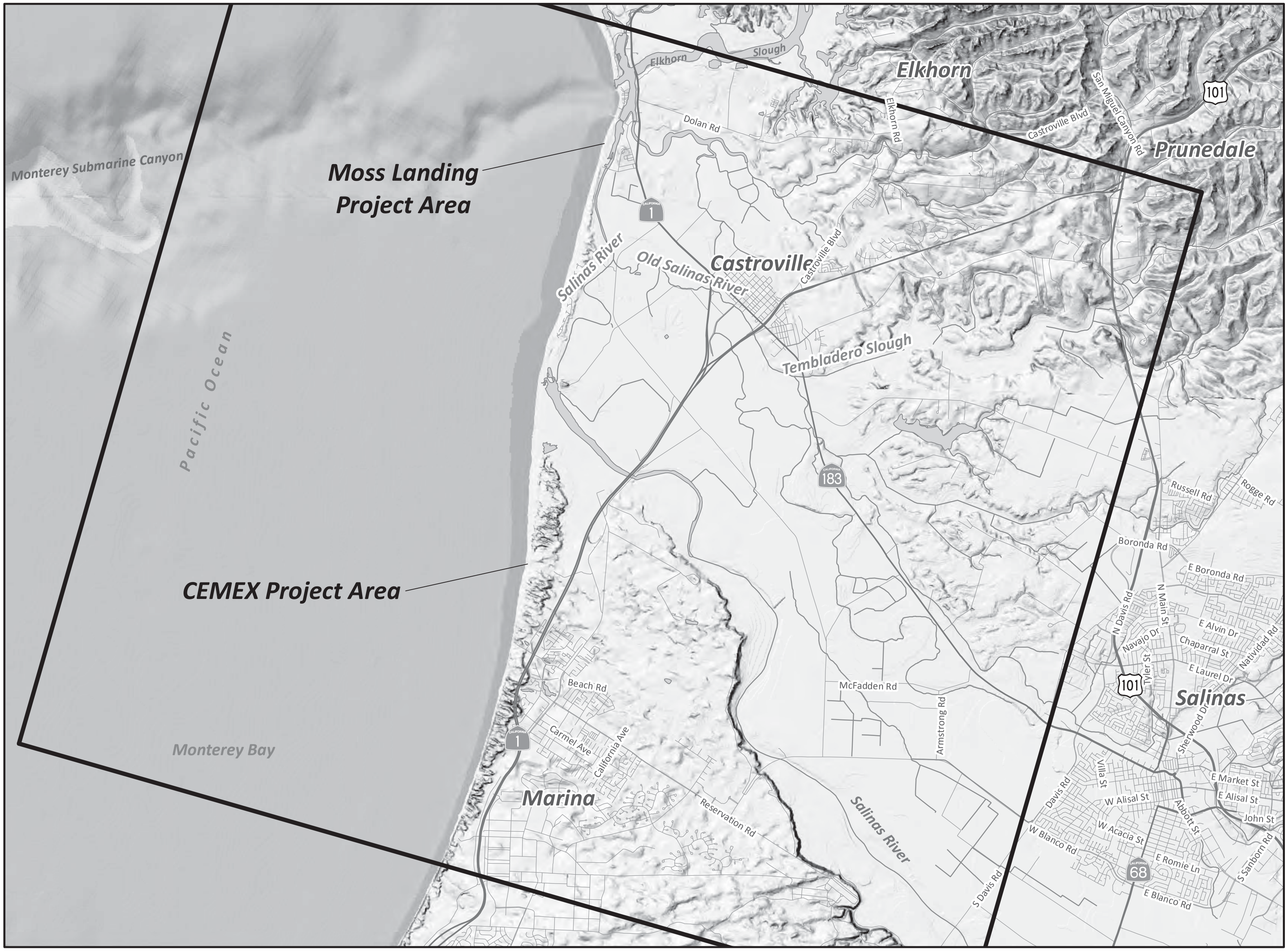


Figure 5-6

CALIFORNIA AMERICAN WATER/RBF CONSULTING

MONTEREY PENINSULA WATER SUPPLY PROJECT
HYDROGEOLOGIC INVESTIGATION WORK PLAN

NORTH MARINA GROUND WATER MODEL



EXPLANATION

North Marina Ground Water Model Boundary

DRAFT

18-Dec-13

Prepared by: DWB. Map Projection: State Plane 1983, Zone IV.

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Figure 8-1

GIS_proj/mcwsp_cal_am//rbf_workplan_7-13/1_Fig_8-1_model_bndry_8x11_12-13.mxd

APPENDIX A

Sampling and Analysis Plan for Monterey Peninsula Water Supply Project Hydrogeologic Investigation Work Plan

GEOSCIENCE

APPENDIX A

SAMPLING AND ANALYSIS PLAN FOR MONTEREY PENNISULA WATER SUPPLY PROJECT HYDROGEOLOGIC INVESTIGATION WORK PLAN

CONTENTS

FIELD FORMS

APPENDIX A

SAMPLING AND ANALYSIS PLAN FOR MONTEREY PENINSULA WATER SUPPLY PROJECT HYDROGEOLOGIC INVESTIGATION WORK PLAN

1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) describes field sampling procedures including water level measurements, ground water sampling, QA/QC, and data management procedures to be used for the proposed ground water sampling program. All field work should be performed in accordance with applicable Site Health and Safety Plan (HASP). These HASP documents will change with each phase of the project and will be included in the appendices to the technical specifications for each phase of work. Data gathered during this investigation will be reviewed and analyzed in order to:

- Characterize the baseline water quality in the aquifer systems;
- Evaluate potential water quality changes during the long-term test slant well pumping test, and;
- Update the water quality component of the NMGWM.

Table 1-1 below provides a list of water quality constituents that will be measured in ground water, along with the reporting limit and analytical method for each water quality parameter.

Table 1-1. Water Quality Analyses

Constituent	Units	Method Reporting Limit	Method
Physical Properties			
Color	Color Units	3.0	SM 2120B/EPA 110.2
Odor	T.O.N.		EPA 140.1
Oxidation-Reduction Potential (Field)	mV	-	Field Meter - Myron L 6PII
pH (Lab)	Units	0.10	SM 4500 H+B
pH (Field)	Units	-	Field Meter - YSI Pro Plus
Turbidity (Laboratory)	NTU	0.20	EPA 180.1/SM 2130B
Turbidity (Field)	NTU	-	Field Meter - Hach 2100P
Temperature (Field)	°C	-	Field Meter - YSI Pro Plus
Dissolved Oxygen (Field)	mg/L	-	Field Meter - YSI Pro Plus
Silt Density Index (Field)	-	-	ASTM D4189-07
Threshold Odor Number	T.O.N.	1.0	EPA 140.1/SM 2150
Total Dissolved Solids (Lab)	mg/L	10	SM 2540 C
Total Dissolved Solids (Field)	mg/L	-	Field Meter - YSI Pro Plus

Constituent	Units	Method Reporting Limit	Method
Specific Conductance (Lab)	µmhos/cm	1	SM 2510 B
Specific Conductance (Field)	µS/cm	-	Field Meter - YSI Pro Plus
General Minerals			
Total Cations	meq/L	-	Calculation
Total Anions	meq/L	-	Calculation
Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Bicarbonate Alkalinity as HCO_3	mg/L	3	SM 2320 B
Carbonate Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Hydroxide Alkalinity as $CaCO_3$	mg/L	3	SM 2320 B
Total Hardness as $CaCO_3$	mg/L	3	Calculation
Aluminum	?g/L	1	EPA 200.7
Arsenic	?g/L	1	EPA 200.7 / EPA 200.8
Barium, Dissolved	?g/L	0.01	EPA 200.7
Boron, Dissolved	?g/L	0.5	EPA 200.8
Bromide, Dissolved	mg/L	0.1	EPA 326.0
Calcium, Dissolved	mg/L	1	EPA 200.7
Chloride, Dissolved	mg/L	1	EPA 300.0
Copper, Total	µg/L	50	EPA 200.7
Fluoride, Dissolved	mg/L	0.10	EPA 300.0 / SM 4500 FC
Iodide, Dissolved	mg/L	0.1	USGS I-2371 / EPA 9056A
Iron, Dissolved	µg/L	100	EPA 200.7 / EPA 200.8
Iron, Total	µg/L	100	EPA 200.7 / EPA 200.8
Lithium	?g/L	10	EPA 200.7 / EPA 6010B
Magnesium, Dissolved	mg/L	1	EPA 200.7
Manganese, Dissolved	µg/L	20	EPA 200.7 / EPA 200.8
Manganese, Total	µg/L	20	EPA 200.7 / EPA 200.8
MBAS	mg/L	0.050	SM 5540 C / EPA 200.8
Nitrogen, Nitrate as NO_3	mg/L	1	EPA 353.2 / EPA 300.0
Nitrogen, Nitrite, Dissolved	mg/L as N	1	SM 4500 NO_2B
Nitrogen, NO_2 + NO_3	mg/L as N	1	EPA 300.0
Nitrogen, Ammonia, Dissolved	mg/L as N	0.1	SM 4500 NH_3H / EPA 350.1
Nitrogen, Ammonia + Organic, Diss. (TKN)	mg/L as N	0.1	EPA 351.2
Phosphorus, Dissolved	mg/L as P	0.01	EPA 365.3
Phosphorus, ortho, Dissolved	mg/L as P	0.01	EPA 365.3
Potassium, Dissolved	mg/L	1	EPA 200.7
Silica, Dissolved	mg/L	1	SM 4500 SiE
Sodium, Dissolved	mg/L	1	EPA 200.7
Strontium, Dissolved	mg/L	0.1	EPA 200.7 / EPA 200.8
Sulfate as SO_4, dissolved	mg/L	0.5	EPA 300.0

Constituent	Units	Method Reporting Limit	Method
Zinc, Total	µg/L	50	EPA 200.7
Radiology / Age Dating Methods			
Delta-Deuterium	δ^2H	-	TC/EA/IRMS
Delta Oxygen-18	$\delta^{18}O$	-	TC/EA/IRMS
Tritium	TU	-	-
Tritium, prec. est.	TU	-	-
Volatile Organic Compounds			
VOCs plus Oxygenates (MTBE)	µg/L	varies	EPA 524.2
EPA Organic Methods			
EDB and DBCP	µg/L	varies	EPA 504.1
Chlorinated Pesticides & PCB's as DCP	µg/L	varies	EPA 508
Chlorinated Acid Herbicides	µg/L	varies	EPA 515
Nitrogen & Phosphorus Pesticides DEHP, DEHA, Benzo(a)Pyrene	µg/L	varies	EPA 525
Carbamates	µg/L	varies	EPA 531.1
Glyphosate	µg/L	varies	EPA 547
Endothall	µg/L	varies	EPA 548.1
Diquat	µg/L	varies	EPA 549.1
Dioxin (2,3,7,8 TCDD)	µg/L	varies	EPA 1613

2.0 SAMPLING FEATURES AND MONITORING FREQUENCY

Sampling points will consist of the monitoring well network, the test slant well, and other local well sampling points as agreed upon by the technical advisory committee. The following table provides details for the proposed monitoring wells. Figure 4-1 shows the location of the test slant well and monitoring wells identified in the table below.

Table 2-1 MPWSP Monitoring Well Information

Monitoring Well No.	Location Relative to Test Slant Well	Targeted Aquifer	Approximate Distance from Test Slant Well [ft]	Estimated Monitoring Well Depth [ft bgs]	Estimated Screen Interval [ft]
MW-1S	Southeast of the Test Slant Well Entry Point	Dune Sand	100	160	40
MW-1M		180-Foot		320	120
MW-1D		400-Foot		450	50
MW-2S	Inland of Test Slant Well Entry Point	Dune Sand	550	160	40
MW-2M		180-Foot		320	120
MW-2D		400-Foot		450	50
MW-3S	North of Test Slant Well Entry Point	Dune Sand	325	160	40
MW-3M		180-Foot		320	120
MW-4S	South of Test Slant Well Entry Point	Dune Sand	225	160	40
MW-4M		180-Foot		320	120
MW-5S	Inland of Test Slant Well Entry Point	Dune Sand	1,150	160	40
MW-5M		180-Foot		320	120
MW-6S	Inland of Test Slant Well Entry Point	Dune Sand	2,000	160	40
MW-6M		180-Foot		320	120
MW-6D		400-Foot		450	50
MW-7S	Inland of Test Slant Well Entry Point	Dune Sand	3,700 ft from Test Slant Well	160	40
MW-7M		180-Foot		320	120

Table 2-2 Monitoring Wells and Ground Water Gradient

Location with Respect to Test Slant Well	Existing Monitoring Points
At Slant Well Entry Point	MW-1 Series
Down-gradient	MW-2 Series
Up-gradient	MW-5 Series, MW-6 Series, and MW-7 Series
Cross-Gradient	MW-3 Series and MW-4 Series

In addition to the monitoring wells, water levels and water quality in the test slant well will be measured. The inclusion of additional monitoring points outside the CEMEX monitoring well network may occur based on opinion of the technical advisory committee.

3.0 GROUND WATER SAMPLING PROCEDURES

Prior to collecting ground water samples, the following activities should be performed:

- Review of the SAP and Site Health and Safety Plan (HASP);
- Assembly of proper sampling equipment and forms;
- Decontamination of purging and sampling equipment; and
- Calibration of field instruments following the manufacturer's instructions.

3.1 Ground Water Level Measurements

Ground water level measurements will be made using an electric water level sounder calibrated to the nearest 0.01 ft. Measurements will be made to the nearest 0.01 ft relative to an established reference point (RP) at the top of each well casing or well sounding tube. Depths to ground water will be compared, in the field, to previous measurements and re-measured if significantly different. Ground water level measurements will be recorded using a permanent ink pen on the field form. An example of the field form for water level measurements is shown in Field Form 1 (Pumping Test Data Sheet). Depth to ground water measurements will be converted to ground water elevations (above mean sea level) by subtracting the depth to water from the known reference point elevation. Whenever possible, water level measurements from all the monitoring wells shall be collected within a 24-hour period. Modified nitrile gloves will be worn as personnel protective equipment while performing this task consists.

3.2 Ground Water Sample Collection

3.2.1 Well Purging and Sample Collection

3.2.1.1 Well- Purging Procedures

The ground water surface in a monitoring well is typically in contact with the atmosphere and it may not be representative of the surrounding aquifer conditions. Contact with the atmosphere allows influx of atmospheric oxygen, which may oxidize some water quality constituents and cause biological growth. It should be noted that purging may induce stresses that can bring small particles into suspension and draw them into the monitoring well. Additionally, purging has the potential to strip volatile organic compounds (VOCs) from the water, if present. In order to mitigate stripping of VOCs and to ensure low turbidity samples, the pump should be operated at reduced flow rates during purging and sample collection.

During isolated aquifer zone testing each borehole will be pumped for approximately four (4) hours. At the end of pumping, water quality samples will be collected. Sampling the exploratory boreholes for VOCs can be performed by using a bailer following removal of the submersible test pump after pumping and purging.

Initial sampling for baseline water quality after construction of the monitoring wells will be by reducing the flow from the 2-inch test pump for sampling. Ongoing quarterly sampling of the monitoring wells for VOCs will be performed by using a low-flow stainless steel submersible pump.

Ongoing quarterly sampling from the test slant well will be performed by collecting samples from a side stream sampling port located on the discharge line near the buried wellhead.

During ongoing sampling, the monitoring wells will first be purged at a rate of approximately 5-7 gallons per minute (gpm) while monitoring drawdown, until the well has been purged of two well-casing volumes.

A well-casing volume (V) will be calculated using Equation 1.

$$= 0.0408 \quad r^2 \qquad (1)$$

where:

V is the volume of water in the well, in gallons,
r is the inside diameter of the well casing, in inches, and
H is the height of water column, in feet.

After the wells have been purged of three well-casing volumes, and field parameters have stabilized, the samples will be collected general mineral, general physical, pesticides, and herbicides. The pumping rate will be reduced to 0.03 gal/min (100ml/min) for sample collection.

Field water-quality properties, water levels, and pumping rates and volumes will be monitored throughout the purge process at regular intervals of about 5- to 15-minutes during the purge of the final well volume (determined by the professional judgment of the field team), and the data recorded on the field form. An example of the field form for water quality sampling is shown on Field Form 2 (Well Sampling Data Sheet).

To monitor pH, conductivity, ORP, temperature, and DO, water will be split from the discharge line and run to a flow-through cell with probes from a multi-parameter water-quality instrument (YSI 556 or equivalent), designed to minimize sample contact with the atmosphere. In addition, aliquots of water will be collected from the purge discharge line to measure turbidity using a portable turbidimeter (Hach 2100P or equivalent).

3.2.1.2 Sample Collection

Ground water samples will be collected immediately following the purging activities described above. All samples collected for laboratory analysis will be collected in laboratory-supplied sample containers, which have been cleaned and prepared according to the analytical method requirements.

The samples will be collected using the same pump and discharge tubing used for purging the well. The pump will be lowered into the well and suspended in the upper portion of the screen interval using a cable marked and measured so that the pump intake is not lowered past the target depth. The submersible pump will be operated at a discharge rate of approximately 100 ml/minute for VOC samples. The following guidelines will be followed when collecting ground water samples:

- Nitrile gloves will be worn during purging and will be discarded and replaced with clean gloves prior to sampling subsequent wells;
- Sample containers will not be opened until immediately prior to filling;
- The insides of sample containers will not be touched;
- Chain-of-custody (COC) forms will be maintained up to date throughout the sampling event;
- Sampling containers will be filled slowly and with minimal aeration;
- Sampling containers will be filled completely, but not overfilled, as this can result in the loss of preservative;
- Sampling containers will be filled as expeditiously as possible to minimize the time between filling the first sample container and the last; and
- Filled sample containers will be placed in an ice chest or cooler immediately after sample collection and kept in chilled storage until they are ready to be transported under proper chain-of-custody protocol to a state-certified laboratory for analysis.

Samples for dissolved and total iron and manganese will be measured by field filtering a sample from the pump discharge directly into an acidified sample container—this will be the dissolved sample. The total sample will be collected—without filtering—directly into the acidified sample container.

3.3 Sample Handling and Documentation

3.3.1 Field Documentation

Information collected during field activities, including field purging and sampling logs, will be recorded in a bound field notebook. Recorded will include, but is necessarily limited to, the following:

- Sampling location ID;
- Summary of daily activities including time of arrivals/departures of Field Technician and/or other visitors to the sampling site(s);
- Weather conditions;
- Any deviations from the associated work plan or this SAP;
- Sample date, time, types, numbers, and quantities;
- Sample container preservation steps performed (if required);
- Sampling equipment used;
- Decontamination steps performed;
- Calibration and maintenance performed;
- Multi-meter manufacturer and model number and serial number, and;
- Confirmation that COC forms were properly completed and sample custody transferred in accordance with this SAP.

3.3.2 Sample Identification and Labeling

Unique sample numbers will be assigned to identify and describe each ground water sample collected in the field. Samples will be identified and tracked by sample point number, where the sample originated, and the date the sample was collected. For example, a sample collected from monitoring well MW-1 on December 10, 2009 at 2:30 pm would be identified as MW-1-121009-1430. Trip blanks will be identified using the sample ID assigned by the laboratory. Duplicate samples will be identified in the same way regular samples are identified (i.e., SAMPLE POINT ID-DATE-TIME) but they will be identified as duplicates in the sampler's notes. Each sample container will be clearly labeled using an indelible permanent ink pen on waterproof adhesive labels. Each sample container will contain the following information:

- Project name;
- Project number;
- Site/project location;
- Sampling point ID (i.e., MW-1);
- Date and time of collection;
- Name of the sampler(s);
- Any preservatives added or present in container; and
- Analysis to be performed.

3.3.3 Chain-of-Custody Procedure

The Chain-of-Custody (COC) procedure provides a record of the possession and handling of individual samples from the time of collection in the field to receipt by the laboratory for analysis. The field COC record is used to record the custody of all samples collected and maintained by sampling personnel. All sample sets will be accompanied by a COC. The COC documents sample custody transfer from the sampling personnel, to another person, or to the laboratory. The COC also serves as a sample logging mechanism for laboratory personnel. The COC form shall contain the following information:

- Individual sample identification;
- Name and signature of sampler(s);
- Project manager and contact information;
- Sample collection time(s);
- Sample matrix;
- Sample preservative(s);
- Total number of sample containers;
- Chain-of-custody record; and
- Analyses to be performed.

3.4 Quality Control Procedures

Field quality control (QC) samples will be collected and analyzed to assess the consistency and performance of the ground water sampling activities. QC samples for the sampling program will include field duplicates, equipment blanks and trip blanks.

3.4.1 Field Duplicates

Field duplicates consist of two samples (an original and a duplicate) of the same matrix that are collected at the same time from the same sampling point. Field duplicate samples are used to evaluate the precision of the overall sample collection and analysis process. Field duplicates shall be collected at a frequency of 1 per 10 regular samples and will be analyzed for the full set of analyses requested for the original sample. Exact locations of duplicate samples and sample identifications shall be recorded in the sampler's field notes.

3.4.2 Equipment Blanks

Collection and analysis of field equipment blanks (EBs) are provided as QC checks of the integrity and effectiveness of field equipment decontamination procedures. Equipment blank samples are prepared by rinsing field sampling equipment, such as a pump, with deionized water and collecting the rinsate in sample bottles. EB samples are assigned unique sample numbers so as to not be identified by the laboratory as EB samples. One EB sample shall be collected for every day of sampling when using non-dedicated equipment to collect ground water samples. The EB samples will be analyzed for the same compounds as those analyzed for the regular ground water samples.

3.4.3 Trip Blanks

Trip blanks are prepared by the laboratory in 40-milliliter (mL) vials using analyte-free water and must be free of headspace. The trip blanks will be carried into the field, stored, and shipped to the laboratory along with the water samples. One trip blank will be shipped with each cooler that contains samples to be analyzed for VOCs. Trip blanks are evaluated to determine whether VOC cross-contamination between samples has occurred during storage and transportation, and apply only to volatile organics.

Table 1

GEOSCIENCE

GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

PUMPING TEST DATA SHEET

Client: ___________________________________ Logged By: __________________________

Well Name: _______________________________ Test Date: ___________________________

Circle Well Type: Pumping Observation (r = ft)

Circle Test Type: Step Drawdown Constant Rate Recovery Development

Reference Point Elevation: __________________ft Pump Depth: ___________________ft bgs

Static Water Level Depth: ___________________ft bgs Totalizer Units: ______________________

Time of Day	Time min Step	Time min Total	Depth to Water (ft brp)	Draw-down (ft)	Pumping Rate (gpm)	Sand Content		Totalizer ( )	Remarks and other data
						Time Interval	ppm		

Field Water Quality Parameters During Constant Rate Pumping Test

Date / Time	Temperature [°C]	Specific Conductance [µS/cm]	Conductivity [µS/cm]	TDS [mg/L]	Salinity [ppt]	Dissolved Oxygen [%]	Dissolved Oxygen [mg/L]	pH [pH units]	ORP [mV]	Turbidity [NTU]

Table 2

GEOSCIENCE

GEOSCIENCE Support Services, Inc. | P (909) 451-6650 | F (909) 451-6638
620 W. Arrow Highway, Suite 2000, La Verne, CA 91750 | Mailing: P.O. Box 220, Claremont, CA 91711