Deep Water Desalination Project
Moss Landing, California

Hydrogeological Consideration for Subsurface Intake Systems

Prepared by

Hany Elwany, Ph.D.
Coastal Environments, Inc.
Ecosystems Management Associates, Inc.

16 June 2014
Shaded relief bathymetry/topography map showing the location of Moss Landing on the eastern shoreline of Monterey Bay
Monterey Bay Study Area showing Pajaro and Salinas Rivers and Elkhorn Slough
Historical changes to the Elkhorn Slough

Monterey Bay groundwater basins and subbasins

From Kulongoski and Belitz (2007).
Location of area impacted by Seawater Intrusion at Pajaro Valley

From PVWMA (2000).
Historic Seawater Intrusion Map
180-foot aquifer at Salinas Valley

Historic Seawater Intrusion Map
400-foot aquifer at Salinas Valley

Locations of Caltrans boreholes
(blue squares, left figure)

From Sea Engineering (2006).
Highway 1 Cross-section: Complex shallow layering with fine-grained sediments

From Sea Engineering (2006).
Geology and selected wells to estimate aquifer thickness in Pajaro Valley, Santa Cruz and Monterey Counties

From Hanson (2003).
Diagram shows the limited area of seawater intrusion, which demonstrates slow recharge; the local seawater intrusion map and graphs show the area extent and timing of the intrusion. Note: The water is saline, but not as salty as the open seawater, which also shows the slow recharge of seawater into the shallow aquifers. From Hanson (2003).
Cross-section across the buried Elkhorn Valley in the vicinity of Moss Landing and Elkhorn Slough

Modified from: Fugro, 1995
Geology map of the Moss Landing area showing well locations and Isopach contours of offshore Holocene sediments (thin green lines in meters) From Fugro (1995).
Resistivity and Geological log for Capurro #516 located North of Elkhorn Slough
Map showing earthquake epicenters (seismicity) and major faults in the vicinity of Moss Landing

From USGS (2000).
Distribution of liquefaction-induced ground failures in the Moss Landing area after the Loma Prieta Earthquake of October 1989

Tsunami Hazards
28 March 1964 Earthquake, Alaska

Monterey tide gauge measurements showing the first 12 hours of the tsunami waves at Moss Landing.
Selected Subsurface Intake Well Systems: Vertical Beach Well
Selected Subsurface Intake Well Systems:  
Slant Well
Selected Subsurface Intake Well Systems: Horizontal Well
Selected Subsurface Intake Well Systems: Radial Collector Well
Selected Subsurface Intake Well Systems: Ranney Collector Well
Number of wells & feed water supply (mgd) for each desalination plant presented in table.
Average well feed water supply (mgd) for each desalination plant presented in table
Challenges for selecting site for Subsurface Intake System

- There are coarse-grained layers with sand and gravel from ancient rivers that may be a good aquifers, but these layers include clay/silt layers that restrict water flow to subsurface intake system.

- The lateral extent of these coarse grain layers on land or offshore is not known and have been complicated by rivers and the Elkhorn Slough inlet migration over thousands of years.

- For any subsurface intake system to function, 3D mapping is needed to determine the lateral extent of aquifer layers and their thickness at the proposed location of the intake.

- The conductivity of various layers must be determined and a calibrated hydraulic model is required to estimate the recharge rate for the proposed system.

- Other issues include engineering, land ownership, environmental impacts, impacts on salt water intrusion to existing wells, power consumption, reliability, maintenance, costs, etc.
1. Major coarse-grained aquifers exist at about 180 ft and 400 ft below sea level in the coastal zone near Moss Landing. There is a shallow aquifer in alluvium, and older dune sands also exist along the coastal zone and can be considered as a salt water source for a subsurface intake system.

2. Seawater intrusion has occurred in these aquifers since at least the 1930s. Seawater transport from offshore to inland areas occurs by lateral flow within the aquifers.

3. Layers of fine-grained deposits between and within the major aquifers form aquitards that limit the vertical flow and recharge of the major aquifers.
4. Natural hazards, including the strong ground motion of earthquakes, liquefaction-induced ground failures, submarine landslides, potential tsunami, storm surges, and sea level rise, may pose significant risks.

5. The construction and operation of a subsurface intake system in or near the Monterey Canyon may impact the stability of the canyon edges. Pumping of groundwater in unconsolidated sediments along submarine slopes may trigger slope failure.

6. A borehole drilled by Cal Am at Moss Landing during 2013 found “intermittent clay layers mixed with silt and fine sand, without enough continuous sand layers to use any type of subsurface intake system efficiently” (The International Desalination & Water Reuse Quarterly website, 5 January 2014).
Summary and Conclusions (Slide 3/4)

7. Subsurface intake systems are newly evolving technologies and, at present, are suitable only for small desalination plants (about 10 mgd) unless very special hydrogeological conditions exist. Their success requires site-specific hydrogeological conditions relative to the recharge rate, water quality, engineering concerns, geological hazards, maintenance, reliability, and economic concerns.

8. Results from 26 operating desalination plants using subsurface intake systems show that the maximum well production was 3.98 mgd. The average production of the wells from these plants was 1.5 mgd. These subsurface intake systems were located within different sediment types and grain sizes, which yield differing amounts of feed seawater.
9. Geohydrological modeling of the aquifer systems in the vicinity of Elkhorn Slough was used to estimate the encroachment of about 3,000 to 5,000 acre-feet per year (2.7 to 4.5 mgd) of seawater into the groundwater system (Fugro, 1995). About 20 percent of this value is due to horizontal flow (seawater intrusion) and the rest to vertical leakage from Elkhorn Slough (Fugro, 1995). In order to provide a 50 mgd feed water, the recharge area or infiltration rates must be increased by at least one order-of-magnitude.

10. A larger area covered by seawater exists offshore and adjacent to the Monterey Canyon. If the shallow alluvial basin (paleochannel) has similar layering of coarse-grained aquifers interbedded with low-permeability clays and silts, as are found in wells onshore (Fugro, 1995), then the area for vertical infiltration systems must be at least 10 times larger than the 1,000 to 2,000 acres assumed for the Elkhorn Slough geohydrological modeling.
Questions?