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An Arizona Guide to Water Quality and Uses

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Introduction

Adult human beings may drink up to two liters/day (approx. two quarts/day) of fresh water to stay alive. However, we can consume up to two quarts/hour of water, depending on the level of activity, ambient temperature, and humidity conditions (Born 2013). We also need fresh water to cook with and to clean ourselves. About 40% of our food production depends on irrigation (UN Water 2013) using water with low salinity and other contaminants. Climate scientists project increasing temperatures and possibly less rainfall in the Southwest now and into the near future, see Extension Publication #AZ1458 (Artiola et al. 2008). Thus, climate change is likely to stress the limited water resources of Arizona and affect water quality by concentrating contaminants and stressing water-dependent environments.

This publication presents brief summaries of the types of water sources, their water quality, and possible uses in Arizona. Since the types and amounts of constituents found in water, whether nutrients, pathogens, contaminants or pollutants, help determine its possible uses, it is necessary to measure water quality to determine treatment options for a given use. To assist in this task, we present a triangle-shaped diagram (Figure 8) which divides water quality into three major groups: Pathogens, Salinity, and Specific Contaminants, placing major water sources in relation to the three groups. Home and well owners can use this diagram as a general aid to evaluate various sources of water, determine their likely water quality, and identify appropriate uses for them.

Groundwater

Arizona has a varied groundwater quality mainly due to its mineral-rich and complex geology. Most of the groundwater resources are located in the basin and range aquifers filled with sediments thousands to millions years old. See Artiola & Uhlman (2009) for a description of Arizona aquifers. Therefore, the water quality varies from basin to basin, and within each basin, due to a unique combination of factors such as aquifer sediment composition, basin origins, and its present hydrology. Water quality often varies with depth in the same aquifer. The Arizona Department of Environmental Quality (ADEQ) Ambient Monitoring Program has published groundwater quality reports for about 25 of the 51 delineated basins in Arizona (Figure 1). This information is available in separate reports and fact sheets (ADEQ-AMP 2013).

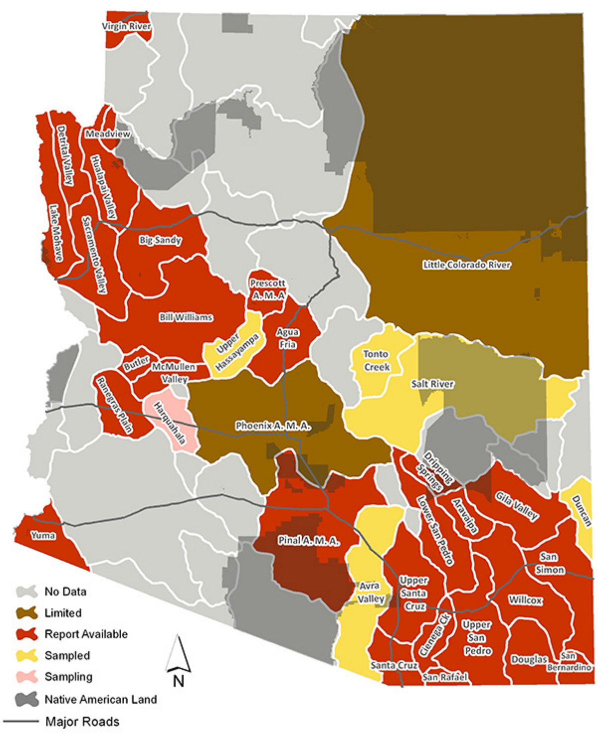

Figure 1. Arizona Basins: Ambient Monitoring Program Activity by Basin. Source: ADEQ-AMP(2013).

These reports contain information about basin geology, hydrology and detailed water quality information such as Total Dissolved Solids (TDS) or salinity, the dominant salts, pH, and specific regulated constituents, that have been detected in water samples; for example: arsenic, nitrate, fluoride, boron, chromium, barium copper, selenium, gross alpha radiation, and others.

An ADEQ report by Hood and Towne (2010) "…summarizes groundwater quality conditions on a regional-scale partially based on water monitoring results by ADEQ and collaborators from 1995 to 2009 for basin-fill aquifers of Arizona.". Local and regional water quality conditions are highlighted in selected basins, aquifers and Active Management Areas

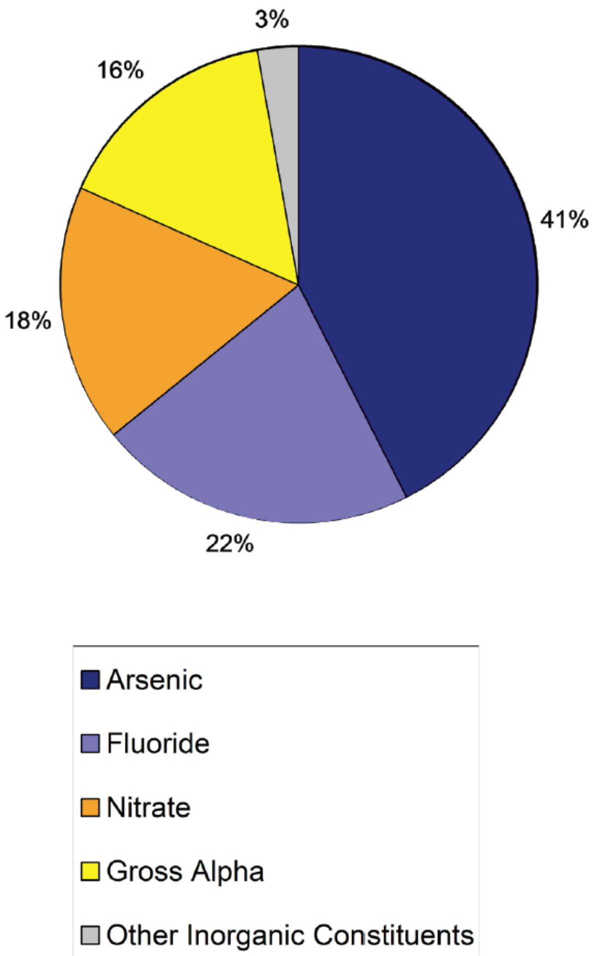

Figure 2. Constituents exceeding primary MCLs in 31% of the GW samples collected during a 15-Year period. Adapted from: Towne & Jones (2011).

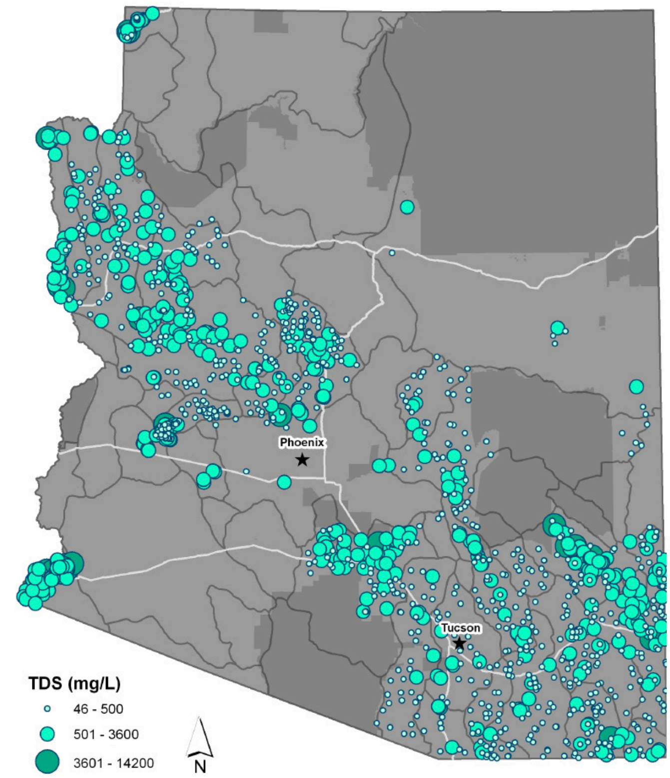

Figure 3. Levels of Total Dissolved solids in groundwater samples collected at 1477 Arizona sites. Adapted from: Towne & Jones (2011).

(See Arizona Water Atlas (ADWR 2010) for more detailed information about Arizona's AMAs). For example, 29% of the groundwater samples collected during this period in the Tucson AMA had a least on constituent above Maximum Contaminant Level[1] (MCL) drinking water standard.

Another ADEQ report by Towne & Jones (2011) summarizes the GW quality of Arizona focusing on the findings from 15 years of groundwater quality data collection done through the AZDEQ Ambient Monitoring Program (AMP). The AMP sampled 1,477 sites during this period, from domestic to municipal wells covering 35 (of the 51) basins in Arizona. According to this report, 31% of the groundwater samples collected had one or more drinking water standard MCL exceeded and 97% of these exceedances were due at least to one of these four constituents: arsenic, fluoride, nitrate, and gross alpha radiation (Figure 2).

Arizona has portions of regional aquifers that have saline water (>3000 mg/L). These salt-impaired aquifer zones, mostly due to natural local geologic conditions, are generally located in the Phoenix basin along the Salt River, the Gila River into the Yuma valley, and on the Holbrook basin located on the Colorado plateau, see Arizona Salt poster (Artiola et al. 2013) or Extension publication # AZ1485 (Artiola & Uhlman, 2009). According to Towne and Jones (2011), 37% of the well water samples had TDS levels above the recommended 500 mg/L secondary MCL (Figure 3). However, in the Hood & Towne (2010) report nearly half (46%) of the 1,767 groundwater samples exceeded the 500 mg/L TDS.

Private and Shared Well Water

There are more than 120,000 private and shared water wells in Arizona that provide water to an estimated 5% of the state's total population. Most of them are concentrated in specific areas where shallow groundwater is obtainable at a rate that justifies the expense of installing and operating a well. In other areas, it is the only possible source of available water (Indian Nations land, National forests). A plot of the location of all known water wells in Arizona is available on the Arizona Department of Water Resources (ADWR) web site.

As discussed above, groundwater in Arizona can vary widely with location, recharge sources, and anthropogenic activities. Shallow groundwater aquifers are the most susceptible to impacts by human activities since contaminants are more likely to reach groundwater sooner than in deep aquifers. Therefore, improperly constructed water wells in these areas are prone to contamination. Very deep wells in aquifers that tap much older water are more likely to have high concentrations of naturally occurring mineralized water.

Well owners should be aware of the local water quality and likely presence of any contaminants in their water sources.

[1] MCLs are from the USEPA National Primary and Secondary Drinking Water Standards. See USEPA (2013a) website.

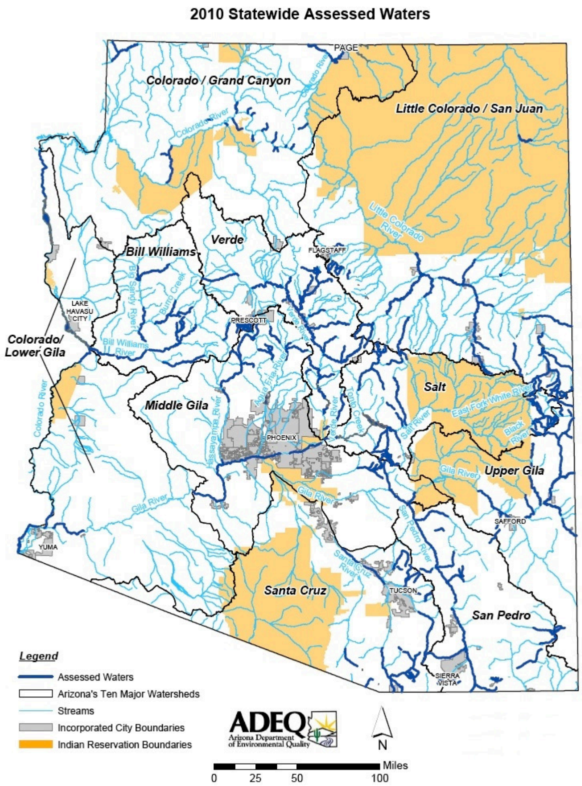

Figure 4. Arizona Streams. Source: ADEQ 2012.

Well owners should use this water quality information as an initial guide to test their well water. Note again that site-specific conditions such as septic systems and nearby activities like agriculture or mining may also affect the well water quality.

No State agency is responsible for monitoring the quality of water from private and shared domestic water wells in Arizona. Therefore it is advisable that all private and shared well owners collect a water sample from their wells and have an Arizona State certified laboratory analyze it for contaminates likely to be present in their area. It is also advisable to sample and test your well water after any wildfire events, or flash floods that occur anywhere near your well or aquifer recharge area. See guidelines on well water testing, drinking water standards, and water treatment options in Extension publications #AZ1485 (Artiola & Uhlman 2009) or #AZ1578 (Artiola et al. 2012).

Public (Community) Water Utilities

Water providers use one or more sources of water that can include local groundwater and surface water imported from nearby reservoirs or from out of state as is the case with the CAP (Central Arizona Project) canal water. The ADEQ regulates water quality in public water systems with at least 15 connections or 25 persons. The ADEQ assures compliance with the federal standards and guidelines for drinking water called Primary and Secondary National Drinking Water Standards (NPDWS and NSDWS, see USEPA (2013a)). This means that public water utilities must regularly test their water sources and distributions systems and comply with the NPDWS or face a penalty. A right-to-know law also requires that water utilities inform consumers about the water quality they deliver (to the house water meter) and the presence of any contaminants above drinking water standards.

Figure 5. Sabino Canyon Stream (intermittent). Photo: J.Artiola.

Consumers should review these water quality reports, usually available online, regularly to be aware of the types of contaminants commonly detected in their local water. More information about drinking water standards can be found in the Extension publication #AZ1578 (Artiola et al. 2012). Water quality may change when it enters their home due to aging pipes, water heaters and the use or misuse of water treatment devices. Therefore, homeowners that wish to test their water should do so at the tap and consider using water treatment devices if they are not satisfied with, for example, the taste of the water. For more information about major sources of water in Phoenix, Tucson, Yuma, and Flagstaff, drinking water standards, and home water treatment options see the Extension publication #AZ1578 (Artiola et al. 2012).

Surface Water

According to ADEQ (2012), Arizona has close to 300,000 acres of lakes and about 90,000 miles of streams (Figure 4). However, only about 60% of the lake surfaces (acres) and 4% of the streams (miles) have water year-around (perennial). Figure 5 shows an example of one of the many streams in AZ that only flow during wet periods. The water quality in these lakes and streams can be affected in many ways, including intermittent flows, floods, recharge, water evaporation, contaminated agricultural, urban, and industrial drainage, discharge, seepage, atmospheric deposition, and recreational activities.

The ADEQ monitors the water quality of these perennial sources of water and ranks them for one or more types of use. These uses include swimming, domestic water source, agricultural irrigation, agricultural livestock watering, and fishing (ADEQ 2012). Water sources that cannot be used for one or more of the uses listed above, are considered "impaired" or stressed due to presence of one or more contaminants that produce unhealthy conditions.

There are numerous water quality-related properties that can degrade the quality and stress the environment of surface waters, which are natural and anthropogenic, including the presence of fecal coliforms, metals (mercury, lead, copper, selenium, manganese…), and chlorinated pesticides. Other parameters that degrade the water environment are high levels of nutrients (phosphate, and nitrogen species: nitrate, ammonia, organic-N), sediments (high turbidity), high or low pH, low oxygen content (DO), and algal growth.

Before coming into contact, fishing or using a water source for irrigation or as drinking water, users should know what water quality contaminants are likely to be present in a river or lake and consider its usage classification. For example, in 2010 ADEQ issued fish consumption advisories for 14 lakes and parts of three streams due to elevated levels of mercury and chlorinated pesticides found in fish. According to AZDEQ (2012), nutrients, DO, and pH are the most common stressor group of contaminants, followed by mercury, in impaired Arizona lakes. Metal contaminants such as lead and cadmium (except mercury), followed by fecal coliforms (pathogens indicated by *E. coli* test) were also regularly detected in impaired Arizona streams monitored by ADEQ between 2005 and 2010.

Recycled Water

Water that is re-introduced into the environment is recycled. Gray water is a form of recycled water (see Gray Water section). Some of the recycled effluent water is called reclaimed water (treated wastewater) that can be reused for certain applications depending on its level of treatment. Urban communities that have centralized wastewater treatment systems produce significant amounts of reclaimed water from household gray and black waters, industrial effluents (usually pretreated), and urban runoff. Wastewaters contain very high levels of pathogens, nitrogen, phosphorous, organic matter, and even residual levels of hazardous industrial chemicals such as solvents, hydrocarbons, pesticides, and other "emerging" contaminants such as pharmaceuticals, personal care products, and human hormones. A large portion of the runoff from roads and parking areas and many industrial wastewaters are treated or pre-treated using infiltration basins, holding ponds, and dry wells. However, household and small businesses wastewaters must be treated using physical, biological, and chemical processes to lower contaminants to levels that enable safe reuse. See Extension publication #AZ1568 (Rock et al. 2012), Table 1 for a primer on common wastewater treatment processes.

Table 1. City of Tucson Reclaimed Water Quality*.

Selected Constituents	Concentration	Units
Total Dissolved Solids (TDS)	752	mg/L**
Sodium Adsorption Ratio (SAR)***	3.62	
Sulfate	1164	mg/L
Chloride	146	"
Sodium	151	"
Calcium	86	"
Magnesium	16	"
Phosphate as P	1.7	"
Alkalinity (as $CaCO_3$)	221	"
Hardness (as $CaCO_3$)	292	"
Total Inorganic Nitrogen	13.8	"
pH	7.52	s.u.
Turbidity	2.72	NTU
E. coli	<1	cfu/100 ml

* Adapted from: City of Tucson (2013).
** milligrams/Liter or parts per million (ppm).
*** Alkalinity Adjusted SAR=5.12

The ADWR (2010) estimates of that effluent reuse was about 3% of the state water resources in 2006. Reclaimed water is sent to local streams to maintain riparian habitats or to basins for recharging local aquifers and used to irrigate parks and golf courses. In Arizona about 90 miles of streams receive reclaimed water (Uhlman et al., 2012), which help maintain riparian zones but impacts stream water quality. See Surface Water section.

Homeowners with access to reclaimed water and proper plumbing may use this growing and renewable water resource to flush toilets and for landscape irrigation. The Extension publication #AZ1568 (Rock et al. 2012) answers many questions about the growing uses of recycled water in Arizona.

Recycled reclaimed water is treated in some countries to meet drinking water standards. In many parts of the U.S., reclaimed water discharged upstream often becomes drinking water for communities downstream. In Arizona, recycled water is not (yet) approved for direct consumption. However, indirect consumption of reclaimed, recharged water blended with groundwater is becoming more common.

Presently, there are no federal standards for reclaimed water use but many states including Arizona have their own reclaimed water reuse regulations. For example, Gilbert, AZ has its own water reuse guidelines, based on Arizona standards. In Arizona reclaimed water is classified depending primarily on varying levels of Fecal Coliforms (FC), also considering the presence or absence of enteric viruses, and

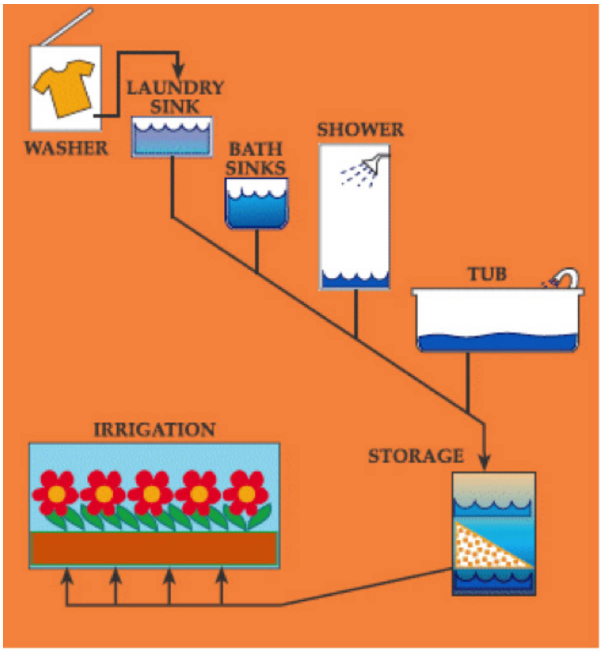

Figure 6. Gray Water Sources in the Home. Source: ADEQ (2013).

levels of turbidity and nitrogen (N), see Extension publication #AZ1568 (Rock et al. 2012), Table 4. For example, Class A+ recycled may have up to 23 colony forming units per 100 milliliters of water (cfu/100 ml), up to 5 Nephelometric Turbidity Units (NTU) turbidity, and less than 10 mg/L nitrogen; whereas, Class C may have up to 1000 cfu/100 ml of FC, but no limits exist for the other three parameters. Arizona regulations allow the use of Class C reclaimed water with FC <1000 cfu/100 ml as a drinking source for non-dairy farm animals.

The city of Tucson provides Arizona Class A reclaimed water to many customers including golf courses, parks, schools, the University of Arizona, and multiple and single family homes (City of Tucson 2013). Table 1 shows the 2011 annual average concentrations of common water constituents found in Tucson's reclaimed water. The data shows that Tucson reclaimed water TDS is about 1.5 times higher than tap water (~450 mg/L) and there are non-detectable *E. coli* levels due to chlorination. Reclaimed water can also be a good source of plant nutrients like nitrogen (N) and phosphorous (P), which are usually much higher than in tap water. Therefore, in general, the higher TDS, N, and P levels found in reclaimed water should not have any adverse effects to plants or crops (Ayers & Westcot 1985).

Gray Water

Residential gray water is all wastewater from a residence excluding wastewater from the toilet, dishwasher or kitchen sink and does not contain hazardous chemicals (oils, solvents, strong acids, pesticides.) Homeowners can recycle their gray water after its initial home use (laundry, showering) with no pretreatment. Arizona residents can use gray water to irrigate their yards operating under a general permit AR18-9-711 (Type 1 Reclaimed Water General Permit for Gray Water). See also ADEQ Publication No. C 10-04 (ADEQ 2013) for guidelines on using gray water at home. Homeowners should know that only wastewater that comes from bathroom sinks, showers, and laundry and does not contain hazardous chemicals (oils, solvents, strong acids, pesticides…) is considered gray water. (Figure 6). Gray water is considered safe to irrigate non-edible garden plants, but may be used to water nut and citrus trees.

However, people, pets, and wildlife should not come into contact with or consume gray water as it often contains fecal matter (from laundered diapers and underwear) and fails the fecal coliform [*Escherichia coli*] test. Gray water is also higher in salinity (TDS)[2] and nitrogen than tap or well water and has elevated levels of soap chemicals such as surfactants, fabric brighteners, and antimicrobial chemicals found in personal care products.

A recently published study (WERF 2012) on the long-term effect of irrigating 22 plants with gray water from Arizona, Texas, and Colorado, concluded that while most plants remained unaffected by gray water after 5 years, salt-sensitive fruit trees such as lemon and mango showed the effects of increasing levels of salinity and boron in the soil. The concentrations of surfactants, salinity, boron, and nitrogen also increased in soils irrigated with gray waters and this could be a threat to shallow groundwater resources (WERF 2012).

We recommend using gray water to irrigate primarily if not exclusively native (salt-tolerant) trees and shrubs and use laundry soaps specifically designated for gray water use, and personal care products that will not harm soils or plants. Newer low water use (front load) laundry machines conserve water but produce less gray water and this may have higher levels of TDS and other chemicals.

Pool/Spa and Home Treated Waters

Homeowners may need to dispose of significant quantities of water that are generated by reverse osmosis (RO) water treatment units (backwash), water softeners (backwash and softened water), and pools or spas/hot tubs. Most home RO units operate at low pressure and generate ~3-8+ gallons of backwash for every gallon of filtered water depending on the RO membrane, source water, TDS and hardness. The RO backwash water contains higher TDS (+10% to +30%) than the untreated water, but should be safe to use as an additional source of gray water to irrigate non-edible native plants and trees.

Water softeners produce two types of water, the backwash water produced during the resin regeneration, which is brackish (high salinity) water, and the softened water, which contains a high ratio of sodium or potassium to calcium and magnesium ions. When this ion replacement occurs, the Sodium Absorption Ratio (SAR) increases and the water quality is affected. The TDS and SAR levels are a measure of irrigation water quality. The TDS should not exceed 1,000-

[2] In general, gray water TDS levels should not exceed reclaimed water TDS values if the same primary water source is used. WERF (2012) reports only one TDS value for Tucson gray water: 930 mg/L and Figure 2 shows Tucson reclaimed water TDS of 761 mg/L.

1,300 mg/L for most garden vegetables, but native plants may tolerate higher TDS in water. Water SAR values above 10 can reduce infiltration to some soils[3] . The use of softened water for garden vegetables or houseplants is discouraged, but if it must be used, choose to soften the water with potassium salt.

Homeowners with septic systems should also be aware that softened water might change their septic field performance[4] . In addition, softened water contains very soluble salts[5] , which makes them more likely to reach down to the local aquifer.

The maintenance of pools and spas generate significant volumes of wastewater at about 1-3+ times/year intervals, depending on use, design, and local weather conditions. In Phoenix, AZ, a typical 20,000-gallon pool will evaporate 1 to 1.5 times as much water in one year. This means that if the initial TDS of the pool is 500 mg/L, evaporation will increase TDS up to 1,100 to 1,500 mg/L the first year and up to 2,200 mg/L to over 3,000 mg/L TDS the during second year of use (excluding the contribution from pool chemicals). To prevent scale formation, aesthetic, and maintenance (pH balance and residual disinfectant) problems, pool professionals recommend the replacement of pool and spa water at TDS levels between 2,000 and 3,000 mg/L. Do not use discarded pool water to irrigate garden plants or vegetables due to its high TDS and residual disinfectant levels. However, this water is safe for irrigating native trees, shrubs, and salt-tolerant grass.

Black and Industrial Waters (Raw Sewage)

Individual water use, both indoors and outdoors, varies across the U.S. depending on climate and lifestyle. The U.S. Environmental Protection Agency (EPA) estimates that about 25% of our daily indoor water use is for flushing toilets (EPA, 2013b). Black water (raw sewage) contains high levels of organic matter (BOD and COD)[6], organic and inorganic forms of nitrogen, sulfur, phosphorous and salinity. In addition, the FC count is extremely high (>10,000 cfu/100 ml), as are the counts of enteric viruses, and intestinal parasites (protozoa), which exceed 100/L (Bitton 2011). This makes ingestion of or even contact with raw sewage very dangerous to humans. To prevent the spread of waterborne diseases like diarrhea and the contamination of water sources with salts and nutrients like nitrogen and phosphorus, do not discharge black waters into open drains, ponds/lakes or waterways. Always dispose of black water in septic systems or wastewater treatment facilities.

It is not wise to touch or use any type of industrial wastewater. In general, industrial wastewaters are pretreated before being discharged into local wastewater treatment facilities or surface waters. Any facility that discharges wastewater directly to surface water must obtain a National Pollutant Discharge Elimination System (NPDES) permit from EPA or ADEQ, the agency in charge of the program (USEPA 2013c). The levels of hazardous chemicals found in industrial wastewaters are monitored and if necessary reduced to meet NPDES Maximum Contaminant Levels (MCLs) before discharge.

Figure 7. Roof harvested rainwater, collected into a concrete cistern, used to water garden plants. Photo: B. Lancaster (www.harvestingrainwater.com)

Household activities that can produce wastewater (sewage water and offsite runoff) tainted with high concentrations of hazardous chemicals include spills and improper disposal of degreasers (solvents), oil-based paints (thinners), motor oils, battery/pool acids, strong bleach solutions, and excessive use of herbicides and insecticides. Ultimately, each homeowner is responsible for keeping hazardous chemicals from contaminating local environment and water sources, their private wells, and septic systems. This is best done by: limiting the use and storage of hazardous chemicals, avoiding spills and improper use of these chemicals, never disposing of products containing hazardous chemicals down the drain, and taking unused portions of these chemicals to local hazardous waste disposal facilities. Never store and avoid spills or applications of chemicals near a wellhead.

Water Harvesting

First practiced thousands of years ago, rainwater harvesting is popular in rural areas with only limited water supplies and in urban environments primarily to supply landscape irrigation needs. Most people view water harvesting as limited to the installation of gutters and downspouts on a building and storage of the water in a cistern called "active" water harvesting. Equally important is "passive" water harvesting, which is the shaping of the landscape around a

3 Water with any SAR values and TDS below 200 mg/L and water with SAR values above 10 and TDS above 500mg/L may cause moderate infiltration reduction in clayey soils.
4 Septic fields located on clay-rich soils may experience decreased percolation rates due to the dispersion of soil clay particles saturated with sodium.
5 Sodium and potassium salts are many times more soluble (likely to stay dissolved in water and move with the flow) than calcium or magnesium salts, which are less water soluble and more likely to drop out of solution and stay fixed in the soils.
6 BOD (biological oxygen demand) measures the amount of oxygen needed to break down organic matter that is biodegradable. COD (chemical oxygen demand) measures the oxygen needed to breakdown (oxidize) all the organic matter present in the wastewater.

Table 2. Water Quality of Cisterns* in Tucson Area.

Organism Or Chemical	NPDWS** Or NSDWS***	No. of Cisterns Exceeding Standards	Units
		Summer/Winter	
Heterotrophic Plate Count (HPC)	500	9/10	HPC cfu/ml
Total Coliforms	1	9/8	Total/100 ml
E. coli	1	3/0	Total/100 ml
Enterococci	1	10/7	Total/100 ml
Turbidity	5	5/0	NTU
Copper	1,300	0/0	ppb
Lead	15	4/0	ppb
Iron***	300	1/0	ppb
Manganese***	50	3/0	ppb
Zinc***	5,000	1/1	ppb

* Adapted from: Phillips et al., (2005).
** US EPA National Primary Drinking Water Standards.
*** US EPA National Secondary Drinking Water Standards.

home or a building to slow the runoff allowing it to soak into the soil so that the offsite runoff is minimized or eliminated. This form of water harvesting uses the soil to store water for plant use.

Rainwater as it falls from the sky is typically low in total dissolved solids and saturated with oxygen and carbon dioxide gases. Because rainwater can and will collect gases, liquids, and solid particles (including microbes) from the atmosphere, and during runoff events, its water quality will vary by location and intensity of rainfall events. Roof harvested rainwater can also pickup dust, bird, and other animal droppings. Passively collected stormwater also contains contaminants. Therefore, harvested rainwater must be initially considered "non-potable" water. Cisterns and other types of rainwater storage should be light tight and dust-free to minimize algal growth and additional contamination (Figure 7). It is also important to screen holes for ventilation and overflow to prevent access of small animals or insects to stored water. Depending on the end use of the water, active water harvesting may require a "First Flush Device" installed to divert the first flush of rainfall runoff from a roof, which has the highest concentration of contaminants. For more information on passive rainwater harvesting and basic components of a rainwater storage system, see Extension publications #AZ1564 and #AZ1565 (Daily & Wilkins 2012).

In 2004 and 2005, a study of the water quality in 12 cisterns was done in the Tucson Metropolitan area, none of which had first flush devices (Phillips et al., 2005). Cistern water was collected for analysis at the beginning of the monsoon season in July and in the winter rainy season. A summary of the microbiological and chemical observations of 10 of the 12 cisterns is shown in Table 2.

The TDS (not shown in Table 2) of the waters in these cisterns ranged from 20-150 ppm (mg/L) in the summer and <1-42 ppm in the winter. These TDS values are well below NSDWS of 500 mg/L recommended for drinking water. The winter cisterns held more water at time of sampling than during the summer sampling (at the beginning of the monsoon season) suggesting an overall dilution effect that benefitted water quality. Thus, Table 2 shows that the number of cisterns exceeding drinking water standards is much lower in the winter than in the summer. For example, turbidity (an indirect measure of contamination) values were above the NPDWS (5 NTU) in half the cisterns in the summer and none in the winter. No detections were observed for: arsenic, antimony, barium, beryllium, cadmium, chromium, cyanide, fluoride, mercury, selenium, thallium, aluminum, or silver. For a complete evaluation of the cisterns' water quality data see the report by Phillips et al. (2005).

Urban and rural Arizona residents that want to use harvested rainwater to supplement their water needs should consider its primary use and design an active and/or passive system(s) that meets their needs. In general, untreated harvested rainwater is not potable for humans, but may be acceptable for farm animals. The low TDS of harvested rainwater makes it ideal to irrigate house and yard plants, in particular ornamentals with low salt tolerance. However, the quality of stored rainwater may or may not be acceptable to edible home garden plants since waterborne pathogens may be present. In addition, repeated use of rainwater to irrigate clayey soils may reduce infiltration rates (See footnote 3). Homeowners that want to use harvested rainwater as drinking water should consider a treatment system that at a minimum includes microfiltration and disinfection. For more information of home water treatment options see #AZ1578 (Artiola et al. 2012).

Reading and Interpreting the Water Quality & Uses Triangle

Each side of the triangle contains a range of expected values for many types of water; from rainwater at the top to black water at the bottom. However, this is not a standard triangular graph where values from each side necessarily converge to a single point or value inside the triangle. Whereas, salinity and pathogens levels should be read vertically (top to bottom), the specific contaminants axis most important part is a column of threshold of values on the left, which are the NPDWS MCLs for each of the contaminant listed. High values (top to bottom and left to right) may or may not exclude the use of this water for uses such as irrigation and swimming, depending on additional testing. Thus, values in the bottom axis may, or may not, be extended to intercept with any particular water classification area inside the triangle.

Note that dashed lines and enclosed areas in the triangle show approximate water quality values and or ranges of values for a given water source. Exceptions may be found that do not fall within these ranges of values.

Note also that the bottom axis lists only a subset of the more than 90 other contaminants and classes of possible contaminants regulated by EPA in drinking water. But again, these values are the MCLs for six common contaminants found in AZ waters (see the EPA 2013a for a complete list). For additional clarifications, it is important to read the triangle footnotes

Example: A homeowner has a well drilled and initial testing for salinity indicates that the water has 950 mg/L TDS. According to the triangle, this water exceeds the recommended TDS level for potable water. The owner does not wish to treat the water but would like to use it for irrigation. According to the triangle, the water may be used for garden (edible) plant irrigation since the TDS is well below 1,300 mg/L, but which plants can she water? The choice of plants requires two (or more) additional tests: total and fecal coliforms and possibly SAR if the soil is high in clays. If the tests fail the Total Coliforms and or fecal coliforms (*E. coli*) tests, the water should not be used to water edible garden plants, but it may be ok to water landscape plants with no human contact. If the well water SAR is above 10 the owner may consider intermittent use of this well water to flood irrigate landscape plants and trees. Further water testing should be done for any contaminant known to be present in the aquifer; for example: arsenic and gross alpha radiation. Levels of much higher than 10 ppb for arsenic and/or 15 pCi/L for gross alpha may limit the use of this well water to non-edible landscape plants.

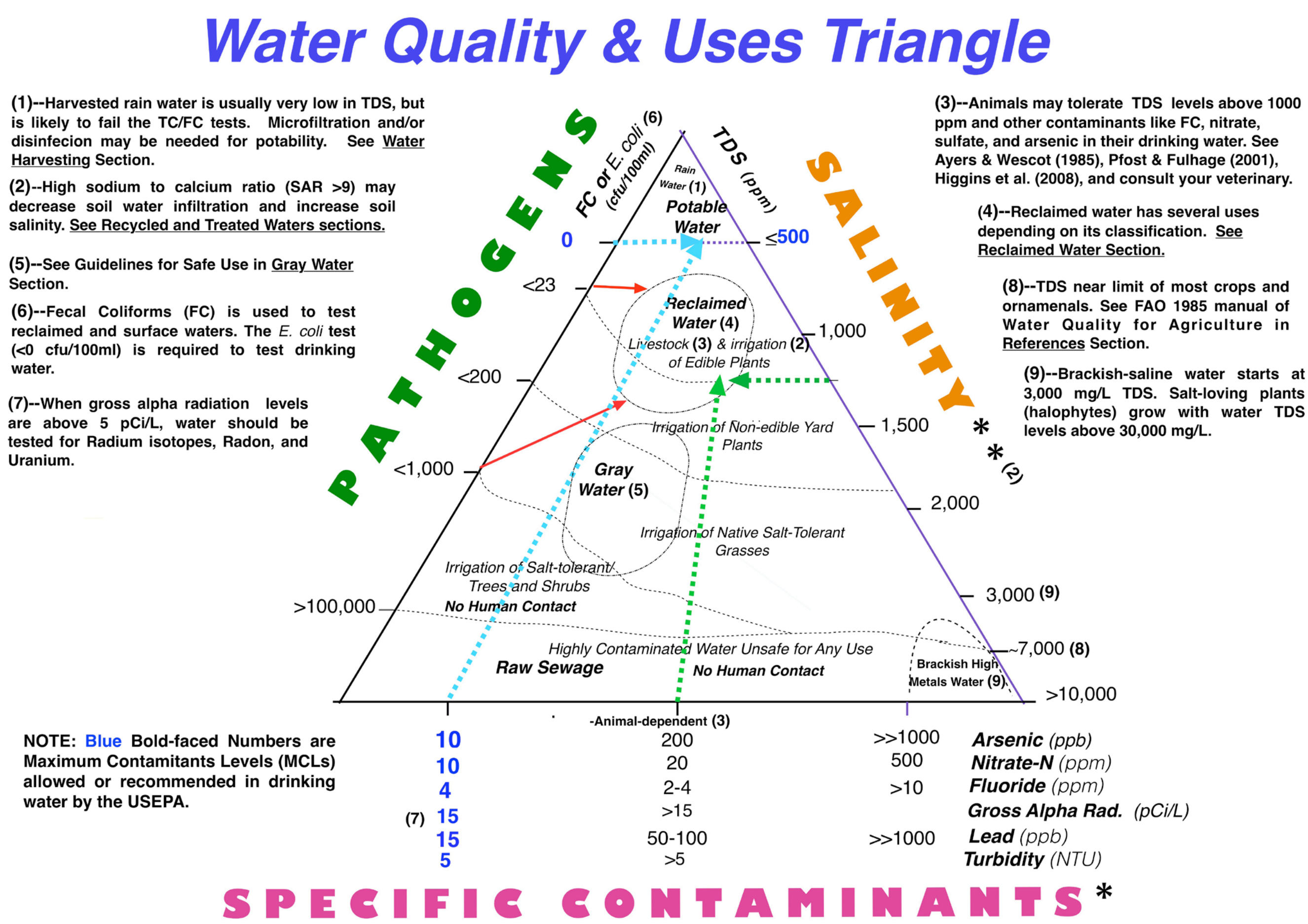

Figure 8. Water Quality and Uses Triangle[7].

* These are common contaminants in AZ water sources. See list of National Primary and Secondary Drinking Water Standards.
** Turbidity (particles larger than 0.5 microns) is usually associated with the presence of pathogens and other contaminants.
*** Besides TDS, SAR (the ratio of three common ions (sodium, and calcium plus magnesium) should also be considered for irrigation water. See triangle footnote (2) and text footnotes (2-4).

[7] Disclaimer: Use this triangle as a guide to determine the types of analyses needed for preferred water uses. Obtain (source) chemical and biological analyses of the water to verify use or uses. If you are not sure about what analyses are needed and/or potential uses of your water, ask UA Cooperative Extension water quality specialists, agronomists, plant specialists, hydrologists, medical and veterinary doctors before using the water. Refer to all applicable Water Quality Standards and guidelines such as USEPA NDWS, and Groundwater Quality reports, Crop Irrigation and Gardening guidelines, Reclaimed Water and Gray Water Use guidelines, Surface Water Quality guidelines, Livestock/Animal Drinking Water guidelines, and other Arizona-specific applicable water-related guidelines.

Summary

Arizona residents have access to numerous but diminishing water sources with varied water quality. All water sources have different levels of contaminants or impairment that limit their uses. Being aware of these water sources, water quality standards and guidelines, and usage classifications can help us manage these sources safely and more efficiently.

The Water Quality and Uses Triangle provides a summary at a glance of the basic information needed to determine water quality, and common water sources and uses that residents might have access to. This information should always be checked with specific analysis and knowledge of water sources uses and regulations.

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Links to Extension Publications

University of Arizona CALS Publications Website: http://cals.arizona.edu/pubs/

University of Arizona CALS Cooperative Extension Website: http://extension.arizona.edu/safe-drinking-water

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cals.arizona.edu/pubs/water/az1610.pdf

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