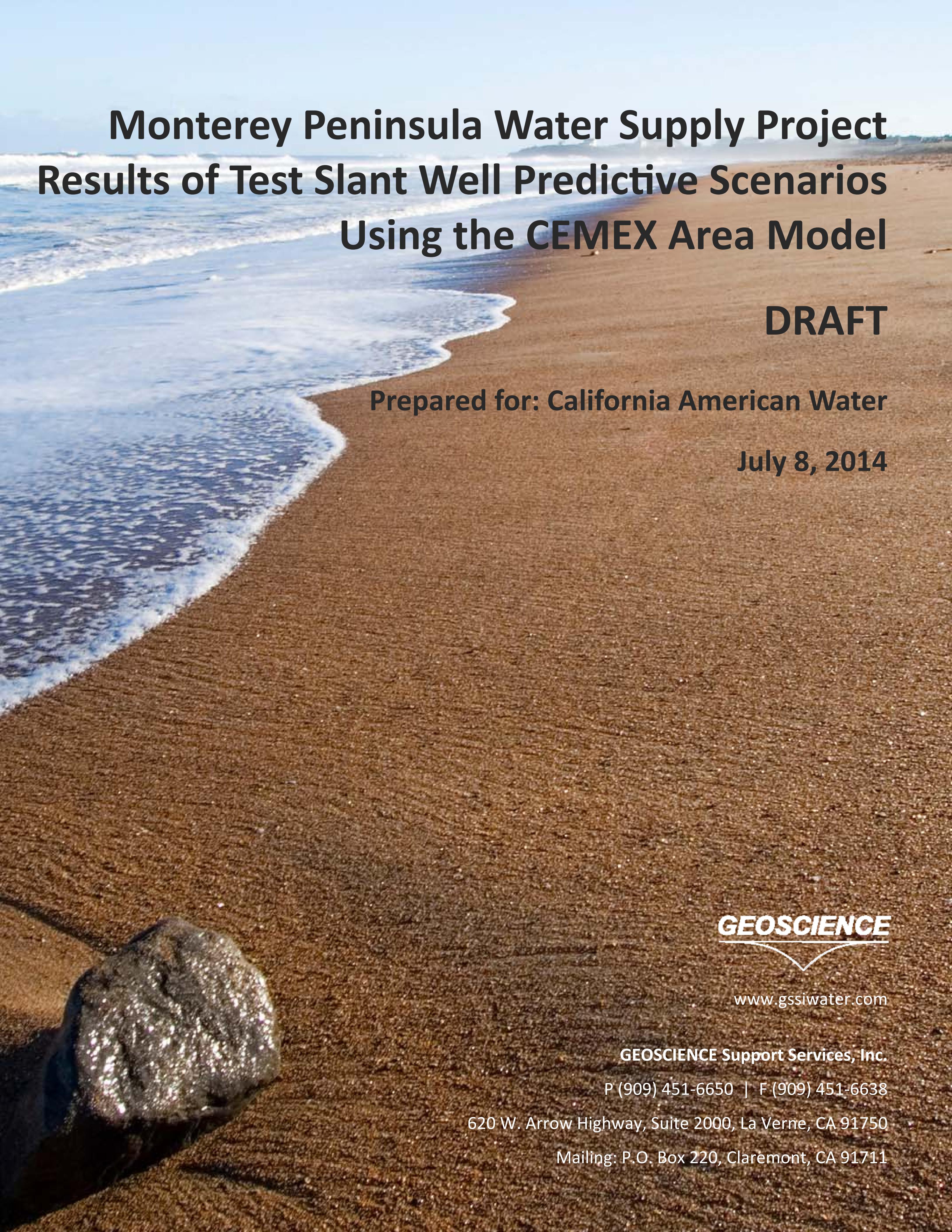
Appendix E1

Test Slant Well Groundwater Modeling and Analysis - CEMEX Active Mining Area



Monterey Peninsula Water Supply Project
Results of Test Slant Well Predictive Scenarios Using the CEMEX Area Model

DRAFT

Prepared for: California American Water

July 8, 2014

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MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS
USING THE FOCUSED CEMEX AREA MODEL

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MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS
USING THE CEMEX AREA MODEL

1.0 EXECUTIVE SUMMARY

This technical memorandum summarizes predictive ground water modeling performed by GEOSCIENCE Support Services, Inc. (GEOSCIENCE) in the vicinity of the proposed test slant well at the CEMEX site and evaluates potential impacts on ground water levels and water quality (total dissolved solids) which may occur during the long-term pumping test. The work included running several ground water models, each successively focusing more on the area of the CEMEX site. The largest model, referred to as the Salinas Valley Integrated Groundwater and Surface Water Model (SVIGSM), covers the entire Salinas Valley. Results from the regional SVIGSM were used as boundary conditions for a more local-scale model, known as the North Marina Ground Water Model (NMGWM). The NMGWM was used to provide boundary conditions for a focused model of the CEMEX area developed for this evaluation. The focused model is referred to herein as the CEMEX Model (CM). Update and refinement of the models was achieved primarily through newly acquired geologic and hydrogeologic data collected during a recent drilling and sampling program.

The following three predictive model scenarios were simulated using the CM:

- Baseline Run: No Test Slant Well Pumping
- Scenario 1: A Test Slant Well Constructed at an Angle of 19 Degrees Below Horizontal
- Scenario 2: A Test Slant Well Constructed at an Angle of 10 Degrees Below Horizontal

For Scenario 1 (i.e., 19 degrees below horizontal), the test slant well was screened in the Dune Sand Aquifer and the 180-Foot Equivalent (180-FTE) Aquifer with a total lineal screen length of 588 ft. For Scenario 2 (i.e., 10 degrees below horizontal), the test slant well was screened in the Dune Sand Aquifer and the 180-FTE Aquifer with a total screen length of 830 ft. For both scenarios, a discharge rate of 2,500 gallons per minute (gpm) was simulated for an eight (8) month period (March 2015 to October 2015).

1.1 Findings

- Based on preliminary ground water modeling, the salinity in the test slant well increases with time approaching 96% ocean water after 16 months of pumping. Data collected during the long-term pumping test will be used to establish salinity trends.

- The inland drawdown in the 180-FTE Aquifer (from slant well pumping), is directly proportional to the amount of pumping stress on the 180-FTE Aquifer: more for Scenario 1 and less for Scenario 2. The reason for difference in drawdown is that the hydraulic conductivity in the 180-FTE Aquifer is lower than that of the shallow Dune Sand Aquifer.

- In the Dune Sand Aquifer after 8 months of pumping, model results show that water levels in MW-1, located 60 ft inland from the test slant well, would decline approximately 3 ft under Scenario 1 and approximately 4 ft under Scenario 2. This decline is directly proportional to the amount of well screen in the Dune Sand Aquifer—being higher in Scenario 2 and less in Scenario 1. Water level declines in the deeper 180-FTE Aquifer beyond 8 months of pumping average 5.6 ft and 2.3 ft for Scenarios 1 and 2, respectively (Table 4).

- After 8-months of pumping, model results show a 0.5 ft decline in ground water levels at a distance of approximately 4,500-5,000 ft from the test slant well for Scenario 1 (180 FTE and Dune Sand aquifers, respectively), and 2,700-2,800 ft for Scenario 2 (Table 5).

- After 8-months of pumping, model results show a 1 ft decline in ground water levels at distance of approximately 2,500-1,800 ft from the test slant well for Scenario 1 (180 FTE and Dune Sand aquifers, respectively), and approximately 800 ft for both aquifers for Scenario 2 (Table 5).

2.0 INTRODUCTION

2.1 Background

California American Water (CalAm) is planning to increase their water supply portfolio to meet the long-term needs of their customers in the Monterey Peninsula. The proposed project is known as the "Monterey Peninsula Water Supply Project" (MPWSP) and will help meet CalAm's long-term regional water demands, improve ground water quality in the seawater-intruded Salinas Basin, and expand agricultural water deliveries. The plan includes construction of a desalination plant to provide a product water quantity ranging from 6.4 million gallons per day (mgd) to 9.6 mgd. The corresponding feedwater supply is estimated to be approximately 15.5 to 24.1 mgd and will be obtained through a subsurface intake system located at the CEMEX site (see Figure 1) consisting of low angled wells (i.e., slant wells) constructed beneath the ocean floor. The full-scale subsurface intake system is proposed to consist of 10 slant wells, arranged in three slant well pods as shown on Figure 1. As part of the investigation phase, a test slant well (northern-most slant well shown on Figure 1) will be constructed and operated at the CEMEX site for a minimum 8 month period or until a stable water quality trend is obtained. This report summarizes results from modeling the test well pumping impacts.

2.2 Purpose and Scope

GEOSCIENCE developed the MPWSP Hydrogeologic Investigation Work Plan (HWP) (GEOSCIENCE, 2013), which is the main working document for all exploratory, testing and modeling work, including:

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

The exploratory borehole work was completed earlier this year (2014) and results are summarized in the Borehole Technical memorandum (GEOSCIENCE, 2014). It was recommended by the Hydrogeology Working Group (HWG) to drill and sample exploratory borings to better understand subsurface conditions prior to test slant well construction. The next step is to construct a test slant well and four monitoring wells at the CEMEX site and conduct a long-term pumping test. The long-term pumping test shall be used to collect data on aquifer properties (e.g., specific capacity, transmissivity, and water quality). The purpose of this modeling is to evaluate and predict the water level and water quality impacts in the area of the CEMEX site during the long-term pumping test.

3.0 GROUND WATER MODELS

3.1 Model Descriptions

The ground water modeling exercise included running several models, each successively more focused and refined. The largest model, referred to as the Salinas Valley Integrated Groundwater and Surface-Water Model (SVIGSM), covers the entire Salinas Valley and develops boundary conditions for a more local model known as the North Marina Ground Water Model (NMGWM). The NMGWM in turn was run and provided boundary conditions for the focused CEMEX area model (CM). Figure 1 shows the areal extent of the ground water models used. Update and refinement of the models was achieved primarily through newly acquired geologic and hydrogeologic data collected during a recent drilling and sampling program. GEOSCIENCE developed the NMGWM, which covers the region in the current project. The NMGWM has been used previously to evaluate several proposed projects in the region. The model was developed using computer codes of MODFLOW and MT3DMS in 2008. More recent work (2013) has included updating the model layers using additional geologic data. However, a considerable amount of new data was generated from the field investigations resulting from exploratory boreholes work (GEOSCIENCE, 2014). The additional data from the exploratory boreholes work was used to update and refine the NMGWM.

In addition, and in order to accurately model local effects of slant well pumping, a focused model, designated as the CEMEX Model (CM), was constructed. The CM is located within the NMGWM, and is centered at the CEMEX site. It was constructed using the SEAWAT computer code (SEAWAT is a generic MODFLOW/MT3DMS-based computer program designed to simulate three-dimensional variable-density ground water flow coupled with solute transport) to allow the simulation of seawater intrusion. The CM model consists of 540 rows and columns with a uniform cell size of 20 feet to a side, which is a significant refinement over the uniform grid size of 200 ft by 200 ft in the NMGWM. The decreased model cell size will allow for a very accurate calibration by matching ground water levels and quality data to be collected during the long-term test slant well pumping test.

The newly collected exploratory boring information provided valuable data needed to determine the thickness and extent of the Dune Sand Aquifer, Perched “A” Aquifer, and the 180-FTE Aquifer, in addition to hydraulic conductivity data and initial total dissolved solids (TDS) for model input. The model layers representing the Dune Sand Aquifer, Perched “A” Aquifer, Salinas Valley Aquitard, and 180-FTE Aquifer were refined using the new data (GEOSCIENCE, 2014). Aquifer parameters used in the models will be updated during and after the test slant well program, as appropriate, to reflect water level changes occurring in the aquifers during the test slant well pumping.

The conceptual model of the NMGWM and CM was developed based on the geologic and hydrostratigraphic units of the area. The correlation of geologic and hydrostratigraphic units with the regional and local models is summarized in Table 1. As shown, the NMGWM was further refined in the CM through the addition of model layers. The NMGWM layers 2 and 4 were each modeled by three layers in the CM (i.e., layers 2 through 4 and layers 6 through 8, respectively).

Table 1 – Correlation of Geologic and Hydrostratigraphic Units with SVIGSM, NMGWM, and CM Layers

180/400-Foot Aquifer Subbasin			CEMEX Area			SVIGSM Layer[1]	NMGWM Layer	CEMEX Model Layer
Surface Geologic Units	**Surface Geologic Units Map Symbol**	**Hydro-stratigraphic Units**	**Surface Geologic Units**	**Surface Geologic Units Map Symbol**	**Hydro-stratigraphic Units**			
Bentic Zone	-	Benthic Zone	-	-	Benthic Zone	Constant Head	1	1
Alluvium	Qal[2]	Perched "A" Aquifer	Dune Sand	Qd	Dune Sand Aquifer	1a	2	2
			Older Dune Sand	Qod				3
								4
Older Alluvium	Qo	Salinas Valley Aquitard	Older Terrace/ Marine Terrace	Qt (Qmt?)	180-FTE Aquifer	1a	3	5
		180-Foot Aquifer				1	4	6
Older Alluvium/ Marine Terrace	Qo/Qmt							7
Older Alluvium/ Older Alluvium Fan-Antioch	Qo/Qfa							8
Older Alluvial Fan – Placentia	Qfp	180/400-Foot Aquitard	Aromas Sand (undifferenciated) (?)	Qar (?)	180/400-Foot Aquitard	2a	5	9
Aromas Sand (undifferentiated)	Qar	400-Foot Aquifer			400-Foot Aquifer	2	6	10
Aromas Sand – Eolian/Fluvial Lithofacies	Qae/Qaf							
Paso Robles Formation	QT	400/900-Foot Aquitard	Paso Robles Formation	QT	400/900-Foot Aquitard	3a	7	11
		900-Foot Aquifer			900-Foot Aquifer	3	8	12

Notes:
180-FTE Aquifer represents "180-Foot Equivalent Aquifer"
Queried (?) Marine Terrace and Aromas Sand units shown are used to indicate that it is at least an equivalent unit in the CM domain.
[1] SVIGSM considers "a" layers to be aquitards (vertical hydraulic conductivity and thickness are input).
[2] Subsurface Holocene geologic unit not mapped at surface.

3.2 Integration of SVIGSM, NMGWM and CM

The SVIGSM was originally developed in February 1994 (Montgomery Watson, 1994) to analyze the ground water resources of the Salinas Valley (Figure 1). It is a regional model encompassing the entire Salinas Valley (approximately 650 square miles). A major refinement occurred in 1996-1997 when the model was used to assist the Salinas Valley Water Project (SVWP) planning and Environmental Impact Report /Environmental Impact Statement (EIR/EIS). During this refinement process, model assumptions and input data were evaluated, updated, and revised. In 2008, WRIME extended the hydrologic period so that the model covered the time period from 1949 through 2004 (WRIME 2008). In addition, updates were made to land use and water use data.

The NMGWM was developed in 2008 to evaluate several proposed projects in the region (GEOSCIENCE, 2008). It is a coastal model covering part of the Pacific Ocean and approximately five miles inland from the coastline with an area of approximately 149 square miles (see Figure 1). The CEMEX Model (CM) is a focused coastal model within the NMGWM and was developed for this project. It covers the CEMEX site and surrounding areas with an area of four square miles (see Figure 1).

The SVIGSM encompasses the entire NMGWM. The calibrated SVIGSM model data including the aquifer parameters, recharge and discharge terms, and boundary conditions in the model area were used to construct the NMGWM. For example, the eastern, northern, and southern boundaries of the NMGWM represent locations of subsurface underflow. The underflow at these locations were simulated using the general-head boundary package in MODFLOW with a time varying specified head based on the model simulated ground water elevation from the SVIGSM. This procedure is similar to the telescopic mesh refinement method (Anderson and Woessner, 1992). The same procedure was used for the CM in that NMGWM data including the aquifer parameters such as recharge and discharge terms, and boundary conditions in the model area were used to construct the CM.

3.3 Conceptual Model

For purposes of this document, the alluvial materials encountered near the coast (in the CEMEX area) are based solely on analyses of borehole samples (and geophysical borehole logs). As of yet, no direct correlation can be made between these coastal alluvial deposits and the standard naming convention found further inland (e.g., 180-Foot Aquifer, 400-Foot Aquifer, and Salinas Valley Aquitard, etc.). Therefore, in this document, the upper materials have been classified as the Dune Sand Aquifer and the alluvial materials below have been referred to as stratigraphically equivalent to the inland 180-Foot Aquifer (or 180-FTE Aquifer).

Until further testing has been completed, including the long-term slant well pumping test, it is assumed for purposes of this report that these materials may or may not correlated and be in hydraulic continuity with the inland aquifer system.

Although 12 model layers are delineated, the ones of interest include layers 2, 3, and 4 (Dune Sand Aquifer), and Layers 6, 7, and 8 (180-FTE Aquifer). Layer 5 is a model layer placeholder for the SVA which does not exist at the coast but is present further inland within the domain of the CM.

3.4 Description of Model Codes

MODFLOW and MT3DMS are the model computer codes used for the NMGWM. MODFLOW is a block-centered, three-dimensional, finite difference ground water flow model developed by the USGS for the purpose of modeling ground water flow. MT3DMS is a modular three-dimensional multispecies transport model for simulation of advection, dispersion, and chemical reactions of contaminants in ground water systems (Zheng and Wang, 1998). SEAWAT is the computer code used for the CM. The SEAWAT program was developed by the United States Geologic Survey (Guo and Langevin, 2002) to simulate three-dimensional, variable density, ground water flow and solute transport in porous media. The source code for SEAWAT was developed by combining MODFLOW and MT3DMS into a single program that solves the coupled flow and solute transport equations.

3.5 Model Domains, Grids and Layers

The regional SVIGSM model grid encompasses approximately 650 square miles. It is a three-layer finite element model, with an average element size of approximately 0.4 square miles (see Figure 1).

The NMGWM, located within the SVIGSM, is a coastal model which covers an area of 149 square miles. It is an eight-layer model and consists of 300 cells in the i-direction (northeast-to-southwest along rows) and 345 cells in the j-direction (northwest-to-southeast along columns) with a uniform cell size of 200 ft by 200 ft. The model grid is rotated 16 degrees clockwise from horizontal (see Figure 1).

The CM is located within the NMGWM, and is centered at the CEMEX site. It covers an area of four square miles and is a 12-layer finite-difference grid consisting of 540 cells in the i-direction (northeast-to-southwest along rows) and 540 cells in the j-direction (northwest-to-southeast along columns). All model cells are represented by squares measuring 20 ft by 20 ft (see Figure 1). The model grid is rotated 16 degrees clockwise from horizontal to match the rotation of the NMGWM.

3.6 Model Calibration

The SVIGSM was originally calibrated for the period from 1949 through 1994 (WRIME, 2008) and the NMGWM was calibrated for the period from 1979 through 1994 (GEOSCIENCE, 2008). The models have been recently updated with the data from the exploratory borehole work (GEOSCIENCE, 2014), and work for recalibration, which will extend the calibration period through 2011, is currently in progress.

3.7 Model Parameters

The parameters of the CM were developed based on the calibrated SVIGSM (WRIME, 2008) and NMGWM (GEOSCIENCE, 2008), as well as updated geohydrologic data from the exploratory borehole work (GEOSCIENCE, 2014). This update includes the use of ninety one (91) control points to develop the thickness of each model layer (GEOSCIENCE, 2014). The points were contoured to provide the rest of the model layer surface. The elevation of each model layer is taken as the top elevation minus the determined thickness. For example, the bottom elevation of model layer 1 is the surface elevation minus the thickness of model layer 1; the bottom elevation of model layer 2 is the bottom elevation of model layer 1 minus the thickness of model layer 2; and so on.

Values for the refinement of model horizontal and vertical hydraulic conductivities were estimated based on the descriptions of borehole samples and a series of curves developed to show the relationship between sediment texture and hydraulic conductivity (GEOSCIENCE, 2014). These curves, representing maximum and minimum horizontal and vertical hydraulic conductivity values, were constructed using the equation and coefficients reported by Durbin (2013).

The specific storativity and effective porosity values were based on published data by Staal, Gardner and Dunne, Inc. (1991) as well as calibrated SVIGSM and NMGWM values. Longitudinal dispersivity was estimated initially from the relationship between longitudinal dispersivity and the scale of observation (Zheng and Bennett, 2002). These values were adjusted during the NMGWM model calibration conducted in 2008 (GEOSCIENCE, 2008). The following table summarizes aquifer parameters used in the CM.

Table 2 – Summary of Aquifer Parameters Used in the CEMEX Model

Model Layer	Horizontal Hydraulic Conductivity [ft/day]	Vertical Hydraulic Conductivity [ft/day]	Specific Yield /Storativity**	Effective Porosity	Dispersivity		
					Horizontal		Vertical
					Longitudinal [ft]	Transverse [ft]	Transverse [ft]
1 Benthic Zone	-	-	-	-	-	-	-
2, 3 and 4 (Dune Sand Aquifer)	210 to 340	0.178 to 46.9	0.065	0.065	20	2	0.2
5 (Variable Layer***)	5 to 340	0.01 to 46.9	$1x10^{-5}$ to 0.065	0.02 to 0.065	20	2	0.2
6,7 and 8 (180-Foot Equivalent Aquifer)	160	0.3527	$4x10^{-3}$	0.09	20	2	0.2
9 (180- /400- Foot Aquitard)	3.1 to 5.4	0.0063 to 0.01086	$1x10^{-5}$	0.02	20	2	0.2
10 (400-Foot Aquifer)	50 to 90	2.5 to 4.5	$4x10^{-4}$ to $2x10^{-3}$	0.1	20	2	0.2
11 (400- /900-Foot Aquitard)	1.8	0.0036	$1x10^{-5}$ to $2x10^{-5}$	0.02	20	2	0.2
12 (900-Foot Aquifer)	25	1.25	$1x10^{-5}$	0.06	20	2	0.2

Note:

*Model input variables are spatially variable and will be modified based on the results of ongoing field investigations.

**All aquifers have a storativity value, even unconfined aquifers. However, in unconfined aquifers the storativity is the sum of the effective porosity (specific yield) and an unconfined storativity. Since the unconfined storativity is so much lower than the effective porosity, it dominates the term.

***Variable layer ranges from Salinas Valley Aquitard to Dune Sand Aquifer; however, the Salinas Valley Aquitard is present only within a small area in the northern model domain.

4.0 PREDICTIVE MODEL SCENARIOS

Assumptions of Predictive Model Scenarios

In order to evaluate and predict the water level and water quality impacts during a long-term pumping test at the test slant well, the following three predictive model scenarios were simulated using the NMGWM and CM:

- Baseline Run: No Test Slant Well,
- Scenario 1: Test Slant Well at 19 degrees below Horizontal, and
- Scenario 2: Test Slant Well at 10 degrees below Horizontal.

The following table summarizes the major assumptions used for these predictive model scenarios:

Table 3 – Assumptions Used for Predictive Model Scenarios

Model Scenarios	Model Time	Hydrology	Non-Test Slant Well Pumping	Test Slant Well Pumping	Test Slant Well Angle
Baseline Run	March 2015 to October 2015 (Eight Months)	2011 March-October[1] Hydrology Used for Model Calibration	2011 March-October[1] Pumping Used for Model Calibration	NA	NA
Scenario 1				2,500 gpm	19 degrees below Horizontal
Scenario 2				2,500 gpm	10 degrees below Horizontal

Notes:
NA – Not Applicable
[1] It was necessary to use October 2010 hydrology and pumping data because data for October 2011 was not available.

Figures 2 and 3 show the cross-section of the test slant well for Scenarios 1 and 2, respectively. For Scenario 1 (i.e., angle of 19 degrees below horizontal), the test slant well will be screened in the Dune Sand Aquifer and 180-FTE Aquifer with a total screen length of 588 ft (see Figure 2). For Scenario 2 (i.e., angle of 10 degrees below horizontal), the test slant well will be screened in the Dune Sand Aquifer and 180-FTE Aquifer with a total screen length of 830 ft (see Figure 3).

4.1 Model Results

4.1.1 Changes in Ground Water Levels - General

The predicted change in water levels from test slant well pumping was calculated as the difference between Baseline (No Test Slant Well) water level elevations and Scenario 1 and 2 water elevations. Figures 4 through 9 show changes in water levels for Scenario 1 (i.e., angle of 19 degrees below horizontal) in model layer 2 (Upper Dune Sand Aquifer), layer 3 (Middle Dune Sand Aquifer), layer 4 (Lower Dune Sand Aquifer), layer 6 (Upper 180-FTE Aquifer), layer 7 (Middle 180-FTE Aquifer) and layer 8 (Lower 180-FTE Aquifer), respectively. Changes in water levels for Scenario 2 (i.e., angle of 10 degrees below horizontal) for the same model layers are shown on Figures 10 through 15. Figures 16 and 17 shows the hydrographs of model-calculated water levels at the proposed monitoring wells for Scenarios 1 and 2, respectively. The following Table 4 summarizes the water level changes under Scenarios 1 and 2 at the four proposed CEMEX site monitoring wells (MW-1 through MW-4).

Table 4 – Summary of Predicted Water Level Changes at the Proposed CEMEX Site Monitoring Wells after 8 Months Pumping under Model Scenarios 1 and 2

Layer	Aquifer/ Aquitard	Scenario 1 (19 Degrees Below Horizontal)				Scenario 2 (10 Degrees Below Horizontal)			
		MW-1	MW-2	MW-3	MW-4	MW-1	MW-2	MW-3	MW-4
Layer 1	**Benthic Zone**								
Layer 2	Dune Sand	-2.7	-2.0	-1.5	-1.0	-4.0	-2.0	-1.2	-0.8
Layer 3	Dune Sand	-2.9	-2.0	-1.5	-1.0	-4.2	-2.0	-1.1	-0.8
Layer 4	Dune Sand	-3.4	-2.0	-1.5	-1.0	-4.1	-2.0	-1.2	-0.8
Average Dune Sand		**-3.0**	**-2.0**	**-1.5**	**-1.0**	**-4.1**	**-2.0**	**-1.2**	**-0.8**
Layer 5	SVA	Not Present in CEMEX area							
Layer 6	180-FTE	-6.2	-3.1	-1.9	-1.2	-3.4	-2.1	-1.4	-0.8
Layer 7	180-FTE	-5.7	-3.7	-2.4	-1.3	-2.2	-1.7	-1.2	-0.8
Layer 8	180-FTE	-4.9	-3.5	-2.5	-1.3	-1.3	-1.1	-1.0	-0.7
Average 180-FTE		**-5.6**	**-3.4**	**-2.3**	**-1.2**	**-2.3**	**-1.6**	**-1.2**	**-0.8**

4.1.1.1 Changes in Ground Water Levels – Dune Sand Aquifer

As shown in Table 4, the average change in ground water level in the Dune Sand Aquifer at MW-1 (i.e., closest monitoring well) is 3 ft for Scenario 1 and approximately 4 ft for Scenario 2. Similarly, the average change in ground water level in the Dune Sand Aquifer at MW-4 (i.e., furthest monitoring well) is 1.0 ft under Scenario 1 and 0.8 ft under Scenario 2.

4.1.1.2 Changes in Ground Water Levels – 180-FTE Aquifer

As shown in Table 4, the average change in ground water level in the 180-FTE Aquifer at MW-1 (i.e., closest monitoring well) is 5.6 ft for Scenario 1 and 2.3 ft for Scenario 2. Similarly, the average change in ground water level in the 180-FTE Aquifer at MW-4 (i.e., furthest monitoring well) is 1.2 ft under Scenario 1 and 0.8 ft under Scenario 2.

4.1.2 Ground Water Level Change with Distance from the Test Slant Well

Table 5 summarizes the approximate distances inland from the test slant well head where ground water levels change by 1 ft and 0.5 ft due to pumping.

Table 5 – Summary of Predicted Effects on Inland Water Levels after 8 Months of Pumping under Scenarios 1 and 2

CEMEX Model Layer	Aquifer / Aquitard	Scenario 1 (19 Degrees Below Horizontal)		Scenario 2 (10 Degrees Below Horizontal)	
		1 ft Change	0.5 ft Change	1 ft Change	0.5 ft Change
Layer 1	Benthic Zone				
Layer 2	Dune Sand	1,871	5,054	775	2,726
Layer 3	Dune Sand	1,869	5,047	771	2,729
Layer 4	Dune Sand	1,793	5,041	789	2,694
Ave. Dune Sand		**1,844**	**5,047**	**778**	**2,716**
Layer 5	SVA	not present in the CEMEX area			
Layer 6	180-FTE	2,190	4,632	988	2,831
Layer 7	180-FTE	2,537	4,520	965	2,885
Layer 8	180-FTE	2,640	4,490	497[1]	2,813
Ave. 180-FTE		**2,456**	**4,547**	**817**	**2,843**

Note:
[1] No well screen in Layer 8.

As shown, the average distance from the test slant well to where water levels change by 1 ft in the Dune Sand Aquifer is 1,844 ft for Scenario 1 and 778 ft for Scenario 2. The average distance from the test slant well to where water levels change by 1 ft in the 180-FTE Aquifer is 2,456 ft for Scenario 1 and 817 ft for Scenario 2. The average distance from the test slant well to where water levels change by 0.5 ft in the Dune Sand Aquifer is 5,047 ft for Scenario 1 and 2,716 ft for Scenario 2. Lastly, the average distance from the test slant well to where water levels change by 0.5 ft in the 180-FTE Aquifer is 4,547 ft for Scenario 1 and 2,843 ft for Scenario 2.

Based on ground water modeling, the percentage of ocean recharge to the test slant well will increase with pumping over time. Model results show that 96% of the recharge to the test slant well will be from ocean sources after 16 months of pumping. However, after 8 months of pumping, the concentration of water extracted from the test slant well approaches the salinity of seawater.

It is CalAm's intent to extract as much seawater as possible, and to minimize recharge from inland sources. The percentage of seawater/inland groundwater identified in this modeling effort will continue to be evaluated and refined based on results of the test well and the modeling of the full scale production wells.

5.0 FINDINGS

- Based on preliminary ground water modeling, the salinity in the test slant well increases with time approaching 96% ocean water after 16 months of pumping. Data collected during the long-term pumping test will be used to establish salinity trends.

- The inland drawdown in the 180-FTE Aquifer (from slant well pumping), is directly proportional to the amount of pumping stress on the 180-FTE Aquifer: more for Scenario 1 and less for Scenario 2. The reason for difference in drawdown is that the hydraulic conductivity in the 180-FTE Aquifer is lower than that of the shallow Dune Sand Aquifer.

- In the Dune Sand Aquifer after 8 months of pumping, model results show that water levels in MW-1, located 60 ft inland from the test slant well, would decline approximately 3 ft under Scenario 1 and approximately 4 ft under Scenario 2. This decline is directly proportional to the amount of well screen in the Dune Sand Aquifer—being higher in Scenario 2 and less in Scenario 1. Water level declines in the deeper 180-FTE Aquifer beyond 8 months of pumping average 5.6 ft and 2.3 ft for Scenarios 1 and 2, respectively (Table 4).

- After 8-months of pumping, model results show a 0.5 ft decline in ground water levels at a distance of approximately 4,500-5,000 ft from the test slant well for Scenario 1 (180 FTE and Dune Sand aquifers, respectively), and 2,700-2,800 ft for Scenario 2 (Table 5).

- After 8-months of pumping, model results show a 1 ft decline in ground water levels at distance of approximately 2,500-1,800 ft from the test slant well for Scenario 1 (180 FTE and Dune Sand aquifers, respectively), and approximately 800 ft for both aquifers for Scenario 2 (Table 5).

6.0 REFERENCES

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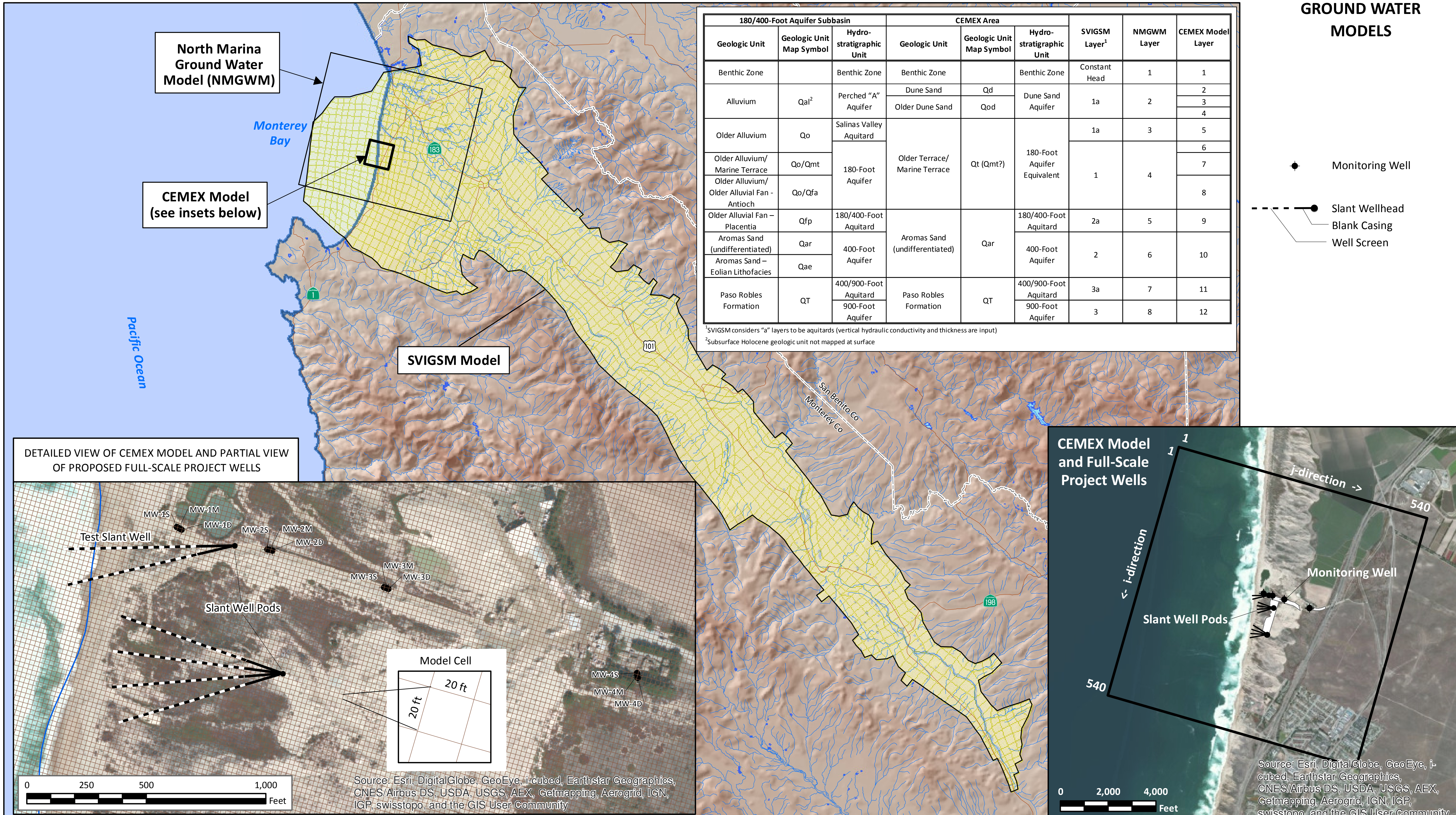
FIGURES

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

GROUND WATER MODELS



180/400-Foot Aquifer Subbasin			CEMEX Area					
Geologic Unit	Geologic Unit Map Symbol	Hydro-stratigraphic Unit	Geologic Unit	Geologic Unit Map Symbol	Hydro-stratigraphic Unit	SVIGSM Layer[1]	NMGWM Layer	CEMEX Model Layer
Benthic Zone		Benthic Zone	Benthic Zone		Benthic Zone	Constant Head	1	1
Alluvium	Qal[2]	Perched "A" Aquifer	Dune Sand	Qd	Dune Sand Aquifer	1a	2	2
			Older Dune Sand	Qod				3
								4
Older Alluvium	Qo	Salinas Valley Aquitard	Older Terrace/ Marine Terrace	Qt (Qmt?)	180-Foot Aquifer Equivalent	1a	3	5
		180-Foot Aquifer				1	4	6
Older Alluvium/ Marine Terrace	Qo/Qmt							7
Older Alluvium/ Older Alluvial Fan - Antioch	Qo/Qfa							8
Older Alluvial Fan – Placentia	Qfp	180/400-Foot Aquitard	Aromas Sand (undifferentiated)	Qar	180/400-Foot Aquitard	2a	5	9
Aromas Sand (undifferentiated)	Qar	400-Foot Aquifer			400-Foot Aquifer	2	6	10
Aromas Sand – Eolian Lithofacies	Qae							
Paso Robles Formation	QT	400/900-Foot Aquitard	Paso Robles Formation	QT	400/900-Foot Aquitard	3a	7	11
		900-Foot Aquifer			900-Foot Aquifer	3	8	12

[1]SVIGSM considers "a" layers to be aquitards (vertical hydraulic conductivity and thickness are input)

[2]Subsurface Holocene geologic unit not mapped at surface

8-Jul-14

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

NORTH

0 5 10 20 Miles

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Figure 1

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_1_gw_model_bndys_7-14.mxd

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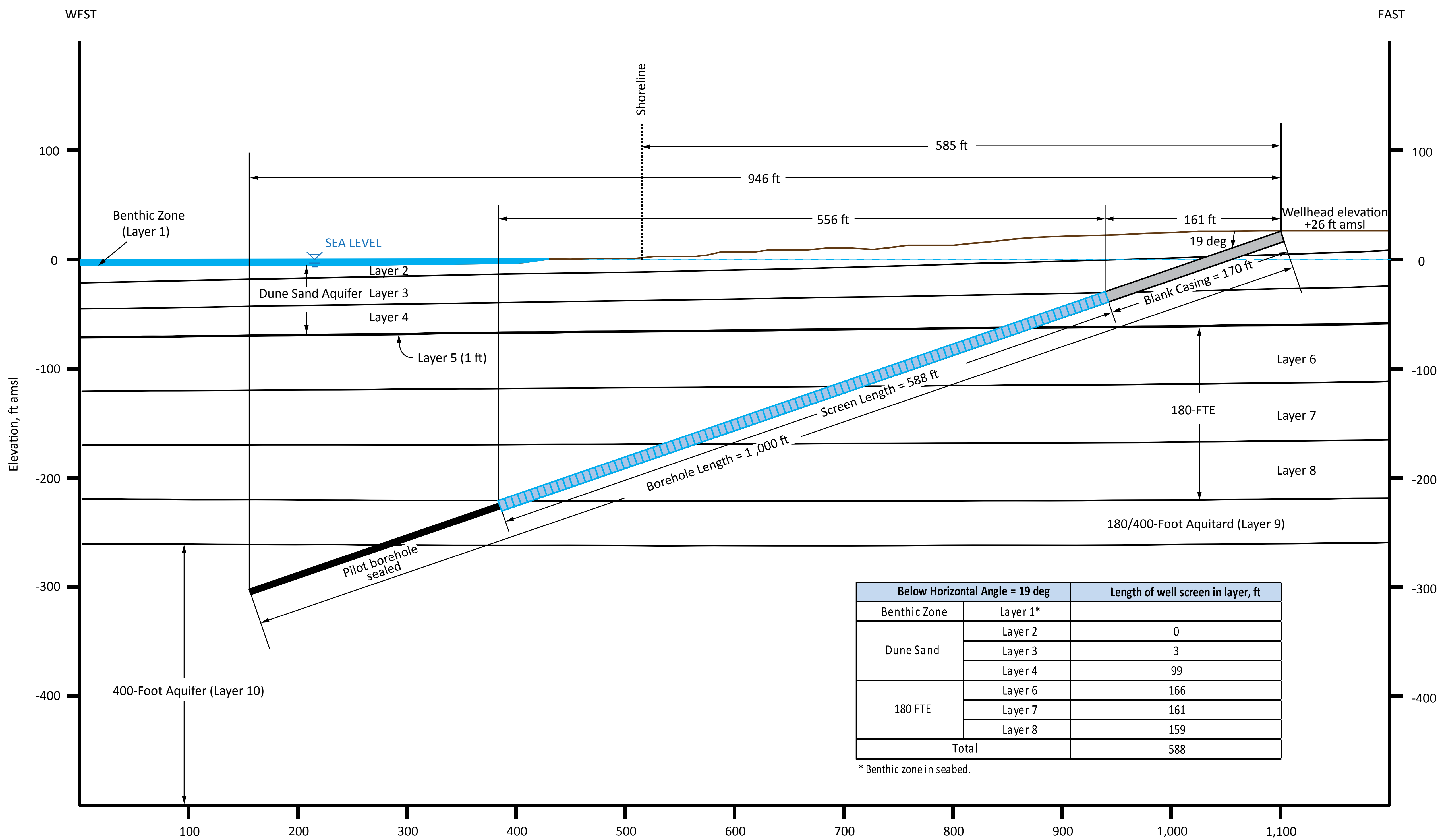
CALIFORNIA AMERICAN WATER

CROSS- SECTION OF TEST SLANT WELL 19 DEGREES BELOW HORIZONTAL



Below Horizontal Angle = 19 deg		Length of well screen in layer, ft
Benthic Zone	Layer 1*	
Dune Sand	Layer 2	0
	Layer 3	3
	Layer 4	99
180 FTE	Layer 6	166
	Layer 7	161
	Layer 8	159
Total		588

* Benthic zone in seabed.

Note: 180-FTE represents 180-Foot Equivalent Aquifer

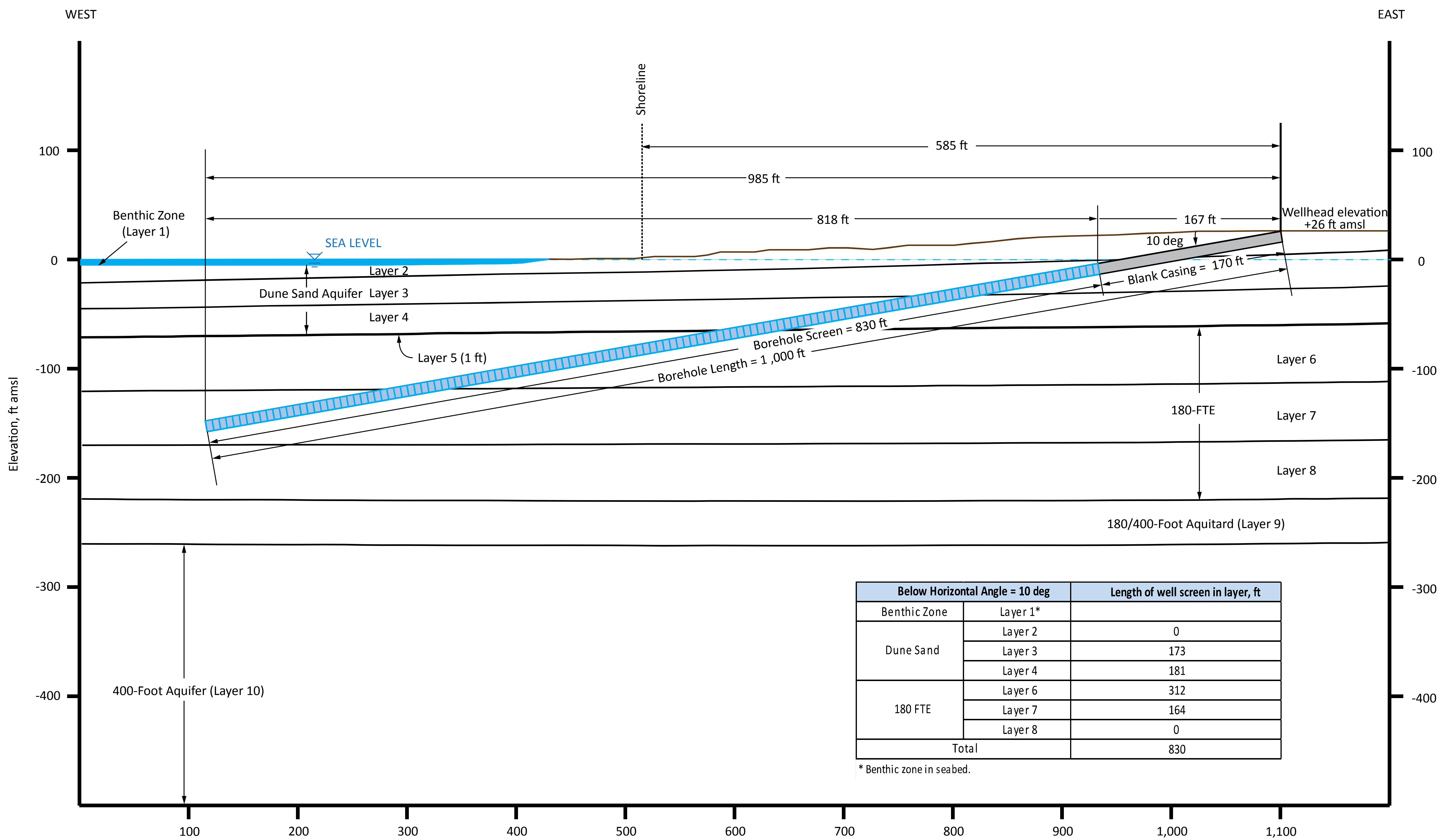
0 100 200
Vertical and Horizontal Scale, ft

DRAFT

Drawn: SS
Checked:
Approved:
Date: 8-Jul-14

Figure 2

X:\Projects\MONTEREY AREA DESAL STUDIES\02) ESA_and_ESA-CalAm\32)TM_Test_Well_Modeling\(1)TM_Test_Well_Modeling\3_FINAL_25Jun14\Figures\0_Fig_2_X-sec_19degrees_7-8.ai



Below Horizontal Angle = 10 deg		Length of well screen in layer, ft
Benthic Zone	Layer 1*	
Dune Sand	Layer 2	0
	Layer 3	173
	Layer 4	181
180 FTE	Layer 6	312
	Layer 7	164
	Layer 8	0
Total		830

* Benthic zone in seabed.

Note: 180-FTE represents 180-Foot Equivalent Aquifer

0 100 200

Vertical and Horizontal Scale, ft

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X:\Projects\MONTEREY AREA DESAL STUDIES\02) ESA_and_ESA-CalAm\32)TM_Test_Well_Modeling\(1)TM_Test_Well_Modeling\3_FINAL_25Jun14\Figures\0_Fig_3_X-sec_10degrees_7-8.ai

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CALIFORNIA AMERICAN WATER

CROSS- SECTION OF TEST SLANT WELL 10 DEGREES BELOW HORIZONTAL

Drawn: SS
Checked:
Approved:
Date: 8-Jul-14

Figure 3

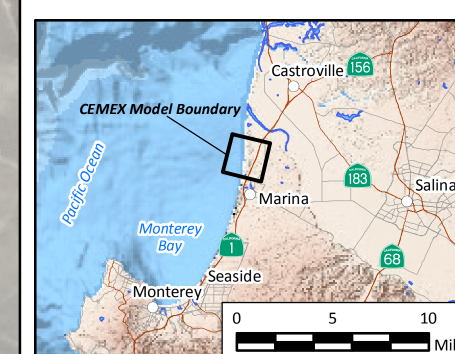
CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 1 MODEL LAYER 2

EXPLANATION

- —0.5— Change in Ground Water Elevation (ft)
- Test Slant Well - Scenario 1, 19 deg
- Test Slant Wellhead
- Blank Casing
- Well Screen
- CEMEX Model Boundary
- Monitoring Well
- Mean High Tide (DOC, NOAA et al., 2011)



8-Jul-14

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

NORTH

0 800 1,600 3,200 Feet

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Figure 4

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_4_dd_L2_scen1_19degrees_7-14.mxd

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL MODELING AT PROPOSED CEMEX SITE

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 1 MODEL LAYER 3

EXPLANATION

—0.5— Change in Ground Water Elevation (ft)

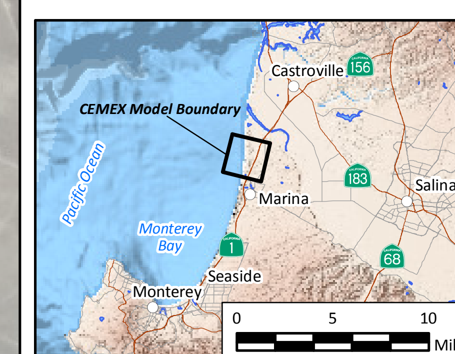
Test Slant Well - Scenario 1
19 deg

Test Slant Wellhead
Blank Casing
Well Screen

CEMEX Model Boundary

Monitoring Well

Mean High Tide (DOC, NOAA et al., 2011)



27-Jun-14

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NORTH

0 800 1,600 3,200 Feet

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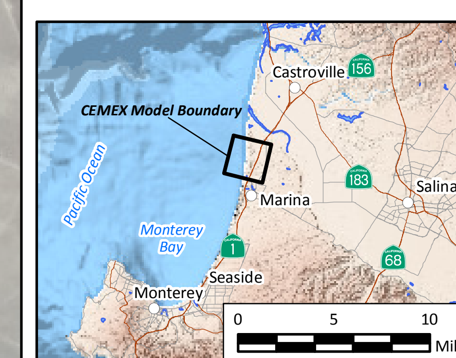
Figure 5

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_6-14/0_Fig_5_dd_L3_scen1_19degrees_6-14.mxd

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 1 MODEL LAYER 4

EXPLANATION

- 0.5 — Change in Ground Water Elevation (ft)
- Test Slant Well - Scenario 1, 19 deg
- Test Slant Wellhead; Blank Casing; Well Screen
- CEMEX Model Boundary
- Monitoring Well
- Mean High Tide (DOC, NOAA et al., 2011)



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NORTH

0 800 1,600 3,200 Feet

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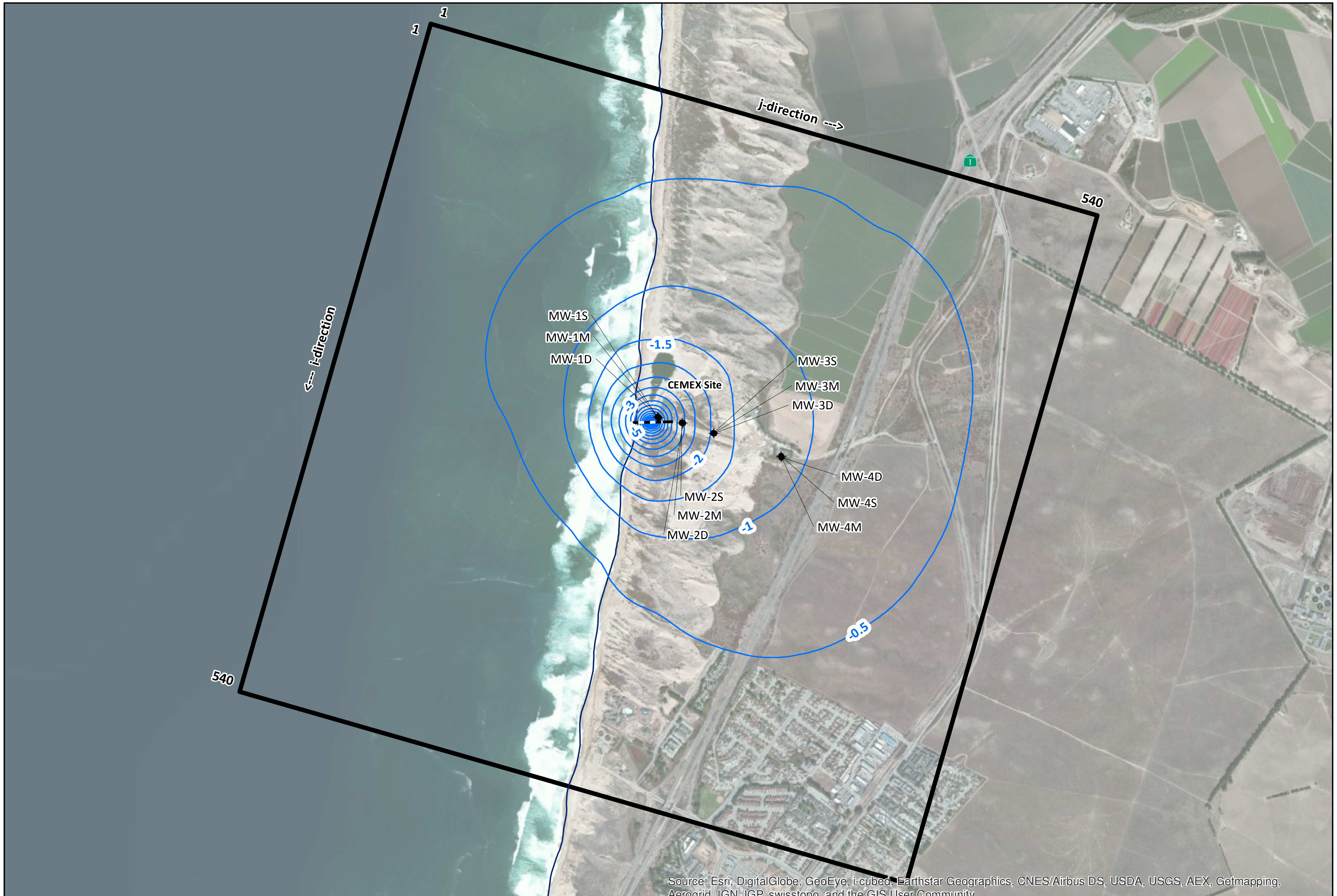
Figure 6

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_6_dd_L4_scen1_19degrees_7-14.mxd

CALIFORNIA AMERICAN WATER

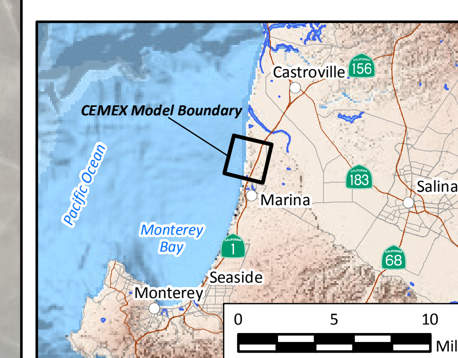
MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 1 MODEL LAYER 6



EXPLANATION

- 0.5 — Change in Ground Water Elevation (ft)
- Test Slant Well - Scenario 1, 19 deg
- Test Slant Wellhead
- Blank Casing
- Well Screen
- CEMEX Model Boundary
- Monitoring Well
- Mean High Tide (DOC, NOAA et al., 2011)



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NORTH

0 800 1,600 3,200 Feet

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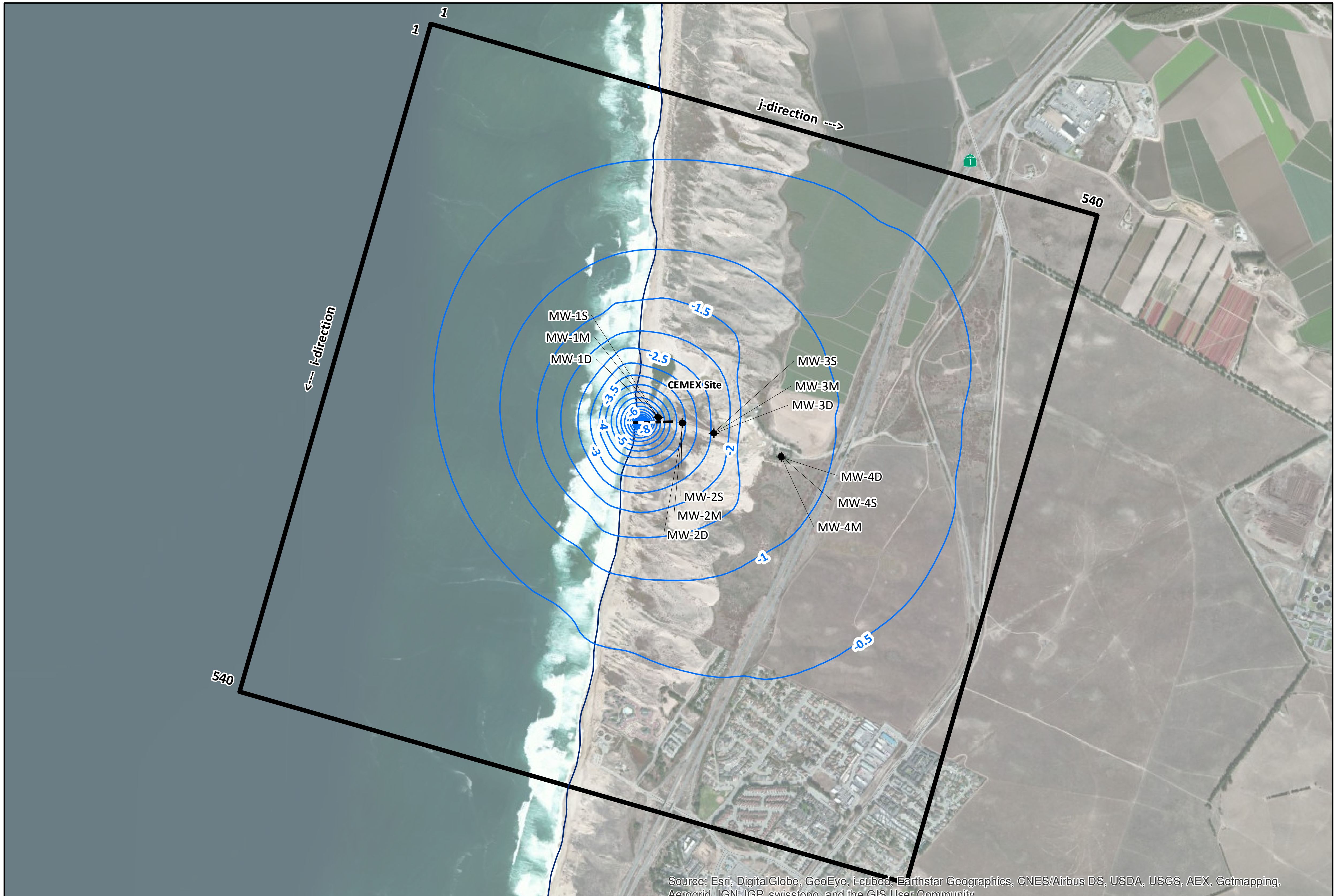
Figure 7

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_7_dd_L6_scen1_19degrees_7-14.mxd

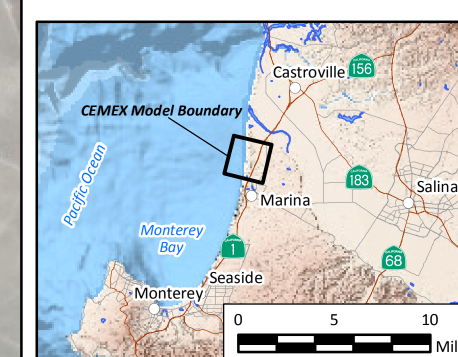
CALIFORNIA AMERICAN WATER

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 1 MODEL LAYER 7



EXPLANATION

- 0.5 — Change in Ground Water Elevation (ft)
- Test Slant Well - Scenario 1, 19 deg
- Test Slant Wellhead; Blank Casing; Well Screen
- CEMEX Model Boundary
- Monitoring Well
- Mean High Tide (DOC, NOAA et al., 2011)



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0 800 1,600 3,200 Feet

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Figure 8

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 1 MODEL LAYER 8

EXPLANATION

—0.5— Change in Ground Water Elevation (ft)

Test Slant Well - Scenario 1 (19 deg)

Test Slant Wellhead

Blank Casing

Well Screen

CEMEX Model Boundary

Monitoring Well

Mean High Tide (DOC, NOAA et al., 2011)

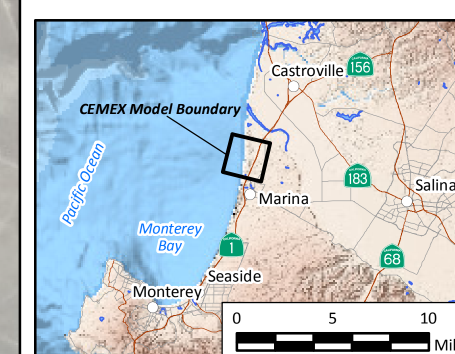

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Figure 9

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_9_dd_L8_scen1_19degrees_7-14.mxd

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 2 MODEL LAYER 2

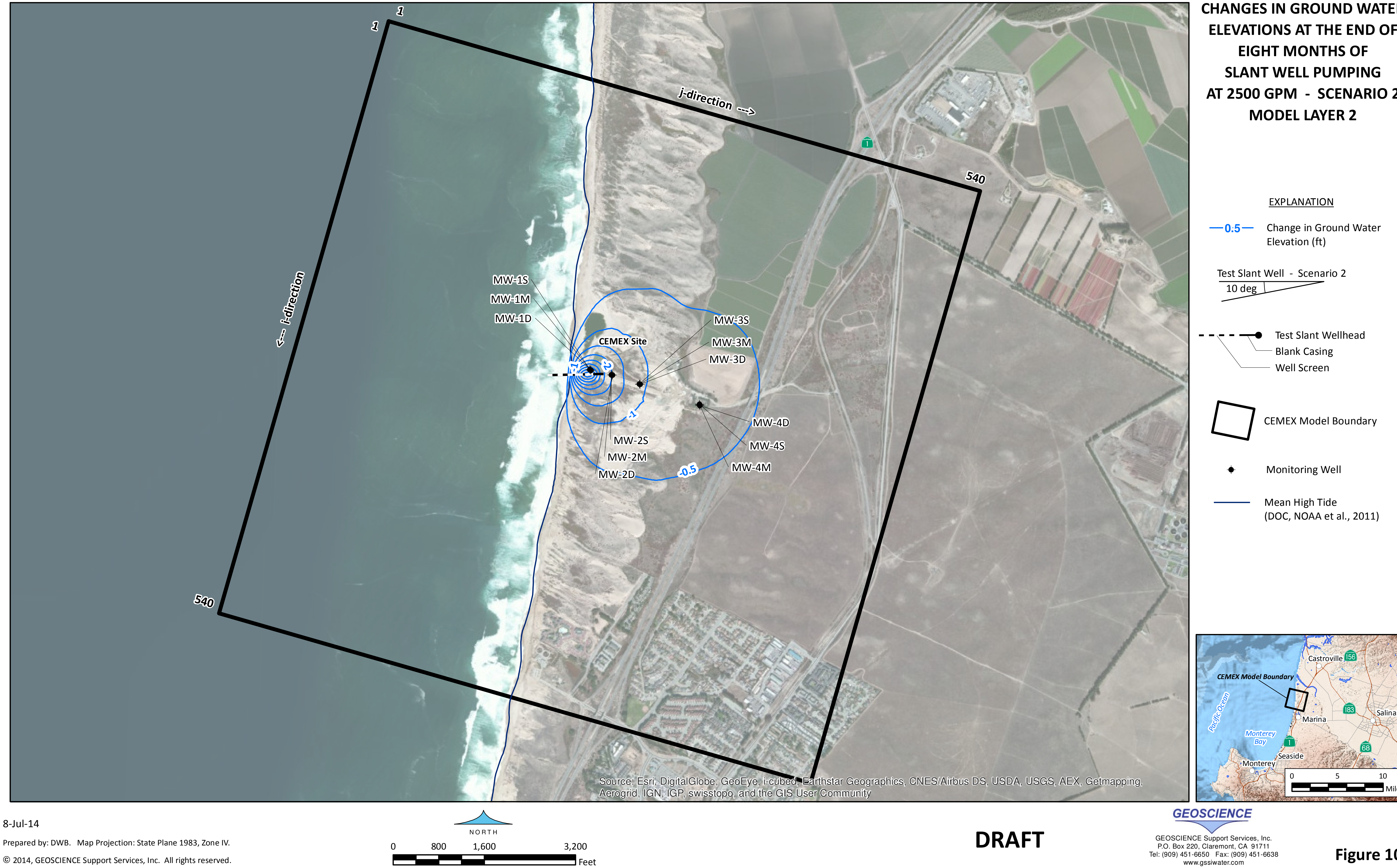

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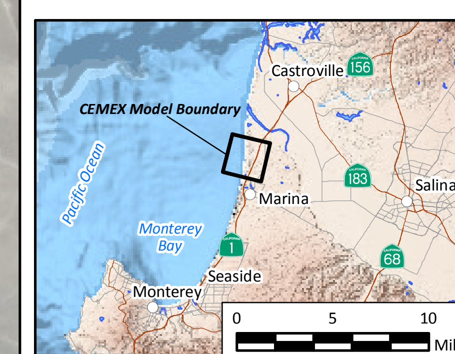
Figure 10

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_10_dd_L2_scen2_10degrees_7-14.mxd

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 2 MODEL LAYER 3

EXPLANATION

- 0.5 — Change in Ground Water Elevation (ft)
- Test Slant Well - Scenario 2 (10 deg)
- Test Slant Wellhead; Blank Casing; Well Screen
- CEMEX Model Boundary
- Monitoring Well
- Mean High Tide (DOC, NOAA et al., 2011)



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NORTH

0 800 1,600 3,200 Feet

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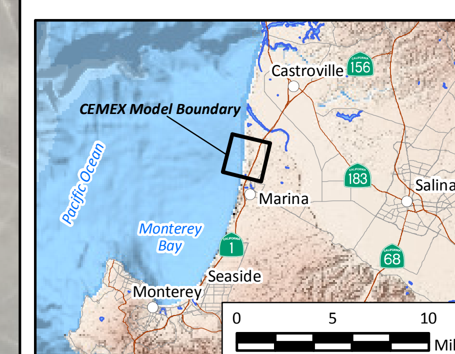
Figure 11

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 2 MODEL LAYER 4

EXPLANATION

- 0.5 — Change in Ground Water Elevation (ft)
- Test Slant Well - Scenario 2, 10 deg
- Test Slant Wellhead; Blank Casing; Well Screen
- CEMEX Model Boundary
- Monitoring Well
- Mean High Tide (DOC, NOAA et al., 2011)



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NORTH

0 800 1,600 3,200 Feet

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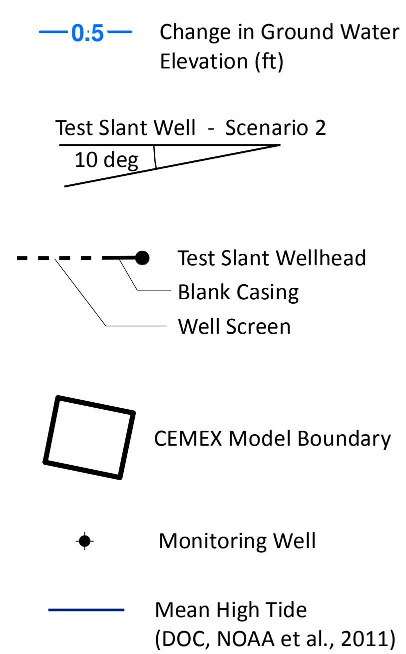
Figure 12

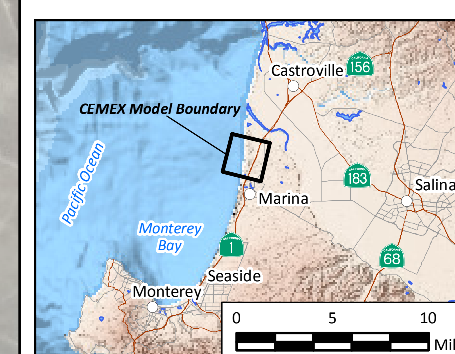
CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 2 MODEL LAYER 6

EXPLANATION





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

NORTH

0 800 1,600 3,200 Feet

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Figure 13

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 2 MODEL LAYER 7

EXPLANATION

—0.5— Change in Ground Water Elevation (ft)

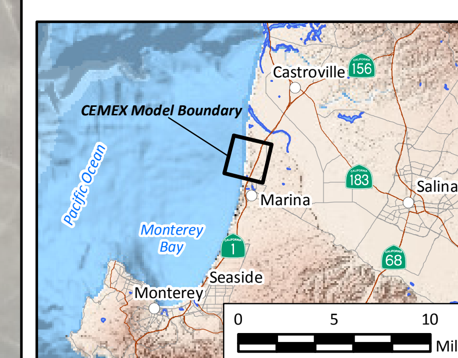
Test Slant Well - Scenario 2
10 deg

Test Slant Wellhead
Blank Casing
Well Screen

CEMEX Model Boundary

Monitoring Well

Mean High Tide (DOC, NOAA et al., 2011)



8-Jul-14

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

NORTH

0 800 1,600 3,200 Feet

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Figure 14

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

CHANGES IN GROUND WATER ELEVATIONS AT THE END OF EIGHT MONTHS OF SLANT WELL PUMPING AT 2500 GPM - SCENARIO 2 MODEL LAYER 8

EXPLANATION

0.5 — Change in Ground Water Elevation (ft)

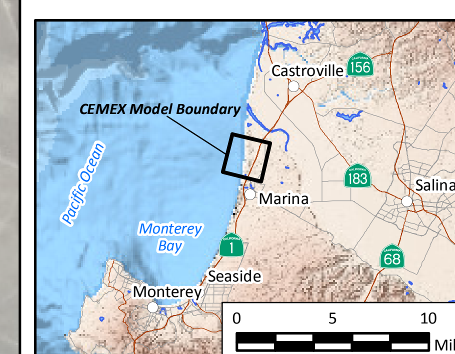
Test Slant Well - Scenario 2
10 deg

Test Slant Wellhead
Blank Casing
Well Screen

CEMEX Model Boundary

Monitoring Well

Mean High Tide (DOC, NOAA et al., 2011)



8-Jul-14

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

NORTH

0 800 1,600 3,200 Feet

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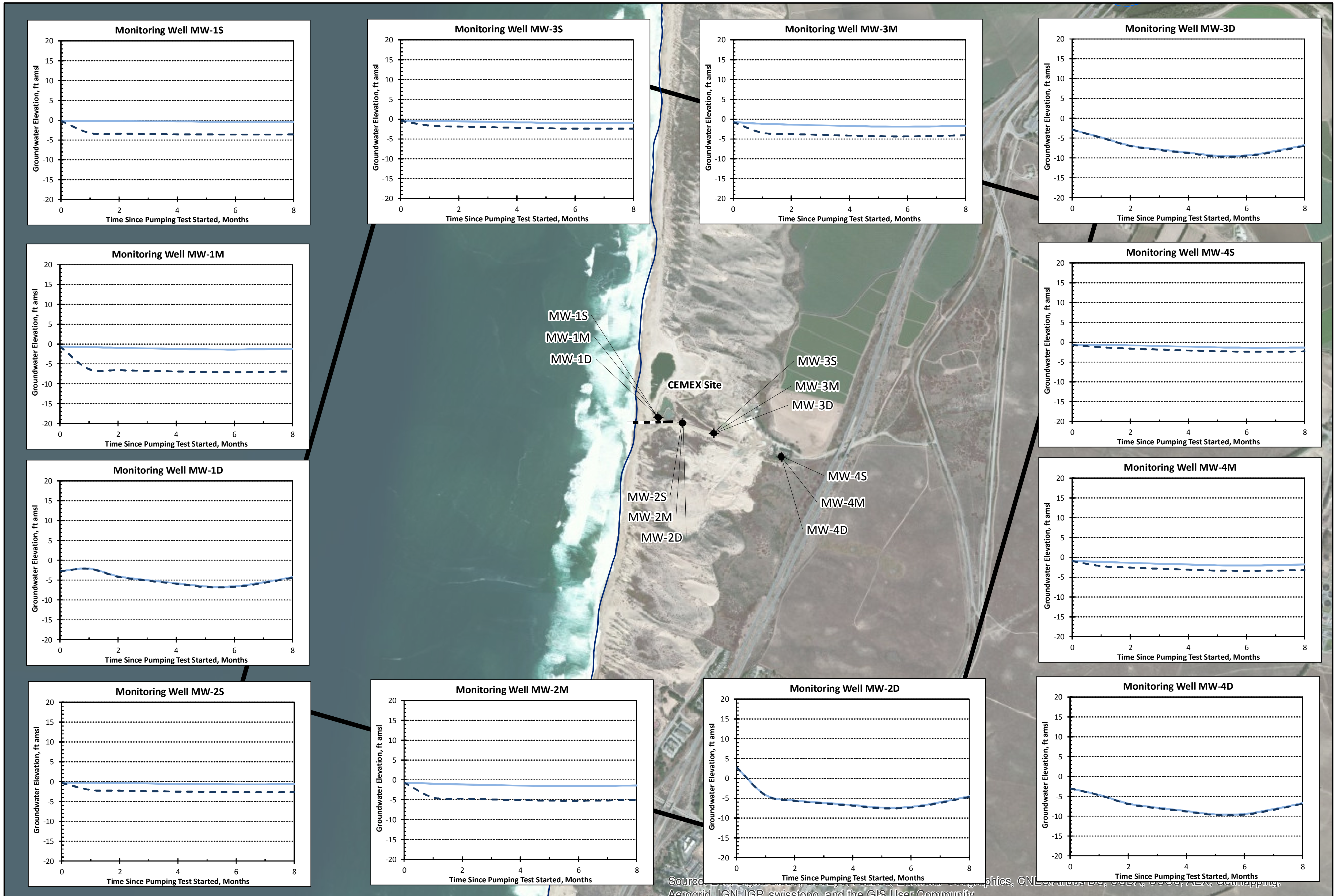
Figure 15

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_15_dd_L8_scen2_10degrees_7-14.mxd

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

HYDROGRAPHS FOR PROPOSED MONITORING WELLS SCENARIO 1

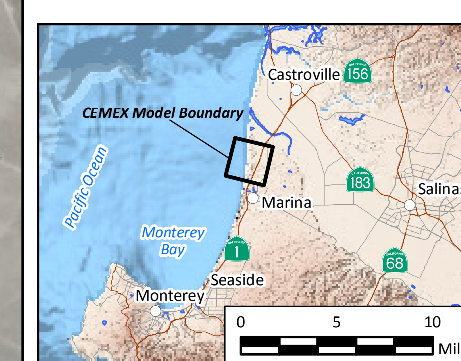


EXPLANATION

- No Test Slant Well
- Test Slant Well at 19 Degrees Below Horizontal

Test Slant Well - Scenario 1
19 deg

- Test Slant Wellhead
- Blank Casing
- Well Screen
- CEMEX Model Boundary
- Monitoring Well
- Mean High Tide (DOC, NOAA et al., 2011)



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NORTH

0 800 1,600 3,200 Feet

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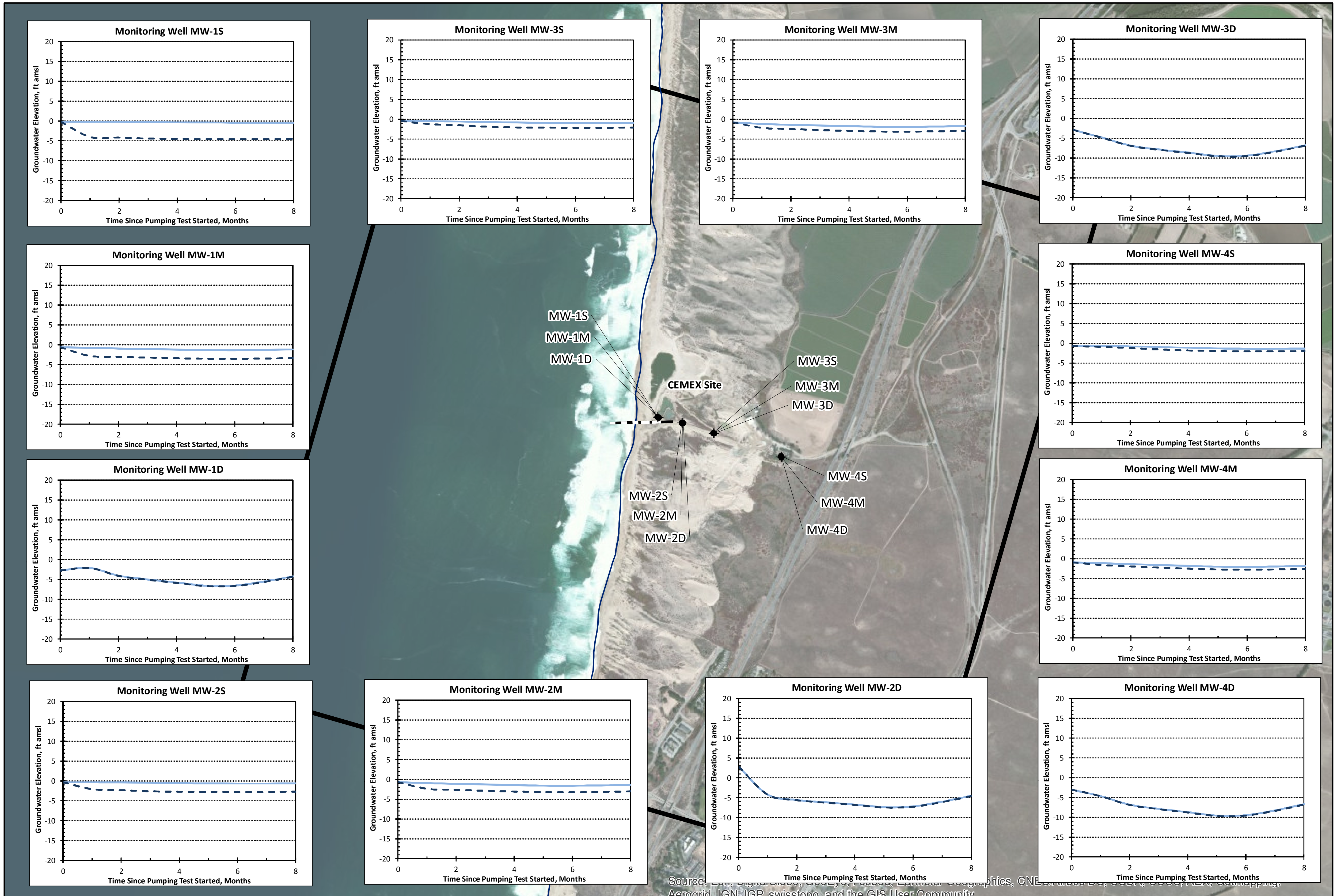
Figure 16

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_16_Hydrograph_scen1_19degrees_7-14.mxd

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL



HYDROGRAPHS FOR PROPOSED MONITORING WELLS SCENARIO 2

EXPLANATION

No Test Slant Well

Test Slant Well at 10 Degrees Below Horizontal

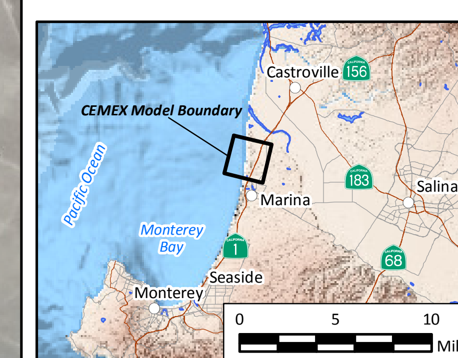
Test Slant Well - Scenario 2
10 deg

Test Slant Wellhead
Blank Casing
Well Screen

CEMEX Model Boundary

Monitoring Well

Mean High Tide
(DOC, NOAA et al., 2011)



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NORTH

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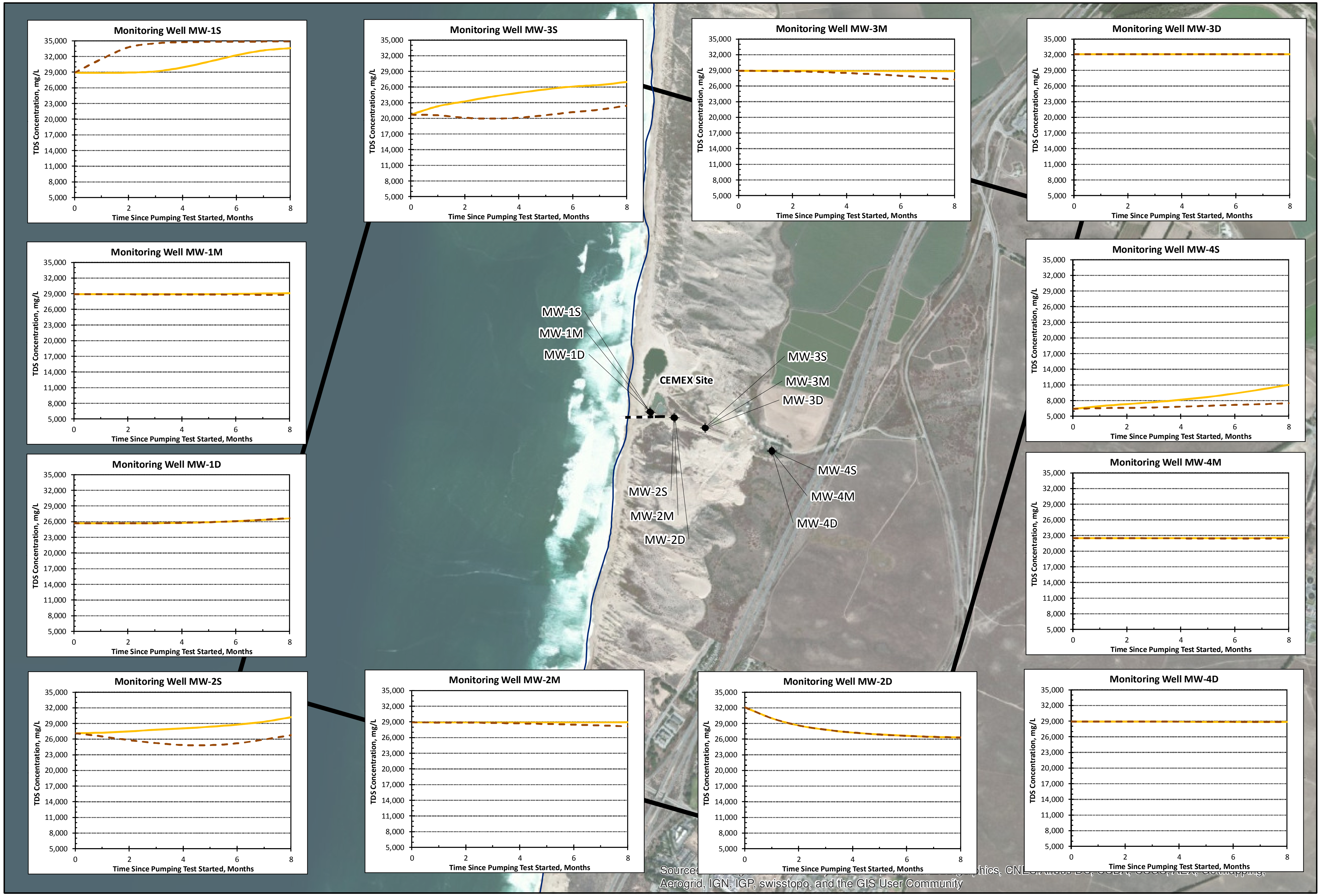
Figure 17

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_17_Hydrograph_scen2_10degrees_7-14.mxd

CALIFORNIA AMERICAN WATER

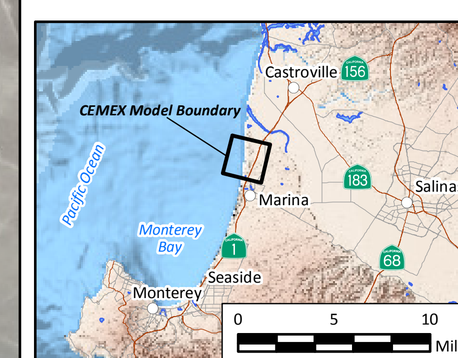
MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL



MODEL-CALCULATED TDS CONCENTRATIONS FOR PROPOSED MONITORING WELLS SCENARIO 1

EXPLANATION

- No Test Slant Well
- Test Slant Well at 19 Degrees Below Horizontal
- Test Slant Well - Scenario 1, 19 deg
- Test Slant Wellhead
- Blank Casing
- Well Screen
- CEMEX Model Boundary
- Monitoring Well
- Mean High Tide (DOC, NOAA et al., 2011)



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NORTH

0 800 1,600 3,200 Feet

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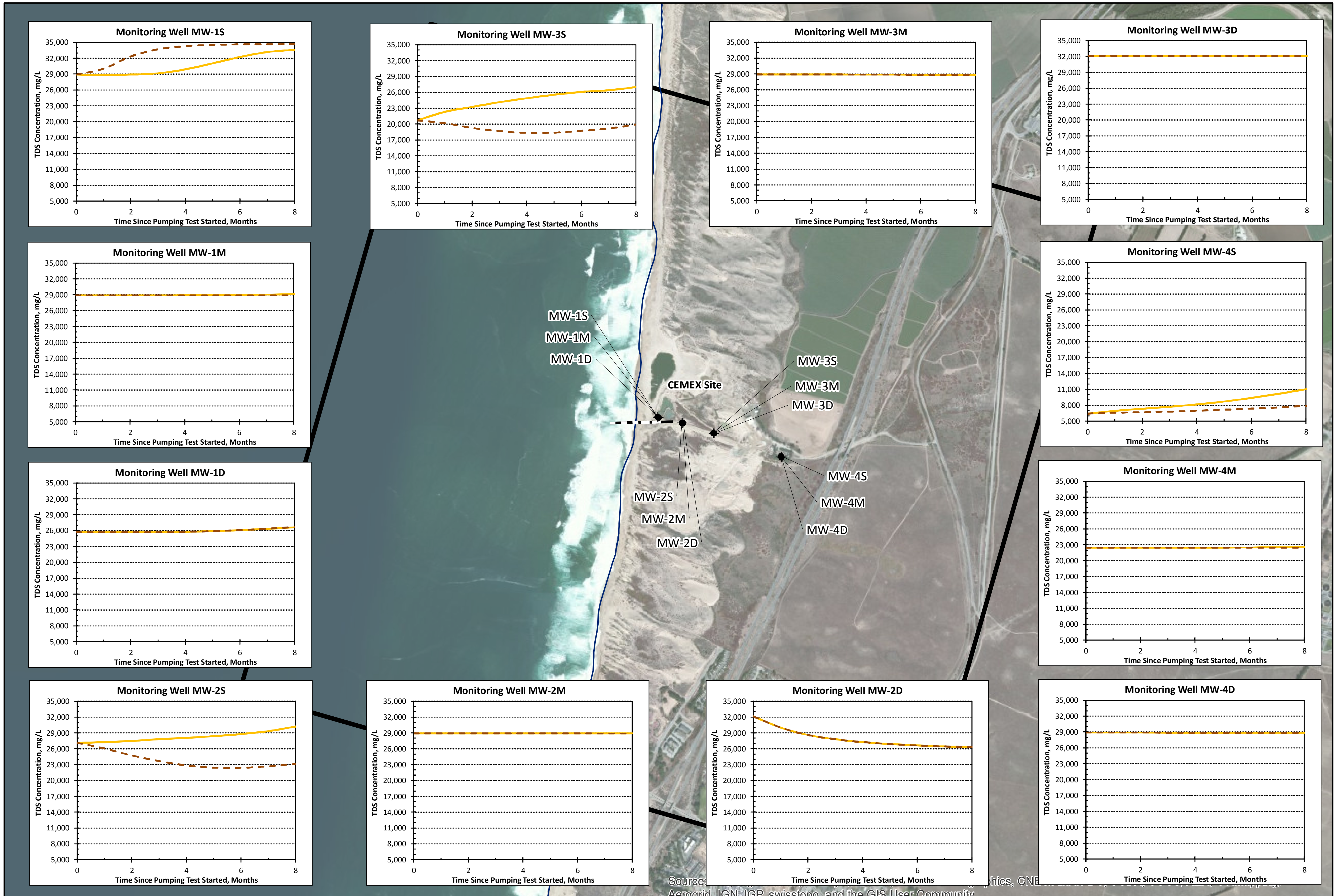
Figure 18

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_18_Chemograph_TDS_scen1_19degrees_7-14.mxd

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
RESULTS OF TEST SLANT WELL PREDICTIVE SCENARIOS USING THE CEMEX AREA MODEL

MODEL-CALCULATED TDS CONCENTRATIONS FOR PROPOSED MONITORING WELLS SCENARIO 2



EXPLANATION

No Test Slant Well

Test Slant Well at 10 Degrees Below Horizontal

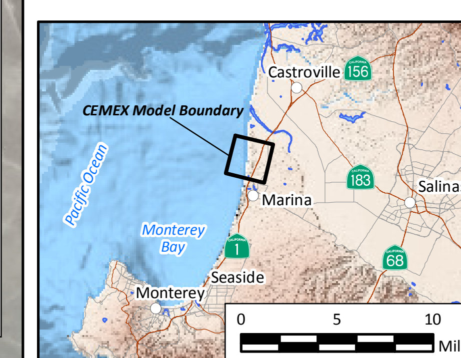
Test Slant Well - Scenario 2
10 deg

Test Slant Wellhead
Blank Casing
Well Screen

CEMEX Model Boundary

Monitoring Well

Mean High Tide (DOC, NOAA et al., 2011)



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NORTH

0 800 1,600 3,200 Feet

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Figure 19

GIS_proj/mcwsp_cal_am/esa_test_slantwell_modeling_7-14/0_Fig_19_Chemograph_TDS_scen2_10degrees_7-14.mxd

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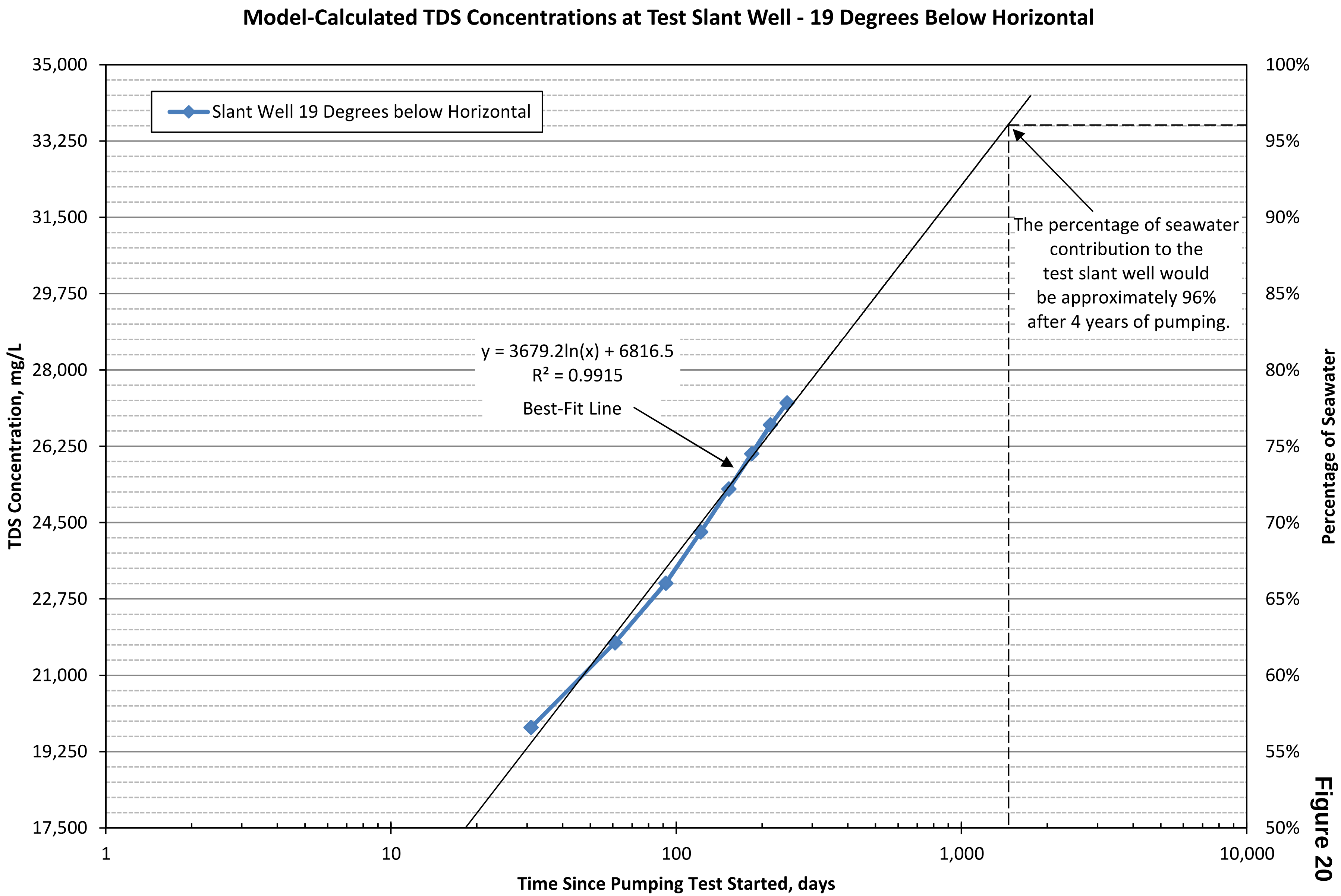

Figure 20

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Model-Calculated TDS Concentrations at Test Slant Well - 10 Degrees Below Horizontal

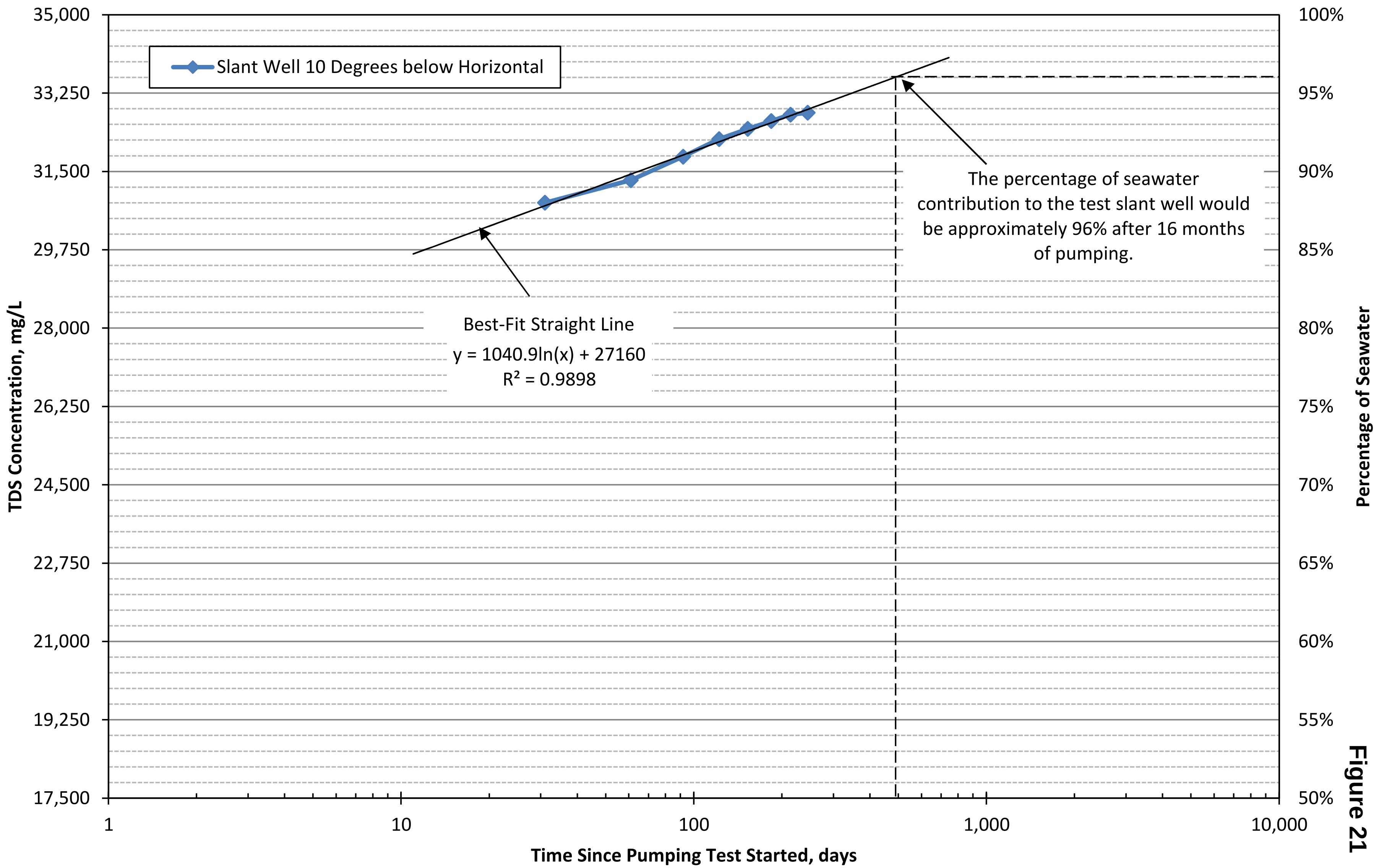

Figure 21

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