ADEQ
Arizona Department of Environmental Quality
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FACT SHEET

Ambient Groundwater of the San Simon Sub-Basin: An ADEQ 2002 Baseline Study - October 2004

INTRODUCTION

Located in southeastern Arizona, the lightly populated San Simon sub-basin (SS) of the Safford groundwater basin consists of ranchland and, near the towns of Bowie and San Simon, irrigated farms. This fact sheet reports upon the results of groundwater quality investigations in the SS and summarizes an extensive report produced by the Arizona Department of Environmental Quality (ADEQ).[1]

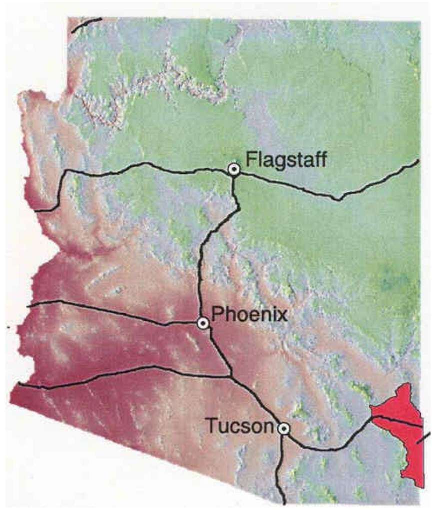

Figure 1- *The San Simon sub-basin (shown in red) is located in southeastern Arizona and extends into New Mexico.*

BACKGROUND

The SS is a large basin traversed by Interstate 10 encompassing 1,930 square miles in Cochise and Graham Counties (Figure 1).[2] It includes the broad San Simon Valley, the eastern slopes of the Chiricahua, Dos Cabezas, and Pinaleno Mountains and the western slope of the Peloncillo Mountains. To the southeast, the New Mexican border creates an arbitrary physical boundary while to the north the SS is divided from the Gila Valley sub-basin near the railroad siding of Tanque.

Uplands in the Chiricahua Mountains are managed by the U.S. Forest Service while other lands in the SS are a mixture of private, State Trust, and Bureau of Land Management. Elevations in the SS range from 9,795 feet at Chiricahua Peak to approximately 3,500 feet where the San Simon River departs the sub-basin.

Vegetation varies with elevation and precipitation, evolving from ponderosa pine forests at the highest elevations to desert shrubs and grasses in the San Simon Valley with chaparral, oak, and pinyon-juniper in intermediate zones.

The mountains in the SS are largely volcanic in origin except for the Dos Cabezas which are chiefly composed of granite, sedimentary, and metamorphic rock.[2] The San Simon Valley was once a rich grassland but overgrazing and drought in the late 1800s resulted in extreme erosion. Restoration efforts in the watershed include the construction of numerous earthen dikes and dams.[4]

HYDROLOGY

Most stream flow in the SS is generated in the mountains in response to storms. The sub-basin is drained by the ephemeral San Simon River which was historically perennial in stretches.[4] The San Simon River flows north out of the SS, debouching into the Gila River near the town of Solomon. The San Simon River's headwaters are the now dry San Simon Cienega, which was created by upwelling water from a partial groundwater divide.[3]

Groundwater in the SS is found in four water-bearing units: *alluvial aquifer, upper aquifer, lower aquifer,* and *bedrock*. The unconfined *alluvial aquifer* occurs south of the San Simon Cienega. North of the cienega are the *upper* and *lower aquifers*. The blue-clay unit separates the groundwater perched in the *upper aquifer* from percolating to the *lower aquifer*, which occurs under either water table or artesian conditions.[3] Artesian pressure in the *lower aquifer* (Figure 2) has declined since first measured in 1913 and only a few wells currently flow.[2] Where sufficiently fractured and faulted, mountain *bedrock* also provides


Figure 2 - *A stark contrast exists between a brimming stock tank supplied by groundwater from Little Artesian Well and the arid landscape of the San Simon Valley. As with many area wells, artesian pressure has decreased and a windmill now assists the water in reaching the surface. Orange Butte, a noted landmark, rises to the east.*

Figure 3 - *In the Pinaleno Mountains, Joe Harmon samples Wood Canyon Windmill which had elevated gross alpha and uranium concentrations.*

limited water supplies (Figure 3).[3]

Groundwater movement in the SS mirrors surface water drainage, moving from the surrounding mountain fronts toward the center of the sub-basin and then down the valley from the south to the northwest.[2] Most recharge occurs from mountain front runoff though the *upper aquifer* also receives seepage from irrigation applications.[2] Groundwater historically has been exchanged from the *lower aquifer* to the *upper aquifer*; however, because of decreasing artesian pressure this relationship has been recently reversed.[2]

METHODS OF INVESTIGATION

This study was conducted by the ADEQ Ambient Groundwater Monitoring Program, as authorized by the legislative mandate in Arizona Revised Statutes §49-225. To characterize regional groundwater quality, 77 sites (71 wells and 6 springs) were sampled. Samples were collected for inorganic constituents at all sites. At selected sites, samples were also collected for isotopes of hydrogen and oxygen (62 sites), radon gas (33 sites), radiochemistry (23 sites), and pesticide (4 sites) analyses.

Sampling protocol followed the *ADEQ Quality Assurance Project Plan*. Based on quality control data, the effects of sampling equipment and procedures were not considered significant.

WATER QUALITY SAMPLING RESULTS

The collected groundwater quality data were compared with Environmental Protection Agency (EPA) Safe Drinking Water (SDW) water quality standards. EPA SDW Primary Maximum Contaminant Levels (MCLs) are enforceable, health-based water quality standards that public systems must meet when supplying water to their customers. Primary MCLs are based on a lifetime daily consumption of two liters of water.

Of the 77 sites sampled, 25 (or 33 percent) had constituent concentrations exceeding a health-based standard (Figure 4). Constituents above Primary MCLs were arsenic (2 sites under current standards, 17 sites under standards effective in 2006), beryllium (2 sites), fluoride (19 sites), nitrate (3 sites), gross alpha (3 sites), and uranium (1 site).

EPA SDW Secondary MCLs are unenforceable, aesthetics-based water quality guidelines for public water systems. Water with Secondary MCL exceedances may be unpleasant to drink and/or create unwanted cosmetic or laundry effects but is not considered a health concern. Of the 77 sites sampled, 49 (or 64 percent) had constituent concentrations exceeding an aesthetic-based standard (Figure 4). Constituents above Secondary MCLs were chloride (6 sites), fluoride (35 sites), iron (5 sites), manganese (3 sites), pH (7 sites), sulfate (18 sites) and total dissolved solids or TDS (34 sites).

GROUNDWATER COMPOSITION

Groundwater in the SS is generally slightly alkaline (>7 standard units), fresh (<1,000 milligrams per liter or mg/L), and hard (> 150 mg/L) based on field pH values and TDS and hardness concentrations. At 86 percent of sites, nitrate (as nitrogen) was found at concentrations under 3 mg/L, which is often interpreted as representing no impact from human activities. Groundwater chemistry varies throughout the sub-basin. Generally the dominant cation is calcium in the south and sodium in the north. Bicarbonate is the dominant anion except for sulfate in some irrigated areas and in the extreme north where mixed-anion chemistry occurs. Arsenic, boron, fluoride, iron, and zinc were the only trace elements detected at more than 15 percent of sites.

GROUNDWATER DEPTH PATTERNS

Many constituents significantly decreased with increasing groundwater depth and/or well depth (regression, $p \leq 0.05$). However, groundwater and/or well depth were often unable to be determined in the field. Groundwater depth data were further compli-

Groundwater Isotope Investigation

Stable isotopes of oxygen (^{18}O) and hydrogen deuterium (D) were collected at 62 sample sites to further examine groundwater quality patterns. This isotopic data was compared to the standard reference water or Global Meteoric Water Line which is based upon world-wide precipitation data not exposed to evaporation. The SS data forms a Local Meteoric Water Line with a slope of 6.5. The most depleted, or isotopically lighter, waters are generally associated with sites in the *lower aquifer* or *bedrock* near the Pinaleno Mountains. Significant differences were found in the δD and $\delta^{18}O$ in *lower aquifer* sites compared with sites in the *alluvial aquifer, bedrock*, or the *upper aquifer*. These sites appear to represent the oldest water in the SS, recharged during a time period cooler than present. No significant differences were found in the δD and $\delta^{18}O$ among the other three water bearing units (ANOVA test in conjunction with the Tukey test, $p \leq 0.05$).

cated by levels representing artesian or partial artesian flows rather than water table conditions. As such, these constituent concentration - groundwater/well depth correlations are considered of limited value.

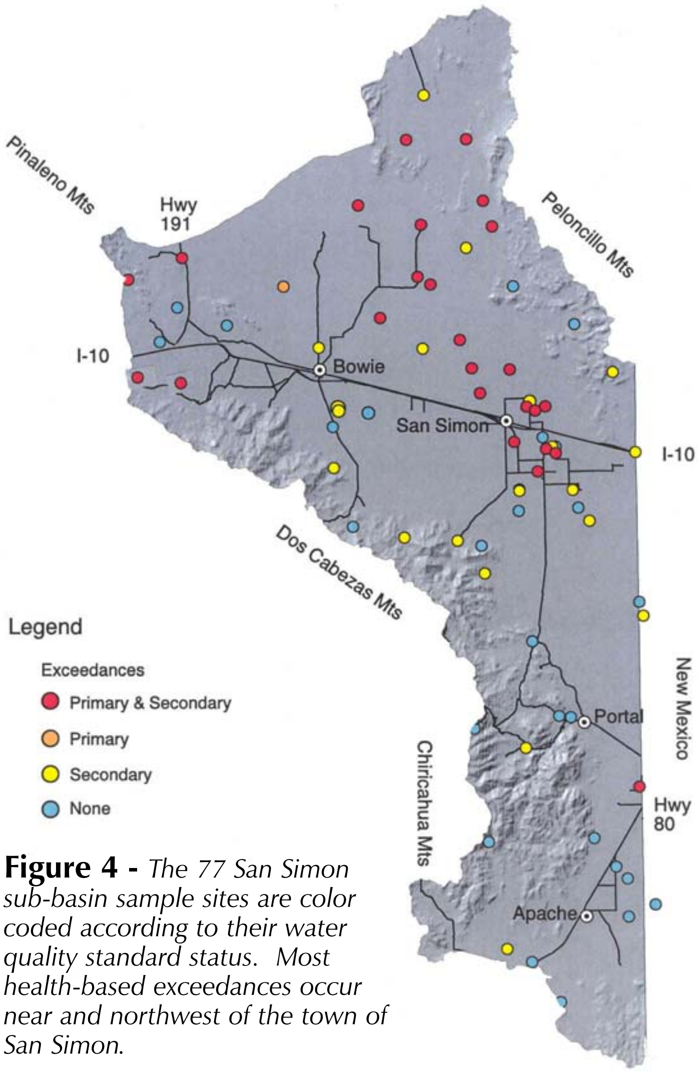

Figure 4 - *The 77 San Simon sub-basin sample sites are color coded according to their water quality standard status. Most health-based exceedances occur near and northwest of the town of San Simon.*

GROUNDWATER QUALITY PATTERNS

Groundwater composition and quality vary significantly in the sub-basin. The limited groundwater in the *bedrock* of the Chiricahua, Dos Cabezas, Peloncillo, and Pinaleno Mountains generally meets health-based standards except for radiochemistry constituents in the granite rock of the western Dos Cabezas and Pinalenos. The elevated gross alpha and uranium concentrations are likely naturally occurring because of the area's granite geology that is frequently associated with elevated radiochemistry concentrations.[5]

Though variable, groundwater chemistry in *bedrock* is most commonly calcium-bicarbonate which is often associated with recharge areas.[6] Concentrations of sodium, potassium, chloride, sulfate, fluoride, boron, and arsenic are lower in *bedrock* than in the *upper* or *lower aquifer* (ANOVA test in conjunction with the Tukey test, $p \leq 0.05$).

Groundwater in the *alluvial aquifer* met all health-based standards (Figure 5) except for fluoride at one site. Fluoride concentrations (< 5 mg/L) in the *alluvial aquifer* are likely controlled by pH values by the exchange of hydroxyl ions (Figure 6).[6] This aquifer is geochemically the most uniform with most sites having a calcium- bicarbonate chemistry. Concentrations of TDS, sodium, chloride, sulfate, boron, and arsenic are lower in the *alluvial aquifer* than in the *upper* or *lower aquifer.* In contrast, there are few significant water quality differences between sites in the *alluvial aquifer* and *bedrock* (ANOVA test in conjunction with the Tukey test, $p \leq 0.05$).

Groundwater in the *lower* or *artesian aquifer* rarely met health-based standards because of frequently elevated fluoride and arsenic concentrations. The high fluoride concentrations (> 5 mg/L) are permitted by very low calcium concentrations (Figure 6) which result from a chemically closed system.[6] A closed system also results in a sodium-bicarbonate or sulfate groundwater chemistry at *lower aquifer* sites. In down-gradient areas, sodium often becomes the dominant cation as the result of silicate weathering, halite dissolution, and/or ion exchange.[6] Aesthetics-based standards for TDS, sulfate, and pH were also frequently exceeded in the *lower aquifer*. TDS concentrations may even be elevated to the extent that the groundwater is considered slightly saline *or* > 1,000 mg/L.

Groundwater in the *upper aquifer* often did not meet health-based standards because of elevated fluoride or nitrate concentrations. Aesthetics-based standards for TDS and sulfate were also frequently exceeded (Figure 8). The least uniform geochemically, *upper aquifer* sites can reflect major impacts from highly saline irrigation recharge and/or leakage from the *lower aquifer*.

Concentrations of calcium, magnesium, hardness, and nitrate were higher in the *upper aquifer* than in the *lower aquifer* (ANOVA test in conjunction with the Tukey test, $p \leq 0.05$). Elevated calcium, hardness, and TDS concentrations may be the result of the dissolution of calcite and salts concentrated by evaporation during irrigation, than recharged to the aquifer.

Figure 5 - *A vintage pumpjack produces water for livestock use that is stored in a former underground storage tank. This 900 deep foot well, like most pumping from the alluvial aquifer, meets all health-based water quality standards.*

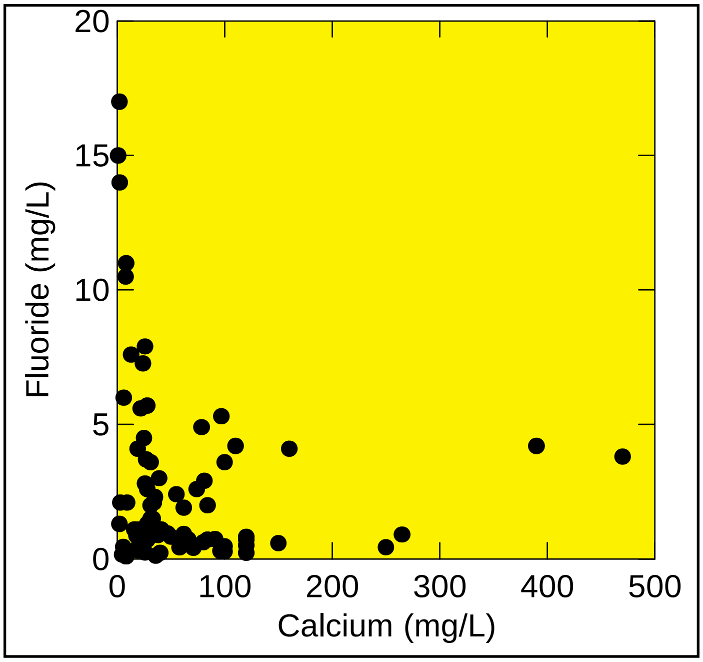

Figure 6 - *This graph illustrates fluoride concentrations >5 mg/L are permitted through dissolution of the mineral fluorite by very low calcium concentrations.*[6]

STUDY CONCLUSIONS

Groundwater in SS often does meet health-based and/or aesthetics-based drinking water standards. Overall, of the 77 sites sampled, only 28 (or 36 percent) met all Federal and State water quality standards. Especially with the frequent overall unacceptability of groundwater quality for drinking water uses in the SS, ADEQ suggests that well owners, particularly those south of Interstate 10, periodically have their groundwater analyzed by certified laboratories. A list of such laboratories may be obtained from the state's Environmental Laboratory Licensure Section at (602) 255-3454.

Figure 7 - *When the wind blows through the San Simon Valley, the fan on the engine block of this 1957 Buick turns as do the blades on the Antelope Well rising in the background. This windmill was sampled both for a 1997 ADEQ watershed study as well as this 2002 ADEQ groundwater study. Based on the sampling results from this and another well, the groundwater data from the two studies were judged able to be used interchangeably.*

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Maps by Larry Stephenson

Figure 8 - *Jason Mahilic samples a well tapping the upper aquifer. A healthy crop of cotton is growing despite the water's "very high salinity-high sodium" irrigation classification.*

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