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Hydrogeochemical and Stable Isotope Characteristics of the Upper Confined Aquifer, Buckman Well Field, New Mexico

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Abstract

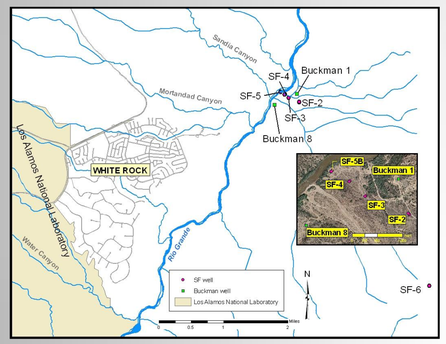
Chemical and isotopic tracer data were obtained at the artesian piezometer SF-5B during 2010. The piezometer is located at the western boundary of the Buckman well field at the confluence of Cañada Ancha and the Rio Grande. The piezometer penetrates the upper confined aquifer at a depth of about 46 m below ground surface (bgs). The thickness of this aquifer at SF-5B is approximately 30 m. Groundwater from SF-5B discharges at a rate of 1 to 2 L/min. The Buckman production wells pump from the deeper confined aquifer at a depth interval of about 76 to 256 m bgs. Water-level monitoring by the United States Geological Survey and the City of Santa Fe reveals that the upper aquifer shows no pressure response to pumping from Buckman 1 or Buckman 8 wells, located approximately 0.4 km equidistance from SF-5B. The upper and lower confined aquifers in this area are composed of fluvial deposits (silts and sands) of the Tesuque Formation.

For this investigation, data were analyzed with the purpose of determining the: a) hydrogeochemical nature of the groundwater in comparison to adjacent aquifers; b) recharge source(s); c) groundwater age or residence time; and d) presence of contamination from human activity. Specifically, samples were analyzed for major ions, trace elements, low-level tritium, low-level perchlorate, δ^2H, $\delta^{18}O$, $\delta^{34}S$ and $\delta^{18}O$ (SO_4^{2-}), $\delta^{13}C$, ^{14}C, and other anthropogenic and natural radioactive elements. Additionally, pH, temperature, specific conductance (SC), oxidation-reduction potential, and dissolved oxygen measurements were made through a flow-through cell at the point of discharge.

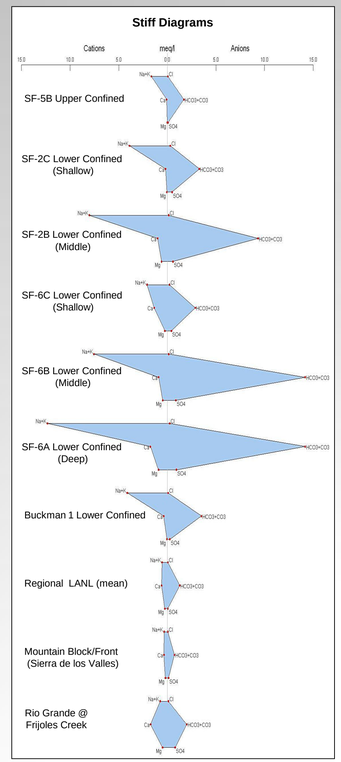
The groundwater consists of a sodium-bicarbonate composition with a calculated total dissolved solids ranging from 105 to 136 mg/L. Average concentrations of chloride, nitrate, sulfate, bicarbonate, and carbonate are 1.82 mg/L, 0.40 mg/L, 3.18 mg/L, 64.5 mg/L and 19.5 mg/L, respectively. Perchlorate was measured at 0.30 µg/L, within the range of background. Average concentrations of calcium, magnesium, potassium, and sodium are 1.55 mg/L, 0.11 mg/L, 0.40 mg/L, and 37.5 mg/L, respectively. Low-level tritium was measured at 0.12 tritium unit (0.39 pCi/L), suggesting that a portion of the the groundwater is younger than 60 years. δ^2H and $\delta^{18}O$ values at SF-5B are more positive compared to the deeper confined aquifer and slightly more negative compared to regional groundwater discharging at the White Rock Canyon springs. The major-ion chemical compositions at SF-5B do not match the deeper confined aquifer at Buckman wells 1 or 8 or the White Rock Canyon springs. The SF-5B piezometer does not show any indication of contamination.

Objectives and Analytical Methods

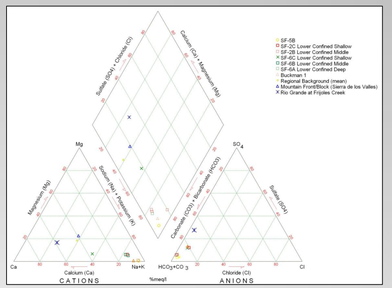
- Characterize hydrogeochemical conditions for the upper confined aquifer at piezometer SF-5B.
- Compare hydrogeochemical signature of the upper confined aquifer to adjacent aquifers.
- Determine source of recharge to the upper confined aquifer.
- Determine age or residence time for groundwater at SF-5B.
- Determine whether groundwater at SF-5B is contaminated from human activity.
- **Major Anions** – ion chromatography.
- **Trace Elements** – inductively couple plasma-atomic emission spectroscopy (ICP-AES), inductively couple plasma-mass spectrometry (ICP-MS), and manual cold-vapor technique (atomic absorption).
- **Low-Level Perchlorate** – liquid chromatography/mass spectrometry/mass spectrometry.
- **Low-Level Tritium** – electrolytic enrichment.
- **Stable Isotopes** – isotope ratio mass spectrometry.
- **Radiocarbon** – accelerator mass spectrometry.



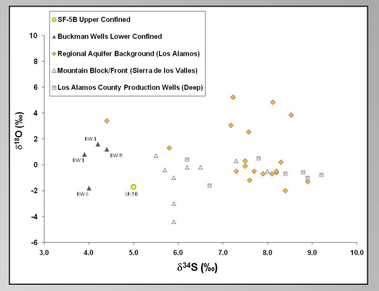
Regional setting of study area



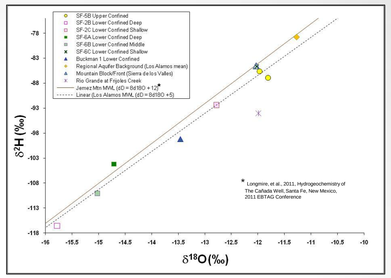
Comparison of local waters in the vicinity of SF-5B. SF series and Buckman 1 represent waters that originate from the eastern portion of the basin. Regional Aquifer, Mountain Block/Front recharge originate from the western portion of the basin. Rio Grande represents dominant perennial surface waters and bisects the basin.



Piper diagram illustrating the major-ion chemistry for groundwater discharging at SF-5B and other aquifers located in the vicinity of SF-5B.



Sulfur-34 and oxygen-18 (sulfate) isotope ratios for groundwater discharging at SF-5B, the nearby Buckman wells, regional background groundwater beneath the Pajarito Plateau, deep block/front groundwater in the production wells at Los Alamos, and mountain Sierra de Los Valles.



Deuterium and oxygen-18 (water) isotope ratios for groundwater discharging at SF-5B and other aquifers located in the vicinity of SF-5B.

DOE OB personnel collecting water samples at SF-5B

Recharge Source(s)?

We hypothesize that groundwater flowing from the upper confined aquifer at SF-5B originated through recharge from either the Pojoaque and/or Tesuque rivers at a location northeast of SF-5B. Hydraulic heads at SF-5B and the nearby piezometers SF-3B and SF-4B (see map) indicate that the potentiometric surface of the upper aquifer generally slopes from the east to west. The upper aquifer, however, does not extend towards the east at piezometer SF-2 or towards the south or southeast along the area of Buckman Well Field. This suggests that the upper confined aquifer may be restricted in its spatial extent with flow paths trending more to the northeast.

Stable-isotope values of hydrogen and oxygen, low dissolved solids, and the position of the upper confined aquifer, suggest that the upper confined aquifer has a different recharge source than the deeper confined aquifer at the Buckman Well Field or the regional aquifer west of the Rio Grande beneath the Pajarito Plateau. Buckman Mesa may also play a role (e.g., boundary condition) in the groundwater flow path in the upper confined aquifer.

Conclusions

- Groundwater at SF-5B consists of a sodium-bicarbonate composition with total dissolved solids ranging from 105 to 136 mg/L or about half the amount observed at the nearby production wells Buckman 1 and 8, which represent the deep confined aquifer.
- The hydrogeochemical characteristics of groundwater at SF-5B are distinct in comparison to adjacent aquifers.
- Low-level tritium was detected near the detection limit (0.09 T.U., 0.28 pCi/L), which suggests that a very small fraction of the groundwater at SF-5B may have been recharged shortly after 1942-43 and that most of the groundwater at SF-5B is greater than about 60 years.
- Contamination from human activity was not observed at SF-5B.

DOE OB personnel assemble sampling apparatus at SF-5B

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DATA SOURCES: (1) New Mexico Environment Department
(2) LANL Earth and Environmental Sciences Geology and Geochemistry Research Lab (EES-14 GGRL)
(3) RACER Database: http://www.racerdat.com
(4) LANL Groundwater Background Investigation Report, Rev 4, 2010