Groundwater Sustainability Plan

for the Marina GSA Area of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, CA

JANUARY

2020

VOLUME I

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LIST OF ABBREVIATIONS

AB	Assembly Bill
ACS	American Community Survey
AEM	Airborne Electromagnetic
AF	acre-feet
AFY	acre-feet per year
AMBAG	Association of Monterey Bay Area Governments
amsl	above mean sea level
APN	County Assessor Parcel Number
bgs	below ground surface
BMP	Best Management Practices
CalAm	California American Water Company
CalEPA	California Environmental Protection Agency
CASGEM	California Statewide Groundwater Elevation Monitoring Program
CCAMP	Central Coast Ambient Monitoring Program
CCC	California Coastal Commission
CCGC	Central Coast Groundwater Coalition
CCR	California Code of Regulations
CCR	Central Coastal Region
CCRWQCB	Central Coast Regional Water Quality Control Board
CCWG	Central Coastlands Wetlands Group
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CDPR	California Department of Pesticide Regulation
CEDEN	California Environmental Data Exchange Network
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CIFP	Capital Improvement and Financing Plan

CIMIS	California Irrigation Management System
CMP	Comprehensive Management Plan
CNDDB	California Natural Diversity Database
CPUC	California Public Utilities Commission
CSD	Community Services District
CSIP	Castroville Seawater Intrusion Project
CWC	California Water Code
DACs	Disadvantaged Communities
DDW	State Water Resources Control Board Division of Drinking Water
DEM	Digital Elevation Model
Df	Dune Land (Surficial Geologic Unit)
DMS	Data Management System
DSA	Dune Sand Aquifer
DTSC	California State Department of Toxic Substances Control
DWPS	Monterey County Drinking Water Protection Services
DWR	California Department of Water Resources
EHB	Monterey County Environmental Health Bureau
EPA	United States Environmental Protection Agency
ERT	Electrical Resistance Tomography
ESHA	Environmentally Sensitive Habitat Areas
ET	Evapotranspiration
FORA	Fort Ord Reuse Authority
FO-SVA	Fort Ord – Salinas Valley Aquitard
ft	feet
GAMA	Groundwater Ambient Monitoring and Assessment Program
GAP	Groundwater Assessment and Protection Program
GDE	Groundwater-dependent ecosystem
GICIMA	Groundwater Information Center Interactive Mapping Application

GIS	Geographic Information System
GMP	Groundwater Management Plan
gpm	gallons per minute
GPS	Global Positioning System
GRC	General Rate Case
GS	ground surface
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
gSSURGO	Gridded Soil Survey Geographic Database
GWR	Monterey Peninsula Groundwater Replenishment Program
HCP	Habitat Conservation Plan
HWG	Hydrogeology Working Group
ILRP	Irrigated Lands Regulatory Program
InSAR	Interferometric Synthetic Aperture Radar
IRWM	Integrated Regional Water Management
IRWMP	Integrated Regional Water Management Plan
ISP	Integrated Sustainability Plan
ISW	Interconnected surface waters
JPA	Joint Powers Authority
JPL	Jet Propulsion Laboratory
LAI	Leaf Area Index
LCIP	Local Coastal Implementation Plan
LCLUP	Local Coastal Land Use Plan
LCP	Local Coastal Program
M	Santa Margarita Sandstone and Monterey Formation
M1W	Monterey One Water
MA	Management Area
MCL	Maximum Contaminant Level

MCFCWCD	Monterey County Flood Control and Water Conservation District
MCRCD	Monterey County Resources Conservation District
MCWD	Marina Coast Water District
MCWRA	Monterey County Water Resources Association
mgd	million gallons per day
mg/L	milligrams per liter
MGSA	City of Marina Groundwater Sustainability Agency
MHI	Median Household Income
MMA	Marina Management Area
MMRP	Mitigation Monitoring and Reporting Plan
MPRPD	Monterey Peninsula Reginal Park District
MPWMD	Monterey Peninsula Water Management District
MPWSP	Monterey Peninsula Water Supply Project
MRWPCA	Monterey Regional Water Pollution Control Agency
msl	mean sea level
NASA	National Aeronautics and Space Administration
NAVD88	North American Vertical Datum of 1988
NCCAG	Natural Communities Commonly Associated with Groundwater
NCSS	National Cooperative Soil Survey
NDMI	Normalized Difference Moisture Index
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OSWCR	Online System for Well Completion Reports
OUCTP	Fort Ord Superfund Site Operable Unit Carbon Tetrachloride Plume
P	Purisima Formation
PARKS	California Department of Parks and Recreation

PWM	Pure Water Monterey
Qa	Alluvium
QAPP	Quality Assurance Project Plan
Qoa	Older Alluvium (Surficial Geologic Unit)
QPc	Aromas Sand (Surficial Geologic Unit)
Qvf	Valley Fill Deposits (Surficial Geologic Unit)
RCDMC	Resource Conservation District of Monterey County
RMS	Representative Monitoring Sites
RP	Reference Point
RTP	Regional Wastewater Treatment Plant
RUWAP	Regional Urban Water Augmentation Project
RWMG	Regional Water Management Group
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCMCGA	Santa Cruz Mid-County Groundwater Agency
SDACs	Severely Disadvantaged Communities
SEBS	Surface Energy Balance System
SGMA	Sustainable Groundwater Management Act
SMC	Sustainable Management Criteria
SMCL	Secondary Maximum Contaminant Level
SRDF	Salinas River Diversion Facility
Subbasin	180/400 Foot Aquifer Subbasin
SVA	Salinas Valley Aquitard
SVBGSA	Salinas Valley Basin Groundwater Sustainability Agency
SVIHM	Salinas Valley Integrated Hydrologic Model
SVRP	Salinas Valley Reclamation Project
SVWC	Salinas Valley Water Coalition
SVWP	Salinas Valley Water Project

SWQCB	State Water Quality Control Board
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
Tc	Paso Robles Formation
TDS	Total Dissolved Solids
µS/cm	micro siemens per centimeter
UNAVCO	University NAVSTAR Consortium
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WDL	Water Data Library
WDR	Waste Discharge Requirement
WRIME	Water Resources and Information Management Engineering, Inc.

EXECUTIVE SUMMARY
Groundwater Sustainability Plan for the Marina GSA Area of the 180/400 Foot Aquifer Subbasin

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Groundwater Sustainability Agency
Marina, California

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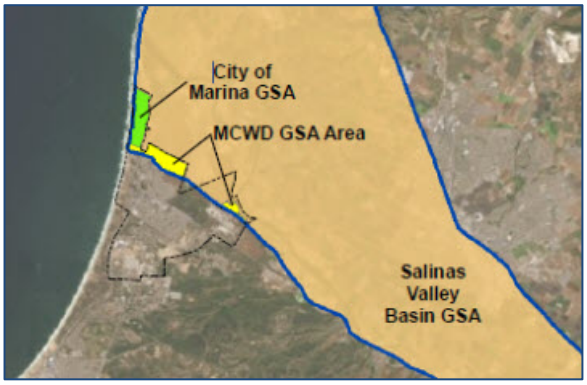
EXECUTIVE SUMMARY

INTRODUCTION

The California Legislature passed the Sustainable Groundwater Management Act (SGMA) in 2014 in response to continued overdraft of California's groundwater resources. SGMA requires Groundwater Sustainability Agencies (GSAs) to prepare Groundwater Sustainability Plans (GSPs) to achieve sustainable groundwater conditions in medium and high priority groundwater basins and subbasins designated by the California Department of Water Resources (DWR). SGMA defines sustainability as long-term management and use of a groundwater basin without "undesirable results." Undesirable results caused by over pumping include chronic decline of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded groundwater quality, land subsidence or depletion of interconnected surface water.



GSA Jurisdictions in the Subbasin

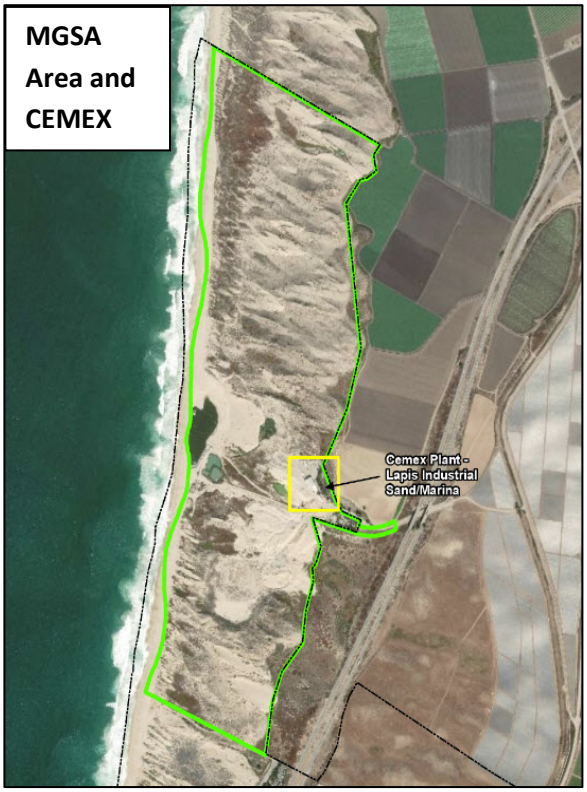
The 180/400 Foot Aquifer Subbasin (Subbasin) is one of 21 groundwater basins designated by DWR as critically overdrafted because chronic over-pumping in the inland part of the Subbasin has led to seawater intrusion. The problem was first identified in the 1940s and has moved inland up to 7 miles in some areas. Groundwater is an extremely important resource in the area, and the only source of water for the City of Marina. Investigations by the Monterey County Water Resources Agency (MCWRA), the United States Geological Survey (USGS), a team of researche versity and several local consultants have revealed that groundwater conditions in t the subbasin are more complex and dynamic than previously thought, and that local resources and water supplies could be at risk of damage from drawdown or further seawater intrusion if the appropriate local management actions are not taken.

In response, the City formed the City of Marina Groundwater Sustainability Agency (MGSA) to prepare a GSP for an approximately 400-acre portion of the Subbasin within its jurisdiction (MGSA Area) that is not served by the Marina Coast Water District (MCWD). MGSA has developed this locally-focused GSP to ensure sustainable groundwater management in the MGSA Area, as well as to support regional efforts to address seawater intrusion and other potential undesirable results, and return the Subbasin to sustainable groundwater management within 20 years, as required by SGMA. MGSA will achieve this by supporting projects and management actions that will be implemented by Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) under its regional GSP that are aligned with MGSA's sustainability goals, and by assuring that local groundwater resources are managed sustainably to protect both local and regional beneficial uses and users.

MGSA is one of three GSAs in the Subbasin. The Salinas Valley Basin GSA is currently preparing a GSP for the Subbasin. MCWD GSA has responsibility to manage MCWD's service areas in the Subbasin, and has entered into an agreement with SVBGSA to prepare the GSP for these areas. MGSA has initiated negotiations with SVBGSA and MCWD GSA to enter into Coordination Agreements that will assure that

the two GSPs developed for the Subbasin are implemented in a coordinated fashion that will result in basin-wide sustainable groundwater management. [Update when agreements are executed.] MGSA notes that on December 11, 2019, the Monterey County Board of Supervisors adopted Resolution 19-171 to create a new GSA in an effort to become the "exclusive" GSA for the MGSA Area. Pursuant to this resolution, County staff filed a GSA notification with DWR to become the GSA for the MGSA area, and on December 18, 2019, DWR posted the County's notification and designated the County the "exclusive" GSA for the MGSA Area. MGSA believes that these County actions and DWR's designation are invalid and ineffective under SGMA. On December 30, 2019, the City and MGSA filed litigation challenging these actions and decisions. Since these matters are in litigation, MGSA does not address them further herein.

PLAN AREA DESCRIPTION, LAND USE AND BENEFICIAL GROUNDWATER USES AND USERS

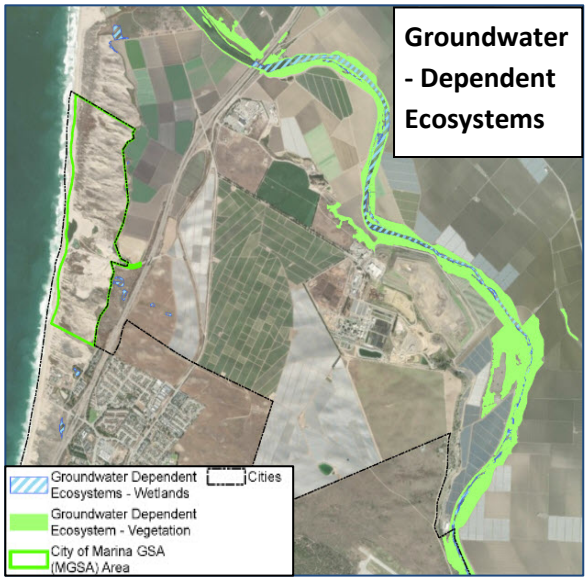


The MGSA Area is located outside the Urban Growth Limits of the City of Marina and has a land use designation of Habitat Preserve and Other Open Space. It is within the California Coastal Zone and contains unique Flandrian dune habitat and other habitat that is protected under the California Coastal Act, which supports special-status plant and animal species, and is considered an Environmentally Sensitive Habitat Area (ESHA). The ownership is private, and the current use is sand mining at the CEMEX Lapis Plant site. In 2017, after combined enforcement actions by the California Coastal Commission, the State Lands Commission and the City, a comprehensive settlement agreement was entered into with RMC Pacific Minerals, doing business as CEMEX, to end sand mining by December 31, 2020. RMC is thereafter required to decommission the plant and fully reclaim and restore the site. The settlement also requires CEMEX to transfer the entire site, including the area where the proposed MPWSP slant wells would be located, at a reduced purchase price to a non-profit organization or government entity approved by the Coastal Commission and the City. A deed restriction will be put in place to protect the property and limit its uses to public access, conservation, low-impact passive recreation, and public education. These provisions will improve public access and enjoyment of the property and will provide benefits to site habitats, plants, and animals.

Land use surrounding the MGSA Area includes open space and agricultural use to the east, the Salinas River and Salinas River National Wildlife Refuge to the north, and the City of Marina and coastal preserves and parks to the south. Current groundwater pumping in the MGSA Area is limited to extraction of approximately 300 acre-feet/year (AFY) of saline groundwater for process use by CEMEX.

The proposed Monterey Peninsula Water Supply Project (MPWSP), a desalination plant with an estimated makeup water demand of approximately 17,400 AFY, would extract shallow groundwater from a series of slant wells near the shore of the MGSA Area, if it is fully permitted and implemented. A test slant well pumping test was conducted at this location between April 2015 and February 2018, and extracted approximately 2,000 AFY of saline groundwater. The extracted groundwater flowed radially to the well and included saline groundwater drawn into the MGSA Area from beneath the Pacific Ocean to the west, and a combination of saline groundwater and higher quality groundwater from inland aquifers within the Subbasin to the north, south and east.

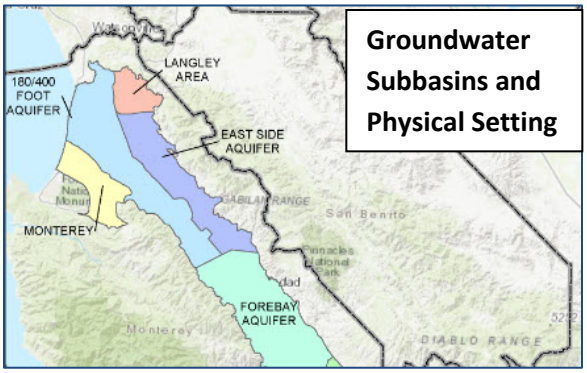
Beneficial groundwater uses in the region surrounding the MGSA Area include urban water demand in Marina, which is met solely by groundwater. Groundwater in MCWD's Central Marina service area is withdrawn from the Deep Aquifer (described below), which is not seawater intruded. MCWD operates several supply wells for their Ord Community service area, which is further inland southeast of the MGSA Area, from shallower 180/400-Foot Aquifers which are seawater intruded further north. Other groundwater use in the area includes agricultural supply and small community and non-community water systems, but is relatively limited due to the effect of seawater intrusion in the area, and the fact that much of the area is provided with reclaimed wastewater as an alternative irrigation water supply as part of the Castroville Seawater Intrusion Project (CSIP). However, as described further below, the aquifers east of the MGSA Area contain significant quantities of groundwater (estimated over 200,000 acre-feet) with concentrations of total dissolved solids (TDS) less than 3,000 milligrams per liter (mg/L). Under State Water Resources Control Board (SWRCB) Resolution No. 88-63, this groundwater has a designated beneficial use as a source of municipal and domestic supply, and must be protected from further degradation under SWRCB Resolution No. 68-16. These resolutions are part of the local Water Quality Control Plan (Basin Plan) administered by the Central Coast Regional Water Quality Control Board (RWQCB).



An evaluation of groundwater-dependent ecosystems (GDEs) near the MGSA Area was conducted using the Natural Communities Commonly Associated with Groundwater dataset (NC Dataset) developed cooperatively by The Nature Conservancy (TNC) and DWR. Potential GDEs identified in this dataset were evaluated using best practices recommended by TNC, and a number of GDEs that

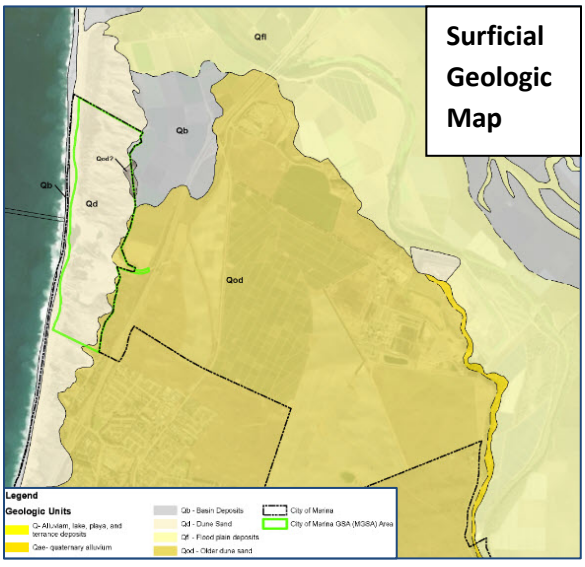
are likely dependent on shallow groundwater in the Dune Sand Aquifer (described below) were identified as additional beneficial groundwater users. These GDEs include a number of "vernal ponds," which are unique coastal wetland communities protected under the California Coastal Act and management plans developed by the City of Marina and environmental stakeholders.

BASIN SETTING AND HYDROGEOLOGIC CONCEPTUAL MODEL



The MGSA Area covers about 400 acres at the western end of the 180/400 Foot Aquifer Subbasin. The Subbasin is at the northern, down-gradient end of the Salinas Valley Groundwater Basin, which is a 90-mile-long alluvial basin underlying the elongated, intermountain valley of the Salinas River. The valley is nestled between two mountain ranges in the California Coast Ranges, the Gabilan Range to the east and the Santa Lucia Range and Sierra de Salinas to the west. The Salinas River flows northwesterly through Salinas Valley and empties into the Pacific Ocean in Monterey Bay north of the MGSA Area. Elevations in the Subbasin range from about 500 feet above mean sea level (msl) along the Sierra de Salinas to sea level at Monterey Bay. The Salinas River carries sand along the valley into the Pacific Ocean, where it is transported southward along the coast by longshore currents and blown onshore by coastal winds, forming a series of coastal dunes along the shore south of the Salinas River. The MGSA Area encompasses an area of coastal dunes at the seaward edge of Salinas Valley on the north side of the City of Marina and south of the Salinas River. The elevation within the MGSA Area ranges from about 100 feet above msl near the top of the coastal dunes to sea level at Monterey Bay.

The Salinas River Valley Basin is a structural basin filled with river, floodplain, shoreline, and offshore gravel, sand, silt, and clay deposits. Near the MGSA Area, shallow deposits include ancient dune sands south of the Salinas River, and river and flood plain deposits to the north. Near the shore is an area of active dunes extending southward from the mouth of the Salinas River. These surface deposits are underlain by a sequence of valley fill sediments consisting of interbedded coarse-grained river deposits, fine grained flood plain and basin deposits, and estuarine muds deposited during times when the lower portion of the valley was inundated by the ocean. In the lower Salinas River Valley, these deposits reach a thickness of about 700 to 900 feet, and are underlain by the Purisima Formation, which consists of a complex series of interbedded marine shelf deposits ranging from coarse grained to fine grained that extends to a depth of over 2,000 feet.



Previous studies in and around the MGSA Area provide detailed background information about the regional hydrostratigraphy. A brief review of the hydrostratigraphy in the coastal region of interest is presented below. The hydrologic units are discussed in order of highest to lowest elevation.

- **Dune Sand Aquifer (DSA).** The DSA is the uppermost aquifer in the vicinity of the MGSA Area and occurs in highly permeable dune sand deposits southwest of the Salinas River. It is not known to be used as a water supply, but is of local importance due to its high rate of recharge, interaction with local GDEs, substantial storage of groundwater with designated beneficial use as a municipal or domestic supply, and importance in maintaining nearshore seawater intrusion dynamics. It has a seaward gradient in the vicinity of the MGSA Area based on measurements in 2017 and 2018.

- **Salinas Valley Aquitard (SVA).** The Salinas Valley Aquitard, and its stratigraphic equivalent, the Fort Ord-SVA, is a laterally clay-rich layer covering much of the Salinas Valley basin. In the Salinas Valley basin, the SVA is thicker and relatively flat, while in the Fort Ord area, the SVA is higher in elevation and dips more steeply toward the coast. Near the coast and south of the Salinas River, the SVA thins out, bringing the Dune Sand Aquifer and the underlying 180-Foot Aquifer into hydraulic connection.

- **180-Foot Aquifer.** The 180-Foot Aquifer is the uppermost groundwater supply aquifer of regional importance throughout the Subbasin. It is seawater intruded in the vicinity of the MGSA Area, but includes significant zones of groundwater with a designated beneficial use as a domestic and municipal supply in and near the MGSA Area. It is used as a process water supply by the CEMEX plant and pumped by several municipal supply wells in the MCWD's Ord Community service area. The current gradient in this aquifer is landward.

- **180/400-Foot Aquitard.** The 180/400-Foot Aquitard is a zone of "discontinuous aquifers and aquitards," of which the aquitards, where present, separate the 180-Foot Aquifer from the underlying 400-Foot Aquifer. The discontinuous nature of the 180/400-Foot Aquitard was documented in and near the MGSA Area by MCWRA (2017) and Gottschalk *et al.* (2018), among others, and a hydraulic connection between the 180-Foot and 400-Foot Aquifers in the vicinity of the MGSA area is substantiated by available hydrographs.

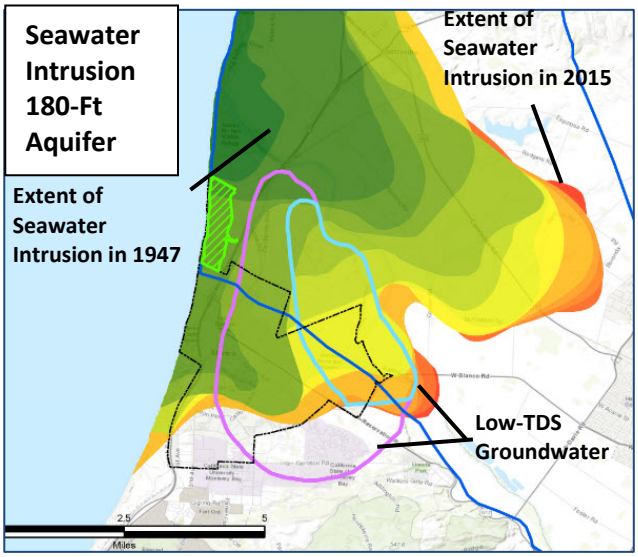
- **400-Foot Aquifer.** This aquifer is regionally extensive and is composed mostly of sand in the area south of the Salinas River. It is typically encountered at depths between 275 and 460 feet, and is correlated with the Aromas Sand and the upper portion of the Paso Robles Formation. Generally speaking, the 400-Foot Aquifer has a lower hydraulic head than the 180-Foot Aquifer. In some areas where the 180/400-Foot Aquitard is absent, saline groundwater has been documented to migrate vertically downwards into the 400-Foot Aquifer, deteriorating water quality in the 400-Foot Aquifer. It is seawater intruded in the vicinity of the MGSA Area, but includes significant zones of groundwater with a designated beneficial use as a domestic and municipal supply in and near the MGSA Area. It is used as a process water supply by the CEMEX plant and pumped by several municipal supply wells in the Ord Community area. The current gradient in this aquifer is landward.

- **400-Foot/Deep Aquitard.** Beneath the 400-Foot Aquifer is a sequence of low permeability units that comprise an aquitard that can be up to several hundred feet thick. Interpretation of the thickness of this aquitard varies by location, and the stratigraphic interval has also been locally identified as containing transmissive aquifer units. The behavior of wells in the Deep Aquifer

suggests that the 400-Foot/Deep Aquitard is leaky. As such, while substantial units of low permeability exist within and beneath the lower portions of the upper aquifer system in the Paso Robles Formation, their regional continuity and competence are not well understood.

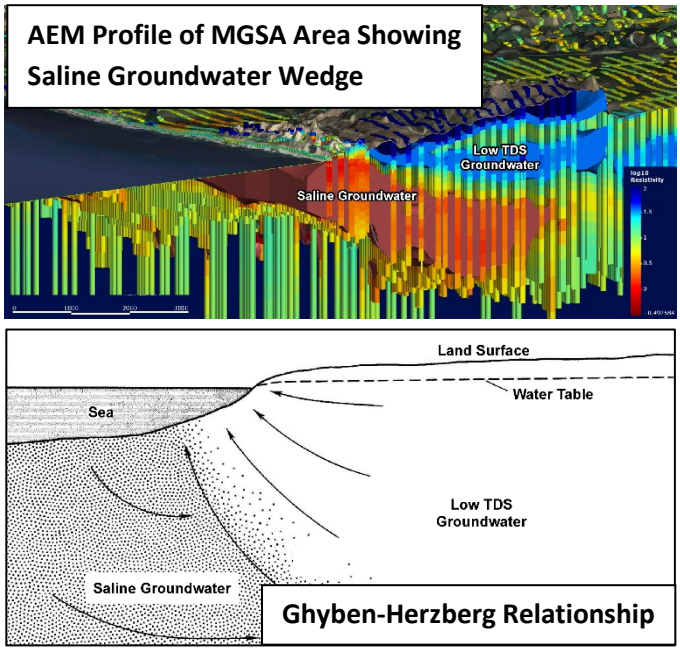
- **Deep Aquifer.** The deepest groundwater supply aquifer in the area is the Deep Aquifer. It lies within the Purisima Formation and contains a system of aquifers and lower permeability sediments that extends to a depth of about 2,000 feet near the MGSA Area. The Deep Aquifer is believed to be recharged by leakance from the overlying 400-Foot Aquifer. It is not seawater intruded and currently provides the only source of municipal water supply for MCWD's Central Marina service area. The current data are insufficient to assess groundwater gradients within this aquifer system, but groundwater levels are below sea level and the Purisima Formation is believed to be exposed offshore in the Monterey Canyon. Due to uncertainty in the competence of the aquitard that separates the Deep Aquifer from the seawater-intruded 400-Foot Aquifer and the potential for seawater intrusion laterally from the west, Monterey County has prohibited the construction of new wells in this aquifer until more thorough characterization can be completed.

The distribution of water quality impacts near the MGSA Area was investigated by a team of researchers from Stanford University in 2017 using Airborne Electromagnetics (AEM). AEM relies on well-proven and long-established geophysical techniques, which have recently been deployed using helicopters. It has been used in other SGMA studies in the state, is an integral part of the SWRCB Regional Monitoring Program for salinity mapping conducted by USGS in areas of oil and gas well stimulation, and is proposed to be used for ongoing monitoring of seawater intrusion under the GSP adopted for the Santa Cruz Mid-County Groundwater Basin. The AEM data were considered together with groundwater quality monitoring data and investigations performed by MCWRA and others to assess the aquifer stratigraphy, water quality, and interaction dynamics of seawater and groundwater with lower concentrations of TDS within the aquifers at the western edge of the 180/400 Foot Subbasin.



The MGSA Area is at the seaward edge of the area affected by seawater intrusion in the 180-Foot and 400-Foot Aquifers. Seawater intrusion in the Salinas Valley Basin has been ongoing since at least the 1940s, and its extent has been defined by the location of the 500 mg/L chloride isoconcentration contour, which is a concentration at which some beneficial uses begin to be affected. However, substantial amounts of groundwater within the affected area still have beneficial uses – geophysical investigations and groundwater sampling have identified a large zone of groundwater in and beneath the Dune Sand Aquifer that contains less than 3,000 mg/L of TDS. Water with TDS less than 3,000 mg/L has a designated use as a municipal and domestic water supply and its degradation is prohibited under State Water Resource Control Board resolutions; however, for water containing TDS or chloride in

excess of drinking water standards, treatment would be required prior to use. This low-TDS groundwater zone is recharged through the Dune Sand Aquifer and extends downward into the 180-Foot and 400-Foot Aquifers. It is estimated to contain approximately 200,000 acre-feet of groundwater in the Dune Sand Aquifer alone.



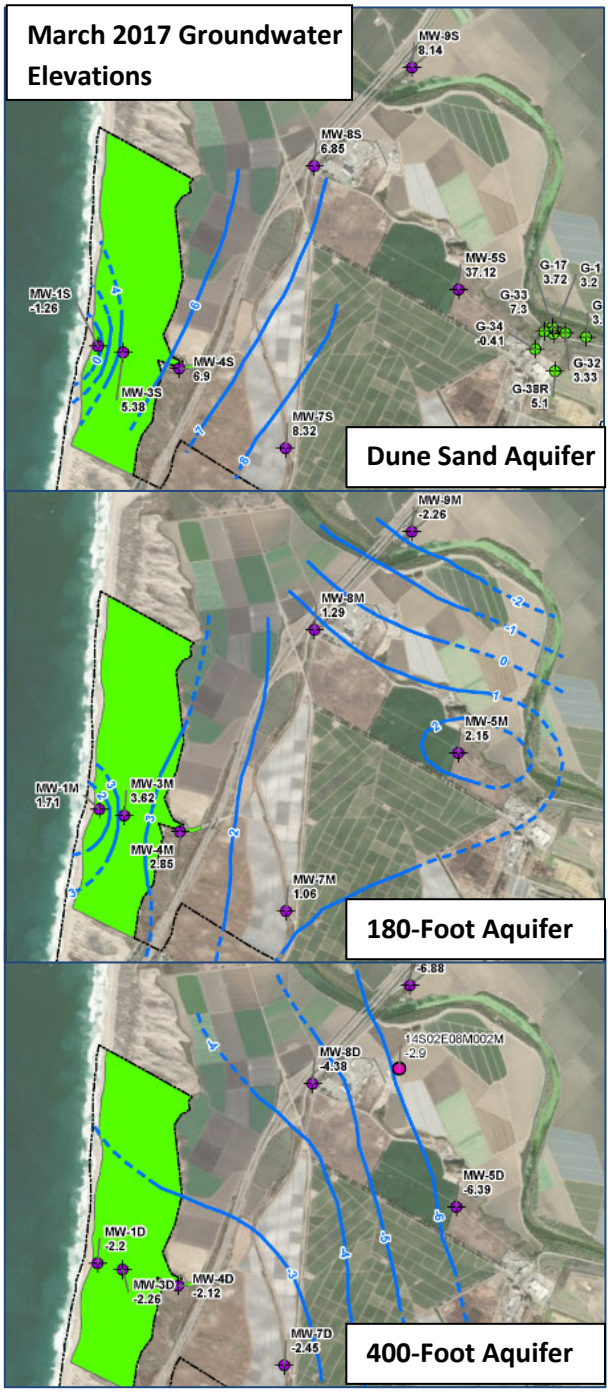
The 2017 AEM survey identified a saline groundwater wedge juxtaposed against a zone of lower TDS groundwater (<3,000 mg/L TDS) underlying the high recharge area in the dune sand deposits that occur between the MGSA Area and the Salinas River. This interface between dense, saline groundwater and the low-TDS zone extends downward into the 180-Foot and 400-Foot Aquifers east of the MGSA Area. The dynamics of such interfaces in coastal aquifers have been extensively studied since the late 19th century, and it has been determined that under equilibrium conditions the extent of saline water intrusion is directly proportional to the thickness of the overlying low-TDS water zone and the difference in density between the two zones. This is known as the Ghyben Herzberg Relationship. Groundwater flow is seaward in the overlying low TDS zone and discharges to the ocean, and flow is landward in the intruding saline groundwater wedge. At the saline/low-TDS groundwater interface, the saline groundwater circulates and mixes with the over-riding low TDS groundwater. Although this equilibrium may have been disturbed at the MGSA Area by pumping of CEMEX well and the test slant well and by recharge of saline water in the CEMEX ponds, the geometry of a saline groundwater wedge dipping beneath an over-riding low-TDS zone is clearly identifiable and consistent with the Ghyben-Herzberg model.

EXISTING CURRENT AND HISTORICAL GROUNDWATER CONDITIONS

The primary feature documented by regional groundwater level monitoring conducted by MCWRA in both the 180-Foot/Shallow East Side Aquifers and 400-Foot/Deep East Side Aquifer maps is a groundwater depression located north of Salinas with groundwater elevations generally -80 to -120 feet msl. Groundwater elevations are generally below sea level for most of the area covered by the maps extending back to 1994. East of the MGSA Area groundwater elevations are generally interpreted to be -10 to -20 feet msl with some years as low as -30 feet msl. The 2017 contour map for the 180-Foot Aquifer indicates an inland flow direction over a broad region surrounding the MGSA Area with a gradient of 0.0014. A similar flow pattern is interpreted for the 400-Foot Aquifer, with a gradient of 0.0013. These groundwater flow data are based on widely spaced wells, and should be considered generalizations for the MGSA Area.

Groundwater level monitoring data gathered by MCWRA indicate that groundwater levels in the Deep Aquifer have been declining since 2006 and are currently below sea level in some areas. However, the data are insufficient to develop contour maps and interpret gradients in this heterogeneous aquifer system.

To analyze local groundwater elevations and flow directions, groundwater elevations from the monitoring well network constructed for the MPWSP test slant well were assessed in the spring of 2015 before the start of test slant well pumping, in the spring of 2017 during test slant well pumping, and in the spring of 2018 after test slant well pumping had ceased. The following conditions were observed:



- An insufficient number of monitoring wells were constructed prior to the test slant well pumping test to allow reliable contouring.
- The direction of groundwater movement in the Dune Sand Aquifer was toward the ocean to the west-northwest in March 2017 with a gradient of about 0.0005. All of the groundwater elevations were above sea level except in MW-1S, near the test slant well. In April 2018, the groundwater flow direction was toward the ocean to the northwest with a gradient of about 0.0006. Near the coast in wells MW-1S and MW-3S, groundwater elevations increased by approximately 7 feet and 1 foot, respectively between March 2017 and April 2018. This may indicate the re-establishment of a seepage face at the shoreline.
- The direction of groundwater movement in the 180-Foot Aquifer was landward in March 2017 with an apparent groundwater divide (mound) beneath agricultural land east of the MGSA Area. Gradients were northeast and southeast away from the divide. The March 2017 gradient near the MGSA Area was about 0.0006. In April 2018, an apparent mound was again observed east of the MGSA area, but its southeastern flank was not resolved by the data. The gradient was about 0.0009 in a landward direction. Groundwater elevations were above sea level in the inland areas near the MGSA Area in both 2017 and 2018.

- For March 2017 and April 2018, the direction of groundwater flow in the 400-Foot Aquifer was landward, and inland groundwater elevations were below sea level. The gradient was east with a magnitude of approximately 0.0008 in March 2017, and east-southeast with a magnitude of 0.0006 in April 2018. A slight groundwater mound was present beneath the agricultural land east of the MGSA Area.

Aside from the impacts of seawater intrusion, groundwater quality in the MGSA Area does not appear to be impacted by point- or non-point sources of pollution. Nitrate concentrations exceeded the Maximum Contaminant Levels (MCLs) for drinking water during one of 13 sampling events of the CEMEX well, but groundwater was being used only for process water purposes. Nitrate concentrations in shallow groundwater underlying the agricultural areas east of the MGSA Area are reported to be close to or exceeding the MCL at a number of locations. Several closed leaking underground storage tank sites are located within 1 mile from the MGSA Area. The Fort Ord Operable Unit Carbon Tetrachloride Plume (OUCTP) is located approximately 7,000 feet southeast of the MGSA and is undergoing active investigation and cleanup. The A-Aquifer (local equivalent of the perched Dune Sand Aquifer) and the 180-Foot Aquifer have been impacted, but the plume currently appears to be stable. The Mitigation, Monitoring, and Reporting Plan adopted for the proposed MPWSP requires that monitoring data regarding this plume be periodically evaluated to assure that, if the MPWSP is fully permitted and implemented, the plume is not captured or induced to migrate by makeup water extraction within the MGSA Area. There are no waste discharge sites, underground storage tank sites or other potential point sources of groundwater pollutants within the MGSA Area. Except for seawater intrusion, there are no known or reported sources of groundwater pollutants in the MGSA Area.

Land subsidence is not closely monitored in the Monterey Bay region and has not been reported in Salinas Valley. In 2014, DWR reported that continuous monitoring stations located near the coast in the Pajaro Valley and Santa Cruz areas displayed a declining trend, but recorded total cumulative subsidence less than 1 inch. Vertical displacement estimates derived from Interferometric Synthetic Aperture Radar (InSAR) data indicate total ground surface displacement in and near the MGSA Area between June 2015 and June 2018 ranged from approximately 0.01 to 0.025 foot which is negligible. During the first two years of this time period, the test slant well for the MPWSP project in the MGSA Area was pumped at a rate of approximately 2,000 gallons per minute. The available data suggest that the vicinity of the MGSA Area has not experienced significant subsidence. However, the data are insufficient to assess the potential vulnerability of this area to future subsidence if groundwater extractions are increased. MGSA will work with SVBGSA to address this data gap during GSP implementation.

In addition to the previously discussed GDEs, groundwater elevations near the Salinas River were found to be shallower than 20 feet below the river thalweg, indicting the lower reach of the river may be groundwater connected. This is also supported by geophysical data, which suggests the existence of shallow groundwater near the river, and of seawater intrusion through the riverbed in the tidally-influenced portion of the river. SVBGSA and MCWRA have indicated the lower reach of the river is a losing stream, which is also consistent with observed hydrograph responses in wells MW-6S, MW-8S, and MW-9s, which are close to the river, to a major discharge event recorded in early 2017. Further inland, near the Spreckels gaging station approximately 13.5 river miles upstream from the Pacific Ocean, groundwater elevations have historically been much deeper than Salinas River, indicating that

the river may be hydraulically disconnected from the regional groundwater aquifers at this location. This analysis of surface-groundwater interaction along the Salinas River is based on limited data and is therefore uncertain. Additional monitoring and further evaluation through groundwater modeling is planned in coordination with the SVBGSA to help address this data gap.

GROUNDWATER BUDGET

The MGSA Area represents a relatively small area within the 180/400 Foot Aquifer Subbasin, for which historical, current, and projected water budgets have been prepared by SVBGSA and presented in their GSP. Since the MGSA Area is hydraulically connected with the surrounding portions of the Subbasin and part of the already developed water budgets, this GSP adopts the SVBGSA's regional historical, current, and future water budgets for the Subbasin, which are included as Appendix 3.E. SVBGSA used the pre-publication version of the USGS Salinas Valley Integrated Hydrological Model (SVIHM) to evaluate and develop future projected water budget for the Subbasin. After the SVIHM is publicly released, SVBGSA intends to use it to update their water budget, further assess groundwater flow conditions and surface-groundwater interactions, and refine prediction of project effectiveness and anticipated groundwater elevation changes. In addition, MCWD GSA plans to develop a refined local groundwater model capable of simulating solute transport and density driven flow to support preparation of their GSP for the Monterey Subbasin. This model is expected to include the MGSA Area and surrounding region of interest to this GSP. MGSA will review the modeling work conducted by SVBGSA and MCWD GSA, and collaborate with these agencies to update the local water budget, sustainable management criteria and management actions in this GSP as appropriate to support the local and regional sustainability goals. With these measures in place, the water budget information presented in this GSP focuses on augmenting the SVBGSA's regional water budgets with local information as needed to prepare a locally focused GSP that complies with the requirements of 23 CCR § 354.18, conveys an adequate understanding of local groundwater conditions, and informs local sustainable groundwater management decisions.

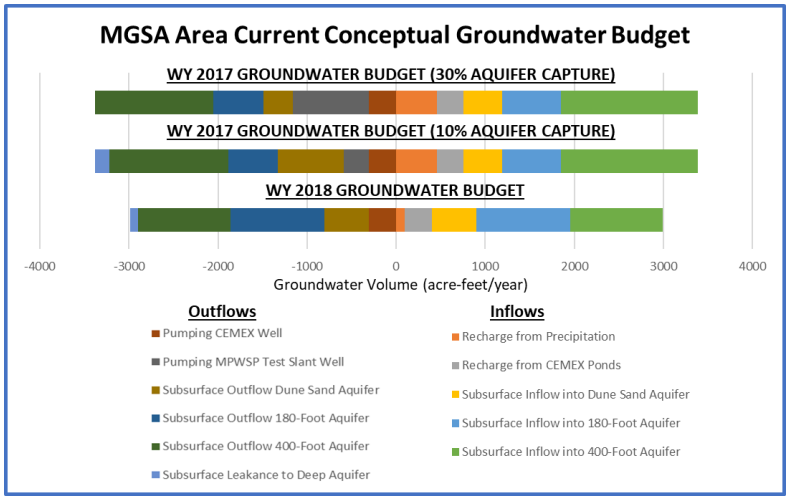
Due to the limitations of the available data, only a current water budget is developed for the MGSA Area, and qualitative water budget information is provided for the historical and predicted water budget for budget components that can be evaluated at this time. For planning purposes, it is reasonable to assume that the historic water budget was similar to the current water budget, as there has not been a significant change in land use or groundwater development within the MGSA Area for decades, with exception of the recent test slant well pumping. The current water budget was calculated using average annual precipitation and evapotranspiration data from Water Year (WY) 2015 through WY 2018, and includes three different water budget scenarios to provide perspective on the local contribution to the regional water budget:

1. A water budget for WY 2017 that assumes 10% of the water extracted from the test slant well during this year was pulled into the well from the aquifers underlying the MGSA Area (as opposed to saline groundwater originating from outside the Subbasin Boundary to the west, which is not included in this water budget assessment);

2. An alternate water budget for WY 2017 that assumes 30% of the water extracted from the test slant well was pulled into the well from the aquifers underlying the MGSA Area (as opposed to saline groundwater originating from outside the Subbasin Boundary to the west, which is not included in this water budget assessment); and

3. A water budget for WY 2018, summarizing conditions after the cessation of test slant well pumping.

Groundwater levels were relatively stable during the periods evaluated, so inflows and outflows were assumed to be equal. A graphical representation of these conceptual water budgets is presented in the inset graph. Based on this assessment, the following conclusions may be made:



- Below average precipitation resulted in less recharge in WY2018.

- When the test slant well was pumping, the majority of recharge from precipitation and inflow in the DSA was captured by the well. The amount of capture increases proportionally to the amount of water the well is assumed to extract from the aquifers in the subbasin.

- The amount of assumed subsurface outflow by leakance to the Deep Aquifer decreases as pumping increases.

- The amount of proposed makeup water pumping for the proposed MPWSP would capture all of the recharge and other inflows in this water budget and would have a significant impact on the regional water budget.

A projected future surface water budget indicates that recharge from precipitation may be expected to increase slightly over the next 50 years due to climate change. Several *in lieu* recharge projects are planned in the portions of the Subbasin east of the MGSA Area and are projected to lead to an increase in local groundwater levels by several feet in the 180-Foot and 400-Foot Aquifers. These projects would increase westward low-TDS groundwater inflows through the DSA and decrease eastward saline groundwater inflows through the 180-Foot and 400-Foot Aquifers. However, sea level is projected to rise by about 17 inches during this time period, increasing the amount of seawater intrusion in the MGSA Area and vicinity. Seawater intrusion will at least partially offset gains from additional groundwater recharge. Pumping of the CEMEX well is expected to cease in December 2020, or, at the latest in December 2024, when CEMEX removes the well resulting in the *in lieu* recharge of approximately 300 AFY of groundwater. Given that the proposed extraction rate for the MPWSP, if implemented, would be approximately 17,400 AFY, it is readily apparent that even if only a small percentage were derived from the aquifers underlying the MGSA Area and the Subbasin, the local groundwater budget would be significantly changed. A large volume of groundwater would be removed

from the DSA as well as the 180-Foot Aquifer. At the same time, a large amount of seawater would be drawn in to replace the aquifer water that is removed from storage. Because the MGSA Area is designated for open space and conservation land use, other potential significant land use and groundwater demand changes are not anticipated.

SUSTAINABILITY GOAL

A sustainability goal is a concise statement of the GSA's objectives and desired conditions of the groundwater basin, how the basin will get to that condition, and why the measures planned will lead to success. Unlike the other sustainable management criteria, the sustainability goal is not quantitative, but represents a statement of objectives supported by locally-defined minimum thresholds and undesirable results. MGSA adopts SVBGSA's sustainability goal for the Subbasin, which is stated as follows:

"MGSA will manage groundwater resources in the MGSA Area in a way that ensures all beneficial uses and users in, or affected by, groundwater management in the MGSA Area are protected from undesirable results, and have access to a safe and reliable groundwater supply that meets current and future demand. This goal will support SVBGSA's sustainability goal by addressing undesirable results at a local level and protecting local resources from further degradation, while coordinating with MCWRA, SVBGSA and MCWD GSA to support regional groundwater management, including ground-water level and seawater intrusion monitoring, and mitigation projects and management actions that will contain and reverse the conditions resulting from regional overdraft."

> "*The goal of this GSP is to manage the groundwater resources of the 180/400-Foot Aquifer Subbasin for long-term community, financial, and environmental benefits to the Subbasin's residents and businesses. This GSP will ensure long-term viable water supplies while maintaining the unique cultural, community, and business aspects of the Subbasin. It is the express goal of this GSP to balance the needs of all water users in the Subbasin.*"

The sustainability goal is supported by several local management objectives. The absence of undesirable results regionally will confirm that the Subbasin is operating within its sustainable yield and that the sustainability goals of all the GSAs in the Subbasin have been achieved.

SUSTAINABLE MANAGEMENT CRITERIA

Sustainable management criteria define the desired future groundwater resources condition of the MGSA Area in the Subbasin and commit MGSA to actions that will meet the objectives of the sustainability goal. Groundwater sustainability under SGMA is managed by avoiding or addressing significant and unreasonable adverse impacts resulting directly or indirectly from groundwater extraction and/or sea water intrusion in the GSP area and related to any of six sustainability indicators. For each sustainability indicator, undesirable results must be defined and assessed, minimum thresholds must be

Sustainability Indicators:

1. ***Chronic Lowering of Groundwater Levels***
2. ***Reduction of Groundwater Storage***
3. ***Seawater Intrusion***
4. ***Degraded Groundwater Quality***
5. ***Land Subsidence***
6. ***Depletion of Interconnected Surface Waters***

developed that quantify the undesirable result and allow it to be measured, and measurable objectives and interim milestones must be established as management goals to guide improvement of existing conditions or avoid their deterioration, as necessary, to achieve sustainable management within 20 years. The sustainable management criteria presented in Table ES-1, below, were developed based on information about the basin from the groundwater conceptual model, current and historical groundwater conditions, the water budget, and other publicly available information. They were also informed by public feedback about groundwater conditions in and near the MGSA Area obtained by the City Council during meetings held over the last three years, during recent public meetings about the GSP development process, and during meetings with MGSA staff.

TABLE ES-1: UNDESIRABLE RESULTS, MINIMUM THRESHOLDS AND MEASURABLE OBJECTIVES FOR SUSTAINABLE GROUNDWATER MANAGEMENT IN THE MGSA AREA

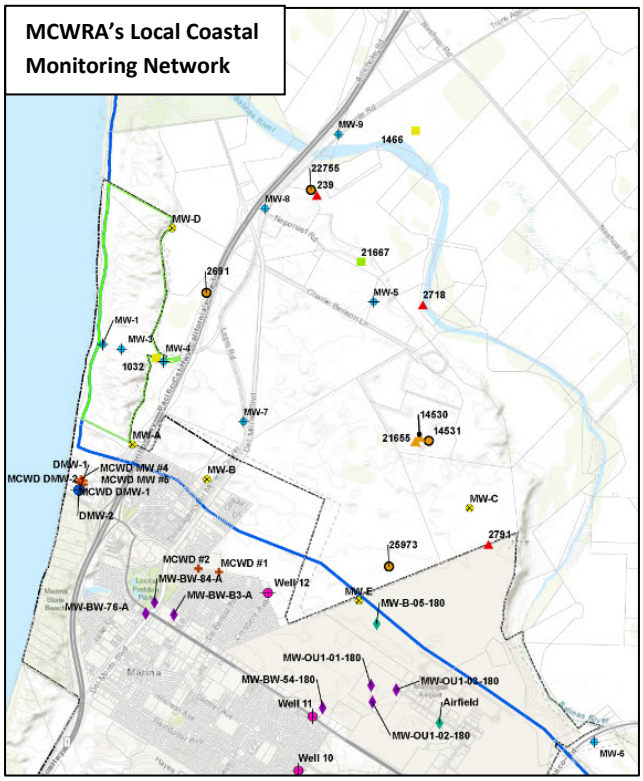
Sustainability Indicator	Minimum Thresholds	Measurable Objectives	Undesirable Results
Chronic Lowering of Groundwater Levels	• **Dune Sand Aquifer** - An elevation of 1 foot above the 2015 low groundwater levels recorded in Dune Sand Aquifer monitoring wells near identified GDEs in the vicinity of the MGSA Area (MW-4S, 7S and 8S) based on potential significant and unreasonable impacts to identified GDEs. Adopted on an interim basis and will be updated based on biological assessment of GDEs in the vicinity of the MGSA Area. • **180-Foot and 400-Foot Aquifer** - An elevation of 1 foot above the 2015 low groundwater levels in wells near receptors east of the MGSA Area (MW 4M, 4D, 5M, 5D, 6M, 6M(L), 7M, 7L, 8M, 8L, 9M, and 9L). based on potential impacts to groundwater users and groundwater levels found by SVBGSA stakeholders to result in significant and unreasonable conditions. Adjusted as needed to maintain local compatibility with thresholds designated by SVBGSA.	• **Dune Sand Aquifer** - An interim measurable objective that is identical to the minimum threshold. • **180-Foot and 400-Foot Aquifer** – Approximately 6 to 7 feet above minimum thresholds to be compatible with elevations specified by SVBGSA in the western portion of the Subbasin, adjusted as needed to match observed gradients so as to be realistically achievable.	• **Dune Sand Aquifer** – Exceedance of minimum thresholds at two or more representative monitoring sites (RMS). To account for uncertainty in aquifer conditions, an exceedance at two locations (66% of the RMS) is considered to provide an adequate level of confidence that an undesirable result is occurring. • **180-Foot and 400-Foot Aquifer** - Exceedance of the minimum thresholds in 15% or more of the RMS (i.e., two or more wells) to account for uncertainty in the aquifer system. The definition is a westward extension of SVBGSA's definition.
Reduction of Groundwater Storage	Because the local tools to further assess the MGSA Area component of the Subbasin-wide sustainable yield are not yet available, this GSP adopts SVBGSA's basin-wide sustainable yield estimate of 112,000 AFY as a minimum threshold, supplemented locally with the following interim minimum threshold related to the low-TDS groundwater zone near the MGSA Area in order to prevent undesirable results form groundwater extraction in the MGSA Area: • A decrease in the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers as measured by groundwater elevations, extraction reporting and induction logging. This interim minimum threshold is adopted to prevent significant and unreasonable impacts to GDEs, seawater intrusion, groundwater quality degradation, and potential harm to overlying groundwater right holders, while the data gaps regarding the sustainable yield are addressed as discussed in Chapters 6 and 7, and until a local sustainable yield volume can be determined.	The GSA adopts the minimum threshold as a measurable objective on an interim basis, until data gaps regarding the basin-wide and local sustainable yield can be addressed consistent with Chapters 6 and 7.	An undesirable result for reduction in groundwater storage is defined based on the minimum threshold as an annual depletion, in any given year, exceeding the Subbasin-wide minimum threshold of 112,000 AFY or resulting in a depletion of low-TDS groundwater storage east of the MGSA Area as measured by groundwater elevations, extraction reporting and induction logging. Because additional local tools to further assess the MGSA Area component of the basin-wide sustainable yield are expected to be available in the near future, MGSA has adopted this definition of undesirable results to prevent undesirable results as data gaps are addressed.
Seawater Intrusion	• **Dune Sand Aquifer**. In compliance with SWRCB Resolution Nos. 88-63 and 68-16, this GSP defines the minimum threshold for significant and unreasonable seawater intrusion into the Dune Sand Aquifer as migration of the 1,700 mg/L chloride isocontour (equivalent to 3,000 mg/L TDS) beyond the location determined by Gottschalk *et al.* (2018). • **180-Foot and 400-Foot Aquifers**. This GSP adopts the SVBGSA minimum threshold of significant unreasonable seawater intrusion beyond the position of the 500 mg/L chloride concentration isocontour interpolated by MCWRA in 2017. • **Deep Aquifer.** In compliance with SWRCB Resolution No. 68-16, this GSP defines significant and unreasonable seawater intrusion into the Deep Aquifer as migration of a 500 mg/L chloride isocontour into the Deep Aquifer landward of the western Subbasin boundary.	• **Dune Sand Aquifer**. The measurable objectives are established to equal the minimum threshold of maintaining the 1,700 mg/L chloride isocontour at its current location. The interim milestones are identical to the measurable objective. • **180-Foot and 400-Foot Aquifers**. MGSA will coordinate with SVBGSA, as appropriate, and support the measurable objective and interim milestones in the SVBGSA's GSP of moving the 500 mg/L chloride isocontour westward to Highway 1 by 2020. **Deep Aquifer.** The measurable objective for the Deep Aquifer will be to prevent significant and unreasonable seawater intrusion and maintain the location of the 500 mg/L chloride isocontour outside the seaward Subbasin Boundary. The interim milestones are identical to the measurable objective.	An undesirable result for seawater intrusion is defined as exceedance of one of the following minimum thresholds: • **Dune Sand Aquifer.** Migration of the 1,700 mg/L chloride isocontour beyond its location in 2018, indicating seawater intrusion into the low-TDS zone identified in Gottschalk *et al.* (2018), as interpreted from water quality sampling and induction logging data collected by MCWRA. • **180-Foot and 400-Foot Aquifer.** Seawater intrusion beyond the position of the 500 mg/L chloride isocontour interpolated by MCWRA in 2017, as determined by seawater intrusion maps prepared by MCWRA. • **Deep Aquifer.** Seawater intrusion beyond a theoretical 500 mg/L chloride isocontour established as the western (seaward) edge of the Subbasin, as interpreted from groundwater quality monitoring data collected by MCWRA.

Sustainability Indicator	Minimum Thresholds	Measurable Objectives	Undesirable Results
Degraded Groundwater Quality	• Significant and unreasonable degradation of water quality in the low-TDS groundwater zone in the Dune Sand, 180-Foot and 400-Foot Aquifers is defined as lateral or vertical migration of the 3,000 mg/L TDS isocontour beyond the location established by the 2018 AEM study (Gottschalk et al. 2018). • Significant and unreasonable degradation of water quality in the Deep Aquifer is defined as exceedance of the TDS or chloride SMCL in one or more public supply wells completed in the Deep Aquifer near the MGSA. • Significant and unreasonable migration of a contamination plume is defined by the following minimum thresholds: ○ Migration or spread of the portion of a contamination plume that exceeds applicable water quality objectives by more than 100 feet toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.	• The measurable objective for degradation of water quality in the low-TDS groundwater zone are defined to be the same as the minimum threshold, which is the 2018 vertical and lateral position of the 3,000 mg/L TDS isocontour in the Dune Sand, 180-Foot, and 400-Foot Aquifers, as determined by the 2018 AEM survey (Gottschalk et al. 2018). • The measurable objective for degradation of water quality in the Deep Aquifer is no supply wells with MCL or SMCL exceedances for TDS or chloride. • The measurable objective for migration of a contamination plume is defined by the following: • An observable spread of the portion of a contamination plume that exceeds applicable water quality objectives over two or more consecutive monitoring events toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.	• **Dune Sand Aquifer.** Migration of the 1,700 mg/L chloride isocontour beyond its location in 2018, indicating seawater intrusion into the low-TDS zone identified in Gottschalk *et al.* (2018), as interpreted from water quality sampling and induction logging data gathered by MCWRA. • **180-Foot and 400-Foot Aquifer.** Seawater intrusion beyond the position of the 500 mg/L chloride isocontour interpolated by MCWRA in 2017, as determined by seawater intrusion maps prepared by MCWRA. • **Deep Aquifer.** Seawater intrusion beyond a theoretical 500 mg/L chloride isocontour established as the western (seaward) edge of the Subbasin, as interpreted from groundwater quality monitoring data gathered by MCWRA. • **Migration of Contamination Plumes.** Migration or spread of the portion of a contamination plume that exceeds applicable water quality objectives by more than 100 feet toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.
Land Subsidence	The minimum thresholds for Chronic Lowering of Groundwater Levels are established as a proxy for land subsidence, based on evidence that they will be protective for both sustainability indicators.	The measurable objectives and interim milestones for Chronic Lowering of Groundwater Levels are established as a proxy for land subsidence, based on evidence that they will be protective for both sustainability indicators.	The undesirable results definition for Chronic Lowering of Groundwater Levels are established as a proxy for land subsidence, based on evidence that it will be protective for both sustainability indicators.
Depletion of Interconnected Surface Waters	The minimum thresholds for Chronic Lowering of Groundwater Levels are established as a proxy for land subsidence, based on evidence that they will be protective for both sustainability indicators.	The measurable objectives and interim milestones for Chronic Lowering of Groundwater Levels are established as a proxy for land subsidence, based on evidence that they will be protective for both sustainability indicators.	The undesirable results definition for Chronic Lowering of Groundwater Levels are established as a proxy for land subsidence, based on evidence that it will be protective for both sustainability indicators.

MONITORING NETWORK

The monitoring network will be used to collect representative information about groundwater conditions as necessary to evaluate and guide implementation of this local GSP for the MGSA Area. Monitoring activities will focus on key resources and the four principal aquifers within and proximal to the MGSA Area. This MGSA GSP monitoring network was established to collect representative information to demonstrate short-term, seasonal, and long-term trends as needed to support SGMA requirements. The monitoring network will be used to monitor changes in groundwater conditions and demonstrate compliance with minimum thresholds and status relative to measurable objectives. The network will be used to monitor impacts to the beneficial uses or users of groundwater, and quantify annual changes in water budget components. In addition, monitoring will be used to assess the criteria that trigger the initiation and completion of management actions and assess their effectiveness under conditions that include minimum threshold exceedances, variable conditions, and adverse impacts to beneficial uses and users of groundwater, including GDEs.

MCWRA's Local Coastal Monitoring Network



There are several existing and well-developed monitoring programs and networks that are used to monitor the four principal aquifers in the 180/400 Foot Aquifer Subbasin. These include regional programs implemented by MCWRA to monitor groundwater elevations and seawater intrusion, including monitoring for the California Statewide Ambient Groundwater Elevation Monitoring (CASGEM) program. Other programs will be implemented by SVBGSA to monitor groundwater storage changes, subsidence, and surface-groundwater interaction for their 180/400 Foot Aquifer Subbasin GSP. These programs are important to this MGSA GSP as they characterize regional conditions and trends in the Subbasin. However, because the MGSA Area makes up a relatively small portion of the Subbasin's seaward edge, the MGSA GSP will rely primarily on data collected by MCWRA from a local monitoring network adopted in and around the MGSA Area under the MMRP for the proposed MPWSP. This "Local Coastal Monitoring Network" includes a variety of existing and proposed wells that would be monitored to assess the effects of proposed MPWSP groundwater extraction in the MGSA Area.

There are currently eight monitoring well clusters with 24 wells within and near the MGSA Area that were installed to monitor test slant well pumping for the MPWSP design and environmental studies (Labeled MW-1 through MW-9 [the MW-2 cluster was not installed]). Each of these clusters has a well completed in the Dune Sand Aquifer, the 180-Foot Aquifer, and the 400-Foot Aquifer. Under the MMRP

for the proposed MPWSP, MCWRA is planning to construct five additional well clusters with three wells each (labeled MW-A through MW-E), and install a deeper Dune Sand Aquifer well at location MW-5 to expand the network of nested monitoring wells to a total of 40 wells. MCWRA will also monitor a number of additional existing wells in the vicinity of the MGSA Area, including 10 wells competed in the Dune Sand Aquifer, eight wells completed in the 180-Foot Aquifer, five wells completed in the 400-Foot Aquifer and 14 wells completed in the Deep Aquifer. This monitoring program is adopted in the GSP and will be monitored quarterly or more frequently to assess conditions during GSP implementation. The 40 nested MPWSP monitoring wells, if constructed, will be utilized as the groundwater elevation, groundwater quality and inductance logging monitoring network to assess compliance with minimum thresholds and status relative to measurable objectives in the upper aquifer system (the Dune Sand, 180-Foot, and 400-Foot Aquifers). The 14 Deep Aquifer wells will be utilized as the monitoring well network to assess compliance with minimum thresholds and status relative to measurable objectives in the Deep Aquifer. Data from the remaining wells will be considered in the interpretation of local conditions, but will not be utilized to assess compliance or status relative to sustainable management criteria. MCWD GSA plans to review the adequacy of this monitoring network to meet the objectives of the GSP being prepared for the Monterey Subbasin, and may recommend or implement modifications. MGSA will review the results of this analysis and may make modifications to its monitoring networks as appropriate to assure compatible monitoring programs are utilized across the subbasin boundaries.

DATA MANAGEMENT SYSTEM

The MGSA Data Management System was created on a Microsoft Access platform. MGSA's database has a simple structure which is shared with the data management system being developed by MCWD GSA in support of its GSP for the Monterey Subbasin. In addition, MGSA is coordinating with SVBGSA to ensure compatibility with the data management system being developed by that agency. Both GSAs will rely extensively on the same monitoring data collected by MCWRA in the 180/400 Foot Aquifer Subbasin. SVBGSA is considering development of a web-based data management system to facilitate basin-wide groundwater management. MGSA will cooperate with this effort and may provide data inputs as needed, but will retain a relatively simple structure for its data management system that is not web-based.

PROJECTS AND MANAGEMENT ACTIONS

MGSA Management Actions:

- ***Management Action 1: Management of seawater intrusion, groundwater quality degradation and low-TDS groundwater zone depletion***
  - ***Phase 1. Detection Monitoring***
  - ***Phase 2. Investigation, Verification and HCM [Hydrogeologic Conceptual Model] Update***
  - ***Phase 3. Characterization, Planning & Implementation***
- ***Management Action 2: Management of impacts to GDEs and interconnected surface waters***
  - ***Phase 1. Detection Monitoring***
  - ***Phase 2. Investigation, Verification and HCM Update***
  - ***Phase 3. Characterization, Planning & Implementation***

The 180/400 Foot Aquifer Subbasin is subject to ongoing seawater intrusion due largely to long-term groundwater extraction in the inland portions of the Subbasin in excess of the sustainable yield. The purpose of this GSP is to ensure sustainable groundwater management in the MGSA Area, as well as to support regional efforts to address this undesirable result and return the Subbasin to sustainable groundwater management within 20 years, as required by SGMA. MGSA will achieve this by supporting projects and management actions

that will be implemented by SVBGSA under its regional GSP that are aligned with MGSA's sustainability goals, and by assuring that local groundwater resources are managed sustainably to protect local and regional beneficial uses and users. MGSA has not identified any feasible projects within the MGSA Area to promote sustainable groundwater management at this time, but plans to continue to evaluate potential projects and will adopt some going forward if and when appropriate. MGSA will also coordinate with SVBGSA and/or MCWD GSA if the possibility for collaboration on such projects is identified in the future. MGSA has identified three management actions that will prevent undesirable results and promote sustainable groundwater management. Several SVBGSA projects and management actions for the Subbasin would provide regional benefits which would also benefit the MGSA Area. MGSA will coordinate with and support SVBGSA in the implementation of these projects and management actions to the extent they provide benefit to the MGSA Area.

PLAN IMPLEMENTATION

There are six main activities for implementation of the MGSA GSP:

Activity 1: Monitoring, Reporting and Outreach
Groundwater elevation monitoring, water quality monitoring, and induction logging will be conducted in the Dune Sand Aquifer, 180-Foot, 400-Foot, and Deep Aquifers by MCWRA. Data collected will be provided to MGSA for evaluation of groundwater level decline, groundwater storage, seawater intrusion, water quality degradation, and land subsidence. River discharge and stage measurements and groundwater elevation data will be used to evaluate interconnected surface waters. Biological monitoring of the vernal ponds will be conducted by an MGSA biologist to evaluate GDEs. Annual reports will be prepared by MGSA and submitted to DWR starting April 1, 2021. Periodic assessment reports will be submitted to DWR every five years starting in 2025. MGSA will work to encourage the active involvement of the community by keeping the community informed about progress in implementing the GSP.

Activity 2: Address Data Gaps
MGSA identified several data gaps, which will be addressed during implementation of the GSP. These data gaps include the following: further development of groundwater elevation and quality data in the MGSA Area; investigation of the interconnection between the Salinas River and the Dune Sand Aquifer and underlying 180-Foot Aquifer; assessment of baseline GDE conditions and the relationship between drawdown and GDE responses; characterization of the Deep Aquifer system; assessment of aquifer parameters; assessment of more depth discrete groundwater data as required; further evaluation of basin susceptibility to land subsidence; and evaluation of potential MPWSP impacts.

Activity 3: Update Data Management System
The data management system (DMS) to support ongoing data-driven GSP implementation will be updated by MGSA as needed.

Activity 4: Refine MGSA GSP Based on Findings from the USGS SVIHM and SVBGSA GSP Addendum
MGSA will refine the MGSA GSP based on the upcoming release of the USGS SVIHM and planned review and use of the SVIHM by SVBGSA to update the SVBGSA GSP. At the same time, MGSA will further

refine this GSP based on the planned development of a locally-refined groundwater flow model by MCWD GSA that is able to simulate solute transport and density-driven flow.

Activity 5: Inter- and Intra-Basin Coordination with SVBGSA and MCWD GSA

MGSA will attend coordination meetings with SVBGSA and MCWD GSA as the various GSPs for the Subbasin are implemented.

Activity 6: Local Management Actions for Seawater Intrusion and Groundwater Quality Degradation, and GDE Impacts

MGSA will monitor and evaluate the potential for significant and unreasonable groundwater level decline that could affect GDEs, seawater intrusion, groundwater quality degradation and/or low-TDS groundwater zone storage depletion as a result of groundwater extraction in the MGSA Area. A baseline biological assessment will also be conducted and a biological resources monitoring plan developed for the GDEs, which may result in additional monitoring requirements. If the data indicate that undesirable results may occur as a result of groundwater pumping in the MGSA Area, then MGSA will implement management actions as triggered by two-tiered thresholds using its powers and authorities in SGMA.

COSTS AND FUNDING

The overall estimated cost for MGSA for the first five years of implementation is $1,100,000 with an average annual cost of $220,000. Costs funded through MGSA include biological monitoring of GDEs, analysis of groundwater monitoring data and data uploads to the data management system; annual reporting, a GSP Addendum Report, and the 5-Year Update Report; communication and outreach, participation in coordination meetings with SVBGSA and MCWD GSA; and implementation of management actions. As initial GSP implementation proceeds, MGSA will evaluate funding mechanisms, application of fees, and fee criteria. MGSA will also evaluate potential funding from state and federal grant sources to support GSP implementation. Appropriate grant funding sources will be pursued collaboratively with MCWD GSA, SVBGSA, MCWRA and others to fill data gaps and support the implementation of projects and management actions.

CHAPTER 1 – INTRODUCTION
Groundwater Sustainability Plan for the Marina GSA Area of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, California

JANUARY 2020

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1 INTRODUCTION

The California Legislature enacted the Sustainable Groundwater Management Act (SGMA) in 2014 in response to continued overdraft of California's groundwater resources (23 California Code of Regulations [CCR] § 350 and California Water Code [CWC] §§ 10720-10736.6). SGMA requires Groundwater Sustainability Agencies (GSAs) to prepare and implement Groundwater Sustainability Plans (GSPs) to achieve sustainable groundwater management in medium- and high-priority groundwater basins and subbasins designated by the California Department of Water Resources (DWR). SGMA defines sustainable groundwater management as "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results." Undesirable results are defined by SGMA as any of the following effects caused by groundwater extraction within the basin (DWR 2017):

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply;
- Significant and unreasonable reduction of groundwater storage;
- Significant and unreasonable seawater intrusion;
- Significant and unreasonable degraded water quality;
- Significant and unreasonable land subsidence; or
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

SGMA requires the following basic activities in groundwater basins and subbasins that are designated as medium or high priority by DWR:

- Formation of one or more GSAs in the basin or subbasin;
- Development (by one or more GSAs) of one or more GSPs in the basin or subbasin;
- Implementation of the GSPs to achieve sustainable groundwater management within 20 years of GSP adoption;
- Regular reporting to DWR; and
- Periodic review and updating of the GSP.

DWR has designated 21 basins and subbasins as being in a state of critical overdraft (DWR 2016a). GSPs for these basins or subbasins must be adopted and submitted to DWR by January 31, 2020. GSPs for the remaining medium- and high-priority basins and subbasins must be adopted and submitted to DWR by January 31, 2022.

The subject of this GSP is a portion of the 180/400 Foot Aquifer Subbasin (Subbasin) (DWR Subbasin Number 3-004.01) of the Salinas Valley Groundwater Basin in the Central Coast Hydrologic Region of

California. The Subbasin is identified by DWR as subject to critical conditions of overdraft (DWR 2016a). As shown on Figure 1-1, four other subbasins of the Salinas Valley Basin adjoin the 180/400 Foot Aquifer Subbasin, including the East Side Aquifer and Langley Area Subbasins to the northeast (DWR Subbasin Numbers 3-004.02 and 3-004.09, respectively), the Forebay Aquifer Subbasin to the southeast (DWR Subbasin Number 3-004.04), and the Monterey Subbasin to the southwest (DWR Subbasin Number 3-004.10). The 180/400 Foot Aquifer Subbasin is bounded to the north by the Pajaro Valley Subbasin (DWR Basin Number 3-002.01), and to the northwest by the Pacific Ocean. The remaining subbasins in the Salinas Valley Basin are designated as medium- and high-priority by DWR, but not critically overdrafted.

1.1 PURPOSE OF THE GSP

On March 20, 2018, the City of Marina's City Council formed the City of Marina Groundwater Sustainability Agency (MGSA) to develop and implement a GSP under SGMA in a portion of the Subbasin that lies within its jurisdictional limits, but outside the jurisdictional limits of the Marina Coast Water District (MCWD) GSA (Figure 1-2). The MGSA Area is bounded by the Pacific Ocean along the western border and includes Monterey County Assessor Parcel Numbers APN 203-011-001, APN 203-011-019, and APN 203-011-020. By letter dated April 16, 2018, MGSA notified DWR, pursuant to CWC § 10723.8(a), of its intent to become the exclusive GSA for this area.

The purpose of this GSP is to comply with the SGMA-mandated requirements for sustainable groundwater management within MGSA's jurisdictional area (hereinafter the MGSA Area). Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) is the lead agency for a GSP covering the remainder of the 180/400 Foot Aquifer Subbasin (SVBGSA 2019), pursuant to an agreement with the Marina Coast Water District (MCWD) GSA, which has SGMA jurisdictional authority over certain parts of the Subbasin. In addition, SVBGSA is the lead agency for GSPs covering four other Salinas Valley subbasins under SVBGSA jurisdiction that are not designated as critically overdrafted and will be submitted to DWR in 2022: the East Side Aquifer Subbasin, Forebay Aquifer Subbasin, Upper Valley Aquifer Subbasin (DWR Subbasin Number 3-004.05), and Langley Area Subbasin. SVBGSA and MCWD GSA each have SGMA jurisdictional authority over subareas of the Monterey Subbasin, which is adjacent to the south of the 180/400 Foot Aquifer Subbasin, and have entered into a Framework Agreement to prepare one single GSP for the Monterey Subbasin (SVBGSA 2018b). Additional information on jurisdictional areas within the MGSA Area and vicinity is provided in Section 2.1.1.

MGSA notes that on December 11, 2019, the Monterey County Board of Supervisors adopted Resolution 19-171 to create a new GSA in an effort to become the "exclusive" GSA for the MGSA Area. Pursuant to this resolution, County staff filed a GSA notification with DWR to become the GSA for the MGSA area, and on December 18, 2019, DWR posted the County's notification and designated the County the "exclusive" GSA for the MGSA Area. MGSA believes that these County actions and DWR's designation are invalid and ineffective under SGMA. On December 30, 2019, the City and MGSA filed litigation

challenging these actions and decisions. Since these matters are in litigation, MGSA does not address them further herein.

The 180/400 Foot Aquifer Subbasin is subject to significant and unreasonable seawater intrusion due largely to long-term groundwater extraction in the inland portions of the Subbasin in excess of the sustainable yield. As a result, it has been identified by DWR as being in a critical condition of overdraft (DWR 2016a). Seawater intrusion was first identified near the MGSA Area in the 1940s, and over the following decades progressed inland for a distance of over 7 miles in some areas. The purpose of this GSP is to support regional efforts to address this undesirable result and return the Subbasin to sustainable groundwater management within 20 years, as required by SGMA. MGSA will achieve this by supporting the projects and management actions that will be implemented by SVBGSA under its regional GSP, and by assuring that local groundwater resources are managed sustainably to protect local and regional beneficial uses and users.

MGSA has developed this locally-focused GSP to provide the framework necessary to ensure sustainable groundwater management in this portion of the Subbasin. This GSP will be implemented together with the regional SVBGSA GSP for the remainder of the Subbasin to sustainably manage the groundwater resources in the 180/400 Foot Aquifer Subbasin. A locally-focused GSP is needed in the MGSA Area to address the hydrogeologic conditions and management needs unique to this portion of the Subbasin.

As discussed in detail in Chapter 3, seawater intrusion was first monitored in the coastal area near the MGSA jurisdiction in 1947, and has been a topic of numerous investigations and monitoring programs by Monterey County Water Resources Agency (MCWRA), United States Geological Survey (USGS), and the proponents of various water supply and management projects. Most recently, subsurface investigation and groundwater monitoring were conducted within and in the vicinity of the MGSA Area by the proponents of the Monterey Peninsula Water Supply Project (MPWSP), and the area was investigated by a Stanford University research team using geophysical techniques as part of a larger study to assess the three-dimensional variability in aquifer stratigraphy and water salinity in the area of seawater intrusion along the Monterey Bay coastline. The GSP Emergency Regulations require that *"[e]ach Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow*" (23 CCR § 354.18 (e)). In compliance with this requirement, this GSP objectively considers all the available data described above to provide a working understanding that is sufficient to address local hydrogeologic conditions, to understand the associated uncertainties and data gaps, and to develop plans to address them as needed to assure sustainable groundwater management.

The MGSA Area is at the seaward edge of an area affected by seawater intrusion that extends inland for several miles. The available hydrogeologic data indicate that the MGSA Area is underlain, in order of depth, by the Dune Sand Aquifer (DSA), the 180-Foot Aquifer, the 400-Foot Aquifer, and the Deep Aquifer. Near the shore, where the highest groundwater salinities have been documented, an interface

between a seawater intrusion wedge and a zone of higher quality groundwater (the low total dissolved solids [TDS] zone) that is locally recharged through the highly permeable Dune Sand Aquifer extends downward into the 180-Foot Aquifer. The existence of this interface was identified using geophysical methods, and is consistent with the available monitoring data as well as expected conditions at the shoreward face of a seawater-intruded aquifer system. The long screen intervals of the monitoring wells installed in the area limit the ability to confirm the exact salinity distribution in the aquifer and the variation in groundwater flow conditions, but the dynamics of similar interfaces in coastal aquifers have been studied for many years and their expected behavior is well understood. Such interfaces tend to follow the Ghyben-Herzberg relationship, for the names of the authors who first documented it between 1888 and 1901 (Ghyben 1888; Herzberg 1901). A state of equilibrium exists between a more saline, dense seawater intrusion wedge that tends to flow landwards, and an over-riding, less dense and higher quality groundwater zone that tends to flow shoreward. Based on the best available science, freshwater that flows from the Dune Sand Aquifer to the upper 180-Foot Aquifer contributes to maintaining this high-quality groundwater zone.

The exact effect of groundwater extraction in the MGSA Area on this interface has not been evaluated, but a probable effect is that capture of groundwater from the seaward-flowing higher quality water zone by extraction wells could decrease the extent and thickness of this zone, which could allow thickening and further landward or downward migration of the more dense saline water wedge. The aquitards that impede downward vertical migration of seawater-intruded groundwater between the 180-Foot and 400-Foot Aquifers elsewhere in the Subbasin are locally thin or absent in this area, potentially allowing higher density saline groundwater to migrate downward if the saline water wedge thickens or moves further inland. Finally, the underlying Deep Aquifer system provides a source of drinking water for the City of Marina and is not yet affected by seawater intrusion. However, MCWRA and SVBGSA, which are responsible for monitoring and regulating groundwater extraction in the seawater-intruded portion of the Subbasin, have stated that the hydraulic separation between the 400-Foot Aquifer and the Deep Aquifers is uncertain, and have therefore prohibited the expansion of groundwater extraction in the Deep Aquifers. As such, a key objective of the MGSA GSP is to protect the existing high quality waters in the Deep Aquifers underlying the MGSA Area.

This MGSA GSP describes local hydrogeologic conditions and establishes local sustainable management criteria to protect beneficial uses and users of groundwater in the MGSA Area, and, in coordination with the Monterey Subbasin GSP and the SVBGSA's GSP for the remainder of the 180/400 Foot Aquifer Subbasin, to ensure sustainable groundwater management in accordance with 23 CCR § 350.4(e). In addition, this GSP provides management actions for assuring sustainability, and includes monitoring and reporting protocols to document the long-term sustainability of locally managed groundwater resources now and into the future.

1.2 SUSTAINABILITY GOAL

Regulation Requirements:
§ 354.24. Sustainability Goal
Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

CWC § 10721 defines sustainable groundwater management as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results." A sustainability goal is the desired culmination of sustainable groundwater management, resulting in the maintenance of sustainable groundwater conditions (the absence of undesirable results), or their achievement within 20 years, when compared to a 2015 baseline condition. The sustainability goal reflects these requirements and succinctly states the GSAs' objectives and the desired conditions of the GSP area.

This GSP adopts SVBGSA's sustainability goal, which is stated as follows (SVBGSA 2019):

> *The goal of this GSP is to manage the groundwater resources of the 180/400-Foot Aquifer Subbasin for long-term community, financial, and environmental benefits to the Subbasin's residents and businesses. This GSP will ensure long-term viable water supplies while maintaining the unique cultural, community, and business aspects of the Subbasin. It is the express goal of this GSP to balance the needs of all water users in the Subbasin.*

The local management objectives (CWC § 10728.2 Evaluation of Plan) in support of this goal include the following:

> *MGSA will manage groundwater resources in the MGSA Area in a way that ensures all beneficial uses and users in, or affected by, groundwater management in the MGSA Area are protected from undesirable results, and have access to a safe and reliable groundwater supply that meets current and future demand. This goal will support SVBGSA's sustainability goal by addressing undesirable results at a local level and protecting local resources from further degradation, while coordinating with MCWRA, SVBGSA and MCWD GSA to support regional groundwater management, including groundwater level and seawater intrusion monitoring, and mitigation projects and management actions that will contain and reverse the conditions resulting from regional overdraft. MGSA will:*
>
> - *Support the protection of reliable groundwater supply and quality to promote the public health and welfare now and into the future;*

- *Ensure that groundwater is available for beneficial and potential beneficial uses, including all of the diverse municipal, domestic, agricultural, industrial, and environmental uses potentially affected by management actions within the MGSA;*
- *Protect the aquifers underlying the MGSA against further seawater intrusion;*
- *Comply with State Water Resources Control Board (SWRCB) Resolution No. 88-63, which designates all groundwaters of the state containing less than 3,000 milligrams per liter (mg/L) of TDS as having a potential beneficial use as a domestic or municipal drinking water supply and SWRCB Resolution No. 68-16, which requires the high quality of these waters to be maintained unless the state finds that certain specific conditions are met;*
- *Maintain or enhance groundwater levels and groundwater discharge where groundwater-dependent ecosystems (GDEs) exist near the MGSA Area;*
- *Maintain operational flexibility within the Subbasin, assuring that groundwater resources are available during times of drought without causing undesirable results;*
- *Account for changing groundwater conditions related to implementation of future groundwater supply projects, projected climate change, and sea level rise, in sustainability planning and management; and*
- *Coordinate with, support, and avoid undesirable results to neighboring GSAs and groundwater basins in regional efforts to achieve groundwater sustainability.*

As discussed previously, MGSA is located at the seaward edge of the interface between the regional saline water wedge that has intruded into the 180-Foot and 400-Foot Aquifers, and an area of lower TDS (higher quality) groundwater that is locally recharged through the Dune Sand Aquifer. Groundwater quality underlying the MGSA Area has been affected by seawater intrusion for several decades as a result of inland overdraft conditions. A key objective of this GSP is to address these conditions at a more local level and protect local resources from further degradation, while coordinating with SVBGSA and MCWD GSA to support regional groundwater level and seawater intrusion monitoring and mitigation projects that will contain and reverse the conditions resulting from regional overdraft. Specifically, monitoring and management actions in the MGSA Area will be focused on preventing future undesirable results in the already degraded Dune Sand Aquifer, 180-Foot Aquifer and 400-Foot Aquifer; protecting the Deeper Aquifers from potential seawater intrusion; and coordinating with the neighboring GSAs to support regional sustainable management goals.

Based on the data discussed in Chapter 3 (Basin Setting), maintaining the groundwater elevations and thickness of the higher quality groundwater zone (low TDS zone) needed to protect against seawater intrusion will largely prevent undesirable results from occurring for all six sustainability indicators in the MGSA Area, and will support the sustainability goals of the neighboring GSAs. Coordination of efforts

among MGSA, SVBGSA, and MCWD GSA is discussed in Sections 1.3 and 1.4, and is intended to assure that the respective sustainability goals of each GSP are met, and that the interests of all beneficial users and uses of groundwater within the Subbasin and the adjacent Monterey Subbasin are protected. A more detailed explanation of how these goals will be met is discussed in Chapter 4 (Sustainable Management Criteria), Chapter 5 (Monitoring Network) and Chapter 6 (Projects and Management Actions).

1.3 INTRA-BASIN COORDINATION AGREEMENTS

Regulation Requirements:

§ 357.4. Coordination Agreements

(a) Agencies intending to develop and implement multiple Plans pursuant to Water Code Section 10727(b)(3) shall enter into a coordination agreement to ensure that the Plans are developed and implemented utilizing the same data and methodologies, and that elements of the Plans necessary to achieve the sustainability goal for the basin are based upon consistent interpretations of the basin setting.

(b) Coordination agreements shall describe the following:

(1) A point of contact with the Department.

(2) The responsibilities of each Agency for meeting the terms of the agreement, the procedures for the timely exchange of information between Agencies, and procedures for resolving conflicts between Agencies.

(3) How the Agencies have used the same data and methodologies for assumptions described in Water Code Section 10727.6 to prepare coordinated Plans, including the following:

(A) Groundwater elevation data, supported by the quality, frequency, and spatial distribution of data in the monitoring network and the monitoring objectives as described in Subarticle 4 of Article 5.

(B) A coordinated water budget for the basin, as described in Section 354.18, including groundwater extraction data, surface water supply, total water use, and change in groundwater in storage.

(C) Sustainable yield for the basin, supported by a description of the undesirable results for the basin, and an explanation of how the minimum thresholds and measurable objectives defined by each Plan relate to those undesirable results, based on information described in the basin setting.

(c) The coordination agreement shall explain how the Plans implemented together, satisfy the requirements of the Act and are in substantial compliance with this Subchapter

(d) The coordination agreement shall describe a process for submitting all Plans, Plan amendments, supporting information, all monitoring data and other pertinent information, along with annual reports and periodic evaluations.

(e) The coordination agreement shall describe a coordinated data management system for the basin, as described in Section 352.6.

(f) Coordination agreements shall identify adjudicated areas within the basin, and any local agencies that have adopted an Alternative that has been accepted by the Department. If an Agency forms in a basin managed by an Alternative, the Agency shall evaluate the agreement with the Alternative prepared pursuant to Section 358.4 and determine whether it satisfies the requirements of this Section.

(g) The coordination agreement shall be submitted to the Department together with the Plans for the basin and, if approved, shall become part of the Plan for each participating Agency.

(h) The Department shall evaluate a coordination agreement for compliance with the procedural and technical requirements of this Section, to ensure that the agreement is binding on all parties, and that provisions of the agreement are sufficient to address any disputes between or among parties to the agreement.

(i) Coordination agreements shall be reviewed as part of the five-year assessment, revised as necessary, dated, and signed by all parties.

MGSA has attempted to negotiate in intra-basin coordination agreement with SVBGSA pursuant to CWC § 10727.6 and 23 CCR § 357.4 to ensure that the MGSA and SVBGSA GSPs for the Subbasin are developed and implemented using the same data and methodologies, and that elements of the GSPs necessary to achieve the sustainability goal for the Subbasin are based on consistent interpretations of

the Subbasin setting. MGSA developed a draft of this agreement and submitted it to SVBGSA for consideration in August 2019; however, SVBGSA failed to act on this agreement.

MGSA maintains its desire to coordinate local sustainable groundwater management with SVBGSA under this GSP pursuant to a Coordination Agreement. The language in this subsection of the GSP will be updated to reflect the Coordination Agreement if and when this occurs.

The Coordination Agreement will designate a point of contact with DWR, the responsibilities of each GSA for meeting the terms of the agreement, the procedures for the timely exchange of information between the GSAs, and procedures for resolving conflicts. [A copy of the agreement will be included as an appendix to this GSP when executed (Appendix 1.A, PLACEHOLDER).]

The designated point of contact with DWR for sustainable groundwater management in the 180/400 Foot Aquifer Subbasin is the following:

[Layne Long
City of Marina
Marina Groundwater Sustainability Agency
211 Hillcrest Avenue
Marina, California 93933
Phone: (831) 884-1212
Email: llong@cityofmarina.org]

[The designated point of contact will be updated when the Coordination Agreement is executed.]

The Coordination Agreement specifically will address the following requirements of 23 CCR § 357 and specifies how MGSA and SVBGSA will collaborate to use the same data and methodologies described in CWC § 10727.6 for coordinated GSP preparation and implementation:

- Coordinated data collection, management and exchange, including common methodologies and data for: a) groundwater elevation data; b) groundwater extraction data; c) surface water supply; d) total water use; e) changes in groundwater storage; f) water budgets; and g) sustainable yield;

- Adoption of shared or complementary sustainability indicators for: a) chronic lowering of groundwater levels; b) reduction in groundwater storage; c) degraded water quality; d) seawater intrusion; and e) land subsidence;

- Collaboration in the establishment of monitoring networks and protocols, including coordinating the methods and frequency of measurement for: a) the amount of current and projected groundwater use; b) aquifer characterization; and c) potential impacts to beneficial uses and users of groundwater and property interests; and

- Coordinated water budget accounting procedures including assessment of the total annual volume of groundwater and surface water entering and leaving the Subbasin; historical, current and projected water budget conditions; changes in groundwater storage; and estimates of future baseline conditions of supply, water demand, and surface water supply availability or reliability over the planning and implementation horizon.

The Coordination Agreement will explain how SGMA is satisfied by the coordinated GSP implementation, and describes a process for submitting the GSPs, Plan amendments, supporting information, monitoring data, and other pertinent information, annual reports, and periodic evaluations [this language will be updated when the agreement is executed]. The Coordination Agreement will describe a coordinated data management system (DMS) for the Subbasin and identifies adjudicated areas within the Subbasin [this language will be updated when the agreement is executed].

MGSA and MCWD GSA will also negotiate an intra-basin Coordination Agreement because MCWD GSA is an authorized GSA for the Marina and Ord subareas of the Subbasin within MCWD GSA's jurisdictional boundaries. MCWD GSA and SVBGSA have agreed that SVBGSA will prepare the GSP for these areas and to actively consult with each other and review draft work products during the GSP development process for the 180/400 Foot Aquifer.

1.4 INTER-BASIN COORDINATION AGREEMENTS

Regulation Requirements:

§ 357.2. Interbasin Agreements

Two or more Agencies may enter into an agreement to establish compatible sustainability goals and understanding regarding fundamental elements of the Plans of each Agency as they relate to sustainable groundwater management. Interbasin agreements may be included in the Plan to support a finding that implementation of the Plan will not adversely affect an adjacent basin's ability to implement its Plan or impede the ability to achieve its sustainability goal. Interbasin agreements should facilitate the exchange of technical information between Agencies and include a process to resolve disputes concerning the interpretation of that information. Interbasin agreements may include any information the participating Agencies deem appropriate, such as the following:

(a) General information:

(1) Identity of each basin participating in and covered by the terms of the agreement.

(2) A list of the Agencies or other public agencies or other entities with groundwater management responsibilities in each basin.

(3) A list of the Plans, Alternatives, or adjudicated areas in each basin.

(b) Technical information:

(1) An estimate of groundwater flow across basin boundaries, including consistent and coordinated data, methods, and assumptions.

(2) An estimate of stream-aquifer interactions at boundaries.

(3) A common understanding of the geology and hydrology of the basins and the hydraulic connectivity as it applies to the Agency's determination of groundwater flow across basin boundaries and description of the different assumptions utilized by different Plans and how the Agencies reconciled those differences.

(4) Sustainable management criteria and a monitoring network that would confirm that no adverse impacts result from the implementation of the Plans of any party to the agreement. If minimum thresholds or measurable objectives differ substantially between basins, the agreement should specify how the Agencies will reconcile those differences and manage the basins to avoid undesirable results. The Agreement should identify the differences that the parties consider significant and include a plan and schedule to reduce uncertainties to collectively resolve those uncertainties and differences.

(c) A description of the process for identifying and resolving conflicts between Agencies that are parties to the agreement.

(d) Interbasin agreements submitted to the Department shall be posted on the Department's website.

MGSA will develop a voluntary inter-basin Coordination Agreement with MCWD GSA to ensure that preparation and implementation of this GSP is effectively coordinated with the GSP in the adjacent Monterey Subbasin that is being prepared by MCWD GSA and SVBGSA, that each subbasin's sustainability goals are met, and that the interests of all beneficial water users and uses in each subbasin are recognized and protected [this language will be updated when the agreement is executed]. [A copy of the inter-basin agreement will be included as an appendix to this GSP when executed (Appendix 1.B, PLACEHOLDER)]. The inter-basin agreement will ensure that implementation of the MGSA GSP will not adversely affect the ability of MCWD to implement its GSP or impede the ability to achieve its sustainability goal [this language will be updated when the agreement is executed]. In addition, the inter-basin agreement should facilitate the exchange of technical information between MGSA and MCWD GSA, and will include a process to resolve disputes concerning the interpretation of that information [this language will be updated when the agreement is executed]. Technical information to be coordinated across subbasin boundaries includes the following:[1]

- Estimates of groundwater flow across GSA Area boundaries, including consistent and coordinated data, methods, and assumptions;
- A common understanding of the geology and hydrology within the adjacent subbasins, hydraulic connectivity as it applies to the determination of groundwater flow across GSA Area boundaries, a description of the different assumptions used by MGSA and MCWD GSA for their individual GSPs, and how differences are reconciled; and
- Sustainable management criteria and a monitoring network that confirm that no adverse impacts will result from the implementation of MGSA and MCWD GSPs.

The agreement will specify how MGSA and MCWD GSA will reconcile differences and manage the groundwater resources to avoid undesirable results if minimum thresholds or measurable objectives differ substantially between GSA Areas [this language will be updated when the agreement is executed]. The agreement will also identify the differences that are considered significant and includes a plan and schedule to reduce and collectively resolve uncertainties and differences [this language will be updated when the agreement is executed].

1.5 AGENCY INFORMATION

Three GSAs are responsible for SGMA implementation in portions of the 180/400 Foot Aquifer Subbasin: SVBGSA, MCWD GSA, and MGSA. DWR considers none of these three GSAs to be exclusive GSAs for the entire Subbasin; however, MCWD GSA is the exclusive GSA for that portion of the Subbasin within its jurisdictional boundaries. MGSA submitted a letter to DWR on April 16, 2018 (Appendix 1.C), providing notification that the City of Marina, a California charter city, elected to become a GSA pursuant to CWC

[1] Because there are no streams that cross or are shared along the Subbasin boundaries between MGSA and MCWD GSA, no coordination is needed regarding estimates of stream-aquifer interactions at GSA Area boundaries.

§ 10723(a), for the MGSA Area within its jurisdictional limits, but which lies outside the jurisdictional limits of MCWD. The City of Marina has land use responsibilities in this area. MGSA intends to undertake sustainable groundwater management for the designated portion of the 180/400 Foot Aquifer Subbasin. The jurisdictional areas of all three GSAs in relation to the 180/400 Foot Aquifer Subbasin boundaries are shown on Figure 1-3.

A copy of Resolution No. 2018-25 of the City Council electing to become a GSA for a portion of the Subbasin is attached as Appendix 1.D. The Resolution was adopted on March 20, 2018, immediately following a legally noticed public hearing. A copy of the proof of publication of the hearing notice is attached as Appendix 1.E.

1.5.1 Name and Mailing Address of MGSA

Regulation Requirements:
§ 354.6(a) The name and mailing address of the Agency

The mailing address and other contact information for MGSA is as follows:

Brian McMinn
City of Marina Groundwater Sustainability Agency
211 Hillcrest Avenue
Marina, CA 93933
Phone: (831) 884-1212
Email: bmcminn@cityofmarina.org

1.5.2 Organization and Management Structure of MGSA

Regulation Requirements:
§ 354.6(b) The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.

MGSA is administered by the City of Marina's City Council. The Marina City Council is comprised of the Mayor and four other City Council Members. MGSA board meetings are held concurrently with City Council meetings, usually at 5:30 p.m. (closed session) and 6:30 p.m. (open session) on the first and third Tuesdays of each month in accordance with the Marina Municipal Code (Chapter 2.04) and City Ordinances: 2001-11 § 1 (2001), 78-12 § 1 (1978), and 75-2 § 1 (1975). The meetings are publicly noticed and agendas are made available on the City's website (https://www.cityofmarina.org/AgendaCenter). The City has full power and authority to adopt, make, exercise, and enforce all legislation, laws, and regulations; to take actions relating to all municipal affairs in general; and to undertake administration of the GSA and GSP, and all other matters related to SGMA implementation and compliance. Resolutions presented to the MGSA board are voted on and require a majority vote of a quorum to be passed and adopted. Open public hearings on specific resolutions may be held during meetings to allow for testimony from the public. Public testimony is considered prior to voting on specific resolutions.

1.5.3 NAME AND CONTACT INFORMATION OF PLAN MANAGER

Regulation Requirements:
§ 354.6(c) The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.

The City of Marina Public Works Director/City Engineer has been designated as Plan Manager for this GSP. Contact information is as follows:

Brian McMinn, Plan Manager
City of Marina Groundwater Sustainability Agency
211 Hillcrest Avenue
Marina, CA 93933
Phone: (831) 884-1212
Email: bmcminn@cityofmarina.org
Website: https://cityofmarina.org/918/Groundwater-Sustainability-Plan

1.5.4 LEGAL AUTHORITY OF MGSA

Regulation Requirements:
§ 354.6(d) The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the plan.

MGSA was formed in accordance with the requirements of CWC §§ 10723, *et seq*. The resolution of formation of MGSA is included in Appendix 1.D. The City of Marina is incorporated under the laws of the State of California. The City of Marina provides water supply and land use planning services to its residents and is therefore a local agency under CWC § 10721 with the authority to establish itself as a GSA. Formation of MGSA gives the City of Marina the authority to regulate groundwater uses within the MGSA Area.

1.5.5 ESTIMATE OF COST OF IMPLEMENTING THE MGSA GSP

Regulation Requirements:
§ 354.6(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.

Implementation of the MGSA GSP requires additional funding sources. MGSA will apply for grants from outside sources to assist in reducing the cost of implementation for City of Marina residents, landowners, and cooperating agencies. However, there will be a need to collect funds from groundwater extractors within the MGSA Area to support implementation. For budgetary purposes, the estimated initial cost of implementation activities is $220,000 per year, including management action costs. MGSA and Marina City Council will evaluate options for securing the needed funding. Chapter 7 (Plan Implementation) provides additional information on GSP implementation costs and funding sources.

1.6 GSP ORGANIZATION AND PREPARATION CHECKLIST

This GSP was developed using the following documents and is consistent with requirements of the GSP Regulations and SGMA:

- Guidance Document for the Sustainable Management of Groundwater, Groundwater Sustainability Plan Annotated Outline (DWR 2016b);
- Guidance Document for the Sustainable Management of Groundwater, Preparation Checklist for GSP Submittal (DWR 2016c); and
- Groundwater-Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans (TNC 2018).

The remainder of the MGSA GSP is organized as follows:

Chapter 2 – Plan Area
Chapter 3 – Basin Setting
Chapter 4 – Sustainable Management Criteria
Chapter 5 – Monitoring Network
Chapter 6 – Projects and Management Actions
Chapter 7 – Plan Implementation
Chapter 8 – References

The Preparation Checklist for the GSP is provided in Table 1-1.

The Executive Summary and Chapters 1 through 8 (text, tables, figures, and appendices) are provided in Volume I. Comments received on the October 2019 Public Review Draft GSP, Master Responses, and the Response to Comment Matrix are provided in Volume II.

TABLE 1-1. PREPARATION CHECKLIST FOR MGSA GSP SUBMITTAL

GSP Regulations Section	Water Code Section	Requirement	Description	Section Number in GSP[2]
Article 3. Technical and Reporting Standards				
352.2		Monitoring Protocols	• Monitoring protocols adopted by the GSA for data collection and management	Appx 5.B
			• Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin	Appx 5.B Appx 5.C
Article 5. Plan Contents, Subarticle 1. Administrative Information				
354.4		General Information	• Executive Summary • List of references	Ex Sum 8.0
354.6		Agency Information	• GSA mailing address • Organization and management structure • Contact information of Plan Manager • Legal authority of GSA • Estimate of implementation costs	1.5.1 1.5.2 1.5.3 1.5.4 1.5.5
354.8(a)	10727.2(a)(4)	Map(s)	• Area covered by GSP • Adjudicated areas, other agencies within the basin, and areas covered by an Alternative • Jurisdictional boundaries of federal or state land • Existing land use designations • Density of wells per square mile	Fig 1-2 Fig 1-3 Fig 2-4 Fig 2-7 Fig 2-9 Fig 2-10 Fig 2-11
354.8(b)		Description of the Plan Area	• Summary of jurisdictional areas and other features	2.1
354.8(c) 354.8(d) 354.8(e)	10727.2(g)	Water Resource Monitoring and Management Programs	• Description of water resources monitoring and management programs • Description of how the monitoring networks of those plans will be incorporated into the GSP • Description of how those plans may limit operational flexibility in the basin • Description of conjunctive use programs	2.2.1 - 2.2.7 2.2.8 2.2.9 2.2.10
354.8(f)	10727.2(g)	Land Use Elements or Topic	• Summary of general plans and other land use plans	2.3.1

[2] Volume I: Executive Summary and Chapters 1 through 8 (text, tables, figures, and appendices).
Volume II: Comments on 2019 Public Review Draft GSP, Master Responses, and Response to Comment Matrix

GSP Regulations Section	Water Code Section	Requirement	Description	Section Number in GSP[2]
		Categories of Applicable General Plans	• Description of how implementation of the GSP may change water demands or affect achievement of sustainability and how the GSP addresses those effects	2.3.2
			• Description of how implementation of the GSP may affect the water supply assumptions of relevant land use plans	2.3.3
			• Summary of the process for permitting new or replacement wells in the basin	2.3.4
			• Information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management	2.3.5
354.8(g)	10727.4	Additional GSP Contents	Description of Actions related to:	
			• Control of saline water intrusion	2.4.1
			• Wellhead protection	2.4.2
			• Migration of contaminated groundwater	2.4.3
			• Well abandonment and well destruction program	2.4.4
			• Replenishment of groundwater extractions	2.4.5
			• Conjunctive use and underground storage	2.4.6
			• Well construction policies	2.4.7
			• Addressing groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects	2.4.8
			• Efficient water management practices	2.4.9
			• Relationships with state and federal regulatory agencies	2.4.10
			• Review of land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity	2.4.11
			• Impacts on groundwater-dependent ecosystems	2.4.12
354.10		Notice and Communication	• Description of beneficial uses and users	2.5.1
			• List of public meetings	2.5.3
			• GSP comments and responses	Volume II
			• Decision-making process	2.5.2
			• Public engagement	2.5.3
			• Encouraging active involvement	2.5.4
			• Informing the public on GSP implementation progress	MGSA Website
Article 5. Plan Contents, Subarticle 2. Basin Setting				
354.14		Hydrogeologic Conceptual Model	• Description of the Hydrogeologic Conceptual Model	3.1
			• Two scaled cross-sections	Fig 3-11 to Fig 3-13

GSP Regulations Section	Water Code Section	Requirement	Description	Section Number in GSP[2]
			• Map(s) of physical characteristics: topographic information, surficial geology, soil characteristics, surface water bodies, source and point of delivery for imported water supplies	Fig 3-4 Fig 3-5 Fig 3-6 Fig 3-7 Fig 3-8 Fig 3-9 Fig 3-10
354.14(c)(4)	10727.2(a)(5)	Map of Recharge Areas	• Map delineating existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas	Fig 3-19
	10727.2(d)(4)	Recharge Areas	• Description of how recharge areas identified in the plan substantially contribute to the replenishment of the basin	3.1.11
354.16	10727.2(a)(1) 10727.2(a)(2)	Current and Historical Groundwater Conditions	• Groundwater elevation data • Estimate of groundwater storage • Seawater intrusion conditions • Groundwater quality issues • Land subsidence conditions • Identification of interconnected surface water systems • Identification of groundwater-dependent ecosystems	3.2.1 3.2.2 3.2.3 3.2.4 3.2.5 3.2.6.1 3.2.6.2
354.18	10727.2(a)(3)	Water Budget Information	• Description of inflows, outflows, and change in storage • Quantification of overdraft • Estimate of sustainable yield • Quantification of current, historical, and projected water budgets	3.3.5 to 3.3.8 3.3.12 3.3.13 3.3.9 to 3.3.11
	10727.2(d)(5)	Surface Water Supply	• Description of surface water supply used or available for use for groundwater recharge or in-lieu use	3.3.6
354.20		Management Areas	• Reason for creation of each management area • Minimum thresholds and measurable objectives for each management area • Level of monitoring and analysis • Explanation of how management of management areas will not cause undesirable results outside the management area • Description of management areas	NA NA NA NA NA
Article 5. Plan Contents, Subarticle 3. Sustainable Management Criteria				
354.24		Sustainability Goal	• Description of the sustainability goal	4.2

GSP Regulations Section	Water Code Section	Requirement	Description	Section Number in GSP[2]
354.26		Undesirable Results	• Description of undesirable results • Cause of groundwater conditions that would lead to undesirable results • Criteria used to define undesirable results for each sustainability indicator • Potential effects of undesirable results on beneficial uses and users of groundwater	4.4.1 4.5.1 4.6.1 4.7.1 4.8.1 4.9.1
354.28	10727.2(d)(1) 10727.2(d)(2)	Minimum Thresholds	• Description of each minimum threshold and how they were established for each sustainability indicator • Relationship for each sustainability indicator • Description of how selection of the minimum threshold may affect beneficial uses and users of groundwater • Standards related to sustainability indicators • How each minimum threshold will be quantitatively measured	4.4.2 4.5.2 4.6.2 4.7.2 4.8.2 4.9.2
354.30	10727.2(b)(1) 10727.2(b)(2) 10727.2(d)(1) 10727.2(d)(2)	Measurable Objectives	• Description of establishment of the measurable objectives for each sustainability indicator • Description of how a reasonable margin of safety was established for each measurable objective • Description of a reasonable path to achieve and maintain the sustainability goal, including a description of interim milestones	4.4.3 4.5.3 4.6.3 4.7.3 4.8.3 4.9.3
Article 5. Plan Contents, Subarticle 4. Monitoring Networks				
354.34	10727.2(d)(1) 10727.2(d)(2) 10727.2(e) 10727.2(f)	Monitoring Networks	• Description of monitoring network • Description of monitoring network objectives • Description of how the monitoring network is designed to: demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features; estimate the change in annual groundwater in storage; monitor seawater intrusion; determine groundwater quality trends; identify the rate and extent of land subsidence; and calculate depletions of surface water caused by groundwater extractions • Description of how the monitoring network provides adequate coverage of Sustainability Indicators • Density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends • Scientific rationale (or reason) for site selection • Consistency with data and reporting standards	5.1 5.1.1 5.2.1 5.2.2 5.2.3 5.2.4.1 5.2.4.2

GSP Regulations Section	Water Code Section	Requirement	Description	Section Number in GSP[2]
			• Corresponding sustainability indicator, minimum threshold, measurable objective, and interim milestone	5.2.6
			• Location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used	Fig 5-2
			• Description of technical standards, data collection methods, and other procedures or protocols to ensure comparable data and methodologies	5.2.5
354.36		Representative Monitoring	• Description of representative sites	5.1.3
			• Demonstration of adequacy of using groundwater elevations as proxy for other sustainability indicators	5.2.6
			• Adequate evidence demonstrating that site reflects general conditions in the area	5.2.1
354.38		Assessment and Improvement of Monitoring Network	• Review and evaluation of the monitoring network	5.1.4
			• Identification and description of data gaps	5.2.7
			• Description of steps to fill data gaps	5.2.7
			• Description of monitoring frequency and density of sites	5.2.3
354.44		Projects and Management Actions	• Description of projects and management actions that will help achieve the basin's sustainability goal	6.1
			• Measurable objective that is expected to benefit from each project and management action	6.2.1.2
			• Circumstances for implementation	6.2.1.4
			• Public noticing	6.4
			• Permitting and regulatory process	6.2.1.5
			• Time-table for initiation and completion, and the accrual of expected benefits	6.2.1.6
			• Expected benefits and how they will be evaluated	6.2.1.3
			• How the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.	6.2.1.1
			• Legal authority required	6.3
			• Estimated costs and plans to meet those costs	6.2.1.7
			• Management of groundwater extractions and recharge	NA
354.44(b)(2)	10727.2(d)(3)		• Overdraft mitigation projects and management actions	6.5

GSP Regulations Section	Water Code Section	Requirement	Description	Section Number in GSP[2]
Article 8. Interagency Agreements				
357.4	10727.6	Coordination Agreements - Shall be submitted to the Department together with the GSPs for the basin and, if approved, shall become part of the GSP for each participating Agency	Coordination Agreements shall describe the following: • A point of contact • Responsibilities of each Agency • Procedures for the timely exchange of information between Agencies • Procedures for resolving conflicts between Agencies • How the Agencies have used the same data and methodologies to coordinate GSPs • How the GSPs implemented together satisfy the requirements of SGMA • Process for submitting all Plans, Plan amendments, supporting information, all monitoring data and other pertinent information, along with annual reports and periodic evaluations • A coordinated data management system for the basin • Identification of adjudicated areas within the basin, and any local agencies that have adopted an alternative that has been accepted by the Department	1.3 1.4 TBD TBD TBD TBD TBD TBD TBD TBD NA

Notes: Volume I: Executive Summary, Chapters 1 through 8 text, tables, figures, and appendices.
Volume II: Comments on 2019 Public Review Draft GSP, Master Responses, and Response to Comment Matrix

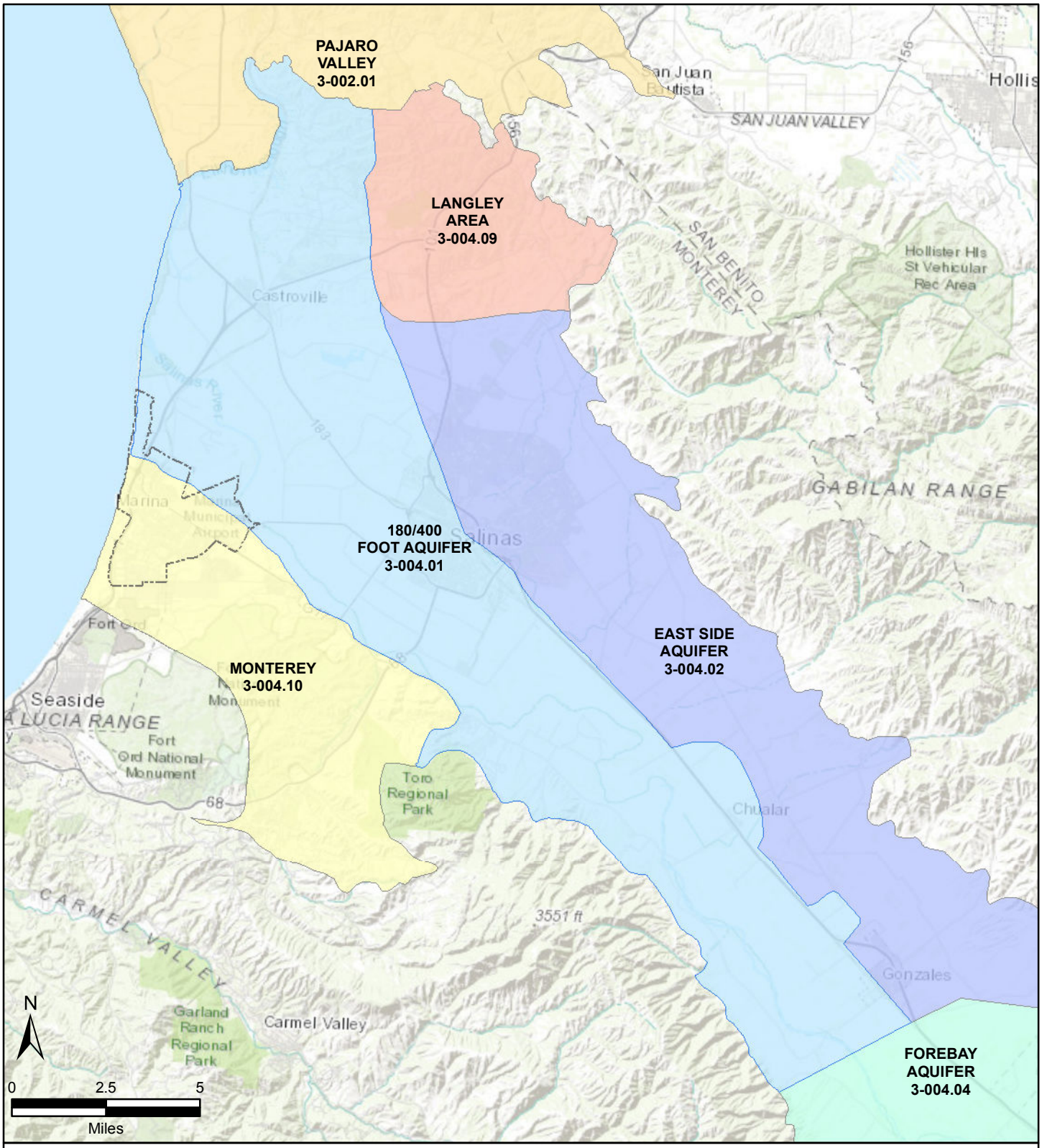

FIGURE 1-1

180/400 Foot Aquifer Subbasin of the Salinas Valley Groundwater Basin

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

Groundwater Subbasins

- Salinas Valley -180/400 Foot Aquifer
- East Side Aquifer
- Forebay Aquifer
- Langley Area
- Monterey
- Pajaro Valley
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://montereycountyopendata-12017-01-13t232948815z-montereyco.opendata.arcgis.com

DATE: DEC, 30, 2019

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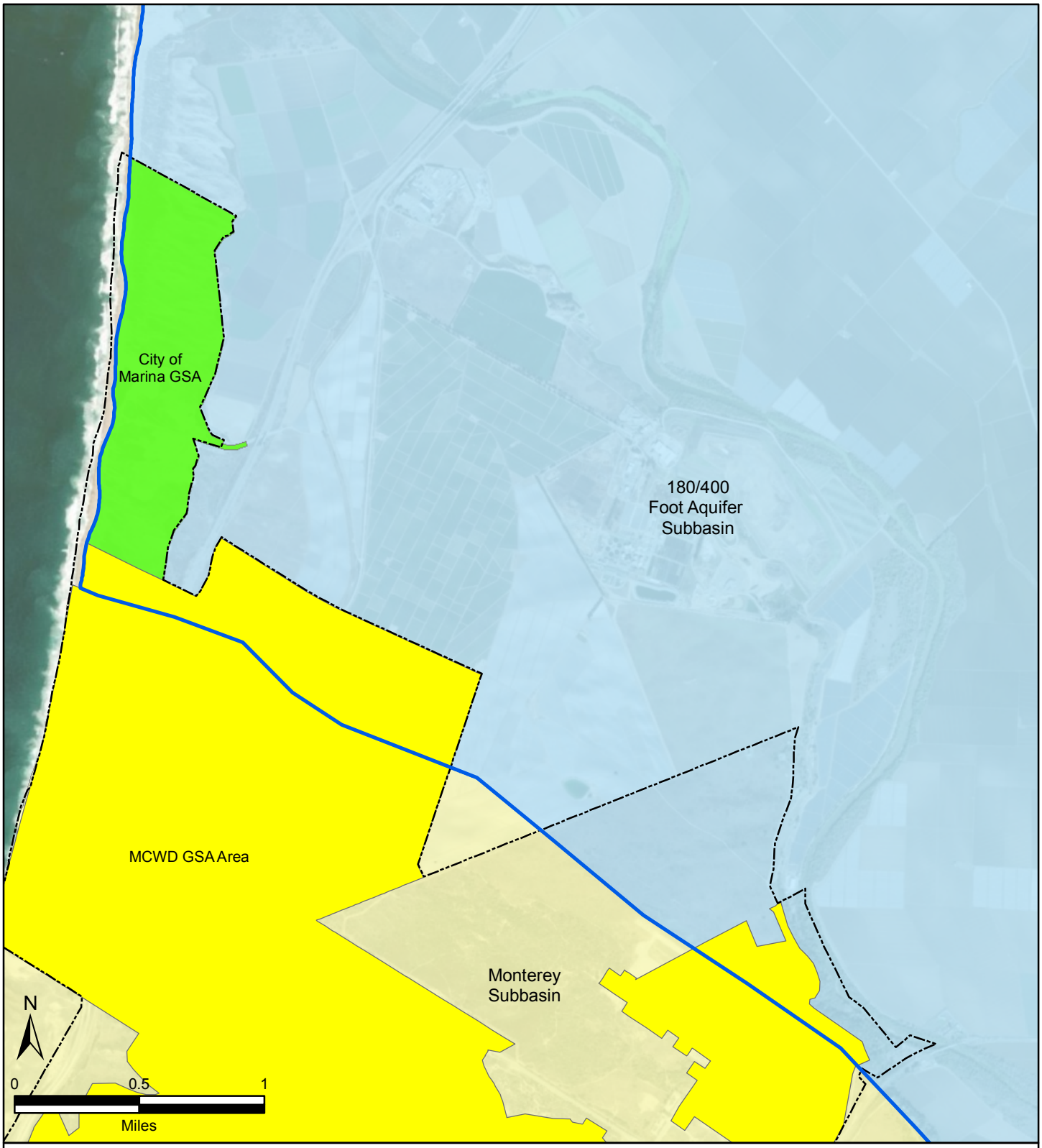

FIGURE 1-2

City of Marina Groundwater Sustainability Agency Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Groundwater Sustainability Agencies (GSAs)

- Marina Coast Water District (MCWD) GSA Areas
- City of Marina GSA (MGSA) Area

Groundwater Subbasins

- 180/400 Foot Aquifer
- Monterey
- 180/400 Foot Aquifer Subbasin
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://montereycountyopendata-12017-01-13t232948815z-montereyco.opendata.arcgis.com

DATE: DEC, 31, 2019

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FIGURE 1-3

Jurisdictional Areas Covered By GSAs

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA (MGSA) Area
- Marina Coast Water District (MCWD) GSA Area
- Salinas Valley Basin GSA Area
- 180/400 Foot Aquifer Subbasin
- Salinas Valley Groundwater Basin
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, montereycountyopendata

DATE: DEC, 31, 2019

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APPENDIX 1.A – SVBGSA INTRA-BASIN COORDINATION AGREEMENT (PLACEHOLDER)

APPENDIX 1.B – MCWD GSA INTER-BASIN COORDINATION AGREEMENT (PLACEHOLDER)

APPENDIX 1.C – GSA NOTIFICATION LETTER

City of Marina

City of Marina
211 HILLCREST AVENUE
MARINA, CA 93933
831- 884-1212; FAX 831- 384-0425
www.ci.marina.ca.us

VIA EMAIL AND U.S. MAIL
Mark.Nordberg@water.ca.gov

April 16, 2018

Mr. Mark Nordberg
GSA Project Manager
California Department of Water Resources
901 P Street, Room 213A
P.O. Box 942836
Sacramento, California 94236-0001

Subject: Notice of the City of Marina GSA Intent to Serve as a Groundwater Sustainability Agency for a Portion of the Salinas Valley Groundwater Basin 180/400 Foot Aquifer Subbasin in Monterey County.

Dear Mr. Nordberg:

This letter is provided as notification to the California Department of Water Resources (DWR) that the City of Marina (City), a California charter city, has elected to become a Groundwater Sustainability Agency (GSA) pursuant to Water Code Section 10723(a). The information provided herein, and the documents enclosed, are provided in compliance with the requirements for notification under Section 10723.8(a).

In the Bulletin 118 Interim 2016 Update, the DWR officially designated eight subbasins of the Salinas Valley Groundwater Basin (SVGB). The City has land use responsibilities and intends to undertake sustainable groundwater management for a portion of the 180/400 Foot Aquifer Subbasin of the SVGB as shown on the map attached as **Exhibit A**. The City's GSA boundaries are entirely within the City's jurisdictional limits and include Monterey County Assessor Parcel Numbers (APN) 203-011-001; 203-011-019; 203-011-020; and portions of APN 203-011-023; 175-011-046; 175-011-031; and 203-011-011.

A copy of the Resolution 2018-25 of the City Council electing to become a GSA for a portion of the 180/400 Foot Aquifer Subbasin is attached as **Exhibit B**. The Resolution was adopted on March 20, 2018, immediately following a legally noticed public hearing. A copy of the proof of publication of the hearing notice is attached as **Exhibit C**.

The City has engaged and is seeking to work cooperatively with other local agencies overlying the 180/400 Foot Aquifer Subbasin as required by the 2014 Sustainable Groundwater Management Act (SGMA) including preparation of a Groundwater Sustainability Plan (GSP) in accordance with California Water Code Section 10727. Other local agencies that have formed a GSA within (or near) the southwest coastal portion of the180/400 Foot Aquifer Subbasin include

the Salinas Valley Basin Groundwater Sustainability Agency and the Marina Coast Water District. There are no local agencies with service areas overlapping those of the City.

In accordance with GSA Formation Notification Guidelines for Local Agencies, the City submits the following information:

Information Submitted within 30 Days
The City conducted a public hearing on March 20, 2018 in accordance with Water Code section 10723(b), to elect to become a GSA.

Map and Description of Service Area Boundaries
The City's service area is depicted on **Exhibit A**. The service area is in the southwest portion of the180/400 Foot Aquifer Subbasin and is bounded by the Pacific Ocean along the western border. There are no other local agencies with overlapping service area boundaries.

Resolution
A copy of Resolution No. 2018-25 electing to become a GSA for a portion of the 180/400 Foot Aquifer Subbasin is attached as **Exhibit B**. Notice of public hearing regarding the City's consideration in becoming a GSA was published per Government Code §6066 and proof of publication of the public hearing regarding the City's intent to become a GSA is attached as **Exhibit C**.

New Bylaws, Ordinances, or New Authorities
The City has not adopted any new bylaws, ordinances, or new authorities in electing to become a GSA.

The City has identified the following interested parties pursuant to Water Code Section 10723.2:

1. Local Water Districts within or adjoining the GSA:
    a. Marina Coast Water District

2. Holders of Overlying Groundwater Rights: agricultural and domestic well owners, municipal well operators and public water systems:
    a. Armstrong Ranch
    b. CEMEX

3. Surface Water Users:
    a. Monterey One Water and Monterey County Water Resources Agency for the Castroville Seawater Intrusion Project

4. Environmental Users of groundwater:
    a. Fort Ord Dunes State Park
    b. Marina Beach State Park

5. Local Land Use Planning Agencies:

a. City of Marina
b. County of Monterey

6. Federal Government:
    a. No federal lands are within the City's proposed GSA management area.

7. California Native American Tribes:
    a. None within the City's proposed GSA management area.

8. Disadvantaged Communities:
    a. None identified

9. Entities listed in California Water Code Section 10927 that are monitoring and reporting groundwater elevations in all or part of the basins to be managed by the City as the designated GSA:
    a. Monterey County Water Resources Agency
    b. Salinas Valley Basin Groundwater Sustainability Agency

10. Other Entities:
    a. Marina Coast Water District GSA
    b. GSAs that may be formed to manage other portions of the 180/400 Foot Aquifer Subbasin
    c. California-American Water Company

The list of interested parties will continue to be updated throughout the City's development and implementation of a GSP for the GSA area. As required by the SGMA (Water Code section 10720, et seq.), the City will consider all beneficial uses of groundwater and the interests of users and managers.

The City will develop an open and inclusive process to implement the [RWR1]SGMA. Interested parties will have opportunities, both formal and informal, to provide input to the City throughout the process of developing, operating, and implementing the GSA and GSP. Such opportunities may include, but are not limited to, public comment periods required by SGMA (e.g., Water Code section 10728.4); opportunities for public comment during regular and special City Council meetings; and at other times to be determined and noticed pursuant to Water Code section 10727.8(a).

The above-referenced agencies, water providers, and other interested stakeholders will be contacted to determine how best to consider and protect their interests, and invited to participate in evaluating and defining roles and responsibilities during the GSP planning and implementation process.

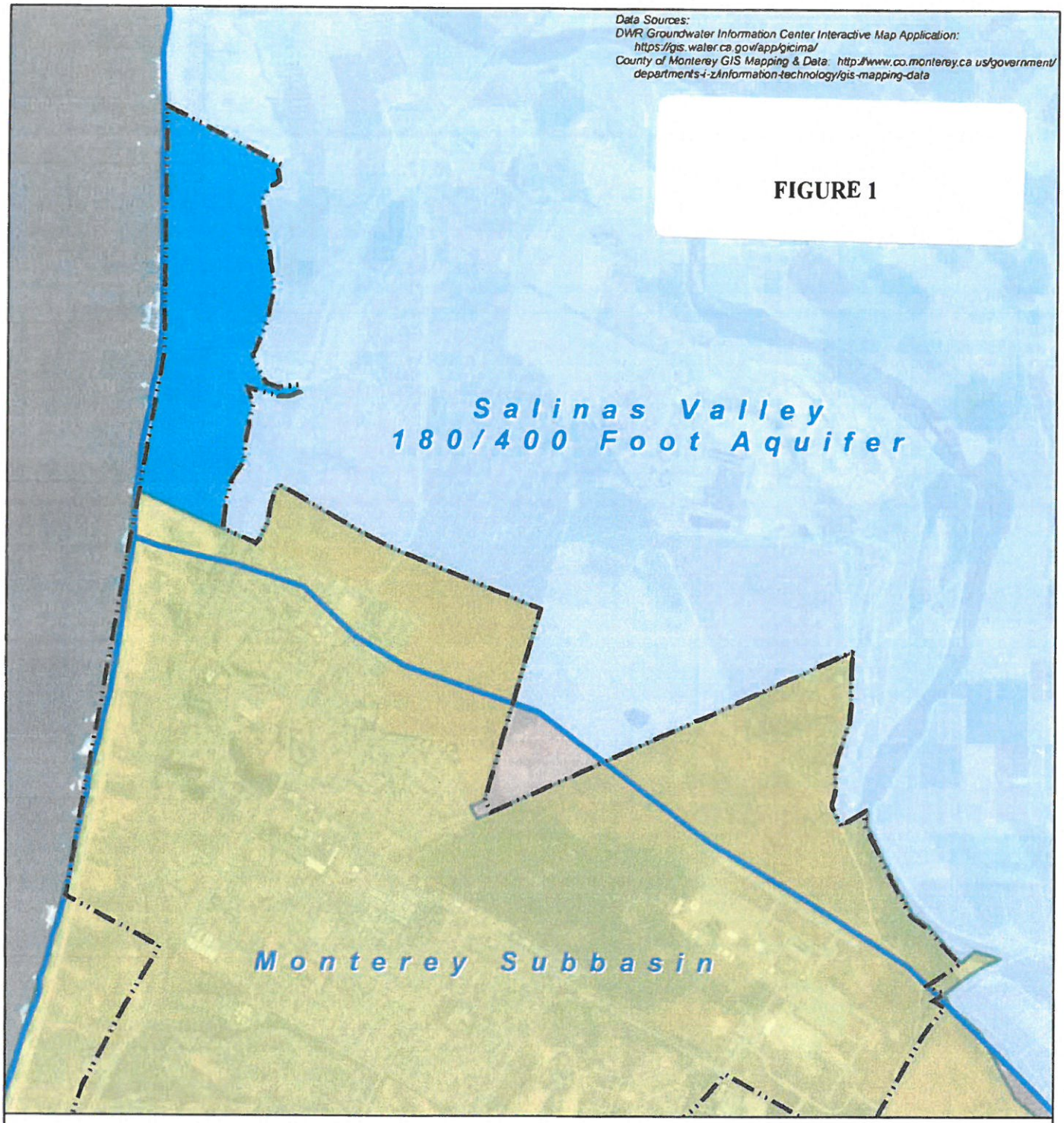
This GSA formation notification along with GIS shape files are being sent electronically to Mark.Nordberg@water.ca.gov.

The undersigned, as the designated representative of the City of Marina, believes that this notification includes all applicable GSA notification requirements in Water Code Section 10723.8(a). If any additional information is required, please contact Public Works Director Brian McMinn at bmcminn@cityofmarina.org or (831) 84-1215.

Sincerely,

Layne Long
City Manager
City of Marina

Attachments: Exhibit A: Map of City of Marina GSA Boundary
Exhibit B: Resolution 2018-25 forming GSA
Exhibit C: Proof of Publication and Notice of Public Hearing



City of Marina Groundwater Sustainability Agency

City of Marina GSA (overlaps existing SVBGSA) Existing Salinas Valley Basin GSA

Existing Marina Coast Water District GSA

Bulletin 118 Groundwater Basin Boundary

City of Marina Limits

N

0 1,500 3,000 Feet

1 inch = 3,000 feet

Map Date: April 2018

APPENDIX 1.D – RESOLUTION NO. 2018-25: MARINA CITY COUNCIL ELECTING TO BECOME A GSA

EXHIBIT B

RESOLUTION NO. 2018-25

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF MARINA FORMING A GROUNDWATER SUSTAINABILITY AGENCY (GSA) AND UNDERTAKE SUSTAINABLE GROUNDWATER MANAGEMENT WITHIN THE PORTION OF THE SALINAS VALLEY GROUNDWATER BASIN 180/400 FOOT AQUIFER SUBBASIN WITH THE CITY AND OUTSIDE THE MARINA COAST WATER DISTRICT SERVICE AREA, AND AUTHORIZE FILING NOTICE OF GSA FORMATION WITH THE CALIFORNIA DEPARTMENT OF WATER RESOURCES (DWR) PURSUANT TO WATER CODE SECTION 10723.8(a), AND AUTHORIZE AND DIRECT THE CITY MANAGER OR HIS DESIGNEE TO SUBMIT NOTICE OF ADOPTION OF THIS RESOLUTION IN ADDITION TO ALL INFORMATION REQUIRED BY THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT (SGMA), INCLUDING BUT NOT LIMITED TO, ALL INFORMATION REQUIRED BY WATER CODE SECTION 10723.4 AND A LIST OF INTERESTED PARTIES AS DESCRIBED IN WATER CODE SECTION 10723.8(A)(4), AND AUTHORIZE THE CITY MANAGER OR HIS DESIGNEE TO TAKE SUCH OTHER FURTHER ACTIONS AS MAY BE NECESSARY TO EFFECTUATE THE PURPOSE OF THIS RESOLUTION, AND FIND THAT THE ADOPTION OF THE RESOLUTION IS EXEMPT FROM THE REQUIREMENTS OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT (PUBLIC RESOURCE CODE SECTION 21000 ET SEQ.) (CEQA) PURSUANT TO SECTION 15061(B)(3) OF THE CEQA GUIDELINES.

WHEREAS, the Sustainable Groundwater Management Act of 2014, Water Code Sections 10720 – 10736.6 ("SGMA") was signed into law on September 16, 2014; and

WHEREAS, SGMA requires that each California groundwater subbasin be managed by a single Groundwater Sustainability Agency ("GSA") or by a combination of GSAs and that such management be implemented pursuant to an approved Groundwater Sustainability Plan, or multiple coordinated GSP's, as the case may be; and

WHEREAS, the legislative intent of the Sustainable Groundwater Management Act is to provide for sustainable management of groundwater subbasins, to enhance local management of groundwater, to establish minimum standards for sustainable groundwater management, and to provide local groundwater agencies with the authority and the technical and financial assistance necessary to sustainably manage groundwater; and

WHEREAS, Water Code Section 10723(a) authorizes any local agency with a service area overlying a groundwater subbasin or portion thereof to establish itself as the GSA for its service area; and

WHEREAS, Water Code Section 10721(j) defines a GSA as one or more local agencies that implement the provisions of SGMA; and

WHEREAS, the City's jurisdictional boundaries overlie a portion of the 180/400 Foot Aquifer Subbasin of the Salinas Valley Groundwater Basin; and

WHEREAS, City staff is proposing that the City become the GSA whose boundaries would encompass Monterey County Assessor Parcel Numbers (APN) 203-011-001; 203-011-019; 203-011-020; and 203-011-011 (See Exhibit "A"); and

WHEREAS, prior to adopting a resolution of intent to establish the City as a GSA, Water Code Section 10723 requires a local agency to hold a public hearing, after publication of notice pursuant to Government Code Section 6066, on whether or not to adopt a resolution to establish a GSA; and

WHEREAS, the notice for the public hearing was published on Thursday, March 1, 2018 and Thursday, March 8, 2018; and

WHEREAS, said public hearing was held on March 20, 2018; and

WHEREAS, the City is committed to the sustainable management of groundwater within the Salinas Valley Ground Water Basin 180/400 Foot Aquifer Subbasin and intends to coordinate with the other GSAs and affected parties and consider the interests of all beneficial users and uses of groundwater within the 180/400 Foot Aquifer Subbasin.

NOW, THEREFORE, BE IT RESOLVED, that the City Council of the City of Marina does hereby:

1. Form a Groundwater Sustainability Agency (GSA) and undertake sustainable groundwater management within the portion of the Salinas Valley Ground Water Basin 180/400 Foot Aquifer Subbasin within the City and outside of the Marina Coast Water District service area. A map of the GSA Boundary is attached hereto as Exhibit A and incorporated herein.
2. Authorize filing notice of GSA formation with the California Department of Water Resources (DWR) pursuant to Water Code Section 10723.8(a).
3. Authorize and direct the City Manager or his designee to submit notice of adoption of this Resolution in addition to all information required by the SGMA, including but not limited to, all information required by Water Code Section 10723.8 to the California Department of Water Resources, and to support the development and maintenance of an interested persons list as described in Water Code Section 10723.4 and a list of interested parties as described in Water Code Section 10723.8(a)(4).
4. Authorize the City Manager or his designee to take such other and further actions as may be necessary to effectuate the purposes of this Resolution.
5. Find that that the adoption of this Resolution is exempt from the requirements of the California Environmental Quality Act (Public Resources Code Section 21000 et seq.) (CEQA) pursuant to Section 15061(b)(3) of the CEQA guidelines.

PASSED AND ADOPTED by the City Council of the City of Marina at a regular meeting duly held on the 20th day of March 2018, by the following vote:

AYES, COUNCIL MEMBERS: Amadeo, Morton, O'Connell, Brown, Delgado
NOES, COUNCIL MEMBERS: None
ABSENT, COUNCIL MEMBERS: None
ABSTAIN, COUNCIL MEMBERS: None

Bruce C. Delgado, Mayor

ATTEST:

Anita Sharp, Deputy City Clerk

APPENDIX 1.E – PROOF OF PUBLICATION OF HEARING NOTICE

EXHIBIT C

MONTEREY HERALD

Published by The Monterey Herald
P.O. Box 271 • Monterey, California 93942
(831) 726.4382

MARINA - CITY CLERK / CITY MANAGER
Account No. 2140479
211 HILLCREST AVE.
MARINA, CA 93933

Legal No. 0006114411
Notice of Public Hearing - COM

Ordered by: Anita Shepherd-Sharp

This space is reserved for the County Clerk's Filing Stamp

PROOF OF PUBLICATION

STATE OF CALIFORNIA
County of Monterey

I am a citizen of the United States and a resident of the County aforesaid. I am over the age of eighteen years, and not a party to or interested in the above-entitled matter. I am the principal clerk of the printer of The Monterey Herald, a newspaper of general circulation, printed and published daily and Sunday in the City of Monterey, County of Monterey, and which newspaper has been adjudged a newspaper of general circulation by the Superior Court of the County of Monterey, State of California; that the notice, of which the annexed is a printed copy (set in type not smaller than 6 point), has been published in each regular and entire issue of said newspaper and not in any supplement thereof on the following dates, to wit:

03/01/18, 03/08/18

I certify (or declare) under penalty of perjury that the foregoing is true and correct.

Executed on 03/08/2018 at Monterey, California.

Danielle Landaker

Signature

NOTICE OF PUBLIC HEARING
City of Marina

Notice is hereby given that City Council of the City of Marina will hold a public hearing regarding the adoption of a Resolution of Intention to form a Groundwater Sustainability Agency (GSA) as outlined in the California Water Code, Part 2.74, Sustainable Groundwater Management Act, Section 10723. The proposed GSA boundaries would encompass Monterey County Assessor Parcel Numbers (APN) 203-011-001; 203-011-019; 203-011-020; and portions of APN 203-011-023; 175-011-046; 175-011-031; and 203-011-011. The public hearing is intended to review, provide explanation of, and allow for public input on the formation of one GSA by the City of Marina within the proposed boundaries.

The public hearing for the proposed formation of the GSA shall be held at the following date, time, and place:

Tuesday, March 20, 2018, at 6:30 pm
Marina City Council Chambers,
211 Hillcrest Avenue,
Marina, CA 93933

If you need special assistance to participate in this public hearing, please contact the City of Marina at (831) 884-1278. Notification 48 hours prior to the hearing will enable the City of Marina to make reasonable arrangements to ensure accessibility to this public hearing. [28 CFR 35.102-35.104 ADA Title II]

FOR ADDITIONAL INFORMATION CONTACT:
Layne Long, City Manager
City of Marina
211 Hillcrest Ave.,
Marina, CA 93933
(831) 884-1278 or llong@cityofmarina.org

Publication date:
March 1, 2018 and
March 8, 2018

CHAPTER 2 – PLAN AREA
Groundwater Sustainability Plan for the Marina GSA Area of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, California

JANUARY 2020

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2 PLAN AREA

Regulation Requirements:

§354.8 Each Plan shall include a description of the geographic areas covered, including the following information:

(a) One or more maps of the basin that depict the following, as applicable:

- **(1)** The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.
- **(2)** Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.
- **(3)** Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.
- **(4)** Existing land use designations and the identification of water use sector and water source type.
- **(5)** The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the department, as specified in section 353.2, or best available information.

This section provides a description of the Salinas Valley Groundwater Basin and its subbasins, including the 180/400 Foot Subbasin. Special emphasis is placed on the area to which this Groundwater Sustainability Plan (GSP) applies, which is the Marina Groundwater Sustainability Agency jurisdiction (the MGSA Area), and vicinity. The description includes cities and geographic features, disadvantaged communities (DACs), land use, federal and state parks and wildlife areas, and locations of groundwater wells. The section also describes existing groundwater and surface water monitoring programs, existing water management programs, general and specific land use plans, and other agreements or programs applicable to the MGSA Area. Additional GSP components are summarized as required, as well as information relating to notification and communication by MGSA with other agencies and interested parties.

2.1 SUMMARY OF JURISDICTIONAL AREA AND OTHER FEATURES

2.1.1 PLAN AREA AND JURISDICTIONS

Regulation Requirements:

§354.8(b) A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.

2.1.1.1 PLAN AREA COVERED BY THE GSP

The Salinas Valley Groundwater Basin includes nine groundwater subbasins designated by the California Department of Water Resources (DWR) in Bulletin 118 (DWR 2004) and shown on Figure 2-1, including the 180/400 Foot Subbasin, East Side Aquifer Subbasin, Forebay Aquifer Subbasin, Upper Valley Aquifer Subbasin, Langley Area Subbasin, Monterey Subbasin, Seaside Subbasin, Atascadero Area Subbasin, and Paso Robles Area Subbasin. The MGSA Area covers 372 acres at the western end of the 180/400 Foot Subbasin, which encompasses an area of approximately 84,400 acres (Figure 1-3). The MGSA Area lateral limits are the Marina City Limits on the north and east, and the 180/400 Foot Aquifer Subbasin boundary on the west and south. The western boundary coincides with the mean high tide line of the

Pacific Ocean. The MGSA Area includes Assessor Parcel Numbers (APN) APN 203-011-001; APN 203-011-019; and APN 203-011-020.

Individual GSPs are being developed cooperatively for four subbasins under Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) jurisdiction in Monterey County, including the East Side Aquifer, Forebay Aquifer, Upper Valley Aquifer, and Langley Area Subbasins. The Monterey Subbasin abuts the 180/400 Foot Aquifer Subbasin and the MGSA Area to the south and is under SVBGSA and Marina Coast Water District (MCWD) GSA jurisdiction (Figure 2-2). It has been subdivided into the Corral de Tierra, Ord, and Marina Subareas. SVBGSA has entered into a Framework Agreement with MCWD GSA to prepare a single GSP for the Monterey Subbasin. SVBGSA will develop information for the Corral de Tierra Subarea and MCWD GSA will develop information for the Ord Subarea and the Marina Subarea, including the portion of the Monterey Subbasin that shares a boundary with MGSA (SVBGSA 2018b, MCWD 2018). A GSP is not being prepared for the Seaside Subbasin because it is adjudicated. Submittal of Alternative Plans is not being proposed for any of the subbasins of the Salinas Valley Groundwater Basin.

The 180/400 Foot Aquifer Subbasin will be managed by three GSAs under two GSPs. The three GSAs with jurisdiction in the Subbasin are MGSA, SVBGSA, and MCWD GSA, whose jurisdictional area extends into the Subbasin in the northern portions of its service area. The portion of the 180/400 Foot Aquifer Subbasin that lies within the MGSA Area will be managed under this GSP. The portion of the Subbasin that lies outside the MGSA Area will be managed under the more regional SVBGSA GSP. Although MCWD agreed that SVBGSA would prepare the GSP for the 180/400 Foot Aquifer Subbasin, including its jurisdictional area, the parties agreed to actively consult with each other and review draft work products during the GSP development process for the 180/400 Foot Aquifer Subbasin.

Figure 2-3 shows the City of Marina (City or Marina) boundaries and key geographic features in the vicinity of the MGSA Area. The MGSA Area lies entirely within the city limits of the City and occupies an approximately 400-acre extension of the City along the coast west of State Highway 1 and south of the Salinas River. Marina is a community of approximately 20,000 residents and is known for its unique Flandrian sand dunes and many protected wildlife species within its coastal areas. Several other communities are located in the vicinity of Marina. Seaside is on Highway 1 about 2 miles south of Marina and has a population of approximately 34,000. Moss Landing, with a population of 200, is about 10 miles north of Marina on Highway 1 at the mouth of Elkhorn Slough, which is one of the largest wetlands in California. Castroville is an agricultural community of about 6,000 people located 10 miles north of Marina and 5 miles east of Moss Landing on State Route 183 in the Salinas Valley. Salinas, also an agricultural community, is in the Salinas Valley about 6 miles east of Marina on Highway 101 and has a population of approximately 155,000.

Figure 2-3 shows the DACs in the Salinas Valley area near Marina. DWR defines DACs as census geographies with an annual median household income (MHI) that is less than 80 percent of the statewide annual MHI. Severely disadvantaged communities (SDACs) are defined as census geographies with an MHI less than 60 percent of the statewide annual MHI. DWR uses the most recently available

five-year American Community Survey (ACS) dataset to identify these areas. DWR's DAC Involvement Program is designed to ensure the involvement of DACs in Integrated Regional Water Management (IRWM) planning efforts. Under Proposition 1, grant funding is available for implementation of water management activities that provide benefits to DACs. Marina has several DAC areas within its boundaries and residents in those DACs utilize and recreate in beach, dune, and coastal habitat areas within the MSGA Area. There are no DAC areas within the MGSA Area.

2.1.1.2 Federal, State, and Locally Managed Lands and Protected Areas

The MGSA Area lies entirely within the City of Marina. It lies outside the jurisdictional boundaries of any water agencies or utility service districts. There are no federal or state lands within the MGSA Area. The entire MSGA Area is located within the designated Coastal Zone under the California Coastal Act. The City has approval and regulatory authority over all development in this Coastal Zone pursuant to its certified Local Coastal Program (LCP). This authority includes revisions to its LCP and the issuance of coastal development permits.

Federal, state, and locally managed lands and protected areas in the vicinity of the MGSA Area are shown in Figure 2-4 and described below:

- **Federal Jurisdiction**. A portion of the Fort Ord former Army base is within the 180/400 Foot Aquifer Subbasin southeast of the MGSA Area. Although DWR land use dataset depicts this as federal land, most of these lands have been transferred to non-federal entities for reuse. The United States Fish and Wildlife Service (USFWS) manages the Salinas River National Wildlife Refuge north of the MGSA Area. The National Oceanic and Atmospheric Administration (NOAA) manages the Monterey Bay National Marine Sanctuary, which is a federally protected marine preserve that stretches along the central coast from San Francisco to Cambria and includes beaches, tide pools, kelp forests, an underwater canyon, and other marine features.
- **State Jurisdiction.** The California Coastal Commission retains some authority under the California Coastal Act for protection of coastal resources, shoreline public access and recreation. The California Department of Parks and Recreation (PARKS) manages Marina State Beach, which is a protected beach within the Marina City Limits that winds through the Marina Dunes Natural Preserve and Fort Ord Dunes State Park, which is south of Marina State Beach outside the Marina City limits. PARKS also has jurisdiction over the Salinas River State Beach, Moss Landing State Beach, Salinas River Dunes Natural Preserve, and the Salinas River Mouth Natural Preserve.
- **County Jurisdiction.** The MGSA Area and the entire 180/400 Foot Aquifer Subbasin lie within Monterey County; and the County has land use jurisdiction over unincorporated County areas near the MGSA Area.
- **Monterey County Water Resources Agency Jurisdiction.** Originally established in 1947 as the Monterey County Flood Control and Water Conservation District in response to concerns about seawater intrusion and flooding in the Salinas Valley, the name of the agency was changed to the Monterey County Water Resources Agency (MCWRA) under Senate Bill 2580 in January 1991

to more accurately reflect its powers and functions (Monterey County 2019). In addition to flood plain management and emergency flood-related preparedness, MCWRA has specified jurisdiction over matters pertaining to water and water supply within the entire Monterey County area, including both incorporated and unincorporated areas under the Monterey County Water Resources Agency Act (Agency Act). MCWRA is authorized to conserve water in any manner; to buy, sell, and purvey water; and to prevent the waste or diminution of the water supply including control of groundwater extractions to prevent the loss of usable groundwater through seawater intrusion.

Groundwater level measurement programs in the Salinas Valley began in the 1940s to investigate the cause and extent of seawater intrusion. By monitoring groundwater levels throughout the Salinas Valley over time, MCWRA tracks storage changes and provides an ongoing assessment of the ability of groundwater supplies to meet pumping demands. In 1992, MCWRA established several zones (Zones 2, 2A, 2B, 2Y, and 2Z) to institute water supply projects and collect assessments to fund them under various Monterey County Ordinances (MCWRA 2019c). The MGSA Area is within Zone 2C, which covers 436,000 acres and was established in 2003 to collect assessments for operations and maintenance of the Nacimiento and San Antonio Dams, but is not within any other MCWRA established management zones. Monterey County Ordinance No. 3717 requires water suppliers within Zones 2, 2A, and 2B to report water-use information for groundwater extraction wells to MCWRA. Several Ordinances (Nos. 3709 and 3790) have been enacted by MCWRA to reduce groundwater extractions and to regulate wells within portions of the Castroville Seawater Intrusion Project (CSIP) area (Figure 2-6). MCWRA collaborates with the Monterey County Health Department during the application and review process for permitting new water supply wells. Under annexation agreements, the MCWRA has specified authority to allocate groundwater in the Central Marina and Ord Community service areas, which are shown on Figure 2-5.

- **City and Water Agency Jurisdiction.** The City of Marina has land use and water management authority within the incorporated area of the City, including the MGSA Area. The land use designation of "Habitat Preserve and Other Open Space" in the General Plan (City of Marina 2011), takes precedence over the zoning designation. The current zoning of the MGSA Area is "Coastal Conservation and Development." A zoning map amendment is in progress to change the zoning to "Open Space."

  MCWD provides potable water service to approximately 33,000 residents within its jurisdictional boundaries, including the City of Marina. The Central Marina service area encompasses 3.2 square miles, and its sphere of influence encompasses an additional 2.4 square miles. The Ord Community service area encompasses 8.7 square miles. Three of MCWD's wells are located in Central Marina and five wells are in the Ord Community. MCWD's jurisdictional area also includes the Ord Development parcels (approximately 6 square miles). Portions of MCWD's Central Marina and Ord Community service areas extend into the 180/400 Foot Aquifer Subbasin as shown on Figure 2-5 and MCWD GSA has jurisdiction to administer the

requirements of SGMA over those areas. MCWD's jurisdictional boundaries do not include the MGSA Area.

- **Pure Water Monterey and Castroville Seawater Intrusion Projects.** The CSIP system is owned by MCWRA but operated by Monterey Regional Water Pollution Control Agency (MRWPCA), now Monterey One Water (M1W). CSIP is the distribution system for recycled wastewater produced by the Regional Treatment Plant and consists of 45 miles of pipelines and 22 wells. The CSIP supplies a combination of recycled water, Salinas River water, and Salinas Valley groundwater for irrigation of 12,000 acres of farmland in its jurisdictional area near and southwest of Castroville (Figure 2-6). The Pure Water Monterey (PWM) Groundwater Replenishment (GWR) Project, proposed by M1W in partnership with Monterey Peninsula Water Management District (MPWMD), will increase the amount of recycled water available to the CSIP system for crop irrigation within the CSIP service area and will also provide 3,500 acre-feet per year (AFY) of potable water for the Monterey Peninsula communities to the south of the City.
- **Parks, Preserves, and Other Protected Areas.** Several other entities support local, state, and federal water management and/or natural habitat management partners in the vicinity of the MGSA Area. The active dunes underlying the MGSA Area are part of the more extensive Monterey Dunes, which extend from Monterey Harbor north to the Salinas River mouth. Monterey Peninsula Regional Park District (MPRPD) manages the Marina Dunes Natural Preserve, which is a narrow strip of land consisting of coastal strand and dune habitat (Figure 2-4). A large area of environmentally sensitive habitat is located along the coast in the Marina Dunes Preserve and to the north in the Marina Dunes (MRPD 2005).

  MPRPD also manages Locke-Paddon Wetland Community Park, which is a 17-acre wetland area that holds a freshwater "vernal pond" that provides habitat for a range of avian wildlife within the City of Marina. Acquisition of the last remaining private parcel bordering the pond is currently underway by MPRPD and will complete a 15-year effort that will also begin the final phase of its original goal – enhancement and restoration of the ponds as critical coastal wetland habitat. As described in Section 3.2.6.1.2, there are six vernal pond areas in the vicinity of Marina, including similar palustrine and emergent wetland features east of the MGSA Area, which were evaluated using procedures recommended by The Nature Conservancy and identified as likely GDEs. Although groundwater-level data were not available for the vicinity of Locke-Paddon Wetland Community Park, it appears to be in a similar setting and may also be a GDE.

  Appendix 2.A provides the results from the California Natural Diversity Database (CNDDB) query including maps of species occurrences and a species list. Section 2.2.5 describes critical habitat zones that have been mapped within the MGSA Area and vicinity.

2.1.2 LAND USE

Figure 2-7 shows the land use in the vicinity of the MGSA Area. Land use patterns surrounding the MGSA Area are dominated by agriculture in the Salinas Valley to the east, and open space (conservation) to the north and south. Mixed use urban developments associated with the City of Marina are located to the southeast. The top three crops by value in Monterey County in 2018 were lettuce, strawberries, and broccoli (Monterey County 2018). Other crops included tomatoes, spinach, cauliflower, wine grapes, artichokes, and celery.

The MGSA Area is located outside the Urban Growth Limits of the City of Marina and has a land use designation of "Habitat Preserve and Other Open Space" (City of Marina 2011). It is zoned "Coastal Conservation and Development;" however, an amendment to change the zoning to "Open Space" is in progress and will require approval of the California Coastal Commission. Marina covers an area of 10 square miles and is sheltered from Monterey Bay by coastal sand dunes. Approximately 2 square miles of the City and 3 miles of coastline are within the California Coastal Zone with a designated land use of Coastal Conservation and Development in the local Coastal Plan (City of Marina 2013a, 2013b, 2019). The Coastal Zone and City of Marina boundaries and urban areas, as well as parks, preserves, rivers, ponds, and protected areas, are shown on Figure 2-4. The coastal area of the city is generally divided north and south by Reservation Road. The predominant coastal use in the area to the south of Reservation Road is state beach. To the north, within the MGSA Area, the ownership is private, and the primary current use is sand mining, chiefly from the tidal zone but also from the dunes.

Figure 2-8 shows the existing surface conditions within the MGSA Area, which are predominantly dune sands. There are four artificial ponds within the MGSA Area on the CEMEX plant site that were constructed to support industrial operations: a dredge pond and three percolation ponds for saline process water. The MGSA Area is characterized by Flandrian dune habitat on dunes formed at the end of the last Ice Age (WRA 2018). Flandrian dune habitat is protected under federal, state, and local jurisdiction in accordance with the California Coastal Act. These dunes are highly vulnerable to wind and wave erosion, and plants established on the dunes can withstand loose shifting soils and harsh conditions. This coastal dune habitat supports seven special-status plant species and is associated with certain special-status animal species (WRA 2018).

The MGSA Area is comprised of Primary and Secondary Habitat as defined under the City of Marina LCP (City of Marina 2013a), which are considered Environmentally Sensitive Habitat Areas (ESHAs) that are designated protected areas within the Coastal Zone of California under the California Coastal Act. Primary Habitat includes:

> "1. Habitat for all identified plant and animal species which are rare, endangered threatened, or are necessary for the survival of an endangered species.
>
> 2. Vernal ponds and their associated wetland vegetation.

3. All native dune vegetation, where such vegetation is extensive enough to perform the special role of stabilizing Marina's natural sand dune formations.

4. Areas otherwise defined as Secondary Habitat that have an especially valuable role in an ecosystem for sensitive plant or animal life, as determined by a qualified biologist approved by the City [Resolution No. 2001-118 (October 16, 2001); approved by the California Coastal Commission on November 14, 2001]."

The Coastal Act requires that ESHAs "shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas" (Public Resources Code, § 30240(a)). Similarly, the Marina LCP limits development in Primary Habitat.

State and federally protected species that have been observed within the MGSA Area or have moderate or high potential to occur are listed in Table 2-1.

TABLE 2-1. STATE OR FEDERALLY PROTECTED SPECIES WITH POTENTIAL TO OCCUR WITHIN THE MGSA AREA

Species	Federal/State Status	MGSA Area
Monterey spineflower (*Chorizanthe pungens* var. *pungens*)	Federally threatened	Observed
Robust spineflower (*Chorizanthe robusta)*	Federally endangered	Moderate potential
Seaside birds-beak (*Cordylanthus rigidus)*	State endangered	Moderate potential
Menzies' wallflower (*Erysimum menziesii)*	Federally endangered State endangered	Moderate potential
Sand gilia (*Gilia tenuiflora* ssp. *arenaria*)	Federally endangered State threatened	High potential
Smith's blue butterfly (*Euphilotes enoptes smithi*)	Federally endangered	High potential
Western snowy plover (*Charadrius nivosus nivosus*)	Federally threatened California Species of Special Concern	Observed

Source: WRA (2018) Review of Biological Resources Components of the Coastal Development Permit Application for the Monterey Peninsula Water Supply Project

Exhibit A of the Marina Local Coastal Land Use Plan (LCLUP), which is part of the LCP, lists a number of other special-status plant and animal species that have been observed or have a moderate to high potential to occur within the MGSA Area including the globose dune beetle (*Coelus globosus*), California legless lizard (*Anniella pulchra*), Salinas kangaroo rat (*Dipodomys heermanni goldmani*), seaside painted cup (*Castilleja latifolia ssp. Latifolia*), Eastwood's ericameria (*Ericameria fasciculata*), coast wallflower (*Erysimum ammophilum*), coastal dunes milkvetch (*Astragulus tener var. titi*), dune gilia (*Gilia tenuiflora*

var. arenaria), wild buckwheat (*Eriogonum latifolium, Eriogonum parvifolium*),[1] and the bush lupine (*Lupinum ssp.*)[2] (City of Marina 2013a).

Marina has been involved in decades of efforts to end the current sand mining activities in the MSGA Area, which have proven to be a very environmentally destructive use for these coastal resources. In 2017, after combined enforcement actions by the California Coastal Commission, the State Lands Commission, and the City, a comprehensive settlement agreement was entered into with RMC Pacific Minerals, doing business as CEMEX, to end this sand mining by December 31, 2020. RMC is thereafter required to fully reclaim and restore the site.

The settlement also requires CEMEX to transfer the entire site, including the area where the slant wells would be located, at a reduced purchase price to a non-profit organization or government entity approved by the Coastal Commission and the City. As part of this conveyance, a deed restriction will be put in place to protect the property and limit its potential uses to public access, conservation, low-impact passive recreation, and public education. These provisions will improve public access and enjoyment of the property, and will provide many benefits to site habitats.

2.1.3 WATER USE AND SOURCES

Three water supply sources are available in the 180/400 Foot Aquifer Subbasin: groundwater, surface water, and recycled water. Groundwater is the primary water source for all water use sectors in the Subbasin. Municipal areas that depend on groundwater in the vicinity of the MGSA Area are shown on Figure 2-6. Urban demand in the vicinity of the MGSA Area is met solely by groundwater. MCWD supplies water to Central Marina and the Ord Community service areas from groundwater in the 180/400-Foot Aquifer and Deep Aquifer. From 2000 to 2014 (pre-drought average), MCWD delivered about 2,300 AFY of water from the 180/400-Foot Aquifer and 2,000 AFY of water from the Deep Aquifers underlying the Monterey and 180/400 Foot Subbasin to its customers in the Central Marina service area (MCWD 2019c). In 2018, MCWD delivered about 1,100 AFY from the 180/400-Foot Aquifer and 2,300 AFY from the Deep Aquifer (MCWD 2019c). MCWD entered into an agreement with M1W to provide up to 1,427 AFY of reclaimed water from their Advanced Water Treatment Facility via the PWM pipeline for delivery to their Ord Community service area customers for commercial irrigation and other uses as part of the Regional Urban Water Augmentation Program (RUWAP, MCWD 2019b).

Although groundwater is also used for agricultural and rural residential domestic supply, small community systems, schools, and small commercial operations, the seawater intruded area on the northwestern side of the Subbasin (where the MGSA Area is located) receives a combination of recycled water, surface water, and groundwater from the Deep Aquifers as part of a conjunctive use strategy intended to decrease groundwater dependence in the seawater intruded area (refer to Section 2.2.10). In the region surrounding the MGSA Area, water from the Salinas Valley Reclamation Project is used on farmland in the CSIP service area, which is shown on Figure 2-6 (Brown and Caldwell 2015). This includes land immediately east of the MGSA Area. The Salinas River Diversion Facility (SRDF) also

[1] Only within the range of Smith's blue butterfly.
[2] Only within the range of the California legless lizard.

provides treated river water to cropland in this area, which reduces the need to pump groundwater except during periods of high demand.

Figure 2-9, Figure 2-10, and Figure 2-11 show the density of domestic, municipal, and production wells per square mile in the vicinity of the MGSA Area, as available from the DWR Well Completion Report Map Application (DWR 2019a). Domestic wells are largely private residential wells. Municipal wells, or public supply wells, are the primary water source for urban and rural communities. Production wells are used primarily for agricultural irrigation and the remainder for industrial purposes. In the Pressure Subarea of the Salinas Valley Groundwater Basin, which includes the 180/400 Foot Aquifer Subbasin and the Monterey Subbasin, approximately 88% of the groundwater pumped is for agricultural use and 12% is for domestic and municipal use combined (MCWRA 2017b). The well count within the MGSA Area is summarized in Table 2-2. CEMEX has two production wells at the CEMEX Lapis Plant sand mine site. One well is active, and the second CEMEX well has collapsed casing and cannot be used without re-drilling. A test slant well was constructed to test the feasibility of a subsurface groundwater supply for a desalination plant as part of California American Water Company's (CalAm's) proposed Monterey Peninsula Water Supply Project (MPWSP). This well is currently scheduled to be closed in 2020 pursuant to the permit issued for it by the California Coastal Commission.

TABLE 2-2. MGSA AREA WELL COUNT SUMMARY

Category	Number of Wells
Domestic	0
Municipal (MPWSP Test Slant Well)	1
Industrial (CEMEX)	2
Total	**3**

Source: DWR (2019) Well Completion Report Map Application

2.2 WATER RESOURCES MONITORING AND MANAGEMENT PROGRAMS

Regulation Requirements:

§354.8(c) Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.

§354.8(d) A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.

§354.8(e) A description of conjunctive use programs in the basin.

The existing water resources monitoring and management programs within and surrounding the MGSA Area are a collection of local, regional, state, and federal programs, each serving its own specific function. Existing monitoring within the Subbasin is performed for a variety of purposes by a variety of entities. This collection of programs will provide data to assist in meeting monitoring needs under the Sustainable Groundwater Management Act (SGMA); however, as pointed out in the SVBGSA GSP

(SVBGSA 2019), some redundancies, inconsistent protocols, and variable timing of monitoring will need to be improved during SGMA implementation. Data from the following agencies and programs is potentially relevant to groundwater management in the 180/400 Foot Aquifer Subbasin:

Statewide Monitoring Programs (Agencies and Databases):

- California Data Exchange Center (CDEC)
- California Department of Pesticide Regulation (CDPR)
- California Environmental Data Exchange Network (CEDEN)
- California State Water Resources Control Board (SWRCB)
    - GeoTracker GAMA
    - Division of Drinking Water (DDW)
- Department of Water Resources (DWR)
    - California Statewide Groundwater Elevation Monitoring (CASGEM)
    - California Statewide Groundwater Elevation Monitoring Groundwater Information Center Interactive Mapping Application (GICIMA)
    - Water Data Library (WDL)
    - Online System for Well Completion Reports (OSWCR)
    - SGMA Data Viewer
- United States Geological Survey (USGS)
    - Water Resources Information System
    - Groundwater Ambient Monitoring and Assessment Program (GAMA)

Regional Monitoring Programs:

- Monterey Peninsula Water Management District (MPWMD)
    - Irrigated Lands Regulatory Program (ILRP)
- Monterey Peninsula Groundwater Replenishment Program (GWR)

Local Monitoring Agencies and Companies:

- Monterey County Water Resources Agency (MCWRA)
- United States Army (Army) Fort Ord
- Marina Coast Water District (MCWD)
- Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA)
- California American Water Company (CalAm)
- City of Marina

See Section 2.2.1 and Chapter 5 (Monitoring Networks) for a description of the monitoring programs that will be used in implementation of the MGSA GSP.

2.2.1 GROUNDWATER LEVEL MONITORING

2.2.1.1 MCWRA GROUNDWATER LEVEL MONITORING

MCWRA has responsibility to monitor groundwater levels, collect water quality data, and collect pumping data in order to inform efforts to address seawater intrusion in the Salinas Valley Groundwater Basin. Based on information posted on the MCWRA Groundwater Level Monitoring webpage (MCWRA 2019b), the agency collects the following groundwater level monitoring data:

- MCWRA collects monthly groundwater level measurements at more than 90 wells throughout the Salinas Valley. Of these wells, 38 are in the Subbasin, and one well is located southwest of the Salinas River within approximately 2 miles of the MGSA Area, which is the general area of interest with respect to collection of groundwater level data that are relevant to the MGSA Area. MCWRA processes these monthly measurements to develop a computed average of depth to water.
- Each fall, MCWRA collects annual groundwater level measurements from approximately 450 wells in the Salinas Valley Groundwater Basin. Of these, 120 wells are in the Subbasin, and one well is located southwest of the Salinas River within approximately 2 miles of the MGSA Area. MCWRA uses these annual measurements to develop contour maps depicting the groundwater table elevation.
- MCWRA collects groundwater level measurements every August at approximately 150 wells in the Subbasin, and one well is located southwest of the Salinas River within approximately 2 miles of the MGSA Area to establish the location and extent of groundwater pumping depressions that drive seawater intrusion. The August measurements usually coincide with the end of the irrigation season, and groundwater levels at this time reflect low groundwater elevations before the onset of seasonal winter recharge. These pumping depressions occur in the Pressure 180-Foot and Pressure 400-Foot Aquifers between the City of Salinas and the coast. MCWRA uses the August groundwater elevation data to develop groundwater contour maps of the coastal pumping depressions in odd-numbered years.

2.2.1.2 CALIFORNIA STATEWIDE GROUNDWATER ELEVATION MONITORING

MCWRA is the responsible monitoring entity for the California Statewide Groundwater Elevation Monitoring (CASGEM) Program in Monterey County. The monitoring network comprises 51 wells throughout the Salinas Valley, which are a subset of the wells monitored by MCWRA described in the previous section. Of these wells, 23 are in the Subbasin, and one is located within approximately 2 miles of the MGSA Area. Some of the CASGEM monitoring wells are CASGEM compliance wells and others are "voluntary wells" that are not officially part of the CASGEM program. MCWRA collects quarterly groundwater elevation data from the CASGEM wells and reports the groundwater elevation data to DWR twice per year. Figure 2-12 shows the locations of the CASGEM monitoring wells in the MGSA Area and local vicinity.

2.2.1.3 PROPOSED MONTEREY PENINSULA WATER SUPPLY PROJECT (MPWSP) MONITORING

CalAm currently proposes to a complete a series of slant wells within the MGSA Area to serve as a source water intake for its MPWSP desalination project. This project is in the process of applying for permits from local, state, and federal agencies, and therefore may or may not be fully approved. There are currently eight monitoring well clusters with 24 wells within and near the MGSA Area that were installed in 2015 to monitor test slant well pumping for MPWSP design and environmental studies (HWG 2017). Each of these clusters has a well completed in the Dune Sand Aquifer (DSA), the 180-Foot Aquifer, and the 400-Foot Aquifer The existing clusters are designated MW-1, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, and MW-9 (the MW-2 cluster was not constructed).[3]

Pursuant to the Mitigation Monitoring and Reporting Program (MMRP) for MPWSP, MCWRA will take over monitoring of these wells to augment its existing regional groundwater monitoring network to focus on the area that could be affected by the proposed slant wells. Under the MMRP for the proposed MPWSP, MCWRA will construct five additional well clusters with three wells each at locations MW-A, MW-B, MW-C, MW-D, and MW-E, and construct another well at MW-5S screened in the DSA below a perched zone, to expand the network of nested monitoring wells to a total of 40 wells (Zidar and Feeney 2019). The locations of these existing and proposed wells are shown in Figure 2-13. In addition, under the MMRP, MCWRA will monitor a number of other existing wells in the vicinity of the MGSA Area that are in the MCWRA, MCWD, or Fort Ord monitoring networks, including 10 wells completed in the DSA, eight wells completed in the 180-Foot Aquifer, five wells completed in the 400-Foot Aquifer, and eight wells completed in the Deep Aquifer. MCWRA will also monitor six nested monitoring wells in the Deep Aquifer constructed by the United States Geological Survey (USGS) at two locations approximately ½-mile south of the MGSA Area. Groundwater levels are monitored in the existing wells on a quarterly basis and recorded continuously using pressure transducers.

It should be noted that MGSA is currently developing an agreement with MCWRA which includes, among other things, a provision that should the MPWSP not move forward, MCWRA, MGSA and other agencies with jurisdiction in the area will work together to develop and implement a suitable monitoring program in the nearshore area of the Subbasin.

2.2.2 GROUNDWATER EXTRACTION MONITORING

MCWRA collects groundwater extraction information from all wells in the Subbasin that have discharge pipes of three inches or greater in diameter. These data have been collected since 1993. Extraction is self-reported by well owners and summarized by MCWRA in annual Groundwater Extraction Summary Reports. The most recent report available on the MCWRA website is the 2015 report, which was finalized in April 2017 (MCWRA 2017b). Extraction data are available for the CEMEX wells in the MGSA Area, which extract groundwater from the 180-Foot and 400-Foot Aquifers. An additional irrigation well

[3] Monitoring data indicate that MW-5S is screened in a perched aquifer above the DSA. Therefore, the monitoring well has been re-designated as MW-5S(P) to indicate that it is representative of a local perched aquifer. Similarly, MW-6D is screened in the lower portion of the 180-Foot Aquifer and has been re-designated as MW-6M(L) to indicate that it represents the 180-Foot Aquifer.

that extracts groundwater from the Deep Aquifer is located within approximately 1.4 miles of the MGSA Area.

2.2.3 GROUNDWATER QUALITY MONITORING

2.2.3.1 PROPOSED MONTEREY PENINSULA WATER SUPPLY PROJECT MONITORING

The monitoring well clusters installed within and near the MGSA Area for the proposed MPWSP are used to collect quarterly water quality data. In addition, specific conductance sensors have been deployed in the wells to monitor conductivity (correlated with salinity) continuously. As discussed above, MCWRA will assume monitoring responsibility for these wells and plans to install five additional monitoring well clusters at the locations shown on Figure 2-13.

2.2.3.2 MCWRA SEAWATER INTRUSION MONITORING

MCWRA monitors seawater intrusion in the Salinas Valley with a network of 121 monitoring wells in the Subbasin. Of those, 96 wells are agricultural production wells that are sampled annually in June and August (during peak pumping), and 27 wells are dedicated monitoring wells that are owned by MCWRA and monitored at regular intervals. Water quality samples from the wells are analyzed for major anions and cations, and conductivity. The data are used to develop time-series plots of chloride and conductivity trends, to create Stiff and Piper diagrams, and to compute molar ratios of chloride to sodium. The data are also used to prepare maps of seawater intrusion in the 180-Foot and 400-Foot Aquifers in odd-numbered years. Additional information about the occurrence and extent of seawater intrusion in both the 180-Foot and 400-Foot Aquifers is provided in Section 3.2.3.

2.2.3.3 OTHER PROGRAMS

Groundwater quality is monitored under several different programs and by different agencies as follows:

- Municipal and community water purveyors, such as MCWD, collect water quality samples on a routine basis for compliance monitoring and reporting to California DDW.
- USGS collects water quality data on a routine basis under the GAMA Program. These data are accessible in the SWRCB GeoTracker GAMA database, which also includes data from other water quality monitoring programs. Figure 2-14 shows the location of wells in the California GAMA GeoTracker database for which water quality data are available within the Subbasin in the vicinity of the MGSA Area. One well is located within approximately 2 miles of the MGSA Area.
- The Army conducts groundwater quality monitoring in the “A-Aquifer” (the local equivalent of the DSA) and 180-Foot Aquifer at Fort Ord.
- Multiple sites are monitoring groundwater quality as part of investigation or compliance monitoring programs through the Central Coast Regional Water Quality Control Board (CCRWQCB).

2.2.4 SURFACE WATER MONITORING

Streamflow gages operated by the USGS in the vicinity of the MGSA Area include the following:

- Reclamation Ditch near Salinas (USGS Site #11152650)
- Salinas River near Spreckels (USGS Site #11152500)

Water levels (stage) in the Salinas River Lagoon are measured by MCWRA at Monte Road and near the slide gate to the Old Salinas River. Monitoring river flow allows MCWRA to manage reservoir releases as well as operations at the SRDF throughout the year. The locations of the surface-water monitoring gages are depicted in Figure 2-15.

2.2.5 WILDLIFE PRESERVE AND CRITICAL HABITAT MONITORING

National wildlife refuges, coastal preserves, sensitive habitats, and critical riparian and aquatic habitat areas are managed and monitored under the oversight of the relevant agencies (United States Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), and local entities, which conduct monitoring as necessary. Critical habitat for Western snowy plover exists along the western shoreline of the MGSA Area, extending to the north and south (USFWS 2019). Critical habitat for tidewater goby (*Eucyclogobius newberryi*) lies to the north within the Salinas River National Wildlife Refuge and mouth of the Salinas River. MGSA will coordinate GSP implementation, monitoring, and management efforts with these responsible agencies as necessary to avoid the occurrence of undesirable results.

2.2.6 EXISTING WATER MANAGEMENT PROGRAMS AND PLANS

2.2.6.1 MONTEREY COUNTY GROUNDWATER MANAGEMENT PLAN

MCWRA developed a Groundwater Management Plan (GMP) that is compliant with Assembly Bill (AB) 3030 and Senate Bill (SB) 1938 legislation (MCWRA 2006) and covers the Salinas Valley Groundwater Basin in Monterey County (exclusive of the Seaside and Paso Robles Subbasins). In the 180/400 Foot Subbasin, this GMP will be superseded by this GSP and by the SVBGSA GSP covering the remainder of the Subbasin. The GMP is predicated in the finding that management of the County's natural water resources is critical to ensuring a long-term sustainable, reliable, and good quality water supply, and includes objectives and plan elements that are incorporated into these GSPs.

The GMP identifies three groundwater management objectives:

- Objective 1: Development of Integrated Water Supplies to Meet Existing and Projected Water Requirements;
- Objective 2: Determination of Sustainable Yield and Avoidance of Overdraft; and
- Objective 3: Preservation of Groundwater Quality for Beneficial Use.

To accomplish these objectives, the GMP identifies 14 elements that include a number of effective ongoing water management activities and new activities for expanded conjunctive use of supplemental

surface water and recycled water with groundwater. The elements reflect the wider focus on groundwater management, which includes continued cooperation among groundwater suppliers and groundwater users in the basin. Plan elements to be implemented by MCWRA include the following:

- Plan Element 1: Monitoring of Groundwater Levels, Quality, Production, and Subsidence;
- Plan Element 2: Monitoring of Surface Water Storage, Flow, and Quality;
- Plan Element 3: Determination of Basin Yield and Avoidance of Overdraft;
- Plan Element 4: Development of Regular and Dry Year Water Supply;
- Plan Element 5: Continuation of Conjunctive Use Operations;
- Plan Element 6: Short-Term and Long-Term Water Quality Management;
- Plan Element 7: Continued Integration of Recycled Water;
- Plan Element 8: Identification and Mitigation of Groundwater Contamination;
- Plan Element 9: Identification and Management of Recharge Areas, Wellhead Protection Areas;
- Plan Element 10: Identification of Well Construction, Abandonment, and Destruction Policies;
- Plan Element 11: Continuation of Local, State, and Federal Agency Relationships;
- Plan Element 12: Continuation of Public Education and Water Conservation Programs;
- Plan Element 13: Groundwater Management Reports; and
- Plan Element 14: Provisions to Update the Groundwater Management Plan.

2.2.6.2 INTEGRATED REGIONAL WATER MANAGEMENT PLAN

The Greater Monterey County Integrated Regional Water Management Plan (IRWMP) was developed by the Greater Monterey County Regional Water Management Group (RWMG) (RWMG 2018), which consists of government agencies, nonprofit organizations, educational organizations, water service districts, private water companies, and organizations representing agricultural, environmental, and community interests. The MGSA Area of the Subbasin falls within the IRWMP area.

Goals and objectives identified by RWMG as critical to address water resource issues within the IRWMP area encompass the following:

- Water supply;
- Water quality;
- Flood protection and floodplain management;
- Environment;
- Regional communication and cooperation;
- DACs; and
- Climate change.

The IRWMP includes more than 25 projects related to regional groundwater management.

2.2.6.3 MCWD URBAN WATER MANAGEMENT PLAN

The MCWD Urban Water Management Plan (UWMP) (Schaaf & Wheeler 2016) describes MCWD's service area; reports historical and projected populations; identifies historical and projected water demand by category (single-family, multi-family, commercial, industrial, institutional/government, and other); identifies water supplies, and describes the distribution system and associated losses. MCWD currently relies solely on groundwater. MCWD has two separate service areas: Central Marina, which encompasses the portion of the City of Marina outside former Fort Ord, and the Ord Community. There are three municipal water production wells in the Central Marina service area completed in the 900-Foot Aquifer (Deep Aquifer). Five municipal production wells are located in the Ord Community service area, three completed in the lower 180/400-Foot Aquifer (Wells 29, 30, and 31), one in the 400-Foot/Deep Aquifer (Well 35), and one in the Deep Aquifer (Well 34) (MCWD 2019b). MCWD also has a small seawater desalination plant located at its main office adjacent to Marina State Beach. Although the facility is not currently in use, it has a design capacity of 300 AFY (Schaaf & Wheeler 2016).

Water use during 2015 for both the Marina and Ord communities was about 3,200 AFY. Based on estimates in the MCWD UMWP, there will be a shortfall of approximately 3,000 AFY in allocated supplies for MCWD's combined Central Marina and Ord Community service systems to meet projected demand by 2035. To address the shortfall, MCWD is looking at various methods of enhancing the water supply including stormwater capture, water recycling, desalination, and conservation and efficient use of water. These water supply projects are described in Section 2.2.10. MCWD's Board of Directors has also considered purchasing surface water rights in the Salinas River Basin as a means of meeting long-term (beyond 2030) demands. In addition, MCWD is conducting a three-party planning process (with Fort Ord Reuse Authority [FORA] and M1W) to identify new water supply options for development in the Fort Ord area (MCWD 2019c). The study began in October 2018 and is anticipated to be completed in early 2020. The study will identify and evaluate water supply alternatives for Fort Ord based on technical/regulatory feasibility, cost/benefit, effectives, among a set of criteria that align with the programs' strategic goal.

2.2.6.4 ANNEXATION AGREEMENTS

In 1993, the United States Government, represented by the Army, and MCWRA entered into an agreement entitled *Annexation of Fort Ord into Zones 2 and 2A of the Monterey County Water Resources Agency* (1993 Annexation Agreement). The purpose of the 1993 Annexation Agreement was to provide terms and conditions under which the Fort Ord Lands could be annexed to MCWRA zones to become part of MCWRA's regional water supply system and to mitigate the effects of seawater intrusion in the Salinas Valley Basin.

In 1996, the City of Marina and other parties entered into an agreement with RMC Lonestar (the owner of the CEMEX Property that now comprises the MGSA Area) entitled *Annexation Agreement and Groundwater Mitigation Framework for Marina Area Lands* (1996 Annexation Agreement). The purpose of the 1996 Annexation Agreement is to "help reduce seawater intrusion and protect the groundwater resource and preserve the environment of the Salinas River Groundwater Basin" and to provide

conditions for annexation of the CEMEX and other properties to MCWRA zones. *Id.* § 1.1. One key Annexation Agreement condition is that "[c]ommencing on the effective date of this Agreement and Framework, Lonestar shall limit withdrawal and use of groundwater from the Basin to Lonestar's historical use of 500 AFY of groundwater." *Id.* § 7.2

Under 1993 and 1996 Annexation Agreements, MCWRA allocated groundwater pumping rights of 3,020 AFY to MCWD and the City of Marina, and 6,600 AFY to the Army for the Ord community (Schaaf & Wheeler 2016). Under the 1996 Annexation Agreement, 920 AFY of groundwater was allocated to Armstrong Ranch development, and 500 AFY (of brackish water) to CEMEX in the MGSA Area.

2.2.7 EXISTING GROUNDWATER REGULATORY PROGRAMS

2.2.7.1 GROUNDWATER EXPORT PROHIBITION

The Monterey County Water Resources Agency Act § 52.21 prohibits the export of groundwater from any part of the Salinas Valley Groundwater Basin, including the 180/400 Foot Subbasin. In particular, the Act states:

> *For the purpose of preserving [the balance between extraction and recharge], no groundwater from that basin may be exported for any use outside the basin, except that use of water from the basin on any part of Fort Ord shall not be deemed such an export. If any export of water from the basin is attempted, the Agency may obtain from the superior court, and the court shall grant, injunctive relief prohibiting that exportation of groundwater.*

2.2.7.2 AGRICULTURAL ORDER

In 2017, the CCRWQCB issued Agricultural Order No. R3-2017-0002, a Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands (Agricultural Order). The permit requires that growers implement practices to reduce nitrate leaching into groundwater and improve surface-receiving water quality. Negotiations with the CCRWQCB staff and Board Members for the next iteration of the Agricultural Order are ongoing; they are expected to conclude in March 2020 with the adoption of a new ILRP Waste Discharge Requirement (WDR) for farming operations in the Salinas Valley Groundwater Basin area (and the entire Central Coast region). There is no agricultural land use within the MGSA Area.

2.2.7.3 WATER QUALITY CONTROL PLAN FOR THE CENTRAL COAST BASINS

The Water Quality Control Plan for the Central Coastal Basin (Basin Plan) was most recently updated in September 2017 (CCRWQCB 2017). The objective of the Basin Plan is to outline how the quality of the surface water and groundwater in the Central Coast Region should be managed to provide the highest water quality reasonably possible. The Basin Plan lists beneficial users, describes the water quality that must be maintained to allow those uses, provides an implementation plan, and details SWRCB and CCRWQCB plans and policies to protect water quality and statewide and regional surveillance and monitoring programs. The SWRCB's Sources of Drinking Water Policy — adopted in Resolution No. 88-63 and incorporated in its entirety into the CCRWQCB's Basin Plan — provides that water with water quality equal to or less than 3,000 milligrams per liter (mg/L) Total Dissolved Solids (TDS) is considered

suitable or potentially suitable as a municipal and domestic water supply. SWRCB Resolution No. 68-16, which is also incorporated into the Basin Plan, requires that the existing high quality of groundwater be maintained unless it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use, and will not result in water quality less than applicable standards.

Present and potential future beneficial uses for surface waters in the Central Coast Basin are: municipal supply (water for community, military, or individual water supplies); agricultural; groundwater recharge; recreational water contact and non-contact; sport fishing; warm fresh water habitat; wildlife habitat; rare, threatened, or endangered species; and spawning, reproduction, and/or early development of fish. Present and potential future beneficial uses for groundwater are municipal supply, agricultural supply, and industrial supply. Groundwater in the MGSA Area is currently used for industrial supply at the CEMEX Lapis Plant sand mine site. The extracted groundwater is reported to contain a concentration of approximately 19,000 mg/L TDS. In addition, groundwater containing less than 3,000 mg/L TDS has a designated potential beneficial use as a source of domestic and municipal supply as noted above.

2.2.7.4 TITLE 22 DRINKING WATER PROGRAM

The SWRCB Division of Drinking Water (DDW) regulates public water systems in the state to ensure the delivery of safe drinking water to the public. A public water system is defined as a system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year. Private domestic wells, wells associated with drinking water systems with less than 15 residential service connections, industrial wells, and irrigation wells are not regulated by the DDW.

DDW enforces the monitoring requirements established in CCR Title 22 for public water system wells, and all the data collected must be reported to DDW. Title 22 also designates the Maximum Contaminant Levels (MCLs) for various waterborne contaminants, including volatile organic compounds, non-volatile synthetic organic compounds, inorganic chemicals, radionuclides, disinfection byproducts, general physical constituents, and other parameters.

2.2.8 INCORPORATION OF REGULATORY PROGRAMS INTO THE GSP

Information from the management plans and monitoring programs described in this section has been incorporated into this GSP, and was considered in establishing the sustainability goal provided in Section 4.2, when setting minimum thresholds and measurable objectives (as described in Chapter 4), and during development of projects and management actions described in Chapter 6.

The existing monitoring programs and monitoring networks constitute a well-developed and broadly distributed system that provides representative data throughout the Subbasin and in the vicinity of the MGSA Area. As discussed in Chapter 5 (Monitoring Networks), the monitoring program of this GSP will incorporate the groundwater level and quality data collected by MCWRA from the nested monitoring wells installed in the vicinity of the MGSA Area under the MMRP adopted for the MPWSP. MCWRA also monitors the nested Deep Aquifer wells installed by USGS about ½-mile south of the MGSA Area, and a

number of other wells in the 180-Foot, 400-Foot, and Deep Aquifers. Water level and quality data collected from these wells will also be incorporated into the monitoring program of this GSP. MCWRA's and SVBGSA's regional monitoring programs will be considered in interpreting the local monitoring data, but will not be a formal component of MGSA's more locally-focused monitoring network.

Plans are in progress by MCWRA to expand the network of nested groundwater monitoring wells in the vicinity of the MGSA Area and incorporate additional wells into this monitoring program. It is anticipated that groundwater level and quality monitoring of the Deep Aquifer will be expanded and improved in the future under programs implemented by MCWRA and MCWD GSA. Applicable program improvements and expansions of these monitoring programs in the vicinity of the MGSA Area will also be incorporated into this GSP as described in Chapter 5 (Monitoring Networks).

The incorporation of these regulatory programs during implementation of this GSP is described in Chapter 7 (Plan Implementation).

2.2.9 Limits to Operational Flexibility

This GSP has been developed to be coordinated with the requirements, management plans and monitoring programs administered by other jurisdictions in the area, including SVBGSA, MCWRA, MCWD GSA, and CCRWQCB. Some of the existing management plans and ordinances include well registration, extraction monitoring, new well restrictions, pumping allowances and restrictions, recharge requirements, and/or water quality protection standards that will limit operational flexibility. However, the limits imposed by these programs and plans have already been considered in the sustainable management criteria, monitoring networks, and projects and management actions described in Chapters 4, 5, and 6, respectively. As such, they are not expected to further limit operational flexibility under this GSP. No other limits to operational flexibility have been identified.

2.2.10 Conjunctive Use Programs

Regulation Requirements:
§354.8(e) A description of conjunctive use programs in the basin.

MCWRA is engaged in a number of conjunctive use projects to help eliminate basin overdraft and seawater intrusion. MCWD works in cooperation with MCWRA to further water supply development and resource management, and is exploring alternative water sources to augment groundwater supplies. The MPWSP will draw groundwater from the Subbasin with subsurface slant intake wells as the water source for the desalination plant. Under the terms of the June 14, 2016 Return Water Settlement Agreement (CalAm 2016), CalAm proposes to replace some of the groundwater it withdraws from the Subbasin by delivering a portion of the "return water" from its desalination treatment plant by providing a portion of the treated water from its desalination plant to Castroville Community Services District (CCSD). The program has not received final approvals or begun operating, and currently lacks any water rights. If it is ever approved, begins operation, and the "return water" program is implemented, the GSP will be revised with further information on the agreement.

2.2.10.1 MONTEREY COUNTY WATER RECYCLING PROJECTS (CSIP/SVRP)

In 1995, MCWRA began construction of the Monterey County Water Recycling Projects to deliver recycled wastewater for irrigation use in the Castroville area in order to reduce groundwater pumping (MCWRA 2019a). The CSIP produces recycled water which is used along the coast instead of pumping groundwater for agricultural irrigation. The CSIP has operated successfully since 1998, reducing groundwater pumping and the rate of seawater intrusion. The success of the CSIP led to the development and implementation of the Salinas Valley Reclamation Project (SVRP) to further address basin overdraft and seawater intrusion. A rubber dam (i.e., the SRDF) was installed on the Salinas River approximately 5 river miles upstream of the river mouth near Marina (MCWRA 2019a). The SRDF was constructed to provide seasonally stored and treated (filtered and chlorinated) river water for irrigation, significantly reducing the need to pump groundwater except in periods of extremely high demand. Recycled water from the SVRP is distributed to approximately 12,000 acres of farmland within the Subbasin via the CSIP distribution system (MCWRA 2019a). The current CSIP distribution area is shown in Figure 2-6. M1W operates a large treatment plant located in the County Environmental Park north of Marina off Del Monte Boulevard. This plant will produce 19,500 AFY of recycled water for irrigation in the Castroville area to contain seawater intrusion. The farmers in this area will be able to reduce groundwater pumping from the aquifer and thereby fight seawater intrusion. This plant will provide recycled water for some landscaped areas in Marina.

2.2.10.2 PURE WATER MONTEREY PROJECT

The PWM Project, which is completing construction and expected to begin delivering water in about October 2019, is an advanced water recycling project that will provide a safe, reliable, and sustainable drinking water supply and will reduce water taken from the Carmel River and the Seaside Subbasin (PWM 2019). The PWM Project will also provide a source of tertiary treated water for the Salinas Valley agricultural industry and provide treatment for impaired surface water. By supplying additional tertiary treated water for CSIP, PWM will reduce the reliance on groundwater pumping, thereby helping to combat the effects of seawater intrusion.

The project is expected to deliver approximately 3,500 AFY of potable water for the Monterey Peninsula and off-set approximately 2,000 AFY of groundwater pumping in the Subbasin (PWM 2019). MPWMD and M1W are also completing a supplemental Environmental Impact Report for a major expansion of the Project that could deliver up to an additional 2,250 AFY of water for Monterey Peninsula water users by fall 2021 (Johnson 2019).

2.2.10.3 MCWD REGIONAL URBAN WATER AUGMENTATION PROJECT

In February 2018, MCWD received a $10.5M Proposition 1 low-interest loan and grant for the RUWAP, a recycled water transmission and distribution system (MCWD 2019b). MCWD and M1W partnered to build a transmission pipeline spanning 10 miles for the purified recycled water. In addition, MCWD constructed a storage reservoir (Blackhorse Recycled Water Reservoir) and distribution pipes to deliver advanced treated water to existing and planned urban irrigation facilities.

The goal of the RUWAP Recycled Water Project is to provide 1,427 AFY of water from sources other than groundwater within the District and up to 3,700 acre-feet (AF) of water to the PWM (MCWD 2019b). The pipeline will initially deliver 600 AF of advanced treated water to MCWD customers in Marina and the Ord Community (MCWD 2019b). The advanced treated water will be suitable for use in Seaside Basin and elsewhere. This water will be of higher quality than tertiary treated and disinfected recycled water, and may be used for urban landscape irrigation reducing the District's reliance on groundwater.

2.2.10.4 MCWD Recycled Water Project

To meet future demands, MCWD is working to maximize existing water supplies and is investing in infrastructure to deliver tertiary treated recycled water (MCWD 2019a). Recycled water is wastewater that is treated, filtered, and disinfected to SWRCB Standards. Recycled water is used to irrigate large landscaped areas (parks, golf courses, and playgrounds) and crops. MCWD currently uses about 600 AFY of recycled water for landscaping in the Marina and Seaside areas. The use of recycled water reduces the amount of groundwater that is pumped from aquifers. In the Salinas Valley, where aquifers are over pumped, reduced pumping decreases the rate of seawater intrusion. MCWD will receive recycled water from M1W (described above) for some landscaped areas in Marina. Presently in Marina, Gloria Jean Tate Park is piped for recycled water. The external landscape of some of the other commercial businesses nearby have also been piped for recycled water.

MCWD is also conducting an indirect potable reuse (IPR) feasibility study to assess using advanced treated recycled water from M1W for groundwater augmentation (EKI 2019). A groundwater-flow model is being developed as part of this study to identify a preferred project for injection of purified recycled water into the Monterey Subbasin for future extraction by MCWD's municipal production wells. The IPR is intended to both supplement MCWD's groundwater supplies, as well as to protect production wells from saline water intrusion.

2.3 General Plans and Other Land Use Plans

2.3.1 Plan Summaries

Regulation Requirements:
§354.8(f) A plain language description of the land use elements or topic categories of applicable general plans that include the following:
(1) A summary of general plans and other land use plans governing the basin.

The City of Marina has land use authority over the incorporated areas of the City of Marina, which includes the Coastal Zone and the MGSA Area. Marina has developed and adopted both a General Plan and a Local Coastal Land Use Plan. Land use is an important factor in water management as described below. Monterey County has land use authority over the unincorporated areas of the county and considers the general plans of all cities within the county to allow for cooperative planning. The following sections provide a general description of these land use plans and how implementation may affect groundwater and its beneficial uses in the MGSA Area and its vicinity.

2.3.1.1 CITY OF MARINA GENERAL PLAN

The City of Marina was founded in 1915 and incorporated in 1975, and the first General Plan was adopted in 1978. The overall goal of the Marina General Plan is "the creation of a community which provides a high quality of life for all its residents; which offers a broad range of housing, transportation, and recreation choices; and which conserves irreplaceable natural resources" (City of Marina 2010). One of the general framework goals of the plan is particularly relevant to this MGSP—"Community development which avoids or minimizes to the greatest extent possible the consumption or degradation of nonrenewable natural resources including natural habitats, water, energy, and prime agricultural land" [1.18.2].

The General Plan specifies open space policies to ensure retention of land with significant natural resource values [2.3.3] and include habitat reserves and other open space for the protection of important habitat and scenic areas [2.7.1]. Habitat reserve and open space include coastal strand and dune areas adjacent to Monterey Bay and wetlands, which provide habitat for rare, threatened wildlife and plant species. Some of the lands designated as "Habitat Reserve and Other Open Space" in the General Plan are as follows (Figure 2-7):

- Approximately 1,600 acres west of Highway 1 are designated as habitat reserve for this purpose [2.10.2].
- An area of 80 acres on the Armstrong Ranch property between Del Monte Boulevard and Highway 1 is designated as Habitat Reserve due to the presence of "vernal ponds" [2.10.4].

The General Plan recognizes that future water demands will require changes in the management of water resources in the area, and water conservation and water reclamation and reuse will constitute major components of future water management efforts. The policies and programs of the General Plan are designed to promote both water conservation and the use of recycled water to protect water quality and to ensure that the demand of future community development does not exceed the capacity to provide water in an environmentally acceptable way [3.42].

The General Plan includes the following measures related to water-supply planning.

- New developments must have identified water sources [3.45].
- A 15% reserve will be maintained between demand and supply. When demand exceeds 85% of the available supply, no new development will be allowed until supplemental water sources are identified [3.47].

The primary responsibility for water resource management in Marina rests with MCWD, as the water purveyor, and MCWRA, which is responsible for managing the surface water and groundwater resources of the Salinas Valley Groundwater Basin.

2.3.1.2 CITY OF MARINA LOCAL COASTAL PROGRAM

The California Coastal Act requires that local governments in the Coastal Zone create and implement Local Coastal Programs (LCPs) to conserve coastal dependent land use. City of Marina has an approved

LCP that consists of a Local Coastal Land Use Plan (LCLUP) and a Local Coastal Implementation Plan (LCIP) (City of Marina 2013a, 2013b). Under the California Coastal Act, City of Marina manages coastal development, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion, and CCC has jurisdiction over such issues below the mean high tide line.

City of Marina's Coastal Zone includes Highway 1 and all lands west of Highway 1 within the incorporated limits. In addition, the Coastal Zone includes two other areas: vacant lands west of Del Monte Boulevard between Reservation Road and the City's southern boundary, including coastal dunes, cultivated acreage, and some substantial "vernal ponds" with associated wetlands; and a narrow strip about 2 miles long west of Highway 1 within the Ford Ord boundary, including the coastal bikeway and the Southern Pacific Railroad tracks. The MGSA Area is within the Coastal Zone.

The critical coastal planning issues in Marina focus on the future of the dunes now that sand mining will cease in December 2020; the future of the vernal ponds; and on establishing uses that would be compatible with the existing ESHA constraints present in the City's Coastal Zone. The policies of the LCLUP as well as the land use designations address these concerns and resolve them in terms of the mandates of the California Coastal Act for the beach, dunes, and vernal ponds. Policies related to habitat management relevant to this GSP are as follows:

- **Vernal Ponds –** To protect and encourage the restoration of the vernal ponds to their original state and allow only those uses adjacent, which will reinforce and conserve the unique habitat qualities of these ponds [24].
- **Dunes –** To protect the habitat of recognized rare and threatened/endangered species found in the coastal dune area [25].

The emphasis of the LCLUP is to maximize public access consistent with the environmental sensitivity of the dune habitat and resident rare and threatened/endangered plants and animals. Coordination with PARKS was initiated to identify areas for park access. However, direct access to the dune vegetation is limited due to the level of use that the vegetation can withstand.

Because Marina is a coastal city, global warming and associated sea level rise are important areas of concern. The City addresses these issues as part of its Local Coastal Program and in connection with its issuance of coastal development permits.

Amendments were made to the City's Open Space Zoning district, and established recreation areas were rezoned as Open Space. The addition of a reclassification section to the Open Space district will allow future areas designated for development to be subsequently rezoned as Open Space and clearly held for the future.

The City has identified that the biodiversity and unique features of coastal vernal ponds in the vicinity of the MGSA Area need to be preserved. The City of Marina LCP, certified by the Coastal Commission on April 20, 1982, guides development within the coastal zone in Marina. A request for a Comprehensive Management Plan (CMP) was initiated in 1990 by the Coastal Commission in response to development

pressures around the City's vernal pond resources. The City of Marina engaged stakeholders in a collaborative effort to prepare the CMP. A Technical Advisory Committee, comprised of representatives from the City of Marina, MPRPD, California Department of Fish and Game (CDF&G), Coastal Commission, Coastal Conservancy, Sierra Club, and other interested residents, was also established to guide development of the plan. Four meetings were held with the Technical Advisory Committee. A public meeting was held on March 18, 1993, to present preliminary findings on the resources of the ponds and solicit comments from the public on management issues. A second public meeting was held on November 18, 1993, to present the draft plan and solicit comments on the proposed management plan recommendations. The final plan was adopted on February 15, 1994 (The Habitat Restoration Group 1994).

City of Marina is preparing an updated CMP for the coastal and/or vernal ponds that will identify guidelines for the preservation, management, and enhancement of the region's wetland resources (City of Marina 2013a). The plan will include both public and privately owned ponds, including those owned and managed by City of Marina, PARKS, and MCWD.

2.3.1.3 MONTEREY COUNTY GENERAL PLAN

Planning in Monterey County began in 1930 when the Planning Commission was created. The Planning Department was established in the 1950s, and the first General Plan was completed in 1968 and updated in 1982. Planning efforts have resulted in growth primarily in and around existing population areas and cities; however, the main objectives are to "provide direction for growth that supports continued viability of agricultural production and preserves as much of the county's scenic and environmental resources as possible." The current Monterey County General Plan was completed in 2010 and the objectives remain the same (Monterey County 2010).

The Monterey County General Plan includes the following goals and policies related to land use, conservation and open space, public water supply and agriculture that are relevant to this GSP:

- Promote appropriate and orderly growth and development while protecting desirable existing land uses [GOAL LU-1].
    - Land uses shall be designated to achieve compatibility with adjacent uses [LU-1.5].
- Encourage the provision of open space lands as part of all types of development including residential, commercial, industrial, and public [GOAL LU-8].
    - Creation of private, nonprofit land trusts and conservation organizations to receive development rights on any lands to be preserved and maintained as open space shall be supported [LU-8.6].
- Conserve listed species, critical habitat, habitat and species protected in area plans; avoid, minimize and mitigate significant impacts to biological resources [GOAL OS-5].
    - Conservation of listed species shall be promoted [OS-5.1].
    - Conservation of species shall be promoted as provided in the Area Plans [OS-5.2].

- Development shall be carefully planned to provide for the conservation and maintenance of critical habitat [OS-5.3].
- Development shall avoid, minimize, and mitigate impacts to listed species and critical habitat to the extent feasible [OS-5.4].
- Efforts to obtain and preserve natural areas of particular biologic, scientific, or educational interest, and restrict incompatible uses from encroaching upon them, shall be encouraged [OS-5.13].
- The County shall prepare, adopt, and implement a program that allows projects to mitigate the loss of critical habitat [OS-5.17].
- Prior to disturbing any federal or state jurisdictional areas, all applicable federal and state permitting requirements shall be met, including all mitigation measures for development of jurisdictional areas and associated riparian habitats [OS-5.18].
- In order to preserve riparian habitat, conserve the value of streams and rivers as wildlife corridors and reduce sediment and other water quality impacts of new development, the county shall develop and adopt a Stream Setback Ordinance [OS-5.22].

- Assure an adequate and safe water supply to meet the county's current and long-term needs [GOAL PS-2].
  - Coordination among, and consolidation with, those public water service providers drawing from a common water table to prevent overdrawing the water table [PS-2.1].
- Ensure that new development is assured a long-term sustainable water supply [GOAL PS-3].
  - Specific criteria for proof of a Long-Term Sustainable Water Supply and an Adequate Water Supply System for new development requiring a discretionary permit shall be developed by ordinance. The following factors shall be used [PS-3.2]:
    - Water quality
    - Production capacity
    - Capability of the water purveyor
    - Source of the water supply and nature of the water rights
    - Cumulative impacts of existing and projected future water demand, and the ability to reverse trends contributing to an overdraft condition
    - Effects of additional extraction or diversion of water on the environment including on in-stream flows necessary to support riparian vegetation, wetlands, fish or other aquatic life
    - Projects or best management practices to renew or sustain aquifer functions.
  - Specific criteria shall be developed by ordinance for use in the evaluation and approval of adequacy of all domestic wells [PS-3.3].
  - The County shall request an assessment of impacts on adjacent wells and instream flows for new high-capacity wells where there may be a potential to affect existing adjacent domestic or water system wells adversely or in-stream flows necessary to support riparian vegetation, wetlands, fish, and other aquatic life [PS-3.4].

- The Monterey County Health Department shall not allow construction of any new wells in known areas of saltwater intrusion. [PS-3.5].
- The County shall coordinate and collaborate with all agencies responsible for the management of existing and new water resources [PS-3.6].
- A program to eliminate overdraft of water basins shall be developed [PS-3.7].
- In order to maximize agricultural water conservation measures to improve water use efficiency and reduce overall water demand, the county shall establish an ordinance identifying conservation measures that reduce agricultural water demand [PS-3.10].
- In order to maximize urban water conservation measures to improve water use efficiency and reduce overall water demand, the county shall establish an ordinance identifying conservation measures that reduce potable water demand [PS-3.11].
- The County shall maximize the use of recycled water [PS-3.12].

- Ensure adequate treatment and disposal of wastewater [GOAL PS-4].
  - The County shall encourage groundwater recharge through the use of reclaimed wastewater, not including primary treated wastewater, in accordance with federal, state, and local laws, regulations and ordinances [PS-4.4].
- Ensure compatibility between the county's agricultural uses and environmental resources [GOAL AG-5].
  - Policies and programs to protect and enhance surface water and groundwater resources shall be promoted but shall not be inconsistent with state and federal regulations [AG-5.2].

The Monterey County General Plan requires discretionary development to provide proof of a long-term sustainable water supply prior to approval. Discretionary development will not be able to proceed in areas wherein new water demands would exacerbate existing seawater intrusion or groundwater overdraft.

2.3.2 Impact of General Plans and Land Use Plans on Water Demands

Regulation Requirements:
§354.8(f) (2) A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects.

The current designated land use of the MGSA Area is Habitat Preserve and Other Open Space. Permitted use of the CEMEX plant will cease in December 2020 and the impacted area will be reclaimed and restored by CEMEX according to its filed reclamation plan. Any new developments in this area should be consistent with the designated land use and therefore should have limited water demand.

CalAm is under court order to cease illegal diversions from the Carmel River and provide an alternative water supply, and requires additional water supplies to address long-term overdraft in the adjudicated

Seaside Subbasin. The proposed MPWSP would provide up to approximately 6,252 AFY of desalinated water to CalAm's service area (CPUC 2018). The proposed MPWSP, if implemented, would consist of a desalination plant that receives source water from five subsurface slant wells (plus two standby wells) near the shore at the CEMEX site (ESA 2018). The slant wells would extract a combined volume of approximately 17,400 AFY (HWG 2017) of groundwater consisting of a combination of saline groundwater (some of which originated in the ocean) and low total dissolved solids (TDS) groundwater from the Dune Sand and 180-Foot Aquifers within the Subbasin. If the proposed MPWSP is fully approved and implemented, or if well extractions by others are proposed, such extractions of groundwater potentially may cause exceedances of measurable objectives established for the MGSA Area and trigger the need for management actions. The monitoring program described in Chapter 5 and the management actions described in Chapter 6 would address this occurrence.

2.3.3 IMPACT OF THE GSP ON LAND USE PLAN ASSUMPTIONS

Regulation Requirements:
§354.8(f) (3) A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.

Implementation of this GSP is consistent with the goals and policies of the City of Marina and Monterey County General Plans, and is expected to aid in their achievement. The designated land use of the MGSA Area is Habitat Preserve and Other Open Space. Permitted use of the CEMEX plant will cease in December 2020. Any future development in this area should be consistent with this designation and should have limited water demand.

The MPWSP is proposed to provide up to approximately 6,252 AFY of desalinated water to CalAm's service area (CPUC 2018). A recent analysis of supply options and demand forecasts indicates that a proposed expansion of the Pure Water Monterey project could provide sufficient water for the Monterey Peninsula for the next 20 years or more, even in the absence of the MPWSP (Stoldt 2019). Current planning data do not extend to the SGMA planning horizon of 50 years; however, this analysis indicates that sufficient long-term water supplies should be available as supply strategies are developed to meet future demands through the SGMA planning and implementation horizon. Demand and supply forecasts will be updated as new information becomes available.

The General Plans for other cities within the Subbasin and for Monterey County provide guidelines to facilitate anticipated growth within the sustainable capacity of existing water resources. Successful land use planning also promotes sustainable water supply, supply development, and use within the Central Coast region. The goals and policies in the General Plans complement this GSP and support the ability of the GSA to achieve sustainability. Implementation of this GSP, including changes in groundwater management, may result in changes in water supplies; however, current projects are anticipated to be able to meet forecast water demands within the General Plan planning horizons.

2.3.4 PERMITTING NEW OR REPLACEMENT WELLS

Regulation Requirements:
§354.8(f) (4) A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.

The Monterey County Health Department, Drinking Water Protection Services (DWPS) well program is responsible for the well permitting process for all domestic, irrigation, agricultural, cathodic protection, monitoring, or heat exchange wells (Monterey County 2019). Under California Water Code (CWC) § 7.70.030, a written permit is required from the Monterey County Health Officer for any new or replacement wells installed under this GSP. In addition, a coastal development permit is required for any well proposed to be drilled in the Coastal Zone. The MGSA Area is located entirely within the California Coastal Zone.

Under CWC § 7.70.060, construction, repair, and destruction of all wells requires the use of a licensed contractor with a current C57 license from the State of California. Similarly, other parties proposing to abandon a well within the MGSA Area will be required to obtain such a permit. The fundamental State Well Standard is augmented in the Salinas Valley by Specifications for Wells in Zone 6 of the Monterey County Flood Control and Water Conservation District, which were adopted by County Health Department in 1988 to protect groundwater quality and prevent corrosion of well casing caused by seawater intrusion in the coastal (Zone 6) portion of the basin (MCWRA 2006). MCWRA collaborates with Monterey County Health Department during the application and review process for permitting new water supply wells.

Wells must meet a 2.5-acre minimum lot size requirement for on-site sewage disposal. If sewage disposal is or will be by an onsite waste disposal system and the lot can be served by a water system, the property must be at least 2.5 acres in order to obtain a permit to construct. Prior to placement of a well seal, the driller must submit a seal proposal to Monterey County Environmental Health Bureau (EHB) for review and approval (see Section 2.4.2).

In the future, SGMA allows that GSAs be consulted to verify that groundwater extraction from new proposed wells is consistent with adopted GSPs prior to issuing well construction permits. MGSA will respond to any requests to comment on applications to construct new wells within its jurisdiction.

2.3.5 LAND USE PLANS OUTSIDE THE MGSA AREA

Regulation Requirements:
§354.8(f) (5) To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.

Applicable land use plans outside the Subbasin include the General Plan for the City of Marina and the County General Plan. This GSP has considered and is aligned with the goals and implementation strategies for these general plans as well as other applicable land use plans, such as the local coastal plan. These land use plans are in alignment with the concerns and plans of the MGSA and should not affect the ability of the MGSA to achieve sustainable groundwater management within the MGSA Area.

Several amendments to the County General Plan, which were approved by the Board of Supervisors in February 2013 (Resolution No. 13-028) require Monterey County to develop a study of a portion of the Salinas Valley Groundwater Basin's water supplies that includes, among other items:

- An assessment of whether the total water demand for all uses designated in the General Plan for 2030 are likely to be reached or exceeded;
- An evaluation and conclusions regarding future expected trends in groundwater elevations; and
- An evaluation and conclusions regarding expected future trends in seawater intrusion.

Should the study conclude that total water demand for all uses is likely to be exceeded by 2030, groundwater elevations are likely to decline by 2030, or the seawater intrusion front is likely to advance inland by 2030, then the study shall make recommendations on how to address those conditions. The settlement agreement furthermore required the development of the Salinas Valley Integrated Hydrologic Model (SVIHM), a pre-released version of which was used for the SVBGSA GSP and which will be used to facilitate implementation and updating of this GSP. Implementation of this GSP is consistent with the above requirements and objectives, and is expected to aid in their achievement.

The City of Marina General Plan contemplates growth and water demand increase at levels that were incorporated into the City's UWMP, discussed in Section 2.2.6.3. The projected increase in the City's water demand is within the groundwater pumping allocations for the Central Marina service system and Armstrong Ranch under the 1993 and 1996 Annexation Agreements (Schaaf & Wheeler 2016). This groundwater extraction will occur from resources within the adjacent Monterey Subbasin. MGSA will coordinate its monitoring program and any necessary management actions MCWD GSA.

2.4 ADDITIONAL GSP COMPONENTS

Regulation Requirements:
§354.8(g) A description of any of the additional Plan elements included in the Water Code Section 10727.4 that the Agency determines to be appropriate.

The Additional GSP Components section of this MGSP provides discussion of additional GSP elements included in CWC § 10727.4 that MGSA has determined are appropriate for this GSP.

2.4.1 SEAWATER INTRUSION

The 180/400 Foot Aquifer Subbasin (Subbasin) is subject to seawater intrusion due largely to long-term groundwater extraction in the inland portions of the Subbasin in excess of the sustainable yield. As a result, it has been identified by DWR as being in a critical condition of overdraft (DWR 2016a). Seawater intrusion was first identified in the MGSA Area in the 1940s, and over the following decades progressed inland for a distance of over 7 miles in some areas. The purpose of this GSP is to support regional efforts to address this undesirable result and return to Subbasin to sustainable groundwater management within 20 years, as required by the Sustainable Groundwater Management Act (SGMA). MGSA will achieve this by supporting the projects and management actions that will be implemented by Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) under its regional Groundwater Sustainability

Plan (GSP), and by assuring that local groundwater resources are managed sustainably to protect local and regional beneficial uses and users.

Seawater intrusion in the Subbasin and in the MGSA Area is described in Section 3.2.3. Section 4.6 addresses seawater intrusion as a sustainability indicator and identifies minimum thresholds, measurable objectives, and interim milestones. Actions to monitor for and identify seawater intrusion early are described in Chapter 5. Proposed projects to control seawater intrusion are described in Chapter 6.

2.4.2 WELLHEAD PROTECTION

Water supply wells and monitoring wells in Monterey County must be constructed in accordance with California Well Standards Bulletin No. 74-81 and No. 74-90 (DWR 1981, 1991), and Monterey County Code Chapter 15.08. Pursuant to Chapter 15.04.120 of the Monterey County Code, the annular well seal is required to:

- Restore, as far as feasible, the controlling hydrological conditions that existed before the well was drilled and constructed, including the elimination of physical hazards.
- Prevent pollution of groundwater and conserve the yield and hydrostatic head of aquifers.
- Prevent intermingling of desirable and undesirable waters.

For any well installed as part of this GSP, the driller must submit the seal proposal to Monterey County EHB for approval and EHB will witness placement of the seal (Monterey County 2019).

The designated land use of the MGSA Area is Habitat Preserve and Other Open Space, so the Wellhead Protection requirements from California Department of Pesticide Regulation (CDPR 2019) will not apply.

2.4.3 MIGRATION OF CONTAMINATED GROUNDWATER

The MMRP adopted for the proposed MPWSP requires that project to incorporate groundwater level and quality monitoring data for the Fort Ord Superfund site Operable Unit Carbon Tetrachloride Plume (OUCTP) in the A-Aquifer and 180-Foot Aquifer into its monitoring program to assure that the proposed groundwater extraction from the project slant intake wells will result in the further migration of that plume (CPUC 2018). These plumes are located approximately 7,000 feet southeast of the MGSA Area. Monterey County established well prohibition/consultation zones at Fort Ord, in areas where groundwater extraction may be impacted by contaminated plumes (Ordinance No. 04011, Monterey County 1999). No other known contamination exists within or near the MGSA Area.

2.4.4 WELL ABANDONMENT/WELL DESTRUCTION PROGRAM

To protect groundwater quality, the Monterey County Health Department DWPS well program is responsible for permitting the abandonment and/or destruction of domestic, irrigation, agricultural, cathodic protection, monitoring, or heat exchange wells. The well program works closely with Monterey County Planning, the cities, MCWRA, and MPWMD. If any wells will be abandoned or destroyed as part

of this GSP, MGSA will obtain a permit and use a contractor with a current C57 license from the State of California, as required by the County (Monterey County 2019). Similarly, other parties proposing to abandon a well within the MGSA Area will be required to obtain such a permit.

2.4.5 REPLENISHMENT OF GROUNDWATER EXTRACTIONS

Replenishment of groundwater extractions is not contemplated under this GSP.

2.4.6 CONJUNCTIVE USE

Existing conjunctive use projects are identified in Section 2.2.10. Chapter 6 describes several conjunctive use projects that are being implemented or proposed by other parties, with which the MGSA will cooperate. This chapter describes the proposed projects and management actions that will address implementing, opportunities for, and removing impediments to conjunctive use or underground storage projects in the Subbasin near the MGSA Area.

2.4.7 WELL CONSTRUCTION POLICIES

Regulatory oversight over sustainable groundwater management expanded when SB 252 was signed into law on October 7, 2017. New proposed wells located in the Subbasin, designated by DWR as a critically overdrafted basin, are subject to the requirements of SB 252. The well applicants must provide the following information as part of the well application:

- A map of the location, including global positioning system (GPS) coordinates and elevation
- Proposed capacity, estimated pumping rate, anticipated pumping schedule, and estimated annual extraction volume
- Geologic siting information (water table depth, seasonal fluctuations, recharge area, recharge rate, location to floodplain)
- Distance from ponds, lakes, and streams within 300 feet
- Estimated cumulative extraction volume before January 1, 2020
- Size of area (acres) to be served by the well

SB 252 is only a temporary measure, meant to expire when GSPs for critically overdrafted basins are submitted to DWR by January 31, 2020. It is expected that further coordination of well permitting procedures with the adopted GSPs will occur after that time.

On May 22, 2018, the Monterey County Board of Supervisors adopted Interim Emergency Ordinance No. 5302 pursuant to Government Code § 65858, which temporarily prohibits new wells in seawater-intruded aquifers pending the County's study and consideration of regulations. The ordinance imposed a moratorium on County Health Department accepting and processing new well permits; it is not a moratorium on additional groundwater pumping from existing wells. The ordinance prohibits the acceptance or processing of any permit applications for new wells in the defined Area of Impact within the Subbasin until May 21, 2020, with exceptions for municipal wells and replacement wells.

2.4.8 GROUNDWATER PROJECTS

Groundwater projects and management actions, including measures to address seawater intrusion, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and/or extraction projects, are described in Chapter 6.

2.4.9 EFFICIENT WATER MANAGEMENT PRACTICES

Ongoing efforts to implement efficient water management practices, as defined in CWC § 10902, for the delivery of water and water conservation methods to improve the efficiency of water use will be consistent with MCWD UWMP, and are described in Section 2.2.6.3.

2.4.10 RELATIONSHIPS WITH STATE AND FEDERAL AGENCIES

A strong relationship between MGSA and federal and state agencies is vital to the success of this GSP. Efforts to develop this relationship are described in Chapter 7 (Plan Implementation).

2.4.11 LAND USE PLANNING

Efforts will be made at the local level to develop a formal opportunity for coordination with other GSAs and planning entities to provide input on the land use and water-related elements of future General Plans and California Environmental Quality Act (CEQA) documentation to promote consistency with this GSP.

2.4.12 GROUNDWATER-DEPENDENT ECOSYSTEMS

The GSP Regulations include specific requirements to identify and consider Groundwater-Dependent Ecosystems (GDEs) (23 CCR § 354.16(g)) when determining whether groundwater conditions are having potential effects on beneficial uses and users. GSAs must also assess whether sustainable management criteria may cause adverse impacts to beneficial uses, which include environmental uses, such as plants and wildlife. As discussed further in Section 3.2.7, there are no GDEs directly within the MGSA Area, but an analysis following guidelines developed by The Nature Conservancy for identification of GDEs (TNC, 2018) identified several likely GDEs in the area east of the MGSA Area. Similar GDEs occur north and south of the MGSA Area. These GDEs have been identified as coastal or vernal ponds, and consist of palustrine and emergent wetlands. They are ESHAs under the Marina LCP and are designated protected areas within the Coastal Zone of California under the California Coastal Act. Groundwater development within the MGSA Area could affect these GDEs. The biodiversity and unique features of coastal vernal ponds in the vicinity of the MGSA Area are protected under the 1994 City of Marina CMP (The Habitat Restoration Group 1994).

2.5 NOTICE AND COMMUNICATION

Regulation Requirements:

§ 354.10. Notice and Communication

Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:

(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

(b) A list of public meetings at which the Plan was discussed or considered by the Agency.

(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.

(d) A communication section of the Plan that includes the following:

(1) An explanation of the Agency's decision-making process.

(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.

(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.

(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

MGSA and City of Marina have developed and followed an open and inclusive process to implement SGMA. Interested parties have opportunities, both formal and informal, to provide input to MGSA throughout the process of developing, operating, and implementing this GSP. Such opportunities include, but are not limited to, public comment periods required by SGMA (CWC § 10728.4), as well as opportunities for public comment during regular and special City Council meetings, and at other times to be determined and noticed pursuant to CWC § 10727.8(a).

Public Meetings/Public Comment Opportunities

- March 20, 2018, General City Council Meeting:
  - Public hearing regarding the City's intent to become a GSA
  - Floor open for public comments concerning adoption of Resolution
  - Resolution 2018-25 adopted (vote unanimous)
- August 7, 2019, General City Council Meeting:
  - Presentation and public meeting/workshop to discuss preparation of a locally focused GSP for a portion of the Subbasin
  - Floor open for public comments concerning preparation of a GSP
- October 8, 2019, Special City Council Meeting:
  - Presentation and public meeting/workshop to filing of a Notice of Intent to adopt a GSP for the MGSA Area of the 180/400 Foot Subbasin
  - Floor open for public comments concerning filing of the Notice of Intent and public review of the draft GSP
- October 11, 2018 – November 25, 2019, 45-Day Public Comment Period
  - Public comment period for interested parties to provide written comments on the public review draft GSP via mail or email
  - Hard copies available at City of Marina City Hall and the Marina Branch Library

  - Responses to comments received during the public comment period are provided in Volume II of this MGSA GSP

- October 29, 2019, Special City Council Meeting:
  - Presentation and public meeting/workshop to discuss the public review draft of the GSP for the MGSA Area of the 180/400 Foot Subbasin
  - Floor open for public comments concerning the public review draft GSP
- January 7, 2020, Special City Council Meeting:
  - Public meeting/hearing to discuss adoption of the GSP for MGSA Area of the 180/400 Foot Subbasin
  - Floor open for public comments concerning the GSP and its adoption
- January 14, 2020, General City Council Meeting:
  - Public meeting/hearing to discuss adoption of the GSP for MGSA Area of the 180/400 Foot Subbasin
  - Floor open for public comments concerning the GSP and its adoption
  - Vote to adopt the GSP

Opportunities for public comments on the MGSA GSP and its implementation will be provided at future General City Council Meetings, which are generally held every second Tuesday. Special presentations may be made regarding implementation status, specific findings, management actions, and other activities related to GSP implementation.

2.5.1 DESCRIPTION OF BENEFICIAL USES AND USERS

Regulation Requirements:

§354.10 Each plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:

(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

SGMA (CWC §§ 10720, *et seq*.) requires that GSAs consider the interests of all beneficial uses and users of groundwater. To meet this requirement (specifically CWC § 10723.4), City of Marina identified the following interested parties and environmental stakeholders:

1. Local water districts adjoining the MGSA Area
   a. MCWD
   b. Monterey One Water and MCWRA for the Castroville Seawater Intrusion Project
2. Holders of overlying groundwater rights (agricultural and domestic well owners, municipal well operators and public water systems)
   a. Armstrong Ranch
   b. CEMEX
3. Surface-water users
   a. Monterey One Water and MCWRA for the Castroville Seawater Intrusion Project

4. Environmental users of groundwater
    a. Fort Ord Dunes State Park
    b. Marina Beach State Park
    c. Salinas River National Wildlife Refuge
    d. City of Marina
    e. County of Monterey
5. Local land use planning agencies
    a. City of Marina
    b. County of Monterey
6. Federal government
    a. No federal lands are within the MGSA Area
    b. Salinas River National Wildlife Refuge
7. California Native American tribes
    a. No Native American tribes are within or near the MGSA Area
8. DACs
    a. Portions of the City of Marina
9. Entities listed in CWC § 10927 that are monitoring and reporting groundwater elevations or quality data near the MGSA Area
    a. MCWRA
    b. SVBGSA
10. Other Entities
    a. MCWD GSA
    b. California American Water Company

The list of interested parties will continue to be updated throughout the MGSA's development and implementation of this GSP. MGSA will engage environmental and include environmental representation throughout development and implementation of this GSP. During development of this GSP, MGSA specifically requested review and input regarding identification, characterization, and management of GDEs located near the MGSA Area. Ongoing engagement during GSP implementation could include input from state and federal resource agencies, nonprofit organizations, and other environmental interests. By engaging these stakeholders, MGSA will benefit from access to additional data and resources, resulting in a more robust and inclusive GSP. As required by SGMA (CWC §§ 10720, *et seq*.), MGSA will consider all beneficial uses of groundwater and the interest of users and managers.

2.5.2 DECISION-MAKING PROCESS

Regulation Requirements:
§354.10 (d) A communication section of the Plan that includes the following:
An explanation of the Agency's decision-making process.

City Council of the City of Marina administers MGSA and is responsible to consider and approve policy decisions for the development, adoption, and implementation of this GSP. MGSA board meetings are held concurrently with City Council meetings on the first and third Tuesdays of each month in

accordance with the Marina Municipal Code (Chapter 2.04) and City Ordinances: 2001-11 § 1 (2001), 78-12 § 1 (1978), and 75-2 § 1 (1975). The meetings are publicly noticed and agendas are made available on the City's website (https://www.cityofmarina.org/AgendaCenter).

Open meetings may be preceded by a closed session if necessary and appropriate. As described in Section 1.5.2, resolutions presented to the City Council are voted on and require a majority vote of a quorum to be passed and adopted. Open public hearings on specific resolutions may be held during meetings to allow for testimony from the public. City Council Members will consider public testimony prior to voting on specific resolutions.

2.5.3 PUBLIC ENGAGEMENT/PUBLIC OUTREACH PLAN

Regulation Requirements:
§354.10 (d)(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.

Federal, state, and local agencies, water providers, property owners, environmental stakeholders, and other interested parties will have opportunities, both formal and informal, to provide input to MGSA throughout the process of developing, operating, and implementing the MGSA GSP. Such opportunities include, but are not limited to, public comment periods required by SGMA (e.g., CWC § 10728.4) as well as opportunities for public comment during regular and special Marina City Council meetings, and at other times to be determined and noticed pursuant to CWC § 10727.8 (a).

The above-referenced agencies, water providers, and other interested stakeholders will be contacted to determine how best to consider and protect their interests and will be invited to participate in evaluating and defining roles and responsibilities during the GSP planning and implementation process.

The MGSA webpage is maintained on a regular basis at https://cityofmarina.org/918/Groundwater-Sustainability-Plan. The webpage includes a brief history of the formation of MGSA, a description of the MGSP groundwater area, and plans for the future. Contact information for the MGSA Plan Manager is provided, as well as background information and related documents. MGSA will post information and updates regarding GSP preparation and the Draft MGSA GSP on this webpage.

2.5.4 ENCOURAGING ACTIVE INVOLVEMENT

Regulation Requirements:
§354.10 (d)
(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of population within the basin.
(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

The City of Marina is a diverse, working-class community that is focused on development, sustainability, and recreation. MGSA and City Council will work together to encourage the active involvement of diverse social, cultural, and economic elements of the community by keeping the community informed about progress implementing projects and management actions under this GSP.

Before any project or management action is implemented under this GSP, it will go through a public notice process to ensure that all groundwater users and other stakeholders have an opportunity to comment prior to adoption and implementation. The general steps in the public notice process will include the following:

- The MGSA GSP Plan Manager will bring an assessment of the need for the project to the Marina City Council in a publicly noticed meeting. This assessment will include:
  - a description of the undesirable result(s) that may occur if action is not taken;
  - a description of the proposed project or management action;
  - an estimated cost and schedule for the proposed project or management action; and
  - any alternatives to the proposed project or management action.
- Marina City Council will notify stakeholders in the area of the proposed project or management action, and allow at least 30 days for public response.
- After the 30-day public response period, Marina City Council will vote whether or not to approve design and construction of the project, or the implementation of the management action.

In addition to the public noticing detailed above, all projects will follow any environmental review and public notice provisions required by the California Environmental Quality Act (CEQA). Management actions are presumed to be exempt from CEQA since they are regulatory actions intended to protect the environment.

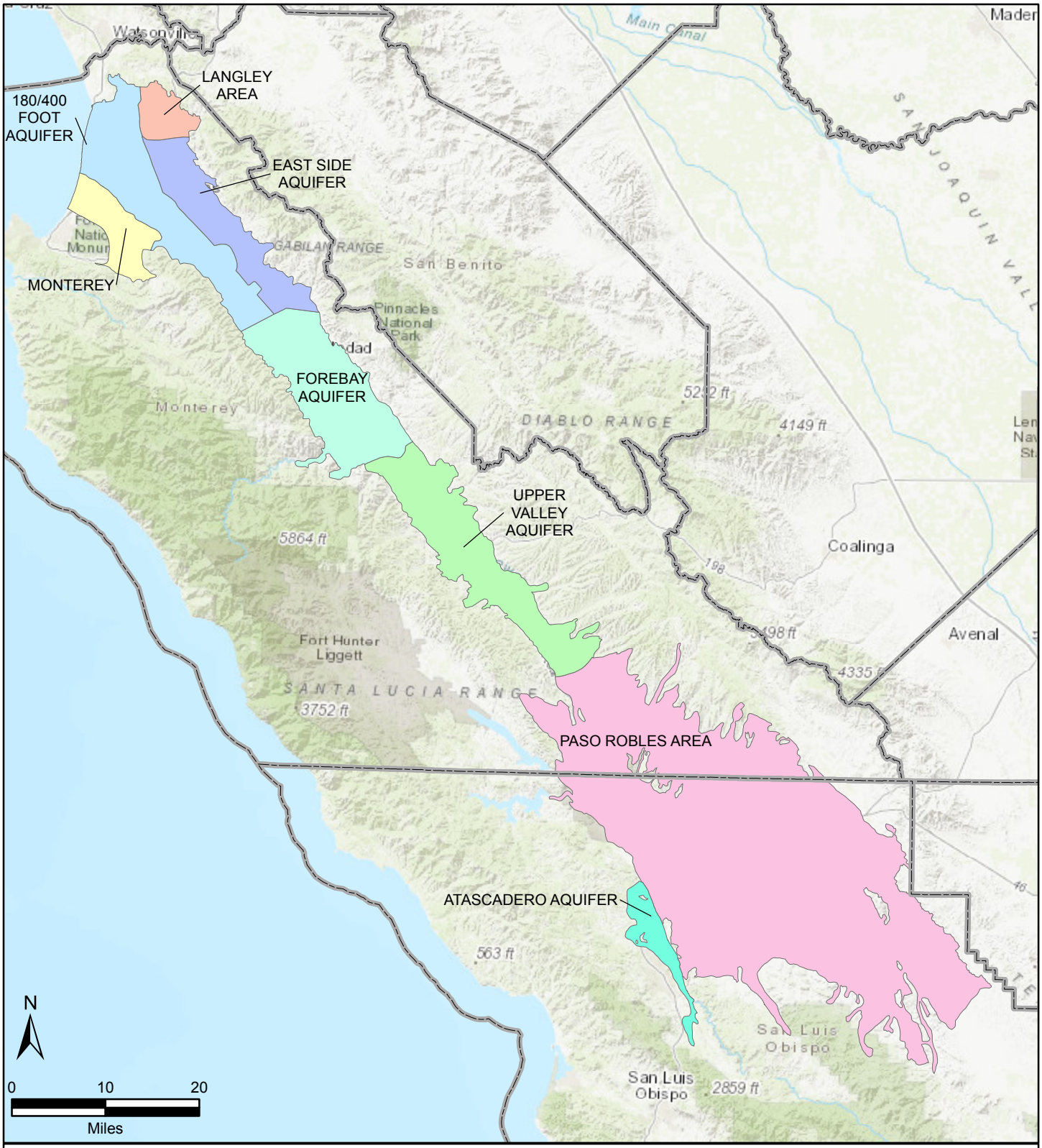

FIGURE 2-1

Salinas Valley Basin and Subbasins

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

Groundwater Subbasins
- 180/400 Foot Aquifer
- Atascadero Area
- East Side Aquifer
- Forebay Aquifer
- Langley Area
- Monterey
- Paso Robles Area
- Upper Valley Aquifer
- Counties

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa montereyco.opendata.arcgis.com

DATE: DEC. 30, 2019

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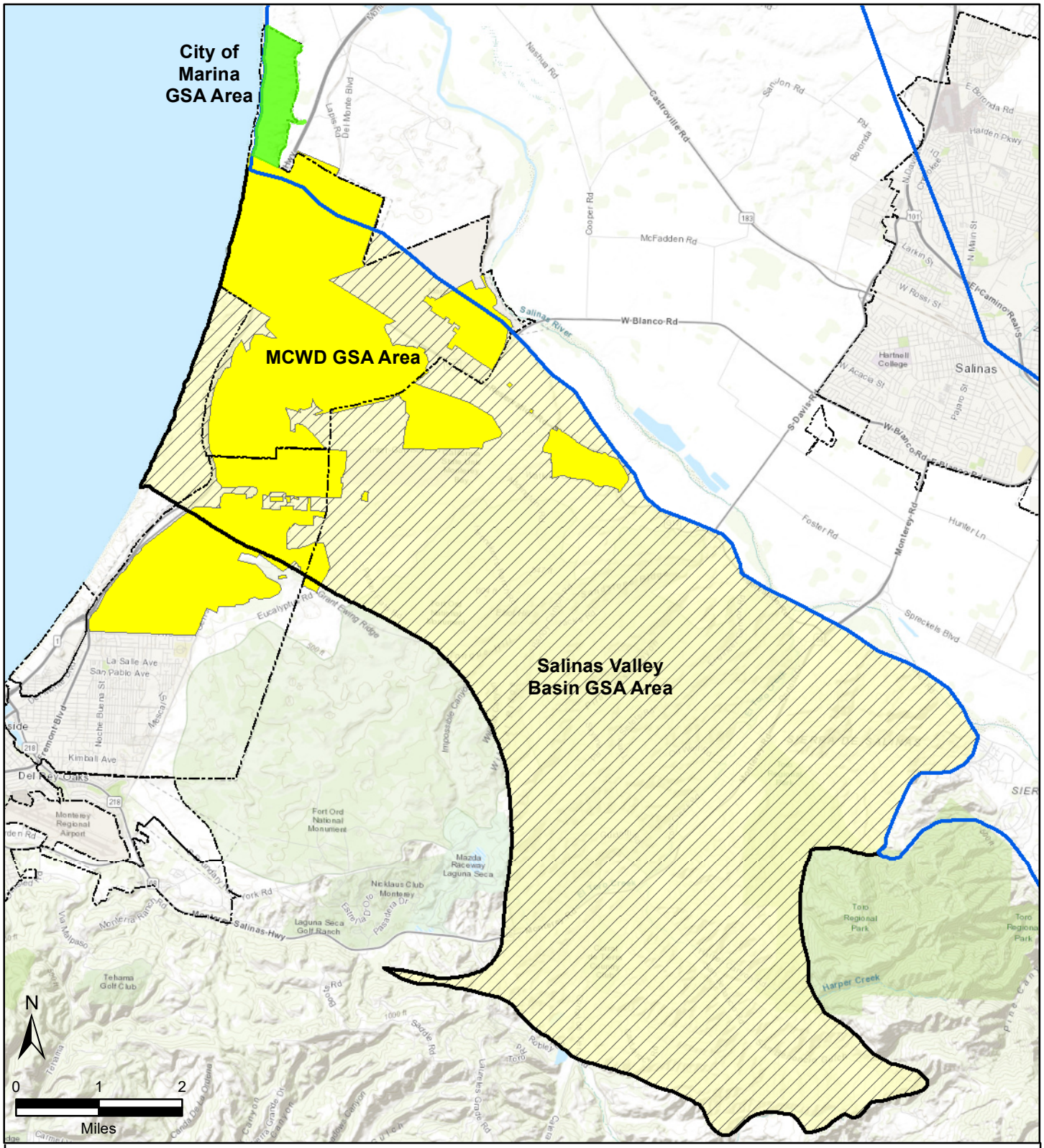

FIGURE 2-2

Monterey Subbasin GSA Areas

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA
- Marina Coast Water District (MCWD) GSA Areas
- Salinas Valley Basin (SVB) GSA Area
- Salinas Valley 180/400 Foot Aquifer Subbasin
- Cities
- Monterey Subbasin

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://montereycountyopendata-12017-01-13t232948815z-montereyco.opendata.arcgis.com

DATE: DEC. 31, 2019

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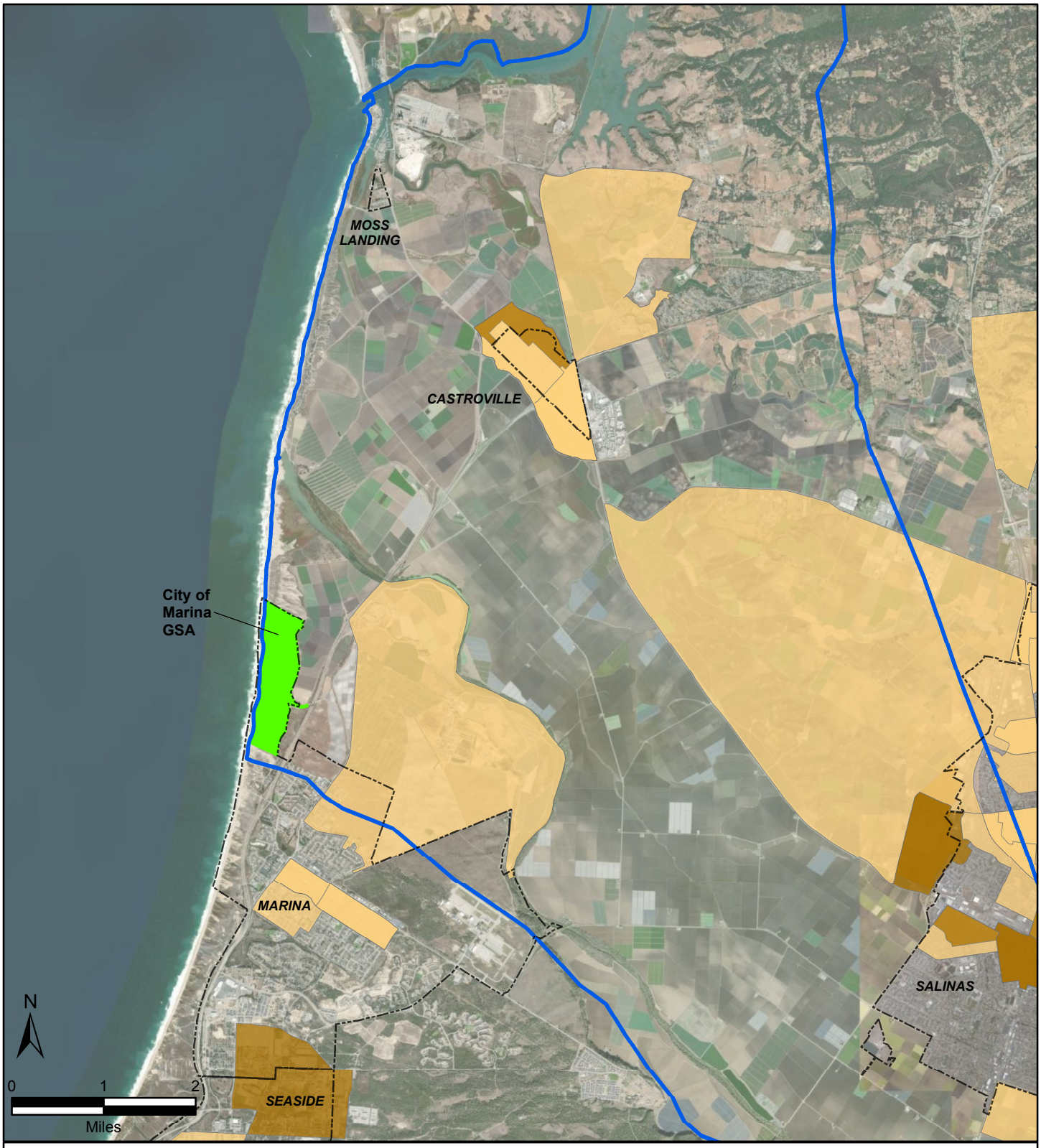

FIGURE 2-3

City Boundaries and Disadvantaged Communities (DACs)

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

Disadvantaged Communities 2016 Census

- Severly Disadvantaged Communities (SDACs) (MHI < 38,270)
- Disadvantaged Communities (DACs) (MHI $38,270 - $51,026)
- City of Marina GSA Area
- Cities
- 180/400 Foot Aquifer Subbasin

Sources: ESRI Map Service Imagery,
https://gis.water.ca.gov/app/dacs/
https://atlas-dwr.opendata.arcgis.com/datasets/6c8eedc1562e4d8b9d5232e23460d0bf_0
https://atlas-dwr.opendata.arcgis.com/datasets/4924738d96794286bf1c95db941d54fe_0
https://atlas-dwr.opendata.arcgis.com/datasets/4091ba7f52764aca868eb525fffadd69_0

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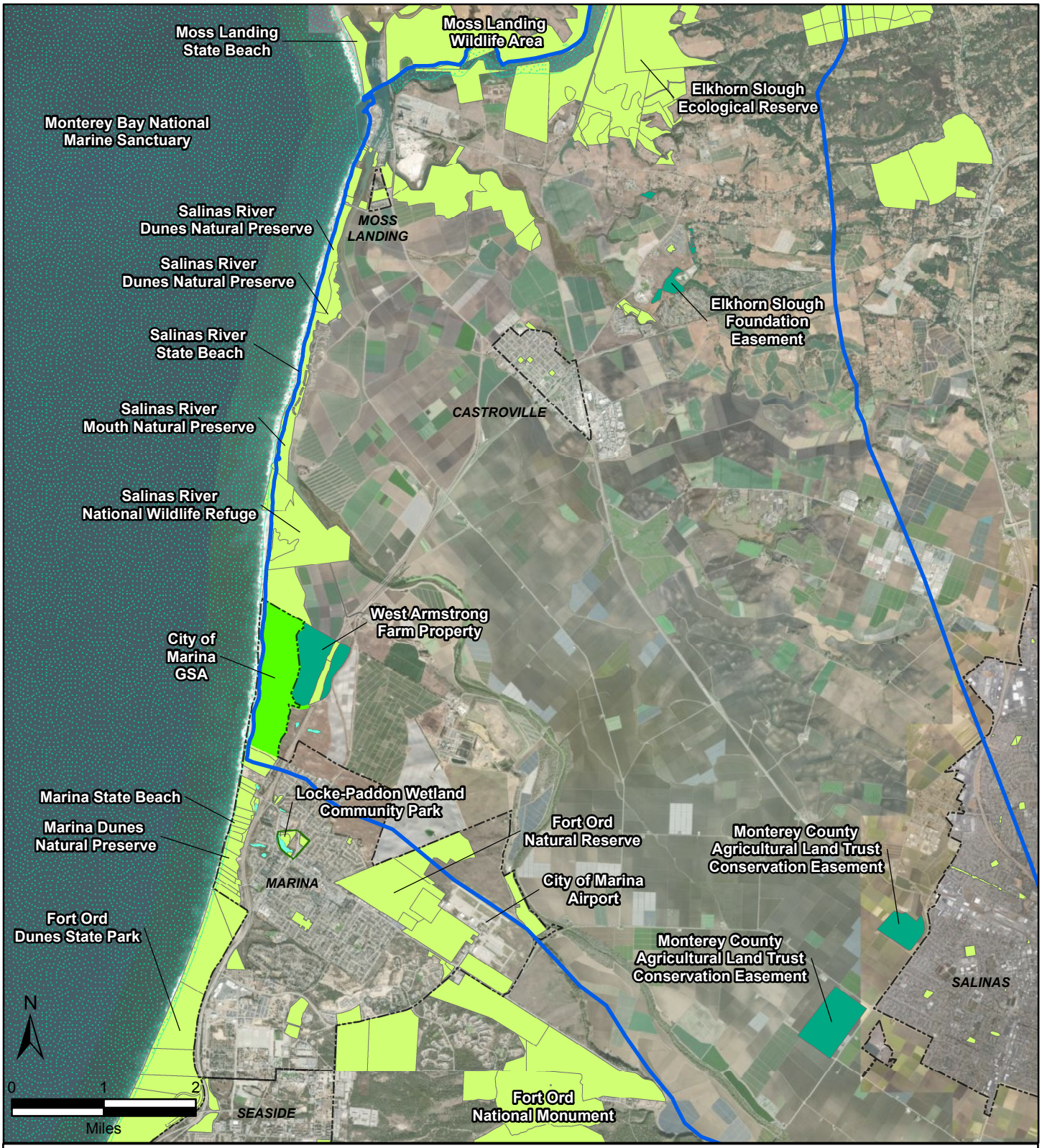

FIGURE 2-4

Federal, State and Local Managed Lands and Protected Areas

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- California Conservation Easements
- Protected Areas
- Vernal Ponds
- City of Marina GSA Area
- Cities
- 180/400 Foot Aquifer Subbasin
- Monterey Bay National Marine Sanctuary

Sources: ESRI Map Service Imagery, California Department of Water Resources, https://www.calands.org

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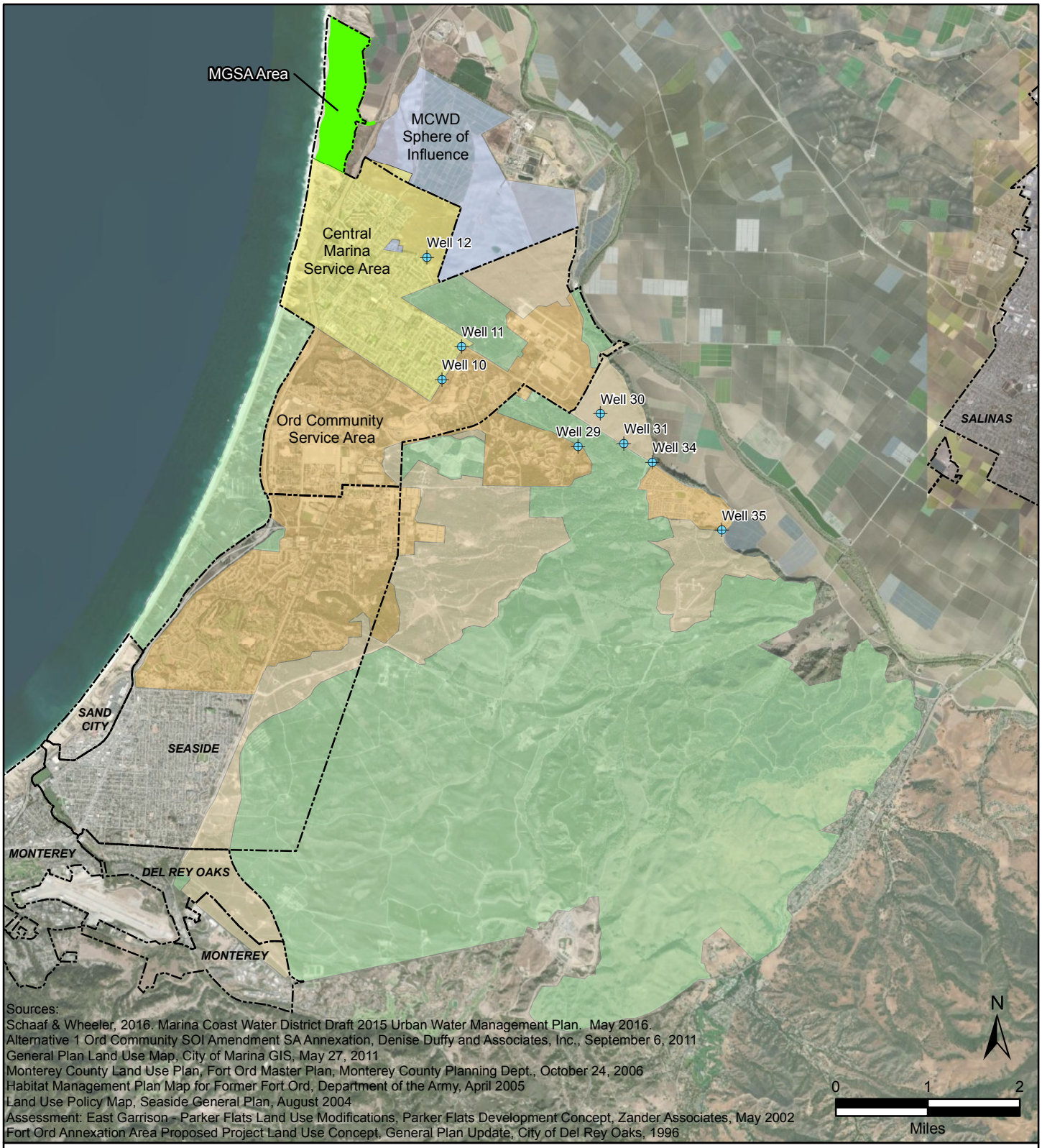

Sources:
Schaaf & Wheeler, 2016. Marina Coast Water District Draft 2015 Urban Water Management Plan. May 2016.
Alternative 1 Ord Community SOI Amendment SA Annexation, Denise Duffy and Associates, Inc., September 6, 2011
General Plan Land Use Map, City of Marina GIS, May 27, 2011
Monterey County Land Use Plan, Fort Ord Master Plan, Monterey County Planning Dept., October 24, 2006
Habitat Management Plan Map for Former Fort Ord, Department of the Army, April 2005
Land Use Policy Map, Seaside General Plan, August 2004
Assessment: East Garrison - Parker Flats Land Use Modifications, Parker Flats Development Concept, Zander Associates, May 2002
Fort Ord Annexation Area Proposed Project Land Use Concept, General Plan Update, City of Del Rey Oaks, 1996

FIGURE 2-5

Water Agency Jurisdiction Areas

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- Water Supply Wells
- City of Marina GSA Area
- Cities
- Habitat/Open Space/Parkland
- MCWD Service Area - Central Marina
- MCWD Service Area - Ord Community
- MCWD Sphere of Influence
- Ord Development Parcels

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FIGURE 2-6

Communities Dependent on Groundwater and the CSIP Distribution Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area
- Communities Dependent on Groundwater
- 180/400 Foot Aquifer Subbasin
- Castroville Seawater Intrusion Project (CSIP) Distribution Area

Sources: ESRI Map Service Imagery, California Department of Water Resources, https://montereycountyopendata-12017-01-13t232948815z-montereyco.opendata.arcgis.com

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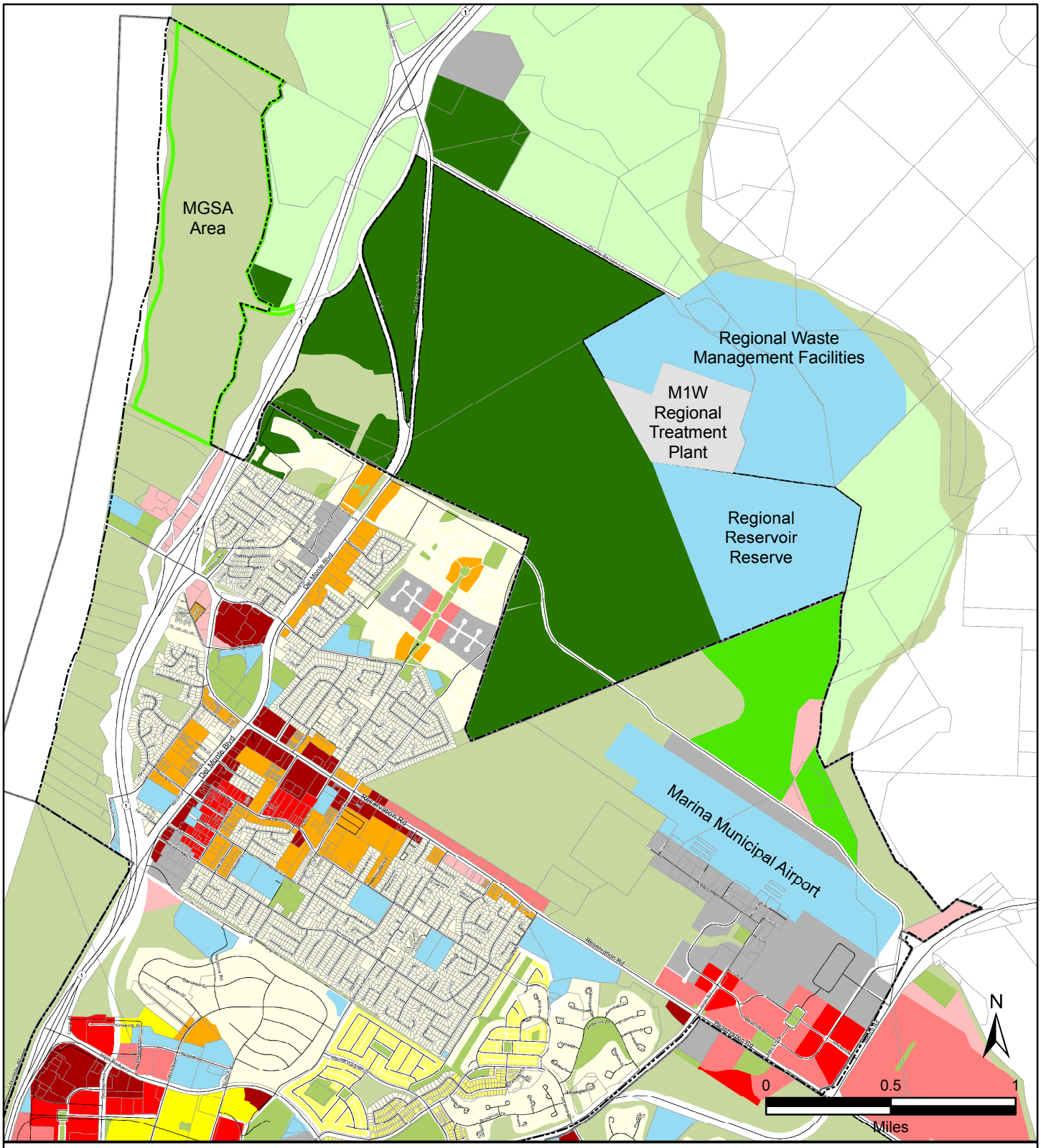

FIGURE 2-7

Land Use in the Vicinity of the MGSA Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area
- Multiple Use
- Retail/Service
- Office/Research
- Visitor-Serving
- Light Industrial/Service Commercial
- Agriculture
- Parks & Recreation
- Habitat Preserve & Other Open Space
- Golf Course
- UGB Open Space
- Public Facilities
- Single Family Residential
- Marina Heights Residential
- University Villages Residential
- Multi-Family Residential
- High Density Residential

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://montereycountyopendata-12017-01-13t232948815z-montereyco.opendata.arcgis.com
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City of Marina GIS
County of Monterey GIS

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FIGURE 2-8

Existing Surface Conditions Within MGSA Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area
- City of Marina

Sources: ESRI Map Service Imagery,
https://sgma.water.ca.gov/portal/gsa
montereyco.opendata.arcgis.com

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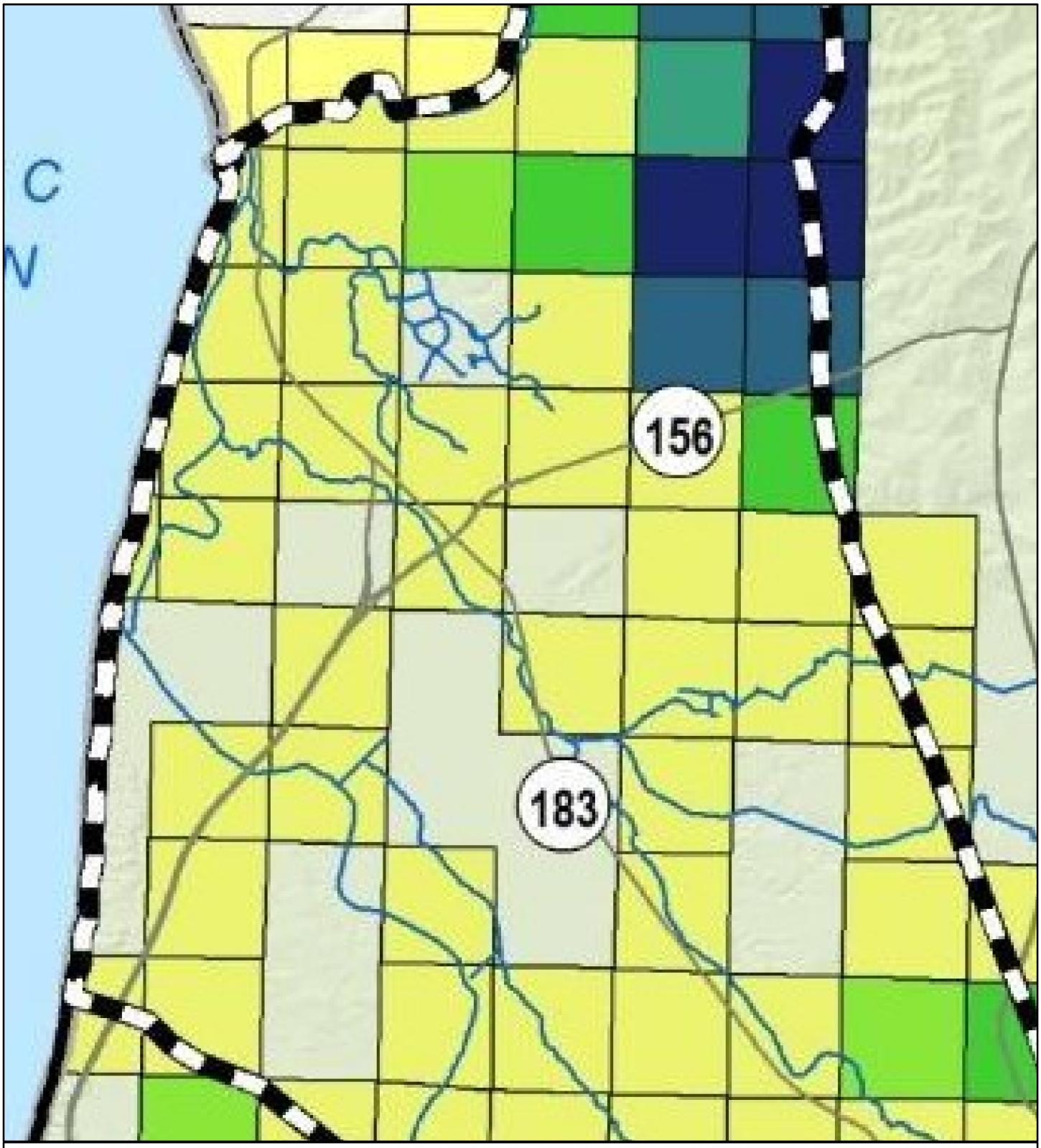

FIGURE 2-9

Density of Domestic Wells per Square Mile

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

Domestic Well Density

- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 40
- >40
- 180/400-Foot Aquifer Subbasin

Source Report: Salinas Valley:
180/400-Foot Aquifer Subbasin
Groundwater Sustainability Plan
November, 2018
Figure 3-7

DATE: DEC. 30, 2019

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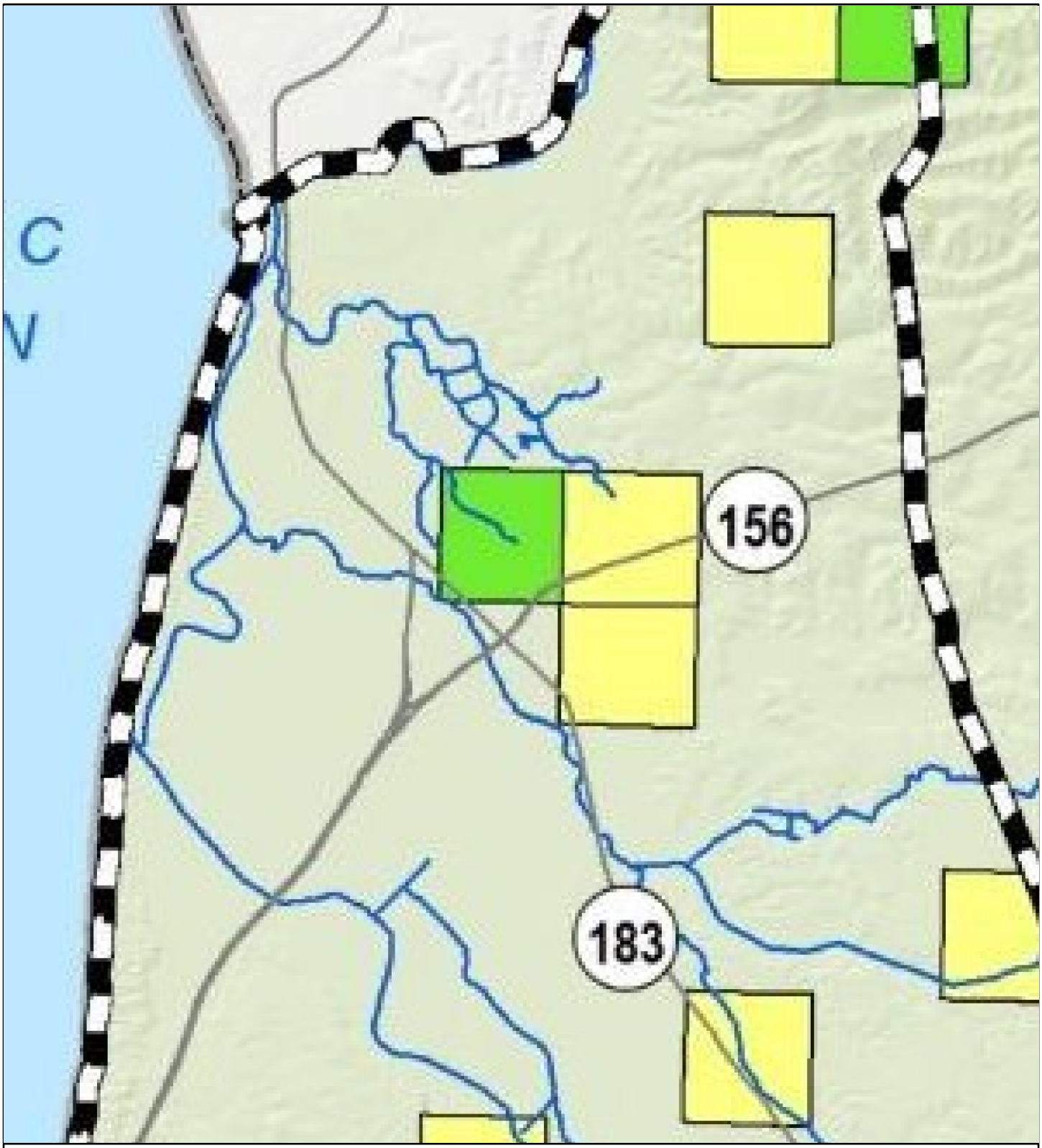

FIGURE 2-10

Density of Municipal Wells per Square Mile

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

Municipal Well Density

1
2
3
4
>4

180/400-Foot Aquifer Subbasin

Source Report: Salinas Valley:
180/400-Foot Aquifer Subbasin
Groundwater Sustainability Plan
November, 2018
Figure 3-9

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FIGURE 2-11

Density of Agricultural Production Wells per Square Mile

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

Agricultural (Production) Well Density
- 1 - 5
- 6 - 10
- 11 - 15
- >15

180/400-Foot Aquifer Subbasin

Source Report: Salinas Valley:
180/400-Foot Aquifer Subbasin
Groundwater Sustainability Plan
November, 2018
Figure 3-8

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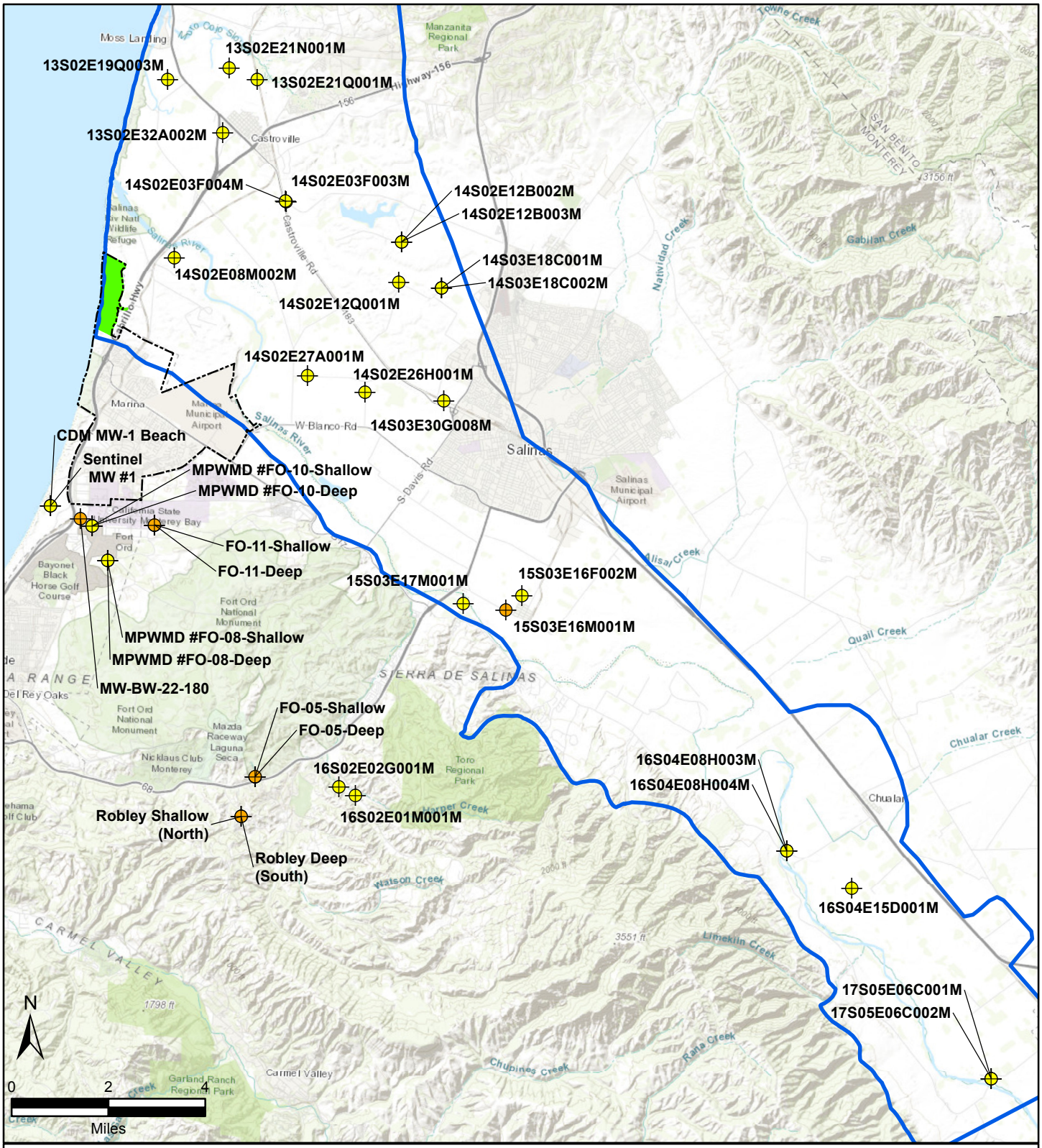

FIGURE 2-12

Locations of CASGEM Wells

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

Well Type

- CASGEM Well
- Participating Well

- City of Marina GSA Area
- City of Marina
- 180/400 Foot Aquifer Subbasin

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://www.casgem.water.ca.gov/OSS

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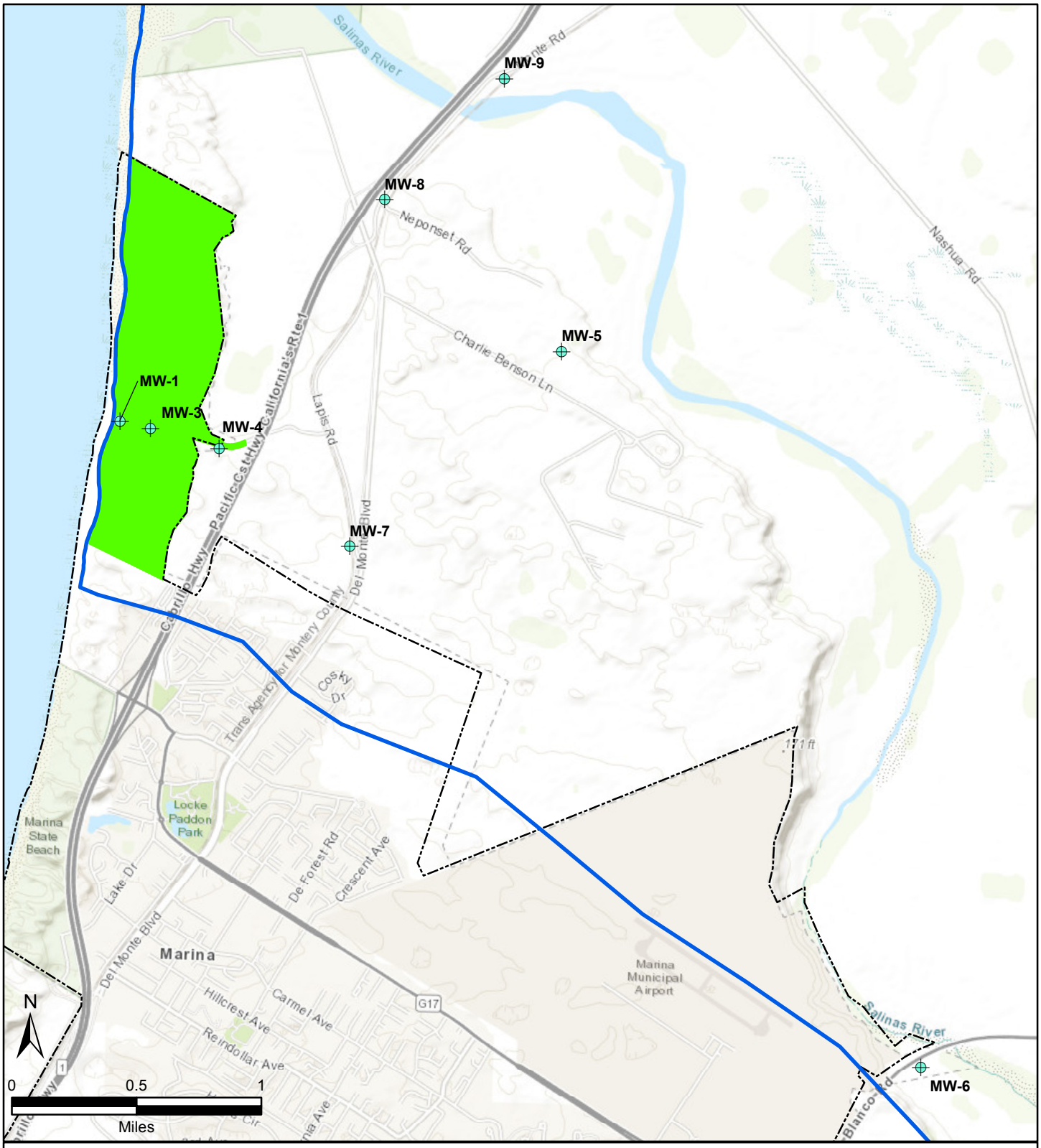

FIGURE 2-13

Locations of MPWSP Wells

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Wells
- City of Marina GSA Area
- City of Marina
- 180/400 Foot Aquifer Subbasin

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Monitoring Report #160 2019

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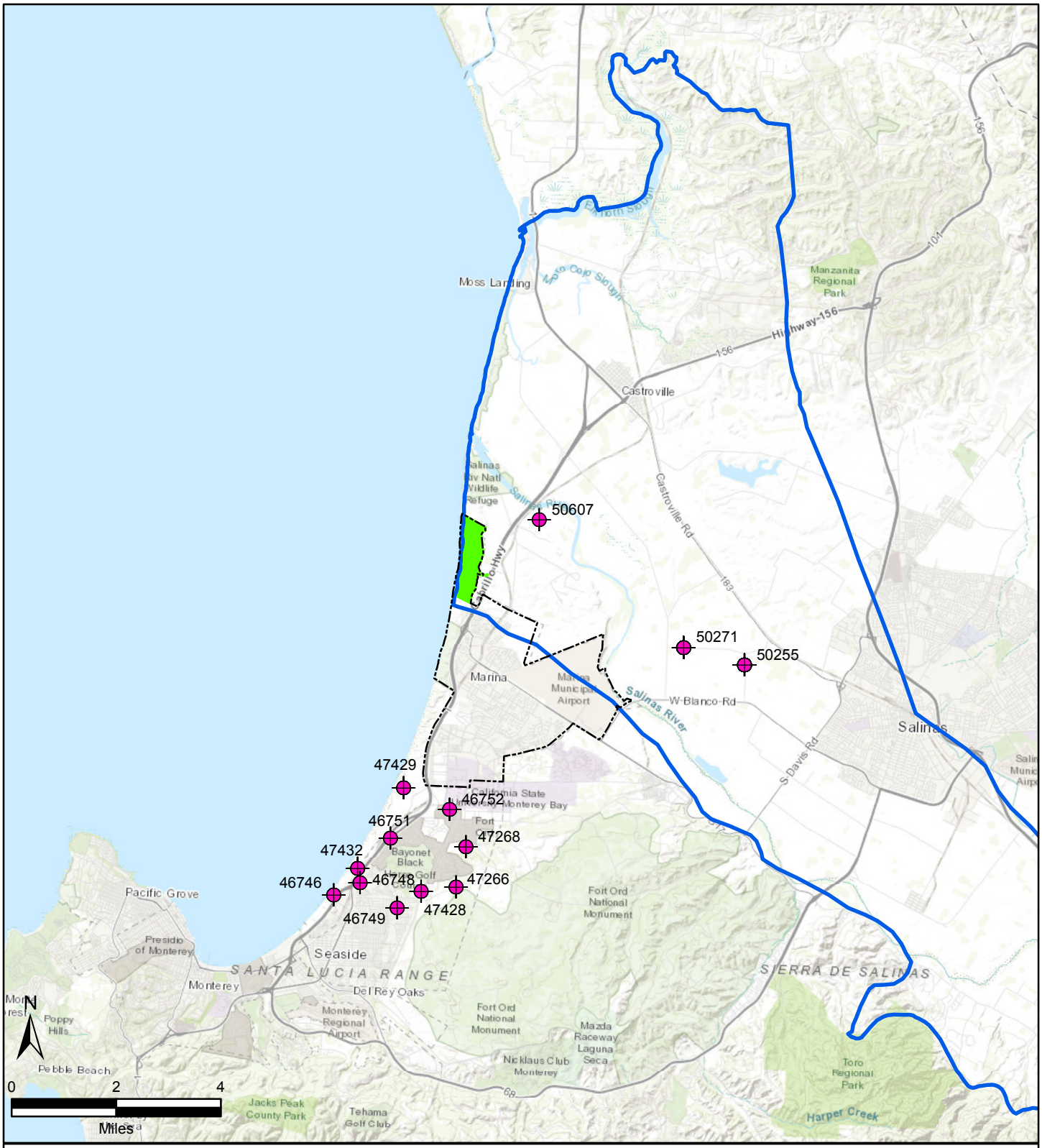

FIGURE 2-14

Locations of USGS GAMA Wells

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- USGS GAMA Wells
- City of Marina GSA Area
- City of Marina
- 180/400 Foot Aquifer Subbasin

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp

DATE: DEC. 30, 2019

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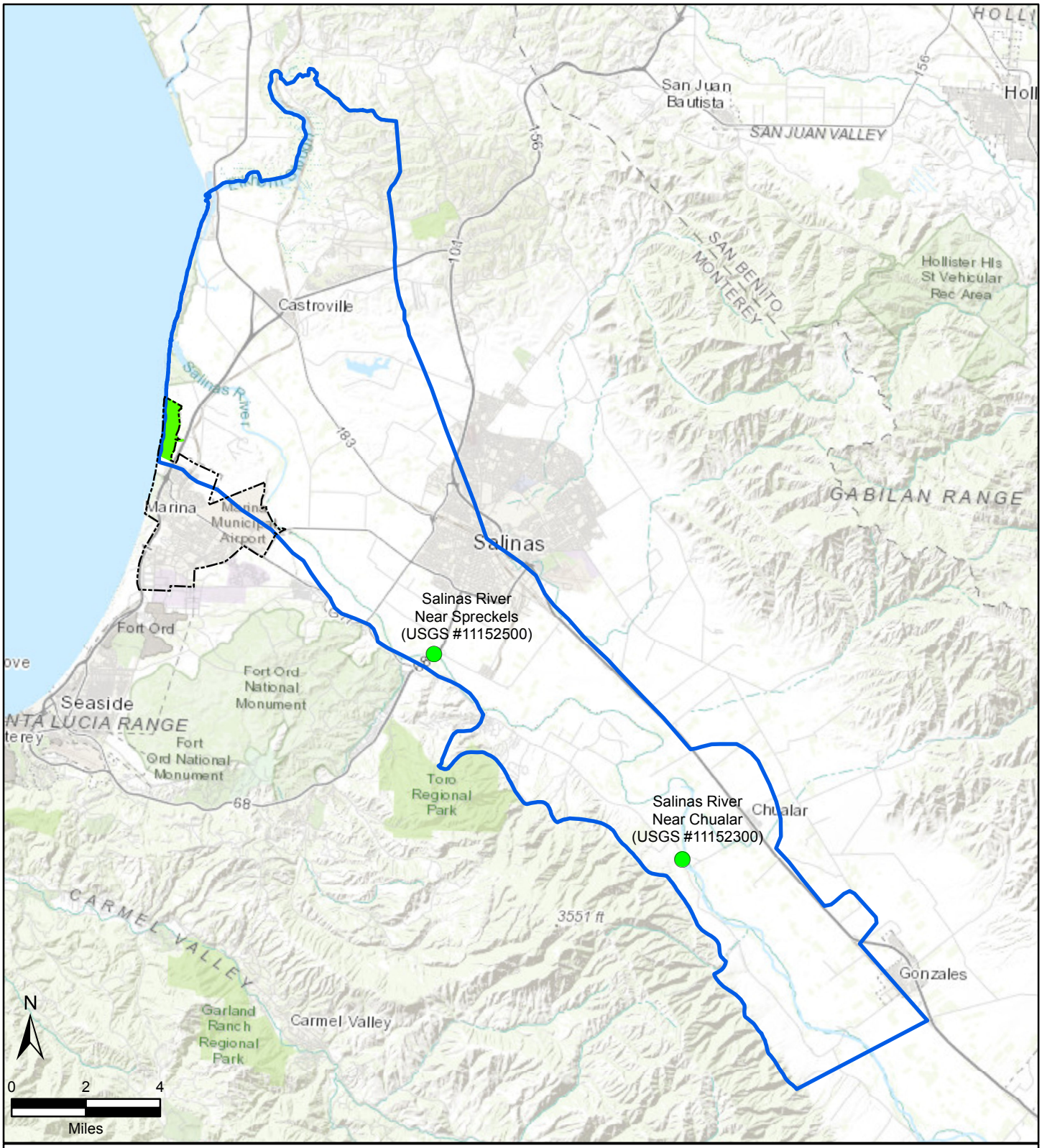

FIGURE 2-15

Surface Water Gaging Locations

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- USGS Stream Gage
- City of Marina GSA Area
- City of Marina
- 180/400 Foot Aquifer Subbasin

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://waterdata.usgs.gov/ca/nwis

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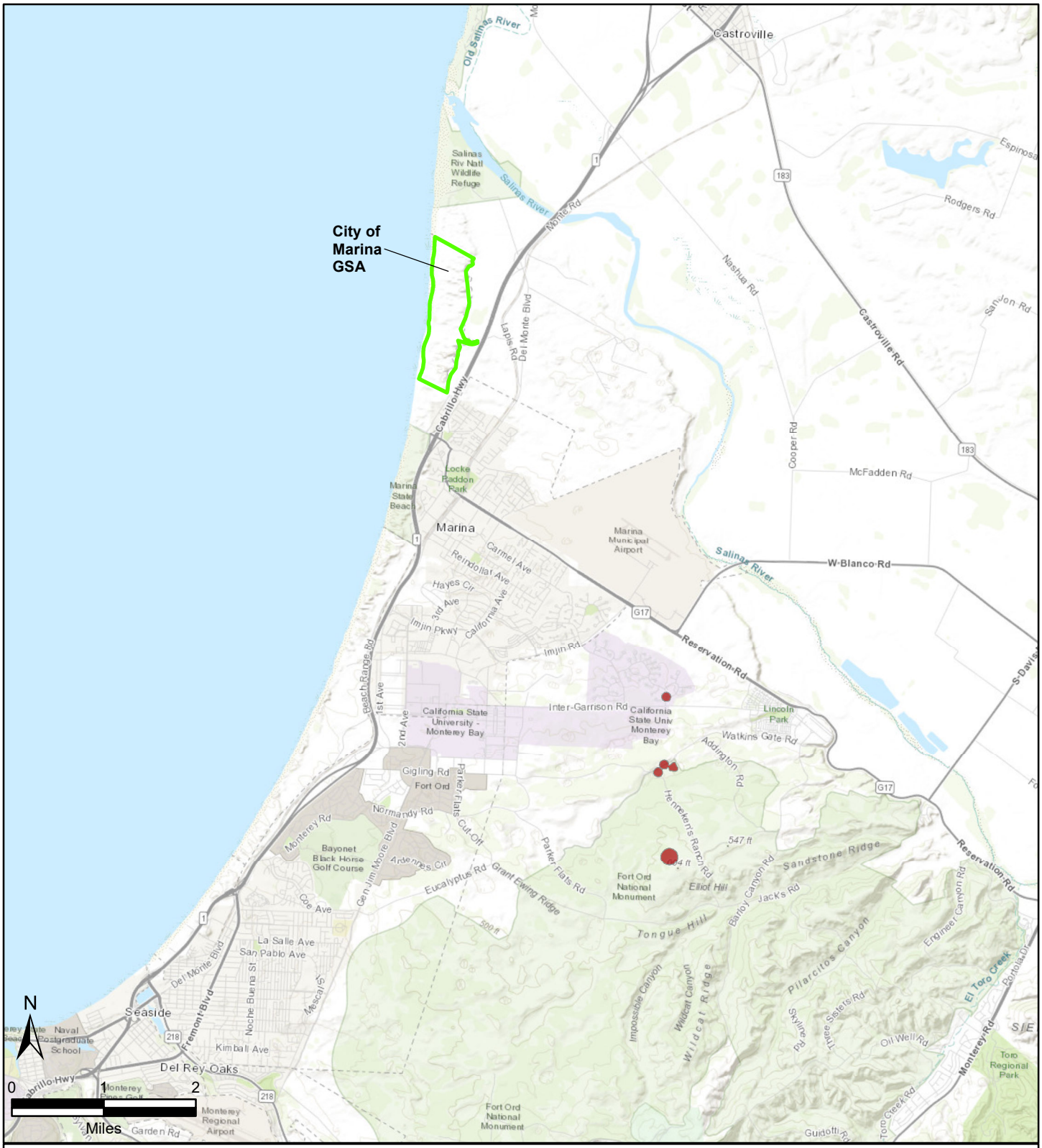
APPENDIX 2.A – CALIFORNIA NATURAL DIVERSITY DATABASE (CNDDB) QUERY RESULTS

This appendix provides the total occurrences of CNDDB species within a 3-mile radius of the Marina GSP area from 1994 to 2019.

Scientific Name	Common Name	Total Occurrences	Federal Status	State Status	Rare Plant Rank	Other Status	Habitats	General Habitat	Micro-Habitat
AMPHIBIANS									
Ambystoma californiense	California tiger salamander	1205	Threatened	Threatened		CDFW_WL-Watch List | IUCN_VU-Vulnerable	Cismontane woodland | Meadow & seep | Riparian woodland | Valley & foothill grassland | Vernal pool | Wetland	Central Valley DPS federally listed as threatened. Santa Barbara and Sonoma counties DPS federally listed as endangered.	Need underground refuges, especially ground squirrel burrows, and vernal pools or other seasonal water sources for breeding.
BIRDS									
Agelaius tricolor	tricolored blackbird	955	None	Threatened		BLM_S-Sensitive | CDFW_SSC-Species of Special Concern | IUCN_EN-Endangered | NABCI_RWL-Red Watch List | USFWS_BCC-Birds of Conservation Concern	Freshwater marsh | Marsh & swamp | Swamp | Wetland	Highly colonial species, most numerous in Central Valley & vicinity. Largely endemic to California.	Requires open water, protected nesting substrate, and foraging area with insect prey within a few km of the colony.
Athene cunicularia	burrowing owl	1988	None	None		BLM_S-Sensitive | CDFW_SSC-Species of Special Concern | IUCN_LC-Least Concern | USFWS_BCC-Birds of Conservation Concern	Coastal prairie | Coastal scrub | Great Basin grassland | Great Basin scrub | Mojavean desert scrub | Sonoran desert scrub | Valley & foothill grassland	Open, dry annual or perennial grasslands, deserts, and scrublands characterized by low-growing vegetation	Subterranean nester, dependent upon burrowing mammals, most notably, the California ground squirrel.
Buteo regalis	ferruginous hawk	107	None	None		CDFW_WL-Watch List | IUCN_LC-Least Concern | USFWS_BCC-Birds of Conservation Concern	Great Basin grassland | Great Basin scrub | Pinon & juniper woodlands | Valley & foothill grassland	Open grasslands, sagebrush flats, desert scrub, low foothills and fringes of pinyon and juniper habitats	Eats mostly lagomorphs, ground squirrels, and mice. Population trends may follow lagomorph population cycles.
Charadrius alexandrinus nivosus	western snowy plover	138	Threatened	None		CDFW_SSC-Species of Special Concern | NABCI_RWL-Red Watch List | USFWS_BCC-Birds of Conservation Concern	Great Basin standing waters | Sand shore | Wetland	Sandy beaches, salt pond levees & shores of large alkali lakes	Needs sandy, gravelly or friable soils for nesting.
Eremophila alpestris actia	California horned lark	94	None	None		CDFW_WL-Watch List | IUCN_LC-Least Concern	Marine intertidal & splash zone communities | Meadow & seep	Coastal regions, chiefly from Sonoma County to San Diego County. Also main part of San Joaquin Valley and east to foothills.	Short-grass prairie, "bald" hills, mountain meadows, open coastal plains, fallow grain fields, alkali flats.
Riparia riparia	bank swallow	298	None	Threatened		BLM_S-Sensitive | IUCN_LC-Least Concern	Riparian scrub | Riparian woodland	Colonial nester; nests primarily in riparian and other lowland habitats west of the desert	Requires vertical banks/cliffs with fine-textured/sandy soils near streams, rivers, lakes, ocean to dig nesting hole.
PLANTS									
Piperia yadonii	Yadon's rein orchid	26	Endangered	None	1B.1		Chaparral | Closed-cone coniferous forest | Coastal bluff scrub	Closed-cone coniferous forest, chaparral, coastal bluff scrub	On sandstone and sandy soil, but poorly drained and often dry. 10-505 m.
Arctostaphylos hookeri ssp. hookeri	Hooker's manzanita	24	None	None	1B.2	BLM_S-Sensitive	Chaparral | Cismontane woodland | Closed-cone coniferous forest | Coastal scrub	Chaparral, coastal scrub, closed-cone coniferous forest, cismontane woodland	Sandy soils, sandy shales, sandstone outcrops. 30-550 m.
Arctostaphylos montereyensis	Toro manzanita	18	None	None	1B.2	BLM_S-Sensitive | SB_SBBG-Santa Barbara Botanic Garden	Chaparral | Cismontane woodland | Coastal scrub	Chaparral, cismontane woodland, coastal scrub	Sandy soil, usually with chaparral associates. 45-765 m.
Arctostaphylos pajaroensis	Pajaro manzanita	28	None	None	1B.1	BLM_S-Sensitive	Chaparral	Chaparral	Sandy soils. 30-170 m.
Arctostaphylos pumila	sandmat manzanita	17	None	None	1B.2	BLM_S-Sensitive | SB_SBBG-Santa Barbara Botanic Garden	Chaparral | Cismontane woodland | Closed-cone coniferous forest | Coastal dunes | Coastal scrub	Closed-cone coniferous forest, chaparral, cismontane woodland, coastal dunes, coastal scrub	On sandy soil with other chaparral associates. 3-210 m.
Castilleja ambigua var. insalutata	pink Johnny-nip	13	None	None	1B.1		Coastal bluff scrub | Coastal prairie	Coastal bluff scrub, coastal prairie	Wet or moist coastal strand or scrub habitats. 3-135 m.
Chorizanthe minutiflora	Fort Ord spineflower	5	None	None	1B.2	SB_SBBG-Santa Barbara Botanic Garden	Chaparral | Coastal scrub	Coastal scrub, chaparral (maritime)	Sandy, openings. 60-145 m.
Chorizanthe pungens var. pungens	Monterey spineflower	51	Threatened	None	1B.2	SB_SBBG-Santa Barbara Botanic Garden | SB_UCBBG-UC Berkeley Botanical Garden	Chaparral | Cismontane woodland | Coastal dunes | Coastal scrub | Valley & foothill grassland	Coastal dunes, chaparral, cismontane woodland, coastal scrub, valley and foothill grassland	Sandy soils in coastal dunes or more inland within chaparral or other habitats. 3-270 m.
Cordylanthus rigidus ssp. littoralis	seaside bird's-beak	40	None	Endangered	1B.1	BLM_S-Sensitive | SB_RSABG-Rancho Santa Ana Botanic Garden | SB_SBBG-Santa Barbara Botanic Garden	Chaparral | Cismontane woodland | Closed-cone coniferous forest | Coastal dunes | Coastal scrub	Closed-cone coniferous forest, chaparral, cismontane woodland, coastal scrub, coastal dunes	Sandy, often disturbed sites, usually within chaparral or coastal scrub. 30-520 m.
Ericameria fasciculata	Eastwood's goldenbush	23	None	None	1B.1	BLM_S-Sensitive	Chaparral | Closed-cone coniferous forest | Coastal dunes | Coastal scrub	Closed-cone coniferous forest, chaparral (maritime), coastal scrub, coastal dunes	In sandy openings. 30-215 m.
Erysimum ammophilum	sand-loving wallflower	58	None	None	1B.2	BLM_S-Sensitive | SB_CRES-San Diego Zoo CRES Native Gene Seed Bank | SB_SBBG-Santa Barbara Botanic Garden	Chaparral | Coastal dunes | Coastal scrub	Chaparral (maritime), coastal dunes, coastal scrub	Sandy openings. 3-320 m.
Erysimum menziesii	Menzies' wallflower	19	Endangered	Endangered	1B.1	SB_RSABG-Rancho Santa Ana Botanic Garden | SB_UCBBG-UC Berkeley Botanical Garden	Coastal dunes	Coastal dunes	Localized on dunes and coastal strand. 1-25 m.

Scientific Name	Common Name	Total Occurrences	Federal Status	State Status	Rare Plant Rank	Other Status	Habitats	General Habitat	Micro-Habitat
Gilia tenuiflora ssp. arenaria	Monterey gilia	29	Endangered	Threatened	1B.2	SB_RSABG-Rancho Santa Ana Botanic Garden	Chaparral | Cismontane woodland | Coastal dunes | Coastal scrub	Coastal dunes, coastal scrub, chaparral (maritime), cismontane woodland	Sandy openings in bare, wind-sheltered areas. Often near dune summit or in the hind dunes; two records from Pleistocene inland dunes. 5-245 m.
Horkelia cuneata var. sericea	Kellogg's horkelia	58	None	None	1B.1	SB_UCSC-UC Santa Cruz | USFS_S-Sensitive	Chaparral | Closed-cone coniferous forest | Coastal dunes | Coastal scrub	Closed-cone coniferous forest, coastal scrub, coastal dunes, chaparral	Old dunes, coastal sandhills; openings. Sandy or gravelly soils. 5-430 m.
Horkelia marinensis	Point Reyes horkelia	36	None	None	1B.2		Coastal dunes | Coastal prairie | Coastal scrub	Coastal dunes, coastal prairie, coastal scrub	Sandy flats and dunes near coast; in grassland or scrub plant communities. 2-775 m.
Monardella sinuata ssp. nigrescens	northern curly-leaved monardella	25	None	None	1B.2	SB_SBBG-Santa Barbara Botanic Garden	Chaparral | Coastal dunes | Coastal scrub | Lower montane coniferous forest	Coastal dunes, coastal scrub, chaparral, lower montane coniferous forest.	Sandy soils. 10-245 m.
Trifolium buckwestiorum	Santa Cruz clover	58	None	None	1B.1	BLM_S-Sensitive | SB_SBBG-Santa Barbara Botanic Garden | SB_UCSC-UC Santa Cruz | SB_USDA-US Dept of Agriculture	Broadleaved upland forest | Cismontane woodland | Coastal prairie	Coastal prairie, broadleafed upland forest, cismontane woodland	Moist grassland. Gravelly margins. 30-805 m.
FISHES									
Eucyclogobius newberryi	tidewater goby	127	Endangered	None		AFS_EN-Endangered | CDFW_SSC-Species of Special Concern | IUCN_VU-Vulnerable	Aquatic | Klamath/North coast flowing waters | Sacramento/San Joaquin flowing waters | South coast flowing waters	Brackish water habitats along the California coast from Agua Hedionda Lagoon, San Diego County to the mouth of the Smith River	Found in shallow lagoons and lower stream reaches, they need fairly still but not stagnant water and high oxygen levels.
INSECTS									
Bombus occidentalis	western bumble bee	282	None	Candidate Endangered		USFS_S-Sensitive | XERCES_IM-Imperiled		Once common & widespread, species has declined precipitously from central CA to southern B.C., perhaps from disease	
Euphilotes enoptes smithi	Smith's blue butterfly	68	Endangered	None		XERCES_CI-Critically Imperiled	Coastal dunes | Coastal scrub	Most commonly associated with coastal dunes & coastal sage scrub plant communities in Monterey & Santa Cruz counties	Hostplant: Eriogonum latifolium and Eriogonum parvifolium are utilized as both larval and adult foodplants.
REPTILES									
Anniella pulchra	northern California legless lizard	375	None	None		CDFW_SSC-Species of Special Concern | USFS_S-Sensitive	Chaparral | Coastal dunes | Coastal scrub	Sandy or loose loamy soils under sparse vegetation	Soil moisture is essential. They prefer soils with a high moisture content.
Emys marmorata	western pond turtle	1375	None	None		BLM_S-Sensitive | CDFW_SSC-Species of Special Concern | IUCN_VU-Vulnerable | USFS_S-Sensitive	Aquatic | Artificial flowing waters | Klamath/North coast flowing waters | Klamath/North coast standing waters | Marsh & swamp | Sacramento/San Joaquin flowing waters | Sacramento/San Joaquin standing waters | South coast flowing waters | South coast standing waters | Wetland	A thoroughly aquatic turtle of ponds, marshes, rivers, streams and irrigation ditches, usually with aquatic vegetation, below 6000 ft elevation	Needs basking sites and suitable (sandy banks or grassy open fields) upland habitat up to 0.5 km from water for egg-laying.
Phrynosoma blainvillii	coast horned lizard	781	None	None		BLM_S-Sensitive | CDFW_SSC-Species of Special Concern | IUCN_LC-Least Concern	Chaparral | Cismontane woodland | Coastal bluff scrub | Coastal scrub | Desert wash | Pinon & juniper woodlands | Riparian scrub | Riparian woodland | Valley & foothill grassland	Frequents a wide variety of habitats, most common in lowlands along sandy washes with scattered low bushes	Open areas for sunning, bushes for cover, patches of loose soil for burial, and abundant supply of ants and other insects.

Scientific Name	Common Name	Total Occurrences	Federal Status	State Status	Rare Plant Rank	Other Status	Habitats	General Habitat	Micro-Habitat
MAMMALS									
Reithrodontomys megalotis distichlis	Salinas harvest mouse	7	None	None			Marsh & swamp | Wetland	Known only from the Monterey Bay region	Occurs in fresh and brackish water wetlands and probably in the adjacent uplands around the mouth of the Salinas River.
Sorex ornatus salarius	Monterey shrew	6	None	None		CDFW_SSC-Species of Special Concern		Riparian, wetland & upland areas in the vicinity of the Salinas River delta	Prefers moist microhabitats. feeds on insects & other invertebrates found under logs, rocks & litter.
Taxidea taxus	American badger	591	None	None		CDFW_SSC-Species of Special Concern | IUCN_LC-Least Concern	Alkali marsh | Alkali playa | Alpine | Alpine dwarf scrub | Bog & fen | Brackish marsh | Broadleaved upland forest | Chaparral | Chenopod scrub | Cismontane woodland | Closed-cone coniferous forest | Coastal bluff scrub | Coastal dunes | Coastal prairie | Coastal scrub | Desert dunes | Desert wash | Freshwater marsh | Great Basin grassland | Great Basin scrub | Interior dunes | Ione formation | Joshua tree woodland | Limestone | Lower montane coniferous forest | Marsh & swamp | Meadow & seep | Mojavean desert scrub | Montane dwarf scrub | North coast coniferous forest | Oldgrowth | Pavement plain | Redwood | Riparian forest | Riparian scrub | Riparian woodland | Salt marsh | Sonoran desert scrub | Sonoran thorn woodland | Ultramafic | Upper montane coniferous forest | Upper Sonoran scrub | Valley & foothill grassland	Most abundant in drier open stages of most shrub, forest, and herbaceous habitats, with friable soils	Needs sufficient food, friable soils and open, uncultivated ground. Preys on burrowing rodents. Digs burrows.
HABITAT TYPE									
Central Dune Scrub	Central Dune Scrub	24	None	None			Coastal dunes		
Northern Coastal Salt Marsh	Northern Coastal Salt Marsh	53	None	None			Marsh & swamp | Wetland		
Central Maritime Chaparral	Central Maritime Chaparral	19	None	None			Chaparral		



APPENDIX 2.A-1

CNDDB Amphibian Species Occurrences

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

City of Marina GSA Area

Amphibians (Common Name)

California tiger salamander

Sources: ESRI Map Service Imagery, https://wildlife.ca.gov/Data/CNDDB

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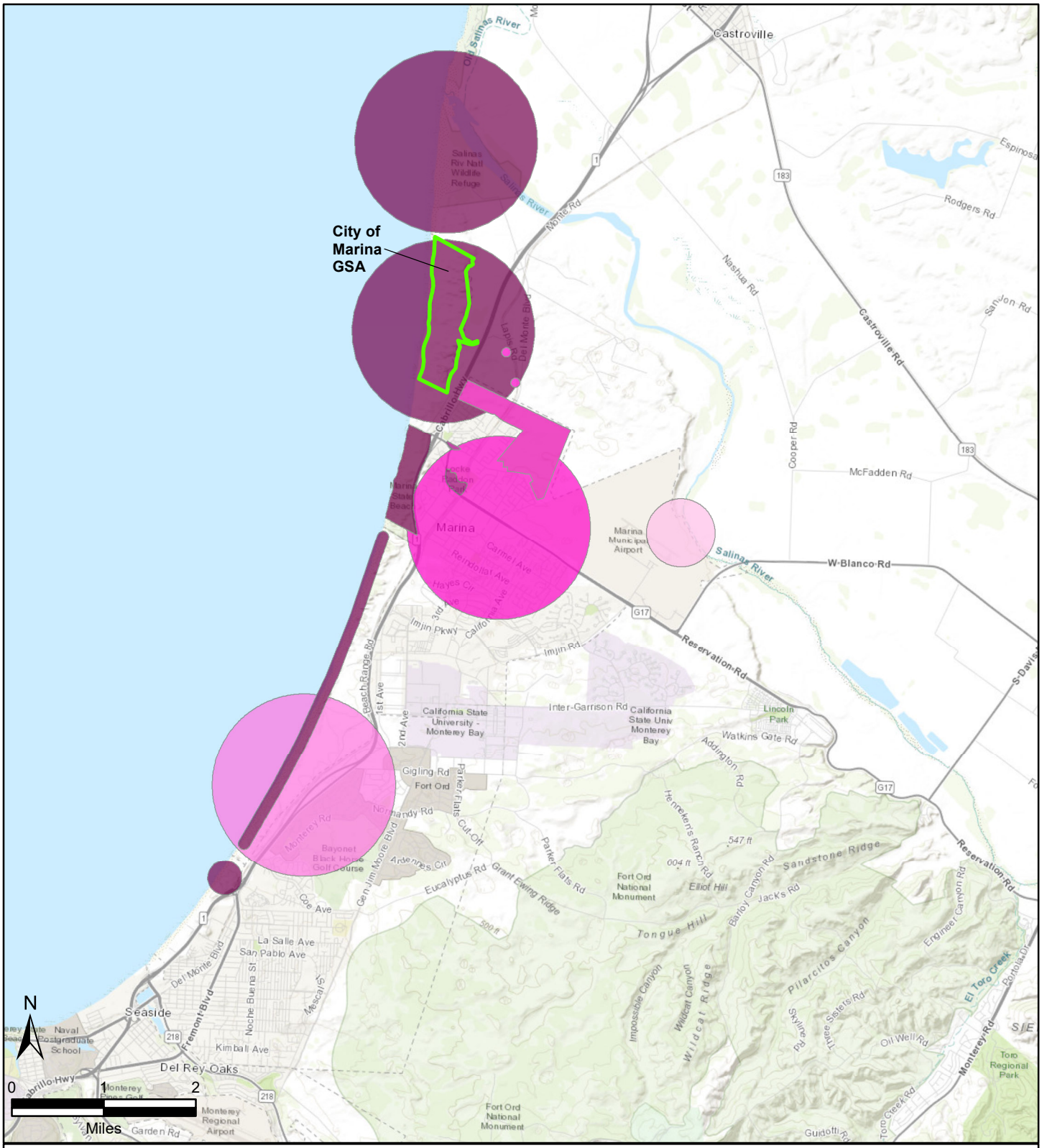

APPENDIX 2.A-2

CNDDB Bird Species Occurrences

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area
- **Birds (Common Name)**
- California horned lark
- Bank swallow
- Burrowing owl
- Ferruginous hawk
- Tricolored blackbird
- Western snowy plover

Sources: ESRI Map Service Imagery, https://wildlife.ca.gov/Data/CNDDB

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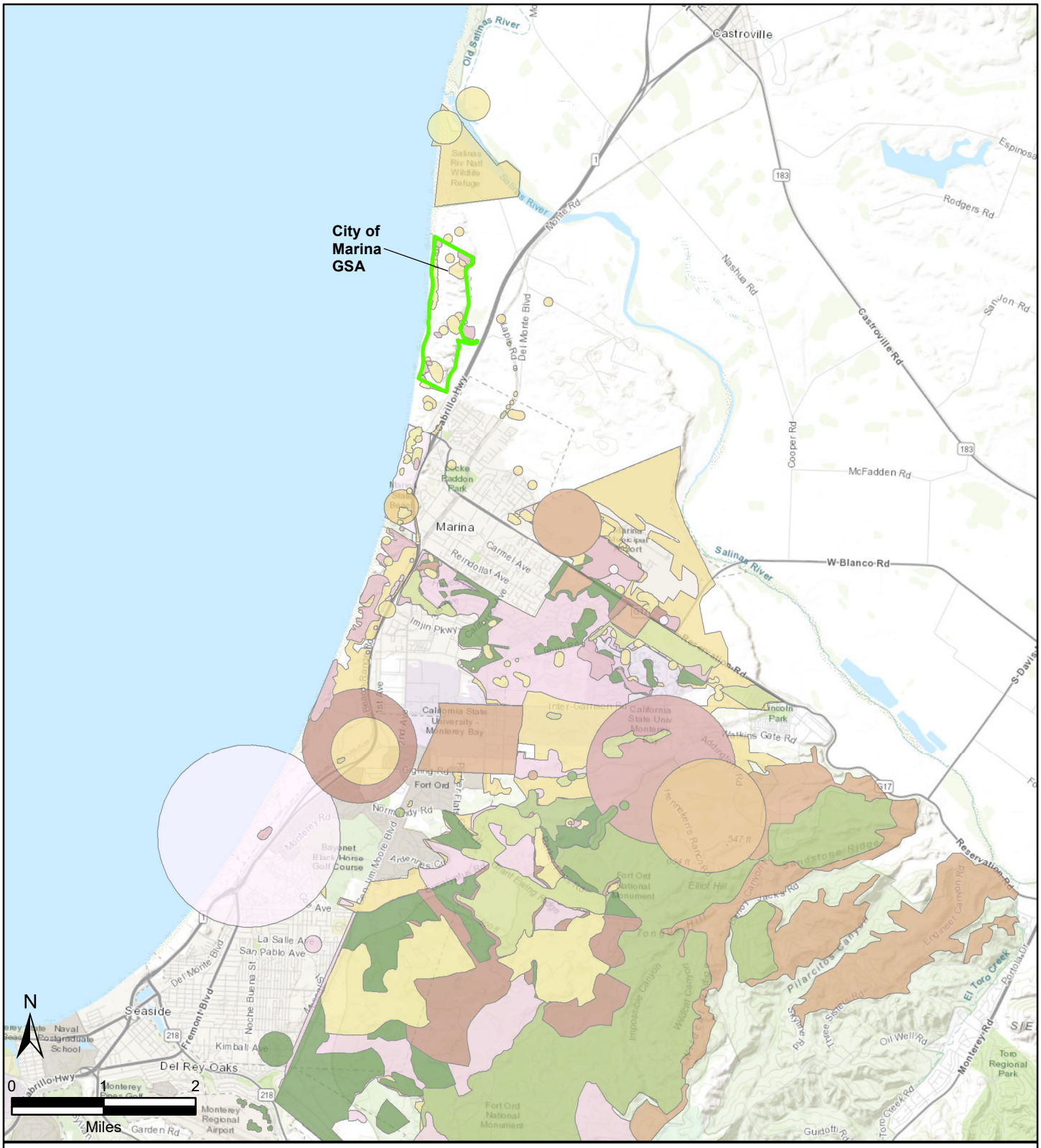

APPENDIX 2.A-3

CNDDB Plant Species Occurrences

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area

Plants (Common Name)

- Eastwood's goldenbush
- Fort Ord spineflower
- Hooker's manzanita
- Kellogg's horkelia
- Menzies' wallflower
- Monterey gilia
- Monterey spineflower
- Pajaro manzanita
- Point Reyes horkelia
- Santa Cruz clover
- Toro manzanita
- Yadon's rein orchid
- Northern curly-leaved monardella
- Pink Johnny-nip
- Sand-loving wallflower
- Sandmat manzanita
- Seaside bird's-beak

Sources: ESRI Map Service Imagery, https://wildlife.ca.gov/Data/CNDDB

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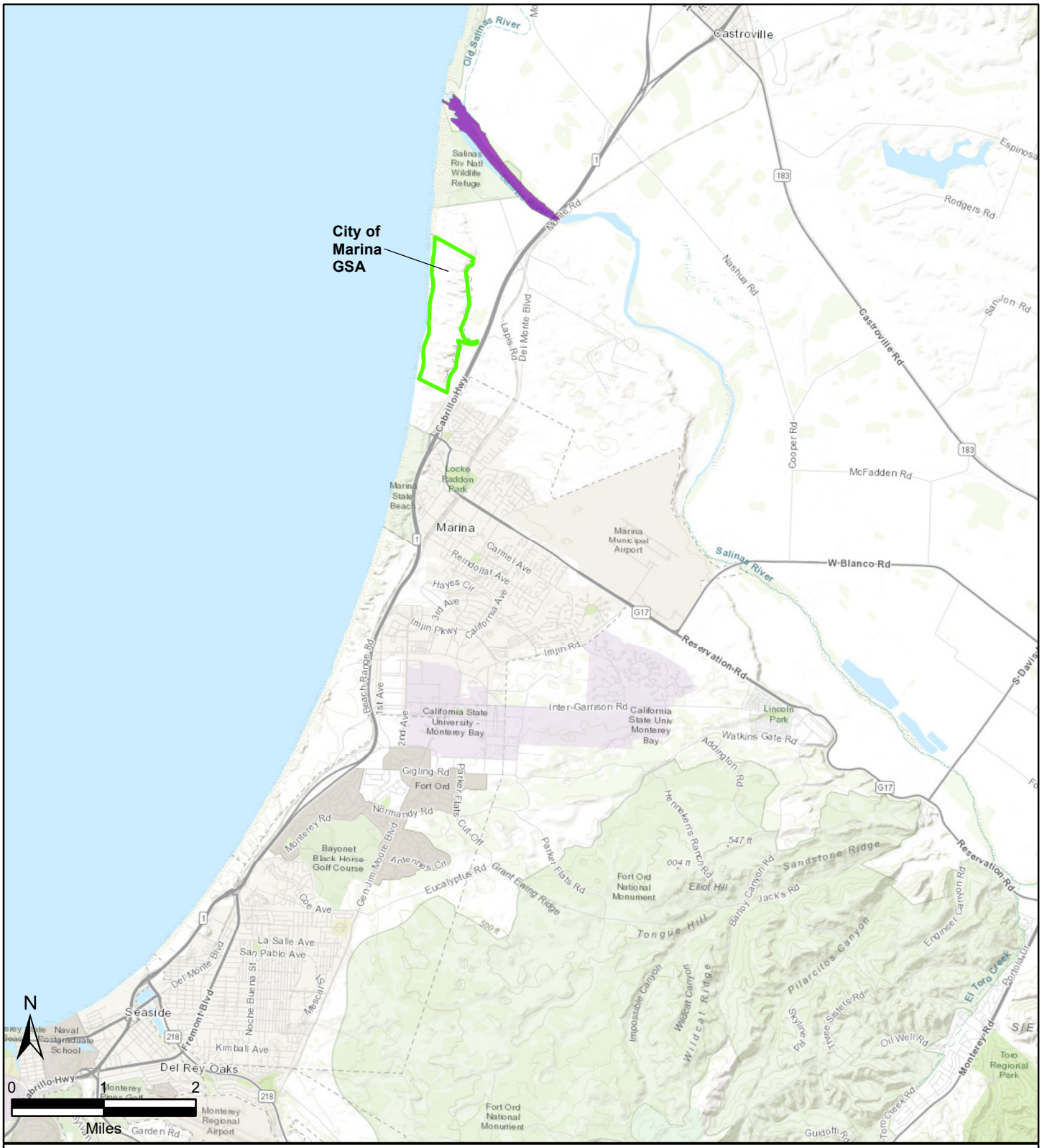

APPENDIX 2.A-4

CNDDB Fish Species Occurrences

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

City of Marina GSA Area

Fish (Common Name)

Tidewater goby

Sources: ESRI Map Service Imagery, https://wildlife.ca.gov/Data/CNDDB

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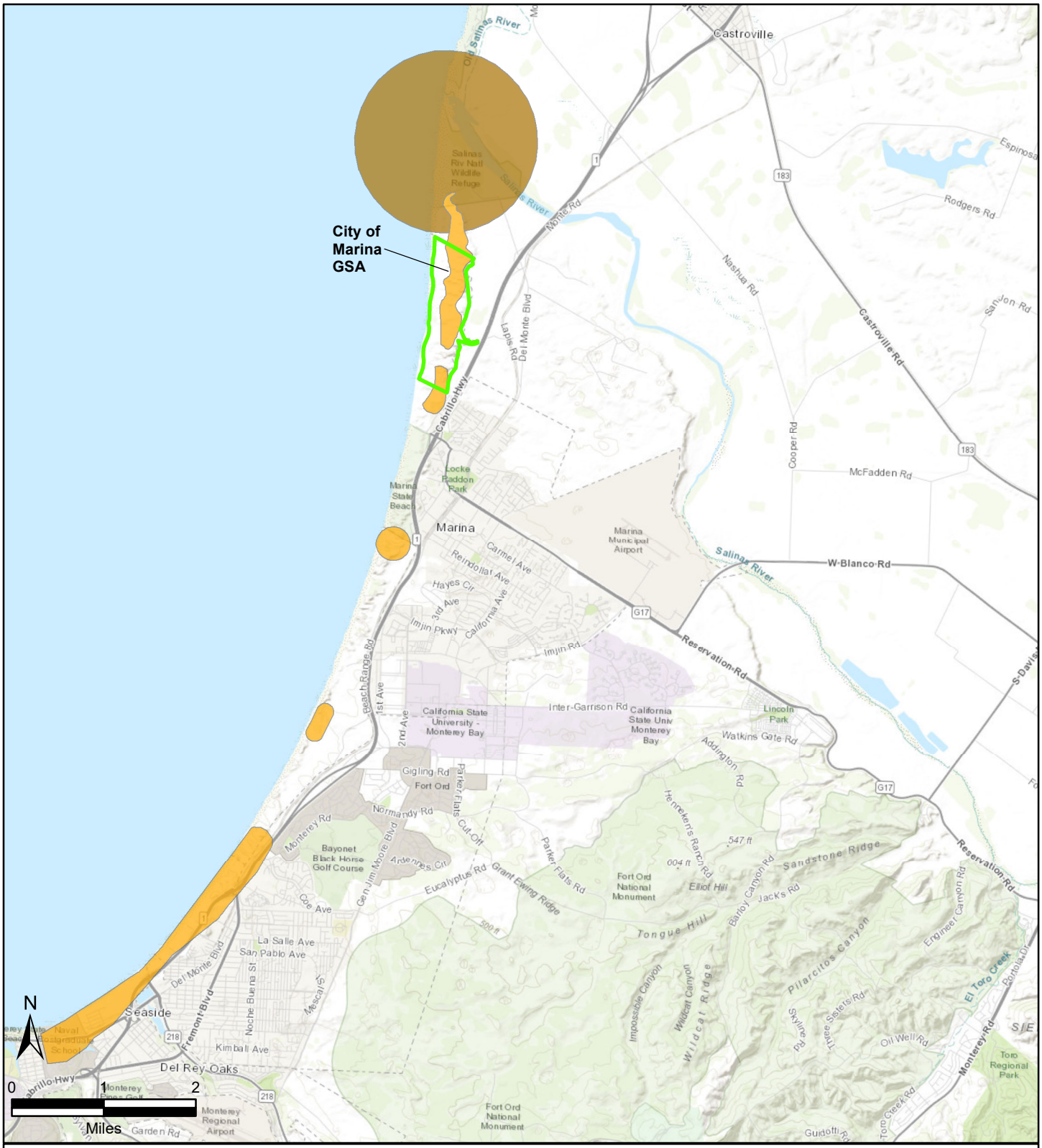

APPENDIX 2.A-5

CNDDB Insect Species Occurrences

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area

Insects (Common Name)

- Smith's blue butterfly
- Western bumble bee

Sources: ESRI Map Service Imagery, https://wildlife.ca.gov/Data/CNDDB

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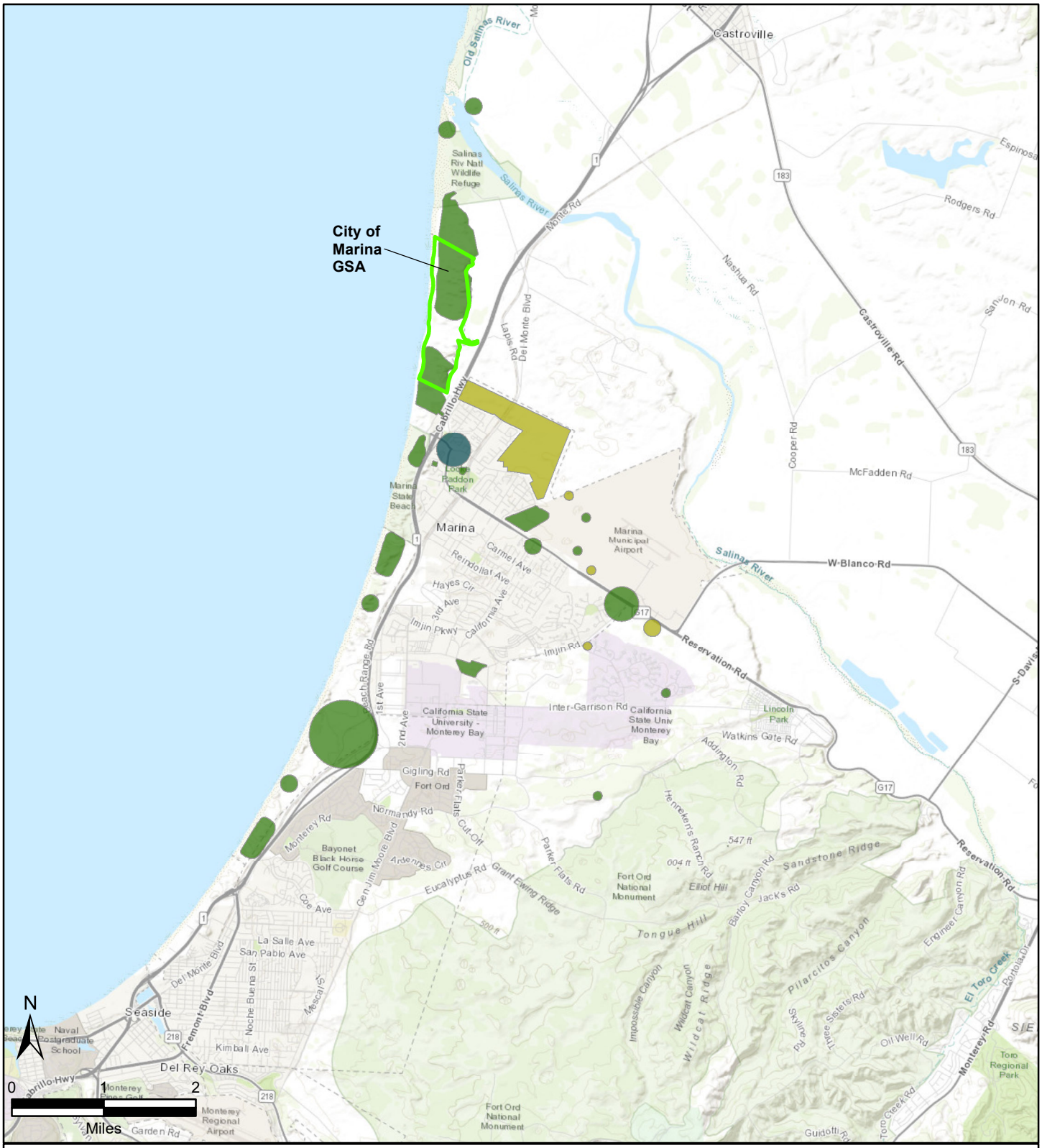

APPENDIX 2.A-6

CNDDB Reptile Species Occurrences

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area

Reptiles (Common Name)

- Coast horned lizard
- Northern California legless lizard
- Western pond turtle

Sources: ESRI Map Service Imagery, https://wildlife.ca.gov/Data/CNDDB

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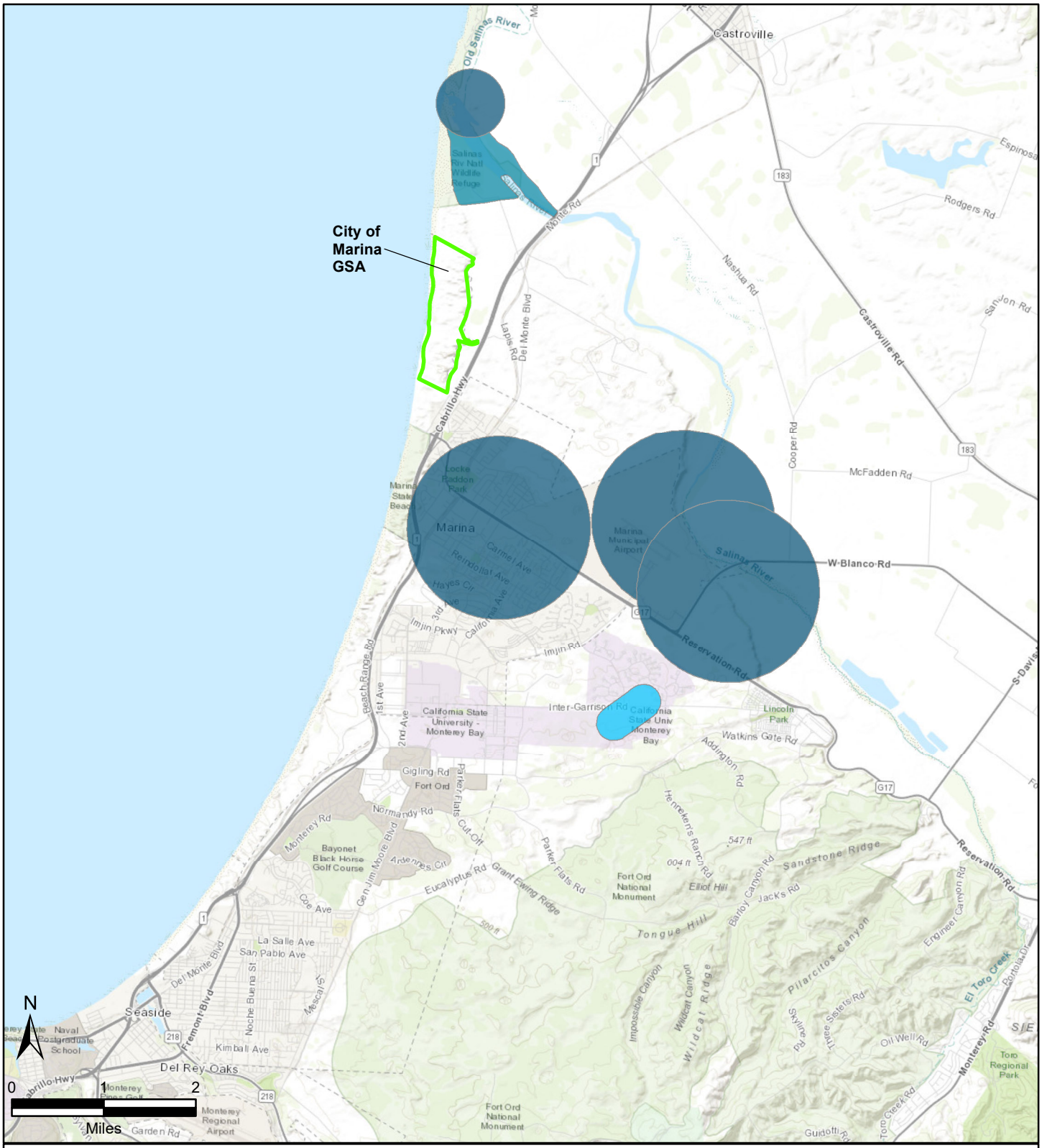

APPENDIX 2.A-7

CNDDB Mammal Species Occurrences

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area

Mammals (Common Name)

- American badger
- Monterey shrew
- Salinas harvest mouse

Sources: ESRI Map Service Imagery, https://wildlife.ca.gov/Data/CNDDB

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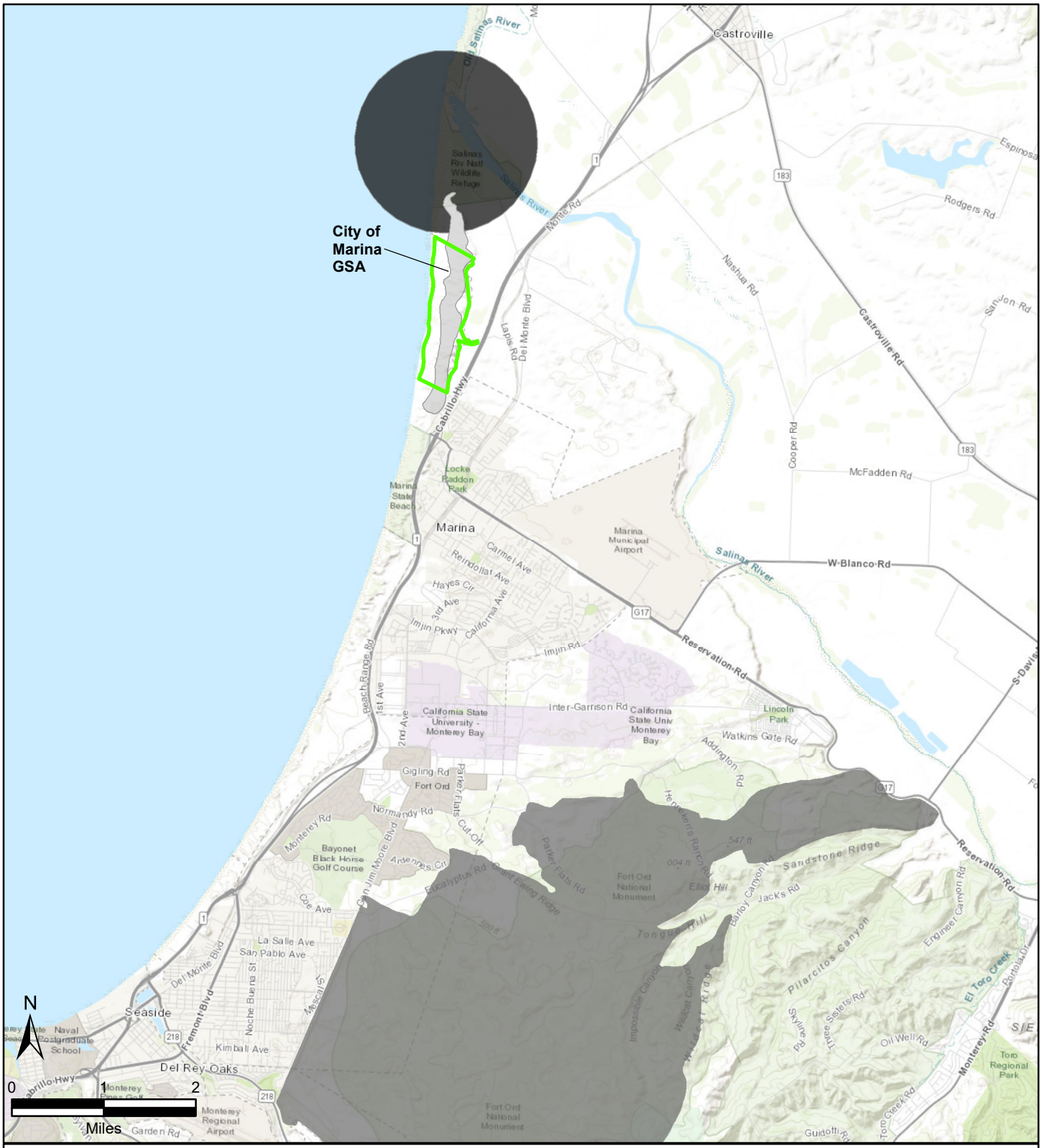

APPENDIX 2.A-8

CNDDB Habitat Species Occurrences

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA Area

Habitat (Common Name)

- Central Dune Scrub
- Central Maritime Chaparral
- Northern Coastal Salt Marsh

Sources: ESRI Map Service Imagery, https://wildlife.ca.gov/Data/CNDDB

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CHAPTER 3 – BASIN SETTING
Groundwater Sustainability Plan for the Marina GSA Area of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, California

JANUARY 2020

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3 BASIN SETTING

Regulation Requirements:

§354.12 Introduction to Basin Setting

This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.

This chapter describes the basin setting of the City of Marina Groundwater Sustainability Agency (MGSA) Area of the 180/400 Foot Subbasin (MGSA Area), a 372-acre area at the western end of the 180/400 Foot Aquifer Subbasin (Subbasin). It includes information regarding the hydrogeologic conceptual model, current and historical groundwater conditions, and historical, current, and projected water budgets. The Subbasin is subject to significant and unreasonable seawater intrusion due largely to long-term groundwater extraction in the inland portions of the Subbasin in excess of the sustainable yield, and has been identified by the Department of Water Resources (DWR) as being in a critical condition of overdraft (DWR 2016a). The purpose of this Groundwater Sustainability Plan (GSP) is to support regional efforts to address this undesirable result and return to Subbasin to sustainable groundwater management within 20 years, as required by the Sustainable Groundwater Management Act (SGMA). MGSA will achieve this by supporting the projects and management actions that will be implemented by Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) under its regional GSP, and by assuring that local groundwater resources are managed sustainably to protect local and regional beneficial uses and users.

The MGSA Area occupies a relatively small area in the larger Subbasin. The basin setting information in the SVBGSA's GSP provides the necessary regional context for Subbasin-wide sustainable groundwater management; however, MGSA has developed this locally focused GSP to provide the framework necessary to ensure sustainable groundwater management in this portion of the Subbasin. The subsequent sections of this chapter provide the necessary local data to support development of a GSP that complies with the requirements of the Sustainable Groundwater Management Act (SGMA) and supports sustainable groundwater management. Information from or references to the SVBGSA's GSP are included where appropriate. In addition, information regarding SVBGSA's regional groundwater budget for the basin is adopted in this GSP, and supplemented with local data as appropriate.

3.1 HYDROGEOLOGIC CONCEPTUAL MODEL

Regulation Requirements:

§354.14(a) Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.

3.1.1 INTRODUCTION

The 372-acre MGSA Area is approximately 7,850 feet long by 2,200 feet wide and is located entirely within the City of Marina (City or Marina) city limits. The Subbasin is at the northern, down-gradient end of the Salinas Valley Groundwater Basin – an approximately 90-mile-long alluvial basin underlying the elongated, intermountain valley of the Salinas River. The Subbasin is oriented southeast to northwest along the coast, with the Salinas River draining toward the northwest into the Pacific Ocean at Monterey Bay. The Salinas River watershed drains approximately 4,600 square miles of land in Monterey and San Luis Obispo Counties, and is the dominant riparian corridor along the central coast of California (RCDMC 2019a). Originating in the Los Padres National Forest, the Salinas River flows northwesterly for about 150 miles through the Salinas Valley and empties into Monterey Bay north of the MGSA Area. The valley is nestled between two sets of mountain ranges, the Gabilan Range to the east and the Santa Lucia Range and Sierra de Salinas to the west, both of which are part of the California Coast Range geomorphic province. The watershed includes 200,000 acres of irrigated farmland. Besides providing aquifer recharge for the irrigation water for Monterey County's agricultural industry, the river and its tributaries provide fish and wildlife habitat.

3.1.2 GSP AREA EXTENT

Regulation Requirements:

§354.14(b)(2) The hydrogeologic conceptual model shall be summarized in a written description that includes lateral basin boundaries, including major geologic features that significantly affect groundwater flow.

§354.14(b)(3) The hydrogeologic conceptual model shall be summarized in a written description that includes the definable bottom of the basin.

The MGSA Area lies within the western portion of the 180/400 Foot Aquifer Subbasin, and is one of nine subbasins of the Salinas Valley Groundwater Basin, of which six subbasins are being managed in part or in whole by SVBGSA. The Subbasin extents are defined by the DWR and are documented in Bulletin 118 (DWR 2003; DWR 2016a). Figure 3-1 illustrates the extent of the MGSA Area within the Subbasin. It is bounded to the south by the Monterey Subbasin, and to the west by the Pacific Ocean.

3.1.2.1 LATERAL SUBBASIN AND GSP AREA BOUNDARIES

The 180/400 Foot Aquifer Subbasin is bounded by a combination of inter-subbasin boundaries within the Salinas Valley Groundwater Basin, and outer boundaries of the Salinas Valley Basin:

- Inter-subbasin boundaries surrounding the 180/400 Foot Aquifer Subbasin generally do not follow physical or hydrologic boundaries, but delineate areas with generally different aquifer characteristics, uses or management requirements. These include inter-subbasin boundaries with the Forebay Subbasin, Eastside Subbasin, Langley Subbasin and Monterey Subbasin.

- Basin boundaries surrounding the 180/400 Foot Aquifer Subbasin that coincide with the Salinas Valley Groundwater Basin follow physical basin and aquifer boundaries or prominent hydrologic features. These include:

- The Monterey Bay Shoreline to the west;
- Elkhorn Slough to the north (which separates the Subbasin from the Pajaro Valley Subbasin; and
- The Sierra de Salinas, which forms the basin and aquifer boundary along the southern half of the southwest Subbasin boundary.

The MGSA Area lateral limits are the City of Marina city limits on the north, west and east, and the Monterey Subbasin boundary on the south. The western boundary coincides with the mean high tide line of the Pacific Ocean (Figure 3-2).

3.1.2.2 VERTICAL SUBBASIN AND MGSA AREA BOUNDARIES

The sedimentary sequence in the Salinas Valley structural trough is 10,000 to 15,000 feet thick. However, the productive drinking water aquifers are only at shallower depths, with the effective thickness of the groundwater Subbasin being approximately 1,500 feet (Durbin *et al.* 1978). The base of the Subbasin is not a sharp interface between permeable sediments and lower-permeability basement rock, but a general transition to less productive and more saline aquifers that may vary in depth by location. With increasing depth, increased consolidation and cementation of the sediments decreases the well yield, and deeper marine formations contain poor-quality saline groundwater unsuitable for most uses.

Figure 3-3 shows a contour map of the estimated depth to the base of the aquifers in the basin (Durbin *et al.* 1978). In the vicinity of the MGSA Area, the aquifers above a depth of approximately 700 feet are seawater intruded, and water supply wells extract groundwater from the "Deep Aquifer," which is a system of aquifers that occurs between approximately 900 and 2,000 feet below ground surface (Hanson *et al.* 2002) within the Pliocene marine Purisima Formation. The wells completed in this aquifer system near the MGSA Area provide the water supply for Marina Coast Water District (MCWD), which serves the City of Marina and the adjacent Ord Community. These wells are completed at depths ranging from approximately 900 to approximately 1,950 feet below ground level. This GSP has adopted the base of the Deep Aquifer system and the vertical boundary of the MGSA Area as 2,000 feet below ground level.

3.1.3 TOPOGRAPHIC INFORMATION

Regulation Requirements:
§354.14(d)(1) Physical characteristics of the basin shall be represented on one or more maps that depict topographic information derived from the U.S. Geological Survey or another reliable source.

The Subbasin and MGSA Area are located at the northern, seaward end of the Salinas Valley. The valley trends north-northwestward between two sets of mountain ranges, the Gabilan Range to the east and the Santa Lucia and Sierra de Salinas to the west, both of which are part of the Pacific Coast Range.

Elevations in the Subbasin range from approximately 500 feet above mean sea level (msl) along the Sierra de Salinas to sea level at Monterey Bay, and fall northwestward at an average grade of approximately 5 feet/mile to the northwest. The Salinas River carries sand along the valley into the Pacific Ocean, where it is transported southward along the coast by longshore currents. The sand is blown onshore by coastal winds, forming a series of coastal dunes along the shore south the Salinas River. The MGSA Area encompasses an area of unique Flandrian coastal dunes at the seaward edge of Salinas Valley on the north side of the City of Marina and south of the Salinas River. The elevation within the MGSA Area ranges from about 100 feet above msl near the top of the coastal dunes to sea level at Monterey Bay. The colored bands on Figure 3-4 show the topography of the Subbasin, derived from the United States Geological Survey (USGS) Digital Elevation Model (DEM).

3.1.4 SURFACE WATER FEATURES

Regulation Requirements:
§354.14(d)(5) Physical characteristics of the basin shall be represented on one or more maps that depict surface water bodies that are significant to the management of the basin.

The Salinas River watershed drains approximately 4,600 square miles of land in Monterey and San Luis Obispo Counties, and is the dominant riparian corridor along the central coast of California (RCDMC 2019a) and the primary surface water body in the Subbasin. The river runs through the entire length of the Subbasin and is fed by local tributaries (Figure 3-5). The Salinas River watershed includes 200,000 acres of irrigated farmland. Originating in the Los Padres National Forest, the Salinas River flows northwesterly for about 150 miles through the Salinas Valley and empties into Monterey Bay approximately 4,000 feet north of the MGSA Area. Besides providing aquifer recharge for the irrigation water for Monterey County's agricultural industry, the river and its tributaries provide fish and wildlife habitat. The mouth of the Salinas River forms a lagoon; its outflow to Monterey Bay is blocked by sand except during winter high-water flows. MCWRA operates a slide-gate to transfer water through a culvert from the lagoon northward into Old Salinas River during the wet season for flood control (MCWRA 1994). The Old Salinas River discharges through tide gates at Potrero Road into Moss Landing Harbor and ultimately the Monterey Bay.

The only surface water features within the MGSA Area are four artificial process ponds on the CEMEX plant site that were constructed to support industrial sand mining and processing operations on the site. These include a dredge pond and three percolation ponds, which are generally devoid of vegetation.

Regionally, the following surface water bodies are located outside of the Subbasin but are important controls on the rate and timing of Salinas River discharges:

- Two reservoirs constructed to control flooding and to increase recharge from Salinas River to groundwater:

- Lake Nacimiento, in San Luis Obispo County, was constructed in 1957 and has a storage capacity of 335,000 acre-feet (MCWRA 2018).
- Lake San Antonio, in Monterey County, was constructed in 1967 and has a storage capacity of 377,900 acre-feet.

- Arroyo Seco, a tributary with a 275-square-mile drainage area that has no dams in its drainage basin and is characterized by both very high flood flows and extended dry periods.

3.1.5 REGIONAL GEOLOGIC AND STRUCTURAL SETTING

Regulation Requirements:
§354.14(b)(1) The hydrogeologic conceptual model shall be summarized in a written description that includes the regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.

The Subbasin was formed through periods of structural deformation and periods of marine and terrestrial sedimentation in a tectonically active area on the eastern edge of the Pacific Plate. Figure 3-6 presents a geologic map of the Salinas Valley Basin and vicinity, illustrating both the locations of faults and the geologic formations present at ground surface. The legend in Figure 3-7 presents the age sequence of the geologic materials from the youngest unconsolidated Quaternary sediments to the oldest basement rock.

Salinas Valley is a structural basin filled with Quaternary alluvial sediments and Tertiary marine and continental deposits. In the vicinity of the MGSA Area Quaternary dune sands generally occur on a terrace south of the Salinas River, and alluvial and flood plain basin deposits occur north of the river (Figure 3-8). There are no known structural features that restrict groundwater flow inside or immediately surrounding the MGSA Area, or within the 180/400 Foot Aquifer Subbasin.

3.1.5.1 GEOLOGIC FORMATIONS

Regulation Requirements:
§354.14(b)(4)(a) Formation names, if defined.

Major geologic units present in the subsurface and on the flanks of the 180/400 Foot Subbasin are described below from youngest to oldest. The corresponding designation on Figure 3-6 is provided in parenthesis. This discussion on the Subbasin geology is derived from the SVBGSA GSP (SVBGSA 2020).

- **Aromas Sand (QPc)** – This Pleistocene unit is composed of cross-bedded sand containing some clayey layers (Harding ESE 2001). This unit was deposited in a combination of eolian, high-energy alluvial, alluvial fan, and shoreline environments (Harding ESE 2001; Greene 1970; and Dupre 1990). The Aromas Sand may be up to 300 feet thick (Harding ESE 2001) in the adjacent Monterey Subbasin (Harding ESE 2001) and likely extends into the northern portion of the

180/400 Foot Aquifer Subbasin (MCWRA [Monterey County Water Resources Agency] 2017a), but it is not found in other portions of the basin.

- **Paso Robles Formation (Tc)** – This Pliocene to lower Pleistocene unit is composed of lenticular beds of sand, gravel, silt, and clay from terrestrial deposition (Thorup 1976, Durbin 1978). The depositional environment is largely fluvial (Durbin 1973) but also includes alluvial fan, lake, and floodplain deposition (Harding ESE 2001, Thorup 1976, Greene 1970). The alternating beds of fine and coarse materials typically have bed thicknesses of 20 to 60 feet (Durbin 1978). The Paso Robles Formation overlies the Purisima Formation and underlies all of the Subbasin but is rarely exposed at the surface. Durham (1974) reports that the thickness is variable due to erosion of the upper part of the unit and that the Formation is approximately 1,500 feet thick near Spreckels and 1,000 feet thick near Salinas. Through most of the subbasin, this is the deepest unit and the underlying marine deposits typically do not yield high rates of low total dissolved solids (TDS) groundwater.

- **Purisima Formation (P)** – This Pliocene unit consists of intercalated siltstone, sandstone, conglomerate (Greene 1977), clay, and shale (Harding ESE 2001) deposited in a shallow marine environment. The Purisima Formation is found in the subsurface in the Subbasin and ranges from 500 to 1,000 feet in thickness (WRIME 2003). It is the youngest consolidated sedimentary unit encountered in the Subbasin vicinity and for the most part underlies the basin.

- **Santa Margarita Sandstone and Monterey Formation (M)** – These Miocene units consist of friable arkosic sandstone (Santa Margarita) and shale/mudstone (Monterey) deposited in a shallow marine environment (Harding ESE 2001, Greene 1977). In some areas, Santa Margarita Sandstone directly underlies the Paso Robles Formation where the Purisima Formation is absent (Greene 1977). These units typically underlie the basin.

3.1.5.2 SURFICIAL GEOLOGY

Regulation Requirements:
§354.14(d)(2) Physical characteristics of the basin shall be represented on one or more maps that depict surficial geology derived from a qualified map including the locations of cross-sections required by this Section.

A local geologic map showing surficial geologic units is presented as Figure 3-8. Surficial geologic units present in the 180/400 Foot Subbasin and MGSA Area consist of Holocene and Quaternary alluvial, dune sand and flood basin deposits, as shown on Figure 3-6 and Figure 3-8. The descriptions below were derived from the SVBGSA GSP (SVBGSA 2020) and other references as noted. Surficial geologic deposits consist of the following from youngest to oldest:

- **Marine and Nonmarine Sands (Qs)** – This unit includes recent (Holocene), active dunes (Qd in Figure 3-6) and old (Pleistocene), vegetated dunes (Qod in Figure 3-8). Active, wind-blown dunes generally extend less than 0.5 mile inland, and older dune sand deposits extend up to 4

miles inland as well as offshore. The active dune areas typically consist of elevated rolling hills composed of loose to moderately consolidated, fine to medium grained, well sorted sand (Ninyo & Moore, 2005; PCE, 2014). Younger, sparsely vegetated, active dunes are present along the coastline and intergrade with well sorted beach sand deposits at the coast. Older, more consolidated, and sometimes weakly cemented dune deposits with more established vegetation are present in the inland areas and underlie most of the area south of the Salinas River near the coast, as well as portions of the offshore area.

- **Alluvium (Q and Qs)** – This Holocene unit predominately consists of unconsolidated layers of mixed sand, gravel, silt, and clay that were deposited in a fluvial environment by the Salinas River and its tributaries. As shown on Figure 3-6, these deposits include active riverbed alluvium, alluvium, and overbank or basin deposits. In the Subbasin, this unit also includes extensive clay layers that were deposited in a shallow marine to brackish-water estuarine environment during periods when sea level rise caused submergence of the northern portion of the basin (Durham 1974). The estuarine deposits extend throughout much of the Subbasin and form prominent aquitards that define the aquifer system discussed in Section 3.1.6. The thickness is not well established because the alluvium is difficult to distinguish from underlying units, but it is likely 100 to 300 feet thick along the axis of the valley (Durham 1974).

- **Older Alluvium (Qoa)** – This Pleistocene unit is composed of alternating, interconnected beds of fine-grained and coarse-grained deposits predominately associated with alluvial fan depositional environments. The Older Alluvium underlies the Qa throughout the Subbasin but is not exposed at the ground surface. The alluvial fan deposits have an estimated maximum saturated thickness of 500 feet (Durham 1974).

3.1.5.3 SOIL CHARACTERISTICS

Regulation Requirements:
§354.14(d)(3) Physical characteristics of the basin shall be represented on one or more maps that depict soil characteristics as described by the appropriate Natural Resource Conservation Service soil survey or other applicable studies.

Regionally, the soils of the Subbasin are derived from the underlying geologic formations and influenced by the historical and current patterns of climate and hydrology. Productive agriculture in the Subbasin is supported by deep, dark, fertile soils. The arable soils of Subbasin historically were classified into four groups (Carpenter and Cosby 1925): residual soils, old valley-filling soils, young valley-filling soils, and recent-alluvial soils. In addition, five classes of miscellaneous soils were mapped that included tidal marsh, peat, coastal beach, and dune sands.

Because the dunes underlying the MGSA Area are active, no significant soil formation has taken place in this area. The soils of the MGSA Area are dune sands (Figure 3-9) listed by USDA Natural Resources Conservation Service (NRCS) as the Dune land (Df) unit (NRCS 2019). More recent surveys classify the soils into categories based on detailed soil taxonomy (U.S. Department of Agriculture [USDA] 2018).

Figure 3-10 is a composite soil map of soils in and near the MGSA Area from NRCS and the Gridded Soil Survey Geographic (gSSURGO) Database that is produced by National Cooperative Soil Survey (NCSS). The soils in the terrace area south of the Salinas River where the MGSA Area is located are generally sandy and well drained to excessively drained with high saturated hydraulic conductivities (Table 3-1). The City of Marina reports that since the soils in the city are dominated by dune sand with a high percolation rate, stormwater runoff from the built environment percolates into the subsurface at a very rapid rate, resulting in little excess runoff and no need for stormwater discharge infrastructure to surface water (City of Marina 2014a).

TABLE 3-1. SUMMARY OF SOIL CHARACTERISTICS IN THE VICINITY OF THE MGSA AREA

Soil Name	Map Symbol	Percent of Area	Drainage Class	Hydrologic Soil Group	Saturated Hydraulic Conductivity (in/hr)
Corducci-Typic Xerofluvents	300	0.1	Somewhat excessively drained	A	19.3
Alviso silty clay loam	Ac	1.3	Very poorly drained	C/D	2.9
Baywood sand	BbC	20.8	Somewhat excessively drained	A	13.0
Clear Lake clay	Cg	7.5	Poorly drained	D	0.8
Coastal beaches	Cm	0.8	Not defined	D[1]	13.0
Cropley silty clay	CnA	0.6	Well drained	C	0.1
Dune land	Df	6.8	Excessively drained	NA[2]	NA
Metz loamy sand	Me	1.0	Somewhat excessively drained	B	2.7
Metz fine sandy loam	Mf	4.2	Somewhat excessively drained	B	1.6
Metz complex	Mg	4.7	Somewhat excessively drained	B	2.7
Mocho silt loam	MnA	3.5	Well drained	B	1.3
Mocho silty clay loam	MoA	0.9	Well drained	C	5.0
Oceano loamy sand	OaD	30.7	Excessively drained	A	13.0
Pacheco clay loam	Pa	10.9	Poorly drained	C	0.6
Pico fine sandy loam	Pf	0.7	Well drained	A	3.3
Salinas clay loam	SbA	1.7	Well drained	C	4.5
Water	W	2.5	Not available	NA	NA
Xerorthents, dissected	Xd	1.2	Well drained	C	0.4

Notes:

[1] Beach sand is assigned Hydrologic Group D because it is assumed to be saturated at a very shallow depth.

[2] Dune land are not assigned a Hydrologic Group; however, are assumed to have low runoff potential.

NA = Data not available.

Hydrologic Group A: Soils having high infiltration rate (low runoff potential) when thoroughly wet.

Hydrologic Group B: Soils having moderate infiltration rate when thoroughly wet.

Hydrologic Group C: Soils having a slow infiltration rate when thoroughly wet.

Hydrologic Group D: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet.

Source: USDA NRCS Web Soil Survey, https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

3.1.5.4 REGIONAL CROSS-SECTIONS

Regulation Requirements:
§354.14(c) The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.

Three regional cross-sections along and across the Subbasin are shown in Figure 3-11, Figure 3-12, and Figure 3-13 (Kennedy-Jenks 2004). These cross sections are adopted from the SVBGSA Subbasin GSP (SVBGSA 2020). The locations of these cross-sections are depicted in Figure 3-6. The hydrogeologic cross-sections are based on geologic logs provided in California DWR Water Well Drillers Reports (DWR-188 forms) filed by the well drillers, and depict the general stratigraphic distribution and lithology of the principal water supply aquifers in the Subbasin. Geologic log descriptions were grouped into hydrologic units as follows:

- Fine-grained sediments (e.g., clay, silt, sandy clay, and gravelly clay) are shown as aquitards;
- Coarse-grained sediments (e.g., sand, gravel, and sand-gravel mixtures) are shown as aquifers; and
- Sediments logged as gravel/clay, sand/clay, and sand/gravel/clay are interpreted to consist of interbedded coarse-grained and fine-grained deposits and are included with aquifer materials.

The cross sections show the extent of the 180-Foot Aquifer and 400-Foot Aquifer and aquitards (Salinas Valley Aquitard and 180/400 Foot Aquitard) throughout the Salinas Valley basin, and illustrate the heterogeneity of these aquifers units and the aquitards that separate them. The major aquitards are discontinuous at various locations, most importantly near the coast, where the MGSA Area is located. Locally important shallow aquifers are not identified at the scale of these cross sections.

3.1.6 AQUIFER SYSTEM

Regulation Requirements:
§354.14(b)(4) The hydrogeologic conceptual model shall be summarized in a written description that includes the principal aquifers and aquitards.
§354.14(b)(4)(c) Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.

Previous hydrogeological studies in and around the region of interest provide detailed background information about the regional hydrostratigraphy (Fugro West Inc. 1995, Harding ESE 2001, Kennedy/Jenks Consultants 2004, MACTEC 2005; Geoscience Support Services 2014, Hopkins Groundwater Consultants 2016). Historically, in hydrostratigraphic investigations, the region that lies north of the Salinas River, which comprises most of the Salinas Valley basin, has been discussed separately from the region south of the Salinas River, which includes the Marina and Fort Ord areas. While there are geological and geographic differences between the two regions, most of the equivalent aquifers produced for beneficial uses in each region are believed to be hydraulically connected. Here, we

present a brief review of the hydrostratigraphy in the coastal region of interest, noting major differences between the regions north and south of the Salinas River. The units are discussed roughly in order of highest to lowest elevation. Much of this discussion is adapted from Gottschalk *et al.* (2018). Though these aquifer-system units are referred to here as "aquifers," they generally constitute heterogenous assemblages of fine- and coarse-grained deposits (Hanson *et al.* 2002).

3.1.6.1 DUNE SAND AQUIFER

The Dune Sand Aquifer is present south of the Salinas River, and is the predominant unconfined aquifer in the Marina and Fort Ord areas. It is composed of fine to medium grained, well sorted aeolian sand of Pleistocene to Recent age that extends offshore and up to 4 miles inland, and extends to depths up to 85 to 95 feet beneath the ground surface at the coast in the MGSA Area. While the Dune Sand Aquifer is laterally continuous at and in the vicinity of the MGSA Area, it is not commonly used for drinking water or agricultural irrigation However, as discussed later in this chapter, the Dune Sand Aquifer is connected to surface water systems and yields significant quantities of groundwater to groundwater-dependent ecosystems (GDE), stores a substantial quantity of low-TDS groundwater with designated beneficial uses, is an important source of low-TDS groundwater recharge to aquifers below it, and contains low-TDS groundwater in equilibrium with an intruding saline water wedge deeper in the aquifer system. Therefore, in this GSP, the Dune Sand Aquifer is considered a principal aquifer because of its local importance.

Within much of the Marina and Fort Ord areas, the Dune Sand Aquifer overlies a clay layer known in Fort Ord groundwater investigations as the Fort Ord- Salinas Valley Aquitard (FO-SVA) and known more regionally as part of the Salinas Valley Aquitard (SVA). When underlain by the SVA, the Dune Sand Aquifer is also referred to as the Perched Dune Sand Aquifer (Hopkins Groundwater Consultants 2016), or the A-Aquifer (Ahtna Environmental Inc. 2017). The underlying SVA or other aquitards, where present, are considered to create a perched or semi-perched condition for the Dune Sand Aquifer. Near the coast and south of the Salinas River, the SVA thins out, bringing the Dune Sand Aquifer and the underlying 180-Foot Aquifer into hydraulic connection. The thinning of the SVA is coincident with a drop in the hydraulic head in the Dune Sand Aquifer. Here the groundwater enters the underlying Upper 180-Foot Aquifer, and flows southeastward, according to the hydraulic gradient (Ahtna Environmental Inc. 2017). In the MGSA Area, the Dune Sand Aquifer is seawater intruded; however, high recharge rates have resulted in a large zone of groundwater containing lower concentrations of TDS immediately east of, and extending into the eastern portion of, the MGSA Area. The seaward discharge of low TDS groundwater from this area, and the flow of groundwater from the Dune Sand Aquifer to the Upper 180-Foot Aquifer, appears to mound groundwater in the Dune Sand and Upper 180-Foot Aquifers near the coast, creating a local groundwater barrier against encroaching seawater intrusion.

As a result of the relatively high permeability of the Dune Sand Aquifer, it supports high recharge rates and has little to no runoff. It is notable that south of the Salinas River, there are no major creeks, streams or rivers that drain at and in the vicinity of the MGSA Area (Figure 3-5), which relates to the high

permeability, high recharge rate of the Dune Sand Aquifer. Groundwater occurs at depth beneath the tall, active dunes at the coast, but can be relatively shallow further inland and beneath hollows and depressions. As discussed in Section 3.2.6.2, near the MGSA Area, the Dune Sand Aquifer is hydraulically connected to, and supports, local groundwater-dependent ecosystems (GDEs), including palustrine and emergent wetlands which support protected species.

3.1.6.2 SALINAS VALLEY AQUITARD (SVA)

The Salinas Valley Aquitard is a laterally extensive clay and sandy clay layer covering much of the Salinas Valley basin, east of Fort Ord, and from the Monterey Bay south past Salinas. It is approximately 100 feet thick west of Salinas (Kennedy/Jenks 2004). South of the Salinas River, a similar unit of clay is locally called the FO-SVA as discussed previously. Harding ESE (2001) concluded that the SVA and the FO-SVA are "either the same or at least hydraulically equivalent." Within this GSP, the two units are referred to collectively as the SVA. In the Salinas Valley basin, the SVA is thicker and relatively flat, while in the Fort Ord area, the SVA is higher in elevation and dips more steeply toward the coast (*ibid*). Near the coast and south of the Salinas River, the SVA thins out, bringing the Dune Sand Aquifer and the underlying 180-Foot Aquifer into hydraulic connection.

3.1.6.3 180-FOOT AQUIFER

The 180-Foot Aquifer underlies the SVA and is the uppermost regional aquifer that has historically been used as a groundwater supply. Near the MGSA area, it is seawater intruded; however, due to recharge from the overlying Dune Sand Aquifer, it contains a zone of groundwater with relatively low concentrations of TDS east of the MGSA Area. The aquifer ranges from 50 to 150 feet in thickness, and within the Salinas Valley basin, the top is often encountered 100 to 150 feet below ground surface (ft bgs) (Kennedy/Jenks 2004). The 180-Foot Aquifer extends across more than one stratigraphic or geologic unit, and various interpretations have correlated it to different combinations of stratigraphic units depending on the investigator, the area under study, and the investigator's interpretation. In the MGSA Area, it has been correlated with the lower portions of the Quaternary Alluvium and the upper portions of the Aromas Sand (ESA 2018). The Upper 180-Foot Aquifer, believed to be 20 to 60 feet thick (Harding ESE 2001), is considered to be in hydraulic connection with the Dune Sand Aquifer near the coast, as the SVA thins out. The Intermediate 180-Foot Aquitard, a sequence of silty and clayey beds, hydraulically separates the sandy Upper 180-Foot Aquifer from the gravelly Lower 180-Foot Aquifer in the Marina and Fort Ord area. Geophysical studies reported by Gottschalk *et al.* (2018) have confirmed this aquitard is discontinuous in the vicinity of the MGSA Area.

3.1.6.4 180/400-FOOT AQUITARD

This 180/400-Foot Aquitard separates the 180-Foot Aquifer from the underlying 400-Foot Aquifer throughout much of the Subbasin. It is a zone of "discontinuous aquifers and aquitards," of which the aquitards, where present, comprise an aquitard that separates the 180-Foot Aquifer from the underlying 400-Foot Aquifer (Geoscience 2014). The discontinuous nature of the 180/400-Foot Aquitard was

documented first by Monterey County Flood Control and Water Conservation District (MCFCWCD 1960) and was a subject of focused studies by Kennedy/Jenks (2004) north of the Salinas River. South of the Salinas River, the 180/400-Foot Aquitard is relatively thin and has been recorded to pinch out at the Main Garrison area of the former Fort Ord (Harding ESE 2001). Geophysical studies reported by Gottschalk *et al.* (2018) have confirmed this aquitard is discontinuous in and near the MGSA Area, and its hydraulic connection to the overlying 180-Foot Aquifer in the vicinity of the MGSA area is substantiated by available hydrographs (Section 3.2.1.3).

3.1.6.5 400-Foot Aquifer

This aquifer is regionally extensive and is composed of sand and gravel packages and is typically encountered between 275 and 460 ft bgs (Kennedy/Jenks, 2004). It is correlated with the Aromas Sand and the upper portion of the Paso Robles Formation (ESA 2018). The thickness and depth of the aquifer are variable throughout the Subbasin. Near Salinas, the aquifer is largely continuous; whereas, near Castroville, it is comprised of multiple sandy packages, separated by thin clay layers. South of the Salinas River, the 400-Foot Aquifer consists mostly of sand. In regions where the 180/400-Foot Aquitard thins out or is absent, the 180-Foot Aquifer and the 400-Foot Aquifer are in direct hydraulic communication. Hydraulic connection allows groundwater to flow unhindered from the aquifer with higher hydraulic head to the aquifer with lower hydraulic head in these areas. Generally speaking, the 400-Foot Aquifer has a lower hydraulic head than the 180-Foot Aquifer. In areas of hydraulic connection between these two aquifers, saline groundwater in the 180-Foot Aquifer, which has been recorded farther inland than in the 400-Foot Aquifer, has been documented to migrate vertically into the 400-Foot Aquifer, deteriorating water quality in the 400-Foot Aquifer (MCWRA 2017).

3.1.6.6 400-Foot/Deep Aquitard

Beneath the 400-Foot Aquifer is an aquitard that can be up to “several hundred feet thick” (Kennedy/ Jenks 2004). Logging of a boring in the City of Marina conducted by the USGS interpreted a zone of silty clay and mudstone from about 700 to 900 feet below the ground surface (Hanson *et al.* 2002). More variable lithology has been interpreted from other deep well geophysical logs in the area (MCWRA 2017), and as discussed below, the USGS acknowledged the stratigraphic interval in which this aquitard was encountered has also been identified as containing transmissive units locally referred to as the 900-Foot Aquifer. As such, while substantial units of low permeability appear to exist within and beneath the lower portions of the upper aquifer system in the Paso Robles Formation, their regional continuity and competence are not well understood.

3.1.6.7 Deep Aquifer

The Deep Aquifer has received different definitions from various reports and consists of a system of aquifers. Kennedy/Jenks (2004) define the Deep Aquifer as the group of deep aquifers located between the depths of approximately 780 and 1,500 ft msl. Previous investigators delineated the Deep Aquifer system as the interval between 1,300 and more than 2,000 feet below ground surface (Geoconsultants,

Inc. 1993) based on data from the MCWD deep-aquifer system water-supply wells. USGS (Hanson *et al.* 2002) states the basal part of the upper aquifer system, encountered from approximately 670 to 955 feet below ground surface at a deep boring in the City of Marina, is locally referred to as the 900-Foot Aquifer, which is generally considered part of the Deep Aquifer system. They conclude this part of the Deep Aquifer system may constitute terrestrial sediments of the Plio-Pleistocene Paso Robles Formation (stratigraphically equivalent to the aquitard described above). ESA (2018) states that in the MGSA Area, the 900-Foot Aquifer correlates with the Paso Robles Formation. The majority of the Deep Aquifer system appears to consist of interbedded sands, silts and clays of the Mio-Pliocene Purisima Formation that were deposited in a marine shelf environment (Hanson *et al.* 2002, ESA 2018). Aquifers within this formation are known to extend to a depth of approximately 2,000 feet. The basal, or lowermost, unit of the Purisima Formation is reported to consist of relatively impermeable clay and shale (ESA 2018). Portions of the Purisima Formation that correlate with the Deep Aquifer system crop out in the submarine Monterey Canyon several miles offshore.

To date, seawater intrusion has not been documented in the Deep Aquifer, even though groundwater elevations in the Deep Aquifer are consistently below sea level. This lack of seawater intrusion in the Deep Aquifer may be due, at least in part, to the geologic setting (Feeney and Rosenberg 2003). groundwater pumping from wells in the Deep Aquifer is thought to be supported primarily by leakance from the overlying aquifer system (*i.e.,* the 180-Foot Aquifer and 400-Foot Aquifer). Some groundwater pumping is derived from depletion of groundwater storage, but hydraulic properties of the Deep Aquifer (specifically storage coefficients) suggest that while some groundwater may come from storage immediately following the onset of pumping a well, very little groundwater is removed from storage over time. Therefore, increases in groundwater pumping in the Deep Aquifer are likely supported by increased leakance from the overlying aquifers (Feeney and Rosenberg 2003). As a result of these findings, the Monterey County Board of Supervisors voted on May 18, 2018 to place a moratorium on the construction of new wells in the Deep Aquifer as a preventive measure because, at present, seawater intrusion has not been observed in the Deep Aquifer.

3.1.7 AQUIFER PROPERTIES

Regulation Requirements:
§354.14(b)(4)(b) Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.

3.1.7.1 GENERAL AQUIFER PROPERTIES

There are two general types of aquifer properties relevant to groundwater management:

- **Groundwater transmission properties** - These properties control the relationship between hydraulic gradients and the rate of groundwater movement or flow; and

- **Aquifer storativity properties** - These properties control the relationship between the volume of groundwater stored in the aquifer and the water elevation measured in the aquifer.

Groundwater transmission properties: Hydraulic conductivity measures the ability of an aquifer to transmit water. Hydraulic conductivity is measured in units of feet per day (ft/day). Units with higher hydraulic conductivities, such as sands and gravels, transmit groundwater more easily than units with lower hydraulic conductivities. Another common measurement of the ability of an aquifer to transmit water is transmissivity. Transmissivity is equivalent to the hydraulic conductivity of an aquifer times the thickness of an aquifer. Unfortunately, very few estimates of hydraulic conductivity or transmissivity exist for the Subbasin.

Aquifer storativity properties: The aquifer properties that characterize the relation between water elevation and aquifer storage volume are "specific yield" for unconfined aquifers and "specific storage" for confined aquifers. The units are dimensionless.

- Specific yield is the amount of water that drains from pores when an unconfined aquifer is dewatered. An example is water draining from the voids between sand grains, but leaving behind water sticking to the grains as a film of water. The pores dewater, they are not dried out. Typical specific yield values for unconfined alluvial systems range from 10% to 30% or 0.1 to 0.3 (Lohman 1972).
- Specific storage (also referred to as storage coefficient) is the amount of water derived from a cubic foot of confined aquifer due to a unit loss of pressure head in the aquifer. Specific storage is effectively a pressure response and is a combination of compression of the aquifer and compression or expansion of water. Specific storage in confined alluvial aquifers typically ranges from about 10^{-3} to 10^{-5} (Lohman 1972).

3.1.7.2 AQUIFER PROPERTIES NEAR THE MGSA AREA

Although there is limited information on aquifer properties at and in the vicinity of the MGSA Area, the CEMEX model used for the MPWSP site investigation assigned aquifer properties to the aquifers and aquitards from the Dune Sand Aquifer down to the Deep Aquifer. While this model is based on a simplified version of the site-specific stratigraphy and initial water elevation conditions that does not consider all of the locally available data, it does provide a reasonable initial estimate of aquifer properties. A list of the assigned aquifer and aquitard parameters adopted in the CEMEX model is listed below (the Deep Aquifer is referred to as the 900-Foot Aquifer in the CEMEX model).

- **Dune Sand Aquifer** - Hydraulic conductivity 210 to 340 ft/day; Specific yield 0.065;
- **Salinas Valley Aquitard** - Hydraulic conductivity and storage – not simulated near MGSA Area;
- **180-Foot Aquifer** - Hydraulic conductivity 160 ft/day; Specific storage $4x10^{-3}$;
- **180/400-Foot Aquitard** - Hydraulic conductivity 3.1 to 5.4 ft/day; Specific storage $1x10^{-5}$;
- **400-Foot Aquifer** - Hydraulic conductivity 50 to 90 ft/day; Specific storage $4x10^{-4}$ to $2x10^{-3}$;

- **400/900-Foot Aquitard** - Hydraulic conductivity 1.8 ft/day; Specific storage $1x10^{-5}$ to $2x10^{-5}$; and
- **900-Foot Aquifer** - Hydraulic conductivity 25 ft/day; Specific storage $1x10^{-5}$.

USGS is developing the Salinas Valley Integrated Hydrologic Model (SVIHM) to simulate surface and groundwater conditions and flow in the Salinas Valley basin and serve as a tool to assess historical, current, and future groundwater conditions. SVBGSA utilized a pre-publication version of this model to support development of its GSP. The above aquifer properties will be updated as more data become available and the USGS SVIHM model is published. Refinement of these aquifer properties and of the local stratigraphic relationships, dimensions, and heterogeneity within and surrounding the MGSA Area will allow a more accurate assessment of groundwater flow and solute transport as the GSPs are implemented.

3.1.8 AQUIFER USES

Regulation Requirements:
§354.14(b)(4)(e) Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.

The Dune Sand Aquifer is not currently used as a water supply, but does support surface water systems and does yield water to GDEs in the immediate vicinity of the MGSA Area (Section 3.2.6.2). Groundwater extraction from the 180-Foot and 400-Foot Aquifers within the Castroville Seawater Intrusion Project (CSIP) service area in the seawater-intruded area on the west side of the Subbasin is regulated by the MCWRA, and groundwater extraction is prohibited in a portion of this area. The SVBGSA's GSP includes a management action to expand the CSIP service area and prohibit new groundwater wells throughout this area. As a result, groundwater extraction in this area is limited. MCWD operates five municipal supply wells that are completed in the 180/400-Foot Aquifer and Deep Aquifer to provide water to the Ord Community, about 4 miles southeast of the MGSA Area (Schaaf & Wheeler 2016, MCWD 2019c). Small non-transient water systems reliant on groundwater are located near Neponset, near the Marina Airport and near the regional wastewater treatment plant located east of the MGSA Area.

Groundwater within the MGSA Area is currently being used by the CEMEX plant for industrial process supply (ESA 2018). CEMEX produces groundwater from a well completed in the 180-Foot and 400-Foot Aquifers. The well was constructed in the 1960s, and currently extracts approximately 305 acre-feet per year (AFY). The amount of groundwater produced from the lower TDS zone in the upper 180-Foot Aquifer vs. saline groundwater from the deeper portions of the 180-Foot Aquifer and the underlying 400-Foot Aquifer is not known. The CEMEX permitted operations will end by December 31, 2020 due to the agency enforcement actions described in Chapter 2, and pumping for the facility will cease by that time (Powder & Bulk Solids 2017) or, at the latest in December 2024, when CEMEX removes the well.

One proposed future use of the aquifers in the MGSA Area is extraction of groundwater for the proposed MPWSP desalination plant. Makeup water for the MPWSP would be pumped from five slant

wells (plus two standby wells) close to the coast. The wells would extract water radially from the DSA and 180-Foot Aquifer near the coast. Groundwater captured by the wells would include saline groundwater originating outside the western (seaward) Subbasin boundary, saline groundwater from aquifers within the Subbasin, and low-TDS groundwater from aquifers within the Subbasin. The amount of makeup water proposed to be pumped from these slant wells under the preferred alternative is approximately 17,400 AFY (HWG 2017).

South of the MGSA Area, MCWD pumps groundwater from three supply wells completed in the Deep Aquifer in the eastern portion of the City for distribution to the Central Marina service area and Armstrong Ranch (Wells #10, #11 and #12). The combined extraction from these wells was approximately 1,823 AFY in 2015, and is forecast to increase to 3,905 AFY by 2035, including supply for development in the Armstrong Ranch area, which was annexed to the City in 2007 (Schaaf & Wheeler 2016). The MCWD wells are located in the Monterey Subbasin in the eastern part of the City of Marina as shown on Figure 3-14.

3.1.9 GENERAL GROUNDWATER QUALITY

Regulation Requirements:
§354.14(b)(4)(d) General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.

Native groundwater in the 180-Foot and 400-Foot Aquifers that is not affected by seawater intrusion is characterized as calcium-sodium bicarbonate water (MCWRA 2017). Groundwater in the Deep Aquifer is characterized as a sodium bicarbonate water (MCWRA 2017). Seawater intrusion into 180-Foot and 400-Foot Aquifers at and in the vicinity of the MGSA Area has created more saline water that is characterized as a sodium chloride water. Figure 3-15 presents a Piper diagram from a report prepared by MCWRA (2017) that plots major ion data from the principal aquifers within and near the Subbasin. The diagram provides a means of representing the proportions of major anions and cations in water samples and thereby can be used to illustrate the character of the water quality.

As discussed further in Section 3.2.3, seawater intrusion into the 180-Foot and 400-Foot Aquifers is monitored by the MCWRA. MCWRA uses a standard of 500 milligrams per liter (mg/L) chloride to define the areas affected by seawater intrusion and inform its management decisions (MCWRA 2017). Based on this standard, seawater intrusion has progressed inland from the coast over a distance of approximately 4 to 7 miles in the 180-Foot Aquifer, and 3 to 4 miles in the 400-Foot Aquifer. In addition, several “chloride islands” have formed in the 400-Foot Aquifer beyond the main intrusion front as a result of downward migration of groundwater containing over 500 mg/L chloride from the 180-Foot Aquifer into the 400-Foot Aquifer in areas where the aquitard separating the two aquifers is thin or absent. Vertical movement of saline groundwater into the 400-Foot Aquifer at “islands” could be due to both downward migration in areas where the aquitard thins or is heterogeneous, or at locations where wells are improperly constructed or abandoned, forming a conduit through which vertical migration may occur.

It is important to note that groundwater in the areas affected by seawater intrusion still has actual and potential beneficial uses. Under State Water Resources Control Board (SWRCB) Resolution No. 88-63, the state considers all groundwater containing TDS at concentrations less than 3,000 mg/L as having a potential beneficial use as a domestic and municipal supply. For water containing TDS or chloride in excess of drinking water standards, treatment would be required prior to use. The Federal Clean Water Act defines groundwater containing less than 10,000 mg/L TDS as an Underground Source of Drinking Water. In addition, there are zones of higher quality, less saline groundwater, which contain lower concentrations of TDS, present at various locations and depths within the seawater-intruded area. As discussed further in Section 3.1.12, a prominent zone of higher quality groundwater extends approximately from the eastern portion of the MGSA Area eastward through the area underlain by the Dune Sand Aquifer, and extends vertically downward into the 180-Foot Aquifer (Gottschalk *et al.* 2018).

Nitrate impacts from historical agricultural uses are widespread in the Subbasin. As discussed further in Section 3.2.4.2, nitrate concentrations detected in wells within the MGSA Area are well below the Maximum Contaminant Level (MCL), except for one outlier of 13 historical sampling events of the CEMEX process water supply well; however, this well produces saline groundwater and is not being used as a source of drinking water. Shallow monitoring wells in the agricultural area east of the MGSA Area generally contain nitrate at concentrations near or exceeding the MCL.

In the vicinity of the MGSA Area, elevated TDS and chloride are the primary constituents of concern due to seawater intrusion. Figure 3-16, Figure 3-17, and Figure 3-18 present the TDS and chloride concentrations detected in the Dune Sand Aquifer, 180-Foot Aquifer, and 400-Foot Aquifer, respectively, in samples collected in April 2019.

3.1.10 Source and Point of Delivery of Imported Water

Regulation Requirements:
§354.14(d)(6) Physical characteristics of the basin shall be represented on one or more maps that depict the source and point of delivery for imported water supplies.

There is no water imported into either the MGSA Area or the 180/400 Foot Aquifer Subbasin.

3.1.11 Recharge and Discharge Areas

Regulation Requirements:
§354.14(d)(4) Physical characteristics of the basin shall be represented on one or more maps that depict delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.

3.1.11.1 Natural Recharge Areas

Monterey County maps the area immediately east of the MGSA Area as a recharge area (Figure 3-19). The area is underlain by the Older Dune Sands (Figure 3-8) and soils in the arear are highly permeable. The City of Marina uses an infiltration rate of 1 foot/hour as a stormwater management design standard

in this area. The active coastal dunes that extend from the Salinas River southward through and past the City of Marina possess similar properties. Although the Dune lands (Df) soils underlying these areas, including the MGSA Area, are not mapped by the County as a recharge area, they are assumed to have similar properties. It is assumed that all rainfall on the Df soil that is not lost to evapotranspiration is recharged to the subsurface aquifer(s). As was noted earlier in Section 3.1.6, south of the Salinas River, there are no major creeks, streams or rivers that drain at and in the vicinity of the MGSA Area (Figure 3-5), which relates to the high permeability, high recharge rate of the Dune Sand Aquifer.

An additional source of recharge is deep percolation of applied irrigation water in the agricultural areas east and northeast of the MGSA Area. This area receives water from the CSIP, and has undergone an expansion of agricultural development by approximately 1,000 acres over the last 10 years. Given the very high permeability of the underlying soils, it is assumed that any applied irrigation water that is not consumptively used by crops recharges the underlying aquifer(s).

The Salinas River is reported to be a "losing" stream in the area near Marina (MCWRA 2018); therefore, it is expected to be a regional source of recharge north and east of the MGSA Area. Salinas River losses per river mile were estimated by MCWRA based on measurements at eight gaging stations (MCWRA 2018) extending upstream from Spreckels. Spreckels is located approximately 13.5 river miles upstream from the river mouth, south of Salinas. Measured river losses ranged from 4.5 cubic feet per second (cfs) to 12.2 cfs per river mile. It should be noted that these river measurements were conducted following a 5-year drought. Assuming these measurements are representative of river losses over a typical year, this would be equivalent to a loss of approximately 3,300 to 8,840 AFY per river mile to groundwater recharge. Assuming half the recharge contributes to recharge on each side of the river and that these measurements apply to the lower reach of the river between Spreckels and the river mouth, this would equate to recharge rates from the river to the Dune Sand and 180-Foot Aquifers of about 1,650 to 4,420 AFY per river mile near the MGSA Area. Recharge derived from infiltration of river water contributes to the subsurface inflow to the MGSA Area, but it is not directly connected to the MGSA Area, as the river passes approximately 4,000 feet to the north and 2 miles to the east.

3.1.11.2 NATURAL DISCHARGE AREAS

Groundwater discharge in the area near the MGSA Area occurs by evapotranspiration (ET) from GDEs and discharge to the Pacific Ocean.

As discussed in Section 3.2.6.2, no GDEs are located within the boundaries of the MGSA Area; however, several GDEs are located in the immediately surrounding area. These GDEs utilize shallow groundwater from the Dune Sand Aquifer to meet a significant portion of their water demand. The amount of consumptive use by these GDEs has not been estimated. The total annual ET from these GDEs will be assessed as part of future groundwater budget updates during GSP implementation.

Three GDEs near the MGSA Area are included in the *Coastal/Vernal Ponds Comprehensive Management Plan* that was developed by the City in 1994 (The Habitat Restoration Group and Michael Swanson and

Associates 1994): Pond 6 – Armstrong Ranch Complex Ponds are immediately to the east of the MGSA Area; Pond 5 – Marina Cost Water District Pond is south of the MGSA Area; and Pond 3 – Marina Landing Pond is south east of the MGSA Area. These features are characterized as emergent or palustrine wetlands in the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset developed by The Nature Conservancy in cooperation with DWR.

Potentiometric surface maps prepared for the vicinity of the MGSA Area indicate the groundwater flow direction in the Dune Sand Aquifer is toward the coast. In addition, there is an upward gradient between the 180-Foot Aquifer and the Dune Sand Aquifer at the monitoring well cluster that is nearest to the coast (Section 3.1.12). This is consistent with seaward discharge of groundwater from the Dune Sand Aquifer and upper 180-Foot Aquifer under Ghyben-Herzberg dynamics (Section 3.1.12).

3.1.12 CONCEPTUAL UNDERSTANDING

When preparing seawater intrusion maps for 2015, MCWRA (2017) noted, for the first time, the existence of three isolated plumes of saline groundwater in the 400-Foot Aquifer inland from the contiguous seawater intrusion front (referred to in the report as “chloride islands”). The existence of these chloride islands suggested that migration of saline groundwater may be occurring downward through gaps in the 180/400-Foot Aquitard. Vertical movement of saline water into the 400-Foot Aquifer at “islands” could be due to both downward migration in areas where the aquitard thins or is heterogeneous, or at locations where wells are improperly constructed or abandoned, forming a conduit through which vertical migration may occur. In response to this finding, MCWRA conducted a detailed review of 187 wells in an effort to better understand the potential pathways for seawater intrusion into the chloride islands. It was found that of the 187 wells evaluated, there are at least 74 wells for which adequate hydraulic separation could not be confirmed of the 400-Foot Aquifer from the overlying, seawater-intruded 180-Foot Aquifer. The MCWRA (2017) report identifies 15 locations where gaps in the 180/400-Foot Aquitard were confirmed to exist. Figure 3-20 presents a map view illustration of the “area of impact” as mapped by MCWRA and the identified aquitard gaps.

In addition to the extensive dataset developed from prior hydrogeologic investigations in the area, from 2011 to 2018, a research team from Stanford University investigated the hydrostratigraphy and seawater intrusion in the upper aquifer system (the Dune Sand, 180-Foot and 400-Foot Aquifers) along the Monterey Bay coast in Santa Cruz and Monterey Counties. The investigations utilized Electrical Resistance Tomography (ERT) and Airborne Electromagnetics (AEM) to investigate variations in subsurface conductivity that were used to interpret stratigraphic and water quality variations by correlating them to the electrical logs of borings drilled near the coast.

Electrical and electromagnetic geophysical techniques provide an efficient means of collecting sufficient data for two- and three-dimensional conceptualization of complex subsurface systems in a way that is not practical with the use of conventional boreholes and monitoring wells alone, and are a widely used and well established investigation technique for characterization of seawater intrusion into coastal

aquifers (Viezzoli, Munday and Cooper 2012, Herckenrath *et al.* 2013, Mills et al. 1988, Kazkis *et al.* 2016, Hazreek *et al.* 2018). The northward extension of the AEM dataset compiled by the Stanford team is currently being used in the preparation of a GSP for the Santa Cruz Mid-County Subbasin and is proposed to perform long term monitoring of seawater intrusion in that area. While the AEM data are not collected using direct measurements (such as, drilling a well bore), using indirect measurement geophysics in subsurface investigations has a long history in groundwater investigations dating back to 1926 when the Schlumberger brothers developed borehole resistivity logging tools (Hilche 1990). Further, airborne electromagnetic surveys are an integral part of the SWRCB Regional Monitoring Program for groundwater monitoring in areas of oil and gas well stimulation for salinity mapping conducted by USGS (SWRCB 2019).

The AEM data provides one snapshot in time covering much of MGSA Area and nearby area of interest. The data are extensive and provide a broader three-dimensional understanding of the subsurface hydrostratigraphy and water quality distribution than well-based data alone.

In 2011 and 2012, ERT profiles were collected along 6.8 kilometers (km) of shoreline along the Monterey Bay near Marina, and in 2014, 40 km of ERT profile data were collected along the Monterey Bay shoreline in Monterey and Santa Cruz Counties (Pidlisecky *et al.* 2016, Goebel *et al.* 2017). In 2017, 395 miles of AEM data were acquired in the northern Salinas Valley near the shore and extending inland across the mapped areas of seawater intrusion (Gottschalk *et al.* 2018). The AEM data were calibrated using electrical well logs and used to refine the previous hydrostratigraphic models developed using borehole data and the North Marina Groundwater Model, and to assess the extent of saline and low-TDS groundwater in the aquifer system. The data were made available in a three-dimensional geologic data visualization package called leapfrog© that is extensively used in the petroleum and mining industries. Figure 3-21 and Figure 3-22 present hydrostratigraphic and water quality cross sections of the data across the MGSA Area and vicinity, and Figure 3-23 presents an oblique block section of the area and a conceptual model drawing taken from the seawater intrusion literature that illustrates the Ghyben-Herzberg relationship of saline-freshwater interfaces. The lithologic and conductivity interpretations were developed as discussed in Gottschalk *et al.* (2018), and the lithologic interpretation presented in the cross sections is based on interpretation of boring logs and modified using the AEM data (Gottschalk's "Model A"). Our findings are summarized below in light of the data presented in the previous sections.

The three-dimensional view of the hydrostratigraphy in the MGSA Area indicates that is more complex than has been previously conceptualized. This is not unexpected given the number of additional data points derived using a geophysical approach. The AEM profiles show the Dune Sand Aquifer extends westward beneath the older and recent dune deposits south and west of the Salinas River, which have been recognized as an area with high recharge rates. The Dune Sand Aquifer lies on top of the Salinas Valley Aquitard, which thins and pinches out toward the west. Beneath the MGSA Area, the Dune Sand Aquifer is in direct hydraulic communication with the underlying 180-Foot Aquifer because the Salinas

Valley Aquitard is not present. The 180-Foot Aquifer is shown as a series of tabular and lenticular bodies, and consists of an upper and a lower member that are partially separated by discontinuous clay layers. The 180/400-Foot Aquitard is discontinuous and notably absent beneath a portion of the MGSA Area and in a large area located just east of the MGSA Area. This occurs in the vicinity of an area where the aquitard was previously judged to be thin or absent by MCWRA (see Figure 3-20). The 400-Foot Aquitard is uneven, and the Deep Aquifer occurs at some locations as shallow as depths of approximately 650 feet below the ground surface.

The water quality data show a prominent saline groundwater wedge (> 10,000 mg/L TDS) which dives downward from the coast through the Dune Sand and 180-Foot Aquifers, and extends downward into the 400-Foot Aquifer through a large gap in the 180/400 Foot Aquitard. This saline groundwater wedge is juxtaposed against a zone of lower TDS groundwater (< 3,000 mg/L TDS) that has developed as a result of freshwater recharge through the high permeability dune sand deposits that occur between the MGSA Area and the Salinas River. This low TDS zone extends downward into the 180-Foot Aquifer east of the MGSA Area.

The saline groundwater wedge and low TDS zone have the geometry of a typical seawater intrusion interface as first characterized by Ghyben and Herzberg, after whom this relationship is named (Ghyben 1889, Herzberg 1901). Seawater interfaces in coastal aquifers have been extensively characterized, and follow what has been termed the Ghyben-Herzberg model, which is illustrated in Figure 3-23. Under equilibrium conditions, the ratio between the depth to the interface below sea level to the height of the water table above sea level remains constant and is proportional to the difference in density between the overlying low TDS native aquifer groundwater and the underlying seawater. This ratio often approximates 40:1, but is dependent on the actual salinity and density contrast. Groundwater flow is seaward in the overlying low TDS zone and discharges to the ocean, and flow is landward in the intruding saline groundwater wedge. At the saline/low-TDS groundwater interface, the saline groundwater circulates and mixes with the over-riding low TDS groundwater and flows back along the interface to discharge at the ocean (Cooper et al., 1964). This pattern is consistent with the water quality distribution interpreted from the AEM data and the water elevation data discussed in Sections 3.1.12 and 3.3.7. Although this equilibrium may have been somewhat disturbed at the MGSA Area by pumping of CEMEX well and the test slant well, and by recharge of saline water in the CEMEX ponds, the geometry of a saline groundwater wedge dipping beneath an over-riding low-TDS zone is clearly identifiable and consistent with the Ghyben-Herzberg model.

3.1.13 IDENTIFICATION OF DATA GAPS

Regulation Requirements:
§354.14(b)(5) Identification of data gaps and uncertainty within the hydrogeologic conceptual model.

The following data gaps and uncertainties have been identified in the hydrogeologic conceptual model for the MGSA Area:

- The period of record for monitoring groundwater elevations and water quality in and near the MGSA Area is limited to 2015 to present, with few exceptions. As such, potential current and historical trends in groundwater elevations and flow, low-TDS groundwater distribution and saline groundwater distribution, are not well understood. Similarly, because monitoring started shortly before a long-term pumping test that was initiated during a historic drought, the effects of pumping and climatic stress on the groundwater system are not well understood. With the exception of the test slant well pumping test, which was conducted from April 2015 to February 2018, the CEMEX well has been the only groundwater development in the MGSA Area since the 1960s. In this GSP, it is therefore assumed that current and historical groundwater conditions as well as the spatial groundwater quality distribution (i.e., extent of seawater intrusion) are generally similar; however, the data to demonstrate this conclusively are not available. MCWRA is planning to add five new monitoring well clusters with wells completed in the Dune Sand Aquifer, 180-Foot Aquifer, and 400-Foot Aquifer (Feeney and Zidar 2019). The Mitigation Monitoring and Reporting Program (MMRP) for the proposed MPWSP includes monitoring of these wells, the existing MPWSP monitoring wells, and a number of other existing wells in the vicinity by MCWRA. During preparation of its GSP for the Monterey Subbasin (due 2022), MCWD GSA plans to assess the adequacy of this monitoring network. MGSA will review the results of this analysis and update the monitoring networks for this GSP as needed to maintain a consistent monitoring approach across GSPs.

- Little information is available regarding the nature and hydraulic properties of the Deep Aquifer system, which includes multiple aquifer units spanning a vertical interval of approximately 1,300 feet. Specifically, the interconnection between the disparate aquifer units in this system, how they are recharged, and the extent of potential leakance from the overlying upper aquifer system are not well understood. Groundwater flow patterns within the Deep Aquifer are not well characterized. The competence of the system of aquitards overlying the Deep Aquifer is of particular concern, as is the aquifer's potential connection to seawater offshore in Monterey Canyon. MCWRA, SVBGSA and MCWD GSA are discussing plans to further investigate the Deep Aquifer system. Although no investigations have been scheduled at this time, there is consensus that better characterization of the Deep Aquifer system is needed early during the GSP implementation process. MGSA will review the results of this investigation and refine the approach to management of the Deep Aquifer consistent with the pertinent findings.

- The available data suggest that the vicinity of the MGSA Area has not experienced significant subsidence. However, the data are insufficient to assess the potential vulnerability of this area to future subsidence if groundwater extractions are increased. MGSA will work with SVBGSA to address this data gap during GSP implementation.

- While projected groundwater elevations in the Dune Sand Aquifer are less than 20 feet below the thalweg in the lower reach of the Salinas River, which suggests the river and aquifer may be

hydraulically interconnected, the nature and degree of the interconnection is not known. SVBGSA is planning to conduct an evaluation of surface water – groundwater interaction, which would include the use of existing shallow wells near the river, and installation of new monitoring wells at up to two locations. After SVBGSA's well construction and data analysis has been conducted, the need for additional information regarding surface water – groundwater interaction will be evaluated by MGSA.

- The response and susceptibility of GDEs to groundwater elevation declines varies depending on local hydrology, soil conditions, the plant species involved and other factors. A correlation between groundwater elevations and GDE stress or habitat quality has not been established.

- The nested monitoring wells installed in and near the MGSA Area for the potential MPWSP have relatively long screen intervals: screen lengths in the Dune Sand Aquifer average 36 feet, screen lengths in the 180-Foot Aquifer average 110 feet, and screen lengths in the 400-Foot Aquifer average 59 feet. While this provides useful aggregate data, depth discreet measurements may be needed to better understand the vertical distribution of lower TDS groundwater in the shallow portions of the 180-Foot Aquifer at and near the MGSA Area. Depth discrete data could be collected either with the installation of new monitoring wells with shorter screen intervals, using passive diffusion bags, induction logs, or other sampling techniques on existing monitoring wells.

- The AEM geophysical surveys provided a snapshot in time of subsurface conditions. Additional geophysical surveys may be needed to evaluate changes in the saltwater wedge over time in the vicinity of the MGSA Area.

- The USGS SVIHM model is being developed, in part, to assist with establishing water budgets for areas within the 180/400 Foot Subbasin. The calibrated model report has not been released to date. Once the SVIHM model is published, the model output will be used to update the current and projected regional water budgets by the SVBGSA. Because MGSA has adopted the SVBGSA water budgets for the MGSA GSP, the SVIHM model will also be used to update the MGSA GSP water budgets.

- A groundwater model that can simulate solute transport and density-driven flow, and that incorporates the heterogeneity of the aquifer system in the Marina area is not available at this time. As such, the potential impacts of significant and prolonged pumping, such as for the proposed MPWSP, on the local water budget, water quality and seawater intrusion cannot be adequately evaluated. Before substantial groundwater extraction is implemented in the MGSA Area, there would be a need for a locally refined groundwater flow model that is able to simulate solute transport and density-driven flow, and for additional targeted investigation for data gaps. MCWD GSA is currently planning to conduct such studies for the area that includes their GSA boundaries and the surrounding region, including the MGSA Area and beyond. MGSA

will collaborate with and review these studies, and update the HCM, sustainable management criteria, monitoring networks and management actions in this GSP to assure the sustainability goals are met.

3.2 CURRENT AND HISTORICAL GROUNDWATER CONDITIONS

Regulation Requirements:
§354.16 Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

This section describes current and historical groundwater conditions in the MGSA Area and the broader 180/400 Foot Aquifer Subbasin. In accordance with the SGMA regulations (23 CCR § 354.16), current conditions are representative conditions occurring after January 1, 2015. By implication, historical conditions are any conditions occurring prior to January 1, 2015. This chapter focuses on summarizing information required by the SGMA regulations, and that provides the necessary context for developing an effective GSP. Little data are available in the MGSA Area and its vicinity prior to 2015; however, as discussed in Section 3.1.13, it is reasonable to assume that historical conditions prior to this time were similar to current conditions. Therefore, the data discussed in this Section is assumed to represent both historical and current conditions. Data from prior to 2015 are discussed to the extent available.

3.2.1 GROUNDWATER LEVEL DATA

Regulation Requirements:
§354.16(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:
1. Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.
2. Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

Groundwater elevations in the Salinas Valley are highly dependent on two sources of climatic variability:

- Annual variation between wet season and dry season that is reinforced and amplified by agricultural irrigation; and
- Wet and dry climatic cycles, characterized by multi-year drought and wet cycles, with a complete cycle often lasting a decade or more.

3.2.1.1 DATA SOURCES

Groundwater elevation data have been collected by the MCWRA on a regional scale since 1944; however, until the installation of monitoring wells to support the MPWSP slant well pumping test in 2015, very little water elevation data is available in the vicinity of the MGSA Area.

The MCWRA regularly collects groundwater elevation measurements from 166 locations in the 180/400 Foot Aquifer Subbasin for various monitoring programs (Section 2.2.1.1). The groundwater elevation

data are primarily from privately-owned wells and are subject to confidentiality agreements between the well owners and MCWRA. Only one well currently monitored by MCWRA is located southwest of the Salinas River within about 2 miles of the MGSA Area, and data from this well is publicly available through other programs. Therefore, confidential MCWRA data are considered in this GSP only in the assessment of regional groundwater elevations and flow direction and are not individually mapped or reported.

MCWRA collects groundwater elevation data at specific times of the year to understand seasonal changes and monitor longer term trends in specific areas. Some of the wells actively monitored for water elevations are equipped with pressure transducers that take automated measurements hourly. Other wells are measured monthly or annually during each fall season to inform the regional measurement program, and/or annually in August to assess maximum drawdown to assess conditions at the end of the irrigation season in the area north and east of Salinas where the greatest drawdowns have occurred (MCWRA 2018a). The fall monitoring program is implemented from mid-November to mid-December. MCWRA conducts their fall measurement program to observe groundwater elevations after the irrigation season ends but before the rainy season begins (Brown and Caldwell 2015), and is believed to provide the most representative year-to-year regional comparison because groundwater elevations have recovered somewhat from the height of irrigation pumping, and are generally not yet greatly influenced by near-term recharge events during the rainy season.

MCWRA recently became the primary local Monitoring Entity for the Salinas Valley Basin under the California Statewide Groundwater Elevation Monitoring Program (CASGEM). Created by the state in 2009, CASGEM is a statewide program to collect groundwater elevations and make the data accessible to the public to support groundwater resource management. In the 180/400 Foot Aquifer Subbasin, 23 wells are monitored under the CASGEM program. Wells were selected for the CASGEM program based on their distribution throughout the basin, the availability of detailed and reliable well construction data, and access considerations (MCWRA 2015). Fifteen wells are equipped with transducers that record groundwater elevations hourly; 8 others are monitored manually on a monthly basis (MCWRA 2015). The average period of record for these wells is 10 years. The earliest groundwater elevations were recorded in 2003. One CASGEM well is located within 2 miles of the MGSA Area as shown on Figure 2-12.

The primary monitoring well network of interest for evaluation of historical groundwater elevation data near the MGSA Area includes 24 monitoring wells installed to assess the effects of test slant well pumping for the proposed MPWSP. These wells were installed in eight multi-depth clusters of three wells each completed in the Dune Sand Aquifer, 180-Foot Aquifer, and 400-Foot Aquifer. The locations of these well clusters are shown on Figure 3-24, and additional details regarding the wells are discussed in Section 5.2.1 and summarized in Table 5-1. These wells were constructed in 2015 and 2016, and include three clusters within the MGSA Area (wells MW-1, MW-3, and MW-4), and five clusters that are

about ½ mile to 4 miles from the MGSA Area boundary. Water elevation data are collected using transducers and hand measurements, and are documented in monthly reports.

The nearest long-term water elevation data collection programs in this area prior to 2015 are associated with the compliance monitoring program associated with the Monterey Peninsula Class III landfill (about 2 miles east of the MGSA Area), the site cleanup program for Fort Ord Operable Unit (OU)-1 Off-Site Plume (about 1.5 to 2.5 miles to the southeast of MGSA), and the cleanup program for the Fort Ord Carbon Tetrachloride Plume (OUCTP) (about 1 to 1.5 miles southeast of the MGSA). The locations of these wells are shown on Figure 3-25. As discussed below, the shallow monitoring wells associated with these programs appear to be completed in locally distinct shallow aquifer areas within the footprint of the Dune Sand Aquifer, but data from the wells was considered in the assessment of groundwater elevation and flow conditions. A few wells associated with the Fort Ord OU-1 Off-Site Plume were apparently completed in the 180-Foot Aquifer; however, these wells were destroyed in 2011. Monitoring of the remaining Fort Ord wells was discontinued in 2014 and 2015. The Fort Ord OUCPT wells continue to be monitored, and several are completed in the 180-Foot Equivalent Aquifer.

3.2.1.2 GROUNDWATER ELEVATION CONTOURS AND HORIZONTAL GROUNDWATER GRADIENTS

To assess groundwater elevation contours, regional contour maps prepared by MCWRA for 2015 and 2017 were reviewed, and local conditions were assessed by preparing several groundwater elevation maps for the MGSA Area and its vicinity. For the MGSA Area, groundwater elevation maps were developed using data from local groundwater monitoring wells during times when data were available. Water elevation maps were prepared for three periods:

- Prior to test pumping of the test slant well to document conditions at the end of the period when only the CEMEX well was being pumped in the MGSA Area (March 20, 2015);
- During the period of test pumping of the test slant well (March 12, 2017); and
- After the cessation of test slant well pumping, during a period with no pumping except by the CEMEX well (April 2, 2018).

Groundwater elevation maps were prepared for each of the three monitored zones on each of these three dates for a total of nine water elevation maps:

- Dune Sand Aquifer (Figure 3-25, Figure 3-26, and Figure 3-27);
- 180-Foot Aquifer (Figure 3-28, Figure 3-29, and Figure 3-30); and
- 400-Foot Aquifer (Figure 3-31, Figure 3-32, and Figure 3-33).

REGIONAL GROUNDWATER LEVELS AND GRADIENTS

Regionally, MCWRA publishes groundwater elevation contour maps for the Salinas Valley Groundwater Basin in odd-numbered years using data from the fall measurement programs. In the 180/400 Foot

Aquifer Subbasin, MCWRA produces separate contour maps for the 180-Foot and 400-Foot Aquifers. The maps extend from Chualar to the mouth of the Salinas River and include both the East Side Aquifer Subbasin and the 180/400-Foot Aquifer Subbasin. Contour maps cover 1994 through 2017 (after 1994 the maps were published in odd numbered years). Proximal to the MGSA Area, depending on the year, the closest contours for the 180-Foot Aquifer are typically drawn 1 to 2 miles from the northeastern edge of the MGSA Area, and the closest 400-Foot Aquifer contours are typically drawn within 2,000 feet of the MGSA Area. The contour intervals are generally about 10 feet, and provide a regional understanding of groundwater flow in the area. For confidentiality reasons, the maps do not plot the wells or groundwater elevation data used to construct the contours. The 1994, 2007, 2015, and 2017 contour maps are included in Appendix 3.A.

The primary feature documented in both the 180-Foot/Shallow East Side Aquifers and 400-Foot/Deep East Side Aquifer maps is a groundwater depression located north of Salinas with groundwater elevations generally -80 to -120 feet msl. Groundwater elevations are generally below sea level for most of the area covered by the maps extending back to 1994. East of the MGSA Area groundwater elevations are generally interpreted to be -10 to -20 feet msl with some years as low as -30 feet msl (for example 2007). The 2017 contour map for the 180-Foot Aquifer indicates an inland flow direction over a broad region surrounding the MGSA Area with a gradient of 0.0014. A similar flow pattern is interpreted for the 400-Foot Aquifer, with a gradient of 0.0013. These groundwater flow data are based on widely spaced wells, and should be considered generalizations for the MGSA Area.

Insufficient data currently exist to map flow directions and groundwater elevations in the Deep Aquifer, and MCWRA does not produce groundwater elevation maps of the Deep Aquifer.

LOCAL DUNE SAND AQUIFER GROUNDWATER LEVELS AND GRADIENTS

For the Dune Sand Aquifer, the March 20, 2015 groundwater elevation contour map includes data for the individual MPWSP wells installed prior to that time (MW-1S, MW-3S, MW-4S and MW-5S), monitoring wells at the Monterey Peninsula Class III Landfill (“Minus 2-Foot Aquifer”) about 2 miles east of the MGSA Area, and monitoring wells for the Fort Ord OU-1 Off-Site Plume (“A-Aquifer”) southeast of the MGSA Area. Based on the groundwater elevation data, the Fort Ord A-Aquifer monitoring wells appear to be completed in a local perched aquifer with groundwater elevations that are about 30 to 40 feet higher than groundwater elevations in the surrounding area. At the landfill, groundwater elevations in the landfill area may be affected by multiple perched layers, the drainage control systems for landfill hydraulic containment, and other factors (RMC Geoscience, Inc., 2019), and are lower than expected. Groundwater flow direction and gradient are influenced by the Salinas River and by pumping from the landfill water supply wells. Groundwater flow is also locally influenced by surface water recharge associated with the storm water percolation pond, the relatively poor drainage conditions south of the landfill whereby water is routed around the landfill in unlined surface channels, and by pumping from the site water supply wells (RMC Geoscience, Inc. 2019).

Due to the sparsity of datapoints to extrapolate groundwater elevations in the Dune Sand Aquifer on this date, the available data were posted, but were not contoured. For the remaining Dune Sand Aquifer groundwater elevation contour maps (March 12, 2017 and April 2, 2018), it was found that groundwater elevations measured in well MW-5S differed from the surrounding wells and may be representative of a local perched zone. Well MW-9S is located north of the Salinas River. Groundwater elevations in this well are generally consistent with what would be expected based on the other wells to the south of the river; however, to avoid conjecture about the effect of river seepage on groundwater elevations in this area, the contours were terminated south of the river. Finally, well MW-6S is located approximately 3.5 to 4 miles southeast of the MGSA Area next to the Salinas River. The pronounced difference between the March 2017 and March 2018 groundwater elevations in this well suggest it may be affected by river stage. In addition, it is located a considerable distance from the MGSA Area. For these reasons, only water elevation data for MW-1S, MW-3S, MW-4S, MW-7S, and MW-8S were contoured.

The direction of groundwater movement in the Dune Sand Aquifer was toward the ocean to the west-northwest in March 2017 with a gradient of about 0.0005, and toward the ocean to the northwest with a gradient of about 0.0006 in April 2018 (Figure 3-25 through Figure 3-27). Near the coast in wells MW-1S and MW-3S, groundwater elevations increased by approximately 7 feet and 1 foot, respectively between March 2017 and April 2018. This may indicate the re-establishment of a seepage face at the shoreline after the cessation of the test slant well pumping program.

LOCAL 180-FOOT AQUIFER GROUNDWATER LEVELS AND GRADIENTS

For the 180-Foot Aquifer, the March 20, 2015 map includes groundwater elevation data for MPWSP wells MW-1M. MW-3M, MW-4M and MW-5M, only. Wells MW-6M, MW-7M, MW-8M, and MW-9M had not yet been installed in March 2015. Due to the sparsity of data, groundwater elevations were not contoured. For the remaining maps (March 12, 2017 and April 2, 2018), groundwater elevation data for wells MW-1M, MW-3M, MW-4M, MW-5M, MW-7M, MW-8M, MW-9M were contoured. Well MW-6M is located a considerable distance from the MGSA Area with no intervening wells; therefore, data for these wells were posted but were not considered in contouring.

The direction of groundwater movement in the 180-Foot Aquifer was landward in March 2017 with an apparent groundwater divide (mound) beneath the agricultural land east of the MGSA. Groundwater gradients were northeast and southeast away from the divide. The March 2017 gradient near the MGSA Area was about 0.0006. In April 2018, an apparent mound was again observed east of the MGSA area, but its southeastern flank was not resolved by the data. The gradient was about 0.0009 in in a landward direction in the vicinity of the MGSA Area (Figure 3-28 through Figure 3-30).

Please note that proposed SVBGSA Priority Management Actions and Preferred Projects include in lieu recharge and direct recharge projects with expected benefits including “arresting the decline, or raising, groundwater elevations” (SVBGSA 2019). For the 180-Foot Aquifer, SVBGSA has estimated a groundwater elevation rise of about 3.5 feet in the vicinity of the Salinas River and 2 feet in the vicinity

of the MGSA as a result of implementing the projects and management actions in their GSP (SVBGSA 20219). Raising groundwater elevations could change groundwater flow gradients, and potentially flow directions in the 180-Foot Aquifer.

LOCAL 400-FOOT AQUIFER GROUNDWATER LEVELS AND GRADIENTS

For the 400-Foot Aquifer, the March 20, 2015 groundwater elevation map includes data for MPWSP wells MW-1D. MW-3D, MW-4D and MW-5D, and State well 14S02E08M002M (located near Neponset, where Highway 1 crosses the Salinas River). Wells MW-6M(L), MW-7D, MW-8D and MW-9D had not yet been installed in March 2015. Due to the sparsity of data, groundwater elevations were not contoured. For the remaining maps (March 12, 2017 and April 2, 2018), groundwater elevation data for wells MW-1D, MW-3D, MW-4D, MW-5D, MW-7D, MW-8D, MW-9D were contoured. Well MW-6M(L) is located a considerable distance from the MGSA Area with no intervening wells and was determined to be within the lower 180-Foot Aquifer, rather than the 400-Foot Aquifer (HWG 2017). In addition, groundwater elevations in State well 14S02E08M002M were different than expected based on the surrounding wells, suggesting it is reflective of different hydrostratigraphic intervals than the MPWSP monitoring wells. For these reasons, data for these two wells (MW-6M(L) and State well 14S02E08M002M were posted but were not considered in contouring. For March 2017 and April 2018, the direction of groundwater flow was landward. The gradient was east with a magnitude of approximately 0.0008 in March 2017, and east-southeast with a magnitude of 0.0006 in April 2018. A slight groundwater mound was present beneath the agricultural land east of the MGSA Area (Figure 3-31 through Figure 3-33).

As noted above, proposed SVBGSA Priority Management Actions and Preferred Projects include *in lieu* recharge and direct recharge projects with expected benefits including "arresting the decline, or raising, groundwater elevations" (SVBGSA 2019). For the 400-Foot Aquifer the SVBGSA has estimated a groundwater elevation rise of about 3.5 feet in the vicinity of the Salinas River and 3 feet in the vicinity of MGSA as a result of implementing the projects and management actions in their GSP (SVBGSA 2019). Raising groundwater elevations could change groundwater flow gradients, and potentially flow directions in the 400-Foot Aquifer.

3.2.1.3 AQUIFER HYDROGRAPHS

Representative temporal trends in groundwater elevations can be assessed with hydrographs – graphs that plot changes in groundwater elevations in a well over time. Groundwater-elevation data from wells within the Subbasin are available from monitoring conducted and reported by MCWRA and in many cases span a period of decades. Hydrographs for the eight MPWSP monitoring wells are available from monitoring reports published for that project. The MPWSP well hydrographs cover the period from early 2015, prior to initiation of test slant well pumping, to the present.

REGIONAL HYDROGRAPHS

MCWRA measures water elevations at more than 90 wells on a monthly basis throughout the Salinas Valley to monitor seasonal groundwater elevation fluctuations. Data from approximately 50 of these

wells are compiled in MCWRA quarterly reports (included in MCWRA 2015, 2016, 2017, 2018). The water elevation measurements are categorized by hydrologic subarea, averaged, and graphed (average hydrographs) to compare current water elevations with selected past conditions. Hydrographs for individual subareas (such as the 180-Foot Pressure and the 400-Foot Pressure subareas) are prepared showing the current year's water elevation conditions, the previous year's conditions, and reference dry conditions. Beginning in 1985, MCWRA produced composite hydrographs showing groundwater elevations for five wells in the 180-Foot Aquifer and 11 wells in the 400-Foot Aquifer to provide perspectives general seasonal and inter-annual groundwater elevation trends. The MCWRA annual reports for 2015 through 2017 compared these composite hydrographs to monthly averages for 1985, and the 2018 annual report included a comparison to monthly averages over 30 years (WY1987-WY2017). A summary table is provided below.

TABLE 3-2. COMPOSITE HYDROGRAPHS SUMMARY FOR THE PRESSURE 180-FOOT AND 400-FOOT AQUIFERS

Area	Water Year	September Average Depth to Water (feet)	September Average Groundwater Elevation* (feet msl)	One-Year Average Change (feet)	Change from WY 1985 (feet)	Difference from 30 Year Average* (feet)	1 Month Change (feet)
Pressure 180-Foot Aquifer	2015	69	NA	down 7	down 18	NA	up 1
	2016	68	NA	no change	down 17	NA	up 1
	2017	58	NA	up 11	down 6	NA	up 1
	2018	NA	5	up <1	NA	down 1	up 4
Pressure 400-Foot Aquifer	2015	59	NA	down 4	down 2	NA	up 2
	2016	57	NA	up 1	down 1	NA	up 2
	2017	49	NA	up 8	up 7	NA	up 3
	2018	NA	-9	down 1	NA	up 4	up 3

Compared to 30-year averages, September 2018 groundwater elevations in the 400-Foot Aquifer were 4 feet higher, and the September 2018 groundwater elevations in the 180-Foot Aquifer were less than 1 foot lower, indicating average stable to somewhat recovering conditions. The composite hydrographs are included in Appendix 3.B.

Hydrographs for eight individual wells in the 180/400 Foot Aquifer Subbasin monitored by MCWRA within approximately 7 miles of the MGSA Area that are not limited by confidentiality agreements are included in Appendix 3.C. The hydrographs provide information on specific wells in the northern 180/400 Foot Aquifer Subbasin and provide subregional information about groundwater elevation trends surrounding the MGSA Area. The locations of these wells are shown in the Appendix. A summary of the individual well hydrographs is provided in Table 3-3.

TABLE 3-3. SUMMARY OF WELL HYDROGRAPHS IN THE NORTHERN 180/400 FOOT AQUIFER SUBBASIN

Well	Period of Record	Aquifer	Difference between Lowest and Highest Elevation (feet)	General Water Level Trend
13S/02E-21Q01	2004 to present	180-Foot	4	stable
14S/02E-03F04	2004 to present	180-Foot	21	declining since 2006
14S/02E-04G02	2000 to present	400-Foot	28	stable to slightly declining
14S/02E09D04	1999 to present	400-Foot	16	stable to slightly declining
14S/02E-15A01	1983 to present	400-Foot	68	declining since 1999
14S/02E-17B03	1999 to present	400-Foot	14	stable
14S/02E-22L01	1993 to present	400-Foot	44	declining since 1999
14S/02E-26H01	2004 to present	180-Foot	44	declining since 2006

Based on the data presented in Appendix 3.C, groundwater elevations in six of eight MCWRA wells within 7 miles of MGSA Area are generally declining over the period of record.

For the Deep Aquifer, MCWRA currently monitors groundwater elevations at 13 locations with varying frequency. Five of the groundwater elevation data collection points are monitoring wells equipped with continuously-recording pressure transducers, and the remaining eight groundwater elevation data collection points are production wells manually monitored on either a monthly (seven wells) or annual (one well) basis. MCWRA analysis of average Deep Aquifer groundwater elevation changes in a subset of wells near the coast indicates that average groundwater elevations generally declined and fell below sea level until the Castroville Seawater Intrusion Project (CSIP) began operations in 1998. Following startup of the CSIP, average groundwater elevations rapidly increased and rose above sea level, then leveled off until approximately 2006. After 2006, average groundwater elevations began to decline once again and are currently below sea level (Figure 3-34).

LOCAL HYDROGRAPHS IN AND NEAR THE MGSA AREA

Appendix 3.D provides copies of the groundwater elevation hydrographs and specific conductance plots for the 24 monitoring wells constructed for the proposed MPWSP. The hydrograph plots group the shallow, middle, and deep wells in each cluster, providing both time-series and vertical gradient information from February 2015 through May 2019. The shallow wells are generally designated Dune Sand Aquifer wells, the middle wells are generally 180-Foot Aquifer wells, and the deep wells are generally 400-Foot Aquifer wells. Well hydrographs are provided for wells MW-1, MW-3, and MW-4 within the MGSA Area, and wells MW-5, MW-6, MW-7, MW-8, and MW-9 located to the east.

Conclusions from review of the hydrographs are provided below:

- Well MW-5S is located at a higher elevation and displays groundwater elevations that are substantially higher than other wells in the surrounding area. This well appears to be associated with a perched aquifer within the footprint of the Dune Sand Aquifer.

- There is little difference in the groundwater elevations for wells MW-6M and MW-6D. The designation for the latter was changed to well MW-6M(L) in recent MPWSP reports, recognition of the fact that it is completed in the lower 180-Foot Aquifer.

- In well clusters MW-7, MW-8 and MW-9, there is less separation between the hydrographs for the middle (M) lower (D) wells than in well clusters MW-1, MW-3, and MW-4, indicating the 180/400-Foot Aquitard may be less competent or absent in this area, as also documented by the AEM surveys in this area (Section 3.1.12).

- In well clusters MW-1 and MW-3, there is less separation between the shallow (S) and middle (M) hydrographs than in well located further east, reflecting the previously documented lack of the SVA in this area.

- In wells MW-6S, MW-8S, and MW-9S there is a groundwater elevation spike in late 2016 and early 2017, with the biggest rise observed at MW-6S (from about 7 feet msl to 17 feet msl). This rise in groundwater elevations occurs at about the same time as a significant stage height increase in Salinas River measured at the USGS Spreckels gaging station (#11152500) from less than 2 feet to 20 feet (web site https://waterdata.usgs.gov/ca/nwis/uv?site_no=11152500). These three wells, especially MW-6S, appear to respond to changes in the stage height of the Salinas River. This indicates that, at least during major rainfall events, the Salinas River is a losing river at MW-6, MW-8 and MW-9 which recharges the shallow aquifer. The immediacy of the response suggests a surface-groundwater interconnection.

- There is a cyclical pattern of high groundwater elevations in the winter/spring and low elevations in the summer/fall. Differences between seasonal high (spring) and low (summer/fall) groundwater elevations vary by completion interval and generally increase in

amplitude with depth. The average amplitude of the seasonal groundwater elevation fluctuation is approximately 0 to 4 feet in the Dune Sand Aquifer, 1.5 to 10 feet in the 180-Foot Aquifer, and 10 to 24 feet in the 400-Foot Aquifer. These seasonal changes are consistent with regional temporal recharge and pumping patterns.

- To further assess the seasonal and inter-annual variability in groundwater levels related to different water year types, groundwater level data from spring and fall 2017 and spring and fall 2018 were compared. The 2017 data represent a wet year (23.0 inches of precipitation compared to the long-term average of 16.9 inches) during pumping of the test slant well, and 2018 data represent a dry year (12.6 inches of precipitation) after shut down of the slant test well pumping in February 2018. Summer/fall groundwater level declines were within the general ranges noted above for both years. In some cases, seasonal groundwater level declines were greater in 2017 than in 2018, but average declines were within were within 1 foot of each other. Spatially, for the 180- and 400-Foot Aquifers, average groundwater level declines were approximately 5 to 6 feet greater in the more easterly wells (MW-5, 6 and 9) than in wells further to the west (MW-4, 7 and 8), leading to greater landward gradients in the summer/fall in these aquifers than in the spring. The interpreted groundwater flow directions for the 180-Foot and 400-Foot Aquifers in the fall of 2017 and 2018 were generally consistent with the spring 2017 and 2018 flow directions discussed in Section 3.3.1.2. In the Dune Sand Aquifer, a consistent pattern in the spatial differences between spring and summer/fall groundwater levels was not evident during either year, and interpreted groundwater flow directions were consistently seaward.

- Groundwater elevations noticeably declined in the Dune Sand Aquifer and 180-Foot Aquifer near the test slant well in the MGSA Area during the pumping test between April 2015 and February 2018. Groundwater elevations declined by approximately 8 feet in MW-1S and MW-1M, and by 3 feet in MW-3S and MW-3M, but recovered after the long-term test was discontinued in February 2018 and have remained relatively stable since then. For the remaining monitoring wells (1,920 to 21,500 feet from the test slant well) pumping-related drawdown was too gradual to be readily distinguishable; however, groundwater elevations in most of these wells appeared to show a relatively abrupt recovery (or rebound) when long-term pumping was temporarily discontinued in March of 2016 and at the end of the long-term test pumping in April 2018, indicating these wells were subject to drawdown related to the test. Recovery in all of the 180-Foot Aquifer and 400-Foot Aquifer monitoring wells was abrupt and distinct, and ranges from approximately 2 to 5 feet in the 400-Foot Aquifer, and 1 to 4 feet in the 180-Foot Aquifer. This observation is consistent with a hydraulic connection between the 180-Foot and 400-Foot Aquifer systems and lower storativities in the 400-Foot Aquifer system compared to the 180-Foot Aquifer system. Recovery in the six Dune Sand Aquifer wells located east of the MGSA Area was generally more muted and approximately 1.5 feet or less. An abrupt response was observed in two wells during the first recovery event (MW- 8S and MW-9S), a

muted/slight response was observed in one monitoring well during both recovery events (MW-4S) and one monitoring well during the first recovery event (MW-6S), and no response was observed in to monitoring wells (MW-6 and MW-7). Although these muted responses are more difficult to distinguish from recovery related to other causes, such as recharge events or the cessation of other pumping, their observed correlation with the cessation of pumping at the test slant well and responses in deeper aquifers is a strong indicator the Dune Sand Aquifer is hydraulically influenced by the underlying aquifer system and was affected by pumping the test slant well. This is consistent with modeling for the proposed MPWSP, which indicates pumping from the Dune Sand and 180-Foot Aquifers to supply water for the project from the MGSA Area is expected to result in drawdown ranging from 1 to 5 feet in the Dune Sand Aquifer between the MPWSP and the Salinas River (ESA 2018).

- Seasonal high groundwater elevations in some of the shallow monitoring wells in the agricultural areas east of the MGSA Area occur later than in deeper wells in the same cluster. For example, seasonal high groundwater elevations in well MW-7S occur approximately 80 to 120 days later than in wells MW-7M and MW-7D. A similar, less pronounced pattern is observed for well MW-8S. This shift may be related to recharge from the deep percolation of irrigation water near these well locations.

3.2.2 ESTIMATE OF GROUNDWATER STORAGE CHANGES

Regulation Requirements:
§354.16(b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.

A graph depicting regional groundwater storage change in the 180/400 Foot Aquifer Subbasin presented in the SVBGSA's regional GSP (SVBGSA 2020) is presented as Figure 3-35. Although groundwater storage, as plotted on the figure, has shown both decreasing and increasing short term trends since the 1940s, overall, Subbasin storage has displayed a decreasing trend. During the recent drought between 2012 and 2016, groundwater storage is estimated in SVBGSA's graph to have decreased by approximately 54,000 AF, to a cumulative maximum depletion since 1940 of 115,000 AF. In 2017, storage recovered by approximately 24,000 AF, indicating that, as had occurred on several past occasions during the period of record, that significant storage recovery is possible within a relatively short period of time.

In the MGSA Area, groundwater elevation data are only available since 2015, and during the period for which data are available, a long-term pumping test of the test slant well for the potential MPWSP was conducted. During this test, approximately 5,450 acre-feet (AF) of groundwater were extracted through September 21, 2017 from the DSA and 180-Foot Aquifer (HWG, 2017), consisting of saline groundwater originating beneath the Pacific Ocean outside the Subbasin boundaries, and a significant but unknown quantity of saline groundwater and low TDS groundwater from the landward side of the Dune Sand and

180-Foot Aquifers within the Subbasin. With the exception of MW-5S, MW-5M and MW-5D, groundwater elevations for the area east of the MGSA are unavailable prior to the pumping test, so an estimate of saline and low-TDS groundwater storage reduction in this area as a result of test slant well pumping is not possible. Since the cessation of test slant well pumping in February 2018, groundwater elevations in some of the monitoring wells east of the MGSA Area have increased slightly; whereas others have decreased, so no clear trends indicating long term storage recovery is evident.

Gottschalk *et al.* (2018) estimated the amount of low-TDS groundwater (defined as "potential drinking water" based on an interpreted TDS concentration less than 3,000 mg/L) in storage in the AEM-surveyed area as 550,000 AF. This includes 188,000 AF in the Dune Sand Aquifer, 291,000 AF in the upper 180-Foot Aquifer, 47,000 AF in the lower 180-Foot Aquifer, and 21,000 AF in the 400-Foot Aquifer. This includes low TDS groundwater identified within the MGSA Area, east of the MGSA Area in the 180-Foot Aquifer Subbasin, southeast of the MGSA Area in the Monterey Subbasin, and north of the area of seawater intrusion in the 180-Foot Aquifer Subbasin. It does not include potential low TDS groundwater in a large area of Dune Sand Aquifer within the Monterey Subbasin southeast of the MGSA Area that could not be surveyed by AEM methods because helicopter overflights were not permitted. These estimates represent a single snapshot in time, but could be used as a baseline to estimate future low TDS groundwater storage changes if the geophysical surveys are updated.

3.2.3 SEAWATER INTRUSION

Regulation Requirements:
§354.16(c) Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.

3.2.3.1 BACKGROUND

Regionally, the 180-Foot and 400-Foot Aquifers have been subject to seawater intrusion for more than 75 years and the 400-Foot Aquifer for 60 years, as demonstrated by increased salt content in wells near the Monterey Bay coastline. The negative impact of seawater intrusion on local water resources and the agricultural economy has been the primary motivation for many studies dating back to 1946 (DWR 1946). MCWRA and others have implemented a series of engineering and management projects including well construction moratoriums, developing the CSIP system, and implementing the Salinas Valley Water Project (SVWP), among other actions to halt seawater intrusion. Although those actions have managed to slow the advance of intrusion and reduce its impacts, seawater intrusion remains an ongoing threat.

The definition of seawater intrusion is generally based on a chloride concentration threshold and is dependent on local beneficial uses and groundwater protection strategies. In the Salinas Valley Groundwater Basin, MCWRA has defined the seawater intrusion threshold as 500 mg/L of chloride. This chloride concentration is significantly lower than the 19,000 mg/L chloride concentration typical of seawater, but it represents a concentration that may begin to impact use of the water. However, the

500 mg/L chloride definition has limited applicability in other circumstances. First, it is entirely possible that in an aquifer area where seawater intrusion has occurred at 500 mg/L chloride, that there will be large groundwater areas within the 500 mg/L impacted area that have higher quality groundwater than at the leading edge. For example, the chloride concentrations detected in wells MW-5M and 6M(L), located within the mapped seawater intrusion zone of the 180-Foot Aquifer, and well MW-9D, located within the mapped seawater intrusion zone of the 400-Foot Aquifer, contain chloride concentrations wells below the 500 mg/L threshold (see Figures 3-17, 3-18, 3-36 and 3-37). Second, although this definition may represent a practical standard for identifying groundwater affected by seawater intrusion, the affected groundwater quality may well be sufficient for many beneficial uses. In other words, the seawater intrusion front defined using the 500 mg/L chloride threshold is a useful guideline for identifying when some seawater affect may be detected, this does not mean that the groundwater within the affected region is no longer suitable for any current or potential beneficial uses.

Specifically, the following beneficial use standards apply to groundwater within the seawater intruded area of the Subbasin:

- Under SWRCB Resolution No. 88-63, the state considers all groundwater containing TDS at concentrations less than 3,000 mg/L as having a potential beneficial use as ("suitable for") a domestic and municipal supply. This Resolution is adopted as part of RWQCB's Water Quality Protection Plan for the region.

- SWRCB Resolution No. 68-16, also known as the Antidegradation Policy, requires that the existing high quality of waters be maintained to the maximum extent possible, and allows degradation only if it is consistent with maximum benefit to the people of the state, will not unreasonably affect present and potential beneficial uses, and will not result in water quality lower than applicable standards.

- For water containing TDS or chloride in excess of drinking water standards, treatment would be required prior to use. It should be noted is not uncommon for municipal or domestic supply systems to treat water prior to potable use. The State of California has adopted an upper Secondary Maximum Contaminant Level (SMCL) of 1,000 mg/L TDS and 500 mg/L chloride, and a short-term maximum SMCL of 1,500 mg/L TDS and 600 mg/L chloride. United States Environmental Protection Agency's (EPA's) and California's recommended maximum secondary limit is 500 mg/L TDS and 250 mg/L chloride. TDS and chloride concentrations in groundwater ranging to the "upper" contaminant level are acceptable if it is neither reasonable nor feasible to provide more suitable water sources. However, for purposes of determining whether groundwater is suitable for domestic and municipal water purposes, SWRCB Resolution No. 88-63, which is incorporated in the RWQCB's Basin Plan, governs over all other standards.

- The Federal Clean Water Act defines groundwater containing less than 10,000 mg/L TDS as an Underground Source of Drinking Water.

An additional important consideration is that the salt concentration at which seawater intrusion is defined in the Subbasin is much lower than the TDS concentration in seawater, which is approximately 35,000 mg/L, and is much lower than the concentration at which gravity-driven flow following Ghyben-Herzberg dynamics would occur (Section 3.1.12). The gravity-driven interface dynamics which occur near the MGSA Area differ from the advective solute transport that characterizes seawater intrusion in more inland areas, where the intruding water has a much lower TDS concentration and density. In these inland areas, dissolved solids essentially behave as a tracer that follows groundwater flow. The "seawater intrusion front" defined by the 500 mg/L chloride isoconcentration contour in the inland area is not expected to follow Ghyben-Herzberg dynamics. It is also important to note that the potential migration of the Ghyben-Herzberg interface in the nearshore environment, which cannot be defined using a 500 mg/L chloride contour, can nevertheless have important implications on the stability and migration of the 500 mg/L chloride isoconcentration contour in the inland areas.

3.2.3.2 Extent and Advance of Seawater Intrusion

The extent and advance of seawater intrusion over time has been well-monitored and reported by MCWRA. Monitoring seawater intrusion has been ongoing since the Agency formed in 1947 and currently includes a network of 96 agricultural wells and 25 dedicated monitoring wells that are sampled twice annually: in June and August. The water samples are analyzed for general minerals; the analytical results are used by MCWRA to analyze and report the following:

- Maps and graphs of historical chloride and specific conductivity trends;
- Stiff diagrams and Piper diagrams; and
- Plots of chloride concentration vs. sodium chloride molar ratio trends.

MCWRA publishes estimates of the extent of seawater intrusion every two years based on the inferred location of the 500 mg/L chloride concentration. MCWRA has developed regional maps of the current and historical extent of seawater intrusion for the 180-Foot Aquifer and the 400-Foot Aquifer. Maps showing the progression of the seawater intrusion front over time up to 2015 in the 180-Foot and 400-Foot Aquifers are presented as Figure 3-36 and Figure 3-37, respectively. These maps were augmented by MGSA to include approximate outlines of the zones of "low TDS groundwater" identified during the AEM survey (Gottschalk *et al*. 2018) on top of MCWRA seawater intrusion maps. Using a standard of 3,000 mg/L TDS to define seawater intrusion into the Dune Sand Aquifer, these figures also show the advance of seawater intrusion into the Dune Sand Aquifer. In each of the two figures, the extent of the color shaded contours represents the extent of groundwater with chloride exceeding 500 mg/L during the referenced year. The maps indicate that seawater intrusion has migrated inland (eastward) in a bilobate zone. In the northern lobe, approximately centered between the current mouth of the Salinas River and Elkhorn Slough, seawater intrusion has progressed inland for a distance of approximately 7.5 miles in the 180-Foot Aquifer and 3 miles in the 400-Foot Aquifer. In the southern lobe, approximately centered on the City of Marina, seawater intrusion has progressed inland approximately 4.5 miles in the

180-Foot Aquifer and 4 miles in the 400-Foot Aquifer. Several "chloride islands were first observed in the 400-Foot Aquifer on the landward side of the previously identified seawater intrusion front, and reflect the vertical migration of seawater intrusion through gaps in the 180/400-Foot Aquitard where the 180-Foot Aquifer and the 400-Foot Aquifer are in direct connection, and/or where vertical migration takes place through wells that have been improperly constructed or boring have been improperly abandoned and serve as conduits that connect the aquifer systems.

Continued seawater intrusion is driven by a large trough north and northeast of Salinas where groundwater elevations have fallen below sea level. SVBGSA estimates of groundwater storage losses due to continued seawater intrusion in the Subbasin range from 8,000 to 14,000 AFY (SVBGSA 2019). As discussed in Chapter 2 and Chapter 6, several projects are being implemented and/or proposed by SVBGSA and others to address ongoing overdraft and seawater intrusion through *in lieu* recharge and direct recharge to reverse this trend. These projects are intended to increase the water elevation in the 180-Foot Aquifer and 400-Foot Aquifer to slow seawater intrusion. Groundwater level rises ranging from approximately 2 to 4 feet are projected between the Salinas River and the MGSA Area, decreasing to the west. Water elevation rise from future projects will decrease landward groundwater gradients, and could potentially reverse the groundwater flow direction in the 180-Foot Aquifer, and 400-Foot Aquifer depending on the extent and success of future projects and other factors.

The distribution of water quality in the Dune Sand Aquifer, 180-Foot Aquifer and 400-Foot Aquifer near the MGSA Area is discussed in Section 3.1.12, and shown graphically in Figure 3-21 to Figure 3-23. Maps showing the distribution of TDS and chloride concentrations detected in monitoring wells near the MGSA Area are shown in Figure 3-16, Figure 3-17, and Figure 3-18 for the Dune Sand, 180-Foot and 400-Foot Aquifers, respectively. As shown in these figures and discussed in Section 3.1.12, a zone of low TDS groundwater (TDS < 3,000 mg/L) exists in an approximately 8,300-acre area that is locally recharged through the Dune Sand Aquifer (Gottschalk *et al*. 2018). TDS concentrations detected in groundwater samples collected from this area in April 2019 range from 896 to 3,000 mg/L, and chloride concentrations range from 112 to 950 mg/L (Figure 3-16). This zone appears to be in a relatively stable state of equilibrium with a saline groundwater intrusion wedge whose upper contact cuts through the eastern side of the MGSA Area. Under Ghyben-Herzberg dynamics, this wedge should remain stable as long as the thickness of the overlying low TDS groundwater zone is maintained.

To date, seawater intrusion has not been reported in the Deep Aquifer. However, due to concern about the potential competence of aquitards separating this aquifer from the overlying seawater-intruded aquifers, MCWRA recommended a moratorium on further development of groundwater supplies in this aquifer (MCWRA 2017). Subsequently, the county adopted Ordinance 5302, prohibiting the construction of new wells in the Deep Aquifer beneath the areas impacted by seawater intrusion.

3.2.4 GROUNDWATER QUALITY

Regulation Requirements:
§354.16(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.

This section presents a summary of current groundwater quality conditions that are not related to seawater intrusion. MGSA does not have regulatory authority over groundwater quality and is not charged with improving groundwater quality in the Subbasin. Projects and actions implemented by MGSA are not required to improve groundwater quality; however, they must not further degrade groundwater quality. Locally, RWQCB, DTSC and Monterey County Environmental Health Bureau oversee and enforce compliance with environmental health and water quality protection regulations in the county.

3.2.4.1 POINT SOURCES OF GROUNDWATER POLLUTANTS

There are no reported contamination incidents, waste discharge sites, underground storage tank sites or other potential point sources of groundwater pollutants within the MGSA Area. There are no active point-sources of water quality pollutants or contamination plumes located within 1 mile from the MGSA; therefore, contamination plumes and point sources of pollutants are discussed narratively below, but a map is not included.

In the vicinity of the MGSA Area, there are three closed underground storage tank cleanup cases located within approximately 1 mile of the MGSA Area (SWRCB 2019). Based on their distance from the MGSA Area (at least 2,500 fee) and the fact that these cases are closed, it is unlikely that management actions or projects within the MGSA Area would result in the capture or spread of contamination from these properties. The MCWD wastewater collection facility, reclamation plant and desalination facility are located approximately 2,000 feet south of the MGSA Area and operate under Waste Discharge Requirements issued by the RWQCB. No violations or releases have been reported at these facilities.

The Ford Ord Superfund Site Operational Unit Carbon Tetrachloride Plume (OUCTP) area is located southeast of the MGSA Area. The OUCTP plume extends off the former army post into the City of Marina and the western extent of the carbon tetrachloride plume is approximately 7,000 feet southeast of the MGSA Area (Ahtna, 2019a). Recent monitoring for September 2018 (Ahtna, 2019b) includes water level and water quality monitoring: water quality monitoring is conducted at four remediation injection wells, 19 remediation extraction wells, and 56 monitoring wells. The September 2018 sampling was conducted in A-Aquifer wells, and carbon tetrachloride was present in 37 of the 56 monitoring wells at concentrations up to 5.8 micrograms per liter (ug/L). The A-Aquifer plume extends north from the post approximately 1 mile, then west northwest into the City of Marina approximately 2 miles. The plume currently appears to be contained by ongoing remediation efforts.

Groundwater elevation data for the 180-Foot Aquifer are also measured at OUCTP, and the direction of groundwater flow for the four quarterly events reported (Q4 2017 to Q3 2018) was generally an

eastward direction for the area within the City of Marina. The 180-Foot Aquifer is not impacted by the OUCTP plume.

Groundwater extraction in the MGSA Area has the potential to affect groundwater gradients near the OUCTP area, potentially causing a change in the direction or rate of plume migration, and interfering with ongoing cleanup efforts. The impacted A-Aquifer in this area is reported to be perched on the Fort Ord/Salinas Valley Aquitard, which may effectively separate it from regional drawdown in the DSA and 180-Foot Aquifer; however, this has not been determined conclusively. The MMRP for the MPWSP requires review of potential changes in OUCTP plume migration that could be induced by MPWSP pumping (CPUC 2018), if the MPWSP is approved and implemented. These evaluations would be reported under MCWRA's monitoring program, which has been incorporated into this GSP.

3.2.4.2 Distribution and Concentrations of Diffuse or Natural Groundwater Constituents

With the exception of seawater intrusion, there are no known or reported sources of diffuse or natural groundwater pollutants in the MGSA Area.

Within the 180/400 Foot Aquifer, the Regional Board monitors and regulates activities and discharges that can contribute to non-point pollutants, which are constituents that are released to groundwater over large areas. In the Subbasin, the most prevalent non-point source water quality concern is nitrate. The current distribution of nitrate was extensively monitored and evaluated by the CCGC and documented in a report submitted to the Regional Board (LSCE 2015).

Six agricultural sites within 1 mile of the MGSA Area are enrolled in the Irrigated Lands Program, which monitors and regulates nitrate discharges to groundwater. Two sources of water quality data were reviewed for the MGSA Area with respect to nitrate (based on prior investigations in the Salinas Valley Basin that identified nitrate as a chemical of concern): data from monitoring wells sampled in support of the MPWSP and groundwater quality data and data posted to the SWRCB GeoTracker GAMA site (SWRCB 2019). Nitrate as nitrogen was detected in three monitoring wells in the MGSA Area at concentrations ranging from less than 1 mg/L to approximately 5 mg/L. Water quality data posted for the CEMEX well indicate 13 samples were collected between 2000 and 2014 and analyzed for nitrate, with reported concentrations ranging from less than 2 mg/L (reporting limit) to 77 mg/L. None of the MPWSP on-site well samples exceeded the Maximum Contaminant Level (MCL) for nitrate as nitrogen in drinking water of 10 mg/L, and only one of the CEMEX well samples exceeded the nitrate MCL of 45 mg/L; however, water produced from this well contains TDS at a concentration of 19,000 mg/L and is not suitable as a source of drinking water.

Groundwater sampled east of the MGSA Area from monitoring wells MW-5S(P), MW-5M, MW-7S, and MW-8S was found to contain nitrate as nitrogen concentrations greater than the 10 mg/L MCL. These wells are located approximately 3,300 to 7,200 feet east of the MGSA Area, in agriculturally developed areas.

3.2.4.3 GROUNDWATER QUALITY SUMMARY

Based on the water quality information presented in the previous sections, the following constituents will be considered for inclusion in the monitoring program adopted in this GSP:

- Chloride; and
- TDS.

The monitoring network is further defined in Chapter 5. The constituents listed above are the constituents of concern for all aquifers in MGSA Area. Nitrate is not proposed to be included because there are no potential nitrate sources within the MGSA Area.

3.2.5 LAND SUBSIDENCE

Regulation Requirements:
§354.16(e) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or best available information.

Land subsidence is not closely monitored in the Monterey Bay region and has not been reported in Salinas Valley. In 2014, DWR reported that continuous monitoring stations located near the coast in the Pajaro Valley and Santa Cruz areas displayed a declining trend, but recorded total cumulative subsidence less than 1 inch (DWR 2014). DWR estimated the potential for future land subsidence in each groundwater basin based on groundwater elevations, previous subsidence studies, borehole extensometer data, and continuous GPS data. It was reported that there was insufficient data in the Salinas Valley Basin to assess its vulnerability to future subsidence.

The DWR SGMA Data Viewer includes estimates of vertical ground surface displacement in Salinas Valley between June 2015 and June 2018 based on satellite data (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub). Vertical displacement estimates are derived from Interferometric Synthetic Aperture Radar (InSAR) data collected by the European Space Agency (ESA) Sentinel-1A satellite and processed by TRE ALTAMIRA Inc. (TRE) under contract with the DWR. The total ground surface displacement reported in and near the MGSA Area during this time period ranged from approximately 0.01 to 0.025 foot. During the first two years of this time period, the test slant well-constructed for the MPWSP project in the MGSA Area was pumped at a rate of approximately 2,000 gallons per minute.

The available data suggest that the vicinity of the MGSA Area has not experienced significant subsidence. However, the data are insufficient to assess the potential vulnerability of this area to future subsidence if groundwater extractions are increased. MGSA will work with SVBGSA to address this data gap during GSP implementation.

3.2.6 INTERCONNECTED SURFACE WATER SYSTEMS

Regulation Requirements:
§354.16(f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or best available information.

The MGSA Area is approximately 4,000 feet from the Salinas River. Little information is available to directly assess the potential interaction between the river and the Dune Sand Aquifer and underlying 180-Foot Aquifer at this location; however, the following data suggest that they are interconnected:

- Measured groundwater elevations in wells in this area range from 6 to 8 feet above mean sea level, which is less than 20 feet below the elevation of the Salinas River thalweg in this area;
- In early 2016, groundwater elevations measured in the shallow wells completed at the MW-6, MW-8 and MW-9 clusters near the Salinas River showed a rapid and pronounced rise up to approximately 7 feet that was closely correlated with a rise in the Salinas River stage at the Spreckels gaging station from 2 to 20 feet.
- Geophysical data collected in 2017 indicate that groundwater elevations in the Dune Sand Aquifer are close to the river stage elevation, and decline away from the river, suggesting a losing condition (Figure 3-22).
- Within approximately ½ mile of the river mouth, the geophysical data suggest that seawater intrusion is occurring through the riverbed and into the Dune Sand Aquifer and underlying 180-Foot Aquifer (Figure 3-22).
- Projected groundwater elevations in the spring of 2018 were within less than 2 to 5 feet of several mapped “vernal ponds” (palustrine and emergent wetlands) located east of the MGSA Area that are designated as environmentally sensitive habitat areas designated for protection under the California Coastal Act (Section 2.1.2).

Further inland, near the Spreckels gaging station approximately 13.5 river miles upstream from the Pacific Ocean, groundwater elevations have historically been much deeper than Salinas River, indicating that the river may be hydraulically disconnected from the regional groundwater aquifers at this location.

This analysis of surface-groundwater interaction along the Salinas River is based on limited data and is therefore uncertain. Additional groundwater elevation data collection using monitoring wells completed in the Dune Sand Aquifer and the 180-Foot Aquifer near the river, and further evaluation through groundwater modeling would help to address this data gap. MGSA will work in coordination with the SVBGSA to help address this data gap in the lower reach of the river near the MGSA Area.

3.2.6.1 GROUNDWATER-DEPENDENT ECOSYSTEMS

Regulation Requirements:
§354.16(g) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or best available information.

Figure 3-38 shows the location of potential groundwater-dependent ecosystems (GDEs) in the vicinity of the MGSA Area based on the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset (https://gis.water.ca.gov/app/NCDatasetViewer/) developed by The Nature Conservancy in collaboration with DWR. The process for assessing whether these potential GDEs are in fact GDEs is discussed below. No potential GDEs are mapped in the MGSA Area, but several potential GDEs are located nearby. Potential GDEs near the MGSA Area include riverine wetlands and riparian habitat along the banks of the Salinas River, and palustrine and emergent wetland areas that are seasonally flooded in depressions a short distance east of the MGSA Area, north in the Salinas River National Wildlife Refuge, and south in the City of Marina.

Several of the potential GDEs identified near the MGSA Area are included in the *Coastal/Vernal Ponds Comprehensive Management Plan* that was developed by the City in 1994 (The Habitat Restoration Group 1994). Despite their sometimes seasonal nature, they are considered coastal wetlands and that provide habitat and cover for migratory waterfowl and a number of animals, including the endangered black legless lizard. Table 3-4 lists the location and current ownership/management of several of the vernal ponds in the City of Marina. The plan was developed to identify guidelines for the preservation, management and enhancement of Marina's wetland resources, and the plan identifies specific measures to be conducted at each pond to preserve, protect, and enhance sensitive resources.

TABLE 3-4. VERNAL PONDS IN MARINA

Pond	Location	Current Ownership/Management
Pond 1	West of Lake Drive	City of Marina
Pond 2	Reservation Road and Seaside Avenue	City of Marina
Pond 3	Reservation Road and Beach Road	Private/City
Pond 4	North of Reservation Road West of Hwy 1	Marina Water District
Pond 5	South of Reservation Road West of Hwy 1	CA Department of Parks and Recreation
Pond 6	West of Hwy 1	Private (unincorporated land outside City of Marina Limits)
Pond 7	West of Lake Drive	City of Marina

Source: City of Marina Local Coastal Program Land Use Plan (City of Marina 2014a)

Ponds 3, 5, and 6 are located closest to the MGSA Area: Pond 6 – Armstrong Ranch Complex Ponds are immediately to the east of the MGSA Area; Pond 5 – Marina Cost Water District Pond is south of the MGSA Area; and Pond 3 – Marina Landing Pond is south east of the MGSA Area. They are described in

City of Marina planning documents as "vernal ponds," which are areas where water pools that expand during the wet season and support marshy wetlands that provide habitat for plants and animals much of the year (City of Marina 2014a). These fresh and brackish water ponds are unique along the California coast and are present when a combination of circumstances (*i.e.,* a depression within the fast-draining sandy soils, a lens of less pervious soil, and a high water table) occur simultaneously.

To evaluate whether these potential GDEs are in fact groundwater dependent and whether they may be affected by groundwater extraction in the MGSA Area, the following information was considered. The Dune Sand Aquifer is the uppermost aquifer in the area and is hydraulically connected to the 180-Foot Aquifer in the MGSA Area (Section 3.1.6). Modeling of potential groundwater resources effects associated with the proposed MPWSP indicates pumping from the Dune Sand and 180-Foot Aquifers to supply water for the project from the MGSA Area is expected to result in drawdown ranging from 1 to 5 feet in the Dune Sand Aquifer in the area between the MPWSP and the Salinas River (ESA 2018). While the actual amount of drawdown is uncertain, the results of this analysis support the interpretation of a nexus between groundwater extraction in the MGSA area and groundwater elevations in the Dune Sand Aquifer in the surrounding area. Consistent with guidance developed by The Nature Conservancy (TNC 2019), an evaluation was conducted to assess the connection of the potential GDEs identified near the MGSA Area (Pond 6) and the Dune Sand Aquifer. Groundwater elevations interpolated from monitoring data in the Dune Sand Aquifer in an area within and east of the MGSA Area (Pond 6) were subtracted from land surface elevations derived from the USGS digital elevation model to determine the depth to groundwater beneath areas where potential GDEs were mapped. In the area where groundwater elevation data were available, it was found that the mapped palustrine and emergent wetlands (coastal vernal ponds) occurred in the areas where the shallowest groundwater elevations were found to exist (0 to 5 feet below ground level), strongly suggesting that these features are groundwater connected and dependent. The results of this analysis are presented as Figure 3-38.

The Armstrong Ranch Ponds are located approximately 300 to 1,000 feet southeast of the MGSA Area and include a series of seasonal wetlands with ponded water in the winter and wet herbaceous meadows likely subsisting on shallow groundwater during the dry season (The Habitat Restoration Group 1994). A representative analysis of evapotranspiration (ET) from one of these ponds is presented in Figure 4-1. Summer (June, July, and August) evapotranspiration was calculated using the surface energy balance method (Paul *et al.* 2018) from remote sensing data generated by the Landsat Satellite mission by Formation Environmental under contract to the Department of Water Resources (DWR). The results indicate summer ET ranged from approximately 5 to 10 inches from 2010 to 2013, then decreased to approximately 1 to 5 inches in 2014 and 2015, and 1 to 3 inches in 2016. In 2017, ET increased to approximately 3 to 10 inches, and in 2018, ET was approximately 5 to 12 inches. The decline in ET from 2014 to 2016 occurred during a period of severe drought; however, the test slant well pumping test was also conducted from April 2015 to February 2018 (Geoscience Support Services 2019). Hydrographs for well MW-4S indicate that the seasonal fluctuation in groundwater elevations in this well was approximately 2 feet, and suggest that pumping-induced drawdown was approximately 1 foot.

The lowest groundwater elevations were observed in the summer of 2016 and averaged about 2 feet higher in summer 2017 and summer 2018.

The above ET analysis demonstrates the correlation between groundwater levels and ET from this wetland, and illustrates its sensitivity to groundwater level declines. The existence of a GDE at this location is therefore considered confirmed, and the remaining vernal ponds are also assumed to be GDEs for the purposes of this GSP. ET, and by correlation biomass productivity, rebounded with groundwater levels; however, it is not known whether the stress induced in the GDE resulted in a change in the vegetation community, habitat degradation, or habitat succession that is not readily reversible. Based on this data, it is not possible to determine the extent to which the drawdown induced during the test slant well pumping test resulted in significant and unreasonable impacts to the GDE, or whether the results were temporary and reversable. The correlation between groundwater elevations and GDE responses is identified as a data gap.

3.3 WATER BUDGET INFORMATION

3.3.1 INTRODUCTION

Regulation Requirements:

§354.18(a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

The MGSA Area represents a relatively small area within the 180/400 Foot Aquifer Subbasin, for which historical, current, and projected water budgets have been prepared by SVBGSA and presented in their GSP (SVBGSA 2020). Since the MGSA Area is hydraulically connected with the surrounding portions of the Subbasin and part of the already developed water budgets, this GSP adopts the SVBGSA's regional historical, current, and future water budgets for the Subbasin (SVBGSA, 2020). Tables summarizing these water budgets are included as Appendix 3.E, and the details and assumptions regarding their derivation are described in the SVBGSA's GSP. The water budget discussion in this GSP focuses on augmenting the SVBGSA's regional water budgets with local water budget information as needed to prepare a locally focused GSP that complies with the requirements of 23 CCR § 354.18, conveys an adequate understanding of local groundwater conditions, and informs local sustainable groundwater management decisions.

Data to assess local water budget components near the MGSA Area are limited. Up to the present time, land use in the MGSA Area was limited to open space and a sand plant with a single saline process water supply well and little attention was paid to groundwater conditions beneath the area, except as part of more regional studies. The sand plant permit to operate and pump water expires on December 31, 2020, which should result in improved groundwater conditions within the MGSA Area.

In order to help assess potential impacts associated with construction of the MPWSP slant makeup water wells for the proposed MPWSP within the MGSA Area, monitoring wells were first installed in 2015 along with the test slant well. As a result, there is little data for development of a local historical water budget prior to 2015. Similarly, while recent investigations focused on this area have revealed the nature and complexity of local subsurface stratigraphic and water quality conditions, the tools to evaluate the response of the low-TDS/saline groundwater interface and the aquifers in this area to pumping to substantial pumping at a local level do not, as yet, exist. This GSP relies on the regional water budget analysis completed by SVBGSA, supplemented by a local water budget under current conditions, and qualitative information regarding local historical and projected water budget conditions. We believe this approach complies with the requirements of 23 CCR § 354.18 and will support sustainable management of groundwater resources in and around the MGSA Area when coupled with appropriate sustainable management criteria, monitoring and management actions discussed in Chapters 4, 5 and 6, respectively.

SVBGSA used a pre-publication version of the USGS SVIHM to evaluate and develop regional water budgets for the Subbasin. The approach, assumptions, and resulting water budgets are described in detail in Chapter 6 of SVBGSA's GSP (SVBGSA 2020). After the SVIHM is publicly released, MGSA will use it as needed during GSP implementation in collaboration with SVBGSA to develop a more refined understanding of the local water budget, flow conditions and project effects, and their integration with regional conditions, and to inform sustainable groundwater management decisions. Chapter 6 includes specific requirements for development of a locally refined groundwater flow model that is able to simulate solute transport and density-driven flow that can be used to evaluate and develop corrective actions if water quality monitoring indicates that significant and unreasonable seawater intrusion or water quality degradation may occur. MCWD GSA is currently planning to conduct such studies for the area that includes their GSA boundaries and the surrounding region, including the MGSA Area and beyond. With these measures in place, the water budget and basin characterization tools that are currently available are sufficient to assure the sustainable management objectives of this GSP and the adjacent GSPs are met.

3.3.2 LIMITATIONS

Several significant data limitations affect the approach to water budget development in this GSP and the interpretation and application of the water budget data. Appropriate care should be taken when applying these data to assess inter-basin flows and the regional effects of seawater intrusion and proposed regional projects, as such assessments will likely require additional focused evaluation. Once the SVIHM groundwater model is made available by the USGS, updated assessments of the historical, current, and future water budgets for the MGSA Area and surrounding regions will be undertaken as needed during GSP implementation in coordination with SVBGSA and MCWD GSA. The following specific data limitations have been identified.

- **Groundwater elevation, flow direction and gradient data** – There are limited data describing the groundwater elevation and flow conditions within and near the MGSA Area. Water elevation data are available for the Dune Sand Aquifer, 180-Foot Aquifer and 400-Foot Aquifer only after early 2015, which limits the ability to assess trends and historical water budget data. The closest Deep Aquifer monitoring well is more than 2 miles south of the MGSA Area. Further, the available Deep Aquifer wells are completed in various aquifer horizons between about 700 and 2,000 feet below ground surface, and are at present insufficient numbers to establish a groundwater gradient; therefore, the subsurface inflow/outflow cannot be estimated for the Deep Aquifer at this time.

- **Upper aquifer system data** – Known heterogeneities in the upper aquifer system (the Dune Sand, 180-Foot and 400-Foot Aquifers), aquitards and groundwater density contacts have not yet been conceptualized in available groundwater models at the local scale.

- **Lower aquifer system data** – The properties of the 400 Foot/Deep Aquitard and Deep Aquifer are not well understood. Refinement of the available modeling tools may be needed during GSP implementation to assess potential future water budget changes.

- **Recharge and vertical leakances data** – Based on regional information and site-specific water elevation data, recharge occurs from deep percolation of precipitation and applied irrigation water. The 180-Foot, 400-Foot and Deep Aquifers all receive recharge from the overlying aquifers in the form of vertical leakance. The lateral extent, thickness and properties of the aquitards separating these aquifers is variable, and the vertical leakance between these aquifers has not been quantified at the local level.

- **Subsurface inflow/outflow data** – Groundwater moves into and out of the MGSA Area as subsurface flow. Under pre-development conditions in the Salinas Valley, the groundwater gradient in all four aquifers is presumed to have been seaward (in a generally westerly direction from the land to the sea). Due to inland pumping, the groundwater gradient has changed, and saltwater has intruded under the land within a portion of Dune Sand, 180-Foot and 400-Foot Aquifers. Developing subsurface inflow/outflow budgets is complicated by the landward flow direction in the 400-Foot Aquifer and at least the lower portions of the 180-Foot Aquifer. With the implementation of in lieu and direct discharge projects in the future, as described in Chapter 6, these gradients are expected to lessen in the future, and water budgets would change as a result of decreasing and potentially even reversed gradients.

- **Groundwater mixing in multiple aquifers** – Pumping from the CEMEX well, MPWSP test slant well and proposed MPWSP slant wells occurs from multiple aquifers, and the contribution from individual aquifers or differing water quality zones is not known. In addition, density-driven convection of saline groundwater in the intruding wedge underlying the MGSA Area likely results in the mixing of saline and low-TDS groundwater in the upper portion of the intruding

wedge, which discharges seaward. Mixing of aquifer water complicates developing inflow and outflow water budgets and the prediction of future water budget effects.

3.3.3 APPROACH

Regulation Requirements:

§354.18(e) Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.

Due to the limitations described in Section 3.3.2, only a current water budget is developed for the MGSA Area, and qualitative water budget information is provided for the historical water budget and predicted water budget to cover the budget components that can be evaluated at this time. However, for planning purposes, it is reasonable to assume that the historic water budget was similar to the current water budget, as there has not been a significant change in land use or groundwater development within the MGSA Area for decades, with exception of the recent test slant well pumping. The current water budget was calculated using average annual data from Water Year (WY) 2015 through WY 2018.

Section 3.3 organized in subsections that develop the supplemental water budget information for the MGSA Area in a methodical fashion using the following approach:

1. Define the water budget boundary.
2. Identify the water budget components to be estimated for the water budget.
3. Identify the source data and quantify each of the groundwater budget components. Separate sections are included quantifying the surface water budget and groundwater inflows and outflows. Component quantification is mainly for the current water budget, with additional information discussed to provide perspective on the historical and projected water budgets.
4. Estimate the change in groundwater in storage.
5. Combine the individual components into a water budget summary in tabulated and graphical form.
6. Discuss the uncertainties in the water budgets.

Development of the supplemental water budget for the MGSA Area is based on the following data:

- 24 years of precipitation data from Monterey airport summarized in Table 3-5 (1995 to 2018);
- Eight years of evapotranspiration data summarized in Table 3-6 (2010 to 2018);

- Four years of water elevation data from MPWSP monitoring wells summarized in Table 3-7 (February 2015 to April 2019);
- Aquifer properties summarized in Section 3.1.7.1; and
- Reported pumpage by the CEMEX and test slant well test.

TABLE 3-5. MONTHLY PRECIPITATION (INCHES) FOR MONTEREY WEATHER FORECAST OFFICE (WFO), CA

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Water Year Total
1996	0.16	0.05	1.61	4.16	6.05	2.87	0.70	1.30	0.03	0.01	T	0.02	**16.96**
1997	0.76	2.07	5.93	7.67	0.05	0.12	0.18	0.12	0.10	T	0.15	0.00	**17.15**
1998	0.57	6.06	3.46	7.55	13.73	3.79	2.98	2.25	0.09	0.06	T	0.10	**40.64**
1999	0.61	2.46	1.19	2.67	3.14	3.39	2.17	0.03	0.20	0.01	0.04	0.40	**16.31**
2000	0.12	1.00	0.16	5.27	5.77	2.44	0.73	0.41	M	0.02	0.00	0.23	**16.15**
2001	3.89	M	0.20	3.55	3.70	1.67	1.78	0.01	0.06	T	0.03	0.11	**15.00**
2002	0.17	2.28	4.78	1.08	0.97	1.04	0.40	0.66	0.03	T	0.01	T	**11.42**
2003	0.01	1.89	6.19	1.02	1.88	0.99	2.15	0.79	0.02	0.01	0.05	0.02	**15.02**
2004	0.35	1.66	5.33	1.34	4.05	0.53	0.01	T	0.06	0.03	0.01	0.08	**13.45**
2005	3.34	1.02	4.92	4.44	4.16	4.15	1.56	0.79	0.28	0.04	0.00	0.00	**24.70**
2006	0.15	1.09	3.62	3.18	0.91	7.11	2.77	0.63	0.00	0.04	0.00	0.00	**19.50**
2007	0.07	1.34	2.30	1.07	3.12	0.52	1.04	0.15	0.06	0.02	0.00	0.44	**10.13**
2008	1.13	0.46	1.07	6.34	2.61	0.52	0.25	0.00	0.01	0.01	0.01	T	**12.41**
2009	0.16	1.32	2.70	2.21	4.96	2.32	0.33	0.20	0.03	0.04	0.08	0.15	**14.50**
2010	2.43	0.25	2.18	5.88	2.87	3.24	3.01	0.55	0.00	0.00	0.15	0.05	**20.61**
2011	0.85	2.15	4.04	2.01	4.52	4.83	0.20	0.86	0.78	0.02	0.07	0.01	**20.34**
2012	1.86	1.44	0.20	1.31	0.74	3.51	2.23	0.13	0.30	0.03	0.03	0.00	**11.78**
2013	0.63	3.45	3.87	0.86	0.79	1.05	0.31	T	0.06	T	0.11	0.04	**11.17**
2014	0.45	0.39	0.30	0.10	3.75	2.63	1.22	0.09	0.01	T	0.06	0.33	**9.33**
2015	1.44	1.39	8.55	T	1.26	0.29	0.89	0.29	0.01	0.13	0.05	0.05	**14.35**
2016	0.13	3.58	3.73	6.40	1.34	5.16	0.59	0.24	0.01	0.00	0.03	0.00	**21.21**
2017	2.73	1.32	1.51	7.49	6.18	2.33	1.24	0.03	0.08	0.00	0.01	0.07	**22.99**
2018	0.14	1.21	0.20	3.44	0.35	4.74	2.33	0.11	0.00	0.02	0.01	0.00	**12.55**
Mean	**0.96**	**1.65**	**2.96**	**3.44**	**3.34**	**2.58**	**1.26**	**0.42**	**0.10**	**0.02**	**0.04**	**0.09**	**16.86**

TABLE 3-6. MONTHLY EVAPOTRANSPIRATION DATA FROM CALETA

Water Year	Units	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
WY2011	Inches	0.57	0.41	0.26	0.42	0.39	0.68	0.93	0.91	0.81	0.76	0.64	0.68	7.47
	Acre-Feet	18.84	13.65	8.74	14.03	13.02	22.57	30.88	30.19	27.03	25.07	21.40	22.57	248.00
WY2012	Inches	0.64	0.44	0.48	0.53	0.60	0.78	0.98	1.00	0.92	0.78	0.76	0.58	8.50
	Acre-Feet	21.25	14.59	15.89	17.50	20.04	26.04	32.49	33.24	30.61	26.04	25.20	19.31	282.19
WY2013	Inches	0.58	0.48	0.32	0.46	0.51	0.81	0.96	0.87	0.81	0.64	0.65	0.69	7.77
	Acre-Feet	19.29	15.88	10.51	15.25	17.02	27.03	31.75	29.00	26.78	21.15	21.45	22.77	257.88
WY2014	Inches	0.45	0.35	0.34	0.35	0.32	0.60	0.77	0.84	0.65	0.70	0.61	0.48	6.46
	Acre-Feet	14.81	11.69	11.30	11.77	10.70	20.00	25.44	27.73	21.61	23.08	20.36	15.97	214.48
WY2015	Inches	0.44	0.30	0.23	0.42	0.55	0.78	0.71	0.64	0.76	0.84	0.72	0.48	6.85
	Acre-Feet	14.51	9.92	7.71	13.92	18.21	25.79	23.52	21.39	25.17	27.78	23.75	15.90	227.59
WY2016	Inches	0.45	0.34	0.32	0.39	0.86	0.98	1.00	0.89	0.89	0.80	0.44	0.63	8.01
	Acre-Feet	14.85	11.45	10.65	13.10	28.43	32.47	33.35	29.53	29.70	26.70	14.66	20.94	265.82
WY2017	Inches	0.58	0.47	0.41	0.53	0.66	1.09	1.12	1.18	1.00	0.93	0.67	0.67	9.30
	Acre-Feet	19.40	15.54	13.45	17.72	21.76	36.11	37.33	39.14	33.12	30.79	22.19	22.30	308.85
WY2018	Inches	0.77	0.49	0.37	0.45	0.64	0.76	0.88	0.91	1.11	1.00	0.65	0.51	8.55
	Acre-Feet	25.59	16.15	12.25	16.51	23.95	28.51	33.37	34.85	42.02	38.32	26.23	20.62	318.36
														Total
Average	Inches	0.56	0.41	0.34	0.44	0.57	0.81	0.92	0.91	0.87	0.80	0.64	0.59	7.86
	Acre-Feet	18.57	13.61	11.31	14.97	19.14	27.31	31.02	30.63	29.51	27.37	21.90	20.05	265.40

TABLE 3-7. GROUNDWATER LEVEL AND VERTICAL GRADIENT DATA FROM MPWSP MONITORING WELLS

Well Name	Top of Casing	Measurement	Groundwater Elevation	Vertical Head Difference between Zones	Relative Vertical Flow Direction
	(ft NAVD88)	Date and Time	(ft NAVD88)	(ft)	
MW-1S	30.51	4/2/2018 12:00	6.05		
				-0.31	up
MW-1M	29.86	4/2/2018 12:00	6.36		
				7.99	down
MW-1D	29.68	4/2/2018 12:00	-1.63		
MW-1S	30.51	3/12/2017 12:00	-1.26		
				-2.97	up
MW-1M	29.86	3/12/2017 12:00	1.71		
				3.91	down
MW-1D	29.68	3/12/2017 12:00	-2.2		
MW-1S	30.19	3/20/2015 12:00	4.42		
				-0.65	up
MW-1M	29.86	3/20/2015 12:00	5.07		
				8.59	down
MW-1D	29.39	3/20/2015 12:00	-3.52		
MW-3S	37.16	3/20/2015 12:00	5.81		
				2.56	down
MW-3M	37.35	3/20/2015 12:00	3.25		
				5.97	down
MW-3D	36.93	3/20/2015 12:00	-2.72		
MW-3S	37.16	3/12/2017 12:00	5.38		
				1.76	down
MW-3M	37.35	3/12/2017 12:00	3.62		
				5.88	down
MW-3D	36.93	3/12/2017 12:00	-2.26		
MW-3S	37.16	4/2/2018 12:00	6.32		
				1.6	down
MW-3M	37.35	4/2/2018 12:00	4.72		
				6.27	down
MW-3D	36.93	4/2/2018 12:00	-1.55		
MW-4S	41.96	3/20/2015 12:00	3.43		
				2.81	down
MW-4M	41.99	3/20/2015 12:00	0.62		
				5.08	down
MW-4D	41.95	3/20/2015 12:00	-4.46		

TABLE 3-7. GROUNDWATER LEVEL AND VERTICAL GRADIENT DATA FROM MPWSP MONITORING WELLS

MW-4S	41.96	3/12/2017 12:00	6.91		
				4.06	down
MW-4M	41.99	3/12/2017 12:00	2.85		
				4.97	down
MW-4D	41.95	3/12/2017 12:00	-2.12		
MW-4S	41.96	4/2/2018 12:00	6.3		
				3.37	down
MW-4M	41.99	4/2/2018 12:00	2.93		
				4.02	down
MW-4D	41.95	4/2/2018 12:00	-1.09		
MW-5S	80.06	3/20/2015 12:00	36.63		
				35.35	down
MW-5M	80.1	3/20/2015 12:00	1.28		
				7.59	down
MW-5D	80.06	3/20/2015 12:00	-6.31		
MW-5S	80.25	3/12/2016 12:00	37.12		
				43.51	down
MW-5D	80.06	3/12/2017 12:00	-6.39		
				-8.54	up
MW-5M	80.48	3/12/2017 12:05	2.15		
MW-5S	80.25	4/2/2018 12:00	40.04		
				38.2	down
MW-5M	80.48	4/2/2018 12:00	1.84		
				4.66	down
MW-5D	80.06	4/2/2018 12:00	-2.82		
MW-6S	35.89	3/12/2017 12:00	20.9		
				28.22	down
MW-6M	35.68	3/12/2017 12:00	-7.32		
				0.88	down
MW-6M(L)	35.82	3/12/2017 12:00	-8.2		
MW-6S	35.89	4/2/2018 12:00	7.89		
				14.42	down
MW-6M	35.68	4/2/2018 12:00	-6.53		
				1.28	down
MW-6M(L)	35.82	4/2/2018 12:00	-7.81		
MW-7S	50.64	3/12/2017 12:00	8.32		
				7.26	down
MW-7M	50.29	3/12/2017 12:00	1.06		
				3.51	down
MW-7D	50.24	3/12/2017 12:00	-2.45		

TABLE 3-7. GROUNDWATER LEVEL AND VERTICAL GRADIENT DATA FROM MPWSP MONITORING WELLS

MW-7S	50.64	4/2/2018 12:00	8.62		
				6.83	down
MW-7M	50.29	4/2/2018 12:00	1.79		
				2.24	down
MW-7D	50.24	4/2/2018 12:00	-0.45		
MW-8S	19.96	3/12/2017 12:00	6.85		
				5.56	down
MW-8M	19.99	3/12/2017 12:00	1.29		
				5.67	down
MW-8D	20.08	3/12/2017 12:00	-4.38		
MW-8S	19.96	4/2/2018 12:00	5.56		
				4.59	down
MW-8M	19.99	4/2/2018 12:00	0.97		
				2.68	down
MW-8D	20.08	4/2/2018 12:00	-1.71		
MW-9S	18.42	3/12/2017 12:00	8.14		
				10.4	down
MW-9M	18.32	3/12/2017 12:00	-2.26		
				4.62	down
MW-9D	18.32	3/12/2017 12:00	-6.88		
MW-9S	18.42	4/2/2018 12:00	7.02		
				9.39	down
MW-9M	18.32	4/2/2018 12:00	-2.37		
				-0.82	up
MW-9D	18.32	4/2/2018 12:00	-1.55		

Notes:

NAVD88 = North American Vertical Datum of 1988

ft = feet

References:

Monthly Groundwater Monitoring Report No. 3

Test Slant Well Long-Term Pumping Monitoring Report No. 97

Test Slant Well Long-Term Pumping Monitoring Report No. 148

3.3.4 WATER BUDGET BOUNDARIES

The supplement water budget information for the MGSA Area is calculated inside the following boundaries that lie within the water budget boundaries for SVBGSA's regional water budget for the Subbasin:

- The lateral boundaries for the water budget calculations are the perimeter of the MGSA Area.
- The bottom boundary for the water budget calculations is the top of the Deep Aquifer. As discussed in Section 3.3.1, data are insufficient to perform water budget calculations for the Deep Aquifer, but a discussion of water budget components for the Deep Aquifer is presented.
- The top boundary of the water budget calculations is above the ground surface; precipitation infiltration and evapotranspiration are included in the water budget.

3.3.5 WATER BUDGET COMPONENTS

3.3.5.1 Surface Water Budget Components

Within the boundaries discussed above, the surface water budget inflows include:

- Precipitation and runoff; and
- Process water discharge to the four man-made ponds that are part of the CEMEX operation.

The surface water budget outflows include:

- Evapotranspiration (ET); and
- Evaporation from the CEMEX ponds.

Due to the high permeability of the dune sands, there is no surface water inflow to the MGSA area. Runon and runoff are negligible.

3.3.5.2 Groundwater Budget Components

Within the boundaries discussed above, the groundwater budget inflows include:

- Deep percolation of precipitation;
- Deep percolation of CEMEX pond water; and
- Subsurface inflows from adjacent areas within the Subbasin.

The groundwater budget outflows include:

- Groundwater pumping;

- Subsurface outflows; and
- Deep percolation.

There are no GDEs in the MGSA Area, so ET of groundwater is not considered an outflow component.

3.3.6 SURFACE WATER INFLOW AND OUTFLOW

Regulation Requirements:
§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(1) Total surface water entering and leaving a basin by water source type.

Surface water inflows under current and historical conditions are similar and include the following components:

- **Precipitation** – Precipitation at the Marina Airport weather station has been measured since 1995, and the mean annual precipitation is reported as 16.90 inches. Marina Airport precipitation data are compiled in Table 3-5. For the MGSA Area (398 acres), this equates to an annual average precipitation input volume of 561 AFY.
- **Process water discharge** – The CEMEX operation discharges saline process water to three infiltration ponds. As discussed in Section 3.3.6, the total process water demand of the CEMEX plant is 305 AFY. The amount of consumptive use is not known, but is assumed to be negligible for the purposes of this water budget; therefore, process water discharge is assumed to be 305 AFY.

Surface water outflows under current and historical conditions are assumed to be similar and include the following components:

- **Evapotranspiration** – Actual ET data for the MGSA Area is available for the period from WY 2011 to WY 2018 from the CalETa data set developed for DWR by Formation Environmental (Paul *et al.* 2018 and 2011). The data set consists of daily evapotranspiration calculated at a resolution of 30 meters by analyzing Landsat satellite and climatic data using the Surface Energy Balance Approach. The mean annual ET between 2010 and 2017 was 7.9 inches, for a total of 265 AFY from the MGSA Area. MGSA Area ET data from WY 2010 to WY 2017 are compiled in Table 3-6.
- **Evaporation from CEMEX ponds** – Evaporation from the four CEMEX ponds is estimated to be less than 5 AFY.

The projected future surface water budget would include the following changes:

- **Precipitation** – Precipitation is forecast to increase statewide by 2.9 percent in and after 2030 and by 5.3 percent in and after 2070 due to climate change (DWR 2018). Projected increases in the Central Coast hydrologic region are projected to be 2.8% by 2030 and 6.5% by 2070. The

precipitation inflow volume is therefore forecast to increase from 512 AFY to 526 AFY in 2030 and to 545 AFY in 2070.

- **Process water discharge** – The CEMEX sand mining facility will cease operation by December 31, 2020. After this time, saline process water discharges to the CEMEX ponds will cease.

- **Evapotranspiration** – ET is forecast to increase by approximately 6% by 2070 (SCMCGA 2020) due to climate change (DWR 2018). The ET outflow volume during this time is therefore forecast to increase from 265 AFY to 281 AFY.

3.3.7 GROUNDWATER INFLOW

Regulation Requirements:
§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.

This section quantifies each of the groundwater inflow components of the supplemental water budget information for the MGSA Area listed in Section 3.3.5.2. These local supplemental water budget components are assumed to be included in the regional water budget adopted for the Subbasin by the SVBGSA and this GSP.

3.3.7.1 Historical and Current Groundwater Inflow Components

Historical data are limited and assumed to be similar to the current water budget, as discussed in Section 3.3.3. Current and historical groundwater inflow components include the following:

- **Deep percolation of precipitation** – Since there is no surface runoff from the MGSA Area, deep percolation of precipitation is equal to total precipitation minus ET. Therefore, the deep percolation from precipitation under current and historical conditions is equal to 512 AFY - 265 AFY = 247 AFY. This is a relatively high recharge rate, and reflects the high permeability and recharge potential of the Dune Sand and Older Dune Sand that underlie the MGSA Area and area southwest of the Salinas River. The deep percolation is assumed to contribute to the low TDS groundwater zone within the Dune Sand Aquifer and the 180-Foot Aquifer noted in Sections 3.1.12 and 3.2.3.

- **Deep percolation of process water** – The CEMEX ponds receive approximately 305 AFY and evaporation is relatively limited and expected to exceed about 5 AFY; therefore, deep percolation of saline CEMEX process water is assumed for current and historical purposes to be approximately 300 AFY.

- **Subsurface inflow from adjacent areas.** Subsurface inflow was estimated using 1) hydraulic gradients derived from groundwater elevations measured on March 12, 2017,[1] 2) hydraulic conductivity values from the CEMEX model (ESA 2018, Geoscience Support Services 2017), and 3) estimated aquifer thicknesses based on monitoring well screen intervals for the Dune Sand Aquifer and the 180-Foot Aquifer, and the estimated aquifer thickness of the 400-Foot Aquifer (Gottschalk, 2018). For current conditions (at the approximately 2,000-foot by 8,000-foot MGSA Area) the calculated subsurface inflows at the MGSA Area boundaries are as follows:
    - 435 AFY in the Dune Sand Aquifer (across the eastern boundary in a seaward direction);
    - 556 AFY in the 180-Foot Aquifer (net saline groundwater flow across the western boundary in a landward direction[2]);
    - 1,333 AFY in the 400-Foot Aquifer (saline groundwater flow across the western boundary in a landward direction); and
    - Groundwater elevation data are insufficient to calculate groundwater inflow and outflow in the Deep Aquifer beneath the MGSA Area.
- **Inter-aquifer fluxes include the following**: Based on the vertical gradients measured in the monitoring well clusters installed in and near the MGSA Area (Table 3-7) the 180-Foot Aquifer receives recharge by vertical leakance from the Dune Sand Aquifer, and the 400-Foot Aquifer receives recharge by vertical leakance from the 180-Foot Aquifer. The only exception occurs at the seaward edge of the 180-Foot Aquifer, where discharge likely occurs upward to the Pacific Ocean from both the Dune Sand and 180-Foot Aquifers. Recharge to the Deep Aquifer is believed to occur via leakance from the 400-Foot Aquifer; however, the data are insufficient to assess the distribution and rate of recharge (MCWRA 2017). The inter-aquifer fluxes have not been assessed through measurement or modeling. For the purposes of this water budget, it is assumed that the leakance rate into and out of each aquifer is equal to the rate of recharge from precipitation to the Dune Sand Aquifer, or 247 AFY.

Under current conditions groundwater flow in the vicinity of the MGSA Area in the upper aquifer system is generally toward or away from the Pacific Ocean, parallel to the boundary between the 180/400 Foot Aquifer Subbasin and the Monterey Subbasin. Significant cross boundary inflows in the upper aquifer system are not anticipated based on the available data; however, the groundwater flow direction in the Deep Aquifer, and the potential for cross boundary inflows, is not known.

[1] Note that as discussed in Section 3.2.1.3, the magnitude of landward gradients in the 180-Foot and 400-Foot Aquifers increases seasonally in the summer and fall, and groundwater inflow and outflow is likely greater at this time.
[2] As discussed in Section 3.1.12, the flow in the upper, lower TDS portion of the 180-Foot Aquifer may be seaward, but this is offset by landward flow in the saline groundwater wedge that intrudes the aquifer from the west.

3.3.7.2 Projected Changes in Groundwater Inflow Components

Recharge from deep percolation of precipitation is projected to increase (both precipitation and evapotranspiration will increase with precipitation increasing more than evapotranspiration) with a net change from the current conditions (247 AFY) to the year 2070 (264 AFY). Recharge inflow from the CEMEX infiltration ponds will be eliminated at the end of 2020, decreasing inflow by 300 AFY. As noted above, proposed SVBGSA Priority Management Actions and Priority Projects include *in lieu* recharge and direct recharge projects with expected benefits including "arresting the decline, or raising, groundwater elevations" (SVBGSA 2019). Raising groundwater elevations in the future could change groundwater flow gradients, and potentially flow directions in the 180-Foot Aquifer and the 400-Foot Aquifer. This would change subsurface inflows into the water budget area. Groundwater flow directions and gradients will be reevaluated during the Five-Year Review, and the water budgets will be updated.

3.3.8 OUTFLOWS FROM GROUNDWATER SYSTEM

Regulation Requirements:
§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.

This section quantifies each of the groundwater outflow components of the supplemental water budget for the MGSA Area listed in Section 3.3.5.2. These supplemental water budget components are assumed to be included in the regional water budget adopted for the Subbasin by the SVBGSA and this GSP.

3.3.8.1 Historical and Current Groundwater Outflow Components

Historical data are limited and assumed to be similar to the current water budget, as discussed in Section 3.3.3. Current and historical groundwater outflow includes the following components:

- **Groundwater pumpage**
    - **CEMEX well** – Process water for the CEMEX operation is extracted from a well on the east side of the MGSA Area. Based on the DWR well log, the well was constructed in 1968 with seven perforated intervals from 200 to 632 feet below ground level in the 180-Foot and 400-Foot Aquifers (included in Appendix 3-5). The well operates 20 hours a day for 255 days a year, with a pumping rate of 325 gallons per minute (gpm) (HWG 2017). Total pumpage from the CEMEX well in the MGSA Area therefore equals 305 AFY. The amount of groundwater drawn by the well from each aquifer is not known.
    - **MPWSP test slant well** – Test pumping of the MPWSP test slant well occurred from April 2015 through February 2018. From October 27, 2015, to September 21, 2017, the test slant well average pumping rate was 2,056 gpm, so the total extracted groundwater volume was approximately 5,450 AF, which would average about 2,860 AFY (HWG

2017). A total volume of approximately 6,000 AF was pumped from the well for the entire test. The test slant well is completed in the Dune Sand Aquifer and the 180-Foot Aquifer. A small portion of the test slant well screen lies outside the MGSA Area and the Subbasin, as the MGSA Area and Subbasin western boundary is the mean high tide mark. The test slant well extracted groundwater from the DSA and the 180-Foot Aquifer in a radial pattern, including saline groundwater from outside the Subbasin boundaries beneath the Pacific Ocean, as well as low-TDS groundwater from the inland portions of DSA and 180-Foot Aquifer within the Subbasin. Specific conductance monitoring during the test indicates that salinity increased after the well pump was turned on, and decreased after it was turned off, suggesting that the amount of lower salinity groundwater captured by the test slant well decreases over time. It has not been established how much groundwater was extracted by the test slant well from the Subbasin aquifers underlying the MGSA Area (including the low-TDS zone) as opposed to saline groundwater originating outside the Subbasin to the west. ESA (2018) estimated an "Ocean Water Percentage" of approximately 90 percent using the CEMEX model during the first year of test slant well pumping for the full MPWSP raw water makeup system; however, the modeling assumed a landward gradient in the DSA. The actual gradient in the DSA is seaward, so the amount of groundwater captured from the DSA from the inland portions of the aquifer would be larger than simulated. The conceptual groundwater budget summaries presented in Table 3-10 and Table 3-11 therefore include alternative budgets based on an estimated 10 percent and 30 percent of the extracted test slant well groundwater being produced from the aquifers underlying the MGSA Area.

- **Subsurface outflow.** The relatively stable groundwater elevations measured in and near the MGSA Area since the cessation of test slant well pumping (Table 3-7, Appendix 3.D) indicate that subsurface outflow is approximately the same as inflow. Based on the observed groundwater gradients, the following outflows are interpreted:[3]

    - Discharge from the Dune Sand Aquifer to the Pacific Ocean is approximately 435 AFY (seaward direction out of the western MGSA boundary). This assumes vertical leakance from the Dune Sand Aquifer into the 180-Foot Aquifer is equal to the rate of recharge from precipitation. This estimate may be refined in the future as additional data and the SVIHM become available.

    - Net saline groundwater discharge in a landward direction through the eastern boundary of the 180-Foot Aquifer is approximately 556 AFY. This assumes vertical leakance from the Dune Sand Aquifer into the 180-Foot Aquifer is approximately equal to vertical leakance out of the 180-Foot Aquifer into the 400-Foot Aquifer. This estimate may be

[3] Note that as discussed in Section 3.2.1.3, the magnitude of landward gradients in the 180-Foot and 400-Foot Aquifers increases seasonally in the summer and fall, and groundwater inflow and outflow is likely greater at this time.

refined in the future as additional data and the SVIHM become available. Note that this outflow estimate is a simplified net value. Under Ghyben-Herzberg dynamics, we would expect that some discharge of mixed saline and low TDS groundwater to the Pacific Ocean would occur in the upper portion of this aquifer; however, the screen lengths of the monitoring wells in the 180-Foot Aquifer do not allow evaluation of vertical variation in water quality or gradient directions to be resolved.

- Landward discharge of saline groundwater from the 400-Foot Aquifer through the eastern MGSA Area boundary is estimated to be 1,333 AFY. This assumes vertical leakance from the 180-Foot Aquifer into the 400-Foot Aquifer is approximately equal to vertical leakance out of the 400-Foot Aquifer into the Deep Aquifer. This estimate may be refined in the future as additional data and the SVIHM become available.
- Groundwater elevation data are insufficient to calculate groundwater inflow and outflow in the Deep Aquifer beneath the MGSA Area.

Under current conditions groundwater flow in the vicinity of the MGSA Area in the upper aquifer system is generally toward or away from the Pacific Ocean, parallel to the boundary between the 180/400 Foot Aquifer Subbasin and the Monterey Subbasin. Significant cross boundary inflows in the upper aquifer system are not anticipated based on the available data; however, the groundwater flow direction in the Deep Aquifer, and the potential for cross boundary outflows, is not known.

3.3.8.2 Projected Changes in Groundwater Outflow Components

Expected increases in inflow (recharge) resulting from changes in climatic conditions over the next 50 years would result in corresponding changes in outflows. In addition, as noted in Section 3.3.7.2, proposed SVBGSA Priority Management Actions and Priority Projects include *in lieu* recharge and direct recharge projects with expected benefits including "arresting the decline, or raising, groundwater elevations" (SVBGSA 2019). Raising groundwater elevations in the future could change groundwater flow gradients, and potentially flow directions in the 180-Foot Aquifer and the 400-Foot Aquifer. Consequently, this could affect the rate and direction of outflows. Groundwater flow directions and gradients will be reevaluated during the 5-Year Review, and the water budgets will be updated.

When groundwater extraction from the CEMEX well ends in 2020, this outflow will be eliminated. If the MPWSP project is implemented, groundwater extraction from the DSA and the 180-Foot Aquifer would increase. In addition, as was noted in Section 3.2.1.3, the 400-Foot Aquifer did experience drawdown during test slant well pumping; therefore, the 400-Foot Aquifer would also be affected by groundwater extraction from the proposed MPWSP pumping. The rate of local proposed groundwater extraction (17,400 AFY) would be greater than the other components of this water budget analysis, indicating significant regional groundwater budget changes would occur, which may affect ET outflow to GDEs and interaction with the Salinas River. Evaluating the potential effects of this proposed groundwater extraction on the MGSA Area and regional water budgets would require the development of a refined local groundwater flow, solute transport, and density-driven flow model. As discussed in Chapter 6,

MCWD GSA plans to develop such a model to evaluate the local groundwater flow, water budgets, seawater intrusion and water quality effects to support preparation of its GSP. MGSA will review the results of this analysis and update this GSP as appropriate.

3.3.9 CHANGE IN GROUNDWATER STORAGE

Regulation Requirements:
§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data: (4) The change in the annual volume of groundwater in storage between seasonal high conditions.

During the test slant well test, groundwater elevations noticeably declined in the Dune Sand and 180-Foot Aquifer near the test slant well in the MGSA Area as groundwater was removed from storage during the pumping test between April 2015 and February 2018. Groundwater elevations declined by approximately 8 feet in MW-1S and MW-1M, and by 3 feet in MW-3S and MW-3M, but recovered relatively quickly to pre-pumping conditions after the long-term test was discontinued, and have remained relatively stable since then. The observed seasonal groundwater elevation fluctuation increases with aquifer depth, and averages approximately 0 to 4 feet in the Dune Sand Aquifer, 1.5 to 10 feet in the 180-Foot Aquifer, and 10 to 24 feet in the 400-Foot Aquifer, indicating a seasonal storage change that is consistent with regional recharge and pumping patterns. However, the available groundwater elevation data (2015 to present) suggest that there is no long-term inter-annual change in storage between seasonal high conditions. Thus, although the Subbasin as a whole has experienced a significant decrease in groundwater storage as described in Section 3.2.2, and the MGSA Area experienced a short-term decline in storage due to the 3-year test slant well test, based on available monitoring data since 2015, the groundwater storage beneath the MGSA Area does not appear to be decreasing at the present. This implies that conditions at the seaward edge of the saline intrusion front in the Subbasin are relatively stable; however, significant changes in groundwater pumping in this area could upset this equilibrium and have both local and inland implications for future seawater intrusion.

3.3.10 SUMMARY OF SUPPLEMENTAL MGSA AREA WATER BUDGETS

Regulation Requirements:

For current water budgets:

§354.18 (c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.

For historical water budgets:

§354.18 (c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:

(A) A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.

(B) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.

(C) A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.

For projected water budgets:

§354.18 (c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:

(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.

(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.

(C) Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(3) Projected water budget information for population, population growth, climate change, and sea level rise.

The following sections present a summary of the supplemental water budgets for the MGSA Area. This information is presented as a supplement to the regional water budget developed for the Subbasin by

SVBGSA to support development of a locally focused GSP within the Subbasin for the MGSA Area. The water budget information presented should be considered preliminary, and is subject to the assumptions and limitations discussed in the preceding sections. Together with the regional water budget, it is intended to fulfill the requirements of 23 CCR § 354.18 and support achievement and maintenance of the sustainability goals identified in this GSP. The water budget was developed based on the data and tools available at this time. During GSP implementation, the water budget will be updated as needed, and as new data and tools become available, in collaboration with SVBGSA and MCWD GSA. SVBGSA will use the SVIHM when it is released to evaluate regional water budgets and surface-groundwater interaction. MCWD GSA proposes to develop a locally refined groundwater flow model that is able to simulate solute transport and density-driven flow. As discussed in Chapters 6 and 7, MGSA will review the results of these efforts and collaborate with SVBGSA and MCWD GSA to update the local and regional water budgets presented in this GSP.

3.3.10.1 Summary of Surface Water Budget

The surface water budget summarized below in Table 3-8 is representative of both historical and current conditions. Inflows and outflows were calculated for years that data for all components were available. The limiting factor was evapotranspiration, for which data were available for WY 2011 through WY 2018 (Table 3-6). Precipitation data were available for 1995 through 2018 (Table 3-5), but only the data from WY 2011 to WY 2018 were used.

Although the period for which sufficient information was available to calculate supplemental water budgets for the MGSA Area is limited, the four years do cover one below average year which was preceded by two drought years (2015), two years with above average precipitation (2016 and 2017), and one below average year (2018). The precipitation during these years was 14.25, 21.21, 21.99, and 12.55 inches of rain, respectively, compared to a 24-year average of 16.86 inches. Thus, especially the surface water budgets provide some perspective on climatic variability and its influence on the water budget.

TABLE 3-8. SUMMARY OF CURRENT AND HISTORICAL SURFACE WATER BUDGET

Surface Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (acre-feet per year)				
Precipitation (2011 to 2018)	309	763	512	63%
Discharge of process water to CEMEX Ponds	305	305	305	37%
Total Inflow			**817**	
Outflows (acre-feet per year)				
Evapotranspiration (2011 to 2018)	215	318	265	32%
Deep Percolation of Precipitation	94 (2014)	454 (2017)	247	30%
Percolation of CEMEX Pond discharge	300	300	300	37%
Evaporation of CEMEX Pond discharge	5	5	5	1%
Total Outflow			**817**	

The projected future surface water budget through 2070 is presented in Table 3-9. Projected future changes include an increase in precipitation and ET, as well as cessation of CEMEX operations and restoration of the ponds, as discussed in Section 3.3.6. As shown in below, deep percolation to groundwater is projected to increase slightly during this time period. No changes to the surface water budget within the MGSA Area are anticipated if the MPWSP is implemented; however, drawdown could decrease the amount of surface water discharge via ET or to the Salinas River.

TABLE 3-9. SUMMARY OF PROJECTED FUTURE SURFACE WATER BUDGET

Surface Water Budget Component	Current Average	2030 Projection	2070 Projection
Inflows (acre-feet per year)			
Precipitation	512	526	545
Discharge of process water to CEMEX Ponds	305	0	0
Total Inflows	**817**	**526**	**545**
Outflows (acre-feet per year)			
Evapotranspiration	265	273	281
Deep Percolation of Precipitation	247	253	264
Percolation of CEMEX Pond discharge	300	0	0
Evaporation of CEMEX Pond discharge	5	0	0
Total Outflow	**817**	**526**	**545**

3.3.10.2 Summary of Current Groundwater Budget Supplement

To provide perspective into the current and historical local groundwater budget components, and insight into and how they may change in the future, the following conceptual water budgets were prepared.

- Table 3-10 presents a water budget based on the assumption that 10 % of the groundwater produced by the test slant well was pulled into the well from the aquifers underlying the MGSA Area (as opposed to saline groundwater originating from outside the Subbasin Boundary to the west, which is not included in this water budget assessment). Although this groundwater would have been extracted from both the DSA and the 180-Foot Aquifer, because of the seaward gradient in the DSA, all of the extraction was assigned to the DSA.

- Table 3-11 presents a water budget based on the assumption that 30 % of the groundwater produced by the test slant well was pulled into the well from the aquifers underlying the MGSA Area (as opposed to saline groundwater originating from outside the Subbasin Boundary to the west, which is not included in this water budget assessment). Although this groundwater would have been extracted from both the DSA and the 180-Foot Aquifer, because of the seaward gradient in the DSA, all of the extraction was assigned to the DSA.

- Table 3-12 presents a WY 2018 water budget for summarizing conditions after the cessation of test slant well pumping.

A graphical representation of these water budget supplement is presented as Figure 3-40. The evaluation of different assumptions regarding the percentage of groundwater that is extracted from aquifers within the Subbasin indicates that during test slant well pumping, much of the inflow into the DSA from the landward side of the MGSA Area was captured by the test slant well, and the amount of inflow captured increased with the proportion of groundwater that the well extracted from the Subbasin Aquifers. The actual amount of groundwater produced from the aquifers within the Subbasin vs. saline groundwater west of the Subbasin and infiltrating seawater cannot be adequately evaluated without a suitable groundwater flow model that can simulate solute transport and density driven flow, and may be different from the above assumptions.

Development of a future groundwater budget also is not possible without a refined groundwater flow model; however, the above conceptual water budgets provide useful perspective. Given that the proposed extraction rate for the MPWSP, if implemented, would be approximately 17,400 AFY, it is readily apparent that even if only a small percentage were derived from the aquifers underlying the MGSA Area and the Subbasin, the local groundwater budget would be significantly changed. A large volume of groundwater would be removed from the DSA as well as the 180-Foot Aquifer. At the same time, a large amount of seawater would be drawn in to replace the aquifer water that is removed from storage. The analysis underscores the need for locally refined groundwater model that can simulate both solute transport and density-driven flow.

TABLE 3-10. WY 2017 CONCEPTUAL GROUNDWATER BUDGET WITH TEST SLANT WELL 10 PERCENT AQUIFER CAPTURE

Groundwater Budget Component	WY2017	Average %	Basis and Assumptions
Inflows (acre-feet per year)			
Recharge from Precipitation	454	15%	WY 2017 precipitation minus evapotranspiration.
Recharge from CEMEX Ponds	300	10%	305 AFY minus nominal evaporation and other losses.
Subsurface Inflow into Dune Sand Aquifer (DSA)	435	14%	Calculated using 3/12/2017 gradient, average screen length, CEMEX model hydraulic conductivity, and transverse length of MGSA.
Subsurface Inflow into 180-Foot Aquifer	657	21%	Equals outflow plus 1/3 CEMEX well pumping volume.
Subsurface Inflow into 400-Foot Aquifer	1,537	50%	Equals outflow plus 2/3 CEMEX well pumping volume.
Total Inflow	**3,383**		
Outflows (acre-feet per year)			
Pumping CEMEX Well	305	10%	Reported annual CEMEX pumping from HWG 2017
Pumping Test Slant Well			
Groundwater Extraction from Dune Sand Aquifer (Assumed to be 10% of extraction rate)	286	9%	Assumed 10 % of extracted water is derived from Subbasin aquifers. Actual rates may be different than assumed. DSA accounts for 45% of well transmissivity; however, because the gradient is seaward in March 2017, most of the captured aquifer water would be from this aquifer. Therefore, assumed all of slant well aquifer water contribution derives from this aquifer.
Groundwater Extraction from the 180-Foot Aquifer	0	0%	Accounts for 55% of well transmissivity; however, gradient is landward in March 2017. Therefore, assumed no aquifer water contribution from this aquifer to slant well pumping.
Subsurface Outflow Dune Sand Aquifer	740	24%	Equals inflow plus recharge from precipitation plus recharge from CEMEX ponds, minus test slant well extraction minus leakance to Deep Aquifer.
Subsurface Outflow 180-Foot Aquifer	556	18%	Calculated using 3/12/2017 gradient, average screen length, CEMEX model hydraulic conductivity, and transverse length of MGSA.
Subsurface Outflow 400-Foot Aquifer	1,333	43%	Calculated using 3/12/2017 gradient, aquifer thickness from Gottschalk *et al.*, 2018, CEMEX model hydraulic conductivity, and transverse length of MGSA.
Subsurface Leakance to Deep Aquifer	163	5%	Steady state leakance to Deep Aquifer (assumed equal to recharge from precipitation) minus test slant well aquifer capture volume.
Total Outflow	**3,383**		

TABLE 3-11. WY 2017 CONCEPTUAL GROUNDWATER BUDGET WITH TEST SLANT WELL 30 PERCENT AQUIFER CAPTURE

Groundwater Budget Component	WY2017	Average %)	Basis and Assumptions
Inflows (acre-feet per year)			
Recharge from Precipitation	454	15%	WY 2017 precipitation minus evapotranspiration.
Recharge from CEMEX Ponds	300	10%	305 AFY minus nominal evaporation and other losses.
Subsurface Inflow into Dune Sand Aquifer (DSA)	435	14%	Calculated using 3/12/2017 gradient, average screen length, CEMEX model hydraulic conductivity, and transverse length of MGSA.
Subsurface Inflow into 180-Foot Aquifer	657	21%	Equals outflow plus 1/3 CEMEX well pumping volume.
Subsurface Inflow into 400-Foot Aquifer	1,537	50%	Equals outflow plus 2/3 CEMEX well pumping volume.
Total Inflow	**3,383**		
Outflows (acre-feet per year)			
Pumping CEMEX Well	305	10%	Reported 305 AFY annual CEMEX pumping
Pumping Test Slant Well			
Groundwater Extraction from Dune Sand Aquifer (Assumed to be 10% of extraction rate)	858	28%	HWG OWP estimate assumed landward gradient in DSA; therefore, a lower OWP (higher aquifer water capture percentage) is a reasonable assumption. Actual rates may be different than the assumed 30%. DSA accounts for 45% of well transmissivity; however, because the gradient is seaward in March 2017, most of the captured aquifer water would be from this aquifer. Therefore, assumed all of slant well aquifer water contribution derives from this aquifer.
Groundwater Extraction from the 180-Foot Aquifer	0	0%	Accounts for 55% of well transmissivity; however, gradient is landward in March 2017. Therefore, assumed no aquifer water contribution from this aquifer to slant well pumping.
Subsurface Outflow Dune Sand Aquifer	331	11%	Equals inflow plus recharge from precipitation plus recharge from CEMEX ponds, minus test slant well extraction minus leakance to Deep Aquifer.
Subsurface Outflow 180-Foot Aquifer	556	18%	Calculated using 3/12/2017 gradient, average screen length, CEMEX model hydraulic conductivity, and transverse length of MGSA.
Subsurface Outflow 400-Foot Aquifer	1,333	43%	Calculated using 3/12/2017 gradient, aquifer thickness from Gottschalk *et al.*, 2018, CEMEX model hydraulic conductivity, and transverse length of MGSA.
Subsurface Leakance to Deep Aquifer	0	0%	Steady state leakance to Deep Aquifer (assumed equal to recharge from precipitation) minus test slant well aquifer capture volume.
Total Outflow	**3,383**		

TABLE 3-12. WY 2018 CONCEPTUAL GROUNDWATER BUDGET

Groundwater Budget Component	WY2018 (Acre-Feet)	Average % (rounded)
Inflows (acre-feet per year)		
Recharge from Precipitation	98	18%
Recharge from CEMEX Ponds	300	9%
Subsurface Inflow into Dune Sand Aquifer	500	12%
Subsurface Inflow into 180-Foot Aquifer	1,059	19%
Subsurface Inflow into 400-Foot Aquifer	1,032	41%
Total Inflow	**2,989**	
Outflows (acre-feet per year)		
Pumping CEMEX Well	305	9%
Subsurface Outflow Dune Sand Aquifer	500	12%
Subsurface Outflow 180-Foot Aquifer	1,059	19%
Subsurface Outflow 400-Foot Aquifer	1,032	41%
Subsurface Leakance to Deep Aquifer	93	18%
Total Outflow	**2,989**	
Change in Storage (acre-feet per year)	**0**	

Groundwater flow in the vicinity of the MGSA Area in the upper aquifer system is generally toward or away from the Pacific Ocean, parallel to the boundary between the 180/400 Foot Aquifer Subbasin and the Monterey Subbasin. Significant cross boundary outflows in the upper aquifer system are not anticipated based on the available data; however, the groundwater flow direction in the deep aquifer, and the potential for cross boundary outflows, is not known.

3.3.10.3 Summary of Historical Groundwater Budget Supplement

Due to a lack of local groundwater elevation data prior to 2015, it was not possible to prepare a complete local historical groundwater budget to supplement the regional historical groundwater budget prepared by SVBGSA. However, as discussed in Section 3.3.3, for planning purposes, it is reasonable to assume that the historic water budget for the MGSA Area is similar to the current WY 2018 water budget, as there has not been a significant change in land use or groundwater development within the MGSA Area for decades, with exception of the recent test slant well pumping.

3.3.10.4 Summary of Projected Groundwater Budget Supplement

The projected surface water budget presented in Table 3-11 indicates that recharge from precipitation may be expected to increase slightly over the next 50 years. Several *in lieu* recharge projects are planned to be implemented in the portions of the basin located east of the MGSA Area, and are projected to lead to an increase in local groundwater elevations by several feet in the 180-Foot and 400-

Foot Aquifers (Chapter 6). However, sea level is projected to rise by approximately 17 inches during this time period, increasing the driver for seawater inflow into the saline groundwater wedge underlying the MGSA Area and its vicinity. This will at least partially offset the gains from additional recharge and groundwater elevation rise in the area. The effects of sea level rise on the local water budget and saline wedge intrusion will be evaluated during GSP implementation once a model capable of simulating density-driven flow is developed by MCWD GSA.

Pumping of the CEMEX well is expected to cease in December 2020 or, at the latest in December 2024, when CEMEX removes the well, resulting in the *in lieu* recharge of approximately 300 AFY of groundwater to the 180-Foot and 400-Foot Aquifers, and the loss of approximately 300 AFY of groundwater recharge to the DSA from saline water discharged to the CEMEX percolation ponds, which will be restored. The partitioning of extraction from the CEMEX well between the 180-Foot and 400-Foot Aquifers, and whether any low-TDS groundwater is currently being withdrawn from this well, is not known.

The proposed pumping of 17,400 AFY of feed water for the MPWSP, if permitted and implemented, would extract saline groundwater from beneath the ocean and saline as well as low-TDS groundwater from the Dune Sand and 180-Foot Aquifers in the Subbasin. In the Monterey Subbasin, groundwater demand from the Deep Aquifer by MCWD to supply the City of Marina is expected to increase as discussed in Chapter 2; however, the increase is projected to be within MCWD's allocated pumping rights. Given that land use in the MGSA Area is designated as open space and conservation land use, other significant land use and groundwater demand changes are not anticipated.

As described in Sections 3.3.2 and 3.3.11, several key data elements needed to evaluate the water budget effects of the above climatic, *in-lieu* recharge and groundwater extraction changes are not available at this time. The available data are insufficient for the evaluation of water budgets for the Deep Aquifer at this time; however, groundwater extraction from the Deep Aquifer is not anticipated in the MGSA Area. For the upper aquifer system (the Dune Sand, 180-Foot, and 400-Foot Aquifers), data gaps include the relatively short period of available groundwater elevation monitoring data, interaction of existing and proposed wells with the aquifer system, vertical flow and leakance rates, and the dynamics of density-driven flow of saline groundwater.

The MGSA Area is relatively small and included within the existing regional groundwater budget developed for the Subbasin by SVBGSA, and future groundwater development focuses primarily on a single large project. Given these facts, reliance of the existing regional water budget as augmented above is an appropriate and adequate basis for implementation of the sustainable management criteria, monitoring program and management actions described in Chapters 4, 5 and 6, respectively. A locally refined groundwater flow model that is able to simulate solute transport and density-driven flow is currently under consideration by MCWD GSA for the area that includes their GSA boundaries and the surrounding region, including the MGSA Area and beyond. MGSA will collaborate with and review these

studies, and update the HCM, sustainable management criteria, monitoring networks and management actions in this GSP to assure the sustainability goals are met.

3.3.10.5 WATER YEAR TYPES ASSOCIATED WITH THE WATER BUDGET

Regulation Requirements:
§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data: (6) The water year type associated with the annual supply, demand, and change in groundwater stored.

Although the period for which sufficient information was available to calculate supplemental water budgets for the MGSA Area, the four years analyzed do cover one below average year which was preceded by two drought years (2015), two years with somewhat above average precipitation (2016 and 2017), and one below average year (2018). The precipitation during these years was 14.25, 21.21, 21.99, and 12.22 inches of rain, respectively, compared to a 24-year average of 16.86 inches.

The CEMEX well was operating during the WY 2015 to WY 2018 period. The test slant well was also pumping during the majority of this period. Therefore, demand was effectively constant and did not change with water year type.

The MPWSP monitoring wells east of the MGSA Area (especially the shallow wells completed in the Dune Sand Aquifer) did not show a direct response to Slant Well pumping during the water budget period; therefore, these wells are suitable for evaluating the climatic (dry-, normal-, and wet-year) and extraction-related groundwater elevation trends during the supplemental water budget period of record. Review of the five shallow monitoring wells located east of the MGSA Area (Appendix 3.D) indicates there is a general upward trend (increasing water elevations) from April 2015 to April 2019. Groundwater elevation trends in wells MW-7S, MW-8S and MW-9S were evaluated for the period from April 2016 to April 2019. Groundwater elevations generally increased at MW-7S, were stable in MW-8S, and appeared to decline slightly in MW-9S. The available data generally reflect a slight increase in groundwater elevations and storage during the transition from a year with below average precipitation at the end of a drought in WY 2015, to two years with above average precipitation in WY 2016 and WY 2017. Groundwater gradients calculated from the Dune Sand Aquifer March 2017 groundwater level map (during a wet year and pumping of the pilot slant well) and April 2018 groundwater level map (during a dry year and after the pilot slant well was shutdown) were similar. In addition, the gradient directions remained similar during the fall of each year; however, the magnitudes of the landward gradients in the 180- and 400-Foot Aquifers increased in the summer and fall.

3.3.11 UNCERTAINTIES IN SUPPLEMENTAL MGSA AREA WATER BUDGET INFORMATION

The level of accuracy and certainty is highly variable between water budget components. The water budget uncertainty will be reduced over time as the GSP monitoring programs are implemented and the resulting data are used to check and improve the water budgets. Refinement of the water budget will be performed in collaboration with SVBGSA and MCWD GSA as necessary, or as required to implement management actions described in Chapter 6.

- **Groundwater elevation data** – The period of record for groundwater elevation data is relatively short and is limited to four years from 2015 through 2019. This prevents development of a quantified historical groundwater budget to supplement the regional historical water budget in this area; however, based on the available data, it is reasonable to infer for planning purposes that historical conditions were likely similar to current conditions.

- **Deep Aquifer water elevation data** – There are no Deep Aquifer wells in the MGSA Area, and a minimum of three would be needed to estimate a groundwater gradient for water budget calculations. Regional data are insufficient to interpolate groundwater flow directions in the Deep Aquifer due to its thickness and heterogeneous nature, and relative paucity of wells.

- **Deep Aquifer recharge and characteristics** – The hydrologic characteristics of the Deep Aquifer and the overlying 400-Foot/Deep Aquitard have not been well characterized and as a result recharge to and flow within this aquifer is uncertain.

- **Vertical leakance** – The vertical leakance between aquifers is not known and is assumed to be equal to recharge at the ground surface.

- **Slant well pumping** – The amount of landward saline and low TDS groundwater from the Subbasin aquifers captured by test slant well pumping is not known. A large portion of the groundwater pumped by the test slant well was saline groundwater originating from beneath the ocean outside the western boundary of the Subbasin; however, a significant volume of saline and low-TDS groundwater was also withdrawn from the aquifers within the Subbasin underlying the MGSA Area and its vicinity. The MPWSP test slant well salinity data and groundwater elevations in the DSA indicate that some groundwater was derived from a low-TDS groundwater source in the Dune Sand and 180-Foot Aquifer. Conceptual water budgets are provided assuming 10 percent of the test slant well groundwater was captured Subbasin groundwater, and 30 percent of the test slant well groundwater was captured Subbasin groundwater; however, the actual percentage of Subbasin groundwater extracted from the Subbasin by the test slant well is not known.

- **CEMEX well pumping** – The CEMEX well is completed in both the 180-Foot Aquifer and the 400-Foot Aquifer, and it is not clear what fraction of the groundwater produced by the well originates from each aquifer. Without this information, it is not possible to predict the effect that the planned shut-down of this well at the end of 2020 will have on the low-TDS zone in the Dune Sand Aquifer and the 180-Foot Aquifer.

- **Local groundwater and density-driven flow model** – A groundwater model that can simulate solute transport and density-driven flow, and that incorporates the heterogeneity of the aquifer system in the Marina area is not available at this time. As such, the potential impacts of a high rate of groundwater extraction in the MGSA Area, such as by the proposed MPWSP, on the local water budget, water quality and seawater intrusion cannot be adequately evaluated. Prior to

initiating rates of groundwater extraction that are substantially higher than historical rates, there would be a need for a locally refined groundwater flow model that is able to simulate solute transport and density-driven flow. MCWD GSA is currently planning to conduct such studies for the area that includes their GSA boundaries and the surrounding region, including the MGSA Area and beyond. MGSA will collaborate with and review these studies, and update the HCM, sustainable management criteria, monitoring networks and management actions in this GSP to assure the sustainability goals are met.

3.3.12 QUANTIFICATION OF OVERDRAFT

Regulation Requirements:
§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data: (5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.

The 180/400 Foot Aquifer Subbasin (Subbasin) is subject to seawater intrusion due largely to long-term groundwater extraction in the inland portions of the Subbasin in excess of the sustainable yield, and has been identified by the Department of Water Resources as being in a critical condition of overdraft (DWR 2016a). In keeping with the objectives of this GSP to support regional efforts that address this overdraft condition by supporting the projects and management actions that will be implemented by SVBGSA under its regional GSP, this section provides an assessment of local overdraft conditions.

The available data to support evaluation of the existing water budget are limited to the time period after 2015. During this time, groundwater elevations declined near the test slant well located on the west side of the MGSA Area during the long-term pumping test from April 2015 to February 2018, and then recovered. The groundwater quality and level monitoring data indicates that some groundwater from the low-TDS zone in the DSA and 180-Foot Aquifer was drawn into the test slant well from the east; however, the data are insufficient to determine whether there was a significant and unreasonable impact to these resources during the test time period, and whether the saline groundwater intrusion wedge advanced inland or thickened as a result.

In the absence of the test slant well pumping test, it would be expected that the saline groundwater intrusion wedge and low TDS groundwater zone currently exist in a relative state of equilibrium since there have been no land use changes that would cause a change in recharge or groundwater pumping near the MGSA Area. The CEMEX well may have contributed to seawater intrusion historically; however, conditions in the nearshore environment were likely stable as of the adoption of SGMA in early 2015. The recovery of groundwater elevations to pre-slant well test elevations shortly after the test suggests the MGSA Area is not currently being overdrafted, and that groundwater conditions are relatively stable. As such, there is no evidence that current activities in the MGSA Area are contributing to the critical conditions of overdraft that are driving seawater intrusion in the inland areas.

The proposed implementation of the MPWSP could change the local water budget and has the potential to impact GDEs, reduce groundwater storage in the low-TDS groundwater zone, induce seawater intrusion and cause groundwater quality degradation. As such, it has the potential to create a future overdraft condition locally and to contribute to regional overdraft conditions. The sustainable management criteria, monitoring program and management actions described in Chapters 4, 5 and 6 are intended to identify and address any overdraft in the MGSA Area (from any cause) before it results in significant and unreasonable impacts.

3.3.13 ESTIMATE OF SUSTAINABLE YIELD

Regulation Requirements:
§354.18(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(7) An estimate of sustainable yield for the basin.

Regionally, based on a water budget analysis, SVBGSA has estimated the historical sustainable yield of the Subbasin as 96,950 AFY and the long-term projected sustainable yield as 112,000 AFY (SVBGSA 2019). SVBGSA states this is an estimate only, and that the sustainable yield estimate for the Subbasin will be modified and updated as more data are collected and more analyses are performed, including evaluation of the SVIHM, which is expected to be released in late 2020. This GSP adopts the regional sustainable yield as estimated for the 180/400 Foot Aquifer Subbasin in SVBGSA's GSP (SVBGSA 2019).

As described further in Chapter 4, locally, the contribution to the sustainable yield from groundwater extraction in the MGSA Area is the amount of groundwater that can be withdrawn annually over a period of time without causing undesirable results within or near the MGSA Area. Undesirable results include, but may not be limited to, the following significant and unreasonable impacts beyond a 2015 baseline condition:

- Chronic groundwater level decline in the DSA that adversely effects GDEs;
- Further seawater intrusion into the Dune Sand, 180-Foot, 400-Foot, and/or Deep Aquifers; or
- Degradation of the low TDS groundwater zone within the Dune Sand, 180-Foot and/or 400-Foot Aquifers.

Pumping of saline groundwater from the CEMEX well (possibly including a mix of saline and low-TDS groundwater from the 180-Foot and 400-Foot Aquifers) has been ongoing since the 1960's at a rate of approximately 300 AFY. Although it is not known if this pumping contributed to historical seawater intrusion in the area, the available data suggest this level of pumping currently coexists with a stable distribution of water quality and groundwater elevations in the area, and is therefore sustainable relative to SGMA's 2015 baseline and the regional sustainable yield estimate.

Water quality trends and groundwater elevations during test slant well pumping at a rate of 2,860 AFY from April 2015 to February 2018 indicate that low TDS groundwater (< 3,000 mg/L TDS) from the inland

portion of the Dune Sand and 180-Foot Aquifers was likely being captured during the test, and that the equilibrium between the saline groundwater wedge and low TDS groundwater zone within and east of the MGSA Area may have been at least temporarily affected. ET from nearby GDEs decreased significantly during this test, due to a combination of drawdown and drought conditions. The ET from this GDE has since recovered, but it is not known whether vegetative stress resulted in longer-term changes to the habitat community composition or quality. For these reasons, without additional data and modeling tools, it is not possible to assess whether continued pumping at the rate of the test slant well would be sustainable in the long term. If the MPWSP is fully approved and implemented, the proposed increased source water pumping rate of 17,400 AFY would have a greater effect on the local groundwater budget, potentially further stressing sustainability indicators including groundwater level decline (and impacts to GDEs), water quality degradation and seawater intrusion.

As discussed further in Chapters 5 and 6, water quality monitoring will be conducted and trigger thresholds are established in this GSP for management actions to require further assessment and corrective action (as appropriate) to help assure protection of GDEs, prevention of further seawater intrusion, and prevention of groundwater quality degradation. The required assessments described in Chapter 6 would aid in the refinement of the estimate of the local contribution to sustainable yield beyond the current rate of 300 AFY, and corrective actions would be implemented as needed to prevent the occurrence of undesirable results.

3.4 WATER SUPPLY AVAILABILITY FOR AUGMENTATION

There are currently no alternative sources of water supply within the MGSA Area. If future development in the MGSA Area were to require a potable water supply, annexation of the MGSA Area into MCWD could be considered.

3.5 MANAGEMENT AREAS

Regulation Requirements:
§354.20 (a) Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.

There are no management areas within the MGSA Area.

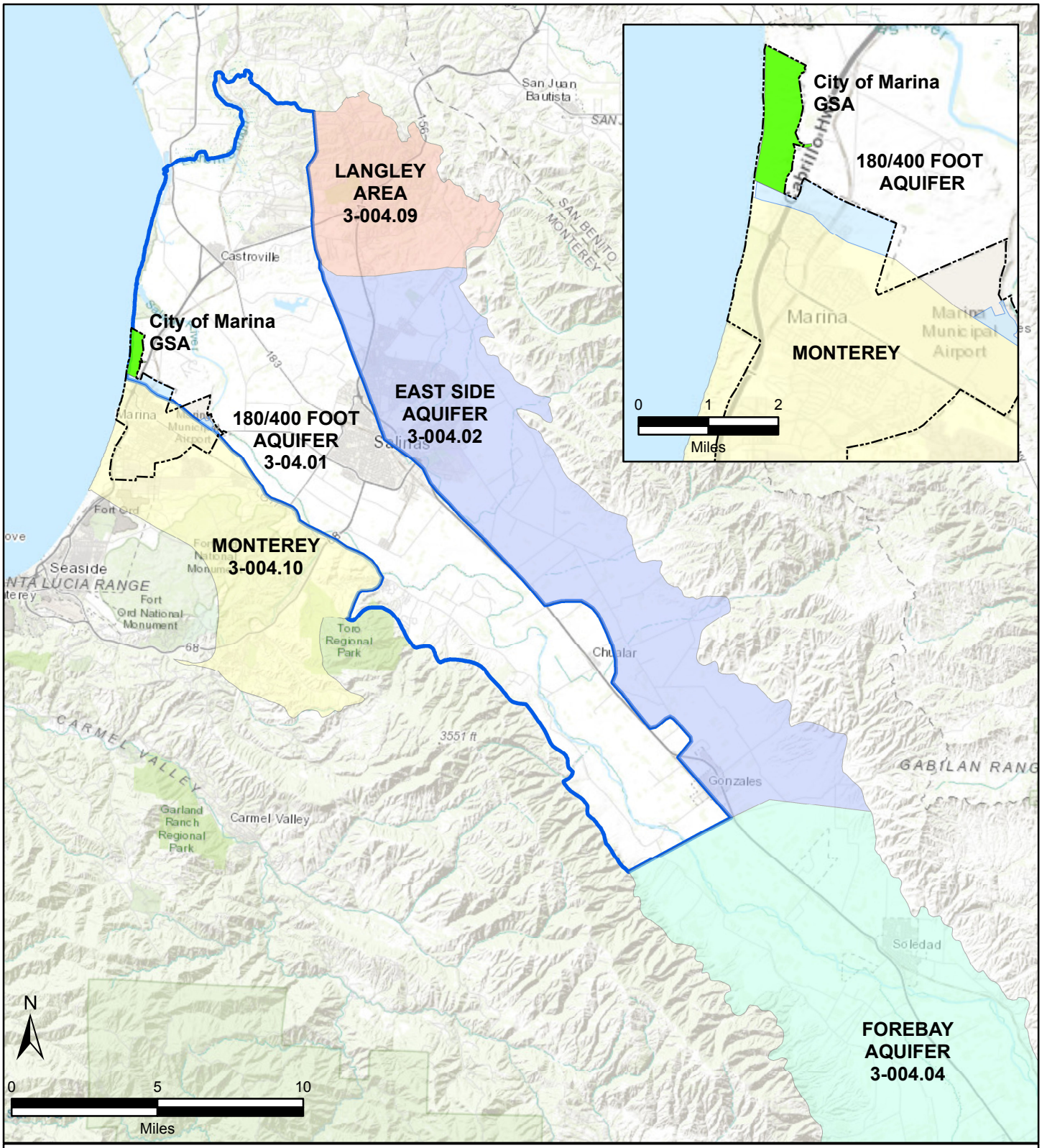

FIGURE 3-1

Extent of the 180/400 Foot Subbasin and Location of the Marina GSA Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina
- 180/400 Foot Aquifer Subbasin
- City of Marina GSA (MGSA) Area

Groundwater Subbasins

- 180/400 FOOT AQUIFER
- EAST SIDE AQUIFER
- FOREBAY AQUIFER
- LANGLEY AREA
- MONTEREY
- PASO ROBLES AREA
- UPPER VALLEY AQUIFER

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, SVBGSA 2020

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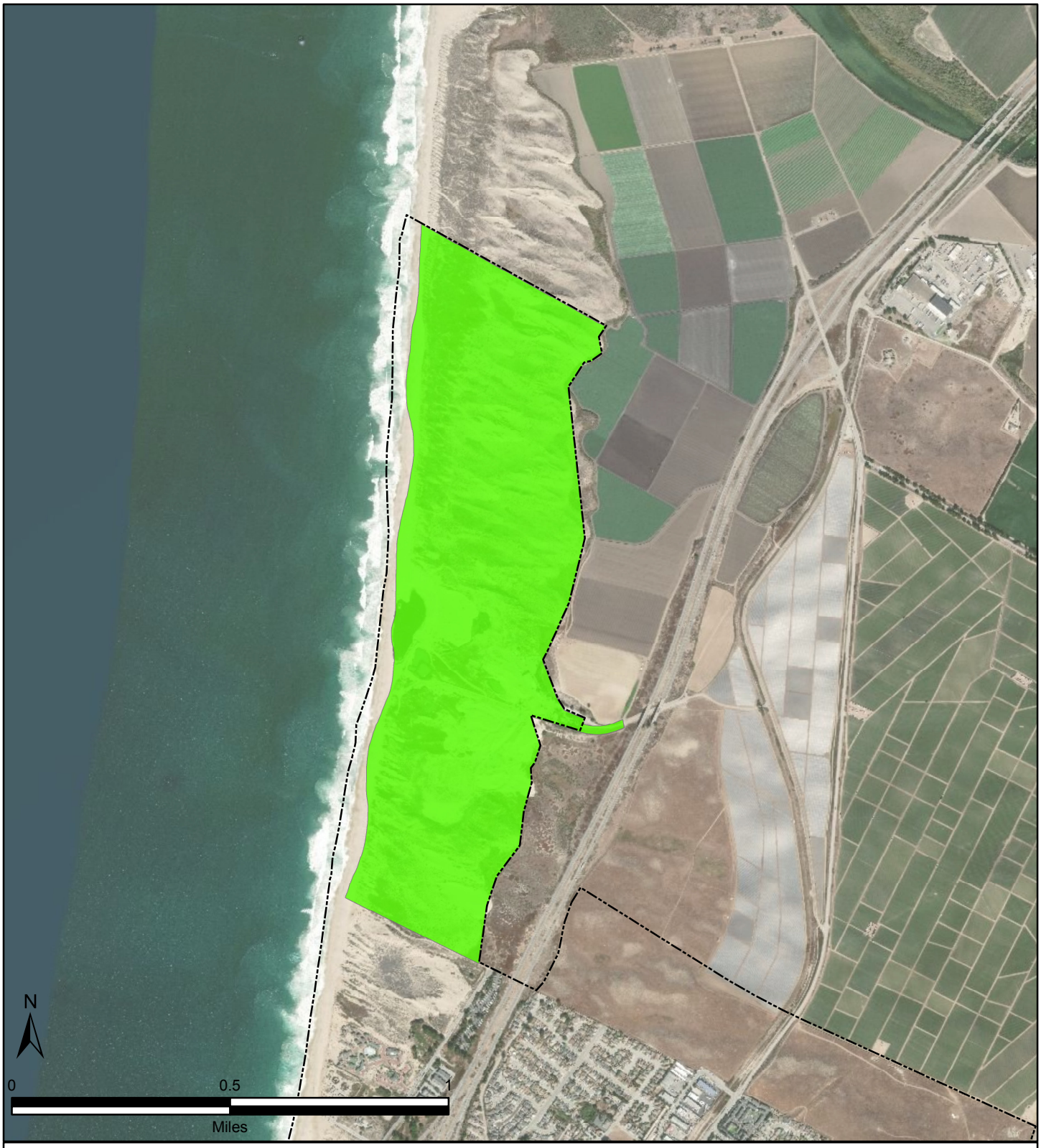

FIGURE 3-2

City of Marina GSA Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina City Limits
- City of Marina GSA (MGSA) Area

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://montereycountyopendata-12017-01-13t232948815z-montereyco.opendata.arcgis.com, SVBGSA 2020

DATE: DEC. 30, 2019

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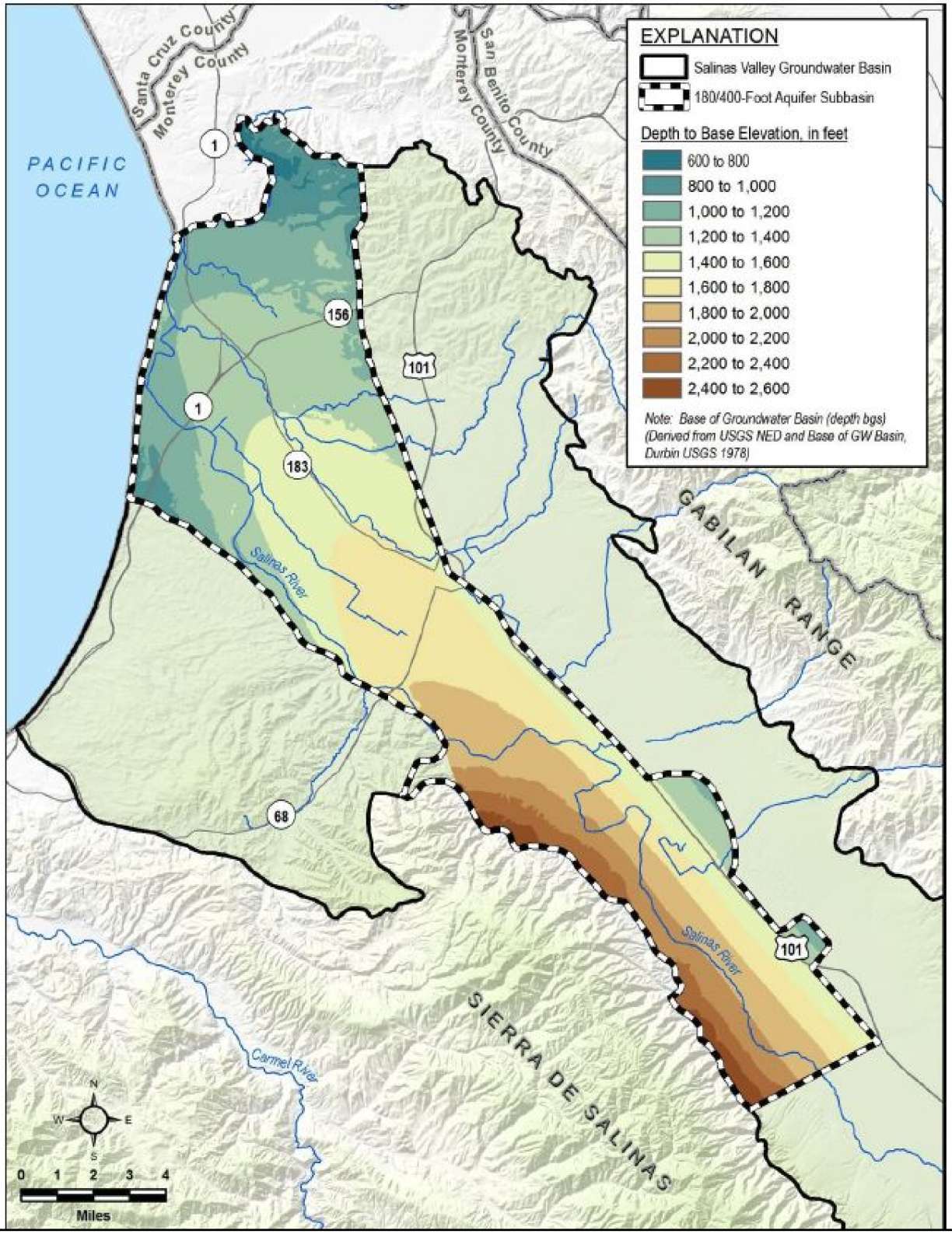

FIGURE 3-3

Depth to Base of 180/400 Foot Subbasin

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Taken from SVBGSA 2020

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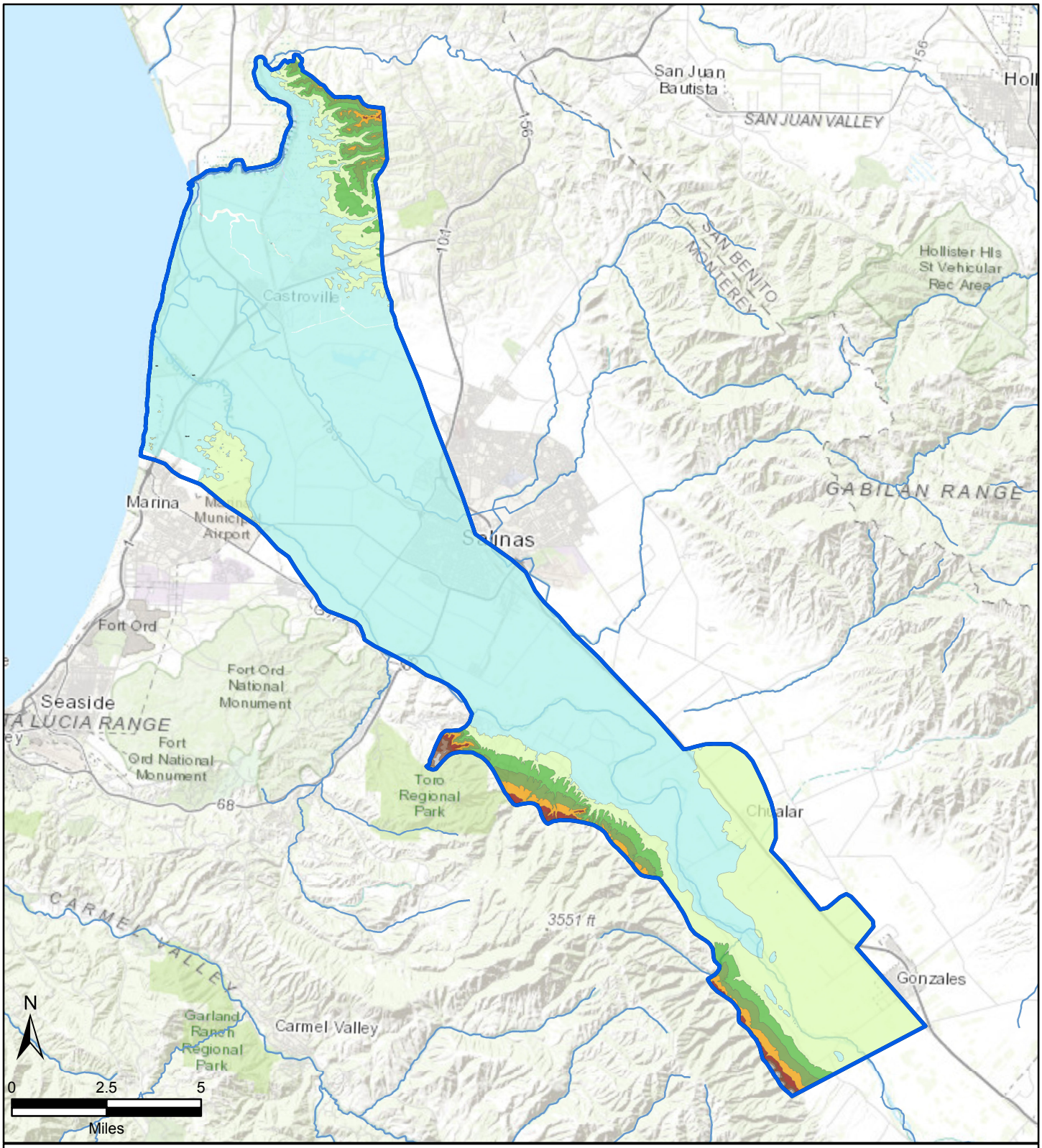

FIGURE 3-4

Topography of the 180/400 Foot Subbasin

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- 180/400 Foot Aquifer Subbasin
- Salinas Valley Groundwater Basin
- Topographic Contour (100-foot interval)

Topography (mean feet above sea level)

- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700
- 700 - 800
- 800 - 900

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, USGS Digital Elevation Model, SVBGSA 2020

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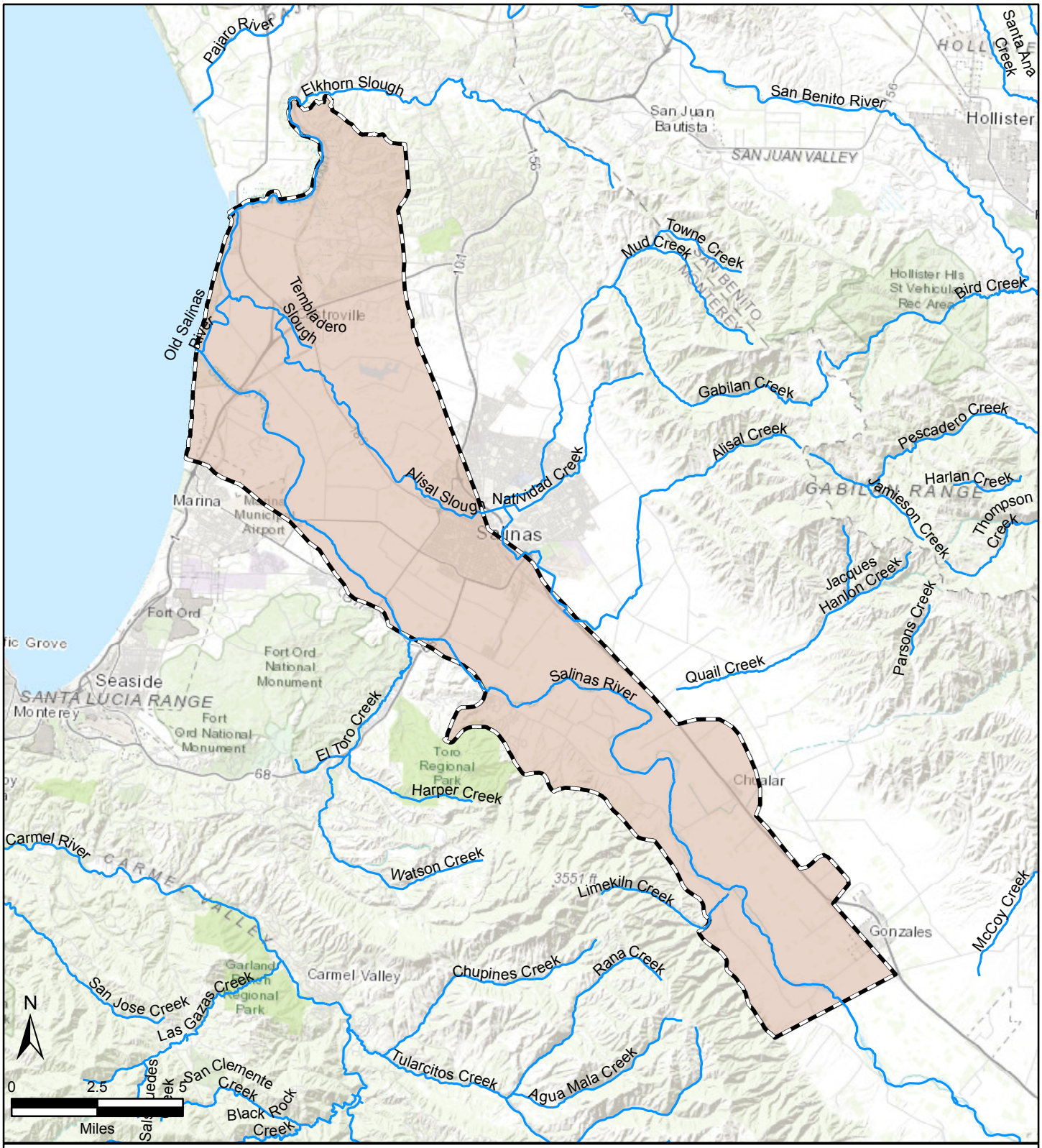

FIGURE 3-5

180/400 Foot Subbasin Surface Water Bodies

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- Rivers and Streams
- 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, National Hydrology Dataset

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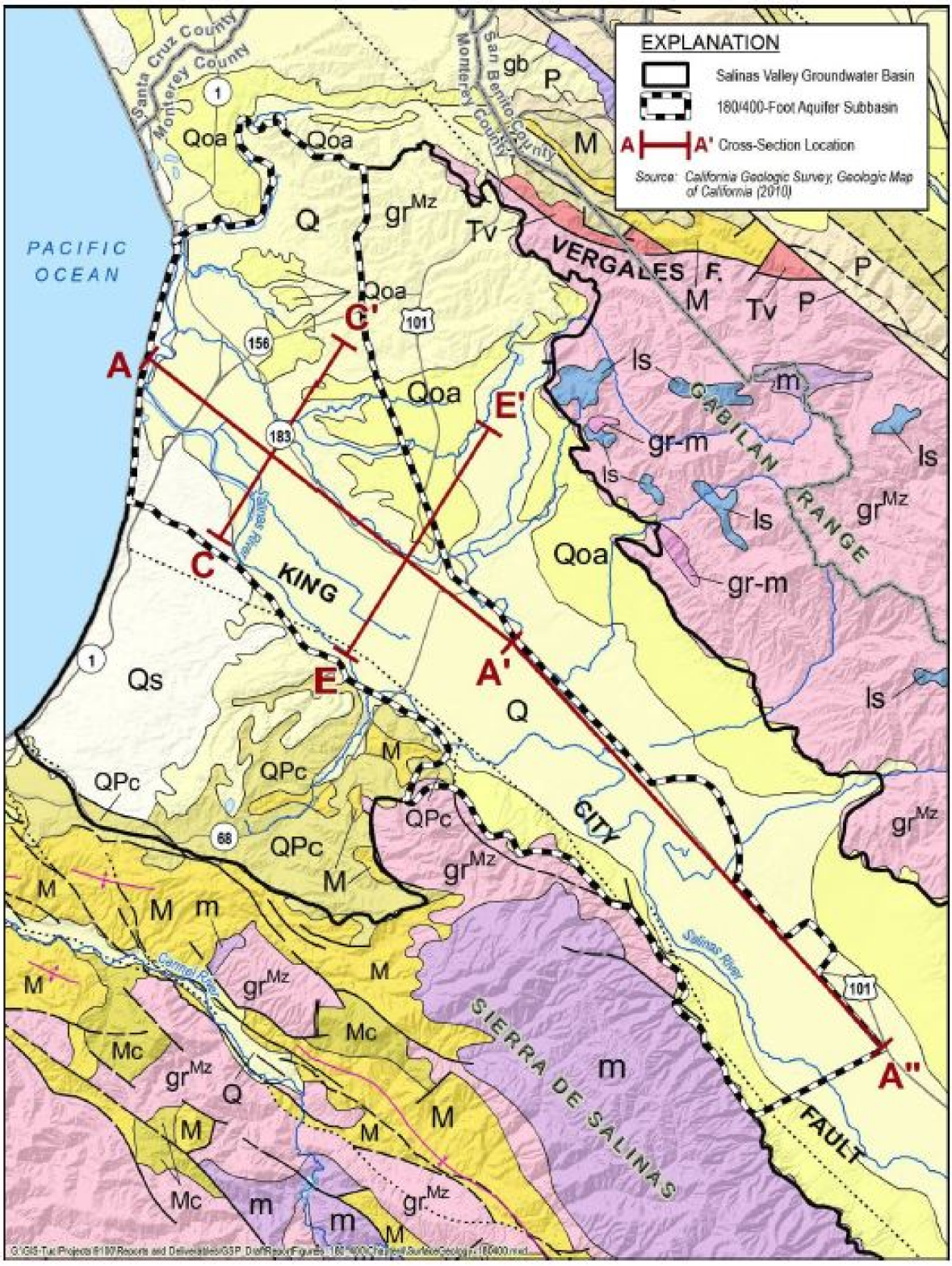

FIGURE 3-6

Geologic Map of the 180/400 Foot Subbasin

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Taken from SVBGSA 2020

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QUATERNARY DEPOSITS

Qs	Extensive marine and nonmarine sand deposits, generally near the coast or desert playas
Q	Alluvium, lake, playa, and terrace deposits; unconsolidated and semi-consolidated
Qoa	Older alluvium, lake, playa, and terrace deposits
QPc	Pleistocene and/or Pliocene sandstone, shale, and gravel deposits, mostly loosely consolidated

TERTIARY SEDIMENTARY ROCKS

P	Pliocene marine sandstone, siltstone, shlae, and conglomerate, mostly moderately consolidated
M	Miocene marine sandstone, shale, siltstone, conglomerate, and breccia, moderately to well consolidated
Mc	Miocene nonmarine sandstone, shale, conglomerate, and fanglomerate, moderately to well consolidated
O	Oligocene marine sandstone, shale, and conglomerate, mostly well consolidated

TERTIARY VOLCANIC ROCKS

Tv	Tertiary volcanic flow rocks, minor pyroclastic deposits

MESOZOIC SEDIMENTARY AND METASEDIMENTARY ROCKS

ls	Limestone, dolomite, and marble whose age is uncertain but probably Paleozoic or Mesozoic

MESOZOIC MIXED ROCKS

gr-m	Mesozoic to Precambrian granitic and metamorphic rocks, mostly gneiss and other metamorphic rocks injected by granitic rocks

MESOZOIC PLUTONIC ROCKS

grMz	Mesozoic granite, quartz monzonite, granodiorite, and quartz diorite
gb	Gabbro and dark dioritic rocks, chiefly Mesozoic

PALEOZOIC MIXED ROCKS

m	Undivided pre-Cenozoic metasedimentary and metavolcanic rocks of great variety. Mostly slate, quartzite, hornfels, chert, phyllite, mylonite, schist gneiss, and minor marble

GEOLOGIC SYMBOLS

- fault, certain
- fault, approx. located
- fault, concealed
- normal fault, approx. located
- dextral fault, certain
- Plunging anticline, certain
- Syncline, certain

FIGURE 3-7

Legend for the Geologic Map of the 180/400 Foot Subbasin

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Taken from SVBGSA 2020

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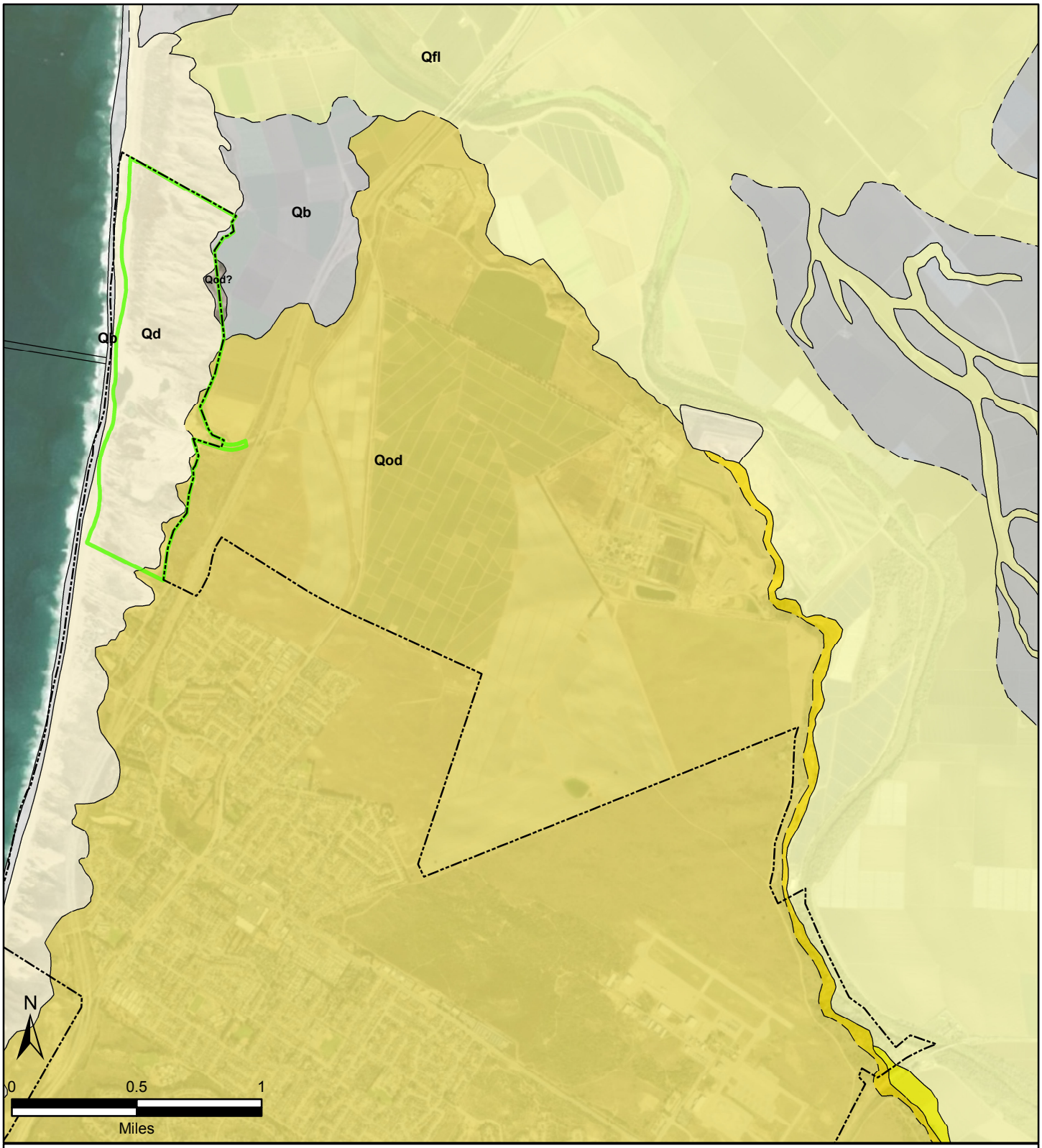

FIGURE 3-8

Surficial Geology of the MGSA Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

Geologic Units

- Q- Alluviam, lake, playa, and terrance deposits
- Qae- quaternary alluvium
- Qb - Basin Deposits
- Qd - Dune Sand
- Qfl - Flood plain deposits
- Qod - Older dune sand
- City of Marina
- City of Marina GSA (MGSA) Area

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, Department of Conservation, California Geological Survey

DATE: DEC. 30, 2019

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FIGURE 3-9

Surficial Soils of the MGSA Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- NRCS Soil Unit Symbol
- City of Marina
- City of Marina (MGSA) GSA Area

NRCS Soil Units

Cm – Coastal Beaches
W – Water
Cg – Clear Lake Clay, 0 to 1 % slopes
BbC – Baywood Sand, 2 to 15 % slopes
OaD – Oceano Loamy Sand
Df – Dune land

Sources: ESRI Map Service Imagery, https://websoilsurvey.sc.egov.usda.gov App/WebSoilSurvey.aspx, USDA NRCS Web Soil Survey

DATE: DEC. 30, 2019

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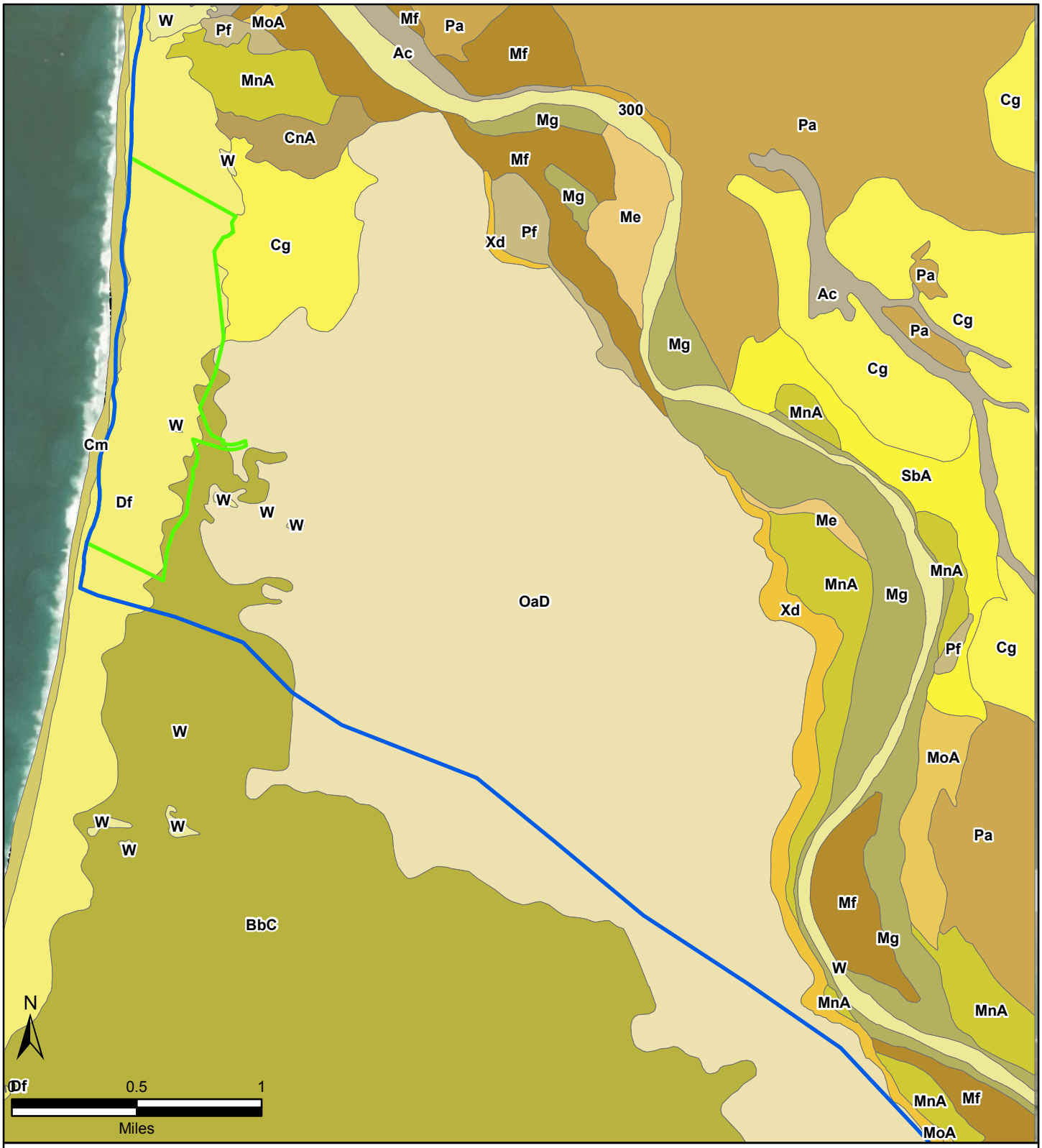

FIGURE 3-10

Soil Map of the 180/400 Foot Subbasin

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

NRCS Soil Unit Symbol

- 300
- Ac
- BbC
- Cg
- Cm
- CnA
- Df
- Me
- Mf
- Mg
- MnA
- MoA
- OaD
- Pa
- Pf
- SbA
- W
- Xd
- City of Marina
- City of Marina GSA (MGSA) Area
- 180/400 Foot Aquifer Subbasin

Sources: ESRI Map Service Imagery, https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

DATE: DEC. 30, 2019

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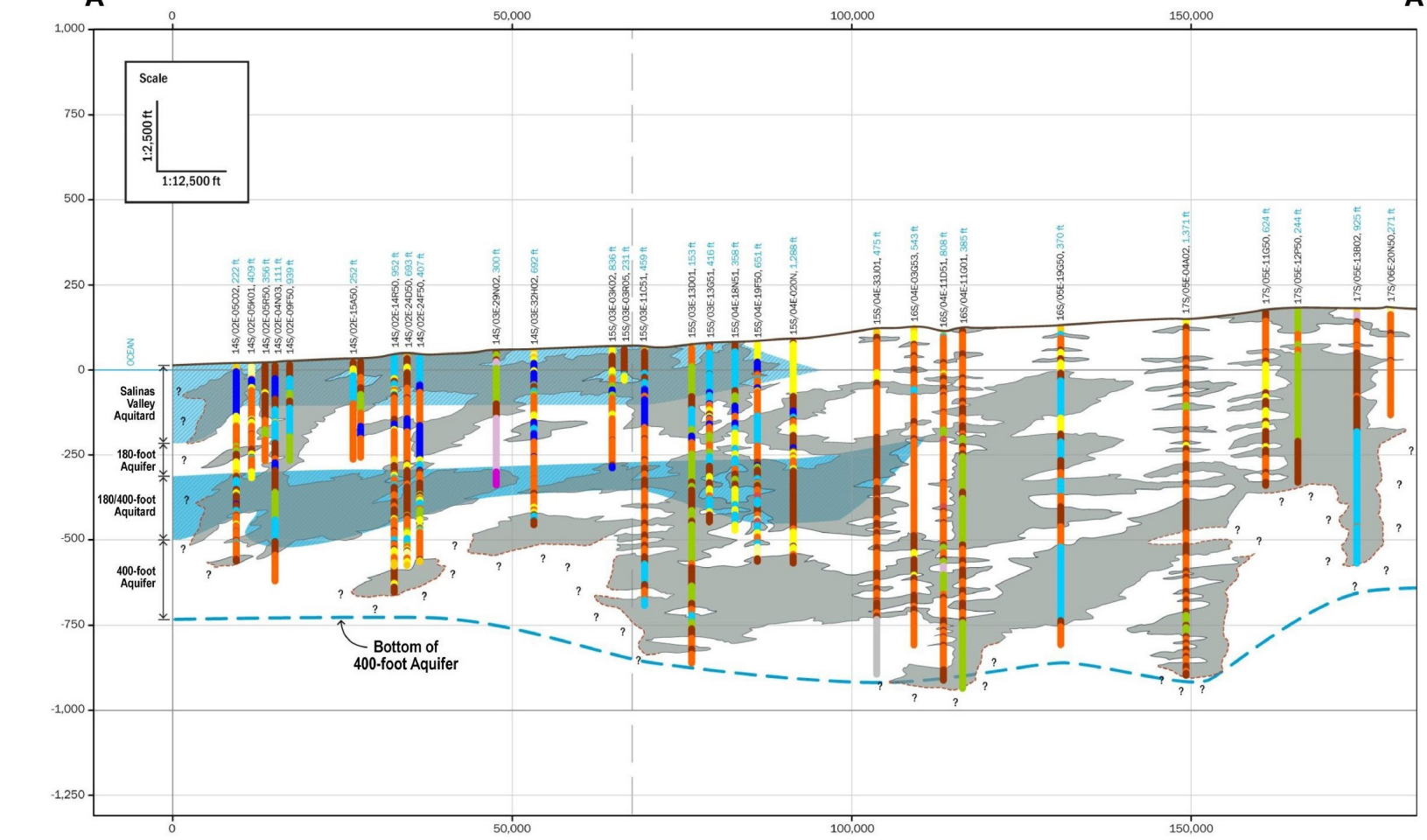

FIGURE 3-11

180/400 Foot Subbasin Regional Cross-Section A-A"

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- Fine Sand
- Coarse Sand
- Blue Clay
- Red Clay
- Yellow, Brown, White Clay
- Sandy/ Gravel, Blue Clay
- Shale
- Gravel/ Rock Clay
- Decomposed Granite
- Gravel/ Sand
- Granite/ Bedrock

DATE: DEC. 30, 2019

Taken from SVBGSA 2020

Notes:
Vertical scale exaggeration is 50:1 in feet MSL.
State Well ID is displayed at each well along with total depth of well.

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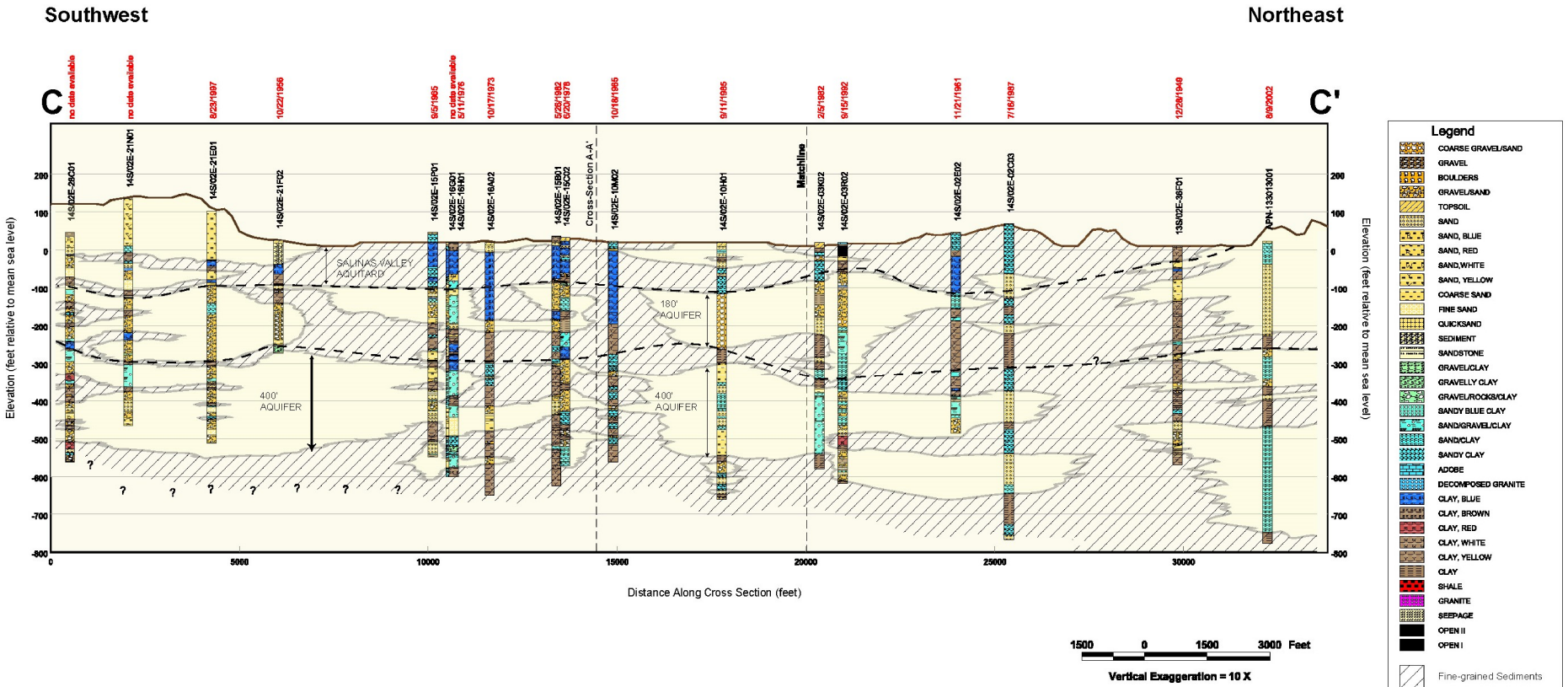

FIGURE 3-12

180/400 Foot Subbasin Regional Cross-Section C-C'

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Taken from SVBGSA 2020

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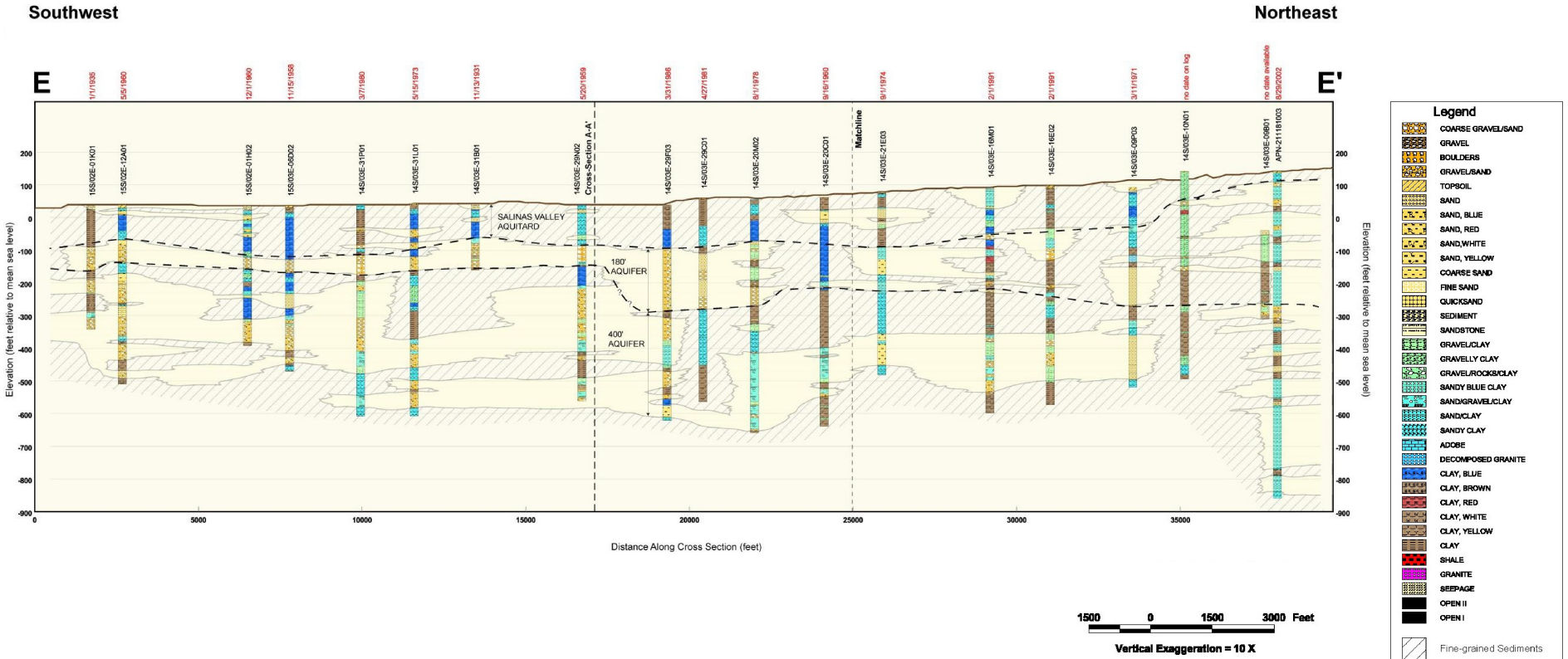

FIGURE 3-13

180/400 Foot Subbasin Regional Cross-Section E-E'

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Taken from SVBGSA 2020

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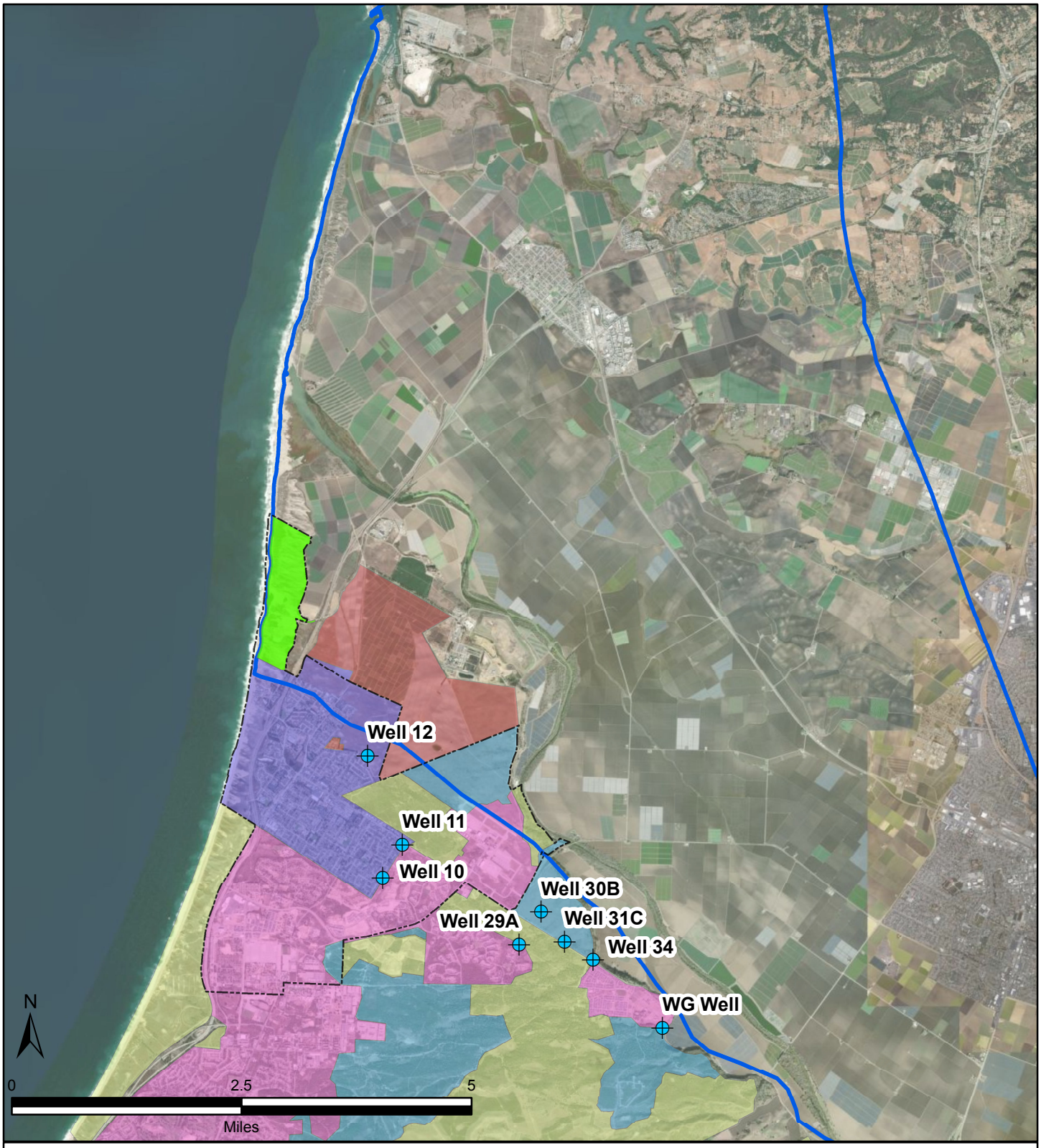

FIGURE 3-14

MCWD Water Supply Wells

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MCWD Water Supply Wells
- 180/400 Foot Aquifer Subbasin
- City of Marina
- City of Marina GSA (MGSA) Area

MCWD Service Areas

- Habitat/Open Space/Parkland
- MCWD Service Area - Central Marina
- MCWD Service Area - Ord Community
- MCWD Sphere of Influence
- Ord Development Parcels

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, Well locations from Jacobson James & Associates, Inc..

DATE: DEC, 30, 2019

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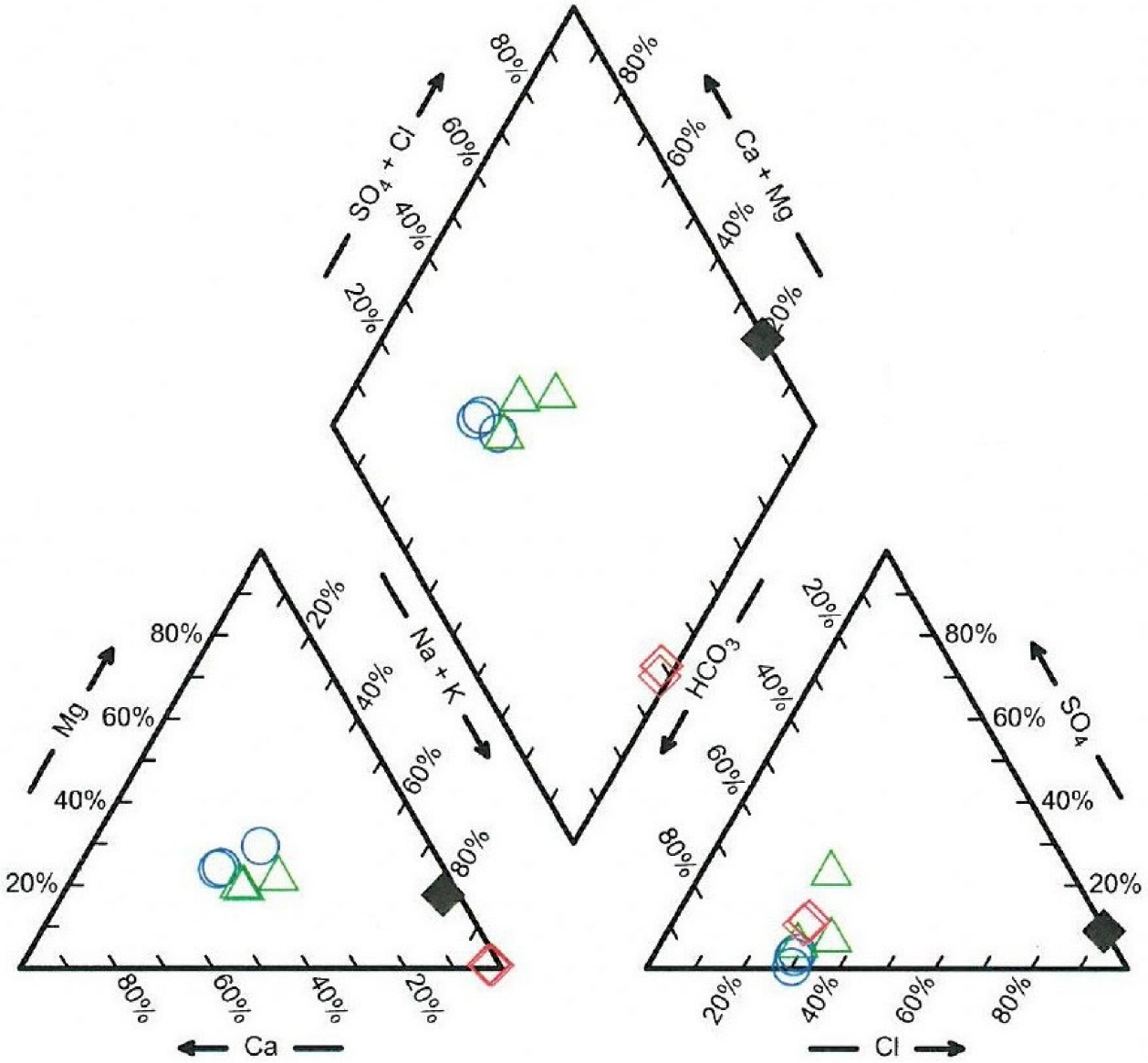

FIGURE 3-15

Regional Water Quality in Principal Supply Aquifers; Piper Diagram

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- ○ Pressure 180-Foot Aquifer
- ◇ Deep Aquifers
- △ Pressure 400-Foot Aquifer
- ◆ Seawater

DATE: DEC. 30, 2019

Taken from MCWRA October 2017

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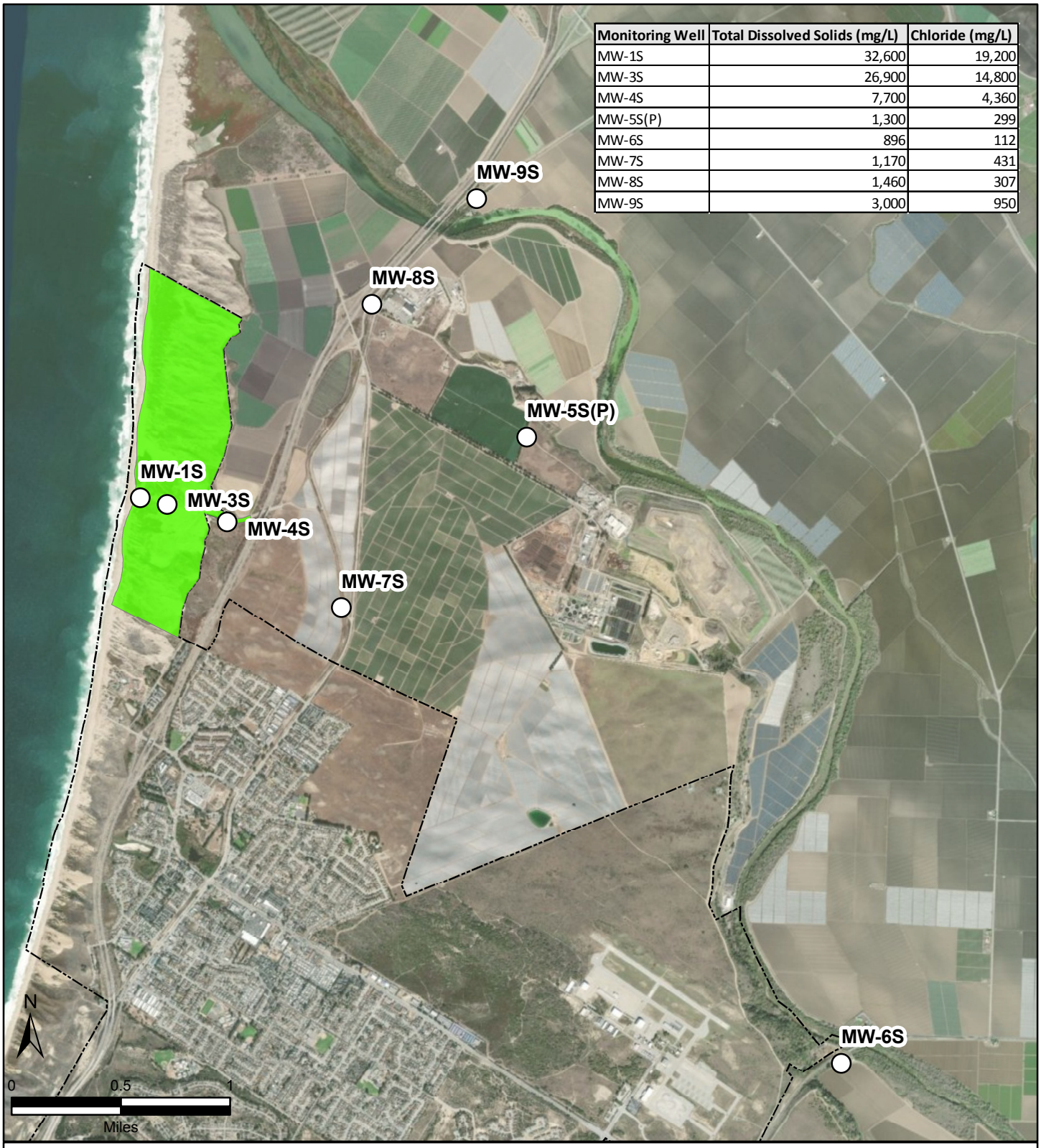

Monitoring Well	Total Dissolved Solids (mg/L)	Chloride (mg/L)
MW-1S	32,600	19,200
MW-3S	26,900	14,800
MW-4S	7,700	4,360
MW-5S(P)	1,300	299
MW-6S	896	112
MW-7S	1,170	431
MW-8S	1,460	307
MW-9S	3,000	950

FIGURE 3-16

TDS and Chloride Concentrations Detected in the Dune Sand Aquifer near the MGSA Area, April 2019

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- Monitoring Well Location
- City of Marina
- City of Marina GSA (MGSA) Area

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Monitoring Report #160 2019

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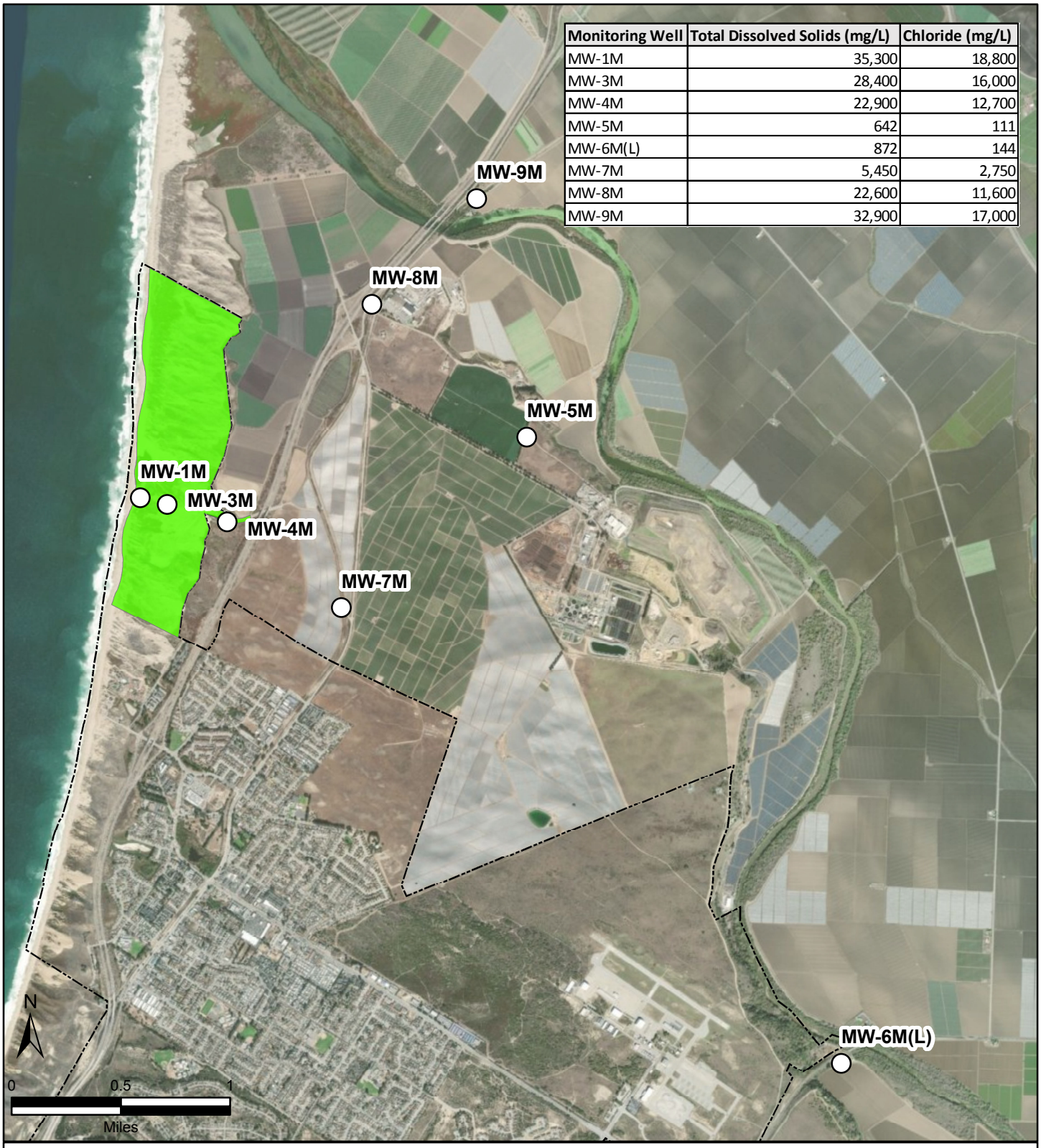


Monitoring Well	Total Dissolved Solids (mg/L)	Chloride (mg/L)
MW-1M	35,300	18,800
MW-3M	28,400	16,000
MW-4M	22,900	12,700
MW-5M	642	111
MW-6M(L)	872	144
MW-7M	5,450	2,750
MW-8M	22,600	11,600
MW-9M	32,900	17,000

FIGURE 3-17

TDS and Chloride Concentrations Detected in the 180-Foot Aquifer near the MGSA Area, April 2019

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

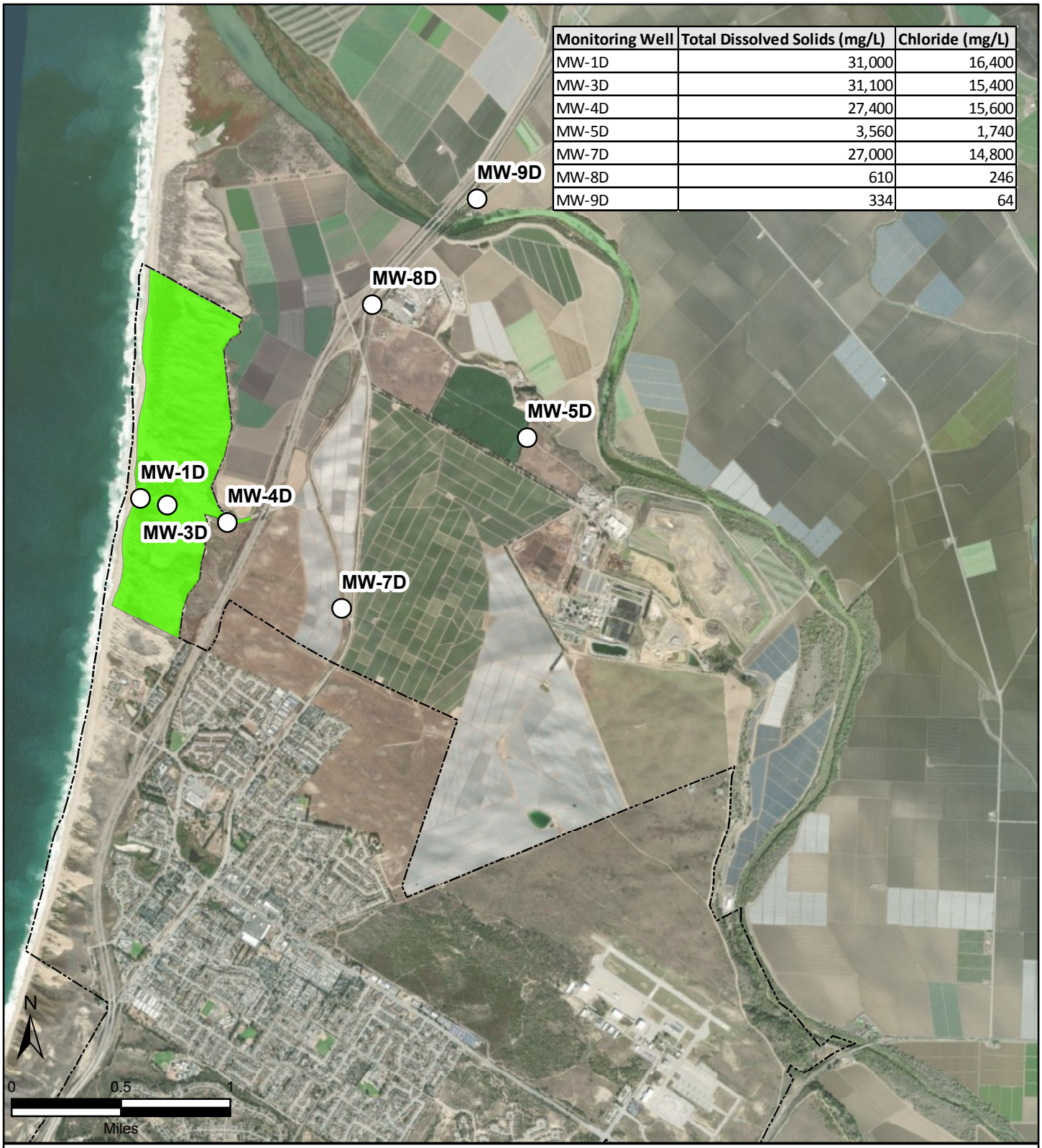
Legend

- Monitoring Well Location
- City of Marina
- City of Marina GSA (MGSA) Area

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Monitoring Report #160

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-17_Local_180_Foot_Aquifer_TDS_Chloride_Map_April_2019.mxd



Monitoring Well	Total Dissolved Solids (mg/L)	Chloride (mg/L)
MW-1D	31,000	16,400
MW-3D	31,100	15,400
MW-4D	27,400	15,600
MW-5D	3,560	1,740
MW-7D	27,000	14,800
MW-8D	610	246
MW-9D	334	64

FIGURE 3-18

TDS and Chloride Concentrations Detected in the 400-Foot Aquifer near the MGSA Area, April 2019

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- Monitoring Well Location
- City of Marina
- City of Marina GSA (MGSA) Area

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Monitoring Report #160

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-18_Local_400_Foot_Aquifer_TDS_Chloride_Map_April_2019.mxd

FIGURE 3-19

Local Recharge Map

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- Recharge Areas Mapped by Monterey County
- CSIP Distribution Recharge Area
- 180/400 Foot Aquifer Subbasin
- City of Marina
- City of Marina GSA (MGSA) Area

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, https://montereycountyopendata-12017-01-13t232948815z-montereyco.opendata.arcgis.com/datasets/recharge-areas-1

DATE: DEC. 30, 2019

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-19_Local Recharge Map.mxd

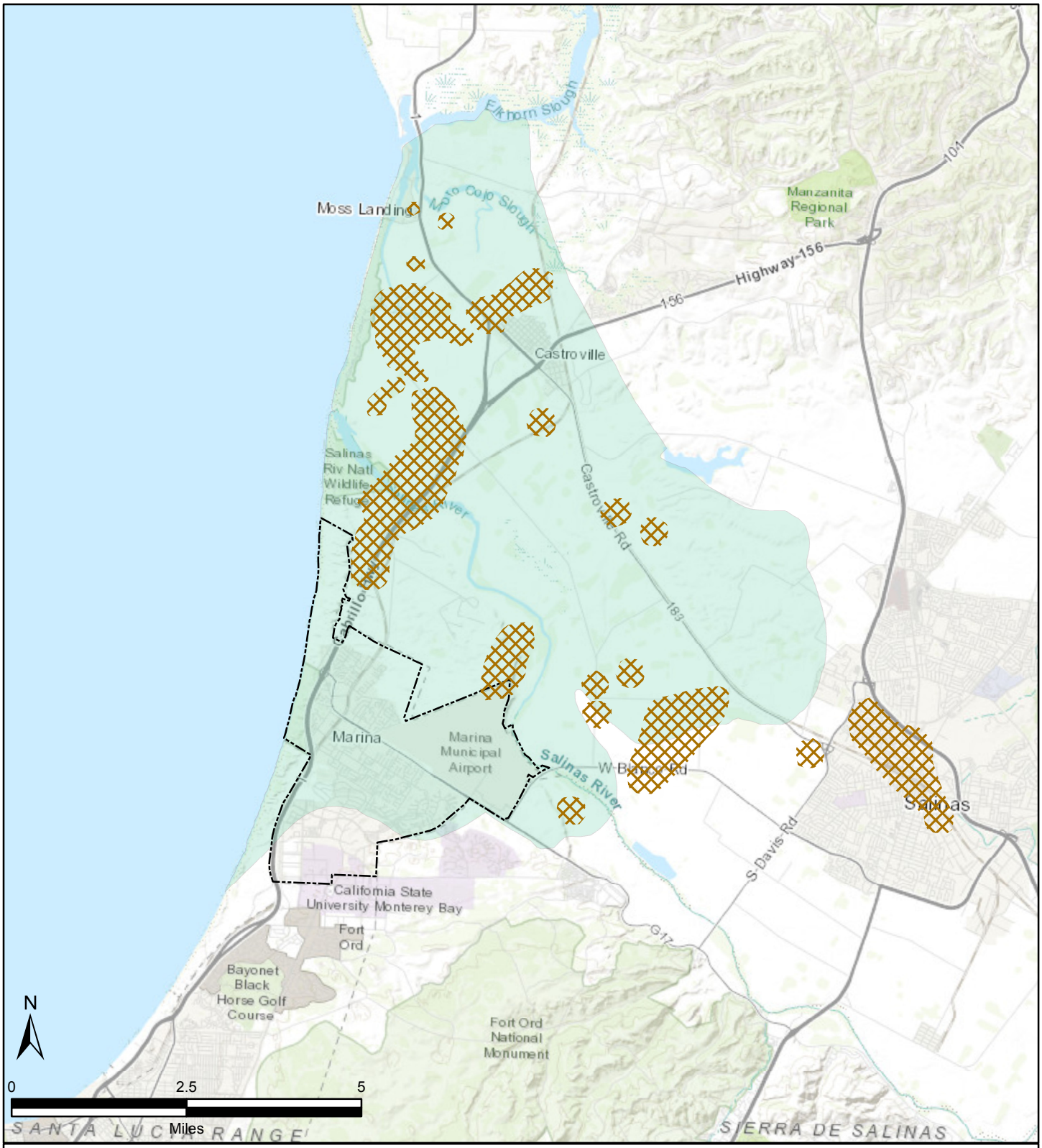


FIGURE 3-20

Gaps in 180/400 Foot Aquitard

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina
- Areas of Thin or Absent Aquitards
- Area of Impact

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MCWRA October 2017

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-20_Gaps_in_180_140Ft_Aquitard.mxd

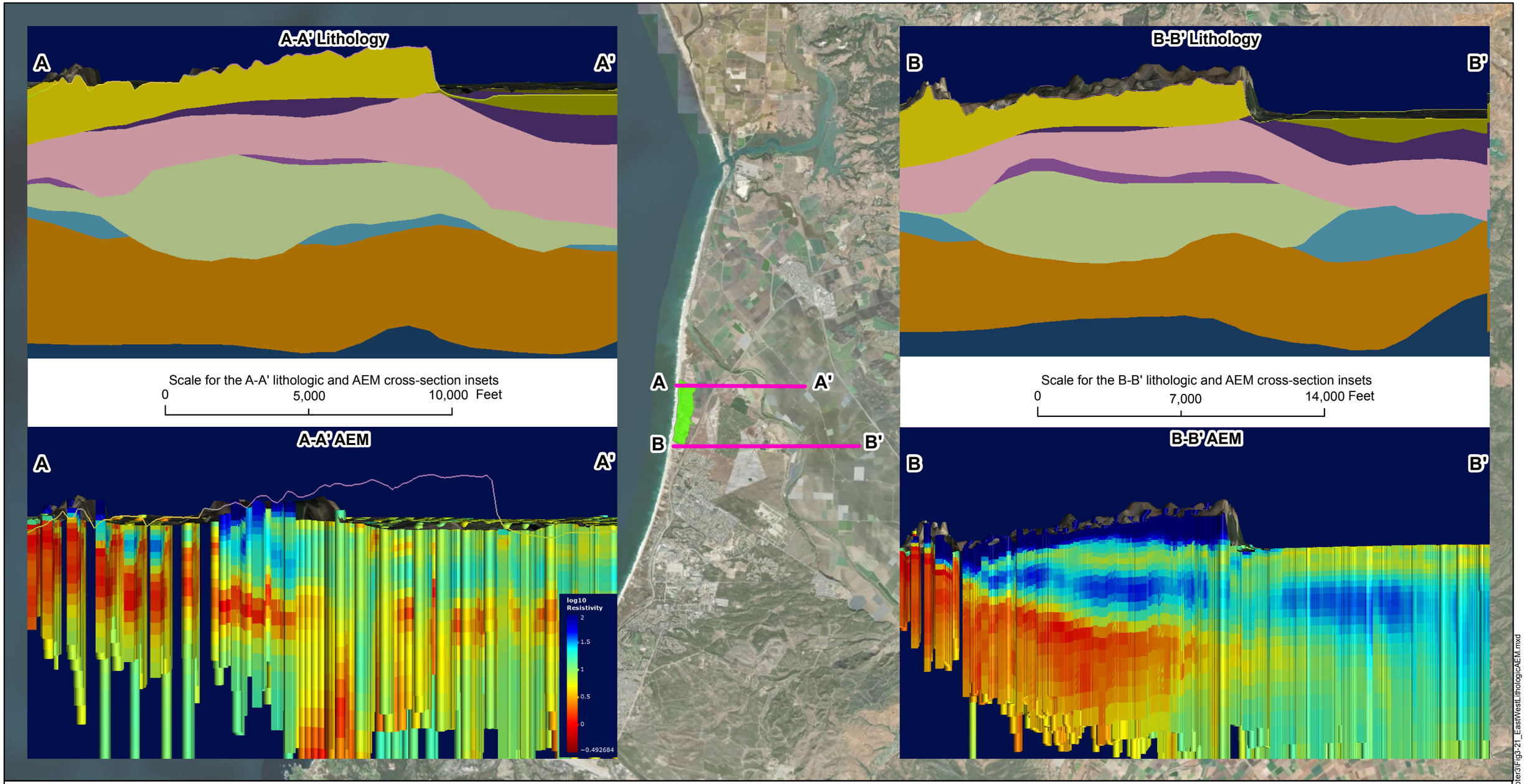


FIGURE 3-21

East-West Lithologic and AEM Cross-Sections Across the MGSA Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

City of Marina GSA (MGSA) Area

Cross-Section Transects

Hydrostratigraphic Unit

- Perched "A" Aquifer
- Dune Sand Aquifer
- Salinas Valley Aquitard
- Upper 180-Foot Aquifer
- Int. 180-Foot Aquitard
- Lower 180-Foot Aquifer
- 180/400-Foot Aquitard
- 400-Foot Aquifer
- 400/Deep Aquitard

Scale for basemap

0 1 2

Miles

N

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, Gottschalk et al 2018

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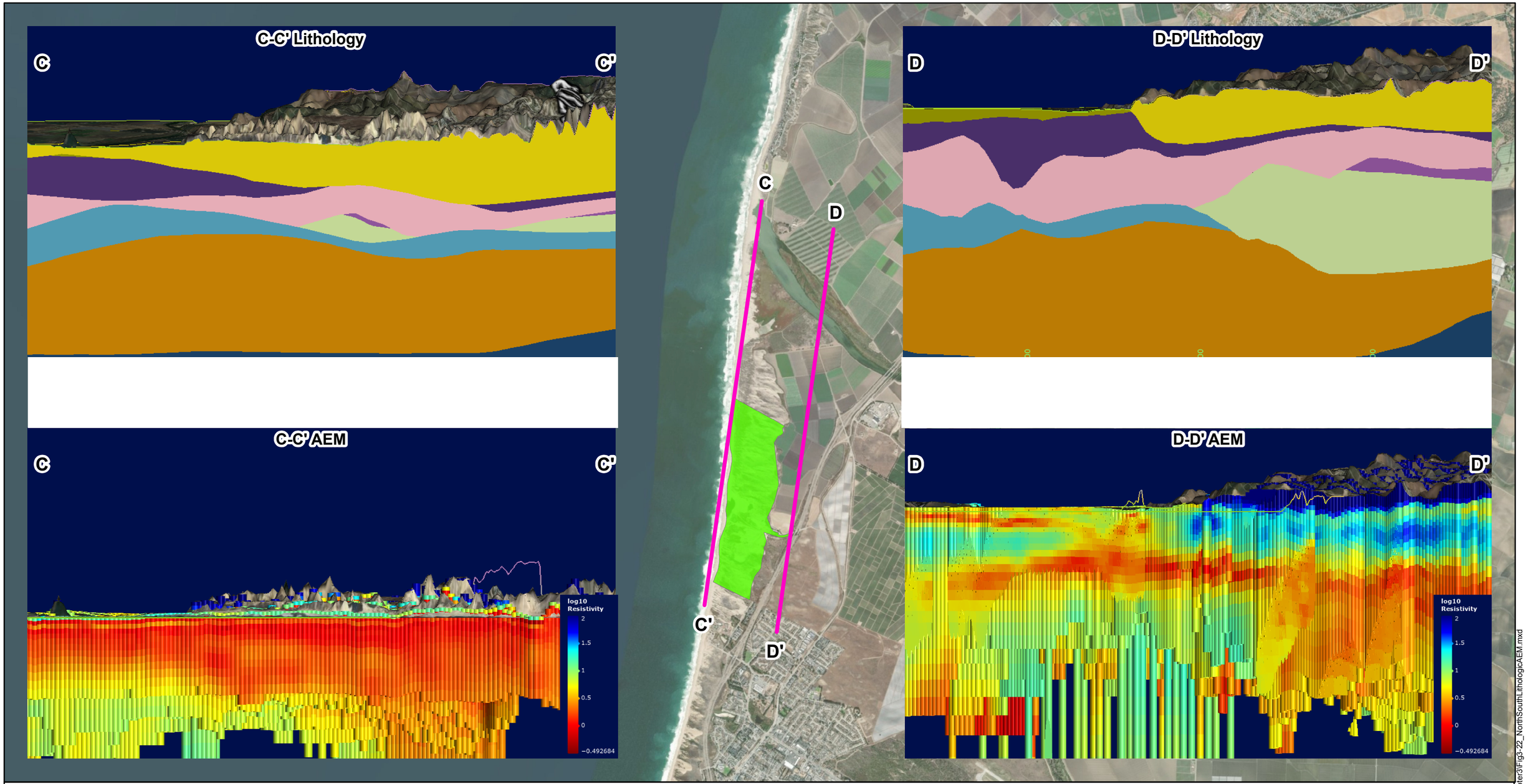

FIGURE 3-22

North-South Lithologic and AEM Cross-Sections Across the MGSA Area

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA (MGSA) Area
- Cross-Section Transects

Hydrostratigraphic Unit

- Perched "A" Aquifer
- Dune Sand Aquifer
- Salinas Valley Aquitard
- Upper 180-Foot Aquifer
- Int. 180-Foot Aquitard
- Lower 180-Foot Aquifer
- 180/400-Foot Aquitard
- 400-Foot Aquifer
- 400/Deep Aquitard

Scale for the lithologic and AEM cross-section insets

0 5,000 10,000 Feet

Scale for basemap

0 0.5 1 Miles

N

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, Gottschalk et al 2018

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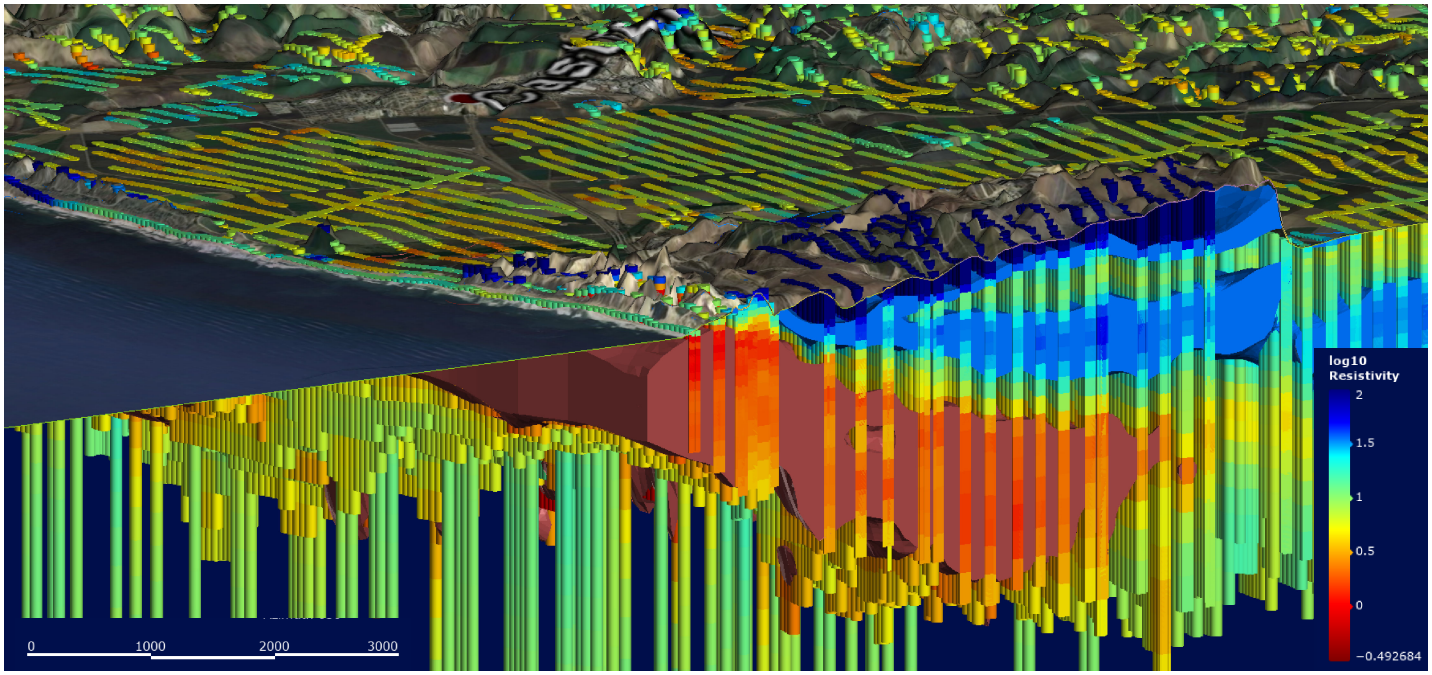

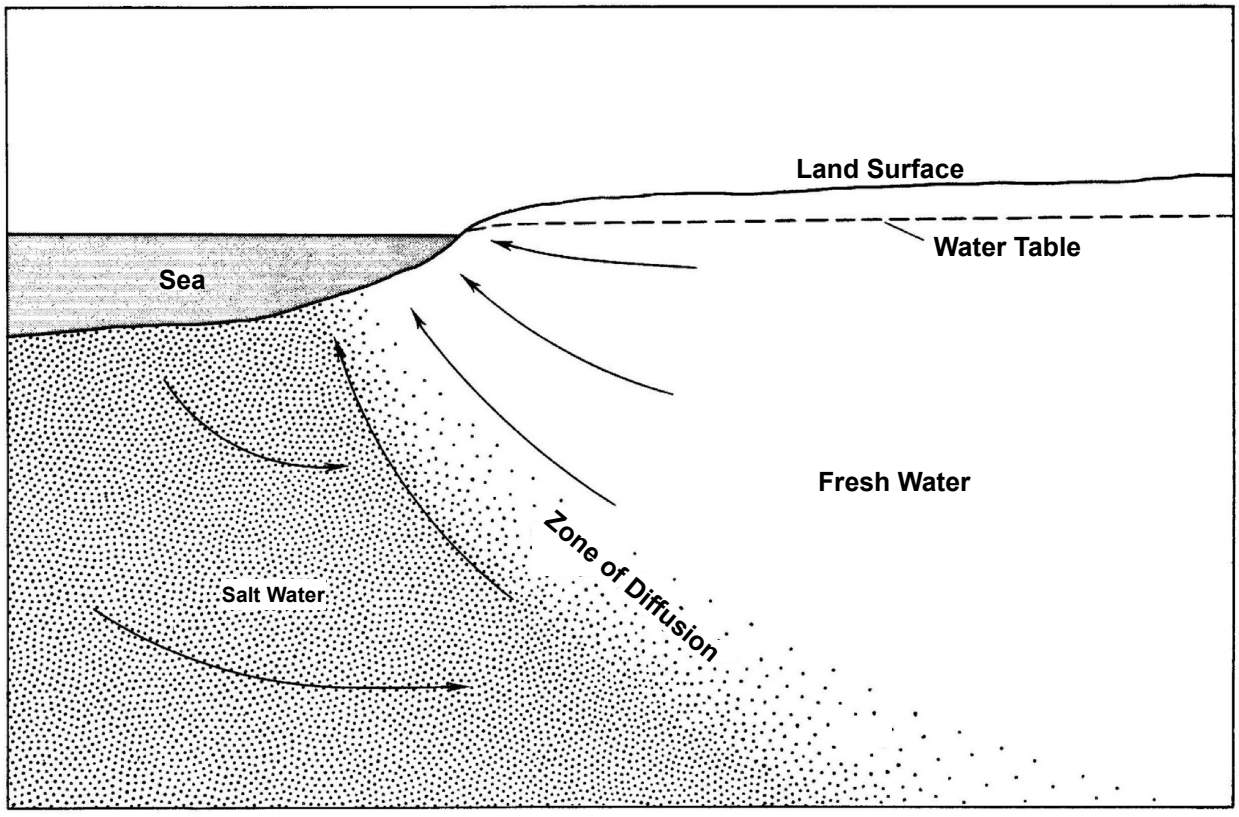

FIGURE 3-23

Oblique View of Seawater Intrusion Front and Low TDS Zone with Ghyben-Herzberg Model Inset

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Sources: Gottschalk et al 2018

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-23_ObliqueViewOfSeawaterIntrusionFrontLowTDSModel.mxd

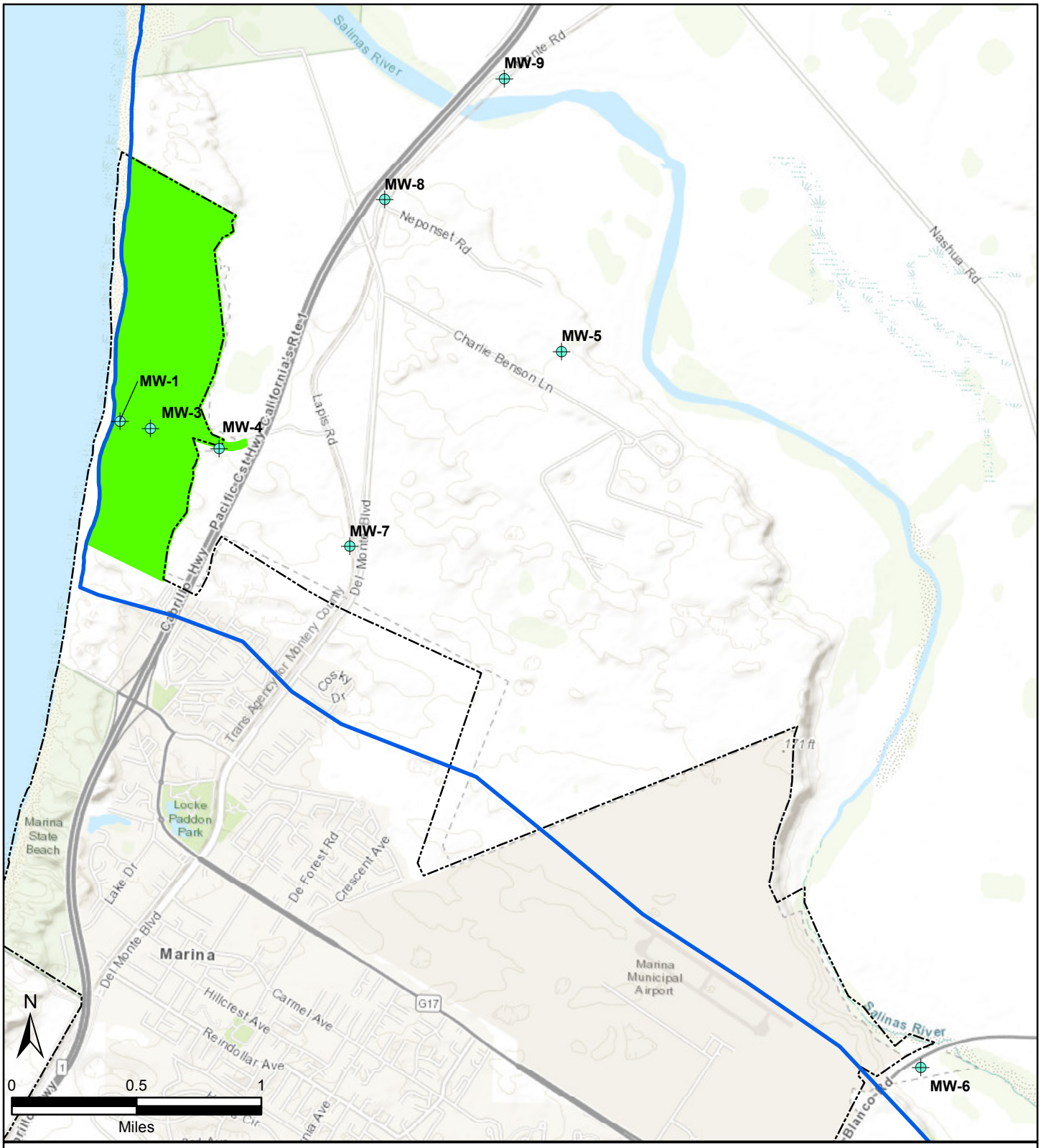

FIGURE 3-24

Locations of MPWSP Wells

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Wells
- City of Marina GSA (MGSA)
- City of Marina
- 180/400 Foot Aquifer

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Monitoring Report #160 2019

DATE: DEC. 30, 2019

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FIGURE 3-25

Local Dune Sand Aquifer Water Level Map, March 20, 2015

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- Monterey Peninsula Landfill Monitoring Well
- Fort Ord OU1 Monitoring Well
- City of Marina GSA (MGSA) Area
- City of Marina

DATE: DEC. 30, 2019

Note: Monterey Peninsula Landfill water levels from March 23-24, 2015.
Fort Ord OU1 water levels from July 1, 2015.

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

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FIGURE 3-26

Local Dune Sand Aquifer Water Level Contour Map, March 12, 2017

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- Monterey Peninsula Landfill Monitoring Well
- Fort Ord OU1 Monitoring Well
- Inferred Potentiometric Contour Line
- Estimated Estimated Potentiometric Contour Line
- City of Marina GSA (MGSA) Area
- City of Marina

Note: Monterey Peninsula Landfill Groundwater Elevations from March 20, 2017.

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

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FIGURE 3-27

Local Dune Sand Aquifer Water Level Contour Map, April 2, 2018

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- Monterey Peninsula Landfill Monitoring Well
- Inferred Potentiometric Contour Line
- Estimated Estimated Potentiometric Contour Line
- City of Marina GSA (MGSA) Area
- City of Marina

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

Note: Monterey Peninsula Landfill Groundwater Elevations from March 21, 2018.

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FIGURE 3-28

Local 180-Foot Aquifer Water Level Map, March 20, 2015

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- MCWD Well, Deep Aquifer
- City of Marina GSA (MGSA) Area
- City of Marina

DATE: DEC. 30, 2019

ESRI Map Service Imagery from October 2018

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

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FIGURE 3-29

Local 180-Foot Aquifer Water Level Contour Map, March 12, 2017

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- MCWD Well, Deep Aquifer
- Inferred Potentiometric Contour Line
- Estimated Estimated Potentiometric Contour Line
- City of Marina GSA (MGSA) Area
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

DATE: DEC. 30, 2019

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FIGURE 3-30

Local 180-Foot Aquifer Water Level Contour Map, April 2, 2018

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- Water Level Well
- MCWD Well, Deep Aquifer
- Inferred Potentiometric Contour Line
- Estimated Estimated Potentiometric Contour Line
- City of Marina GSA (MGSA) Area
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

DATE: DEC, 30, 2019

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FIGURE 3-31

Local 400-Foot Aquifer Water Level Map, March 20, 2015

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- Water Level Well
- MCWD Well, Deep Aquifer
- City of Marina GSA (MGSA) Area
- City of Marina

ESRI Map Service Imagery from October 2018

DATE: DEC, 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

CITY OF MARINA

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FIGURE 3-32

Local 400-Foot Aquifer Water Level Contour Map, March 12, 2017

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- Water Level Well
- MCWD Well, Deep Aquifer
- Inferred Potentiometric Contour Line
- Estimated Estimated Potentiometric Contour Line
- City of Marina GSA (MGSA) Area
- City of Marina

ESRI Map Service Imagery from October 2018

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

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FIGURE 3-33

Local 400-Foot Aquifer Water Level Contour Map, April 2, 2018

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MPWSP Monitoring Well
- Water Level Well
- MCWD Well, Deep Aquifer
- Inferred Potentiometric Contour Line
- Estimated Estimated Potentiometric Contour Line
- City of Marina GSA (MGSA) Area
- City of Marina

DATE: DEC. 30, 2019

ESRI Map Service Imagery from October 2018

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Report 148, 2018, Monterey Peninsula Landfill First 2019 Semiannual Water Quality Monitoring Report October 2018, Final 2016 Annual Groundwater Monitoring Report, Operable Unit 1, Fritzsche Army Airfield Fire Drill Area, Former Fort Ord

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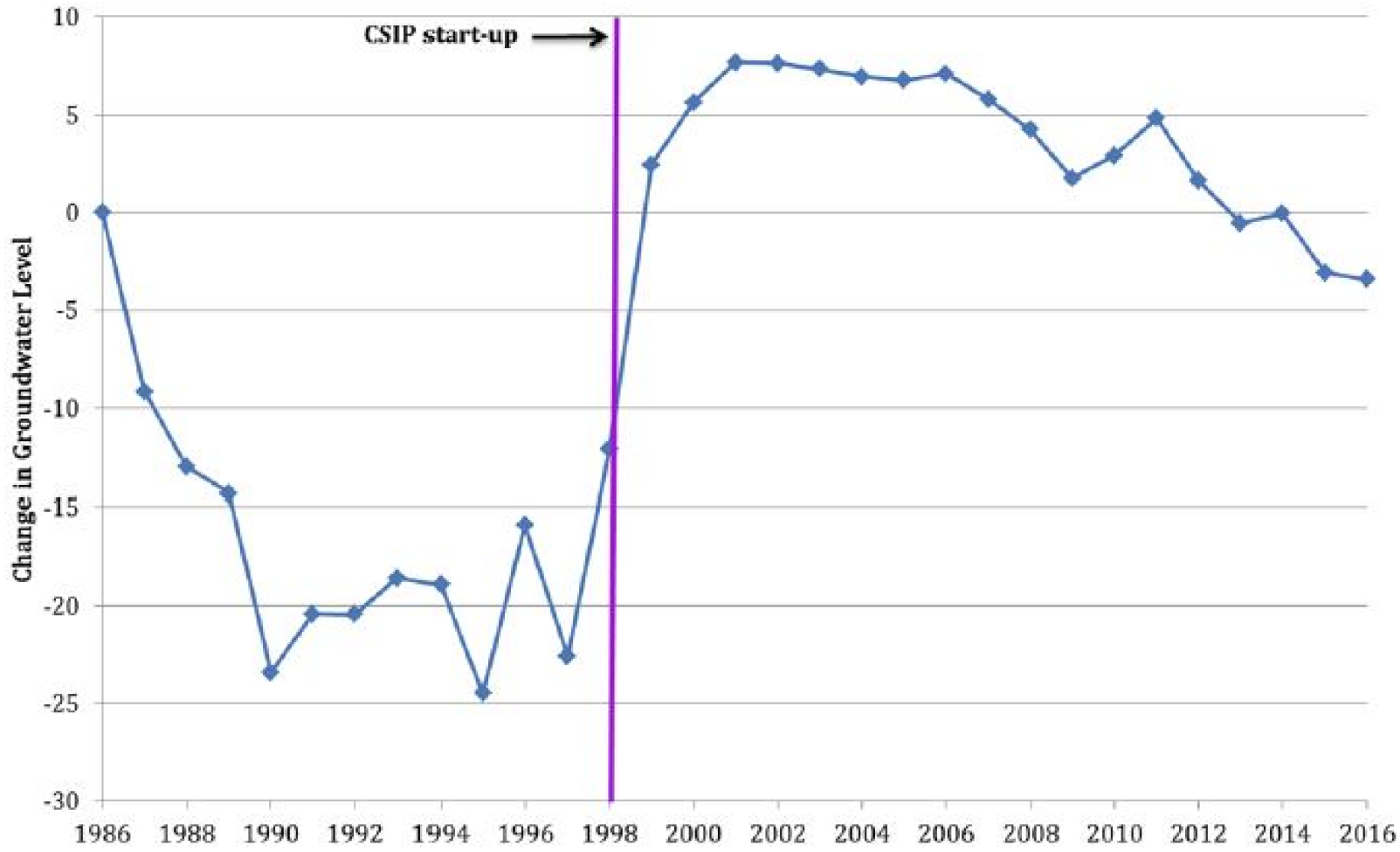

FIGURE 3-34

Average Groundwater Level Changes in the Deep Aquifers

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Taken from MCWRA 2017

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-34_AverageGroundwaterLevelChangesinDeepAquifers.mxd

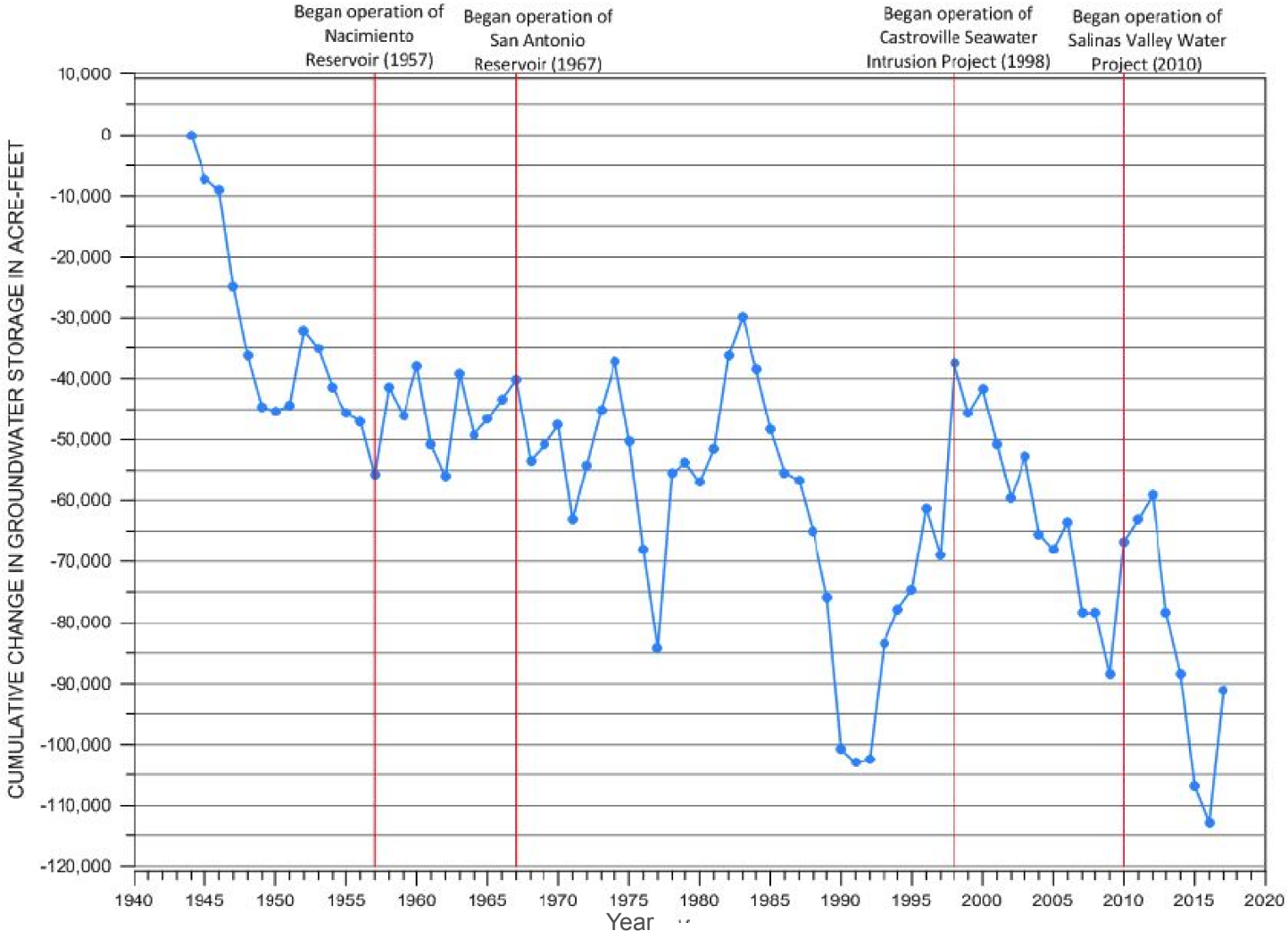

FIGURE 3-35

Cumulative Change in Groundwater Storage Based on Groundwater Elevations

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

Taken from SVBGSA 2020, MCWRA 2018

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-35_Cumulative_Change_in_Groundwater_Storage_Based_On_Groundwater_Elevations.mxd

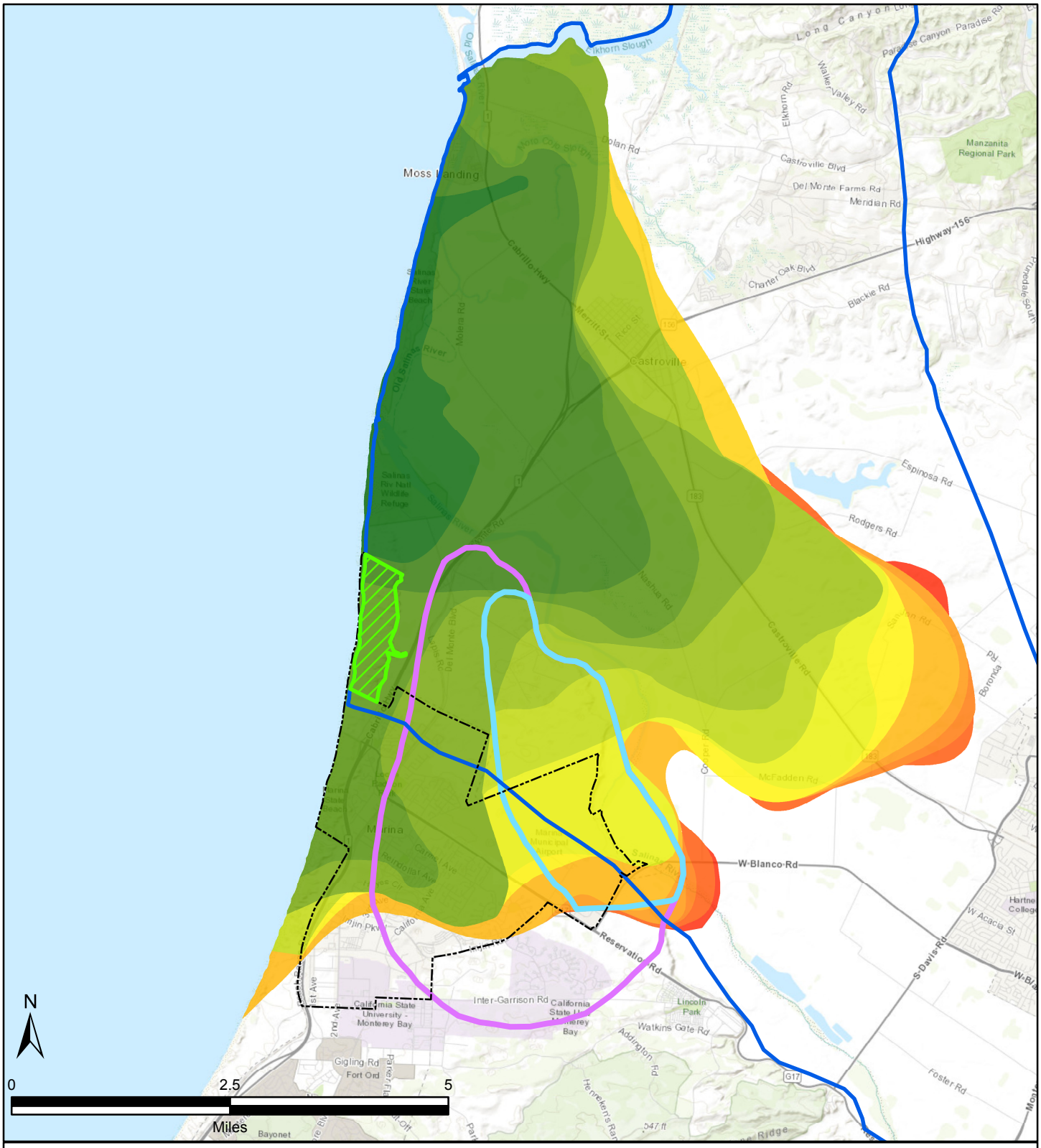

FIGURE 3-36

MCWRA Seawater Intrusion Map 180-Foot Aquifer with Low TDS Groundwater

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA (MGSA) Area
- City of Marina
- 180/400 Foot Aquifer Subbasin

Low TDS Groundwater

- 180-Foot Aquifer
- Dune Sand Aquifer

Yearly Seawater Intrusion

- 1944
- 1965
- 1975
- 1985
- 1993
- 1997
- 1999
- 2001
- 2003
- 2005
- 2007
- 2009
- 2011
- 2015

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MCWRA October 2017, Gottschalk, et at. 2018

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-36_MCWRA_seawater_intrusion_map_180_foot_aquifer_with_freshwater_bubbles.mxd

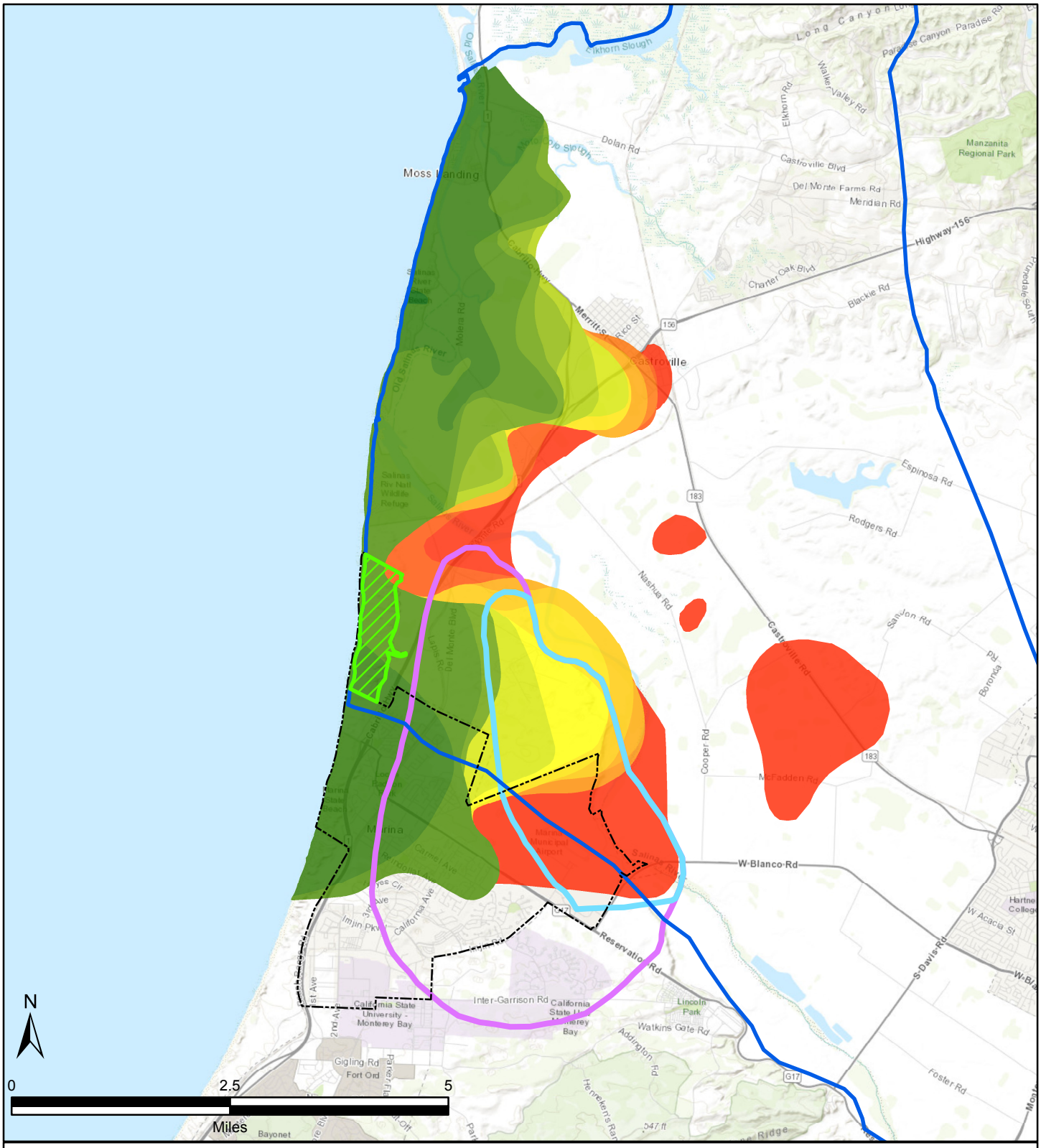

FIGURE 3-37

MCWRA Seawater Intrusion Map 400-Foot Aquifer with Low TDS Groundwater

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA (MGSA) Area
- City of Marina
- 180/400 Foot Aquifer Subbasin

Low TDS Groundwater

- 180-Foot Aquifer
- Dune Sand Aquifer

Yearly Seawater Intrusion

- 1959
- 1975
- 1985
- 1990
- 1993
- 1995
- 1997
- 1999
- 2001
- 2003
- 2005
- 2007
- 2009
- 2011
- 2015

DATE: DEC. 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MCWRA October 2017, Gottschalk, et at. 2018

\\sa\m\Marina\GIS\FormationLayers\MXD\Chapter3\Fig3-37_MCWRA_seawater_intrusion_map_400_foot_aquifer_with_freshwater_bubbles.mxd

FIGURE 3-38

Potential GDE Locations and Depth to Uppermost Groundwater in the Dune Sand Aquifer

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Groundwater Dependent Ecosystems - Wetlands

Cities

Groundwater Dependent Ecosystem - Vegetation

City of Marina GSA (MGSA) Area

DATE: DEC, 30, 2019

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa

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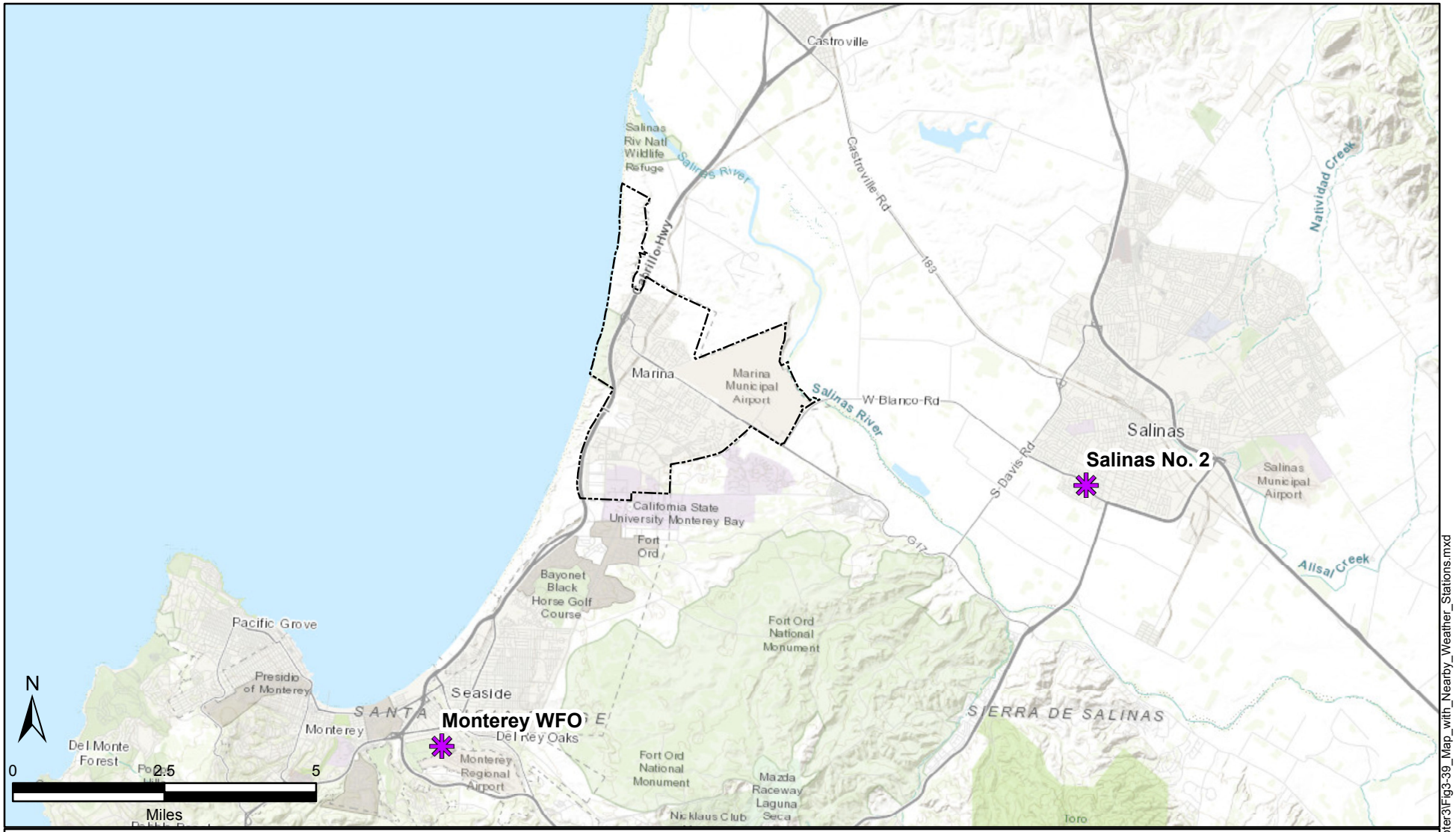

FIGURE 3-39

Nearby Weather Stations

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- Weather Stations
- City of Marina

DATE: DEC. 30, 2019

Sources: http://goto.arcgisonline.com/maps/World_Topo_Map, National Weather Service - NWS San Francisco/Monterey Bay Area

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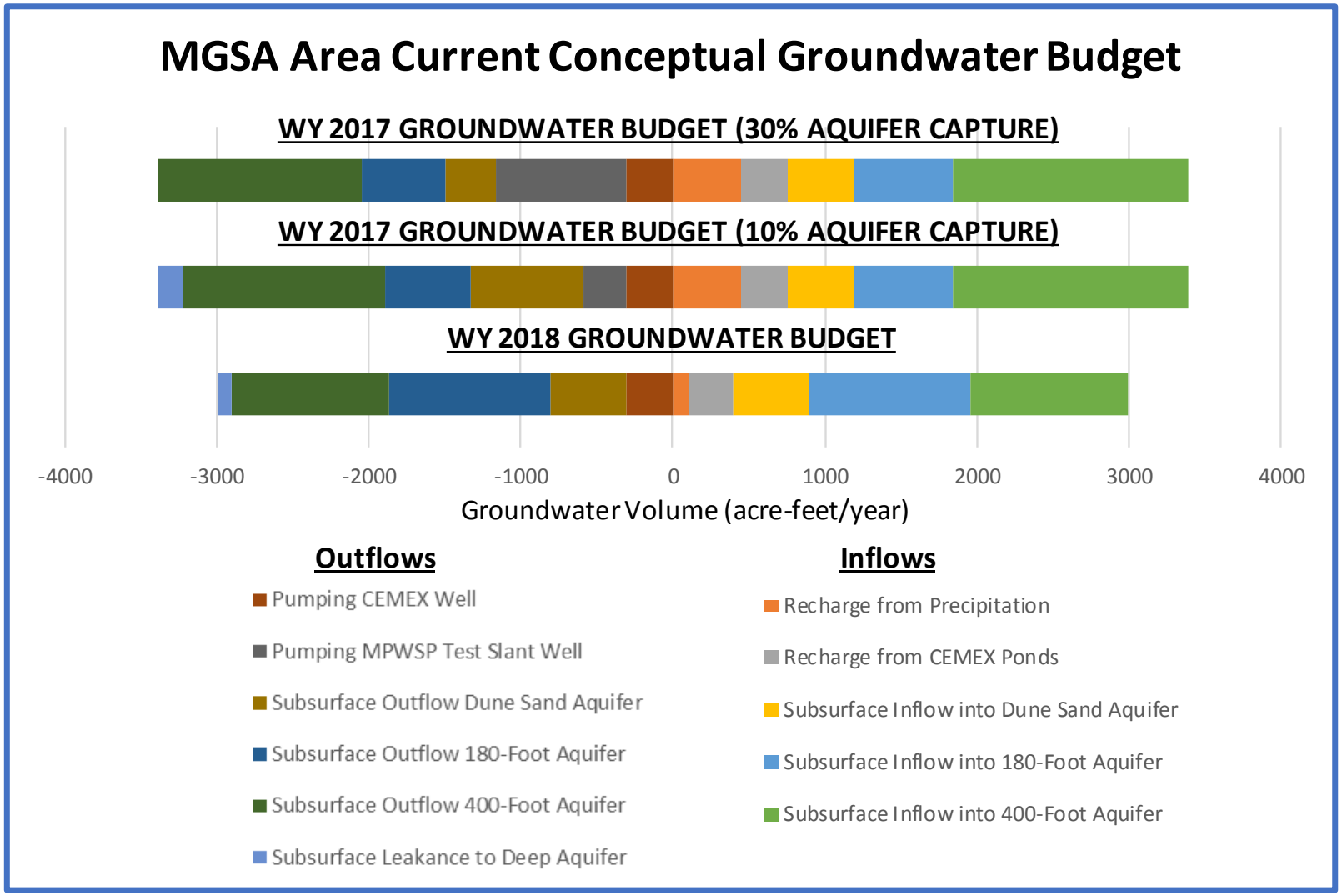

FIGURE 3-40

MGSA Area Current Conceptual Groundwater Budget

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC. 30, 2019

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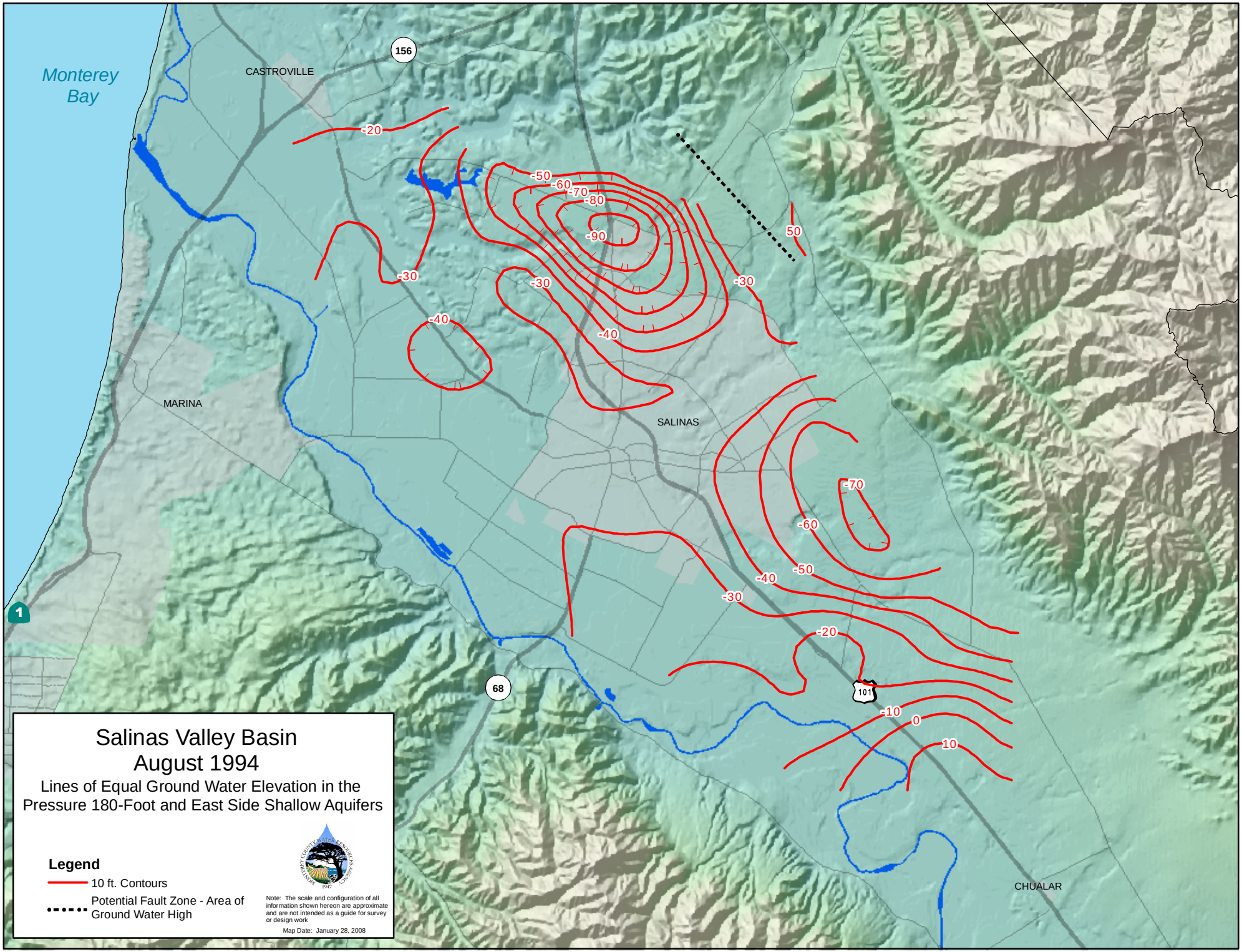
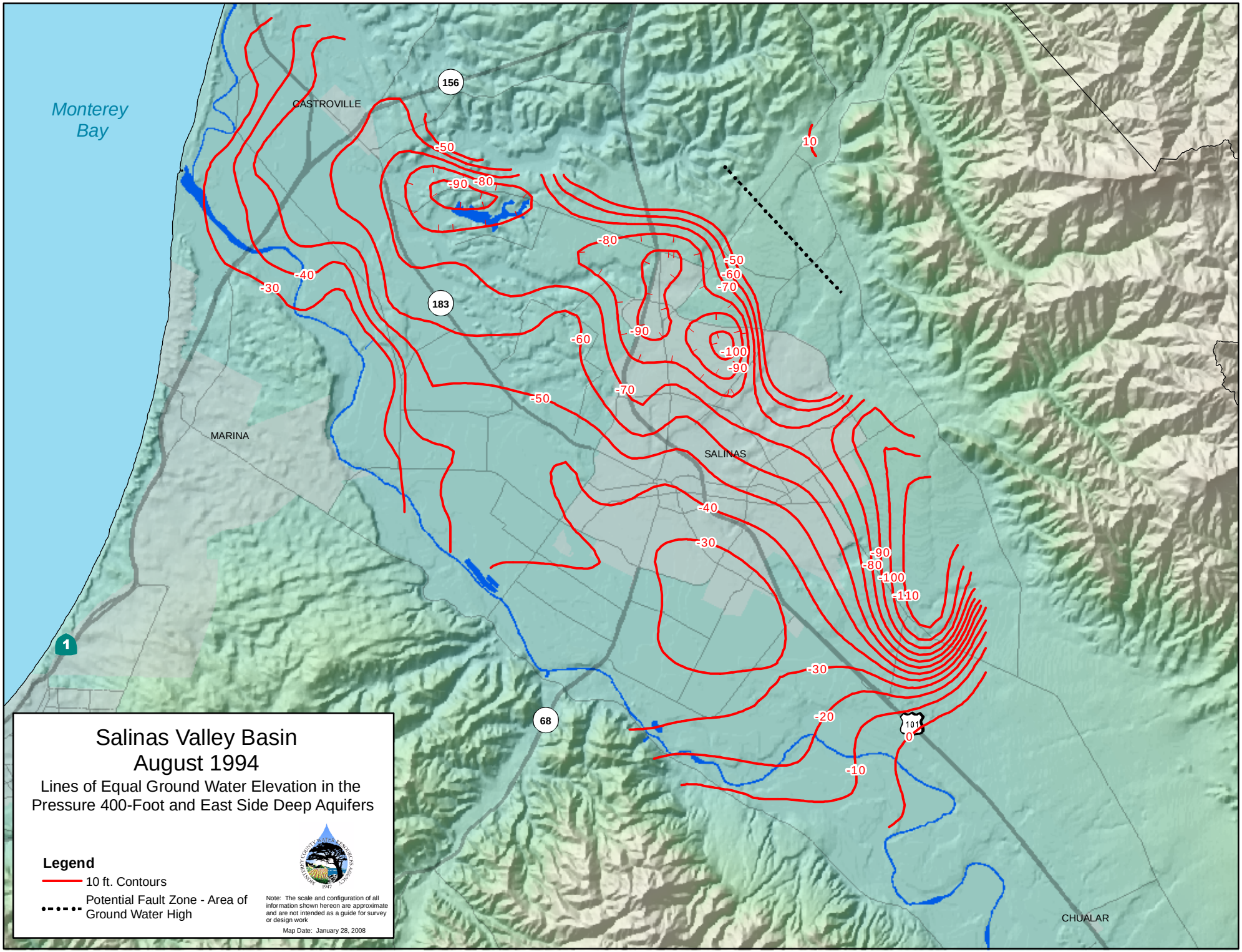
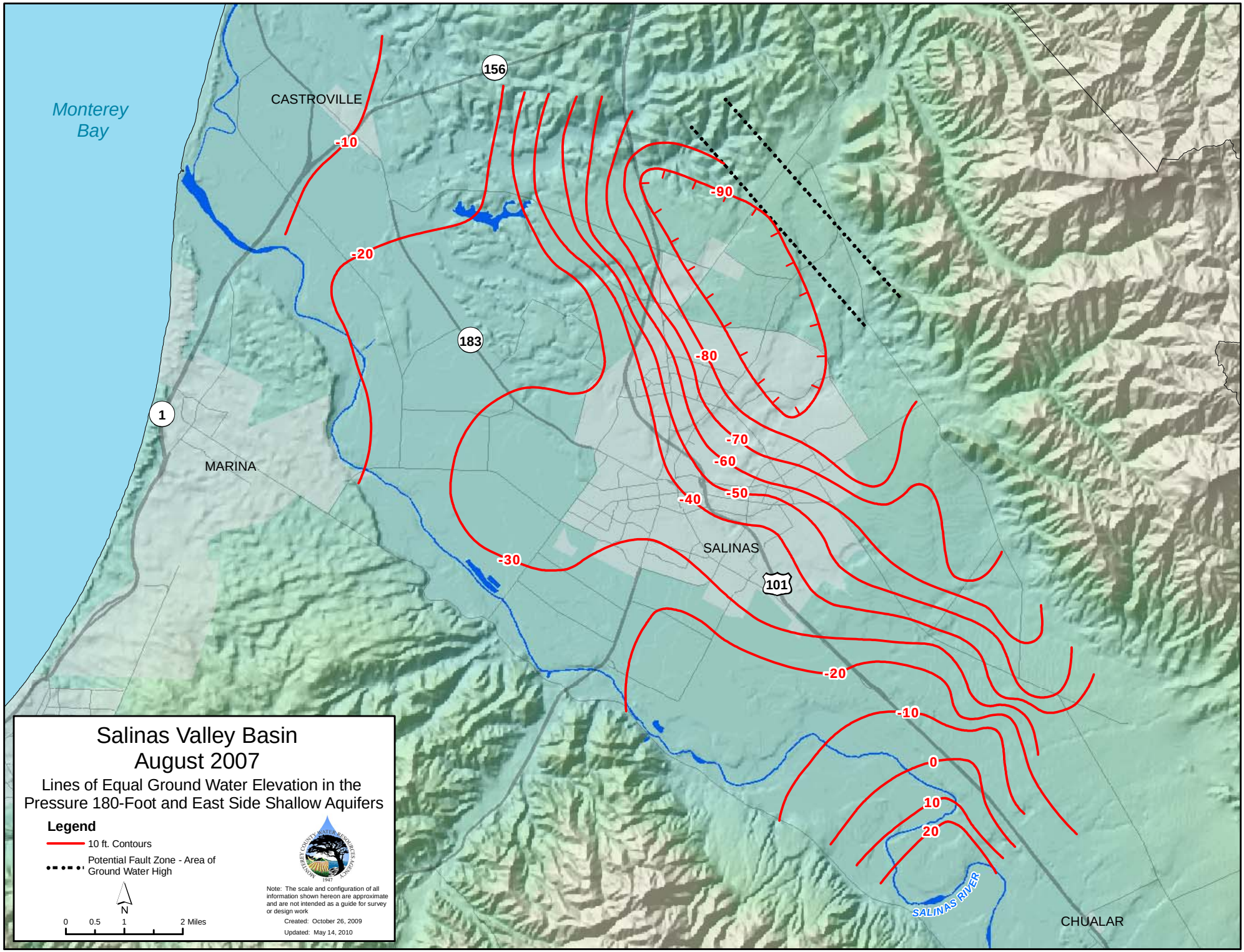
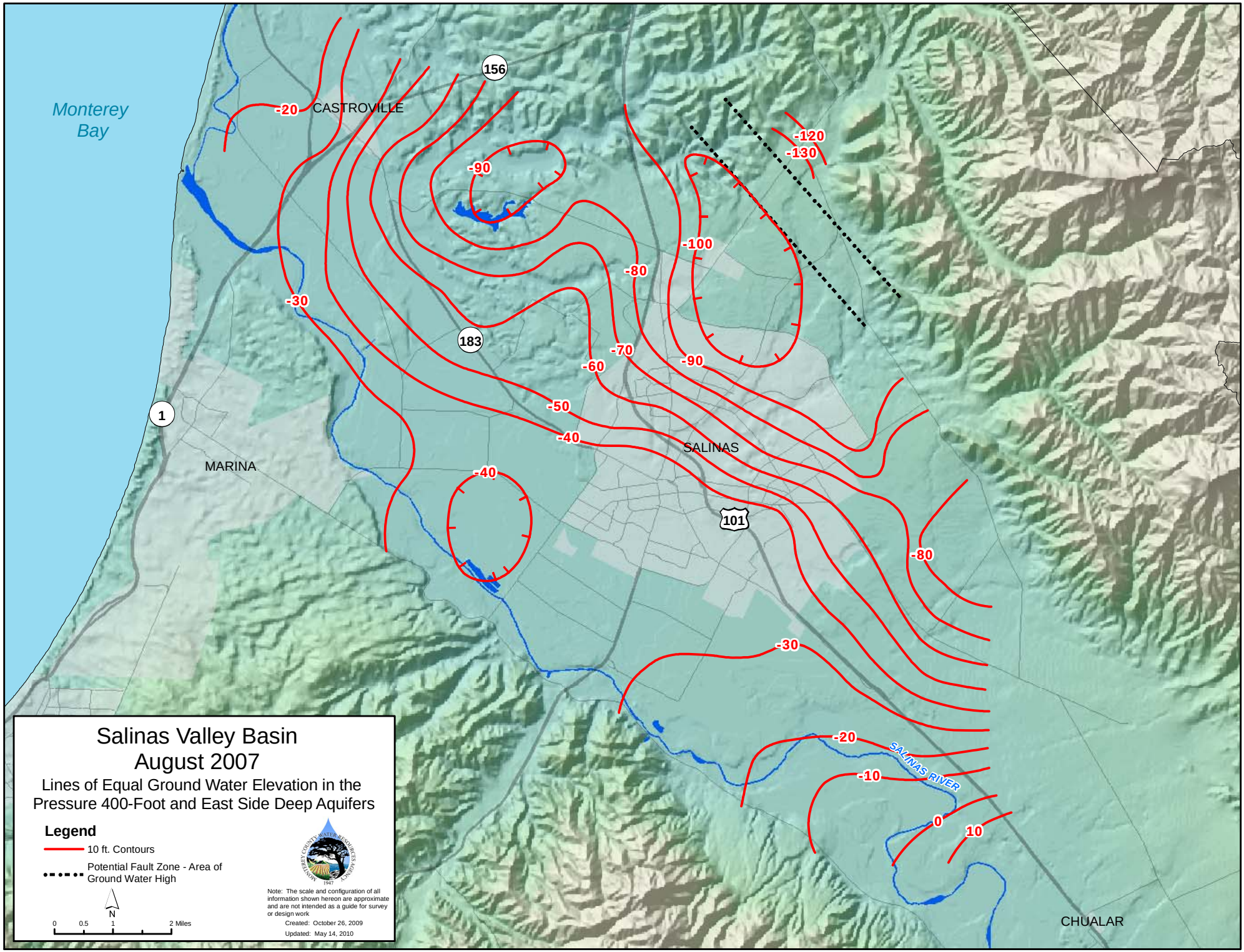
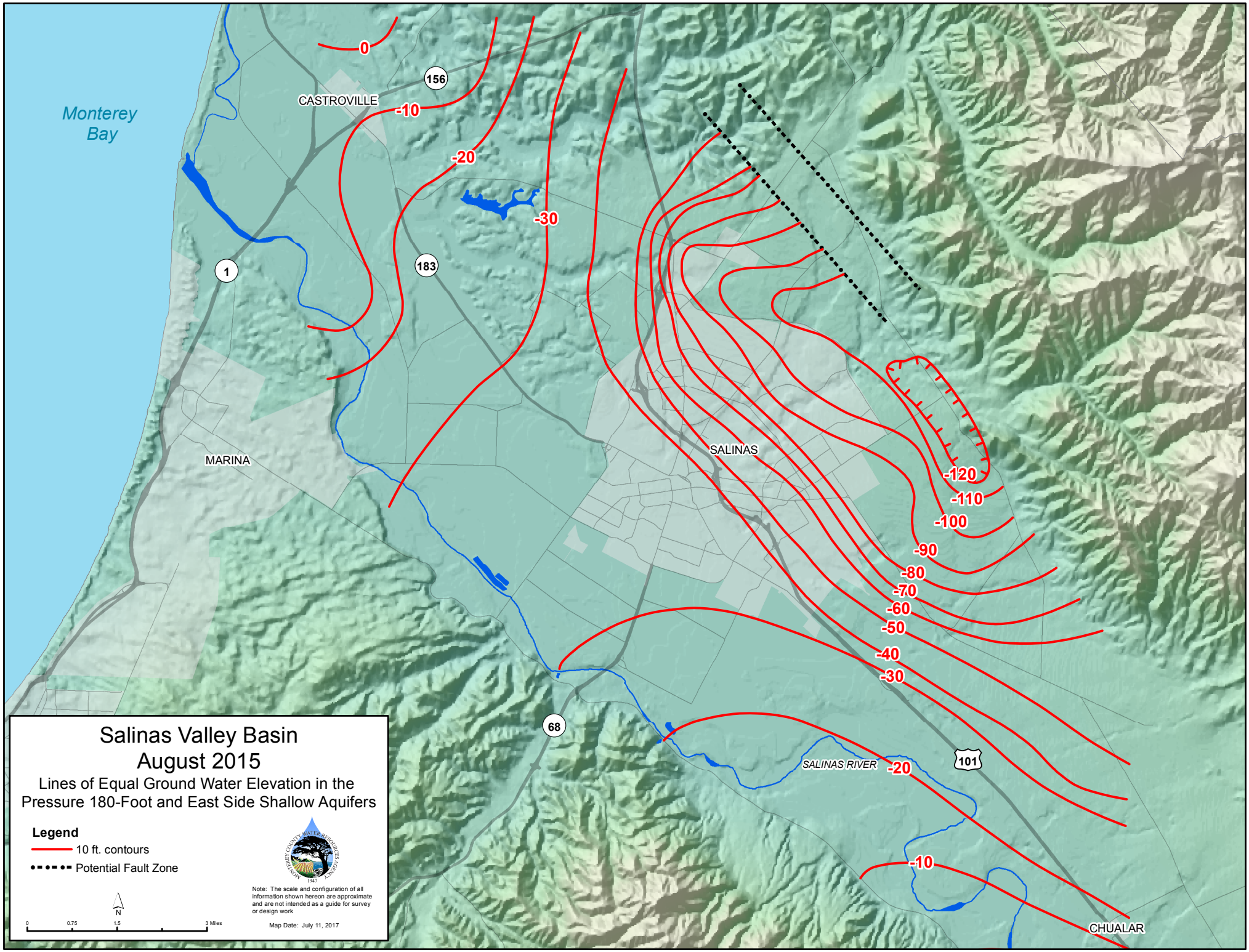
APPENDIX 3.A – 1994, 2007, 2015, AND 2017 CONTOUR MAPS

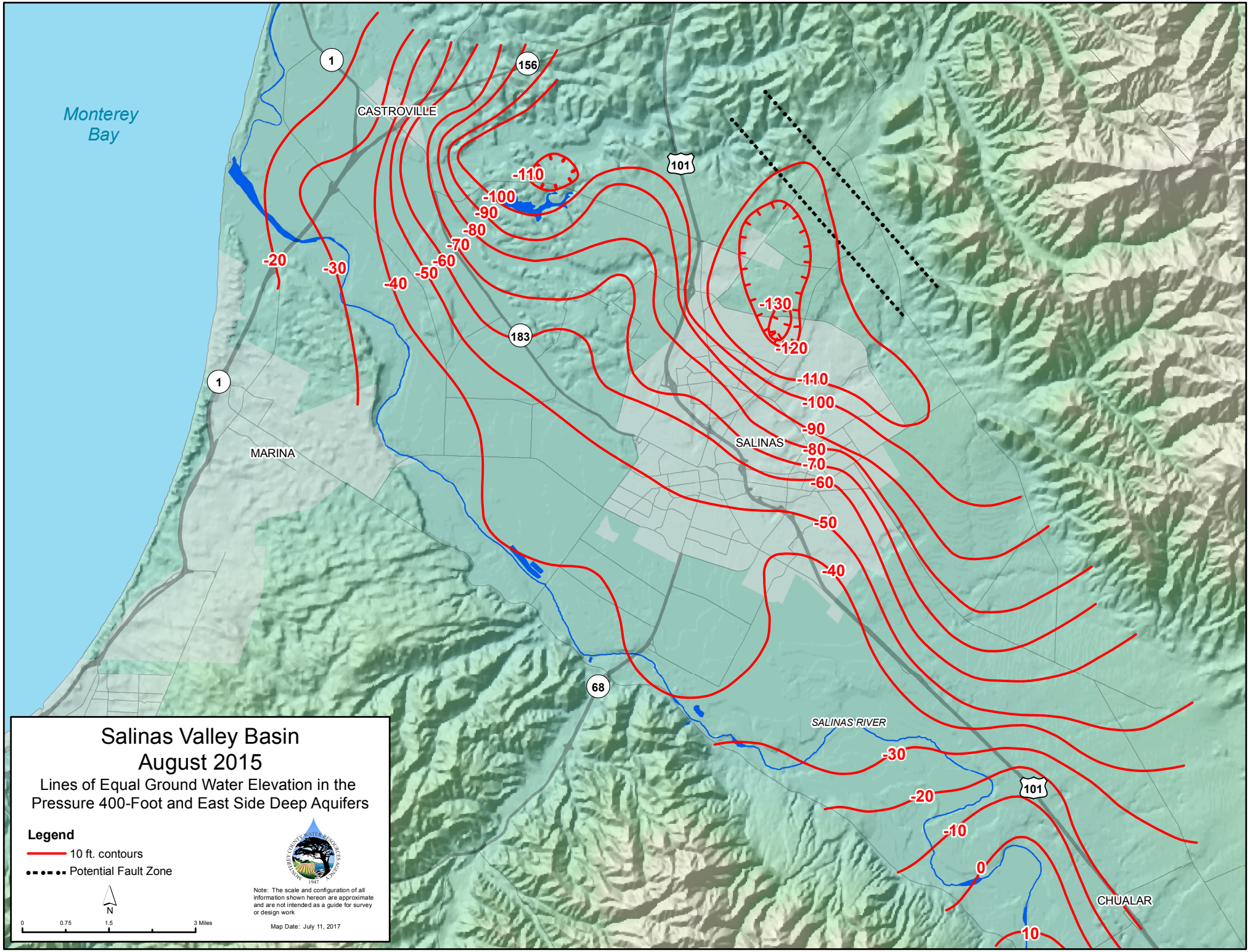

Monterey Bay
CASTROVILLE
MARINA
SALINAS
CHUALAR
156
1
68
101
-20
-50
-60
-70
-80
-90
-30
-40
50
-10
0
10
Salinas Valley Basin
August 1994
Lines of Equal Ground Water Elevation in the Pressure 180-Foot and East Side Shallow Aquifers
Legend
10 ft. Contours
Potential Fault Zone - Area of Ground Water High
Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work
Map Date: January 28, 2008

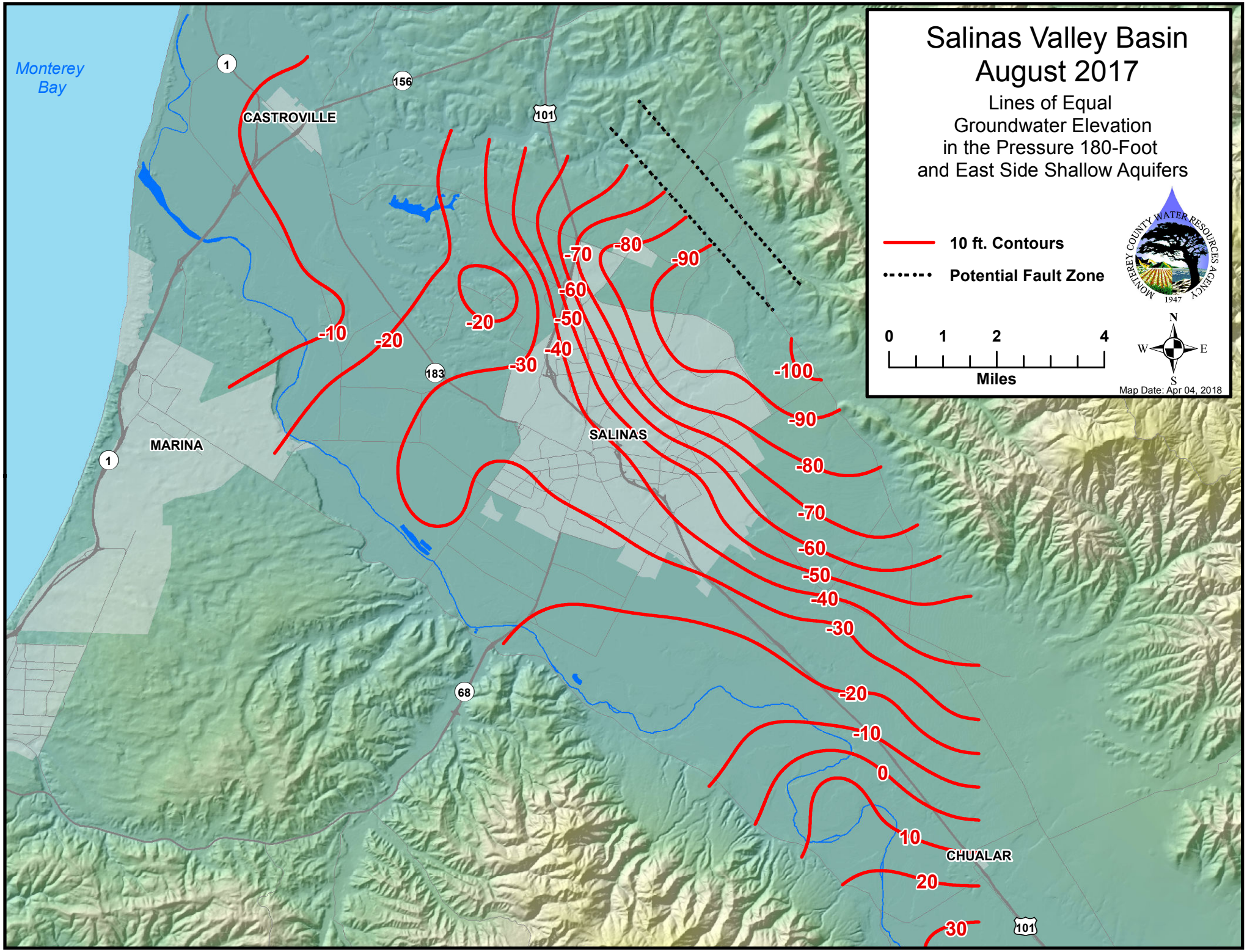

Monterey Bay
CASTROVILLE
MARINA
SALINAS
CHUALAR
156
183
68
1
101
10
-10
0
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
Salinas Valley Basin
August 1994
Lines of Equal Ground Water Elevation in the Pressure 400-Foot and East Side Deep Aquifers
Legend
10 ft. Contours
Potential Fault Zone - Area of Ground Water High
Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work
Map Date: January 28, 2008

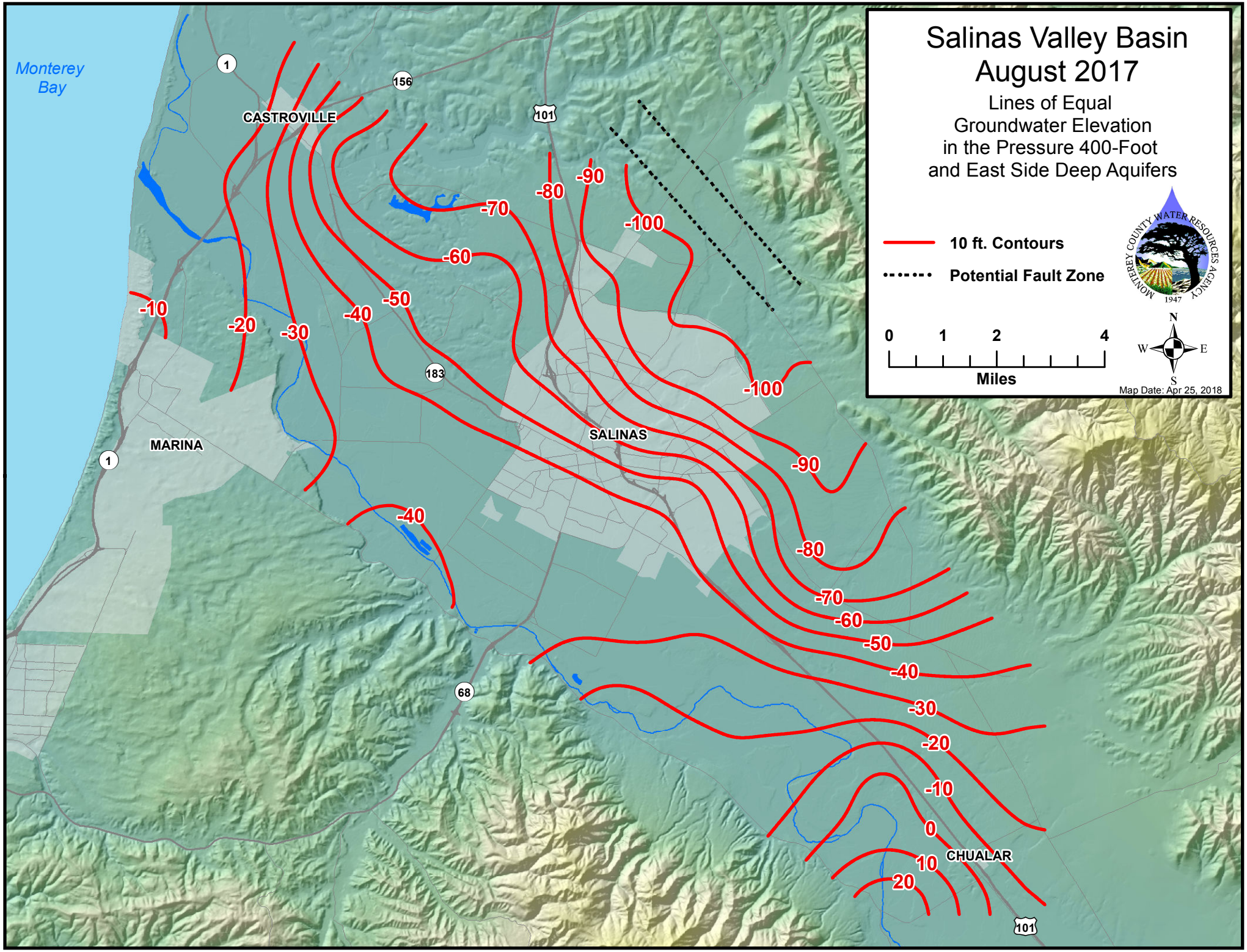

Monterey Bay
CASTROVILLE
156
-10
-20
183
-90
-80
-70
-60
-50
-40
-30
1
MARINA
SALINAS
101
-20
-10
0
10
20
SALINAS RIVER
CHUALAR
Salinas Valley Basin
August 2007
Lines of Equal Ground Water Elevation in the
Pressure 180-Foot and East Side Shallow Aquifers
Legend
10 ft. Contours
Potential Fault Zone - Area of Ground Water High
N
0 0.5 1 2 Miles
Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work
Created: October 26, 2009
Updated: May 14, 2010


Monterey Bay
CASTROVILLE
MARINA
SALINAS
CHUALAR
SALINAS RIVER
156
183
1
101
-20
-30
-40
-50
-60
-70
-80
-90
-100
-120
-130
-10
0
10
Salinas Valley Basin
August 2007
Lines of Equal Ground Water Elevation in the
Pressure 400-Foot and East Side Deep Aquifers
Legend
10 ft. Contours
Potential Fault Zone - Area of Ground Water High
N
0
0.5
1
2 Miles
Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work
Created: October 26, 2009
Updated: May 14, 2010


Monterey Bay
CASTROVILLE
MARINA
SALINAS
CHUALAR
SALINAS RIVER
156
1
183
68
101
0
-10
-20
-30
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
Salinas Valley Basin
August 2015
Lines of Equal Ground Water Elevation in the
Pressure 180-Foot and East Side Shallow Aquifers
Legend
10 ft. contours
Potential Fault Zone
N
0
0.75
1.5
3 Miles
Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work
Map Date: July 11, 2017


Monterey Bay
CASTROVILLE
MARINA
SALINAS
SALINAS RIVER
CHUALAR
1
156
101
183
68
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-10
0
10
Salinas Valley Basin
August 2015
Lines of Equal Ground Water Elevation in the
Pressure 400-Foot and East Side Deep Aquifers
Legend
10 ft. contours
Potential Fault Zone
N
0
0.75
1.5
3 Miles
Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work
Map Date: July 11, 2017


Monterey Bay
CASTROVILLE
MARINA
SALINAS
CHUALAR
1
156
101
183
68
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
10
20
30
Salinas Valley Basin
August 2017
Lines of Equal
Groundwater Elevation
in the Pressure 180-Foot
and East Side Shallow Aquifers
10 ft. Contours
Potential Fault Zone
0 1 2 4
Miles
N
W E
S
MONTEREY COUNTY WATER RESOURCES AGENCY
1947
Map Date: Apr 04, 2018

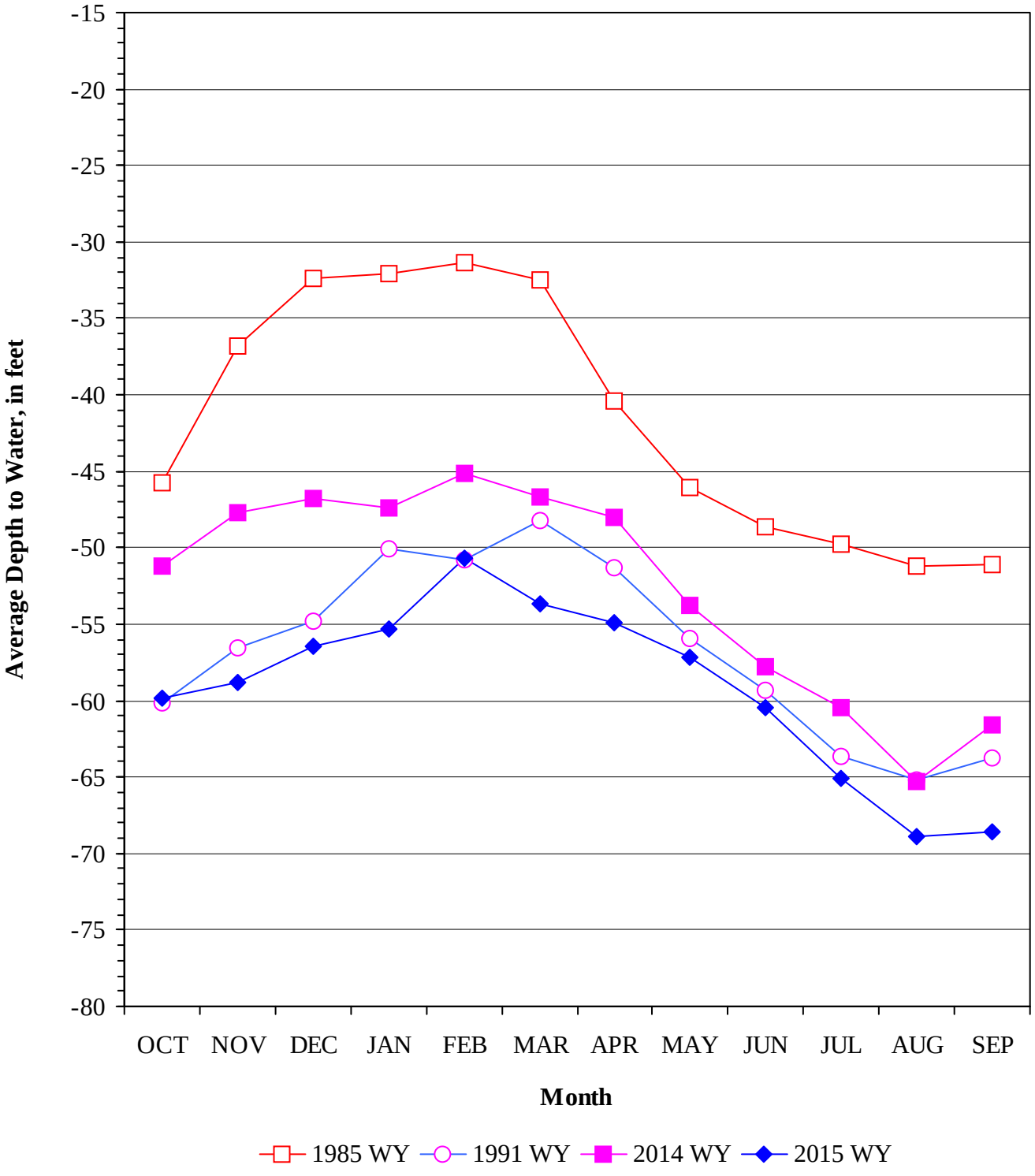

Monterey Bay
CASTROVILLE
MARINA
SALINAS
CHUALAR
1
156
101
183
68
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
10
20
Salinas Valley Basin
August 2017
Lines of Equal
Groundwater Elevation
in the Pressure 400-Foot
and East Side Deep Aquifers
10 ft. Contours
Potential Fault Zone
0 1 2 4
Miles
N
W E
S
Map Date: Apr 25, 2018

APPENDIX 3.B – MCWRA COMPOSITE HYDROGRAPHS

HISTORIC GROUNDWATER TRENDS

PRESSURE 180-FOOT AQUIFER

5 Wells

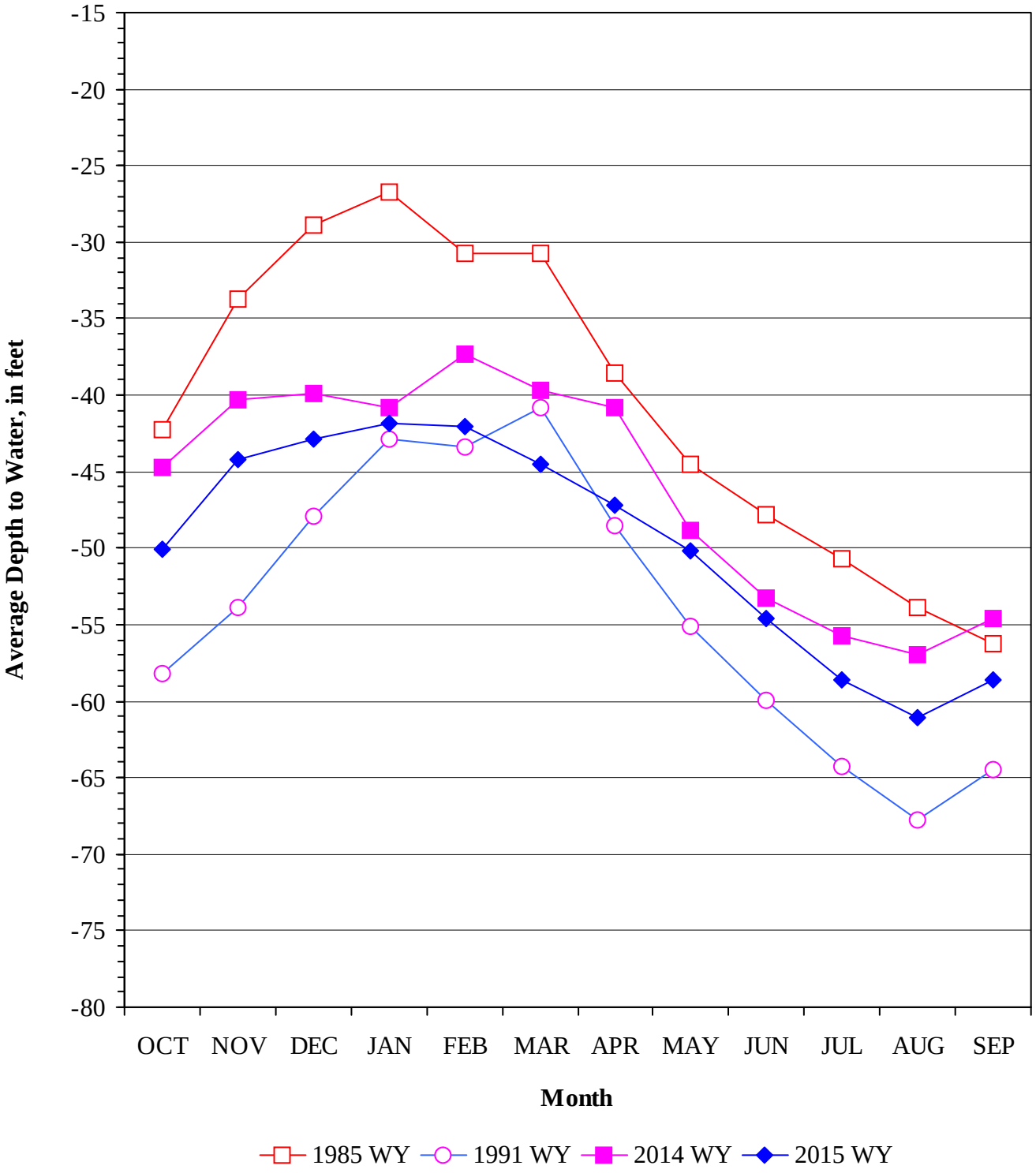


ATTACHMENT D

HISTORIC GROUNDWATER TRENDS

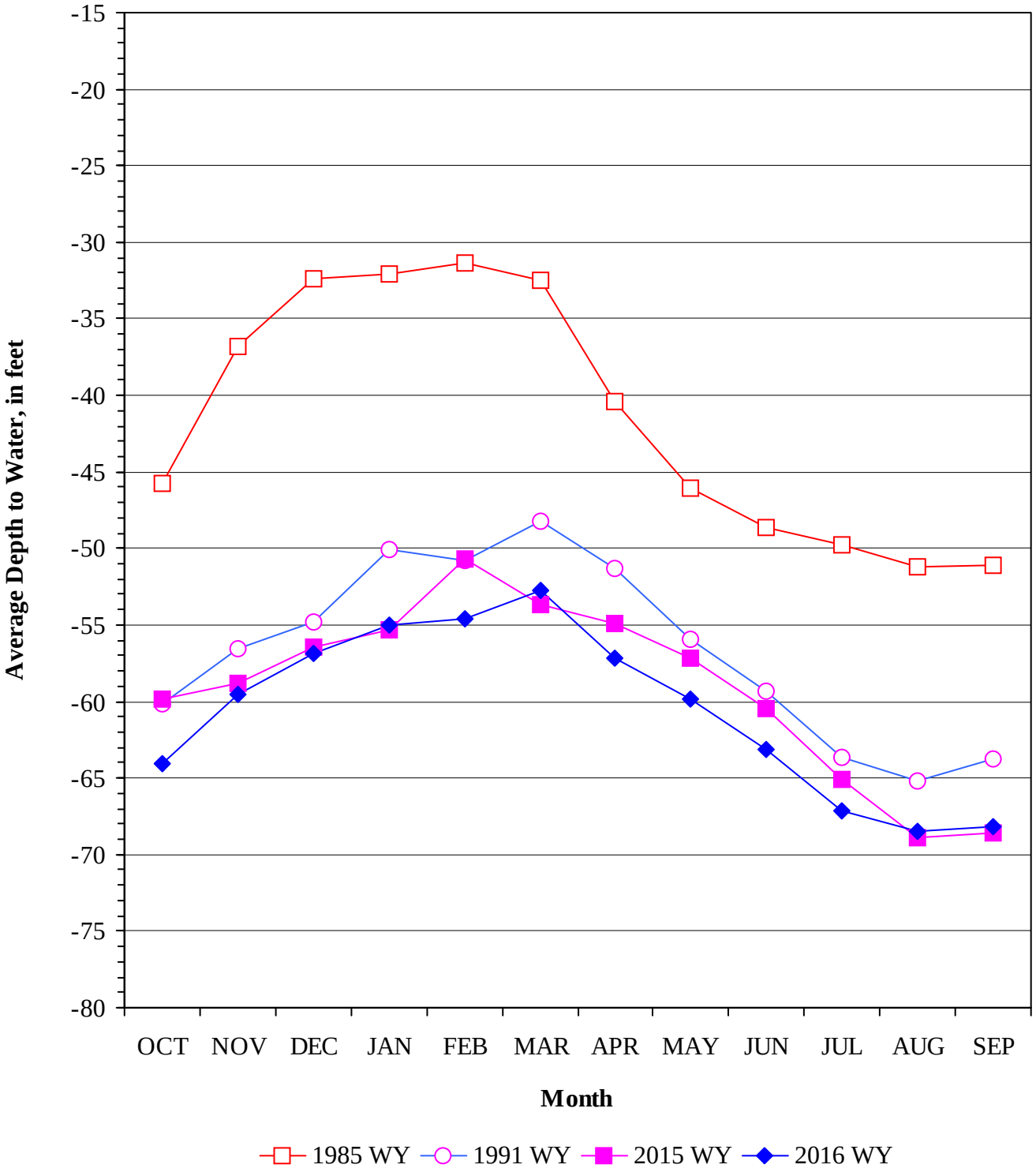
PRESSURE 400-FOOT AQUIFER

11 Wells



ATTACHMENT E

GROUNDWATER TRENDS
PRESSURE 180-FOOT AQUIFER
5 Wells

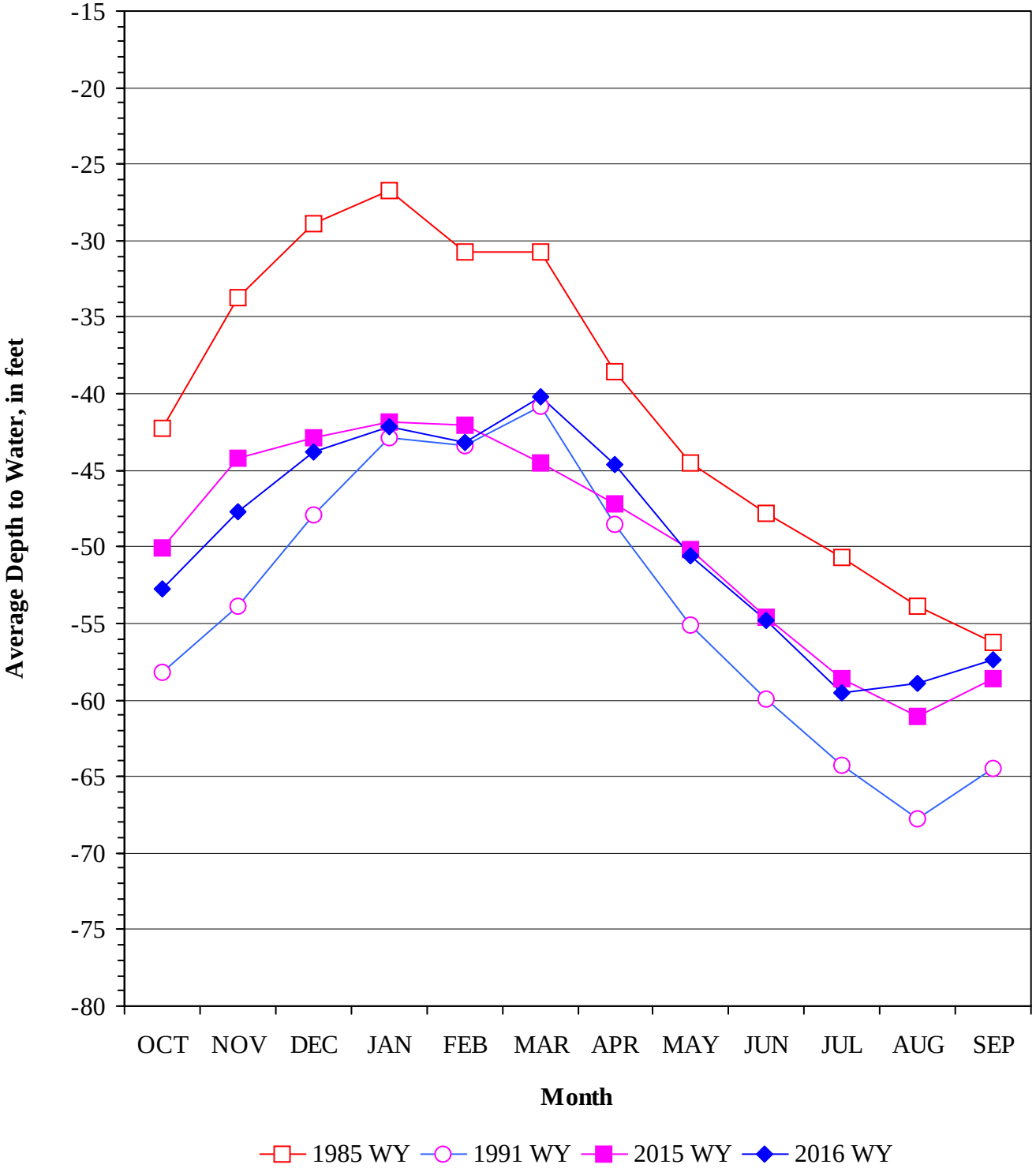


ATTACHMENT E

GROUNDWATER TRENDS

PRESSURE 400-FOOT AQUIFER

11 Wells

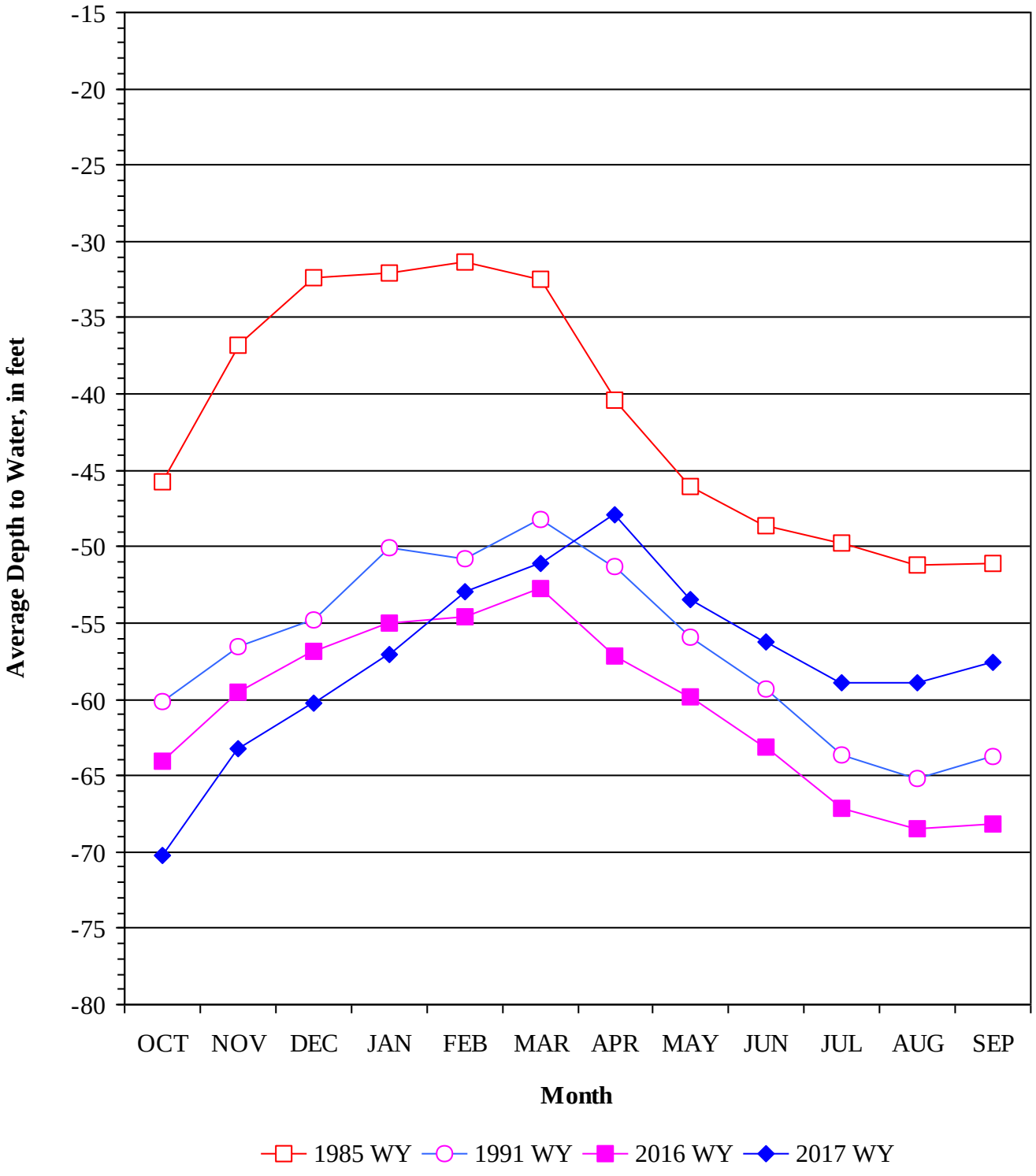


ATTACHMENT F

GROUNDWATER TRENDS

PRESSURE 180-FOOT AQUIFER

5 Wells

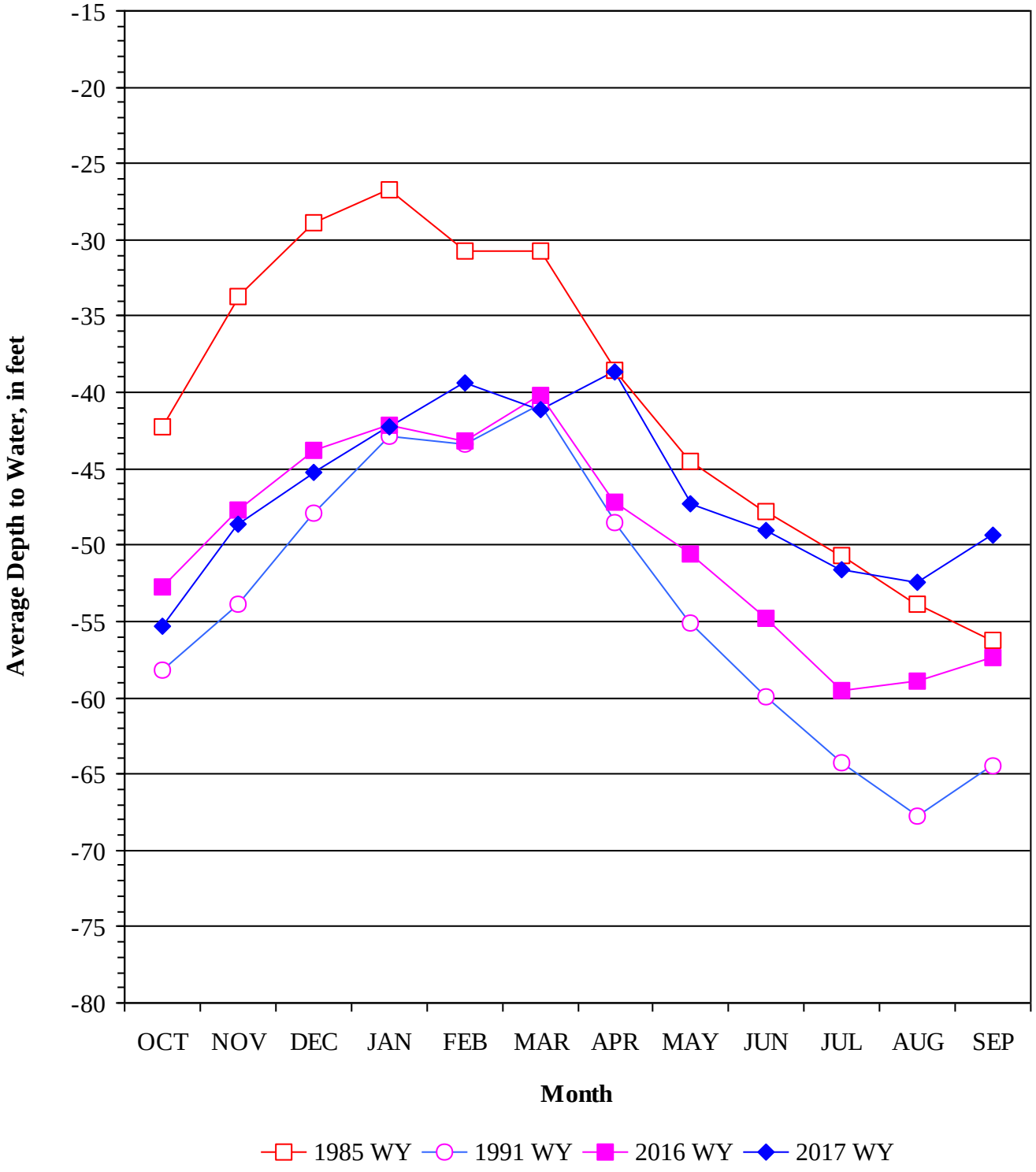


ATTACHMENT E

GROUNDWATER TRENDS

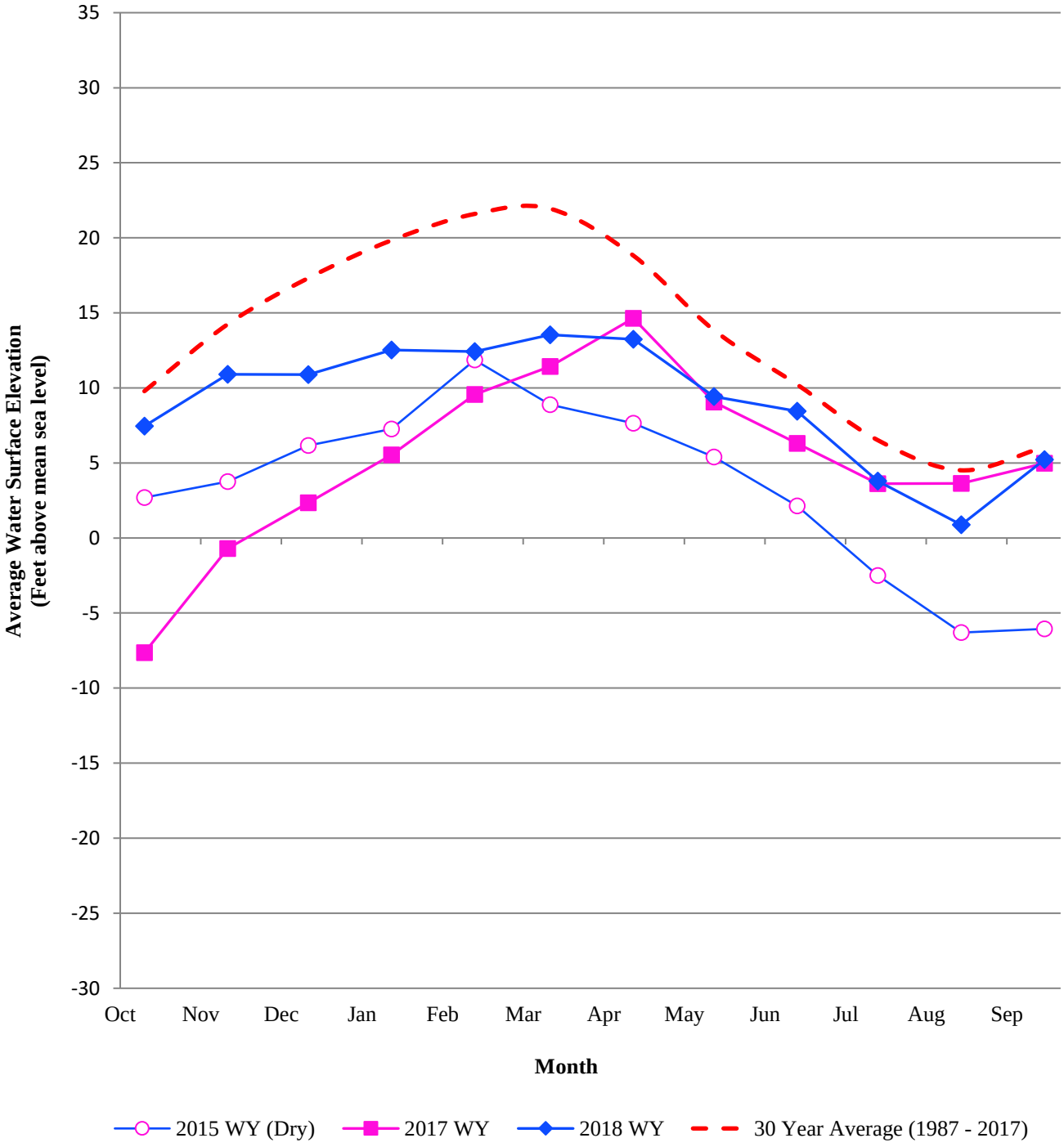
PRESSURE 400-FOOT AQUIFER

11 Wells



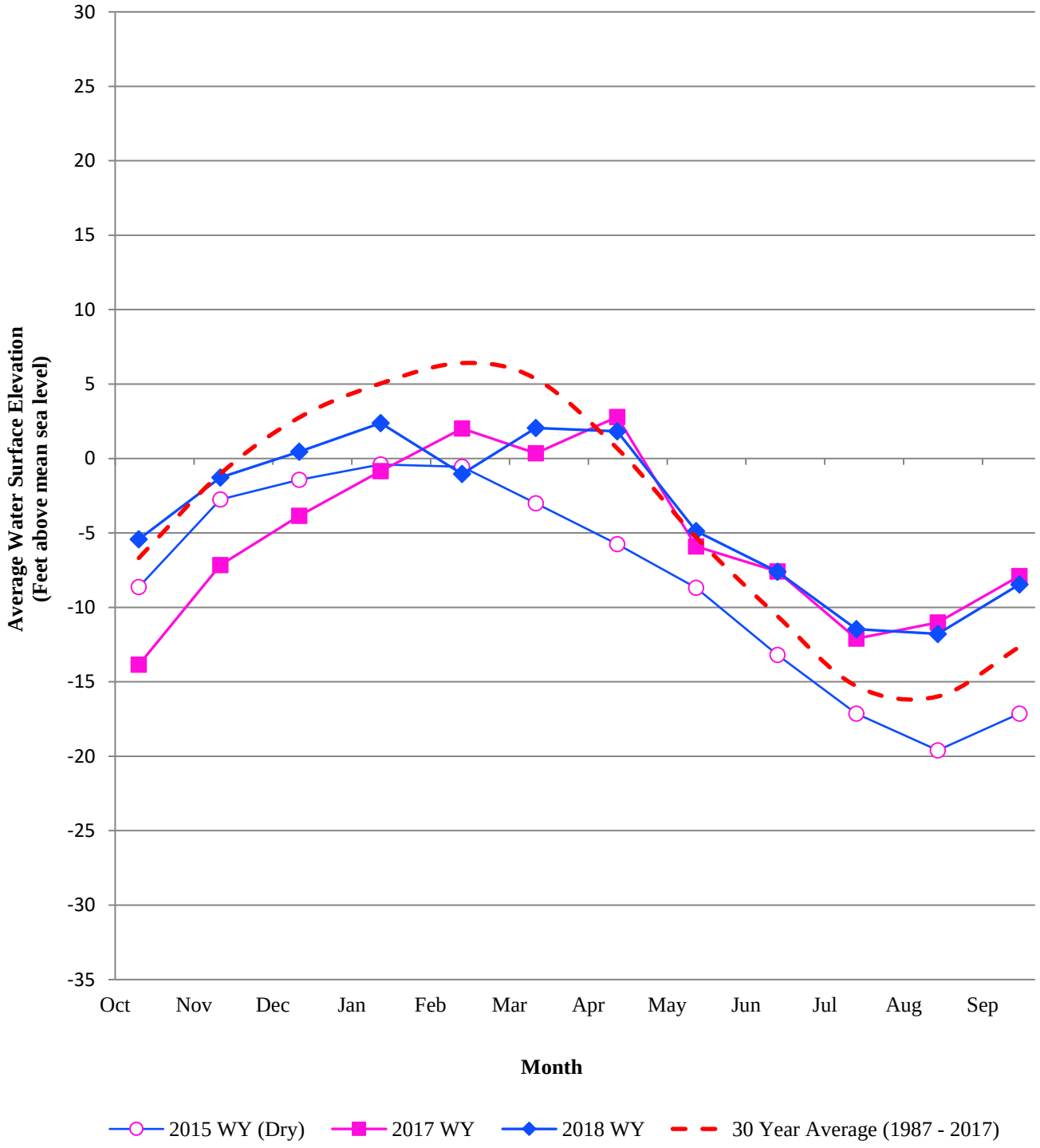
ATTACHMENT F

GROUNDWATER TRENDS
PRESSURE 180-FOOT AQUIFER
5 Wells



ATTACHMENT E

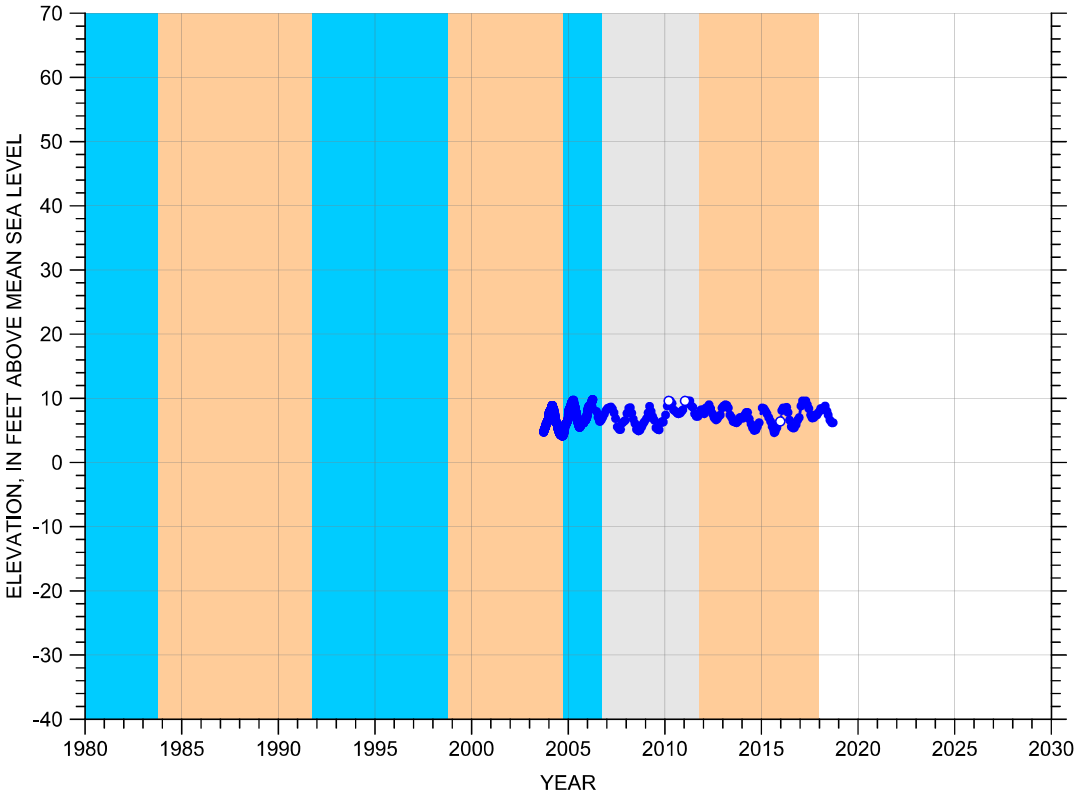
GROUNDWATER TRENDS
PRESSURE 400-FOOT AQUIFER
11 Wells



ATTACHMENT F

APPENDIX 3.C – SELECTED MCWRA HYDROGRAPHS

HYDROGRAPH OF MEASURED GROUNDWATER ELEVATION FOR 13S/02E-21Q01



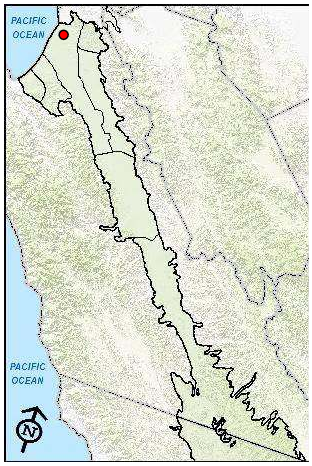
EXPLANATION

GROUNDWATER ELEVATION ESTIMATED ELEVATION

CLIMATE PERIOD CLASSIFICATION

DRY AVERAGE/ALTERNATING WET

Subbasin: 180/400-Foot Aquifer Subbasin (180-Foot Aquifer)
Well Depth: 157.4 feet
Screened Interval: 105-155 feet below land surface



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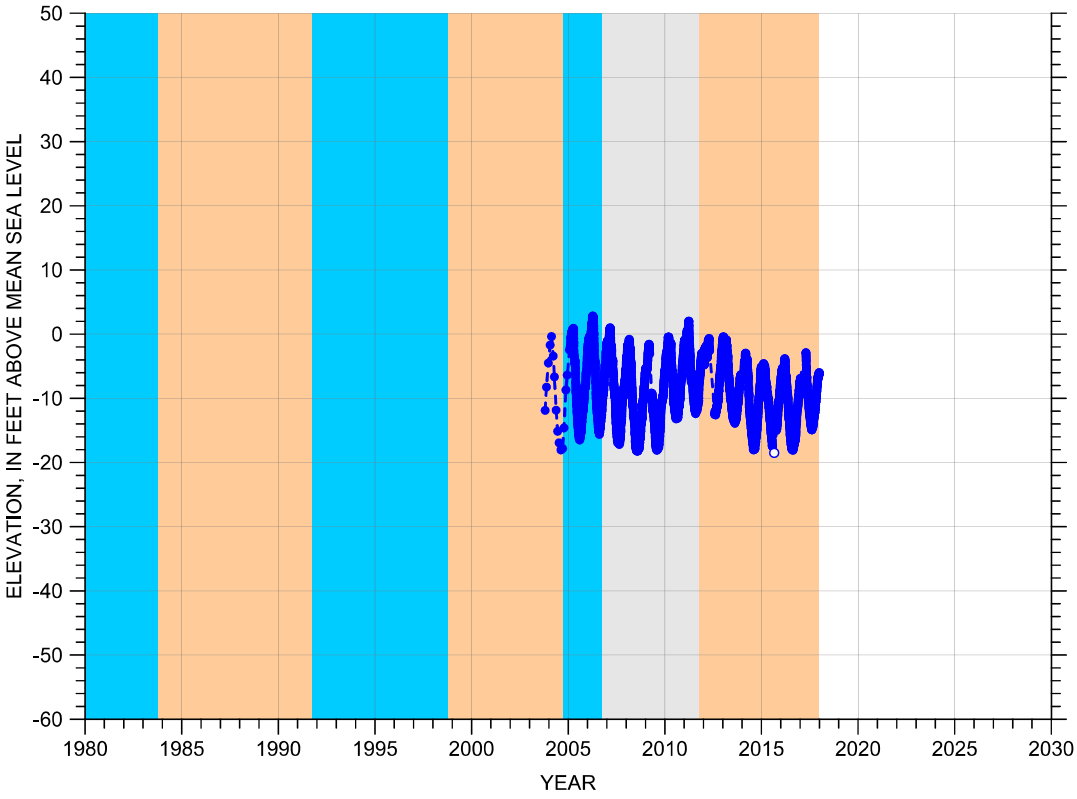
HYDROGRAPH OF MEASURED GROUNDWATER ELEVATION FOR 14S/02E-03F04



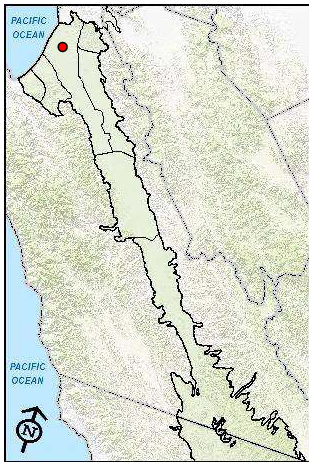
EXPLANATION

GROUNDWATER ELEVATION ESTIMATED ELEVATION

CLIMATE PERIOD CLASSIFICATION

DRY AVERAGE/ALTERNATING WET

Subbasin: 180/400-Foot Aquifer Subbasin (180-Foot Aquifer)
Well Depth: 205 feet
Screened Interval: 154-204 feet below land surface



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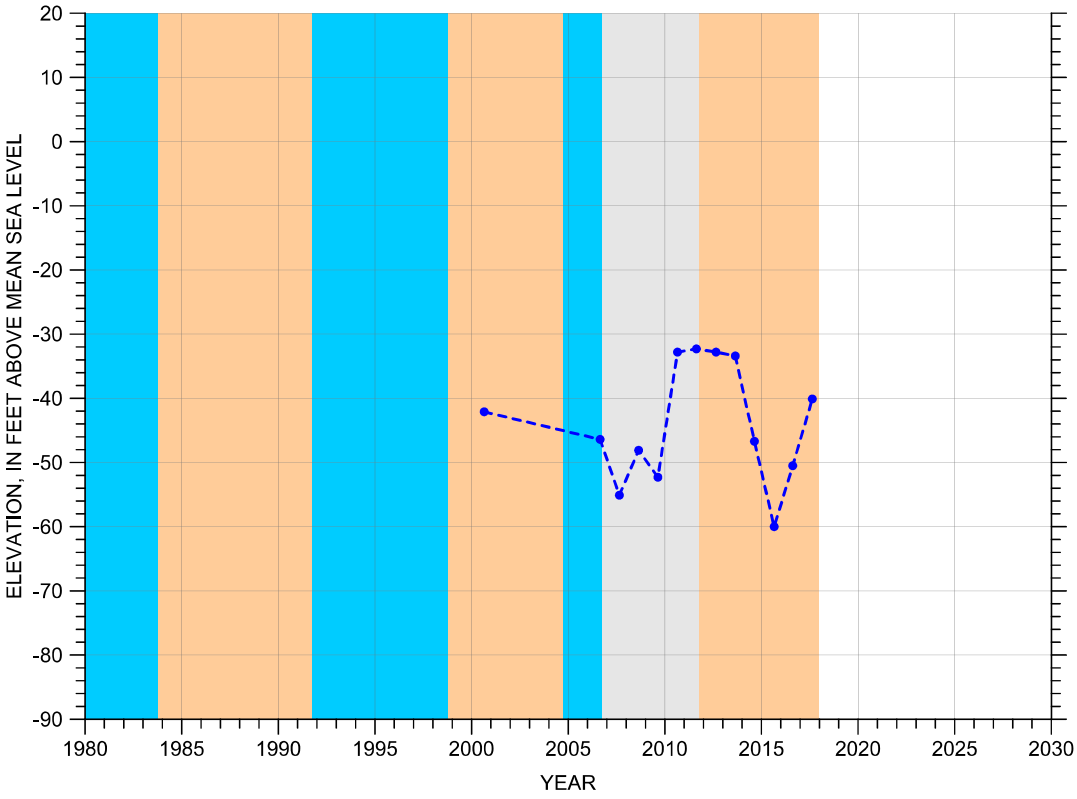
HYDROGRAPH OF MEASURED GROUNDWATER ELEVATION FOR 14S/02E-04G02



EXPLANATION

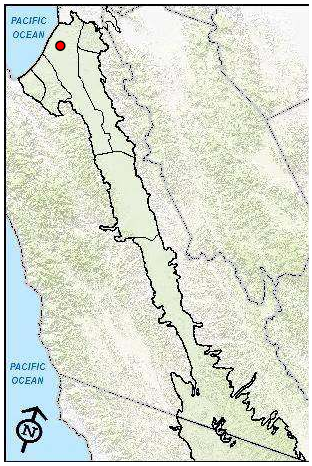
GROUNDWATER ELEVATION ESTIMATED ELEVATION

CLIMATE PERIOD CLASSIFICATION

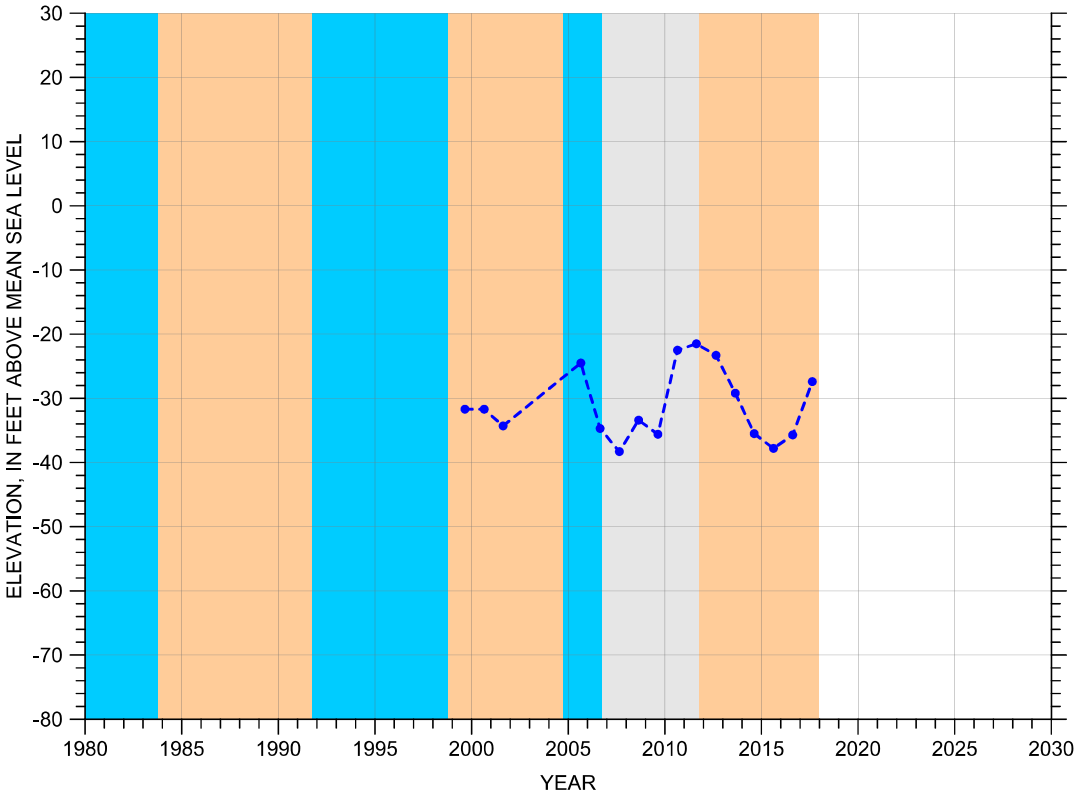
DRY AVERAGE/ALTERNATING WET

Subbasin: 180/400-Foot Aquifer Subbasin (400-Foot Aquifer)
Well Depth: 620 feet
Screened Interval: 370-610 feet below land surface

S:\projects\9100_Salinas_GSP\analysis\water_levels\Hydrographs_MCWRA\pasoDroughtIndex\grf\14S_02E-04G02.grf



HYDROGRAPH OF MEASURED GROUNDWATER ELEVATION FOR 14S/02E-09D04



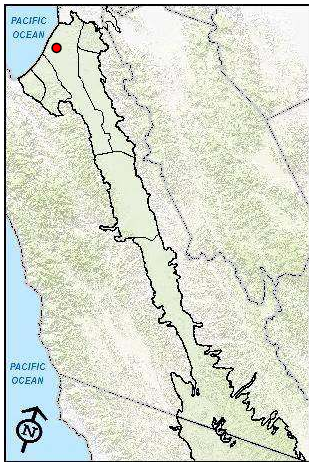
EXPLANATION

GROUNDWATER ELEVATION ESTIMATED ELEVATION

CLIMATE PERIOD CLASSIFICATION

DRY AVERAGE/ALTERNATING WET

Subbasin: 180/400-Foot Aquifer Subbasin (400-Foot Aquifer)
Well Depth: 610 feet
Screened Interval: 350-600 feet below land surface



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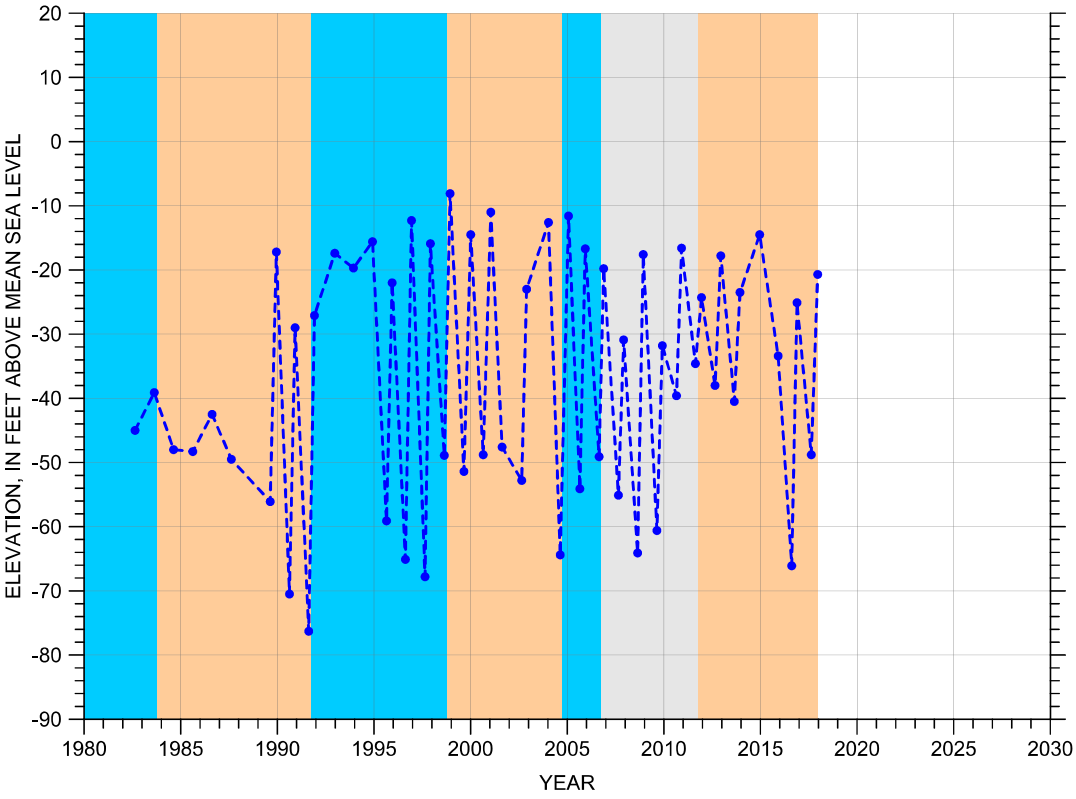
HYDROGRAPH OF MEASURED GROUNDWATER ELEVATION FOR 14S/02E-15A01



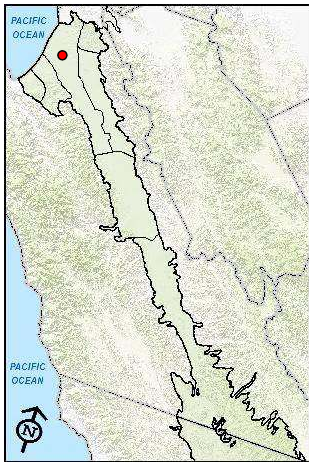
EXPLANATION

GROUNDWATER ELEVATION ESTIMATED ELEVATION

CLIMATE PERIOD CLASSIFICATION

DRY AVERAGE/ALTERNATING WET

Subbasin: 180/400-Foot Aquifer (400-Foot Aquifer)
Well Depth: 623 feet
Screened Interval: 386-608 feet below land surface



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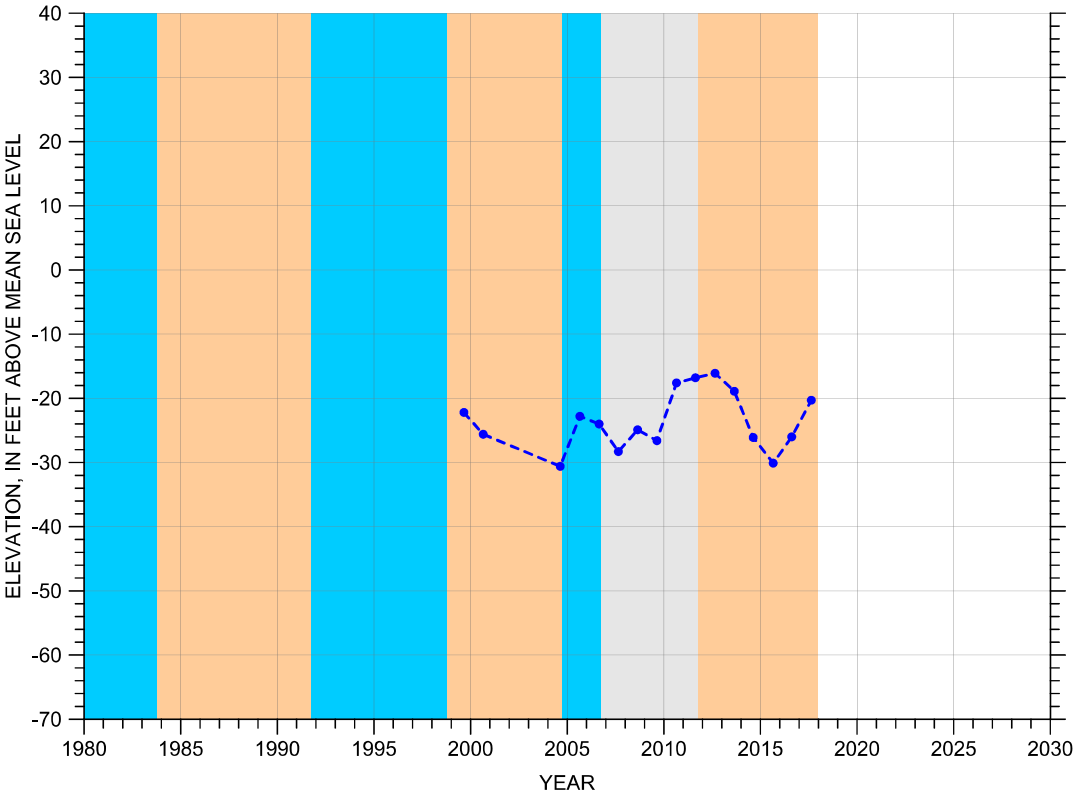
HYDROGRAPH OF MEASURED GROUNDWATER ELEVATION FOR 14S/02E-17B03



EXPLANATION

GROUNDWATER ELEVATION ESTIMATED ELEVATION

CLIMATE PERIOD CLASSIFICATION

DRY AVERAGE/ALTERNATING WET

Subbasin: 180/400-Foot Aquifer Subbasin (400-Foot Aquifer)
Well Depth: 615 feet
Screened Interval: 330-600 feet below land surface

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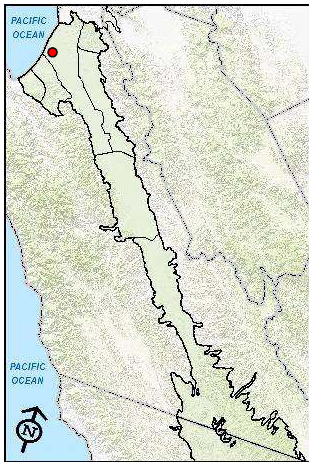
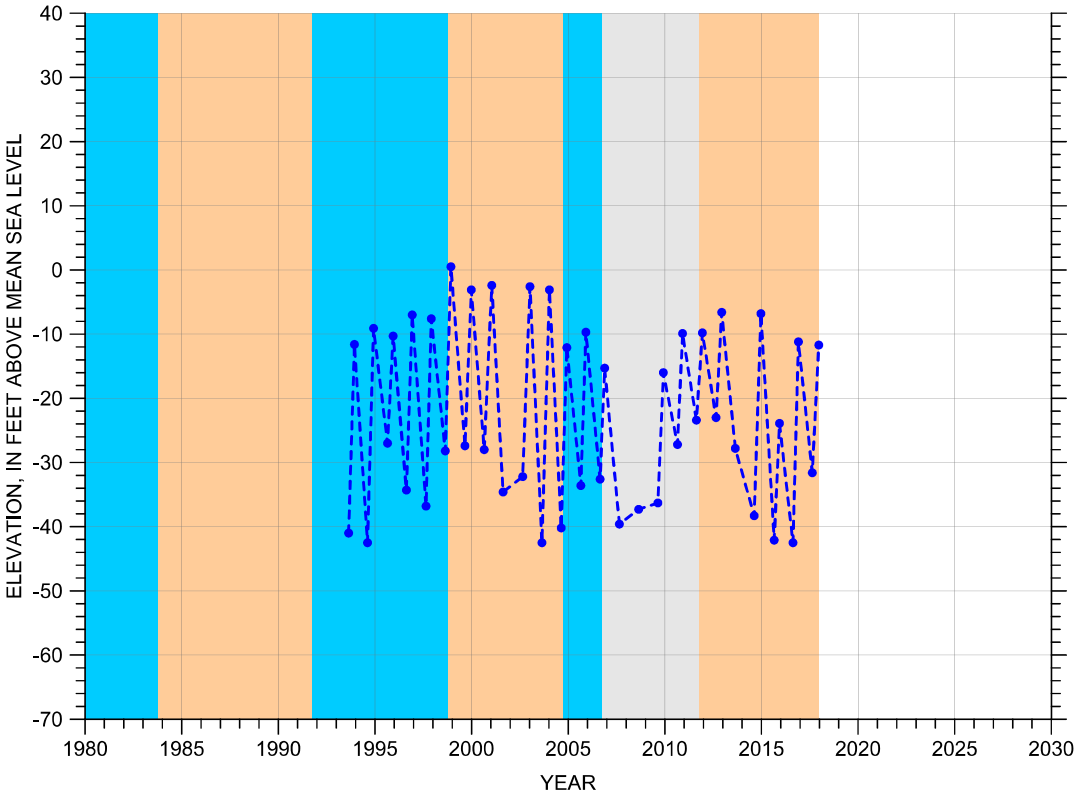


HYDROGRAPH OF MEASURED GROUNDWATER ELEVATION FOR 14S/02E-22L01



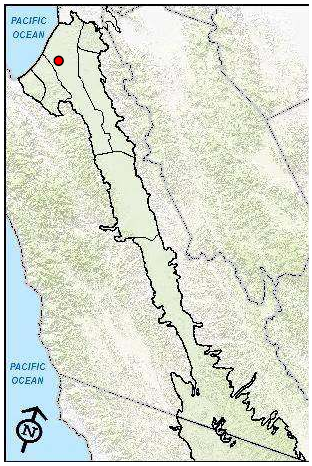
EXPLANATION

GROUNDWATER ELEVATION ESTIMATED ELEVATION

CLIMATE PERIOD CLASSIFICATION

DRY AVERAGE/ALTERNATING WET

Subbasin: 180/400-Foot Aquifer Subbasin (400-Foot Aquifer)
Well Depth: 680 feet
Screened Interval: 420-680 feet below land surface



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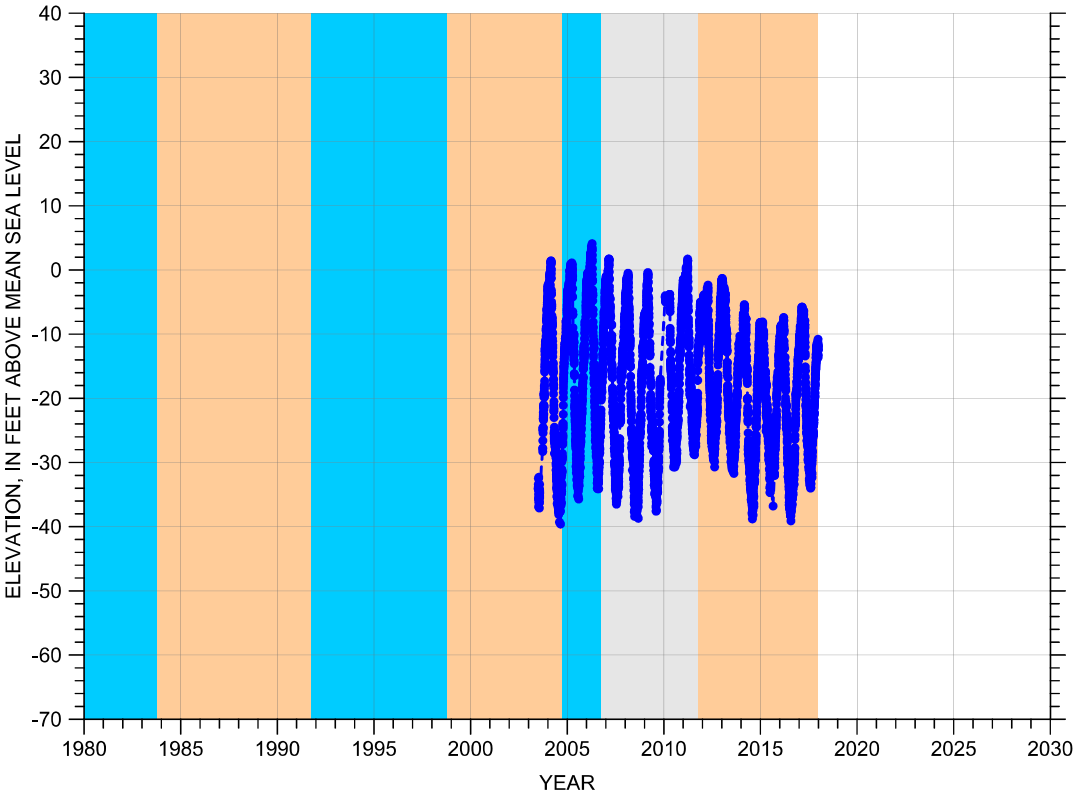
HYDROGRAPH OF MEASURED GROUNDWATER ELEVATION FOR 14S/02E-26H01



EXPLANATION

GROUNDWATER ELEVATION ESTIMATED ELEVATION

CLIMATE PERIOD CLASSIFICATION

DRY AVERAGE/ALTERNATING WET

Subbasin: 180/400-Foot Aquifer Subbasin (180-Foot Aquifer)
Well Depth: 339.3 feet
Screened Interval: 287-337 feet below land surface

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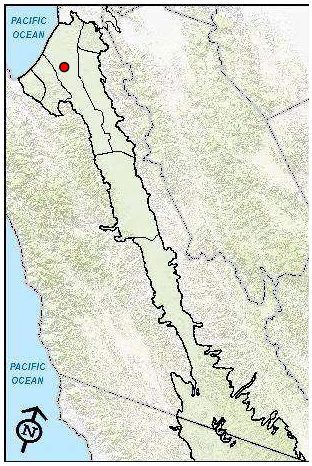


APPENDIX 3.D – GW ELEVATION HYDROGRAPHS AND SPECIFIC CONDUCTANCE PLOTS FOR MPWSP WELLS

Groundwater Elevation in MPWSP MW-1

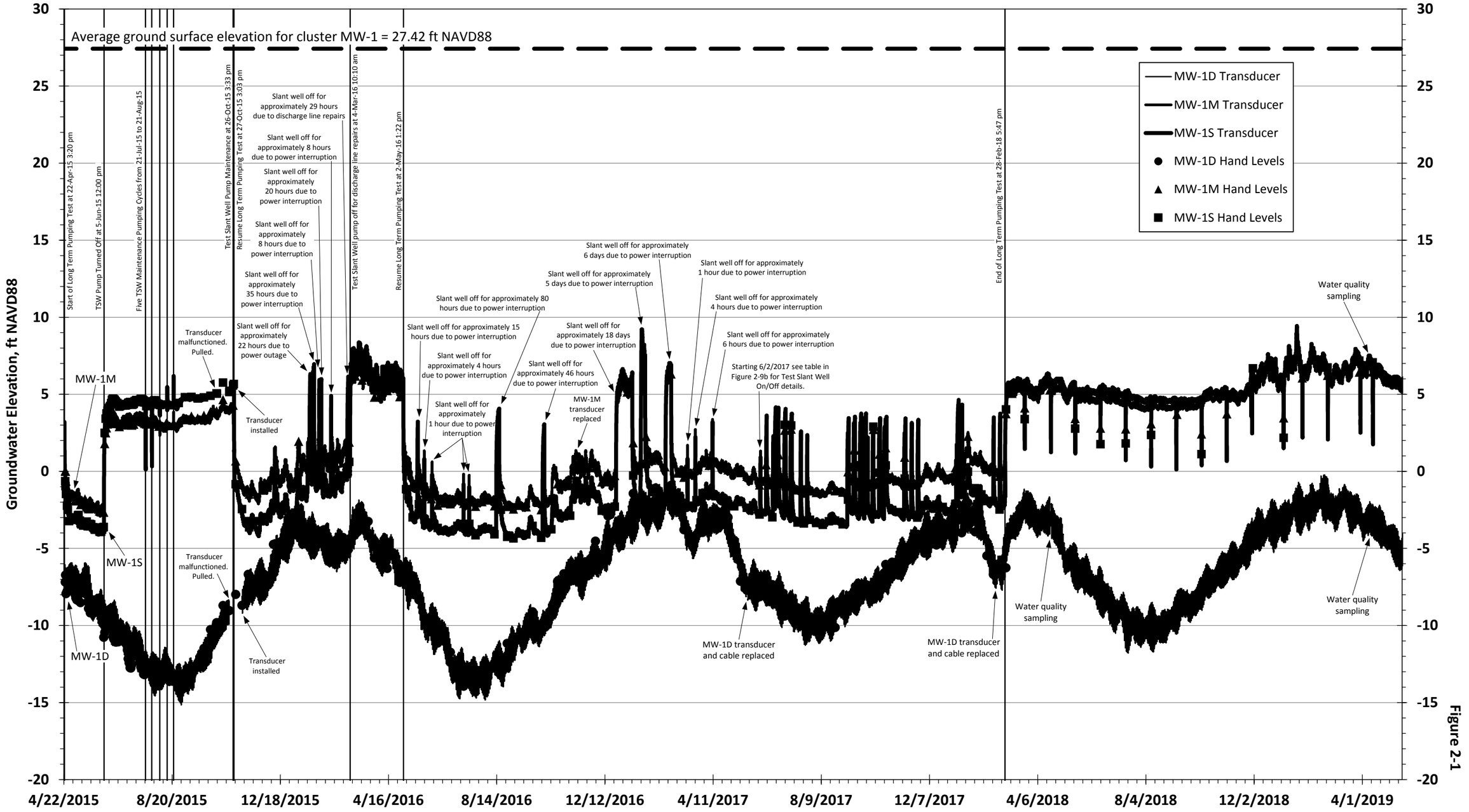


Figure 2-1

Groundwater Elevation in MPWSP MW-3

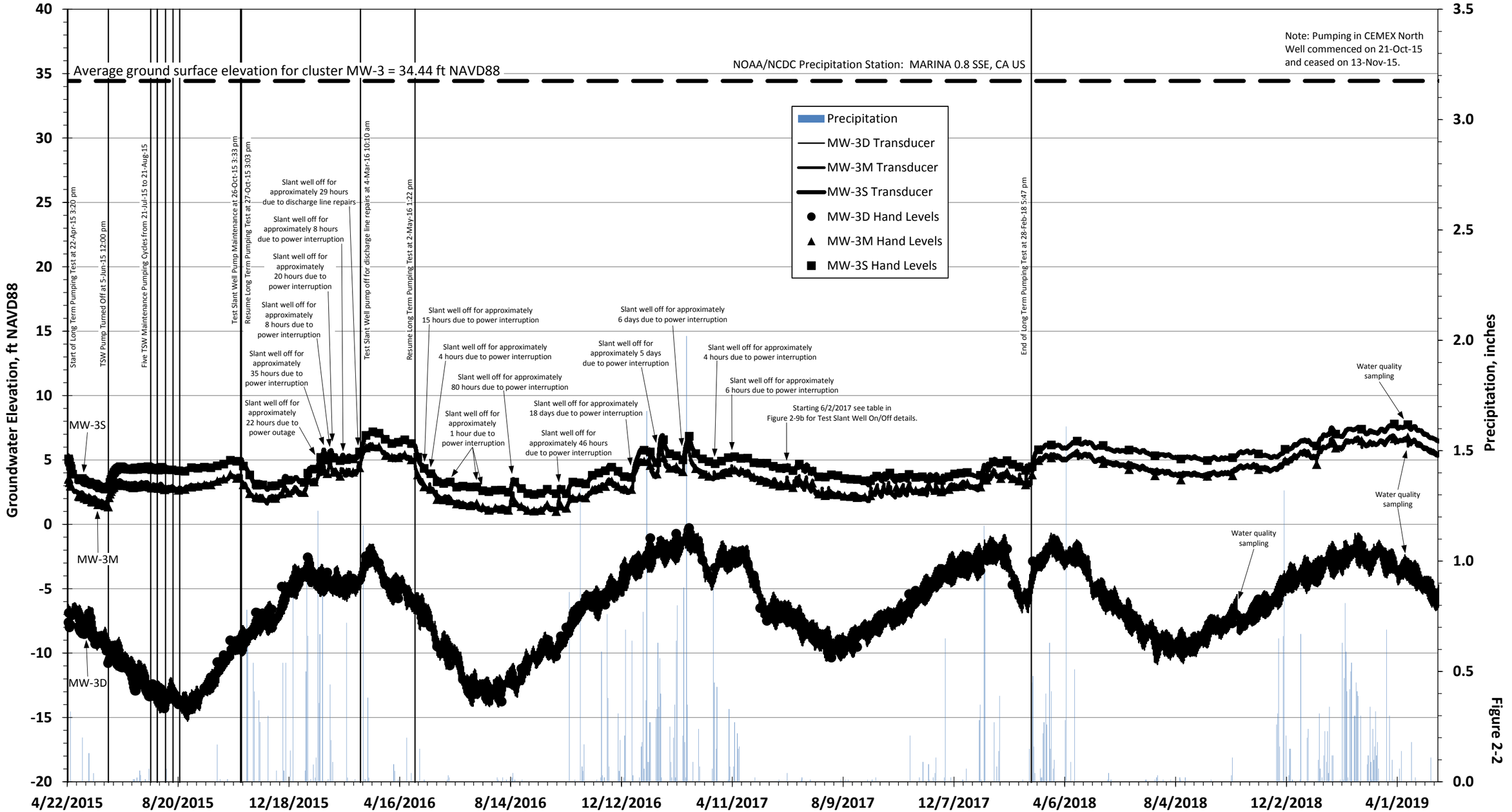


Figure 2-2

Groundwater Elevation in MPWSP MW-4

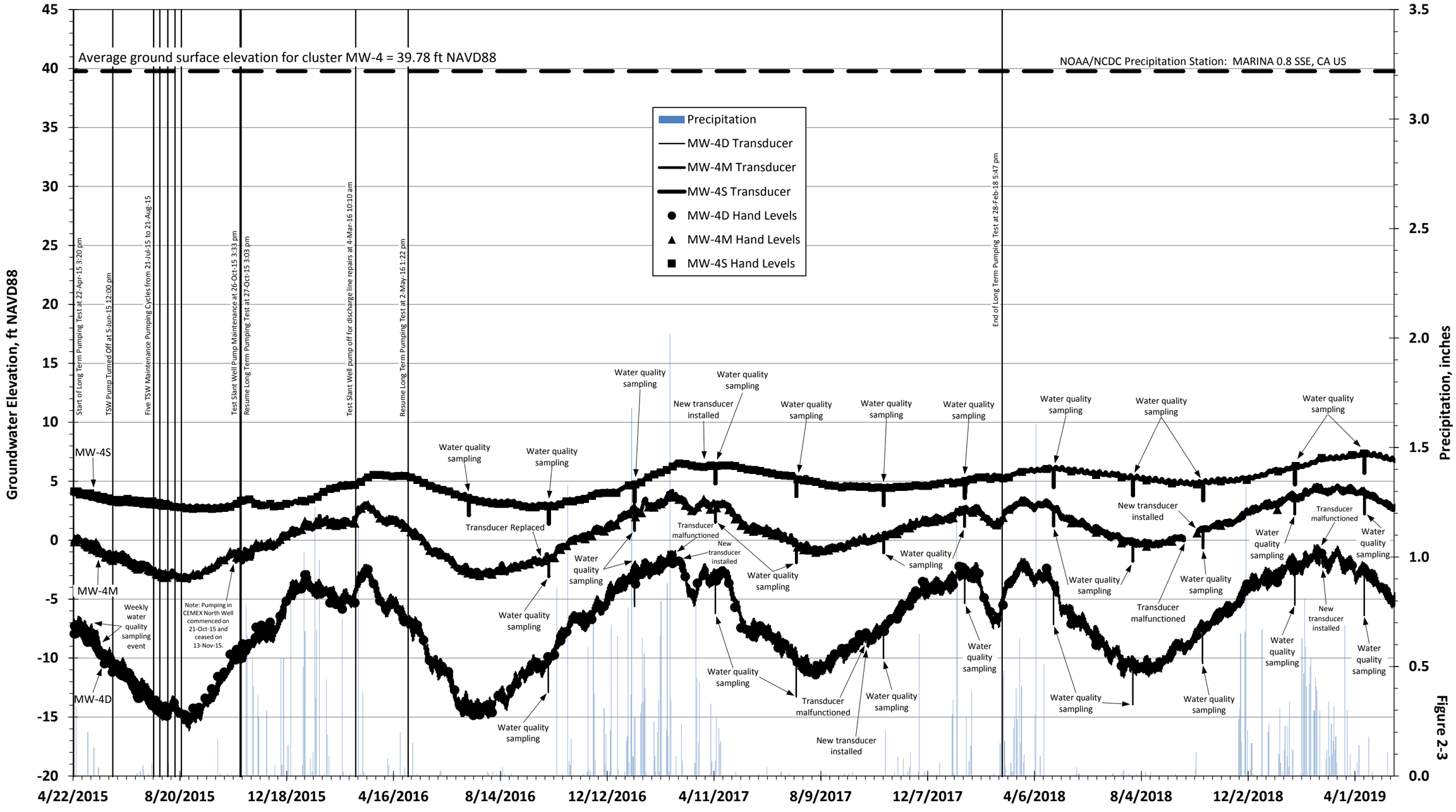


Figure 2-3

Groundwater Elevation in MPWSP MW-5

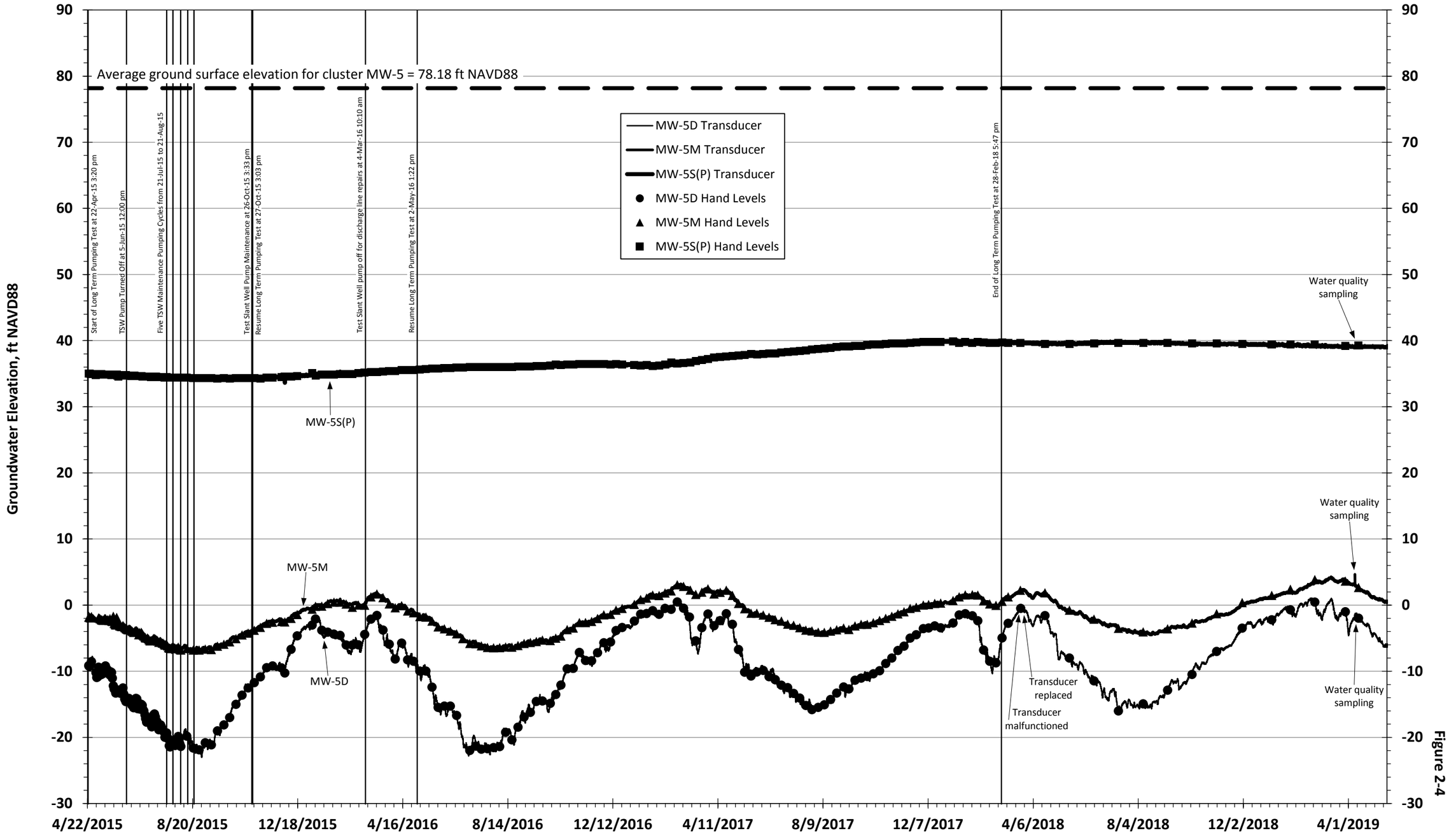


Figure 2-4

Groundwater Elevation in MPWSP MW-6

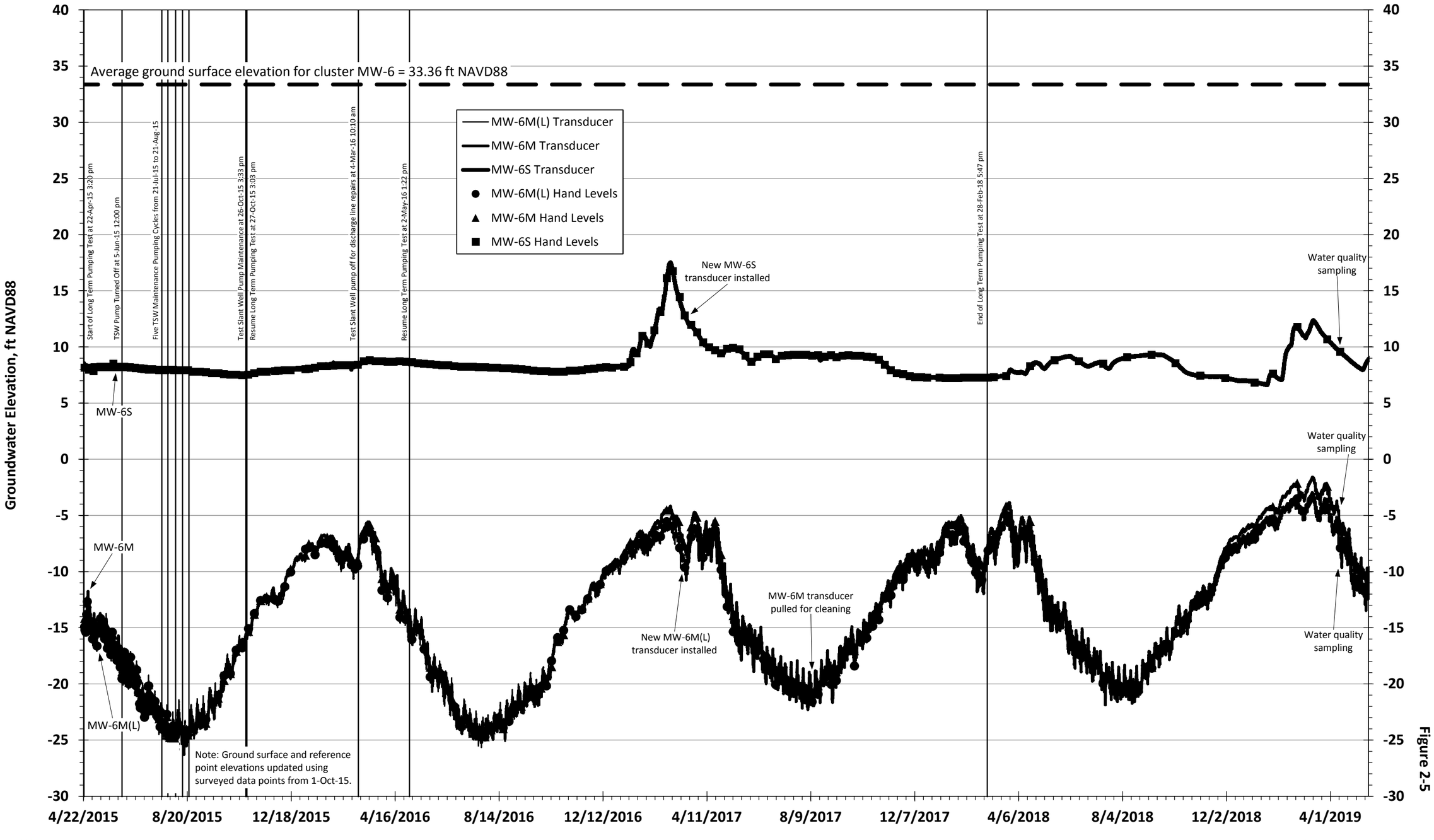


Figure 2-5

Groundwater Elevation in MPWSP MW-7

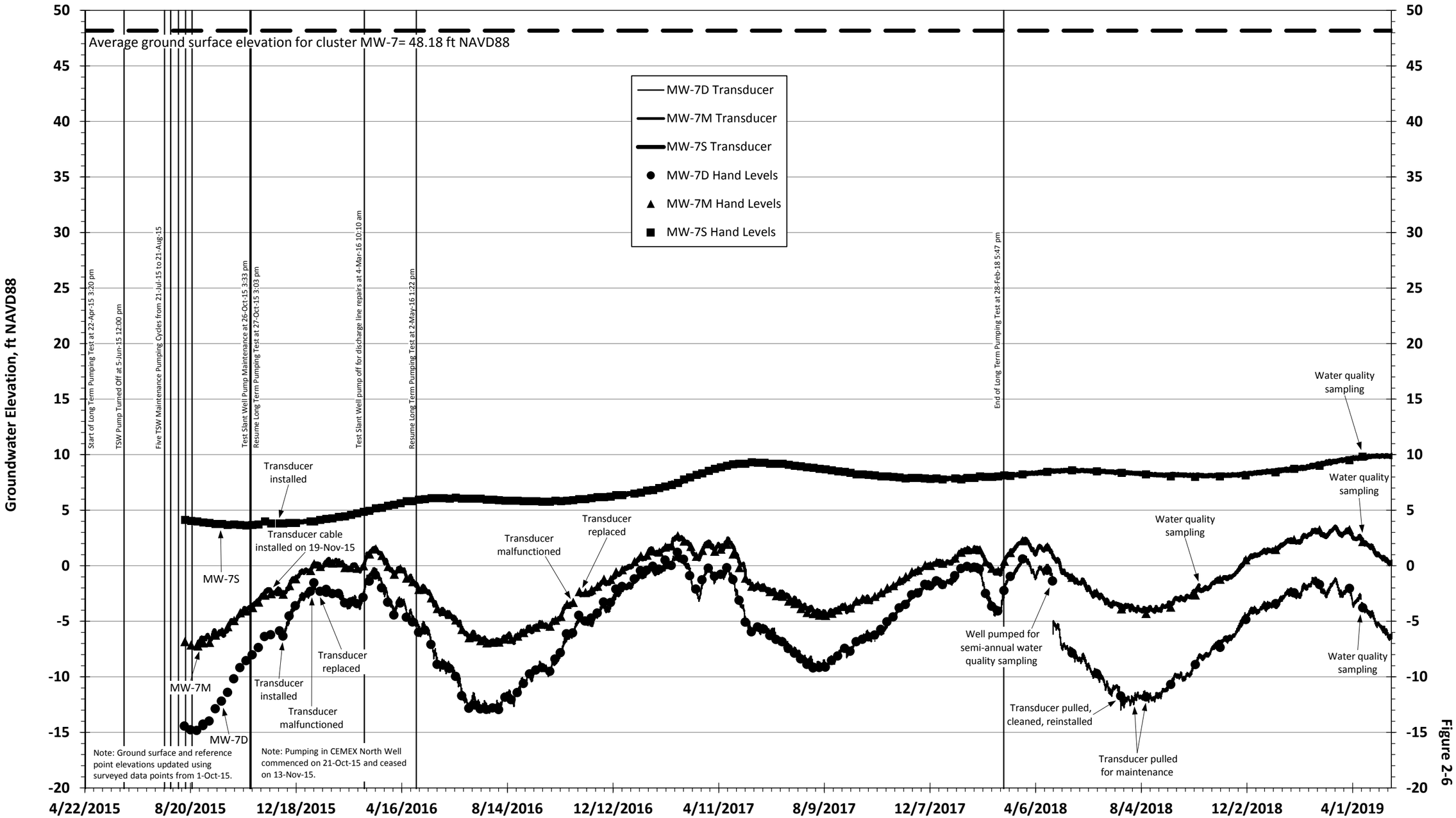


Figure 2-6

Groundwater Elevation in MPWSP MW-8

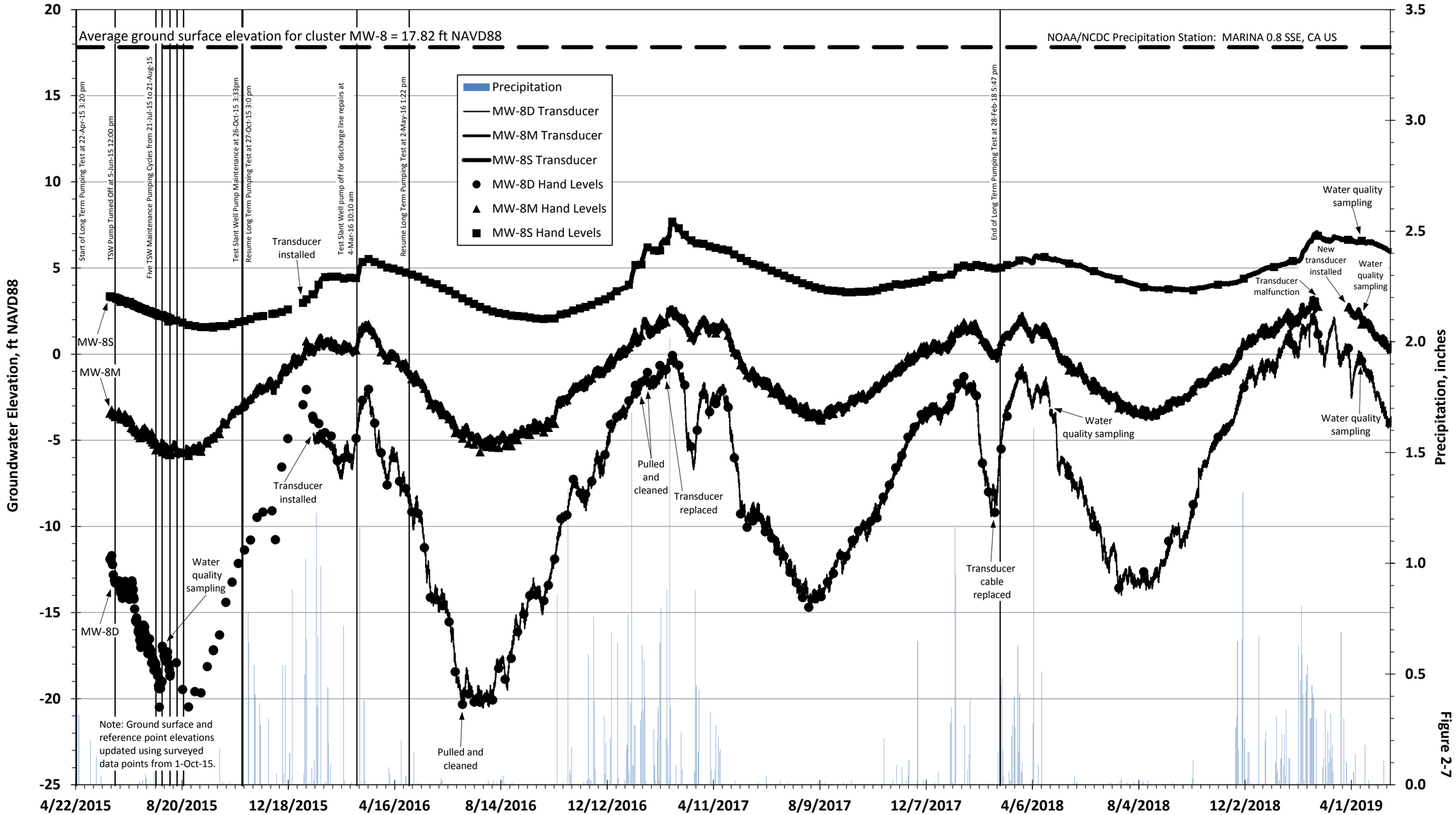


Figure 2-7

Groundwater Elevation in MPWSP MW-9

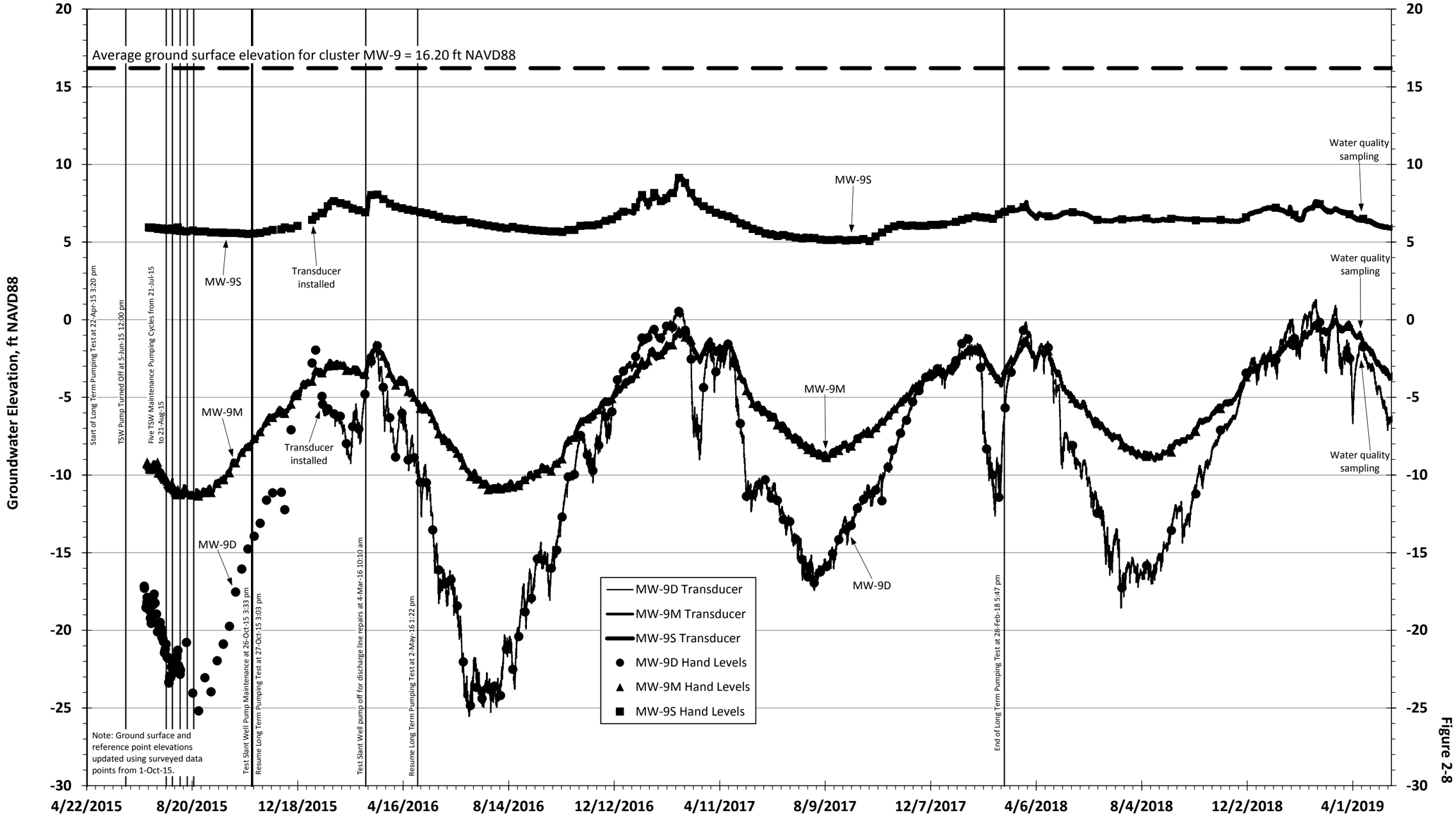
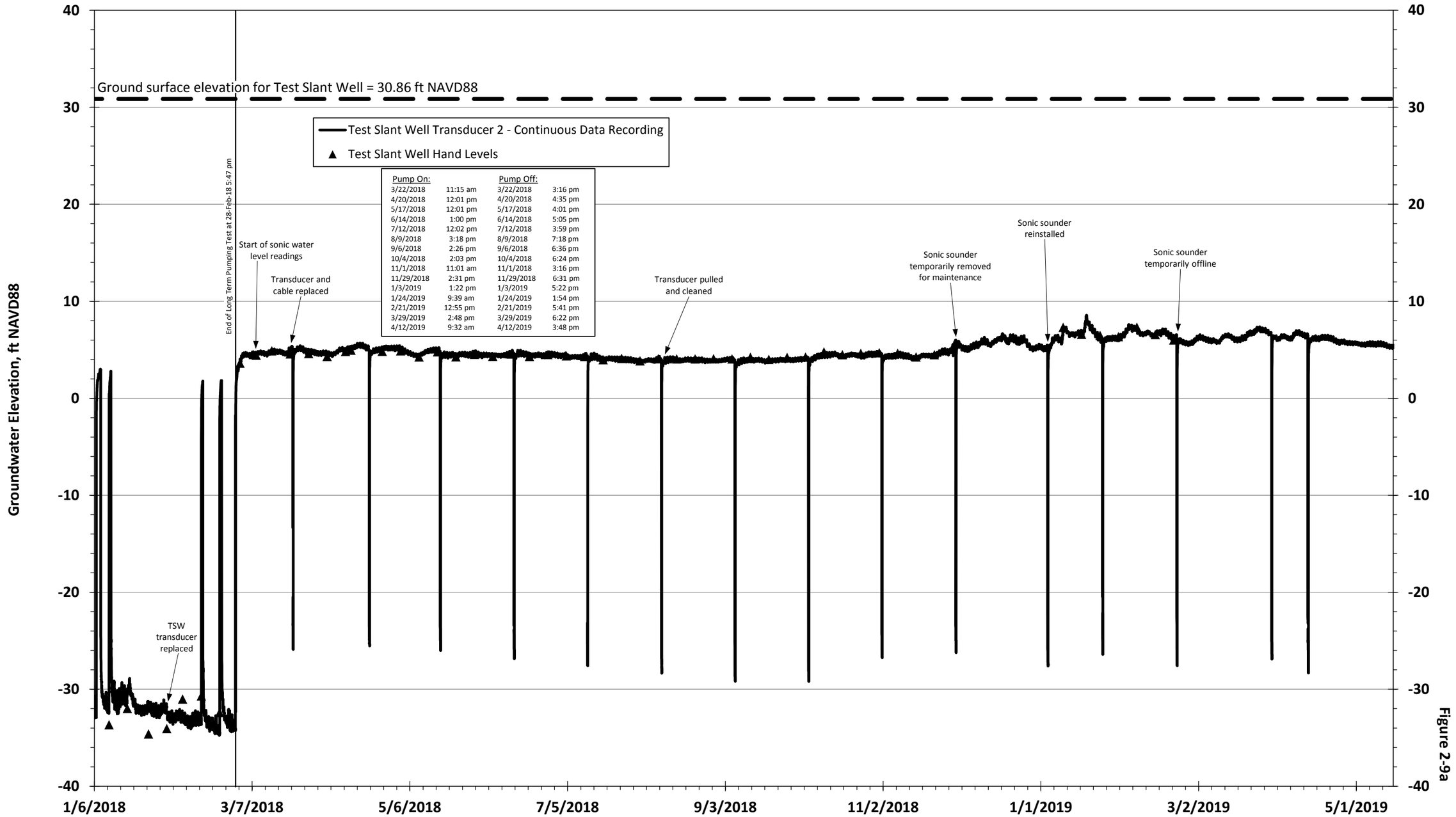


Figure 2-8

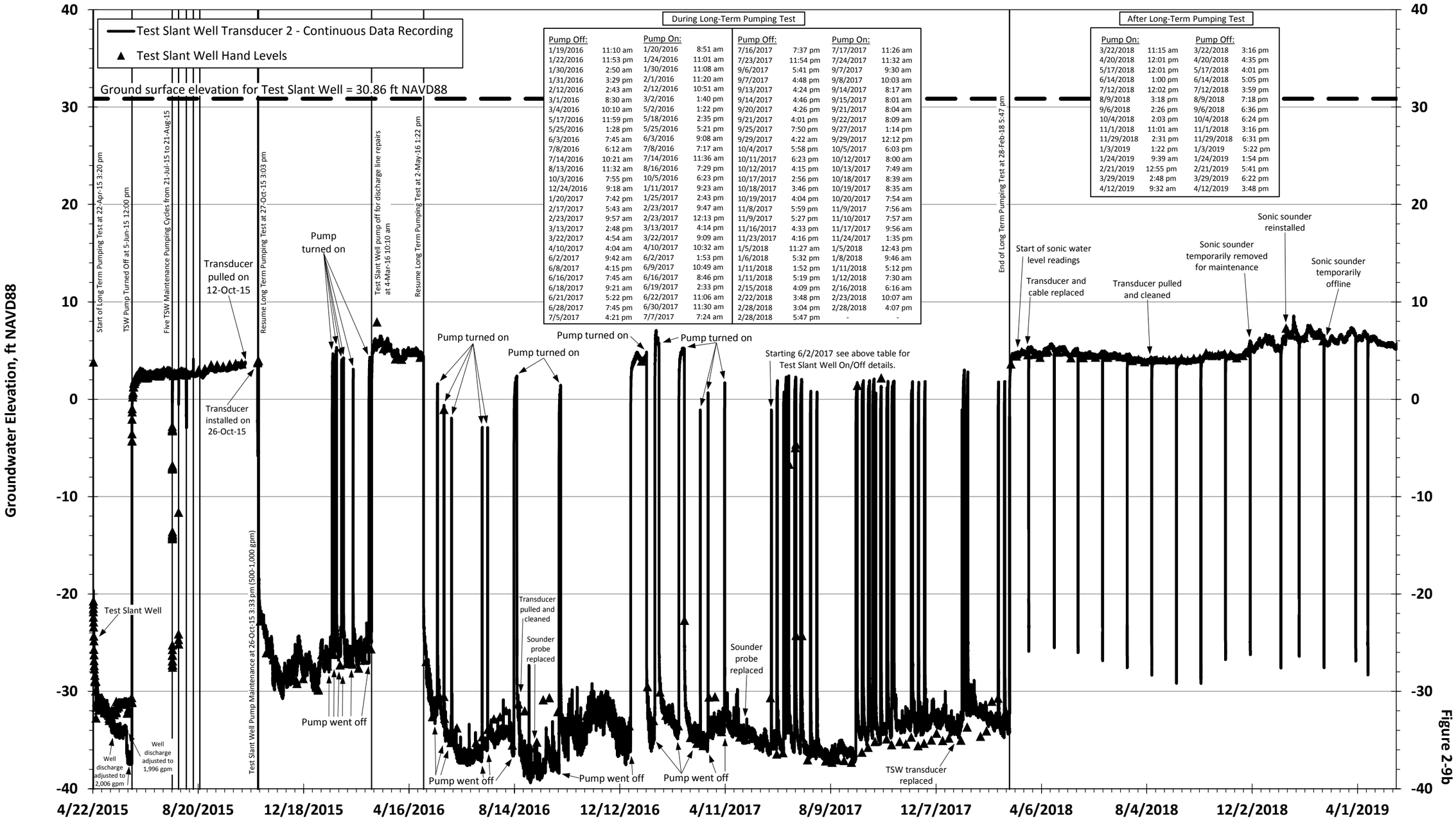
Groundwater Elevation in MPWSP Test Slant Well



Pump On:		Pump Off:	
3/22/2018	11:15 am	3/22/2018	3:16 pm
4/20/2018	12:01 pm	4/20/2018	4:35 pm
5/17/2018	12:01 pm	5/17/2018	4:01 pm
6/14/2018	1:00 pm	6/14/2018	5:05 pm
7/12/2018	12:02 pm	7/12/2018	3:59 pm
8/9/2018	3:18 pm	8/9/2018	7:18 pm
9/6/2018	2:26 pm	9/6/2018	6:36 pm
10/4/2018	2:03 pm	10/4/2018	6:24 pm
11/1/2018	11:01 am	11/1/2018	3:16 pm
11/29/2018	2:31 pm	11/29/2018	6:31 pm
1/3/2019	1:22 pm	1/3/2019	5:22 pm
1/24/2019	9:39 am	1/24/2019	1:54 pm
2/21/2019	12:55 pm	2/21/2019	5:41 pm
3/29/2019	2:48 pm	3/29/2019	6:22 pm
4/12/2019	9:32 am	4/12/2019	3:48 pm

Figure 2-9a

Groundwater Elevation in MPWSP Test Slant Well During and After Long-Term Pumping Test



During Long-Term Pumping Test

Pump Off:		Pump On:	
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1/22/2016	11:53 pm	1/24/2016	11:01 am
1/30/2016	2:50 am	1/30/2016	11:08 am
1/31/2016	3:29 pm	2/1/2016	11:20 am
2/12/2016	2:43 am	2/12/2016	10:51 am
3/1/2016	8:30 am	3/2/2016	1:40 pm
3/4/2016	10:10 am	5/2/2016	1:22 pm
5/17/2016	11:59 pm	5/18/2016	2:35 pm
5/25/2016	1:28 pm	5/25/2016	5:21 pm
6/3/2016	7:45 am	6/3/2016	9:08 am
7/8/2016	6:12 am	7/8/2016	7:17 am
7/14/2016	10:21 am	7/14/2016	11:36 am
8/13/2016	11:32 am	8/16/2016	7:29 pm
10/3/2016	7:55 pm	10/5/2016	6:23 pm
12/24/2016	9:18 am	1/11/2017	9:23 am
1/20/2017	7:42 pm	1/25/2017	2:43 pm
2/17/2017	5:43 am	2/23/2017	9:47 am
2/23/2017	9:57 am	2/23/2017	12:13 pm
3/13/2017	2:48 pm	3/13/2017	4:14 pm
3/22/2017	4:54 am	3/22/2017	9:09 am
4/10/2017	4:04 am	4/10/2017	10:32 am
6/2/2017	9:42 am	6/2/2017	1:53 pm
6/8/2017	4:15 pm	6/9/2017	10:49 am
6/16/2017	7:45 am	6/16/2017	8:46 pm
6/18/2017	9:21 am	6/19/2017	2:33 pm
6/21/2017	5:22 pm	6/22/2017	11:06 am
6/28/2017	7:45 pm	6/30/2017	11:30 am
7/5/2017	4:21 pm	7/7/2017	7:24 am
7/16/2017	7:37 pm	7/17/2017	11:26 am
7/23/2017	11:54 pm	7/24/2017	11:32 am
9/6/2017	5:41 pm	9/7/2017	9:30 am
9/7/2017	4:48 pm	9/8/2017	10:03 am
9/13/2017	4:24 pm	9/14/2017	8:17 am
9/14/2017	4:46 pm	9/15/2017	8:01 am
9/20/2017	4:26 pm	9/21/2017	8:04 am
9/21/2017	4:01 pm	9/22/2017	8:09 am
9/25/2017	7:50 pm	9/27/2017	1:14 pm
9/29/2017	4:22 am	9/29/2017	12:12 pm
10/4/2017	5:58 pm	10/5/2017	6:03 pm
10/11/2017	6:23 pm	10/12/2017	8:00 am
10/12/2017	4:15 pm	10/13/2017	7:49 am
10/17/2017	2:56 pm	10/18/2017	8:39 am
10/18/2017	3:46 pm	10/19/2017	8:35 am
10/19/2017	4:04 pm	10/20/2017	7:54 am
11/8/2017	5:59 pm	11/9/2017	7:56 am
11/9/2017	5:27 pm	11/10/2017	7:57 am
11/16/2017	4:33 pm	11/17/2017	9:56 am
11/23/2017	4:16 pm	11/24/2017	1:35 pm
1/5/2018	11:27 am	1/5/2018	12:43 pm
1/6/2018	5:32 pm	1/8/2018	9:46 am
1/11/2018	1:52 pm	1/11/2018	5:12 pm
1/11/2018	5:19 pm	1/12/2018	7:30 am
2/15/2018	4:09 pm	2/16/2018	6:16 am
2/22/2018	3:48 pm	2/23/2018	10:07 am
2/28/2018	3:04 pm	2/28/2018	4:07 pm
2/28/2018	5:47 pm	-	-

After Long-Term Pumping Test

Pump On:		Pump Off:	
3/22/2018	11:15 am	3/22/2018	3:16 pm
4/20/2018	12:01 pm	4/20/2018	4:35 pm
5/17/2018	12:01 pm	5/17/2018	4:01 pm
6/14/2018	1:00 pm	6/14/2018	5:05 pm
7/12/2018	12:02 pm	7/12/2018	3:59 pm
8/9/2018	3:18 pm	8/9/2018	7:18 pm
9/6/2018	2:26 pm	9/6/2018	6:36 pm
10/4/2018	2:03 pm	10/4/2018	6:24 pm
11/1/2018	11:01 am	11/1/2018	3:16 pm
11/29/2018	2:31 pm	11/29/2018	6:31 pm
1/3/2019	1:22 pm	1/3/2019	5:22 pm
1/24/2019	9:39 am	1/24/2019	1:54 pm
2/21/2019	12:55 pm	2/21/2019	5:41 pm
3/29/2019	2:48 pm	3/29/2019	6:22 pm
4/12/2019	9:32 am	4/12/2019	3:48 pm

Figure 2-9b

Specific Conductivity in MPWSP MW-1

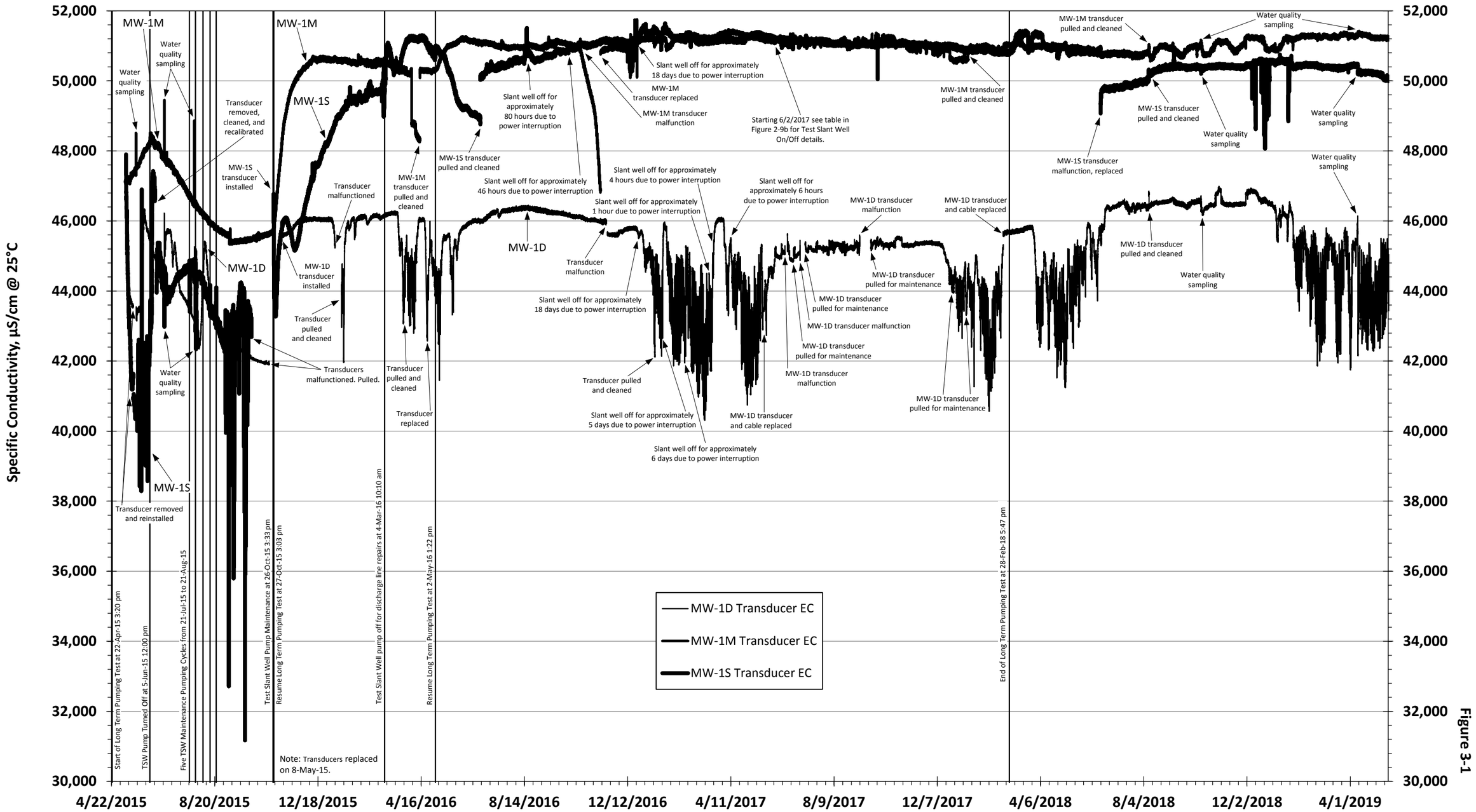


Figure 3-1

Specific Conductivity in MPWSP MW-3

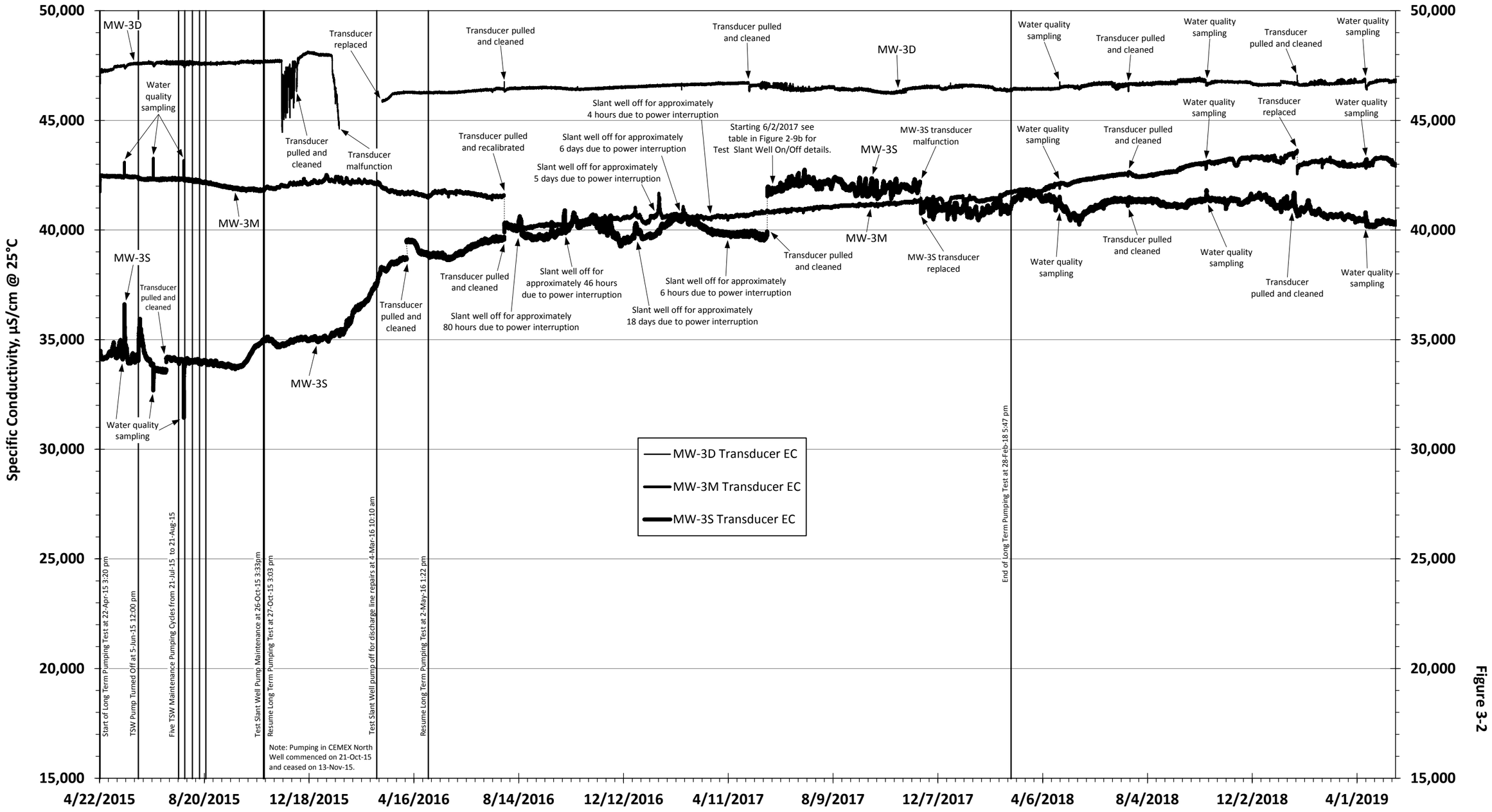


Figure 3-2

Specific Conductivity in MPWSP MW-4

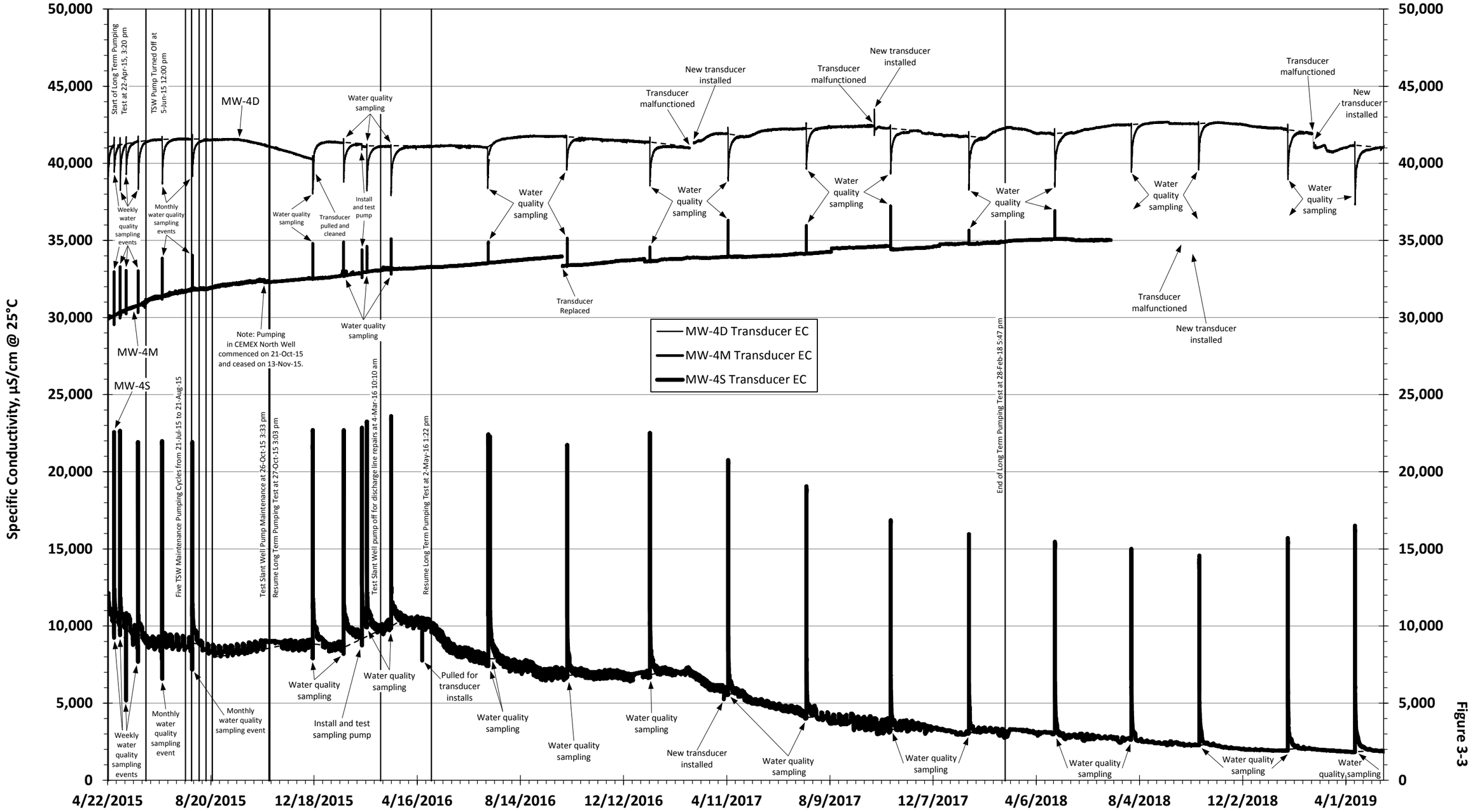


Figure 3-3

Specific Conductivity in MPWSP MW-5

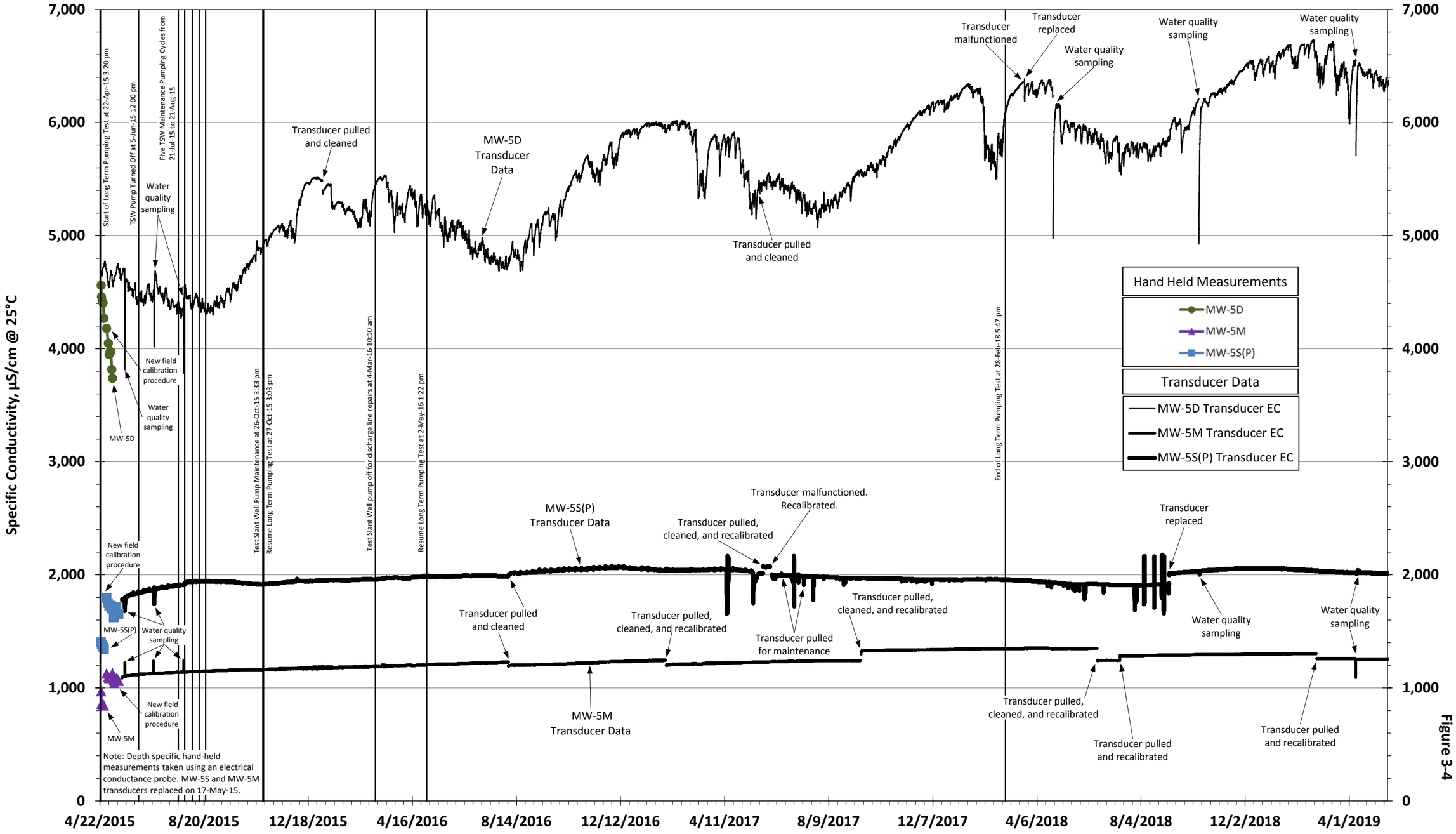


Figure 3-4

Specific Conductivity in MPWSP MW-6

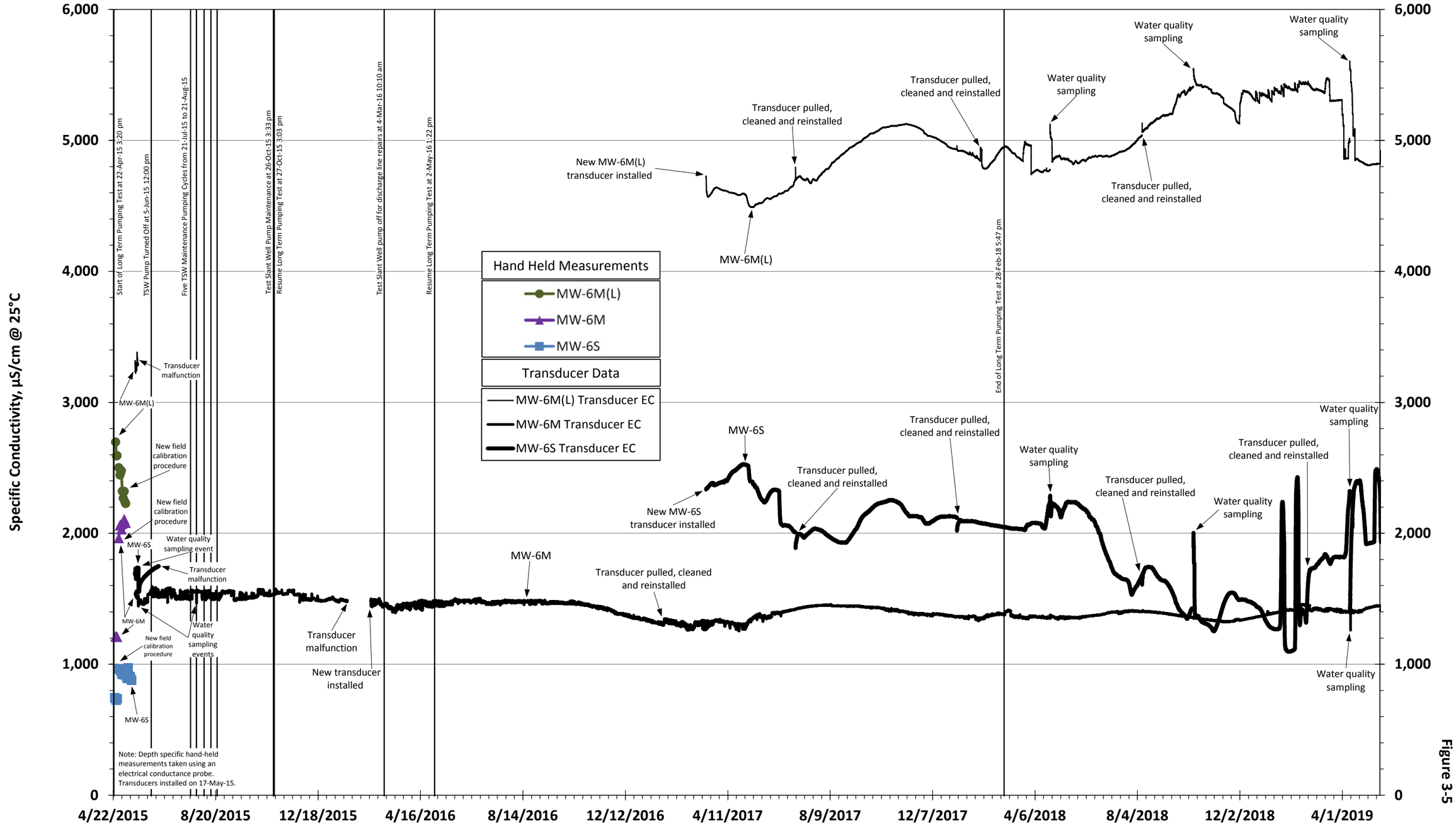


Figure 3-5

Specific Conductivity in MPWSP MW-7

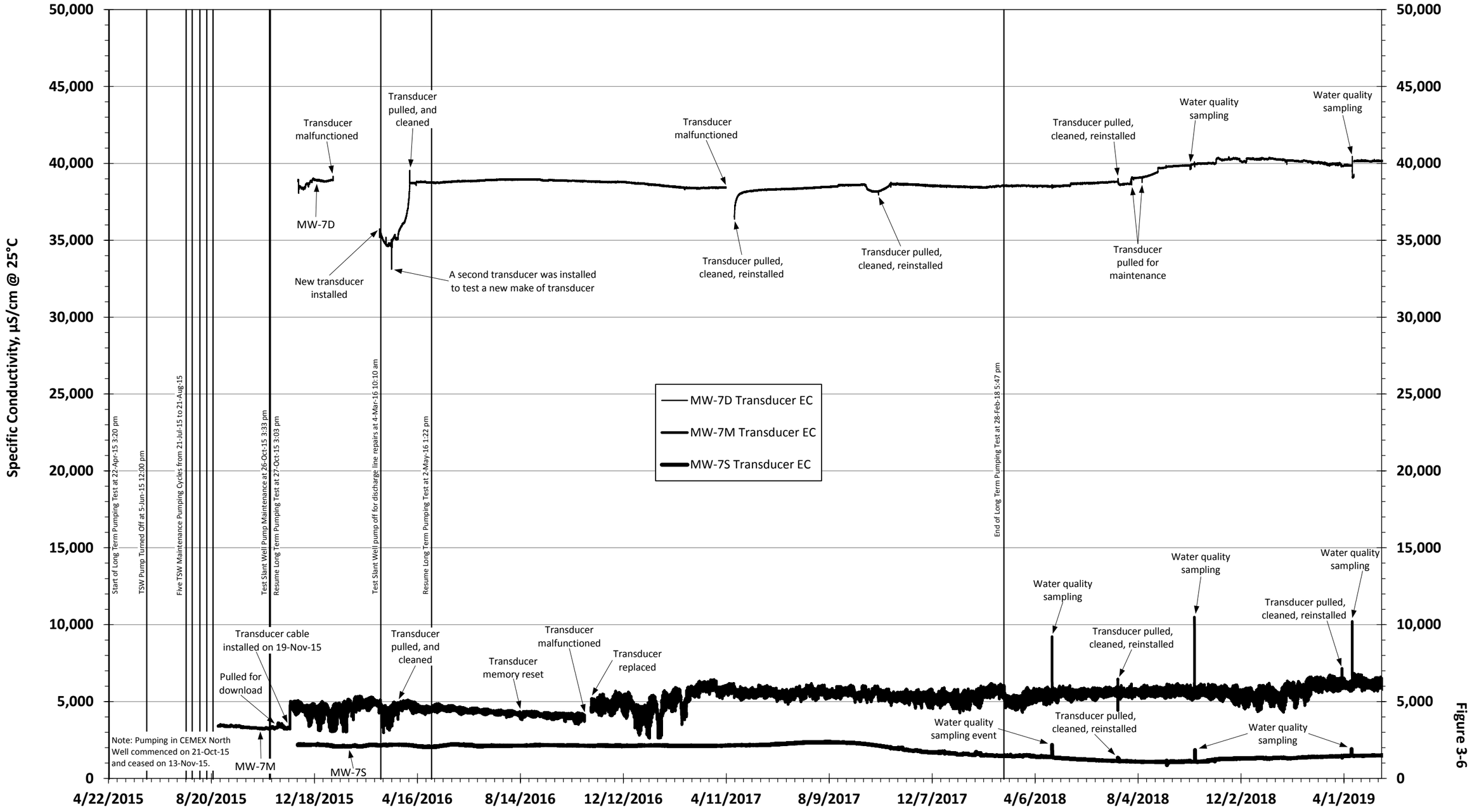


Figure 3-6

Specific Conductivity in MPWSP MW-8

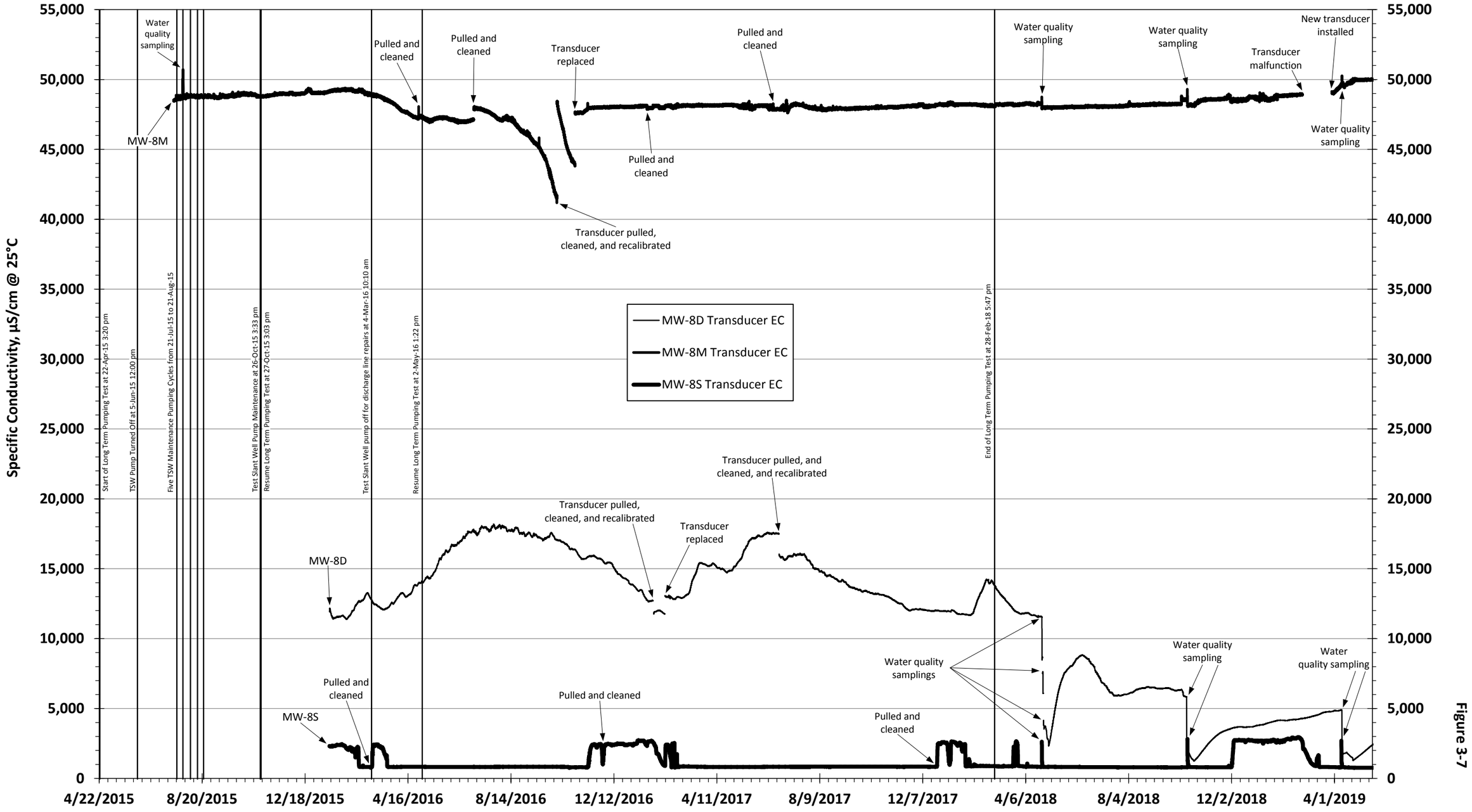


Figure 3-7

Specific Conductivity in MPWSP MW-9

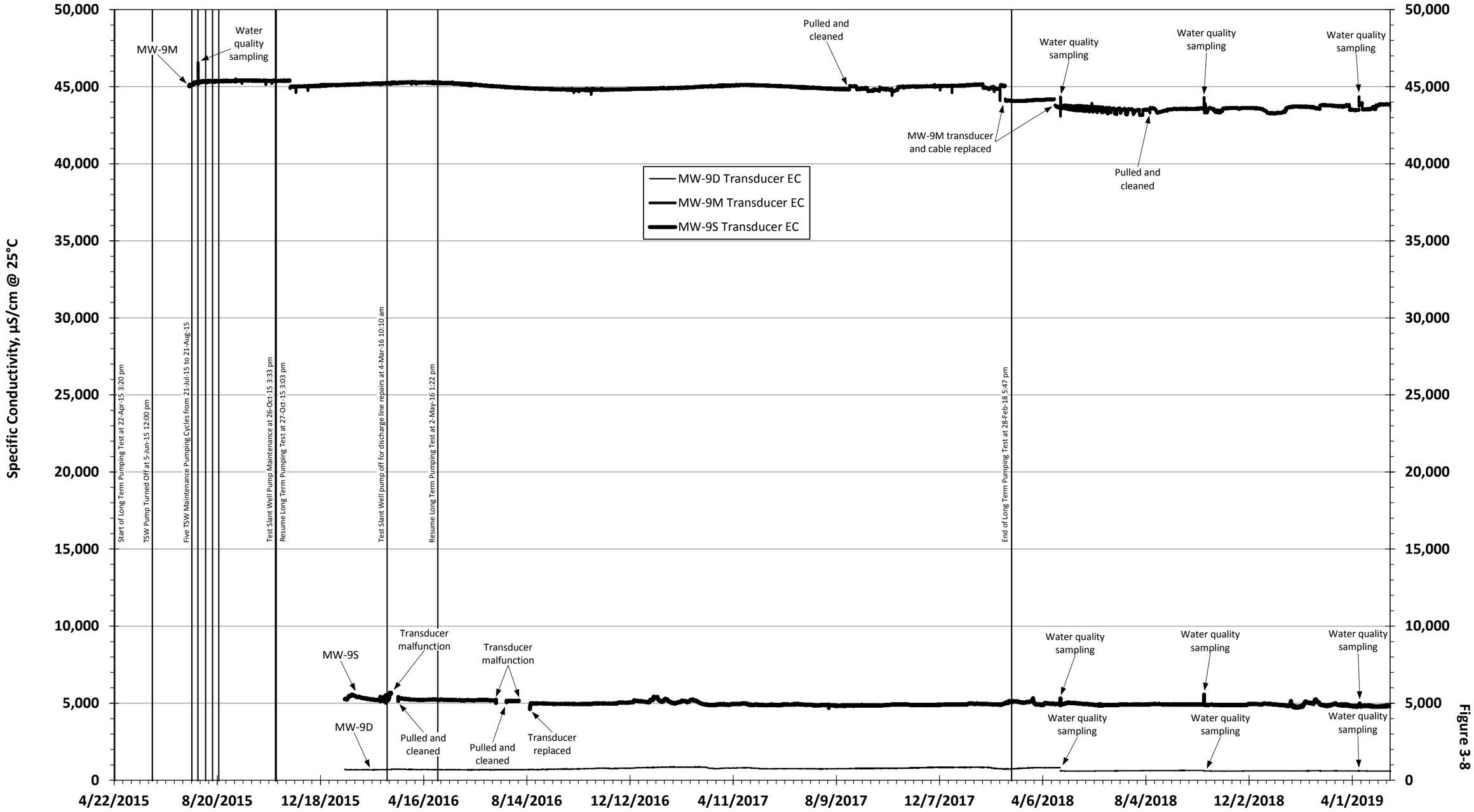
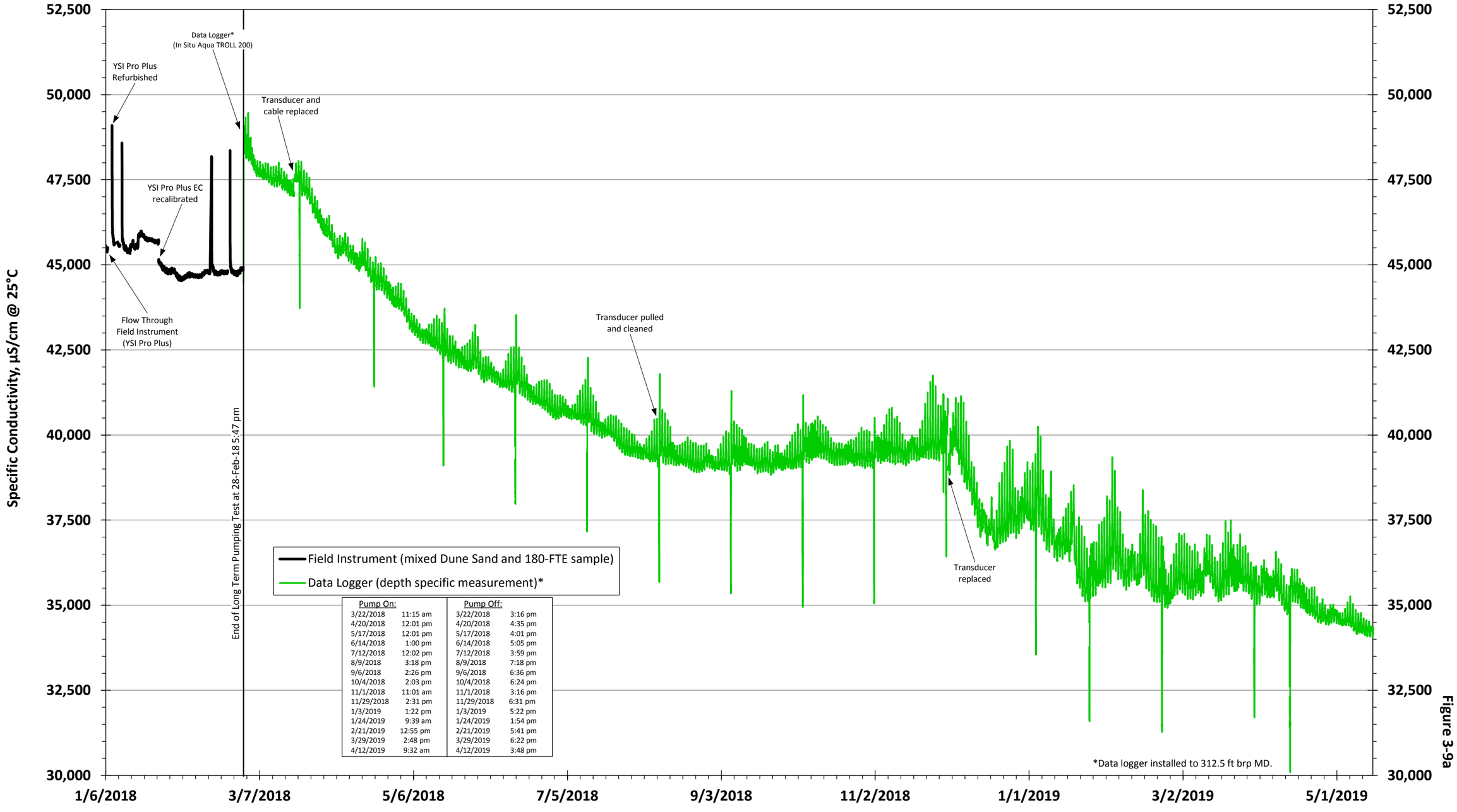


Figure 3-8

Specific Conductivity in MPWSP Test Slant Well



Pump On:		Pump Off:	
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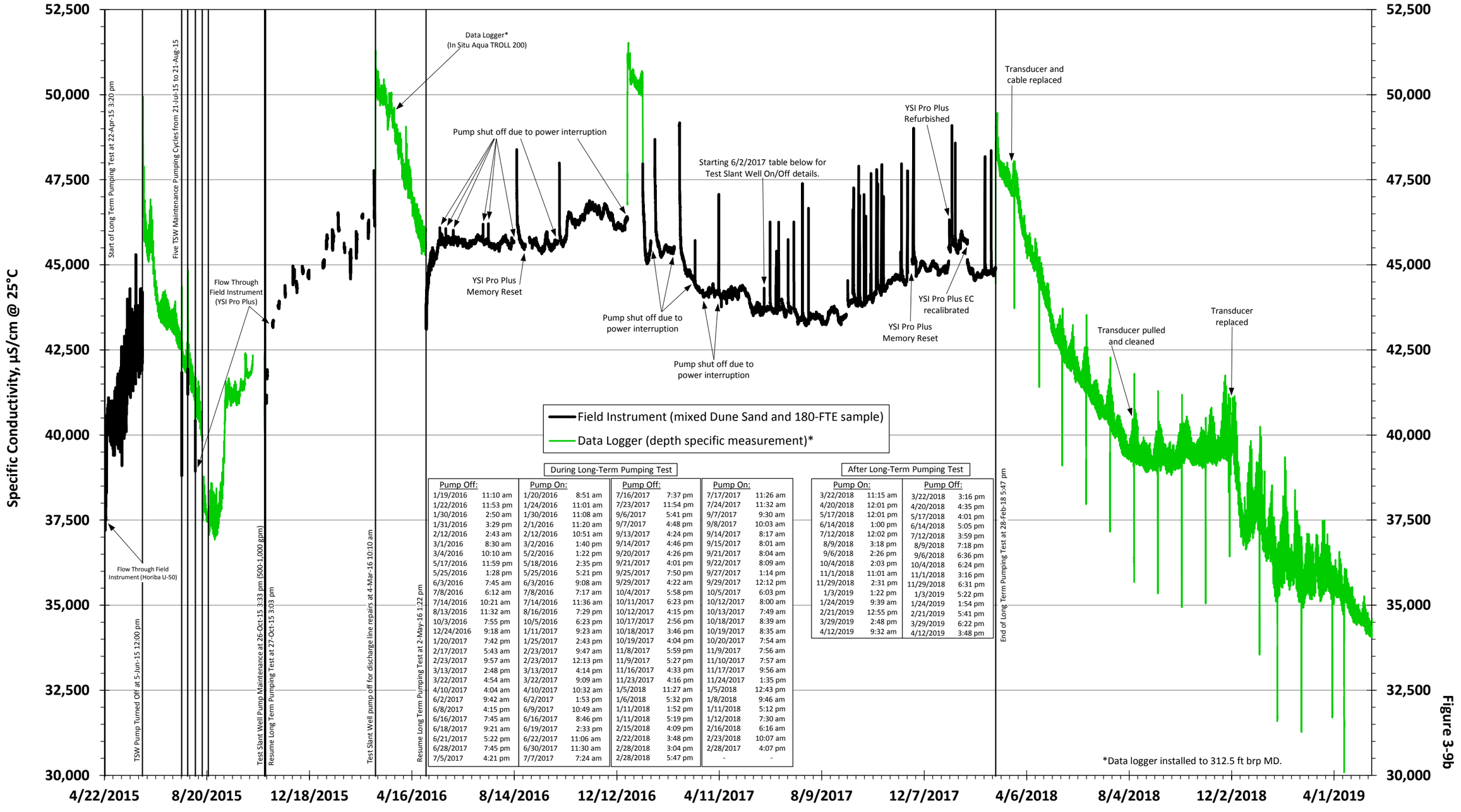
4/20/2018	12:01 pm	4/20/2018	4:35 pm
5/17/2018	12:01 pm	5/17/2018	4:01 pm
6/14/2018	1:00 pm	6/14/2018	5:05 pm
7/12/2018	12:02 pm	7/12/2018	3:59 pm
8/9/2018	3:18 pm	8/9/2018	7:18 pm
9/6/2018	2:26 pm	9/6/2018	6:36 pm
10/4/2018	2:03 pm	10/4/2018	6:24 pm
11/1/2018	11:01 am	11/1/2018	3:16 pm
11/29/2018	2:31 pm	11/29/2018	6:31 pm
1/3/2019	1:22 pm	1/3/2019	5:22 pm
1/24/2019	9:39 am	1/24/2019	1:54 pm
2/21/2019	12:55 pm	2/21/2019	5:41 pm
3/29/2019	2:48 pm	3/29/2019	6:22 pm
4/12/2019	9:32 am	4/12/2019	3:48 pm

Figure 3-9a

Specific Conductivity in MPWSP Test Slant Well During and After Long-Term Pumping Test



During Long-Term Pumping Test

Pump Off:		Pump On:		Pump Off:		Pump On:	
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1/22/2016	11:53 pm	1/24/2016	11:01 am	7/23/2017	11:54 pm	7/24/2017	11:32 am
1/30/2016	2:50 am	1/30/2016	11:08 am	9/6/2017	5:41 pm	9/7/2017	9:30 am
1/31/2016	3:29 pm	2/1/2016	11:20 am	9/7/2017	4:48 pm	9/8/2017	10:03 am
2/12/2016	2:43 am	2/12/2016	10:51 am	9/13/2017	4:24 pm	9/14/2017	8:17 am
3/1/2016	8:30 am	3/2/2016	1:40 pm	9/14/2017	4:46 pm	9/15/2017	8:01 am
3/4/2016	10:10 am	5/2/2016	1:22 pm	9/20/2017	4:26 pm	9/21/2017	8:04 am
5/17/2016	11:59 pm	5/18/2016	2:35 pm	9/21/2017	4:01 pm	9/22/2017	8:09 am
5/25/2016	1:28 pm	5/25/2016	5:21 pm	9/25/2017	7:50 pm	9/27/2017	1:14 pm
6/3/2016	7:45 am	6/3/2016	9:08 am	9/29/2017	4:22 am	9/29/2017	12:12 pm
7/8/2016	6:12 am	7/8/2016	7:17 am	10/4/2017	5:58 pm	10/5/2017	6:03 pm
7/14/2016	10:21 am	7/14/2016	11:36 am	10/11/2017	6:23 pm	10/12/2017	8:00 am
8/13/2016	11:32 am	8/16/2016	7:29 pm	10/12/2017	4:15 pm	10/13/2017	7:49 am
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12/24/2016	9:18 am	1/11/2017	9:23 am	10/18/2017	3:46 pm	10/19/2017	8:35 am
1/20/2017	7:42 pm	1/25/2017	2:43 pm	10/19/2017	4:04 pm	10/20/2017	7:54 am
2/17/2017	5:43 am	2/23/2017	9:47 am	11/8/2017	5:59 pm	11/9/2017	7:56 am
2/23/2017	9:57 am	2/23/2017	12:13 pm	11/9/2017	5:27 pm	11/10/2017	7:57 am
3/13/2017	2:48 pm	3/13/2017	4:14 pm	11/16/2017	4:33 pm	11/17/2017	9:56 am
3/22/2017	4:54 am	3/22/2017	9:09 am	11/23/2017	4:16 pm	11/24/2017	1:35 pm
4/10/2017	4:04 am	4/10/2017	10:32 am	1/5/2018	11:27 am	1/5/2018	12:43 pm
6/2/2017	9:42 am	6/2/2017	1:53 pm	1/6/2018	5:32 pm	1/8/2018	9:46 am
6/8/2017	4:15 pm	6/9/2017	10:49 am	1/11/2018	1:52 pm	1/11/2018	5:12 pm
6/16/2017	7:45 am	6/16/2017	8:46 pm	1/11/2018	5:19 pm	1/12/2018	7:30 am
6/18/2017	9:21 am	6/19/2017	2:33 pm	2/15/2018	4:09 pm	2/16/2018	6:16 am
6/21/2017	5:22 pm	6/22/2017	11:06 am	2/22/2018	3:48 pm	2/23/2018	10:07 am
6/28/2017	7:45 pm	6/30/2017	11:30 am	2/28/2018	3:04 pm	2/28/2017	4:07 pm
7/5/2017	4:21 pm	7/7/2017	7:24 am	2/28/2018	5:47 pm	-	-

After Long-Term Pumping Test

Pump On:		Pump Off:	
3/22/2018	11:15 am	3/22/2018	3:16 pm
4/20/2018	12:01 pm	4/20/2018	4:35 pm
5/17/2018	12:01 pm	5/17/2018	4:01 pm
6/14/2018	1:00 pm	6/14/2018	5:05 pm
7/12/2018	12:02 pm	7/12/2018	3:59 pm
8/9/2018	3:18 pm	8/9/2018	7:18 pm
9/6/2018	2:26 pm	9/6/2018	6:36 pm
10/4/2018	2:03 pm	10/4/2018	6:24 pm
11/1/2018	11:01 am	11/1/2018	3:16 pm
11/29/2018	2:31 pm	11/29/2018	6:31 pm
1/3/2019	1:22 pm	1/3/2019	5:22 pm
1/24/2019	9:39 am	1/24/2019	1:54 pm
2/21/2019	12:55 pm	2/21/2019	5:41 pm
3/29/2019	2:48 pm	3/29/2019	6:22 pm
4/12/2019	9:32 am	4/12/2019	3:48 pm

Figure 3-9b

APPENDIX 3.E – SVBGSA WATER BUDGETS

Table 6-19: Summary of Current Groundwater Budget

Inflow		Average (AF/yr.)	Minimum (AF/yr.)	Maximum (AF/yr.)
	Net Percolation of Streamflow to Groundwater	31,100	3,300	80,000
	Precipitation Percolation to Groundwater	6,500	0	10,800
	Irrigation Percolation to Groundwater	4,500	-9400[1]	15,500
	Subsurface Inflows from Adjacent Subbasins	20,000	20,000	20,000
TOTAL INFLOW		62,100	38,700	101,400

Outflow		Average (AF/yr.)	Minimum (AF/yr.)	Maximum (AF/yr.)
	Pumping - Total Subbasin	109,300	108,400	111,000
	Agricultural	91,900	89,000	97,700
	Urban	17,000	12,900	19,000
	Rural Domestic	400	400	400
	Riparian Evapotranspiration	12,000	12,000	12,000
	Subsurface Outflows to Adjacent Subbasins/Basin	9,500	9,500	9,500
TOTAL OUTFLOW		130,800	129,900	132,600

Storage		Average (AF/yr.)	Minimum (AF/yr.)	Maximum (AF/yr.)
	Change in Storage	-68,700	-28,500	-93,800

[1]Negative percolation due to extremely high flows in the Rec ditch in 2017, which is all subtracted from irrigation. Some Rec Ditch flows should be subtracted from precipitation. The total recharge from both irrigation and precipitation is correct

The annual groundwater budget components are variable, although not as variable as the surface water budget components. Figure 6-4 illustrates the annual inflow and outflow components for the historical budget period. The diagram uses stacked bar height to illustrate the magnitude of budget components for each year, with inflows shown on the positive y-axis and outflows on the negative y-axis. The inflow and outflow components for each year are tabulated in Appendix 6A.

Table 6-27: Average Annual Groundwater Budget for Projected Climate Change Conditions (acre-ft/year)

Projected Climate Change Timeframe	2030 (AF/yr.)	2070 (AF/yr.)
Net GW Extraction	-115,00	-120,600
Net Drain Flow	-7,100	-8,000
Net Stream Exchange	69,700	69,800
Net Deep Percolation	41,200	45,100
Ocean Outflow	-800	-700
Net flow from Monterey	5,500	6,200
Net flow to Eastside	-7,200	-6,200
Net flow from Forebay	5,000	5,000
Net flow from Langley	1,600	1,600
Net mountain front recharge	1,700	1,800
Net flow to Pajaro	-800	-800
Net Storage Change	-4,600	-4,700

Table 6-28: Total Groundwater Inflows and Outflows for Projected Groundwater Budgets

Projected Climate Change Timeframe	2030 (AF/yr.)	2070 (AF/yr.)
Total In	295,700	308,600
Total Out	294,200	307,100
In-Out	1,500	1,600
%Error	0.50%	0.51%

Combining the land surface and groundwater budgets, groundwater pumping by water use sector can be summarized, as shown in Table 6-29.

Table 6-29: Projected Annual Groundwater Pumping by Water Use Sector

Water Use Sector	2030 Average	2070 Average
Agricultural	94,800	99,500
Urban (total pumping minus agricultural)	20,500	21,100
Rural-Domestic (not simulated in model, considered minimal)	0	0
Total Pumping	135,800	141,600

CHAPTER 4 – SUSTAINABLE MANAGEMENT CRITERIA
Groundwater Sustainability Plan
for the Marina GSA Area
of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, California

JANUARY 2020

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Figure 4-2. Measurable Objectives for the Seawater Intrusion Sustainability Indicator

4 SUSTAINABLE MANAGEMENT CRITERIA

4.1 INTRODUCTION AND BACKGROUND

Regulation Requirements:

§354.22 This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.

California Department of Water Resources (DWR) has identified the 180/400 Foot Aquifer Subbasin (Subbasin) as subject to significant and unreasonable seawater intrusion due largely to long-term groundwater extraction in the inland portions of the Subbasin in excess of the sustainable yield, and DWR has also identified the Subbasin as one of 21 California basins that are in a condition of "critical overdraft" (DWR 2016a). Seawater intrusion was first identified in the jurisdictional area of the Marina Groundwater Sustainability Agency (the MGSA Area) in the 1940s, and over the following decades progressed inland for a distance of over 7 miles in some areas. The purpose of this GSP is to consider local efforts and support regional efforts to address this undesirable result and return to Subbasin to sustainable groundwater management within 20 years, as required by the Sustainable Groundwater Management Act (SGMA). MGSA will achieve this by evaluating local projects and supporting the projects and management actions that will be implemented by Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) under its regional Groundwater Sustainability Plan (GSP), and by assuring that local groundwater resources are managed sustainably to protect local and regional beneficial uses and users.

This chapter of the GSP presents the criteria that constitute sustainable groundwater management in the MGSA Area and describes significant regulatory requirements. These "Sustainable Management Criteria" define the desired future groundwater resources condition of the MGSA Area in the Subbasin and commit MGSA to actions that will meet these objectives. The sustainable management criteria defined in this chapter include the following components (definitions for the terms in quotes are presented further below):

- The "Sustainability Goal" for the MGSA Area of the Subbasin is presented;
- "Undesirable Results" applicable to each "Sustainability Indicator" are identified;
- The "Minimum Thresholds" by which these Undesirable Results may be recognized are selected; and
- "Measurable Objectives" by which the groundwater resources in the MGSA Area may be managed are established.

The following definitions are used to guide the development of sustainable management criteria for the MGSA Area:

- A **Sustainability Goal** is a succinct statement of the GSA's objectives and desired conditions of the groundwater basin, how the basin will get to that desired condition, and why the measures planned will lead to success. Unlike the other sustainable management criteria, the

sustainability goal is not quantitative, but supported by locally-defined minimum thresholds and undesirable results. Demonstration of the absence of undesirable results supports a determination that the basin is operating within its sustainable yield and, thus, that the sustainability goal has been achieved (DWR 2017).

- **Sustainability Indicators** are any of the following six effects potentially caused by groundwater conditions that, when significant and unreasonable, cause undesirable results (California Water Code (CWC) § 10721(x)):
  - Chronic Lowering of Groundwater Levels;
  - Reduction of Groundwater Storage;
  - Degraded Groundwater Quality;
  - Land Subsidence;
  - Seawater Intrusion; and
  - Depletion of Interconnected Surface Waters.
- **Undesirable Results** occur when significant and unreasonable effects for any of the sustainability indicators defined by SGMA are caused by groundwater conditions occurring in the basin. Undesirable results are included as sustainable management criteria as a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin. A description of undesirable results should include the potential effects on the beneficial uses and users of groundwater, land uses and property interests, and other potential effects that may occur or are occurring from the undesirable result. (23 California Code of Regulations (CCR) § 354.26)

  Undesirable results may be defined by minimum threshold exceedances at a single monitoring site, multiple monitoring sites, a portion of a basin, a management area, or an entire basin.
- **Minimum Thresholds** refers to a numeric value or values for each sustainability indicator used to define undesirable results. (23 CCR § 354.28)

  Minimum thresholds are quantitative values that represent groundwater conditions at representative monitoring points and that indicate an unreasonable condition. For example, a discrete groundwater or salinity level in a well may be a minimum threshold because groundwater levels dropping below or salinity levels rising beyond the specified level would be an unreasonable condition.
- **Measurable Objectives** refer to specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin. Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon. (23 CCR § 354.30)

  Measurable objectives are goals that the GSP is designed to achieve. Measurable objectives are set so there is a reasonable margin of operational flexibility between the minimum threshold and measurable objective that will accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities. For some

sustainability indicators, projects and management actions are needed to achieve measurable objectives. Although measurable objectives are not enforceable during implementation of the GSP, the GSP needs to demonstrate that there is a planned path toward achieving measurable objectives.

This chapter includes or references the data used to develop the sustainable management criteria and to evaluate how they influence the beneficial uses and users of groundwater within and surrounding the MGSA Area. The sustainable management criteria discussed in this chapter were developed based on information about the basin from the hydrogeologic conceptual model (Section 3.1), information about current and historical groundwater conditions (Section 3.2), the water budget (Section 3.3), other publicly available information, information and public feedback about groundwater conditions near the MGSA Area obtained during City Council meetings held over the last three years and during recent public MGSA meetings about the GSP development process, and meetings with MGSA staff.

To retain an organized approach, this chapter follows the same section/subsection structure for each sustainability indicator. The result is somewhat repetitive, but is complete and systematic when addressing the SGMA requirements. Each section follows a consistent format that contains the information required by 23 CCR §§ 354.22 et. seq and outlined in the Sustainable Management Criteria Best Management Practices guidance document developed by DWR (DWR 2017).

4.2 SUSTAINABILITY GOAL

Regulation Requirements:

§ 354.24. Sustainability Goal

Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

CWC § 10721 defines sustainable groundwater management as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results." A sustainability goal is the desired culmination of sustainable groundwater management, resulting in the maintenance of sustainable groundwater conditions (the absence of undesirable results), or their achievement within 20 years, when compared to a 2015 baseline condition. The sustainability goal reflects these requirements and succinctly states the GSAs' objectives and the desired conditions of the GSP area.

The sustainable yield is defined as the amount of groundwater that can be withdrawn annually over a period of time without causing undesirable results. Regionally, the primary undesirable result in the 180/400 Foot Aquifer Subbasin has been seawater intrusion in the 180-Foot and 400-Foot Aquifers caused by long-term overdraft and declining groundwater levels in the inland portions of the Subbasin (SBVGSA 2019, MCWRA 2017a). Chronic declines in inland groundwater levels have led to a reversal in the groundwater gradients in the 180-Foot and 400-Foot Aquifers from shoreward to landward, causing water affected by seawater intrusion to flow inland for a distance of up to approximately 7 miles. As a

result of these conditions, DWR designated the 180/400 Foot Subbasin as being subject to "Critical Conditions of Overdraft" (DWR 2016a), which means that preparation of GSPs in the Subbasin must be expedited to meet a January 31, 2020 submittal deadline.

Based on a water budget analysis, SVBGSA has estimated the historical sustainable yield of the Subbasin as 96,950 acre-feet per year (AFY), and the long-term average sustainable yield as 112,000 AFY (SVBGSA 2019).[1] In addition, as discussed in Chapter 6, SVBGSA plans to implement a number of projects and management actions to raise groundwater levels in the inland portions of the Subbasin through *in lieu* and applied recharge, with a goal of arresting and even reversing seawater intrusion. This GSP adopts, and MGSA will support, the regional sustainable yield as estimated for the 180/400 Foot Aquifer Subbasin in SVBGSA's GSP. In addition, MGSA will support SVBGSA's projects and management actions that are expected to benefit groundwater elevations at and in the vicinity of the MGSA Area.

Locally, the contribution to the sustainable yield from groundwater extraction in the MGSA Area is defined as the amount of groundwater that can be withdrawn annually over a period of time from the MGSA Area without causing undesirable results within or near the MGSA Area. Current and historical groundwater extraction in the MGSA Area has been limited to process water pumping for the CEMEX sand plant (approximately 300 AFY), which represents the only long-term groundwater extraction within the MGSA Area. Data are not available to assess if groundwater extraction from the CEMEX well historically contributed to seawater intrusion in this area since the 1960s when pumping started. Due to concern about limiting extractions to avoid seawater intrusion, the City of Marina and several other agencies entered into the 1996 Annexation Agreement limiting extractions at the CEMEX property to 500 AFY. Based on available water quality data for the CEMEX well, long-term pumping has likely reached a state of equilibrium as of the SGMA baseline date of 2015. As such, CEMEX well pumping has not resulted in significant and unreasonable seawater intrusion or groundwater quality degradation as defined by SGMA. Pumping of the CEMEX well will cease when the plant closes at the end of 2020, or at the latest in December 2024 when CEMEX removes the well (Section 3.1.8).

In the future, groundwater extraction rates in the MGSA Area are proposed to be increased significantly for the proposed MPWSP. If the proposed MPWSP is implemented, the proposed slant wells for the project would pump up to 17,400 AFY (HWG 2017). As discussed in Section 3.3.13, without additional data and modeling tools, it is not possible to assess the rate of the slant well pumping that would be sustainable in the long term. MGSA will update the estimate for the local sustainable yield and coordinate with SVBGSA to update the basin-wide sustainable yield as needed and as information becomes available during GSP implementation. The sustainable management criteria defined in this chapter, combined with the monitoring program specified in Chapter 5 and the management actions outlined in Chapter 6, are intended to assure that any groundwater extraction in the MGSA Area is managed sustainably, and that undesirable results do not occur in the MGSA Area or the surrounding Subbasin area.

[1] SVBGSA states this is an estimate only, and that the sustainable yield estimate for the Subbasin will be modified and updated as more data are collected and more analyses are performed, including evaluation of the United States Geological Survey (USGS) Salinas Valley Integrated Hydrologic Model (SVIHM), which is expected to be released in late 2020.

Undesirable results potentially associated with future groundwater extraction in the MGSA Area include the following significant and unreasonable impacts, which are further evaluated and discussed in the subsequent sections of this chapter:

- Groundwater level decline which adversely impacts beneficial groundwater uses and/or users, especially near the MGSA Area where several existing groundwater supply wells and groundwater dependent ecosystems (GDEs) are present;
- Reduction in groundwater storage which adversely impacts beneficial groundwater uses and/or users;
- Further seawater intrusion into the Dune Sand, 180-Foot and 400-Foot Aquifers, and/or seawater intrusion into the Deep Aquifer;
- Degradation of groundwater quality within the Dune Sand, 180-Foot and/or 400-Foot Aquifers that adversely affects beneficial uses or users, especially in the low-TDS groundwater zone;
- Land subsidence that adversely affects surface land uses; and
- Surface water depletion that adversely affects beneficial surface water uses or users, including GDEs.

This GSP adopts SVBGSA's sustainability goal, which is stated as follows (SVBGSA 2019):

> *The goal of this GSP is to manage the groundwater resources of the 180/400-Foot Aquifer Subbasin for long-term community, financial, and environmental benefits to the Subbasin's residents and businesses. This GSP will ensure long-term viable water supplies while maintaining the unique cultural, community, and business aspects of the Subbasin. It is the express goal of this GSP to balance the needs of all water users in the Subbasin.*

Local implementation objectives in support of this goal include the following:

> *MGSA will manage groundwater resources in the MGSA Area in a way that ensures all beneficial uses and users in, or affected by, groundwater management in the MGSA Area are protected from undesirable results, and have access to a safe and reliable groundwater supply that meets current and future demand. This goal will support SVBGSA's sustainability goal by addressing undesirable results at a local level and protecting local resources from further degradation, while coordinating with MCWRA, SVBGSA and MCWD GSA to support regional groundwater management, including groundwater level and seawater intrusion monitoring, and mitigation projects and management actions that will contain and reverse the conditions resulting from regional overdraft. MGSA will:*
>
> - *Support the protection of reliable groundwater supply and quality to promote the public health and welfare now and into the future;*

- *Ensure that groundwater is available for beneficial and potential beneficial uses, including all of the diverse municipal, domestic, agricultural, industrial, and environmental uses potentially affected by management actions within the MGSA Area;*
- *Protect the aquifers underlying the MGSA Area against further seawater intrusion;*
- *Comply with State Water Resources Control Board (SWRCB) Resolution No. 88-63, which designates all groundwaters of the State containing less than 3,000 milligrams per liter (mg/L) of total dissolved solids (TDS) as having a potential beneficial use as a domestic or municipal drinking water supply, and SWRCB Resolution No. 68-16, which requires the high quality of these waters to be maintained unless the state finds that certain specific conditions are met;*
- *Maintain or enhance groundwater levels and groundwater discharge where GDEs exist near the MGSA Area;*
- *Maintain operational flexibility within the Subbasin, assuring that groundwater resources are available during times of drought without causing undesirable results;*
- *Account for changing groundwater conditions related to implementation of future groundwater supply projects, projected climate change, and sea level rise, in sustainability planning and management; and*
- *Coordinate with, support, and avoid undesirable results to neighboring GSA areas and groundwater basins in regional efforts to achieve groundwater sustainability.*

To achieve the sustainability goal, MGSA will undertake the following measures:

- Establish sustainable management criteria, including definition of minimum thresholds, measurable objectives, interim milestones and undesirable results as discussed in this chapter;
- Implement a monitoring program as discussed in Chapter 5 for each sustainability indicator at and in the vicinity of the MGSA Area to assess compliance with, and progress toward the identified measurable objectives and interim milestones;
- Implement the management actions identified in Chapter 6 to assure compliance with the measurable objectives and interim milestones identified in this chapter, and to prevent the occurrence of undesirable results; and
- Complete the actions identified in Chapter 7 to implement the GSP, address data gaps, support the plan review and updates, and fulfill reporting obligations.

4.3 APPROACH

Locally-defined significant and unreasonable conditions were identified based on assessment of hydrogeologic conditions, beneficial uses and users of groundwater, existing and historical undesirable

results, potential future groundwater level, storage and quality trends, existing applicable standards and potential future groundwater demands. The consistency of the locally-defined criteria with criteria developed by SVBGSA in their GSP was evaluated, so that the sustainable management criteria in this GSP would address local conditions while remaining regionally compatible. The assessment was conducted based upon the hydrogeologic conceptual model and water budget information summarized in Chapter 3, and was discussed with MGSA staff and local consultants, and coordination discussions were held with SVBGSA, Marina Coast Water District (MCWD) GSA, and Monterey County Water Resources Agency (MCWRA).

As discussed in Chapters 6 and 7, the United States Geological Survey (USGS) is developing the Salinas Valley Integrated Hydrologic Model (SVIHM) as a tool to improve groundwater and surface water management strategies in the Salinas Valley Basin. SVBGSA intends to use this model to refine its assessment of groundwater budgets and flow, and to update its GSP. MGSA intends to cooperate and coordinate with SVBGSA in this effort, assess the need for additional studies and modeling refinement, and update this GSP, including the sustainable management criteria described in this chapter. In addition, MCWD GSA intends to construct a locally-refined groundwater flow model that can incorporate solute transport and density driven flow, to support development and implementation of its GSP in the Monterey Subbasin. MGSA intends to cooperate and coordinate with MCWD GSA and SVBGSA in this effort and will assess using the resulting model to update and refine this GSP.

Similar to SVBGSA's GSP, this chapter follows the same structure for each Sustainability Indicator. A separate subsection is included for each sustainability indicator, with subsections that address each of the regulatory requirements of 23 CCR §§ 354.22, *et. seq* and outlined in the DWR guidance (DWR 2017). Each Sustainability Indicator subsection includes a description of:

- The local factors potentially contributing to significant and unreasonable conditions;
- How minimum thresholds were developed, including:
    - The information and methodology used to develop the minimum thresholds (23 CCR § 354.28 (b)(1));
    - The relationship between minimum thresholds and the sustainability indicators, and how they will avoid undesirable results (23 CCR § 354.28 (b)(2));
    - The effect of minimum thresholds on neighboring basins' and GSPs' ability to meet sustainability goals (23 CCR § 354.28 (b)(3));
    - The effect of minimum thresholds on beneficial uses and users of groundwater (23 CCR § 354.28 (b)(4));
    - Relevant federal, state, or local standards (23 CCR § 354.28 (b)(5)); and
    - The method for quantitatively measuring minimum thresholds (23 CCR § 354.28 (b)(6));

- How measurable objectives were developed, including:
    - The methodology for setting measurable objectives (23 CCR § 354.30); and
    - Interim milestones, as applicable (23 CCR § 354.30 (a), §354.30 (e), §354.34 (g)(3)).
- How locally- significant and unreasonable conditions (undesirable results) were defined, including:
    - The criteria for defining undesirable results (23 CCR § 354.26 (b)(2));
    - The potential causes of undesirable results (23 CCR § 354.26 (b)(1)); and
    - The effects of these undesirable results on the beneficial users and uses (23 CCR § 354.26 (b)(3))

4.4 . CHRONIC DECLINE OF GROUNDWATER LEVELS

4.4.1 LOCAL FACTORS POTENTIALLY CONTRIBUTING TO SIGNIFICANT AND UNREASONABLE CONDITIONS

Regionally, chronic lowering of groundwater levels in the Subbasin's aquifers has historically occurred and is ongoing due to groundwater production for agricultural, municipal, and domestic use that exceeds the long-term sustainable yield of the Subbasin and the absence of viable alternative sources of water supply (SVBGSA 2019). A groundwater depression has developed north of Salinas and is visible on both the 180-Foot/Shallow East Side Aquifer and 400-Foot/Deep East Side Aquifer maps, where elevations are generally -80 to -120 feet mean sea level (msl). Groundwater elevation contour maps for the 180-Foot and 400-Foot Aquifers indicate an inland flow direction over a broad region surrounding the MGSA Area (see for example the groundwater elevation contour maps included in MCWRA [2017a]). East of the MGSA Area, groundwater levels were generally historically interpreted to be -10 to -20 feet msl in the 180-Foot Aquifer and -20 to -30 feet msl in the 400-Foot Aquifer during August measurements (when groundwater elevations are generally lowest), with the depth to groundwater increasing toward the Salinas River. These groundwater gradient data are based on widely spaced wells, and should be considered generalizations for the vicinity of the MGSA Area.

SVBGSA's GSP defines significant and unreasonable groundwater elevation declines in the Subbasin as those that:

- Are at or below the lowest groundwater elevations observed between 1994 and 2015 (based on public and stakeholder input that identified historically low groundwater elevations as significant and unreasonable);
- Cause significant financial burdens to local municipalities, landowners, and farmers; and/or
- Interfere with other sustainability indicators (i.e., seawater intrusion, subsidence, etc.).

With respect to potential future groundwater extraction in the MGSA Area, potential adverse impacts to beneficial users and uses from groundwater level decline include adverse impacts to GDEs, development or worsening of gradients that promote seawater intrusion, well interference drawdown, and lowering of groundwater elevations to uneconomical levels. In the vicinity of the MGSA Area, groundwater extraction from the seawater-intruded portions of the 180-Foot Aquifer and 400-Foot Aquifer is currently relatively limited, and SVBGSA proposes to adopt an ordinance that would prohibit the construction and operation of supply wells within the Castroville Seawater Intrusion Project (CSIP) service area east and northeast of the MGSA Area (Section 6.6.3). Based on this information, this GSP considers significant and unreasonable groundwater elevation declines in and near the MGSA Area as those that:

- Are at or below the lowest groundwater elevations observed between 1994 and 2015 identified regionally by SVBGSA (based on regional public and stakeholder input to SVBGSA that identified these historically low groundwater elevations as significant and unreasonable);
- Cause significant financial burdens to local municipalities, landowners, and farmers through interference drawdown or groundwater pumping level reduction to less economical levels; and/or
- Result in significant adverse impacts to GDEs.

Insufficient data currently exist to map flow directions and groundwater elevations in the Deep Aquifer, and MCWRA does not produce groundwater level maps of the Deep Aquifer. The construction of new wells in the Deep Aquifer is currently prohibited and there are no plans to construct any Deep Aquifer wells within the MGSA Area. As discussed in Chapter 6, MGSA will support management actions by SVBGSA to strengthen these prohibitions. As such, under current and foreseeable future conditions, there will be no groundwater extraction from the Deep Aquifer that could affect the groundwater level decline sustainability indicator that can be managed under this GSP. For these reasons, this sustainability indicator is considered currently inapplicable to this GSP, and undesirable results, minimum thresholds, and measurable objectives for chronic groundwater level decline are not adopted for the Deep Aquifer. This determination will be reassessed during future GSP updates, and additional sustainable management criteria for the Deep Aquifer will be added if appropriate.

4.4.2 MINIMUM THRESHOLDS

Regulation Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting. (d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:

(A) The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.

SVBGSA determined that average groundwater elevations in 2015 and 2016, at the end of a significant drought, represented a significant and unreasonable condition relative to groundwater elevation decline. Using a composite hydrograph analysis approach for the Subbasin, SVBGSA determined that the lowest average groundwater elevations during the representative climatic cycle (from 1967 to 1998) occurred in 1991 and 1992, and were on average 1 foot above the 2015 and 2016 elevations. The minimum thresholds for significant and unreasonable groundwater level decline were therefore established as 1 foot above 2015 groundwater elevations. A groundwater level map was prepared defining this "compliance surface," and minimum thresholds were determined for designated representative monitoring sites (RMS) by determining the elevation of this surface at each site.

Locally, groundwater extraction within the MGSA Area has the potential to draw down groundwater levels below minimum threshold elevations established by SVBGSA. However, SVBGSA has not designated any RMS near the MGSA Area, so there is limited possibility that groundwater extraction in this area would create an undesirable result detected under their Regional GSP. A single 400-Foot Aquifer well is located approximately 1 mile from the MGSA Area and a single 180-Foot Aquifer well is located approximately 4 miles from the MGSA Area. There are no RMS designated in the Dune Sand Aquifer in SVBGSA's GSP. Groundwater elevation data for existing wells near the MGSA Area do not have sufficient long-term groundwater elevation data to establish historical low groundwater levels prior to 2015. Several wells monitored by MCWRA with data beginning in approximately 2005 are located about 4 miles from the MGSA Area to the east and northeast (Zidar and Feeney 2019). Examination of the hydrographs for these wells indicates groundwater elevations in these wells were either at their lowest point, or near their lowest point, in 2015 and 2016.

Groundwater extraction for the test slant well pumping test performed for the MPWSP resulted in approximately 1 to 5 feet of drawdown (decreasing with distance from the MGSA Area), which recovered rapidly after the end of the test (Sections 3.2.1.2 and 3.2.1.3) and does not represent "chronic" or long-term groundwater elevation decline. As summarized in the following section, an

analysis of evapotranspiration (ET) from a GDE located near the MGSA Area indicates that from 2014 to 2016, a combination of drought conditions and drawdown in the Dune Sand Aquifer resulted in a substantial decrease in summertime ET, indicating vegetative stress. ET from the GDE has since recovered; however, it is not known whether the habitat suffered long term changes and degradation in the process, or if the habitat was able to recover. For these reasons, it is not known whether pumping of the test slant well during this time caused undesirable results. Future groundwater extraction is proposed to be increased significantly above the test slant well extraction rates, which potentially place additional stress on sustainability indicators. The sustainable management criteria in this chapter, and the monitoring and management action programs described in Chapters 5 and 6 are intended to assure sustainable groundwater management.

The following sections describe the process used to establish minimum thresholds for RMS designated under this GSP to address chronic decline in groundwater levels in the MGSA Area. The minimum thresholds and measurable objectives established for RMS near the MGSA are presented in Table 4-1.

TABLE 4-1. MINIMUM THRESHOLDS AND MEASURABLE OBJECTIVES FOR CHRONIC DECLINE IN GROUNDWATER LEVELS

Monitoring Site	Aquifer	Approximate date of Lowest Groundwater Level	2015 Summer/Fall Lowest Groundwater Level (ft NAVD88)	Minimum Threshold (ft NAVD88)	Measurable Objective (ft NAVD88)
MW-4S	Dune Sand	Mid Sept 2015	3.0	4.0	4.0
MW-4M	180-Foot	Mid Aug 2015	-3.0	-2.0	-0.1
MW-4D	400-Foot	Late Aug 2015	-15.9	-14.9	-8.8
MW-5M	180-Foot	Mid Aug 2015	-4.8	-3.8	-2.8
MW-5D	400-Foot	Late Aug 2015	-22.0	-16.0	-10.0
MW-6M	180-Foot	Mid Aug 2015	-26.0	-25.0	-18.0
MW-7S	Dune Sand	Mid Oct 2015	3.8	4.8	4.8
MW-7M	180-Foot	Late Aug 2015	-7.1	-6.1	-2.5
MW-7D	400-Foot	Late Aug 2015	-14.9	-13.9	-7.8
MW-8S	Dune Sand	Mid Sept 2015	1.6	2.6	2.6
MW-8M	180-Foot	Late Aug 2015	-5.9	-4.8	-2.1
MW-8D	400-Foot	Late Aug 2015	-21.0	-14.0	-8.0
MW-9M	180-Foot	Late Aug 2015	-11.4	-10.4	-7.0
MW-9D	400-Foot	Late Aug 2015	-25.1	-24.1	-18.0

Notes:
ft NAVD88 = feet above the North American Vertical Datum of 1988

4.4.2.1 DUNE SAND AQUIFER

As discussed in Sections 2.3.1.2 and 3.2.6.1, several areas of “vernal ponds” are located near the MGSA Area and have been identified as GDEs. Vernal ponds include palustrine and emergent wetlands which are considered locally unique and are protected as Environmentally Sensitive Habitat Areas (ESHA) under the California Coastal Act and managed under a plan prepared by the City of Marina and local environmental stakeholders.

The ecological water requirements and thresholds of responses to changes in groundwater levels differ among GDEs. Deep-rooted obligate phreatophytes such as oak trees are not expected to be significantly affected by drawdown which is within the range of natural groundwater level fluctuations or occurs over a period of years. The gradual change would allow the root systems to adapt. Similarly, the effect of drawdown on riparian woodlands and wetlands that have significant surface water inflows from streams, canals, and agricultural drains is expected to be less significant. However, wetlands such as the vernal ponds present east of the MGSA Area are likely to be more highly groundwater dependent and contain sensitive communities that could be adversely affected by drawdown. The ability of such GDEs to adapt or recover from groundwater declines depends largely on the overall water budget and the degree to which the GDE is dependent on groundwater. The degree of interaction between wetlands and groundwater can vary greatly and depends on many factors including their position in the landscape, the permeability of the substrate, depth to the water table, and seasonal fluctuations in water inputs. GDEs develop in response to unique timing, duration, frequency, and chemistry of water inputs. Major changes in wetland hydrology would be expected to significantly affect ecological function. However, minor changes in hydrology may result in little to no change in the ecological function of wetlands, depending on baseline conditions and whether those changes are short- or long-term and offset by seasonal recharge of the aquifer or surface inputs (JJ&A 2018).

The condition and species composition of wetland vegetation can serve as an early warning indicator of water stress. A compilation of studies conducted by The Nature Conservancy in the western United States that examined plant response of 17 herbaceous wetland indicator species (11 common and six rare) to groundwater drawdown, indicated gradual loss of indicator species starting with as little as 0.66 feet (0.2 meter) of drawdown, with a median of 2.99 feet (0.91 meter), and complete loss at 6.23 feet (1.9 meter) (Gerla *et al.* 2015). Rhode *et al.* (2017) reviewed policies adopted for management of GDEs in the United States and globally, and assessed that thresholds for GDE responses to groundwater level decline are often assumed to follow linear, curvilinear, or step-wise functions, but that in reality they are likely habitat specific. A study of the effects of regulatory drawdown thresholds on inundation area and plant community composition in southeast Australia suggested that drawdowns from 0.82 feet (0.25 meter) to 0.98 feet (0.3 meter) represent a threshold where community composition is likely to change (Deane *et al.* 2017). The study setting was a regional unconfined aquifer with shallow groundwater levels and wetlands dependent on groundwater discharge, and included wetlands considered sensitive to even small declines in groundwater level. Thresholds were assigned based on ecological value, with higher functioning wetlands sensitive to changes assigned a threshold of up to 0.82 feet (0.25 meter) of acceptable drawdown over the course of five years; regional triggers were set at 1.64 feet (0.50 meter) over five years. Drawdown in shallow groundwater systems may alter community composition by increasing cover of exotic and terrestrial species, and increasing soil salinity from evapotranspiration; drawdown in deeper water systems may result in community change with conditions supporting greater cover of sedge species.

The Armstrong Ranch Ponds (Vernal Pond #6) are located approximately 300 to 1,000 feet east of the MGSA Area and include a series of seasonal wetlands with ponded water in the winter and wet herbaceous meadows likely subsisting on shallow groundwater during the dry season (The Habitat

Restoration Group 1994). An analysis of ET from these ponds and the surrounding area is presented in Figure 4-1. Summer (June, July, and August) ET was calculated using the surface energy balance method (Paul *et al.* 2011, 2018) from remote sensing data generated by the Landsat Satellite mission by Formation Environmental under contract to DWR. The results indicate summer ET ranged from approximately 5 to 10 inches from 2010 to 2013, then decreased to approximately 1 to 5 inches in 2014 and 2015, and 1 to 3 inches in 2016. In 2017, ET increased to approximately 3 to 10 inches, and in 2018, ET was approximately 5 to 12 inches. The decline in ET from 2014 to 2016 occurred during a period of severe drought; however, the test slant well pumping test was also conducted from April 2015 to February 2018 (GeoScience Support Services 2019). Hydrographs for well MW-4S indicate that the seasonal fluctuation in groundwater elevations in this well was approximately 2 feet, and suggest that pumping-induced drawdown was approximately 1 foot. The lowest groundwater elevations were observed in the summer of 2016; groundwater elevations averaged about 2 feet higher in summer 2017 and summer 2018.

The above ET analysis demonstrates the correlation between groundwater levels and ET from this GDE, and illustrates its sensitivity to groundwater level declines. ET, and by correlation biomass productivity, rebounded with groundwater levels; however, it is not known whether the stress induced in the GDE resulted in a change in the vegetation community, habitat degradation, or habitat succession that is not readily reversible. Based on this data, it is not possible to determine the extent to which the drawdown induced during the test slant well pumping period resulted in significant and unreasonable impacts to the GDE, or whether the results were temporary and reversable.

For these reasons, the minimum thresholds for chronic groundwater level decline in the Dune Sand Aquifer are established as an elevation of 1 foot above the 2015 low groundwater levels recorded in Dune Sand Aquifer monitoring wells near identified GDEs in the vicinity of the MGSA Area (MW-4S, 7S and 8S). This threshold is based on potential significant and unreasonable impacts to identified GDEs. It is adopted on an interim basis based on the rationale above. The threshold will be updated based on biological assessment of GDEs in the vicinity of the MGSA Area to determine their sensitivity to groundwater elevation declines and confirmation by SVBGSA as to the degree to which potential GDEs along Salinas River are groundwater vs. surface water reliant. The minimum thresholds are established based on the following approach:

- At each RMS for the Dune Sand Aquifer, a groundwater elevation minimum threshold is calculated as a groundwater elevation that is 1 foot above 2015 summertime or fall low groundwater elevation documented in well hydrographs for the shallow MPWSP monitoring wells (Appendix 3.D).

The correlation between groundwater elevations and GDE responses for the identified GDEs is identified as a data gap. In addition, the degree of groundwater dependence of potential GDEs located near Salinas River is a data gap. As discussed in Chapter 7, a baseline biological assessment of the GDEs in the vicinity of the MGSA Area will be performed, and the minimum thresholds and measurable objectives will be adjusted, as appropriate. In addition, the GDE monitoring approach will be refined as discussed in Chapter 5, and the management actions will be updated as discussed in Chapter 6.

4.4.2.2 180-FOOT AND 400-FOOT AQUIFER

Minimum thresholds for the 180-Foot and 400-Foot Aquifers are driven by the potential for well interference drawdown and consistency with minimum thresholds adopted by SVBGSA which are intended, in part, to decrease the inland gradients that have led to regional seawater intrusion. As discussed in Section 4.4.2, SVBGSA determined that average groundwater elevations in 2015 and 2016, at the end of a significant drought, represented a significant and unreasonable condition relative to groundwater elevation decline, and established initial minimum thresholds 1 foot above this elevation. These thresholds were then locally adjusted based on hydrograph analysis at some individual RMS.

Thresholds of significance for well interference drawdown vary, but are commonly lower for domestic wells, which tend to be shallower and have less available drawdown, and greater for irrigation, industrial or municipal supply wells, which are generally deeper and have more available drawdown. A study of well interference drawdown thresholds adopted for projects in California conducted in Stanislaus County concluded that a well interference threshold of 5 feet for domestic wells and 20 feet for higher capacity production wells is unlikely to lead to significant and unreasonable impacts (JJ&A 2018). The range of documented seasonal fluctuation in groundwater elevations in the 180-Foot and 400-Foot Aquifers varies from approximately 5 feet within about 2 miles of the MGSA Area to between approximately 10 to 30 feet further inland about 4 miles from the MGSA Area (Section 3.2.1.2).

The minimum threshold for groundwater elevation decline in the 180-Foot and 400-Foot Aquifers is therefore established consistent with the SVBGSA regional thresholds of groundwater elevations at RMS in the 180-Foot or 400-Foot Aquifers that are 1 foot above historical low groundwater elevations measured in 2015 as determined from analysis of the hydrographs included in Appendix 3.D. For RMS located near well 14S/02E-08M02, which is approximately 1 mile northeast of the MGSA Area, minimum thresholds were adjusted to better match the minimum threshold adopted by SVBGSA for the 400-Foot Aquifer at this location, and in the overlying 180-Foot Aquifer in accordance with existing vertical gradients.. These elevations are generally relatively consistent with SVBGSA's minimum thresholds and are appropriate given seasonal groundwater level fluctuation as well as thresholds commonly used to assess interference drawdown to prevent nearby groundwater users from experiencing significant and unreasonable impacts.

4.4.2.3 RELATIONSHIP BETWEEN MINIMUM THRESHOLDS AND OTHER SUSTAINABILITY INDICATORS

Regulation Requirements

§ 354.28 (b) The description of minimum thresholds shall include the following:

(2) The relationship between the minimum thresholds for each sustainability indictor, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:

(B) Potential effects on other sustainability indicators.

The groundwater elevation minimum thresholds are derived from historical groundwater elevation measurements. Therefore, the minimum thresholds are unique at every RMS, but when combined

represent a "compliance surface." The distribution of groundwater elevations in this compliance surface is a historically accurate, and reasonably achievable condition; that is, individual minimum threshold values at each well will not conflict with each other.

Groundwater elevation minimum thresholds can influence other sustainability indicators. The groundwater elevation minimum thresholds are selected to avoid undesirable results for other sustainability indicators.

- **Reduction in groundwater storage**. As discussed in Section 4.5, a significant and unreasonable condition for change in groundwater storage is defined as an annual extraction of groundwater in the MGSA Area that falls above the total long-term sustainable yield of the Subbasin established by SVBGSA or that results in depletion of the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers east of the MGSA Area. The minimum thresholds for groundwater elevation decline were selected to protect the beneficial uses of groundwater in the Dune Sand Aquifer by GDEs and to provide continuity with regional minimum thresholds for the 180-Foot and 400-Foot Aquifer. Decline of groundwater elevations would be associated with changes in storage, and will be used in combination with water quality monitoring to assess changes in low-TDS groundwater storage. These sustainable management criteria will be used in combination to manage both chronic decline in groundwater levels and reduction in groundwater storage. Although the minimum thresholds may not be precisely aligned, they are compatible and related, and will be used in combination to assure sustainable groundwater management. These thresholds may be refined during GSP implementation as more information and better tools become available. Therefore, the groundwater elevation decline minimum threshold is unlikely to result in a significant and unreasonable reduction in groundwater storage.

- **Seawater intrusion.** As discussed in Section 4.6, significant and unreasonable seawater intrusion is defined as the migration of chloride isocontours that define the extent of seawater intrusion as of 2017 (for the 180-Foot, 400-Foot and Deep Aquifers) or 2018 (for the Dune Sand Aquifer). Groundwater elevation minimum thresholds were established to be consistent with thresholds established by SVBGSA to prevent inland gradients that may result in the advance of seawater intrusion in the 180- and 400-Foot Aquifers. As discussed in Section 3.2.3.2, a decline in groundwater levels would lead to a change in the interface dynamics between the saline water intrusion wedge and the overlying low-TDS zone. Compliance with the groundwater elevation decline minimum threshold will help to assure a reasonable balance is maintained. As such, the minimum thresholds for groundwater elevation decline and seawater intrusion are compatible and related, and will be used in combination to assure sustainable groundwater management. Furthermore, the thresholds may be adjusted during GSP implementation as more information becomes available in order to refine their alignment. Therefore, the groundwater level decline minimum threshold is unlikely to result in significant and unreasonable seawater intrusion, but rather, will help to prevent seawater intrusion.

- **Degraded water quality**. As discussed in Section 4.7, significant and unreasonable degradation of groundwater quality is defined as the lateral or vertical migration of a TDS isocontour, or the induced migration of a contaminant contour exceeding water quality objectives in a nearby contamination plume. This sustainability indicator is closely related to changes in the dynamic equilibrium between the saline water intrusion wedge near the shore and the overlying low-TDS groundwater zone that could be caused by groundwater level decline. As such, although the

minimum thresholds may not be precisely aligned, they are compatible and related, and will be used in combination to assure sustainable groundwater management. Furthermore, the thresholds for degraded water quality and groundwater elevation decline may be adjusted during GSP implementation as more information becomes available in order to refine their alignment. Therefore, the groundwater elevation decline minimum threshold is unlikely to result in significant and unreasonable degraded water quality, but rather, will help to protect water quality.

- **Subsidence**. A significant and unreasonable condition for subsidence is any measurable long-term inelastic subsidence that damages existing infrastructure. Subsidence is caused by depressurization and compaction of fine-grained sediments in response to lowering groundwater levels, especially in confined systems when groundwater elevations fall below historical lows. The groundwater elevation minimum thresholds are set within 1 foot of historical low groundwater elevations, making measurable subsidence unlikely.
- **Depletion of interconnected surface waters.** A significant and unreasonable condition for the depletion of interconnected surface waters is depletion that induces significant and unreasonable degradation of GDEs, seawater intrusion in the tidal reaches of the river, or groundwater pumping-induced depletion of flow in the Salinas River that results in significant and unreasonable impacts to surface water uses. Lowering average groundwater elevations in areas adjacent to GDEs or other interconnected surface water bodies will incrementally increase depletion rates; however, the thresholds for groundwater level decline are set within the range of historical groundwater elevations in the Dune Sand Aquifer, which is unlikely to increase depletion to the point where it adversely affects GDEs or beneficial uses of surface water in the Salinas River. Furthermore, the threshold for groundwater level decline in the Dune Sand Aquifer was set specifically to be protective of the beneficial uses of surface water by wetland communities. For these reasons, the minimum threshold for chronic decline of groundwater levels is unlikely to result in significant and unreasonable impacts to the beneficial uses of surface water.

4.4.2.4 Minimum Thresholds in Relation to Adjacent Subbasins and GSPs

Regulation Requirements
§ 354.28 (b) The description of minimum thresholds shall include the following:
(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The MGSA Area is located adjacent to the Monterey Subbasin and shares boundaries with MCWD GSA and SVBGSA. The minimum threshold was selected to prevent potential locally-caused undesirable results from unsustainable groundwater extraction in the MGSA Area, while retaining compatibility with regional sustainable management criteria. Sustainable management criteria were established in coordination with MCWD GSA to support its sustainable management strategy. In addition, the minimum threshold for the 180-Foot and 400-Foot Aquifers was selected to be compatible with SVBGSA's minimum thresholds, which apply to the remainder of the Subbasin and to the portion of the Monterey Subbasin that is not managed by MCWD GSA. The thresholds represent a smooth groundwater elevation surface and would be continuous across inter-agency and inter-basin boundaries. As such, these thresholds will promote cohesive management to achieve the sustainability goals of MGSA, SVBGSA, and MCWD GSA.

MGSA's local sustainable management criteria for the Dune Sand Aquifer are compatible with SVBGSA's management strategy for the underlying regional aquifers. The minimum thresholds for the Dune Sand Aquifer to address local resource conditions will not impede or conflict with SVBGSA's ability to reach their sustainability goals. To the contrary, they will protect sensitive local resources in the portion of the Subbasin managed by SVBGSA from potential harm caused by unsustainable groundwater extraction in the MGSA Area.

4.4.2.5 Impact of Minimum Thresholds on Beneficial Uses and Users

Regulation Requirements:
§ 354.28 (b) The description of minimum thresholds shall include the following:
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The groundwater elevation minimum thresholds may have the following effects on beneficial users and land uses in the Subbasin:

- The threshold for the Dune Sand Aquifer is designed to prevent significant impacts to GDEs by assuring the groundwater supply on which they rely is not unreasonably affected by groundwater extraction in the MGSA Area. This will help to preserve protected habitats and species.
- The threshold for the 180-Foot and 400-Foot Aquifers is set within the range of historical groundwater level fluctuation, with the intent that beneficial users of groundwater for domestic, irrigation and small non-transient supply systems near the MGSA Area would not experience significant interference drawdown as a result of groundwater pumping in the MGSA Area. In addition, gradients that could induce the advancement of seawater intrusion would be controlled consistent with SVBGSA's regional strategy, so that the effect of seawater intrusion on downgradient groundwater users and property owners would not increase, and potentially could decrease as planned recharge and *in lieu* recharge projects are implemented.
- By setting the threshold within the historical range of groundwater level fluctuation, the likelihood of significant depletion of groundwater resources is decreased, protecting the water rights of potential beneficial users.
- If the MPWSP is constructed and groundwater elevations decline to trigger levels established in Chapter 6, management actions will be implemented to address groundwater level decline before undesirable results occur.

4.4.2.6 Current Standards Relevant to Sustainability Indicator

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

No federal, state, or local standards exist for chronic lowering of groundwater elevations.

4.4.2.7 MEASUREMENT OF MINIMUM THRESHOLDS

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater elevation minimum thresholds will be directly measured at RMS in the monitoring well network. The groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Chapter 5. Furthermore, the groundwater level monitoring will meet the requirements of the technical and reporting standards included in DWR's Regulations. A biological resource investigation will be conducted as described in Chapter 7 to assess GDE susceptibility to drawdown, establish current baseline conditions, and develop a GDE response monitoring program.

4.4.3 MEASURABLE OBJECTIVES AND INTERIM MILESTONES

Regulation Requirements:
§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.
(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.
(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.
(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

The measurable objectives for chronic lowering of groundwater levels represent target groundwater elevations that are higher than the minimum thresholds in order to provide early warning so potentially adverse trends can be addressed in a timely fashion. Measurable objectives are also established to leave adequate operating flexibility to deal with anticipated variability in conditions such as seasonal and inter-annual climatic variations and droughts, uncertainties in aquifer conditions or unanticipated events. As stated in Section 4.2,

> *"MGSA will manage groundwater resources in the MGSA Area in a way that ensures all beneficial uses and users in, or affected by, groundwater management in the MGSA Area are protected from undesirable results, and have access to a safe and reliable groundwater supply that meets current and future demand."*

The measurable objectives established for groundwater level decline are summarized in Table 4-2, and were developed based on the following approach:

- **Dune Sand Aquifer.** An elevation 1 foot above 2015 low groundwater levels in RMS near GDEs located east of the MGSA Area was adopted to establish the interim minimum thresholds. These minimum thresholds will be updated as warranted based on future planned investigations to address existing data gaps in the relationship between groundwater level declines and GDE response, as discussed in Chapter 7. MGSA adopts these minimum thresholds as measurable

objectives on an interim basis as the data gaps are addressed and sustainable management criteria are updated early during the GSP implementation process. Based on the limited amplitude of seasonal and inter-annual fluctuation in groundwater levels in the Dune Sand Aquifer and the planned schedule for data gap analysis, this approach allows for protection of GDEs while allowing near-term flexibility in groundwater management.

TABLE 4-2. MEASURABLE OBJECTIVES AND INTERIM MILESTONES FOR CHRONIC DECLINE IN GROUNDWATER LEVELS

Monitoring Site	Aquifer	Minimum Threshold (ft NAVD88)	Current Groundwater Level* (ft NAVD88)	Interim Milestone at Year 2025 (ft NAVD88)	Interim Milestone at Year 2030 (ft NAVD88)	Interim Milestone at Year 2035 (ft NAVD88)	Measurable Objective (goal at Year 2040) (ft NAVD88)
MW-4S	Dune Sand	4.0	6.2	5.6	5.1	4.5	4.0
MW-4M	180-Foot	-2.0	0.8	0.4	-0.1	-0.5	-1.0
MW-4D	400-Foot	-14.9	-9.4	-9.3	-9.1	-9.0	-8.8
MW-5M	180-Foot	-6.3	-3.2	-3.1	-3.0	-2.9	-2.8
MW-5D	400-Foot	-16.0	-14.4	-13.3	-12.2	-11.1	-10.0
MW-6M	180-Foot	-25.0	-17.6	-17.7	-17.8	-17.9	-18.0
MW-7S	Dune Sand	4.8	8.8	7.8	6.8	5.8	4.8
MW-7M	180-Foot	-6.1	-2.9	-2.8	-2.7	-2.6	-2.5
MW-7D	400-Foot	-13.9	-10.6	-9.9	-9.2	-8.5	-7.8
MW-8S	Dune Sand	2.6	4.6	4.1	3.6	3.1	2.6
MW-8M	180-Foot	-4.8	-2.2	-2.2	-2.2	-2.1	-2.1
MW-8D	400-Foot	-14.0	-10.6	-10.0	-9.3	-8.7	-8.0
MW-9M	180-Foot	-10.4	-7.6	-7.4	-7.3	-7.1	-7.0
MW-9D	400-Foot	-24.1	-13.5	-14.6	-15.8	-16.9	-18.0

Notes:
NAVD88 = North American Vertical Datum of 1988

- **180-Foot and 400-Foot Aquifers.** Measurable objectives were established to be consistent with those established by SVBGSA to provide a uniform and compatible and implementable strategy that addresses undesirable results regionally and allows for appropriate operating flexibility. SVBGSA identifies few RMS near the MGSA Area, but in order to establish measurable objectives, the groundwater elevation of SVBGSA's measurable objectives above its minimum thresholds for the nearest RMS in the 180- and 400-Foot Aquifers was utilized to establish compatible measurable objectives for this GSP, as follows:
    - The nearest SVBGSA RMS identified for the 180-Foot Aquifer are well 4S/02E-03F04, located about 4 miles northeast of the MGSA Area, and well 14S/02E-27A01, located about 4 miles to the east. The measurable objectives for these wells are set at 6.1 and 8 feet above the minimum thresholds, for an average of 7.0 feet. Therefore, for each 180-Foot Aquifer RMS in this GSP, the measurable objective was initially established at an elevation that is 7.0 feet above the minimum threshold. Hydrographs for the nested wells at each RMS location were then reviewed, and the measurable objective 180-Foot

Aquifer Wells was adjusted by scaling between the measurable objectives for the shallow and deep wells in accordance with observed vertical gradients to help assure that measurable objectives are set at realistically achievable elevations. Finally, for RMS at which minimum thresholds were adjusted to better match minimum thresholds adopted by SVBGSA, the measurable objectives were adjusted accordingly.

- The nearest SVBGSA RMS identified for the 400-Foot Aquifer is well 14S/02E-08M02, located about 1 mile northeast of the MGSA Area. The measurable objectives for this well is set at 6.1 feet above the minimum threshold. Therefore, for each 400-Foot Aquifer RMS in this GSP, the measurable objective was initially established at an elevation that is 6.1 feet above the minimum threshold. A similar approach to the above was used for final adjustments for RMS near well 14S/02E-08M02.

The above-derived measurable objectives will be further updated as appropriate as additional modeling data from the SVIHM and other tools and studies become available, and in coordination with SVBGSA's update of its GSP.

4.4.4 UNDESIRABLE RESULTS

Regulation Requirements:

§354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

§354.26 (b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

§354.26 (c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

Under SVBGSA's GSP, the groundwater elevation undesirable result for the Subbasin, on a regional scale, is reached when over the course of any one year, more than 15% of the groundwater elevation minimum thresholds are exceeded in any single aquifer (*i.e.*, either in the 180-Foot or the 400-Foot Aquifer). The 15% limit on minimum threshold exceedances for chronic lowering of groundwater levels allows for four exceedances in the 23 existing monitoring wells in SVBGSA's current monitoring network: two in the 180-Foot Aquifer and two in the 400-Foot Aquifer. This was considered by SVBGSA a reasonable number of exceedances given the hydrogeologic uncertainty of the Subbasin. Although the monitoring well network currently employed by SVBGSA does not include any wells located southwest of the Salinas River near the MGSA Area, the sustainable management criteria adopted by SVBGSA, combined with their projects and management actions, are expected by SVBGSA to lead to stabilization and likely improvement of the landward gradients in the 180-Foot and 400-Foot Aquifers that have led to seawater intrusion regionally.

Based on the information in the previous sections, the local definition for significant and unreasonable groundwater level decline considers the following additional criteria:

- Groundwater drawdown in the 180-Foot or 400-Foot Aquifers below historical low groundwater elevations during SVBGSA's representative hydrologic period, assumed to be 1 foot above low groundwater levels measured in 2015 has been determined to be an appropriate definition of minimum thresholds by both SVBGSA and MGSA;

- This minimum threshold addresses potential undesirable results related to interference drawdown that adversely affects the capacity or economic viability of existing wells;

- This minimum threshold also limits landward gradients that drive inland seawater intrusion; and

- A similar approach has been determined by MGSA to be an appropriate definition for minimum thresholds in the Dune Sand Aquifer and would prevent drawdown in the Dune Sand Aquifer that is sufficient to cause vegetative stress in GDEs that leads to habitat degradation or harm to protected species.

The causes of potential undesirable results are discussed in Section 4.4.1 and the potential effects of undesirable results on the beneficial users of groundwater, land uses and property owners are discussed in Sections 4.4.1 and 4.4.2.

An undesirable result for chronic decline in groundwater levels is defined using the following combinations of minimum thresholds identified in Section 4.4.2:

- For the Dune Sand Aquifer, an undesirable result is defined to occur when minimum thresholds are exceeded at two or more RMS. There are currently three RMS located near GDEs proximal to the MGSA Area (MW 4S, 7S and 8S). Review of hydrographs for the Dune Sand Aquifer included in Appendix 3.D indicates that groundwater levels can be affected by a variety of influences, including groundwater extraction, recharge from precipitation, recharge from the Salinas River and climatic factors. In order to account for uncertainty in aquifer conditions, an exceedance at two locations (66% of the RMS) is considered to provide an adequate level of confidence that an undesirable result is occurring given uncertainty about the aquifer system.

- The definition for undesirable results in the 180-Foot and 400-Foot Aquifers is an exceedance of the minimum thresholds in 15% or more of the RMS (i.e., two or more wells) in the MGSA groundwater elevation monitoring well network that are located proximal to potential drawdown receptors (MW 4M, 4D, 5M, 5D, 6M, 6M(L), 7M, 7L, 8M, 8L, 9M, and 9L).

The above definitions are effectively a westward and upward extension of the undesirable result definition adopted by SVBGSA for the Subbasin, so as to avoid the formation of regional groundwater gradients that were determined to be significant and unreasonable and that could result in the advancement of seawater intrusion. Based on the available data, these thresholds will also be adequate to prevent significant and unreasonable well interference drawdown. There are at least three small water supply systems reliant on groundwater in the area, and additional irrigation and domestic wells may exist. Therefore, interference drawdown of existing wells is a potential impact to be monitored as

part of the Mitigation Monitoring and Reporting Plan (MMRP) (Zidar and Feeney 2019) for the proposed MPWSP and is a potential impact prevented under this GSP.

Additional beneficial users of shallow groundwater within the Dune Sand Aquifer include GDEs which could also be adversely affected by groundwater elevation declines induced by pumping in the MGSA Area. As discussed in Section 3.2.6.1, several GDEs that support protected habitat and species are located in the vicinity of the MGSA Area. The identified GDEs include palustrine and emergent wetlands (vernal ponds) with protected habitat and species, and are located to the east, northeast and southeast of the MGSA Area. In addition, riparian vegetation and riverine wetlands were identified along the Salinas River that may be at least partly dependent on groundwater. Shallow groundwater drawdown induced by pumping in the MGSA Area could adversely affect these GDEs, harming or degrading protected habitat, and harming protected species. Drawdown of the shallow groundwater table below the normal range of seasonal variation has the potential to induce stress in vegetation that is dependent upon groundwater for all or a portion of the year, and unable to adapt to the greater groundwater depths. As a result, GDEs can be destroyed, undergo succession to a different state, or be otherwise degraded. The above definition of undesirable results recognizes this possibility and is the basis for sustainable management of this resource that would prevent significant and unreasonable impacts.

4.5 REDUCTION IN GROUNDWATER STORAGE

4.5.1 LOCAL FACTORS POTENTIALLY CONTRIBUTING TO SIGNIFICANT AND UNREASONABLE CONDITIONS

Regionally, reduction in storage in the Subbasin's aquifers has historically occurred and is ongoing due to groundwater production for agricultural, municipal, and domestic use that exceeds the long-term sustainable yield of the Subbasin (SVBGSA 2019). As previously described, a large groundwater depression has developed north of Salinas and is apparent on both the 180-Foot/Shallow East Side Aquifers and 400-Foot/Deep East Side Aquifer maps, where elevations are generally -80 to -120 feet msl, and has led to other undesirable results. As a result, less groundwater in storage is available as a buffer against surface water supply shortfalls without causing undesirable results, most notably seawater intrusion. In keeping with this condition, SVBGSA's GSP defines significant and unreasonable reductions in groundwater storage in the Subbasin as those that:

- Lead to long-term reduction in groundwater storage;
- Lead to seawater intrusion and a reduction of water quality;
- Interfere with other sustainability indicators; and
- Affect GDEs and interconnected surface water.

Locally, the MGSA Area is located at the western edge of a substantial zone of low-TDS groundwater (TDS < 3,000 mg/L) extending vertically from the DSA into the180-Foot Aquifer and the 400-Foot Aquifer Sections 3.1.12 and 3.2.2. The volume of low-TDS groundwater in storage within the DSA alone has been estimated to be 188,000 acre-feet (Gottschalk *et al.* 2018). The State Water Resources Control Board (SWRCB) has designated groundwater with TDS concentrations of less than 3,000 mg/L as having an actual or potential beneficial use as municipal and domestic supply (SWRCB Resolution No. 88-63).

The proposed MPWSP slant supply wells would draw source water from the Dune Sand and 180-Foot Aquifers, including water from this low-TDS zone. California law and the California Public Utilities Commission decision regarding the proposed MPWSP require that groundwater extraction for that proposed project may not adversely affect existing beneficial groundwater users or groundwater right holders (CPUC 2018). Thus, this low-TDS groundwater zone is the primary Subbasin groundwater storage that could be depleted by groundwater extraction in the MGSA Area.

As described Section 3.3.13, the local contribution to the sustainable yield from groundwater extraction in the MGSA Area is the amount of groundwater that can be withdrawn annually over a period of time without causing undesirable results within or near the MGSA Area. Undesirable results include, but may not be limited to, the following significant and unreasonable impacts beyond a 2015 baseline condition:

- Chronic groundwater level decline in the Dune Sand Aquifer that adversely effects GDEs or other beneficial groundwater users, including holders of overlying groundwater rights;
- Further seawater intrusion into the Dune Sand, 180-Foot, 400-Foot, and/or Deep Aquifers; or
- Degradation of the low-TDS groundwater zone within the Dune Sand and/or 180-Foot Aquifer.

Groundwater extraction for the CEMEX plant has been ongoing since the 1960s without reports of undesirable results, and represents the only long-term groundwater extraction within the MGSA Area. It is possible that this well is withdrawing a combination of saline and low-TDS groundwater. Data are not available to assess if groundwater extraction from the CEMEX well historically contributed to seawater intrusion in this area since the 1960s when pumping started, but based on the available data the groundwater level and quality conditions associated with this extraction were likely stable by 2015 and therefore considered sustainable under SGMA. However, due to concern about limiting extractions to avoid seawater intrusion, the City of Marina, MCWD, and Monterey County entered into the 1996 Annexation Agreement (provided as Appendix 8.B) limiting extractions at the CEMEX property to 500 AFY.

Water quality trends and groundwater elevations during test slant well pumping at a rate of 2,860 AFY from April 2015 to February 2018 indicate that low TDS groundwater (< 3,000 mg/L TDS) from the inland portion of the Dune Sand and 180-Foot Aquifers was likely being captured during the test, and that the equilibrium between the saline groundwater wedge and low TDS groundwater zone within and east of the MGSA Area may have been at least temporarily affected. As previously described, ET from nearby GDEs decreased significantly during this test, due to a combination of drawdown and drought conditions. The ET from this GDE has since recovered, but it is not known whether vegetative stress resulted in longer-term changes to the habitat community composition or quality. For these reasons, without additional data and modeling tools, it is not possible to assess whether continued pumping at the rate of the test slant well would be sustainable in the long term or whether it would cause undesirable results that indicate a significant and unreasonable reduction in groundwater storage. If the MPWSP is fully approved and implemented, the proposed increased source water pumping rate of 17,400 AFY would have a greater effect on the local groundwater budget, potentially further stressing

sustainability indicators including groundwater level decline (and impacts to GDEs), water quality degradation, and seawater intrusion.

The construction of new wells in the Deep Aquifer is currently prohibited and there are no plans to construct any Deep Aquifer wells within the MGSA Area. As discussed in Chapter 6, MGSA will support management actions by SVBGSA to strengthen these prohibitions. For these reasons, undesirable results, minimum thresholds, and measurable objectives for reduction in groundwater storage are not adopted for the Deep Aquifer in this GSP.

4.5.2 MINIMUM THRESHOLDS

Regulation Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(2) Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Section 354.28(c)(2) of the Regulations state that "*The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results*." SVBGSA has adopted a basin-wide minimum threshold equal to the total volume of groundwater that can be annually withdrawn from the Subbasin without leading to a long-term reduction in groundwater storage or interfering with other sustainability indicators, which is a calculated long-term average sustainable yield of 112,000 AFY. The minimum threshold applies to pumping of natural recharge only. Pumping of intentionally recharged water that is not part of the natural recharge is not considered when compared against the minimum threshold. SVBGSA's calculations account for current land use, future urban growth, and anticipated reasonable climate change. Seawater intrusion (i.e., seawater inflow volume) is not considered part of the sustainable yield. SVBGSA's GSP states that during average hydrogeologic conditions, and as a long-term average over all hydrogeologic conditions, total groundwater pumping shall not exceed the minimum threshold, which is equivalent to the long-term sustainable yield of the aquifers in the Subbasin. SVBGSA states the sustainable yield is an estimate only and will be updated as additional studies are undertaken and data are compiled (e.g., to address identified data gaps). Release of the SVIHM by the USGS, which is currently expected in late 2020, will represent a significant improvement in the tools available for assessment of Subbasin sustainable yield, and SVBGSA, MCWD GSA and MGSA all plan to use this tool to refine their understanding of the local and regional water budgets.

Because the local tools to further assess the MGSA Area component of the Subbasin-wide sustainable yield are not yet available, this GSP adopts SVBGSA's basin-wide sustainable yield estimate as a minimum threshold, supplemented locally by the following interim minimum threshold related to the low-TDS groundwater zone near the MGSA Area in order to prevent undesirable results from groundwater extraction in the MGSA Area:

- A decrease in the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers as measured by groundwater elevations, extraction reporting and induction logging.

This interim minimum threshold is adopted to prevent significant and unreasonable impacts to GDEs, seawater intrusion, groundwater quality degradation, and potential harm to overlying groundwater right holders, while the data gaps regarding the sustainable yield are addressed as discussed in Chapters 6 and 7, and until a local sustainable yield volume minimum threshold can be determined.

The relationship between groundwater elevations (combined with induction logging and extraction volume logging to assess changes in the volume of low-TDS groundwater storage) and undesirable results related to chronic groundwater level decline (through significant and unreasonable impacts to GDEs), seawater intrusion and groundwater quality degradation is discussed in Section 4.5.1.

4.5.2.1 Relationships Between Minimum Thresholds and Other Sustainability Indicators

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

The minimum threshold for reduction in groundwater storage is based on a basin-wide estimate of sustainable yield shared by the GSAs with jurisdiction in the Subbasin, supplemented by a local storage threshold that prevents undesirable results while data gaps in the local and regional sustainable yield are addressed. Therefore, there is no conflict between the minimum threshold application at different locations in the Subbasin.

Groundwater storage reduction thresholds are related to other sustainability indicators in the MGSA Area and its vicinity. The groundwater storage reduction threshold was selected to avoid undesirable results for other sustainability indicators and to promote compatible management strategies. By definition, the sustainable yield must avoid undesirable results related to any of the other sustainability indicators. If measurable objectives and interim milestones are not met, MGSA will act to curtail local pumping to sustainable levels and refine the local sustainable yield estimate. MGSA will also coordinate with SVBGSA to update the regional sustainable yield estimate as appropriate.

- **Chronic decline in groundwater levels**. As discussed in Section 4.4, a significant and unreasonable condition for change in groundwater elevations is a decline below levels that cause GDE stress, result in significant and unreasonable interference drawdown, or decline below levels regionally determined by SVBGSA to result in undesirable conditions related to

seawater intrusion. Decline of groundwater elevations would be associated with changes in storage and will be used in combination with water quality monitoring to assess changes in low-TDS groundwater storage. These sustainable management criteria will be used in combination to manage both chronic decline in groundwater levels and reduction in groundwater storage. Although the minimum thresholds may not be precisely aligned, they are compatible and related, and will be used in combination to assure sustainable groundwater management. Indeed, the interim minimum threshold for reduction in storage has been developed to prevent potential undesirable results related to decline in groundwater levels. These thresholds may be refined during GSP implementation as more information and better tools become available. Therefore, the groundwater storage reduction minimum threshold is unlikely to result in significant and unreasonable groundwater level decline.

- **Seawater intrusion.** As discussed in Section 4.6, significant and unreasonable seawater intrusion is defined as the migration of chloride isocontours that define the extent of seawater intrusion as of 2017 (for the 180-Foot, 400-Foot and Deep Aquifers) or 2018 (for the Dune Sand Aquifer). This sustainability indicator is closely related to changes in the dynamic equilibrium between the saline water intrusion wedge near the shore and the overlying low-TDS groundwater zone. By definition, sustainable yield is predicated in the avoidance of undesirable results, including seawater intrusion, and the sustainable management of seawater intrusion and reduction in storage will be coordinated. Indeed, the interim minimum threshold for reduction in storage has been developed to prevent potential undesirable results related to seawater intrusion. The thresholds for seawater intrusion and reduction in storage may be adjusted during GSP implementation as more information becomes available in order to refine their alignment and assure the avoidance of undesirable results. Therefore, the groundwater storage reduction minimum threshold is unlikely to result in significant and unreasonable seawater intrusion, but rather, may help to prevent seawater intrusion.

- **Degraded water quality**. As discussed in Section 4.7, significant and unreasonable degradation of groundwater quality is defined as the lateral or vertical migration of a TDS isocontour, or the induced migration of a contaminant contour exceeding water quality objectives in a nearby contamination plume. This sustainability indicator is closely related to seawater intrusion. By definition, sustainable yield is predicated in the avoidance of undesirable results, including degradation in groundwater quality, and the sustainable management of groundwater quality degradation and reduction in storage will be coordinated. Indeed, the interim minimum threshold for reduction in storage has been developed to prevent potential undesirable results related to groundwater quality degradation. The thresholds for degraded water quality and reduction in storage may be adjusted during GSP implementation as more information becomes available in order to refine their alignment and assure the avoidance of undesirable results. Therefore, the groundwater storage reduction minimum threshold is unlikely to result in significant and unreasonable degraded water quality, but rather, may help to protect water quality.

- **Subsidence**. A significant and unreasonable condition for subsidence is any measurable long-term inelastic subsidence that damages existing infrastructure. Subsidence is caused by depressurization and compaction of fine-grained sediments in response to lowering groundwater levels, especially in confined systems when groundwater elevations fall below historical lows. Since the threshold for reduction in groundwater storage is unlikely to be associated with significant and unreasonable declines in groundwater elevations, measurable subsidence is unlikely.

- **Depletion of interconnected surface waters.** A significant and unreasonable condition for the depletion of interconnected surface waters is depletion that induces significant and unreasonable degradation of GDEs, seawater intrusion in the tidal reaches of the river, or groundwater pumping-induced depletion of flow in the Salinas River that results in significant and unreasonable impacts to beneficial surface water uses. As discussed above, the minimum threshold for reduction in groundwater storage is unlikely to result in a significant and unreasonable decline in groundwater levels. Without a significant decline in groundwater levels, significant changes in surface water depletion are not anticipated. Therefore, the groundwater storage reduction minimum threshold is unlikely to result in significant and unreasonable depletion of interconnected surface water.

4.5.2.2 Minimum Thresholds in Relation to Adjacent Subbasins and GSPs

Regulation Requirements
§ 354.28 (b) The description of minimum thresholds shall include the following:
(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The MGSA Area is located adjacent to the Monterey Subbasin and shares boundaries with MCWD GSA and SVBGSA. The aquifers for which the minimum thresholds were developed extend from the 180/400 Foot Aquifer Subbasin into the Monterey Subbasin south and southeast of the MGSA Area. The minimum threshold was selected to prevent potential locally-caused undesirable results caused by unsustainable groundwater extraction in the MGSA Area, while retaining compatibility with regional sustainable management criteria that will be coordinated across Subbasin boundaries. Sustainable management criteria were coordinated with MCWD to support their sustainable management strategy in the adjacent Monterey Subbasin. MCWD also participated in the development of SVBGSA's GSP, including establishment of the regional sustainable management criteria for groundwater storage depletion adopted in this GSP, and therefore, the sustainable management criteria are regionally compatible across the jurisdictions of all the GSAs in the 180/400 Foot Aquifer Subbasin and the adjacent Monterey Subbasin, and will promote cohesive management to achieve the sustainability goals of MGSA, SVBGSA, and MCWD GSA.

SVBGSA's GSP does not present sustainable management criteria for the Dune Sand Aquifer; however, the SVBGSA GSP water budget and sustainable yield estimates include recharge through the Dune Sand Aquifer, so in effect, it is included in these estimates. In addition, we understand that MCWD GSA intends to manage the Dune Sand Aquifer as a principal aquifer in the GSP for the Monterey Subbasin. As such, the fact that the minimum threshold for groundwater storage depletion in this GSP applies to the Dune Sand as well as the 180-Foot and 400-Foot Aquifers will not conflict with the ability of MCWD GSA or SVBGSA to meet their respective sustainability goals.

4.5.2.3 Impact of Minimum Thresholds on Beneficial Uses and Users

Regulation Requirements:
§ 354.28 (b) The description of minimum thresholds shall include the following:
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The groundwater storage reduction minimum threshold may have the following effects on beneficial users and land uses in the Subbasin:

- The threshold will help to maintain the amount of low-TDS water in storage with a designated potential beneficial use for domestic and municipal supply.
- The threshold will serve to assure that the low-TDS/saline water balance in the seaward side of the Subbasin is retained, helping to control seawater intrusion and benefiting municipal and irrigation groundwater uses and users.
- The threshold will help assure the future availability of groundwater with potential beneficial uses to groundwater right holders.

4.5.2.4 CURRENT STANDARDS RELEVANT TO SUSTAINABILITY INDICATOR

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

No federal, state, or local standards exist for reduction of groundwater storage. California water law requires that if the MPWSP is fully approved and implemented, the project will not obtain appropriative water rights if the extraction of groundwater causes injury to existing beneficial users or water rights in the Subbasin.

4.5.2.5 MEASUREMENT OF MINIMUM THRESHOLDS

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater storage reduction will be measured using the MGSA monitoring well network using a combination of groundwater level monitoring together with extraction reporting and induction logging to calculate changes in low-TDS groundwater storage as an interim proxy for extraction volume estimates alone. The groundwater level and quality monitoring will be conducted in accordance with the monitoring plan outlined in Chapter 5, and will meet the requirements of the technical and reporting standards included in the Regulations.

4.5.3 MEASURABLE OBJECTIVES AND INTERIM MILESTONES

Regulation Requirements:

§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

SVBGSA has set a measurable objective for reduction in groundwater storage that is the same as its minimum threshold, which is the estimated sustainable yield of the Subbasin of 112,000 AFY. Recognizing the practical limitations imposed by the current data gaps, the MGSA adopts the same approach in this GSP. This GSP therefore adopts a regional measurable objective equal to the estimated Subbasin sustainable yield of 112,000 AFY, supplemented locally by an interim measurable objective of a decrease in the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers as measured by groundwater elevations, extraction reporting and induction logging. Interim milestones shall be equal to the measurable objectives. The interim local measurable objective will be updated as local and regional data gaps regarding Subbasin sustainable yield are addressed in accordance with Chapters 6 and 7.

4.5.4 UNDESIRABLE RESULTS

Regulation Requirements:

§354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

§354.26 (b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

§354.26 (c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

Based on the information in the previous sections, the local definition for significant and unreasonable reduction in groundwater storage considers the following:

- The GSP regulations define the minimum threshold for reduction in groundwater storage as a groundwater volume that can be withdrawn without causing conditions that may lead to

undesirable results (23 CCR § 354.28(c)(2)). By definition, this requires consideration of and close coordination with management of other sustainable management criteria.

- Depletion of groundwater storage has the potential to cause, or lead to conditions that in the future may cause, significant and unreasonable:
    - Impacts to GDEs;
    - Seawater intrusion or groundwater quality degradation that affects agricultural, municipal and other beneficial uses and potential beneficial uses; and/or
    - Reduction in the availability of groundwater and surface water by water right holders, or increased pumping or treatment costs.

The causes of potential undesirable results are further discussed in Section 4.5.1 and the potential effects of undesirable results on the beneficial users of groundwater, land uses, and property owners are discussed in Sections 4.5.1 and 4.5.2.

An undesirable result for reduction in groundwater storage is defined based on the minimum threshold discussed in Section 4.5.2 as an annual depletion, in any given year, exceeding the Subbasin-wide minimum threshold of 112,000 AFY or resulting in a depletion of low-TDS groundwater storage east of the MGSA Area as determined as measured by groundwater elevations, extraction reporting and induction logging. Because additional local tools to further assess the MGSA Area component of the basin-wide sustainable yield are expected to be available in the near future, MGSA has adopted this definition of undesirable results to prevent undesirable results as data gaps are addressed.

4.6 SEAWATER INTRUSION

4.6.1 LOCAL FACTORS POTENTIALLY CONTRIBUTING TO SIGNIFICANT AND UNREASONABLE CONDITIONS

As discussed in Section 3.2.3.2, MCWRA has been designated as the agency responsible for monitoring seawater intrusion in the Subbasin and publishes estimates of the extent of seawater intrusion every two years based on the inferred location of the 500 mg/L chloride concentration isocontour. Maps showing the progression of the seawater intrusion front over time up to 2015 in the 180-Foot and 400-Foot Aquifers are presented as Figure 4-1 and Figure 4-2, respectively. These figures also show the advance of seawater intrusion into the Dune Sand Aquifer using a standard of 3,000 mg/L TDS (or 1,660 mg/L chloride using a conversion factor of 0.554 for the chloride content of seawater) identified during the airborne electromagnetic (AEM) survey (Gottschalk *et al*. 2018). Continued seawater intrusion is driven by a large trough north and northeast of Salinas where groundwater elevations have fallen below sea level. SVBGSA estimates of groundwater storage losses due to continued seawater intrusion in the Subbasin range from 8,000 to 14,000 AFY (SVBGSA 2019).

As part of its Best Management Practices (BMPs) for Monitoring Networks[2] for seawater intrusion, DWR emphasizes the importance of capturing "*changes in water quality conditions associated with the dynamic seawater-freshwater interface along coastal aquifers. This system is largely controlled by differences in water density and hydraulic head to maintain the advancement of the seawater front. A robust understanding is necessary to identify the preferential flow pathways where seawater can intrude inland and associate with freshwater groundwater extractions or declines in head*." In compliance with these requirements, the MGSA GSP uses all the available data, including AEM geophysical data, to describe the extent of seawater intrusion, and considers both the nearshore dynamics as well as the inland intrusion front described in SVBGSA's GSP.

Locally, the MGSA Area is located on the seaward side of the interface between a dense saline water intrusion wedge and an over-riding zone of low-TDS groundwater that is locally recharged through the Dune Sand Aquifer. The interface extends from the Dune Sand Aquifer in the eastern portion of the MGSA Area and dips eastward down through the 180-Foot Aquifer and into the 400-Foot Aquifer and is subject to density-driven flow in general conformance with Ghyben-Herzberg dynamics (Sections 3.1.12 and 3.2.2). Groundwater extraction in the MGSA Area has the potential to affect the dynamic equilibrium of this nearshore groundwater system and cause seawater intrusion through the migration of the saline water wedge, which could in turn lead to deeper seawater intrusion into the currently unintruded Deep Aquifer, or promote the lateral migration or persistence of seawater intrusion (as defined by the 500 mg/L chloride concentration isocontour) further inland.

As discussed in Section 3.2.3.1, the gravity-driven interface dynamics which occur near the MGSA Area differ from the advective solute transport that characterizes seawater intrusion in more inland areas, where the intruding water has a much lower TDS concentration and density. In these inland areas, dissolved solids essentially behave as a tracer that follows groundwater flow landward in the 180- and 400-Foot Aquifers and seaward in the Dune Sand Aquifer. Portions of the seawater intruded areas of these aquifers contain groundwater designated as suitable or potentially suitable for municipal and domestic supply under SWRCB Resolution No. 88-63, that are required to be protected from further degradation by seawater intrusion under SWRCB Resolution No. 68-16. The sustainable management criteria for seawater intrusion must therefore address local conditions and anticipated groundwater demand changes so as to supplement and support the regional definition, thus maintaining and achieving sustainable management both locally and regionally.

The Deep Aquifer is not currently seawater intruded. As discussed in Chapter 3, however, the Deep Aquifer is believed to receive recharge via leakance from the overlying 400-Foot Aquifer. The competence and lateral continuity of the aquitards that separate the Deep Aquifer system from the overlying aquifers has not been well characterized; therefore, Monterey County has adopted an ordinance prohibiting further development of this aquifer until the required characterization is complete. As discussed in Chapters 6 and 7, plans are being discussed by MCWRA, SVBGSA and MCWD

[2] California Department of Water Resources (DWR), *Best Management Practices for the Sustainable Management of Groundwater, Monitoring Networks and Identification of Data Gaps BMP*, California Department of Water Resources Sustainable Groundwater Management Practices (December 2016).

GSA to address this data gap. Based on this information, the possibility exists that seawater intrusion could migrate vertically from the 400-Foot Aquifer into the Deep Aquifer. There are currently no Deep Aquifer wells in the MGSA Area, and this GSP includes support for prohibition of installation of Deep Aquifer production wells in the MGSA Area. Nevertheless, groundwater extraction from the upper aquifer system could cause further seawater intrusion by expansion or migration of the saline water wedge that underlies this area. Such an expansion or migration would put the Deep Aquifer at greater risk of seawater intrusion.

4.6.2 MINIMUM THRESHOLDS

Regulation Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(3) Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:

(A) Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.

(B) A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence

Section 354.28(c)(3) of the Regulations states that "*The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results*." Regionally, SVBGSA's GSP defines significant and unreasonable seawater intrusion in the Subbasin as seawater intrusion beyond the position of the 500 mg/L chloride isoconcentration contour interpolated by MCWRA in 2017 for the 180-Foot and 400-Foot Aquifers (SVBGSA 2019). The minimum threshold adopted by the SVBGSA for seawater intrusion into the Deep Aquifer is the location of the 500 mg/L chloride isocontour at Highway 1. SVBGSA does not present a minimum threshold for the Dune Sand Aquifer.

Locally, the minimum thresholds for seawater intrusion were developed based on assessment of the following additional criteria:

- The extent of the saline water intrusion wedge (TDS > 10,000 mg/L) interpreted from airborne electromagnetic surveys performed in 2017 (Gottschalk *et al.* 2018) plays an important role in seawater intrusion dynamics recognized in the DWR guidance and could affect both lateral and vertical seawater intrusion;
- Seawater intrusion into the Deep Aquifer has not yet been observed; and

- The Dune Sand Aquifer stores significant volumes of low-TDS groundwater with TDS concentrations less than 3,000 mg/L (chloride < 1,660 mg/L) with a designated beneficial use for domestic and municipal supply.

Based on this information, MGSA established the following minimum thresholds for significant and unreasonable seawater intrusion in this GSP:

- **Dune Sand Aquifer**. In compliance with SWRCB Resolution Nos. 88-63 and 68-16, this GSP defines the minimum threshold for significant and unreasonable seawater intrusion into the Dune Sand Aquifer as migration of the 1,700 mg/L chloride isocontour (equivalent to 3,000 mg/L TDS) beyond the location determined by Gottschalk *et al.* (2018) (Figure 4-2).
- **180-Foot and 400-Foot Aquifers**. This GSP adopts the SVBGSA minimum threshold of significant unreasonable seawater intrusion beyond the position of the 500 mg/L chloride concentration isocontour interpolated by MCWRA in 2017 (Figure 4-2).
- **Deep Aquifer.** In compliance with SWRCB Resolution No. 68-16, this GSP defines significant and unreasonable seawater intrusion into the Deep Aquifer as migration of a 500 mg/L chloride isocontour into the Deep Aquifer landward of the western Subbasin boundary (Figure 4-2).

As discussed in Chapter 6, MCWD GSA plans to develop a groundwater model that incorporates solute and transport and density driven flow, and that can be used to evaluate the effectiveness of local management actions and projects to address seawater intrusion, as well as the potential impacts of increased groundwater extraction. This model will include the MGSA Area and will incorporate the effects of sea level rise. The minimum thresholds adopted herein may be refined or revised based upon the results of this model, when available. Therefore, the minimum thresholds and actions to avoid undesirable results will address sea level rise.

4.6.2.1 Relationships Between Minimum Thresholds and Other Sustainability Indicators

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:

(2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

The minimum thresholds for seawater intrusion chloride and TDS isocontours are interpolated from water quality, conductance sensor and inductance logging data. Seawater intrusion minimum thresholds are related to several other sustainability indicators. The seawater intrusion thresholds were selected to avoid undesirable results for other sustainability indicators and to promote compatible management strategies.

- **Chronic decline in groundwater levels**. As discussed in Section 4.4, a significant and unreasonable condition for change in groundwater elevations is a decline below levels that cause GDE stress, result in significant and unreasonable interference drawdown, or decline below levels regionally determined by SVBGSA to result in undesirable conditions related to seawater intrusion. A decline of groundwater elevations would likely be associated with any measured migration of the TDS isocontour in the Dune Sand Aquifer, and will be considered in combination with water quality data to assess the relationship of seawater intrusion to pumping

in the MGSA Area. These sustainable management criteria will be used in combination to manage both chronic decline in groundwater levels and seawater intrusion. Although the minimum thresholds may not be precisely aligned, they are compatible and related, and will be used in combination to assure sustainable groundwater management. These thresholds may be refined during GSP implementation as more information and better tools become available. Therefore, the seawater intrusion minimum threshold is unlikely to result in significant and unreasonable groundwater level decline.

- **Reduction in groundwater storage**. As discussed in Section 4.5, a significant and unreasonable condition for change in groundwater storage is defined as an annual extraction of groundwater in the MGSA Area that falls above the total long-term sustainable yield of the Subbasin established by SVBGSA or that results in depletion of the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers east of the MGSA Area. By definition, sustainable yield is predicated on the avoidance of undesirable results, including seawater intrusion, and the sustainable management of seawater intrusion and reduction in storage will be coordinated. In addition, reduction in the amount of low-TDS groundwater in storage may be associated with seawater intrusion; therefore, storage reduction will be assessed using both groundwater level and quality data. The minimum threshold for seawater intrusion is intended to protective of groundwater quality and will not interfere with the assessment of storage depletion. Although these minimum thresholds may not be precisely aligned, they are compatible and related, and will be used in combination to assure sustainable groundwater management. These thresholds may be refined during GSP implementation as more information and better tools become available. Therefore, the seawater intrusion minimum threshold is unlikely to result in significant and unreasonable reduction in groundwater storage.

- **Degraded water quality**. As discussed in Section 4.7, significant and unreasonable degradation of groundwater quality is defined as the lateral or vertical migration of a TDS isocontour, or the induced migration of a contaminant contour exceeding water quality objectives in a nearby contamination plume. This sustainability indicator is closely related to seawater intrusion. Although the minimum thresholds may not be precisely aligned, they are compatible and related, and will be used in combination to assure sustainable groundwater management. Furthermore, the thresholds for degraded water quality and seawater intrusion may be adjusted during GSP implementation as more information becomes available in order to refine their alignment. Therefore, the seawater intrusion minimum threshold is unlikely to result in significant and unreasonable degraded water quality, but rather, will protect water quality.

- **Subsidence**. A significant and unreasonable condition for subsidence is any measurable long-term inelastic subsidence that damages existing infrastructure. Subsidence is caused by depressurization and compaction of fine-grained sediments in response to lowering groundwater levels, especially in confined systems when groundwater elevations fall below historical lows. Seawater intrusion thresholds are unrelated to the cause of land subsidence.

- **Depletion of interconnected surface waters.** A significant and unreasonable condition for the depletion of interconnected surface waters is depletion that induces, significant and unreasonable degradation of GDEs, seawater intrusion in the tidal reaches of the river, or groundwater pumping-induced depletion of flow in the Salinas River that results in significant and unreasonable impacts to surface water uses. The seawater intrusion thresholds will not affect the mechanics of surface-groundwater interaction, but could theoretically affect the quality of groundwater that is discharged to surface water discharge zones, such as wetlands.

However, the seawater intrusion thresholds include water quality thresholds intended to prevent the significant degradation of groundwater quality that would adversely affect wetlands. In addition, as discussed in Section 4.9, declining groundwater levels near the tidally-influenced lower reach of the Salinas River could cause seawater intrusion through the river bed. The minimum thresholds for groundwater level decline are intended to prevent significant additional seawater intrusion from the lower reaches of the Salinas River. The minimum thresholds established for seawater intrusion are not expected to affect these dynamics.

4.6.2.2 Minimum Thresholds in Relation to Adjacent Subbasins and GSPs

Regulation Requirements
§ 354.28 (b) The description of minimum thresholds shall include the following:
(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The MGSA Area is located adjacent to the Monterey Subbasin and shares boundaries with MCWD GSA and SVBGSA. The seawater intruded areas for which the minimum thresholds were developed and the associated saline water intrusion wedge and low-TDS groundwater zone occur, extend from the 180/400 Foot Aquifer Subbasin into the Monterey Subbasin south and southeast of the MGSA Area. The minimum thresholds were selected to align with and support regional efforts to contain seawater intrusion in the 180- and 400-Foot Aquifers and also address local seawater intrusion into the Dune Sand and Deep Aquifers. Sustainable management criteria were established in collaboration with MCWD to support their sustainable management strategy for the Dune Sand and Deep Aquifers in the adjacent Monterey Subbasin. In addition, minimum thresholds for the 180-Foot and 400-Foot Aquifers align with SVBGSA's minimum thresholds for regional groundwater management, which apply to the remainder of the Subbasin and to the portion of the Monterey Subbasin that is not managed by MCWD GSA.

Differences between this GSP and the SVBGSA GSP include that this GSP (1) establishes a minimum threshold for seawater intrusion into the Dune Sand Aquifer to protect significant local resources, and (2) establishes the location of the chloride isocontour that defines the minimum threshold for seawater intrusion into the Deep Aquifer at the coastal margin of the Subbasin rather than at Highway 1 in order to fully protect this important groundwater resource and comply with applicable water quality protection standards. These measures are considered necessary to address gaps in the SVBGSA's regional GSP and support locally-defined sustainable groundwater management and will be coordinated with SVBGSA and MCWD GSA. As such, these thresholds will promote cohesive management to achieve the sustainability goals of MGSA, SVBGSA, and MCWD GSA, which will be refined as needed during GSP implementation.

4.6.2.3 Impact of Minimum Thresholds on Beneficial Uses and Users

Regulation Requirements:
§ 354.28 (b) The description of minimum thresholds shall include the following:
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The seawater intrusion minimum thresholds may have the following effects on beneficial users and land uses in the Subbasin:

- The threshold will help to prevent the regional advance of seawater intrusion in the 180- and 400-Foot Aquifers in the inland areas east of the Subbasin. Local monitoring in support of this minimum threshold will help to fill existing data gaps regarding nearshore processes related to density-driven flow.
- The threshold for the Dune Sand Aquifer will help to protect the quality of low-TDS water in storage with a designated potential beneficial use for domestic and municipal supply from further degradation by seawater intrusion.
- The threshold will help to protect the Deep Aquifer, which is an important municipal and agricultural water supply and currently the only source of municipal water for the City of Marina, from seawater intrusion.
- If the MPWSP is constructed and the seawater intrusion measurable objectives described in Section 4.6.3 are reached, the management actions described in Section 6.2.1 will be implemented.

4.6.2.4 CURRENT STANDARDS RELEVANT TO SUSTAINABILITY INDICATOR

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

The seawater intrusion minimum thresholds incorporate the locally defined 500 mg/L chloride standard for definition of seawater intrusion into the 180-Foot, 400-Foot, and Deep Aquifers. In addition, the seawater intrusion minimum threshold addresses applicable Water Quality Standards incorporated into the Regional Water Quality Control Board's Water Quality Control Plan, including SWRCB Resolution Nos. 88-63 and 68-16.

4.6.2.5 MEASUREMENT OF MINIMUM THRESHOLDS

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Seawater intrusion will be measured from the MGSA monitoring well network using groundwater quality monitoring, including groundwater sampling and analysis, specific conductance sensors, and semi-annual induction logging to assess the lateral and vertical distribution of salinity. The groundwater quality monitoring will be conducted in accordance with the monitoring plan outlined in Chapter 5. Groundwater quality data to evaluate compliance with minimum thresholds and measurable objectives for seawater intrusion will be gathered from the wells listed in Tables 5-1, 5-2, and 5-3 for the Dune Sand, 180-Foot and 400-Foot Aquifers, respectively. Groundwater quality data to evaluate compliance with minimum thresholds and measurable objectives in the Deep Aquifer will be gathered from the supply wells listed in Table 5-4 (MCWD #'s 10, 11 and 12; and MCWRA #'s 25973, 21655 and 22755).

4.6.3 MEASURABLE OBJECTIVES AND INTERIM MILESTONES

Regulation Requirements:

§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

The measurable objectives for seawater intrusion represent positions of chloride concentration isocontours that define the desired future state of the Subbasin. Measurable objectives are also established to leave adequate operating flexibility to deal with anticipated variability in conditions such as seasonal and inter-annual climatic variations and droughts, uncertainties in aquifer conditions or unanticipated events. As stated in Section 4.2,

> "*MGSA will manage groundwater resources in the MGSA Area in a way that ensures all beneficial uses and users in, or affected by, groundwater management in the MGSA Area are protected from undesirable results, and have access to a safe and reliable groundwater supply that meets current and future demand*."

The following measurable objectives are established in this GSP:

- **Dune Sand Aquifer**. The measurable objectives are established to equal the minimum threshold of maintaining the 1,700 mg/L chloride isocontour at its current location. The interim milestones are identical to the measurable objective.
- **180-Foot and 400-Foot Aquifers**. MGSA will coordinate with SVBGSA, as appropriate, and support the measurable objective and interim milestones in the SVBGSA's GSP of moving the 500 mg/L chloride isocontour westward to Highway 1 by 2020.
- **Deep Aquifer.** The measurable objective for the Deep Aquifer will be to prevent significant and unreasonable seawater intrusion and maintain the location of the 500 mg/L chloride isocontour outside the seaward Subbasin Boundary. The interim milestones are identical to the measurable objective.

4.6.4 UNDESIRABLE RESULTS

Regulation Requirements:

§354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

Based on the information in the previous sections, the local definition for significant and unreasonable seawater intrusion considers the following:

- Ongoing seawater intrusion in the 180- and 400-Foot Aquifers has been regionally identified based on the migration of seawater intrusion beyond the documented position of the 500 mg/L chloride isocontour, and has resulted in the designation by DWR of the aquifer being in a condition of critical overdraft. SVBGSA's GSP does not consider nearshore seawater intrusion dynamics and preferential pathways that are important to understanding this process. The monitoring program discussed in Chapter 5 will provide additional data to promote understanding of the process. Nevertheless the 500 mg/L chloride isocontour is an adequate and appropriate measure of undesirable results.

- The SVBGSA's GSP does not establish a definition for significant and unreasonable seawater intrusion into the Dune Sand Aquifer; however, this GSP considers that this aquifer contains a significant quantity of low-TDS groundwater that requires protection from degradation by seawater intrusion under SWRCB Resolution Nos. 88-63 and 68-16. In order to comply with these resolutions, this GSP defines undesirable results for seawater intrusion into the Dune Sand Aquifer.

- The Deep Aquifer is not currently seawater intruded and is an important local and regional source of municipal and agricultural groundwater supply. Any seawater intrusion into this aquifer would violate existing water quality standards and put this important water supply at risk; therefore, any seawater intrusion into the Deep Aquifer is considered an undesirable result.

The causes of potential undesirable results related to seawater intrusion are further discussed in Section 4.6.1 and the potential effects of undesirable results on the beneficial users of groundwater, land uses and property owners are discussed in Sections 4.6.1 and 4.6.2.

An undesirable result for seawater intrusion is defined as follows based on the minimum thresholds discussed in Section 4.6.2:

- **Dune Sand Aquifer.** Migration of the 1,700 mg/L chloride isocontour beyond its location in 2018, indicating seawater intrusion into the low-TDS zone identified in Gottschalk *et al.* (2018), as interpreted from water quality sampling and induction logging data collected by MCWRA.
- **180-Foot and 400-Foot Aquifer.** Seawater intrusion beyond the position of the 500 mg/L chloride isocontour interpolated by MCWRA in 2017, as determined by seawater intrusion maps prepared by MCWRA.
- **Deep Aquifer.** Seawater intrusion beyond a theoretical 500 mg/L chloride isocontour established as the western (seaward) edge of the Subbasin, as interpreted from groundwater quality monitoring data collected by MCWRA.

4.7 DEGRADED GROUNDWATER QUALITY

4.7.1 LOCAL FACTORS POTENTIALLY CONTRIBUTING TO SIGNIFICANT AND UNREASONABLE CONDITIONS

Regionally, SVBGSA's GSP defines significant and unreasonable changes in water quality in the Subbasin as increases in the concentrations of chemical constituents that either:

- Result in groundwater concentrations in a public supply well above an established Maximum Contaminant Level (MCL) or Secondary Maximum Contaminant Level (SMCL); or
- Lead to reduced crop production.

SVBGSA defines undesirable results based on the exceedance of MCLs or SMCLs in public supply wells, or the exceedance of agricultural standards in irrigation wells. Noting that minimum thresholds are based on a degradation of groundwater quality, not an improvement of groundwater quality, SVBGSA's approach is designed to avoid any action by SVBGSA that may inadvertently move groundwater constituents that have already been identified in the Subbasin in such a way that the constituents have a significant and unreasonable impact to public supply or irrigation wells that would not otherwise occur. A list of constituents of concern was developed based on reported detections of constituents in the Subbasin above levels of concern.

Locally, the MGSA Area is located at the western edge of a substantial zone of low-TDS groundwater (TDS < 3,000 mg/L) extending from the Dune Sand Aquifer into the 180-Foot Aquifer and the 400-Foot Aquifer (Sections 3.1.12 and 3.2.2). Groundwater with TDS concentrations less than 3,000 mg/L is designated as having a potential beneficial use as municipal and domestic supply (SWRCB Resolution No. 88-63) and is required to be protected from degradation under SWRCB Resolution No. 68-16. The California Public Utility Commission's decision regarding the proposed MPWSP requires that groundwater extraction for that proposed project may not cause injury to existing beneficial groundwater users or groundwater water right holders. Groundwater extraction in the MGSA Area could disturb the equilibrium that exists between the saline water intrusion wedge and overlying low-TDS groundwater zone, cause mixing of low-TDS and saline groundwater or otherwise lead to the capture and migration of saline groundwater, potentially impacting the low-TDS groundwater zone or existing supply wells in the area.

Contaminant plumes that are known to impair water quality locally and could be captured by or induced to migrate by groundwater extraction in the MGSA Area include the Fort Ord Superfund Site Operable Unit Carbon Tetrachloride (OUCTP) plume, located in the shallow "A-Aquifer" and 180-Foot Aquifer approximately 2 to 3 miles southeast of the MGSA Area in the Monterey Subbasin. As a required mitigation measure for the proposed MPWSP, MCWRA is tasked with reviewing the monitoring data for this plume to assess whether groundwater extraction for the proposed MPWSP in the MGSA Area is capturing this plume and causing it to migrate. The results of this assessment will be reported annually and will be reviewed by MCWRA.

Other than potential seawater intrusion, no sources of potential point- or non-point source water quality degradation have been identified in the Deep Aquifer. The sustainable management criteria and monitoring programs developed for the Deep Aquifer to address seawater intrusion are sufficient to address potential water quality degradation, and no sustainable management criteria are developed in this GSP for the deep aquifer for the degradation of water quality sustainability indicator.

4.7.2 MINIMUM THRESHOLDS

Regulation Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(4) Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be used on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Section 354.28(c)(4) of the Regulations states that "*the minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be used on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin*." SVBGSA has adopted the potential exceedance of MCLs or SMCLs in public supply wells, or the exceedance of agricultural standards in irrigation wells, as a basis for assignment of Subbasin-wide minimum thresholds to wells.

Locally, the minimum thresholds for degradation of groundwater quality were developed considering the following additional criteria:

- Violation of water quality objectives for the low-TDS groundwater zone, including SWRCB Resolution No. 88-63 and SWRCB Resolution No. 68-16;
- Degradation of groundwater quality in nearby public supply wells, including the exceedance of MCLs or SMCLs; and
- Interference with or obstruction of ongoing requirements to investigate or clean up a contamination plume.

Based on this assessment, the following minimum thresholds were established:

- Significant and unreasonable degradation of water quality in the low-TDS groundwater zone in the Dune Sand, 180-Foot and 400-Foot Aquifers is defined as lateral or vertical migration of the 3,000 mg/L TDS isocontour beyond the location established by the 2018 AEM study (Gottschalk *et al.* 2018).
- Significant and unreasonable degradation of water quality in the Deep Aquifer is defined as exceedance of the TDS or chloride SMCL in one or more public supply wells completed in the Deep Aquifer near the MGSA.
- Significant and unreasonable migration of a contamination plume is defined by the following minimum thresholds:
    - Migration or spread of the portion of a contamination plume that exceeds applicable water quality objectives by more than 100 feet toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.

4.7.2.1 Relationships Between Minimum Thresholds and Other Sustainability Indicators

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

The minimum thresholds for reduction in groundwater storage are thickness measurements of the low-TDS groundwater zone made by induction logging at monitoring well locations, combined with groundwater level measurements to verify influence by pumping in the MGSA Area. These minimum thresholds will complement each other.

Degradation of groundwater quality minimum thresholds are related to several other sustainability indicators. The groundwater quality degradation thresholds were selected to avoid undesirable results for other sustainability indicators and to promote compatible management strategies.

- **Chronic decline in groundwater levels**. As discussed in Section 4.4, a significant and unreasonable condition for change in groundwater elevations is a decline below levels that cause GDE stress, result in significant and unreasonable interference drawdown, or decline below levels regionally determined by SVBGSA to result in undesirable conditions related to

seawater intrusion. Decline of groundwater elevations would be associated with changes in groundwater quality and will be used in combination with water quality monitoring to assess the relationship of water quality changes to pumping in the MGSA Area. These sustainable management criteria will be used in combination to manage both chronic decline in groundwater levels and groundwater quality degradation. Although the minimum thresholds may not be precisely aligned, they are compatible and related, and will be used in combination to assure sustainable groundwater management. These thresholds may be refined during GSP implementation as more information and better tools become available. Therefore, the groundwater quality degradation minimum threshold is unlikely to result in significant and unreasonable groundwater level decline.

- **Reduction in groundwater storage**. As discussed in Section 4.5, a significant and unreasonable condition for change in groundwater storage is defined as an annual extraction of groundwater in the MGSA Area that falls above the total long-term sustainable yield of the Subbasin established by SVBGSA or that results in depletion of the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers east of the MGSA Area. . By definition, sustainable yield is predicated in the avoidance of undesirable results, including seawater intrusion, and the sustainable management of seawater intrusion and reduction in storage will be coordinated. In addition, reduction in the amount of low-TDS groundwater in storage may be associated with seawater intrusion; therefore, storage reduction will be considered when assessing the potential for seawater intrusion. Reduction in the amount of low-TDS groundwater in storage may be associated with changes in groundwater quality and their distribution; therefore, storage reduction will be assessed using both groundwater level and quality data. The minimum threshold for degradation of groundwater quality is intended to protective of groundwater quality and will not interfere with the assessment of storage depletion. Although these minimum thresholds may not be precisely aligned, they are compatible and related, and will be used in combination to assure sustainable groundwater management. These thresholds may be refined during GSP implementation as more information and better tools become available. Therefore, the groundwater quality degradation minimum threshold is unlikely to result in significant and unreasonable reduction in groundwater storage.

- **Seawater intrusion.** As discussed in Section 4.6, significant and unreasonable seawater intrusion is defined as the migration of chloride isocontours that define the extent of seawater intrusion as of 2017 (for the 180-Foot, 400-Foot and Deep Aquifers) or 2018 (for the Dune Sand Aquifer). Migration of the saline water wedge that underlies the coastal area could be associated with degradation of groundwater quality; as such, the two sustainability indicators and their minimum thresholds are potentially related. Both are intended to prevent related undesirable results. Thus, the minimum threshold for degradation of groundwater quality may help to prevent seawater intrusion.

- **Subsidence**. A significant and unreasonable condition for subsidence is any measurable long-term inelastic subsidence that damages existing infrastructure. Subsidence is caused by depressurization and compaction of fine-grained sediments in response to lowering groundwater levels, especially in confined systems when groundwater elevations fall below historical lows. Water quality thresholds are unrelated to the cause of land subsidence.

- **Depletion of interconnected surface waters.** A significant and unreasonable condition for the depletion of interconnected surface waters is depletion that induces significant and

unreasonable degradation of GDEs, seawater intrusion in the tidal reaches of the river, or groundwater pumping-induced depletion of flow in the Salinas River that results in significant and unreasonable impacts to beneficial surface water uses. The water quality thresholds will not affect the mechanics of surface groundwater interaction; however, they could affect the quality of groundwater that is discharged to surface water discharge zones, such as wetlands. The minimum thresholds for the low-TDS zone will prevent the significant degradation of groundwater quality that would adversely affect wetlands.

4.7.2.2 Minimum Thresholds in Relation to Adjacent Subbasins and GSPs

Regulation Requirements
§ 354.28 (b) The description of minimum thresholds shall include the following:
(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The MGSA Area is located adjacent to the Monterey Subbasin and shares boundaries with MCWD GSA and SVBGSA. The low-TDS groundwater zone for which the minimum thresholds were developed extends from the 180/400 Foot Aquifer Subbasin into the Monterey Subbasin south and southeast of the MGSA Area. The OUCTP plume is located in the Monterey Subbasin southeast of the MGSA Area. The Deep Aquifer underlies both the 180/400 Foot Aquifer Subbasin and the Monterey Subbasin. The minimum threshold was selected to prevent potential locally-caused undesirable results from unsustainable groundwater extraction in the MGSA Area, while retaining compatibility with regional sustainable management criteria. Sustainable management criteria were established in collaboration with MCWD to support their sustainable management strategy in the adjacent Monterey Subbasin. In addition, minimum thresholds for the 180-Foot and 400-Foot Aquifers were selected to be compatible with SVBGSA's minimum thresholds for regional groundwater management, which apply to the remainder of the Subbasin and to the portion of the Monterey Subbasin that is not managed by MCWD GSA. As such, these thresholds will promote cohesive management to achieve the sustainability goals of MGSA, SVBGSA and MCWD GSA.

SVBGSA's GSP does not present sustainable management criteria for the Dune Sand Aquifer because its GSP is more regionally focused. MGSA's locally-developed minimum thresholds for degradation of groundwater quality are compatible with SVBGSA's regional sustainable management criteria for the underlying regional aquifers and will protect resources of local value, while also preventing the degradation of water quality in the underlying aquifers caused by groundwater extraction in the MGSA Area.

4.7.2.3 Impact of Minimum Thresholds on Beneficial Uses and Users

Regulation Requirements:
§ 354.28 (b) The description of minimum thresholds shall include the following:
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The groundwater quality degradation minimum thresholds may have the following effects on beneficial users and land uses in the Subbasin:

- The threshold will help to maintain the quality of low-TDS water in storage with a designated potential beneficial use for domestic and municipal supply.
- The threshold will help assure the future availability of low-TDS groundwater with potential beneficial uses to groundwater beneficial users, including GDEs and water right holders.

4.7.2.4 CURRENT STANDARDS RELEVANT TO SUSTAINABILITY INDICATOR

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:

(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

The groundwater quality minimum thresholds specifically incorporate state and federal standards for drinking water and applicable Water Quality Standards incorporated into the Regional Water Quality Control Board's Water Quality Control Plan, including SWRCB Resolution Nos. 88-63 and 68-16.

4.7.2.5 MEASUREMENT OF MINIMUM THRESHOLDS

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater quality degradation will be measured from the monitoring network using groundwater quality monitoring, including groundwater sampling and analysis, the use of specific conductance sensors, and annual induction logging to assess the lateral and vertical distribution of TDS. The groundwater quality monitoring will be conducted in accordance with the monitoring plan outlined in Chapter 5. Groundwater quality data to evaluate compliance with minimum thresholds and measurable objectives for groundwater quality degradation will be gathered from the wells listed in Tables 5-1, 5-2, and 5-3 for the Dune Sand, 180-Foot and 400-Foot Aquifers, respectively. Groundwater quality data to evaluate compliance with minimum thresholds and measurable objectives in the Deep Aquifer will be gathered from the supply wells listed in Table 5-4 (MCWD #'s 10, 11 and 12; and MCWRA #'s 25973, 21655 and 22755).

4.7.3 MEASURABLE OBJECTIVES AND INTERIM MILESTONES

Regulation Requirements:

§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

The measurable objectives for degradation of groundwater quality in the low-TDS groundwater zone positions of concentration isocontours that define the desired future state of the Subbasin, which is to protect and preserve this resource in compliance with SWRCB Resolution Nos. 88-63 and 68-16. The measurable objectives for water quality degradation in the Deep Aquifer, for which no historical degradation has been reported to date, are intended as indicators that provide early warning so potentially adverse trends can be addressed in a timely fashion. Measurable objectives are also established to leave adequate operating flexibility to deal with anticipated variability in conditions such as seasonal and inter-annual climatic variations and droughts, uncertainties in aquifer conditions or unanticipated events. As stated in Section 4.2,

> "*MGSA will manage groundwater resources in the MGSA Area in a way that ensures all beneficial uses and users in, or affected by, groundwater management in the MGSA Area are protected from undesirable results, and have access to a safe and reliable groundwater supply that meets current and future demand*."

The following measurable objectives have been established for groundwater quality degradation:

- The measurable objective for degradation of water quality in the low-TDS groundwater zone are defined to be the same as the minimum threshold, which is the 2018 vertical and lateral position of the 3,000 mg/L TDS isocontour in the Dune Sand, 180-Foot, and 400-Foot Aquifers, as determined by the 2018 AEM survey (Gottschalk *et al.* 2018).
- The measurable objective for degradation of water quality in the Deep Aquifer is no supply wells with MCL or SMCL exceedances for TDS or chloride.
- The measurable objective for migration of a contamination plume is defined by the following:
    - An observable spread of the portion of a contamination plume that exceeds applicable water quality objectives over two or more consecutive monitoring events toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.

If significant and unreasonable migration of a contamination plume is identified, it may be assumed that the agencies responsible for oversight of the cleanup will work with groundwater extractors to implement appropriate corrective actions and establish interim milestones as needed.

4.7.4 UNDESIRABLE RESULTS

Regulation Requirements:

§354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

§354.28 (c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(4) Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be used on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.

Based on the information in the previous sections, the local definition for significant and unreasonable groundwater quality degradation considers the following:

- The SVBGSA's GSP does not establish a definition for significant and unreasonable groundwater quality degradation in the Dune Sand Aquifer; however, this GSP considers that this aquifer and the underlying portions of the 180-Foot and 400-Foot Aquifers contain a significant quantity of low-TDS groundwater that requires protection from degradation under SWRCB Resolution Nos. 88-63 and 68-16. In order to comply with these resolutions, this GSP defines undesirable results for groundwater quality degradation of the low-TDS zone in the Dune Sand, 180-Foot, and 400-Foot Aquifers.

- The Deep Aquifer is not currently seawater intruded and is an important local and regional source of municipal and agricultural groundwater supply. Any water quality degradation of this aquifer would violate existing water quality standards and put this important water supply at risk; therefore, any degradation of water quality in municipal supply wells in the Deep Aquifer beyond applicable water quality objectives is considered an undesirable result.

The causes of potential undesirable results related to groundwater quality degradation are further discussed in Section 4.7.1 and the potential effects of undesirable results on the beneficial users of groundwater, land uses, and property owners are discussed in Sections 4.7.1 and 4.7.2.

An undesirable result for groundwater quality degradation is defined as follows based on the minimum thresholds discussed in Section 4.7.2:

- **Dune Sand Aquifer.** Migration of the 1,660 mg/L chloride isocontour beyond its location in 2018, indicating seawater intrusion into the low-TDS zone identified in Gottschalk *et al.* (2018), as interpreted from water quality sampling and induction logging data gathered by MCWRA.
- **180-Foot and 400-Foot Aquifer.** Seawater intrusion beyond the position of the 500 mg/L chloride isocontour interpolated by MCWRA in 2017, as determined by seawater intrusion maps prepared by MCWRA.
- **Deep Aquifer.** Seawater intrusion beyond a theoretical 500 mg/L chloride isocontour established as the western (seaward) edge of the Subbasin, as interpreted from groundwater quality monitoring data gathered by MCWRA.
- **Migration of Contamination Plumes.** Migration or spread of the portion of a contamination plume that exceeds applicable water quality objectives by more than 100 feet toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.

4.8 LAND SUBSIDENCE

4.8.1 LOCAL FACTORS POTENTIALLY CONTRIBUTING TO SIGNIFICANT AND UNREASONABLE CONDITIONS

Regionally, land subsidence is not closely monitored in the Monterey Bay region and has not been reported in Salinas Valley. In 2014, DWR reported that continuous monitoring stations located near the coast in the Pajaro Valley and Santa Cruz areas displayed a declining trend, but recorded total cumulative subsidence of less than 1 inch (DWR 2014). Vertical displacement estimates between June 2015 and June 2018 derived from Interferometric Synthetic Aperture Radar (InSAR) data collected by the European Space Agency (ESA) Sentinel-1A satellite and processed by TRE ALTAMIRA Inc. (TRE) under contract with DWR ranged from approximately 0.01 to 0.025 foot near the MGSA Area. This data is subject to a measurement error of 0.1 feet (SVBGSA 2019), so reported subsidence magnitudes are not significant. During the first two years of this time period, the test slant well-constructed for the MPWSP project in the MGSA Area was pumped at a rate exceeding 2,000 gallons per minute.

The risk of land subsidence results from lowered groundwater elevations, specifically when groundwater elevations decrease to levels significantly below the lowest historical groundwater elevations, leading to the depressurization and consolidation of fine-grained sediments. When groundwater elevations fluctuate only within the range of historical conditions, the alluvial layers are not subject to effective stress greater than historical conditions and therefore are generally not at significant risk of subsidence. In addition, sediments in unconfined and predominantly coarse-grained aquifers are at lower risk of significant subsidence. The subsidence risk in and near the MGSA Area is relatively low.

Because seasonal fluctuation and inter-annual variability in groundwater elevations in the unconfined Dune Sand Aquifer are in the range of 1 to 4 feet, subsidence resulting for groundwater level changes in this aquifer are not reasonably anticipated and no sustainable management criteria are established for the Dune Sand Aquifer for the subsidence sustainability indicator. Similarly, there are no Deep Aquifer extraction wells in the MGSA Area, and none are reasonably foreseen. As such, because no Deep

Aquifer groundwater extraction from the MGSA Area requires sustainable management, no sustainable management criteria are established for the Deep Aquifer for the subsidence sustainability indicator.

4.8.2 MINIMUM THRESHOLDS

Regulation Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(5) Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:

(A) Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including and explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.

(B) Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Section 354.28(c)(5) of the Regulations states that "*The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results*." Section 354.28(d) of the Regulations states that "*an Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence*."

This GSP uses groundwater elevation data as a proxy for land subsidence measurements. According to the "Draft Sustainable Management Criteria BMP" (DWR 2017), an example land subsidence minimum threshold while using a groundwater elevation proxy can be determined as follows:

> *"Groundwater level minimum thresholds are above historical low groundwater levels. The GSA determines and documents that avoidance of the minimum thresholds for groundwater levels will also ensure that subsidence will be avoided. In this approach, the GSA would be applying the same numeric definition to two undesirable results – chronic lowering of groundwater and subsidence."*

As noted in Section 4.8.1, pumping of the test slant well from 2015 to early 2018 did not result in significant measurable subsidence. Vertical displacement estimates between June 2015 and June 2018 ranged from approximately 0.01 to 0.025 foot near the MGSA Area, which is negligible. The slant well pumping represents the highest historical rate of groundwater extraction in the MGSA, and likely also the lowest drawdown. It did not result in significant subsidence; therefore, application of the groundwater level decline minimum thresholds, which are above historical low groundwater levels, is

very unlikely to result in significant subsidence. Drawdown within the MGSA Area will be greater; however, the aquifers that would be pumped by the MPWSP are the unconfined to semi-confined Dune Sand and 180-Foot Aquifers. These aquifers are relatively granular and are not overlain by infrastructure in the MGSA Area that is vulnerable to damage from subsidence. For these reasons, the minimum thresholds established for the groundwater level decline RMS are an adequate proxy for the management of subsidence. Therefore, this GSP adopts the minimum thresholds presented in Table 4-1 as a proxy for subsidence.

4.8.2.1 Relationships Between Minimum Thresholds and Other Sustainability Indicators

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:

(2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

Subsidence minimum thresholds have little or no impact on other minimum thresholds, as described below.

- **Chronic lowering of groundwater elevations.** As discussed in Section 4.4, a significant and unreasonable condition for change in groundwater elevations is a decline below levels that cause GDE stress, result in significant and unreasonable interference drawdown, or decline below levels regionally determined by SVBGSA to result in undesirable conditions related to seawater intrusion. Subsidence minimum thresholds are set to be the chronic lowering of groundwater elevation minimum thresholds. Managing subsidence to groundwater elevation minimum thresholds could not cause unacceptably low groundwater levels. Therefore, the subsidence proxy minimum thresholds will not compel a significant or unreasonable lowering of groundwater levels.

- **Change in groundwater storage**. As discussed in Section 4.5, a significant and unreasonable condition for change in groundwater storage is defined as an annual extraction of groundwater in the MGSA Area that falls above the total long-term sustainable yield of the Subbasin established by SVBGSA or that results in depletion of the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers east of the MGSA Area. The subsidence proxy minimum thresholds will not increase the amount of pumping and will not result in a significant or unreasonable change in groundwater storage.

- **Seawater intrusion**. As discussed in Section 4.6, significant and unreasonable seawater intrusion is defined as the migration of chloride isocontours that define the extent of seawater intrusion as of 2017 (for the 180-Foot, 400-Foot, and Deep Aquifers) or 2018 (for the Dune Sand Aquifer). The subsidence proxy minimum thresholds will maintain groundwater levels above historic lows and therefore will not induce additional advancement of seawater intrusion.

- **Degraded water quality**. As discussed in Section 4.7, significant and unreasonable degradation of groundwater quality is defined as the lateral or vertical migration of a TDS isocontour, or the induced migration of a contaminant contour exceeding water quality objectives in a nearby contamination plume. The subsidence sustainability indicator is closely related to the decline of groundwater elevations and is limited by the proxy minimum thresholds presented in Section 4.4.2. As discussed in Section 4.4.2.3, the minimum thresholds for groundwater level decline

will not lead to degradation of groundwater quality; therefore use of these proxy thresholds for subsidence will not result in a significant or unreasonable change in groundwater quality.

- **Depletion of interconnected surface waters.** A significant and unreasonable condition for the depletion of interconnected surface waters is depletion that causes significant and unreasonable degradation of GDEs, induces seawater intrusion in the tidal reaches of the river, or groundwater pumping-induced depletion of flow in the Salinas River that results in significant and unreasonable impacts to surface water uses. The ground level subsidence minimum thresholds will not change the amount or location of pumping (and therefore, surface water depletion) and will not result in a significant or unreasonable depletion of interconnected surface waters.

4.8.2.2 MINIMUM THRESHOLDS IN RELATION TO ADJACENT SUBBASINS AND GSPS

Regulation Requirements
§ 354.28 (b) The description of minimum thresholds shall include the following:
(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The MGSA Area is located adjacent to the Monterey Subbasin and shares boundaries with MCWD GSA and SVBGSA. The MGSA uses groundwater elevation data as a proxy for the land subsidence minimum threshold. The minimum threshold was selected to address potential locally-caused undesirable results associated with groundwater extraction, while retaining compatibility with regional sustainable management criteria. Sustainable management criteria were established in collaboration with MCWD to support their sustainable management strategy. In addition, the proxy minimum threshold for the 180-Foot and 400-Foot Aquifers were selected to be compatible with SVBGSA's minimum thresholds, which apply to the remainder of the Subbasin and to the portion of the Monterey Subbasin that is not managed by MCWD GSA. These thresholds will promote cohesive management to achieve the sustainability goals of MGSA, SVBGSA and MCWD GSA.

4.8.2.3 IMPACT OF MINIMUM THRESHOLDS ON BENEFICIAL USES AND USERS

Regulation Requirements:
§ 354.28 (b) The description of minimum thresholds shall include the following:
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The subsidence proxy minimum thresholds are set to prevent long-term inelastic subsidence that could harm infrastructure. Available data indicate that there is currently no long-term subsidence occurring in the Subbasin that affects infrastructure, and reductions in pumping, to the extent required, are already required by minimum thresholds for other sustainability indicators. Therefore, the subsidence proxy minimum thresholds do not require any additional reductions in pumping and there is no negative impact on beneficial users.

4.8.2.4 CURRENT STANDARDS RELEVANT TO SUSTAINABILITY INDICATOR

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:

(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

There are no federal, state, or local regulations related to subsidence.

4.8.2.5 MEASUREMENT OF MINIMUM THRESHOLDS

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater elevation proxy minimum thresholds will be directly measured from the RMS in the monitoring well network. Groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Section 5. Furthermore, the groundwater level monitoring will meet the requirements of the technical and reporting standards included in the Regulations.

4.8.3 MEASURABLE OBJECTIVES AND INTERIM MILESTONES

Regulation Requirements:

§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

The measurable objectives for subsidence are proxy groundwater levels which represent target groundwater elevations that are higher than the proxy minimum thresholds in order to provide early warning so potentially adverse trends can be addressed in a timely fashion. Measurable objectives are also established to leave adequate operating flexibility to deal with anticipated variability in conditions such as seasonal and inter-annual climatic variations and droughts, uncertainties in aquifer conditions or unanticipated events. As stated in Section 4.2,

> "*MGSA will manage groundwater resources in the MGSA Area in a way that ensures all beneficial uses and users in, or affected by, groundwater management in the MGSA Area are protected from undesirable results, and have access to a safe and reliable groundwater supply that meets current and future demand*."

This GSP adopts the measurable objectives and interim milestones summarized in Table 4-2 as a proxy for the subsidence sustainability indicator.

4.9 DEPLETION OF INTERCONNECTED SURFACE WATER

4.9.1 LOCAL FACTORS POTENTIALLY CONTRIBUTING TO SIGNIFICANT AND UNREASONABLE CONDITIONS

The MGSA Area is located approximately 4,000 feet from the Salinas River, and projected groundwater elevations are within less than 20 feet of the river thalweg elevation, suggesting an interconnection may exist between the Dune Sand Aquifer and the river at this location (Section 3.2.6.1.1). Geophysical data collected in 2017 indicate that groundwater elevations in the Dune Sand Aquifer are close to the river stage elevation, and decline away from the river, suggesting a losing condition. Within approximately ½ mile of the river mouth, the geophysical data suggest that seawater intrusion may be occurring through the riverbed and into the Dune Sand Aquifer and underlying 180-Foot Aquifer (Figure 3-22). Under these conditions, a decline in groundwater elevations near the river would affect river flows and could increase the infiltration of saline water from the river into the aquifer. In addition, although they are likely to be primarily dependent on surface water flows, riverine wetlands and riparian habitat located further upstream along the river could be affected by groundwater elevation declines (Figure 3-38).

As discussed in Section 3.2.6.1.1, projected groundwater elevations in the spring of 2018 were within less than 2 to 5 feet of several mapped vernal ponds (palustrine and emergent wetlands) located east of the MGSA Area that are designated as environmentally sensitive habitat areas that are protected by the California Coastal Act, other laws and mitigation agreements (Section 2.1.2). Groundwater elevation declines beneath these GDEs could adversely affect protected habitats and species.

Groundwater modeling for the proposed MPWSP predicted that the amount of river flow depletion would result from makeup groundwater pumping to supply the project would be 400 AFY (ESA 2018). These modeling results have not been verified for preparation of this GSP; however, for perspective, the predicted depletion is less than 1 cubic foot/second and would be unlikely to have a significant and unreasonable effect on the beneficial uses of water in the Salinas River. The USGS is developing the SVIHM as a regional modeling and hydrogeologic assessment tool, and this model is expected to be more robust and refined than the model used for the MPWSP impact analysis. As discussed in Chapters 6 and 7, SVBGSA intends to use the USGS SVIHM to evaluate surface-groundwater interaction. Additionally, the MCWD GSA intends to build a refined local model that may incorporate the Salinas River. MGSA intends to engage with these efforts and review the modeling investigations, and to refine, among other things, the assessment of surface-groundwater interaction along the lower reach of the Salinas River.

The geophysical investigation data illustrated in Figure 3-22 suggest that seawater intrusion through the riverbed in the lower ½ mile reach of the river has historically occurred; however, the data are insufficient to assess whether current intrusion rates differ from historical baseline rates. Review of historical evapotranspiration data suggest a decline in groundwater availability to GDEs east of the MGSA Area occurred during the test slant well pumping test conducted from April 2015 to February

2018; however, this period also coincided with a drought, and measured groundwater elevation declines resulted from both drought and pumping conditions. ET rates in 2017 and 2018 appeared to recover to their pre-test levels. It is not known whether the GDEs were adversely affected during this period of stress. As such, it is not known if there were recent significant and unreasonable impacts to GDEs.

4.9.2 MINIMUM THRESHOLDS

Regulation Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(6) Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:

(A) The location, quantity, and timing of depletions of interconnected surface water.

(B) A description of the groundwater and surface model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph. (B) Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Section 354.28(d) of the Regulations states that "*an Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence*." According to the "Draft Sustainable Management Criteria BMP" (DWR 2017), one possible approach to using minimum thresholds for chronic groundwater level decline as a proxy for another minimum threshold is to:

> *"[d]emonstrate that the minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of other sustainability indicators will be prevented. In other words, demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for not only chronic lowering of groundwater levels but other sustainability indicators at a given site."*

Depletion of interconnected surface water is directly related to groundwater level decline in the uppermost aquifer system which is in contact with the stream or wetland being affected, in this case, the Dune Sand Aquifer. As discussed in Section 4.9.2, groundwater modeling for the proposed MPWSP predicted that, if implemented, the project would result in a river flow depletion less than 1 cubic foot/second, which would be unlikely to have a significant and unreasonable effect on the beneficial uses of water in the Salinas River(ESA 2018). As such, the primary potential effect of concern associated

with the decline of groundwater levels in the Dune Sand Aquifer is potential stress to GDEs. The rationale for establishment of a minimum threshold for the Dune Sand Aquifer to prevent potential significant and unreasonable impacts to GDEs is described in Section 4.4.2, and also applies to establishment of a minimum threshold for depletion of interconnected surface water. For these reasons, the minimum thresholds established for the groundwater level decline RMS are an adequate proxy for the depletion of interconnected surface water. Therefore, this GSP adopts the minimum thresholds for RMS in the Dune Sand Aquifer presented in Table 4-1 as a proxy for depletion of interconnected surface water based on the potential for adverse impacts to GDEs. Because 180-Foot, 400-Foot and Deep Aquifers are not directly interconnected to surface water, no minimum thresholds or measurable objectives are established for these aquifers.

4.9.2.1 Relationships Between Minimum Thresholds and Other Sustainability Indicators

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:

(2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

The interconnected surface water minimum thresholds use the groundwater elevation decline minimum thresholds for the Dune Sand Aquifer as a proxy. They are derived from historical groundwater elevation measurements. Therefore, the minimum thresholds are unique at every well, but when combined represent a "compliance surface" that represents a cohesive dataset. There is no conflict between the thresholds at adjacent locations.

Interconnected surface water minimum thresholds can influence other sustainability indicators. The groundwater elevation minimum thresholds are selected to avoid undesirable results for other sustainability indicators.

- **Chronic lowering of groundwater elevations.** As discussed in Section 4.4, a significant and unreasonable condition for change in groundwater elevations is a decline below levels that cause GDE stress, result in significant and unreasonable interference drawdown, or decline below levels regionally determined by SVBGSA to result in undesirable conditions related to seawater intrusion. The thresholds for depletion of interconnected surface water and chronic groundwater level decline are identical and will prevent undesirable results for both sustainability indicators.
- **Reduction in groundwater storage**. As discussed in Section 4.5, a significant and unreasonable condition for change in groundwater storage is defined as an annual extraction of groundwater in the MGSA Area that falls above the total long-term sustainable yield of the Subbasin established by SVBGSA or that results in depletion of the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers east of the MGSA Area. Decline of groundwater elevations would be associated with changes in storage, therefore, limiting changes in storage would also limit groundwater level declines and changes in surface-groundwater interaction. The minimum thresholds for both sustainability indicators will have the same effect – these thresholds will complement each other.

- **Seawater intrusion.** As discussed in Section 4.6, significant and unreasonable seawater intrusion is defined as the migration of chloride isocontours that define the extent of seawater intrusion as of 2017 (for the 180-Foot, 400-Foot and Deep Aquifers) or 2018 (for the Dune Sand Aquifer). As discussed in Section 3.2.3.2, a decline in groundwater levels would lead to a change in the interface dynamics between the saline water intrusion wedge and the overlying low-TDS zone, and could potentially result in seawater intrusion; however, the minimum threshold for groundwater level decline in the Dune Sand Aquifer is set at a much lower level based on protection of GDEs. Thus, these minimum thresholds are adequate to address both seawater intrusion and depletion of interconnected surface water. Groundwater elevation declines could induce additional saline water intrusion the bed of the lowermost reaches of the Salinas River; however, the minimum threshold for interconnected surface waters is set above recent groundwater elevations, so the compliance with the minimum threshold should prevent a worsening of seawater intrusion beyond historical levels. For these reasons, the interconnected surface water minimum threshold is unlikely to result in significant and unreasonable seawater intrusion, but rather, will help to protect water quality.
- **Degraded water quality**. As discussed in Section 4.7, significant and unreasonable degradation of groundwater quality is defined as the lateral or vertical migration of a TDS isocontour, or the induced migration of a contaminant contour exceeding water quality objectives in a nearby contamination plume. This sustainability indicator is closely related to the decline of groundwater elevations; however, the minimum threshold for groundwater level decline in the Dune Sand Aquifer is set at a much lower level based on protection of GDEs. . For these reasons, the interconnected surface water minimum threshold is unlikely to result in significant and unreasonable degraded water quality, but rather, will help to protect water quality.
- **Subsidence**. A significant and unreasonable condition for subsidence is any measurable long-term inelastic subsidence that damages existing infrastructure. Subsidence is caused by depressurization and compaction of fine-grained sediments in response to lowering groundwater levels, especially in confined systems when groundwater elevations fall below historical lows. The groundwater elevation minimum thresholds are set 1 foot above recent low groundwater elevations, making measurable subsidence unlikely.

4.9.2.2 Minimum Thresholds in Relation to Adjacent Subbasins and GSPs

Regulation Requirements
§ 354.28 (b) The description of minimum thresholds shall include the following:
(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The proxy minimum thresholds for the Depletion of Interconnected Surface Water are the same as the minimum thresholds for the Chronic Decline of Groundwater Levels in the Dune Sand Aquifer, and are compatible across Subbasin and GSP boundaries.

The MGSA Area is located adjacent to the Monterey Subbasin and shares boundaries with MCWD GSA and SVBGSA. The minimum threshold was selected to address potential locally-caused undesirable results associated with groundwater extraction, while retaining compatibility with regional sustainable management criteria. Sustainable management criteria were established in collaboration with MCWD to support their sustainable management strategy. The thresholds represent a smooth groundwater elevation surface and would be continuous across inter-agency and inter-basin boundaries. As such,

these thresholds will promote cohesive management to achieve the sustainability goals of MGSA, SVBGSA, and MCWD GSA. SVBGSA's GSP does not present sustainable management criteria for the Dune Sand Aquifer; however, the minimum thresholds established in MGSA's GSP for the Dune Sand Aquifer are compatible with SVBGSA's management strategy for the underlying regional aquifers. The minimum thresholds for the Dune Sand Aquifer to address local resource conditions will not impede or conflict with SVBGSA's ability to reach their sustainability goals. To the contrary, they will protect sensitive local resources in the portion of the Subbasin managed by SVBGSA from potential harm caused by groundwater extraction in the MGSA Area.

SVBGSA has identified aquifer interaction with interconnected surface water and GDEs as a data gap it plans to investigate further through the installation of additional monitoring wells and the use of the United States Geological Survey (USGS) soon to be released Salinas Valley integrated Hydrologic Model (SVIHM). As discussed in Chapters 6 and 7, MGSA plans to support SVBGSA's evaluation and to review the results and other available hydrologic and biological data to determine whether modification of the sustainable management criteria for interconnected surface water in this GSP require updating. The application of the minimum threshold for interconnected surface water in this GSP will not interfere with SVBGSA's management or data gap investigation, and any data gleaned during implementation of the GSP will be shared with SVBGSA.

4.9.2.3 Impact of Minimum Thresholds on Beneficial Uses and Users

Regulation Requirements:
§ 354.28 (b) The description of minimum thresholds shall include the following:
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The interconnected surface water groundwater proxy minimum thresholds for beneficial uses are the same as groundwater elevation minimum thresholds. Specifically, relative to interconnected surface water, they may have the following effects on beneficial users and land uses in the Subbasin:

- The groundwater elevation threshold for the Dune Sand Aquifer will assure that GDEs are not adversely affected by groundwater extraction in the MGSA Area. This will help to preserve protected habitats and species.
- The threshold will prevent an increase in the rate of seawater intrusion through the riverbed in the lower, tidally-influenced reach of the Salinas River.

4.9.2.4 Current Standards Relevant to Sustainability Indicator

Regulation Requirements:
§354.28 (b) The description of minimum thresholds shall include the following:
(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

Streamflow requirements as described in the National Marine and Fisheries Service (NMFS) *Salinas Valley Water Project Flow Prescription for Steelhead Trout in the Salinas River* (MCWRA 2005). MCWRA currently manages flows in the Salinas River to meet the requirements of the National Marine Fisheries

biological opinion (National Marine Fisheries Service 2007). The NMFS biological opinion was developed using measured streamflows between 1995 and 2005. The measured streamflow reflects current surface water depletion rates, and therefore current depletion rates are already incorporated into the river management plan. Releases from Nacimiento Reservoir and San Antonio Reservoir have successfully maintained required environmental flows under current groundwater pumping and surface water depletion conditions. The Steelhead Trout flow prescriptions are described in MCWRA, 2005. This document guides the operating rules for the San Antonio and Nacimiento reservoir releases.

4.9.2.5 Measurement of Minimum Thresholds

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater elevation minimum thresholds will be directly measured from the monitoring well network. The groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Chapter 5. Furthermore, the groundwater level monitoring will meet the requirements of the technical and reporting standards included in the Regulations.

4.9.3 Measurable Objectives and Interim Milestones

Regulation Requirements:

§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

As discussed in Section 4.4 and Chapter 7, groundwater elevation minimum thresholds and measurable objectives are established for the Dune Sand Aquifer on an interim basis until investigations to address data gaps in the degree of groundwater connection of riverine wetlands and GDEs, and the response of other GDEs to groundwater level decline, can be assessed. Because the documented historical range in groundwater elevations in the Dune Sand Aquifer is relatively limited, the interim measurable objectives are established equal to the minimum thresholds, and interim milestones are established at the same elevations.

4.9.4 UNDESIRABLE RESULTS

Regulation Requirements:

§354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

Regionally, the SVBGSA describes significant and unreasonable depletion of interconnected surface water in the Subbasin as depletion of interconnected surface water flows that may prevent the MCWRA from meeting biological flow requirements in the Salinas River, or would cause an unreasonable impact on other water rights holders. The following criteria were considered by SVBGSA (2019):

- MCWRA currently manages flows in the Salinas River to meet the requirements of the National Marine Fisheries Service (NMFS) biological opinion (NMFS 2007). The NMFS biological opinion was developed using measured streamflows between 1995 and 2005. The measured streamflow reflects current surface water depletion rates, and therefore current depletion rates are already incorporated into the river management plan. Furthermore, releases from Nacimiento Reservoir and San Antonio Reservoir have successfully maintained required environmental flows under current groundwater pumping and surface water depletion conditions. The Steelhead Trout flow prescriptions are described in *Salinas Valley Water Project Flow Prescription for Steelhead Trout in the Salinas River* (MCWRA 2005). This document guides the operating rules for the San Antonio and Nacimiento reservoir releases. Therefore, steelhead flow requirements are being met and current surface water depletion rates are not unreasonable with regards to maintaining flow required in the biological opinion.

- In addition to managing the river for environmental needs, the MCWRA manages the Salinas River to maintain adequate water supply for other beneficial uses. The Nacimiento and San Antonio reservoirs provide flood control benefits as well as groundwater recharge benefits through its sandy channels, where water rights holders along the river can pump out water according to their water rights. Therefore, among other things, the Salinas River is managed to satisfy the water supply needs of riparian pumpers and the existing depletions are neither significant nor unreasonable.

- Regionally, there is significant leakance from the Salinas River to the underlying groundwater, but it is not considered unreasonable with regards to riparian rights holders. To the extent that groundwater pumping depletes surface water flows, these depletions and the potential surface

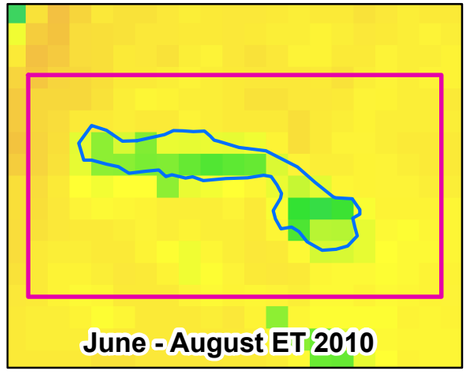
water limitations would be injurious only if the surface water right holders held rights senior to the groundwater pumpers.

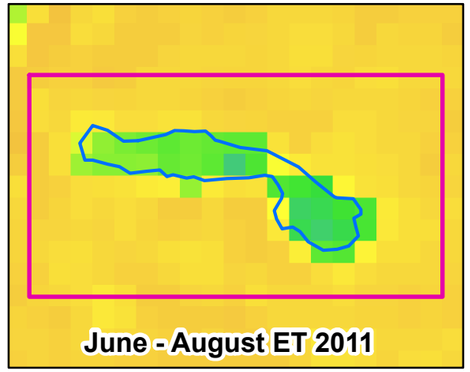
Locally, the following additional criteria were considered in defining undesirable results for this GSP:

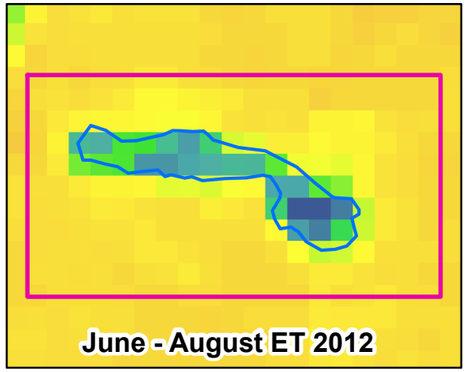
- Potential seawater intrusion through the bed of the tidally-influenced reach of the Salinas River resulting from groundwater drawdown in the Dune Sand Aquifer near the river; and
- Groundwater drawdown in the Dune Sand Aquifer near GDEs that is sufficient to cause vegetative stress that leads to habitat degradation or harm to protected species.

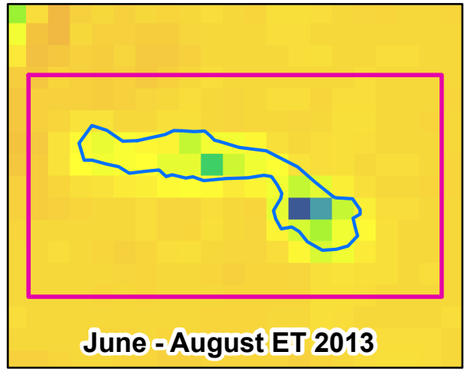
The causes of potential undesirable results are further discussed in Section 4.9.1 and the potential effects of undesirable results on the beneficial users of groundwater, land uses, and property owners are discussed in Sections 4.9.1 and 4.9.2.

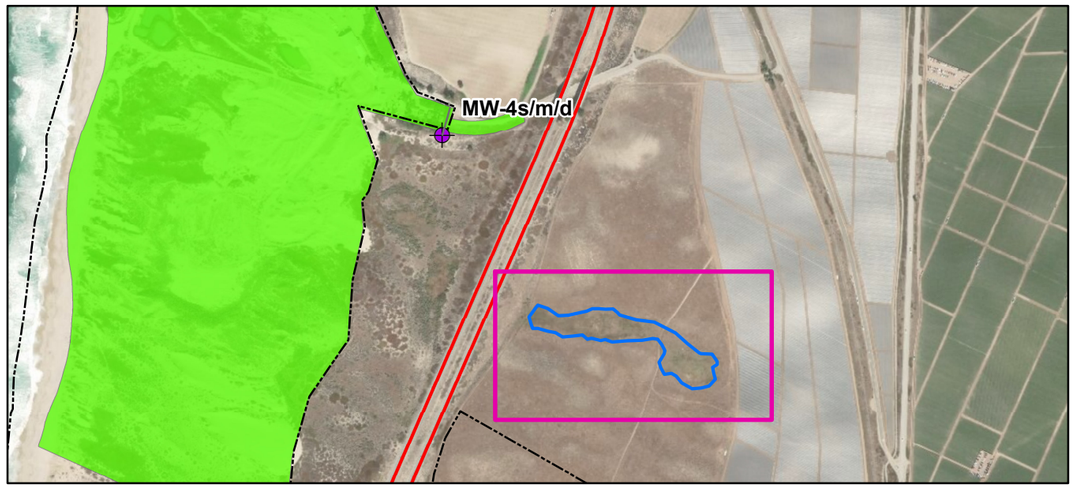
Based on this information, undesirable results for the depletion of interconnected surface water sustainability indicator are defined as an exceedance of the groundwater elevation proxy minimum thresholds at two or more locations in the Dune Sand Aquifer in any given year.

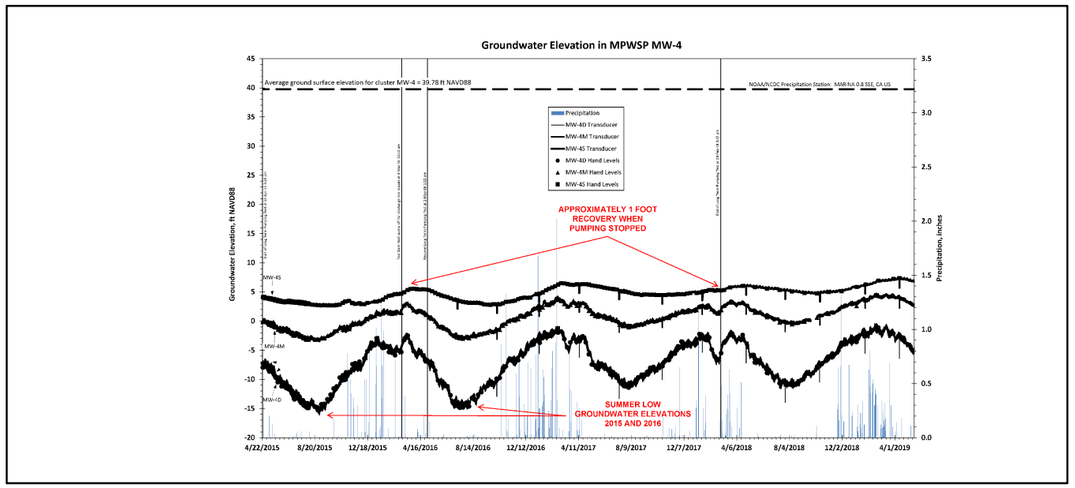


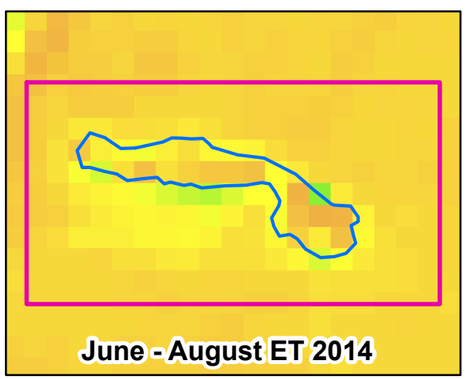


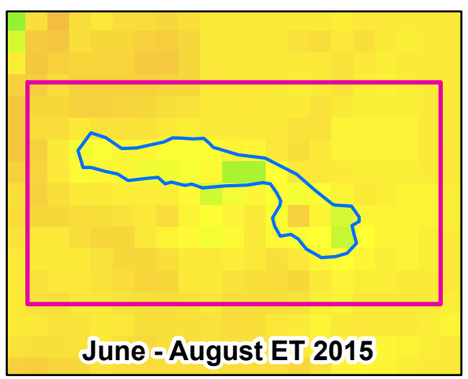


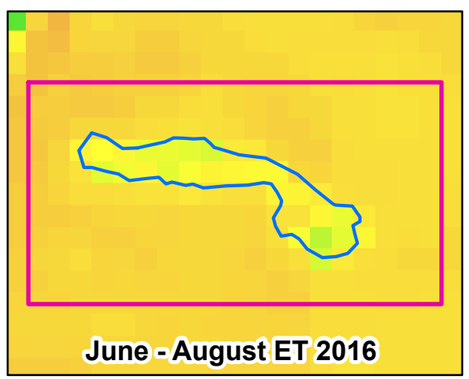


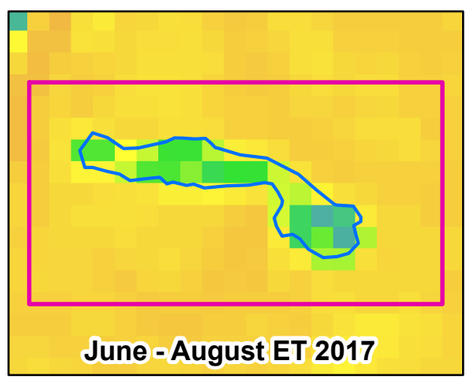












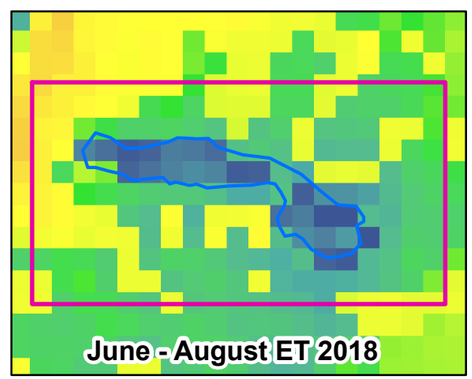


FIGURE 4-1

Analysis of Evapotranspiration from a GDE at the Armstrong Ranch Vernal Pond Complex

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

ET (Inches)

High : >10

Low : 0

MW-4s/m/d

Area of Interest

Wetland

Highway 1

City of Marina

City of Marina GSA (MGSA) Area

Sources: ESRI Map Service Imagery, Geoscience Support Services 2019, Paul et al. 2018, and the NC Dataset https://gis.water.ca.gov/app/NCDatasetViewer/

DATE: DEC. 30, 2019

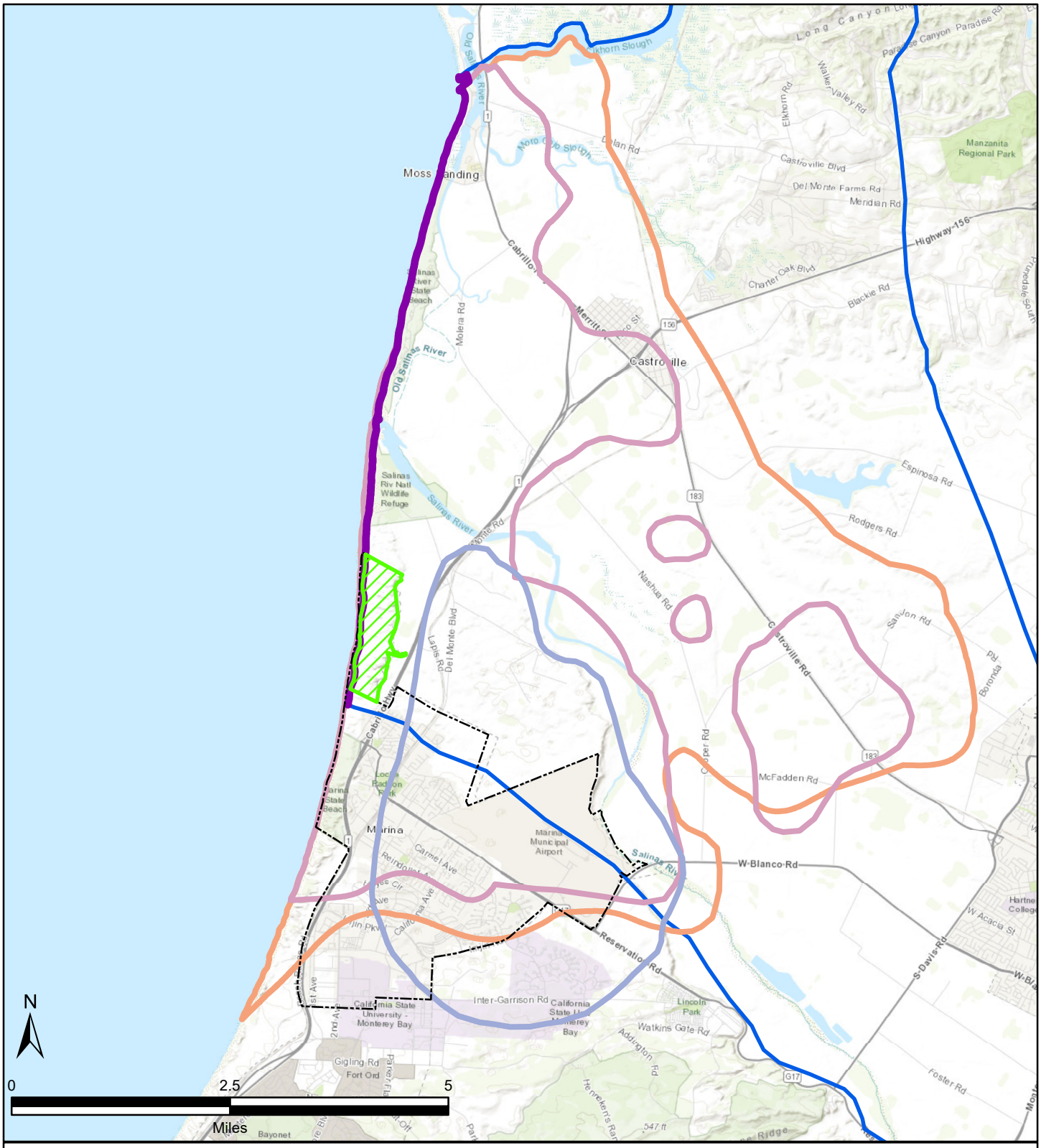


FIGURE 4-2

Minimum Thresholds for Seawater Intrusion

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA (MGSA) Area
- City of Marina
- 180/400 Foot Aquifer Subbasin
- Deep Aquifer Minimum Threshold: Theoretical 500 mg/L chloride isocontour
- Dune Sand Aquifer Minimum Threshold: 1,660 mg/L chloride isocontour in 2018
- 400-Foot Aquifer Minimum Threshold: 500 mg/L chloride isocontour in 2017
- 180-Foot Aquifer Minimum Threshold: 500 mg/L chloride isocontour in 2017

DATE: JAN. 07, 2020

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, reference attached MCWRA 2018 map, reference attached MCWRA 2018 map, reference Gottschalk et al 2018.

M:\Marina\180_400_FootAquiferGSP\GIS\FormationLayers\MXD\Chapter4\Fig4-02_MCWRA_seawater_intrusion_map_all_aquifers.mxd

CHAPTER 5 – MONITORING NETWORK
Groundwater Sustainability Plan
for the Marina GSA Area
of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, California

JANUARY 2020

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Appendix 5.C – Chloride Data Contouring Protocols

Appendix 5.D – Induction Logging

5 MONITORING NETWORK

Regulation Requirements:

§354.32 This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.

This chapter describes the monitoring networks used to collect data to support implementation of the Groundwater Sustainability Plan (GSP) for the Marina Groundwater Sustainability Agency (MGSA) Area. This chapter has been prepared in accordance with Title 23, California Code of Regulations (CCR) § 354.32 and describes monitoring objectives, monitoring protocols, and data reporting requirements.

5.1 INTRODUCTION

Regulation Requirements:

§354.34(a) Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan Implementation.

The MGSA Area covers approximately 372 acres and is part of the broader 180/400 Foot Aquifer Subbasin (Subbasin). Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) manages the portions of the Subbasin that lie outside the MGSA Area under a regional GSP (Figure 5-1). Marina Coast Water District Groundwater Sustainability Agency (MCWD GSA) has jurisdiction over the Central Marina and Ord Community portions of its service area in this Subbasin, although MCWD has entered into an agreement with SVBGSA for SVBGSA to prepare the GSP in these areas.

This chapter describes the monitoring network that will be used to collect representative information about groundwater conditions as necessary to evaluate and guide implementation of the local GSP for the MGSA Area. Monitoring activities will focus on key resources and the following four principal aquifers within and proximal to the MGSA Area, which are further described in Section 3.1.6:

- **Dune Sand Aquifer (Dune Sand Aquifer).** The uppermost aquifer, which is of local importance due to its interaction with local groundwater-dependent ecosystems (GDEs), substantial storage of groundwater with designated potential beneficial use as a municipal or domestic supply, and importance in maintaining nearshore seawater intrusion dynamics;

- **180-Foot Aquifer.** The uppermost groundwater supply aquifer of regional importance in the Subbasin, which is seawater intruded in the vicinity of the MGSA Area, but includes significant zones of groundwater with a designated beneficial use as a domestic and municipal supply in the vicinity;

- **400-Foot Aquifer.** The second groundwater supply aquifer of regional importance in the Subbasin, which is seawater intruded in the vicinity of the MGSA Area, but includes significant

zones of groundwater with a designated beneficial use as a domestic and municipal supply in the vicinity; and

- **Deep Aquifer.** The deepest regional groundwater supply aquifer, which is not seawater intruded and currently provides the only source of municipal water supply for the City of Marina.

As described in Chapter 2, several existing monitoring programs that are being implemented by Monterey County Water Resources Agency (MCWRA), SVBGSA or others are relevant to the MGSA Area and data collected for these programs will be used for the monitoring program for this MGSA GSP as described further below.

In the event that the Monterey Peninsula Water Supply Project (MPWSP) is not implemented, MGSA will explore alternative arrangements with MCWRA to implement the monitoring program. MGSA is in the process of developing an agreement with MCWRA regarding utilization of monitoring data from its proposed coastal monitoring program. Once developed, this agreement would recognize that if the MPWSP does not move forward, MCWRA will consult with GSAs having jurisdiction in the area to develop an alternative coastal monitoring program using the existing monitoring and supply wells identified in the Mitigation Monitoring and Reporting Program (MMRP) for the MPWSP (CPUC 2018, Zidar and Feeney 2019).

5.1.1 MONITORING NETWORK OBJECTIVES

Regulation Requirements:

§354.34(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:

1) Demonstrate progress toward achieving measurable objectives described in the Plan.
2) Monitor impacts to the beneficial uses or users of groundwater.
3) Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.
4) Quantify annual changes in water budget components.

The Sustainable Groundwater Management Act (SGMA) requires that monitoring networks be developed to promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in groundwater basins managed by GSAs, and to evaluate changing conditions that occur as GSPs are implemented. The monitoring networks must be established to collect representative information to demonstrate short-term, seasonal, and long-term trends as needed to support the following SGMA requirements:

- Monitor changes in groundwater conditions and demonstrate compliance with minimum thresholds and progress toward achieving measurable objectives and interim milestones, as appropriate;

- Monitor impacts to the beneficial uses or users of groundwater;

- Quantify annual changes in water budget components; and
- Assess the criteria that trigger the implementation and termination of management actions and assess their effectiveness under conditions that include minimum threshold exceedances, variable conditions, and adverse impacts to beneficial uses and users of groundwater.

5.1.2 NETWORK DEVELOPMENT PROCESS

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
[§354.34(c)(1) through §354.34(c)(6) are individually listed below]

Monitoring networks are developed for each of the six sustainability indicators identified in SGMA, including:

- Chronic Lowering of Groundwater Levels;
- Reduction in Groundwater Storage;
- Seawater Intrusion;
- Degraded Groundwater Quality;
- Land Subsidence; and
- Depletion of Interconnected Surface Water.

Since DWR's regulations allow MGSA to use existing monitoring sites in its monitoring network, the monitoring networks described in this chapter include existing locations as well as currently planned expansions of existing programs. As described in Section 2.2, there are several existing and well-developed monitoring programs and networks that are used to monitor the principal aquifers in the 180/400 Foot Aquifer Subbasin. These include regional programs implemented by MCWRA to monitor groundwater elevations and seawater intrusion, including monitoring for the California Statewide Ambient Groundwater Elevation Monitoring (CASGEM) program. Other programs will be implemented by SVBGSA to monitor groundwater storage changes, subsidence, and surface-groundwater interaction for their 180/400 Foot Aquifer Subbasin GSP. These programs are pertinent to this MGSA GSP as they characterize regional conditions and trends in the Subbasin. However, because the MGSA Area comprises a relatively limited portion of the Subbasin's seaward edge, the MGSA GSP will rely primarily on data collected from a local monitoring network adopted in and around the MGSA Area under the Mitigation, Monitoring and Reporting Program (MMRP) for the proposed Monterey Peninsula Water Supply Project (MPWSP) (CPUC 2018, Zidar and Feeney 2019).

In the event that the MPWSP is not implemented, MGSA will explore alternative arrangements with MCWRA to implement the monitoring program. MGSA is in the process of developing an agreement with MCWRA regarding utilization of monitoring data from its proposed coastal monitoring program. Once developed, this agreement would recognize that if the MPWSP does not move forward, MCWRA will consult with GSAs having jurisdiction in the area to develop an alternative coastal monitoring program using the existing monitoring and supply wells identified in the MMRP for the MPWSP.

The locations of the existing and proposed wells in MCWRA's MMRP monitoring program are shown in Figure 5-2. There are currently eight monitoring well clusters with 24 wells within and near the MGSA Area that were installed to monitor test slant well pumping for the MPWSP design and environmental studies. Each of these clusters has a well completed in the Dune Sand Aquifer, the 180-Foot Aquifer, and the 400-Foot Aquifer The existing clusters are designated MW-1, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, and MW-9 (the MW-2 cluster was not constructed).[1] Under the MMRP for the proposed MPWSP, if the project moves forward, MCWRA will construct five additional well clusters with three wells each at locations MW-A, MW-B, MW-C, MW-D and MW-E, and construct another well at MW-5S screened in the Dune Sand Aquifer below the perched zone, to expand the network of nested monitoring wells to a total of 40 wells (Zidar and Feeney 2019). In addition, under the MMRP MCWRA will monitor a number of other existing wells in the vicinity of the MGSA Area that are in the MCWRA, MCWD or Fort Ord monitoring networks, including 10 wells completed in the Dune Sand Aquifer, eight wells completed in the 180-Foot Aquifer, five wells completed in the 400-Foot Aquifer and eight wells completed in the Deep Aquifer. MCWRA will also monitor six nested monitoring wells in the Deep Aquifer constructed by the United States Geological Survey (USGS) at two locations approximately ½ mile south of the MGSA Area. The locations and construction details of these 77 wells are summarized in Tables 5-1 through 5-4 for the Dune Sand, 180-Foot, 400-Foot, and Deep Aquifers, respectively. Boring logs and well completion diagrams are provided in Appendix 5.A.

This MGSA GSP monitoring network will include the MCWRA's MMRP monitoring program wells as described in the following sections. Data from all of the monitoring wells will be considered to characterize regional groundwater conditions surrounding the MGSA Area, but only a subset of wells will be included in the monitoring networks used to assess groundwater level and quality conditions for compliance with the measurable objectives and minimum thresholds established in Chapter 4. Tables 5-1 through 5-4 identify the wells which are included in the MGSA groundwater elevation, groundwater quality and/or induction logging monitoring networks. In addition to groundwater monitoring data, some sustainability indicators may rely on collection of other types of data (e.g., induction logging, groundwater extraction reporting and biological monitoring). Data gaps are identified for each monitoring network; filling these data gaps and developing more extensive and complete monitoring programs will improve MGSA's and others' ability to support sustainable groundwater management and refine the existing conceptual and numerical hydrogeologic models.

5.1.3 REPRESENTATIVE MONITORING SITES

Regulation Requirements:

§354.36 Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:

§354.36(a) Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.

[1] Monitoring data indicates MW-5S is screened in a perched aquifer above the DSA. Therefore, the monitoring well has been re-designated as MW-5S(P) to indicate it is representative of a local perched aquifer. Similarly, MW-6D is screened in the lower portion of the 180-Foot Aquifer and has been re-designated as MW-6M(L) to indicate it represents the 180-Foot Aquifer.

Representative monitoring sites (RMS) are defined in the regulations as a subset of monitoring sites that are considered representative of conditions in a subbasin. The subset of wells designated as the RMS for the Dune Sand Aquifer, 180-Foot, and the 400-Foot Aquifers in Chapter 4 was used to establish minimum thresholds and measurable objectives for each of the sustainability indicators (refer to Table 4-1). The network that will be used to collect data to evaluate the sustainability indicators will include all of the monitoring wells that are part of MCWRA's MMRP monitoring program and are identified in Tables 5-1 through 5-4, and discussed in the subsections for each sustainability indicator.

5.1.4 Review and Evaluation of Monitoring Network

Regulation Requirements:

§354.38(a) Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.

MGSA will review the monitoring network described in this GSP at a frequency of not greater than every five years to assess whether data gaps exist that could affect MGSA's ability to achieve the sustainability goals for the MGSA Area. An initial evaluation will be conducted in collaboration with Marina Coast Water District (MCWD) GSA, SVBGSA, and MCWRA when the United States Geologic Survey (USGS) releases the Salinas Valley Integrated Hydrologic Model (SVIHM), as described below. Data gaps, if identified, could result in the need to install additional monitoring wells or add additional monitoring locations or procedures to complement the existing network and/or to increase the frequency of monitoring. Reviews and appropriate response actions will be performed in collaboration with SVBGSA, MCWRA and MCWD GSA. Several areas of review are identified at this time:

- As discussed in Section 7.1.4, USGS anticipates releasing its fully calibrated SVIHM in late 2020 (SVBGSA 2019). The SVIHM, when available, will represent the state of the science when it comes to groundwater management tools in the Salinas Valley Basin, and SVBGSA intends to update its GSP based on refined information regarding the groundwater flow system, water budgets and predictive capability of that model. MGSA intends to work in parallel with SVBGSA in its review of the calibrated SVIHM and update this GSP at the same time. If the new information is significant for local groundwater management, MGSA will prepare an addendum or update report refining the GSP.

- Monitoring of the Deep Aquifer in the 180/400 Foot Aquifer Subbasin has historically been limited considering the thickness and complexity of this aquifer system. The 14 Deep Aquifer wells included in the groundwater level and quality monitoring networks for this GSP help to address this data gap. Additional characterization and monitoring of the Deep Aquifer are currently being discussed by MCWRA, SVBGSA and MCWD GSA, and it is possible that additional monitoring wells will be completed in the Deep Aquifer near the MGSA Area in the future. Monitoring of the Deep Aquifer, for the purposes of this GSP, will be accomplished using

information from existing USGS and other monitoring wells that are being monitored by MCWRA, and expanded if new wells are installed in the area.

- MCWD GSA will review the adequacy of this monitoring well network during development of the GSP for the Monterey Subbasin, which is due to be completed in 2022. This review will be conducted in the context of developing a locally-refined groundwater flow, solute transport, and density-driven flow model. Any refinements or changes in the monitoring network adopted by MCWD GSA will be reviewed and considered for adoption in this GSP to ensure that the local monitoring system provides consistent data for both GSPs.

5.2 CHRONIC LOWERING OF GROUNDWATER LEVELS

Regulation Requirements:

§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:

A) A sufficient density of monitor wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.

B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.

The sustainability indicator for Chronic Lowering of Groundwater Levels is evaluated by monitoring groundwater elevations. The regulations require a network of monitoring wells sufficient to demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features.

The California Statewide CASGEM program provides groundwater elevation data in a format that is readily and widely available to the public and can be readily adopted into SGMA compliance programs. SVBGSA has adopted the Subbasin CASGEM program into its monitoring network for the Subbasin. However, there is only one CASGEM well in the vicinity of the MGSA Area, which is not sufficient to fulfill the requirements of the GSP regulations for monitoring under this GSP. Therefore, groundwater elevation monitoring network of this GSP will include the existing and planned monitoring well clusters associated with the MPWSP to monitor the Dune Sand Aquifer, 180-Foot Aquifer and 400-Foot Aquifer, the existing USGS monitoring wells approximately ½ mile south of the MGSA Area to monitor the Deep Aquifer, and the remaining Deep Aquifer wells included in the MMRP monitoring program. Monitoring of these wells will be conducted by MCWRA under the *Integrated Coastal Groundwater Monitoring Program and Plan* (Zidar and Feeney 2019).

5.2.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:

§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36

§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

Chronic Lowering of Groundwater Levels is related in various ways to each of the other sustainability indicators. It has the potential to cause well interference, result in regionally greater pumping depths, reduce groundwater storage, result in additional seawater intrusion, degrade water quality, cause subsidence, and deplete interconnected surface waters. Beneficial users of shallow groundwater such as groundwater-dependent ecosystems (GDEs) could also be adversely affected by groundwater elevation declines.

In the vicinity of the MGSA Area, groundwater extraction from the seawater-intruded portions of the 180-Foot Aquifer and 400-Foot Aquifer is generally limited. As one of the management actions in SVBGSA's GSP for the Subbasin (SVBGSA 2019), SVBGSA proposes to adopt an ordinance that would prohibit the construction and operation of water supply wells within the Castroville Seawater Intrusion Project (CSIP) service area east and northeast of the MGSA Area. Nevertheless, small non-transient water systems reliant on groundwater are located near Neponset, near the Marina Airport and near the regional wastewater treatment plant located east of the MGSA Area (Section 3.1.8). In addition, interference drawdown with existing wells is a potential impact in the vicinity of the MGSA Area that is identified in the MMRP for the proposed MPWSP. Also, as discussed in Section 3.2.6.2, several GDEs that support protected habitat and species are located east of the MGSA Area, and similar features occur farther to the north and south. Based on this information, undesirable results for the Chronic Lowering of Groundwater Levels sustainability indicator in the MGSA Area are defined based on significant and unreasonable well interference drawdown, and significant and unreasonable hydrological or biological impacts to GDEs.

As described in Chapter 4, minimum thresholds and measurable objectives for the Chronic Lowering of Groundwater Levels sustainability indicator are defined for the principal aquifers as follows:

- **Dune Sand Aquifer** – MGSA has established the minimum threshold and measurable objective in the Dune Sand Aquifer as 1 foot above the 2015 low groundwater levels recorded in monitoring wells in the groundwater elevation monitoring network near GDEs in the vicinity of the MGSA Area, based on potential significant and unreasonable impacts to GDEs. The specific Minimum Thresholds and Measurable Objectives designated for each RMS are indicated on Table 4-1. These values are adopted on an interim basis based on the rationale in Section 4.4.2.1, and will be updated as discussed in Chapter 7 based on a baseline biological assessment of the GDEs to address a data gap in the understanding of GDE response and sensitivity to groundwater elevation declines.

- **180-Foot and 400-Foot Aquifers** – MGSA has established the minimum threshold at 1 foot above historical low groundwater elevations measured in 2015, adjusted for local hydrogeologic conditions and corresponding measurable objectives for SVBGSA RMS near the area as discussed in Section 4.4.2 and summarized in Table 4-1. Measurable objectives are also summarized in Table 4-1, and were established to provide sufficient operational flexibility under

variable conditions consistent with the nearest SVBGSA RMS, and in several cases were similarly adjusted.

- **Deep Aquifer** – Because groundwater is not currently extracted from the Deep Aquifer in the MGSA Area and future construction of new supply wells is currently prohibited, minimum thresholds and measurable objectives were not established for the Chronic Lowering of Groundwater Levels sustainability indicator in this aquifer. The need to establish sustainable management criteria for the Deep Aquifer for the decline in groundwater levels sustainability indicator will be reassessed during future reviews and GSP updates.

Tables 5-1 through 5-4 identify the monitoring wells included in the groundwater elevation monitoring network for each aquifer, provide summary information regarding these wells. These tables include wells utilized to assess groundwater occurrence, flow directions and hydraulic gradients, as well as RMS designated in Chapter 4. Boring logs and well completion diagrams are provided in Appendix 5-A.

The MPWSP monitoring wells were installed to monitor the effects of pumping the test slant well. The locations of the MPWSP monitoring wells are shown on Figure 5-2. Each monitoring location from MW-1 to MW-9 consists of a cluster of three wells (the MW-2 well cluster was not constructed). The individual wells in each cluster were drilled to monitor responses in the Dune Sand Aquifer (shallow well, *e.g.* MW-1S), 180-Foot Aquifer (moderate depth well, *e.g.* MW-1M), and 400-Foot Aquifer (deep well, *e.g.* MW-1D). Each of the MPWSP monitoring wells is equipped with a water level transducer that logs information at 5- to 15-minute intervals. Three of the existing MPWSP well clusters (MW-1, MW-3, and MW-4) are located within the MGSA Area. MCWRA is currently planning the installation of five new monitoring well clusters to provide additional coverage to monitor the hydrogeological effects of the MPWSP, if it is implemented (Zidar and Feeney 2019). These proposed well cluster locations have been preliminarily named MW-A through MW-E and are shown on Figure 5-2. Once installed, the new monitoring well clusters would be added to the existing monitoring network for the purposes of this MGSA GSP.

The USGS monitoring wells include two clusters of nested wells screened at differing intervals within the Deep Aquifer system. Information regarding the nested USGS wells is presented on Table 5-4, and the location of the nested wells is shown on Figure 5-2. The USGS wells are located approximately ½ mile south of the MGSA Area, and are equipped with pressure transducers and monitored quarterly by MCWRA. MCWRA will conduct monitoring of seven other Deep Aquifer wells as part of the MMRP. Locations of these wells are shown on Figure 5-2, and well construction and monitoring information is presented in Table 5-4. Although these other monitoring wells are not currently equipped with water level transducers, MCWRA plans to install transducers.

The current CASGEM monitoring network proposed in the SBVGSA GSP consists of 23 wells with publicly available data within the 180/400 Foot Aquifer Subbasin. As a voluntary program, MCWRA based the CASGEM network primarily on wells that were owned and monitored by MCWRA prior to initiation of the CASGEM program. The MGSA GSP will consider information from these CASGEM wells to interpret

the regional setting for its local groundwater monitoring program; however, these wells will not be part of the monitoring network for this GSP.

5.2.2 ADEQUACY OF THE MONITORING NETWORK

Regulation Requirements:
§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.
§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.

Each MPWSP monitoring well cluster, both existing and planned for installation in the future, includes wells with generally similar depths and screen intervals completed in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer. Overall, with the planned additions, the MPWSP monitoring well network will include 40 monitoring wells within and adjacent to the MGSA Area (Tables 5-1 to 5-3 and Figure 5-2). The existing and proposed monitoring well clusters are designed and distributed to assess the potential groundwater level effects of groundwater extraction within the MGSA Area. The nearest existing Deep Aquifer monitoring wells are approximately ½ mile from the MGSA Area; however, no groundwater extraction from the Deep Aquifer using wells completed in the MGSA Area is anticipated.

Specific considerations related to the adequacy and sufficiency of the MGSA GSP groundwater elevation monitoring network include the following:

- **Dune Sand Aquifer** – The existing (and planned) MPWSP monitoring wells completed in the Dune Sand Aquifer and included in the MGSA GSP groundwater elevation monitoring network will provide relatively broad coverage to assess potential groundwater elevation declines associated with groundwater extraction in the MGSA Area, potential reduction of groundwater storage in the low total dissolved solids (TDS) zone in the DSA, changes in the low-TDS zone gradients and thickness that could portend advancing seawater intrusion, potential depletion of interconnected surface water, and potential adverse effects on beneficial groundwater users including GDEs.

- **180-Foot Aquifer** – The existing (and planned) MPWSP monitoring wells completed in the 180-Foot Aquifer and included in the MGSA GSP groundwater elevation monitoring network provide relatively broad coverage to assess potential groundwater level decline, interference drawdown effects to existing supply wells and net gradient changes. However, the length of the screened intervals of these wells (average 110 feet for existing wells) precludes assessment of gradient changes between the upper and lower 180-Foot Aquifer or thinning of the low TDS zone within this aquifer. MCWD will review the general adequacy of the monitoring well networks in the area to support the GSP being developed for the Monterey Subbasin. MGSA will review the outcome of this analysis and any additional studies, and the monitoring program of this GSP may be refined if needed to facilitate inter-basin coordination of groundwater monitoring programs.

- **400-Foot Aquifer** – The existing (and planned) MPWSP monitoring wells completed in the 400-Foot Aquifer and included in the MGSA GSP groundwater elevation monitoring network provide broad coverage to assess potential groundwater level decline, interference drawdown effects to existing supply wells, and gradient changes. Coverage is limited to the upper portion of the 400-Foot Aquifer.

- **Deep Aquifer** – The six existing nested USGS monitoring wells completed in the Deep Aquifer, and an additional eight supply wells included in the MGSA GSP groundwater elevation monitoring network cover a considerable area surrounding the MGSA Area; however, the Deep Aquifer is a complex system that is 1,300 feet thick. As such, these wells provide an indication of groundwater elevation trends, but may not be sufficient to assess gradients. MGSA will cooperate with planned efforts by MCWRA, SVBGSA and MCWD GSA to further investigate and monitor the Deep Aquifer during GSP implementation.

5.2.3 Density of Monitoring Sites and Frequency of Measurements

Regulation Requirements:

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

Based on DWR's SGMA regulations and the Best Management Practices (BMPs) published by DWR on monitoring networks (DWR 2016d), a visual analysis of the proposed MGSA GSP monitoring network was performed using professional judgment to evaluate whether there are data gaps in the groundwater elevation monitoring network in terms of density and frequency of measurements. While there is no definitive requirement on monitoring well density, DWR's BMPs cite several studies (Heath 1976, Sophocleous 1983, Hopkins 1994) that recommend 0.2 to 10 wells per 100 square miles for basin-wide groundwater management programs. The BMPs note that professional judgment should be used to design the monitoring network to account for high-pumping areas, proposed projects, and other subbasin specific factors.

The MGSA Area encompasses approximately 372 acres and is proposed as the location for the extraction of 17,400 acre-feet/year (AFY) of groundwater from slant wells screened in the Dune Sand Aquifer and 180-Foot Aquifer stratigraphic intervals for the MPWSP (HWG 2017). This proposed high rate of groundwater extraction at a single site is unique in the area, and assessing potential undesirable results associated with this extraction rate requires a relatively denser monitoring network and monitoring frequency than for the general regional groundwater management applications contemplated in DWR's BMPs. As described in previous subsections, the monitoring well network adopted for the MGSA GSP, if all wells are installed as proposed, will ultimately consist of up to 13 monitoring wells in each of the

Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer. These wells are (or will be) equipped with pressure transducers and will be monitored at least quarterly. The frequency and density of measurements is adequate for assessing potential effects that could lead to undesirable results in this setting; however, as discussed previously, the vertical distribution of monitoring points in the 180-Foot Aquifer is limited.

The six USGS monitoring wells and the other eight wells used to monitor the Deep Aquifer also are (or will be) equipped with pressure transducers and are monitored quarterly, which is an adequate monitoring frequency. These wells provide relatively good coverage around the MGSA Area; however, because of the thickness and complexity of the Deep Aquifer they may be insufficient to assess lateral gradients. Regionally, the monitoring well density in the Deep Aquifer has been identified by SVBGSA and MCWRA as being insufficient to assess conditions in this aquifer system (SVBGSA 2019, MCWRA 2017a). MCWRA, SVBGSA and MCWD GSA are discussing plans to investigate the Deep Aquifer system in the Salinas Valley. It is anticipated that the investigation results will provide information regarding the nature and hydraulic properties of the Deep Aquifer. Specifically, the groundwater flow patterns in the Deep Aquifer, the interconnection between the disparate aquifer units in this system, how they are recharged, and the extent of potential leakance from the overlying upper aquifer system is expected to be addressed. No specific scope or schedule has been proposed at this time. MGSA will provide comments on the scope and results of this study and incorporate the results into a future update of the MGSA GSP.

5.2.4 Additional Monitoring Network Information

5.2.4.1 Scientific Rationale for Site Selection

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(1) Scientific rationale for the monitoring site selection process.

The MPWSP monitoring wells, both existing and planned for installation in the future, are adopted as the MGSA GSP groundwater elevation monitoring network because the wells are specifically designed and completed to monitor the effects of groundwater withdrawals associated with the MPWSP in the Dune Sand Aquifer, the 180-Foot Aquifer, and the 400-Foot Aquifer. The proposed additional well locations were designated by MCWRA under the MMRP for that project to address data gaps (CPUC 2018, MCWRA 2019e). Monitoring of the Deep Aquifer will be accomplished using wells constructed by USGS to investigate and characterize the Deep Aquifer at multiple depth intervals, and augmented with other available wells monitored by MCWRA.

The CASGEM network consists of much more widely distributed wells that are of limited use for managing groundwater in the MGSA Area but provide an informative regional context. For this reason, the CASGEM well information will be used only as necessary to augment data from the MPWSP and USGS wells. Information from other wells in the MCWRA network monitored as part of the MMRP will be used to interpret the regional setting for MGSA's local groundwater monitoring program.

5.2.4.2 CONSISTENCY WITH DATA AND REPORTING STANDARDS

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

SGMA requires certain data and reporting standards for groundwater monitoring wells that are used for GSP purposes. Relevant standards include the following:

- Field measurements of elevations of groundwater and land surface shall be measured and reported in feet to an accuracy of at least 0.1 feet relative to NAVD88;
- Geographic locations shall be reported in latitude and longitude coordinates in decimal degrees to five decimal places, to a minimum accuracy of 30 feet relative to NAD83;
- A description of well use, such as public supply, irrigation, monitoring, etc.;
- Casing perforations, borehole depth, and total well depth;
- Well completion reports, if available, from which the names of private owners have been redacted;
- Geophysical logs, well construction diagrams, or other relevant information if available;
- Identification of principal aquifers monitored; and
- Other relevant well construction information, such as well capacity, casing diameter, or casing modifications, as available.

The MPWSP and USGS wells that comprise the monitoring network for the MGSA GSP meet all of these relevant reporting standards as shown in Tables 5-1 through 5-4 and Appendix 5.A.

5.2.5 MONITORING PROTOCOLS

Regulation Requirements:
§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:
(a) Monitoring protocols shall be developed according to best management practices.
(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.
(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.
§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Chapter 4 of the MCWRA CASGEM monitoring plan (MWCRA 2015) includes a description of the monitoring procedures employed by that agency. These CASGEM groundwater elevation monitoring

protocols will be utilized by MCWRA to implement their monitoring program. The monitoring protocols are included in Appendix 5.B. Groundwater elevation data are currently collected both by hand and using automated pressure transducers. The monitoring protocols established by MCWRA cover multiple monitoring methods for collection of data by hand and by automated pressure transducers. Data collected by MCWRA are anticipated to be provided to MGSA for this GSP.

5.2.6 USE OF GROUNDWATER ELEVATIONS AS PROXY FOR OTHER SUSTAINABILITY INDICATORS

Regulation Requirements:

§354.36(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:

1) Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.
2) Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.

§354.36(c) The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.

MGSA will use groundwater elevations as a proxy to monitor for the Land Subsidence and Depletion of Interconnected Surface Water sustainability indicators. As discussed in Section 4.8.2, the risk of land subsidence results from lowered groundwater elevations, specifically when groundwater elevations decrease to levels below the lowest historical water elevations, which leads to the depressurization and consolidation of fine-grained sediments. When groundwater elevations fluctuate within the range of historical conditions, the alluvial layers are not subject to effective stress greater than historical conditions and therefore are generally not at significant risk of subsidence.

As discussed in Section 4.9.2, groundwater elevations in the Dune Sand Aquifer will be used to monitor potential effects to interconnected surface waters (ISW) and GDEs. Change in the potential relationship between groundwater and ISW is directly proportional to the induced gradient changes resulting from groundwater drawdown in shallow aquifers. Similarly, the interaction between groundwater elevations and GDEs is strongly correlated when the GDEs include wetlands, or when groundwater-dependent vegetation cannot adequately adapt to changing groundwater elevations.

5.2.7 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:
1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring.

(d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:
1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The potential data gaps identified for the MGSA GSP groundwater elevation monitoring network are as follows:

- **Groundwater elevation and quality data in the MGSA Area** – The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer and assess recent trends in seawater intrusion. The installation of monitoring well clusters at five additional locations by MCWRA as proposed (and as revised if necessary) will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Interconnection between the Salinas River and the Dune Sand Aquifer and 180-Foot Aquifer** – Limited data are available to assess the degree to which the Salinas River is connected to the underlying groundwater systems (Dune Sand Aquifer and 180-Foot Aquifer). This data gap will be addressed in collaboration with SVBGSA's efforts to assess surface-groundwater interaction along the river regionally through monitoring and use of the Salinas Valley Integrated Hydrologic Model (SVIHM). Locally, MGSA will evaluate potential interconnection between the Dune Sand Aquifer and the 180-Foot Aquifer and the Salinas River by examining river stage measurements and the groundwater elevations in the MW-6 and MW-9 well clusters.

- **Deep Aquifer system** – Deep Aquifer monitoring wells near the MGSA area are present at 10 locations, with multiple-depth completions at two locations. Although this network provides relatively well dispersed coverage laterally near the MGSA Area, the Deep Aquifer is relatively thick (1,300 feet) and the existing monitoring well network may be inadequate to reliably assess groundwater gradients. Groundwater extraction from the Deep Aquifer occurs outside the MGSA Area within the portions of the Subbasin managed by MCWD GSA and SVBGSA. These

agencies will play the primary role in investigating and monitoring the Deep Aquifer in this area, and MGSA will cooperate with and support their actions, including expansion of the monitoring well network, to incorporate new wells, if appropriate.

- **Depth discrete groundwater data** – Certain wells in the 180-Foot Aquifer and 400-Foot Aquifer were constructed with very long screened intervals (e.g., over 100 feet in many cases), which introduces uncertainty with respect to the specific aquifer horizon monitored by the well, and the interpretation of local groundwater gradients. This data gap will be addressed as necessary during implementation of the GSP, in collaboration with MCWD GSA. The need to address this data gap may depend on whether the monitoring data indicate that the triggers for the management actions described in Chapter 6 are being exceeded, and whether more vertically discrete data are needed for the implementation and monitoring of those management actions.

5.3 REDUCTION IN GROUNDWATER STORAGE

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(2) Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.

Regionally, reduction in storage in the Subbasin's aquifers has historically occurred and is ongoing due to groundwater production for agricultural, municipal, and domestic use that exceeds the long-term sustainable yield of the Subbasin and the absence of viable alternative sources of water supply. As described in Chapter 3, a large groundwater depression has developed north of Salinas and is apparent on both the 180-Foot/Shallow East Side Aquifers and 400-Foot/Deep East Side Aquifer maps, where elevations are generally -80 to -120 feet msl, and has led to other undesirable results. As a result, less groundwater in storage is available as a buffer against surface water supply shortfalls without causing undesirable results, most notably seawater intrusion. The sustainability indicator for Reduction in Groundwater Storage is evaluated by monitoring groundwater elevations, performing induction logging and collecting extraction data from groundwater users within the Subbasin on an annual basis. The regulations require a network of monitoring wells sufficient to provide an estimate of the change in annual groundwater in storage.

5.3.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36
§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

Because the local tools to further assess the MGSA Area component of the Subbasin-wide sustainable yield are not yet available, this GSP adopts SVBGSA's basin-wide sustainable yield estimate of 112,000 AFY as a minimum threshold, supplemented locally with the following interim minimum threshold

related to the low-TDS groundwater zone near the MGSA Area in order to prevent undesirable results from groundwater extraction in the MGSA Area:

- A decrease in the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers as measured by induction logging.

The regional minimum threshold applies to pumping of natural recharge only. Pumping of intentionally recharged water that is not part of the natural recharge is not considered when compared against the minimum threshold. SVBGSA's calculations account for current land use, future urban growth, and anticipated reasonable climate change. Seawater intrusion (i.e., seawater inflow volume) is not considered part of the sustainable yield. SVBGSA states the sustainable yield is an estimate only and will be updated as additional studies are undertaken and data are compiled (e.g., to address identified data gaps when the SVHM becomes available). The local interim minimum threshold is adopted to prevent significant and unreasonable impacts to GDEs, seawater intrusion, groundwater quality degradation, and potential harm to overlying groundwater right holders, while the data gaps regarding the sustainable yield are addressed as discussed in Chapters 6 and 7, and until a local sustainable yield volume can be determined. It is based on assessment of the amount of low-TDS groundwater in storage, which has been determined to be related to these other sustainability indicators.

The existing (and planned) MPWSP monitoring wells will serve as the MGSA GSP groundwater storage monitoring network. Well information is provided on Tables 5-1 through 5-3, the boring logs and well completion diagrams are provided in Appendix 5.A, and the locations of the MPWSP monitoring wells are shown on Figure 5-2. Groundwater extraction data for the MGSA Area will be obtained from pumpers and compiled. MGSA will prepare annual estimates of the changes in low-TDS groundwater in storage near the MGSA. This estimate will be conducted based on annual induction logging conducted by MCWRA, and will be used to assess changes in the amount of low-TDS water in storage in the aquifer system. Finally, MGSA will estimate of the amount of low-TDS groundwater withdrawn annually from the aquifer system based on pumping and water quality data provided by pumpers within the MGSA Area. The estimates will be made using volume and mass balance calculations, and supported by modeling and assessment of water quality data as necessary. Data will be provided to SVBGSA for consideration in their annual assessment of groundwater storage reduction.

5.3.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.

3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation monitoring network is discussed in Section 5.2.2. Groundwater extraction within the MGSA Area will be metered and reported by extractors, and groundwater extraction from wells in the adjacent areas is reported to and complied by MCWRA. These components together result in an adequate monitoring network for the purpose of assessing potential groundwater storage changes. The density and frequency of groundwater elevation measurements in the MPWSP wells is discussed in Section 5.2.3. Groundwater extraction data is compiled annually, which is adequate to allow interpretation of the nature and cause of potential volume changes.

Procedures and examples of the use of induction logging to assess salinity contrast distributions and changes are provided by Zidar and Feeney (2019) and are included as Appendix 5.D. Induction logging will be conducted annually at each of the nested MPWSP monitoring well locations. Vertical contrasts from borehole geophysical logs can typically be identified to a resolution of approximately 5 feet. The inherent uncertainty in the storage change estimates will be assessed and discussed; the certainty of estimates may range from order of magnitude to more refined volume estimates.

5.3.3 Additional Monitoring Network Information

5.3.3.1 Scientific Rationale for Site Selection

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(1) Scientific rationale for the monitoring site selection process.

The scientific rationale for the selection of sites for the groundwater storage monitoring network is the same as for the groundwater elevation monitoring network discussed in Section 5.2.4.1. Induction logging will be used to assess the vertical distribution of groundwater of varying salinity at each well cluster. Induction logging is a geophysical method analogous to AEM that is often used to assess salinity distribution and changes in wells. Induction logging each nested MPWSP well site will provide a vertical profile of salinity distribution in the upper aquifer system to the approximate maximum depth of the low-TDS zone across the MGSA Area and eastward, at a lateral spacing that is suitable for assessment of the approximate change of low-TDS water in storage.

5.3.3.2 Consistency with Data and Reporting Standards

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP monitoring network are consistent with the reporting standards required by SGMA. Reductions in low-TDS groundwater storage

will be estimated based on the calculated changes in storage volumes in acre-feet of groundwater and pumping volumes will be reported in acre-feet per year. .

5.3.4 MONITORING PROTOCOLS

Regulation Requirements:

§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Chapter 4 of the MCWRA CASGEM monitoring plan (MWCRA 2015) includes a description of the monitoring procedures employed by that agency. These CASGEM groundwater elevation monitoring protocols will be utilized by MCWRA to implement their monitoring program. The monitoring protocols are included in Appendix 5.B. Procedures and examples of the use of induction logging to assess salinity contrast distributions and changes are provided by Zidar and Feeney (2019) and are included as Appendix 5.D.

MGSA will coordinate with SVBGSA and MCWRA to acquire information regarding groundwater withdrawals that are relevant to the MGSA Area. Pumping volume and water quality data for groundwater extraction within the MGSA Area will be obtained directly from the extractors and from MCWRA. SVBGSA has stated that it will download data directly from the State's Drinking Water Information Clearinghouse website ("Drinking Water Information Clearinghouse") regarding municipal groundwater users and small water systems. No other protocols are required. For agricultural groundwater users, SVBGSA will work with MCWRA to develop a protocol for sharing data that is currently reported under County Ordinance 3717.

5.3.5 USE OF GROUNDWATER ELEVATIONS AS PROXY FOR OTHER SUSTAINABILITY INDICATORS

Regulation Requirements:

§354.36(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:

1) Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.
2) Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.

§354.36(c) The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.

As discussed in Section 5.3.1, groundwater elevations will be used in combination with induction logging and extraction volumes to estimate changes in the volume of low-TDS groundwater in storage as an interim proxy for sustainable yield volume estimates. The relationship between the amount of low-TDS

groundwater in storage and potential local undesirable results related to chronic decline in groundwater levels (significant and unreasonable impacts to GDEs), seawater intrusion and water quality degradation is discussed in Section 3.5.1.

5.3.6 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The following data gaps associated with the monitoring network in the vicinity of the MGSA Area are relevant to this sustainability indicator:

- **Sustainable yield** – SVBGSA indicates that its Subbasin-wide minimum threshold and sustainable yield volume of 112,000 AFY is an estimate and subject to refinement and update after the SVIHM becomes available. Similarly, the modeling tools needed to assess the local sustainable yield in the MGSA Area are expected to become available during the early phases of GSP implementation and will be used to address data gaps in the local and regional sustainable yield estimates as discussed in Chapters 6 and 7.

- **Groundwater extraction data** – The CEMEX well is currently the only extraction well in the MGSA Area of the Subbasin. MGSA will coordinate with SVBGSA and MCWD GSA to determine the local contribution to the sustainable yield from groundwater extraction in the MGSA Area, which is the amount of groundwater that can be withdrawn annually over a period of time without causing undesirable results within or near the MGSA Area.

- **Groundwater elevation and quality data in the MGSA Area** – The available data to characterize groundwater elevations in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer and assess recent trends in seawater intrusion. The installation of monitoring well clusters at five additional locations by MCWRA as proposed (and as revised if necessary) will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Depth discrete groundwater data** – Certain wells in the 180-Foot Aquifer and 400-Foot Aquifer were constructed with very long screened intervals (e.g., over 100 feet in many cases), which introduces uncertainty with respect to the specific aquifer horizon monitored by the well, and the interpretation of local groundwater gradients. This data gap will be addressed as necessary during implementation of the GSP, in collaboration with MCWD GSA. The need to address this data gap may depend on whether the monitoring data indicate that the triggers for the management actions described in Chapter 6 are being exceeded, and whether more vertically discrete data are needed for the implementation and monitoring of those management actions.

5.4 SEAWATER INTRUSION

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(3) Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.

Seawater intrusion will be evaluated using the MPWSP monitoring well network to collect a combination of groundwater quality and induction logging data to interpolate chloride isocontours and provide additional data regarding the nearshore processes that drive seawater intrusion regionally, including density-driven flow and preferential pathways for vertical migration.

5.4.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36
§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

MGSA established the following minimum thresholds for significant and unreasonable seawater intrusion in this GSP:

- **Dune Sand Aquifer**. In compliance with SWRCB Resolution Nos. 88-63 and 68-16, this GSP defines the minimum threshold for significant and unreasonable seawater intrusion into the Dune Sand Aquifer as migration of the 1,700 mg/L chloride isocontour (equivalent to 3,000 mg/L TDS) beyond the location determined by Gottschalk *et al.* (2018) (Figure 4-2).

- **180-Foot and 400-Foot Aquifers**. This GSP adopts the SVBGSA minimum threshold of significant unreasonable seawater intrusion beyond the position of the 500 mg/L chloride concentration isocontour interpolated by MCWRA in 2017 (Figure 4-2).

- **Deep Aquifer.** In compliance with SWRCB Resolution No. 68-16, this GSP defines significant and unreasonable seawater intrusion into the Deep Aquifer as migration of a 500 mg/L chloride isocontour into the Deep Aquifer landward of the western Subbasin boundary.

The following measurable objectives are established for Seawater Intrusion:

- **Dune Sand Aquifer**. The measurable objectives are established to equal the minimum threshold of maintaining the 1,700 mg/L chloride isocontour at its current location. The interim milestones are identical to the measurable objective.

- **180-Foot and 400-Foot Aquifers**. MGSA will collaborate with SVBGSA and support the measurable objective and interim milestones in the SVBGSA's GSP of moving the 500 mg/L chloride isocontour westward to Highway 1 by 2020.

- **Deep Aquifer.** The measurable objective for the Deep Aquifer will be to prevent significant and unreasonable seawater intrusion and maintain the location of the 500 mg/L chloride isocontour outside the seaward Subbasin Boundary. The interim milestones are identical to the measurable objective.

The following data are needed to assess compliance with the minimum thresholds:

- Groundwater quality data for chloride at various depths and locations over time form the primary basis for interpolation of chloride concentration isocontour maps to assess compliance related to this sustainability indicator.

To provide additional data regarding the nearshore processes that drive seawater intrusion regionally, including density-driven flow and preferential pathways for vertical migration, the following data will be collected:

- Groundwater elevation data are necessary to understand the lateral and vertical gradients that may drive seawater intrusion, and to assess gradients and drawdown in the area affected by pumping within the MGSA Area; and

- Induction logging data from each monitoring well location will be used as an additional data source to assess the lateral and vertical distribution of low-TDS and more highly saline groundwater.

As described in Section 5.2.1, the existing (and planned) MPWSP monitoring wells are included in the MGSA GSP seawater intrusion monitoring network. Well information is provided on Tables 5-1 through 5-4, the boring logs and well completion diagrams are provided in Appendix 5.A, and the locations of the MPWSP monitoring wells are shown on Figure 5-2.

5.4.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation and quality monitoring network is discussed in Section 5.2.2, and adequacy of the induction logging monitoring network is discussed in 5.3.2. The density and frequency of groundwater elevation and groundwater quality measurements in the MPWSP wells is discussed in Section 5.2.3 and 5.3.3. Given the spatial distribution of the low-TDS groundwater zone and the saline water intrusion wedge in the vicinity of the MGSA Area (Figures 3-21, 3-22 and 3-23) and the use of continuous induction logging at each well cluster, the locations and completion depths of the existing and proposed monitoring wells will provide a generally adequate monitoring network to assess the potential migration of the wedge both laterally and vertically. The data gap related to long screen intervals will partly addressed through the use of induction logging, and the need for additional vertically-delineated monitoring zones will be evaluated in cooperation with MCWD GSA during GSP implementation. The collection of quarterly or more frequent data meets or exceeds the standards normally applied for the assessment of seawater intrusion or solute plume migration.

Monitoring data from the Deep Aquifer wells will provide an indication as to whether the Deep Aquifer system in this area is being affected by seawater intrusion; however, the existing monitoring well network in the Deep Aquifer system may be insufficient to interpret groundwater gradients. In addition, the potential vertical leakance from overlying seawater intruded aquifers remains unknown. These data gaps have been proposed to be addressed by SVBGSA, MCWRA and MCWD GSA. The MGSA will cooperate with these investigative activities.

5.4.3 Additional Monitoring Network Information

5.4.3.1 Scientific Rationale for Site Selection

Regulation Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

(1) Scientific rationale for the monitoring site selection process.

As discussed above, the existing and proposed monitoring well network and monitoring frequency provide an adequate basis for assessment of chloride isocontour migration and potential water quality and gradient changes that could be indicative of active seawater intrusion in the vicinity of the saline water intrusion wedge in this area. The Deep Aquifer well location and completions were selected by USGS to optimally investigate the hydrostratigraphy of the Deep Aquifer at this location, and are supplemented by additional Deep Aquifer wells in MCWRA's monitoring program.

5.4.3.2 CONSISTENCY WITH DATA AND REPORTING STANDARDS

Regulation Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP groundwater elevation and quality monitoring network are consistent with the reporting standards required by SGMA. Increases in seawater intrusion will be assessed by determining whether interpolated chloride isocontours, reported in mg/L for each of the principal aquifers, have moved.

5.4.4 MONITORING PROTOCOLS

Regulation Requirements:

§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

MCWRA has established protocols for collecting groundwater quality data from monitoring wells and analyzing those data for seawater intrusion. These protocols are also applied to collection of groundwater quality data from the MPWSP monitoring wells and the USGS Deep Aquifer wells. The groundwater quality data monitoring protocols are available in the Monterey County Quality Assurance Project Plan (QAPP) and included in Appendix 5.B. MCWRA also established chloride data contouring protocols to develop the isoconcentration contour map, provided in Appendix 5.C. Data collected by MCWRA in accordance with these protocols is anticipated to be provided to MGSA for this GSP. Induction logging will be performed in accordance with the procedures presented in Zidar and Feeney (2019) and included in Appendix 5.D.

5.4.5 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The following potential data gaps identified for the MGSA GSP groundwater elevation monitoring network are applicable to the Seawater Intrusion sustainability indicator:

- **Groundwater elevation and quality data in the MGSA Area**: The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer and assess recent trends in seawater intrusion. The installation of monitoring well clusters at five additional locations by MCWRA as proposed (and as revised if necessary) will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Interconnection between the Salinas River and the Dune Sand Aquifer and 180-Foot Aquifer**: Limited data are available to assess the degree to which the Salinas River is connected to the underlying groundwater systems (Dune Sand Aquifer and 180-Foot Aquifer). The available data suggest that seawater intrusion may be occurring through the bed of the Salinas River near the river mouth (Section 3.2.6.1, Figure 3-22), where the river may be tidally influenced. Decreased groundwater elevations in the Dune Sand Aquifer could result in additional seawater intrusion in this area. This data gap will be addressed in collaboration with SVBGSA's efforts to assess surface-groundwater interaction along the river regionally through monitoring and use of the SVIHM. Locally, MGSA will evaluate potential interconnection between the Dune Sand Aquifer and the 180-Foot Aquifer and the Salinas River by examining river stage measurements and the groundwater elevations in the MW-6 and MW-9 well clusters.

- **Deep Aquifer system:** The of Deep Aquifer monitoring wells may be insufficient to interpret groundwater gradients and may be insufficient to provide early warning of potential seawater intrusion. Groundwater extraction from the Deep Aquifer occurs outside the MGSA Area within

the portions of the Subbasin managed by MCWD GSA and SVBGSA. These agencies will play the primary role in investigating and monitoring the Deep Aquifer in this area, and MGSA will cooperate with and support their actions.

- **Depth discrete groundwater data** – Certain wells in the 180-Foot Aquifer and 400-Foot Aquifer were constructed with very long screened intervals (e.g., over 100 feet in many cases), which introduces uncertainty with respect to the specific aquifer horizon monitored by the well, and the interpretation of local groundwater gradients. This data gap will be addressed as necessary during implementation of the GSP, in collaboration with MCWD GSA. The need to address this data gap may depend on whether the monitoring data indicate that the triggers for the management actions described in Chapter 6 are being exceeded, and whether more vertically discrete data are needed for the implementation and monitoring of those management actions.

5.5 WATER QUALITY DEGRADATION

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.

Groundwater quality degradation will be measured from the monitoring well network using groundwater quality monitoring, including groundwater sampling and analysis, the use of specific conductance sensors, and annual induction logging to assess the lateral and vertical distribution of TDS and chloride.

5.5.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36
§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

The following minimum thresholds were established for the groundwater quality degradation sustainability indicator:

- Significant and unreasonable degradation of water quality in the low-TDS groundwater zone in the Dune Sand, 180-Foot and 400-Foot Aquifers is defined as lateral or vertical migration of the 3,000 mg/L TDS isocontour beyond the location established by the 2018 AEM study (Gottschalk *et al.* 2018).

- Significant and unreasonable degradation of water quality in the Deep Aquifer is defined as exceedance of the TDS or chloride SMCL in one or more public supply wells completed in the Deep Aquifer near the MGSA Area.

- Significant and unreasonable migration of a contamination plume is defined by the following minimum threshold:
    - Migration or spread of the portion of a contamination plume that exceeds applicable water quality objectives by more than 100 feet toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.

The following measurable objectives have been established for groundwater quality degradation:

- The measurable objective for degradation of water quality in the low-TDS groundwater zone are defined to be the same as the minimum threshold, which is the 2018 vertical and lateral position of the 3,000 mg/L TDS isocontour in the Dune Sand, 180-Foot and 400-Foot Aquifers, as determined by the 2018 AEM survey (Gottschalk *et al.* 2018).
- The measurable objective for degradation of water quality in the Deep Aquifer is no supply wells with MCL or SMCL exceedances for TDS or chloride.
- The measurable objective for migration of a contamination plume is defined by the following:
    - An observable spread of the portion of a contamination plume that exceeds applicable water quality objectives over two or more consecutive monitoring events toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.

The following data are needed to assess compliance with these thresholds:

- Groundwater quality data for TDS and chloride at various depths and locations over time within the low-TDS groundwater zone form the primary basis for assessing compliance related to this sustainability indicator in the Dune Sand, 180-Foot and 400-Foot Aquifers;
- Induction logging data from each monitoring well location will be used to additionally assess the lateral and vertical distribution of TDS and chloride at each MPWSP monitoring well cluster and assess changes; and
- Groundwater level contour maps and plume maps for the OUCTP area of the Fort Ord Superfund Site.

Summary information for the groundwater elevation and quality monitoring network that will be used to assess this sustainability indicator is presented in Tables 5-1 through 5-3, and boring logs and well completion diagrams are provided in Appendix 5-A. The location of these monitoring wells is shown on Figure 5-2, which also presents the locations of five additional monitoring well clusters that are proposed to be installed by MCWRA.

5.5.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.
§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.
§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:
1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation and quality monitoring network is discussed in Section 5.2.2. The density and frequency of groundwater elevation and quality measurements in the MPWSP wells is discussed in Section 5.2.3 and 5.3.3, and the adequacy of the induction logging monitoring network is discussed in 5.3.2. Given the spatial distribution of the low-TDS zone in the vicinity of the MGSA Area (Figures 3-21, 3-22 and 3-23) and the use of continuous induction logging at each well cluster, the locations and completion depths of the existing and proposed monitoring wells will provide a generally adequate monitoring network to assess the potential migration of this zone both laterally and vertically. The data gap related to long screen intervals will partly addressed through the use of induction logging, and the need for additional vertically-delineated monitoring zones will be evaluated in cooperation with MCWD GSA during GSP implementation. The collection of quarterly or more frequent data meets or exceeds the standards normally applied for the assessment of seawater intrusion or solute plume migration.

5.5.3 Additional Monitoring Network Information

5.5.3.1 Scientific Rationale for Site Selection

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(1) Scientific rationale for the monitoring site selection process.

As discussed above, the existing monitoring well network and monitoring frequency provide an adequate basis for assessment of potential water quality changes that could be indicative of water quality degradation in the low-TDS groundwater zone.

5.5.3.2 Consistency with Data and Reporting Standards

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP groundwater elevation and quality monitoring network are consistent with the reporting standards required by SGMA. The

groundwater quality minimum thresholds specifically incorporate state and federal standards for drinking water and applicable Water Quality Standards incorporated into the Regional Water Quality Control Board's Water Quality Control Plan, including SWRCB Resolution Nos. 88-63 and 68-16.

5.5.4 MONITORING PROTOCOLS

Regulation Requirements:

§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

MCWRA has established protocols for collecting groundwater quality data from monitoring wells and analyzing those data for the water quality effects of seawater intrusion. These protocols are also applied to collection of groundwater quality data from the MPWSP monitoring wells and the USGS Deep Aquifer wells. The groundwater quality data monitoring protocols are available in the Monterey County Quality Assurance Project Plan (QAPP) and included in Appendix 5.B. Data collected by MCWRA in accordance with these protocols is anticipated to be provided to MGSA for this GSP. Induction logging will be performed in accordance with the procedures presented in Zidar and Feeney (2019) and included in Appendix 5.D.

5.5.5 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The following potential data gaps identified for the MGSA GSP groundwater elevation monitoring network are applicable to the Degradation of Groundwater Quality sustainability indicator:

- **Groundwater elevation and quality data in the MGSA Area**: The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer and assess recent trends in seawater intrusion. The installation of monitoring well clusters at five additional locations by MCWRA as proposed (and as revised if necessary) will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Depth discrete groundwater data** – Certain wells in the 180-Foot Aquifer and 400-Foot Aquifer were constructed with very long screened intervals (e.g., over 100 feet in many cases), which introduces uncertainty with respect to the specific aquifer horizon monitored by the well, and the interpretation of local groundwater gradients. This data gap will be addressed as necessary during implementation of the GSP, in collaboration with MCWD GSA. The need to address this data gap may depend on whether the monitoring data indicate that the triggers for the management actions described in Chapter 6 are being exceeded, and whether more vertically discrete data are needed for the implementation and monitoring of those management actions.

5.6 LAND SUBSIDENCE

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(5) Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.

Section 354.28(d) of the Regulations states that "*an Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence*." The MGSA GSP uses groundwater elevation data as a proxy for land subsidence measurements based on the rationale described in Section 4.8.2. Groundwater elevation proxy minimum thresholds will be directly measured from the monitoring well network. In addition, in collaboration with SVBGSA, MGSA will obtain and review subsidence measurements and remote sensing data from DWR and other entities.

5.6.1 DESCRIPTION OF MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.
§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

This GSP adopts the following groundwater elevation minimum thresholds that serve as a proxy for land subsidence minimum thresholds:

- **Dune Sand Aquifer** – The minimum thresholds for the Dune Sand Aquifer are established as an elevation of 1 foot above the 2015 low groundwater levels recorded in Dune Sand Aquifer monitoring wells near identified GDEs in the vicinity of the MGSA Area, and presented for wells MW-4S, 7S and 8S in Table 4-1. These minimum thresholds will be updated as warranted based on future planned investigations to address existing data gaps in the relationship between groundwater level declines and GDE response, as discussed in Chapter 7.

- **180-Foot and 400-Foot Aquifers** – The minimum thresholds for the 180-Foot and 400-Foot Aquifers are 1 foot above historical low groundwater elevations measured in 2015 as determined from analysis of the hydrographs included in Appendix 3.D. For RMS located near well 14S/02E-08M02, which is approximately 1 mile northeast of the MGSA Area, minimum thresholds were adjusted to better match the minimum threshold adopted by SVBGSA for the 400-Foot Aquifer at this location, and in the overlying 180-Foot Aquifer in accordance with existing vertical gradients. Values for RMS are presented in Table 4-1.

- **Deep Aquifer** – Because groundwater is not currently extracted from the Deep Aquifer in the MGSA Area, minimum thresholds and measurable objectives were not established for the Chronic Lowering of Groundwater Levels sustainability indicator in this aquifer and none are therefore adopted for subsidence.

This GSP adopts the following groundwater elevation measurable objectives that serve as a proxy for land subsidence minimum thresholds:

- **Dune Sand Aquifer.** MGSA adopts the above minimum thresholds as measurable objectives on an interim basis as data gaps are addressed and sustainable management criteria for GDEs are updated early during the GSP implementation process. Based on the limited amplitude of seasonal and inter-annual fluctuation in groundwater levels in the Dune Sand Aquifer and the planned schedule for data gap analysis, this approach allows for protection of GDEs while allowing near-term flexibility in groundwater management.

180-Foot and 400-Foot Aquifers – For the 180-Foot Aquifer, measurable objectives were initially established at an elevation that is 7.0 feet above the minimum threshold and for the 400-Foot Aquifer measurable objectives were initially set at 6.1 feet above the minimum threshold, in accordance with the operating range adopted under SVBGSA's GSP in the westernmost portion of the Subbasin. Elevations were then adjusted based on proximity to well 14S/02E-08M02 and local gradient data. Given that land subsidence is directly related to groundwater elevations and that the subsidence risk near the MGSA Area is relatively low, the MGSA GSP monitoring network for Land Subsidence will be the same monitoring network as that for Chronic Lowering of Groundwater Levels described in Section 5.2. Well information for the wells in the MGSA GSP monitoring network is provided on Tables 5-2 and 5-3, the boring logs and well completion diagrams are provided in Appendix 5.A, and the locations of the MPWSP monitoring wells are shown on Figure 5-2. No other monitoring is proposed, except for periodic review of subsidence measurement maps published by USGS, DWR, Jet Propulsion Laboratories (JPL) and others, including remote sensing InSAR data.

5.6.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation monitoring network is discussed in Section 5.2.2. The density and frequency of groundwater elevation measurements in the existing and proposed MPWSP wells is discussed in Section 5.2.3. Given the anticipated spatial distribution of drawdown associated with groundwater extraction in the MGSA Area, the locations and completion depths of the existing monitoring wells will provide an adequate monitoring network to assess the potential for subsidence related to groundwater level decline.

5.6.3 Additional Monitoring Network Information

5.6.3.1 Scientific Rationale for Site Selection

Regulation Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

(1) Scientific rationale for the monitoring site selection process.

In order to assess the potential for subsidence induced by pumping in the MGSA Area, groundwater elevation monitoring is needed at locations and depths where drawdown will be at maximum and where fine-grained aquitards could potentially be depressurized. The existing monitoring network of wells completed in the 180-Foot Aquifer and 400-Foot Aquifer meet this need.

5.6.3.2 Consistency with Data and Reporting Standards

Regulation Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP groundwater elevation and quality monitoring network are consistent with the reporting standards required by SGMA.

5.6.4 MONITORING PROTOCOLS

Regulation Requirements:

§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Chapter 4 of the MCWRA CASGEM plan (MWCRA 2015) includes a description of the monitoring procedures employed by that agency. These CASGEM groundwater elevation monitoring protocols will be utilized by MCWRA to implement the monitoring program that is adopted by this GSP. The MCWRA monitoring protocols are included in Appendix 5.B. Groundwater elevation data are currently collected both by hand and using automated pressure transducers. The monitoring protocols established by MCWRA cover multiple monitoring methods for collection of data by hand and by automated pressure transducers.

5.6.5 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

Although the available data suggest that the vicinity of the MGSA Area has not experienced significant subsidence, the data are reported to be insufficient to assess the potential future vulnerability of this area to future subsidence if groundwater extractions are increased. MGSA will work with SVBGSA to address this data gap as needed during GSP implementation. Given the relatively low risk of subsidence near the MGSA Area, the monitoring of groundwater elevations and review of remote sensing data periodically published by DWR, USGS or others should be an adequate monitoring program for this sustainability indicator.

5.7 DEPLETION OF INTERCONNECTED SURFACE WATER

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions.

Depletion of interconnected surface water is directly related to groundwater level decline in the uppermost aquifer system which is in contact with the stream or wetland being affected, in this case, the Dune Sand Aquifer. As such, the primary potential effect of concern associated with the decline of groundwater levels in the Dune Sand Aquifer is potential stress to GDEs. The minimum thresholds established for the groundwater level decline RMS are an adequate proxy for the depletion of interconnected surface water. Groundwater elevation minimum thresholds will be directly measured in shallow wells in the monitoring well network.

5.7.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(c)(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:
A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.
B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.
D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water. **§354.34(h)** The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.

This GSP adopts the following groundwater elevation minimum thresholds that serve as a proxy for depletion of surface water minimum thresholds:

- **Dune Sand Aquifer** – The minimum thresholds for the Dune Sand Aquifer are established as an elevation of 1 foot above the 2015 low groundwater levels recorded in Dune Sand Aquifer monitoring wells near identified GDEs in the vicinity of the MGSA Area, and presented for wells MW-4S, 7S and 8S in Table 4-1. These minimum thresholds will be updated as warranted based on future planned investigations to address existing data gaps in the relationship between groundwater level declines and GDE response, as discussed in Chapter 7. Measurable objectives are identical to minimum thresholds.

- **180-Foot, 400-Foot and Deep Aquifers** – Because these aquifers are not directly interconnected to surface water, no minimum thresholds or measurable objectives are established.

The following data are needed to assess compliance with these thresholds:

- To assess surface-groundwater interactions at the GDEs, shallow groundwater elevation data are needed proximal to the surface water resources being considered.
- The reliance by GDEs on groundwater, and their ability to adapt to groundwater elevation declines, is variable depending on the nature of the habitat and species involved. As discussed in Chapter 7, this has been identified as a data gap to be addressed during GSP implementation. The baseline biological conditions of the vernal ponds near the MGSA Area will be documented, and a biological monitoring program will be implemented to evaluate the effect of groundwater level changes on GDE habitat composition annually.

Summary information for the groundwater elevation and quality monitoring network that will be used to assess this sustainability indicator is presented in Table 5-1 and the boring logs and well completion diagrams are provided in Appendix 5.A. The locations of these monitoring wells are shown on Figure 5-2, which also presents the location of five additional monitoring well clusters that are proposed to be installed by MCWRA.

5.7.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation monitoring network is discussed in Section 5.2.2. The density and frequency of groundwater elevation measurements in the MPWSP wells is discussed in Section 5.2.3. The existing and proposed wells are sufficiently spread out through the area to assess drawdown distribution in the Dune Sand Aquifer that could affect vernal ponds.

The shallow Dune Sand Aquifer wells that are the RMS for this sustainability indicator are co-located with nested wells completed in the 180-Foot and upper 400-Foot Aquifers. In addition, two nested monitoring well clusters are located proximal to the Salinas River (MW-6 and MW-9). As discussed in Section 4.9.2, the potential undesirable results from surface water depletion associated with pumping in the MGSA Area are only anticipated to be associated with vernal ponds, and not with depletion of flow

in the Salinas River. For this reason, the RMS do not include the wells located near the Salinas River and the existing RMS are considered adequate for sustainable groundwater management. However, interaction of groundwater extraction with the Salinas River is designated as a data gap and will be assessed in coordination with SVBGSA as discussed in Chapter 7. Groundwater level data collected from these wells, and from deeper wells in the remaining well clusters, will be used to further assess vertical hydraulic communication between the principal aquifers and surface-groundwater interaction along the Salinas River. This information may be used to refine the Hydrogeologic Conceptual Model, and the sustainable management criteria and monitoring networks may be refined in future updates of the GSP.

5.7.3 Additional Monitoring Network Information

5.7.3.1 Scientific Rationale for Site Selection

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(1) Scientific rationale for the monitoring site selection process.

The existing and proposed wells are sufficiently spread out in the Dune Sand Aquifer to assess groundwater level decline in areas that could be affected by groundwater extraction in the MGSA Area that are proximal to identified vernal pond GDEs. Biological surveys by a wetlands expert will allow assessments of GDE habitat composition and vigor to be made, as discussed in Chapter 7, will establish baseline conditions, and will allow correlations to be established between groundwater levels in the Dune Sand Aquifer and ecosystem responses in the GDEs .

5.7.3.2 Consistency with Data and Reporting Standards

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP groundwater elevation monitoring network are consistent with the reporting standards required by SGMA. Reporting standards for biological survey data have not been established.

5.7.4 Monitoring Protocols

Regulation Requirements:
§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:
(a) Monitoring protocols shall be developed according to best management practices.
(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.
(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.
§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Chapter 4 of the MCWRA CASGEM plan (MWCRA 2015) includes a description of the monitoring procedures employed by that agency. These CASGEM groundwater elevation monitoring protocols will be utilized by MCWRA to implement their monitoring program. The monitoring protocols are included in Appendix 5.B. Groundwater elevation data are currently collected both by hand and using automated pressure transducers. The monitoring protocols established by MCWRA cover multiple monitoring methods for collection of data by hand and by automated pressure transducers. Data collected by MCWRA are anticipated to be provided to MGSA for this GSP.

5.7.5 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

Regionally, the SVBGSP has identified surface-groundwater interaction along the Salinas River as a data gap. The available data evaluated in this GSP indicate that the lower reach of the Salinas River is likely in hydraulic communication with the Dune Sand Aquifer; however, the tools to evaluate the extent and nature of the interaction between the Dune Sand Aquifer and the river do not exist at this time. SVBGSA noted that the release of the calibrated USGS SVIHM will provide an important new tool and valuable additional data regarding the interconnection between the Salinas River and the Dune Sand Aquifer and other shallow aquifers, and the underlying 180-Foot Aquifer (SVBGSA 2019). Furthermore, SVBGSA has proposed a regional investigation to assess the level of river interconnection using existing shallow wells located adjacent to the Salinas River in combination with the SVIHM. MGSA will review the results of SVBGSA's investigation, perform supplemental local evaluations as needed, and incorporate them into updates of the MGSA GSP.

The following specific data gaps identified for the MGSA GSP groundwater level monitoring network are applicable to the Depletion of Interconnected Surface Water sustainability indicator:

- **Biological survey data for GDEs**: Limited current data are available to characterize wetland vegetation and habitat in and around the vernal ponds in the City of Marina and within the MGSA Area, and their potential sensitivity to pumping-induced drawdown. Such data are needed to assess the wetland habitat and any special-status plant and animal species present

and to determine if drawdown of shallow groundwater is affecting, or may affect, the GDEs. Completion of a baseline biological survey and then performance of a biological survey by a wetlands expert once a year for the first five years will address this data gap.

- **Groundwater elevation and quality data in the vicinity of GDEs**: The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to assess surface water-groundwater interactions for GDEs in vernal ponds within the City of Marina and in the MGSA Area. The installation of monitoring well clusters at five additional locations by MCWRA will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Groundwater elevation and quality data in the MGSA Area**: The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer and the 180-Foot Aquifer and assess spatial and temporal evidence for surface-groundwater interaction with the Salinas River and with GDEs (palustrine and emergent wetlands), especially to the northeast and southeast of the MGSA Area. The installation of monitoring well clusters at five additional locations by MCWRA will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

5.8 REPORTING MONITORING DATA TO THE DEPARTMENT

Regulation Requirements:

§ 352.6 Data Management System

Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin.

§354.40 Reporting Monitoring Data to the Department

Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.

A Microsoft Access DMS has been created to store GSP monitoring data in accordance with 23 CCR § 352.6, which requires that each GSA shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the GSP and monitoring of the Subbasin. MGSA's database has a simple structure which is shared with the DMS being developed by MCWD GSA in support of its GSP for the Monterey Subbasin, which abuts the MGSA Area to the south. In addition, MGSA plans to coordinate with database personnel from SVBGSA to assure compatibility with the DMS being developed by that agency. Both GSAs will rely extensively on the same monitoring data collected by MCWRA; therefore, it is anticipated that very little data transfer will actually need to occur. SVBGSA is considering development of a web-based DMS to facilitate basin-wide groundwater management. MGSA will cooperate with this effort, but will retain a relatively simple structure for its DMS that is not web-based.

MGSA's Access DMS includes the following information:

- Physical well data, including location, elevation, type, depth, aquifer, construction date, and details, and ownership information;
- Depth to water measurements, reference point elevations and groundwater elevation elevations;
- Well production data;
- Well chemical data for TDS, chloride, specific conductance, and other selected general mineral parameters;
- Precipitation data including meteorological station location and monthly precipitation totals; and
- Gaging station location, stage, and discharge data.

MGSA's DMS will be periodically updated with monitoring data. It will be used to analyze and compare data, evaluate statistical relationships and trends, and provide model inputs and calibration datasets if needed, and create data tables and other outputs. In addition, information in the database has been migrated into a geodatabase in ESRI ArcGIS format to facilitate spatial analysis, production of graphics and communication with regional GIS users. The Geodatabase also includes various data for various mapped layers including:

- Topography, surface infrastructure, jurisdictional boundaries, land use designations, protected areas, and disadvantaged community areas;
- Hydrologic features and GDEs;
- Geologic and soils information;
- Groundwater elevation data;
- Groundwater chemical data including chloride and TDS isoconcentration contour data; and
- Geophysical investigation data.

The Access DMS and geodatabase will be used in combination to support adaptive management during GSP implementation and reporting to DWR. In accordance with 23 CCR § 352.6, a copy of the monitoring data will be included in the Annual Report and submitted electronically on forms provided by DWR.

TABLE 5-1. WELL INFORMATION AND DATA COLLECTED FOR WELLS IN THE DUNE SAND AQUIFER

Well Name	Latitude	Longitude	Well Type	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
MW-1S	36.71314	-121.80588	Monitoring	105	30.51	55	95	WL, WQ	C, C
MW-3S	36.71280	-121.80375	Monitoring	100	37.16	50	90	WL, WQ	C, C
MW-4S	36.71173	-121.79876	Monitoring	110	41.96	60	100	WL, WQ	C, C
MW-5S	36.71798	-121.77461	Monitoring	93	80.25	43	83	WL, WQ	C, C
MW-6S	36.67713	-121.74723	Monitoring	70	35.89	30	60	WL, WQ	C, C
MW-7S	36.70626	-121.78927	Monitoring	90	50.64	60	80	WL, WQ	C, C
MW-8S	36.72648	-121.78753	Monitoring	90	19.96	40	80	WL, WQ	C, C
MW-9S	36.73373	-121.77935	Monitoring	120	18.42	30	110	WL, WQ	C, C
MW-AS	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-BS	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-CS	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-DS	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-ES	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-5S	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MCWD MW#4	TBD	TBD	Monitoring	110	61	64	106	WL, WQ	C, C
MCWD MW#5	TBD	TBD	Monitoring	107	61	60	100	WL, WQ	C, C
MW-BW-76-A	TBD	TBD	Monitoring	50	17	20	50	TBD	TBD
MW-BW-84-A	TBD	TBD	Monitoring	65	19	24	64	TBD	TBD
MW-BW-83-A	TBD	TBD	Monitoring	68	24	26	66	TBD	TBD

Well Name	Latitude	Longitude	Well Type	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
MW-OU1-01-180	TBD	TBD	Monitoring	175	126	155	175	TBD	TBD
MW-OU1-02-180	TBD	TBD	Monitoring	195	138	175	195	TBD	TBD
MW-OU1-03-180	TBD	TBD	Monitoring	183	141	163	183	TBD	TBD
MW-BW-54-180	TBD	TBD	Monitoring	201	128	161	201	TBD	TBD
21667	TBD	TBD	Production	140	56	80	140	WL, WQ	M, A

Notes:
Proposed wells are italicized; MW-5S is a proposed replacement well for the existing well screened in a perched zone in the Dune Sand Aquifer.
Latitude and longitude in decimal degrees.
RP = Reference Point (top of casing), ft = feet, bgs = below ground surface, msl = mean sea level, Perfs = Perforations
Dune Sand Aquifer = Dune Sand Aquifer, (L) = Lower interval in 180-Foot Aquifer, WL = Water Level, WQ = Water Quality, IN = Induction Logging, C = Continuous, A = Annual
Source: Monterey Peninsula Water Supply Project (HWG 2016); Integrated Coastal Groundwater Monitoring Plan (MCRWA 2019)

TABLE 5-2. WELL INFORMATION AND DATA COLLECTED FOR WELLS IN THE 180-FOOT AQUIFER

Well Name	Latitude	Longitude	Well Use	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
MW-1M	36.71316	-121.80591	Monitoring	235	29.86	115	225	WL, WQ	C, C
MW-3M	36.71278	-121.80371	Monitoring	225	37.35	105	215	WL, WQ	C, C
MW-4M	36.71174	-121.79879	Monitoring	270	41.99	130	260	WL, WQ	C, C
MW-5M	36.71796	-121.77462	Monitoring	320	80.48	100	310	WL, WQ	C, C
MW-6M	36.67712	-121.74726	Monitoring	220	35.68	150	210	WL, WQ	C, C
MW-6M(L)	36.67710	-121.74729	Monitoring	335	35.82	255	325	WL, WQ	C, C
MW-7M	36.70629	-121.78928	Monitoring	230	50.29	130	220	WL, WQ	C, C
MW-8M	36.72645	-121.78755	Monitoring	225	19.99	125	215	WL, WQ	C, C
MW-9M	36.73375	-121.77932	Monitoring	235	18.32	145	225	WL, WQ	C, C
MW-AM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-BM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-CM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-DM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-EM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MCWD DMW-1	TBD	TBD	Monitoring	240	60	190	230	WL, WQ	C, P
MCWD DMW-2	TBD	TBD	Monitoring	236	61	180	230	WL, WQ	C, P
MCWD Well #1	TBD	TBD	Production	225	84	124	NA	WL	C
MCWD Well #2	TBD	TBD	Production	200	75	128	NA	WL	C
14530	TBD	TBD	Production	350	103	260	340	WL	C

Well Name	Latitude	Longitude	Well Use	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
14531	TBD	TBD	Production	350	116	260	340	WL	C
MW-B-05-180	TBD	TBD	Production	210	120	175	205	WL, WQ	C, P
Airfield	TBD	TBD	Production	396	142	318	379	WL, WQ	C, P

Notes:
Proposed wells are italicized.
Latitude and longitude in decimal degrees
RP = Reference Point (top of casing), ft = feet, bgs = below ground surface, msl = mean sea level, Perfs = Perforations
Dune Sand Aquifer = Dune Sand Aquifer, (L) = Lower interval in 180-Foot Aquifer, WL = Water Level, WQ = Water Quality, IN = Induction Logging, C = Continuous, A = Annual
Source: Monterey Peninsula Water Supply Project (HWG 2016); Integrated Coastal Groundwater Monitoring Plan (MCRWA 2019)

TABLE 5-3. WELL INFORMATION AND DATA COLLECTED FOR WELLS IN THE 400-FOOT AQUIFER

Well Name	Latitude	Longitude	Well Type	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
MW-1D	36.71317	-121.80594	Monitoring	337	29.68	277	327	WL, WQ, IN	C, C, A
MW-3D	36.71277	-121.80367	Monitoring	340	36.93	285	330	WL, WQ, IN	C, C, A
MW-4D	36.71174	-121.79883	Monitoring	340	41.95	290	330	WL, WQ, IN	C, C, A
MW-5D	36.71793	-121.77463	Monitoring	445	80.06	395	435	WL, WQ, IN	C, C, A
MW-7D	36.70632	-121.78929	Monitoring	355	50.24	295	345	WL, WQ, IN	C, C, A
MW-8D	36.72642	-121.78757	Monitoring	360	20.08	300	350	WL, WQ, IN	C, C, A
MW-9D	36.73377	-121.77929	Monitoring	403	18.32	353	393	WL, WQ, IN	C, C, A
MW-AD	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
MW-BD	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
MW-CD	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
MW-DD	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
MW-ED	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
1032	TBD	TBD	Production	506	31	400	506	WQ	A
239	TBD	TBD	Production	500	14	314	456	WL	M
2791	TBD	TBD	Production	600	140	438	580	WL	A
2718	TBD	TBD	Production	615	19	330	600	WL	A
1466	TBD	TBD	Production	556	16	395	540	WL, WQ	A, A

Notes:
Proposed wells are italicized; Latitude and longitude in decimal degrees.
RP = Reference Point (top of casing), ft = feet, bgs = below ground surface, msl = mean sea level, Perfs = Perforations
Dune Sand Aquifer = Dune Sand Aquifer, (L) = Lower interval in 180-Foot Aquifer, WL = Water Level, WQ = Water Quality, IN = Induction Logging, C = Continuous, A = Annual
Source: Monterey Peninsula Water Supply Project (HWG 2016); Integrated Coastal Groundwater Monitoring Plan (MCRWA 2019)

TABLE 5-4. WELL INFORMATION AND DATA COLLECTED FOR WELLS IN THE DEEP AQUIFER

Well Name	Latitude	Longitude	Well Use	Depth (ft bgs)	Elevation (ft NAVD88)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
DMW1-1	36.69917	-121.80750	Monitoring	960	60	930	950	WL, WQ	C, P
DMW1-2	36.69917	-121.80750	Monitoring	1070	60	1040	1060	WL, WQ	C, P
DMW1-3	36.69917	-121.80750	Monitoring	1440	60	1410	1430	WL, WQ	C, P
DMW1-4	36.69917	-121.80750	Monitoring	1890	60	1820	1860	WL, WQ, IN	C, P, A
DMW2-S	36.69917	-121.80750	Monitoring	1100	142	1040	1090	WL	C
DMW2-D	36.69917	-121.80750	Monitoring	1740	142	1680	1730	WL, IN	C, A
MCWD Well #10	TBD	TBD	Production	1500	153	930	1540	WL, WQ	P, A
MCWD Well #11	TBD	TBD	Production	1700	155	970	1650	WL, WQ	P, A
MCWD Well #12	TBD	TBD	Production	2023	109	1410	1960	WL, WQ	P, A
25973	TBD	TBD	Production	1780	132	1030	1780	WQ	A
21655	TBD	TBD	Production	825	105	670	805	WQ	A
22755	TBD	TBD	Production	1573	25	1450	1450	WQ	A
2691	TBD	TBD	Production	870	29	666	834	TBD	TBD
1672	TBD	TBD	Production	1560	6	880	1540	WL	M

Notes:
Latitude and longitude in decimal degrees; Perfs = Perforations
Ft = feet, bgs = below ground surface; NAVD88 = North American Vertical Datum of 1988
WL = Water Level, WQ = Water Quality, IN = Induction Logging, C = Continuous, P = Periodic, A = Annual
Source: Geohydrology of a Deep-Aquifer System Monitoring-Well Site (Hanson *et al.* 2002); Integrated Coastal Groundwater Monitoring Plan (MCRWA 2019)

FIGURE 5-1

Jurisdictional Areas Covered By GSAs

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA (MGSA) Area
- Marina Coast Water District (MCWD) GSA Area
- Salinas Valley Basin GSA Area
- 180/400 Foot Aquifer Subbasin
- Salinas Valley Groundwater Basin
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, montereycountyopendata

DATE: DEC, 31, 2019

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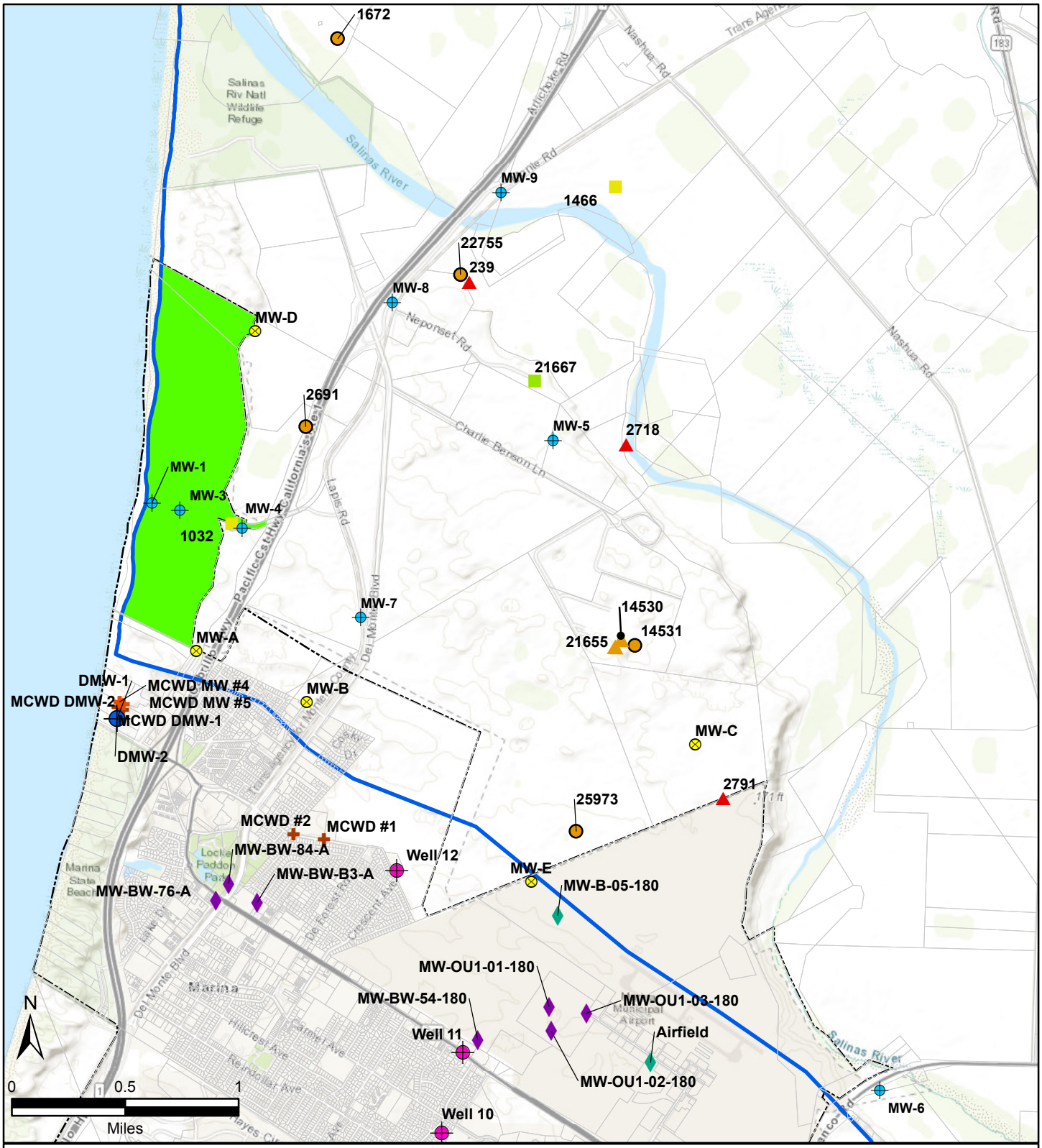

FIGURE 5-2

Locations of Wells in the MGSA GSP Monitoring Network

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MCWD Water Supply Wells
- Proposed Wells (Locations are approximate)
- MPWSP Wells
- MCWRA Water Quality Wells- Shallow
- MCWD Shallow Wells
- Fort Ord Monitoring Wells- Perforation Elevations: -50 to 0 ft
- MCWD Wells- 180 ft/FTE
- MCWRA Water Level Wells- Pressure 180
- Fort Ord Monitoring Wells- Perforation Elevations: -270 to -50 ft
- USGS Deep Wells
- MCWRA Water Level Wells- Pressure 400
- MCWRA Water Quality Wells- Pressure 400
- MCWD Other Deep Aquifer Wells
- City of Marina GSA (MGSA) Area
- 180/400 Foot Aquifer Subbasin
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Monitoring Report #160 2019

DATE: DEC. 30, 2019

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APPENDIX 5.A – MPWSP LOGS AND WELL COMPLETION DIAGRAMS

APPENDIX C

Monitoring Well Information

GEOSCIENCE

APPENDIX C:

MONITORING WELL INFORMATION

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APPENDIX C: MONITORING WELL INFORMATION

PICTURES OF MONITORING WELL CLUSTER COMPLETIONS

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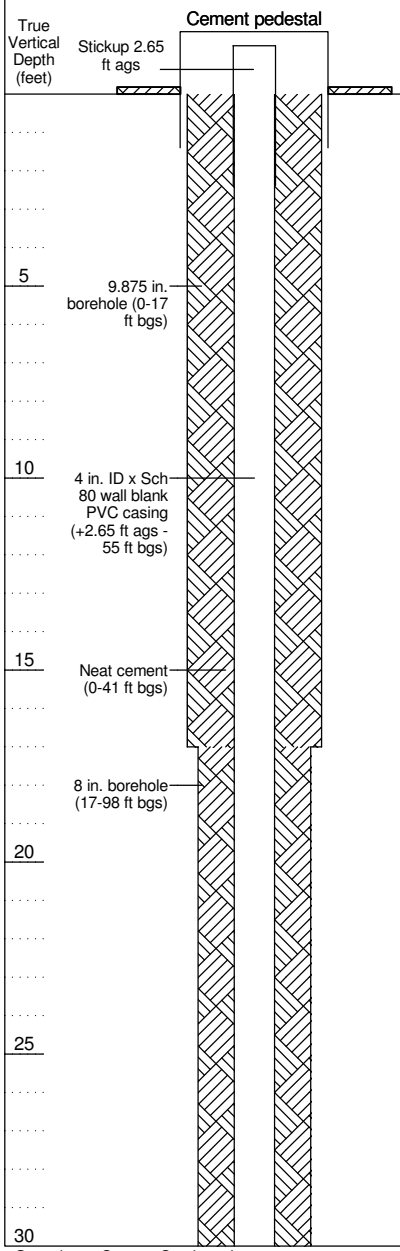
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-1S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: A. Patricio	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.65**	**55**	**57.65**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**55**	**95**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**95**	**97.5**	**2.5**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	27.86 ft NAVD88									
TOC ELEVATION	30.51 ft NAVD88 (RP)									
START DATE	1/24/15									
FINISH DATE	1/26/15									



Graphic Log

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Depth bgs (feet)	Lithologic Log	Sieve Sample Number	Drill Rate (ft/hr)
0	SAND (SP): dark yellowish brown (10YR 4/4), 90% sand, subangular to subrounded, predominantly fine to medium grained; 5% fine to coarse gravel subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, amphibole, and other.		
5	SAND (SP): yellowish brown (10YR 5/4) and brownish yellow (10YR 6/6), 100% medium to coarse grained sand, subangular to subrounded, trace fine grained; trace silt; well sorted; contains quartz, feldspar, and amphibole.		
10			
15	SAND (SP): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; trace silt; well sorted; contains quartz, feldspar, and amphibole.		
20			
25	SAND (SP): pale brown (10YR 6/3), 100% fine to medium grained sand, subangular to subrounded; well sorted; contains quartz, feldspar, and amphibole; predominantly quartz; coarser with depth.		25
30			

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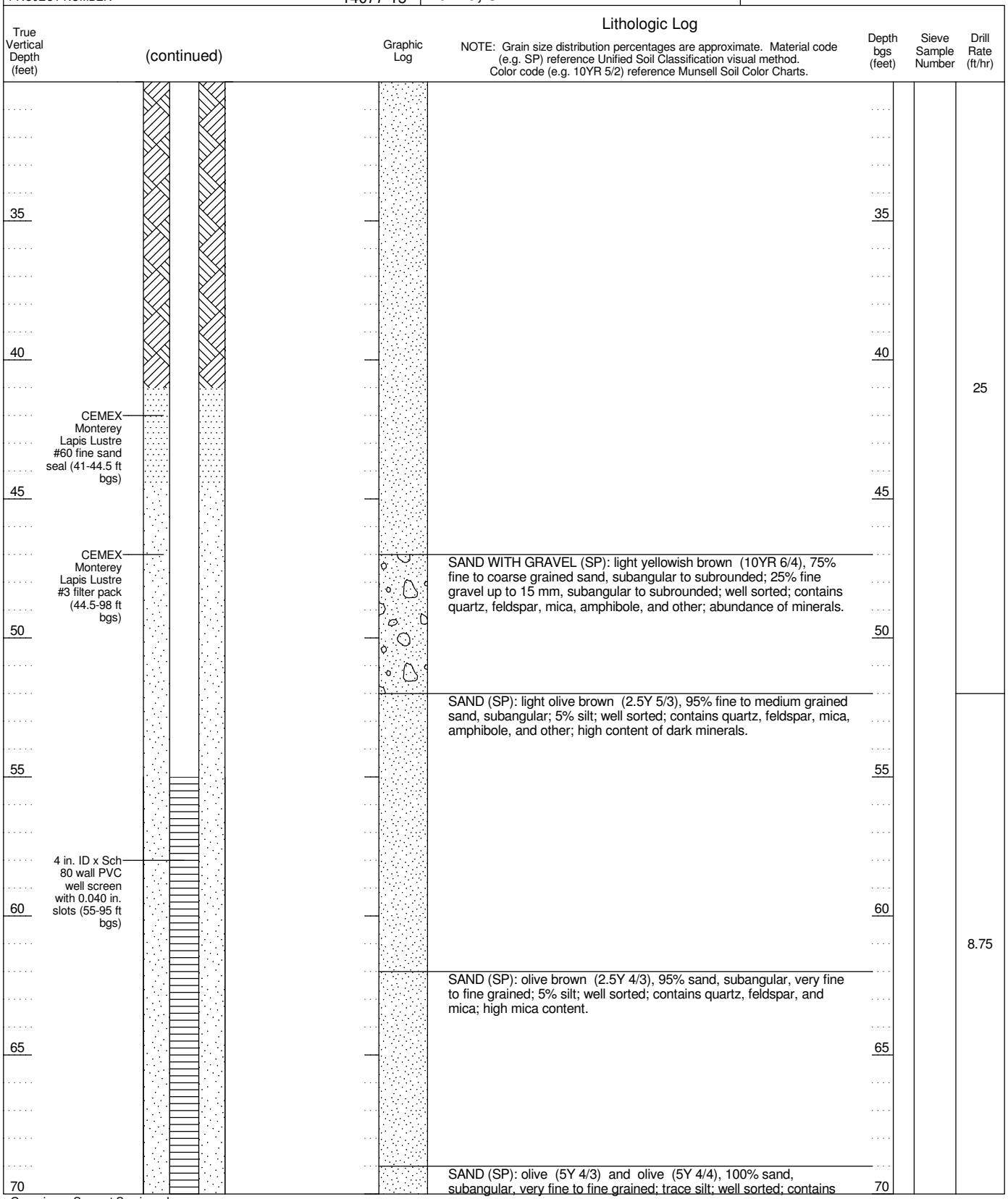
WELL NUMBER **MPWSP MW-1S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-1S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	quartz, feldspar, and mica; high mica content.			
75		75		8.75
80		80		
85	SAND (SP): olive (5Y 4/4), 90% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 10 mm, subangular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, mica, and amphibole.	85		
	SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 75% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel up to 42 mm, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.			
90		90		
	SAND (SP): light olive brown (2.5Y 5/3), 95% fine to medium grained sand, subangular; 5% silt; well sorted; contains quartz, feldspar, mica, and amphibole; high mica content.			10
95	SAND WITH GRAVEL (SP): yellowish brown (10YR 5/8), 85% fine to coarse grained sand, subangular to subrounded; 15% fine gravel up to 15 mm, subangular to subrounded; medium sorted; contains quartz, feldspar, and amphibole.	95		
	SAND WITH SILT (SP-SM): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded, trace coarse; 10% silt; trace fine gravel subangular to subrounded; well sorted; contains quartz, feldspar, mica, and amphibole.			
	Bottom of borehole at 98 feet.			

Blank casing with end cap (95-97.5 ft bgs)

TD 98 ft bgs

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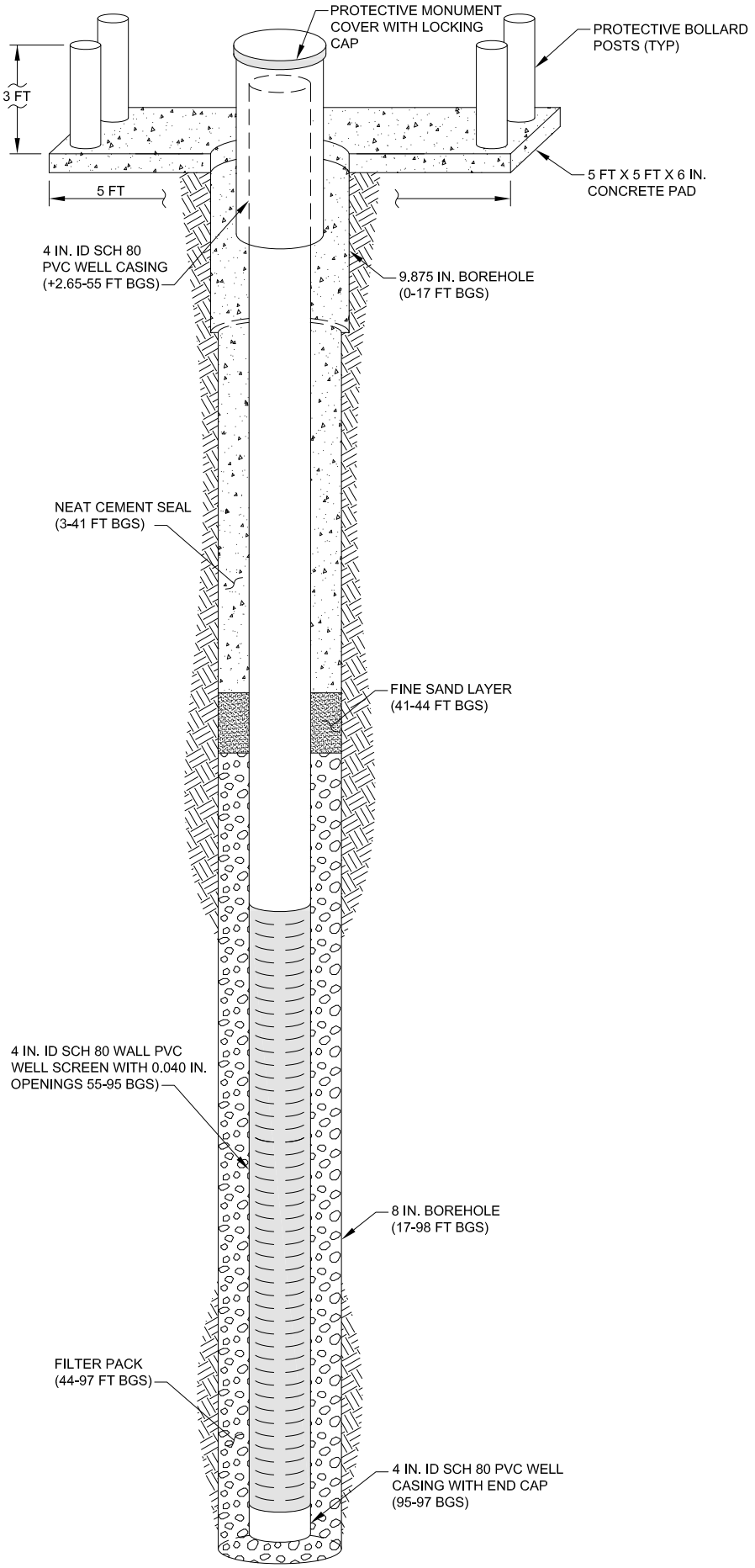

WELL PROFILE

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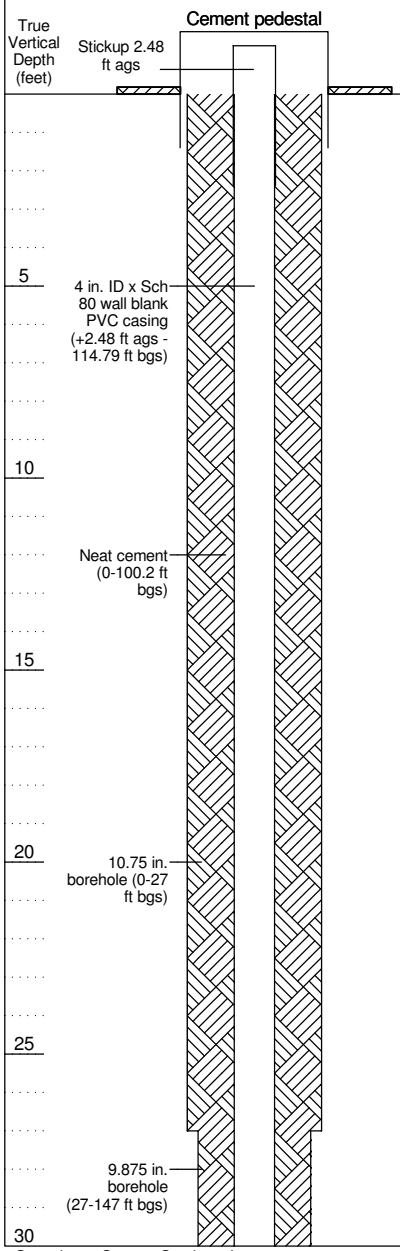
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-1M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: A. Patricio	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.48**	**114.79**	**117.27**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**114.79**	**224.79**	**110**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**224.79**	**227.5**	**2.71**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	27.38 ft NAVD88									
TOC ELEVATION	29.86 ft NAVD88 (RP)									
START DATE	1/20/15									
FINISH DATE	1/24/15									



Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; trace silt; contains quartz, feldspar, and amphibole.			
	SAND (SP): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; trace clay, dark, low plasticity.	5		
	SAND (SP): brownish yellow (10YR 6/6) and brown (10YR 4/3), 100% medium to coarse grained sand, subangular to subrounded; trace silt; contains quartz, feldspar, and amphibole; grades finer with depth.	10		
		15		
		20		
		25		
	SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole.	30		

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35				35		
			SAND (SP): pale brown (10YR 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole.			
40				40		
45				45		
			SAND WITH GRAVEL (SP): light yellowish brown (10YR 6/4), 80% fine to coarse grained sand, subangular to subrounded; 20% fine gravel up to 12 mm, subangular to subrounded; contains quartz, feldspar, mica, and amphibole; high amphibole content.			
50				50		30
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to medium grained sand, subangular; 5% silt; contains quartz, feldspar, mica, and amphibole; high dark mineral content.			
55				55		
60				60		
			SAND (SP): olive brown (2.5Y 4/3), 95% sand, subangular, very fine to fine grained; 5% silt; well sorted; contains quartz, mica, and amphibole; high mica content.			
65				65		
						13.3
70			SAND (SP): olive brown (2.5Y 4/3), 100% sand, subangular, very fine to fine grained; trace silt; well sorted; contains quartz, mica, and	70		

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			amphibole; high mica content.			
75				75		
						13.3
80				80		
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to coarse grained sand, subangular to subrounded, predominantly medium to coarse sand; 5% fine gravel subangular to subrounded; contrains feldspar, amphibole, and trace quartz.			
85			SAND WITH GRAVEL (SP): yellowish red (5YR 5/6), 80% fine to coarse grained sand, subangular to subrounded; 20% fine gravel up to 10 mm, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	85		
			SAND (SP): dark yellowish brown (10YR 4/4), 95% sand, subangular, very fine to fine grained; 5% silt; well sorted; contains quartz, feldspar, mica, and amphibole.			
90			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 80% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel up to 45 mm, subangular to subrounded; trace cobbles; contains quartz, feldspar, mica, and amphibole.	90		
95			SAND (SP): light olive brown (2.5Y 5/3), 100% fine to medium grained sand, subangular; contains quartz, feldspar, mica, and amphibole; grades finer with depth; high mica content.	95		
			SAND WITH SILT (SP-SM): brown (10YR 4/3), 90% fine grained sand, subangular to subrounded, trace coarse grains; 10% silt; well sorted; contains quartz, feldspar, mica, and amphibole.			
100				100		
	CEMEX Monterey #60 fine sand seal (100.2-104 ft bgs)					
105				105		
	CEMEX Monterey #3 filter pack (104-227.5 ft bgs)					
110				110		

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
115		SAND (SP): brownish yellow (10YR 6/6) and gray (5Y 6/1), 100% fine to coarse grained sand, subangular to subrounded; trace silt; contains quartz, feldspar, and amphibole; iron oxidation.	115		
120		SILTY SAND (SM): strong brown (7.5YR 5/6), 85% fine to medium grained sand, subrounded, predominately fine sand; 15% silt; contains quartz, feldspar, mica, and amphibole.	120		
		SILTY SAND (SM): light yellowish brown (10YR 6/4), 75% fine grained sand, subangular; 25% silt; well sorted; contains quartz, feldspar, mica, and amphibole.			
125		SAND (SP): reddish yellow (7.5YR 6/8), 85% fine to coarse grained sand, angular to subangular; 10% fine to coarse gravel angular to subangular; 5% clay, low plasticity.	125		
		CLAYEY SAND (SC): pale olive (5Y 6/3), 85% fine grained sand, subangular; 15% clay, low plasticity; contains quartz, and amphibole.			
		SAND WITH GRAVEL (SP): brown (7.5YR 5/4), 80% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; 5% clay, low to medium plasticity, clay balls.			
130			130		
		SILTY SAND (SM): dark yellowish brown (10YR 4/4), 85% fine to medium grained sand, subrounded; 15% silt; contains quartz, feldspar, and amphibole; high dark mineral content.			
135			135		
140			140		
145			145		
150		FAT CLAY WITH SAND (CH): light olive brown (2.5Y 5/4) and pale olive (5Y 6/3), 85% clay, medium plasticity; 15% fine to medium grained sand, subangular; contains quartz, mica, and amphibole.	150		

4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (114.79-224.79 ft bgs)

8 in. borehole (147-227.5 ft

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	bgs)					
155			CLAYEY SAND (SC): light olive brown (2.5Y 5/4), 80% fine to medium grained sand, subangular; 20% clay, low plasticity; contains quartz, mica, and amphibole.	155		
160			CLAYEY SAND (SC): dark yellowish brown (10YR 4/4), 75% fine to medium grained sand, subangular to subrounded; 25% clay, low plasticity; contains quartz, feldspar, and amphibole.	160		
165				165		
170			SAND (SP): dark yellowish brown (10YR 4/4), 95% fine to medium grained sand, subangular, trace coarse sand; 5% silt.	170		
175				175		
180			CLAYEY SAND (SC): yellowish red (5YR 4/6) and olive gray (5Y 4/2), 85% fine to medium grained sand, subangular to subrounded; 15% clay, low plasticity; weak cementation; contains quartz, feldspar, and amphibole; high dark mineral content.	180		
185				185		
190			SAND (SP): dark brown (10YR 3/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; weak cementation; contains quartz, feldspar, and amphibole; high dark mineral content.	190		

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			195		
200		SAND WITH SILT (SP-SM): dark brown (10YR 3/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; contains quartz, feldspar, and amphibole; high dark mineral content.	200		
205		SILT (ML): light olive brown (2.5Y 5/3), 100% silt, brittle.	205		
210		SAND WITH CLAY (SP-SC): pale olive (5Y 6/3), 85% fine to coarse grained sand, subangular; 10% clay, low plasticity; 5% fine gravel subangular, trace coarse gravel; contains quartz, feldspar, mica, and amphibole.	210		
215		CLAYEY SAND (SC): light olive gray (5Y 6/2), 75% fine to coarse grained sand, subangular to subrounded; 15% clay, low plasticity; 10% fine to coarse gravel subangular to subrounded.	215		
		SAND (SP): olive (5Y 5/3) and light olive gray (5Y 6/2), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; contains quartz, feldspar, mica, and amphibole; predominantly quartz.			
220			220		
		SILT (ML): light olive brown (2.5Y 5/4), 100% silt, low plasticity; contains mica.			
225			225		
		Bottom of borehole at 227.5 feet.			

Blank casing with end cap (224.79-227.5 ft bgs)

TD 227.5 ft bgs

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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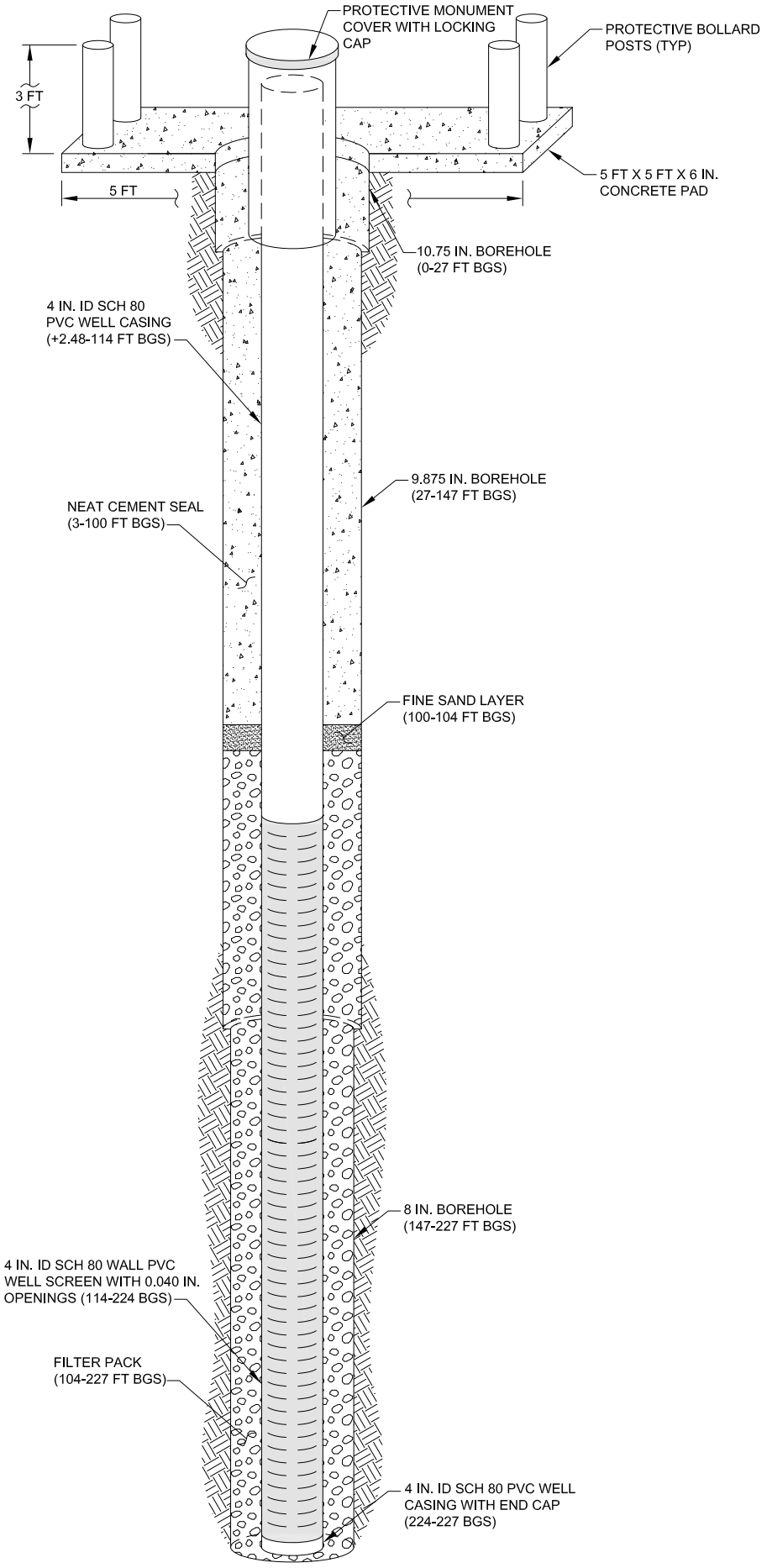

WELL PROFILE

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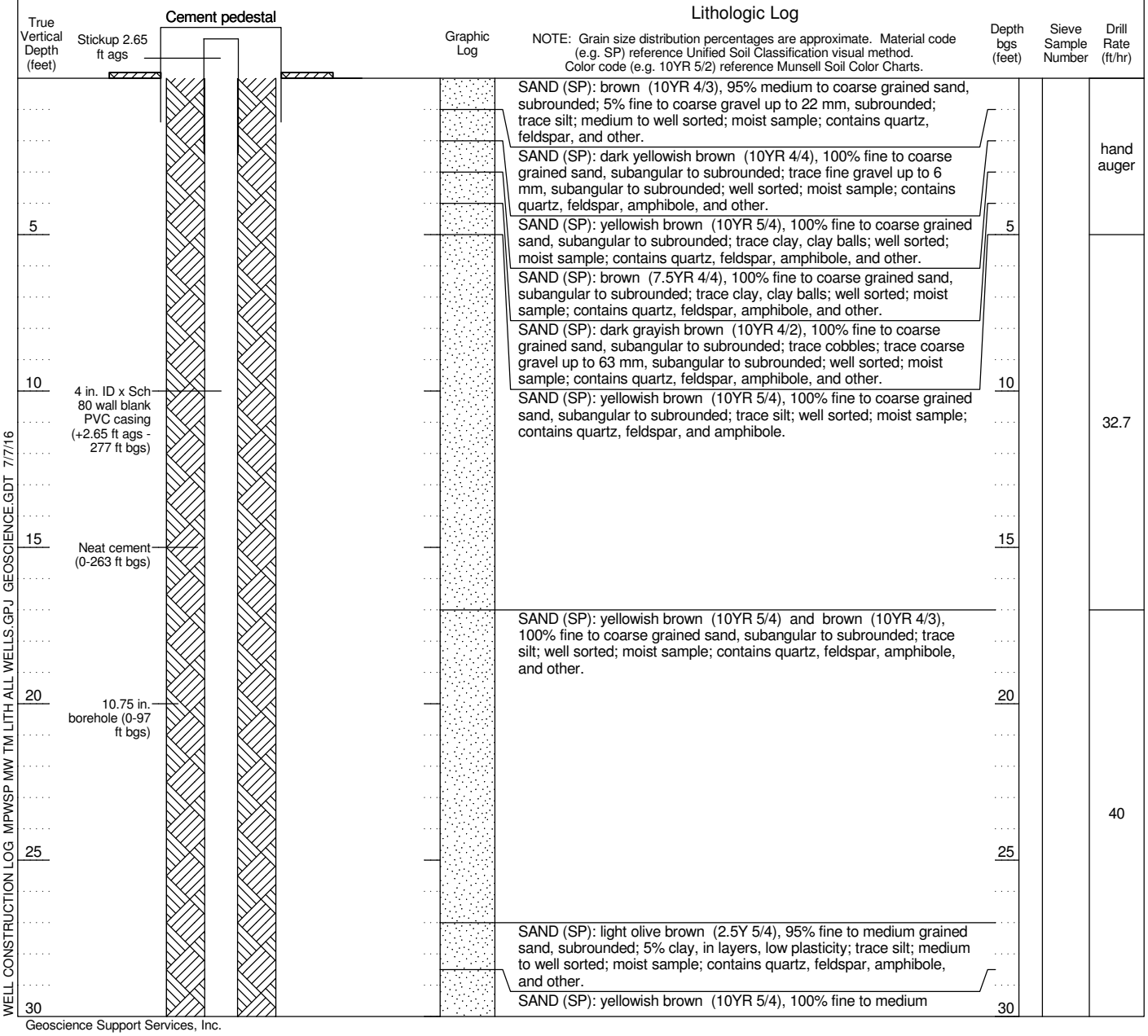
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-1D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY
DRILLER: A. Patricio	**J. Sobolew**

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T	**Blank**	**-2.65**	**277**	**279.65**	**PVC**	**Sch 80**	**4 / ID**		
DRILLING METHOD	Sonic	**Screen**	**277**	**327**	**50**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
SAMPLING METHOD	Core	**Blank**	**327**	**329.55**	**2.55**	**PVC**	**Sch 80**	**4 / ID**		
BOREHOLE DIAMETER	10.75, 9.875, 8 in									
SURFACE ELEVATION	27.03 ft NAVD88									
TOC ELEVATION	29.68 ft NAVD88 (RP)									
START DATE	12/10/14									
FINISH DATE	12/19/14									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

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

WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			grained sand, subrounded; trace silt; well sorted; moist sample; contains quartz, feldspar, amphibole, and other.			
35			SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, angular to subangular; well sorted; moist sample; contains quartz, feldspar, mica, amphibole, and other.	35	1	
			SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, angular to subangular; well sorted; moist sample; contains quartz, feldspar, mica, amphibole, and other; saturated at 41 ft bgs.		2	
40				40		
45				45		
			SAND WITH GRAVEL (SP): light yellowish brown (10YR 6/4), 85% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 27 mm, subangular to subrounded; medium sorted; saturated sample; contains quartz, feldspar, amphibole, and other.		3	
50				50		40
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to medium grained sand, subangular to subrounded; 5% clay, clay balls, low plasticity; trace fine gravel up to 5 mm, subangular to subrounded; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other.			
55			SAND (SP): light olive brown (2.5Y 5/3), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel up to 5 mm, subangular to subrounded; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.	55		
60				60		
			SAND (SP): brown (10YR 4/3), 100% fine grained sand, subrounded; trace silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.			
65				65		
			SAND (SP): brown (10YR 5/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel up to 10 mm, subangular to subrounded; trace silt; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other; very fine sand with gravel and trace silt at 69-70 ft bgs.		4	
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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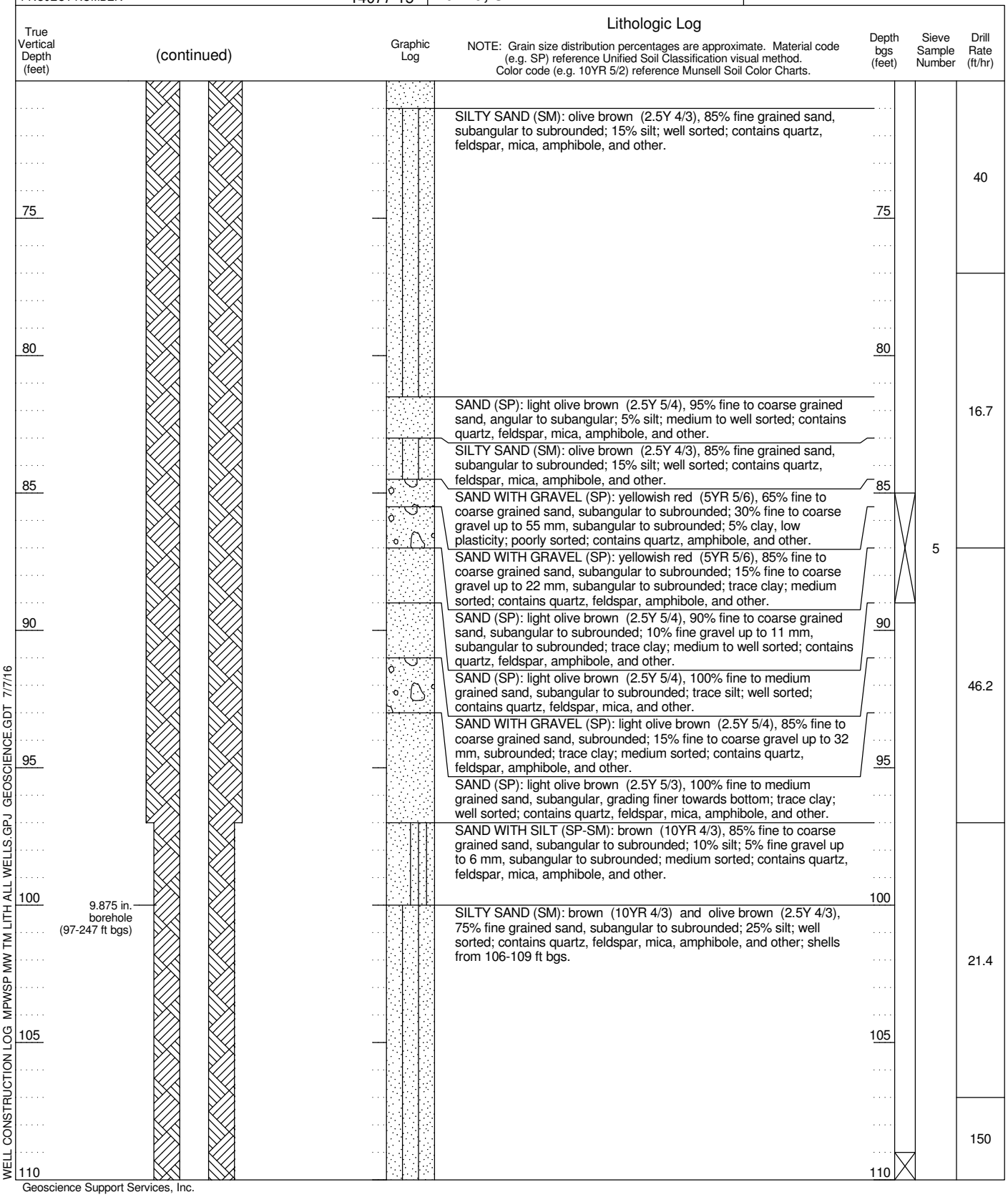
WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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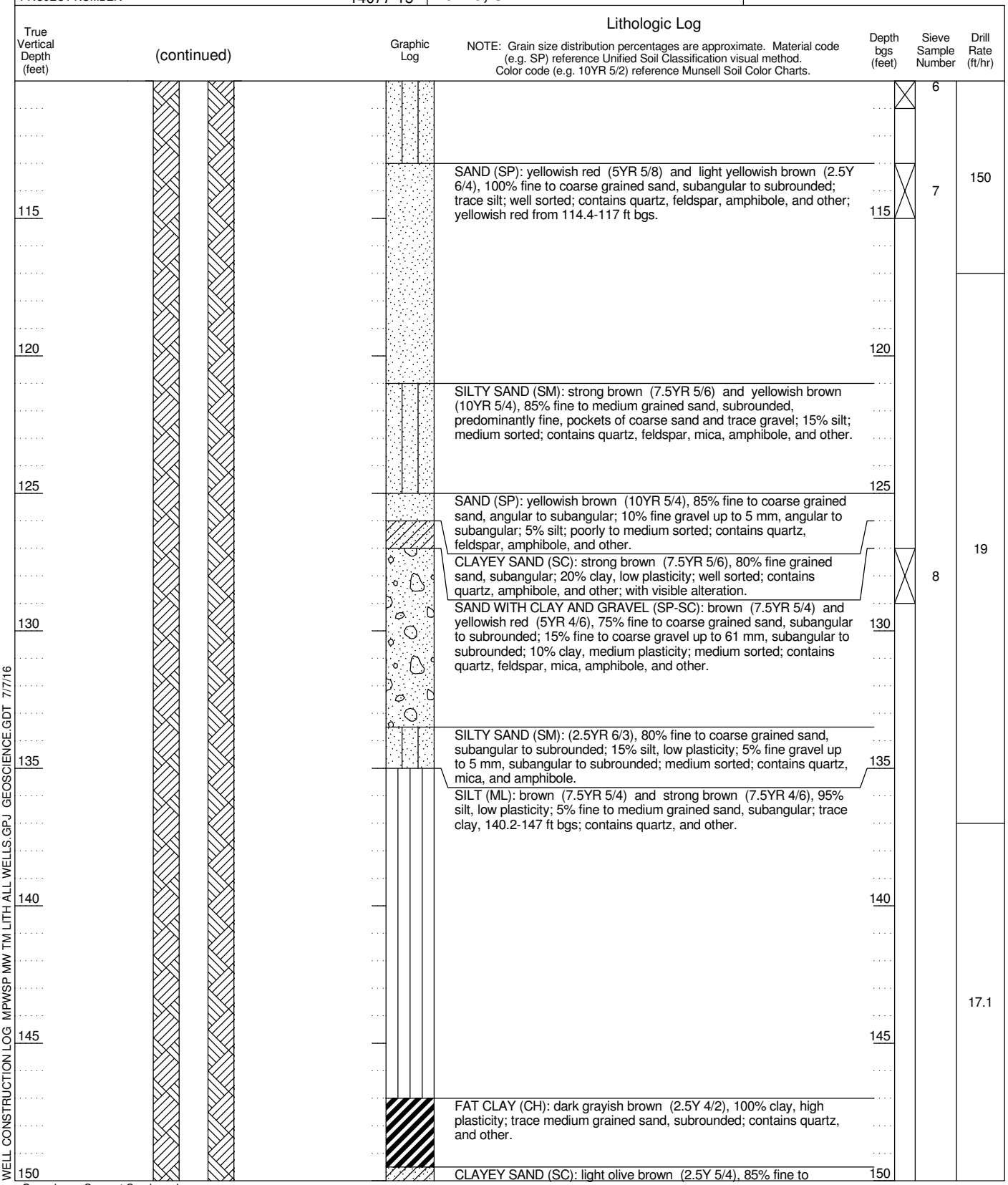
WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
155			medium grained sand, subangular; 15% clay, low plasticity; medium sorted; contains quartz, amphibole, and other.	155	9	17.1
160			CLAYEY SAND (SC): dark yellowish brown (10YR 4/4), 85% fine grained sand, subangular; 15% clay, low to medium plasticity; medium sorted; contains quartz, amphibole, and other.	160		11.8
165				165		
170			SAND (SP): dark yellowish brown (10YR 4/4), 95% fine to medium grained sand, subangular, trace coarse; 5% silt; well sorted; contains quartz, feldspar, amphibole, and other.	170	10	
175				175		34.3
180			CLAYEY SAND (SC): yellowish red (5YR 4/6) and olive gray (5Y 4/2), 85% fine to medium grained sand, subangular to subrounded; 15% clay, low to high plasticity; medium sorted; contains quartz, feldspar, amphibole, and other; with visible alteration.	180		
185				185		
190				190	11	8.6

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195		195		8.6
	SILTY SAND (SM): dark brown (10YR 3/3), 85% fine to medium grained sand, subangular to subrounded, predominantly fine; 15% silt; medium sorted; contains quartz, amphibole, and other.			
200		200		
205		205		16
210		210		
	FAT CLAY (CH): light olive brown (2.5Y 5/3), 100% clay, high plasticity; trace fine grained sand, subangular; contains quartz, and other.			
215		215		
220		220	12	
	FAT CLAY WITH SAND (CH): olive yellow (2.5Y 6/6), 85% clay, medium to high plasticity; 15% fine to medium grained sand, subangular; contains quartz, feldspar, mica, amphibole, and other.			20
225		225		
	FAT CLAY (CH): olive gray (5Y 5/2), 100% clay, high plasticity; with visible alteration.			
230		230		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235				235		20
240				240		
			SANDY CLAY (CL): light olive gray (5Y 6/2), 65% clay, low to medium plasticity; 35% fine to medium grained sand, subangular; contains quartz, mica, amphibole, and other.			
245			SAND WITH GRAVEL (SP): light yellowish brown (2.5Y 6/3), 55% fine to coarse grained sand, subangular; 40% fine to coarse gravel up to 46 mm, subangular, one large cobble; 5% clay; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.	245	13 14	
			FAT CLAY (CH): pale olive (5Y 6/3) and dark gray (N4), 100% clay, high plasticity.			
250	8 in. borehole (247-337 ft bgs)			250		3.7
255				255		
260				260		17
	CEMEX Monterey Lapis Lustre #60 fine sand seal (263-267 ft bgs)		SANDY FAT CLAY (CH): light olive brown (2.5Y 5/3), 60% clay, medium to high plasticity; 30% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel up to 53 mm, subangular to subrounded; contains quartz, amphibole, and other.			
265	CEMEX Monterey Lapis Lustre #3 filter pack (267-337 ft bgs)		CLAY WITH SAND (CL): olive gray (5Y 5/2), 85% clay, medium plasticity; 10% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 5 mm, subangular to subrounded; contains quartz, feldspar, mica, amphibole, and other.	265		14.6
270			SAND WITH CLAY AND GRAVEL (SP-SC): light brownish gray (2.5Y	270		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			6/2), 75% fine to coarse grained sand, subangular; 15% fine to coarse gravel up to 19 mm, subangular; 10% clay, low to medium plasticity; poorly sorted; contains quartz, feldspar, amphibole, and other; predominantly quartz.			
			CLAYEY GRAVEL WITH SAND (GC): light yellowish brown (10YR 6/4) and dark gray (N4), 45% fine to coarse gravel up to 75 mm, subangular; 40% fine to coarse grained sand, subangular; 15% clay, low to medium plasticity; trace cobbles; poorly sorted; contains quartz, feldspar, mica, amphibole, and other; trace cobbles to 81mm; chert.			
275			FAT CLAY (CH): olive brown (2.5Y 4/3), 100% clay, medium plasticity, brittle; trace fine to medium grained sand, subangular to subrounded.	275		
			SAND (SP): pale brown (10YR 6/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel up to 7 mm, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, amphibole, and other; some grading.		15	
280	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (277-327 ft bgs)			280		
			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 65% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel up to 21 mm, subangular to subrounded; 5% clay, low plasticity; poorly sorted; contains quartz, feldspar, amphibole, and other.		16	
285				285		
			SANDY SILT (ML): brown (7.5YR 5/4), 70% silt; 30% fine grained sand, subrounded, very fine; contains quartz, feldspar, mica, and other.		17	
290				290		14.6
			SAND (SP): light yellowish brown (10YR 6/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 5 mm, subangular to subrounded; trace silt; medium sorted; contains quartz, feldspar, mica, amphibole, and other.			
295				295		
300				300		
			SAND WITH CLAY AND GRAVEL (SW-SC): yellowish brown (10YR 5/4), 65% medium to coarse grained sand, subangular to subrounded, predominantly fine to medium; 25% fine to coarse gravel up to 20 mm, subangular to subrounded; 10% clay, low plasticity; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.			
305				305		
310				310		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER
MPWSP MW-1D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
315			315	18	14.6
		SAND (SP): brown (7.5YR 4/2), 95% fine to medium grained sand, subrounded, predominantly very fine to fine; 5% silt; well sorted; contains quartz, amphibole, and other.		19	
320		SILT (ML): brown (7.5YR 4/4), 100% silt, low plasticity; trace fine grained sand, subrounded; contains quartz, mica, and other.	320		
325		SAND (SP): brown (10YR 5/3), 100% fine to medium grained sand, subangular to subrounded; trace silt; well sorted; contains quartz, mica, amphibole, and other.	325		7.9
		FAT CLAY (CH): dark yellowish brown (10YR 4/4) and olive gray (5Y 5/2), 100% clay, high plasticity, brittle from 327-329.3 ft bgs.			
330			330		
335			335		

Blank casing with end cap (327-329.5 ft bgs)

TD 337 ft bgs

Bottom of borehole at 337 feet.

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No.	19027
File No.	

Company	CASCADE DRILLING
Well	MPWSP MW-1D
Field	MARINA
County	MONTEREY
State	CA

Location

CEMEX PLANT OFF OF LAPIS RD.
GPS: N 36o 42.787' W 121o 48.350'

Other Services:

DUAL INDUCTION
GAMMA-RAY

Permanent Datum	G.L.	Elevation	Elevation
Log Measured From	G.L.	0' above perm. datum	K.B.:
Drilling Measured From	G.L.		D.F.:
			G.L.:

Date	12-14-2014
Run Number	ONE
Depth Driller	334'
Depth Logger	334'
Bottom Logged Interval	334'
Top Log Interval	0'
Open Hole Size	9" (97'-247')
Type Fluid	WATER
Density / Viscosity	N/A
Fluid Level	26'
Bentonite Seal	N/A
Time Well Ready	1200
Time Logger on Bottom	1330
Equipment Number	PS-7
Location	LA
Recorded By	SCHUMACHER
Witnessed By	J. SOBOLEW

Borehole Record

Run Number	Bit	From	To
ONE	10"	0'	97'
TWO	9"	97'	247'
THREE	8"	247'	337'

Tubing Record

Size	Wgt/Ft	Top	Bottom
8" (247'-337')		0'	334'

	Size	Wgt/Ft	Top	Bottom
Casing Record	10"	N/A	0'	97'
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	334'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

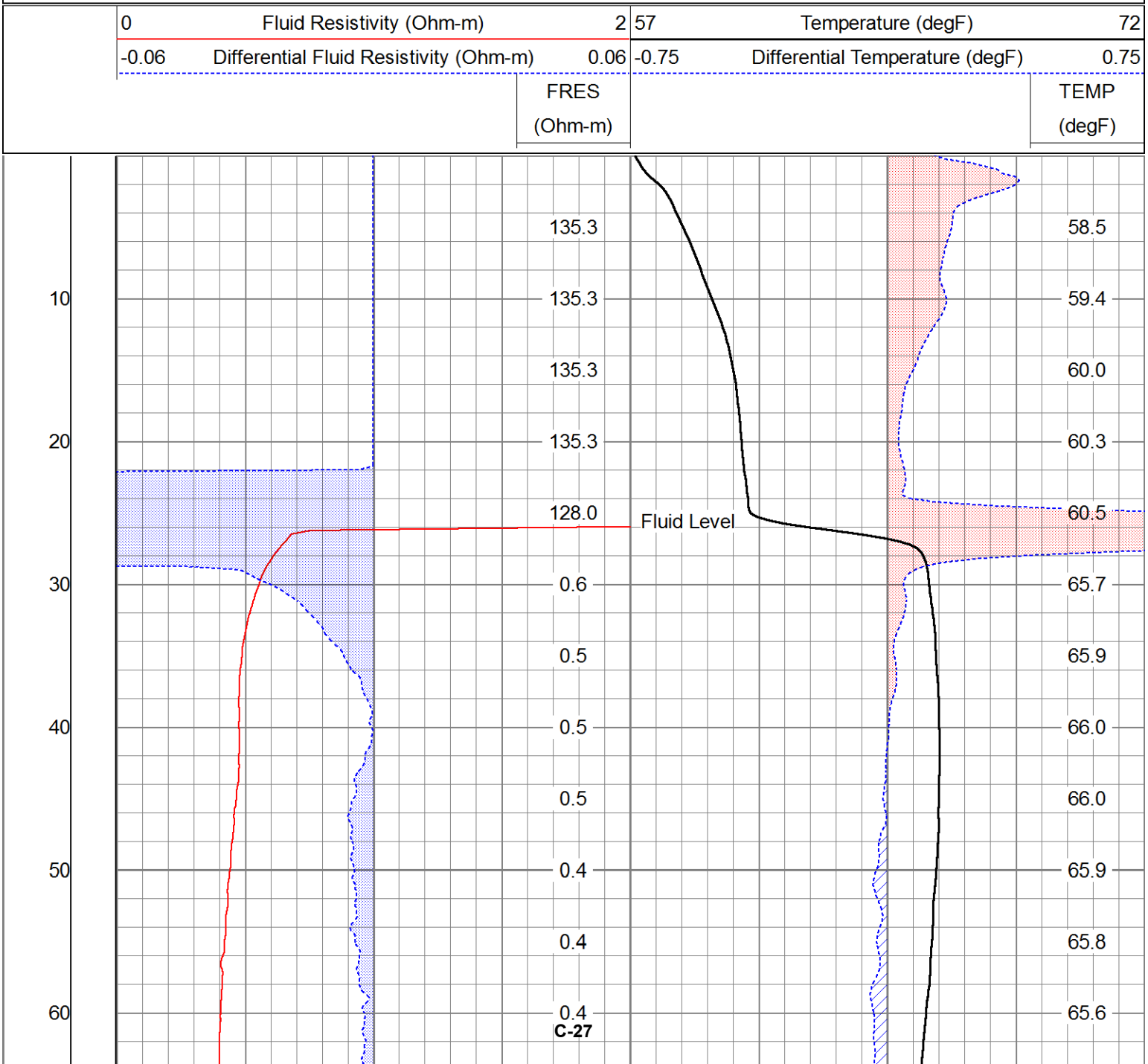
Calibration Report

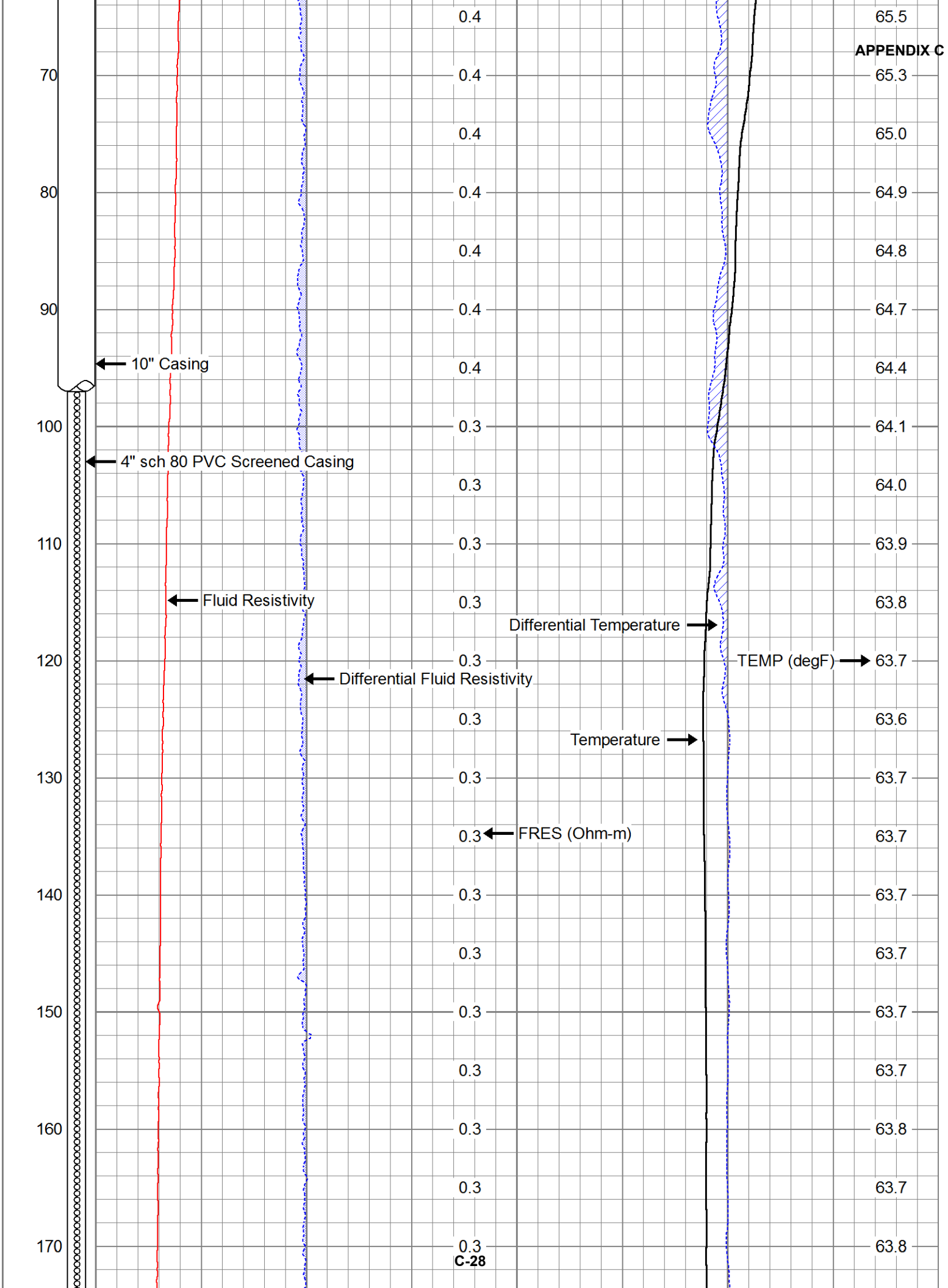
Database File	19027.db
Dataset Pathname	TEMP
Dataset Creation	Sun Dec 14 13:47:01 2014

Temperature Calibration Report

Serial Number:	3553		
Tool Model:	MLS		
Performed:	Wed Aug 29 07:13:35 2012		
	Reference		Reading
Low Reference:	43.34	degF	1441.00cps
High Reference:	149.00	degF	4545.00cps
Gain:	0.03		
Offset:	-5.71		
Delta Spacing	2		

Database File	19027.db
Dataset Pathname	TEMP
Presentation Format	frttemp2
Dataset Creation	Sun Dec 14 13:47:01 2014
Charted by	Depth in Feet scaled 1:120

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0.3
65.5
65.3
65.0
64.9
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63.9
63.8
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63.7
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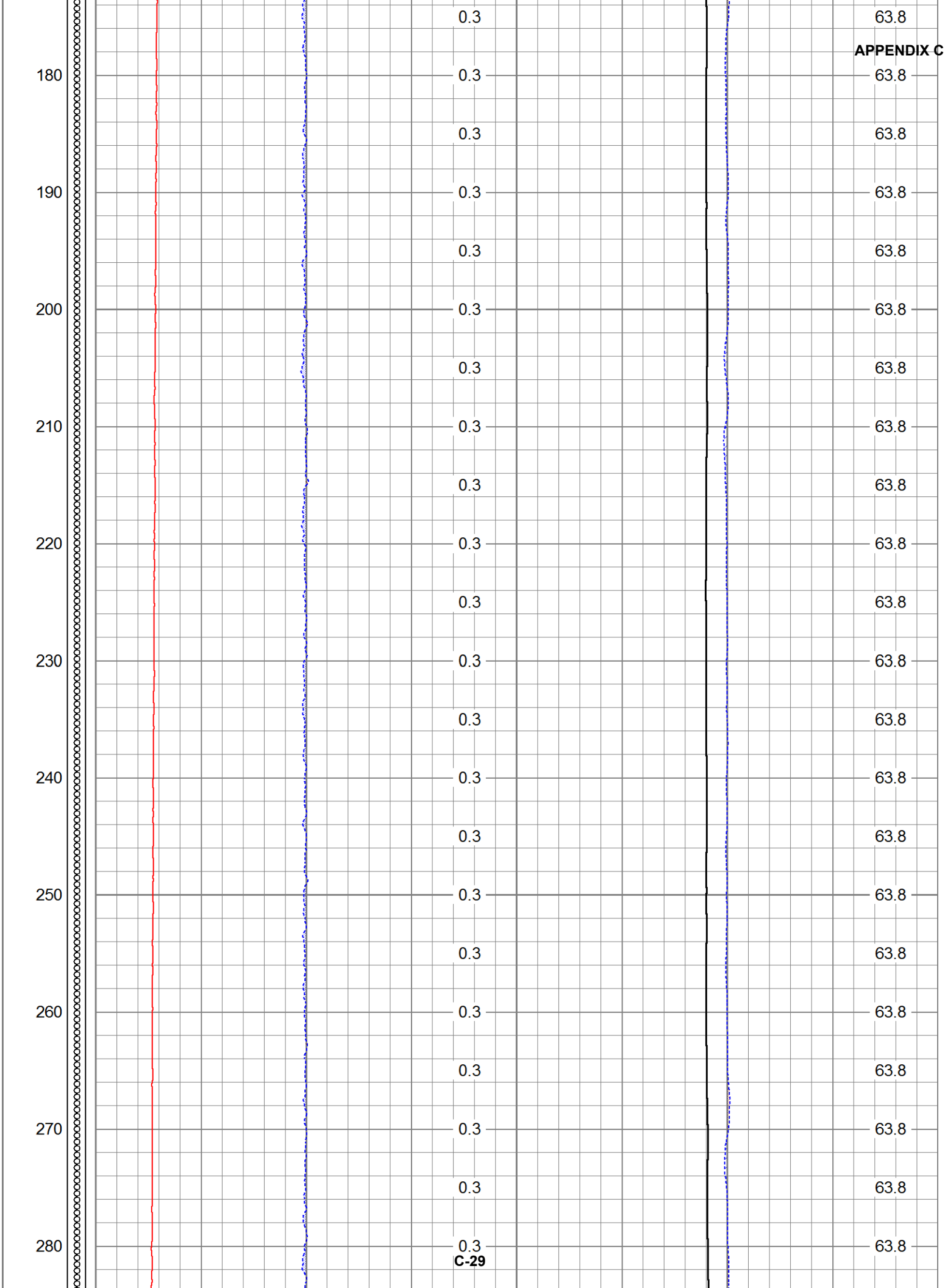
63.7
63.7
63.7
63.8
63.7
63.8
10" Casing
4" sch 80 PVC Screened Casing
Fluid Resistivity
Differential Fluid Resistivity
Differential Temperature
TEMP (degF)
Temperature
FRES (Ohm-m)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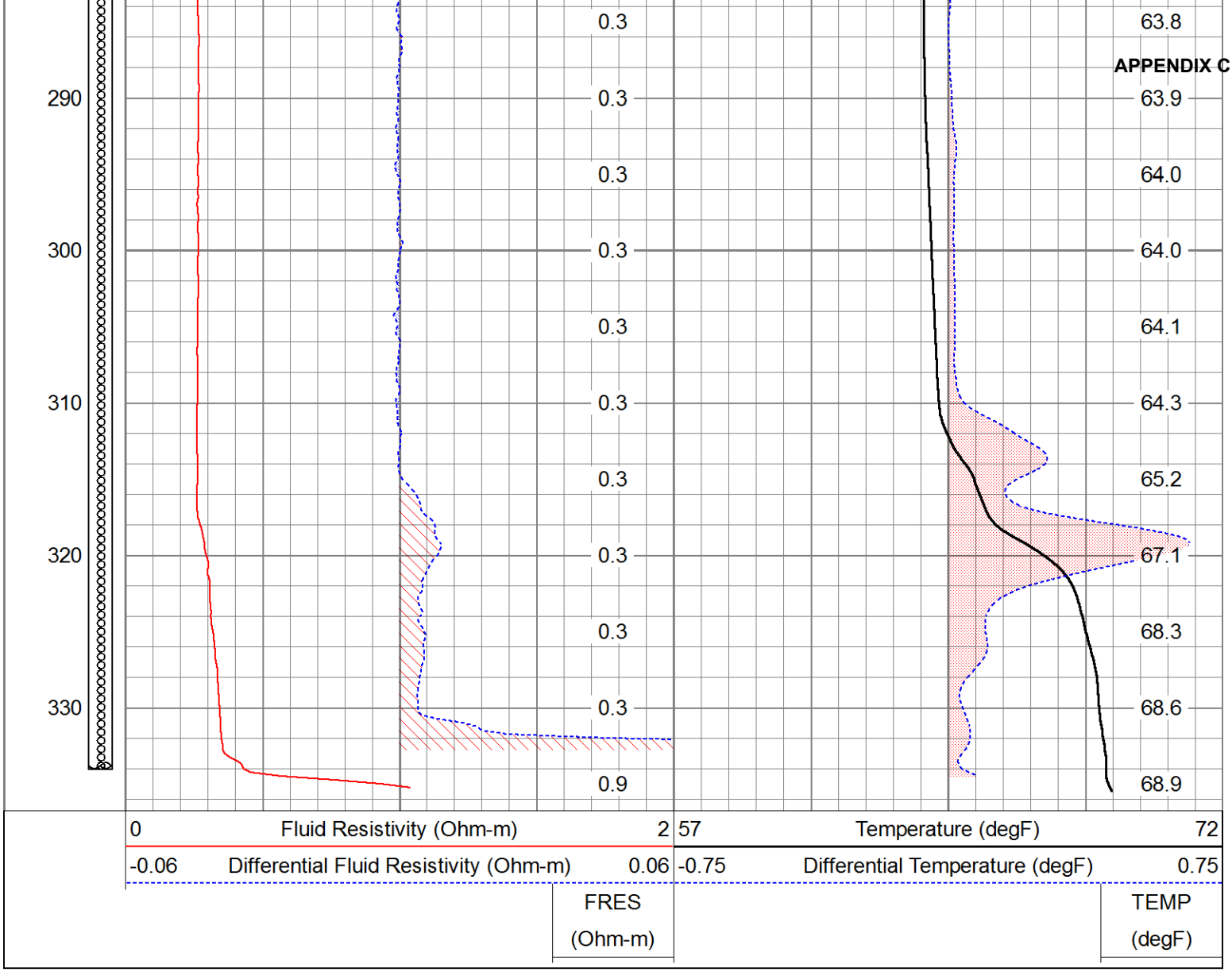
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63.9
64.0
64.0
64.1
64.3
65.2
67.1
68.3
68.6
68.9
0
Fluid Resistivity (Ohm-m)
2
-0.06
Differential Fluid Resistivity (Ohm-m)
0.06
FRES
(Ohm-m)
57
Temperature (degF)
72
-0.75
Differential Temperature (degF)
0.75
TEMP
(degF)

APPENDIX C

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19027

File No.

Company CASCADE DRILLING

Well MPWSP MW-1D

Field MARINA

County MONTEREY State CA

Location

CEMEX PLANT OFF OF LAPIS RD.
GPS: N 36o 42.787' W 121o 48.350'

Other Services:

TEMPERATURE
FLUID RESISTIVITY

Permanent Datum	G.L.	Elevation above perm. datum	Elevation K.B.
Log Measured From	G.L. 0'		D.F.
Drilling Measured From	G.L.		G.L.

Date	12-14-2014		
Run Number	ONE		
Depth Driller	334'		
Depth Logger	334'		
Bottom Logged Interval	334'		
Top Log Interval	0'		
Open Hole Size	9" (97'-247')	8" (247'-337')	
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	26'		
Bentonite Seal	N/A		
Time Well Ready	1200		
Time Logger on Bottom	1330		
Equipment Number	PS-7		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	J. SOBOLEW		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10"	0'	97'				
TWO	9"	97'	247'				
THREE	8"	247'	337'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	10"	N/A	0'	97'
Prot. String				
Production String	4" PVC	SCH 80	0'	334'
Liner				

<<< Fold Here >>>

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Comments

Calibration Report

Database File 19027.db
Dataset Pathname dil
Dataset Creation Sun Dec 14 14:35:19 2014

Dual Induction Calibration Report

Serial-Model:	0001-ALT	
Surface Cal Performed:	Sat Dec 13 17:32:36 2014	

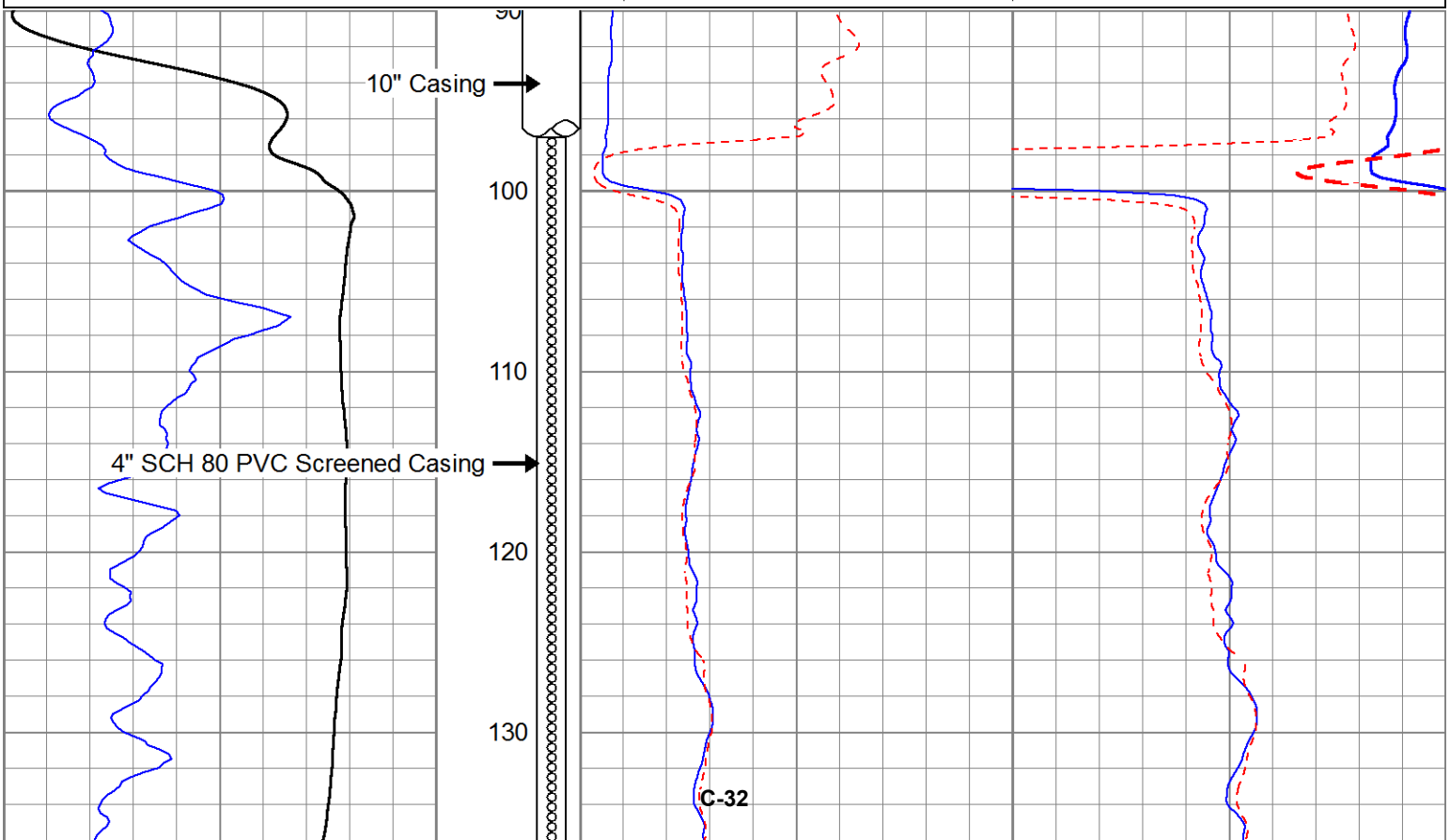
Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1405.080	3665.050	cps	0.000	612.000	mmho/m	0.271	-380.495
Medium	2052.170	14102.500	cps	0.000	1960.000	mmho/m	0.163	-333.788

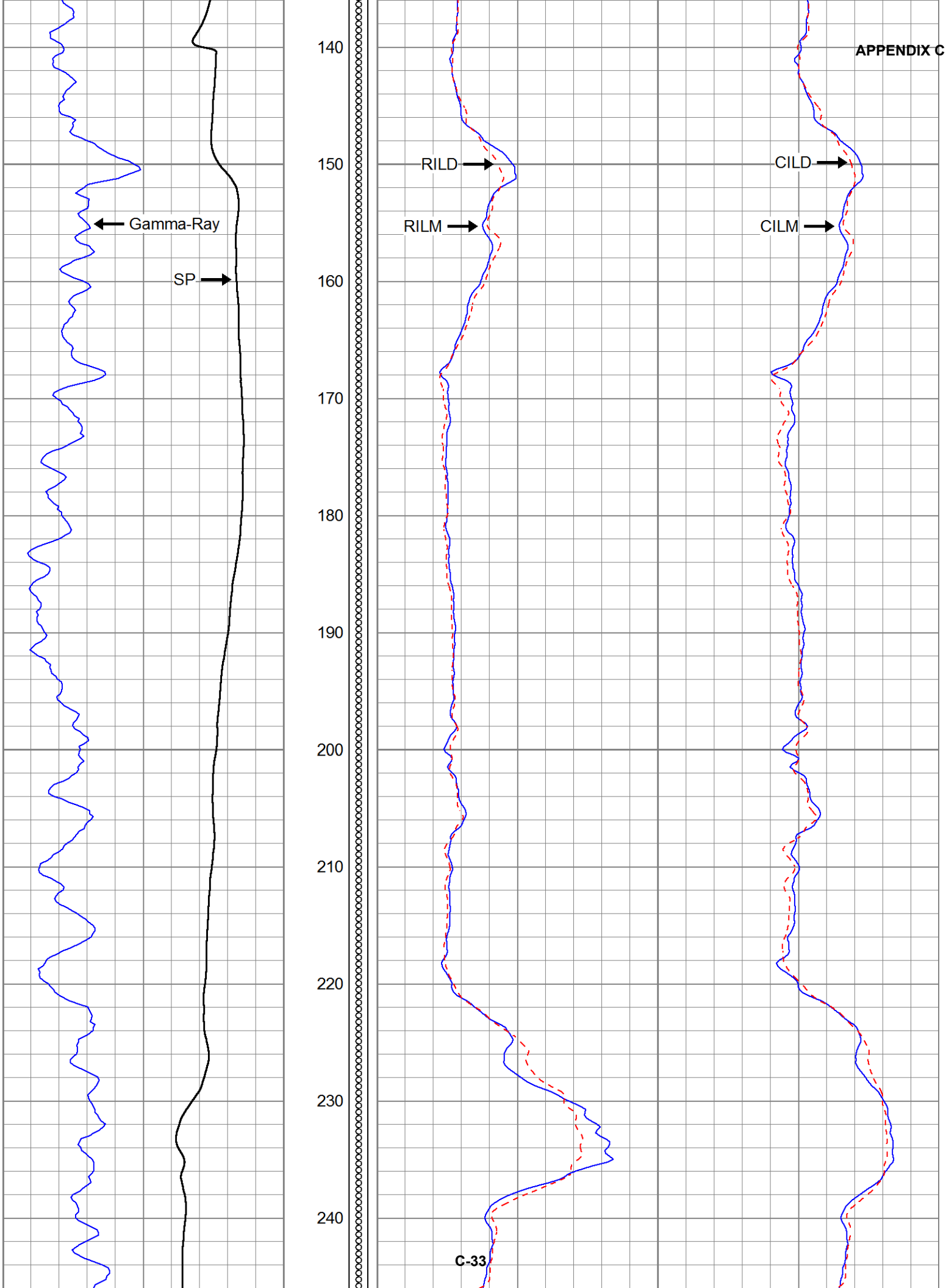
Gamma Ray Calibration Report

Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Dec 13 17:32:47 2014	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

Database File	19027.db
Dataset Pathname	dil
Presentation Format	dil_ps
Dataset Creation	Sun Dec 14 14:35:19 2014
Charted by	Depth in Feet scaled 1:120

-100	SP (mV)	0	0	RILM (Ohm-m)	5	1500	CILM (mmho/m)	0
30	Gamma Ray (GAPI)	130	0	RILD (Ohm-m)	5	1500	CILD (mmho/m)	0
			5	RILM backup (Ohm-m)	50	15000	CILM backup (mmho/m)	1500
			5	RILD backup (Ohm-m)	50	15000	CILD backup (mmho/m)	1500

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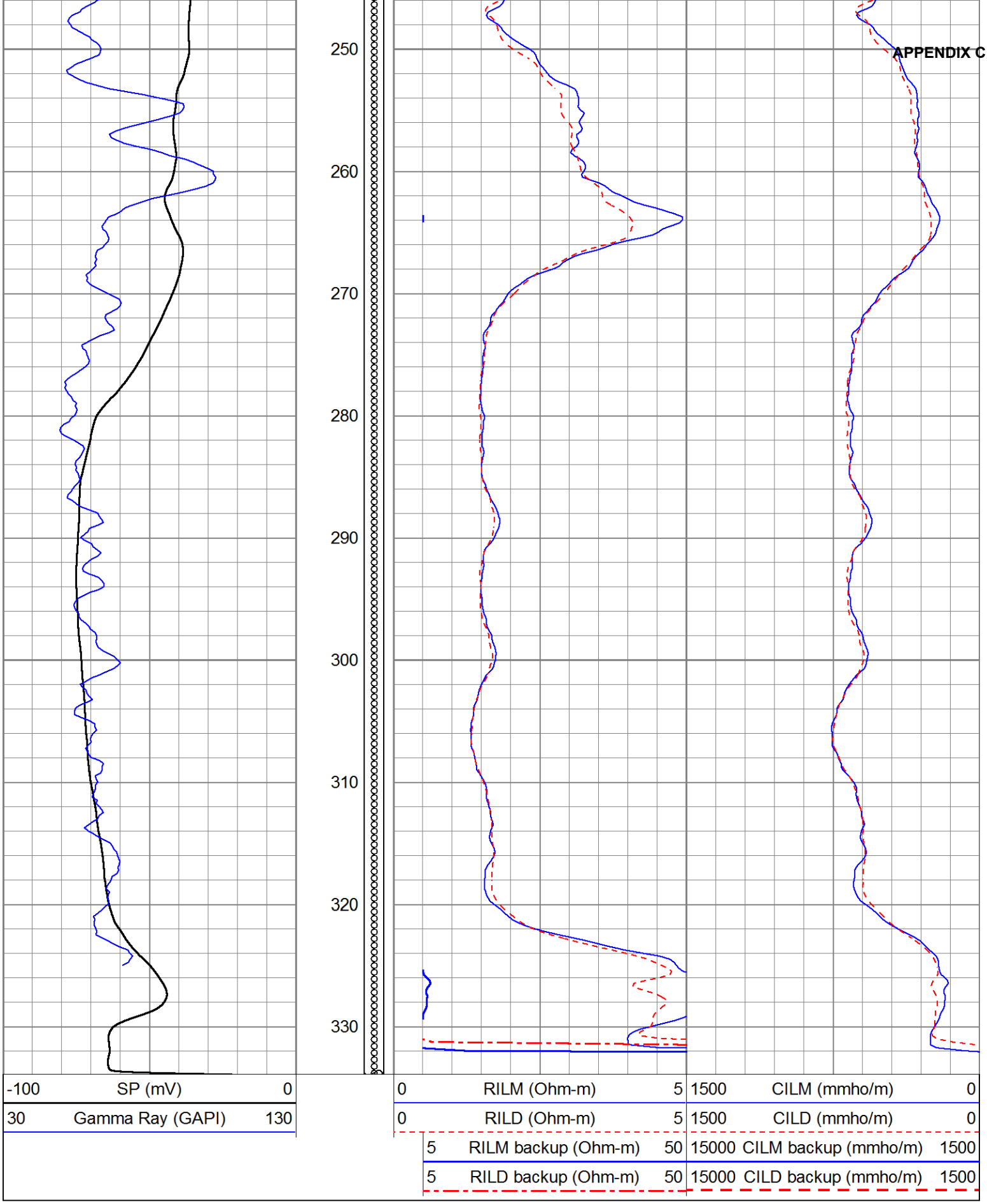
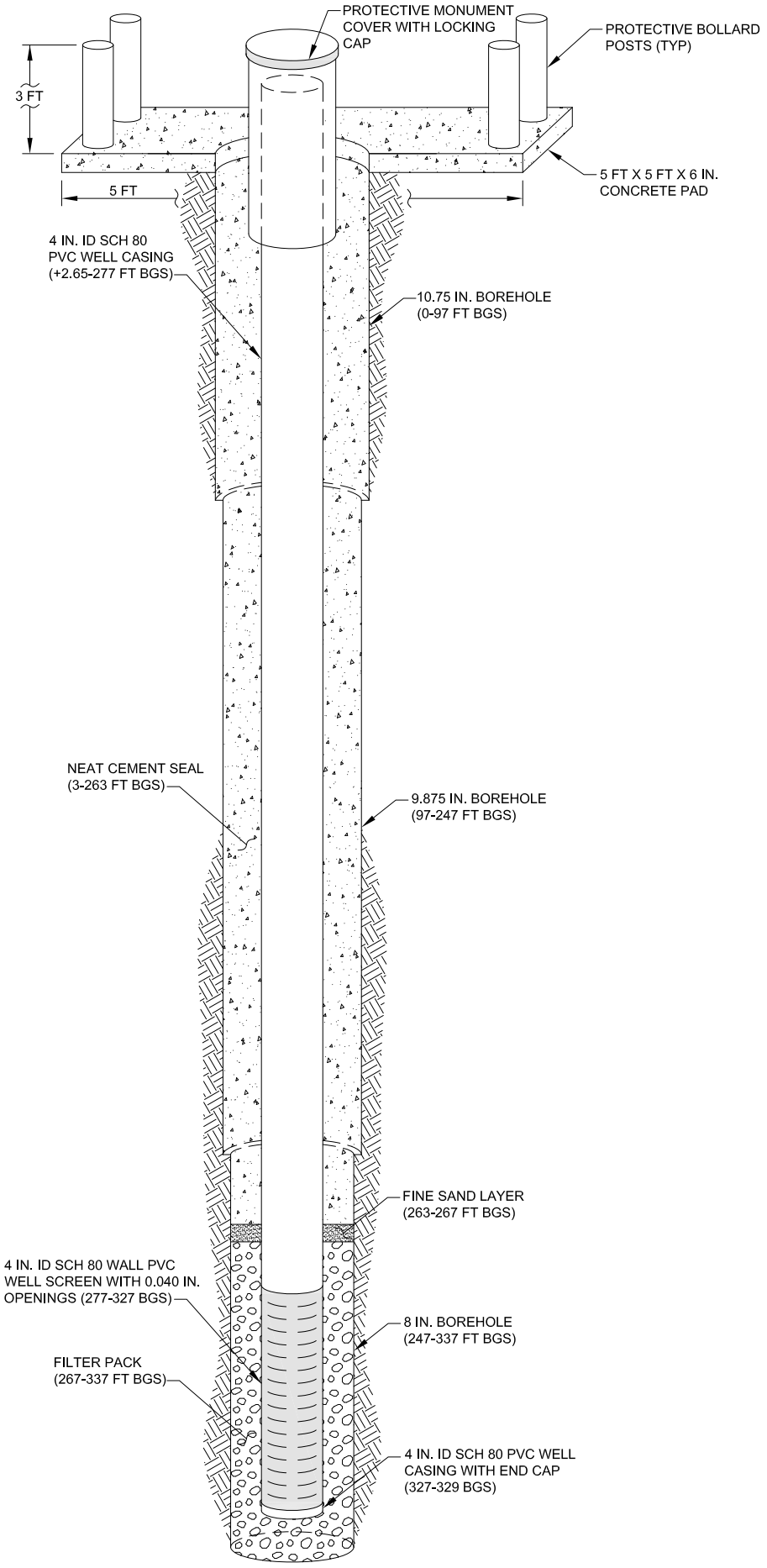
150
160
170
180
190
200
210
220
230
240
Gamma-Ray
SP
RILD
RILM
CILD
CILM


250
260
270
280
290
300
310
320
330
-100 SP (mV) 0
30 Gamma Ray (GAPI) 130
0 RILM (Ohm-m) 5
0 RILD (Ohm-m) 5
5 RILM backup (Ohm-m) 50
5 RILD backup (Ohm-m) 50
1500 CILM (mmho/m) 0
1500 CILD (mmho/m) 0
15000 CILM backup (mmho/m) 1500
15000 CILD backup (mmho/m) 1500



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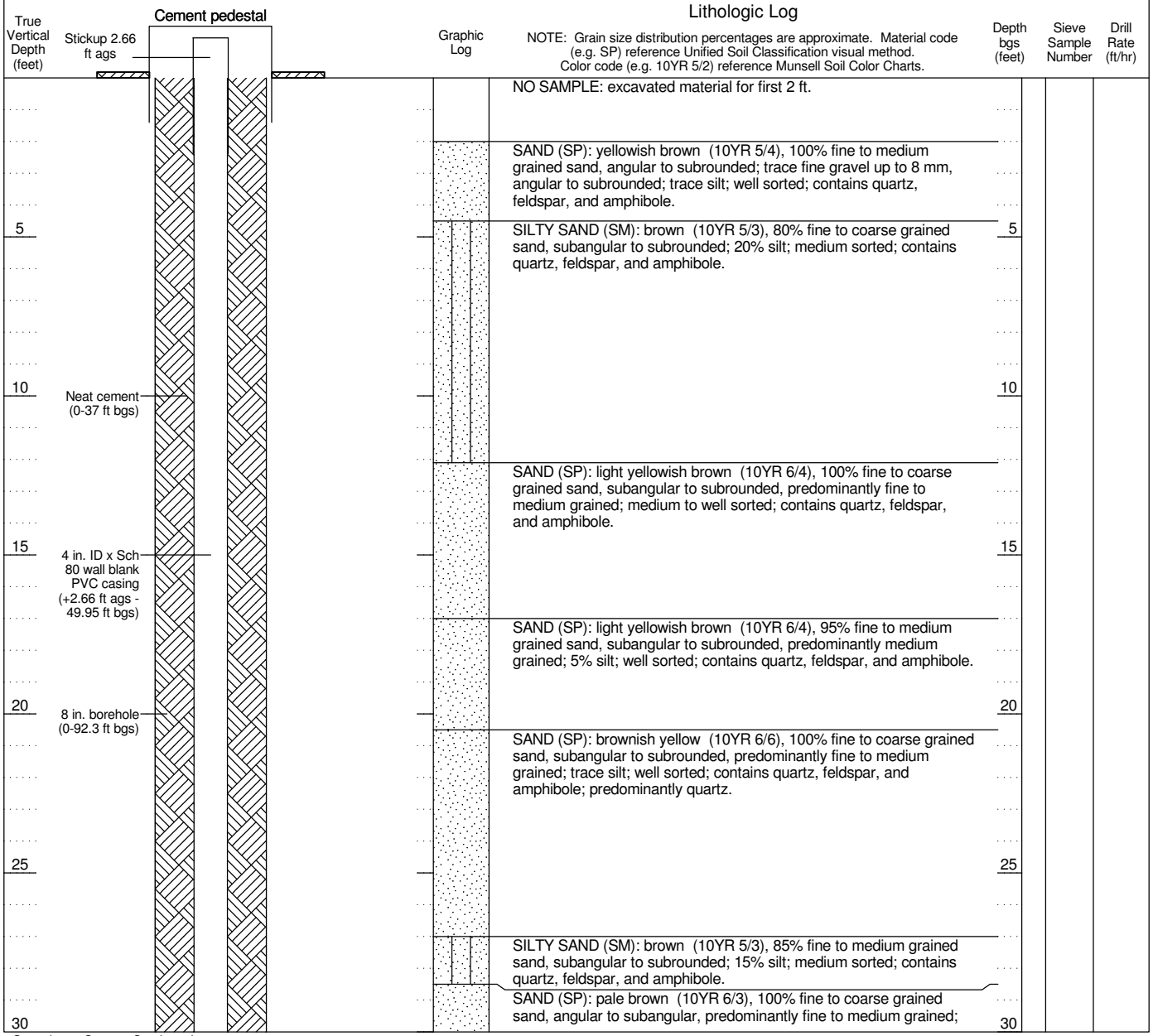
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-3S**	
CLIENT / PROJECT NUMBER: Cal Am 14077-15	LOCATION: **Marina, CA** **CEMEX**
REPORT DATE	
DRILLING CONTRACTOR / DRILLER: Cascade Drilling	LOGGED BY: **J. Sobolew**

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.66**	**49.95**	**52.61**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**49.95**	**89.95**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**89.95**	**92.3**	**2.35**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	34.50 ft NAVD88									
TOC ELEVATION	37.16 ft NAVD88 (RP)									
START DATE	2/18/15									
FINISH DATE	2/19/15									



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WELL NUMBER **MPWSP MW-3S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		medium sorted; contains quartz, feldspar, and amphibole; water level at approximately 33 ft bgs.			
35			35		
		SAND (SP): pale brown (10YR 6/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; medium sorted; contains quartz, feldspar, and amphibole.			
40			40		
45			45		
50			50		
55		SAND (SP): light olive gray (5Y 6/2), 90% fine to coarse grained sand, subangular; 10% fine gravel; trace silt; medium sorted; contains quartz, feldspar, mica, and amphibole.	55		8.6
60			60		
65		SAND (SP): olive (5Y 5/3), 100% sand, subangular to subrounded, very fine to fine grained; trace silt; well sorted; contains quartz, feldspar, mica, and amphibole; high mica content.	65		
70		SAND (SP): olive brown (2.5Y 4/3), 95% sand, subrounded, fine to very fine, trace medium grained; 5% silt; well sorted; contains quartz, mica, and amphibole; high mica content.	70		

CEMEX Monterey Lapis Lustre #60 fine sand seal (37-40 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (40-92.3 ft bgs)

4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (49.95-89.95 ft bgs)

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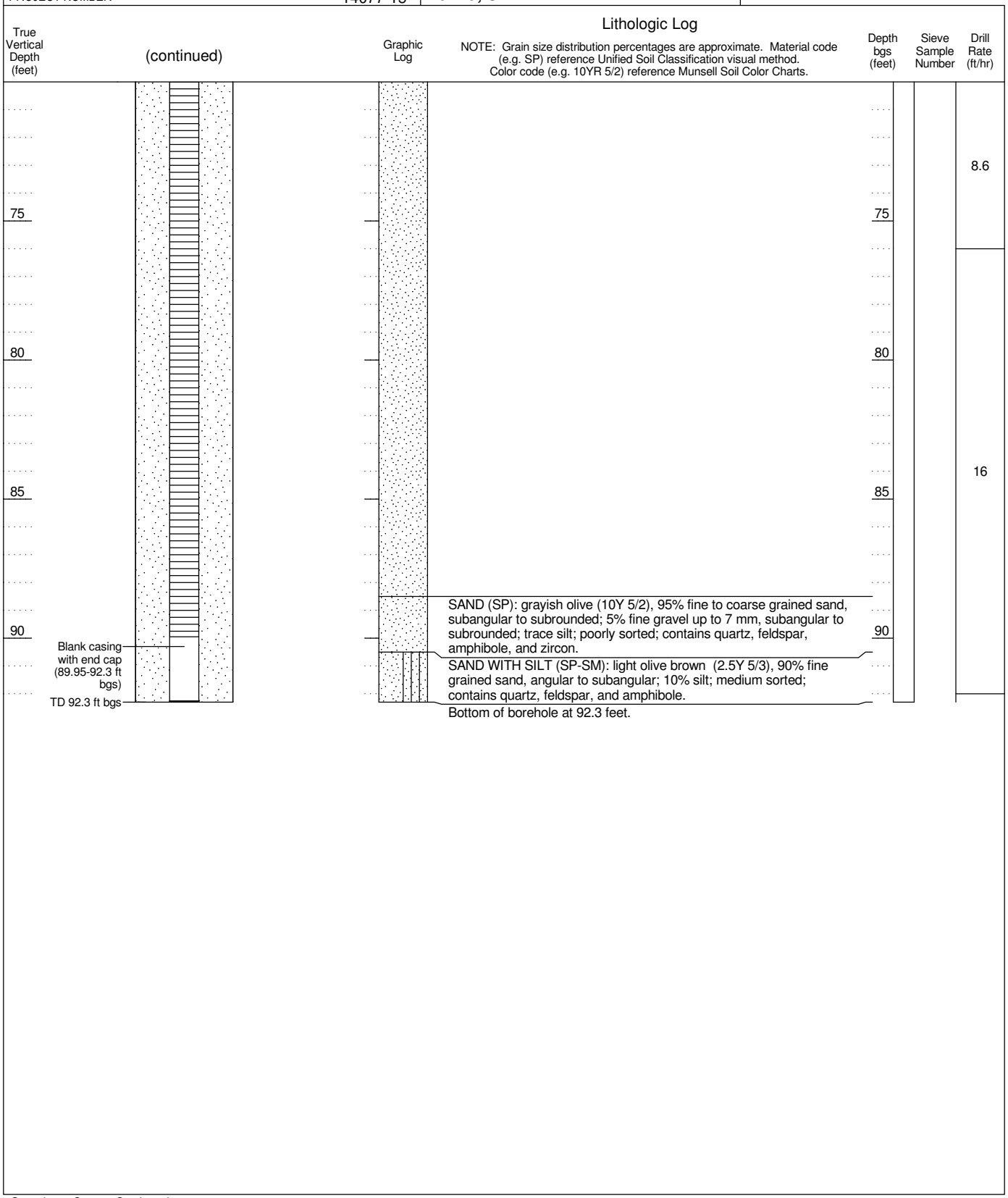
WELL NUMBER **MPWSP MW-3S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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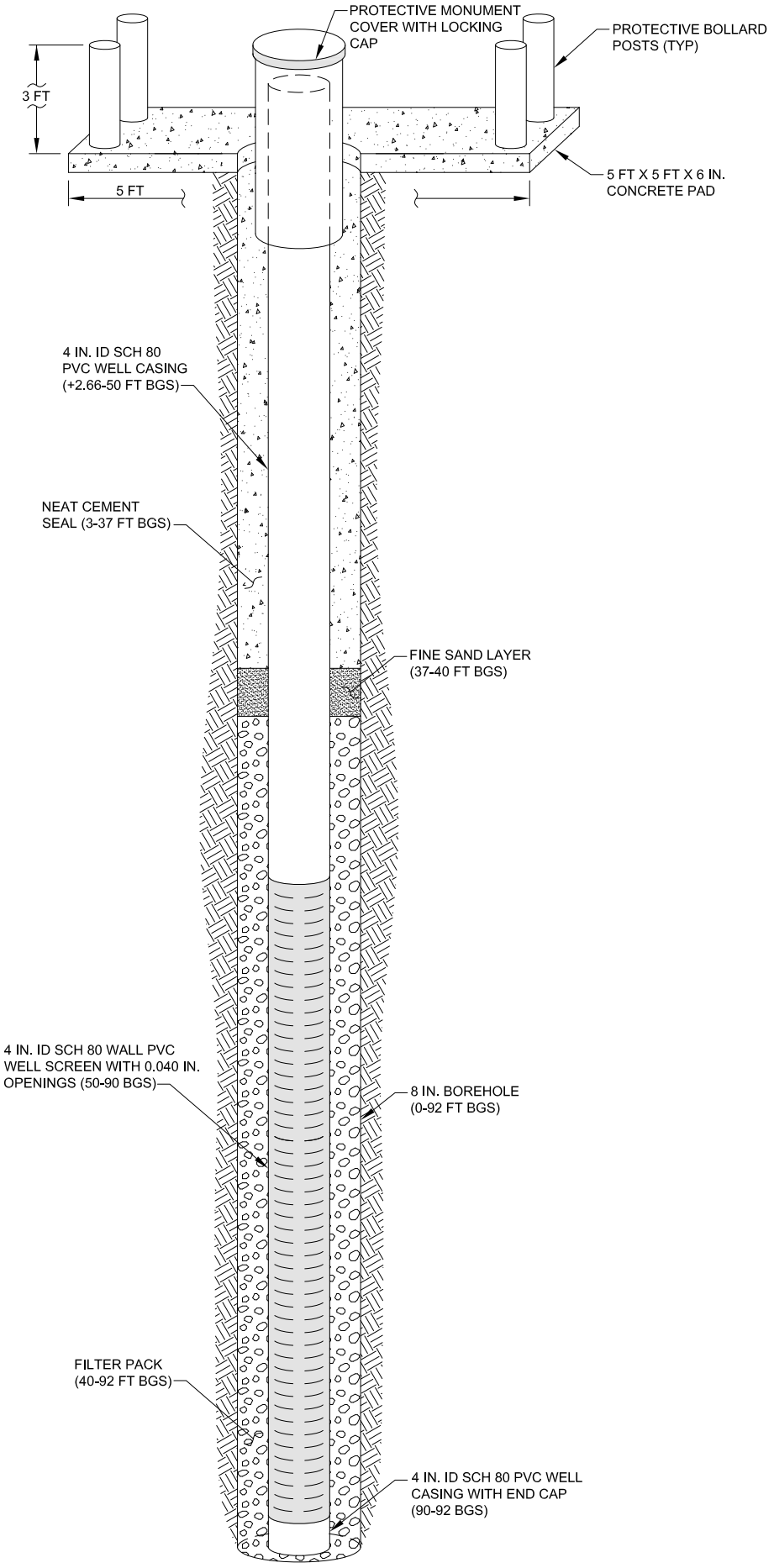

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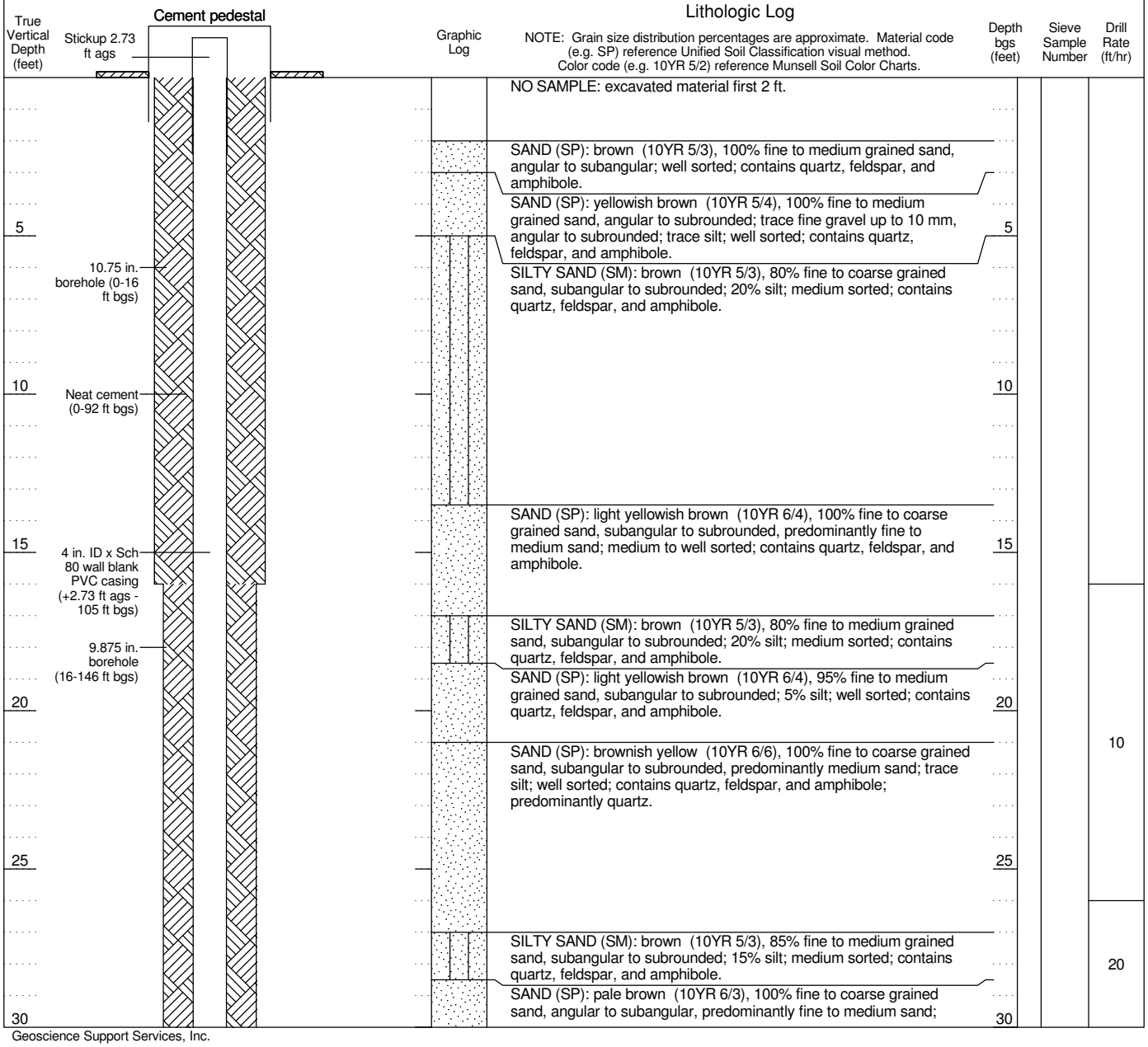
WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG

CLIENT	Cal Am	LOCATION	**Marina, CA**
PROJECT NUMBER	14077-15		**CEMEX**
REPORT DATE			
DRILLING CONTRACTOR	Cascade Drilling	LOGGED BY	**J. Sobolew**
DRILLER			

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T	**Blank**	**-2.73**	**105**	**107.73**	**PVC**	**Sch 80**	**4 / ID**		
DRILLING METHOD	Sonic	**Screen**	**105**	**215**	**110**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
SAMPLING METHOD	Core	**Blank**	**215**	**217.345**	**2.345**	**PVC**	**Sch 80**	**4 / ID**		
BOREHOLE DIAMETER	10.75, 9.875, 8 in									
SURFACE ELEVATION	34.62 ft NAVD88									
TOC ELEVATION	37.35 ft NAVD88 (RP)									
START DATE	2/09/15									
FINISH DATE	2/17/15									



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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			medium sorted; contains quartz, feldspar, and amphibole; water level at approximately 30 ft bgs.			
35				35		
			SAND (SP): pale brown (10YR 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; trace silt; medium sorted; contains quartz, feldspar, and amphibole.			20
40				40		
45				45		
50				50		
			SAND (SP): light olive gray (5Y 6/2), 100% fine to coarse grained sand, subangular; trace silt; medium sorted; contains quartz, feldspar, mica, and amphibole.			
55				55		
60				60		
			SAND (SP): olive (5Y 5/3), 100% fine grained sand, subangular to subrounded, very fine to fine sand; trace silt; well sorted; contains quartz, feldspar, mica, and amphibole; high biotite mica content.		
65				65		
			SAND (SP): olive brown (2.5Y 4/3), 95% sand, subrounded, very fine to fine and trace medium sand; 5% silt; well sorted; contains quartz, mica, and amphibole; high mica content.			
70				70		

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			75		
80			80		
85			85		
		SAND (SP): grayish olive (10Y 5/2), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel up to 7 mm, subangular to subrounded; trace silt; poorly sorted; contains feldspar; contains quartz, feldspar, amphibole, and zircon.			
90		SAND (SP): light yellowish brown (2.5Y 6/4), 95% fine to coarse grained sand, subangular to subrounded, predominantly medium to coarse sand; 5% fine gravel up to 9 mm, subangular to subrounded; trace silt; medium sorted; contains quartz, feldspar, mica, and amphibole.	90		
		SAND WITH SILT (SP-SM): light olive brown (2.5Y 5/3), 90% fine grained sand, angular to subangular; 10% silt; well sorted; contains quartz, feldspar, and amphibole; contains shells.			10
95			95		
		SAND (SP): light yellowish brown (2.5Y 6/3), 85% fine to coarse grained sand, subangular to subrounded; 10% fine gravel up to 12 mm, subangular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, and amphibole; alternates grain size from fine to medium to fine to coarse to fine to medium from 96 to 107 ft bgs.			
100			100		
105			105		
		SILTY SAND (SM): light olive brown (2.5Y 5/3), 80% fine grained sand, angular to subangular; 20% silt; contains quartz, feldspar, mica, and amphibole; contains shells from 114 to 116 ft.			
110			110		

CEMEX Monterey Lapis Lustre #60 fine sand seal (92-94 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (94-218.5 ft bgs)

4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (105-215 ft bgs)

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115			115		
		SAND (SP): light olive brown (2.5Y 5/3) and olive (5Y 5/4), 95% fine to medium grained sand, subangular to subrounded, trace coarse sand; 5% clay; well sorted; contains quartz, feldspar, and amphibole; 10% fine to coarse gravel from 116 to 119 ft; becomes finer with increasing depth; oxidation.			
120			120		10
125			125		
		FAT CLAY (CH): olive (5Y 5/3), 100% clay, medium plasticity.			
		SAND (SP): light gray (2.5Y 7/2), 95% fine to medium grained sand, subangular to subrounded, trace coarse sand; 5% silt; well sorted; contains some amphibole but predominantly quartz; oxidation.			
130			130		
135		CLAYEY SAND (SC): light olive brown (2.5Y 5/4), 75% fine grained sand, subangular; 25% clay; medium to well sorted; contains quartz, mica, and amphibole.	135		
		SILTY SAND (SM): pale olive (5Y 6/3), 80% fine to coarse grained sand, subangular to subrounded; 15% silt; 5% fine gravel up to 10 mm, subangular to subrounded; poorly to medium sorted; contains quartz, feldspar, mica, and amphibole.			
140		CLAYEY SAND (SC): pale olive (5Y 6/3), 85% fine grained sand, subangular to subrounded; 15% clay, low plasticity; well sorted; contains quartz, feldspar, and amphibole.	140		
		CLAYEY SAND WITH GRAVEL (SC): dark yellowish brown (10YR 4/4), 65% fine to coarse grained sand, subangular to subrounded; 20% clay, low plasticity; 15% fine to coarse gravel up to 20 mm, subangular to subrounded; poorly sorted; contains quartz, feldspar, and amphibole; gravel grades finer with depth.			
145		SAND WITH CLAY AND GRAVEL (SP-SC): pale olive (5Y 6/3), 70% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel up to 20 mm, subangular to subrounded; 10% clay; poorly to medium sorted; contains quartz, feldspar, and amphibole.	145		
150		SAND WITH SILT (SP-SM): yellowish brown (10YR 5/6), 90% fine grained sand, subrounded; 10% silt; well sorted; contains quartz, feldspar, and amphibole.	150		

8 in. borehole (146-230 ft bgs)

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
155				155		
160			SAND (SP): dark yellowish brown (10YR 4/6), 95% sand, subangular to subrounded, fine to very fine sand; 5% silt; well sorted; weak cementation; contains quartz, feldspar, and amphibole.	160		
			FAT CLAY (CH): brown (10YR 4/3), 100% clay, high plasticity; trace fine grained sand; up to 10% fine to medium sand from 165 to 166 ft bgs.			
165				165		
			SAND WITH SILT (SP-SM): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; well sorted; contains quartz, mica, and amphibole.			
170				170		
			SAND (SP): olive (5Y 5/3), 95% fine to medium grained sand; 5% silt; well sorted; contains quartz, mica, and amphibole; interbeds of medium to high plasticity.			
175			SAND (SP): pale olive (5Y 6/3), 95% fine to medium grained sand, subangular to subrounded, interbeds of coarse sand; 5% silt; well sorted; contains quartz, feldspar, mica, and amphibole.	175		12
180			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; trace silt; well sorted; weak cementation; contains quartz, mica, and amphibole; high dark mineral content.	180		
185				185		
190				190		

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
				12
195	CLAYEY SAND (SC): brown (7.5YR 4/4), 70% fine grained sand, subrounded; 30% clay, low plasticity; well sorted; weak cementation; contains quartz, feldspar, and amphibole.	195		
	SANDY CLAY (CL): yellowish brown (10YR 5/6), 60% clay, low to medium plasticity; 40% fine grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole.			
200	CLAYEY SAND (SC): dark yellowish brown (10YR 4/6), 65% fine grained sand, subangular to subrounded; 35% clay, low plasticity; well sorted; contains quartz, feldspar, and amphibole; high content dark mineral content.	200		
	SILTY SAND (SM): brown (10YR 5/3), 60% fine grained sand, subangular to subrounded; 40% silt; well sorted; weak cementation; contains quartz, feldspar, and amphibole; high dark mineral content.			
205		205		
	SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; well sorted; weak cementation; contains quartz, feldspar, and amphibole; high dark mineral content; oxidation.			
210	SANDY CLAY (CL): olive brown (2.5Y 4/3), 70% clay, low to high plasticity; 30% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole.	210		
	CLAY (CL): olive (5Y 5/3), 100% clay, medium plasticity; oxidation from 213 to 214.5 ft.			
215		215		
	SAND (SP): pale olive (5Y 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; trace gravel subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.			
	SAND (SP): olive (5Y 4/3), 90% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, mica, and amphibole.			
220	SAND (SP): light olive gray (5Y 6/2), 85% fine to coarse grained sand, angular to subrounded; 10% fine gravel up to 16 mm, angular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, mica, and amphibole.	220		
225		225		
	SILT WITH SAND (ML): olive (5Y 5/3), 85% silt; 15% fine to medium grained sand, subrounded; contains quartz.			
	SANDY SILT (ML): light olive brown (2.5Y 5/4), 70% silt; 30% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
230	Bottom of borehole at 230 feet.	230		

Blank casing with end cap (215-217.345 ft bgs)

Backfill with native material (218.5-230 ft bgs)

TD 230 ft bgs

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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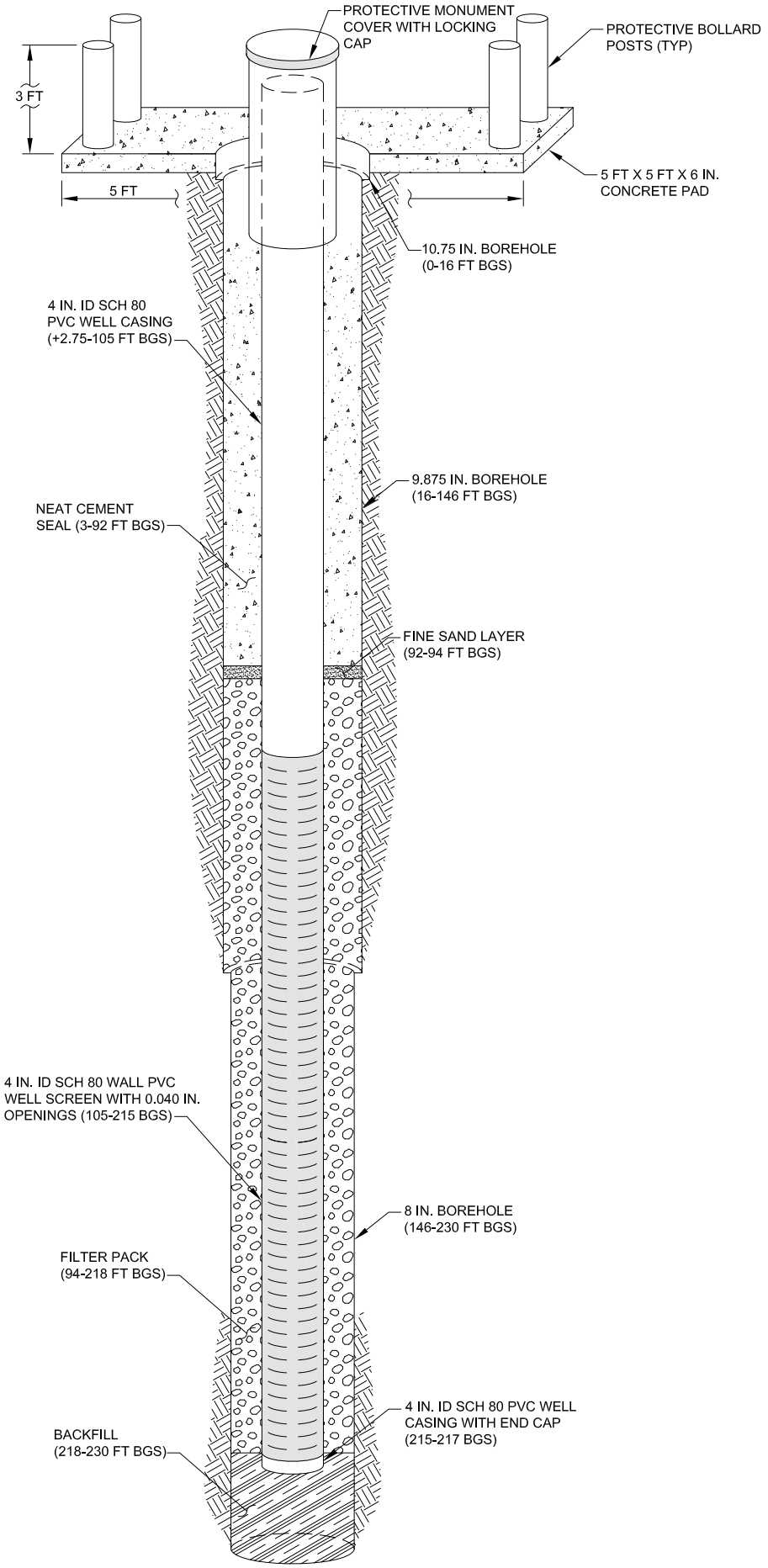

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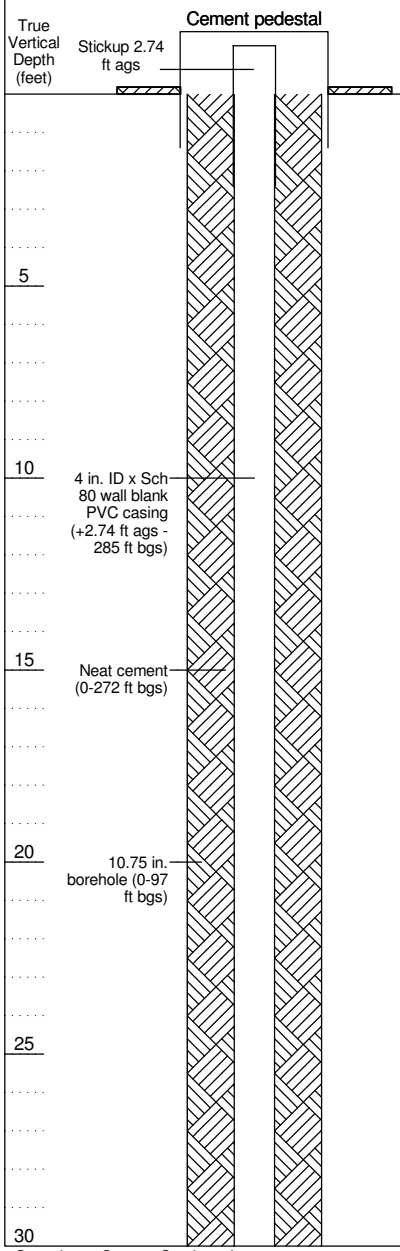
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-3D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: A. Patricio	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.74**	**285**	**287.74**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**285**	**330**	**45**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**330**	**332.26**	**2.26**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	34.19 ft NAVD88									
TOC ELEVATION	36.93 ft NAVD88 (RP)									
START DATE	2/02/15									
FINISH DATE	2/09/15									



Lithologic Log

Graphic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Depth bgs (feet) | Sieve Sample Number | Drill Rate (ft/hr)

NO SAMPLE: excavated material recompacted for first 2 ft.

SAND (SP): brown (10YR 5/3), 100% fine to medium grained sand, angular to subangular; well sorted; dry sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): yellowish brown (10YR 5/4), 100% fine to medium grained sand, angular to subrounded; trace fine gravel up to 10 mm, angular to subrounded; trace silt; well sorted; dry sample; contains quartz, feldspar, amphibole, and other.

SILTY SAND (SM): brown (10YR 5/3), 80% fine to coarse grained sand, subangular to subrounded; 20% silt; medium sorted; moist sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): light yellowish brown (10YR 6/4), 100% fine to coarse grained sand, subangular to subrounded, predominantly fine to medium grains; medium to well sorted; dry sample; contains quartz, feldspar, amphibole, and other.

SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular to subrounded; 15% silt; medium sorted; moist sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): light yellowish brown (10YR 6/4), 95% fine to medium grained sand, subangular to subrounded; 5% silt; well sorted; dry sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): brownish yellow (10YR 6/6), 100% fine to coarse grained sand, subangular to subrounded, predominantly medium grains; trace silt; well sorted; moist sample; contains quartz, amphibole, and other.

SAND WITH SILT (SP-SM): brown (10YR 5/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; medium sorted; moist sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, angular to subangular; medium sorted; wet sample; contains

Drill Rate (ft/hr): 12, 22

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			quartz, feldspar, amphibole, and other.			
35				35		22
			SAND (SP): pale brown (10YR 6/3), 95% fine to coarse grained sand, angular to subangular; 5% fine gravel up to 5 mm, angular to subangular; trace silt; medium to well sorted; wet sample; contains quartz, feldspar, amphibole, and other; 10% gravel from 50.1-50.2 ft bgs.			
40				40		
45				45		
50				50		
			SAND (SP): light olive gray (5Y 6/2), 100% fine to coarse grained sand, subangular; trace silt; medium to well sorted; wet sample; contains quartz, feldspar, mica, amphibole, and other; fine to medium sand (52.4 to 54.6 ft bgs) grading to coarse sand (54.6 to 60.7 ft bgs).			
55				55	1	
60				60		
			SAND (SP): olive (5Y 5/3), 100% sand, subangular to subrounded, very fine to fine; trace silt; well sorted; moist sample; contains quartz, feldspar, mica, amphibole, and other; high mica and biotite content.			
65				65		
			SAND (SP): olive brown (2.5Y 4/3), 95% sand, subrounded, very fine to fine with trace medium grains; 5% silt; well sorted; wet sample; contains quartz, mica, amphibole, and other; high mica content.			
70				70		

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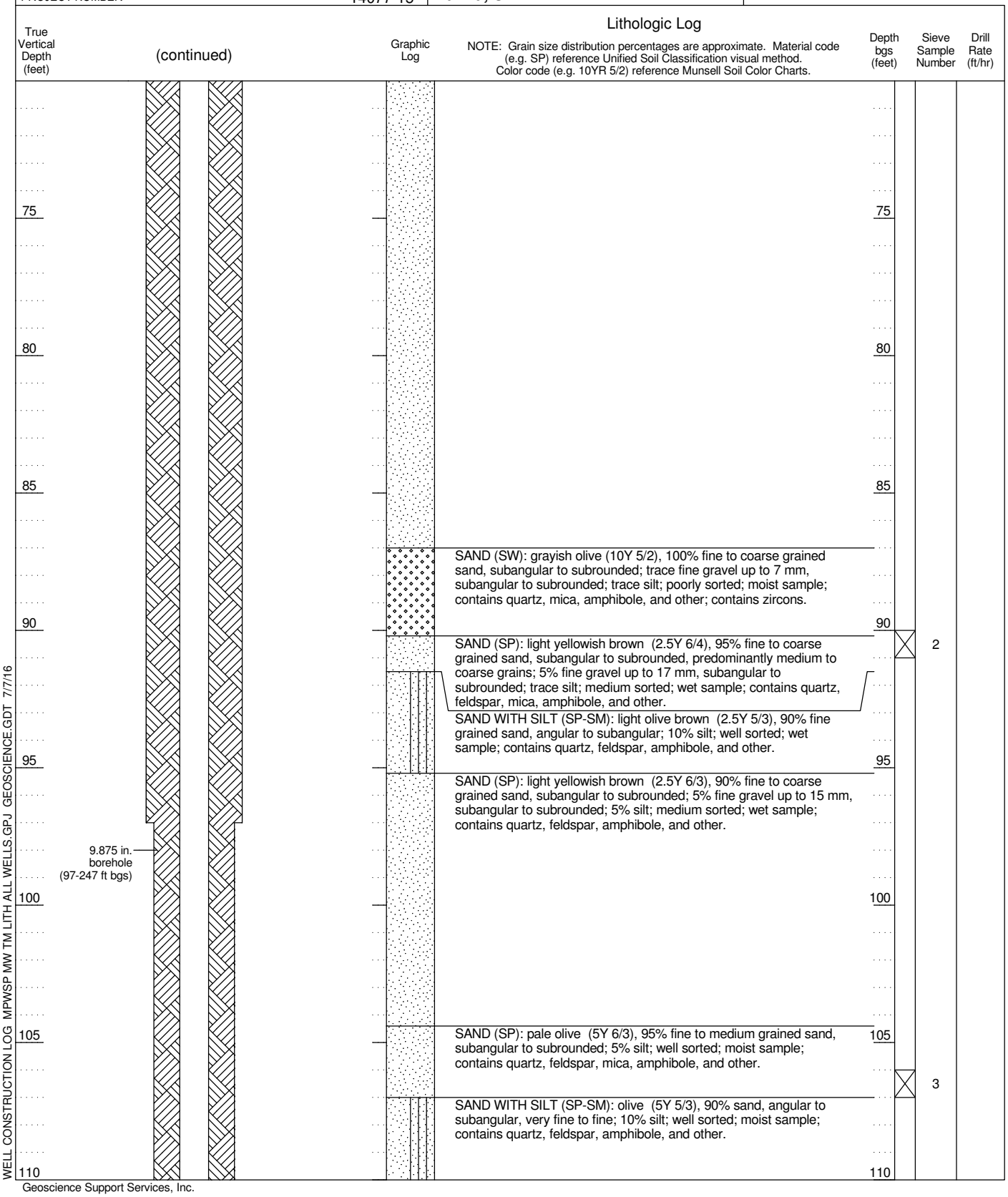
WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115				115		
			SAND (SP): light olive brown (2.5Y 5/3) and pale olive (5Y 6/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, amphibole, and other; pale olive from 112.5 to 117 ft.			
120				120		
125				125	4	20
			SAND (SP): light gray (2.5Y 7/2), 95% fine to medium grained sand, subangular to subrounded, trace coarse; 5% silt; well sorted; contains quartz, and amphibole; predominantly quartz.			
130				130		
135				135		
			CLAYEY SAND (SC): light olive brown (2.5Y 5/4), 85% fine grained sand, subangular; 15% clay, low plasticity; well sorted; contains quartz, mica, amphibole, and other.			
			SILTY SAND (SM): pale olive (5Y 6/3), 80% fine to coarse grained sand, subangular to subrounded; 15% silt; 5% fine gravel up to 38 mm, subangular to subrounded; poorly to medium sorted; contains quartz, feldspar, mica, and amphibole.			
140				140		
			CLAYEY SAND (SC): pale olive (5Y 6/3), 85% fine grained sand, subangular to subrounded; 15% clay, low plasticity; well sorted; contains quartz, feldspar, and amphibole.			
			CLAYEY SAND WITH GRAVEL (SC): dark yellowish brown (10YR 4/4), 65% fine to coarse grained sand, subangular to subrounded; 20% clay, low plasticity; 15% fine to coarse gravel up to 20 mm, subangular to subrounded; poorly sorted; contains quartz, feldspar, amphibole, and other.			15
145			CLAY (CH): light olive brown (2.5Y 5/3), 100% clay, high plasticity.	145		
			SAND WITH CLAY AND GRAVEL (SP-SC): pale olive (5Y 6/3), 70% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel up to 20 mm, subangular to subrounded; 10% clay, low to medium plasticity; poorly to medium sorted; contains quartz, feldspar, amphibole, and other.		5	
			SAND WITH GRAVEL (SP): light olive gray (5Y 6/2), 75% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel; medium sorted; contains quartz, feldspar, amphibole, and			
150				150		

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			other.			
			SAND WITH SILT (SP-SM): yellowish brown (10YR 5/6), 90% sand, subrounded, very fine to fine; 10% silt; well sorted; contains quartz, feldspar, amphibole, and other.			
155				155		15
160			SAND (SP): dark yellowish brown (10YR 4/6), 95% sand, subangular to subrounded, very fine to fine; 5% silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other.	160		
			CLAY (CH): brown (10YR 4/3), 100% clay, high plasticity; contains mica; trace fine mica.			
165				165		
			SILTY SAND (SM): pale olive (5Y 6/3), 85% fine grained sand, subangular to subrounded; 15% silt; well sorted; contains quartz, mica, amphibole, and other.			
170				170	6	
			SILT (ML): light olive brown (2.5Y 5/4), 100% silt, brittle; low plasticity; thin interbeds of medium to coarse sand from 170.5 to 171 ft bgs.			
			SAND (SP): olive (5Y 5/3), 95% fine to medium grained sand; 5% silt; well sorted; contains quartz, mica, and amphibole; interbeds of high to medium plasticity clay.			
175				175		
			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; trace silt; well sorted; weak cementation; contains quartz, mica, amphibole, and other; high dark mineral content.			
180				180		
185				185		
190				190		

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	Lithologic Log (continued)	Graphic Log	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			CLAYEY SAND (SC): brown (7.5YR 4/4), 60% fine grained sand, subrounded; 40% clay, low plasticity; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other.	195		
			SANDY CLAY (CL): yellowish brown (10YR 5/6), 60% clay, low to medium plasticity; 40% fine grained sand, subangular to subrounded; contains quartz, feldspar, amphibole, and other.			
200			SANDY CLAY (CL): dark yellowish brown (10YR 4/6), 60% clay, low plasticity; 40% fine grained sand, subangular to subrounded; contains quartz, feldspar, amphibole, and other; high dark mineral content.	200		
			SANDY SILT (ML): brown (10YR 5/3), 55% silt; 45% fine grained sand, subangular to subrounded; weak cementation; contains quartz, feldspar, amphibole, and other; high dark mineral content.		7	
205			SILTY SAND (SM): light olive brown (2.5Y 5/3), 60% fine to medium grained sand, subangular to subrounded; 40% silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; high dark mineral content.	205	8	
			SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; oxidation; high dark mineral content.			
210				210		
			SILTY SAND (SM): olive (5Y 5/3), 80% fine to medium grained sand, subangular to subrounded; 20% silt; well sorted; contains quartz, feldspar, amphibole, and other; high abundance of minerals; oxidation from 215 to 216 ft.			
215				215		
			SILT (ML): olive (5Y 5/3), 100% silt, brittle; low plasticity.			15
220			SAND (SP): pale olive (5Y 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, mica, amphibole, and other.	220		
			SAND WITH CLAY AND GRAVEL (SP-SC): pale olive (5Y 6/3), 75% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 25 mm, subangular to subrounded; 10% clay, low plasticity; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.			
225			SAND (SP): light olive gray (5Y 6/2), 85% fine to coarse grained sand, angular to subangular; 10% fine gravel angular to subangular; 5% clay; medium sorted; contains quartz, feldspar, mica, and amphibole.	225	9	
			SANDY SILT (ML): olive (5Y 5/3), 65% silt, low plasticity; 35% fine grained sand, subangular; contains quartz, and mica.			5
230				230		

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		SAND WITH SILT (SP-SM): light olive brown (2.5Y 5/4), 90% fine to medium grained sand, subangular to subrounded; 10% silt; medium sorted; contains quartz, feldspar, mica, amphibole, and other.		10	
235		SILT (ML): light olive brown (2.5Y 5/3), 100% silt; medium plasticity; trace mica.	235		
240			240		
		CLAY (CH): olive brown (2.5Y 4/4), 100% clay, medium to high plasticity.			5
245		CLAY (CH): dark greenish gray (10Y 4/1), 100% clay, high plasticity; olive (5Y 5/3) from 247-249.3 ft bgs.	245		
250		CLAYEY SAND (SC): olive (5Y 4/3), 85% fine grained sand, subangular; 15% clay, low plasticity; well sorted; weak cementation; contains quartz, feldspar, mica, amphibole, and other.	250		
		SAND WITH CLAY (SP-SC): olive (5Y 5/3), 85% fine to coarse grained sand, subangular to subrounded; 10% clay; 5% fine to coarse gravel up to 19 mm, subangular to subrounded; medium sorted; contains quartz, mica, amphibole, and other.			
255		SAND (SP): olive gray (5Y 5/2), 85% medium to coarse grained sand, subangular to subrounded; 10% gravel up to 12 mm, subangular to subrounded; 5% clay; medium sorted; contains quartz, feldspar, mica, amphibole, and other.	255	11	
		SAND (SP): light brownish gray (2.5Y 6/2), 80% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 26 mm; 5% clay; medium sorted; contains quartz, feldspar, mica, amphibole, and other.			
260			260		
					15
265		CLAY (CH): olive (5Y 5/3), 100% clay, high plasticity.	265		
270			270		

8 in. borehole (247 - 332.5 ft bgs)

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
275	CEMEX Monterey Lapis Lustre #60 fine sand seal (272-275 ft bgs)		CLAY (CL): olive gray (5Y 5/2), 80% clay, low to medium plasticity; 15% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 15 mm; contains quartz, feldspar, amphibole, and other.	275		
			GRAVELLY CLAY (CL): pale olive (5Y 6/3), 60% clay, medium plasticity; 30% fine to coarse gravel up to 45 mm, subrounded; 10% fine to coarse grained sand, subrounded; contains quartz, feldspar, amphibole, and other.			
	CEMEX Monterey Lapis Lustre #3 filter pack (275-332.5 ft bgs)		SAND WITH CLAY (SP-SC): olive gray (5Y 5/2), 90% fine grained sand, subangular to subrounded, trace medium grains; 10% clay, no to low plasticity; medium to well sorted; contains quartz, mica, amphibole, and other.		12	15
280			SANDY CLAY (CL): pale olive (5Y 6/3), 55% clay, low plasticity; 30% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 60 mm, subangular to subrounded; contains quartz, mica, and amphibole; increased gravel with depth to 35%.	280		
			CLAY (CH): light olive brown (2.5Y 5/4), 100% clay, medium to high plasticity.			
285			SAND (SP): light olive brown (2.5Y 5/4), 95% fine to medium grained sand, subangular to subrounded, trace coarse; 5% clay; contains quartz, feldspar, mica, and amphibole.	285		
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (285-330 ft bgs)		SAND (SP): grayish brown (2.5Y 5/2), 95% fine to coarse grained sand, subangular to subrounded; 5% fine to coarse gravel up to 40 mm; trace clay; contains quartz, feldspar, mica, and amphibole.			
290				290		
			SAND WITH GRAVEL (SP): light yellowish brown (2.5Y 6/3), 70% medium to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel up to 35 mm, subangular to subrounded; 5% clay; contains quartz, feldspar, mica, and amphibole.			
295			CLAY (CH): yellowish brown (10YR 5/6), 100% clay, medium plasticity; trace interbeds of medium to coarse sand.	295		
			SAND WITH CLAY AND GRAVEL (SP-SC): light olive brown (2.5Y 5/3), 65% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel up to 22 mm, subangular to subrounded; 10% clay, low plasticity; medium sorted; contains quartz, feldspar, mica, and amphibole.		13	
300			SAND (SP): light olive brown (2.5Y 5/6), 95% fine to medium grained sand, subangular to subrounded; 5% clay; well sorted; contains quartz, feldspar, mica, and amphibole.	300		
305				305	14	
			SAND (SP): olive brown (2.5Y 4/3), 85% fine to coarse grained sand; 10% fine gravel up to 6 mm; 5% clay; medium sorted; contains quartz, feldspar, mica, and amphibole.			
310				310		

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WELL NUMBER
MPWSP MW-3D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/4), 80% fine to coarse grained sand, angular to subangular; 15% fine to coarse gravel up to 15 mm, angular to subangular; 5% clay; medium sorted; contains quartz, feldspar, mica, and amphibole.			
315			CLAYEY GRAVEL WITH SAND (GC): light olive brown (2.5Y 5/4), 45% fine to coarse gravel up to 15 mm, subrounded; 30% clay, medium plasticity; 25% fine to coarse grained sand, subrounded; poorly sorted; contains quartz, feldspar, and amphibole.	315		
			SAND (SP): light olive brown (2.5Y 5/3), 85% fine to coarse grained sand, subangular to subrounded; 10% fine gravel up to 7 mm, subangular to subrounded; 5% clay, low plasticity; medium sorted; contains quartz, feldspar, mica, and amphibole; gravel up to 45 mm from 315.2 to 315.5 ft.			
320			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 75% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel up to 60 mm; 5% clay; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.	320		
			GRAVEL WITH CLAY AND SAND (GP-GC): pale olive (5Y 6/3), 55% fine to coarse gravel up to 29 mm, subangular to subrounded; 35% fine to coarse grained sand; 10% clay, low plasticity; poorly to medium sorted; contains quartz, feldspar, mica, and amphibole.			
			SAND (SP): pale olive (5Y 6/3), 85% fine to coarse grained sand; 10% fine gravel up to 7 mm; 5% clay; medium to well sorted; contains quartz, feldspar, mica, and amphibole.			
325				325		
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to medium grained sand, subangular to subrounded; 5% clay; well sorted; contains quartz, feldspar, mica, and amphibole.			
330				330		
	Blank casing with end cap (330-332.26 ft bgs) TD 332.5 ft bgs		Bottom of borehole at 332.5 feet.			

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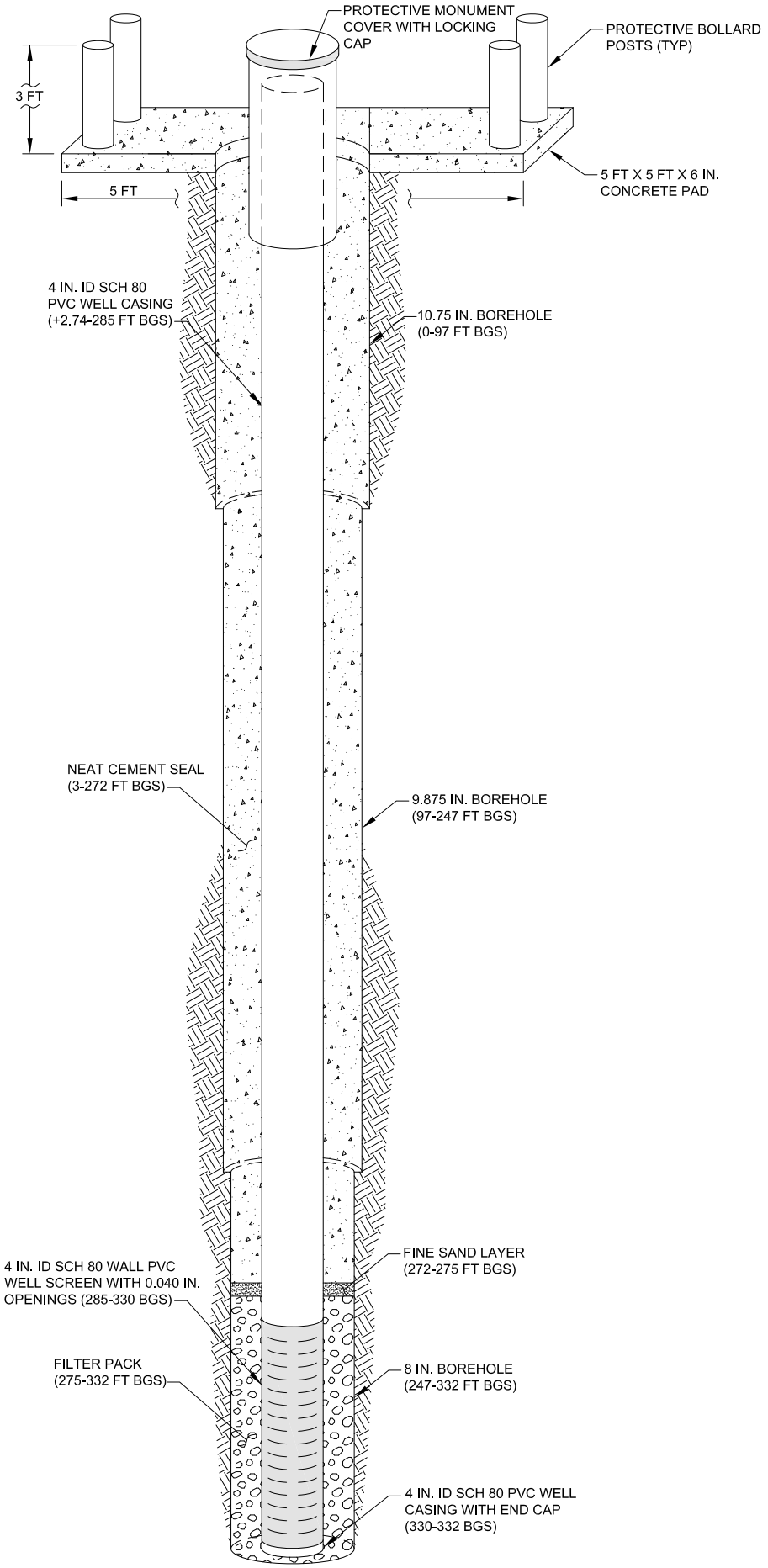

WELL PROFILE

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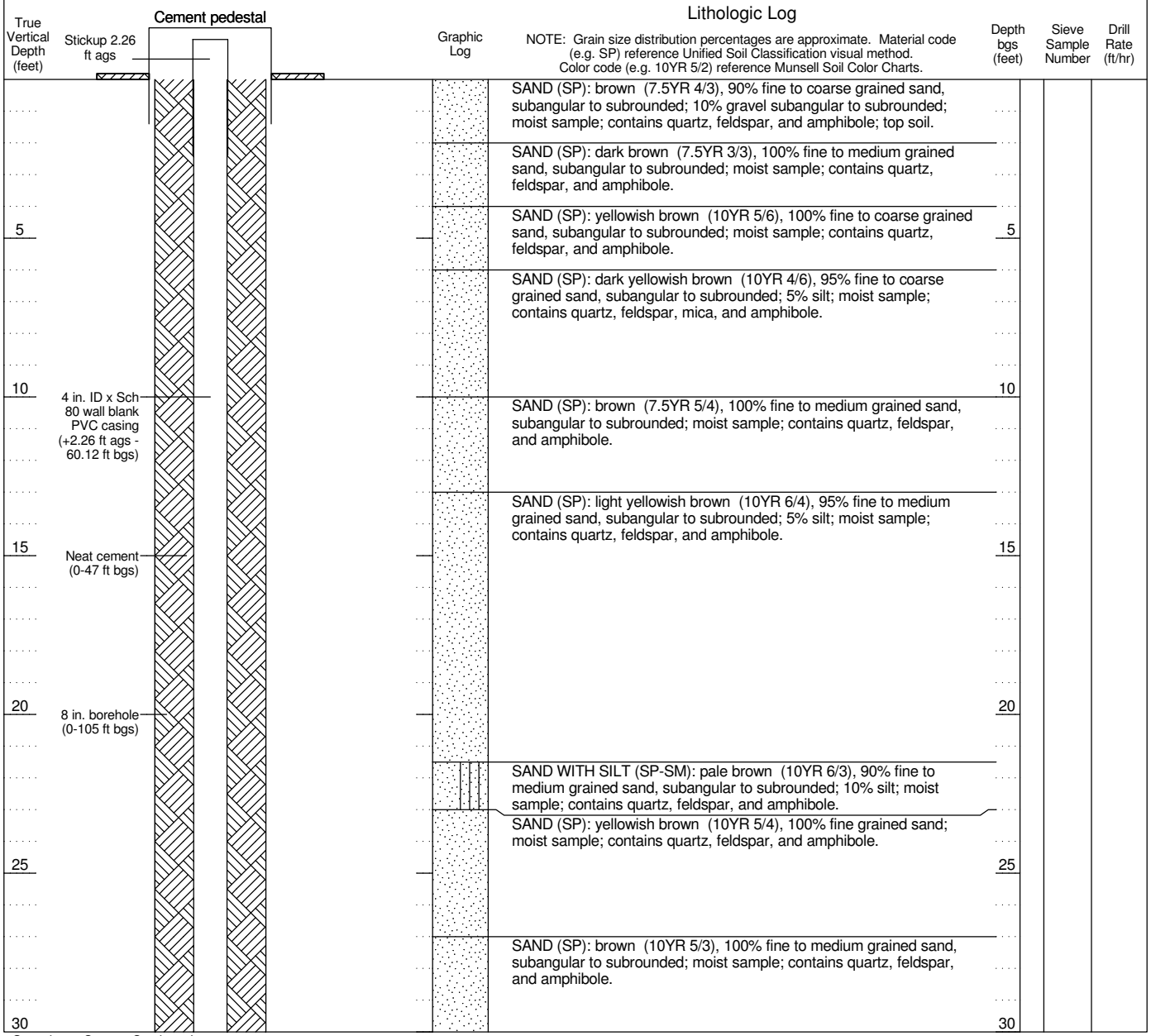
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-4S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Entrance to CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.26**	**60.12**	**62.38**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**60.12**	**100.12**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**100.12**	**102.5**	**2.38**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	39.70 ft NAVD88									
TOC ELEVATION	41.96 ft NAVD88 (RP)									
START DATE	2/10/15									
FINISH DATE	2/11/15									



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WELL NUMBER **MPWSP MW-4S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35			SAND (SP): light brown (7.5YR 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; moist sample; contains quartz, feldspar, mica, and amphibole.	35		
40			SAND (SP): brown (7.5YR 5/4), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; moist sample; contains quartz, feldspar, mica, and amphibole; contains coarse sand layers.	40		
45				45		
50	CEMEX Monterey Lapis Lustre #60 fine sand seal (47-50 ft bgs)		SAND (SP): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole.	50		
			SAND (SP): brown (10YR 5/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; moist sample; contains quartz, feldspar, mica, and amphibole.			19
55	CEMEX Monterey Lapis Lustre #3 filter pack (50-105 ft bgs)			55		
60				60		
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (60.12-100.12 ft bgs)		SAND (SW): brown (10YR 5/3), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole.			
65			SAND WITH GRAVEL (SP): brown (10YR 5/3), 75% fine to coarse grained sand, subangular to subrounded, mostly coarse grained; 25% fine gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	65		
70			SAND (SP): brown (10YR 5/3), 95% fine grained sand, very fine grained; 5% silt; wet sample; contains quartz, feldspar, mica, and	70		

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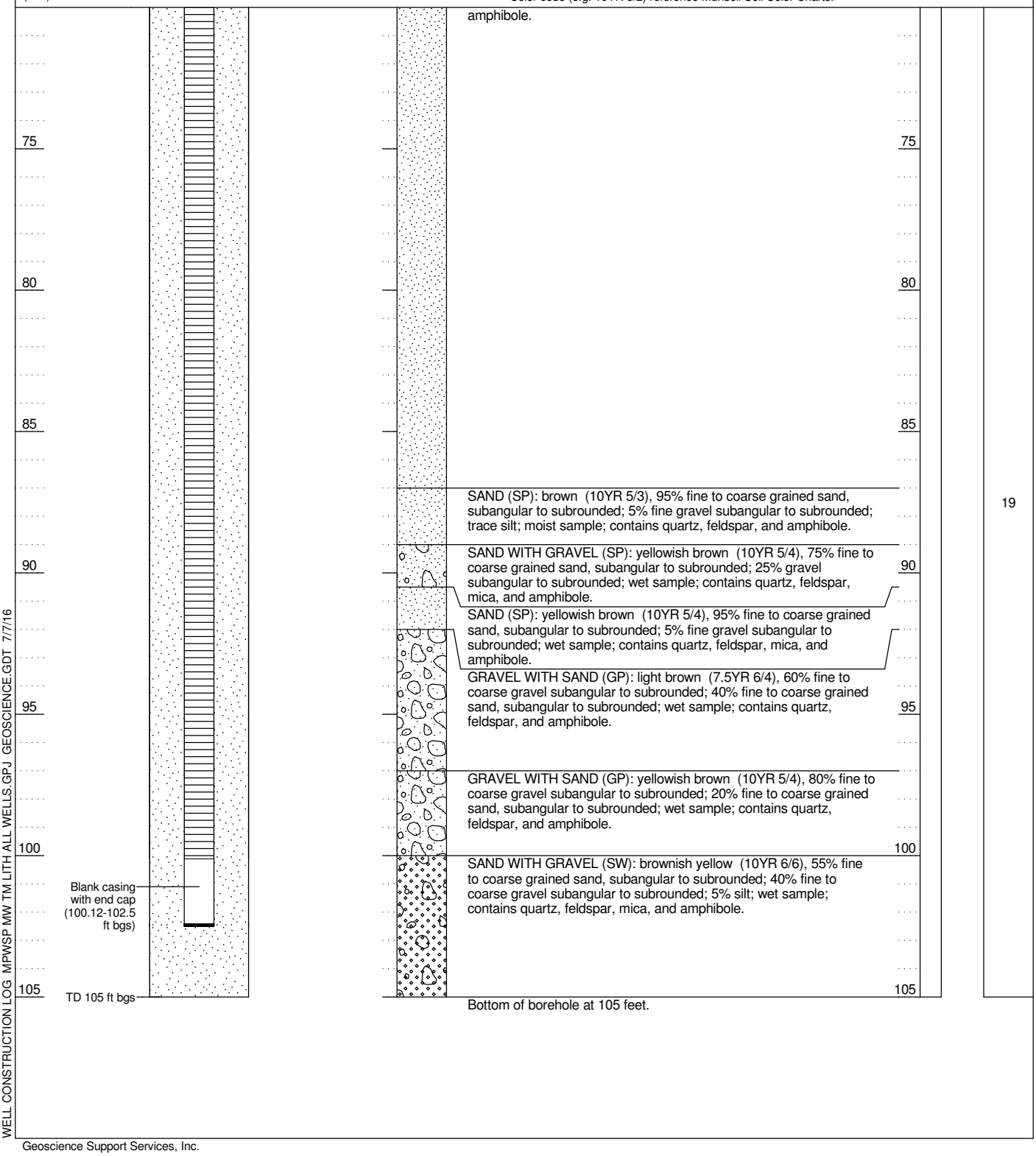
WELL NUMBER **MPWSP MW-4S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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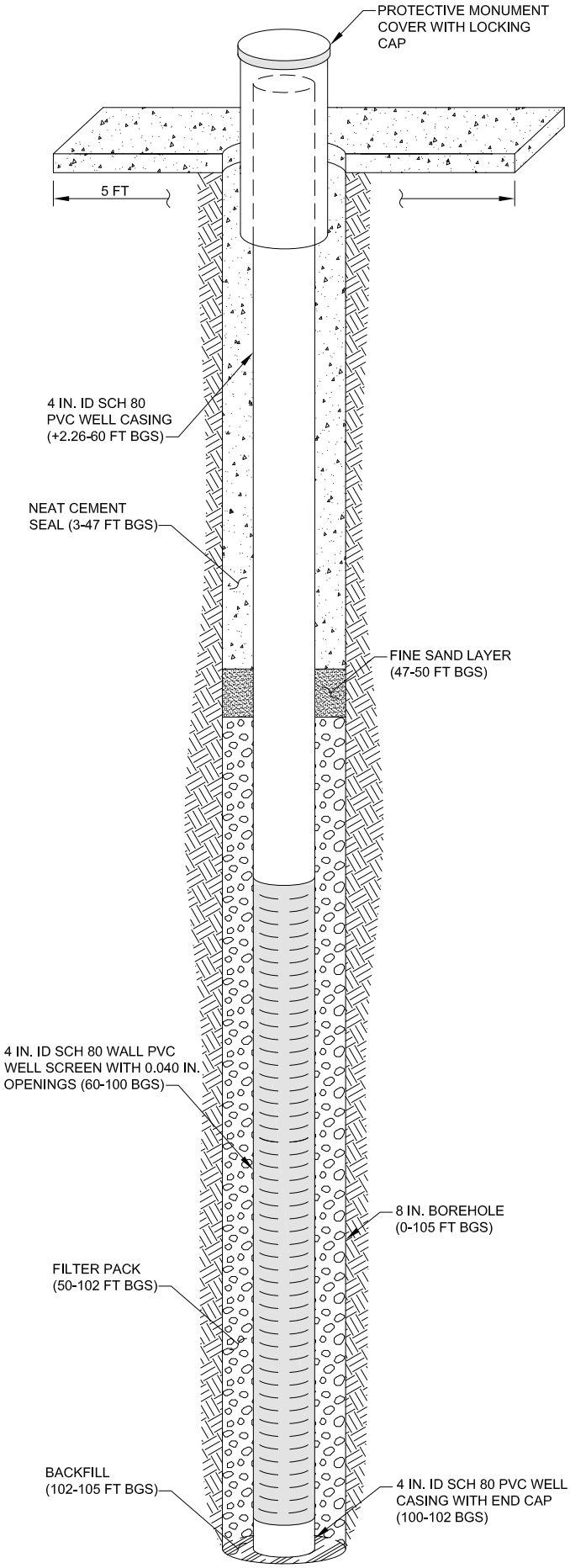

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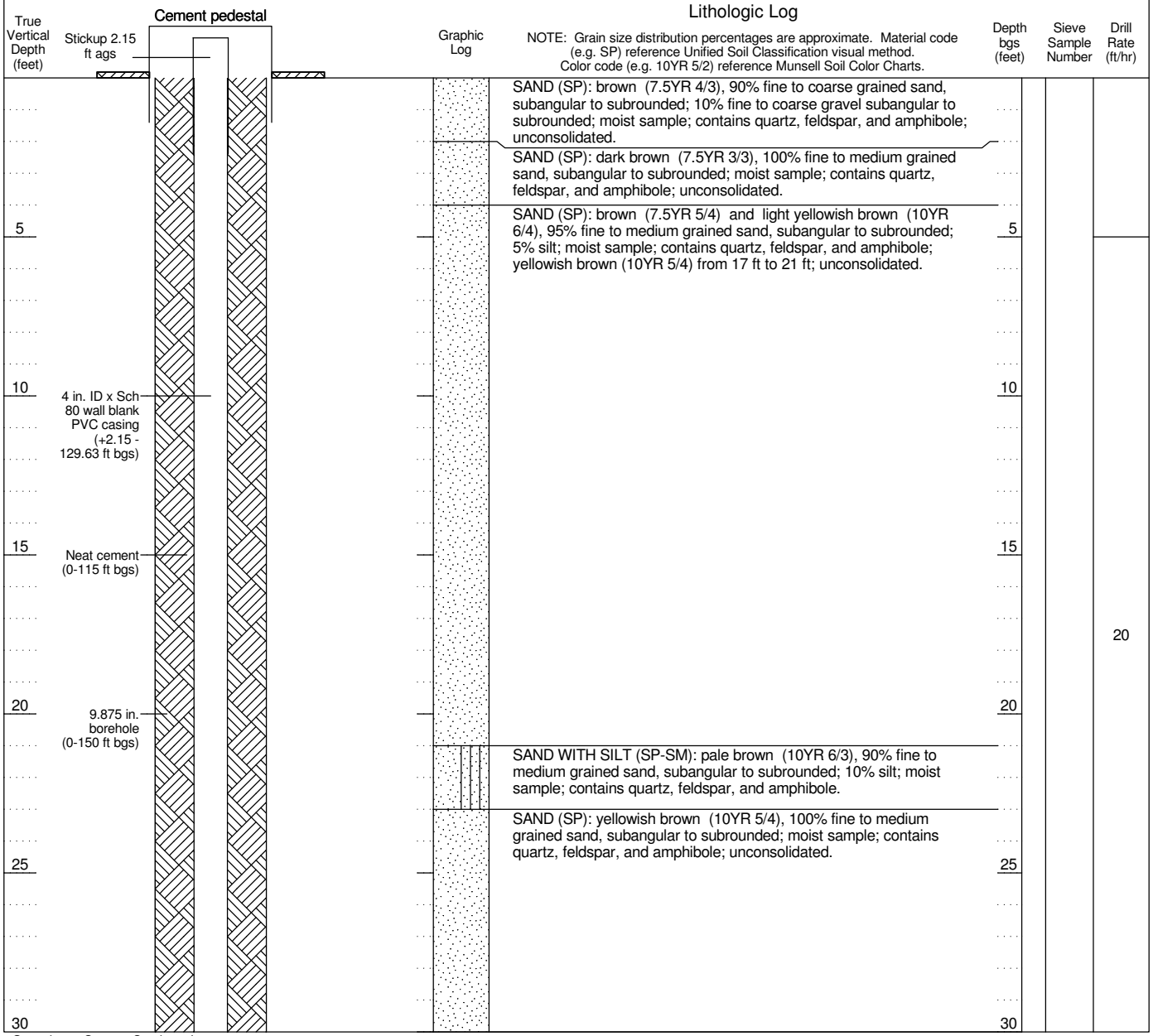
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-4M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Entrance to CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.15**	**129.63**	**131.78**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**129.63**	**259.63**	**130**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**259.63**	**262**	**2.37**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	39.84 ft NAVD88									
TOC ELEVATION	41.99 ft NAVD88 (RP)									
START DATE	2/06/15									
FINISH DATE	2/09/15									



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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND (SP): brown (7.5YR 5/3), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, and amphibole.			
35			SAND (SP): light brown (7.5YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	35		
40				40		
45			SAND (SP): brown (7.5YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	45		
50			SAND (SW): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, angular to subangular; moist to wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	50		20
55			SAND (SP): brown (10YR 5/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; moist to wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	55		
60				60		
65			SAND (SW): brown (10YR 5/3), 95% fine to coarse grained sand; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	65		
			SAND WITH GRAVEL (SP): brown (10YR 5/3), 75% fine to coarse grained sand, subangular to subrounded; 25% fine gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
70			SAND (SP): brown (10YR 5/3), 100% sand, subangular to subrounded, very fine to fine grained; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	70		

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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75				75		
80				80		
85				85		
90			SAND (SP): light yellowish brown (10YR 6/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	90		20
			SAND WITH GRAVEL (SP): yellowish brown (10YR 5/4), 80% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
			SAND (SP): yellowish brown (10YR 5/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
95			GRAVEL WITH SAND (GP): light brown (7.5YR 6/4), 60% fine gravel subangular to subrounded; 40% fine to coarse grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; transitions to approximately 80% gravel and 20% sand with increasing depth; unconsolidated.	95		
100			SAND WITH GRAVEL (SP): brownish yellow (10YR 6/6), 55% fine to coarse grained sand, subangular to subrounded; 40% fine to coarse gravel subangular to subrounded; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	100		
105			SAND (SP): light brown (7.5YR 6/4), 95% fine to medium grained sand, subangular to subrounded; 5% fine to coarse gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	105		
110			SAND (SP): light brown (7.5YR 6/4), 100% fine to medium grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	110		

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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115		SAND (SP): brown (7.5YR 5/3), 100% sand, subangular to subrounded, very fine to fine grained; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	115		
		CEMEX Monterey Lapis Lustre #60 fine sand seal (115-119.5 ft bgs)			
120			120		
		CEMEX Monterey Lapis Lustre #3 filter pack (119.5-265.5 ft bgs)			
		CLAY (CL): yellowish brown (10YR 5/6), 90% clay, high plasticity; 5% medium grained sand, subangular to subrounded; 5% silt; moist sample; contains quartz, feldspar, and amphibole.			
125		SAND WITH CLAY (SP-SC): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded; 5% silt; 5% clay; moist sample; contains quartz, mica, and amphibole; low plasticity.	125		
		CLAY (CL): brownish yellow (10YR 6/6), 95% clay, medium plasticity; 5% medium grained sand, subangular to subrounded; moist sample; contains quartz, mica, and amphibole.			20
130		SAND WITH SILT (SP-SM): pale yellow (5Y 7/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	130		
		SAND (SP): brownish yellow (10YR 6/6), 95% sand, subangular to subrounded, very fine to fine grained; 5% silt, low plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
		4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (129.63-259.63 ft bgs)			
		SAND WITH CLAY (SP-SC): light brown (7.5YR 6/3), 90% sand, subangular to subrounded, very fine to fine grained; 10% clay, low plasticity; moist sample; oxidation.			
135		SAND (SP): light brown (7.5YR 6/3), 90% sand; 5% gravel; 5% silt.	135		
		SAND WITH SILT (SP-SM): very pale brown (10YR 7/4), 90% fine to coarse grained sand, subangular to subrounded; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
140			140		
145			145		23.7
150			150		

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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
8 in. borehole (150-265.5)		SILTY SAND (SM): light yellowish brown (10YR 6/4), 85% fine to medium grained sand, subangular to subrounded; 15% silt, low plasticity; moist to wet sample; contains quartz, mica, and amphibole.			
		SAND (SP): light brownish gray (2.5Y 6/2), 95% fine to coarse grained sand, subangular to subrounded; 5% clay, low plasticity; moist to wet sample; contains quartz, feldspar, and amphibole.			
155		SAND (SP): light yellowish brown (10YR 6/4), 85% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subangular to subrounded; 5% clay; moist to wet sample; contains quartz, feldspar, and amphibole.	155		
		SAND (SP): reddish yellow (7.5YR 6/6), 90% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
160			160		
		GRAVEL WITH SILT AND SAND (GP-GM): pale brown (10YR 6/3), 55% fine to coarse gravel subangular to subrounded, rounded coarse gravel; 35% fine to coarse grained sand, subangular to subrounded; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
165			165		
		SAND WITH SILT (SP-SM): dark yellowish brown (10YR 4/4), 90% sand, subangular to subrounded, very fine to fine grained; 10% silt; moist to wet sample.			
		FAT CLAY (CH): yellowish brown (10YR 5/8), 90% clay, high plasticity; 5% sand, very fine; 5% silt; moist sample.			
170			170		23.7
175			175		
		CLAYEY SAND (SC): brown (7.5YR 5/3), 70% fine to medium grained sand, subrounded to rounded; 25% clay, low to medium plasticity; 5% fine to coarse gravel subrounded to rounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole.			
180		SAND (SP): light brown (7.5YR 6/3), 95% fine to coarse grained sand, angular to subangular; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	180		
		SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular to subrounded; 15% silt, low plasticity; moist sample; contains quartz, mica, and amphibole; unconsolidated.			
		SAND (SP): light brownish gray (10YR 6/2), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
185			185		
190			190		

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WELL NUMBER
MPWSP MW-4M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			SAND (SP): dark yellowish brown (10YR 4/6) and brown (10YR 4/3), 95% fine to coarse grained sand, subangular to subrounded, higher concentration of coarse sand; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	195		
200				200		
205				205		
210				210		23.7
215				215		
220			SAND (SP): brown (7.5YR 4/2) and red (2.5YR 4/6), 100% sand, subangular to subrounded, very fine to fine grained; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	220		
225				225		
230			SILT (ML): pale olive (5Y 6/4), 100% silt, very dense, medium plasticity; moist sample; oxidized staining; black ash.	230		

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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235		SAND WITH SILT (SP-SM): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	235		
		SAND (SP): light olive brown (2.5Y 5/3), 100% fine to coarse grained sand, subangular to subrounded; moist to wet sample; unconsolidated.			
240		SAND (SP): brown (7.5YR 5/3), 90% medium to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	240		
		SAND (SP): light yellowish brown (2.5Y 6/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; moist sample; unconsolidated.			
245		SAND (SP): pale brown (10YR 6/3), 100% fine to medium grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	245		23.7
250			250		
255		GRAVEL WITH CLAY AND SAND (GP-GC): pale olive (5Y 6/3), 50% fine to coarse gravel subangular to subrounded; 40% fine to coarse grained sand, subangular to subrounded; 10% clay, low plasticity; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	255		
260		SILT (ML): olive (5Y 5/3), 85% silt; 15% clay; moist sample; medium to high plasticity.	260		
265		Bottom of borehole at 265.5 feet.	265		

Blank casing with end cap (259.63-262 ft bgs)

TD 265.5 ft bgs

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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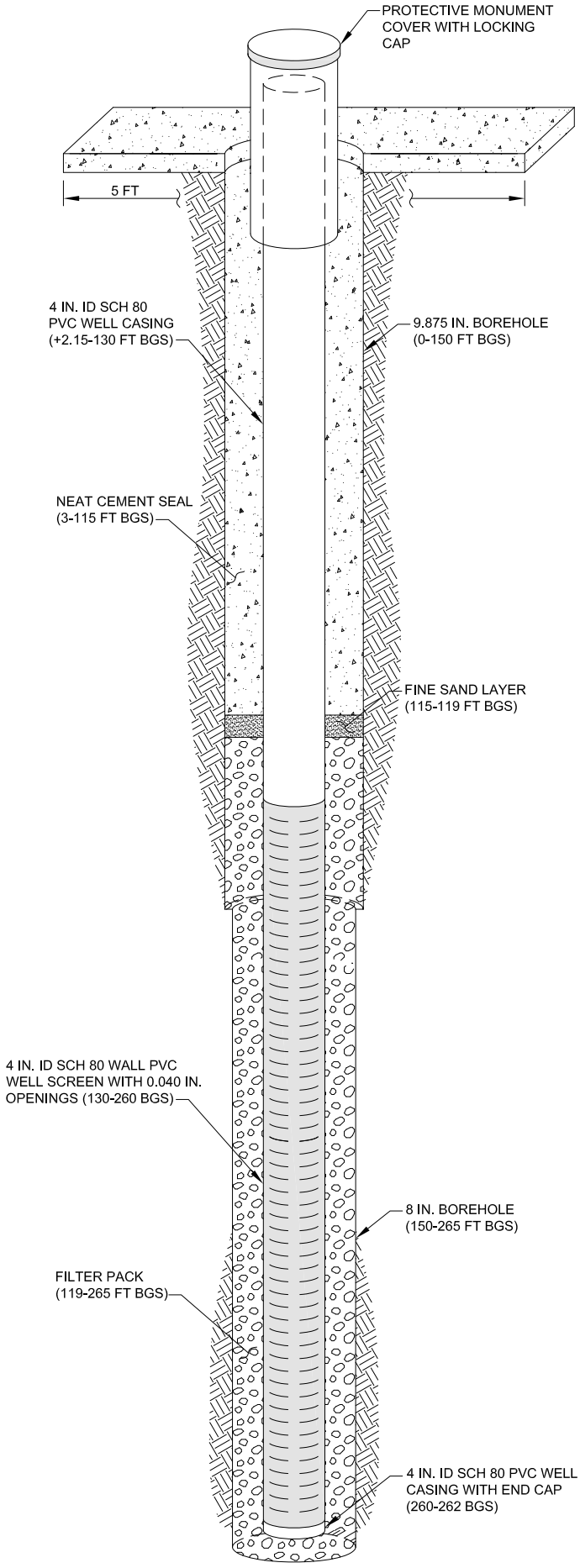

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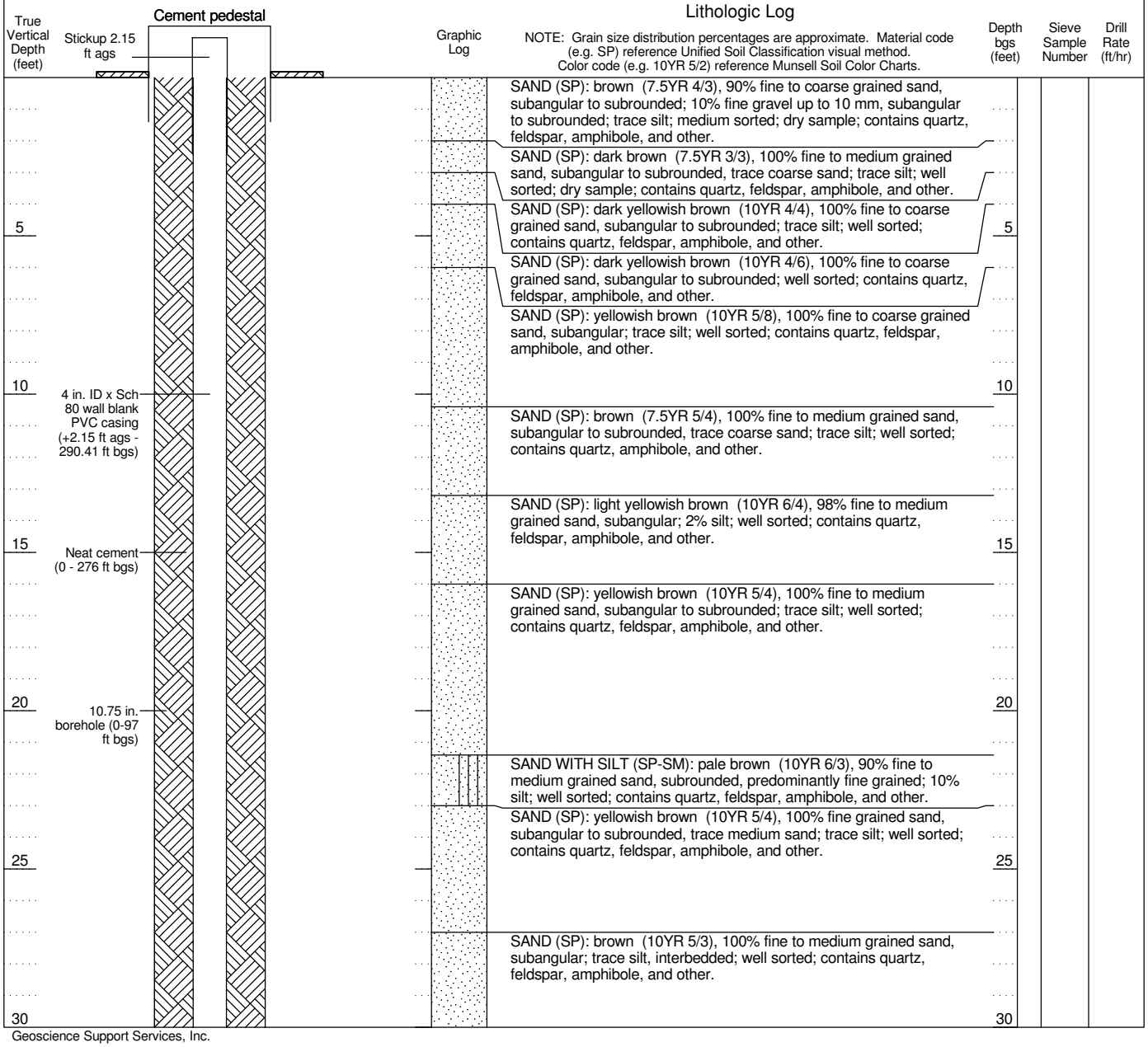
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-4D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Entrance to CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: A. Patricio	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.15**	**290.41**	**292.56**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**290.41**	**330.41**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**330.41**	**332.41**	**2**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	39.80 ft NAVD88									
TOC ELEVATION	41.95 ft NAVD88 (RP)									
START DATE	12/20/14									
FINISH DATE	1/19/15									



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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	Lithologic Log (continued)	Graphic Log	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35				35		
			SAND (SP): light brown (7.5YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; trace silt; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.			
40				40	1	
			SAND (SP): brown (7.5YR 5/4), 95% fine to medium grained sand, subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.			
45				45		
					2	
50			SAND (SW): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.	50		
			SAND (SP): brown (10YR 5/3), 95% fine to coarse grained sand, subangular to subrounded, predominantly fine to medium grained; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other; high mica content.			20
55				55		
60				60		
			SAND (SW): brown (10YR 5/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; trace fine gravel up to 5 mm, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.			
65				65		
			SAND WITH GRAVEL (SP): brown (10YR 5/3), 75% fine to coarse grained sand, subangular to subrounded, predominantly coarse; 25% fine to coarse gravel up to 9 mm, subangular to subrounded, predominantly fine; trace silt; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other.		3	
70			SAND (SP): brown (10YR 5/3), 95% fine grained sand, subangular;	70		

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WELL NUMBER
MPWSP MW-4D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.			20
75				75	4	
80				80		
85				85		
			SAND (SP): light yellowish brown (10YR 6/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 5 mm, subangular to subrounded; trace silt; medium to well sorted; contains quartz, feldspar, amphibole, and other.			
90			SAND WITH GRAVEL (SP): yellowish brown (10YR 5/4), 75% fine to coarse grained sand, subangular to subrounded; 25% fine gravel up to 16 mm, subangular to subrounded; trace silt; medium sorted; contains quartz, amphibole, and other; contains chert.	90	5	
			SAND (SP): yellowish brown (10YR 5/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 5 mm, subangular to subrounded; trace silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.			10
95			GRAVEL WITH SAND (GP): light brown (7.5YR 6/4), 60% fine gravel up to 13 mm, subangular to subrounded; 40% fine to coarse grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, amphibole, and other.	95	6	
	9.875 in. borehole (97-247 ft bgs)		GRAVEL WITH SAND (GP): yellowish brown (10YR 5/4), 80% fine to coarse gravel up to 56 mm, subangular to rounded; 20% medium to coarse grained sand, subangular to rounded; trace silt; medium sorted; contains quartz, feldspar, amphibole, and other.			
100			SAND WITH GRAVEL (SW): brownish yellow (10YR 6/6), 55% fine to coarse grained sand, subangular to subrounded; 40% fine to coarse gravel up to 53 mm, subangular to subrounded; 5% silt; poorly to medium sorted; contains quartz, feldspar, amphibole, and other.	100	7	
105			SAND (SP): light brown (7.5YR 6/4), 95% fine to medium grained sand, subangular to subrounded, trace coarse sand; 5% fine gravel up to 18 mm, subangular to subrounded; trace silt; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.	105		
110			SAND (SP): light brown (7.5YR 6/4), 100% fine to medium grained sand, subangular to subrounded; trace fine gravel up to 6 mm, subangular to subrounded; trace silt; well sorted; contains quartz,	110		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			feldspar, mica, amphibole, and other.			
115			SAND (SP): brown (7.5YR 5/3), 100% fine grained sand, subangular to subrounded; trace silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.	115	8	
120			FAT CLAY (CH): pale olive (5Y 6/3), 95% clay, medium plasticity; 5% medium grained sand, subrounded; contains quartz, and other.	120		
125			SAND WITH CLAY (SP-SC): yellowish brown (10YR 5/6), 90% fine to medium grained sand, subrounded; 5% silt; 5% clay, low plasticity; well sorted; contains quartz, mica, amphibole, and other. FAT CLAY (CH): pale olive (5Y 6/3), 100% clay, medium plasticity; trace fine grained sand, subrounded; contains quartz, and mica.	125		
130			SAND WITH SILT (SP-SM): brownish yellow (10YR 6/6), 90% fine to medium grained sand, subangular; 10% silt; medium to well sorted; contains quartz, mica, and other; predominantly quartz. SAND (SP): pale yellow (5Y 7/3), 95% fine grained sand, subangular, very fine to fine grains; 5% silt; well sorted; contains quartz, mica, amphibole, and other; high mica content. SAND (SP): brownish yellow (10YR 6/6), 100% fine to medium grained sand, subangular to subrounded; trace silt; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.	130		
135			SAND WITH CLAY (SP-SC): pale yellow (2.5Y 7/3), 90% fine grained sand, subangular, very fine to fine grains; 10% clay, low plasticity; well sorted; contains quartz, mica, amphibole, and other; oxidation in layers. SAND (SP): light brown (7.5YR 6/3), 100% fine to coarse grained sand, angular to subrounded; trace fine gravel up to 6 mm, angular to subrounded; trace silt; trace clay; well sorted; contains quartz, feldspar, amphibole, and other; layer of clay with shells.	135		
140			SAND WITH SILT (SP-SM): very pale brown (10YR 7/4), 90% fine to medium grained sand, subrounded to rounded; 10% silt; well sorted; contains quartz, amphibole, and other; predominantly rounded quartz.	140		20
145				145	9	
150				150		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	SILTY SAND (SM): light yellowish brown (10YR 6/4), 85% fine to medium grained sand, subangular to subrounded; 15% silt, low plasticity; medium sorted; contains quartz, mica, amphibole, and other.		
	SAND (SP): light brownish gray (2.5Y 6/2), 95% fine to coarse grained sand, subangular to subrounded; 5% clay, low plasticity; well sorted; contains quartz, mica, amphibole, and other; high mica content.		
155	155	10	
	SAND (SP): light yellowish brown (10YR 6/4), 85% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel up to 34 mm, subangular to subrounded; 5% clay, no to low plasticity; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other; oxidation apparent.		
	SAND (SP): reddish yellow (7.5YR 6/6), 90% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel up to 29 mm, subangular to subrounded; trace silt; medium sorted; contains quartz, feldspar, mica, amphibole, and other; oxidation apparent.		
160	160		
	GRAVEL WITH CLAY AND SAND (GP-GC): pale brown (10YR 6/3), 55% fine to coarse gravel up to 55 mm, subangular to subrounded; 35% fine to coarse grained sand, subangular to subrounded; 10% clay, no to low plasticity; medium sorted; contains quartz, feldspar, mica, amphibole, and other; rounded clasts of gravel.		20
165	165		
		11	
	SAND WITH SILT (SP-SM): dark yellowish brown (10YR 4/4), 90% fine grained sand, subrounded; 10% silt; well sorted; contains quartz, mica, amphibole, and other.	12	
	FAT CLAY (CH): yellowish brown (10YR 5/8), 100% clay, high plasticity; trace fine grained sand, subrounded; trace silt; contains quartz, and mica; transition silt to clay from 168.4 to 177 ft bgs.		
170	170		
175	175		
	CLAYEY SAND (SC): brown (7.5YR 5/3), 75% fine to medium grained sand, subangular; 25% clay, low to medium plasticity; trace fine gravel up to 15 mm, subangular; well sorted; contains quartz, mica, amphibole, and other; trace chert.		
	SAND (SP): light brown (7.5YR 6/3), 95% fine to coarse grained sand, angular to subangular; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other; predominantly quartz.		
180	180		
	SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular, predominantly fine grained; 15% silt, low plasticity; medium sorted; contains quartz, mica, amphibole, and other.		
	SAND (SP): light brownish gray (10YR 6/2), 95% fine to coarse grained sand, subangular to subrounded, coarser grained from 187 to 189 ft bgs; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.		
185	185	13	
		14	
			10
190	SAND (SP): dark yellowish brown (10YR 4/6), 95% fine grained sand, subangular to subrounded; 5% silt; well sorted; contains quartz,	190	

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			feldspar, amphibole, and other; predominantly dark-colored minerals.			
195				195		10
200				200		
205				205		
210				210		10
215				215		
			SAND (SP): brown (7.5YR 4/2), 100% fine grained sand, subrounded; trace silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; higher quartz content.		15	
220			SAND (SP): strong brown (7.5YR 4/6), 95% fine grained sand, subangular to subrounded; 5% silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; abundant dark minerals; faint rusty color.	220		
225			SAND (SP): olive brown (2.5Y 4/3), 100% fine grained sand, subangular to subrounded; trace silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; abundant dark minerals.	225		
230			SILT (ML): pale olive (5Y 6/4), 100% silt, dense, low plasticity; horizontal, dark, oxidized laminations 227-227.5 ft bgs.	230		6

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
235	SAND WITH SILT (SP-SM): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded, trace coarse grains; 10% silt; medium sorted; contains quartz, mica, amphibole, and other; no to low plasticity.	235		
	SAND (SP): light olive brown (2.5Y 5/3), 100% fine to coarse grained sand, subangular to subrounded, predominantly medium to coarse grains; trace fine gravel up to 6 mm, subangular to subrounded; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.		16	6
240	SAND (SP): brown (7.5YR 5/3), 90% fine to coarse grained sand, subangular to subrounded, predominantly medium to coarse grains; 10% fine to coarse gravel up to 35 mm, subangular to subrounded; trace silt; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other.	240		
	SAND WITH GRAVEL (SW): light yellowish brown (2.5Y 6/3), 85% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 26 mm, subrounded; trace silt; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.			
245	SAND (SP): light yellowish brown (2.5Y 6/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.	245		
	SAND (SP): pale brown (10YR 6/3), 100% fine to medium grained sand, subangular, predominantly medium grained; trace silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.		17	
250	8 in. borehole (247-332.8 ft bgs)	250		
255	GRAVEL WITH CLAY AND SAND (GP-GC): pale olive (5Y 6/3), 50% fine to coarse gravel up to 38 mm, subangular to subrounded; 40% fine to coarse grained sand, subangular to subrounded; 10% clay, low plasticity; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.	255	18	
260	SILT (ML): olive (5Y 5/3), 100% silt, dense, low to medium plasticity.	260		
265		265		
	SILTY SAND (SM): olive (5Y 5/3), 65% fine grained sand, subrounded; 35% silt, low plasticity; well sorted; contains quartz, mica, and other.			20
270	SAND (SP): olive gray (5Y 5/2), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; trace fine gravel up to 6 mm,	270		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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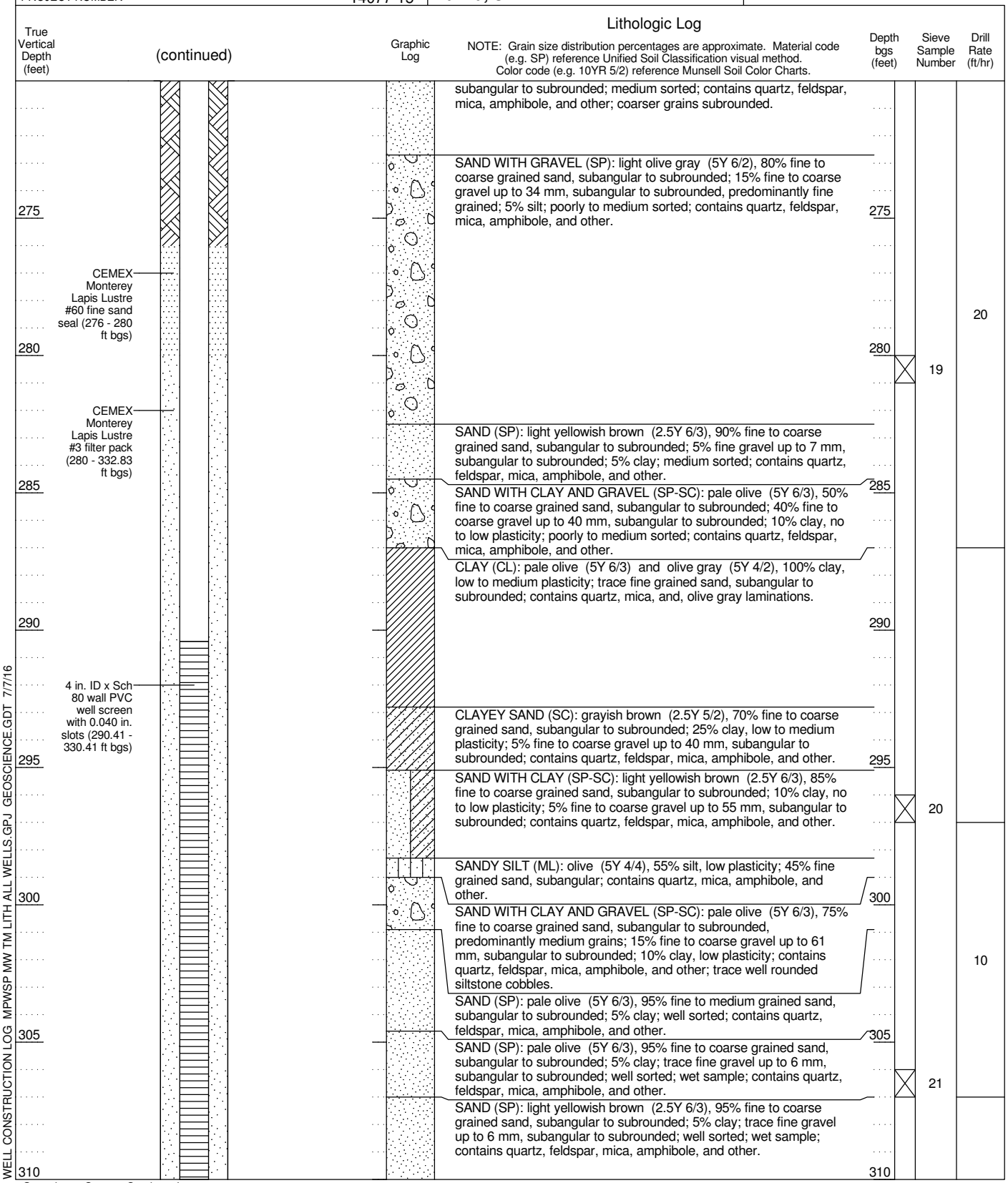
WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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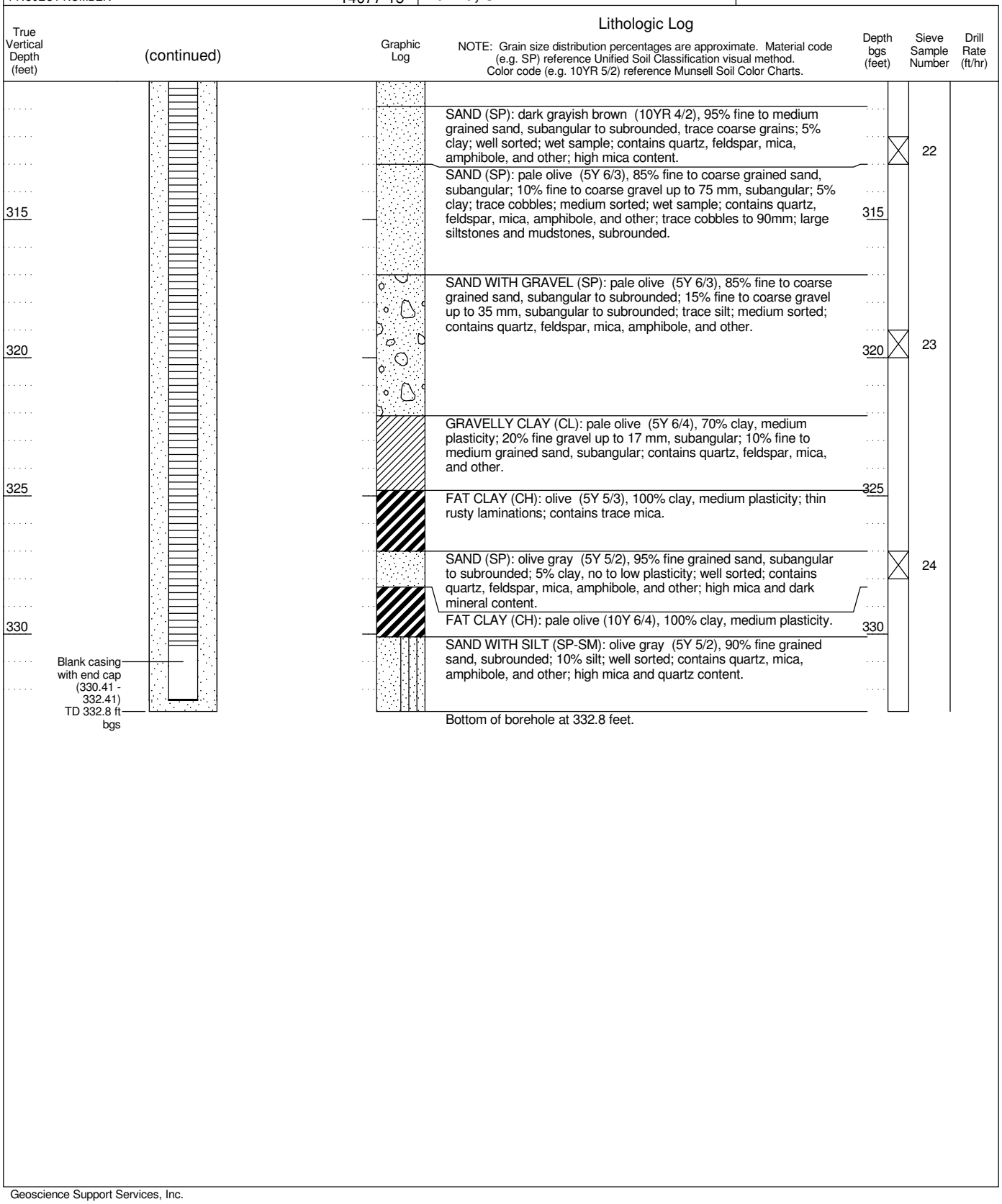
WELL NUMBER
MPWSP MW-4D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19138

File No.

Company CASCADE DRILLING

Well MW-4D

Field MARINA

County MONTEREY State CA

Location

CEMEX PLANT OFF OF LAPIS RD.
GPS: N36o 42' 42" W121o 47' 55"

Other Services:

DIL/GR

		Elevation above perm. datum	Elevation
Permanent Datum	G.L.		K.B.:
Log Measured From	G.L.	0'	D.F.:
Drilling Measured From	G.L.		G.L.:

Date	01-10-2014										
Run Number	ONE										
Depth Driller	332'										
Depth Logger	332.2'										
Bottom Logged Interval	332'										
Top Log Interval	10'										
Open Hole Size	10"										
Type Fluid	WATER										
Density / Viscosity	N/A										
Fluid Level	34'										
Bentonite Seal	N/A										
Time Well Ready	10:30										
Time Logger on Bottom	12:30										
Equipment Number	PS-8										
Location	L.A.										
Recorded By	RIDDER										
Witnessed By	J. SOBOLEW										

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10"	0'	97'				
	9"	97'	247'				
	8"	247'	332'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	12"	N/A	0'	17'
Prot. String				
Production String				
Liner				

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Comments

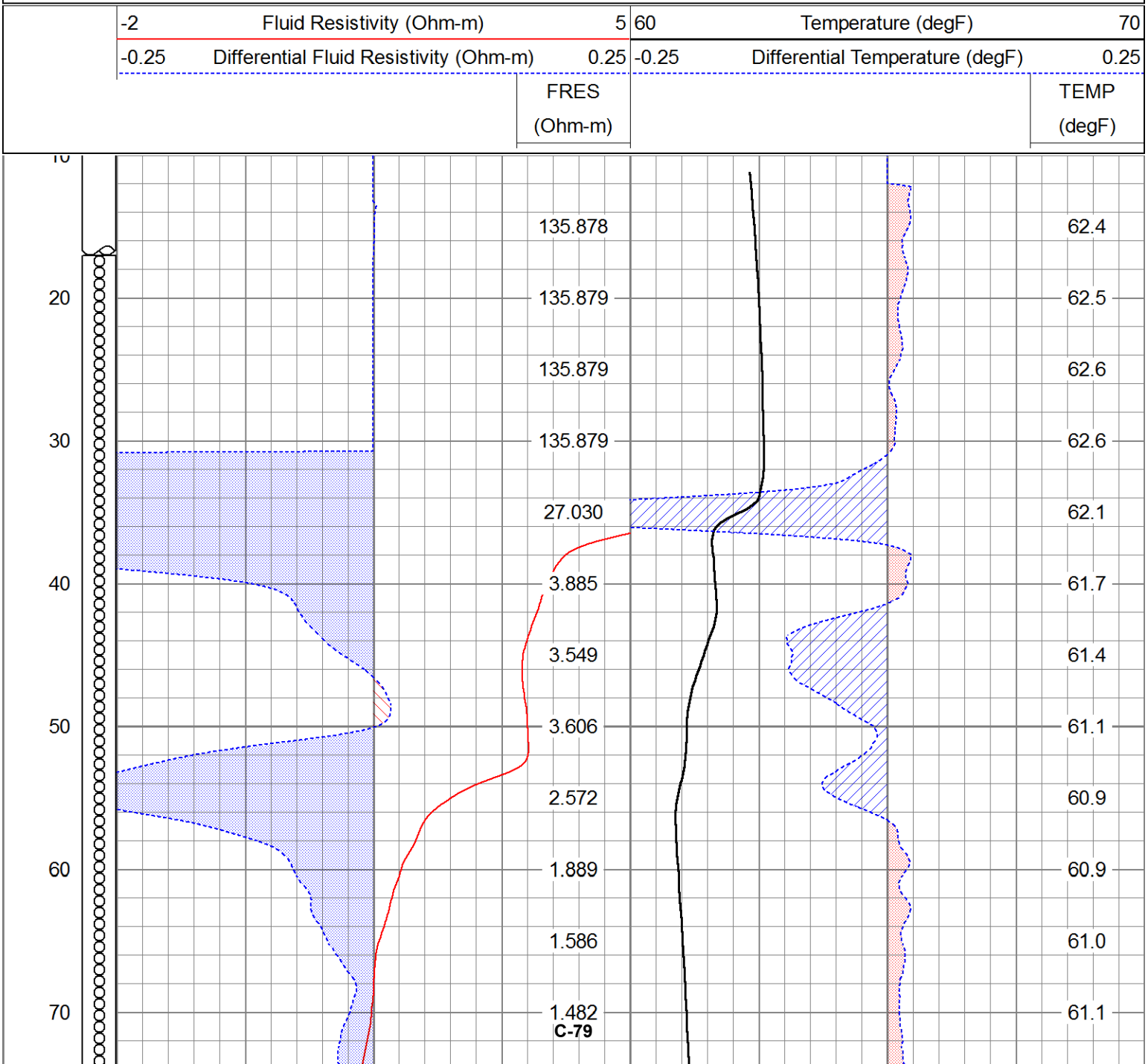
Calibration Report

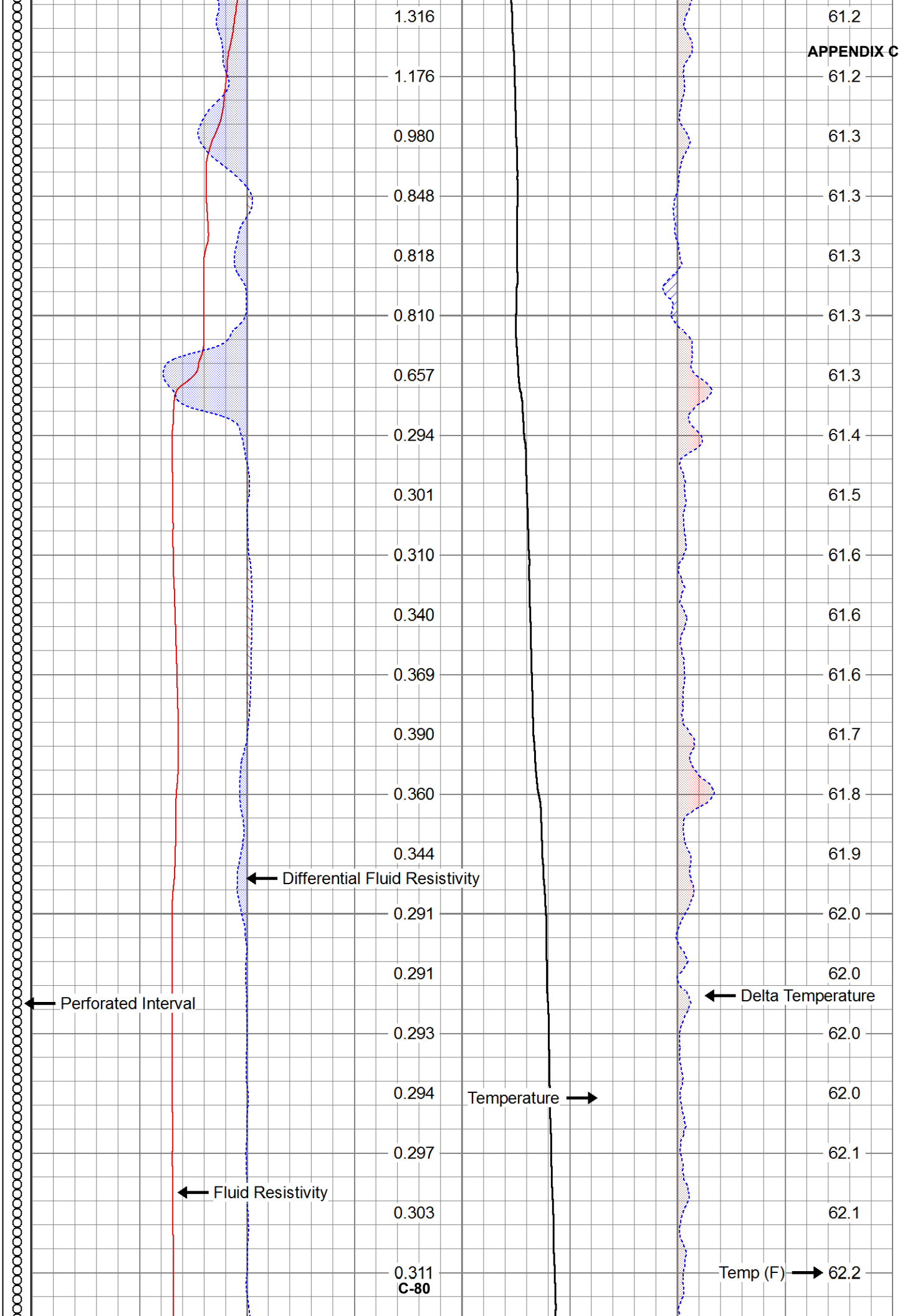
Database File	19138.db
Dataset Pathname	temp2
Dataset Creation	Sat Jan 10 14:33:28 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Sat Jan 10 12:25:28 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

Database File	19138.db
Dataset Pathname	temp2
Presentation Format	frttemp2
Dataset Creation	Sat Jan 10 14:33:28 2015
Charted by	Depth in Feet scaled 1:120




APPENDIX C
80
90
100
110
120
130
140
150
160
170
180
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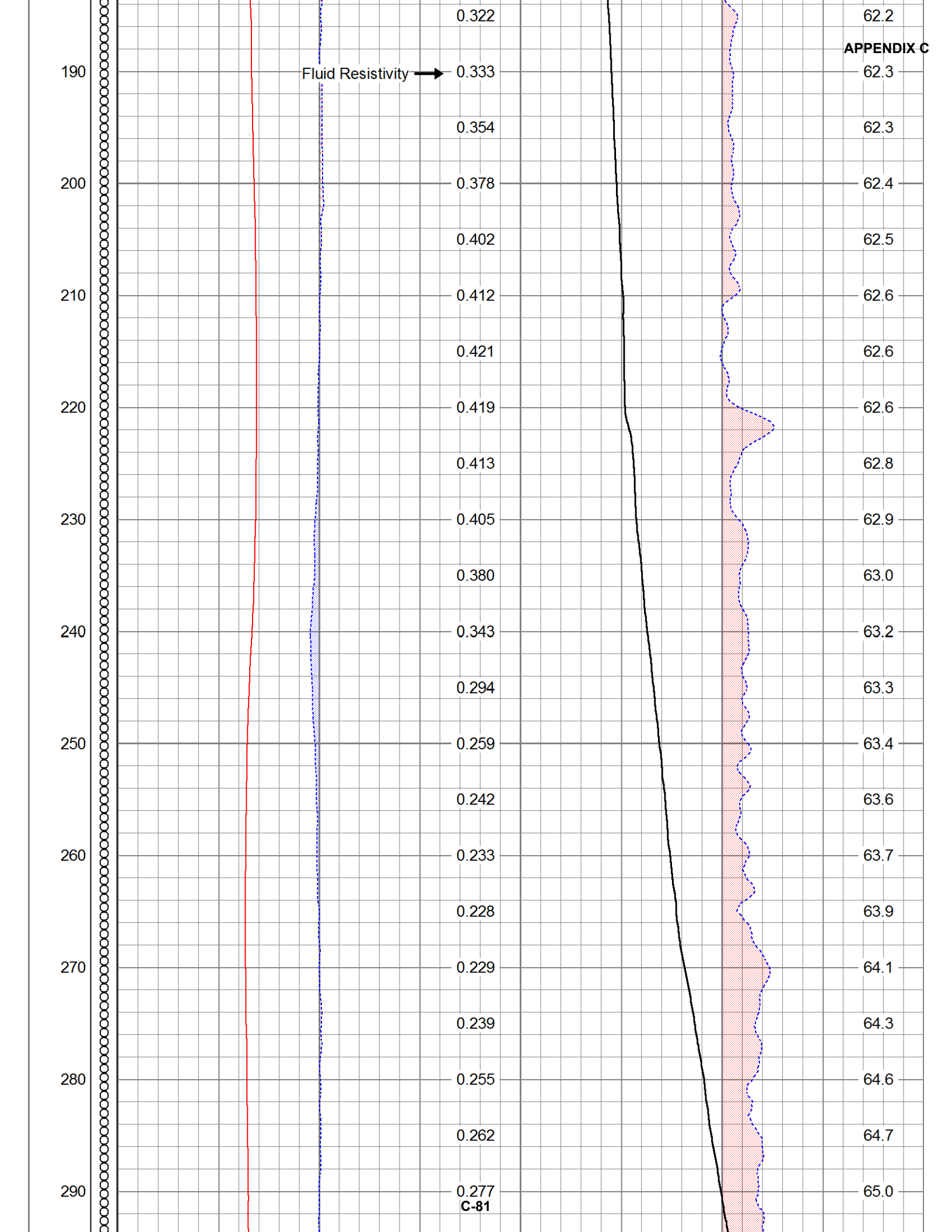
1.176
0.980
0.848
0.818
0.810
0.657
0.294
0.301
0.310
0.340
0.369
0.390
0.360
0.344
0.291
0.291
0.293
0.294
0.297
0.303
0.311
61.2
61.2
61.3
61.3
61.3
61.3
61.4
61.5
61.6
61.6
61.6
61.7
61.8
61.9
62.0
62.0
62.0
62.0
62.1
62.1
62.2
Differential Fluid Resistivity
Perforated Interval
Delta Temperature
Temperature
Fluid Resistivity
Temp (F)


Fluid Resistivity
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200
210
220
230
240
250
260
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280
290
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0.402
0.412
0.421
0.419
0.413
0.405
0.380
0.343
0.294
0.259
0.242
0.233
0.228
0.229
0.239
0.255
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62.2
62.3
62.3
62.4
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62.6
62.6
62.6
62.8
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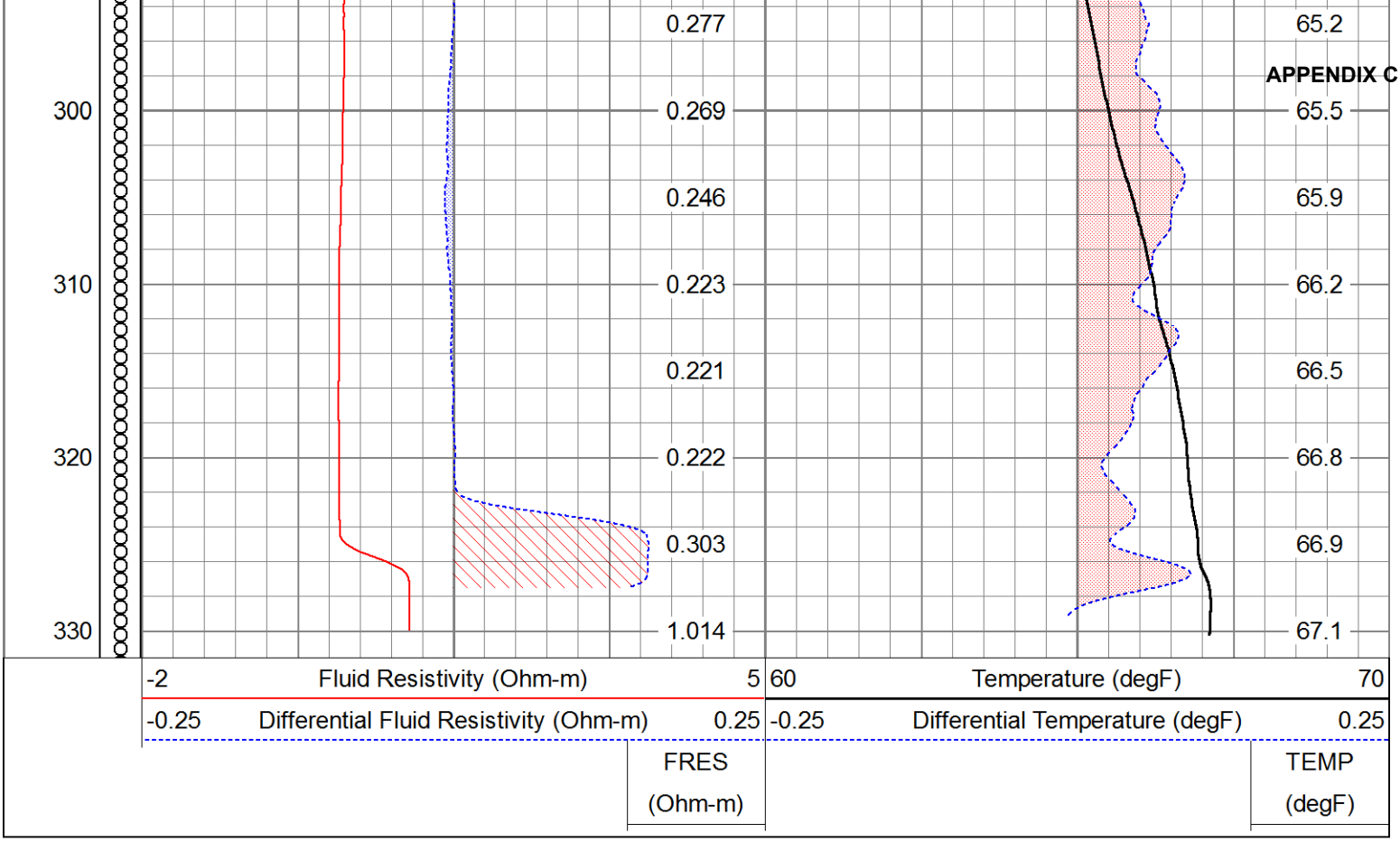
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310
320
330
0.277
0.269
0.246
0.223
0.221
0.222
0.303
1.014
65.2
65.5
65.9
66.2
66.5
66.8
66.9
67.1
-2
Fluid Resistivity (Ohm-m)
5
-0.25
Differential Fluid Resistivity (Ohm-m)
0.25
FRES
(Ohm-m)
60
Temperature (degF)
70
-0.25
Differential Temperature (degF)
0.25
TEMP
(degF)

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19138

File No.

Company CASCADE DRILLING

Well MW-4D

Field MARINA

County MONTEREY State CA

Location

CEMEX PLANT OFF OF LAPIS RD.
GPS: N36o 42' 42" W121o 47' 55"

Other Services:

TEMP/FR

				Elevation	
Permanent Datum	G.L.		Elevation above perm. datum	K.B.:	
Log Measured From	G.L.	0'		D.F.:	
Drilling Measured From	G.L.			G.L.:	

Date	01-10-2014							
Run Number	ONE							
Depth Driller	332'							
Depth Logger	332.2'							
Bottom Logged Interval	332'							
Top Log Interval	10'							
Open Hole Size	10"							
Type Fluid	WATER							
Density / Viscosity	N/A							
Fluid Level	34'							
Bentonite Seal	N/A							
Time Well Ready	10:30							
Time Logger on Bottom	12:30							
Equipment Number	PS-8							
Location	LA							
Recorded By	RIDDER							
Witnessed By	J. SOBOLEW							

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10"	0'	97'				
	9"	97'	247'				
	8"	247'	332'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	12"	N/A	0'	17'
Prot. String				
Production String				
Liner				

<<< Fold Here >>>

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Comments

Calibration Report

Database File	19138.db
Dataset Pathname	DIL
Dataset Creation	Sat Jan 10 13:34:14 2015

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1405.080	3665.050	cps	0.000	612.000	mmho/m	0.271	-380.496
Medium	2052.170	14102.500	cps	0.000	1960.000	mmho/m	0.163	-333.788

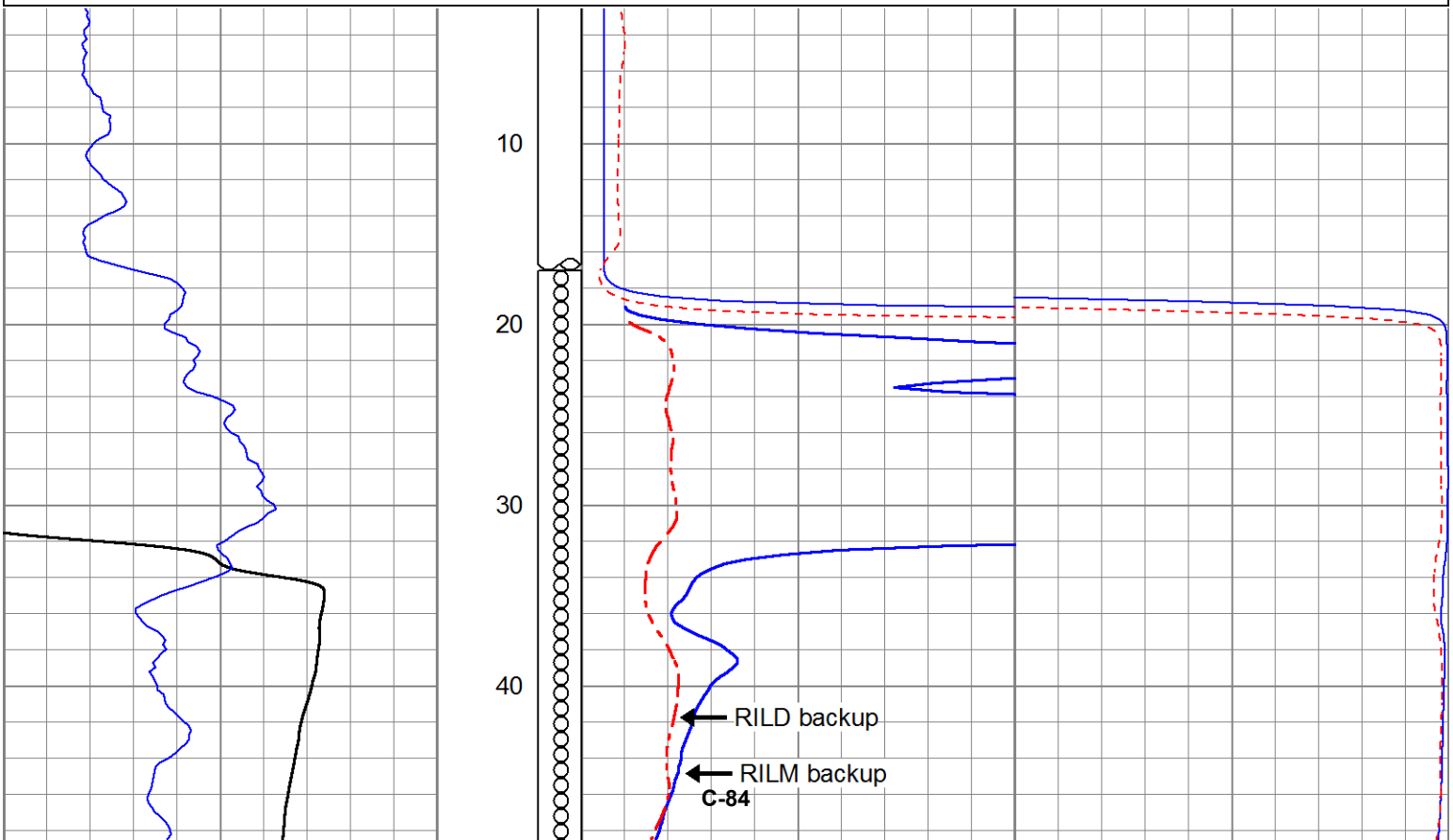
Gamma Ray Calibration Report

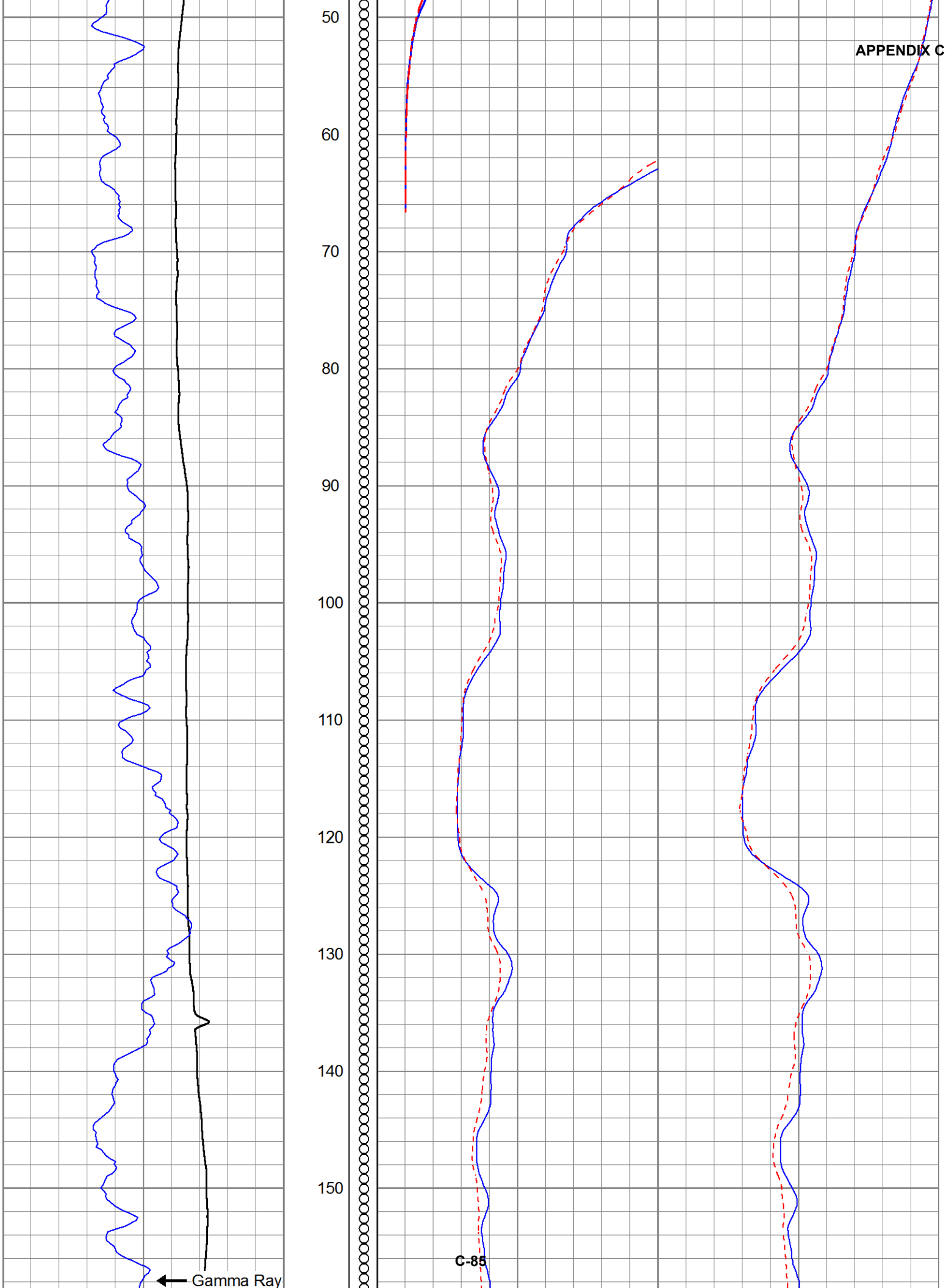
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

Database File	19138.db
Dataset Pathname	DIL
Presentation Format	dil
Dataset Creation	Sat Jan 10 13:34:14 2015
Charted by	Depth in Feet scaled 1:120

0	SP (mV)	200	0	RILM (Ohm-m)	5
10	Gamma-Ray (GAPI)	110	0	RILD (Ohm-m)	5
			5	RILM backup (Ohm-m)	500
			5	RILD backup (Ohm-m)	500

1000	CILM (mmho/m)	0
1000	CILD (mmho/m)	0

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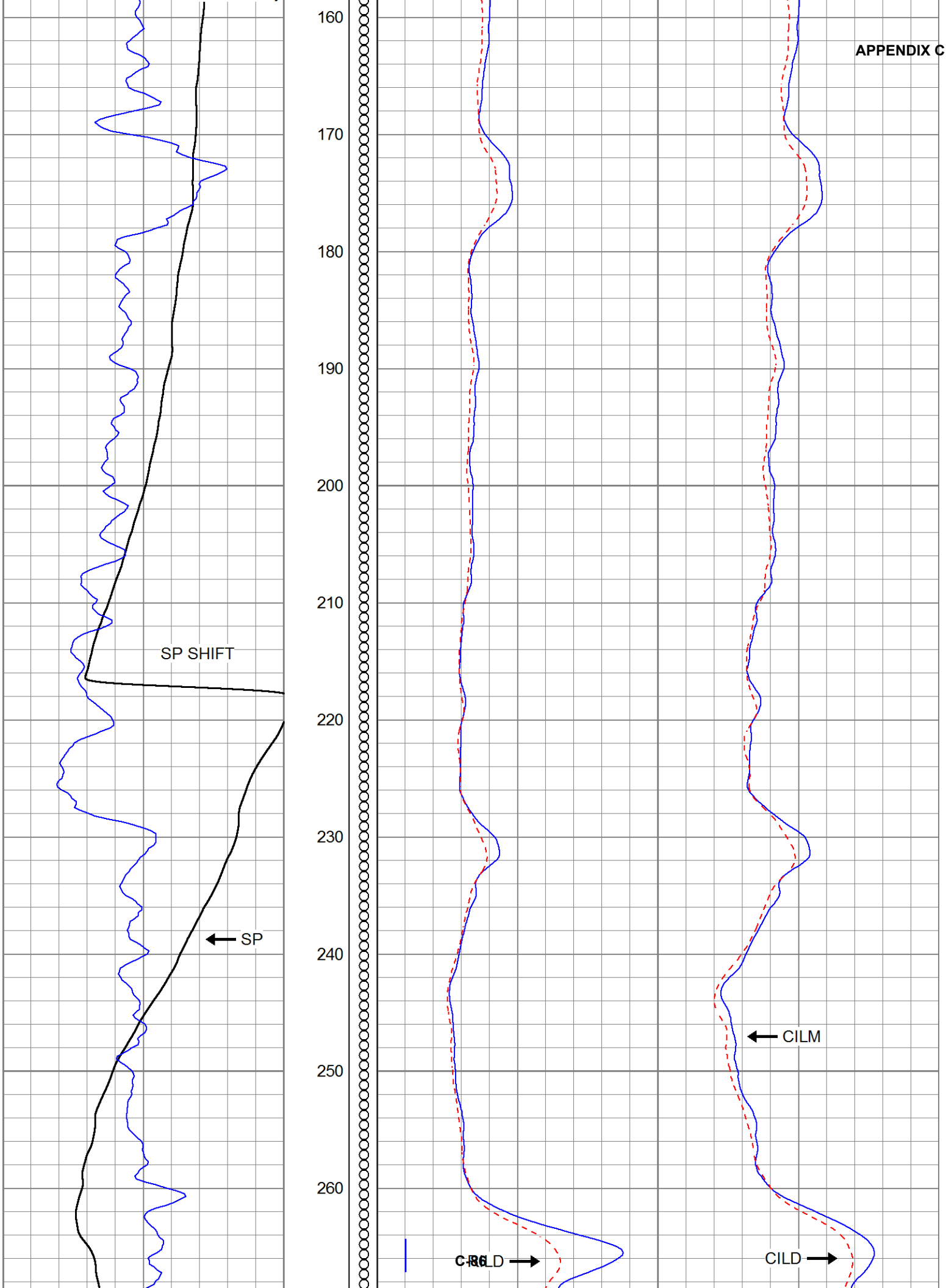
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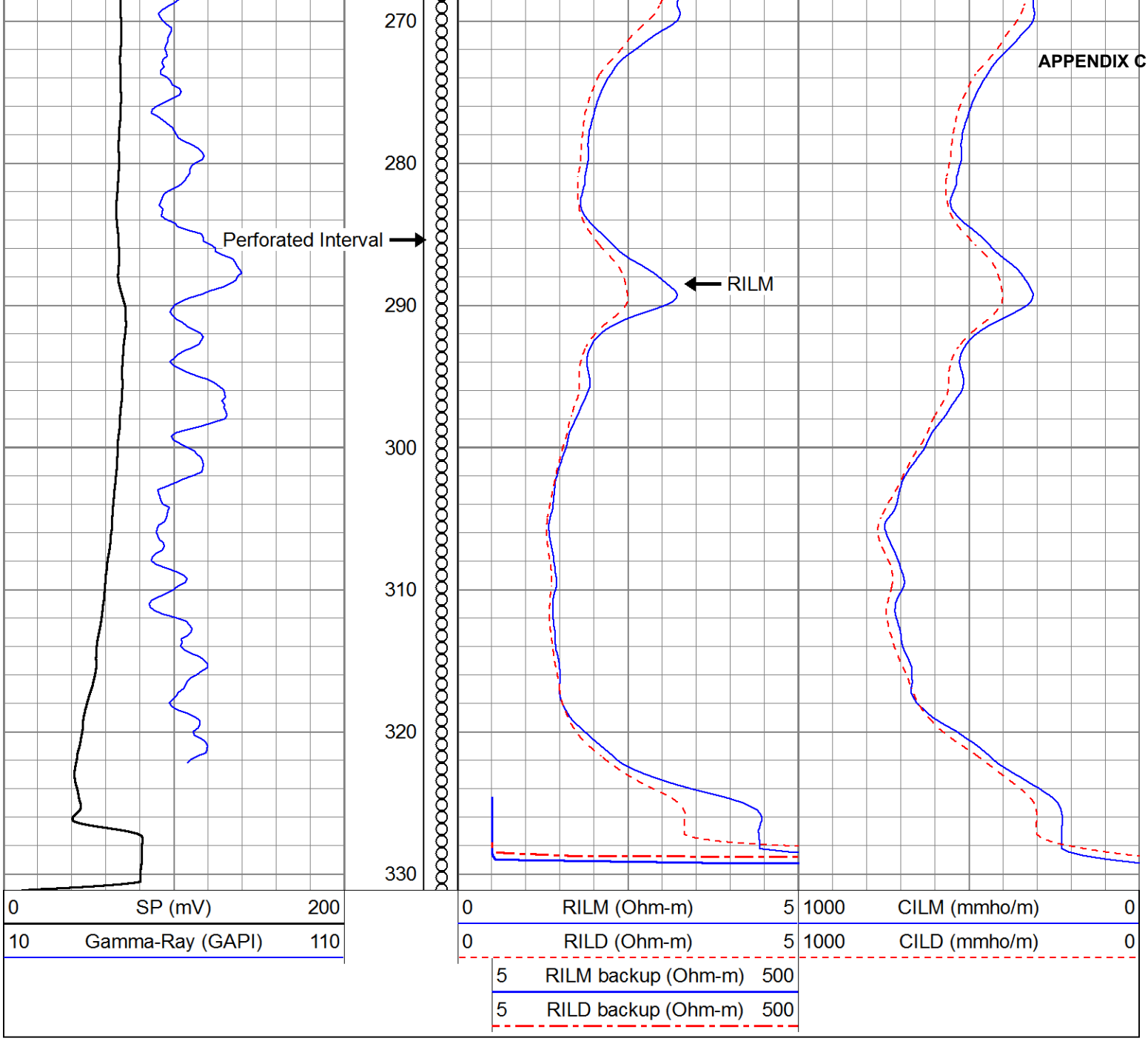
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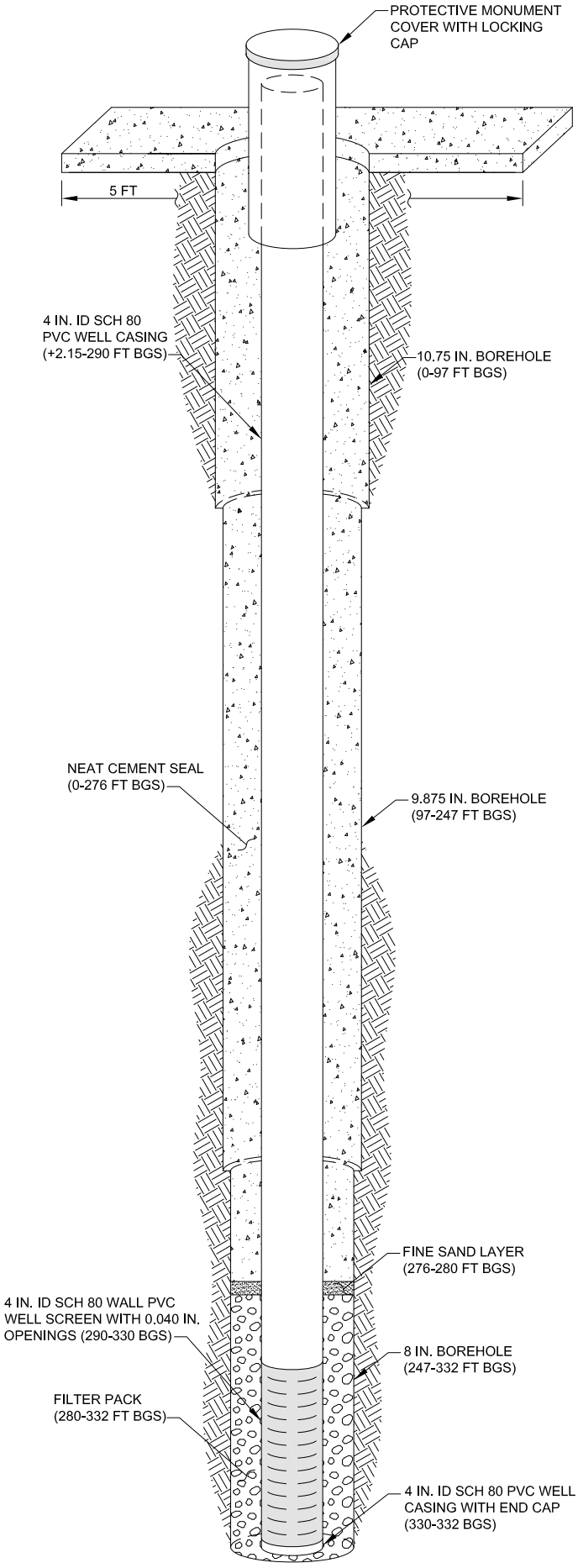
280
290
300
310
320
330
Perforated Interval
RILM
0 SP (mV) 200
10 Gamma-Ray (GAPI) 110
0 RILM (Ohm-m) 5
0 RILD (Ohm-m) 5
5 RILM backup (Ohm-m) 500
5 RILD backup (Ohm-m) 500
1000 CILM (mmho/m) 0
1000 CILD (mmho/m) 0



WELL PROFILE

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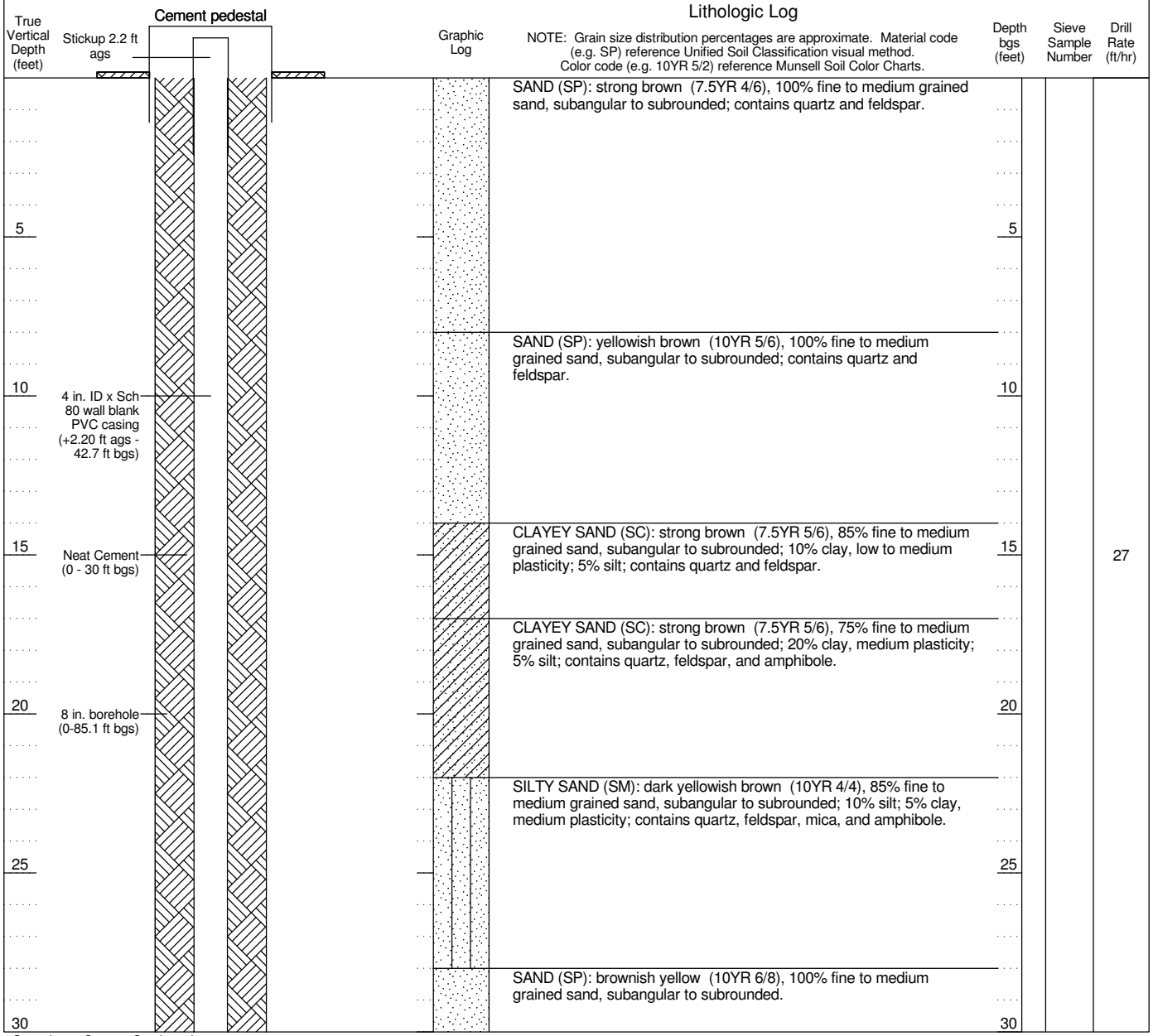
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-5S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Neponset Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.2**	**42.7**	**44.9**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**42.7**	**82.7**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**82.7**	**85.1**	**2.4**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	78.05 ft NAVD88									
TOC ELEVATION	80.25 ft NAVD88 (RP)									
START DATE	1/28/15									
FINISH DATE	2/02/15									



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WELL NUMBER **MPWSP MW-5S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		CEMEX Monterey Lapis Lustre #60 fine sand seal (30 - 33 ft bgs)			
35			35		
		CEMEX Monterey Lapis Lustre #3 filter pack (33 - 85.1 ft bgs)			
		SAND (SP): dark yellowish brown (10YR 4/6), 95% fine grained sand, subangular to subrounded; 5% silt; contains quartz, feldspar, and mica.			
40			40		
45			45		
		4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (42.7 - 82.7 ft bgs)			
		SILTY SAND (SM): dark gray (10YR 4/1), 80% fine grained sand, subangular to subrounded; 20% silt; contains quartz, feldspar, and mica.			
50			50		27
		SILT (ML): gray (10YR 5/1), 60% silt; 30% clay, medium plasticity; 10% fine grained sand, subangular to subrounded; contains quartz, feldspar, and mica; black ash spots.			
55			55		
		SILTY SAND (SM): greenish gray (10GY 5/1), 70% fine grained sand, subangular to subrounded; 30% silt; contains quartz, feldspar, and mica.			
		CLAY (CL): greenish gray (10GY 5/1), 90% clay, medium to high plasticity; 5% fine grained sand, subangular to subrounded; 5% silt.			
60			60		
65			65		
70			70		

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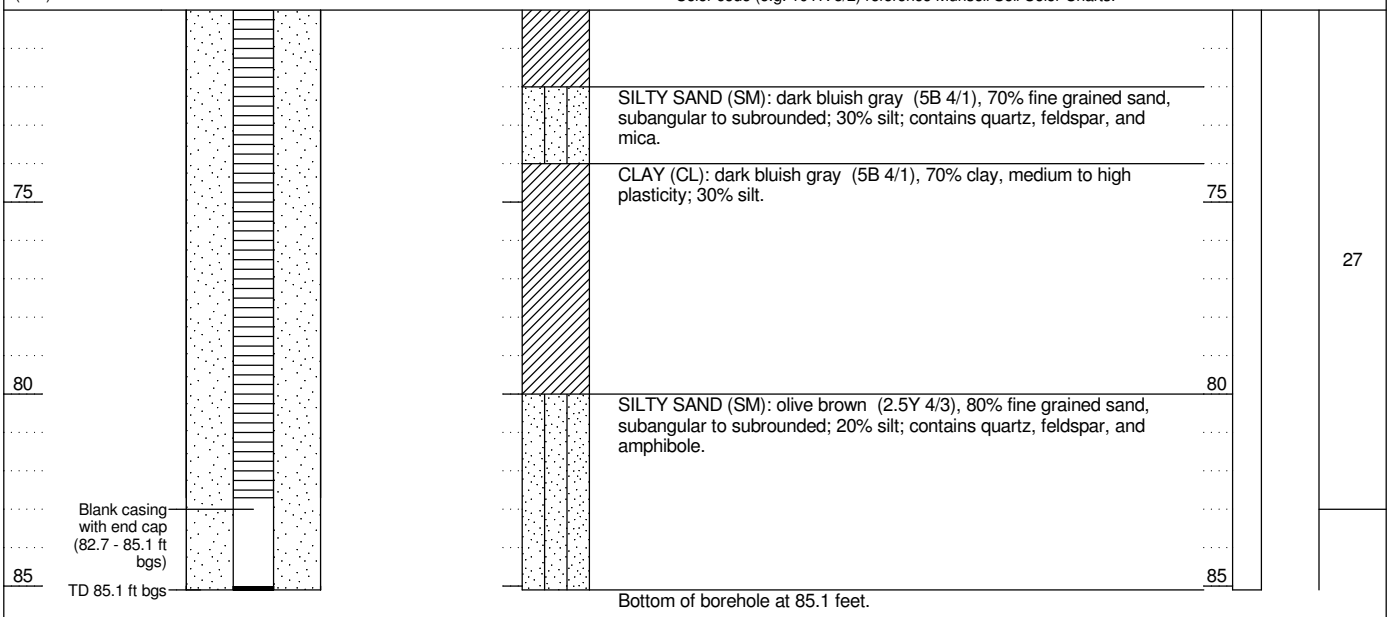
WELL NUMBER **MPWSP MW-5S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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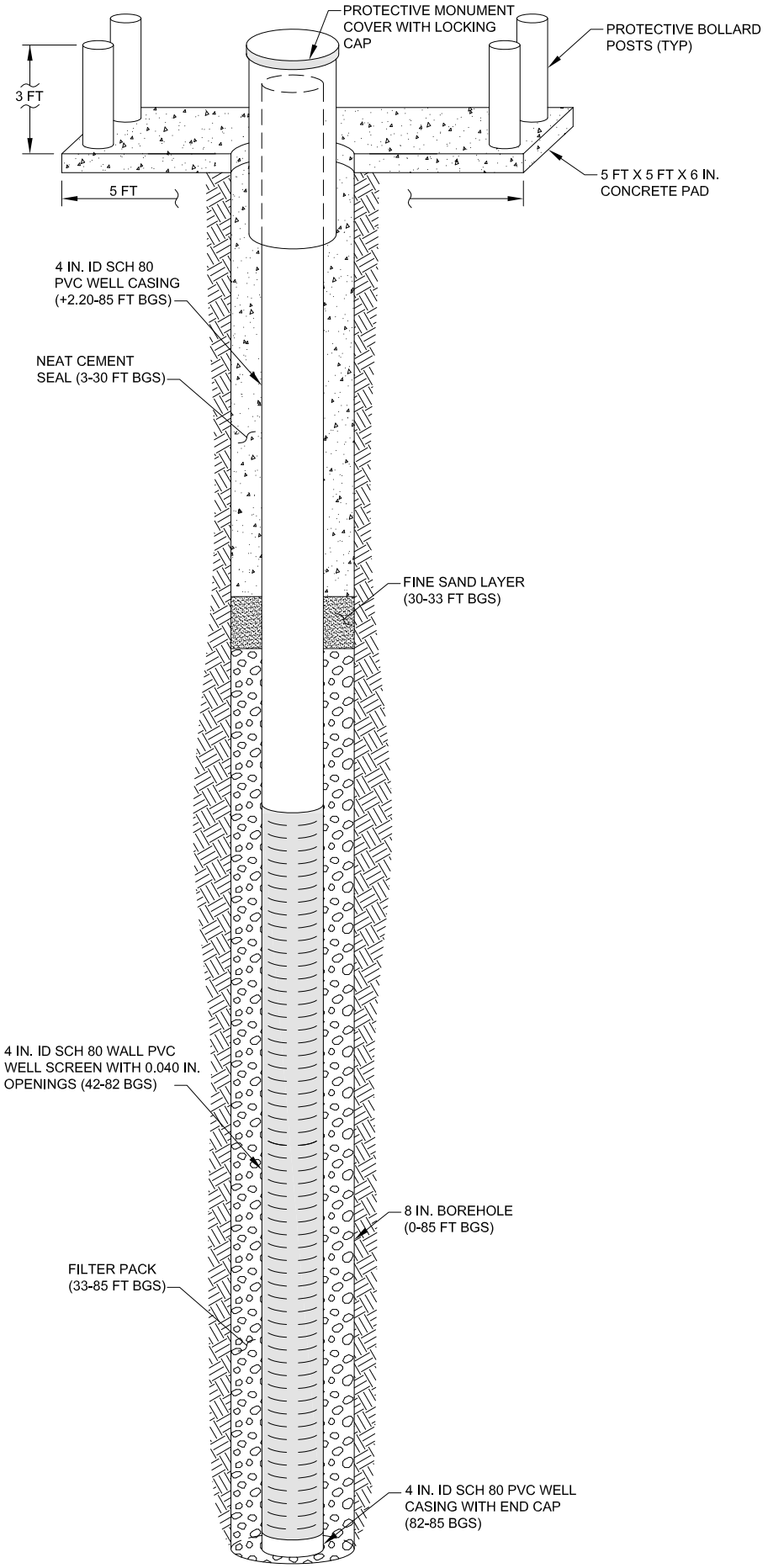

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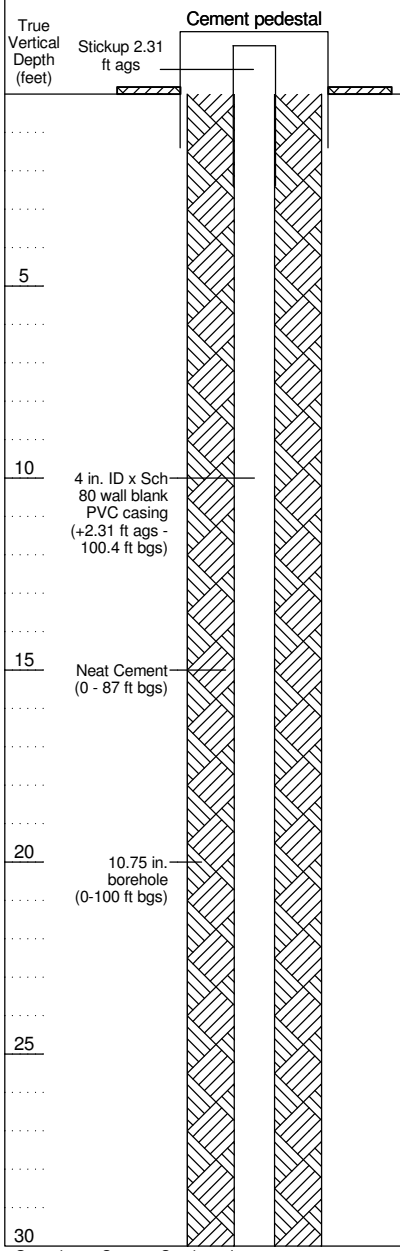
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-5M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Neponset Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.31**	**100.4**	**102.71**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**100.4**	**310.4**	**210**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**310.4**	**312.7**	**2.3**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	78.17 ft NAVD88									
TOC ELEVATION	80.48 ft NAVD88 (RP)									
START DATE	1/21/15									
FINISH DATE	1/27/15									



Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Graphic Log | Depth bgs (feet) | Sieve Sample Number | Drill Rate (ft/hr)

SAND (SP): strong brown (7.5YR 4/6), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz and feldspar; unconsolidated.

SAND (SP): yellowish brown (10YR 5/6), 100% fine to medium grained sand, subangular to subrounded, trace coarse grains; moist sample; contains quartz and feldspar; unconsolidated.

CLAYEY SAND (SC): strong brown (7.5YR 4/6), 85% fine to medium grained sand, subangular to subrounded; 10% clay, low to medium plasticity; 5% silt; moist sample; contains quartz, feldspar, and amphibole; unconsolidated.

CLAYEY SAND (SC): strong brown (7.5YR 5/6), 75% fine to medium grained sand, subangular to subrounded; 20% clay, medium plasticity; 5% silt; moist sample; contains quartz, feldspar, and amphibole; unconsolidated.

SILTY SAND (SM): dark yellowish brown (10YR 4/4), 85% fine to medium grained sand, subangular to subrounded; 10% silt; 5% clay, medium plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.

SAND (SP): brownish yellow (10YR 6/8), 100% sand, subangular to subrounded, very fine to fine; moist sample; contains quartz, feldspar, and mica; unconsolidated.

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Depth bgs (feet)	Lithologic Log	Sieve Sample Number	Drill Rate (ft/hr)
35		35			
40		40	SAND (SP): dark yellowish brown (10YR 4/6), 95% sand, subangular to subrounded, very fine to fine; 5% silt; moist to wet sample; contains quartz, feldspar, and mica; unconsolidated.		
45		45			
50		50	SILTY SAND (SM): dark gray (10YR 4/1), 80% sand, subangular to subrounded, very fine to fine; 20% silt; moist to wet sample; contains quartz, feldspar, and mica; unconsolidated.		
55		55	SILT (ML): gray (10YR 5/1), 60% silt; 30% clay, medium plasticity; 10% sand, subangular to subrounded, very fine; moist sample; contains quartz, feldspar, and mica.		
60		60	SILTY SAND (SM): very dark gray (10YR 3/1), 70% sand, subangular to subrounded, very fine to fine; 30% silt; moist sample; contains quartz, feldspar, and mica; unconsolidated. SAND (SP): dark yellowish brown (10YR 3/4), 100% sand, subangular to subrounded, very fine to fine; moist to wet sample; contains quartz, feldspar, and mica; unconsolidated. SANDY CLAY (CL): greenish gray (10GY 5/1), 65% clay, medium plasticity; 30% sand, subangular to subrounded, very fine to fine; 5% silt; moist sample; contains quartz, feldspar, and mica. CLAY (CL): greenish gray (10GY 5/1), 90% clay, medium to high plasticity; 5% sand, subangular to subrounded, very fine to fine; 5% silt; moist sample.		15
65		65	CLAY (CL): dark bluish gray (5B 4/1), 95% clay, high plasticity; 5% silt; moist sample.		
70		70			

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75		SILTY SAND (SM): dark bluish gray (5B 4/1), 70% sand, subangular to subrounded, very fine to fine; 30% silt; moist sample; contains quartz, feldspar, and mica; unconsolidated.	75		
80		CLAY (CL): dark bluish gray (5B 4/1), 70% clay, medium to high plasticity; 30% silt; moist sample.	80		
85		SILTY SAND (SM): olive brown (2.5Y 4/3), 80% sand, subangular to subrounded, very fine to fine; 20% silt; contains quartz, feldspar, and amphibole; unconsolidated.	85		
90		CLAY (CL): very dark greenish gray (5GY 3/1), 95% clay, high plasticity; 5% silt; moist sample. SAND (SP): light olive brown (2.5Y 5/6), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	90		15
95		SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, and amphibole; unconsolidated.	95		
100		SAND (SP): light olive brown (2.5Y 5/3), 100% fine to medium grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	100		
105			105		
110			110		

CEMEX Monterey Lapis Lustre #60 fine sand seal (87 - 90 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (90 - 315 ft bgs)

9.875 in. borehole (100-250 ft bgs)

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (100.4 - 310.4 ft bgs)					15
115				115		
120			SAND (SP): light olive brown (2.5Y 5/4), 100% medium grained sand, subangular to subrounded, trace fine and course grains; moist to wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	120		
125				125		
130			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 70% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded; 5% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	130		
135			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 75% medium to coarse grained sand; 20% fine to coarse gravel; 5% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	135		12.6
140			SAND (SP): olive brown (2.5Y 4/4), 100% fine grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	140		
145				145		
150				150		

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WELL NUMBER
MPWSP MW-5M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
155				155		
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/4), 80% medium to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; 5% cobbles; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
160				160		
			SAND WITH GRAVEL (SP): yellowish brown (10YR 5/4), 50% coarse grained sand, subangular to subrounded; 40% fine to coarse gravel subangular to subrounded; 10% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			12.6
165				165		
			SAND (SP): light yellowish brown (2.5Y 6/4), 100% fine to medium grained sand, subangular to subrounded; contains quartz and feldspar; unconsolidated.			
170				170		
175				175		
			FAT CLAY (CH): light olive brown (2.5Y 5/3), 80% clay, medium to high plasticity; 20% silt; moist sample; contains reddish iron staining.			
			SILT (ML): grayish brown (2.5Y 5/2), 80% silt; 20% clay, low to medium plasticity; moist sample; contains red and black staining.			
180				180		
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 80% medium to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; 5% cobbles; contains quartz and feldspar; unconsolidated.			
185				185		
190				190		

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			CLAYEY SAND WITH GRAVEL (SC): strong brown (7.5YR 5/6), 55% fine to coarse grained sand, subangular to rounded; 25% clay, no to low plasticity; 15% fine gravel subangular to rounded; 5% silt; moist sample; contains quartz, feldspar, and amphibole; moderate to high cementation.	195		
			SAND (SP): 95% fine grained sand, subangular to subrounded, some medium to coarse grains; 5% fine gravel subangular to subrounded; moist to wet sample; contains quartz and feldspar; unconsolidated.			
200			SAND WITH GRAVEL (SP): dark yellowish brown (10YR 4/6), 70% coarse grained sand, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded; 5% cobbles; moist to wet sample; moderate cementation; contains quartz, feldspar, and amphibole.	200		
205				205		
210				210		
215				215		
			FAT CLAY (CH): grayish brown (2.5Y 5/2), 60% clay, medium to high plasticity; 30% silt; 10% sand, very fine with trace coarse grains; moist sample.		
220				220		
			SILT (ML): light olive brown (2.5Y 5/3), 60% silt; 30% clay, medium to high plasticity; 10% fine to coarse grained sand, subrounded; trace fine gravel subrounded; moist sample.			
225				225		
			SAND (SP): strong brown (7.5YR 4/6), 95% fine to coarse grained sand, subangular to rounded; 5% fine gravel subangular to rounded; wet sample; contains quartz, feldspar, and amphibole; unconsolidated.			
			SAND (SP): dark brown (10YR 3/3), 100% fine grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			4.6
230				230		

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235				235		
240				240		4.6
			SAND (SP): dark brown (10YR 3/3), 100% fine grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
245				245		
250				250		
	8 in. borehole (250-315 ft bgs)					
255				255		
260				260		18.5
			SILTY SAND (SM): dark brown (7.5YR 3/3), 80% fine grained sand, subangular to subrounded; 20% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
265				265		
270				270		

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
275			SAND (SP): dark brown (7.5YR 3/2), 95% sand, subangular to subrounded, very fine to fine grained; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	275		
280				280		
			SILTY SAND (SM): dark brown (7.5YR 3/4), 85% sand, subangular to subrounded, very fine to fine grained; 15% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
285			SAND (SP): dark brown (7.5YR 3/3), 95% sand, subangular to subrounded, very fine to fine grained; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	285		
290				290		18.5
295				295		
300				300		
305				305		
310			CLAYEY SAND (SC): olive (5Y 5/4), 60% sand, subangular to subrounded, very fine to fine grained; 30% clay, low plasticity; 10%	310		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-5M**

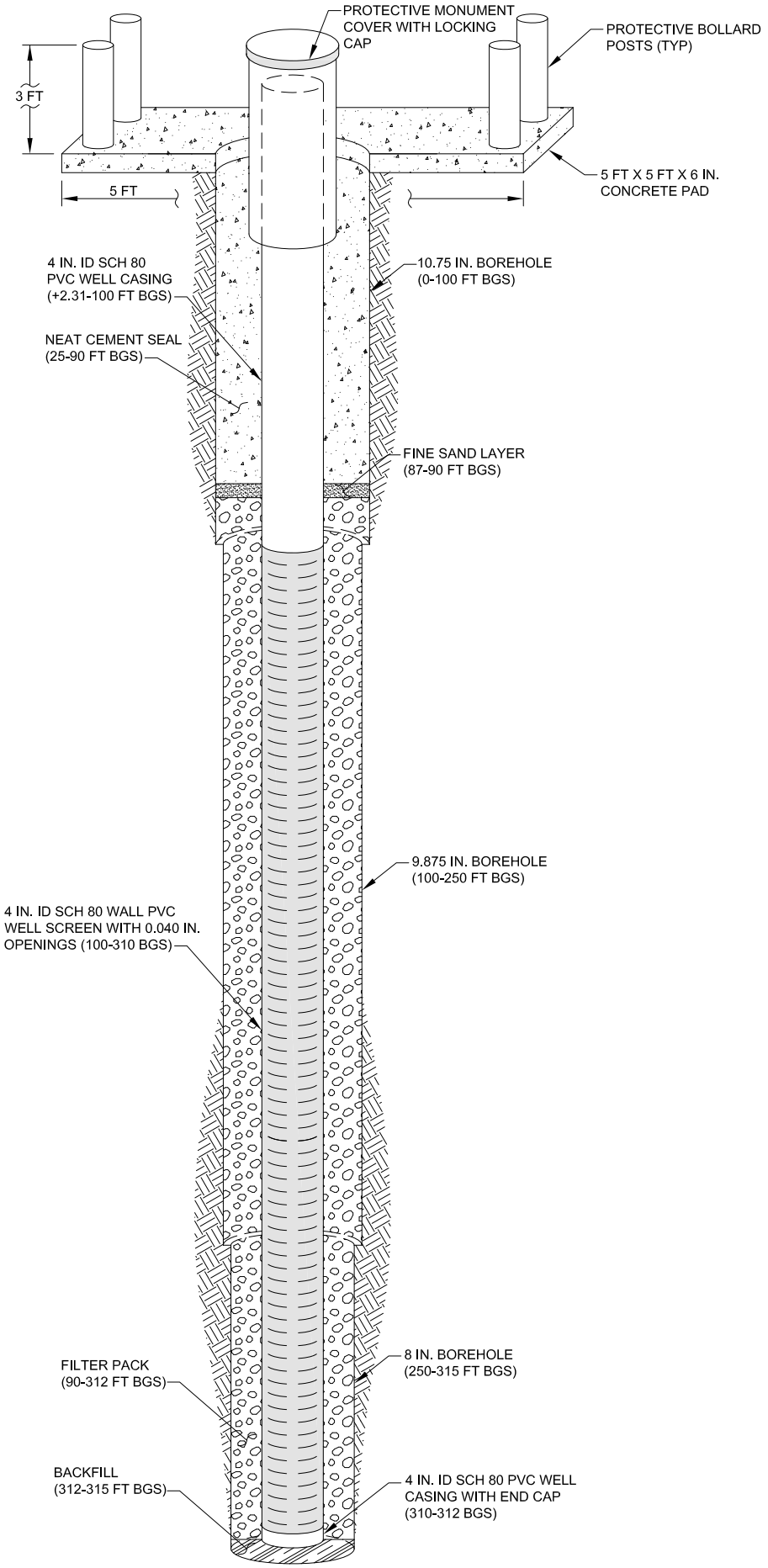
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	Blank casing with end cap (310.4 - 312.7 ft bgs)		silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			18.5
315	TD 315 ft bgs			315		

Bottom of borehole at 315 feet.

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16



WELL PROFILE

NOT TO SCALE

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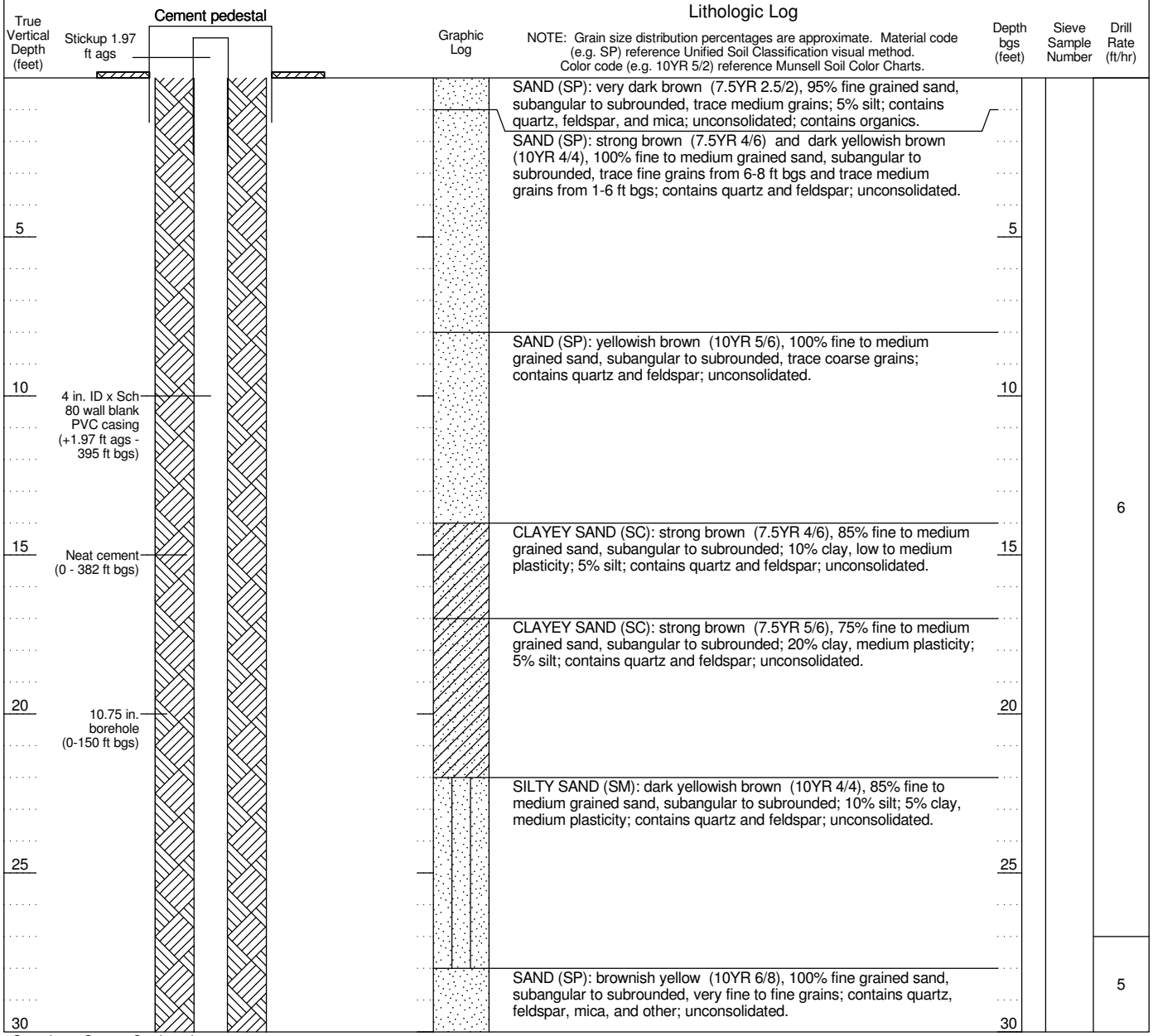
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-5D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Neponset Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-1.97**	**395**	**383.97**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**395**	**435**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**435**	**437.3**	**2.3**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	78.09 ft NAVD88									
TOC ELEVATION	80.06 ft NAVD88 (RP)									
START DATE	12/16/14									
FINISH DATE	1/21/15									



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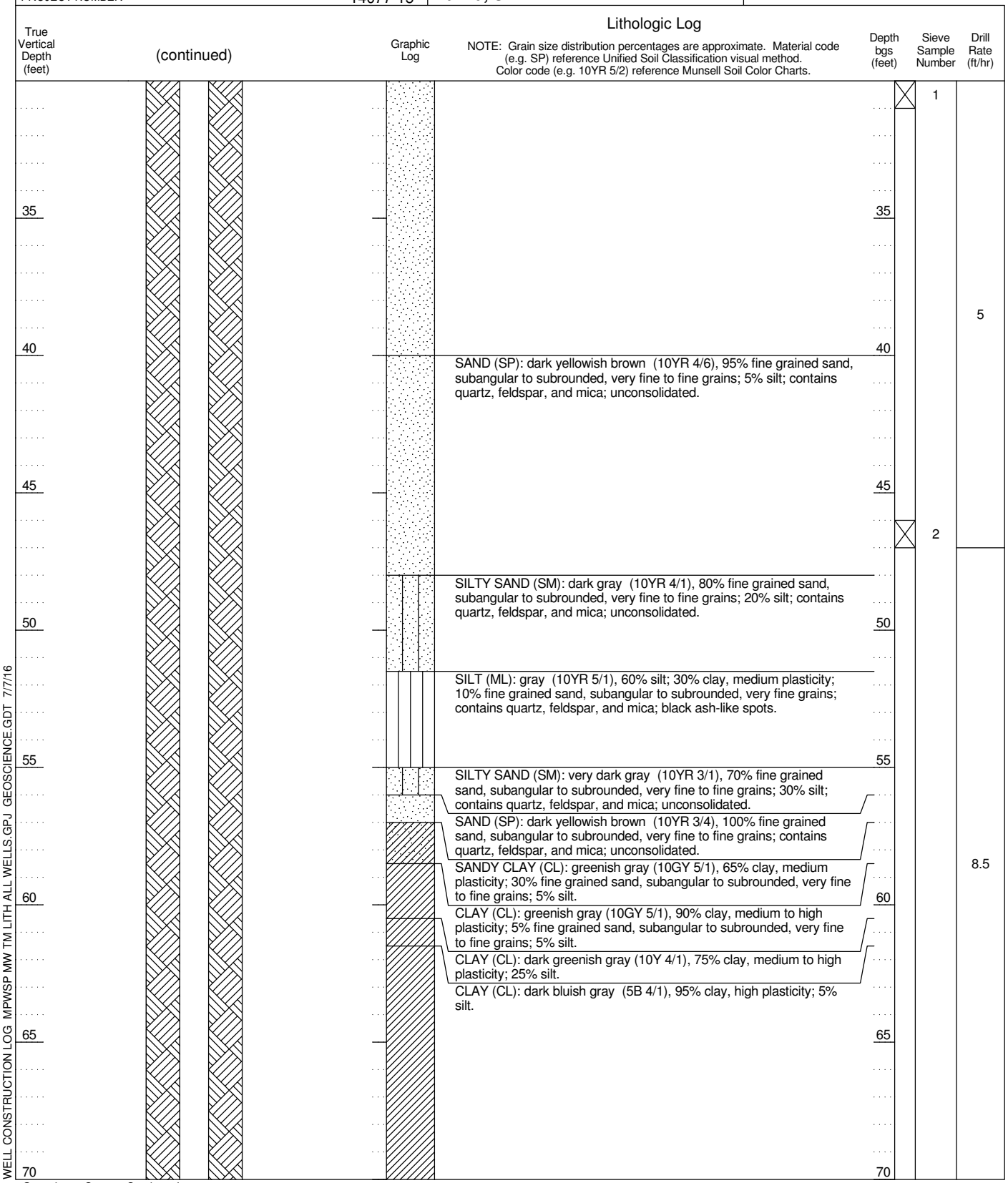
WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND (SP): olive brown (2.5Y 4/3), 100% fine grained sand, subangular to subrounded, very fine to fine grains; contains quartz, feldspar, and mica.	75		8.5
			SILTY SAND (SM): dark bluish gray (5B 4/1), 70% fine grained sand, subangular to subrounded, very fine to fine grains; 30% silt; contains quartz, feldspar, and mica.			
			CLAY (CL): dark bluish gray (5B 4/1), 70% clay, medium to high plasticity; 30% silt; clay content increases with depth.			
80			SILTY SAND (SM): olive brown (2.5Y 4/3), 80% fine grained sand, subangular to subrounded, very fine to fine grains; 20% silt; contains quartz, feldspar, and mica; with visible alteration; iron oxide staining; 20% clay and 30% silt from 84-85 ft bgs.	80		
85			CLAY (CL): very dark greenish gray (5GY 3/1), 95% clay, high plasticity; 5% silt; black ash-like spots.	85		10
90			SAND (SP): light olive brown (2.5Y 5/6), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole; shell fragments to 2mm.	90		
95			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole; trace shell fragments to 2mm.	95	3	
100			SAND (SP): light olive brown (2.5Y 5/3), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole; shell fragments to 0.43mm.	100		
105				105	4	
110				110		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115				115	5	
			SAND (SP): light olive brown (2.5Y 5/4), 100% fine to coarse grained sand, subangular to subrounded, predominantly medium grained; contains quartz, feldspar, and amphibole; shell fragments to 4.8mm.			
120				120	6	
125				125		
			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 70% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel up to 75 mm, subangular to subrounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; shell fragments to 4.8mm.			
130				130	7	
			SILTY SAND (SM): light olive brown (2.5Y 5/6), 80% fine to coarse grained sand, subangular to subrounded; 15% silt; 5% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; shell fragments to 2mm.			
135			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 75% medium to coarse grained sand, subrounded to rounded; 20% fine to coarse gravel subrounded to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; shell fragments to 4.8mm.	135	8	
			SAND (SP): light olive brown (2.5Y 5/4), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; shell fragments to 4.8mm.			
140				140	9	
			SAND (SP): olive brown (2.5Y 4/4), 100% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
145				145	10	
150				150		

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WELL NUMBER
MPWSP MW-5D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	9.875 in. borehole (150-300 ft bgs)					
155			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/4), 80% medium to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; trace cobbles; shell fragments to 2mm.	155	11	
160			SAND WITH GRAVEL (SP): yellowish brown (10YR 5/4), 55% fine to coarse grained sand, angular to rounded; 45% fine to coarse gravel angular to rounded; contains quartz, feldspar, mica, and amphibole; trace cobbles.	160	12	
165				165		
170			SAND (SP): light reddish brown (2.5YR 6/4), 100% fine to medium grained sand, subangular to subrounded; contains quartz and feldspar.	170	13	
175				175		
180			FAT CLAY (CH): light olive brown (2.5Y 5/3), 80% clay, medium to high plasticity; 20% silt; with visible alteration; iron oxide staining. SAND (SP): light olive brown (2.5Y 5/4), 100% medium to coarse grained sand, subangular to subrounded; contains quartz, feldspar, and mica; shell fragments to 2mm. SILT (ML): grayish brown (2.5Y 5/2), 80% silt; 20% clay; red and black staining; low to medium plasticity.	180		9
185			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 80% medium to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz and feldspar; trace cobbles; clay lens from 190-190.5; chert; gravel content increases with depth.	185	14	
190				190		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			CLAYEY SAND WITH GRAVEL (SC): strong brown (7.5YR 4/6), 55% fine to coarse grained sand, subrounded to rounded, medium to coarse grained from 197-198 ft bgs; 25% clay, no to low plasticity; 15% fine gravel subrounded to rounded; 5% silt; moderate cementation; contains quartz, feldspar, and amphibole.			
195			SAND (SP): gray (7.5YR 5/1), 95% fine to coarse grained sand, subrounded to rounded, predominantly fine; 5% fine gravel subrounded to rounded; contains quartz and feldspar.	195		
			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 65% fine to coarse grained sand, subrounded to rounded, predominantly medium to coarse; 35% fine to coarse gravel subrounded to rounded; weak cementation; contains quartz, feldspar, and amphibole; trace cobbles; trace clay; iron oxide staining.			
200				200	15	
			SAND WITH GRAVEL (SP): dark yellowish brown (10YR 4/6), 70% coarse grained sand, subangular to rounded; 30% fine to coarse gravel subangular to rounded; moderate cementation; contains quartz, feldspar, and amphibole; trace cobbles.			
205				205	16	
			SAND (SP): grayish brown (10YR 5/2), 88% fine to coarse grained sand, subrounded to rounded, trace fine grained; 12% fine to coarse gravel subrounded to rounded; contains quartz, feldspar, and amphibole; trace cobbles; trace shell fragments to 2mm.			
210			SAND (SP): grayish brown (10YR 5/2), 85% fine to coarse grained sand, subrounded to rounded, trace fine grained; 15% fine to coarse gravel subrounded to rounded; moderate cementation; contains quartz, feldspar, and amphibole; trace cobbles.	210		9
			SAND (SP): dark grayish brown (10YR 4/2), 100% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
			SAND WITH GRAVEL (SP): grayish brown (2.5Y 5/2), 70% medium to coarse grained sand, subrounded to rounded; 30% fine to coarse gravel subrounded to rounded; contains quartz, and feldspar; trace cobbles; trace clay from 217-217.5 ft bgs.			
215				215	17	
			FAT CLAY (CH): brown (10YR 5/3), 95% clay, high plasticity; 5% silt.			
220			FAT CLAY (CH): brown (10YR 4/3), 60% clay, medium to high plasticity; 30% silt; 10% fine grained sand, trace coarse grains.	220		
			SILT (ML): light olive brown (2.5Y 5/3), 60% silt; 30% clay, medium to high plasticity; 10% sand, subrounded, fine and coarse; trace fine gravel subrounded.			
225				225		
			SAND WITH GRAVEL (SP): strong brown (7.5YR 4/6), 85% fine to coarse grained sand, subrounded to rounded, predominantly fine grained; 15% fine gravel subrounded to rounded; weak cementation; contains quartz, feldspar, and amphibole; trace shell fragments to 2mm; red iron oxide staining.			
			SAND (SP): dark brown (10YR 3/3), 100% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole; trace silt at 240 ft bgs; friable sandstone to 75mm.			
230				230		

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WELL NUMBER
MPWSP MW-5D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235				235	18	
240				240	19	9
245				245		
250				250		
255				255	20	
260				260		
265			SILTY SAND (SM): dark brown (7.5YR 3/3), 80% fine grained sand, subangular to subrounded; 20% silt; contains quartz, feldspar, mica, and amphibole.	265		16
270				270		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
275	SAND (SP): dark brown (7.5YR 3/2), 95% fine grained sand, subangular to subrounded, very fine to fine grains; 5% silt; contains quartz, feldspar, mica, and amphibole.	275	21	
280	SILTY SAND (SM): dark brown (7.5YR 3/4), 85% fine grained sand, subangular to subrounded, very fine to fine grains; 15% silt; contains quartz, feldspar, mica, and amphibole.	280		16
285	SAND (SP): dark brown (7.5YR 3/3), 95% fine grained sand, subangular to subrounded, very fine to fine grains; 5% silt; contains quartz, feldspar, mica, and amphibole.	285		
290		290	22	
295		295		
300	8 in. borehole (300-440 ft bgs)	300		3.6
305		305	23	
310	CLAY WITH SAND (CL): olive (5Y 5/4), 80% clay, medium to high plasticity; 15% fine grained sand, subangular to subrounded, very fine to fine grains; 5% silt; contains quartz, feldspar, mica, and amphibole.	310		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
	CLAYEY SAND (SC): olive (5Y 4/4), 60% fine grained sand, subangular to subrounded, very fine to fine grains; 30% clay, low plasticity; 10% silt; contains quartz, feldspar, mica, and amphibole.			
315		315		
	SAND (SP): dark brown (7.5YR 3/3), 100% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
	SILTY SAND (SM): olive brown (2.5Y 4/3), 80% fine to medium grained sand, subangular to subrounded; 15% silt; 5% clay; contains quartz, feldspar, mica, and amphibole.			
320		320		
	SAND WITH GRAVEL (SP): very dark grayish brown (2.5Y 3/2), 80% fine to medium grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; trace cobbles; chert; trace shell fragments to 4.8mm.			
325		325		
	CLAYEY SAND (SC): light olive brown (2.5Y 5/3), 75% fine grained sand, subangular to subrounded; 20% clay, low plasticity; 5% silt; contains quartz, feldspar, mica, and amphibole.			
	CLAY (CL): dark greenish gray (10Y 4/1), 90% clay, medium plasticity; 10% silt; gray and black ash-like spots.			
330		330		
	SILTY SAND (SM): dark yellowish brown (10YR 4/4), 65% fine grained sand, subangular to subrounded, very fine to fine grains; 35% silt.			
	SILT WITH SAND (ML): greenish gray (10Y 5/1), 60% silt; 25% clay, low plasticity; 15% fine grained sand, very fine grains.			
335	SANDY CLAY (CL): greenish black (10GY 2.5/1), 60% clay, medium plasticity; 40% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	335		
340		340		6
	CLAYEY SAND (SC): olive (5Y 4/4), 60% fine to coarse grained sand, subangular to subrounded; 30% clay, low plasticity; 10% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; chert.			
345	SILT (ML): dark greenish gray (10Y 4/1), 60% silt; 30% clay, low plasticity; 10% fine grained sand, subangular to subrounded, very fine grains.	345		
	CLAY (CL): dark grayish brown (2.5Y 4/2), 90% clay, medium to high plasticity; 5% fine grained sand, very fine grains; 5% silt.			
350		350		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
355		SANDY CLAY (CL): dark greenish gray (10Y 4/1), 50% clay, low to medium plasticity; 35% fine grained sand, subangular to subrounded, very fine to fine grains; 15% silt.	355		
360			360		6
365		SANDY CLAY (CL): dark yellowish brown (10YR 4/4), 50% clay, low plasticity; 45% fine grained sand, subangular to subrounded; 5% silt.	365		
370		CLAY (CL): dark yellowish brown (10YR 4/4), 85% clay, medium to high plasticity; 15% silt; gray spots to 3mm.	370		
375			375		
380		CLAY WITH SAND (CL): dark yellowish brown (10YR 4/6), 60% clay, medium plasticity; 25% fine grained sand, very fine grains; 15% silt.	380		
385		SILT WITH SAND (ML): dark yellowish brown (10YR 3/6), 50% silt; 25% fine grained sand, very fine grains; 25% clay, medium to high plasticity.	385		6.6
390		CLAY (CL): light olive brown (2.5Y 5/3), 100% clay, medium to high plasticity.	390		

CEMEX Monterey Lapis Lustre #60 fine sand seal (382 - 385 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (385 - 440 ft bgs)

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SANDY SILT (ML): dark grayish brown (2.5Y 4/2), 50% silt; 40% fine grained sand, very fine grains; 10% clay.			
			FAT CLAY WITH SAND (CH): dark olive brown (2.5Y 3/3), 75% clay, high plasticity; 25% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
395			SAND WITH GRAVEL (SP): dark greenish gray (10Y 4/1) and dark brown (10YR 3/3), 80% medium to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; chert; shell fragments to 4.8mm; larger grains from 397.5-407.5 ft bgs.	395		
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (395 - 435 ft bgs)					
400				400	24	
405				405		
			SAND (SP): dark yellowish brown (10YR 3/6), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole; trace shell fragments to 4.8mm.			
410				410	25	6.6
415				415		
420				420		
			SAND WITH GRAVEL (SP): grayish brown (2.5Y 5/2), 85% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subrounded to rounded; contains quartz, feldspar, mica, and amphibole; trace cobbles.			
425			SAND (SP): grayish brown (2.5Y 5/2), 95% medium to coarse grained sand, subangular to subrounded; 5% fine to coarse gravel rounded; contains quartz, feldspar, mica, and amphibole.	425	26	
			SAND (SP): light olive brown (2.5Y 5/4), 95% medium grained sand, subangular to subrounded; 5% fine gravel rounded; contains quartz, feldspar, mica, and amphibole.			
			CLAYEY SAND WITH GRAVEL (SC): light olive brown (2.5Y 5/4), 45% fine to medium grained sand, subangular to subrounded; 25% clay, medium to high plasticity; 20% fine to coarse gravel subangular			
430				430		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

GEOSCIENCE
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Claremont, CA 91711
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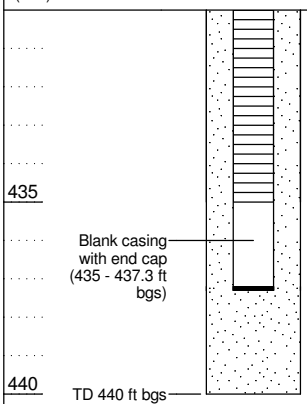
Fax: (909) 451-6638
www.gssiwater.com

WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)



True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		to rounded; 10% cobbles; contains quartz, feldspar, mica, and amphibole.			
		SAND (SP): greenish black (5GY 2.5/1), 90% medium to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subrounded; contains quartz, feldspar, mica, and amphibole.			
		SAND (SP): very dark greenish gray (10Y 3/1), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
435			435		
		SAND WITH GRAVEL (SP): dark grayish brown (2.5Y 4/2), 80% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subangular to rounded; 10% cobbles; contains quartz, feldspar, mica, and amphibole; trace cobbles.		27	
440		Bottom of borehole at 440 feet.	440		

APPENDIX C

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19106

File No.

Company CASCADE DRILLING

Well MW-5 DEEP

Field SALINAS

County MONTEREY State CA

Location

OFF OF NEPONSET RD.
GPS: N 36o 43.075' W 121o 46.472'

Other Services:

DUAL INDUCTION
GAMMA-RAY

			Elevation
Permanent Datum	G.L.	Elevation above perm. datum	K.B.
Log Measured From	G.L.	0'	D.F.
Drilling Measured From	G.L.		G.L.

Date	01-08-2015		
Run Number	ONE		
Depth Driller	432'		
Depth Logger	430'		
Bottom Logged Interval	430'		
Top Log Interval	0'		
Open Hole Size	12" (0'-20')	10.75" (20"-100')	9.875" (100'-300')
Type Fluid	WATER		8" (300'-432')
Density / Viscosity	N/A		
Fluid Level	73'		
Bentonite Seal	N/A		
Time Well Ready	1500		
Time Logger on Bottom	1515		
Equipment Number	PS-7		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	N. REYNOLDS		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	12"	0'	20'				
TWO	10.75"	20'	100'				
THREE	9.875"	100'	300'				
FOUR	8"	300'	432'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	432'
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

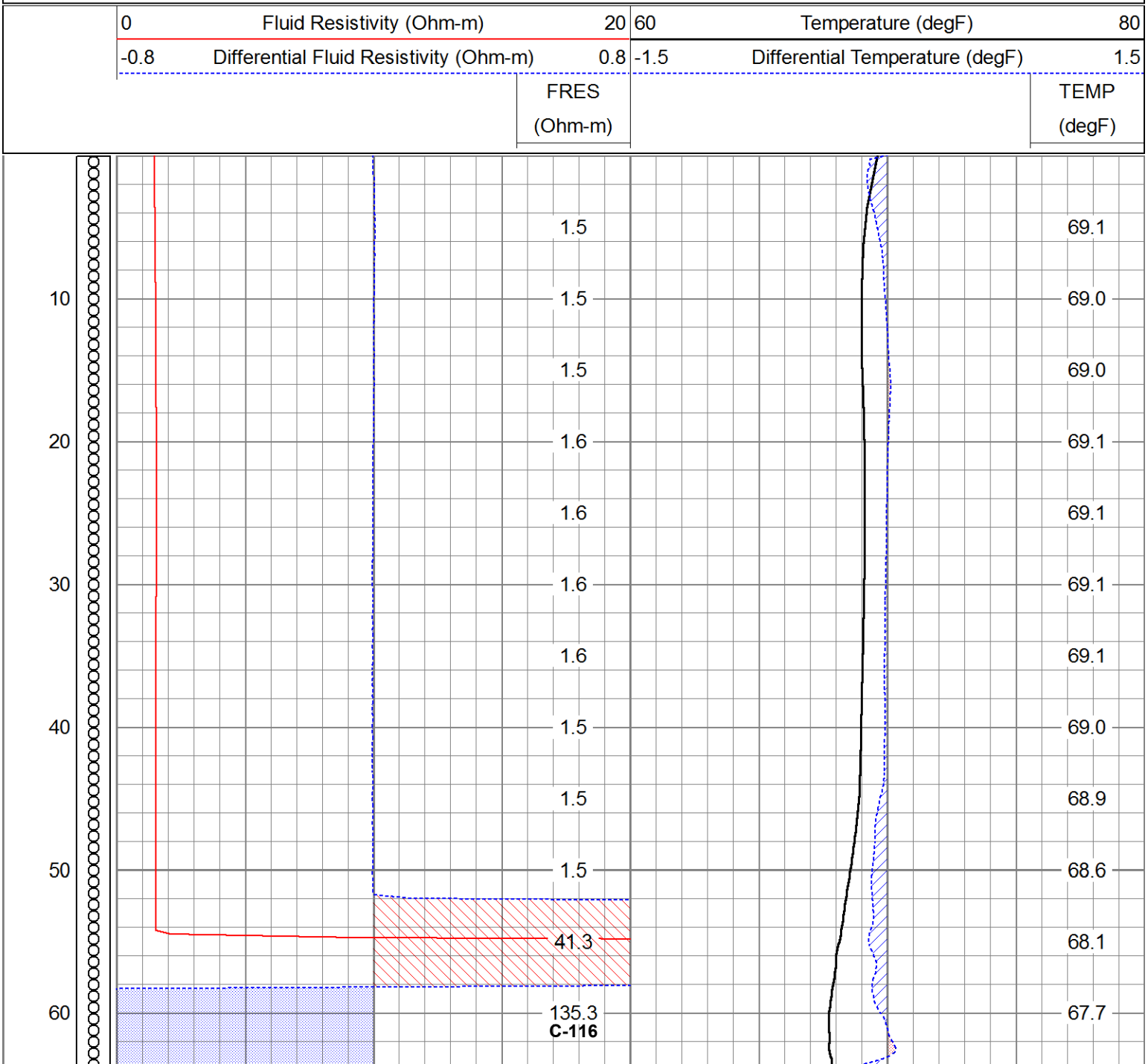
Database File 19106.db
Dataset Pathname tmp
Dataset Creation Thu Jan 08 15:02:34 2015

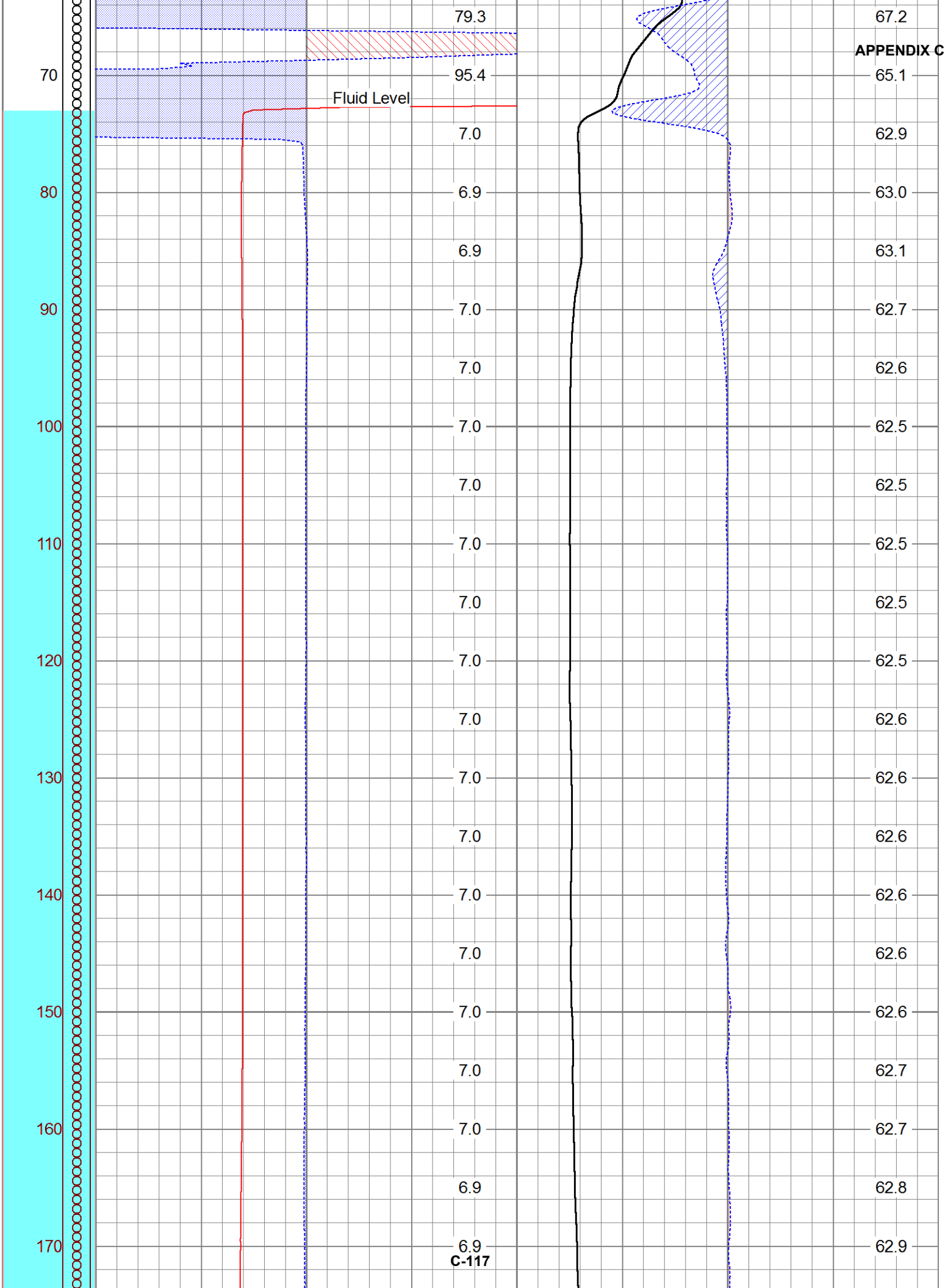
Temperature Calibration Report

APPENDIX C

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Wed Aug 29 07:13:35 2012	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-5.71	
Delta Spacing	2	

Database File	19106.db
Dataset Pathname	tmp
Presentation Format	frttemp2
Dataset Creation	Thu Jan 08 15:02:34 2015
Charted by	Depth in Feet scaled 1:120




Fluid Level
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80
90
100
110
120
130
140
150
160
170
79.3
95.4
7.0
6.9
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7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
6.9
6.9
67.2
65.1
62.9
63.0
63.1
62.7
62.6
62.5
62.5
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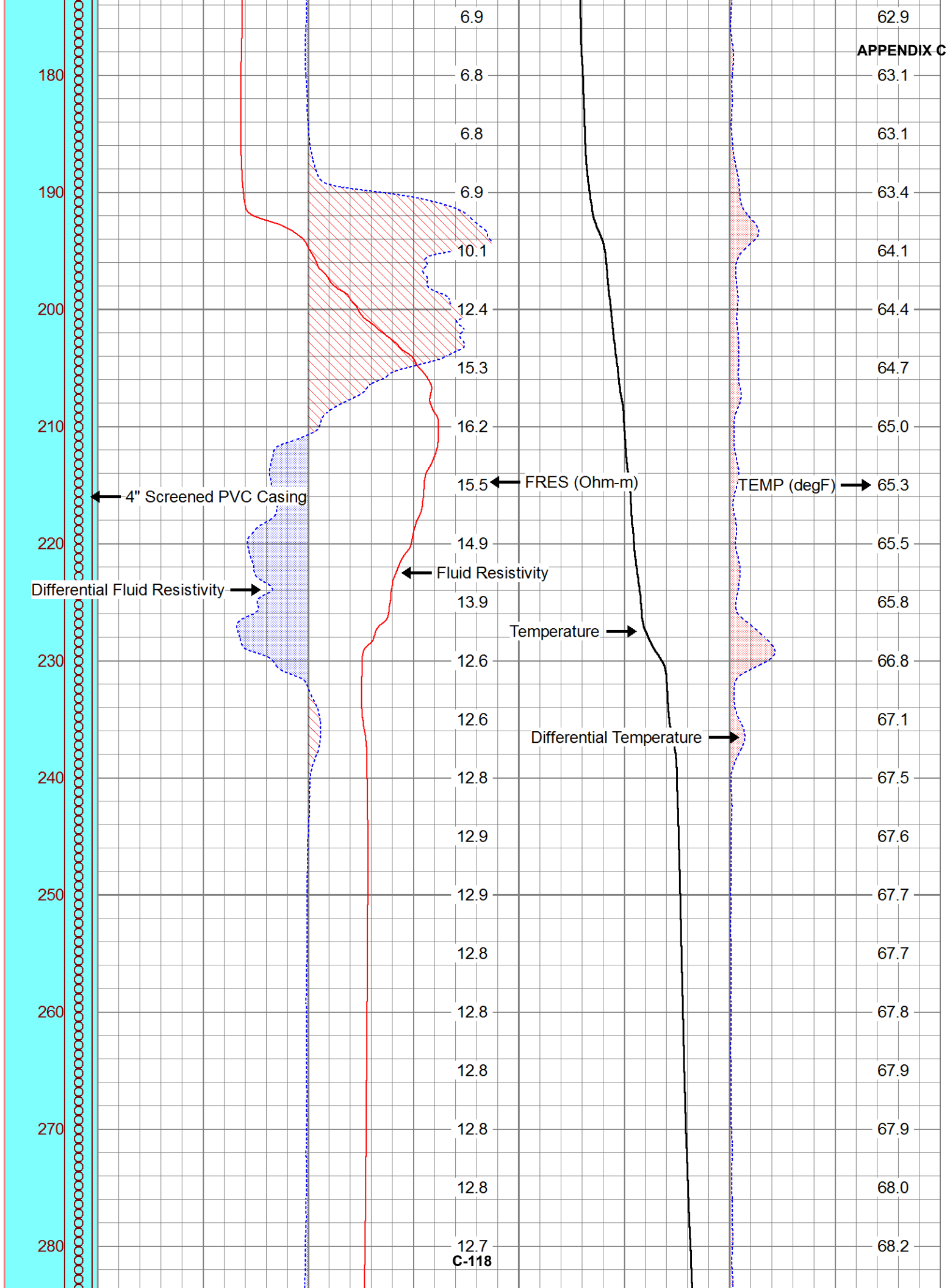
62.9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280
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6.8
6.8
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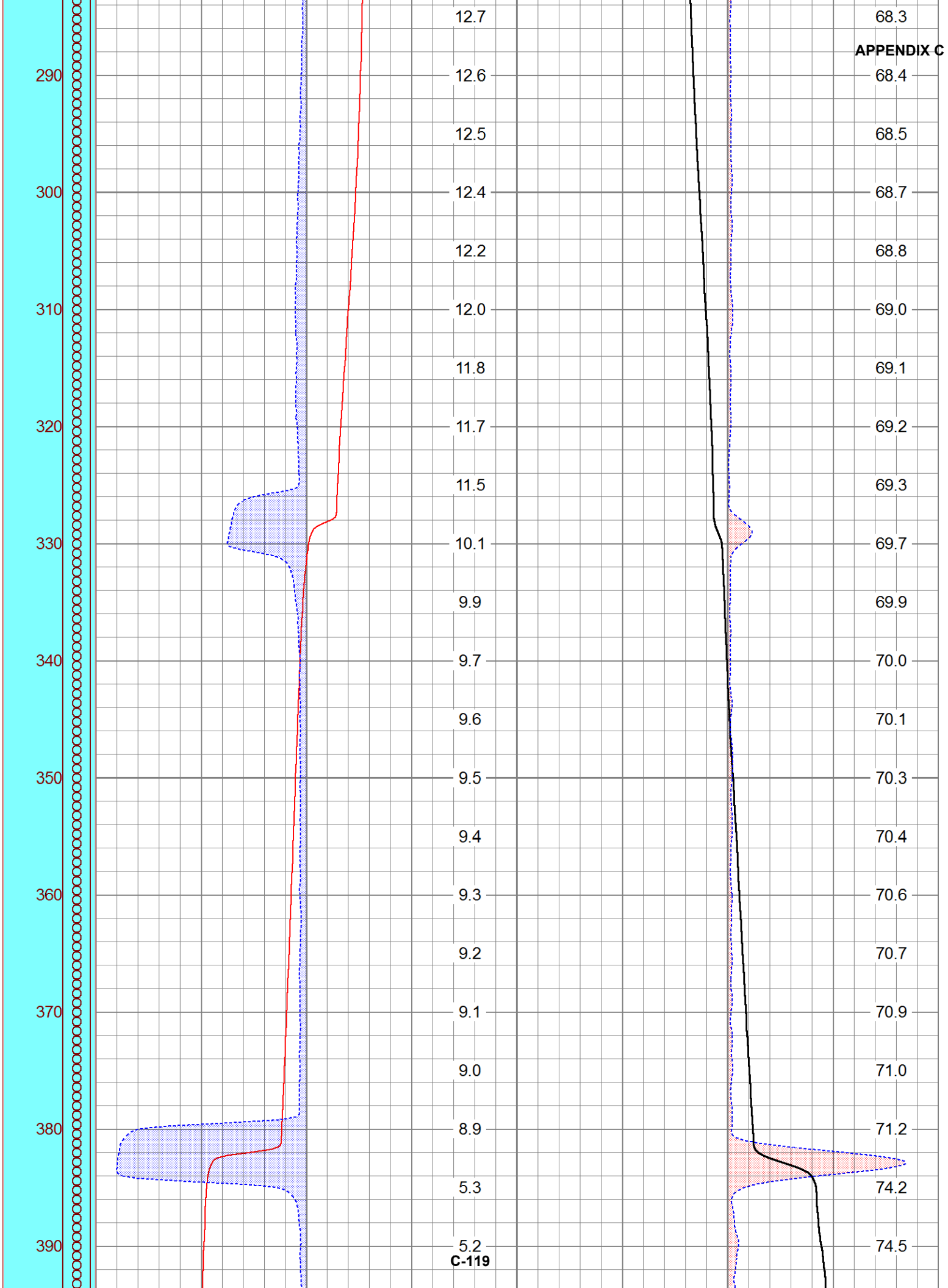
10.1
12.4
15.3
16.2
15.5
14.9
13.9
12.6
12.6
12.8
12.9
12.9
12.8
12.8
12.8
12.8
12.7
62.9
63.1
63.1
63.4
64.1
64.4
64.7
65.0
65.3
65.5
65.8
66.8
67.1
67.5
67.6
67.7
67.7
67.8
67.9
67.9
68.0
68.2
4" Screened PVC Casing
Differential Fluid Resistivity
Fluid Resistivity
FRES (Ohm-m)
Temperature
Differential Temperature
TEMP (degF)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320
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340
350
360
370
380
390
12.7
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11.8
11.7
11.5
10.1
9.9
9.7
9.6
9.5
9.4
9.3
9.2
9.1
9.0
8.9
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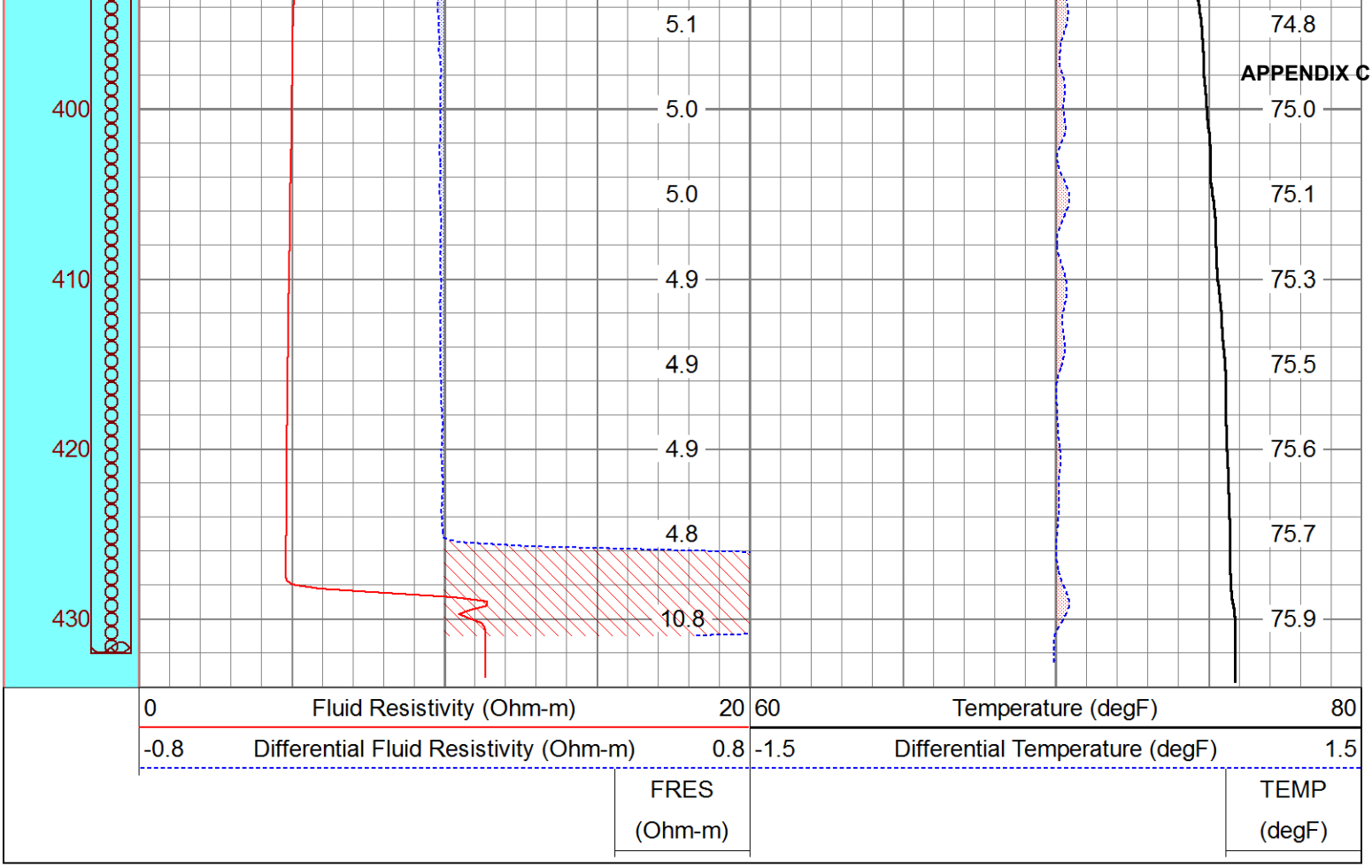
71.2
74.2
74.5


400
410
420
430
5.1
5.0
5.0
4.9
4.9
4.9
4.8
10.8
74.8
75.0
75.1
75.3
75.5
75.6
75.7
75.9
0
Fluid Resistivity (Ohm-m)
20
-0.8
Differential Fluid Resistivity (Ohm-m)
0.8
FRES
(Ohm-m)
60
Temperature (degF)
80
-1.5
Differential Temperature (degF)
1.5
TEMP
(degF)

APPENDIX C

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19106

File No.

Company CASCADE DRILLING

Well MW-5 DEEP

Field SALINAS

County MONTEREY State CA

Location

OFF OF NEPONSET RD.
GPS: N 36o 43.075' W 121o 46.472'

Other Services:

TEMPERATURE
FLUID RESISTIVITY

Permanent Datum	G.L.	Elevation above perm. datum	Elevation K.B. D.F. G.L.
Log Measured From	G.L.	0'	
Drilling Measured From	G.L.		

Date	01-08-2015		
Run Number	ONE		
Depth Driller	432'		
Depth Logger	430'		
Bottom Logged Interval	430'		
Top Log Interval	0'		
Open Hole Size	12" (0'-20')	10.75" (20"-100')	9.875" (100'-300')
Type Fluid	WATER		8" (300'-432')
Density / Viscosity	N/A		
Fluid Level	26'		
Bentonite Seal	N/A		
Time Well Ready	1500		
Time Logger on Bottom	1515		
Equipment Number	PS-7		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	N. REYNOLDS		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	12"	0'	20'				
TWO	10.75"	20'	100'				
THREE	9.875"	100'	300'				
FOUR	8"	300'	432'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	432'
Liner				

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Comments

Calibration Report

Database File 19106.db
Dataset Pathname DIL.1
Dataset Creation Thu Jan 08 17:02:19 2015

Dual Induction Calibration Report

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

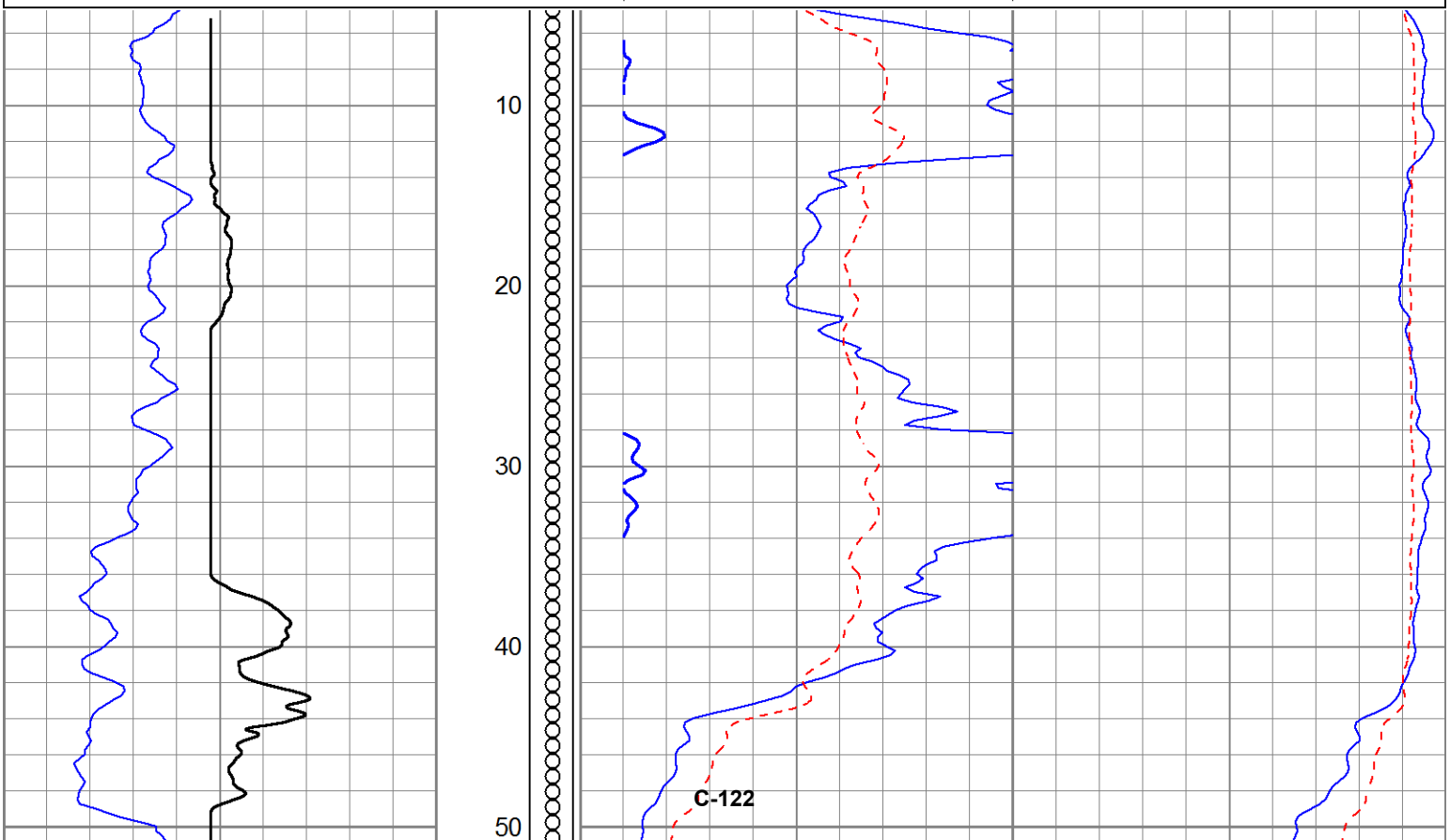
Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1405.080	3665.050	cps	0.000	612.000	mmho/m	0.271	-380.495
Medium	2052.170	14102.500	cps	0.000	1960.000	mmho/m	0.163	-333.788

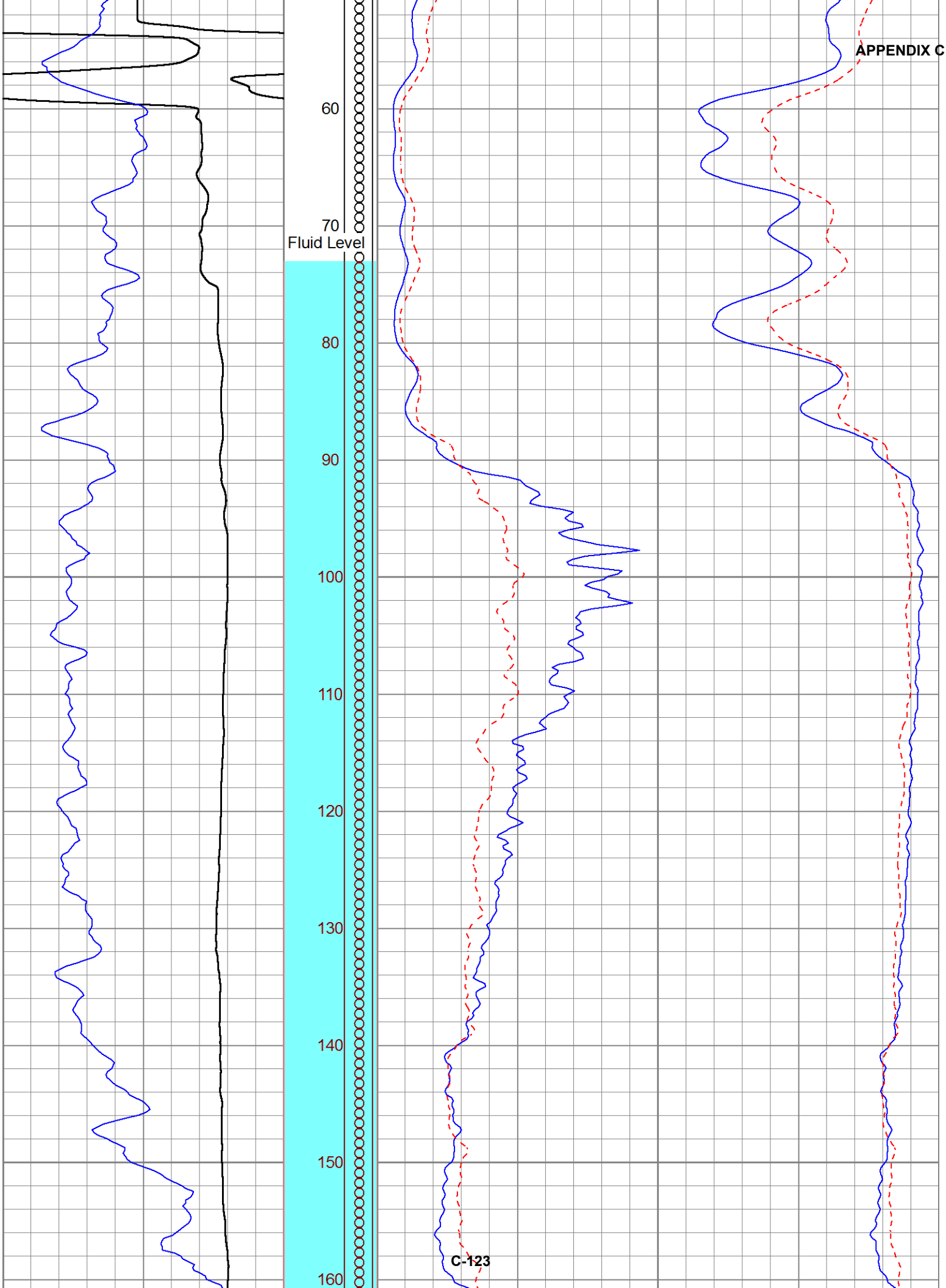
Gamma Ray Calibration Report

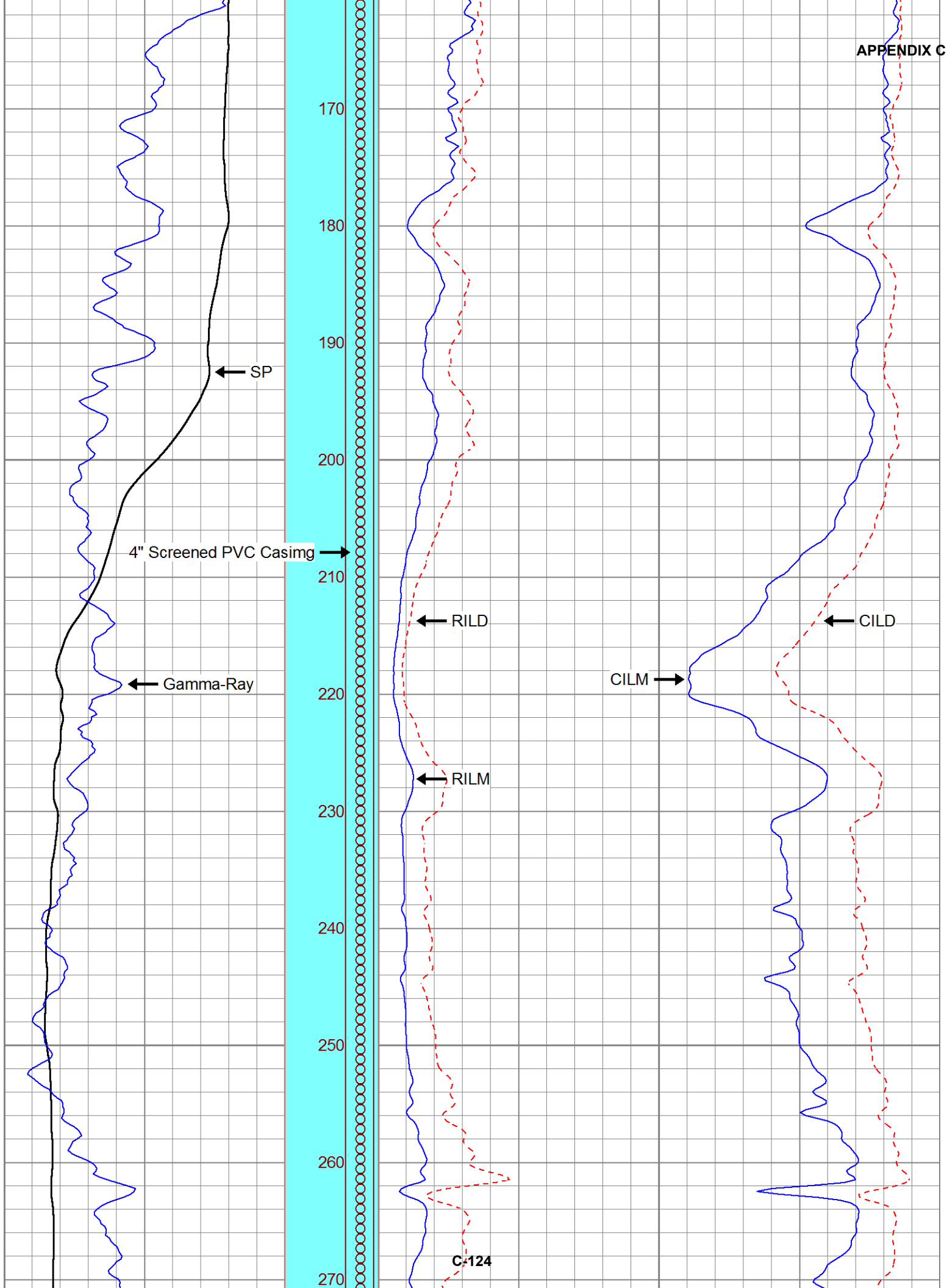
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Dec 13 17:32:47 2014	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

Database File	19106.db
Dataset Pathname	DIL.1
Presentation Format	dil_ps
Dataset Creation	Thu Jan 08 17:02:19 2015
Charted by	Depth in Feet scaled 1:120

-100	SP (mV)	100	0	RILM (Ohm-m)	100	200	CILM (mmho/m)	0
20	Gamma Ray (GAPI)	120	0	RILD (Ohm-m)	100	200	CILD (mmho/m)	0
			100	RILM backup (Ohm-m)	1000	2000	CILM backup (mmho/m)	200
			100	RILD backup (Ohm-m)	1000	2000	CILD backup (mmho/m)	200




APPENDIX C
60
70
Fluid Level
80
90
100
110
120
130
140
150
160
C-123


170
180
190
200
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220
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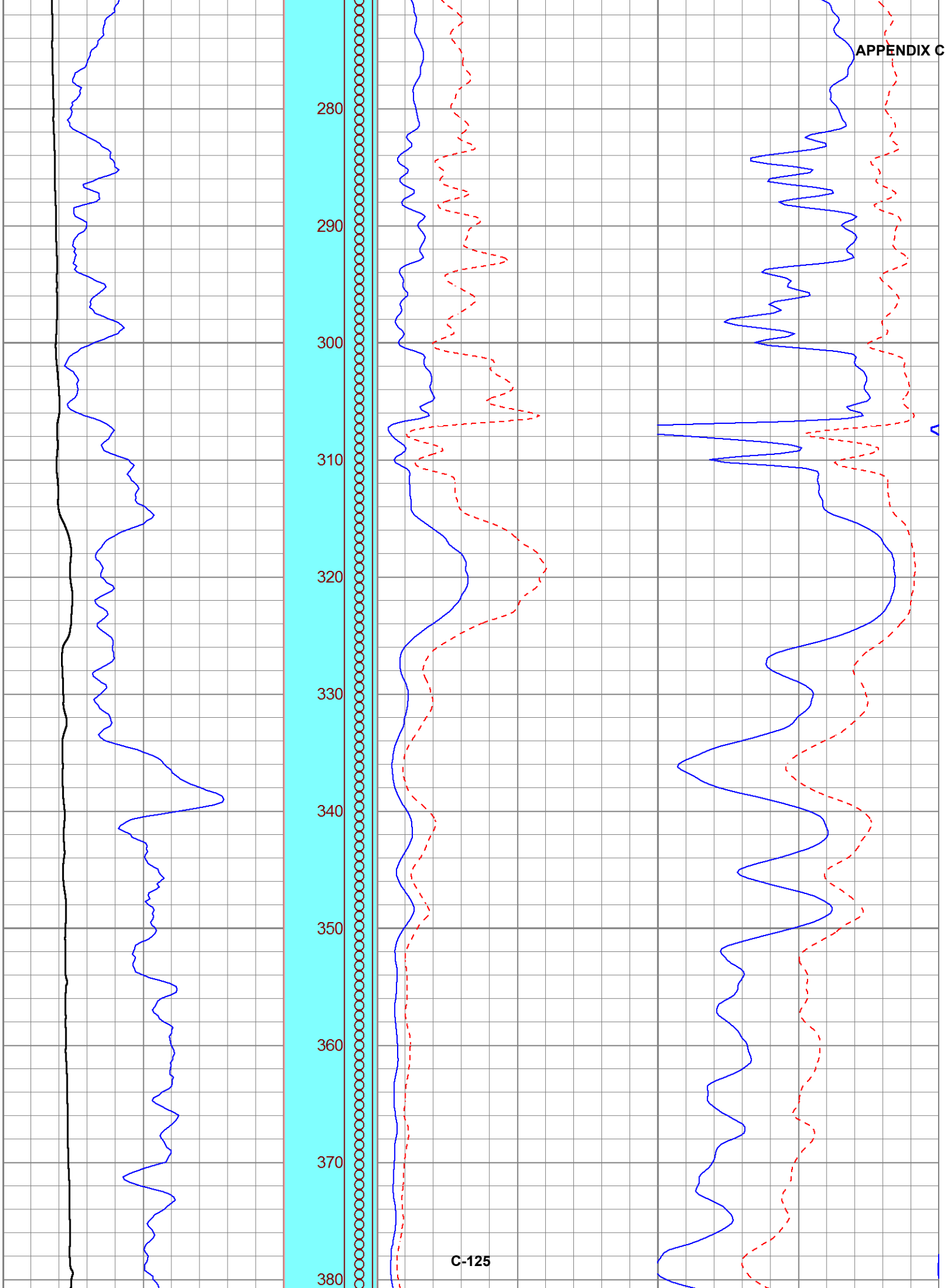
240
250
260
270
SP
4" Screened PVC Casimg
Gamma-Ray
RILD
RILM
CILD
CILM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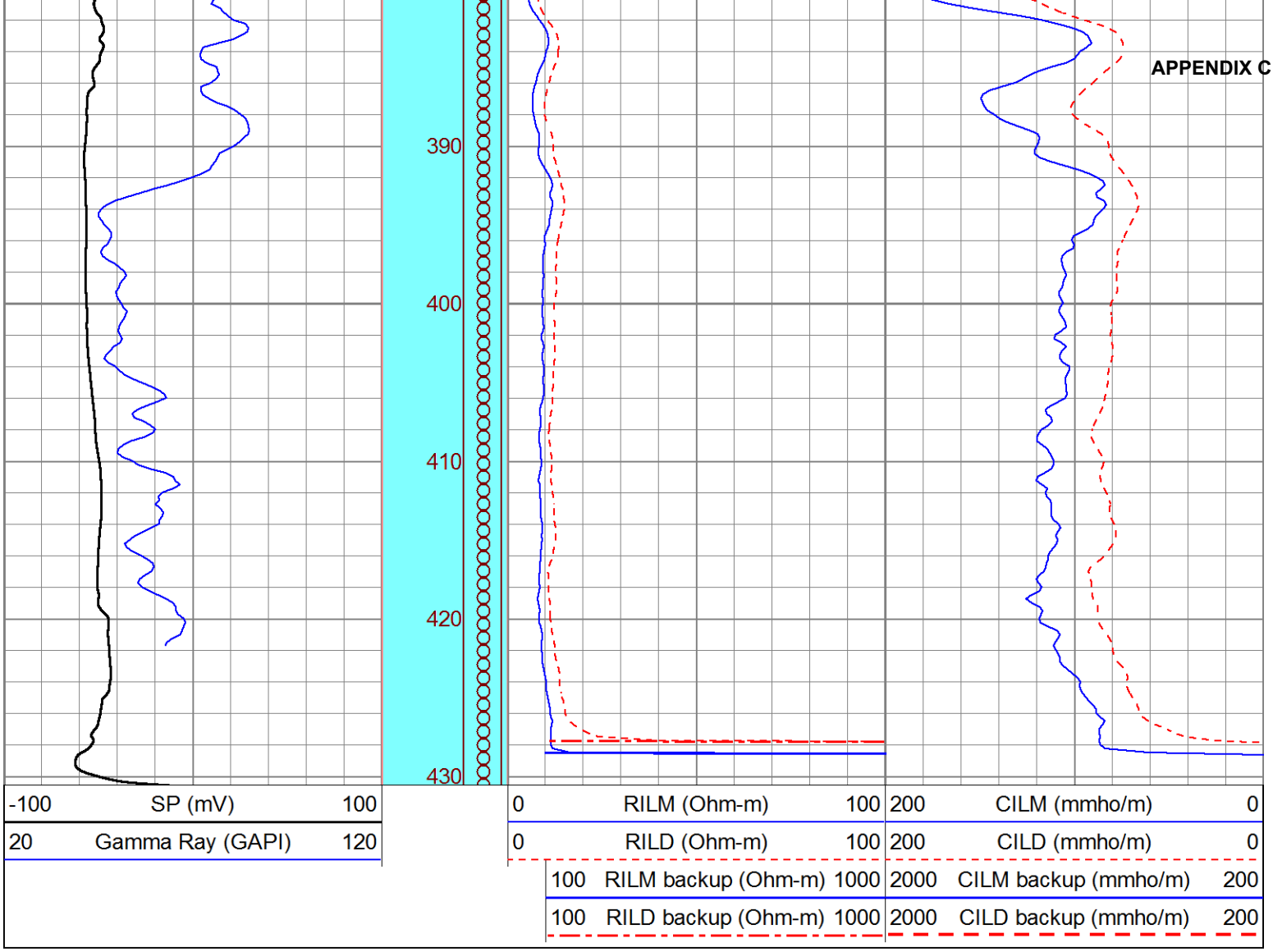
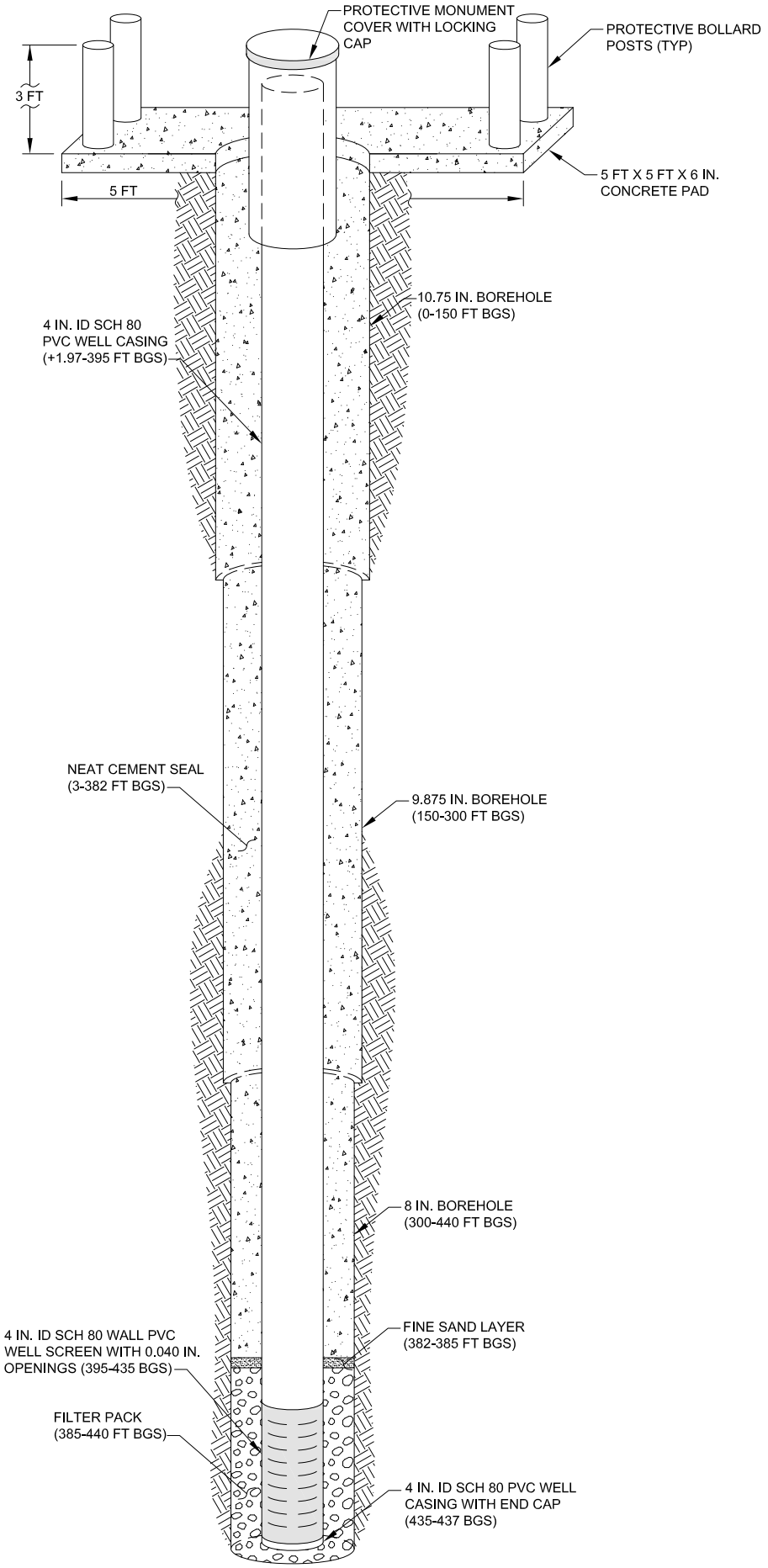
290
300
310
320
330
340
350
360
370
380


390
400
410
420
430
-100 SP (mV) 100
20 Gamma Ray (GAPI) 120
0 RILM (Ohm-m) 100
0 RILD (Ohm-m) 100
100 RILM backup (Ohm-m) 1000
100 RILD backup (Ohm-m) 1000
200 CILM (mmho/m) 0
200 CILD (mmho/m) 0
2000 CILM backup (mmho/m) 200
2000 CILD backup (mmho/m) 200



WELL PROFILE

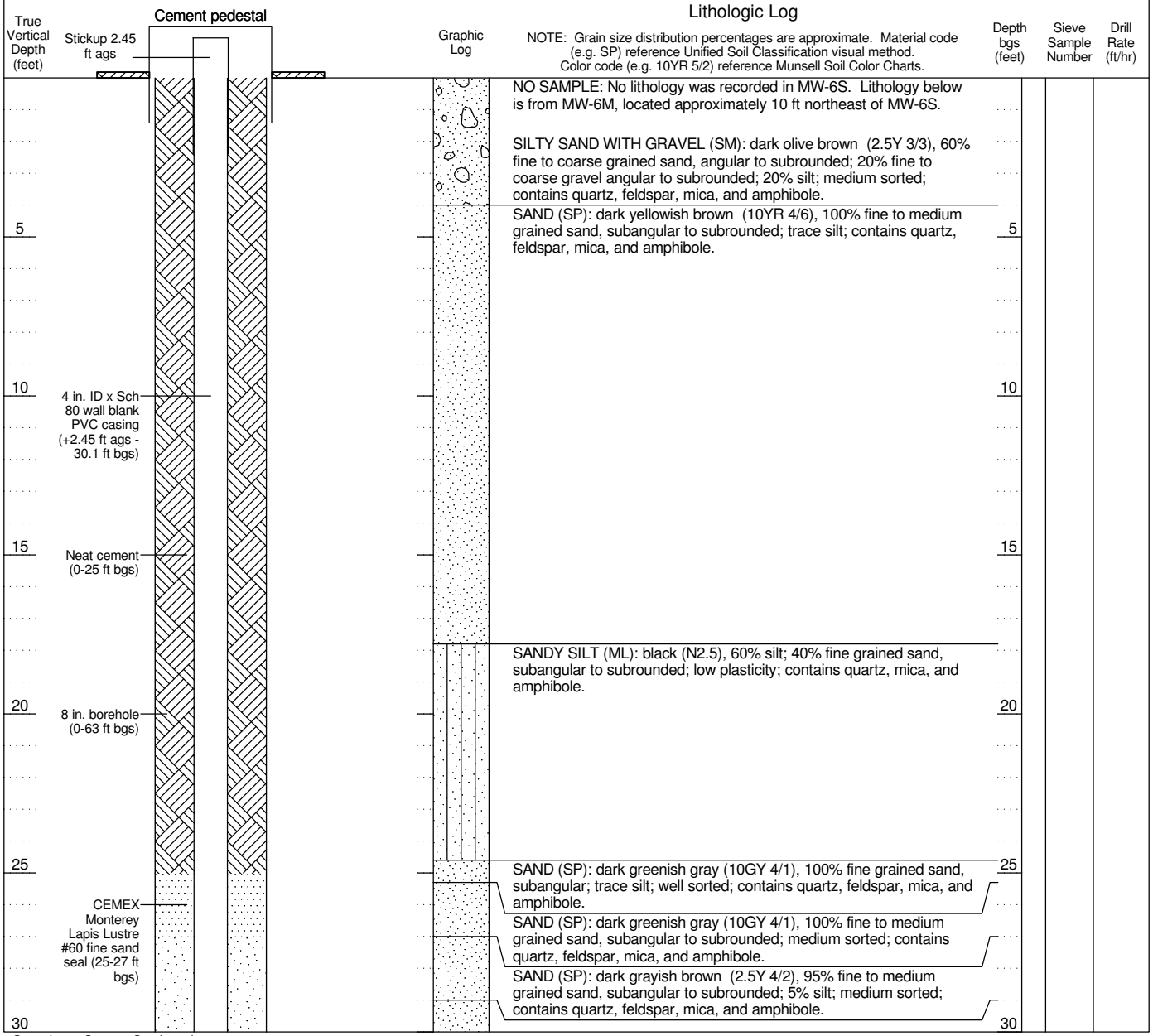
NOT TO SCALE

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

BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-6S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Blanco Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **NOT LOGGED**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.45**	**30.1**	**32.55**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**30.1**	**60.1**	**30**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**60.1**	**62.5**	**2.4**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	33.44 ft NAVD88									
TOC ELEVATION	35.89 ft NAVD88 (RP)									
START DATE	3/20/15									
FINISH DATE	3/21/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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www.gssiwater.com

WELL NUMBER **MPWSP MW-6S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		SAND (SP): grayish brown (2.5Y 5/2), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
35		SAND (SP): dark gray (2.5Y 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.	35		
		CLAYEY SAND (SC): black (N2.5), 50% medium grained sand, subangular to subrounded; 20% silt; 20% clay, low plasticity; 10% fine gravel subangular to subrounded.			
40		SAND (SP): dark greenish gray (10GY 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.	40		
		SAND (SP): very dark greenish gray (10G 3/1), 95% fine to coarse grained sand, angular to subrounded; 5% clay; trace fine gravel angular to subrounded; trace silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
45			45		
50		FAT CLAY WITH SAND (CH): very dark greenish gray (5GY 3/1), 50% clay, medium to high plasticity; 30% silt; 20% fine grained sand, subangular to subrounded.	50		
55			55		
		SAND (SP): greenish black (5G 2.5/1), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
60			60		
		CLAY (CL): very dark greenish gray (5GY 3/1), 80% clay, low plasticity; 20% silt.			
		Bottom of borehole at 63 feet.			

CEMEX Monterey Lapis Lustre #3 filter pack (27-63 ft bgs)

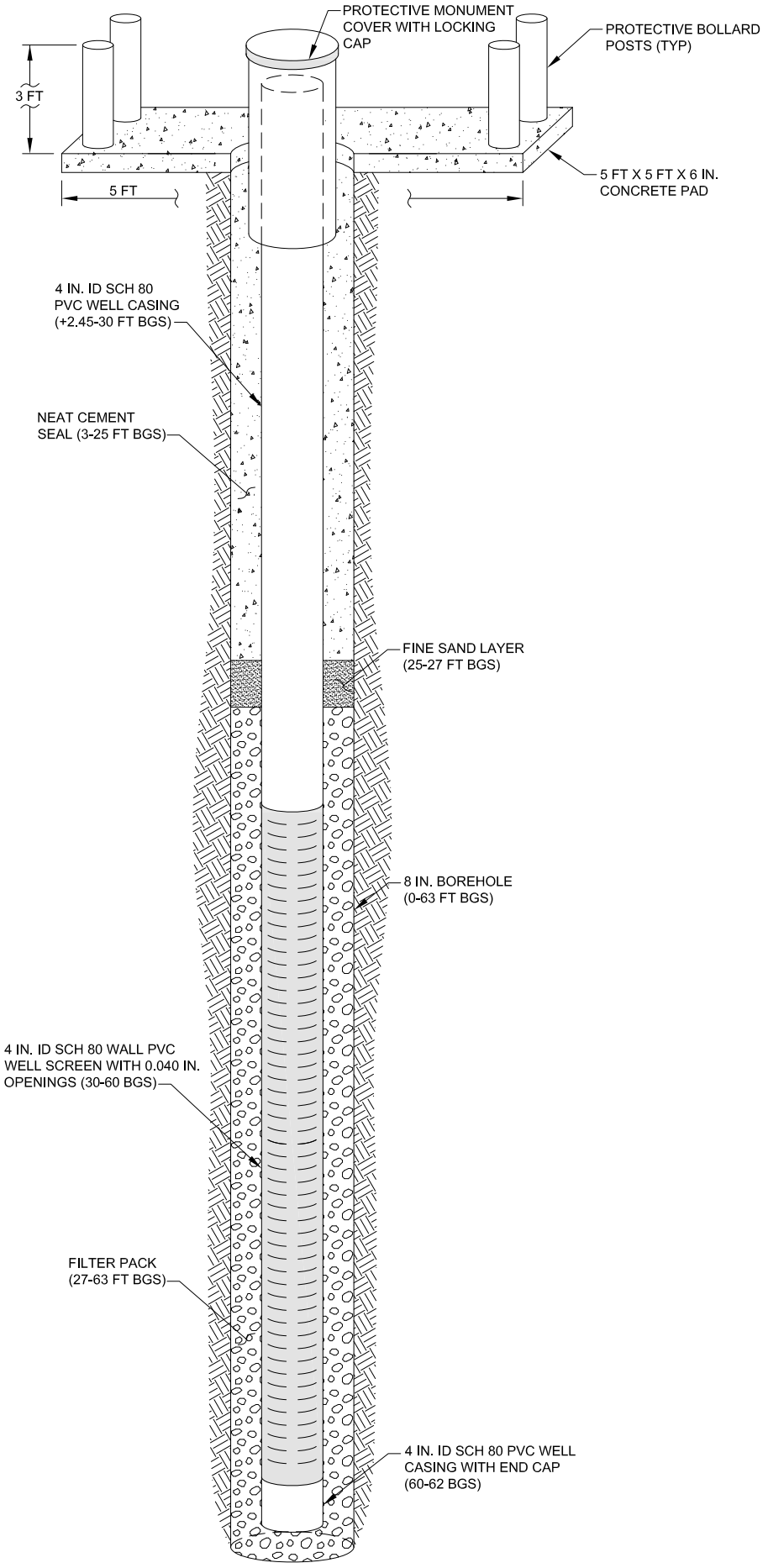
4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (30.1-60.1 ft bgs)

Blank casing with end cap (60.1-62.5 ft bgs)

TD 63 ft bgs

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.



WELL PROFILE

NOT TO SCALE

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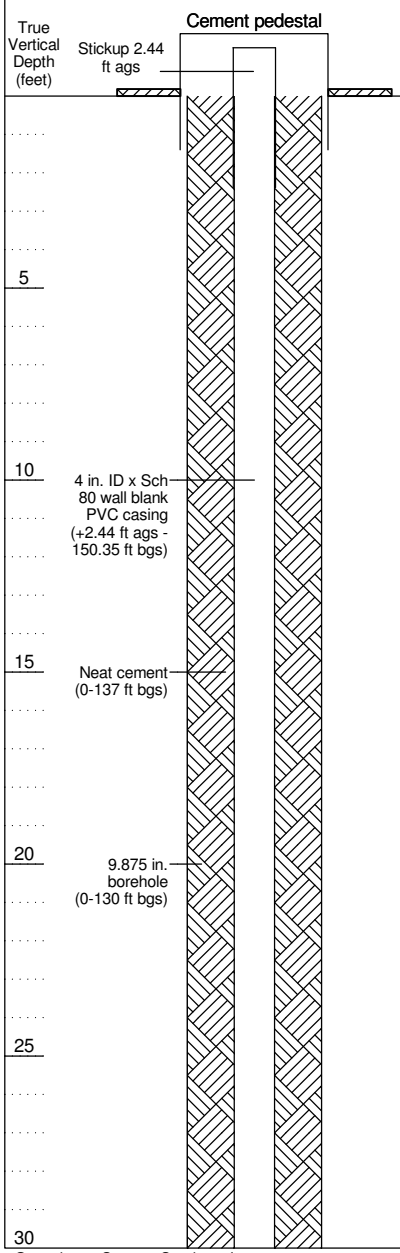
Claremont, CA 91711
Telephone: (909) 451-6650
Fax: (909) 451-6638
www.gssiwater.com

BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-6M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Blanco Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew and A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.44**	**150.35**	**152.79**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**150.35**	**210.35**	**60**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**210.35**	**212.7**	**2.35**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	33.24 ft NAVD88									
TOC ELEVATION	35.68 ft NAVD88 (RP)									
START DATE	3/10/15									
FINISH DATE	3/20/15									



Lithologic Log

Graphic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Depth bgs (feet) | Sieve Sample Number | Drill Rate (ft/hr)

SILTY SAND WITH GRAVEL (SM): dark olive brown (2.5Y 3/3), 60% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel angular to subrounded; 20% silt; medium sorted; contains quartz, feldspar, mica, and amphibole.

SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; trace silt; contains quartz, feldspar, mica, and amphibole.

SANDY SILT (ML): black (N2.5), 60% silt; 40% fine grained sand, subangular to subrounded; low plasticity; contains quartz, mica, and amphibole.

18

SAND (SP): dark greenish gray (10GY 4/1), 100% fine grained sand, subangular; trace silt; well sorted; contains quartz, feldspar, mica, and amphibole.

SAND (SP): dark greenish gray (10GY 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.

SAND (SP): dark grayish brown (2.5Y 4/2), 95% fine to medium grained sand, subangular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, mica, and amphibole.

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WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35			SAND (SP): grayish brown (2.5Y 5/2), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	35		
			SAND (SP): dark gray (2.5Y 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.			
			CLAYEY SAND (SC): black (N2.5), 50% medium grained sand, subangular to subrounded; 20% silt; 20% clay, low plasticity; 10% fine gravel subangular to subrounded.			
40			SAND (SP): dark greenish gray (10GY 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.	40		
			SAND (SP): very dark greenish gray (10G 3/1), 95% fine to coarse grained sand, angular to subrounded; 5% clay; trace fine gravel angular to subrounded; trace silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			18
45				45		
			FAT CLAY WITH SAND (CH): very dark greenish gray (5GY 3/1), 50% clay, medium to high plasticity; 30% silt; 20% fine grained sand, subangular to subrounded.			
50				50		
55				55		
			SAND (SP): greenish black (5G 2.5/1), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
60				60		
			CLAY (CL): very dark greenish gray (5GY 3/1), 80% clay, low plasticity; 20% silt.			
65				65		
70				70		

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WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SILT WITH SAND (MH): black (N2.5), 60% silt; 20% fine grained sand, subangular to subrounded; 15% clay, high plasticity; 5% fine gravel subangular to subrounded. FAT CLAY (CH): greenish black (10GY 2.5/1), 80% clay, high plasticity; 20% silt.	75		
80				80		
85				85		
90			FAT CLAY (CH): greenish black (10GY 2.5/1), 100% clay, high plasticity.	90		21
95				95		
100				100		
105				105		
110				110		

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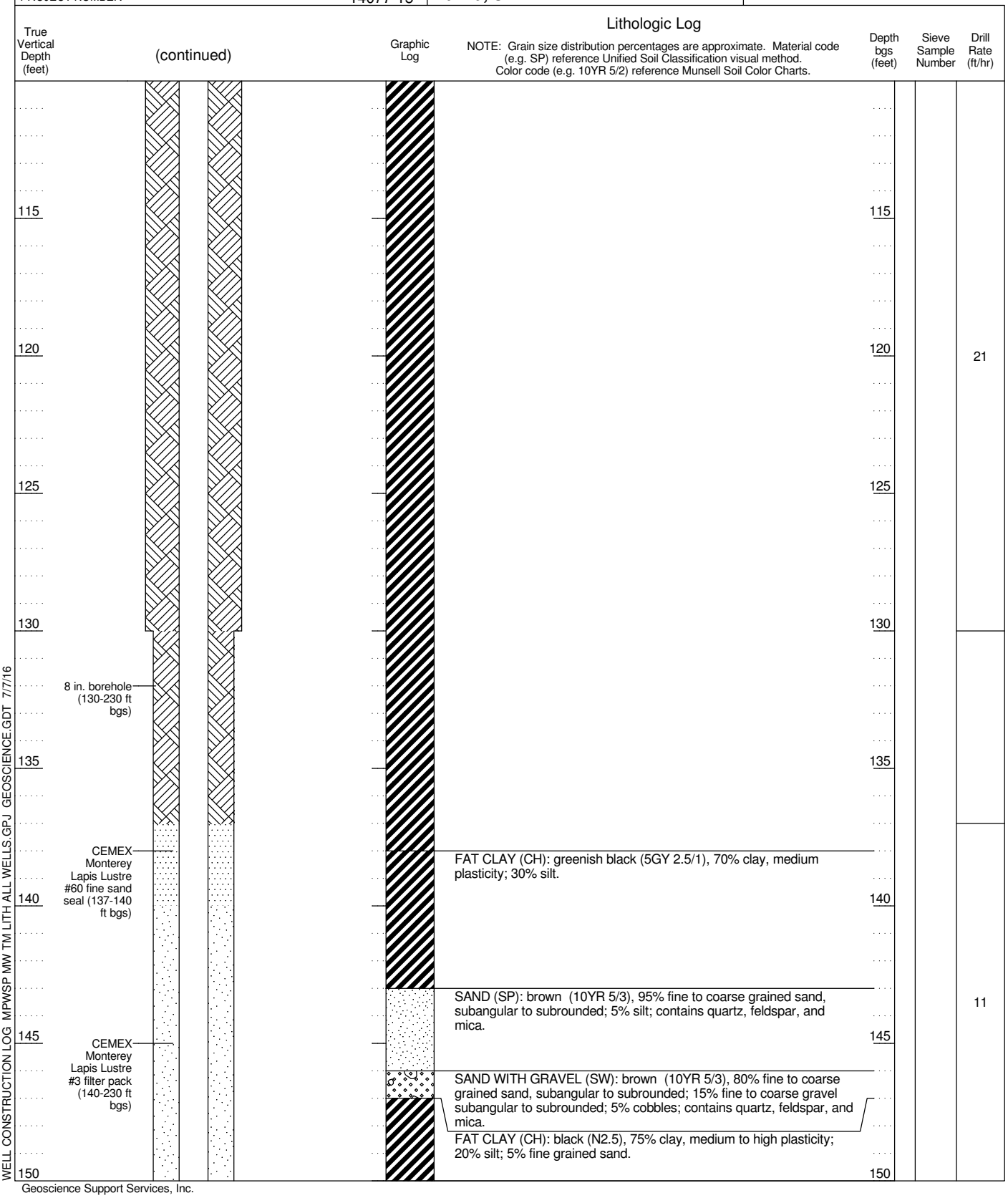
WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
155		4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (150.35-210.35 ft bgs) SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 70% medium to coarse grained sand, subangular to subrounded; 30% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole.	155		
		SAND (SP): olive brown (2.5Y 4/3), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
		FAT CLAY (CH): black (N2.5), 80% clay; 10% silt; 5% fine to coarse gravel; 5% fine to coarse grained sand; contains quartz, feldspar, mica, and amphibole.			
160		SAND WITH GRAVEL (SP): olive gray (5Y 4/2), 60% fine to coarse grained sand, subangular to subrounded; 30% fine gravel subangular to subrounded; 10% cobbles; contains quartz, feldspar, and amphibole.	160		
165			165		
170			170		11
		SAND (SP): gray (2.5Y 5/1), 95% fine to coarse grained sand, angular to subrounded; 5% fine gravel angular to subrounded; contains quartz, feldspar, and amphibole.			
175			175		
180		SAND (SP): gray (2.5Y 5/1), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	180		
		GRAVEL (GP): dark grayish brown (2.5Y 4/2), 80% fine gravel subangular to subrounded; 10% fine to coarse grained sand, subangular to subrounded; 5% silt; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			
185			185		
		CLAY (CL): light olive brown (2.5Y 5/4), 85% clay, medium to high plasticity; 10% silt; 5% fine grained sand.			
190		SILTY SAND (SM): light olive brown (2.5Y 5/4), 60% fine grained sand; 25% silt; 15% clay, low plasticity; contains quartz, feldspar, and mica.	190		

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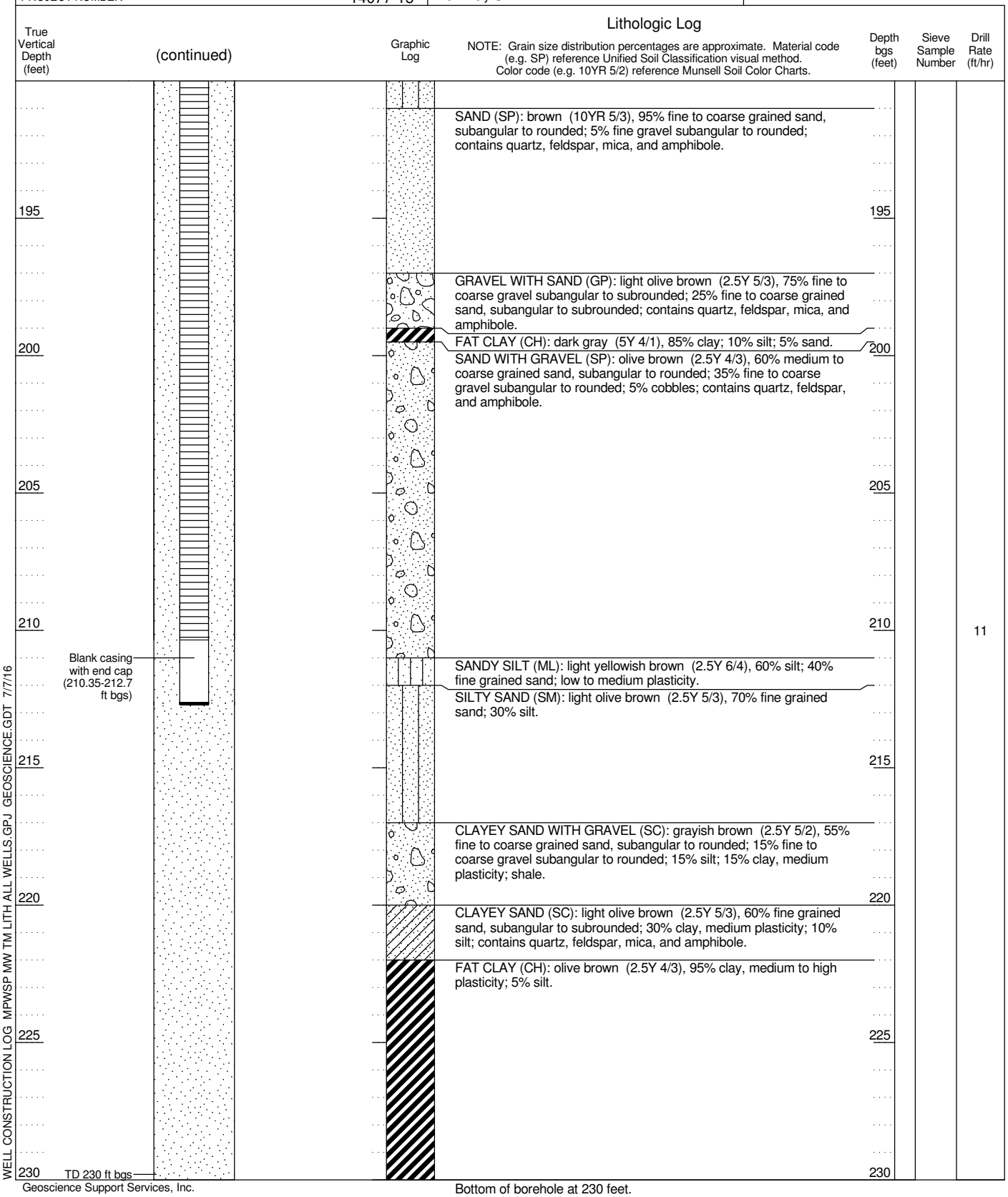
WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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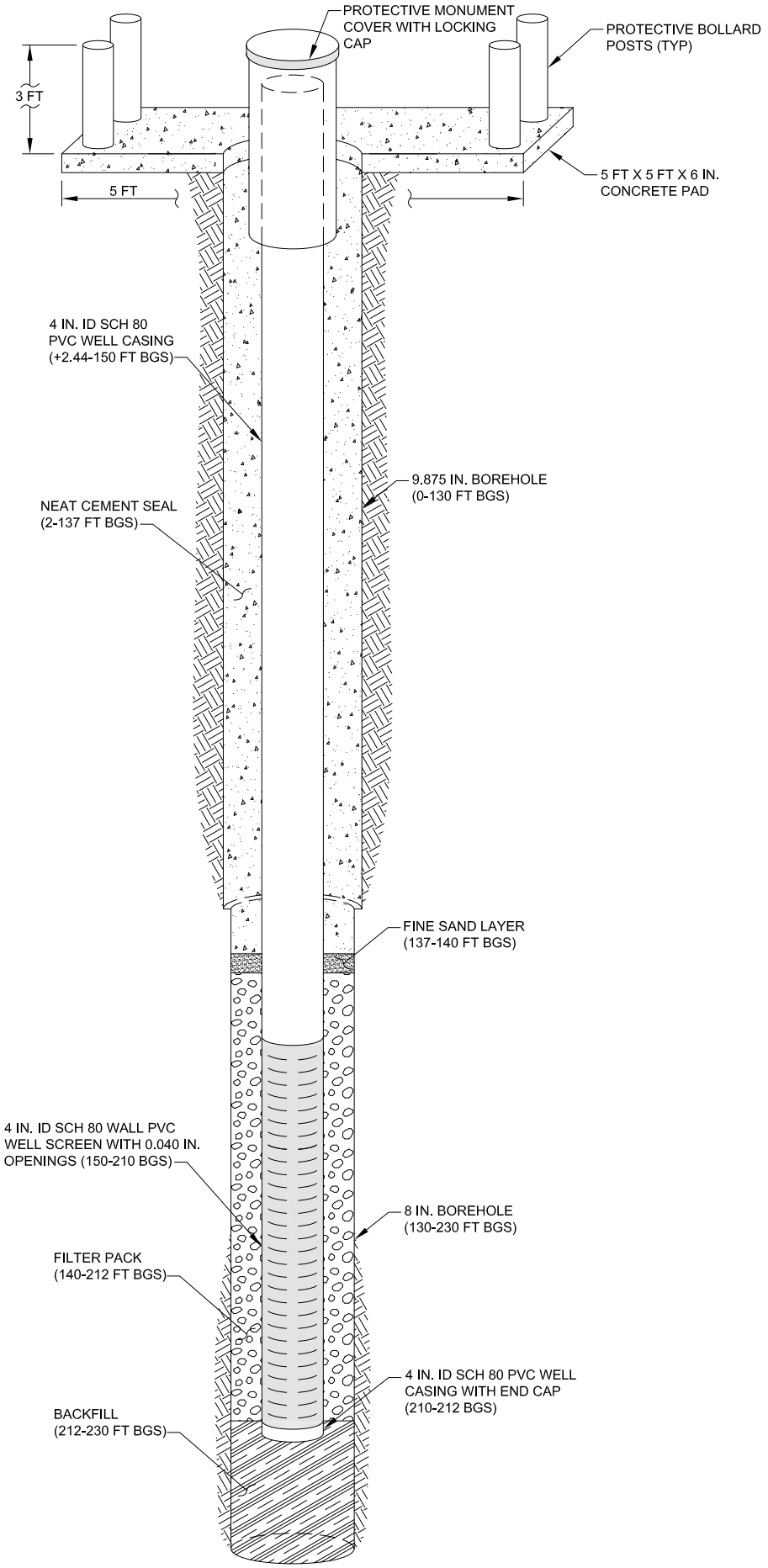
Bottom of borehole at 230 feet.



WELL PROFILE

NOT TO SCALE

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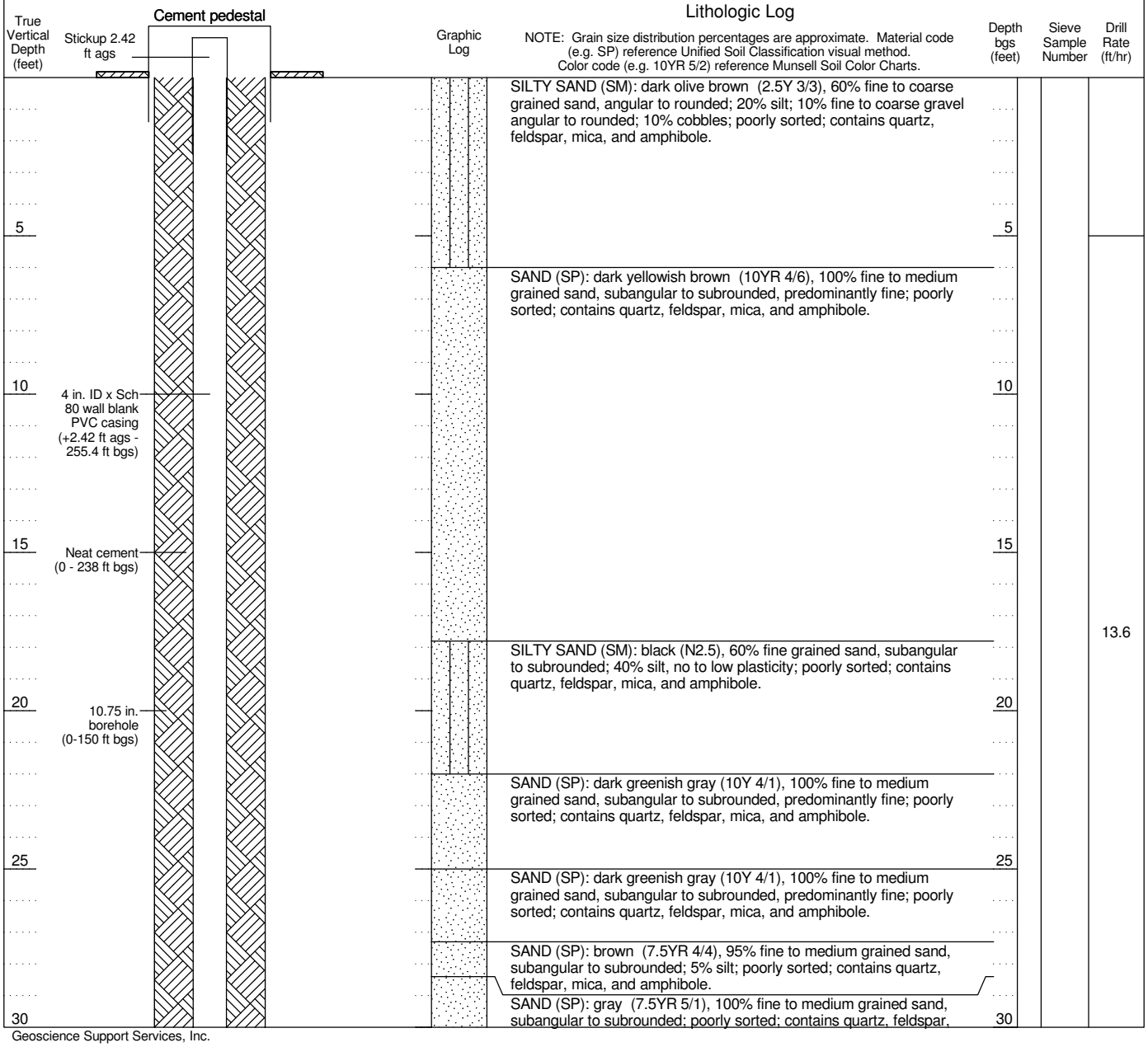
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-6D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Blanco Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.42**	**255.4**	**257.82**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**255.4**	**325.4**	**70**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**325.4**	**327.75**	**2.35**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	33.40 ft NAVD88									
TOC ELEVATION	35.82 ft NAVD88 (RP)									
START DATE	2/19/15									
FINISH DATE	3/10/15									



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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			mica, and amphibole.			
35				35		
40			CLAYEY SAND (SC): black (N2.5), 50% medium grained sand, subangular to subrounded; 20% silt; 20% clay, medium to high plasticity; 10% fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	40		
			SAND (SP): very dark greenish gray (5GY 3/1), 100% fine to medium grained sand, subangular to subrounded; trace fine gravel subangular to subrounded; trace silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
45				45		
50				50		13.6
			FAT CLAY WITH SAND (CH): very dark greenish gray (5GY 3/1), 50% clay, high plasticity; 30% silt; 20% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
55				55		
			SAND (SP): greenish black (5GY 2.5/1), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
60				60		
			FAT CLAY (CH): very dark greenish gray (5GY 3/1), 80% clay, high plasticity; 20% silt.			
65				65		
70				70		

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75		SILT WITH SAND (MH): black (N2.5), 60% silt, high plasticity; 20% fine grained sand, subangular to subrounded; 15% clay; 5% fine gravel subangular to subrounded.	75		
		FAT CLAY (CH): greenish black (10GY 2.5/1), 80% clay, high plasticity; 20% silt.			
80			80		
85			85		13.6
		FAT CLAY (CH): greenish black (10GY 2.5/1), 100% clay, high plasticity.			
90			90		
95			95		
100			100		
105			105		9
110			110		

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115				115		
120				120		
125				125		
130				130		9
135				135		
140			FAT CLAY (CH): greenish black (5GY 2.5/1), 70% clay, medium plasticity; 30% silt.	140		
145			SAND (SP): brown (10YR 5/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; poorly sorted; contains quartz, feldspar, and mica.	145		
150			SAND WITH GRAVEL (SW): brown (10YR 5/3), 70% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole. FAT CLAY (CH): black (N2.5), 75% clay, medium to high plasticity; 20% silt; 5% fine grained sand.	150		

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
155	SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 70% medium to coarse grained sand, subangular to rounded; 30% fine gravel subangular to rounded; poorly sorted; contains quartz, feldspar, amphibole, and other.	155		
	SAND (SP): olive brown (2.5Y 4/3), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
	FAT CLAY (CH): black (N2.5), 80% clay, high plasticity; 10% silt; 5% fine gravel subangular to subrounded; 5% fine to medium grained sand, subangular to subrounded.			
160	GRAVEL WITH SAND (GP): olive gray (5Y 4/2), 50% fine to coarse gravel subangular to rounded, predominantly coarse; 40% fine to coarse grained sand, subangular to rounded; 10% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.	160		
	SAND (SP): olive gray (5Y 4/2), 95% fine to coarse grained sand, subangular to subrounded; 5% fine to coarse gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
165	SAND WITH GRAVEL (SP): olive gray (5Y 4/2), 60% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel subangular to subrounded; 10% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and evaporites; shale.	165		
170	GRAVEL WITH SAND (GP): dark yellowish brown (10YR 4/4), 50% fine to coarse gravel subangular to rounded; 35% fine to coarse grained sand, subangular to rounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, and amphibole.	170		9
175	SAND (SP): gray (2.5Y 5/1), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	175		
180	GRAVEL WITH SAND (GP): dark grayish brown (2.5Y 4/2), 80% fine gravel subangular to subrounded; 15% fine to coarse grained sand, subangular to subrounded; 5% silt; poorly sorted; contains quartz, feldspar, amphibole, and other.	180		
185	GRAVEL (GP): dark gray (2.5Y 4/1), 85% fine to coarse gravel subangular to rounded; 5% fine to coarse grained sand, subangular to rounded; 5% silt; 5% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.	185		
	GRAVEL WITH SAND (GP): brown (10YR 5/3), 65% fine to coarse gravel subangular to rounded; 30% fine to coarse grained sand, subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.			7
190	CLAY (CL): light olive brown (2.5Y 5/4), 85% clay, low to medium plasticity; 10% silt; 5% fine grained sand; red iron-oxide staining at	190		

9.88 in. borehole (150-300 ft bgs)

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			188.7 ft contact.			
			SILTY SAND (SM): light olive brown (2.5Y 5/4), 60% fine grained sand, subangular to subrounded; 25% silt; 15% clay, low plasticity; poorly sorted; contains quartz, feldspar, and mica.			
			SAND (SP): olive brown (2.5Y 4/4), 95% fine to medium grained sand, subangular to subrounded; 5% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
195			SAND (SP): brown (10YR 5/3), 95% fine to coarse grained sand, subangular to rounded; 5% fine gravel subangular to rounded; poorly sorted; contains quartz, feldspar, mica, and amphibole; shale.	195		
			SILTY SAND WITH GRAVEL (SM): light olive brown (2.5Y 5/3), 40% fine to coarse gravel subangular to rounded; 40% fine to coarse grained sand, subangular to rounded; 15% silt; 5% clay, low plasticity; poorly sorted; contains quartz, feldspar, and amphibole.			
200			FAT CLAY (CH): dark gray (5Y 4/1), 85% clay, high plasticity; 10% silt; 5% medium grained sand, subangular to subrounded.	200		
			SAND (SW): dark grayish brown (2.5Y 4/2), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; well sorted; contains quartz, feldspar, amphibole, and other; trace shale.			
205			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 60% medium to coarse grained sand, subangular to rounded; 35% fine to coarse gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, and amphibole; trace shale.	205		
210				210		7
			SANDY SILT (ML): light yellowish brown (2.5Y 6/4), 60% silt, low to medium plasticity; 40% fine grained sand.			
			SILTY SAND (SM): light olive brown (2.5Y 5/3), 70% fine grained sand; 30% silt; poorly sorted.			
215				215		
			CLAYEY SAND WITH GRAVEL (SC): grayish brown (2.5Y 5/2), 55% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; 15% silt; 15% clay, medium plasticity; poorly sorted; trace shale.			
220				220		
			CLAYEY SAND (SC): grayish brown (2.5Y 5/2), 60% fine grained sand, subangular to subrounded; 30% clay, medium plasticity; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			FAT CLAY (CH): light olive brown (2.5Y 5/3), 70% clay, medium plasticity; 20% silt; 10% fine grained sand.			
			FAT CLAY (CH): olive brown (2.5Y 4/3), 95% clay, medium to high plasticity; 5% silt.			
225				225		
230				230		

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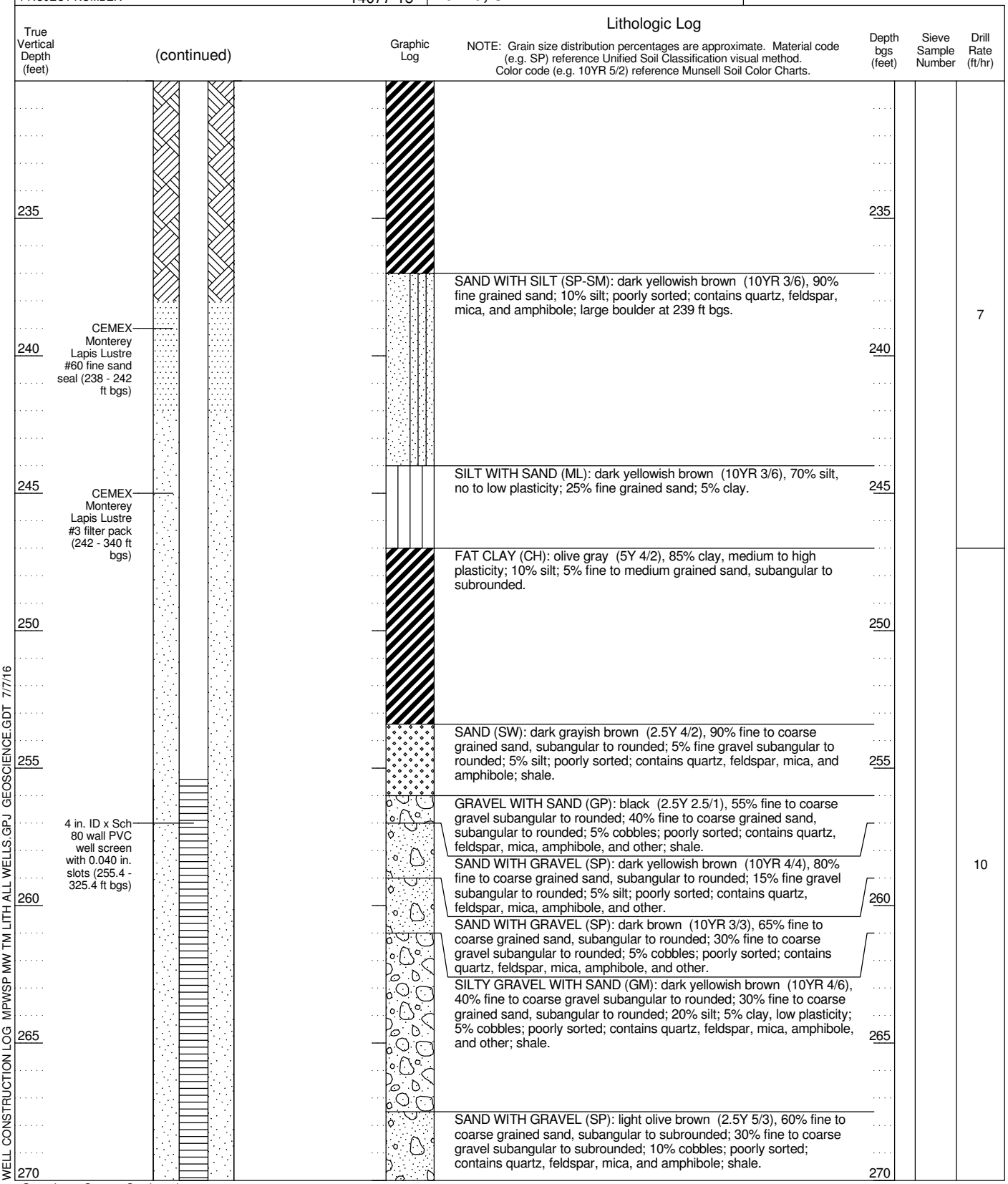
WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
275			CLAY WITH GRAVEL (CL): light olive brown (2.5Y 5/3), 65% clay, medium to high plasticity; 20% fine to coarse gravel rounded; 5% medium grained sand, rounded; 5% silt; 5% cobbles; contains quartz, feldspar, mica, amphibole, evaporites, and other; shale.	275		
			SAND WITH GRAVEL (SW): dark yellowish brown (10YR 3/4), 80% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.			
280				280		
			GRAVELLY FAT CLAY (CH): olive (5Y 4/4), 45% clay; 35% fine to coarse gravel subangular to rounded; 10% coarse grained sand, subangular to rounded; 5% silt; 5% cobbles; contains quartz, feldspar, amphibole, and other; trace shale.			
285			SAND WITH SILT AND GRAVEL (SP-SM): dark olive gray (5Y 3/2), 65% fine to coarse grained sand, subangular to rounded; 20% fine to coarse gravel subangular to rounded; 10% silt; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and other; shale.	285		
			SAND WITH SILT AND GRAVEL (SP-SM): olive gray (5Y 4/2), 60% fine to coarse grained sand, subangular to rounded, predominantly coarse; 20% fine to coarse gravel subangular to rounded, predominantly fine; 10% silt; 10% cobbles; poorly sorted; shale.			
290				290		10
295				295		
			SILTY SAND (SM): light olive brown (2.5Y 5/4), 60% fine grained sand; 40% silt; poorly sorted.			
300			SILT WITH SAND (ML): light olive brown (2.5Y 5/6), 75% silt, low plasticity; 15% fine grained sand; 10% clay.	300		
	8 in. borehole (300-340 ft bgs)		FAT CLAY (CH): olive (5Y 5/3), 90% clay, medium to high; 10% silt.			
305				305		
			SAND (SP): olive brown (2.5Y 4/3), 90% fine to medium grained sand, subangular to rounded; 5% fine gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.			
			SAND WITH GRAVEL (SP): pale brown (10YR 6/3), 75% fine to coarse grained sand, subangular to rounded, grades coarser towards 312 ft bgs; 20% fine to coarse gravel subangular to rounded; 5%			
310				310		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER
MPWSP MW-6D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other; shale.			
315				315		
320				320		
			SAND (SW): dark yellowish brown (10YR 4/6), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, and amphibole.			
325	Blank casing with end cap (325.4-327.75 ft bgs)			325		10
			SAND WITH SILT AND GRAVEL (SP-SM): dark grayish brown (2.5Y 4/2), 45% fine to coarse grained sand, subangular to rounded; 35% fine to coarse gravel subangular to rounded; 10% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.			
330				330		
335				335		
			GRAVELLY FAT CLAY (CH): olive gray (5Y 4/2), 45% clay, medium to high plasticity; 35% fine to coarse gravel subangular to rounded; 10% fine to coarse grained sand, subangular to rounded; 5% silt; 5% cobbles; contains quartz, feldspar, amphibole, and other; shale.			
340	TD 340 ft bgs		Bottom of borehole at 340 feet.	340		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19184

Company CASCADE DRILLING

Well MW-6D

Field SALINAS

County MONTEREY State CA

File No.

Location

799 W. BLANCO RD.
GPS: N 36o 40' 37" W 121o 44' 49"

Other Services:

DUAL INDUCTION
GAMMA-RAY

		Elevation		Elevation
Permanent Datum	G.L.			
Log Measured From	G.L.	0' above perm. datum	K.B.	
Drilling Measured From	G.L.		D.F.	
			G.L.	

Date	02-24-2015										
Run Number	ONE										
Depth Driller	340'										
Depth Logger	335'										
Bottom Logged Interval	324'										
Top Log Interval	0'										
Open Hole Size	10.75" (0'-100')						9.875" (100'-250')			8" (250'-340')	
Type Fluid	WATER										
Density / Viscosity	N/A										
Fluid Level	38'										
Bentonite Seal	N/A										
Time Well Ready	1000										
Time Logger on Bottom	1100										
Equipment Number	PS-8										
Location	LA										
Recorded By	SCHUMACHER										
Witnessed By	A. KHALIGHI										

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	100'				
TWO	9.875"	100'	250'				
THREE	8"	250'	340'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	340'
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19184.db
Dataset Pathname	tmp3
Dataset Creation	Tue Feb 24 12:10:17 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Mon Feb 23 16:47:18 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

FRT Calibration Report

Serial Number:	3553
Tool Model:	MLS
Performed:	Mon Feb 23 16:47:15 2015

Resistivity Calibration:

System Reading	Calibration Reference
32145.000 cps	1.800 Ohm-m
11466.000 cps	86.960 Ohm-m

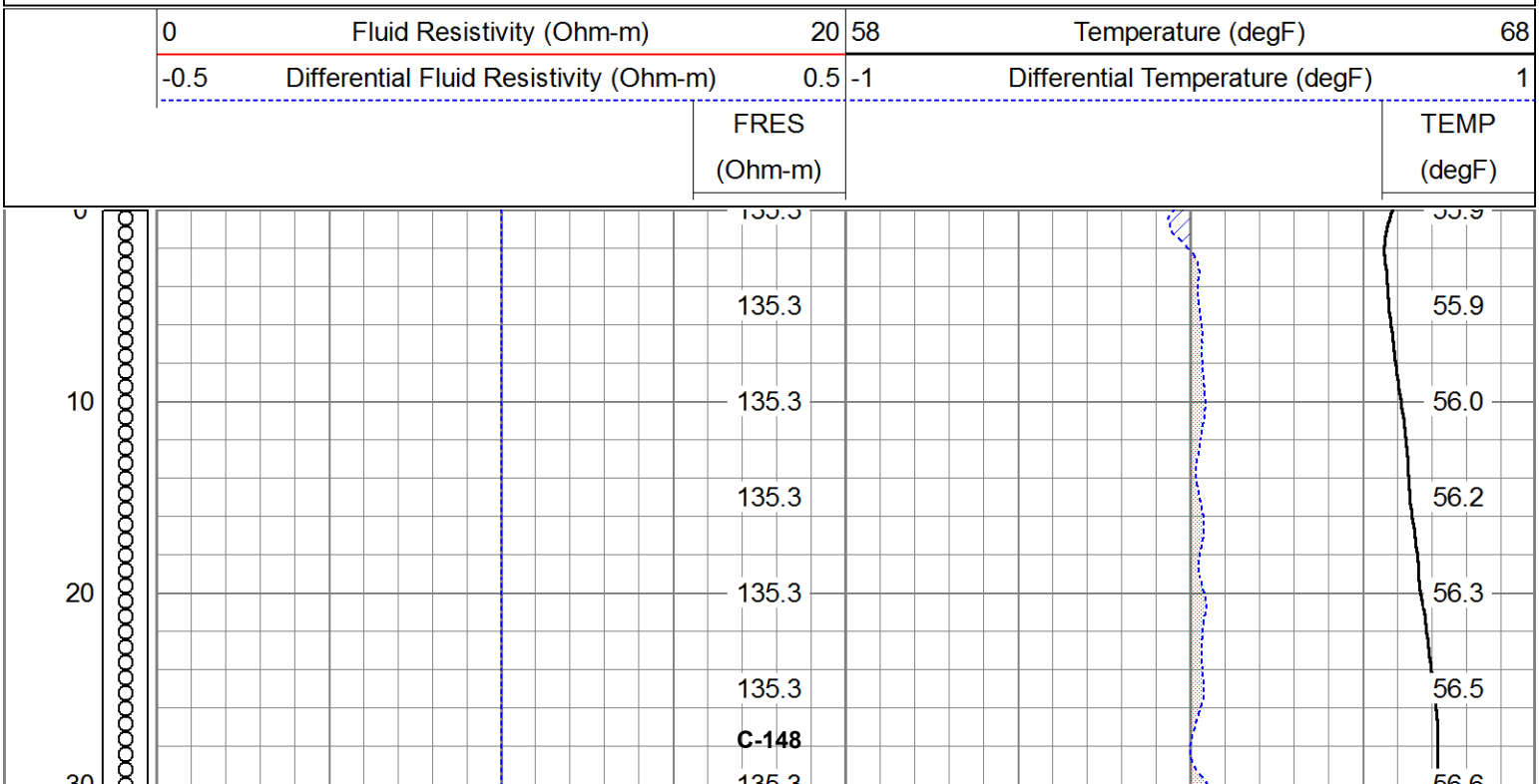
Gain: -0.004
Offset: 135.338

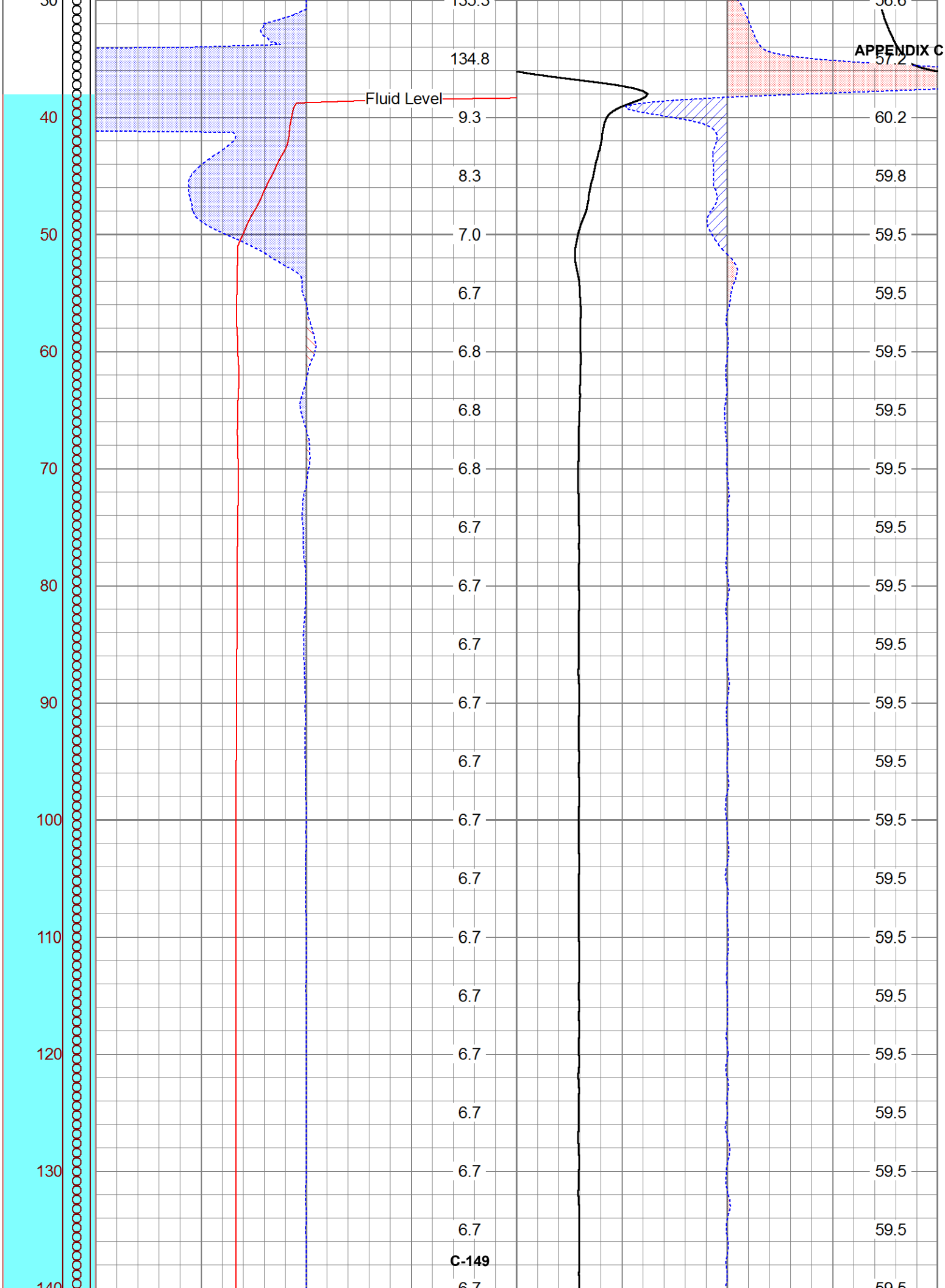
Conductivity Calibration:

System Reading	Calibration Reference
0.000 cps	0.000
1.000 cps	1.000

Gain: 1.000
Offset: 0.000

Database File	19184.db
Dataset Pathname	tmp3
Presentation Format	frttemp2
Dataset Creation	Tue Feb 24 12:10:17 2015
Charted by	Depth in Feet scaled 1:120




APPENDIX C
Fluid Level
134.8
9.3
8.3
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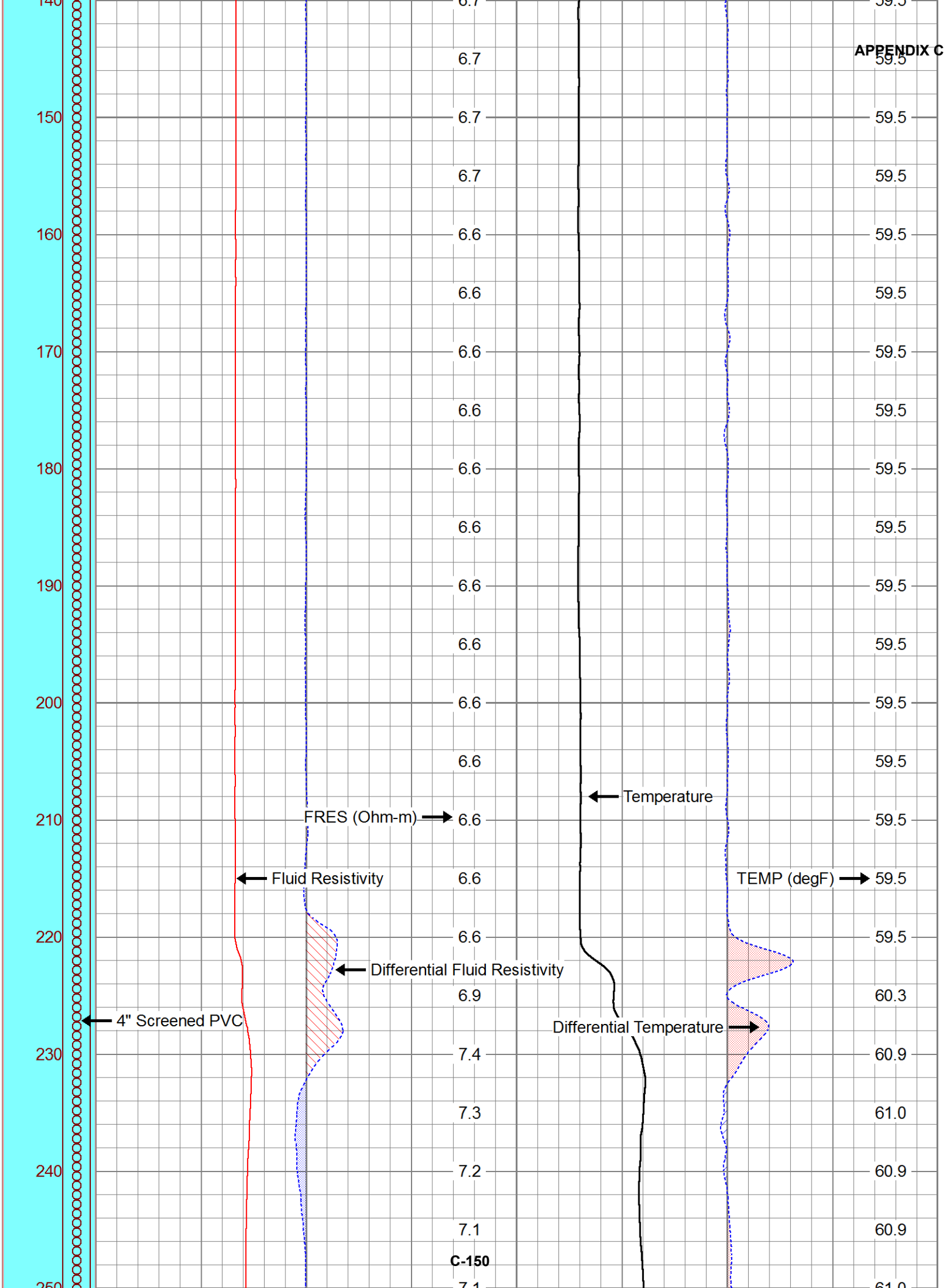
6.7
6.7
6.7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6.6
6.9
7.4
7.3
7.2
7.1
59.5
59.5
59.5
59.5
59.5
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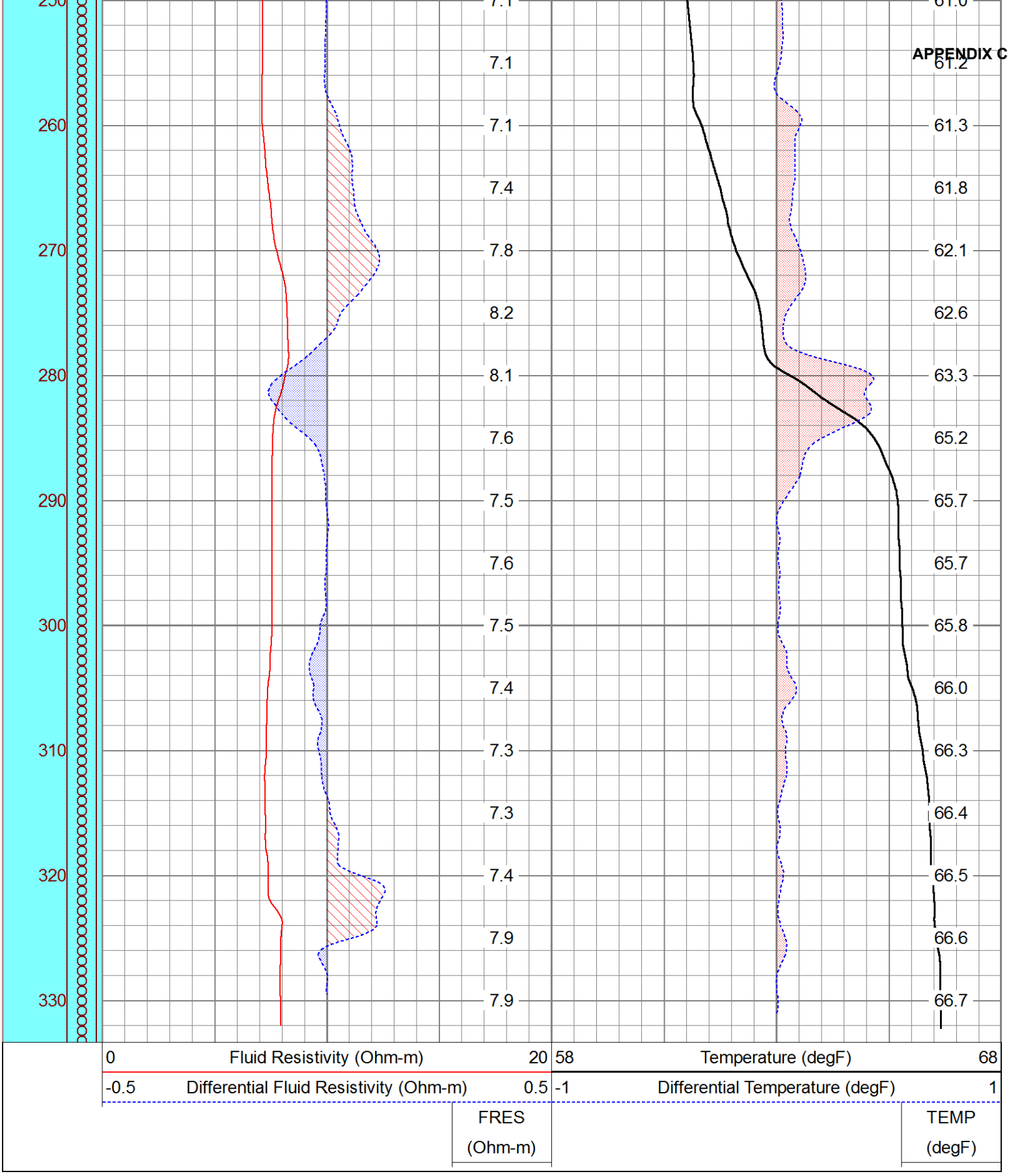
59.5
59.5
59.5
59.5
60.3
60.9
61.0
60.9
60.9
61.0
Temperature
FRES (Ohm-m)
Fluid Resistivity
TEMP (degF)
Differential Fluid Resistivity
4" Screened PVC
Differential Temperature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7.4
7.3
7.3
7.4
7.9
7.9
61.2
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61.8
62.1
62.6
63.3
65.2
65.7
65.7
65.8
66.0
66.3
66.4
66.5
66.6
66.7
0
Fluid Resistivity (Ohm-m)
20
-0.5
Differential Fluid Resistivity (Ohm-m)
0.5
FRES
(Ohm-m)
58
Temperature (degF)
68
-1
Differential Temperature (degF)
1
TEMP
(degF)

APPENDIX C

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19184

File No.

Company CASCADE DRILLING

Well MW-6D

Field SALINAS

County MONTEREY State CA

Location

799 W. BLANCO RD.
GPS: N 36o 40' 37" W 121o 44' 49"

Other Services:

TEMPERATURE
FLUID RESISTIVITY

Permanent Datum	G.L.	Elevation above perm. datum	Elevation K.B. / D.F. / G.L.
Log Measured From	G.L.	0'	
Drilling Measured From	G.L.		

Date	02-24-2015		
Run Number	ONE		
Depth Driller	340'		
Depth Logger	335'		
Bottom Logged Interval	335'		
Top Log Interval	0'		
Open Hole Size	10.75" (0'-100')	9.875" (100'-250')	8" (250'-340')
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	38'		
Bentonite Seal	N/A		
Time Well Ready	1000		
Time Logger on Bottom	1100		
Equipment Number	PS-8		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	A. KHALIGHI		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	100'				
TWO	9.875"	100'	250'				
THREE	8"	250'	340'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	340'
Liner				

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Comments

Calibration Report

Database File 19184.db
Dataset Pathname DIL2
Dataset Creation Tue Feb 24 14:05:16 2015

C-152

Dual Induction Calibration Report

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

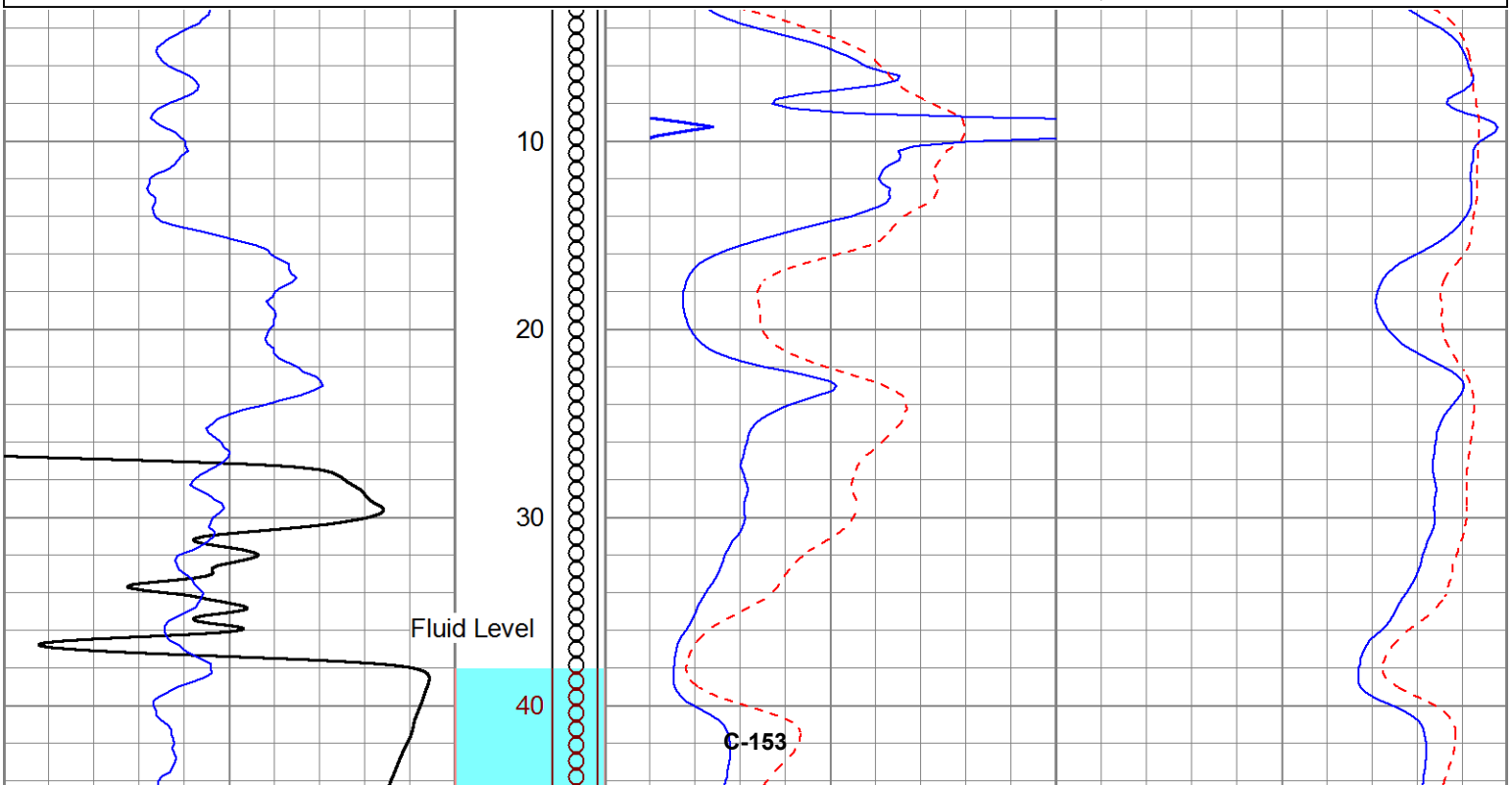
Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1418.047	3489.658	cps	0.000	612.000	mmho/m	0.295	-418.923
Medium	2156.841	14524.973	cps	0.000	1960.000	mmho/m	0.158	-341.798

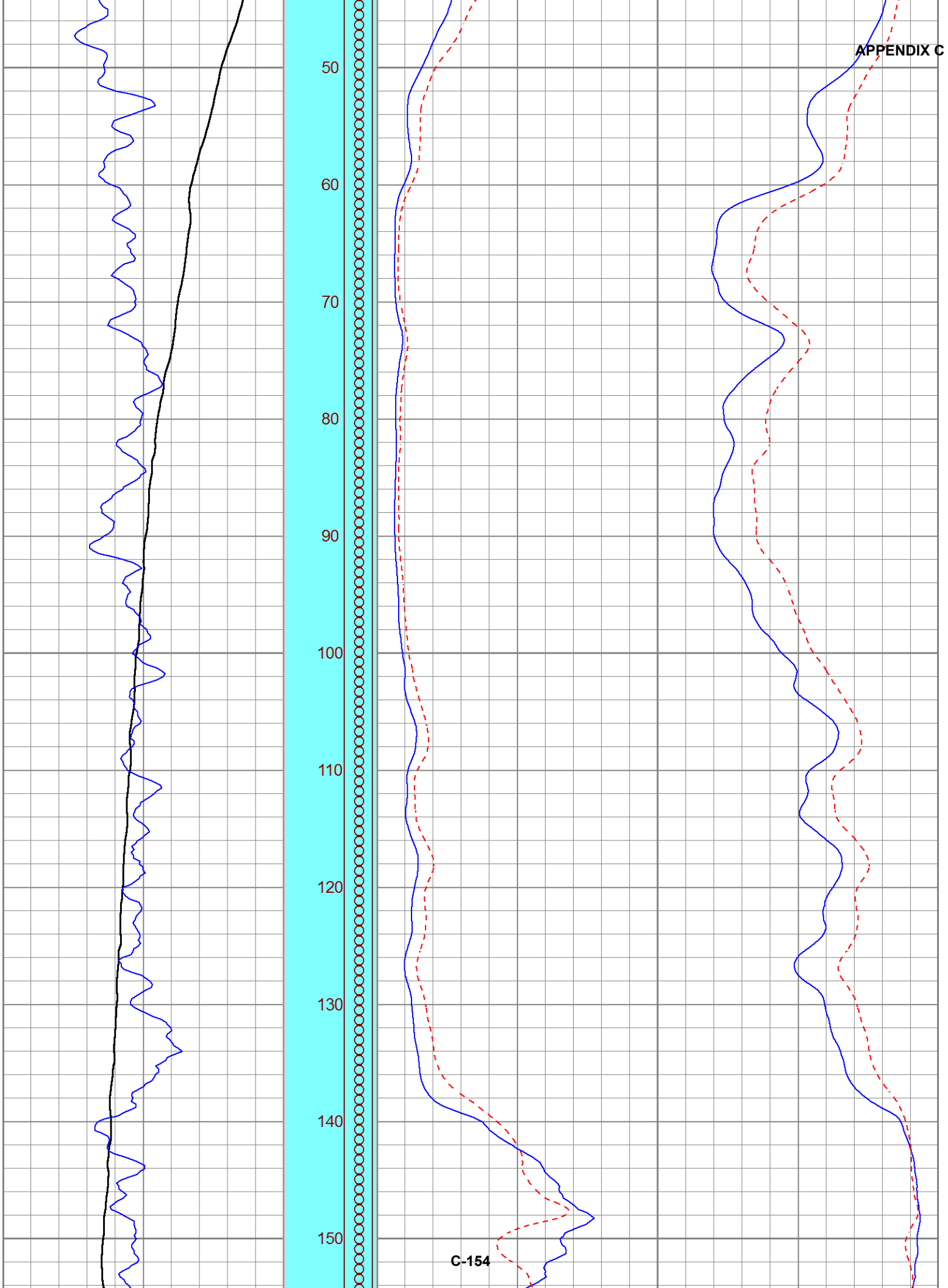
Gamma Ray Calibration Report

Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

Database File	19184.db
Dataset Pathname	DIL2
Presentation Format	dil
Dataset Creation	Tue Feb 24 14:05:16 2015
Charted by	Depth in Feet scaled 1:120

-30 SP (mV) 120	0 RILM (Ohm-m) 100	200 CILM (mmho/m) 0
20 Gamma-Ray (GAPI) 120	0 RILD (Ohm-m) 100	200 CILD (mmho/m) 0
	100 RILM backup (Ohm-m) 1000	2000 CILD backup (mmho/m) 200
	100 RILD backup (Ohm-m) 1000	2000 CILM backup (mmho/m) 200

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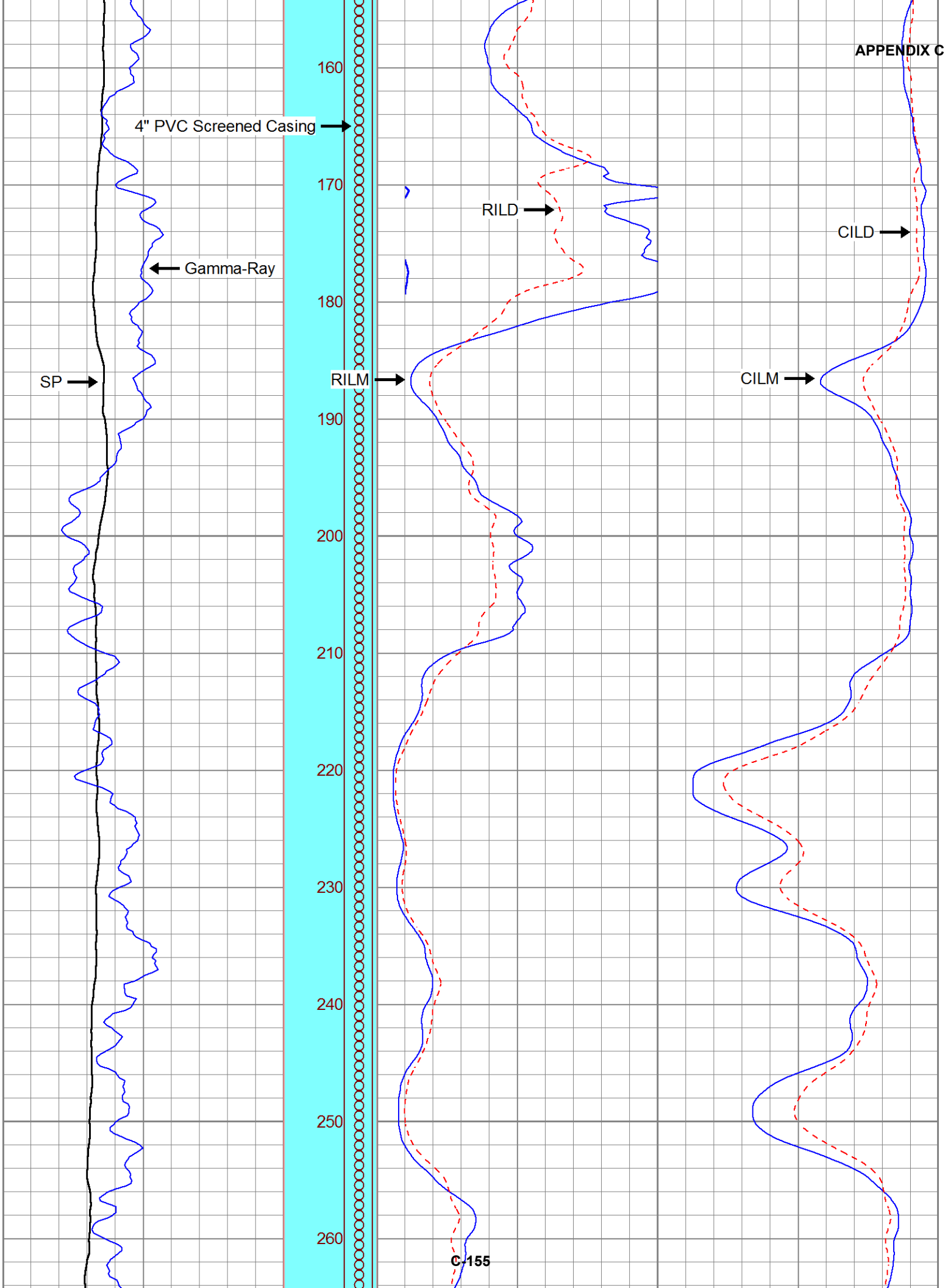
90
100
110
120
130
140
150


160
170
180
190
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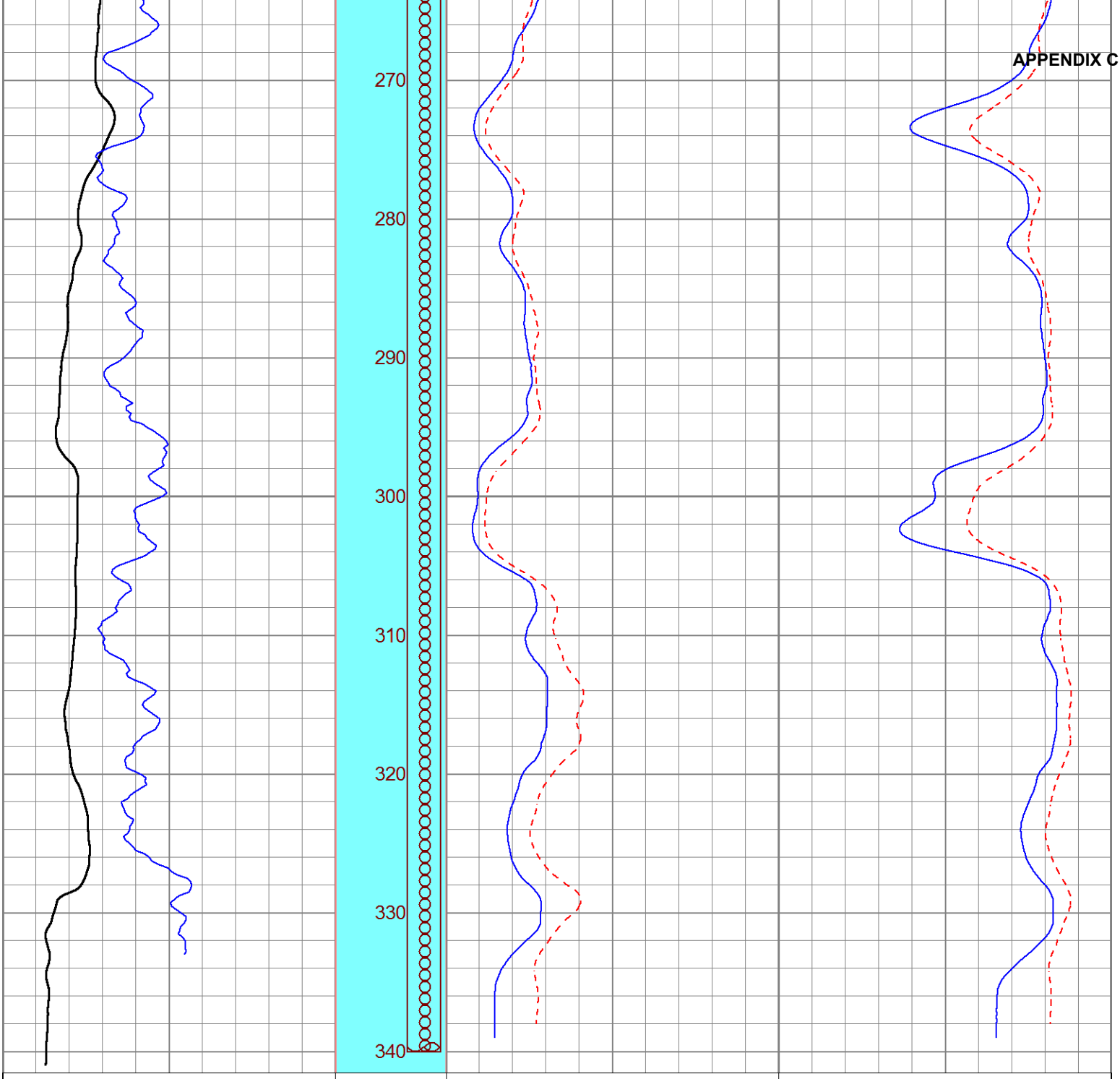
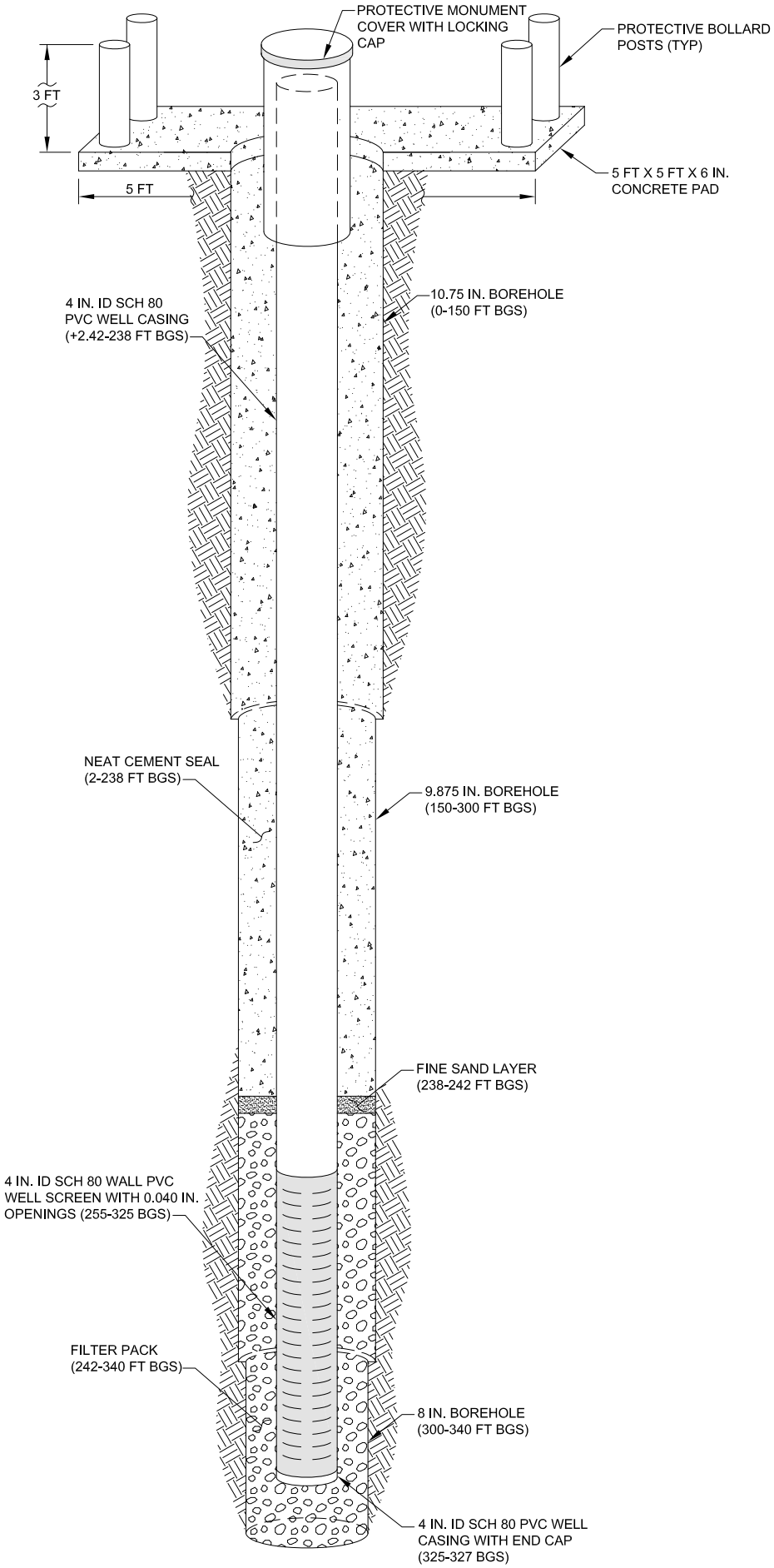
220
230
240
250
260
4" PVC Screened Casing
Gamma-Ray
SP
RILD
RILM
CILD
CILM


270
280
290
300
310
320
330
340
-30 SP (mV) 120
20 Gamma-Ray (GAPI) 120
0 RILM (Ohm-m) 100
0 RILD (Ohm-m) 100
100 RILM backup (Ohm-m) 1000
100 RILD backup (Ohm-m) 1000
200 CILM (mmho/m) 0
200 CILD (mmho/m) 0
CILD backup
2000 (mmho/m) 200
CILM backup
2000 (mmho/m) 200



WELL PROFILE

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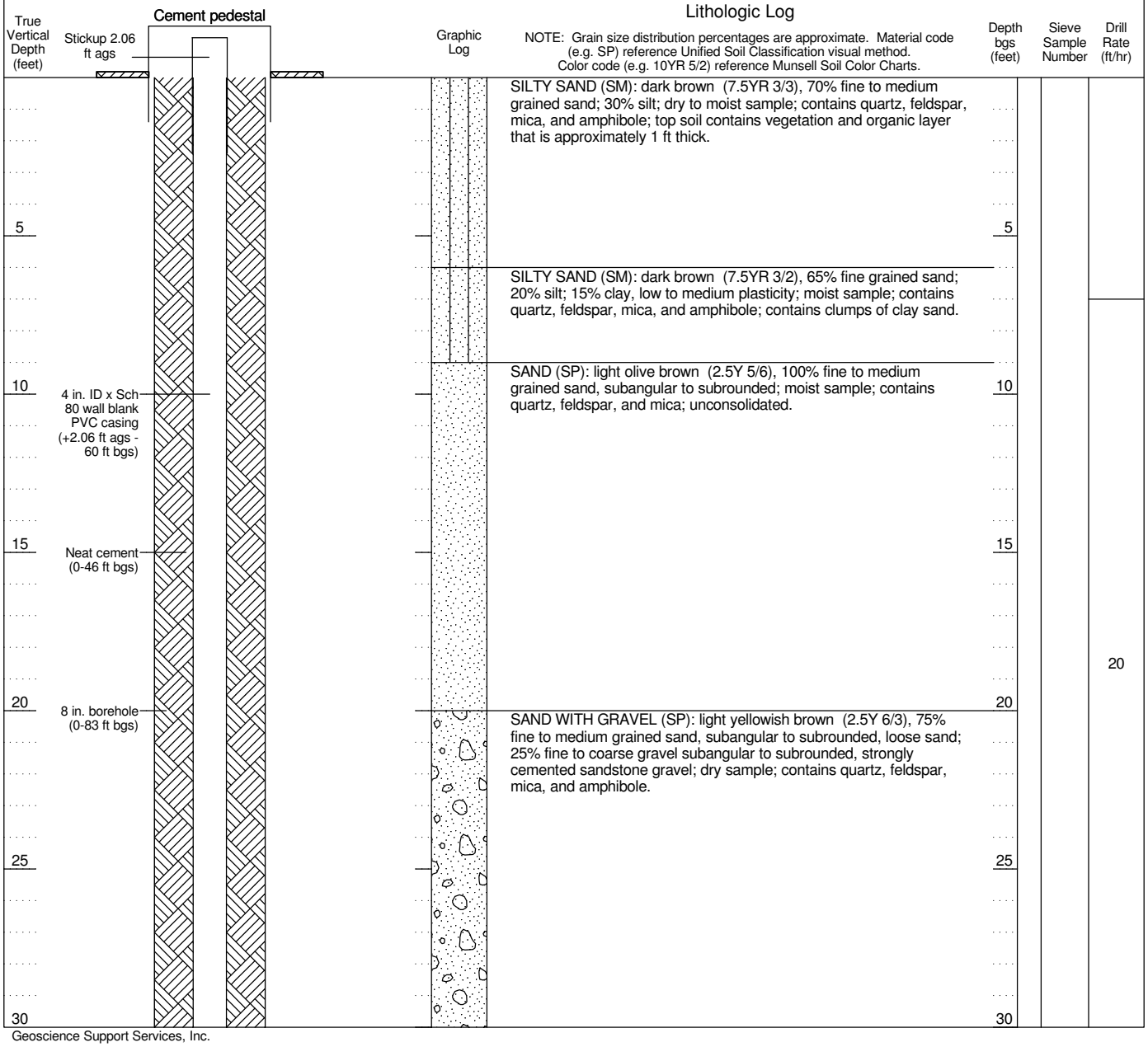
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-7S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Lapis Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.06**	**60**	**62.06**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**60**	**80**	**20**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**80**	**82.4**	**2.4**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	48.58 ft NAVD88									
TOC ELEVATION	50.64 ft NAVD88 (RP)									
START DATE	7/22/15									
FINISH DATE	7/23/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35			SILTY SAND (SM): brown (10YR 4/3), 85% sand; 15% silt, none to low plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	35		
40			SAND (SP): yellowish brown (10YR 5/4), 100% fine grained sand; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	40		
45			NO SAMPLE: No recovery; lost core within borehole.	45		
50	CEMEX Monterey Lapis Lustre #60 fine sand seal (46 - 49.5 ft bgs)		SAND (SP): pale brown (10YR 6/3), 90% medium to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	50		20
			SAND (SP): light brownish gray (10YR 6/2), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
	CEMEX Monterey Lapis Lustre #3 filter pack (49.5 - 83 ft bgs)		SAND (SP): light brownish gray (10YR 6/2), 100% medium to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole.			
55			SAND WITH GRAVEL (SP): dark yellowish brown (10YR 3/6), 80% fine to coarse grained sand, subangular to subrounded; 20% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	55		
60			SAND (SP): dark yellowish brown (10YR 4/4), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	60		
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (60 - 80 ft bgs)					
65			SAND (SP): strong brown (7.5YR 4/6), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	65		
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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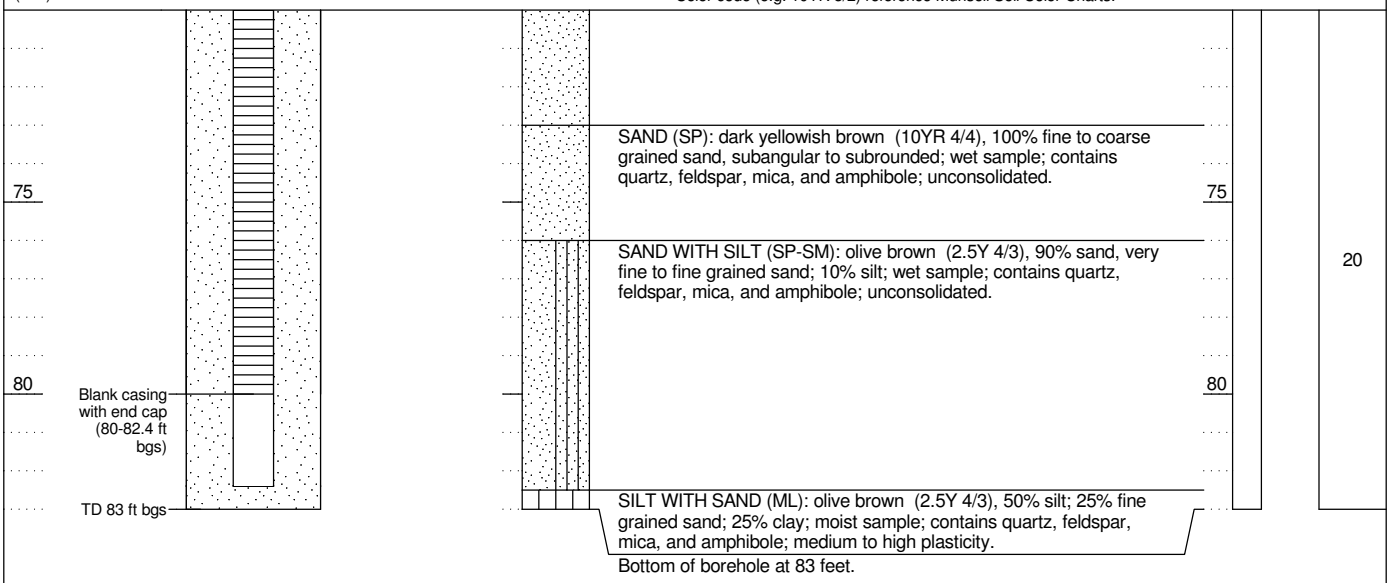
WELL NUMBER **MPWSP MW-7S**

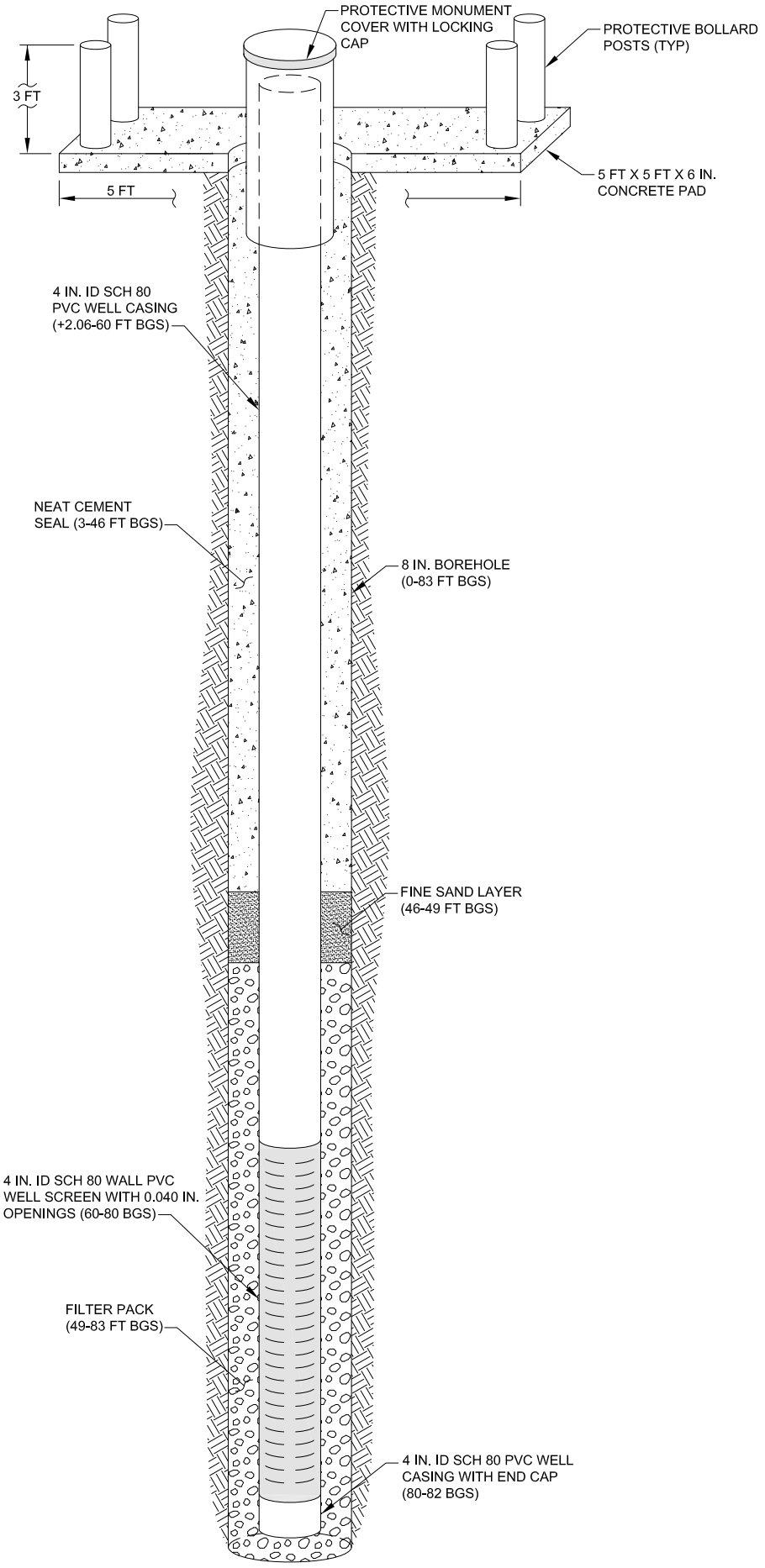
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.



WELL PROFILE

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GEOSCIENCE

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CALIFORNIA AMERICAN WATER

Date: 09-AUG-16

Drawn: AS

Checked: LW

Approved: PK

CLIENT: CALIFORNIA AMERICAN WATER

PROJECT: MONTEREY PENINSULA WATER SUPPLY PROJECT

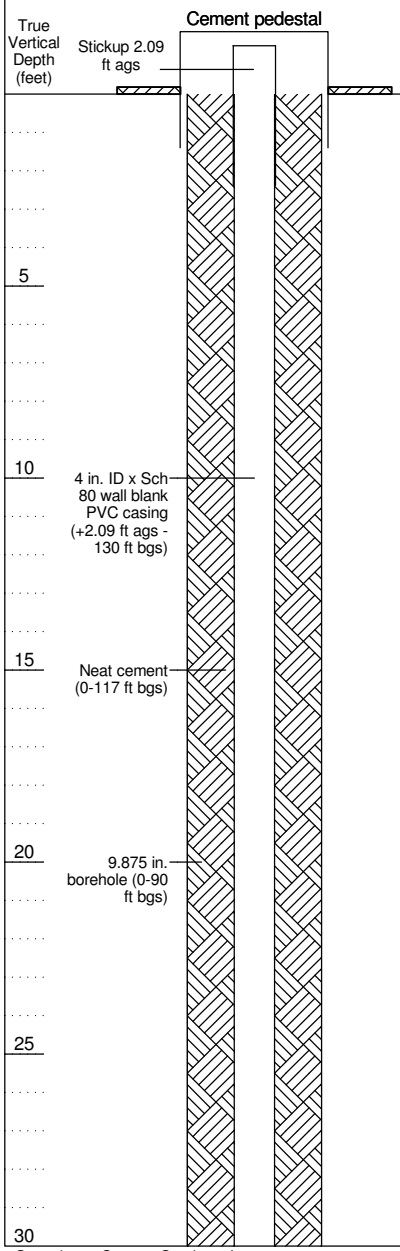
MW-7S AS-BUILT

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

BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-7M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Lapis Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.09**	**130**	**132.09**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**130**	**220**	**90**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**220**	**222.375**	**2.375**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	48.20 ft NAVD88									
TOC ELEVATION	50.29 ft NAVD88 (RP)									
START DATE	7/13/15									
FINISH DATE	7/22/15									



Lithologic Log

Graphic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Depth bgs (feet)	Lithologic Description	Sieve Sample Number	Drill Rate (ft/hr)
	SILTY SAND (SM): dark brown (7.5YR 3/3), 70% fine to medium grained sand; 30% silt; dry to moist sample; contains quartz, feldspar, mica, and amphibole; contains top soil.		
5	SILTY SAND (SM): dark brown (7.5YR 3/2), 65% fine grained sand; 20% silt; 15% clay, low to medium plasticity; contains quartz, feldspar, mica, and amphibole; contains clumps of clayey sand.		
10	SAND (SP): light olive brown (2.5Y 5/6), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, and mica; unconsolidated.		
15			
20	SAND WITH GRAVEL (SP): light yellowish brown (2.5Y 6/3), 75% fine to medium grained sand, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded; dry sample; contains quartz, feldspar, mica, and amphibole; contains strongly cemented sand with gravel matrix; loose sand.		
25			
30			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

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

WELL NUMBER **MPWSP MW-7M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILTY SAND (SM): brown (10YR 4/3), 85% sand, very fine to fine grained; 15% silt, none to low plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
35				35		
			SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
40				40		
45				45		
50				50		
			SAND (SP): pale brown (10YR 6/3), 90% medium to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; unconsolidated.		
			SAND (SP): light brownish gray (10YR 6/2), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
55				55		
60				60		
			SAND (SP): yellowish brown (10YR 5/4), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
			SAND (SP): strong brown (7.5YR 4/6), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
65				65		
70				70		

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WELL NUMBER **MPWSP MW-7M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 90% sand, very fine to fine grained; 10% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	75		
80				80		
85				85		
90			SILT WITH SAND (ML): light olive brown (2.5Y 5/3), 80% silt; 20% sand, very fine to fine grained; low to medium plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	90		
	8 in. borehole (90-223 ft bgs)		CLAY (CL): greenish black (10GY 2.5/1), 100% clay, high plasticity; moist sample.			
95			SAND (SP): dark yellowish brown (10YR 4/4), 100% medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	95		
100				100		5
105				105		
110			CLAY (CL): greenish black (10GY 2.5/1), 100% clay, high plasticity; moist sample.	110		

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WELL NUMBER
MPWSP MW-7M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115			SAND (SP): dark yellowish brown (10YR 3/6), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	115		
120	CEMEX Monterey Lapis Lustre #60 fine sand seal (117 - 120 ft bgs)		SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular to subrounded; 15% silt, none to low plasticity; moist to wet sample; contains quartz, feldspar, and mica; unconsolidated.	120		
125	CEMEX Monterey Lapis Lustre #3 filter pack (120 - 223.375 ft bgs)		SAND (SP): brown (10YR 5/3), 100% sand, very fine to fine grained; contains quartz, feldspar, mica, and amphibole; unconsolidated.	125		5
130				130		
135	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (130 - 220 ft bgs)			135		
140				140		
145			CLAY (CL): greenish gray (10GY 6/1), 100% clay, high plasticity; moist sample.	145		
150				150		

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WELL NUMBER **MPWSP MW-7M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILT (ML): dark greenish gray (10Y 4/1), 90% silt; 10% sand, very fine to fine grained; low plasticity; moist sample.			
			CLAY (CL): dark greenish gray (10Y 4/1), 85% clay, low plasticity; 10% sand, very fine grained; 5% silt; moist sample.			
155			SILTY SAND (SM): dark greenish gray (10Y 4/1), 75% sand, very fine grained; 20% silt; 5% clay; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	155		
160			SAND WITH CLAY (SP-SC): dark greenish gray (10Y 4/1), 90% fine to coarse grained sand, subangular to subrounded; 10% clay; wet sample; contains quartz, feldspar, mica, and amphibole; contains clumps of clay.	160		
			CLAYEY SAND WITH GRAVEL (SC): grayish brown (2.5Y 5/2), 65% sand, subangular to subrounded; 20% clay, low plasticity; 15% gravel subangular to subrounded; trace cobbles; moist sample; contains quartz, feldspar, mica, and amphibole.			
165				165		
			SAND (SP): dark yellowish brown (10YR 4/6), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
170				170		
175				175		
180				180		
185				185		
			GRAVEL WITH SAND (GP): dark brown (7.5YR 3/2), 60% fine to coarse gravel rounded; 35% fine to coarse grained sand, subangular to subrounded; 5% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; contains trace round cobbles; unconsolidated.			
190				190		

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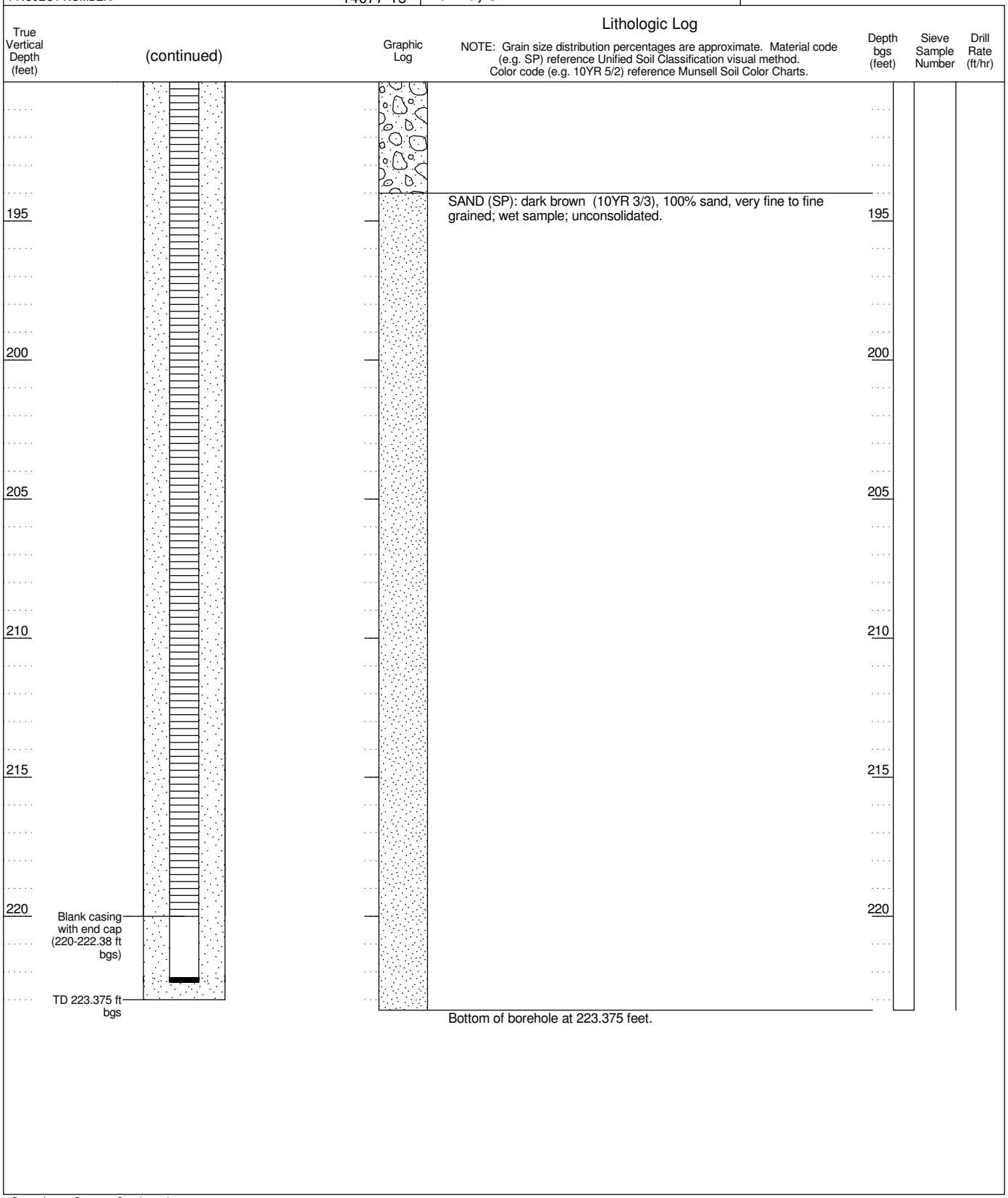
WELL NUMBER
MPWSP MW-7M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No.	19868
Company	CASCADE DRILLING
Well	MW-7M
Field	MARINA
File No.	
County	MONTEREY
State	CA

Location

LAPIS RD. NEAR SOUTHERN INT. WITH DEL MONTE BLVD.
GPS: N 36o 42' 23" W 121o 47' 20"

Other Services:
DUAL INDUCTION
GAMMA-RAY

		Elevation		
Permanent Datum	G.L.		K.B.:	
Log Measured From	G.L.	0' above perm. datum	D.F.:	
Drilling Measured From	G.L.		G.L.:	

Date	07-13-2015
Run Number	ONE
Depth Driller	87'
Depth Logger	86'
Bottom Logged Interval	86'
Top Log Interval	0'
Open Hole Size	8" (0'-87')
Type Fluid	WATER
Density / Viscosity	N/A
Fluid Level	45'
Bentonite Seal	N/A
Time Well Ready	1330
Time Logger on Bottom	1345
Equipment Number	PS-8
Location	LA
Recorded By	SCHUMACHER
Witnessed By	A. KHALIGHI

Borehole Record

Run Number	Bit	From	To
ONE	8"	0'	87'

Tubing Record

Size	Weight	From	To
4" PVC	SCH 80	0'	87'

	Size	Wgt/Ft	Top	Bottom
Casing Record				
Surface String				
Prot. String				
Production String				
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19868.db
Dataset Pathname	tmpFR
Dataset Creation	Mon Jul 13 13:54:24 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Mon Feb 23 16:47:18 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

FRT Calibration Report

Serial Number:	3553
Tool Model:	MLS
Performed:	Mon Feb 23 16:47:15 2015

Resistivity Calibration:

System Reading	Calibration Reference
32145.000 cps	1.800 Ohm-m
11466.000 cps	86.960 Ohm-m

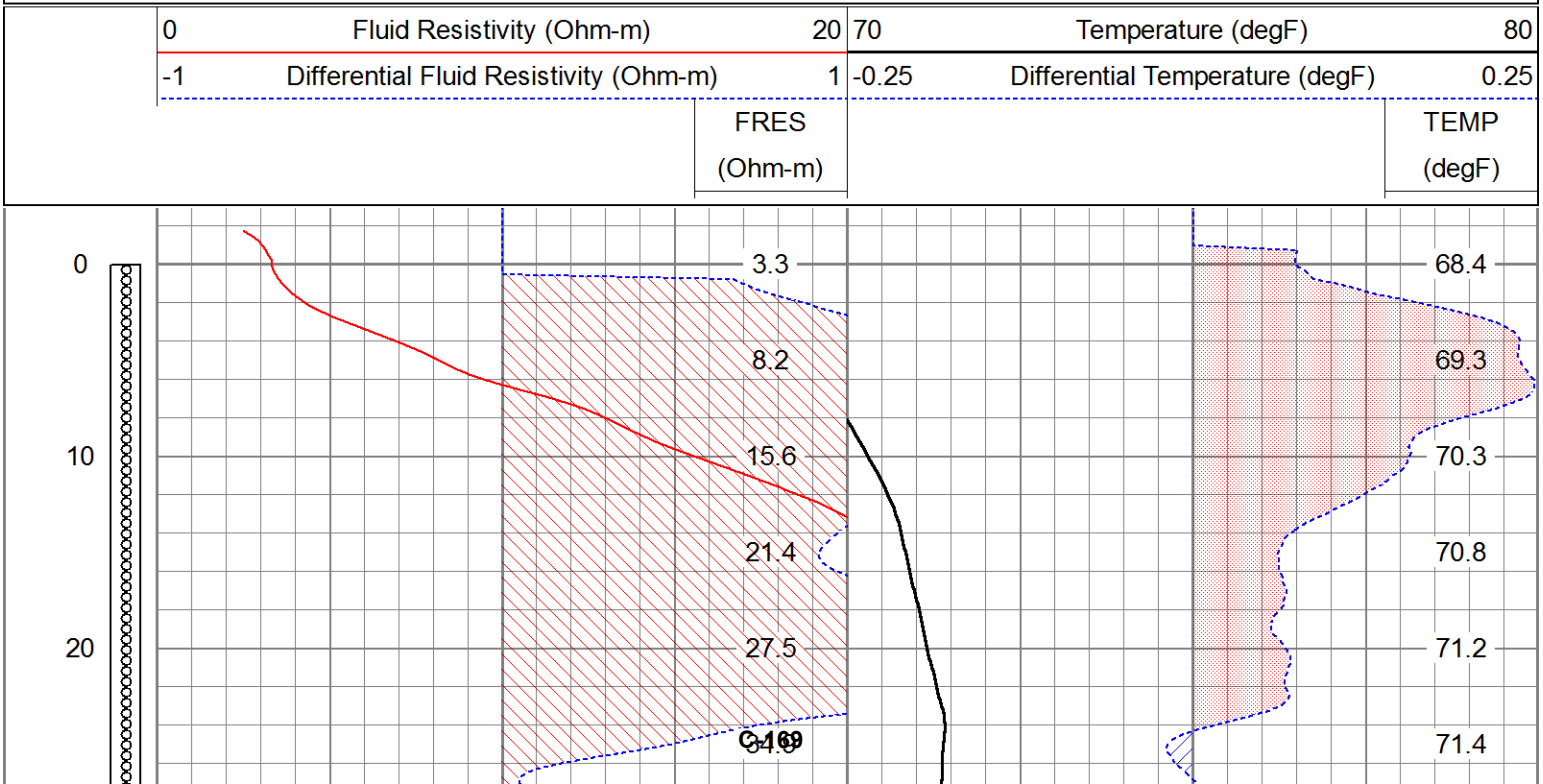
Gain: -0.004
Offset: 135.338

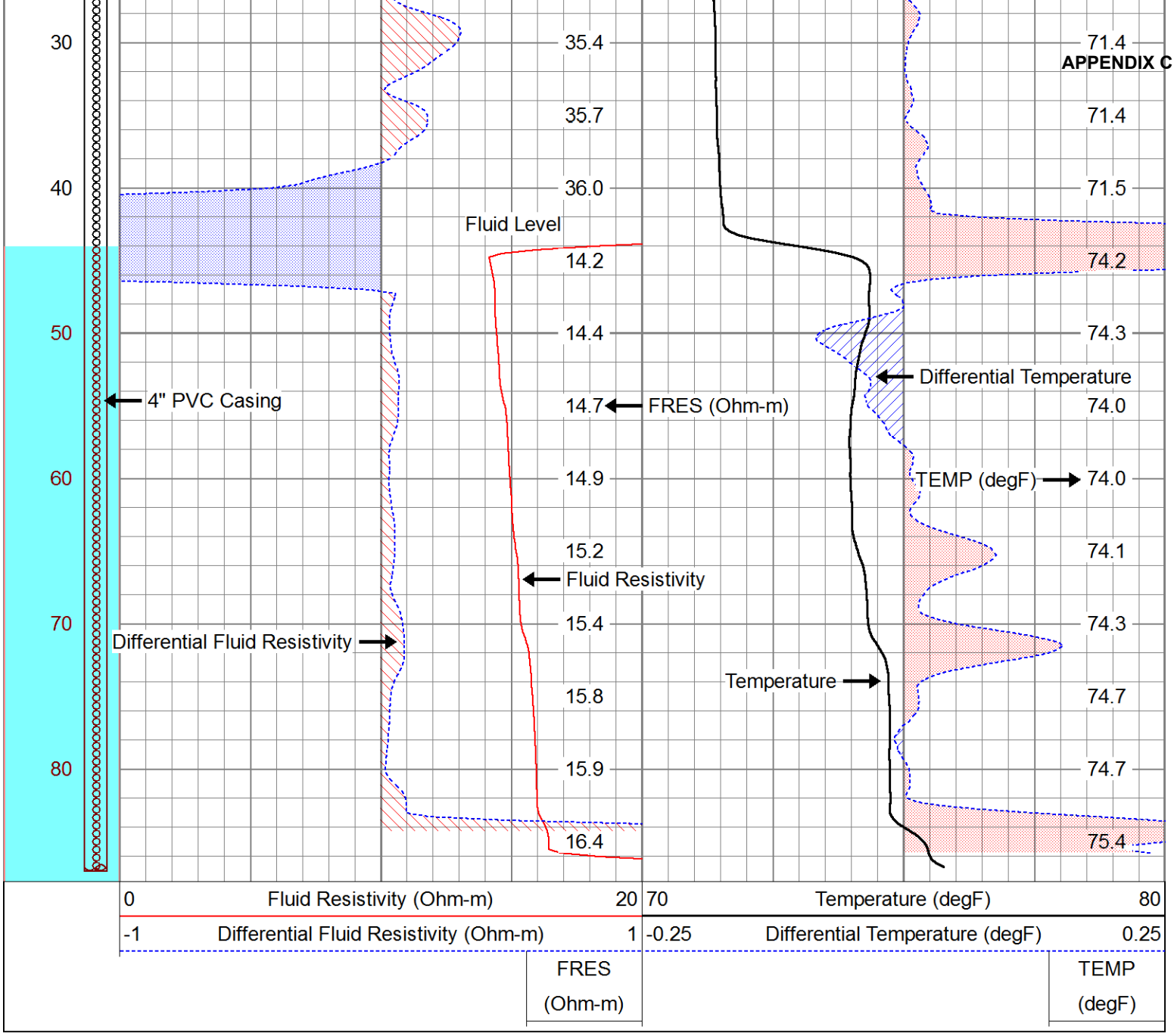
Conductivity Calibration:

System Reading	Calibration Reference
0.000 cps	0.000
1.000 cps	1.000

Gain: 1.000
Offset: 0.000

Database File	19868.db
Dataset Pathname	tmpFR
Presentation Format	frttemp2
Dataset Creation	Mon Jul 13 13:54:24 2015
Charted by	Depth in Feet scaled 1:120




APPENDIX C
30
40
50
60
70
80
35.4
35.7
36.0
14.2
14.4
14.7
14.9
15.2
15.4
15.8
15.9
16.4
71.4
71.4
71.5
74.2
74.3
74.0
74.0
74.1
74.3
74.7
74.7
75.4
Fluid Level
4" PVC Casing
FRES (Ohm-m)
Differential Temperature
TEMP (degF)
Fluid Resistivity
Differential Fluid Resistivity
Temperature
0
Fluid Resistivity (Ohm-m)
20
70
Temperature (degF)
80
-1
Differential Fluid Resistivity (Ohm-m)
1
-0.25
Differential Temperature (degF)
0.25
FRES
(Ohm-m)
TEMP
(degF)

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19868

File No.

Company CASCADE DRILLING

Well MW-7M

Field MARINA

County MONTEREY State CA

Location

LAPIS RD. NEAR SOUTHERN INT. WITH DEL MONTE BLVD.
GPS: N 36o 42' 23" W 121o 47' 20"

Other Services:

TEMPERATURE
FLUID RESISTIVITY

				Elevation	
Permanent Datum	G.L.	Elevation		K.B.:	
Log Measured From	G.L.	0'	above perm. datum	D.F.:	
Drilling Measured From	G.L.			G.L.:	

Date	07-13-2015							
Run Number	ONE							
Depth Driller	87'							
Depth Logger	86'							
Bottom Logged Interval	86'							
Top Log Interval	0'							
Open Hole Size	8" (0'-87')							
Type Fluid	WATER							
Density / Viscosity	N/A							
Fluid Level	45'							
Bentonite Seal	N/A							
Time Well Ready	1330							
Time Logger on Bottom	1345							
Equipment Number	PS-8							
Location	LA							
Recorded By	SCHUMACHER							
Witnessed By	A. KHALIGHI							

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	8"	0'	87'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	87'
Liner				

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Comments

Calibration Report

Database File	19868.db
Dataset Pathname	dil2
Dataset Creation	Mon Jul 13 15:22:33 2015

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

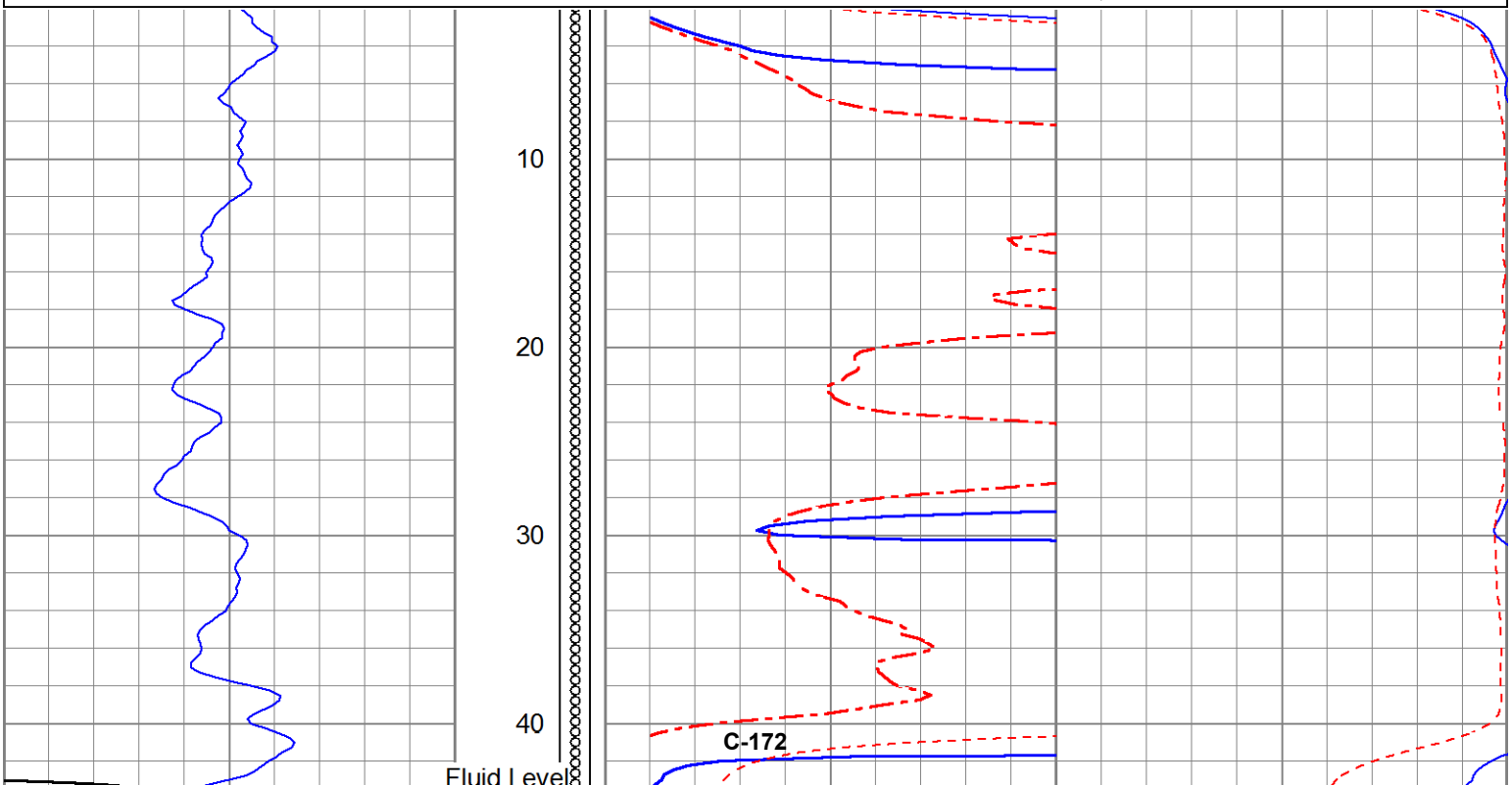
Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1408.289	3426.231	cps	0.000	612.000	mmho/m	0.303	-427.105
Medium	2130.555	14599.017	cps	0.000	1960.000	mmho/m	0.157	-334.916

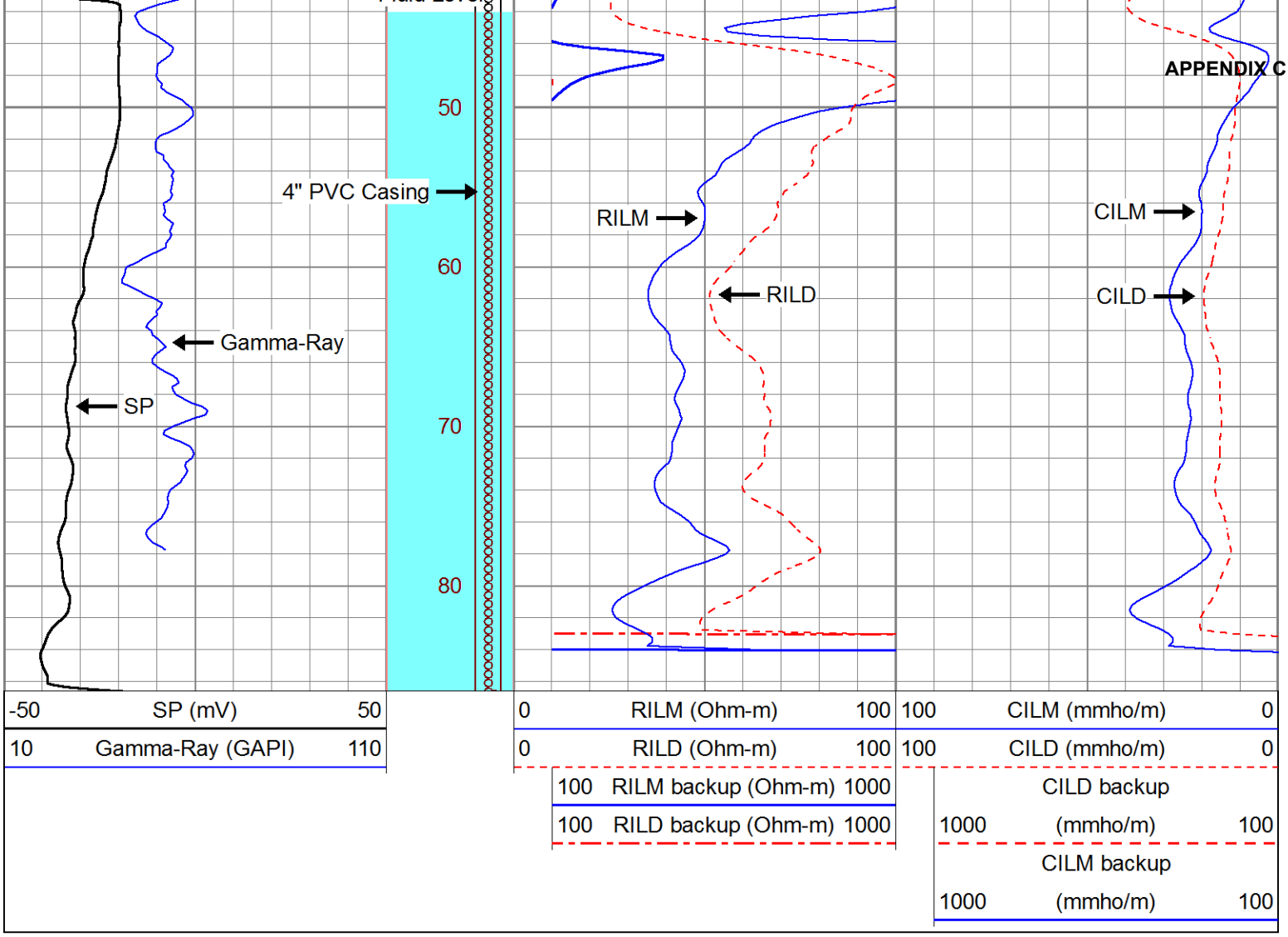
Gamma Ray Calibration Report

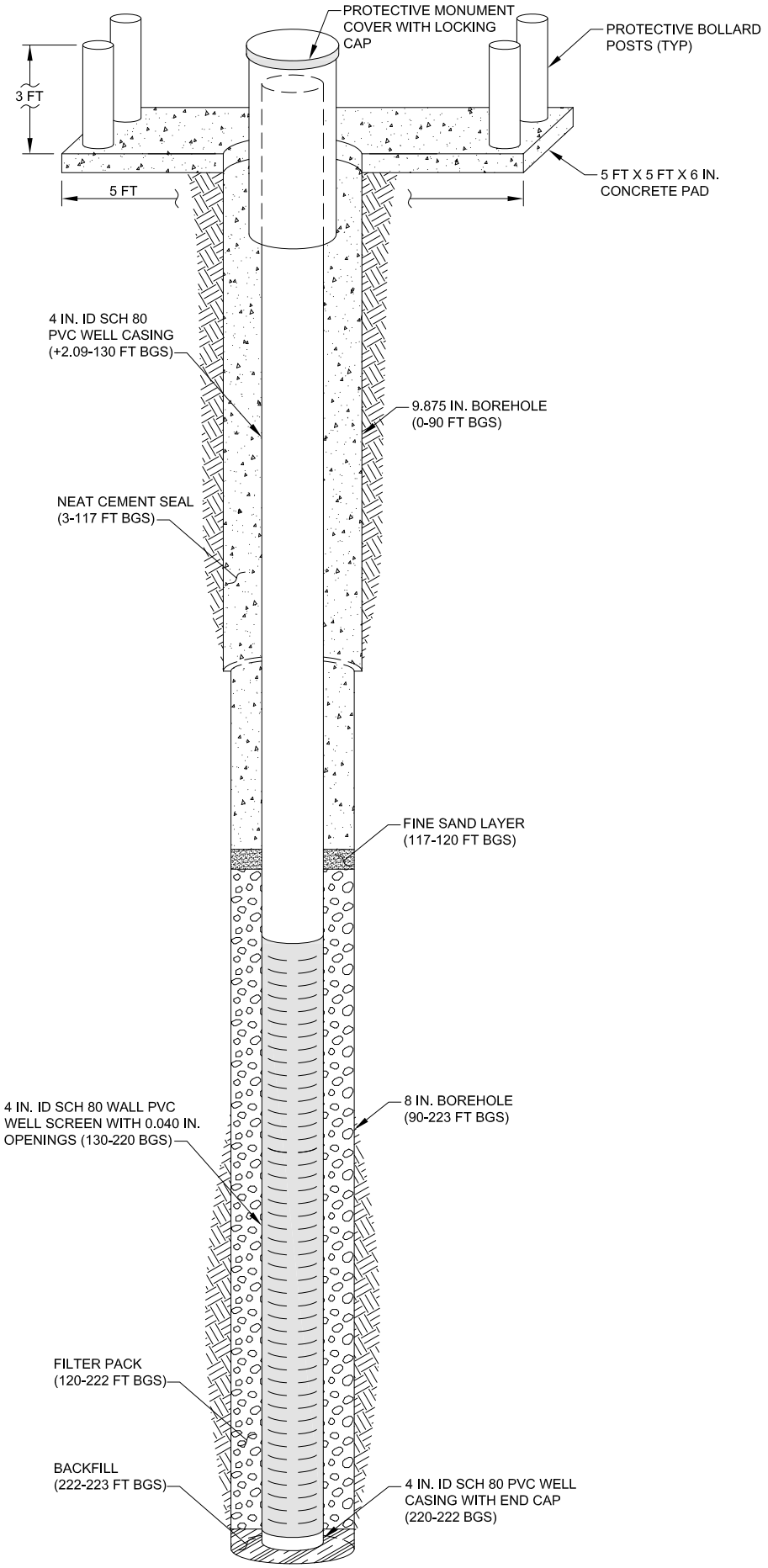
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

Database File	19868.db
Dataset Pathname	dil2
Presentation Format	dil
Dataset Creation	Mon Jul 13 15:22:33 2015
Charted by	Depth in Feet scaled 1:120

-50 SP (mV) 50	0 RILM (Ohm-m) 100	100 CILM (mmho/m) 0
10 Gamma-Ray (GAPI) 110	0 RILD (Ohm-m) 100	100 CILD (mmho/m) 0
	100 RILM backup (Ohm-m) 1000	CILD backup 1000 (mmho/m) 100
	100 RILD backup (Ohm-m) 1000	CILM backup 1000 (mmho/m) 100




50
60
70
80
4" PVC Casing
Gamma-Ray
SP
RILM
RILD
CILM
CILD
-50 SP (mV) 50
10 Gamma-Ray (GAPI) 110
0 RILM (Ohm-m) 100
0 RILD (Ohm-m) 100
100 RILM backup (Ohm-m) 1000
100 RILD backup (Ohm-m) 1000
100 CILM (mmho/m) 0
100 CILD (mmho/m) 0
CILD backup
1000 (mmho/m) 100
CILM backup
1000 (mmho/m) 100



WELL PROFILE

NOT TO SCALE

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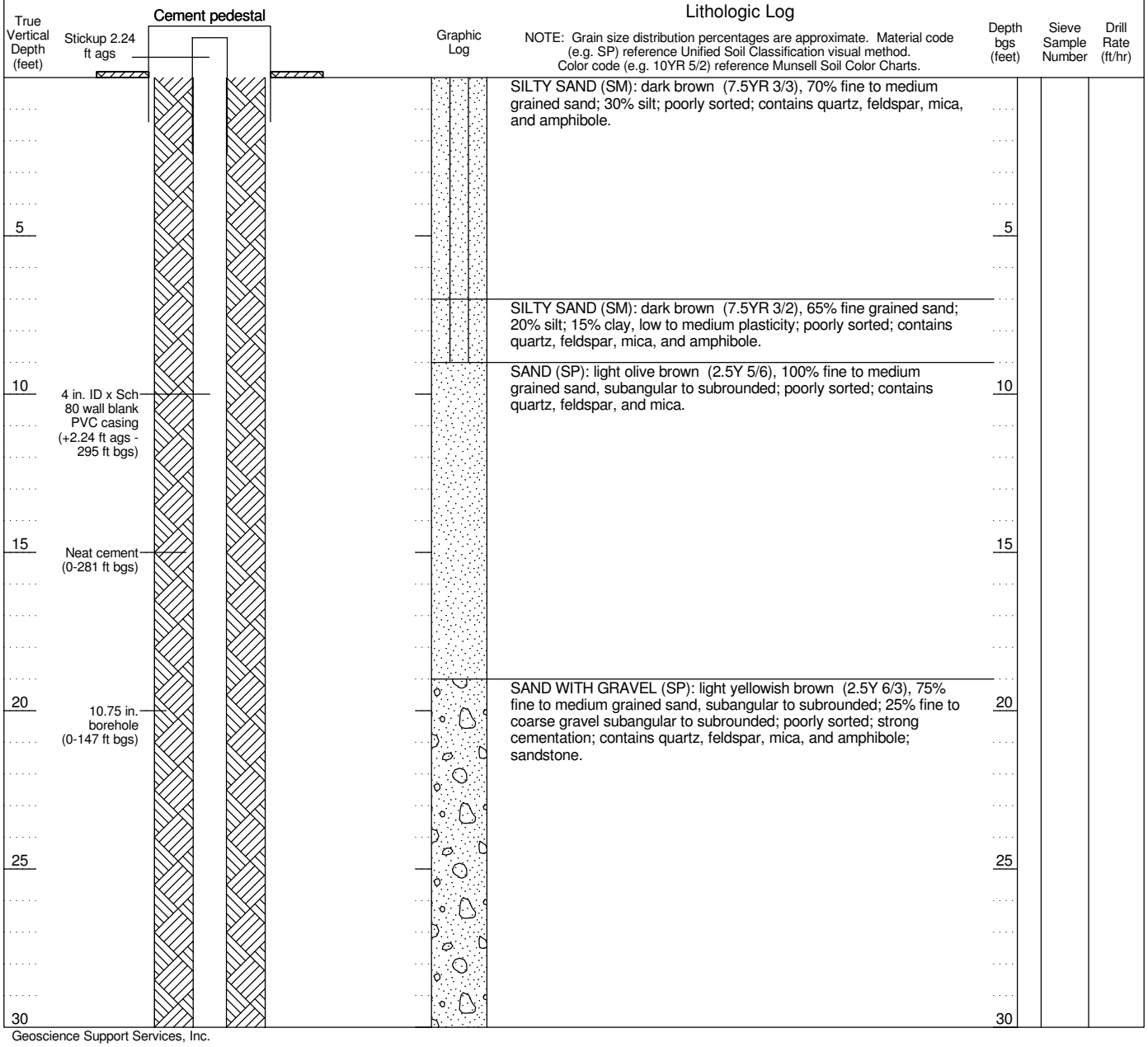
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-7D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Lapis Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.24**	**295**	**297.24**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**295**	**345**	**50**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**345**	**347.77**	**2.77**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	48.05 ft NAVD88									
TOC ELEVATION	50.24 ft NAVD88 (RP)									
START DATE	6/27/15									
FINISH DATE	7/13/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILTY SAND (SM): brown (10YR 4/3), 85% fine grained sand; 15% silt, no to low plasticity; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
35				35		
			SAND (SP): yellowish brown (10YR 5/4), 100% fine grained sand; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
40				40		
			SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
45				45		
50				50		
			SAND (SP): pale brown (10YR 6/3), 90% medium to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.		
			SAND (SP): light brownish gray (10YR 6/2), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
55			SAND (SP): dark yellowish brown (10YR 3/6), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	55		
			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
60				60		
			SAND (SP): yellowish brown (10YR 5/4), 100% fine grained sand; poorly sorted; contains quartz, feldspar, mica, and amphibole.		1	
65			SAND (SP): strong brown (7.5YR 4/6), 95% fine to coarse grained sand, subangular to rounded; 5% fine gravel subangular to rounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	65		
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
	SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
	SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 90% fine grained sand; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
75		75	2	
80		80		
	ELASTIC SILT WITH SAND (MH): olive brown (2.5Y 4/3), 50% silt, medium to high plasticity; 25% fine grained sand; 25% clay; contains quartz, feldspar, mica, and amphibole.			
85	SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	85		
	SILT WITH SAND (ML): light olive brown (2.5Y 5/3), 80% silt, low to medium plasticity; 20% fine grained sand; contains quartz, feldspar, mica, and amphibole.			
90		90		
	SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, and mica.		3	
	CLAY (CL): greenish black (10GY 2.5/1), 100% clay, high plasticity.			
95		95		
	SAND (SP): dark yellowish brown (10YR 4/4), 100% medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole. NO SAMPLE.			
100		100		10
105		105		
	SAND (SP): dark yellowish brown (10YR 4/4), 100% medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
110	FAT CLAY (CH): black (N2.5), 100% clay, high plasticity.	110		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115		SAND WITH SILT (SP-SM): yellowish brown (10YR 5/4), 90% fine to medium grained sand, subangular to subrounded; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.	115		
		SAND (SP): dark yellowish brown (10YR 3/6), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
		SAND (SP): brown (10YR 5/3), 90% fine to coarse grained sand, subangular to rounded; 5% fine to coarse gravel subangular to rounded; poorly sorted; contains quartz, feldspar, mica, and amphibole; 5% cobbles.		4	
120		SILTY SAND (SM): yellowish brown (10YR 5/4), 70% fine grained sand; 30% silt, no to low plasticity; poorly sorted; contains quartz, feldspar, and mica.	120		
		SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular to subrounded; 15% silt, no to low plasticity; poorly sorted; contains quartz, feldspar, and mica.			
125			125		
		SAND (SP): brown (10YR 5/3), 100% fine grained sand; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
130			130		
				5	
135			135		
140			140		
		SAND (SP): brown (10YR 4/3), 100% fine grained sand; poorly sorted.			
		SAND (SP): brownish yellow (10YR 6/8), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, and mica.			
145			145		
				6	
		FAT CLAY (CH): greenish gray (10GY 6/1), 100% clay, high plasticity.			
150			150		

9.875 in. borehole (147-297 ft bgs)

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILT (ML): greenish gray (10Y 6/1), 90% silt, low plasticity; 10% fine grained sand.			
			CLAY (CL): greenish gray (10GY 6/1), 85% clay, low plasticity; 10% fine grained sand; 5% silt.			
155			SILTY SAND (SM): dark greenish gray (10GY 4/1), 75% fine grained sand; 20% silt; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.	155		
			SILTY SAND (SM): dark greenish gray (10GY 4/1), 70% fine to coarse grained sand, subangular to subrounded; 20% silt; 5% fine to coarse gravel subangular to subrounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
160			SAND (SP): dark greenish gray (10GY 4/1), 90% fine to coarse grained sand, subangular to rounded; 5% fine gravel subangular to rounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.	160		
			CLAYEY SAND (SC): light yellowish brown (2.5Y 6/3), 75% fine to coarse grained sand, subangular to subrounded; 20% clay, high plasticity; 5% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
165			CLAYEY SAND WITH GRAVEL (SC): grayish brown (2.5Y 5/2), 65% fine to coarse grained sand, subangular to subrounded; 20% clay, low plasticity; 15% fine to coarse gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	165		
			SAND (SP): dark yellowish brown (10YR 3/4), 100% fine grained sand; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
170				170	7	
			SANDY CLAY (CL): greenish gray (10GY 6/1), 60% clay, high plasticity; 40% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
175			SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	175		11
180				180	8	
			SAND (SP): light yellowish brown (2.5Y 6/4) and strong brown (7.5YR 4/6), 100% medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
185				185		
			GRAVEL WITH SAND (GP): dark brown (7.5YR 3/2), 60% fine to coarse gravel subangular to rounded; 40% fine to coarse grained sand, subangular to rounded; trace cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole; trace cobbles.			
190				190		

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WELL NUMBER
MPWSP MW-7D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): brown (10YR 5/3), 75% fine to coarse grained sand, subangular to rounded; 20% fine to coarse gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole; 5% cobbles.		9	
195			SAND (SP): dark brown (10YR 3/3), 100% fine grained sand; trace cobbles; trace fine to coarse gravel; trace silt; poorly sorted; contains quartz, feldspar, mica, and amphibole; sandstone.	195		
200				200	10	
205				205		
210				210		11
215				215		
220				220	11	
225			FAT CLAY (CH): dark greenish gray (10Y 4/1), 100% clay, high plasticity.	225		
			CLAYEY SAND (SC): brown (10YR 4/3), 70% fine grained sand; 20% clay, low plasticity; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
230				230		

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235			SAND WITH CLAY (SP-SC): olive brown (2.5Y 4/4), 90% fine grained sand; 5% silt; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.	235		
			SAND WITH SILT (SP-SM): olive brown (2.5Y 4/4), 80% fine to coarse grained sand, subangular to rounded; 10% silt; 5% fine to coarse gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			SANDY CLAY WITH GRAVEL (CL): olive brown (2.5Y 4/4), 50% clay, high plasticity; 20% fine to coarse gravel subangular to rounded; 20% fine to coarse grained sand, subangular to rounded; 5% silt; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			
240			SAND (SP): olive brown (2.5Y 4/4), 95% fine to medium grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	240		
			CLAYEY GRAVEL WITH SAND (GC): olive brown (2.5Y 4/4), 50% fine to coarse gravel subangular to rounded; 25% fine to coarse grained sand, subangular to rounded; 10% silt; 10% clay; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
245			SAND WITH CLAY (SP-SC): olive brown (2.5Y 4/4), 90% fine to coarse grained sand, subangular to subrounded; 5% silt; 5% clay; poorly sorted; contains quartz, feldspar, and amphibole.	245		
			CLAY WITH SAND (CL): olive gray (5Y 4/2), 75% clay, low to medium plasticity; 15% fine to coarse grained sand, subangular to rounded; 5% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			11
250			CLAYEY SAND (SC): brown (7.5YR 4/4), 80% fine to coarse grained sand, subangular to subrounded; 10% silt; 10% clay, low plasticity; poorly sorted; contains quartz, feldspar, mica, and amphibole.	250		
255				255		
			CLAYEY SAND (SC): grayish brown (2.5Y 5/2), 65% fine to medium grained sand, subangular to subrounded; 20% clay, medium to high plasticity; 15% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
260			SAND (SP): grayish brown (2.5Y 5/2), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	260	12	
265			FAT CLAY (CH): light yellowish brown (2.5Y 6/3), 70% clay, medium to high plasticity; 30% silt.	265		
			SAND (SP): dark grayish brown (2.5Y 4/2), 95% fine grained sand; 5% silt; trace fine gravel; trace clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			8
270				270		

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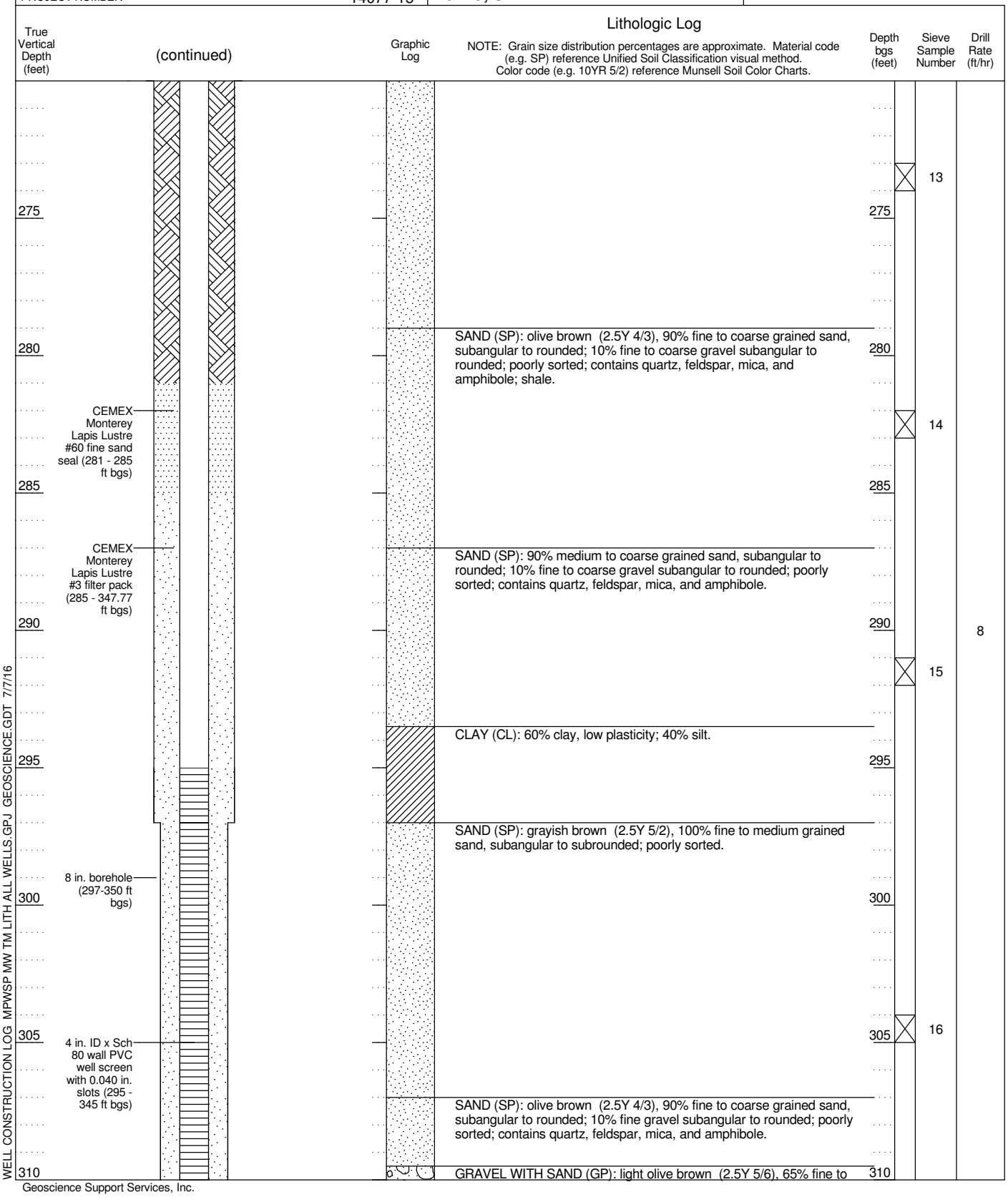
WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			coarse gravel subangular to subrounded; 20% fine to coarse grained sand, subangular to subrounded; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			SAND WITH CLAY AND GRAVEL (SP-SC): light olive brown (2.5Y 5/3), 65% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; 5% silt; 5% clay; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
315				315		
			SAND WITH GRAVEL (SP): grayish brown (2.5Y 5/2), 75% coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; 5% silt; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			FAT CLAY WITH GRAVEL (CH): olive gray (5Y 5/2), 55% clay, medium to high plasticity; 15% fine to coarse gravel subangular to subrounded; 10% fine to coarse grained sand, subangular to subrounded; 5% silt; 15% cobbles; contains quartz, feldspar, mica, and amphibole.			
320				320		
			FAT CLAY (CH): olive gray (5Y 5/2), 100% clay, high plasticity.			
325			SAND (SP): olive gray (5Y 4/2), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	325	17	
330				330		8
			GRAVEL WITH SAND (GP): olive brown (2.5Y 4/3), 50% fine to coarse gravel subangular to subrounded; 35% fine to coarse grained sand, subangular to subrounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole; shale.			
335				335		
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 50% fine to coarse grained sand, subangular to subrounded; 35% fine to coarse gravel subangular to subrounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
340				340	18	
			GRAVELLY FAT CLAY (CH): olive brown (2.5Y 4/3), 50% clay, high plasticity; 35% fine to coarse gravel subrounded to rounded; 10% fine to coarse grained sand, subrounded to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			
345			SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 80% fine to coarse grained sand; 10% fine gravel; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.	345		
	Blank casing with end cap (345 - 347.77 ft bgs)		SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 50% fine to coarse grained sand, subangular to subrounded; 35% fine to coarse gravel subangular to subrounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
	Backfill with native material (347.77-350 ft bgs)		GRAVELLY FAT CLAY (CH): light yellowish brown (2.5Y 6/3), 50% clay, high plasticity; 35% fine to coarse gravel subrounded to rounded; 10% fine to coarse grained sand, subrounded to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			
350	TD 350 ft bgs			350	19	

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 50% fine to coarse grained sand, subangular to subrounded; 35% fine to coarse gravel subangular to subrounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			Bottom of borehole at 350 feet.			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

APPENDIX C

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19744

File No.

Company CASCADE DRILLING

Well MW-7D

Field MARINA

County MONTEREY State CA

Location

LAPIS RD. NEAR SOUTHERN INT. WITH DEL MONTE BLVD.
GPS: N 36o 42' 23" W 121o 47' 20"

Other Services:

DUAL INDUCTION
GAMMA-RAY

Permanent Datum	G.L.	Elevation above perm. datum	Elevation K.B.
Log Measured From	G.L.	0'	D.F.
Drilling Measured From	G.L.		G.L.

Date	07-07-2015		
Run Number	ONE		
Depth Driller	351'		
Depth Logger	350'		
Bottom Logged Interval	350'		
Top Log Interval	40'		
Open Hole Size	10.75" (0'-97')	9.875" (97'-257')	8" (257'-351')
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	45'		
Bentonite Seal	N/A		
Time Well Ready	1230		
Time Logger on Bottom	1245		
Equipment Number	PS-8		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	J. SOBOLEW		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	97'				
TWO	9.875"	97'	257'				
THREE	8"	257'	351'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	351'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File 19744.db
Dataset Pathname tmp
Dataset Creation Tue Jul 07 12:51:37 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Mon Feb 23 16:47:18 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

FRT Calibration Report

Serial Number:	3553
Tool Model:	MLS
Performed:	Mon Feb 23 16:47:15 2015

Resistivity Calibration:

System Reading	Calibration Reference
32145.000 cps	1.800 Ohm-m
11466.000 cps	86.960 Ohm-m

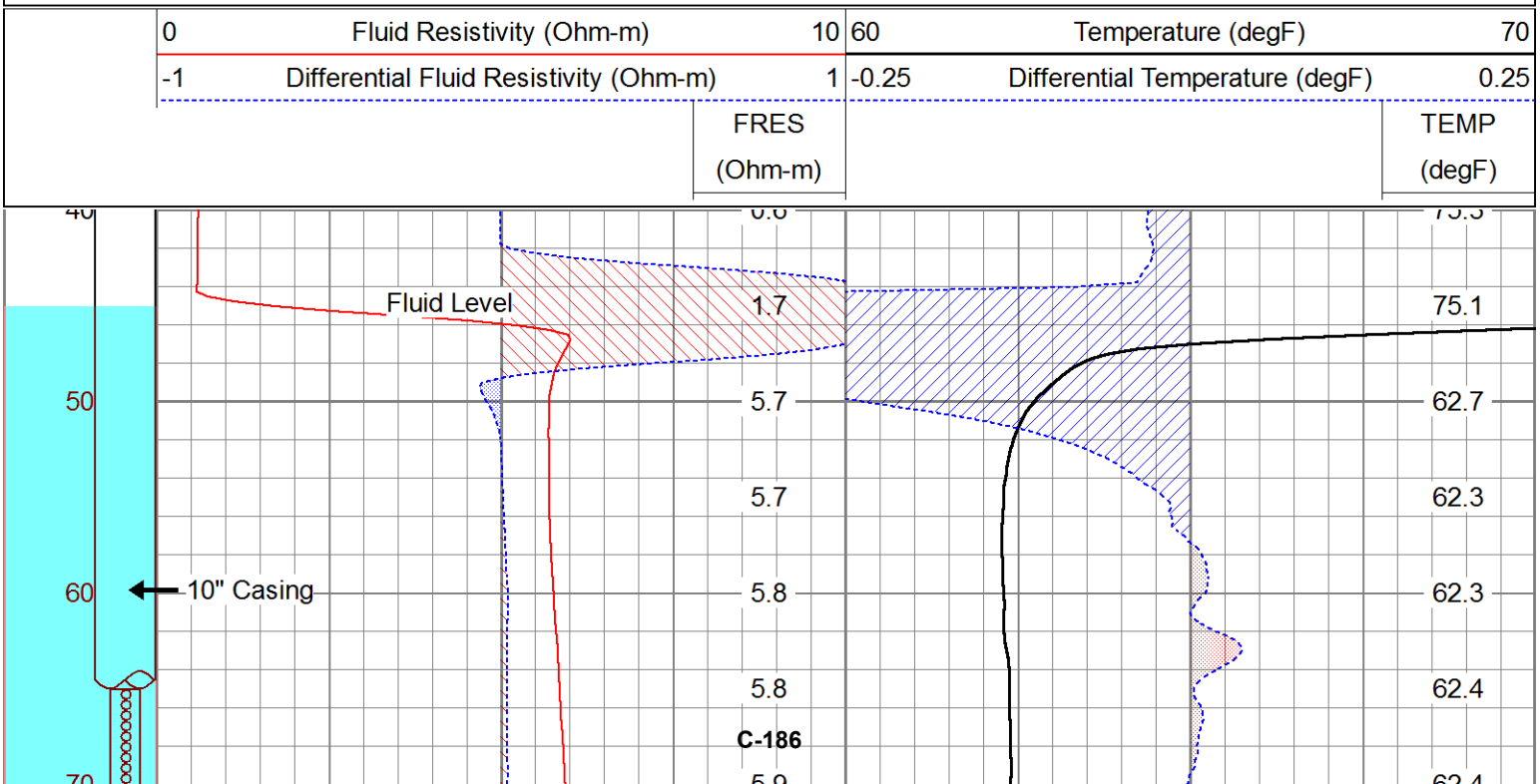
Gain: -0.004
Offset: 135.338

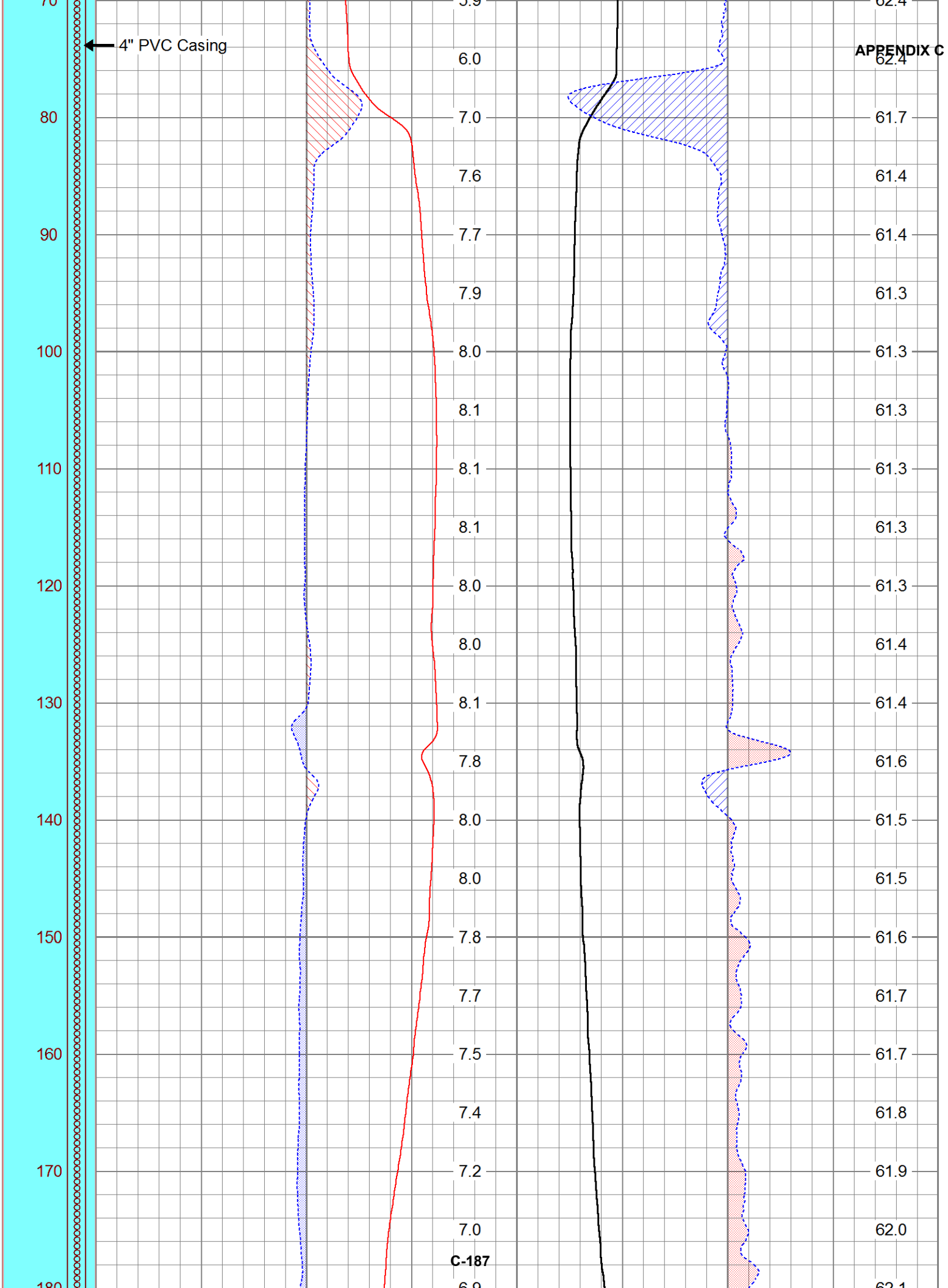
Conductivity Calibration:

System Reading	Calibration Reference
0.000 cps	0.000
1.000 cps	1.000

Gain: 1.000
Offset: 0.000

Database File	19744.db
Dataset Pathname	tmp
Presentation Format	frttemp2
Dataset Creation	Tue Jul 07 12:51:37 2015
Charted by	Depth in Feet scaled 1:120




4" PVC Casing
APPENDIX C
70
80
90
100
110
120
130
140
150
160
170
180
6.0
7.0
7.6
7.7
7.9
8.0
8.1
8.1
8.1
8.0
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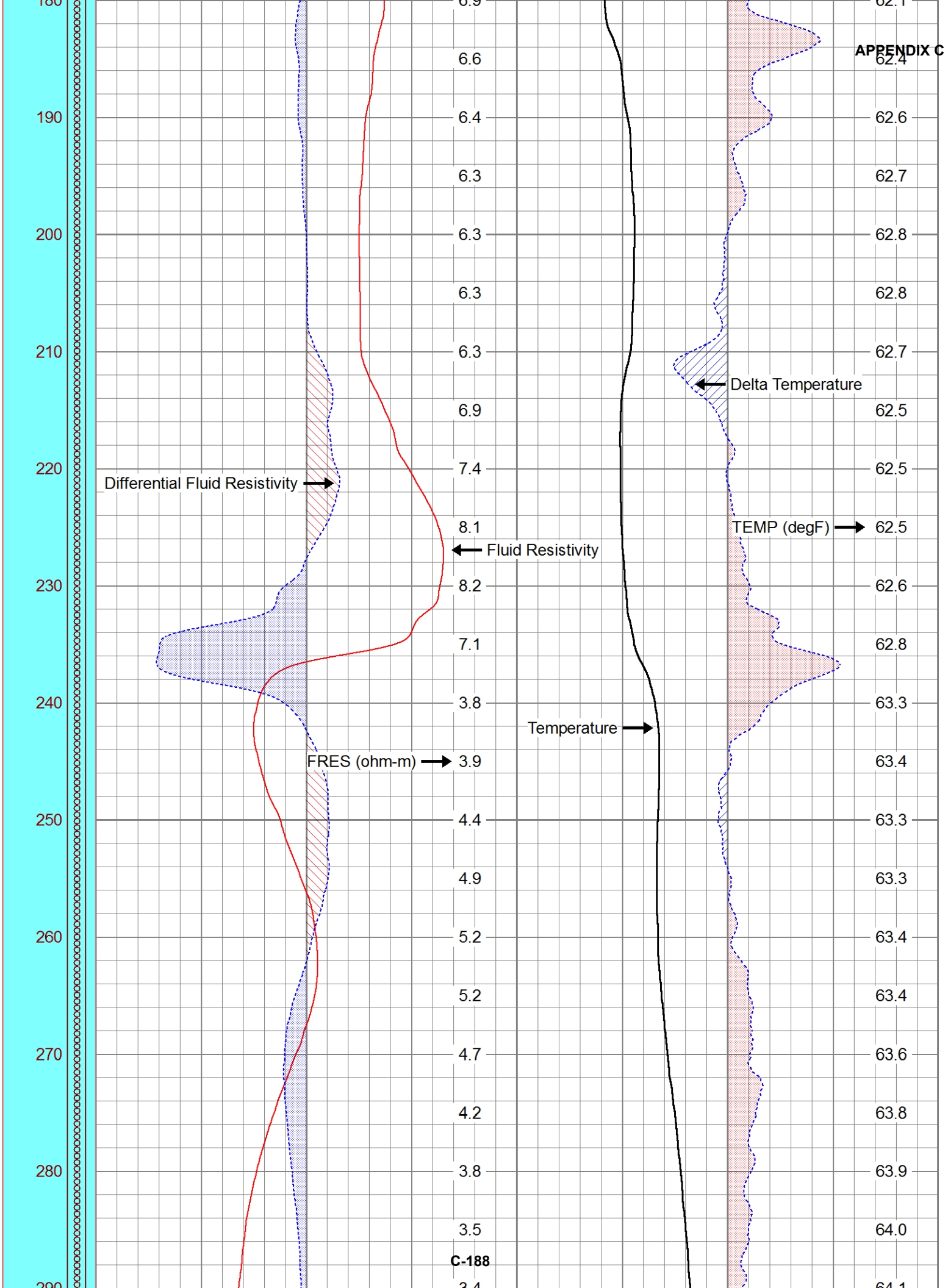
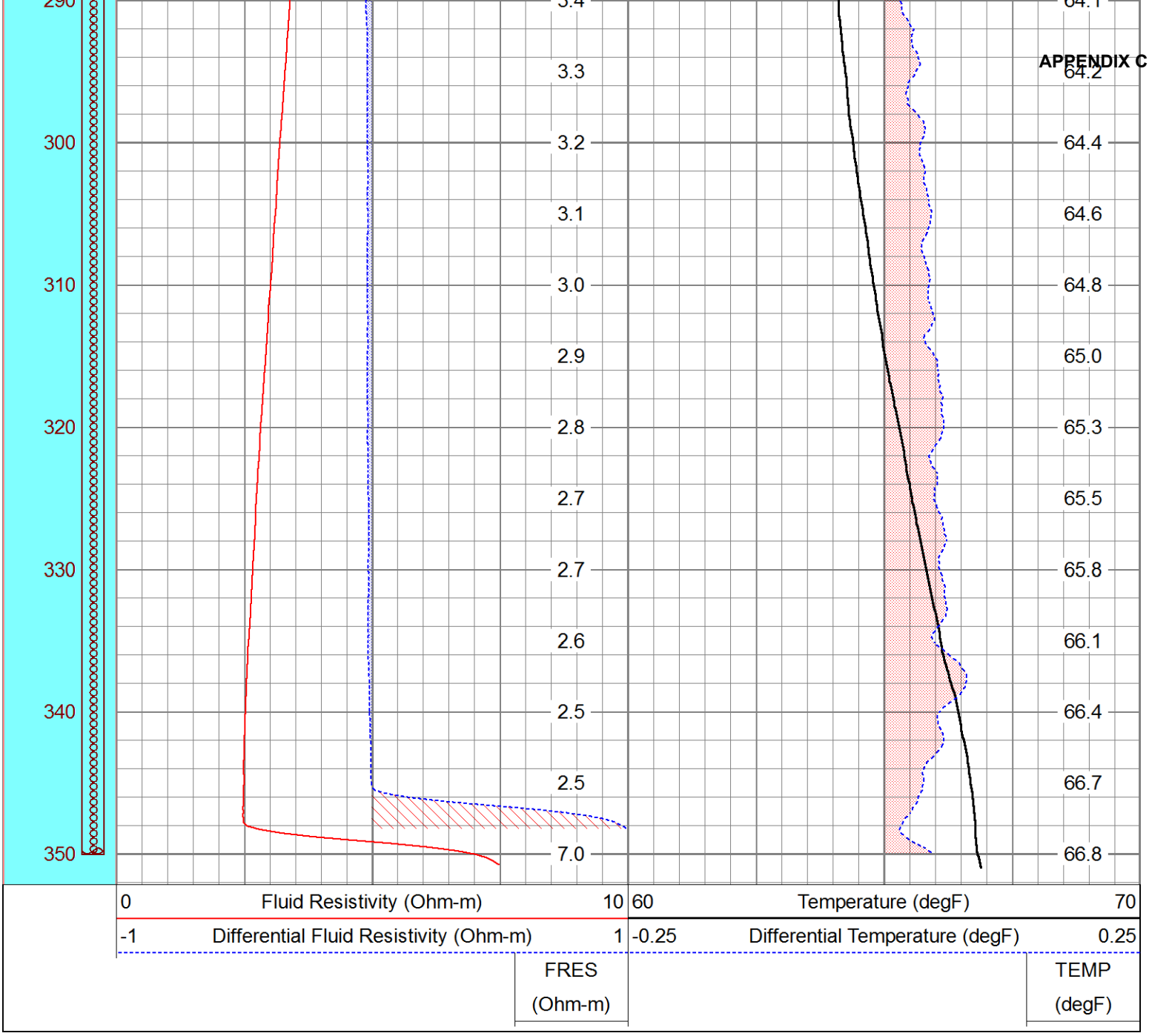
62.0
C-187


Differential Fluid Resistivity
Fluid Resistivity
FRES (ohm-m)
Temperature
Delta Temperature
TEMP (degF)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300
310
320
330
340
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3.1
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2.5
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7.0
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64.2
64.4
64.6
64.8
65.0
65.3
65.5
65.8
66.1
66.4
66.7
66.8
0
Fluid Resistivity (Ohm-m)
10
-1
Differential Fluid Resistivity (Ohm-m)
1
FRES
(Ohm-m)
60
Temperature (degF)
70
-0.25
Differential Temperature (degF)
0.25
TEMP
(degF)

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19744

File No.

Company CASCADE DRILLING

Well MW-7D

Field MARINA

County MONTEREY State CA

Location

LAPIS RD. NEAR SOUTHERN INT. WITH DEL MONTE BLVD.
GPS: N 36o 42' 23" W 121o 47' 20"

Other Services:

TEMPERATURE
FLUID RESISTIVITY

Permanent Datum	G.L.	Elevation 0'	above perm. datum	Elevation K.B.:	
Log Measured From	G.L.			D.F.:	
Drilling Measured From	G.L.			G.L.	

Date	07-07-2015								
Run Number	ONE								
Depth Driller	351'								
Depth Logger	350'								
Bottom Logged Interval	350'								
Top Log Interval	40'								
Open Hole Size	10.75" (0'-97')			9.875" (97'-257')			8" (257'-351')		
Type Fluid	WATER								
Density / Viscosity	N/A								
Fluid Level	45'								
Bentonite Seal	N/A								
Time Well Ready	1230								
Time Logger on Bottom	1245								
Equipment Number	PS-8								
Location	LA								
Recorded By	SCHUMACHER								
Witnessed By	J. SOBOLEW								

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	97'				
TWO	9.875"	97'	257'				
THREE	8"	257'	351'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	351'
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19744.db
Dataset Pathname	dil
Dataset Creation	Tue Jul 07 13:52:31 2015

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1432.080	3651.560	cps	0.000	612.000	mmho/m	0.276	-394.883
Medium	2032.000	14281.200	cps	0.000	1960.000	mmho/m	0.160	-325.140

Gamma Ray Calibration Report

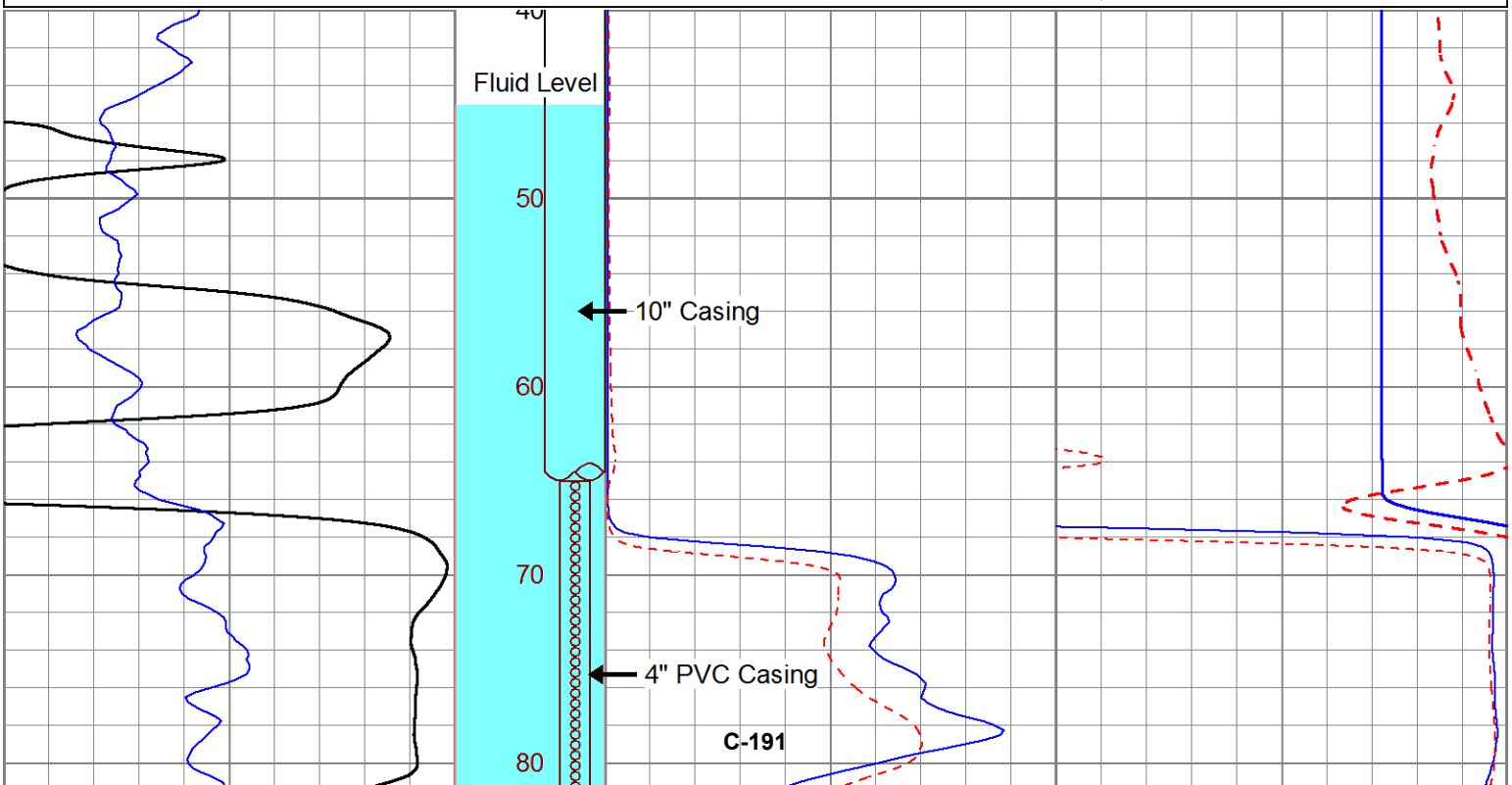
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

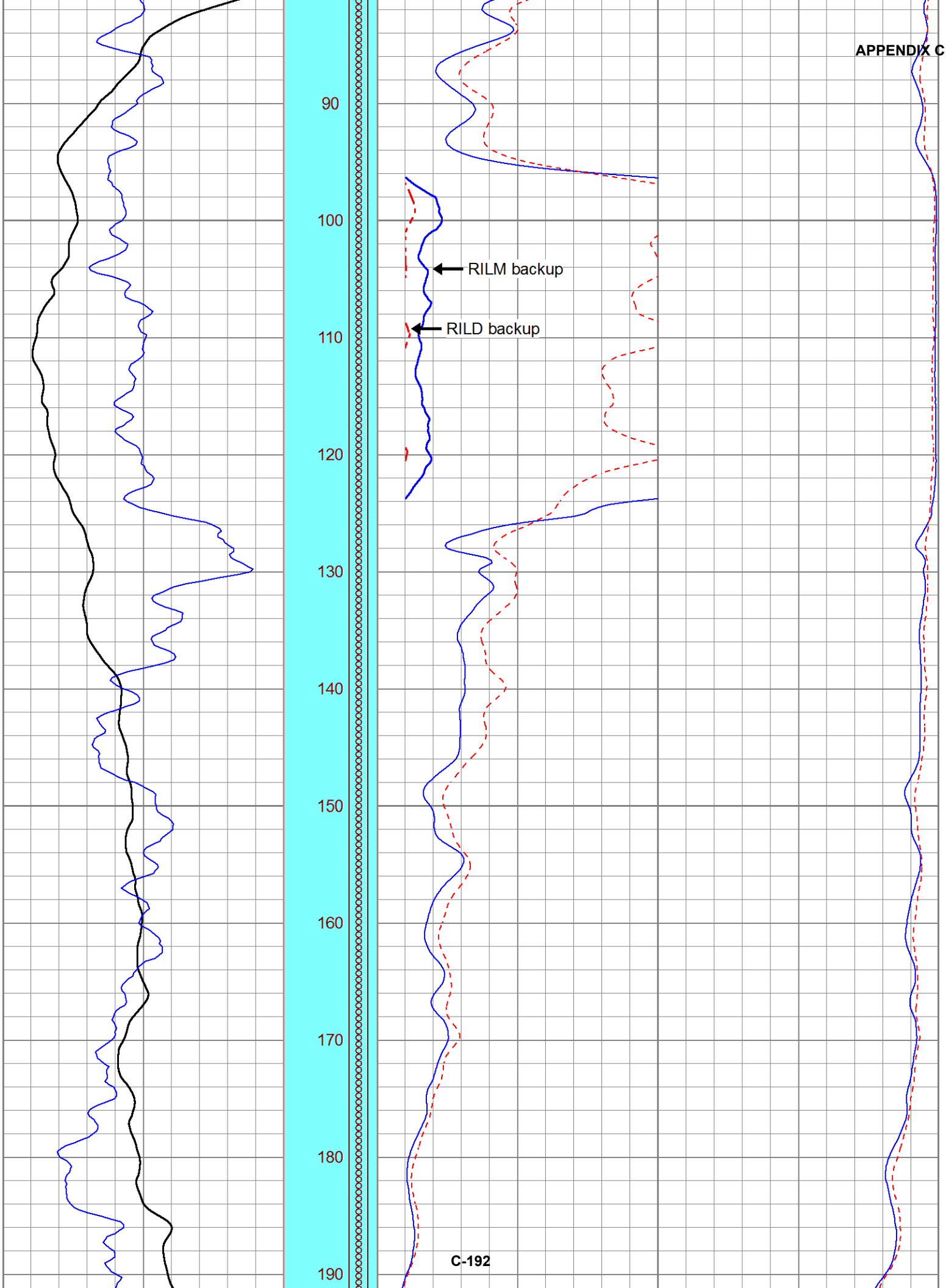
Database File	19744.db
Dataset Pathname	dil
Presentation Format	dil
Dataset Creation	Tue Jul 07 13:52:31 2015
Charted by	Depth in Feet scaled 1:120

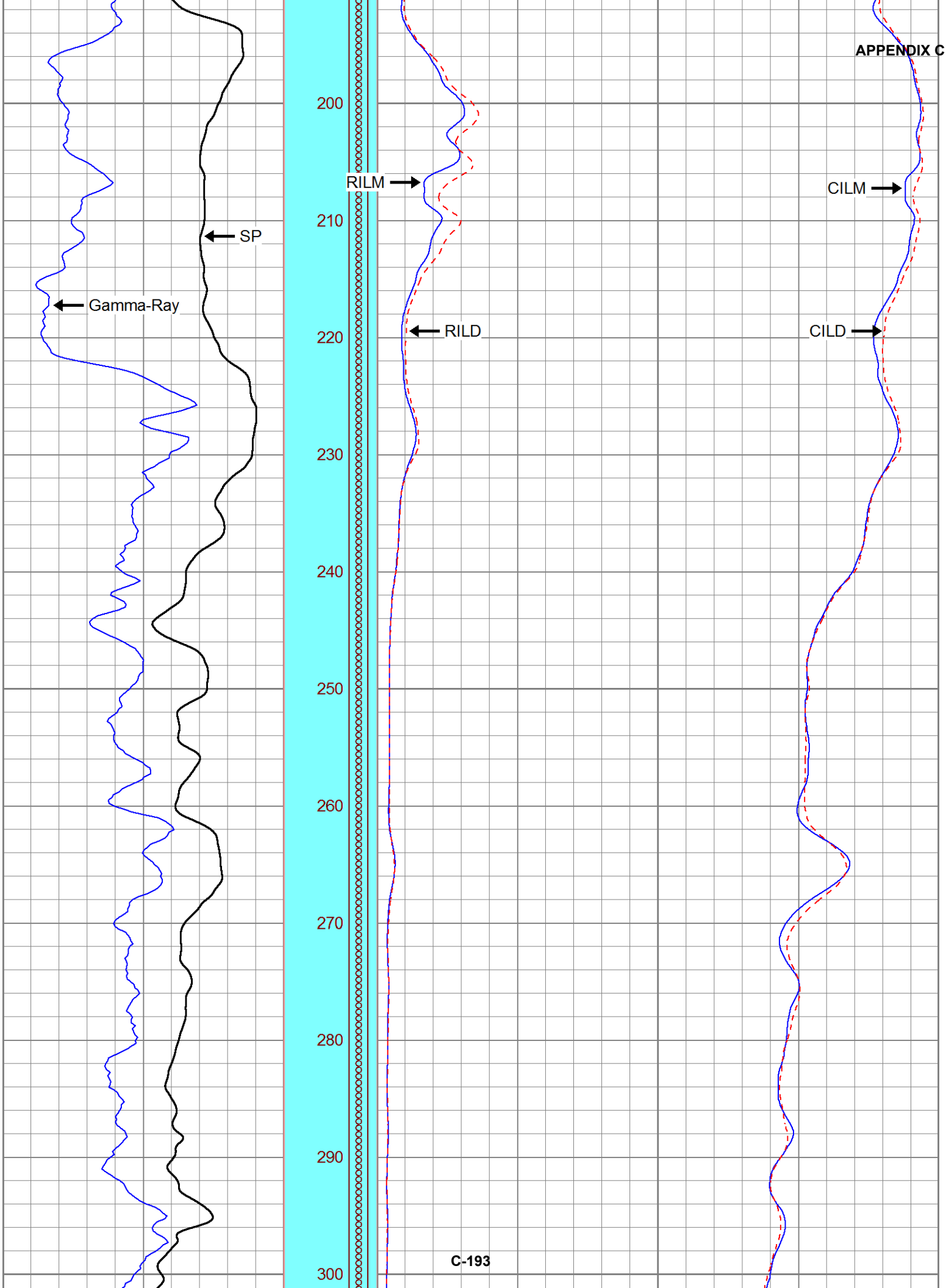
-10	SP (mV)	90
10	Gamma-Ray (GAPI)	110

0	RILM (Ohm-m)	50
0	RILD (Ohm-m)	50
50	RILM backup (Ohm-m)	500
50	RILD backup (Ohm-m)	500

1000	CILM (mmho/m)	0
1000	CILD (mmho/m)	0
	CILD backup	
10000	(mmho/m)	1000
	CILM backup	
10000	(mmho/m)	1000




90
100
110
120
130
140
150
160
170
180
190
RILM backup
RILD backup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210
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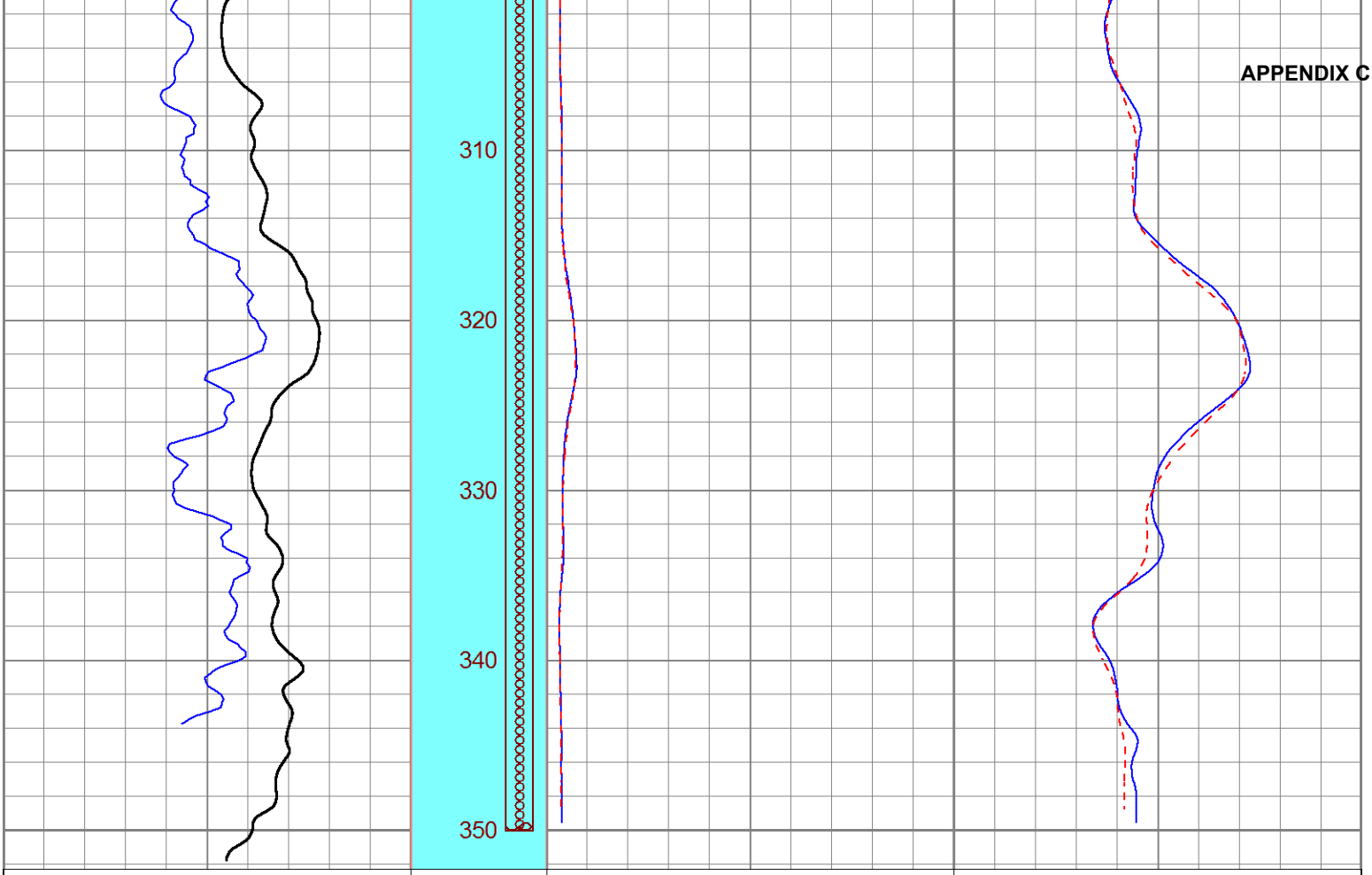
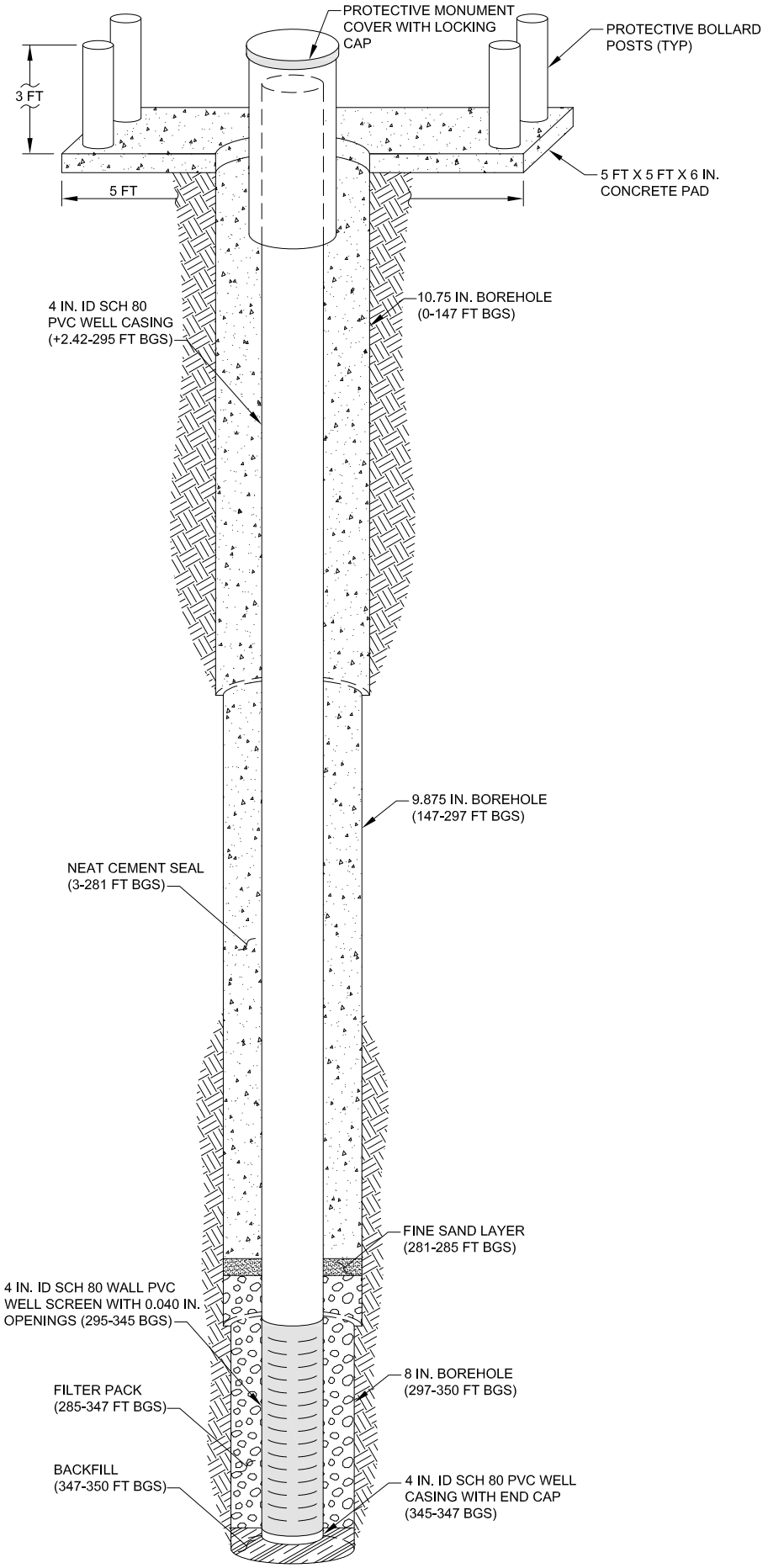
240
250
260
270
280
290
300
SP
Gamma-Ray
RILM
RILD
CILM
CILD


310
320
330
340
350
-10 SP (mV) 90
10 Gamma-Ray (GAPI) 110
0 RILM (Ohm-m) 50
0 RILD (Ohm-m) 50
50 RILM backup (Ohm-m) 500
50 RILD backup (Ohm-m) 500
1000 CILM (mmho/m) 0
1000 CILD (mmho/m) 0
CILD backup
10000 (mmho/m) 1000
CILM backup
10000 (mmho/m) 1000



WELL PROFILE

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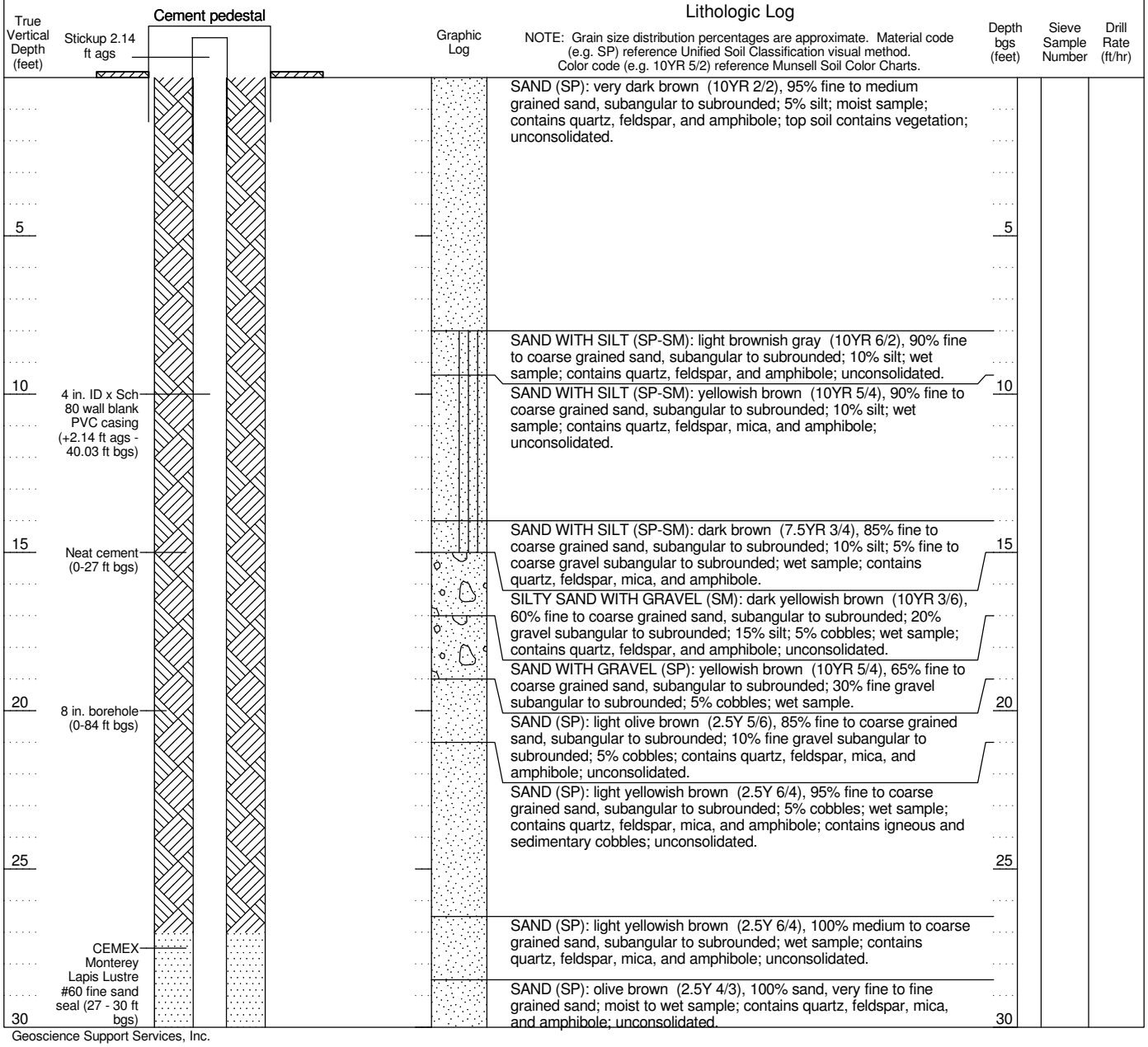
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-8S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.14**	**40.03**	**42.17**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**40.03**	**80.03**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**80.03**	**82.54**	**2.51**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	17.82 ft NAVD88									
TOC ELEVATION	19.96 ft NAVD88 (RP)									
START DATE	5/12/15									
FINISH DATE	5/13/15									



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WELL NUMBER **MPWSP MW-8S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35	CEMEX Monterey Lapis Lustre #3 filter pack (30 - 82.54 ft bgs)			35		
40			CLAY (CL): olive gray (5Y 4/2), 90% clay, high plasticity; 10% silt; moist sample.	40		
45	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (40.03-80.03 ft bgs)		SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	45		
50			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	50		
55			SAND (SP): brown (10YR 4/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole; contains igneous and sedimentary gravel; unconsolidated.	55		
60			SAND (SP): grayish brown (10YR 5/2), 100% medium to coarse grained sand, subangular to rounded, predominately coarse grained sand; wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	60		
65			SAND (SP): dark brown (10YR 3/3), 95% sand, very fine to fine grained sand; 5% silt; trace cobbles; moist to wet sample; contains rounded igneous and sedimentary cobbles (less than 5%); unconsolidated.	65		4
70				70		

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WELL NUMBER
MPWSP MW-8S

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 80% fine to coarse grained sand, subangular to subrounded; 15% gravel subangular to subrounded; 5% cobbles; contains quartz, feldspar, and amphibole; contains igneous and sedimentary cobbles; unconsolidated.			
75			SAND (SP): dark yellowish brown (10YR 3/4), 100% sand, very fine to fine grained sand; moist to wet sample; contains quartz, feldspar, mica, and amphibole; contains lens of coarse gravel; unconsolidated.	75		4
80	Blank casing with end cap (80.03-82.54 ft bgs)			80		
	TD 84 ft bgs		Bottom of borehole at 84 feet.			

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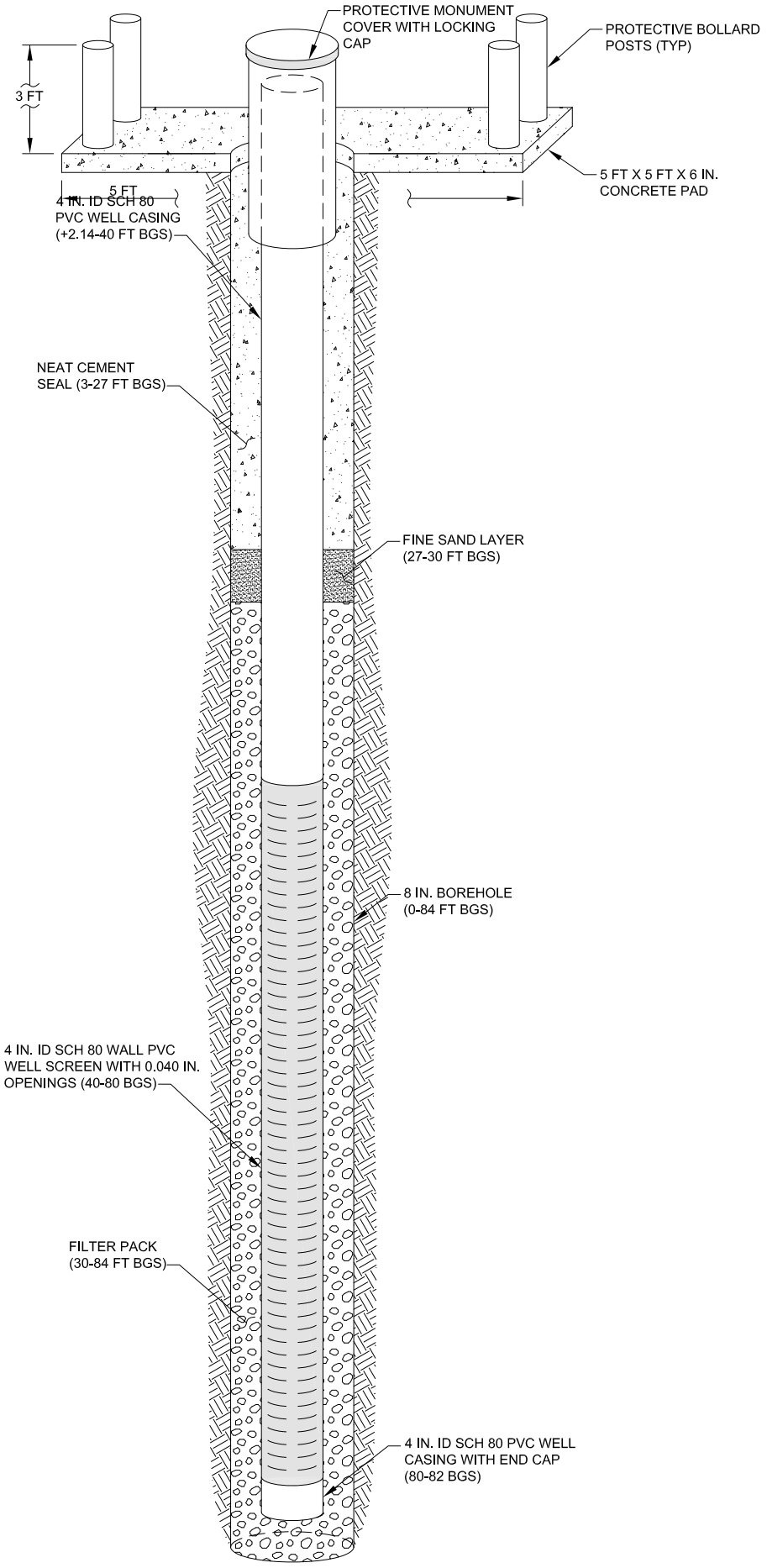

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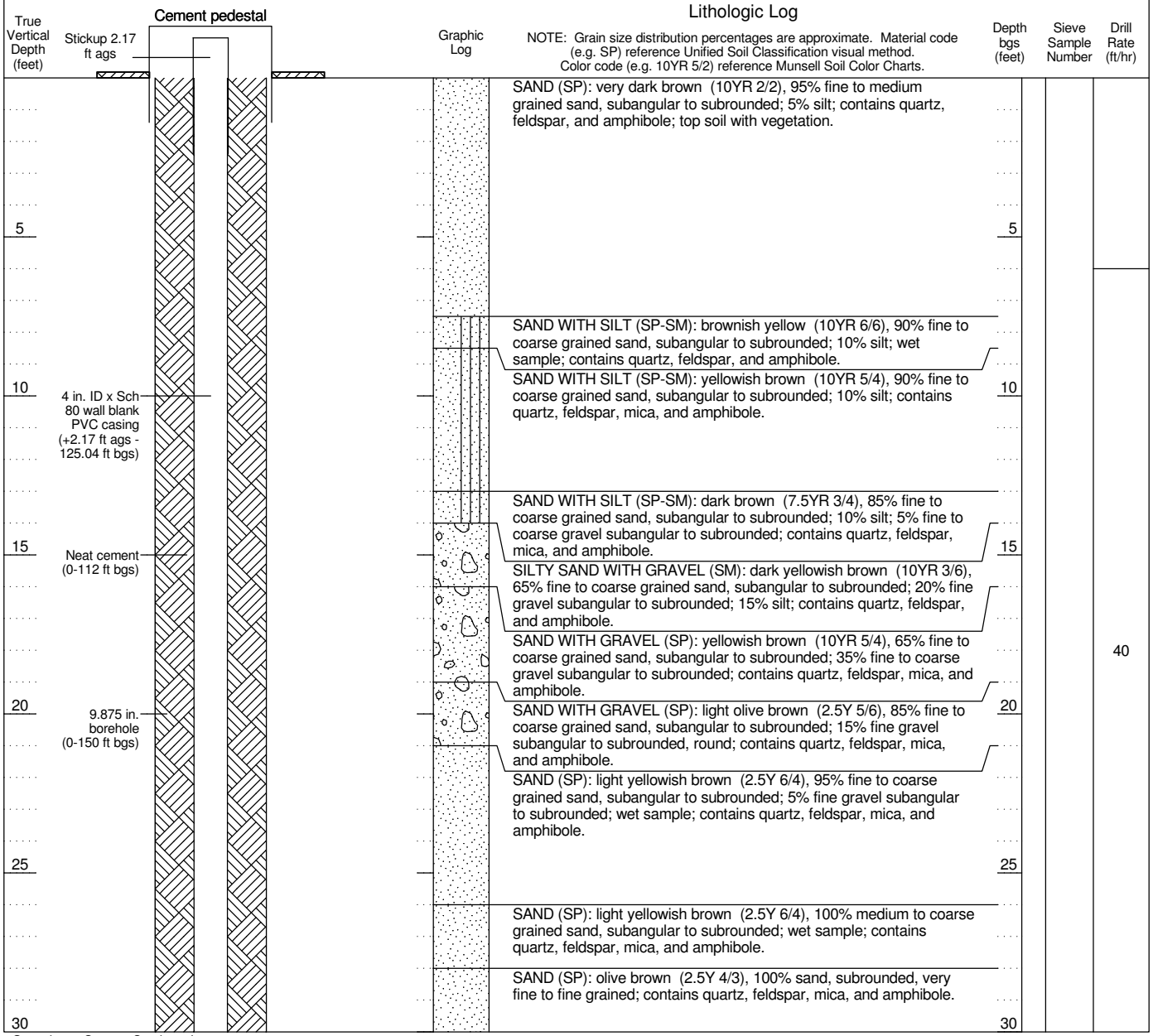
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-8M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.17**	**125.04**	**127.21**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**125.04**	**215.04**	**90**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**215.04**	**217.54**	**2.5**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	17.82 ft NAVD88									
TOC ELEVATION	19.99 ft NAVD88 (RP)									
START DATE	5/04/15									
FINISH DATE	5/12/15									



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WELL NUMBER **MPWSP MW-8M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35				35		40
40			SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole.	40		
45				45		
50			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole.	50		26
55				55		
60			SAND (SP): brown (10YR 4/3), 90% fine to coarse grained sand, subangular to subrounded; 10% gravel subangular to subrounded; contains quartz, feldspar, and amphibole. SAND (SP): grayish brown (10YR 5/2), 100% medium to coarse grained sand, subangular to rounded, predominantly coarse grained; wet sample; contains quartz, feldspar, and amphibole.	60		
65			SAND (SP): dark brown (10YR 3/3), 95% sand, very fine to fine grained; 5% silt; trace cobbles; moist sample; contains trace cobbles.	65		
70				70		

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WELL NUMBER **MPWSP MW-8M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 80% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subrounded to rounded; contains quartz, feldspar, and amphibole.	75		26
80			SAND (SP): dark yellowish brown (10YR 3/4), 100% sand, very fine to fine grained; moist sample; contains quartz, feldspar, mica, and amphibole.	80		
85			SANDY SILT (ML): dark yellowish brown (10YR 4/6), 60% silt; 40% sand, very fine to fine grained; contains quartz, feldspar, mica, and amphibole.	85		
90			FAT CLAY (CH): grayish brown (2.5Y 5/2) and grayish green (5G 4/2), 100% clay, high plasticity.	90		
95				95		
100				100		
105				105		
110			SILT (ML): light olive brown (2.5Y 5/4), 75% silt; 15% clay, medium plasticity; 10% fine grained sand; moist sample.	110		

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WELL NUMBER
MPWSP MW-8M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115	CEMEX Monterey Lapis Lustre #60 fine sand seal (112 - 115 ft bgs)		SAND (SP): light olive brown (2.5Y 5/3), 100% fine to medium grained sand, subangular to subrounded, predominantly medium grained; moist sample; contains quartz, feldspar, mica, and amphibole.	115		
120	CEMEX Monterey Lapis Lustre #3 filter pack (115 - 220 ft bgs)		SAND WITH GRAVEL (SP): brown (10YR 5/3), 85% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, and amphibole; contains slight clay matrix.	120		
125				125		
130	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (125.04-215.04 ft bgs)			130		8
135			FAT CLAY (CH): light yellowish brown (2.5Y 6/3), 100% clay, medium plasticity.	135		
140			SAND WITH GRAVEL (SP): dark grayish brown (10YR 4/2), 70% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel subangular to subrounded; trace silt; contains quartz, feldspar, mica, and amphibole.	140		
			SILT (ML): olive (5Y 5/3), 100% silt; low to medium plasticity.			
145			SAND WITH GRAVEL (SP): pale brown (10YR 6/3), 75% fine to coarse grained sand; 25% fine to coarse gravel; medium sorted; contains quartz, feldspar, mica, and amphibole.	145		
150			SILT (ML): olive (5Y 5/3), 100% silt.	150		

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WELL NUMBER **MPWSP MW-8M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
8 in. borehole (150-220 ft bgs)		SAND WITH GRAVEL (SP): dark yellowish brown (10YR 4/6), 75% fine to coarse grained sand, subangular to subrounded, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded, subrounded; contains quartz, feldspar, and amphibole.			
155			155		
160		CLAYEY GRAVEL (GC): dark olive gray (5Y 3/2), 50% fine to coarse gravel subrounded to rounded; 45% clay, medium plasticity; 5% fine to coarse grained sand, subrounded to rounded; contains quartz, feldspar, and amphibole.	160		
		SAND WITH GRAVEL (SP): very dark grayish brown (10YR 3/2), 75% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded; trace silt; wet sample; contains quartz, feldspar, and amphibole; contains Monterey Shale.			8
165			165		
		SAND WITH GRAVEL (SP): dark yellowish brown (10YR 3/6), 85% fine to coarse grained sand, subrounded to rounded; 15% fine to coarse gravel subrounded to rounded; wet sample; contains quartz, feldspar, and amphibole; contains Monterey Shale.			
170			170		
		SAND (SP): very dark grayish brown (10YR 3/2), 100% fine grained sand; wet sample; weak cementation; contains quartz, feldspar, mica, and amphibole; grain size becomes fine from 210 ft to 220 ft and contains high amphibole content and silt (5% to 10%).			
175			175		
180			180		30
185			185		
190			190		

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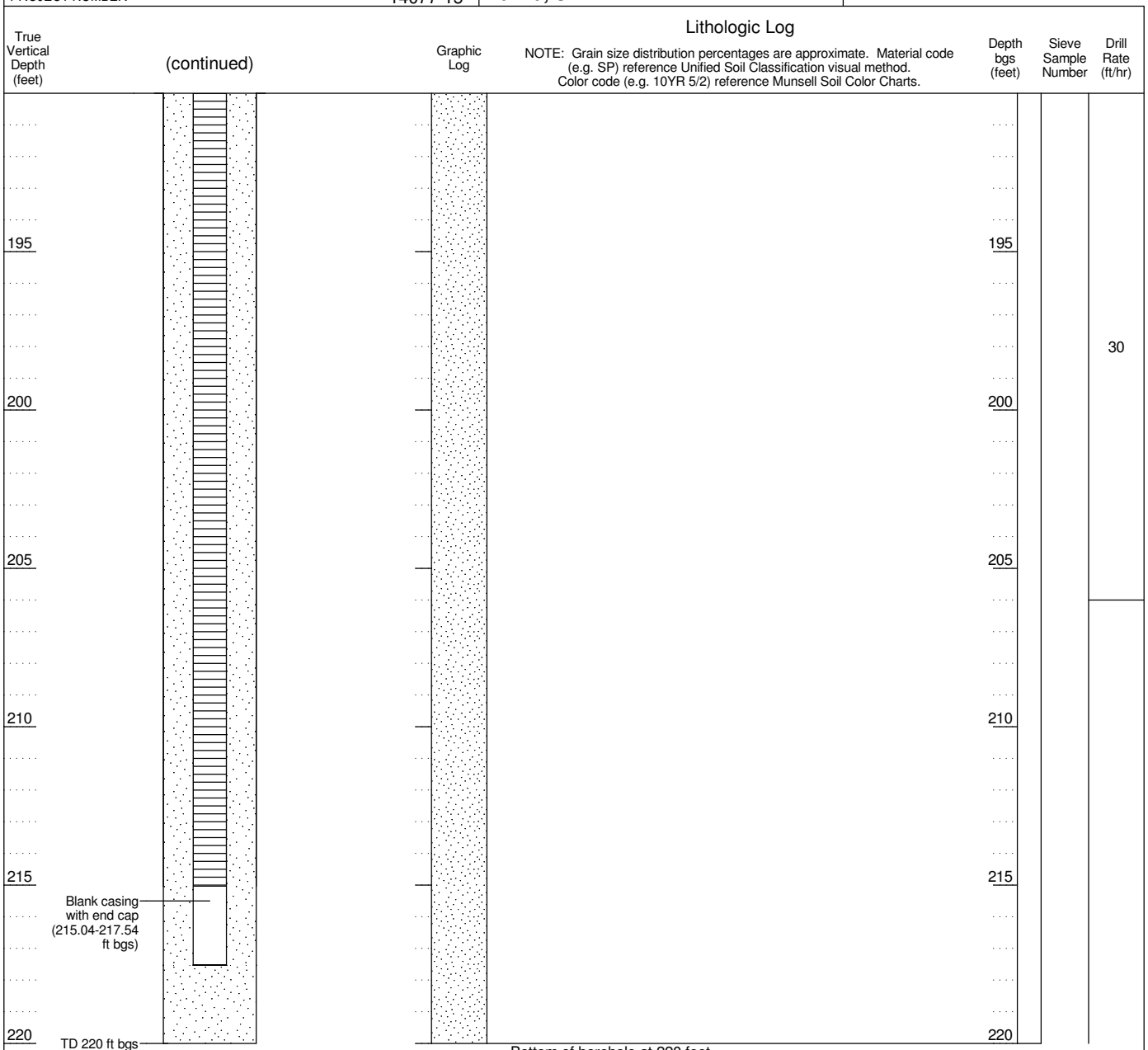
WELL NUMBER **MPWSP MW-8M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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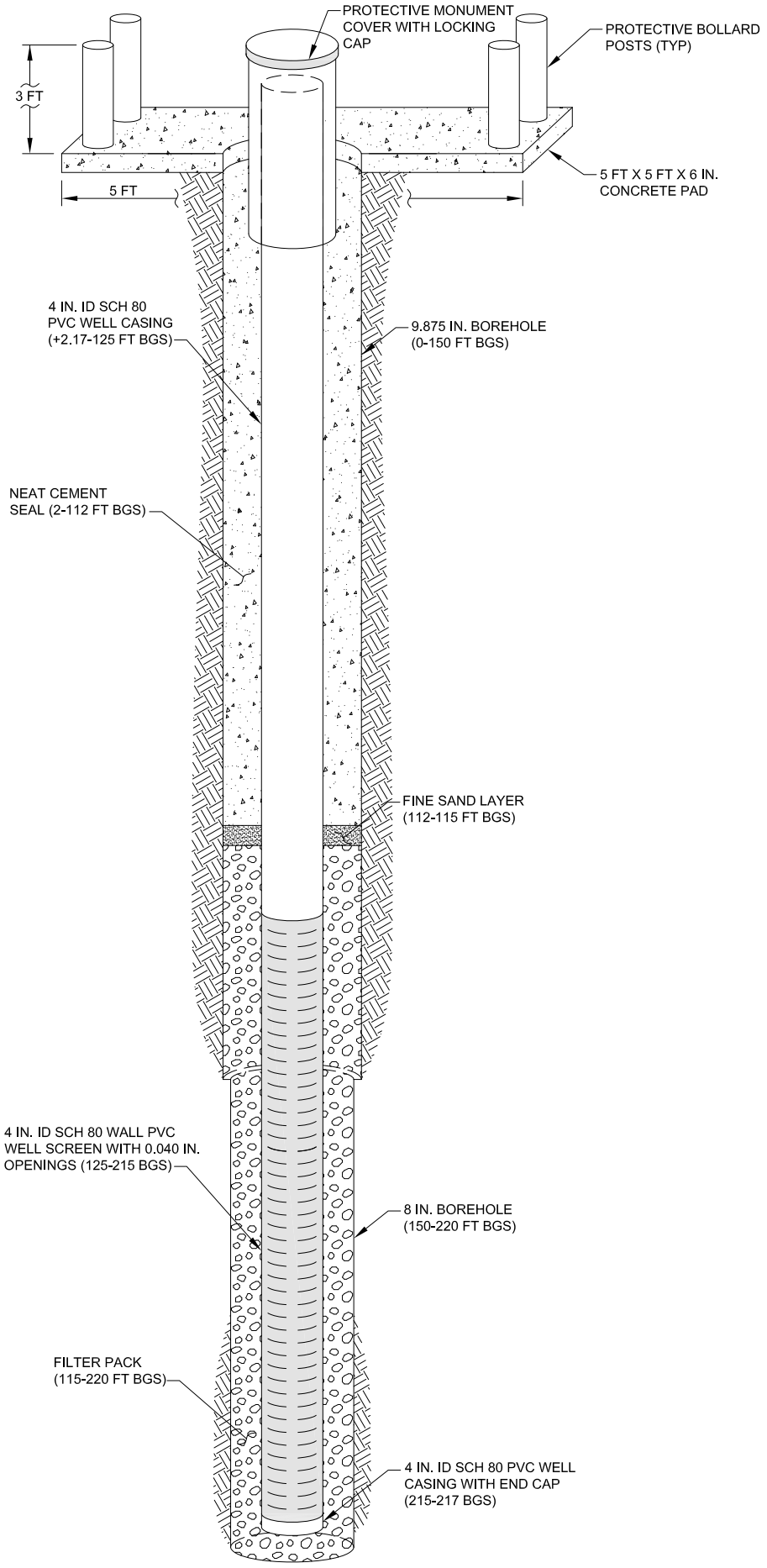

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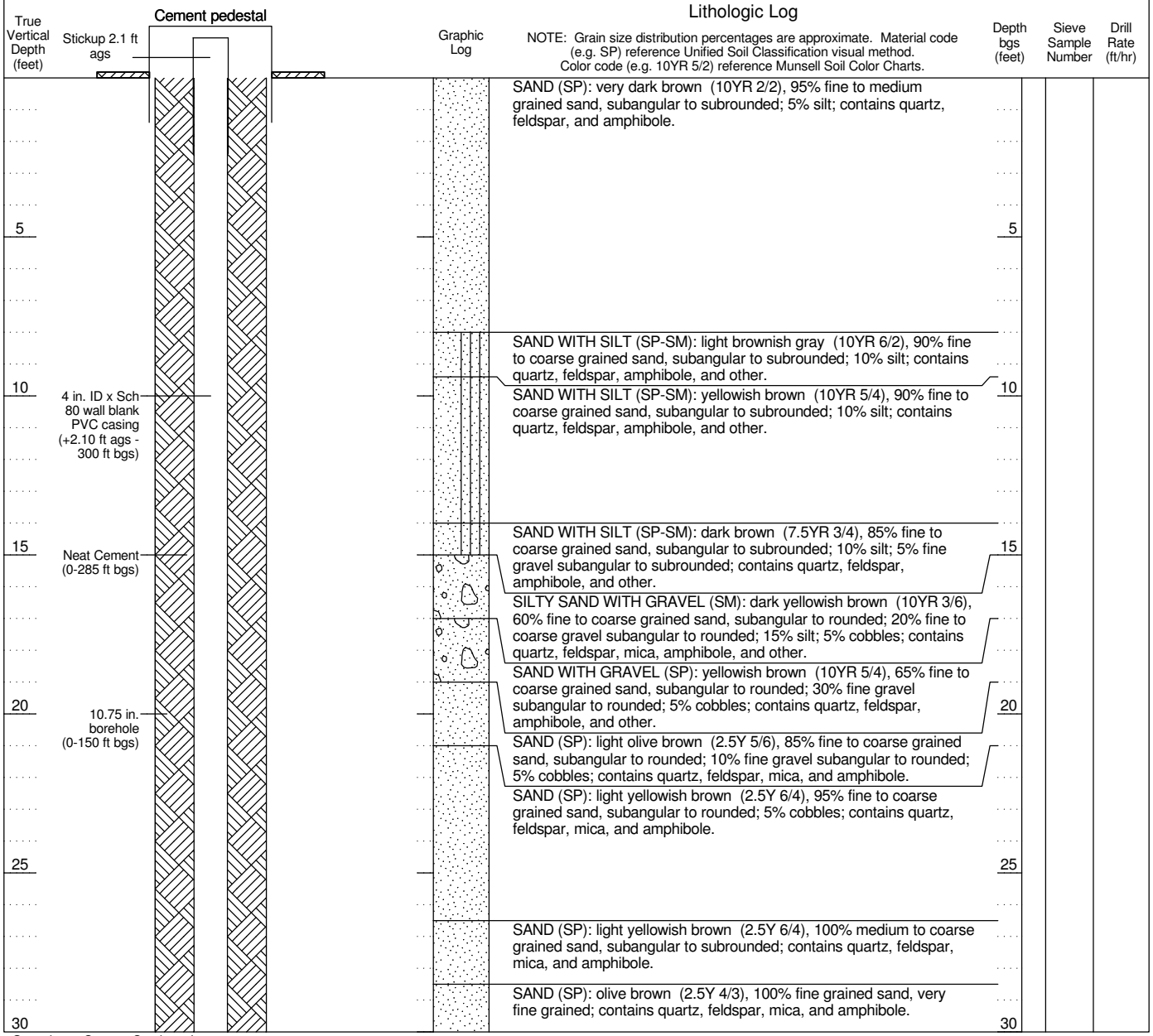
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-8D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.1**	**300**	**302.1**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**300**	**350**	**50**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**350**	**352.8**	**2.8**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	17.98 ft NAVD88									
TOC ELEVATION	20.08 ft NAVD88 (RP)									
START DATE	4/14/15									
FINISH DATE	5/03/15									



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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35				35		
40				40		
			CLAY (CL): olive gray (5Y 4/2), 90% clay, high plasticity; 10% silt.			
			SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, amphibole, and other.			
45				45		
			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole.			
50				50		
			SAND (SP): brown (10YR 4/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole.		1	
55			SAND (SP): grayish brown (10YR 5/2), 100% medium to coarse grained sand, subangular to rounded; contains quartz, feldspar, and amphibole.	55		
60				60	2	
			SAND (SP): dark brown (10YR 3/3), 95% fine grained sand, subangular to subrounded; 5% silt; trace cobbles; contains quartz, feldspar, mica, and amphibole.			
65				65		
						9
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 80% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, and amphibole.		3	
75			SAND (SP): dark yellowish brown (10YR 3/4), 100% fine grained sand, some very fine; contains quartz, feldspar, mica, and amphibole.	75		
80				80	4	
85			SAND WITH GRAVEL (SP): grayish brown (2.5Y 5/2), 85% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; contains quartz, feldspar, and amphibole.	85		
			SAND (SP): black (N2.5), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole.			
			FAT CLAY (CH): grayish brown (2.5Y 5/2), 100% clay, medium to high plasticity.			
90				90		9
			FAT CLAY (CH): grayish green (5G 4/2), 100% clay, medium to high plasticity.			
95				95		
100				100		
105				105		
			SILT (ML): light olive brown (2.5Y 5/4), 60% silt; 30% clay, low to medium plasticity; 10% fine grained sand.			
110				110		

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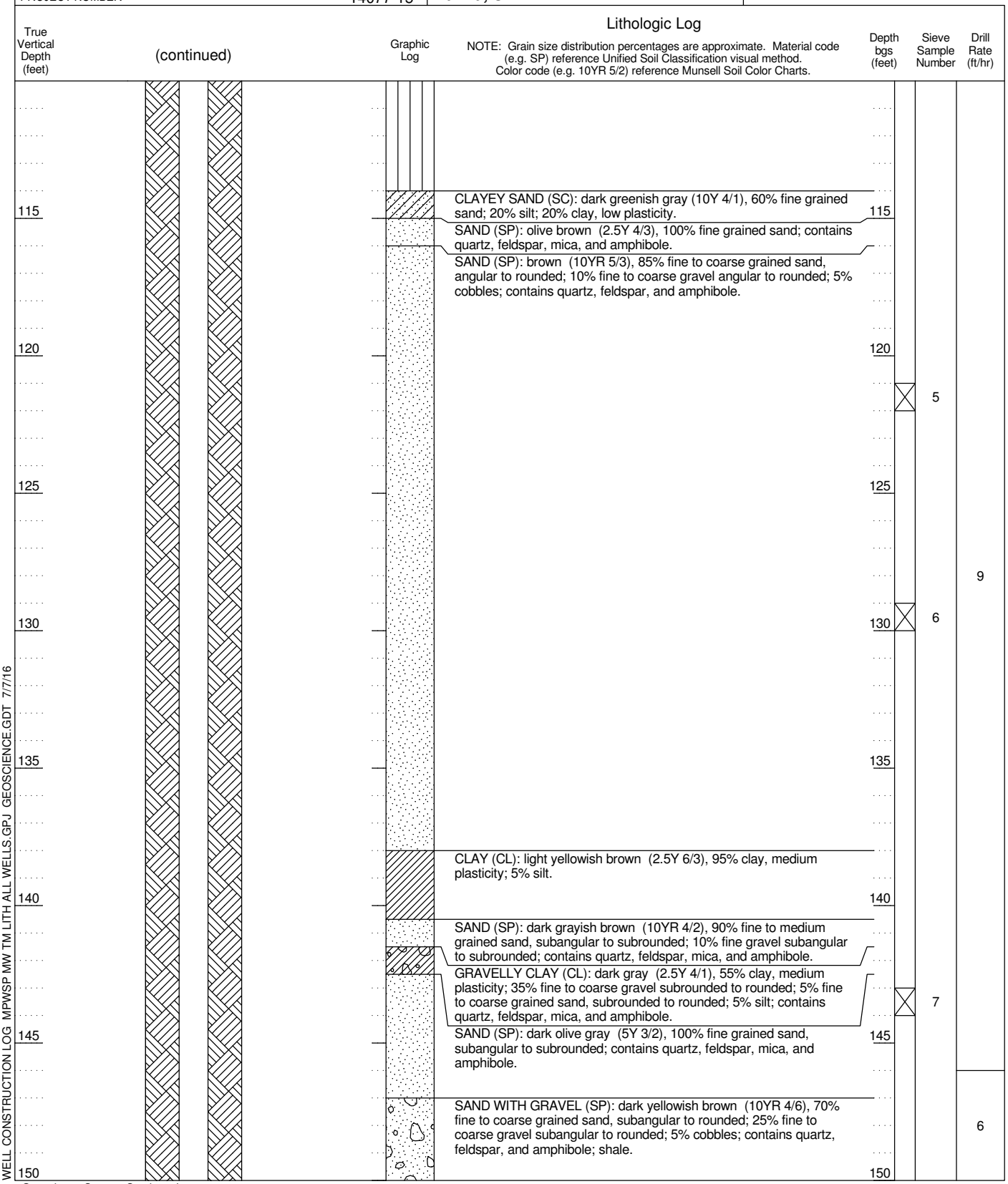
WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	9.875 in. borehole (150-280 ft bgs)				8	
155			CLAYEY GRAVEL (GC): dark olive gray (5Y 3/2), 50% fine to coarse gravel subangular to rounded; 30% clay, medium to high plasticity; 5% fine to coarse grained sand, subangular to rounded; 5% silt; 10% cobbles; contains quartz, feldspar, and amphibole; shale.	155		
			SAND WITH GRAVEL (SP): dark yellowish brown (10YR 4/6), 70% fine to coarse grained sand, subangular to rounded; 25% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, and amphibole; shale.			
160				160		
			SAND (SP): yellowish brown (10YR 5/4), 90% fine grained sand, subrounded to rounded; 5% fine to coarse gravel subrounded to rounded; 5% cobbles; contains quartz, feldspar, and amphibole; shale.		9	
165			SAND WITH GRAVEL (SP): very dark grayish brown (10YR 3/2), 70% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; 5% silt; 5% cobbles; contains quartz, feldspar, and amphibole.	165		
			GRAVEL WITH SAND (GP): dark yellowish brown (10YR 3/6), 80% fine to coarse gravel subrounded to rounded; 15% fine to coarse grained sand, subrounded to rounded; 5% cobbles; contains quartz, feldspar, and amphibole.			
170				170		6
			SAND (SP): very dark grayish brown (10YR 3/2), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole; friable sandstone.			
175				175	10	
180				180		
185				185		
					11	
190				190		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			SAND WITH SILT (SP-SM): very dark grayish brown (10YR 3/2), 90% fine grained sand; 10% silt; contains quartz, feldspar, mica, and amphibole; friable sandstone.	195	12	
200			SAND (SP): very dark grayish brown (10YR 3/2), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole; friable sandstone.	200		6
205			SAND WITH CLAY (SP-SC): very dark grayish brown (10YR 3/2), 85% fine grained sand; 10% silt; 5% clay; contains quartz, feldspar, mica, and amphibole; friable sandstone.	205	13	
210				210		
215				215	14	
220				220		8
225				225	15	
230			CLAY WITH SAND (CL): light olive brown (2.5Y 5/3), 80% clay, low to medium plasticity; 20% fine grained sand.	230		

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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILTY SAND (SM): light olive brown (2.5Y 5/4), 60% fine grained sand; 30% silt; 10% clay, no to low plasticity; contains quartz, feldspar, mica, and amphibole.			
			CLAY WITH SAND (CL): olive brown (2.5Y 4/3), 70% clay, low to medium plasticity; 20% fine to medium grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; 5% silt; shale.			
235			SILTY SAND WITH GRAVEL (SM): olive brown (2.5Y 4/3), 60% fine to coarse grained sand, subangular to subrounded; 15% coarse gravel subangular to subrounded; 15% silt; 10% clay, not to low plasticity; contains quartz, feldspar, and amphibole; shale.	235		
			SILTY SAND (SM): light olive brown (2.5Y 5/3), 75% fine grained sand; 20% silt; 5% clay; contains quartz, feldspar, and amphibole.			
			SANDY SILT (ML): light olive brown (2.5Y 5/3), 60% silt; 30% fine grained sand; 10% clay, no to low plasticity; contains quartz, feldspar, mica, and amphibole.			
240				240		
			CLAYEY SAND (SC): light olive brown (2.5Y 5/3), 70% fine to medium grained sand, subangular to subrounded; 20% clay; 10% silt; contains quartz, feldspar, mica, and amphibole.			
245				245		
			CLAY WITH SAND (CL): light olive brown (2.5Y 5/3), 70% clay, low to medium plasticity; 15% fine to medium grained sand, subrounded to rounded; 10% fine gravel subrounded to rounded; 5% silt; contains quartz, feldspar, mica, and amphibole.			
250			CLAYEY SAND (SC): light olive brown (2.5Y 5/3), 70% fine to coarse grained sand, subangular to rounded; 20% clay; 5% fine to coarse gravel subangular to rounded; 5% silt; trace cobbles; contains quartz, feldspar, mica, and amphibole.	250		8
			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 80% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; 5% silt; trace cobbles; contains quartz, feldspar, and amphibole.		16	
255				255		
			CLAY (CL): light brownish gray (2.5Y 6/2), 95% clay, low to medium plasticity; 5% silt.			
			CLAY WITH SAND (CL): light yellowish brown (2.5Y 6/4), 70% clay, low plasticity; 25% fine to coarse grained sand; 5% silt.			
260				260		
265				265		
			CLAY (CL): dark yellowish brown (10YR 4/4), 85% clay, low plasticity; 10% fine grained sand; 5% silt.			
270			CLAYEY SAND (SC): olive brown (2.5Y 4/3), 70% fine grained sand; 30% clay, low plasticity; contains quartz, feldspar, mica, and	270		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			amphibole.			
			CLAY (CL): dark grayish brown (2.5Y 4/2), 100% clay, medium plasticity.			8
275				275		
			CLAY (CL): dark yellowish brown (10YR 3/6), 100% clay, medium to high plasticity.			
280	8 in. borehole (280-360 ft bgs)			280		
285				285		
	CEMEX Monterey Lapis Lustre #60 fine sand seal (285 - 288 ft bgs)		SILTY SAND (SM): light olive brown (2.5Y 5/4), 80% fine grained sand; 15% silt; 5% clay, no to low plasticity.			
290				290		
	CEMEX Monterey Lapis Lustre #3 filter pack (288 - 360 ft bgs)					5
295			CLAY (CL): light olive brown (2.5Y 5/3), 80% clay, low plasticity; 15% silt; 5% fine grained sand.	295		
			SAND WITH GRAVEL (SP): gray (2.5Y 5/1), 85% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; contains quartz, feldspar, and amphibole; shale.			
300				300	17	
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (300 - 350 ft bgs)					
305				305		
310				310		

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WELL NUMBER
MPWSP MW-8D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
					18	
			SAND WITH GRAVEL (SP): gray (2.5Y 5/1), 65% fine to coarse grained sand, subangular to rounded; 35% fine to coarse gravel subangular to rounded; trace clay; contains quartz, feldspar, and amphibole; shale.			
315			FAT CLAY WITH SAND (CH): light olive brown (2.5Y 5/3), 70% clay, medium to high plasticity; 10% fine to coarse gravel subrounded to rounded; 10% fine to coarse grained sand, subrounded to rounded; 10% cobbles; contains quartz, feldspar, and amphibole.	315		5
			SAND WITH GRAVEL (SP): gray (2.5Y 5/1), 60% fine to coarse grained sand, subrounded to rounded; 20% fine to coarse gravel subrounded to rounded; 20% cobbles; contains quartz, feldspar, and amphibole; shale.			
320			SAND (SP): light olive brown (2.5Y 5/3), 90% fine to coarse grained sand, subangular to rounded; 5% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, and amphibole.	320		
					19	
325			FAT CLAY (CH): yellowish brown (10YR 5/8), 100% clay, high plasticity.	325		
330			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole.	330		
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
335				335	20	
340				340		
			SAND (SP): olive brown (2.5Y 4/4), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
345				345		
350				350		

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WELL NUMBER
MPWSP MW-8D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	Blank casing with end cap (350-352.8 ft bgs)		FAT CLAY WITH GRAVEL (CH): light olive brown (2.5Y 5/3), 70% clay, medium to high plasticity; 15% fine to coarse gravel subrounded to rounded; 10% fine to coarse grained sand, subrounded to rounded; 5% cobbles; contains quartz, feldspar, and amphibole; shale.			
			FAT CLAY (CH): light olive brown (2.5Y 5/3), 100% clay, medium to high plasticity.			
355				355		
			SILTY SAND (SM): dark gray (2.5Y 4/1), 70% fine to coarse grained sand, subrounded to rounded; 10% fine to coarse gravel subrounded to rounded; 10% silt; 5% clay; 5% cobbles; contains quartz, feldspar, and amphibole; shale.			
360	TD 360 ft bgs		FAT CLAY WITH GRAVEL (CH): light olive brown (2.5Y 5/3), 85% clay, medium to high plasticity; 15% fine to coarse gravel rounded; rounded; trace cobbles; shale.	360		
			Bottom of borehole at 360 feet.			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19537

File No.

Company CASCADE DRILLING

Well MW-8D

Field SALINAS

County MONTEREY State CA

Location

325 MONTE RD.
GPS: N 36o 43' 36" W 121o 47' 15"

Other Services:

DUAL INDUCTION
GAMMA-RAY

		Elevation	Elevation
Permanent Datum	G.L.		
Log Measured From	G.L.	0' above perm. datum	K.B.:
Drilling Measured From	G.L.		D.F.:
			G.L.:

Date	04-20-2015										
Run Number	ONE										
Depth Driller	360'										
Depth Logger	355'										
Bottom Logged Interval	355'										
Top Log Interval	0'										
Open Hole Size	10.75" (0'-150')						9.875" (150'-276')			8" (250'-340')	
Type Fluid	WATER										
Density / Viscosity	N/A										
Fluid Level	14'										
Bentonite Seal	N/A										
Time Well Ready	1200										
Time Logger on Bottom	1230										
Equipment Number	PS-8										
Location	LA										
Recorded By	SCHUMACHER										
Witnessed By	A. KHALIGHI										

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	150'				
TWO	9.875"	150'	276'				
THREE	8"	267'	360'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	360'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19537.db
Dataset Pathname	tmp
Dataset Creation	Mon Apr 20 12:35:45 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Mon Feb 23 16:47:18 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

FRT Calibration Report

Serial Number:	3553
Tool Model:	MLS
Performed:	Mon Feb 23 16:47:15 2015

Resistivity Calibration:

System Reading	Calibration Reference
32145.000 cps	1.800 Ohm-m
11466.000 cps	86.960 Ohm-m

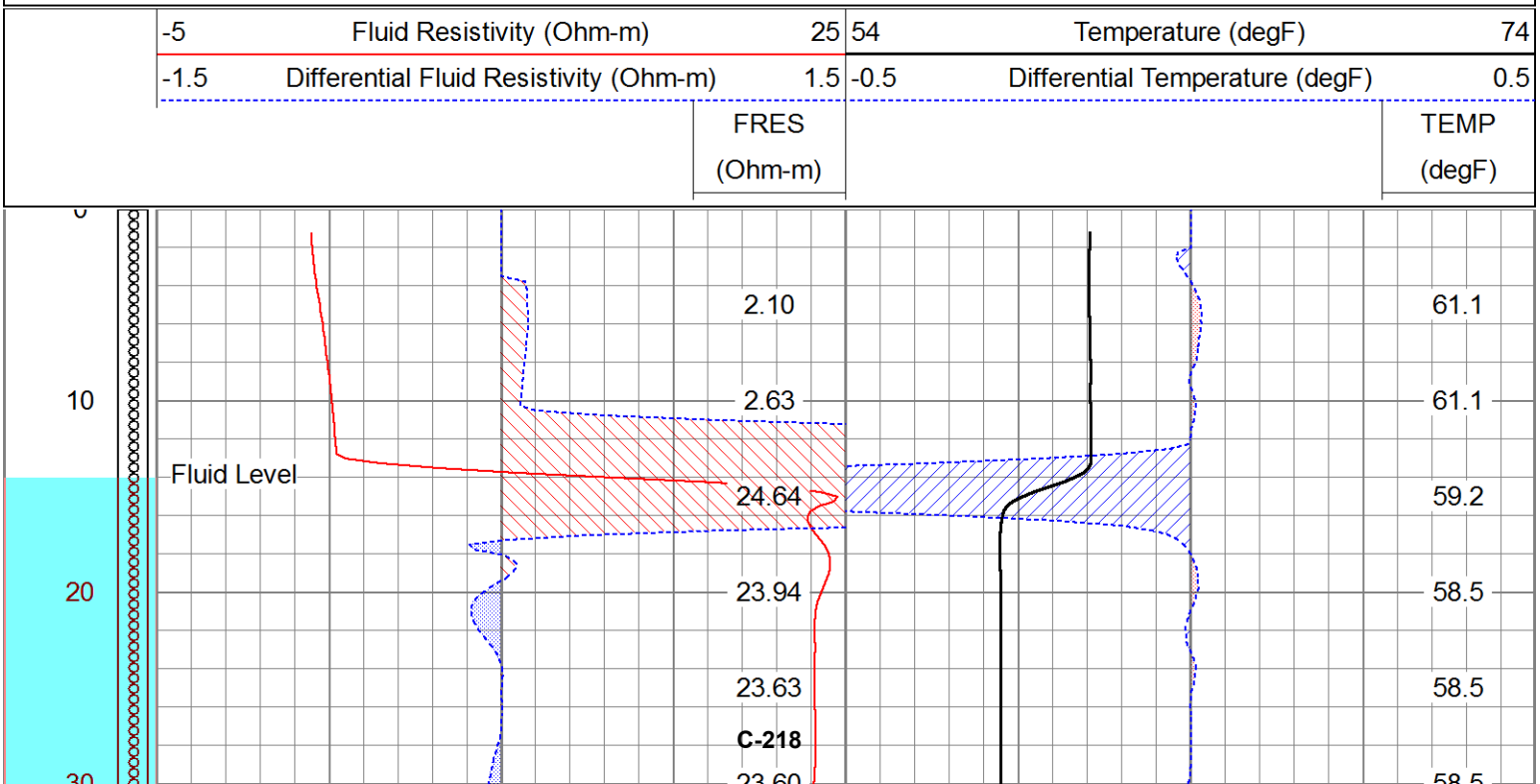
Gain: -0.004
Offset: 135.338

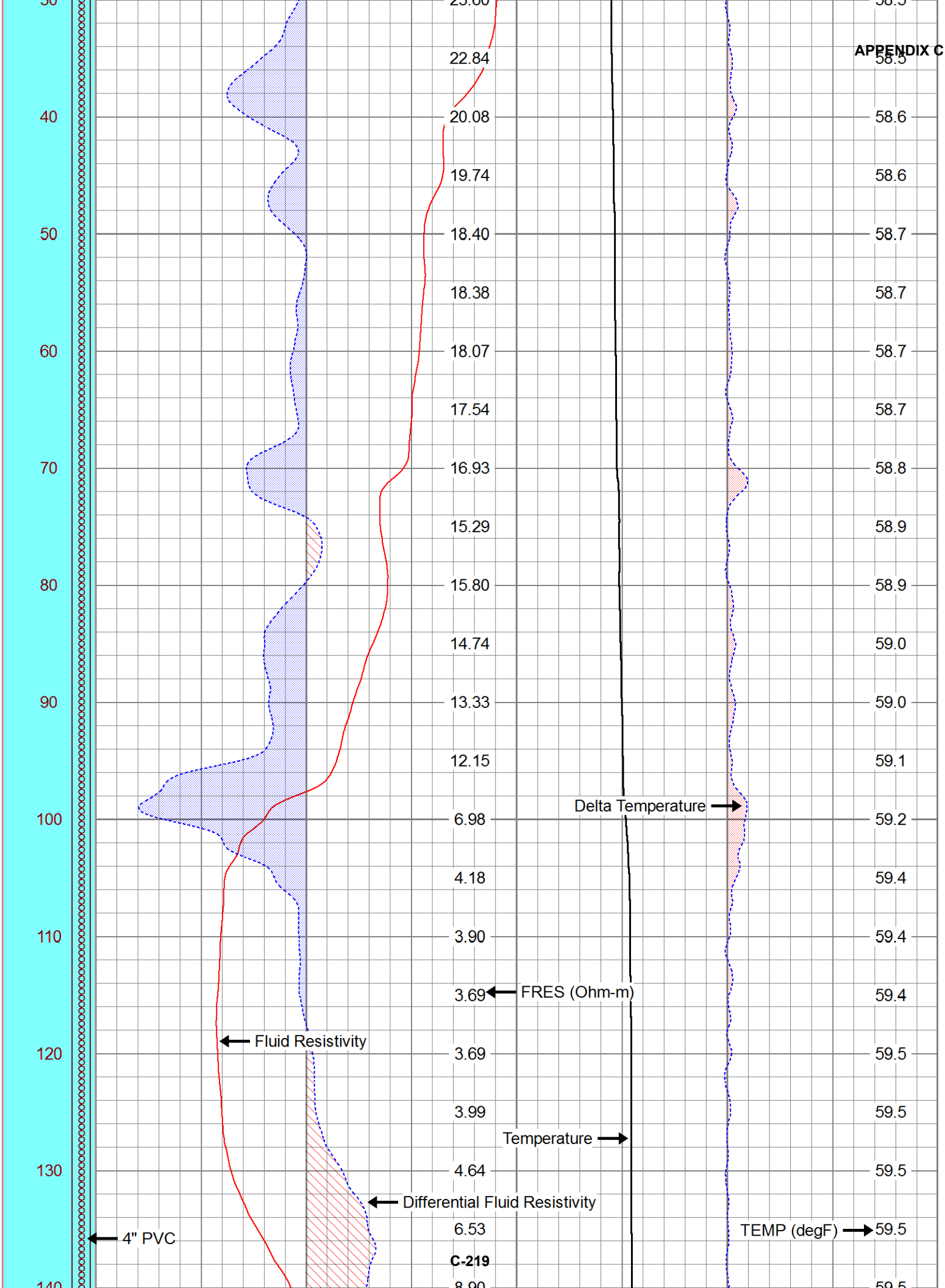
Conductivity Calibration:

System Reading	Calibration Reference
0.000 cps	0.000
1.000 cps	1.000

Gain: 1.000
Offset: 0.000

Database File	19537.db
Dataset Pathname	tmp
Presentation Format	frttemp2
Dataset Creation	Mon Apr 20 12:35:45 2015
Charted by	Depth in Feet scaled 1:120

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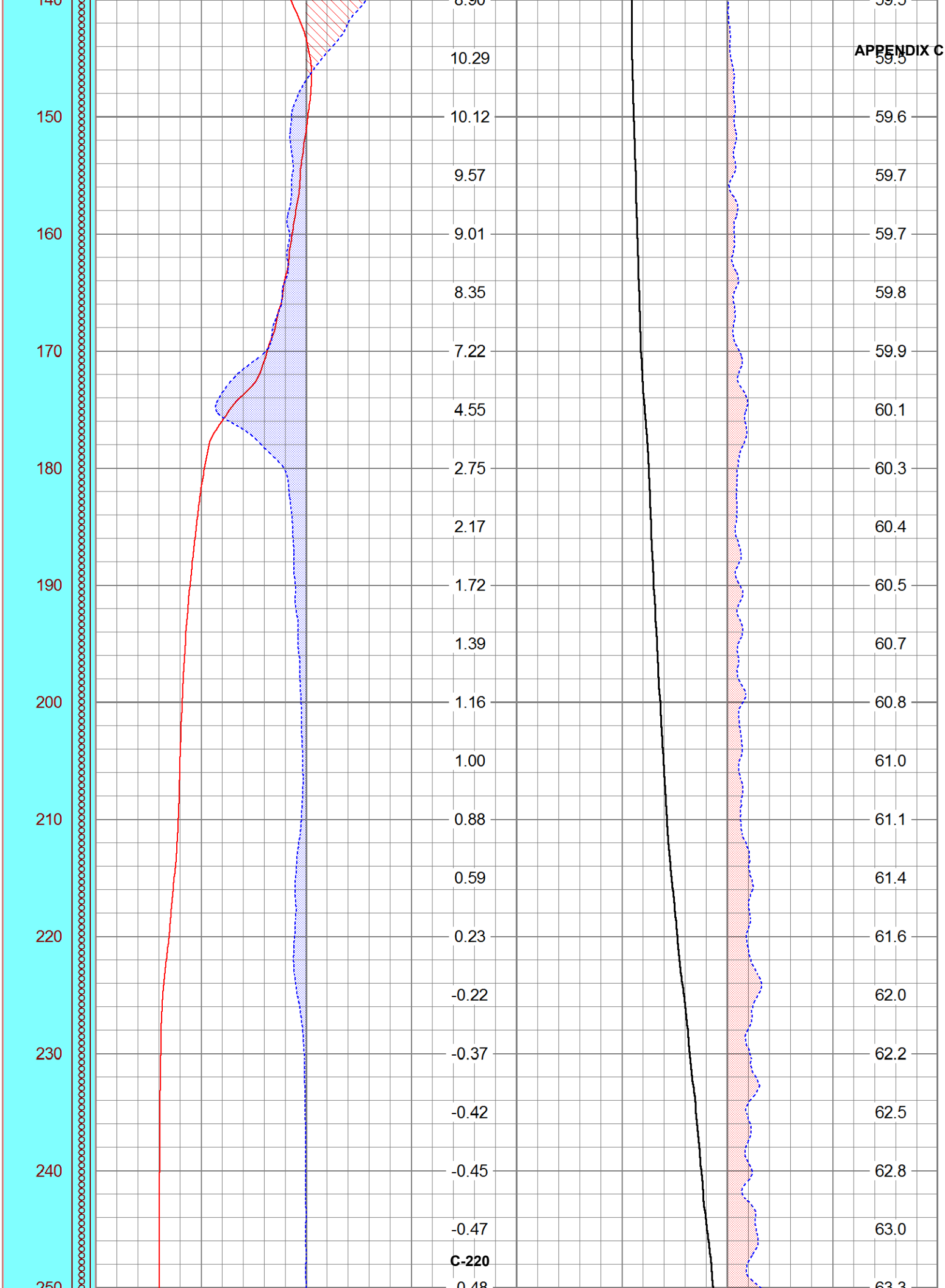
Delta Temperature
FRES (Ohm-m)
Fluid Resistivity
Temperature
Differential Fluid Resistivity
4" PVC
TEMP (degF)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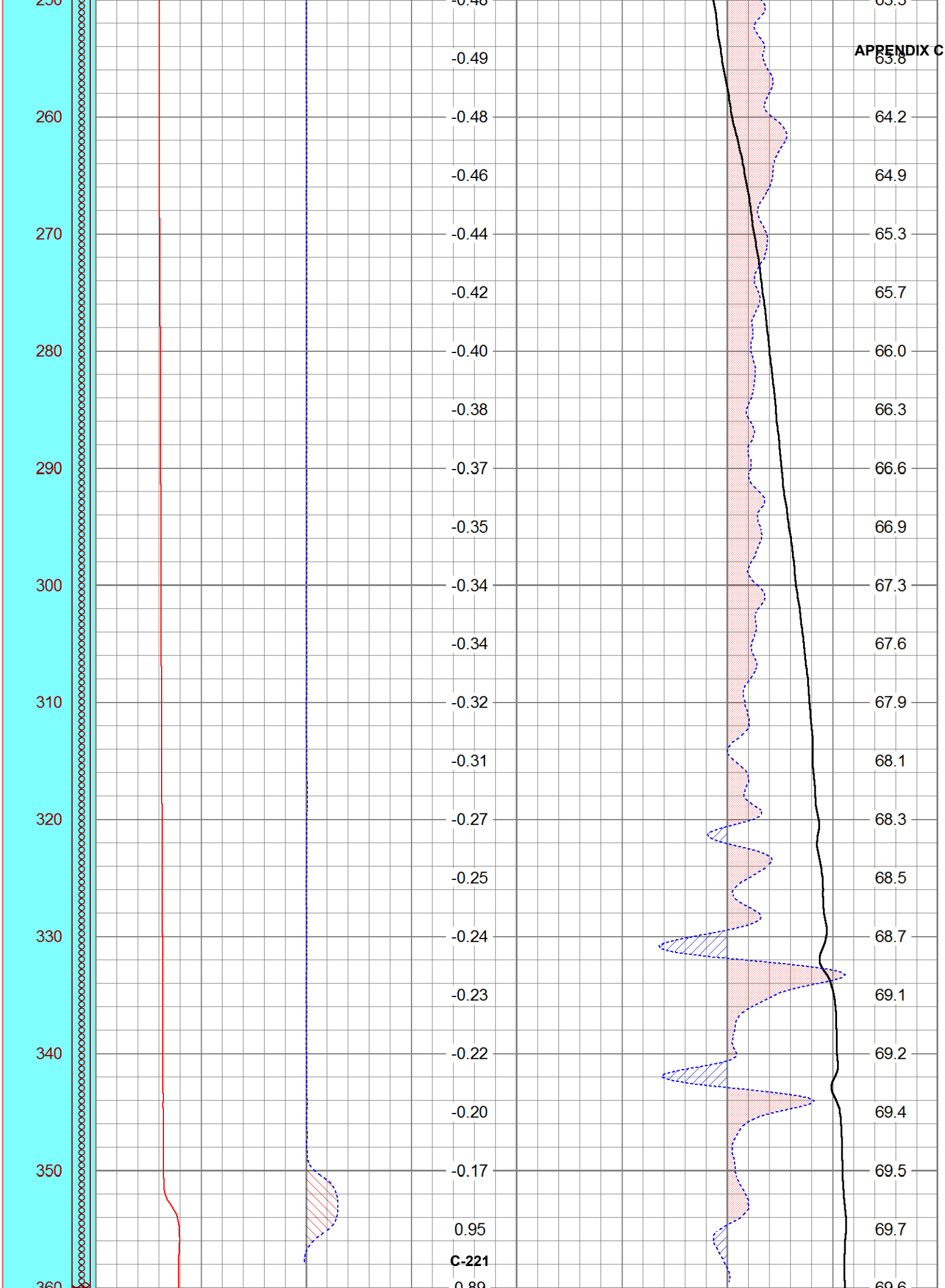
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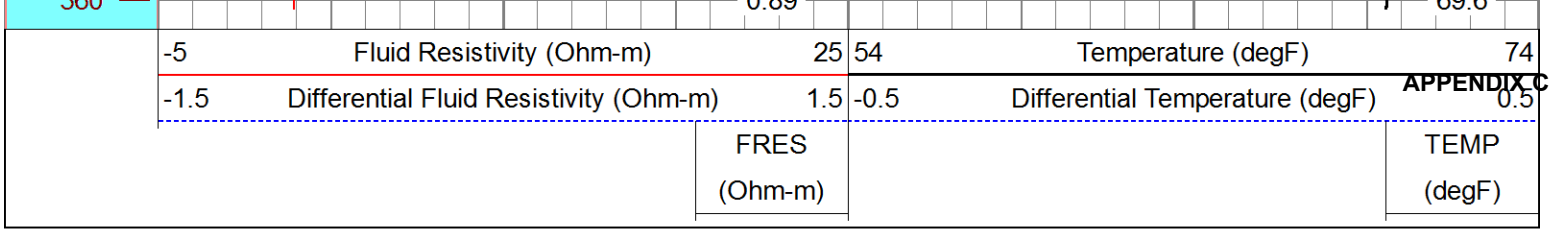
69.5
69.7
C-221


360
0.89
69.6
-5
Fluid Resistivity (Ohm-m)
25
54
Temperature (degF)
74
-1.5
Differential Fluid Resistivity (Ohm-m)
1.5
-0.5
Differential Temperature (degF)
0.5
FRES
(Ohm-m)
TEMP
(degF)

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19537

File No.

Company CASCADE DRILLING

Well MW-8D

Field SALINAS

County MONTEREY State CA

Location

325 MONTE RD.
GPS: N 36o 43' 36" W 121o 47' 15"

Other Services:

TEMPERATURE
FLUID RESISTIVITY

				Elevation
Permanent Datum	G.L.			K.B.:
Log Measured From	G.L.	0'	above perm. datum	D.F.:
Drilling Measured From	G.L.			G.L.:

Date	04-20-2015							
Run Number	ONE							
Depth Driller	360'							
Depth Logger	355'							
Bottom Logged Interval	355'							
Top Log Interval	0'							
Open Hole Size	10.75" (0'-150')			9.875" (150'-276')			8" (250'-340')	
Type Fluid	WATER							
Density / Viscosity	N/A							
Fluid Level	14'							
Bentonite Seal	N/A							
Time Well Ready	1200							
Time Logger on Bottom	1230							
Equipment Number	PS-8							
Location	LA							
Recorded By	SCHUMACHER							
Witnessed By	A. KHALIGHI							

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	150'				
TWO	9.875"	150'	276'				
THREE	8"	267'	360'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	360'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19537.db
Dataset Pathname	dil1
Dataset Creation	Mon Apr 20 14:03:49 2015

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1432.079	3651.555	cps	0.000	612.000	mmho/m	0.276	-394.883
Medium	2031.999	14281.231	cps	0.000	1960.000	mmho/m	0.160	-325.140

Gamma Ray Calibration Report

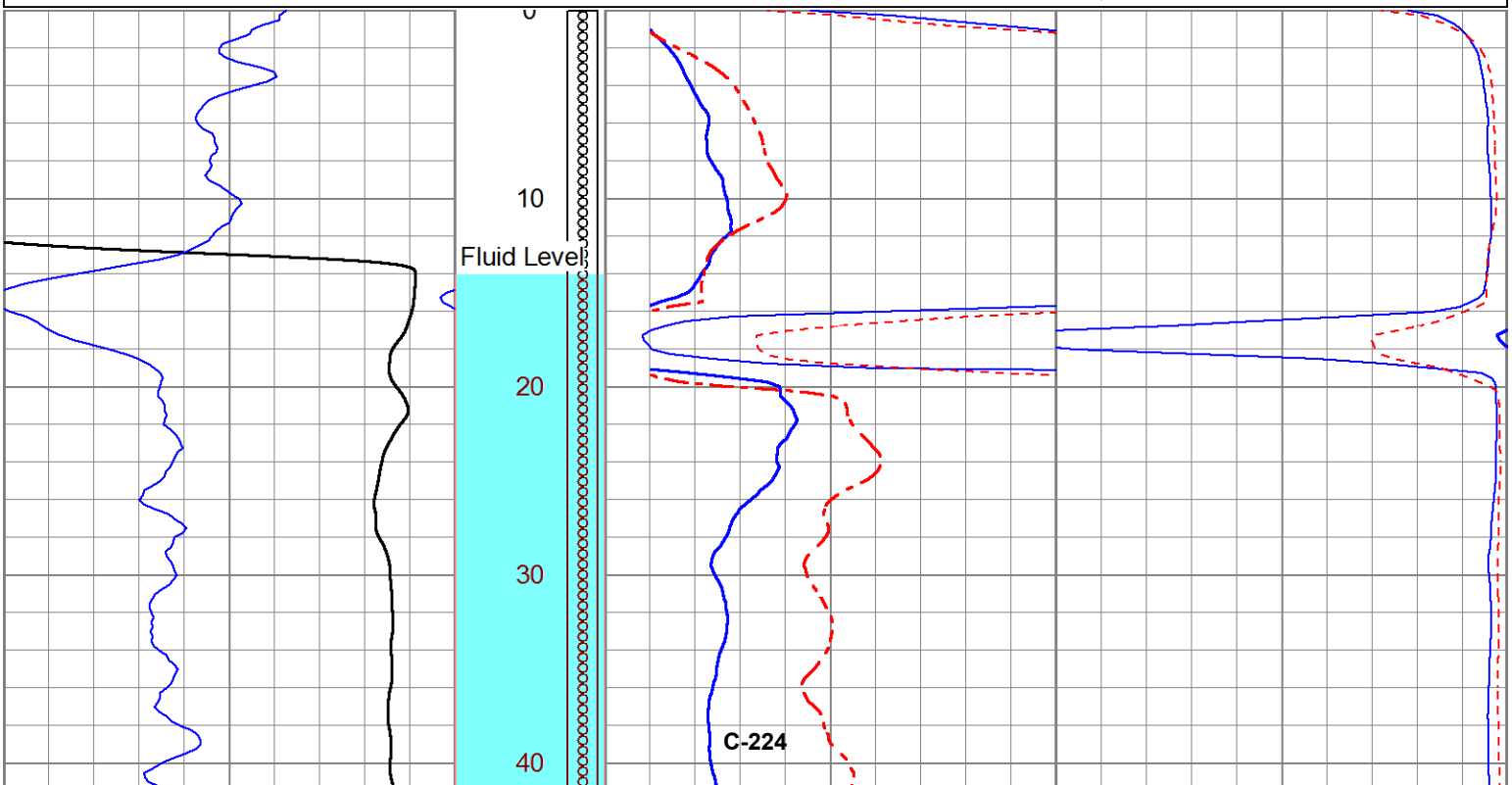
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

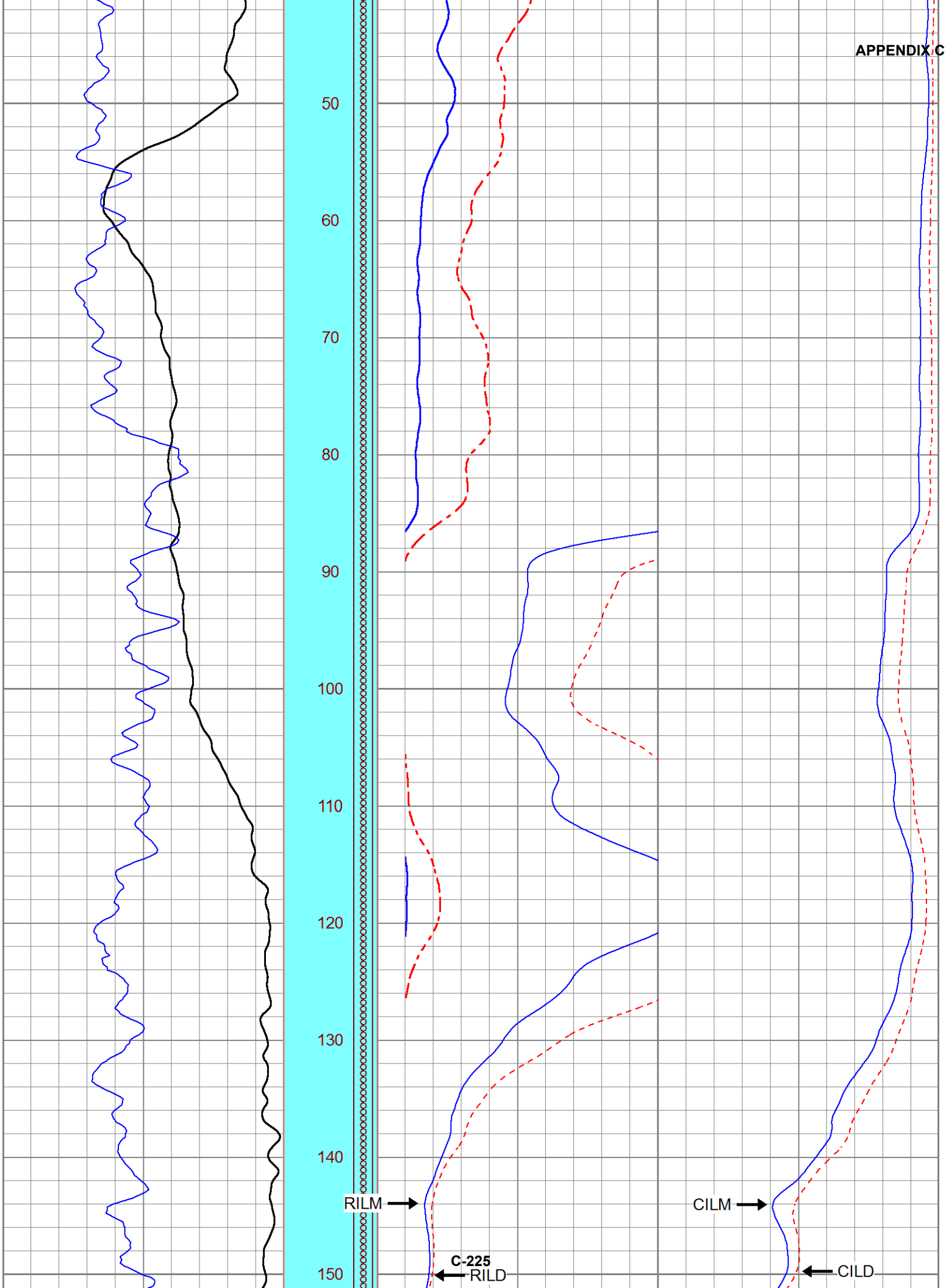
Database File	19537.db
Dataset Pathname	dil1
Presentation Format	dil
Dataset Creation	Mon Apr 20 14:03:49 2015
Charted by	Depth in Feet scaled 1:120

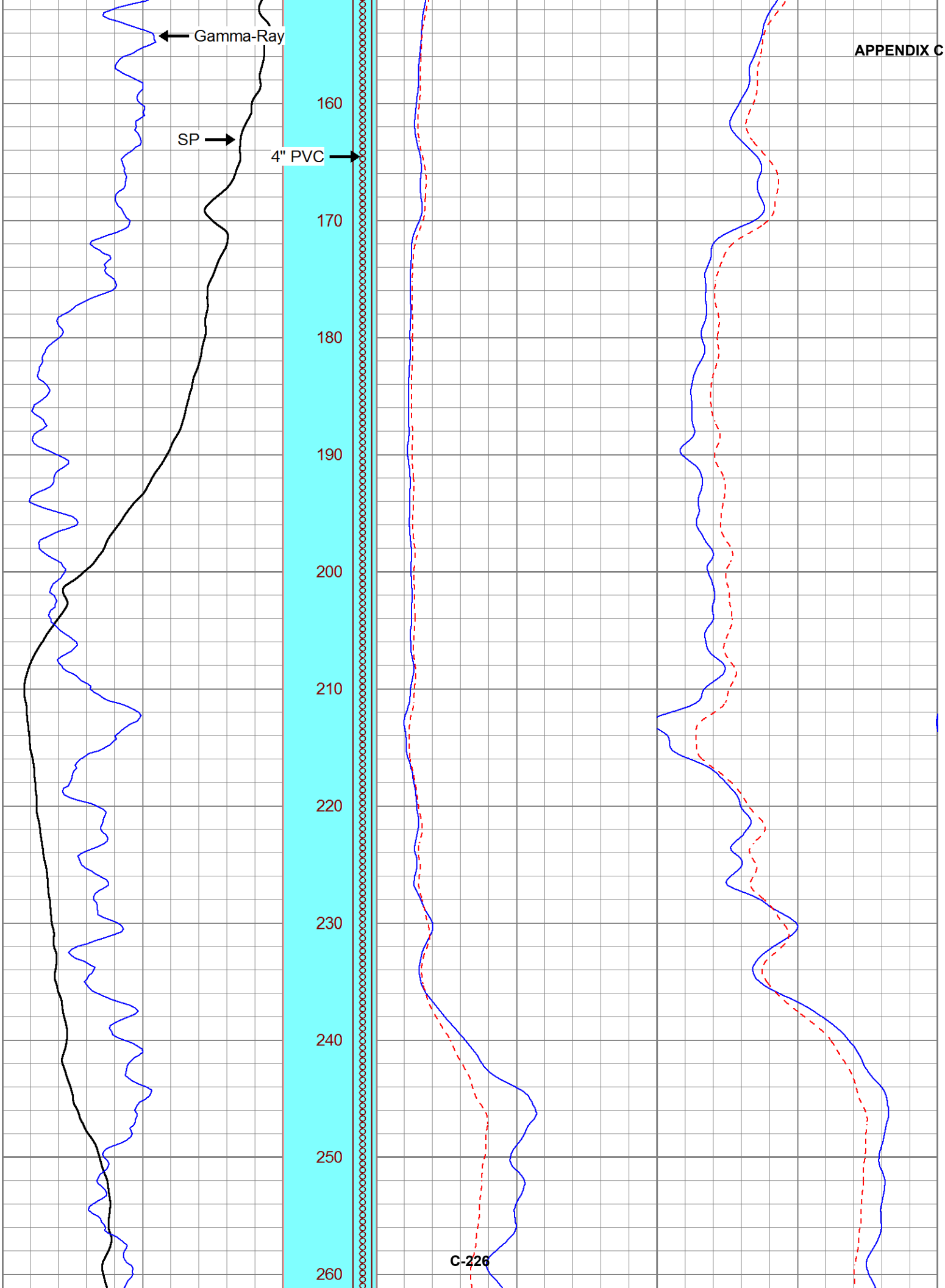
-140	SP (mV)	60
20	Gamma-Ray (GAPI)	120

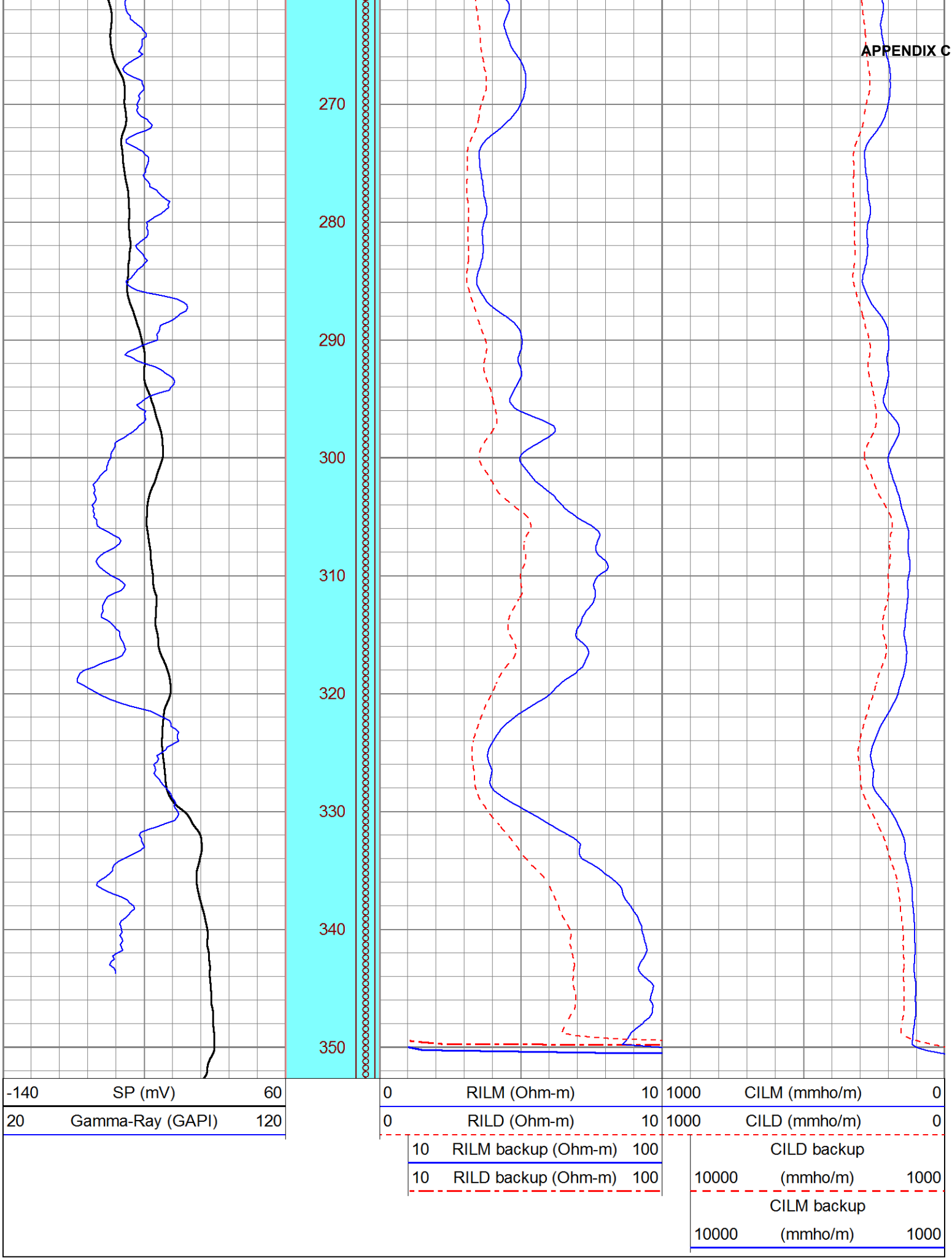
0	RILM (Ohm-m)	10
0	RILD (Ohm-m)	10
10	RILM backup (Ohm-m)	100
10	RILD backup (Ohm-m)	100

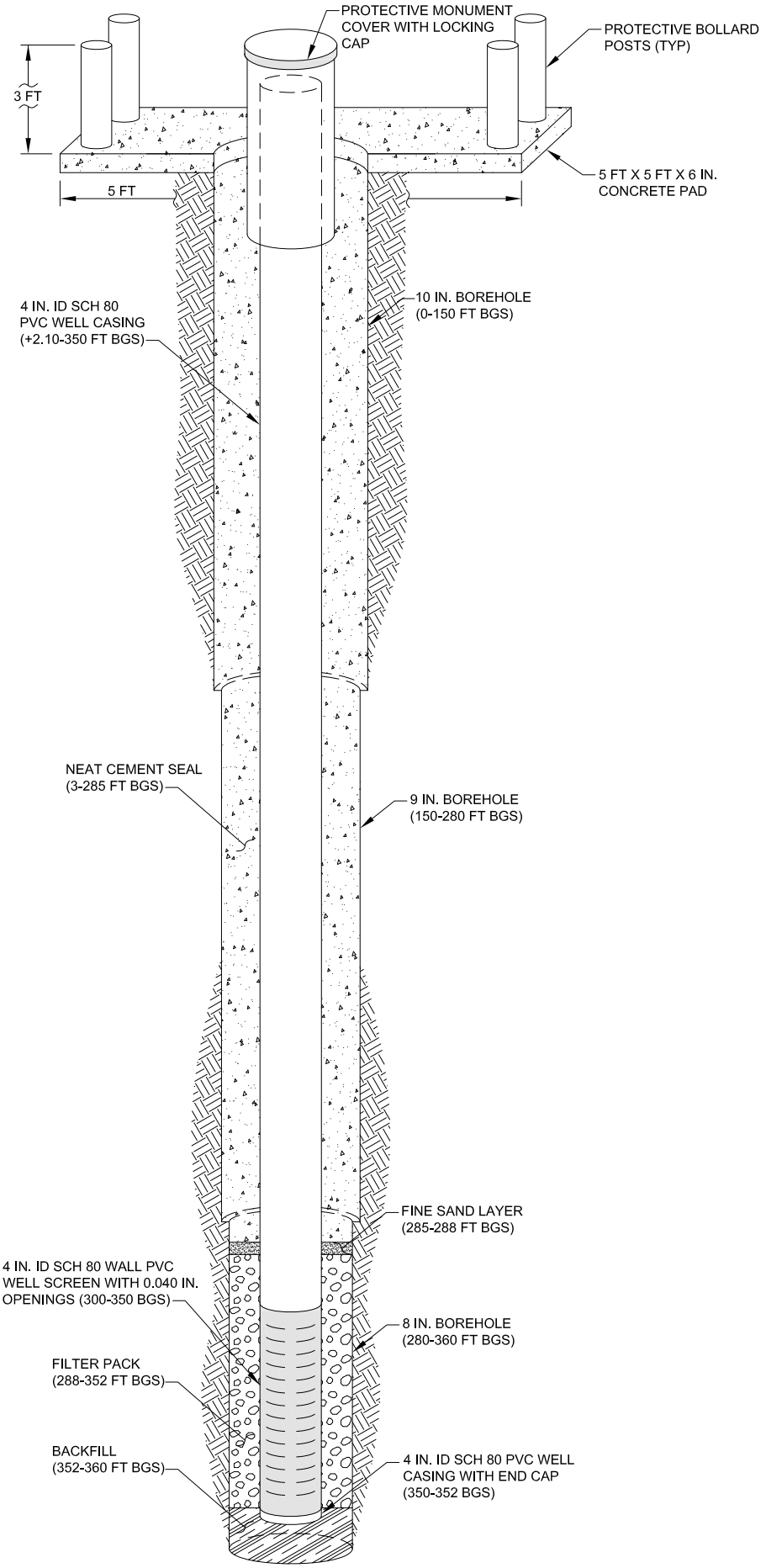
1000	CILM (mmho/m)	0
1000	CILD (mmho/m)	0
	CILD backup	
10000	(mmho/m)	1000
	CILM backup	
10000	(mmho/m)	1000




50
60
70
80
90
100
110
120
130
140
150
RILM
RILD
CILM
CILD
C-225


Gamma-Ray
SP
4" PVC
160
170
180
190
200
210
220
230
240
250
260


270
280
290
300
310
320
330
340
350
-140 SP (mV) 60
20 Gamma-Ray (GAPI) 120
0 RILM (Ohm-m) 10
0 RILD (Ohm-m) 10
10 RILM backup (Ohm-m) 100
10 RILD backup (Ohm-m) 100
1000 CILM (mmho/m) 0
1000 CILD (mmho/m) 0
CILD backup
10000 (mmho/m) 1000
CILM backup
10000 (mmho/m) 1000



WELL PROFILE

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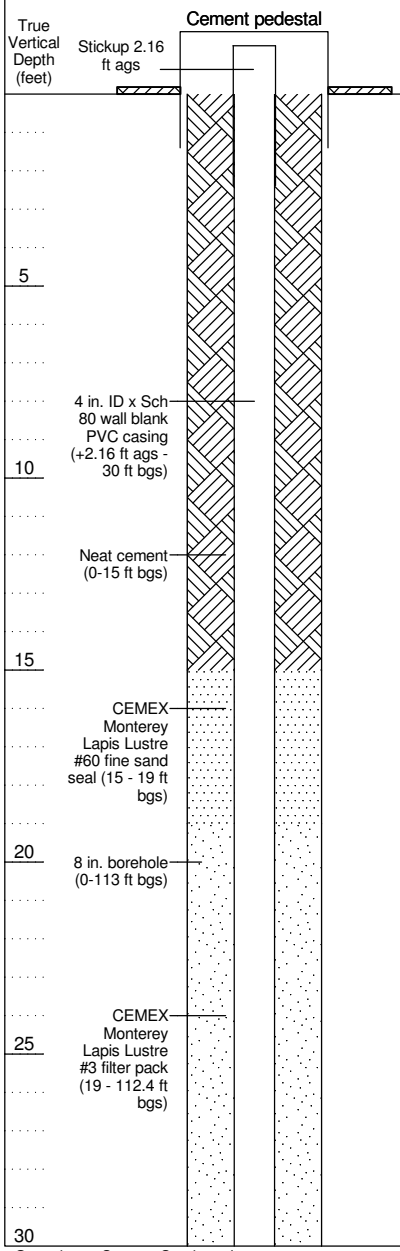
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-9S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER:	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.16**	**30**	**32.16**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**30**	**110**	**80**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**110**	**112.4**	**2.4**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	16.26 ft NAVD88									
TOC ELEVATION	18.42 ft NAVD88 (RP)									
START DATE	6/13/15									
FINISH DATE	6/14/15									



Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	SAND WITH SILT (SP-SM): dark yellowish brown (10YR 4/4), 90% sand, very fine to fine grained; 10% silt; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	5		
	SILTY SAND (SM): dark olive brown (2.5Y 3/3), 75% sand, very fine to fine grained; 25% silt; low plasticity; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
	SILTY SAND (SM): greenish black (10Y 2.5/1), 70% sand, very fine to fine grained; 30% silt; low plasticity; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	10		
	SAND (SP): very dark greenish gray (10Y 3/1), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	15		35
	SAND WITH CLAY (SP-SC): (5BG 2.5/1), 90% fine grained sand; 5% silt; 5% clay, low plasticity; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	20		
	SAND (SP): dark greenish gray (5GY 4/1), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; grading becomes fine to coarse sand from 30 ft to 32 ft; unconsolidated.	25		
		30		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-9S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (30-110 ft bgs)		SAND (SP): dark greenish gray (10GY 4/1), 100% sand, subangular to subrounded, very fine to fine grained; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
35			SAND (SP): dark greenish gray (5GY 4/1), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	35		
			SANDY SILT (ML): very dark greenish gray (5GY 3/1), 40% silt; 30% sand, very fine grained; 30% clay, low to medium plasticity; moist sample; contains quartz, feldspar, mica, and amphibole.			
40				40		
45				45		
			SAND (SP): very dark greenish gray (5GY 3/1), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.		
			CLAY (CL): very dark greenish gray (5GY 3/1), 80% clay, high plasticity; 15% silt; 5% sand, very fine to fine grained; moist sample; contains shells.			
50			SILT (ML): black (N2.5), 70% silt; 30% clay, medium plasticity; contains shells from 56 ft to 57 ft.	50		35
55				55		
60				60		
			SAND WITH SILT (SP-SM): very dark gray (N3), 90% sand, subangular to subrounded, very fine to fine grained; 10% silt; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.		
65			SILT (ML): very dark gray (N3), 70% silt; 30% clay, medium plasticity; fine grained sand; moist sample; contains shells from 67 ft to 69 ft.	65		
70			SILT WITH SAND (ML): very dark gray (N3), 80% silt; 15% sand, very fine sand; 5% clay, low to medium plasticity; moist sample.	70		

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WELL NUMBER **MPWSP MW-9S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND WITH SILT (SP-SM): very dark gray (N3), 90% sand, very fine to fine sand; 10% silt; moist to wet sample; contains quartz, mica, and amphibole; unconsolidated.	75		35
80				80		
85				85		
90				90		
95			SILTY SAND (SM): very dark gray (N3), 60% sand, very fine grained; 40% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	95		
100			SAND (SP): greenish black (5GY 2.5/1), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	100		25
105			SAND (SP): dark olive gray (5Y 3/2), 100% fine to coarse grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole.	105		
110			CLAY (CL): greenish black (5GY 2.5/1), 85% clay, low plasticity; 15% silt. SAND (SP): grayish green (5G 5/2), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and mica; unconsolidated.	110		

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WELL NUMBER **MPWSP MW-9S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

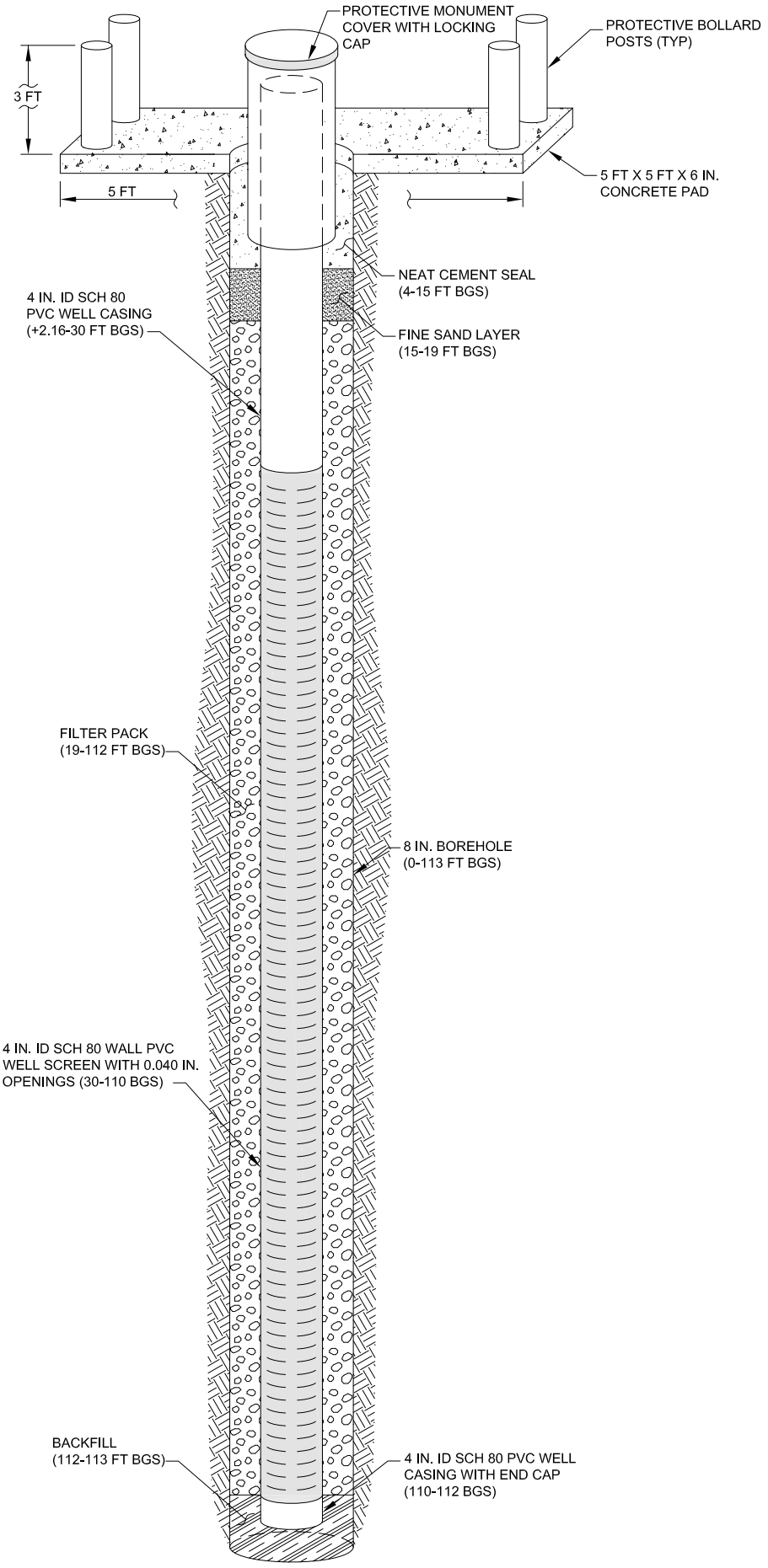
(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
Blank casing with end cap (110-112.4 ft bgs)				25
Backfill with native material (112.4-113 ft bgs) TD 113 ft bgs	CLAY (CL): greenish gray (5GY 6/1), 100% clay, high plasticity; moist sample.			
	Bottom of borehole at 113 feet.			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16



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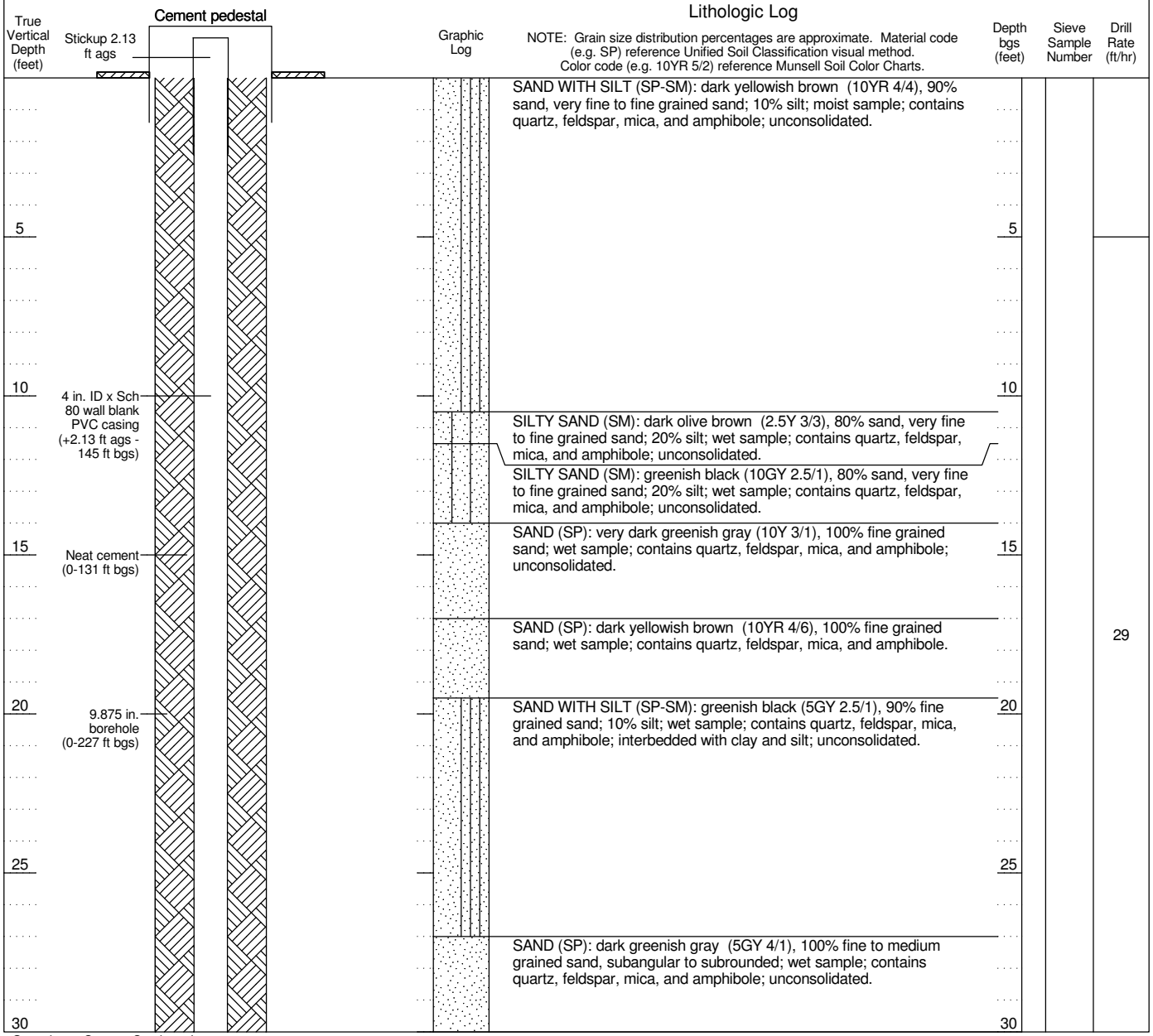
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-9M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.13**	**145**	**147.13**	**PVC**	**Sch 80**	**4 /**		
SAMPLING METHOD	Core	**Screen**	**145**	**225**	**80**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875 in	**Blank**	**225**	**227**	**2**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	16.19 ft NAVD88									
TOC ELEVATION	18.32 ft NAVD88 (RP)									
START DATE	6/03/15									
FINISH DATE	6/13/15									



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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILTY SAND (SM): dark greenish gray (5GY 4/1), 75% fine grained sand; 15% silt; 10% clay, low to medium plasticity; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
35			SAND (SP): dark greenish gray (5GY 4/1), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	35		
			SAND (SP): gray (N5), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
40			SANDY SILT (ML): very dark greenish gray (5GY 3/1), 40% silt; 30% sand, very fine grained sand; 30% clay, low to medium plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	40		
45			SAND (SP): very dark greenish gray (5GY 3/1), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	45		
			CLAY (CL): very dark greenish gray (5GY 3/1), 80% clay, high plasticity; 20% silt; trace sand; moist sample; unconsolidated.			
50			SAND (SP): greenish black (5G 2.5/1), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	50		29
55			SILT (ML): black (N2.5), 70% silt; 30% clay, medium to high plasticity; moist sample.	55		
60				60		
65				65		
			SILT WITH SAND (ML): black (N2.5), 80% silt; 15% sand, very fine grained sand; 5% clay, low to medium plasticity; moist sample.			
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
						29
75			SAND WITH SILT (SP-SM): black (N2.5), 90% sand, very fine to fine grained sand; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	75		
80				80		
85				85		
90				90		
			SILTY SAND (SM): black (N2.5), 60% sand, very fine grained sand; 40% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			15
95			SAND (SP): greenish black (5GY 2.5/1), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	95		
100				100		
105			SAND (SP): dark olive gray (5Y 3/2), 100% fine to coarse grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole.	105		
110			SAND (SP): greenish black (10Y 2.5/1), 95% fine to coarse grained sand; 5% fine gravel; moist sample; contains quartz, feldspar, mica,	110		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		and amphibole.			
		CLAY (CL): greenish gray (5G 6/1), 100% clay, high plasticity; moist sample.			15
115			115		
120			120		
125			125		
		SILTY SAND (SM): very dark greenish gray (5GY 3/1), 70% fine grained sand; 30% silt; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
		CLAY (CL): dark greenish gray (5GY 4/1), 100% clay, high plasticity; moist sample.			
130			130		
		SAND (SP): dark greenish gray (5GY 4/1), 100% fine to medium grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			13
135			135		
140			140		
		SAND WITH GRAVEL (SP): dark greenish gray (5GY 4/1), 70% fine to coarse grained sand, subrounded to rounded; 20% fine to coarse gravel subrounded to rounded fine gravel and rounded coarse gravel; 10% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; contains Monterey Shale and round cobbles; unconsolidated.			
145			145		
150			150		

CEMEX Monterey Lapis Lustre #60 fine sand seal (131 - 135 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (135 - 227 ft bgs)

4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (145-225 ft bgs)

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND (SP): dark greenish gray (5GY 4/1), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole; unconsolidated.			13
155			SAND WITH GRAVEL (SP): dark greenish gray (5GY 4/1), 65% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel; 10% cobbles; contains quartz, feldspar, and amphibole; contains Monterey Shale, round gravel and igneous rocks as cobbles; unconsolidated.	155		
			GRAVEL WITH SAND (GP): grayish brown (2.5Y 5/2), 65% fine to coarse gravel subangular to subrounded; 20% fine to coarse grained sand, subangular to subrounded, predominately medium to coarse grained sand; 15% cobbles; wet sample; contains quartz, feldspar, and amphibole; contains inclusions of shales and various igneous rocks as gravel; unconsolidated.			
160				160		2.5
			SAND (SP): grayish brown (2.5Y 5/2), 90% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
165			GRAVEL WITH SAND (GP): olive brown (2.5Y 4/3), 70% fine to coarse gravel rounded; 20% fine to coarse grained sand, subangular to subrounded; 10% cobbles; moist sample; contains quartz, feldspar, mica, and amphibole; contains round cobbles; grading with depth: cobbles increase to 25%, sand to 20% and gravel to 55%.	165		
			SAND WITH GRAVEL (SP): very dark greenish gray (5GY 3/1), 70% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
170				170		
			SAND (SP): dark grayish brown (2.5Y 4/2), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
175			GRAVEL WITH SAND (GP): dark olive brown (2.5Y 3/3), 75% fine to coarse gravel rounded; 20% fine to coarse grained sand, subangular to subrounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; unconsolidated.	175		
			SAND (SP): gray (2.5Y 5/1), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
180				180		
			GRAVEL WITH SAND (GP): gray (2.5Y 5/1), 70% fine to coarse gravel subrounded to rounded; 15% fine to coarse grained sand, subangular to subrounded; 15% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; includes Monterey Shale with various igneous and sedimentary rocks; unconsolidated.			20
185				185		
			SAND WITH GRAVEL (SP): dark grayish brown (2.5Y 4/2), 80% medium to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; Includes Monterey Shale and various igneous and sedimentary rocks as gravel; unconsolidated.			
190				190		

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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			GRAVEL (GP): dark grayish brown (2.5Y 4/2), 70% fine to coarse gravel subrounded to rounded, subrounded to rounded; 30% cobbles; subrounded to rounded; wet sample; includes round cobbles and Monterey Shale with various igneous and sedimentary rocks; unconsolidated.	195		
			GRAVEL WITH SAND (GP): dark grayish brown (2.5Y 4/2), 50% fine to coarse gravel subrounded to rounded coarse gravel; 45% medium to coarse grained sand, subangular to subrounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; contains subrounded and rounded cobbles and Monterey Shale; unconsolidated.			20
200			SAND (SP): dark brown (7.5YR 3/4), 100% fine grained sand; trace fine gravel; wet sample; contains quartz, feldspar, mica, and amphibole; contains weakly cemented clasts; trace gravel at 207 ft; unconsolidated.	200		
205				205		
210			SAND (SP): dark brown (7.5YR 3/4), 100% fine to medium grained sand; contains quartz, feldspar, mica, and amphibole; contains weakly cemented clasts that increase in quantity; unconsolidated.	210		
215				215		16
220				220		
225	Blank casing with end cap (225-227 ft bgs) TD 227 ft bgs		Bottom of borehole at 227 feet.	225		

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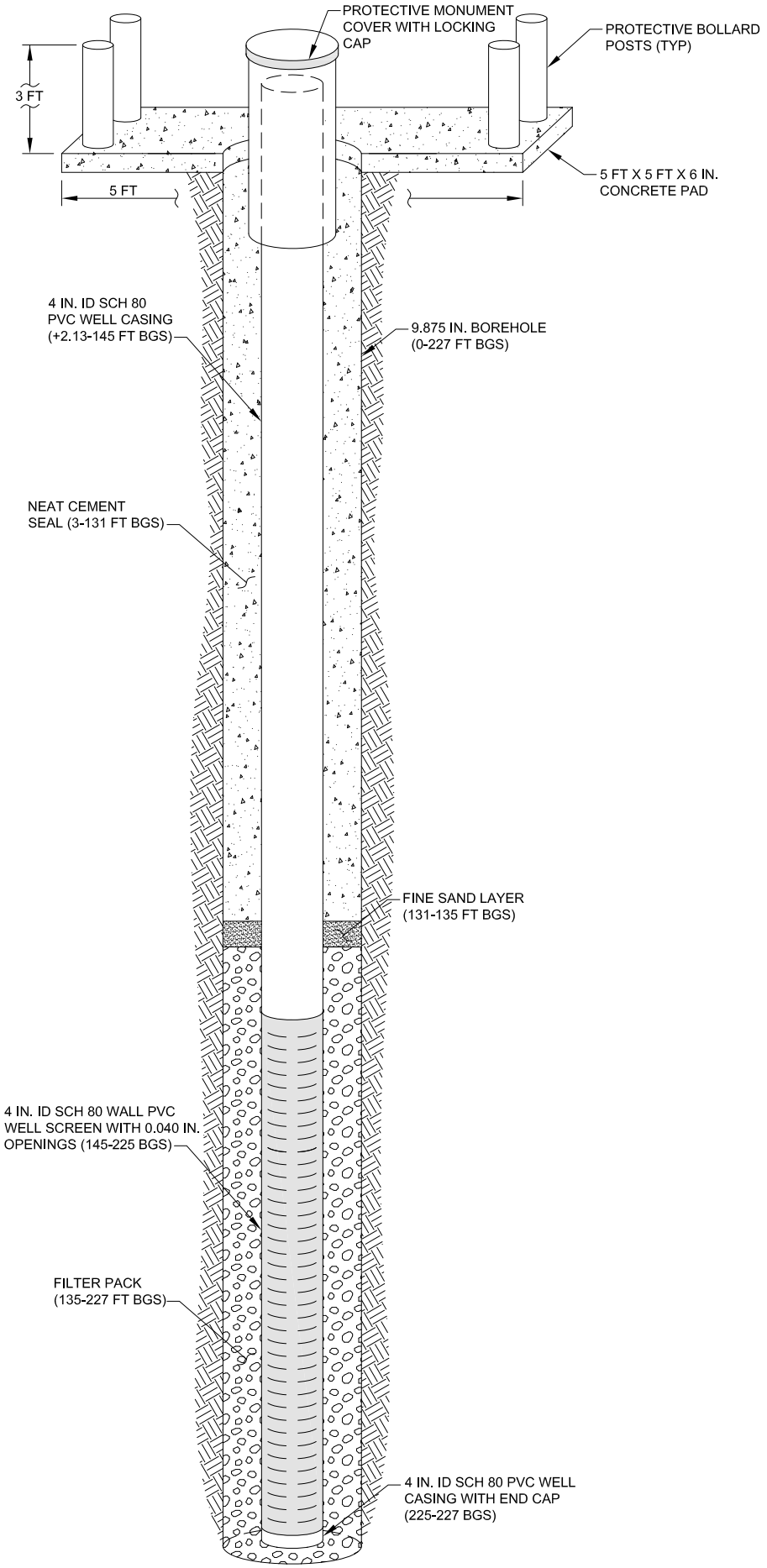

WELL PROFILE

NOT TO SCALE

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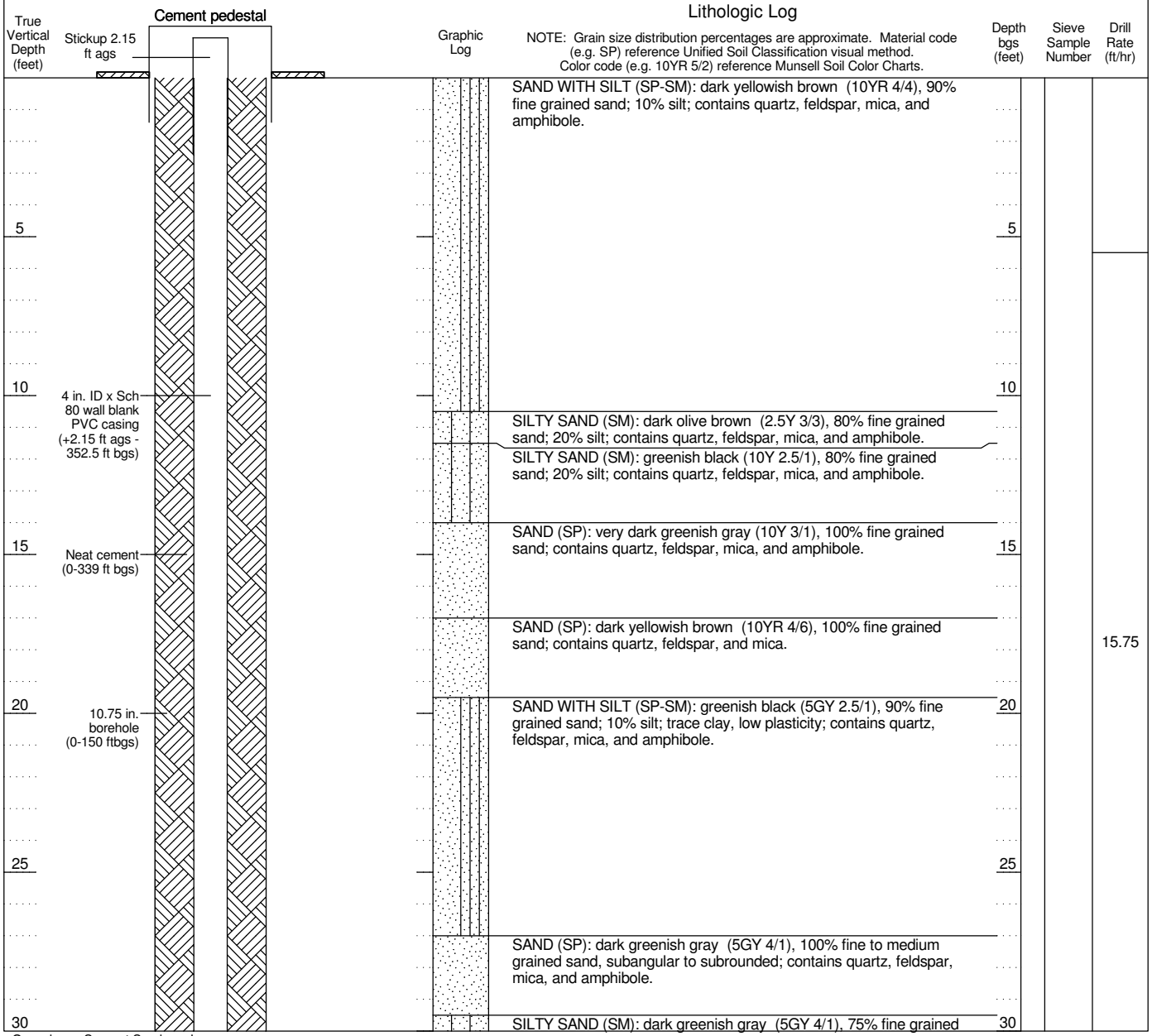
BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-9D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi and E. Crow-Willard**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.15**	**352.5**	**354.65**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**352.5**	**392.5**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**392.5**	**395**	**2.5**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	16.17 ft NAVD88									
TOC ELEVATION	18.32 ft NAVD88 (RP)									
START DATE	5/15/15									
FINISH DATE	6/03/15									



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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	sand; 15% silt; 10% clay, low to medium plasticity; contains quartz, feldspar, mica, and amphibole.			
	SAND (SP): dark greenish gray (5GY 4/1), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole.			15.75
35		35		
	SAND (SP): gray (N5), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
40	SANDY SILT (MH): very dark greenish gray (5G 3/1), 40% silt; 30% fine grained sand; 30% clay, medium to high plasticity; contains quartz, feldspar, mica, and amphibole.	40		
45		45		
	CLAYEY SAND (SC): very dark greenish gray (5G 3/1), 70% fine grained sand; 15% silt; 15% clay, no to low plasticity; contains quartz, feldspar, mica, and amphibole.			
	SAND (SP): very dark greenish gray (5G 3/1), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; contains quartz, feldspar, mica, and amphibole; sea shells.			
50	FAT CLAY (CH): very dark greenish gray (5GY 3/1), 75% clay, high plasticity; 20% silt; 5% fine grained sand.	50		
	SAND (SP): greenish black (5GY 2.5/1), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole.			
	SILT (MH): black (N2.5), 70% silt; 30% clay, medium to high plasticity; trace sand; black ash spots, more sand with depth.			
55		55		
60		60		
65		65		
	SILT WITH SAND (ML): black (N2.5), 80% silt; 15% fine grained sand; 5% clay, low to medium plasticity.			
70		70		

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND WITH SILT (SP-SM): black (N2.5), 90% fine grained sand; 10% silt; contains quartz, feldspar, mica, and amphibole.	75	1	
80				80		
85				85		
90				90	2	
			SILTY SAND (SM): black (N2.5), 60% fine grained sand; 40% silt; contains quartz, feldspar, mica, and amphibole.			
95			SAND (SP): greenish black (5GY 2.5/1), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	95		
100				100		
105			SAND (SP): dark olive gray (5Y 3/2), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, and mica.	105	3	
110			SAND (SP): dark gray (5Y 4/1), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded;	110		

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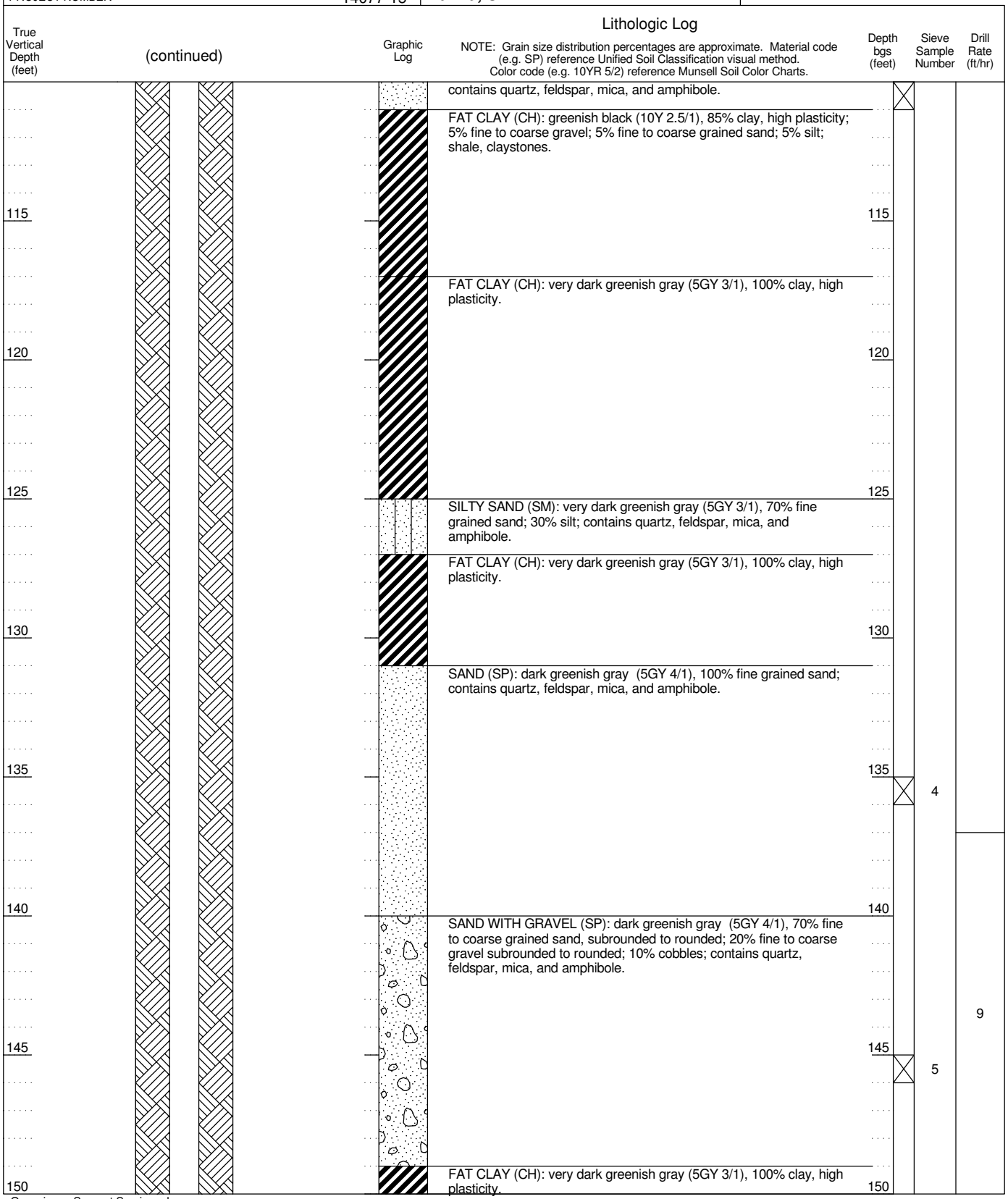
WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		SAND (SP): dark greenish gray (5GY 4/1), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole.			
155		SAND WITH GRAVEL (SP): dark greenish gray (5GY 4/1), 65% fine to coarse grained sand, subangular to rounded; 25% fine to coarse gravel subangular to rounded; 10% cobbles; contains quartz, feldspar, and amphibole; shale.	155	6	
160		GRAVEL WITH SAND (GP): dark greenish gray (5GY 4/1), 70% fine to coarse gravel subangular to subrounded; 15% fine to coarse grained sand, subangular to subrounded; 15% cobbles; contains quartz, feldspar, and amphibole; shale.	160		
		SAND (SP): grayish brown (2.5Y 5/2), 90% fine to coarse grained sand, subangular to rounded; 10% fine gravel subangular to rounded; contains quartz, feldspar, mica, and amphibole.			
165		GRAVEL WITH SAND (GP): olive brown (2.5Y 4/3), 70% fine to coarse gravel subangular to rounded; 20% fine to coarse grained sand, subangular to rounded; 10% cobbles; contains quartz, feldspar, mica, and amphibole.	165	7	
		SAND WITH GRAVEL (SP): very dark greenish gray (5GY 3/1), 70% fine to coarse grained sand, subangular to rounded; 30% fine to coarse gravel subangular to rounded; contains quartz, feldspar, mica, and amphibole; shale; more gravel with depth.			
170			170		9
		SAND (SP): dark grayish brown (2.5Y 4/2), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
175		GRAVEL WITH SAND (GP): dark olive brown (2.5Y 3/3), 75% fine to coarse gravel subangular to rounded; 20% fine to coarse grained sand, subangular to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole.	175	8	
		SAND (SP): gray (2.5Y 5/1), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
180			180		
		GRAVEL WITH SAND (GP): gray (2.5Y 5/1), 70% fine to coarse gravel subrounded to rounded; 15% fine to coarse grained sand, subrounded to rounded; 15% cobbles; contains quartz, feldspar, mica, and amphibole.			
185			185	9	
		SAND WITH GRAVEL (SP): dark grayish brown (2.5Y 4/2), 80% medium to coarse grained sand, subangular to rounded; 20% fine to coarse gravel subangular to rounded; contains quartz, feldspar, mica, and amphibole; shale.			
190			190		

9.875 in. borehole (150-300 ft bgs)

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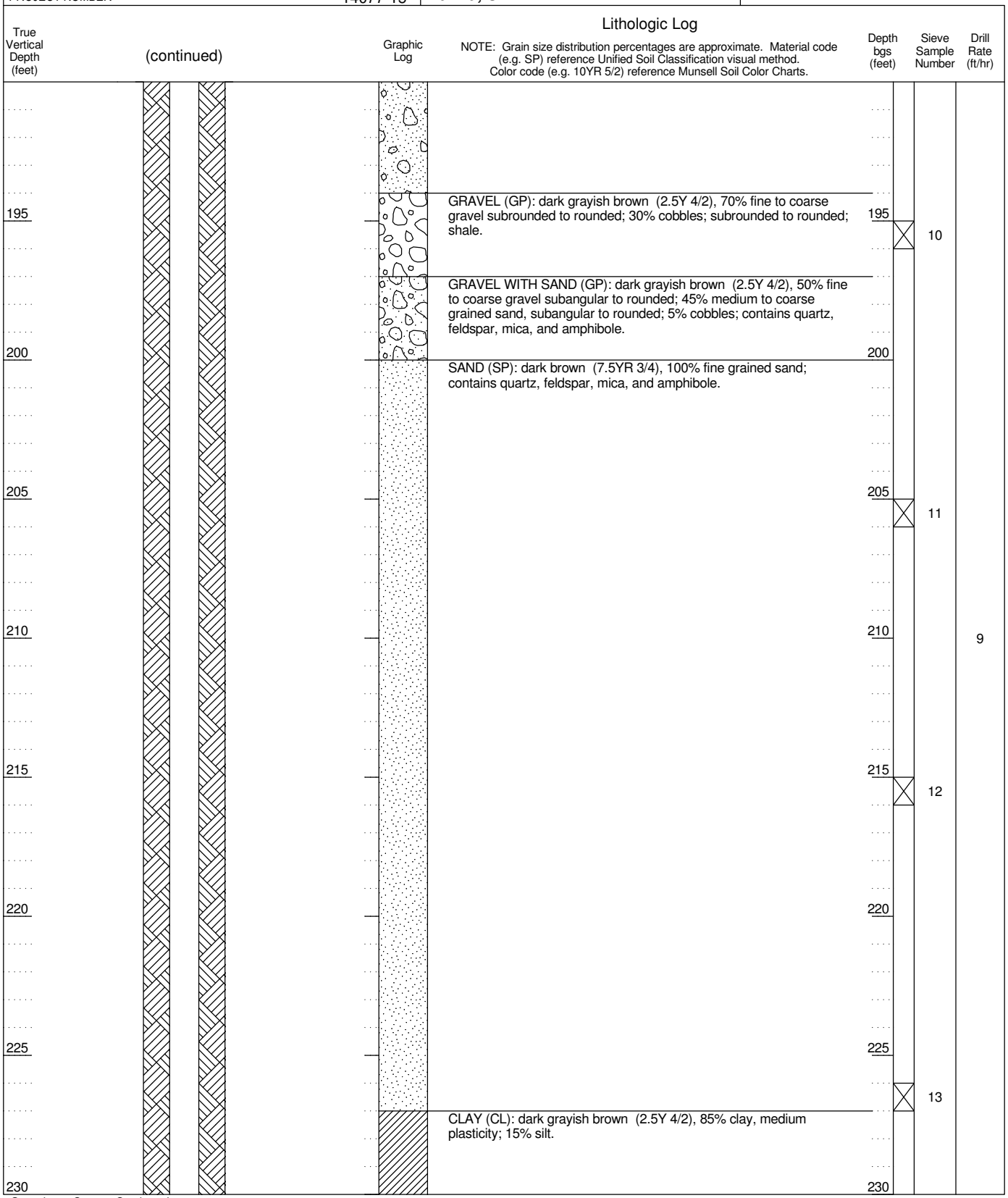
WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235			SAND (SP): dark olive brown (2.5Y 3/3), 95% fine grained sand; 5% silt; contains quartz, feldspar, mica, and amphibole. CLAY (CL): greenish gray (10Y 5/1), 90% clay, low to medium plasticity; 10% silt.	235		
240			SANDY FAT CLAY (CH): grayish brown (2.5Y 5/2), 65% clay, medium plasticity; 30% fine grained sand; 5% silt.	240		
245			CLAYEY SAND (SC): grayish brown (2.5Y 5/2), 80% fine grained sand; 15% clay, low plasticity; 5% silt; contains quartz, feldspar, mica, and amphibole.	245		9 4 4
250			SILTY SAND (SM): light olive brown (2.5Y 5/3), 80% fine grained sand; 15% silt; 5% clay, low plasticity; contains quartz, feldspar, mica, and amphibole. FAT CLAY WITH SAND (CH): dark greenish gray (10Y 4/1), 70% clay, medium to high plasticity; 25% fine grained sand; 5% silt. SAND WITH SILT (SP-SM): dark olive gray (5Y 3/2), 90% fine to medium grained sand, subangular to subrounded; 10% silt; contains quartz, feldspar, mica, and amphibole.	250		
255			FAT CLAY (CH): dark greenish gray (10Y 4/1), 100% clay, high plasticity.	255		
260			FAT CLAY WITH SAND (CH): olive brown (2.5Y 4/3), 75% clay, high plasticity; 20% fine grained sand; 5% silt.	260		8.5
265				265		
270				270		

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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
275		SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 75% fine to coarse grained sand, subangular to rounded; 20% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; shale.	275		
		SAND (SW): olive brown (2.5Y 4/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole.		14	
		FAT CLAY (CH): light olive brown (2.5Y 5/4), 100% clay, low to medium plasticity; trace sand.			
280			280		
285			285		
		SANDY CLAY (CL): light olive brown (2.5Y 5/4), 60% clay, low to medium plasticity; 35% fine grained sand, subangular to subrounded; 5% fine to coarse gravel subangular to subrounded; sandstone and claystone.			
290			290		8.5
295			295		
		FAT CLAY (CH): light olive brown (2.5Y 5/3), 90% clay, high plasticity; 10% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
300			300		
		CLAYEY SAND (SC): light olive brown (2.5Y 5/3), 85% fine grained sand, subangular to subrounded; 15% clay; well sorted; contains quartz, feldspar, mica, and amphibole.			
305			305		
		FAT CLAY (CH): light olive brown (2.5Y 5/3), 100% clay, high plasticity; trace fine grained sand, subangular to subrounded; strong cementation; contains mica, and amphibole; mudstone.			
310			310		

8 in. borehole (300-395 ft bgs)

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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
						8.5
315			SANDY FAT CLAY (CH): light olive brown (2.5Y 5/3), 60% clay, high plasticity; 40% fine grained sand, subangular to subrounded, predominantly between 315.5-316 ft bgs; moderate cementation; contains quartz, feldspar, mica, and amphibole.	315		
			SANDY FAT CLAY (CH): light olive brown (2.5Y 5/3) and grayish brown (2.5Y 5/2), 60% clay, high plasticity; 40% fine grained sand, subangular to subrounded; moderate cementation.			
320			CLAYEY SAND (SC): light olive brown (2.5Y 5/3) and grayish brown (2.5Y 5/2), 60% fine grained sand, subangular to subrounded, trace medium grained; 40% clay, high plasticity; well sorted; moderate cementation; contains quartz, feldspar, mica, and amphibole.	320		
325				325		
			FAT CLAY (CH): greenish gray (10GY 5/1) and (10B 4/1), 100% clay, medium to high plasticity; trace fine grained sand, subangular to subrounded, predominantly 334.4-335 ft bgs; trace silt; strong cementation; contains quartz, feldspar, mica, and amphibole.			
330				330		
335				335		
			FAT CLAY (CH): olive (5Y 5/3), 90% clay, high plasticity; 10% silt; trace fine grained sand, subangular to subrounded; strong cementation; contains quartz, feldspar, mica, and amphibole.		
340	CEMEX Monterey Lapis Lustre #60 fine sand seal (339 - 343 ft bgs)			340		
345	CEMEX Monterey Lapis Lustre #3 filter pack (343 - 395 ft bgs)			345		
			SANDY FAT CLAY (CH): grayish brown (2.5Y 5/2), 60% clay, high plasticity; 40% fine to coarse grained sand, angular to subrounded; trace fine to coarse gravel up to 70 mm, angular to subrounded; moderate cementation; contains quartz, feldspar, mica, and amphibole; petrified wood.			
350				350		

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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH CLAY (SP-SC): light yellowish brown (2.5Y 6/3), 90% fine to coarse grained sand, angular to subrounded; 10% clay; trace fine to coarse gravel up to 65 mm, angular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			CLAYEY SAND WITH GRAVEL (SC): light yellowish brown (2.5Y 6/3), 60% fine to coarse grained sand, angular to subrounded; 25% clay; 15% fine to coarse gravel up to 25 mm, angular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
355	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (352.5-392.5 ft bgs)		SAND (SP): light yellowish brown (2.5Y 6/3), 90% fine to coarse grained sand, angular to subrounded; 5% fine to coarse gravel up to 35 mm, angular to subrounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.	355		
			SAND (SP): light yellowish brown (2.5Y 6/3), 90% fine to coarse grained sand, angular to subrounded; 5% fine to coarse gravel up to 50 mm, angular to subrounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
360				360		
			SAND (SP): light olive brown (2.5Y 5/3), 90% fine to coarse grained sand, angular to subrounded; 5% fine to coarse gravel up to 35 mm, angular to subrounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
365			SANDY FAT CLAY WITH GRAVEL (CH): light olive brown (2.5Y 5/3), 50% clay, medium plasticity; 35% fine to coarse grained sand; 15% fine to coarse gravel up to 40 mm; strong cementation; contains quartz, feldspar, mica, and amphibole; red alteration; mudstone.	365		
			FAT CLAY (CH): light olive brown (2.5Y 5/4), 100% clay, high plasticity; strong cementation.			
			SAND WITH CLAY (SP-SC): light olive brown (2.5Y 5/3), 90% fine to coarse grained sand, angular to subrounded; 10% clay; trace fine to coarse gravel up to 28 mm, angular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
370			SAND (SP): light yellowish brown (2.5Y 6/3), 95% fine to coarse grained sand, angular to subrounded; 5% fine to coarse gravel up to 70 mm, angular to subrounded; trace clay; poorly sorted; contains quartz, feldspar, mica, and amphibole; grades finer with depth; mudstone.	370		
375				375		
			SAND WITH GRAVEL (SP): light yellowish brown (2.5Y 6/3), 80% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel up to 45 mm, angular to subrounded; trace clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
380				380		
			SANDY FAT CLAY WITH GRAVEL (CH): light olive brown (2.5Y 5/4), 50% clay; 30% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel up to 70 mm, angular to subrounded; strong cementation; contains quartz, feldspar, mica, and amphibole.			
385			SAND WITH CLAY AND GRAVEL (SP-SC): light yellowish brown (2.5Y 6/3), 70% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel up to 65 mm, angular to subrounded; 10% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole; mudstone.	385		
			SAND WITH CLAY AND GRAVEL (SP-SC): light olive brown (2.5Y 5/3), 70% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel up to 60 mm, angular to subrounded; 10% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole; mudstone.			
390				390		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

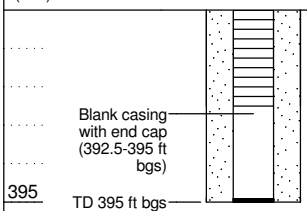
Geoscience Support Services, Inc.

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

WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



True Vertical Depth (feet)	(continued) Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Graphic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	SAND WITH CLAY (SP-SC): light olive brown (2.5Y 5/4), 80% fine to coarse grained sand, angular to subrounded; 10% fine to coarse gravel up to 40 mm, angular to subrounded; 10% clay; medium sorted; contains quartz, feldspar, mica, and amphibole.				
395	SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 70% fine to coarse grained sand, angular to subrounded; 30% fine to coarse gravel up to 40 mm, angular to subrounded; trace clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.		395		
	Bottom of borehole at 395 feet.				

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

APPENDIX C

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPURATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19633

File No.

Company CASCADE DRILLING

Well MW-9D

Field SALINAS

County MONTEREY State CA

Location

NORTH OF SALINAS RIVER ON MONTE RD.
GPS: N 36o 44.026' W 121o 46.750'

Other Services:

DIL/GR

			Elevation	Elevation
Permanent Datum	G.L.			
Log Measured From	G.L.	0'	above perm. datum	K.B.
Drilling Measured From	G.L.			D.F.
				G.L.

Date	05-28-2015		
Run Number	ONE		
Depth Driller	395'		
Depth Logger	395'		
Bottom Logged Interval	395'		
Top Log Interval	0'		
Open Hole Size	10.75" (65'-149')	9.875" (149'-249')	8" (249'-395')
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	22'		
Bentonite Seal	N/A		
Time Well Ready	1300		
Time Logger on Bottom	1330		
Equipment Number	PS-3		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	A KHALIGHI		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	149'				
TWO	9.875"	149'	249'				
THREE	8"	249'	395'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	10.75" OD	N/A	0'	65'
Prot. String				
Production String	4" PVC	SCH 80	0'	395'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File 19633.db
Dataset Pathname tmp
Dataset Creation Thu May 28 13:17:56 2015

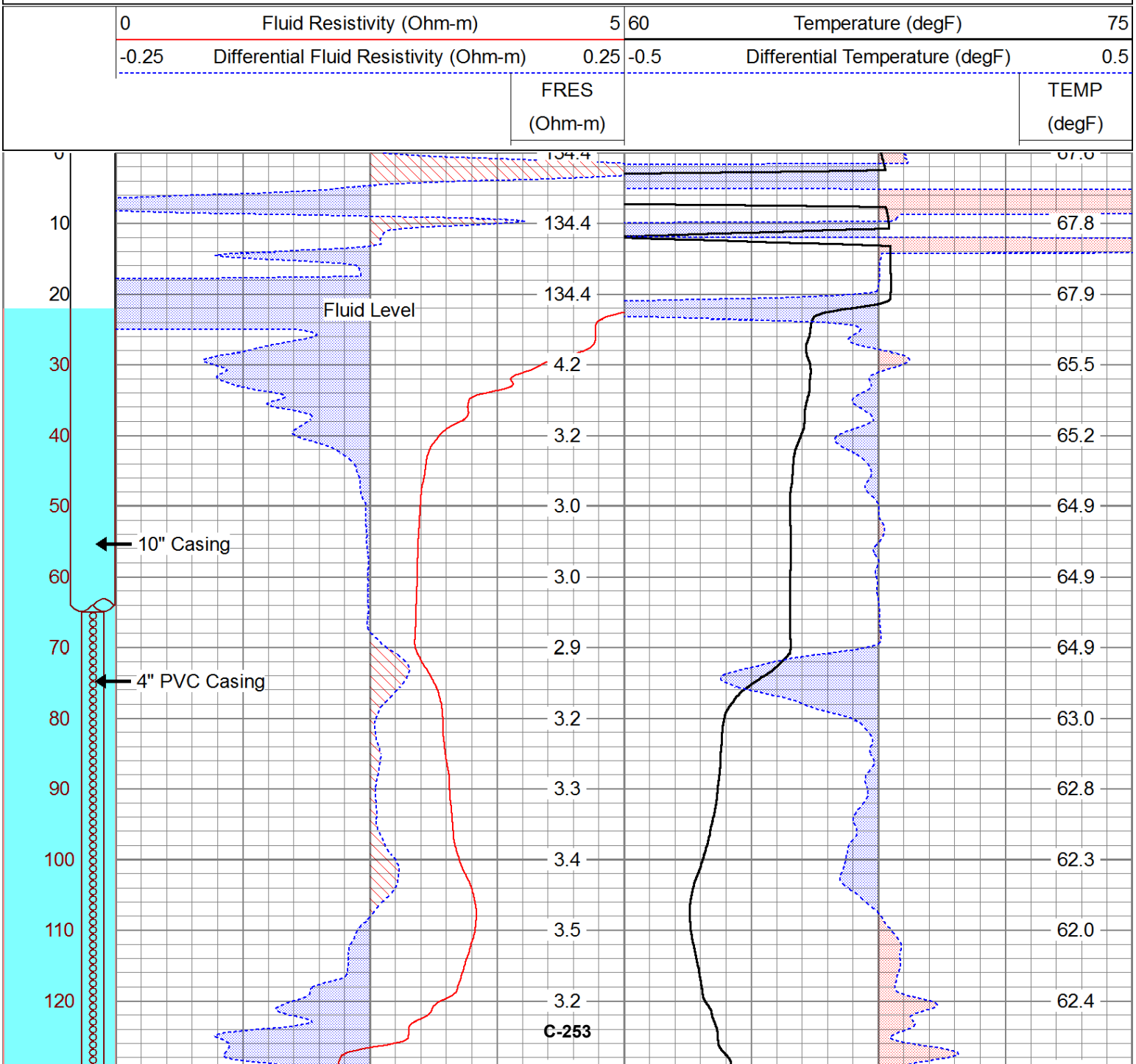
C-252

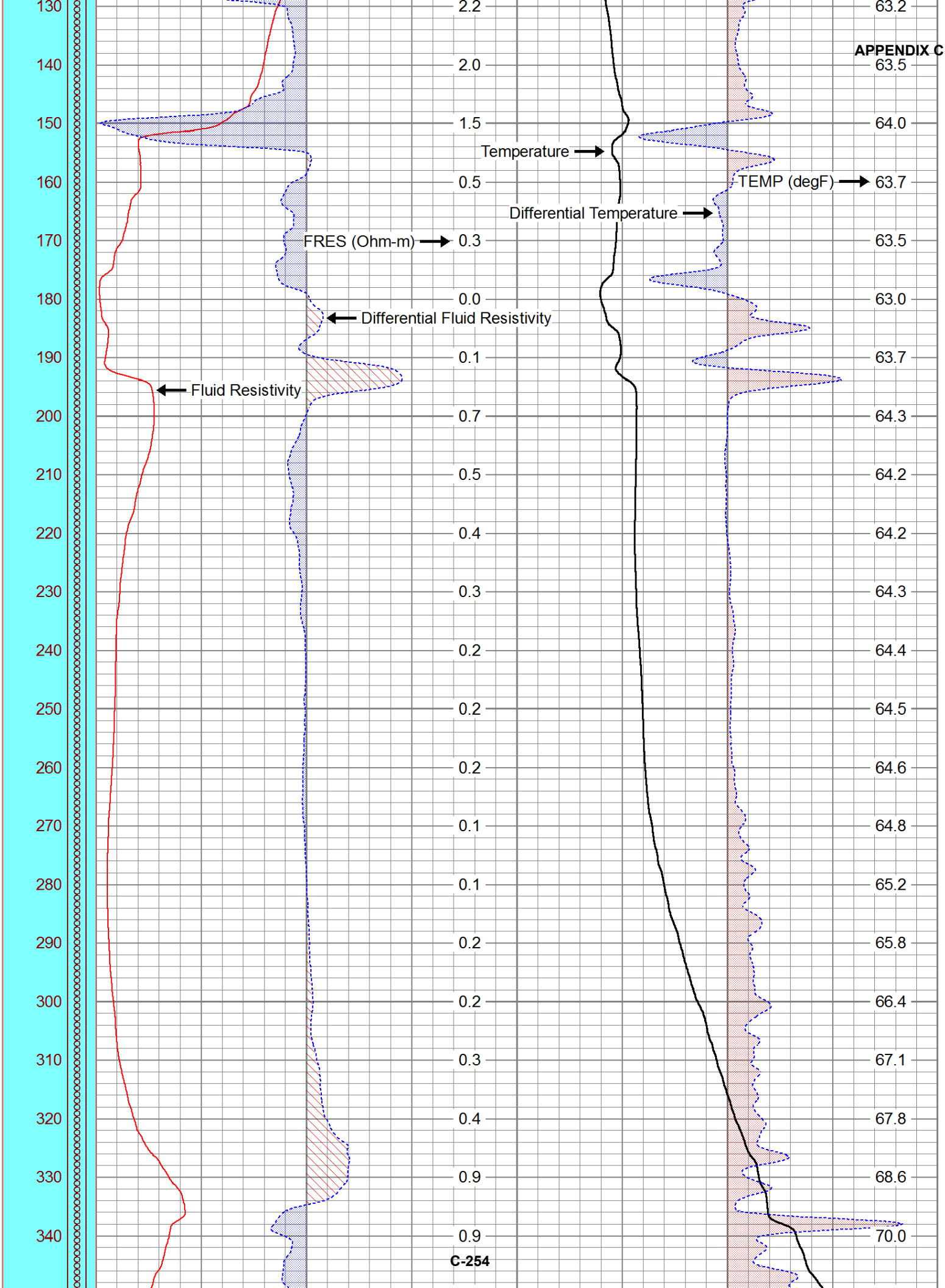
Temperature Calibration Report

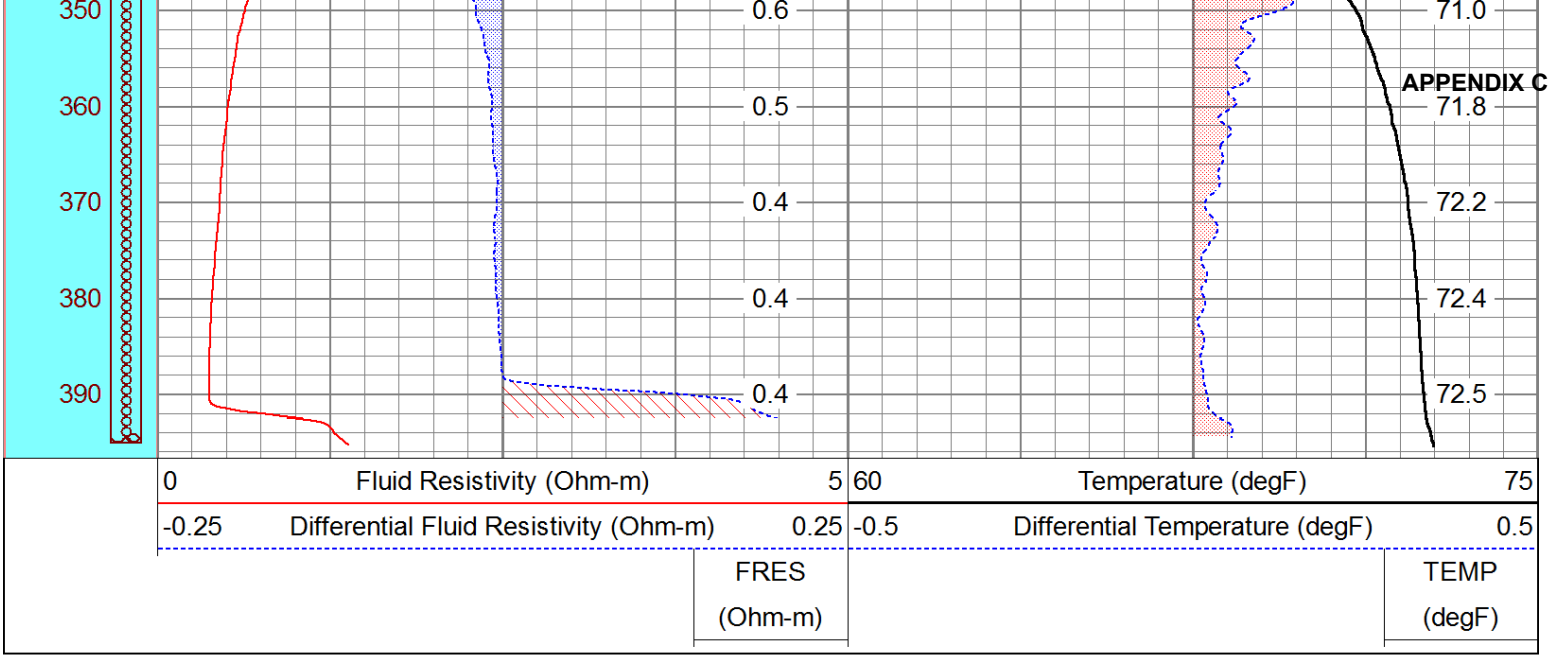
APPENDIX C

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Wed Jan 14 15:09:13 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

Database File	19633.db
Dataset Pathname	tmp
Presentation Format	frttemp2
Dataset Creation	Thu May 28 13:17:56 2015
Charted by	Depth in Feet scaled 1:240




130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
2.2
2.0
1.5
0.5
0.3
0.0
0.1
0.7
0.5
0.4
0.3
0.2
0.2
0.1
0.1
0.2
0.2
0.3
0.4
0.9
0.9
63.2
63.5
64.0
63.7
63.5
63.0
63.7
64.3
64.2
64.2
64.3
64.4
64.5
64.6
64.8
65.2
65.8
66.4
67.1
67.8
68.6
70.0
Temperature
TEMP (degF)
Differential Temperature
FRES (Ohm-m)
Differential Fluid Resistivity
Fluid Resistivity


350
360
370
380
390
0.6
0.5
0.4
0.4
0.4
71.0
71.8
72.2
72.4
72.5
APPENDIX C
0
Fluid Resistivity (Ohm-m)
5
60
Temperature (degF)
75
-0.25
Differential Fluid Resistivity (Ohm-m)
0.25
-0.5
Differential Temperature (degF)
0.5
FRES
(Ohm-m)
TEMP
(degF)

APPENDIX C

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19633

File No.

Company CASCADE DRILLING

Well MW-9D

Field SALINAS

County MONTEREY State CA

Location

NORTH OF SALINAS RIVER ON MONTE RD.
GPS: N 36o 44.026' W 121o 46.750'

Other Services:

TRMPERATURE
FLUID RESISTIVITY

			Elevation	Elevation
Permanent Datum	G.L.			
Log Measured From	G.L.	0'	above perm. datum	K.B.
Drilling Measured From	G.L.			D.F.
				G.L.

Date	05-28-2015		
Run Number	ONE		
Depth Driller	395'		
Depth Logger	395'		
Bottom Logged Interval	395'		
Top Log Interval	0'		
Open Hole Size	10.75" (65'-149')	9.875" (149'-249')	8" (249'-395')
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	22'		
Bentonite Seal	N/A		
Time Well Ready	1300		
Time Logger on Bottom	1330		
Equipment Number	PS-3		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	A KHALIGHI		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	149'				
TWO	9.875"	149'	249'				
THREE	8"	249'	395'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	10.75" OD	N/A	0'	65'
Prot. String				
Production String	4" PVC	SCH 80	0'	395'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File 19633.db
Dataset Pathname DIL
Dataset Creation Thu May 28 14:22:35 2015

C-256

Dual Induction Calibration Report

Serial-Model:	0001-ALT		
Surface Cal Performed:	Thu May 28 14:18:00 2015		**APPENDIX C**

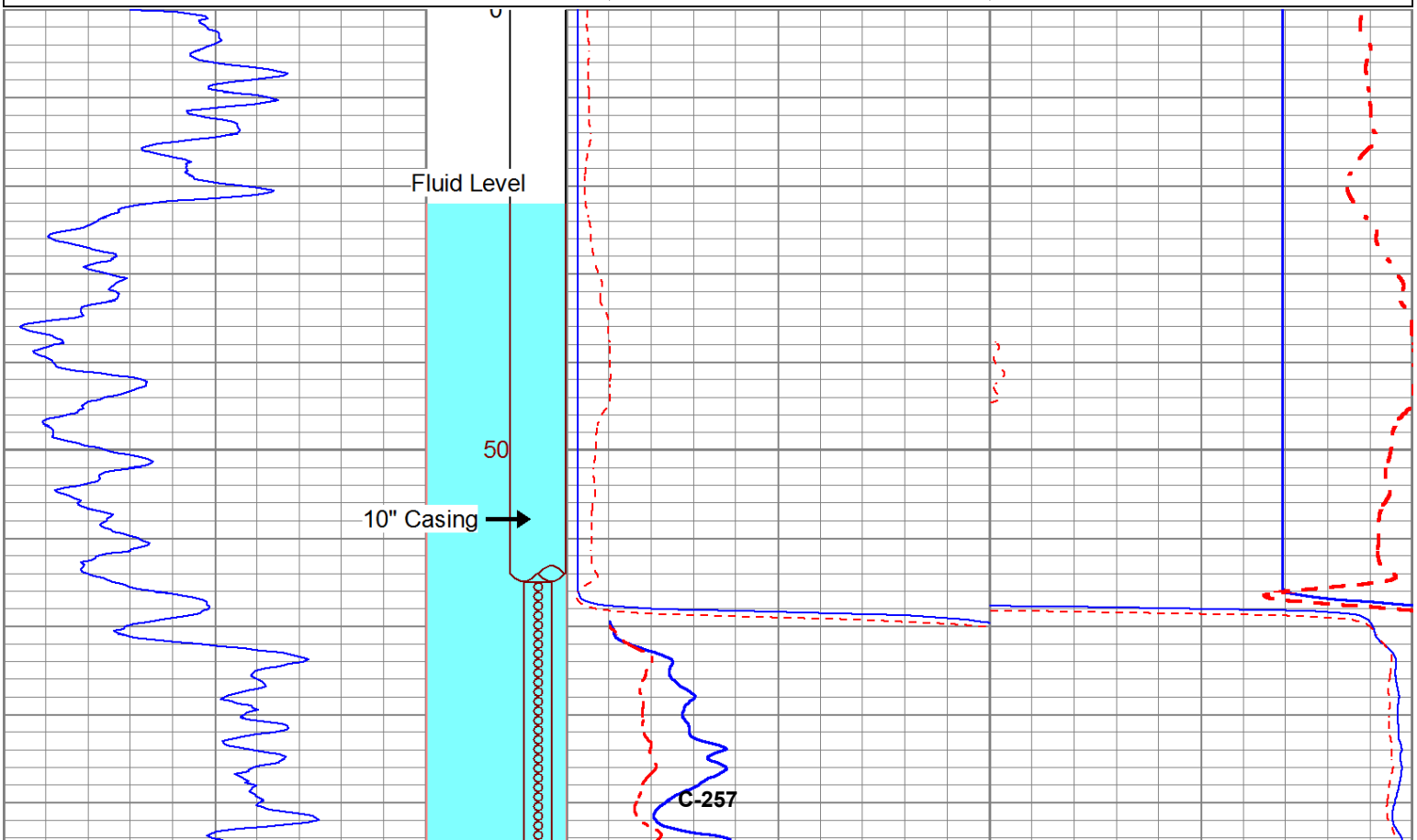
	Readings			References			Results	
Loop:	Air	Loop		Air	Loop		m	b
Deep	1415.523	3902.666	cps	0.000	612.000	mmho/m	0.246	-348.312
Medium	2127.303	14352.315	cps	0.000	1960.000	mmho/m	0.160	-341.064

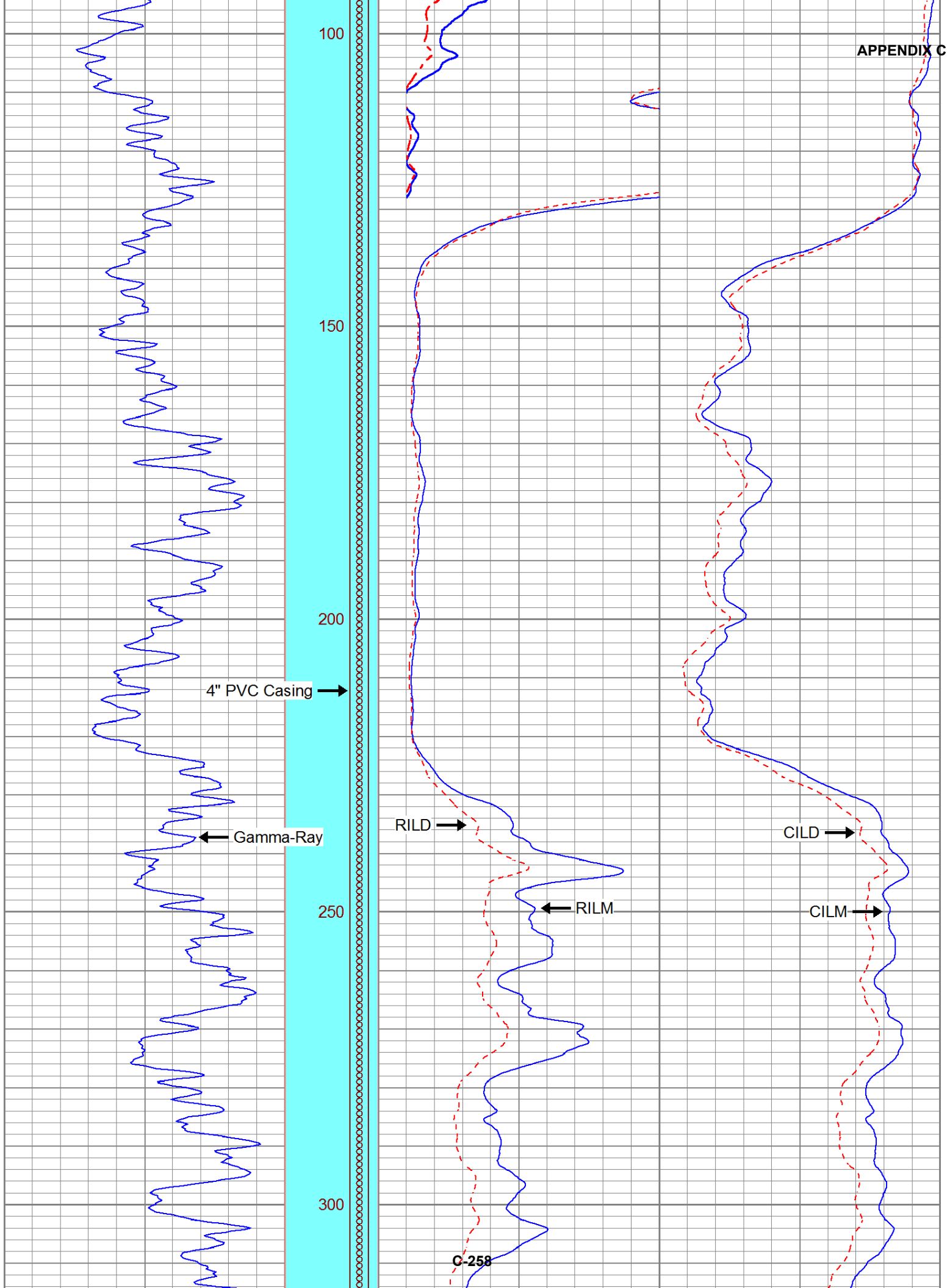
Gamma Ray Calibration Report

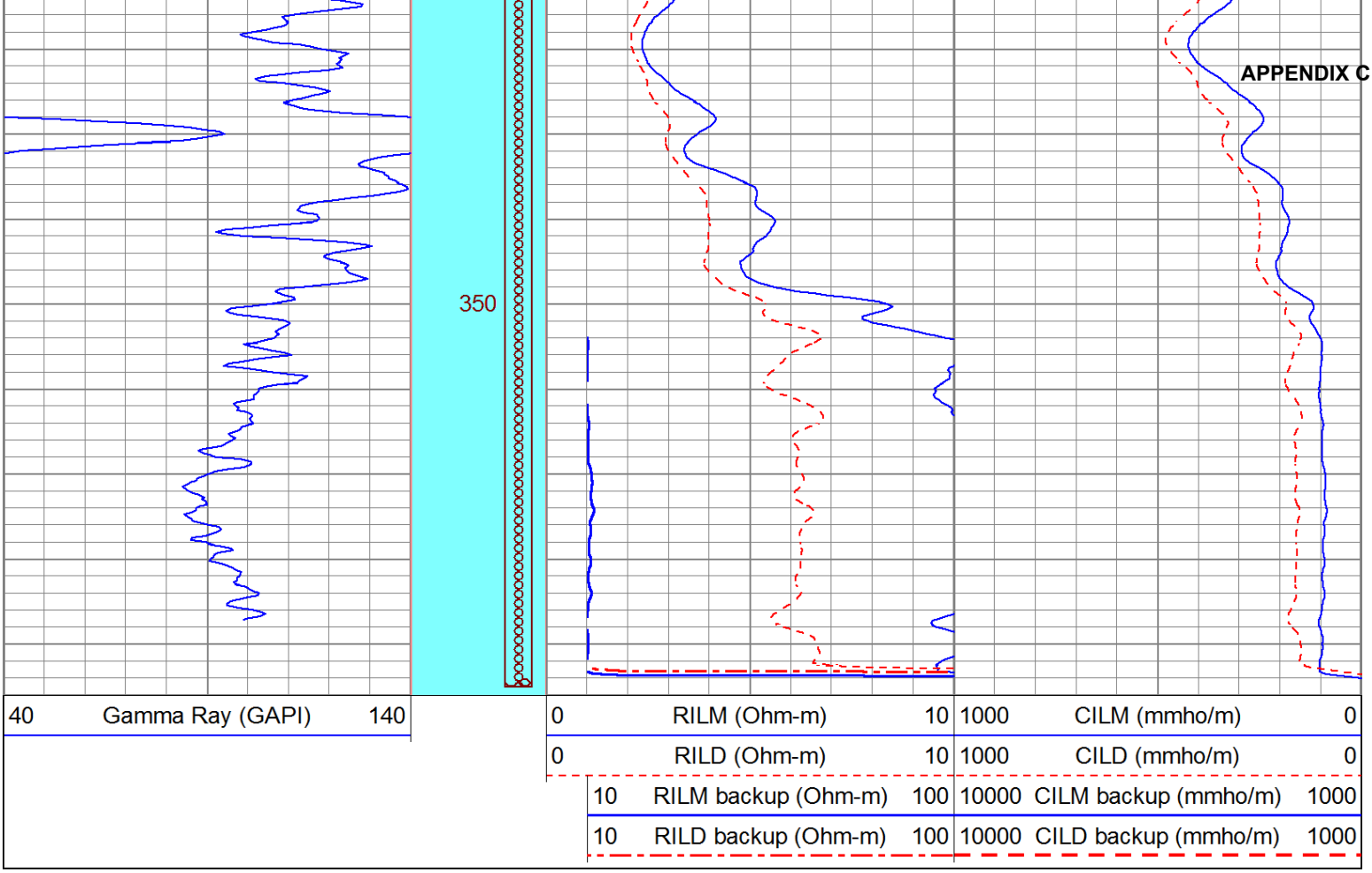
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Thu Jul 31 14:56:36 2014	
Calibrator Value:	162.0	GAPI
Background Reading:	43.3	cps
Calibrator Reading:	130.3	cps
Sensitivity:	1.8626	GAPI/cps

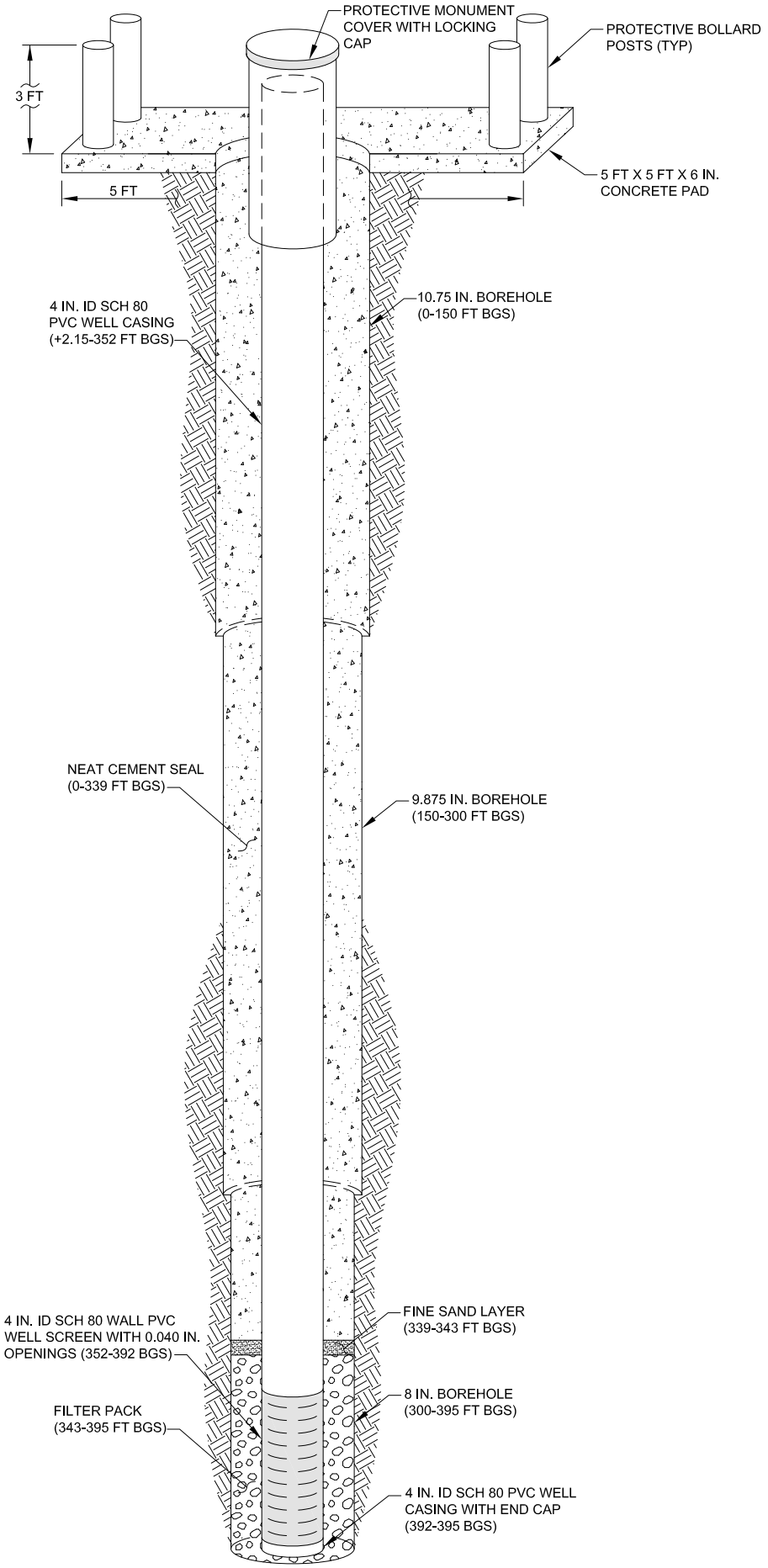
Database File	19633.db
Dataset Pathname	DIL
Presentation Format	dil_ps
Dataset Creation	Thu May 28 14:22:35 2015
Charted by	Depth in Feet scaled 1:240

40	Gamma Ray (GAPI)	140	0	RILM (Ohm-m)	10	1000	CILM (mmho/m)	0
			0	RILD (Ohm-m)	10	1000	CILD (mmho/m)	0
			10	RILM backup (Ohm-m)	100	10000	CILM backup (mmho/m)	1000
			10	RILD backup (Ohm-m)	100	10000	CILD backup (mmho/m)	1000




100
150
200
250
300
4" PVC Casing
Gamma-Ray
RILD
RILM
CILD
CILM


350
40 Gamma Ray (GAPI) 140
0 RILM (Ohm-m) 10
0 RILD (Ohm-m) 10
10 RILM backup (Ohm-m) 100
10 RILD backup (Ohm-m) 100
1000 CILM (mmho/m) 0
1000 CILD (mmho/m) 0
10000 CILM backup (mmho/m) 1000
10000 CILD backup (mmho/m) 1000



WELL PROFILE

NOT TO SCALE

APPENDIX 5.B – MCWRA MONITORING PROTOCOLS

Quality Assurance Project Plan (QAPP)
For
Water Quality Monitoring
Associated with the Salinas Valley Integrated Water Management Plan (SVIWMP)

EPA R9#03-238
X-97994701-0

UNDER REVISION
(10/19)

Monterey County Water Resources Agency
P.O. Box 930
Salinas, CA 93902
Telephone: (831) 755-4860
Fax: (831) 424-7935
Website: http://www.mcwra.co.monterey.ca.us

WATR0584QV4 (copy 2)

1.0 PROJECT MANAGEMENT

1.1 TITLE AND APPROVAL PAGE

Quality Assurance Project Plan
For
Water Quality Monitoring Associated with
The Salinas Valley Integrated Water Management Plan (SVIWMP)
EPA R9#03-238
X-97994701-0

Prepared by:
Monterey County Water Resources Agency (MCWRA)
P.O. Box 930
Salinas, CA 93902

Prepared for:
US EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105-3901

Approval Signatures

Elizabeth Krafft Agency Project Manager:	Date: 8/17/07
Kathleen Thomasberg Agency Project QA/Task Manager:	Date: 8/17/07
Eugenia McNaughton, Ph.D. USEPA Region 9 QA Program Manager:	Date: 10/22/07
Carolyn Yale USEPA Region 9 Project Officer:	Date: 12/3/07
Mark Kutnink USEPA Region 9 Chemist:	Date: 22 Oct 2007

UNDER REVISION (10/2019)

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7 Coastal Ground Water Monitoring Program Wells

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2 Quality Control Requirements for Laboratory Analyses
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B-3 Example of Photo-Log

UNDER REVISION (10/2019)

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C-2 Laboratory Data Review Checklist
D Monterey County Consolidated Chemistry Laboratory
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D-2 Specific Conductance
D-3 pH
D-4 Total Alkalinity
D-5 Metals
D-6 Anions

UNDER REVISION
(10/2019)

1.3 DISTRIBUTION LIST

The following is a list of organizations and persons who will receive copies of the approved QA Project Plan and any subsequent revisions:

Monterey County Water Resources Agency (Agency)
P.O. Box 930
Salinas, CA 93902

Elizabeth Krafft
Project Manager
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krafftea@co.monterey.ca.us

Kathleen Thomasberg
Project QA/Task Manager
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Hydrologist/ Team Lead
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Carla James
Water Resources Technician/ Field Sampler
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JamesCR@co.monterey.ca.us

Tamara Voss
Water Resources Technician/ Field Sampler
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U.S. Environmental Protection Agency, Region 9
75 Hawthorne Street
San Francisco, CA 94105-3901

Eugenia McNaughton, Ph.D.
QA Program Manager
(415) 972-1111

Carolyn Yale
Project Officer
(415) 972-3482

Mark Kutnink
Chemist
(415) 972-3801

UNDER REVISION (10/2019)

Monterey County Consolidated Chemistry Laboratory (CCL)
1270 Natividad Road, Room A15
Salinas, CA 93906

Germain Guibert
Laboratory Director
(831) 755-4516

1.4 PROJECT/TASK ORGANIZATION

The organization responsible for overseeing this ground water monitoring program is the Monterey County Water Resources Agency (Agency). This project is funded through a grant from the Environmental Protection Agency (EPA), under the authority of Section §104 (b)(3) of the Clean Water Act. This project falls under the Monitoring and Assessment funding category. The Monterey County Health Department's Consolidated Chemistry Laboratory is a California state certified laboratory that will perform the chemical analyses for this ground water monitoring program. The laboratory will use standard analytical methods.

The roles and responsibilities of those involved in the implementation of the ground water monitoring program are described below. An organizational chart for the program is shown below.

Project Manager is the responsible official who will oversee the preparation of grants and the fiscal management of the project.

Project QA Manager is in charge of establishing the QA/QC protocols found in the QAPP as part of the sampling and analysis procedures. The QA Manager will also review and assess all analytical data from the contract laboratory and will be the liaison regarding data quality issues and concerns. She may stop all actions, including those conducted by the contract laboratory and will be responsible for ensuring that any amended versions of the QAPP are distributed to the organizations and individuals listed in Section 1.3.

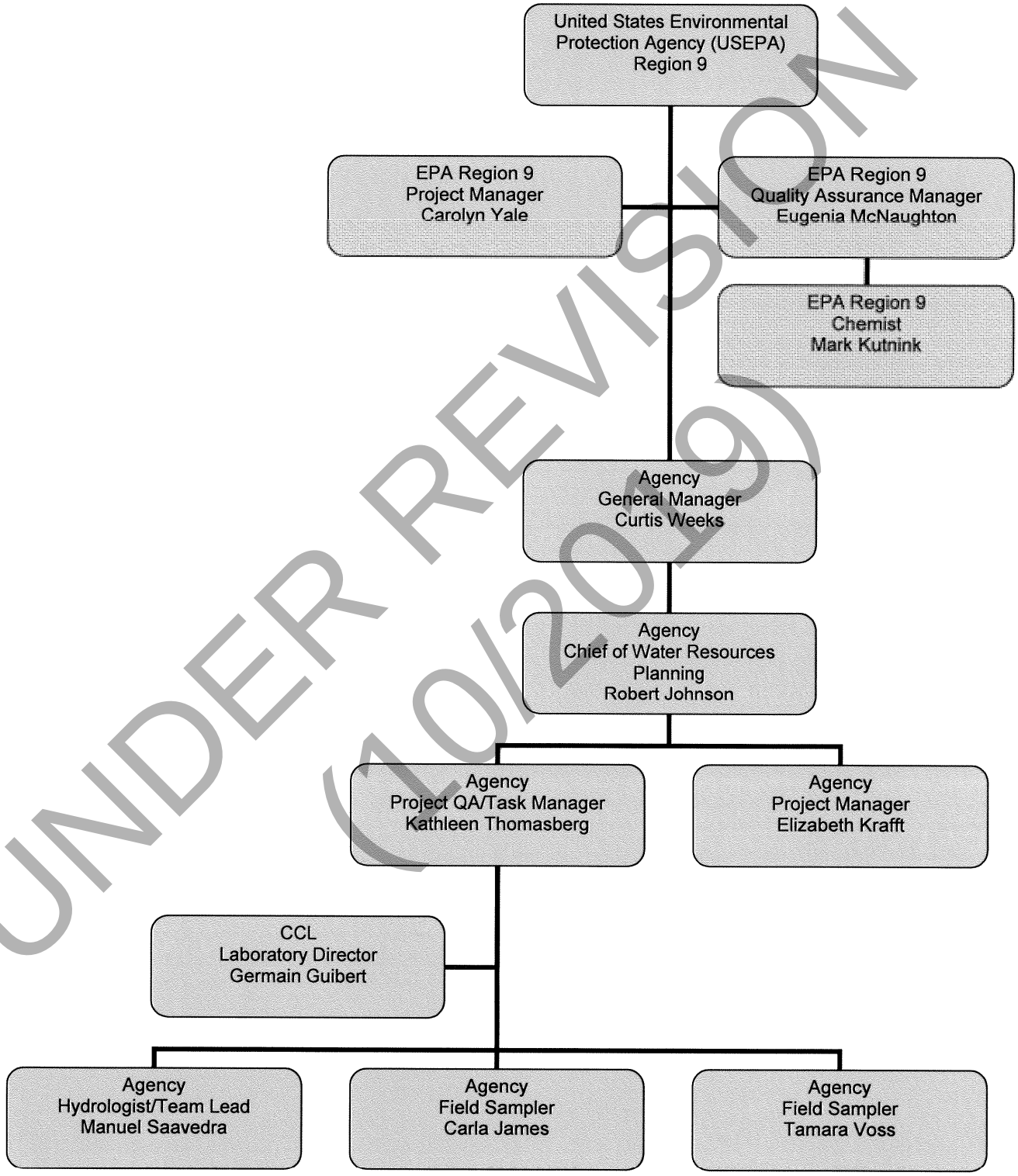
Project Task Manager will oversee the ground water monitoring program. She will ensure that all QAPP protocols are followed and will oversee the writing and revisions of the QAPP. Since the Agency's Water Quality Department is not large, the Project Task Manager will function in the dual role of Task Manager and QA Manager.

Hydrologist/Team Lead will be responsible for coordinating with the Water Resources Technicians/ Field Samplers to review field and analytical requirements, documentation, and sampling schedules.

Water Resources Technicians/Field Samplers will be responsible for sample collection and communication with the contract laboratory regarding the sampling shipment schedule. They are also responsible for writing the QAPP.

UNDER REVISION (10/2019)

ORGANIZATIONAL CHART



UNDER REVISION (10/2019)

1.5 PROBLEM DEFINITION/BACKGROUND

1.5.1 Background

The Monterey County Water Resources Agency's (Agency) mission is to manage, protect, and enhance the quantity and quality of water for present and future generations of Monterey County (County). Monterey County, located along the California Central Coast, covers 3,322 square miles (8604 km^2) and has a resident population of 424,842 (Fact Finder, 2007). The County supports a $3.4 billion agricultural industry (Ag Commission, 2006) and a $1.75 billion tourism industry (EPA Grant R9#03-238). The primary land use within the Salinas Valley is agricultural. Since the 1940's, irrigated acreage within the valley has increased substantially. Coastal regions of California are subject to rapid urbanization, and the milder coastal climate supports year-round intensive cultivation of many high-value crops (Hunt et al, 2003). As agricultural and urban areas have expanded, so have the water needs of the County (EPA Grant R9#03-238).

The Agency uses a network of wells to monitor ground water conditions in the Salinas Valley Ground Water Basin (Basin) (Geomatrix, 2001). The Basin is situated entirely within the County (EPA Grant R9#03-238). The Salinas Valley is surrounded by the Gabilan and Diablo Ranges on the east, by the Sierra de Salinas and Santa Lucia Range on the west, and is drained by the Salinas River, which empties into Monterey Bay in the north (DWR 1946a) (Fig 1). Four subareas based on differences in local hydrogeology and recharge have been identified (White Paper, 1995; DWR, 2003). These are known as the Pressure, East Side, Forebay, and Upper Valley subareas (Fig 2). These subareas are hydrologically and hydraulically connected (EPA Grant R9#03-238); all information collected to date indicates there are no barriers to the horizontal flow (of ground water) between these subareas (White Paper, 1995). The "boundaries" between these subareas have been identified as zones of transition between different depositional environments in past millennia (White Paper, 1995).

The primary surface water features overlying and influencing the Basin's hydrology are the Salinas River and its tributaries, the Nacimiento and San Antonio reservoirs, and the Monterey Bay (EPA Grant R9#03-238). The Salinas River extends approximately 120 miles from the river's headwaters in San Luis Obispo County, near Santa Margarita, and flows north/northwest and discharges into the Monterey Bay National Marine Sanctuary near Moss Landing in Monterey County (EPA Grant R9#03-238). The Nacimiento and San Antonio reservoirs, located in the upper watershed, serve as storage and flood control for the Basin.

Ground water recharge in Salinas Valley is principally from infiltration from the Salinas River, Arroyo Seco Cone, and to a much lesser extent, from deep percolation of rainfall (White Paper, 1995). Deep percolation of applied irrigation water is the second largest component of the ground water budget, but because it represents recirculation of existing ground water rather than an inflow of "new" water, it is not considered a source of recharge (White Paper, 1995). Nitrate contamination of ground water poses a significant threat to the beneficial use of ground water for drinking water and for some agricultural water uses (White Paper, 1995). Nitrate concentrations exceed drinking water standards in some parts of the Basin (MCWRA, 1997). The principal source of nitrates to ground water is almost certainly excess fertilizer that is leached by rainfall and applied irrigation water (White Paper, 1995).

Seawater intrusion is another source of inflow to the Basin, but because it is not usable freshwater it is also excluded as a source of recharge (White Paper, 1995). Historically, ground water flowed from subareas to the south and east through the (Pressure) and seaward to discharge zones in the walls of the submarine canyon in Monterey Bay (Durbin et al 1978; Greene 1970). Within the Pressure subarea, due to the impermeable nature of the clay aquitard above the 180-Foot Aquifer,

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recharge from precipitation, agricultural return flows, or river flow is nil (DWR, 2003). Instead, recharge is from underflow originating in Upper Valley areas such as the Arroyo Seco Cone and Salinas River bed or the East Side subarea, and more recently, from seawater intrusion (DWR, 2003). Heavy pumping of the Pressure-180 Foot and Pressure-400 Foot aquifers has caused significant seawater intrusion into both of these aquifers, which was first documented in the1930's (DWR 1946a). Ground water flow in the northernmost area of the Pressure subarea has been directed from the Monterey Bay inland since this time (DWR, 2003). With increased pumping in the East Side subarea since the 1970's, ground water flow is dominantly northeast in the Pressure's central and southern locations (DWR, 2003).

Declining ground water levels in the Pressure and East Side subareas, Basin overdraft, ground water contamination, including nitrate and seawater intrusion are serious concerns for the Agency. (EPA Grant R9#03-238)

1.5.2 Program Objectives

The Agency is charged with management of the Basin's ground water resources. Much of the Agency's investigative work pertaining to the occurrence and use of ground water is to identify the quality, quantity, and temporal trends of ground water resources within the County. A network of monitoring wells provides the information needed to manage and protect ground water resources and sustain beneficial uses. In order for the Agency to develop projects to mitigate problems, such as seawater intrusion, local ground water overdraft, and high nitrate concentrations, the Agency must first implement an effective and accurate monitoring program to identify the extent of the potential problem.

The Ground Water Quality Monitoring Objectives are:
-continued monitoring of the ambient ground water quality, including general minerals
-continued monitoring of coastal aquifers (including Pressure Deep Aquifer) for detection of advancing seawater intrusion
-continued monitoring to determine distribution of conductivity in ground water
-continued monitoring to determine distribution of nitrate in ground water and identification of problem areas

Ambient ground water quality will be used to establish a cohesive and succinct Water Quality Management Plan in accordance to the work begun under EPA-I and continued under EPA-II. For the purposes of this QAPP, the EPA-I grant has funded the Agency to develop this QAPP. The EPA-II grant is funding the Agency to implement the sampling described in the QAPP.

1.5.3 Program Goals

The ground water monitoring objectives in the Salinas Valley will be met by the goal of sampling all 344 wells located throughout the four subareas within the Salinas Valley Ground Water Basin, during the 2007 summer field season.

The ground water monitoring objectives along the coast, specifically located within the Pressure subarea will be met by the goal of sampling all 85 monitoring wells, during the 2007 summer field season.

The Agency's overarching goal for this program is the continued monitoring of the Basin's ambient ground water for use in the management of this important resource, and *not* for the purpose of regulatory control.

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1.6 PROJECT/TASK DESCRIPTION

1.6.1 Work Statement and Produced Products

The Salinas Valley Ground Water monitoring will sample 344 wells located throughout the Salinas Valley Ground Water Basin for ten constituents (Table 1). Each well will be sampled once. Samples will be collected during the 2007 summer agricultural growing season and analyzed for a complete mineral panel. The Coastal Ground Water monitoring will sample 85 wells located within the area of historic seawater intrusion. Each well in the Coastal Program will be sampled once a month during the agricultural growing season. The first month's sample will be analyzed for complete mineral panel and the two remaining sampling events will by analyzed for partial mineral panel (three constituents) (Table 1). All water monitoring samples will be delivered the same day as collected to the contract laboratory for analysis.

All ground water sampling locations are accessible using a 4-wheel drive vehicle. All samples will be collected as a grab sample. All sampling locations will be recorded using global positioning system (GPS) equipment, and digital pictures will be taken at each site.

After laboratory analysis and data validation is completed, a technical memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment) will be written and submitted to US EPA. The technical memorandum, EPA II, XP-96995301 Task 2 Water Quality Assessment, will include result tables for chloride, nitrate, and specific conductivity, and maps of chloride, nitrate, and specific conductivity gradient contours.

1.6.2 Constituents to be monitored and measurement techniques

Samples will be sent to an off-site laboratory for analysis. Ground water samples will be analyzed for either complete or partial mineral panels. A complete mineral panel includes calcium, cation-anion balance, chloride, conductivity, magnesium, nitrate, pH, potassium, sodium, sulfate, and total alkalinity. A partial mineral panel consists of chloride, conductivity, and nitrate.

Sample analysis will be preformed at the Monterey County Consolidated Chemistry Laboratory (CCL), which is part of the Environmental Health Department. Listed below is the laboratory's contact information and ELAP Certification number.

Laboratory Name	*Contact Information*	*Abbreviation*
Monterey County Consolidated Chemistry Laboratory ELAP Certification No 1395	1270 Natividad Road Salinas, CA 93906 Phone: 831-755-4516 Fax: 831-755-4652 http://www.co.monterey.ca.us/health	CCL

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1.6.3 Project Schedule

The proposed project schedule is summarized below.

Prior to Sample Collection	
January 2006 - January 2007	: Develop project strategy
15 January, 2007	: Submit Draft QA Project Plan
22 March, 2007	: Receive review comments on QA Project Plan from US EPA
6 July, 2007	: Submit Draft Final QA Project Plan
13 July, 2007	: Obtain QA Project Plan approval (to begin fieldwork)
20 July, 2007	: Submit Final QA Project Plan (signatory copy) EPA R9#03-238; X-97994701-0
Sample Collection	
August 2007 - September 2007	: Coastal Ground Water (each well 3x, once per month)
August 2007 - September 2007	: Salinas Valley Ground Water (each well 1x)
Post Sample Collection	
November 2007	: Compile all remaining laboratory analyses reports
1 - 15 December, 2007	: Evaluate laboratory data for QA/QC requirements
15 December, 2007	: Copy of analytical results sent to well owner/operators
16 - 31 December, 2007	: Summarize and tabulate data
January 2008	: Write Technical Memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment)
March 2008	: Submit Technical Memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment) to US EPA

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1.6.4 Geographical Setting

The Salinas Ground Water Basin encompasses approximately 537.5 square miles (1,392 km^2). The regional ground water flow is to the northwest. Seawater intrusion is a result of coastal pumping (Figure 3). Ground water pumping can dramatically impact localized coastal ground water flow.

1.6.5 Constraints

Ground water samples must be taken from the well while the pump is operating to ensure that the sample is representative of the aquifer and not standing water within the well casing. The Agency wants to measure the water quality when the aquifers are stressed due to pumping. For this reason the 2007 field sampling season will coincide with the agricultural irrigation season.

1.7 DATA QUALITY OBJECTIVES FOR MEASUREMENT DATA

This section describes the data objectives of the project and defines the measurement performance criteria deemed necessary to meet those objectives.

1.7.1 Objectives and Project Decisions

In Monterey County the Salinas Valley and Coastal Ground Water ambient monitoring programs are designed to characterize the ground water quality conditions of the Basin. All data generated from the sampling program in this project are tabulated as they have been over the many years of the program. Data generated from these monitoring activities allows the Agency to track changes in ground water quality over time and to assess potential impacts to ground water in the Basin. Water resource management and policy decisions may follow based on maps and tabulated data generated as a part of this project (program).

For the coastal ground water sampling program, the general mineral data are evaluated to determine if seawater intrusion is progressing landward as indicated by increasing well chloride values. The chloride values for all wells are evaluated, and then the 500mg/L chloride isochlor contours are mapped for the two coastal aquifers. When the maps are published, the information generated by MCWRA staff and approved by the MCWRA Board of Directors, is posted and passed on to Monterey County departments, regional government regulatory agencies, and public / private entities via the MCWRA web page, presentations, public meetings, and networking.

Monterey County departments such as the Planning Department and Health Department utilize the advancement of seawater as it relates to potable water and public health, while the agricultural community becomes aware of the proximity of their wells to the intrusion advancement, and the possible need for funds to drill new, deeper, wells and destroy the older high nitrate wells. Actions by regulators, depending on the entity, are related to prioritization of Regional Watershed and Water Quality Action Plans, and the associated success of MCWRA capital projects to halt seawater intrusion as governed by the State Water Resources Control Board adjudication process.

Actions by the MCWRA after the landward advancement of seawater have been ongoing for many years. Actions include consideration of more stringent Monterey County well drilling ordinances for assuring the continued prevention of cross-aquifer contamination in the coastal Salinas Valley, *"Zone 6 Drilling Standards", April 19, 1988;* the development and implementation of the Monterey County Recycling Projects, a tertiary treatment plant and treated water distribution system, to help further reduce agricultural pumping in the coastal Salinas Valley for halting seawater intrusion; and future use of these data will be utilized by the newly established Seaside Watermaster for comparison to and the development of the Monterey Peninsula seawater intrusion front.

For the Salinas Valley general mineral ground water sampling program, nitrate data tabulation and map representation has been the focus of the MCWRA for many years. All results over the laboratory's practical quantitative limit generated from this program are tabulated to evaluate the minimum, maximum, median, and mean value of nitrate as NO_3 in mg/L for each of the Salinas Valley Hydrogeologic Subareas.

For the Salinas Valley monitoring program, the Agency sends the general mineral testing results, including nitrate, to the well owners/growers who operate the wells sampled. Also, in this transmittal, the well operators are also provided with a conversion sheet of the nitrate concentration *from mg/L nitrate as NO_3 to pounds of nitrate per acre inch of water*, agricultural terms. If a nitrate

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value in ground source water is elevated, then that growers can incorporate this available nitrate into their fertilizer crop scheduling. This is a method for growers to reduce applied nitrate to crops, while maintaining maximum crop productivity.

And, as with the Coastal monitoring program, the tabulated and mapped Salinas Valley nitrate data are posted and passed on to Monterey County departments, regional government regulatory agencies, and public / private entities via the MCWRA web page.

The MCWRA uses the well nitrate data during the technical well application review process. Monterey County Health Department (Heatlh Department) issues well permits after the Agency provides a technical review of well applications for new, abandoned, or repaired wells. The well application proposal is evaluated with other well construction and water quality within a one miles radius of the new well and represented on a map. Agency staff makes qualitative recommendations to the Health Department on the new well's sanitary seal based on other well seals, the perforated intervals, and the nitrate values of wells in the area. The final decision for the well construction is made by the Health Department after the well drilling progresses.

Actions taken by the MCWRA are conditional. If extreme nitrate values are observed in agricultural production wells, then re-sampling of the wells may take place to confirm the elevated concentrations and may lead to increased sampling points for wells in the same vicinity and with the same well design. Continued increases in Salinas Valley ground water nitrate values could lead to special nitrate investigations on movement of nitrate in ground water and also outreach to the public on the reduction of nitrate to the environment.

1.7.2 Action Limits/Levels

Since the overarching goal for this project is the continued monitoring of ambient ground water, the Agency has set no specific water quality standards. As a result, the laboratory's practical quantitation limits (PQL) will serve as the Project Action Levels (PALs). Table 1 provides a listing of the parameter to be sampled and a summary of the laboratory's method detection limit, those minimum concentrations that can be detected above the instrumental background/baseline signal noise. Table 1 also provides the PQL, lowest calibration standard and PALs required by the Agency for the QAPP. The quality limits listed are deemed acceptable by the Agency to meet the project objectives.

1.7.3 Measurement Performance Criteria

The objective of data collection for this Monitoring Project is to produce data that represent the *in situ* conditions of the ground water. This objective will be achieved by using accepted standard methods for water collection and analysis and defining data quality indicators (DQIs) for each analytical parameter. The DQIs include accuracy, precision, comparability, sensitivity, completeness, and representativeness and are defined below and presented in Table 2. Some DQIs will be assessed quantitatively, while others will be qualitatively assessed. Example calculations have been provided for quantitative assessments and appropriate quality control (QC) samples have been identified. Laboratory Data Quality Objectives are given in Table 3.

Accuracy, or bias, is a measure of how close a result is to the expected value of the target analyte in a sample. Accuracy will be determined by the analysis of certified reference materials and matrix spikes, where the results can be compared with an expected value and expressed as %recovery. This is an assessment of laboratory analytical methods. For Laboratory Control Samples (LCS), it will be expressed as %recovery by the following equation:

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$$\%Recovery = \frac{X}{T} \times 100$$

where,

X = Measured concentration
T = True spiked concentration

or, for Matrix Spike (MS) samples, by the following equation:

$$\%Recovery = \frac{(B - A)}{T} \times 100$$

where,

B = Measured concentration of spiked sample
A = Measured concentration of unspiked sample
T = True spiked concentration

The frequency of the LCS and MS samples associated with the analytical parameters will be 5%. MS and MSD samples will be spiked at 3-10 times the native sample concentration.

Accuracy/bias as related to contamination involves both field and laboratory components. Field blanks will be collected at a frequency of 5%. Laboratory blanks will be prepared and analyzed at a one per batch or 5% frequency.

Precision is concerned with the ability to quantitatively repeat results. To demonstrate the precision of a method or instrument, field duplicates will be collected, analyzed, and their results compared. Precision is expressed as relative percent difference (RPD) by the following equation:

$$RPD\ (\%) = \frac{|X_1 - X_2|}{(X_1 + X_2)/2} \times 100$$

where,

X_1 = Original sample concentration
X_2 = Duplicate sample concentration
$|X_1 - X_2|$ = Absolute value of $X_1 - X_2$

Field duplicates will be collected at a frequency of 10% for the first two sampling events. If the criterion of <25% RPD is met, then the remaining field duplicates will be collected at a 5% frequency. Laboratory duplicates will be prepared and analyzed at a one per batch or 5% frequency.

Comparability of the data can be defined as the similarity of data generated by different monitoring programs. Comparability helps to measure the scientific coherence and validity of a project. This objective is addressed primarily by using standard sampling and analytical procedures. Additionally, comparability of analytical data is addressed by result comparison of certified reference materials.

Sensitivity of the analytical instrument or method is the ability to detect and quantify an analytical parameter at the concentration level of interest. Sensitivity can be evaluated by method or instrument detection limit studies (MDL and IDL) or calculated practical quantitative limits (PQL) and method report limits (MRL).

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Completeness is a measure of the amount of successfully collected and validated data relative to the amount of data planned to be collected for the project. Project completeness is typically based on the percentage of the data needed for the program or study to reach statistically valid conclusions. Because the SVIWMP is a monitoring program, data that are not successfully collected for a specific sample event or site can typically be recollected at a later sampling event. For this reason, most of the data planned for collection can not be considered statistically critical, and it is difficult to set a meaningful objective for data completeness. However, some reasonable objectives for the data are desirable, if only to measure the effectiveness of the Monitoring Program. %Completeness will be expressed by the following equation:

$$\%\text{Completeness} = \frac{N}{T} \times 100$$

where,

N = Number of usable results
T = Total number of samples planned to be collected

A completeness goal of 90% has been set for the ground water monitoring program.

Representativeness can be defined as the degree to which the environmental data generated by the monitoring program accurately and precisely represent actual environmental conditions. This objective is addressed by the overall design of the monitoring program. Specifically, assuring the representativeness of the data is addressed primarily by selecting appropriate locations, methods, times, and frequencies of sampling for each environmental parameter, and by maintaining the integrity of the sample after collection. Representativeness judges how well a single sample can describe the conditions of an entire sample population. Accurate, artifact-free sampling procedures and appropriate sample homogenization achieve representativeness.

1.8 TRAINING REQUIREMENTS/CERTIFICATION

1.8.1 Training of Field Personnel

A specialized training requirement for this project is for the use of Global Positioning Systems (GPS) Technology. Training in the use of handheld GPS units and software will be performed on an individual basis between the trainer and the trainee. Training will be provided by staff experienced in the use of GPS and Geographic Information Systems (GIS).

Field personnel will also be given initial instructions prior to the beginning of sample collection activities. These initial instructions will help familiarize the field personnel with sample collection containers, sample handling techniques, chain-of-custody forms, and sample transport. New field personnel will be accompanied by a trainer in the field as part of the initial instructions. All field samplers have completed a four-hour training session in the field. Training included confirmation of the well ID electrical meter tag number and MCWRA tag number, recognizing the appropriate sampling port, sample collection technique, proper handling of the sample during transportation to the lab, and accurate completion of the chain-of-custody forms. The completion of field training session has been documented in the Agency's personnel files.

All field personnel will follow sample collection procedures from accepted methods for the collection of ground water. Sample collection will follow protocols in accordance with recommended guidelines established by the U.S. Geological Survey (USGS) for ground water collection as described in the

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National Field Manual for the Collection of Water-Quality Data, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 9, Chapters A1-A9. Field personnel will be familiar with the above-mentioned document.

Field personnel will also read and be familiar with this Quality Assurance Project Plan (QAPP) prior to beginning any sample collection activities.

1.8.2 Training of Laboratory Personnel

No specialized training of laboratory personnel is required for this project. The ground water constituents to be analyzed by the laboratory are routine and do not require additional expertise. In addition, the laboratory's QA plan notes that analysts 'must conduct sufficient preliminary tests using the methodology and typical samples to demonstrate competence in the use of the measurement procedure'.

1.8.3 GPS Training Documentation

Documentation of field personnel training for GPS includes: the name of the staff member being trained, the training date, the name of the trainer (instructor), and a checklist of satisfactory completion of each step. These training records are stored inside a monitoring binder and filed in the Agency's Water Quality Section. A sample GPS training record is attached in Appendix A.

Training documentation of laboratory personnel for routine methods is kept on file at the Consolidated Chemistry Laboratory (CCL). The CCL has written a policy regarding laboratory personnel training in their lab QA plan.

1.9 DOCUMENTATION AND RECORDS

1.9.1 QA Project Plan Distribution

The MCWRA Hydrologist/ Team Lead will safeguard the original QAPP and any subsequent revisions (both hard and electronic), plus keep a record of the distribution list in order to send out amendments to the QAPP and retrieve any obsolete versions (from the individuals listed earlier in section 1.3).

1.9.2 Field Documentation and Records

All field documentation generated by the sampling program will be kept on file in the Water Quality Section of the Agency. Field documentation includes field sheets, chain of custody (COC) forms, photographs, and labels (see Appendix B for examples of each).

1.9.2.1 Field Sheets

Field sheets are used to aid in the identification of each ground water source (well). The field sheets list the name of each well (as assigned by the well owner) and the State Well Number. The field sheets also contain a section that describes who the sampler should contact in order to have a well turned on, where to find the sample port, etc. The sampler is responsible for recording the sample date and time on the field sheet. Site observations should be written in the comments section of the field sheet, and initialed by the sampler. Site observations may include information such as detailed directions to the well location, changes to the electrical meter tag number, and the owner contact name and phone number. Field sheets also contain PG&E electrical meter numbers, which can be either verified or updated while the sampler is in the field.

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Field sheets are double-checked by the sampler for completeness and accuracy while still in the field. The sampler should look for: incomplete and/or missing data/omissions, incorrect or invalid information, and clarity problems. Any discrepancies should be cleared up before the sampler leaves the field. Data that has been entered by one field sampler will be reviewed by a different field sampler to verify that no transcription errors have occurred. These data entry reviews will take place at least weekly.

Original field sheets are categorized (according to Coastal wells or Salinas Valley wells) inside binders which are kept in the Water Quality Section at the Agency for a period of 10 years. After such time, the copies are transferred to the Monterey County Record Retention Center and archived for a period of 5 years.

Data collected on field sheets will also be recorded electronically and stored in an Access database inside a shared network drive that is backed-up on a daily basis. These electronic records will be retained permanently.

1.9.2.2 Chain Of Custody (COC) Forms

Chain-of-custody (COC) forms will be provided by the Consolidated Chemistry Laboratory and filled out while the sampler is in the field. The COC will accompany the samples at all times in order to insure the custodial integrity of the samples. A sample is considered to be in custody if it is: in someone's physical possession, in someone's view, locked up, or secured in an area that is restricted to authorized personnel.

Care should be taken to protect the COC from physical damage (i.e., water, wind, etc). The COC will have the following information:

- Client Code
- Client Name
- Client Address
- Client Phone Number
- Client Fax Number
- Report Attention
- Sampler Name
- Collection Date
- Collection Time
- Sample Site (identified by state well identification number) or QC sample (if appropriate)
- Sample Type (all of the samples in this project will be **grab** samples)
- Matrix (all of the samples in this project will be **ground water** samples)
- Analyses Requested

Upon relinquishing the sample(s) to the Consolidated Chemistry Laboratory, the sampler will sign and date the COC form. Lab personnel will then receive the sample(s), mark the date and time received, assign unique lab identification numbers (lab IDs) to each sample, and sign the COC form. The signed COC form is then photocopied; the lab keeps the original, and a copy is given to the sampler.

Hard copies of COC forms are categorized (Coastal wells or Salinas Valley wells) inside binders which are kept in the Water Quality Section at the Agency for a period of 10 years. After such time,

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the copies are transferred to the Monterey County Record Retention Center and archived for a period of 5 years.

Electronic COC information is also stored in an Access database inside a shared network drive that is backed-up on a daily basis. These electronic records will be retained permanently.

1.9.2.3 Photographs

The Agency maintains a photo catalog which contains photographs of the Coastal well site locations. The photo catalog is carried into the field to assist with the identification of each well. If there are significant changes to the appearance of the well site, then staff will take a new digital photo. The old photo in the catalog will then be replaced with a copy of the new photo. Photographs will be taken of the Salinas Valley wells after confirming the correct well location of each.

Two photographs of each well location will be taken using a high resolution digital camera. One photograph will be from a distance of 100 ft. or more to aid in the identification of the correct site location. The second photograph will be a close up of the well and pump head, which will be used to verify location of the correct sampling port. Printed hard copies of these two photographs for each well will be kept in the photo log book and labeled with the state well identification number as listed on the field sheets.

Photographs will serve to help verify information entered into the field sheets. Photographs are stored in an electronic database and labeled according to site number and date last photographed. Previous photos will be archived electronically for retrieval purposes if the need arises.

1.9.2.4 Labels

Labels for each sample site are pre-printed on Avery (size 5163) sheets (10 labels per sheet). Indelible ink will be used on the labels and clear packing tape will be applied over the label to prevent it from coming off if it gets wet. Each label will have the following information:

- Sample Site (pre-printed)
- Collection Date (to be filled out in the field)
- Collection Time (to be filled out in the field)
- Analyses Requested (complete or partial mineral panel)
- Sampler Name (to be filled out in the field)
- Comments (if any)

The sample site name (state well identification number) will serve as the unique identifier for each sample (e.g. 14S/02E-08M02). When the samplers arrive at the CCL a unique in-house lab number is assigned to each sample.

1.9.2.5 Field Quality Control Sample Records

Quality Control samples from the field will be identified using the state well identification number plus either -1 or -2 (e.g. 14S/02E-08M02-1, for a field blank).

- -1 = Field Blank
- -2 = Field Duplicate

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1.9.3 Laboratory Documentation and Records

The Consolidated Chemistry Laboratory will keep a sample receiving log containing the completed COC forms submitted with the samples collected for this project. The CCL will keep records of all analyses performed as well as associated QC information, including: laboratory blanks, laboratory duplicates, matrix spikes, matrix spike duplicates and laboratory control samples. Hard copy data of analytical results will be maintained for three years by the CCL. The CCL maintains a Laboratory Information Management System (LIMS) which will be used to store electronic data.

The data generated by the CCL for each sampling event will be compiled into individual data reports. The individual data reports will include the following information:

- Sample results and associated Quantitative Limits (QLs)
- Cation-Anion Balance Sheet
- QC check sample records and acceptance criteria for the following:
    - Laboratory Control Sample(s)
    - Matrix Spike(s)
    - Matrix Spike Duplicate(s)
    - Analytical Duplicate(s)
    - Method Blank(s)
- Project narrative including a discussion of problems or unusual events (including, but not limited to, topics such as: receipt of samples in incorrect, broken, or leaky containers, with improperly or incompletely filled out COC forms; receipt and/or analysis of samples after the holding times have expired; summary of QC results exceeding acceptance criteria; etc.)

The above information is logged into the LIMS database at CCL.

The Public Health Chemist of the Consolidated Chemistry Laboratory will be responsible for reviewing, validating, and/or qualifying results on the data reports. Any deviations from sample preparation, analysis, and/or QA/QC procedures will be documented. Departure from QC acceptance limits will be highlighted. Once the data reports are finalized, the hard copy will be sent to the Project QA Manager at the Agency.

At the end of the sampling season, all data for both programs (Coastal and Salinas Valley) will be electronically transferred to the Agency. After data verification, the Agency Hydrologist/ Team Lead will upload the data to the Agency's Water Resources Agency Information Management System (WRAIMS) relational database.

1.9.4 Technical Reviews and Evaluations

Technical reviews and evaluations are limited to Field Activities and Laboratory Data Review Checklists.

1.9.4.1 Field Activities Review Checklist

Field personnel will be required to fill out a Field Activities Review Checklist as part of the double-check process upon returning from the field after each sampling event (see Appendix C).

1.9.4.2 Laboratory Data Review Checklist

Laboratory data reports from the CCL will be routed to the Project QA Manager at the Agency, who will do a preliminary assessment of the data. The data reports will then be given to the Agency

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Hydrologist/ Team Lead who will be responsible for completing a Laboratory Data Review Checklist (see Appendix C).

1.9.5 Technical Memorandum

The Agency Project QA Manager is responsible for the preparation of the technical memorandum. The technical memorandum will be written in the "post sample collection" phase (see section 1.6.3). The technical memorandum will be submitted to USEPA for review by the EPA Region 9 Project Manager.

The technical memorandum will contain the following elements:

- Table of results for Chloride
- Table of results for Nitrate
- Table of results for Specific Conductance
- Map of Chloride contours for 500 mg/L values
- Map of Nitrates showing those sites which have values above and below the Drinking Water Standard Limit of 45 mg/L (nitrate as NO3)
- Map of Conductivity contours

2.0 DATA GENERATION AND ACQUISITION

2.1 SAMPLING DESIGN

In the Salinas Valley, there are four hydrogeologic subareas: Pressure, East Side, Forebay, and Upper Valley. All four subareas were selected using a directed sampling design approach. These subareas were selected deliberately based on knowledge from previous monitoring work to contain analytes of interest, specifically nitrate and conductivity in the Salinas Valley Program, and chloride and conductivity in the Coastal Program. Actual sampling sites/wells within the Salinas Valley Basin Monitoring Program were chosen using a non-deliberate sampling approach. The wells included are acquired opportunistically. Site accessibility is a key issue for sampling. Permission of property owners must be secured before accessing private wells.

There are just over 1700 active wells in the Salinas Valley. Of this total number of wells, 344 wells make up the Salinas Valley Ground Water program and 85 wells make up the Coastal Ground Water program. The wells that make up these two programs have all been sampled in the past; some have data sets as far back as the 1950's, when this was a State of CA Department of Public Works (now the Department of Water Resources) program. The Agency wants to keep as complete and continuous a data set for each of these wells as possible.

Due to the time constraints the Agency is facing during this shortened 2007 field season, June - September, staff will prioritize which wells within the Salinas Valley portion of this project will be sampled. Wells to be sampled first will be located within approximately one mile radius of municipalities and industries (such as vegetable packing plants). We refer to these areas as high beneficial use areas. Ground water wells will be identified by State Well Numbers (Township, Range, Section, and Subsection).

All wells are high production agricultural wells. All wells are sampled in the same way, if the pump is in operation then a sample will be collected. If the pump if not operating then the field sampler will note it on the field sheets and come back to the well at a later date when the well is in operation. The pump must be operating for a sample to be collected. The age of well does not alter sampling

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protocols. If a well is found to have been abandoned since the Agency last sampled the well, a notation will be made on the field sheets and the well will be removed from future sampling efforts.

2.1.1 Salinas Valley Ground Water

While it is known that high levels of nitrates exist in some aquifers of the Salinas Valley Ground Water Basin, a significant sampling effort to determine the extent in the ground water has not been conducted by the Agency for several years. There are a total of 344 sample locations within the Salinas Valley monitoring program. Sample locations are operational ground water wells, the majority of which are used for agricultural irrigation. The Pressure subarea has 158 wells, the East Side subarea has 66 wells, the Forebay has 84 wells, and the Upper Valley has 35 wells (Figures 4-7). Each of these wells will be sampled once during the 2007 summer field season (July-September). The primary criterion currently used to determine if a well will be included in the Salinas Valley monitoring program has been its status as previously sampled. This program is an ongoing ambient ground water monitoring program and continuity in sampling the same wells each field year is of prime importance, especially for water quality trend analysis. Other factors that are important in deciding if a well should be included in the monitoring program are; copy of the well completion report (commonly referred to as the driller's log), location of the perforation interval along the well casing to determine which aquifer is sampled, age of the well, and construction method used to drill the well. Additionally it is useful to know the proximity of the well to other water use (industrial, municipal, or domestic) areas. A list of Salinas Valley well names and locations are given in Table 4. All wells on this program are planned to be part of the monitoring design for subsequent years. Until these monitoring wells are abandoned or destroyed, they will remain part of this program.

2.1.2 Coastal Ground Water

The Agency currently conducts a seawater intrusion monitoring and mapping program (EPA II). This program will continue to evaluate the extent and status of seawater intrusion in the coastal areas of the Salinas Valley Basin (EPA II). The Coastal portion of the ground water program contains 85 wells, most of which are located in the Pressure subarea (Figure 8). Each well will be sampled three times, once each month of the summer 2007 field season (July-September). The first sample collection at each well will be analyzed for a complete mineral panel (Table 1), and following two collections will be analyzed for a partial mineral panel (Table 1). There are 21 wells located in the Pressure 180-Foot Aquifer, 52 wells within the Pressure 400-Foot Aquifer, two wells with perforations within both the Pressure180-Foot and 400-Foot Aquifers, four wells are located within the Pressure Deep Zone Aquifer, three in the East Side Deep Aquifer, one in the East Side Shallow Aquifer, and one in the Prunedale Aquifer. The principal criterion for inclusion in the Coastal monitoring program is historical sampling and well availability. Additional criteria for selecting a well for inclusion into the Coastal monitoring program are: a well completion report, location of the perforation interval along the well casing to determine which aquifer is sampled (180, 400, or deep zone AQ), well age, and well construction type. A list of Coastal sites and their representative aquifers are listed in Table 5.

It can not be stressed enough how important the continued monitoring of these ground water wells are for the Agency to meet its mission of monitoring the quality of the County's ground water resources. Some of these well have been sampled since the 1950's and the loss of such a long term water quality record within the County of Monterey would irreplaceable.

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2.2 SAMPLING METHODS

The objectives of the sampling procedure are to minimize changes in ground water chemistry during sample collection and transport to the laboratory, and to maximize the probability of obtaining a representative, reproducible ground water sample. This well-volume purging procedure provides a reproducible sampling technique with the goal that the samples obtained will represent water quality over the entire screen interval of the well.

Standing water in the well casing can be of a different chemical composition than that contained in the aquifer to be sampled. Solutes may be adsorbed on to, or desorbed from the well casing material, oxidation may occur, and biological activity is possible. Therefore, the stagnant water within the well must be purged so that the sample is representative of the aquifer. As a result, a well may be sampled only after the pump has been in operation for at least 15-20 minutes.

All the wells included in this project, from both the Salinas Valley area and the Coastal monitoring area are high production agricultural wells that contain deep turbine pumps operating at 500-1200 gallons per minute (gpm). Over the years of managing the ambient monitoring program, the Agency has determined that operating a deep turbine pump for 15-20 minutes before taking a sample is sufficient time to clear the entire well casing of three well volumes for ensuring a representative well sample. For referencing well casing volume, the Agency uses the well casing size provided in the well completion reports (driller's log) for each of the wells included in this monitoring program (National Field Manual for the Collection of Water-Quality Data, Chapter A2).

Sample bottles and caps are rinsed three times with ambient ground water prior to collection. The sample container is then filled, tightly capped, and labeled. No field sample filtration is required. Samples are put into a cooler with ice immediately and maintained at 4°C and delivered to the laboratory daily. See Table 6 for sample collection requirements. Extra sample containers, caps and field supplies will be carried in the truck as back-up should any problem arise in the field. Additionally, the Field Sampler will carry and maintain an updated hardcopy of the QAPP in the field to be used as a reference.

The following precautions will be followed in order to limit sampling error at the wellhead:

- Operate the pump long enough to produce water that is representative of the aquifer and not stagnant water from the casing.
- Take samples at the wellhead or near the wellhead and away from fertilizer injection ports.

Sample collection will follow protocols in accordance with recommended guidelines established by the U. S. Geological Survey (USGS) for ground water collection as described in the National Field Manual for the Collection of Water-Quality Data.

The National Field Manual for the Collection of Water-Quality Data, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 9, Chapters A1-A9 is maintained as a web-based document and is located at http://pubs.water.usgs.gov/twri9A. Updates and revisions for the National Field Manual can be found using this web-based approach.

2.3 SAMPLE HANDLING AND CUSTODY

This section describes how all samples will be treated after collection, during transport, and upon arrival at the CCL. It also includes information on proper sample disposal after laboratory analysis.

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2.3.1 *Sample Containers and Preservatives*

Sample containers to be used in this project are high density polyethylene (HDPE), one pint (~0.5 L) and 0.5 gallon (~2 liter) sizes, for partial mineral or complete mineral analyses, respectively. The Agency has used these same sample container types during previous years of this ongoing ambient monitoring program and has never had any problems with container contamination issues. Field blanks will be closely monitored and, should a problem arise, corrective actions will be taken. Only one container (pint *or* half gallon) is needed per sampling site to provide the necessary volume to run the required lab analyses (see Table 6). Sample containers and caps are purchased in bulk from a plastic container manufacturer (Consolidated Container Company). The caps for the containers are packaged separately. The containers and caps are clean upon receipt, as long as they arrive with the outer cardboard packaging intact. The containers will be kept in a closed, dry environment away from the outside elements. Sterility is not of importance because this sampling project does not include microbiological testing. As previously mentioned, all containers and caps will be rinsed three times with ambient sample water prior to sample collection.

Sample containers are labeled with pre-printed labels, which lists which panel of analytes is requested, either complete mineral or partial mineral. The collection date, collection time, and sampler name are recorded in the field with an indelible marker. After being filled out, labels will be covered with clear plastic tape (packaging type) to protect the labels from destruction during transport.

No chemical *field preservation* of the samples is required. All samples will be kept at 4±2ºC.

Preservation of samples, if required prior to analysis, will be the responsibility of the contract lab (CCL). Part of the CC lab sample receiving protocols includes lab personnel verifying, at the time of sample receipt, if any samples require lab preservation. Refer to Table 6 for listings of preservatives for specific analytes.

2.3.2 *Sample Packaging and Transport*

All samples will be handled, prepared, transported and stored in a manner so as to minimize contamination and spills. After collection, sample caps will be checked for tightness, and the samples will be put in ice chests immediately. During travel between sites, ice chest lids will be kept tightly closed in order to keep the samples at the correct temperature and protect them from sunlight. Ice used for maintaining sample temperature will be double-bagged inside durable plastic bags (Ziploc type) and be of sufficient quantity so that all samples will stored at 4±2ºC. Maximum holding times for specific analytes are listed in Table 6.

2.3.3 *Sample Custody*

Chain of custody (COC) procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of the analytical results. A completed chain of custody form is to accompany the samples to the contract laboratory (CCL). Requirements for COC paperwork can be found in Section 1.9.2.2 of this document.

All samples collected for this project will be transported from the field to the CCL via an Agency vehicle. The field sampler will deliver the samples directly to the CCL daily; there will be no intermediary transfers. Samples need to arrive at the CCL no later than 15:00, to ensure log-in and laboratory preservation. Personnel at the CCL will examine the samples for correct documentation and holding times. The CCL will follow sample custody procedures as outlined in their QA plan (see Appendix D).

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2.3.4 Sample Disposal

All samples remaining after successful completion of analyses will be disposed of properly. It is the responsibility of the personnel at the CCL to ensure that all applicable regulations are followed in the disposal of samples or related chemicals. Sample disposal procedures used by the CCL are discussed in their QA plan (see Appendix D).

2.4 ANALYTICAL METHODS

All samples will be analyzed at the County Consolidated Chemistry Laboratory (CCL). Analyses will be performed following either EPA approved methods or methods from *Standard Method for the Examination of Water and Wastewater, 18th Edition,* see Table 1 (CCL's QA Manual cites *18th Edition,* see Appendix D). Standard operating procedures (SOPs) from CCL have been included in Appendix D for each of the analyses. Should there be any deviation from these SOPs the Laboratory Director must contact the Project QA Manager.

The CCL will submit a data report and associated QC results after analyses are complete to the Project QA Manager. This data report is described in Section 1.9.3. After a preliminary assessment the Project QA Manager will pass the data on to the Team Lead, who will review the data report and QC results and evaluate its quality and usability in addressing the Project objectives.

2.5 QUALITY CONTROL

2.5.1 Field Sampling Quality Control

The assessment of field measurements will be determined from the collection and analysis of field blanks and field duplicates. For this monitoring program the field blanks will be collected at one every 20 samples or a frequency of 5%. Field duplicates will be collected at a frequency of 10% for the first two sampling events. If the criterion of <25% RPD is met, then the remaining field duplicates will be collected at a 5% frequency. Analytical acceptance criteria and corrective actions for field QC are listed in Table 2.

Deionized (DI) water will be acquired from the CCL and kept at 4±2ºC, while transported into the field. Field blank samples will be obtained by pouring DI water into a pint (~500 mL) HDPE sample container that has been triple-rinsed with DI water at the sampling location. The container will be tightly capped, placed in the cooler and delivered to the contract laboratory. Field blanks are labeled with the sampling location (State Well Number) followed by "-1".

Field blanks will be used to evaluate the collection process (from field sampling through sample analysis) for contamination from exposure to ambient conditions, from sample containers or from improper sampling and handling technique. If target analytes are found in field blanks, sampling and handling procedures will be reevaluated and corrective actions taken. Corrective actions may consist of, but are not limited to, re-training of field personnel, discussions with the contract laboratory, invalidation or qualifying of results.

Field duplicates will be collected for every analytical parameter. The duplicate sample will be collected immediately after collection of the native, following the same sampling protocols. Field duplicates are labeled with the sampling location (State Well Number) followed by "-2".

Field duplicates will be used to evaluate the precision of the sample collection through analysis. The combined variability from sampling and analysis technique, in addition to sample heterogeneity, will

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be assessed using field duplicates. If acceptance criteria are exceeded, field sampling and handling protocols will be reviewed and problems corrected. These may consist of, but are not limited to, additional training, revised sampling techniques and reevaluation of sampling location.

2.5.2 Laboratory Analyses Quality Control (Contract Laboratory)

The Monterey County Consolidated Chemistry Laboratory's (CCL) personnel are responsible for analytical Quality Control. Standard laboratory quality control elements include method blanks, laboratory control samples, analytical duplicates, matrix spikes and calibration procedures. Laboratory data quality objectives include QC acceptance criteria, frequency of analysis, and corrective actions. These data quality objectives and quality control elements for CCL are described in its QA Manual (Appendix D) and SOPs (Appendix D) and are listed in Table 3. After examination of these documents, the Agency believes that the laboratory will be able to meet the project data quality needs. Any deviation from these written procedures must be documented by the laboratory and reported to the Project QA Manager.

2.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

Testing, inspection, and maintenance of laboratory equipment are the responsibility of the Monterey County Consolidated Chemistry Laboratory and are detailed in its QA manual in Appendix D.

2.7 INSTRUMENT CALIBRATION AND FREQUENCY

Instrument calibrations are the responsibility of the Monterey County Consolidated Chemistry Laboratory and acceptance criteria for calibrations are detailed in its QA manual in Appendix D.

2.8 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES

2.8.1 Initial Inspection of Supplies

As mentioned previously in Section 2.3.1, sample containers are purchased in bulk from an outside vendor who specializes in supplying plastics to the beverage industry. An initial inspection will be conducted upon receipt of each shipment. Each shipment will be considered acceptable for use if *all* of the following are true:

- The shipment arrives with the outer cardboard packaging intact.
- The containers are the correct type (HDPE) and size (0.5 gal/~2L *or* 1 pint/~0.5L).
- The insides of the containers are dry.
- The insides of the containers are free of dirt or any particulate matter.

2.8.2 Field Inspection of Supplies

Immediately prior to sample collection, field samplers will visually inspect each sample container for the following:

- Dirt or any particulate matter
- Cracks of any size
- Improper fit of the cap on the container

If the field sampler observes any of the above, then the container will be discarded and an acceptable container will be used instead.

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2.8.3 Laboratory Inspection of Supplies

CCL will be responsible for establishing inspection and acceptance criteria for supplies that adhere to their internal QA/QC policies.

2.9 DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

Non-direct measurement data will not be used during this monitoring program. Should at some time in the future the Agency decide to use data from an external source, QA/QC requirements will be established. Should this occur, an addendum to this QAPP will be submitted to USEPA.

2.10 DATA MANAGEMENT

Data, as related to documentation and records, will be managed as outlined earlier in Section 1.9 of this QAPP.

In addition, the CCL will group QA/QC data under a separate client code so that QA/QC data can be filtered from regular sample data before being uploaded into the Agency's Data Management System (WRAIMS). This allows the Agency a greater flexibility both in quickly and easily accessing the data that included QA/QC samples for initial review, and increased flexibility in uploading and moving large data sets.

3.0 ASSESSMENT AND RESPONSE ACTIONS

This section lists review procedures that will be taken to ensure all the protocols outlined in the QAPP are consistently followed.

3.1 REVIEWS

3.1.1 Readiness Reviews

Water Resources Technicians/ Field Samplers will be trained by the Hydrologist/Team Lead before any field sampling begins. Training will cover proper sample collection and handling and the completion of all paperwork (COCs, field logbooks, etc). The Team Lead will ensure that Field Samplers have properly prepared all collection containers, paperwork and other supplies needed to complete a successful sampling event. Any problems discovered during the readiness review will be corrected before the Samplers begin work.

3.1.2 Field Reviews

The Team Lead will be responsible for overseeing that all field activities are incompliance with Agency protocols. The Team Lead will be available via phone should any questions arise while the Samplers are in the field. The Team Lead will also review all field paperwork such as COCs and field logbooks for completion. Additionally the field QC samples (field blanks and duplicates) will be used to evaluate the individual Sampler's technique. If problems are exposed they will be corrected straight away so that all further samples are valid. A stop-work order may be issued by the Project QA Manager at any time if a discrepancy or error is found that could negatively affect the data being collected.

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3.1.3 Post Sampling Reviews

Post sampling reviews will be conducted following each sampling event in order to ensure all information is complete. Reviews will be conducted by the Field Sampler due to the small size of the staff. They will include evaluation of sampling activities and field documentation and will take place in the office, not in the field. Findings will be passed on to the Team Lead and the Project QA Manager to be incorporated into the next field event.

3.1.4 Laboratory Data Reviews

The Team Lead will be responsible for reviewing the laboratory's data for completeness and accuracy. The data will also be checked to determine that all specified methods were used and all related QC data was provided with the sample analytical results. These reviews will take place immediately upon receipt of data reports from the laboratory. This will ensure that any method deviations are corrected or explained, and any missing or incomplete data are provided. The Project QA Manager has the authority to request re-testing of laboratory data if it is invalid or would otherwise compromise the quality of the resulting project conclusions.

3.2 REPORTS

The Project QA Manager will be responsible for the technical memorandum (EPA R9# 03-238 Task 3.3) which will be provided in March 2008 to US EPA. The technical memorandum (EPA R9# 03-238 Task 3.3) will include result tables for chloride, nitrate, and specific conductivity, and maps of chloride, nitrate, and specific conductivity gradients. The technical memorandum will include a summary of any significant QA/QC issues and how they were resolved. It is currently understood that this project is of short enough duration that only a final technical memorandum to the EPA is necessary.

4.0 DATA VALIDATION AND USABILITY

4.1 DATA VERIFICATION AND VALIDATION

Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly. The Team Lead is responsible for the data review. This examination will check for data entry errors, calculation errors, and data omission errors. If possible these errors will be corrected.

4.1.1 Field Data

Field data include logbooks, photographs, and COCs. The Field Sampler is responsible for reviewing the field data at the end of the sampling event. This includes determining that all information is complete and any deviations from the sampling methodologies are documented using the Field Activities Review Checklist (Appendix C).

4.1.2 Laboratory Data

Initial evaluation of the laboratory data are carried out by the CCL in agreement with protocols listed in their SOPs and QA manual. The Team Lead will also conduct an independent review of the data and QC parameters as described in sections 3.1.4 and using the Laboratory Data Review Checklist as detailed in section 1.9.4.4 and Appendix C.

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4.2 RECONCILIATION WITH USER REQUIREMENTS

The purpose of the continued ambient monitoring of the Salinas Valley Basin Ground Water is to assess the water quality to manage and protect ground water resources. For data to be useful in developing the overreaching Salinas Valley Integrated Water Management Plan, it must first meet the requirement of this QA project Plan. The Project QA Manager will be responsible for making the final evaluation of the data's usability in meeting the Project objectives. All data passing this final evaluation will then be used to establish a cohesive and succinct Water Quality Management Plan in accordance to the work begun under EPA-I and continued under EPA-II. Additionally, the Agency will integrate these ground water quality data with previously collected data for use in trend analysis.

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5.0 REFERENCES

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FIGURES

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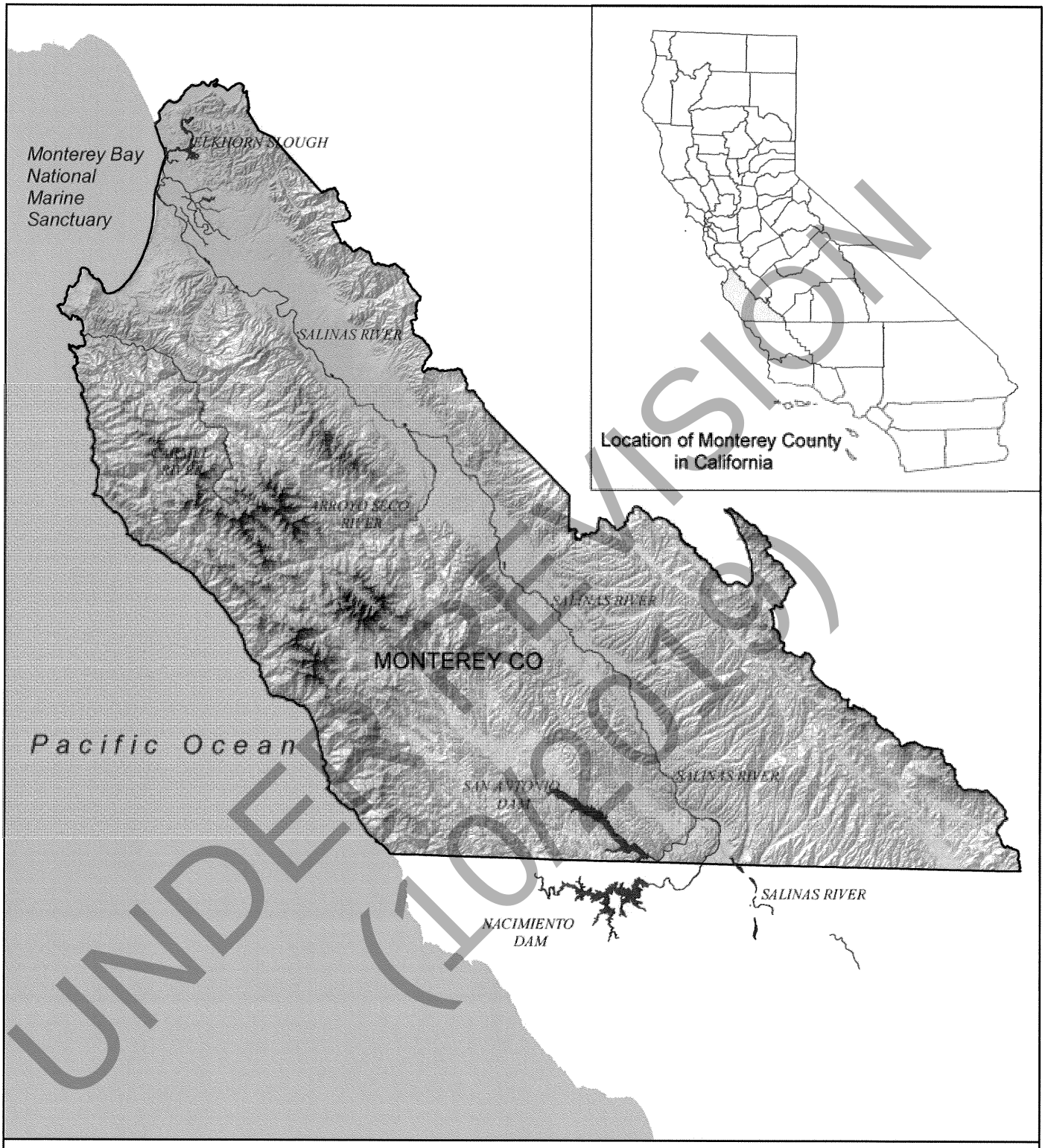

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(10/2010)

Legend

Water Bodies/ Channels

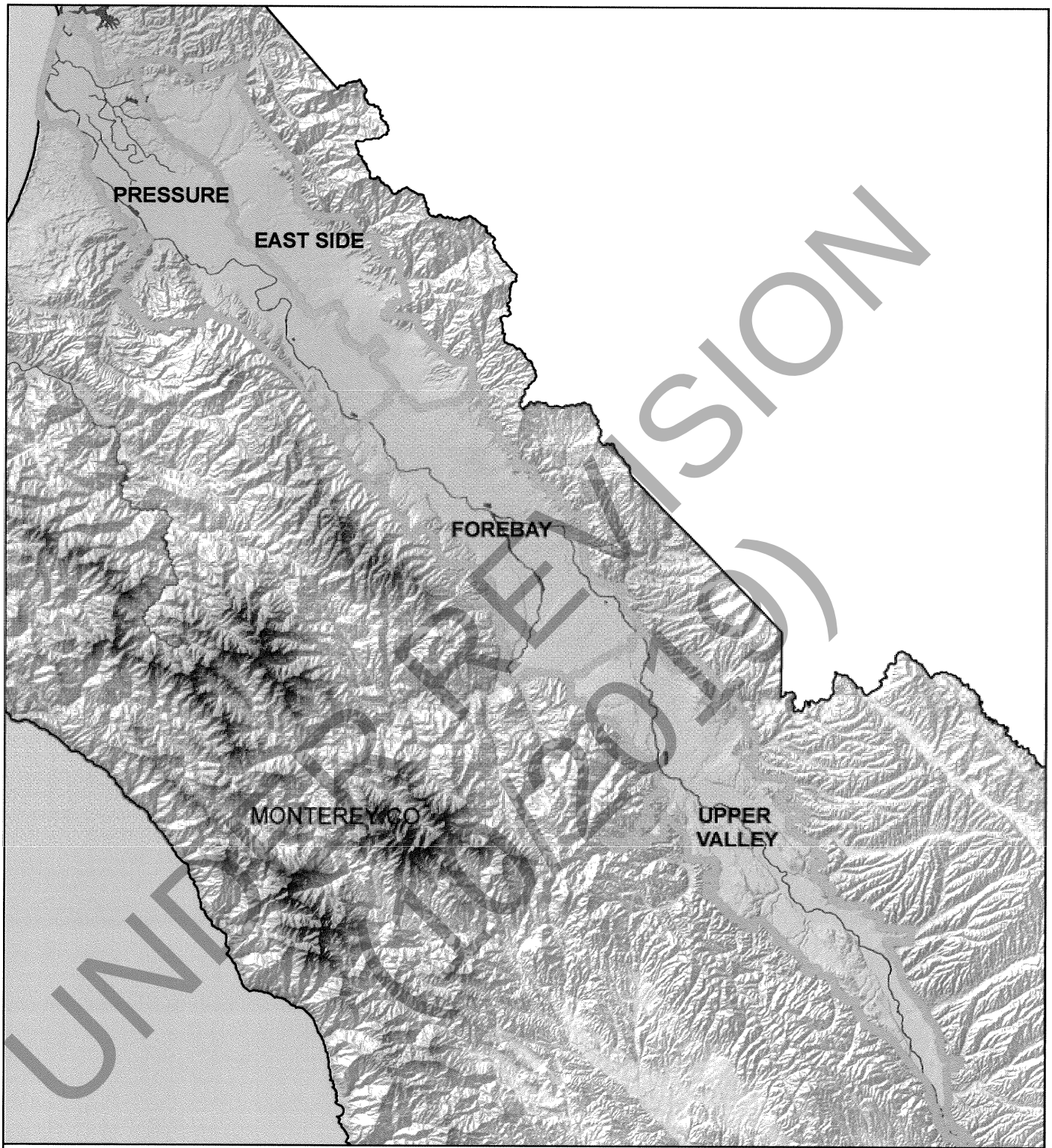
Monterey County, California

Figure 1

0 4 8 12 16 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



UNDER REVISION

Legend

Water Bodies/ Channels

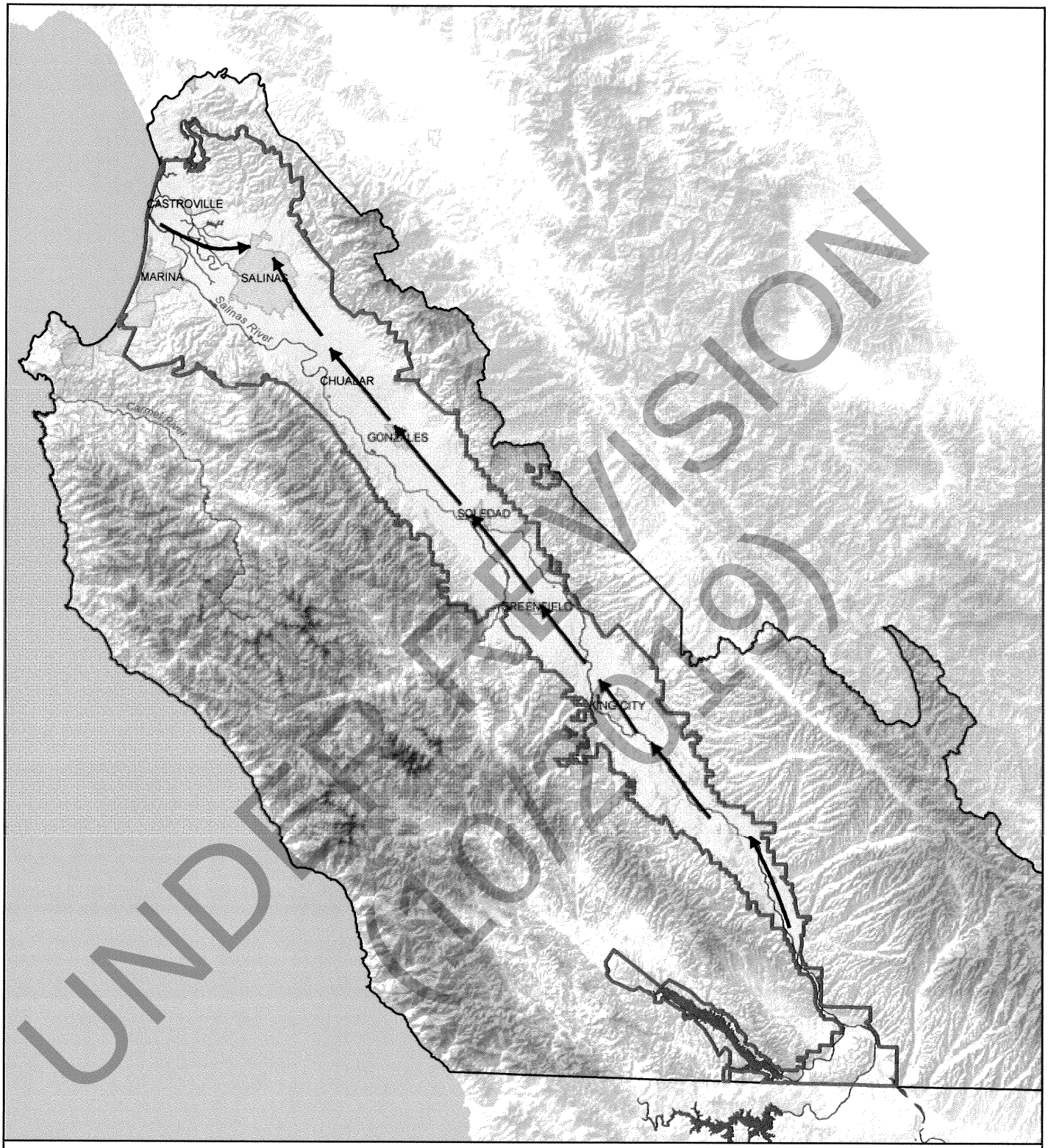
Salinas Valley Aquifers

Figure 2

0 2 4 6 8 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



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Ground Water Flow Direction in the Salinas Valley

Figure 3

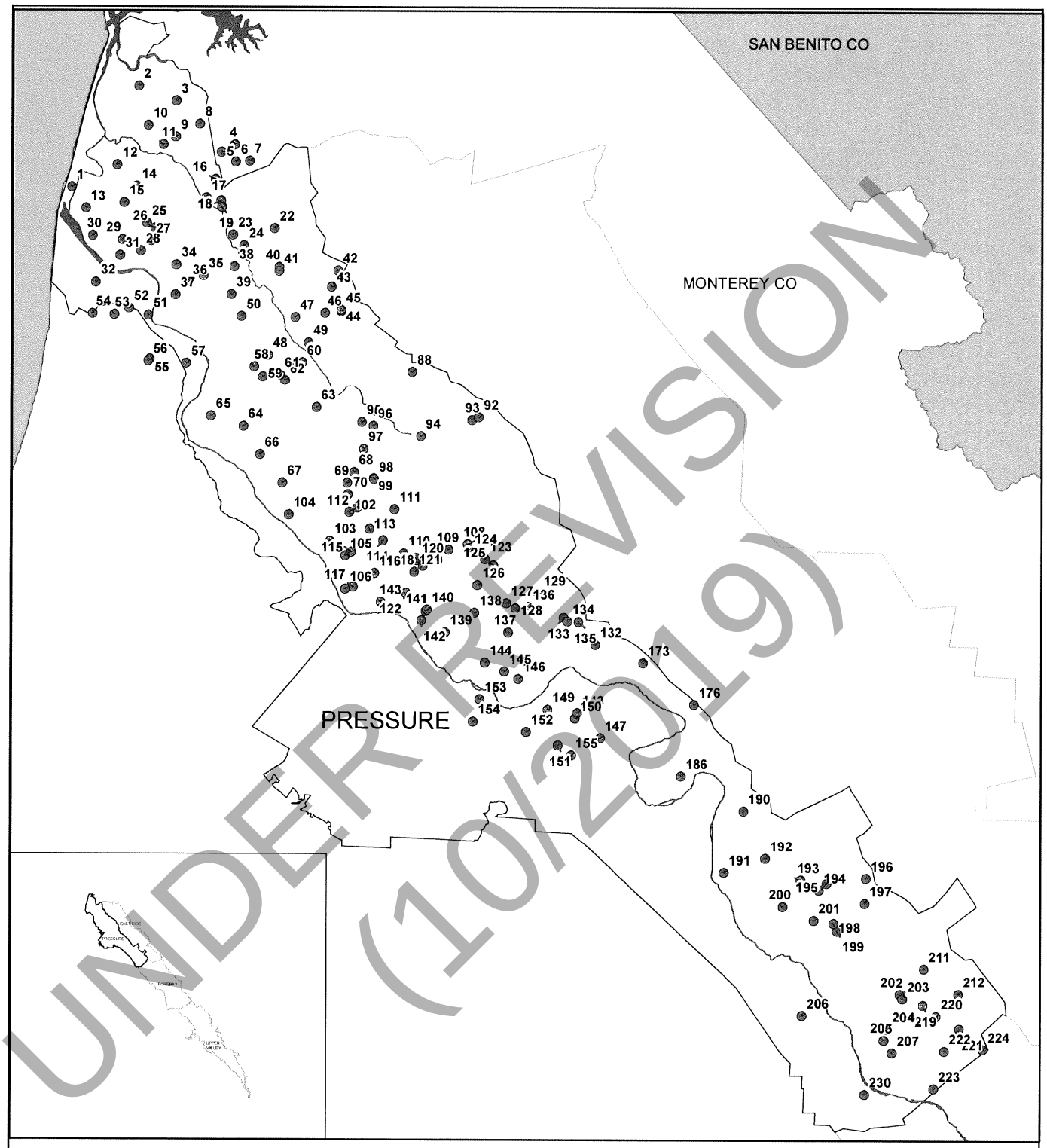
Legend

- Ground Water Flow Direction
- Assessment Zone 2C
- Monterey County
- Rivers and Other Bodies of Water

0 10 20 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 6, 2007



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Legend:

- Study Well
- Rivers

SUBAREA

- SUBAREA
- PRESSURE

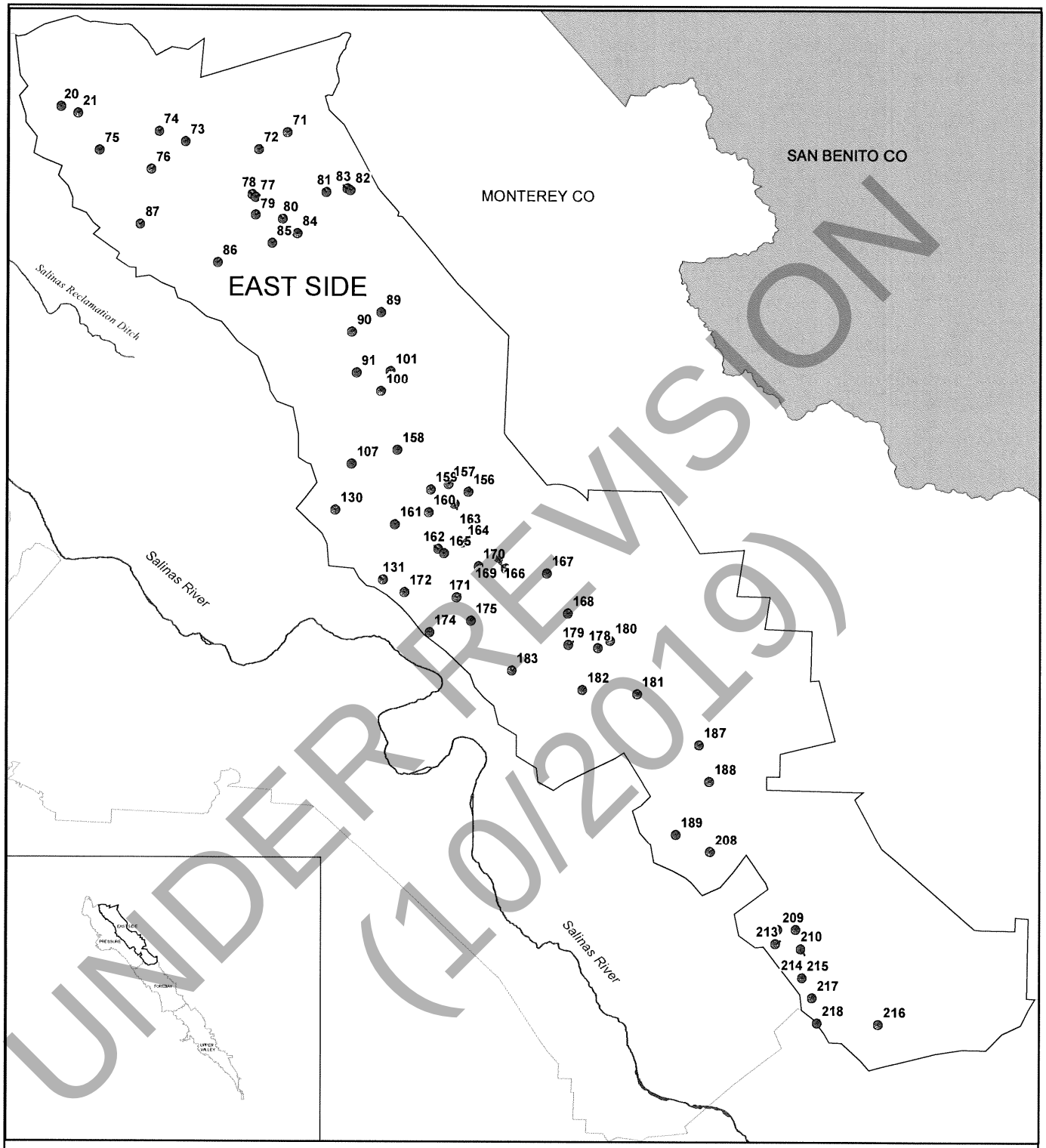
Salinas Valley Wells in the Pressure Subarea

Figure 4

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Legend:

- Study Well
- Rivers

SUBAREA

- SUBAREA
- EAST SIDE

Salinas Valley Wells in the East Side Subarea

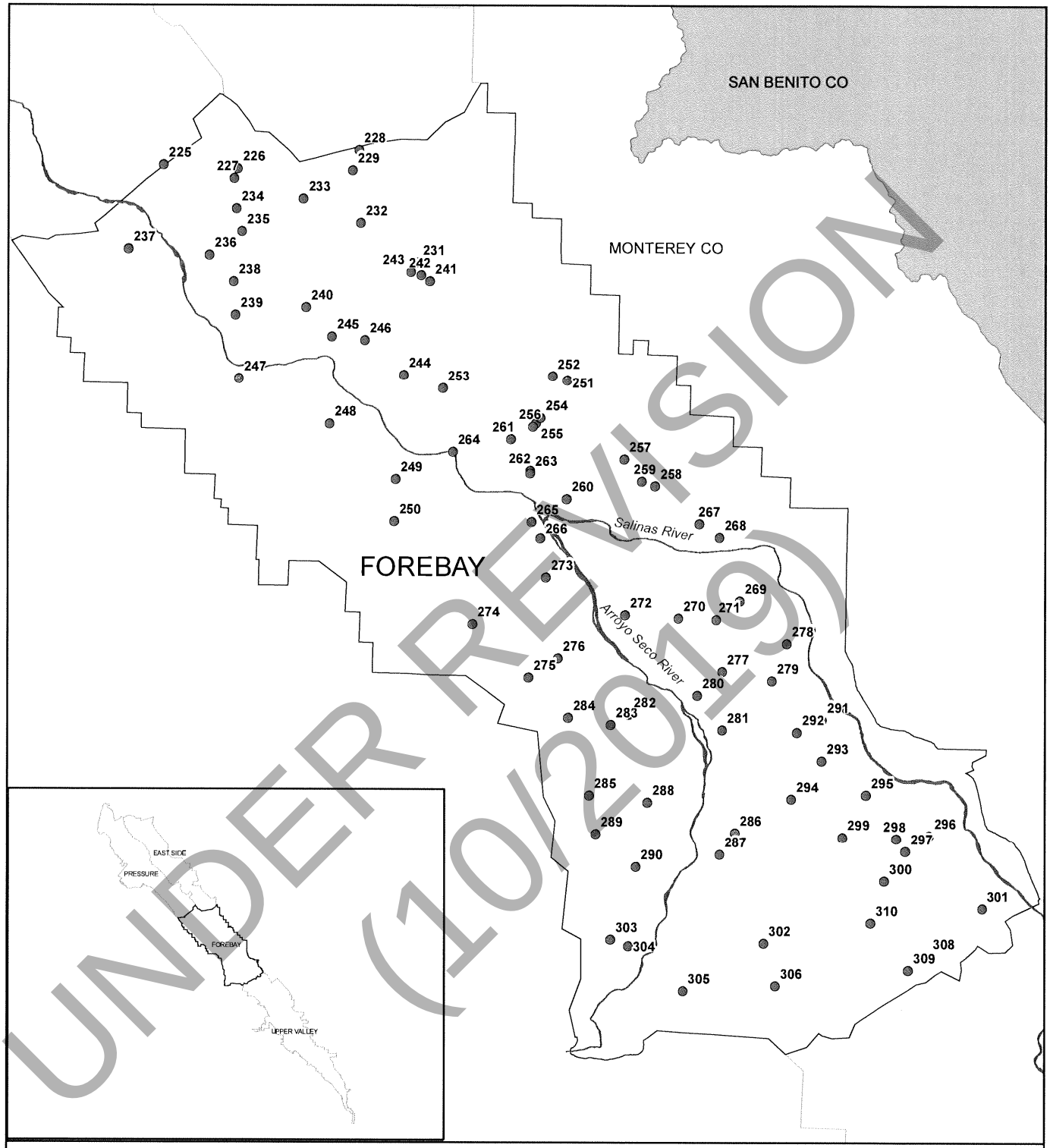
Figure 5

N W E S

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Legend:

- Study Well
- Rivers

SUBAREA

- SUBAREA
- FOREBAY

Salinas Valley Wells in the Forebay Subarea

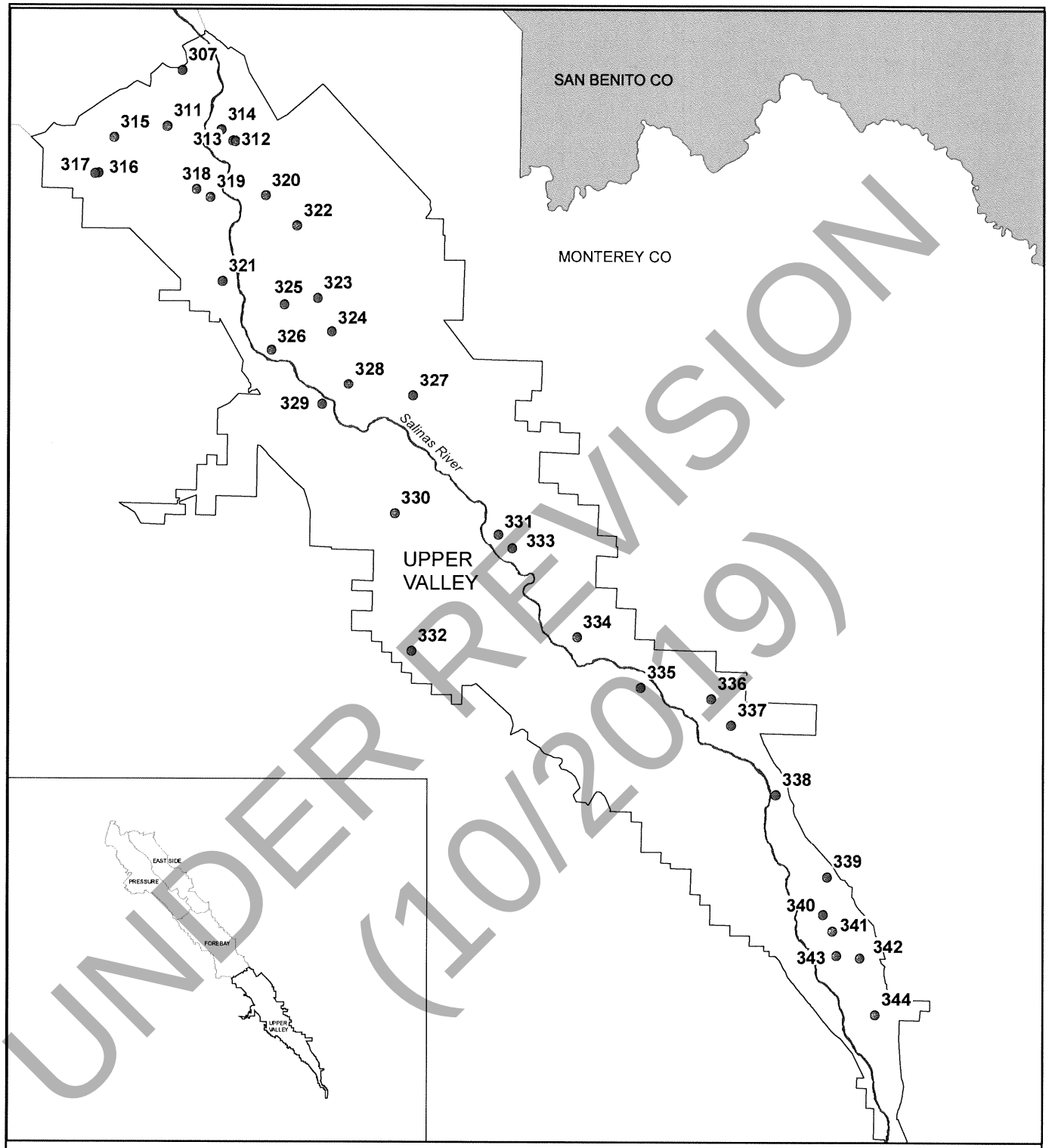
Figure 6

N
W
E
S

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



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Salinas Valley Wells in the Upper Valley Subarea

Figure 7

Legend:

- Study Well
- Rivers

SUBAREA

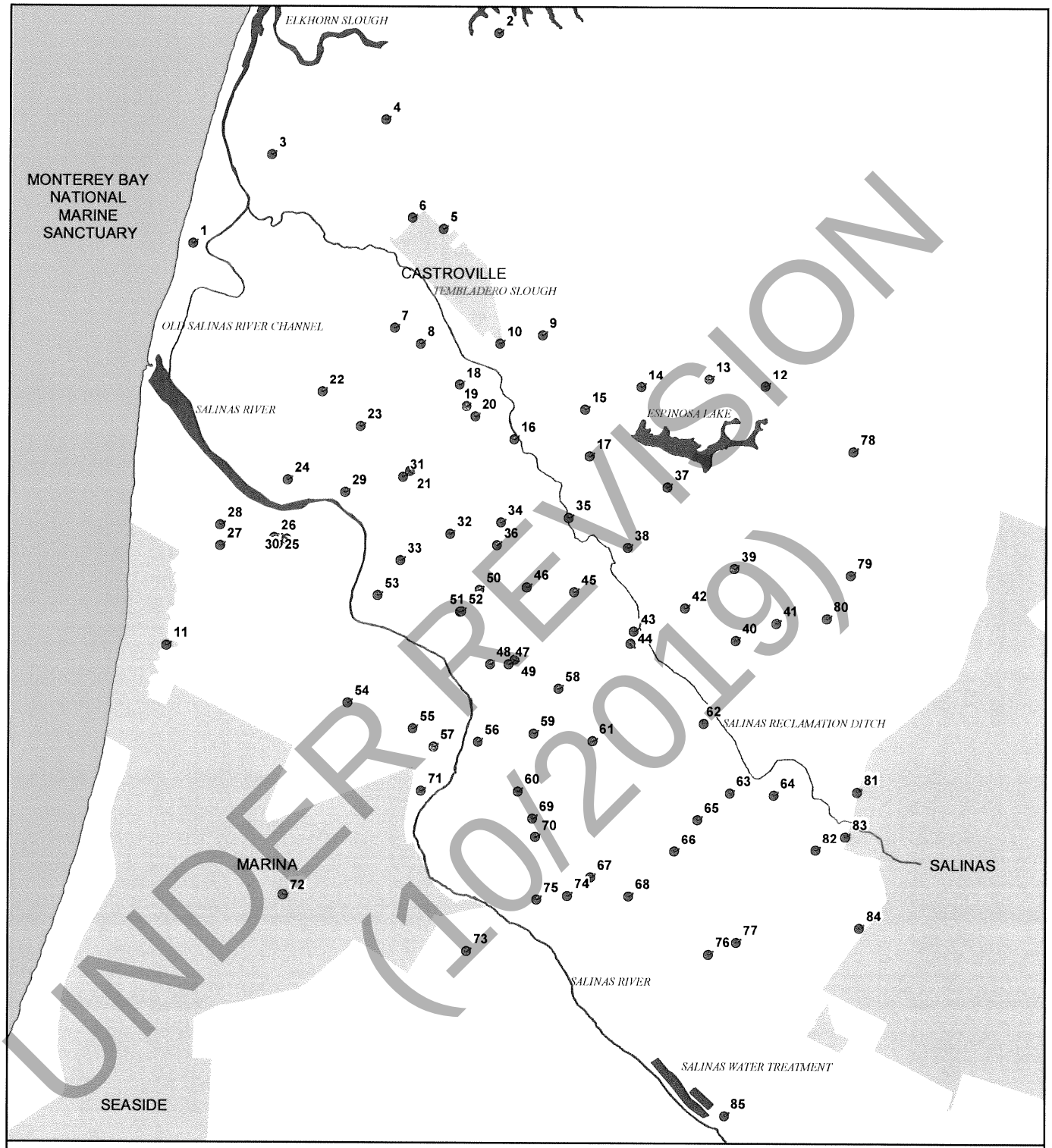
- SUBAREA
- UPPER VALLEY

N
W E
S

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



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Coastal Ground Water Monitoring Program Wells

Figure 8

Legend:

- Study Well
- Cities
- Water Bodies/ Channels

N W E S

0 0.5 1 1.5 2 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 02, 2007

TABLES

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Table 1 COMPLETE MINERAL PANEL ANALYTES

ANALYTE	*METHOD*	*LABORATORY MDL***	*LABORATORY PQL*	*LOWEST CALIB. STD.*	*PAL*
Calcium (Ca)	SM 3111 B[1]	0.02 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L
CATION ANION BALANCE	Calculated	--	--	--	--
*Chloride (Cl)	EPA 300.0[2]	0.01 mg/L	1.0 mg/L	0.1 mg/L	1.0 mg/L
*Conductivity (SEC)	SM 2510 B	1 umho/cm @ 25 C	1 umho/cm @ 25 C	N/A	1 umho/cm @ 25 C
Magnesium (Mg)	SM 3111 B	0.005 mg/L[1]	1.0 mg/L	0.1 mg/L	1.0 mg/L
*Nitrate (NO3)	EPA 300.0	0.002 mg/L[2]	1.0 mg/L	0.1 mg/L	1.0 mg/L
pH (Laboratory)	SM 4500-H B	pH Units (2 sig figs)	pH Units (2 sig figs)	N/A	pH Units (2 sig figs)
Potassium (K)	SM 3111 B	0.025 mg/L[1]	0.1 mg/L	0.1 mg/L	0.1 mg/L
Sodium (Na)	SM 3111 B	0.03 mg/L[1]	1.0 mg/L	0.1 mg/L	1.0 mg/L
Sulfate (SO4)	EPA 300.0	0.03 mg/L[2]	1.0 mg/L	0.1 mg/L	1.0 mg/L
Total Alkalinity (as CaCO3)	SM 2320 B	1.0 mg/L	1.0 mg/L	N/A	1.0 mg/L

[1] = MDL study completed February 2007

[2] = MDL study completed May 2007

* = Partial Mineral Panel analytes

** = These are the laboratory's latest MDLs and supersede the MDLs listed in Appendix D-1.

MDL = method detection limit; PQL = practical quantitative limit; PAL = project action level

All laboratory results are bracketed by calibration standards. No "estimated" results (below the lowest calib std and above the MDL) are given to the Agency.

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Table 2 QUALITY CONTROL REQUIREMENTS FOR LABORATORY ANALYSES

QA PROCEDURE	QA PARAMETER	FREQUENCY	CRITERION	CORRECTIVE ACTION
Field Blank	Field Contamination	1/20 field samples; 5% frequency	<MDL	Recollect sampling event or flag data if unable recollect
Field Duplicate	Field Precision	1/10 field samples for first two events; if criterion is met, then 1/20 field samples	RPD < 25%	Recollect sampling event or flag data if unable recollect
Method Blank	Analytical Contamination	3 per analytical batch	< RL	Reanalyze analytical batch
LCS (CRM)	Accuracy	1 per analytical batch	80-120% REC	Reanalyze analytical batch
Analytical Duplicate	Analytical Precision	1 per analytical batch	RPD < 25%	Reanalyze analytical batch
Matrix Spike	Matrix Interference and Accuracy	1 per analytical batch; at 3-10x the native conc.	75-125% REC	Reanalyze analytical batch
Matrix Spike Duplicate	Precision and Accuracy	1 per analytical batch; at 3-10x the native conc.	RPD <25%	Reanalyze analytical batch
Continuing Calibration	Analytical Control	1 per 10 sample runs	80-120% of initial slope	Reanalyze analytical batch
Assess percent of data successfully collected	Data Completeness	N/A	90%	N/A

MDL=Method Detection Limit; RPD=Relative Percent Difference; RL=Report Limit;
REC=Recovery; LCS=Laboratory Control Sample; CRM=Certified Reference Material
An analytical batch is defined as 20 or fewer samples.

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Table 3 LABORATORY DATA QUAILITY OBJECTIVES (DQOs)

ANALYTE	METHOD BLANK	LCS (CRM)	ANALYTICAL DUPLICATE	MATRIX SPIKE	MATRIX SPIKE DUPLICATE	CONTINUING CALIBRATION
Calcium (Ca)	yes	yes	yes	yes	yes	yes
Chloride (Cl)	yes	yes	yes	yes	yes	yes
Conductivity (SEC)	yes	yes	yes	no	no	yes
Magnesium (Mg)	yes	yes	yes	yes	yes	yes
Nitrate (NO3)	yes	yes	yes	yes	yes	yes
pH (Laboratory)	no	yes	yes	no	no	yes
Potassium (K)	yes	yes	yes	yes	yes	yes
Sodium (Na)	yes	yes	yes	yes	yes	yes
Sulfate (SO4)	yes	yes	yes	yes	yes	yes
Total Alkalinity (as CaCO3)	yes	yes	yes	no	no	yes

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Table 4 SALINAS VALLEY WELLS AND LOCATIONS

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
13S/01E-36J01	PRESSURE 900	1	5741483.0	2170847.00002
13S/02E-20M02	PRESSURE 400	2	5748878.5	2182094.25003
13S/02E-21N01	PRESSURE 400	3	5753018.5	2180456.75002
13S/02E-27L01	PRESSURE 180	4	5759500.0	2175572.50002
13S/02E-27M01	PRESSURE 400	5	5758010.0	2174784.50002
13S/02E-27P01	PRESSURE 400	6	5759593.5	2173660.50002
13S/02E-27Q02	PRESSURE 400	7	5761129.5	2173768.75002
13S/02E-28B01	PRESSURE 400	8	5755624.0	2177900.75002
13S/02E-28E01	PRESSURE 400	9	5752984.0	2176434.75002
13S/02E-29F02	PRESSURE 400	10	5749961.0	2177732.25002
13S/02E-29J01	PRESSURE 400	11	5751657.5	2175604.25002
13S/02E-31A02	PRESSURE 900	12	5746516.5	2173308.00002
13S/02E-31N02	PRESSURE 400	13	5743060.5	2168496.25002
13S/02E-32M02	PRESSURE 900	14	5748673.0	2170965.00002
13S/02E-32N01	PRESSURE 400	15	5747285.0	2169132.75003
13S/02E-33H03	PRESSURE 180	16	5757325.5	2171726.00002
13S/02E-33R01	PRESSURE 180	17	5756359.5	2169699.75003
13S/02E-34M02	PRESSURE 180	18	5757952.0	2169365.25003
13S/02E-34N01	PRESSURE 180	19	5758043.5	2168657.25003
13S/02E-36J01	EAST SIDE BOTH	20	5772057.0	2168257.00002
14S/02E-01A01	EAST SIDE	21	5773736.0	2167596.00002
14S/02E-02E02	PRESSURE 400	22	5763989.0	2166284.00003
14S/02E-03F02	PRESSURE 180	23	5759284.0	2165549.00003
14S/02E-03K02	PRESSURE 400	24	5760546.0	2164390.00002
14S/02E-05F04	PRESSURE 400	25	5749784.5	2166850.50002
14S/02E-05G03	PRESSURE 400	26	5750701.5	2166258.50002
14S/02E-05K01	PRESSURE 400	27	5750303.5	2164892.00002
14S/02E-05P02	PRESSURE 400	28	5749120.0	2163754.25002
14S/02E-06J03	PRESSURE 400	29	5747119.5	2164986.75002
14S/02E-06L01	PRESSURE 900	30	5743826.5	2165438.75002
14S/02E-06R02	PRESSURE 400	31	5746852.5	2163229.50003
14S/02E-07K01	PRESSURE 400	32	5744199.0	2160286.75002
14S/02E-08A01	PRESSURE 400	33	5751818.0	2162226.75002
14S/02E-09D03	PRESSURE 400	34	5753098.5	2162246.50002
14S/02E-09H03	PRESSURE 400	35	5756070.0	2161048.75002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-09L02	PRESSURE 400	36	5754291.5	2160250.25002
14S/02E-09N01	PRESSURE 400	37	5752950.5	2158867.00003
14S/02E-10C01	PRESSURE 400	38	5759437.0	2162015.75002
14S/02E-10P02	PRESSURE 400	39	5759125.0	2158942.75002
14S/02E-11C01	PRESSURE 180	40	5764471.5	2161959.50002
14S/02E-11D01	PRESSURE 180	41	5764508.5	2161568.25002
14S/02E-12B01	PRESSURE 400	42	5771184.5	2161614.00002
14S/02E-12L02	PRESSURE 400	43	5770434.5	2159815.50002
14S/02E-12Q01	PRESSURE 400	44	5771537.0	2157088.75002
14S/02E-13B02	PRESSURE 180	45	5771526.0	2157219.75003
14S/02E-13D01	PRESSURE 180	46	5769699.5	2156883.75002
14S/02E-14B01	PRESSURE 180	47	5766275.0	2156434.00002
14S/02E-14N03	PRESSURE 400	48	5763230.0	2152205.50003
14S/02E-14R01	PRESSURE 180	49	5767842.5	2153580.50002
14S/02E-15B01	PRESSURE 400	50	5760275.5	2156533.25002
14S/02E-17B02	PRESSURE 400	51	5749990.5	2156598.25002
14S/02E-17C01	PRESSURE 180	52	5747844.0	2157381.75003
14S/02E-18A01	PRESSURE 400	53	5746233.0	2156686.25002
14S/02E-18C01	PRESSURE 400	54	5743827.5	2156787.25002
14S/02E-20B01	PRESSURE 180	55	5750165.5	2151711.75003
14S/02E-20B02	PRESSURE 180	56	5750001.0	2151554.75003
14S/02E-21F02	PRESSURE 180	57	5754169.5	2151251.50002
14S/02E-22H01	PRESSURE 400	58	5761690.5	2150902.75002
14S/02E-22H02	PRESSURE 180	59	5762674.0	2149777.00002
14S/02E-23A01	PRESSURE 180	60	5767130.0	2151399.50002
14S/02E-23F01	PRESSURE 180	61	5764570.5	2149971.00002
14S/02E-23L03	PRESSURE 400	62	5765164.5	2149382.00002
14S/02E-25D03	PRESSURE 400	63	5768753.5	2146325.50002
14S/02E-27K01	PRESSURE 180	64	5760536.0	2144212.25002
14S/02E-28H02	PRESSURE 180	65	5756940.5	2145354.75002
14S/02E-34A03	PRESSURE 400	66	5762394.5	2141097.75002
14S/02E-35L02	PRESSURE 400	67	5764879.0	2137944.25002
14S/02E-36H01	PRESSURE 180	68	5773015.5	2139158.50003
14S/02E-36J02	PRESSURE 400	69	5772268.5	2137939.00002
14S/02E-36R02	PRESSURE 400	70	5772326.5	2136698.50002
14S/03E-02E03	EAST SIDE BOTH	71	5794727.5	2165742.50002
14S/03E-03K01	EAST SIDE BOTH	72	5791884.0	2164011.25002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/03E-04E01	EAST SIDE BOTH	73	5784479.5	2164809.75002
14S/03E-05B02	EAST SIDE BOTH	74	5781839.5	2165837.25002
14S/03E-06L01	EAST SIDE SHALLOW	75	5775895.0	2163924.50003
14S/03E-08C01	EAST SIDE BOTH	76	5781050.5	2162072.25002
14S/03E-10F02	EAST SIDE	77	5791569.0	2159330.50002
14S/03E-10F03	EAST SIDE BOTH	78	5791236.5	2159578.00002
14S/03E-10P01	EAST SIDE	79	5791544.0	2157558.25002
14S/03E-10R02	EAST SIDE BOTH	80	5794251.5	2157151.00002
14S/03E-11H01	EAST SIDE SHALLOW	81	5798504.0	2159823.00002
14S/03E-12E01	EAST SIDE SHALLOW	82	5800865.5	2160009.25003
14S/03E-12E02	EAST SIDE	83	5800608.5	2160173.25003
14S/03E-14D01	EAST SIDE SHALLOW	84	5795697.5	2155748.25003
14S/03E-15H03	EAST SIDE BOTH	85	5793222.5	2154777.00002
14S/03E-16K03	EAST SIDE	86	5787748.0	2152845.50003
14S/03E-17D01	EAST SIDE	87	5779979.0	2156594.00002
14S/03E-20D01	PRESSURE 400	88	5779540.0	2150357.75002
14S/03E-24H01	EAST SIDE SHALLOW	89	5803951.0	2147934.50002
14S/03E-24N01	EAST SIDE	90	5801060.0	2146002.50002
14S/03E-25L02	EAST SIDE BOTH	91	5801508.5	2141975.75002
14S/03E-28B02	PRESSURE 400	92	5786919.0	2145249.50002
14S/03E-28F02	PRESSURE 400	93	5786200.6	2144963.98574
14S/03E-29L04	PRESSURE 180	94	5780547.4	2143125.21920
14S/03E-30E01	PRESSURE 180	95	5773899.5	2144670.25003
14S/03E-30F02	PRESSURE 180	96	5775180.5	2144268.50002
14S/03E-30N01	PRESSURE 180	97	5774083.5	2141696.50002
14S/03E-31F01	PRESSURE 180	98	5775271.5	2138346.50003
14S/03E-31F02	PRESSURE 400	99	5775228.5	2138492.00002
14S/03E-36A01	EAST SIDE SHALLOW	100	5803921.0	2140085.50002
14S/04E-30N01	EAST SIDE BOTH	101	5804847.5	2142132.00001
15S/02E-01A03	PRESSURE 400	102	5772482.0	2134724.00002
15S/02E-01K01	PRESSURE 180	103	5770291.5	2131514.75002
15S/02E-02G01	PRESSURE 400	104	5765615.0	2134401.50002
15S/02E-12A01	PRESSURE 400	105	5772051.5	2129878.50002
15S/02E-12R01	PRESSURE 400	106	5772057.5	2126203.25003
15S/03E-01L01	EAST SIDE	107	5801038.5	2132896.75002
15S/03E-04K03	PRESSURE 400	108	5785732.5	2131172.00002
15S/03E-04N03	PRESSURE 400	109	5783621.0	2130577.75002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/03E-05N01	PRESSURE 180	110	5778619.0	2130164.00003
15S/03E-06A03	PRESSURE 180	111	5777613.0	2135010.00002
15S/03E-06D02	PRESSURE 400	112	5773392.0	2135175.75002
15S/03E-06F02	PRESSURE 400	113	5774781.5	2132857.75002
15S/03E-06K01	PRESSURE 400	114	5776302.5	2131605.50002
15S/03E-07D02	PRESSURE 400	115	5772729.0	2130304.25002
15S/03E-07G01	PRESSURE 400	116	5775356.0	2127909.75002
15S/03E-07N01	PRESSURE 180	117	5772911.5	2126430.50002
15S/03E-08B04	PRESSURE 400	118	5780790.5	2128738.25002
15S/03E-08C06	PRESSURE 180	119	5780025.5	2129640.75003
15S/03E-08C07	PRESSURE 400	120	5780124.5	2129385.50002
15S/03E-08F07	PRESSURE 400	121	5779786.0	2128096.50002
15S/03E-08N03	PRESSURE 400	122	5778859.5	2125760.50002
15S/03E-09B01	PRESSURE 180	123	5787613.5	2129526.50003
15S/03E-09C01	PRESSURE 180	124	5785912.0	2130387.75002
15S/03E-09H02	PRESSURE 180	125	5788543.5	2128841.50003
15S/03E-09K04	PRESSURE 400	126	5786815.0	2126625.50003
15S/03E-10P01	PRESSURE 180	127	5789973.0	2124641.25002
15S/03E-10P03	PRESSURE 180	128	5790992.5	2124075.25002
15S/03E-10R02	PRESSURE 180	129	5793537.5	2125764.25002
15S/03E-12E02	EAST SIDE BOTH	130	5799472.0	2128349.25000
15S/03E-13J02	EAST SIDE	131	5804170.5	2121482.50002
15S/03E-13N01	PRESSURE 180	132	5799834.5	2120075.00003
15S/03E-14C01	PRESSURE 180	133	5796323.5	2123063.75002
15S/03E-14G01	PRESSURE 180	134	5796738.0	2122656.50003
15S/03E-14H01	PRESSURE 180	135	5797941.0	2122606.00002
15S/03E-15B01	PRESSURE 400	136	5792336.0	2124219.00002
15S/03E-15L02	PRESSURE 180	137	5790177.0	2121393.00002
15S/03E-16B03	PRESSURE 400	138	5786481.0	2123545.50002
15S/03E-16M01	PRESSURE 180	139	5783233.5	2121388.25002
15S/03E-17B01	PRESSURE 180	140	5781259.5	2123911.75003
15S/03E-17B02	PRESSURE 180	141	5781099.5	2123757.50002
15S/03E-17G01	PRESSURE 180	142	5780630.0	2122750.25002
15S/03E-18B01	PRESSURE 180	143	5776074.5	2124737.50002
15S/03E-21A01	PRESSURE 180	144	5787617.0	2118056.00002
15S/03E-22F02	PRESSURE 180	145	5789756.5	2117099.00002
15S/03E-22G01	PRESSURE 180	146	5791343.0	2116241.25002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/03E-25L01	PRESSURE 180	147	5800408.5	2109728.50003
15S/03E-26A01	PRESSURE 400	148	5797857.5	2112518.00002
15S/03E-26D01	PRESSURE 180	149	5794548.5	2112893.75003
15S/03E-26H02	PRESSURE 180	150	5797573.5	2111904.75002
15S/03E-26P01	PRESSURE 400	151	5795686.5	2108925.25002
15S/03E-27J01	PRESSURE 400	152	5792207.5	2110413.00002
15S/03E-28B02	PRESSURE 400	153	5787075.5	2113993.25002
15S/03E-28G01	PRESSURE 180	154	5786358.0	2111546.50003
15S/03E-35B05	PRESSURE 180	155	5797153.0	2107813.50003
15S/04E-05K01	EAST SIDE	156	5812585.0	2130171.00001
15S/04E-05M01	EAST SIDE BOTH	157	5810608.5	2130920.50001
15S/04E-06D04	EAST SIDE BOTH	158	5805535.0	2134296.75001
15S/04E-06R01	EAST SIDE BOTH	159	5808832.0	2130397.50001
15S/04E-07A01	EAST SIDE BOTH	160	5808667.0	2128112.25001
15S/04E-07E02	EAST SIDE	161	5805290.0	2126918.25001
15S/04E-07R01	EAST SIDE SHALLOW	162	5809617.5	2124497.75001
15S/04E-08C01	EAST SIDE SHALLOW	163	5811226.0	2128961.75001
15S/04E-08L01	EAST SIDE BOTH	164	5812038.0	2125163.50001
15S/04E-08N01	EAST SIDE BOTH	165	5810237.5	2124086.00001
15S/04E-09N01	EAST SIDE	166	5815679.0	2123673.25001
15S/04E-15D02	EAST SIDE SHALLOW	167	5820525.5	2122131.50001
15S/04E-15P02	EAST SIDE BOTH	168	5822591.0	2118164.75001
15S/04E-16D01	EAST SIDE BOTH	169	5816370.5	2122604.00001
15S/04E-17B01	EAST SIDE	170	5813674.5	2122802.00001
15S/04E-17P02	EAST SIDE SHALLOW	171	5811444.0	2119748.75001
15S/04E-18L01	EAST SIDE	172	5806258.0	2120249.25001
15S/04E-19D02	PRESSURE 400	173	5805231.0	2118084.25001
15S/04E-19H03	EAST SIDE	174	5808765.0	2116311.75003
15S/04E-20B02	EAST SIDE SHALLOW	175	5812893.0	2117437.00001
15S/04E-20N01	PRESSURE 400	176	5810999.0	2113437.25001
15S/04E-20Q01	EAST SIDE	177	5813019.5	2113916.75003
15S/04E-22J01	EAST SIDE	178	5825620.5	2114797.50001
15S/04E-22L02	EAST SIDE BOTH	179	5822626.0	2115130.25001
15S/04E-23M01	EAST SIDE	180	5826800.0	2115510.00001
15S/04E-26G01	EAST SIDE	181	5829452.0	2110273.75001
15S/04E-27G01	EAST SIDE BOTH	182	5824082.0	2110658.00001
15S/04E-28C01	EAST SIDE	183	5817013.0	2112539.50001

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/04E-28C01	EAST SIDE	184*	*	*
15S/04E-29K03	EAST SIDE	185*	*	*
15S/04E-32E01	PRESSURE 180	186	5809573.0	2105524.75003
15S/04E-36H01	EAST SIDE BOTH	187	5835591.5	2105235.00001
15S/04E-36R02	EAST SIDE BOTH	188	5836592.5	2101652.75001
16S/04E-01L02	EAST SIDE	189	5833261.5	2096387.25003
16S/04E-04C01	PRESSURE 400	190	5816563.5	2101653.00001
16S/04E-08J01	PRESSURE 180	191	5814399.5	2094772.87501
16S/04E-09A01	PRESSURE 180	192	5818962.5	2096385.75001
16S/04E-10K01	PRESSURE 400	193	5822871.5	2093933.87501
16S/04E-10R02	PRESSURE 400	194	5824891.5	2092808.00001
16S/04E-11E02	PRESSURE 400	195	5825734.0	2093587.12501
16S/04E-12M01	PRESSURE 400	196	5830110.0	2094179.62501
16S/04E-13D01	PRESSURE 400	197	5829977.5	2091400.75001
16S/04E-14M01	PRESSURE 400	198	5826507.0	2089158.00001
16S/04E-14M02	PRESSURE 400	199	5826934.0	2088314.12501
16S/04E-15D01	PRESSURE 180	200	5820915.5	2091029.00003
16S/04E-15H02	PRESSURE 400	201	5824314.0	2089470.00001
16S/04E-24R01	PRESSURE 400	202	5833826.5	2081330.00003
16S/04E-25A01	PRESSURE 400	203	5834115.0	2080854.00001
16S/04E-25K01	PRESSURE 180	204	5832503.0	2077482.12501
16S/04E-25Q01	PRESSURE 400	205	5832125.5	2076199.75001
16S/04E-27G01	PRESSURE 180	206	5823057.0	2078926.75001
16S/04E-36B01	PRESSURE 180	207	5833029.5	2074811.87501
16S/05E-07G01	EAST SIDE BOTH	208	5836648.0	2094674.00003
16S/05E-17P01	EAST SIDE BOTH	209	5843361.0	2086999.12503
16S/05E-17R01	EAST SIDE SHALLOW	210	5845212.0	2087024.25003
16S/05E-19F01	PRESSURE 180	211	5836477.0	2084158.37503
16S/05E-19R01	PRESSURE 180	212	5840423.0	2081360.37503
16S/05E-20C01	EAST SIDE	213	5843125.0	2085585.12503
16S/05E-20H01	EAST SIDE	214	5845691.0	2085074.25003
16S/05E-20R01	EAST SIDE BOTH	215	5845834.0	2082220.00003
16S/05E-27G01	EAST SIDE	216	5853466.8	2077678.05320
16S/05E-28D01	EAST SIDE BOTH	217	5846865.0	2080272.25003
16S/05E-28P01	EAST SIDE BOTH	218	5847355.5	2077784.37503
16S/05E-30C01	PRESSURE 180	219	5836401.5	2080129.50003
16S/05E-30G01	PRESSURE 180	220	5837912.0	2078876.87503

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
16S/05E-30J02	PRESSURE 400	221	5840526.5	2077512.50003
16S/05E-31A01	PRESSURE 180	222	5838804.0	2075067.12503
16S/05E-31Q01	PRESSURE 180	223	5837656.0	2070857.75003
16S/05E-32C01	PRESSURE 180	224	5843159.0	2075228.62503
16S/05E-32M01	FOREBAY	225	5840439.0	2072879.00003
16S/05E-33F01	FOREBAY	226	5847064.0	2072544.75003
16S/05E-33Q01	FOREBAY	227	5846731.0	2071679.00003
16S/05E-35C01	FOREBAY	228	5857923.0	2074215.75003
16S/05E-35L01	FOREBAY	229	5857341.0	2072381.25003
17S/04E-01D01	PRESSURE 180	230	5829970.4	2070190.88233
17S/05E-01R01	FOREBAY	231	5863270.5	2064114.75003
17S/05E-02G01	FOREBAY	232	5858061.5	2067655.75001
17S/05E-03B01	FOREBAY	233	5852910.5	2069821.37503
17S/05E-04C01	FOREBAY	234	5846947.5	2068985.25003
17S/05E-04K01	FOREBAY	235	5847433.5	2066928.37503
17S/05E-04N01	FOREBAY	236	5844523.0	2064819.50003
17S/05E-06Q01	FOREBAY	237	5837274.0	2065350.12503
17S/05E-09G01	FOREBAY	238	5846689.0	2062431.75003
17S/05E-09Q01	FOREBAY	239	5846868.5	2059437.25003
17S/05E-10Q01	FOREBAY	240	5853142.5	2060133.00003
17S/05E-12B01	FOREBAY	241	5864362.0	2062470.37503
17S/05E-12B02	FOREBAY	242	5863570.5	2063023.50003
17S/05E-12B03	FOREBAY	243	5862636.0	2063300.00003
17S/05E-13L02	FOREBAY	244	5861995.0	2054065.12503
17S/05E-14D01	FOREBAY	245	5855476.7	2057512.98904
17S/05E-14G01	FOREBAY	246	5858431.5	2057156.87503
17S/05E-21A01	FOREBAY	247	5847203.9	2053734.78530
17S/05E-23L01	FOREBAY	248	5855276.5	2049667.00003
17S/05E-25L01	FOREBAY	249	5861282.5	2044709.87503
17S/05E-36F02	FOREBAY	250	5861156.5	2040988.13679
17S/06E-16N01	FOREBAY	251	5876658.0	2053579.37503
17S/06E-17R01	FOREBAY	252	5875370.0	2053960.00003
17S/06E-19D01	FOREBAY	253	5865512.0	2052870.75003
17S/06E-20K01	FOREBAY	254	5874270.5	2050202.50003
17S/06E-20Q02	FOREBAY	255	5873861.0	2049734.12503
17S/06E-20Q03	FOREBAY	256	5873624.0	2049413.37503
17S/06E-27E03	FOREBAY	257	5881725.5	2046512.12503

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
17S/06E-27K01	FOREBAY	258	5884526.5	2044144.50003
17S/06E-27L01	FOREBAY	259	5883319.0	2044534.62503
17S/06E-28N01	FOREBAY	260	5876603.5	2042971.37503
17S/06E-29C01	FOREBAY	261	5871659.0	2048323.00003
17S/06E-29K01	FOREBAY	262	5873377.5	2045490.50003
17S/06E-29Q01	FOREBAY	263	5873361.0	2045274.25003
17S/06E-30F01	FOREBAY	264	5866434.0	2047190.00003
17S/06E-32G01	FOREBAY	265	5873481.5	2040947.12503
17S/06E-32J02	FOREBAY	266	5874264.0	2039466.50003
17S/06E-35F01	FOREBAY	267	5888535.0	2040776.00003
17S/06E-35J01	FOREBAY	268	5890370.5	2039573.75003
18S/06E-01E01	FOREBAY	269	5892201.0	2033873.12503
18S/06E-02N01	FOREBAY	270	5886656.0	2032336.12503
18S/06E-02R01	FOREBAY	271	5890070.0	2032210.75003
18S/06E-03P01	FOREBAY	272	5881836.0	2032629.37503
18S/06E-05H01	FOREBAY	273	5874765.0	2035980.12503
18S/06E-07A01	FOREBAY	274	5868250.5	2031805.25003
18S/06E-08R01	FOREBAY	275	5873246.0	2027074.87503
18S/06E-09M02	FOREBAY	276	5875856.5	2028751.00003
18S/06E-11J01	FOREBAY	277	5890622.5	2027590.87503
18S/06E-12A01	FOREBAY	278	5896424.0	2030093.87503
18S/06E-12R02	FOREBAY	279	5895096.5	2026768.25003
18S/06E-14B01	FOREBAY	280	5888379.5	2025469.87503
18S/06E-14R01	FOREBAY	281	5890625.0	2022391.37503
18S/06E-15F01	FOREBAY	282	5882187.0	2023781.12503
18S/06E-15M01	FOREBAY	283	5880584.0	2022838.50003
18S/06E-16L01	FOREBAY	284	5876773.5	2023478.50003
18S/06E-21Q01	FOREBAY	285	5878665.0	2016542.37503
18S/06E-25F01	FOREBAY	286	5891762.0	2013188.12503
18S/06E-26R01	FOREBAY	287	5890408.5	2011271.25003
18S/06E-27A01	FOREBAY	288	5883864.0	2015914.75003
18S/06E-28J01	FOREBAY	289	5879251.0	2013091.87503
18S/06E-34B01	FOREBAY	290	5882838.0	2010128.37503
18S/07E-18K01	FOREBAY	291	5899619.5	2023322.62503
18S/07E-18P01	FOREBAY	292	5897367.5	2022162.75003
18S/07E-19G02	FOREBAY	293	5899561.5	2019657.12503
18S/07E-19N01	FOREBAY	294	5896875.0	2016213.75002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
18S/07E-20K01	FOREBAY	295	5903526.5	2016596.50003
18S/07E-28K01	FOREBAY	296	5909064.5	2012996.12503
18S/07E-28N02	FOREBAY	297	5906995.5	2011573.25003
18S/07E-29J01	FOREBAY	298	5906172.5	2012704.50003
18S/07E-29M01	FOREBAY	299	5901432.0	2012790.87503
18S/07E-32G02	FOREBAY	300	5905129.0	2008896.37503
18S/07E-34P02	FOREBAY	301	5913853.5	2006429.50003
19S/06E-01H01	FOREBAY	302	5894418.0	2003322.50003
19S/06E-03E02	FOREBAY	303	5880577.0	2003637.62503
19S/06E-03K01	FOREBAY	304	5882172.5	2003068.00003
19S/06E-11C01	FOREBAY	305	5887118.5	1999053.25003
19S/06E-12A01	FOREBAY	306	5895441.5	1999532.50003
19S/07E-03H02	UPPER VALLEY	307	5916058.0	2002263.25003
19S/07E-04G01	FOREBAY	308	5908976.0	2002192.50003
19S/07E-04Q01	FOREBAY	309	5907241.5	2000938.12503
19S/07E-05B02	FOREBAY	310	5903922.5	2005128.00003
19S/07E-10P02	UPPER VALLEY	311	5914112.0	1994937.37503
19S/07E-13D01	UPPER VALLEY	312	5923060.5	1993005.87503
19S/07E-13D02	UPPER VALLEY	313	5922703.0	1993016.87503
19S/07E-13D03	UPPER VALLEY	314	5921177.5	1994464.25003
19S/07E-16D01	UPPER VALLEY	315	5907215.0	1993447.25003
19S/07E-20A01	UPPER VALLEY	316	5904728.0	1988737.75003
19S/07E-20A02	UPPER VALLEY	317	5905140.0	1988780.50003
19S/07E-23F01	UPPER VALLEY	318	5917918.5	1986682.87503
19S/07E-23G01	UPPER VALLEY	319	5919819.5	1985678.50003
19S/07E-24H02	UPPER VALLEY	320	5927076.5	1985899.12503
19S/07E-36N01	UPPER VALLEY	321	5921376.0	1974705.75003
19S/08E-30A01	UPPER VALLEY	322	5931268.5	1981945.62503
20S/08E-05C02	UPPER VALLEY	323	5933968.0	1972500.37503
20S/08E-05R03	UPPER VALLEY	324	5935855.5	1968133.00003
20S/08E-06B01	UPPER VALLEY	325	5929631.0	1971657.50003
20S/08E-07E01	UPPER VALLEY	326	5927847.5	1965744.25003
20S/08E-15H03	UPPER VALLEY	327	5946414.0	1959720.37503
20S/08E-16C01	UPPER VALLEY	328	5938055.0	1961243.37501
20S/08E-17K03	UPPER VALLEY	329	5934573.0	1958618.62503
20S/08E-34G01	UPPER VALLEY	330	5944061.5	1944379.50003
20S/08E-36R01	UPPER VALLEY	331	5957517.0	1941628.62503

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
21S/08E-15J01	UPPER VALLEY	332	5946267.0	1926489.62503
21S/09E-06C01	UPPER VALLEY	333	5959365.5	1939884.62503
21S/09E-16E02	UPPER VALLEY	334	5967913.5	1928310.37503
21S/09E-22J01	UPPER VALLEY	335	5976378.5	1921774.75003
21S/09E-24Q01	UPPER VALLEY	336	5985537.5	1920320.00003
21S/10E-30E02	UPPER VALLEY	337	5988110.5	1916891.25003
21S/10E-32N01	UPPER VALLEY	338	5993930.5	1907839.00003
22S/10E-09P01	UPPER VALLEY	339	6000619.0	1897117.87503
22S/10E-16P01	UPPER VALLEY	340	6000072.0	1892154.87503
22S/10E-21C01	UPPER VALLEY	341	6001268.5	1890089.75003
22S/10E-22N01	UPPER VALLEY	342	6004921.0	1886561.87503
22S/10E-28B01	UPPER VALLEY	343	6001816.0	1886849.25003
22S/10E-34G01	UPPER VALLEY	344	6007012.0	1879185.87503

[1] State Plane Coordinate System, California Zone IV, Feet, North American Datum 1983

*Coordinates to be collected

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Table 5 COASTAL WELLS AND LOCATIONS

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
13S/01E-25R01	PRESSURE 900	1	5742345.5	2174687.00002
13S/02E-15M01	PRUNEDALE	2	5757881.5	2185405.50002
13S/02E-19Q03	PRESSURE 900	3	5746313.5	2179184.50002
13S/02E-20J01	PRESSURE 400	4	5752096.0	2180981.25002
13S/02E-28L02	PRESSURE BOTH	5	5755055.5	2175441.75002
13S/02E-28M02	PRESSURE 400	6	5753447.0	2175997.50002
13S/02E-32J03	PRESSURE 400	7	5752560.0	2170401.75002
13S/02E-33N04	PRESSURE 400	8	5753898.0	2169605.00002
13S/02E-34G01	PRESSURE 400	9	5760129.5	2170052.25002
13S/02E-34M01	PRESSURE 400	10	5757997.5	2169621.75002
14S/01E-13J02	PRESSURE 400	11	5741048.0	2154289.50002
14S/02E-01C01	EASTSIDE DEEP	12	5771477.5	2167454.25002
14S/02E-02A02	EASTSIDE DEEP	13	5768561.0	2167823.50002
14S/02E-02C03	PRESSURE 400	14	5765109.0	2167416.00002
14S/02E-03H01	PRESSURE 400	15	5762283.0	2166255.50002
14S/02E-03M02	PRESSURE 400	16	5758710.5	2164740.50002
14S/02E-03R02	PRESSURE 400	17	5762517.0	2163892.75002
14S/02E-04B01	PRESSURE 400	18	5755909.0	2167499.00002
14S/02E-04G02	PRESSURE 400	19	5756262.0	2166403.75002
14S/02E-04H01	PRESSURE 400	20	5756715.0	2165886.25002
14S/02E-04N03	PRESSURE 400	21	5753365.0	2163112.75002
14S/02E-05C03	PRESSURE 400	22	5748893.5	2167132.50002
14S/02E-05K02	PRESSURE 400	23	5750829.0	2165370.75002
14S/02E-07A01	PRESSURE 400	24	5747142.5	2162655.25002
14S/02E-07J02	PRESSURE 400	25	5746655.0	2159408.25002
14S/02E-07J03	PRESSURE DEEP ZONE	26	5746476.9	2159735.06998
14S/02E-07L04	PRESSURE 400	27	5743780.0	2159328.00002
14S/02E-07L05	PRESSURE 400	28	5743784.5	2160380.50002
14S/02E-08C03	PRESSURE 400	29	5750055.0	2162036.75002
14S/02E-08M02	PRESSURE 400	30	5747103.0	2159672.50002
14S/02E-09D04	PRESSURE 400	31	5753016.5	2162818.75002
14S/02E-09K02	PRESSURE 400	32	5755450.0	2159946.25002
14S/02E-09N02	PRESSURE 400	33	5752897.5	2158609.50002
14S/02E-10E02	PRESSURE 400	34	5758062.0	2160525.75002
14S/02E-10H01	PRESSURE 400	35	5761492.0	2160761.75002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-10M02	PRESSURE 400	36	5757853.5	2159387.75002
14S/02E-11B01	PRESSURE 400	37	5766446.0	2162325.25002
14S/02E-11M03	PRESSURE 400	38	5764448.5	2159266.75002
14S/02E-12N02	PRESSURE 180	39	5769893.5	2158219.50002
14S/02E-13F01	PRESSURE 180	40	5769952.5	2154587.75002
14S/02E-13G01	PRESSURE 400	41	5772057.5	2155470.50002
14S/02E-14A01	PRESSURE 400	42	5767367.0	2156210.25002
14S/02E-14L02	PRESSURE 180	43	5764775.5	2155024.75003
14S/02E-14L03	PRESSURE 400	44	5764610.5	2154419.75002
14S/02E-15A01	PRESSURE 400	45	5761774.5	2157015.50002
14S/02E-15C02	PRESSURE 400	46	5759385.5	2157259.00002
14S/02E-15L02	PRESSURE 180	47	5758452.0	2153366.00003
14S/02E-15N01	PRESSURE 400	48	5757522.5	2153353.25002
14S/02E-15P01	PRESSURE 400	49	5758767.5	2153584.50002
14S/02E-16A02	PRESSURE 400	50	5756957.5	2157123.50002
14S/02E-16G01	PRESSURE 400	51	5755957.0	2155999.50002
14S/02E-16H01	PRESSURE 400	52	5756041.0	2156035.25002
14S/02E-17A02	PRESSURE 400	53	5751744.5	2156837.50002
14S/02E-20B03	PRESSURE 900	54	5750210.5	2151407.25003
14S/02E-21E01	PRESSURE 400	55	5753561.0	2150101.50003
14S/02E-21J01	PRESSURE 180	56	5756896.0	2149447.75002
14S/02E-21L01	PRESSURE 180	57	5754605.0	2149175.75002
14S/02E-22B01	PRESSURE 400	58	5760986.0	2152124.75002
14S/02E-22L01	PRESSURE 400	59	5759725.0	2149855.00002
14S/02E-22P02	PRESSURE 180	60	5758952.5	2146937.25002
14S/02E-23M01	PRESSURE 180	61	5762708.0	2149478.75002
14S/02E-24E01	PRESSURE 180	62	5768326.5	2150393.25002
14S/02E-24P02	PRESSURE 400	63	5769670.0	2146858.75002
14S/02E-24Q01	PRESSURE 180	64	5771942.5	2146772.50003
14S/02E-25D04	PRESSURE 180	65	5768019.0	2145519.50003
14S/02E-26J03	PRESSURE 400	66	5766847.5	2143883.00002
14S/02E-26N03	PRESSURE 180	67	5762617.0	2142567.75002
14S/02E-26P01	PRESSURE 180	68	5764519.0	2141615.00003
14S/02E-27C02	PRESSURE 400	69	5759686.0	2145562.00002
14S/02E-27F02	PRESSURE 180	70	5759825.0	2144647.75002
14S/02E-28C01	PRESSURE 400	71	5753983.5	2146953.50002
14S/02E-32D06	PRESSURE 180	72	5746981.0	2141653.75003

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-33P01	PRESSURE BOTH	73	5756348.0	2138806.75003
14S/02E-34A04	PRESSURE 180	74	5761465.0	2141623.00002
14S/02E-34B03	PRESSURE 180	75	5759909.5	2141431.00002
14S/02E-36E01	PRESSURE 180	76	5768600.0	2138685.00002
14S/02E-36G01	PRESSURE 400	77	5770039.0	2139297.50002
14S/03E-06L02	EASTSIDE DEEP	78	5775957.0	2164155.50002
14S/03E-07P02	EASTSIDE SHALLOW	79	5775832.0	2157899.00003
14S/03E-18E02	PRESSURE 400	80	5774633.5	2155704.50003
14S/03E-19Q02	PRESSURE 180	81	5776192.0	2146948.50002
14S/03E-30E03	PRESSURE 400	82	5774081.0	2143975.75002
14S/03E-30F01	PRESSURE 180	83	5775609.5	2144673.00002
14S/03E-31B01	PRESSURE 180	84	5776312.0	2140030.50002
15S/02E-12C01	PRESSURE 180	85	5769441.0	2130513.75002

[1] State Plane Coordinate System, California Zone IV, Feet, North American Datum 1983

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Table 6 REQUIREMENTS FOR SAMPLE COLLECTION[1]

ANALYTE	CONTAINER TYPE	SAMPLE VOLUME	PRESERATIVE	HOLDING TIME
Calcium (Ca)	polyethylene (HDPE[2])	200 mL[3]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
CATION ANION BALANCE[4]	N/A Calculation	N/A Calculation	N/A Calculation	N/A Calculation
Chloride (Cl)[5]	polyethylene (HDPE[1])	100 mL[2]	4±2ºC	28 days
Conductivity (SEC)[5]	polyethylene (HDPE[1])	100 mL[2]	4±2ºC	28 days
Magnesium (Mg)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Nitrate (NO3)[5]	polyethylene (HDPE[1])	100 mL[2]	none HSO_4; pH<2	48 hours at 4° C 28 days
pH (Laboratory)	polyethylene (HDPE[1])	30 mL[2]	none	48 hours at 4° C
Potassium (K)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Sodium (Na)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Sulfate (SO4)	polyethylene (HDPE[1])	100 mL[2]	4±2ºC	28 days
Total Alkalinity (as CaCO3)	polyethylene (HDPE[1])	100 mL[2]	4±2ºC	14 days

[1] = CCL QA Manual and SOPs

[2] = High Density Polyethylene

[3] = only one 0.5 gal (~2L) container is needed for all analyses

[4] = Cation anion balance is a calculation

[5] = Analytes in partial mineral panel, one pint (~500 mL) container is need for analyses

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APPENDICES

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(10/2019)

APPENDIX A

GLOBAL POSITIONING SYSTEM (GPS) TRAINING

Appendix A-1: GPS Training Record

Appendix A-2: TSC1 Asset Surveyor Manual

Appendix A-3: Pro XR/XRS Receiver Manual

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Geographic Positioning System (GPS) Training Record

Name of Trainee Name of Trainer Date of Training

	Satisfactory Completion / Understanding
Verification of access to Pathfinder Office software	
Preparation of data dictionary	
Set-up of equipment	
Trimble® TSC1 Asset Surveyor[1]	
Trimble® Pro XR Receiver[1]	
Connector cables	
Batteries (Asset Surveyor and Receiver)	
Confirmation of communication between Asset Surveyor and Receiver	
Acquiring satellites	
Setting up and checking critical settings	
-logging intervals	
-PDOP mask[2]	
Proper packing and unpacking of equipment	
Transferring data files from Asset Surveyor to the computer	

[1] The Agency uses Trimble® products, the GPS industry standard.
[2] PDOP = Position Dilution Of Precision

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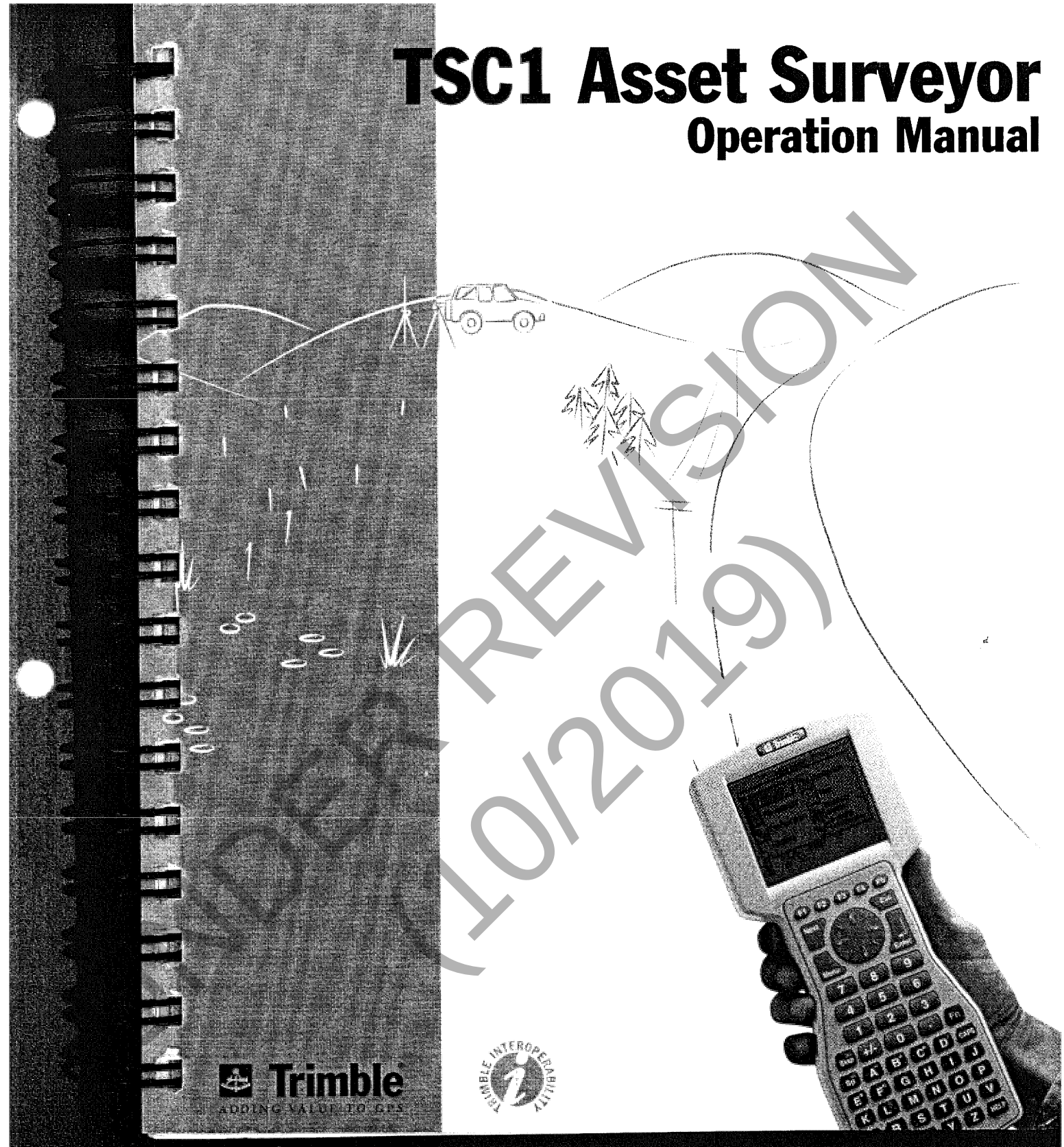
TSC1 Asset Surveyor
Operation Manual



Trimble
ADDING VALUE TO GPS

REVISION
(10/2019)

TSC1 Asset Surveyor

Operation Manual

Part Number 34182-05-ENG

Version 5.00

October 1999

Revision A

Trimble Navigation Limited
Mapping & GIS Systems
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UNDER REVISION (10/2019)

1 Quick Setup

The instructions in this chapter are a simplified version of the various steps found in Chapters 4, 5, and 6 of this manual. The purpose of the simplified version is to provide quick setup guides with reasonable default values that can be distributed to field crews to ensure proper setup of rover or base station receivers.

Data is logged to the TSC1 with the Asset Surveyor software. For full details on configuration and data collection, refer to the *TSC1 Asset Surveyor Software User Guide*.

Note – The steps outlined in this chapter do not include steps required to collect data using carrier phase information. For instructions on how to collect high accuracy features, see Chapter 7, Carrier Phase Data Collection.

1.1 Before Leaving the Office

1. Install the Pathfinder Office software on your office computer (refer to the *Pathfinder Office Getting Started Guide*).
2. Using the Pathfinder Office software, prepare any data files or data dictionaries you require, and transfer them to the TSC1. If you want to update GPS or attribute information on features stored in a GIS, import the data files and data dictionary into Pathfinder Office and then transfer them to the TSC1. You may also want to transfer any waypoint and coordinate system files to the datalogger.

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3. Check that you have all the required equipment, and that it is operational. Set up and connect your GPS system (the appendix for your GPS receiver lists the equipment and shows you how to connect it).

4. If the GPS receiver has an On/Off switch, turn it on (the Series 4000, GPS Total Station 4700, GPS Total Station 4800, Site Surveyor 4400 and 4600LS receivers have an On/Off switch).

   Start the Asset Surveyor software to check that it and the GPS receiver are communicating correctly. If communication is established, the GPS status line appears. If communication fails, an error message pops up on the screen.

5. Check all critical settings in the Asset Surveyor software.

   You should also check non-critical and display settings, especially if the system has been used by someone else recently. For details of how to configure Asset Surveyor, refer to the *TSC1 Asset Surveyor Software User Guide*.

6. Turn everything off and pack it into carrying cases if you have to travel a significant distance to the survey site. Pack spare sets of batteries if you expect to operate the receiver for any length of time.

1.2 In the Field

1. Travel to the survey site, remembering to carry all the required equipment with you.

2. Reassemble the system.

3. If the GPS receiver has an On/Off switch, turn it on. Then start the Asset Surveyor software, if it is not already on.

   Wait until the GPS receiver acquires enough satellites to start computing GPS positions, before beginning to work. The number of satellites being tracked displays on the status line.

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You should now change some of the configuration settings as follows:

Main menu

1.	*Configuration*	Highlight *Configuration* then press the Enter key

Configuration menu

2.	*GPS rover options*	Press Enter
3.	*Logging options*	Press Enter

Logging options screen

4.	*Point feature*	Synchronized with the base station
5.	*Line/area*	Synchronized with the base station
6.	*Not in feature*	Synchronized with the base station
7.	*Minimum positions*	3
8.	*Allow GPS update*	'Warn first'
9.	*Warning distance*	'Any'
10.	To accept	Press Enter

Position filters screen

11.	*Position mode*	'Manual 3D' or 'Overdet. 3D' depending on canopy density
12.	*PDOP mask*	4 or 6 (depending on receiver)
13.	To accept	Press Enter

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TSC1 Asset Surveyor Operation Manual Trimble

4. Create a new data file, associating the correct data dictionary with it. Alternatively, re-open an existing data file.
5. Begin collecting data. Collect, review and update all the features necessary.
6. Close the data file.
7. Disconnect and repack the components of the system. Remember to turn off the GPS receiver, if it has an On/Off switch. Return to your office.

1.3 Back in the Office

1. Transfer the data files from the TSC1 to the PC using the Pathfinder Office software.
2. Use the Pathfinder Office software for differential correction, plotting, and exporting the data file(s) to a GIS.
3. Recharge the TSC1 datalogger and GPS receiver batteries.

1.4 Rover Configuration

Use the following procedure to set up your system in a rover configuration.

From the *Utilities* menu, select *Factory defaults*. This resets the Asset Surveyor software to its default configuration and then restarts the datalogger.

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Antenna options screen

14. *Height*	Height to antenna's phase center
15. *Measure*	'Vertical'
16. *Type*	For a list of antenna types, see the *TSC1 Asset Surveyor Software User Guide*
17. *Confirm*	Select 'Per feature', 'Per file', or 'Never'
18. To accept	Press Enter

GPS rover options menu

19. To return to the *Configuration* menu	Press Esc

Configuration menu

20. *Communication options*	Press Enter
21. *Real-time input options*	Press Enter

Real-time input options screen

22. RTCM age limit	5 or 10 (depending on your radio)
23. To accept	Press Enter
24. To return to the *Configuration* menu	Press Esc

Configuration menu

25. To exit the *Configuration* menu	Press Esc

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1.4.1 Data Collection

Use the following procedure to set up your system for rover data collection.

Main menu

1. Select *Data collection* and press Enter

***Data collection* menu**

2.	Create a data file	Select *Create new file*: Press Enter and then press Enter
	-or-	-or-
	Open an existing data file	Select *Open existing file*. Press Enter Select an existing file to append to or update, and press Enter
3.	To exit *Data collection*	Press Esc and press Yes to confirm exit

1.5 Base Station Configuration

Use the following procedure to set up your system in a base station configuration.

Main menu

1.	*Configuration*	Highlight *Configuration* then press the Enter key

***Configuration* menu**

2.	*GPS base station options*	Press Enter
3.	*Logging options*	Press Enter

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Logging options screen

4.	*Measurements*	One to five seconds (depending on rover interval and free space)
5.	To accept	Press Enter
6.	To return to the *Configuration* menu	Press Esc

Configuration menu

7.	To exit the *Configuration* menu	Press Esc

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1.5.1 Base Station Data Collection

Use the following procedure to set up your system for base station data collection.

Main menu

1. *Data collection* — Press Enter

***Data collection* menu**

2. *Create base file* — Press Enter

***Create File* screen**

3. Create file — Press Enter

***Antenna options* screen**

4. *Height* — Height to antenna's phase center
5. *Measure* — 'Vertical'
6. *Type* — For a list of antenna types, see the *TSC1 Asset Surveyor Software User Guide*
7. To accept — Press Enter

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TSC1 Asset Surveyor Operation Manual Trimble

Reference Position screen

8.	Enter reference position	Type lat/lon (or north/east) and altitude, and press Enter
	-or-	-or-
	Use an existing waypoint	Press WayPt, select the waypoint and press Enter
	-or-	-or-
	Use an approximate position	Press Here and press Enter
	-or-	-or-
	Leave as is and set in the Pathfinder Office software	Press Enter

Base Station screen

9.	To exit *Base station*	Press Enter and press Yes to confirm exit.

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Key Symbols

The Asset Surveyor software uses both *hard* (that is, physical) keys on a keypad and *soft* (that is, visual) keys on the datalogger's screen.

Hard (physical) keys on the TSC1 keypad are indicated as follows:

Enter, ◄, F1, and so on.

Softkeys on the TSC1 screen are indicated as follows:

Create, Del, Edit, and so on.

A softkey is activated by pressing the corresponding function key (F1...F5) on the TSC1 keypad.

Warnings, Cautions, Notes, and Tips

Warnings, cautions, notes, and tips draw attention to important information, and indicate its nature and purpose.

Warning – Warnings alert you to situations that could cause personal injury or unrecoverable data loss.

Caution – Cautions alert you to situations that could cause hardware damage or software error.

Note – Notes give additional significant information about the subject to increase your knowledge, or guide your actions.

Tip – Tips indicate a shortcut or other time- or labor-saving hint that can help you make better use of the product.

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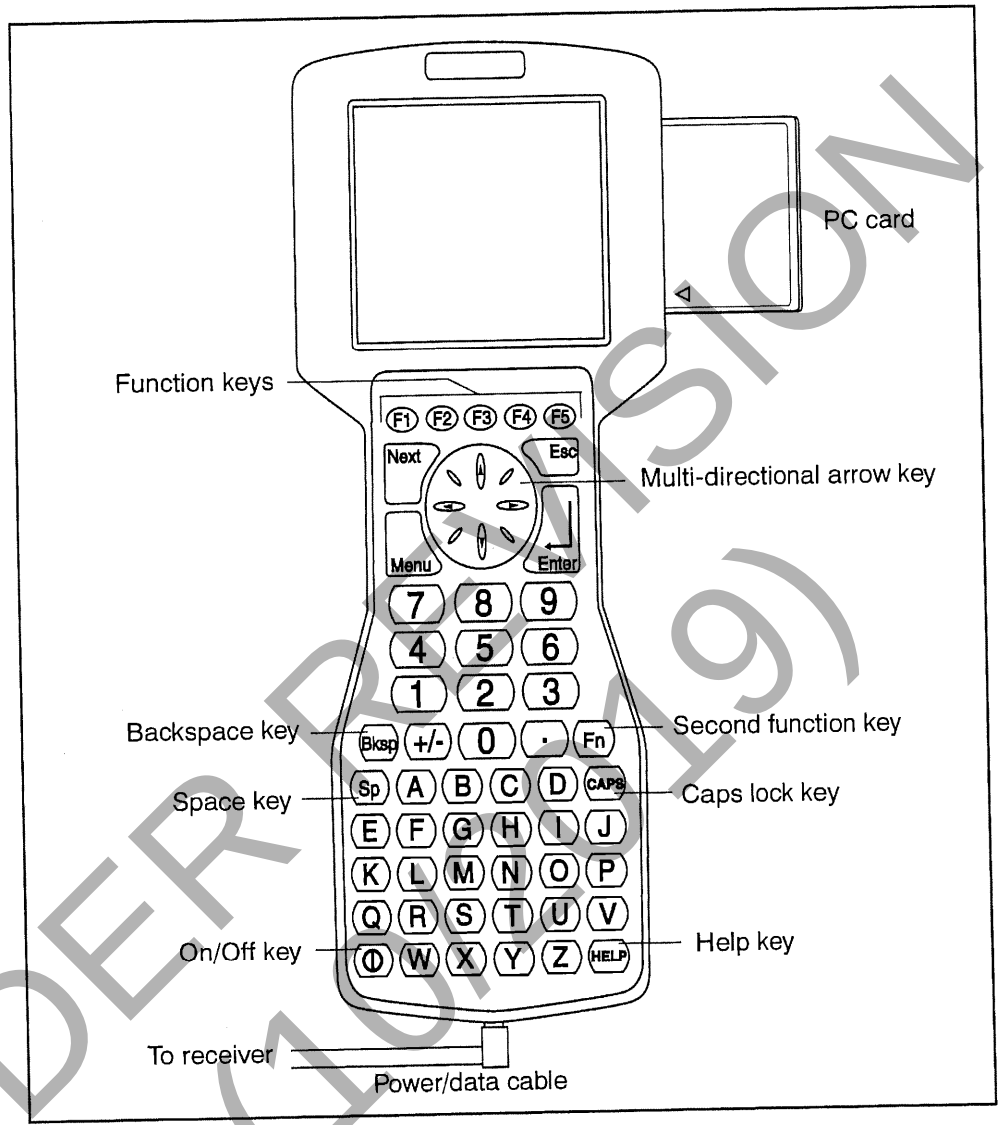

Figure 3-1 Front View of the TSC1 Datalogger

UNDER REVISION (10/19)

TSC1 Asset Surveyor Operation Manual Trimble

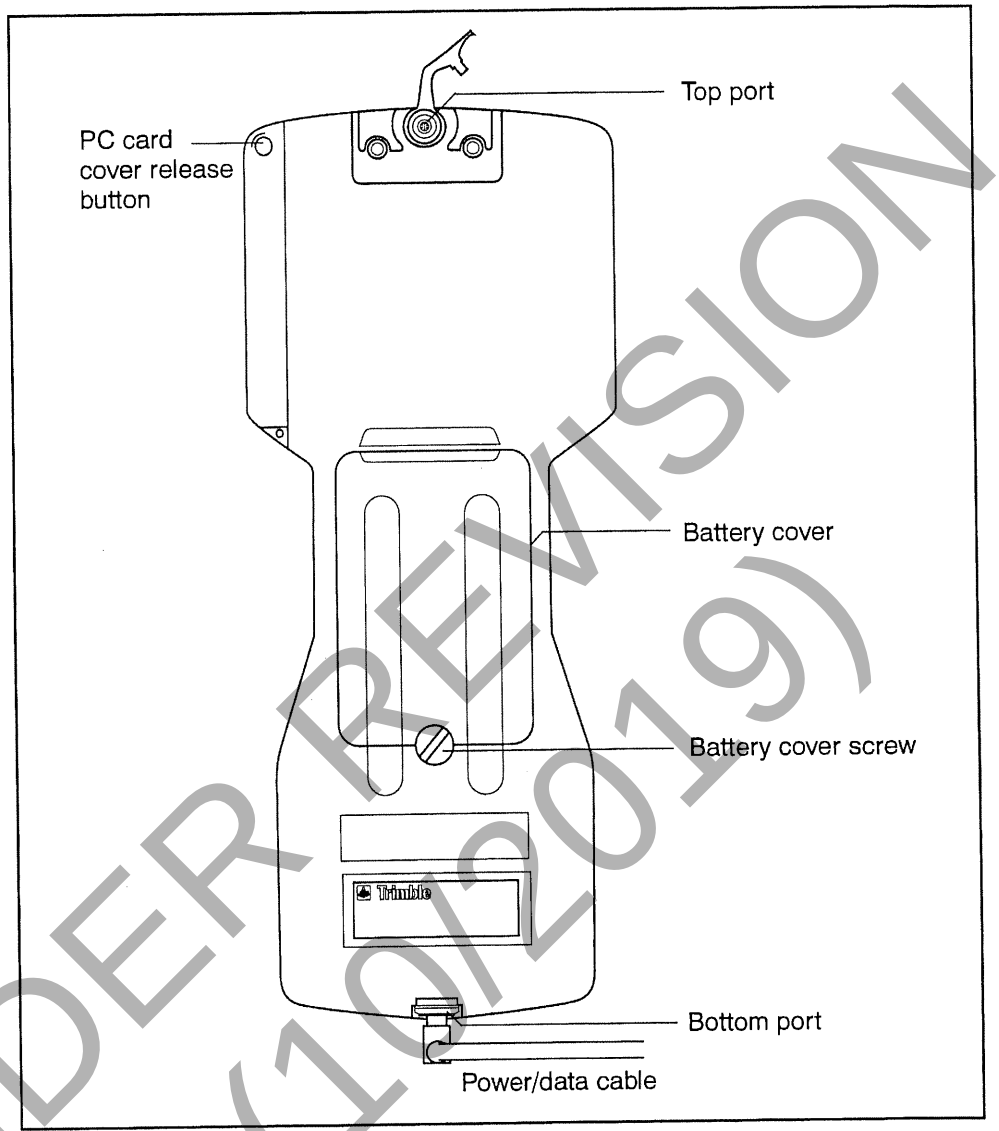

Figure 3-2 Back View of the TSC1 Datalogger

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3.2 Turning the TSC1 Datalogger On and Off

To turn on the TSC1 datalogger, make sure that power is supplied (see Power Sources, page 3-11). Then press the green on/off key marked [⏻].

To turn off the TSC1, hold down [⏻] for one second.

Tip – For the location of the [⏻] key and other keys on the TSC1 datalogger's keypad, refer to Figure 3-1.

3.2.1 Hard Keys

Hard keys are the physical keys on the TSC1 keypad, such as [1], [A], [Enter], [◄►], [▲▼], and [Esc]. Use these keys to enter data and to access different screens.

3.2.2 Alternate Keys

Alternate keys give some hard keys a second function. Some of the second functions are displayed on the hard keys in small yellow lettering. To use a second function, press the [Fn] hard key and then press the alternate hard key.

Table 3-1 shows some of the functions that you can access using alternate keys.

Table 3-1 Useful Second Functions

Keys	Function
[Fn] [▼]	Page down
[Fn] [▲]	Page up
[Fn] [◄]	Home
[Fn] [►]	End
[Fn] [Next]	Previous screen
[Fn] [E]	Contrast up
[Fn] [F]	Contrast down

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3.2.3 Softkeys

Softkeys are displayed on the bottom line of the TSC1 screen. A softkey corresponds to the adjacent hard key: F1, F2, F3, F4, F5. Press the hard key to activate the softkey on the screen. To activate the Pause softkey, for example, press F1. See Figure 3-3.

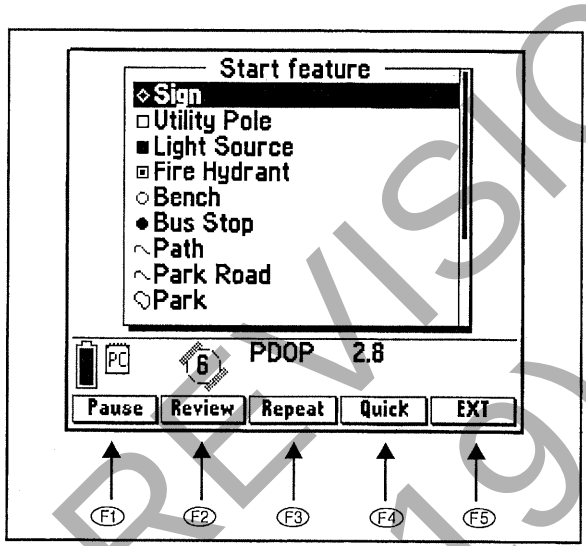

Figure 3-3 How Function Keys Correspond to Softkeys

Softkeys relate to particular forms or fields and only appear when these forms or fields are accessed. For example, the Seg softkey only appears when a line feature is opened for data collection, as this functionality applies to line features only.

3.2.4 Menu Key

To return to the *Main menu* at any time, press the Menu hard key. Use this key in conjunction with the Next key to move around the Asset Surveyor screens quickly.

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3.2.5 Next Key

To simplify the task of moving around menus, the Next hard key offers quick access to open screens (windows).

3.2.6 Help Key

Press the HELP hard key at any time to obtain further information about a topic. When you press it, the *Help* menu appears. To exit *Help*, press Esc from the *Help* menu.

3.3 Screen

The TSC1 has an LCD screen. This screen responds to heat, and prolonged exposure to full sunlight can cause it to darken. If the screen does darken, turn it away from direct sunlight until it returns to normal.

Caution – Repeated exposure to direct sunlight can cause the screen to degrade.

3.3.1 Contrast

To increase the screen contrast, press Fn E.

To decrease the screen contrast, press Fn F.

3.3.2 Backlight

To toggle the screen backlight on and off, press Fn L.

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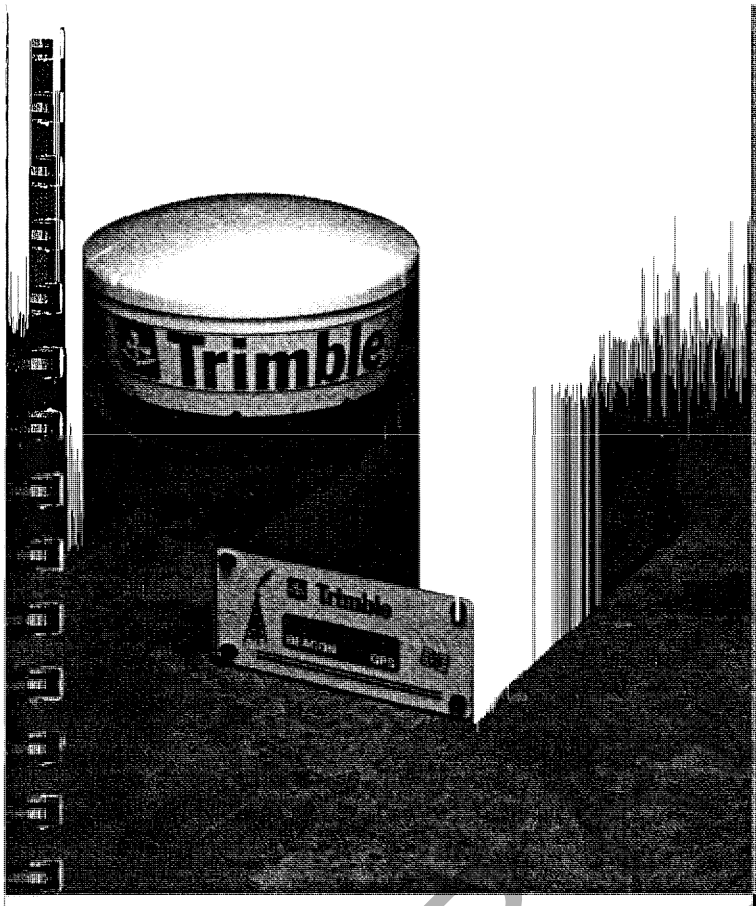
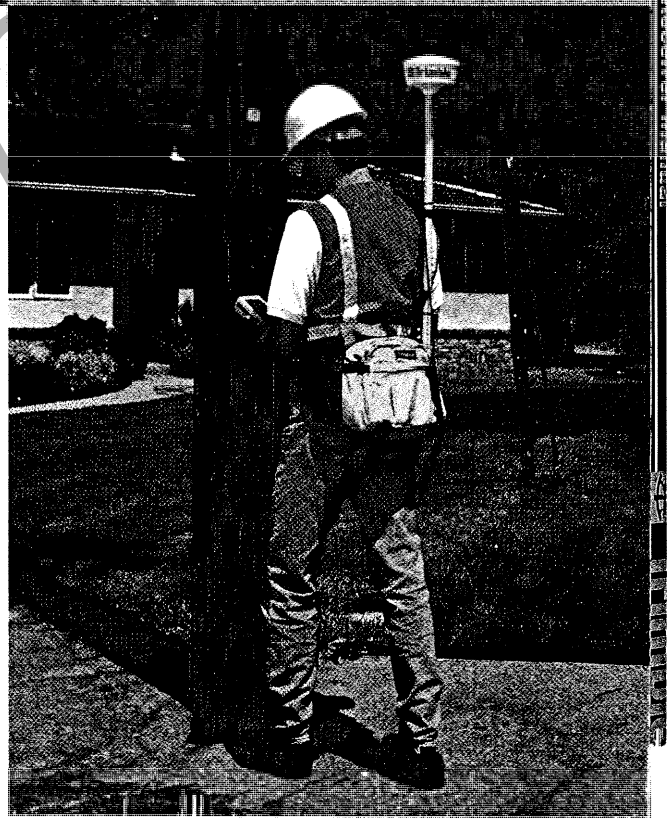


Pro XR/XRS
Receiver Manual



UNDER
(10/

Trimble

Pro XR/XRS

Receiver Manual

Part Number 31172-20-ENG

Revision A

May 1998

Trimble Navigation Limited
Mapping and GIS Systems Division
645 North Mary Avenue
P.O. Box 3642
Sunnyvale, CA 94088-3642
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1-800-827-8000 in North America
+1-408-481-8000 International
Fax: +1-408-481-7744
www.trimble.com

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4 Pro XR/XRS System Equipment

This chapter provides details of the equipment associated with the Pro XR and Pro XRS receivers and shows how to assemble the equipment.

4.1 Pro XR Receiver Front Panel

The Pro XR receiver, shown in Figure 4-1, is mounted in a weatherproof housing.

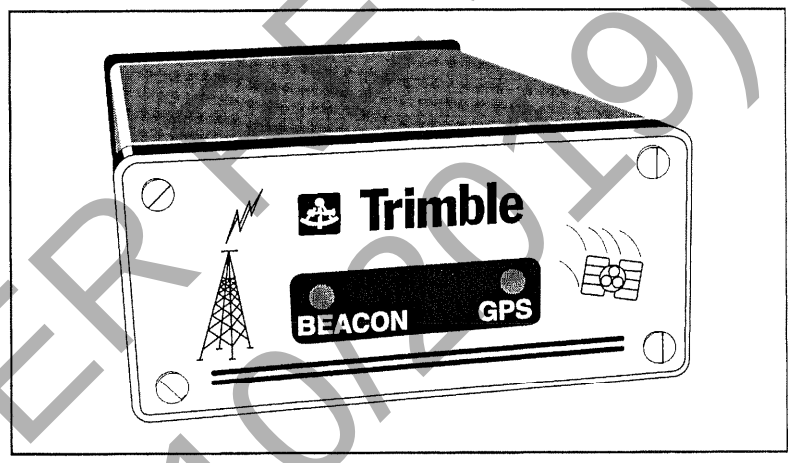

Figure 4-1 Pro XR Receiver Front Panel

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4.2.1 Pro XR Status Lights

The two status lights on the front panel of the Pro XR receiver provide the status information listed in Table 4-1.

Table 4-1 Pro XR Status Lights

	GPS	Beacon
OFF	Unit not powered up	Unit not powered up or beacon function is disabled
FAST FLASH	Searching for satellites	Searching for MSK signals
SLOW FLASH	Found one or more satellites. Not enough for a position fix.	Found MSK signal. RTCM data has not been sent to GPS receiver.
ON	Performing position fixes	Good RTCM data is being provided to the GPS receiver

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4.3 Back Panel

The Pro XR and Pro XRS receivers have two serial communications ports (RS232) and an antenna cable port. The serial communications ports, shown in Figure 4-3, are 12-pin(m) bulkhead connectors located on the back panel of the Pro XR and Pro XRS receivers.

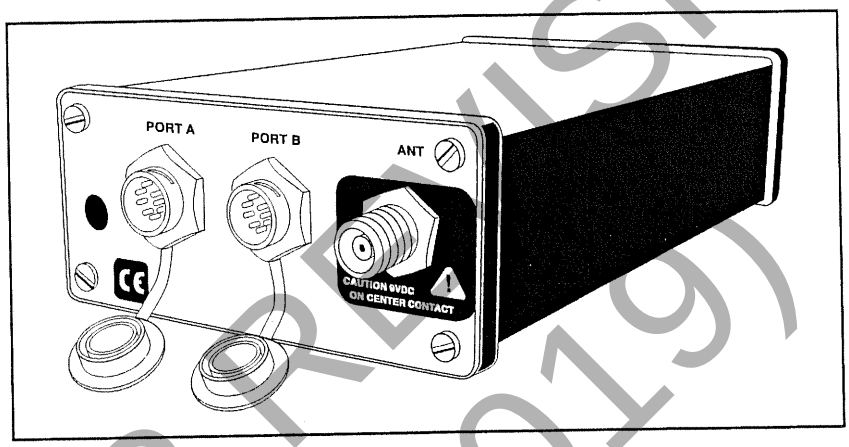


Figure 4-3 Pro XR/XRS Receiver Back Panel

4.3.1 Port A

Port A offers RS232 communication standards. It is designed for NMEA-0183 output and RTCM input.

4.3.2 Port B

Port B also offers RS232 communication standards. It is designed for two-way data flow, external sensor input and power.

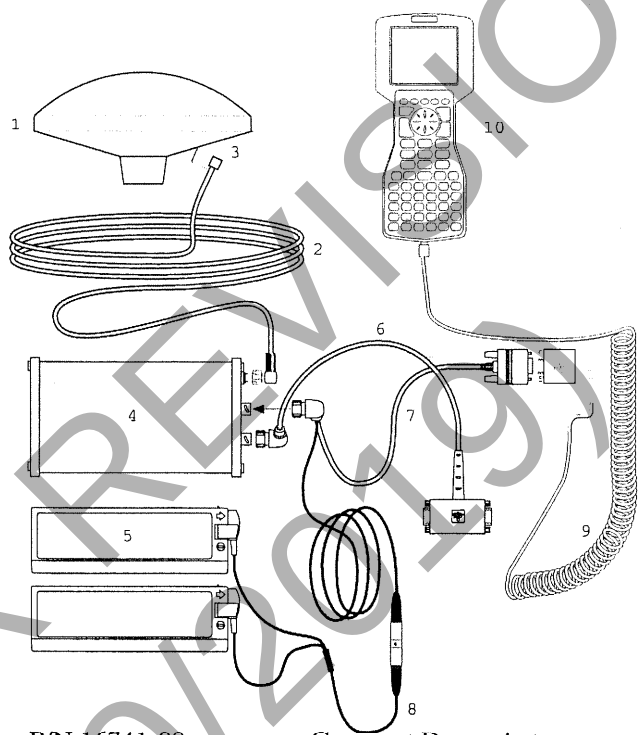
4.3.3 Antenna Port

The antenna connector is a TNC(f) connector located on the far right on the back panel of the Pro XR or Pro XRS receiver.

UNDER REVISION (10/2019)

4.4 GPS Pro XR Cabling

To use the TSC1 handheld with a GPS Pro XR receiver, connect the system as shown in Figure 4-4.



1	P/N 16741-00	Compact Dome Antenna
2	P/N 22628	Antenna Cable
3	P/N 31180	Antenna Cable Adapter
4	P/N 29654-11	12-channel Pro XR receiver
5	P/N 17466	Camcorder Batteries
6	P/N 30232-00	NMEA/RTCM Cable
7	P/N 30231-00	Data/Power Cable
8	P/N 24333	Dual Battery Cable
9	P/N 32287-00	TSC1 Data/ESP Cable
10	P/N 29673-50	TSC1 Handheld

Figure 4-4 GPS Pro XR / TSC1 Connection Diagram

UNDER REVISION 10/29/97

4.7 Pro XR/XRS System Hip Pack

The Pro XR and Pro XRS systems come equipped with an ergonomic hip pack carrying system, see Figure 4-18. The receiver, batteries and antenna are carried in the field using this hip pack/strapping system.

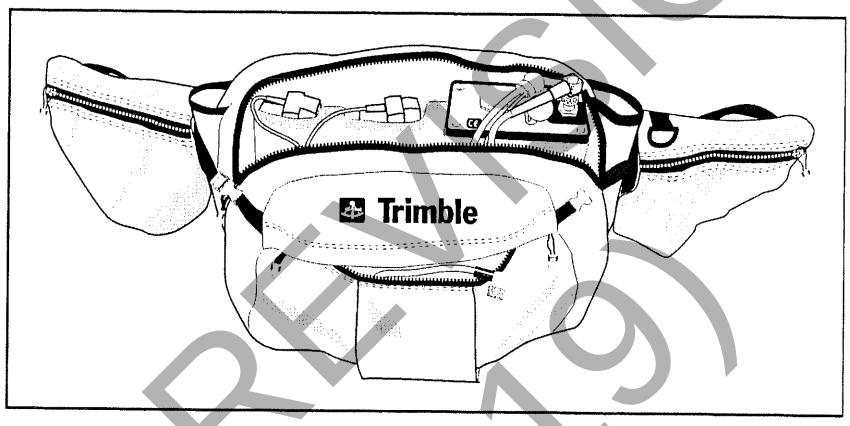


Figure 4-18 Pro XR/XRS System Hip Pack

4.7.1 Pro XR/XRS Hip Pack Contents

The Pro XR and Pro XRS systems are packed so that they are almost ready for use. The items not included in the hip pack are three 1-foot antenna poles, one 6-inch antenna pole and the data collector cable (P/N 30233-00 for TDC1, P/N 30234 for TDC2, or P/N 30236 for Field Computer/MC-V). These are located inside the shipping case.

The large interior of the hip pack contains: the Pro XR or Pro XRS receiver, two camcorder batteries, the power/data cable, and the camcorder power cable. All of these are set up inside the pack and ready for use. The exterior pocket of the hip pack contains a 3-meter antenna cable attached to the receiver and routed through a passage between the large interior pocket and exterior pocket. Both the data collector cable and antenna are routed out of the exterior pocket through the double zipper.

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To route the data collector cable:

1. Locate the data collector cable and connect it to the data power cable, DE-9 connector labeled TO RECEIVER.
2. Once connected, feed the coiled cable through the passage and into the exterior pocket.

4.7.2 Wearing and Adjusting the Hip Pack

The Pro XR/XRS hip pack, once adjusted to suit, is comfortable and easy to use. See Figure 4-19.

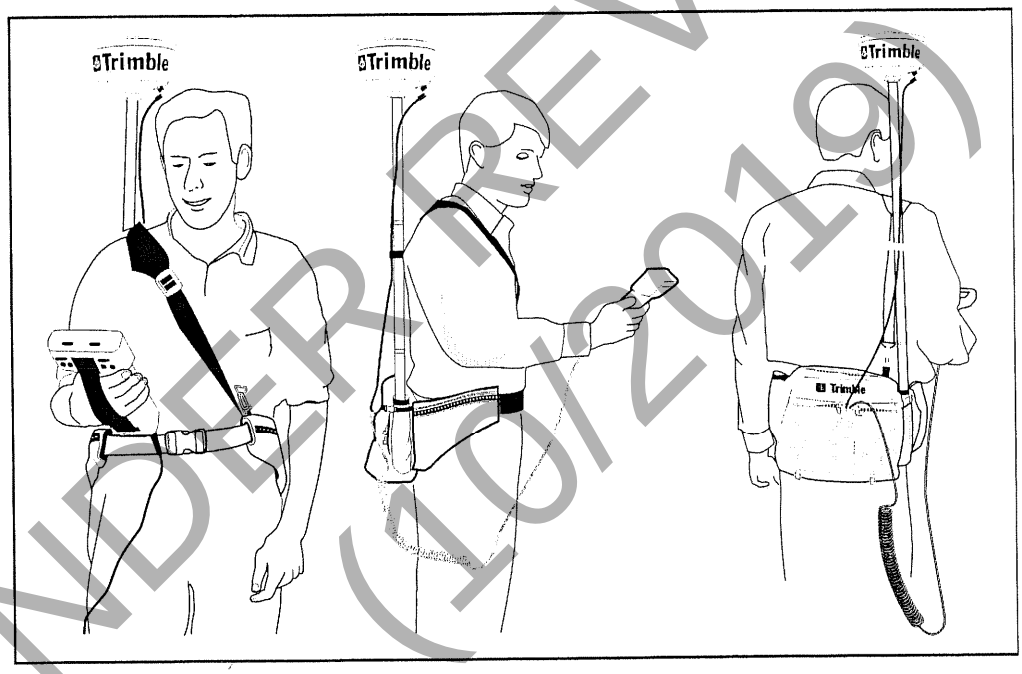

Figure 4-19 View of Hip Pack Setup

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Antenna

When wearing the hip pack, the antenna height should be 3-4 inches above your head. The number of antenna pole sections required varies depending on your height. For example, if you are 5'5" tall, you may need two 1-foot and one 6-inch pole sections. If you are 6'2" tall, you may need three 1-foot poles. Try out different pole heights.

To set up the antenna with the hip pack:

1. Attach the pole sections together and connect the antenna onto the top of the pole sections.
2. Attach the pole/antenna to the hip pack.
3. Choose the side of your body that you prefer the antenna to be on and slide the pole sections into the small sleeve on that side of the hip pack.

Hip Pack and Strap

To adjust the hip pack and strap:

1. Connect the strap to the rear D-ring on the side of the pack on which the antenna is located.
2. Connect the other end of the strap to the D-ring on the belt on the opposite of the bag.
3. Slide the antenna pole through the velcro connection on the strap.
4. Put the strap over your head and across your opposite shoulder.

   At this point, the shoulder strap should lead naturally from the antenna pole across your chest to the belt.
5. Buckle the hip pack around your waist/hip area so that the belt buckle is centered in the middle of your body.

   The pack should adjust to fit close to the small of your back.

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6. Adjust the front and back straps so the shoulder strap is situated squarely on your shoulder.

7. Put the pack on by slipping the strap over your head and across your body and then buckling the belt of the hip pack.

   The hip pack includes side compression straps that can be pulled towards you to hold the pack firmly and comfortably against your back.

Remove the hip pack/strap by unbuckling the belt and slipping the strap over your head.

The hip pack and strap can also double as a shoulder bag. Tuck the belt portion of the pack into the webbing material on the back of the pack and hook the strap on the large D-rings of the pack. The unit can now be carried on your shoulder instead of around your waist.

The pack has extra room in the interior and exterior pockets for additional items you may need in the field. The hip pack also includes straps on the bottom of the pack to secure an extra sweater or coat while in the field.

4.8 Optional Range Poles and Tripods

Range poles and tripods are very useful when collecting carrier phase data. The height of the antenna can be accurately measured, and the antenna can be held still easily, compared to an antenna mounted from the hip pack.

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APPENDIX B

FIELD DOCUMENTATION

Appendix B-1: Example of Field Sheet

Appendix B-2: Example of Chain of Custody Form (COC)

Appendix B-3: Example of Photo-Log

Appendix B-4: Example of Sample Labels

UNDER REVISION (10/2019)

UNDER REVISION (10/2019)

MONTEREY COUNTY WATER RESOURCES AGENCY - COASTAL GROUND WATER MONITORING PROGRAM **June 2007**

F CODE	SWID	STATUS	AQUIFER	USE	WELL NAME	METER No	PLANT No	SMPLE PT	VISIT DATE	APPT. DATE	SMPLE DATE	SMPLE TIME	SMPLER	REMARKS
886	14S/02E-24E01	ACTIVE	P400	AG	R5P1	4571R8	92205	DL						D'Arrigo Bros. R5P1. Tag #1164. Well is at corner of San Jon Rd an Hwy 183. Go twice then call Ed Mora 206-9164 or Jesse Aragon 90 9073. See photo
331	14S/02E-36E01	ACTIVE	P180	AG	BARDIN 12	0R1749	92428	faucet on booster						T & A. Bardin #12. Tag #1037. Well on Hitchcock Rd. off Blanco l office. Go twice, then call Dennis. See photo
673	14S/02E-13F01	ACTIVE	P180	AG	SAN JON B	R39873	95522	DL						Sea Mist. San Jon well B. Tag #1186. Call Chris. Three day notice. S photo
975	14S/02E-12N02	CSIP-SBI	P180	AG		92593R	91785	DL						Schneider. Domestic well. Tag #2960. Run for 30 min. to stabilize conductivity, EC = 2920 (Jul '04). Call Tim Schneider 449-0874. Tv week notice. Take EC meter, a bucket and last years results. See pho
1055	14S/02E-15A01	CSIP-SUPP	P400	AG	15A01	R69587	94951	DL			6/12/2007	9:05:00 AM		CSIP-SUPP. Well 15A1. PCA site #17. Go twice, then call Bill or Je See photo
1324	14S/02E-15C02	CSIP-SUPP	P400	AG	15C02	42542R		DL			6/12/2007	8:55:00 AM		CSIP-SUPP. Well 15C2. Tag #2838. PCA site #19. Go twice, then c Bill or Jesse. See photo
861	14S/02E-15P01	CSIP-SBA	P400	AG	MORO COJO#1 (YARD)	31535R	95209	DL						Higashi Farms. Moro Cojo #1. By house and shed. Call Peter. 2 day notice. See photo
279	14S/02E-16H01	CSIP-SBA	P400	AG	CONLEY	91R418		DL						Higashi Farms. Connely Ranch well. Tag #2856. Call Peter Odello 5 7926 or Charlie 578-7416. See photo. INACTIVE
2779	14S/02E-21E01	ABAN	P400	AG	MARINA-ARMSTRONG WELL	02384R		DL						Armstrong. Marina-Amstrong well. Tag #2962. SW of MRWPCA, sample from ball valve on pressure/flow control valve. Jack Armstro 455-1901 See photo. INACTIVE
766	14S/02E-22P02	ACTIVE	P180	AG	VIERRA#1	1843T	95485	truck fill valve						Crown Packing. Vierra #1. Tag #1095. Call Bill or Jose. Two day notice. See photo
859	14S/02E-15N01	CSIP-SBA	P400	AG	MORO COJO#2	3538R4	95037	DL						Higashi Farms. Moro Cojo #2. Big yellow truck-fill. Call Peter. 2 day notice. See photo
1282	14S/02E-24P02	ACTIVE	P400	AG	BORONDA SCHOOLHOUSE#1	93258T		DL						Crown Packing. Boronda Schoolhouse well. Tag #1099. Call Bill Sullivan 214-4650 or Jose Luis Lepe 970-6889. Well next to house/metal shed on McFadden Road, close to elem. school. Two day
22929	14S/02E-28H04	ACTIVE	PDEEP	AG	JACKS YARD									New Deep aquifer well located .54 mi W of Cooper Rd & .27 mi S of McFadden Rd on the Nissen Rch

ENVIRONMENTAL ANALYSIS REQUEST FORM

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY
1270 NATIVIDAD ROAD, SALINAS, CALIFORNIA 93906 Phone (831) 755-4516

Shaded areas for laboratory use only

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Chain of Custody:

Collected by (Print & sign):	Received by:	Date & Time:
Relinquished by:	Received for Laboratory:	Date & Time:

Client Name:	Report Attention:	
Address:	Copy to:	
City, State, Zip:	Phone:	Fax:

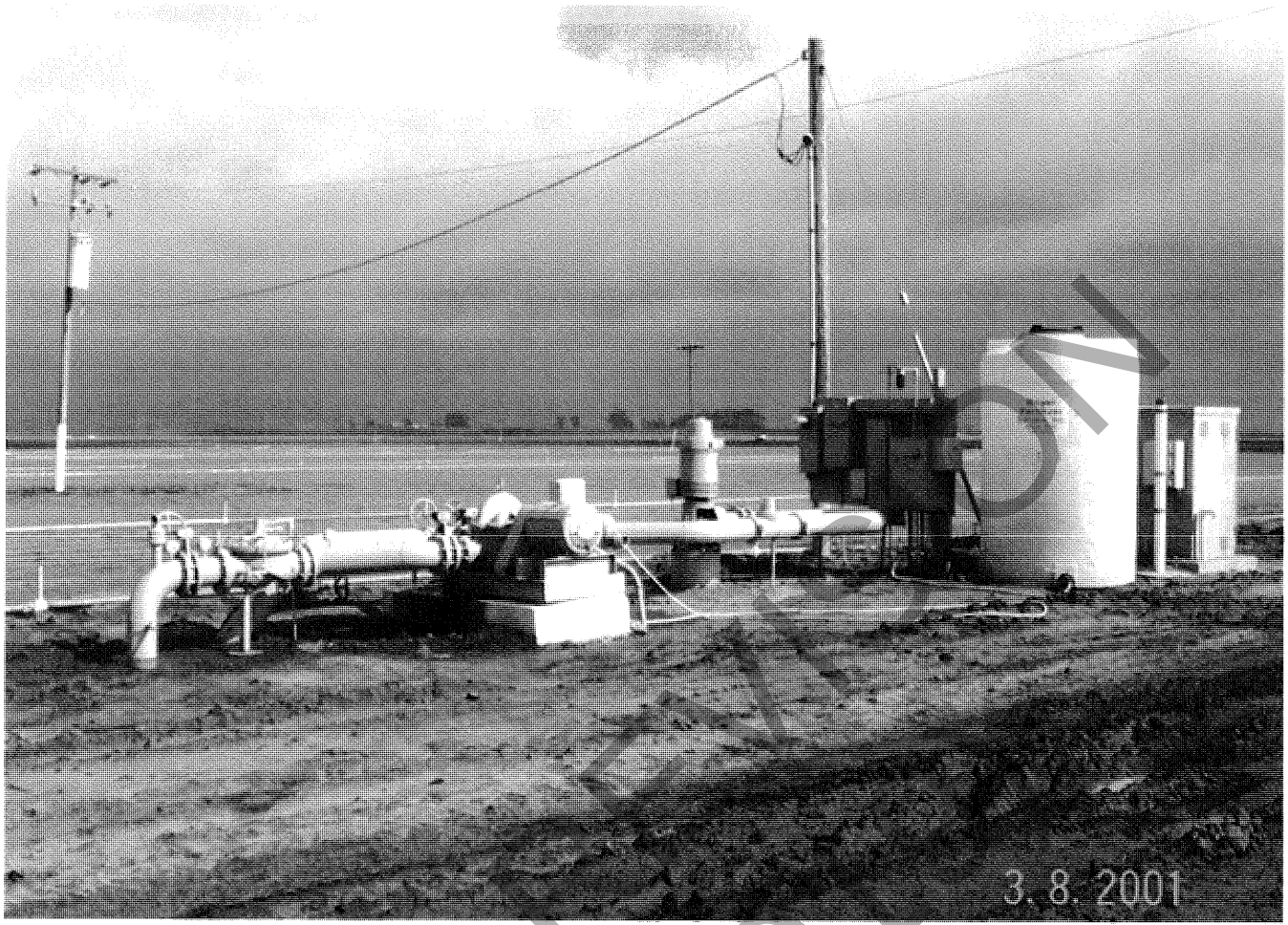
Laboratory Number	Sample ID or System #	Sample Site or Description	Collection Date & Time	Matrix[1] 1-Routine 2-Repeat 3-Replacement	No. of Containers	Coliform MMO..... ☐ Quanti..... ☐ Low-D..... ☐	Nitrate					

ANALYSES REQUESTED

[1] **D**=Drinking Water (Specify as routine, repeat or replacement) **W**=Wastewater (Specify as grab or composite) **O**=Other (identify)

[ ] Payment received with delivery Amount: _____
Check: _____ Initials: _____
Receipt #: _____ Date: _____

Sample comments (irregularities/preservation, billing information if different than reporting):



UNDER

15S/04E-07A01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-08M04

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-15D02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-17P02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-19H03

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-20B02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-26G01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-36H01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

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APPENDIX C

REVIEW CHECKLISTS

Appendix C-1: Field Activities Review Checklist

Appendix C-2: Laboratory Data Review Checklist

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Field Activities Review Checklist

Sampling Location(s): _____

Sampling Date: _____

Item	Yes	No	NA	Comment
All required information was entered into field sheets in ink, and sheets were signed and dated by the field sampler.				
Deviations from SOPs, along with any pertinent verbal approval authorizations and dates, were documented on the field sheets.				
Samples were collected at the correct sites.				
The correct number of samples for each type of analysis and the correct volume was collected (0.5 gal/ ~2L for complete mineral panel OR one pint/ ~0.5L for partial mineral panel).				
Acceptable sample containers, appropriate for the intended analysis, were used.				
Field blanks were collected, and at the correct frequency (one every 25 samples).				
Field duplicates were collected, and at the correct frequency (one every 25 samples).				
Samples were packed with double-bagged ice and transported at the proper temperature (4±2°C).				
Chain of custody (COC) documents were completed properly.				
Sample holding times were not exceeded during field operations. See Table 6 (QAPP).				

Reviewer's Name (print): _____

Reviewer's Signature: _____

Reviewer's Title: _____

Date of Review: _____

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Laboratory Data Review Checklist

Sampling Location(s): _____

Sampling Date: _____

Item	Yes	No	NA	Comment
Samples arrived at the laboratory at the proper temperature (4±2°C).				
All requested analyses were performed and were documented in the analytical report.				
Analyses were performed according to the methods specified in the approved QA Project Plan.				
Holding times for extraction and analysis were not exceeded. See Table 6 (QAPP).				
Field Blanks results were below MDLs and were analyzed at a frequency of one every 25 samples.				
Field Duplicate results were ≤ 25% RPD and were analyzed at a frequency of one every 25 samples.				
Method detection limits were included in the report.				
A narrative summarizing the analyses and describing any analysis problems was included in the data report.				
Data qualifiers and flags were explained in the data report.				
Initial calibration data were within laboratory SOP defined acceptance criteria ($r^2 \geq 0.995$) for all analyses.				
Method blanks were performed at 3 per analytical batch, and were below MDL.				
Laboratory Control Sample (LCS) data were included for all analyses for every analytical batch.				
Laboratory Control Sample Results were within 80-120% recovery.				

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Item	Yes	No	NA	Comment
Analytical Duplicate data were included for all analyses for every analytical batch.				
Analytical Duplicate results were < 25% RPD.				
Matrix spike data were included for all pertinent analyses for every analytical batch, and recoveries were within 75-125%.				
Matrix spike additions were at 3-10x the native.				
Matrix spike duplicates were ≤ 25% RPD.				
Continuing calibration data were within QAPP defined acceptance criteria (80-120% of initial slope) for all analyses.				

Reviewer's Name (print): _____

Reviewer's Signature: _____

Reviewer's Title: _____

Date of Review: _____

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APPENDIX D

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY

QA MANUAL AND STANDARD OPERATING PROCEDURES

Appendix D-1: QA Manual

Appendix D-2: Specific Conductance, based on SM 2510 B

Appendix D-3: pH, based on SM 4500-H B

Appendix D-4: Total Alkalinity, based on SM 2320 B

Appendix D-5: Metals, based on SM 3111 B

Appendix D-6: Anions, based on EPA 300.0

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ORGANIZATION AND RESPONSIBILITY

On October 11, 1988, the Monterey County Board of Supervisors, in Resolution No. 88-508, authorized the Director of the County Health Department and the General Manager of Monterey County Flood Control and Water Conservation District (MCFC&WCD) to consolidate laboratory services for their respective programs into one facility. A Laboratory Steering Committee, comprised of representatives from both agencies, was established for the purpose of providing the planning, operation, and future development of the Consolidated Environmental Laboratory.

Each year the Steering Committee develops a Memorandum of Agreement (MOA) that describes and confirms the services to be provided by the Health Department to the Water Resources Agency (formerly the Flood Control and Water Conservation District) and defines the responsibilities of each party. In addition to providing laboratory support for the Health Department and the Water Resources Agency, the Consolidated Chemistry Laboratory provides analytical services to the Monterey Regional Water Pollution Control District, the County Department of Public Works and numerous water supply systems and wastewater treatment facilities.

The Consolidated Environmental Laboratory is accredited by the State Department of to perform tests in the following fields: 1) microbiology of drinking water and waste water; 2) inorganic chemistry and physical properties of drinking water; 3) analysis of toxic chemical elements in drinking water; 4) wastewater inorganic chemistry, nutrients and demand; and 5) toxic chemical elements in wastewater. A list of analyses and methods used in the laboratory is included in Appendix A.

The following is a brief description of the staff support for the Consolidated Chemistry Laboratory:

1. Director - Plans, organizes and controls laboratory operations. Coordinates laboratory interactions with other programs in the Health Department. Administers laboratory budget, billing and purchasing. Develops laboratory policy and procedures and supervises staff.

2. Public Health Chemist – Principal analyst. Performs complex organic and inorganic chemical analysis, evaluates and implements laboratory methods, develops and maintains quality assurance, reports results and maintains records, purchases equipment and supplies, provides technical consultation to Environmental Health and Water Resources Agency. Trains analysts and documents competency

3. Water Quality Specialist- Performs broad range of professional scientific work related to water quality and environmental issues; is proficient in

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performing water quality analyses and managing the laboratory water quality database. Interpret and explain regulatory guidelines to clients.

4. Public Health Microbiologists - Assist Public Health Chemist in performing microbiological analyses and performing quality control.

5. Laboratory Assistant - Prepares culture media and reagents, assists in the processing of specimens, performs low to moderately complex environmental analyses and clinical analyses where interpretation or medical judgement is not required.

5. Laboratory Helper - Washes and sterilizes glassware and supplies. Prepares and labels mailing containers and specimen collection kits. Accession laboratory specimens. Sterilizes and disposes infectious waste. Maintains stockroom.

6. Typist-Clerk II - Enters clients and laboratory results into computer. Prints reports/forms. Prepares billing statements; receives and accounts for payments. Distributes laboratory results, and maintains laboratory files.

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QUALITY ASSURANCE OJECTIVES FOR MEASUREMENT OF DATA

Quality Assurance (QA) includes all aspects of laboratory operation that affect the accuracy and reliability of sample test results. In addition to quality control of the analytical test process, quality assurance practices include: 1) proper sample collection, receiving and holding, 2) proper maintenance of equipment, 3) accurate data reduction, validation and reporting; and, 4) periodic performance and systems audits.

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CUSTODY, HOLDING AND DISPOSAL OF SAMPLES

Quality assurance includes proper labeling of samples, proper completion of the chain of custody/analysis request form, proper collection, preservation and storage of samples, proper accessioning of samples, and proper disposal of the sample.

1) Sample Collection/Labeling. Sample collection is a coordinated effort between the client and the laboratory. The laboratory will provide clients with appropriate sample containers and sample collection/preservation instructions. The laboratory will also request duplicates and blanks according to client's sample plan requirements. All samples submitted for testing should be appropriately labeled. Sample containers provided by our laboratory have a suitable label which should be filled out at the time of sampling by the sample collector. The following information must be provided with all samples:

   a) Sample identification - submitters identification of sample (e.g. well number)

   b) Location - an address or brief description of the place the sample was taken.

   c) Time and date taken.

   d) Name of sample collector.

   e) Any preservatives

2) Chain of Custody/Analysis Request Form. A Chain of Custody/Analysis Request form should accompany all samples (see Appendix B). The Chain of Custody/Analysis Request form must include the following information: submitter name and address; sample identification; location of sample collection; date & time of collection; sample type; analysis to be performed; signatures of persons involved in the collection and chain of possession; and inclusive dates of possession.

3) Sample Receiving. Laboratory personnel receiving samples should assure that samples are properly collected, labeled, and the Custody/Analysis Request form has been completed:

   a) The laboratory assistant receiving the specimen must sign and date the Custody/Analysis Request form. Make sure that any special requests made by the client are recorded under the comments section of the form

   b) Assign each sample a unique laboratory identification number. Place

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preprinted lab number on analysis request form and sample container. When a sample is collected in multiple containers for different analyses, each container should receive the same laboratory number. (Exception: sample containers for analytes requiring a rapid turnaround time (e.g. coliforms) may receive separate number to expedite reporting).

c) Check that the samples meet the criteria described in Table 1006:I Summary of Special Sampling or Handling Requirements in 18th ed. of *Standard Methods for the Examination of Water and Wastewater* (Appendix C)

   i) Samples should be collected in a suitable container; samples collected in bottles of unknown origin or questionable cleanliness should be brought to the attention of the Water Quality Specialist or the Public Health Chemist.

   ii) Samples should be adequately labeled

   iii) Samples should be checked for proper preservative, holding time, and holding temperature.

   iv) Samples should be adequately sealed. Notify public health chemist if there is evidence of leakage. Verify that adequate sample volume exists to perform requested analysis.

d) NOTE: Samples that are not properly identified or are otherwise unsuitable for testing (e.g. improperly preserved or exceeding holding/ transport time) are recorded on the "Sample Invalidation Log" and the Water Quality Specialist or Public Health Chemist notifies the client. Samples not meeting collection/preservation criteria may be tested only if resampling is impossible; results from such samples must be qualified on the laboratory report by comments describing sample deficiency.

4) When the sample meets criteria for acceptance by the laboratory, required preservatives are added immediately and the sample is stored under conditions specified by the analytical method to be used. For samples requiring thermal preservation, a laboratory refrigerator and freezer is available. The temperature is maintained at 4 degrees and below -10°C respectively. Temperatures are monitored each day.

5) Chain of Custody/Analysis Request forms are given to the clerk to enter into a password protected computer laboratory information management system. Refer to "Water Sample Entry" in Clerical Manual for instructions on sample log-in.

6) Disposal of samples: Upon completion of all analyses, any remaining

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sample will be stored for at least one month prior to disposal. Chain-of-Custody form, worksheets and lab reports are retained for three years. NOTE: Longer retention of samples or data may be required when legal action is probable. The samples and any associated extracts or digests are disposed of following recommendations found in the book, *Prudent Practices for Disposal of Chemicals from Laboratories*, National Academy Press, Washington, D.C. 1983.

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CALIBRATION PROCEDURES AND FREQUENCY

Calibration is the process for determining the correctness of the assigned values of the physical standards used or the scales of the measuring instruments. Calibration accuracy is critically dependent on the reliability of the standards used for the required comparisons. Only the highest quality chemicals are used to provide necessary standard solutions, and due care is exercised in their preparation. The concentrations of the calibration standards bracket the expected concentration of the analyte in the samples. No data is reported beyond the range of calibration of the methodology. The calibration data, when plotted graphically, is referred to as a calibration curve. The calibration must be done under the same instrumental and chemical conditions as those that will exist during the measurement process. The frequency of calibration depends on the accuracy requirements of the investigation and the stability of the instrument used for the measurements:

At a minimum, three different dilutions of the standard will be measured when an analysis is initiated. Correlation coefficient must be > 0.995. Reportable analytical results are those within the range of the standard dilutions used. Do not report values above the highest standard. The lowest reportable value is the Method Detection Limit (MDL), providing that the lowest calibration standard is less than 10 times the MDL.

1) Atomic Absorption Spectrophotometers - Two approaches are used to calibrate atomic absorption spectrophotometers. These methods are direct comparison and standard additions.

   a) Direct comparison is the simple approach, and can be used with many instruments to give a direct readout of the concentration of an element in an unknown sample. To obtain good precision (e.g., 1-2% coefficient of variation), the absorbance levels measured must be about 0.1 to 0.6 units. Standard and sample solutions should be similar in bulk matrix constituents, particularly acid and salt content. Interference suppressants are used in all solutions when required. A number of standards (usually three to five in increasing concentration) as well as a blank, are prepared to cover the concentration range. A volume of type II reagent water with the same amounts of acids as the samples and standards) will be used for calibration blank. These solutions are run in absorbance to check linearity of the calibration curve.

   b) The method of standard additions is used when samples contains severe matrix interference. In this case it is possible to add small amounts of conventional standard solutions, in increasing amounts, to aliquots of each sample. A calibration graph can then be constructed. This method will often be used in work with the graphite furnace.

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2) UV-VIS Spectrophotometer - The calibration procedure for the UV-VIS spectrophotometer is similar to that for the A.A. spectrophotometers. An integration interval is not required as the signal is very stable. It is important to use blanks and allow at least 1/2 hour warm up time.

3) PH Meters - The proper calibration of pH meters requires the use of two buffer solutions and a thermometer. The two buffer solutions must cover the expected range of samples to be tested. A third buffer is used to confirm calibration. The pH meter should be calibrated each day. The temperature of the buffers must be entered into the meter.

4) Conductivity Meter - The conductivity meter does not require frequent calibration but should be checked against a known standard each day of use. Recalibrate when there is significant deviation with the value of the standard.

5) Ion Chromatograph- Calibration of the Ion Chromatograph is performed at least once each year and whenever: 1) Controls are out of range; or, 2) the column, suppressor or detector is changed.

6) Inductively Coupled Plasma/Mass Spectrometer – Calibration of the ICP-MS is performed every day of analysis and whenever controls are out of range. See the SOP for more information.

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ANALYTICAL PROCEDURES

The laboratory employs only methods approved by Environmental Laboratory Accreditation Program. Analysts must conduct sufficient preliminary tests using the methodology and typical samples to demonstrate competence in the use of the measurement procedure.

Each time an analytical procedure is performed controls are included and duplicate samples and known additions are tested to insure accuracy and precision. Results are not reported unless all controls are within acceptance limits referenced in Standard Methods 18th Edition, 1992.

To monitor reliability of analytical measurements, data is periodically obtained on detection limits, accuracy, precision and recovery.

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ACQUISITION, REDUCTION, VALIDATION OF REPORTING DATA

The analytical chemist is responsible for describing and reporting the data in an appropriate manner. In order to insure the accurate transcription, calculation and reporting of analytical data, the chemist will adhere to the following quality assurance procedures.

1) Use documented procedures and record all significant experimental details in such a way that the measurements could be reproduced by a competent analyst at a later date.

2) All measurements are made so that results are representative of the matrix (soil, water, etc.) and conditions being measured.

3) Report data only to the number of significant figures consistent with their limits of uncertainty.

4) Report data with the proper units of concentration. Units should be chosen which clearly indicate whether the concentration is in terms of weight by weight, weight by volume or volume by volume. Unless otherwise specified, all data are calculated and reported in standard units to allow comparison with data reported by other laboratories.

5) The analytical methodology used will be cited. The raw data for each sample, along with reagent blanks, control, and spiked samples will be suitably identified if included in the report. If average values are reported, an expression of the precision, including the number of measurements, must be included.

6) The report should include date and place of sampling, sampling point, the name of the sample collector, identification as to type of sample, date and time of submittal to the lab, date of analysis, name of the analyst, and the result. Any conditions which may effect the interpretation of the data should be noted in the report.. All results will be reviewed by a Water Quality Specialist or Public Health Chemist before a final report is released.

7) Laboratory records will be retained in a permanent file for three years.

8) Retain samples for one month after issuing final report and retain data and documentary evidence for three years.

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INTERNAL QUALITY CONTROL

Quality Control (QC) may be defined as those measures undertaken in the laboratory to maintain the analytical testing process within acceptable limits of accuracy and precision.
The Quality Control Program consists of the following elements: documentation of operator competence, recovery of known additions, analysis of externally supplied standards, analysis of method blanks, and testing of replicate samples:

1) Operator competence The principal analyst is responsible for: 1) developing a standardized training syllabus for the methods employed in the laboratory; 2) assuring that test personnel are adequately trained; 3) assessing the competency of test personnel, and 4) maintaining documentation of training and competency of all test personnel.

   a) Before test personnel are permitted to do reportable work , competency in performing the analysis is to be demonstrated. Commonly, the analyst performs replicate analysis under the supervision of the principal analyst. General limits for acceptable work are found in Standard Methods 18th Edition, 1992 in Table 1020 :I.

   b) After initial demonstration of competency, the principal analyst will assure test personnel maintain competency through testing internal or external proficiency test samples at least once each year.

2) With each batch of samples tested, controls will be tested to verify the accuracy of results as described below. Controls used with each method are outlined in Appendix D.

   a) Recovery of known additions as part of all regular analytical protocols except titrimetric and gravimetric methods. Use known additions to verify the absence of matrix effects. Spiked samples shall be analyzed with a minimum frequency of ten percent of the samples per matrix per batch of samples. Spike recovery must be between 80-120% for potable water (75-125% for waste water). When a spike sample fails to meet this criteria, retest all samples following the last acceptable spike sample. Spike recovery calculated as % of the known addition recovered.

   b) Analyze control standards with a minimum frequency of ten percent of the samples per matrix, per batch of samples. If there are less than 10 samples in a batch, at least one per matrix per batch must be analyzed. The concentration of the sample shall be within the working range of the method. Sources of these samples include but are not limited to: performance evaluation samples from the EPA, commercially available standards, or standards prepared in-house but from sources different

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from calibration standard. Control standards must be within the published acceptance range (for external controls). If the control standard does not have a published acceptance range, recovery of the control should be within 10% of the known value. When a control standard fails to meet this criteria, retest all samples following the last acceptable control.

c) Method blanks will be analyzed with each batch of samples. The use of method blanks provides a measurement of laboratory contamination. Blanks cannot exceed the minimum detection level. See Appendix A.

d) Replicate samples will be analyzed with a minimum frequency of ten percent of samples per matrix, per batch of samples for drinking water. For wastewater the requirement is 5%. If there are less than ten samples per batch, at least one sample per matrix per batch must be analyzed. If the analyte is not detected, replicate matrix spike samples will be analyzed. The percent difference between replicate samples must be within 20% for potable water (25% for wastewater). When a replicate sample fails to meet this criteria, retest all samples following the last acceptable replicates. Duplicate % difference calculated as the difference as a percent of the mean. [100(X1-X2)/avg].

e) In addition to the control standards tested with each run, an external reference standard for each analyte will be tested at least once each quarter.

All of the quality assurance control procedures will be followed in the laboratory. All documentation for these checks should be available for inspection by laboratory management.

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PREVENTIVE MAINTENANCE

As part of the QA plan, the laboratory has a comprehensive preventive maintenance program. Balances, spectrophotometers, and other instruments undergo routine maintenance and accuracy checks by a manufacturer's representative or by laboratory personnel as described below. All preventive maintenance performed in-house is documented on preventive maintenance forms. Instrument s which undergo routine professional maintenance have labels affixed to indicate date of last servicing. Manufacturer's instructions and service manuals are readily accessible.

Adequate spare parts are kept on hand to perform routine maintenance and minimize downtime. The spectrophotometers have maintenance contracts that provide for immediate servicing in the event of malfunction. Equipment records documenting preventive maintenance and emergency servicing/repairs are kept for a minimum of three years.

1) Thermometer/temperature-reading instruments: Accuracy of thermometers or recording instruments are checked annually against a certified National Bureau of Standards (NBS) thermometer or one traceable to NBS and conforming to NBS specifications. All thermometers a relabeled with date calibrated and correction factor.

2) Balance: Balance accuracy is verified each week using ASTM type 1 reference weights. Accuracy checks are documented on preventive maintenance chart. Balances are serviced and certified annually through a maintenance contract. Type 1 weights are re-certified at least every five years.

3) pH meter: pH meters are standardized with at least two NIST traceable standard buffers (pH 4.0, 7.0, or 10.0) and compensated for temperature before each series of tests. A third buffer is used to confirm calibration. Date buffer solutions when opened and discard buffer after expiration date on bottle. Buffers prepared from powders are replaced after four weeks.

4) Water deionization unit: Conductivity of the RO and Nanopure water is checked each month. A heterotrophic plate count on Nanopure water is also performed monthly. Filters are changed as indicated by conductivity readings and heterotrophic plate count. Records are maintained on preventive maintenance chart. Water is tested annually for bacteriologic quality and heavy metals.

5) Autoclave: Autoclave charts are used to document date, time, temperature and contents of each load. Chem-di indicators and heat sensitive tape are used with each load to identify materials that have been autoclaved; results are recorded on autoclave chart. Autoclave performance is

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checked each month with biological indicator (e.g. spore suspension). Autoclaves are serviced quarterly under maintenance contract. The accuracy of autoclave recording thermometer is checked annually. The autoclave operating temperature is monitored on a weekly basis.

6) Refrigerator: Temperatures are recorded daily and units defrosted and cleaned as needed. All media and reagents stored in the refrigerator are labeled.

7) Freezer: Temperatures are recorded daily. Identify and date materials stored. Defrost and clean semiannually; discard outdated materials.

8) Ultraviolet sterilization lamps: Unit is cleaned monthly by wiping lamps with a soft cloth moistened with ethanol. Test lamps quarterly with UV light meter and replace if they emit less than 70 % of initial output or if agar spread plates containing 200 to 250 microorganisms, exposed to the light for 2 minutes, do not show a count reduction of 99%.

9) Water bath: Fecal coliform water bath is checked twice daily. All other water baths are checked each day of use.

10) Incubator: Check and record temperature twice daily (morning and afternoon) on the shelf areas in use. Locate incubator where room temperature is in the range of 16 to 27O C.

11) Fume hoods/Biological Safety Cabinets: Fume hoods are checked once each month using a velometer; readings are recorded on preventive maintenance chart. Hoods and safety cabinets are certified annually through service contract.

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PERFORMANCE AND SYSTEMS AUDITS

Corrective action is required when data is outside of predetermined limits for acceptability. The corrective actions can be triggered by the following quality assessment activities: Control Chart analysis; proficiency evaluation testing; and QA audits.

1) CONTROL CHART ANALYSIS:

The laboratory's quality assessment techniques will be used to maintain the precision and accuracy of all laboratory analyses within a state of statistical control. Precision and accuracy measurements are the best way to assess analytical performance. Precision is the degree of reproducibility of a particular analytical procedure. Accuracy is a measure of the agreement between an experimental determination and the true value.

a) PRECISION - Assess precision by replicate analysis, by repeated analysis of a stable standard, or by analysis of known additions to samples. Precision is specified by the standard deviation of the results. The formula for determining standard deviation (SD) is:

$$SD = \sqrt{\Sigma (X1-X)^2/(N-1)}$$

X1 is the value of the individual measurements; X is the mean of all measurements for a given sample and N is the number of measurements.

The purpose of determining precision is to establish the typical variance of the method in the absence of any matrix influence. In the course of determining precision, there are two cases that indicate there is a problem with the precision data:

i) The measured values show wide variation from one to another for a given day.

ii) The measured values show little variance from one to another for a given day, but the mean and standard deviation show wide variation from one day to another.

If either of the above occurs, factors such as sample homogeneity, instrument calibration, or analyst error should be checked, documented, and corrected. The precision measurements should then be repeated.

b) ACCURACY - The best method to determine accuracy is to spike an alequot of reagent water with a known amount of the constituent being measured and analyze the sample. The amount spiked should be at least five to ten times greater than the analytical detection limit.

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To evaluate the data accuracy, the percent recovery of the spike must be determined. The formula for determining percent recovery is:

$$\% \text{ recovery} = [100(S - S1) \div S2]$$

Where S is the concentration of the spiked sample; S1 is the concentration of the unspiked sample; S2 is the concentration of the spike added to the sample.

If the percent recovery deviates significantly from 100% and the method has not demonstrated significant bias, the problem must be detected and corrected prior to continuing the analysis. Sources of this problem include incorrect standard or spike solution concentration or a problem in the procedural detection system.

Precision, accuracy, and detection limits for all methods used in the laboratory is comparable to values referenced in Standard Methods 18th Edition, 1992 and EPA Methods for Chemical Analysis of Water and Wastes, March 1983.

2) PERFORMANCE EVALUATION SAMPLES: The laboratory director is responsible for enrolling the laboratory in ELAP approved proficiency testing program(s) and assuring that proficiency testing is performed for all regulated tests. The principal analyst (Public Health Chemist) will conduct and document internal proficiency testing at least once a year for tests where proficiency testing is not available. Proficiency test samples are treated in the same manner as routine samples (ie. tested the same number of times, tested using personnel who routinely perform testing, tested using routine methods and tested during patient testing).

3) QUALITY ASSURANCE AUDIT: The quality assurance program will be audited quarterly and any deviations from the program will signal corrective action to be taken. Quality assurance audit will be documented in a written report. The audit will include the following aspect:

   a) Competency of test personnel must be evaluated annually and be documented

   b) Evidence of the systematic use of control samples, replicate measurements and reference materials all in conjunction with control charts.

   c) Proper labeling of reagents and samples.

   d) Use of approved methods.

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e) Results on blind samples.

f) Acceptable safety equipment and procedures.

g) Quality assurance reports generated on a regular basis.

h) Documentation on equipment performance and maintenance.

i) Training records.

j) All relevant files accessible and organized.

k) Laboratory personnel following good laboratory practices.

l) Laboratory personnel following good measurement practices

The Public Health Chemist will be responsible for initiating and documenting any corrective action necessary. Corrective action will be documented on the appropriate control chart, performance evaluation report, or QA audit report. No data shall be reported until the cause of the problem is located and corrected or the laboratory demonstrates the cause was a random event and no longer affects data. Although the elimination of events requiring corrective action may not be achieved, a reduction in the repetition of these events is the objective of this program.

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REFERENCES FOR QUALITY ASSURANCE DOCUMENT

1) Standard Method for the Examination of Water and Wastewater, 18th edition, 1992.

2) Handbook for Analytical Quality Control in Water and Wastewater Laboratories. EPA-600/4-79-019, March 1979, USEPA.

3) Manuals for the Certification of Laboratories Analyzing Drinking Water Criteria and Procedures/Quality Assurance. EPA QAMS-005/80, Interim Guidelines, EPA-570/9-82-009, USEPA.

4) Methods for Chemical Analysis for Water and Waste. EPA-600/4-79-020, March 1983.

UNDER REVISION
(10/2019)

Written by: Gerry Guibert & David Holland

Date: May 1993

Revised: January 1999
Revised: September 21, 2004

Approved by: _____

(Laboratory Director's Signature)

Appendix A

Monterey County
Consolidated Chemistry Laboratory

ANALYTICAL METHODS FOR WATER ANALYSIS

PARAMETER	HOLD TIMES	METHOD REFERENCE	MDL	UNITS
Free Chlorine	.25 h; ASAP	SM 4500-Cl G	0.02	mg/L
Total Chlorine	.25 h; ASAP	SM 4500-Cl G	0.05	mg/L
Enterococcus	8 h	IDEXX	1/100 ml	
Heterotrophic Plate Count	8 h	SM 9215 B	1	CFU
E. coli – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	2/100 ml	
Fecal Coliform – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	1/100 ml	
Total Coliform – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	2/100 ml	
Total Coliform – Quantitray	6 h waste 8 h source 30 h potable	SM 9223	1/100 ml	
E. coli – Presence/Absence	30 h potable	SM 9223	1/100 ml	
Total Coliform – P/A	30 h potable	SM 9223	1/100 ml	
pH	.25 h; ASAP	SM4500H B		pH units
Bicarbonate	ASAP (with pH)	SM 2320 B	10	mg/L
Calcium Carbonate	ASAP (with pH)	SM 2320 B	1	mg/L
Carbonate	ASAP (with pH)	SM 2320 B	1	mg/L
Solids	24 h	SM 2540 F	0.1	mL/L
Color Determination	48 h	SM 2120 B	2	CU
Odor	NS; 48 h (rec 6h)	SM 2150 B	1	TON
Turbidity	48 h	SM 2130 B	0.05	NTU
Nitrate	48 h	EPA 300.0	1	mg/L
Nitrite as (N)	48 h	SM 4500 NO2-B	10	ug/L
Total Dissolved Solids	7 d	SM 2540 C	5	mg/L
Total Suspended Solids	7 d	SM 2540 D	5	mg/L
Alkalinity	14 d	SM 2320 B	1.0	mg/L, CaCO3
Bromide	28 d	EPA 300.0	1	mg/L
Chloride	28 d	EPA 300.0	1	mg/L
Fluoride	28 d	EPA 300.0	0.02	mg/L
Sulfate	28 d	EPA 300.0	1	mg/L
Conductivity	28 d	SM 2510 B	1	umhos at 25C
Ammonia (N)	28 d	SM 4500 NH3 F	0.05	mg/L
Orthophosphate	NS; 28 d	SM 4500 P E	0.03	mg/L
Total Phosphorus	28 d	SM 4500 P E	0.03	mg/L

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PARAMETER	HOLD TIMES	METHOD REFERENCE	MDL	UNITS
Aluminum	6 months	EPA 200.8	5	ug/L
Antimony	6 months	EPA 200.8	0.5	ug/L
Arsenic	6 months	EPA 200.8	1	ug/L
Barium	6 months	EPA 200.8	0.5	ug/L
Beryllium	6 months	EPA 200.8	0.5	ug/L
Cadmium	6 months	EPA 200.8	0.5	ug/L
Chromium	6 months	EPA 200.8	5	ug/L
Copper	6 months	EPA 200.8	0.5	ug/L
Iron	6 months	SM 3111B	100	ug/L
Lead	6 months	EPA 200.8	0.5	ug/L
Manganese	6 months	EPA 200.8	0.5	ug/L
Mercury	6 months	EPA 200.8	0.25	ug/L
Nickel	6 months	EPA 200.8	0.5	ug/L
Selenium	6 months	EPA 200.8	5	ug/L
Silver	6 months	EPA 200.8	5	ug/L
Thallium	6 months	EPA 200.8	0.5	ug/L
Zinc	6 months	EPA 200.8	5	ug/L
Calcium	6 months	SM 3111B	1.0	mg/L
Magnesium	6 months	SM 3111B	0.1	mg/L
Potassium	6 months	SM 3111B	0.1	mg/L
Sodium	6 months	SM 3111B	0.1	mg/L
Hardness as CaCO3	6 months	SM 2340 B	1.0	mg/L
Boron	6 months	SM 4500 B B	0.1	mg/L

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Appendix B

ENVIRONMENTAL ANALYSIS REQUEST FORM

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY
1270 NATIVIDAD ROAD, SALINAS, CALIFORNIA 93906 Phone (831) 755-4516

Shaded areas for laboratory use only

UNDER REVISION (10/2019)

Chain of Custody:

Collected by (Print & sign):	Received by:	Date & Time:
Relinquished by:	Received for Laboratory:	Date & Time:

Client Name:	Report Attention:	
Address:	Copy to:	
City, State, Zip:	Phone:	Fax:

Laboratory Number	Sample ID or System #	Sample Site or Description	Collection Date & Time	Matrix(1) 1-Routine 2-Repeat 3-Replacement	No. of Containers	Coliform	MMO..... ☐ Quanti..... ☐ Low-D..... ☐	Nitrate					

ANALYSES REQUESTED

(1) **D**=Drinking Water (Specify as routine, repeat or replacement) **W**=Wastewater (Specify as grab or composite) **O**=Other (identify)

[ ] Payment received with delivery Amount: _____

Check: _____ Initials: _____

Receipt #: _____ Date: _____

Sample comments (irregularities/preservation, billing information if different than reporting):

SPECIFIC CONDUCTANCE
EPA 120.1/SM 2510 B
umhos at 25°C

Scope and Application:
This method is applicable to drinking, surface and saline waters, domestic and industrial wastes and acid rain.

Summary of Method:
The specific conductance of a sample is measured by use of a self-contained conductivity meter, the YSI Model 32. The conductivity meter is used in the temperature compensated mode.

Sample Criteria & Acceptability:
A minimum of 100 ml sample should be submitted in a clean container provided by the laboratory. Samples can be stored for up to 28 days at 4oC. The samples must be brought to room temperature before testing. If the sample does not meet the above criteria, document it on the worksheet but perform the test.

Reagents:
0.02 Molar Standard Potassium Chloride Solution:

1. Dry 0.85 g of Reagent Grade Potassium Chloride (KCl) for 4 hours at 105°C. Use immediately or store in a desiccator until use.
2. Dissolve 0.7456g of pre-dried potassium chloride in a 1 liter Class A volumetric flask using deionized water.
3. Label the flask with Potassium Standard Solution, 0.7456 g KCl/L, date made, outdate of 3 months, and initial.
4. Alternately, order two 500 ml containers of the Traceable Conductivity Calibration Standard near the 1414 micromho/cm range; from Fisher Scientific, Cat No. 09-328-11.

Control

1. Check deionized water. It should read less than 1 umho. If the reading is higher, clean cell and repeat reading of deionized water. If reading is still high, notify the Chemist.
2. Use current Quality Control sample with each run. The control must be in range before proceeding with specimens. The 0.01 M KCl can be used as control.

Conductance Meter Maintenance:

1. Store cell in deionized water. If the cell has been stored dry, soak in deionized water for 24 hours.
2. Check the platinum black coating on the electrode. If the coating appears thin or if it is flaking off the electrode, the cell should be cleaned and the electrodes replatinized. See "Instruction Manual YSI Model 32 Conductance Meter" pages 11 and 12 for instructions.
3. The electrode should be cleaned and replatinized every four months. Record the preventative maintenance on the "PM Worksheet".

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Conductance Meter Calibration Check:

Instrument must be standardized with KCl solution before daily use.

1. Pour 50 ml of the standard potassium chloride solution into a 250 ml beaker. Alternately, immerse the conductivity cell and thermometer in the Rinse Bottle, then transfer to the Read Bottle for actual reading
2. Immerse conductivity cell in sample. The electrodes must be submerged and the electrode chamber must be free of trapped air. Tap the cell to remove any bubbles, and dip it two or three times to assure proper wetting.
3. Rotate the Range Switch to the lowest range position that gives a reading (within range) on the display. An over-range value is indicated by a "1" followed by blanks. An under-range value is indicated by a reading followed by a small letter "u". Readings may be in error when operating in the under range conditions. On the 0.1 – 2 micromho range; allow extra time to stabilize.
4. The conductance value of the solution is displayed on the meter. The units in which it is to be read are determined by the Range Switch, either in mU or in uU (or milli and micro siemens).

   2 uU, 20 uU, 200 uU reading = final result
   2 mU, 20 mU, 200 mU readings x 1000 = final result

5. Use the table below to check accuracy of cell constant:

Conductivity of 0.01 M KCl	
Temperature in Centigrade	Micro-omhos/cm
21	1305
22	1332
23	1359
24	1386
25	1413
26	1441
27	1468
28	1496

6. If the standard is within range, rinse the cell three times with deionized water, and start testing unknowns as described in steps 2-4.

Reporting:

Report results to three significant figures. Report in units of micromhos per centimeter at 25 ^{o}C

References:

1. Instruction Manual YSI Model 32 Conductance Meter", Item 060818, PN A32018 R, October 88 EP
2. Methods for Chemical Analysis of Water and Wastes", EPA- 600: 4-79-020, March 1983, pages 120.1-1 to 120.1-3.
3. "Standard Methods for the Examination of Water and Wastewater", 18th Edition, 1992.

Written by: David Perez, Date: February 1993
Revised: January 12, 2007

Approved by:_____
Chemist

UNDER REVISION (10/2019)

pH
SM 4500-H B
Electrometric

UNDER REVISION (10/2019)

Scope and Application
Application to drinking, surface, ground and saline waters as well as acid rain, and wastewater (domestic and industrial.

Principle of Operation
pH is defined as the negative logarithm of the hydrogen ion concentration in moles per liter. The pH scale goes from zero to fourteen with a value of seven units to be considered neutral. Values below seven are acid; values above seven are basic. It is important to note that a one-unit change in pH represents a ten-fold change in the concentration of the hydrogen ion.

pH has a great impact on almost all biological and chemical processes used for water and wastewater treatment, and proper measurement of this value is critical. pH is measured using a pH meter consisting of a potentiometer, glass pH electrode, reference electrode and temperature compensating device. When calibrating the instrument, use two buffers that bracket the expected pH value for greatest accuracy.

Specimen collection and Handling
Collect sample in plastic or glass container. Test sample immediately upon receiving and/or within two hours after collection.

Instrument Calibration:
Two buffer calibration:

1. Fill a 50 ml beaker with up to 30 ml of pH 7 buffer. Add a stir bar and set the knob on the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 7 buffer; make sure that the reference electrode is filled with KCl and is open. Allow the electrode to equilibrate for 5 minutes.

2. Release Standby button and press the pH button. Measure the temperature of the buffer solution and set the temperature control. Turn the large slope knob to 100 and the inner know fully clockwise.

3. Adjust the calibration control until the readout displays 7.00. Press the mv button and record the mv reading on the worksheet. Remove electrodes from the buffer and rinse with deionized water.

4. Fill a 50 ml beaker with up to 30 ml of pH 4 buffer. Add a stir bar and set the knob n the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 4 buffer and allow the electrode to equilibrate for 5 minutes. Press the pH button.

5. Adjust the slope knob until the readout displays 4.00. Press the mv button and record the mv reading on the worksheet. Remove electrodes from the buffer and rinse with deionized water.

6. Fill a 50 ml beaker with up to 30 ml of pH 6.86 buffer. Add a stir bar and set the knob n the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 6.86 buffer and allow the electrode to equilibrate for 5 minutes. Press the pH button and record the result on the worksheet and quality control graph. PH should be 6.86 ± 0.1; notify chemist if out of range.

7. Rinse the electrodes with deionized water.

8. Record mv readings of calibration buffers. Calculate change in millivolts and divide by 3. The result should be 58 ± 2 mv.

9. If the slope is within limits, begin testing unknowns. If the slope is out of range, re-calibrate the pH meter. If the second calibration slope is out of range, notify the chemist.

Controls

1. Run every tenth specimen in duplicate. The duplicates should be within 20% of each other.

2. Check the 6.86 control buffer after every tenth specimen. Record the results on the worksheet and quality control chart.

Procedure

Once the pH meter has been calibrated, the unknown samples can be tested.

1. Pour 30 ml of unknown (or 50 ml of unknown if also testing for alkalinity) into a 150 ml beaker containing a small stir bar. Start the stirrer. Keep the automatic stirrer at a constant moderate rate (The speed is marked on the dial by a pen marking).
2. Allow the display to stabilize, and record the results on the worksheet.
3. Rinse the electrode with deionized water between specimens. Blot dry with a 'kimwipe'. Do not rub the electrode; the static electricity can alter readings.

Reporting

Report the result to the nearest tenth (0.1).

References:

1. "Method for Chemical analysis of Water and Wastes", EPA 600/4-79-020, Revised March 1983.
2. Standard Methods for the Examination of Water and Wastewater 18th edition 1992

UNDER REVISION
(10/2019)

Written by: David Perez
Date: December 1994

Approved by: _____
Chemist

Total Alkalinity
SM 2320 B
Titration

Principle
Total alkalinity is defined as the acid-neutralizing capability of water. It is reported as due to bicarbonate (HCO3), carbonate (CO3), and hydroxide (OH). Unaltered sample is titrated potentiometrically to pH 8.3 endpoint for "carbonate" alkalinity and 4.5 endpoint for "bicarbonate" alkalinity.
Note: Samples with a pH less than 8.3 (i.e. most drinking water samples) are reported as having non-detectable hydroxide and carbonate alkalinity; for these samples total alkalinity is due entirely to the bicarbonate content of the water. Bicarbonate alkalinity (as HCO3) can be calculated from total alkalinity (as CaCO3) by multiplying by a factor of 1.22.
Applicable to drinking and surface waters, domestic and industrial wastes, and saline waters.

Sample Criteria & Acceptability
Samples should be submitted in clean containers provided by the laboratory. A minimum of 100ml of sample should be submitted for testing. Samples, which cannot be tested within 24 hours of collection, should be stored at 4°C and tested within 14 days. If any sample does not meet the above criteria, document it on the worksheet but perform the test.

Equipment
1. pH meter that can read to 0.05 pH units.
2. Two 1,000 ml Class A volumetric flasks.
3. Magnetic stirrer and magnetic stir bars.
4. Two 100 mL beakers.
5. One 250 mL flask
6. One 50 mL graduated cylinder

Reagents
The day before preparing standardize sulfuric acid, dry 0.1 g of Tris Buffer for at least 3 hours at 103 C (overnight is acceptable). After drying, immediately weigh out the Tris buffer. If that is not possible, store the reagent in the desiccators until used.
1. Standardized 0.02 N H_2SO_4 (sulfuric acid) + 0.004 units:

   The concentrated H_2SO_4 and stock 1.0 N H2SO4 may be found in acid cabinet below hood.
   a. Prepare a 1.0 N H H_2SO_4 Stock Solution: Fill a 1,000 ml Class A volumetric flask three quarters full with deionized water. Carefully add 28.0 mL of concentrated H_2SO_4 using a 25 mL and 3 mL Class A volumetric pipette. Fill to the mark with deionized water and mix. Transfer to plastic bottle and label as 1.0 N H_2SO_4 Stock Solution, date made, outdate of 1 year, and initial. Cap tightly.

   b. Prepare a standardized 0.02 N H_2SO_4.
      1. Fill a 1,000 mL Class A volumetric flask three quarters full with deionized water. Carefully add 20.0 mL of the Stock H_2SO_4 using a 20 mL Class A pipette. Fill to mark and mix thoroughly.
      2. Weigh out between 0.0700 to 0.0800 g of Tris buffer using the analytical balance. Record the weight of the Tris Buffer to four places in the "Standard & Reagent Preparation" notebook. Add the buffer to 250 mL flask containing 25 mL of deionized water and stir bar; mix.

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3. Add 3 drops of Hach Brom Cresol Green-Methyl Red indicator solution (Hach cat. number 451) to the Tris buffer solution.
4. Fill the titrating buret with the 0.02 N H_2SO_4 solution. Titrate the solution until a stable pink color is reached. Record the volume of reagent used.
5. Calculations:
   Normality of H_2SO_4 = Wt of Tris Buffer (g) ÷ (0.121137 g/meq Tris X mL of 0.02 N H_2SO_4 used)
   Example:
   0.0879 g Tris Buffer ÷ (0.121137 g/meq Tris X 35.7 ml H_2SO_4) = 0.0203 N H H_2SO_4
6. Transfer the 0.02 N H_2SO_4 to a one liter plastic bottle. Record the normality on the bottle, date made, outdate of 3 months, and initial. Store at room temperature.

2. Alternatively, order 0.02 N H_2SO_4, already prepared and standardized from a vendor such as Fisher Scientific. Record lot on QC worksheet.

Controls

1. Run deionized water as blank. Value of blank should be less than 2 mg/L of calcium carbonate (approximately 0.1 mL of H_2SO_4).

2. Use one quality control standard. This is a solution of sodium bicarbonate (100 mg/l). Run once with each set of samples and record results on control chart. Consult chemist if out of control situation exists.

3. Run every 10th specimen in duplicate. Calculate the relative standard deviation (RSD) of the replicates using the following formula: RSD=SD ÷ mean x 100. The RSD should be less than 10% If the replicates are outside of this range, repeat the specimen a third time. Check with the chemist for instructions.

4. Each quarter an external reference sample is to be analyzed. In the case of results exceeding acceptance values, document corrective action. Place any corrective action records in proficiency file

Procedure:

If applicable, standardize the pH meter each day of use (see supplemental procedure). Record slope with offset on worksheet.

Run the blank and control first. If the control is within range (range found in the "QC Inorganic True Value" binder), run the samples. Repeat the control if it is out of range. Notify the chemist if the control is out of range a second time.

1. Add 50 mL of control or sample to a 100 ml beaker containing a magnetic stir bar. Set magnetic stirrer at low speed.

2. Carefully lower pH probe into the solution. **If the pH is above 8.3 consult principal analyst!**

3. Fill the titrating buret to the zero mark with the standardized H2SO4. Carefully add the H2SO4 to the sample until a pH of 4.5 ± 0.05 is reached.

4. Record the volume of H_2SO_4 added to the sample, to the nearest tenth, on the chemistry worksheet.

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5. Rinse the pH electrode with deionized water. Measure out the next sample, refill the buret, and titrate the next specimen.

Calculations:

Use the following formula to calculate the alkalinity as mg/L of calcium carbonate.

Exception: For alkalinity below 20 mg/L use low alkalinity calculation procedure (refer to SM2320B part 5)

mg/L = (mL of H_2SO_4 – 0.1) X normality of H_2SO_4 X (50,000 ÷ ml of sample)

Example (for 50 ml sample):

(28.6 mL – 0.1) X 0.02 X (50,000÷50ml) = 570 mg/L of Calcium Carbonate

or

(28.6 ml – 0.1 ml) X (20) = 570 mg/L of Calcium Carbonate

Reporting

Report in **whole** numbers; round off to 3 significant figures. Examples:
2,902.5 = 2,900; 1,125.9 = 1,130; 23.65 = 24

References

Standard Methods for the Examination of Water and Wastewater 18th edition 1992

UNDER REVISION (10/2019)

Written by: David Perez
Date: January 1993
Revised by: G. R. Guibert
Date: August, 1998

Approved by: _____
Principal Analyst

Varian Flame AA Procedure
SM 3111B
For Ca, Mg, Na, K and Fe

Principle:
In flame atomic absorption spectrometry, a sample is aspirated into a flame and atomized. A light beam is directed through the flame, into a monochrometer and into a detector that measures the amount of light absorbed. Because each metal has its own characteristic absorption wavelength, a source lamp composed of that element is used. The amount of energy absorbed in the flame is proportional to the concentration of the element in the sample.

Sample Collection/Handling:
Use metal free collection bottle to collect sample. Collect one liter of sample. Smaller volumes (not less than 200 ml) can be used if necessary. On collection, acidify samples to pH <2 with 1:1 nitric acid, usually 3ml per liter. If samples are not acidified at time of collection, add acid upon receipt in lab and hold for minimum of 16 hours before analysis.[40 CFR 141.23(K)].

Sample Preparation:
Samples containing particulate or organic material require pretreatment before analysis. Samples with a turbidity <1 NTU, no odor and single phase may be analyzed directly. Digest all other samples before determining total metals.

Digestion Procedure for total metals:
Drinking water samples with turbidity >1 NTU can be analyzed following digestion with nitric acid. See procedure SM 3030E (Nitric Acid Digestion). Wastewater samples are better digested using method SM 3030F part b (Nitric Acid-Hydrochloric Acid Digestion). Report as total recoverable metal.

Sample criteria:
Except as noted, specimens that do not meet the criteria below should be immediately reported as "no test" with an explanatory note:

1. Samples submitted in improper collection container.
2. Sample inadequately identified. (Sample has no identification, or cannot be matched to a laboratory request form).
3. Sample quantity insufficient
4. Sample container broken or leaked in transit.

Special Instructions:
All glassware and pipettes used in this procedure must be cleaned using glassware-cleaning procedure. See document in kitchen.

Reagents:

1. Nitric Acid (HNO3). Use high purity nitric acid 1+1.
2. Lanthanum solution (1.11%): Dissolve 58.65 g lanthanum oxide in 250 ml of conc HCL. Add slowly with stirring until dissolved and dilute to about 900 ml. Allow to cool for a few hours then dilute to final 1000 ml volume. Used for Ca, Mg, Na, and K analysis.
3. Calcium solution: Dissolve 630 mg calcium carbonate, CACO3, in 50 ml of 1+5 HCL. If necessary, boil gently to obtain complete solution. Cool and dilute to 1000 mL with water. Used for Fe analysis.
4. Standard Metal solutions: Standard metal solutions are prepared from 1000 mg/l AA or ICP-MS standards purchased from Ricca Chemical company, Spex Certiprep, LabChem, Fisher Scientific or VWR. A standard from EM scientific (ICP Multi-element Standard) is very convenient for calibration standards.
5. Deionized Water from Millipore system – metal free water.

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Instrument Set-up:
Use the Varian Spectra 300AA operating in the flame mode with Air Acetylene burner.

1. Turn on exhaust hood. Switch is located in the corner by the Chemistry room refrigerator. Note: Turn switch until it clicks on. If you continue turning the switch after it clicks, the airflow will be reduced.

2. Turn on "Acetylene" gas cylinder located outside in the "Safety Storage" shed. The correct door housing the tank is labeled "Acetylene". Pressure should be set at 8-9 PSI.
   Note: The cylinder valve is opened by turning the handle only 1/4 turn counterclockwise. Replace cylinder when pressure in tank drops below 100 psi. This prevents acetone from entering instrument.

3. Check the Varian Spectra AA 300A unit to see if the burner is installed.

4. Check to see if the cathode lamp required is in the correct socket position, and it is lined up in the "Operating Lamp"
   Note: Lamps are stored in the top drawer located directly across from the GTA 96 Graphite Tube Atomizer (next to hood).

5. Turn on the equipment in the following order (allow a 20 minute warm-up period):
   Note: If the computer is already on, turn it off.
   a. Spectra AA 300A: switch located on lower right front of instrument.
   b. IBM PC and Printer: Turn surge suppressor on (power supply); hit reset button.

Once the unit has been set-up, program the machine for testing by:

1. Start at the "C:" prompt. Press "M" and "Enter".

2. Press "Spectra Flame"

3. Press "Index" (F10). Enter number 10, "Sequence Selection", press "Enter" key.

4. Select element to be tested

5. Press "Sequence Control" (F6). Enter number of samples to be tested.

6. Press "Index" (F10), enter number 6, "Optimization", press "Enter" key.

7. The Screen will display two signal bar graphs. Check the previous week worksheet for the "Photomultiplier voltage" reading.

8. Maximize the lamp signal of the Cathode tube using the two thumbscrews located on the back of the lamp socket (see figure 5.8).
   a. Watch the bar graph as you turn one thumbscrew. Once the value reaches .9 or greater press "Rescale" (F1).
   b. Check the Photomutiplier Voltage display on the screen, after rescaling. If the voltage is higher than the preceding week, continue adjusting and rescaling until the proper voltage is reached. If you are unable to reach the proper voltage, try adjusting the second screw.
   c. Note: Normally the voltage stays the same from week to week, but as the lamp nears the end of its usefulness, the voltage reading will go up. If a new lamp is installed, the starting voltage may be different than the previous lamp. Record millivolt reading on worksheet.

9. After adjusting for maximum signal, hit "Rescale" (F1). The photomultiplier voltage will be displayed. If the reading matches the previous week, record the voltage on the new worksheet. If it is out of range, readjust lamps. If voltage is still out of range, notify Chemist.

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10. Press "Index" (F10) key and select "Standards" (number 7). Verify that the values of the standards are correct (see previous worksheet for standard values). To select a value to change, use the up and down arrows. Enter the correct value with the keyboard.

11. Check to see that drain hose, located below the Spectra 300A, is inserted into the drain bottle. (empty after each use).

12. Press "Index" key, enter number 18 (Signal Graphics), and press "Enter".

13. Press "Shift" and "Instrument Zero" (F10).

14. Light burner by pressing ignite button. Aspirate DI water for about 10 minutes. This will allow burner temperature to stabilize.

Standard and Sample Preparation:
Required sample preparation depends on the metal form being measured.

Procedure for Ca, Mg, Na, and K
1. Label the 10 ml beakers with the standard value; label the sample beakers with the last three numbers of the tiny tab number. Using the adjustable pipette, pipette 1.0 ml of sample or standard into each disposable beakers.

2. Add 9.0 ml of 1.11% lanthanum to each sample or standard using the adjustable pipette.

3. Repeat the process once again by diluting 1 ml of the diluted sample to 10 ml with the 1.11% Lanthanum. The samples have now been diluted 1:10 and 1:100. Alternatively use proportionally smaller volumes (i.e. .5 ml sample and 4.5 ml of 1.11% lanthanum).

4. The standards are prepared from stock solutions that when diluted 1:10 will give the necessary concentrations for calibration. The stock solutions are prepared from 1000 ppm standard metal solutions purchased from Ricca Chemical Co. Record dates of preparation and expiration (3 months) in sample prep manual.

5. The final concentration of calibration standards will be,

    1. Ca: 1.00, 3.00, 5.00 and 10.00 mg/l
    2. Mg 0.10, 0.50, 1.00 and 1.50 mg/l
    3. Na 0.10, 0.50, 1.00, 1.50 and 2.50 mg/l
    4. K 0.10, 0.50, 1.00, 1.50 and 2.50 mg/l

6. Set report format: Go back to index by pressing the "Index" (F10) key, then select the "Report Format" (number 13). Here you can enter the name of the operator, batch name, and date. No other changes are usually necessary.

7. Start program: Press the "Start" (F11). The screen will show the message "Select Lamp 3"; press "Start" (F11). The program will now run to completion.

8. Calibration of other Metals besides Fe/Mn: The other metals tested by flame AA does not require an ionization suppressor and can be directly aspirated. See specific method on computer for required calibration standards.

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Standard and Sample Preparation: Procedure for Fe:

1. Label the sample beakers with the last three numbers of the tiny tab number. Using the adjustable pipette, pipette 1.0 ml of Ca solution into each disposable beakers.

2. Add 4.0 ml of sample to each beaker using the adjustable pipette.

3. The standards are prepared from 1000 ppm standard metal solutions purchased from LabChem or Spex Certiprep. Add 20 ml Ca solution and 1 ml conc HNO3 to each 100 ml of standard prepared. Record dates of preparation and expiration (3 months) in sample prep manual.

4. The final concentration of Fe calibration standards will be: 0.3, 0.5, 1.0, and 3.00 mg/l

5. Set report format: Go back to index by pressing the "Index" (F10) key, then select the "Report Format" (number 13). Here you can enter the name of the operator, batch name, and date. No other changes are usually necessary.

6. Start program: Press the "Start" (F11). The screen will show the message "Select Lamp 3"; press "Start" (F11). The program will now run to completion.

Quality Control:

1. Analyze a Blank after every 10 samples to verify baseline stability. Rezero when necessary.
2. Duplicate Spikes - replicate spikes are to be performed on 10% of samples. Recovery of spike in drinking water should be between 80% and 120% with a precision of 20%. Recovery of spike in wastewater should be between 75-125% with a precision of 25%. Spike level should not exceed MCL for analyte. Spiking solutions are available from Cresent Chemical Co.or SPEX.
3. External Reference Sample - Analyze a known reference sample after initial calibration and after every ten samples to confirm the test is in control.
4. See Table 3111:III in Standard Methods for recommended concentrations of standards to be run, limits of acceptability, and reported single operator precision data.
5. Analyze External Reference Sample on quarterly basis. Solutions available from APG, ERA or SPEX.

CRITERIA FOR ACCEPTABILITY OF RUN

1. Recoveries of spikes and controls are within acceptable range.
2. Blank values below detection levels.
3. Acceptable levels of precision.

NOTE: If any of the acceptance criteria are not met, the analyst must stop the run, correct the problem and and retest the samples.

OUT OF CONTROL PLAN

No sample should be reported until the all acceptance criteria have met. Or the out-of-control condition has been corrected and any problems or departure from protocol identified.

Trouble Shooting:

1. PROBLEM - poor precision,
   Check alignment of hollow cathode lamp. Check that capillary hose is not clogged. Make sure burner is clean and flame appears smooth and even. Replace pinched or crimped capillary tubing.

2. PROBLEM - error message
   Refer to instrument service manual

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3. PROBLEM - Contamination

Check supplies associated with sample collection for contamination. Check rinse water, sample diluent, pipettes, sample cups. Make sure work area is free from dust.

Shutdown Procedure:

Turn off acetylene, IBM PC,and AA300, and exhaust hood, in that order.

Calculations:

The results will be printed and should be recorded on a worksheet. The dilution factor must be shown and considered in the calculations.

Reporting:

1. The data from the printout should be transferred to the worksheet. Verify that controls were within acceptable range and that duplicates are within range.

2. The lab clerk enters the results into the computer. Results are reported in units and number of significant figures consistent with MDL of method.

References:

1. "Analytical Methods for Flame Atomic Absorption Spectrometry" Varian Techtron Pty, Limited, 1989.

2."Standard Methods for the Examination of Water and Wastewater"
18th Edition 1992 by APHA, AWWA, and the WEF.

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Written by: David Holland
Date: January 1999

Approved by:_____
Laboratory Director

DETERMINATION OF INORGANIC ANIONS
BY ION CHROMATOGRAPHY (EPA METHOD 300.0)
USING THE DIONEX DX-80 ION ANALYZER

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PRINCIPLE

This method determines the following inorganic anions: fluoride, chloride, nitrite, bromide, nitrate, phosphate and sulfate.

A small volume of sample (approx. 1 ml) is loaded into the ion chromatograph. The injection valve injects 10 ul of the sample into the flow of eluent. The eluent (a NaHCO3 - Na2CO3 solution) flows continuously through the IC and serves as a carrier for the 10 ul of sample and facilitates in the separation process.

The anions of interest are separated using suppressed conductivity detection, and are identified and quantified by comparing data to those obtain from a standard solution. The major parts of the system are the liquid eluent, high pressure pump, sample injector, guard column, the separator column, the chemical suppressor and the conductivity detector. The guard column protects the separator column, which separates the anions based on their size and charge. The function of the suppressor is to chemically reduce the background conductivity of the electrolytes in the eluent, and to convert the sample anions into a more conductive form. The detector then detects the conductivity of the solution, which varies depending on the concentrations of the anions (higher conductivity indicates a greater concentration of the anion).

SAMPLE CRITERIA

The holding times for drinking water samples are as follows:

Fl^-	28 days
Cl^-	28 days
NO_2^-	48 hours
NO_3^-	48 hours
SO_4^-	28 days
Br^-	28 days

Samples submitted for IC testing routinely should be run within 48 hours of collection, especially for nitrite and nitrate. If testing needs to be delayed, the sample can be preserved with sulfuric acid; preserved samples can be held for up to 28 days and the nitrate results reported as combined Nitrate/Nitrite. Any samples not tested within specified holding times should be identified on the worksheet.

Samples bottles dedicated for IC testing only are placed on the IC bench. As soon as a sample is setup, place it on the white tray for easier storage. After 6 weeks the containers should be emptied and discarded. Nondedicated samples (i.e. those also submitted for additional testing) should be returned to the designated cart after IC testing.

QUALITY ASSURANCE

Operator competency - Ion chromatography may be performed only by analysts who have been trained and who have demonstrated competency with the procedure. One check consists of preparing the calibration standards and calibrating the I.C. An r-value of 0.995 or higher (correlation coefficient of 99.95%) in the linear fit type must be attained for each analyte of interest. Another way to demonstrate competence is to run a minimum of four replicate analyses of an independently prepared sample. Each analyte of interest in the sample should have a known concentration between 5 and 50 times the MDL.

Blank - A blank consisting of nanopure water should be included at the beginning of each run. The results for the blank must be below the MDL for each analyte.

Control standard(s) - Controls representing two concentration levels for each analyte (ICMIX HIGH & ICMIX LOW) must be analyzed as described below. The source of the analytes used to prepare these controls must be different from the source used to prepare the calibration standards. An ICMIX HIGH stock solution of the 7 anions with the following final concentrations:

Anion	*Final Conc*	*Preparation in 500 ml volumetric flask*
Fl^-	20 ppm	10 ml of 1000 ppm Fl std
Cl^-	100 ppm	50 ml of 1000 ppm Cl std
NO2	65.5 ppm	10 ml of 1000 ppm NO2-N std
Br^-	20 ppm	10 ml of 1000 ppm Br std
NO3	100 ppm	50 ml of 1000 ppm NO3 std
PO4	100 ppm	50 ml of 1000 ppm PO4 std
SO4	100 ppm	50 ml of 1000 ppm SO4 std

should be kept on hand. Use this undiluted at the beginning of the run and after every tenth sample. Each week, prepare an ICMIX LOW solution from the ICMIX HIGH solution as follows: Using a 100 ml volumetric flask add 1 ml if ICMIX HIGH using the 1 ml volumetric pipet and fill to mark with nanopure water. Record date made in the IC logbook under Quality Control. Run the IC LOW at the beginning of the days run and after every 10th sample after the IC HIGH. The percent recovery for each anion should be between 90 and 110%.

Duplicate spikes – Duplicate spikes should be run after every tenth sample. The spike should not be less than four times the MDL, and it should increase each anion concentration by more than 25% of the background value. A suitable spike can be prepared by adding one part ICMIX HIGH to three parts sample. The average percent recovery for each anion should be between 80 and 120%. The duplicate spikes should be within 10% of each other. Record average percent recovery of spikes and duplicate percent difference on worksheets. Note: if the concentration of the spike is less than 25% of the background concentration, the spike recovery should not be calculated.

If any of the above control criteria are not met, do not report sample results until the problem has been resolved.

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External controls & chart analysis - In addition to the control standards tested with each batch of samples, an external reference standard (i.e. SPEX IC standard or WS proficiency sample) should be tested on a quarterly basis; however we like to run one at the end of each run.

CALIBRATION FOR GOUNDWATER (DRINKING WATER AND MONITORING WELLS):

Calibration for groundwater samples is described below. Calibration should be performed whenever: 1) controls are out of range; 2) a new batch/lot of eluent/regenerant is made or 3) when a column, suppressor or detector is changed.

1. Prepare 1/10, 1/100, 1/1000 dilutions of the calibration standard ordered from Dionex, which contains 20 mg/l fluoride, 100mg/l chloride, 100 mg/L nitrite, 100 mg/L bromide, l00 mg/l nitrate, 200 mg/L phosphate and 100 mg/l sulfate.

2. Run calibration standards beginning with the highest dilution (1/1000) first.

3. Create calibration sequence: File – New – Sequence – Standards – Next. Skip section on Choosing Timebase – name the sequence *calibMMDDYEAR* and initials – Next – Done.

4. Add sequence to batch file before starting

5. After all four calibration standards have been ran, check the calibration curve.

   a) Double click on any of the calibration standards (Cal Std 1). You will get a chromatograph

   b) Click on Calibration Plot icon, upper right corner or click on VIEW – Calibration Plot. You will see a graph of the first analyte along with the correlation coefficient percentage for each analyte. Only anaytes with percentage of 99.5 or greater are acceptable. Generally try for a 99.98% for an average of all seven analytes to pass quality control checks. Scc the principle analyst if the result is a lesser value.

   c) The mean retention times and detection range are automatic on the DX-80 Ion Analyzer and can not be changed or edited.

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PREPARE MDL STUDY

The Method Detection Limit is the lowest concentration of a substance that can be identified with accuracy and confidence by a certain method or analysis.

1) Prepare a Cal Std 1 level each analyte separately using the secondary standards (not Dionex mix)
2) Make seven replicates of this dilution and run through the Ion Analyzer under the Unknown Method.
3) Collect data and calculate the standard deviation for the seven replicates. Multiply the standard deviation values by 3.143. This number will be the Method Detection Limit.

GENERATE BACKLOG REPORT:

1) On a network computer – not the Instrument computer. Double click on LABWORKS icon. Enter password. Click on OK. Click on backlog. Click on analysis code. Click on OK. Type in #ICANION. Click on OK. Click on display report. Click on print. Click on exit until you are out.

2) Check the clipboard to see if a worksheet has been initiated listing samples that need repeat testing; if so, append worksheet with samples on backlog report.
   a) Account for all specimens on backlog report
      i) Samples may have been tested in a previous run but not recorded. Record these results and give to the clerk.
      ii) If a sample appears on the backlog but needs to be tested by a different method (i.e. wastewater), inform the clerk so that the analysis ordered can be modified.
   b) Include any "new" samples on the I.C. bench that have not yet been entered into the computer.

SAMPLE PREPARATION

Groundwater (drinking water and monitoring wells) should be filtered through 0.45 um membrane filters before injection:

1) Rinse the syringe once with the sample water. Then fill syringe with about 10 ml of sample water.
2) Filter a minimum of 2 ml of sample through the 0.45 membrane into a labeled autosampler vial discarding the first few drops.
3) Place autosampler cap on vial and press down using the provided tool. Make sure the cap goes in straight and remove any air bubbles seen in the vial (invert or knock gently).
4) Place sample in autosampler rack. The order in the rack must match that on the schedule. Note: If you suspect the result of a sample to be above that of the calibration standard for an analyte, make an appropriate dilution. Check by measuring conductivity – anything greater than 700 uS will need to be diluted.
5) Include duplicate spikes for every 10th sample. Add 1 part ICMIX high to 3 parts filtered sample. Then IC HIGH, LRB, IC LOW. The laboratory reagent blank (LRB) is necessary to minimize carry over as the IC low is 100 times less than the High. Double check any samples where analyte concentrations are low after a high sample to verify analyte is even detected.

Samples which may contain high concentrations of chloride or organic contaminants (Carmel Area Wastewater District and ESF), are run on the DX-100 and require additional filtering through Dionex OnGuard P, Dionex OnGuard Ag, and Dionex OnGuard H filters before injection. See supplemental procedures.

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SYSTEM START-UP:

1) Ensure the **eluent** bottle is at least ¼ full. If it is less, depending on size of run, prepare new eluent (and regenerant):
   a) Prepare 2 liters of a final eluent concentration of 8.0 mM Sodium Carbonate and 1.0 mM Sodium Bicarbonate by diluting one Dionex AS 14A Eluent Concentrate bottle (P/N 057060) into two 1L-volumetric flasks. Bring each to volume (1000 ml) with nanopure water. Makes 2 liters.
   b) Use the designated filter/vacuum flask, a filter funnel, a clean 0.45um membrane filter, and a large magnetic stir bar to degas the eluent. Pour the eluent into the filter funnel and turn on the vacuum. Set the magnetic sticker at medium to high speed. Once all the eluent has been filtered, keep the vacuum and magnetic stirrer on for 15-20 minutes, allowing the eluent to degas.
   c) Turn off the magnetic stirrer and the vacuum. Remove the filter funnel. Carefully decant the degassed eluent into the eluent bottle, without aerating. Make sure the cap is on tightly, and the tubes are securely attached.

2) Whenever new eluent is prepared, new **regenerant** must also be made.
   a) Prepare 2 liters of a final anion regenerant concentration of 72 mN Sulfuric Acid by adding one Dionex Anion Regenerant Concentrate bottle (P/N 057559) to two liters of nanopure water.
   b) Mix in the regenerant in the designated filter flask using the stir bar and degas for 15-20 minutes.
   c) Turn off the magnetic stirrer and the vacuum. Remove the filter funnel. Carefully decant the degassed regenerant into the REGEN bottle, without aerating. Make sure the cap is on tightly, and the tubes are securely attached.

DX-80 OPERATION

1) Turn on nitrogen gas cylinder (main knob only), autosampler (rear right hand corner), ion analyzer (rear panel right hand side) and computer.

2) Double click on Peaknet to open computer program. **File – Panels\Dionex DX-80 System** for the Control Panel.

3) Under the DX-80 Status click on **CONNECT** to connect analyzer to computer

4) Turn on the pump by clicking the **ON** button on the DX-80 Control Panel. **Prime** the pump by turning the pump head waste valve knob counter clockwise and leaving it open for about 5 seconds. Close the pump valve knob by turning clockwise until secure. After changing to new eluent, it is a good idea to leave pump valve open until all air bubbles have been purged – look for the air bubbles coming out the eluent bottle until it reaches the waste line at the pump. This will allow any air bubbles to be pumped to waste instead of through the columns.
5) Allow the system to **equilibrate** for 30 minutes minimum, generally one hour if new eluent is used. Once ready, the **operating pressure** should be 2000+- 300 psi (usu 2100

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psi); and the operating **total conductivity** background should be < 30 uS (usually 25.00uS). You can offset the background and zero the reading by clicking the Autozero button on the Control Panel.

6) To begin a run, create a sequence worksheet by clicking on **File – New – Sequence**. (May have to do this twice if worksheet is not already open.)
   a. It will then prompt you to choose Standard or Unknowns. Choose **Unknowns - Next**
   b. Skip **next** screen where it prompts you to specify timebase,
   c. **Estimate** number of unknowns (you can always add or delete samples from sequence when done.
   d. Fill out file name you wish to save the file We save under ***MMDDYEAR*** and **initials**: (*05052002tl)* and press **enter**.
   e. Press **Done** when prompted to exit wizard.
   f. A worksheet will appear where sample identifications can be added after the calibration data (line #5). Follow printed worksheet – first include a *blank, ic low, ic high, lrb*, then the samples. Note for the first set, the lrb is listed as a sample. *Duplicate spikes* are required for every 10th sample or a minimum of 10% of samples. Finish off sequence with a known quality control standard, usually a proficiency standard such as *WS 60* or Ultra QC and another blank (LRB).
   g. Change *dilution factor* if sample was diluted; default is one. Save by pressing the SAVE icon (floppy disk).

7) To start the run – click on **Batch – Edit – Add** – double click on the newly created sequence, or the one you want run – then **Start** to begin.

8) Make sure autosampler vials are in order and the green light is on 'Run' not 'Hold'.

9) Record date, total conductivity and pressure in the log notebook at which the run has started.

10) During or after the run, verify that the blank and QCs (IC HIGH, IC LOW, IC CHECK) are within range. If not stop the run by clicking on **Batch – Stop - after current sample**, and notify principal analyst to investigate and solve the problem before resuming the run.

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REPORTING RESULTS

1) When run is complete the analyst performing the run is responsible for recording and reporting results. Review each chromatogram to verify that the peaks were properly identified. Retention times may shift if there was a sudden change in pressure. Changes to the peak name can be made by a right click on the peak and choosing the correct analyte then save.

2) The results are found on the worksheet next to the sample ID and can be exported to an excel file for accuracy calculation:
   a) Click on any sample cell – i.e. ic low, cell will be outlined.

b) Click on **File – Batch Report – Export** (unclick the Printout option- computer is not connected to any printer) – **Excel file format**
c) For sheets to be exported, choose only " **Summary – INJ vs. Area, Ht, Amt**." Unclick the Integration, Calibration, Peak analysis, Summary-INJ vs. Anion, and Audit Trail options as they are extra and rarely needed for our purpose.
d) Click on **Finish** then **OK** on batch menu. Status will appear and when transfer is complete, press **OK** to exit.

3) To copy exported file onto a floppy, right click on Start icon on lower left screen and choose EXPLORE for Windows Explorer. Under **C:\Chromel\Export** folders are the files just exported. Highlight the correct sequence and drag to **A:** drive to copy file. (Make sure you have a floppy disk inserted).

4) Open exported file under an EXCEL program – the instrument computer does not have one so use a network computer. You will see three types of charts: first- Sample vs. Area, second - Sample vs. Height, and third - Sample vs. Amount. Copy all of the **Sample vs. Amount** table to an old/previous excel file.

5) The Excel Results worksheet is permanently saved under **G:\Laboratory\Data\Water\IC Data\2002** under the correct month. It is also saved in Tess' computer under **C:\My Documents\IC Data** and correct year and month. Easiest way to create the worksheet is to open a previously saved file (of the same year and month) and then cut and paste the data. There are two worksheets in each file, one for the complete results, the other for the raw data (the Sample vs Amount table exported from peaknet).
a) Before any changes are made, save the file under a new name: MMDDYY and initials
b) On RAW worksheet, delete old table and replace with recently ran sequence data. Add a column between Sample ID and Fluoride Amount for the dilution factor.
c) Change Date Analyzed and Analyst if applicable. Calibrations are generally done once a month with the most recent noted under Date of Calibration – change if necessary.
d) **Copy** and paste data results from raw worksheet onto Results worksheet under correct sample name. Use the **Paste Special option – Values** - to retain similar fonts on results worksheet. **% Recoveries** will be automatically calculated as will **% Differences**, and **Averages** for the duplicate spikes but references to certain cells may need to be changed for the correct result.
e) Verify that all QC are accurate before entering into labworks.

6) For drinking water, results should be recorded as ND – Not Detected for levels below DLR (Detection Limit for Reporting) as follows:
a) Fluoride 0.1 mg/L
b) Nitrate 2.0 mg/L
c) Sulfate 0.5 mg/L
d) Bromide 0.1 mg/L
e) Chloride, Nitrite, Phosphate 1.0 mg/L

f) Any samples with readings above the calibration range (20 mg/L fluoride, 100 mg/l chloride, nitrite, bromide, nitrate, sulfate, and 200 mg/l phosphate) needs to be diluted and

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repeated in the next run. List these samples on a new worksheet with the appropriate dilution and place the worksheet on the clipboard.

7) Do not report results if control/spike values do not fall within limits (refer to section on quality control). If controls, spikes, etc. are out of range, notify the principal analyst. If controls are within limits, date and initial the worksheet and give the worksheet to the clerk for data entry. When the worksheet and backlog are returned place them in the binder.

SHUT DOWN

After the run is complete the Ion Analyzer can be shut down. The IC should be shut down on weekends if the system is not in operation on Friday night so as not to damage the suppressor unit:

1) On the Control Panel screen of Peaknet - turn **OFF** pump and **DISCONNECT** DX-80
2) Close Peaknet.
3) Turn off DX-80, autosampler and close nitrogen cylinder valve.

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PREVENTIVE MAINTENANCE:

1) Each quarter, replace the bed supports on guard column
2) Maintain the following spare parts. These items are considered consumables:
   a) Anion Refill Kit (Part No. 057069) contains 4 bottles each of AS14A eluent and anion regenerant concentrate.
   b) AS14A anion separator column, 3 mm (Part No. 056901)
   c) AS14G anion guard column (Part No. 056899)
   d) AMMS III suppressor (Part No. 056751)
   e) DS5 Detection Stabilizer (Part No. 057290T)

DOS AND DON'TS

* Try to make additions, changes, and deletions to the sequence during the middle of a run and then save immediately. If the changes are not saved immediately, the program may get confused on which sequence to use and will freeze. If this happens, wait until the current sample is completed, turn off all equipment and wait for about 15 minutes before restarting.

* Be gentle when loading samples onto the autosampler, especially the first rack. If racks are installed too roughly, conveyor belt may get stuck and samples will not be injected in the proper sequence.

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REFERENCES:

1) DX-80 Ion Chromatograph with SRS Control Operator's Manual, Dionex Corporation, 2002.
2) Methods for the Determination of Inorganic Substances in Environmental Samples, Method Number 300.0, Determination of Inorganic Anions by Ion Chromatography, John D. Pfaff, U.S. Environmental Protection Agency, 1993.
3) Standard Methods, 18th Edition, 1992. Part 4110.

Originally written by: Johanna Rosen for DX-100
Date: 12-96
Updated by: Theresa Lam for DX-80 Ion Analyzer
Date: 05-02

Approved by: _____
(Lab Director's signature)

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APPENDIX 5.C – CHLORIDE DATA CONTOURING PROTOCOLS

CONTOURING PROTOCOLS

FOR CHLORIDE ISOCONTOUR MAPS

WATER RESOURCES AGENCY

MEMORANDUM

Monterey County

DATE: April 17, 2018

FROM: Sean Noble

TO: Water Quality

SUBJECT: How to Contour SWI in ArcGIS

DRAFT

Background

The purpose of this memo is to describe the process of creating the initial seawater intrusion contours using ArcGIS. This is an attempt to standardize the process. Contours are based on chloride (Cl) data sampled from coastal wells in the Pressure 400-Foot and Pressure 180-Foot Aquifers. This data for comes from three primary sources. First, coastal wells are sampled twice each summer by Agency staff. Second, monitoring wells are sampled once each summer, using a portable pump. Finally, data from outside sources are pulled in to supplement the data and create better geospatial coverage. Historically contours are generated on every odd year, using even year data to fill any data gaps. Data is used to create contours that are then added to the historical seawater intrusion maps. The maps are as follows:

P180 Sea Water Intrusion Map
P400 Sea Water Intrusion Map

(In the future the deep aquifer may be added to the process)

After reviewing all the data and uploading it to the WRAIMS database, we are ready to move on to ArcGIS.

**** The 2017 year Pressure 400 will be used as an example ****

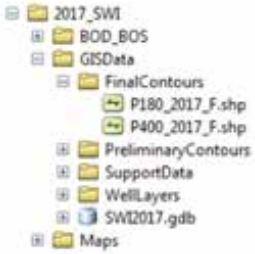
ArcCatalog

Open ArcCatalog and navigate to R:\Workspace\Common\WaterQuality\SWI. Notice that the folders are labeled by year with the exception of the CommonDirectories. This folder stores GIS data that can be used for any year that is contoured. It contains commonly used boundaries, databases, and layers.

In ArcCatalog copy/paste folder of the last year contoured (2015_SWI) and rename current year (2017_SWI).

This will be the naming convention for naming files:

Aquifer_Year _Version(if applicable), examples:



Within each year there are two main folders:

GISData

FinalContours, storage of approved shapefiles
PreliminaryContours – primary exported contour shapefiles
SupportData – secondary export shapefiles, database tables, and imagery

Maps

Stores final project maps and products

ArcMap

Step 1 – Project Formatting

Rename the ArcMap contour projects stored in the Maps folder:
R:\Workspace\Common\WaterQuality\SWI\2017_SWI\Maps**P400_2015.mxd** ->
R:\Workspace\Common\WaterQuality\SWI\2017_SWI\Maps**P400_2017.mxd**
By using the previous project, all of the background shapefiles can stay and be reused for the new project.

Step 2 – Database Formatting

Navigate to:
R:\Workspace\Common\WaterQuality\SWI\CommonDirectories\Databases
And open the **SWIContours (Current).mdb** database
First, make sure that all relevant data has been reviewed and loaded to WRAIMS. Open the **_Contouring_Start_** table and edit the year to the year being contoured.

Run the macro: **SWI_ContourTables**

The macro SWI_ContourTables runs four make table queries to produce these tables:

SWI180_ALL
SWI400_ALL
SWI_180_CONTOUR_WELLS

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SWI_400_CONTOUR_WELLS

The '…_ALL' tables include all wells that are in the Monthly Water Quality program and in the appropriate aquifers. Some wells have the aquifer designation PRESSURE BOTH. These well are included in both '…_ALL' tables, but are not included in the contouring. The '…_CONTOUR_WELLS' tables are a subsection of the '…_ALL' tables and only include wells to be used in contouring for the respective aquifers.

If certain wells need to be excluded, modify the **tblExcludedWells** table. Wells are excluded based on facility code and aquifer (180 or 400), so make sure both of those fields are filled out correctly. This table is used dictate which wells are excluded and to document which wells have been excluded and why. It should be kept updated as changes to the dataset are made. After adding new wells to tblExcludedWells, rerun the macros to update the tables.

The **ExternalData** table can be used to add data that is not stored in WRAIMS but has been approved to be used for contouring. In the 2017 example, the data from the Monterey Peninsula Water Supply Project monitoring wells was added this way. Only wells with a FACILITY_CODE and in the WellsAll GIS layer can be utilized in this manner (R:\Workspace\Common\MapElements\WellsAll.lyr).

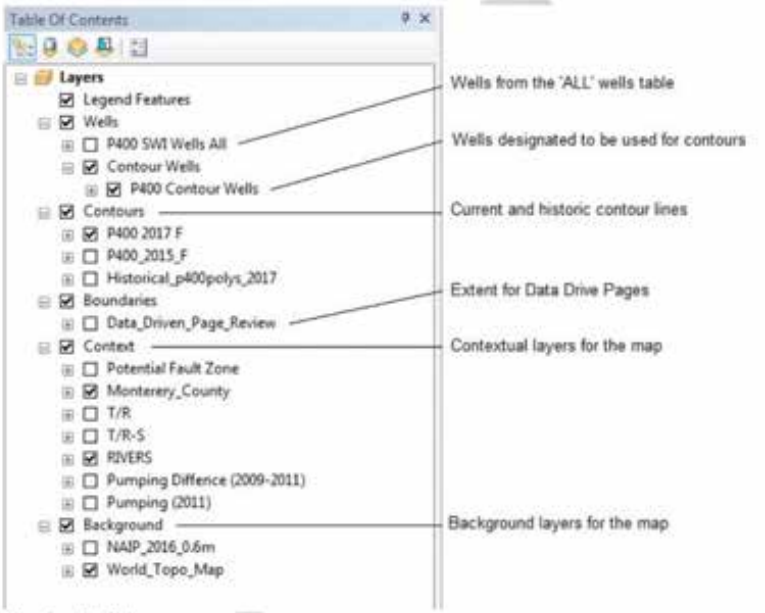
The tables include both present and past measurements and automatically include data from the previous year if the current year is missing data.

Field Name	Description
FACILITY_CODE	Facility Code of the well
FACILITY_NAME	State Well ID based on township and range
BASIN_NAME	Aquifer designation
ContourValue	Value used to contour as a year average of all samples taken during the most recent year
ContourValYr	Year that the value used to contour was sampled
ConYrCl	Contour year average of Cl data
ConYrStDev	Contour year standard deviation of Cl data
1yrBackCl	Previous year average of Cl data (2016)
1YrStDev	Previous year standard deviation of Cl data (2016)
2yrBackCl	Two years prior average of Cl data (2015)
2YrStDev	Two years prior standard deviation of Cl data (2015)
3yrBackCl	Three years prior average of Cl data (2014)
3YrStDev	Three years prior standard deviation of Cl data (2014)
PERF_START	Start of recorded perforation in well casing
PERF_END	End of recorded perforation in well casing
Use	Abbreviation of the wells primary uses
WATER_USE_DESCRIPTION	Description of the wells primary uses
FACILITY_STATUS_NAME	The status of the well

https://cloudshare.elmontgomery.com/s/Cm8HHen2GXgbY5g#pdfviewer 154/226

Step 3 – Data Labeling & Symbology

In ArcGIS:
All of the well layers in the ArcMap projects should automatically update to the 'Current' database values. The projects should be laid out in similar formats as demonstrated below. Compare the values and dates of various wells with recorded values in WRAIMS to ensure the correct data is being used.



Step 4 – Draft 1

To generate profiles run the tool
ArcToolbox -> SWIContouringTools -> SWI_Spline_Coastal_Contouring

And fill out the fields

Contour Wells:	Wells\Contour Wells\P180 Contour Wells
Z value field:	SWI_400_CONTOUR_WELLS.ContourValue
Spline type:	TENSION
Number of points:	4
Weight:	0.01

Contour Output:
R:\Workspace\Common\WaterQuality\SWI\2017_SWI\GISData\PreliminaryContours\p400_2017_v1.shp

In Layout view change any labels and titles to match the current year and draft, and make any appropriate changes to the legends.

Export to PDF, R:\Workspace\Common\WaterQuality\SWI\2017_SWI\GISData\PreliminaryContours\p400_2017_V1.pdf. From PDF, print to 11x17 and review. If all the data is there and the labels and symbology are correct then Print to Plotter, 30x30.

Steps Summary

Version 1 is the computers attempt to contour the data based on all the data that has been collected and reviewed for the appropriate aquifer. The next set of versions are created through careful examination of the data to establish what wells will be excluded from the contouring. Use past exclusion to help with wells with ambiguous aquifer designations and refer to well logs, well measurement histories, piper diagrams, and sample notes for wells that don't seem to fit the general trend. Once the list of wells to exclude is agreed upon, run the tool again. This process is iterated until **tblExcludedWells** is agreed to be final by the project supervisor. The next step is to generate the last set of computer generated lines (AT_2017_F) and edit them to match previous contours and represent the general trend of seawater intrusion.

Editing Contour Lines

The computer generated AT_2017_F needs to stay intact incase it has to be referenced at some point. The first thing to do is copy/paste AT_2017_F into the R:\Workspace\Common\WaterQuality\SWI\2017_SWI\GISData\FinalContours folder (this will be the version you edit). In ArcGIS:

Right click on the layer you wish to edit
Go to **Edit Features**
Click **Start Editing**

It sometimes makes editing easier to make the edited layer the only selectable layer.

Right click on layer
Go to **Selection**
Click on **Make This The Only Selectable Layer**

Double-click on the contour line you wish to modify. Many vertices will appear on the line as boxes. These are the points to drag in order to modify the line. When adding lines remember to edit the attribute table to add the appropriate contour value. Due to the limited data the contours will have to be heavily edited to achieve a general representation of sea water intrusion into the aquifers. As a general rule, lines will not recede approved by the project lead. Unless otherwise

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directed, lines that are seaward of past contours will default to the furthest inland historical extent (use the historical contour lines). Judgement will have to be used to decide how to alter lines to represent general seawater intrusion: work with the project lead on hand kriging and editing.

Final Clean Up

Once the list of excluded wells has been finalized copy the "Current" database and rename it with the contour year. This creates a backup and documents which wells were used and what values. Similarly, ensure that all shape files are in the correct places and properly labeled, especially the final contours.

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APPENDIX 5.D – INDUCTION LOGGING

APPENDIX D
INDUCTION LOGGING

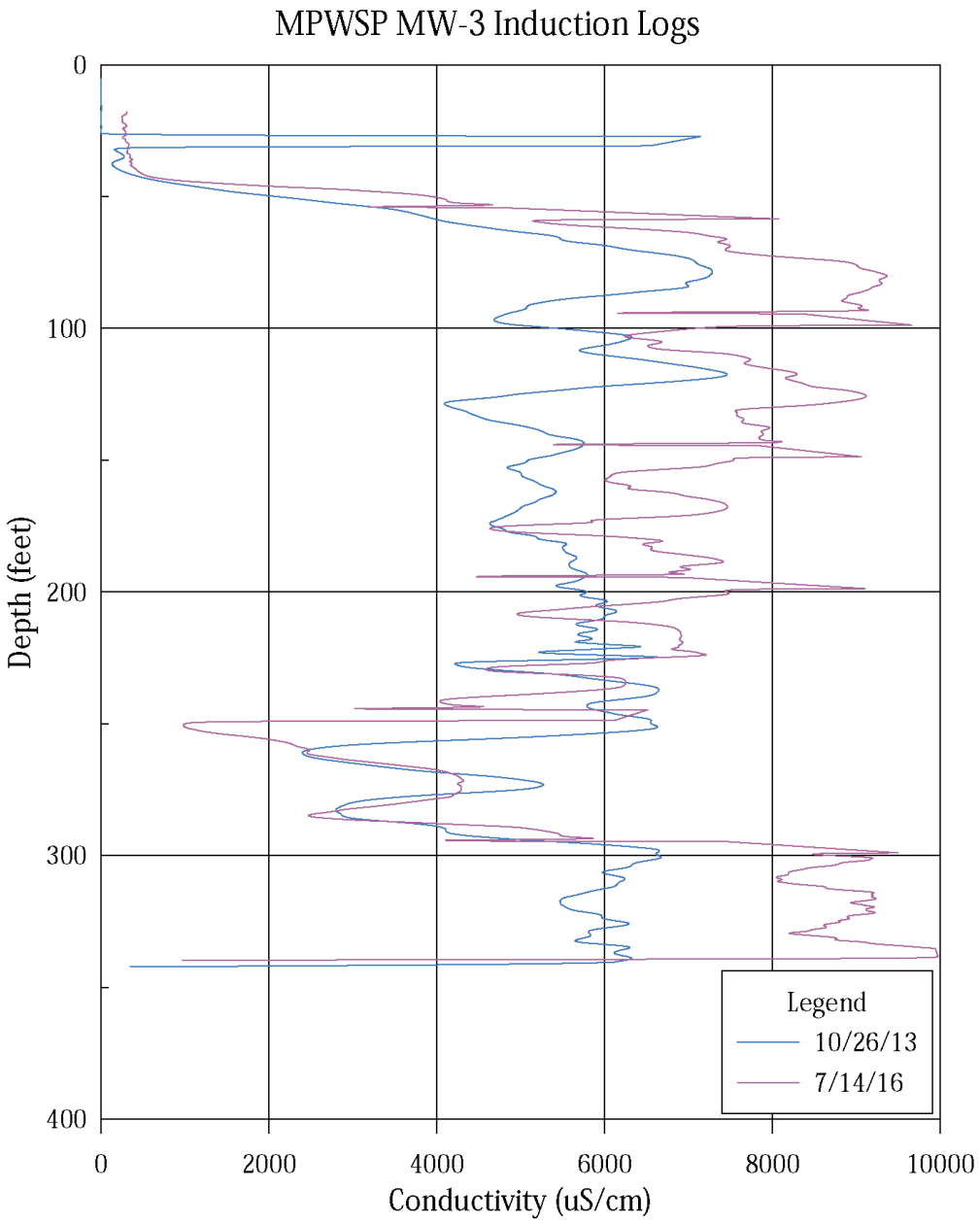
This appendix is presented to provide additional background on induction logging and its application in detecting changes in groundwater quality. The following are presented:

1. Two to three sets of induction logs were performed on some the MPWSP monitoring wells. These are presented with explanations of the measured changes visible in the results.

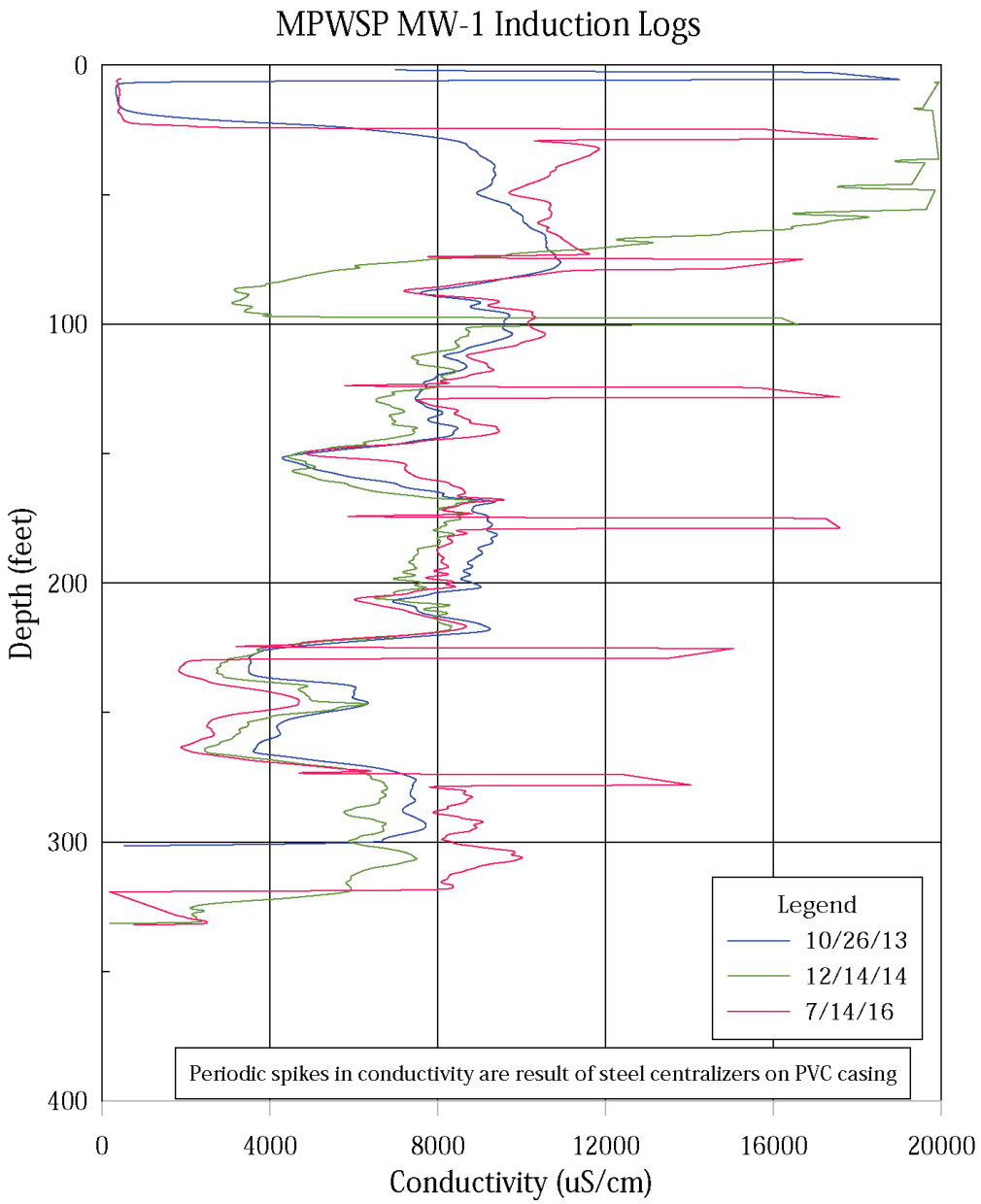
2. The cumulative results of the on-going induction logging program of the Seaside Basin Watermaster's four Sentinel Wells located in coastal Fort Ord. This program court-ordered involves semi-annual induction logging for purposes of detecting seawater intrusion. The Sentinel Wells are approximately 1,500 feet deep and the logging program is designed to detect changes in water quality throughout the entire thickness of sediments. To date, intrusion has only been detected in the shallow-most sediments which have been documented as intruded for decades.

3. Excerpts from the USGS Water Supply Paper (*Keys, W.S., 1990, Borehole geophysics applied to ground-water investigations: U.S. Geological Survey Techniques of Water-Resources Investigation)* explaining induction logging.

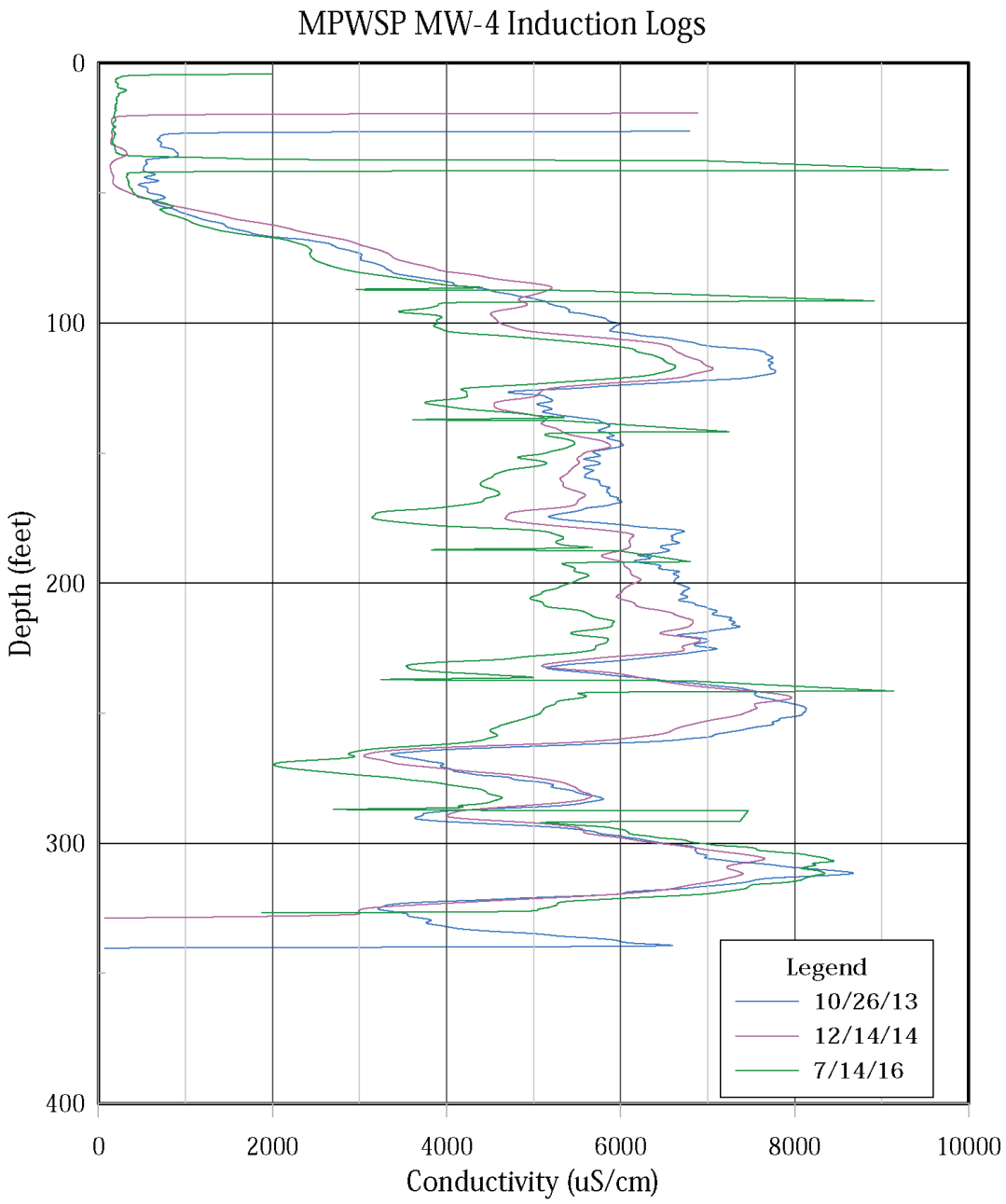
4. A recent paper from Ground Water Magazine detailing the use of induction logging in the Stockton Area. *Electromagnetic-Induction Logging to Monitor Changing Chloride Concentrations, Loren Metzer and John Izbicki, Ground Water Volume 51, Issue 1, p. 108-121*



Explanation: In general, groundwater conductivity increased throughout the entire depth of the well in the period between logging. In the upper portions above 290 feet, the increase is interpreted to be induced flow of seawater as it circles around in the capture zone of the well. Below 290 feet, the increase is due to continued seawater intrusion in the 400-foot aquifer.

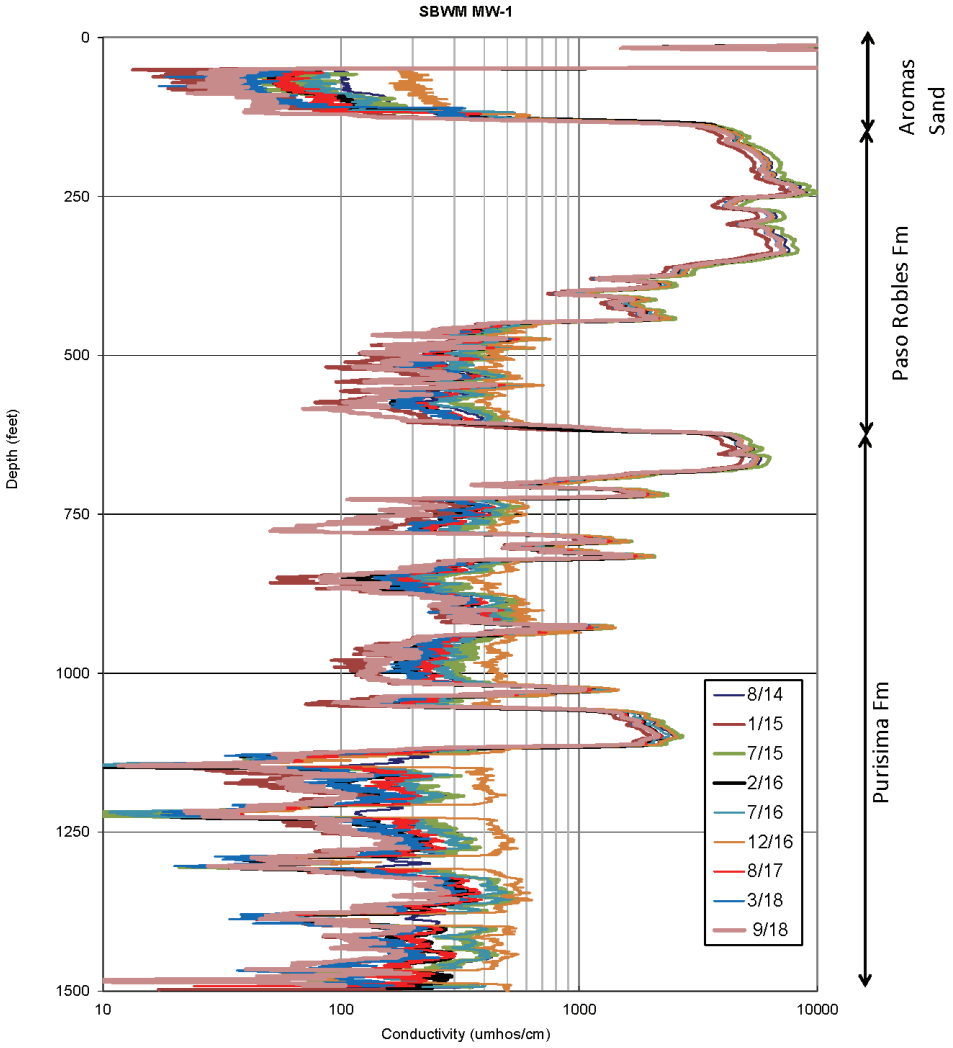


Explanation: Most obvious is the large increase in conductivity of the 12/14/14 log above 100 feet. This is interpreted as the result of very high surf which resulted in localized recharge of ocean water to the shallow zone near this well. Below this depth, and above 270 feet, groundwater condutivities are relatively unchanged. Below 270 feet, evidence of increasing intrusion of the 400-foot aquifer is apparent in the increasing conductivity.

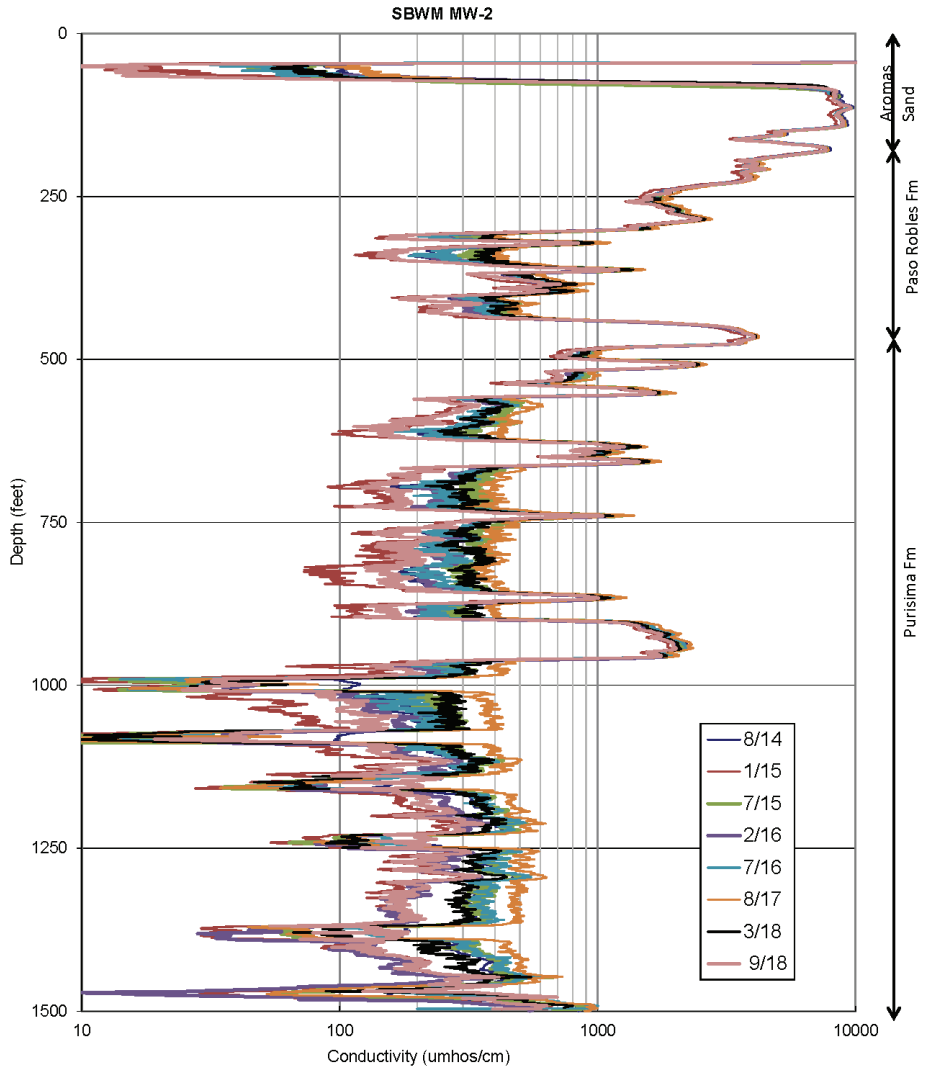


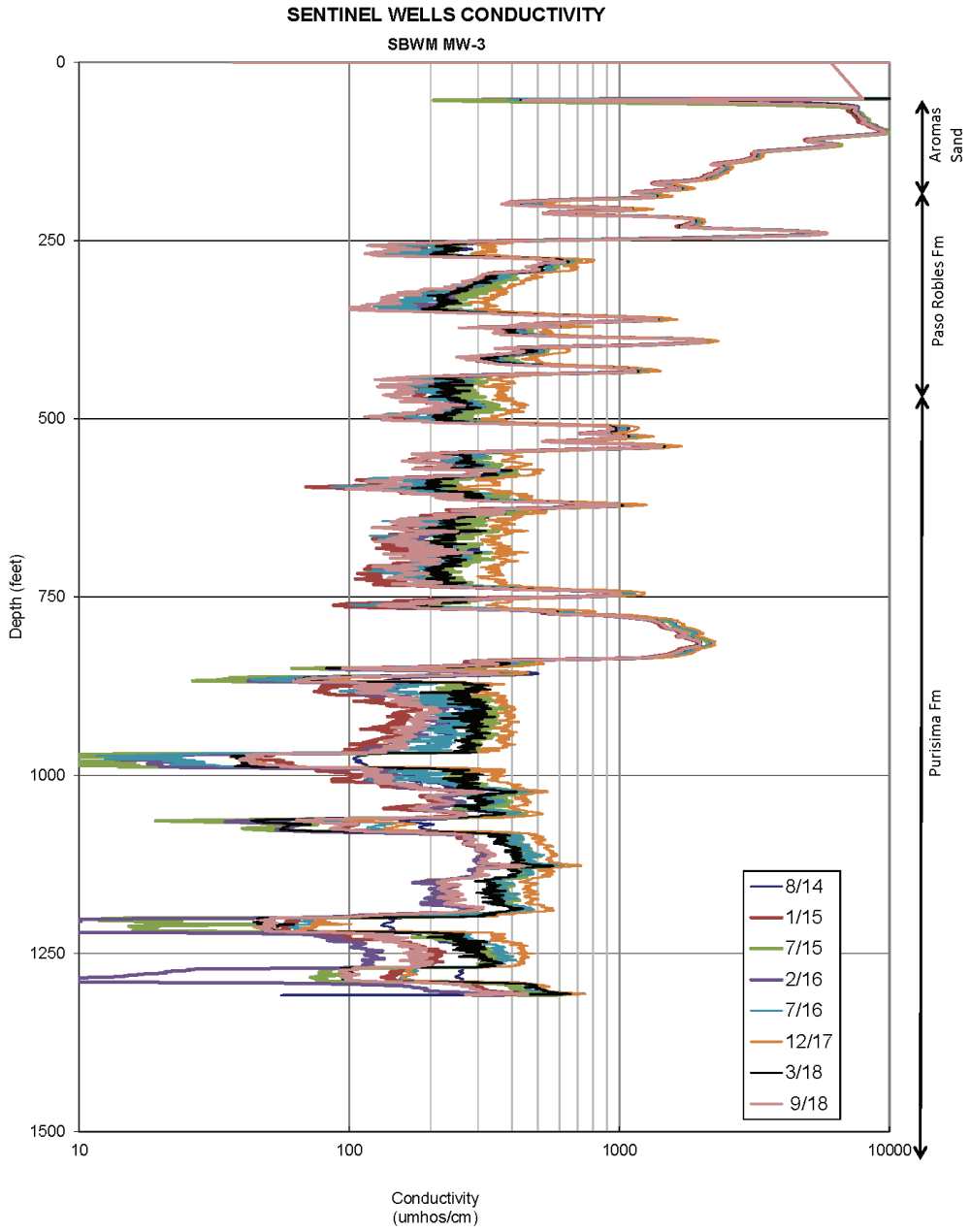
Explanation: In general, groundwater quality is relatively unchanged throughout the thickness of the aquifer system. If, anything the most recent log reveals groundwater quality to be slightly fresher.

SENTINEL WELLS CONDUCTIVITY

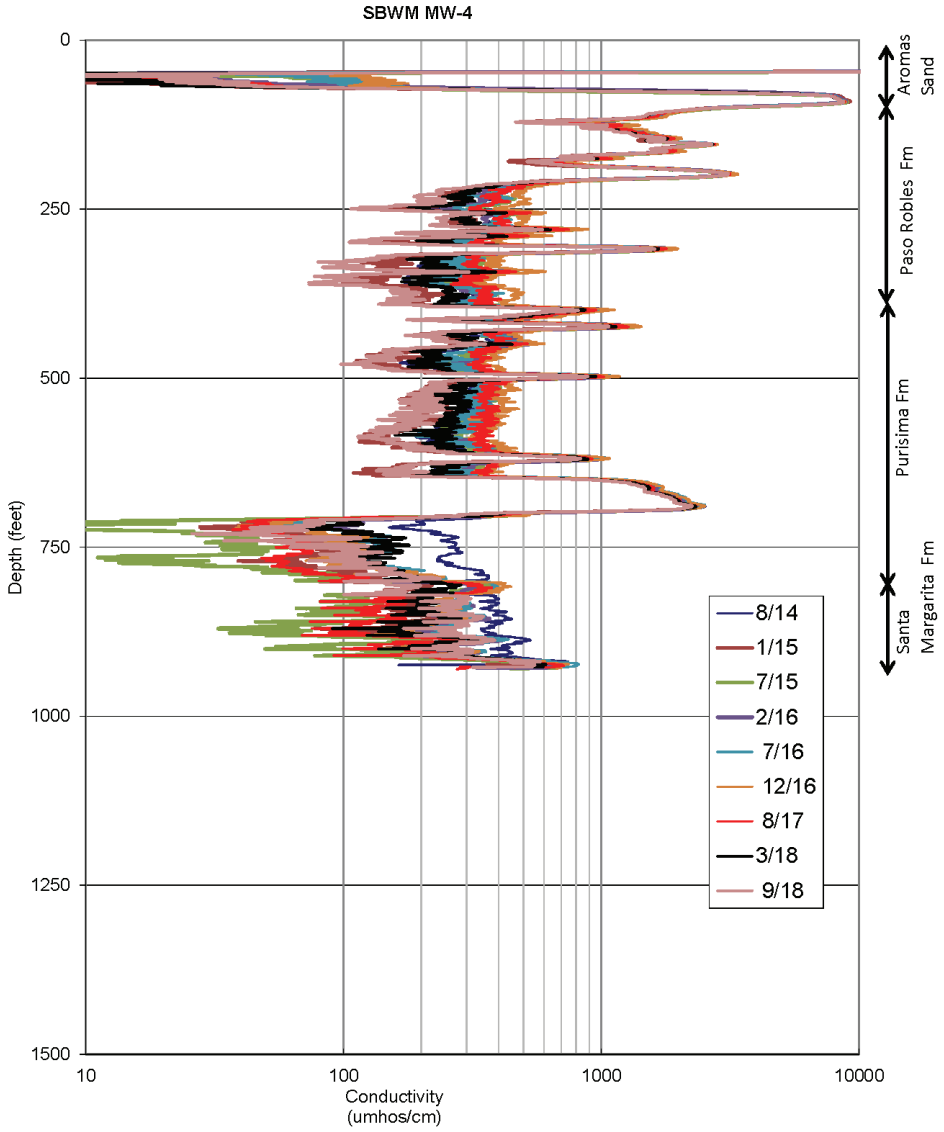


SENTINEL WELLS CONDUCTIVITY




SENTINEL WELLS CONDUCTIVITY
SBWM MW-3
Depth (feet)
0
250
500
750
1000
1250
1500
10
100
1000
10000
Conductivity
(umhos/cm)
Aromas Sand
Paso Robles Fm
Purisima Fm
8/14
1/15
7/15
2/16
7/16
12/17
3/18
9/18

SENTINEL WELLS CONDUCTIVITY



Link back to USGS publications

Techniques of Water-Resources Investigations
of the United States Geological Survey

Chapter E2

BOREHOLE GEOPHYSICS APPLIED TO GROUND-WATER INVESTIGATIONS

By W. Scott Keys

Book 2
COLLECTION OF ENVIRONMENTAL DATA

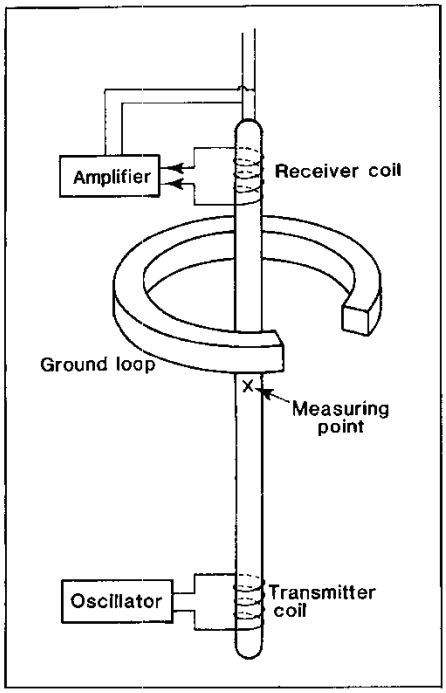


Figure 39.—System for making induction logs.

used widely in ground-water hydrology, but the equipment is still available through oil-well logging-service companies.

Induction logging

Induction-logging systems originally were designed to solve the problem of measuring resistivity in oil-based drilling mud, where no conductive medium is present between the probe and the formation. A basic induction-logging system is illustrated in figure 39. A simple version of an induction probe contains two coils, one for transmitting an alternating current into the surrounding rocks and the other for receiving the returning signal. The transmitted alternating current, at about 20,000 cycles per second (20 kHz), induces the flow of eddy currents (a ground loop) in conductive rocks penetrated by the borehole. These eddy currents set up secondary magnetic fields that induce a voltage in the receiving coil. That signal is amplified and converted to direct current before being transmitted up the cable. The magnitude of the received current is proportional to the electrical conductivity of the rocks. Induction logs measure electrical conductivity, which is the reciprocal of resistivity. Additional coils usually are included to focus the current in a manner similar to that used in the guard type of focused-resistivity systems.

Induction-logging systems provide resistivity measurements regardless of whether the well contains oil-based mud or is filled with air or fresh mud. The measurement of electrical conductivity usually is inverted to provide curves of both resistivity and electrical conductivity. The unit of measurement for conductivity is the mho-meter; however, induction logs are calibrated in millimho-meters. Calibration is checked by suspending the probe in air, where humidity is minimal, in order to obtain zero electrical conductivity. A copper hoop is suspended around the probe while it is in the air to simulate known resistivity values. It is also possible to suspend the probe in a lake or other body of water that is large enough to be infinite with respect to probe response. The electrical conductivity of the water can be measured with a conductivity cell.

The volume of investigation of an induction probe is a function of coil spacing, which varies among the probes provided by different service companies. For most probes, the diameter of material investigated is 40 to 60 in. For some probes, the signal produced by material closer than 30 in is small, and borehole diameter and properties of the invaded zone have little effect on measured resistivities. Although induction probes are not greatly affected by changes in borehole diameter, they are affected by eccentricity, so they usually are centralized. Vertical resolution of the logs is good for beds that are more than 6 ft thick.

The application of induction logs in ground-water hydrology is limited because the probe is most responsive to small changes in resistivity when background resistivity is minimal. The dual induction log configuration where the probe measures resistivity uses two different volumes of investigation is one of the most common electric logs used in the petroleum exploration industry. The ratio of Rm to Rw usually determines the applicability of induction probes. If the value of Rw exceeds 5 times Rm, which is common in wells containing freshwater, resistivity values on an induction log depart substantially from Rt.

Microresistivity logging

A large number of microresistivity probes is available, but all have short electrode spacing, and thus a shallow depth of investigation. They are of two general types: nonfocused and focused. Both types incorporate pads or some kind of contact electrodes to decrease the effect of the borehole fluid.

ground water

Electromagnetic-Induction Logging to Monitor Changing Chloride Concentrations

by Loren F. Metzger[1] and John A. Izbicki[2]

Abstract

Water from the San Joaquin Delta, having chloride concentrations up to 3590 mg/L, has intruded fresh water aquifers underlying Stockton, California. Changes in chloride concentrations at depth within these aquifers were evaluated using sequential electromagnetic (EM) induction logs collected during 2004 through 2007 at seven multiple-well sites as deep as 268 m. Sequential EM logging is useful for identifying changes in groundwater quality through polyvinyl chloride-cased wells in intervals not screened by wells. These unscreened intervals represent more than 90% of the aquifer at the sites studied. Sequential EM logging suggested degrading groundwater quality in numerous thin intervals, typically between 1 and 7 m in thickness, especially in the northern part of the study area. Some of these intervals were unscreened by wells, and would not have been identified by traditional groundwater sample collection. Sequential logging also identified intervals with improving water quality—possibly due to groundwater management practices that have limited pumping and promoted artificial recharge. EM resistivity was correlated with chloride concentrations in sampled wells and in water from core material. Natural gamma log data were used to account for the effect of aquifer lithology on EM resistivity. Results of this study show that a sequential EM logging is useful for identifying and monitoring the movement of high-chloride water, having lower salinities and chloride concentrations than sea water, in aquifer intervals not screened by wells, and that increases in chloride in water from wells in the area are consistent with high-chloride water originating from the San Joaquin Delta rather than from the underlying saline aquifer.

Introduction

Chloride concentrations in water from wells in the Stockton area of the Eastern San Joaquin Groundwater Subbasin, California, 130 km east of San Francisco (Figure 1), have increased as a result of groundwater pumping and subsequent declines in groundwater levels (Izbicki et al. 2006). The concentration of chloride in some wells has exceeded the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level (SMCL) of 250 mg/L, and some public-supply wells have been removed from service due to high-chloride concentrations. Potential sources of high-chloride water to wells in the subbasin include: (1) high-chloride surface water from the San Joaquin Delta, (2) saline aquifers that underlie fresh water aquifers, (3) soluble salts emplaced in delta sediments by the evaporation of groundwater discharge from fresh water and saline aquifers along the delta margin, and (4) irrigation return water (Izbicki et al. 2006).

Sequential electromagnetic (EM) induction logging was performed to identify the sources and assess the spatial and vertical distribution of high-chloride water in the Eastern San Joaquin Groundwater Subbasin near the San Joaquin Delta. The EM logs were collected between spring 2004 and fall 2007 in polyvinyl chloride (PVC)-cased monitoring wells installed as part of this

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Received May 2011, accepted March 2012

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doi: 10.1111/j.1745-6584.2012.00944.x

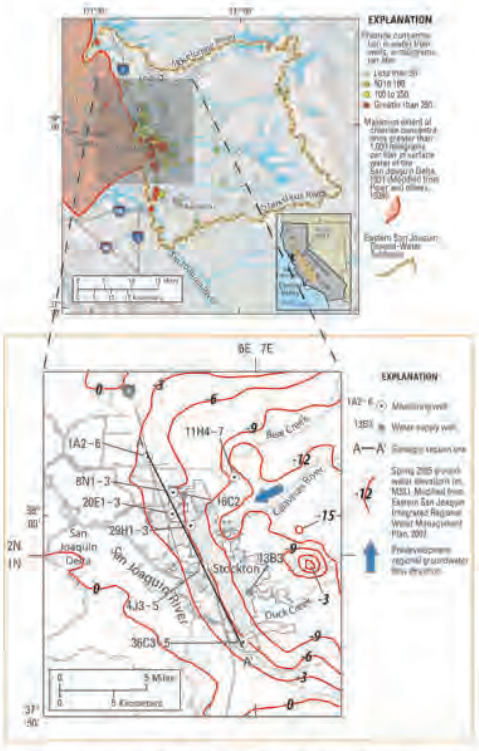

Figure 1. Location of the study area in the Eastern San Joaquin Groundwater Subbasin, near Stockton, California.

study (Clark et al. in review) and during previous work (California Department of Water Resources 2003). EM logs collected from PVC-cased wells provide an opportunity to supplement traditional hydrologic data collected from wells by assessing changes in groundwater quality in intervals not screened by wells. The monitoring wells installed for this study consisted of multiple wells installed in a single borehole. The individual wells were perforated over small intervals to provide depth-dependent data; as a consequence of this design, large portions of the aquifer system are not sampled by wells. For example, the multiple-well site 2N/5E-1A2-6, drilled to a depth of more than 300 m below land surface (bls), contains five wells in a single borehole having a combined screen length of 27 m. This multiple-well site samples less than 10% of the aquifer, leaving groundwater quality in more than 90% of the aquifer unmeasured. Although much of the unmeasured aquifer was composed of fine-grained deposits that were less suitable for well installation, the wells at the site may not adequately monitor groundwater quality in all the intervals contributing to the increasing chloride concentrations in production wells in the subbasin. Collection of sequential EM logs, in conjunction with conventional water quality sampling from wells, provides a way to evaluate the vertical distribution of groundwater quality throughout the entire aquifer encountered by the deepest PVC-cased monitoring well at each site.

The basis for EM logging is the relationship between geologic materials, fluid conductivity, and electrical resistivity (Archie 1942; McNeil 1980; Biella et al. 1983; Kwader 1985). EM probes are more sensitive when bulk aquifer resistivity is low and less sensitive when the aquifer resistivity is high; therefore, EM logging is best suited for use in aquifers intruded by sea water or other strong brines that provide a large resistivity contrast with aquifer materials (Keys 1990). The tool sensitivity was initially believed to limit the practical application of EM tools for field studies. In most cases, the EM properties of the aquifer materials are unknown or uncertain; however, aquifer lithology remains constant through time (neglecting possible changes caused by subsidence). Therefore, changes in bulk EM resistivity measured during sequential EM logging of wells can only be caused by changes in groundwater quality (Williams et al. 1993). Collection of sequential EM logs in a well over time eliminates the uncertainty associated with the estimation of the EM properties of aquifer materials and can provide an estimate of the relative changes in groundwater quality with time.

One of the first applications of EM logs from PVC-cased boreholes was by Stewart and Hermeston (1990) in the upper Floridian Aquifer along the central west coast of Florida. Stewart and Hermeston (1990) demonstrated that EM logs could be used to estimate pore-fluid conductivity and the extent of sea water intrusion in karstic aquifers. They also demonstrated that EM logs could be reproduced with the high degree of precision needed to allow direct comparison of changes in pore-fluid composition through time (Stewart 1999). The approach was combined with a wide range of advanced borehole geophysical methods and extended to determining the extent and movement of sea water intrusion in marine deposits underlying Long Island (Stumm 1993, 2001), and for saline water in Florida (Paillet et al. 1999). Hanson (2003) and Land et al. (2004) combined the approach with geochemical data and extended the technique to alluvial aquifers impacted by sea water intrusion in central and southern California. In the California studies, predictive relations were developed between measured bulk EM resistivity from boreholes and pore-fluid conductance in water from observation wells. Land et al. (2004) used this relation to determine the extent of the sea water intrusion front and the presence of fresh water injected by wells used to form a barrier to control the landward movement of sea water.

Most of the published applications of EM logs involve estimating changes in water quality resulting from the direct movement of sea water into fresh water aquifers. Sea water is highly saline, having a chloride concentration of 19,000 mg/L, and provides a large resistivity contrast with native fresh water. In contrast, alluvial deposits in the Eastern San Joaquin Groundwater Subbasin are not directly connected to the ocean. The principal sources of high-chloride water in the subbasin include lateral movement of saline water from delta deposits along the

San Joaquin River, or upward migration of saline water from the underlying saline aquifers. The chloride concentrations of these sources are less than sea water, typically about 3000 mg/L (Izbicki et al. 2006). Movement of groundwater through alluvial deposits, such as those found in the study area, occurs through coarse-grained sands and gravels deposited by streams and rivers. As a consequence, specific depth intervals having high-chloride water may be difficult to identify. Because the resistivity contrast between high-chloride water from the San Joaquin Delta and other sources, and that of the native fresh water is much less than the contrast between fresh water and sea water, conventional analysis of EM borehole logs needs to be refined to understand the distribution and movement of high-chloride water to wells in this setting.

Purpose and Scope

The purpose of this study is to relate changes in the bulk EM properties of formation materials and pore fluids to changes in chloride concentrations in selected wells in the Eastern San Joaquin Groundwater Subbasin, near Stockton California. The scope of the study included collection of EM induction logs and water quality data from seven multiple-well monitoring sites in the Stockton area during July 2004 through September 2007.

Hydrogeology

The Eastern San Joaquin Groundwater Subbasin is about 2860 km^2 (California Department of Water Resources 2006) and is part of the larger San Joaquin Groundwater Basin that forms the southern two-thirds of the Central Valley of California. The climate is characterized by hot, dry summers, and cool, moist winters. Average annual precipitation in Stockton averages about 350 mm and falls primarily during the November through March rainy season (National Climatic Data Center 2007). During the years of this study, 2004 through 2007, annual precipitation was close to average with the exception of 2007 when only 60% of normal precipitation was recorded. Precipitation is greater in the Sierra Nevada to the east of the study area. Runoff from the Sierra Nevada, primarily as snowmelt, sustains flows in the Mokelumne and Stanislaus Rivers that bound the study area to the north and south, respectively. The San Joaquin River, which drains the San Joaquin Valley to the south, bounds the study area to the west, and the foothills of the Sierra Nevada bound the study area to the east (Figure 1).

The Eastern Jan Joaquin Groundwater Subbasin is underlain by 150 to 300 m of consolidated, partly consolidated, and unconsolidated sedimentary deposits that form the principal fresh water aquifer system (California Department of Water Resources 1967). These deposits consist of alluvial-fan deposits eroded from the Sierra Nevada and its foothills, and delta deposits along the San Joaquin River. The alluvial-fan deposits are pumped extensively for water supply. Volcanic deposits underlie the sedimentary deposits throughout the subbasin and separate the fresh water aquifer from underlying marine deposits. The volcanic deposits consist of andesitic tuffs and lahars (Curtis 1954) blanketed by a layer of alluvium eroded from these deposits (California Department of Water Resources 1967) that are collectively known as the Mehrten Formation. The underlying marine deposits contain fresh water near the mountain front, but contain saline water in most parts of the subbasin.

Prior to the development of groundwater for agriculture during the later half of the 19th century, regional groundwater flow was generally from northeast to southwest (Figure 1). Under steady-state conditions, groundwater flowed from recharge areas along the margin of the San Joaquin Valley toward topographically low areas along the San Joaquin River and the delta (Williamson et al. 1989). As a result of groundwater development, pumping in excess of recharge led to the formation of a cone of depression centered to the east of Stockton (Figure 1). Present-day groundwater-level elevations in much of the study area are below sea-level and groundwater flow is from the delta toward Stockton (Northeast San Joaquin County Groundwater Banking Authority 2007).

Groundwater recharge to the subbasin is estimated to average about 111×10^7 m^3/year (CDM Inc. 2001). Pumping for municipal and agriculture supplies in 2000 was estimated to exceed recharge by 18.5×10^7 m^3/year (CDM Inc. 2001). In 2000, the subbasin had a population of about 580,000 (CDM Inc. 2001) and the population is expected to increase to more than 1.2 million by 2040 (CDM Inc. 2001). Pumping is expected to increase with increasing population, potentially resulting in greater overdraft.

Chloride concentrations have increased in a number of water-supply wells in the Stockton area. For example, chloride concentrations in water from water-supply well 1N/6E-13B3, located about 3 km north of multiple-well site (1N/6E-36C3-5) have increased from 26 mg/L in 1970 to 567 mg/L as of 2006, more than two times the 250-mg/L SMCL for chloride (U.S. EPA 2008). In comparison, chloride concentrations in other public-supply wells, such as 2N/6E-16C2, have increased, but at a slower rate—from 32 to 64 mg/L in the same time period (Figure 2).

Under predevelopment conditions, prior to the construction of reservoirs on rivers tributary to the San Joaquin River Delta, sea water intruded the delta during low-flow periods resulting in chloride concentrations as high as 1000 mg/L in the San Joaquin River near Stockton (Piper et al. 1939). Under present-day conditions, surface flows are managed to prevent the inland movement of sea water and to protect fresh water resources in the delta. However, high-chloride water trapped in delta sediments may intrude fresh water aquifers. Constituents dissolved within this water may retain a chemical composition consistent with a sea water origin (Izbicki et al. 2006). High-chloride water may also originate from soluble salts emplaced in delta sediments from evaporation of groundwater discharge along the delta margin (Izbicki et al. 2006). Constituents dissolved within this

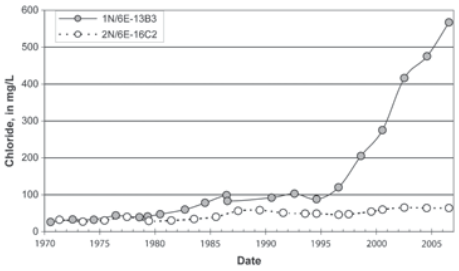

Figure 2. Chloride concentrations in samples from wells 1N/6E-13B3 and 2N/6E-16C2, Stockton, California, 1970 through 2007.

water would have a chemical composition different from sea water. Water from deeper aquifers that underlie fresh water aquifers pumped for supply also has a markedly different chemical composition and may contribute high-chloride water to wells in different parts of the subbasin (Izbicki et al. 2006). In addition, irrigation return may increase chloride concentrations near the water table. To further complicate the issue, multiple sources of high-chloride water may occur at the same location but at different depths within the aquifer (Izbicki et al. 2006).

Approach

Sequential EM logs were collected from the deepest accessible well at seven multiple-well sites in the study area between July 2004 and October 2007 (Table 1). EM log data were compared with lithologic and geophysical data collected from the wells during test drilling. EM log data were also compared with chloride and specific conductance data collected concurrently with EM logging from each well at all seven sites during the study period. In addition, EM log data were compared with chloride

Table 1
Well Construction Data and Dates of EM Induction Log Collection for Selected Multiple-Well Sites, Near Stockton, California

Site[1]	State Well Number	Local Name	Date Drilled	Depth Cased (m)	Screened Interval Depths (m)	Available EM Induction Data
Victory	1N/6E-4J3	STK4-1	9/16/2005	170.7	164.6–170.7	9/13/2005, 1/26/2006, 3/30/2007, 9/24/2007
	1N/6E-4J4	STK4-2		109.7	103.6–109.7	
	1N/6E-4J5	STK4-3		67.1	61.0–67.1	
Sperry	1N/6E-36C3	MW-1	5/10/2002	141.7	134.1–140.2	5/6/2002, 7/15/2004, 1/26/2006, 3/29/2007, 9/24/2007
	1N/6E-36C4	MW-2	5/15/2002	96.6	79.9–86.0, 92.0–95.1	
	1N/6E-36C5	MW-3	5/16/2002	39.3	34.7–37.8	
Oak Grove	2N/5E-1A2	STK1-1	5/6/2005	268.2	262.1–268.2	5/3/2005, 1/24/2006, 4/10/2007, 9/25/2007
	2N/5E-1A3	STK1-2		164.6	158.5–164.6	
	2N/5E-1A4	STK1-3		115.8	109.7–115.8	
	2N/5E-1A5	STK1-4		73.2	67.1–73.2	
	2N/5E-1A6	STK1-5		20.7	17.7–20.7	
Sandman	2N/6E-8N1	STK5-1	5/16/2006	176.8	170.7–176.8	5/13/2006, 7/13/2006, 4/11/2007, 5/24/2007, 9/26/2007
	2N/6E-8N2	STK5-2		131.1	125.0–131.1	
	2N/6E-8N3	STK5-3		70.1	64.0–70.1	
Morada	2N/6E-11H4	STK2-1	5/16/2005	193.6	187.4–193.6	5/13/2005, 1/23/2006, 4/10/2007, 9/26/2007
	2N/6E-11H5	STK2-2		164.6	158.5–164.6	
	2N/6E-11H6	STK2-3		91.4	85.3–91.4	
	2N/6E-11H7	STK2-4		67.1	61.0–67.1	
Swenson	2N/6E-20E1	MW-1	5/23/2002	154.5	146.9–153.1	5/20/2002, 7/15/2004, 1/24/2006, 3/28/2007, 9/25/2007
	2N/6E-20E2	MW-2	5/29/2002	97.2	89.6–95.7	
	2N/6E-20E3	MW-3	5/29/2002	63.7	59.1–62.2	
Atherton	2N/6E-29H1	STK6-1	5/26/2006	170.7	164.6–170.7	5/22/2006, 6/20/2006, 4/11/2007, 9/26/2007
	2N/6E-29H2	STK6-2		143.3	137.2–143.3	
	2N/6E-29H3	STK6-3		79.3	73.2–79.2	

[1]The EM-induction logs were generally collected from the deepest well at each multiple-well site.

and specific conductance data from water extracted from core samples collected at the time of drilling by pressure extractions. A statistical relation between EM resistivity and chloride concentration of water from wells and extracted from core material was developed and used to estimate chloride concentrations at multiple-well sites in intervals not screened by wells.

Electromagnetic Induction Log Collection

Electromagnetic induction logs were collected using a Century model 9511 tool (Century Geophysical Corporation, Tulsa, Oklahoma). The tool uses an EM field to induce an electrical current in the surrounding formation (Johnson and Williams 2003). The induced current sets up a secondary magnetic field that is measured, amplified, and then transmitted to the surface as a direct current. The magnitude of the direct current is proportional to the electrical conductivity of the formation, which is a function of lithology and pore-fluid conductivity (Keys 1990; Paillet et al. 1999). The volume of the material measured by a typical EM logging tool is a donut-shaped torus (Geonics, Inc. 2005; Century Geophysical Corp. 2008). The size of the torus is dependent upon the coil spacing within the tool. The inner and outer diameters of the torus measured by the Century 9511 tool range approximately from 46 to 127 cm, respectively (Century Geophysical Corp. 2008). As a consequence, the tool is relatively insensitive to borehole fill material adjacent to the well (McNeill et al. 1990).

Additional measured parameters include fluid conductivity in mmho/m, corrected for temperature and skin effects, and natural gamma in API (American Petroleum Institute) units. Resistivity (ohm-m) is automatically calculated from measured conductivity. Because aquifer lithology remains constant, repeat EM logs collected from a PVC-cased well can be used to measure changes in pore-fluid conductivity with time. The range of conductivity that can be measured is 0 to 1000 mmho/m (resistivity 500 to 1 ohm-m) with an accuracy of ±5 mmho/m over the entire range (B. Petersen, Century Geophysical Corporation, oral communication, 2008).

Electromagnetic induction measurements may be affected by borehole size (including wash-outs during drilling that increase borehole diameter), metallic minerals, and well construction components such as centralizers (Century Geophysical Corp. 2008). Metal centralizers installed at 9- to 18-m intervals during construction of wells 1N/6E-36C3 and 2N/6E-20E1 created interference over approximately 15% of the depth of each well, including the bottom 9 and 6 m, respectively. These intervals of poor-quality data were omitted prior to data processing and analysis of the EM logs.

Calibration and operation of the EM tool was carried out according to the manufacturer's guidelines in an effort to ensure repeatability between sequential logs at each site. Calibration was checked at each site prior to logging by using a two-point calibration technique. Suspending the tool in air upside down, induction values were alternately checked using free air as a zero value and a calibration-ring sleeve, placed over the bottom end of the inverted tool. The calibration ring is manufactured to have a value of 705 mmho/m. Tool adjustment is required if the induction values exceed 10% of the factory calibration (Century Geophysical Corp. 2008). At sites where signal interference from nearby cultural artifacts (overhead power lines, metal fences, underground utilities) made recalibration difficult or impossible, the existing calibration values from previous logs were retained.

Wells were logged in the upward direction, to maintain tension on the draw-works cable, at a speed of about 6 m/min. The deepest well at each of the multiple-well sites was logged three to four times during the course of the study (Table 1), with the exception of multiple-well site 2N/6E-8N1-3, where an obstruction in the well necessitated the use of the second deepest well (2N/6E-8N2) for logging in May and September 2007.

Duplicate logs were collected from well 1N/6E-4J3 in 2006 and from wells 1N/6E-36C3, 2N/6E-8N1, 2N/6E-8N2, and 2N/6E-20E1 in 2007 to verify the repeatability of measurements. The precision of these duplicate logs as indicated by R^2 and coefficient of variance ranged from 0.993 to 0.997 and from 2.32 to 4.46, respectively. As an example, duplicate logs for well 1N/6E-36C3 (Figure 3) indicate good agreement with an R^2 value of 0.996 and a coefficient of variance of 2.86. The logs show higher variability at higher resistivity and less variability (greater precision) at lower resistivity (Figure 3), typical of EM induction logs data described by Keys (1990). However, the variability at higher resistivity is not so great as to preclude the use of the EM tool in the study area.

Results

Electromagnetic resistivity in logged wells ranged from 2.5 to 50 ohm-m. In general, EM resistivity was lower in fine-grained deposits and higher in coarser-grained deposits consistent with the properties of these materials (McNeil 1980; Biella et al. 1983; Kwader 1985; McNeil et al. 1990). Regardless of lithology, EM

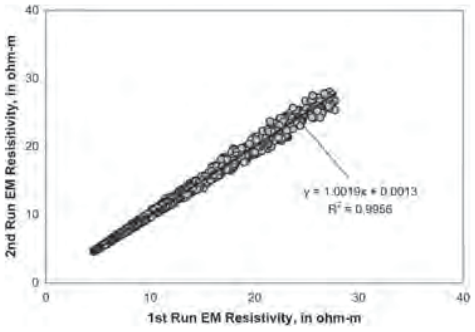

Figure 3. Electromagnetic resistivity data for duplicate logs from well 1N/6E-36C3, Stockton, California, March 2007.

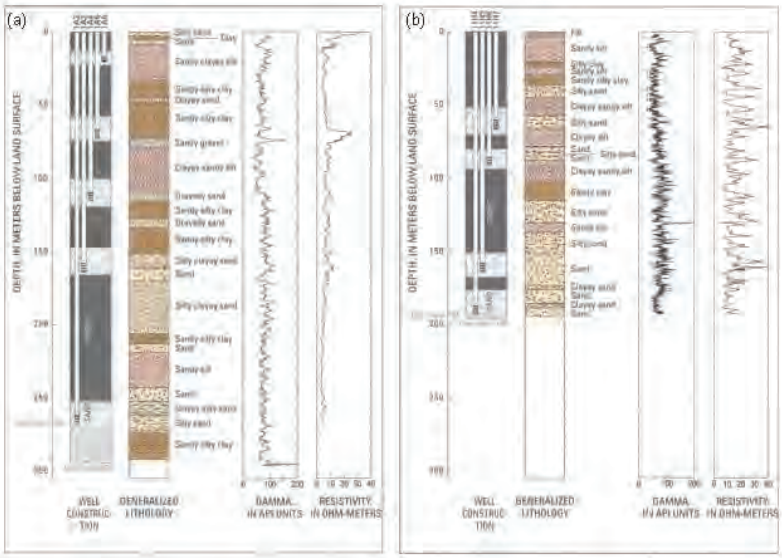

Figure 4. Well construction, generalized lithology, natural gamma, and EM resistivity logs (September 2007) for multiple-well sites (a) 2N/5E-1A2-6 and (b) 2N/6E-11H4-7, near Stockton, California.

resistivity was less in multiple-well site 2N/5E-1A2-6 closest to the delta and higher in multiple-well site 2N/6E-11H4-7 farthest from the delta (Figure 4). EM logs and dates of collection are listed in Table 1.

Chloride concentrations in 24 wells sampled between April 2004 and March 2007 ranged from 4 to 2050 mg/L (Table 2). The highest chloride concentrations were in water from wells at multiple-well site 2N/5E-1A2-6 closest to the San Joaquin Delta. The lowest chloride concentrations were in water from wells at multiple-well site 2N/6E-11H4-7. During the study period, samples from 9 of 24 wells showed increasing chloride concentrations, 12 wells showed decreasing chloride concentrations, and 3 wells showed almost no change (Table 2). The comparatively large number of wells with no change, or decreased chloride concentrations, may result from groundwater management practices, including pumping restrictions and artificial recharge, intended to control the movement of high-chloride water from the delta.

Chloride concentrations in eight samples of water pressure-extracted from core material using methods described by Manheim et al. (1994) ranged from 28 to 3590 mg/L (Table 3). The highest chloride concentrations were in core material collected from multiple-well site 2N/5E-1A2-6 and from an adjacent test boring drilled in July 2007 after installation of the original site. Core material was collected from finer-grained deposits rather than from the sand and gravel layers screened by wells, and provided for the range in geologic materials necessary for incorporating lithology into equations relating EM resistivity to chloride concentrations and specific conductivity of groundwater.

Discussion

EM logs were analyzed to determine depth intervals within the aquifer where changes in water quality occurred by comparing logs collected from the same well at different times. For these logs, the percent change between measurements for data collected at the same depth was calculated and plotted as a function of well depth. A percent change greater than ±1 standard deviation was used to identify depth intervals where the EM resistivity increased or decreased between collections of the logs. This approach is illustrated for data from well 2N/5E-1A2 (Figure 5).

Changes in EM resistivity identified within wells in the study area occurred in thin intervals, ranging from 1 to 7 m in thickness (Table 4). Lithologic data collected during drilling show that these intervals were generally coarser grained, and presumably have higher hydraulic conductivities than the surrounding finer-grained zones. Changes in EM resistivity, and therefore changes in groundwater quality, were measured both in intervals sampled by wells and in intervals not sampled by wells (Table 4). The unsampled intervals represent as much as 90% of the alluvial deposits encountered at each site.

Multiple-well sites 2N/5E-1A2-6 and 2N/6E-8N1-3 (Table 4) had the greatest number of depth intervals with decreasing EM resistivity during 2004 through 2007. These sites are closer to the San Joaquin Delta (Figure 1). Production wells located east of these monitoring wells may be inducing the lateral movement of high-chloride water from the delta. In contrast, depth intervals showing increasing resistivity (freshening water quality) occurred at one or more depth intervals at all seven multiple-well

Table 2
Chloride Concentrations in Water from Wells at Selected Multiple-Well Sites, Stockton, California, 2004 to 2007

Site	State Well Number	Screened Interval (m blsd)	Chloride (mg/L)								Overall Chloride Change (%)
			Spring 2004	Spring 2005	Winter 2006	Spring 2006	Summer 2006	Winter 2007	Spring 2007	Fall 2007	
Victory	1N/6E-4J3	164.6–170.7	—	—	292	—	310	—	305	311	6.5
	1N/6E-4J4	103.6–109.7	—	—	506	—	487	—	367	340	–32.8
	1N/6E-4J5	61.0–67.1	—	—	123	—	63.0	—	60.2	62.4	–49.3
Sperry	1N/6E-36C3	134.1–140.2	165	—	—	—	—	—	111	163	–1.2
	1N/6E-36C4	79.9–95.1[1]	22.4	—	—	—	—	—	22.4	20.8	–7.4
	1N/6E-36C5	34.7–37.8	20.2	—	—	—	—	—	18.0	18.2	–9.9
Oak Grove	2N/5E-1A2	262.1–268.2	—	1730	—	—	1820	—	1820	1940	12.1
	2N/5E-1A3	158.5–164.6	—	626	—	—	580	—	591	596	–4.8
	2N/5E-1A4	109.7–115.8	—	962	—	—	932	—	929	962	0.0
	2N/5E-1A5	67.1–73.2	—	547	—	—	551	—	538	627	14.6
	2N/5E-1A6	17.7–20.7	—	1840	—	—	1900	—	1970	2050	11.4
Sandman	2N/6E-8N1	170.7–176.8	—	—	—	—	112	—	158	112	0.0
	2N/6E-8N2	125.0–131.1	—	—	—	—	37.7	—	34.6	34.5	–8.5
	2N/6E-8N3	64.0–70.1	—	—	—	—	19.9	—	19.1	18.1	–9.0
Morada	2N/6E-11B4	187.5–193.6	—	10.0	—	11[2]	11[2]	12[2]	12[2]	—	20
	2N/6E-11B5	158.5–164.6	—	5.6	—	6[2]	5[2]	5[2]	5[2]	—	–11
	2N/6E-11B6	85.4–91.5	—	8.8	—	9[2]	7[2]	8[2]	9[2]	—	2
	2N/6E-11H7	61.0–67.1	—	3.9	—	5[2]	5[2]	5[2]	5[2]	—	28
Swenson	2N/6E-20E1	146.9–153.0	60.4	—	—	—	—	—	60.0	59.9	–0.8
	2N/6E-20E2	89.6–95.7	28.9	—	—	—	—	—	27.2	25.8	–10.7
	2N/6E-20E3	59.1–62.2	10.0	—	—	—	—	—	9.5	10.7	7.0
Atherton	2N/6E-29H1	164.6–170.7					38.1			38.5	1.0
	2N/6E-29H2	137.2–143.3					13.5			12.7	5.9
	2N/6E-29H3	73.2–79.2					5.6			5.4	3.6

Note: blsd = below land-surface datum.
[1]Two separate screens at 79.9–86.0 and 92.0–95.1 m.
[2]Samples collected and analyzed by California Department of Water Resources (CADWR).

Table 3
Chloride Concentrations in Water Pressure Extracted from Core Material Collected During Drilling, Near Stockton, California, April 2005–July 2006

Site	State Well Number	Chloride (mg/L)		
		Core Sample Depth[1] (m blsd)	Spring 2005	Summer 2006
Oak Grove	2N/5E-1A2-6	15.2	—	3590, 1120[2]
		15.7	—	2400
		22.9	1270	—
		294.4	490	—
Sandman	2N/6E-8N1-3	16.9	—	51.4
		186.8	—	142
Atherton	2N/6E-29H1-3	18.9	—	28.1
		188.4	—	47.2

Notes: mg/L, milligrams per liter; blsd, below land-surface datum.
[1]Depths listed represent bottom of generally less than 1 m cores.
[2]Second sample.

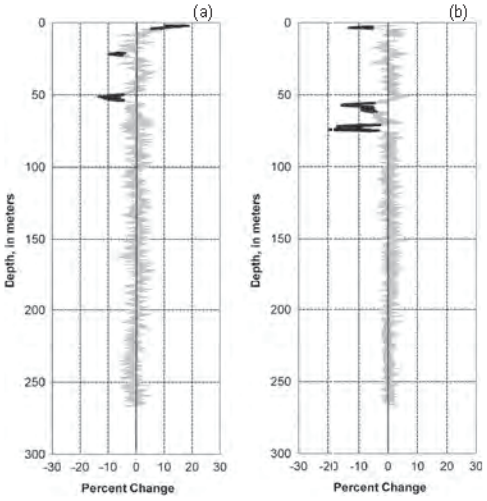

Figure 5. Percent change in electromagnetic resistivity with depth for (a) January 2006 to April 2007 and (b) April 2007 to September 2007 from well 2N/5E-1A2, near Stockton, California. Highlighted depth intervals show change greater than 1 standard deviation.

sites (Table 4). The greatest number of depth intervals with increasing resistivity was at multiple-well site 2N/6E-29H1-3. Increasing resistivity at this site may be related to infiltration of water from several nearby unlined man-made lakes. Alternatively, groundwater management and a reduction in pumping in recent years (CDM Inc. 2001) and increased groundwater recharge (O'Leary 2011) could be another explanation for the increasing EM resistivity and improving water quality at some depths in aquifers underling the study area.

Increases in EM resistivity were present at relatively shallow depths less than 30 m bls at multiple-well sites 2N/5E-1A2-6, 2N/6E-11H4-7, and 2N/6E-20E1-3. These increases reflect seasonal water-level fluctuations rather than changes in groundwater quality. Depth to water at these sites during the course of this study generally ranged from 3 to 25 m bls (Table 4).

No changes were identified in the EM resistivity on the basis of sequential logs below approximately 150 m bls. Most production wells in the area are screened above 150 m bls, and well-bore flow data show that most of water enters these wells at the shallower depths perforated by the wells (Clark et al. in review). These results are consistent with increases in chloride in water from wells originating from the San Joaquin Delta rather than underlying saline aquifer. However, with the exception of well 2N/5E-1A2, none of the other EM-logged wells are greater than 180 m deep, and additional well drilling and monitoring well installation at greater depths would be needed to evaluate changes in EM resistivity and pore-fluid resistivity at these depths.

Comparison Between EM Resistivity, Chloride, and Specific Conductance

Comparison of EM resistivity data with chloride data from monitoring wells showed lower resistivity at depths where higher chloride concentrations were measured. However, data from multiple-well site 2N/5E-1A2-6 collected between spring and fall 2007 (Figure 6) show that the percent change in chloride concentration, rather than the absolute magnitude of the change, creates larger differences in EM resistivity (and conductivity not shown in Figure 6) between the two logs. In this example, the increase in chloride concentration, about 80 mg/L, was similar for each well; however, the percent change in chloride concentration was 4% for well 1A6 and 17% for well 1A5. (Additionally, the EM log data for the interval sampled by well 1A5 show a decrease in resistivity in only the bottom half of the well screen, indicating that high-chloride water was moving through the aquifer in an interval thinner than the 6-m long well screen.) Data

Table 4
Depth Intervals Showing a Net Decrease in Electromagnetic Resistivity Associated with Poorer Water Quality (bold) or a Net Increase in Electromagnetic Resistivity Associated with Improving Water Quality (*italic*), Based on Sequential Electromagnetic Induction Logging at Multiple-Well Monitoring Sites Near Stockton, California 2004–2007

	Oak Grove 2N/5E-1A2-6	Sandman 2N/6E-8N1-3	Morada 2N/6E-11H4-7	Swenson 2N/6E-20E1-3	Atherton 2N/6E-29H1-3	Victory 1N/6E-4J3-5	Sperry 1N/6E-36C3-5
	1.8–4.3	**8.5–10.7**	*11.6–17.4*	*24.1–26.5*	**7.9–14.6**	*63.7–67.1*	**12.2–14.6**
	49.6–54.1	**21.3–24.4**	**18.0–19.8**	*67.1–68.9*	**17.7–18.9**	*104.5–107.3*	**31.7–37.8**
	55.6–61.9	**58.5–59.7**	*43.3–45.4*	*91.7–93.6*	*73.5–75.6*	**116.1–118.0**	*80.8–83.8*
	70.8–75.3	**62.8–70.1**	*110.4–112.5*	**106.7–111.0**	*89.0–91.4*		*84.7–86.6*
		76.5–80.8		**124.1–126.2**	*95.1–96.0*		*92.0–95.4*
		93.9–99.1			*103.6–104.9*		
		110.6–113.4			*126.5–128.3*		
					136.2–142.6		
Total well depth (m)	268.2	176.8	193.6	154.5	170.7	170.7	141.7
Depth-to-water range (m)	3.4–10.0[1]	6.7–11.3[2]	17.1–24.7[3]	6.7–8.8[4]	7.0–11.3[2]	3.0–10.0[5]	9.1–12.5[4]

[1]Overall range for all piezometers based on continuous recording water-level transducers, April 2006 through 2007.
[2]Overall range for all piezometers based on continuous recording water-level transducers, December 2006 through February 2008
[3]Overall range for all piezometers based on continuous recording water-level transducers, January 2006 through 2007.
[4]Overall range for all piezometers based on periodic water-level measurements.
[5]Overall range for all piezometers based on continuous recording water-level transducers, March 2006 through 2007.

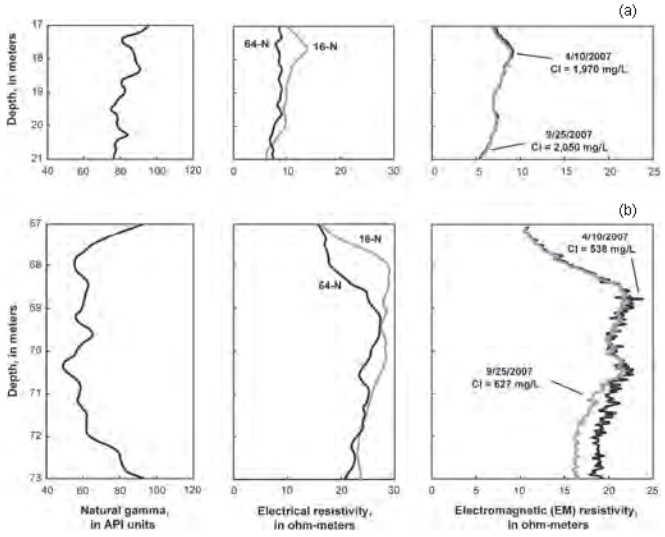

Figure 6. Comparison of natural gamma, electrical resistivity, and electromagnetic resistivity (EM) logs collected April 2007 and September 2007 from (a) well 2N/5E-1A6 and (b) well 2N/5E-1A5, near Stockton, California.

collected as part of this study suggest that a 10 to 15% change in chloride concentration is required to produce a measurable change in EM resistivity (or its inverse conductivity).

A least-squares regression equation was developed to relate changes in EM resistivity to changes in the chloride concentration in water from wells:

$$\text{Log}_{10}\ \text{Cl} = 4.36 - 2.12\ \text{log}_{10}\ \text{EM} \qquad (1)$$

where Cl is the chloride concentration in water from screened intervals of wells near the time of the EM log

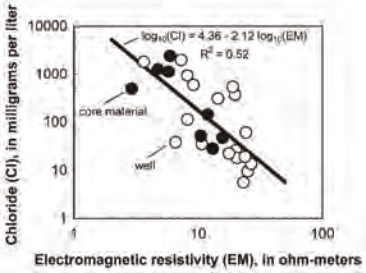

Figure 7. Chloride concentrations in water from monitoring wells (open circles) and water pressure extracted from core material (solid circles) as a function of electromagnetic-log resistivity in wells 2N/5E-1A2-5, 2N/6E-20E1, 1N/6E-4J3-5, and 1N/6E-36C3, near Stockton, California, 2004 through 2007.

and in core material at the time the multiple-well site was drilled in milligrams per liter, and EM is the average electromagnetic resistivity in ohm-meters over the screened interval of the sampled well, typically 6 m, or over the length of the sampled core, typically 0.75 m.

This equation was statistically significant on the basis of the F-test (Neter and Wasserman 1974) with the confidence criteria of $\alpha = 0.001$, and an R^2 of 0.52 (Figure 7).

Examination of the data in Figure 7 shows that the data are not randomly distributed about the regression line. Instead, the higher chloride values tend to plot above the regression line (have positive residuals), whereas the lower chloride values tend to plot below the regression line (have negative residuals). This distribution suggests that there may be additional explanatory variables to be considered that may further refine this relationship.

One variable considered was aquifer lithology, specifically the presence of clay within the deposits. For the purposes of this study, natural gamma was used as an indicator of the amount of clay in the aquifer (Paillet and Crowder 1996). Although not perfect, as the clay content of the materials increases, the natural gamma values increase. When natural gamma (gamma) was incorporated into the equation, the least-squares regression equation became:

$$\text{Log}_{10}\ \text{Cl} = 4.67 - 2.23\ \log_{10}\text{EM} - 0.005\ \text{gamma} \quad (2)$$

This equation was also statistically significant on the basis of the F-test (Neter and Wasserman 1974) with the confidence criteria of $\alpha = 0.001$, and an R^2 of 0.58. The inclusion of natural gamma was statistically significant in this equation on the basis of the F-test with the confidence criterion of $\alpha = 0.1$. When specific conductance was the predicted variable, the R^2 increased to 0.61.

Equation 2 was used to estimate pore-fluid concentrations in the aquifer at the multiple-well sites (Figure 8). The uncertainty associated with the predicted pore-fluid chloride concentrations was evaluated as the $\pm 2\sigma$ uncertainty associated with the gamma term that ranged from −0.01 to 0 (Figure 8). Given the comparatively low R^2 of 0.58 associated with the equation, calculated pore-fluid chloride concentrations are best interpreted in a relative sense rather than in terms of absolute numbers.

The calculated pore-fluid data show higher chloride concentrations in fine-grained materials than in the coarser-grained materials screened by wells. This is consistent with the hypothesis that much of the high-chloride water in the aquifer originated from salt-affected delta deposits. Equation 2 overpredicts chloride concentrations for the pore-fluids squeezed from core material that had chloride concentration less than 100 mg/L and underpredicts chloride concentrations for cores with chloride concentrations greater than 100 mg/L (Figures 7 and 8). However, the equation correctly estimated the low-chloride concentrations in water from multiple-well site 2N/6E-11H4-7 farthest from the delta.

Hydrogeologic Implications

Geologic section A-A′ shows multiple-well sites drilled as part of this study along a north-south section through the study area (Figures 1 and 9). Natural gamma logs are shown along with predicted (best solution) chloride concentrations in aquifer intervals not sampled by wells. Only about 10% of the aquifer at each multiple-well site was screened by wells leaving the bulk of groundwater in the aquifer unmeasured. Intervals having changing EM resistivity also are shown in Figure 9. An equal number of intervals (16) showed increasing resistivity (freshening water quality) and decreasing resistivity (degrading water quality). Only one-third (11) of the 33 depth intervals identified as having changing EM resistivity coincided either completely or partially with a screened interval.

Decreasing resistivity and predicted increases in chloride concentrations were more prevalent in the northern part of the study area (sites 2N/5E-1A2-6 and 2N/6E-8N1-3), especially between about 50 and 75 m bls (Figure 9). Decreasing resistivity at site 1A2-6 appears to be occurring in intervals already containing high-chloride water. However, decreasing resistivity and predicted increases in chloride concentrations also appear to be occurring in fresher intervals not previously impacted by high-chloride water from the San Joaquin Delta at site 8N1-3. The changes in resistivity and predicted changes in chloride concentrations may be the result of pumping by public-supply wells to the east of these sites.

Increasing EM resistivity and predicted decreases in chloride concentrations at other sites may represent improvements in water quality resulting from management efforts to reduce groundwater overdraft, raise water levels, and reduce the invasion of high-chloride water. However, the intervals interpreted as having decreasing chloride concentrations are primarily in multiple-well sites located near recreational lakes and stormwater detention ponds (multiple-well sites 2N/6E-29H1-3 and 1N/6E-36C3-5, respectively) and may result from local sources of recharge. For example, O'Leary et al. (2011) showed water from a stormflow detention pond used for groundwater recharge in the study area moved as deep as 100 m

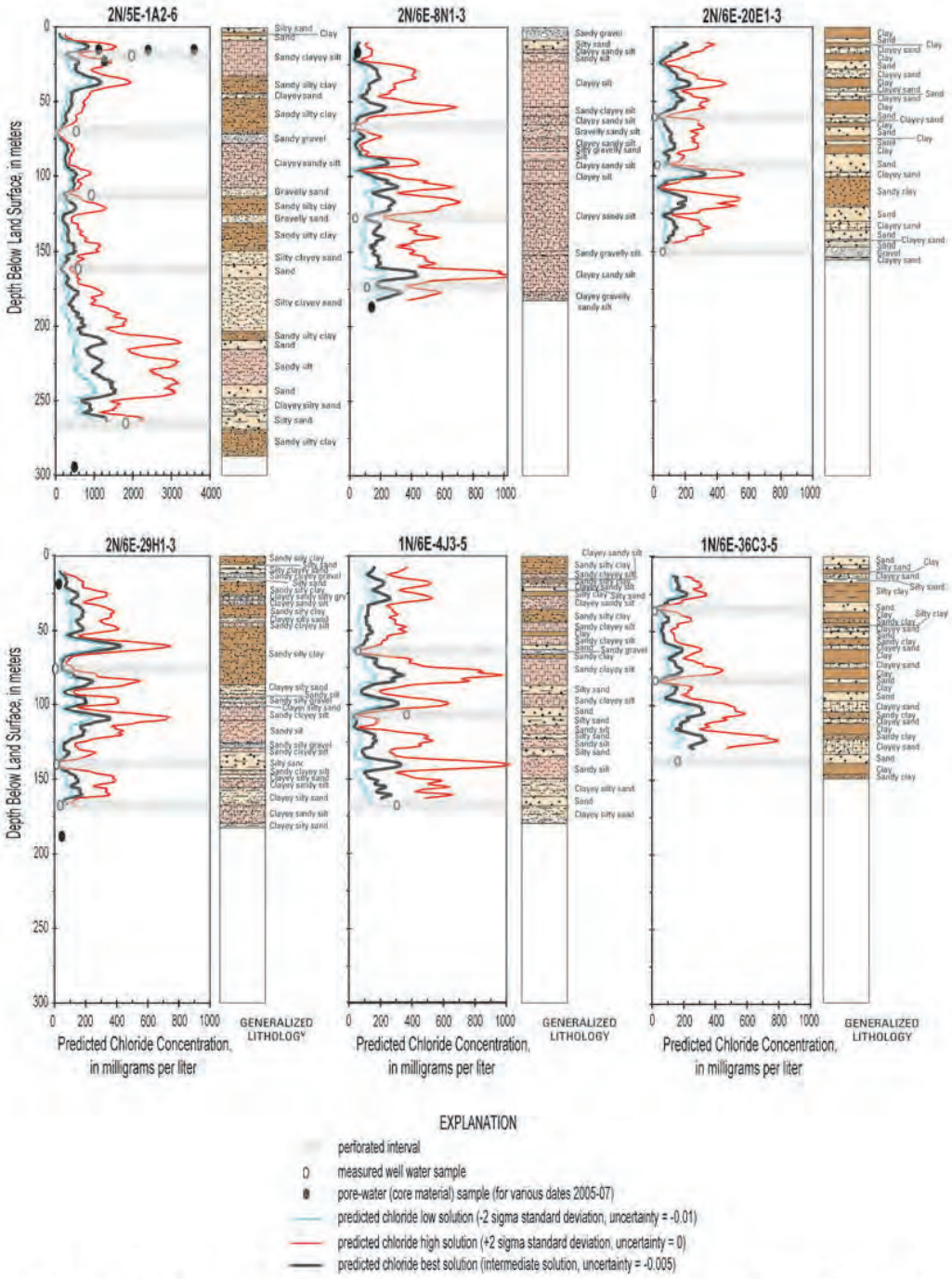

Figure 8. Predicted vs. measured chloride concentrations for selected multiple-well sites, near Stockton, California, spring 2007.

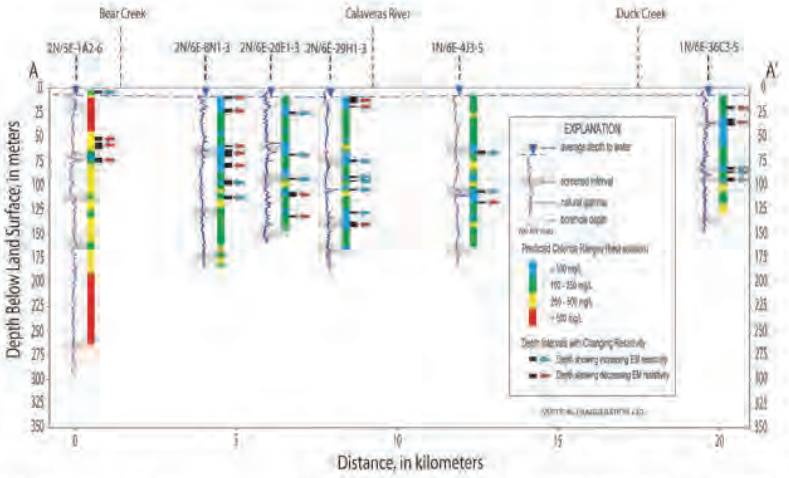

Figure 9. Natural gamma, predicted chloride concentrations, and intervals having changing EM resistivity for selected multiple-well sites along geologic section A-A′ near Stockton, California.

bls within several months of application of sulfur hexafluoride tracer.

Intervals showing decreasing EM resistivity and increasing chloride concentrations are thin, coarser-grained deposits that do not appear to be related to regional changes in subsurface geology or associated basal gravel units that are conduits for sea water intrusion in coastal California aquifers (Nishikawa 1997). These thin, coarse-grained layers may be lenticular stream channel deposits, similar to those described by Burow et al. (2004) in the Modesto area to the south of the study area. Such thin, lenticular units would be difficult to identify using any technique that does not provide continuous data throughout available boreholes. The source of the high-chloride water appears to be saline water trapped within finer-grained deposits associated with the San Joaquin Delta, rather than deeper saline groundwater that underlies fresh water aquifers. Saline water mobilized from fine-grained deposits has been identified as a source of high-chloride water to fresh-water aquifers elsewhere in California (Izbicki 1996; Izbicki et al. 2003). Additional deep monitoring sites may need to be constructed to assess contributions from deeper sources.

Summary and Conclusions

Previous studies have used EM logging to assess the movement of sea water into fresh water aquifers. The Eastern San Joaquin Groundwater Subbasin is not affected by sea water intrusion directly from the ocean, but rather by the movement of saline water from the San Joaquin Delta and underlying saline aquifers. The area provided a setting for testing EM logging techniques to assess changes in pore-fluid composition under lower salinity conditions than those evaluated in most previous studies.

Results of this study suggest that sequential EM logging may be a useful screening tool for detecting the early onset of increasing chloride concentrations. This is because changes in logs collected sequentially through time show small magnitude changes in 1- to 7-m-thick thin aquifer layers that are associated with increasing chloride concentrations. The data show that EM induction logs can be used to identify brine invasion before concentrations reach levels of concern for groundwater management. The results of this study also suggest that this technique can be used to identify the movement of brines having lower salinities and chloride concentrations than sea water. These data may serve as an early warning monitoring technique that is useful for detecting the initial changes in groundwater quality resulting from brine invasion or from sea water intrusion.

Sequential EM logging is uniquely suited for monitoring the unscreened portion of wells within an aquifer. In this study, approximately 90% of the aquifer at each multiple-well site was unscreened. EM logging can provide a continuous profile of changes in groundwater quality within an aquifer penetrated by a PVC-cased well, thereby permitting the identification of zones of poor-quality water that may otherwise be missed by traditional water quality sampling from wells.

At present, EM logs are best used qualitatively to compare sequential changes in groundwater quality at a single well location through time. However, an equation relating chloride concentration with EM resistivity and natural gamma (as a surrogate for aquifer lithology) enabled the estimation of chloride concentrations within the aquifer. The inclusion of natural gamma in the regression equation was possible because chloride concentrations in water from pressure extracts from fine-grained core material composed of silts and clays were available.

Chloride concentrations in water from wells are typically from coarser-grained sands and gravels that yield water to wells and the pressure-extract data were from finer-grained intervals not normally screened by wells.

The comparatively low R^2 of the equations presented in this study limits their use for quantitative analysis. However, improvements in study design that result in improved data collection and analysis may result in increased predictive power and increasing the quantitative analysis of EM log data in settings where sufficient data are available.

Improvements in study design for EM data collection and interpretation include the following. First, monitoring wells can be constructed with at least 3 m of blank casing between the end of the well casing and the bottom of the well screen to facilitate access for the EM induction tool through the entire screened interval of the well. Second, water sampling and induction logging should be carried out at the same time to minimize variability in the data and improve the relation between measured chloride concentrations and EM resistivity. Finally, scheduling for sampling and sequential logging should also take into consideration the time of year and factors such as groundwater pumping cycles, to enable long-term trends to be distinguished from seasonal variations in chloride concentrations and EM resistivity.

Acknowledgments

This study is part of larger study to quantify the sources, areal extent, and vertical distribution of high-chloride water to wells in the Eastern San Joaquin Groundwater Subbasin. Funding was provided cooperatively by the Northeastern San Joaquin Groundwater Banking Authority and the California Department of Water Resources. The authors thank local agencies for access to wells for sample collection and EM logging. The authors also thank Brandon Nakagawa of the Northeastern San Joaquin Groundwater Banking Authority, Anthony Tovar of the City of Stockton, and Tanya Meeth of the California Department of Water Resources for logistical and technical support during this study. The authors also thank the cooperators, U.S. Geological Survey, and journal reviewers for their comments and assistance in the preparation of the manuscript, especially Dr. Fred Paillet for his comments during review.

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CHAPTER 6 – PROJECTS AND MANAGEMENT ACTIONS
Groundwater Sustainability Plan
for the Marina GSA Area
of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, California

JANUARY 2020

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6 PROJECTS AND MANAGEMENT ACTIONS

Regulation Requirements:

§354.42 Introduction to Projects and Management Actions. This Subarticle describes the criteria for projects and management actions to be included in a Plan to meet the sustainability goal for the basin in a manner that can be maintained over the planning and implementation horizon.

§354.44(a) Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.

(b) Each Plan shall include a description of the projects and management actions that include the following:

(1) A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:

(A) A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.

(B) The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.

(2) If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.

(3) A summary of the permitting and regulatory process required for each project and management action.

(4) The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.

(5) An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.

(6) An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.

(7) A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.

(8) A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.

(9) A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.

(c) Projects and management actions shall be supported by best available information and best available science.

(d) An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.

6.1 INTRODUCTION

The 180/400 Foot Aquifer Subbasin (Subbasin) is subject to ongoing seawater intrusion due largely to long-term groundwater extraction in the inland portions of the Subbasin in excess of the sustainable yield. As a result, it has been identified by California Department of Water Resources (DWR) as being one of 21 basins in a condition of critical overdraft (DWR 2016a). Seawater intrusion was first identified in the area of Marina Groundwater Sustainability Agency (the MGSA Area) in the 1940s, and over the following decades progressed inland for a distance of over 7 miles in some areas. The purpose of this GSP is to support regional efforts to address this condition and return the Subbasin to sustainable groundwater management within 20 years, as required by the Sustainable Groundwater Management

Act (SGMA). MGSA will achieve this by supporting the projects and management actions that will be implemented by Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) under its regional Groundwater Sustainability Plan (GSP), and by assuring that local groundwater resources are managed sustainably to protect local and regional beneficial uses and users.

This chapter describes management actions that will be implemented by MGSA to assure sustainable groundwater management in the MGSA Area and prevent undesirable results. MGSA has not identified any feasible projects within the MGSA Area to promote sustainable groundwater management at this time, but will continue to evaluate potential projects. In addition, MGSA will consult and coordinate with SVBGSA and/or MCWD GSA to identify and support implementation of such projects in the future, as appropriate. Also included in this chapter is a brief description of SVBGSA projects and management actions for the Subbasin, some of which would provide regional benefits which include the MGSA Area and vicinity. MGSA will coordinate with and support SVBGSA in the implementation of projects and management actions it has determined to be locally and regionally beneficial, but they are not adopted and will not be implemented under this GSP. Additional details on SVBGSA's projects and management actions can be found in Chapter 9 of their GSP for the Subbasin (SVBGSA 2019).

6.2 MGSA MANAGEMENT ACTIONS

In this GSP, the term "groundwater management actions" refers to activities that prevent undesirable results and promote sustainable groundwater management that do not require infrastructure or capital improvements. They include, among other things, the exercise of the powers and authorities set forth in Chapter 5 of SGMA, California Water Code (CWC) §§ 10725-10726.9. Management actions will be implemented based on an objective system of pre-established monitoring triggers in order to respond to potentially adverse conditions and prevent undesirable results as defined in Chapter 4. MGSA's management actions are described below.

6.2.1 MGSA MANAGEMENT ACTION 1: MANAGEMENT OF SEAWATER INTRUSION AND GROUNDWATER QUALITY DEGRADATION

6.2.1.1 DESCRIPTION

In the vicinity of the MGSA Area, the undesirable results of seawater intrusion, water quality degradation and groundwater level decline are related. Each is a function of the MGSA Area's setting on the seaward side of the interface between a dense saline water intrusion wedge and an over-riding zone of low-total dissolved solids (TDS) groundwater (< 3,000 milligrams per liter [mg/L] TDS) that is locally recharged through the Dune Sand Aquifer. Groundwater extraction in the MGSA Area has the potential to affect the dynamic equilibrium of this nearshore groundwater system and cause seawater intrusion through the migration of the saline water wedge, which could in turn lead to further seawater intrusion into the Dune Sand Aquifer, vertical seawater intrusion into the currently unintruded Deep Aquifer, or promote the lateral migration or persistence of seawater intrusion farther inland. Groundwater

extraction could also lead to water quality degradation in the low-TDS groundwater zone by causing mixing of saline and low-TDS groundwater.

As described in Chapter 5, MGSA will monitor and evaluate the potential for groundwater elevation and water quality changes that are indicative of the above undesirable results. If the data indicate that the triggers associated with the above undesirable results and included in this chapter may be reached as a result of these groundwater extractions, then MGSA will implement a series of escalating management actions. These management actions will include the following three general phases, with the progression between each phase set by a sequence of objective decision triggers:

(1) Detection Monitoring;

(2) Investigation, Verification and Hydrogeologic Conceptual Model Update; and

(3) Characterization, Response Action Planning and Implementation.

The components of Management Action 1 are shown graphically in Figure 6-1, and may be summarized as follows. The Detection Monitoring phase presents the first tier of triggers that are specific to detecting groundwater quality degradation and related proxies for seawater intrusion, water quality degradation and low-TDS groundwater storage depletion at an early stage. Management Action 1 will be implemented if any of the following Tier 1 Trigger Thresholds are reached or exceeded:

- Trigger A - For seawater intrusion into the Dune Sand Aquifer:
    - A decrease in the thickness of the low TDS zone of more than 5 feet (considering seasonal variability) identified by induction logging three or more wells in the induction logging monitoring well network; or
    - An increase in the thickness of the saline groundwater wedge of more than 5 feet identified by induction logging in three or more deep monitoring wells in the induction monitoring well network; and
    - A spatial distribution of groundwater level decline that indicates the logged changes identified above occur within the zone of drawdown influence of groundwater extraction in the MGSA Area.[1]
- Trigger B - For degradation of groundwater quality in the low-TDS groundwater zone in the Dune Sand Aquifer, 180-Foot Aquifer, 400-Foot Aquifer or Deep Aquifer:
    - A statistically significant ($p < 0.1$) increasing trend in groundwater concentrations of chloride or TDS in three or more wells in the water quality monitoring well network for any one aquifer at the 90% confidence level using an appropriate Mann-Kendall trend test (e.g. Seasonal Mann-Kendall) (US EPA 2009);

[1] This second requirement for the trigger threshold is included because MGSA only has authority to regulate groundwater extractions within its jurisdictional boundaries.

- A statistically significant increase (SSI) above baseline chloride or TDS concentration in three or more wells at the 90% confidence level using an appropriate statistical technique per EPA 2009; and
- A spatial pattern of groundwater level declines that indicates the statistically-significant water quality changes identified above occur within the zone of drawdown influence of groundwater extraction in the MGSA Area.

If Trigger A or B are reached or exceeded, then a Tier 1 Trigger threshold has been reached. Confirmation monitoring will be conducted to confirm that a Tier 1 Trigger event has occurred. If confirmed, a Tier 1 Trigger will either segue the management action into: (a) Tier 2 Investigation, Verification and Hydrogeologic Conceptual Model Updates for the Dune Sand, 180-Foot and 400-Foot Aquifer systems, or (b) if the Tier 1 Trigger event occurred in the Deep Aquifer, directly to the Characterization, Corrective Action Planning and Implementation phase.

The Investigation, Verification and Hydrogeologic Conceptual Model Update phase is in place to conduct additional investigation to determine the need for groundwater management (CWC § 10725.4), specifically, it consists of a focused evaluation to confirm that seawater intrusion or water quality degradation is occurring, and is causing or is likely to cause significant and unreasonable effects. The Investigation, Verification and Hydrogeologic Conceptual Model Updates phase requires updating and refining the three-dimensional Hydrogeologic Conceptual Model with historic and current data sources (e.g., groundwater elevation, groundwater chemistry, geophysical data, etc.), and using two- and three-dimensional quantitative geostatistical techniques to assess if: (a) the low-TDS groundwater zone is thinning over time; (b) the saline groundwater wedge is expanding over time; and/or (c) water quality is degrading in the low-TDS groundwater zone. Evaluations will be data-driven, consisting of space-time geostatistical evaluations and/or plume stability analysis.

If one or more of these three conditions is met, then the management action for the Dune Sand, 180-Foot and 400-Foot Aquifers segues from Phase 2 into the Characterization, Response Action Planning and Implementation phase. The second phase Hydrogeologic Conceptual Model Update will also help identify and localize critical data gaps, uncertainties and risks so they can be considered during planning for characterization and corrective action.

The third phase of MGSA Management Action 1 is Characterization, Response Action Planning and Implementation. The following activities constitute the third phase:

- Alternative cause investigation to confirm that groundwater extractions in the MGSA Area are responsible for causing the effects of concern;
- Further Hydrogeologic Conceptual Model refinement to fill critical data gaps, and groundwater model development;
- Response action evaluation and selection;
- Stakeholder consultation (i.e., SVBGSA, MCWD GSA, Monterey County Water Resources Agency [MCWRA], environmental groups, and others);

- Response action implementation; and
- Monitoring of response action effectiveness.

Alternative cause investigations are necessary to establish the mechanism and function of the observed seawater intrusion, groundwater quality degradation, and/or low-TDS zone storage depletion, and verify they are resulting from groundwater extraction within the MGSA Area. If the cause is due to groundwater extraction within the MGSA Area, then a response action by MGSA and the groundwater extractor is appropriate to prevent or correct undesirable results. Response action identification and implementation will likely require the development of a three-dimensional numerical groundwater model that is capable of simulating seawater intrusion through advective solute transport and density-driven flow (or use of such a model if it has been developed by MCWD GSA, as discussed in Section 4.3). The updated Hydrogeologic Conceptual Model developed during the Investigation, Verification and Hydrogeologic Conceptual Model Update phase will, in part, serve to support the conceptual design and parameterization inputs for constructing or refining the local groundwater model as needed.

The locally refined groundwater model and updated Hydrogeologic Conceptual Model will provide data-driven information to evaluate and select appropriate response action(s), including key design considerations and prediction of future implementation effectiveness and establishment of timetables. During the response action selection process, stakeholders including SVBGSA, MCWD GSA, MCWRA, environmental groups, and other interested parties will be consulted to provide input and coordinate implementation of response actions in their jurisdictional areas. Once implemented, criteria for monitoring action effectiveness will be data-driven and include multiple lines of evidence, such as, for example: (a) evaluating TDS and chloride temporal trend behaviors to see if trends shift from increasing to decreasing or insignificant; (b) determining if TDS/chloride concentrations reach baseline threshold levels and are stable over time; and/or (c) assessing if the TDS/chloride wedge and low-TDS zone thickness and storage become stable and/or improve over time. New Measurable Objectives and Interim Milestones would be established to achieve and maintain the sustainability goals of the GSP.

If the response action does not produce multiple lines of evidence showing the successful mitigation of the seawater intrusion, storage depletion and/or water quality degradation, or the new Measurable Objectives and Interim Milestones are not achieved, then the response action would be amended, re-implemented and monitored until the objectives are achieved. If implementation of the response action does achieve the Measurable Objectives, then a decision will be made to segue the groundwater program back into the first phase (Detection Monitoring). Detection Monitoring would then continue as described in this GSP.

6.2.1.2 Relevant Measurable Objectives

The measurable objectives benefiting from this management action include:

- Groundwater storage reduction measurable objective. Effective response actions would assure that groundwater extraction within the MGSA would occur within the sustainable yield of the basin, without causing undesirable results.

- The seawater intrusion measurable objective. Effective response actions would prevent or reverse further seawater intrusion in the upper aquifer system and return it to stable conditions, and prevent or reverse seawater intrusion advancement into the Deep Aquifer.
- Groundwater quality measurable objective. Effective response actions would prevent or reverse degradation groundwater quality by TDS and chloride in the low-TDS zone of the Dune Sand, 180-Foot and 400-Foot Aquifer, or in the Deep Aquifer, and return it to stable and/or improving trends.

6.2.1.3 Expected Benefits and Evaluation of Benefits

The primary benefit from implementing MGSA Management Action 1 is to avoid undesirable results related to seawater intrusion and groundwater quality degradation, protecting the current and future beneficial uses of groundwater.

6.2.1.4 Circumstances for Implementation

The management action will be implemented depending upon evaluation of monitoring data and if Tier 1 and Tier 2 Trigger Thresholds are reached.

6.2.1.5 Permitting and Regulatory Process

No permitting or regulatory processes are necessary.

6.2.1.6 Implementation Schedule

Implementation will be dependent upon whether Tier 1 and Tier 2 Trigger Thresholds are reached. The Investigation, Verification and Hydrogeologic Conceptual Model Updates phase would take approximately six months to a year to implement, and the Characterization, Corrective Action Planning and Implementation phase would take approximately one to two years to implement, and could continue for a longer period of time if conditions warrant.

6.2.1.7 Estimated Costs

Estimated costs to coordinate implementation are approximately $50,000 per year. Implementation costs would vary depending on the scope of investigation and corrective action, and would be developed prior to implementation and paid or reimbursed by the responsible groundwater extractors.

6.2.2 MGSA Management Action 2: Management of Impacts to Groundwater Dependent Ecosystems and Interconnected Surface Waters

6.2.2.1 Description

As discussed in Section 2.4.12, 3.2.6.1.2, and 4.4.2.2, an evaluation of available data regarding potentially sensitive habitat and groundwater conditions indicates there are several significant GDEs that could be affected by groundwater withdrawal within the MGSA Area. Potential GDE's were identified near the MGSA Area in the California Department of Water Resources (DWR) "NC Dataset Viewer" of the "Natural Communities Commonly Associated with Groundwater" database compiled by The Nature Conservancy in cooperation with DWR. Using best practices recommended by The Nature

Conservancy (TNC 2019), these GDEs were determined to likely be dependent on the presence of shallow groundwater within the Dune Sand Aquifer. The identified GDEs include palustrine and emergent wetlands (sometimes referred to as "vernal ponds") with protected habitat and species, and are located to the east, northeast and southeast of the MGSA Area. In addition, riparian vegetation and riverine wetlands were identified along the Salinas River that may be at least partly dependent on groundwater. Shallow groundwater drawdown induced by pumping in the MGSA Area could adversely affect these GDEs, harming or degrading protected habitat, and harming protected species.

As described in Chapter 5, MGSA will monitor and evaluate the potential for groundwater elevation changes that are indicative of the above undesirable results. If groundwater level monitoring collected from wells near identified GDEs reaches the trigger thresholds presented below, then MGSA will implement a series of escalating management actions. These management actions will include the following three general phases, with the progression between each phase set by a sequence of objective decision triggers:

(1) Detection Monitoring;

(2) Biological and Hydrologic Assessment; and

(3) Response Action Planning and Implementation.

The components of Management Action 2 are shown graphically in Figure 6-2, and may be summarized as follows. The Detection Monitoring phase presents the first tier of triggers that are specific to detecting potential adverse impacts to GDEs at an early stage. The triggers are an elevation 1 foot above the 2015 low groundwater levels recorded in monitoring wells near GDEs in the vicinity of the MGSA Area.[2]

Confirmation evaluation will be conducted to verify that a Tier 1 Trigger event has occurred by conducting a biological reconnaissance to observe and document conditions in the potentially affected GDE, determining whether vegetation stress and habitat degradation is occurring that is distinguishable from conditions documented during the baseline assessment described in Section 7.1.2.3, and assessing whether the groundwater level decline observed near the GDE is likely attributable to groundwater extraction within the MGSA Area.[3] If confirmed, a Tier 1 Trigger will segue the management action into Tier 2 Biological and Hydrologic Assessment.

The Biological and Hydrologic Assessment phase is in place to conduct additional investigation and focused evaluation to characterize the cause, nature and extent of the habitat degradation and assess whether significant and unreasonable impacts to the GDE are occurring or likely to occur as a result of

[2] This trigger threshold is an interim value for wells MW-4S, MW-7s and MW-8S until a baseline biological assessment as discussed in Section 7.1.2.3. Based on this baseline biological assessment, a biological monitoring plan will be developed and the minimum thresholds and measurable objectives described in Section 4.4 may be modified, and the triggers and management actions described in this section refined.

[3] If the observed decline in groundwater levels is attributable to pumping outside the MGSA Area, SVBGSA will be advised.

groundwater extraction in the MGSA Area. This investigation will build on the baseline biological assessment discussed in Section 7.1.2.3, and determine whether changes in vegetation vigor, community composition, or habitat quality and structure are taking place, and to quantify them if possible. Targeted evaluations will be conducted as needed to establish linkages to climatic variability and groundwater fluctuations and drawdown, and to assess potential future GDE responses. Investigations will be data-driven, and will rely on quantifiable metrics, as appropriate. If the potential for significant habitat degradation or significant harm to protected species is identified, then the management will segue from the Assessment Phase into the Response Action Planning and Implementation Phase. The second phase will also help identify and localize critical data gaps, uncertainties and risks so they can be considered during planning for corrective action.

The third phase of MGSA Management Action 2 is Response Action Planning and Implementation. The third phase may include, but not be limited to, the following activities:

- Response action evaluation;
- Consultation with California Department of Fish and Wildlife (CDFW), other appropriate agencies and stakeholders;
- Response action implementation; and
- Monitoring of response action effectiveness.

The Biological and Hydrologic Assessment will provide data-driven information to evaluate and select appropriate response action(s), including performance objectives, mitigation alternatives, prediction of future implementation effectiveness and establishment of timetables. Once implemented, criteria for monitoring action effectiveness will be data-driven and include multiple lines of evidence, such as, for example: (a) evaluating groundwater elevation rebound; and (b) evaluating and comparing plant vigor, habitat quality and species quantities and diversity to baseline conditions to assess improvement and restoration. Measurable Objectives and Interim Milestones would be established to achieve and maintain the sustainability goals of the MGSA GSP.

If the response action does not produce multiple lines of evidence showing the successful mitigation of harmful impacts to the GDEs, or the Measurable Objectives and Interim Milestones are not achieved, then the response action would be amended, re-implemented and monitored until the objectives are achieved. If implementation of the response action does achieve the Measurable Objectives, then a decision will be made to segue the groundwater program back to the first phase (Detection Monitoring). Detection Monitoring would then continue as described in this GSP.

6.2.2.2 RELEVANT MEASURABLE OBJECTIVES

The measurable objectives benefiting from this management action include:

- Groundwater elevation measurable objectives for the Dune Sand Aquifer for protection of GDEs. Effective response action would reverse groundwater elevation decline and return groundwater

elevations to the normal range of seasonal values, protecting the GDE habitat from significant and unreasonable impacts.

6.2.2.3 Expected Benefits and Evaluation of Benefits

The primary benefit from implementing this management action is to avoid significant and unreasonable impacts to GDEs in the vicinity of the MGSA Area. These GDEs include designated environmentally sensitive habitat areas, wetland areas protected under mitigation agreements and laws, and habitats that support threatened, endangered, and other protected species. Implementation of the management actions will protect these valuable resources and help to assure compliance with state and federal regulations that govern them.

6.2.2.4 Circumstances for Implementation

The management action will be implemented depending upon evaluation of monitoring data and if Tier 1 and Tier 2 Trigger Thresholds are reached.

6.2.2.5 Permitting and Regulatory Process

Prior to adoption or implementation of response actions, informal consultation with CDFW will be undertaken. Informal consultation with United States Fish and Wildlife Service (USFWS) will be undertaken for any federally listed species.

6.2.2.6 Implementation Schedule

Implementation will be dependent upon whether Tier 1 and Tier 2 Trigger Thresholds are reached. It is expected that the Biological and Hydrologic Assessment Phase will take approximately six months to complete and the Response Action Implementation Phase will take up to approximately one year to complete, depending on the necessary action any additional data needs that must be addressed.

6.2.2.7 Estimated Costs

The estimated costs to implement Tier 2 investigations or coordinate response action implementation are approximately $50,000 per year. Implementation costs would vary depending on the scope of investigation and corrective action, and would be developed prior to implementation and paid or reimbursed by the responsible groundwater extractors.

6.3 Legal Authority

The CWC provides MGSA the following powers and authorities, among others, to implement the above management actions:

- CWC § 10725.4 (a) provides GSAs the authorities to conduct investigations to determine the need for groundwater management, and to monitor compliance and enforcement of a GSP.

- CWC § 10726.4 (a)(2) provides GSAs the authorities to control groundwater extractions by regulating, limiting, or suspending extractions from individual groundwater wells or extractions from groundwater wells in the aggregate.
- CWC § 10725.2. provides that a GSA may perform any act necessary or proper to implement the above authorities, and may adopt rules, regulations, ordinances, and resolutions as necessary to do so.

It is anticipated that, in the process of implementing the above authorities, MGSA may work with groundwater extractors to identify and implement alternative response actions that can comply with the Sustainable Management Criteria identified in this GSP.

6.4 PUBLIC NOTICING

The City Council of the City of Marina administers MGSA and is responsible to consider and approve decisions regarding the implementation of the management actions described in this GSP. MGSA board meetings are held concurrently with City Council meetings on the first and third Tuesdays of each month in accordance with the Marina Municipal Code (Chapter 2.04) and City Ordinances: 2001-11 § 1 (2001), 78-12 § 1 (1978), and 75-2 § 1 (1975). The meetings are publicly noticed and agendas are made available on the City's website (https://www.cityofmarina.org/AgendaCenter). Open meetings may be preceded by a closed session if necessary and appropriate. As described in Section 1.5.1, resolutions presented to City Council are voted on and require a majority vote of a quorum to be passed and adopted. Open public hearings on specific resolutions may be held during meetings to allow for testimony from the public. City Council Members will consider public testimony prior to voting on specific resolutions.

As part of disseminating information to the general public, MGSA will post updates on its website to notify the public that the implementation of management actions is being considered or has been implemented. This will include a description of the actions to be taken. Additional noticing for the public will be conducted consistent as required in the case of the enactment of fees or assessments. Outreach may include public notices, meetings, website or social media presence, and email announcements.

6.5 SVBGSA AND MCWRA PROJECTS AND MANAGEMENT ACTIONS SUPPORTED BY MGSA

SVBGSA projects involve new or improved infrastructure to meet the regional Sustainable Management Criteria identified in SVBGSA's GSP for the Subbasin (SVBGSA 2019). MCWRA and others are proposing additional projects that will help to improve the understanding and sustainable management of groundwater resources in and near the MGSA Area. Several projects are discussed below based on their relevance to the MGSA Area and vicinity. Included are six projects that are planned for implementation or are already in progress (including four SVBGSA "Priority Projects"), and two SVBGSA "Alternative

Projects" that will be implemented only if they are deemed cost effective or necessary to achieve sustainability.

Management actions in SVBGSA's GSP were defined as new or revised non-structural programs or policies that are intended to reduce or optimize local groundwater use (SVBGSA 2019). Management actions will be implemented only if they are deemed cost effective or necessary to achieve sustainability. The four SVBGSA management actions discussed below are considered potentially relevant to achieving the sustainability objectives of the MGSA GSP in and near the MGSA Area. These management actions are not adopted as part of this GSP; however, MGSA will cooperate with and support them because they provide benefits to the MGSA Area.

The proposed SVBGSA projects and management actions will provide *in lieu* recharge and direct recharge benefits including "arresting the decline, or raising, groundwater elevations" (SVBGSA 2019). For the 180-Foot Aquifer, SVBGSA has estimated a groundwater elevation rise of about 3.5 feet in the vicinity of the Salinas River and 2 feet in the vicinity of the MGSA Area as a result of implementing these project and management actions (SVBGSA 2019). For the 400-Foot Aquifer, SVBGSA has estimated a groundwater elevation rise of about 3.5 feet in the vicinity of the Salinas River and 3 feet in the vicinity of the MGSA Area. Raising groundwater elevations could change groundwater flow gradients, and potentially flow directions, in the 180-Foot and 400-Foot Aquifers.

These projects and management actions are further described in the following subsections.

6.5.1 Optimize Castroville Seawater Intrusion Project Operations (SVBGSA GSP Priority Project 2)

The Castroville Seawater Intrusion Project (CSIP) system will be optimized to better accommodate diurnal and seasonal fluctuation in irrigation demand, maximizing use of water supplied from the Salinas Valley Reclamation Project (SVRP) and the Salinas River Diversion Facility (SRDF), thereby reducing the need for groundwater pumping in the CSIP service area, which includes area east and northeast of the MGSA Area (Figure 2-6). This project aligns CSIP irrigation with availability of water rather than demand, to ensure the available supply water can be used to a greater extent. Refer to Chapter 9 of SVBGSA's GSP (SVBGSA 2019) for further details.

The primary benefits from *in lieu* recharge projects such as CSIP optimization include reduction or avoidance of groundwater pumping from wells in the CSIP area throughout the year. This is beneficial to MGSA because of its proximity to the CSIP service area and because pumping reductions in these areas support measurable objectives related to groundwater elevation, groundwater storage and seawater intrusion. A direct correlation between CSIP optimization and changes in groundwater elevations, subsidence, or seawater intrusion is likely not possible to assess because this is only one among several similar management actions and projects that will be implemented in the Subbasin. This project is anticipated to take three years to implement.

6.5.2 IMPROVE SRDF DIVERSION (SVBGSA GSP PRIORITY PROJECT 3)

The SRDF Diversion improvements include installing a radial collector well to provide additional diversion capacity at the SRDF. The project includes installing additional water storage for the proposed 85 cubic feet per second (cfs) capacity of the SRDF. Refer to Chapter 9 of SVBGSA's GSP (SVBGSA 2019) for further details.

The primary benefits from in lieu recharge or Aquifer Storage and Recovery (ASR) projects such as SRDF expansion include provision of additional water supply to the CSIP system, allowing for its expansion into new service areas as well as providing a potential source of water for aquifer recharge. The expanded SRDF has the potential to yield up to 20,800 AFY if operated April through October. This is beneficial to the MGSA Area because of its proximity to the CSIP service area and because pumping reductions in these areas support measurable objectives related to groundwater elevation, groundwater storage and seawater intrusion. It is anticipated to take five to six years to implement this project.

6.5.3 MODIFY MONTEREY ONE WATER RECYCLED WATER PLANT (SVRP MODIFICATIONS) (SVBGSA GSP PRIORITY PROJECT 4)

Monterey One Water (M1W) is currently designing and permitting this project and SVBGSA intends to work closely with M1W on project implementation. M1W's Regional Wastewater Treatment Plant (RTP), located approximately 2 miles east of the MGSA Area, has a maximum capacity of 29.6 million gallons per day (mgd). Currently, the facility is only treating 16 to 18 mgd of influent wastewater. During the wet weather months, 100% of all secondary treated wastewater is discharged to the ocean, forgoing the opportunity for beneficial reuse. During the wet weather months, there is some demand for recycled water in the CSIP system; however, M1W cannot efficiently produce the tertiary treated water needed to meet agricultural demand during this time. As a result, growers turn to the groundwater basin for their irrigation needs during these months. Modifications are required at the M1W RTP in order to efficiently treat and store recycled water during the wet weather months. Refer to Chapter 9 of SVBGSA's GSP (SVBGSA 2019) for further details.

The primary benefits from *in lieu* recharge projects such as M1W SVRP Modifications is additional water supply to the CSIP system during low-demand wet weather months, reducing groundwater pumping. The M1W SVRP Modifications project has the potential to yield up to 1,100 AFY via *in lieu* recharge, providing an alternative to groundwater sources in the CSIP area. This is beneficial to MGSA because of its proximity to the CSIP service area and because pumping reductions in these areas support measurable objectives related to groundwater elevation, groundwater storage and seawater intrusion. This project will benefit other subbasins, such as the Monterey Subbasin by reducing pumping that impacts the neighboring subbasins. It is anticipated to take approximately two years to implement.

6.5.4 EXPAND AREA SERVED BY CSIP (SVBGSA GSP PRIORITY PROJECT 5)

The CSIP expansion project involves enlarging the system's service area, thereby increasing available water supplies in the spring and fall and lessening dependence on existing groundwater wells. It is likely

that the existing CSIP supplies are not sufficient to meet the summertime demand of the expanded CSIP area without a significant increase in water supply from the Salinas River Diversion Facility (SRDF) or another source. Refer to Chapter 9 of SVBGSA's GSP (SVBGSA 2019) for further details.

The benefits of this project are similar to SVBGSA Project 1, described above. The expanded service area would lessen groundwater pumping by an amount equal to the quantity delivered: approximated as 9,900 AFY. This is beneficial to MGSA because of its proximity to the CSIP service area and because pumping reductions in these areas support measurable objectives related to groundwater elevation, groundwater storage and seawater intrusion. This project is anticipated to take five years to implement.

6.5.5 Construct Additional Nested Monitoring Wells in the Dune Sand and 180/400-Foot Aquifers Near the MGSA Area (Planned MCWRA Project)

As part of its obligation to implement the Mitigation, Monitoring and Reporting Program (MMRP) for the proposed Monterey Peninsula Water Supply Project (MPWSP), MCWRA plans to install and monitor five additional clusters of monitoring wells in the area surrounding the MGSA Area where spatial groundwater monitoring data gaps have been identified (CPUC 2018, MCWRA 2019d). These new wells would have similar screened intervals to the existing monitoring wells installed at eight locations to monitor the effects of pumping the full slant well array for the proposed MPWSP if it is fully approved and implemented. At each location, three monitoring wells would be constructed: one each in the Dune Sand Aquifer, 180-Foot Aquifer and 400-Foot Aquifer. These wells would be added to the monitoring well network, for a total of 40 wells, and would be monitored quarterly or more frequently by MCWRA. MCWRA has indicated it plans to proceed with this project in the near future.

6.5.6 Regional Deep Aquifer Characterization (Potential Project by MCWRA, SVBGSA and MCWD)

MCWRA, SVBGSA and MCWD GSA are discussing plans to investigate the Deep Aquifer system in the Salinas Valley. Although no specific plans are proposed at this time, there is broad consensus that this important data gap must be addressed during the early stages of GSP implementation to ensure that this important aquifer is sustainably managed. It is anticipated that the investigation results will provide information regarding the nature and hydraulic properties of the Deep Aquifer system. Specifically, the groundwater flow patterns in the Deep Aquifer, the interconnection between the disparate aquifer units in this system, how they are recharged, and the extent of potential leakance from the overlying upper aquifer system is expected to be addressed. No specific scope or schedule has been proposed at this time. MGSA will provide comments on the scope and results of this study, and incorporate the results into a future update of this GSP.

6.5.7 AGRICULTURAL LAND AND PUMPING ALLOWANCE RETIREMENT (SVBGSA GSP MANAGEMENT ACTION 1)

SVBGSA water charges revenues would be used to acquire and retire irrigated land and/or pumping allowances (potentially including carryover credits and recharge credits) to reduce pumping. All acquisitions would be completed on a voluntary basis from willing sellers at negotiated market prices. SVBGSA would cease irrigation on acquired land to reduce pumping. SVBGSA would coordinate with other local agencies and stakeholders to determine beneficial uses of the acquired land (e.g. establishment of native vegetation). Landowners selling pumping allowances to SVBGSA separate from land would be permitted to convert their land to rural residential use. The number of *de-minimis* wells authorized on converted land would be based on the amount of pumping allowance sold to SVBGSA. The final ratio of sold pumping allowance to the number of *de-minimis* wells allowed will be agreed to in the final water charges framework.

The benefit from land or pumping allowance retirement will be reduced pumping and either arresting groundwater elevation decline or raising groundwater elevations. Depending on the location of the land retirement, ancillary benefits include reducing seawater intrusion rates. Because it is unknown how many landowners will willingly enter the land retirement program, it is difficult to quantify the expected benefits at this time. The option for land retirement will begin immediately after SVBGSA's water charges framework is finalized and adopted. Although the land retirement program would be ongoing, it will be reliant on willing sellers and will likely be implemented intermittently.

6.5.8 RESERVOIR REOPERATION (SVBGSA MANAGEMENT ACTION 2)

Reservoir reoperation entails a revised management scheme for the reservoirs that control the Salinas River flows. The purpose of this management action is to operate the reservoirs to achieve two goals:

- Allow surface flow releases to recharge groundwater in the various Salinas Valley Subbasins every winter; and
- Allow both natural and surplus flows to better reach the SRDF diversion.

The reservoir reoperations would more tightly integrate environmental flows with sustainable groundwater management activities to improve water availability for agricultural users and other groundwater users. The major beneficiaries of this management action would be the Upper Valley and Forebay Subbasins, as they receive most of the river percolation. There is limited benefit for the 180/400 Foot Aquifer Subbasin, primarily to allow enough water to flow to the SRDF for CSIP operations; for this reason, it would potentially benefit the MGSA Area.

Reservoir operations are managed by MCWRA, and would not be directly modified by SVBGSA. Over the next few years, MCWRA plans to prepare a Habitat Conservation Plan (HCP) that re-establishes the reservoir operating rules for the Salinas Valley. The HCP offers an opportunity for reservoirs to be explicitly operated for improved groundwater management as well as environmental flows and flood

control. SVBGSA will participate in developing the HCP to implement the reservoir operations in a way that promotes this strategy.

The primary benefit from reservoir reoperation is increased flows in the Salinas River in the winter, to allow for additional groundwater recharge in the subbasins and more flexible use of the groundwater in storage. A second benefit is the availability of water at the SRDF diversion to allow for greater surface water use in the CSIP area, and potentially allow for CSIP area expansion (see SVBGSA Priority Project 5). The reservoir reoperation management action schedule will be contingent upon the development and finalization of the HCP and other reservoir operations criteria. The implementation schedule will start as soon as new reservoir operations criteria are developed in collaboration with MCWRA.

6.5.9 Restrict Pumping in CSIP Area (SVBGSA Management Action 3)

A number of the priority projects adopted by SVBGSA are designed to ensure a reliable, year-round supply of water to growers in the CSIP area. These projects will remove any need for groundwater pumping in the CSIP area. To promote use of CSIP water, SVBGSA may pass an ordinance preventing any pumping for irrigating agricultural lands served by CSIP. The benefit from the CSIP pumping restrictions is reduced Subbasin pumping and either arresting groundwater elevation decline or raising groundwater elevations. An ancillary benefit from shallower groundwater elevations may include reducing seawater intrusion. CSIP pumping restrictions would be implemented within one year of substantially completing the CSIP optimization projects.

6.5.10 Support and Strengthen MCWRA Restrictions on Additional Wells in the Deep Aquifer (SVBGSA Management Action 4)

MCWRA Ordinance No. 5302 restricts drilling new wells in the Deep Aquifer in an Area of Impact that is generally northwest of Davis Road. Exceptions are made for replacement wells, domestic wells, and municipal supply wells. This is a temporary urgency ordinance pending development of permanent regulations and is intended to decrease the potential for seawater intrusion into the Deep Aquifer until sufficient information can be obtained to assess its sustainable yield. SVBGSA plans to work with MCWRA to strengthen the ordinance to prevent any new wells from being drilled into the Deep Aquifer until more is known about the Deep Aquifer's sustainable yield. MGSA will support this management action because it will promote groundwater sustainability as defined in this GSP. The Deep Aquifer pumping restrictions will be implemented within one year of MCWRA completing its Deep Aquifer study (described in Section 6.5.6).

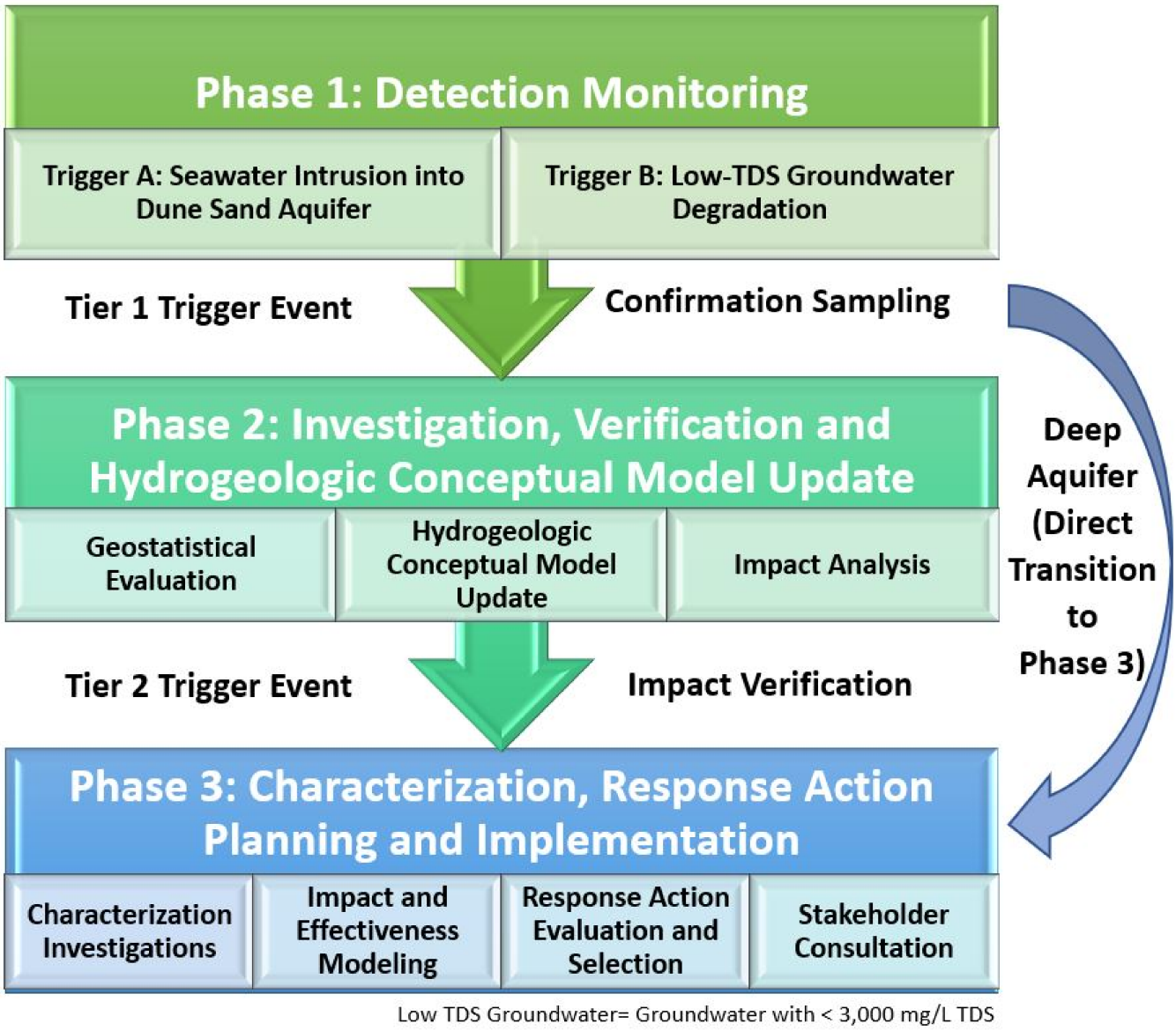

FIGURE 6-1

Management Action 1 Workflow

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

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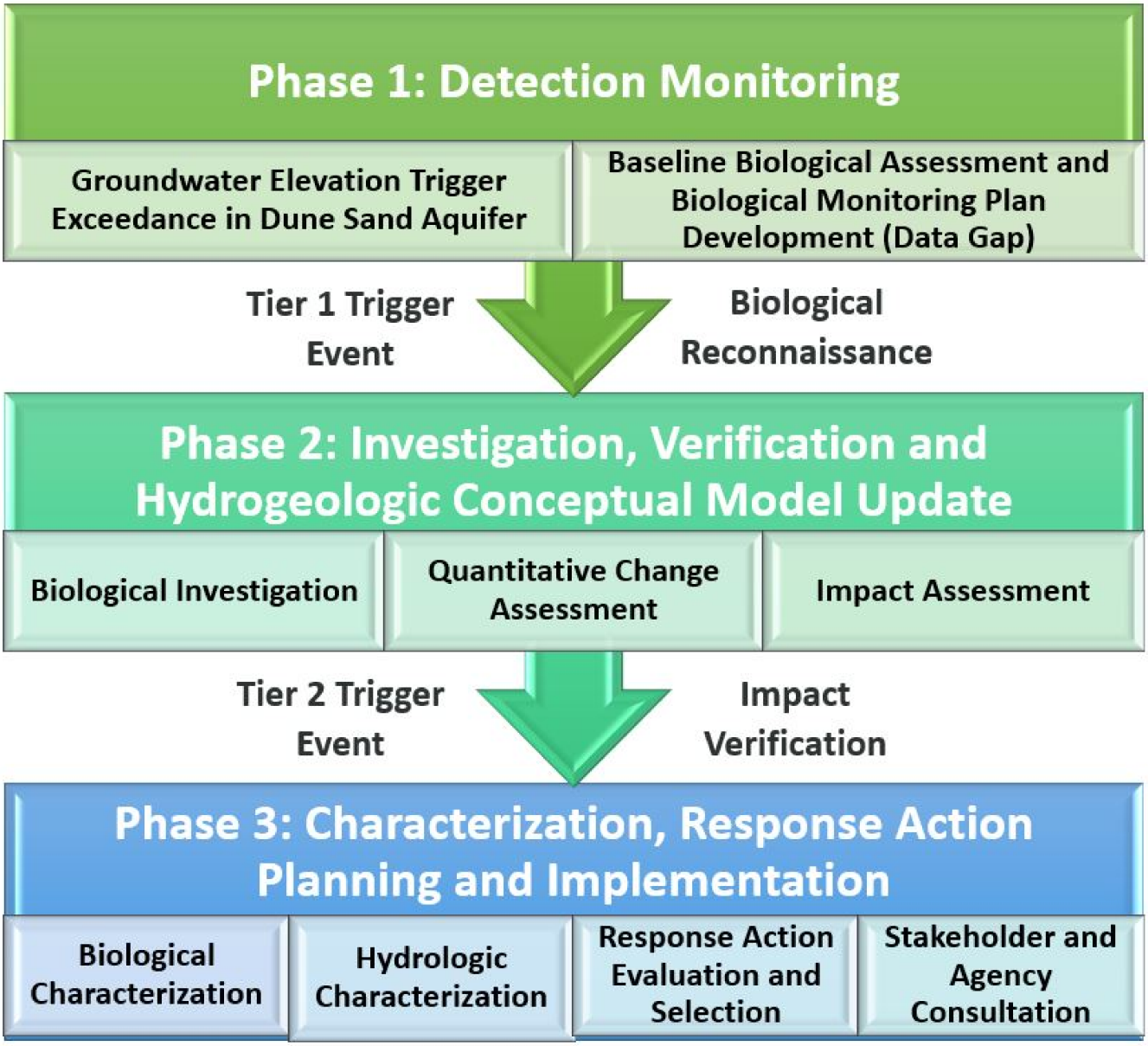

FIGURE 6-2

Management Action 2 Workflow

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

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CHAPTER 7 – PLAN IMPLEMENTATION
Groundwater Sustainability Plan for the Marina GSA Area of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, California

JANUARY 2020

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7 PLAN IMPLEMENTATION

The 180/400 Foot Aquifer Subbasin (Subbasin) is subject to significant and unreasonable seawater intrusion due largely to long-term groundwater extraction in the inland portions of the Subbasin in excess of the sustainable yield, and has been identified by California Department of Water Resources (DWR) as being in a critical condition of overdraft (DWR 2016a). The purpose of this Groundwater Sustainability Plan (GSP) is to support regional efforts to address this condition and achieve sustainable groundwater management within 20 years, as required by the Sustainable Groundwater Management Act (SGMA). MGSA will achieve this by supporting the projects and management actions that will be implemented by Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) under its regional Groundwater Sustainability Plan (GSP), and by assuring that local groundwater resources are managed sustainably to protect local and regional beneficial uses and users. This chapter describes how the Groundwater Sustainability Plan (GSP) for the Marina Groundwater Sustainability Agency (MGSA) jurisdiction (MGSA Area) in the 180/400 Foot Aquifer Subbasin will be implemented and describes the main activities needed for GSP implementation. The primary activities are listed below and are described in the subsequent sections of this chapter:

- Monitoring and reporting groundwater data, including coordination with Monterey County Water Resources Agency (MCWRA), which is responsible for implementation of most of the data collection activities needed to support the monitoring programs described in this GSP;
- Addressing data gaps;
- Updating the data management system (DMS) to support ongoing data-driven GSP implementation as needed;
- Refining the GSP based on the upcoming release of the United States Geological Survey (USGS) Salinas Valley Integrated Hydrologic Model (SVIHM) and planned review and use of the SVIHM by Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) to update its GSP;
- Concurrent with the above update, refining the GSP based on the planned development of a locally-refined groundwater flow model by Marina Coast Water District (MCWD) GSA that is able to simulate solute transport and density-driven flow (these activities will also be coordinated with SVBGSA);
- Intra- and Inter-Basin coordination with SVBGSA and MCWD GSA, respectively; and
- Implementation of management actions, as appropriate and as triggered by thresholds identified in Chapter 6.

In general, MGSA (like all other GSAs) has the powers and authorities granted to GSAs set forth in Chapter 5 of SGMA, in California Water Code (CWC) §§ 10725 through 10726.9. Among other things, when implementing this GSP, MGSA (like all other GSAs) has the power and authority to:

- Adopt rules, regulations, ordinances and resolutions (§ 10725.2);
- Conduct investigations (§ 10725.4);
- Require registration (§ 10725.6);
- Require measurement and reporting of extractions (§ 10725.8);
- Implement the GSP (§ 10726.2);
- Regulate groundwater extraction (§ 10726.4);
- Enter into agreements with private parties (§ 10726.5); and
- Exercise judicial and enforcement authority (§§ 10726.6, 10732, 10732.2).

The implementation plan in this chapter is based on the understanding of the Subbasin presented in Chapters 2 and 3, an assessment of planned SVBGSA projects and MCWD GSA activities pertinent to the MGSA Area summarized in Chapter 6, and MGSA management actions described in Chapter 6. The current understanding of the Subbasin and details of projects and management actions will evolve over time based on additional data collection, release of the SVIHM and other tools and planned studies, activities to address data gaps by SVBGSA, MCWD GSA and others, and implementation of projects and management actions. This chapter addresses activities needed for MGSA GSP implementation between 2020 and 2040. However, it particularly focuses on activities between 2020 and 2025, at which point significant updates to the GSP are expected to be implemented in collaboration with SVBGSA and MCWD GSA. Implementation activities are described in Section 7.1. Implementation costs and schedules are described in Sections 7.2 and 7.3.

7.1 IMPLEMENTATION ACTIVITIES

The main activities for implementation of this GSP include the monitoring, evaluating, and reporting of sustainability conditions; the implementation of management actions; and the coordination of sustainable groundwater management activities with SVBGSA, MCWD GSA and MCWRA. MGSA will hire technical consultants, as needed, to evaluate the monitoring data and prepare reports.

7.1.1 ACTIVITY 1: MONITORING, REPORTING, AND OUTREACH

7.1.1.1 MONITORING

Monitoring of the six sustainability indicators will be initiated after adoption of the MGSA GSP as described in Chapter 5. Groundwater Dependent Ecosystems (GDEs) are beneficial users of the Dune Sand Aquifer and some are associated with vernal ponds and the Salinas River, and therefore associated with both the Chronic Groundwater Level Decline and Interconnected Surface Water sustainability indicators. They are discussed separately below. Most of the monitoring activities necessary to support

this GSP are currently being conducted by MCWRA; however, MCWD GSA is in the process of evaluating the adequacy of local monitoring networks and plans to construct a locally refined groundwater flow, solute transport and density driven flow to support preparation of its GSP. The results of these studies and investigations, and the availability of refined tools and monitoring networks, may lead to changes in local monitoring networks and approaches during GSP implementation or as part of the planned five-year GSP update. These activities will also be coordinated with SVBGSA.

Historical and current monitoring networks near the MGSA Area include eight clusters of nested monitoring wells constructed in the MGSA Area and its vicinity as part of the test slant well pumping test for the proposed Monterey Peninsula Water Supply Project (MPWSP), two clusters of monitoring wells constructed by USGS to investigate the Deep Aquifer approximately ½ mile south of the MGSA Area, and a number of supply wells completed in the 180-Foot, 400-Foot and Deep Aquifers that are included in various MCWRA monitoring programs. All of these wells are currently monitored by MCWRA as previously described in Chapter 5. Each MPWSP monitoring well cluster includes a shallow well completed in the Dune Sand Aquifer (DSA), a medium-depth well completed in the 180-Foot Aquifer, and a deep well completed in the 400-Foot Aquifer.

MCWRA plans to implement a groundwater level and quality monitoring program to comply with the Mitigation, Monitoring and Reporting Program (MMRP) for the MPWSP that includes all of the above wells, adds additional existing wells and includes installation and monitoring of five additional clusters of monitoring wells in the area surrounding the MGSA Area where data gaps have been identified (CPUC 2018, Zidar and Feeney 2019). These new wells will have similar screened intervals as the existing MPWSP test slant well monitoring wells and will be added to the existing monitoring network. The monitoring program adopted in this GSP includes the wells identified in the monitoring plan for the MPWSP MMRP. The specific wells used for assessing compliance with the groundwater level and quality measurable objectives and minimum thresholds described in Chapter 4 are identified in Chapter 5. Monitoring of the wells will be conducted by MCWRA. MGSA will compile and evaluate the monitoring results semiannually as described in Chapter 5 to determine if progress is being made toward sustainability or alternatively if management triggers have been reached and management actions need to be implemented. Data will be uploaded and maintained in the DMS. It should be noted that MGSA is currently working to develop an agreement with MCWRA to that includes provisions that, should the MPWSP not move forward, MGSA and MCWRA will work with other agencies with jurisdiction in the area to develop and maintain a suitable monitoring program in the nearshore area of the Subbasin.

7.1.1.1.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring will be conducted in the DSA, 180-Foot Aquifer, 400-Foot Aquifer and Deep Aquifer by MCWRA. Data include continuously recorded transducer data as well as quarterly (or more frequent) hand gaging data. The monitoring data will be compiled and evaluated semi-annually in accordance with the procedures described in Chapter 5 to assess the potential for significant and unreasonable impacts to beneficial groundwater users, including operators of existing wells and GDEs. The implementation of management actions is described in Section 7.1.6. The data will be

uploaded to the DMS and will be used to create tables and figures for MGSA's annual report submitted to DWR.

7.1.1.1.2 GROUNDWATER STORAGE MONITORING

Groundwater elevation monitoring data, water quality data, and induction logging data collected from the monitoring wells identified in Chapter 5 will be compiled and evaluated semi-annually in accordance with the procedures identified in Chapters 5 and 6. If the data indicate that undesirable results may be occurring, then MGSA will implement a series of escalating management actions to further investigate the potential depletion of the zone with low total dissolved solids (TDS) groundwater underlying the DSA to determine whether it has been significantly and unreasonably depleted. The implementation of management actions is described in Section 7.1.6. In addition, groundwater extraction data will be provided by groundwater extractors in the MGSA Area and will be provided by MCWRA annually for supply wells in the surrounding area. These data will be evaluated annually to help assess the nature and cause of any observed depletions.

7.1.1.1.3 SEAWATER INTRUSION MONITORING

Water quality monitoring and induction logging to assess seawater intrusion will be conducted at least quarterly based on analysis of samples collected from the monitoring wells identified in Chapter 5 for TDS and chloride, and assessment of induction logs to evaluate potential changes in saline water depth and extent. The data will be compiled and evaluated semi-annually in accordance with the procedures identified in Chapters 5 and 6. The evaluation will include an assessment of whether the concentration and/or trend triggers investigation or management actions regarding the potential for significant migration of the saline water intrusion wedge underlying the area. The implementation of management actions is described in Section 7.1.6. Monitoring data will be uploaded to the DMS and will be used to create tables and figures for the annual report.

7.1.1.1.4 GROUNDWATER QUALITY MONITORING

Water quality monitoring to assess potential water quality degradation in the low TDS groundwater zone underlying the DSA will be conducted at least quarterly based on analysis of samples collected from the monitoring wells identified in Chapter 5 for TDS and chloride. The data will be compiled and evaluated semi-annually in accordance with the procedures identified in Chapters 5 and 6. The evaluation will include an assessment of whether the concentration and trend triggers management actions to further investigate the potential for significant water quality degradation. The implementation of management actions is described in Section 7.1.6. Monitoring data will be uploaded to the DMS and will be used to create tables and figures for the annual report.

In addition, MCWRA is tasked with assessing whether groundwater extraction related to the MPWSP (if implemented) causes additional migration of groundwater contamination associated with the Ford Ord Superfund Site Operable Unit Carbon Tetrachloride Plume (OUCTP) area, located about 1mile southeast

of the MGSA Area. Data from MCWRA's annual review will be provided to MGSA for review and consideration annually.

7.1.1.1.5 Land Subsidence Monitoring

Land subsidence has not been reported in the Salinas Valley. Given that the risk of land subsidence results from lowered groundwater elevations, especially when groundwater elevations fall below historical lows in confined aquifer systems, MGSA will rely on the groundwater elevation monitoring data described in Section 7.1.1.1.1. In addition, in collaboration with SVBGSA, MGSA will obtain and review data regarding subsidence measurements from USGS, DWR, Jet Propulsion Laboratories (JPL) and others, including remote sensing Interferometric Synthetic Aperture Radar (InSAR) data.

7.1.1.1.6 Interconnected Surface Water Monitoring

Interconnected surface water monitoring will be conducted at wells MW-6S and MW-9S, and will be used to augment regional monitoring and modeling studies planned by SVBGSA to assess surface-groundwater interaction along the Salinas River. Shallow groundwater data, along with river discharge and stage data will be assessed to evaluate the extent, nature and impacts of the interconnection of the Salinas River with the DSA and the underlying 180-Foot Aquifer.

7.1.1.1.7 Groundwater Dependent Ecosystem Monitoring

The response of GDEs to groundwater level declines depends on a number of factors, including the tolerance of the vegetation species to seasonal, inter-annual and long-term groundwater elevation changes, and the availability and proximity of potential surface water sources. Monitoring of GDEs will rely on the shallow groundwater elevation and quality monitoring network described in Chapter 5. In addition, the baseline biological conditions of the vernal ponds near the MGSA Area will be assessed and documented, and a biological monitoring program will be implemented to evaluate the effect of groundwater level changes on GDE habitat composition and vigor once the baseline assessment is completed. The evaluation will include an assessment of whether triggers for management actions have been reached. The implementation of management actions is described in Section 7.1.6.

7.1.1.1.8 Reporting

7.1.1.1.9 Annual Reports

Regulation Requirements:

§ 356.2. Annual Reports

Each Agency shall submit an annual report to the Department by April 1 of each year following the adoption of the Plan. The annual report shall include the following components for the preceding water year:

(a) General information, including an executive summary and a location map depicting the basin covered by the report.

(b) A detailed description and graphical representation of the following conditions of the basin managed in the Plan:

(1) Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:

(A) Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.

(B) Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.

(2) Groundwater extraction for the preceding water year. Data shall be collected using the best available measurement methods and shall be presented in a table that summarizes groundwater extractions by water use sector, and identifies the method of measurement (direct or estimate) and accuracy of measurements, and a map that illustrates the general location and volume of groundwater extractions.
(3) Surface water supply used or available for use, for groundwater recharge or in-lieu use shall be reported based on quantitative data that describes the annual volume and sources for the preceding water year.
(4) Total water use shall be collected using the best available measurement methods and shall be reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.
(5) Change in groundwater in storage shall include the following:
(A) Change in groundwater in storage maps for each principal aquifer in the basin. (B) A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.
(c) A description of progress towards implementing the Plan, including achieving interim milestones, and implementation of projects or management actions since the previous annual report.

Annual reports will be prepared in accordance with 23 CCR § 356.2 as summarized above, and will be submitted to DWR starting April 1, 2021. The reports will include a summary of the monitoring and groundwater extraction data collected and an evaluation of the data compared to the sustainable management criteria as detailed in Chapter 4, and the management actions described in Chapter 6. Management actions will be adapted as necessary based on the evaluation of current conditions and the sustainability goal. It is anticipated that the annual reports will be prepared by technical consultants in coordination with MGSA staff. The estimated cost of the annual reports is presented in Table 7-1.

7.1.1.1.10 PERIODIC ASSESSMENTS

Regulation Requirements:

§ 356.4. Periodic Evaluation by Agency

Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended, and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:
(a) A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones and minimum thresholds.
(b) A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.
(c) Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.
(d) An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the Agency's evaluation shows that the basin is experiencing overdraft conditions, the Agency shall include an assessment of measures to mitigate that overdraft.
(e) A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:
(1) An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.
(2) If the Agency identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.
(3) The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.

(f) A description of significant new information that has been made available since Plan adoption or amendment, or the last five-year assessment. The description shall also include whether new information warrants changes to any aspect of the Plan, including the evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.
(g) A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the Plan.
(h) Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin.
(i) A description of completed or proposed Plan amendments.
(j) Where appropriate, a summary of coordination that occurred between multiple Agencies in a single basin, Agencies in hydrologically connected basins, and land use agencies.
(k) Other information the Agency deems appropriate, along with any information required by the Department to conduct a periodic review as required by Water Code Section 10733.

Periodic assessment reports will be submitted to DWR every five years starting in 2025. The reports will be produced in accordance with 23 CCR § 356.4 as summarized above, and will include an evaluation of how well the MGSA GSP is meeting the sustainability goals. Management actions will be adapted as necessary based on the evaluation of current conditions and the sustainability goal. The assessment report will also include a description of significant new information and whether this information warrants any changes to the GSP including monitoring, measurable objectives, minimum thresholds, criteria defining undesirable results, or management actions. It is anticipated that the assessment reports will be prepared by technical consultants in coordination with MGSA staff. The estimated cost of the five-year assessment report is presented in Table 7-1. Because the SVIHM is expected to become available within the next five years and will provide an important new tool for assessment of groundwater flows, water budgets, projects and sustainability indicators, it is expected that the first five-year update will result in substantial revisions to the MGSA GSP in parallel with changes to the regional GSP developed by SVBGSA.

7.1.1.1.11 COMMUNICATION AND OUTREACH

MGSA will work to encourage the active involvement of diverse social, cultural, and economic elements of the community by keeping the community informed about progress in implementing the GSP. Federal, state, and local agencies, water providers, property owners, environmental stakeholders, and other interested parties will have opportunities, both formal and informal, to provide input to MGSA regarding implementation of this GSP. Such opportunities include, but are not limited to, public comment periods required by SGMA (*e.g.,* CWC § 10728.4) as well as opportunities for public comment during regular and special Marina City Council meetings, and at other times to be determined and noticed pursuant to CWC § 10727.8 (a).

MGSA will periodically provide information to the public about GSP implementation and progress towards groundwater sustainability on the city's website, https://cityofmarina.org/918/Groundwater-Sustainability-Plan. The MGSA webpage will be maintained on a regular basis, and provides a brief history of the formation of MGSA, a description of the MGSP Area, and plans for the future. Contact information for the MGSA Plan Manager is provided, as well as background information and related

documents. MGSA will post information and updates regarding MGSP implementation and progress on this webpage.

7.1.2 ACTIVITY 2: ADDRESS DATA GAPS

Chapters 3 identified the following main data gaps related to the hydrogeologic conceptual model (HCM) and the water budget:

1. **Groundwater elevation and quality data in the MGSA Area** – There is limited proximal data to the MGSA Area to characterize groundwater flow patterns in the vicinity of the MGSA Area and the low TDS water zone in the Dune Sand Aquifer and 180-Foot Aquifer. There is also a limited period of record for monitoring groundwater elevations and water quality in and near the MGSA Area (generally 2015 to present).

2. **Interconnection between the Salinas River and the DSA and underlying 180-Foot Aquifer** – The nature and degree of the interconnection between the lower reach of the Salinas River and the DSA and underling 180-Foot Aquifer is unknown due to the limited amount of data.

3. **Effect of drawdown in the DSA on GDEs** – The effect of shallow groundwater drawdown on a GDE depends on the species present, the amount and rate of groundwater level decline, and hydrology of the GDE system and the extent to which it is groundwater dependent or supplemented by other sources. The linkage between groundwater level declines and the GDEs located near the MGSA Area has not been quantified, and the ability of the GDEs to recover from drawdown-induced stress is not known.

4. **Deep Aquifer system** –There is very little data regarding the nature and hydraulic properties of the Deep Aquifer system, and its potential connection to the overlying, seawater-intruded, 400-Foot Aquifer.

5. **Aquifer parameters** – There are very few measured aquifer parameters for the Dune Sand, 180-Foot, 400-Foot and Deep Aquifers.

6. **Depth discrete groundwater data** – There are long screened intervals in wells near the MGSA Area, particularly for the 180-Foot Aquifer (110 feet). These screen lengths are too long to resolve vertical variations in groundwater quality and gradients.

7. **Airborne Electromagnetic (AEM) geophysical survey data** – The available geophysical data are temporally limited. An AEM survey was recently completed that provided a snapshot in time of current subsurface conditions.

8. **Land Subsidence** – Although available data suggest that the vicinity of the MGSA Area has not experienced significant subsidence, the data are insufficient to assess the potential vulnerability of this area to future subsidence if groundwater extractions are increased.

9. **Potential MPWSP Impacts** – The tools to adequately assess the potential impacts of the proposed MPWSP on the minimum thresholds identified in Chapter 4 are not sufficiently refined to allow prediction of the sustainable yield of this project. If the MPWSP is fully approved and permitted, there would be a need for additional modeling and targeted data collection to evaluate and address any impacts the project would have on the sustainability goals.

These data gaps will be addressed as described below.

7.1.2.1 GROUNDWATER ELEVATION AND QUALITY DATA IN THE MGSA AREA

To increase the amount of groundwater elevation and quality data in the MGSA Area, MCWRA is planning to install five additional wells clusters in the DSA, 180-Foot Aquifer and 400-Foot Aquifer (Zidar and Feeney 2019). Data from these new wells and additional monitoring data from the existing wells will address spatial data gaps in the existing monitoring system. In addition, MCWD GSA will evaluate the adequacy of the existing monitoring networks in the area surrounding their jurisdiction in the Monterey and 180/400 Foot Aquifer Subbasins during preparation of the GSP for the Monterey Subbasin and address additional data gaps as needed. MGSA will review the outcome of this analysis and any additional studies, and the monitoring program of this GSP will be refined as needed to collaborate with MCWD GSA in meeting the sustainability goals of both GSAs. While the lack of historical groundwater elevation and quality monitoring data in and near the MGSA Area cannot be remedied, future monitoring will address the data gap related to a limited period of record over time.

7.1.2.2 INTERCONNECTION BETWEEN SALINAS RIVER AND THE DUNE SAND AQUIFER

SVBGSP has noted that the release of the calibrated USGS SVIHM will provide an important new tool and valuable additional data regarding the interconnection between the Salinas River and the DSA and other shallow aquifers, and the underlying 180-Foot Aquifer. Furthermore, SVBGSA has proposed a regional investigation to assess the level of interconnection using existing shallow wells located adjacent to the Salinas River (if any can be identified) and up to two new shallow wells along the Salinas River. MGSA will review the model results and the results of the SVBGSA investigation, perform supplemental local or regional evaluations as needed, and incorporate them into updates of the GSP.

7.1.2.3 BASELINE BIOLOGICAL ASSESSMENT OF GDES

As discussed in Sections 3.2.6.1.2 and 4.4.2.1, the ecological water requirements and thresholds of response to changes in groundwater levels differ among GDEs. The ability of such GDEs to adapt or recover from groundwater declines depends largely on the overall water budget and the degree to which the GDE is dependent on groundwater. The degree of interaction between wetlands and groundwater can vary greatly and depends on many factors including their position in the landscape, the permeability of the substrate, depth to the water table, and seasonal fluctuations in water inputs. GDEs develop in response to unique timing, duration, frequency and chemistry of water inputs. An analysis of historical evapotranspiration (ET) variability, groundwater levels and drawdown at the Armstrong Ranch ponds demonstrates a correlation between groundwater levels and biomass productivity in this GDE,

and illustrates its sensitivity to groundwater level declines. Biomass productivity rebounded with groundwater levels; however, it is not known whether the stress induced in the GDE resulted in a change in the vegetation community, habitat degradation, or habitat succession that is not readily reversible.

At this time, it is not possible to determine precisely what level of drawdown imposed on natural groundwater elevation fluctuations would have a significant and unreasonable impact on the GDEs near the MGSA Area. To address this data gap, MGSA will retain a qualified biologist to perform a baseline assessment of the vernal ponds that may be affected by groundwater elevation declines. The purpose of this baseline assessment will be to characterize these wetlands and their dependence on groundwater and potential sensitivity to groundwater elevation declines, and to establish baseline conditions for future comparison. Based on the findings of the baseline assessment, a monitoring plan will be developed to assess changes in the vigor and quality of the GDE habitats over time and allow correlation of changes to shallow groundwater elevations. Quantitative approaches, such as the development of habitat suitability index models, state and succession models, or similar assessment tools, will be developed to assess possible future changes in habitat quality, services and succession.

7.1.2.4 Deep Aquifer System

MCWRA, MCWD GSA and SVBGSA are discussing plans to investigate the Deep Aquifer system in the Salinas Valley. Although no specific plans are proposed at this time, there is broad recognition that this important data gap must be addressed during the early stages of GSP implementation for the Subbasin to assure that this aquifer is sustainably managed. MGSA will cooperate with these efforts, review the investigation results and update the Hydrogeologic Conceptual Model (HCM), sustainable management criteria, monitoring program and management actions in this GSP, as appropriate. It is anticipated that the investigation results will provide information regarding the nature and hydraulic properties of the Deep Aquifer system. Specifically, the groundwater flow patterns in the Deep Aquifer, the interconnection between the disparate aquifer units in this system, how they are recharged, and the extent of potential leakance from the overlying upper aquifer system.

7.1.2.5 Aquifer Parameters

SVBGSA is proposing to conduct aquifer testing on up to three wells in the 180-Foot Aquifer and up to three wells in the 400-Foot Aquifer. These one-time aquifer tests are proposed to last for a minimum of 8 hours followed by a 4-hour monitored recovery period. Additional details regarding the aquifer tests can be found in Section 10.3 of SVBGSA's GSP for the Subbasin. Additional aquifer tests may be conducted by others, including in the DSA or the Deep Aquifer. MGSA will review the aquifer test results and update the GSP HCM.

7.1.2.6 Depth Discrete Groundwater data

As discussed in Section 7.1.2.1, MCWD GSA will evaluate the adequacy of the existing monitoring networks in the area surrounding their jurisdiction in the Monterey and 180/400 Foot Aquifer Subbasins

during preparation of GSPs for those Subbasins and address additional data gaps as needed. This will include the limitations posed by long monitoring well screen intervals on the identification of vertical groundwater gradient and quality trends that influence seawater intrusion locally. This data gap is partially addressed through the induction logging of deep monitoring wells; however, additional monitoring wells completed at various vertically-discrete depths may be needed. MGSA will review the outcome of this analysis and any additional studies, and the monitoring program of this GSP will be refined as needed to collaborate with MCWD GSA in meeting the sustainability goals of both GSAs.

7.1.2.7 GEOPHYSICAL SURVEY DATA

Additional geophysical surveys may be needed to evaluate potential changes in groundwater elevations, groundwater quality, and/or seawater intrusion in the event that the MPWPS slant well pumping is approved and occurs as well as other projects in the vicinity of the MGSA. MGSA will coordinate with MCWD GSA regarding the need for additional surveys and with the evaluation of the survey results.

7.1.2.8 LAND SUBSIDENCE

Given the relatively low risk of subsidence near the MGSA Area, the monitoring of groundwater elevations and review of remote sensing data periodically published by DWR, USGS or others should be an adequate monitoring program for this sustainability indicator. However, some uncertainty remains regarding the potential vulnerability of the Subbasin to land subsidence, and MGSA will work with SVBGSA to address this data gap during GSP implementation.

7.1.2.9 POTENTIAL MPWSP IMPACTS

A groundwater model that can simulate solute transport and density-driven flow, and that incorporates the heterogeneity of the aquifer system in the Marina area is not available at this time. The potential effects of the proposed MPWSP on the local water budget, water quality and seawater intrusion cannot be adequately evaluated without such a model. If the MPWSP is fully approved and permitted, there would be a need for a locally-refined groundwater flow model that is able to simulate solute transport and density-driven flow, and for additional targeted investigation to conduct studies to address data gaps. MCWD GSA is currently planning to conduct such studies for the area that includes their GSA boundaries and the surrounding region, including the MGSA Area and beyond. MGSA will collaborate with and review these studies, and update the HCM, sustainable management criteria, monitoring networks and management actions in this GSP to assure the sustainability goals are met if the MPWSP is implemented. These activities will also be coordinated with SVBGSA.

7.1.3 ACTIVITY 3: UPDATE DATA MANAGEMENT SYSTEM

Regulation Requirements:

§ 352.6. Data Management System

Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin.

As described in Chapter 5, a Microsoft Access DMS has been created to store GSP monitoring data. The DMS contains well construction details, well ownership information, GIS well coordinates including well elevation and top of casing, well production data, groundwater elevations, and groundwater quality data. Salinas River streamflow gauge data from USGS will also be stored in the database. MGSA's database has a simple structure which is shared with the DMS being developed by MCWD GSA in support of the GSP for the Monterey Subbasin, which abuts the MGSA Area to the south. In addition, MGSA is coordinating with database personnel from SVBGSA to assure compatibility with the DMS being developed by that agency. Both GSAs will rely extensively on the same monitoring data collected by MCWRA; therefore, it is anticipated that very little data transfer will actually need to occur. SVBGSA is considering development of a web-based DMS to facilitate basin-wide groundwater management. MGSA will cooperate with this effort, but will retain a relatively simple structure for its DMS that is not web-based. MGSA's DMS will be periodically updated with monitoring data as described in Section 7.1.1, and will be used to create tables for data evaluation, model inputs and calibration if needed, adaptive management and reporting to DWR.

7.1.4 Activity 4: Refine GSP based on Findings from the USGS SVIHM and SVBGSP Addendum

SVBGSA noted in its GSP that USGS anticipates releasing its fully calibrated SVIHM in late 2020 (SVBGSA 2019). The SVIHM, when available, will represent the state of the science when it comes to groundwater management tools in the Salinas Valley Basin. SVBGSA intends to update its GSP based on refined information regarding the groundwater flow system, water budgets and predictive capability of that model. SVBGSA intends to review and potentially update (if warranted) the following:

- Historical, current, and projected water budgets;
- Sustainable yield;
- Numerical minimum thresholds for the depletion of interconnected surface water; and
- Benefits of the proposed management actions and priority projects.

SVBGSA intends to incorporate their updates in either an addendum to their GSP for the 180/400 Foot Aquifer Subbasin, or in the 5-year GSP update report. For additional details on these expected updates, please refer to Chapter 10 of SBVGSA's GSP.

Because the MGSA Area is located at the seaward edge of the much larger 180/400 Foot Aquifer Subbasin area managed by SVBGSA, the data and HCM contained in SVBGSA's GSP provides important regional context and understanding for the MGSA GSP. In addition, MGSA has adopted the regional water budgets and several of the regional sustainable management criteria contained in SVBGSA's GSP. Therefore, MGSA intends to work in parallel with SVBGSA in its review of the calibrated SVIHM, and update this GSP at the same time. If the new information is significant for local groundwater management, MGSA will prepare an addendum or update report refining the following items in the MGSA GSP:

- The local Hydrogeologic Conceptual Model (HCM);
- Local historical, current, and projected water budgets;
- Local groundwater elevation and gradient changes potentially resulting from the implementation of regional priority projects; and
- Local sustainable yield estimates, minimum thresholds and other sustainable management criteria.

7.1.5 Activity 5: Inter and Intra Basin Coordination with SVBGSA and MCWD GSA

MGSA will attend coordination meetings with SVBGSA and MCWD GSA as the GSPs for the Subbasin are implemented. It is anticipated that during the first year, coordination meetings will be monthly and then quarterly in subsequent years. The meeting agenda for these coordination meetings will likely include a discussion of the implementation of regional priority projects and management actions, as well as the potential coordination of local data and management actions. As these projects and management actions are implemented, the meeting agenda will likely include the impacts of the actions and evaluation of how well the GSPs are meeting their mutual goals for sustainable management of the Subbasin.

7.1.6 Activity 6: Local Management Actions for Seawater Intrusion and Groundwater Quality Degradation and GDE Impacts

MGSA will monitor and evaluate the potential for significant and unreasonable groundwater level decline that could affect GDEs, seawater intrusion, groundwater quality degradation and/or low-TDS groundwater zone storage depletion as a result of groundwater extraction in the MGSA Area. As discussed in Chapter 6, if the data indicate that undesirable results may occur as a result of these groundwater extractions, then MGSA will implement a series of escalating management actions using its powers and authorities in SGMA. The management actions for the Seawater Intrusion and Groundwater Quality Degradation sustainability indicators are described in Chapter 6 and include the following three general phases: (1) Detection Monitoring; (2) Investigation, Verification and Hydrogeologic Conceptual Model Update; and (3) Characterization, Action Planning and Implementation. For GDEs, the following three phases apply: (1) Detection Monitoring; (2) Biological Investigation and Verification; and (3) Action Planning and Implementation. The progression between each phase is set by a sequence of objective decision triggers which are described in detail in Chapter 6.

7.2 Estimate of GSP Implementation Costs

Regulation Requirements:

§ 354.6. Agency Information

When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:

(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.

The estimated costs for the initial five years of GSP implementation are summarized in Table 7-1. These costs are estimates and will likely change in the future as more data becomes available. A 10% contingency has been added to the implementation costs since these costs are estimates. The overall estimated cost for MGSA for the first five years of implementation is $1,100,000 with an average annual cost of $220,000. The following assumptions have been incorporated into this estimate:

- Collection of groundwater elevation and quality data for the existing monitoring well network will be borne by MCWRA and is therefore not included in the GSP implementation costs; however, a line item for consultation and data management support by MCWRA is included.
- Performance of the baseline biological assessment and annual biological monitoring will be funded through MGSA.
- Analysis of monitoring data and uploading the data to the DMS will be funded through MGSA.
- Expansion of the monitoring well network by adding five cluster monitoring wells will be funded by MCWRA.
- Any additional future expansion of the monitoring well network in the area surrounding MCWD's service system will be funded by MCWD GSA. Investigation, characterization and expanded monitoring of the Deep Aquifer is expected to be performed collaboratively by MCWD GSA, SVBGSA and at their expense. A line item for MGSA collaboration with these activities is included in the budget.
- Annual reporting, a GSP Addendum Report (if needed), and the 5 Year Update Report will be funded through MGSA.
- Communication and Outreach will be funded through MGSA.
- The MGSA will attend coordination meetings with SVBGSA and MCWD GSA to sustainably manage the 180/400 Foot Aquifer Subbasin. MGSA participation in this activity will be funded through MGSA.
- If monitoring data indicate that seawater intrusion, water quality degradation, storage depletion or GDE impacts likely are occurring, then MGSA will implement the management actions described in Section 7.1.6 and Chapter 6. Initial funding for this oversight will be provided through MGSA; however, direct funding by the responsible groundwater extractors within the MGSA may be implemented.

As initial GSP implementation proceeds, MGSA will evaluate funding mechanisms, application of fees, and fee criteria. MGSA will implement an assessment to establish equitable contributions from groundwater extraction fees in the MGSA Area as authorized by SGMA in order to cover MGSA's expenses. MGSA will also evaluate potential funding from state and federal grant sources to support

GSP implementation. Appropriate grant funding sources will be pursued collaboratively with MCWD GSA, SVBGSA, MCWRA and others to fill data gaps and support the implementation of projects and management actions.

7.3 SCHEDULE FOR IMPLEMENTATION

Regulation Requirements:

§ 350.4. General Principles

Consistent with the State's interest in groundwater sustainability through local management, the following general principles shall guide the Department in the implementation of these regulations.

(f) A Plan will be evaluated, and its implementation assessed, consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation without adversely affecting the ability of an adjacent basin to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon.

Figure 7-1 provides a summary of the schedule for the first five years of GSP implementation. The schedule includes the principal implementation activities described in Section 7.1, which are monitoring, reporting, communication and outreach, data management, addressing data gaps, and management actions. Many of these categories consist of ongoing activities that will be conducted throughout the GSP implementation. Annual reports will be submitted to DWR by April 1st of each year, starting in 2021. Periodic reports will be submitted to DWR by April 1st at least every 5 years or following major GSP amendments.

TABLE 7-1. MGSA GSP IMPLEMENTATION COSTS FOR THE FIRST FIVE YEARS

Activity	Estimated Cost	Cost Unit	Assumptions
Consultation and Data Management Support provided by MCWRA	$17,000	Annual	Annual data and technical support from MCWRA
Data Analysis-Monitoring Groundwater Elevations, Groundwater Quality, and Seawater Intrusion	$15,000	Annual	Reviewing data from MCWRA and other pertinent sources
Baseline Biological Assessment	$50,000	One-Time Lump Sum	Biological assessment and documentation of existing GDE conditions and development of a monitoring plan
Biological Monitoring	$10,000	Annual	Annual surveys of GDEs
Data Management	$8,000	Annual	Updating database with new monitoring data
Annual Reporting	$20,000	Annual	Preparing annual reports starting in 2021.
2 Year Addendum Report/Local Model development	$100,000	One-Time Lump Sum	Assumes SVBGSA will be submitting an addendum report based on review of the USGS groundwater model. MGSA to coordinate with SVBGSA and MCWD GSA on model review and significant outcome. Assumes need for local dual density model developed primarily by MCWD in cooperation with MGSA.
Supplemental Monitoring Wells and Deep Aquifer Investigations	$20,000	One-Time Lump Sum	MGSA will coordinate with MCWRA, SVBGSA and/or MCWD GSA as appropriate on the installation of additional monitoring wells to augment potential MPWSP wells, and/or investigate the Deep Aquifer
5 Year Update Report	$80,000	One-Time Lump Sum	Preparing 5-year GSP update
Outreach and Education	$10,000	Annual	Tasks related to City's outreach regarding GSP implementation progress
Coordination Meetings with SVBGSA and MCWD	$12,000	Annual	Based on monthly meetings the first year ($20,000) and then quarterly meetings subsequent years ($10,000)
Coordination of Required Management Actions	$50,000	Annual	This is an order of magnitude estimate; There is no conceptual engineering at this point.
Fee Assessment	$30,000	One-Time Lump Sum	Rate study to establish equitable contribution for groundwater extraction fees in MGSA Area
Total Annual Costs (5 Years)	$720,000		
Total One-Time Costs	$280,000		
Contingency (10%)	$100,000		Since costs are preliminary estimates
Total (First Five Years)	$1,100,000		
Average Annual Costs for Five Years	$220,000		

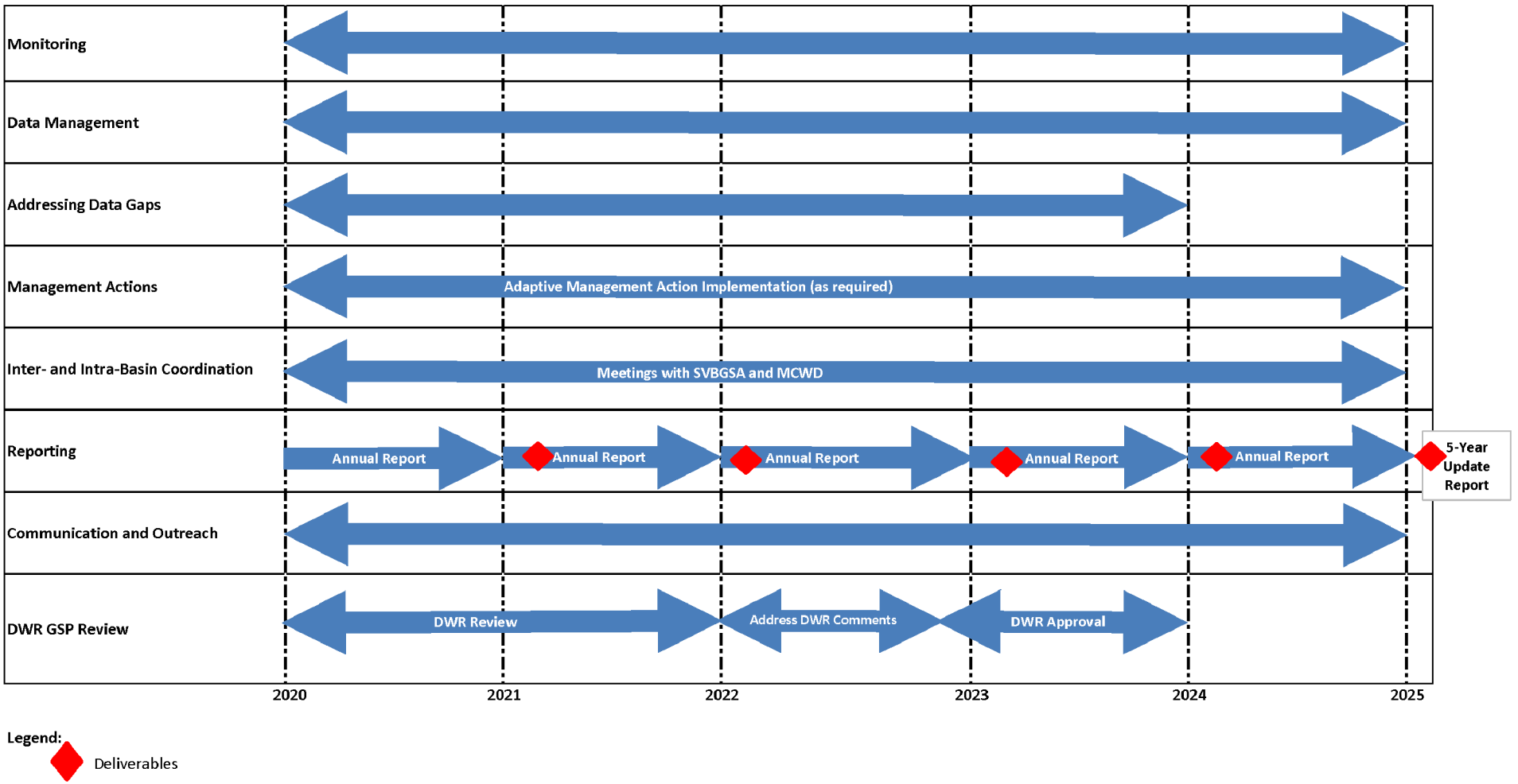

FIGURE 7-1

GSP Implementation Schedule for First Five Years

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

DATE: DEC 20, 2019

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8 REFERENCES

Regulation Requirements:

§ 354.4. General Information
Each Plan shall include the following general information:
(b) A list of references and technical studies relied upon by the Agency in developing the Plan. Each Agency shall provide to the Department electronic copies of reports and other documents and materials cited as references that are not generally available to the public.
Note: Authority cited: Section 10733.2, Water Code.
Reference: Sections 10733.2 and 10733.4, Water Code.

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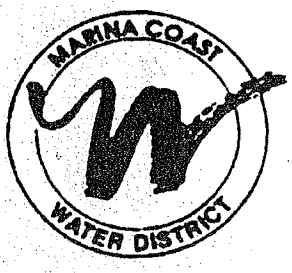
APPENDIX 8.A – CITY OF MARINA, MARINA COAST WATER DISTRICT, AND MONTEREY COUNTY, 1996, ANNEXATION AGREEMENT



Annexation Agreement and Groundwater Mitigation Framework for Marina Area Lands

March 1996

ANNEXATION AGREEMENT AND GROUNDWATER MITIGATION FRAMEWORK FOR MARINA AREA LANDS

EXECUTIVE SUMMARY

PURPOSE--Groundwater Planning. This Agreement and Framework provides for annexing lands in the Marina area to MCWRA Zones 2 and 2A, the benefit assessment zones for the Nacimiento and San Antonio reservoirs. The Agreement and Framework establishes a groundwater mitigation framework process for the lands to be annexed, and provides money from the Marina area for Basin management planning.

ANNEXATION TO ZONES 2 AND 2A--MCWD, Armstrong, Lonestar. Annexation proceeds under section 7 of the MCWRA Act for lands within the service area of MCWD, and lands owned by Armstrong and Lonestar. Annexation of the MCWD service area was effective immediately upon approval by the MCWRA Board of Supervisors. The Armstrong Ranch annexation will be effective when LAFCO approves concurrent annexation to MCWD and the City of Marina on conditions satisfactory to Armstrong (including recordation of a final subdivision map). The Lonestar annexation will take effect when the Lonestar Property is annexed to MCWD.

Annexation Fees--more than $3,500,000. Annexation fees are based on $277/acre of land annexed, and $783/af of water to be used. The fee for land on which water is not used is $27.70/acre. The fee for agricultural water is $261/af. Annexation fees total more than $3,500,000, plus interest, as follows:

Fees for MCWD are $2,449,410, based on 1,750 acres @ $277/ac. and 3,020 afy of water @ $783/af, and a credit of $400,000 already paid by MCWD for groundwater management planning.

Fees for Armstrong will be about $970,000 for Area A (urban), based on 900 acres @ $277/ac. and 900 afy @ $783/af, and an amount subject to final determination upon actual annexation for Area B (irrigated and unirrigated agriculture). If the annexation of the Armstrong Ranch occurs more than seven years after MCWRA approves the Annexation Agreement, Armstrong will pay the then-current annexation fees. If the agricultural water use on Area B of the Armstrong Ranch changes, Armstrong will pay an additional 2/3 of the then-current water charge portion of the annexation fee, and if water is used on any area annexed as unirrigated, Armstrong will pay an additional 9/10 of the then current land charge.

Fees for Lonestar will be $166,621, based on 104 acres using water @ $277/ac., and 264 acres of unirrigated, vacant land @ $27.70/ac., and 500 afy of water with quality below agricultural standards @ $261/af. If Lonestar's use changes to a potable use, or if Lonestar is supplied water from the MCWD or has water available from the BMP, or if Lonestar uses water on the open-space area, Lonestar will pay the other two-thirds of the water charge.

Payments for MCWD, Armstrong and Lonestar may be in a lump sum, or in installments over 10 years from the date of annexation, with 6% annual interest.

Annexation fees will be dedicated to paying costs of a BMP process that includes benefits for the Marina Area, and for management and protection of the deep aquifer.

Annual Assessments. After annexation, Marina area lands will pay annual assessments for MCWRA Zones 2, 2A and 2Z.

GROUNDWATER LIMITS--4,440 AFY

Pumping Limits. Under the Agreement and Framework, the present MCWD service area is limited to **3020** afy of potable groundwater. Non-agricultural use of Basin groundwater on the Armstrong Ranch is limited to **920** afy, 20 afy when the Agreement and Framework becomes effective, an additional 150 afy upon annexation, and additional increments of 150 afy every two years thereafter. Groundwater underlying approximately 730 acres of the Armstrong Ranch is limited to agricultural use, except that **20** afy can be used for potable uses, and water from that area can also be used at the regional treatment plant. Lonestar will limit its pumping to its current use of **500** afy.

Reclaimed Water Management. MCWD has the right to receive tertiary treated water from the SVRP plant. MCWD will defer taking summer flows of more than 300 afy (all summer flows if a reservoir is built). MCWD will take its entitlement over 300 afy from winter flows, and plan to store the water for use in the summer. MCWD will pay MCWRA for each acre-foot of reclaimed water received from the SVRP, with the price determined each year by a formula.

Water Storage Site. Armstrong will reserve not more than 250 acres of land for the MCWD for a possible water storage site, subject to planning and CEQA compliance. Armstrong will donate the land over about 12 years, as Armstrong's entitlement to potable groundwater use increases in 150 afy increments, or MCWD can acquire land as needed by paying $25,000 per acre (which can be recovered in Armstrong's fees to annex land to MCWD). MCWD, MCWRA, the City of Marina (and MRWPCA, if it signs the Addendum) agree not to take any more land on the Armstrong Ranch, except for specified, limited purposes. Armstrong has reserved well

sites to irrigate Area B and to provide water for MRWPCA's regional treatment plant.

Alternate Water Supplies--300 afy of new water.

BMP. MCWRA's BMP planning will include consideration of the Marina area for a Basin alternative to groundwater pumping in the Marina area.

MCWD. MCWD will continue to plan for new water supplies, such as wastewater reclamation and desalination, to replace and supplement groundwater pumping.

Deep Aquifer Management. MCWRA and MCWD will manage the 900' aquifer to protect and preserve it and to sustain a secure water supply source for MCWD.

Water Source for Fort Ord. MCWD's deep wells may be used to provide up to 1400 afy of water already allocated to Fort Ord as part of the Fort Ord annexation to Zones 2 and 2A.

CONSERVATION. MCWD's aggressive water conservation program will continue in the Marina area.

EQUAL TREATMENT. The MCWRA will not impose greater restrictions on the Marina area's water use from the Basin than are imposed on water use or supply for use within the City of Salinas.

MRWPCA ADDENDUM. The Addendum attached to the Agreement and Framework as Exhibit "G" would provide for MRWPCA to join the Agreement and Framework on terms which would include possible acquisition of a buffer zone for the Regional Treatment Plant, and agreement to the other terms of the Agreement and Framework.

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"D" Lonestar property to be annexed

"E" Calculation of Incremental Cost for Tertiary Treated Water

"F" Armstrong Areas Reserved For Transfer to MCWD

"G" MRWPCA Addendum

ANNEXATION AGREEMENT AND GROUNDWATER MITIGATION FRAMEWORK FOR MARINA AREA LANDS

SUBJECT: **Management and Protection of Salinas River Groundwater Basin; Annexation of Marina Area Lands To Zones 2 and 2A of the Monterey County Water Resources Agency**

1. PURPOSE AND AUTHORITY.

1.1. Purpose. The purpose of this Agreement and Framework is to help reduce seawater intrusion and protect the groundwater resource and preserve the environment of the Salinas River Groundwater Basin through voluntary commitments by the Parties to limit, conserve and manage the use of groundwater from the Salinas River groundwater basin, and to provide the terms and conditions for the annexation of certain territory in the Marina area to the Monterey County Water Resources Agency's benefit assessment Zones 2 and 2A as a financing mechanism providing additional revenues to the Monterey County Water Resources Agency to manage and protect the groundwater resource in the Salinas River Groundwater Basin and to reduce seawater intrusion.

1.2. Authority. This Agreement and Framework is entered into under the authority of the Agency Act, the California Water Code, and the California Government Code.

2. DEFINITIONS AND DESIGNATIONS. The following definitions and designations apply to this Agreement and Framework:

2.1. Parties.

2.1.1. Marina Coast Water District ("MCWD"). A political subdivision of the State of California, located in Monterey County, governed by MCWD's Board of Directors.

2.1.2. Monterey County Water Resources Agency ("MCWRA"). A water and flood control agency created by the State of California, with jurisdiction coextensive with Monterey County, governed by the Monterey County Water Resources Agency Board of Supervisors.

2.1.3. J. G. Armstrong Family Members ("Armstrong"). The owners of the Armstrong Ranch in the Marina area of Monterey County.

2.1.4. RMC Lonestar ("Lonestar"). A California general partnership and owner of the Lonestar property in the Marina area of Monterey County.

2.1.5. City of Marina ("City"). An incorporated municipality within Monterey County, organized and operating under the laws of the State of California, governed by its City Council.

2.2. AFY. Acre-feet per year.

2.3. Agency Act. MCWRA's enabling legislation adopted by Chapter 1159 of the Statutes of 1990, and Chapter 1130 of the Statutes of 1991, set forth in full in West's California Water Code Appendix, Chapter 52.

2.4. Armstrong Ranch. About 1850 acres of land in the Marina area, as shown on Exhibit "C," about 322 acres of which is within the City of Marina, plus an additional 150 acres not shown on Exhibit "C" which is already in the Zones.

2.5. Basin. The Salinas River Groundwater Basin.

2.6. BMP. The MCWRA's Basin Management Plan for the Salinas River Groundwater Basin.

2.7. CEQA. The California Environmental Quality Act, Public Resources Code sections 21000 and following.

2.8. CSIP. The Castroville Seawater Intrusion Project, a distribution system project already approved and being implemented by MCWRA to provide reclaimed water for irrigation in the Castroville Area of Monterey County.

2.9. Effective Date. Subject to paragraph 4, this Agreement and Framework shall be fully effective when executed by all the Parties.

2.10. Exhibits.

"A" The general geographic relationship of MCWD, Armstrong and Lonestar to the Basin and to the Zones is shown on the diagram attached to this Agreement and Framework as Exhibit "A."

"B" MCWD service area to be annexed

"C" Armstrong Ranch land to be annexed

"D" Lonestar property to be annexed

"E" Calculation of Incremental Cost for Tertiary Treated Water

"F" Armstrong Areas Reserved For Transfer to MCWD

"G" MRWPCA Addendum

2.11. FEIR. The Final Environmental Impact Report for the Salinas Valley Seawater Intrusion Program (February 1992).

2.12. Fort Ord. The land within the boundaries of the former Fort Ord Military Reservation.

2.13. Lonestar Property. A parcel containing about 400 acres of land in the Marina area, as shown on Exhibit "D."

2.14. Marina Area. Lands served by, adjacent to, or within the sphere of influence of MCWD.

2.15. MCWD Water Plans. The Urban Water Master Plan and the Urban Water Shortage Contingency Plan adopted by MCWD.

2.16. MCWRA/MRWPCA Agreement. Monterey County Agreement No. A-6078, "Agreement Between The Monterey County Water Resources Agency And The Monterey Regional Water Pollution Control Agency For Construction And Operation Of A Tertiary Treatment System," dated for reference purposes June 16, 1992, as amended on or before December 1, 1995.

2.17. Mitigation Plan. A plan for a potable water supply capable of mitigating the effects of seawater intrusion and providing a long-term potable water supply to MCWD's distribution system.

2.18. Mitigation Plan Implementation. The Mitigation Plan shall be considered "implemented" upon the delivery of potable water to MCWD's distribution system from a completed, long-term, potable water supply system, after system testing has been successfully completed.

2.19. Agreement and Framework. This Annexation Agreement and Groundwater Framework for Marina Area Lands.

2.20. Monterey Regional Water Pollution Control Agency ("MRWPCA"). A joint powers authority providing sewage treatment service to its member entities in Northern Monterey County, governed by its Board of Directors.

2.21. MRWPCA Annexation Agreement. "Annexation Agreement Between The Marina County Water District And The Monterey Regional Water Pollution Control Agency," dated April 25, 1989, as amended on or before December 1, 1995.

2.22. 1990 Agreement. Monterey County Agreement No. A-5471, "Preliminary Agreement Between United States of America, Marina Coast Water District, and Monterey County Flood Control and Water Conservation District," dated July 12, 1990.

2.23. SVRP. The Salinas Valley Reclamation Project, a project already approved and being implemented by MCWRA, in

cooperation with MRWPCA, to reclaim water at the MRWPCA's regional treatment plant, for irrigation through the CSIP.

2.24. Zones. Zones 2 and 2A of the MCWRA, which are the zones of benefit and assessment for the MCWRA's Nacimiento and San Antonio reservoirs.

3. FACTS AND CIRCUMSTANCES. This Agreement and Framework is entered into with regard to the following facts and circumstances:

3.1. The MCWRA has approved fourteen other annexations to Zones 2 and 2A since 1991. Like other areas which have been annexed, the Marina area is within the Salinas River Groundwater Basin, has been using groundwater for many years, and has strong claims to groundwater rights. Since the Fort Ord annexation in 1993, the Marina area is surrounded on three sides by Zones 2 and 2A, and by Monterey Bay to the west.

3.2. MCWRA agreed in the 1990 Agreement to "encourage and support" annexing MCWD to Zones 2 and 2A. MCWD has worked for about thirteen years with the MCWRA on plans for a reliable, long-term water supply for the northern Basin area, including the Marina area and Fort Ord. MCWD's participation has included payment of money to assist the planning effort. As part of the 1990 Agreement, MCWD paid for survey and planning work for the long-term water supply effort. Sums paid by MCWD to MCWRA total over $400,000. The work for which MCWD paid will be useful for the Mitigation Plan.

3.3. MCWD, City, Armstrong and Lonestar claim the right to use groundwater from the Basin, to the full extent provided by law. MCWD takes water from wells owned and operated by MCWD and drilled into the "180-foot", "400-foot" and "900-foot" aquifers in the Basin. About ninety-eight percent of potable water used currently by MCWD comes from the 900-foot aquifer. MCWD's current maximum pumping capacity is 5,800 gpm (9,350 afy) of potable water and 1,100 gpm (1,770 afy) of other usable water. Allowing for routine maintenance and providing a contingency factor for emergency shutdown, MCWD's current estimated operational pumping capacity for potable water is 3900 gpm (6,000 afy).

3.4. MCWD agreed in writing in 1988 to cooperate with the City in providing water service to the Lonestar property and the Armstrong Ranch. A coordinated and centralized water supply for the Marina Area in furtherance of that 1988 agreement will facilitate management and protection of the groundwater resource in the Marina Area. Armstrong claims the right and ability to use not less than 920 afy of potable water from the Basin to provide potable water service to the Armstrong Ranch, and the right to use water for agricultural purposes. MCWD currently supplies some water to the Armstrong Ranch. The Armstrong Ranch will need reclaimed water for golf course purposes, park purposes and such other general uses as may be required by any agency having

jurisdiction as a condition of development. The Lonestar property currently uses about 500 afy of groundwater from the Basin.

3.5. The MCWD Water Plans are based on a total need within MCWD's current boundaries of 3,020 afy of water for potable uses and about 280 afy additional water suitable for irrigation, and on additional projected need by the rest of the Marina area as specified in the MCWD Water Plans.

3.6. MCWRA has previously annexed Fort Ord into Zones 2 and 2A. The September 1993 Agreement for that annexation provides that until implementation of a project to provide a substitute supply, a maximum of 6,600 afy may be withdrawn from the Basin for use on Fort Ord lands, provided no more than 5,200 afy are withdrawn from the 180-foot aquifer and 400-foot aquifer. The USA received a credit against annexation fees for about $400,000 paid under the 1990 Agreement.

3.7. Pursuant to paragraph 12 of the MRWPCA Annexation Agreement, MCWD has the right to obtain from the MRWPCA, at the regional treatment plant, treated wastewater for reuse by the MCWD in quantities equal to the volume of MCWD wastewater treated by MRWPCA and such additional quantities as from time to time are not committed to any other users for beneficial use. MCWD's cost for such treated wastewater will be the MRWPCA's incremental cost over secondary treatment, to meet applicable local, state and federal requirements for water reuse.

3.8. The MCWRA/MRWPCA Agreement provides that the SVRP shall be designed and built for tertiary treatment of wastewater to be used for irrigation through the CSIP. That Agreement also mentions possible future interties with other agencies. The MCWRA/MRWPCA Agreement commits flows of wastewater to the CSIP as provided in Article IV and Exhibit C of that Agreement, excepting flows taken by MCWD pursuant to the MRWPCA Annexation Agreement.

4. REQUEST FOR ANNEXATION.

4.1. Request by MCWD, Armstrong, and Lonestar. Execution of this Agreement and Framework shall be deemed to be a formal and joint request by the signatories that the MCWRA's Board of Supervisors exercise their authority under section 7 of the Agency Act (West's California Water Code App. § 52-7) to annex to the Zones the lands described in Exhibits "B", "C" and "D" to this Agreement and Framework, on the terms and conditions of this Agreement and Framework as executed by the requesting signatories. No other terms or conditions shall apply to any annexation under this Agreement and Framework without the written agreement of all the Parties affected by the change.

4.2. Request by MCWD. MCWD is requesting immediate annexation of all the lands described in Exhibit "B." The lands to be annexed include the land which contains Olson School and the Methodist Church.

4.3. Request by Armstrong. Armstrong is requesting annexation of its land described in Exhibit "C", which annexation would take effect as provided in paragraph 6.2 of this Agreement and Framework.

4.4. Request by Lonestar. Lonestar is requesting immediate annexation of its land described in Exhibit "D", which annexation would take effect as provided in paragraph 7.3. of this Agreement and Framework.

4.5. Effect of Request. Other than to serve as a formal annexation request pursuant to section 7 of the Agency Act, this Agreement and Framework shall have no effect until its execution by the MCWRA.

5. TERMS AND CONDITIONS--MCWD.

5.1. Quantity limitations on MCWD's groundwater pumping.

5.1.1. Commencing on the effective date of this Agreement and Framework and continuing until Mitigation Plan Implementation, MCWD will limit its withdrawal of potable groundwater from the Basin for land in the Marina area and outside the former Fort Ord Military Reservation to 3,020 afy of potable groundwater, and only such additional quantities as are permitted by this paragraph 5.1. MCWRA's groundwater resource planning for the existing MCWD service area will be based on the latest information and projections contained in the MCWD Water Plans, using 3,020 afy as a planning guideline for potable water use.

5.1.1.1. After compliance with all applicable requirements of law, including but not limited to CEQA, MCWD may improve the interconnection between the MCWD water system and the water system serving Fort Ord, to provide for joint, conjunctive and concurrent use of all system facilities to serve Fort Ord and other areas served by MCWD, and the other Parties will cooperate on MCWD's increased withdrawal of potable groundwater by up to 1,400 afy from the 900-foot aquifer to enable the increased withdrawals from 5200 afy to 6600 afy for use on Fort Ord, as provided in paragraph 4.c. of the September 1993 Agreement between The United States of America and the MCWRA.

5.1.1.2. If the Armstrong property has been annexed to the Zones, the other Parties will cooperate on MCWD's increased withdrawal of up to 920 afy from the Basin, on the condition that such withdrawals shall be used only to provide water to the Armstrong Ranch and, to the extent that such water is requested and accepted by Armstrong, such use shall in its entirety be applied to the satisfaction of Armstrong's entitlement under paragraph 6.9. of this Agreement and Framework.

5.1.1.3. If the Lonestar property has been annexed to the Zones, the other Parties will cooperate on MCWD's

increased withdrawal of up to 500 afy from the Basin, on the condition that such withdrawals shall be used only to provide water to the Lonestar property, and, to the extent that such water is requested and accepted by Lonestar, such use shall in its entirety be applied to the satisfaction of Lonestar's entitlement under paragraph 7.2. of this Agreement and Framework.

5.1.2. Conditioned upon MCWRA's compliance with paragraphs 5.1, 5.2, 5.3., 5.5, 5.7, 8.1, 8.2 and 8.3, after Mitigation Plan Implementation, MCWD will be governed by such limitations on the withdrawal of water from the Basin as shall be included in the terms of the Mitigation Plan.

5.2. No objection by MCWRA to MCWD withdrawals except pursuant to section 22 of Agency Act. The MCWRA shall not object to any withdrawal by MCWD which is mentioned in section 5.1 above, except in compliance with section 22 of the Agency Act. All groundwater withdrawn from the Basin by MCWD may be used only within the Basin.

5.3. Management of 900-foot aquifer. The Parties agree that the "900-foot" aquifer should be managed to provide safe, sustained use of the water resource, and to preserve to MCWD the continued availability of water from the "900-foot" aquifer. The Parties will work to include in a Mitigation Plan the concept that water from the Mitigation Plan which costs less than the cost of desalinated water should be the primary source of potable water for the lands described in Exhibits "B", "C", and "D", and wells in the "900-foot" aquifer should be a secondary source, if seawater intrusion is shown to be affecting the "900-foot" aquifer by credible scientific evidence. The Parties will also work together on measures to protect the "900-foot" aquifer.

5.4. Compliance with CEQA and other applicable laws. MCWD's participation in the Mitigation Plan or any other alternative water supply plan is subject to compliance with all applicable laws, including but not limited to CEQA, and to review and approval by the MCWD.

5.5. MCWD development of alternative water supplies. MCWRA agrees that it is appropriate for MCWD to plan for and develop any new water supplies, including but not limited to wastewater reclamation and desalination, that help to meet MCWD's needs, except that the MCWRA believes that the unilateral development of water by MCWD would not be appropriate from any of the following sources: the 180-foot and 400-foot confined aquifers in the Pressure Area of the Salinas Valley Groundwater Basin, the unconfined aquifer in the three other areas in the Salinas Valley Groundwater Basin (East side, Forebay, and Upper Valley), and the Salinas River and its tributaries.

5.6. MCWD payment to MCWRA for tertiary treated water. In satisfaction of paragraph 12 of the MRWPCA Annexation Agreement, MCWD will pay to MCWRA the incremental cost over secondary

treatment to receive tertiary treated water from MRWPCA's planned tertiary treatment facilities at its regional treatment plant. The Parties agree that this cost shall be calculated as set forth on Exhibit "E" to this Agreement and Framework.

5.7. MCWD right to receive tertiary treated water from MRWPCA plant.

5.7.1. Pursuant to the MRWPCA Annexation Agreement, on or after the date of first delivery of water from the CSIP and upon compliance with all then-applicable requirements of law, including but not limited to CEQA, MCWD shall have the right to receive tertiary treated water from the tertiary treatment plant constructed and maintained pursuant to the SVRP, as provided herein.

5.7.2. The CSIP requires maximum available reclaimed water flows from the SVRP during the months of April through September to replace historically high uses of groundwater during those months, and to thereby maximize environmental benefits. Accordingly, during the months of April through September, MCWD agrees to defer taking any water over 300 afy it is entitled to take from the tertiary treatment plant under the MRWPCA Annexation Agreement. MCWD will also defer taking the first 300 afy of such flows to which it is entitled, if and after MCWD constructs a reservoir to store replacement winter flows.

5.7.3. During the months of October through March, MCWD may take the full amount of the reclaimed water to which it would, under the MRWPCA Annexation Agreement, have first priority during those months, together with an amount of water equal to the amount deferred during the immediately preceding months of April through September under paragraph 5.7.2. above. MCWD will take the deferred amount in equal or approximately equal monthly portions spread throughout the October-March period, or as otherwise agreed in writing by the MCWD and the MCWRA.

5.7.4. If MCWD's ability to supply reclaimed water is interrupted for any reason, MCWD and MCWRA will act jointly and diligently, together and with MRWPCA, to mitigate possible damage to users of such flows, including possible interim use of MCWD's wells to provide a substitute source of water.

5.8. Effective date of annexation. The annexation to Zones 2 and 2A of the MCWD lands described in Exhibit "B" shall take effect immediately upon approval of the annexation by the MCWRA Board of Supervisors on the terms of this Agreement and Framework, or, if the annexation is approved by ordinance, then thirty (30) days after adoption of an ordinance approving the terms of this Agreement and Framework.

5.9. Annexation fee.

5.9.1. Amount of MCWD annexation fee. To annex all the land described in Exhibit "B" to the Zones, MCWD shall pay to MCWRA an annexation fee in the amount of Two Million Eight Hundred Forty-Nine Thousand Four Hundred and Ten Dollars ($2,849,410.00) (based on 1750 acres in the MCWD service area and water extraction use of 3020 afy). MCWD shall pay this amount, subject to any adjustments hereinafter described, in semi-annual installments as provided in paragraph 5.9.3. below. By giving written notice to MCWRA on or before May 1, 1997, MCWD may elect to pay the annexation fee in full, without interest, in one lump sum on or before July 1, 1997.

5.9.2. Credit. MCWD shall have a credit of $400,000 against the annexation fee, based on the 1990 Agreement and the similar credit previously given to the U.S.A. on the annexation of Fort Ord to the Zones.

5.9.3. Payment of annexation fee. MCWD shall pay its annexation fee as follows:

5.9.3.1. From the total amount of the annexation fee, subtract the credit of $400,000, to determine the "net annexation fee." MCWD may elect to pay the net annexation fee in one lump sum, as provided in paragraph 5.9.1, or may pay in installments as provided below. If MCWD elects to pay in one lump sum, any late payment shall bear interest at the annual rate of 6% from the due date and shall be subject to the same penalties and collections procedures as are set forth in paragraph 6.7. of this Agreement and Framework.

5.9.3.2. MCWD may pay in twenty semi-annual installments, beginning in the fiscal year commencing on July 1, 1997, with interest at the annual rate of six percent (6%) on the unpaid principal balance accruing from July 1, 1997, and with semi-annual payments due on November 1 and February 1 and delinquent on December 10 and April 10 each fiscal year. The interest included in payments consisting of both principal and interest shall be calculated as though the installment were paid on the last day before delinquency, even if the installment is paid in advance of that date. The total amount of each installment paid on the net annexation fee shall be sufficient to amortize the full amount of principal and interest in twenty (20) equal semi-annual installments. There shall be no pre-payment penalty.

5.10. MCWD use of revenues prior to full payment of annexation fee. Until MCWD pays or receives credit for the entire annexation fee and all accrued interest on the fee, all revenue received by MCWD from the lands annexed to the Zones pursuant to this Agreement and Framework for or in connection with providing water and sewer service to the lands shall be used only for activities and functions duly performed by MCWD in connection with

providing water and sewer service, including, but not limited to, the payments required under this Agreement and Framework.

6. TERMS AND CONDITIONS--ARMSTRONG.

6.1. Ranch Areas. Annexation of the Armstrong Ranch to the Zones contemplates two general areas of the Ranch, which are designated for convenience "Area A" and "Area B." Area A consists of about 900 acres which is expected to be developed for urban uses. Area B consists of about 950 acres, a portion of which is expected to be used for irrigated agriculture, and about 220 acres of which is expected to be given to MCWD to store treated water. For purposes of determining assessments, standby charges and the like, the initial classification of the land within Area B will be determined at the time of annexation.

6.2. Effective Date of Annexation. Approval of this Agreement and Framework by the MCWRA Board of Supervisors shall constitute approval for annexation of the Armstrong Ranch to the Zones at the time and on conditions approved by LAFCO and satisfactory to Armstrong for concurrent annexation of the Armstrong Ranch to MCWD and the City of Marina, including recordation of a final subdivision map upon conditions satisfactory to Armstrong.

6.3. Participation by Armstrong in MCWD water sources. Subject to compliance with all then-applicable requirements of law, including but not limited to CEQA, Armstrong Ranch shall be entitled at all times to participate on an equitable basis with MCWD in potable water sources developed by MCWD pursuant to paragraph 5.5. of this Agreement and Framework, in which event the limitations concerning the use of water on the Armstrong Ranch, as set forth in paragraph 6.9. shall not be applicable to using potable water developed pursuant to paragraph 5.5.

6.4. Prerequisites to annexation to MCWD and the City of Marina. Any application to LAFCO for annexation of any Armstrong Ranch property to either MCWD or the City of Marina shall be concurrently submitted by the City and MCWD, and shall provide that such property to be annexed shall be within the boundaries of both MCWD and the City of Marina.

6.5. Annexation fee.

6.5.1. When the Armstrong Ranch has been annexed to the Zones, Armstrong will pay to MCWRA an annexation fee computed as the sum of

6.5.1.1. the product of multiplying the number of acres annexed by $277/acre for land intended for urban or irrigated use and $27.70/acre for land intended for grazing, dry land farming or other unirrigated use, and

6.5.1.2. the product of multiplying the number of afy of water from the Basin or the Mitigation Plan allocated to the annexed land by $783/af for potable water intended for urban use and $261/af for water intended for agricultural use. Such charge shall not be applicable to any water from a source other than the Salinas Valley Groundwater Basin or the Salinas River and its tributaries.

6.5.2. Fees for Armstrong are estimated to be about $969,660 for Area A, based on 900 acres @ $277/ac. and 920 afy @ $783/af, and an amount subject to final determination upon actual annexation for Area B. For example, based on 250 irrigated acres @ $277/ac., 700 unirrigated acres @ $27.70/ac., and 650 afy of water @ $261/af, the annexation fees for Area B would be about $258,000.

6.5.3. If annexation of the Armstrong Ranch occurs more than seven years after MCWRA approves this Agreement and Framework, Armstrong shall pay the then-current annexation fees, instead of the fees set forth in paragraph 6.5.1 above.

6.5.4. Armstrong may elect to pay the annexation fee in a lump sum as provided in paragraph 6.6 below, or may pay the annexation fee in installments as provided in paragraph 6.7 below. There shall be no prepayment penalty.

6.5.5. If the agricultural water use on Area B is changed to a potable or industrial use, then Armstrong shall pay to the MCWRA as an additional annexation fee, an additional water charge computed as two-thirds (2/3rds) of the product of the number of afy changed multiplied by the then-current annexation water charge. If Armstrong uses water on any part of the Armstrong Ranch which is initially annexed as land for unirrigated use, Armstrong shall pay an additional land fee of nine times the land fee specified for such land in 6.5.1.1 above. The additional water charge or land fee will be paid either in one lump sum, due and payable on the July 1 immediately following the change in water use, or in twenty (20) equal semi-annual installments over ten (10) years, with the payment period and interest accrual beginning on that July 1, in the same manner as prescribed for Armstrong's original annexation fee and subject to the same rules.

6.6. Payment of annexation fee in lump sum. If paid in a lump sum, the annexation fee shall be due and payable in full on July 1, next succeeding the first March 1 after the effective date of the annexation. Armstrong may elect to pay the annexation fee in full in one lump sum by giving written notice of such election to MCWRA not later than the May 1 immediately preceding the date payment is due. Any late payment shall bear interest at the annual rate of 6% from the due date, and shall be subject to the same penalties and collection procedures as are set forth in paragraph 6.7.

6.7. Payment of annexation fee in installments.

6.7.1. If paid in installments, the installments shall include interest on the unpaid principal balance at the annual rate determined in the manner hereinafter set forth, which interest shall begin to accrue on July 1, next succeeding the first March 1 after the effective date of the annexation. The interest rate on installments shall be six percent per annum. The interest included in each installment shall be calculated as though the installment were paid on the last day before delinquency, even if the installment is paid in advance of that date.

6.7.2. The amount of each semi-annual installment shall be sufficient to amortize the full amount of principal and interest in twenty (20) equal semi-annual installments.

6.7.3. The semi-annual installments shall be paid and collected at the same time and in the same manner and by the same persons as, and together with and not separately from, general agency and zone taxes and shall be delinquent at the same time and thereafter subject to the same delinquency penalties. The first installment shall be due on November 1 following July 1, next succeeding the first March 1 after the effective date of the annexation and shall be delinquent if not paid on or before the following December 10. The second installment shall be due on the following February 1 and shall be delinquent if not paid on or before the following April 10. Thereafter, installments shall fall due and become delinquent on the same dates each year.

6.7.4. The full amount of principal and interest shall be paid not later than April 10, in the tenth year following July 1, next succeeding the first March 1 after the effective date of the annexation.

6.7.5. The amount of each installment shall constitute a lien on each annexed parcel as of noon on the March 1 immediately preceding the fiscal year (July 1-June 30) in which payment of the installment will be due. If the property is subdivided, then a prorata share of the annexation fee shall become a lien on each individual parcel, based upon the ratio that the land area of the individual parcel bears to the total land area of all parcels against which the annexation fee is a lien. All laws applicable to the levy, collection and enforcement of general agency and zone taxes, including, but not limited to, those pertaining to delinquency, correction, cancellation, refund and redemption, shall be applicable to such installments.

6.7.6. MCWD shall pay to MCWRA any fees to annex the lands within the MCWD Reserved Area described in paragraph 6.10 and shown on Exhibit "F" to this Agreement and Framework.

6.8. Costs, assessments, fees and charges. Costs, assessments, fees and charges imposed by MCWD in connection with providing water and wastewater treatment capacity and service to

the Armstrong Ranch must be equitable and reasonable and must be reasonably related to services and benefits received, consistent with the County Water District Law (Water Code sections 30,000 and following), with Government Code sections 50076 and 66013, and with applicable case law.

6.9. Quantity limitations on Armstrong water use.

6.9.1. Armstrong shall have the right to utilize on the Armstrong Ranch groundwater for irrigation, and 920 afy of additional water for potable uses withdrawn from the Basin, subject to the limitations set forth herein. Armstrong shall limit potable water withdrawn from the Basin and used for potable purposes on the Armstrong Ranch to no more than 20 afy when this Agreement and Framework becomes effective, 150 afy upon annexation to the Zones, and an additional 150 afy every two years thereafter, up to the total of 920 afy for potable purposes from the Basin.

6.9.2. MCWD shall provide Armstrong with water service for all residential, municipal and industrial uses on the Armstrong Ranch. In providing such service, the water allocation for Armstrong, set forth above in paragraph 6.9.1., shall be added to the MCWD water allocation, as provided in paragraph 5.1.

6.9.3. Groundwater underlying Area B shall be used solely for agricultural activities conducted on Area B, except that not more than 20 afy of such groundwater may be used for potable uses on the Armstrong Ranch, and additional groundwater underlying Area B also may be used by the MCWD on the part of Area B conveyed to MCWD and may also be used on the adjacent lands of the MRWPCA.

6.9.4. The limits on water use provided by this paragraph 6.9. shall not apply to use of reclaimed water or of potable water developed from a source other than the Salinas Valley Groundwater Basin or the Salinas River and its tributaries.

6.10. Reservation of lands for MCWD.

6.10.1. MCWD Reserved Area. Armstrong shall reserve, for use by MCWD, the area shown diagrammatically on Exhibit "F" to this Agreement and Framework as "MCWD Reserved Area", and the non-exclusive easements shown on Exhibits "C" and "F" in favor of MCWD, appurtenant to said MCWD Reserved Area and to MCWD's reclaimed water system and transferrable with either, for construction, roads, utilities (including communications), pipelines, and any other purpose for which a road may be used, subject to the non-exclusive easements shown on Exhibits "C" and "F" to be reserved in favor of Armstrong, which said reserved easements in favor of Armstrong shall be for wells (located within the southerly 60' of the 160' x 1000' strip as shown on Exhibit "F", which wells may be relocated within said strip from time to time, on well sites which may extend north of the southerly 60' of the strip) for agricultural irrigation, roads, utilities (including

communications), pipelines, and any other purpose for which a road may be used, shall be freely assignable and usable by others, and not subject to being extinguished or limited because of overburden or surcharge, and which said reserved easements shall not interfere or be used so as to interfere with the use of the balance of said MCWD Reserved Area for the production, storage, or distribution of treated water (tertiary treatment or its equivalent), or potable water. Before either MCWD or Armstrong installs any facilities in the reserved easements, MCWD and Armstrong will meet and confer to assure that their respective uses of and facilities in the said reserved easements will not conflict. Both parties shall act reasonably in considering the needs of the other. MCWD shall not place any non-potable water impoundment within the 160' x 1000' strip, nor any non-potable water pipeline closer than 110' north of the southerly boundary. MCWD shall not be required to move any facilities the installation of which has been approved by Armstrong. Water from wells located in said reserved strip shall be used only on lands of Armstrong and also may be used by the MCWD on the part of Area B conveyed to MCWD and may also be used on the adjacent lands of the MRWPCA.

6.10.1.1. The MCWD Reserved Area, which shall not exceed 250 acres within the boundaries shown on Exhibit "F", will be "office" surveyed at the expense of MCWD within sixty days, and "field" surveyed at the expense of MCWD within one year, following approval by the MCWRA Board of Supervisors of this Agreement and Framework.

6.10.1.2. MCWD will diligently undertake, and MCWRA, City and Armstrong will cooperate in the planning and conduct of, the appropriate environmental review and application for appropriate permits to use MCWD Reserved Area for facilities for the production, storage, or distribution of treated water (tertiary treatment or its equivalent), or potable water. Any use other than for the production, storage, or distribution of treated water (tertiary treatment or its equivalent), or potable water, shall require the prior written approval of Armstrong, and any conveyances from Armstrong to MCWD shall contain appropriate restrictions on such additional use in the form of a condition subsequent to the conveyances and a power of termination in favor of Armstrong. Any attempt to condemn the power of termination shall be subject to the provisions of paragraph 6.10.3. as if it were a condemnation of fee title.

6.10.1.3. MCWD may use and take conveyance of the MCWD Reserved Area in phases of not less than 40 acres. Armstrong's obligation to reserve the MCWD Reserved Area shall expire at midnight on June 30, 2003, or upon delivery to Armstrong of written notice from MCWD cancelling MCWD's right to receive conveyance of the MCWD Reserved Area. Armstrong's obligation to reserve the MCWD Reserved Area shall be extended to July 1, 2010, if MCWD has begun to use at least 40 acres of the MCWD Reserved Area by June 30, 2003.

6.10.2. Gift by Armstrong or payment by MCWD. Armstrong has offered to make a gift to MCWD, at the agreed value of $25,000 per acre, of 50 acres of the MCWD Reserved Area for the first 150 afy of water which Armstrong is entitled to withdraw from the Basin as provided in paragraph 6.9. of this Agreement and Framework, and 40 acres for each additional 150 afy which Armstrong may withdraw pursuant to paragraph 6.9, or less than 40 acres for the last 150 afy, if the last remaining portion of the MCWD Reserved Area is less than 40 acres, but in no event to exceed the total acreage of the area shown as the MCWD Reserved Area on Exhibit "F" to this Agreement and Framework. This offer may be accepted by MCWD following such final annexation at any time during the time Armstrong is reserving the MCWD Reserved Area. In any event, however, and notwithstanding the foregoing, upon receipt by Armstrong of written request from MCWD, Armstrong will forthwith convey all or part of the MCWD Reserved Area to MCWD by grant deed. Any such part must begin in the southwest corner of MCWD Reserved Area, must be parallel to the southerly and westerly boundaries of the MCWD Reserved Area, must be rectangular or trapezoidal in shape, must be at least 40 acres in size, and must be free of any financial encumbrances except taxes and assessments not delinquent, but subject to all other encumbrances, and further subject to all laws, ordinances, regulations and rights of all governmental bodies having jurisdiction in, on or over the subject real property as they may from time to time exist. Title shall also be subject to the lien of a first deed of trust for each conveyance, executed by MCWD in favor of Armstrong securing the obligation of MCWD in favor of Armstrong next hereinafter referred to. Beginning six months after conveyance of any part of the MCWD Reserved Area which is not conveyed as a gift to MCWD, MCWD shall commence paying to Armstrong a sum calculated by multiplying the number of acres in such conveyance by Twenty-Five Thousand Dollars ($25,000.00). The price of $25,000 per acre shall be adjusted as of July 1, 2003, if Armstrong's obligation to reserve the property is extended to 2010 pursuant to paragraph 6.10.1.3. of this Agreement and Framework. In such event, the price per acre shall be computed by multiplying $25,000 by the percentage increase or decrease in the Cost of Living Index for all urban consumers in the San Francisco-Oakland-San Jose Area (1982-1984=100), occurring between July 1, 1997 and July 1, 2003, or the closest dates to such dates for which figures are available. Payment shall be made in 20 equal semi-annual payments, commencing six months after such conveyance, sufficient to amortize the obligation fully, with the unpaid principal balance bearing interest from the date of conveyance to MCWD, at the prime rate of the Bank of America in San Francisco, California, as of July 1 each year during the term of this obligation, but not to exceed the maximum rate permitted by law to be charged by Armstrong in such transaction. Any such payments made or to be made by MCWD, together with interest from the date of MCWD's payment, through December 31, 2010, at the prime rate of interest of the Bank of America in San Francisco, California, shall be included in computing annexation fees, capacity charges and service charges charged by MCWD for the part of the Armstrong Ranch to which the payments made by MCWD to Armstrong relate.

6.10.3. Waiver of further acquisitions by MCWD, MCWRA, and City of Marina; liquidated damages. Except for incidental water system and wastewater system and storm water system easements, incidental access easements, incidental road easements, and incidental utility easements, as may be necessary from time to time, and further excepting land dedicated to public uses through the development process as a condition of development, MCWD, City, and MCWRA shall not seek to acquire fee title to land or easements thereon on any part of the Armstrong Ranch by eminent domain for use in providing water or wastewater service, or for any other public purpose whatsoever, except that, as to City only, said prohibition shall apply only with respect to eminent domain for water or sanitary sewer facilities and shall not be applicable to eminent domain for other public purposes; provided, however, that in the event that any of said agencies shall, notwithstanding the foregoing covenant, warranty and representation, seek to exercise the power of eminent domain for any other purpose except as excepted above, then, and in that event, all Parties hereto hereby agree that the fair market value of and the price to be paid for all such land lying within MCWD Reserved Area as shown on Exhibit "F" hereto (and any additional area shown on an exhibit to a fully executed addendum to this Agreement and Framework) shall be the sum of Twenty-Five Thousand Dollars ($25,000.00) cash per acre and the fair market value and purchase price for all land lying outside of said MCWD Reserved Area as shown on Exhibit "F" hereto (and any additional area shown on an exhibit to a fully executed addendum to this Agreement and Framework) shall be the sum of ONE HUNDRED THOUSAND Dollars ($100,000.00) cash per acre. FURTHERMORE, IN THE EVENT THAT MCWD, CITY, AND MCWRA, OR ANY OF THEM, SHOULD BREACH THIS COVENANT, WARRANTY AND REPRESENTATION, THEN, AND IN THAT EVENT, THE PARTIES AGREE THAT ARMSTRONG SHALL BE ENTITLED TO RECOVER FROM SUCH BREACHING PARTY, AS LIQUIDATED DAMAGES, AN AMOUNT EQUAL TO THE DIFFERENCE BETWEEN THE PRICE PER ACRE ACTUALLY PAID AND TWENTY-FIVE THOUSAND DOLLARS ($25,000.00) PER ACRE MULTIPLIED BY THE NUMBER OF ACRES SO TAKEN IN THE CASE OF LAND WITHIN SAID MCWD RESERVED AREA (AND ANY ADDITIONAL AREA SHOWN ON AN EXHIBIT TO A FULLY EXECUTED ADDENDUM TO THIS AGREEMENT AND FRAMEWORK), AND THE DIFFERENCE BETWEEN THE PRICE PER ACRE ACTUALLY PAID AND ONE HUNDRED THOUSAND DOLLARS ($100,000.00) PER ACRE MULTIPLIED BY THE NUMBER OF ACRES TAKEN IN THE CASE OF LAND LYING OUTSIDE OF MCWD RESERVED AREA (AND ANY ADDITIONAL AREA SHOWN ON AN EXHIBIT TO A FULLY EXECUTED ADDENDUM TO THIS AGREEMENT AND FRAMEWORK), AS LIQUIDATED DAMAGES, WHICH THE PARTIES AGREE IS A REASONABLE SUM CONSIDERING ALL THE CIRCUMSTANCES EXISTING ON THE DATE OF THIS AGREEMENT AND FRAMEWORK, INCLUDING THE RELATIONSHIP OF THE SUM TO THE RANGE OF HARM TO ARMSTRONG THAT REASONABLY COULD BE ANTICIPATED AND THE ANTICIPATION THAT PROOF OF ACTUAL DAMAGES WOULD BE COSTLY OR INCONVENIENT. IN PLACING THEIR SIGNATURES BELOW, EACH PARTY SPECIFICALLY CONFIRMS THE ACCURACY OF THE STATEMENTS MADE ABOVE AND THE FACT THAT EACH PARTY WAS REPRESENTED BY COUNSEL WHO EXPLAINED THE CONSEQUENCES OF THIS LIQUIDATED DAMAGES PROVISION AT THE TIME THIS AGREEMENT AND FRAMEWORK WAS MADE.

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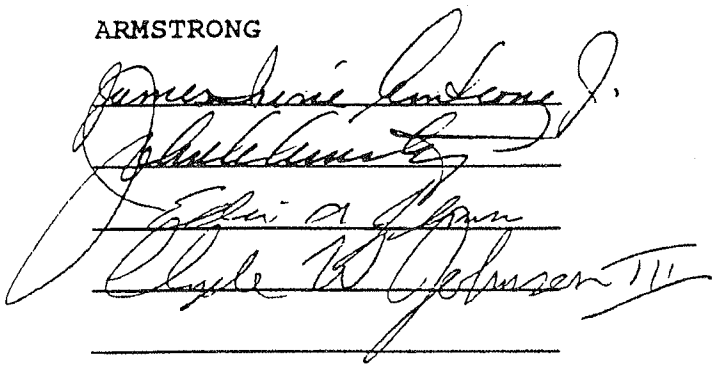

MCWD

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MCWRA

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7. TERMS AND CONDITIONS--LONESTAR.

7.1. Compliance with Agency Act Section 22. The MCWRA acknowledges that it may not object to any withdrawal by Lonestar permitted by this section 7, except in compliance with section 22 of the Agency Act. All groundwater withdrawn from the Basin by Lonestar may be used only within the Basin.

7.2. Quantity Limitations. Commencing on the effective date of this Agreement and Framework, Lonestar shall limit withdrawal and use of groundwater from the Basin to Lonestar's historical use of 500 afy of groundwater.

7.3. Annexation of Lonestar Property to the Zones. Approval of this Agreement and Framework by the MCWRA Board of Supervisors shall constitute approval for annexation of the Lonestar Property in accordance with the terms of this Agreement and Framework. The actual annexation will occur as follows: The Lonestar Property annexation to the Zones will not take effect until the Lonestar Property has been approved for prior or concurrent annexation into MCWD. When such approval has been

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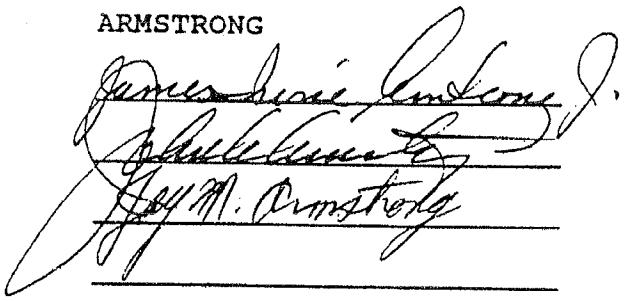

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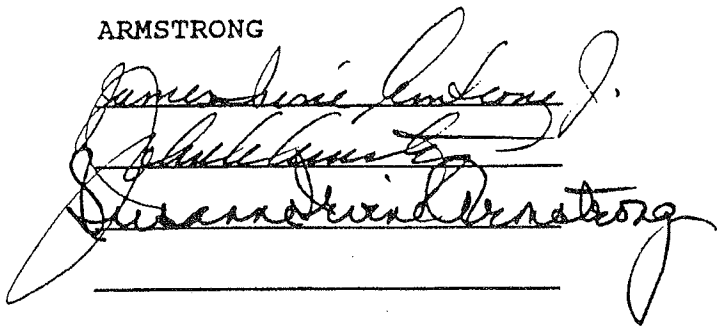

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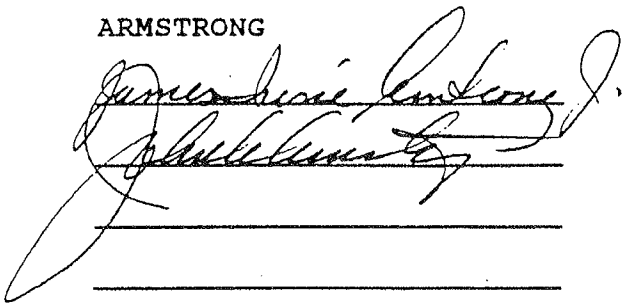

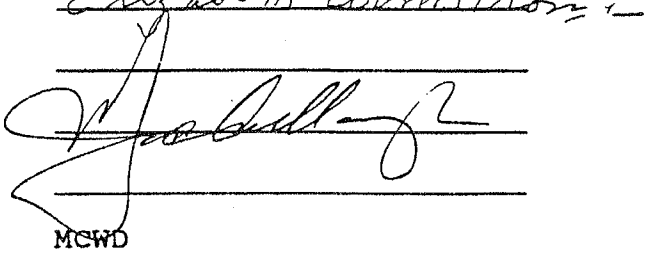

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Thomas P. Moore April 12, 1

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obtained, Lonestar shall notify MCWRA, and the MCWRA Board of Supervisors shall declare by resolution the effective date of the annexation.

7.4. Annexation fee.

7.4.1. Amount of original annexation fee. When the Lonestar Property has been annexed to the Zones, Lonestar will pay to MCWRA an annexation fee computed as follows:

104 acres x $277 (land fee)	=	$ 28,808
264 acres x $27.70 (open space)	=	7,313
500 afy x $783/3 (water charge)	=	130,500
Total principal (original fee)	=	166,621
Total interest @ 6%	=	57,370
Total payment	=	223,991
Semi-annual payments	=	11,200

7.4.2. Choice of lump sum or installment. Lonestar may elect to pay the annexation fee in one lump sum or may pay in semi-annual installments.

7.4.3. Lump sum payment. If paid in a lump sum, the original annexation fee shall be due and payable in full on July 1, next succeeding the first March 1 after the effective date of the annexation. Lonestar may elect to pay the annexation fee in full in one lump sum by giving written notice of such election to MCWRA not later than the May 1 immediately preceding the date payment in a lump sum would be due. Any late payment shall bear interest at the annual rate of 6% from the due date, and shall be subject to the same penalties and collection procedures as are set forth in paragraph 7.4.4.

7.4.4. Installment payments.

7.4.4.1. If the original annexation fee or any addition thereto is paid in installments, the installments shall include interest on the unpaid principal balance at the annual rate determined pursuant to this Agreement and Framework. The interest rate on installments on the original annexation fee shall be six (6) percent per annum and shall begin to accrue on July 1, next succeeding the first March 1 after the effective date of the annexation. The interest rate for the additional water charge shall be equivalent to that which the County would pay for funds borrowed at the time the additional water charge is determined and shall begin to accrue at the beginning of the applicable payment period. The interest included in each installment shall be calculated as though the installment were paid on the last day

before delinquency, even if the installment is paid in advance of that date.

7.4.4.2. The amount of each semi-annual installment shall be sufficient to amortize the full amount of principal and interest in twenty (20) equal semi-annual installments.

7.4.4.3. The semi-annual installments shall be paid and collected at the same time and in the same manner and by the same persons as, and together with and not separately from, general agency and zone taxes and shall be delinquent at the same time and thereafter subject to the same delinquency penalties. The first installment shall be due on November 1 following July 1, next succeeding the first March 1 after the effective date of the annexation and shall be delinquent if not paid on or before the following December 10. The second installment shall be due on the following February 1 and shall be delinquent if not paid on or before the following April 10. Thereafter, installments shall fall due and become delinquent on the same dates each year.

7.4.4.4. The full amount of principal and interest shall be paid not later than April 10, in the tenth year following July 1, next succeeding the first March 1 after the effective date of the annexation.

7.4.4.5. The amount of each installment shall constitute a lien on the annexed property as of noon on the March 1 immediately preceding the fiscal year (July 1-June 30) in which payment of the installment will be due. If the property is subdivided, then a prorata share of the annexation fee shall become a lien on each individual parcel, based upon the ratio that the land area of the individual parcel bears to the total land area of all parcels against which the annexation fee is a lien. All laws applicable to the levy, collection and enforcement of general agency and zone taxes, including, but not limited to, those pertaining to delinquency, correction, cancellation, refund and redemption, shall be applicable to such installments.

7.4.5. Additional annexation fee for change in water use. If the water use on the Lonestar Property is changed from an industrial or agricultural use to a potable or other use, or if MCWD delivers potable water to the Lonestar Property pursuant to paragraph 5.1.1.3., then Lonestar shall pay to the MCWRA as an additional annexation fee, an additional water charge computed as two-thirds (2/3rds) of the product of 500 afy multiplied by the then-current annexation water charge. If Lonestar uses water on the 264-acre open-space area, Lonestar shall pay an additional land fee of nine times the land fee specified for the area in 7.4.1. above. The additional water charge or land fee will be paid either in one lump sum, due and payable on July 1, immediately following the change in water use, or in twenty (20) equal semi-annual installments over ten (10) years, with the payment period and interest accrual beginning on that July 1, in the same manner as

prescribed for Lonestar's original annexation fee and subject to the same rules.

7.4.6. Additional annexation fee for Mitigation Plan water supply allocation. If a substitute supply of potable Mitigation Plan water is approved for the Lonestar Property pursuant to Section 22 of the MCWRA Act, then, when the contract for construction of the Mitigation Plan has been approved by the MCWRA Board of Supervisors, and when Lonestar begins using water for potable uses, Lonestar will pay as an addition to its annexation fee an additional water charge computed as two-thirds (2/3rds) of the product of the amount so allocated multiplied by the then-current annexation water charge. The additional water charge will be paid either in one lump sum, due and payable on July 1, immediately following approval of both the Mitigation Plan water supply for Lonestar and the construction contract for the Mitigation Plan, or in twenty (20) equal semi-annual installments over ten (10) years, with the payment period and the interest accrual beginning on that July 1, in the same manner as prescribed for Lonestar's original annexation fee and subject to the same rules.

7.4.7. Non-duplication of additional annexation fees. The additional annexation fees set forth in paragraphs 7.4.5 and 7.4.6 above are not intended to be cumulative. If Lonestar becomes liable to pay both of the additional annexation fees, then Lonestar shall be obligated to pay only the higher of the two fees, and any amounts previously paid towards the lower additional fees shall be credited towards payment of the higher.

8. TERMS AND CONDITIONS--GENERAL.

8.1. Equal treatment by MCWRA and MCWD. If future litigation, regulation or other unforeseen action diminishes the total water supply available to MCWRA, MCWRA agrees that it will exercise its powers so that MCWD, Armstrong and Lonestar shall be no more severely affected in a proportional sense than other lawful users of water from the Zones, based on the right before the imposition of any uniform and generally applicable restrictions as described in paragraph 8.2 to use at least the quantities of water from the Basin described in paragraphs 5.1., 6.9., and 7.2. MCWRA shall not at any time seek to impose greater restrictions on water use from the Basin by MCWD, Armstrong or Lonestar than are imposed on users either supplying water for use or using water within the city limits of the City of Salinas. MCWD, Armstrong and Lonestar will comply with any basin-wide or area-wide water allocation plans established by the MCWRA which include MCWD, Armstrong and Lonestar, and which do not impose on use of water on the lands described in Exhibits "B", "C", and "D" restrictions greater than are imposed on users either supplying water for use or using water within the City of Salinas, and which satisfy the requirements of paragraph 5.2 of this Agreement and Framework.

8.2. Water Conservation Measures. MCWD, Armstrong and Lonestar shall use, and MCWD may require the use of reasonable and appropriate water conservation measures on the lands described in Exhibits "B", "C" and "D" to this Agreement and Framework, which water conservation measures shall be uniformly applied and may be more restrictive but shall not be less restrictive than measures implemented by MCWRA as part of a Basin-wide or area-wide water conservation program. All planning and environmental review for the lands described in Exhibits "B", "C", and "D" to this Agreement and Framework shall be based on the requirement that development on such lands shall use reasonable and appropriate water conservation measures comparable to measures implemented by MCWRA as part of a Basin-wide or area-wide water conservation program, and by MCWD as part of a water conservation program applicable uniformly within MCWD's service area.

8.3. Defense of Rights. Upon Mitigation Plan Implementation, MCWRA will defend the rights of MCWD, Armstrong and Lonestar to a supply of water from the Mitigation Plan, as though those rights were the rights of MCWRA. Participation by MCWD, Armstrong and Lonestar in the Mitigation Plan or any other alternative water supply plan is subject to compliance with all applicable laws, including but not limited to CEQA.

8.4. Use of Annexation Fees. Annexation fees from the MCWD service area, the Armstrong Ranch and the Lonestar Property shall be used by MCWRA to pay the costs of a BMP process that includes mitigation plans for the Marina Area based on the planning guidelines contained in this Agreement and Framework. Such annexation fees shall also be used for management and protection of the "900-foot aquifer."

8.5. Assessments. After approval by the Board of Supervisors of annexation to the Zones of any property described in the exhibits to this Agreement and Framework, each parcel annexed shall be subject to all uniform assessments, charges, fees, and other exactions levied in Zones 2 and 2A for the fiscal year beginning on July 1, next succeeding the first March 1 after the effective date of the annexation, and shall remain subject thereto for as long as such exactions are levied and the parcel remains within the levying zone.

8.6. Recordation. Upon approval of this Agreement and Framework by the Board of Supervisors and execution by all Parties, this Agreement and Framework shall be recorded in the office of the Monterey County Recorder. All signatures shall be notarized as necessary to record the Agreement and Framework.

9. DISPUTE RESOLUTION PROCEDURE.

9.1. If any dispute arises between the Parties as to the proper interpretation or application of this Agreement and Framework, the Parties shall first seek to resolve the dispute in accordance with this Agreement and Framework, and the Parties must

meet and confer under this Agreement and Framework before filing any court action.

9.2. If any dispute under this Agreement and Framework arises, the Parties shall first meet and confer, in an attempt to resolve the matter between themselves. Each party shall make all reasonable efforts to provide to the other Parties all the information that the party has in its possession that is relevant to the dispute, so that all Parties will have ample information with which to reach a decision.

9.3. If, notwithstanding the good faith efforts of a party requesting in writing the resolution of a dispute under this Agreement and Framework, a dispute remains unresolved sixty-one (61) days after delivery of the request to the other party, the party requesting resolution may file suit for legal and equitable relief, including specific performance, as appropriate.

10. CHALLENGE OF LAWS. Nothing herein contained shall be construed as stopping or otherwise preventing any party to this Agreement and Framework from contesting by litigation or other lawful means the validity, constitutionality, construction, or application of any law of this State, any ordinance of the public entities that are Parties hereto, or any rule, regulation or practice of the public entities that are Parties hereto.

11. WAIVER OF RIGHTS. Any waiver at any time by any party hereto of its rights with respect to a default or any other matter arising in connection with this Agreement and Framework shall not be deemed to be a waiver with respect to any other default or matter. None of the covenants or agreements herein contained can be waived except by the written consent of the waiving party.

12. NOTICES. All notices and demands required under this Agreement and Framework shall be deemed given by one party when delivered personally to the principal office of the other party; when faxed to the other party, to the fax number provided by the receiving party; or five days after the document is placed in the United States mail, first class, registered mail, or certified mail, postage prepaid, addressed to the other party as follows:

To MCWD:
11 Reservation Road
Marina, CA 93933-2099
Phone No.: (408) 384-6131
Fax No.: (408) 384-2479

To MCWRA:
General Manager
P. O. Box 930
Salinas, CA 93902-0930
Phone No.: (408)
Fax No.: (408) 424-7935

To City:

City Manager
211 Hillcrest Avenue
Marina, CA 93933
Phone No.: (408) 384-3715
Fax No.: (408) 384-0425

To Armstrong:

John A. Armstrong
270 River Road
Salinas, CA 93908
Phone No.: (408) 455-1907
Fax No.: (408) 455-2817

To Lonestar:

RMC LONESTAR
Attention: Mr. John Rubiales
P.O. Box 5252
Pleasanton, CA 94566
Phone No.: (510) 426-8787
Fax No.: (510) 426-2225

The address or fax number to which any notice or other writing may be given or made or sent to any party may be changed upon written notice given by such party as above provided.

13. SEVERABILITY. If any one or more of the covenants or agreements set forth in this Agreement and Framework on the part of MCWRA, MCWD, City, Armstrong or Lonestar, or any of them, to be performed should be contrary to any provision of law or contrary to the policy of law to such extent as to be unenforceable in any court of competent jurisdiction, then such covenant or covenants, agreement or agreements, shall be null and void and shall be deemed separable from the remaining covenants and agreements and shall in no way affect the validity of this Agreement and Framework; provided, that if voiding of such individual covenants or agreements without voiding the whole agreement would frustrate a material purpose of Lonestar in entering into this Agreement and Framework, then this whole Agreement and Framework shall be null and void ab initio as to Lonestar only.

14. PARAGRAPH HEADINGS. Paragraph headings in this Agreement and Framework are for convenience only and are not to be construed as a part of this Agreement and Framework or in any way limiting or amplifying the provisions hereof.

15. SUCCESSORS AND ASSIGNS. This Agreement and Framework and all the terms, covenants, agreements and conditions herein contained shall inure to the benefit of and be binding upon the successors and assigns of the Parties hereto.

16. ADMINISTRATORS. MCWD and MCWRA hereby designate their respective General Managers as their Administrators for this Agreement and Framework. City designates its City Manager as City's Agreement and Framework Administrator. Armstrong designates Mr. John A. Armstrong as its Agreement and Framework Administrator. Lonestar designates Mr. John Rubiales as its Agreement and

Framework Administrator. All matters concerning this Agreement and Framework shall be submitted to the Agreement and Framework Administrators or such other representatives as the Agreement and Framework Administrators may designate for their respective agencies. Any party may, in its sole discretion, change its designation of the Agreement and Framework administrator and shall promptly give written notice to the other Parties of any such change.

17. NEGOTIATED AGREEMENT AND FRAMEWORK. This Agreement and Framework has been arrived at through negotiation between the Parties. Neither party is to be deemed the party which prepared this Agreement and Framework within the meaning of Civil Code section 1654.

18. AMENDMENT. This Agreement and Framework may be amended only by a writing signed by the Parties affected by the amendment.

19. COUNTERPARTS. This Agreement and Framework may be executed in counterparts. Each fully executed counterpart shall be deemed a duplicate original, and all counterparts which together contain the signatures of all the Parties shall be deemed, when attached together, one complete and integrated original document.

20. ADDENDUM. A form of Addendum for the MRWPCA is attached hereto as Exhibit "G." When the Addendum is fully executed in its present form or in an amended form, it shall be attached to this Agreement and Framework as an integral part of this Agreement and Framework, and the provisions of the Addendum shall be deemed specifically and fully incorporated into this Agreement and Framework by this reference.

IN WITNESS WHEREOF, the Parties execute this Agreement and Framework as follows:

Dated: March 26, 1996

MONTEREY COUNTY WATER RESOURCES AGENCY

By _____
Edith Johnsen
Chair, Board of Supervisors

Dated: _____, 1996

MARINA COAST WATER DISTRICT

By _____
Thomas P. Moore
President, Board of Directors

By _____
Malcolm D. Crawford
Secretary, Board of Directors

STATE OF CALIFORNIA)
COUNTY OF MONTEREY) ss.

On this 26th day of March, 1996, before me, Ernest K. Morishita, Clerk of the Board of Supervisors, in and for said County and State, personally appeared Edith Johnson, known to me to be the Chairperson of said Board of Supervisors of the County of Monterey, and known to me to be the person who executed the within instrument on behalf of said political subdivision, and acknowledged to me that such County of Monterey executed the same.

ERNEST K. MORISHITA, Clerk of the
Board of Supervisors of Monterey
County, State of California

By: Pamela Olivas
Deputy Clerk

Framework Administrator. All matters concerning this Agreement and Framework shall be submitted to the Agreement and Framework Administrators or such other representatives as the Agreement and Framework Administrators may designate for their respective agencies. Any party may, in its sole discretion, change its designation of the Agreement and Framework administrator and shall promptly give written notice to the other Parties of any such change.

17. NEGOTIATED AGREEMENT AND FRAMEWORK. This Agreement and Framework has been arrived at through negotiation between the Parties. Neither party is to be deemed the party which prepared this Agreement and Framework within the meaning of Civil Code section 1654.

18. AMENDMENT. This Agreement and Framework may be amended only by a writing signed by the Parties affected by the amendment.

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20. ADDENDUM. A form of Addendum for the MRWPCA is attached hereto as Exhibit "G." When the Addendum is fully executed in its present form or in an amended form, it shall be attached to this Agreement and Framework as an integral part of this Agreement and Framework, and the provisions of the Addendum shall be deemed specifically and fully incorporated into this Agreement and Framework by this reference.

IN WITNESS WHEREOF, the Parties execute this Agreement and Framework as follows:

Dated: _____, 1996

MONTEREY COUNTY WATER RESOURCES AGENCY

By _____
Edith Johnsen
Chair, Board of Supervisors

Dated: April — 12, 1996

MARINA COAST WATER DISTRICT

By Thomas P. Moore
Thomas P. Moore
President, Board of Directors

By Malcolm D. Crawford
Malcolm D. Crawford
Secretary, Board of Directors

Dated: Apr 18, 1996

Jay Max Armstrong
JAY MAX ARMSTRONG

Dated: _____, 1996

THE SANDRA ARMSTRONG MURRAY REVOCABLE TRUST UTA dated March 7, 1989

By _____
DARRELL L. MURRAY, Trustee

Dated: _____, 1996

THE LOIS AND CLYDE JOHNSON, JR., 1989 IRREVOCABLE TRUST

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

THE JOHNSON FAMILY REVOCABLE LIVING TRUST UTA dated November 29, 1989

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

_____
CLYDE W. JOHNSON III

Dated: _____, 1996

_____
EDWIN A. JOHNSON

Dated: Mar 29, 1996

John A. Armstrong II
JOHN A. ARMSTRONG II

Dated: _____, 1996

_____
SUSANNE IRVINE ARMSTRONG

Dated: Mar. 29, 1996

James Irvine Armstrong Jr.
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

JAY MAX ARMSTRONG

Dated: _____, 1996

THE SANDRA ARMSTRONG MURRAY REVOCABLE TRUST UTA dated March 7, 1989

By _____ 4/4/96
DARRELL L. MURRAY, Trustee

Dated: _____, 1996

THE LOIS AND CLYDE JOHNSON, JR., 1989 IRREVOCABLE TRUST

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

THE JOHNSON FAMILY REVOCABLE LIVING TRUST UTA dated November 29, 1989

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

CLYDE W. JOHNSON III

Dated: _____, 1996

EDWIN A. JOHNSON

Dated: Mar 29, 1996

JOHN A. ARMSTRONG II

Dated: _____, 1996

SUSANNE IRVINE ARMSTRONG

Dated: Mar. 29, 1996

JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

JAY MAX ARMSTRONG

Dated: _____, 1996

THE SANDRA ARMSTRONG MURRAY REVOCABLE TRUST UTA dated March 7, 1989

By _____
DARRELL L. MURRAY, Trustee

Dated: 4-4-, 1996

THE LOIS AND CLYDE JOHNSON, JR., 1989 IRREVOCABLE TRUST

By _____ Trustee
CLYDE W. JOHNSON III, Trustee

Dated: 4-4, 1996

THE JOHNSON FAMILY REVOCABLE LIVING TRUST UTA dated November 29, 1989

By _____ Trustee
CLYDE W. JOHNSON III, Trustee

Dated: 4-4, 1996

_____
CLYDE W. JOHNSON III

Dated: 4-4, 1996

_____
EDWIN A. JOHNSON

Dated: Mar 29, 1996

_____
JOHN A. ARMSTRONG II

Dated: _____, 1996

_____
SUSANNE IRVINE ARMSTRONG

Dated: Mar. 29, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

_____
JAY MAX ARMSTRONG

Dated: _____, 1996

THE SANDRA ARMSTRONG MURRAY REVOCABLE TRUST UTA dated March 7, 1989

By _____
DARRELL L. MURRAY, Trustee

Dated: _____, 1996

THE LOIS AND CLYDE JOHNSON, JR., 1989 IRREVOCABLE TRUST

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

THE JOHNSON FAMILY REVOCABLE LIVING TRUST UTA dated November 29, 1989

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

_____
CLYDE W. JOHNSON III

Dated: _____, 1996

_____
EDWIN A. JOHNSON

Dated: Mar 29, 1996

_____
JOHN A. ARMSTRONG II

Dated: _____, 1996

_____
SUSANNE IRVINE ARMSTRONG

Dated: Mar. 29, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

_____
JAY MAX ARMSTRONG

Dated: _____, 1996

THE SANDRA ARMSTRONG MURRAY REVOCABLE TRUST UTA dated March 7, 1989

By _____
DARRELL L. MURRAY, Trustee

Dated: _____, 1996

THE LOIS AND CLYDE JOHNSON, JR., 1989 IRREVOCABLE TRUST

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

THE JOHNSON FAMILY REVOCABLE LIVING TRUST UTA dated November 29, 1989

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

_____
CLYDE W. JOHNSON III

Dated: _____, 1996

_____
EDWIN A. JOHNSON

Dated: Mar 29, 1996

_____
JOHN A. ARMSTRONG II

Dated: _____, 1996

_____
SUSANNE IRVINE ARMSTRONG

Dated: Mar. 29, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

Dated: Apr. 4, 1996

By _____
SUSANNE IRVINE ARMSTRONG, Trustee

Dated: Mar 29, 1996

By _____
JOHN A. ARMSTRONG II, Trustee

Dated: Mar. 29, 1996

By _____
JAMES IRVINE ARMSTRONG, JR., Trustee

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: _____, 1996

RMC LONESTAR, a California general partnership

By _____

Dated: _____, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

Dated: _____, 1996

By _____
SUSANNE IRVINE ARMSTRONG, Trustee

Dated: Mar 29, 1996

By _____ Trustee
JOHN A. ARMSTRONG II, Trustee

Dated: Mar. 29, 1996

By _____ Trustee
JAMES IRVINE ARMSTRONG, JR., Trustee

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: _____, 1996

RMC LONESTAR, a California general partnership

By _____

Dated: _____, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

Dated: _____, 1996

By _____
SUSANNE IRVINE ARMSTRONG, Trustee

Dated: Mar 29, 1996

By _____
JOHN A. ARMSTRONG II, Trustee

Dated: Mar. 29, 1996

By _____
JAMES IRVINE ARMSTRONG, JR., Trustee

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: _____, 1996

RMC LONESTAR, a California general partnership

By _____

Dated: _____, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

Dated: _____, 1996

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

By _____
_____, Trustee

Dated: _____, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: MAR 26, 1996

RMC LONESTAR, a California general partnership

By Ronald Z Black

Dated: _____, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

Dated: _____, 1996

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

By _____
_____, Trustee

Dated: _____, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: _____, 1996

RMC LONESTAR, a California general partnership

By _____

Dated: 4/8/96, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

APPROVED AS TO FORM:

Dated: 8/5, 1996

William K. Rentz

WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: _____, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: _____, 1996

_____
ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: _____, 1996

THOMPSON, HUBBARD & OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: _____, 1996

PILLSBURY, MADISON AND SUTRO

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR

APPROVED AS TO FORM:

Dated: _____, 1996

_____
WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: March 26, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: _____, 1996

_____
ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: _____, 1996

THOMPSON, HUBBARD & OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: _____, 1996

PILLSBURY, MADISON AND SUTRO

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR

APPROVED AS TO FORM:

Dated: _____, 1996

_____
WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: _____, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: July 29, 1996

Robert R. Wellington
ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: _____, 1996

THOMPSON, HUBBARD & OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: _____, 1996

PILLSBURY, MADISON AND SUTRO

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR

APPROVED AS TO FORM:

Dated: _____, 1996

_____
WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: _____, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: _____, 1996

_____
ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: MARCH 29, 1996

THOMPSON, HUBBARD & OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: _____, 1996

PILLSBURY, MADISON AND SUTRO

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR

APPROVED AS TO FORM:

Dated: _____, 1996

_____
WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: _____, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: _____, 1996

_____
ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: _____, 1996

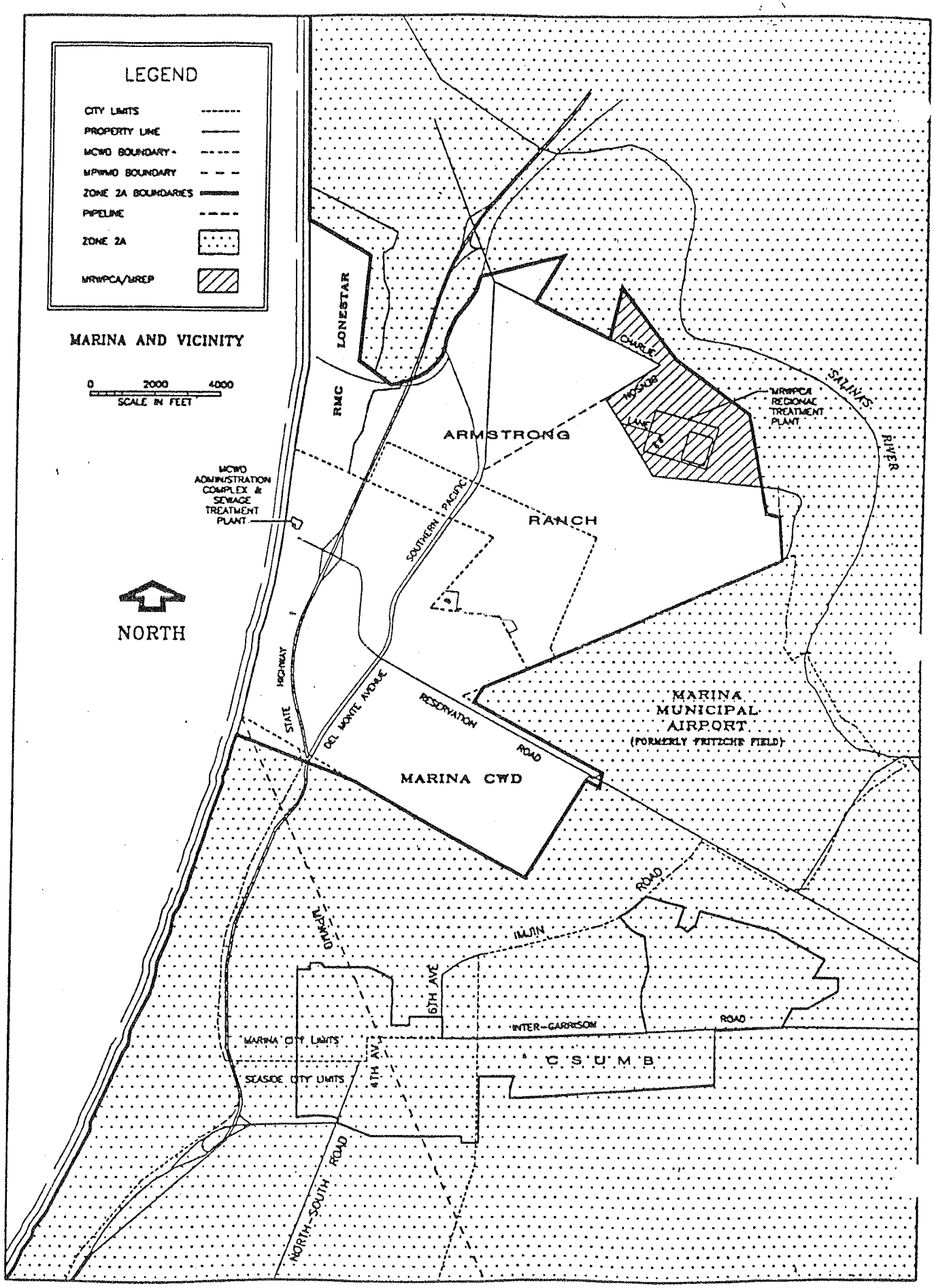
THOMPSON, HUBBARD & OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: March 26, 1996

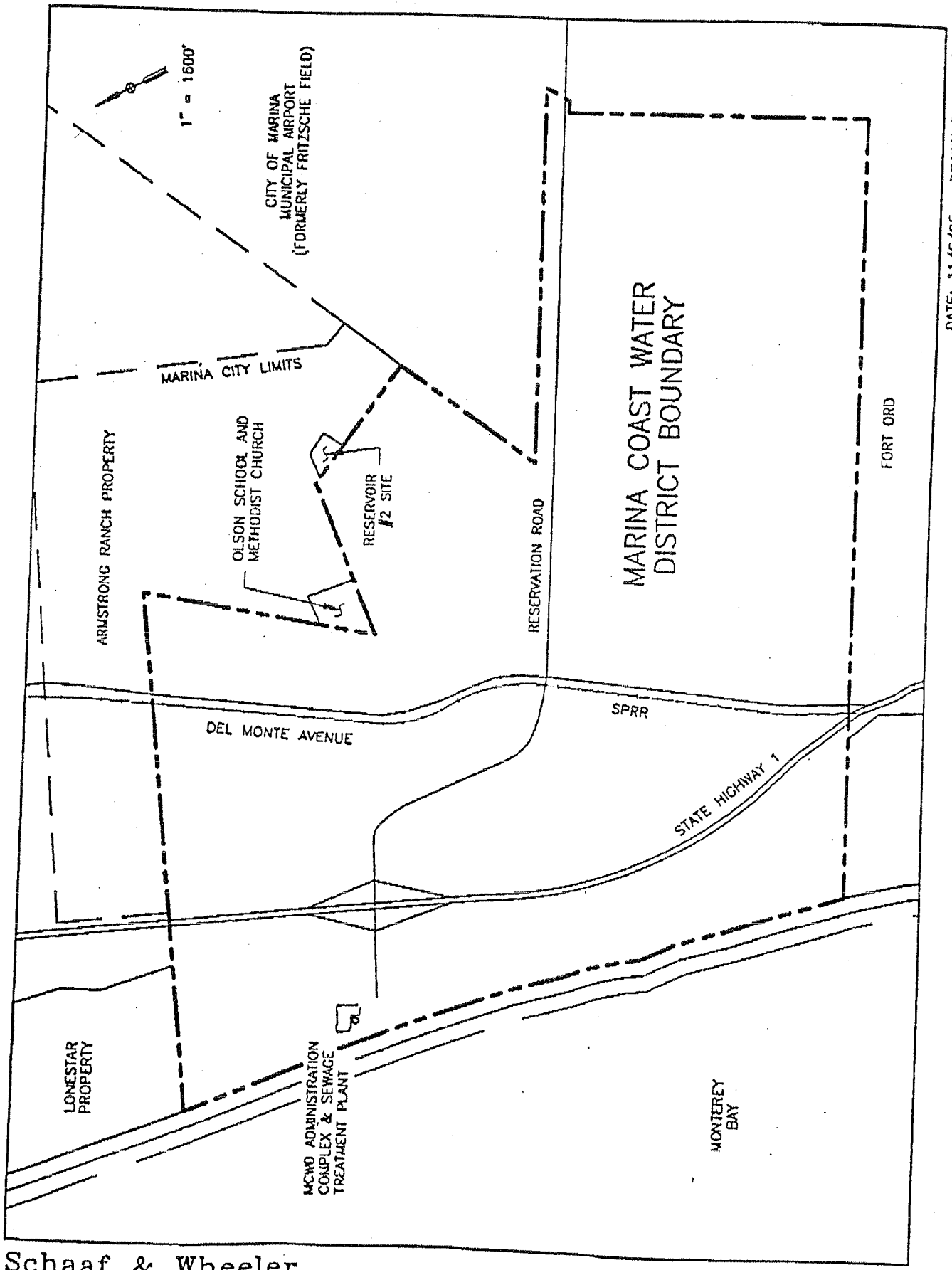
~~PILLSBURY, MADISON AND SUTRO~~ The Genesis Law Group LLP

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR



Schaaf & Wheeler

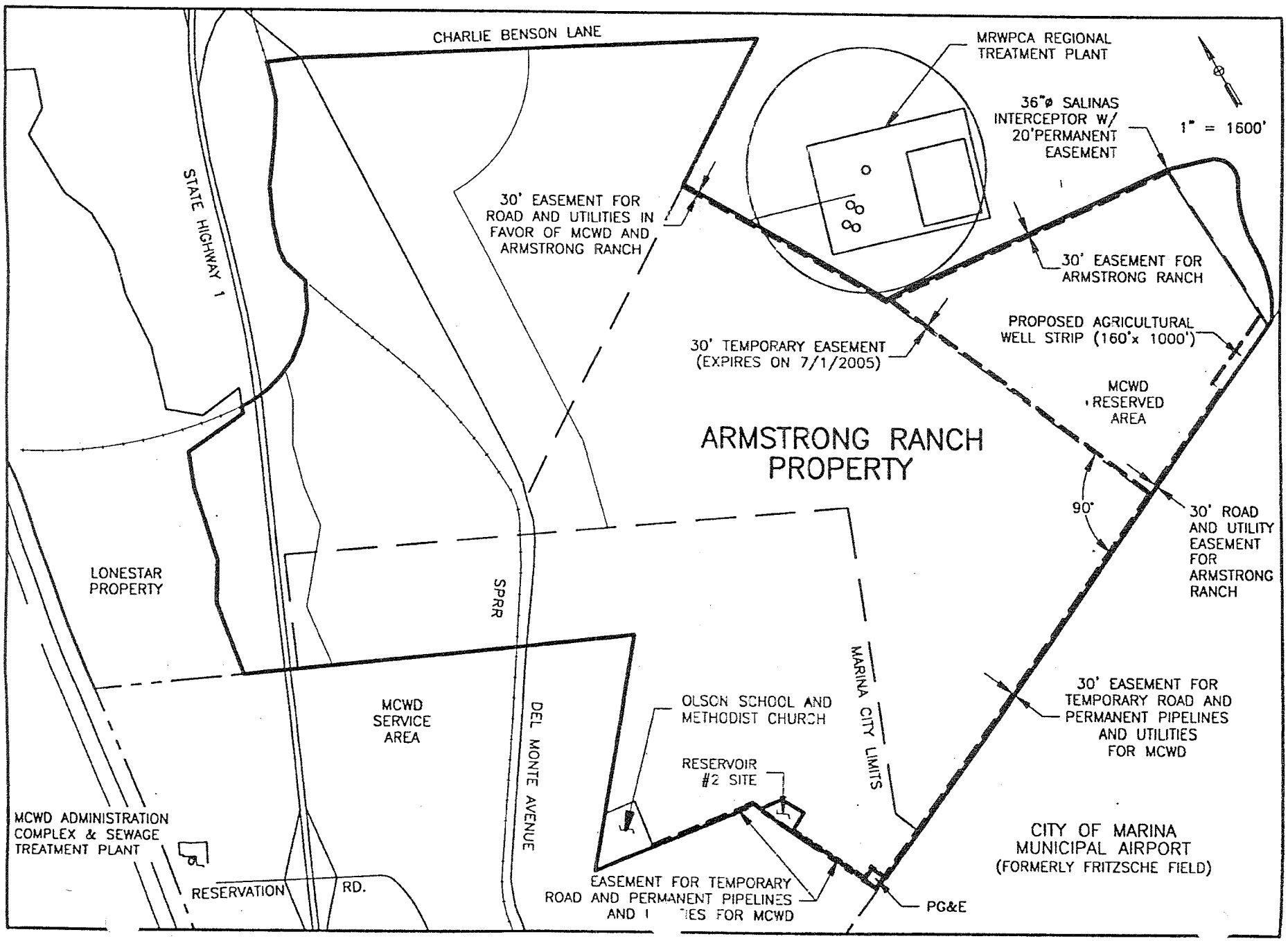
EXHIBIT "A"



Schaaf & Wheeler

EXHIBIT "B"

Schaaf & Wheeler



DATE: 3/5/96 DRAWN BY: LJK/JHL

EXHIBIT "C"

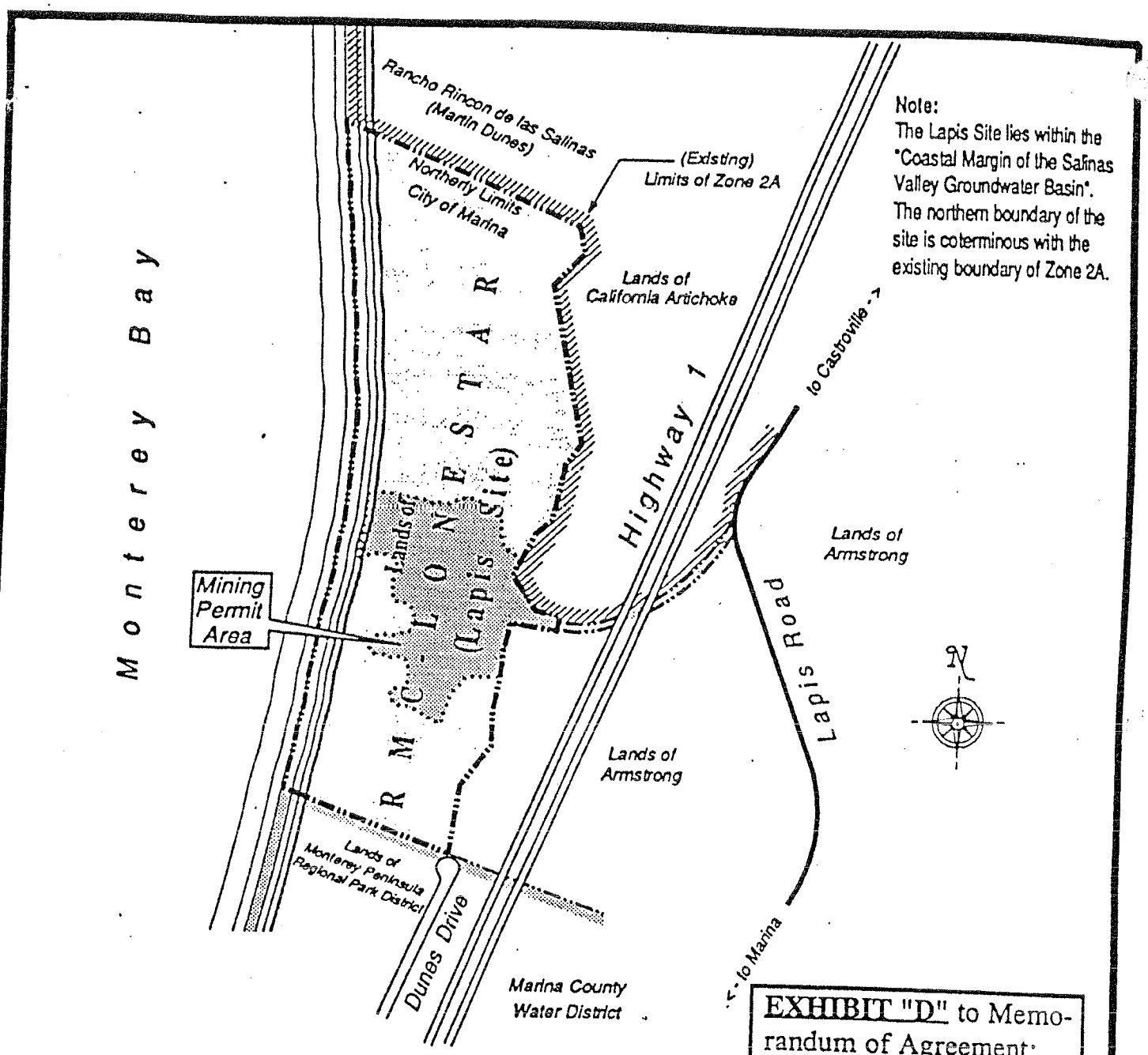


EXHIBIT "D" to Memorandum of Agreement: "Lonestar Property to be Annexed."

VICINITY MAP

Grant Deed

Grant deed dated April 22, 1929
recorded August 29, 1929
Volume 204 Official Records, at page 127.
(See Exhibit D1 for Legal Description)

Assessor's Parcel Numbers

203-011-01
203-011-16
203-011-17
203-011-19
203-011-20

michael d. ashley
CIVIL ENGINEER
(415) 341-2669

EXHIBIT "D1"

LEGAL DESCRIPTION - LANDS OF RMC-LONESTAR

(based on preliminary report from Western Title Insurance Company dated December 12, 1986)

Said land is situate in the County of Monterey, State of California, and is described as follows:

PARCEL 1

A part of Monterey City Lands Tract No. 1 embracing the sand dunes along the shore of Monterey Bay, described as follows, to-wit:

BEGINNING at the common corner of the Rancho Rincon de las Salinas and the Monterey City Lands Tract No. 1 on the shore of Monterey Bay, from which an old Four inch by Four inch post marked "R S 3 Wit" standing on Rancho boundary bears South 63° 20' East Twelve and 79/100 chains distant; thence Variation 16° 50' East, following the shore line of bay South 1° 05' West Sixty and 00/100 chains to station; thence South 5° 40' West Thirty-three and 00/100 chains to station; thence South 11° 30' West Thirty-one and 02/100 chains to the Northerly boundary of the land of David Jacks; thence leaving the shore of the Monterey Bay and following the fence along the Northerly line of the land of David Jacks Corporation South 65° 30' East, Twenty-three and 61/100 chains to station; thence South 65° 12' East Five and 31/100 chains a Four inch by Four inch post marked "E. B. & A. L. S. Cor. No. 1" standing at the foot of sand hills and at the Easterly side thereof, Seven and 23/100 chains to station from which the point of intersection of Jacks boundary fence with the center line of the S. P. R. R. at station 281 plus Fifty-one and 6/10 bears South 65° 12' East Fifty-one and 73/100 chains distant; thence leaving the Jacks boundary and following the old fence skirting the Easterly side of sand dunes North 7° 30' East Eleven and 00/100 chains; thence North 15° 15' East Five and 87/100 chains to station; thence North 34° East Six and 92/100 chains to station; thence North 11° 30' East One and 00/100 chains to station; thence North 5° 45' West Five and 18/100 chains to station; thence North 12° 15' East Five and 66/100 chains to station; thence North 4° West 3 and 60/100 chains to station; thence North 34° East One and 27/100 chains to station; thence North 14° 30 East Three and 29/100 chains to station; thence North 6° 45' West Three and 83/100 chains to center line of Lapis Spur track; thence North 0° 15' East Five and 51/100 chains to station; thence North 22° 30' East Four and 10/100 chains to station; thence North 16° 45' East Five and 05/100 chains to station; thence North 34° East Four and 17/100 chains to station; thence North 13° East Ten and 15/100 chains to station; thence North 30° 45' East Two and 45/100 chains to

station; thence North 13° 40′ East Two and 72/100 chains to an old fence corner; thence North 9° 35′ West One and 83/100 chains to station 17; thence North 9° 35′ West Twenty-seven and 60/100 chains to station 18; thence North 32° 40′ East Five and 21/100 chains to station 19; thence North 70° East Two and 27/100 chains to station 20; thence North 46° 50′ East Two and 16/100 chains to station 21; thence North 12° 45′ West Three and 05/100 chains to station 22; thence North 26° 30′ East One and 92/100 chains to a Four inch by Four inch post marked E. B. & A. L. S. Cor. No. 23" standing in the fence on the line between the Monterey City Lands and the Rancho Rincon de las Salinas, thence leaving foot of sand hills and following said line fence across same North 63° 20′′ West Forty-two and 02/100 chains to the place of beginning.

PARCEL 2

All those certain lots, pieces or parcels of land situate, lying and being in the County of Monterey, State of California, described as follows:

A PART of Monterey City Lands Tract No. 1, described as follows:

A strip of land one hundred feet wide measured at right angles to and lying fifty feet on each side of a line located and described as follows:

BEGINNING at a point on the Eastern boundary of the piece of land here-in-before described as Parcel 1, said point bearing North 6° 45′ West from station numbered 9 on said boundary line and distant Two hundred fifty-two and 5/10 feet therefrom thence by a straight line bearing South 77° 29′ East Five hundred seventy-nine and 38/100 feet; thence by a 6° 00′ curve to the left (radius 955.04 feet), Five hundred seventy-six and 81/100 feet; thence by a straight line bearing North 67° 54-1/2′ East Six hundred forty-eight and 08/100 feet; thence by a 5° 00′ curve to the left (radius 1146.01 feet) Eleven hundred thirty-nine and 2/10 feet, more or less, to the Western line of the Southern Pacific Company's Railroad right of way.

EXCEPTING THEREFROM that portion conveyed to the State of California by deed dated May 31, 1974 and recorded August 19, 1974, on Reel 930, Official Records, at page 909, Monterey County Records.

PARCEL 3

All those certain lots, pieces or parcels of land situate, lying and being in the County of Monterey, State of California, described as follows:

All that portion of Monterey City Lands Tract No. 1 lying between the Western boundary line of Parcel 1 of the property described in the deed from John A. Armstrong et al, to E. B. & A. L. Stone Company, a corporation, dated January 24, 1907, and recorded January 24, 1907 in Liber 95 of Deeds, page 388, and the Western boundary line of the property patented to the City of Monterey, by patent, dated November 19, 1891, and recorded November 16, 1896 in Liber "F" of patents at page 178.

PARCEL 4

All those certain lots, pieces or parcels of land situate, lying and being in the County of Monterey, State of California, described as follows:

All that part of Monterey City Lands Tract No. 1 described as follows:

BEGINNING at a Four inch by Four inch post marked "B 6" standing in the Eastern Boundary of the certain 399.70 acre tract conveyed by J. G. Armstrong Co., a corporation, to the E. B. & A. L. Stone Co., a corporation by deed dated January 31, 1911, and recorded in volume 117, of Deeds at page 283, Monterey County Records, from which station 9 of said boundary bears South 6° 45′ East one hundred ninety-five and 08/100 feet distant; thence along said Eastern boundary North 6° 45′ West Fifty-seven and 7/10 feet to a station in center line of one hundred foot right of way as shown in above mentioned deed; thence North 0° 15′ East, still along said Eastern boundary three hundred sixty-three and 6/10 feet to a station; thence North 22° 30′ East one hundred seven and 0/10 feet to a four inch by four inch post marked "B 1" in said Eastern boundary; thence leave said boundary South 29° 50′ East three hundred ninety-two and 2/10 feet to a four inch by four inch post marked "b 2"; thence South 45° 29′ East one hundred thirty-one and 0/10 feet to a four inch by four inch post marked "B 3"; thence South 77° 40′ East two hundred seventy-six and 0/10 feet to a four inch by four inch post marked "B 4"; thence South 12° 20′ West, at fourth-nine and 9/10 feet to the Northern line of above mentioned one hundred foot right of way at one hundred forty-nine and 9/10 feet the Southern line of same, one hundred fifty-five and 0/10 feet to a four inch by four inch post marked "b 5", thence North 77° 40′ West, five feet southerly of and parallel with the Southern line of said right of way five hundred seventy-four and 3/10 feet to the place of beginning.

Courses all true variation of magnetic needle being 17° 15′ East. Surveyed by Cozzens & Davies, Salinas, California, March 1922

EXHIBIT E

ELEMENTS OF YEARLY INCREMENTAL COSTS
FOR ADD-ON OF RECLAIMED WATER FOR M & I PUROSES OVER AND ABOVE
THAT COMMITTED TO THE CASTROVILLLE SEAWATER IRRIGATION PROJECT

1) Operation and Maintenace (O&M) Element of costs to provide tertiary treatment (in $/acre-foot for the year of ?). Costs for the previous year will be used to estimate the next year costs. An adjustment will be included in the following year to reflect actual costs. The next year flow volume demand for MCWD will be based on a projection submitted by the MCWD to the MCWRA by June 30, three months before delivery of next year reclaimed water to the MCWD reservoir.

- Chemical costs
- Power costs
- Sludge management costs
- Labor costs
- Repair and replacement costs

$$\text{O\&M ELEMENT (in \$/acre-foot)} = \frac{\sum \text{chemicals + power + sludge mgmt. + labor + repair \& replacement costs}}{\text{Projected Next Year Flow Volume Demand [CSIP(afy) + MCWD(afy)]}} \pm \text{adjustment for previous year}$$

2) Bureau of Reclamation Loan Element (BRLE). Includes Reimbursible Interest During Construction (RIDC) and Emergency Reserve Fund Contribution (ERFC) in $ / acre-foot for the year of ?.

$$\text{APPLICABLE ANNUAL PERCENTAGE for M\&I (AAPM\&I)} = \frac{\text{Projected next year flow volume demand for MCWD (afy)}}{\text{Projected Next Year Flow Volume Demand [CSIP(afy) + MCWD(afy)]}}$$

$$\text{BRLE(\$) FOR YEAR (?)} = \frac{\text{AAPM\&I x [PRINCIPAL + INTEREST(7.625\%) ON OUTSTANDING PRINCIPAL + RIDC + ERFC FOR YEAR(?)]}}{\text{Projected next year flow volume demand for MCWD (afy)}}$$

3) Increased capital cost element to cover M&I for the MCWD.

No additional capital costs.

4) Capital Risk Share Element (CRSE) in $ / acre-foot for the year of ?.

$$\text{CRSE (\$)} = \frac{\text{AAPM\&I x [SVRP Debt Service for State Revolving Fund(Schedule A Line 18)+ 1/3 of Bonds (Schedule A, Line 25) FOR YEAR(?)]}}{\text{Projected next year flow volume demand for MCWD (afy)}}$$

SVRP ANNUAL DEBT SERVICE - SCHEDULE A

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Fiscal Year Ending	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total 2011-2037	($ Thousands) TOTAL
US Bureau of Reclamation Loan - SVRP																		
Principal Payment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	588.6	588.6	588.6	588.6	588.6	588.6	588.6	588.6	15891.4	20600.0
Interest Payment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1570.8	1535.0	1496.5	1455.0	1410.4	1362.4	1310.8	1255.2	8802.9	
Interest Payment - 22%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	345.6	337.7	329.2	320.1	310.3	299.7	288.4	276.1	1936.6	6220.2
RIDC Payment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5	1255.5	1627.5
Emergency Reserve Fund Contributions	0.0	0.0	0.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	0.0	0.0	0.0	0.0	130.0
Total US Bureau of Reclamation Debt Service SVRP	0.0	0.0	0.0	13.0	13.0	13.0	13.0	13.0	993.7	935.8	977.3	968.2	958.4	934.8	923.5	911.2	19083.5	28577.7
Line 6 + Line 7 + Line 9 + Line 10									2218.9	2133.1	2144.6	2103.1	2058.5	1997.5	1945.9	1890.3		
State Revolving Fund Loan - SVRP																		
Principal Payment	0.0	0.0	0.0	0.0	347.2	358.0	369.2	380.7	392.6	434.9	417.6	430.6	444.1	457.9	472.3	487.0	4077.1	9448.1
Interest Payment	0.0	0.0	0.0	0.0	295.3	284.5	273.3	261.7	249.8	237.6	224.9	211.8	198.4	184.5	170.2	155.4	247.1	3400.4
Emergency Reserve Fund Contributions	0.0	0.0	0.0	0.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	0.0	0.0	0.0	130.0
Total State Revolving Fund Debt Service SVRP	0.0	0.0	0.0	0.0	687.5	687.5	687.5	687.5	687.5	687.5	687.5	687.5	687.5	687.5	642.5	642.5	4324.2	12978.5
Bonds - Variable/Fixed																		
Principal Payment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.6	70.3	75.4	80.8	86.6	92.8	99.5	106.7	8792.8	9470.5
Interest Payment	0.0	0.0	0.0	1387.5	2322.4	1896.7	1437.6	955.9	881.9	677.2	672.1	666.7	660.9	654.6	647.9	640.8	11388.5	130.0
Total Bond Debt Service	0.0	0.0	0.0	1387.5	2322.4	1896.7	1437.6	955.9	747.5	747.5	747.5	747.5	747.5	747.4	747.4	747.5	20181.3	9600.5
Total Bond Debt Service for SVRP (1/3 of Total)	0.0	0.0	0.0	462.0	773.4	631.6	478.7	331.6	248.9	248.9	248.9	248.9	248.9	248.9	248.9	248.9	6720.4	3197.0
																		130.0
TOTAL ANNUAL DEBT SERVICE FOR SVRP - INCLUDES $4,000,000 FOR PIPELINE	*0.0*	*0.0*	*0.0*	*475.0*	*1473.8*	*1332.1*	*1179.2*	*1032.1*	*1930.0*	*1922.2*	*1913.7*	*1904.6*	*1894.8*	*1871.2*	*1814.8*	*1802.6*	30128.1	*44753.2*
Line 18 + Line 25				462.0	1460.8	1319.1	1166.2	1019.1	936.4	936.4	936.4	936.4	936.4	936.3	891.3	891.4		
Annual Demand Projections																		
Projected CSIP Demand (afy)	0	0	15000.0	16,000	17,000	18,000	19,000	20,000	20,300	20,600	20,000	20,000	20,000	20,000	20,000	20,000		
Projected MCWD M&I Demand (afy)	0	0	70	100	150	500	1,550	1,800	2,000	2,200	2,200	2,200	2,200	2,200	2,200	2,200		
Total CSIP + MCWD Pojected Demand	0	0	15,070	16,100	17,150	18,500	20,550	21,800	22,300	22,200	22,200	22,200	22,200	22,200	22,200	22,200		
AAPM & I	0.0000	0.0000	0.0046	0.0062	0.0087	0.0270	0.0754	0.0826	0.0909	0.0991	0.0991	0.0991	0.0991	0.0991	0.0991	0.0991		
Elements of Incremental M&I Costs - See Exhibit E																		
O&M Element for M&I - See Exhibit E Item 1																		
Projected O&M Cost --																		
PCA LETTER OF 10/24/95	0	0	1,667	1,717	1,769	1,822	1,876	1,933	1,990	2,050	2,112	2,175	2,240	2,308	2,377	2,448		
$1,526,000, 1994 @ 3%/YR																		
O&M Element in $/acre ft																		
Projected O&M Cost in $/acre ft / Total CSIP + MC	0	0	111	107	103	98	91	89	90	92	95	98	101	104	107	110		
Bureau Loan Element - See Exhibit E Item 2																		
(BRLE) in $/acre ft																		
(Line 12 x Line 38) / Line 36	0	0	0	0	0	0	0	0	101	98	97	95	93	90	88	85		
Increase in Capital Costs for M & I Element																		
No increase in Capital $	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Capital Risk Share Element (CRSE) - See Exhibit E Item 4																		
Line 29 x Line 38 / Line 36 in $/acre ft	0.0	0.0	0.0	28.7	85.2	71.3	56.7	46.7	42.6	42.2	42.2	42.2	42.2	42.2	40.2	40.2		
Total Incremental Cost																		
Line 45 + Line 51 + Line 54 + Line 57	0.0	0.0	110.6	135.3	188.3	169.8	148.0	135.4	233.9	232.9	233.9	234.9	235.8	236.1	234.9	235.6		
Amortization of $4,000,000 @ 5low share									28446.1	31008.8	31008.8	31008.8	31008.8	31008.8	31008.8	31008.8		
									14.2	14.1	14.1	14.1	14.1	14.1	14.1	14.1		

Schaaf & Wheeler

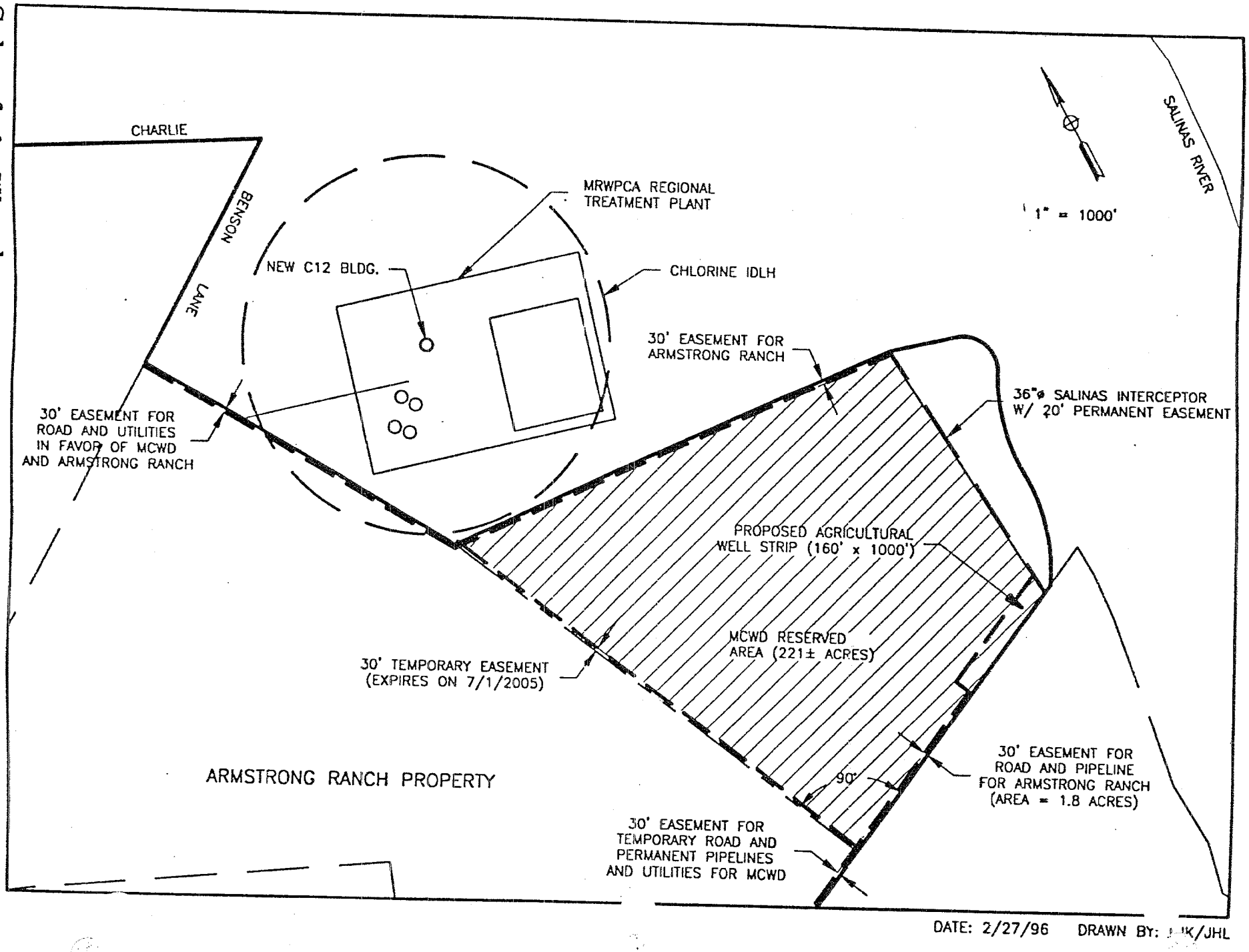


EXHIBIT "F"

EXHIBIT G

MONTEREY REGIONAL WATER POLLUTION CONTROL AGENCY
ADDENDUM TO

ANNEXATION AGREEMENT AND GROUNDWATER MITIGATION FRAMEWORK
FOR
MARINA AREA LANDS

1. PURPOSE. The Parties to the Agreement and Framework agree with the Monterey Regional Water Pollution Control Agency ("MRWPCA") that it is in the best interests of all of them and the persons they represent if the MRWPCA is also a party to the Agreement and Framework, with certain additional terms specific to the MRWPCA. If this Addendum is approved by the MRWPCA within one year of approval of the Agreement and Framework and this Addendum by the other Parties, this Addendum will become part of the Agreement and Framework, and the MRWPCA will be considered a party to the Agreement and Framework, effective from the date the Agreement and Framework and this Addendum are approved by the Board of Supervisors of the MCWRA.

2. MRWPCA. MRWPCA is a joint powers authority providing sewage treatment service to its member entities in Northern Monterey County, governed by its Board of Directors.

3. MRWPCA SUPPORT FOR ANNEXATION. MRWPCA is supporting the request for annexation contained in paragraph 4.1 of the Agreement and Framework to encourage reasonable and beneficial water reuse, and to help implement the MCWRA/MRWPCA Agreement, the MRWPCA Annexation Agreement, and the SVRP.

4. RESERVATION FOR MRWPCA. Armstrong shall reserve, for use by MRWPCA, the area shown diagrammatically on Exhibit "I" to this Addendum (hereinafter the "MRWPCA Reserved Area"), subject to the non-exclusive easements shown on Exhibit "I" to be reserved in favor of Armstrong and MCWD, which said reserved easements in favor of Armstrong and MCWD shall be for roads, utilities (including communications), pipelines, and any other purpose for which a road may be used, shall be freely assignable and usable by others, and not subject to surcharge.

4.1. Survey. The MRWPCA Reserved Area, which shall not exceed 10 acres, will be "field" surveyed at the expense of MRWPCA within one year following approval by the MCWRA Board of Supervisors of the annexation to the Zones of any of the lands described in Exhibit "C" to the Agreement and Framework.

4.2. Use. MRWPCA will diligently undertake, and MCWD, City, MCWRA and Armstrong will cooperate in the planning and conduct of, the appropriate environmental review and application for appropriate permits to use the MRWPCA Reserved Area solely and

exclusively as a buffer zone between the existing Regional Treatment Plant and the Armstrong Ranch. Any additional use is subject to the written approval of Armstrong first had and obtained, and any conveyance from Armstrong to MRWPCA shall contain appropriate restrictions on such additional use in the form of a condition subsequent and a power of termination in favor of Armstrong. Any attempt to condemn the power of termination shall be subject to the provisions of paragraph 6.10.3 as if it were a condemnation of fee title.

4.3. Expiration of Reservation. Armstrong's obligation to reserve the MRWPCA Reserved Area shall expire at midnight on June 30, 2003, or upon delivery to Armstrong of written notice from MRWPCA cancelling MRWPCA's right to receive conveyance of the MRWPCA Reserved Area.

4.4. Payment. Upon conveyance of the MRWPCA Reserved Area to MRWPCA, MRWPCA shall pay to Armstrong a sum calculated by multiplying the number of acres in such conveyance by Twenty-Five Thousand Dollars ($25,000.00).

4.5. Title. Upon receipt by Armstrong of written request from MCWD, Armstrong will forthwith convey all or part of the MRWPCA Reserved Area to MRWPCA by grant deed, free of any financial encumbrances except taxes and assessments not delinquent, but subject to all other encumbrances, and further subject to all laws, ordinances, regulations and rights of all governmental bodies having jurisdiction in, on or over the subject real property as they may from time to time exist.

5. ATTACHMENT TO AGREEMENT AND FRAMEWORK; INCORPORATION BY REFERENCE. When this Addendum is fully executed, it shall be attached to the Agreement and Framework as an integral part of the Agreement and Framework, and the provisions of Sections 1, 2, 3, 8, and 9 through 20, inclusive, and paragraphs 4.5, 5.6, 5.7 and 6.10.3 of the Agreement and Framework are specifically incorporated into this Addendum by this reference and shall apply to the terms of this Addendum and as fully to MRWPCA as though MRWPCA had signed the Agreement and Framework. A person duly authorized by MRWPCA places his or her initials here to indicate MRWPCA's specific agreement to the provisions of paragraph 6.10.3:

Signature: _____

Printed Name and Title: _____

STATE OF CALIFORNIA)
COUNTY OF MONTEREY) ss.

On this 26th day of March, 1996, before me, Ernest K. Morishita, Clerk of the Board of Supervisors, in and for said County and State, personally appeared Edith Johnsen, known to me to be the Chairperson of said Board of Supervisors of the County of Monterey, and known to me to be the person who executed the within instrument on behalf of said political subdivision, and acknowledged to me that such County of Monterey executed the same.

ERNEST K. MORISHITA, Clerk of the
Board of Supervisors of Monterey
County, State of California

By: Pamela Olivas
Deputy Clerk

6. NOTICES. Notices to MRWPCA under this Addendum and the Agreement and Framework shall be addressed as follows:

General Manager
5 Harris Court, Building D
Monterey, CA 93940
Phone No.: (408) 372-3367
Fax No.: (408) 372-6178

The address or fax number to which any notice or other writing may be given or made or sent may be changed upon written notice given as provided in paragraph 12 of the Agreement and Framework.

7. ADMINISTRATOR. MRWPCA hereby designates MRWPCA's General Manager as its Administrator for this Agreement and Framework.

IN WITNESS WHEREOF, the Parties execute this Addendum as follows:

Dated: _____, 1996 MRWPCA

By _____
Keith Israel, Agency Director

Dated: March 26, 1996 MONTEREY COUNTY WATER RESOURCES AGENCY

By _____
Edith Johnsen
Chair, Board of Supervisors

Dated: _____, 1996 MARINA COAST WATER DISTRICT

By _____
Thomas P. Moore
President, Board of Directors

By _____
Malcolm D. Crawford
Secretary, Board of Directors

Dated: _____, 1996

_____
JAY MAX ARMSTRONG

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5 Harris Court, Building D
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By _____
Edith Johnsen
Chair, Board of Supervisors

Dated: _____, 1996 MARINA COAST WATER DISTRICT

By Thomas P. Moore
Thomas P. Moore
President, Board of Directors

By Malcolm D. Crawford
Malcolm D. Crawford
Secretary, Board of Directors

Dated: _____, 1996

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JAY MAX ARMSTRONG

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By _____
Keith Israel, Agency Director

Dated: _____, 1996 MONTEREY COUNTY WATER RESOURCES AGENCY

By _____
Edith Johnsen
Chair, Board of Supervisors

Dated: _____, 1996 MARINA COAST WATER DISTRICT

By _____
Thomas P. Moore
President, Board of Directors

By _____
Malcolm D. Crawford
Secretary, Board of Directors

Dated: April 8, 1996

Jay M. Armstrong
JAY MAX ARMSTRONG

Dated: _____, 1996

THE SANDRA ARMSTRONG MURRAY REVOCABLE TRUST UTA dated March 7, 1989

By _____ 4/4/96
DARRELL L. MURRAY, Trustee

Dated: _____, 1996

THE LOIS AND CLYDE JOHNSON, JR., 1989 IRREVOCABLE TRUST

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

THE JOHNSON FAMILY REVOCABLE LIVING TRUST UTA dated November 29, 1989

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

_____
CLYDE W. JOHNSON III

Dated: _____, 1996

_____
EDWIN A. JOHNSON

Dated: Mar 29, 1996

_____
JOHN A. ARMSTRONG II

Dated: _____, 1996

_____
SUSANNE IRVINE ARMSTRONG

Dated: Mar. 29, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

THE SANDRA ARMSTRONG MURRAY REVOCABLE TRUST UTA dated March 7, 1989

By _____
DARRELL L. MURRAY, Trustee

Dated: 4-4, 1996

THE LOIS AND CLYDE JOHNSON, JR., 1989 IRREVOCABLE TRUST

By _____
CLYDE W. JOHNSON III, Trustee

Dated: 4-4, 1996

THE JOHNSON FAMILY REVOCABLE LIVING TRUST UTA dated November 29, 1989

By _____
CLYDE W. JOHNSON III, Trustee

Dated: 4-4, 1996

_____
CLYDE W. JOHNSON III

Dated: 4-4, 1996

_____
EDWIN A. JOHNSON

Dated: Mar 29, 1996

_____
JOHN A. ARMSTRONG II

Dated: _____, 1996

_____
SUSANNE IRVINE ARMSTRONG

Dated: Mar. 29, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

THE SANDRA ARMSTRONG MURRAY REVOCABLE TRUST UTA dated March 7, 1989

By _____
DARRELL L. MURRAY, Trustee

Dated: _____, 1996

THE LOIS AND CLYDE JOHNSON, JR., 1989 IRREVOCABLE TRUST

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

THE JOHNSON FAMILY REVOCABLE LIVING TRUST UTA dated November 29, 1989

By _____
CLYDE W. JOHNSON III, Trustee

Dated: _____, 1996

_____
CLYDE W. JOHNSON III

Dated: _____, 1996

_____
EDWIN A. JOHNSON

Dated: Mar 29, 1996

_____
JOHN A. ARMSTRONG II

Dated: Apr. 4, 1996

_____
SUSANNE IRVINE ARMSTRONG

Dated: Mar. 29, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

Dated: Apr 4, 1996

By _____
SUSANNE IRVINE ARMSTRONG, Trustee

Dated: Mar 29, 1996

By _____
JOHN A. ARMSTRONG II, Trustee

Dated: Mar. 29, 1996

By _____
JAMES IRVINE ARMSTRONG, JR., Trustee

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: _____, 1996

RMC LONESTAR, a California general partnership

By _____

Dated: _____, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

Dated: _____, 1996

By _____
SUSANNE IRVINE ARMSTRONG, Trustee

Dated: Mar 29, 1996

By _____
JOHN A. ARMSTRONG II, Trustee

Dated: Mar. 29, 1996

By _____
JAMES IRVINE ARMSTRONG, JR., Trustee

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: _____, 1996

RMC LONESTAR, a California general partnership

By _____

Dated: _____, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

Dated: _____, 1996

By _____
SUSANNE IRVINE ARMSTRONG, Trustee

Dated: Mar 29, 1996

By _____
JOHN A. ARMSTRONG II, Trustee

Dated: Mar. 29, 1996

By _____
JAMES IRVINE ARMSTRONG, JR., Trustee

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: _____, 1996

RMC LONESTAR, a California general partnership

By _____

Dated: _____, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

Dated: _____, 1996

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

By _____
_____, Trustee

Dated: _____, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: MAR 26, 1996

RMC LONESTAR, a California general partnership

By Ronald B Black

Dated: _____, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

Dated: _____, 1996

SUSANNE IRVINE ARMSTRONG, JAMES IRVINE ARMSTRONG, JR., and JOHN A. ARMSTRONG II, as Trustees of the Trust for the benefit of MARY JANET ARMSTRONG WEBER as set forth in the Order Settling Report of Trustees due to the death of Lois Armstrong, etc., in the Estate of Irvine Armstrong, also known as James Irvine Armstrong, Deceased, recorded January 4, 1988, in Reel 2191, Official Records of Monterey County at page 643 therein (hereinafter referred to as the "Mary Janet Armstrong Weber Trust")

By _____
_____, Trustee

Dated: _____, 1996

_____
JAMES IRVINE ARMSTRONG, JR.

Dated: _____, 1996

THE 1990 ARMSTRONG FAMILY TRUST established by Declaration dated July 2, 1990

By _____
Walter J. McCullough

By _____
Elizabeth S. Armstrong

Dated: _____, 1996

RMC LONESTAR, a California general partnership

By _____

Dated: 4/8/96, 1996

CITY OF MARINA

By _____
James L. Vocelka, Mayor

APPROVED AS TO FORM:

Dated: 8/5, 1996

William K. Rentz

WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: _____, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: _____, 1996

_____
ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: _____, 1996

_____
ROBERT R. WELLINGTON
Legal Counsel for MRWPCA

Dated: _____, 1996

THOMPSON, HUBBARD AND OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: _____, 1996

PILLSBURY, MADISON AND SUTRO

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR

APPROVED AS TO FORM:

Dated: _____, 1996

WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: March 26, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: _____, 1996

ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: _____, 1996

ROBERT R. WELLINGTON
Legal Counsel for MRWPCA

Dated: _____, 1996

THOMPSON, HUBBARD AND OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: _____, 1996

PILLSBURY, MADISON AND SUTRO

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR

APPROVED AS TO FORM:

Dated: _____, 1996

_____
WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: _____, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: July 29, 1996

_____
ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: July 29, 1996

_____
ROBERT R. WELLINGTON
Legal Counsel for MRWPCA

Dated: _____, 1996

THOMPSON, HUBBARD AND OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: _____, 1996

PILLSBURY, MADISON AND SUTRO

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR

APPROVED AS TO FORM:

Dated: _____, 1996

WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: _____, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: _____, 1996

ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: _____, 1996

ROBERT R. WELLINGTON
Legal Counsel for MRWPCA

Dated: MARCH 29, 1996

THOMPSON, HUBBARD AND OMETER
A Law Corporation

By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: _____, 1996

PILLSBURY, MADISON AND SUTRO

By _____
Thomas P. O'Donnell
Legal Counsel for RMC LONESTAR

APPROVED AS TO FORM:

Dated: _____, 1996

WILLIAM K. RENTZ
Deputy County Counsel, Monterey County

Dated: _____, 1996

NOLAND, HAMERLY, ETIENNE & HOSS
A Professional Corporation

By _____
Lloyd W. Lowrey, Jr.
Legal Counsel for MARINA COAST WATER DISTRICT

Dated: _____, 1996

ROBERT R. WELLINGTON
Legal Counsel for CITY OF MARINA

Dated: _____, 1996

ROBERT R. WELLINGTON
Legal Counsel for MRWPCA

Dated: _____, 1996

THOMPSON, HUBBARD AND OMETER
A Law Corporation

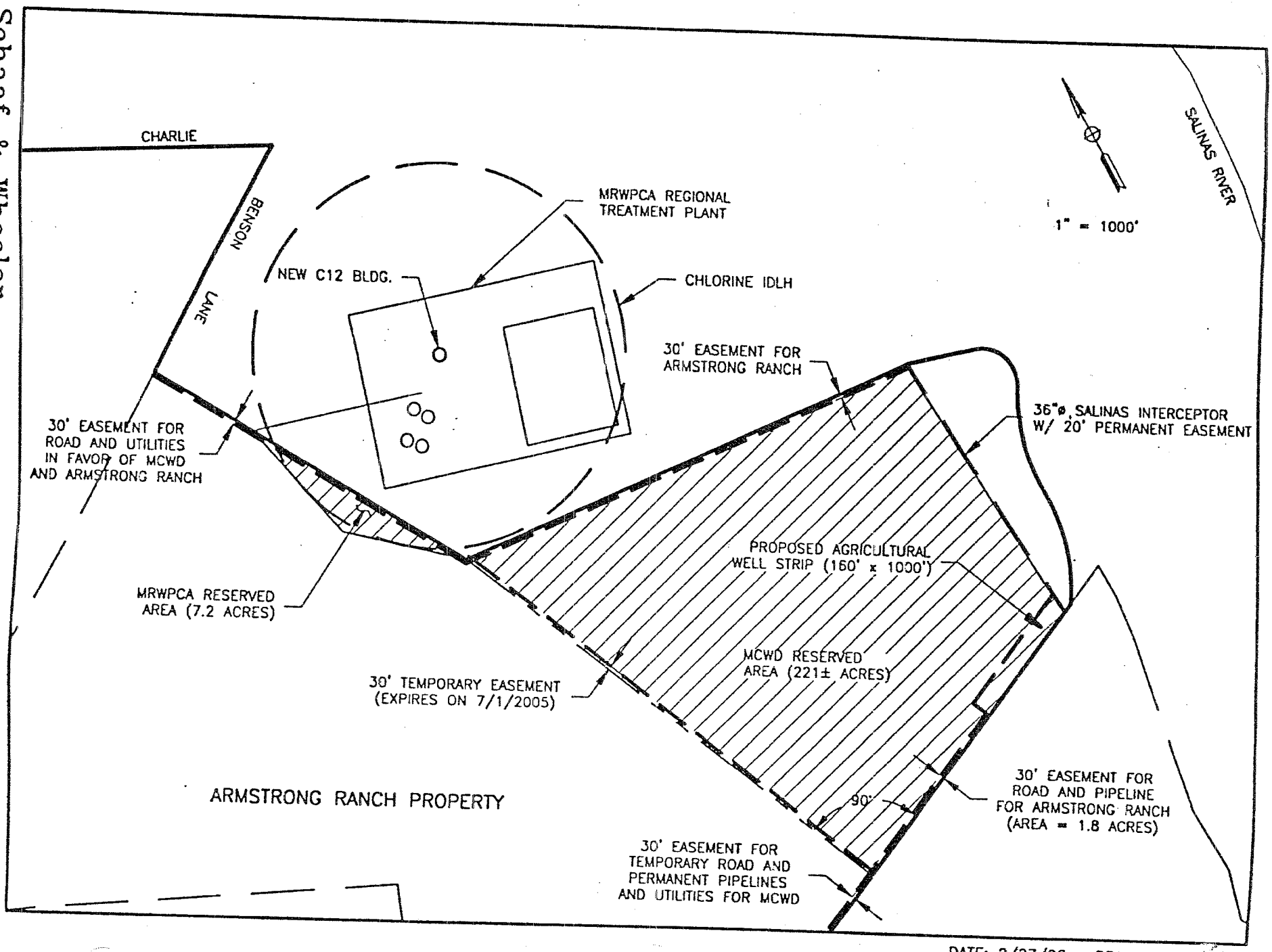
By _____
Donald G. Hubbard
Legal Counsel for J.G. ARMSTRONG FAMILY MEMBERS

Dated: March 26, 1996

~~PILLSBURY, MADISON AND SUTRO~~ The Genesis Law Group

By _____
~~Thomas P. O'Donnell~~
Legal Counsel for RMC LONESTAR

Schaaf & Wheeler



DATE: 2/27/96 DRAWN BY: I JLH

EXHIBIT "I"

CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

State of CALIFORNIA

County of MONTEREY

On 04-12-96 (Date) before me, *SONIA L. ANGELO, NOTARY PUBLIC* * (Name and Title of Officer (e.g., "Jane Doe, Notary Public"))

personally appeared * * * * * *THOMAS P. MOORE* * * * * * (Name(s) of Signer(s))

☐ personally known to me – **OR** – ☒ proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

SONIA L. ANGELO
Comm. # 1087856
NOTARY PUBLIC - CALIFORNIA
Monterey County
My Comm. Expires Feb. 16, 2000

WITNESS my hand and official seal.

Signature of Notary Public

OPTIONAL

Though the information below is not required by law, it may prove valuable to persons relying on the document and could prevent fraudulent removal and reattachment of this form to another document.

Description of Attached Document

Title or Type of Document: ANNEXATION AGREEMENT AND GROUNDSWATER MITIGATION FRAMEWORK FOR MARINA AREA LANDS

Document Date: APRIL 12, 1996 Number of Pages: 27 w/ EXH A-F

Signer(s) Other Than Named Above: NONE

Capacity(ies) Claimed by Signer(s)

Signer's Name: THOMAS P MOORE

☐ Individual
☒ Corporate Officer
Title(s): PRESIDENT, BOARD OF DIRECTORS
☐ Partner — ☐ Limited ☐ General
☐ Attorney-in-Fact
☐ Trustee
☐ Guardian or Conservator
☐ Other: _____

RIGHT THUMBPRINT OF SIGNER
Top of thumb here

Signer Is Representing:

MARINA WATER COAST DISTRICT

Signer's Name: _____

☐ Individual
☐ Corporate Officer
Title(s): _____
☐ Partner — ☐ Limited ☐ General
☐ Attorney-in-Fact
☐ Trustee
☐ Guardian or Conservator
☐ Other: _____

RIGHT THUMBPRINT OF SIGNER
Top of thumb here

Signer Is Representing:

© 1994 National Notary Association • 8236 Remmet Ave., P.O. Box 7184 • Canoga Park, CA 91309-7184 Prod. No. 5907 Reorder: Call Toll-Free 1-800-876-6827

CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

State of CALIFORNIA

County of MONTEREY

On APRIL 17, 1996 (Date) before me, * *SONIA L. ANGELO, NOTARY PUBLIC* * (Name and Title of Officer (e.g., "Jane Doe, Notary Public"))

personally appeared * *MALCOLM D. CRAWFORD* * * * * * * (Name(s) of Signer(s))

☐ personally known to me – OR – ☒ proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

SONIA L. ANGELO
Comm. # 1087856
NOTARY PUBLIC - CALIFORNIA
Monterey County
My Comm. Expires Feb. 16, 2000

WITNESS my hand and official seal.

Signature of Notary Public

OPTIONAL

Though the information below is not required by law, it may prove valuable to persons relying on the document and could prevent fraudulent removal and reattachment of this form to another document.

Description of Attached Document

Title or Type of Document: ANNEXATION AGREEMENT AND GROUNDSWATER MITIGATION FRAMEWORK FOR MARINA AREA LANDS

Document Date: APRIL 17, 1996 Number of Pages: 27 w/EXH A-F

Signer(s) Other Than Named Above: NONE

Capacity(ies) Claimed by Signer(s)

Signer's Name: MALCOLM D. CRAWFORD

☐ Individual
☒ Corporate Officer
Title(s): SECRETARY, BOARD OF DIRECTORS
☐ Partner — ☐ Limited ☐ General
☐ Attorney-in-Fact
☐ Trustee
☐ Guardian or Conservator
☐ Other: _____

RIGHT THUMBPRINT OF SIGNER
Top of thumb here

Signer Is Representing:

MARINA WATER COAST DISTRICT

Signer's Name: _____

☐ Individual
☐ Corporate Officer
Title(s): _____
☐ Partner — ☐ Limited ☐ General
☐ Attorney-in-Fact
☐ Trustee
☐ Guardian or Conservator
☐ Other: _____

RIGHT THUMBPRINT OF SIGNER
Top of thumb here

Signer Is Representing:

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CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

State of CALIFORNIA

County of MONTEREY

On APRIL 12, 1996 (Date) before me, * *SONIA L. ANGELO, NOTARY PUBLIC* * * * (Name and Title of Officer (e.g., "Jane Doe, Notary Public"))

personally appeared * *THOMAS P. MOORE* * * * * * * (Name(s) of Signer(s))

☐ personally known to me – OR – XX proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/~~are~~ subscribed to the within instrument and acknowledged to me that he/~~she~~/~~they~~ executed the same in his/~~her~~/~~their~~ authorized capacity(~~ies~~), and that by his/~~her~~/~~their~~ signature(~~s~~) on the instrument the person(~~s~~), or the entity upon behalf of which the person(~~s~~) acted, executed the instrument.

SONIA L. ANGELO
Comm. # 1087856
NOTARY PUBLIC - CALIFORNIA
Monterey County
My Comm. Expires Feb. 16, 2000

WITNESS my hand and official seal.

Signature of Notary Public

OPTIONAL

Though the information below is not required by law, it may prove valuable to persons relying on the document and could prevent fraudulent removal and reattachment of this form to another document.

Description of Attached Document

EXHIBIT G

Title or Type of Document: MONTEREY REGIONAL WATER POLLUTION CONTROL AGENCY ADDENDUM TO ANNEXATIO AGREEMENT AND GROUNDWATER MITIGATION FRAMEWORK FOR MARINA AREAL LANDS

Document Date: APRIL 12, 1996 Number of Pages: SIX

Signer(s) Other Than Named Above: NONE

Capacity(ies) Claimed by Signer(s)

Signer's Name: THOMAS P. MOORE

☐ Individual
XX Corporate Officer
Title(s): PRESIDENT, BOARD OF DIRECTORS
☐ Partner — ☐ Limited ☐ General
☐ Attorney-in-Fact
☐ Trustee
☐ Guardian or Conservator
☐ Other: _____

RIGHT THUMBPRINT OF SIGNER
Top of thumb here

Signer Is Representing:

MARINA COAST WATER DISTRICT

Signer's Name: _____

☐ Individual
☐ Corporate Officer
Title(s): _____
☐ Partner — ☐ Limited ☐ General
☐ Attorney-in-Fact
☐ Trustee
☐ Guardian or Conservator
☐ Other: _____

RIGHT THUMBPRINT OF SIGNER
Top of thumb here

Signer Is Representing:

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CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

State of CALIFORNIA

County of MONTEREY

On 04-17-96 (Date) before me, *SONIA L. ANGELO, NOTARY PUBLIC* * * (Name and Title of Officer (e.g., "Jane Doe, Notary Public"))

personally appeared * * *MALCOLM D. CRAWFORD* * * * * * * (Name(s) of Signer(s))

☐ personally known to me – OR – XX proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/~~are~~ subscribed to the within instrument and acknowledged to me that he/~~she/they~~ executed the same in his/~~her/their~~ authorized capacity(~~ies~~), and that by his/~~her/their~~ signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

WITNESS my hand and official seal.

SONIA L. ANGELO
Comm. # 1087856
NOTARY PUBLIC - CALIFORNIA
Monterey County
My Comm. Expires Feb. 16, 2000

Signature of Notary Public

OPTIONAL

Though the information below is not required by law, it may prove valuable to persons relying on the document and could prevent fraudulent removal and reattachment of this form to another document.

Description of Attached Document

EXHIBIT G

Title or Type of Document: MONTEREY REGIONAL WATER POLLUTION CONTROL AGENCY ADDENDUM TO ANNEXATION AGREEMENT AND GROUNDWATER MITIGATION FRAMEWORK FOR MARINA AREA LANDS

Document Date: APRIL 17, 1996 Number of Pages: 6

Signer(s) Other Than Named Above: NONE

Capacity(ies) Claimed by Signer(s)

Signer's Name: MALCOLM D. CRAWFORD

☐ Individual
XX Corporate Officer
Title(s): SECRETARY, BOARD OF DIRECTORS
☐ Partner — ☐ Limited ☐ General
☐ Attorney-in-Fact
☐ Trustee
☐ Guardian or Conservator
☐ Other:

RIGHT THUMBPRINT OF SIGNER
Top of thumb here

Signer Is Representing:

MARINA COAST WATER DISTRICT

Signer's Name:

☐ Individual
☐ Corporate Officer
Title(s):
☐ Partner — ☐ Limited ☐ General
☐ Attorney-in-Fact
☐ Trustee
☐ Guardian or Conservator
☐ Other:

RIGHT THUMBPRINT OF SIGNER
Top of thumb here

Signer Is Representing:

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ACKNOWLEDGMENT

STATE OF New Mexico)
: ss.
COUNTY OF Bernalillo)

On April 8, 1996, before me, Lupe Estrada, a Notary Public, duly commissioned and sworn, personally appeared JAY MAX ARMSTRONG

☐ personally known to me, or

☒ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Lupe Estrada
Signature

OFFICIAL SEAL
LUPE ESTRADA
NOTARY PUBLIC-STATE OF NEW MEXICO
My commission expires: 3-29-98

{Seal}

ACKNOWLEDGMENT

STATE OF WASH)
: ss.
COUNTY OF KING)

On 4/4, 1996, before me, SANDRA G. HARVEY, a Notary Public, duly commissioned and sworn, personally appeared DARRELL L. MURRAY

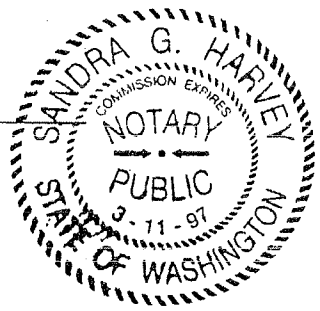
☑ personally known to me, or

☐ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Sandra G. Harvey
Signature



{Seal}

ACKNOWLEDGMENT

STATE OF CALIFORNIA)
: ss.
COUNTY OF Fresno)

On April 4, 1996, 1996, before me, Lupe M. Perez, a Notary Public, duly commissioned and sworn, personally appeared CLYDE W. JOHNSON III

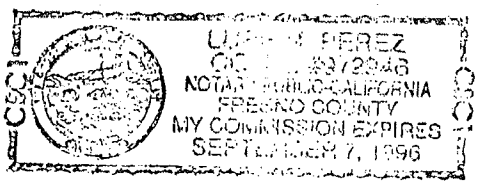
☐ personally known to me, or

☑ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Signature



{Seal}

ACKNOWLEDGMENT

STATE OF CALIFORNIA)
: ss.
COUNTY OF Fresno)

On April 4, 1996, before me, Lupe M. Perez, a Notary Public, duly commissioned and sworn, personally appeared EDWIN A. JOHNSON

☐ personally known to me, or

☒ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Signature _____

LUPE M. PEREZ
COMM. #972946
NOTARY PUBLIC-CALIFORNIA
FRESNO COUNTY
MY COMMISSION EXPIRES
SEPTEMBER 7, 1996

{Seal}

ACKNOWLEDGMENT

STATE OF CALIFORNIA)
: ss.
COUNTY OF MONTEREY)

On March 29, 1996, before me, Jeannine L. Kreider, a Notary Public, duly commissioned and sworn, personally appeared JOHN A. ARMSTRONG II

☒ personally known to me, or

☐ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Jeannine L. Kreider
Signature {Seal}

Jeannine L. Kreider
Comm. #1090740
NOTARY PUBLIC - CALIFORNIA
MONTEREY COUNTY
Comm. Exp. March 17 2000

ACKNOWLEDGMENT

STATE OF CALIFORNIA)
: ss.
COUNTY OF MONTEREY)

On March 29, 1996, before me, Jeannine L. Kreider, a Notary Public, duly commissioned and sworn, personally appeared JAMES IRVINE ARMSTRONG, JR.

☒ personally known to me, or

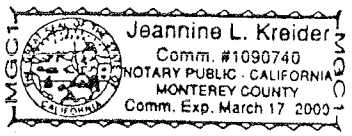
☐ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Jeannine L. Kreider
Signature

{Seal}



ACKNOWLEDGMENT

STATE OF CALIFORNIA)
: ss.
COUNTY OF Yolo)

On April 4, 1996, before me, Kara K Walker, a Notary Public, duly commissioned and sworn, personally appeared SUSANNE IRVINE ARMSTRONG

☒ personally known to me, or

☐ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that she executed the same in her authorized capacity, and that by her signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Kara K. Walker
Signature

{Seal}

KARA K. WALKER
Comm. #992609
NOTARY PUBLIC · CALIFORNIA
YOLO COUNTY
Comm. Expires April 25, 1997

ACKNOWLEDGMENT

STATE OF CALIFORNIA)
: ss.
COUNTY OF Monterey)

On MAY 6, 1996, before me, Paul M. Hamerly, a Notary Public, duly commissioned and sworn, personally appeared WALTER J. McCULLOUGH

☑ personally known to me, or

☐ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Signature

{Seal}

VRS2 PAUL M. HAMERLY COMM. #1033393 Notary Public-California Monterey County My Comm. Exp. Sept. 20, 1998 VRS2

ACKNOWLEDGMENT

STATE OF CALIFORNIA)
: ss.
COUNTY OF Monterey)

On May 6, 1996, before me, Paul M. Hamerly, a Notary Public, duly commissioned and sworn, personally appeared ELIZABETH S. ARMSTRONG

☑ personally known to me, or

☐ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that she executed the same in her authorized capacity, and that by her signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Paul M Hamerly
Signature {Seal}

VRS2 PAUL M. HAMERLY COMM. #1033393 Notary Public-California Monterey County My Comm. Exp. Sept. 20, 1998 VRS2

State of California

County of Alameda

On April 1, 1996, before me, Judith Ann Duit/Notary Public, personally appeared Ronald L. Blick, personally known to me to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by signature on the instrument the person, or the entity upon behalf of which the person acted, executed the instrument.

WITNESS my hand and official seal.

Judith Ann Duit, Notary Public

PWR1 JUDITH ANN DUIT Comm. # 1036845 NOTARY PUBLIC - CALIFORNIA Alameda County My Comm. Expires Aug. 21, 1998 PWR1

OPTIONAL INFORMATION

The information below is not required by law. However, it could prevent fraudulent attachment of this acknowledgment to an unauthorized document.

CAPACITY CLAIMED BY SIGNER (PRINCIPAL)

- ☐ INDIVIDUAL
- ☑ CORPORATE OFFICER

President RMC LONESTAR
TITLE(S)

- ☐ PARTNER(S)
- ☐ ATTORNEY-IN-FACT
- ☐ TRUSTEE(S)
- ☐ GUARDIAN/CONSERVATOR
- ☐ OTHER:

SIGNER IS REPRESENTING:
Name of person(s) or entity(ies)
RMC LONESTAR

DESCRIPTION OF ATTACHED DOCUMENT

Annexation Agreement and Groundwater Mitigation Framework for Marina Area Lands
TITLE OR TYPE OF DOCUMENT

27 plus exhibit A - I
NUMBER OF PAGES

3/26/96
DATE OF DOCUMENT

OTHER

City of Marina

211 HILLCREST AVENUE
MARINA, CA 93933
TELEPHONE (408) 384-3715
FAX (408) 384-0425

CERTIFICATE OF ACKNOWLEDGEMENT

STATE OF CALIFORNIA)
) *ss.*
County of Monterey)

On April 5, 1996, before me, Joy P. Junsay, City Clerk of the City of Marina, California, personally appeared James L. Vocelka, Mayor of the City of Marina, California, personally known to me to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument the person, or the entity upon behalf of which the person acted, executed the instrument.

WITNESS my hand and official seal of the City of Marina, California.

Dated this 8th day of April, 1996.

Joy P. Junsay, City Clerk

ACKNOWLEDGMENT

STATE OF CALIFORNIA)
: ss.
COUNTY OF MONTEREY)

On March 29, 1996, before me, Jeannine L. Kreider, a Notary Public, duly commissioned and sworn, personally appeared DONALD G. HUBBARD

☒ personally known to me, or

☐ proved to me on the basis of satisfactory evidence

to be the person whose name is subscribed to the within instrument and acknowledged to me that he executed the same in his authorized capacity, and that by his signature on the instrument, the person, or the entity upon behalf of which the person acted, executed the same.

WITNESS my hand and official seal.

Signature

{Seal}

Jeannine L. Kreider
Comm. #1090740
NOTARY PUBLIC - CALIFORNIA
MONTEREY COUNTY
Comm. Exp. March 17 2000

APPENDIX 8.B – PLACEHOLDER APPENDIX COVER PAGE