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FACT SHEET

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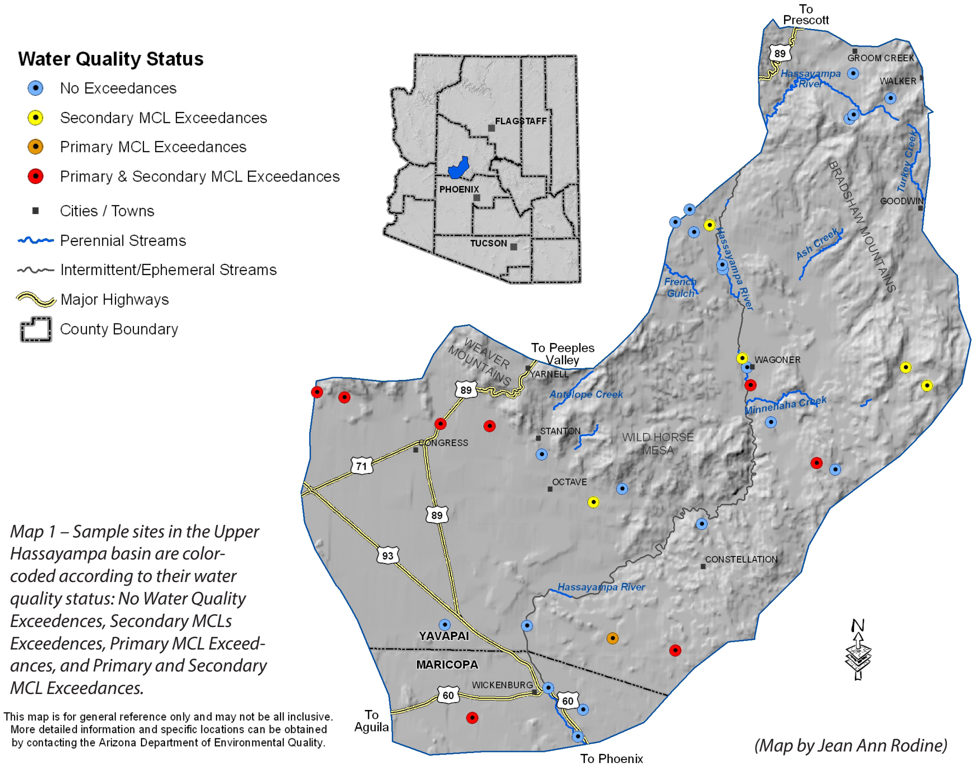
Ambient Groundwater Quality of the Upper Hassayampa Basin: A 2003-2009 Baseline Study – June 2013

Introduction

A baseline groundwater quality study of the Upper Hassayampa basin was conducted from 2003 to 2009 by the Arizona Department of Environmental Quality (ADEQ) Ambient Groundwater Monitoring Program. ADEQ carried out this task pursuant to Arizona Revised Statutes §49-225 that mandates ongoing monitoring of waters of the state including its aquifers. This fact sheet is a synopsis of the ADEQ Open File Report 13-03.[1]

The Upper Hassayampa groundwater basin covers approximately 787 square miles within Maricopa and Yavapai counties and is located about 60 miles northwest of Phoenix (Map 1). The basin is characterized by mid-elevation mountains and had an estimated population of 10,479 in 2000.[2] The largest population center is the Town of Wickenburg. Other communities include Congress and Groom Creek. Low-intensity livestock grazing is the predominant land use and most ranches have limited acreages



Map 1 – Sample sites in the Upper Hassayampa basin are color-coded according to their water quality status: No Water Quality Exceedences, Secondary MCLs Exceedences, Primary MCL Exceedances, and Primary and Secondary MCL Exceedances.

(Map by Jean Ann Rodine)

Figure 1 – The storage tank of the "ML Windmill" also serves as a sign post along the rugged Wagoner Road that connects the communities of Kirkland Junction located west of the basin and Crown King located east of the basin.

of irrigated pasture to raise additional animal feed. There are no surface water diversions or impoundments besides small stock ponds within the basin.[2] Groundwater is the only source for public water supply, domestic, irrigation and industrial purposes. Public water supply uses the most groundwater in the basin.[2]

The basin is bounded on the north by the Weaver Mountains, on the northwest by the Date Creek Mountains, on the south by the Vulture Mountains, and on the east by the Bradshaw Mountains. Elevations range from approximately 7,000 feet above mean sea level (amsl) in the Bradshaw Mountains to 1,900 feet amsl along the Hassayampa River about five miles south of Wickenburg. The basin is comprised of federal land managed by the U.S. Forest Service (25 percent) and Bureau of Land Management (BLM) (21 percent), State Trust lands (38 percent) and private land (16 percent).[2]

Hydrology

The basin is drained by the Hassayampa River which flows from north to south. The river is intermittent over much of its course but has perennial flow in its upper reaches in the Bradshaw Mountains and where bedrock brings groundwater to the surface a few miles south of Wickenburg. Some of its tributaries, – including Antelope Creek, Ash Creek, Minnehaha Creek, and Weaver Creek – have limited stretches of perennial flow.[2]

Groundwater is found primarily in the basin-fill sediments found in the southeast portion of the basin. The aquifer consists of gravel, sand, silt and clay and is capable of yielding several hundred gallons per minute. Smaller alluvial deposits are found along the Hassayampa River in the northern part of the basin. Groundwater is also found in limited amounts in the consolidated crystalline and sedimentary rocks that constitute most of the basin.[2]

Groundwater movement mirrors surface flow, going from north to south. Depth to groundwater varies across the basin, ranging from just a few feet below land surface along some stretches of the Hassayampa River to more than 1,000 feet below land surface in the center of the basin. Natural recharge for the basin is estimated to be 8,000 acre-feet per year while groundwater use is estimated to be 3,900 acre-feet per year.[2]

Methods of Investigation

To characterize regional groundwater quality, samples were collected from 34 sites (27 wells and seven springs). Of the 27 wells, 20 had submersible pumps, six were windmills, and one was a monitoring well.

Samples for inorganic constituents and isotopes (oxygen and deuterium) were collected from each site while radon (17 sites) and radionuclide (12 sites) samples were collected at selected sites. Sampling protocol followed the ADEQ Quality Assurance Project Plan *(see www.azdeq.gov/function/programs/lab/)*. The effects of sampling equipment and procedures were not significant based on quality assurance/quality control evaluations.

Water Quality Sampling Results

Groundwater sample results were compared with the Safe Drinking Water Act (SDWA) health and aesthetics-based water quality standards.

Public drinking water systems must meet health-based, water quality standards, called Primary Maximum Contaminant Levels (MCLs), when supplying water to their customers. These enforceable standards are based on a daily lifetime (70 years) consumption of two liters.[3] Primary MCLs were exceeded at nine of the 34 sites (27 percent). Constituents exceeding Primary MCLs include arsenic (one site), gross alpha (five sites), and nitrate (four sites).

Public drinking water systems are encouraged by the SDWA to meet 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.[3] Secondary MCLs were exceeded at 13 of the 34 sites (38 percent). Constituents exceeding Secondary MCLs include chloride (one site), fluoride (four sites), iron (two sites), manganese (four sites), sulfate (one site), and TDS (eight sites).

Figure 2 – Intermittent flow in the Hassayampa River at the Wagoner Road Bridge. The stream is perennial at higher and lower elevations in the basin.

Figure 3 – An unused aqueduct, the Leppe Wash flume, is located on the historic TK Bar Ranch along the Hassayampa River near Kirkland, Arizona.

Radon is a naturally occurring, intermediate breakdown product from the radioactive decay of uranium-238 to lead-206. Of the 17 sites sampled for radon, none 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.[3] Eight sites (47 percent) exceeded the proposed 300 pCi/L standard that would apply if Arizona does not develop a multimedia program.[3]

Groundwater Composition

Groundwater composition varied throughout the basin in the following ways:

- Groundwater chemistry in the basin is most commonly calcium-bicarbonate or mixed-bicarbonate.
- Levels of pH measured in the field were slightly alkaline (above seven standard units) except for five sample sites that were slightly acidic (below seven standard units).
- Total dissolved solids (TDS) concentrations were considered fresh (below 999 mg/L) at 32 sites and slightly saline (1,000 – 3,000 mg/L) at two sites.
- Hardness concentrations were moderately hard (75 - 150 mg/L) at two sites, hard (151 - 300 mg/L) at 22 sites, very hard (301 – 600 mg/L) at eight sites, and extremely hard (above 600 mg/L) at two sites.
- Nitrate (as nitrogen) concentrations at most sites may have been influenced by human activities and were divided into natural background (eight sites at <0.2 mg/L) may or may not indicate human influence (20 sites at 0.2 – 3.0 mg/L)), may result from human activities (two sites at 3.0 – 10 mg/L), and probably result from human activities (four sites > 10 mg/L).[4]
- Most trace elements such as aluminum, antimony, arsenic, beryllium, boron, cadmium, chromium, iron, lead, manganese, mercury, nickel, selenium, silver, and thallium were rarely detected. Only barium, fluoride, and zinc were detected at more than one-third of the sites.

Oxygen and deuterium isotope values at most sites appear to be a product of the elevation at which the sample sites were located. The five samples that experienced little evaporation were characterized as depleted and were collected from sites located high in the Bradshaw Mountains. The remaining 29 samples were more enriched, suggesting the water from these lower elevation sites was subject to much greater evaporation.[5]

Groundwater Patterns

Groundwater constituent concentrations were influenced by recharge group and geology. Constituents such as temperature, pH-lab, sodium, potassium, chloride, fluoride, oxygen-18 and deuterium had significantly higher constituent concentrations at sites with enriched samples than at sites with depleted samples (Kruskal-Wallis test, $p \leq 0.05$). Constituents such as temperature, sodium, sulfate, nitrate, fluoride, and deuterium had significantly greater concentrations in sites located in unconsolidated sediments than in consolidated rock; turbidity had the opposite pattern (Kruskal-Wallis test, $p \leq 0.05$).

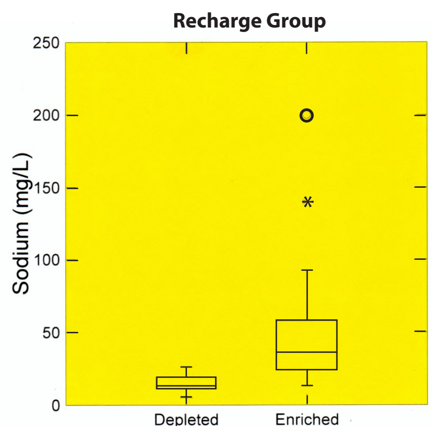


Figure 4 – Sites consisting of enriched samples have significantly higher sodium concentrations than sites consisting of depleted samples (Kruskal-Wallis, $p \leq 0.05$). Recharge areas typically have low sodium concentrations though sodium often becomes the dominant cation in downgradient areas. [8]

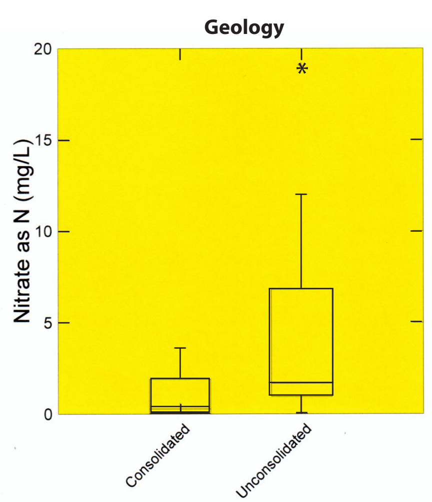


Figure 5 – Sample sites located in unconsolidated sediments have significantly higher nitrate concentrations than sample sites located in consolidated rock (Kruskal-Wallis, $p \leq 0.05$). This pattern may be due to increased residential and commercial development that has occurred in basin-fill areas.

Discussion

Groundwater in the basin is generally suitable for drinking water use based on the results of this ADEQ ambient study. Samples from 20 of the 34 sites met all water quality standards.[3] Moreover, samples from four other sites had only minor exceedances of aesthetics-based standards for TDS, iron, and/or manganese, making 24 of the 34 sample sites (71 percent) acceptable as a drinking water source. Of the remaining 10 sample sites, the constituents that most commonly impacted the acceptability of water for drinking purposes were gross alpha and nitrate.

Gross alpha exceeded health-based, water quality standards in radionuclide samples collected from five sites. Radionuclide samples were collected however, at only 12 of the 34 sites, so gross alpha had a 42 percent water quality standard exceedance rate. This finding is not unexpected as large portions of the basin consist of granitic geology and a few sites were in the vicinity of historic mining activity, both of which are associated with elevated radionuclide concentrations in groundwater.[6] Based on these results, future basin studies should better characterize gross alpha concentrations by collecting additional radionuclide samples.

Nitrate exceeded health-based, water quality standards in samples collected from four wells. Three exceedances were barely over the 10 mg/L nitrate (as nitrogen) standard while the fourth was almost double the standard at 19 mg/L. Potential nitrogen sources included effluent from septic systems and wastewater from agricultural operations.

Arsenic was the other health-based exceedance in a sample which also had the study's highest fluoride concentrations and pH levels. Chemically, the sample was similar to groundwater in the nearby McMullen Valley basin.[7] Hydroxyl ion exchange is the likely reason for the elevated fluoride and arsenic concentrations. The high pH value (8.41 standard units) of the sample allows an exchange of hydroxyl for fluoride ions thereby increasing fluoride in solution.[8] Arsenic is also affected by reactions with hydroxyl ions though elevated concentrations are also influenced by aquifer residence time, an oxidizing environment, and lithology.[8]

Another sample with unusual water chemistry was collected east of Wickenburg. The sample exceeded water quality standards for gross alpha, TDS, sulfate, fluoride, and manganese and had the study's highest concentrations of TDS (2,300 mg/L) and sulfate (1,100 mg/L). The sulfate result was almost nine times the next highest concentration found in the basin. Based on these results, the sample is strongly influenced by nearby inactive mines.[8] Furthermore, the presence of high concentrations of iron, manganese, and TKN combined with a non-detection of nitrate suggest unusual reducing conditions in the groundwater.[8] Thus, the sample from this remote stock well appears to be site specific and probably is not reflective of regional groundwater conditions.

In the basin, there is some tendency for constituent concentrations to be significantly higher in groundwater sites collected in unconsolidated sediment and/or which consist of enriched recharge. These trends however, do not impact the acceptability of these sites for use as a drinking water source.

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