Water Quality in Pima County

Prepared for the Pima County Comprehensive Plan and Sonoran Desert Conservation Plan

March 2002

Prepared by

Pima Association of Governments

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Introduction

Background

Since 1998, Pima County has been working toward a comprehensive assessment of urban growth and the environment which has led to the creation of the Sonoran Desert Conservation Plan. Development of this plan has been prompted in part by the federal Endangered Species Act. In addition, the County is updating its Comprehensive Plan as required by the state's recently adopted Growing Smarter legislation. The two plans will contain a water quality element in order to meet the requirements of the Growing Smarter legislation, and to ensure the preservation of species dependent on surface water or shallow groundwater in Pima County.

Pima Association of Governments (PAG) is assisting with the preparation of the Water Quality Element at the County's request. This request was prompted in part by the fact that PAG is the state-designated Water Quality Planning Agency for Pima County under Section 208 of the Clean Water Act.

PAG's Section 208 Water Quality Management Plan consists of a document written in 1978 and all of the subsequent amendments and updates to that document. The 208 Plan addresses one of the major water quality concerns associated with growth, which is the disposition of waste. The original PAG 208 Plan and several amendments also identified various point- and non-point sources of pollutants. However, the 208 Plan has not had a recent comprehensive, countywide update and it does not include site-specific programs for unique aquatic habitats identified in the Sonoran Desert Conservation Plan. Therefore, reliance on the existing 208 Plan would probably not meet the County's needs, and development of additional planning materials is warranted.

Purpose

The purpose of this report is to provide, using existing literature to the extent possible, a brief, descriptive overview of the quality of various water sources found in Pima County. By identifying high-quality water sources as well as areas with potential water quality problems, it will be possible to prioritize regional water quality planning efforts. These plans could include additional monitoring, assigning appropriate uses for some water sources, improving the quality of some sources where necessary, and protecting the water quality of other sources. This report, along with a separate report summarizing existing regulations, plans and programs related to water quality management and protection, will provide a foundation on which the water quality element of the County plan can be developed.

Information and Data Sources

Much of the information in this report comes from previously published documents containing information about water quality in Pima County. In particular, this report relies heavily on the following: *Water Quality State of the Region Report* (PAG, 1994); *Tucson Active Management Area Third Management Plan* (ADWR, 1999); *The Status of Water Quality in Arizona - Clean Water Act Section 305b Report* (ADEQ, 2000); *Water Quality Assessment for the Tucson Active Management Area Northwest Replenishment Program Feasibility Study* (PAG, 1996); City of Tucson's *Municipal Stormwater Annual Report for Fiscal Year 1998-1999;* and *Pima County NPDES Stormwater Discharge Permit (No. AZS000002) Third Annual Report, September 2000.*

Scope and Limitations

This report is the first deliverable under PAG's contract with Pima County to provide assistance with developing the Water Quality Element of the *Sonoran Desert Conservation Plan* and the *Comprehensive Land Use Plan*. The study area is all of Pima County, excluding Indian reservations. However, the emphasis is on eastern Pima County.

This report, in accordance with the PAG-Pima County contract, relied primarily on data that were readily available in existing literature. No original data were collected for this project, and PAG did not attempt to verify the accuracy of the data contained in the sources used. In addition, the time and budget available for this project did not permit an exhaustive search for all literature that might be available on water quality in Pima County. Additional data, including monitoring results more current than the data used for this report, are probably available. However, it is assumed that the data used for this report are adequate to provide a general, descriptive overview of water quality in the county. PAG only used data from previously published, peer-reviewed literature, or data provided by organizations with an extensive history of water quality monitoring and data reporting, for this project.

This report should not be used for a detailed, quantitative comparison of the different water sources, or for concluding that one water source is "better" or "worse" than another. In order to conduct such an analysis, a consistent set of data, from samples collected at approximately the same time and by consistent methods and under the same QA/QC protocols, would be necessary. The data in this report represent sampling and analyses that were completed by various organizations at different times and for different purposes. PAG did not verify that consistent methods and QA/QC standards were followed. Therefore, variability in the data from one water source to the next could be due, at least in part, to differences in sampling programs. The sampling programs would not be expected to be the same for different water sources, because different water sources are used for different purposes, regulated under different programs, and monitored for different reasons, for different constituents and at different frequencies.

A more appropriate use of this report is to review the information for the individual water sources, and use the information as the basis for discussions of: (1) adequacy of the quality of each source for its current or intended use; (2) potential suitable uses for each water source in the future; (3) data gaps and regional priorities for additional monitoring; and (4) regional priorities for water quality protection and/or improvements. In this way, the report should be a useful starting point for an update to existing countywide water quality plans.

Study Area Description

Pima County is large and diverse. It is 9,240 square miles in area and within its boundaries are some of the most pristine, unfrequented landscapes in the United States, as well as one of the nation's fastest growing metropolitan areas. It includes the second largest Indian reservation in the country, irrigated farmlands, open pit copper mines, military facilities, National Parks and Monuments, National Forests, National Wildlife Refuges, County-managed natural preserves, major corporate and university research facilities, world-class tourist resorts, urban districts, suburbs, and commercial areas.

Based on 2000 Census data, the population of Pima County is approximately 840,000; the population of Tucson, the largest incorporated city, is approximately 490,000. The towns of Marana and Oro Valley were the fastest and second-fastest growing towns in Arizona in the 1990s.

Natural Setting

Pima County is in the Basin and Range physiographic province, which is characterized by northwest-trending mountain ranges separated by alluvial basins. Land surface elevations in Pima County range from less than 2,000 feet above sea level on the basin floors to more than 9,000 feet above sea level in the mountains. Most of the Tucson metropolitan area lies within the Tucson basin, a gently sloping plain between 2,000 and 3,000 feet in elevation, which is ringed by eight mountain ranges. The highest of these are the Santa Rita, Santa Catalina and Rincon ranges, all of which reach elevations above 8,000 feet.

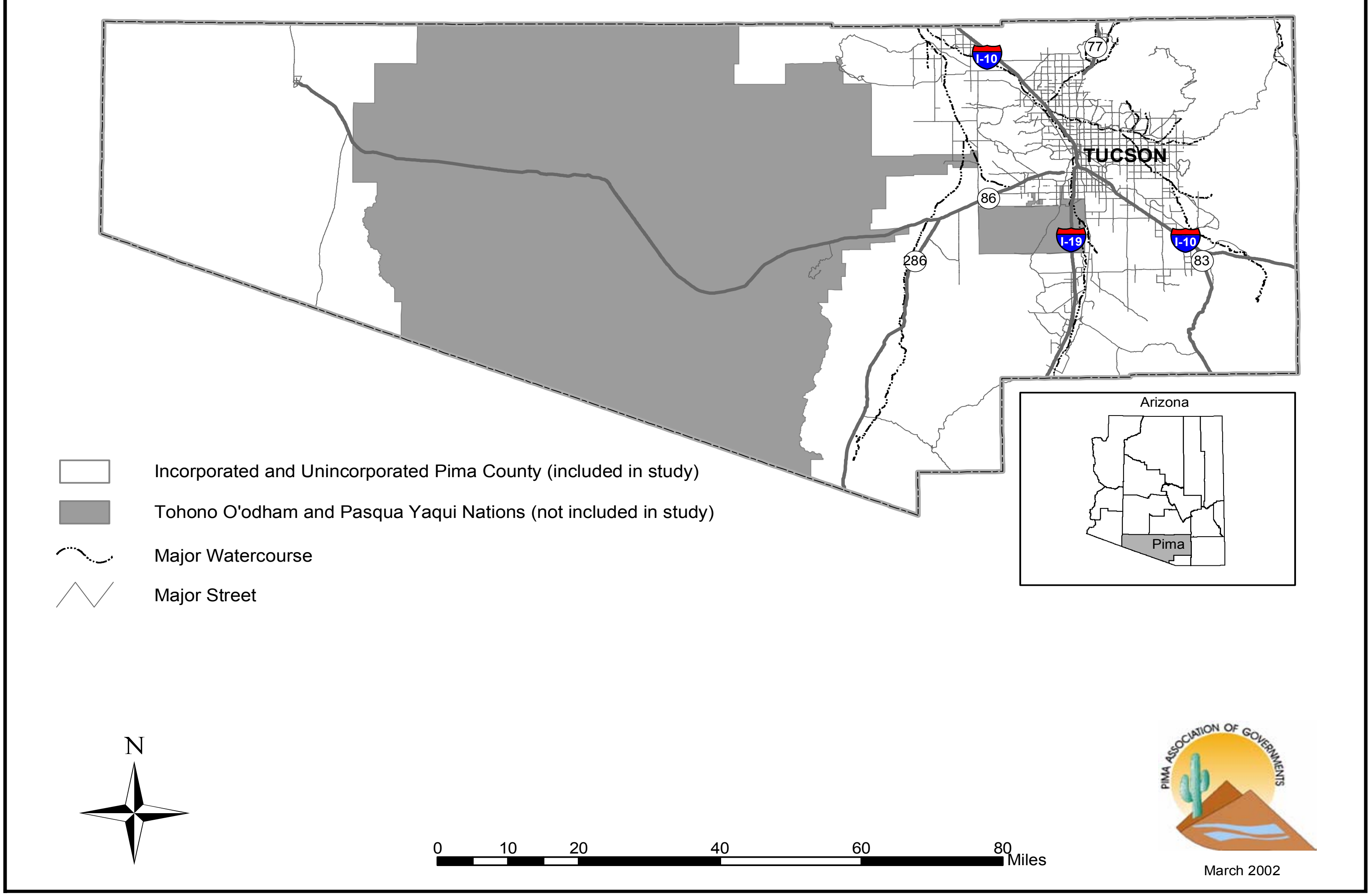
A large portion of eastern Pima County lies in two alluvial basins: Avra Valley in the west and the Tucson basin in the east. The basins are separated by the Tucson Mountains. Land use in Avra Valley consists mostly of open space and agriculture. Much of the Tucson basin is urbanized, but outside the Tucson metropolitan area, the predominant land uses are agriculture, mining, and open space.

The Santa Cruz River and its tributaries form eastern Pima County's regional drainage network. The Santa Cruz River is a tributary of the Gila River, which in turn flows into the Colorado River.

Climate

The climate is arid to semi-arid in the basins, with summertime temperatures often exceeding 100 degrees Fahrenheit. Precipitation in the Tucson basin averages 12 inches per year (NOAA, 1998). Most of the precipitation occurs in the form of intense, localized thunderstorms during the summer and gentle, regional rains during the winter. Natural vegetation in the basins is sparse, ranging from Lower Sonoran Desert shrubs and cacti to Upper Sonoran Desert grasslands. Lower temperatures and increased precipitation in the mountains support mid-elevation oak and juniper woodlands, and at the highest elevations, coniferous forests.

Figure 1. Study Area.



Principal Water Sources of Pima County

Five principal categories of water sources are present in Pima County:

- Groundwater pumped from wells;
- Naturally occurring perennial and intermittent surface waterbodies, such as streams, springs, and spring-fed ponds and pools;
- Stormwater runoff;
- Imported Central Arizona Project (CAP) water; and
- Treated wastewater.

These water sources are closely linked in many ways. Therefore, in many aspects of planning, they should not be treated entirely separately. For example, springs and many perennial and intermittent streams are directly fed by groundwater. Wastewater is also primarily derived from groundwater that is used for domestic, commercial and industrial purposes. Therefore, the quality of wastewater and many surface waters can be influenced by the quality of local groundwater. Also, stormwater, CAP water, and wastewater recharge groundwater in many locations of the County, either naturally or artificially. The quality of these sources can therefore affect the quality of local groundwater.

Each of these water source categories is described briefly below. A detailed report on water resources, entitled *Water Resources in Pima County*, July 2001, has been prepared by the Water Resources Research Center.

Groundwater

Historically, groundwater has been the most widely used water resource in Pima County. Throughout most of the County, groundwater is drawn from wells that tap deep aquifers found in the alluvial basins. These aquifers consist of unconsolidated to semi-consolidated silts, sands, gravels, and clays derived from the mountain ranges surrounding the basins. Elsewhere, groundwater is drawn from shallow wells tapping comparatively localized sources, such as fractured bedrock, flood plain aquifers, or perched aquifers.

Most of the groundwater development has occurred in eastern Pima County, in the Upper Santa Cruz Basin and Avra Valley. Groundwater in these areas is used for public drinking water supply, landscape and crop irrigation, and industry. Pumpage of groundwater for these uses totals more than 300,000 acre-feet per year in the Tucson Active Management Area, which includes most of eastern Pima County and part of Pinal County (ADWR, 1999). This greatly exceeds the volume of groundwater recharge, resulting in water-table declines of over 200 feet (Tucson Water, 1998). Depths to groundwater in eastern Pima County currently range from less than 50 feet to greater than 700 feet below land surface (Tucson Water, 2000a). In general, water level declines can lead to lower well productivity, increased pumping costs, declining water quality, and land subsidence (Water Resources Research Center, 1999). For these and other reasons, there is widespread interest in developing and using other water sources instead of relying entirely on groundwater pumpage.

Surface Waterbodies

According to the Arizona Department of Water Resources, in its Third Management Plan for the Tucson Active Management Area (TAMA), the main surface water drainage in the TAMA is the Santa Cruz River. The river, which is about 60 miles long within the AMA, flows north through the Upper Santa Cruz Valley Subbasin and then northwest into the Avra Valley Subbasin. From the Roger Road wastewater treatment plant an approximately nine mile reach of the Santa Cruz has perennial flow due to treated effluent discharged into the channel at Roger Road and Ina Road. The remainder of the Santa Cruz within the TAMA is ephemeral (ADWR, 1999).

Major tributaries of the Santa Cruz River in the Upper Santa Cruz Valley Subbasin include the Canada del Oro, which drains the northern part of the Upper Santa Cruz Valley Subbasin, and Rillito Creek and its tributaries, which drain the area north and east of Tucson. Tributaries to Rillito Creek include Pantano Wash and Tanque Verde Creek. Pantano Wash receives flow from Rincon Creek and Cienega Creek. Tanque Verde Creek receives flow from Sabino Creek. In the Avra Valley Subbasin, Altar Wash originates in the southern part of the valley and flows north to become Brawley Wash. Brawley Wash flows to the north and northwest through Avra Valley to its confluence with the Santa Cruz River southwest of Red Rock.

The San Pedro River is a tributary of the Gila River and drains 4485 square miles of Arizona and Mexico. The San Pedro River enters the northeastern corner of Pima County in what is considered the Lower San Pedro Basin. The river is fed by flow from the northeast side of the Santa Catalina Mountains and by two significant drainages from the Galiuro Mountains. Most of the stream reaches on the San Pedro are intermittent, but in the area around Bingham Cienega there is both perennial and intermittent flow (Royayne, M.J. and T. Maddock III, 1996).

The vast majority of the watercourses in Pima County are ephemeral, and do not represent a significant water source, except for stormwater runoff. In contrast, the number of perennial and intermittent watercourses is relatively small, but the surface water in these waterbodies is very important habitat for terrestrial and aquatic species.

Prior to the initiation of research for the Sonoran Desert Conservation Plan (SDCP), a comprehensive assessment of perennial and intermittent streams in Pima County was not available. In January 2000, however, a countywide assessment of these watercourses was completed, and a GIS coverage showing the locations of perennial and intermittent streams was created for the SDCP. Fifty-five perennial stream reaches and eighty-two intermittent stream reaches from a total of seventy-four different streams were identified (PAG, 2000a).

The identified perennial and intermittent streams of Pima County are in a variety of locations and environments, and most are located in eastern Pima County. This is likely due to the presence of higher land elevations and greater precipitation. Thirty-eight streams that had perennial or intermittent reaches had flows that originated in the Santa Catalina, Rincon or Santa Rita Mountains (PAG, 2000a).

The identified natural perennial and intermittent streams flowing in eastern Pima County are shown on the following tables. Some of the streams are listed on both tables because they contain both perennial and intermittent reaches.

Table 1. Perennial Streams in Pima County (PAG, 2000a).

Apache Spring 0.03 miles	Montosa Creek 0.2 miles
Arivaca Creek * 2.7 miles	Nogales Spring 0.3 miles
Bingham Cienega	Posta Quemada 0.3 miles
Buehman Canyon (three reaches) * 5.1 miles	Quitobaquito (Pond and Spring)
Bullock Canyon 0.7 miles	Romero Canyon 0.4 miles
Canada Del Oro 4.2 miles	Ruelas Canyon 0.1 miles
Cienega Creek (nine reaches) * 10.5 miles	Sabino Creek (3 reaches) * 15 miles
Cinco Canyon 0.2 miles	San Pedro River (2 reaches) * 1.2 miles
Davidson Canyon 0.7 miles	Santa Cruz River (effluent dependent) * 6.8 miles
Edgar Canyon * 0.7 miles	Scholefield Spring 0.04 miles
Empire Gulch (two reaches) 1.4 miles	Simpson Spring 0.4 miles
Espiritu Canyon 2.2 miles	Tanque Verde 0.5 miles
Honey Bee Canyon 0.2 miles	Wakefield Canyon (3 reaches) 1.2 miles
Lemmon Creek 2.7 miles	Wild Burro Canyon (5 reaches) 0.6 miles
Little Nogales Spring 0.2 miles	Wild Cow Spring 0.05 miles
Mattie Canyon 1.3 miles	Youtcy Canyon (2 reaches) 1.3 miles

*- Indicates water quality data are available on these streams and are included in this report.

Table 2. Intermittent Streams in Pima County (PAG, 2000a)

Agua Verde Creek 15.0 miles	Madrona Canyon 3.4 miles
Alder Canyon 1.2 miles	Mattie Canyon 0.4 miles
Arivaca Creek* 0.7 miles	Miller Creek 4.1 miles
Ash Creek 3.1 miles	Molino Canyon 5.2 miles
Atchley Canyon 1.8 miles	Mud Spring Canyon 2.6 miles
Barrel Canyon 1.3 miles	Paige Creek (2 reaches) 3.0 miles
Bear Canyon (2 reaches) 9 miles	Palisade Canyon Creek (2 reaches) 4.5 miles
Bear Creek 3.2 miles	Peck Basin 1.2 miles
Bootlegger Spring 0.1 miles	Pima Canyon 1.8 miles
Box Canyon 4.1 miles	Rincon Creek 11.3 miles
Brown Canyon 3.4 miles	Romero Canyon (2 reaches) 4.8 miles
Buehman Canyon (2 reaches)* 2.5 miles	Rose Canyon Creek 0.4 miles
Bullock Canyon (3 reaches) 3.1 miles	Sabino Canyon 3.4 miles
Canada Agua 0.01 miles	San Pedro River (3 reaches) 10.6 miles
Canada del Oro 1.2 miles	Santa Cruz River (2 reaches) 20.4 miles
Cargodera Canyon 0.2 miles	Smitty Spring 0.1 miles
Chiminea Creek 4.1 miles	Soldier Creek 2.9 miles
Chimney Canyon 3.3 miles	Sutherland Wash 6.5 miles
Cienega Creek (8 reaches)* 9.4 miles	Sycamore Canyon 1.1 miles
Davidson Canyon (3 reaches) 1.2 miles	Tanque Verde Creek (5 reaches) 17.1 miles
Deer Creek 2.5 miles	Thomas Canyon 3.0 miles
Distillery Canyon 3.3 miles	Turkey Creek 3.2 miles
East Fork Sabino Canyon 1.3 miles	Unnamed tributary to Ash Creek 1.2 miles
Espiritu Canyon 6.9 miles	Unnamed Spring 0.2 miles
Finger Rock Canyon 2.8 miles	Unnamed Spring 0.9 miles
Florida Canyon 3.4 miles	Ventana Canyon (3 reaches) 9.2 miles
Gardner Canyon 0.5 miles	Wakefield Canyon 0.8 miles
Geesaman Wash 1.1 miles	West Fork Sabino Creek 2.4 miles
La Milagrosa Canyon 0.9 miles	Youtcy Canyon (2 reaches) 1.6 miles
Madera Canyon * 1.5 miles	

*- Indicates water quality data are available on these streams and are included in this report.

Many of the streams in Pima County are located, totally or partially, in areas protected by the National Park Service, National Forest Service or Pima County Parks and Recreation. However, a number of important stream reaches are outside protected areas. These include Davidson Canyon south of Interstate 10, the San Pedro River, portions of Arivaca Creek, several streams draining the northeast side of the Santa Catalina Mountains, Agua Verde Creek, Wakefield Canyon, Rincon Creek, Tanque Verde Creek, and others.

One of the perennial streams, Cienega Creek, is an important water, recreation and wildlife resource located southeast of Tucson in the Santa Cruz watershed. It is one of the few low-elevation streams in Pima County that exhibits significant perennial flow. The section of Cienega Creek that flows from Interstate 10 to the Del Lago dam has been designated by the Arizona Department of Environmental Quality (ADEQ) as a "Unique Water", which means it has been classified as an "outstanding state resource water". Buehman Canyon, another perennial stream in Pima County, has also been designated a "Unique Water" by the State.

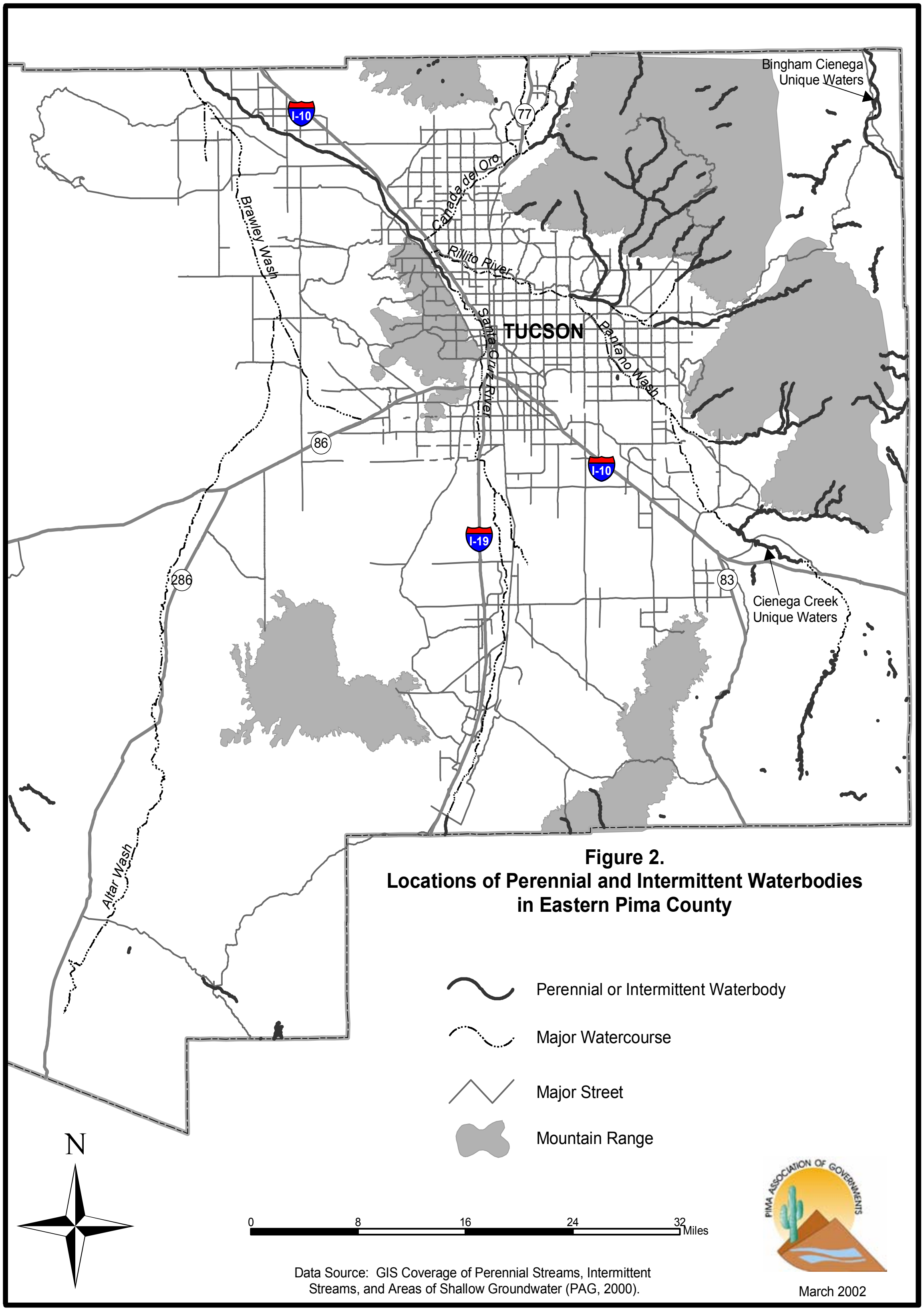


Figure 2.
Locations of Perennial and Intermittent Waterbodies in Eastern Pima County

Stormwater Runoff

Because stormwater runoff is typically short-term and occurs in response to precipitation events, the direct use of this surface water has been limited. However, surface water flow is an important source of recharge to the aquifer in the Tucson AMA. Groundwater conditions can be greatly affected by occasionally large surface water flows in the Santa Cruz River and its tributaries. Surface water flows recharge the groundwater system in the vicinity of the stream as water infiltrates through the stream channel sediments to the underlying aquifer. Stream channel recharge in the Upper Santa Cruz Valley Subbasin is estimated at 30,960 acre-feet per year and in the Avra Valley Subbasin at around 6695 acre-feet per year (ADWR, 1999).

Stormwater runoff in major urbanized areas is regulated by the USEPA's National Pollutant Discharge Elimination System program (NPDES), and these urban areas are required to obtain stormwater permits. The intent of the permit program is to improve the quality of the stormwater runoff and its subsequent impact, if any, on surface water. Regulated municipalities must develop a plan with mechanisms designed to locate and eliminate discharge into storm sewers from sources other than stormwater. They must also have a mechanism for erosion and sediment control for preventing and reducing other pollutants associated with construction activity. In addition, they must also inspect industrial facilities to ensure that measures are in place to prevent stormwater contamination. Finally, they must have an operation and maintenance program to prevent or reduce pollutant runoff from all municipal operations (City of Tucson, 1999). Stormwater NPDES permits have been issued to Pima County and the City of Tucson. Both entities conduct stormwater monitoring and implement programs to reduce pollutant runoff.

Although the use of stormwater is currently very limited, it is an important resource that should be considered in water-related planning efforts. Stormwater runoff supports riparian vegetation along washes, and it can create aquatic habitats at retention basins. For example, the Ajo Detention Basin has recently been constructed and designed to utilize stormwater. In addition, stormwater has been considered as a potential source water for artificial groundwater recharge projects in Pima County. In particular, Rillito Creek has been proposed as a site for artificial recharge of stormwater (Pima County Department of Transportation and Flood Control District, 1986). However, CH2M Hill and others (1988) reported in a recharge feasibility assessment for the Tucson area that the potential for artificial recharge using stormwater is limited to 17,000 acre-feet annually. The variability of flows complicates recharge and the design of any in-stream recharge system must take into account the heavy sediment loads associated with stormwater. A major problem with recharging stormwater is the clogging caused by the settling of suspended sediment (CH2M Hill, 1988).

CAP Water

To address groundwater depletion throughout the state, the Central Arizona Project (CAP) aqueduct was constructed. The CAP aqueduct is 326 miles long and transports water from the Colorado River to southern Arizona. The CAP aqueduct delivers Colorado River Water from Lake Havasu to cities, towns, and agricultural areas in central and southern Arizona. Some of the water is stored along the way in Lake Pleasant, which is impounded by the New Waddell

Dam on the Agua Fria River northwest of Phoenix. Releases of stored water from Lake Pleasant contribute to variations in the chemistry of the water delivered to Tucson.

Tucson Water has the largest allocation of CAP water in the area with approximately 138,920 acre-feet per year. Other jurisdictions, water companies, and public and private entities also have CAP water allocations. These include: Metropolitan Domestic Water Improvement District (8858 acre-feet), Spanish Trail Water Company (3037 acre-feet), Community Water Company of Green Valley (1337 acre-feet), Green Valley Water Company (1900 acre-feet), the Town of Oro Valley (1500 acre-feet) and others (ADWR, 1999).

Tucson Water began direct delivery of CAP water in November of 1992, but ended it in October of 1994, due to persistent problems of corrosion in the public and private water lines. In April of 1996 Tucson Water began a recharge and recovery pilot project in Avra Valley called the Central Avra Valley Storage and Recovery Project (CAVSARP). Recharge operations began in the summer of 1996. In June of 1999, Tucson Water began delivering a blend of recovered CAP water and groundwater to the first of four neighborhoods in its service area as a demonstration that the blended water would be acceptable to area residences and that it would not cause the same corrosion problems as before (PAG, 1999a). The demonstration projects were successful and Tucson Water began system-wide delivery of the blended groundwater/recovered CAP water in May of 2001.

Permits from the Arizona Department of Water Resources (ADWR) are required whenever water is intentionally added to an aquifer. As of 2001 there were four Underground Storage Facilities (USF) for CAP water in the TAMA. They include: CAVSARP, Pima Mine Road Recharge Project (PMRRP), Avra Valley Recharge Project, and the Lower Santa Cruz Recharge Project (ADWR, 1999; CAP, 2001).

Tucson Water's Clearwater Renewable Resource Facility is a water supply project in Avra Valley designed to recharge Colorado River water to blend with native groundwater in the aquifer. The blend is then piped to the greater Tucson area and distributed to Tucson Water's customers. CAVSARP is the primary structural element of the larger Clearwater Facility. It provides the means to take water from the CAP canal, recharge the water in basins in Avra Valley, and then recover and pump the water as far as the Hayden-Udall Water Treatment Plant. The Clearwater Project also includes blending of the recovered water with waters from other wellfields, delivery of the blended water to water customers, and ultimately the shut-down of many wells in the central wellfield (Tucson Water, 2000b). As of December 31, 2000 the total net recharge volume for the Clearwater Renewable Resources Facility was 43,290 acre-feet.

The Pima Mine Road Recharge Project is a constructed facility located approximately 15 miles south of Tucson which is jointly owned by the Central Arizona Water Conservation District and Tucson Water. The pilot testing was conducted from March 1997- March 1999. A full-scale underground storage facility permit, allowing up to 30,000 acre-feet of CAP water to be recharged per year, was issued in September of 2000. As of December 31, 2000, the total net recharge volume for the project was 25,185.29 acre-feet. (CAWCD, 2001).

The Avra Valley Recharge Project is operated by the Central Arizona Project, using CAP water purchased by Metropolitan Domestic Water Improvement District and the Arizona Water Bank (PAG, 1999). It consists of four off-channel constructed shallow spreading basins which have a combined area of about 11.4 acres (PAG, 1999a). The facility is located northeast of the Avra

Valley airport. The permit for the pilot project allowed for 8,300 acre-feet maximum volume and the full-scale facility permit allows for 11,000 acre-feet annually (ADWR, 1999).

The Lower Santa Cruz Recharge Project was dedicated in November 2000. This project is a joint effort by CAP, Town of Marana, Pima County Flood Control District and BKW Farms. Approximately 30,000 acre-feet of Colorado River water will be recharged each year at this facility (CAP, 2001).

Additional uses for CAP water include agriculture and industry. Many potential agricultural users in the Tucson AMA declined their CAP water allocations mainly due to the high cost of the water and infrastructure. In 1997 agriculture use of CAP was approximately 25,000 acre-feet. The City of Tucson also has groundwater savings facilities involving several irrigation districts, where CAP water is utilized for irrigation in lieu of groundwater. ADWR (1999) has indicated that industrial uses of CAP water are limited due to costs and water quality concerns. The mines are the largest volume industrial water users in the TAMA. The lack of delivery infrastructure, costs associated with CAP water quality as it affects operations, and the cost of the water may preclude direct CAP use (ADWR, 1999).

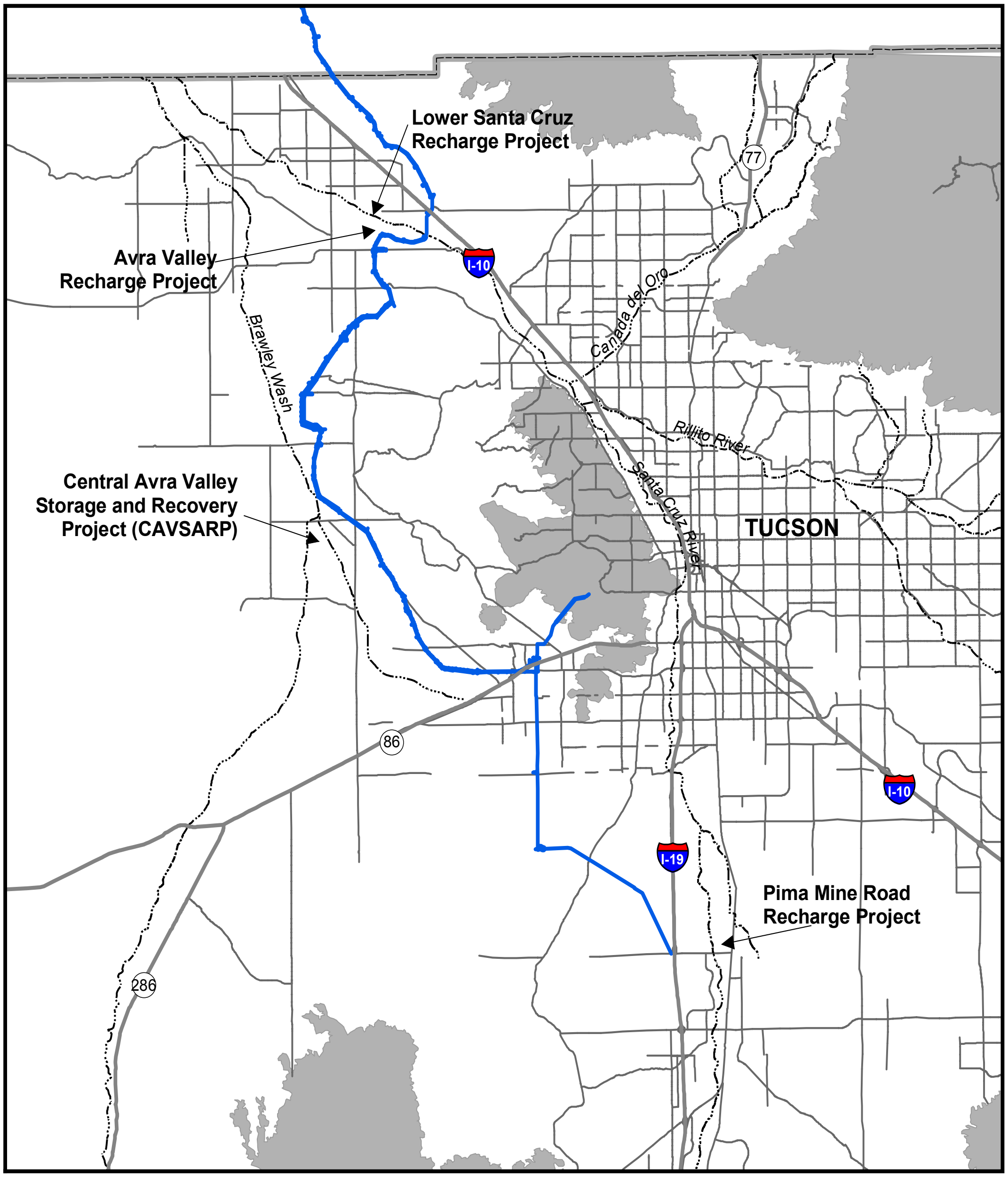


Figure 3. Locations of Central Arizona Project (CAP) Canal and Underground Storage Facilities in Pima County

CAP Canal
Mountain Range
Major Watercourse
Major Street

N

0 5 10 15 20 Miles

Data Source: Location of CAP canal provided by Pima County Land Information System (PCLIS) CD-ROM.
Names and locations of recharge facilities from ADWR (1998) and CAP (2001).

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Treated Wastewater

For purposes of this report, treated wastewater is defined as water that has been used for domestic, commercial or industrial purposes, conveyed via sewer lines to either the Ina Road or Roger Road wastewater treatment facility, and either reused directly, discharged to the Santa Cruz River, or further treated and distributed through the City's reclaimed water system. Additional wastewater treatment facilities are located throughout Pima County. Effluent from these plants is not addressed in this report, because the vast amount of effluent generated for reuse comes from the two above- referenced facilities. The capacities of the Ina Road and Roger Road treatment facilities are 25 mgd and 41 mgd, respectively (PAG, 1999a). These two plants treated approximately 68,664 acre-feet of wastewater during fiscal year 1999-2000 (PCWMD, 2001). The discharges support an effluent dependent stream and a diverse riparian habitat, subject to flood events, along a river channel that would otherwise be ephemeral. Pima County also supplies approximately 500 acre-feet per year of treated effluent to the Arthur Pack Golf Course for irrigation. The effluent discharges also recharge the regional aquifer for many miles along the Santa Cruz River.

The reclaimed water treatment process begins at Pima County's Roger Road Treatment Facility. The County treats the wastewater to secondary standards required by state and federal agencies. A portion of this treated wastewater is piped into Tucson Water's reclaimed water filtration plant. The water is filtered through pressure filters containing anthracite coal and sand, and disinfected. The treated reclaimed water is gravity-fed to a 3-million-gallon reservoir on-site, ready for distribution to customers (Malcolm Pirnie, 1999). The delivery system includes more than 85 miles of separate piping and five separate reservoirs with a combined storage capacity of 15 million gallons (Tucson Water 2001a).

According to Tucson Water (2001a), more than 3 billion gallons of reclaimed water were delivered to customers in 1999. Currently, over eight percent of Tucson Water's total demand for water is met with reclaimed water. There are over 250 reclaimed water customers including 14 golf courses, 34 schools, and 30 parks. It is anticipated that in the future 15 percent of total water demand will be met by the use of reclaimed water.

Some of the water treated at the Roger Road Facility is piped to Tucson Water's Sweetwater Recharge Facilities where it is naturally filtered through the earth and stored underground for future use. The filtered water is recovered through wells and piped to the chlorine contact chamber where it is chlorinated and mixed with the filtered water produced at the plant (Tucson Water, 2001a).

Tucson Water operates the Sweetwater Wetlands on the east side of the Santa Cruz River. The constructed wetlands occupy 17 acres and consist of two settling ponds and two polishing ponds. The backwash water from the filtration plant is piped to the Sweetwater Wetlands where it is naturally treated before it is released into the recharge basin (Tucson Water, 2001; PAG, 1999a).

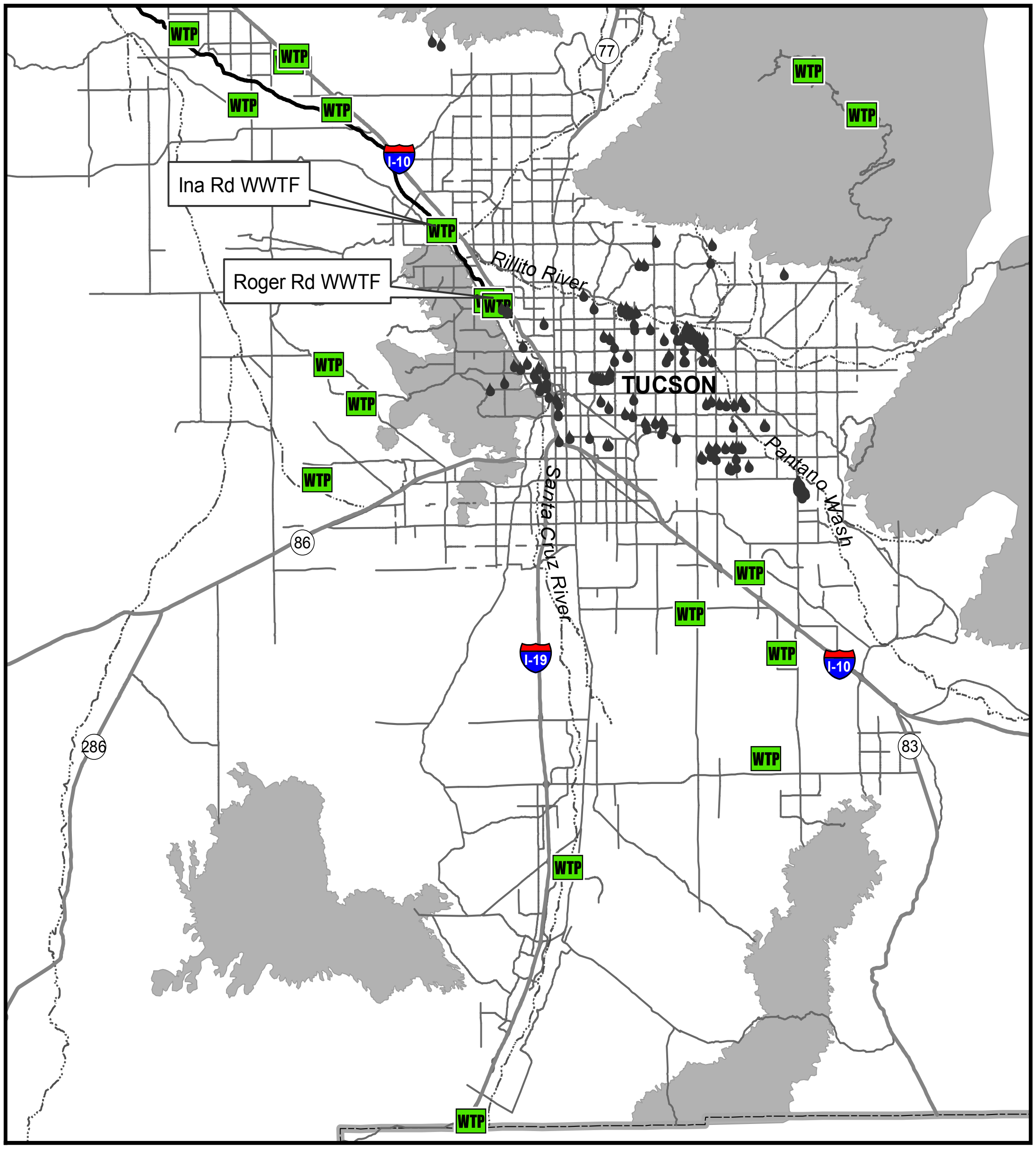

Figure 4. Wastewater Treatment Facilities (WWTF) and Effluent Use in Eastern Pima County

Effluent User
Existing Wastewater Treatment Facility
Effluent Dominated Water (EDW)
Major Watercourse
Major Street
Mountain Range

N

0 7.5 15 22.5 30 Miles

Data Source: Locations of effluent users provided by Tucson Water. Locations of wastewater treatment facilities based on PAG WWTF inventory (1999c).

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Water Quality in Pima County

Groundwater Quality

Natural factors and human activities affect groundwater quality. Natural factors that have the most effect in the basins of south-central Arizona are depth in the aquifer and distance from major faults. Groundwater temperatures and pH significantly increase with well depth. In a United States Geological Survey (USGS) study, concentrations of dissolved solids, alkalinity, calcium, potassium, chloride and sulfate were significantly higher in samples collected from wells less than 2 kilometers from major fault lines. The groundwater quality in basins that do not have significant urban or agricultural development is primarily a factor of natural processes such as interaction with sediments and rock. Natural sources of dissolved solids and nitrate can impact water quality in these basins. However, areas with urban or agricultural development can also impact nitrate concentrations (USGS, 1999; USGS, 2000). The mineralogy of the aquifer material also influences water quality.

Most existing groundwater quality data for Pima County is representative of eastern Pima County, because more groundwater development has occurred there. Monitoring data in this area are abundant, due to a variety of regulatory requirements. In general, groundwater in the Tucson AMA is of acceptable quality for most uses. Most of the groundwater resources meet federal and state drinking water standards, though contaminant levels exceed primary safe drinking water standards in a few areas. Groundwater withdrawals from wells within these identified areas have been discontinued or are in the process of remediation. Other areas of known contamination not currently under remediation are monitored to ensure that contaminants do not spread (ADWR, 1999). In addition, the concentration of arsenic in groundwater would likely be of concern in several areas if an arsenic standard of 10 ppb is enacted.

Groundwater is the main drinking water source for Pima County. For this report general water quality data from various drinking water providers in the County were reviewed. Drinking water providers are required to sample the water that is delivered to their customers and report those constituents that were detected during the required monitoring. A detected result means a concentration that is above the minimum value that can be measured by a laboratory. In most cases, the minimum detectable level of a constituent is well below the USEPA's regulatory limit for that constituent (Tucson Water, 2000). A review of water quality data from Pima County drinking water providers for the 1998-2000 sampling years indicated the most common regulated constituents detected were nitrate, fluoride, arsenic, and chromium. Though these constituents were detected in the drinking water supplies, none were seen at levels that exceeded the established drinking water maximum contaminant levels (MCLs).

Concentrations of selected constituents in eastern Pima County groundwater are shown on Table 3. The data are from Tucson Water's wellfields, which encompass large areas of the Tucson basin and Avra Valley in eastern Pima County. The wells vary in depths, are regularly monitored, and for the purpose of this report are considered to be fairly representative of the area. Table 4 shows groundwater quality data from western Pima County.

Table 3. Concentrations of Selected Constituents In Tucson-Area Groundwater, 2000-2001 (Tucson Water web site 2001).

Parameter	Tucson Water Supply Source				
	Clearwater	Avra Valley Wells	Santa Cruz Wells	Central Wells	South Side / TARP
Fluoride, mg/L F	0.51	0.46	0.85	0.37	0.72
Hardness, mg/L CaCO3	83	79	178	106	226
Nitrate as Nitrogen, mg/L N	1.36	2.04	4.53	2.04	1.94
Sodium, mg/L Na	44	37	38	39	66
TDS, mg/L	227	In Progress	In Progress	258	In Progress
pH, Std. Units	8.04	8.13	7.66	7.85	7.96

"In Progress" indicates that the data is under development and will be included in the table as the data becomes available.

Arsenic in groundwater in the Tucson Water well fields was measured during 2000.
Four of the 161 points of entry (POE) tested had maximum arsenic concentrations greater than 9.0 µg/l, with the highest maximum value of 10 µg/l found at one site. 56 of the POEs had maximum arsenic values of < 2 µg/l (Tucson Water, 2001b).

Table 4. Detected Inorganic Water Quality Constituents, Arizona Water Company, Ajo, Arizona, 2000 Annual Report. (Arizona Water Co., 2001)

Parameter	Units	MCLG	MCL	Highest Level detected	Sample Year
Arsenic	ppb	0	50	22	2000
Chromium	ppb	100	100	20	2000
Fluoride	ppm	4	4	1.7	2000
Nitrate	ppm	10	10	3	2000
Sodium	ppm			190	1998
Sulfate	ppm			160	1998

In the 1970's and 1980's some additional groundwater studies were conducted in western Pima County by the USGS. Samples from three groundwater sources Bonita Well, Pozo Salado Well, and Quitobaquito Spring, all located within the Organ Pipe Cactus National Monument, indicate that the major-ion chemistry is similar to chemistry of groundwater in other alluvial basins in southern Arizona. The upgradient well, Bonita Well had dissolved solids measures at 338 mg/l and 0.4 mg/l of fluoride. This is similar to analyses of groundwater sampled from recharge areas in other alluvial basins in southern Arizona (Robertson, 1991). Readings for pH ranged from 7.4 in the upgradient well to 8.4 in the downgradient well. Dissolved solids and fluoride also increased from the upgradient well to the downgradient site and ranged from 338mg/l to 1500mg/l and 0.4 mg/l to 5.4 mg/l respectively (Carruth, 1996)

Land uses that have reportedly led to historic groundwater contamination in eastern Pima County include: landfills and disturbed areas, wells no longer in service that have not been capped properly, irrigated agriculture, animal impoundments, underground storage tanks, surface impoundments, wastewater treatment facilities, mines, and industry and commerce (PAG, 1994). Common groundwater contaminants in the Tucson area groundwater include volatile organic compounds (VOC), nitrates, petroleum hydrocarbons, and heavy metals.

Areas of contamination in eastern Pima County include: Broadway- Pantano WQARF Site, Davis Monthan Air Force Base, Downtown Tucson, El Camino Del Cerro WQARF Site, Tucson Airport Area Remediation Project (TARP), Air Force Plant 44, Los Reales WQARF Site, Price Service Center, Silverbell Jail Annex Landfill/Miracle Mile WQARF Site and Shannon Road-Rillito Creek WQARF Site. The groundwater is usually considered contaminated if the most recent well sample data available indicated an MCL exceedance (PAG, 1994).

Broadway-Pantano WQARF Site

The Broadway landfill was closed in 1971 and since that time a groundwater contaminant plume has developed beneath the site. Four public drinking water wells have been removed from service due to the PCE contamination at this site. Contaminant levels near the edge of the plume are 5ppb. The highest concentration measured was 100 ppb directly adjacent to the landfill. An activated carbon adsorption system has been selected to treat the contaminated groundwater. Treatment will focus on pumping the aquifer and re-injecting the water to achieve hydraulic containment (PAG, 2000b).

Davis Monthan Air Force Base

In 1985 groundwater contaminated with jet fuel was found on the base in the area of the air strip called the J-3 pump house. A soil vapor extraction system was used to remove jet fuel from the soil and reduce the groundwater contamination. This system has been in operation since the early 1990's and the contamination remains localized on the Air Force Base. (PAG, 1994).

Downtown Tucson

Groundwater in the vicinity of downtown Tucson contains petroleum products and VOCs at various locations. Diesel fuel is the most widespread contaminant. Chlorinated VOCs such as TCE and PCE are present in more localized areas, including the Mission Linen site, where PCE concentrations have been reported at levels as high as 11,000 µg/l (ADWR, 1999). The 7th Street and Arizona Avenue and Park-Euclid WQARF sites are located within the downtown Tucson area (ADEQ, 2001).

El Camino del Cerro WQARF Site

The El Camino del Cerro WQARF site is located in northwest Tucson. The primary contaminants of concern include PCE, TCE, vinyl chloride, and benzene (ADEQ web site, 2001). Nitrate contamination is also present (PAG, 1994). Groundwater monitoring and field investigations are underway. Pima County is operating a landfill gas extraction system at the closed El Camino del Cerro landfill. VOCs have been removed at a rate of 30 to 40 pounds per week (PAG, 2000b).

Tucson Airport Area Remediation Project (TARP)

This is a federal Superfund site. Groundwater in the area is contaminated with TCE, and a pump and treat remediation system has been in operation since 1994. Contaminants are being removed using three air stripping towers. The design rate was 5,800 gpm and the average expected TCE concentration of the influent was approximately 15-35 µg/l. By the end of 1999 the system had treated approximately 13.4 billion gallons of water and had removed 1,400 pounds of TCE. This plant supplies almost 9% of Tucson's total drinking water supply (PAG, 2000b).

Air Force Plant 44

This location is part of the Tucson Area Superfund Site plume, south of Los Reales Road in the Tucson metropolitan area. The groundwater contamination plume beneath the site contains chromium and TCE. Remediation at this site began in 1987 and uses air strippers with carbon adsorption and a re-injection system (PAG, 1994).

Los Reales WQARF Site

Groundwater downstream of the Los Reales Landfill is contaminated with TCE and PCE in a plume that measured approximately ½ mile wide by ½ mile long. No public water supply wells have been impacted by this contamination, which is trapped in the upper aquifer. An air stripper remediation system was installed to contain the groundwater plumes. The average concentration of TCE in the groundwater entering the treatment system is approximately 7 ppb (PAG, 1994; PAG 2000a).

Price Service Center

Petroleum contaminated groundwater is present in the area of the City of Tucson's Price Service Center. This contamination resulted from leaks and damage to several underground storage tanks. The shallow groundwater has had benzene detected at concentrations as high as 30,000 ppb. No public water wells have been impacted by this contamination (PAG, 1994).

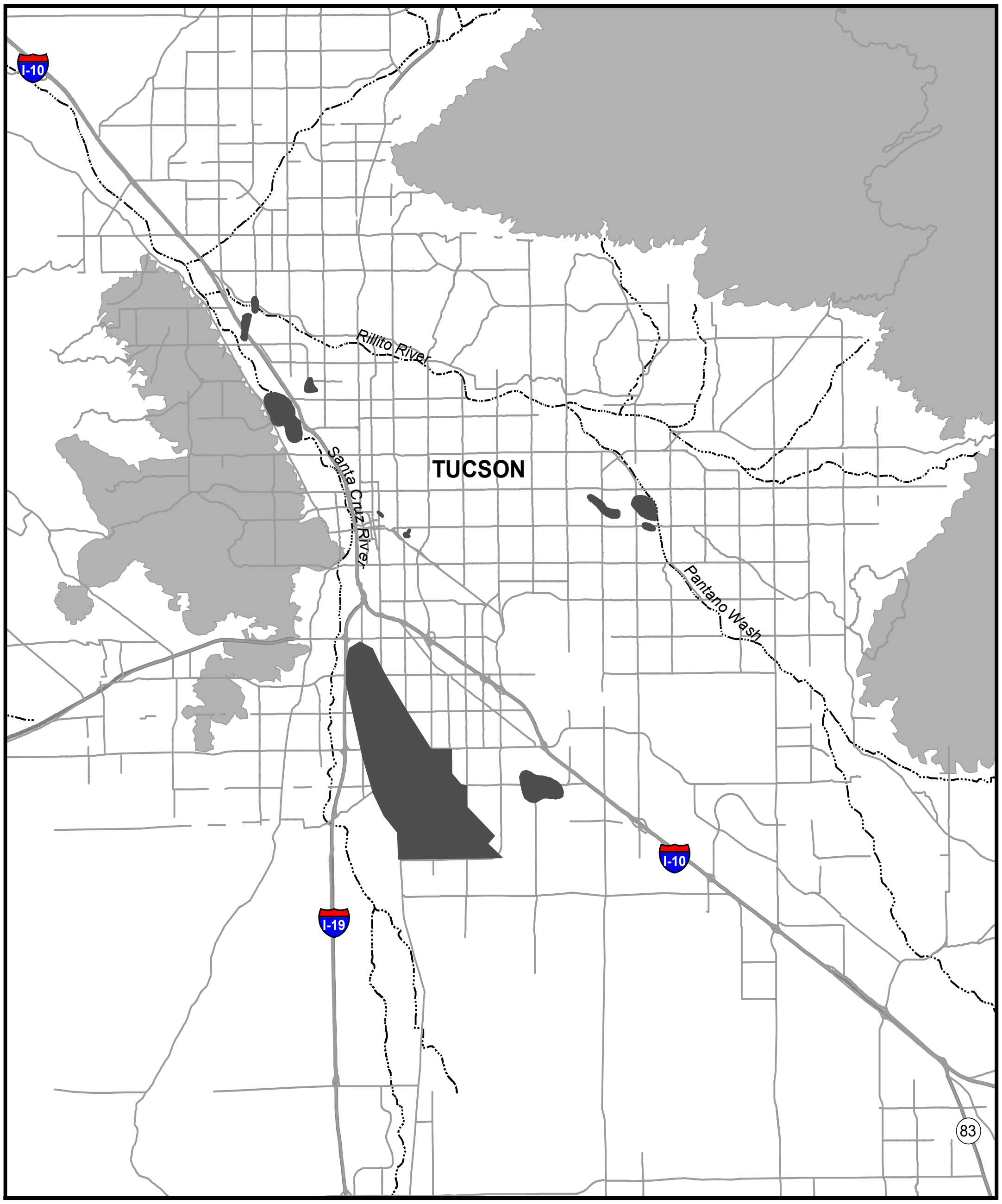

Figure 5. Locations of State (WQARF) and Federal Superfund Sites in Pima County

WQARF or Superfund Site

Major Watercourse

Major Street

Mountain Range

N

0 4 8 12 16 Miles

Data Source: Locations of WQARF and Superfund Sites provided electronically by Arizona Department of Environmental Quality (ADEQ).

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Silverbell Jail Annex/Miracle Mile WQARF Site

TCE and PCE have been found at concentrations of 13.5 ppb and 154 ppb respectively. In addition, the inorganic groundwater quality of the area is naturally poor with high TDS, sulfate, and chloride concentrations. High nitrate concentrations have also been present since the 1950's. This contamination has impacted two public-supply wells serving mobile home parks in the area. (PAG, 1994). A pilot remediation project using a re-circulation well system at Silverbell Landfill has been in use for several years (PAG, 2000b).

Shannon Road-Rillito Creek WQARF Site

PCE was detected in the groundwater at this site in 1993. Metro Water installed a well head treatment system on the South Shannon well. Two public supply wells have been impacted. One owned by the City of Tucson has been shut down and the other, owned by a mobile home park, has been equipped with a carbon treatment system since July 1997 (PAG, 2000b).

Other Sites

In addition to the above listed sites, there are a number of former landfill sites and underground storage tank sites that may have impacted the local groundwater. Also, an area encompassing 42 square miles in the south Santa Cruz area, which extends from two miles south of the Tucson City limit to just north of Green Valley, contains seven public supply wells that have exceeded the MCL for nitrate. Historical data indicate the high nitrate concentrations in this area developed between the late 1940's and the mid-1960s. The nitrate contamination in this area appears to be a result of a combination of irrigated agriculture, sewage effluent, septic tanks and animal feed lots (PAG, 1992).

Surface Waterbodies Water Quality

Stream water quality in the higher elevations of Pima County is primarily determined by natural factors. Processes such as chemical weathering of bedrock and soils, biological activity in soils, groundwater discharge to streams, and runoff determine the water quality of these streams. Locally, stream water quality may be affected by agriculture, mining and urban land use. Nutrient and dissolved-solids concentrations fluctuate seasonally in these streams. The patterns of rainfall and snowmelt account for the seasonal fluctuations in concentrations of nutrients. Concentrations increase in streams during times of rainfall and snowmelt runoff because the runoff carries nutrients washed off the land surface into the streams. Seasonal patterns of dissolved solids are opposite to those of nutrients. During periods of runoff, flow in streams is diluted and the dissolved-solids concentrations are lower. Streams affected by human activities may have elevated concentrations of dissolved solids from a variety of activities including urban and agricultural runoff. Man made compounds such as pesticides and volatile organic compounds (VOC) in streams are a direct result of human activities (USGS, 2000).

ADEQ Monitoring

Arizona Department of Environmental Quality (ADEQ) assessed 281 miles of streams and six lakes in the Santa Cruz-Rio Magdalena-Rio Sonoyta Watershed, which includes Santa Cruz County and a large portion of eastern Pima County. This watershed is 11,096 square miles and makes up about 10% of the state's land. The watershed is a composite of two surface water basins: the Santa Cruz which flows north to the Gila River, and the Rio Magdalena and Rio Sonoyta drainages which flow south into Mexico. In its report, *The Status of Water Quality in Arizona, Clean Water Act Section 305(b) Report 2000,* ADEQ tabulated the results of the stream assessments. The data for streams and lakes in Pima County are included in Appendix A.

ADEQ performs two types of assessments: "monitored" and "evaluated." Monitored assessments are based on current data that are less than five years old and normally there are at least four monitoring events within a year. Evaluated assessments are based on less data and information. Assessment reliability generally increases with increased quantity and diversity of data.

Three lakes, Arivaca Lake, Kennedy Lake, and Lakeside Lake, in Pima County were assessed by ADEQ. Though none were found to be in full support of their designated uses, ADEQ recognized that smaller lakes were more likely to be in the partial support or non-support category. Through its monitored assessment ADEQ found Arivaca Lake to be non-supporting of its designated use due to high pH, low dissolved oxygen and mercury.

The following area streams were monitored or evaluated by ADEQ and determined to be in full support of their designated uses: Arivaca Creek (headwaters to Altar Wash), Canada del Oro (headwaters to Big Wash), Cienega Creek (headwaters to Del Ago Dam), Sabino Canyon Creek (headwaters to the Tanque Verde Creek), Tanque Verde Creek, and Madera Canyon Creek (headwaters to the Santa Cruz River). Only the Santa Cruz River (Canada del Oro to Guild Wash) was found to be non-supporting due to some of the samples indicating low dissolved oxygen, but this reach is in full support with regard to turbidity.

The State is required to develop water quality improvement plans for any streams and lakes that have been identified as impaired. The TMDL Program (Total Maximum Daily Load) is a separate but closely related effort to the Water Quality Assessment Program. The purpose of the program is to identify the sources and quantities of pollutants being delivered to a waterbody and to identify the maximum quantities of the pollutant that the waterbody can assimilate and still meet water quality standards. The goal is to develop a plan which identifies how all the various contributors of pollutants can work together to reduce pollutant loading and help get the water body back into compliance with the water quality standard. Waterbodies that are scheduled for development of TMDLs are identified on the state's "water quality limited waters" list, which is commonly referred to as the "303(d) list"(ADEQ, 2000).

Only one water in Pima County was on the state's 1998 303(d) list. Arivaca Lake was listed with mercury as the primary stressor, along with a fish consumption advisory. Arivaca Creek was de-listed in 1998 for dissolved oxygen, which was determined to be a natural condition.

ADEQ has additional water quality monitoring data for area streams. The following table includes selected data from ADEQ's surface water quality database.

Table 5. Selected Stream Water Quality Data, 1989-2000, From ADEQ Database

Site	Ca Total (mg/l)	Mg Total (mg/l)	Na Total (mg/l)	K Total (mg/l)	Bicarbonate Total (mg/l)	SO4 Total (mg/l)	Cl Total (mg/l)	F Total (mg/l)	Arsenic Total (mg/l)	TDS (mg/l)
Arivaca Creek at Ruby Rd 3/23/93	70.7	9.9	16.2	1.88	265	ND	9.8	0.23	ND	287
Madera at Whitehouse, 12/19/90	71.3	12.6	17.7	1.1	141	100	6.9	0.36	<.005	320
Tanque Verde Creek 8/1/89	11.2	1.8	6.6	2.1	32	13	3.7	0.12	<.005	90
Sabino Creek 5/13/91	11.0	1.8	2.3	0.5	31*	5.55*	2.1	0.13	<.005	60
San Pedro River 8/31/91	57.4	12.9	46.0	4.4	183	87	15	0.82	<0.005	340
Buehman Canyon 5/18/00	71	8.2	20	2.5	260	21	8	0.68	ND	295

Notes: Sabino Creek below Summerhaven; Buehman Canyon 2 miles below confluence with Bullock Canyon; Tanque Verde at Sabino Canyon Road and San Pedro at Redington. ND= not detected, *- average of two sample results, mg/l= milligrams per liter.

Sonoran Desert Conservation Plan Studies

In addition to ADEQ's monitoring, several waterbodies that are potentially very important aquatic habitat in Pima County have been sampled for studies conducted by PAG and Pima County Flood Control District as part of the Sonoran Desert Conservation Plan. These include Cienega Creek, Bingham Cienega, and the San Pedro River.

A portion of Cienega Creek has been designated by the state as a "unique water", which means it qualifies for site-specific water quality standards established to maintain and protect the existing water quality. The water quality of Cienega Creek was described in the Unique Waters Final Nomination Report submitted to the state. This report concluded that the water quality of base flows in the reach nominated for Unique Water status met standards designed for designated uses, including aquatic and wildlife (warm-water). The lowermost reaches of Cienega Creek were sampled more recently (in the late 1990s) as part of a two-year study by PAG and Pima County Flood Control District to determine the source of the water. The results are summarized on Table 6.

Bingham Cienega is a rare, perennial wetland located approximately 2000 feet west of the lower San Pedro River, and ¼ mile north of the settlement of Redington. PAG and the Pima County Flood Control District sampled Bingham Cienega, the San Pedro River, and Edgar Canyon (a tributary to the San Pedro) in the late 1990s, in order to identify the water source of the cienega. The results are summarized on Table 6.

Table 6. Average Values, Water Quality Data for Selected Streams in Pima County September 1998-June 2000 ***(PAG, 2001; PAG 2000).***

Site	Ca dissolved (mg/l)	Mg dissolved (mg/l)	Na dissolved (mg/l)	K dissolved (mg/l)	Alkalinity CaCO3 (mg/l)	SO4 dissolved (mg/l)	Cl dissolved (mg/l)	F dissolved (mg/l)	Arsenic dissolved (mg/l)	TDS (mg/l)
Cienega Creek	109	32	61	5.9	252	257	14	0.57	0.0006	737
Bingham Cienega	64	12	40	1.7	219	55.8	11	1.14	.0043	280
San Pedro River	64	16	55	2	222	90.2	18	0.92	0.0022	344
Edgar Canyon	64	15	24	1.1	238	18.6	6.9	0.39	0	287

Notes: 0 = constituent was not detected at the Practical Quantitation Limit (PQL).
mg/l= milligrams per liter

Most of the natural surface water sources are located in eastern Pima County. An exception is the Quitobaquito Spring and pond, which are located in Organ Pipe National Monument near Lukeville Arizona and the Mexican border. Water quality data collected from several aquatic studies are shown below.

Table 7. Chemical Constituents in Water at Quitobaquito, Arizona. From: Description and Conservation Status of *Cyprinodan macularius eremus*. A New Subspecies of Pupfish from Organ Pipe Cactus National Monument, Arizona. (Miller and Fuiman, 1987).

*Parameter	Quitobaquito Pond, 1982,	Quitobaquito Pond, 1963, 1964	Quitobaquito Spring, 1982	Quitobaquito Spring, 1963-64
TDS	820		670	
TSS	<10		<10	
pH	9.22		8.07	
HCO3	220	411	300	316-402
F	4.9	5.3	4.1	4.3
Cl	190	383	150	148-318
PO4	<0.50		<0.50	
NO3	<0.50		9.9	
SO4	110	100	95	71-91
Na	230	350	188	191-284
K	3.1	7.0	2.7	4.5-6.0

* No units were included in the journal article for this data, convention is mg/l for these parameters except pH, which is in standard units

PAG is unaware of any extensive water quality monitoring data for most of the streams in Pima County with one or more reaches of perennial and/or intermittent flow. Although it is likely that additional studies and monitoring data are available for some streams, it appears that the vast majority of the aquatic habitats in Pima County have not been adequately monitored for water quality.

Stormwater Runoff Water Quality

For the purpose of this report PAG reviewed historical stormwater quality data from the 1996 *Water Quality Assessment for the Tucson Active Management Area Northwest Replenishment Program Feasibility Study,* and NPDES stormwater monitoring reports submitted by the City of Tucson and Pima County to the EPA.

Historical Data

The Lower Santa Cruz River

For the Lower Santa Cruz River, PAG (1991) reported water quality data for a sample collected by ADEQ on October 6, 1989, from the Santa Cruz River and Congress Street Bridge. Concentrations of the major constituents are shown on the following table.

Table 8. Stormwater Quality Data for the Santa Cruz River at Congress Street Bridge Collected by ADEQ October 6, 1989 (PAG, 1991).

Parameter	Concentration (mg/l) milligrams per liter
Calcium	17.6
Magnesium	2.32
Sodium	9.1
Potassium	9.3
Bicarbonate	75
Chloride	1.1
Sulfate	10
NO2+NO3	0.61
TDS (total dissolved solids)	90
TSS (total suspended solids)	10,600

In addition Harding Lawson Associates (1987) reported water quality data for a Santa Cruz River sample collected upstream of the Roger Road treatment plant in 1985. The results were as follows: Bicarbonate 104 mg/l, TDS 230 mg/l, and TSS 11,724 mg/l. No other data for this sample were reported.

The Rillito Creek Basin

Water Quality data (PAG, 1996) for the Rillito Creek basin included concentrations of major ions, nutrients, trace metals, suspended sediments and organics reported by the USGS for the years 1986-1993. Slightly less than two thirds of the samples were collected automatically. Automatic samplers were programmed to activate when the flow stage exceeded a threshold value of 0.2 feet in 2 minutes. A sample was collected every 5 minutes during a rising stage, and every 10 minutes during a falling stage. The samples were composited. Samples were not collected on a regular basis (e.g. once a month), or at a consistent time of day, presumably because the frequency of runoff events in the Tucson area is highly irregular. However, the data represented nearly equal numbers of winter and summer storms (PAG, 1996). The data are shown on Tables 9 and 10.

Table 9. 1986-1993 Stormwater Quality Data for Tanque Verde Creek at Sabino Canyon Road (USGS, 1995; USGS, 1994)

Constituent	Average (mg/l)*	Minimum (mg/l)	Maximum (mg/l)
Calcium	10.4	4.3	25
Magnesium	1.6	0.98	4.6
Sodium	6.0	4.1	10
Potassium	2.2	0.7	6.5
Aluminum (total)	117	0.47	410
Bicarbonate	34	14	68
Chloride	4.0	2.1	7.2
Sulfate	9.9	4.5	16
Nitrate	0.3	0.07	0.81
TDS	93	41	205
TOC	84	8.8	240
TSS	2891	22	10300

*mg/l= milligrams per liter.

Table 10. 1986-1993 Stormwater Quality Data for Rillito Creek at Dodge Boulevard (USGS, 1995;USGS 1994).

Constituent	Average (mg/l)*	Minimum (mg/l)	Maximum (mg/l)
Calcium	15	8.2	46
Magnesium	1.9	0.8	5.9
Sodium	6.6	1.9	15
Potassium	2.5	0.8	5.1
Aluminum (total)	195	44	550
Bicarbonate	53	28	121
Chloride	3.8	1.5	12
Sulfate	13	4.6	52
Nitrate	0.5	0.18	1.3
TDS	100	19	243
TOC	117	19	210
TSS	12089	21	36700

*mg/l= milligrams per liter

Brown and Caldwell (1984) and CH2M Hill and others (1988) have reported that stormwater runoff can contain elevated levels of trace metals. Some of the undissolved metals in the stormwater samples (particularly aluminum, which is abundant in clays) may be naturally occurring in sediments that are eroded during storm events. These sediments are carried downstream in suspension, and metals contained in (or sorbed onto) these sediments are included in the analysis of total metals (PAG, 1996).

Municipal NPDES Monitoring Data

The City of Tucson's Municipal Stormwater Permit stipulates that the City will implement the stormwater monitoring program as described in the City's October 1996 permit application. EPA amended the monitoring program slightly by adding the chemical DDE to the list of pollutants for which sampling and analysis was to be conducted. The purpose of the monitoring program was to develop a substantial local database of land-use-specific stormwater quality data, and to develop a focused management program (City of Tucson, 1999).

Analysis of 15 constituents is required under the monitoring program approved for the City's NPDES Municipal Stormwater permit (permit # AZS000001) and includes the following constituents: Arsenic (As), copper (Cu), lead (Pb), zinc (Zn), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrogen as nitrite, nitrogen as nitrate, total dissolved solids (TDS), total suspended solids (TSS), total kjeldahl nitrogen (TKN), DDE, oil and grease, total phenols and total phosphorous. Under the approved monitoring program each sampling site was automated in 1999 to allow better response to storm events with the goal of sampling each site once during the winter rainy season and once during the summer rainy season. Because the automated units were not yet operating according to EPA protocol manual, samples were manually collected for the 1998-99 reporting period (City of Tucson, 1999).

Stormwater was monitored at five locations representing different land uses typical to Tucson. They include: single family residential site, multi-family residential site, commercial site, industrial site, and a mixed-use site. Table 11 summarizes the analyses results for the events sampled during the 1998-99 fiscal year.

Table 11. Fiscal Year 1998-99 Monitoring Results for City of Tucson Stormwater. Municipal Stormwater Annual Report, City of Tucson (City of Tucson, 1999).

DATE	7/22/98	7/31/98	4/01/99	8/05/98	9/16/98	10/21/98	MAX	MIN
Facility	Mfr	Sfr	Sfr	Mxu	Ind	Com		
Rainfall (in)	0.55	0.50	1.20	0.15	0.10	0.10	1.20	0.10
Duration (hours)	3 hours	2 hours 20 min	16 hours	3 hours	2 hours	1 hour 20 min.	16 hour	1 hour 20 min
Last Rain (days)	4	9	115	3	12	47	115	3
Temperature	25.9	27.1	N/T	N/T	27.5	18.2	27.5	18.2
pH	7.1	7.4	7.2	6.7	6.7	6.5	7.4	6.5
Total Flow (gal)	151,814	92,111	356,823	269,451	148,672	21,790	356,823	21,790
As (mg/l)	<0.005	<0.005	<0.003	<0.005	0.006	<0.005	0.006	ND
Cu (mg/l)	<0.015	0.026	0.056	<0.016	0.063	<0.005	0.063	ND
Pb (mg/l)	<0.005	0.026	0.036	0.043	0.022	0.010	0.043	ND
Zn (mg/l)	0.07	0.16	0.32	0.44	0.34	0.35	0.44	0.07
BOD (mg/l)	10	20	N/A	35	48	98	98	10
COD (mg/l)	89	209	334	285	371	582	582	89
Nitrate+nitrite (mg/l)	0.5	1.0	1.5	1.7	2.2	1.3	2.2	0.5
Total Phosphorus (mg/l)	0.89	4.3	0.83	2.55	6.96	1.60	6.96	0.83
TDS (mg/l)	53	116	236	118	233	383	383	53
TSS (mg/l)	71	160	136	186	16	29	186	16
TKN (mg/l)	0.50	1.70	5.92	1.70	1.10	2.30	5.92	0.50
DDE (µg/l)	<1.0	<1.0	<0.02	<1.0	N/A	N/A	ND	ND
Oil & Grease (mg/l)	<5.0	<5.0	N/A	<5.0	<5.0	<5.0	ND	ND
Phenols (µg/l)	<5.0	<5.0	N/A	<5.0	<10	<5.0	ND	ND

Sfr= Single family residential-Grant Road and Wilson Ave Mfr = Mutli-family residential-Greenlee Rd.

Com = Commercial El Con Mall- Randolf Way Mxu = Mixed use-First Ave at Limberlost

Ind = Industrial 17th Street N/T = Not Taken- Due to Equipment Failure

N/A = Lab Quality Control Failure, No data available ND = Non-detected

The 1998-99 sampling results, similar to the results submitted in the previous annual report, indicated that Tucson stormwater was essentially free of the man-made contaminants included in the monitoring program. The results were variable, with no definite trends identified.

Similar to the City of Tucson, Pima County has an NPDES stormwater permit, no. AZS000002. The permit stipulates that a summary of the required monitoring data, accumulated throughout the reporting period, be submitted to the USEPA in the form of an annual report. Wet weather monitoring is conducted in accordance to permit requirements with samples collected biannually at five monitoring stations, once during the winter rainy season and once during the summer rainy season. Those results are shown on Table 12.

Table 12. Monitoring Results for Pima County Stormwater, Second Reporting Period, September 2000. From the Third Annual Report, Pima County NPDES Stormwater Discharge Permit (Pima County, 2000).

Facility	Site 1	Site 1	Site 1	Site2A	Site 3	Site 3	Site 3	Site 4	Site 4	Site 4	Site 5	Site 5
Date	7/14/99	3/6/00	6/22/00	7/6/99	7/14/99	3/6/00	6/22/00	7/14/99	3/6/00	6/22/00	7/5/99	6/19/00
H2O Temperature on arrival °C	29.3	9.6	23.0	24.0	31.3	10.5	24.5	30.0	10.4	26.4	27.2	22.2
H2O Temperature + 1 hour °C	-	9.0	-	23.9	-	10.1	27.1	-	11.1	25.7	27.8	25.1
H2O Temperature +2 hours °C	-	-	-	-	-	9.7	-	-	11.5	25.8	27.9	29.8
H2O Temperature + 3 hours °C	30.7	9.2	23.3	24.6	29.6	9.7	25.6	28.4	11.6	25.6	-	30.7
pH at arrival s.u.	9.07	6.97	8.03	7.94	6.58	7.43	7.79	7.32	7.39	7.76	8.03	8.65
pH + 1 hour s.u.	-	7.45	-	7.91	-	7.55	7.05	-	7.44	7.67	7.84	8.06
pH+ 2 hours s.u.	-	-	-	-	-	7.51	-	-	7.54	7.81	7.94	7.90
pH + 3 hours s.u.	8.16	7.5	7.42	7.25	7.72	7.45	7.15	8.24	7.46	7.95	-	7.90
Fecal coliform on arrival Mpn/100ml	3000	500	3000	160000	3000	11000	900	9000	17000	50000	5000	900
Fecal coliform +1 hour Mpn/100ml	-	-	-	-	-	-	-	-	-	-	-	-
Fecal coliform + 2 hours Mpn/100ml	-	-	-	-	-	-	-	-	-	-	-	-
Fecal coliform + 3 hours MPn/100ml	220	1300	2400	30000	1700	30000	1600	2400	1700	900	300	16000
Cu (µg/l)(total)	183	13.6	21.6	21.5	27.9	18.4	31.9	34.0	29.8	50.0	81.2	107
Pb (µg/l)(total)	210	ND	17.4	T	ND	ND	T	T	T	T	93.3	136
Zn (µ/l)(total)	476	36.2	48.9	78.6	161	129	183	46.5	165	155	214	305
Hardness (calculated) mg/l	876	46.1	57.5	41.1	32.2	27.7	54.3	88	36.0	58.0	285	272
TSS mg/l	5631	49	273	125	55	29	32	120	65	52	712	596
4,4-DDE (µg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

s.u.-standard units, °C- degrees Celsius, Mpn/100mg/l- most probable number per 100mg/l, mg/l- milligrams per liter, µg/l-micrograms per liter, --- no measurement taken or no sample collected, ND- not detected at or above the laboratory detection limit. T-trace

Site 1-Residential, low density
Site 2A- Residential, medium density
Site 3- Residential, high density
Site 4- Commercial
Site 5- Industrial

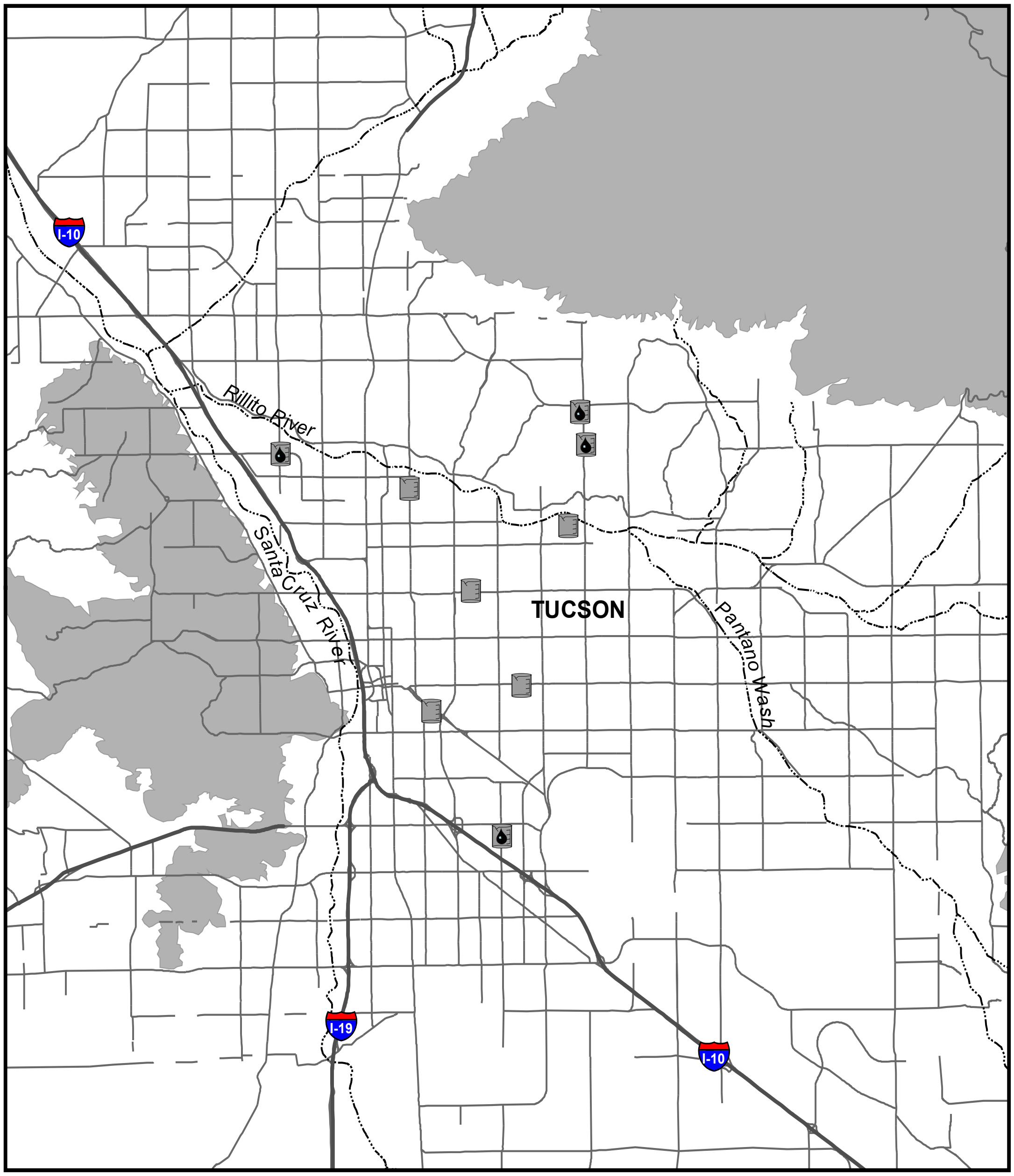

Figure 6. Stormwater Sampling Locations in Eastern Pima County

Sampling Site (City of Tucson)

Sampling Site (Pima County)

Major Watercourse

Major Street

Mountain Range

N

0 3 6 9 12 Miles

Data Source: Stormwater sampling locations provided by Pima County Department of Environmental Quality and City of Tucson DOT Stormwater Managment Division.

March 2002

CAP Water Quality

The CAP water delivered to the Tucson area is a mixture of Colorado River Water, Bill Williams River water, and Agua Fria River water. However, the Colorado River water is the most significant source. The CAP water delivered to the Tucson area is a sodium-sulfate water type and with the exception of turbidity and total coliform bacteria, which is expected in surface water, meets all primary drinking water standards established by the USEPA and ADEQ (Tucson Water, 2000b).

Total dissolved solids (TDS) concentrations in Colorado River water between 1972 and 1999 ranged between 535 and 747 and averaged 644 mg/l. Review of the data indicates the TDS concentration in Colorado River water is generally lower during periods of abundant precipitation within the Colorado River watershed (Tucson Water, 2000b).

Analytical results for common constituents for all CAP water samples collected at the pump station at the CAP aqueduct (Tucson Water sample point 713) between October 1997 and April 2000 are summarized on Table13. The data were collected by Tucson Water, which conducts extensive monitoring of CAP water delivered to the Clearwater Renewable Resource Facility.

CAP water quality was also monitored at the Pima Mine Road Recharge Project during the year 2000. Analytical results of the source water samples did not indicate the presence of any analyte at concentrations exceeding the Arizona Aquifer Water Quality Standards (AWQS). No pesticides or herbicides were detected above the laboratory reporting limits. Results of the general minerals, and physical parameters (except temperature) were remarkably consistent among the three sampling periods conducted in 2000 (CAWCD, 2001). Results of the source water samples for mineral and physical parameters are shown on Table14.

Table 13. Summary of Water Quality for Untreated CAP Water at the Clearwater Site, October 1997-April 2000 (Tucson Water, 2000b).

Constituent (mg/l)	Mean	Std. Dev.	Min.	Max.	MCL	No.of samples
Cations (mg/l)						
Calcium	66	4.53	56	75	-	14
Magnesium	28	3.05	26	38	-	14
Potassium	5.0	0.76	4.5	7.5	-	14
Sodium	92	12.8	85	135	-	14
Anions (mg/l)						
Bicarbonate*	133	24.4	70	156	-	18
Bromide	@0.015	0.041	<0.1	0.14	-	13
Chloride	82	13.2	72	123	-	13
Sulfate	248	30.5	227	348	-	13
Nitrate (as Nitrogen)	@0.0077	0.0277	<0.025	0.1	10	13
Fluoride	0.313	0.051	0.24	0.44	4	13
Orthophosphate (as phosphorus)	<0.3	0	<0.3	<0.3	-	11
Bicarbonate alkalinity as mg/l	109	20	57	128	-	18
Total Alkalinity	129	16.6	84	148	-	11
TDS	603	48	566	712	-	14
Hardness calculated as CaCO3	280	12.6	261	303	-	13
Field Parameters						
pH	8.34	0.43	7.70	9.37	-	16
Electrical Conductivity	949	58.6	880	1010	-	4
Temperature (Celsius)	22.6	5.1	10.6	32.1	-	16
Dissolved Metals (mg/l)						
Aluminum	<0.1	0	<0.1	<0.1	-	5
Arsenic	@0.0023	0.0015	<0.002	0.0057	0.05	14
Barium	0.105	0.0102	0.095	0.13	2	14
Boron	0.131	0.0213	0.12	0.2	-	14
Iron	@0.072	0.120	<0.02	0.38	-	9
Lead	@0.0051	0.017	<0.002	0.064	0.015	14
Selenium	<0.005	0	<0.005	<0.005	0.05	12
Silicon	3.9	0.71	2.5	5.2	-	13
Zinc	@0.052	0.093	<0.02	0.31	-	10
Total Trihalomethane (µg/l)	<0.5	0	<0.5	<0.5	100	17
Haloacetic acids (µg/l)	<3	0	<3	<3	-	5
Total Coliform MPN-CFU/100ml	@60	101	<2	300	-	8
TOC	3.3	0.32	2.7	3.81	-	18
Radon (pCi/l)	<22	-	<22	<22	-	1
Perchlorate	@0.0066	0.005	<0.004	0.014	-	6

Source: Sample point 713 (CAP Aqueduct M.P. 308.175)
Mg/l- milligram per liter
*Bicarbonate concentration- 1.22 times the results of bicarbonate alkalinity reported above.
µmho/cm- micromohos per centimeter
MPN/100 ml- most probable method; results given in colony forming units (CFU) per 100 milliliters
< less than; constituent not detected above the laboratory reporting limit
@- Constituent was not detected above the laboratory reporting limit in some or all of the samples included in calculation

Table 14. Water Quality Monitoring Results, Source Water, Pima Mine Road Recharge Project Mineral and Physical Parameters (CAWCD, 2001).

Parameter	Units	AWQS limit	Sample date 01/06/2000 Results	Sample Date 03/03/2000 Results	Sample Date 10/19/2000 Results
Alkalinity, total	mg/l		109	110	104
Alkalinity, bicarbonate	mg/l		133	133	126
Alkalinity, Carbonate	mg/l		0.864	1.72	1.30
Chloride	mg/l		76.3	72.2	88.7
Fluoride	mg/l	4	0.32	0.31	0.36
Nitrate (as N)	mg/l	10	ND	ND	ND
pH	Std unit		8.0	8.3	8.2
Specific Conductance	Us/cm		915	855	905
Sulfate	mg/l		253	236	267
Total Dissolved Solids	mg/l		530	530	650
Temp (field)	°F		65.5	74.1	nm
Aluminum, dissolved	mg/l		ND	ND	ND
Antimony, dissolved	mg/l	0.006	ND	ND	ND
Arsenic, dissolved	mg/l	0.05	0.0045	0.0025	0.004
Barium, dissolved	mg/l	2	0.066	0.091	0.105
Beryllium, dissolved	mg/l	0.004	ND	ND	ND
Cadmium, dissolved	mg/l	0.005	ND	ND	ND
Calcium	mg/l		120*	68	62
Chromium, dissolved	mg/l	0.1	ND	0.0041	ND
Copper, dissolved	mg/l		ND	0.0037	0.021
Iron, dissolved	mg/l		ND	ND	ND
Lead, dissolved	mg/l	0.05	0.019	ND	0.66
Magnesium	mg/l		18.1*	29	31
Mercury, dissolved	mg/l	0.002	ND	ND	ND
Nickel, dissolved	mg/l	0.01	ND	0.005	ND
Potassium	mg/l		3.5*	4.1	5.5
Selenium, dissolved	mg/l	0.05	ND	ND	ND
Silver, dissolved	mg/l		ND	ND	ND
Sodium, dissolved	mg/l		51.5*	84	100
Thallium, dissolved	mg/l	0.002	ND	ND	ND
Zinc, dissolved	mg/l		0.14	0.015	0.088
TOC	mg/l		0.9	2.8	3
nm=not measured		Nd= Not detected above		Laboratory reporting limit	

* results are questionable for these analytes, laboratory results appear to have been switched with another sample but could not be confirmed by the laboratory.

Treated Wastewater Water Quality

Roger and Ina Road Effluent

The Roger Road Wastewater Treatment Facility (WWTF) and the Ina Road Water Pollution Control Facility (WPCF) are required to monitor for a number of parameters to comply with NPDES (1999) and Aquifer Protection Permits (2001). These monitoring requirements, provided by Pima County Wastewater Management Department, are shown on Tables 15 and 16.

Table 15. Roger Road WWTF Monitoring Requirements

Daily	Monthly	Bi-monthly	Quarterly
BOD	Enteric Virus	As, Cd, Cu, Cr	1,1,1-TCA
TSS	Acute Toxicity	Cyanide	
Fecal Coliform	Chronic Toxicity	Pb, Hg, Se, Ag, Zn	
Settleable Solids	Alkalinity	phenols	
Residual Chlorine		phthalates	
pH		methylene chloride	
		chloroform	
		PCE, PCA	

Table 16. Ina Road WPCF Monitoring Requirements

Daily	Monthly	Bi-monthly
BOD	Enteric Virus	As, Cd, Cu, Cr
TSS	Acute Toxicity	Cyanide
Fecal Coliform	Chronic Toxicity	Pb, Hg, Se, Ag, Zn
Settleable Solids	Alkalinity	phenols
Residual Chlorine		PCE
pH		Total Ammonia
		Temperature
		Dissolved Oxygen

The data collected from the County's monitoring have been summarized in several previous studies, including those by PAG (1994b, 1996) and Malcolm Pirnie (1994). In addition, more recent monitoring data were provided by Pima County Wastewater Management Department for this report; these data included information summarized from year 2000 discharge monitoring reports. The recent data, shown on Table 17 and 18, indicate that the effluent water quality is well within the NPDES and APP permit limits.

Table 17. Roger Road Wastewater Treatment Facility Discharge Monitoring Report Summarized Information Year 2000 (PCWMD, 2001a).

Constituent (Units)*	Permit Limit	1st Quarter Averages Jan- Mar	2nd Quarter Averages Apr-June	3rd Quarter Averages July-Sept	4th Quarter Averages Oct-Dec
Flow (MGD)	Up to 41	26.3	23.2	28.0	29.2
Suspended Solids (Kg/day)	4,654	2,217	2,090	1,470	2,247
Suspended Solids (mg/l)	45	25	30	16	23.5
Fecal Coliform (#/100ml)	200	4	16	35	12
pH	6.5 - 9.0	7.6	7.6	7.6	7.6
Disinfectant Residual (mg/l)	0.5	0.22	0.07	0.15	0.09

*MGD- Million gallons per day, Kg/day- Kilograms per day, mg/l- Milligrams per liter
#/100 ml- counts per 100 milliliters.

Table 18. Ina Road Water Pollution Control Facility Discharge Monitoring Report Summarized Information Year 2000 (PCWMD, 2001a).

Constituents (Units)*	Permit Limits	1st Quarter Averages Jan - Mar	2nd Quarter Averages Apr - Jun	3rd Quarter Averages Jul - Sept	4th Quarter Averages Oct-Dec
Flow (MGD)	Up to 25	22.5	23.1	22.1	24.3
Suspended Solids (Kg/day)	2,839	1,516	1,398	1,151	2,103
Suspended Solids (mg/l)	45	19	18	16	31
Fecal Coliform (#/100ml)	200	5	14	31	28
pH	6.5 - 9.0	7.1	7.1	7.2	7.2
Disinfectant Residual (mg/l)	0.5	0.30	0.44	0.15	0.35

*MGD- Million gallons per day, Kg/day- Kilograms per day, mg/l- Milligrams per liter
#/100 ml- counts per 100 milliliters.

Appendix B includes priority pollutant quarterly sampling results for the Roger Road and Ina Road facilities. Most of the parameters that the county tests for are not detected in the effluent water samples. When a parameter is detected the result is compared to the water quality standard. Tables 19 and 20 lists those compounds that were detected in the quarterly monitoring during 2000.

Table 19. Quarterly Priority Pollutant Organic Compounds Detected in Effluent from Ina Road WPCF, 2000 (PCWMD, 2001a).

Parameter	Ina Road number of samples detected	Ina Road Results mean – max. µg/l	Water Quality Standard	Were Standards exceeded
Chloroform	4 of 4	1.6- 2.0	1400	No
1,4-Dichlorobenzene	4 of 4	4.0-6.4	1880	No
Methylene Chloride	4 of 4	<1.0-1.02	8400	No
Tetrachloroethene	1 of 4	<0.5	1400	No
Toluene	2 of 4	<0.32-<0.5	8700	No
Diethyl phthalate	1 of 4	<5	26000	No
Bis(2-ethylhexyl)phthalate	4 of 4	14.7-34.8	400	No

Table 20. Quarterly Priority Pollutant Organic Compounds Detected in Effluent from Roger Road WWTF, 2000 (PCWMD, 2001a).

Parameter	Roger Road number of samples detected	Roger Road Results mean-max. µg/l	Water Quality Standard	Were Standards exceeded
Chloroform	4 of 4	<0.81-1.32	1400	No
1,4-Dichlorobenzene	2 of 4	<1.25-<5	1880	No
Methylene Chloride	4 of 4	<1.41-1.63	8400	No
G-BHC(gamma)	1 of 4	0.38	7.6	No
Toluene	3 of 4	<0.41-<0.5	8700	No
Bis(2-ethylhexyl)phthalate	2 of 4	<7.1-16.3	400	No
Pentachlorophenol	1 of 4	<10.0	17	No

Additional sampling data are available in ADEQ's Year 2000 305(b) report and 1998 Water Quality Limited Waters 303(d) List, and the United States Geological Survey's 2000 report *Water Quality in the Central Arizona Basins, 1995 - 98*. These data are for the effluent dependent reach of the Santa Cruz River downstream from the treatment facilities. Stressors of concern noted in this literature included turbidity and dissolved oxygen, with the standard for dissolved oxygen being exceeded in 6 of 12 samples collected by the USGS and the standard for turbidity being exceeded in only 1 of 12 samples. In its 1998 303(d) report, ADEQ de-listed this reach of the Santa Cruz, noting that only one sample had exceeded the turbidity standard.

Although the USGS (2000) suggested that the quality of effluent-dependent streams, including low dissolved oxygen, limits restoration of in stream communities and presents a challenge for fish survival, they also noted that these streams provide a variety of benefits, including riparian communities with a high level of terrestrial plant and animal diversity. This observation is supported by literature available from Pima County's Water Quality Research Project, which seeks to identify appropriate water quality standards for ephemeral and effluent-dependent streams in the arid western United States (PCWMD, 2001).

Additional data for surface water samples collected from 10 locations in the Santa Cruz River downstream from the two wastewater treatment facilities during the year 2001, indicate acceptable levels of dissolved oxygen. The results are shown on Table 21.

Also, extensive monitoring at three locations in the effluent dependent Santa Cruz River was conducted over a 32 month period between 1992 and 1994. The results indicated acceptable dissolved oxygen levels. The samples were collected at the Ina Road outfall, the Cortaro Road Bridge, and the Avra Valley Road Bridge. Out of the 228 DO samples collected, only two samples showed a concentration of DO less than 3.0 mg/l. Those results were 2.9 mg/l and 2.8 mg/l. (PCWMD, 2000).

Table 21. Summary of Dissolved Oxygen Field Measurements in the Santa Cruz River (PCWMD, 2001a).

Sample Location	Sample Date	# of Miles downstream from Roger Rd WWTP	# of Miles downstream from Ina Road WPCF	Dissolved Oxygen (mg/l)
SC-01	1/24/01	0.60	--	5.36
	8/13/01			5.47
SC-02	2/28/01	2.93	--	8.43
	8/13/01			4.83
SC-03	1/24/01	5.93	0.08	7.49
	2/28/01			10.13
	8/13/01			5.18
SC-04	8/13/01	7.70	1.85	3.28
SC-05	1/24/01	8.94	3.09	5.36
	8/14/01			4.83
SC-06	8/14/01	10.02	4.17	5.05
SC-07	1/24/01	12.11	6.26	6.81
	8/17/01			4.56
SC-08	2/13/01	13.23	7.38	6.58
	5/10/01			7.08
	8/16/01			4.31
SC-09	2/13/01	16.65	10.80	6.73
	5/10/01			8.99
	8/16/01			8.51
SC-10	2/13/01	17.93	12.08	7.92
	5/10/01			8.97
	8/16/01			7.88

Note: Samples are collected as a grab sample from a free flow portion of the stream. Each sample location is adjacent to groundwater monitor well locations.

Table 22 shows results from the year 2000 effluent sampling for metals at the Roger Road and Ina Road wastewater treatment facilities.

Table 22. Priority Pollutant- Metals, Quarterly Sampling for 2000 (PCWMD, 2001a).

Parameter	Ina Road WPCF 12 month mean mg/l	Ina Road WPCF 12 month max. mg/l	Roger Road WWTP 12 month mean mg/l	Roger Road WWTP 12 month max mg/l
Antimony	<0.0021	<0.0037	<0.0021	<0.0037
Arsenic	<0.0039	<0.0080	<0.0081	<0.0100
Beryllium	<0.0009	<0.0013	<0.0007	<0.0013
Cadmium	<0.0006	<0.0008	<0.0018	<0.0050
Chromium	<0.0054	0.0134	<0.0065	0.0188
Copper	0.0256	0.0270	0.018	0.025
Cyanide	<0.008	<0.015	<0.005	<0.005
Lead	<0.0019	<0.0050	<0.0019	<0.0050
Mercury	<0.000026	<0.000026	<0.000026	<0.000026
Molybdenum	<0.0066	<0.0079	0.0207	0.0251
Nickel	<0.0029	<0.0050	0.0050	0.0058
Selenium	<0.0022	<0.0038	<0.0022	<0.0038
Silver	<0.0015	<0.0019	<0.0036	<0.0050
Thallium	<0.0017	<0.0047	<0.0017	<0.0047
Zinc	0.0377	0.0434	0.0346	0.0394

"<" indicates the value was below the detection limit.

Reclaimed Water

Reclaimed water is ideally suited for turf irrigation and other commercial and industrial uses (Tucson Water, 2001; PAG, 1994a). Under a state wastewater reuse permit the reclaimed water is monitored for flow, turbidity, fecal coliform, pH, enteric virus, and *Ascaris lumbricoides* (Dotson, 2001). Water is sampled at a point that is representative of the quality of water received by the reclaimed water customers. The reclaimed water has a higher TDS concentration than secondary effluent. This is due in part to mixing with groundwater at the facility, where background TDS levels are higher than most Tucson Water wellfields (PAG, 1994a). Tables 23 and 24 present data provided by Tucson Water for this sample point. All of the data are within permitted limits.

Table 23. Average Values, Water Quality Data, Tucson Water Reclaim System, January--July 2001. Data from Tucson Water.

Constituent	Average	No. of Samples
Total Dissolved Solids	657 mg/l	6
Total Kjeldahl Nitrogen	10.09 mg/l	6
Total Organic Carbon	7.75 mg/l	6
Total Suspended Solids	1.6 mg/l*	7
Turbidity	3.28 NTU	6
Ammonia as N	6.29 mg/l	6
Nitrate as N	3.87 mg/l	7
Chloride	107.43 mg/l	7
pH	7.7 su	6
Conductivity	1012.66 umhos/cm	6
Fluoride	0.9	7
Potassium	8.2 mg/l	2
Phosphate as P	1.52 mg/l	6
Sulfate	120.8	7
Calcium	59.5	2
Total Alkalinity	247	3
Sodium	130 mg/l	2

*- This value calculated using a value of zero for one sample with a result of <1.

Samples collected on January 4, 2001, and April 12, 2001, were also analyzed for VOCs and metals. In general these constituents were only detected at levels less than the lowest standard or quantification limit of the method. Aluminum, Arsenic, Barium, Boron, Copper, Iron, Magnesium, Nickel and Zinc were all present at detectable levels, but below permit limits. The results of the two samples are listed on Table 24.

Table 24. Analytical Results for Reclaimed Water, Sample Dates January 4, 2001 and April 12, 2001. Data provided by Tucson Water.

Constituent (mg/l)	Sample Date 1/4/01	Sample Date 4/12/01
Aluminum, Total	<.1	.12
Arsenic, Total	0.0038	0.0055
Barium, Total	0.033	0.031
Boron, Total	0.3	0.29
Copper, Total	0.015	<0.01
Iron, Total	0.11	0.084
Magnesium, Total	10	9.9
Nickel, Total	0.013	<0.01
Zinc, Total	0.026	0.039

mg/l= milligrams per liter.

Summary and Conclusions

Summary

This report summarizes general findings about water sources and their quality in Pima County. Water sources in Pima County include groundwater, CAP water, treated wastewater, stormwater runoff, and perennial and intermittent surface waterbodies.

General water quality in Pima County is summarized on the following table. Mean values are presented for each constituent. Reclaimed water has the highest TDS of the water sources, with a mean value of 657 mg/l. Water from stormwater has the lowest TDS, with a mean value of 93 mg/l. Mean hardness values for the CAP water are higher than well water with CAP water at 280 mg/l as CaCO3 and well water having a mean value of 119 mg/l as CaCO3 (PAG, 1994).

Table 25. Average Water Quality Data (mg/l) for Selected Tucson Area Water Sources

Constituent	Tucson Water 2001 Systemwide average*	Combined Effluent**	Reclaimed Water (avg.)***	CAP Water ‡ (avg.)	Stream Water (avg.)+	Stormwater (avg.)†
TDS	322	509	657	603	232	93
Hardness as CaCO3	115	139	-	280	56.2	-
Sodium	40.0	109	130	92	18.1	6.0
Chloride	16.6	83.2	107.4	82	7.6	4.0
Calcium	38	46.6	59.5	66	48.8	10.4
Magnesium	4.7	6.25	10	28	7.9	1.6
Sulfate	44	85	120.8	248	37.76	9.9
Alkalinity	130	224	247	129	-	-

* Average drinking water quality for Tucson Water main system, 2001 data supplied by Tucson Water. Hardness is Total, mg/l, TDS Calculated

** Combined effluent is flow-weighted average secondary effluent quality for Ina and Roger Road Wastewater Treatment Plants. Data from PCWMD.

***- Reclaimed Water, average values from January 2001- July 2001. Data from Tucson Water.

‡ Data from CAP water at the Clearwater Site October 1997-April 2000. Tucson Water

+ Average stream water quality for 6 streams in Pima County, data from ADEQ

† Average Stormwater quality data from USGS measurements at Tanque Verde Creek at the Sabino Canyon confluence.

Conclusions

Groundwater

Groundwater is the most widely used water resource in Pima County. Water quality data for this source are abundant, due to its extensive use and regulatory monitoring requirements. It is generally of very good quality and suitable for its intended uses, which include drinking water, irrigation and industry. Groundwater contamination has occurred in several locations. Nitrates and VOCs are the predominant contaminants. Other contaminants, such as metals and pesticides, are insignificant compared to VOCs. Contaminated groundwater is generally not used for potable purposes, with the exception of locations where it is either treated or blended to meet drinking water standards. Contaminated groundwater in Pima County is intensively monitored, and in most cases is either under remediation or further investigation.

CAP Water

CAP water is being used in increasing quantities in Pima County. Current uses include potable supply, artificial groundwater recharge and crop irrigation. The quality of this water is extensively monitored, and its quality is sufficient for its intended uses, which include drinking water, aquifer recharge, irrigation and industry.

Treated Wastewater

Treated wastewater is also being used in increasing quantities. It is extensively monitored, and its quality meets standards for its intended uses, which include reuse for turf irrigation, agriculture and discharge to an effluent dependent stream. The effluent discharges currently support valuable riparian habitat subject to major stormwater events.

Stormwater Runoff

This water is not widely used as a resource. However, it is extensively monitored under existing regulations. The water quality meets NPDES permit requirements.

Surface Waterbodies

Although it is relatively scarce, naturally occurring surface water in perennial and intermittent streams provides very important habitat in Pima County. Most of the streams that have been monitored are of a quality sufficient for their intended use or habitat. However, monitoring is very limited compared to the other water sources. The vast majority of perennial and intermittent streams in Pima County are not regularly monitored for water quality.

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APPENDIX A

Arizona Department of Environmental Quality
Santa Cruz-Rio Magdalena-Rio Sonoyta
Watershed Stream Assessments and Stream Monitoring Data

Appendix A: Santa Cruz-Rio Magdalena-Rio Sonoyta Watershed Streams Assessments and Streams Monitoring Data (ADEQ).

SANTA CRUZ - RIO MAGDALENA - RIO SONOYTA WATERSHED STREAMS ASSESSMENTS

WATERBODY NAME SEGMENT WATERBODY SIZE WATERBODY ID	TYPE OF ASSESSMENT BIOASSESSMENT* YEAR ADDED TO 303(d) LIST	DESIGNATED USE SUPPORT	STRESSORS	POTENTIAL SOURCES	ASSESSMENT COMMENTS
Alamo Wash headwaters-Rillito Creek 9 miles AZ15050302-002	Monitored -- --	Partial	Copper	Urban runoff	USGS study of water and sediment from stormwater discharges in Alamo Wash in 1993, 5 samples: copper exceeded standard once (Tadayon, 1995).
Arivaca Creek headwaters-Puertocito/Altar Wash 15 miles AZ15050304-008	Evaluated -- --	Fully			ADEQ 3 stations 1991-93 with a total of 39 samples: full support. Low dissolved oxygen due to spring sources and low flows (all natural).
Canada del Oro headwaters-Big Wash 31miles AZ15050301-017	Evaluated -- --	Fully			ADEQ bioassessment site (phys/chem monitoring) 1992-94, 3 samples: full support. Biassessment not appropriate, because Index of Biological Integrity developed for perennial waters cannot be applied to intermittent waters.
Cienega Creek Interstate 10 to Del Lago Dam 11 miles AZ15050302-006B	Monitored Exceptional community --	Fully			ADEQ monitoring at 6 sites 1991-1998, 26 samples: full support.
Cienega Creek headwaters-Interstate 10 38 miles AZ15050302-006A	Evaluated -- --	Fully			ADEQ monitoring 1992-1998, 5 sites, 8 samples: full support.

Madera Canyon Creek headwaters-Santa Cruz 13 miles AZ15050301-322	Evaluated -- --	Fully			ADEQ 2 stations in 1991 (Roundup and Whitehorse) 2 samples: full support. ADEQ Biocriteria Development Reference Site (phys/chem monitoring) 1992-94, 3 samples: full support.
Sabino Canyon Creek headwaters-Tanque Verde River 20 miles AZ15050302-014	Evaluated Good community --	Fully			ADEQ monitoring (Summerhaven) 1990-93, 10 samples: full support. ADEQ Biocriteria Development Sit 1992-96, 4 samples: full support.
Santa Cruz River Canada del Oro-Guild Wash 9 miles AZ15050301-001	Monitored -- --	Not supporting	Low dissolved oxygen	Point source, sand and gravel operations, bridge repair, natural conditons	USGS NAWQA site 1996-1997, 12 samples: dissolved oxygen did not meet standards in half of the samples. Pima County Wastewater Management Department instream monitoring 1992-1994, 2 sites, total of 130 dissolved oxygen and ammonia samples: full support but median value for dissolved oxygen dropped every year. ADEQ fixed site 1991-1993, 20 samples: full support.
Santa Cruz River Josephine Canyon-Tubac Bridge 6 miles AZ15050301-008A	Monitored -- 1992	Not supporting	Turbidity, unknown toxic	Land development, grazing, natural, wastewater treatment plant	USGS NAWQA site 1996-97, 25 samples: full support (no turbidity samples). ADEQ monitoring 2 sites 1991-95, 13 samples: turbidity exceeds standards. USFWS report (King et al., 1999) indicates toxicity is occurring.
Santa Cruz River Tubac Bridge-Sopori Wash 9 miles AZ15050301-008B	Monitored -- --	Fully			ADEQ monitoring at Chavez Siding Road, 19 samples 1992-1995: full support.
Tanque Verde Creek Wentworth Road-Rillito Creek 10 miles AZ15050302-009B	Evaluated -- --	Fully			USGS monitoring 1990-94, 9 samples: full support.

WATERBODY NAME SEGMENT WATERBODY SIZE WATERBODY ID	TYPE OF ASSESSMENT *BIOASSESSMENT** YEAR ADDED TO 303(d) LIST	DESIGNATED USE SUPPORT	STRESSORS	POTENTIAL SOURCES	ASSESSMENT COMMENTS
Arivaca Lake 119 acres AZL15050304-0080	Monitored Hypereutrophic 1996	Not supporting	Mercury, low dissolved oxygen, high pH	Resource extraction, lake design and maintenance, natural, unknown, atmospheric deposition	Fish advisory due to mercury in fish tissue 1995 (AGFD and ADEQ samples). ADEQ and EPA water samples collected in 1997-1998, total of 52 samples: high pH and low dissolved oxygen. TMDL completed in 1999 for mercury.
Kennedy Lake 10 acres AZL15050301-0720	Monitored Eutrophic --	Not supporting	High pH	Point source, lake design and maintenance, natural	AGFD routine monitoring 1994-1997, 3 sampling events: high pH. AGFD urban lakes project, 11 field measurements, 4 lab samples: high pH (some low dissolved oxygen).
Lakeside Lake 15 acres AZL15050302-0760	Monitored Hypereutrophic --	Partial	High pH, low dissolved oxygen	Point source, lake design and maintenance, natural	AGFD routine monitoring 1994-1997, 4 sampling events: low dissolved oxygen. AGFD urban lakes project monitoring 1998, 11 field measurements, 4 lab chemistries: partial support due to low DO and high pH.

From: Arizona Department of Environmental Quality, *The Status of Water Quality in Arizona, Clean Water Act Section 305(b) Report 2000.*

Appendix A: Santa Cruz-Rio Madalena-Rio Sonoyta Watershed Streams Assessments and Streams Monitoring Data (ADEQ).

. **SANTA CRUZ-RIO MAGDALENA-RIO SONOYTA WATERSHED -- STREAMS MONITORING DATA**

STREAM NAME SEGMENT WATERBODY ID DESIGNATED USES	AGENCY PROGRAM SITE DESCRIPTION SITE ID	SAMPLES	PARAMETER UNITS	STANDARD	RANGE OF RESULTS (MEDIAN)	FREQUENCY EXCEEDED STANDARDS	USE SUPPORT*	COMMENTS
Agua Caliente headwaters-Coronado Forest AZ15050302-348A A&Ww, FC, FBC, AgL	ADEQ Biocriteria Program Above Coronado Natl Forest Boundary SCACW004.93	1995 - 1 water, bugs	Ok					Need more information to assess.
Alamo Wash headwaters-Rillito Creek AZ15050302-002 A&We, PBC	USGS #09485570 USGS report 95-4062 At Fort Lowell Road SCAAW001.27	1991-1994 - 9 water	Copper (dissolved)µg/l	varies (12)	<10-80	1 of 6	Partial A&We	Stormwater only.
Arivaca Creek headwaters-Puertocito/Alta AZ15050304-008 A&Ww, FC, FBC, AgL	ADEQ Fixed Station Network At Figueroa Spring SCARI008.19	1991 - 6 water 1992 - 6 water 1993 - 4 water	Dissolved oxygen mg/l	6.0 (90% saturation)	5.3-10.1 (68.5-128.6%)	1 of 10	Full	Naturally low dissolved oxygen during low flows.
	ADEQ Fixed Station Network At Ruby Road SCARI010.54	1991 - 8 water 1992 - 6 water 1993 - 4 water	Dissolved oxygen mg/l	6.0 (90% saturation)	1.1-12.0 (14.2-119%)	8 of 18	Full	Naturally low dissolved oxygen during low flow.
	ADEQ Fixed Station Network Near headwater spring SCARI010.86	1991 - 4 water 1992 - 1 water 1993 - 1 water	Dissolved oxygen mg/l	6.0 (90% saturation)	5.2-6.91 (60.6-77.1%)	3 of 6	Full	Naturally low Dissolved oxygen at springs.
Cave Creek headwaters-Cienega Creek AZ15050302-185 A&Ww, FC, FBC, AgL	ADEQ Biocriteria Program Near Mount Wrightson Wilderness SCCAV002.95	1992 - 1 water, bugs	Ok					Need more information to assess.

Canada del Oro headwaters-Big Wash AZ15050301-017 A&Ww, FC, FBC, DWS, AgI, AgL	ADEQ Biocriteria Program South of Pinal County Line SCCDO016.55	1992 - 1 water, bugs 1993 - 1 water, bugs 1994 - 1 water, bugs	Ok				Full	
Cienega Creek Interstate 10-Del Lago Dam AZ15050302-006B A&Ww, FBC, FC, AgL	ADEQ Stream Ecosystem Monitoring Above Diversion Dam SCCIE000.4	1998 - 1 water, bugs, physical	Dissolved oxygen mg/l	6.0 (90% saturation)	4.59	1 of 1	Full	Naturally low DO. Interrupted stream flow with spring source.
	ADEQ Stream Ecosystem Monitoring Below Davidson Canyon SCCIE001.1	1998 - 1 water, bugs, physical	Ok				Full	
	ADEQ Stream Ecosystem Monitoring Above Davidson Canyon SCCIE001.2	1998 - 1 water, bugs, physical	Dissolved oxygen mg/l	6.0 (90% saturation)	5.4	1 of 1	Full	Naturally low DO. Interrupted stream flow with spring source.
	ADEQ Fixed Station Network At Marsh Station Road SCCIE002.86	1991 - 6 water 1992 - 6 water 1993 - 4 water 1995 - 4 water	Dissolved oxygen mg/l	6.0 (90% saturation)	4.75-11.2 (60.6-110%)	1 of 25	Full	
	ADEQ Stream Ecosystem Monitoring Below tilted beds SCCIE003.5	1998 - 1 water, bugs, physical	Ok				Full	
	ADEQ Fixed Station Network At Tilted Bed site SCCIE005.36	1993 - 2 water	Ok				Full	

STREAM NAME SEGMENT WATERBODY ID DESIGNATED USES	AGENCY PROGRAM SITE DESCRIPTION SITE ID	SAMPLES	PARAMETER UNITS	STANDARD	RANGE OF RESULTS (MEDIAN)	FREQUENCY EXCEEDED STANDARDS	USE SUPPORT*	COMMENTS
Cienega Creek Headwaters-Interstate 10 AZ15050302-006A A&Ww, FC, FBC, AgL	BLM Routine Monitoring At Narrows SCCIE010.99	1993 - 1 water (2 sites)	Ok				Full	
	ADEQ Stream Ecosystem Monitoring Below Stevenson Canyon SCCIE011.8	1998 - 1 water, bugs, physical	Ok				Full	
	ADEQ Stream Ecosystem Monitoring Below narrows SCCIE012.4	1998 - 1 water, bugs, physical	Ok				Full	
	ADEQ Biocriteria Program Above the Narrows SCCIE012.55	1992 - 1 water, bugs 1993 - 1 water, bugs 1994 - 1 water, bugs 1996 - 1 water, bugs	Ok				Full	
	ADEQ Fixed Station Network Below E.C. Conserv. SCCIE013.61	1992 - 1 water 1993 - 1 water	Ok				Full	
Gardner Canyon Creek headwaters-Cienega Creek AZ15050302-195 A&Ww, FC, FBC	ADEQ Biocriteria Program Near Mount Wrightson Wilderness SCGDN010.49	1992 - 1 water, bugs	Ok					Need more information to assess.

STREAM NAME SEGMENT WATERBODY ID DESIGNATED USES	AGENCY PROGRAM SITE DESCRIPTION SITE ID	SAMPLES	PARAMETER *UNITS*	STANDARD	RANGE OF RESULTS (MEDIAN)	FREQUENCY EXCEEDED STANDARDS	USE SUPPORT*	COMMENTS
Madera Canyon Creek headwaters-Santa Cruz AZ15050301-322 A&Ww, FC, FBC, AgL	ADEQ Fixed Station Network 2 sites (Whitehorse and Round-up) SCMAD006.20	1991 - 1 sample (2 sites)	Ok				Full	
	ADEQ Biocriteria Program 1 mile below Sprung Spring SCMAD007.63	1992 - 1 water, bugs 1993 - 1 water, bugs 1994 - 1 water, bugs	Ok				Full	
Sabino Canyon Creek Headwaters-Tanque Verde RAZ15050302-014 A&Wc, FC, FBC, DWS, AgI	ADEQ Fixed Station Network At USGS gage SCSAB003.66	1991 - 2 water	Ok				Full	
	ADEQ Biocriteria Program Above East Fork Sabino Canyon SCSAB007.56	1992 - 1 water, bugs 1993 - 1 water, bugs 1994 - 1 water, bugs 1996 - 1 water, bugs	Dissolved oxygen mg/l	7.0 (90% saturation)	3.99-9.5	1 of 4	Full	Only a few isolated slow moving pools - natural low DO.
	ADEQ Fixed Station Network Below Summerhaven on Mount Lemmon SCSAB012.35	1991 - 9 water 1992 - 1 water & 5 bacts 1993 - 3 bacts	Ok				Full	
Santa Cruz Josephene-Tubac bridge AZ15050301-008A A&Wedw, PBC, AgL	ADEQ Fixed Station Network At Tubac bridge SCSCR077.08	1991 - 1 water 1992 - 2 water	Ok				Full	
			Turbidity NTU	50	6.25-72	1 of 3	Partial A&Wedw	
	ADEQ Fixed Station Network At Tumacacori SCSCR080.43	1993 - 5 water 1995 - 6 water (limited)	Copper (dissolved) µg/l	varies (35)	4-70	1 of 3	Partial A&Wedw	
			Cyanide (total) µg/l	41	7-1500	1 of 5	Partial A&Wedw	
			Turbidity NTU	50	6.5-114	1 of 16	Full	
Santa Cruz River Tubac bridge-Sopori Wash AZ15050301-008B A&We, PBC, AgL	ADEQ Fixed Station Network Chavez Siding Road SCSCR074.67	1992 - 1 water 1993 - 9 water 1995 - 6 water	Ok				Full	

Santa Cruz River Airport Wash-Rillito Creek AZ15050301-003 A&We, PBC, AgL	ADEQ Fixed Station Network At Congress Street SCSCR038.95	1991 - 1 water	Ok					Need more information to assess.
Santa Cruz River Canada del Oro-Guild Wash AZ15050301-001 A&Wedw, PBC	USGS NAWQA Site #09486500 At Cortaro, AZ SCSCR029.16	1996 - 8 water 1997 - 4 water	Dissolved oxygen mg/l	3.0 (3 hours after sunrise to sunset)	2.0-3.7	6 of 12	Non A&Wedw	
	ADEQ Fixed Station Network At Cortaro Road bridge SCSCR029.18	1991 - 8 water 1992 - 6 water 1993 - 6 water	Turbidity NTU	50	10.3-8970	1 of 12	Full	
Tanque Verde Creek Wentworth Road-Rillito Creek AZ15050302-009B A&We, PBC, AgL	USGS #09484500 USGS report 95-4062 At Sabino Canyon Road SCTAN001.29	1991-1994 - 9 water	Ok				Full	Stormwater only.

From: Arizona Department of Environmental Quality, *The Status of Water Quality in Arizona, Clean Water Act Section 305 (b) Report 2000.*

Appendix B

Priority Pollutant Quarterly Sampling 2000
For Ina Road WPCF and Roger Road WWTP

(Note: Appendix B is only available in hardcopy formats of the report)