Groundwater Monitoring Protocols for Seawater Intrusion
Example of Challenges and Experiences in a Coastal Groundwater Basin

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Outline

- Sustainable Groundwater Management Act (SGMA)
  - Seawater Intrusion: minimal thresholds; monitoring network
- Oxnard Plain
- Previous Studies
  - Major and minor-ion chemistry,
  - Trace element analysis,
  - Specific isotope chemistry,
  - Depth dependent water quality sampling, and
  - Surface geophysical methods.
- Conclusions: What did we learn?
- References
2014 Sustainable Groundwater Management Act (SGMA)

- Sustainability Goal
- Sustainable Management
- Sustainable Yield

Prevent “Undesirable Results”

- Lowering of Groundwater Levels
- Reduction in Groundwater Storage
- Seawater Intrusion
- Water Quality Degradation
- Land Subsidence
- Depletion of Surface Waters
Seawater Intrusion

“Seawater intrusion refers to the advancement of seawater into a groundwater supply that results in degradation of water quality in the basin, and includes seawater from any source.” – GSP Emergency Regulations
Seawater Intrusion

**GSP Emergency Regulations:**

§ 354.28. Minimum Thresholds

(3) Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour…

§ 354.34. Monitoring Network

(3) Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations…
Oxnard Plain basin

**Groundwater Basin**
- Oxnard Plain Basin
- Oxnard Forebay Basin

**City Boundary**
- Oxnard
- Port Hueneme

**UWCD Boundary and Facilities**
- Floodplain and Creeks
- Bathymetry

Stratigraphy of Oxnard Plain

### Hydrostratigraphy

- **Semi-perched Aquifer**
- **Oxnard Aquifer**
- **Mugu Aquifer**
- **Hueneme Aquifer**
- **Fox Canyon Aquifer – main**
- **Fox Canyon Aquifer – basal**
- **Grimes Canyon Aquifer**

### Aquifer System
- **Upper Aquifer System**

### Formation
- **Unnamed Alluvium**
- **San Pedro Formation**
- **Santa Barbara Formation**

### Age
- **Holocene & Late Pleistocene**
- **Late Pleistocene**
- **Early Pleistocene**
Historic High Chloride Levels

- First observed in 1930s

- 100 mg/l chloride defined leading edge

- Used existing production wells and older abandoned wells as monitoring points.
  - Misrepresentation: Some samples with high chloride concentrations were related to poor quality water leaking from the Semi-perched aquifer

Source: Izbicki, 1996
Previous Studies

- 1989 USGS Regional Aquifer-System Analysis (RASA)

Water quality evaluation:
1. Major and minor-ion chemistry
2. Trace element analysis
3. Specific isotope chemistry
4. Depth dependent water quality sampling
5. Surface geophysical methods

These methods allowed differentiation between chloride from different sources of salinity.
UWCD – Saline Intrusion Updates
Major and minor-ion chemistry

**Explanation**
- Seawater
- Imported water
- Local runoff
- Oil-field brine

**Chemical Processes**
- Base exchange-mixing
- Sea water intrusion-mixing
- Mixing
- Cation exchange-calcite precipitation; sulfate reduction
- Gypsum dissolution - mixing

**Diagram**

- **Explanation**
  - HIGH-CHLORIDE WATER FROM THE LOWER SYSTEM NEAR POINT MUDY
  - ALL OTHER HIGH-CHLORIDE WATER
  - ALL OTHER WATER
  - COMPOSITION OF SEAWATER

- **Legend**
  - Semi-Perched Zone Wells
  - UAS Wells
  - LAS Wells
Major and minor-ion chemistry

Upper Aquifer System samples

Stiff Diagram

Cations

Anions

Lower Aquifer System samples

Stiff Diagram

Cations

Anions
Trace element analysis

**Figure 5.** Chloride-to-boron ratio as a function of chloride in water from wells on the Oxnard Plain.

- Irrigation return water

**Figure 6.** Chloride-to-iodide ratio as a function of chloride in water from wells on the Oxnard Plain.

- LAS wells near Mugu

Source: Izbicki, 1991
Specific isotope chemistry

Hueneme Submarine Canyon
- Pacific Ocean
- UAS
- Partly Consolidated Marine and Volcanic Rocks
- LAS

Mugu Submarine Canyon
- UAS
- LAS
- Fault

Source: Izbicki, 1991
vertical scale greatly exaggerated

Source: Izbicki, 1991
Depth dependent water quality sampling

Pleasant Valley wells yielding high-chloride water may have been drilled too deep and directly penetrate formations having high-chloride water, or brines may have invaded deep freshwater aquifers from surrounding and underlying deposits as a result of pumping stresses.

Source: Izbicki et al, 1999
Surface geophysical methods

Figure 3. Map showing chloride concentrations (mg/l) in the Oxnard aquifer, 1989 (modified from County of Ventura Public Works Agency, 1990). Source: Zohdy, 1993
Conclusions: What did we learn?

Chloride degradation in the Oxnard Plain and Pleasant Valley basins is related to four sources and processes:

1) Lateral Seawater Intrusion
2) Cross Contamination
3) Compaction of Salt-Laden Marine Clays
4) Lateral Movement of Brines from Tertiary formations

Well Location, chloride concentration (mg/l), interpreted source of elevated chloride:
California Department of Water Resources (CA DWR) presentation: DWR’s Role in Sustainable Groundwater Management.


