CALIFORNIA AMERICAN WATER / RBF CONSULTING
MONTEREY PENINSULA WATER SUPPLY PROJECT HYDROGEOLOGIC INVESTIGATION
TECHNICAL MEMORANDUM (TM 1)
SUMMARY OF RESULTS - EXPLORATORY BOREHOLES

1.0 EXECUTIVE SUMMARY

1.1 Introduction

The investigation and findings described in this Technical Memorandum are the result of collaborative planning and discussions among the hydrogeologic experts that represent key stakeholders for groundwater use and management in the Salinas Valley and Monterey Peninsula area of central California. The Hydrogeology Working Group (HWG) consisted of the following experts: Mr. Tim Durbin and Mr. Martin Feeney (both representing the Salinas Valley Water Coalition and the Monterey County Farm Bureau), Mr. Peter Leffler (representing CalAm), and Dr. Dennis Williams (representing the CPUC CEQA Team). The HWG was formed as a result of a 2013 Settlement Agreement among parties to an ongoing CPUC-proceeding resulting from CalAm's proposed Monterey Peninsula Water Supply Project, to review and approve the scope of field investigation and development of a hydrogeologic conceptual model from which to construct the groundwater modeling tools. The names of the HWG members are presented here to indicate the general agreement among the members on the core findings of the investigative work described herein.

The work completed for this investigation was described in the Hydrogeologic Investigation Workplan (Workplan), Attachment 1, dated 18-Dec-2013. This investigation represents the first phase of field data gathering to develop a hydrogeologic conceptual model for the project area that is accepted by the stakeholders. The conceptual model will be used to refine the existing North Marina Ground Water Model (NMGWM) and construct a new focused model (CEMEX model). These models will be used to evaluate proposed project operations and impacts. Additional phases of field testing are planned and outlined in the Workplan.

Since September 2013, six exploratory boreholes were drilled at the CEMEX facility. Total borehole depth ranged from 250 feet (ft) below ground surface (bgs) to 350 ft bgs. Three of the boreholes were used to collect continuous soil cores, undisturbed soils samples, samples for mechanical grading analysis, and geophysical logs. Two borings were used to construct isolated zones[1] for collecting water quality samples from aquifers at discrete depths and the last borehole (CX-B4) was used to collect continuous soil cores, undisturbed soils samples, samples for mechanical grading analysis, geophysical logs, and to collect water quality samples. A total of fifteen (15) aquifer zone tests have been completed at the CEMEX site. Water quality samples collected from the isolated aquifer zones were analyzed for the same suite of analytes outlined in the Workplan and included general physical, general mineral, volatile organic compounds, pesticides, tritium, and stable isotopes of oxygen and hydrogen.

Since September 2013, seven exploratory boreholes were drilled in the Moss Landing area. Six borings were drilled to a depth of 200 ft bgs. One boring (MDW-1) was drilled to a depth of 300 ft bgs. Each borehole was used to collect continuous soil cores, undisturbed soil samples, samples for mechanical grading analysis, and geophysical logs. Two isolated aquifer zones were constructed in boreholes ML-1, ML-2, ML-3, ML-4, ML-6, and PR-1 (for a total of 12 zones) to collect depth-specific groundwater quality samples. Four isolated aquifer zones were constructed to collect groundwater samples from Boring MDW-1.

1.2 Findings

1.2.1 General

- The conceptual hydrogeologic model developed from this investigation suggests that a feedwater supply system using slant wells at the CEMEX site is feasible and can utilize the Dune Sand Aquifer and underlying terrace deposits (180-Foot Equivalent Aquifer) as conduits to extract water through the seafloor beneath Monterey Bay.
- This opinion will be tested using the newly constructed CEMEX Model and the refined NMGWM and will be field tested using a test slant well and groundwater monitoring system as described in the Hydrogeologic Investigation Workplan.
- The conceptual model also indicates that the Perched "A" Aquifer between the Molera and Sandholt Road Salinas River State Beach parking lots could provide an alternative target for construction of a subsurface feedwater supply system.

1.2.2 CEMEX Area

The CEMEX facility is located on the westernmost edge of the 180/400-Foot Aquifer Subbasin of the Salinas Valley Groundwater Basin, as currently mapped by DWR (2003) and the MCWRA (2011). The findings of the investigation at CEMEX are summarized below:

[1] An isolated zone is constructed by the installation of well screen at a selected depth interval and isolating the well screen above and below using bentonite seals. Construction of isolated zones allows depth specific sampling of groundwater.

- A significant clay layer is not present beneath the Dune Sand Aquifer at the CEMEX site at elevations commonly attributed to the Salinas Valley Aquitard (SVA), suggesting a different depositional environment than that of the 180-Foot Aquifer in the Salinas Valley. The water quality data suggests groundwater in the Dune Sand Aquifer may be in hydraulic continuity with the underlying aquifer units. The degree of hydraulic continuity will be determined by construction of aquifer specific monitoring wells and the long-term pumping test of the test slant well.

- Stratigraphic relationships and lithologic observations indicate that the aquifer system underlying the Dune Sand Aquifer consists of terrace deposits that are older than the inland 180-Foot Aquifer deposits, since they underlie the Older Dune Sand.

- The terrace deposits appear to be a distinct lithologic unit in terms of geologic history and depositional environment in the Dune Highland area and may be hydrostratigraphically equivalent to the 180-Foot Aquifer in the Salinas Valley.

- 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, SVA, etc). Consequently, the naming convention agreed upon by the HWG, includes the word “equivalent” since the lithologic units that make up the aquifers at CEMEX and in the Salinas Valley are chronologically different, but stratigraphically equivalent.

- As a hydrogeologic unit, the terrace deposits will be designated as the 180-Foot Equivalent (180-FTE) Aquifer. The extent of hydrostratigraphic equivalence will be evaluated through a pumping test utilizing the test slant wells and a monitoring network.

- The current interpretation of the distinctive dark greenish-gray clay found at depths ranging from 241 to 282 ft bgs at CEMEX is that it may represent a change in the depositional history and is underlain by a unit equivalent to the Aromas Sand(?)/400-Foot Aquifer.

- Both the Dune Sand Aquifer and the underlying 180-FTE Aquifer extend seaward beneath the Monterey Bay.

- Groundwater in the Dune Sand Aquifer and most of the groundwater in the 180-FTE Aquifer exhibit high concentrations of total dissolved solids (TDS), ranging from 24,000 to 32,000 mg/L, indicating a seawater source.

- Hydraulic conductivity for the Dune Sand at CEMEX ranged from an average low value of 273 ft/day to an average high value of 779 ft/day.

- Hydraulic conductivity for the Older Dune Sand at CEMEX ranged from an average low value of 136 ft/day to an average high value of 372 ft/day.
- Hydraulic conductivity of the terrace deposits that make up the 180-FTE Aquifer ranged from an average low value of 113 ft/day to an average high value of 342 ft/day.
- Hydraulic conductivity values will be further refined based on the long-term test slant well pumping test.
- Analysis of cation/anion ratios indicates that groundwater in the lower portion of 180-FTE Aquifer and in the 400-Foot Aquifer have been geochemically altered due to seawater intrusion.
- Tritium results indicate that groundwater in the lower portion of the 180-FTE Aquifer is older than groundwater in the upper portion of the 180-FTE Aquifer and the Dune Sand Aquifer.
- Analysis of oxygen and hydrogen isotopes suggests that at both the CEMEX and Moss Landing sites, saltwater from the ocean is mixing with a freshwater source that has not undergone significant evaporation (as would be expected of a surface water source).
- Hydrostratigraphic relationships indicate that slant wells drilled into the Dune Sand Aquifer and 180-FTE Aquifer will receive recharge primarily from ocean sources through vertical leakage from the sea floor and horizontal recharge from offshore subsea aquifers. This will be tested by the CEMEX and refined NMGWMs as well as field pumping tests.

1.2.3 Moss Landing Area

The Moss Landing area is located north of the mouth of the Salinas River, which overlies the westernmost edge of the 180/400-Foot Aquifer Subbasin. Borings were drilled and sampled at Moss Landing Harbor and at the Molera, Potrero Road, and Sandholt Road parking lots of Salinas River State Beach. The exploratory borings primarily penetrated fluvial sediments associated with Holocene and Late Pleistocene Salinas River deposition.

The Perched[2] “A” Aquifer is ascribed to the Holocene river alluvium and considered to be the hydrostratigraphic equivalent of the Dune Sand Aquifer located to the south.

- The Perched “A” Aquifer in the Moss Landing area is composed of interbedded river and floodplain deposits.

[2] The term Perched “A” Aquifer refers to the shallow aquifer above the Salinas Valley Aquitard. Traditionally, the term “perched” aquifer refers to a hydrogeologic condition where an aquifer is formed by groundwater being present above (perching on) an impermeable unit such as clay but with an unsaturated portion of an aquifer between the bottom of the clay and the underlying saturated portion of a lower aquifer.

- With the exception of the sediments penetrated in Boring PR-1 and MDW-1, individual sand and sand and gravel lenses do not appear to be either vertically or areally extensive in Moss Landing.
- Significant variations in TDS concentrations suggest that groundwater is mixed with seawater, and is likely present in semi-isolated lenticular deposits.
- In general, the upper isolated aquifer test zones were above a depth of 110 ft bgs. TDS concentrations ranged from 3,200 mg/L to 34,000 mg/L.
- The lower isolated aquifer zones were generally constructed at depths exceeding 150 ft bgs. With the exception of Zone 1 of PR-1 (190-200 feet) at 630 mg/L, the TDS concentrations ranged from 7,400 mg/L to 34,000 mg/L.
- Boring PR-1 penetrated a very permeable unit in the Perched "A" Aquifer from 54 to 139 ft bgs. Groundwater in this interval approximated seawater quality (i.e., 34,000 mg/L). This unit is interpreted to continue, but decrease in thickness southward towards Boring MDW-1. To the north, the unit is interbedded with fine-grained units.
- It is interpreted that the lowest portion of Boring PR-1 penetrated the SVA. Very low TDS concentrations (630 mg/L) encountered in the lowest zone in Boring PR-1 suggest that isolated zones of freshwater may exist within the 180-Foot Aquifer or that the sand unit is laterally discontinuous and may be interbedded with the SVA. In this last interpretation, Boring PR-1 did not completely penetrate the SVA.
- Hydraulic conductivity values for the permeable portion of the Perched "A" Aquifer penetrated in PR-1 ranged from 194 ft/day to 717 ft/day, based upon relationships between grain size distribution and hydraulic conductivity.
- The permeable unit between Boring PR-1 and MDW-1 represents a potential location for slant wells.
- The Moss Landing Borings (ML-1, ML-2, ML-3, ML-4, and ML-6) did not penetrate significant thicknesses of permeable deposits to produce the required feedwater supply volume for the MPWSP.

1.2.4 Refinement of NMGWM and Development of Focused CEMEX Model

The geologic and hydrogeologic data collected during this investigation was used to prepare the interpretations of hydrostratigraphic relationships in the Moss Landing and CEMEX areas. A conceptual model of the hydrostratigraphic units from the Moss Landing to CEMEX area as interpreted from data collected from this investigation is shown below on Figure 1-1

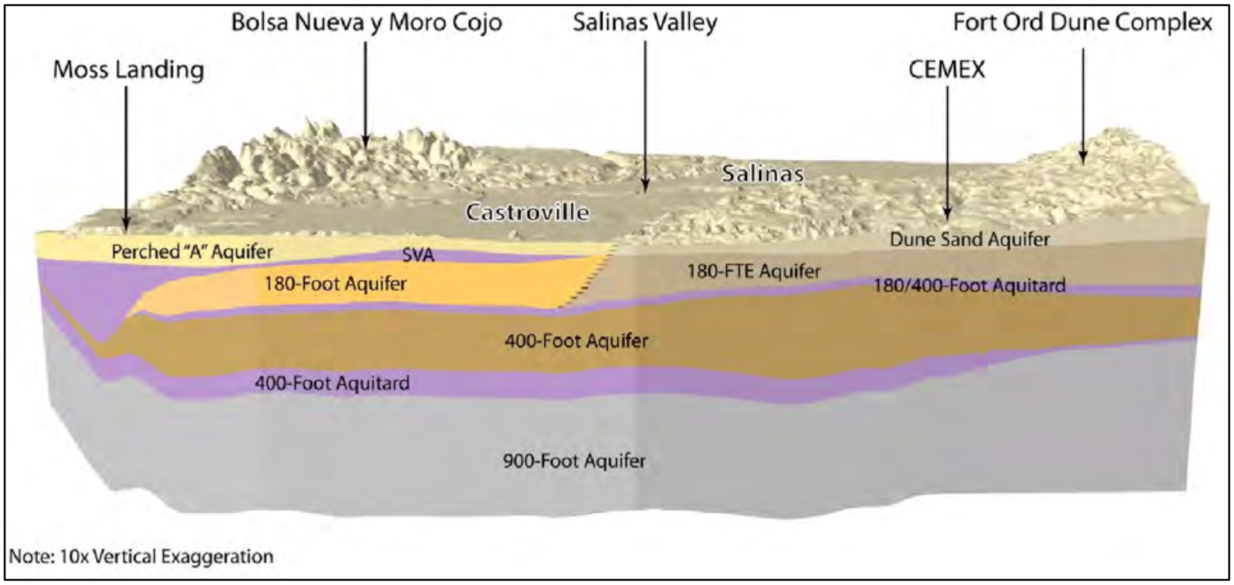

Figure 1-1. Hydrostratigraphic Model – Moss Landing to CEMEX Area

The following table provides a correlation of the geologic and hydrostratigraphic units to groundwater model layers of the Salinas Valley Integrated Groundwater and Surface Water Model (SVIGSM) and the NMGWM. In addition, the project technical advisory group described in Section 2.4 requested that a third model (a focused model) be constructed in the CEMEX area. The new focused model is designated as the CEMEX Model (CM) and will be discussed in Section 6. The model layers of the CM, as correlated to the SVIGSM and NMGWM, are also shown on Table 1-1.

Table 1-1.
Correlation of Geologic and Hydrostratigraphic with SVIGSM, NMGWM, and CM Model Layers

180/400-Foot Aquifer Subbasin			CEMEX Area					
Surface Geologic Units	Surface Geologic Units Map Symbol	Hydro-stratigraphic Units	Surface Geologic Units	Surface Geologic Units Map Symbol	Hydro-stratigraphic Units	SVIGSM Layer[1]	NMGWM Layer	CEMEX Model Layer
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-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

[1]SVIGSM considers "a" layers to be aquitards (vertical hydraulic conductivity and thickness are input)
[2]Subsurface Holocene geologic unit not mapped at surface