SOURCES OF HIGH-CHLORIDE WATER TO WELLS IN A COASTAL SOUTHERN CALIFORNIA AQUIFER

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Abstract

The U.S. Geological Survey currently is assessing the regional ground-water resources in the San Diego area. *The Sweetwater Authority, a local retailer, provides ground water from wells penetrating the San Diego Formation, which underlies alluvial deposits in the Sweetwater River channel. Water from a number of these municipal supply wells exceeds the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level for chloride of 250 milligrams per liter (mg/L). A major goal of the regional assessment is to gain a better understanding of the sources of high-chloride ground water to wells in the San Diego Formation. The initial part of that assessment included the installation of 4 multi-level well sites to depths of as much as 1,500 feet.*

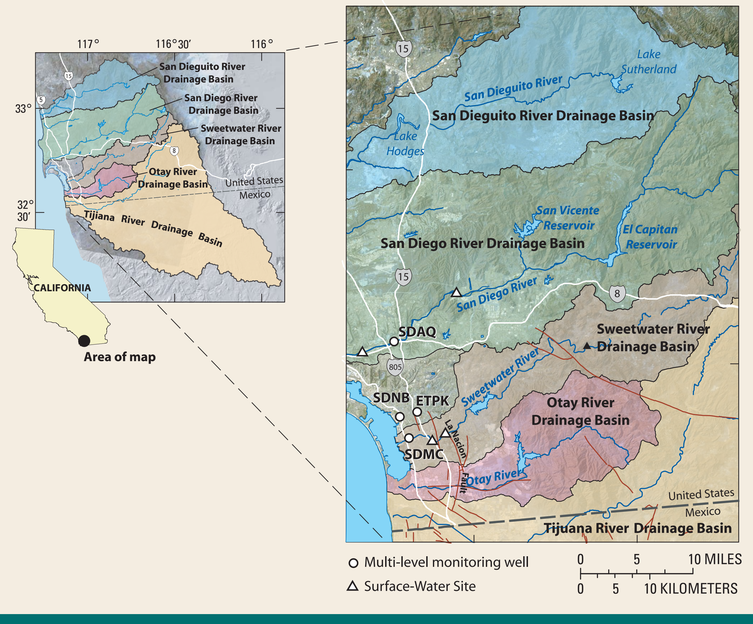
Percentages of major ions in ground-water samples collected from the 20 monitoring wells indicate the chemical composition of the ground water in the San Diego area can be separated into three distinct groups, with the chemical character in several water samples resembling the chemical character of seawater. Ratios of selected minor ions to Cl^- as a function of Cl^-, were used to distinguish between high-Cl^- water from marine rocks and seawater. These results suggest that the dissolution of soluble salts characteristic of the underlying marine deposits is the predominant source of high-Cl^- ground water in the San Diego Formation.

The stable isotopes of hydrogen and oxygen indicate three distinct sources of recharge distinguishable by: (1) isotopic values that are comprised of a mixture of ground water and seawater; (2) lighter (more negative) ground-water isotopic values that are characteristic of recharge which originates in the mountains to the east of the San Diego area; and (3) intermediate isotopic values that are characteristic of local runoff. Tritium and carbon-14 age-dating techniques indicate most of the ground water in the San Diego area was recharged prior to about 1950. Isotopic values in ground-water samples suggests seawater intrusion could become a predominant source of high Cl^- water to the San Diego Formation in the future.

Study Area

The regional assessment of ground-water resources in the San Diego area was designed as an integrated set of five drainage-basin investigations, in order to most effectively gather detailed information about the largely unresearched and areally extensive San Diego Formation. The San Diego Formation is composed of thinly bedded sandstone and conglomerate, which originated as marine and non-marine sediment during the late Pliocene and early Pleistocene, ranges in thickness from about 100 feet to more than 800 feet, and is overlain by about 100 feet of unconsolidated Quaternary deposits.

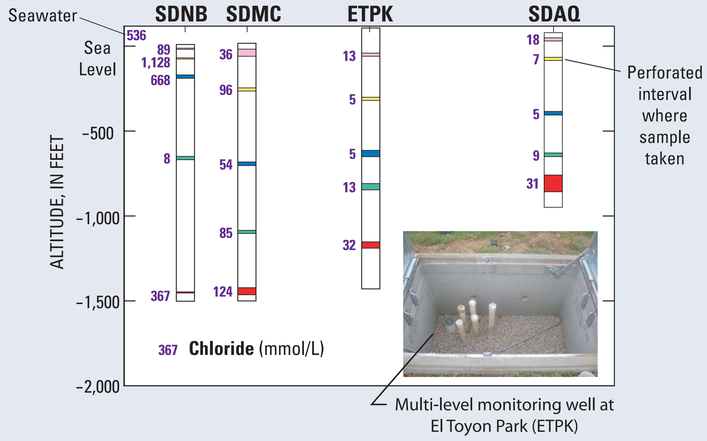
Phase I of the assessment focused on the Sweetwater River drainage and was funded by the Sweetwater Authority. The Sweetwater Authority, a local retailer, provides water from wells designed to extract ground water from the San Diego Formation, which underlies alluvial deposits in the Sweetwater River channel. Water from a number of these municipal supply wells exceeds the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level for chloride of 250 milligrams per liter (mg/L). This poster describes results from an initial part of the regional assessment.



Methods

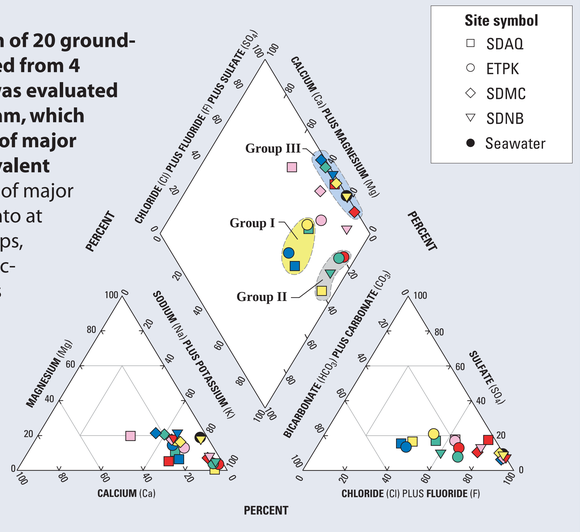
Multi-level monitoring wells were installed at 4 sites to depths of as much as 1,500 feet. Data includes geologic and geophysical logs, cores from selected depths, water-quality samples analyzed for a broad range of constituents including major and minor ions, trace elements, volatile organics, pesticides, wastewater indicators and isotope, and water levels. Surface-water samples were collected and analyzed primarily for isotopes.

In addition, the wells are equipped with real-time, water-level recording equipment and the data is available via the project website: ***http://ca.water.usgs.gov/sandiego***



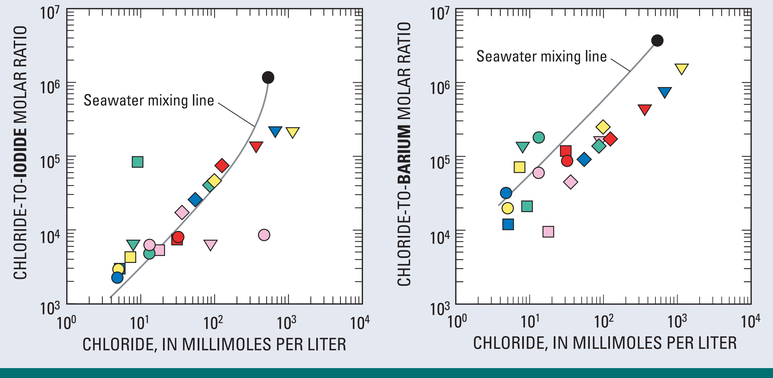
Major-ion Chemistry

Major-ion composition of 20 ground-water samples collected from 4 multi-level well sites was evaluated using a trilinear diagram, which plots the percentages of major ions on a charge-equivalent basis. The percentages of major ions can be separated into at least three distinct groups, with the chemical character of the water samples in Group III resembling the major-ion composition of seawater.



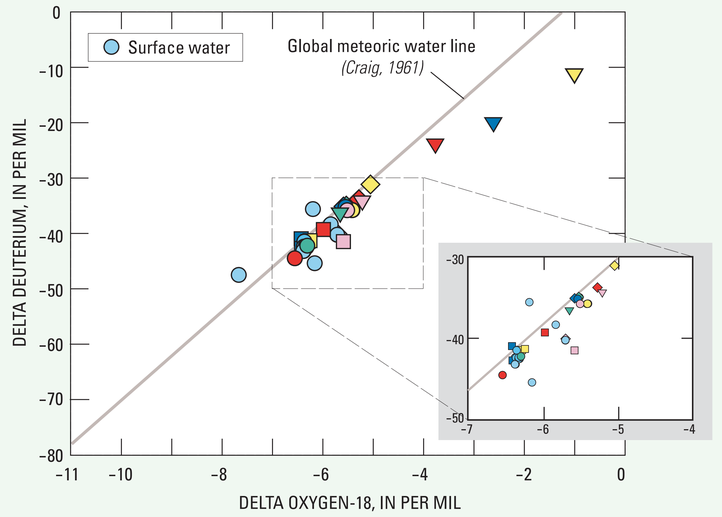
Minor-ion Chemistry

The composition of selected minor ions in water (bromide, iodide, barium, and boron), relative to Cl^- concentrations, was analyzed to distinguish between high-Cl^- water from different sources. Iodide, for example, is an excellent indicator of the geologic material that water has encountered as if flows through aquifers, whereas barium is an indicator of water from deeper aquifers where sulfate reduction may be occurring.



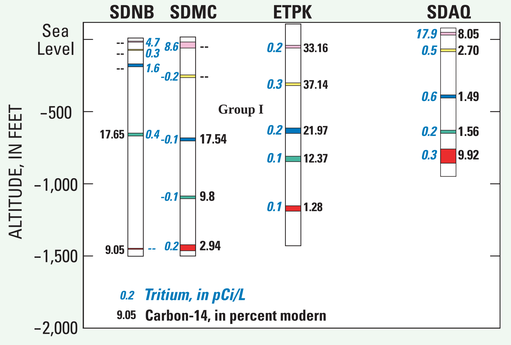
Stable Isotopes of H and O

The stable isotopes of hydrogen and oxygen indicate the ground water in the San Diego area can be separated into at least three distinct sources of recharge. These three sources are distinguishable by: **(1)** isotopic values comprised of a mixture of ground water and seawater (about –1 per mil $\delta^{18}O$); **(2)** lighter (more negative) ground-water isotopic values that are characteristic of recharge which originates in the mountains to the east of the San Diego area (about –6.3 per mil $\delta^{18}O$); and **(3)** intermediate isotopic values which are characteristic of local precipitation as the source of recharge to the monitoring wells (about –5.6 per mil $\delta^{18}O$).



Age Dating

All water samples collected from the 4 multi-level well sites were analyzed for tritium. Subsequently, those water samples that had no detectable tritium were analyzed for carbon-14. The carbon-14 ages calculated for ground water were as great as 30,000 years, but are interpretive and subject to considerable uncertainty, although that uncertainty is reduced for aquifers where the chemistry is well understood.



Significant Findings

- **The percentages of major ions indicate the ground water in the Sweetwater and San Diego River drainage basins can be separated into at least three distinct groups.**
  - *(1) Water from wells in the upper aquifer system near recharge areas along mountain fronts;*
  - *(2) Water from deep wells and wells at the downgradient end of long flowpaths; and*
  - *(3) Water from wells affected by seawater intrusion and (or) mixing with high-chloride water from fine-grained deposits.*
- **Ratios of minor ions to Cl^- as a function of Cl^-, indicate that the dissolution of soluble salts characteristic of the underlying marine deposits is the predominant source of high-Cl^- ground water in the San Diego Formation.**
- **Tritium and carbon-14 age dating techniques indicate most of the ground water in the San Diego area was recharged prior to about 1950.**
- **Isotopic values in ground-water samples suggests seawater intrusion could become a predominant source of high Cl^- water to the San Diego Formation in the future.**