ADEQ
Arizona Department of Environmental Quality

FACT SHEET

Ambient Groundwater Quality of the Cienega Creek Basin: A 2000-2001 Baseline Study – November 2012

INTRODUCTION

A baseline groundwater quality study of the Cienega Creek basin was conducted in 2000-2001 by the Arizona Department of Environmental Quality (ADEQ) Ambient Groundwater Monitoring Program. ADEQ conducted this monitoring pursuant to Arizona Revised Statutes §49-225 that mandates ongoing monitoring of waters of the state including its aquifers. The fact sheet is a synopsis of the ADEQ Open File Report 12-02.[1]

The Cienega Creek groundwater basin includes approximately 606 square miles in southeastern Arizona within Cochise, Pima, and Santa Cruz counties (Map 1).[2] The Cienega Creek basin is a narrow, northwest-trending alluvial valley surrounded by fault-block mountains within the basin and range physiographic province. The basin is bounded on the west by the Santa Rita and Empire Mountains, on the north by the Rincon Mountains, on the east by the Whetstone and Mustang Mountains, and on the south by the Canelo Hills and Patagonia Mountains.

In 2000, the basin had a population of 4,355 which includes the town of Patagonia and the community of Sonoita.[2] The basin predominantly consists of federal land (53 percent) including the Coronado National Forest managed by the Forest Service (41 percent) and the Las Cienegas National Conservation Area administered by the Bureau of Land Management (12 percent). State Trust lands (24 percent) and private holdings (23 percent) constitute the remainder of the basin.[2]

Figure 1 - Windmills are a popular method of pumping groundwater in the Cienega Creek basin. This well is located near the town of Sonoita in grasslands made verdant by monsoon precipitation.

SURFACE WATER HYDROLOGY

A surface water divide near the community of Sonoita separates the Cienega Creek watershed in the north from the Sonoita Creek watershed in the south. There is also a small portion of the Babocomari River watershed in the extreme eastern part of the groundwater basin.

Cienega Creek is an intermittent stream with perennial stretches that drains north into the Tucson Active Management Area and eventually empties into the Santa Cruz River. Within the basin, the creek contains upper and lower sections that are divided at a bedrock formation called "the Narrows." Cienega Creek has an annual surface discharge averaging 1,900 acre-feet per year.[2] Sonoita Creek is a perennial stream that flows to the southwest through a narrow valley and debouches into the Santa Cruz River north of Nogales. Surface flow averages 5,850 acre-feet per year.[2]

GROUNDWATER WATER HYDROLOGY

Groundwater in the Cienega Creek basin occurs in two main aquifers: streambed alluvium and basin-fill deposits. In addition, limited groundwater is found in the Pantano Formation located only in the lower section of Cienega Creek, and the bedrock of the surrounding fault-block mountains.[2]

The streambed alluvium is composed of sand and gravel deposited along major waterways and is the most important aquifer in the lower Cienega Creek and the Sonoita Creek watershed. The main aquifer in the upper Cienega Creek is basin-fill alluvium which is composed of interbedded clay, silt, sand, and gravel layers. The basin-fill is an unconfined aquifer except where clay layers create confining conditions northeast of the town of Sonoita.[2] In the Sonoita Creek watershed, washes dissect the basin-fill and dewater the formation except where it extends below the level of Sonoita Creek.[2]

Groundwater is the source for all domestic, public supply, and irrigation uses, and most stock uses in the basins.[2] An average of 1,200 acre-feet is pumped annually. Groundwater usage is roughly equal to recharge as suggested by little significant change in long-term water levels. Recharge occurs along mountain fronts and the infiltration of runoff along major streams. The total amount of recoverable groundwater in storage to a depth of 1,200 acre-feet below land surface (bls) is estimated to be 5.1 million acre-feet.[2]

METHODS OF INVESTIGATION

To characterize regional groundwater quality in the Cienega Creek basin, samples were collected from 20 sites (15 domestic wells, four stock wells, and one spring used for stock) located throughout the basin. Inorganic constituents were collected at all 20 sites. At 10 sites radionuclide, radon, and volatile organic compound (VOC) samples were also collected.

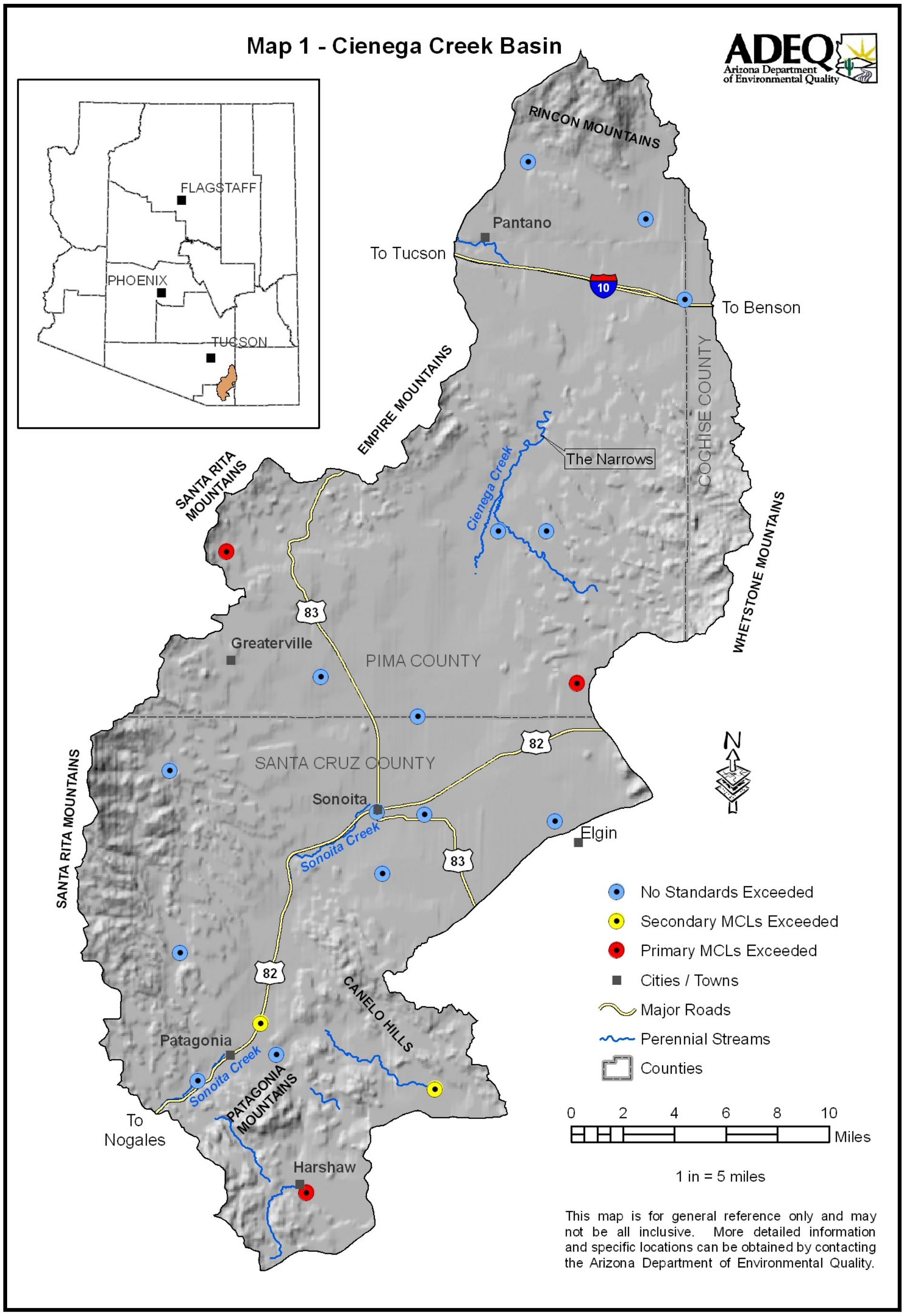
Sampling protocol followed the *ADEQ Quality Assurance Project Plan* (see www.azdeq.gov/function/programs/lab/).[3] The effects of sampling equipment and procedures were not found to be significant based on seven quality assurance/quality control tests.

WATER QUALITY SAMPLING RESULTS

Groundwater sample results were compared with the Safe Drinking Water Act (SDWA) water quality standards. Public drinking water systems must meet these enforceable, health-based, water quality standards, called Primary Maximum Contaminant Levels (MCLs), when supplying water to their customers. Primary MCLs are based on a lifetime (70 years) consumption of two liters of water per day.[4] Of the 20 sites sampled, three had constituent concentrations that exceeded Primary MCLs. These exceedances included arsenic at one site and gross alpha at two sites.

Groundwater sample results were also compared with SDWA water quality guidelines. Public drinking water systems are encouraged to meet these unenforceable, aesthetics-based water quality guidelines, called Secondary MCLs, when supplying water to their customers. Water exceeding Secondary MCLs may be unpleasant to drink and/or create unwanted cosmetic or laundry effects but is not considered a health concern.[4] Of the 20 sites sampled, two had constituent concentrations (iron, manganese, sulfate, and TDS) that exceeded Secondary MCLs.

Radon is a naturally occurring, intermediate breakdown product from the



Map 1 – Sample sites in the Cienega Creek basin are color-coded according to their water quality status. Of the 20 sites sampled, 75 percent met all health and aesthetics based water quality standards.

radioactive decay of uranium-238 to lead-206. Of the 10 sites sampled for radon, one site exceeded the proposed 4,000 picocuries per liter (pCi/L) standard that would apply if Arizona establishes a multimedia program to address the health risks from radon in indoor air. Nine sites exceeded the proposed 300 pCi/L standard that would apply if Arizona does not develop a multimedia program. There were no detections of any of the 34 compounds at the 10 sites where VOC samples were collected.

Figure 2 – ADEQ's Elizabeth Boettcher examines the lush riparian habitat nourished by a perennial stretch of Sonoita Creek located southwest of the town of Patagonia.

GROUNDWATER COMPOSITION

Groundwater in the Cienega Creek basin was predominantly of calcium- bicarbonate chemistry, slightly alkaline (above 7 su pH), and fresh (TDS below 1,000 mg/L). Hardness concentrations varied from moderately hard to very hard.

Nitrate concentrations were divided into natural background (four sites at <0.2 mg/L), may or may not indicate human influence (16 sites at 0.2 – 3.0 mg/L), may result from human activities (0 sites at 3.0 – 10 mg/L), and probably result from human activities (0 sites >10 mg/L).[5] Most trace elements such as antimony, arsenic, beryllium, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and thallium were rarely – if ever - detected. Only barium, fluoride, and zinc were detected at more than 20 percent of the sites.

GROUNDWATER PATTERNS

Statistically significant groundwater quality patterns were found between watersheds, aquifers, and watershed/aquifer combinations. Well depth, groundwater depth, pH-field, and pH-lab were greater in the Cienega Creek watershed than the Sonoita Creek watershed; specific conductivity, TDS, hardness, calcium, and sulfate had the opposite pattern. Well depth, groundwater depth, and pH-lab were greater in the basin-fill aquifer than the streambed alluvium aquifer. Well depth, groundwater depth, pH-field, pH-lab, hardness, calcium, and magnesium were generally greater in the Sonoita Creek streambed aquifer than the Cienega Creek streambed or basin-fill aquifers (Kruskal-Wallis test, $p \leq 0.05$).

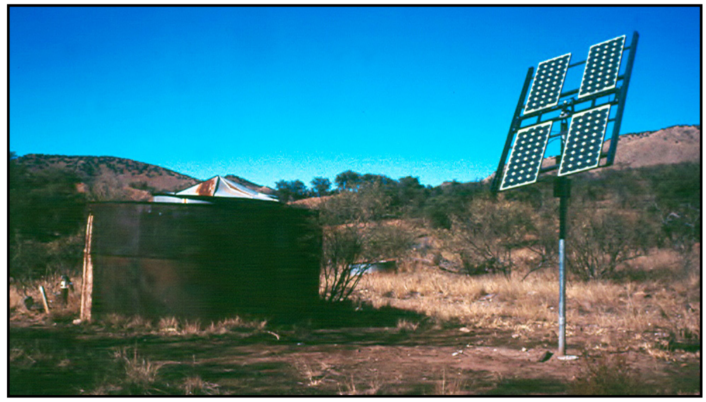


Figure 3 – Coronado Well, located in Red Rock Canyon in the southeast portion of the Cienega Creek basin, is powered by solar cells. The sample collected from the well exceeded aesthetics-based, water quality standards for TDS, iron, and manganese.

SUMMARY AND CONCLUSIONS

Interpretation of the analytical results of the 20 samples indicates that groundwater in the Cienega Creek basin generally meets drinking water standards and is suitable for domestic, stock, municipal, and irrigation purposes. The few groundwater quality exceedances appear to be the result of natural chemical reactions though sulfate, TDS, and gross alpha can be further mobilized by anthropomorphic activities such as historic mining activity.[6]

Groundwater quality parameter differences between the Cienega Creek and Sonoita Creek watersheds, the basin-fill and streambed aquifers, and combinations of these hydrology factors are influenced by the basin's geohydrology. The deep, basin-fill deposits in the Cienega Creek watershed impact the aquifer's deeper well and groundwater depths. Similarly, its higher pH levels are the result of older, more evolved groundwater found in the deeper aquifer.[6] In contrast, the Sonoita Creek watershed's main aquifer is shallow, streambed alluvium; its higher concentrations of calcium and hardness are reflective of recent recharge occurring from perennial stream flow.[6]

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Maps by Jean Ann Rodine

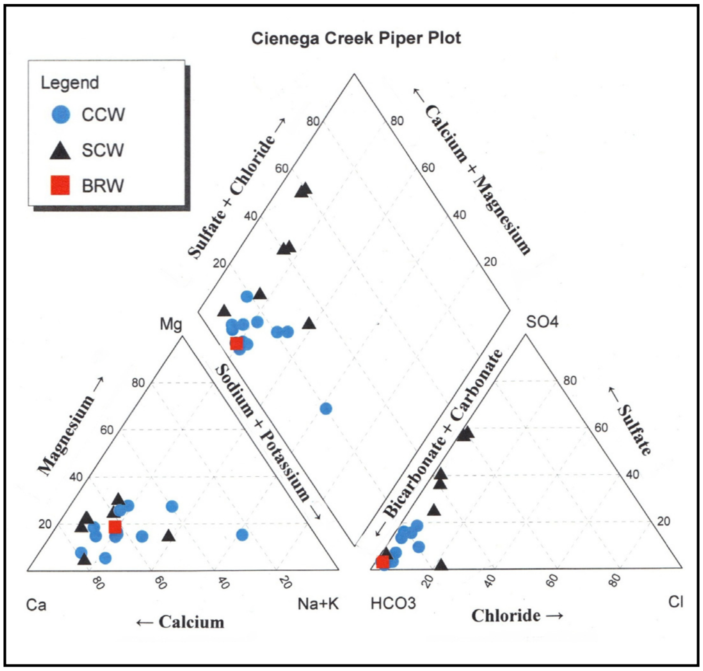

Figure 4 – Groundwater in the Cienega Creek basin is predominantly calcium-bicarbonate which indicates it's likely of recent origin occurring from precipitation in the nearby mountains and recharged along mountain fronts and major streams.[6]

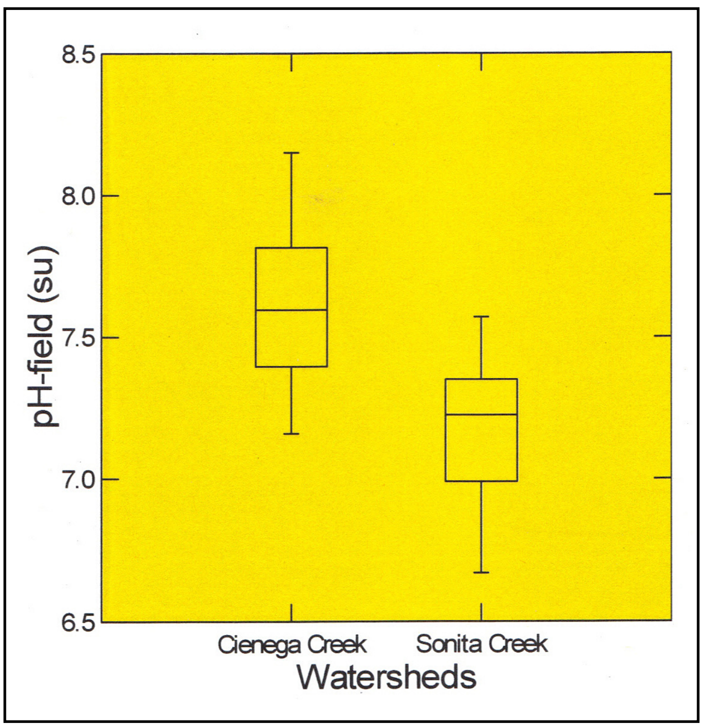

Figure 5 – Sample sites in the Cienega Creek watershed have significantly higher pH levels than those in the Sonoita Creek watershed (Kruskal-Wallis test, $p \leq 0.05$). Perennial flow in Sonoita Creek recharges the streambed aquifer creating groundwater that is usually near neutral (7.0 su). In the basin-fill aquifer prevalent in the Cienega Creek watershed, pH values increase downgradient through hydrolysis reactions.[6]

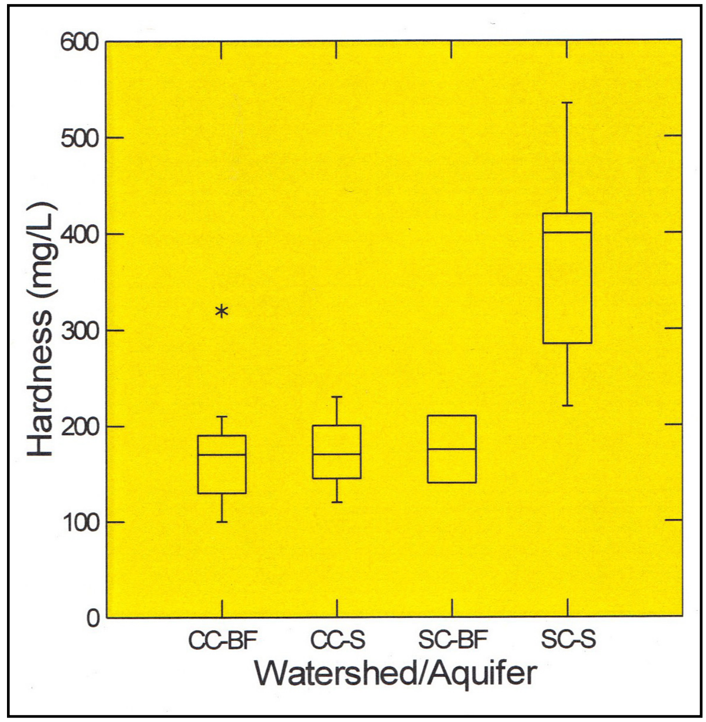

Figure 6 – Sample sites in the Sonoita Creek streambed (SC-S) aquifer have significantly higher hardness concentrations than sites located in each of the other three watershed/aquifer combinations (Kruskal-Wallis test, $p \leq 0.05$). The Sonoita Creek streambed aquifer receives recharge from the perennial flow in the creek. Elevated hardness concentrations are often associated with recharge areas and the elevated calcium and magnesium concentrations that cause hardness typically decrease downgradient in basins containing dilute waters.[6]

References Cited

1 Towne, D.C., 2012, Ambient groundwater quality of the Cienega Creek basin: A 2000-2001 baseline study: Arizona Department of Environmental Quality Open File Report 12-02, 46 p.

2 Arizona Department of Water Resources Web site, 2012, www.azwater.gov/azdwr/default.aspx, accessed 07/11/12.

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5 Madison, R.J., and Brunett, J.O., 1984, Overview of the occurrence of nitrate in ground water of the United States, in National Water Summary 1984-Water Quality Issues: U.S. Geological Survey Water Supply Paper 2275, pp. 93-105.

6 Robertson, F.N., 1991, Geochemistry of ground water in alluvial basins of Arizona and adjacent parts of Nevada, New Mexico, and California: U.S. Geological Survey Professional Paper 1406-C, 90 p.