ADEQ
Arizona Department of Environmental Quality
Janet Napolitano, Governor
Stephen A. Owens, ADEQ Director

FACT SHEET

Ambient Groundwater Quality of the Pinal Active Management Area: A 2005-06 Baseline Study – October 2007

INTRODUCTION

In 2005-06, a baseline groundwater quality study of the Pinal Active Management Area (AMA) was conducted by the Arizona Department of Environmental Quality (ADEQ) Ambient Groundwater Monitoring Program. ADEQ conducts monitoring pursuant to Arizona Revised Statutes §49-225. This fact sheet is a synopsis of the ADEQ Open File Report OFR 08-01.[1]

The Pinal AMA is located within Pinal, Pima and Maricopa counties in south-central Arizona between Phoenix and Tucson. Created by the Arizona Groundwater Management Act of 1980, the Arizona Department of Water Resources (ADWR) is charged with managing the Pinal AMA's diminishing groundwater resources.[2] The Pinal AMA covers approximately 4,100 square miles and contains five incorporated communities: Casa Grande, Coolidge, Eloy, Florence and Maricopa. Approximately half of the Pinal AMA (2,100 square miles) is composed of Native American lands including the Ak-Chin Indian Community and portions of the Gila River Indian Community and the Tohono O'odham Nation (Map 1).[2] The Pinal AMA is largely rural, but both agricultural and desert land in the area is rapidly transitioning into urban land use (Figure 1).

Figure 1 – A housing development near the city of Maricopa encroaches upon an irrigation well operated by the Maricopa-Stanfield Irrigation and Drainage District. In many areas of the Pinal AMA, farmland is rapidly transitioning to urban land uses.

HYDROLOGY

The Gila River and Santa Cruz River are the major drainages in the Pinal AMA, though both are typically dry. Except during floods, the entire flow of the Gila River is diverted northeast of Florence for irrigation use (Figure 2) while the Santa Cruz River has only a limited stretch of flow maintained by upstream wastewater discharges. There is no recorded natural perennial flow in any of the other gauged drainages in the AMA.[3]

Basin sediments in the Pinal AMA consist primarily of alluvial fill extending up to several thousand feet in thickness.[4] Prior studies have classified these sediments in various ways. Three water zones were defined in the Eloy and Maricopa-Stanfield sub-basins by an ADWR study: a lower main water zone, upper main water zone, and local water zones.[3] The lower main water zone is the deepest and most extensive with the majority of recharge occurring from natural sources. Above it is the upper main water zone, the primary source for well production. Recharge to this zone comes from natural sources as well as leakage from unlined irrigation canals and percolation from excess irrigation water applied to crops.[3] There are at least three shallow local water zones perched on fine-grained deposits which receive most of their recharge from human activities such as leakage from

Publication Number: C 07-27

Map 1 - Pinal AMA

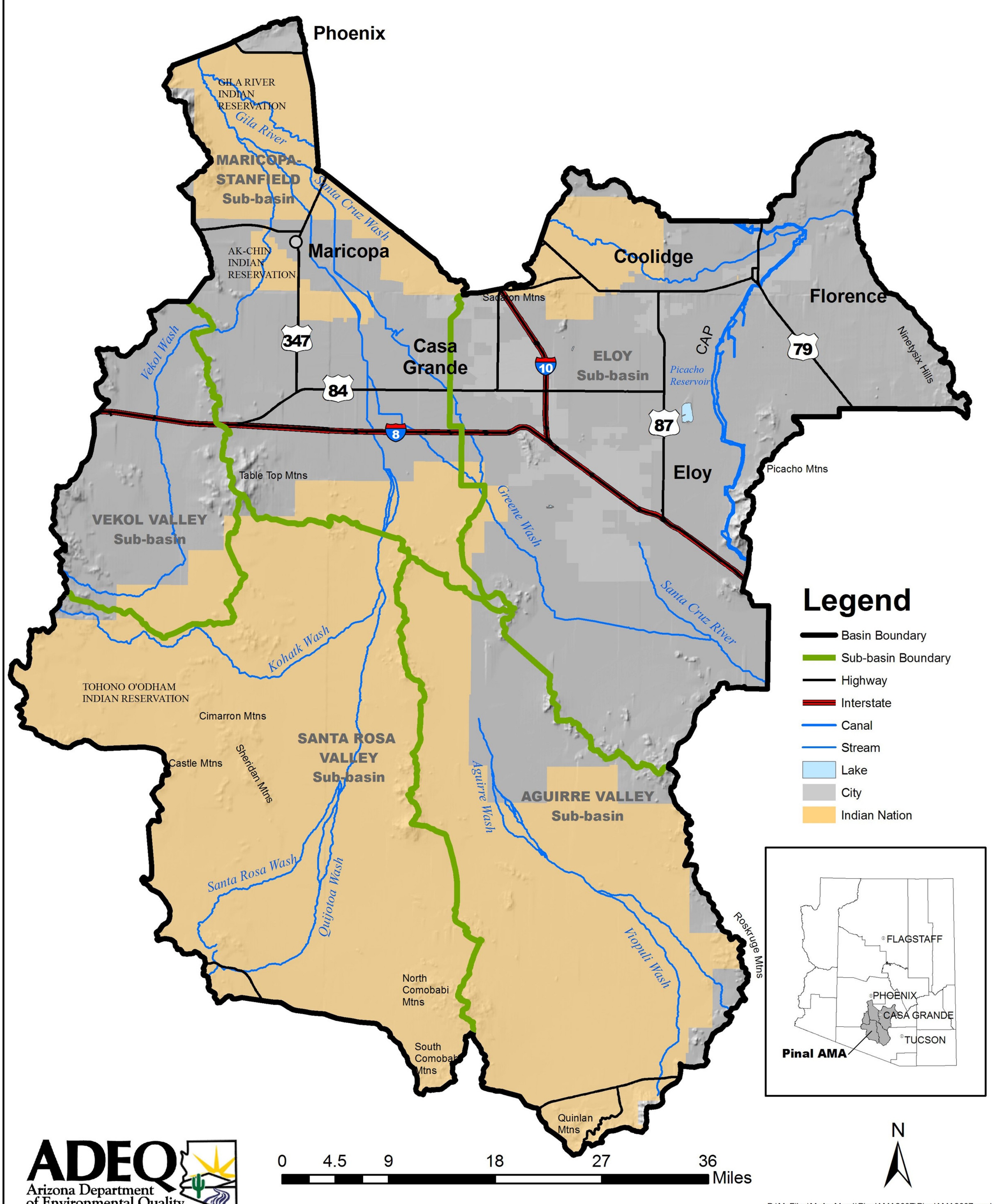


Figure 2 – The Ashurst-Hayden Dam on the Gila River northeast of Florence, built in 1922, diverts the flow of the Gila River for irrigation use. The importation of this surface water for irrigation has helped maintain fairly shallow groundwater depths in the northern part of the Eloy sub-basin.

unlined irrigation canals and percolation from excess irrigation water applied to crops.[3]

The Pinal AMA has been divided into five sub-basins by ADWR: Eloy, Maricopa-Stanfield, Aguirre Valley, Santa Rosa Valley and Vekol Valley (Map 1).[4] The Eloy sub-basin is further divided into northern and southern portions by a groundwater ridge that lies approximately along the Casa Grande Canal alignment.[3]

WATER DEVELOPMENT

The vast majority of water use in the Pinal AMA occurs in the two northern sub-basins: Eloy and Maricopa-Stanfield.[2] Groundwater is the primary source for municipal and domestic supply.

Both surface water and groundwater are used for non-Indian irrigated agriculture, which constituted 75 percent of water usage in the Pinal AMA in 1995.[2] The largest water users are four irrigation and drainage districts: the Central Arizona (CAIDD), Hohokam (HIDD), Maricopa-Stanfield (MSIDD), and San Carlos (SCIDD).[2] The SCIDD and HIDD are located in the Eloy sub-basin north of the groundwater ridge, the CAIDD is located in the Eloy sub-basin south of the groundwater ridge, and MSIDD is located in the Maricopa-Stanfield sub-basin.

Although the Gila River has been diverted for agricultural use since the 1860s in the area, the SCIDD has used flow from this waterway supplemented with limited groundwater pumping since its formation in the 1920s for irrigation.[2] In contrast the CAIDD, HIDD and MSIDD were dependent on groundwater (Figure 3) for irrigation. Since 1987, these three irrigation districts have received and distributed Colorado River water provided through the Central Arizona Project though groundwater is still pumped to supplement the water supply (Figure 4).[2]

METHODS OF INVESTIGATION

To characterize regional groundwater quality, samples were collected from 86 sites located on non-Indian lands. Roughly two-thirds of the sampled sites were irrigation wells using turbine pumps with the remainder mostly domestic wells using submersible pumps. Among sub-basins, the majority of groundwater samples were collected in Eloy (50 sites) and Maricopa-Stanfield (27 sites) with the remainder in Aguirre Valley (5 sites) and Vekol Valley (4 sites). No sites were sampled in the Santa Rosa Valley sub-basin that consists almost entirely of Native American land.

All sites were sampled for inorganic constituents and oxygen and deuterium isotopes. Samples for radon (41 sites), radiochemistry (21 sites) and organics (semi-volatile compounds, chlorinated pesticides and

Figure 3 – Groundwater from a 1,200-foot-deep irrigation well operated by the Central Arizona Irrigation and Drainage District supplements Colorado River water flowing in the Central Main Canal. Water from the canal irrigates crops, mostly upland cotton, in the Santa Cruz Flats south of the town of Eloy.

Figure 4 – Colorado River water now supplements groundwater for irrigation needs in the Maricopa-Stanfield Irrigation and Drainage District. This irrigation district has a much greater depth to groundwater than the San Carlos Irrigation and Drainage District because, previous to 1987, it solely relied upon groundwater for irrigation needs.

organophosphorus pesticides) (14 sites) were also collected at selected sites.

Sampling protocol followed the *ADEQ Quality Assurance Project Plan*.[5] The effects of sampling equipment and procedures were not found to be significant based on seven standard quality assurance/quality control tests.

WATER QUALITY SAMPLING RESULTS

The analytical results were compared with Environmental Protection Agency (EPA) Safe Drinking Water (SDW) 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 daily lifetime consumption of two liters of water. Of the 86 sites sampled, 60 sites (70 percent) had concentrations of at least one constituent that exceeded a Primary MCL (Map 2). Health-based exceedances included arsenic (33 sites), fluoride (7 sites), gross alpha (5 sites), nitrate (23 sites), and uranium (2 sites).

EPA SDW Secondary MCLs are unenforceable, aesthetics-based water quality guidelines for public water systems. Water with Secondary MCLs may be unpleasant to drink and/or create unwanted cosmetic or laundry effects but is not considered a health concern. At 59 sites (69 percent), concentrations of at least one constituent exceeded a Secondary MCL (Map 2). Aesthetics-based exceedances included chloride (25 sites), fluoride (19 sites), iron (2 sites), pH-field (8 sites), sulfate (26 sites) and total dissolved solids or TDS (50 sites).

There were no detections of any semi-volatile compounds, chlorinated pesticides or organophosphorus pesticides in the 14 organic samples. Two radon samples exceeded the proposed EPA SDW standard of 4,000 picocuries per liter.

GROUNDWATER COMPOSITION

Analytical results indicated that groundwater in the Pinal AMA was generally *slightly alkaline*, *fresh*, and *hard* to *very hard* based on pH values, TDS and hardness concentrations. Groundwater chemistry varied widely with samples from the upper main water zone tending to be of calcium-sulfate/chloride composition while samples from the lower main water zone were generally of a sodium-bicarbonate composition. Among trace elements, only arsenic, boron and fluoride were detected at more than 20 percent of sample sites. Nitrate (as nitrogen) was often elevated with 73 percent of sample sites having concentrations greater than >3.0 milligrams per liter suggesting influence by human activities.

GROUNDWATER QUALITY PATTERNS

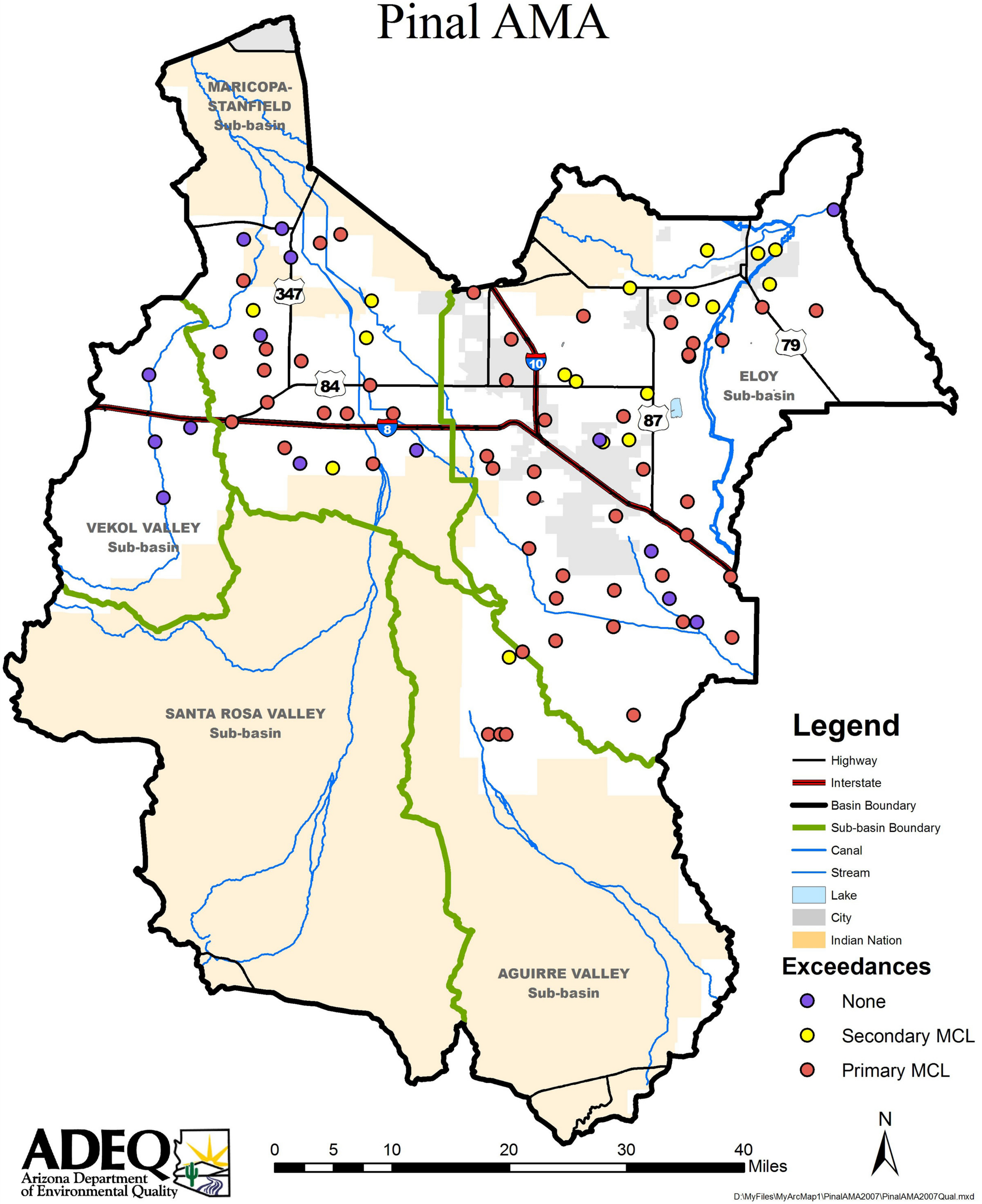
Statistically-significant patterns were found among groundwater sub-basins, land uses, irrigation districts and water zones (Kruskal-Wallis test with Tukey test, $p \leq 0.05$).

Differences Among Sub-Basins - Among the four sub-basins sampled, temperature was higher in Aguirre Valley than in Eloy, fluoride and pH-field were higher in Maricopa-Stanfield than in Eloy, and oxygen and deuterium were higher in both Maricopa-Stanfield and Vekol Valley than in Eloy.

Comparing the Eloy and Maricopa-Stanfield sub-basins - where almost 90 percent of the samples were collected - revealed additional significant differences. Groundwater depth, temperature, pH-field, pH-lab, sodium, fluoride, radon, gross beta, oxygen and deuterium were higher in Maricopa-Stanfield than in Eloy. Calcium and boron were higher in Eloy than in Maricopa-Stanfield.

Differences Between Land Uses - Within the Eloy and Maricopa-Stanfield sub-basins, well depth, TDS,

Map 2 - Water Quality Status
Pinal AMA



hardness, calcium, magnesium, potassium, chloride and sulfate were higher in the agricultural areas than in the non-agricultural areas. In contrast, temperature, pH-field, pH-lab and fluoride (Figure 5) were significantly higher in non-agricultural areas than in agricultural areas.

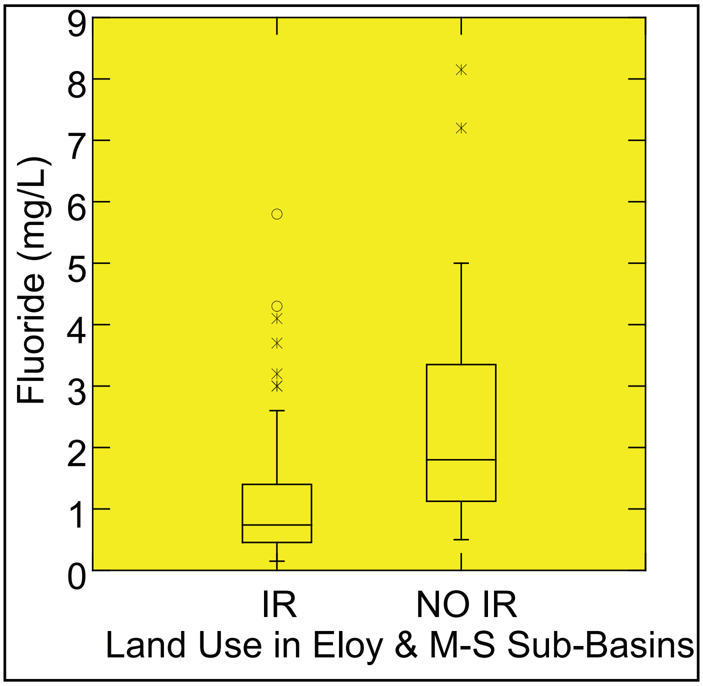


Figure 5 – Fluoride concentrations are significantly higher in non-irrigated areas than in irrigated areas within the Eloy and Maricopa-Stanfield sub-basins (Kruskal-Wallis test, $p \leq 0.05$). In the box plot diagram, the central vertical line marks the median, the length of the box shows the range within which the central 50 percent of values fall and the box edges are the first and third quartiles. The asterisks represent "outside values" and empty circles represent "far outside values".

Differences Among Irrigation Districts - Analytical results were compared among groundwater samples collected in three irrigation districts: CAIDD, MSIDD and SCIDD. Since the HIDD and SCIDD have somewhat intermingled boundaries and both are north of the groundwater ridge dividing the Eloy sub-basin, the samples collected in the HIDD were combined with those collected in the SCIDD to reflect conditions in the northern section of the Eloy sub-basin.[3]

Groundwater depth, temperature, pH-field and pH-lab were higher in the CAIDD and MSIDD than in SCIDD. TDS, SC-field, SC-lab, hardness (Figure 6), calcium, magnesium, potassium, chloride, sulfate, TKN and boron were higher in the SCIDD than in CAIDD and MSIDD. Unique patterns were found with seven constituents: sodium and oxygen (MSIDD & SCIDD > CAIDD), bicarbonate (SCIDD > CAIDD), arsenic and radon (MSIDD > SCIDD), fluoride (MSIDD > CAIDD) and deuterium (MSIDD > CAIDD & SCIDD).

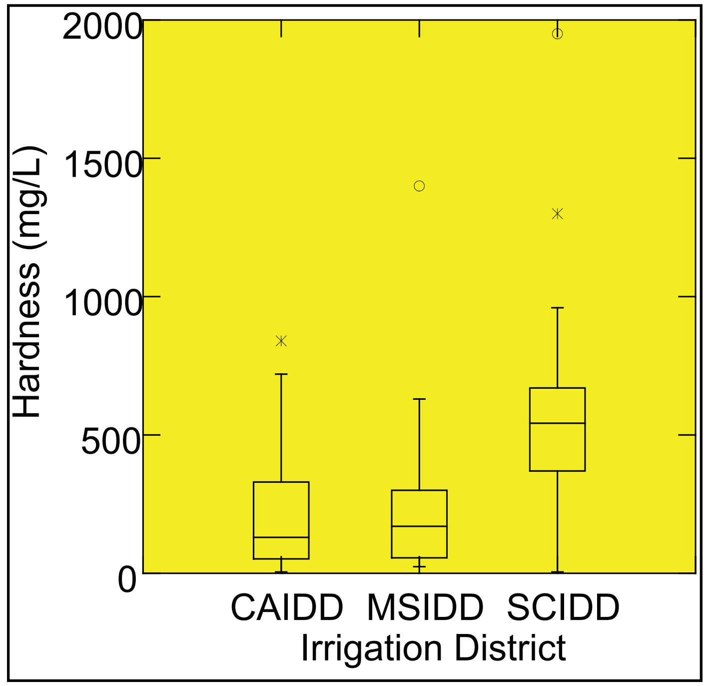


Figure 6 – Among irrigation districts, hardness concentrations are significantly higher in the San Carlos than in either Central Arizona or Maricopa-Stanfield (Kruskal-Wallis with Tukey test, $p \leq 0.05$). The San Carlos district appears to have been more heavily impacted by saline recharge from irrigation applications because of the short distance this water has to percolate before contacting shallow groundwater.[6]

Differences Among Groundwater Zones - Analytical results were compared among groundwater samples collected in the three water zones within the Eloy and Maricopa-Stanfield sub-basins: lower main water zone, upper main water zone and local water zones.

Well depth, groundwater depth, temperature, pH-field and pH-lab were higher in the lower main water zone than in upper and local water zones. TDS, SC-field, SC-lab, hardness, calcium, magnesium, sodium, chloride, sulfate and nitrate (Figure 7) were higher in the upper and local water zones than in the lower main water zones. Potassium, TKN and boron were higher in the upper main water zone than in the lower main water zone.

CONCLUSIONS

Of the water quality patterns found, the most numerous are those involving groundwater zones and irrigation districts. Several factors contribute to these water quality patterns, including evaporate deposits such as gypsum, salt and gypsiferous mudstone, but their specific impacts are difficult to quantify.[3] The most important factor however, appears to be the effect of salts and calcite concentrated by evaporation during irrigation and then recharged to the upper main or local water zones.[6]

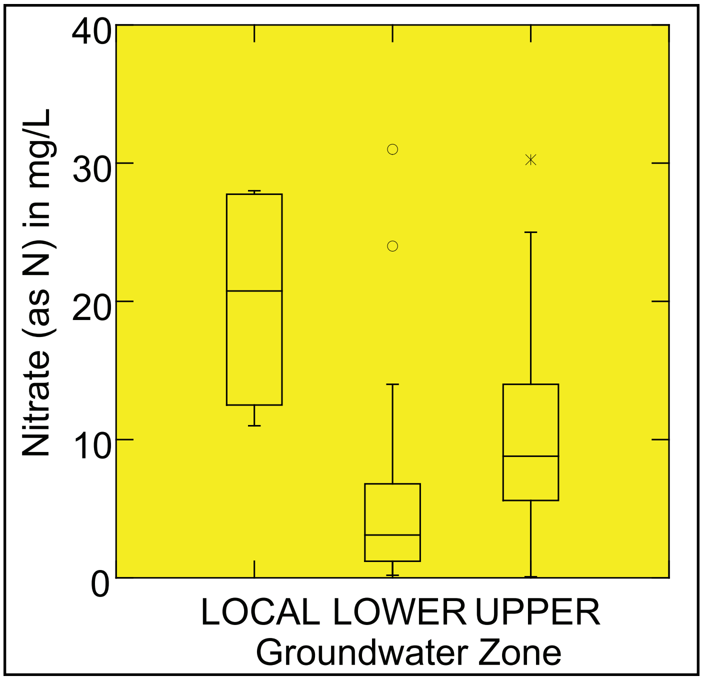


Figure 7 – Nitrate concentrations are significantly higher in the local and upper water zones than in the lower water zone (Kruskal-Wallis with Tukey test, $p \leq 0.05$). The elevated nitrate concentrations found in the local and upper water zones are likely the result of several sources, including saline recharge from irrigation that also carries nitrates as a result of nitrogen fertilizer applied to crops.[6]

Since water from the Gila River is the main source of irrigation for the SCIDD, its importation maintains relatively shallow groundwater levels in this irrigation district. Thus, there is little lag time before the highly saline recharge from irrigation applications percolates to the aquifer and impacts groundwater quality in the SCIDD.

In contrast, before 1987, the CAIDD and the MSIDD used groundwater as the sole source of irrigation water. This has led to declining groundwater depths in these districts, but has probably protected the groundwater from the full impacts of saline recharge from irrigation applications because of the increased distance necessary for this water to percolate to the aquifer.[6]

This ADEQ study revealed that 70 percent of the 86 sites sampled did not meet health-based Primary MCL water quality standards. Previous assessments of groundwater quality in the Pinal AMA indicated that, aside from a few wells having high concentrations of nitrate and fluoride, there were no major issues affecting water quality.[2] Much of the disparity between these two assessments can be attributed to the lowering of the arsenic standard from 0.05 mg/l to 0.01 mg/l in 2006, a change that resulted in exceedances at 33 sites—instead of one site—for arsenic in the ADEQ study.

Another important facet of this study revealed no significant differences involving nitrate concentrations between non-irrigated portions of the Eloy and Maricopa-Stanfield sub-basins and areas in irrigated agricultural production. Previous assessments had characterized the non-irrigated portions of these sub-basins as having lower contaminant levels.[4] This finding appears to indicate that nitrate concentrations are the result of both agricultural sources, such as crop fertilizer and confined animal feeding operations, and non-agricultural sources such as on-site wastewater septic systems.

ADEQ CONTACTS

Douglas C. Towne
ADEQ Hydrologist
Monitoring Unit
1110 W. Washington St. #5330D
Phoenix, AZ 85007

E-mail: dct@azdeq.gov

(602) 771-4412 or
toll free at (800) 234-5677 Ext. 771-4412
Hearing impaired persons call
ADEQ's TDD line: (602) 771-4829

Web site:
azdeq.gov/environ/water/assessment/ambient.html

Maps by Steve Callaway, senior hydrologist

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