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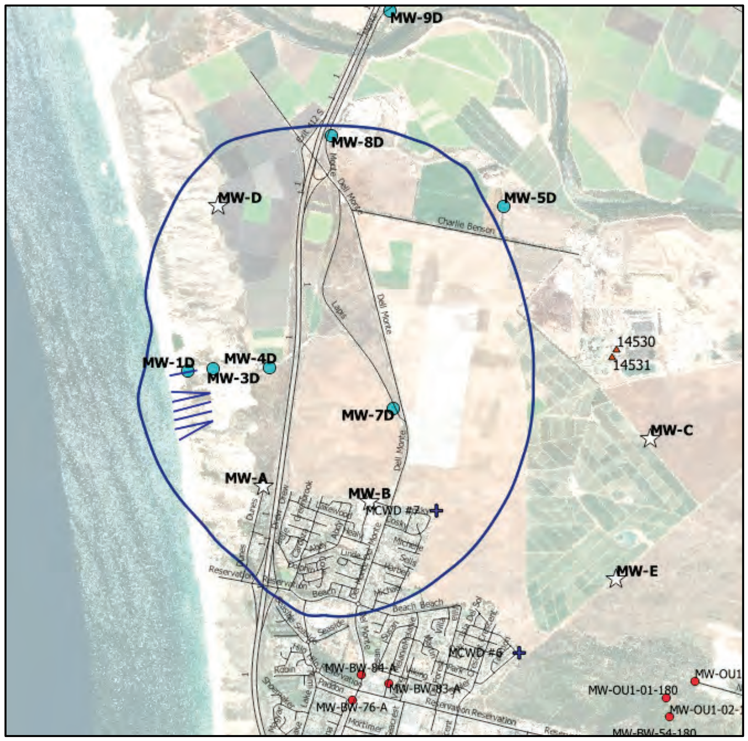
INTEGRATED COASTAL GROUNDWATER MONITORING PROGRAM AND PLAN



for
Monterey County Water Resources Agency

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INTRODUCTION

California American Water Company (CalAm) is working to increase sustainability of their water supply portfolio to meet the long-term needs of customers in their service area on the Monterey Peninsula. Accordingly, CalAm has proposed the Monterey Peninsula Water Supply Project (MPWSP). The MPWSP includes a desalination plant, distribution pipelines, aquifer storage and recovery and in-lieu use of desalinated water. Feedwater for the desalination plant would be from a seawater intake system consisting of slant wells constructed into the shallow aquifers at the coastal margin of the Salinas Valley Groundwater Basin (SVGB). The objective of the MPWSP is to meet CalAm's long-term water demands and comply with state imposed regulatory requirements[1]. A MPWSP Test Slant Wells Study (HWG, 2017) was conducted to evaluate project effects and support preparation of a draft and Final Environmental Impact Statement/Environmental Impact Report (EIR/EIS) (ESA, 2017). CalAm has received a Certificate of Public Convenience and Necessity CPCN) for the MPWSP from the California Public Utilities Commission (CPUC)[2]. The EIR/EIS supported the CPUC decision. This document presents a proposed Coastal Monitoring Plan (Monitoring Plan) to continue observing the MPWSP effects, if any, on the SVGB.

MPWSP Project Description

The MPWSP facilities are shown in **Figure 1** and would include a seawater intake system of seven subsurface slant wells (six active and one on standby) extending offshore into the submerged lands of the Monterey Bay National Marine Sanctuary (MBNMS), and a Source Water Pipeline. The slant wells would be constructed at the CEMEX sand mining site in the northern coastal area of the City of Marina and would extract 15.5 million gallons per day (mgd) of source water through the seafloor in the MBNMS. A 6.4 mgd capacity desalination plant would be constructed in unincorporated Monterey County northeast of the City of Marina and would produce approximately 7,000 acre-feet per year (afy) of treated water. Related facilities would include pretreatment, reverse osmosis, and post-treatment systems; backwash supply and filtered water equalization tanks; chemical feed and storage facilities; brine storage and conveyance facilities; and other associated non-process facilities. The proposed project also includes improvements to the existing Seaside Groundwater Basin aquifer storage and recovery system facilities, which would also enable CalAm to inject desalinated product water into the groundwater basin for subsequent extraction and distribution to customers.

Desalinated water conveyance facilities would include a stand-alone Carmel Valley Pump Station, a Terminal Reservoir, and approximately 21 miles of water pipelines that convey source water between the subsurface intakes and the desalination plant, and desalinated water between the desalination plant and the Terminal Reservoir. Treated water will also be conveyed to the SVGB to address any potential impacts to existing overlying groundwater users and return water that may have been pumped from the slant wells that originated in the SVGB aquifers.

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[1] SWRCB Order 95-10 and subsequent related orders.

[2] On April 23, 2012, CalAm filed at the PUC Application No. 12-04-019, "Application of the California-American Water Company (U210W) for Approval of the Monterey Peninsula Water Supply Project and Authorization to Recover All Present and Future Costs in Rates" ("CAW Application").

Figure 1 - MPWSP Location and Facilities

Source: ESA 2017

Hydrogeologic Setting, Conceptual Model and NMGWM

A detailed discussion of the regional hydrogeology and conceptual models of the coastal area of the Salinas Valley Basin can be found in a number of publications which provide the contemporary knowledge base (MCWRA, 2017; Brown and Caldwell, 2015; Kennedy/Jenks, 2004; HWG, 2017). The reader is directed to these documents for more detailed discussions. In general, the upper aquifer units in the Salinas Valley are essentially undeformed, flat-lying alluvial deposits reflecting different deposition environments in response to sea level changes. For purposes of developing and evaluating a monitoring network, it is most important that there is agreement between and within networks that the same hydrogeologic unit is being monitored. To that end, the following discussion provides a brief overview of each of the six hydrogeologic units found in the Study Area (see page 9 for description).

Surficial Deposits (Dune Sand Aquifer) consisting of dune sand at the coast and shallow alluvium farther inland. These deposits generally lie above an elevation of approximately -100 feet mean sea level (msl). For the purpose of this study this unit will also be referred to as the "Shallow Aquifer."

Underlying the **Shallow Aquifer**, in most portions of the Study Area, is a regional clay unit referred to as the "Salinas Valley Aquitard." This unit varies in thickness but generally lies between elevations of -100 and -130 feet, msl.

In the valley floor, the **Salinas Valley Aquitard**, overlies the 180-foot Aquifer. The 180-foot Aquifer consists of coarse-grained alluvial deposits. In the area south of the valley floor, the 180-foot Aquifer is stratigraphically equivalent to a sequence of terrace deposits consisting predominately of sand. The equivalent layer has been referred to as the 180-foot Equivalent Aquifer or the 180-FTE. Both units generally lie between the elevations of -130 and -280 feet, msl.

The **180-foot Aquifer and 180-FTE** are underlain by a regional clay unit that is areally extensive, although some erosional gaps have been detected. This so-called "180/400-foot Aquitard" hydraulically separates the overlying 180-foot/FTE aquifers from the underlying material. The 180/400-foot Aquitard lies at an approximate elevation of -280 to -320 feet, msl.

The **400-foot Aquifer** underlies the **180/400-foot Aquitard**. The 400-foot Aquifer is comprised of fine to medium-grained alluvial deposits with thin interbeds of finer-grained materials. The 400-foot Aquifer is generally considered to lie between the elevations of -320 and -500 feet, msl.

The **Deep Aquifers** underlie the 400-foot Aquifer; the geologic record suggests a period of lower energy resulting in the deposition of hundreds of feet of predominately finer-grained materials. Below this clay-dominated thickness, there are two formational aquifer units: (1) the non-marine Paso Robles Formation and (2) the marine Purisima and Santa Margarita Sandstone formations. Unlike the overlying sediments, these units are structurally deformed due to faulting and folding. The top of the water-bearing portion of the Paso Robles Formation generally occurs at an elevation of approximately -800 feet, msl, whereas the top of the Purisima Formation is generally considered to be below an elevation of approximately -1300 feet, msl.

A Hydrogeologic Work Group (HWG) was formed pursuant to the Settlement Agreement (among certain parties participating in the CPUC approval process for the MPWSP). The HWG consisted of hydrogeologists representing various settling parties. The HWG served as an internal peer review group to establish the test slant well monitoring program, evaluate data, advise and review model development and application, and prepare investigation documents. This included the MPWSP Hydrogeologic Investigation Work Plan (HWP) (Geoscience, 2013), monthly monitoring reports as required by the California Coastal Commission (CCC), and a final report prepared to provide technical input to the EIR/EIS (HWG, 2017). The HWP reviewed data developed from drilling and monitoring well construction. The well logs were used to develop the hydrogeologic conceptual model that was then used to refine the North Marina Groundwater Model (NMGWM), which was originally developed to simulate impacts of a previously proposed regional project. The updated NMGWM was then used to evaluate the feasibility and environmental impacts of the MPWSP project (HydroFocus, 2016).

Requirements for Groundwater Monitoring

Groundwater monitoring has been or is to be required under three primary planning and policy drivers: (1) a separate Settlement Agreement (between CalAm and Monterey County agencies) (Monterey County, 2012); (2) the State Water Resources Control Board (SWRCB) (SWRCB, 2013); and (3) the MPWSP California Environmental Quality Act/National Environmental Policy Act (CEQA/NEPA) draft and final MPWSP EIR/EIS (ESA, 2017) and associated Mitigation Monitoring and Reporting Program (MMRP)[3] (CPUC, 2018). As part of this study a memorandum was prepared to define the policy directives and basis for designing the network (**Appendix A**). Relevant sections of the MMRP are also presented in **Appendix B**. The MMRP Section 4.4-3 succinctly states that the purpose of the Monitoring Plan and program is:

- to ensure that owners of existing public or private groundwater supply wells within the Monitoring Area on the date the MPWSP commences slant well pumping (“Active Supply Wells”) suffer no harm as a result of MPWSP slant well pumping, and
- to augment the Monterey County Water Resources Agency (MCWRA or Agency) existing regional groundwater monitoring network.

The MMRP identifies CalAm, Independent Hydrogeologist, MCWRA and the CPUC as the future users of the data collected. The Monitoring Plan is being designed in anticipation of the future information needs and to support subsequent decisions and actions .

EIR/EIS Findings

The MPWSP EIR/EIS analysis did not find significant effects to groundwater resources from the MPWSP. Regardless, the EIR/EIS and the associated MMRP included Applicant Proposed Mitigation Measure 4.4-3, “Groundwater Monitoring and Avoidance of Well Damage”, to monitor changes in the groundwater surface elevations and quality that might be caused by the MPWSP pumping at the slant wells during full operation. If it is determined that the project is causing groundwater level and quality changes to damage local active wells within the Dune Sand, 180-Foot/FTE, 400-Foot Aquifer or Deep Aquifers, this measure would ensure that active wells are repaired or replaced.

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3 On August 13, 2018, the PUC published Decision Approving a Modified Monterey Peninsula Water Supply Project, Adopting Settlement Agreements, Issuing Certificate of Public Convenience and Necessity and Certifying Combined Environmental Report, Application 12-04-019; Application of California-American Water Company (U210W) for Approval of the Monterey Peninsula Water Supply Project and Authorization to Recover All Present and Future Costs in Rates.

The Monitoring Plan seeks to provide data that can be used to validate the model result, HWG conclusions, and EIR/EIS finding of "no significant impact". The findings may serve as the hypothesis which is then tested by the monitoring and observed data. The EIR/EIS made the following findings.

- "The proposed project would not deplete groundwater supplies in the Dune Sand, the 180-FTE Aquifer, the 400-Foot Aquifer or the Deep Aquifer; it would extract primarily seawater and a smaller volume of highly brackish ambient groundwater from a localized coastal capture area.
- The slant wells would not extract potable groundwater. MPWSP capture zone created is within an area that has been degraded by SWI and therefore unusable for potable water supply due to its high salinity.
- There are no active production wells extracting groundwater from the Dune Sand or 180-FTE Aquifers within the boundaries of the area projected as the MPWSP capture zone. There are no public or private wells completed in the Dune Sand Aquifer within the projected area of influence of MPWSP pumping.
- Water levels in nearby wells may decline in the 180-FTE Aquifer between 1 and 5 feet, but that would not expose screens, cause damage, or reduce yield in the groundwater supply wells. Injection and extraction through the ASR well system would be managed so that the water provided from the desalination plant would not constitute a net change in storage.
- When desalinated water is returned to the SVGWB as part of the MPWSP, groundwater conditions in the 400-Foot Aquifer underlying the CSIP, CCSD, and adjacent areas would improve as water levels increase from in-lieu groundwater recharge.
- The desalinated water returned to the SVGB would essentially put the SVGB in a "no net loss" position in terms of fresh water quantity and would benefit legal water users by providing fresh water for beneficial use in lieu of SVGB pumping.
- The proposed slant well pumping would not influence groundwater levels in the deeper aquifers and there would be no direct groundwater drawdown impact from the MPWSP on the deeper aquifers.
- Based on current groundwater quality and the minimal groundwater use within the area affected by slant well pumping, the localized change in groundwater quality that could occur because of slant well pumping is not expected to violate water quality standards or interrupt or eliminate the potable or irrigation groundwater supply available to other basin users, and this impact is considered less than significant.
- The MPWSP would not exacerbate SWI, and groundwater extraction from the coast, as part of project operations, would be expected to retard future inland migration of the SWI front.
- The proposed project would extract mostly seawater and some brackish groundwater from a localized area; no fresh water supplies would be removed from the basin. When water is returned to the basin, groundwater elevations and the volume of water in storage would increase in the 400-Foot Aquifer underlying the CSIP and CCSD and adjacent areas.
- From the time the slant wells begin pumping, and throughout the life of the project, local groundwater quality within the capture zone could change from highly brackish (23,400 mg/L TDS to 30,900 mg/L TDS) to more saline groundwater (seawater TDS is about 33,500 mg/L). The degradation in water quality (measured as an increase in TDS) would occur because the slant wells would first draw in the ambient, highly brackish groundwater that is currently within the aquifer formation and, because the capture zone would be adjacent to the coast, seawater would flow in to replace it. This effect would occur only in the confines of the capture zone near the CEMEX site and would not affect groundwater from inland portions of

the aquifers because inland groundwater east of the capture zone is under the influence of the inland, regional groundwater gradient."

Although the scientific analysis performed for the EIR/EIS predicted no impacts, there was some disagreement amongst experts and minority opinions which allege that impacts will occur. The proposed Monitoring Plan is intended to provide additional insights and to address these concerns.

Study Purpose

The specific purpose for this study is to:

- Design a Monitoring Plan and well network to observe MPWSP project long-term effects at full operations; and to meet the requirements of the Settlement Agreement, EIR/EIS and associated MMRP, and SWRCB intent to confirm prediction of a lack of harm to the SVGB.
- Conduct both a management and technical evaluation to define short-term, start-up and capital costs to implement the Monitoring Plan, and long-term costs to operate and maintain the network.
- Evaluate alternative management approaches to monitoring and recommend a final approach.
- Develop a cost-effective monitoring network and implementation program for the Monitoring Plan.

Although the Monitoring Plan and its implementation may have benefits to other groundwater management efforts (e.g., Sustainable Groundwater Management Act [SGMA]), these benefits are ancillary and not a goal of this Monitoring Plan.

Study Approach

This report identifies the proposed monitoring network objectives, locations for additional monitoring wells, the recommended design and construction of any such wells, use of existing wells, constituents and parameters to measure, frequency of measurement, and a procedure for the monitoring, testing, analysis, data management and reporting from any such wells. The existing networks and prior study reports provided the starting point to evaluate the data gaps, approach to fill these gaps, and the costs for collection, analysis and reporting of the data. Work included:

- Reviewing and documenting the existing monitoring networks within the study area
- Developing monitoring network objectives and questions that the network is to address
- Identifying data gaps to meet objectives and answer questions
- Developing approaches to filling data gaps
- Reviewing the analysis of existing collection methods and frequency
- Designing the network (locations, depth, frequency, collection methods) to provide a basis for comparison of management and operations costs
- Evaluating the pros/cons of the management alternatives for the idealized network, including documenting constraints and opportunities (e.g., integration with the long-term, ambient coastal monitoring network)
- Reviewing data management, analysis, exchange and reporting needs and approach
- Making final findings, conclusions and recommendations for the Monitoring Plan.

To conduct the groundwater monitoring network design, the work considered:

- Spatial and temporal coverage of the existing sampling locations
- The sensitivity of the existing networks to the expected aquifer response to the project operation
- Competing objectives of the existing monitoring programs
- Compatibility and comparability of data from different established networks
- Limitations of existing data collection methods in capturing data that are representative
- Uncertainties in the complex nature of geologic, hydrologic, and other environmental factors
- Decisions and actions supported by the information to be generated
- Audiences reliant on the generated information
- Analysis, maps and figures used to communicate the data to a range of audiences, and
- Range of management costs and the approaches and methods for network operations and maintenance.

Monitoring Network Objectives

Selection of existing wells, or drilling proposed new monitoring wells, will be based on whether the location supports the overall monitoring network objectives which include:

- Obtain groundwater level and quality data to document baseline conditions, and identify background variations in groundwater level and quality that are not associated with the MPWSP
- Track the operational effects of the MPWSP project and identify groundwater level and quality changes or effects, if any
- Provide data to support future updates to the NMGWM
- Measure the accuracy of the predicted groundwater levels against the background fluctuations associated with agronomic activities and climatic fluctuations
- Verify EIR/EIS findings and provide information to CalAm, MCWRA and CPUC to identify if or when further mitigation may be required.

Study Area and Monitoring Plan Area

As required by the MMRP, the study area is formally defined by the boundary of the North Monterey Groundwater Model as shown on **Figure 2**. The study area is located in the extreme coastal portion of the Salinas Valley.

The Monitoring Plan must be able to delineate between the MPWSP effect and the regional background fluctuations in groundwater levels and water quality that currently exist. A water level decline or change in water quality from the MPWSP operation would have to be strong, sustained, chronic observable changes, and would not be masked by the existing regional groundwater level fluctuations.

The NMGWM was used to determine the extent of the cone of depression and the zone of influence resulting from the operation of the MPWSP seawater intake slant wells. The NMGWM identified where the MPWSP would result in a -1 ft decline in groundwater levels under full and long- term operations.

Historical groundwater monitoring of groundwater levels and water quality document the long-term chronic overdraft and seawater intrusion in the Salinas Valley. The historical data demonstrate large regional fluctuations in water levels and water quality as a result of the seasonal irrigated agricultural operations and other coastal pumping and existing pumping stresses on the groundwater system.

Plate 1 presents hydrographs available for the 180-ft/FTE Aquifer in the area of the project. As can be seen, to the east of the project, water levels fluctuate on the order of 30 feet seasonally with weekly and daily signals superimposed. These water level fluctuations will be discussed further below. To detect water –related impacts from the MPWSP, the proposed Monitoring Plan program needs to focus on an area closer to the project such that potential impacts can be measured/detected against the background of the historical and current stresses.

As such, the Monitoring Plan area has been redefined to a smaller area relative to the study area, where project impacts can be observed independent of the background fluctuations. Detection of water level declines or water quality changes in wells in the geographic area outside of the Monitoring Plan area will be impossible to attribute to any particular stress but serve to inform the baseline. The smaller Monitoring Plan area was defined based on the NMGWM impact analysis, and the findings and recommendations of the HWG and the EIR/EIS. The modeling shows that project pumping from the slant wells would cause a response in a much smaller area than the NMGWM domain (i.e., study area), and MPWSP effects would be more localized in both the Dune Sand Aquifer and the 180-foot/FTE Aquifer. The -1 ft drawdown contour line is the area of influence for the Shallow and the 180-Foot Aquifers, as shown on **Plates 2 and 3**, respectively.

As shown on **Figure 2**, this study included a 0.5-mile buffer outside and inside of the -1 ft zone of influence. The purpose was to provide an "error band" that recognized uncertainty in the modeling; to provide for collection of baseline data and track regional, non-project effects to the groundwater basin; and to document if the MPWSP area of influence expands beyond the extent identified through modeling. This buffer is also shown on **Plates 2 and 3** for the Shallow and 180-Foot Aquifers, respectively. The modeling analysis did not suggest impacts to either the 400-foot or Deep Aquifers systems. As such, this study adopted the impact zones for the overlying aquifers.

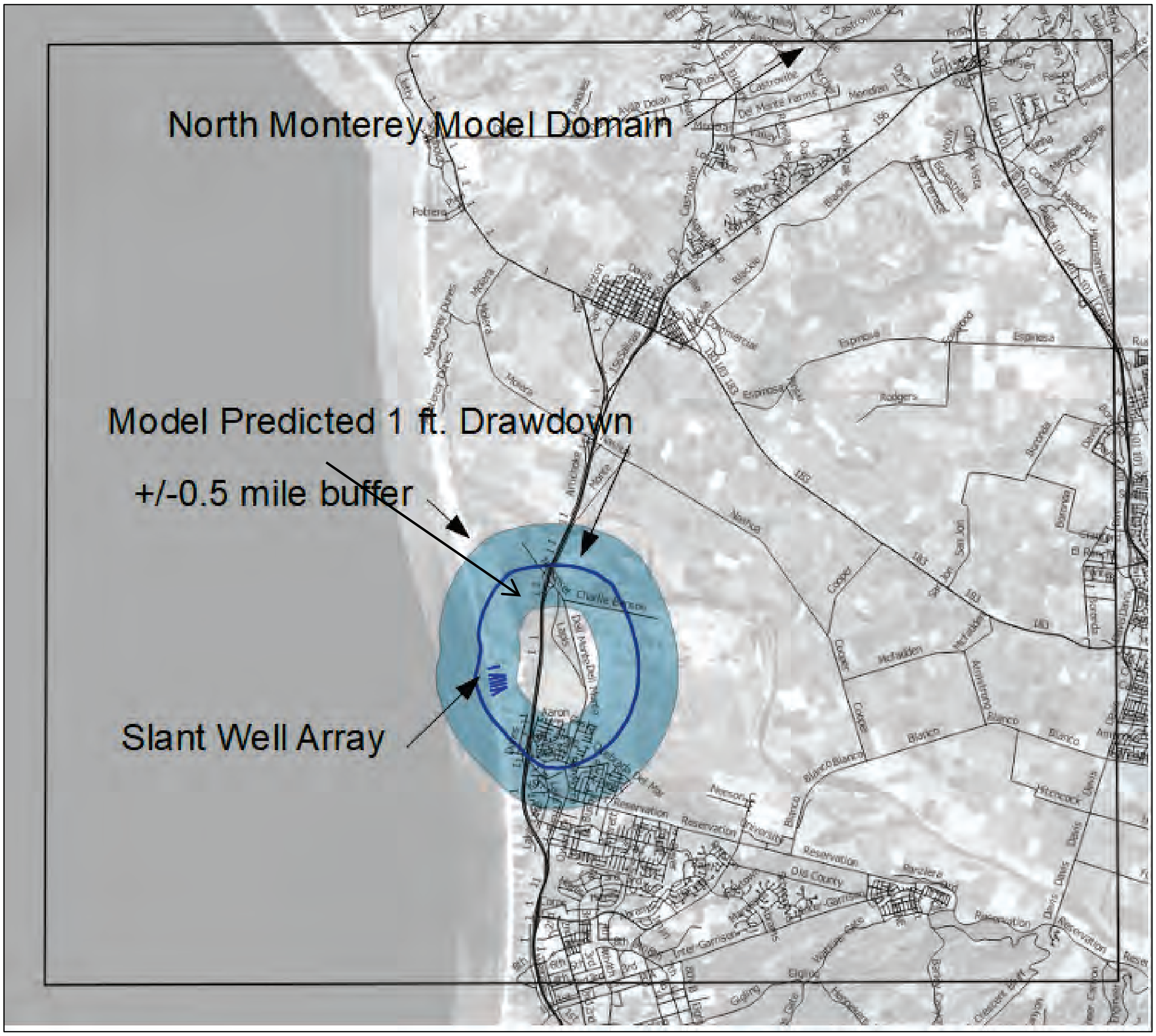
Any of the existing wells with networks contained in the redefined Monitoring Plan area are candidates for inclusion in the revised Monitoring Plan network. Wells outside of the Monitoring Plan area do not need to be considered for inclusion in this Monitoring Plan.

Limits of the Study

The Monitoring Plan is based on readily available hydrogeologic and well data. The study is not intended to refine the hydrogeologic conceptual model, though ultimately new wells will likely be constructed and provide additional hydrogeologic data that can be instrumental in future refinements of the hydrogeologic conceptual model and NMGWM.

Figure 2 -- NMGWM Domain and Study Area

Showing redefined Monitor Plan Area



MMRP Mitigation Measure 4.4-3 Number 2 requires CalAm, in coordination with MCWRA, to identify "Active Supply Wells" in the Monitoring Area and offer to owners of identified Active Supply Wells the opportunity to participate in the program for groundwater elevation and water quality monitoring.

This study does not include tasks to identify the Participating Active Supply Wells. Activities to identify the Active Supply Wells should be included as part of future implementation activities. It is anticipated that wells identified by others can be added to the established network at a future date. Although modeling efforts predicted no influence on the on-going contamination remediation activities at the former Fort Ord, Mitigation Measure 4.4-4, *Groundwater Monitoring and Avoidance of Impacts on Groundwater Remediation Plumes*, requires that groundwater elevation data be obtained from the periodic monitoring reports developed by the U.S. Army and its contractors using the most recent monitoring reports available. Data collected under this Monitoring Plan, in combination with the data from the existing on-going Fort Ord groundwater remediation monitoring, will support future evaluations to determine if the Ft Ord contamination plumes are being affected.

NETWORK EVALUATION AND DESIGN

This section describes the current monitoring programs in the study area, reviews design issues and considerations, and presents the recommended monitoring network design.

Inventory of Existing Monitoring Wells

An inventory of current monitoring programs was conducted to determine whether the wells included in the existing monitoring programs within the Monitoring Plan area may be appropriate to be integrated into the Monitoring Plan. Data are collected by different agencies for different purposes. A description of the programs, sampling methodologies, QA/QC, reporting and data access are presented in **Appendix C**. The primary entities collecting data in the Monitoring Plan area include:

- Monterey County Water Resources Agency (MCWRA)
- CalAm/MPWSP
- Marina Coast Water District (MCWD)
- Castroville Community Services District (CCSD)
- US Army/Ft Ord Remediation Program

Design Issues and Considerations

Baseline Conditions and Regional Influences

The monitoring is primarily to detect any physical changes that are specifically associated with the operation of the MPWSP. Baseline conditions were reviewed to help isolate the project-induced variability in groundwater levels and quality from the other regional influences.

Water Level

The purpose of the proposed groundwater level monitoring is to determine if the MPWSP pumping cone of depression is deeper or the zone of influence is expanding beyond what was anticipated through modeling. The NMGWM predicted that the few existing wells located within the Monitoring Area (i.e., slant well area of influence) could experience a change in groundwater level between 1 and 5 feet during the life of the project and that there would be no impact on the levels of production at these wells (ESA, 2017). This 1 to 5-foot MPWSP effect will occur in the context of other existing regional influences on groundwater levels.

The sources of variability have been documented in the data collected by the MCWRA and MPWSP groundwater level and quality programs. These include:

- Daily tidal variations
- Seasonal climatic variations
- Annual changes in recharge and pumping related to cropping patterns and water delivery
- Long-term changes associated with sea level rise

These sources of water level variability provide “noise” which makes identification of separate MPWSP effects more complex. The background data from the MCWRA and MPWSP monitoring indicate that there is a chronic, systemic hydraulic gradient from the coast to inland areas where current pumping levels create the depression that has resulted in the historical occurrence of SWI.

As was observed in the records from the MPWSP monitoring wells, water levels in the confined 400-Foot Aquifer can vary up to 1 foot a day due to tidal influences. Tidal fluctuations were less obvious in the unconfined portions of the 180-Foot Aquifer or in the Shallow Aquifer zone. Farther from the coast, the tidal signature is diminished, but the other sources of variability remain.

Plate 1, as mentioned above, shows some of the MPWSP and MCWRA groundwater level well hydrographs to demonstrate the magnitude of the seasonal recharge and pumping fluctuations in the 180-ft/FTE Aquifer. The MCWRA compiles annual regional groundwater level data on a quarterly basis for the SVGB including the Pressure 180-foot Aquifer and Pressure 400-foot Aquifer and compares the data to a representative dry water year and the 30-year average (MCWRA, 2018). According to MCWRA water level data, the 30-year average (1987 to 2017) groundwater levels in the Pressure 180-foot Aquifer fluctuate seasonally about 17 feet -- from about 22 feet above mean sea level (amsl) in the winter months to 5 feet amsl in the summer. The lowest seasonal average water levels are recorded during drought years where, the maximum seasonal fluctuation can be like the 30-year average (about 17 feet) but the groundwater levels drop about 10 feet overall relative to the average, as was the case during the peak of the most recent drought period when in 2015 the groundwater levels reached an annual low of about 6 feet below mean sea level. The groundwater level trends are similar in the Pressure 400-foot Aquifer where the annual seasonal fluctuation is about 24 feet -- between 7 feet amsl in the winter months to 17 feet below mean sea level in the summer. The drought year groundwater level fluctuation (about 22 feet) was like the 30-year average, but the groundwater levels dropped about 7 feet in the dry water year of 2015, relative to the average.

Given the background fluctuations that currently exist under the regional pumping regime, project-related groundwater level changes would have to be large, sustained, and chronic to be observed and not be masked by the fluctuations associated with other influences.

Water Quality

Chloride and Total Dissolved Solids (TDS) concentrations are most often used to document SWI. The historical measure of the SWI front used by MCWRA is the 500 mg/L chloride concentration. The measure of freshwater is 500 mg/L TDS, consistent with secondary drinking water standards. Locally, seawater is approximately 33,500 mg/L TDS with chloride ion concentrations of approximately 19,000 mg/L. Water that is a combination of fresh water and seawater can have TDS levels that range between 500 mg/L and 33,500 mg/L.

Water quality samples from production and monitoring wells provide the information to identify SWI, and areas where water quality is impaired and does not meet standards for municipal or agricultural uses. Both MCWRA and MPWSP water quality sampling documents the presence of seawater in the shallow, 180- and 400-foot Aquifers in the Monitoring Plan area. In and around the Monitoring Plan area, municipal and agricultural wells have been abandoned due to SWI.

The Salinas Basin has been impacted by SWI since the 1930s (MCWRA, 2016)[4]. In many areas of the shallow and 180- and 400-foot Aquifers, water quality has been impaired over time due to seawater moving inland and mixing with fresh water in response to regional depressions (troughs) in the water surface that result from the cumulative pumping for all uses. The rate and volume of SWI and mixing with the freshwater in the confined 180- and 400-foot Aquifers varies with pumping, seasonal water supply and because of variations (heterogeneity) in the aquifer materials. Different layers in the same aquifer may be more transmissive, thus allow faster rates of seawater migration and higher concentrations of TDS and chlorides.

In the shallow saturated sediments known as the unconfined Shallow Aquifer, elevated salinity may also be the result of land use activities contributing to salt and nitrate loads or other contaminants. There can be cross contamination between aquifers, unconfined to confined or between confined layers, as result of gaps in the clays (confining layers), in wells completed in multiple aquifers, or down leaky or improperly sealed wells.

As an artifact of historical land use, the MCWRA has not had many wells in its network in the Monitoring Plan area. For the MPWSP, data collection of the monitoring well network began in February 2015. To document baseline conditions, five weekly reports were prepared and made available to the public on the project website (www.watersupplyproject.org), between the start of monitoring and the commencement of the test well pumping (HWG, 2017). MPWSP MW-1, MW-3, MW-4, as shown on **Plates 1-3**, were tested in 2015 and contained TDS concentrations ranging from 11,900 mg/L to 32,600 mg/L with chloride ranging from 5,497 mg/L to 16,069 mg/L. MPWSP well clusters located farther from the slant well site, MW-7, MW-8, and MW-9, contained TDS concentrations ranging from 29,000 mg/L (MW-9M) to 366 mg/L (MW-9D) with chloride ranging between 16,519 mg/L to 74 mg/L in these same wells. Monitoring well clusters MW-5 and MW-6, located the farthest distance from the test slant well site, contained TDS concentration ranging from 2,616 mg/L (MW-5D) to 608 mg/L (MW-6S), with chloride ranging from 57 mg/L to 1,168 mg/L. These data indicate that the CEMEX site and areas inland have been intruded, to varying degrees, with seawater. The range of TDS/chloride concentrations indicates that certain areas are undergoing different stages of SWI. This variable distribution of intrusion is a result of the location and concentrations of historical pumping stresses, ion exchange between the soil and the incoming seawater, and the shape of the seawater intrusion wedge (seawater intrusion occurs in a wedge shape where, because of higher density seawater, the leading edge is normally in the lower portion of the aquifer).

The spatial variations in water quality and aquifer formations were also studied using Electrical Resistivity Tomography and Airborne Electro Magnetics (AEM) (Gottschalk, Knight, Asch, Abraham, & Cannia, 2018). The AEM study shows the complex nature of the formations, aquifer mixing and the SWI process. The HWG overlaid the known regional hydrostratigraphy on the AEM cross-sectional profile generated in the AEM study to show the semi-perched and regional water tables. The overlay showed general consistency between MPWSP monitoring well data and the hydrogeologic conceptual model developed by the HWG. In addition, the HWG modified the AEM resistivity profile to more

[4] Also see http://www.co.monterey.ca.us/home/showdocument?id=63713; and http://www.co.monterey.ca.us/home/showdocument?id=63715

correctly illustrate the distribution of water quality in the aquifers using the same control points, but using known groundwater conductivity measured in the monitoring wells. The results showed a distribution of groundwater chemistry that is consistent with the findings of the HWG hydrogeologic investigation and generally consistent with the salinity mapping for the 180-foot and 400-foot Aquifers published by the MCWRA (ESA, 2017).

Data Gaps and Redundancies

The purpose of the HWP was to close data gaps needed to evaluate the MPWSP environmental impacts and for final project design. The MMRP states that the existing slant well study monitoring wells will be included in the Monitoring Plan, but that the existing wells are subject to relocation, replacement or substitution by new or other monitoring wells as determined by MCWRA. In addition, the MMRP states that new wells may be required to fill data gaps related to evaluation of the impacts to SVGB groundwater pumpers from the long-term operation of the full MPWSP. The basis for defining a gap is to establish whether the current available networks provide representative coverage to track baseline conditions and/or to detect changes associated with the MPWSP.

We reviewed whether there were data gaps or redundancies related to monitoring location (spatial), depth (aquifers monitored), or frequency of sampling (temporal). No major redundancies were identified, though it is believed that there are alternative approaches to groundwater sampling and monitoring, as proposed below. Also discussed below, there are a number of spatial data gaps that can be filled through construction of new wells, as well as changes to the sampling methods, and use of an adaptive management approach to monitoring.

Representative Water Quality Sampling and "The Scale Problem"

The groundwater level sampling program is relatively straight forward as compared to the groundwater quality sampling program. Wells can be designed and completed in representative aquifers to capture groundwater elevation data and evaluate flow direction or pumping influences. However, obtaining representative water quality samples from either production or dedicated monitoring wells is more complicated for several reasons.

There are some inherent challenges in interpreting the extent of SWI using different types of wells. The HWG noted that the MCWRA generally relies on water quality data from high pumping capacity production wells for its SWI mapping. The smaller diameter monitoring wells, like those constructed for the MPWSP or the Agency's dedicated monitoring wells, are typically purged at relatively low pumping rates for groundwater quality sampling. While both types of wells are important and useful for SWI mapping, it should be recognized that there are variables that can influence whether the sample is representative of true water quality at all zones within the aquifer.

All aquifer systems are essentially an assemblage of smaller micro-aquifers that make up the larger aquifer body. Each of these micro-aquifers has differing hydraulic properties -- some have higher transmissivity than others. Other factors being equal, the higher transmissivity zones tend to have slightly lower piezometric head than the lower transmissivity zones. This is due to flatter hydraulic gradients in more permeable layers related to higher hydraulic conductivities. When these micro-aquifers are cross-connected by a well screen, water can move under static (non-pumping) conditions (driven by head differences) from one micro-aquifer to another.

Under static (non-pumping) conditions, groundwater will move from zones of higher head to zones of lower head within a well. As stated above, zones of higher transmissivity will tend to have lower head than zones of lower transmissivity. SWI will tend to preferentially flow through zones of higher transmissivity. The movement of groundwater through a well casing under static (non-pumping) conditions tends to result in lower salinity water (from zones that have higher piezometric heads) flowing into the well. This lower salinity water within the well casing will then be "injected" into the lower head/higher transmissivity zones (that have higher ambient salinity). When a well is pumped, most water initially is derived from the well casing and higher head zones (that have lower salinity groundwater). Lower salinity water "injected" into higher salinity zones under non-pumping conditions must first be removed (purged) from the well upon initial pumping to get a more accurate representation of aquifer water quality. If the discharge rate is sufficiently high (and pumping time is long enough), the bulk of the water is ultimately derived from the more transmissive zones and a more accurate representation of true bulk aquifer water quality is obtained.

This dynamic in wells influenced by SWI can "tag" the data from differing types of wells and differing rates of discharge. Wells pumped at high discharge rates will provide water quality of the more transmissive zones (that have higher salinity), whereas wells pumped at low discharge rates will provide water from the higher head, lower transmissivity zones (that have lower salinity). SWI will be moving inland in the most transmissive zones that have the lower static heads. As such, analysis of samples from a given well at low discharge rates can be significantly different from samples collected from the same (or adjacent) well at higher discharge rates (due to the time-dependent dynamics of the heterogeneous, stratified aquifer system).

As of result of the vertical and horizontal variability of the movement of seawater-degraded water in the aquifer system, the representativeness of the water quality of the aquifer system from any given well used for monitoring is varied. The water quality data from a specific monitoring point will be affected by the type of well, selection of screened interval, screen length, sampling method, purge volumes, and sampling depth. In seawater intruded areas, the best observation data may be obtained from large capacity wells that adequately stress the aquifer. For small diameter monitoring wells, the pumping rates and volumes may not be enough to obtain a truly representative sample of bulk aquifer water quality. This information should not be inferred to mean that monitoring is inaccurate or does not provide valuable information. It merely implies that the data must be interpreted while respecting the sampling methods, well type, well construction and awareness of the range of influences.

The MPWSP water level and water quality data demonstrate the issues associated with downhole sampling versus pumped sampling at the small diameter monitoring wells. The data indicate that the water quality in the aquifers at MW-3 and MW-4 wells exhibits vertical stratification. Therefore, direct correlation between laboratory samples collected by pumping the monitoring wells and *in situ* electrical conductivity (EC) data cannot be made since the pumped samples represent a mixing of waters from the entire screen interval and the transducer records EC from a single depth (generally mid-screen). The downhole EC probe data show that the measurements obtained are representative of the level where the probe is placed. Within an aquifer unit there are vertical variations in salinity due to variations in permeability and pressure. For example, in 1991 the Marina Coast Water District

(Staal, Gardner and Dunne, Inc, 1991) performed a study on one of their 180-foot Aquifer wells (Well No. 5) which had been pulled out of service for high salinity. In this study investigators found, through downhole salinity surveys while pumping, that the majority of the water coming from the perforated interval within the 180-foot Aquifer was of good quality, however, water with a concentration of one-fifth seawater was coming from an 8-foot zone within the well. Review of the lithologic log showed this 8-foot zone to be the coarsest, most transmissive zone. Contribution from this single zone rendered the well unusable for potable supply.

NETWORK DESIGN RECOMMENDATIONS

Based on the above, a network of monitoring points within the Monitoring Plan area has been assembled for each of the four aquifer systems. The wells included in the network consist of existing wells selected from several of the existing networks. These are predominately existing monitoring wells, but also include several idle and active production wells. These wells would be supplemented with the construction of new well clusters, as further described in this document.

The location of the selected existing wells and the proposed new wells are shown on **Plates 2-5**. **Tables 1-4** present the selected monitoring wells, along with well depths and completions, distance from the project wellfield, current data collected and the frequency of that collection. The assumed construction of the proposed monitoring wells is also shown in these tables.

Recommended New Well Locations and Well Completions

Each of the existing MPWSP clusters has shallow, medium and deep wells to capture data from the Dune Sand, 180-foot and 400-foot Aquifers, respectively. To be consistent and allow for comparisons with the existing monitoring wells, the new monitoring wells should consist of a cluster of three wells intended to provide more complete vertical and spatial coverage. In its final report (HWG, 2017), the HWG found that[5] the groundwater monitoring network provided the appropriate coverage for areas within and outside the influence of pumping, also finding that additional monitoring wells could be located near the boundary of the Monitoring Area to identify changes in groundwater levels due to the much larger impacts of local pumping.

Five locations for new well clusters are suggested. The sites are positioned to allow confirmation of drawdown signals from the slant wells. As such, where existing wells are available along the trace of the predicted -1 ft drawdown, the suggested new wells are generally located at points half way between the slant wellfield and the predicted -1 ft drawdown line. Alternatively, where no other wells are available along the trace of the approximate location of the -1 ft drawdown line wells, the suggested new wells are along the line. New wells are sited to provide groundwater elevation transects to the north, east and south of the area of influence. Through distance-drawdown analysis, these locations will allow capture of data that will allow confirmation of possible drawdown signals at wells located farther from the slant wellfield.

In addition to the five new well clusters, it is recommended that the shallow completion at MW-5 location (MW-5S(P) be replaced with a deeper completion. The current well was not perforated in the appropriate monitoring zone, leaving a data gap. Data collected subsequent to the well's completion

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5 HWG, 2017. Section 5.5 Full-Scale System Water Level and Water Quality Monitoring. Pg. 86

reveal that this well is perforated in a perched aquifer above the shallow aquifer and is not representative of the shallow conditions captured by the other Shallow Aquifer completions.

No new wells are recommended for the Deep Aquifers, because, due to recent well construction, several new Deep Aquifers system wells are now located in the area. Current regulations require data collection and sharing by the operators of these wells with the MCWRA. The existing monitoring of Deep Aquifers is adequate, and additional monitoring beyond that which is already occurring is not warranted for inclusion in this Monitoring Plan. Any new or replacement wells in the Deep Aquifers require[6] meters, monitoring of groundwater levels and quality, and submission of all data to the MCWRA. The well owner or operator is required to purchase a transducer or data logger and necessary equipment which meet MCWRA specifications for continuous monitoring of groundwater levels and conductivity. The equipment is then installed and monitored for use by MCWRA staff. The Deep Aquifers were not predicted to experience any effects from project-related operations during the long-term test pumping or during modeling.

Monitoring Well Design

The recently completed MPWSP network monitoring wells have set a high standard for well design and construction. Additional monitoring well cluster installations should be of similar design. Each well cluster would consist of a grouping of 3 individual wells – one completed in the Shallow Aquifer, one completed in the 180-ft/FTE Aquifer and one completed in the 400–foot Aquifer. The technical specifications for well construction were provided as part of the MPWSP workplan (Geoscience, 2013)[7] . These specifications should be used to construct the new wells. The Generalized Well Design is presented in **Appendix E**.

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6 Monterey County Interim Ordinance 5302

7 See Attachment 3, Technical Specifications – Monitoring Wells, dated August 8, 2014.

Table 1 – Monitoring Points – Shallow Aquifer

Well Name/Facility Code	Well Type	Network	Status	Depth (feet)	Elevation (ft,msl)	Top of Perforations (feet)	Bottom of Perforations (feet)	Elev. of Top of Perforations (ft,msl)	Elev. of Bottom of Perforations (ft,msl)	Distance from Project Wellfield (feet)
MW-1S	Mon	MPWSP	Existing	105	31	55	95	-24.49	-64.5	211
MW-3S	Mon	MPWSP	Existing	100	37	50	90	-12.84	-52.8	428
MW-4S	Mon	MPWSP	Existing	110	42	60	100	-18.04	-58.0	1,940
MW-5S (P)	Mon	MPWSP	Existing	93	80	43	83	37.25	-2.8	9,135
MW-6S	Mon	MPWSP	Existing	70	36	30	60	5.89	-24.1	21,436
MW-7S	Mon	MPWSP	Existing	90	51	60	80	-9.36	-29.4	5,274
MW-8S	Mon	MPWSP	Existing	90	20	40	80	-20.04	-60.0	7,116
MW-9S	Mon	MPWSP	Existing	120	18	30	110	-11.58	-91.6	10,677
MW-AS	*Mon*	*MPWSP*	*Proposed*	*120*	*62*	*70*	*110*	*-8*	*-48*	*2,187*
MW-BS	*Mon*	*MPWSP*	*Proposed*	*100*	*38*	*50*	*90*	*-12*	*-52*	*4,603*
MW-CS	*Mon*	*MPWSP*	*Proposed*	*170*	*106*	*120*	*160*	*-14*	*-54*	*11,446*
MW-DS	*Mon*	*MPWSP*	*Proposed*	*70*	*8*	*20*	*60*	*-12*	*-52*	*4,180*
MW-ES	*Mon*	*MPWSP*	*Proposed*	*170*	*112*	*120*	*160*	*-8*	*-48*	*11,536*
MW-5S	*Mon*	*MPWSP*	*Proposed*	*130*	*80*	*80*	*120*	*0*	*-40*	*9,008*
MCWD MW#4	Mon	MCWD	Existing	110	61	64	106	-3	-45	4,872
MCWD MW#5	Mon	MCWD	Existing	107	61	60	100	1	-39	4,950
MW-BW-76-A	Mon	FO	Existing	50	17	20	50	-3	-33	8,073
MW-BW-84-A	Mon	FO	Existing	65	19	24	64	-5	-45	7,605
MW-BW-83-A	Mon	FO	Existing	68	24	26	66	-2	-42	8,184
MW-OU1-01-180	Mon	FO	Existing	175	126	155	175	-29	-49	13,903
MW-OU1-02-180	Mon	FO	Existing	195	138	175	195	-37	-57	14,236
MW-OU1-03-180	Mon	FO	Existing	183	141	163	183	-22	-42	14,343
MW-BW-54-180	Mon	FO	Existing	201	128	161	201	-33	-73	13,372
21667	Prod	MCWRA	Existing	140	56	80	140	-24	-84	9174

		Current		Proposed		
Well Name/Facility Code	Data Collected	Current WL Frequency	Current WQ Frequency	Proposed WL Changes	Proposed WQ Changes	Access Permission Required
MW-1S	WL,WQ	C	C*		In_A*	
MW-3S	WL,WQ	C	C*		In_A*	
MW-4S	WL,WQ	C	C*		In_A*	
MW-5S (P)	WL,WQ	C	C*		In_A*	
MW-6S	WL,WQ	C	C*		In_A*	
MW-7S	WL,WQ	C	C*		In_A*	
MW-8S	WL,WQ	C	C*		In_A*	
MW-9S	WL,WQ	C	C*		In_A*	
MW-AS	*WL,WQ*			*C*	In_A*	*City of Marina*
MW-BS	*WL,WQ*			*C*	In_A*	*City of Marina*
MW-CS	*WL,WQ*			*C*	In_A*	*MCWD*
MW-DS	*WL,WQ*			*C*	In_A*	*Cemex/Ag Trst*
MW-ES	*WL,WQ*			*C*	In_A*	*City of Marina*
MW-5S	*WL,WQ*			*C*	In_A*	
MCWD MW#4	*WL,WQ*	P,?	P,?	*C*	In_A*	MCWD
MCWD MW#5	*WL,WQ*	P,?	P,?	*C*	In_A*	MCWD
MW-BW-76-A	TBD			*C*		FO (Ahna/Shaw)
MW-BW-84-A	TBD			*C*		FO (Ahna/Shaw)
MW-BW-83-A	TBD			*C*		FO (Ahna/Shaw)
MW-OU1-01-180	TBD			*C*		FO (Ahna/Shaw)
MW-OU1-02-180	TBD			*C*		FO (Ahna/Shaw)
MW-OU1-03-180	TBD			*C*		FO (Ahna/Shaw)
MW-BW-54-180	TBD			*C*		FO (Ahna/Shaw)
21667	WL,WQ	P,M	P,A			

C=Continuous; P=Periodic: M=Monthly, S=Semi-Annual, A=Annual, I=Intermitttent, ?=Unknown

*EC, Lab WQ, Quarterly

In_A*= Induction Logging of Adjacent Deeper Well

Table 2 – Monitoring Points – 180-ft/FTE Aquifer

Well Name/Facility Code	Well Type	Network	Status	Depth (feet)	Elevation (ft,msl)	Top of Perforations (feet)	Bottom of Perforations (feet)	Elev. of Top of Perforations (ft,msl)	Elev. of Bottom of Perforations (ft,msl)	Distance from Project Wellfield (feet)
MW-1M	Mon	MPWSP	Existing	235	30	115	225	-85.14	-195.1	220
MW-3M	Mon	MPWSP	Existing	225	37	105	215	-67.65	-177.7	441
MW-4M	Mon	MPWSP	Existing	270	42	130	260	-88.01	-218.0	1,929
MW-5M	Mon	MPWSP	Existing	320	80	100	310	-19.52	-229.5	9,131
MW-6M	Mon	MPWSP	Existing	220	36	150	210	-114.32	-174.3	21,431
MW-6M(L)	Mon	MPWSP	Existing	335	36	255	325	-219.18	-289.2	21,427
MW-7M	Mon	MPWSP	Existing	230	50	130	220	-79.71	-169.7	5,266
MW-8M	Mon	MPWSP	Existing	225	20	125	215	-105.01	-195.0	7,106
MW-9M	Mon	MPWSP	Existing	235	18	145	225	-126.68	-206.7	10,687
MW-AM	*Mon*	*MPWSP*	*Proposed*	*320*	*62*	*210*	*310*	*-148*	*-248*	*2187*
MW-BM	*Mon*	*MPWSP*	*Proposed*	*290*	*38*	*180*	*280*	*-142*	*-242*	*4603*
MW-CM	*Mon*	*MPWSP*	*Proposed*	*360*	*106*	*250*	*350*	*-144*	*-244*	*11446*
MW-DM	*Mon*	*MPWSP*	*Proposed*	*260*	*8*	*150*	*250*	*-142*	*-242*	*4180*
MW-EM	*Mon*	*MPWSP*	*Proposed*	*360*	*112*	*250*	*350*	*-138*	*-238*	*11536*
MCWD DMW-1	Mon	MCWD	Existing	240	60	190	230	-130	-170	4795
MCWD DMW-2	Mon	MCWD	Existing	236	61	180	230	-119	-169	4975
MCWD Well #1	Idle Prod	MCWD	Existing	225	84	124	NA	-40	-141	8821
MCWD Well #2	Idle Prod	MCWD	Existing	200	75	128	NA	-53	-125	8460
14530	Idle Prod	MCWRA	Existing	350	103	260	340	-157	-247	10775
14531	Idle Prod	MCWRA	Existing	350	116	260	340	-144	-234	10750
MW-B-05-180	Mon	FO	Existing	210	120	175	205	-55	-85	12740
Airfield	Mon	FO	Existing	396	142	318	379	-176	-237	15508

		Current		Proposed		
Well Name/Facility Code	Data Collected	Current WL Frequency	Current WQ Frequency	Proposed WL Changes	Proposed WQ Changes	Access Permission Required
MW-1M	WL,WQ	C	C*		In_A*	
MW-3M	WL,WQ	C	C*		In_A*	
MW-4M	WL,WQ	C	C*		In_A*	
MW-5M	WL,WQ	C	C*		In_A*	
MW-6M	WL,WQ	C	C*		In_A*	
MW-6M(L)	WL,WQ	C	C*		In_A*	
MW-7M	WL,WQ	C	C*		In_A*	
MW-8M	WL,WQ	C	C*		In_A*	
MW-9M	WL,WQ	C	C*		In_A*	
MW-AM	*WL,WQ*			*C*	In_A*	*City of Marina*
MW-BM	*WL,WQ*			*C*	In_A*	*City of Marina*
MW-CM	*WL,WQ*			*C*	In_A*	*MCWD*
MW-DM	*WL,WQ*			*C*	In_A*	*Cemex/Ag Trst*
MW-EM	*WL,WQ*			*C*	In_A*	*City of Marina*
MCWD DMW-1	WL,WQ	P,?	P,?	C	In_A	MCWD
MCWD DMW-2	WL,WQ	P,?	P,?	C	In_A	MCWD
MCWD Well #1	none			C		MCWD
MCWD Well #2	none			C		MCWD
14530	WL	P,M		C		
14531	WL	P,M		C		
MW-B-05-180	WL,WQ	P,M		C		FO (Ahna/Shaw)
Airfield	WL,WQ	P,M		C		FO (Ahna/Shaw)

C=Continuous; P=Periodic: M=Monthly, S=Semi-Annual, A=Annual, I=Intermitttent, ?=Unknown

*EC, Lab WQ, Quarterly

In_A= Induction Logging_Annually In_A*= Induction Logging of Adjacent Deeper Well

Table 3 – Monitoring Points – 400-ft Aquifer

Well Name/Facility Code	Well Type	Network	Status	Depth (feet)	Elevation (ft,msl)	Top of Perforations (feet)	Bottom of Perforations (feet)	Elev. of Top of Perforations (ft,msl)	Elev. of Bottom of Perforations (ft,msl)	Distance from Project Wellfield (feet)
MW-1D	Mon	MPWSP	Existing	337	30	277	327	-247.32	-297.3	230
MW-3D	Mon	MPWSP	Existing	340	37	285	330	-248.07	-293.1	451
MW-4D	Mon	MPWSP	Existing	340	42	290	330	-248.05	-288.1	1,918
MW-5D	Mon	MPWSP	Existing	445	80	395	435	-314.94	-354.9	9,126
MW-7D	Mon	MPWSP	Existing	355	50	295	345	-244.76	-294.8	5,260
MW-8D	Mon	MPWSP	Existing	360	20	300	350	-279.92	-329.9	7,096
MW-9D	Mon	MPWSP	Existing	403	18	353	393	-334.68	-374.7	10,697
MW-AD	*Mon*	*MPWSP*	*Proposed*	*390*	*62*	*340*	*380*	*-278*	*-318*	*2187*
MW-BD	*Mon*	*MPWSP*	*Proposed*	*370*	*38*	*320*	*360*	*-282*	*-322*	*4603*
MW-CD	*Mon*	*MPWSP*	*Proposed*	*430*	*106*	*380*	*420*	*-274*	*-314*	*11446*
MW-DD	*Mon*	*MPWSP*	*Proposed*	*330*	*8*	*280*	*320*	*-272*	*-312*	*4180*
MW-ED	*Mon*	*MPWSP*	*Proposed*	*320*	*112*	*400*	*440*	*-288*	*-328*	*11536*
1032	*Prod*	MCWRA	Existing	*506*	*31*	*400*	*506*	*-369*	*-475*	*1200*
239	Prod	MCWRA	Existing	500	14	314	456	-300	-442	9060
2791	Prod	MCWRA	Existing	600	140	438	580	-298	-440	14206
2718	Prod	MCWRA	Existing	615	19	330	600	-311	-581	10885
1466	Prod	MCWRA	Existing	556	16	395	540	-379	-524	13200

		Current		Proposed		
Well Name/Facility Code	Data Collected	Current WL Frequency	Current WQ Frequency	Proposed WL Changes	Proposed WQ Changes	Access Permission Required
MW-1D	WL,WQ	C	C*		In-A	
MW-3D	WL,WQ	C	C*		In-A	
MW-4D	WL,WQ	C	C*		In-A	
MW-5D	WL,WQ	C	C*		In-A	
MW-7D	WL,WQ	C	C*		In-A	
MW-8D	WL,WQ	C	C*		In-A	
MW-9D	WL,WQ	C	C*		In-A	
MW-AD	*WL,WQ*			C	In-A	*City of Marina*
MW-BD	*WL,WQ*			C	In-A	*City of Marina*
MW-CD	*WL,WQ*			C	In-A	*MCWD*
MW-DD	*WL,WQ*			C	In-A	*Cemex/Ag Trst*
MW-ED	*WL,WQ*			C	In-A	*City of Marina*
1032	*WQ*		P,A			
239	WL	P,M				
2791	WL	P,A				
2718	WL	P,A				
1466	WL,WQ	P,A	P,A			

C=Continuous; P=Periodic: M=Monthly, S=Semi-Annual, A=Annual, I=Intermitttent, ?=Unknown

*EC, Lab WQ, Quarterly

In_A= Induction Logging_Annually

Table 4 – Monitoring Points – Deep Aquifers

Well Name/Facility Code	Well Type	Network	Status	Depth (feet)	Elevation (ft,msl)	Top of Perforations (feet)	Bottom of Perforations (feet)	Elev. of Top of Perforations (ft,msl)	Elev. of Bottom of Perforations (ft,msl)	Distance from Project Wellfield (feet)
DMW#1-1	Mon	MCWRA	Existing	960	60	930	950	-870	-890	5092
DMW#1-2	Mon	MCWRA	Existing	1070	60	1040	1060	-980	-1000	5092
DMW#1-3	Mon	MCWRA	Existing	1440	60	1410	1430	-1350	-1370	5092
DMW#1-4	Mon	MCWRA	Existing	1890	60	1820	1860	-1760	-1800	5092
DMW#2-S	Mon	MCWRA	Existing	1100	142	1040	1090	-898	-948	19299
DMW#2-D	Mon	MCWRA	Existing	1740	142	1680	1730	-1538	-1588	19299
MCWD Well #10	Prod	MCWD	Existing	1500	153	930	1540	-777	-1387	15303
MCWD Well #11	Prod	MCWD	Existing	1700	155	970	1650	-815	-1495	13965
MCWD Well #12	Prod	MCWD	Existing	2023	109	1410	1960	-1301	-1851	16079
#15-12607	Prod	none	Existing	1680	82	1120	1680	-1038	-1598	
25973	Prod	none	Existing	1780	132	1030	1780	-898	-1648	11724
21655	Prod	none	Existing	825	105	670	805	-595	-700	10770
22755	Prod	MCWRA	Existing	1573	25	1450	1450	1570	-1427	
2691 "Big Well"	Idle Prod	none	Existing	870	29	666	834	-595	-805	3615
1672	Idle Prod	MCWRA	Existing	1560	6	880	1540	-874	-1534	11507
10164	Mon	MCWRA		1610	8	775	1585	-595	-1577	

		Current		Proposed		
Well Name/Facility Code	Data Collected	Current WL Frequency	Current WQ Frequency	Proposed WL Changes	Proposed WQ Changes	Access Permission Required
DMW#1-1	WL,WQ	C	P,I			
DMW#1-2	WL,WQ	C	P,I			
DMW#1-3	WL,WQ	C	P,I			
DMW#1-4	WL,WQ	C	P,I		Id_A	
DMW#2-S	WL	C				
DMW#2-D	WL	C			Id_A	
MCWD Well #10	WL,WQ	P,?	A			MCWD
MCWD Well #11	WL,WQ	P,?	A			
MCWD Well #12	WL,WQ	P,?	A			MCWD
#15-12607						
25973	WQ		P,A			
21655	WQ		P,A			
22755	WQ		P,A			
2691 "Big Well"	none			C		Ag Land Trust
1672	WL	M				
10164	WL,WQ	C	P,A			

C=Continuous; P=Periodic: M=Monthly, S=Semi-Annual, A=Annual, I=Intermitttent, ?=Unknown

*EC, Lab WQ, Quarterly

In_A= Induction Logging_Annually

Data Collection Methods

Groundwater Level

Currently, groundwater levels at MPWSP wells and at MCWRA dedicated monitoring wells are recorded with water level dataloggers. Water levels are collected hourly and data are downloaded monthly and a manual measurement made during the monthly site visit. As shown in **Tables 1-4**, there are also several existing monitoring wells that were not part of the MPWSP test slant well program, but which are recommended for continuous water level measurements with monthly downloads. This includes several MCWD, MCWRA and Fort Ord wells. With the construction of the proposed new wells and the addition to the network of the suggested existing wells, 33 additional water level data loggers will be required. These solid-state data collection platforms and transducers for recording groundwater levels are reliable and accurate. For planning purposes, a service life of 5 years for water level data loggers is appropriate. Planning for maintenance, repair and replacement will be needed. Recommendations for instrumentation are presented in **Appendix F**.

Groundwater Quality

For the current water quality program, water quality data are collected predominately in two ways. Conductivity is collected and recorded by downhole water level/conductivity data loggers. In addition, periodic water samples are collected for laboratory analysis.

The conductivity loggers are downloaded monthly along with the water level data. As discussed above, the probes are generally placed mid-screen, measuring conductivity at this interval and the data are not necessarily representative of what is happening throughout the entire aquifer, due to salinity stratification of water in the well. The EC probes have proven to be problematic in the highly saline environments. The EC probes employed for the MPWSP demonstrated issues with drift, failure, and the chronic need for replacement of the probes.

Samples for lab analysis are collected with small-diameter downhole pumps from the MW-4 cluster on a quarterly basis and semi-annually at the other MPWSP wells. Samples were taken from each well with the low volume pumps (~10 gpm), with the pump set above the top of the screen. For reasons discussed above, at this low discharge rate, in wells with relatively long screens, the water samples collected are likely more representative of the uppermost portion of the screen or the zone with the highest piezometric pressure. These samples will not be representative of the same well, if that same well was sampled at a higher discharge rate or if the pump was set at a different depth.

Both the conductivity and sampling methodologies provide valid useful data. However, the data need to be understood and interpreted in the context of how the data were collected and the hydraulics of a well that is either idle or only slightly stressed. A comparison of data from physical laboratory samples and downhole conductivity loggers, along with interpretations, is presented in **Table 5**. The largest disparities are shown in bold.

Table 5 - Comparison of Collected Sample Conductivity and Transducer Data from MPWSP Network Wells

Well	Sample Date	Specific Conductance µm/cm Sample	Specific Conductance µm/cm Transducer[1]	Comments
MW-1D	7/27/15	43,350	43,000	
MW-1M	7/27/15	44,420	47,500	
MW-1S	7/27/15	49,654	NA	
MW-3D	7/27/15	45,042	46,200	
MW-3M	7/27/15	40,998	42,000	
MW-3S	**7/27/15**	**33,334**	**39,000**	Well has 40 feet of screen. Transducer mid-screen. Sampling produces partially from above transducer.
MW-4D	4/12/17	39,150	42,000	
MW-4M	4/12/17	33,600	34,200	
MW-4S	**4/12/17**	**16,820**	**5,500**	Transducer placed 6 feet below top of screen. Known salinity stratification in well. After sampling transducer spikes to ~ 20,000 uS, then declines.
MW-5D	**7/27/15**	**3,908**	**4,500**	Transducer placed mid-screen. Likely fresher water in upper portion of screen. Produced when pumped. After sampling transducer spikes down to ~ 3,700 uS, then rises.
MW-5M	**7/27/15**	**757**	**1,250**	Well has 210' screened interval. Transducer placed mid-screen. Samples taken with pump above top of perforations. Likely fresher water in upper portion of screen.
MW-5S	7/27/15	1,861	1,750	
MW-6D	7/28/15	3,121	3,100	
MW-6M	7/15/15	1,552	1,500	
MW-6S	7/28/15	1,060	NA	
MW-7D	8/9/15	38,800	NA	
MW-7M	**8/2/15**	**5,650**	**3,000**	Well has 90' screened interval. Transducer placed mid-screen. Samples taken with pump above top of perforations
MW-7S	8/3/15	1,768	NA	
MW-8D	7/28/15	6,610	NA	
MW-8M	**7/28/15**	**29,750**	**48,200**	Well has 90' screened interval. Transducer placed mid-screen. Samples taken with pump above top of perforations
MW-8S	7/28/15	1,966	NA	
MW-9D	7/28/15	617	NA*	
MW-9M	7/28/15	44,660	45,500	
MW-9S	7/28/15	5,190	NA*	

[1] Transducer value estimated from chart. NA – Logger not yet installed or failed. NA*-- Logger installed soon after, value close.

As can be seen in **Table 5**, several of the wells show large discrepancies between the laboratory value and the transducer value. The reasons for these discrepancies are basically an artifact of the fact that the transducer, which in most cases is placed in the mid-point of the screen, is measuring different water than is produced by the sampling pump. Due to well hydraulics, at the low discharge rates at which the samples are collected (corresponding to low aquifer-induced stresses), most of the water comes from the uppermost portion of the screen. This is further complicated by salinity stratification in the well that can result in upconing during sampling.

In addition to the conductivity loggers and the periodic sampling, on several occasions the deeper well at three of the MPWSP well clusters has been induction logged. The results of this effort are presented in **Appendix D**. **Appendix D** also presents additional theory of induction logging and examples of its application in similar situations. Briefly, induction logging measures the bulk electroconductivity of the aquifer materials and formation water within an approximate 6-foot diameter sphere of the tool. The tool is lowered down the well and captures the combined conductivity of the fluid and solids in and surrounding the casing for the length of the well. In addition, induction logging is simply a vertical application of the technology employed recently by

Stanford researchers in their areal resistivity mapping. Its effectiveness for capturing changes in water quality relies on the fact that the solids (sand and clay) that comprise the materials outside the casing have constant conductivities, whereas the conductivity of the pore fluid can change over time. Because of the size of the zone of investigation, the induction log is relatively insensitive to the quality of the water within the casing or screen because the properties of the surrounding materials dominate. If water of poorer or better quality replaces existing pore water in the formation, conductivities will increase or decrease, respectively, and the relative changes can be measured through induction logging. In small diameter monitoring wells built with PVC casing, induction logging can provide a vertical profile of the actual conductivity in the formation. Sequential logging provides an easy way to capture temporal conductivity changes in the aquifer system. Induction logging will capture qualitative changes in the water quality. If significant changes are detected in a well with induction logging and when comparing to the baseline measurements, follow-up downhole water quality sampling can be conducted to confirm and quantify the observed changes through further sampling and lab analysis.

A comparison of the methods described above is presented below in **Table 6**.

Table 6 - Comparisons of Water Quality Data Collection Approaches

Method	Description	Pros	Cons	Required Labor
Conductivity Dataloggers	Dedicated conductivity logger in each well. Data downloaded periodically.	Allows continuous data collection. Easily deployed	Collected data is only representative of water quality at location in well that data logger is suspended Have shown tendency to drift or fail in previous deployments	Data download at periodic intervals Periodic Replacement Data Management
Sampling for Lab Analysis	Collection of samples from each well with temporary pump Samples analyzed at lab	Discrete samples Constituents quantified Sampling service can be provided at reduced cost by specialized vendor	Labor intensive to install pump and collect samples Inability to pump at a rate to simulate a production well at same location. Results in WQ data that may not be comparable. Sample WQ sensitive to pump setting.	Removal and replacement of instrumentation Installing pump, purging, collecting sample, removing pump at each well. Deliver samples to lab Data Management
Induction Logging	Periodic conductivity logging of the deep well at each location. Comparison of sequential logs for detection of changes in conductivity in formation	Provides vertical conductivity profiles of entire well depth regardless of perforations. Only the deepest well at each location would need to be logged. Insensitivity to quality of water within casing/screen – measures bulk formation conductivity. Fast and Cost-effective	Instrumentation needs to be removed and replaced from well. Provides qualitative data, although with additional effort can be quantified. Requires vendor with specialized tools.	Coordinating with vendor Removal and replacement of instrumentation Data Management

Each of the water quality data collection approaches has their advantages and disadvantages. Each of them provides additional insight in the understanding of the water quality of the aquifer system. The data logger provides continuous data at a single location in the aquifer; the sampling provides quantifiable chemistry of a select time but it is not necessarily representative of bulk aquifer water quality; induction logging provides a conductivity image of the entire thickness of the aquifer but is best used sequentially to assess qualitative changes. It is recommended that these three approaches be integrated into the water quality data collection and allow the data to be complimentary.

Constituents for Lab Analysis

During the MPWSP slant test slant well monitoring, an extensive suite of chemical constituents was analyzed (Geoscience, 2013)[8], including some organic compounds. Moving forward, the number of constituents for lab analysis can be reduced to focus on constituents that will capture water quality changes due to possible SWI. A panel of constituents for monitoring SWI was developed by the Monterey Peninsula Water Management District for monitoring the Seaside Basin Watermaster's Sentinel Wells. It includes major cations and anions, total dissolved solids, along with iodide and bromide. It is recommended that this panel be adopted for this network. The list of constituents in the Sentinel Well Panel is included in **Table 7**. This allows for analysis of SWI from laboratory results using geochemical analysis tools, including Piper diagrams, Stiff diagrams, chloride versus sodium/chloride molar ratios, and evaluation of halogen ratios. These allow detection of the chemical changes that occur in the initial stages of SWI. These analyses also allow for distinguishing whether the source of chloride concentrations in a well is from SWI or from other sources such as deep percolation of irrigation applied water or from septic or wastewater sources.

Table 7- Sentinel Well Panel

Constituent	Constituent
Alkalinity, Total (as CaCO3)	Manganese, Total
Boron	Manganese, Dissolved
Barium, Total	Sodium
Bromide	Nitrite as N
Calcium	Nitrate as N
Chloride	pH (Laboratory)
Fluoride	Orthophosphate as P
Iron, Total	Specific Conductance (EC)
Iron, Dissolved	Sulfate
Potassium	Total Dissolved Solids
Magnesium	QC Ratio TDS/SEC
	Iodide

Adaptive Management and Data Collection Frequency

Adaptive management is a structured, iterative process of decision making when there is uncertainty. The aim is to reducing uncertainty over time via system monitoring and potentially changing monitoring protocols. Adaptive management is a tool which should be used not only to learn about the system but to prioritize action. It supports iterative decision-making by evaluating results and adjusting actions based on what has been learned. There is feedback between monitoring and decisions. The MPWSP decisions are related to determining if there are impacts or harm to current overlying water users and whether the CPUC must require subsequent actions to mitigate any impacts should they be observed. For the MPWSP Monitoring Plan, adaptive management implies that the frequency of collection, locations for collection, and methods of collection, may be altered over time based on the incoming data.

[8] See Appendix A, Sampling and Analysis Plan for Monterey Peninsula Water Supply Project Hydrogeologic Investigation Work Plan, Table 1-1, Water Quality Analyses.

Under an adaptive management approach, there are three stages where the monitoring program may be amended in terms of the number of locations, frequency and type of data collected, consisting of:

- **Baseline Stage** - Prior to MPWSP becoming operational.
- **Preliminary Operations Stage** - After MPWSP operations begin and continuing for at least two years. During this period, stresses to the aquifer system will result in relatively rapid changes in water level and water quality in the area proximate to the slant wellfield.
- **Ongoing Operations Stage** - After the two years or once the observed data indicate that the groundwater system has stabilized under the full MPWSP operations. Two conditions may be observed: 1) the data indicate there is no impact or harm, or 2) data indicate that there is harm and further mitigation may be required by the CPUC. The Monitoring Plan would be modified to meet its objectives under either condition.

Once groundwater levels and quality stabilize and it is determined that there is no harm (after the Preliminary Operations Stage), the number of well monitoring sites should be further reviewed to identify if there is redundancy and whether some of the wells could be decommissioned and/or removed from the program.

The frequency of collection may later be changed as part of adaptive management and upon review of the data collected during the Baseline and Preliminary Operations Stages. For the Ongoing Operations Stage, measurement frequency could be reduced, and the data could be downloaded quarterly. The suggested frequency of data collection is presented in **Table 8**.

Table 8 - Data Collection Schedule

Program	Baseline Stage	Preliminary Operations Stage	Ongoing Operations Stage*
Water Level	Continuous – Monthly Download	Continuous – Monthly Download	Continuous – Quarterly Download
Water Quality			
Conductivity Logging	Continuous – Monthly Download	Continuous – Monthly Download	Continuous – Quarterly Download
Well Sampling	Quarterly	Quarterly	Annually
Induction Logging	Quarterly	Quarterly	Bi-annually

*Subject to modification in response to collected data.

Table 8 is relatively self-explanatory. It should be noted that induction logging would only be performed on the deepest well at any location as it will capture data throughout the entire aquifer thickness regardless of the location of perforations. Conductivity logging and well sampling would be performed at all wells.

IMPLEMENTATION

Implementation - Well Construction and Equipment Installation

The program will include:

- Construction of five well clusters consisting of 3 wells each
- Construction of one replacement well
- The instrumentation of an additional 33 wells with water level/conductivity dataloggers
- Sampling Equipment for Monitoring Wells[9]

[9] Sampling Equipment would not be required if sampling performed by specialty vendor.

The implementation of the new well construction and purchase of monitoring equipment are up-front capital expenses. The elements to **implement** the monitoring well network include overall program/project management and coordination, siting wells, obtaining site access, permitting, contracting and supervising drilling (e.g., borehole and geophysical logging, initial water quality sampling, well development, etc.), filing of drillers reports, and purchase and installation of monitoring equipment. The well drilling and construction tasks are most suited for contracting. It needs to be determined who would serve as overall project manager to implement the planned facilities and coordinate between CalAm, contractors and other stakeholders, contract and manage the implementation of the well development and appurtenances. This would also include developing agreements for access to any existing wells included in the Monitoring Plan (e.g., MCWD). CalAm could continue to coordinate through its current contractor with oversight provided by the MCWRA, which would avoid the complications related to bidding through the Agency's process. It is believed that this is the most expeditious approach. The Agency would then provide overall coordination between the CPUC, CalAm, and Contractors to ensure delivery of the wells.

MMRP Requirements, Roles, Management Elements

The MMRP identifies the requirements, roles, and responsibilities for developing and implementing the Monitoring Plan. Where not specifically identified, there could be alternative management approaches to Monitoring Plan implementation and operation beyond that discussed herein.

The MMRP:

- Assigns the cost for development, implementation and ongoing operation of the monitoring network, and is to be borne by CalAm, either directly or through funding of MCWRA's staff, consultants and program activities
- Charges MCWRA with network development, including the number of new monitoring well sites and the specific well locations
- Defers subsequent decisions regarding implementation and management of the network to MCWRA
- Places ultimate responsibility on the CPUC to accept the Monitoring Plan, implement the MMRP requirements, and decide any future actions based on analysis of the monitoring results
- Assigns MCWRA with the responsibility "*to evaluate whether MPWSP slant well pumping is causing consistent and measurable drawdown of local groundwater levels that is distinguishable from seasonal or multi-year groundwater level fluctuations"*
- Requires an Independent Hydrogeologist with responsibility to "*determine if the observed degree of drawdown would damage or otherwise adversely affect any existing Participating Active Supply Wells"*.

Operations and Management

The elements to **operate** the monitoring network are discussed below along with alternative approaches and where the MMRP is prescriptive. The MMRP leaves decisions on how the program will operate to the Agency. **Table 9** reviews the MMRP requirements, the current programs, and potential alternatives.

The MMRP identifies the general roles and responsibilities for monitoring and the intent to have the program augment the MCWRA's existing regional groundwater monitoring network with focus on the area that could be affected by the proposed slant wells. As previously discussed, the level of MCWRA responsibility to implement the monitoring program is subject to interpretation and can be bracketed by the least level of involvement and the greatest level of involvement.

The **least** level of involvement would consist of a minimal amount of Agency engagement in the program implementation. The MMRP states that the data developed by the program be *collected or provided* to the MCWRA and preliminary evaluation of the MPWSP effects. The Agency's role would be analysis and evaluation to trigger the review by the Independent Hydrogeologist. The other functions would involve use of contractors and consultants.

The **greatest** level of Agency involvement would imply the Agency would coordinate the full Monitoring Plan implementation, including siting new wells, coordinating/contracting the drilling and procuring and installing of monitoring equipment. The Agency would conduct the ongoing maintenance and operation of the network, including conducting field work and data collection, coordinating lab analysis, quality control, data management, reporting and providing for data access.

The Agency's capabilities, expertise, job classifications and staff qualifications are suitable to implement and operate the Monitoring Plan. The actual level of participation may ultimately be based more on other constraints such as staff and resources availability, Agency roles and strategic considerations. Current levels of MCWRA staffing would constrain the level of Agency involvement and additional staff would need to be retained to implement and operate the program.

Table 9 - Operations: MMRP Requirements, Current Programs, Alternatives

	MMRP Requirement	Current Programs		Alternatives and Other Considerations
		MCWRA	MPWSP	
Field Data Collection	Not prescriptive	Agency staff. Existing program is mature and well developed	Cal Am contractor is GeoScience who developed the MPWSP test slant well network	Could be: 1) existing CalAm, 2) MCWRA, or 3) new contract managed by MCWRA
Lab Analysis	Not prescriptive	CCL	Commercial	
QA/QC	Not prescriptive	Well defined and documented	Well defined and documented	
Equipment	Not prescriptive	Level TROLL 500; hung from surface.	In Situ Aqua Troll 200, non-vented, cable to surface for downloading	Deep well specification in County Ordinance; In-Situ Aqua TROLL 200 with In-Situ Rugged Twist-Lock Cable (vented).
Data Analysis and Interpretation	MCWRA makes preliminary interpretation related to MPWSP specific effects	Mature program and capability	Mature program and capability	Contracted by: 1) CalAm 2) MCWRA 3) CPUC
	Independent Hydrogeologist reviews MCWRA analysis, independent analysis of "harm"			Alternative: Form a TAC similar to the HWG
Reporting	45 days to report collected data to MCWRA if they are not in the lead	Existing reporting would incorporate new data	Current weekly and monthly report formats and reporting to CPUC	MCWRA conducts preliminary analysis and produces a new Agency report
	CalAm is to report monitoring and analysis results to the CPUC			
Data Access	Not prescriptive	MCWRA Web Page has a map-based interface (dash board) that allows selection of the well and viewing of the hydrographs.	MPWSP Web page, PDF of collected data in weekly and monthly reports.	

Approaches

There are several approaches to performing the work associated with implementing the Monitoring Plan. These include performance of the work entirely by the MCWRA, MCWRA contracting for some or all of the work, or some combination of these two. Regardless of how the work is performed, the final interpretation of the collected data will be by the designated Hydrogeologist. Each of these approaches is discussed in more detail below.

MCWRA Sole Source

The MCWRA would be in charge and conduct actual field operations. This would include downloading data loggers, taking water levels, performing water quality sampling, and coordinating and supervising induction logging. MCWRA would also be tasked with QA/QC, data entry and archival, data digestion and presentation. MCWRA would perform initial interpretation of the data and confer with designated Hydrogeologist as necessary.

MCWRA w/Technical Vendor Support

In this variant, MCWRA would be in charge but would contract out for field operations with a specialty vendor. This would include data logger downloads, collection of water level data, and well sampling. MCWRA would still contract and supervise induction logging. The rest of the effort, as described above, would be MCWRA responsibility.

MCWRA w/Consultant Oversight & Interpretation

Alternatively, MCWRA could take on solely the field operations, under the supervision and management of a qualified consultant. Consultant would be responsible for data digestion, presentation and interpretation. Consultant would coordinate with both the MCWRA and the designated Hydrogeologist.

Consultant

MCWRA could contract out the entire program, data collection and interpretation, to a Consultant. Consultant would coordinate with both the MCWRA and the designated Hydrogeologist.

There are obviously other combinations of MCWRA, technical vendor, and Consultant that would also work.

Data Management

The establishment of a monitoring network will, by design, result in the acquisition of a significant amount of data. This will include continuous water level and conductivity data from 57 wells, water quality data from these same wells and induction log data from 15 wells. These data need to be archived in a secure manner that allows easy access for interested parties. The networks of MCWRA and MPWSP have established protocols and platforms that can be built upon. As MCWRA has primary responsibility as assigned by the MMRP, it may be most efficient to transfer data archive responsibilities, including data accumulated to date, to MCWRA. The management of the data collected from the project network will likely require some changes to the MCWRA database and will require some effort from IT support.

Additionally, the MCWRA will need to provide on-line access to either the data or data summaries. This could possibly be added to the MCWRA webpage. Again, this will require IT support.

Program Costs

Estimated cost of the program was developed from MCWRA fully loaded hourly rates and generalized hourly rates for consultant services. Estimates of time to conduct various field activities as well as data entry and QA/QC obligations were developed from review of MCWRA costs for their on-going programs. This information was supplemented with costs provided from CalAm's consultant and their technical services contractor (Blaine Technical Services). Construction costs were provided by Cascade Drilling and data logger costs were provided by In-Situ, Inc.

Capital Cost

The up-front capital costs for the Monitoring Plan derive from the need to install the five proposed well clusters and the instrumentation of these new wells and other existing wells that have been included in the Monitoring Plan. The total capital costs are estimated at between $1.77 and 1.86M. This includes well construction costs, permitting costs, consulting costs, equipment purchase and installation. No costs are assumed for land acquisition for well sites. These costs, if required, would be supplemental.

Ongoing Costs

Ongoing costs for the Monitoring Plan were estimated for the three operational stages defined above. During the Baseline Stage, which focused on collection of sufficient data to establish a baseline against which changes could be detected, the estimated annual cost is between approximately $658 and 824K, depending on how the work is staffed and implemented. During the Preliminary Operation Stage, the level of effort is estimated to be approximately equal with the annual cost estimated at between approximately $654 and 820K. After groundwater conditions stabilize, during the Ongoing Operations Stage, the data collection effort will be reduced and annual cost for the program is estimated to range between $360 and 459K, again depending on selected approach to implementation. The costs for each of the stages (including the capital improvements) are presented in **Table 10** below. The detailed breakdown of estimated costs and personnel hours is included in **Appendix F**.

Table 10 - Estimated Program Costs

Project Stage	Median Estimated Cost
Capital/Start-up	$1.82M
Baseline	$740K
Preliminary Operations	$737K
Ongoing Operations Stage	$410K

CONCLUSIONS AND RECOMMENDATIONS

Current monitoring (MPWSP)

Water Level: Currently, water level and conductivity data are downloaded from monitoring wells on a weekly basis. Hand-measured groundwater levels are also recorded every time a well is accessed.

Water quality: Water quality samples are collected on a periodic basis and delivered to the Monterey Bay Analytical Services (MBAS) laboratory for analysis.

Proposed Monitoring

1. The existing modeled area of influence using the -1 foot contour plus a buffer zone should be the Monitoring Plan area (**Plates 2 and 3**).
2. We concur with the HWG findings that additional monitoring wells should also be sited to fill in data gaps and collect additional baseline data and variations, and in anticipation of the full-scale system being operational. This will enable the extent of the actual capture zone to be identified and monitored. As such, five new well clusters of three wells each are recommended. These wells will allow for: (1) the assessment of baseline conditions and variations not related to the project, (2) identification of drawdown due to full-scale project pumping should the area of influence expand more than anticipated based on the modeling, (3) refinement of the model, and (4) identification of harm and need for further mitigation.
3. Groundwater level data can be measured hourly using transducers and data pods, with monthly download and processing, and quarterly reporting. Manual measurements should be made when the digital data are collected/downloaded.
4. Current water quality collection methods include downhole conductivity data loggers and periodic water sample collection and analysis. These approaches provide valid data but can result in data that are not representative of the aquifer system as a whole. The limitations of these methods should be understood and incorporated into subsequent interpretations of the data. These methods should be supplemented with periodic induction logging.
5. Potential data gaps exist in the area north, east and south of the MPWSP. Using an adaptive management approach, these can be further evaluated based on the data collected after the MPWSP begins operation using the existing test slant well monitoring network. Observations will be used to establish criteria that would trigger the construction of additional monitoring wells.
6. Inclusion of existing MCWD monitoring wells and idle production wells are essential for the success of the Monitoring Plan implementation. If these wells are unavailable, the Monitoring Plan will need to be supplemented with additional new wells.
7. Given the potential for the variability in data results from the different data collection methods to be employed under the Monitoring Plan, the importance of consistency in data collection methods going forward must be strongly emphasized. For example, monitor well WQ sample depths, purge rates and volumes should be repeatable for all sampling events in order to reduce the uncertainties that might be associated with data collection inconsistencies.

Implementation and Management

1. The process to identify Participating Active Supply Wells should be initiated as soon as possible so baseline data may be collected.

2. The MCWRA has the ability to cost-effectively conduct field data collection, laboratory testing through CCL, QA/QC, data management and for initial analysis and interpretation of monitoring results. Ongoing operations of the data collection program, including field operations and data storage, and interpretation is estimated to require 1,200 hours of field technician time and 150 hours of Hydrologist time, annually.
3. Some reduction in overall costs (~$30K) is available by using a technical vendor for the bulk of the field operations. This would also reduce the required technician commitment for the MCWRA. It would also remove the need for the MCWRA to purchase specialized well sampling equipment; equipment that is integral to the vendor's operations.
4. The Hydrogeologist is needed to review the well characteristics of these wells and to interpret the data collected to determine harm, and should be retained as soon as possible. This role could be met by a consulting hydrogeologist or an advisory committee.
5. Adaptive management is recommended to identify the criterion and "triggers" that would indicate if the MPWSP area of influence becomes greater than the area identified by the modeling and memorialized in the EIR/EIS and MMRP. The recommended new monitoring wells would be installed when the existing test slant well monitoring network indicates that the MPWSP area of influence has expanded beyond the area identified by the -1 foot contour line.
6. An Integrated Coastal Monitoring Agreement between CalAm and MCWRA is needed to provide for the implementation of the final Monitoring Plan and should define responsibilities, roles, costs, liabilities, metrics and process for decisions and subsequent action (adaptive management approach), and the process to evaluate data and document if there is actual harm and impacts that need to be mitigated.
7. The MMRP calls for a Hydrogeologist to analyze and interpret the data from the Monitoring Plan network. The Hydrogeologist needs to be independent. This could be an individual retained under the Integrated Coastal Monitoring Network Agreement or a Technical Advisory Group like the HWG that is responsible for interpreting the collected data and making the findings per the MMRP.

Recommendations

1. Develop an agreement between MCWRA and CalAm to provide for the continued financial support for data collection. This should include the mechanism to support continued ownership of the wells and for retaining responsibility for destruction/closure.
2. The process for identifying "Participating Active Supply Wells" should be initiated as soon as possible to obtain data from these wells, and an independent "Hydrogeologist" should be retained for the purpose of carrying out this task.
3. The annual reports for cleanup operations on the former Fort Ord in the study area should be reviewed annually by the Agency and Hydrogeologist to monitor remediation activities as related to MPWSP operations.
4. Until such time as the MCWRA can take responsibility for data collection, ensure there is continued data collection by CalAm using a contractor to support and verify the pre-project construction baseline with minor modifications to the frequency of groundwater level and quality data as identified above.
5. The MMRP requires a Hydrogeologist to evaluate and analyze the collected data to determine whether harm is occurring, and further mitigation is required. This process needs to be finalized and included in the MCWRA/CalAm Agreement.

Next Steps

CalAm is funding the Monitoring Plan development under direction from MCWRA. The MCWRA-approved Monitoring Plan is to be sent to the CPUC for confirmation prior to project operation of the slant wells.

An independent California-certified hydrogeologist (the "Hydrogeologist") is to be retained prior to initiation of MPWSP slant well pumping, and is to be directed by MCWRA to evaluate the conditions and characteristics (e.g., well depth, well screen interval, pump depth and condition, flow rates, and drawdown) of each Participating Active Supply Well and develop pre-pumping data for each well (Mitigation 4.4-3(2)).

The groundwater section of the EIR/EIS listed the known production wells [10] but these may not meet the requirements for identifying the Participating Active Supply Wells and additional work by CalAm is required.

[10] FEIR/FEIS Table 4.4-10 Known Active Supply Wells Within Vicinity of The Proposed MPWSP Slant Wells

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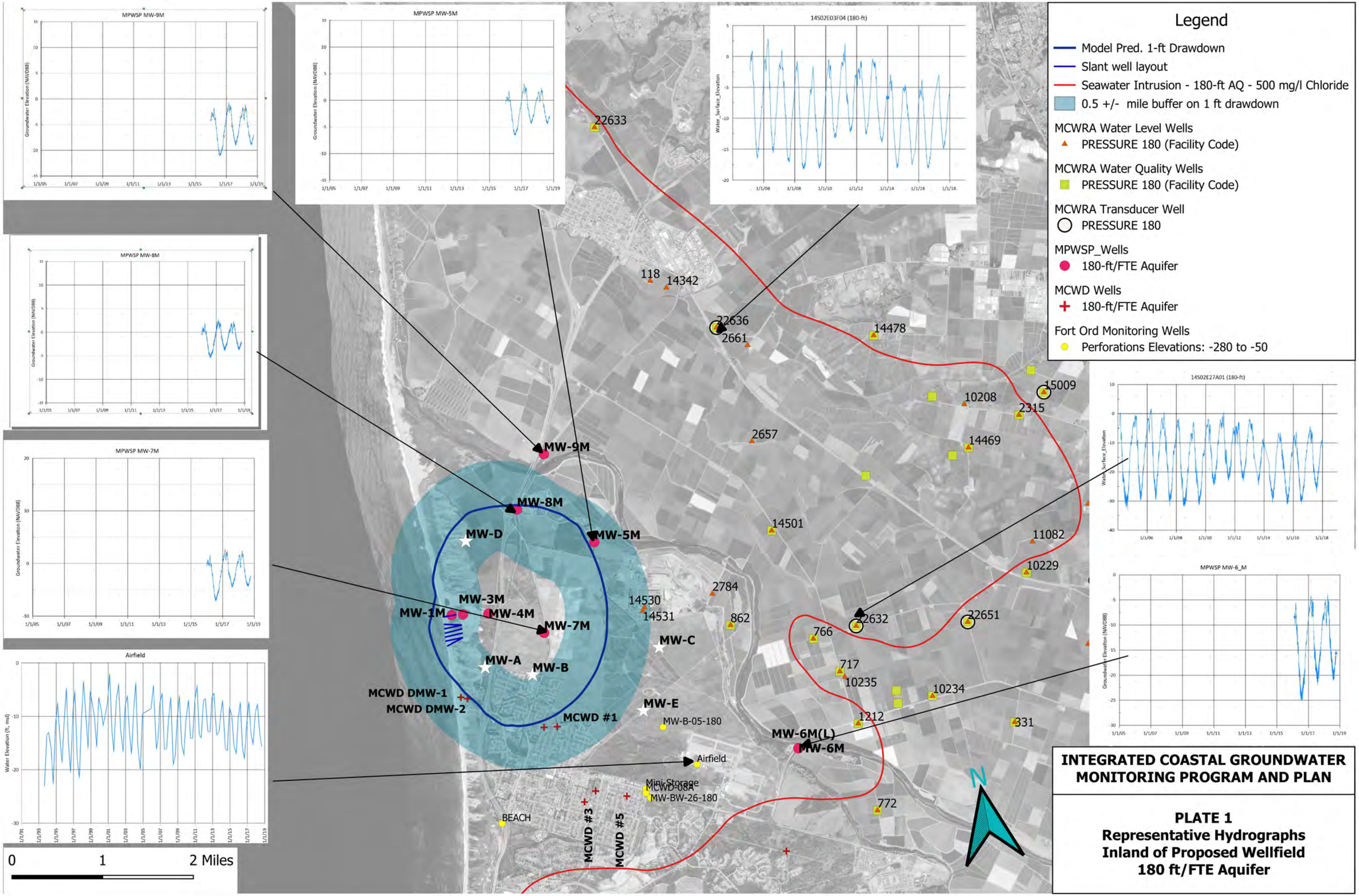
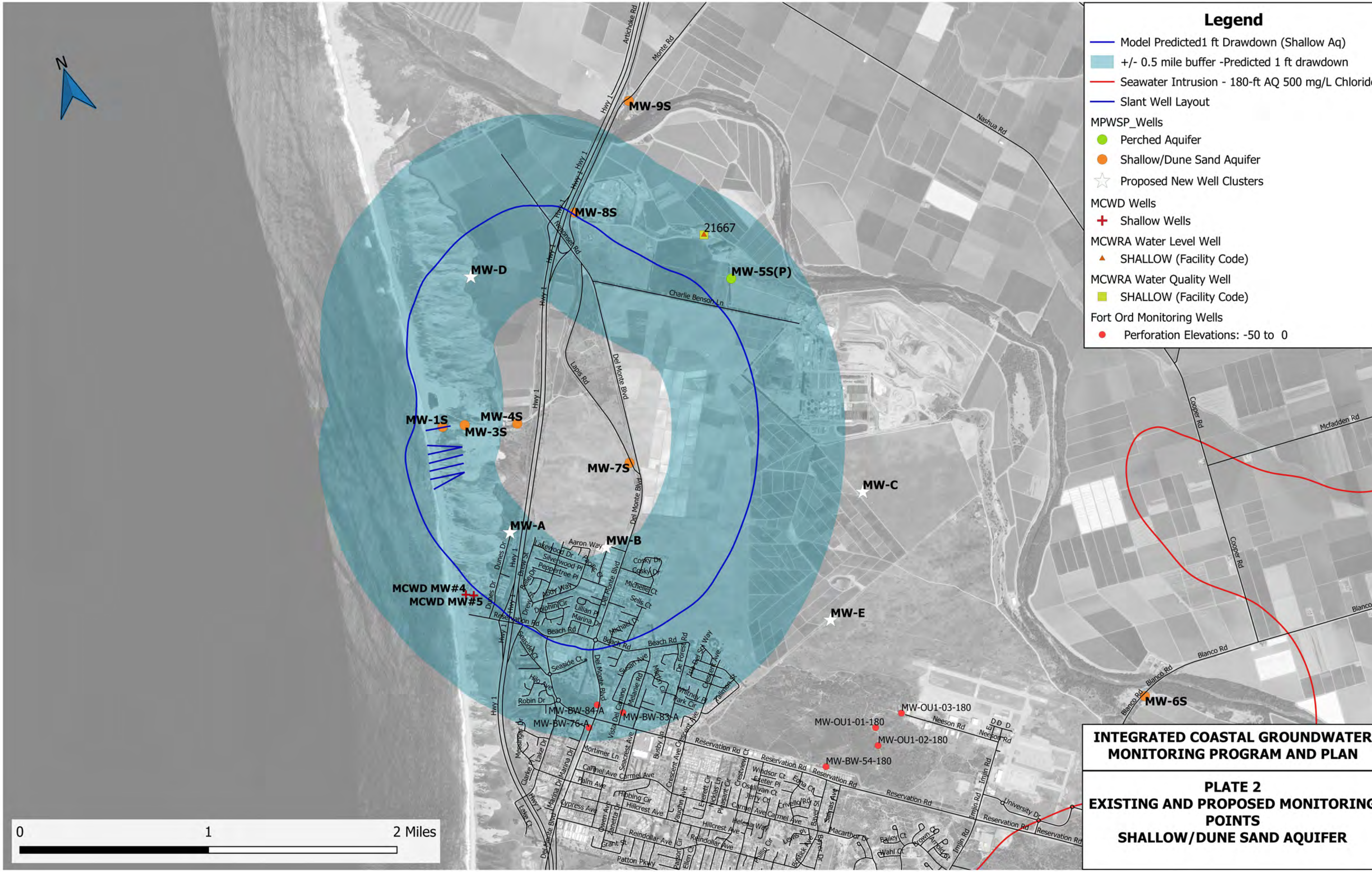
PLATES



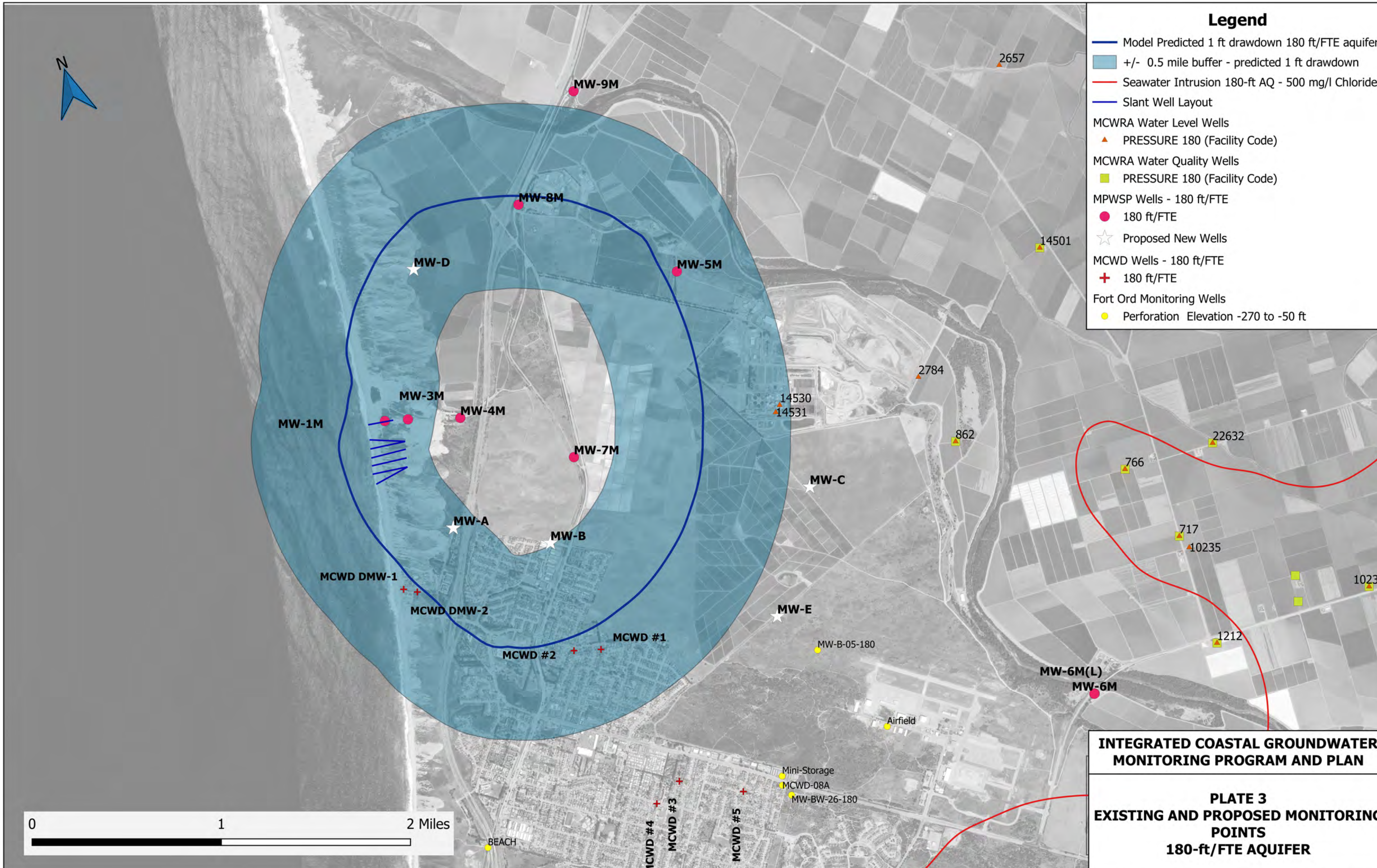
INTEGRATED COASTAL GROUNDWATER MONITORING PROGRAM AND PLAN

PLATE 1
Representative Hydrographs
Inland of Proposed Wellfield
180 ft/FTE Aquifer



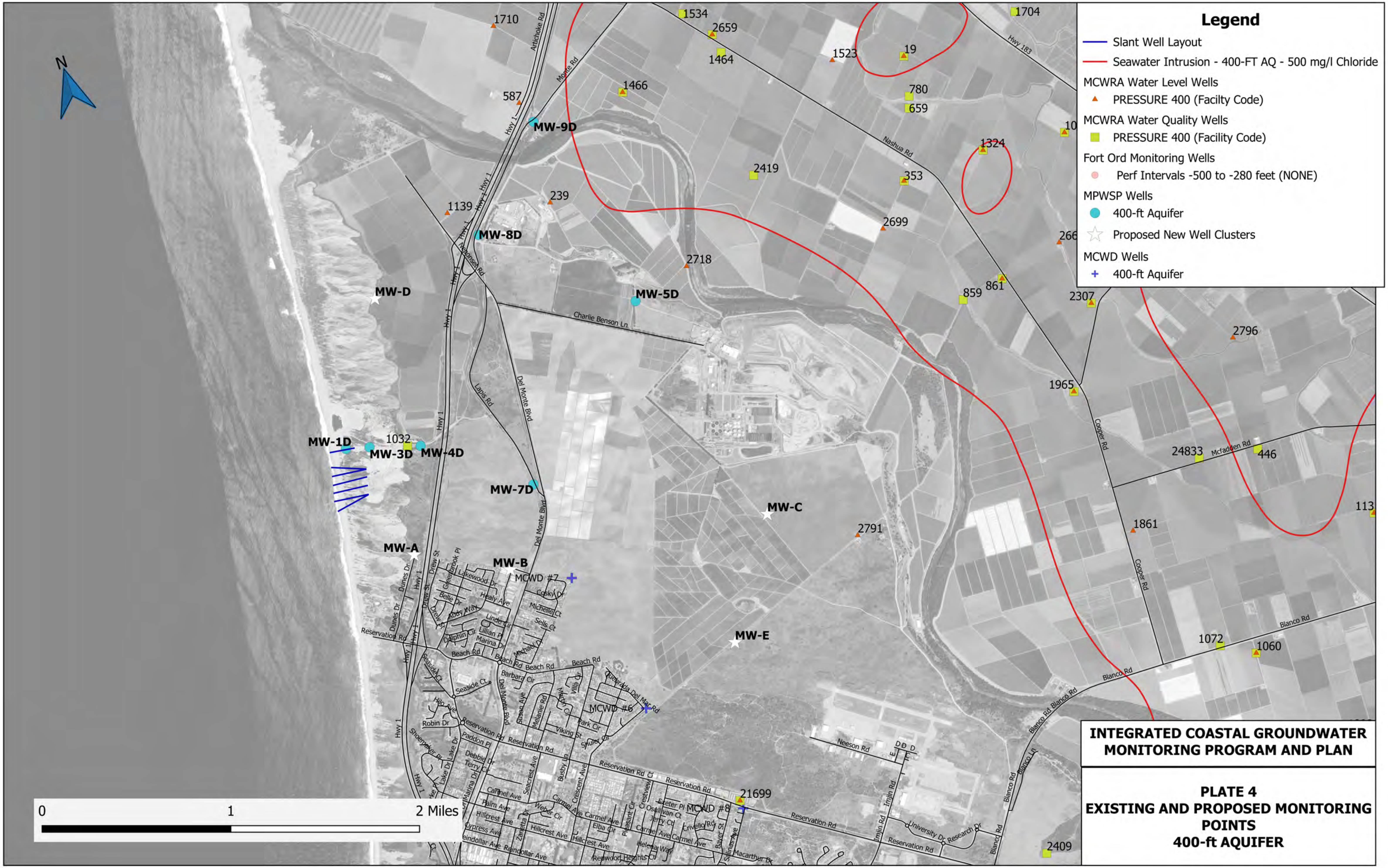
INTEGRATED COASTAL GROUNDWATER MONITORING PROGRAM AND PLAN

PLATE 2
EXISTING AND PROPOSED MONITORING POINTS
SHALLOW/DUNE SAND AQUIFER



INTEGRATED COASTAL GROUNDWATER MONITORING PROGRAM AND PLAN

PLATE 3
EXISTING AND PROPOSED MONITORING POINTS
180-ft/FTE AQUIFER



INTEGRATED COASTAL GROUNDWATER MONITORING PROGRAM AND PLAN

PLATE 4
EXISTING AND PROPOSED MONITORING POINTS
400-ft AQUIFER


Legend
Slant well layout
MCWRA Water Level Well
PRESSURE DEEP ZONE (Facility Code)
MCWRA Water Quality Well
PRESSURE DEEP ZONE (Facility Code)
MCWD Wells
Deep Aquifers Well
Other Deep Aquifers Wells (Facity Code, if assigned)
N
0
1
2 Miles
MCWD #7
MCWD #6
MCWD #8
Airfield
INTEGRATED COASTAL GROUNDWATER MONITORING PROGRAM AND PLAN
PLATE 5
MONITORING POINTS
DEEP AQUIFERS

APPENDIX A
REGULATORY AND POLICY DRIVERS MEMO

Memo

To: Martin Feeney, Tamara Voss (MCWRA)

From: Matt Zidar

CC:

Date: July 2, 2018

Re: Background and Policy Basis for Network Design

In 2004, CalAm filed Application A.04-09-019 seeking a Certificate of Public Convenience and Necessity from the CPUC for the Coastal Water Project. The Coastal Water Project (CWP) was the precursor to the Monterey Peninsula Water Supply Project (MPWSP). Both were intended to replace existing Carmel River water supplies for the CalAm Monterey District service area that are constrained by legal decisions of SWRCB. In January 2009, the CPUC published a Draft EIR analyzing the environmental impacts of the CWP and two project alternatives—the North Marina Project and the Regional Project. The CPUC published the Coastal Water Project Final EIR (SCH No. 2006101004) in October 2009 and certified the Final EIR in December 2009 (Decision D.09-12-017). A year later, in Decision D.10-12-016, the CPUC approved implementation of the Regional Project alternative. Litigation ensued resulting in the Settlement Agreement. Subsequently, input on the necessary data collection and technical analysis was obtained from the SWRCB, and further environmental review was conducted.

SETTLEMENT AGREEMENT REQUIREMENTS

A Settlement Agreement[11] between CalAm, Monterey County Water Resources Agency (MCWRA) and others, was executed in 2012 to resolve outstanding litigation related to the previously proposed desalination project. The purpose of the Settlement Agreement was to promote the development, construction and operation of a successful water project to provide a long-term, stable source of potable water for Monterey Peninsula and the County. Under the Settlement Agreement MCWRA is to develop a Groundwater Monitoring Plan to monitor the operations and any potential effects of the MPWSP on the Salinas Valley Groundwater Basin. The Settlement Agreement called for development of a groundwater monitoring plan[12] which states:

"The Plan will be developed with appropriate public input and is expected to address various matters related to those responsibilities, including but not limited to the need for monitoring wells, the design and construction of any such wells, and a procedure for the testing and analysis of water from any such wells. CAW will promptly pay the costs of developing and implementing the Plan throughout the life of the MPWSP upon submission of invoices from the Agency or its successor. Should the Agency determine a monitoring well agreement is appropriate, the Parties shall negotiate in good faith to develop and sign such an agreement".

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[11] Settlement Agreement and Mutual Release. December 4, 2012 ("Execution Date") between the California-American Water Company, County of Monterey, and the Monterey County Water Resources Agency ("Agency"), Item 9, Groundwater Monitoring.

[12] Settlement Agreement, No. 9 Groundwater Monitoring

CalAm and the MCWRA have approved the agreement to support this network design study.

SWRCB INFORMATION REQUIREMENTS

The SWRCB is responsible for management of water rights and quality under the California Water Code. The SWRCB identified potential impacts to existing overlying users of Salinas Valley Basin groundwater users and this provided the basis for the MPWSP special studies monitoring program (SWRCB, 2013). The SWRCB objectives in providing input was to ensure that data and analysis would be generated and used to evaluate the potential for harm to existing overlying users or beneficial uses from the test well program or from the long-term operation of the proposed MPWSP.

SWRCB identified three possible categories of injury that could occur from the MPWSP including: 1) a reduction in the overall availability of fresh water due to possible incidental extraction by the MPWSP; 2) a reduction in water quality in those wells in a localized area within the capture zone (area of influence); and, 3) a reduction in groundwater elevations requiring users to expend additional pumping energy to extract water from the Basin. From its review of the project, SWRCB stated that:

"Key factors will be 1) how much fresh water Cal-Am extracts as a proportion of the total pumped amount, (to determine the amount of water, that after treatment, would be considered desalinated seawater available for export as developed water); 2) whether pumping affects the water table level in existing users' wells, 3); whether pumping affects seawater intrusion within the Basin 4) how Cal-Am returns any fresh water it extracts to the Basin to prevent injury to others; and (5) how groundwater rights might be affected in the future if the proportion of fresh and seawater changes in the larger Basin area or the immediate area around CalAm's wells."

The SWRCB provided recommendations for additional studies to clarify the hydrogeologic conditions that would allow for a more complete review of potential harm. A Hydrogeologic Work Group (HWG) was formed to coordinate the Hydrogeologic Investigation Work Plan (HWP) (Geoscience, 2013) which identified a test slant well special study to provide data for both the EIR/EIS impact evaluation pursuant CEQA/NEPA, and to evaluate potential harm to current groundwater users pursuant to the California Water Code and SWRCB concerns.

MPWSP Hydrogeologic Investigation Workplan (HWP): Outlines the HWG agreed upon process and procedures for obtaining information on the MPWSP's impact on the Salinas River Groundwater Basin (SRGB) and its users.
MPWSP Hydrogeologic Investigation Technical Memorandum No. 1 (TM-1) Summary of Results – Exploratory Boreholes: Summary of data collected during the initial investigation conducted at Moss Landing, the State Park Potrero Road parking lot, and at the CEMEX site.
MPWSP Hydrogeologic Investigation Technical Memorandum No. 2 (TM-2) Monitoring Well Completion Report and CEMEX Model Update: Summary of data collected because of the constructed monitoring well network, including subsurface geologic conditions, hydrogeologic conditions, groundwater levels, and groundwater quality data.
Monthly Monitoring Reports: As required by the California Coastal Commission (CCC) presenting a review of weekly monitoring data documenting the regional/background groundwater elevation trends and Total Dissolved Solids (TDS) level trends.

The interim results and final report (HWG, 2017) provided the basis for the environmental review of the proposed project. The conceptual hydrogeologic model and the numerical model used for the FEIR reflects what the scientific community currently accepts as the most reasonable description of the subsurface geologic units and the depth and extent of aquifers and the aquitards and of the potential environmental impacts.

MPWSP ENVIRONMENTAL REVIEW REQUIREMENTS

CalAm withdrew its support for the Regional Project in January 2012 and submitted Application A.12-04-019 to the CPUC for the MPWSP. The MPWSP includes many of the same elements previously analyzed but proposed the use of slant wells to provide source water intake system to the desalination plant. The CPUC issued a Notice of Preparation (NOP) for an EIR for the revised proposal for the CalAm Coastal Water Project and a Draft EIR was released in April 2013.

As discussed above. CalAm also designed the special study monitoring program to obtain data to design the project, evaluate environmental impacts and seek to demonstrate there would be no harm to existing overlying groundwater users. The development of the test slant well and other monitoring required a coastal development permit. The California Coastal Commission(CCC) issued Coastal Development Permit #A-3-MRA-14-0050 dated 8-Dec-14 (CDP) granted CalAm permission for development consisting of: Construction, operation and decommissioning of a test slant well at the CEMEX sand mining facility in the City of Marina and beneath Monterey Bay in the County of Monterey. Special condition 11 “Protection of Nearby Wells” requires groundwater monitoring of a minimum of four wells on the CEMEX site within 2,000 ft. of the test well and one or more offsite wells to record water and salinity levels. As per the CDP reports are prepared monthly summarizing water level and water quality data from the Test Slant Well and monitoring well network. The purpose of these monthly reports is to identify any potential impacts from slant well pumping to inland aquifers.

In September 2015 and based on public comment, the CPUC decided to recirculate the document and prepare a joint EIR/EIS with the National Oceanic Atmospheric Administration’s Office of National Marin Sanctuaries serving as lead federal agency. The Draft MPWSP EIR/EIS (ESA, 2017) that was published on January 2017 and the Final EIR/EIS (ESA, 2017) was produced in March 2018. The MPWSP EIR/EIS analyzed the full range of environmental effects and sought to analyze whether there would be harm to overlying groundwater users in the Salinas Valley Groundwater Basin (SVGB). A Mitigation Monitoring and Reporting Program (MMRP) has not been prepared as of this writing. The analysis concludes that the proposed project would not conflict with any applicable plan, policy, or regulation, as noted in the MMRP.

Through use of the substantial evidence generated through the monitoring and modeling, the FEIR/FEIS found that the were less than significant impacts to groundwater resources from construction or operation of the proposed project. The analysis evaluated the extraction and return water components of the proposed project to determine their physical effects on the SVGB and determines whether the changes, if any, constitute a significant impact. The significance criterion used in the environmental review states that an impact would occur if extraction from the subsurface slant wells substantially depleted groundwater in the SVGB such that there would be a net deficit in aquifer volume. As described in FEIR/FEIS, a substantial net deficit in aquifer volume, for the purposes of this analysis, refers to the removal of groundwater from the aquifer at a rate that exceeds natural recharge such that: 1) groundwater levels are permanently lowered and could not recover to pre-project conditions; 2)production well yields in neighboring active wells decline to such a degree that other groundwater users in the basin experience an intolerable decrease in available groundwater supply, or; 3) the lowering of groundwater results in subsidence and compaction that reduces the available volume of groundwater storage. The FEIR/FEIS found no significant impacts.

Despite the finding of no impact, CalAm recognizes the long-term nature of the proposed project and the need to provide continued verification that the project would not contribute to lower groundwater levels in nearby wells within the SVGB. So, as part of the project, CalAm proposes to fund the expansion of the existing regional groundwater monitoring program. This is to be coordinated with the requirements of the Settlement Agreement for increased regional monitoring. The FEIR/FEIS includes the applicant proposes Mitigation Measure 4.3-4 to ensure there are no significant hydrology and water quality impacts or harm to SVGWB groundwater users. Specifically, Applicant Proposed Measure 4.4-3, Groundwater Monitoring and Avoidance of Well Damage", states that:

Prior to the start of MPWSP slant well construction, CalAm, working with MCWRA, shall develop a groundwater monitoring and reporting program (the "Program") to the satisfaction of MCWRA. All costs of Program development and implementation shall be borne by CalAm either directly or through funding of MCWRA's staff, consultants and Program activities. The Program shall augment the MCWRA's existing regional groundwater monitoring network to focus on the area that could be affected by the proposed slant wells. The geographic area of the Program shall be within the model domain of the North Marina Groundwater Model, also referred to as NMGWM2016 and include the Dune Sand Aquifer, the 180-Foot Aquifer, the 400-Foot Aquifer and the Deeper Aquifer (i.e., the 900-Foot Aquifer) of the Salinas Valley Groundwater Basin (the "Monitoring Area"). The purpose of the Program is to identify owners of existing public or private groundwater supply wells within the Monitoring Area on the date the MPWSP commences slant well pumping suffers no harm as a result of MPWSP slant well pumping. The elements of the Program proposed under this measure are described below.

A network of monitoring wells has been completed on and near the CEMEX property as part of the CalAm test slant well project. These well clusters monitor water elevation and quality at various depth intervals within the Dune Sand Aquifer, the 180-Foot Aquifer, and the 400-Foot Aquifer and shall be included in the Program's monitoring network. These existing monitoring wells are subject to relocation, replacement, or substitution by new or other monitoring wells developed as part of the Program as determined by MCWRA.

In addition, using information from the Groundwater Extraction Management System (GEMS) maintained by MCWRA and from the State Water Resources Control Board's Division of Drinking Water, CalAm, in coordination with MCWRA, shall identify Active Supply Wells in the Monitoring Area and offer to owners of identified Active Supply Wells the opportunity to participate in the Program for groundwater elevation and water quality monitoring. The owners of Active Supply Wells in the Monitoring Area will receive at least 60 days' notice (via email, if available, and via certified mail) of the opportunity to participate in the Program and may elect in writing to participate in the Program as to their Active Supply Wells ("Participating Active Supply Wells"). This opt-in process must occur sufficiently in advance of MPWSP slant well pumping so that information on pre-MPWSP conditions can be obtained for each Participating Active Supply Well. Prior to the start of MPWSP slant well pumping, an independent California-certified hydrogeologist retained and directed by MCWRA (the "Hydrogeologist") shall evaluate the conditions and characteristics (e.g., well depth, well screen interval, pump depth and condition, flow rates, and drawdown) of each Participating Active Supply Well to develop pre-pumping data for each well. Water elevation and quality monitoring pursuant to the Program shall begin following initial groundwater well assessment and shall continue at intervals specified in the Program (e.g., more frequently at the beginning of MPWSP slant well pumping and less *often after stabilization of groundwater levels) until the well owner ceases pumping from the monitored well, or until the well owner agrees that monitoring is no longer required.*

Prior to the start of MPWSP slant well pumping, CalAm and MCWRA shall review the current (as updated if needed) inventory of monitoring wells within the Monitoring Area and identify locations within the Monitoring Area lacking monitoring coverage and that warrant monitoring in order to evaluate potential effects on Participating Active Supply Wells from MPWSP slant well pumping. Based upon that review, MCWRA may require that CalAm fund the installation of new monitoring wells in the Monitoring Area to be installed before MPWSP slant well pumping begins. The number of new monitoring well sites in the Monitoring Area and the location of those new monitoring well sites shall be determined by MCWRA. The area of groundwater monitoring under the Program may be extended outside of the Monitoring Area if warranted to evaluate potential MPWSP slant well pumping effects on Participating Active Supply Wells and recommended by the Hydrogeologist.

The groundwater data developed through the Program shall be collected by or provided to MCWRA at intervals identified in the Program, but in no event longer than 45 days from such data being obtained, to evaluate whether MPWSP slant well pumping is causing consistent and measurable drawdown of local groundwater levels that is

Mitigation Measure 4.4-4 requires monitoring of the OUCTP A-Aquifer plume as well as an additional plume in the Fort Ord area- the OUCTP Upper 180-Foot Aquifer Plume. Previous monitoring data for the plumes will be obtained from the U.S. Army, and CalAm will conduct quarterly monitoring of the plumes in conjunction with its expanded monitoring program under Applicant Proposed Measure 4.4-3.402 CalAm will continuously coordinate with the U.S. Army. Mitigation Measure 4.4-4 sets specific performance standards and requires further study to determine if and when action is required to mitigate for the potential impact, because specific data concerning any potential impacts is not known at this time.

APPENDIX B
MITIGATION MONITORING AND REPORTING PLAN, APPLICANT PROPOSED MEASURE 4.4-3, GROUNDWATER MONITORING AND AVOIDANCE OF WELL DAMAGE

TABLE 1 (Continued)
CALAM MONTEREY PENINSULA WATER SUPPLY PROJECT
MITIGATION MONITORING AND REPORTING PROGRAM

Impact **Mitigation Measure**	Applicable Site(s): Intake Site	Offshore Brine Discharge Site	Desalination Plant Site	ASR	Carmel Valley Pump Station	Conveyance Pipelines	Monitoring and Reporting Program: Monitoring and Reporting Actions: *CalAm Reports On, and the CPUC Monitors all Mitigation Measures*	Implementation Schedule	Effectiveness Criteria
Section 4.4: Groundwater Resources (cont.)									
4. The groundwater data developed through the Program shall be collected by or provided to MCWRA at intervals identified in the Program, but in no event longer than 45 days from such data being obtained, to evaluate whether MPWSP slant well pumping is causing consistent and measurable drawdown of local groundwater levels that is distinguishable from seasonal or multi-year groundwater level fluctuations. In the event that MCWRA identifies a consistent and measurable drawdown in groundwater levels and determines that such drawdown is potentially attributable to MPWSP slant well pumping and independent of seasonal or multi-year groundwater level fluctuations or any regional trends, the Hydrogeologist shall then determine if the observed degree of drawdown would damage or otherwise adversely affect any existing Participating Active Supply Wells. Adverse effects from lowered groundwater levels in Participating Active Supply Wells may include water elevation acute and long-term declines that draw water below pump intakes, causing cavitation due to exposure of the well screen, reduced well yields and pumping rates, increased energy costs to power the well, or changes in groundwater quality indicating that MPWSP slant well pumping is drawing lower quality water toward the well. Active Supply Wells that are not Participating Active Supply Wells will be considered for a determination by the Hydrogeologist of potential damage or adverse effects reasonably attributable to MPWSP slant well pumping (as described above) if substantial, credible evidence is submitted by the owners of such Active Supply Wells concerning damage or adverse effects at such wells, and such effects are verified by CalAm and the Hydrogeologist. If the Hydrogeologist determines that a Participating Active Supply Well or an Active Supply Well that CalAm and the Hydrogeologist have verified for damage or adverse effects pursuant to Section 4 above, has been damaged or otherwise negatively affected by MPWSP slant well pumping, CalAm and the Hydrogeologist shall coordinate with the well owner to develop and implement a mutually agreed upon course of action. Such course of action may include but not be limited to repairing or deepening the existing well, restoring groundwater yield by improving well efficiency, facilitating an interim or long-term replacement of water supply, constructing a new well, or compensating the owner for increased pumping costs. Any interim or long-term replacement water supply shall be of the same or better quality (i.e., potable or non-potable) and predicted quantity as the existing supply of the Active Supply Well and shall be suitable for the purposes served by the existing Active Supply Well. Before CalAm undertakes any course of action to remedy the MPWSP slant well pumping effects on an Active Supply Well, the Hydrogeologist shall authorize such action and provide notice of such action to MCWRA. **Applicant Proposed Measure 4.4-3** would monitor changes in the groundwater surface elevations caused by the proposed pumping at the slant wells through a voluntary program and use of new groundwater monitoring wells. If it is determined that the project is causing groundwater levels to damage local active wells within the Dune Sand, 180-Foot/FTE, 400-Foot Aquifer or Deeper Aquifer, this measure would ensure that active wells are repaired or replaced. Implementation of **Applicant Proposed Measure 4.4-3** is not necessary to address any significant project effect.									
Impact 4.4-4: Violate any groundwater quality standards or otherwise degrade groundwater quality during operations. **Mitigation Measure 4.4-4: Groundwater Monitoring and Avoidance of Impacts on Groundwater Remediation Plumes.** Prior to the start of MPWSP construction, CalAm shall incorporate the future quarterly groundwater elevation monitoring results for the OUCTP A-Aquifer and 180-Foot Aquifer (upper and lower) plumes into the well monitoring program described above in **Applicant Proposed Measure 4.4-3** until the two OUCTP plumes have been appropriately remediated and the RWQCB no longer requires remediation activities. Groundwater elevation data shall be obtained from the periodic monitoring reports developed by the U.S. Army and its contractors. The elements of the additions to the groundwater monitoring program proposed under this mitigation measure are described below. • CalAm shall incorporate into its well monitoring program (described above for **Applicant Proposed Measure 4.4-3**), the most recent monitoring reports available through the U.S. Army and its contractors for the monitoring wells that are necessary to characterize the flow direction and water quality of the three OUCTP plumes located in the A-Aquifer, the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer.	X						CalAm will conduct quarterly groundwater monitoring program to monitor the potential effect of drawdown on the OUCTP plumes prior to their remediation. Results of the monitoring program will be incorporated in the MCWRA-approved Program and sent to CPUC for review. CalAm will coordinate with the U.S. Army on the monitoring program results. CalAm will inform U.S. Army, RWQCB, DTSC, and U.S. EPA, and CPUC simultaneously if the monitoring program results show the 1-foot contour approaching the OUCTP plumes. CalAm, in coordination with the U.S. Army, RWQCB, DTSC, and U.S. EPA are responsible for developing a plan if drawdown affects remediation of the plumes.	Prior to and during operation	No intersection with or impact on the OUCTP plumes by slant well pumping.

TABLE 1 (Continued)
CALAM MONTEREY PENINSULA WATER SUPPLY PROJECT
MITIGATION MONITORING AND REPORTING PROGRAM

Impact **Mitigation Measure**	**Applicable Site(s)** Intake Site	Offshore Brine Discharge Site	Desalination Plant Site	ASR	Carmel Valley Pump Station	Conveyance Pipelines	**Monitoring and Reporting Program** **Monitoring and Reporting Actions:** ***CalAm Reports On, and the CPUC Monitors all Mitigation Measures***	**Implementation Schedule**	**Effectiveness Criteria**
Section 4.4: Groundwater Resources									
Impact 4.4-3: Deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level during operations. **Applicant Proposed Measure 4.4-3: Groundwater Monitoring and Avoidance of Well Damage.** Prior to the start of MPWSP slant well construction, CalAm, working with MCWRA, shall develop a groundwater monitoring and reporting program (the "Program") to the satisfaction of MCWRA. All costs of Program development and implementation shall be borne by CalAm either directly or through funding of MCWRA's staff, consultants and Program activities. The Program shall augment the MCWRA's existing regional groundwater monitoring network to focus on the area that could be affected by the proposed slant wells. The geographic area of the Program shall be within the model domain of the North Marina Groundwater Model, also referred to as NMGWM[illegible] and include the Dune Sand Aquifer, the 180-Foot Aquifer, the 400-Foot Aquifer and the Deeper Aquifer (i.e., the 900-Foot Aquifer) of the Salinas Valley Groundwater Basin (the "Monitoring Area"). The purpose of the Program is to ensure that owners of existing public or private groundwater supply wells within the Monitoring Area on the date the MPWSP commences slant well pumping ("Active Supply Wells") suffer no harm as a result of MPWSP slant well pumping. The elements of the Program proposed under this measure are described below. 1. A network of monitoring wells has been completed on and near the CEMEX property as part of the CalAm test slant well project. These well clusters monitor water elevation and quality at various depth intervals within the Dune Sand Aquifer, the 180-Foot Aquifer, and the 400-Foot Aquifer and shall be included in the Program's monitoring network. These existing monitoring wells are subject to relocation, replacement, or substitution by new or other monitoring wells developed as part of the Program as determined by MCWRA. 2. In addition, using information from the Groundwater Extraction Management System (GEMS) maintained by MCWRA and from the State Water Resources Control Board's Division of Drinking Water, CalAm, in coordination with MCWRA, shall identify Active Supply Wells in the Monitoring Area and offer to owners of identified Active Supply Wells the opportunity to participate in the Program for groundwater elevation and water quality monitoring. The owners of Active Supply Wells in the Monitoring Area will receive at least 60 days' notice (via email, if available, and via certified mail) of the opportunity to participate in the Program, and may elect in writing to participate in the Program as to their Active Supply Wells ("Participating Active Supply Wells"). This opt-in process must occur sufficiently in advance of MPWSP slant well pumping so that information on pre-MPWSP conditions can be obtained for each Participating Active Supply Well. Prior to the start of MPWSP slant well pumping, an independent California-certified hydrogeologist retained and directed by MCWRA (the "Hydrogeologist") shall evaluate the conditions and characteristics (e.g., well depth, well screen interval, pump depth and condition, flow rates, and drawdown) of each Participating Active Supply Well to develop pre-pumping data for each well. Water elevation and quality monitoring pursuant to the Program shall begin following initial groundwater well assessment, and shall continue at intervals specified in the Program (e.g., more frequently at the beginning of MPWSP slant well pumping and less often after stabilization of groundwater levels) until the well owner ceases pumping from the monitored well, or until the well owner agrees that monitoring is no longer required. 3. Prior to the start of MPWSP slant well pumping, CalAm and MCWRA shall review the current (as updated if needed) inventory of monitoring wells within the Monitoring Area, and identify locations within the Monitoring Area lacking monitoring coverage and that warrant monitoring in order to evaluate potential effects on Participating Active Supply Wells from MPWSP slant well pumping. Based upon that review, MCWRA may require that CalAm fund the installation of new monitoring wells in the Monitoring Area to be installed before MPWSP slant well pumping begins. The number of new monitoring well sites in the Monitoring Area and the location of those new monitoring well sites shall be determined by MCWRA. The area of groundwater monitoring under the Program may be extended outside of the Monitoring Area if warranted to evaluate potential MPWSP slant well pumping effects on Participating Active Supply Wells and recommended by the Hydrogeologist.	X						CalAm shall prepare the Program to be reviewed and approved by MCWRA. The MCWRA-approved Program will be sent to CPUC for confirmation prior to operation of the slant wells. CPUC will monitor and review procedures to prevent harm to local groundwater supply well owners and ensure their receipt of replacement water, as directed in the mitigation measure.	Prior to and during operation	No harm or injury to existing active groundwater supply wells.

TABLE 1 (Continued)
CALAM MONTEREY PENINSULA WATER SUPPLY PROJECT
MITIGATION MONITORING AND REPORTING PROGRAM

Impact **Mitigation Measure**	Applicable Site(s): Intake Site	Offshore Brine Discharge Site	Desalination Plant Site	ASR	Carmel Valley Pump Station	Conveyance Pipelines	Monitoring and Reporting Program: Monitoring and Reporting Actions: *CalAm Reports On, and the CPUC Monitors all Mitigation Measures*	Implementation Schedule	Effectiveness Criteria
Section 4.4: Groundwater Resources (cont.)									
• The groundwater elevation results shall be evaluated by CalAm and its consultants on a quarterly basis to assess whether the -1-foot drawdown contour from the proposed subsurface intake system is approaching the edge of the OUCTP plumes. CalAm shall continuously coordinate with and include the U.S. Army in all pertinent correspondence during the groundwater data evaluation stages. If the analysis concludes that the slant well pumping could intersect or could influence the flow direction of the OUCTP plumes, then CalAm shall contact the U.S. Army, the Regional Water Quality Control Board – Central Coast Region, the California Department of Toxic Substance Control, and the U.S. EPA to initiate communications and develop and implement a plan to either stop or decrease the pumping to prevent any impact on the OUCTP plumes. In the unlikely event that an impact does occur, CalAm shall bear the necessary additional costs to address changes in the plume flow direction, arrest migration of the plumes, and/or to remediate areas of new contamination created by slant well pumping. CalAm shall consider using existing groundwater remediation and monitoring wells that remain on the site to expand the existing treatment systems. • When the ongoing remediation of the OUCTP plumes has been completed and the RWQCB authorizes closure of the two OUCTP plumes remediation activities, this mitigation measure shall no longer apply.									
Section 4.5: Marine Biological Resources									
Impact 4.5-C1: Cumulative impacts on marine biological resources. **Mitigation Measure 4.3-4**		X					See above under Mitigation Measure 4.3-4		
Section 4.6: Terrestrial Biological Resources									
Impact 4.6-1: Result in substantial adverse effects on species identified as candidate, sensitive, or special-status, either directly, indirectly or through habitat modification, during construction. **Mitigation Measure 4.6-1a: Retain a Lead Biologist to Oversee Implementation of Protective Measures.** Prior to initiation of construction, CalAm and/or representatives of CalAm shall retain a qualified Lead Biologist to oversee compliance with avoidance and minimization measures for all special-status species and sensitive habitats. The Lead Biologist shall be onsite, or shall appoint qualified biologists and/or qualified biological monitors to be onsite, during all fencing and ground disturbance activities. The Lead Biologist, qualified biologists, and qualified biological monitors shall be subject to approval by resource agencies with jurisdiction over the special-status species with potential to occur at the project site (and local agencies, if required). Only the Lead Biologist and/or qualified biologists may lead protocol surveys and relocate special-status species, as authorized by the resource agencies with jurisdiction over these species. In the event that construction-related activities have the potential to violate the prescribed special-status species and habitat protection measures, the project Lead Biologist, or other appointed qualified biological monitors shall report to construction or operational site supervisors with authority to stop work to prevent any violations. Work shall proceed only after the construction-related hazards to special-status species and habitats are removed. If a special-status wildlife species is present, work shall proceed only if the species is no longer at risk of injury or death. Violations shall be thoroughly documented as part of compliance monitoring activities. The Lead Biologist shall ensure that all compliance monitoring activities are documented on a daily basis, and shall prepare a summary monitoring report on a monthly basis to be submitted to regulatory agencies upon their request. The monthly summary monitoring report shall provide information regarding the worker awareness training (see Mitigation Measure 4.6-1b below), surveys, and any observed special-status species, including any accidental injuries or fatalities. The monthly report shall also document the effectiveness and practicality of the prescribed avoidance and minimization measures and recommend modifications to the measures if needed. The Lead Biologist shall supply agency staff with copies of compliance records, including any reports of non-compliance, upon request.	X		X	X	X	X	CalAm will secure approvals from all resource agencies, with jurisdiction of special-status species with potential to occur on the Project site, of the qualifications and the retention of a Lead Biologist. In addition, CalAm will secure approvals for any qualified biologists and qualified monitors from the same resource agencies. CalAm will provide CPUC with copies of the approvals for the Lead Biologist, qualified biologists, and qualified monitors to CPUC prior to project construction. CalAm will provide daily and monthly compliance summary monitoring reports containing all information required by the mitigation measure to the resources agencies and CPUC.	Prior to and during construction activities and during maintenance activities at the slant well sites.	No violation of prescribed special-status species and habitat protection measures, and if work is stopped to prevent any such violation, work shall proceed only after the construction-related hazards to special-status species and habitats are removed (i.e., the species is no longer at risk of injury or death).

APPENDIX C
INVENTORY OF CURRENT MONITORING PROGRAMS IN STUDY AREA

The initial task of the development of monitoring network was an inventory of the existing groundwater collection networks in the study area – their scope, methods, and protocols. In the study area there are five active networks portions of which might be incorporated in to the coastal network. These networks include:

Monterey County Water Resources Agency (MCWRA)
Castroville Community Service District (CCSD)
Monterey Peninsula Water Supply Project (MPWSP)
Marina Coast Water District (MCWD)
Fort Ord (FO)

MCWRA Monitoring Program

MCWRA maintains the regional groundwater level and quality monitoring program at the coast which includes data collection, quality control, data management, analysis and reporting. MCWRA has a legislative mandate[13] to collect and analyze water resources data. The Monterey County Flood Control & Water Conservation District, predecessor to the MCWRA, began data collection and management of the regional monitoring network in 1947. MCWRA continued with the data program upon its formation in 1990. The purpose of the program is to document the extent and movement of Seawater Intrusion (SWI), document groundwater levels and quality at the coast, and observe the effects of the management measures and projects of the Agency.

Groundwater Level Program

Groundwater level measurements are used as a tool to understand the changes in groundwater storage, impacts of pumping, the benefits of recharge operations and reservoir releases, and the scale and geographic extent of conditions contributing to SWI. An understanding of the dynamic configuration of the hydraulic gradients within the basin contributes to the understanding of pathways for SWI.

MCWRA's water level network in the study area includes 142 wells. The location of these wells, segregated by aquifer are shown on Plata A-C1 –A-C4. The details as to the wells construction are included in Tables A-C1 – C4. Most of the wells are production wells (both active and idle), however, there are some dedicated smaller diameter monitoring wells. Data from these wells are used to support three annual data collection efforts. These are the:

Monthly Groundwater Level Survey
Annual Groundwater Level Survey
August Trough Survey

[13] Monterey County Water Resources Agency Act. (1990 Stats. 1159, 1991 Stats. 1130, 1993 Stats. 234, And 1994 Stats. 803), Water Code Appendix, Chapter 52. http://www.co.monterey.ca.us/Home/ShowDocument?id=19488

From these surveys, the MCWRA periodically produces water level contours of each aquifer system and hydrographs of selected wells. The MCWRA produces a quarterly water conditions report to the Board of Directors[14] and posts the information on the agency web site.

Groundwater Quality

MCWRA's water quality network in the study area includes 128 wells. Many of these wells are also water level wells. The location of these wells, again, segregated by aquifer are shown on Plata A-C1 –A-C4. The

Agency conducts two groundwater quality sampling events each year during the period of peak groundwater pumping, typically in June and August, to monitor groundwater quality in the coastal region of the Salinas Valley. The Agency defines the SWI front as the inland extent at which the concentration of chloride in groundwater is at least 500 mg/L. A chloride concentration of 500 mg/L represents a level that is twice the National Secondary Drinking Water Regulation (250 mg/L) and which exceeds the concentration for water considered to be of "Class III - injurious or unsatisfactory" quality for agricultural irrigation (350 mg/L). The Agency maps the 500 mg/L chloride line using the collected data. MCWRA also tries to map the 100 and 250 mg/L line to help assess timing and rate of movement of the chloride line.

Ground water samples are analyzed for the Agricultural Waivers Panel. A suite of geochemical tools are used to evaluate laboratory results, including Piper, Stiff diagrams, and an evaluation of chloride concentrations versus sodium/chloride molar ratios. These geochemical tools allow the Agency to discern whether SWI is the source of chloride concentrations in a well or if the observed chloride is due to another source such as irrigation return flows.

Quality Control

Groundwater Level monitoring quality control procedures used by MCWRA are defined in several documents:

The Standard Operating Procedure – Groundwater Level Data Collection (MCWRA, 2018) describes general and Agency specific procedures to be used when collecting static groundwater levels.
The Standard Operating Procedures, Groundwater Level Data Processing memorandum (MWRA, 2018) which describes general and Agency specific procedures to be used when integrating field-collected depth to water (DTW).

The MCWRA water quality monitoring quality control is described in the Water Quality QAPP (MCWRA, 2007), which outlines the approaches for:

- Project management, including training, roles and responsibilities, documentation and records, lab documentation and reports, technical review and evaluation
- Data generation and acquisition, including sampling process design, sampling methods, sample handling and custody, analytical methods, instrumentation and calibration, data management

[14] Example quarterly reports can be found at http://www.co.monterey.ca.us/government/government-links/water-resources-agency/documents/quarterly-salinas-valley-water-conditions#wra.

- Assessment and response actions
- Data validation

All field documentation generated by the sampling program is kept on file at the Agency. Field documentation includes field sheets, chain of custody (COC) forms, photographs, and labels. Water Quality sample collection follows 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 (USGS) is maintained as a web-based document[15]. The Monterey County Environmental Health Department Consolidated Chemistry Laboratory (CCL) provides laboratory services and is ELAP certified. They keep a sample receiving log containing the completed chain of custody forms submitted with the samples collected for this project. The CCL keeps 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. The CCL maintains a Laboratory Information Management System (LIMS). The CCL Public Health Chemist is responsible for reviewing, validating, and/or qualifying results on the data reports. CCL has its own QA Manual and Standard Operating Procedures. Analyses are performed following either EPA approved methods or methods from Standard Method for the Examination of Water and Wastewater[16]. Final water quality lab results are sent digitally to the MCWRA for loading, management and reporting in the Agency's Water Resources Agency Information Management System (WRAIMS) database.

Data Management and Access

The MCWRA operates the WRAIMS, an Oracle/ArcMap integration used to manage all water level, water quality, pumping and well related data. The system is used to support mapping, reporting and analysis. It is an internal system and only selected data is currently available on-line since much is considered proprietary as part of the cooperative program that is supported by growers who voluntarily provide access to production wells.

MPWSP Test Slant Well Study Monitoring Network

There is a total of 27 wells in the Monterey Peninsula Water Supply Monitoring Network (MPWSP). The locations of the wells, segregated by aquifer, are shown on Plates A-C1 through A-C4. Table A-C1 summarizes general technical details of the monitoring wells. The objectives for the MPWSP study network were to:

- Characterize the baseline water quality and levels in the aquifer systems
- Evaluate potential water quality and level changes during the test slant well pumping test, and
- Assess and continually evaluate the hydrogeologic technical aspects of the project
- Evaluate potential impacts to critical inland water resources
- Assess the movement of ocean water into the test slant well, and
- Collect data to calibrate groundwater models

Both on-site and off-site monitoring wells were constructed to allow evaluation of groundwater levels and quality for a baseline period and during the long-term pumping test period. Each monitoring well

[15] http://pubs.water.usgs.gov/twri9A
[16] https://www.standardmethods.org/store/ProductList.cfm?EPAApproved=1

site consists of a cluster of three monitoring wells completed at different depth intervals. The individual wells were drilled to monitor responses in the Dune Sand (S), 180-ft/FTE (M), 180-foot (M) and 400-foot (D) Aquifers. The naming convention for the monitoring wells in each cluster is as follows: MW 1S, MW-1M and MW-1D refer to shallow, middle and deep monitoring zones respectively for monitoring well cluster [17]. On-site monitoring well clusters at the CEMEX site include MW-1[18], MW-3, and MW-4. Off-site wells, which provide regional data for evaluation of potential impacts, include MW-5, MW-6, MW-7, MW-8, and MW-9.

Groundwater Levels

Groundwater levels in all the monitoring wells, are recorded using In-Situ AquaTROLL 200 Data Loggers at intervals ranging from 5 to 15 minutes. Hand water levels were collected weekly using an electronic wireline sounder. This protocol was followed through the long-term test pumping and post pumping monitoring.

Groundwater Quality

Water quality samples from all of the monitoring wells were collected at the end of well development at time of construction.

For the baseline data collection program, In-Situ AquaTROLL 200 data loggers were installed in the all network wells to measure pressure, specific conductance (r EC) and temperature. Probes were installed in the screened section of the monitoring wells to record specific conductance every 5 to 15 minutes.

Water quality samples for laboratory analysis were also manually collected from the wells on a quarterly basis. Sampling was performed with a small diameter sampling pump. Samples were collected after field parameters had stabilized. Samples were analyzed by Monterey Bay Analytical Services (MBAS) laboratory. Samples were tested for a wide array of organic and inorganic constituents.

Following the completion of the Test Slant Well Long- Term Pumping Test in February 2018, groundwater quality samples were collected from the MPWSP monitoring wells in April 2018. The plan currently is to collect semiannual (twice a year) samples from the monitoring wells through 2019. Samples are also collected from the MW-4 monitoring wells quarterly.

Data Management and Access

GeoScience maintains a database for the test slant well program and published the data via the MPWSP web site[19]. Data management is not well defined in the Sampling and Analysis Plan. Data are in electronic formats and could be accessed for use if needed.

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[17] Data collected from Monitoring MW-5S over the duration of the monitoring program revealed that the MW-5S well screen is not screened in the shallow Dune Sand Aquifer as originally believed, but rather is screened in a perched aquifer that lies above the Dune Sand Aquifer or its equivalent in the Landfill highland area. Therefore, the monitoring well has been re-designated as MW-5S(P) to indicate that it is shallow screened monitoring well which provides representative groundwater levels in a perched aquifer.

[18] There is no MW-2 – its location was superseded by the test slant well.

[19] https://www.watersupplyproject.org/

Groundwater level and quality data were provided in weekly reports published by CalAm and reviewed by the HWG. Test Slant Well Long-Term Pumping Monthly Monitoring Reports were also prepared for the California Coastal Commission. Since completing the testing of the Test Slant Well pumping at the end of February 2018 and ending the Long- Term Test, CalAm has voluntarily elected to continue the monitoring program and issuing monthly monitoring reports to compare water level and water quality trends during pumping and non-pumping periods.

Marina Coast Water District

Marina Coast Water District (MCWD) owns 23 wells. These include 11 monitoring wells, 4 idle production wells and 8 active production wells. The location of MCWD's wells, segregated by aquifer, are shown on Plates A-C1 through A-C4. MCWD well attributes are shown in Table A-C.

The MCWD currently provides municipal water supplies produced from eight wells. Four supply wells (10, 11, 12, and 34) from the Deep Aquifers System of the SVGB. Four supply wells (29, 30, 31, and Watkins Gate), located in the Ord Community, draw groundwater from the SVGB Basin's lower 180-foot and 400-foot aquifers. Ten (10) production wells have historically been abandoned due to contamination, primarily SWI, but three (3) of the shallow wells were abandoned due to nitrates exceeding standards.

Water Level

Historically, MCWD has collected water level data from their wells intermittently. The MCWRA has begun working with MCWD to collect and share groundwater level and quality data and restart some of the historical monitoring wells data collection and sharing activities.

Water Quality

MCWD collects groundwater quality data from its municipal production wells to document compliance with Title 22 Drinking Water Standards pursuant to the California Health and Safety Code the State Water Board Division of Drinking Water regulations. MCWD collects pumping levels in the production wells. In the past they have collected groundwater level and quality data from the ten monitoring wells. The MCWD shares water quality data for their production wells with the MCWRA.

Quality Control

No published quality control plan is known. It is assumed that water quality compliance samples are collected by standard methods.

Data Management and Access

MCWD produces the consumer confidence reports consistent with state requirements. Current and prior year reports are available at the agency web site[20]. Laboratory results and data are also submitted electronically to the SWRCB Division of Drinking Water's water quality analyses database for public access to current and historical records[21].

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[20] http://www.mcwd.org/gsa_ccr.html

[21] https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EDTlibrary.html

The MCWD has formed a Groundwater Sustainability Agency to develop a Groundwater Sustainability Plan (GSP) pursuant to the Sustainable Groundwater Management Act (SGMA). MCWD is also working with a consultant to develop a monitoring network to comply with SGMA. As part of the SGMA requirements MCWD will produce a GSP that must identify a monitoring network and plan.

Fort Ord Networks

The groundwater monitoring program (GWMP) at the former Fort Ord began in 1993 because of a Base-wide Remedial Investigation/Feasibility Study (RI/FS) conducted in accordance with the Federal Facility Agreement. The Federal Facility Agreement became effective in 1990 by the State and Federal agencies. More than 1,000 monitoring wells have been installed. Most of the wells are idle and currently not monitored. The remaining are part of active remediation operations. The Army groundwater monitoring program currently includes monitoring the progress of remedial actions at three sites: Sites 2 and 12 (Sites 2/12) and OU2. Many of the wells have been destroyed, having served their purpose. There are two locations where active monitoring continues.

There remain more than 500 monitoring wells in the designated study area. Most of these wells are very shallow, designed to detect, delineate and remediate shallow contamination. The existing monitoring wells of Fort Ord segregated by aquifer are presented on Plates A-C1 through A-C4. Carbon Tetrachloride Plume (OUCTP)migrated west to the edge of the Fort Ord Salinas Valley Aquitard (FO-SVA) where it entered the Upper 180-foot Aquifer and migrated east and then down into the Lower 180-foot Aquifer through a natural discontinuity in the Intermediate 180-foot Aquitard. It has been estimated that the clean-up will take an additional 17 years (Ahtna, 2018).

Quality Control

Quality control for both sampling and laboratory testing are consistent with Federal and State requirements, and as defined in the Quality Assurance Project Plan (QAPP) for the former Fort Ord (U.S. Dept of the Army , 2017). The Quality Assurance Project Plan (QAPP) provides documentation of the collection protocols and procedures, reporting requirements and data systems (Ahtna, 2017).

Data Management and Access

There is an enormous amount of data collected by the Army and its Contractors. The Army and its contractors have requirements for electronic data processing from the field through the laboratory.

Annual and quarterly reports are produced and include detailed tables of water quality data, well hydrographs, water quality and level contour maps. All of the collected data are accessible on the web. The reports, data exchange and access are consistent with Federal Law governing clean up and remediation at federal sites, there is an extensive administrative record of documents maintained and accessible via the web site[22].

[22] http://fortordcleanup.com/documents/administrative-record/

CCSD

Castroville Community Service District (CCSD) is a small water purveyor. It maintains four water supply wells. Three of these well produce from the 400-ft aquifer, whereas one produces from the deep aquifers system.

CCSD collects continuous water level data on their production wells. Water quality data are collected in accordance with SWRCB-DDW requirements. Additionally, MCWRA has incorporated CCSD's wells into their network.

Quality Control

No published quality control plan is known. It is assumed that water quality compliance samples are collected by standard methods.

Data Management and Access

CCSD produces the consumer confidence reports consistent with state requirements. CCSD archives water level data in their SCADA system for 90 days. Data are shared with MCWRA and archived in the Agency's database.

Plate A-C1

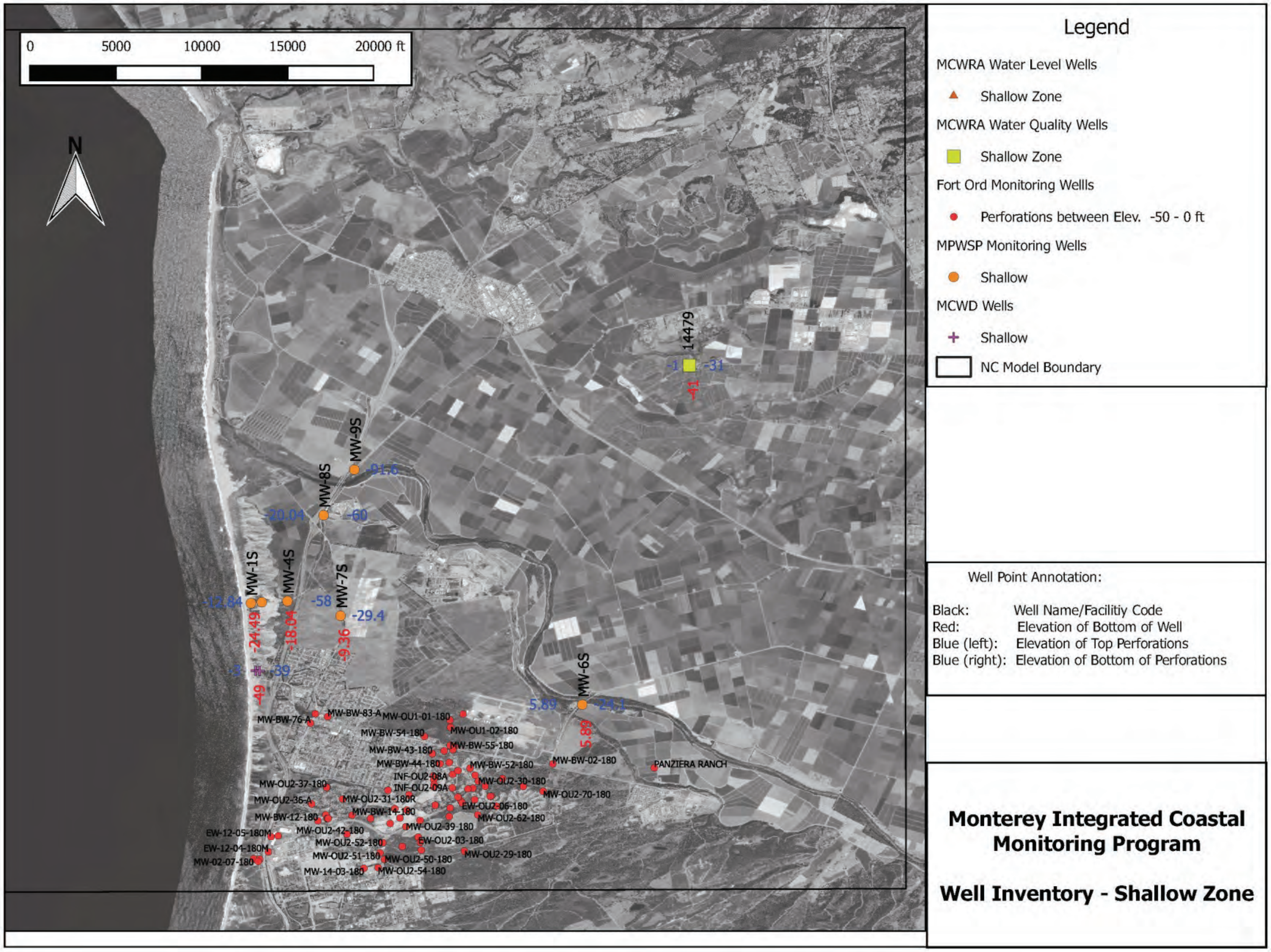

0 5000 10000 15000 20000 ft
N
14479
MW-9S
MW-8S
MW-1S
MW-4S
MW-7S
MW-6S
PANZIERA RANCH
Legend
MCWRA Water Level Wells
Shallow Zone
MCWRA Water Quality Wells
Shallow Zone
Fort Ord Monitoring Wellls
Perforations between Elev. -50 - 0 ft
MPWSP Monitoring Wells
Shallow
MCWD Wells
Shallow
NC Model Boundary
Well Point Annotation:
Black: Well Name/Facilitiy Code
Red: Elevation of Bottom of Well
Blue (left): Elevation of Top Perforations
Blue (right): Elevation of Bottom of Perforations
Monterey Integrated Coastal Monitoring Program
Well Inventory - Shallow Zone

Plate A-C2

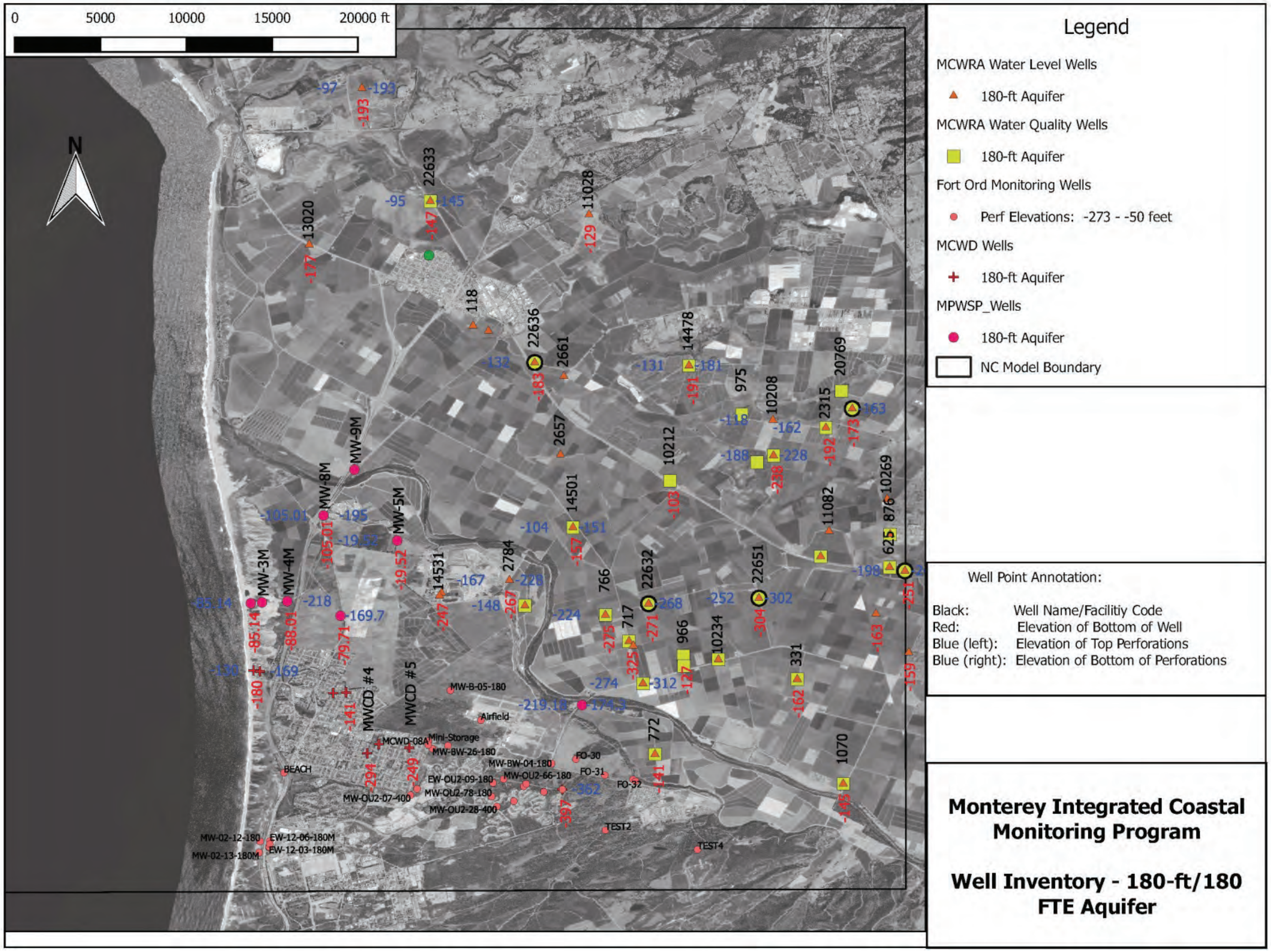
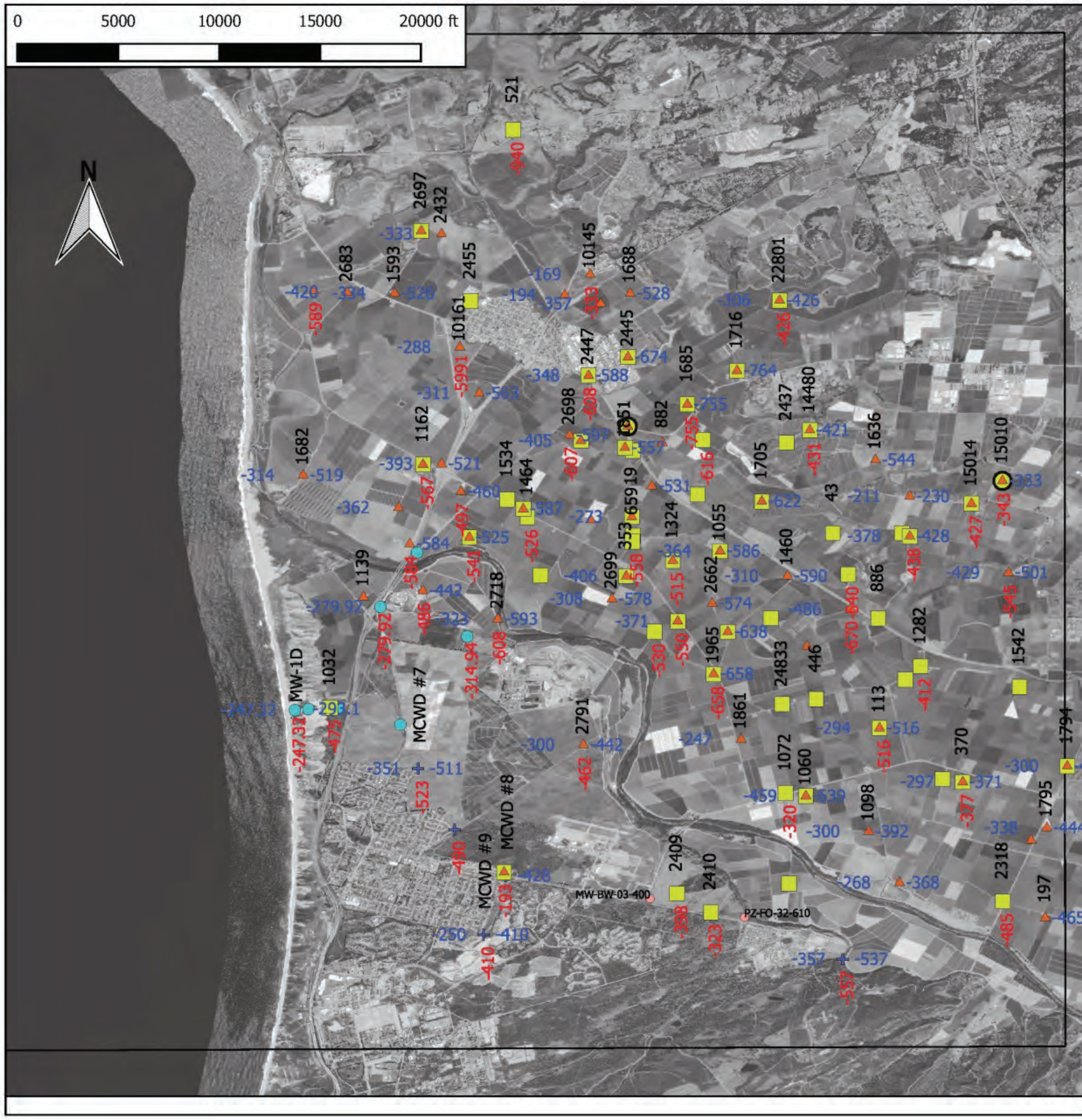

0 5000 10000 15000 20000 ft
N
Legend
MCWRA Water Level Wells
180-ft Aquifer
MCWRA Water Quality Wells
180-ft Aquifer
Fort Ord Monitoring Wells
Perf Elevations: -273 - -50 feet
MCWD Wells
180-ft Aquifer
MPWSP_Wells
180-ft Aquifer
NC Model Boundary
Well Point Annotation:
Black: Well Name/Facilitiy Code
Red: Elevation of Bottom of Well
Blue (left): Elevation of Top Perforations
Blue (right): Elevation of Bottom of Perforations
Monterey Integrated Coastal Monitoring Program
Well Inventory - 180-ft/180 FTE Aquifer

Plate A-C3



Legend

MCWRA Water Level Wells

- 400-ft Aquifer

MCWRA Water Quality Wells

- 400-ft Aquifer

Fort Ord Monitoring Wells

- Perf Elevations: -417 - -273

MCWD Wells

- 400-ft Aquifer

MPWSP_Wells

- 400-ft Aquifer

NC Model Boundary

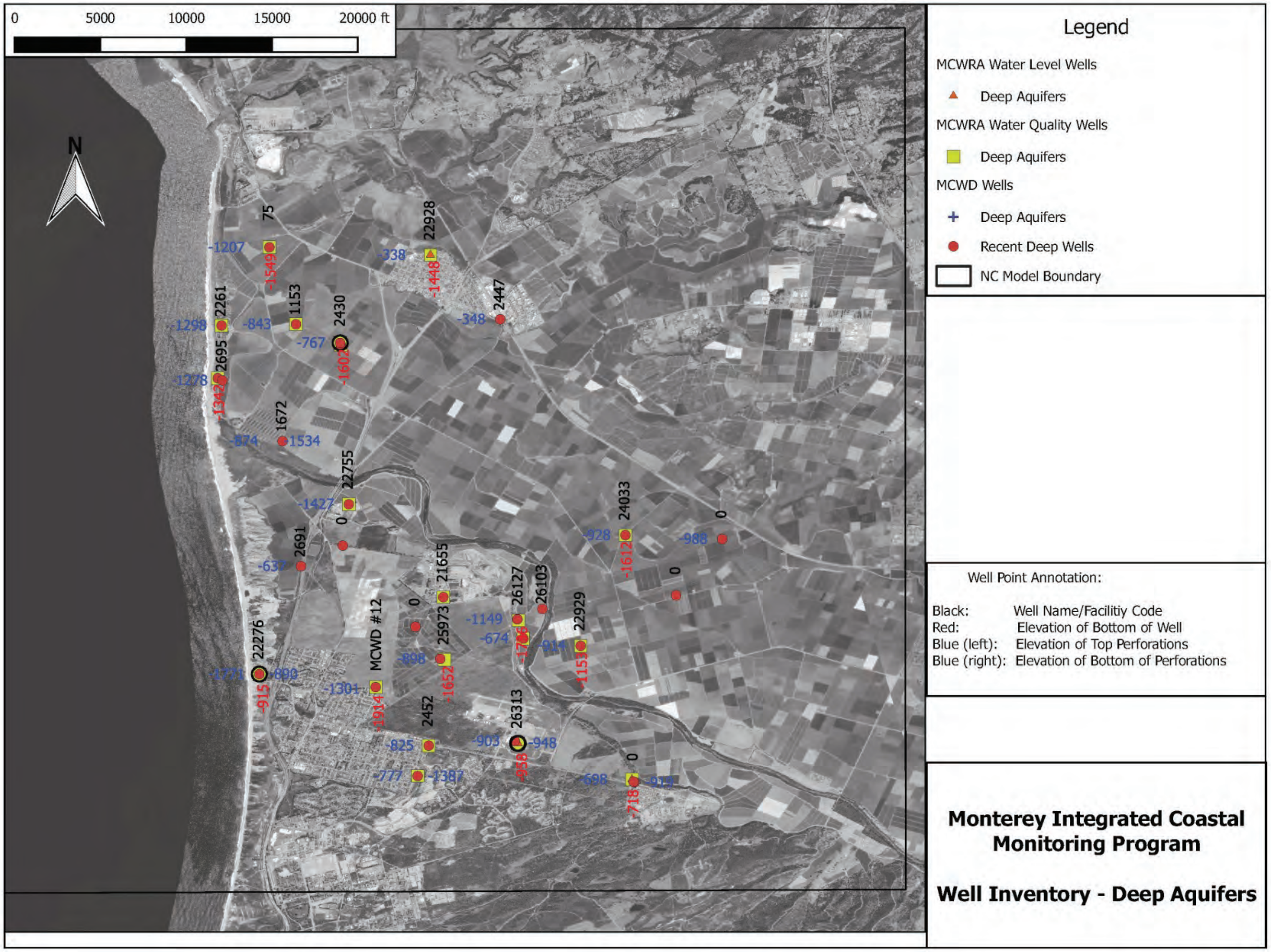
Well Point Annotation:

Black: Well Name/Facilitiy Code
Red: Elevation of Bottom of Well
Blue (left): Elevation of Top Perforations
Blue (right): Elevation of Bottom of Perforations

Monterey Integrated Coastal Monitoring Program

Well Inventory - 400-ft Aquifer

Plate A-C4


0
5000
10000
15000
20000 ft
N
Legend
MCWRA Water Level Wells
Deep Aquifers
MCWRA Water Quality Wells
Deep Aquifers
MCWD Wells
Deep Aquifers
Recent Deep Wells
NC Model Boundary
Well Point Annotation:
Black: Well Name/Facilitiy Code
Red: Elevation of Bottom of Well
Blue (left): Elevation of Top Perforations
Blue (right): Elevation of Bottom of Perforations
Monterey Integrated Coastal Monitoring Program
Well Inventory - Deep Aquifers

WELL INVENTORIES

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
PANZIERA RANCH	Water Supply	400-Foot	0	406	0	348	0	-348	Accessible
MW-BW-03-400	Monitoring	400-Foot	141.32	480.8	457	477	-315.68	-335.68	Accessible
MW-OU2-07-400	Monitoring	400-Foot	174.98	580	381.9	579.4	-206.92	-404.42	Accessible
MW-OU2-28-400	Monitoring	400-Foot	198.33	435	405	435	-206.67	-236.67	Accessible
MP-BW-30	Mulitple Port	400-Foot	156.08	0	467.27	467.27	-311.19	-311.19	Accessible
MP-BW-30	Mulitple Port	400-Foot	156.08	0	536.97	536.97	-380.89	-380.89	Accessible
MP-BW-31	Mulitple Port	400-Foot	137.11	0	457.27	457.27	-320.16	-320.16	Accessible
MP-BW-31	Mulitple Port	400-Foot	137.11	0	521.67	521.67	-384.56	-384.56	Accessible
MP-BW-32	Mulitple Port	400-Foot	153.04	0	472.53	472.53	-319.49	-319.49	Accessible
MP-BW-32	Mulitple Port	400-Foot	153.04	0	522.41	522.41	-369.37	-369.37	Accessible
MP-BW-34	Mulitple Port	400-Foot	127.61	0	490.42	490.42	-362.81	-362.81	Accessible
MP-BW-34	Mulitple Port	400-Foot	127.61	0	534.49	534.49	-406.88	-406.88	Accessible
MP-BW-35	Mulitple Port	400-Foot	138.56	0	526.61	526.61	-388.05	-388.05	Accessible
MP-BW-35	Mulitple Port	400-Foot	138.56	0	561.18	561.18	-422.62	-422.62	Accessible
MW-OU2-06-400	Monitoring	400-Foot	153.8	539	316.7	438	-162.9	-284.2	Accessible (TBD)
MW-OU2-22-400	Monitoring	400-Foot	110.75	307	275	307	-164.25	-196.25	Accessible (TBD)
MW-40-01-A	Monitoring	A	139.55	97	74	94	65.55	45.55	Accessible
MW-B-02-A	Monitoring	A	123.08	80	55	75	68.08	48.08	Accessible
EW-OU1-17-A	Extraction	A	148.66	124	94	121.6	54.66	27.06	Accessible
EW-OU1-18-A	Extraction	A	135.33	107	77	104.7	58.33	30.63	Accessible
EW-OU1-92-A	Extraction	A	105.72	89.21	58.5	88.5	47.22	17.22	Accessible
EW-OU1-93-A	Extraction	A	92.3	75	43.5	73.5	48.8	18.8	Accessible
MW-B-10-A	Monitoring	A	106	90	65	85	41	21	Accessible
MW-BW-10-A	Monitoring	A	143.09	105	72	102	71.09	41.09	Accessible
MW-OU1-01-A	Monitoring	A	139.36	102	70.1	99.5	69.26	39.86	Accessible
MW-OU1-02-A	Monitoring	A	172.81	128	96.1	125.5	76.71	47.31	Accessible
MW-OU1-03-A	Monitoring	A	140.2	103.8	71.8	101.3	68.4	38.9	Accessible
MW-OU1-04-A	Monitoring	A	145.5	118.5	87.1	116.5	58.4	29	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-OU1-06-A	Monitoring	A	140.77	99.5	67.6	97	73.17	43.77	Accessible
MW-OU1-07-A	Monitoring	A	126.94	99.5	53	93	73.94	33.94	Accessible
MW-OU1-08-A	Monitoring	A	152.88	112.5	75	110	77.88	42.88	Accessible
MW-OU1-09-A	Monitoring	A	138.7	113	81	111	57.7	27.7	Accessible
MW-OU1-10-A	Monitoring	A	141.73	118	85.8	115	55.93	26.73	Accessible
MW-OU1-12-A	Monitoring	A	128.38	100	40	100	88.38	28.38	Accessible
MW-OU1-13-A	Monitoring	A	151.34	124.5	0	122	151.34	29.34	Accessible
MW-OU1-14-A	Monitoring	A	149.31	124.7	0	122.1	149.31	27.21	Accessible
MW-OU1-15-A	Monitoring	A	135.28	110.5	0	107.9	135.28	27.38	Accessible
MW-OU1-16-A	Monitoring	A	135.7	109.4	0	106.8	135.7	28.9	Accessible
MW-OU1-17-A	Monitoring	A	148.66	124	0	121.6	148.66	27.06	Accessible
MW-OU1-18-A	Monitoring	A	135.33	107	0	104.7	135.33	30.63	Accessible
MW-OU1-19-A	Monitoring	A	147.61	118	86	116	61.61	31.61	Accessible
MW-OU1-20-A	Monitoring	A	159.07	119	86	116	73.07	43.07	Accessible
MW-OU1-21-A	Monitoring	A	136	111	80.5	110.5	55.5	25.5	Accessible
MW-OU1-22-A	Monitoring	A	148.44	122	101.5	121.5	46.94	26.94	Accessible
MW-OU1-23-A	Monitoring	A	154.33	128.5	98.5	127.5	55.83	26.83	Accessible
MW-OU1-24-AR	Monitoring	A	147.78	127.3	86.5	126.5	61.28	21.28	Accessible
MW-OU1-25-A	Monitoring	A	151.71	125.5	59	89	92.71	62.71	Accessible
MW-OU1-26-A	Monitoring	A	129.51	102	82	102	47.51	27.51	Accessible
MW-OU1-27-A	Monitoring	A	106.55	89.8	55	85	51.55	21.55	Accessible
MW-OU1-28-A	Monitoring	A	118.24	95	64.5	94.5	53.74	23.74	Accessible
MW-OU1-29-A	Monitoring	A	110.41	89.5	59	89	51.41	21.41	Accessible
MW-OU1-30-A	Monitoring	A	126.25	102.5	72	102	54.25	24.25	Accessible
MW-OU1-31-A	Monitoring	A	111.41	81.5	50	80	61.41	31.41	Accessible
MW-OU1-32-A	Monitoring	A	145	98.65	80	100	65	45	Accessible
MW-OU1-33-A	Monitoring	A	144.76	120	110	120	34.76	24.76	Accessible
MW-OU1-34-A	Monitoring	A	114.68	94.2	63.5	93.5	51.18	21.18	Accessible
MW-OU1-36-A	Monitoring	A	128.05	80	65	80	63.05	48.05	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-OU1-37-A	Monitoring	A	127.79	90	75	90	52.79	37.79	Accessible
MW-OU1-38-A	Monitoring	A	144.96	102	87	102	57.96	42.96	Accessible
MW-OU1-39-A	Monitoring	A	148.17	97	82	97	66.17	51.17	Accessible
MW-OU1-40-A	Monitoring	A	149.36	106.5	81.5	106.5	67.86	42.86	Accessible
MW-OU1-41-A	Monitoring	A	110.32	97	65	95	45.32	15.32	Accessible
MW-OU1-42-A	Monitoring	A	104.04	87	54	84	50.04	20.04	Accessible
MW-OU1-43-A	Monitoring	A	114.4	104.5	66	96	48.4	18.4	Accessible
MW-OU1-44-A	Monitoring	A	127.32	96	63	93	64.32	34.32	Accessible
MW-OU1-45-A	Monitoring	A	110.56	83	53	83	57.56	27.56	Accessible
MW-OU1-46-A	Monitoring	A	130.78	105	75	105	55.78	25.78	Accessible
MW-OU1-75-A	Monitoring	A	110.62	95	65	95	45.62	15.62	Accessible
MW-OU1-76-A	Monitoring	A	109.5	98	68	98	41.5	11.5	Accessible
MW-OU1-77-A	Monitoring	A	94.12	74	44	74	50.12	20.12	Accessible
MW-OU1-78-A	Monitoring	A	100.22	80	50	80	50.22	20.22	Accessible
MW-OU1-79-A	Monitoring	A	95.18	75	45	75	50.18	20.18	Accessible
MW-OU1-80-A	Monitoring	A	97.64	88	58	88	39.64	9.64	Accessible
MW-OU1-81-A	Monitoring	A	95.51	93	63	93	32.51	2.51	Accessible
MW-OU1-89-A	Monitoring	A	109.73	93.3	60.5	90.5	49.23	19.23	Accessible
MW-OU1-90-A	Monitoring	A	93.23	89	54.5	84.5	38.73	8.73	Accessible
MW-OU1-91-A	Monitoring	A	96.76	93.5	60	90	36.76	6.76	Accessible
MW-OU1-94-A	Monitoring	A	80.95	90	59.5	89.5	21.45	-8.55	Accessible
PZ-OU1-13-A	Piezometer	A	151.34	124.5	92.6	122	58.74	29.34	Accessible
PZ-OU1-14-A	Piezometer	A	149.31	124.7	92.8	122.1	56.51	27.21	Accessible
PZ-OU1-15-A	Piezometer	A	135.28	110.5	78.1	107.9	57.18	27.38	Accessible
PZ-OU1-16-A	Piezometer	A	135.7	109.4	77	106.8	58.7	28.9	Accessible
PZ-OU1-35-A	Piezometer	A	109.43	91.8	70.5	90.5	38.93	18.93	Accessible
EW-OU2-01-A	Extraction	A	109.98	144	113	143	-3.02	-33.02	Accessible
EW-OU2-02-A	Extraction	A	116.26	141.5	109.5	139.5	6.76	-23.24	Accessible
EW-OU2-03-A	Extraction	A	84.33	116	75	115	9.33	-30.67	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
EW-OU2-04-A	Extraction	A	109.47	136	95	135	14.47	-25.53	Accessible
EW-OU2-05-A	Extraction	A	108.99	131	100	130	8.99	-21.01	Accessible
EW-OU2-06-A	Extraction	A	105.57	131	100	130	5.57	-24.43	Accessible
EW-OU2-07-A	Extraction	A	158.56	129	103	127	55.56	31.56	Accessible
EW-OU2-08-A	Extraction	A	162.96	136	105	135	57.96	27.96	Accessible
EW-OU2-09-A	Extraction	A	162.91	136	105	135	57.91	27.91	Accessible
EW-OU2-10-A	Extraction	A	167.59	142	110	141	57.59	26.59	Accessible
EW-OU2-11-A	Extraction	A	170.78	141	110	140	60.78	30.78	Accessible
EW-OU2-12-A	Extraction	A	175.39	143	106	142	69.39	33.39	Accessible
EW-OU2-13-A	Extraction	A	180.15	143	115	146	65.15	34.15	Accessible
EW-OU2-14-A	Extraction	A	185.85	137	92.3	132.3	93.55	53.55	Accessible
EW-OU2-15-A	Extraction	A	194.26	143.5	103.9	135	90.36	59.26	Accessible
EW-OU2-16-A	Extraction	A	165.43	112	79.5	109.5	85.93	55.93	Accessible
MW-14-02-A	Monitoring	A	195.54	151	120	151	75.54	44.54	Accessible
MW-16-01-A	Monitoring	A	136.63	117.5	101.4	115.9	35.23	20.73	Accessible
MW-17-01-A	Monitoring	A	165.48	163.5	147	161	18.48	4.48	Accessible
MW-BW-01-A	Monitoring	A	141.17	102.9	79.8	99.3	61.37	41.87	Accessible
MW-BW-11-A	Monitoring	A	112.34	122	99	119	13.34	-6.66	Accessible
MW-BW-13-A	Monitoring	A	103.16	129	76	126	27.16	-22.84	Accessible
MW-OU2-01-A	Monitoring	A	269.9	201.5	174.5	199	95.4	70.9	Accessible
MW-OU2-02-A	Monitoring	A	185.5	130	98	127.5	87.5	58	Accessible
MW-OU2-03-A	Monitoring	A	196.69	155.5	133	153	63.69	43.69	Accessible
MW-OU2-04-A	Monitoring	A	111.56	87	55	84.5	56.56	27.06	Accessible
MW-OU2-05-A	Monitoring	A	149.05	130.5	98.2	127.7	50.85	21.35	Accessible
MW-OU2-06-A	Monitoring	A	154.82	131.5	100	129	54.82	25.82	Accessible
MW-OU2-07-A	Monitoring	A	176.84	144.7	113	142.5	63.84	34.34	Accessible
MW-OU2-08-A	Monitoring	A	160.35	127.7	97.5	127.5	62.85	32.85	Accessible
MW-OU2-09-A	Monitoring	A	159.59	134	102	131	57.59	28.59	Accessible
MW-OU2-12-A	Monitoring	A	180.05	146.2	114.5	144	65.55	36.05	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-OU2-13-A	Monitoring	A	209.8	146.5	114.7	145	95.1	64.8	Accessible
MW-OU2-20-A	Monitoring	A	113.34	136	110	140	3.34	-26.66	Accessible
MW-OU2-21-A	Monitoring	A	140.61	110	80	110	60.61	30.61	Accessible
MW-OU2-23-A	Monitoring	A	183.05	135	102	134	81.05	49.05	Accessible
MW-OU2-25-A	Monitoring	A	208.99	160	130	160	78.99	48.99	Accessible
MW-OU2-26-A	Monitoring	A	215.3	150	119.5	149.5	95.8	65.8	Accessible
MW-OU2-27-A	Monitoring	A	185.66	129	95	125	90.66	60.66	Accessible
MW-OU2-28-A	Monitoring	A	198.04	139	105	135	93.04	63.04	Accessible
MW-OU2-29-A	Monitoring	A	253.39	179.4	150	180	103.39	73.39	Accessible
MW-OU2-30-A	Monitoring	A	163.2	110.3	85	115	78.2	48.2	Accessible
MW-OU2-31-A	Monitoring	A	65.41	82.5	50	80	15.41	-14.59	Accessible
MW-OU2-32-A	Monitoring	A	114.23	140	110	140	4.23	-25.77	Accessible
MW-OU2-33-A	Monitoring	A	120.93	151.2	120	150	0.93	-29.07	Accessible
MW-OU2-34-A	Monitoring	A	142.65	166	135	165	7.65	-22.35	Accessible
MW-OU2-35-A	Monitoring	A	238.78	166.8	137	167	101.78	71.78	Accessible
MW-OU2-36-A	Monitoring	A	94.39	135	123	133	-28.61	-38.61	Accessible
MW-OU2-37-A	Monitoring	A	125.44	164	152	162	-26.56	-36.56	Accessible
MW-OU2-40-A	Monitoring	A	110.35	124	103	123	7.35	-12.65	Accessible
MW-OU2-41-A	Monitoring	A	115.61	135.5	115	134	0.61	-18.39	Accessible
MW-OU2-44-A	Monitoring	A	165.65	100	70	100	95.65	65.65	Accessible
MW-OU2-45-A	Monitoring	A	195.03	136	105	135	90.03	60.03	Accessible
MW-OU2-46-A	Monitoring	A	176.61	112	82	112	94.61	64.61	Accessible
MW-OU2-57-A	Monitoring	A	194.86	133	103	132	91.86	62.86	Accessible
MW-OU2-58-A	Monitoring	A	154.46	101	71	100	83.46	54.46	Accessible
MW-OU2-59-A	Monitoring	A	173.34	124.3	93	122	80.34	51.34	Accessible
MW-OU2-60-A	Monitoring	A	174.24	118	88	117	86.24	57.24	Accessible
MW-OU2-73-A	Monitoring	A	172.18	137	104	134	68.18	38.18	Accessible
MW-OU2-74-A	Monitoring	A	234.45	170.8	138	168	96.45	66.45	Accessible
MW-OU2-75-A	Monitoring	A	160.53	120	90	120	70.53	40.53	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-OU2-76-A	Monitoring	A	148.39	132.3	99	129	49.39	19.39	Accessible
MW-OU2-77-A	Monitoring	A	185.24	128	94	124	91.24	61.24	Accessible
MW-OU2-79-A	Monitoring	A	120.15	127	97	127	23.15	-6.85	Accessible
MW-OU2-80-A	Monitoring	A	200.15	135	105	135	95.15	65.15	Accessible
MW-OU2-81-A	Monitoring	A	171.42	126	96	126	75.42	45.42	Accessible
EISB-EW-06	Extraction	A	77.29	69.94	36.5	66.5	40.79	10.79	Accessible
EISB-EW-08	Extraction	A	65.14	82.7	49	79	16.14	-13.86	Accessible
EW-BW-104-A	Extraction	A	163.94	116.5	83	112.75	80.94	51.19	Accessible
EW-BW-106-A	Extraction	A	167.77	122	89.5	119.5	78.27	48.27	Accessible
EW-BW-108-A	Extraction	A	147.569	104.5	73.5	103.5	74.069	44.069	Accessible
EW-BW-109-A	Extraction	A	157.85	113	82	111.75	75.85	46.1	Accessible
EW-BW-112-A	Extraction	A	143.45	102.5	71	101	72.45	42.45	Accessible
EW-BW-113-A	Extraction	A	155.59	108.5	77	107	78.59	48.59	Accessible
EW-BW-115-A	Extraction	A	142.75	100	68	98	74.75	44.75	Accessible
EW-BW-116-A	Extraction	A	152.45	108	76.43	105.43	76.02	47.02	Accessible
EW-BW-119-A	Extraction	A	139.3	114	80	110	59.3	29.3	Accessible
EW-BW-120-A	Extraction	A	142.65	104	71.4	101.4	71.25	41.25	Accessible
EW-BW-121-A	Extraction	A	141.932	109	77	107	64.932	34.932	Accessible
EW-BW-123-A	Extraction	A	142.911	100	69	99	73.911	43.911	Accessible
EW-BW-124-A	Extraction	A	153.667	109.5	78.5	108.5	75.167	45.167	Accessible
EW-BW-126-A	Extraction	A	145.193	105	72.85	102.85	72.343	42.343	Accessible
EW-BW-127-A	Extraction	A	145.69	102	71	101	74.69	44.69	Accessible
EW-BW-131-A	Extraction	A	142.386	100	68.7	98.7	73.686	43.686	Accessible
EW-BW-133-A	Extraction	A	160.303	120	87.5	117.5	72.803	42.803	Accessible
EW-BW-135-A	Extraction	A	145.132	101.5	70.5	100.5	74.632	44.632	Accessible
EW-BW-138-A	Extraction	A	157.379	109.6	78.6	108.6	78.779	48.779	Accessible
EW-BW-140-A	Extraction	A	164.379	134	101	131	63.379	33.379	Accessible
EW-BW-142-A	Extraction	A	167.196	129	90.5	120.5	76.696	46.696	Accessible
EW-BW-143-A	Extraction	A	151.77	105	74	104	77.77	47.77	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
EW-BW-144-A	Extraction	A	169.578	141.5	110.5	140.5	59.078	29.078	Accessible
EW-BW-146-A	Extraction	A	155.71	112	79.5	109.5	76.21	46.21	Accessible
EW-BW-149-A	Extraction	A	165.066	118	84	114	81.066	51.066	Accessible
EW-BW-150-A	Extraction	A	159.81	132	99	129	60.81	30.81	Accessible
EW-BW-154-A	Extraction	A	156.364	124	91	121	65.364	35.364	Accessible
EW-BW-156-A	Extraction	A	136.335	103	71.5	101.5	64.835	34.835	Accessible
EW-BW-159-A	Extraction	A	159.85	115.5	81	111	78.85	48.85	Accessible
EW-BW-85-A	Extraction	A	187.11	128	97	127	90.11	60.11	Accessible
EW-BW-86-A	Extraction	A	192.41	128	97	127	95.41	65.41	Accessible
EW-BW-87-A	Extraction	A	179.19	124	91.5	121.5	87.69	57.69	Accessible
EW-BW-91-A	Extraction	A	180.78	129	102.5	132.5	78.28	48.28	Accessible
EW-BW-92-A	Extraction	A	191.76	134	102	132	89.76	59.76	Accessible
EW-BW-93-A	Extraction	A	173.61	119.5	87	117	86.61	56.61	Accessible
IW-BW-103-A	Injection	A	174.359	120.03	91.5	121.5	82.859	52.859	Accessible
IW-BW-105-A	Injection	A	158.69	112	81	111	77.69	47.69	Accessible
IW-BW-106-A	Injection	A	0	0	0	0	0	0	Accessible
IW-BW-107-A	Injection	A	151.83	103.5	70.5	100.5	81.33	51.33	Accessible
IW-BW-110-A	Injection	A	150.03	105	74	104	76.03	46.03	Accessible
IW-BW-111-A	Injection	A	162.41	0	0	0	162.41	162.41	Accessible
IW-BW-114-A	Injection	A	149.54	104	71.75	101.75	77.79	47.79	Accessible
IW-BW-117-A	Injection	A	141.96	99.5	66	96	75.96	45.96	Accessible
IW-BW-118-A	Injection	A	141.96	100.5	69.5	99.5	72.46	42.46	Accessible
IW-BW-128-A	Injection	A	143.441	100	68.5	98.5	74.941	44.941	Accessible
IW-BW-134-A	Injection	A	154.447	110.5	78.5	108.5	75.947	45.947	Accessible
IW-BW-136-A	Injection	A	145.503	115	73.5	103.5	72.003	42.003	Accessible
IW-BW-137-A	Injection	A	164.114	136	105	135	59.114	29.114	Accessible
IW-BW-139-A	Injection	A	151.469	107	71.5	101.5	79.969	49.969	Accessible
IW-BW-145-A	Injection	A	157.822	112	79.5	109.5	78.322	48.322	Accessible
IW-BW-147-A	Injection	A	170.905	132	99	129	71.905	41.905	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
IW-BW-152-A	Injection	A	154.443	133	94	124	60.443	30.443	Accessible
IW-BW-153-A	Injection	A	156.884	136.8	100.5	130.5	56.384	26.384	Accessible
IW-BW-158-A	Injection	A	167.608	113.81	86	116	81.608	51.608	Accessible
IW-BW-88-A	Injection	A	188.17	134	101.5	131.5	86.67	56.67	Accessible
IW-BW-89-A	Injection	A	196.01	142.5	110.5	140.5	85.51	55.51	Accessible
IW-BW-90-A	Injection	A	187.46	134	102.5	132.5	84.96	54.96	Accessible
IW-BW-94-A	Injection	A	181.6	119.44	92	122	89.6	59.6	Accessible
IW-BW-99-A	Injection	A	171.28	111.35	81.5	111.5	89.78	59.78	Accessible
MP-BW-46	Mulitple Port	A	151.83	230	79.06	79.06	72.77	72.77	Accessible
MP-BW-46	Mulitple Port	A	151.83	230	94.102	94.102	57.728	57.728	Accessible
MP-BW-48	Mulitple Port	A	195.24	285	113.148	113.148	82.092	82.092	Accessible
MP-BW-48	Mulitple Port	A	195.24	285	133.13	133.13	62.11	62.11	Accessible
MW-B-12-A	Monitoring	A	98.92	75	50	70	48.92	28.92	Accessible
MW-B-14-A	Monitoring	A	144.48	101	76	96	68.48	48.48	Accessible
MW-BW-15-A	Monitoring	A	148.27	104.5	76.5	106.5	71.77	41.77	Accessible
MW-BW-16-A	Monitoring	A	135.07	98.7	66	96	69.07	39.07	Accessible
MW-BW-17-A	Monitoring	A	144.24	99.3	68	98	76.24	46.24	Accessible
MW-BW-18-A	Monitoring	A	127.77	95	65	95	62.77	32.77	Accessible
MW-BW-23-A	Monitoring	A	177.62	135.1	102.5	132.5	75.12	45.12	Accessible
MW-BW-24-A	Monitoring	A	145.99	96	64	94	81.99	51.99	Accessible
MW-BW-25-A	Monitoring	A	143.58	100	68	98	75.58	45.58	Accessible
MW-BW-26-A	Monitoring	A	165.51	131.9	101	130	64.51	35.51	Accessible
MW-BW-27-A	Monitoring	A	155.79	111	79	109	76.79	46.79	Accessible
MW-BW-28-A	Monitoring	A	143.16	104.2	83	113	60.16	30.16	Accessible
MW-BW-30-A	Monitoring	A	152.12	106.5	76	106	76.12	46.12	Accessible
MW-BW-31-A	Monitoring	A	126.07	96.5	65	95	61.07	31.07	Accessible
MW-BW-32-A	Monitoring	A	113.48	83	52	82	61.48	31.48	Accessible
MW-BW-33-A	Monitoring	A	126.52	101	70	100	56.52	26.52	Accessible
MW-BW-34-A	Monitoring	A	128.6	98	67	97	61.6	31.6	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-BW-35-A	Monitoring	A	112.29	91	59	89	53.29	23.29	Accessible
MW-BW-36-A	Monitoring	A	114.66	87	55	85	59.66	29.66	Accessible
MW-BW-37-A	Monitoring	A	99.58	74.3	45	75	54.58	24.58	Accessible
MW-BW-38-A	Monitoring	A	115.68	86	55	85	60.68	30.68	Accessible
MW-BW-39-A	Monitoring	A	79.86	57	26	56	53.86	23.86	Accessible
MW-BW-40-A	Monitoring	A	89.57	71	40	70	49.57	19.57	Accessible
MW-BW-41-A	Monitoring	A	87.12	68	37	67	50.12	20.12	Accessible
MW-BW-42-A	Monitoring	A	88.52	58	26	56	62.52	32.52	Accessible
MW-BW-43-A	Monitoring	A	60.698	39	15	35	45.698	25.698	Accessible
MW-BW-44-A	Monitoring	A	79.3	85	52.3	82.3	27	-3	Accessible
MW-BW-45-A	Monitoring	A	77.4	87.6	57	87	20.4	-9.6	Accessible
MW-BW-46-A	Monitoring	A	67.72	84	53	83	14.72	-15.28	Accessible
MW-BW-47-A	Monitoring	A	48.655	68	38	68	10.655	-19.345	Accessible
MW-BW-48-A	Monitoring	A	45.925	61.8	31	61	14.925	-15.075	Accessible
MW-BW-49-A	Monitoring	A	44.488	62	31.5	61.5	12.988	-17.012	Accessible
MW-BW-50-A	Monitoring	A	182.25	129	96	126	86.25	56.25	Accessible
MW-BW-51-A	Monitoring	A	146.14	94	62	92	84.14	54.14	Accessible
MW-BW-52-A	Monitoring	A	158.966	108.5	76	106	82.966	52.966	Accessible
MW-BW-53-A	Monitoring	A	175.717	125.5	92.5	122.5	83.217	53.217	Accessible
MW-BW-54-A	Monitoring	A	146.544	89	58	88	88.544	58.544	Accessible
MW-BW-55-A	Monitoring	A	155.9	110	79	109	76.9	46.9	Accessible
MW-BW-56-A	Monitoring	A	142.74	100	67	97	75.74	45.74	Accessible
MW-BW-57-A	Monitoring	A	146.11	105	74	104	72.11	42.11	Accessible
MW-BW-58-A	Monitoring	A	132.48	90	59	89	73.48	43.48	Accessible
MW-BW-59-A	Monitoring	A	79.5	69	38	68	41.5	11.5	Accessible
MW-BW-60-A	Monitoring	A	141.28	95	64	94	77.28	47.28	Accessible
MW-BW-61-A	Monitoring	A	180.93	130	99.5	129.5	81.43	51.43	Accessible
MW-BW-62-A	Monitoring	A	180.39	128	98	128	82.39	52.39	Accessible
MW-BW-63-A	Monitoring	A	182.28	128	97.5	127.5	84.78	54.78	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-BW-64-A	Monitoring	A	177.26	128	97.5	127.5	79.76	49.76	Accessible
MW-BW-65-A	Monitoring	A	49.52	71	40.5	70.5	9.02	-20.98	Accessible
MW-BW-66-A	Monitoring	A	86.48	67.5	37	67	49.48	19.48	Accessible
MW-BW-67-A	Monitoring	A	111.16	88	57.5	87.5	53.66	23.66	Accessible
MW-BW-71-A	Monitoring	A	191.91	145	113	143	78.91	48.91	Accessible
MW-BW-73-A	Monitoring	A	44.88	59	29	59	15.88	-14.12	Accessible
MW-BW-74-A	Monitoring	A	30.47	59.5	29	59	1.47	-28.53	Accessible
MW-BW-75-A	Monitoring	A	32.32	54.5	24	54	8.32	-21.68	Accessible
MW-BW-76-A	Monitoring	A	16.87	50.5	20	50	-3.13	-33.13	Accessible
MW-BW-77-A	Monitoring	A	82.3	93	52.5	92.5	29.8	-10.2	Accessible
MW-BW-78-A	Monitoring	A	64.48	87	46.5	86.5	17.98	-22.02	Accessible
MW-BW-79-A	Monitoring	A	65.17	84.5	42.5	82.5	22.67	-17.33	Accessible
MW-BW-80-A	Monitoring	A	51.33	75	34.5	74.5	16.83	-23.17	Accessible
MW-BW-81-A	Monitoring	A	51.23	82	39.5	79.5	11.73	-28.27	Accessible
MW-BW-82-A	Monitoring	A	38.75	74	31.5	71.5	7.25	-32.75	Accessible
MW-BW-83-A	Monitoring	A	23.72	68	26	66	-2.28	-42.28	Accessible
MW-BW-84-A	Monitoring	A	18.59	65	24	64	-5.41	-45.41	Accessible
PS-CT-01	Monitoring	A	187.99	137.2	106.7	136.7	81.29	51.29	Accessible
PS-CT-02	Monitoring	A	185.02	133.7	103.2	133.2	81.82	51.82	Accessible
PS-CT-03	Monitoring	A	186.47	135.7	105.2	135.2	81.27	51.27	Accessible
PS-CT-04	Monitoring	A	184.11	132.8	102.3	132.3	81.81	51.81	Accessible
PS-CT-05	Monitoring	A	185.42	134.3	103.8	133.8	81.62	51.62	Accessible
PS-CT-06	Monitoring	A	186.69	135.2	104.7	134.7	81.99	51.99	Accessible
PS-CT-07	Monitoring	A	183.72	130.5	100	130	83.72	53.72	Accessible
PS-CT-08	Monitoring	A	185.25	134	103.5	133.5	81.75	51.75	Accessible
PS-CT-09	Monitoring	A	183.43	132.5	102	132	81.43	51.43	Accessible
PS-CT-IW	Injection	A	186.08	134.5	109	134	77.08	52.08	Accessible
PZ-BW-44-A	Piezometer	A	79.17	85	54.5	84.5	24.67	-5.33	Accessible
MW-36-01-A	Monitoring	A	137.25	125	77.5	127.5	59.75	9.75	Accessible (TBD)

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-B-01-A	Monitoring	A	156.34	100	75	95	81.34	61.34	Accessible (TBD)
MW-B-16-A	Monitoring	A	133.59	70	45	65	88.59	68.59	Accessible (TBD)
MW-B-17-A	Monitoring	A	127.42	89.7	55	85	72.42	42.42	Accessible (TBD)
MW-B-18-A	Monitoring	A	125.72	87.6	56	86	69.72	39.72	Accessible (TBD)
MW-B-19-A	Monitoring	A	125.43	87.6	56	86	69.43	39.43	Accessible (TBD)
MW-B-20-A	Monitoring	A	125.38	87.5	56	86	69.38	39.38	Accessible (TBD)
MW-14-04-A	Monitoring	A	200.97	138.5	118.5	137.5	82.47	63.47	Accessible (TBD)
MW-OU2-04-AX	Monitoring	A	113.89	86.5	66	86	47.89	27.89	Accessible (TBD)
MW-OU2-05(PA1)-A	Monitoring	A	149.32	132.5	99.6	129.9	49.72	19.42	Accessible (TBD)
MW-OU2-05(PA2)-A	Monitoring	A	143.86	125	92.2	122.5	51.66	21.36	Accessible (TBD)
EISB-EW-01	Extraction	A	91.18	82.8	51	81	40.18	10.18	
EISB-EW-02	Extraction	A	93.72	82.88	50.5	80.5	43.22	13.22	
EISB-EW-03	Extraction	A	91.67	86.75	52	82	39.67	9.67	
EISB-EW-04	Extraction	A	87.2	80.6	50.5	80.5	36.7	6.7	
EISB-EW-05	Extraction	A	82.37	84.1	51	81	31.37	1.37	
EISB-EW-07	Extraction	A	67.69	84.3	51	81	16.69	-13.31	
EISB-EW-09	Extraction	A	61.1	82.75	53	83	8.1	-21.9	
EISB-EW-10	Extraction	A	64.98	85.1	52.5	82.5	12.48	-17.52	
EISB-EW-11	Extraction	A	65.34	84.97	51	81	14.34	-15.66	
EISB-EW-12	Extraction	A	73.01	89.3	57	87	16.01	-13.99	
EISB-EW-13	Extraction	A	78.27	95.4	64.5	94.5	13.77	-16.23	
EISB-EW-14	Extraction	A	67.91	63.99	32	62	35.91	5.91	
EISB-EW-15	Extraction	A	64.39	81.3	51.5	81.5	12.89	-17.11	
EISB-IW-01	Injection	A	89.67	85.7	51.5	81.5	38.17	8.17	
EISB-IW-02	Injection	A	85.42	81.2	50.5	80.5	34.92	4.92	
EISB-IW-03	Injection	A	73.51	78.6	46.5	76.5	27.01	-2.99	
EISB-IW-04	Injection	A	62.96	84.4	52.5	82.5	10.46	-19.54	
EISB-IW-05	Injection	A	68.27	85.45	53	83	15.27	-14.73	
EISB-IW-06	Injection	A	67.58	82.5	49.5	79.5	18.08	-11.92	

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
EISB-IW-07	Injection	A	62.28	77	48.5	78.5	13.78	-16.22	
EISB-MW-01	Monitoring	A	80.23	77	45	75	35.23	5.23	
EISB-MW-02	Monitoring	A	63.7	84.75	47	82	16.7	-18.3	
EISB-MW-03	Monitoring	A	63.32	83.4	47	82	16.32	-18.68	
EISB-MW-04	Monitoring	A	63.38	84.55	48	83	15.38	-19.62	
EISB-MW-05	Monitoring	A	65.02	81.5	53	83	12.02	-17.98	
MW-OU1-11-SVA	Monitoring	A,Salinas Valley Aquiclude	140.7	157.5	127.5	157.5	13.2	-16.8	Accessible
EW-BW-101-A	Extraction	A,Salinas Valley Aquiclude	174.399	120.31	91.5	121.5	82.899	52.899	Accessible
EW-BW-102-A	Extraction	A,Salinas Valley Aquiclude	179.652	124.15	95.5	125.5	84.152	54.152	Accessible
EW-BW-129-A	Extraction	A,Salinas Valley Aquiclude	156.11	108	76	106	80.11	50.11	Accessible
EW-BW-132-A	Extraction	A,Salinas Valley Aquiclude	144.695	102	69	99	75.695	45.695	Accessible
EW-BW-148-A	Extraction	A,Salinas Valley Aquiclude	169.3	134	100.5	131.5	68.8	37.8	Accessible
EW-BW-155-A	Extraction	A,Salinas Valley Aquiclude	140.734	109	73	103	67.734	37.734	Accessible
EW-BW-95-A	Extraction	A,Salinas Valley Aquiclude	178.666	115.16	87	117	91.666	61.666	Accessible
EW-BW-97-A	Extraction	A,Salinas Valley Aquiclude	175.07	119.17	91.5	121.5	83.57	53.57	Accessible
IW-BW-122-A	Injection	A,Salinas Valley Aquiclude	147.178	102.5	71.5	101.5	75.678	45.678	Accessible
IW-BW-125-A	Injection	A,Salinas Valley Aquiclude	144.029	102	71.5	101.5	72.529	42.529	Accessible
IW-BW-130-A	Injection	A,Salinas Valley Aquiclude	144.506	102.5	71.5	101.5	73.006	43.006	Accessible
IW-BW-141-A	Injection	A,Salinas Valley Aquiclude	165.562	138.5	107.5	137.5	58.062	28.062	Accessible
IW-BW-151-A	Injection	A,Salinas Valley Aquiclude	163.376	132	99	129	64.376	34.376	Accessible
IW-BW-96-A	Injection	A,Salinas Valley Aquiclude	176.909	118.22	91.5	121.5	85.409	55.409	Accessible
EW-BW-98-A	Extraction	A,Salinas Valley Aquiclude	161.134	102.49	72	102	89.134	59.134	
MCWD-02	Water Supply	Confined Upper 180-Foot	0	200	128	200	-128	-200	Accessible
MW-B-05-180	Monitoring	Confined Upper 180-Foot	120.74	210	175	205	-54.26	-84.26	Accessible
MW-OU1-01-180	Monitoring	Confined Upper 180-Foot	126.2	175	155	175	-28.8	-48.8	Accessible
MW-OU1-02-180	Monitoring	Confined Upper 180-Foot	138.25	195	175	195	-36.75	-56.75	Accessible
MW-OU1-03-180	Monitoring	Confined Upper 180-Foot	141.53	183	163	183	-21.47	-41.47	Accessible
EW-OU2-01-180	Extraction	Confined Upper 180-Foot	110.79	174	143	173	-32.21	-62.21	Accessible
EW-OU2-02-180	Extraction	Confined Upper 180-Foot	167.28	241	200	240	-32.72	-72.72	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
EW-OU2-03-180	Extraction	Confined Upper 180-Foot	188.39	270	210	260	-21.61	-71.61	Accessible
EW-OU2-04-180	Extraction	Confined Upper 180-Foot	238.55	323	247	297	-8.45	-58.45	Accessible
EW-OU2-05-180	Extraction	Confined Upper 180-Foot	170.72	250	180	240	-9.28	-69.28	Accessible
EW-OU2-06-180	Extraction	Confined Upper 180-Foot	166.96	240	173	233	-6.04	-66.04	Accessible
MW-14-03-180	Monitoring	Confined Upper 180-Foot	195.14	221.2	200	226	-4.86	-30.86	Accessible
MW-BW-02-180	Monitoring	Confined Upper 180-Foot	141.25	169	146.4	166.4	-5.15	-25.15	Accessible
MW-BW-12-180	Monitoring	Confined Upper 180-Foot	112.34	185	157	182	-44.66	-69.66	Accessible
MW-BW-14-180	Monitoring	Confined Upper 180-Foot	119.74	182.65	155	180	-35.26	-60.26	Accessible
MW-OU2-05-180	Monitoring	Confined Upper 180-Foot	152.65	218	194	214	-41.35	-61.35	Accessible
MW-OU2-06-180R	Monitoring	Confined Upper 180-Foot	152.51	215.4	195	215	-42.49	-62.49	Accessible
MW-OU2-07-180R	Monitoring	Confined Upper 180-Foot	176.14	241	220	240	-43.86	-63.86	Accessible
MW-OU2-09-180R	Monitoring	Confined Upper 180-Foot	159.6	211	190	210	-30.4	-50.4	Accessible
MW-OU2-20-180	Monitoring	Confined Upper 180-Foot	112.88	184	154	184	-41.12	-71.12	Accessible
MW-OU2-20-180X	Monitoring	Confined Upper 180-Foot	116.59	175.4	160	185	-43.41	-68.41	Accessible
MW-OU2-23-180	Monitoring	Confined Upper 180-Foot	182.35	240	210	240	-27.65	-57.65	Accessible
MW-OU2-24-180	Monitoring	Confined Upper 180-Foot	181.67	231	201	231	-19.33	-49.33	Accessible
MW-OU2-28-180	Monitoring	Confined Upper 180-Foot	198.2	255	225	255	-26.8	-56.8	Accessible
MW-OU2-29-180	Monitoring	Confined Upper 180-Foot	252.78	286	264	286	-11.22	-33.22	Accessible
MW-OU2-30-180	Monitoring	Confined Upper 180-Foot	163.59	220	190	220	-26.41	-56.41	Accessible
MW-OU2-31-180R	Monitoring	Confined Upper 180-Foot	65.65	121	100	120	-34.35	-54.35	Accessible
MW-OU2-36-180	Monitoring	Confined Upper 180-Foot	94.63	152	140	150	-45.37	-55.37	Accessible
MW-OU2-37-180	Monitoring	Confined Upper 180-Foot	126.24	185	173	183	-46.76	-56.76	Accessible
MW-OU2-39-180	Monitoring	Confined Upper 180-Foot	198.58	246.5	225	245	-26.42	-46.42	Accessible
MW-OU2-42-180	Monitoring	Confined Upper 180-Foot	127.12	166	142	162	-14.88	-34.88	Accessible
MW-OU2-43-180	Monitoring	Confined Upper 180-Foot	104.94	161	140	160	-35.06	-55.06	Accessible
MW-OU2-44-180	Monitoring	Confined Upper 180-Foot	162.44	195	174	194	-11.56	-31.56	Accessible
MW-OU2-46-180	Monitoring	Confined Upper 180-Foot	174.47	207	186.5	206.5	-12.03	-32.03	Accessible
MW-OU2-47-180	Monitoring	Confined Upper 180-Foot	167.89	233.5	203.5	233.5	-35.61	-65.61	Accessible
MW-OU2-49-180	Monitoring	Confined Upper 180-Foot	154.18	235	205	235	-50.82	-80.82	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-OU2-50-180	Monitoring	Confined Upper 180-Foot	189.52	226.2	203.5	223.5	-13.98	-33.98	Accessible
MW-OU2-51-180	Monitoring	Confined Upper 180-Foot	173.89	236.1	205.5	235.5	-31.61	-61.61	Accessible
MW-OU2-52-180	Monitoring	Confined Upper 180-Foot	190.61	238	217.5	237.5	-26.89	-46.89	Accessible
MW-OU2-53-180	Monitoring	Confined Upper 180-Foot	196.8	266	236	266	-39.2	-69.2	Accessible
MW-OU2-54-180	Monitoring	Confined Upper 180-Foot	194.85	230	202.5	222.5	-7.65	-27.65	Accessible
MW-OU2-55-180	Monitoring	Confined Upper 180-Foot	242.28	283	263	283	-20.72	-40.72	Accessible
MW-OU2-56-180	Monitoring	Confined Upper 180-Foot	193.81	236	215.5	235.5	-21.69	-41.69	Accessible
MW-OU2-61-180	Monitoring	Confined Upper 180-Foot	165.08	189.1	168	189	-2.92	-23.92	Accessible
MW-OU2-62-180	Monitoring	Confined Upper 180-Foot	202.99	234	213	233	-10.01	-30.01	Accessible
MW-OU2-63-180	Monitoring	Confined Upper 180-Foot	160.21	196.5	176	196	-15.79	-35.79	Accessible
MW-OU2-64-180	Monitoring	Confined Upper 180-Foot	142.28	200	180	200	-37.72	-57.72	Accessible
MW-OU2-67-180	Monitoring	Confined Upper 180-Foot	162.8	213	193	213	-30.2	-50.2	Accessible
MW-OU2-70-180	Monitoring	Confined Upper 180-Foot	196.79	243.5	220	240	-23.21	-43.21	Accessible
MW-BW-20-180	Monitoring	Confined Upper 180-Foot	146.51	197.5	177.5	197.5	-30.99	-50.99	Accessible
MW-BW-21-180	Monitoring	Confined Upper 180-Foot	144.67	196.4	173	193	-28.33	-48.33	Accessible
MW-BW-22-180	Monitoring	Confined Upper 180-Foot	154.76	197.5	177.5	197.5	-22.74	-42.74	Accessible
MW-BW-26-180	Monitoring	Confined Upper 180-Foot	165.21	249	227	247	-61.79	-81.79	Accessible
MW-BW-29-180	Monitoring	Confined Upper 180-Foot	148.8	221	200	220	-51.2	-71.2	Accessible
IW-OU2-03-180	Injection	Confined Upper 180-Foot	145.2	247	170	246	-24.8	-100.8	Accessible (TBD)
MW-17-02-180	Monitoring	Confined Upper 180-Foot	171.52	184	165.3	184.8	6.22	-13.28	Accessible (TBD)
MW-BW-14-180X	Monitoring	Confined Upper 180-Foot	121.39	183	157.5	182.5	-36.11	-61.11	Accessible (TBD)
MW-OU2-48-180	Monitoring	Confined Upper 180-Foot	136.47	190.5	170	190	-33.53	-53.53	Accessible (TBD)
MCWD-10	Water Supply	Deep Aquifer	152.27	1550	930	1550	-777.73	-1397.73	Accessible
MCWD-11	Water Supply	Deep Aquifer	152.73	1660	970	1650	-817.27	-1497.27	Accessible
MCWD-12	Water Supply	Deep Aquifer	109.1	1970	1410	1960	-1300.9	-1850.9	Accessible
MP-BW-30	Mulitple Port	Intermediate 180-Foot	156.08	0	282.68	282.68	-126.6	-126.6	Accessible
MP-BW-32	Mulitple Port	Intermediate 180-Foot	153.04	0	287.62	287.62	-134.58	-134.58	Accessible
MP-BW-33	Mulitple Port	Intermediate 180-Foot	153.85	0	272.47	272.47	-118.62	-118.62	Accessible
MW-12-12-180L	Monitoring	Lower 180-Foot	72.49	179	161	176	-88.51	-103.51	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
BEACH	Monitoring	Lower 180-Foot	50.23	294	139	235	-88.77	-184.77	Accessible
TEST2	Monitoring	Lower 180-Foot	252	425	345	420	-93	-168	Accessible
TEST4	Monitoring	Lower 180-Foot	290.66	490	380	485	-89.34	-194.34	Accessible
MW-BW-04-180	Monitoring	Lower 180-Foot	140.97	364.5	343	363	-202.03	-222.03	Accessible
MW-OU2-66-180	Monitoring	Lower 180-Foot	144.27	339	318	338	-173.73	-193.73	Accessible
MW-OU2-68-180	Monitoring	Lower 180-Foot	162.33	280.2	257	277	-94.67	-114.67	Accessible
MW-OU2-69-180	Monitoring	Lower 180-Foot	156.27	346	325	345	-168.73	-188.73	Accessible
MW-OU2-71-180	Monitoring	Lower 180-Foot	197.44	296	273	293	-75.56	-95.56	Accessible
MW-OU2-72-180	Monitoring	Lower 180-Foot	197.48	374	354	374	-156.52	-176.52	Accessible
MW-OU2-78-180	Monitoring	Lower 180-Foot	167.04	341	320	340	-152.96	-172.96	Accessible
MW-OU2-82-180	Monitoring	Lower 180-Foot	187.03	367	345	365	-157.97	-177.97	Accessible
Mini-Storage	Monitoring	Lower 180-Foot	0	330	250	330	-250	-330	Accessible
MP-BW-37	Mulitple Port	Lower 180-Foot	135.76	477	304.63	304.63	-168.87	-168.87	Accessible
MP-BW-37	Mulitple Port	Lower 180-Foot	135.76	477	329.651	329.651	-193.891	-193.891	Accessible
MP-BW-37	Mulitple Port	Lower 180-Foot	135.76	477	369.56	369.56	-233.8	-233.8	Accessible
MP-BW-37	Mulitple Port	Lower 180-Foot	135.76	477	399.523	399.523	-263.763	-263.763	Accessible
MP-BW-37	Mulitple Port	Lower 180-Foot	135.76	477	460.727	460.727	-324.967	-324.967	Accessible
MP-BW-38	Mulitple Port	Lower 180-Foot	126.17	457	327.458	327.458	-201.288	-201.288	Accessible
MP-BW-38	Mulitple Port	Lower 180-Foot	126.17	457	339.423	339.423	-213.253	-213.253	Accessible
MP-BW-38	Mulitple Port	Lower 180-Foot	126.17	457	351.352	351.352	-225.182	-225.182	Accessible
MP-BW-38	Mulitple Port	Lower 180-Foot	126.17	457	368.643	368.643	-242.473	-242.473	Accessible
MP-BW-38	Mulitple Port	Lower 180-Foot	126.17	457	418.49	418.49	-292.32	-292.32	Accessible
MP-BW-39	Mulitple Port	Lower 180-Foot	140.42	467	310.246	310.246	-169.826	-169.826	Accessible
MP-BW-39	Mulitple Port	Lower 180-Foot	140.42	467	330.166	330.166	-189.746	-189.746	Accessible
MP-BW-39	Mulitple Port	Lower 180-Foot	140.42	467	350.188	350.188	-209.768	-209.768	Accessible
MP-BW-39	Mulitple Port	Lower 180-Foot	140.42	467	394.529	394.529	-254.109	-254.109	Accessible
MP-BW-40	Mulitple Port	Lower 180-Foot	126.42	496	332.943	332.943	-206.523	-206.523	Accessible
MP-BW-40	Mulitple Port	Lower 180-Foot	126.42	496	353.004	353.004	-226.584	-226.584	Accessible
MP-BW-40	Mulitple Port	Lower 180-Foot	126.42	496	374.77	374.77	-248.35	-248.35	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MP-BW-40	Mulitple Port	Lower 180-Foot	126.42	496	399.837	399.837	-273.417	-273.417	Accessible
MP-BW-41	Mulitple Port	Lower 180-Foot	157.06	407	284.438	284.438	-127.378	-127.378	Accessible
MP-BW-41	Mulitple Port	Lower 180-Foot	157.06	407	316.472	316.472	-159.412	-159.412	Accessible
MP-BW-41	Mulitple Port	Lower 180-Foot	157.06	407	351.452	351.452	-194.392	-194.392	Accessible
MP-BW-41	Mulitple Port	Lower 180-Foot	157.06	407	394.373	394.373	-237.313	-237.313	Accessible
MP-BW-42	Mulitple Port	Lower 180-Foot	148.69	467	295.269	295.269	-146.579	-146.579	Accessible
MP-BW-42	Mulitple Port	Lower 180-Foot	148.69	467	314.329	314.329	-165.639	-165.639	Accessible
MP-BW-42	Mulitple Port	Lower 180-Foot	148.69	467	345.213	345.213	-196.523	-196.523	Accessible
MP-BW-42	Mulitple Port	Lower 180-Foot	148.69	467	400.116	400.116	-251.426	-251.426	Accessible
FO-31	Water Supply	Lower 180-Foot	171.47	490	285	470	-113.53	-298.53	Accessible
PZ-02-01-180L	Piezometer	Lower 180-Foot	64.04	153	143	153	-78.96	-88.96	Accessible (TBD)
MCWD-09	Water Supply	Lower 180-Foot,400-Foot	171.49	600	0	588	171.49	-416.51	Accessible
EW-OU2-07-180	Extraction	Lower 180-Foot,400-Foot	163.39	265	210	260	-46.61	-96.61	Accessible
Airfield	Monitoring	Lower 180-Foot,400-Foot	142	396	318	379	-176	-237	Accessible
MCWD-08A	Monitoring	Lower 180-Foot,400-Foot	151.89	399	280	399	-128.11	-247.11	Accessible
MP-BW-30	Mulitple Port	Lower 180-Foot,400-Foot	156.08	0	317.66	317.66	-161.58	-161.58	Accessible
MP-BW-30	Mulitple Port	Lower 180-Foot,400-Foot	156.08	0	342.66	342.66	-186.58	-186.58	Accessible
MP-BW-30	Mulitple Port	Lower 180-Foot,400-Foot	156.08	0	397.53	397.53	-241.45	-241.45	Accessible
MP-BW-31	Mulitple Port	Lower 180-Foot,400-Foot	137.11	0	292.56	292.56	-155.45	-155.45	Accessible
MP-BW-31	Mulitple Port	Lower 180-Foot,400-Foot	137.11	0	332.6	332.6	-195.49	-195.49	Accessible
MP-BW-31	Mulitple Port	Lower 180-Foot,400-Foot	137.11	0	362.55	362.55	-225.44	-225.44	Accessible
MP-BW-31	Mulitple Port	Lower 180-Foot,400-Foot	137.11	0	407.33	407.33	-270.22	-270.22	Accessible
MP-BW-32	Mulitple Port	Lower 180-Foot,400-Foot	153.04	0	332.6	332.6	-179.56	-179.56	Accessible
MP-BW-32	Mulitple Port	Lower 180-Foot,400-Foot	153.04	0	367.58	367.58	-214.54	-214.54	Accessible
MP-BW-32	Mulitple Port	Lower 180-Foot,400-Foot	153.04	0	412.5	412.5	-259.46	-259.46	Accessible
MP-BW-33	Mulitple Port	Lower 180-Foot,400-Foot	153.85	0	317.46	317.46	-163.61	-163.61	Accessible
MP-BW-33	Mulitple Port	Lower 180-Foot,400-Foot	153.85	0	352.4	352.4	-198.55	-198.55	Accessible
MP-BW-33	Mulitple Port	Lower 180-Foot,400-Foot	153.85	0	397.36	397.36	-243.51	-243.51	Accessible
MP-BW-34	Mulitple Port	Lower 180-Foot,400-Foot	127.61	0	292.25	292.25	-164.64	-164.64	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MP-BW-34	Mulitple Port	Lower 180-Foot,400-Foot	127.61	0	357.07	357.07	-229.46	-229.46	Accessible
MP-BW-34	Mulitple Port	Lower 180-Foot,400-Foot	127.61	0	421.47	421.47	-293.86	-293.86	Accessible
MP-BW-35	Mulitple Port	Lower 180-Foot,400-Foot	138.56	0	312.42	312.42	-173.86	-173.86	Accessible
MP-BW-35	Mulitple Port	Lower 180-Foot,400-Foot	138.56	0	367.51	367.51	-228.95	-228.95	Accessible
MP-BW-35	Mulitple Port	Lower 180-Foot,400-Foot	138.56	0	402.45	402.45	-263.89	-263.89	Accessible
MP-BW-35	Mulitple Port	Lower 180-Foot,400-Foot	138.56	0	467.09	467.09	-328.53	-328.53	Accessible
MP-BW-49	Mulitple Port	Lower 180-Foot,400-Foot	167.37	413	285	295	-117.63	-127.63	Accessible
MP-BW-49	Mulitple Port	Lower 180-Foot,400-Foot	167.37	413	312	322	-144.63	-154.63	Accessible
MP-BW-49	Mulitple Port	Lower 180-Foot,400-Foot	167.37	413	334	344	-166.63	-176.63	Accessible
MP-BW-49	Mulitple Port	Lower 180-Foot,400-Foot	167.37	413	365	375	-197.63	-207.63	Accessible
MP-BW-49	Mulitple Port	Lower 180-Foot,400-Foot	167.37	413	398	408	-230.63	-240.63	Accessible
MP-BW-50	Mulitple Port	Lower 180-Foot,400-Foot	136.34	397	287	292	-150.66	-155.66	Accessible
MP-BW-50	Mulitple Port	Lower 180-Foot,400-Foot	136.34	397	307	312	-170.66	-175.66	Accessible
MP-BW-50	Mulitple Port	Lower 180-Foot,400-Foot	136.34	397	337	342	-200.66	-205.66	Accessible
MP-BW-50	Mulitple Port	Lower 180-Foot,400-Foot	136.34	397	357	362	-220.66	-225.66	Accessible
MP-BW-50	Mulitple Port	Lower 180-Foot,400-Foot	136.34	397	382	387	-245.66	-250.66	Accessible
MP-BW-51	Mulitple Port	Lower 180-Foot,400-Foot	158.59	427	312	317	-153.41	-158.41	Accessible
MP-BW-51	Mulitple Port	Lower 180-Foot,400-Foot	158.59	427	337	342	-178.41	-183.41	Accessible
MP-BW-51	Mulitple Port	Lower 180-Foot,400-Foot	158.59	427	367	372	-208.41	-213.41	Accessible
MP-BW-52	Mulitple Port	Lower 180-Foot,400-Foot	138.52	421	321	326	-182.48	-187.48	Accessible
MP-BW-52	Mulitple Port	Lower 180-Foot,400-Foot	138.52	421	336	341	-197.48	-202.48	Accessible
MP-BW-52	Mulitple Port	Lower 180-Foot,400-Foot	138.52	421	361	366	-222.48	-227.48	Accessible
MP-BW-52	Mulitple Port	Lower 180-Foot,400-Foot	138.52	421	386	391	-247.48	-252.48	Accessible
MP-BW-52	Mulitple Port	Lower 180-Foot,400-Foot	138.52	421	406	411	-267.48	-272.48	Accessible
FO-29	Water Supply	Lower 180-Foot,400-Foot	175.08	557	315	535	-139.92	-359.92	Accessible
FO-30	Water Supply	Lower 180-Foot,400-Foot	146.84	552	315	535	-168.16	-388.16	Accessible
MCWD-07	Water Supply	NA	0	574	0	562	0	-562	Accessible
EW-OU1-47-A	Extraction	NA	119.08	111	0	0	119.08	119.08	Accessible
EW-OU1-48-A	Extraction	NA	109.03	127	0	0	109.03	109.03	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
EW-OU1-49-A	Extraction	NA	125.61	112	0	0	125.61	125.61	Accessible
EW-OU1-52-A	Extraction	NA	152.34	122	0	0	152.34	152.34	Accessible
EW-OU1-53-A	Extraction	NA	156.09	132	0	0	156.09	156.09	Accessible
EW-OU1-54-A	Extraction	NA	158.95	112	0	0	158.95	158.95	Accessible
EW-OU1-55-A	Extraction	NA	146.6	125	0	0	146.6	146.6	Accessible
EW-OU1-60-A	Extraction	NA	104.85	95.7	55.2	95.2	49.65	9.65	Accessible
EW-OU1-62-A	Extraction	NA	107.4	100.9	60.4	100.4	47	7	Accessible
EW-OU1-63-A	Extraction	NA	101.63	91.5	51	91	50.63	10.63	Accessible
EW-OU1-66-A	Extraction	NA	105.96	101.6	56.1	101.1	49.86	4.86	Accessible
EW-OU1-71-A	Monitoring	NA	120.55	0	66	116	54.55	4.55	Accessible
EW-OU1-72-A	Monitoring	NA	116.87	0	61	111	55.87	5.87	Accessible
IW-OU1-01-A	Injection	NA	153.96	127	0	0	153.96	153.96	Accessible
IW-OU1-02-A	Injection	NA	134.95	135	0	0	134.95	134.95	Accessible
IW-OU1-05-A	Injection	NA	152.74	107	0	0	152.74	152.74	Accessible
IW-OU1-10-A	Injection	NA	145.2	142	0	0	145.2	145.2	Accessible
IW-OU1-13-A	Injection	NA	114.38	118	0	0	114.38	114.38	Accessible
IW-OU1-24-A	Injection	NA	158.13	117	0	0	158.13	158.13	Accessible
IW-OU1-25-A	Injection	NA	154.9	122	0	0	154.9	154.9	Accessible
IW-OU1-73-A	Monitoring	NA	129.2	0	76.5	126.5	52.7	2.7	Accessible
IW-OU1-74-A	Monitoring	NA	124.23	119.5	70	120	54.23	4.23	Accessible
IW-OU1-ERD-01-A	Injection	NA	106.99	88.8	53.5	88.8	53.49	18.19	Accessible
IW-OU1-ERD-02-A	Injection	NA	106.77	87.8	52.5	87.5	54.27	19.27	Accessible
IW-OU1-ERD-03-A	Injection	NA	106.66	88.3	53	88	53.66	18.66	Accessible
IW-OU1-ERD-04-A	Injection	NA	106.47	87.8	52.5	87.5	53.97	18.97	Accessible
MW-OU1-46-AD	Monitoring	NA	130.37	125	0	0	130.37	130.37	Accessible
MW-OU1-50-A	Monitoring	NA	109.43	111	0	0	109.43	109.43	Accessible
MW-OU1-51-A	Monitoring	NA	118.38	122	0	0	118.38	118.38	Accessible
MW-OU1-56-A	Monitoring	NA	99.45	95	0	0	99.45	99.45	Accessible
MW-OU1-57-A	Monitoring	NA	104.27	97	0	0	104.27	104.27	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-OU1-58-A	Monitoring	NA	107.88	102	0	0	107.88	107.88	Accessible
MW-OU1-59-A	Monitoring	NA	114.38	112	0	0	114.38	114.38	Accessible
MW-OU1-61-A	Monitoring	NA	107.54	96.5	91.2	96.2	16.34	11.34	Accessible
MW-OU1-64-A1	Monitoring	NA	102.65	95.2	85	95	17.65	7.65	Accessible
MW-OU1-64-A2	Monitoring	NA	102.79	80.2	50	80	52.79	22.79	Accessible
MW-OU1-65-A	Monitoring	NA	101.73	90.3	50	90	51.73	11.73	Accessible
MW-OU1-67-A	Monitoring	NA	108.21	102.3	92	102	16.21	6.21	Accessible
MW-OU1-68-A	Monitoring	NA	111.37	103.8	58.5	103.5	52.87	7.87	Accessible
MW-OU1-69-A2	Monitoring	NA	104.39	96.5	56.3	96.3	48.09	8.09	Accessible
MW-OU1-70-A	Monitoring	NA	100.47	91.5	61.3	91.3	39.17	9.17	Accessible
MW-OU1-82-A	Monitoring	NA	128.16	0	73	123	55.16	5.16	Accessible
MW-OU1-83-A	Monitoring	NA	129.97	0	73	123	56.97	6.97	Accessible
MW-OU1-84-A	Monitoring	NA	133.61	0	80.5	130.5	53.11	3.11	Accessible
MW-OU1-85-A	Monitoring	NA	124.52	0	72.1	122.1	52.42	2.42	Accessible
MW-OU1-86-A	Monitoring	NA	131.68	0	76	126	55.68	5.68	Accessible
MW-OU1-87-A	Monitoring	NA	125.97	0	71	121	54.97	4.97	Accessible
MW-OU1-88-A	Monitoring	NA	126.23	0	72	122	54.23	4.23	Accessible
MW-OU1-ERD-01-A	Monitoring	NA	106.15	85.8	45	85	61.15	21.15	Accessible
MW-OU1-ERD-02-A	Monitoring	NA	106.88	87.5	45	86.5	61.88	20.38	Accessible
MW-OU1-ERD-03-A	Monitoring	NA	105.01	87.3	46.5	86.5	58.51	18.51	Accessible
MW-OU1-ERD-04-A	Monitoring	NA	104.93	89.3	48	88.5	56.93	16.43	Accessible
MW-OU1-ERD-05-A	Monitoring	NA	107.29	91.3	50	90.5	57.29	16.79	Accessible
MW-OU1-ERD-06-A	Monitoring	NA	106.2	90.8	50	90	56.2	16.2	Accessible
MW-OU1-ERD-07-A	Monitoring	NA	109.91	92.8	51.5	91.5	58.41	18.41	Accessible
MW-OU1-ERD-08-A	Monitoring	NA	114.41	97.8	57	97	57.41	17.41	Accessible
PZ-OU1-02-A1	Piezometer	NA	134.02	137	0	0	134.02	134.02	Accessible
PZ-OU1-10-A1	Piezometer	NA	139.29	118.5	83.5	118.5	55.79	20.79	Accessible
PZ-OU1-46-AD2	Piezometer	NA	131.47	126	81	126	50.47	5.47	Accessible
PZ-OU1-49-A1	Piezometer	NA	126.19	122	0	0	126.19	126.19	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
INF-OU2-06A	Infiltration	NA	0	0	0	0	0	0	Accessible
INF-OU2-07A	Infiltration	NA	0	0	0	0	0	0	Accessible
INF-OU2-08A	Infiltration	NA	0	0	0	0	0	0	Accessible
INF-OU2-09A	Infiltration	NA	0	0	0	0	0	0	Accessible
INF-OU2-10A	Infiltration	NA	0	0	0	0	0	0	Accessible
EW-BW-100-A	Extraction	NA	172.86	120.7	91.5	121.5	81.36	51.36	Accessible
MP-BW-51	Mulitple Port	NA	158.59	427	402	407	-243.41	-248.41	Accessible
MCWD-06	Water Supply	Not Assigned (NA)	0	517	0	0	0	0	Accessible
PZ-FO-32-440	Piezometer	Paso Robles	185	440	420	440	-235	-255	Accessible
PZ-FO-32-610	Piezometer	Paso Robles	185	610	590	610	-405	-425	Accessible
PZ-FO-32-910	Piezometer	Paso Robles	185	910	890	910	-705	-725	Accessible
IW-02-01-180	Injection	Unconfined Upper 180-Foot	56.77	109	41	104	15.77	-47.23	Accessible
IW-02-02-180	Injection	Unconfined Upper 180-Foot	55.75	111	42	105	13.75	-49.25	Accessible
MW-02-01-180	Monitoring	Unconfined Upper 180-Foot	65.12	88.5	48.5	88.5	16.62	-23.38	Accessible
MW-02-02-180	Monitoring	Unconfined Upper 180-Foot	64.02	89.6	48	88	16.02	-23.98	Accessible
MW-02-03-180	Monitoring	Unconfined Upper 180-Foot	57.5	82	42	82	15.5	-24.5	Accessible
MW-02-04-180	Monitoring	Unconfined Upper 180-Foot	99.3	110.3	87.5	107.5	11.8	-8.2	Accessible
MW-02-05-180	Monitoring	Unconfined Upper 180-Foot	57.84	69	48	68	9.84	-10.16	Accessible
MW-02-06-180	Monitoring	Unconfined Upper 180-Foot	99.75	109.7	89	109	10.75	-9.25	Accessible
MW-02-07-180	Monitoring	Unconfined Upper 180-Foot	61.19	133.75	110	130	-48.81	-68.81	Accessible
MW-02-09-180	Monitoring	Unconfined Upper 180-Foot	61.86	75	52	72	9.86	-10.14	Accessible
MW-02-10-180	Monitoring	Unconfined Upper 180-Foot	49.54	64.4	38	58	11.54	-8.46	Accessible
MW-02-11-180	Monitoring	Unconfined Upper 180-Foot	95.61	100	80	100	15.61	-4.39	Accessible
MW-02-12-180	Monitoring	Unconfined Upper 180-Foot	60.18	134	113	128	-52.82	-67.82	Accessible
MW-02-13-180M	Monitoring	Unconfined Upper 180-Foot	63.06	137	116	132	-52.94	-68.94	Accessible
MW-02-13-180U	Monitoring	Unconfined Upper 180-Foot	63.62	78	54	74	9.62	-10.38	Accessible
MW-02-14-180M	Monitoring	Unconfined Upper 180-Foot	67.98	133	110	126	-42.02	-58.02	Accessible
MW-02-14-180U	Monitoring	Unconfined Upper 180-Foot	69.2	83	57	77	12.2	-7.8	Accessible
MW-02-15-180M	Monitoring	Unconfined Upper 180-Foot	68.01	131.5	115	130	-46.99	-61.99	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-02-15-180U	Monitoring	Unconfined Upper 180-Foot	69.09	82	58	78	11.09	-8.91	Accessible
PZ-02-03-180	Piezometer	Unconfined Upper 180-Foot	61.09	63	0	0	61.09	61.09	Accessible
PZ-02-04-180	Piezometer	Unconfined Upper 180-Foot	37.76	62	0	0	37.76	37.76	Accessible
PZ-02-05-180	Piezometer	Unconfined Upper 180-Foot	43.09	61	0	0	43.09	43.09	Accessible
EW-12-03-180M	Extraction	Unconfined Upper 180-Foot	69.91	142	120	135	-50.09	-65.09	Accessible
EW-12-03-180U	Extraction	Unconfined Upper 180-Foot	69.64	88	61	81	8.64	-11.36	Accessible
EW-12-04-180M	Extraction	Unconfined Upper 180-Foot	74.6	145	120	140	-45.4	-65.4	Accessible
EW-12-04-180U	Extraction	Unconfined Upper 180-Foot	74.54	93	68	88	6.54	-13.46	Accessible
EW-12-05-180M	Extraction	Unconfined Upper 180-Foot	70.16	140	120	135	-49.84	-64.84	Accessible
EW-12-06-180M	Extraction	Unconfined Upper 180-Foot	70.99	150	130	145	-59.01	-74.01	Accessible
EW-12-07-180M	Extraction	Unconfined Upper 180-Foot	75.17	150	130	145	-54.83	-69.83	Accessible
MW-12-01-180	Monitoring	Unconfined Upper 180-Foot	82.24	110	70	101	12.24	-18.76	Accessible
MW-12-03-180	Monitoring	Unconfined Upper 180-Foot	78.27	110	65	106	13.27	-27.73	Accessible
MW-12-05-180	Monitoring	Unconfined Upper 180-Foot	82.99	89.69	69	89	13.99	-6.01	Accessible
MW-12-07-180	Monitoring	Unconfined Upper 180-Foot	76.73	92	69	89	7.73	-12.27	Accessible
MW-12-08-180	Monitoring	Unconfined Upper 180-Foot	89.42	101	78	98	11.42	-8.58	Accessible
MW-12-09R-180	Monitoring	Unconfined Upper 180-Foot	72.55	138	115	135	-42.45	-62.45	Accessible
IW-OU2-01-180	Injection	Unconfined Upper 180-Foot	94.61	157	116	156	-21.39	-61.39	Accessible
IW-OU2-02-180	Injection	Unconfined Upper 180-Foot	133.33	158	117	157	16.33	-23.67	Accessible
MW-18-01-180	Monitoring	Unconfined Upper 180-Foot	136.93	165.5	125	165	11.93	-28.07	Accessible
MW-18-02-180	Monitoring	Unconfined Upper 180-Foot	109.91	135	95	135	14.91	-25.09	Accessible
MW-18-03-180	Monitoring	Unconfined Upper 180-Foot	168.35	195	155	195	13.35	-26.65	Accessible
MW-02-02-180X	Monitoring	Unconfined Upper 180-Foot	61.66	97	62	92	-0.34	-30.34	Accessible (TBD)
MW-02-11-180X	Monitoring	Unconfined Upper 180-Foot	95.07	112	79	109	16.07	-13.93	Accessible (TBD)
PZ-02-01-180M	Piezometer	Unconfined Upper 180-Foot	65.26	112.8	102.7	112.7	-37.44	-47.44	Accessible (TBD)
PZ-02-01-180U	Piezometer	Unconfined Upper 180-Foot	65.45	66.8	56.7	66.7	8.75	-1.25	Accessible (TBD)
MW-02-08-180	Blocked	Unconfined Upper 180-Foot	50.7	63.4	37	57	13.7	-6.3	Blocked
MW-02-08-180X	Blocked	Unconfined Upper 180-Foot	51.56	81	48.5	78.5	3.06	-26.94	Blocked
INF-02-01-180	Infiltration	Unconfined Upper 180-Foot	0	0	0	0	0	0	

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
INF-02-02-180	Infiltration	Unconfined Upper 180-Foot	0	0	0	0	0	0	
INF-02-03-180	Infiltration	Unconfined Upper 180-Foot	0	0	0	0	0	0	
MW-12-14-180M	Monitoring	Unconfined Upper 180-Foot	75.9	140	116	136	-40.1	-60.1	
MW-12-15-180M	Monitoring	Unconfined Upper 180-Foot	74.16	140	117	137	-42.84	-62.84	
MW-12-16-180M	Monitoring	Unconfined Upper 180-Foot	69.05	140	117	137	-47.95	-67.95	
EW-OU2-08-180	Extraction	Upper 180-Foot	162.31	0	175	215	-12.69	-52.69	Accessible
EW-OU2-09-180	Extraction	Upper 180-Foot	0	227	175	215	-175	-215	Accessible
MW-OU2-81-180	Monitoring	Upper 180-Foot	171.09	215	194	214	-22.91	-42.91	Accessible
MP-BW-35	Mulitple Port	Upper 180-Foot	138.56	0	242.59	242.59	-104.03	-104.03	Accessible
MP-BW-37	Mulitple Port	Upper 180-Foot	135.76	477	179.62	179.62	-43.86	-43.86	Accessible
MP-BW-37	Mulitple Port	Upper 180-Foot	135.76	477	194.456	194.456	-58.696	-58.696	Accessible
MP-BW-41	Mulitple Port	Upper 180-Foot	157.05	407	200.517	200.517	-43.467	-43.467	Accessible
MP-BW-41	Mulitple Port	Upper 180-Foot	157.05	407	229.547	229.547	-72.497	-72.497	Accessible
MP-BW-41	Mulitple Port	Upper 180-Foot	157.05	407	254.468	254.468	-97.418	-97.418	Accessible
MP-BW-42	Mulitple Port	Upper 180-Foot	148.69	467	195.286	195.286	-46.596	-46.596	Accessible
MP-BW-42	Mulitple Port	Upper 180-Foot	148.69	467	215.305	215.305	-66.615	-66.615	Accessible
MP-BW-42	Mulitple Port	Upper 180-Foot	148.69	467	235.394	235.394	-86.704	-86.704	Accessible
MP-BW-46	Mulitple Port	Upper 180-Foot	151.83	230	169.162	169.162	-17.332	-17.332	Accessible
MP-BW-46	Mulitple Port	Upper 180-Foot	151.83	230	184.178	184.178	-32.348	-32.348	Accessible
MP-BW-46	Mulitple Port	Upper 180-Foot	151.83	230	199.228	199.228	-47.398	-47.398	Accessible
MP-BW-46	Mulitple Port	Upper 180-Foot	151.83	230	214.182	214.182	-62.352	-62.352	Accessible
MP-BW-48	Mulitple Port	Upper 180-Foot	195.24	285	212.975	212.975	-17.735	-17.735	Accessible
MP-BW-48	Mulitple Port	Upper 180-Foot	195.24	285	227.965	227.965	-32.725	-32.725	Accessible
MP-BW-48	Mulitple Port	Upper 180-Foot	195.24	285	242.923	242.923	-47.683	-47.683	Accessible
MP-BW-48	Mulitple Port	Upper 180-Foot	195.24	285	267.921	267.921	-72.681	-72.681	Accessible
MW-BW-43-180	Monitoring	Upper 180-Foot	132.85	200.5	180	200.5	-47.15	-67.65	Accessible
MW-BW-44-180	Monitoring	Upper 180-Foot	147.16	227	195	215	-47.84	-67.84	Accessible
MW-BW-45-180	Monitoring	Upper 180-Foot	140.03	197	175.5	195.5	-35.47	-55.47	Accessible

FORT ORD WELLS WITHIN STUDY AREA

Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen (ft, msl)	Elev Bottom of Screen (ft, msl)	Status
MW-BW-49-180	Monitoring	Upper 180-Foot	164.57	221	190	220	-25.43	-55.43	Accessible
MW-BW-50-180	Monitoring	Upper 180-Foot	178.65	240.5	200	240	-21.35	-61.35	Accessible
MW-BW-51-180	Monitoring	Upper 180-Foot	148.83	200	170	200	-21.17	-51.17	Accessible
MW-BW-52-180	Monitoring	Upper 180-Foot	148.47	205	165	205	-16.53	-56.53	Accessible
MW-BW-53-180	Monitoring	Upper 180-Foot	170.88	221	191	221	-20.12	-50.12	Accessible
MW-BW-54-180	Monitoring	Upper 180-Foot	127.78	201	161	201	-33.22	-73.22	Accessible
MW-BW-55-180	Monitoring	Upper 180-Foot	144.47	201.5	171	201	-26.53	-56.53	Accessible
MW-BW-56-180	Monitoring	Upper 180-Foot	178.29	230	189.5	229.5	-11.21	-51.21	Accessible
PZ-OU2-06-180	Extraction		0	0	0	0	0	0	
MW-BW-70-A	Extraction		0	0	0	0	0	0	

MPWSP Network Well Information Table

Well Name	Well Type	Aquifer	RP Elevation (ft*)	RP Height (ft above GS)	Distance of RP from Slant Well Head (ft)	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen	Elev Bottom of Screen	Program	Data Start	Data Collected	Status
MW-1S	M	S	30.51	2.65 [1]	211	105	55	95	-24.49	-64.5		19-Feb-15	WL,EC	Active
MW-1M	M	M	29.86	2.48	220	235	115	225	-85.14	-195.1		19-Feb-15	WL,EC	Active
MW-1D	M	D	29.68	2.65 [1]	230	337	277	327	-247.32	-297.3		19-Feb-15	WL,EC	Active
MW-3S	M	S	37.16	2.66	428	100	50	90	-12.84	-52.8		4-Mar-15	WL,EC	Active
MW-3M	M	M	37.35	2.73	441	225	105	215	-67.65	-177.7		4-Mar-15	WL,EC	Active
MW-3D	M	D	36.93	2.74	451	340	285	330	-248.07	-293.1		4-Mar-15	WL,EC	Active
MW-4S	M	S	41.96	2.26	1,940	110	60	100	-18.04	-58.0		9-Mar-15	WL,EC	Active
MW-4M	M	M	41.99	2.15	1,929	270	130	260	-88.01	-218.0		9-Mar-15	WL,EC	Active
MW-4D	M	D	41.95	2.15	1,918	340	290	330	-248.05	-288.1		20-Feb-15	WL,EC	Active
MW-5S(P)	M	P	80.25	2.20 [1]	9,135	93	43	83	37.25	-2.8		10-Mar-15	WL,EC	Active
MW-5M	M	M	80.48	2.31 [1]	9,131	320	100	310	-19.52	-229.5		10-Mar-15	WL,EC	Active
MW-5D	M	D	80.06	1.97	9,126	445	395	435	-314.94	-354.9		19-Feb-15	WL,EC	Active
MW-6S	M	S	35.89	2.45 [1]	21,436	70	30	60	5.89	-24.1		22-Apr-15	WL,EC	Active
MW-6M	M	M	35.68	2.44 [1]	21,431	220	150	210	-114.32	-174.3		22-Apr-15	WL,EC	Active
MW-6M(L)	M	M	35.82	2.42 [1]	21,427	335	255	325	-219.18	-289.2		22-Apr-15	WL,EC	Active
MW-7S	M	S	50.64	2.06	5,274	90	60	80	-9.36	-29.4		13-Aug-15	WL,EC	Active
MW-7M	M	M	50.29	2.09	5,266	230	130	220	-79.71	-169.7		13-Aug-15	WL,EC	Active
MW-7D	M	D	50.24	2.24	5,260	355	295	345	-244.76	-294.8		13-Aug-15	WL,EC	Active
MW-8S	M	S	19.96	2.14 [3]	7,116	90	40	80	-20.04	-60.0		30-May-15	WL,EC	Active
MW-8M	M	M	19.99	2.17 [2]	7,106	225	125	215	-105.01	-195.0		30-May-15	WL,EC	Active
MW-8D	M	D	20.08	2.10 [3]	7,096	360	300	350	-279.92	-329.9		30-May-15	WL,EC	Active
MW-9S	M	S	18.42	2.16 [3]	10,677	120	30	110	-11.58	-91.6		1-Jul-15	WL,EC	Active
MW-9M	M	M	18.32	2.13 [2]	10,687	235	145	225	-126.68	-206.7		29-Jun-15	WL,EC	Active
MW-9D	M	D	18.32	2.15 [3]	10,697	403	353	393	-334.68	-374.7		26-Jun-15	WL,EC	Active
MRWPCA Well No. 1	M	M	114.00	1.60	10,898		260	340	-146.00	-226.0		19-Feb-15	WL,EC	Active
MRWPCA Well No. 2	M	M	115.00	1.65	10,892		260	340	-145.00	-225.0		19-Feb-15	WL,EC	Active
Test Slant Well	P	S,M	30.86	0	0		46**	231**	-15.14	-200.1		1-Apr-15	WL,EC	Active
CEMEX North Well	P	D,M	39.20	0.25	1,529		244	481	-204.80	-441.8		1-Apr-15	WL,EC	Active
CEMEX South Well[4]	P	M	31.00	0	1,518		400	506	-369.00	-475.0			-	Active

MCWD District Wells

Well Name	Well Type	Aquifer	Reference Point (RP)	RP Elevation ft NAVD88	Distance of RP from Slant Well Head (ft)	Depth	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen	Elev Bottom of Screen*	Data Collected	Status
MCWD DMW-1	M	M	GS	60	4795	240	190	230	-130	-170	WL	Active
MCWD DMW-2	M	M	GS	61	4975	236	180	230	-119	-169	WL	Active
MCWD MW#4	M	S	GS	61	4872	110	64	106	-3	-45	WL	Active
MCWD MW#5	M	S	GS	61	4950	107	60	100	1	-39	WL	Active
USGS DMW-1_A	M	DZ	GS	60	5092	960	930	950	-870	-890	?	Active
USGS DMW-1_B	M	DZ	GS	60	5092	1070	1040	1060	-980	-1000	?	Active
USGS DMW-1_C	M	DZ	GS	60	5092	1440	1410	1430	-1350	-1370	?	Active
USGS DMW-1_D	M	DZ	GS	60	5092	1890	1820	1860	-1760	-1800	?	Active
DMW-2-S	M	DZ	GS	142	19299	1100	1040	1090	-898	-948	?	Active
DMW-2-D	M	DZ	GS	142	19299	1740	1680	1730	-1538	-1588	?	Active
MWCD #1	P	S,M	GS	84	8821	225	124		-40	-141	?	Active
MWCD #2	P	S,M	GS	75	8460	200	128		-53	-125	?	Idle
MWCD #3	P	S,M	GS	89	13120	207	137		-48	-118	?	Idle
MWCD #4	P	M	GS	92	13409	386				-294	?	Idle
MWCD #5	P	M	GS	129	14667	378	216	368	-87	-239	?	Destroyed
MCWD #6	P	D	GS	98	11372	588				-490	?	Destroyed
MCWD #7	P	D	GS	51	7382	574	402	562	-351	-511	?	Destroyed
MCWD #8	P	D	GS	150	15317	578				-428	?	Destroyed
MCWD #9	P	D	GS	178	17235	588	428	588	-250	-410	?	Destroyed
MCWD #10	P	DZ	GS	153	15303	1500	930	1540	-777	-1387	?	Active
MCWD #11	P	DZ	GS	155	16459	1700	970	1650	-815	-1495	?	Active
MCWD #12	P	DZ	GS	109	16079	2023	1410	1960	-1301	-1851	?	Active
MCWD FO-#29	P	M,D	GS	173	23686	570	315	535	-142	-362	?	Idle?/Destroyed?
MCWD FO-#30	P	M,D	GS	145	23176	570	315	540	-170	-395	?	Standby
MCWD FO-#31	P	M,D	GS	169	25289	510	285	470	-116	-301	?	Active
MCWD FO-#32	P	M,D	GS	178	27041	540	260	500	-82	-322	?	Destroyed
MCWD #34	P	DZ	GS	176	27087	1105	705	1095	-529	-919	?	Active
MCWD Watkins Gate	P	D	GS	43	32919	600	400	580	-357	-537	?	Active

* when perfs not available the bottom of screen elevation btm of casing

Castroville WD Well Information Table

State Well No.	Well Name	Well Type	Aquifer	RP Elevation ft NAVD88	Distance of RP from Slant Well Head (ft)	Depth (ft)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev Top of Screen	Elev Bottom of Screen	Data Collected	Data Start	Data Stop	Status
T13S/R2E-28L02	2	P	180,400	20	25885	650	228	600	-208	-580	WL, Cl	1964	current	Active
T13S/R2E-34M01	3	P	400	23	23665	645	370	610	-347	-587	WL, Cl	1982	current	Idle
T13S/R2E-34G01	4	P	400	52.3	25463	745	410	725	-357.7	-672.7	WL, Cl	1980	current	Active
T13S/R2E-34G02	5	P	DZ	9	255768	1480	1080	1470	-1071	-1461	WL, Cl	2007	current	Active

MCWRA Water Level Wells

Fac_Code	State Well No.	Well Type	Aquifer Assignment	Reference Point (RP)	RP Elevation ft NAVD88	Depth (ft)	Dia (in)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev_Well_Btm	Elev Top of Screen	Elev Bottom of Screen	WQ Program	Data Start	Data Stop	Status	Annual	Monthly	August Trough	Transducer
22681	13S/01E-36J02	DOM	PRESSURE DEEP ZONE	22.1	23	1364	8	1301	1361	-1342	-1279	-1339	YES	8/20/2008	6/15/2018	ACTIVE	TRUE	TRUE		
12672	13S/02E-13N01	IRR	PRUNEDALE	74.6878	78	200	10	132	192	-125	-57	-117		12/8/1960	1/2/2018	UNKNOWN	TRUE			
10138	13S/02E-16D01	IRR	PRESSURE 180	27.2354	27	220	12	124	220	-193	-97	-193		12/1/1965	12/18/2017	ABAN	TRUE			
75	13S/02E-19Q03	IRR	PRESSURE DEEP ZONE	12.9859	18	1562	12	1220	1550	-1549	-1207	-1537	YES	10/5/1983	6/15/2018	CSIP-DOM	TRUE	TRUE		
2697	13S/02E-20J01	DOM/IRR	PRESSURE 400	14.68	20	0	0	0	0	0	0	0	YES	12/10/1956	12/18/2017	CSIP-DOM	TRUE		TRUE	
2432	13S/02E-21N01	IRR	PRESSURE 400	16.7	17.3	0	16	350	550	0	-333	-533		3/23/1953	6/15/2018	CSIP-SBI	TRUE	TRUE	TRUE	
22633	13S/02E-21Q01	MON	PRESSURE 180	10	9.65	157	3	105	155	-147	-95	-145	YES	9/23/2003	6/15/2018	ACTIVE	TRUE	TRUE	TRUE	
11028	13S/02E-26L01 N	KNOWN WATER	PRESSURE 180	121.147	109.13	250	0	0	0	-129	0	0		12/27/1960	12/18/2017	UNKNOWN	TRUE		TRUE	
10145	13S/02E-27L01	MUN	PRESSURE 400	55.1486	54.1	388	8	224	368	-333	-169	-313		7/21/1978	12/18/2017	ACTIVE	TRUE		TRUE	
2436	13S/02E-27M01	IRR	PRESSURE 400	14.1377	14.3	0	16	208	628	0	-194	-614		8/15/1978	12/18/2017	CSIP-SBI	TRUE		TRUE	
1720	13S/02E-27P01	IRR	PRESSURE 400	54.7465	50.5	0	12	412	572	0	-357	-517		8/20/1978	12/18/2017	CSIP-SBI	TRUE		TRUE	
1688	13S/02E-27Q02	IRR	PRESSURE 400	63.3046	61.8	0	16	245	591	0	-182	-528		8/14/1994	8/19/2017	CSIP-SBI			TRUE	
2446	13S/02E-28L02	MUN	PRESSURE BOTH	19.0063	16.5	600	12	228	600	-581	-209	-581	YES	8/19/1986	12/16/2017	ACTIVE	TRUE		TRUE	
2683	13S/02E-29D03	IRR	PRESSURE 400	11.8963	8.9	0	14	432	632	0	-420	-620		12/2/1969	12/18/2017	CSIP-ABAN	TRUE			
13020	13S/02E-29D04	DOM	PRESSURE 180	12.755	11	190	8	0	0	-177	0	0		11/15/2005	12/18/2017	ABAN	TRUE		TRUE	
1593	13S/02E-29F02	IRR	PRESSURE 400	13.2086	15.1	0	16	347	539	0	-334	-526		3/13/1956	12/18/2017	CSIP-SBI	TRUE		TRUE	
10156	13S/02E-30A01	IRR	PRESSURE 400	13.1296	16.2	602	16	0	0	-589	0	0		11/28/1952	6/15/2018	ABAN	TRUE	TRUE	TRUE	
1153	13S/02E-31A02	IRR	PRESSURE DEEP ZONE	7.1	9.1	0	16	850	1600	0	-843	-1593	YES	1/15/1986	6/15/2018	CSIP-SBA	TRUE	TRUE		
1682	13S/02E-31N02	IRR	PRESSURE 400	9.7	10.9	0	16	324	529	0	-314	-519		3/5/1952	6/15/2018	CSIP-DOM	TRUE	TRUE	TRUE	
10161	13S/02E-32A02	IRR	PRESSURE 400	12.2244	10.6	6003	0	300	600	-5991	-288	-588		3/20/1959	6/15/2018	CSIP-ABAN	TRUE	TRUE	TRUE	
10164	13S/02E-32E05	OBSERVATION	PRESSURE DEEP ZONE	7.89071	18.8	1610	8	775	1585	-1602	-767	-1577	YES	12/20/1984	1/31/2018	DEEP faci				TRUE
2429	13S/02E-32J03	IRR	PRESSURE 400	12.5525	10.9	0	14	324	576	0	-311	-563		8/18/1974	12/18/2017	CSIP-DOM	TRUE		TRUE	
118	13S/02E-33R01	IRR	PRESSURE 180	24.7	25.3	0	12	0	0	0	0	0		12/1/1944	6/15/2018	CSIP-SBI	TRUE	TRUE	TRUE	
2445	13S/02E-34G01	MUN	PRESSURE 400	50.5753	52.3	765	12	410	725	-714	-359	-674	YES	8/19/1986	12/16/2017	ACTIVE	TRUE		TRUE	
2447	13S/02E-34M01	MUN	PRESSURE 400	22.2545	23	630	16	370	610	-608	-348	-588	YES	8/19/1986	12/16/2017	ACTIVE	TRUE		TRUE	
22801	13S/02E-35H01	IRR	PRESSURE 400	14	15	440	16	320	440	-426	-306	-426	YES	12/16/2005	12/7/2017	ACTIVE	TRUE		TRUE	
267	13S/02E-36F01	IRR	EAST SIDE BOTH	14.5553	10	580	0	0	0	-565	0	0		3/21/1960	12/7/2017	ABAN	TRUE		TRUE	
1717	13S/02E-36J01	IRR	EAST SIDE BOTH	19.7917	15	0	14	207	533	0	-187	-513		12/10/1962	12/7/2017	CSIP-SBI	TRUE			
13783	13S/03E-19H01	DOM	PRUNEDALE	141.08	140	192	10	132	700	-51	9	-559		12/8/1960	1/3/2018	UNKNOWN	TRUE			
22802	13S/03E-19P01	IRR	PRUNEDALE	179	180	700	16	0	0	-521	0	0		11/15/2005	11/29/2016	ACTIVE	TRUE			
13866	13S/03E-20P01	IRR	PRUNEDALE	230.958	223	192	8	148	164	39	83	67		12/27/1960	1/4/2018	UNKNOWN	TRUE			
14072	13S/03E-29A01	DOM	PRUNEDALE	74.8001	70.5	200	10	40	327	-125	35	-252		12/19/1960	1/4/2018	UNKNOWN	TRUE			
14115	13S/03E-29K01	DOM	PRUNEDALE	69.449	170.7	335	10	0	0	-266	0	0		12/13/1979	1/4/2018	UNKNOWN	TRUE			
22274	14S/01E-24L02	MON	PRESSURE DEEP ZONE	55	57.4	1880	2	1820	1860	-1825	-1765	-1805	YES	8/21/2001	12/31/2017	ACTIVE				TRUE
22275	14S/01E-24L03	MON	PRESSURE DEEP ZONE	55	58.4	1430	2	1410	1430	-1375	-1355	-1375	YES	11/1/2002	12/31/2017	ACTIVE				TRUE
22276	14S/01E-24L04	MON	PRESSURE DEEP ZONE	55	57.7	1080	2	1040	1060	-1025	-985	-1005	YES	11/1/2002	12/31/2017	ACTIVE				TRUE
22277	14S/01E-24L05	MON	PRESSURE DEEP ZONE	55	57.9	970	2	930	950	-915	-875	-895	YES	11/1/2002	12/31/2017	ACTIVE				TRUE
1715	14S/02E-01C01	IRR	EAST SIDE DEEP	68.9531	64.4	0	0	350	591	0	-281	-522	YES	8/22/1993	12/7/2017	CSIP-SUPP	TRUE		TRUE	
1706	14S/02E-02A02	IRR	EAST SIDE DEEP	53.6858	54.8	0	16	360	810	0	-306	-756	YES	8/22/1993	12/7/2017	CSIP-SUPP	TRUE		TRUE	
1716	14S/02E-02C03	IRR	PRESSURE 400	67.5192	60.4	0	16	393	832	0	-325	-764	YES	8/22/1993	12/7/2017	CSIP-SUPP	TRUE		TRUE	
22635	14S/02E-03F03	MON	PRESSURE 400	26	25.5	455	3	420	450	-429	-394	-424	YES	10/23/2003	12/31/2017	ACTIVE				TRUE
22636	14S/02E-03F04	MON	PRESSURE 180	22	21.5	205	3	154	204	-183	-132	-182	YES	10/23/2003	12/31/2017	ACTIVE				TRUE
1685	14S/02E-03H01	IRR	PRESSURE 400	44.7276	41.7	800	16	350	800	-755	-305	-755	YES	8/22/1993	8/19/2017	CSIP-SUPP			TRUE	
2661	14S/02E-03K01	IRR	PRESSURE 180	22.4311	37	0	12	0	0	0	0	0		10/12/1933	12/7/2017	CSIP-ABAN	TRUE		TRUE	
882	14S/02E-03K02	IRR	PRESSURE 400	22.4311	22.1	0	16	0	0	0	0	0		8/19/1984	12/7/2017	CSIP-DOM	TRUE		TRUE	
1851	14S/02E-03M02	IRR	PRESSURE 400	12.5886	17.3	590	12	400	570	-577	-387	-557	YES	8/17/1975	12/7/2017	CSIP-SBA	TRUE		TRUE	
14342	14S/02E-04A01	IRR	PRESSURE 180	22.5647	16.4	227	0	0	0	-204	0	0		9/3/1944	8/14/1988	DESTROYED		TRUE		
2698	14S/02E-04G02	IRR	PRESSURE 400	12.5879	15	620	22	370	610	-607	-357	-597		8/27/2000	8/19/2017	CSIP-SUPP			TRUE	
1849	14S/02E-04H01	IRR	PRESSURE 400	12.5748	18	0	16	418	487	0	-405	-474	YES	8/17/1975	12/7/2017	CSIP-SBA	TRUE		TRUE	
1162	14S/02E-05C03	IRR	PRESSURE 400	12.674	13.4	580	16	300	565	-567	-287	-552	YES	8/20/1989	12/7/2017	CSIP-SBI	TRUE		TRUE	
1169	14S/02E-05F04	IRR	PRESSURE 400	12.5788	13.6	582	16	406	534	-569	-393	-521		8/20/1956	12/7/2017	CSIP-SBI	TRUE		TRUE	
1157	14S/02E-05K01	IRR	PRESSURE 400	12.5787	16.8	510	20	442	473	-497	-429	-460		3/15/1956	12/7/2017	CSIP-DOM	TRUE		TRUE	
1710	14S/02E-06J03	IRR	PRESSURE 400	12.5787	8.2	0	16	375	550	0	-362	-537		8/16/1953	12/7/2017	CSIP-SBI	TRUE		TRUE	
1672	14S/02E-06L01	IRR	PRESSURE DEEP ZONE	6	8	0	16	880	1540	0	-874	-1534		10/5/1983	6/15/2018	CSIP-SBI	TRUE	TRUE		
587	14S/02E-07A01	IRR	PRESSURE 400	15.7	17.8	600	16	390	600	-584	-374	-584		12/11/2013	12/7/2017	CSIP-SBA	TRUE		TRUE	
1139	14S/02E-07K01	IRR	PRESSURE 400	12.5787	13.1	0	0	0	0	0	0	0		3/5/1952	12/18/2017	CSIP-SBI	TRUE		TRUE	
1466	14S/02E-08C03	IRR	PRESSURE 400	15.4784	16.4	556	16	395	540	-541	-380	-525	YES	3/23/1956	12/18/2017	CSIP-SBA	TRUE		TRUE	
239	14S/02E-08M02	IRR	PRESSURE 400	13.5	14.6	500	16	314	456	-486	-300	-442		11/17/1931	6/15/2018	CSIP-DOM	TRUE	TRUE	TRUE	
2659	14S/02E-09D04	IRR	PRESSURE 400	12.9416	17	610	22	350	600	-597	-337	-587	YES	8/29/1999	8/19/2017	CSIP-SUPP			TRUE	
1523	14S/02E-09H03	IRR	PRESSURE 400	14.5	16	0	16	378	485	0	-363	-470				CSIP-SBI	TRUE		TRUE	
1076	14S/02E-10C01	IRR	PRESSURE 400	22.879	22.2	566	12	378	554	-543	-355	-531		12/6/1978	12/18/2017	CSIP-DOM	TRUE		TRUE	
19	14S/02E-10E02	IRR	PRESSURE 400	25	25.5	717	16	298	660	-692	-273	-635	YES	8/22/1993	12/18/2017	CSIP-SUPP	TRUE		TRUE	
2657	14S/02E-10P01	IRR	PRESSURE 180	19	19.2	186	0	0	0	-167	0	0		8/22/1982	12/18/2017	CSIP-ABAN	TRUE		TRUE	
14478	14S/02E-11A02	MON	PRESSURE 180	58.5623	59	250	6	190	240	-191	-131	-181	YES	7/23/1993	6/15/2018	CSIP-MON	TRUE	TRUE	TRUE	
14480	14S/02E-11A04	MON	PRESSURE 400	59.0731	58.9	490	6	450	480	-431	-391	-421	YES	7/23/1993	6/15/2018	CSIP-MON	TRUE	TRUE	TRUE	
1705	14S/02E-11M03	IRR	PRESSURE 400	38.3834	41.5	0	16	400	660	0	-362	-622	YES	8/22/1993	12/18/2017	CSIP-SUPP	TRUE		TRUE	

MCWRA Water Level Wells

Fac_Code	State Well No.	Well Type	Aquifer Assignment	Reference Point (RP)	RP Elevation ft NAVD88	Depth (ft)	Dia (in)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev_Well_Btm	Elev Top of Screen	Elev Bottom of Screen	WQ Program	Data Start	Data Stop	Status	Annual	Monthly	August Trough	Transducer
~~14455~~	~~14S/02E-12B02~~	~~MON~~	~~EAST SIDE SHALLOW~~	~~42.3181~~	~~52.8~~	~~265~~	~~2~~	~~210~~	~~260~~	~~-223~~	~~-168~~	~~-218~~	~~YES~~	~~8/22/1993~~	~~12/31/2017~~	~~CSIP-MON~~				~~TRUE~~
14456	14S/02E-12B03	MON	EAST SIDE DEEP	42.554	53.2	390	2	350	380	-346	-306	-336	YES	8/22/1993	12/31/2017	CSIP-MON				TRUE
1636	14S/02E-12L02	IRR	PRESSURE 400	35.7603	40.8	0	12	435	580	0	-399	-544		8/22/1993	12/21/2017	CSIP-SBI	TRUE			
~~1707~~	~~14S/02E-12Q01~~	~~DOM~~	~~PRESSURE 400~~	~~62~~	~~64~~	~~0~~	~~16~~	~~273~~	~~292~~	~~0~~	~~-211~~	~~-230~~		~~11/30/1931~~	~~6/15/2018~~	~~CSIP-DOM~~	~~TRUE~~	~~TRUE~~		
10208	14S/02E-13B02	DOM	PRESSURE 180	42.1136	60.6	208	8	160	200	-166	-118	-158		6/27/1974	12/21/2017	UNKNOWN	TRUE		TRUE	
14468	14S/02E-13F02	MON	PRESSURE 400	42.1139	44.6	480	2	420	470	-438	-378	-428	YES	8/22/1993	6/15/2018	ACTIVE	TRUE	TRUE	TRUE	
14469	14S/02E-13F03	MON	PRESSURE 180	42.1139	44.8	280	2	230	270	-238	-188	-228	YES	8/22/1993	6/15/2018	ACTIVE	TRUE	TRUE	TRUE	
1460	14S/02E-14L03	IRR	PRESSURE 400	22.4311	26	0	16	332	612	0	-310	-590		8/22/1993	11/22/2016	CSIP-SUPP			TRUE	
1055	14S/02E-15A01	IRR	PRESSURE 400	22.4311	24.9	623	14	386	608	-601	-364	-586	YES	8/22/1982	12/18/2017	CSIP-SUPP	TRUE		TRUE	
1324	14S/02E-15C02	IRR	PRESSURE 400	35.1969	25	550	16	328	550	-515	-293	-515	YES	8/20/1989	8/21/2017	CSIP-SUPP			TRUE	
2662	14S/02E-15K01	IRR	PRESSURE 400	26.2303	31.6	0	16	300	600	0	-274	-574		12/9/1994	12/18/2017	CSIP-ABAN	TRUE		TRUE	
14501	14S/02E-15L02	DOM	PRESSURE 180	44	46.5	201	14	148	195	-157	-104	-151	YES	2/18/2015	2/15/2018	ACTIVE	TRUE	TRUE	TRUE	
861	14S/02E-15P01	IRR	PRESSURE 400	44.8254	30.3	595	10	416	555	-550	-371	-510	YES	12/6/1978	12/18/2017	CSIP-SBA	TRUE		TRUE	
353	14S/02E-16A02	IRR	PRESSURE 400	24.4805	21.2	669	12	430	618	-645	-406	-594	YES	12/12/1984	12/18/2017	CSIP-SBA	TRUE		TRUE	
2699	14S/02E-16G01	IRR	PRESSURE 400	22.285	16.6	0	22	330	600	0	-308	-578		8/29/1999	8/14/2016	CSIP-SUPP			TRUE	
2718	14S/02E-17B03	IRR	PRESSURE 400	7.27433	19.3	615	22	330	600	-608	-323	-593		8/29/1999	8/19/2017	CSIP-SUPP			TRUE	
21667	14S/02E-17C02	DOM	PRESSURE 180	54.5	55.5	140	5	80	140	-85	-25	-85	YES	2/17/2015	6/15/2018	ACTIVE	TRUE	TRUE	TRUE	
14530	14S/02E-20B01	IND	PRESSURE 180	103	0	350	10	0	0	-247	0	0				ACTIVE		TRUE		
14531	14S/02E-20B02	IND	PRESSURE 180	116	0	350	10	0	0	-234	0	0				ACTIVE		TRUE		
2784	14S/02E-21F02	IRR	PRESSURE 180	32.8	33.8	300	12	200	261	-267	-167	-228		8/27/2000	12/20/2017	INACTIVE	TRUE		TRUE	
862	14S/02E-21L01	IRR	PRESSURE 180	27.1	28.1	0	0	175	270	0	-148	-243	YES	3/22/1961	12/20/2017	ACTIVE	TRUE		TRUE	
2791	14S/02E-21N01	IRR	PRESSURE 400	138.237	140	600	16	438	580	-462	-300	-442		8/27/2000	8/19/2017	ABAN			TRUE	
24033	14S/02E-22A03	IRR	PRESSURE DEEP ZONE	28	29	1640	16	980	1640	-1612	-952	-1612	YES	4/21/2016	4/20/2018	ACTIVE		TRUE		
2307	14S/02E-22B01	IRR	PRESSURE 400	31.5596	31.8	670	16	410	670	-638	-378	-638	YES	8/22/1993	8/21/2017	CSIP-SUPP			TRUE	
1965	14S/02E-22L01	IRR	PRESSURE 400	22.4311	21.9	680	16	420	680	-658	-398	-658	YES	8/22/1993	12/20/2017	CSIP-SUPP	TRUE		TRUE	
766	14S/02E-22P02	IRR	PRESSURE 180	28.6895	28.2	304	16	253	304	-275	-224	-275	YES	8/10/1952	12/21/2017	ACTIVE	TRUE		TRUE	
21550	14S/02E-23A02	IRR	PRESSURE 400	32.2736	33.9	702	12	518	572	-670	-486	-540		8/29/1999	12/18/2017	ACTIVE	TRUE		TRUE	
2796	14S/02E-23F50	IRR	PRESSURE 400	32	33.6	680	16	430	530	-648	-398	-498		12/9/2013	12/18/2017	ACTIVE	TRUE		TRUE	
11082	14S/02E-24J01	KNOWN WATER	U PRESSURE 180	43.714	40	0	10	0	0	0	0	0		12/13/1974	12/18/2017	ABAN	TRUE		TRUE	
10229	14S/02E-24Q01	DOM	PRESSURE 180	42.1161	45.394	0	0	0	0	0	0	0	YES			ACTIVE	TRUE			
22651	14S/02E-26H01	MON	PRESSURE 180	35.4	35	339.3	3	287	337	-304	-252	-302	YES	7/3/2003	12/31/2017	ACTIVE				TRUE
113	14S/02E-26J03	IRR	PRESSURE 400	35.5544	30.5	552	16	330	552	-516	-294	-516	YES	12/5/1978	12/20/2017	ACTIVE	TRUE		TRUE	
10234	14S/02E-26P01	DOM	PRESSURE 180	35.5544	29	0	12	0	0	0	0	0	YES	10/13/1931	12/20/2017	ACTIVE	TRUE		TRUE	
22632	14S/02E-27A01	MON	PRESSURE 180	22.4	22	293	3	240	290	-271	-218	-268	YES	2/12/2004	12/31/2017	ACTIVE				TRUE
717	14S/02E-27F02	IRR	PRESSURE 180	29	30.5	354	12	258	338	-325	-229	-309	YES	12/21/2017	12/21/2017	ACTIVE	TRUE			
10235	14S/02E-27G02	DOM	PRESSURE 180	28.9927	31.2	0	12	0	0	0	0	0		10/20/1944	12/20/2017	UNKNOWN	TRUE		TRUE	
1861	14S/02E-27G03	IRR	PRESSURE 400	28.9927	26	0	16	276	368	0	-247	-339		12/13/1984	12/20/2017	ACTIVE	TRUE			
23135	14S/02E-28C02	IRR	PRESSURE DEEP ZONE	40.8884	45	1160	9	720	1140	-1119	-679	-1099	YES	8/24/2008	5/18/2018	ACTIVE	TRUE	TRUE	TRUE	
22929	14S/02E-28H04	IRR	PRESSURE DEEP ZONE	26.7	23	1180	9	940	1030	-1153	-913	-1003	YES	8/27/2006	5/18/2018	ACTIVE	TRUE	TRUE	TRUE	
21699	14S/02E-32D06	IND	PRESSURE 400	136.999	137.5	330	8	250	330	-193	-113	-193	YES	8/27/2000	8/19/2017	ACTIVE			TRUE	
26313	14S/02E-33E01	MON	PRESSURE DEEP ZONE	143	143	1095	2	1045	1095	-952	-902	-952	YES	1/30/2014	2/7/2018	ACTIVE				TRUE
26314	14S/02E-33E02	MON	PRESSURE DEEP ZONE	143	143	1760	3	1680	1760	-1617	-1537	-1617	YES	1/30/2014	2/7/2018	ACTIVE				TRUE
1060	14S/02E-34A03	IRR	PRESSURE 400	31	32.5	670	16	490	670	-639	-459	-639	YES	1/19/1995	6/19/2018	ACTIVE	TRUE	TRUE	TRUE	
1212	14S/02E-34B03	IRR	PRESSURE 180	32.2736	30.7	346	0	306	344	-314	-274	-312	YES	12/9/1971	12/20/2017	ACTIVE	TRUE		TRUE	
1098	14S/02E-35L02	IRR	PRESSURE 400	35.5544	29	0	14	336	428	0	-300	-392		11/15/1957	12/20/2017	ACTIVE	TRUE		TRUE	
331	14S/02E-36E01	IRR	PRESSURE 180	35.5544	32.5	198	12	0	0	-162	0	0	YES	11/30/1944	12/20/2017	INACTIVE	TRUE		TRUE	
370	14S/02E-36G01	IRR	PRESSURE 400	38.8352	35	416	12	336	410	-377	-297	-371	YES	3/27/1961	12/20/2017	ACTIVE	TRUE			
24651	14S/03E-05L01	IRR	EAST SIDE DEEP	124	126	770	17	410	750	-646	-286	-626		12/12/2012	12/22/2017	ACTIVE	TRUE			
25733	14S/03E-06F01	IRR	EAST SIDE DEEP	81	82.5	0	0	0	0	0	0	0	YES	12/21/2017	12/21/2017	ACTIVE	TRUE			
10254	14S/03E-06L01	DOM	EAST SIDE SHALLOW	81.486	78	402	16	0	0	-321	0	0		11/15/1945	12/21/2017	UNKNOWN	TRUE		TRUE	
920	14S/03E-06L02	IRR	EAST SIDE BOTH	82.3369	81	654	14	210	620	-572	-128	-538		3/18/1957	12/21/2017	INACTIVE	TRUE		TRUE	
901	14S/03E-06R01	IRR	EAST SIDE SHALLOW	91.2	91.9	0	12	0	0	0	0	0		11/18/1931	6/15/2018	ACTIVE	TRUE	TRUE	TRUE	
1167	14S/03E-07A01	IRR	EAST SIDE SHALLOW	91.3285	90.5	0	14	184	325	0	-93	-234		11/28/1944	12/21/2017	ACTIVE	TRUE		TRUE	
867	14S/03E-08C01	IRR	EAST SIDE BOTH	111.014	109.5	0	16	0	0	0	0	0		11/28/1944	12/22/2017	INACTIVE	TRUE			
15009	14S/03E-18C01	MON	PRESSURE 180	51.844	52.1	225	2	165	215	-173	-113	-163	YES	8/22/1993	12/31/2017	ACTIVE				TRUE
15010	14S/03E-18C02	MON	PRESSURE 400	51.844	52.2	395	2	270	385	-343	-218	-333	YES	8/22/1993	12/31/2017	CSIP-MON				TRUE
2315	14S/03E-18E03	MON	PRESSURE 180	68.3174	69.8	260	2	230	250	-192	-162	-182	YES	3/17/1994	6/15/2018	ACTIVE	TRUE	TRUE	TRUE	
15014	14S/03E-18E04	MON	PRESSURE 400	68.3174	69.9	495	2	335	485	-427	-267	-417	YES	11/17/1993	6/15/2018	ACTIVE	TRUE	TRUE	TRUE	
23134	14S/03E-19C51		PRESSURE 400	68.5	69.5	614	16	498	570	-545	-429	-501		12/13/2013	12/21/2017	ACTIVE	TRUE			
10269	14S/03E-19G01	IRR	PRESSURE 180	57.8266	56	277	12	0	0	-219	0	0		11/19/1931	12/21/2017	ABAN	TRUE		TRUE	
876	14S/03E-19Q02	IRR	PRESSURE 180	51.9757	45.3	0	12	0	0	0	0	0	YES	11/29/1944	12/21/2017	ACTIVE	TRUE		TRUE	
625	14S/03E-30F01	IRR	PRESSURE 180	42	42	0	0	0	0	0	0	0	YES	12/20/2017	12/20/2017	ACTIVE	TRUE			
22650	14S/03E-30G08	MON	PRESSURE 180	42.1	41.6	293	3	240	290	-251	-198	-248	YES	10/23/2003	12/31/2017	ACTIVE				TRUE
1539	14S/03E-30N01	IRR	PRESSURE 180	42.1161	40.9	205	20	0	0	-163	0	0		12/6/1944	12/20/2017	ACTIVE	TRUE		TRUE	
10280	14S/03E-31F01	DOM	PRESSURE 180	42.1161	37.8	201	12	0	0	-159	0	0	`	10/14/1931	6/19/2018	ABAN	TRUE	TRUE	TRUE	
1794	14S/03E-31F02	DOM/IRR	PRESSURE 400	37.2	38.8	0	16	337	459	0	-300	-422	YES	3/13/1959	6/25/2018	ACTIVE	TRUE	TRUE	TRUE	

MCWRA Water Level Wells

Fac_Code	State Well No.	Well Type	Aquifer Assignment	Reference Point (RP)	RP Elevation ft NAVD88	Depth (ft)	Dia (in)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev_Well_Btm	Elev Top of Screen	Elev Bottom of Screen	WQ Program	Data Start	Data Stop	Status	Annual	Monthly	August Trough	Transducer
1357	15S/02E-01A03	IRR	PRESSURE 400	38.8352	36	0	14	366	475	0	-327	-436		12/5/1960	12/22/2017	ACTIVE	TRUE			
888	15S/02E-02G01	IRR	PRESSURE 400	32.2736	30	0	16	300	400	0	-268	-368		3/25/1955	12/21/2017	ACTIVE	TRUE		TRUE	
772	15S/02E-03C01	IRR	PRESSURE 180	39	40	180	12	0	0	-141	0	0	YES	12/21/2017	12/21/2017	ACTIVE	TRUE			
21354	15S/02E-04A01	MON	FORT ORD	192	194	446	2.5	420	446	-254	-228	-254		1/18/2017	6/18/2018	ACTIVE	TRUE	TRUE		
21355	15S/02E-04A02	MON	FORT ORD	192	194	610	2.5	590	610	-418	-398	-418		1/18/2017	6/18/2018	ACTIVE	TRUE	TRUE		
21356	15S/02E-04A03	MON	PRESSURE DEEP ZONE	192	194	910	2.5	890	910	-718	-698	-718	YES	1/18/2017	6/18/2018	ACTIVE	TRUE	TRUE		
197	15S/02E-12A01	IRR	PRESSURE 400	42.1161	43	0	16	398	507	0	-356	-465		12/5/1960	11/30/2016	ACTIVE	TRUE			
1070	15S/02E-12C01	IRR	PRESSURE 180	37.2	38.2	182	12	0	0	-145	0	0	YES	11/30/1944	12/21/2017	ACTIVE	TRUE			
1795	15S/03E-06D02	IRR	PRESSURE 400	38.8352	35	0	16	377	483	0	-338	-444		3/13/1959	8/19/2017	ACTIVE	TRUE		TRUE	
22928	13S/02E-28L03	IRR	PRESSURE DEEP ZONE	12.1511	0	1460	0	350	1080	-1448	-338	-1068	YES	1/1/2018	1/1/2018	ACTIVE	TRUE		TRUE	

MCWRA Water Quality Wells

Fac_Code	State Well No.	Well Type	RP Elevation ft NAVD88	RP Height (ft above GS)	Aquifer Assignment	Depth (ft)	Dia (in)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev_Well_Bt m	Elev Top of Screen	Elev Bottom of Screen	WL Program	Data Start	Data Stop	Status
22656	14S/03E-07P50	IRR	71.8647	0	EAST SIDE DEEP	1140	16	510	1125	-1068	-438	-1053		7/20/2011	8/7/2017	ACTIVE
1698	14S/03E-07K51	IRR	38.0975	0	EAST SIDE DEEP	600	16	400	600	-562	-362	-562		7/20/2011	8/9/2017	ACTIVE
14456	14S/02E-12B03	MON	43.554	53.2	EAST SIDE DEEP	390	2	350	380	-346	-306	-336	YES	10/6/1994	10/10/2017	CSIP-MON
214	14S/03E-07D50	IRR	74.9244	0	EAST SIDE DEEP	600	12	400	460	-525	-325	-385		11/14/2002	8/9/2017	ACTIVE
25733	14S/03E-06F01	IRR	81	82.5	EAST SIDE DEEP	0	0	0	0	0	0	0	YES	7/14/2015	8/29/2017	ACTIVE
1715	14S/02E-01C01	IRR	68.9531	64.4	EAST SIDE DEEP	0	0	350	591	0	-281	-522	YES	8/30/1994	8/4/2016	CSIP-SUPP
1706	14S/02E-02A02	IRR	53.6858	54.8	EAST SIDE DEEP	0	16	360	810	0	-306	-756	YES	7/20/1995	6/28/2017	CSIP-SUPP
22687	13S/02E-36F50	IRR	57.9962	0	EAST SIDE DEEP	660	16	410	510	-602	-352	-452		7/15/2011	8/14/2017	ACTIVE
14455	14S/02E-12B02	MON	42.3181	52.8	EAST SIDE SHALLOW	265	2	210	260	-223	-168	-218	YES	10/6/1994	10/10/2017	CSIP-MON
1012	14S/01E-13J01	MUN	27.0897	0	MARINA	0	0	0	0	0	0	0		8/17/1987	8/25/2017	ACTIVE
21048	13S/02E-15R03	MON	86.5431	0	MORO COJO	205	2	150	200	-118	-63	-113		12/5/1994	9/1/2015	ACTIVE
21047	13S/02E-15R02	MON	86.0105	0	MORO COJO	585	2	530	580	-499	-444	-494		12/5/1994	9/1/2015	ACTIVE
14479	14S/02E-11A03	MON	59.0985	59	PERCHED	100	2	60	90	-41	-1	-31		10/11/1994	9/25/2013	CSIP-MON
1070	15S/02E-12C01	IRR	37.2	38.2	PRESSURE 180	182	12	0	0	-145	0	0	YES	8/11/1971	8/18/2017	ACTIVE
772	15S/02E-03C01	IRR	39	40	PRESSURE 180	180	12	0	0	-141	0	0	YES	8/21/2012	8/31/2017	ACTIVE
331	14S/02E-36E01	IRR	35.5544	32.5	PRESSURE 180	198	12	0	0	-162	0	0	YES	8/29/1973	8/29/2017	INACTIVE
1212	14S/02E-34B03	IRR	32.2736	30.7	PRESSURE 180	346	0	306	344	-314	-274	-312	YES	7/1/1981	9/1/2017	ACTIVE
10234	14S/02E-26P01	DOM	35.5544	29	PRESSURE 180	0	12	0	0	0	0	0	YES	7/1/1980	8/29/2017	ACTIVE
966	14S/02E-26N50	IRR	34.9577	0	PRESSURE 180	0	12	0	0	0	0	0		6/16/2015	6/6/2017	ACTIVE
757	14S/02E-26N03	IRR	34.6596	0	PRESSURE 180	162	8	144	331	-127	-109	-296		7/1/1980	8/29/2017	ACTIVE
22650	14S/03E-30G08	MON	42.1	41.6	PRESSURE 180	293	3	240	290	-251	-198	-248	YES	6/2/2003	10/13/2017	ACTIVE
717	14S/02E-27F02	IRR	29	30.5	PRESSURE 180	354	12	258	338	-325	-229	-309	YES	7/1/1989	8/29/2017	ACTIVE
625	14S/03E-30F01	IRR	42	42	PRESSURE 180	0	0	0	0	0	0	0	YES	7/29/1955	9/1/2017	ACTIVE
22651	14S/02E-26H01	MON	35.4	35	PRESSURE 180	339.3	3	287	337	-304	-252	-302	YES	6/9/2003	10/13/2017	ACTIVE
766	14S/02E-22P02	IRR	28.6895	28.2	PRESSURE 180	304	16	253	304	-275	-224	-275	YES	3/24/1971	8/21/2017	ACTIVE
22632	14S/02E-27A01	MON	22.4	22	PRESSURE 180	293	3	240	290	-271	-218	-268	YES	7/17/2003	10/13/2017	ACTIVE
10229	14S/02E-24Q01	DOM	42.1161	45.394	PRESSURE 180	0	0	0	0	0	0	0	YES	7/1/1957	6/16/2017	ACTIVE
876	14S/03E-19Q02	IRR	51.9757	45.3	PRESSURE 180	0	12	0	0	0	0	0	YES	8/21/1973	8/14/2017	ACTIVE
862	14S/02E-21L01	IRR	27.1	28.1	PRESSURE 180	0	0	175	270	0	-148	-243	YES	7/25/1991	8/29/2017	ACTIVE
14501	14S/02E-15L02	DOM	44	46.5	PRESSURE 180	201	14	148	195	-157	-104	-151	YES	7/1/1988	6/14/2017	ACTIVE
673	14S/02E-13F01	IRR	45.3811	0	PRESSURE 180	0	0	0	0	0	0	0		9/7/1994	6/29/2016	INACTIVE
14469	14S/02E-13F03	MON	42.1139	44.8	PRESSURE 180	280	2	230	270	-238	-188	-228	YES	10/6/1994	10/3/2017	ACTIVE
10212	14S/02E-14L02	DOM	22.4311	34.586	PRESSURE 180	125	6	0	0	-103	0	0		8/11/1987	8/29/2017	ACTIVE
2315	14S/03E-18E03	MON	68.3174	69.8	PRESSURE 180	260	2	230	250	-192	-162	-182	YES	9/14/1994	10/6/2017	ACTIVE
15009	14S/03E-18C01	MON	51.844	52.1	PRESSURE 180	225	2	165	215	-173	-113	-163	YES	10/6/1994	9/27/2016	ACTIVE
21667	14S/02E-17C02	DOM	54.5	55.5	PRESSURE 180	140	5	80	140	-85	-25	-85	YES	9/19/2000	8/18/2017	ACTIVE
20769	14S/03E-07P02	DOM	55.0345	0	PRESSURE 180	296	6	16	296	-241	39	-241		4/11/1994	8/23/2017	ACTIVE
975	14S/02E-12N02	DOM	53.5284	0	PRESSURE 180	0	12	150	290	0	-96	-236		7/7/1993	9/29/2017	CSIP-SBI
14478	14S/02E-11A02	MON	58.5623	59	PRESSURE 180	250	6	190	240	-191	-131	-181	YES	10/11/1994	10/10/2017	CSIP-MON
22636	14S/02E-03F04	MON	22	21.5	PRESSURE 180	205	3	154	204	-183	-132	-182	YES	8/4/2003	10/10/2017	ACTIVE

MCWRA Water Quality Wells

Fac_Code	State Well No.	Well Type	RP Elevation ft NAVD88	RP Height (ft above GS)	Aquifer Assignment	Depth (ft)	Dia (in)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev_Well_Bt m	Elev Top of Screen	Elev Bottom of Screen	WL Program	Data Start	Data Stop	Status
22633	13S/02E-21Q01	MON	10	9.65	PRESSURE 180	157	3	105	155	-147	-95	-145	YES	7/23/2003	10/10/2017	ACTIVE
2318	15S/02E-01Q50	IRR	38.7811	0	PRESSURE 400	524	16	350	518	-485	-311	-479		7/10/2012	8/7/2017	ACTIVE
2410	15S/02E-04A50	MUN	166.733	0	PRESSURE 400	490	16	285	470	-323	-118	-303		6/25/2001	7/12/2005	ACTIVE
25173	15S/02E-03B04	IRR	36.0504	0	PRESSURE 400	540	16	290	520	-504	-254	-484		7/12/2012	8/29/2017	ACTIVE
2409	14S/02E-33Q01	MUN	154.126	0	PRESSURE 400	552	16	315	535	-398	-161	-381		6/25/2001	7/12/2005	ACTIVE
1794	14S/03E-31F02	DOM/IRR	37.2	38.8	PRESSURE 400	0	16	337	459	0	-300	-422	YES	6/14/1977	8/7/2017	ACTIVE
370	14S/02E-36G01	IRR	38.8352	35	PRESSURE 400	416	12	336	410	-377	-297	-371	YES	8/5/1969	8/9/2017	ACTIVE
24834	14S/02E-36F03	IRR	38.8352	0	PRESSURE 400	602	16	420	532	-563	-381	-493		7/26/2012	9/1/2017	ACTIVE
1060	14S/02E-34A03	IRR	31	32.5	PRESSURE 400	670	16	490	670	-639	-459	-639	YES	6/29/1995	8/31/2017	ACTIVE
21699	14S/02E-32D06	IND	136.999	137.5	PRESSURE 400	330	8	250	330	-193	-113	-193	YES	7/17/2000	8/23/2017	ACTIVE
1072	14S/02E-34A04	IRR	32.2736	0	PRESSURE 400	352	14	286	326	-320	-254	-294		7/24/2002	9/1/2017	ACTIVE
113	14S/02E-26J03	IRR	35.5544	30.5	PRESSURE 400	552	16	330	552	-516	-294	-516	YES	7/1/1980	8/7/2017	ACTIVE
1542	14S/03E-30E03	IRR	40.2948	0	PRESSURE 400	0	14	337	385	0	-297	-345		6/14/1977	8/31/2017	ACTIVE
22746	14S/02E-25D51	IRR	32.2736	0	PRESSURE 400	700	12	340	622	-668	-308	-590		7/26/2013	8/7/2017	ACTIVE
446	14S/02E-26C50	IRR	32.2736	0	PRESSURE 400	594	16	410	570	-562	-378	-538		7/19/2011	9/1/2017	ACTIVE
24833	14S/02E-22R01	IRR	28.1413	0	PRESSURE 400	672	0	606	672	-644	-578	-644		7/26/2012	8/29/2017	ACTIVE
1282	14S/02E-24P02	IRR	42.106	0	PRESSURE 400	454	16	333	420	-412	-291	-378		7/1/1980	8/9/2017	ACTIVE
1965	14S/02E-22L01	IRR	22.4311	21.9	PRESSURE 400	680	16	420	680	-658	-398	-658	YES	9/1/1994	6/28/2017	CSIP-SUPP
886	14S/02E-24E01	IRR	33.8163	0	PRESSURE 400	0	12	284	458	0	-250	-424		7/29/1955	8/14/2017	ACTIVE
2307	14S/02E-22B01	IRR	31.5596	31.8	PRESSURE 400	670	16	410	670	-638	-378	-638	YES	8/23/1994	9/29/2017	CSIP-SUPP
14491	14S/02E-14N03	IRR	25.7119	0	PRESSURE 400	590	0	400	590	-564	-374	-564		7/1/1991	8/12/2016	ACTIVE
859	14S/02E-15N01	IRR	22.4311	0	PRESSURE 400	552	14	309	464	-530	-287	-442		6/14/2001	8/29/2017	CSIP-SBA
861	14S/02E-15P01	IRR	44.8254	30.3	PRESSURE 400	595	10	416	555	-550	-371	-510	YES	7/1/1980	9/1/2017	CSIP-SBA
23107	14S/02E-14R50	IRR	49.8922	0	PRESSURE 400	690	16	472	592	-640	-422	-542		6/20/2016	9/1/2017	ACTIVE
1032	14S/01E-13J02	MUN	31.1715	41	PRESSURE 400	506	14	400	506	-475	-369	-475		8/30/1972	6/10/2016	ACTIVE
14468	14S/02E-13F02	MON	42.1139	44.6	PRESSURE 400	480	2	420	470	-438	-378	-428	YES	10/6/1994	10/3/2017	ACTIVE
22828	14S/02E-13E50	IRR	43.7706	0	PRESSURE 400	596	16	506	596	-552	-462	-552		7/7/2011	8/29/2017	ACTIVE
15014	14S/03E-18E04	MON	68.3174	69.9	PRESSURE 400	495	2	335	485	-427	-267	-417	YES	10/11/1994	10/6/2017	ACTIVE
43	14S/02E-14A01	IRR	43.4804	0	PRESSURE 400	532	20	472	550	-489	-429	-507		12/1/1999	8/14/2014	CSIP-SUPP
15010	14S/03E-18C02	MON	51.844	52.2	PRESSURE 400	395	2	270	385	-343	-218	-333	YES	10/6/1994	10/6/2017	CSIP-MON
353	14S/02E-16A02	IRR	24.4805	21.2	PRESSURE 400	669	12	430	618	-645	-406	-594	YES	9/7/1994	7/23/2015	CSIP-SBA
1055	14S/02E-15A01	IRR	22.4311	24.9	PRESSURE 400	623	14	386	608	-601	-364	-586	YES	7/1/1982	9/29/2017	CSIP-SUPP
1324	14S/02E-15C02	IRR	35.1969	25	PRESSURE 400	550	16	328	550	-515	-293	-515	YES	9/8/1994	6/18/2015	CSIP-SUPP
2419	14S/02E-09N02	IRR	19.1404	0	PRESSURE 400	622	16	408	622	-603	-389	-603		7/9/2001	6/30/2017	CSIP-SBA
659	14S/02E-10N51	IRR	22.4311	0	PRESSURE 400	580	20	416	558	-558	-394	-536		6/18/2015	8/18/2017	CSIP-SBA
780	14S/02E-10M02	IRR	21.295	0	PRESSURE 400	585	16	330	545	-564	-309	-524		7/1/1989	6/30/2017	CSIP-SBA
1705	14S/02E-11M03	IRR	38.3834	41.5	PRESSURE 400	0	16	400	660	0	-362	-622	YES	8/30/1994	6/28/2017	CSIP-SUPP
19	14S/02E-10E02	IRR	25	25.5	PRESSURE 400	717	16	298	660	-692	-273	-635	YES	8/22/1994	1/30/2014	CSIP-SUPP
1704	14S/02E-10H01	IRR	22.4311	0	PRESSURE 400	640	14	440	640	-618	-418	-618		7/1/1991	9/29/2017	CSIP-SUPP
1466	14S/02E-08C03	IRR	15.4784	16.4	PRESSURE 400	556	16	395	540	-541	-380	-525	YES	7/1/1981	6/23/2017	CSIP-SBA

MCWRA Water Quality Wells

Fac_Code	State Well No.	Well Type	RP Elevation ft NAVD88	RP Height (ft above GS)	Aquifer Assignment	Depth (ft)	Dia (in)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev_Well_Btm	Elev Top of Screen	Elev Bottom of Screen	WL Program	Data Start	Data Stop	Status
1464	14S/02E-09D03	IRR	15.859	0	PRESSURE 400	542	16	401	478	-526	-385	-462		9/9/1994	8/21/2017	CSIP-SBA
2437	14S/02E-11B01	IRR	49.9193	0	PRESSURE 400	0	16	466	546	0	-416	-496		8/30/1994	9/29/2017	CSIP-SUPP
2659	14S/02E-09D04	IRR	12.9416	17	PRESSURE 400	610	22	350	600	-597	-337	-587	YES	4/27/1996	9/29/2017	CSIP-SUPP
14480	14S/02E-11A04	MON	59.0731	58.9	PRESSURE 400	490	6	450	480	-431	-391	-421	YES	10/11/1994	10/10/2017	CSIP-MON
1534	14S/02E-05R03	IRR	12.5787	0	PRESSURE 400	0	16	385	648	0	-372	-635		7/23/2013	6/6/2017	CSIP-SBA
944	14S/02E-03R02	IRR	22.0328	0	PRESSURE 400	638	20	552	572	-616	-530	-550		8/24/1994	9/29/2017	CSIP-SUPP
22833	14S/02E-03P01	IRR	12.5886	0	PRESSURE 400	614	16	478	602	-601	-465	-589		8/2/2007	9/1/2017	CSIP-SBA
1851	14S/02E-03M02	IRR	12.5886	17.3	PRESSURE 400	590	12	400	570	-577	-387	-557	YES	7/1/1981	8/29/2017	CSIP-SBA
1849	14S/02E-04H01	IRR	12.5748	18	PRESSURE 400	0	16	418	487	0	-405	-474	YES	9/9/1992	8/21/2017	CSIP-SBA
22635	14S/02E-03F03	MON	26	25.5	PRESSURE 400	455	3	420	450	-429	-394	-424	YES	8/12/2003	10/10/2017	ACTIVE
1685	14S/02E-03H01	IRR	44.7276	41.7	PRESSURE 400	800	16	350	800	-755	-305	-755	YES	9/6/1994	9/29/2017	CSIP-SUPP
1162	14S/02E-05C03	IRR	12.674	13.4	PRESSURE 400	580	16	300	565	-567	-287	-552	YES	8/25/1989	8/31/2017	CSIP-SBI
1716	14S/02E-02C03	IRR	67.5192	60.4	PRESSURE 400	0	16	393	832	0	-325	-764	YES	8/24/1994	9/29/2017	CSIP-SUPP
2447	13S/02E-34M01	MUN	22.2545	23	PRESSURE 400	630	16	370	610	-608	-348	-588	YES	2/7/2001	8/31/2017	ACTIVE
2445	13S/02E-34G01	MUN	50.5753	52.3	PRESSURE 400	765	12	410	725	-714	-359	-674	YES	2/7/2001	8/31/2017	ACTIVE
22801	13S/02E-35H01	IRR	14	15	PRESSURE 400	440	16	320	440	-426	-306	-426	YES	7/7/2011	8/14/2017	ACTIVE
2455	13S/02E-28M02	IRR	11.7787	0	PRESSURE 400	0	12	310	760	0	-298	-748		7/1/1987	9/1/2017	CSIP-SBA
2697	13S/02E-20J01	DOM/IRR	14.68	20	PRESSURE 400	0	0	0	0	0	0	0	YES	7/1/1956	9/1/2017	CSIP-DOM
521	13S/02E-15M01	DOM	74.0322	0	PRESSURE 400	1014	12	400	850	-940	-326	-776		8/6/1982	6/14/2017	ACTIVE
2408	15S/02E-04C01	MUN	173.532	0	PRESSURE BOTH	557	16	315	535	-383	-141	-361		6/25/2001	7/12/2005	ACTIVE
104	14S/02E-27C02	IRR	28.9927	0	PRESSURE BOTH	488	16	279	454	-459	-250	-425		7/1/1989	6/6/2017	ACTIVE
1687	14S/02E-13G01	IRR	49.3461	0	PRESSURE BOTH	0	14	170	655	0	-121	-606		8/7/1995	8/7/2017	ACTIVE
2446	13S/02E-28L02	MUN	19.0063	16.5	PRESSURE BOTH	600	12	228	600	-581	-209	-581	YES	2/7/2001	8/31/2017	ACTIVE
21356	15S/02E-04A03	MON	192	194	PRESSURE DEEP ZONE	910	2.5	890	910	-718	-698	-718	YES			ACTIVE
2453	14S/02E-31H01	MUN	159.719	144	PRESSURE DEEP ZONE	1550	16	930	1080	-1390	-770	-920		7/7/1999	7/12/2005	ACTIVE
26314	14S/02E-33E02	MON	143	143	PRESSURE DEEP ZONE	1760	3	1680	1760	-1617	-1537	-1617	YES			ACTIVE
26313	14S/02E-33E01	MON	143	143	PRESSURE DEEP ZONE	1095	2	1045	1095	-952	-902	-952	YES			ACTIVE
2452	14S/02E-32D04	MUN	147.439	140	PRESSURE DEEP ZONE	1660	30	970	1650	-1513	-823	-1503		7/7/1999	7/12/2005	ACTIVE
22929	14S/02E-28H04	IRR	26.7	23	PRESSURE DEEP ZONE	1180	9	940	1030	-1153	-913	-1003	YES	8/10/2007	8/9/2017	ACTIVE
2451	14S/02E-30G03	MUN	110.001	112	PRESSURE DEEP ZONE	1950	16	1390	1700	-1840	-1280	-1590		7/7/1999	7/12/2005	ACTIVE
25973	14S/02E-29C01		127.78	0	PRESSURE DEEP ZONE	1780	18	1030	1780	-1652	-902	-1652		6/10/2016	8/29/2017	ACTIVE
23135	14S/02E-28C02	IRR	40.8884	45	PRESSURE DEEP ZONE	1160	9	720	1140	-1119	-679	-1099	YES	6/19/2009	8/18/2017	ACTIVE
26127	14S/02E-21L02	IRR	43.6118	0	PRESSURE DEEP ZONE	1780	0	1240	1780	-1736	-1196	-1736				ACTIVE
22274	14S/01E-24L02	MON	55	57.4	PRESSURE DEEP ZONE	1880	2	1820	1860	-1825	-1765	-1805	YES	10/2/2001	8/15/2003	ACTIVE
22275	14S/01E-24L03	MON	55	58.4	PRESSURE DEEP ZONE	1430	2	1410	1430	-1375	-1355	-1375	YES	6/1/2001	8/15/2003	ACTIVE
22276	14S/01E-24L04	MON	55	57.7	PRESSURE DEEP ZONE	1080	2	1040	1060	-1025	-985	-1005	YES	10/8/2001	8/18/2003	ACTIVE
22277	14S/01E-24L05	MON	55	57.9	PRESSURE DEEP ZONE	970	2	930	950	-915	-875	-895	YES	6/1/2001	8/18/2003	ACTIVE
21655	14S/02E-20B03	IND	103.493	0	PRESSURE DEEP ZONE	825	22	670	805	-722	-567	-702		8/7/2001	6/6/2017	ACTIVE
24033	14S/02E-22A03	IRR	28	29	PRESSURE DEEP ZONE	1640	16	980	1640	-1612	-952	-1612	YES	7/20/2011	8/29/2017	ACTIVE
22755	14S/02E-07J03	IND	24.5604	0	PRESSURE DEEP ZONE	1573	12	1450	1570	-1548	-1425	-1545		6/24/2005	8/29/2017	CSIP-COM/IND

MCWRA Water Quality Wells

Fac_Code	State Well No.	Well Type	RP Elevation ft NAVD88	RP Height (ft above GS)	Aquifer Assignment	Depth (ft)	Dia (in)	Top of Screen Interval (ft below GS)	Bottom of Screen Interval (ft below GS)	Elev_Well_Bt m	Elev Top of Screen	Elev Bottom of Screen	WL Program	Data Start	Data Stop	Status
22681	13S/01E-36J02	DOM	22.1	23	PRESSURE DEEP ZONE	1364	8	1301	1361	-1342	-1279	-1339	YES	7/1/2004	8/25/2017	ACTIVE
2430	13S/02E-32M02	IRR	7.94783	0	PRESSURE DEEP ZONE	1630	12	780	1590	-1622	-772	-1582		9/20/1988	6/28/2001	CSIP-SBI
10164	13S/02E-32E05	OB	7.89071	18.8	PRESSURE DEEP ZONE	1610	8	775	1585	-1602	-767	-1577	YES			DEEP faci
1153	13S/02E-31A02	IRR	7.1	9.1	PRESSURE DEEP ZONE	0	16	850	1600	0	-843	-1593	YES	7/1/1987	8/18/2017	CSIP-SBA
2261	13S/01E-25R01	DOM	26.8904	0	PRESSURE DEEP ZONE	1393	6	1323	1383	-1366	-1296	-1356		7/1/1992	8/25/2017	ACTIVE
22928	13S/02E-28L03	IRR	12.1511	0	PRESSURE DEEP ZONE	1460	0	350	1080	-1448	-338	-1068	YES			ACTIVE
75	13S/02E-19Q03	IRR	12.9859	18	PRESSURE DEEP ZONE	1562	12	1220	1550	-1549	-1207	-1537	YES	10/16/1981	8/25/2017	CSIP-DOM

APPENDIX D
INDUCTION LOGGING

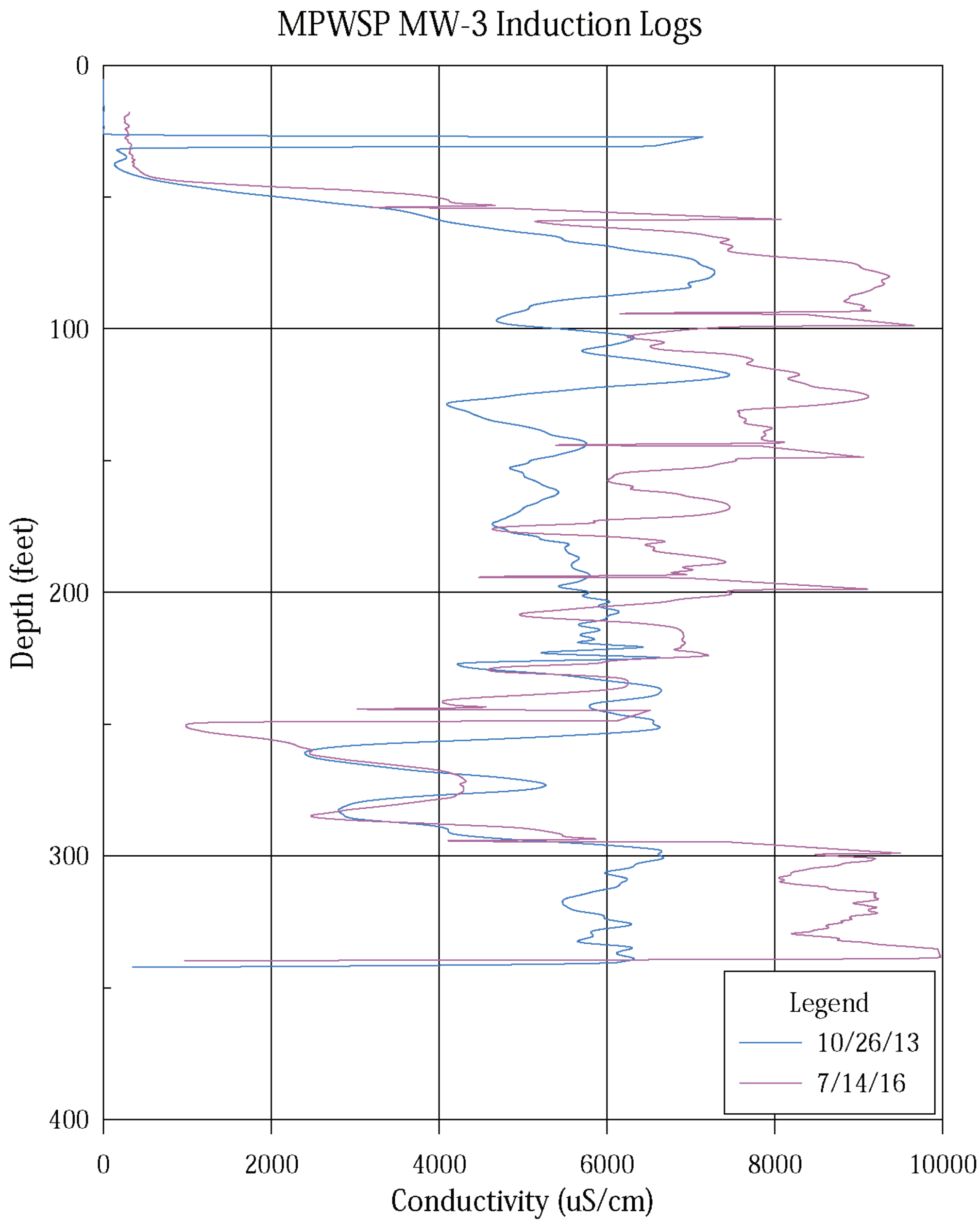
This appendix is presented to provide additional background on induction logging and its application in detecting changes in groundwater quality. The following are presented:

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.

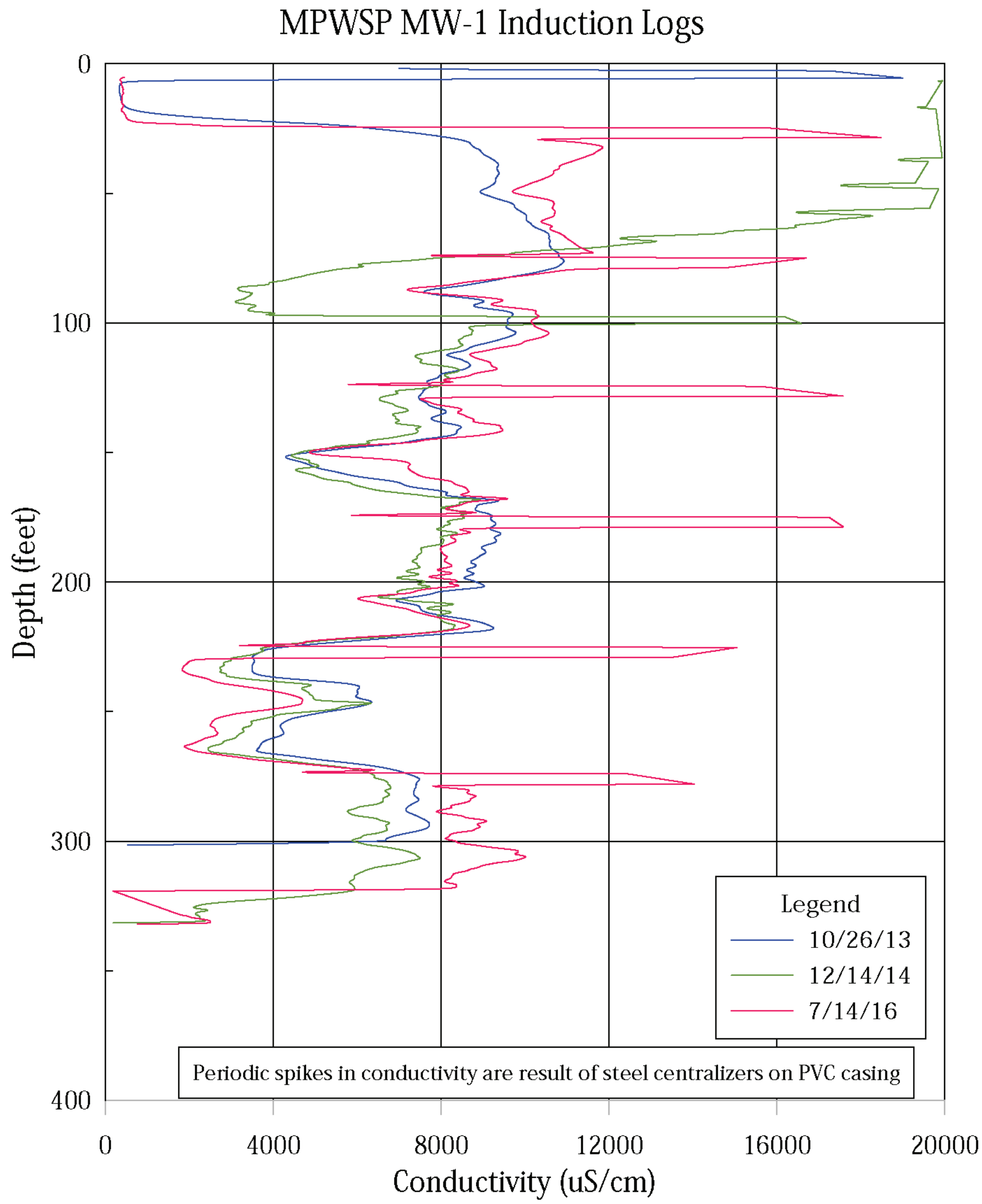
2. The cumulative results of the on-going induction logging program of the Seaside Basin Watermaster's four Sentinel Wells located in coastal Fort Ord. This program court-ordered involves semi-annual induction logging for purposes of detecting seawater intrusion. The Sentinel Wells are approximately 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.

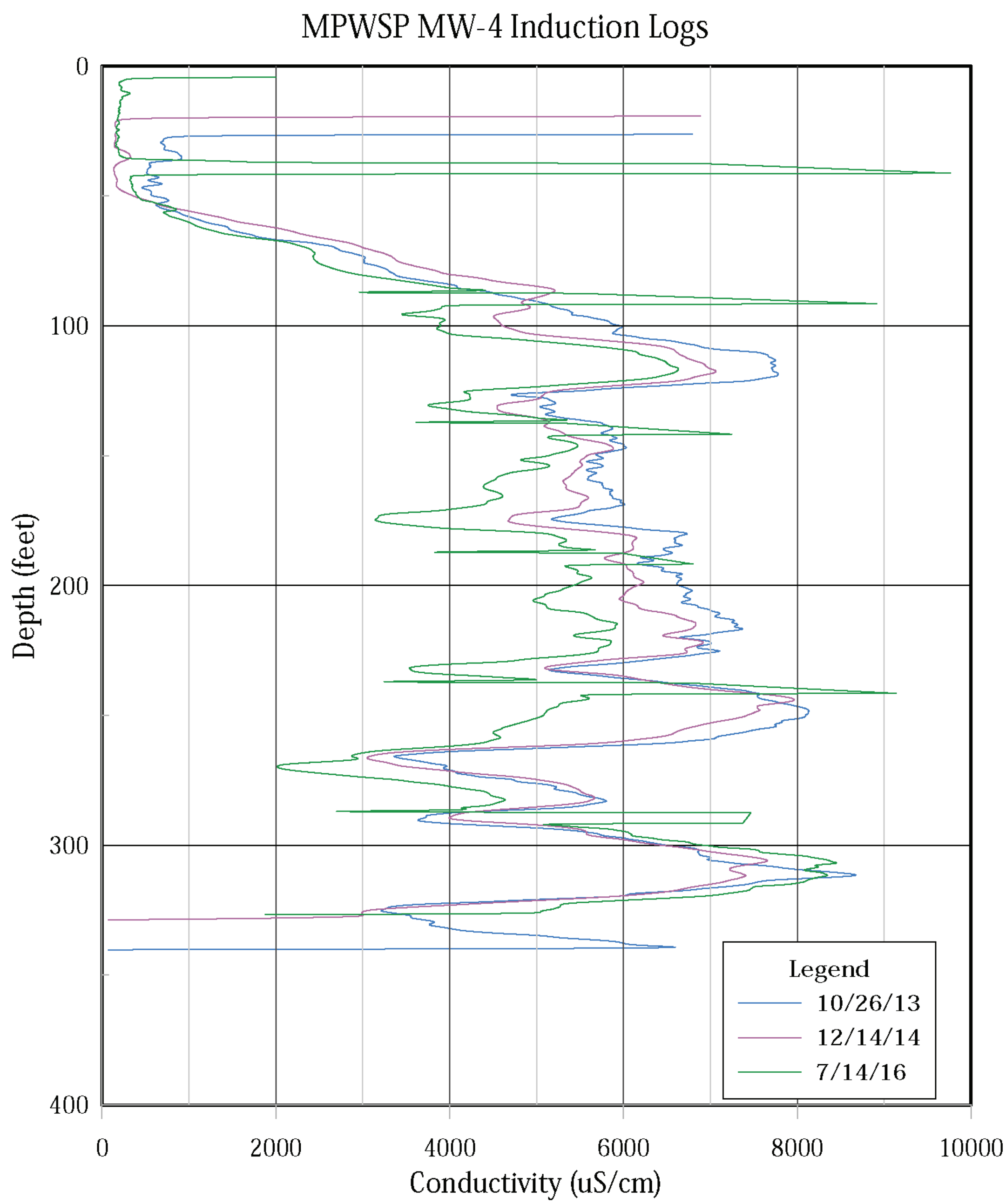
4. A recent paper from Ground Water Magazine detailing the use of induction logging in the Stockton Area. *Electromagnetic-Induction Logging to Monitor Changing Chloride Concentrations, Loren Metzer and John Izbicki, Ground Water Volume 51, Issue 1, p. 108-121*



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.

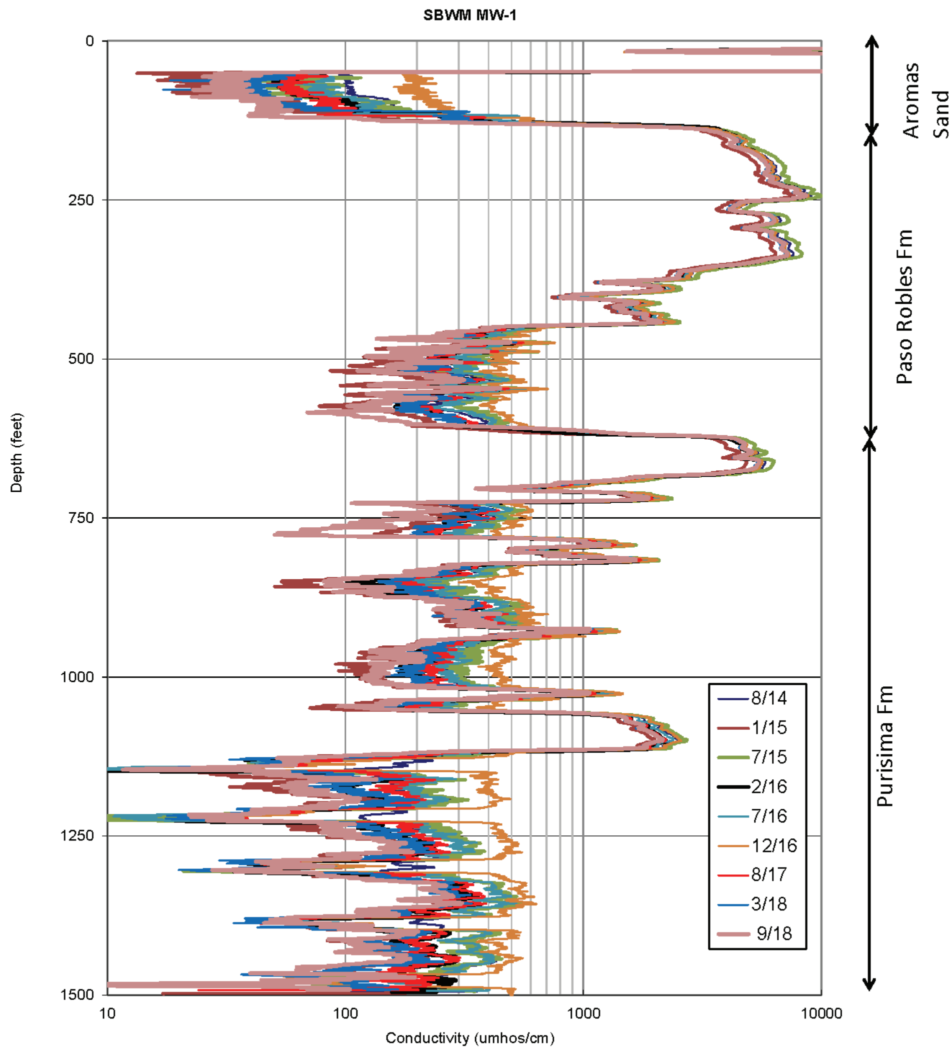


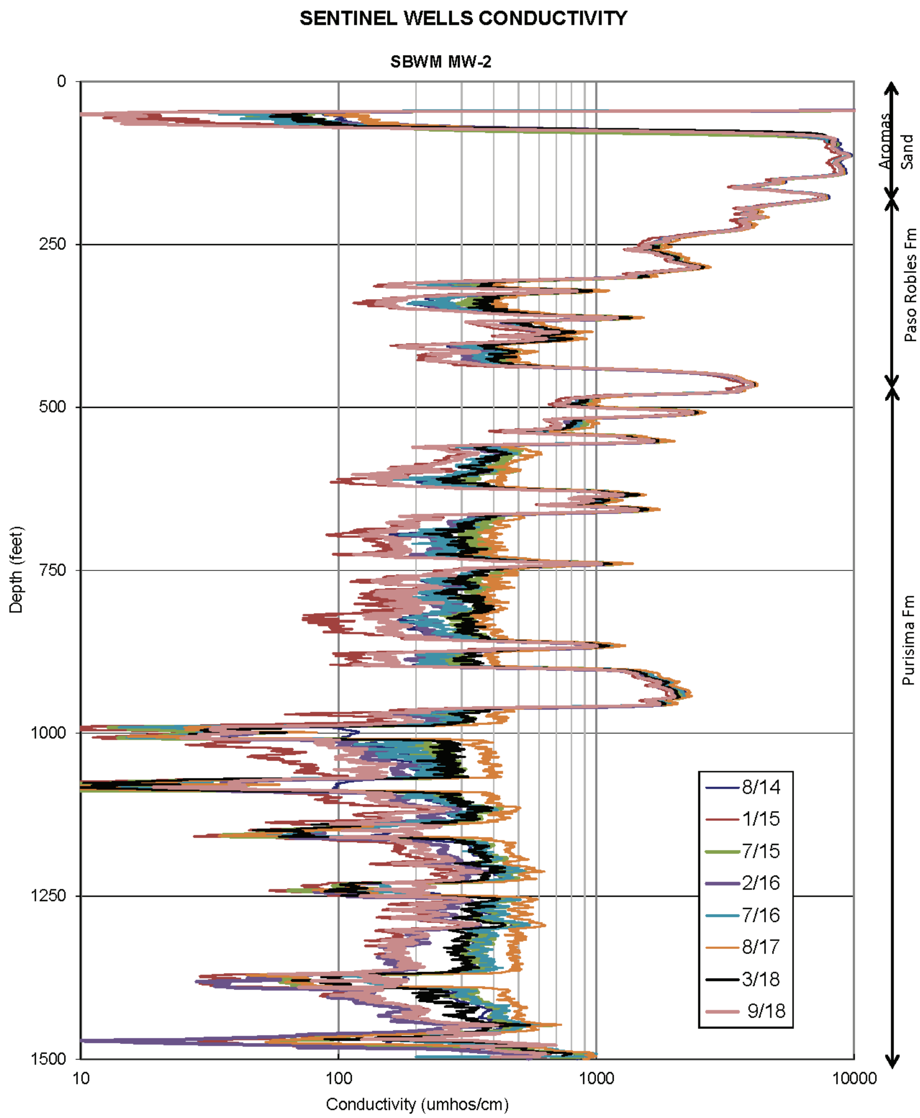
Explanation: Most obvious is the large increase in conductivity of the 12/14/14 log above 100 feet. This is interpreted as the result of very high surf which resulted in localized recharge of ocean water to the shallow zone near this well. Below this depth, and above 270 feet, groundwater condutivities are relatively unchanged. Below 270 feet, evidence of increasing intrusion of the 400-foot aquifer is apparent in the increasing conductivity.

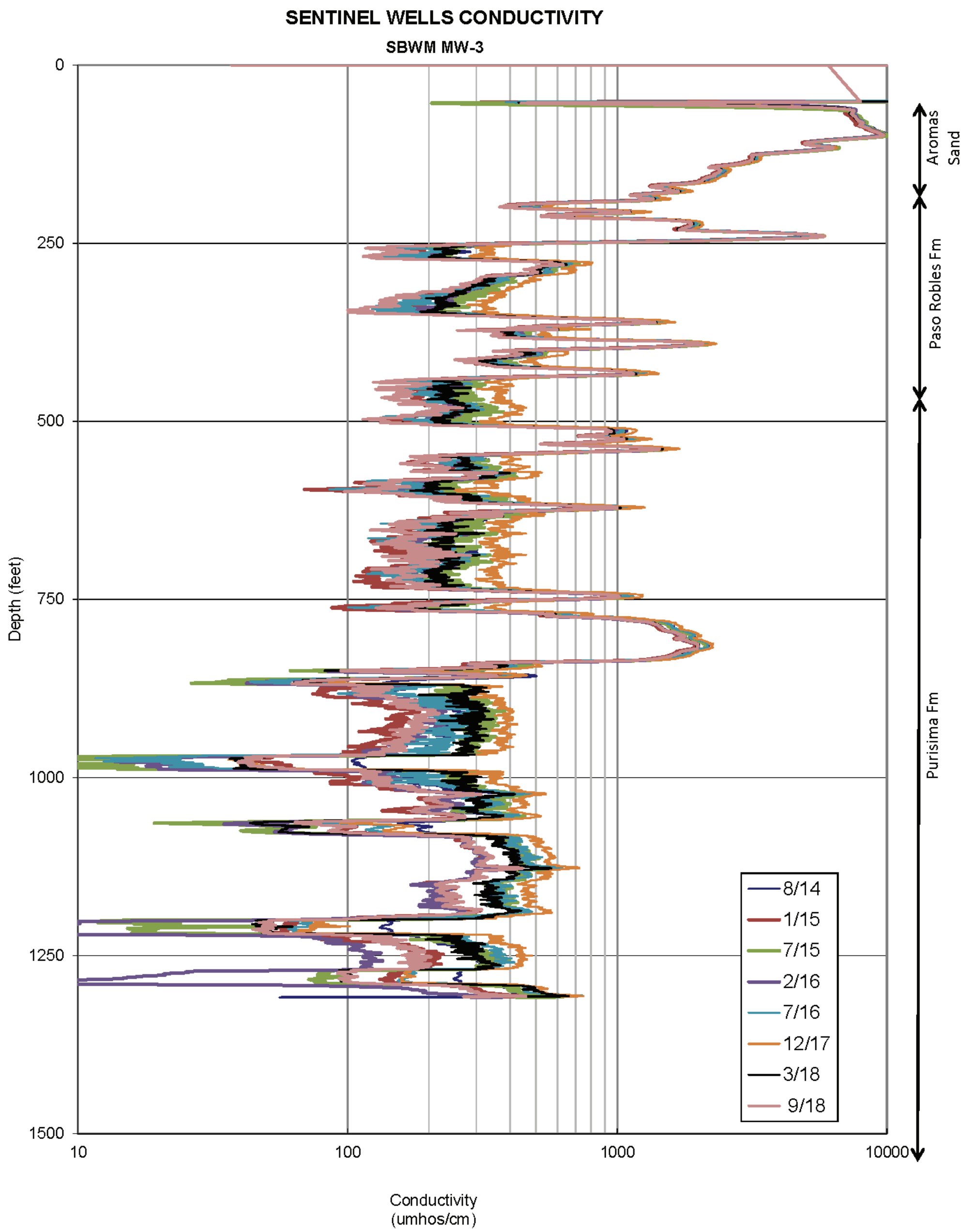


Explanation: In general, groundwater quality is relatively unchanged throughout the thickness of the aquifer system. If, anything the most recent log reveals groundwater quality to be slightly fresher.

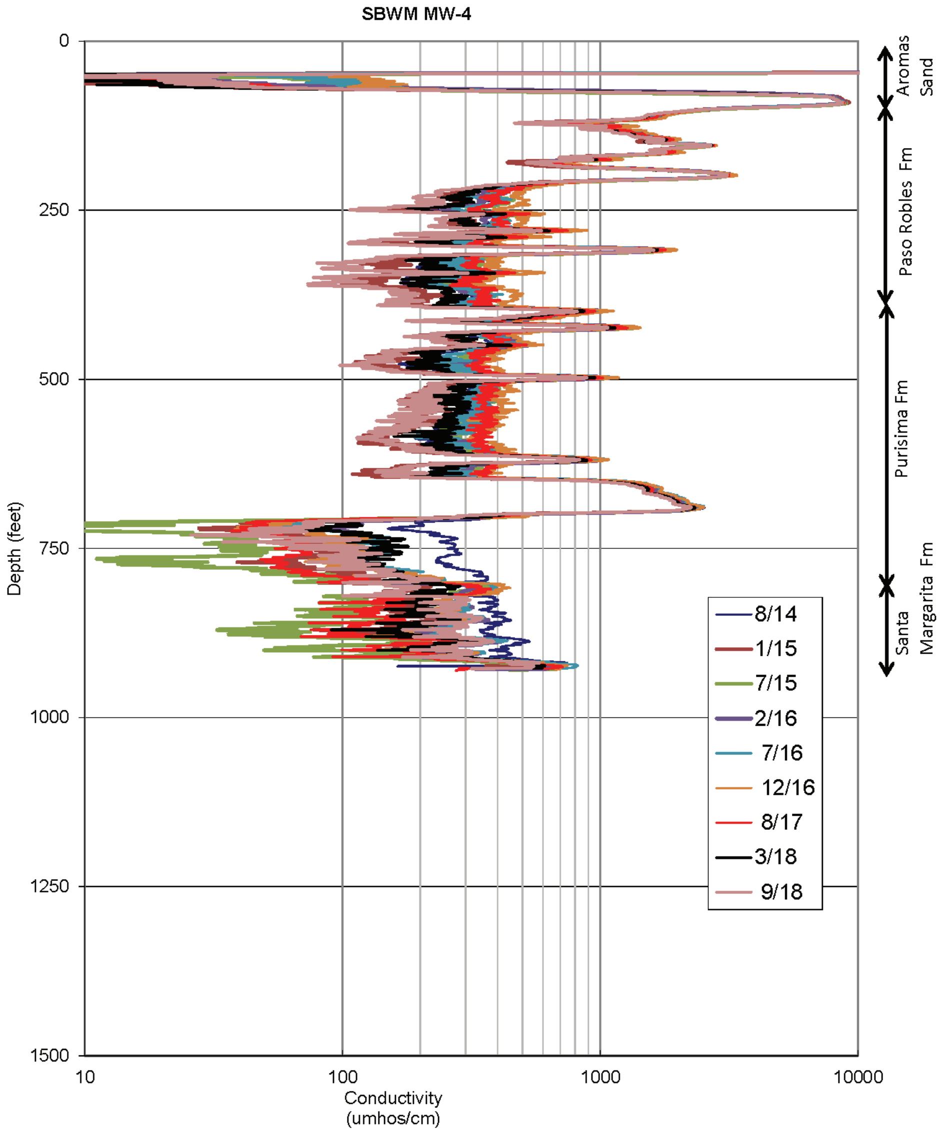
SENTINEL WELLS CONDUCTIVITY




SENTINEL WELLS CONDUCTIVITY
SBWM MW-2
Depth (feet)
0
250
500
750
1000
1250
1500
10
100
1000
10000
Conductivity (umhos/cm)
8/14
1/15
7/15
2/16
7/16
8/17
3/18
9/18
Aromas Sand
Paso Robles Fm
Purisima Fm


SENTINEL WELLS CONDUCTIVITY
SBWM MW-3
Depth (feet)
0
250
500
750
1000
1250
1500
10
100
1000
10000
Conductivity
(umhos/cm)
8/14
1/15
7/15
2/16
7/16
12/17
3/18
9/18
Aromas Sand
Paso Robles Fm
Purisima Fm

SENTINEL WELLS CONDUCTIVITY



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

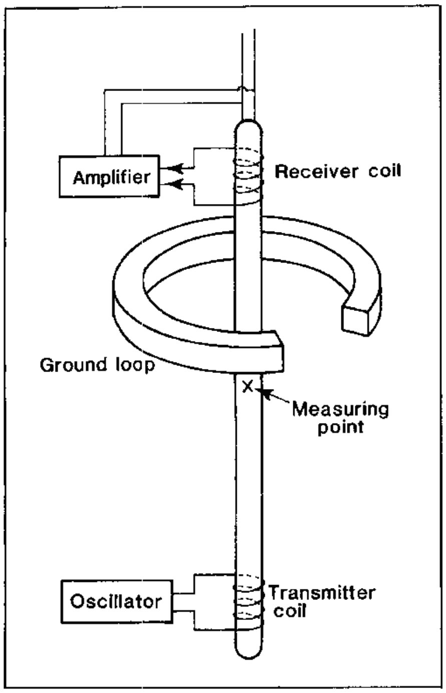


Figure 39.—System for making induction logs.

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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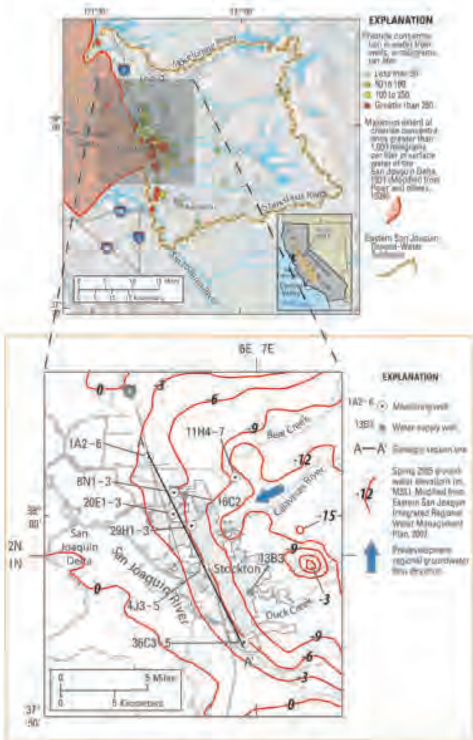

Figure 1. Location of the study area in the Eastern San Joaquin Groundwater Subbasin, near Stockton, California.

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

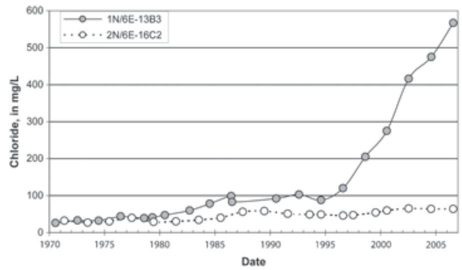

Figure 2. Chloride concentrations in samples from wells 1N/6E-13B3 and 2N/6E-16C2, Stockton, California, 1970 through 2007.

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

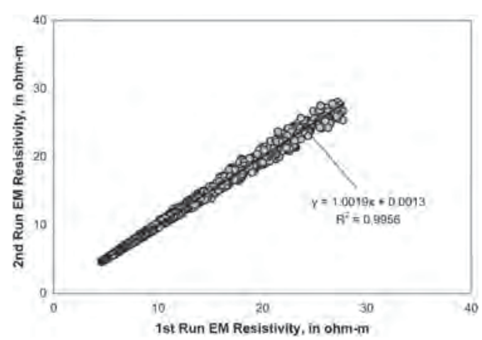

Figure 3. Electromagnetic resistivity data for duplicate logs from well 1N/6E-36C3, Stockton, California, March 2007.

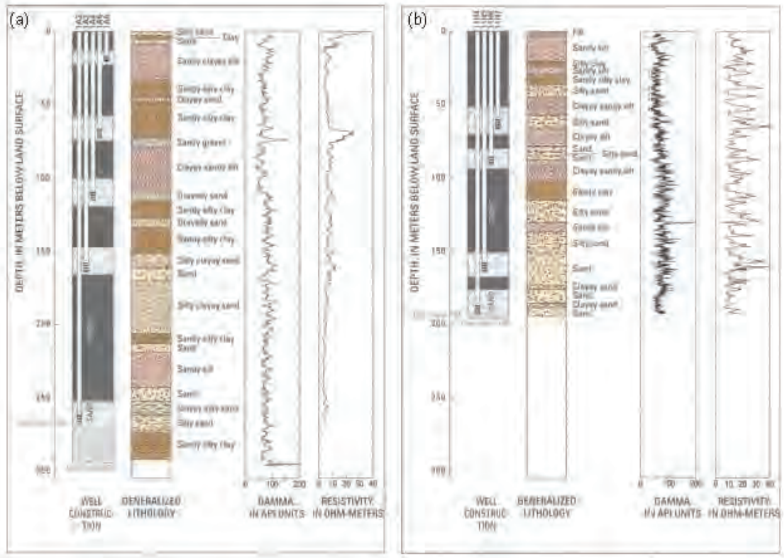

Figure 4. Well construction, generalized lithology, natural gamma, and EM resistivity logs (September 2007) for multiple-well sites (a) 2N/5E-1A2-6 and (b) 2N/6E-11H4-7, near Stockton, California.

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) Spring 2004	Spring 2005	Winter 2006	Spring 2006	Summer 2006	Winter 2007	Spring 2007	Fall 2007	Overall Chloride Change (%)
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-11H4	187.5–193.6	—	10.0	—	11[2]	11[2]	12[2]	12[2]	—	20
	2N/6E-11H5	158.5–164.6	—	5.6	—	6[2]	5[2]	5[2]	5[2]	—	−11
	2N/6E-11H6	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.

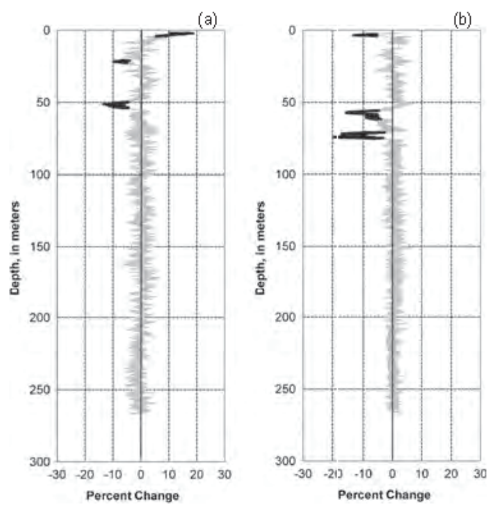

Figure 5. Percent change in electromagnetic resistivity with depth for (a) January 2006 to April 2007 and (b) April 2007 to September 2007 from well 2N/5E-1A2, near Stockton, California. Highlighted depth intervals show change greater than 1 standard deviation.

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.

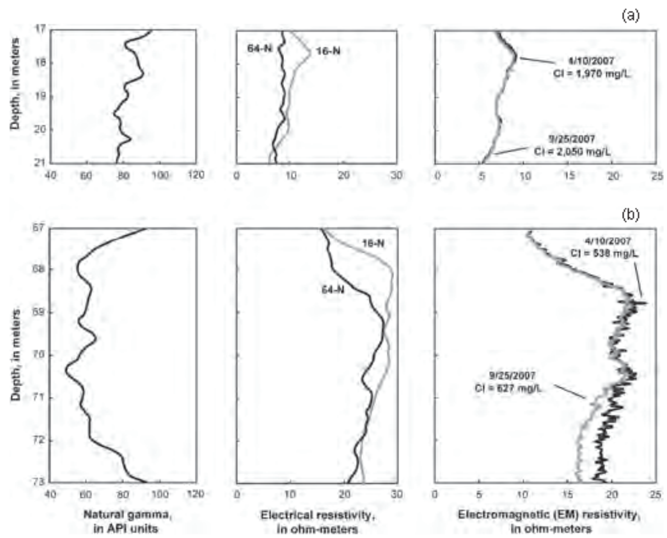

Figure 6. Comparison of natural gamma, electrical resistivity, and electromagnetic resistivity (EM) logs collected April 2007 and September 2007 from (a) well 2N/5E-1A6 and (b) well 2N/5E-1A5, near Stockton, California.

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:

$$\mathrm{Log}_{10}\ \mathrm{Cl} = 4.36 - 2.12\ \log_{10}\ \mathrm{EM} \qquad (1)$$

where Cl is the chloride concentration in water from screened intervals of wells near the time of the EM log

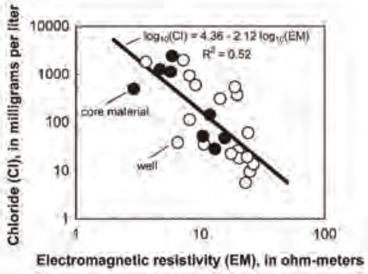

Figure 7. Chloride concentrations in water from monitoring wells (open circles) and water pressure extracted from core material (solid circles) as a function of electromagnetic-log resistivity in wells 2N/5E-1A2-5, 2N/6E-20E1, 1N/6E-4J3-5, and 1N/6E-36C3, near Stockton, California, 2004 through 2007.

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

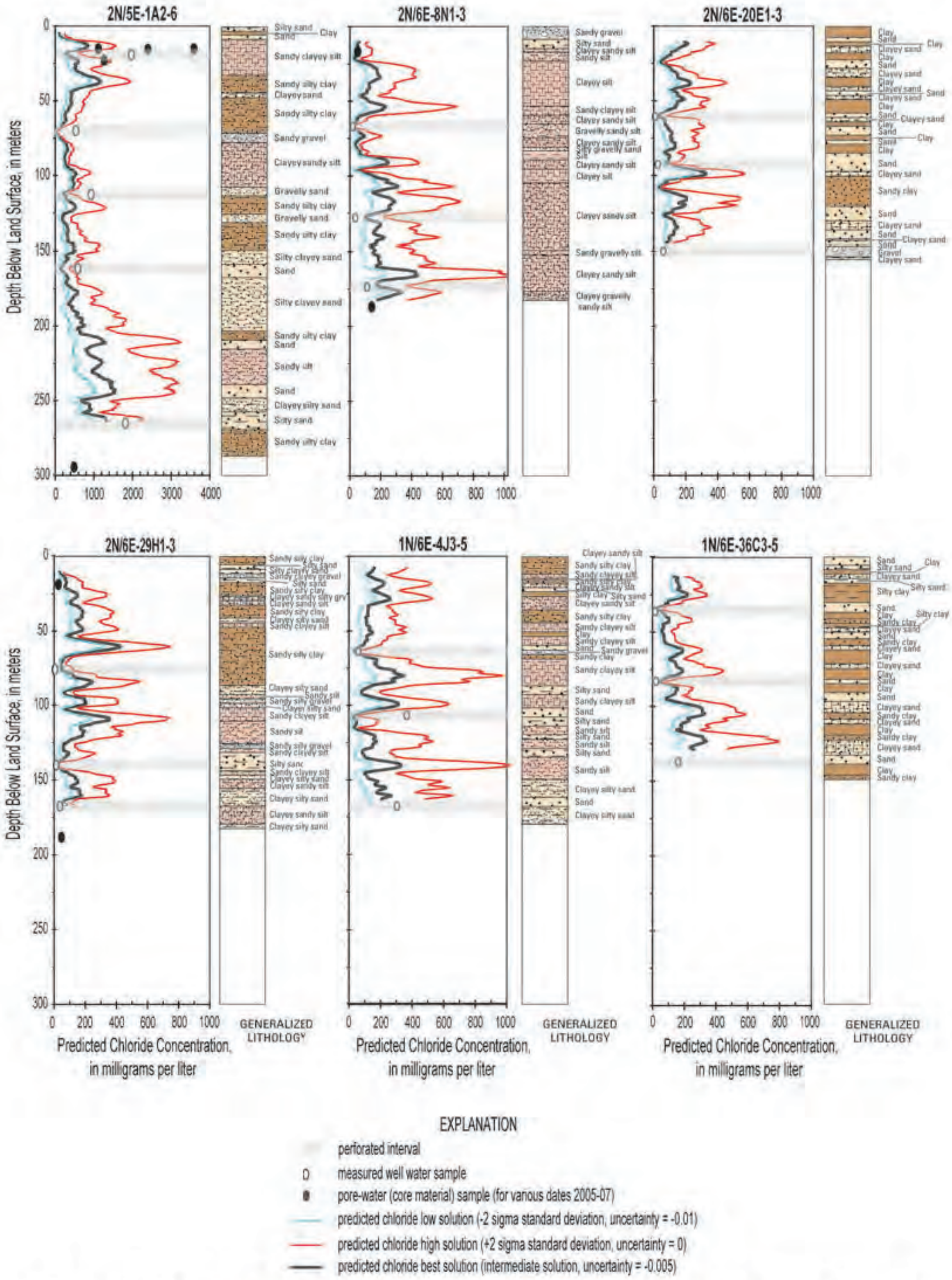

Figure 8. Predicted vs. measured chloride concentrations for selected multiple-well sites, near Stockton, California, spring 2007.

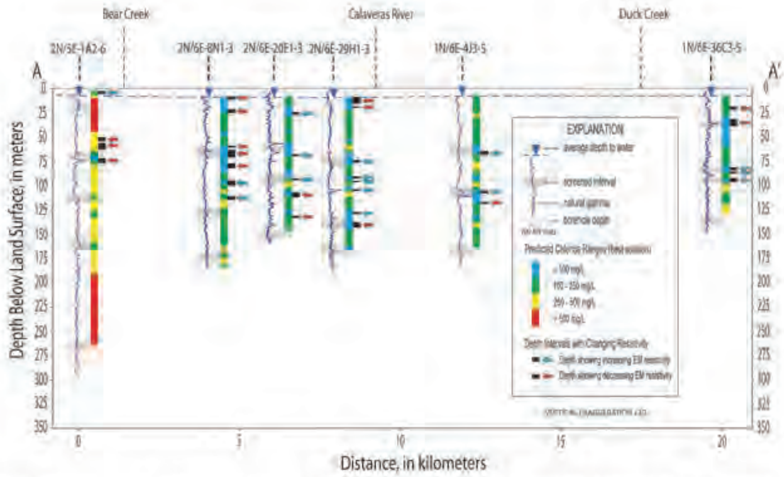

Figure 9. Natural gamma, predicted chloride concentrations, and intervals having changing EM resistivity for selected multiple-well sites along geologic section A-A′ near Stockton, California.

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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APPENDIX E
MONITORING WELL DESIGN

Monitoring Well Design Recommendations

The recently completed MPWSP network monitoring wells have set a high standard for well design and construction. Additional monitoring well clusters installations should be of similar design. Each well cluster would consist of a grouping of 3 individual wells – one completed in the Shallow Aquifer, one completed in the 180-ft/FTE Aquifer and one completed in the 400–foot Aquifer.

The design recommendations are outlined below.

Drilling Method: Wells should be drilled by the sonic method. This will allow continuation of the collection of high quality lithologic data. Continuous cores should collected from the deepest boring at each site. For well design purposes, the deep boring should be drilled first and the suite of geophysical logs should include induction logging at the time of drilling.

Well Completions: Subject to revision with site-specific lithologic and geophysical data, wells should be completed with perforations placed in the ranges of elevation for each of the aquifer units, as discussed herein.

Completion Materials: 4- to 5-inch diameter PVC casing and screen, 0.040-inch slots, plastic casing centralizers, select gravel. If allowed by the drilling method, preference would be 5-inch diameter casing allowing a 4-inch pump installation.

Development Methods: After completion, each well should be bailed or swabbed, air-lifted and pumped.

Geophysical Logging: After completion and development of the deepest well at each site, the well should include induction logging to establish a baseline for future comparison.

Surface Completion: Depending on the location, wells should be protected in above ground casings or traffic rated surface vaults.

Survey: After completion of surface improvements, reference points for each well should be established by surveying.

Well Completion Reporting: Subsequent to new monitoring well completions, a brief report should be prepared to document the details of the well completions for future reference.

Suggested Well Locations

Five locations for well clusters are suggested. The sites are positioned to allow confirmation of drawdown signals from the slant wells. As such, where existing wells are available along the trace of the predicted 1 ft drawdown, the suggested new wells are generally sited at a location half way between the slant wellfield and the predicted 1 ft drawdown line. Alternatively, where no other wells are available along the trace of the approximate location of the 1 ft drawdown line wells, the suggested wells are along the line. The suggested locations are described below and are shown on Plates 1-3. The location and reasons for selection of each site are discussed in below.

MW-A-This site is located at the northern terminus of Dunes Dr. on property controlled by City of Marina. The location was selected to provide an intermediate point between the monitoring wells located at MCWD facility at the end of Reservation Road and the wellfield. The wells could be drilled in the pavement of the turnaround and finished in traffic rated vaults. Alternatively, the well could be across Highway 1 on southwest corner of the agricultural parcel.

MW-B – This site is located at the north end of Paul Davis Drive at the location of the City of Marina's percolation pond. Construction of the wells would require temporary removal of the fence along the north side. This location was selected because it is approximately half way between the predicted 1 foot drawdown line and the well field. Drawdown impacts would be more easily distinguished from background noise. Alternatives for this site include the agricultural parcel to the north or the abandoned piece of the right-of-way on the east end of Marina Green Drive.

MW-C -- This site is located due south of the MRWPCA facility on property owned by MCWD. Although well beyond the predicted 1 ft drawdown line and buffer zone, this site was selected because it is at the edge of a proposed groundwater banking project by MCWD. Locating the well here would allow determination of impacts.

MW-D – This site is located on property owned by CEMEX north of the wellfield and close to the predicted 1 foot drawdown line. Data from this location would allow development of the distance drawdown relationships when use with data from MW-8.

MW-E – This site is located west of the Marina Airport on property owned by the City of Marina. This site was selected to capture data at the Marina City limits. An alternative location would be on the agricultural parcel immediately across the road to the west.

APPENDIX F
PROGRAM COSTS

CAPITAL COSTS

	Materials/Contracting (dollars) Units	Cost/Unit	Cost	Technical/Professional Services (hours) Technician	Professional	
Well Construction						
Access Permission					160	
Bidding/Permitting					80	
Well Construction	5.4	$ 220,000	$ 1,188,000			
Consulting				550	220	
Instrumentation						
WL/EC Data Loggers /cable,hardware	33	$ 3,000	$ 99,000			
Installation				132	16	
Water Sampling Equipment (for MCWRA)	1	$ 30,000	$ 30,000			
Database Integration/Upgrade (County ITD)	1	$ 125,000	$ 125,000			
			$ 1,442,000	682	476	
		Consultant		$ 91,388	$ 85,680	$ 177,068
		Agency		$ 61,380	$ 66,640	$ 128,020
		Technical Services Vendor		NA	NA	
Contingency and Inflation	15%					
	low	high				
Capital Costs -	**$ 1,771,023**	**$ 1,861,928**				

Rates	Technician	Professional
Consultant	$ 134	$ 180
Agency	$ 90	$ 140
Technical Services Vendor	$ 105	-

rates do not include mileage or per diem

notes:
- Rates from MCWRA, GeoScience and Blaine Technical Services
- Hours for data collection from review of MCWRA and GeoSccience Records
- Cost for Induction Logging from Pacific Surveys
- Well Construction cost from Cascade Drilling 10/17 - adjusted
- Data Logger Cost - In-situ 12/18 AquaTroll 200
- 5.4 well clusters, accounts for 5 clusters plus mobilization and cost to construct replacement at MW-5 location

Baseline

OPERATIONS AND MAINTENANCE	Sites	Cost/Site	Hours/ Well	Frequency (annual)	Outside Cost	Technical/Professional Services (hours) Technician	Professional	
Data Collection								
Data Logger Data Collection/WL Measurement	57		0.75	12		513	96	
Water Quality Sampling	57		4	4		912	136	
Water Quality Analysis	57	$ 225	-	4	$ 51,300			
Induction Logging	14	$ 1,070	3	4	$ 59,920	168	32	
Data Logger Maintenance/Replacement		$ 3,000	-	4	$ 12,000	104	16	
					$ 123,220	1697	280	
			Consultant			$ 227,398	$ 50,400	$ 277,798
			Agency			$ 152,730	$ 39,200	$ 191,930
			Technical Services Vendor			$ 178,185	NA	
	low	high						
Data Collection Costs -	**$ 340,605**	**$ 401,018**						
QA/QC, Data Entry and Management								
QA/QC				2			136	
Data Entry/Database Management				4		448	280	
IT Support						116	128	
Data Review/Interpretation								
Process data/plot trends				4		412	136	
Review trends				4			168	
Review Fort Ord Clean up Reports				1			16	
coordinate with "Monitoring Program Hydrogeologist"				1			32	
Review Deep Aquifers Data				4			128	
						976	1024	
			Consultant			$ 130,784	$ 184,320	$ 315,104
			Agency			$ 87,840	$ 143,360	$ 231,200
			Technical Services Vendor			NA	NA	
	low	high						
QA/QC-Data Entry-Data Review Costs	**$ 231,200**	**$ 315,104**						
Contingency and Inflation	15%							
Total Operations	**$ 657,576**	**$ 823,540**						
	$ 740,558							

Rates	Technician	Professional
Consultant	$ 134	$ 180
Agency	$ 90	$ 140
Technical Services Vendor	$ 105	-

rates do not include mileage or per diem

notes:
Rates from MCWRA, GeoScience and Blaine Technical Services
Hours for data collection from review of MCWRA and GeoScience
Cost for Induction Logging from Pacific Surveys

Preliminary Operations Stage

OPERATIONS AND MAINTENANCE	Sites	Cost/Site	Hours/ Well	Frequency (annual)	Outside Cost	Technical/Professional Services (hours) Technician	Professional	
Data Collection								
Data Logger Data Collection/WL Measurement	57		0.75	12		513	96	
Water Quality Sampling	57		4	4		912	136	
Water Quality Analysis	57	$ 225	-	4	$ 51,300			
Induction Logging	14	$ 1,070	3	4	$ 59,920	168	32	
Data Logger Maintenance/Replacement		$ 3,000	-	3	$ 9,000	104	16	
					$ 120,220	1697	280	
			Consultant			$ 227,398	$ 50,400	$ 277,798
			Agency			$ 152,730	$ 39,200	$ 191,930
			Technical Services Vendor			$ 178,185	NA	
	low	high						
Data Collection Costs -	**$ 337,605**	**$ 398,018**						
QA/QC, Data Entry and Management								
QA/QC				4			136	
Data Entry/Database Management				4		448	280	
IT Support						116	128	
Data Review/Interpretation								
Process data/plot trends				2		412	136	
Review trends				2			168	
Review Fort Ord Clean up Reports				1			16	
coordinate with "Monitoring Program Hydrogeologist"				1			32	
Review Deep Aquifers Data				2			128	
						976	1024	
			Consultant			$ 130,784	$ 184,320	$ 315,104
			Agency			$ 87,840	$ 143,360	$ 231,200
			Technical Services Vendor			NA	NA	
	low	high						
QA/QC-Data Entry-Data Review Costs	**$ 231,200**	**$ 315,104**						
Contingency and Inflation	15%							
Total Operations	**$ 654,126**	**$ 820,090**						
	$ 737,108							

Rates	Technician	Professional
Consultant	$ 134	$ 180
Agency	$ 90	$ 140
Technical Services Vendor	$ 105	-

rates do not include mileage or per diem

notes:
Rates from MCWRA, GeoScience and Blaine Technical Services
Hours for data collection from review of MCWRA and GeoScience
Cost for Induction Logging from Pacific Surveys

Ongoing Operations Stage

OPERATIONS AND MAINTENANCE

Data Collection

	Sites	Cost/Site	Hours/ Well	Frequency (annual)	Outside Cost	Technical/Professional Services (hours) Technician	Professional	
Data Logger Data Collection/WL Measurement	57		0.75	12		513	96	
Water Quality Sampling	57		4	2		456	68	
Water Quality Analysis	57	$ 225	-	2	$ 25,650			
Induction Logging	14	$ 1,070	3	0.5	$ 7,490	21	8	
Data Logger Maintenance/Replacement		$ 3,000	-	3	$ 9,000	78	12	
					$ 42,140	1068	184	
			Consultant			$ 143,112	$ 33,120	$ 176,232
			Agency			$ 96,120	$ 25,760	$ 121,880
			Technical Services Vendor			$ 112,140	NA	
	low	high						
Data Collection Costs -	$ **180,040**	$ **218,372**						

QA/QC, Data Entry and Management

	Sites	Cost/Site	Hours/ Well	Frequency (annual)	Outside Cost	Technician	Professional	
QA/QC				2			68	
Data Entry/Database Management				2		224	140	
IT Support						116	128	

Data Review/Interpretation

	Sites	Cost/Site	Hours/ Well	Frequency (annual)	Outside Cost	Technician	Professional	
Process data/plot trends				2		206	68	
Review trends				2			84	
Review Fort Ord Clean up Reports				1			16	
Coordinate with "Monitoring Program Hydrogeologist"				1			32	
Review Deep Aquifers Data				2			64	
						546	600	
			Consultant			$ 73,164	$ 108,000	$ 181,164
			Agency			$ 49,140	$ 84,000	$ 133,140
			Technical Services Vendor			NA	NA	
	low	high						
QA/QC-Data Entry-Data Review Costs	$ **133,140**	$ **181,164**						
Contingency and Inflation	15%							
Total Operations	**$ 360,157**	**$ 459,466**						
	$ 409,812							

Rates	Technician	Professional
Consultant	$ 134	$ 180
Agency	$ 90	$ 140
Technical Services Vendor	$ 105	-

rates do not include mileage or per diem

notes:
Rates from MCWRA, GeoScience and Blaine Technical Services
Hours for data collection from review of MCWRA and GeoScience
Cost for Induction Logging from Pacific Surveys

APPENDIX G
INSTRUMENTATION

Implementation of the proposed Monitoring Plan will require continuous monitoring of both water level and electrical conductivity in all the wells in the network. This is the standard of practice set by the data collection program established for the MPWSP. Water level and conductivity data loggers are produced by several manufacturers and their use and utility is well established. Continuous monitoring would be at a standard interval (a set number of minutes) – that interval set based on the estimated degree of fluctuation of the parameter. For example, the frequency of water level measurements near the coast would be established to capture tidal fluctuations. Farther from the coast, the interval could possibly be reduced to capture only daily trends.

Deployment: Water level and conductivity data loggers have differing deployment criteria to collect the required data. To capture the required data, water level data loggers need only be deployed at a depth such that they remain submerged below the lowest anticipated water level in the well. However, conductivity loggers need to be deployed at often significantly deeper depths – typically in the middle of the screened interval.

Data Retrieval: Data loggers have internal memory capable of storing significant amounts of data. Theoretically, the data loggers could be left deployed for extended periods (years) and the data later collected. However, due to the need to review the collected data periodically and to prevent loss of data due to device failure, data are typically retrieved from the data loggers at more frequent intervals (monthly, quarterly). Data retrieval requires physically hooking up to the device and transferring the data digitally. This is done by either pulling the device from the well and physically connecting to the device or connecting to a data transmission cable that extends from the device to the surface. The former approach is awkward and time-consuming, the latter more expensive due to the expense of data cabling for each device. The existing MPWSP monitor wells have dedicated data transmission cables.

Equipment: There are many manufacturers of instrumentation suitable for this application. The most prominent are In-Situ, Inc., and Solinst, Inc. Both of these companies manufacture data loggers for water level data, conductivity data, or both combined. The MPWSP monitor wells currently utilize In-Situ equipment, as does the MCWRA. The needs of the program could be met with a single level/conductivity device in each well or two devices – one for conductivity and one for water levels. Both approaches have pros and cons. The combined device approach requires only one data transmission cable, reducing cabling costs. However, if two devices were utilized, the extra cabling cost is limited because the water level device does not need to be in the perforations, and therefore the cable is generally much shorter. The usefulness of the combined device approach is that it only requires hooking up to one device for data transfer instead of two. Another factor that needs to be considered is that conductivity devices typically have much shorter service lives than water level devices. This means that when the conductivity function of the combined device fails, you would be paying to replace partially functioning hardware. If two devices were utilized, just the conductivity device could be replaced if it fails.

Required Features:

Water Level Range: Water level responses in the study area are constrained by high transmissivities and the ocean boundary. 30 meter/100 ft range is adequate.

Electrical Conductivity Range: Conductivity probes should have a minimum range of 0-50 mS near the coast and 0-10 mS inland.

Battery Life: Most of the manufacturers produce devices with permanent (factory replaceable) batteries capable of at least 5 years of operation.

Memory: Most data loggers have memory for more than 100,000 data points and have wrapable memory such that should memory be exceed the device over writes the oldest data. With periodic downloading and memory reset this is not a critical issue.

Data Recovery Method: As discussed above, data can be retrieved by direct connection or data cable. The choice is one of convenience and cost.

Recommendations:

Given the above, the preliminary recommendation is to adopt the precedent utilized in the existing MPWSP monitor well network. This would entail the use of combined level/conductivity dataloggers as manufactured by In-Situ Inc., deployed in the middle of the screen interval in each well. The estimated project costs are based on this preliminary recommendation.