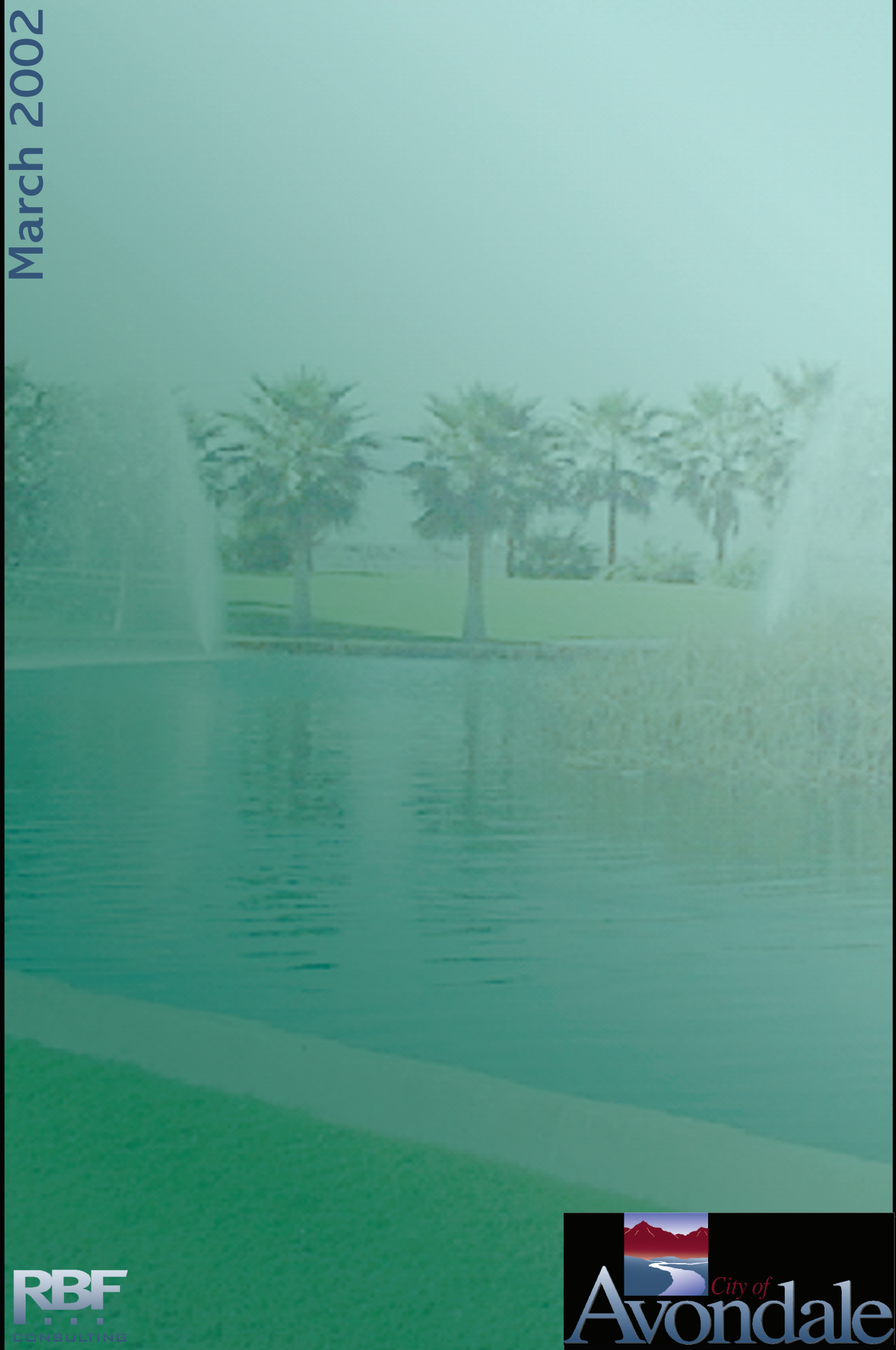

Water Resources Master Plan

March 2002

RBF CONSULTING

City of Avondale

March 2002

FINAL

Water Resources Master Plan
City of Avondale

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Executive Summary

E.1 Authorization

The City of Avondale, Arizona authorized RBF Consulting to complete a Water Resources Master Plan in order to identify the current status of the City's water resources, as well as improvements that will increase the future water supply.

E.2 Purpose of Plan

In order to assure a consistent and long-term water supply, the City of Avondale has commissioned the development of this Water Resources Master Plan. The purpose of this study is to develop strategies for acquiring and managing the City's long-term water resources needs. This will allow the City to ensure orderly, sustainable, and cost effective long-term development. This Water Resources Master Plan will identify long-range strategies to better anticipate future water requirements and ensure that water will be legally and physically available to meet the City's future demands.

E.3 Water Law

Being located in the desert southwest, the state of Arizona has enacted many laws in order to better regulate the state's water resources. These laws affect how the City of Avondale may acquire and use water supplies to meet the needs of its citizens. The 1980 Arizona Groundwater Management Act and amendments to the Act since 1980 (collectively, the "Groundwater Management Act" or "Act"), provide the framework for how the City may withdraw and use groundwater. Groundwater use is further restricted by the Assured Water Supply Rules adopted by the Director of the Arizona Department of Water Resources in 1995.

An assured water supply (AWS) means that sufficient water of adequate quality will be continuously available to satisfy the needs of the development for at least 100 years, consistent with the management plans of the active management area (AMA). The City of Avondale received this designation on August 16, 1999. In order to meet the AWS designation the City is claiming CAP and SRP surface water, and groundwater. A breakdown of the quantities of water that have been approved in the AWS for each of the City's resources is listed in Table E.1, AWS Approved Amounts. The recommendations set forth in this master plan have been selected to maintain the City's AWS designation.

Table E.1 AWS Approved Amounts

Source	Amount (AFY)
SRP water	8,463
CAP water	4,746
Groundwater Allowance	273
Incidental Recharge	221-503
CAGRD	0-3,444

E.4 Water Supply

Many critical factors must be considered when establishing the water supply for a community. Due to the arid desert nature of this state, sufficient, renewable water supplies play a crucial role in the growth and development of a community. The City of Avondale currently meets its water demand requirements by utilizing both ground and surface water sources. The City of Avondale is meeting its water demands by claiming Salt River Project surface water, CAP water, and groundwater, through the groundwater allowance, incidental recharge, and membership in the Central Arizona Groundwater Replenishment District (CAGRD). A summary of the raw water supply that the City is entitled to is outlined in Table E.2 below. A brief description of each of these water resources is included within this executive summary.

Table E.2 Raw Water Supply Summary

Supply Source	Current Quantity (AFY)	Build Out Quantity (AFY)
CAP	4,746	4,746
SRP	6,619	14,512*
Phase In Allowance	265	265
Incidental Recharge	221	1,664†
Sub Total	11,851	21,108
Reclaimed Water	-	13,607+
Conservation Efforts	-	2,847§
Total	11,851	37,562

* This value is based on the *SRP Revised Water Entitlement Report* which is the water assessment and the normal flow water for a drought condition. The City would be required to file an application for modification of its designation of assured water supply with ADWR to have this quantity of water counted towards the assured water supply.

† 4.43% of total water demand.

+ Reclaimed water plan is described in detail in Section 6.2.

§Conservation Efforts assume that a reduction in the total gpcd will be realized through the City's Conservation plan. This assumes a total reduction from 200 gpcd to 185 gpcd.

E.4.1 SRP

Salt River Project (SRP) surface water makes up the bulk of the water supplied to the City of Avondale. This water originates in the Salt and Verde River Watersheds and is transported through a network of canals to municipal, industrial, and agricultural water users located on lands within the Salt River Valley Water Users Association (SRVWUA). SRP water may be used only on lands entitled to receive water from the SRVWUA (Section 2.1.2, Water Agreements and Contracts). Generally, the SRVWUA on-project lands within Avondale are located east of the Agua Fria River.

According to the City of Avondale SRP Water Entitlement Report (January 18, 2002), the City currently has 2,206 acres of lands that are considered on-project. SRP generally provides 3 acre-feet per year (AFY) for each acre of on-project land. Currently the City is entitled to 6,619.05 AFY. At build-out, when all agricultural land is anticipated to be converted to municipal use, the total on-project acreage will be 6,559.75 acres with an associated entitlement of 19,679.25 AFY.

It is important to note that the City's current Assured Water Supply (AWS) designation, which was based on the City's projected demand and committed demand for the year 2010 and not build-out, shows that the City is allotted only 8,463 AFY of SRP water. This quantity of water was computed from 1990 census projections, and will need to be modified through an application to ADWR for a "modification of designation". Based on discussions with SRP and ADWR, and the City of Avondale SRP Water Entitlement Report (January 18, 2002), during drought conditions the City of Avondale would be able to receive 14,512 AFY at build out.

E.4.2 CAP

One of Avondale's renewable sources of water is Central Arizona Project (CAP) water. The City of Avondale currently has a CAP allocation of 4,746 acre-feet per year. The City of Avondale receives CAP water through the CAP canal and the SRP canal system. Unlike SRP water, CAP water can be used at any location throughout the City's water service area.

E.4.3 Groundwater

The City of Avondale meets its domestic water demands through the pumping of surface water that has been stored underground ("stored water"). The City receives allocations of surface water from various sources, and recharges this water into the aquifer for treatment and storage. The water is then extracted by one of the City's permitted recovery wells. Additionally, the City of Avondale receives a small allowance of groundwater that they may extract each year that is not considered recovered water.

E.4.4 CAGRD

The Central Arizona Groundwater Replenishment District (CAGRD) was established by the legislature to replenish groundwater pumped by certain landowners and municipal providers located within the Active Management Areas. Membership in CAGRD is an alternative mechanism to help demonstrate an assured water supply. If a municipal provider or a developer can prove that groundwater is physically available to meet its needs, by joining CAGRD, it obtains the right to use more groundwater than would otherwise be allowed. The landowner or municipal provider must then pay CAGRD to replenish the excess groundwater used.

E.5 Water Treatment Requirements

The City of Avondale is required to meet the Federal water quality standards established by the U.S. Environmental Protection Agency (USEPA) and detailed in the Safe Drinking Water Act (SDWA). At the present time, Maximum Contaminant Levels (MCLs) have been established for 83 regulated contaminants, and treatment technique (TT) requirements have been set for an additional 9 contaminants (Specific treatment methods are required for these 9 contaminants rather than numeric limits). In addition to the regulations enacted into law, USEPA has established a number of drinking water rules, which also require compliance. The City's water treatment currently meets the established standards, however with the implementation of the new Arsenic rule, some of the City's wells will be out of compliance.

On January 22, 2001, the EPA proposed a reduction in the current arsenic standard from 50 μg/L to 10 μg/L. The proposed new standard has significant cost implications for water utilities, and as such, significant discussion surrounding the revised MCL was conducted. The Bush administration reviewed the rule and affirmed it in October 2001. This rule became effective on February 22, 2002. The date by which the City of Avondale must comply with the new arsenic standard is January 23, 2006. As reported in Section 5.5.2 Water Quality Data, several City of Avondale wells (6, 7, 11, 14, and 15) currently exceed the future MCL for arsenic (10 μg/L).

E.6 Water Demands

Avondale's Municipal Planning Area (MPA), which was established in the General Plan, was used for this master plan. The MPA identifies the boundaries that the City of Avondale intends to annex in the future. The MPA starts north of the Estrella Mountains and terminates at Indian School Road. The population growth for this area and the corresponding water demand was computed in the *2001 Water Infrastructure Master Plan*. A summary of these populations and demands is shown in Table E.3, Population and Demand Projections.

Table E.3 Population and Demand Projections

Year	Population	Demand (Ac-ft/year)
2001	40,350	8,012*
2006	61,845	13,855
2011	83,506	18,708
2016	105,167	23,560
2021	126,828	28,413
2026	148,489	33,266
2040	167,665	37,562

The population based water demands presented in Table E.3 are based on the recommended combined per capita flow rate of 200 gallons per capita per day. This flow rate averages the total residential and nonresidential flow within the City of Avondale over each resident. It is important to note that this water demand provides a high estimate of the water demands within the City of Avondale. The City currently has a combined demand of 183 gpcd, and has not yet reached the 200 gpcd rate. The larger rate was used to provide a factor of safety in researching the quantity of additional water supplies that the City must acquire. Recommendations for reducing the City's gpcd rate are provided in the Section E.8.1, Conservation.

E.7 Third Management Plan

In order to better utilize the water resources located within the state of Arizona, the legislature passed the 1980 Groundwater Management Act. As part of this Act, certain areas within the state where groundwater mining was most severe were divided into active management areas (AMA). The City of Avondale is located within the Phoenix AMA. The goal of each AMA is to achieve a safe-yield of groundwater. Safe-yield is defined as a balance between the amount of groundwater extracted and replenished. In order to meet the safe-yield goal of the AMA, various management plans have been defined. Under the management plans, each water provider located within the AMA is required to meet a specified water usage amount. The City is currently regulated under the Third Management Plan

In order to provide an estimate of the allowable water usage in the City of Avondale based on the Third Management Plan, the future total water usage allowed was projected for the years 2001 to 2011. These allowable water usage projections were based on the population projections for the City as described in the *2001 Water Infrastructure Master Plan*. The population projections were broken down linearly for the first 10 years of the study, and the calculations assume that 90% of the new population growth each year is single family residential, and 10% of the new population growth each year is multifamily residential. The allowable GPCD projections for the next ten years according to

the requirements of the Third Management Plan are shown in Table E.4, Future Allowable GPCD Projections.

Table E.4 Future Allowable GPCD Projections

Year	Population	Total GPCD
2001	40,350	**186**
2002	44,649	**167**
2003	48,948	**167**
2004	53,247	**167**
2005	57,546	**158**
2006	61,845	**158**
2007	66,177	**158**
2008	70,509	**158**
2009	74,842	**158**
2010	79,174	**148**
2011	83,506	**148**

An analysis was also performed to evaluate how Avondale's projected water consumption over the next 10 years compares with the future allowable GPCD. Table E.5, Water Consumption and GPCD Comparison, shows the water demand projected for each of the planning periods, along with the allowable water demand according to the GPCD projections.

Table E.5 Water Consumption and GPCD Comparison

Year	Population	Projected Demand	Effluent	GPCD Demands	3rd Mgmt Allocation
2001	40,350	8,012	-	8,012	8,398
2006	61,845	13,855	-	13,855	10,927
2011	83,506	18,708	6,777	11,931	13,844
2016	105,167	23,560	8,535	15,025	17,435
2021	126,828	28,413	10,292	18,121	21,026
2026	148,489	33,266	12,050	21,216	24,617
2040	167,665	37,562	13,607	23,955	27,796

It can be seen from the table above that, except for the year 2001, the projected demand for the City of Avondale exceeds the water allocation from the Third Management Plan. It is important to understand however, that effluent water does not count against the GPCD requirement. Therefore, for the years where the proposed reclaimed water plan is in place (2011-Future), the City of Avondale remains in compliance with the goals of the Third Management Plan. It is also important to note that the Fourth Management Plan goals will go into effect in the year 2011. These requirements will be available before January 1, 2008.

As demonstrated in the table above, unless the City's per capita water demand decreases, the City will be out of compliance with the Third Management Plan.

There are various options that the City of Avondale may implement in order to maintain compliance with the Plan. These options include implementing stricter conservation measures, implementing the proposed effluent recharge program immediately, or seeking acceptance into the non per capita conservation program (NPCCP).

One method of maintaining compliance is to implement stricter conservation measures. The City must reduce their water demand by 16 GPCD by the year 2002 and then by an additional 9 GPCD by the year 2005 in order to remain in compliance. This is a realistic goal that can be reached through the implementation of the conservation measures listed in Table E.6, Avondale Conservation Options. By implementing a stricter conservation program, the City's water demand will decrease, maintaining compliance with the Third Management Plan, and reducing the overall water usage of the City.

A second option for maintaining compliance with the Third Management Plan is to implement the reclaimed water plan immediately. By implementing a reclaimed water plan, the effluent used is not counted against the GPCD usage. This extra water would allow Avondale to maintain their current usage rates and remain in compliance with the goals of the AMA. This option however, would require an outlay of capital immediately, instead of at a future time (2011) when the reclaimed water plan must be implemented to maintain sufficient supplies.

Another option for maintaining compliance with the Third Management Plan would be for Avondale to seek acceptance to the NPCCP in place of the GPCD program. Under the NPCCP, the provider must have a plan under which it will deliver no mined groundwater after January 1, 2010. Additionally, the provider must agree to implement reasonable conservation measures (RCMs) that ADWR determines will achieve a water use efficiency equivalent to the GPCD requirements.

E.8 Water Supply Recommendations

One of the fundamental purposes of this Water Resources Master Plan is to evaluate Avondale's current water supply and demand situation as well as the future demand and supply for the four separate planning periods. While the City of Avondale currently has adequate water resources to meet demand, the implementation of a program to acquire additional water resources must begin immediately, in order to meet future water demand requirements. Based on the analysis performed in Section 4 of this Water Resources Master Plan, water demand will begin to outstrip the current supply during the 2006-2011 planning period. Therefore, additional water resources must be acquired and implemented during the current planning period (2001 to 2006).

Additional water resources that provide a good potential for increasing the City's water supply include SRP, CAGRD, the Buckeye Waterlogged Area, and effluent water.

A good portion of the lands within Avondale are located within the Salt River Reservoir District and are entitled to delivery of water from SRP (on-project lands). The City of Avondale's AWS designation currently allots 8,463 acre-feet of SRP water to the City of Avondale. According to discussions with SRP, it is believed that the City will be able to include up to 14,512 acre-feet per year of SRP water in the City's AWS designation. It is recommended that the City of Avondale continue discussions with SRP and ADWR, in order to assure that the SRP water is being counted toward the AWS. It is also recommended that the City of Avondale file with ADWR an application to modify its designation during the 2006-2011 planning period in order to increase the amount of SRP water in the AWS designation. Additionally, an application to modify the designation should be filed as often as additional water from SRP is allotted to the City.

Another water resource that the City of Avondale may utilize is its membership in CAGRD. If the City's recharge amounts and accrued credits fall below Avondale's ongoing usage, Avondale would need to pump "excess groundwater" and pay CAGRD to replenish this groundwater. For the year 2002/3, CAGRD charges $198 per acre-foot (AF) for replenishment water. This rate is scheduled to increase to $202/AF for 2003/4; and to $207/AF for 2004/5. This is an all-inclusive cost and gives the City the right to pump its local groundwater.

Located within the southern portion of the City of Avondale is a portion of the Buckeye waterlogged area and the St. Johns waterlogged area. As described in Section 3.2 of the Water Resources Master Plan, it is possible to exclude from groundwater calculations and water storage account debits water withdrawn from a waterlogged area. While the water quality in the Buckeye waterlogged area is currently unknown (it is believed to be very poor), it is recommended that the City of Avondale perform a feasibility study to determine the possibility and the costs associated with using this water to meet future water demand requirements.

E.8.1 Conservation Plan

One recommendation that will significantly help the City of Avondale's water supply is the implementation of a comprehensive water conservation program. Not only is the City required to implement conservation measures, but also by lowering the average GPCD, water supplies are extended. In order to aid the City in maintaining sufficient water supply for the future, a comprehensive water conservation plan has been developed. It is strongly recommended that these measures be implemented in order to better utilize the City's water supply.

The annual GPCD measures the amount of water pumped annually by the City divided by the population served. This is also the unit used by the Arizona

Department of Water Resources (ADWR) to measure a community's compliance with the requirements of the Groundwater Management Act. For the year 2000, the City's average water use was 183 GPCD.

To reduce the water rates within the City of Avondale, there are many types of programs that could be implemented. However, ADWR has identified what it calls Reasonable Conservation Measures. This is a list of over 15 different residential and non-residential interior and exterior conservation measures. Table E.6, Avondale Water Conservation Options, lists these conservation measures, along with the conservation measures currently in place within the City of Avondale.

Table E.6 Avondale Water Conservation Options

ADWR Reasonable Conservation Measures	Avondale Existing Program	Avondale Programs Under Consideration
A. Residential Interior	***A. Residential Interior***	***A. Residential Interior***
1. Water Audit and Fixture Retrofit Program for Existing Customers	a. City distributed 4,000 water conservation kits	a. Initiate retrofitting rebate plumbing program b. Offer plumbing workshops
2. Ordinance or Condition of New Service Prohibiting Installation or Replacement of Plumbing Fixtures in Residential Housing Units Unless Fixtures Meet Water Saving Standards	b. City passed low flow plumbing code	
B. Residential Exterior		***B. Residential Exterior***
1. Audit Program for Existing Residential Customers		a. Initiate retrofitting rebate landscaping program b. Offer landscape workshops
2. Landscape Watering Advice Program for Existing and New Residential Customers		
3. Ordinances or Conditions of New Service for Model Homes in New Residential Developments		
4. Prohibit the Creation of New Covenants, Conditions and Restrictions which require the Use of Water-Intensive Landscaping or Which Prohibits the Use of Low Water Use Landscaping in Residential Developments		

ADWR Reasonable Conservation Measures	Avondale Existing Program	Avondale Programs Under Consideration
5. Options		
a. Ordinances or Conditions of New Service Limiting Use of Turf and Other Water-Intensive Landscaping in New Multi-Family Developments		
b. Ordinance or Conditions of New Service Limiting Use of Turf and Other Water-Intensive Landscaping in Common Areas of New Single Family and Multi-Family Developments.		
c. Rebate Program for New Residential Customers for efficiently designed landscapes		
C. Non-Residential Interior		
1. Interior Audit Program for Existing Facilities		
2. Ordinance or Condition of New Service Prohibiting Installation or Replacement of Plumbing Fixtures in Non-Residential Facilities Unless Fixtures Meet Water Saving Standards	Initiated program requiring multi-family units to change existing water fixtures to water conserving fixtures.	
3. Distribution of Conservation Information to All Non-Residential Customers and Submittal of Water Use Plan by New Large Facilities	New businesses must submit Water Conservation Report.	
D. Non-Residential Exterior		
1. Exterior Audit Program for Existing Non-Residential Customers		

ADWR Reasonable Conservation Measures	Avondale Existing Program	Avondale Programs Under Consideration
2. Landscape Ordinance or Conditions of New Service for New Facilities	a. City amended landscaping ordinance to require the use of the ADWR low water use plants list in all ROW landscaping and for the installation of automatic sprinkler system. b. Adopted ordinance making it mandatory for commercial developments to have at least 20% of their landscaping be low water use.	Ordinance for increasing low water use landscaping from 20% to 50%
E. Education 1. Public Information and Education Programs	a. Regular newspaper articles. b. Development and distribution of water conservation materials. c. K-5 schools program.	Increase school education program
	General Programs a. Implementation of block water rate. b. Leak detection and repair program. c. Replacement of all City water meters.	

E.8.2 Reclaimed Water Plan

One constant and renewable source of water that the City should take advantage of is its wastewater treatment plant effluent. Based on the analysis performed for this Water Resources Master Plan, a reclaimed water plan must be implemented in order to meet the City's build out water demands. It is recommended that the City of Avondale begin the design and implementation of a reclaimed water plan within the 2006-2011 planning period. A detailed discussion of the reclaimed water plan is provided below.

Effluent from the Avondale Wastewater Treatment Plant is currently discharged to the Agua Fria River. It is important to note that the discharge to the river has created a wetland type habitat. If the effluent were utilized in some fashion, a portion of the effluent might still have to be discharged to maintain the habitat.

This issue would need to be worked out with the regulatory agencies during the design and construction of any effluent reuse facilities.

As part of the reclaimed water plan, the effluent produced by the City of Avondale was projected. Table E.7, Projected Wastewater Flows, provides the anticipated flow amounts based on the City's population projections.

Table E.7 Projected Wastewater Flows

Year	Wastewater Flow* (mgd)
2006	6.0
2011	8.0
2026	14.3
2040	16.2

*These flows are annual average day flows.

Based on an analysis of the possible end uses of effluent within the City of Avondale, it is recommended that the effluent be recharged using the City's recharge basins, and later extracted using the recovery wells.

Avondale has an active recharge program for its surface water supplies. The existing recharge site has land available for future expansion that could include effluent recharge. Effluent recharge would require pumping and transmission of the effluent from the plant to the recharge site. No additional treatment would be necessary and this approach minimizes the amount of pipe required. However, use of the City's reclaimed water for recharge will require additional permitting. The City currently maintains a full-scale Underground Storage Facility (USF) permit issued by ADWR that is valid until December 31, 2018. A revised or new USF permit will be required to allow recharge of reclaimed water. A Water Storage Facility permit and Recovery Well permit will also be required along with an Aquifer Protection permit for the recharge site. A planning level cost estimate for the facilities required for recharge is $6,000,000. This includes the pump station, pipeline, and construction of the Phase III recharge basins. The facility sizing and cost should be verified in a facility pre-design study.

E.8.3 Recovery Wells

As discussed throughout this Water Resources Master Plan, the City of Avondale recharges their surface water allocations and should plan to recharge their effluent. This water is then treated through natural processes, and pumped from the ground using recovery wells. This method of recharge and extraction provides additional treatment to the City's water before use. It is anticipated that this process will continue in the future.

As the City of Avondale grows and develops, it will be necessary to construct additional groundwater wells in order to have sufficient water resources capacity

to serve the City. Over the course of the next 40 years, it is anticipated that 30 additional 1,500 gpm wells will be required. In order to obtain sufficient wells to access the water, the City will need to utilize various methods for acquiring these wells. The City of Avondale should look at drilling new wells, purchasing existing high production wells from other owners (e.g. SRP), or exchanging wells in order to obtain wells with higher production and better water quality.

In order to facilitate the process, a well site prioritization map was created. This map can be seen in Figure 5.18, Well Site Prioritization Map. Based on the analyses and findings, it is recommended that new City of Avondale public water supply wells be located within the areas delineated as having "good" or "moderate" groundwater production potential when possible. The well siting prioritization provided in this report should be used to provide guidance to City of Avondale decision-makers, for selection of optimum well sites on the basis of currently available information. It is recommended that a site-specific hydrogeologic analysis (pilot hole analysis or exploratory boring analysis) be conducted in association with the installation of each new water supply well.

Detailed technical discussion and analyses, which support the recommendations presented in this executive summary, are provided in the Water Resources Master Plan Report.

1.0 Introduction

1.1 Authorization

The City of Avondale, Arizona authorized RBF Consulting to complete a Water Resources Master Plan for both immediate and future water resources and water supply improvements.

1.2 Background Information

The City of Avondale currently meets its water demand requirements by utilizing both ground and surface water sources. While the City has no formal surface water treatment plant, the Wetlands of Avondale (a constructed wetlands facility) provides both treatment and banking of surface water supplies. The City of Avondale is meeting its water demands by claiming Salt River Project surface water, CAP water, and groundwater, through the groundwater allowance, incidental recharge and membership in the Central Arizona Groundwater Replenishment District (CAGRD).

1.3 Previous Master Plans

Over the past few years, the City of Avondale has been a rapidly growing and dynamically changing City. Currently Avondale is one of the fastest growing cities in the west valley. In order to grow and develop responsibly, the City of Avondale has commissioned that a water master plan be developed every five years. In 1996 RUST Environmental and Infrastructure Inc., developed a water system master plan for the City of Avondale. This master plan has served as a tool to aid in the effective development of the City of Avondale.

1.4 Purpose of Study

In order to assure a consistent and long-term water supply, the City of Avondale has commissioned the development of this Water Resources Master Plan. The purpose of this study is to develop strategies for acquiring and managing the City's long-term water resources needs. This will allow the City to ensure orderly, sustainable, and cost effective long-term development. This Water Resources Master Plan will identify long-range strategies to better anticipate future water requirements and ensure that water will be legally and physically available to meet the City of Avondale's future water requirements.

This Water Resources Master Plan will, together with the Water Infrastructure Master Plan, provide a comprehensive strategy to maintain adequate water supply, and to support future growth within the City of Avondale.

1.5 Scope of Work

In order to effectively project the future water requirements for the City of Avondale and the best ways to meet these water requirements, this plan will identify the City's current water supply and demands and discuss strategies for

consistently providing sufficient water. This water resources master plan also includes a hydrogeologic study to aid the City in identifying the locations with the best potential for future well supply. A water conservation program has been designed, and is included in this report. This report also includes an analysis of existing and future water demand and supply. Various methods to obtain the required water to meet projected demands are set forth, and recommended options for increasing water supply are discussed.

2.0 Water Supply and Historical Information

2.1 Historical Information

Many factors have played a role in the development of renewable water supply sources within the State of Arizona, and the City of Avondale specifically. Due to the arid desert nature of this state, sufficient, renewable water supplies play a crucial role in the growth and development of a community. The sections below provide an overview of the agreements and entities which play a major part in the water supply for the City of Avondale.

Historically, the City of Avondale met its domestic water demands solely through the use of groundwater. With the onset of the 1980 Groundwater Management Act as well as other legislation, the State of Arizona was striving towards safe yield. Achieving safe-yield, as defined in the Arizona Revised Statues, means "to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial groundwater recharge in the active management area" (A.R.S. 45-561(12)). In the mid 1990's, the City of Avondale had the foresight and initiative to implement a groundwater recharge program to effectively remove the City from its reliance upon groundwater. The Wetlands of Avondale was constructed to treat and recharge Avondale's Salt River Project (SRP) entitlements and Central Arizona Project (CAP) water allotments.

2.1.1 Assured Water Supply

The City of Avondale's "deemed "assured water supply status expired at the end of 1997. However, on December 27, 1996, the City of Avondale submitted a complete and correct application to the Arizona Department of Water Resources requesting that the department designate Avondale as having an assured water supply. This action allowed Avondale to maintain their "deemed" status while the application was under review. On August 16, 1999, ADWR issued Decision and Order No. 26-002003 designating the City of Avondale as having an assured water supply (AWS 99-001). A copy of the Decision and Order can be found in Appendix A. To receive this designation Avondale demonstrated the physical, legal and continuous availability of 14,211 acre-feet of Salt River Project surface water, CAP water, and groundwater for 100 years, which is enough to meet its projected demands through the year 2010.

The Decision and Order also subjected Avondale to conditions requiring the City to provide ADWR the following information annually:

1. The estimated future demand of platted, undeveloped lots which are located in Avondale's service area.
2. The projected water demand at build-out for customers that Avondale has provided a notice of intent to serve.
3. A report regarding Avondale's compliance with water quality requirements.
4. The depth-to static water level of all wells from which Avondale withdrew water during the calendar year.

2.1.2 Water Agreements and Contracts

In order to provide sufficient water, the City of Avondale has entered into various agreements with both public and private agencies. The agreements govern the amount of water that the City receives as well as the uses and distribution of that water. A brief discussion of the permits, agreements and contracts which the City of Avondale has in effect, are provided below. A summary of the permits and agreements is provided in Table 2.1, Water Permits and Agreements Summary.

Table 2.1 Water Permits and Agreements Summary

Agreement Title	Agency	Number	Issue Date	Expiration Date
Underground Storage Facility Permit- Constructed	ADWR	71-565257	2-Dec-98	31-Dec-18
Water Storage Permit	ADWR	73-565257	2-Dec-98	31-Dec-18
Long Term Storage Account	ADWR	70-441135	-	-
Water Delivery and Use Agreement	SRVWUA	-	17-Dec-96	31-Dec-01
CAP/SRP Interconnection Facility & Lease Agreement	SRVWUA	-	17-Dec-96	1-Jan-06
Water Transportation Agreement	SRVWUA	-	27-Sep-91	30-Jun-14
Subcontract Providing For Water Service	CAWCD	7-07-30-W0146	23-Oct-86	1-Jan-43
Amendment No. 1 to Water Service Subcontract	CAWCD	5-07-30-W0100	3-Dec-97	1-Jan-43
Member Service Area Agreement	CAWCD	-	16-Jan-98	-

2.1.2.1 ADWR-Underground Storage Facility Permit (Constructed)

Avondale received an Underground Storage Facility Permit – Constructed (Permit No. 71-565257) from ADWR on December 2, 1998 (Appendix B-1). This permit, which expires on December 31, 2018, grants authority to the City of Avondale to operate a constructed underground storage facility. The permit provides monitoring criteria and requires the facility to be operated in accordance with the operational plan identified in the "hydrologic report" that was submitted by Avondale with the permit application.

Although the Wetlands of Avondale treatment cells have been designed to hydraulically process 15,000 acre-feet per year, this permit allows for the storage of up to 10,000 acre-feet per annum of SRP water and CAP water. The facility shall be operated in conjunction with the Water Storage Permit (Permit No. 73-565257).

2.1.2.2 ADWR – Water Storage Permit

Avondale received a Water Storage Permit (Permit No. 73-565257) from ADWR on December 2, 1998 (Appendix B-2). This permit, which expires on December 31, 2018, allows for the storage of up to 10,000 acre-feet per annum of SRP surface water and CAP water at the City of Avondale Underground Storage Facility (Wetlands of Avondale Recharge Site). Pursuant to this permit, water may be stored only at the Constructed Underground Storage Facility (Permit No. 71565257). A provision of the permit requires the City to comply with the plan of operation associated with the Constructed Underground Storage Facility.

2.1.2.3 ADWR – Long Term Storage Account

Avondale's Long Term Storage Account number is 70-441135. This account reflects all of Avondale's recharge and recovery activity in the Phoenix AMA. The long-term storage account balance was 16,242 AF as of December 31, 2000 (Appendix B-3, 2000 Long Term Storage Account Summary).

2.1.2.4 ADWR – Recovery Well Permit

Part of Avondale's recharge program is the recovery of stored water. The City is currently served by ten groundwater wells: well numbers 1, 6, 7, 8, 10, 11, 12, 14, 15, and 18. City well numbers 2, 4, 5 and Cashion are not in production. The total current available pump capacity from the ten wells is approximately 13,311 gallons per minute (gpm). According to ADWR records the available combined capacity of all of the City's wells is 14,211 ac-ft/year. All of the City's existing wells, excluding well number 18, are permitted as recovery wells (Permit No.74-553424.0002). A copy of the Recovery Well Permit can be seen in Appendix B-4.

In addition to Well 18, the City is currently constructing well 19 which has not been permitted as a recovery well. It is recommended that the City amend the recovery well permit to include well 18 and the future well 19. The City should also ensure that all future wells are also covered under the recovery well permit. A list of all permitted recovery wells is shown in Table 2.2, City of Avondale Recovery Wells.

Table 2.2 City of Avondale Recovery Wells

COA well Number	Well Registration Number	Location of Well (All located within GSRB&M)	Available Pump Capacity (GPM)	Design Pump Capacity (GPM)	Well Depth (Feet)	Casing Diameter (Inches)	Maximum Annual recovery (Acre Feet)
1	55-608731	NW¼ SE¼ SE¼ Sec.10 T1N, R1W	1068	1200	456	16	1000
2	55-608732	SW¼ SW¼ SE¼ Sec 10,T1N,R1W	0	1200	460	20	500
4	55-608729	NW¼ NW¼ NW¼ Sec.15 T1N, R1W	0	880	400	14	500
5	55-608733	NE¼ SW¼ SE¼ Sec.15 T1N, R1W	0	1200	550	16	500
6	55-501247	NE¼ NE¼ NE¼ Sec.26 T2N, R1W	1448	1650	608	18	1500
7	55-501288	SE¼ SE¼ SE¼ Sec.23 T2N, R1W	1358	1600	530	18	1500
8	55-520499	NE¼ SE¼ SE¼ Sec.32 T2N, R1E	616	1750	660	16	500
10	55-608792	NE¼ NW¼ NW¼ Sec.36 T2N, R1W	2071	1500	866	20	1500
11	55-608791	NE¼ NW¼ SW¼ Sec.36 T2N, R1W	1638	1500	618	20	1500
12	55-608793	NE¼ NE¼ SE¼ Sec.35 T2N, R1W	1761	3000	458	20	1500
14	55-583017	SE¼ NW¼ SW¼ Sec.2 T1N, R1W	450	450[1]	800	20	970
15	55-578749	NW¼ NW¼ NE¼ Sec.11 T1N, R1W	600	600	800	20	970
Cashion	55-626592	NW¼ SW¼ NE¼ Sec.18 T1N, R1E	0	500	538	12	500

1. Recovery well permit reflects Design Pump Capacity of 1,000 gpm. However, aquifer yield was much less so actual pump was designed for 450 gpm.

The Recovery Well Permit allows the City of Avondale to recover the water it has stored in the Phoenix AMA. It also provides for the recovery of long-term storage credits assigned to the City of Avondale's long-term storage account.

2.1.2.5 SRVWUA – Water Delivery and Use Agreement

On December 17, 1996, the City entered into a Water Delivery and Use Agreement (Appendix B-5) with the Salt River Valley Water Users Association (SRVWUA). SRVWUA acts as an agent for the Salt River Project Agricultural Improvement and Power District, a political subdivision of the State of Arizona. SRVWUA is responsible for the operation of the Salt River Project water delivery system, which is a federal reclamation project.

The Water Delivery and Use Agreement expires on December 31, 2101. The agreement allows the City of Avondale to receive water from the SRVWUA ("entitlement water") for distribution to lands within the City's water service area that are entitled to water from SRVWUA ("entitlement lands"). See Figure 2.1, SRP Entitlement Lands Within Avondale.

Under the terms of this agreement, the City may store entitlement water underground, but must recover the approximate amount of water in the same calendar month that it was stored.

The agreement also provides for water exchanges. The City is permitted to deliver entitlement water to lands which are not normally eligible to receive this

water, if the City delivers a like quantity of municipal water to SRVWUA lands. While there is no obligation to exchange any specific quantity of water in any calendar year, the maximum amount of water that may be exchanged in a single calendar year is 23,498 acre feet.

2.1.2.6 SRVWUA – CAP/SRP Interconnection Facility and Lease Agreement

On December 17, 1996, the City entered into a CAP/SRP Interconnection Facility and Lease Agreement (Appendix B-6) with the SRVWUA. This agreement will remain in effect until it expires on January 1, 2006. The agreement allows the City of Avondale to lease capacity in the CAP/SRP interconnection facility in order to deliver CAP water to Avondale via SRVWUA's water delivery system.

2.1.2.7 SRVWUA – Water Transportation Agreement

On September 27, 1991, the City entered into a Water Transportation Agreement (Appendix B-7) with the SRVWUA. The agreement remains in effect through June 30, 2041. The agreement allows for the City of Avondale to transport City water through the SRVWUA water delivery system between the interconnection facility and the City's facilities.

2.1.2.8 CAWCD – Subcontract Providing for Water Service

On October 23, 1986 the City entered into a subcontract (Subcontract No. 7-07-30-W0146) with the Bureau of Reclamation (B of R) and the Central Arizona Water Conservation District (CAWCD). This agreement can be seen in Appendix B-8.1. This subcontract remains in effect for a period of 50 years beginning with January 1 of the year following that in which the Secretary of Interior issues the Notice of Completion of the CAP water supply system. The Secretary of the Interior signed the Notice of Completion on September 30, 1993 (See Appendix B-8.2). Therefore, the subcontract expires on January 1, 2044. The subcontract provides for delivery of up to 4,099 acre-feet of CAP water for M&I use by the City, including but not limited to groundwater recharge.

The subcontract subjects Avondale to certain conditions, some of which are as follows:

1. The City shall pump groundwater only for use within its service area.
2. The City will not sell or dispose of any CAP water for use outside of Maricopa, Pinal, and Pima Counties.
3. If CAP water is resold or exchanged by the City, for an amount in excess of that amount paid to CAWCD plus cost of transportation, treatment and distribution, the excess amount is to be paid to CAWCD for application against the repayment obligation to the United States.

Additionally, by October 1 of each year, the City is required to submit a water delivery schedule to CAWCD indicating the amount of CAP water desired for

each month of the following year, along with a preliminary estimate for the succeeding two years. Generally, CAWCD will not deliver from the CAP water supply system a total amount of CAP water greater than 11 percent of the City's maximum entitlement in any one month. In case of water shortages, non-Indian CAP water will be reduced pro rata beginning with miscellaneous water, followed by agricultural water, and then by non-Indian M&I water.

A Water and Air Pollution Control provision of the Subcontract requires the City to comply with all applicable water and air pollution laws and regulations of the United States and the State of Arizona and obtain all required permits or licenses from the appropriate Federal, State, or local authorities.

A Water Conservation Program provision requires the City to develop and implement an effective water conservation program for all uses of water that is provided from or conveyed through Federally constructed or financed facilities. That water conservation program is to incorporate definite goals, appropriate water conservation measures, and time schedules for meeting the water conservation objectives. Avondale is required to resubmit the water conservation plan to CAWCD every five years.

2.1.2.9 CAWCD – Amendment No. 1 to Water Service Subcontract

On December 3, 1997 the City entered into an agreement amending the water service subcontract (Subcontract No. 7-07-30-W0146) with the B of R and the CAWCD (Appendix B-8.3). This subcontract remains in effect for the same period of time as the original Subcontract Providing for Water Service. Therefore, the amended subcontract expires on January 1, 2044.

The amended subcontract provides for transferring to the City of Avondale 647 acre-feet of CAP water formerly subcontracted for by the McMicken Irrigation District (Subcontract No. 5-07-30-W0100). This amendment increases Avondale's CAP M&I water entitlement from 4,099 acre-feet to 4,746 acre-feet.

2.1.2.10 CAWCD – Agreement Providing for Delivery of CAP Incentive Recharge Water

On November 12, 1999 the City entered into an agreement with the CAWCD (Appendix B-9). This agreement terminates on December 31, 2003 unless the parties agree in writing to extend the term. This agreement provides for CAWCD to deliver incentive recharge water to the City of Avondale (at the interconnection facility or other approved point of delivery) in so far as supplies and delivery capabilities permit. The intent for using incentive recharge water is the recharge and use of the water will be for the Avondale water service area.

2.1.2.11 CAWCD – Member Service Area Agreement

On January 16, 1998 the City entered into a Member Service Area Agreement (Appendix B-10) with the CAWCD. This agreement is irrevocable as long as

CAWCD is required to meet the groundwater replenishment obligation under the groundwater replenishment statutes. This agreement provides for the Central Arizona Groundwater Replenishment District, an operating subdivision of CAWCD, to perform groundwater replenishment on behalf of the City of Avondale. To the extent Avondale's groundwater pumping exceeds the amount of groundwater it may pump under its designation of assured water supply, CAGRD will recharge a like amount of water and assess the City for the cost of doing so.

2.1.3 Assured Water Supply Application

In order to receive a Designation of an Assured Water Supply, a provider must meet five basic regulatory criteria:

1. The water supply pledged must be physically, legally, and continuously available for a 100 year period.
2. The supplies must be of adequate quality.
3. The use of the water must be consistent with the management plan conservation requirements for the provider.
4. The use of the water must be consistent with the management goal of the AMA.
5. The provider must have the financial capability to construct necessary storage, treatment, and distribution systems.

The Assured Water Supply Application which was submitted by the City of Avondale states that in 1998, Avondale's water demand was 5,523 acre-feet. Avondale's total projected and committed demand for the year 2010 was estimated at 14,211 acre-feet.

The water which Avondale has claimed for present and future sources consists of both surface water and groundwater supplies. In order to supply the citizens of Avondale with water, the City utilizes Salt River Project (SRP) surface water, Central Arizona Project (CAP) water, and groundwater through the groundwater allowance, incidental recharge, and membership in the Central Arizona Groundwater Replenishment District (CAGRD).

2.1.4 Central Arizona Groundwater Replenishment District

The Assured Water Supply Rules provide a method to aid municipal providers that do not have enough renewable water supplies available to remain consistent with the management goal criteria. Through membership in the Central Arizona Groundwater Replenishment District (CAGRD), a municipal provider can pay a replenishment tax to CAGRD to recharge CAP water on the provider's behalf. However, since the municipal provider will continue to pump groundwater from within its service area, it must demonstrate that sufficient groundwater is physically and legally available within that service area.

On January 16, 1998, the City of Avondale and CAGRD executed the Member Service Area Agreement (Section 2.1.2.11) that allows the City to pump groundwater in excess of its groundwater allocation, beginning in 1999 and for every year thereafter. It is important to note that recovery of recharge water credits is not considered pumping of the City's groundwater allocation.

2.1.4.1 CAGRD History and Operations

In 1993, the legislature created a groundwater replenishment authority to be operated by the Central Arizona Water Conservation District (CAWCD) throughout its three-county service area. This replenishment authority of CAWCD is commonly referred to as the Central Arizona Groundwater Replenishment District (CAGRD). In 1999, the legislature expanded CAWCD's replenishment authorities and responsibilities by passing the Water Sufficiency and Availability Act (from CAGRD membership information, 2001). The purpose of the CAGRD is to provide a mechanism for landowners and water providers to demonstrate an assured water supply under the new Assured Water Supply Rules (AWS Rules), which became effective in 1995.

Under the 1993 CAGRD enabling legislation, membership in the CAGRD provides a means by which an AWS applicant can satisfy AWS criterion number 4 above (Section 2.1.3, Assured Water Supply Application), which requires that the proposed water use be consistent with the water management goals of the particular AMA. The "consistency with management goals" section of the AWS Rules limits the quantity of mined groundwater that an applicant may use to demonstrate an AWS. The effect of this groundwater pumping limitation is to prevent new development from relying solely on mined groundwater to serve its water demands.

Development, however, is not necessarily stymied for those landowners and water providers who have no direct access to CAP water or other renewable supplies. If a water provider or a landowner has access to groundwater and desires to rely exclusively on groundwater to demonstrate a 100-year water supply, it may do so, provided it joins the CAGRD. As a member of the CAGRD, the landowner or provider must pay the CAGRD to replenish any groundwater pumped by the member that exceeds the pumping limitations imposed by the AWS Rules.

In summary, under the 1995 AWS Rules, groundwater may not be the basis for any new development in the Phoenix AMA. If a development does not have CAP water or other renewable supplies, it must join the CAGRD.

2.1.4.2 Replenishment Obligation of the CAGRD

The CAGRD must replenish (or recharge) in each AMA the amount of groundwater pumped by or delivered to its members which exceeds the pumping

limitations imposed by the AWS Rules. This category of water is referred to as "excess groundwater".

Recharge may be accomplished through the operation of underground storage facilities or groundwater savings facilities. CAWCD may sell its indirect storage and recovery credits to the CAGRD at fair value.

Water used for replenishment may be CAP water or water from any other lawfully available source, except groundwater withdrawn from within an AMA. For the foreseeable future, the water that the CAGRD will use for replenishment will likely be excess CAP water.

2.1.4.3 Membership

Membership in CAGRD is voluntary. Any city, town, water company, subdivision or homeowner's association located in Maricopa County may join the CAGRD.

There are two types of members:

a. Member Service Areas: The service area of a city, town or private water company, including any additions to or extensions of the service area. This is the type of membership that Avondale has entered into (see Appendix B-10, Member Service Area Agreement).

b. Member Lands: An individual subdivision with a defined legal description.

2.1.4.4 Physical Access to Groundwater

Under the provisions of the 1993 CAGRD enabling legislation, membership in the CAGRD does not waive the requirement under the AWS Rules that an applicant must demonstrate the physical and legal availability of groundwater. Providers or subdivisions which rely on the CAGRD to meet the AWS requirements must still meet the depth to groundwater criteria established in the AWS Rules and have the legal right to withdraw groundwater from the point of withdrawal. The new authorities provided to the CAGRD in 1999 modify this requirement to some extent for Member Service Areas, as described later in this section.

2.1.4.5 Replenishment Taxes/Assessments

Costs of the CAGRD will be covered by a replenishment tax or replenishment assessment levied on CAGRD members. Water providers serving Member Service Areas, such as the City of Avondale, will pay a replenishment tax directly to the CAGRD according to the number of acre-feet of excess groundwater they deliver within their service areas during a year. For Member Lands, a replenishment assessment will be collected by the county assessor from each tax parcel according to the number of acre-feet of excess groundwater delivered to that parcel.

2.1.4.6 Amount of the Replenishment Tax/Assessment

The amount of the replenishment tax/assessment will be the CAGRD's total cost per acre-foot of recharging groundwater, including: the capital costs of constructing recharge facilities, water acquisition costs, operation and maintenance costs and administrative costs.

2.1.4.7 Additional Authorities Provided by the Legislature in 1999

In 1999, the legislature expanded CAWCD's replenishment authorities and responsibilities by passing the Water Sufficiency and Availability Act. Under this legislation, CAGRD's role in helping members prove an AWS is extended beyond the "consistency with management goal" criterion described above. The CAGRD may assist a Member Service Area in satisfying criterion number 1, (i.e., proof that a sufficient quantity of water is continuously available to satisfy the water demands within the service area for 100 years).

The new legislation allows ADWR to grant a designation of assured water supply to a water provider whose service area has been enrolled as a Member Service Area of the CAGRD and has been granted "Water Availability Status" by the CAWCD Board. If the CAGRD decides to grant "Water Availability Status" to a Member Service Area, it must formally adopt a resolution and prepare and file a detailed "Capability Plan" with ADWR. The plan must include a description of the replenishment facilities, transportation facilities, and water supplies which will be used to provide a physically available supply of water to the Member Service Area. It must be a 100-year plan, which is subject to public review and a public hearing. The plan is to be updated every ten years. The bill also allows the CAGRD to make direct deliveries, under certain conditions, to Member Service Areas which have been granted Water Availability Status.

It is important to understand that the legislation giving CAGRD the authority to grant water availability status to a member service area was passed under intense lobbying by Vidler Water Company, and developers within the City of Scottsdale. Vidler Water Company is a private corporation owning several thousand acres of land within the Harquahala Irrigation Non-Expansion Area that hopes to sell groundwater pumped from that land for use in the Phoenix AMA. The authority of CAGRD under this legislation is limited to a total annual amount of 20,000 acre-feet. (A.R.S. § 45-3772(10))

2.1.5 SRP and CAP Service Areas

Salt River Project (SRP) surface water and Central Arizona Project (CAP) surface water currently make up the bulk of the water supplied to the City of Avondale. As described in Section 2.1.2, Water Agreements and Contracts, SRP water may be used only on lands entitled to receive water from the SRVWUA. CAP water on the other hand may be used anywhere within the City of Avondale's service area. In general terms, the SRVWUA on project lands are

located east of the Agua Fria River. An accurate representation of the location of the on project lands is shown in Figure 2.1, SRP Entitlement Lands within Avondale.

2.2 Water Supply

In order to meet its water supply demands, the City of Avondale is currently using surface water delivered by the Salt River Project (SRP), Colorado River water delivered by the Central Arizona Project (CAP), and groundwater supplies. The City is also banking excess surface water in order to accrue long-term storage credits for future use. This section provides a description of the water supplies available to the City.

2.2.1 Groundwater Supplies

The City of Avondale meets its domestic water demands through the pumping of surface water that has been stored underground ("stored water"). The City receives allocations of surface water from various sources, and recharges this water into the aquifer for treatment and storage. The water is then extracted by one of the City's permitted recovery wells, as described in more detail in Section 2.1.2.4, ADWR- Recovery Well Permits.

2.2.2 CAP

One of Avondale's renewable sources of water is Central Arizona Project (CAP) water. CAP municipal supplies are allocated based on 50-year subcontracts between the U.S. Bureau of Reclamation and the water provider (see CAWCD – Subcontract providing for Water Service in Section 2.1.2.8). The City of Avondale receives CAP water through the CAP canal and the SRP canal system. Avondale has signed an interconnection agreement with SRVWUA under which SRP transfers CAP water from the CAP system into the SRP system via the interconnection facility (see SRVWUA – CAP/SRP Interconnection Facility and Lease Agreement in section 2.1.2.5). Avondale has also signed a transportation agreement with SRVWUA to convey CAP water through SRP's water system (see SRVWUA –Water Transportation Agreement in section 2.1.2.7).

The City of Avondale currently has a CAP allocation of 4,746 acre-feet per year. This amount of water consists of the City's original allocation and an allocation transferred from the McMicken Irrigation District. The original allocation of CAP water to the City is 4,099 AFY, as authorized under City of Avondale resolution number 531, dated December 3, 1984, and the 50-year subcontract with the Central Arizona Water Conservation District, executed October 23, 1986. The City entered into an agreement with the McMicken Irrigation District on March 15, 1995, which provided an additional 647 AFY.

SRP Entitlement Lands in Avondale

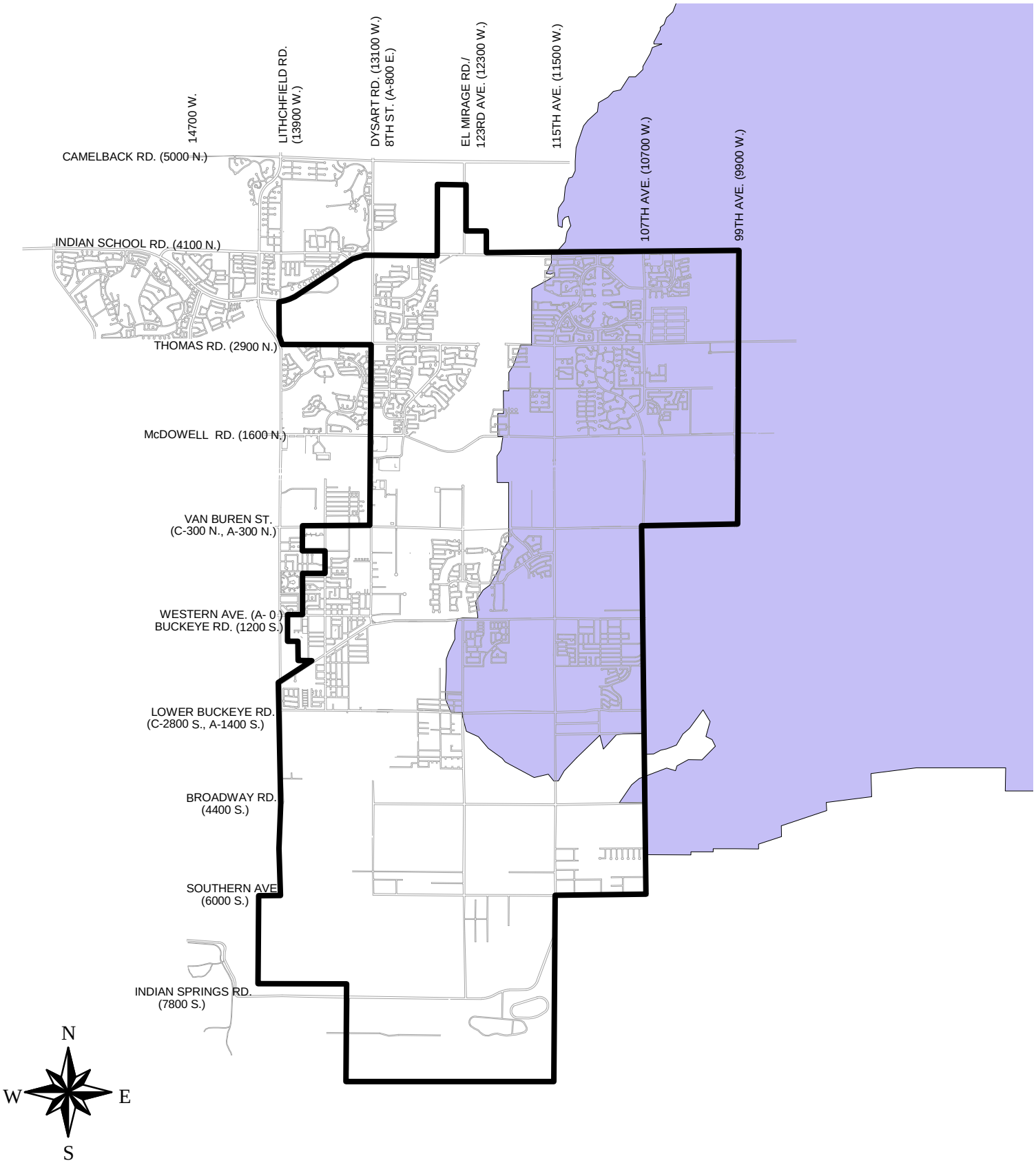

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Figure 2.1
SRP Entitlement Lands in Avondale

Avondale Boundary
Streets
SRP Member Land

2.2.3 SRP

A second source of renewable water supply to the City of Avondale is through the Salt River Project (SRP). The water delivered by SRP originates in the Salt and Verde River Watersheds. This water is transported through a network of canals to municipal, industrial, and agricultural water users located on lands within the Salt River Valley Water Users Association (SRVWUA). The water users located in the SRVWUA have rights to this water based on the Kent Decree and state and federal laws. The amount of water delivered to each municipal provider serving lands within the SRVWUA is based on the number of acres within the providers service area having rights to water from SRVWUA.

According to the City of Avondale SRP Water Entitlement Report (January 18, 2002), the City of Avondale currently has 2,206 acres of assessed lands that are considered on project. According to the SRP agreements, SRP generally provides 3 AFY for each acre of on project land. Currently the City is entitled to 6,619.05 AFY. At City build-out, when all agricultural land is anticipated to be converted to municipal use, the total "on project" acreage will be 6,559.75 acres with an associated entitlement of 19,679.25 AFY.

It is important to note that the City's current Assured Water Supply (AWS) designation, which was based on the City's projected demand and committed demand for the year 2010 and not build-out, shows that the City is allotted only 8,463 AFY of SRP water. This quantity of water was computed from 1990 census projections, and will need to be modified through an application to ADWR for a "modification of designation". Based on discussions with SRP and ADWR, and the City of Avondale SRP Water Entitlement Report (January 18, 2002)(see Appendix C-2), during drought conditions the City of Avondale would be able to receive 14,512 AFY at build out. This quantity of water is computed by utilizing 2 acre-feet of surface water per acre of on project land, plus 1,313.4 acre-feet of normal flow water.

2.2.4 Incidental Recharge

Another source of water to the City is incidental recharge. Incidental recharge is the quantity of water that is assumed to be added to the aquifer from other uses of the water. Examples of incidental recharge include excess water applied to crops and turf. As part of its duties under the Groundwater Management Act, the Arizona Department of Water Resources developed an assessment of the quantity of incidental recharge water. The baseline quantity for Phoenix AMA providers is 4% of the total annual demand. For Avondale, an extra incidental recharge rate of 0.43% is added based on the ADWR's analysis of Avondale's turf-related facilities.

2.2.5 Phase-In Allowance

Assure Water Supply Rules (AWS Rules) allow a small quantity of mined groundwater to be pumped to allow providers time to "phase-in" renewable water

supplies. The phase-in allowance which has been determined for the City of Avondale is its 1994 total water demand (3,536 AF) multiplied by 7.5 and averaged over 100 years. This results as an additional source of water of 265 AFY.

2.2.6 Long Term Storage Account

The City of Avondale has a Long Term Storage Account with ADWR (see Section 2.1.2.3, ADWR- Long Term Storage Account). This account allows the City of Avondale to recharge excess surface water and bank credits for this excess water stored. In the future, the City will be able to withdraw the excess water that it has stored and use this water to meet its domestic demands. For example, the water that was recharged and not recovered in 1999 and 2000 is now part of the City's long-term storage account.

When CAP water is introduced into long-term storage, the amount stored is subject to 5% "cut" to the aquifer, thereby reducing the amount in storage and recoverable to 95% of the amount recharged. The City's long-term storage account balance was 16,242 AF as of December 31, 2000. For the near future, this long-term storage account will continue to accrue credits as long as the amount of the water stored in the Wetlands of Avondale recharge facility exceeds the City's current water supply and demand.

According to the SRVWUA agreement, the City of Avondale does not receive long-term storage credits for SRP water that is recharged to the aquifer. SRP water must be recovered in the same calendar month that it was stored, or Avondale will lose the credits for recharging that water.

2.2.7 Reclaimed Water Supplies

One constant and renewable source of water that the City should take advantage of is the use of its wastewater treatment plant effluent. Effluent from the Avondale Wastewater Treatment Plant is currently discharged to the Agua Fria River. Since long-term storage credits for recharge of reclaimed water accrue at 100% of the recharged quantity (i.e., there is no "cut" to the aquifer), the City's renewable water supply will be increased significantly through the implementation of a reclaimed water plan. Utilization of these supplies will require design and installation of additional conveyance and recharge facilities and permitting through ADWR and ADEQ). A detailed description of anticipated reclaimed water demands, as well as a plan for utilizing this water resource is described in more detail in Section 6.2, Reclaimed Water Plan.

2.3 Water Supply Summary

Table 2.3, Raw Water Supply Summary, provided below provides a general summary of the water sources and quantities which are described in this section. A detailed analysis of the City's water resources for each of the planning periods is provided in Section 4.6, Water Supply and Demand Analysis.

Table 2.3 Raw Water Supply Summary

Supply Source	Current Quantity (AFY)	Build Out Quantity (AFY)
CAP	4,746	4,746
SRP	6,619	14,512*
Phase In Allowance	265	265
Incidental Recharge	221	1,664†
Sub Total	11,851	21,108
Reclaimed Water	-	13,607+
Conservation Efforts	-	2,847§
Total	11,851	37,562

* This value is based on the *SRP Revised Water Entitlement Report* which is the water assessment and the normal flow water for a drought condition. The City would be required to file an application for modification of its designation of assured water supply with ADWR to have this quantity of water counted towards the assured water supply.

† 4.43% of total water demand.

+ Reclaimed water plan is described in detail in Section 6.2.

§Conservation Efforts assume that a reduction in the total gpcd will be realized through the City's Conservation plan. This assumes a total reduction from 200 gpcd to 185 gpcd.

3.0 Laws and Regulations

Many state laws affect how the City of Avondale may acquire and use water supplies to meet the needs of its citizens. The 1980 Arizona Groundwater Management Act and amendments to the Act since 1980 (collectively, the "Groundwater Management Act" or "Act"), provide the framework for how the City may withdraw and use groundwater. Groundwater use is further restricted by the Assured Water Supply Rules adopted by the Director of the Arizona Department of Water Resources in 1995. Arizona has also enacted comprehensive laws governing the manner in which the City, and others, may store water underground and the circumstances under which the City may exchange water with other users. As a member service area of the Central Arizona Groundwater Replenishment District (CAGRD), the City's rights to withdraw groundwater are expanded. This chapter summarizes these laws and how they apply to the City of Avondale.

Maintaining adequate water quality is also a concern of the City of Avondale. The laws and rules governing water quality, as well as the water quality standards that the City must maintain are also summarized in this section.

3.1 The Groundwater Management Act

Arizona's major water problem has always been an imbalance between water consumption and dependable supply. The state relies heavily on groundwater, and for decades, has been mining its groundwater supplies to meet ever-increasing demands. Despite the work of several special commissions, the state failed to enact measures to meaningfully restrict groundwater uses. The development of groundwater laws fell to the courts in the context of disputes between water users and resulted in an inflexible body of law that did not recognize hydrological principles.

In 1976, the Arizona Supreme Court handed down a decision that would change the nature of groundwater use in Arizona forever. The case, *Farmers Investment Company v. Bettwy (FICO)*, 113 Ariz. 520, 558 P.2d. 14, involved a large pecan farming corporation in Pima County, the City of Tucson, and several copper mining companies. The Court prohibited Tucson and the mines from pumping groundwater and transporting it for use at a different location if the wells of the farming corporation or other water users were affected. In essence, the decision authorized FICO to severely curtail pumping by Tucson and the mines.

The FICO decision spurred the legislature to establish yet another commission, the Groundwater Management Study Commission, to rewrite Arizona's groundwater laws. After two and a half years of negotiation by the Commission, including six months of closed-door meetings by representatives of the cities, mines, and agriculture, the Commission agreed upon comprehensive legislation

to regulate groundwater uses. The legislation was passed by the legislature in a one-day special session and signed into law by Governor Bruce Babbitt on June 12, 1980.

The Groundwater Management Act quantifies and regulates rights to withdraw groundwater in geographic areas of the state where the overdraft, or mining, of groundwater is most severe. These areas, called Active Management Areas or AMAs, include the Phoenix AMA in which the City of Avondale is located. Within the AMAs, the Act identifies and places limits on rights to withdraw groundwater, regulates the drilling of new wells, and requires groundwater users to conserve groundwater pursuant to management plans adopted by the Department of Water Resources. The Act also prohibits urban development where there is not a 100-year assured water supply. Following is a summary of the major provisions that affect the City of Avondale's ability to pump groundwater.

3.1.1 Service Area Rights

Under the Groundwater Management Act, cities, towns and private water companies, known as municipal providers, may withdraw groundwater pursuant to a service area right (A.R.S. § 45-492). This right allows the City of Avondale to pump groundwater within its service area for the benefit of landowners and residents within its service area. The City's service area is defined as the area of land actually being served water by the City and any additions to such area that contain an operating distribution system owned by the City (A.R.S. § 45-402).

Along with the City of Avondale, three private water companies serve portions of the City. These companies, Wilhoit Water Company, Rigby Water Company, and Litchfield Park Service Company (LPSCO), are regulated by the Arizona Corporation Commission as well as ADWR. The City's service area and the service areas for the three private water companies are delineated in Figure 3.1, Water Provider Service Boundaries.

The City currently has ten service area wells, which are described in Section 2.1.2.4. The City may drill new service are wells only within its service area. While the City may expand its service area, it may not do so primarily to include a well field in that area. (A.R.S. § 45-493) Under ADWR's informal policy, a well drilled by a municipal provider within 660 feet of the provider's distribution system is considered to be within the provider's service area. If the provider wishes to drill further away from its distribution system, it must use a Type 2 Grandfathered Right to do so. Type 2 Grandfathered Rights are not appurtenant to any land and may be sold or leased. Many such rights are available for purchase or lease within the Phoenix AMA.

Water Provider Service Boundaries

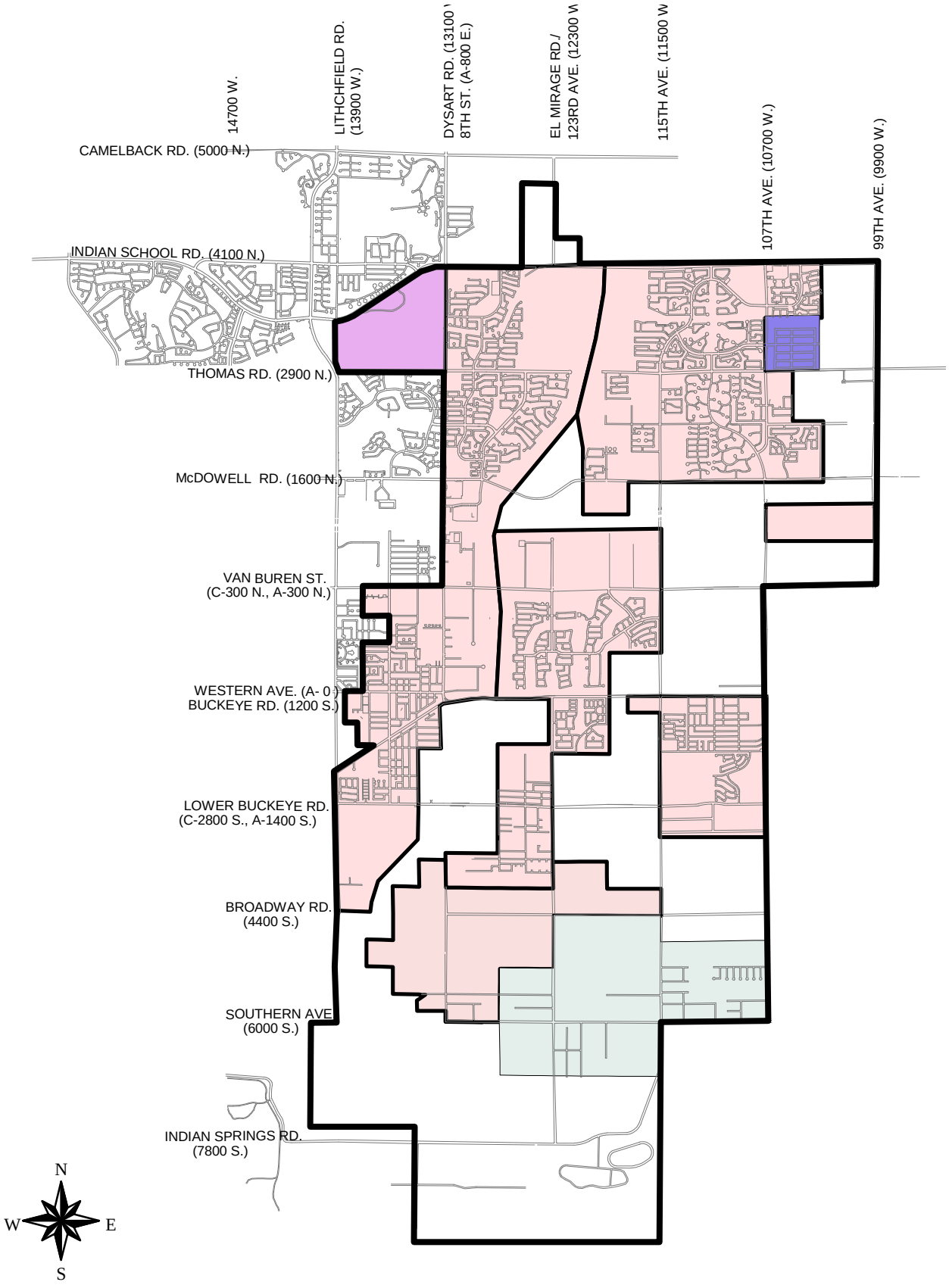

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Figure 3.1
Water Provider Service Boundaries

Avondale Boundary
Streets
Avondale Water
LPSCO
Wilhoit Water Company
Rigby Water Company

3.1.2 Management Plans

The City's service area right is constrained by the management plans adopted by the Arizona Department of Water Resources (ADWR). The Groundwater Management Act requires ADWR to adopt a series of management plans for each AMA designed to achieve the AMA's management goal. The management goal for the Phoenix AMA is safe-yield (A.R.S. § 45-562). Safe-yield is a long-term balance between the annual amount of groundwater withdrawn in the AMA and the annual amount of natural and artificial recharge in the AMA (A.R.S. § 45-561). Each management plan must include a continuing mandatory conservation program for all persons withdrawing groundwater in the AMA (A.R.S. § 45-563).

In the early 1990s, the City of Avondale was exceeding its gpcd requirement for the second management plan for the Phoenix AMA. Consequently, in 1994, the City entered into a stipulation and consent order with DWR under which it agreed to establish a number of water conservation programs in order to meet the goal of 174 gpcd. These programs are discussed in greater detail in Chapter 6.

The Management Plan for the Third Management Period for the Phoenix AMA requires large municipal providers, such as the City of Avondale, to comply with the Total Gallons Per Capita Per Day (GPCD) Program, unless the provider is regulated under the Non-Per Capita Conservation Program (NPCCP) or the Alternative Conservation Program (ACP). Most municipal providers, including Avondale, are regulated under the GPCD Program. The GPCD Program uses a complicated formula, which includes existing residential population, new single and multi-family populations, and lost and unaccounted for water. Exclusions are provided for certain non-residential customers. Under the Plan, the City's gpcd goal for the period 2002 to 2004 is 154 gpcd, comprised of 118 gpcd for residential use and 36 gpcd for non-residential use. Based on the estimated growth within the City, the final GPCD rate for the end of the Third Management Period (2010) is estimated at 148 gpcd.

The City of Avondale's water use increased to 183 gpcd in 2000. As discussed in Chapter 6, the City will need to implement additional conservation measures and programs to use treated wastewater in order to comply with the requirements of the Third Management Plan. Another option for achieving compliance with the Third Management Plan requirements is to seek acceptance into the NPCCP or ACP. Failure to comply with the management plan requirements could result in penalties imposed by ADWR, including daily fines, loss of recharge credits, and revocation of the City's designation of assured water supply.

Both the NPCCP and ACP are available only through an application process. The provider must limit or reduce its use of groundwater in order to qualify for either program. Under the NPCCP, the provider must have a plan under which it will deliver no mined groundwater after January 1, 2010. Additionally, the

provider must agree to implement reasonable conservation measures (RCMs) that ADWR determines will achieve a water use efficiency equivalent to the GPCD requirements. Under the ACP, the provider may achieve compliance with groundwater use limitations by extinguishing grandfathered rights, serving groundwater that will be replenished by the Central Arizona Groundwater Replenishment District, using remediated groundwater, using non-groundwater supplies, or using groundwater withdrawn from outside the AMA.

3.1.3 Assured Water Supply

The City of Avondale's ability to withdraw groundwater is further constrained by the Groundwater Management Act's requirement that new residential developments must have an assured water supply (A.R.S. § 45-576). An assured water supply means that sufficient water of adequate quality will be continuously available to satisfy the needs of the development for at least 100 years, consistent with the management plans and the achievement of the management goal for the AMA. The Act requires ADWR to designate municipal providers where an assured water supply exists. ADWR has adopted rules to implement the assured water supply provisions. These rules and the City's designation are discussed below.

3.1.4 Well-Drilling Permits

The Groundwater Management Act requires a permit to drill a non-exempt well in a new location (A.R.S. § 45-599). Municipal wells are non-exempt wells. Prior to issuing a permit, ADWR must determine that the proposed well will not unreasonably increase damage to surrounding land and other water users from the concentration of wells (A.R.S. § 45-598). Under temporary rules adopted by ADWR in 1983 (A.A.C. R12-15-830), the applicant for a permit for a new well with a design pumping capacity in excess of 500 gallons per minute must submit a hydrological study of the projected declines in water levels from the operation of the proposed well. ADWR will approve the permit application if it determines that the probable impact of the proposed well on any well of record with ADWR will not exceed ten feet of additional drawdown over a five-year period. If ADWR determines that the probable impact of the proposed well will exceed 25 feet of additional drawdown over a five-year period, ADWR must deny the application. If the additional drawdown from the proposed well is greater than ten but less than 25 feet, ADWR may consider several factors in determining whether to grant the application. These factors include the existing rate of decline in the area, current costs of pumping, and any efforts of the applicant to mitigate the projected damage.

The Groundwater Management Act allows the City to deepen or replace an existing well without obtaining a permit from ADWR. (A.R.S. § 45-597) ADWR's temporary rules define a replacement well as a well located no greater than 660 feet from the original well that will not withdraw an annual amount of groundwater in excess of the historical withdrawls from the original well. (A.A.C R12-15-840)

3.2 Assured Water Supply Rules

ADWR has adopted rules to implement the Groundwater Management Act's assured water supply provisions (A.A.C. R12-15-701 et seq). The rules clarify how a municipal provider may become a "designated provider" (a provider designated as having an assured water supply). Under the rules, groundwater in the Phoenix AMA is "physically available" only if it is pumped from a depth that does not exceed 1,000 feet below land surface (A.A.C. R12-15-703.B). Central Arizona Project (CAP) water is physically available if the provider has a long-term subcontract for CAP water. Other CAP water is physically available only if the provider demonstrates a back-up supply of water. Surface water other than CAP water (such as water from the Salt and Verde Rivers) is physically available under a formula provided in the rules. Effluent and water recovered from an underground water storage project may also be physically available to the provider pursuant to criteria contained in the rules.

If a proposed source of water for an assured water supply is water to be recovered from an underground storage project, ADWR will include as legally available the volume of water represented by stored water credits existing on the date of the application for designation of an assured water supply. If the applicant wants to use credits for stored water that do not exist at the date of the application, ADWR will evaluate several criteria in determining whether to include the proposed credits. These criteria include the physical availability of the water to be stored and the presence of an existing storage project.

The assured water supply rules further limit the amount of groundwater a municipal provider may withdraw "consistent with the management goal" of the AMA. The volume of groundwater the provider may withdraw is calculated pursuant to a formula contained in the rules (A.A.C. R12-15-705.G). This amount of groundwater is increased by an incidental recharge baseline factor of 4%. As discussed in Section 2.2.4, Incidental Recharge, Avondale is allotted an additional 0.43% based on ADWR's analysis of Avodale's turf-related facilities. The amount of groundwater may also be increased for any credits the provider has for the extinguishment of grandfathered rights. Extinguishment credits are calculated by multiplying 1.5 acre-feet by the number of acres with a grandfathered right, then multiplying this product by the number of years between extinguishment and 2025. Avondale should consider applying for extinguishment credits if Irrigation Grandfathered Rights, or Non-Irrigation Grandfathered Rights are available to them.

The Act provides a mechanism for a designated provider to increase the amount of groundwater it may withdraw pursuant to the assured water supply rules. Under A.R.S. § 45-576.01, ADWR must find that a water provider's use of groundwater is consistent with the management goal if the provider is a member service area of the Central Arizona Groundwater Replenishment District

(CAGRD) and ADWR has approved CAGRD's plan of operation. As long as the groundwater is physically available, the municipal provider may pump more groundwater than the assured water supply rules allow. However, as a member of CAGRD, the provider must pay CAGRD for the cost of recharging a like amount of water. CAGRD is discussed in more detail below.

The assured water supply rules also allow ADWR to exclude from the calculation of groundwater withdrawn by a municipal provider "groundwater withdrawn within a portion of an active management area which is exempt from conservation requirements . . . due to waterlogging." (A.A.C. R12-15-705.T.3). The Groundwater Management Act exempts from conservation requirements the Arlington Canal Company, the Buckeye Water Conservation and Drainage District, and the St. John's Irrigation District (A.R.S. § 45-411.01). Although ADWR has yet to apply this provision of the rules to any specific situation, ADWR staff anticipates that a designated municipal provider will be able to request a written exemption from ADWR under this provision. This exemption would allow the municipal provider to include groundwater withdrawn from a waterlogged area as part of its assured water supply designation. Portions of the Buckeye waterlogged area and St. Johns waterlogged area are located within the City of Avondale's master planning area. A map of these areas is shown in Figure 3.2, Buckeye/St. Johns Waterlogged Area.

According to ADWR, Avondale must submit a letter to ADWR requesting an exemption for water withdrawn from a waterlogged area. A map must be provided showing the location of the well within the waterlogged area. Once ADWR has made the determination that the submitted information is true and correct, a letter will be issued on the water log exemption.

ADWR recently amended its assured water supply rules to limit when CAP water or Colorado River water leased from an Indian community is legally available for purposes of demonstrating an assured water supply (A.A.C. R12-15-703.01). Under the new rule, the lease must provide a water supply for 100 years. For the first 50 years, the lease will continue to meet the 100-year assured water requirement. After 50 years, in order to maintain its designation the municipal provider must present evidence to ADWR of ongoing negotiations with the Indian community to renew the lease. The municipal provider is allowed ten years to complete an agreement for the renewal of the lease. Additionally, the municipal provider must show that either no more than 15% of its total water supplies are obtained through leases with Indian communities, or that another source of water will be available to it to substitute for the leased water for the remainder of the 100-year period.

Buckeye/St. Johns Waterlogged Area

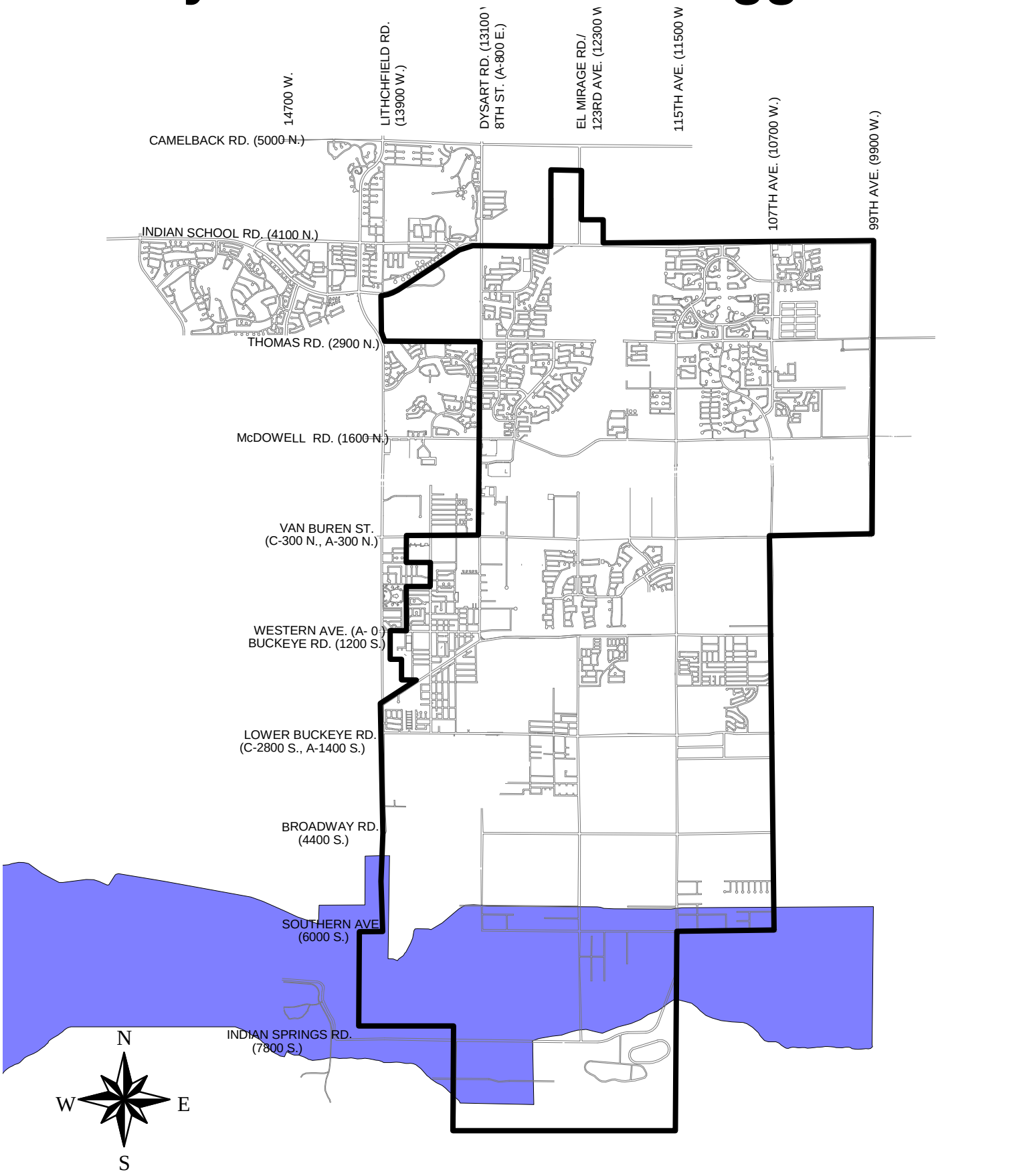

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Figure 3.2
Buckeye/St. Johns Waterlogged Area

Streets
Avondale MPA
Buckeye Waterlogged Area

3.2.1 Avondale's Assured Water Supply Designation

On August 16, 1999, ADWR issued an order designating the City of Avondale as having an assured water supply. The designation was based on the City's projected and committed demand of 14,211 acre-feet for the year 2010. The order states that "Avondale has demonstrated the physical, legal and continuous availability of Salt River Project surface water, CAP water, and groundwater in a volume of 14,211 acre-feet per year for a minimum of 100 years" and that Avondale is a member service area of CAGRD. Attached to the order is a summary document further explaining how ADWR determined that the City has an assured water supply. While neither the order nor the summary document break down the City's assured water supply by type of water, Appendix A to the summary document lists the "approved" amounts of the various sources. The amounts listed in this summary are shown in Table 3.1, AWS Approved Amounts.

Table 3.1 AWS Approved Amounts

Source	Amount (ac-ft)
SRP water	8,463
CAP water	4,746
Groundwater Allowance	273
Incidental Recharge	221-503
CAGRD	0-3,444

Avondale will need to amend its designation if it wishes to use more than the 14,211 acre-feet specified in the designation order. An amendment would be warranted for incorporating the increased CAP quantities due to the transfer of the McMicken allocation to Avondale. Another appropriate time to amend the designation order is when SRP revises their AWS study, increasing Avondale's designated amount. Future water demand is projected in Section 4.0, Water Demands.

According to Cliff Neal who heads CAGRD. CAGRD's replenishment plans are based on Avondale's maximum pumping capacity of 14,211 acre-feet. CAGRD views this capacity as a limit on CAGRD's responsibility to replenish water on behalf of Avondale. Further, CAGRD would be involved in discussions with ADWR of any proposed amendment to the City's assured water supply designation.

3.3 Underground Water Storage, Savings and Replenishment

In 1986, Arizona enacted laws to allow and encourage the storage of water underground. These laws were substantially revised in 1994. Water may be

stored underground only by a person who has received a water storage permit from ADWR (A.R.S. § 45-831.01) and only at a storage facility that has received a permit from ADWR (A.R.S. § 45-8111.01). Recovery of stored water requires a recovery well permit issued by ADWR (A.R.S. § 45-834.01). If the water stored underground is surface water and its use is based on a decreed or appropriative water right (e.g., Salt and Verde River water), the water may be recovered only in the same calendar year in which it was stored (A.R.S. § 45-851.01). Effluent and water that could not have reasonably been used directly are eligible for long-term storage allowing these sources to be recovered in a subsequent year or years (A.R.S. § 45-852.01). Long-term storage credits may be sold, leased or exchanged (A.R.S. § 45-854.01) and may be used in demonstrating an assured water supply (A.R.S. § 45-855.01).

If the water stored is effluent or water from outside the AMA that would not have reached the AMA without the efforts of the holder of the long-term storage credits, 100 percent of the water is recoverable. Otherwise, only 95 percent of the water qualifying for long-term storage credits is recoverable (A.R.S. § 45-852.01). Stored water may be used or exchanged only in the manner it was permissible to use or exchange the water before it was stored (A.R.S. § 45-832.01). In other words, the water retains its legal characteristics even if the actual molecules recovered are groundwater.

3.4 Water Exchanges

Arizona's statutes governing exchanges of water were enacted in 1992. A "water exchange" is a trade of one water source for another. Each party to the exchange must have a right to use the water it gives in trade (A.R.S. § 45-1001). Additionally, each party to the exchange may use the water it receives only in the manner in which it had the right to use the water given in trade (A.R.S. § 45-1003). Certain water exchanges do not require a permit from ADWR. These exchanges include those in which the amount exchanged does not exceed 50 acre-feet in any twelve-month period and certain exchanges made pursuant to contract that is enrolled with ADWR (A.R.S. § 45-1002). Other water exchanges require a permit from ADWR (A.R.S. § 45-1041).

3.5 Central Arizona Groundwater Replenishment District

The Central Arizona Groundwater Replenishment District (CAGRD) was established by the legislature in 1993 when it required the Central Arizona Water Conservation District (CAWCD), which manages the CAP, to replenish groundwater pumped by certain landowners and municipal providers in AMAs. Membership in CAGRD is an alternative mechanism to help demonstrate an assured water supply. If a municipal provider or a developer can prove that groundwater is physically available to meet its needs, by joining CAGRD, it obtains the right to use more groundwater than would otherwise be allowed under the assured water supply rules. The landowner or municipal provider must pay CAGRD to replenish the excess groundwater used. CAGRD must replenish

in the same AMA from which the groundwater was pumped. As discussed earlier, the City of Avondale is a member service area of CAGRD.

3.6 Water Treatment

3.6.1 Primary Drinking Water Regulations

The Federal regulations pertaining to water quality, established by the U. S. Environmental Protection Agency (USEPA), were originally detailed in the Safe Drinking Water Act (SDWA) of 1974. The SDWA established drinking water standards for 32 contaminants. Since then, the act has been amended several times and the most recent amendment in 1996 increased the list of regulated contaminants with Maximum Contaminant Levels (MCLs) to 83 with treatment technique (TT) requirements for 9 additional contaminants. (Specific treatment methods are required for these 9 contaminants rather than numeric limits.) The Primary Drinking Water Maximum Contaminmant Levels (MCLs) are presented in Appendix D, Primary Drinking Water Standards.

In addition to the regulations enacted into law, USEPA has established a number of drinking water rules, which also require compliance. These rules are discussed in the following paragraphs:

3.6.1.1 Surface Water Treatment Rule (SWTR)

On June 29, 1989, the EPA published the final Surface Water Treatment Rule (SWTR). For drinking water systems using surface water sources, the SWTR requires that treatment be provided to reduce turbidity, *Giardia*, *Legionella*, viruses, and heterotrophic plate count bacteria (HPC). Specifically, the SWTR established treatment and performance standards to provide a minimum reduction of 99.9 percent (3-log) for *Giardia* cysts, and 99.99 percent (4-log) for viruses. The overall reduction of *Giardia* and viruses is to be achieved through a combination of physical removal by pretreatment and filtration, and inactivation by disinfection.

Treatment effectiveness under this rule is determined through turbidity measurements:

- The turbidity of representative samples of a system's combined filtered water must be less than or equal to 0.5 NTU in at least 95 percent of the measurements taken each month.
- The turbidity level of representative samples of a system's combined filtered water must at no time exceed 5 NTU.

Well operated conventional treatment plants which at least meet the 0.5 NTU effluent turbidity standard are credited with a 2.5-log removal of *Giardia* cysts and a 2-log removal of viruses. The remainder of the overall 3-log *Giardia* cyst and 4-log virus treatment is provided by inactivation using disinfection. Compliance with the disinfection requirement must be demonstrated by meeting minimum

"CT" requirements, where C is the residual disinfectant concentration in mg/L, and T is the effective contact time in minutes with the disinfectant.

3.6.1.2 Interim Enhanced Surface Water Treatment Rule (IESWTR)

This rule, finalized in December 1998, is the first regulation to specifically address chlorine resistant pathogens such as *Cryptosporidium*. In addition to the requirements of the Surface Water Treatment Rule, this rule establishes a Maximum Contaminant Level Goal (MCLG) of zero for *Cryptosporidium*, the organism which causes *cryptosporidiosis*. This rule introduces a number of new monitoring requirements related to halogenated disinfection byproducts. It also lowered the combined filter effluent turbidity to less than or equal to 0.3 NTU in 95 percent of all measurements. Systems that meet the turbidity standard are assumed to provide at least 2-log *Cryptosporidium* removal through filtration. This rule also establishes criteria for systems that must establish a disinfection profile by collecting additional data related to the disinfection process and DBP formation.

3.6.1.3 Long-Term enhanced Surface Water Treatment Rule and Filter Backwash Rule (LT1FBR)

This rule was finalized June 8, 2001 and is referred to as the LT1FBR, since it combines the LT1SWTR and Filter Backwash Rule. The purpose of the rule is to minimize *Cryptosporidium* concentrations in the treated water as a result of recycling sludge supernatant and filter backwash wastewater to the head of the treatment plant. The major requirements of the proposed rule are as follows:

- Systems that recycle backwash waste must do so prior to the point of application of primary coagulant.
- Direct filtration plants could be required to provide detailed recycle treatment information to the State (which could then require modifications).
- Conventional treatment plants with 20 or fewer filters must conduct a one-month (one-time) self-assessment, including hydraulic flow monitoring.

3.6.1.4 Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)

The LT2ESWTR is scheduled for finalization in May 2002 and should become effective in May 2005. This rule requires proportional treatment levels or watershed-based treatment levels based on *Giardia* and *Cryptosporidium* levels in the source water. Other pathogens such as *Cyclosporeae* and *Legionella* may also be included in this rule, if information on occurrence, health effect, and treatment demonstrate a need for these regulations.

The additional treatment requirements for *Cryptosporidium* inactivation are presented in Table 3.2, *Cryptosporidium* Inactivation Requirements Per LT2ESWTR. They are based, in part, on the assumption that conventional treatment plants in compliance with the IESWTR achieve an average of 3-log removal of *Cryptosporidium*. The total *Cryptosporidium* removal requirements for

the action bins with 1-log, 2-log and 2.5-log additional treatment correspond to total *Cryptosporidium* removals of 4-log, 5-log and 5.5-log, respectively.

Table 3.2 *Cryptosporidium* Inactivation Requirements Per LT2ESWTR

Bin No.	Average Source Water *Cryptosporidium* Concentration	Additional treatment requirements For systems with conventional treatment That are in full compliance with IESWTR
1	*Cryptosporidium* < 0.075/L	No action
2	0.075/L < *Cryptosporidium* < 1.0/L	1-log treatment (systems may use any technology or combination of technologies from toolbox as long as total credit is at least 1-log)
3	1.0/L < *Cryptosporidium* < 3.0/L	2-log treatment (systems must achieve at least 1-log of the required 2-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)
4	*Cryptosporidium* ≥ 3.0/L	2.5-log treatment (system mush achieve at least 1-log of the required 2.5-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)

3.6.1.5 Stage 1 and 2 Disinfectants/Disinfection By-Products Rules (D/DBPR)

The Stage 1 D/DBPR has been finalized and becomes effective for public water systems serving more than 10,000 people in December 2001. This rule replaces the previous total trihalomethane (TTHM) standard of 0.1 mg/L (100 μg/L) with 0.08 mg/L (80 μg/L). It also regulates the sum of five haloacetic acids (HAA-5) at 60 μg/L, and establishes the MCL for bromate ion (BrO^-_3) at 10 μg/L. This rule also requires total organic carbon (TOC) monitoring and TOC removal to be investigated by enhanced coagulation or enhanced softening. The rule further specifies the percentage of influent TOC that must be removed based on the raw water TOC, ultraviolet (UV) light absorbance, and alkalinity levels, as shown in Table 3.3, Percentage of TOC Reduction Requirements Per Stage 1 D/DBPR.

Table 3.3 Percentage of TOC Reduction Requirements Per Stage 1 D/DBPR

Raw Water TOC (mg/L)	Raw Water Alkalinity (mg/L as $CaCO_3$)		
	< 60	60 – 120	> 120
> 2 – 4	35%	25%	15%
> 4 – 8	45%	35%	25%
> 8	50%	40%	30%

TTHMs include the following four compounds:
- Chloroform
- Bromoform
- Bromodichloromethane
- Dibromochloromethane

The five regulated haloacetic acids are:
- Chloroacetic acid
- Dichloroacetic acid
- Trichloroacetic acid
- Bromoacetic acid
- Dibromoacetic acid

The Stage 2 version of this rule is scheduled for finalization in May 2002 and should become effective in May 2005. MCLs will remain at 80 μg/L for TTHM and at 60 μg/L for HAA-5 but must be calculated using the Locational Running Annual Average (LRAA). Each site of sampling must not exceed these MCLs. In addition, the MCL for bromate ion remains at 10 μg/L, based upon current alternative technology utilization and upon current understanding of bromate ion formation as a result of bromide concentrations. EPA is committed to review the bromate ion MCL as part of a 6-year review to determine whether the MCL should remain at 10 μg/L or be reduced to 5 μg/L or a lower concentration.

3.6.1.6 Radionuclides Rule

On December 7, 2000, the EPA announced updated standards for radionuclides and a new standard for uranium, as required in the amendments to the 1986 Safe Drinking Water Act (SDWA). The revised standards are as follows:
- Combined Radium, 226 and 228 5 pCi/L
- Total Beta emitters 4 mrem
- Gross Alpha, MCL 15 pCi/L
- Uranium, MCL 30 μg/L

This rule becomes effective on December 8, 2003. The monitoring requirements are being phased in from December 2000 to December 2003. Water systems will determine initial compliance under the new monitoring requirements using the average of four quarterly samples, or at State direction, using appropriate grandfathered data.

3.6.1.7 Arsenic Rule

On January 22, 2001, the EPA proposed a reduction in the current arsenic standard from 50 μg/L to 10 μg/L. The proposed new standard has significant cost implications for water utilities, and as such, significant debate surrounding the revised MCL was conducted. The Bush administration reviewed the rule and affirmed it in October 2001. This rule became effective on February 22, 2002. The date by which the City of Avondale must comply with the new arsenic standard is January 23, 2006. As reported in Section 5.5.2 Water Quality Data, several City of Avondale wells (6, 7, 11, 14, and 15) currently exceed the future MCL for arsenic (10 μg/L).

3.6.1.8 Lead and Copper Rule

The USEPA established the Lead and Copper Rule in 1991. This rule differs from the other rules because it applies at the customer's tap rather than at the plant or in the distribution system. Action levels for lead and copper, 0.015 mg/L and 1.3 mg/L respectively, have been established to minimize corrosion in the distribution system. In addition, the rule seeks source water treatment, if appropriate, public education and lead service line replacement.

Avondale is required to perform a series of lead and copper tests throughout the community every three years. The last series of tests were completed in July 2001 showing that Avondale is in compliance with the lead and copper rule.

3.6.1.9 Groundwater Disinfection Rule

This rule will establish disinfection requirements against microbial contamination for groundwater systems. For systems which are not disinfecting, sanitary surveys, hydrologic sensitivity studies, and potentially, source water monitoring will be required. For systems which are disinfecting, compliance monitoring for 4-log (99.99%) virus inactivation or removal will be required. This rule was proposed in May of 2000 and should be finalized in early 2002.

3.6.2 Secondary Drinking Water Regulations

Secondary Drinking Water Regulations essentially function as guidelines for water utilities because they are not enforceable by law. This is in contrast to the Primary Drinking Water Regulations discussed previously in this chapter. A total of 15 contaminants are covered by the Secondary Drinking Water Regulations. Only those with particular applicability to Avondale are presented below.

Taste and odor is an aesthetic issue which is addressed by the Threshold Odor Number (TON). The secondary standard for TON is 3. The TON test involves diluting several aliquots of the finished water with odor free water, and warming them to 110 degrees F (45ºC). The samples are smelled by one or more individuals and the highest dilution in which an odor can be perceived is identified. The dilution of that sample is reported as the TON. Typically, the results for this test are an integer number with the lowest being 1 (i.e. undiluted sample).

Water color is limited to 15 Color Units (CU). Color is measured by comparing the water to known standards and determining the closest match. Color in water is usually associated with organics in the water or specific metals such as iron or manganese. Organic removal is now required by the various surface water treatment and disinfection byproduct rules. As noted below specific secondary standards exist for iron and manganese.

To avoid either corrosion or scaling of the distribution system, a pH range of 6.5 to 8.5 is included in the secondary standards.

The secondary standards limit Total Dissolved Solids (TDS) to 500 mg/L to improve palatability and to reduce negative physiological reaction in transient consumers. Similarly, chloride and sulfate ions are limited to 250 mg/L each. In addition, these limits tend to reduce corrosion.

Fluoride ion is limited to 2.0 mg/L to prevent negative effects on children's teeth. It should be noted, that there is also a primary standard for fluoride ion of 4.0 mg/L as indicated in Table 3.1.

Iron and manganese are both limited to reduce color in the water and to prevent staining of clothing during washing. Iron is limited to 0.3 mg/L and manganese is limited to 0.05 mg/L.

3.7 Regulatory Impact on Avondale

All of the laws, regulations, and rules presented above are applicable to the City of Avondale. The Surface Water Treatment Standards will be applicable only if Avondale elects to treat and use surface water directly instead of the current recharge approach. The current recharge of surface water in essence converts it to ground water and the surface water rules do not apply. Limits on arsenic and nitrate will impact those wells which exceed the limits. Specific well water qualities will need to be considered in formulating the proper treatment response for individual wells or groups of wells. Treatment requirements for existing wells are discussed in Section 6.3.2.

4.0 Water Demands

One of the fundamental issues in projecting the water resources needs for the City of Avondale, is the development of accurate water demand predictions. In order to project future water demands within the City of Avondale, population projections were studied. In the *2001 Water Infrastructure Master Plan*, population projections through 2040 were developed, along with their corresponding water demand. These population based demand projections are briefly described below and are compared with land use based demands which have been computed here.

Water demand planning criteria has been established on a gallons per acre per day level for various different land use types. These planning demands will help establish an overview of the water duty which will be required for a specific land use type. It is important to note, that the water demands established here are for planning purposes only. Water requirements for design purposes are described in the *2001 Water Infrastructure Master Plan*.

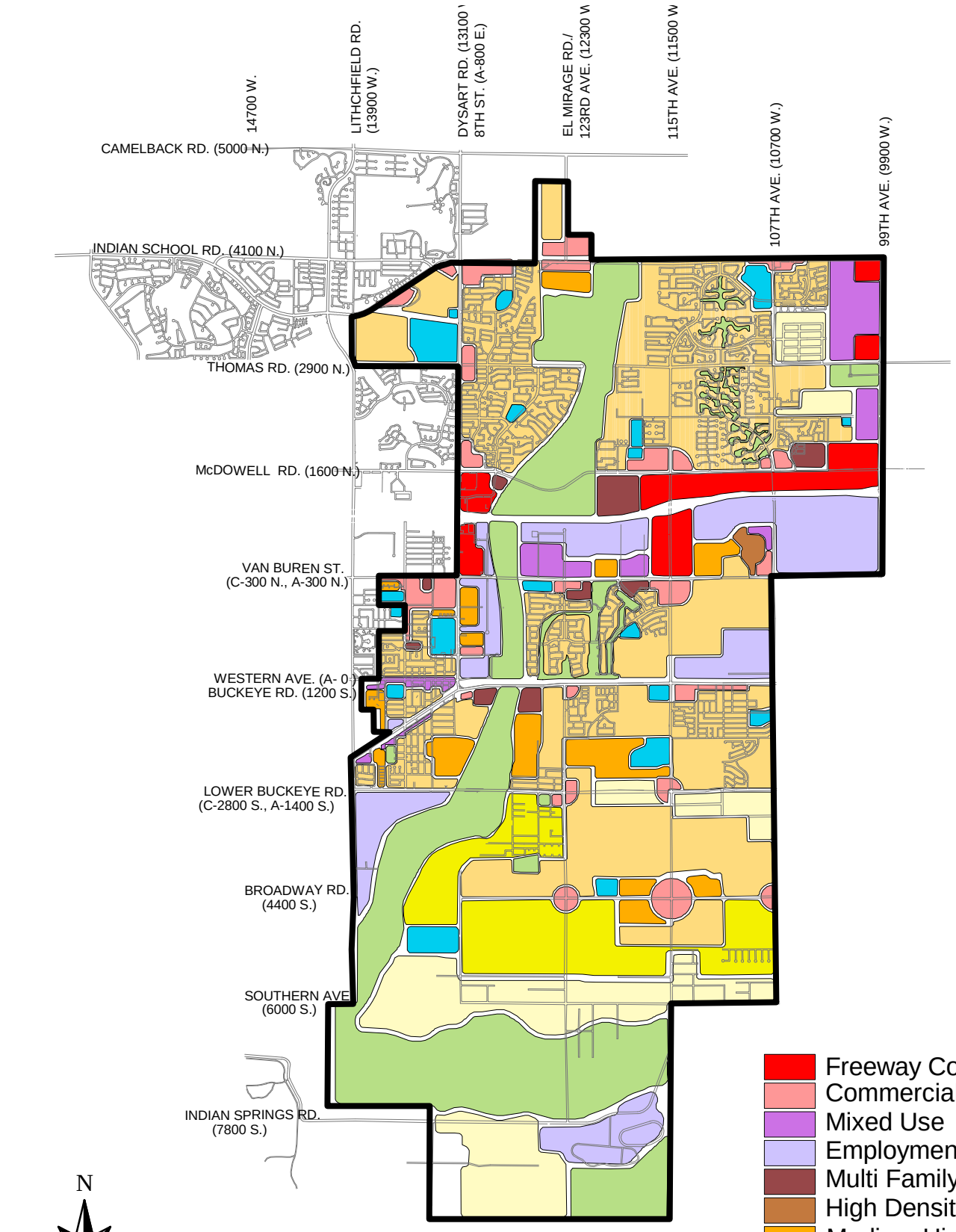
4.1 Planning Area

Avondale's Municipal Planning Area (MPA), which was established in the General Plan, was used for this master plan. The MPA identifies the boundaries that the City of Avondale intends to annex in the future. Figure 4.1, Avondale Municipal Planning Area (Northern) shows the MPA for the City of Avondale as well as the study area for this project. The MPA is divided into two sections, a northern portion which starts north of the Estrella Mountains and terminates at Indian School Road, and a southern portion which runs from the Estrella Mountains south to Patterson Road.

The projected populations and corresponding water demands were computed in the *2001 Water Infrastructure Master Plan*. A summary of these populations and demands is shown in Table 4.1, Population and Demand Projections. The projected populations only included those areas in the northern portion of the MPA. It is anticipated that there will be approximately 44,000 additional people in the southern MPA requiring an additional 9,857 acre-feet of water per year.

Table 4.1 Population and Demand Projections

Year	Population	Demand (Ac-ft/year)
2001	40,350	8,012*
2006	61,845	13,855
2011	83,506	18,708
2016	105,167	23,560
2021	126,828	28,413
2026	148,489	33,266
2040	167,665	37,562



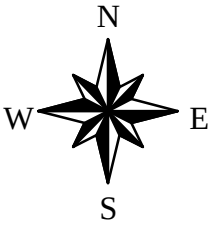


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Figure 4.1
Avondale Municipal Planning Area (Northern)

The population based water demands which are presented in Table 4.1 are based on the recommended combined per capita flow rate of 200 gallons per capita per day. This flow rate averages the total residential and nonresidential flow within the City of Avondale over each resident.

Avondale's total MPA was analyzed, and it was determined that the entire projected area, as shown in the City's General Plan, will remain within the boundaries of the Phoenix AMA.

The main focus of this Water Resources Master Plan, is to identify the water resource requirements for the northern portion of the Avondale MPA. When the portion of the City south of the Estrella Mountains is developed, it is recommended that the developers in that area be responsible for locating sufficient water supplies to meet the needs of their developments. One possible source that the developers may consider is utilizing Indian lease water.

4.2 Demand Categories

In order to establish a reliable and consistent planning criteria, water demands were established in a gallons per acre per day format for various water use categories. The following categories were used as the representative land uses within the City of Avondale: Residential, Turf, Commercial, and Nonresidential. Table 4.2, Water Consumption by Category, shows the water consumption along with the water use category.

Table 4.2 Water Consumption by Category

Category	Consumption (gal/ac/day)
Low Density Residential (2du/ac)	1,000
Med Density Residential (4du/ac)	2,000
High Density Residential (10du/ac)	5,000
Commercial	2,000
Non-Residential	1,000
Turf	4,000

The water consumption requirements shown above were established based on City of Avondale production and use data. This information should be used for general planning purposes only. Various assumptions were made in developing these consumptive uses. The Residential demands are broken out for three generic densities only. Adequate commercial flow data was unobtainable from the City's meter records. It is therefore recommended that a consumption of 2,000 gallons per acre per day be used based on the commercial water requirements from other municipalities located within the Phoenix Metropolitan Area. Non-residential consumption data was obtained by averaging the

demands of other uses within the City of Avondale. The consumptive use for turf was computed based on average consumptive use calculations for Bermuda and Rye grass within the Phoenix area of the state of Arizona. Additional water use by category information as provided by the City of Avondale can be seen in Appendix F-1, Consumptive Use by Categories.

4.3 Water Planning Zones

The City of Avondale was divided into four water planning zones to analyze the water demands for the four separate planning periods. The water demands computed in the *Water Infrastructure Master Plan* were based on population projections which were computed for the various planning periods. The population based water demands were further broken down to compute specific demands for each of the water planning zones. The four water planning zones for the City of Avondale are:

- North of I-10, east of the Agua Fria River (NE)
- North of I-10, west of the Agua Fria River (NW)
- South of I-10, east of the Agua Fria River (SE)
- South of I-10, west of the Agua Fria River (SW)

The present day water demands do not include the water usage from users served by private water companies. For the purposes of this study, it is anticipated that the City of Avondale will acquire the Wilhoit Water Company before the year 2006, and the remaining water companies at the time significant development in the City reaches those areas. Therefore, the water demands for the private water companies are separated from the composite demands for the present day only, and are included with the demands for the remaining planning periods.

The water demands based on land use were calculated for a single build out period. The land use map shown in Figure 4.1, Avondale Municipal Planning Area (Northern) defines the projected land uses for various segments of the City for the ultimate build out period. The results of this analysis as well as the planning zone boundaries are shown in Figure 4.2, Planning Zone Water Demands. Table 4.3, Planning Zone Water Demands, also lists the water demands for each of the planning zones.

Table 4.3 Planning Zone Water Demands (acre-feet/year)

	2001	2006	2011	2026	2040	Land Use
NE	3,745[1]	5,143	5,237	7,309	8,793	8,943
NW	2,125[1]	2,895	3,984	4,549	4,549	4,223
SE	1,745[1]	4,089	7,519	18,616	21,380	19,666
SW	1,425	1,674	1,967	2,791	2,840	4,168
Total	9,040	13,800	18,708	33,266	37,562	37,000

[1]The 2001 water demand does not include consumption the private water company service areas.

Planning Zone Water Demands

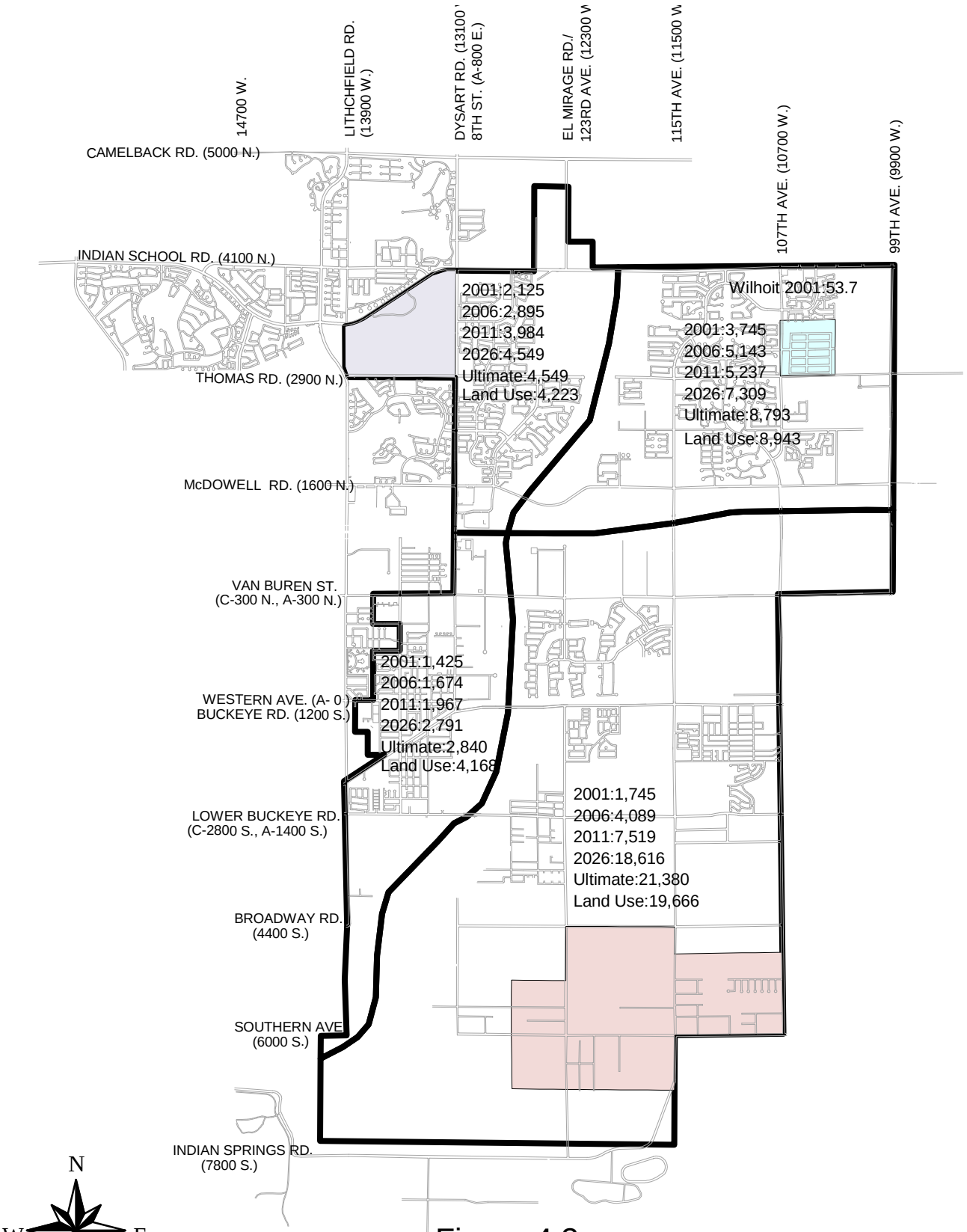

Figure 4.2
Planning Zone Water Demands

Demands (ac-ft)
Streets
Rigby Water Company (Acquisition Anticipated by 2026)
Wilhoit Water Company (Acquisition Anticipated by 2006)
LPSCO (Acquisition Anticipated by 2011)

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It can be seen in Table 4.2, that the ultimate demand based on the population projections is 37,562 AFY, while the ultimate demand based on land use projections is 37,000 AFY. These two values vary due to the different methods used for computing the water demands. The population based demands were calculated using the design factors specified earlier. The land use based demands were calculated utilizing Table 4.2, Water Consumption by Categories, and the areas for each land use in Figure 4.1, Avondale Municipal Planning Area (Northern). In computing the land use based demand, the assumption was made that each open space area would have a turf cover of 75% of the total area. These land use based projections could vary widely based on the actual growth patterns in the City, the conservation measures implemented, and the type of open space that is developed. The land use computations are shown in greater detail in Appendix E-5, Land Use Areas.

4.4 Hydrologic Year

The water demands summarized above represent the demands for a normal hydrologic year. This would be a year, in which a normal amount of rainfall occurs. It is also important to consider the effects on water demands during drought years.

There are various definitions to the term drought, and no single defining definition could be established to evaluate drought conditions. The National Oceanic and Atmospheric Association gives four definitions for the term drought, which are provided below.

> Meteorological - a measure of departure of precipitation from normal. Due to climatic differences what is considered a drought in one location may not be a drought in another location.
> Agricultural - refers to a situation when the amount of moisture in the soil no longer meets the needs of a particular crop.
> Hydrological - occurs when surface and subsurface water supplies are below normal.
> Socioeconomic- refers to the situation that occurs when physical water shortage begins to affect people.

While a drought can be defined in a variety of different ways and can have many different effects, SRP was contacted to determine their definition of a drought. While SRP has no official definition of a drought, the *SRP Strategic Water Resource Plan", January 1994, Section V.C., Severe Drought Plan Results*, Paragraph 2, in part, states that:

> The term "drought" is synonymous with life in the desert, and occurs frequently and for long periods of time on SRP's watershed. The definition for drought is most commonly associated with below normal precipitation and

surface water runoff. For SRP, the duration of below normal precipitation and runoff has dictated whether the watershed is in a drought condition.

Through the development of the Severe Drought Plan the following results indicate what the term "drought" means to SRP:

- Drought is defined as three or more consecutive years of annual reservoir inflows 15% or more below normal.
- SRP has experienced ten drought periods since 1889.
- All drought events have happened simultaneously on both Salt and Verde river systems.

SRP also indicated that any official definition of a drought must come through the Arizona Department of Water Resources. In discussing the effects of a drought, typically extra conservation measures are put into place during times of drought, in order to preserve the limited water supply. Generally, during times of drought a water provider will be required to rely more heavily on groundwater supply due to the decreased availability of surface water.

4.5 On Project vs. Off Project Demands

In determining the amount of water that the City of Avondale must provide, it is important to distinguish between “on project” and “off project” demands. As discussed previously in Section 2.1.3.1, SRP water may only be used to meet the water demands from SRP project lands. A map of the SRP project land can be seen in Figure 2.1, SRP Member Lands within Avondale. It has been estimated, that at buildout there will be 6,559.75 acres of SRP project lands cut to the City (Appendix C-2, City of Avondale SRP Water Entitlement – as of December 31,2001).

The historical water usage for both the “on project” and “off project” lands was analyzed for the years 1998-2000, and then extrapolated for the remainder of 2001 as well as for each of the planning periods. Based on the population projections, the water demands were determined for each of the planning periods for both “on project” demands, and “off project” demands. Table 4.4, On Project and Off Project Demands, shows the total water demand as well as the projected on-project and off-project demands.

Table 4.4 On Project and Off Project Demands (acre-feet/year)

	1998	1999	2000	2001	2006	2011	2026	2040
ON	2,007	3,003	3,327	4,419	7,417	9,278	15,380	17,469
OFF	2,534	3,020	3,638	4,123	6,438	9,430	17,885	20,093
Total	4,541	6,023	6,965	8,542	13,855	18,708	33,266	37,562

4.6 Water Supply and Demand Analysis

In order to better plan for the City's future water resources needs, it is important to identify those areas where the City of Avondale must acquire additional water supply, as well as recognizing the amount of supply that must be acquired. A description of the City's raw water supply was given in Section 2.2, Water Supply, of this document. Table 4.5, Water Supply Analysis, provides a summary of the current (2001) and projected water supplies, as well as the projected water demand.

Table 4.5 Water Supply Analysis (acre-ft/year)

	2001	2006	2011	2026	2040
CAP	4,746	4,746	4,746	4,746	4,746
SRP[1]	6,619	8,463	8,878	13,017	14,433
Phase In Allowance	265	265	265	265	265
Incidental Recharge	221	614	829	1,474	1,664
Subtotal	11,851	14,088	14,718	19,501	21,108
Reclaimed Water	-	-	6,777	12,050	13,607
Long Term Storage or CAGRD	-	-	-	1,714	2,847
Total Water Supply	11,851	14,088	21,495	33,266	37,562
Water Demand	8,542	13,855	18,708	33,266	37,562
Excess	3,309	233	2,787	0	0

1. SRP water used to meet "on project" demand only.

As can be seen from Table 4.5, Avondale currently has more than sufficient water supplies to meet their current demand. Avondale is making use of these supplies by recharging the excess water when allowed, and receiving long-term storage credits.

In order to have sufficient water resources available to the City, Avondale must take two critical steps. The City of Avondale must increase their AWS designation for SRP Water, implement a reclaimed water plan, and implement a conservation plan.

Currently the City of Avondale's AWS designation for SRP water is only 8,463 AFY. This quantity of water is projected to be sufficient through 2006. Based on discussions with SRP, there is a greater quantity of water available which the City is entitled to. The projected quantity of water from SRP sources is described in greater detail in Section 2.2.3, SRP. The projected SRP values are shown in Table 4.5, however, in order to have these values recognized in the AWS designation, a "modification of designation" must be filed with ADWR requesting that the additional supply be included.

The second renewable source of water which must be developed in order for Avondale to maintain sufficient water supplies, is a reclaimed water plan. Section 6.2 provides a detailed description of the reclaimed water plan which must be developed. Based on the projections shown above, the reclaimed water plan must be in place in the 2006-2011 planning period.

It can be seen from Table 4.5, that if the water supply recommendations are followed, the City of Avondale will need to utilize their Long Term Storage Credits, or CAGRD water by the year 2026. It is projected that 1,714 AFY and 2,847 AFY will be required from these sources in the 2026 and 2040 respectively. It is important to note, that while these sources of water must be utilized in order to maintain the City's AWS designation, SRP projects that they will be able to provide the City with 19,578 AFY of water to meet the on-project demands during drought conditions. Based on the analysis presented here however, only 17,469 AFY of water would be able to be utilized since this is the projected on project demand. If the City of Avondale receives this quantity of SRP water, they will have an excess of 189 AFY at build out without utilizing CAGRD or their long-term storage credits.

Another method that will reduce the City's need for additional water resources is the implementation of a conservation program. A conservation program has been developed as part of this master plan, and is provided in Section 6.4, Water Conservation Measures.

5.0 Hydrogeologic Study

A well siting study was performed within the City of Avondale to identify favorable locations for future water supply wells. This report represents the compilation, review, and analysis of existing data to identify and prioritize preferred water supply well sites within the City of Avondale. The study area is approximately bounded by the Dobbins Road alignment to the south, ½ mile west of Litchfield Road to the west, ½ mile east of 99th Avenue to the east, and ½ mile north of Indian School Road to the north. The study area encompasses approximately 58 square miles and includes portions of Townships 1 North, 1 South, and 2 North; and Ranges 1 West and 1 East. The study area boundary is shown on Figure 5.1, Well Location Map.

The purpose of this report is to identify favorable well locations based on available geologic and hydrogeologic data. A discussion of the hydrogeologic setting of the study area is presented in Section 5.1, Hydrogeology, and the groundwater quality of the area is presented in Section 5.2, Groundwater Quality. A description of the land and infrastructure evaluation process is presented in Section 5.3, Land and Infrastructure Evaluation, and the well siting evaluation process is presented in Section 5.4, Well Site Analysis. The conclusions and recommendations are presented in Section 5.5, Conclusions and Recommendations, data tables are presented in Appendix F-1, Tables and Results, and references used in this report are included in Section 7.0. Ownership of land parcels within the study area is not considered in this well siting study. The determination of land ownership should be addressed by the City at a later time to fully evaluate potential well sites.

This well siting study is based on existing data sources including: the Arizona Department of Water Resources (ADWR); the United States Geological Survey (USGS); the City of Avondale (City) files; unpublished consultants' reports; driller's logs; and Clear Creek Associates files. Clear Creek Associates interpretation of the subsurface geology is based on these data sources.

5.1 Hydrogeology

5.1.1 Regional Geologic Setting

The study area is located in the west Salt River Valley, which lies within the Basin and Range Physiographic Province. The Basin and Range Physiograghic Province is characterized by isolated mountain ranges separated by alluvial valleys. The mountain blocks are composed of a complex suite of igneous, metamorphic, sedimentary, and volcanic rocks. The basins in the Basin and Range Province are tectonically induced troughs that have been filled to great depths with sediment eroded from the surrounding mountain blocks. The basin-fill deposits of the West Salt River Valley range in thickness from a few tens of

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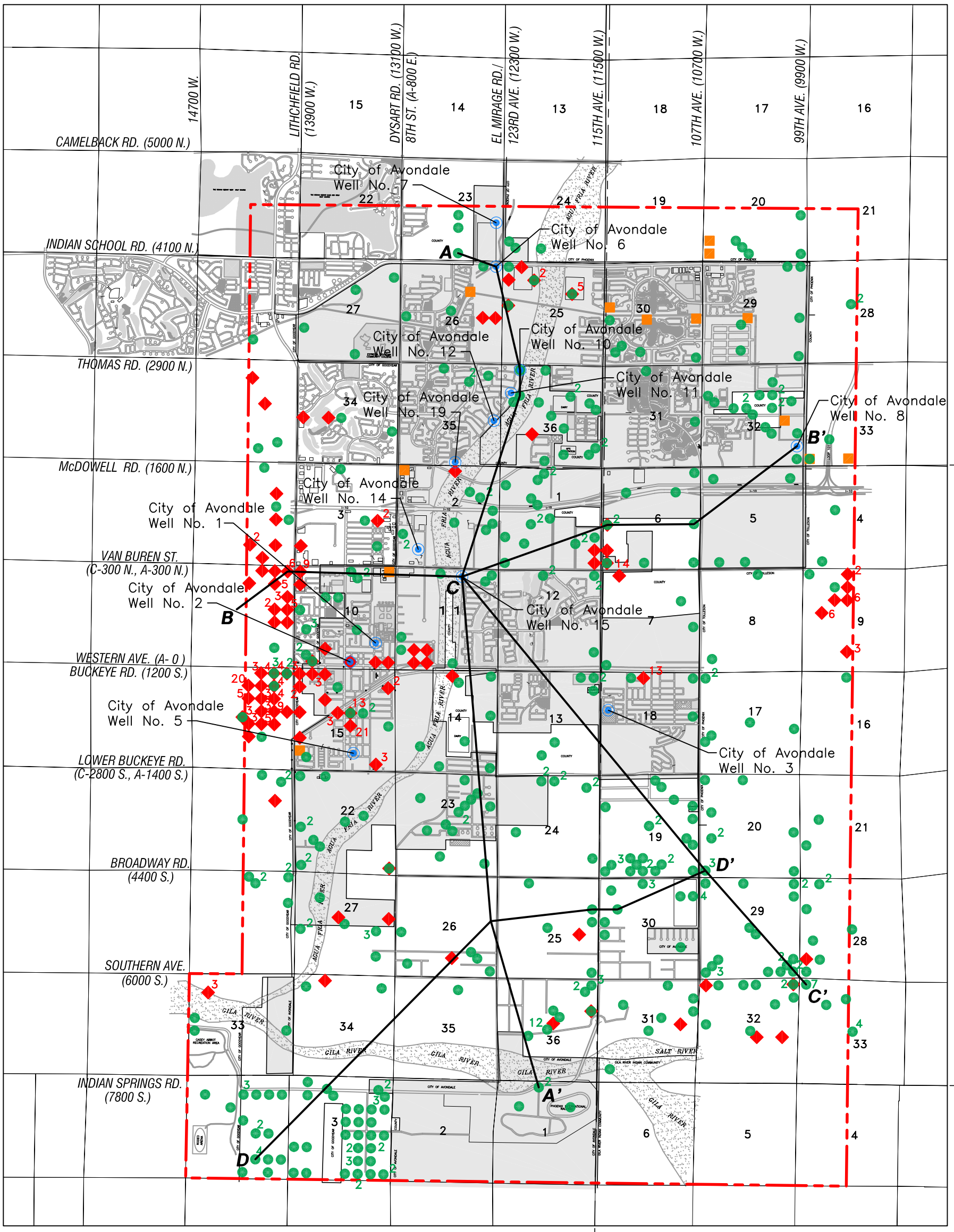

Explanation

- City of Avondale Active/Recovery Well
- Roosevelt Irrigation District Well
- Monitor or Test Well
- Other Well
- 2 — Number of Wells at Location
- Study Area
- A — A' Location of Cross–Section

SCALE
2640' 0 2640' 5280'

Source: ADWR well registry database August, 2001. (See Table 5A–1)

FIGURE 5-1
Well Location Map
City of Avondale
Water Resource Master Plan
Avondale, Arizona

feet along the basin margins to more than 11,000 feet near the center of the basin where a large structural depression forms the down-faulted core of the West Salt River Valley (Brown and Pool, 1989). Metamorphic, granitic, and crystalline extrusive rocks comprise the mountains that border the basin and underlie the basin-fill deposits. The sediment comprising the subsurface strata was eroded from the surrounding highlands and deposited in the basin by streams (fluvial deposition), gravity (colluival deposition), or lakes (lacustrine deposition). The basin-fill sediments are characterized by wide variability in their lateral and vertical distribution. Fluvial deposits of the Gila, Salt, and Agua Fria River channels and floodplains are located within the study area.

The basin-fill deposits are discontinuous and lenticular in character due to variations in the source rocks and depositional processes over time. Although the strata underlying the West Salt River Valley are discontinuous, they have been divided into recognizable stratigraphic units by various agencies. The United States Bureau of Reclamation (USBR) conducted a geologic investigation for installation of the Central Arizona Project (CAP) canal. During that investigation, the USBR (1976) defined three hydrogeologic units that are designated (from top to bottom) as the Upper Alluvial Unit, the Middle Fine-Grained Unit, and the Lower Conglomerate Unit. The USGS also recognized three hydrogeologic units, and further subdivided the basal unit into upper and lower portions. The hydrogeologic units described by Brown and Pool (1989) are the Upper Unit; the Middle Unit; and the Lower Unit; which was further subdivided into an upper part and a lower part. The Arizona Department of Water Resources (ADWR) also recognized and described three stratigraphic units for the Salt River Valley. The stratigraphic units defined by ADWR are (from top to bottom) the Upper Alluvial Unit, the Middle Alluvial Unit, and the Lower Alluvial Unit (Corkhill and others, 1993). The Red Unit and crystalline rocks represent progressively deeper geologic units that underlie the basin-fill alluvium. The nomenclature for these rocks is generally consistent between USBR, USGS, and ADWR. This report refers to the Upper Alluvial Unit, the Middle Alluvial Unit, and the Lower Alluvial Unit only when identifying aquifer characteristics from the ADWR Regional Groundwater Flow Model of the Salt River Valley (Corell and Corkhill, 1994).

Crystalline rocks in the southern region of the study area consist primarily of metasedimentary, metavolcanic, gneissic, and granitic rocks of the Sierra Estrella Mountains (Reynolds and Skotnicki, 1993). The crystalline rocks have a northeast trending foliation and are in unconformable contact with the overlying strata.

The principal faults in the West Salt River Valley are oriented north-south along the western margin of the basin, westward along the southern margin of the basin, and northwestward along the northern margin of the basin. Based on gravity data, Brown and Pool (1989) mapped an east-west trending normal fault,

which is located in the area between Lower Buckeye Road and Broadway Road. Near the Luke Salt Body, approximately 2 miles northwest of the study area, the depth to bedrock has been estimated from 10,000 feet to 15,000 feet (Eaton and others, 1972). A horst (fault-bounded uplift) was mapped beneath the Luke Salt Body by Brown and Pool (1989).

5.1.2 Local Geology

The available geologic data indicates that an extensive and relatively thick layer of clay is present beneath much of the study area. The significant thickness of the clay strata is evidenced by City of Avondale Well No. 15 (Figure 5.1, Well Location Map), which reportedly penetrated approximately 900 feet of clay. Drillers' logs and consultants' logs were used to prepare a map showing the depth of the top of this extensive clay unit (Figure 5.2, Depth to Top of Extensive Clay Unit). The top of the clay unit is deepest in the vicinity of City of Avondale Wells No. 15 and 19. The depth of the bottom of the clay unit is poorly defined due to a lack of deep wells that have completely penetrated the clay unit. Therefore, the thickness of the clay unit could not be determined.

Four hydrogeologic cross-sections and a fence diagram using lithologic descriptions from driller's logs and consultant reports (Appendix F-2, Well Drillers Reports) were prepared. The cross-section locations are presented on Figure 5.1, Well Location Map, and for reference, an explanation of the well numbering system in Arizona is presented in Appendix F-3, Legal Description of Well Locations. Cross-section A-A' is oriented north to south, cross-section B-B' is oriented southwest to northeast, cross-section C-C' is oriented northwest to southeast, and cross-section D-D' is oriented southwest to northeast across the study area. The perspective of the fence diagram is to the northeast, and includes cross-sections A-A', B-B', and C-C'. Cross-sections A-A', B-B', C-C', and D-D' are presented on Figures 5.3 through 5.6, respectively, and the fence diagram is presented on Figure 5.7, Generalized Fence Diagram. The cross-sections and fence diagram indicate the generally lenticular and discontinuous units of sand, gravel, and clay (or mixtures of these sediments), which overly the extensive clay unit.

Review of the available data indicates that the depth to bedrock within the study area varies from 0 feet below land surface (bls) (at a rock outcrop on Monument Hill) to over 9,000 feet bls (Brown and Pool, 1989 and Oppenheimer and Sumner, 1980) (Figure 5.8, Depth to Bedrock). Several driller's logs indicate that bedrock was penetrated in the southern portion of the study area (Appendix F-2, Well Drillers Reports). Cross-section A-A' (Figure 5.3, Generalized Cross Section A-A'), cross-section D-D' (Figure 5.6, Generalized Cross Section D-D'), and the fence diagram (Figure 5.7, Generalized Fence Diagram) are based on depth-to-bedrock values from Brown and Pool (1989) and driller's logs.

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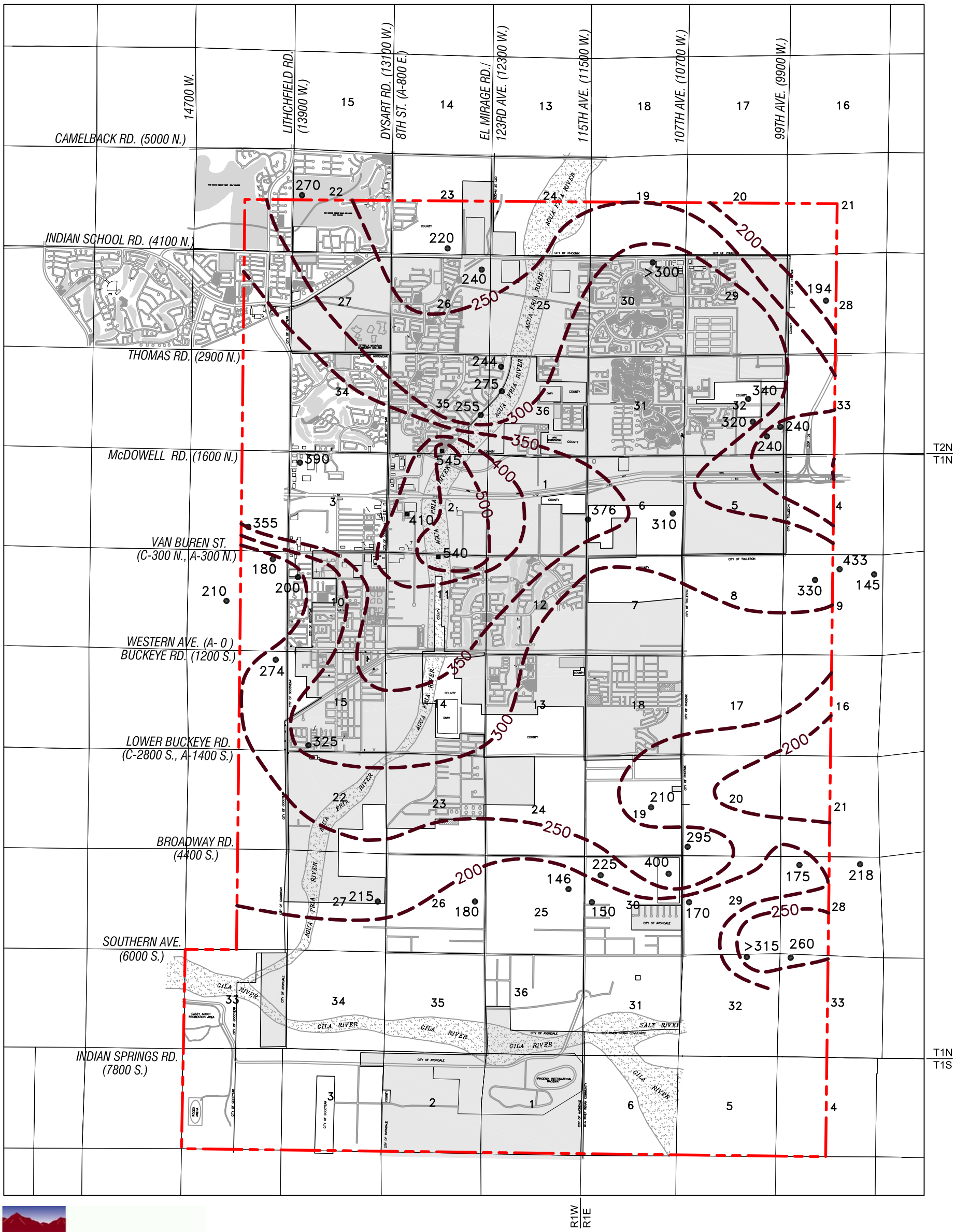

City of Avondale

Explanation

- ■110 — Well Location, Consultant Log
- ●150 — Well Location, Driller Log
- 400 — Inferred Depth to Top of Extensive Clays (feet below land surface)
- Study Area

SCALE

2640' 0 2640' 5280'

CONTOUR INTERVAL 50 Ft.

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CLEAR CREEK ASSOCIATES

Source: ADWR Drillers Logs.

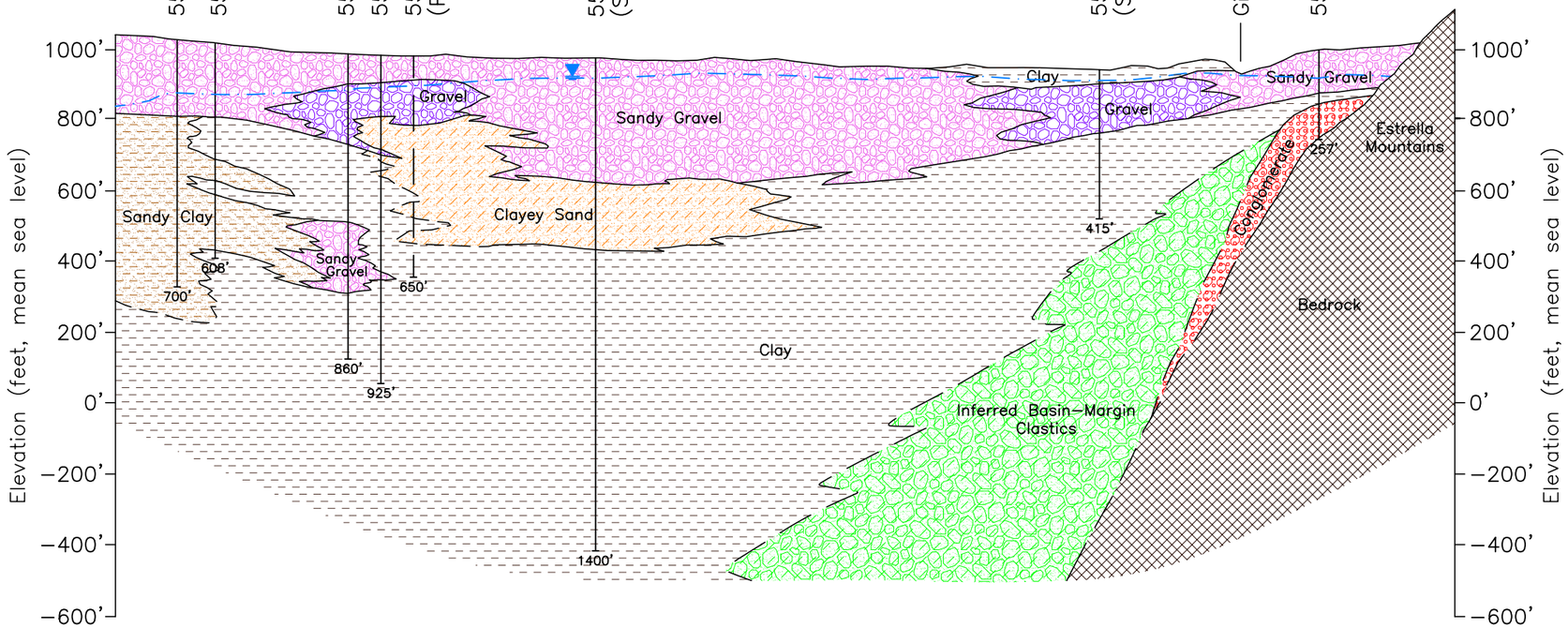
FIGURE 5-2
Depth to Top of Extensive Clay Unit
City of Avondale
Water Resource Master Plan
Avondale, Arizona

City of Avondale

NORTH
A

SOUTH
A'

55-533836
55-501247 (COA #6) - - BIS
55-608792 (COA #10) - - BIS
55-504634
55-588631 (COA #19)
(Projected east approx. 1/2 mile)
55-578749 (COA #15) - - BIS
(Section B-B')
55-559740 - - BIS
(Section D-D')
Gila River
55-582986



SECTION A-A'
Looking East

Horizontal Scale 1"=5280'
Vertical Scale 1"=400'
Vertical Exaggeration = 13.2
BIS = Bend in Section
55-533836 = ADWR Well Registration Number
(COA #15) = City of Avondale Well Number

Explanation

Approximate Groundwater Level

1400' — Well Trace with Hole Bottom Depth (feet below land surface)

Generalized Stratigraphic Units

- Clay
- Silty Clay
- Sandy Clay
- Clayey Sand
- Sand
- Sandy Gravel
- Gravel
- Inferred Basin-Margin Clastics
- Conglomerate
- Bedrock

Notes

Generalized stratigraphic units are based on drillers and consultants logs (dashed where inferred).

Bedrock depth location inferred from regional geophysical study (Brown and Pool, 1989) and drillers log.

See Figure 5-1 for cross-section location.

Approximate groundwater levels from ADWR GWSI database for the period October through December 1997.

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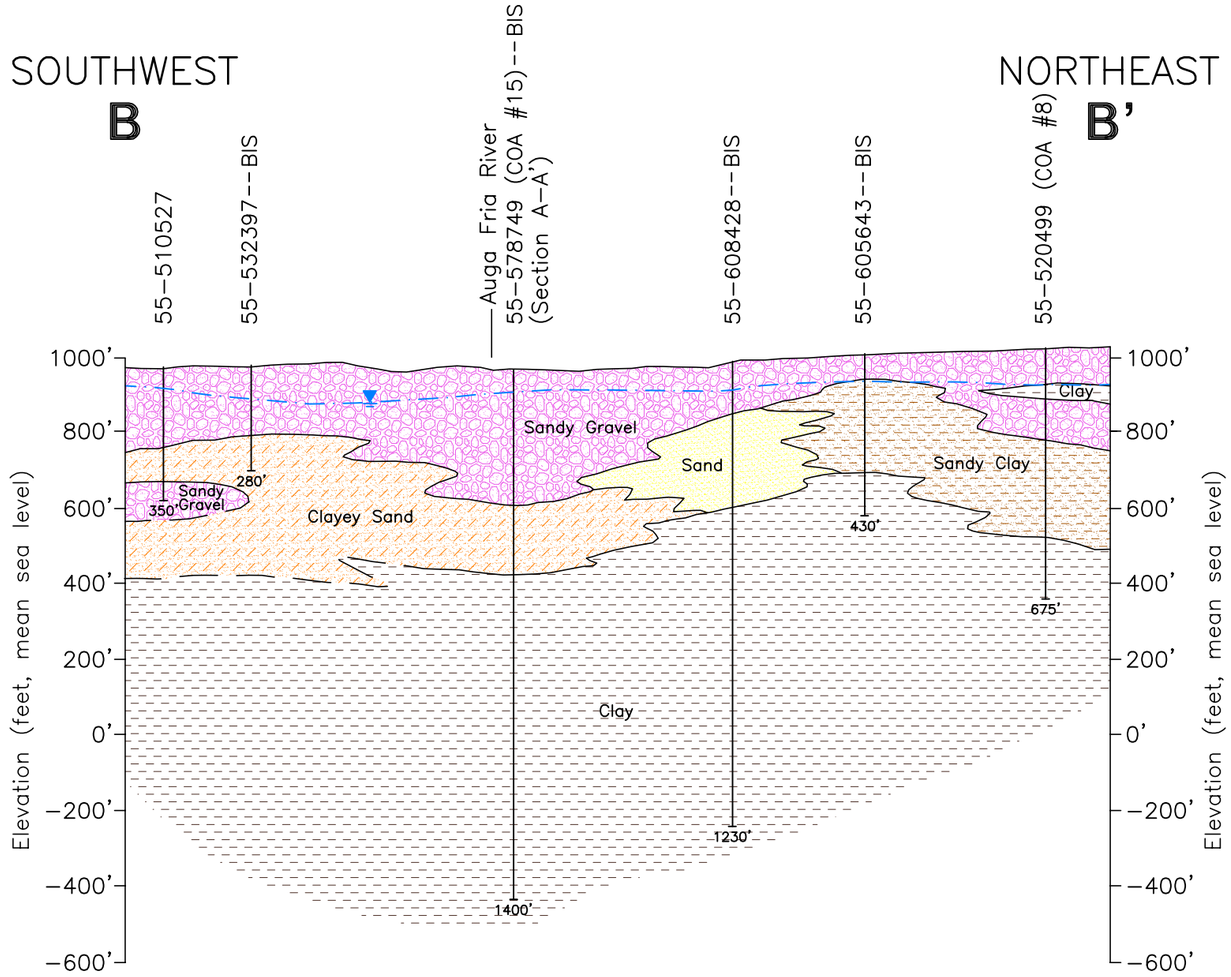
FIGURE 5-3
Generalized Cross-Section A-A'
City of Avondale
Water Resource Master Plan
Avondale, Arizona



SECTION B–B'

Looking North

Horizontal Scale 1"=5280'
Vertical Scale 1"=400'
Vertical Exaggeration = 13.2
BIS = Bend in Section
55–510527 = ADWR Well Registration Number
(COA #15) = City of Avondale Well Number

Explanation

Approximate Groundwater Level

Well Trace with Hole Bottom Depth (feet below land surface)

1400'

Generalized Stratigraphic Units

- Clay
- Silty Clay
- Sandy Clay
- Clayey Sand
- Sand
- Sandy Gravel
- Gravel
- Inferred Basin–Margin Clastics
- Conglomerate
- Bedrock

Notes

Generalized stratigraphic units are based on drillers and consultants logs (dashed where inferred).

See Figure 5–1 for cross–section location.

Approximate groundwater levels from ADWR GWSI database for the period October through December 1997.

FIGURE 5-4
Generalized Cross-Section B-B'
City of Avondale
Water Resource Master Plan
Avondale, Arizona

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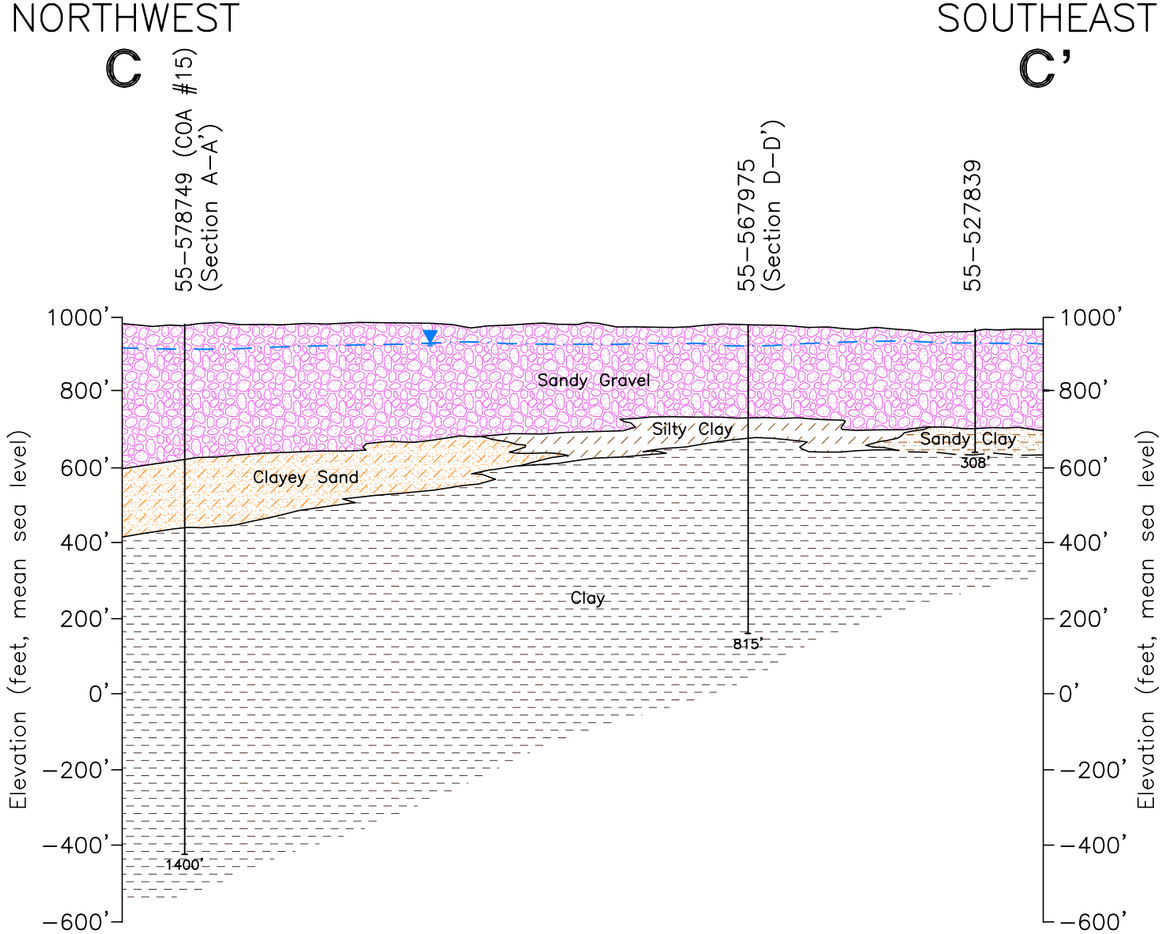
AutoCAD FILE: CCA-AVONDALE-5-4.DWG

NORTHWEST

C

SOUTHEAST

C'



SECTION C–C'

Looking N48 E

Horizontal Scale 1"=5280'
Vertical Scale 1"=400'
Vertical Exaggeration = 13.2
BIS = Bend in Section
55-578749 = ADWR Well Registration Number
(COA #15) = City of Avondale Well Number

Explanation

Approximate Groundwater Level

Well Trace with Hole Bottom Depth (feet below land surface)

1400'

Generalized Stratigraphic Units

- Clay
- Silty Clay
- Sandy Clay
- Clayey Sand
- Sand
- Sandy Gravel
- Gravel
- Inferred Basin–Margin Clastics
- Conglomerate
- Bedrock

Notes

Generalized stratigraphic units are based on drillers and consultants logs (dashed where inferred).

See Figure 5–1 for cross–section location.

Approximate groundwater levels from ADWR GWSI database for the period October through December 1997.

FIGURE 5-5
Generalized Cross-Section C-C'
City of Avondale
Water Resource Master Plan
Avondale, Arizona

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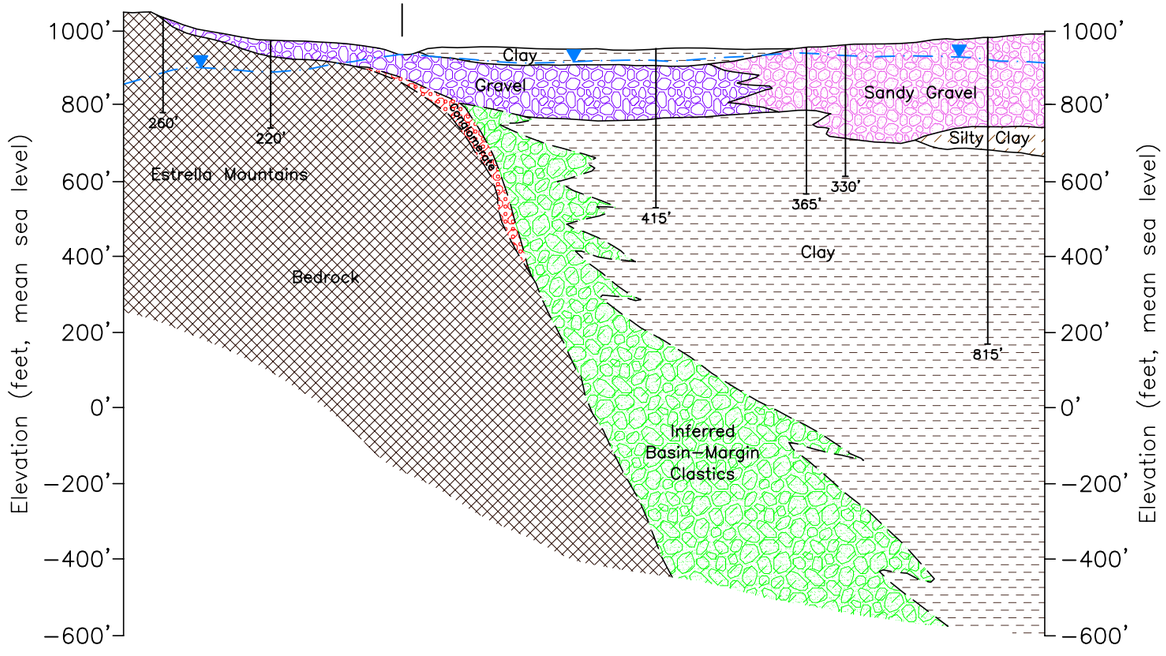
AutoCAD FILE: COA-AVONDALE-5-5.DWG

SOUTHWEST

D

NORTHEAST

D'



SECTION D–D'

Looking N35 W

Horizontal Scale 1"=5280'
Vertical Scale 1"=400'
Vertical Exaggeration = 13.2
BIS = Bend in Section
55–578749 = ADWR Well Registration Number
(COA #15) = City of Avondale Well Number

Explanation

Approximate Groundwater Level

1400' — Well Trace with Hole Bottom Depth (feet below land surface)

Generalized Stratigraphic Units

- Clay
- Silty Clay
- Sandy Clay
- Clayey Sand
- Sand
- Sandy Gravel
- Gravel
- Inferred Basin–Margin Clastics
- Conglomerate
- Bedrock

Notes

Generalized stratigraphic units are based on drillers and consultants logs (dashed where inferred).

Bedrock depth location inferred from regional geophysical study (Brown and Pool, 1989) and drillers log.

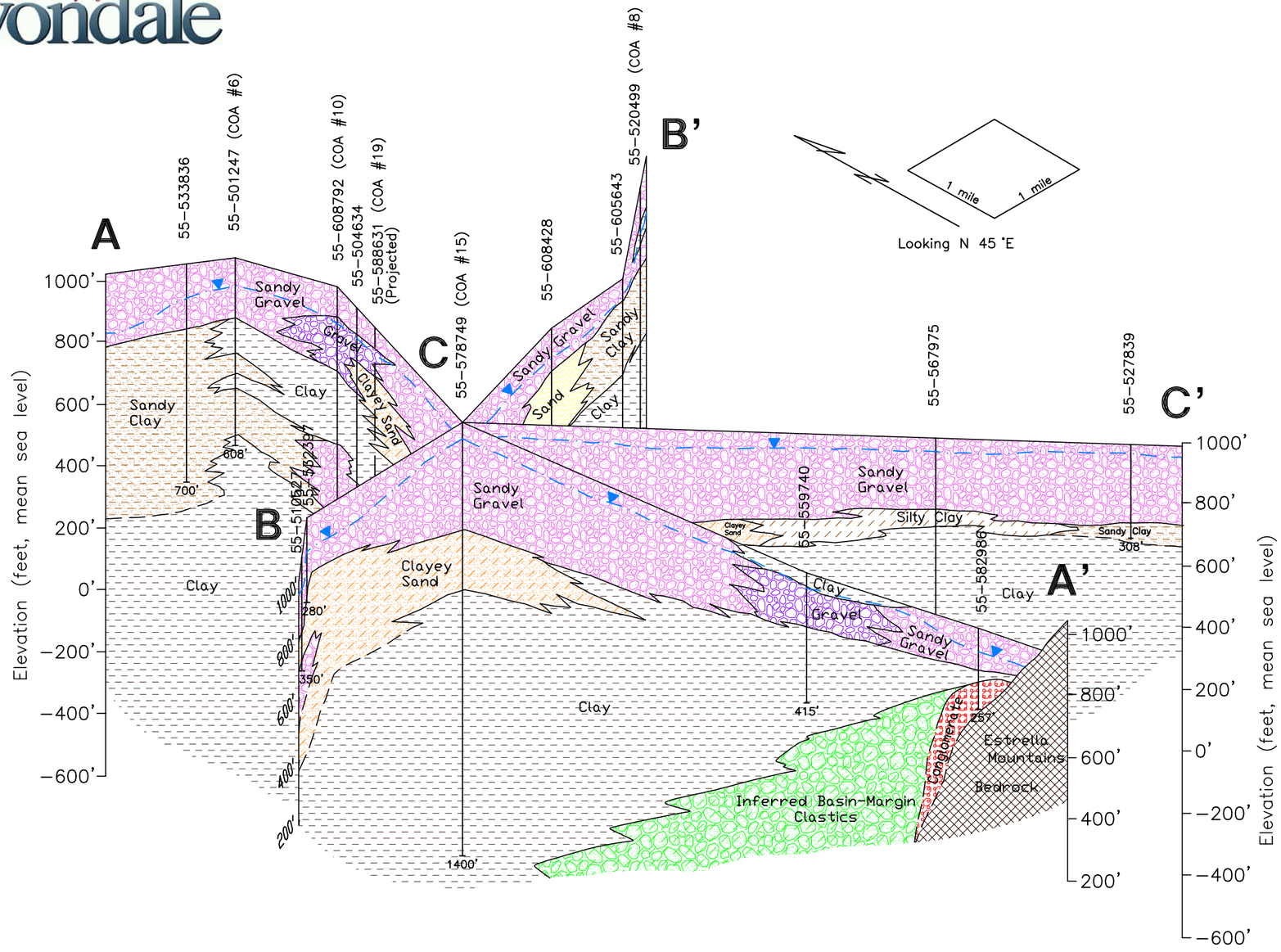
See Figure 5–1 for cross–section location.

Approximate groundwater levels from ADWR GWSI database for the period October through December 1997.

FIGURE 5-6
Generalized Cross-Section D-D'
City of Avondale
Water Resource Master Plan
Avondale, Arizona

RBF CONSULTING
CLEAR CREEK ASSOCIATES

AutoCAD FILE: CCA-AVONDALE-5-6.DWG



Explanation

Approximate Groundwater Level

1400' — Well Trace with Hole Bottom Depth (feet below land surface)

Generalized Stratigraphic Units

- Clay
- Silty Clay
- Sandy Clay
- Clayey Sand
- Sand
- Sandy Gravel
- Gravel
- Inferred Basin-Margin Clastics
- Conglomerate
- Bedrock

Notes

Generalized stratigraphic units are based on drillers and consultants logs (dashed where inferred).

Bedrock depth location inferred from regional geophysical study (Brown and Pool, 1989) and drillers log.

See Figure 5-1 for cross-section locations.

55-578749 = ADWR well registration number.

FIGURE 5-7
Generalized Fence Diagram
City of Avondale
Water Resource Master Plan
Avondale, Arizona

RBF CONSULTING
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AutoCAD FILE: COA-AVONDALE-5-7.DWG

Cross-section A-A' (Figure 5.3, Generalized Cross Section A-A') indicates that the alluvium in the study area is generally coarser-grained in the upper near-surface strata, and finer-grained at greater depths. The coarse-grained alluvium is thicker in the center of cross-section A-A' in the vicinity of City of Avondale Well No. 15 (Figures 5.1 and 5.3). The thickness of alluvial material along this cross-section is generally from 0 feet (bedrock outcrop) to more than 1,400 feet. The consultant's log of City of Avondale Well No. 15 reported penetrating clay from approximately 480 feet bls to 1,400 feet bls (Figure 5.3). Well 55-582986 (located at C(1-1)1baa) is a water production well that reportedly penetrated bedrock (granite) at a depth of approximately 255 feet bls (Appendix F-2). An inferred geologic unit is shown in the southern portion of the study area on cross-section A-A', to represent coarse-grained basin-margin clastic material that would be expected to have been shed from the Estrella Mountains. This unit has not been penetrated by wells, but has been inferred to provide a more realistic conceptual model of the subsurface geology along the basin margin.

Cross-section B-B' (Figure 5.4, Generalized Cross Section B-B') also indicates an increase in the finer-grained alluvium in the northeast portion of the cross-section. The total thickness of alluvial material along this cross-section is generally more than 1,400 feet.

Cross-section C-C' (Figure 5.5, Generalized Cross Section C-C') indicates a slight increase in the finer-grained alluvium in the southeast portion of the cross-section. The total thickness of alluvial material along this cross-section is generally more than 1,400 feet.

Cross-section D-D' (Figure 5.6, Generalized Cross Section D-D') suggests that the coarse-grained strata above the extensive clay unit thins toward the Estrella Mountains. As in cross-section A-A', an inferred basin-margin clastic unit is shown to provide a more realistic conceptual model of the subsurface geology along the basin margin. The thickness of alluvial material along this cross-section ranges from 0 (bedrock outcrop) to more than 815 feet. Two wells (55-567600 and 55-525153) along this cross-section reportedly penetrated bedrock (granite) at depths of approximately 18 feet and 35 feet bls, respectively (Figure 5.6 and Appendix F-2).

A generalized fence diagram (Figure 5.7) was prepared to provide an oblique perspective of the stratigraphic relationships beneath the study area. The fence diagram shown on Figure 5.7 represents a compilation of the geologic interpretations shown on cross-sections A-A', B-B', and C-C' (Figures 5.3, 5.4, and 5.5, respectively). The perspective of the fence diagram is looking toward the northeast, and this diagram provides a general indication of the interpreted location and thickness of various geologic units in 3-dimensions, beneath the study area.

5.1.3 Local Hydrogeology

A well inventory for the study area was conducted by reviewing ADWR's well database. Information relating to the wells within the study area is presented in Appendix F-1.1, Well Inventory, and the locations of the wells are indicted on Figure 5.1, Well Location Map. During the compilation of this well inventory, it became evident that the study area contains numerous small domestic water wells. This is problematic in some areas, because ADWR regulations limit the impact of new wells on existing wells (excluding monitoring wells) in terms of additional water-level declines that may be caused by the new well. Prior to obtaining an ADWR permit to drill a new well, the predicted impact of that new well on neighboring wells must be calculated. If the new well is determined to cause a water-level decline of 10 feet or more after a 5-year pumping period, Avondale would need to obtain a signed waiver from the owner of the impacted well or purchase the well from the well owner. Based on experience, signed waivers such as this are typically difficult to obtain.

A 1997 Groundwater Elevation Contour Map was prepared using the most recent available water-level data for wells within the study area, as reported in ADWR's Groundwater Site Inventory (GWSI) Database. The 1997 Groundwater Contour Map is presented on Figure 5.9, and the information used to compile the groundwater elevation map is presented in Appendix F-1.2, Water Level Elevations. The 1997 Groundwater Elevation Contour Map indicates the predominant groundwater flow direction of westward and northward, across the study area (Figure 5.9, 1997 Groundwater Elevation Contour Map). The depth to groundwater beneath the study area ranges from approximately 17 feet bls in the southern portion of the study area, to about 194 feet bls in the northern portion of the study area.

The water table depth (Figure 5.9, 1997 Groundwater Elevation Contour Map), and the thickness of non-clay alluvial sediments (Figures 5.3 through 5.6) were used to prepare an aquifer Isopach (thickness) map of the study area. The Aquifer Isopach Map is shown in Figure 5.10. The aquifer thickness was calculated as the sum thickness of the coarse-grained (non-clay) sediment layers that lie below the water table. In the southern region of the study area, the inferred basin-margin clastics unit (described in Section 5.2.2, Local Geology) was incorporated into the estimated aquifer thickness. The aquifer isopach map assumes an arbitrary maximum aquifer depth of 1,500 feet bls, because pumping from greater depths would require very deep and expensive wells, and may require treatment of poor-quality groundwater that may generally be expected in the lower portions of an aquifer. The aquifer thickness ranges from less than 250 feet, to more than 750 feet beneath the southwest portion of the study area (Figure 5.10, Aquifer Isopach Map). The increasing aquifer isopach contours in the southern portion of the study area reflect the lack of deeper wells with driller's logs in that area. Therefore, the aquifer thickness in the southern part of the

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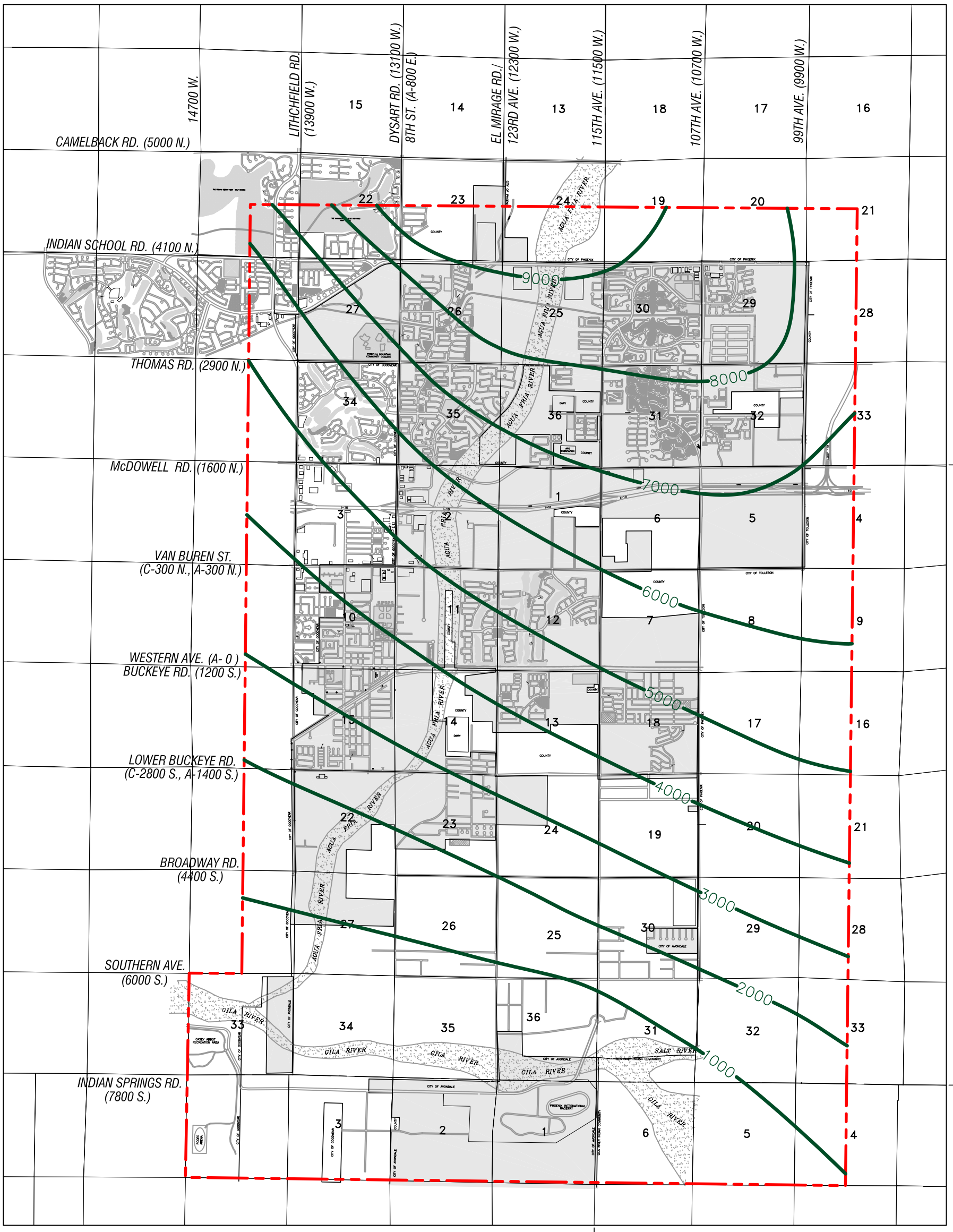

City of Avondale

Explanation

900 — Depth to Bedrock (feet below land surface)

Study Area

SCALE

2640' 0 2640' 5280'

CONTOUR INTERVAL 1000 Ft.

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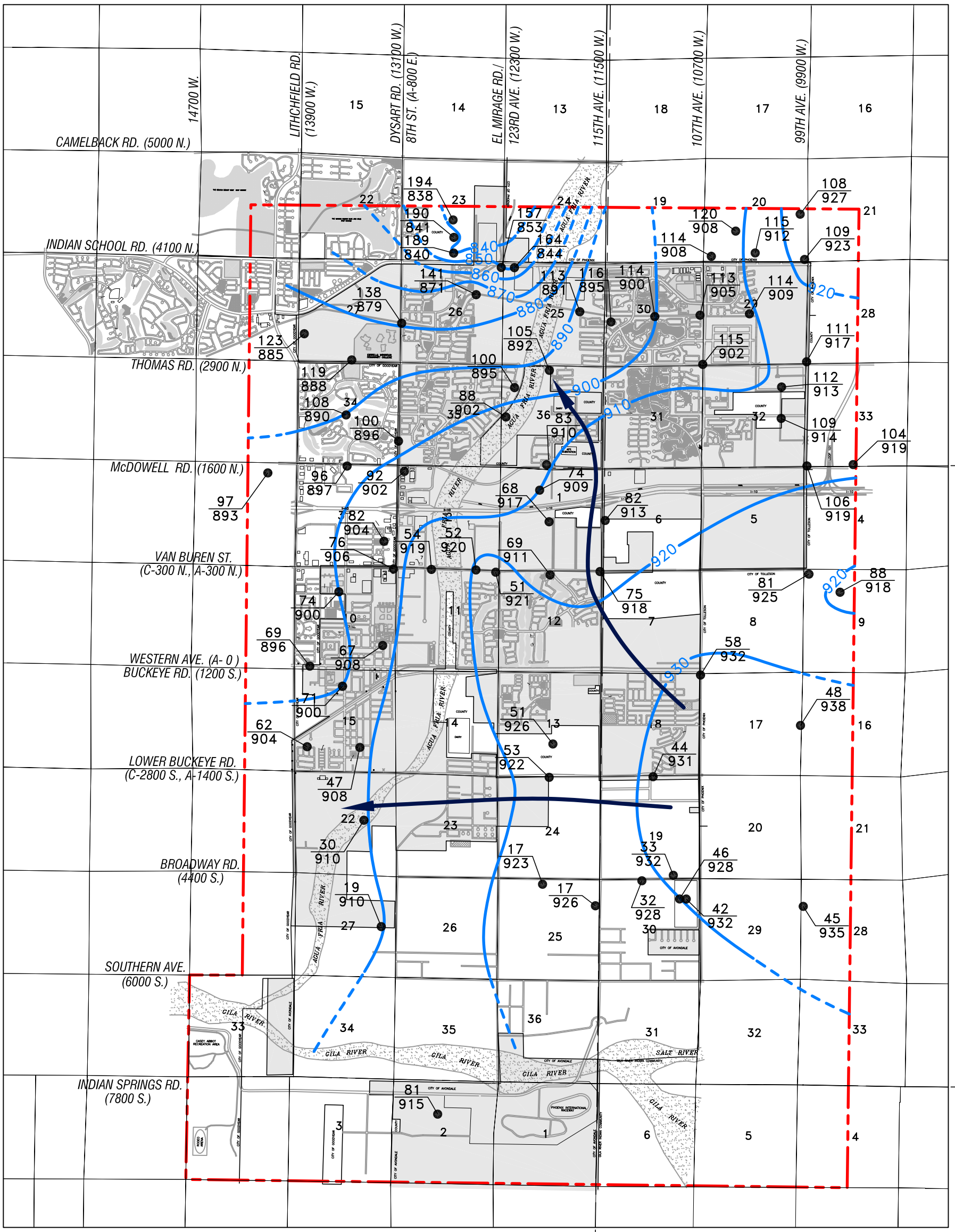
Depth to bedrock countours based on:
Brown and Pool, 1989
Oppenheimer and Sumner, 1980

FIGURE 5-8
Depth to Bedrock
City of Avondale
Water Resource Master Plan
Avondale, Arizona

AutoCAD FILE: *CCA-AVONDALE-5-9.DWG*



City of Avondale

Explanation

58 / 909 — Depth to Water (feet below land surface) / Elevation of the Water Level (feet above mean sea level)

900 — Water Level Contour (feet above mean sea level) Dashed Where Inferred, Contour Interval = 10 Feet

Approximate Groundwater Flow Direction

Study Area

SCALE

2640' 0 2640' 5280'

CONTOUR INTERVAL 10 Ft.

Source: ADWR water level database— water levels measured between October and December 1997. (See Table 5A–2)

RBF CONSULTING

CLEAR CREEK ASSOCIATES

FIGURE 5-9

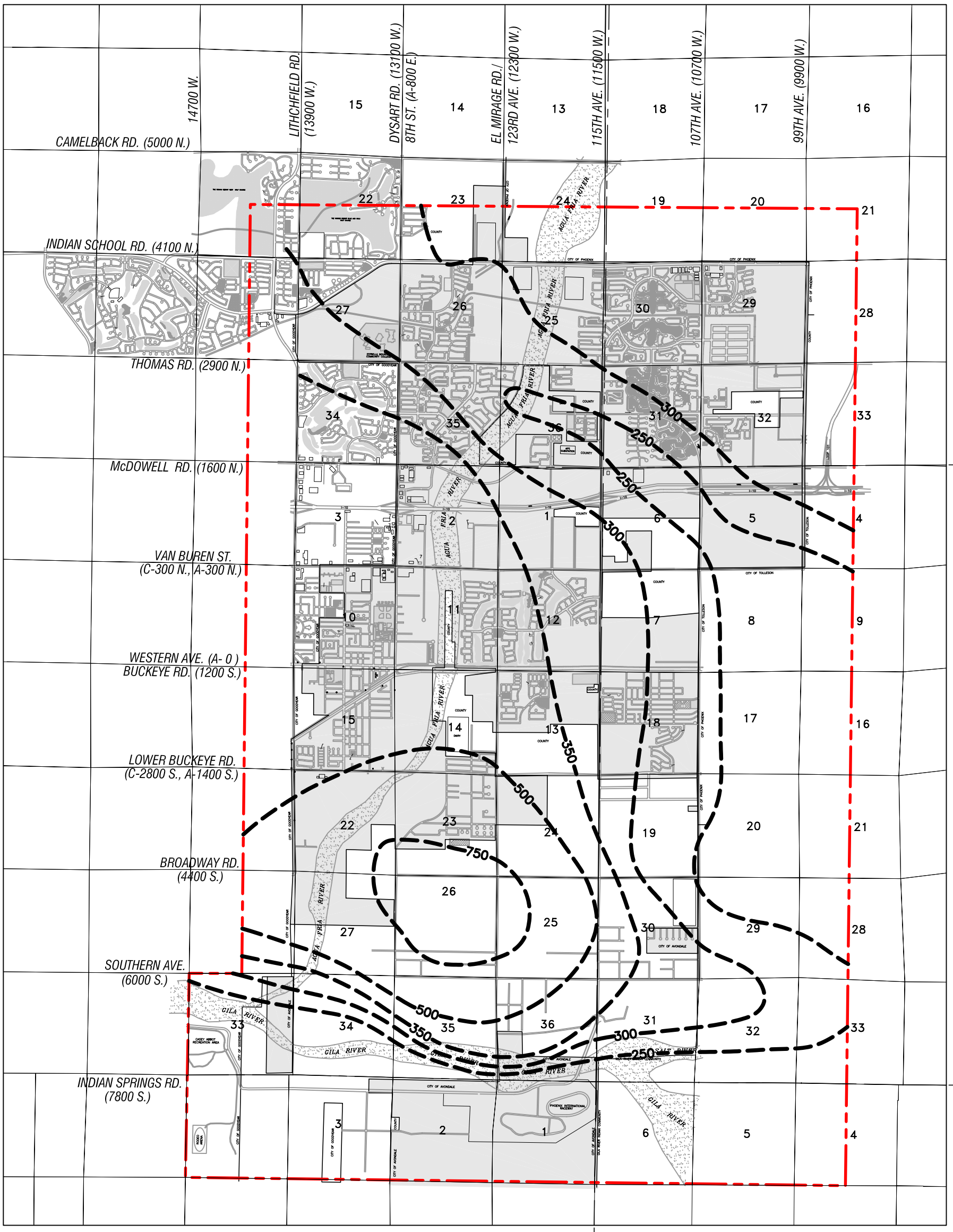
1997 Groundwater Elevation Contour Map

City of Avondale

Water Resource Master Plan

Avondale, Arizona

AutoCAD FILE: *CCA-AVONDALE-5-10.DWG*



City of Avondale

SCALE

2640' 0 2640' 5280'

CONTOUR INTERVAL 50 Ft.

Explanation

1200 — Estimated Aquifer Thickness (feet) Assumes a maximum aquifer thickness of 1500 feet below land surface. Aquifer thickness calculated by summing the coarse–grained sediments from the water table to a depth of 1500 feet.

Study Area

Source: 1. ADWR Driller Logs.

2. ADWR water level database– water levels measured between October and December 1997.

3. Depth to bedrock, Brown & Pool, 1989 Oppenheimer and Sumner, 1980

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CLEAR CREEK ASSOCIATES

FIGURE 5-10
Aquifer Isopach Map
City of Avondale
Water Resource Master Plan
Avondale, Arizona

study area is more influenced by the arbitrary maximum aquifer depth of 1,500 feet and the inferred basin-margin clastic sediments (Figures 5.3 and 5.6).

The ability of an aquifer to transport water to a pumping well is expressed as the *transmissivity* of the aquifer. The *hydraulic conductivity* of an aquifer describes the rate at which groundwater can move through a unit volume of the permeable aquifer material. The hydraulic conductivity (K) and the aquifer thickness (b) are related to the aquifer transmissivity (T) by the relationship T = Kb. Therefore, while transmissivity values change with differences in aquifer thickness, the hydraulic conductivity is a characteristic inherent to the aquifer material from place to place.

ADWR prepared a Regional Groundwater Flow Model of the Salt River Valley (Corell and Corkhill, 1994), which identified average transmissivity and hydraulic conductivity values for the Upper Alluvial Unit (UAU), Middle Alluvial Unit (MAU), and Lower Alluvial Unit (LAU) throughout the Salt River Valley on a section-by-section basis. ADWR estimated that MAU transmissivity values within the study area range from 7,481 gallons per day per foot (gpd/ft) (or approximately 1,000 square feet per day [ft^2/day]) to 287,270 gpd/ft (38,400 ft^2/day). The UAU transmissivity values within the study area were reported by ADWR to range from 8,977 gpd/ft (1,200 ft^2/day) to 374,050 gpd/ft (50,000 ft^2/day). Aquifer tests have been performed on City of Avondale Wells 14, 15, and 19. The reported transmissivity values for Wells 14, 15, and 19 are 3,740 gpd/ft (500 ft^2/day), 6,700 gpd/ft (896 ft^2/day), and approximately 72,090 gpd/ft (9,636 ft^2/day), respectively (URS, unpublished consultant reports, 2001 and 2002).

ADWR also estimated the hydraulic conductivity values within the study area. They estimate the MAU hydraulic conductivity values within the study area range from 15 gallons per day per square foot (gpd/ ft^2) (approximately 2 feet per day [ft/day]) to 224 gpd/ft^2 (30 ft/day). The UAU hydraulic conductivity values within the study area were reported by ADWR to range from 60 gpd/ft^2 (8 ft/day) to 1,496 gpd/ft^2 (200 ft/day).

Figure 5.11, Hydraulic Conductivity of Upper Alluvial Unit, Figure 5.12, Hydraulic Conductivity of Middle Alluvial Unit, and Figure 5.13, Hydraulic Conductivity of Lower Alluvial Unit, present the average hydraulic conductivity for the UAU, MAU, and LAU, respectively. Figures 5.11 through 5.13 are based on hydraulic conductivity values reported by ADWR, but hydraulic conductivity values from site-specific aquifer test data are also incorporated into Figures 5.11 and 5.12, based on unpublished consultant reports (URS, 2001 and 2002). Transmissivity values from aquifer tests conducted on City of Avondale Wells 14 and 15 (which are screened entirely within the MAU) were incorporated into Figure 5.12, and those values compare fairly well with ADWR reported hydraulic conductivities. An aquifer test was also conducted on City of Avondale Well No. 19 (screened both within the UAU and MAU), which indicates that the combined UAU/MAU

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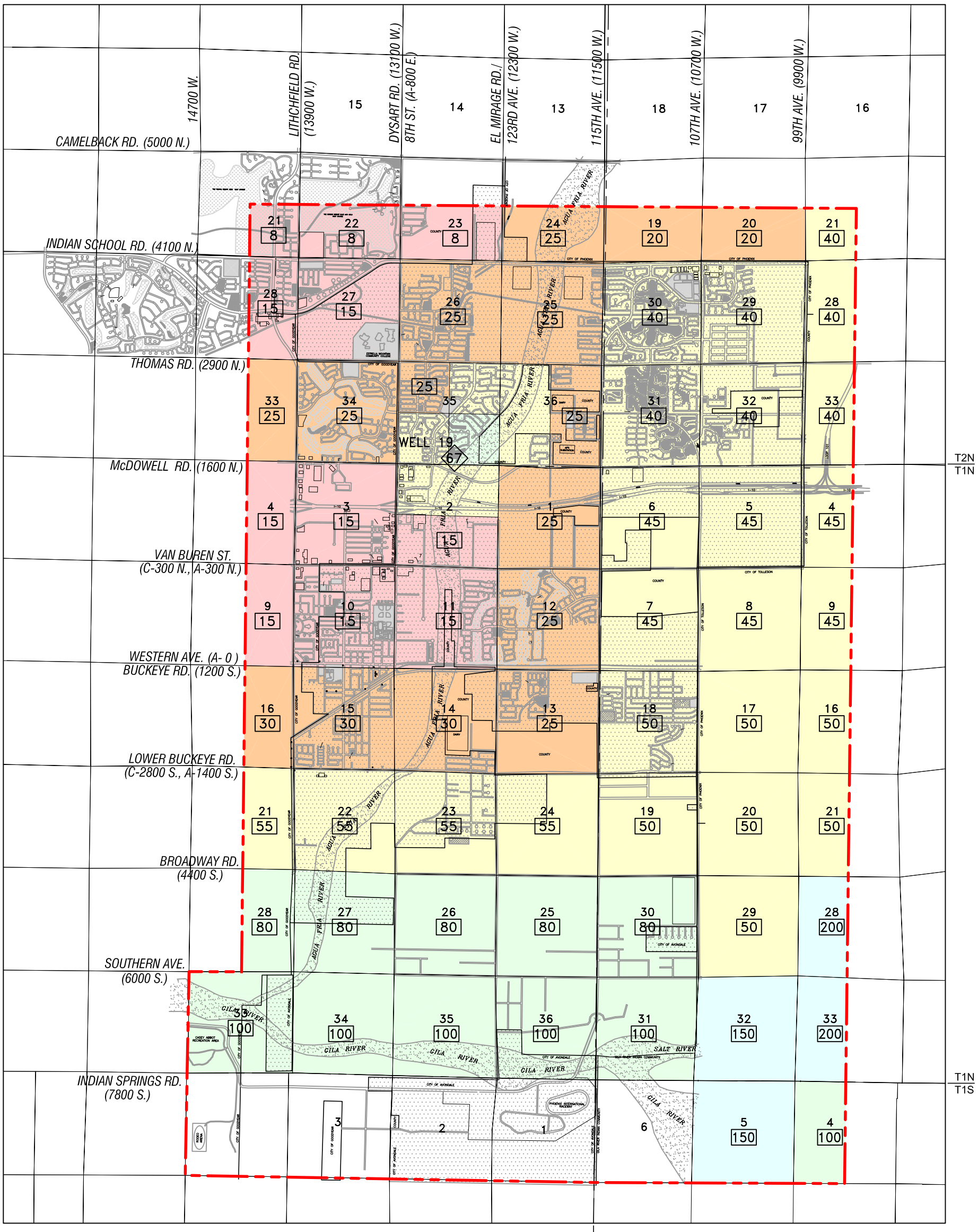

Explanation

- Study Area
- 40 — Hydraulic Conductivity (ft/day) of Upper Alluvial Unit (UAU)
- 67 — Hydraulic Conductivity (ft/day) from City of Avondale Well Aquifer Test *
- Hydraulic Conductivity of 8–15 ft/day
- Hydraulic Conductivity of 16–30 ft/day
- Hydraulic Conductivity of 31–55 ft/day
- Hydraulic Conductivity of 56–100 ft/day
- Hydraulic Conductivity of 101–200 ft/day

SCALE
2640' 0 2640' 5280'

Data Source: ADWR Salt River Valley Model (Corell and Corkhill 1994)

* Value calculated assuming a MAU hydraulic conductivity of 9 ft/day and a UAU/MAU transmissivity of 72,090 gpd/ft (see Section 5.1.3 of report).

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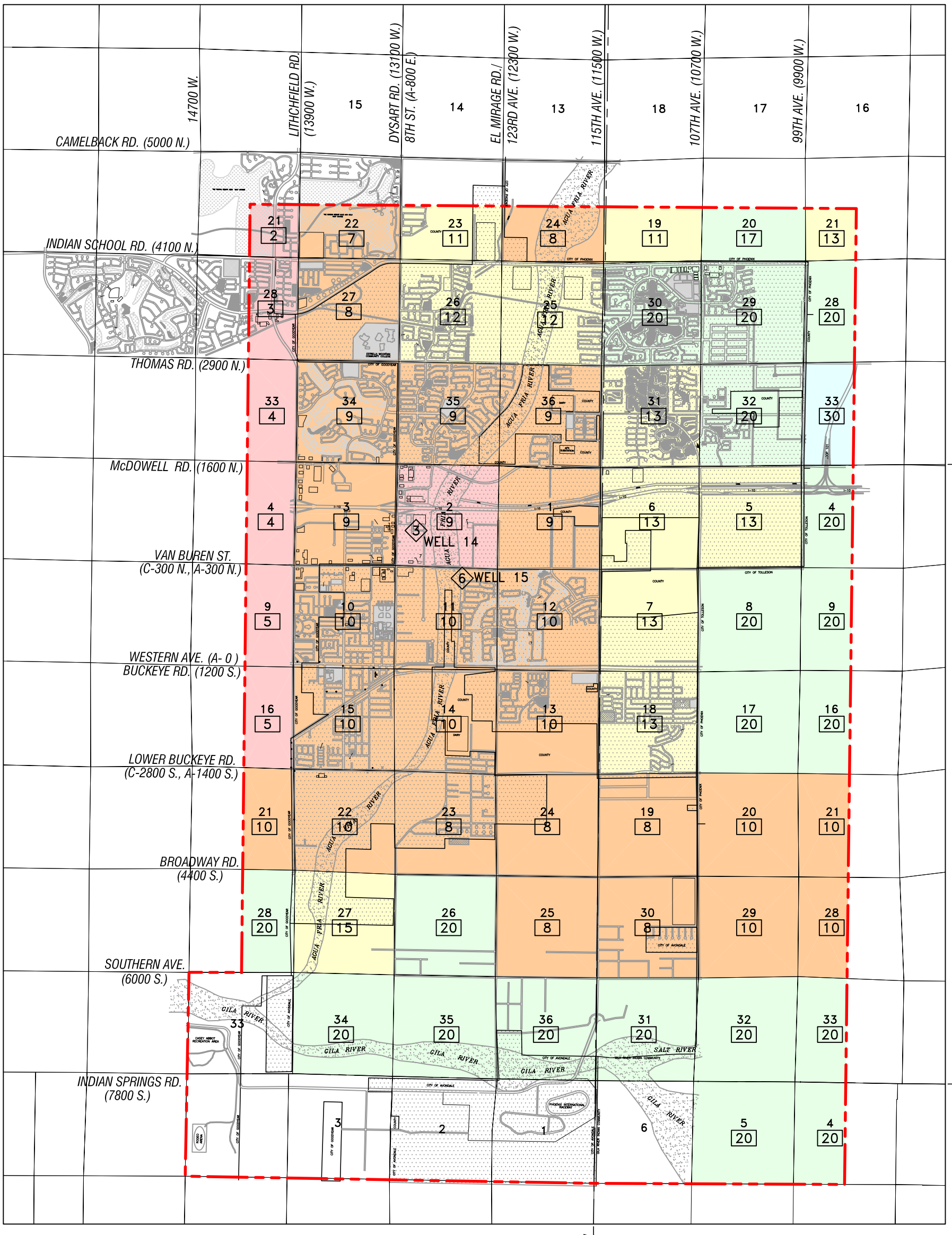
FIGURE 5-11
Hydraulic Conductivity of Upper Alluvial Unit
City of Avondale
Water Resource Master Plan
Avondale, Arizona

AutoCAD FILE: *CCA-AVONDALE-5-12.DWG*



Explanation

- Study Area
- 20 — Hydraulic Conductivity (ft/day) of Middle Alluvial Unit (MAU)
- 3 — Hydraulic Conductivity (ft/day) from City of Avondale Well Aquifer Test
- Hydraulic Conductivity of 1–5 ft/day
- Hydraulic Conductivity of 6–10 ft/day
- Hydraulic Conductivity of 11–15 ft/day
- Hydraulic Conductivity of 16–20 ft/day
- Hydraulic Conductivity of 21–30 ft/day

SCALE
2640' 0 2640' 5280'

Data Source: ADWR Salt River Valley Model (Corell and Corkhill 1994)

FIGURE 5-12
Hydraulic Conductivity of Middle Alluvial Unit
City of Avondale
Water Resource Master Plan
Avondale, Arizona

AutoCAD FILE: *CCA-AVONDALE-5-13.DWG*

14700 W. | LITHCHFIELD RD. (13900 W.) | DYSART RD. (13100 W.) / 8TH ST. (A-800 E.) | EL MIRAGE RD./ 123RD AVE. (12300 W.) | 115TH AVE. (11500 W.) | 107TH AVE. (10700 W.) | 99TH AVE. (9900 W.)

15 | 14 | 13 | 18 | 17 | 16

CAMELBACK RD. (5000 N.)

INDIAN SCHOOL RD. (4100 N.)

THOMAS RD. (2900 N.)

McDOWELL RD. (1600 N.)

VAN BUREN ST. (C-300 N., A-300 N.)

WESTERN AVE. (A- 0) BUCKEYE RD. (1200 S.)

LOWER BUCKEYE RD. (C-2800 S., A-1400 S.)

BROADWAY RD. (4400 S.)

SOUTHERN AVE. (6000 S.)

INDIAN SPRINGS RD. (7800 S.)

T2N / T1N

T1N / T1S

R1W / R1E

AGUA FRIA RIVER | GILA RIVER | SALT RIVER

CITY OF GOODYEAR | CITY OF AVONDALE | CITY OF PHOENIX | CITY OF TOLLESON

21 / 2	22 / 6	23 / 9	24 / 6	19 / 6	20 / 9	21 / 6
28 / 2	27 / 6	26 / 9	25 / 9	30 / 9	29 / 9	28 / 12
33 / 2	34 / 6	35 / 6	36 / 6	31 / 6	32 / 9	33 / 9
4 / 2	3 / 6	2 / 6	1 / 6	6 / 6	5 / 6	4 / 6
9 / 4	10 / 12	11 / 12	12 / 12	7 / 12	8 / 12	9 / 12
16 / 4	15 / 12	14 / 12	13 / 12	18 / 12	17 / 12	16 / 12
21 / 10	22 / 15	23 / 15	24 / 15	19 / 15	20 / 15	21 / 12
28 / 30	27 / 15	26 / 15	25 / 15	30 / 15	29 / 15	28 / 15
33	34 / 15	35 / 15	36 / 15	31 / 15	32 / 15	33 / 15
	3	2	1	6	5 / 20	4 / 20

City of Avondale

SCALE

2640' 0 2640' 5280'

Explanation

- Study Area
- 20 — Hydraulic Conductivity (ft/day) of Lower Alluvial Unit (LAU)
- Hydraulic Conductivity of 1–5 ft/day
- Hydraulic Conductivity of 6–10 ft/day
- Hydraulic Conductivity of 11–15 ft/day
- Hydraulic Conductivity of 16–20 ft/day
- Hydraulic Conductivity of 21–30 ft/day

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Data Source: ADWR Salt River Valley Model (Corell and Corkhill 1994)

FIGURE 5-13
Hydraulic Conductivity of Lower Alluvial Unit
City of Avondale
Water Resource Master Plan
Avondale, Arizona

hydraulic conductivity is 26.8 ft/day. Geologic, geophysical, and hydrologic information from City of Avondale Wells 14, 15, and 19 suggest that the MAU hydraulic conductivity value for the Well 19 site would be similar to the values reported by ADWR (approximately 9 ft/day). Based on the assumption of 9 ft/day for the MAU, the prorated hydraulic conductivity value for the UAU at Well 19 is approximately 67 ft/day (Figure 5.11). This value is greater than the UAU hydraulic conductivity value of 25 ft/day reported by ADWR for this location (Figure 5.11). Therefore, the ¼-section of land containing City of Avondale Well No. 19, along with selected adjacent ¼-sections were adjusted to represent hydraulic conductivity values that reflect the probable transition in the geologic facies in the area (Figure 5.11). For reference, the depth to the bottom of the Upper and Middle Alluvial Units are presented on Figures 5.14, Depth to Bottom of Upper Alluvial Unit, and 5.15, Depth to Bottom of Middle Alluvial Unit, respectively (Corkhill and others, 1993). The geological unit that primarily serves as the regional aquifer for the study area is the MAU. Therefore, only that unit is considered in the prioritization of potential future well sites (see Section 5.4.2.5, Aquifer Characteristics Ranking Rationale).

5.2 Groundwater Quality

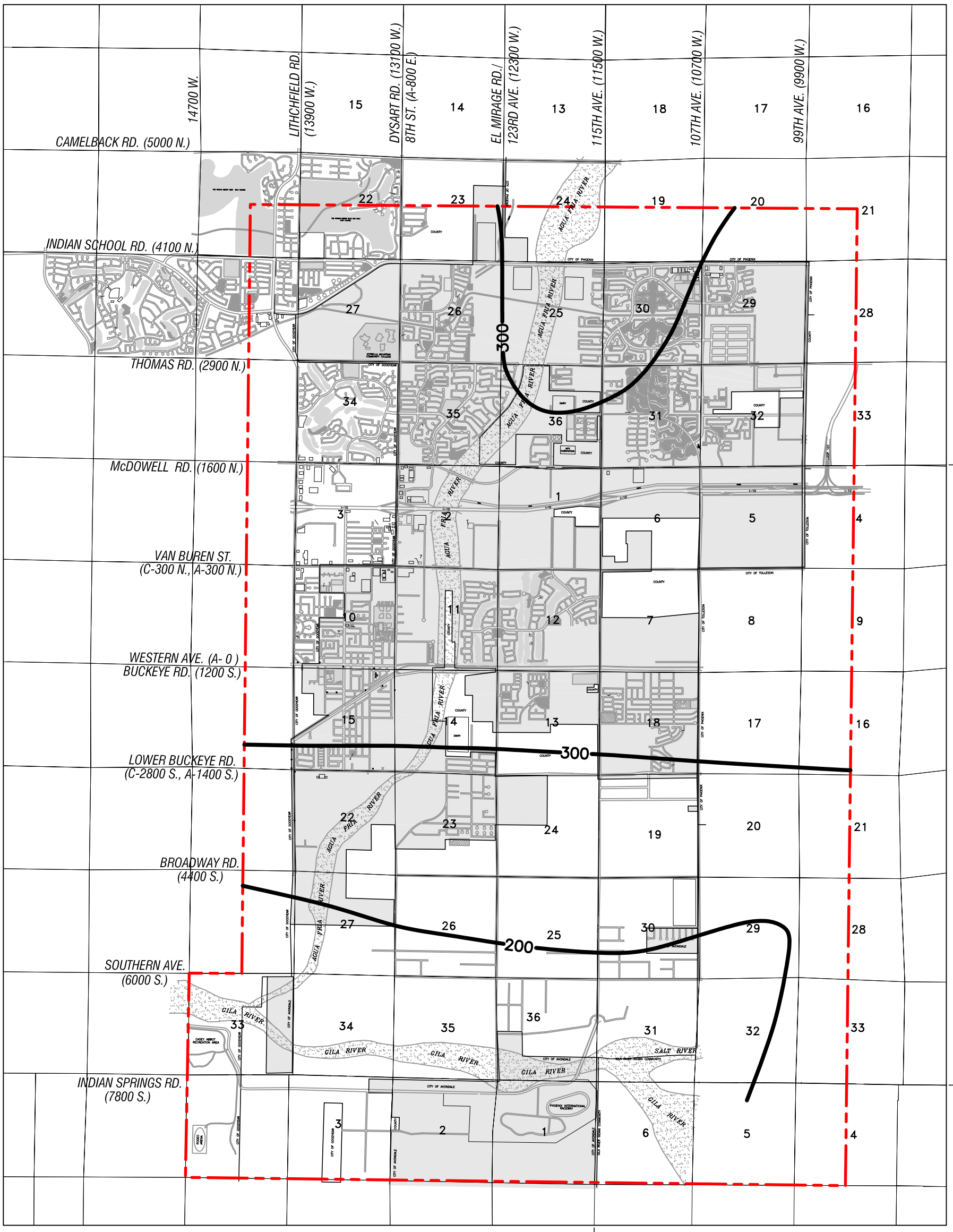
5.2.1 General Water Quality Characteristics

Inorganic groundwater quality data was collected from the City of Avondale, Roosevelt Irrigation District (RID), the Salt River Project (SRP), and Phoenix International Raceway (PIR), this information was then reviewed. Our water-quality evaluation focused on the more common inorganic water quality parameters that may affect the siting of water production wells, including nitrate, fluoride, arsenic, chromium, and total dissolved solids (TDS). The most recently reported concentrations of these constituents for wells within the study area are presented on Figure 5.16, Water Quality Map, and in Appendix -1.3, Water Quality. The reported concentrations of chromium were below the Maximum Contaminant Level (MCL) and therefore, are not shown on Figure 5.16.

5.2.2 Water Quality Standards

The State and Federal drinking water standards that define the MCL are enforceable by regulatory agencies. Nitrate has an MCL of 10.0 milligrams per liter (mg/L), and fluoride has an MCL of 4.0 mg/L. Arsenic currently has an MCL of 0.05 mg/L, or 50 micrograms per liter (μg/L), but that standard has been revised to a more stringent MCL of 0.01 mg/L (10 μg/L), which must be met by January 2006. TDS has a drinking water standard of 500 mg/L, which is a Secondary Drinking Water Standard that is only a non-enforceable guideline.

AutoCAD FILE: *CCA-AVONDALE-5-14.DWG*



Explanation

200 — Depth to Bottom of Upper Alluvial Unit (UAU) Contour (feet below land surface)

Study Area

SCALE

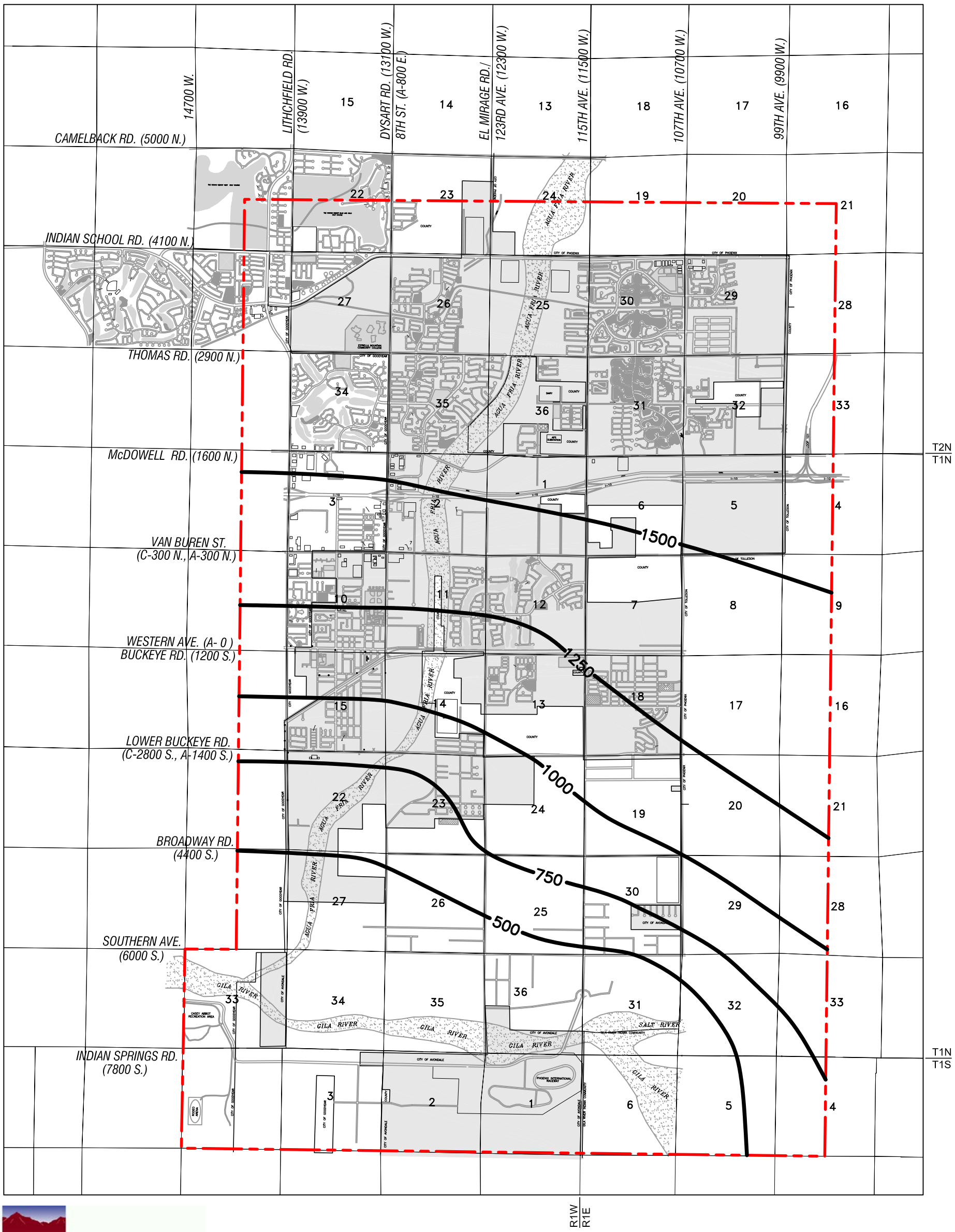
2640' 0 2640' 5280'

CONTOUR INTERVAL 100 Ft.

Source: Contours based on ADWR Salt River Valley Model (Corkhill and others, 1993)

FIGURE 5-14
Depth to Bottom of Upper Alluvial Unit
City of Avondale
Water Resource Master Plan
Avondale, Arizona

AutoCAD FILE: *CCA-AVONDALE-5-15.DWG*



City of Avondale

Explanation

500 — Depth to Bottom of Middle Alluvial Unit (MAU) Contour (feet below land surface)

Study Area

SCALE

2640' 0 2640' 5280'

CONTOUR INTERVAL 250 Ft.

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Source: Contours based on ADWR Salt River Valley Model (Corkhill and others, 1993)

FIGURE 5-15
Depth to Bottom of Middle Alluvial Unit
City of Avondale
Water Resource Master Plan
Avondale, Arizona

5.2.3 Water Quality Data

The reported nitrate concentrations in several non-City wells exceed the MCL for nitrate of 10 mg/L (Appendix F-1.3). The nitrate concentrations range from 1.6 to 32.5 mg/L, with the highest concentrations of nitrate (concentrations greater than 10 mg/L) occurring in agricultural wells owned by RID or SRP, which are probably screened in the upper portion of the aquifer, where elevated nitrate concentrations commonly result from percolation of agricultural leachate beneath farm fields. The MCL for both fluoride (4.0 mg/L) and arsenic (50 μg/L) was not exceeded at any of the reported wells within the study area. However, there are several City of Avondale wells (6, 7, 11, 14, and 15) that exceed the future MCL for arsenic (10 μg/L) that will go into effect in January 2006.

The reported TDS concentrations in all but five wells within the study area exceed the Secondary Maximum Contaminant Level for TDS (500 mg/L). The reported TDS concentrations ranged from 292 to 3,050 mg/L. The highest concentrations of TDS (>1,000 mg/L) come from PIR and SRP wells. These wells are probably screened in the upper portion of the aquifer where elevated TDS concentrations may result from agricultural leachate.

5.2.4 Superfund/WQARF Sites

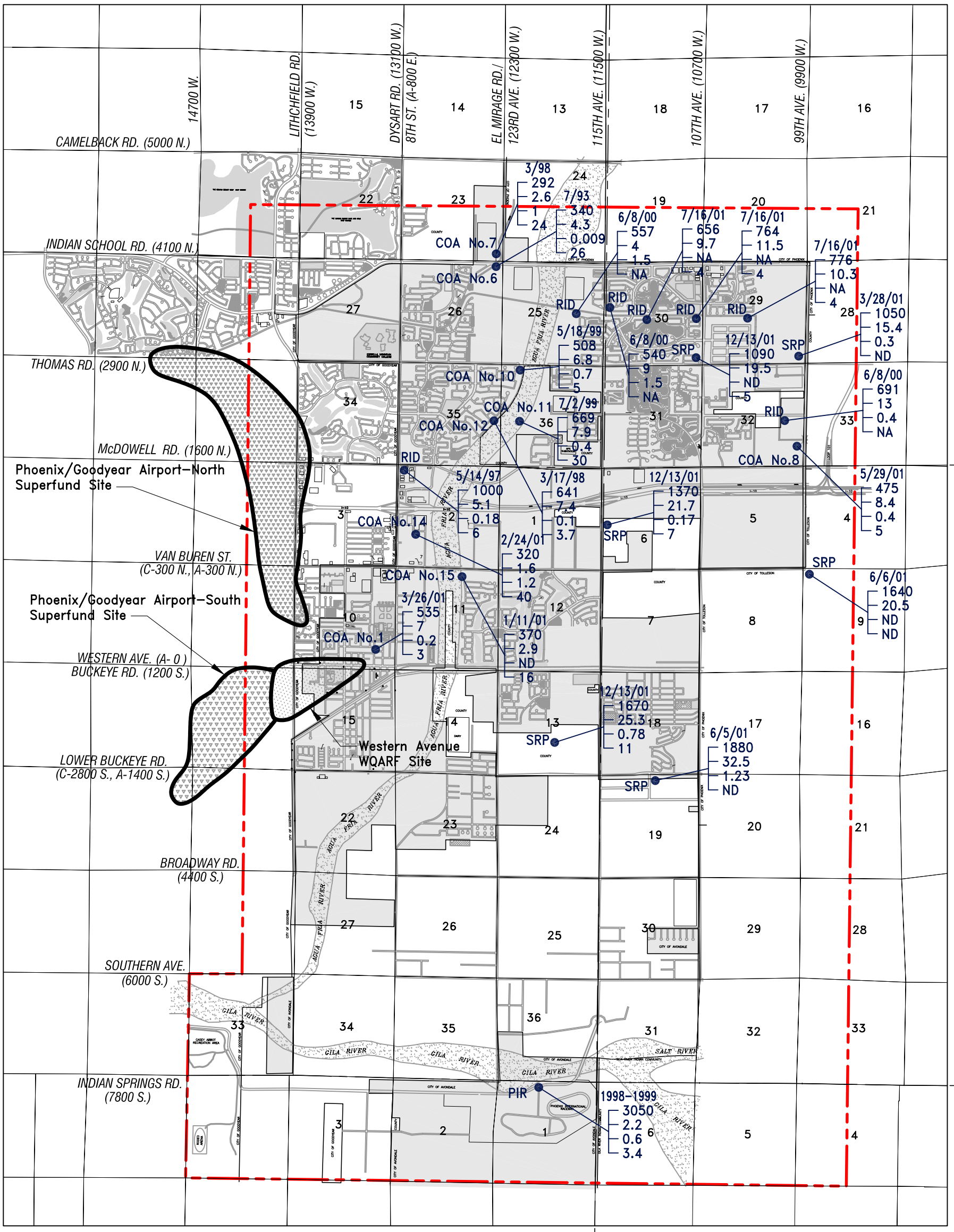
Organic water quality data were collected by the City of Avondale, ADEQ, and various other entities to characterize the extent of several anthropogenic contaminated groundwater sites in the vicinity of the study area. These sites are the Phoenix/Goodyear Airport-North Superfund Site, Phoenix/Goodyear Airport-South Superfund Site, and the Western Avenue WQARF Site, which are all located along the western boundary of the study area (see Figure 5.16, Water Quality Map). The primary contaminants of concern within these areas are tetrachloroethene, trichloroethene, perchlorate, and chromium (ADEQ, 2001).

5.3 Land and Infrastructure Evaluation

5.3.1 Land Evaluation

A criterion that was reviewed for well site prioritization is whether land parcels have SRP Member land status, versus areas that are considered Non-Member lands. Non-Member lands are not appurtenant to water rights associated with the Salt River Valley Water Users Association (SRP). Municipal water purveyors such as the City of Avondale may receive surface water from SRP that can be used on Member lands. This water can also be used on Non-Member lands if the City later “pays back” the excess water by pumping groundwater back into the SRP canals. However, the pay-back wells cannot be located within SRP Member lands, since wells on Member lands are within the SRP service area and

AutoCAD FILE: *CCA-AVONDALE-5-16.DWG*



Superfund Site Programs

WQARF:	Major Contaminants:
Western Avenue Site	Tetrachloroethene (~60–110 feet below land surface)
Superfund:	Major Contaminants:
Phoenix/Goodyear Airport–North	Trichloroethene, Perchlorates (~70–130 feet below land surface)
Phoenix/Goodyear Airport–South	Trichloroethene, Chromium (~surface to 360 feet below land surface)

Source: ADEQ

SCALE
2640' 0 2640' 5280'

Explanation

3/15/99 — Date of Sample
800 — Total Dissolved Solids (mg/L)
2.3 — Nitrate as N (mg/L)
0.10 — Fluoride (mg/L)
5.0 — Arsenic (µg/L)

NA = Not Analyzed
ND = Not Detected

WELL OWNERS
COA = City of Avondale
SRP = Salt River Project
RID = Roosevelt Irrigation District
PIR = Phoenix International Raceway

Study Area

Source: See Table 5A–3.

FIGURE 5-16
Water Quality Map
City of Avondale
Water Resource Master Plan
Avondale, Arizona

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therefore, are not considered to provide an additional water supply to SRP from a regulatory perspective. Thus, water supply wells with SRP Non-Member land status provide greater value to the City, because the City would have the flexibility to utilize those wells as SRP pay-back wells, when needed. SRP Non-Member lands in the City of Avondale were generally restricted to portions of the City west of the Agua Fria River.

5.3.2 Infrastructure Evaluation

The criterion that was reviewed for infrastructure evaluation included proximity to the City water delivery system. This criterion was included to enable the City to minimize capital and operational costs associated with a larger water pipeline distribution grid within the City. Figure 5.17, Water Delivery Pipeline Map, shows the location of Avondale's water distribution pipelines within the study area. Pipelines of 6 to 36-inches in diameter are shown. It is preferred to connect water supply wells to 16-inch diameter pipelines or larger, to minimize impacts to the existing water delivery system. However, the optimal condition would be to connect water supply wells to transmission lines with no direct connections to the water distribution system.

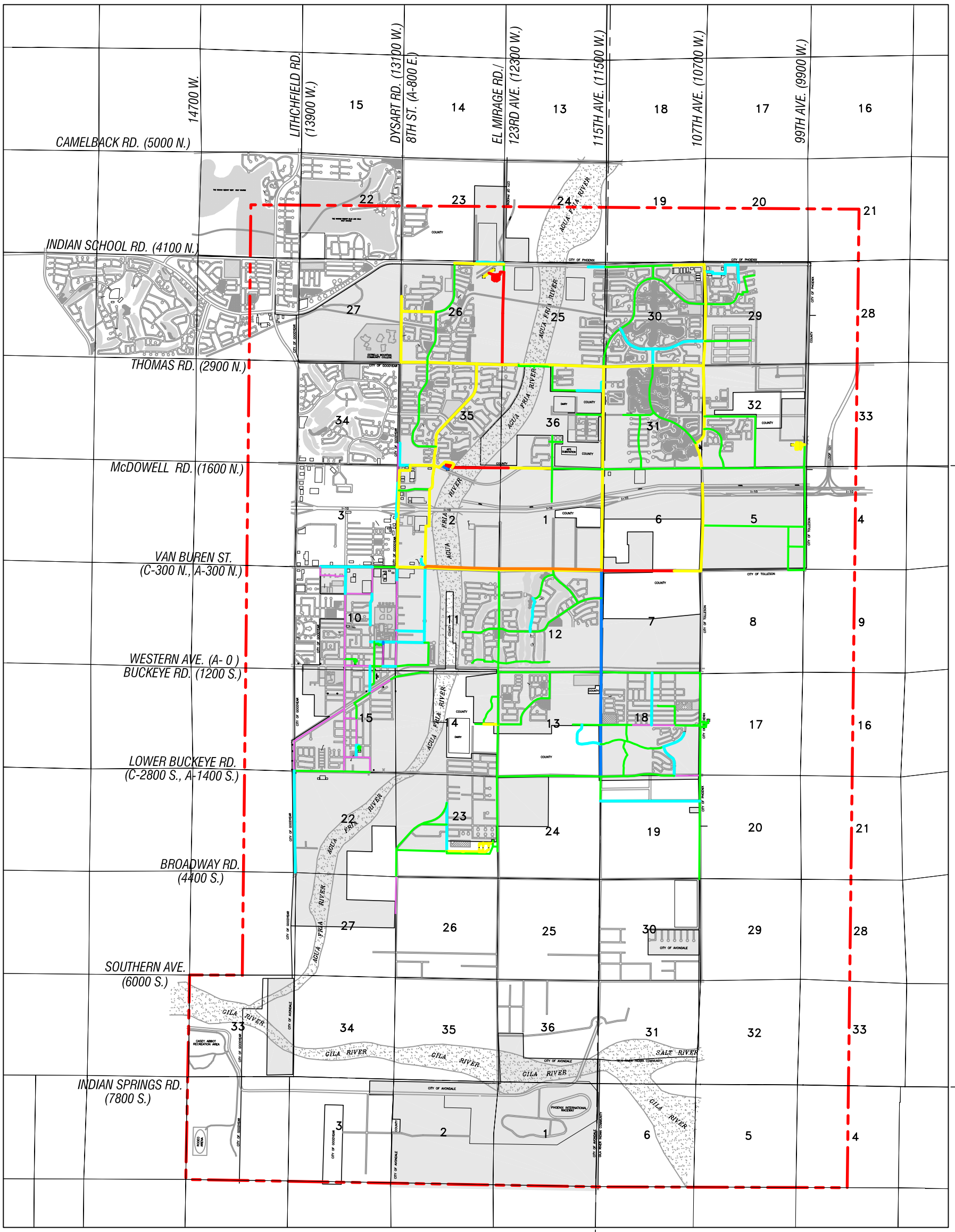
5.4 Well Site Analysis

On the basis of the hydrogeological, land, and infrastructure evaluations discussed above, an analysis of the study area was performed to identify and prioritize candidate sites for the installation of new public supply wells to meet the City's current and future water demand.

5.4.1 Prioritization Methodology

The prioritization of well sites within the study area was conducted on the basis of six prioritization criteria. Based on the relative importance of each criterion on the utility and value of a well site to the City of Avondale, each criterion was assigned a multiplier. The multiplier provides a weighted value to each criterion, and assigns the appropriate degree of importance to it, which can then be considered in the overall ranking of the well sites. For example, the *proximity of a well to an existing pipeline* is less important than the *groundwater quality* at that location. This is because the additional cost for installing a pipeline extension is expected to be less than the additional cost for water treatment or blending. The six criteria used in the analysis, along with their multipliers, are presented below:

AutoCAD FILE: *CCA-AVONDALE-5-17.DWG*



City of Avondale

Explanation

- 6–Inch Pipeline
- 8–Inch Pipeline
- 12–Inch Pipeline
- 16–Inch Pipeline
- 20–Inch Pipeline
- 24–Inch Pipeline
- 36–Inch Pipeline
- Study Area

N

SCALE

2640' 0 2640' 5280'

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FIGURE 5-17
Existing Water Delivery Pipeline Map
City of Avondale
Water Resource Master Plan
Avondale, Arizona

Criterion for Prioritization	Multiplier	Maximum Points Achievable
Non-Member Land	1	2
Proximity to Existing Pipelines	1	2
Impacts on Existing Wells	3	6
Groundwater Quality	5	15
Aquifer Characteristics	8	40
Aquifer Thickness	10	30

The criteria with larger multipliers, such as aquifer thickness, are more heavily considered in this analysis. The magnitude of each multiplier is proportionate to the actual impact that the criterion would have on potential well sites. While the Maximum Points Achievable values are not directly correlative to the multiplier values (due to the impact of the site-by-site rankings discussed below), they also provide an indication of the relative importance assigned to each criterion.

The aquifer thickness criterion has the highest relative importance because the cost of well installation would not be substantiated at locations with inadequate groundwater production. The aquifer characteristics criterion was ranked second in importance since the amount of water yielded by a well directly relates to the permeability (aquifer characteristic) of the aquifer. Groundwater quality was ranked third in importance because poor quality water is unacceptable for potable use without expensive treatment or blending. The impact of a potential new well to existing wells was the fourth-ranked criterion. Due to the number of existing wells in the City, and the limitations of the ADWR rules regarding well impact limitations, the well impact criterion is a major concern. The SRP off-project land status and the proximity to pipelines were both assigned the lowest relative value. While the SRP off-project land status is an important consideration, it has a relatively low impact on the utility and value of a completed public supply well, in comparison to the other criteria. Similarly, the proximity of a potential well site to an existing pipeline is an important consideration, but this criterion is less critical than the overlying importance of the other higher-valued criteria.

After a multiplier was assigned to each ranking criterion, the City of Avondale study area was evaluated and ranked on a ¼-section by ¼-section basis. The ranked value of each ¼-section (160-acre) parcel was then multiplied by the multiplier value of that particular criterion, to result in a *weighted prioritization value*, as follows:

(rank) x (multiplier) = weighted prioritization value

The sum of all the weighted prioritization values (from all six criteria) for each ¼-section parcel was then used to make a valid comparison between that ¼-section

parcel and all other parcels within the study area, and to assign a ranking to the various potential well sites.

The assigned rank and calculated prioritization value for each ¼-section parcel within the study area is presented in Appendix F-1.4, Weighted Prioritization Values. The sum of the calculated prioritization values for each parcel of land resulted in a ranking of "good", "moderate", "poor", or "not recommended". The higher the weighted prioritization value; the greater the potential for a well in that ¼ section. The well site rankings are presented graphically on Figure 5.18, Well Site Prioritization Map.

The ¼-section well site parcels presented in Appendix F-1.4, Weighted Prioritization Values, are organized in progressive order, from north-to-south, and west-to-east, with a column and row designation. The columns and rows that are referenced in Appendix F-1.4 , Weighted Prioritization Values are also shown on Figure 5.18 for cross-reference. The cross-reference between Appendix F-1.4, Weighted Prioritization Values and Figure 5.18 allows for easy correlation between the numerical ranking of each parcel (Appendix F-1.4, Weighted Prioritization Values.) and the graphical prioritization of each parcel (Figure 5.18). For example, Section 5 in Township 1 North, Range 1 East is located in column 6 and row 4 (Figure 5.18). This section can be found in Appendix F-1.4, Weighted Prioritization Values by looking up the corresponding column and row numbers. The section is then broken down into ¼-sections, and each quarter is assigned a letter in counter-clockwise order, where:

a = the northeast ¼-section,
b = the northwest ¼-section,
c = the southwest ¼-section, and
d = the southeast ¼-section.

This assignment of ¼-sections (160 acres) uses the ADWR cadastral method.

5.4.2 Rationale for Ranking of Each Criterion

Each of the six prioritization criteria were ranked for each ¼-section parcel.

5.4.2.1 Off-Project Land Ranking Rationale

Whether or not a potential well site is on SRP Member land or off-project land affects the alternatives for use of the well, and may impact the ease of acquiring access to the land. Therefore, the basis for the Non-Member land ranking was:

SRP Member Status	Rank
On-Project	1
Off-Project	2

AutoCAD FILE: *CCA-AVONDALE-5-18.DWG*

Column 1 | Column 2 | Column 3 | Column 4 | Column 5 | Column 6 | Column 7

14700 W. | LITHCHFIELD RD. (13900 W.) | DYSART RD. (13100 W.) | 8TH ST. (A-800 E.) | EL MIRAGE RD./ 123RD AVE. (12300 W.) | 115TH AVE. (11500 W.) | 107TH AVE. (10700 W.) | 99TH AVE. (9900 W.)

Row 1 | Row 2 | Row 3 | Row 4 | Row 5 | Row 6 | Row 7 | Row 8 | Row 9 | Row 10

CAMELBACK RD. (5000 N.)
INDIAN SCHOOL RD. (4100 N.)
THOMAS RD. (2900 N.)
McDOWELL RD. (1600 N.)
VAN BUREN ST. (C-300 N., A-300 N.)
WESTERN AVE. (A- 0) BUCKEYE RD. (1200 S.)
LOWER BUCKEYE RD. (C-2800 S., A-1400 S.)
BROADWAY RD. (4400 S.)
SOUTHERN AVE. (6000 S.)
INDIAN SPRINGS RD. (7800 S.)

T2N / T1N / T1S

R1W / R1E

AGUA FRIA RIVER
GILA RIVER
SALT RIVER

City of Avondale

SCALE
2640' 0 2640' 5280'

Explanation

Study Area

Prioritization Ranking

>75	Good Groundwater Production Potential
60–74	Moderate Groundwater Production Potential
46–59	Poor Groundwater Production Potential
<45	Not Recommended

Note:
See Table 5A–4 for prioritization criteria ranks and values.

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FIGURE 5-18
Well Site Prioritization Map
City of Avondale
Water Resource Master Plan
Avondale, Arizona

5.4.2.2 Proximity to Existing Pipelines Ranking Rationale

The proximity to an existing pipeline (16-inch diameter or greater) will impact the ultimate cost of the water. A well further than ½ mile from a large diameter pipe would require a significant expenditure for pipeline installation. Therefore, the basis for the proximity to pipelines ranking was:

Distance from Well Site to Pipeline	Rank
More than ½-mile from a 16-inch pipeline	1
Less than ½-mile from a 16-inch pipeline	2

5.4.2.3 Impacts on Existing Wells Ranking Rationale

The Arizona Department of Water Resources (ADWR) regulations do not allow a new water supply well to impact any existing wells in the area. Numerous existing wells are located within the study area. Therefore, the basis for the impacts on existing wells ranking was:

Number of Existing Non-City Wells in Same ¼-Section	Rank
1 or more existing wells within ¼-section	1
0 existing wells within ¼-section	2

5.4.2.4 Groundwater Quality Ranking Rationale

Groundwater of poor quality may require blending or treatment prior to its use, at substantial additional cost. Review of the available groundwater quality data for the study area indicated that generally, nitrate and TDS are elevated in the eastern and southern portions of the study area, and arsenic appears to be elevated in some portions of the northwest study area. In addition to elevated nitrate, TDS, and arsenic concentrations, several areas of anthropogenic (man-caused) groundwater contamination are present along the western margin of the study area. Therefore, the basis for the groundwater quality ranking was:

Water Quality	Rank
Within ½-mile of superfund site	1
> 10 mg/L nitrate within 1 mile	1
> 0.01 mg/L arsenic within 1 mile	1
> 1,000 mg/L TDS within 1 mile	1
No water quality data available	2
< 10 mg/L nitrate within 1 mile	3

5.4.2.5 Aquifer Characteristics Ranking Rationale

Aquifer characteristics significantly influence the amount of groundwater that can be produced from a pumping well. Zones of greater permeability (hydraulic conductivity) will yield greater amounts of groundwater than zones with lower permeability. Therefore, the basis for the aquifer characteristics ranking was:

Hydraulic Conductivity of MAU	Rank
1 to 5 feet per day	1
6 to 10 feet per day	2
11 to 15 feet per day	3
16 to 20 feet per day	4
21 to 30 feet per day	5

5.4.2.6 Aquifer Thickness Ranking Rationale

The thickness of the aquifer directly impacts the quantity of groundwater that will be available for long-term pumping. As with aquifer characteristics, this criterion significantly influences the water production that can be expected from a pumping well. Therefore, the basis for the aquifer thickness ranking was:

Aquifer Thickness	Rank
Less than 250 feet	1
250 to 500 feet	2
More than 500 feet	3

5.5 Conclusions and Recommendations

On the basis of the well siting evaluation, the following conclusions and recommendations are made regarding the siting of public supply wells within the City of Avondale area.

5.5.1 Conclusions

The sum of the calculated prioritization values for each ¼-section parcel of land within the study area are shown in Appendix F-1.4, Weighted Prioritization Values. The land parcels that were evaluated have been prioritized into four general categories, to facilitate graphical delineation of the well site prioritization zones (Figure 5.18, Well Site Prioritization Map). The basis for the well site prioritization ranking was:

Sum of Calculated Value	Rank
More than 75	Good Groundwater Production Potential
60 to 74	Moderate Groundwater Production Potential
46 to 59	Poor Groundwater Production Potential
Less than 45	Not Recommended

The well site rankings are presented graphically on Figure 5.18, Well Site Prioritization Map.

5.5.2 Recommendations

Based on the analyses and findings, it is recommended that new City of Avondale public water supply wells be located within the areas delineated as having “good” or “moderate” groundwater production potential (Figure 5.18, Well Site Prioritization Map) when possible. However, some sites categorized as “poor” may provide a sufficient groundwater supply if the available data were insufficient to reveal the actual site conditions. The well siting prioritization provided in this report should be used to provide guidance to City of Avondale decision-makers, for selection of optimum well sites on the basis of currently available information. It is recommended that a site-specific hydrogeologic analysis (pilot hole analysis or exploratory boring analysis) be conducted in association with the installation of each new water supply well. Also, the City should perform site specific hydrogeologic analysis and water quality testing as a separate project within areas where full spectrum water quality is unknown. Additionally, the City should explore the inferred basin margin clastic area at the base of the Estrella mountains.

The primary basis for the well siting prioritization presented in this report is the hydrogeology of the study area. This aspect of the well siting evaluation process will not change over time (for example, the location of sand and gravel layers will not change over time). However, as additional information becomes available, the current hydrogeologic interpretation may be revised. The infrastructure criteria considered in this evaluation may also change with time, as the City grows and development proceeds. Demographic, regulatory, infrastructural, operational, or political considerations may require revision to the current well site prioritization. Therefore, a periodic review/update of this well siting evaluation should be conducted to keep abreast of the changing conditions in the area.

6.0 Recommendations

One of the fundamental purposes of this Water Master Plan is to evaluate Avondale's current water supply and demand situation as well as the future demand and supply for the four separate planning periods. While the City of Avondale currently has adequate water resources to meet demand, the implementation of a program to acquire additional water resources must begin immediately, in order to meet future water demand requirements.

Based on the analysis performed in Section 4 of this Water Master Plan, water demand will begin to outstrip the current supply during the 2006-2011 planning period. Therefore, additional water resources must be acquired and implemented during this planning period. Various recommendations are presented in this section which will aid the City in obtaining sufficient water supply to meet the anticipated demands.

6.1 Resource Development

In order to meet the City's future water demands, additional water resources must be developed. Many alternative water resource options were evaluated as part of this water master plan. The water resources, which are anticipated to increase the City's water supply in the most cost effective manner, comprise the recommendations described within this section.

6.1.1 SRP Allotments

As discussed previously in this document, a good portion of the lands within Avondale are located within the Salt River Reservoir District and are entitled to delivery of water from SRP ("on project" lands). Currently, SRP allots three acre-feet per year for each acre of "on project" land. Avondale's 1995 Assured Water Supply Application, anticipated that Avondale would have a legal entitlement to 19,578 acre-feet of water per year delivered by SRP for on project lands, based on the anticipated build out land use. However, since the City's designation was based on the projected and committed demand of 14,211 acre-feet for the year 2010, the quantity of SRP water specified in the City's AWS designation is only 8,463 acre-feet.

Since SRP water can only be used on "on project" lands and can not be stored underground, it is recommended that in the years that the City of Avondale can receive more than the 8,463 acre-feet of SRP water, that this additional water be utilized to satisfy the demands of on project lands in the current year. Therefore, water from other sources that had been used for the SRP lands could instead be recharged for long-term storage credits.

Based on recent studies by SRP, it is anticipated that the City will be able to amend the AWS designation to account for a greater supply of water from SRP (see Section 2.2.3, SRP and Section 4.6, Water Supply and Demand Analysis).

According to discussions with SRP, it is believed that the City will be able to include up to 14,433 acre-feet per year of SRP water in the City's AWS designation. It is recommended that the City of Avondale continue discussions with SRP and ADWR, in order to assure that the SRP water is being counted toward the AWS. It is also recommended that the City of Avondale file with ADWR an application to modify its designation during the 2006-2011 planning period in order to increase the amount of SRP water in the AWS designation. Additionally, an application to modify the designation should be filed as often as additional water from SRP is allotted to the City.

6.1.2 CAGRD

Avondale is currently a member of CAGRD, but has not yet actually paid CAGRD to replenish water for Avondale because of the City's existing underground storage project. If the recharge amounts and accrued credits fall below Avondale's ongoing usage, Avondale would need to pump "excess groundwater" and pay CAGRD to replenish this groundwater at a CAGRD contract facility. The determination of "excess groundwater" is based upon annual reporting provided by Avondale to CAGRD, as per the City's CAGRD membership agreement.

For the year 2002/3, CAGRD charges $198 per AF for replenishment water. This rate is scheduled to increase to $202/AF for 2003/4; and to $207/AF for 2004/5. This is an all-inclusive cost and gives the City the right to pump its local groundwater. Groundwater extraction costs, and any local treatment and conveyance costs would be in excess of this amount, but are well established based upon current City operations.

CAGRD water is currently being recharged at the Granite Reef Underground Storage Project (GRUSP) and at the Agua Fria Recharge Facility. Although the recharged water may never physically reach Avondale, the credits are accrued by CAGRD, in arrears, on behalf of its members and can be used as if the actual water was provided at the point of extraction. It is possible that in the future, CAGRD may implement recharge projects in the west Salt River Valley to ensure that pumping by CAGRD members does not generate excessive drawdown of the local water table.

6.1.3 Buckeye Waterlogged Area

Located within the southern portion of the City of Avondale is a portion of the Buckeye waterlogged area and the St. Johns waterlogged area. As described in Section 3.2, it is possible to exclude from groundwater calculations and water storage account debits water withdrawn from a waterlogged area. While the water quality in the Buckeye waterlogged area is currently unknown (it is believed to be very poor), it is recommended that the City of Avondale perform a feasibility study to determine the possibility and the costs associated with using this water to meet future water demand requirements such as for park landscape irrigation,

replenishment of WWTP effluent withdrawn from the Agua Fria River, and Tres Rios or Agua Fria trail system landscape irrigation.

6.1.4 Indian Lease Water

In a limited number of situations, Colorado River water that has been leased from an Indian tribe may be utilized to demonstrate an assured water supply. It is recommended that the possibility of leasing water from an Indian tribe be further investigated as a potential option in the future.

The potential for leasing Colorado River water from an Indian tribe was discussed with Greg Buma of the Colorado River Indian Tribe (CRIT). He mentioned that the tribe has a very large allotment of Colorado River Water, which they are looking into recharging so that they can receive credits. They would be interested in talking to the City of Avondale about a lease agreement for some of this water. Mr. Buma claims they have ways to be able to have the water transported down the CAP canal. This may be a way that the area south of the Estrella Mountains could get a water lease that would satisfy the Department of Water Resources. This would be nearly a fifteen-year process, but may be worth looking into as a potential source of water for the Southern portion of Avondale. It is important to understand that there are many obstacles to obtaining water from CRIT, including the fact that it is currently unclear whether the Tribe has the authority to lease such water or use the CAP canal to transport it.

6.1.5 Legal Consultant

The City of Avondale has entered into many agreements with various entities regarding its water storage and supply. In order to assure that the City of Avondale is meeting the contractual requirements, as well as to assure that the City is receiving its full allocations, it is recommended that the City hire a legal consultant to provide an audit of the City's agreements, and to provide legal guidance to ensure that the City is receiving the maximum amount under the agreements.

6.1.6 Water Master Plan Update

Over the next 5 years, many changes will take place in the City of Avondale. The City will continue to grow and expand as more homes are developed, and commercial growth continues within the area. In order to make sure that this Water Resources Master Plan continues to provide the most effective guidance to the City of Avondale, it is recommended that this Plan be revised and updated every 5 years.

6.2 Reclaimed Water Plan

One constant and renewable source of water that the City should take advantage of is wastewater treatment plant effluent. Based on the analysis performed for this Water Resources Master Plan, a reclaimed water plan must be implemented

in order to meet the City's build out water demands. Based on the water supply analysis in Section 4.6, it is recommended that the City of Avondale begin the design and implementation of a reclaimed water plan within the 2006-2011 planning period. A detailed discussion of the reclaimed water plan is provided below.

Effluent from the Avondale Wastewater Treatment Plant is currently discharged to the Agua Fria River. The wastewater treatment includes nitrification-denitrification in a biological process followed by chlorination-dechlorination. The plant does not currently have filters, but they are planned for the future. The effluent is Class B+ suitable for recharge, irrigation of an orchard, irrigation of golf courses, restricted access landscape irrigation, landscape impoundment, dust control, construction water, milking animal pasture irrigation and livestock watering, and street cleaning as well as those uses approved for Class C effluent. Class C effluent can be used for pasture or livestock watering for non-dairy animals; irrigation of sod farms; irrigation of fiber, forage, seed or other similar crops and silviculture.

The plant is being expanded to 6.2 mgd capacity and will continue to produce Class B+ effluent.

The discharge to the river has created a wetland type habitat. If the effluent were utilized in some fashion, a portion of the effluent might still have to be discharged to maintain the habitat. This issue would need to be worked out with the regulatory agencies during the design and construction of any effluent reuse facilities.

6.2.1 Flow

In order to plan for reclaimed water use the available quantity of reclaimed water must be determined. For current flows this is not a problem because wastewater flows at the plant are measured. However for the future, a method of projecting available reclaimed water must be developed. The simplest approach is to determine the current relationship between water and wastewater flows and use this relationship to project future reclaimed water quantities. Table 6.1, Annual Water and Wastewater Flows, presents water and wastewater quantities on an annual basis for the most recent three years the data is available.

Table 6.1 Annual Water and Wastewater Flows

Year	Water Pumped (gal)	Wastewater (gal)	Wastewater (% Total Water)
1998	1,595,622,900	729,651,600	45.7
1999	1,968,106,215	901,027,300	45.8
2000	2,254,045,857	1,205,104,000	53.5

For the three years the wastewater flow averaged 48.3% of the potable water pumped into the distribution system.

Several factors could affect this ratio and the total available reclaimed water in the future. If outside water use is restricted in the future to reduce per capita demands, the ratio of wastewater to water use would go up. However, if the water use decreases due to less use outside, the quantity of reclaimed water could remain essentially the same. If further indoor conservation measures are implemented, the ratio could go down and total flow might also decrease. With the apparent potential future uncertainty of reclaimed water flows, for planning purposes the current ratio will be used and applied to the future water demand projections. This should provide a conservative approach for this planning effort.

Future projected wastewater influent flows are presented in Table 6.2, Projected Wastewater Flows, based on the ratio calculated above.

Table 6.2 Projected Wastewater Flows

Year	Wastewater Flow* (mgd)
2006	6.0
2011	8.0
2026	14.3
2040	16.2

*These flows are annual average day flows.

6.2.2 Effluent Management Alternatives

Use of reclaimed water can offset a portion of the per capita demand pumped from the ground as calculated by ADWR as part of the Management Plans under the Groundwater Management Act. This is discussed in more detail in the Water Conservation section of this report. Reclaimed water can be used directly to reduce the amount of potable water consumed, exchanged with another entity to reduce the amount of ground water pumped by that entity or recharged to offset groundwater pumping by Avondale. Reclaimed water is such a valuable water resource that it ALL should be reused or recharged.

6.2.2.1 Direct Reuse

Since the effluent from the Avondale Wastewater Treatment Plant is not Class A it is restricted to those uses mentioned in Section 6.2. For more general use the treatment would need to include filtration and chemical addition. Also direct reuse would require a distribution system including pumping, transmission and storage. In addition, alternative disposal would have to be included to accommodate those times of the year when the demand for effluent is less than the production.

A review of potential reuse sites indicates an extensive reclaimed water distribution system would be required and that recharge facilities would be necessary to handle all of the effluent. This would be in addition to the required treatment plant modifications. These costs would be significant.

6.2.2.2 Exchange

Avondale could provide effluent to another entity such as Roosevelt Irrigation District (RID) and receive in exchange credits to pump groundwater that the entity did not pump as a result of using the effluent. To achieve such an exchange the effluent quality would have to be increased to Class A so the entity could use the water freely. RID was contacted as a possible exchange partner. However, if effluent was added to the RID canal, RID would lose its existing exemption from the NPDES permit program. The addition of NPDES permitting requirements is unacceptable to RID. Therefore, exchange using the RID canal to transport effluent is not a viable option.

6.2.2.3 Recharge

Avondale has an active recharge program for its surface water supplies. The site has land available for future expansion which could include effluent recharge. Effluent recharge would require pumping and transmission from the plant to the recharge site. No additional treatment would be required and this approach minimizes the amount of pipe required. In either reuse or exchange a line would be required to the recharge site to accommodate those times when reuse or exchange could not take all of the reclaimed water.

As indicated on the previous table, the ultimate average day wastewater flow is 16.2 mgd. There will be water losses in the plant for sludge disposal and in-plant reclaimed water use. Some effluent will need to be discharged to maintain the existing wetlands and there will also be losses to evaporation at the recharge basins. These can be accounted for by reducing the wastewater flow by 25% or to 12.15 mgd (13,610 acre feet per year) for the amount of recharge credits which Avondale can expect from ADWR.

Facilities needed for the recharge option include a pump station at the treatment plant, a pipeline to the recharge facility and expansion of the recharge basins. The pump station should be sized for the peak day (assuming some available diurnal equalization storage) to be able to transfer all of the reclaimed water to the basins. Only the pumps required for the immediate future need to be installed, others can be installed in the station as the plant expands. The pipeline should be sized for ultimate flows with lower velocities in the early years. With this as a base, the pump station would have an ultimate capacity of about 24 mgd and the pipe would be 36 inches in diameter.

The existing Phase I recharge basins can handle up to 15,000 acre feet per year. In the future Phases II and III of the recharge basins would have to be added to

accommodate the increased wastewater flows. In order for the existing basins to handle the full 15,000 acre feet per year, the two trailer parks southeast of the basins, Community Hills and Pecan Tree, have to be on the sewer system. The septic tanks currently used by the parks limit the operation of the recharge basins.

The City has already acquired the majority of the Phase II and Phase III recharge areas. This was mostly done in 2001 through a 62-acre purchase of Arizona Department of Transportation property. The property encompassed all of the Phase III lands located south of McDowell Road and the central and eastern portion of the Phase II lands located north of McDowell, but south of the Phase I area.

The western portion of the Phase II lands are owned by Maricopa County Flood Control District and are currently under consideration for purchase by the City. Purchase of these lands is recommended in order to ensure that the City establishes and controls this vital land that will be used as a substation component of its future water supply facilities. All of this Phase II and III area will be needed to construct recharge basins to meet the City's anticipated build-out water demands.

Use of the City's reclaimed water for recharge will require additional permitting. The City currently maintains a full-scale Underground Storage Facility (USF) permit issued by ADWR that is valid until December 31, 2018. A revised or new USF permit will be required to allow recharge of reclaimed water. A Water Storage Facility permit and Recovery Well permit will also be required along with an Aquifer Protection permit for the recharge site.

One evolving aspect related to artificial recharge and subsequent reuse of effluent, that is important to consider, are any chemicals that may only be partially treated and removed from the source water. Based on recent research, certain classes of chemicals are not degraded in wastewater treatment processes. These classes of chemicals can be potentially deleterious to subsequent human consumption, even with treatment approaches currently in place and anticipated for future upgrades to Avondale's wastewater treatment plant. These chemicals include, but are not limited to, pharmaceuticals, chemotherapy drugs, caffeine, endocrine disruptors, and estrogen compounds. Additional treatment may likely occur in the vadose zone during groundwater recharge, although the amount of reduction may not be complete. Many regulatory agencies seek a "multiple barrier" approach to removal of various constituents in wastewater and other flows. The combined treatment at the wastewater plant and the recharge basin bottoms and underlying vadose zone is consistent with this preference. ADEQ is aware of the concerns related to these classes of constituents, but has not drafted or promulgated regulations.

6.2.3 Evaluation and Recommendation

Direct reuse of the reclaimed water will be expensive except as incidental to the transmission of the reclaimed water to the recharge site, such as freeway irrigation. Direct reuse would require the addition of filters at the WWTP, an extensive transmission and distribution system to provide water to the users, transmission to the recharge site to handle excess reclaimed water and expansion of the recharge ponds. Exchange of the reclaimed water will result in similar costs to those of direct reuse.

The least expensive approach is to provide transmission of the reclaimed water to the existing recharge site. This would also allow direct reuse of the water for potential freeway irrigation and possible irrigation of trails along the river. A planning level cost estimate for the facilities required for recharge is $6,000,000. This includes the pump station, pipeline, and construction of the Phase III recharge basins. The facility sizing and cost should be verified in a facility predesign study.

6.3 Treatment Options

The regulations presented in Section 3 along with the supply water quality determine the treatment requirements for a particular water supply. This section includes an evaluation of the direct use of surface water following treatment along with treatment considerations for ground water.

6.3.1 Surface Water

Avondale currently recharges its surface water following treatment in a wetlands facility to reduce the nitrate content of the water. Avondale's location on the canal system puts it at somewhat of a disadvantage from a water quality perspective, since the canal contains irrigation tail water and groundwater, both of which may have levels of nitrate exceeding the limit of 10mg/L of nitrate as nitrogen. The wetland reduces the nitrate nitrogen below the limit.

A potential supplement to recharging the surface water would be to build a treatment plant that would deliver water meeting all of the regulatory requirements. This approach would require a plant which addressed not only the normal surface water issues such as turbidity, taste, odor, disinfection by-products and stability but also the issue of nitrogen. A conventional plant to address the normal surface water issues would cost in the range of $1.50 per gallon. So a 10 mgd plant would be about $15,000,000. The nitrate issue would require the addition of ion exchange or membrane treatment with reverse osmosis (RO). Nitrate levels in the surface water are generally less than 12 mg/L so only a portion of the flow would need to be treated prior to being blended with the remainder of the flow.

While the conventional plant has residuals which create disposal issues, the brine from either an ion exchange or RO plant is extremely difficult to handle. A

plant producing 10 mgd of treated water with an influent nitrate of 12 mg/L would produce about 750,000 gallons of brine per day, which would go to a brine evaporation pond. Nitrogen removal is limited to about three months per year. At six feet of net evaporation per year the brine pond would have to be a minimum of 40 acres. Treatment for nitrogen removal including brine disposal would add $3,000,000 to $5,000,000 to the treatment plant cost for 10 mgd.

If the surface water were treated and used directly, a backup supply would be required for times of canal outage. Other cities in the valley with surface water treatment plants use plants on other canal systems or wells as backup for a surface water treatment plant. Since Avondale does not have ready access to another surface supply, the backup would have to be wells. As will be discussed in the next section, well head treatment will be required in Avondale for some current wells and for a portion of the wells which will be drilled in the future. If wells were to be used as a backup to a surface treatment plant, then an investment is required in both the plant and the wells. Continuing to recharge the surface water and recover it in wells will provide a continuous water supply, and it will save what would have been invested in the surface water treatment plant.

Based on this analysis, treatment of surface water is not recommended. Avondale should continue to recharge its surface water supply, pump water from the ground and provide well head treatment as necessary.

6.3.2 Well Head

Avondale well water quality is generally good except for two parameters. Nitrate is near or exceeds regulatory limits in three of the existing wells and arsenic exceeds the new standard of 10 μg/L in six of the wells. The nitrate standard of 10 mg/L of nitrogen is currently enforceable while the arsenic standard will not be enforced until January of 2006. While the arsenic standard is not currently enforceable, it is only prudent for the City to begin providing well head treatment for arsenic remediation. Well water quality data for Avondale's existing wells is shown in Table 6.3, Well Water Quality, below.

Table 6.3 Well Water Quality

Well	Arsenic (μg/L)	Nitrate (mg/L)	Flow (gpm)
1	3-20	7-11	1,060
6	18 - 26	2.6 - 4.3	1,300
7	24 - 26	2.6 - 4.5	1,220
8	5-20	8.4 - 9	560
10	5	5.8 - 6.8	2,025
11	ND* - 5	8.4 - 11	1,650
12	3.7 - 6	6 - 7.4	2,000
14	40	1.6	450
15	16	2.9	600
18	6	5.1	2,000

* ND - Non-detect

Three wells are near or exceed the nitrate limits. There are several ways to address the nitrate issue: blending with water from other wells with better quality, shutting off the well or treatment with ion exchange or RO. Well 1 can be blended with water from the north in the reservoir at Well 1. The current CIP has pipelines in 10th Street and Riley to accomplish this blending. Well 8 has both nitrogen and arsenic issues and a very low pumping rate. There are no wells nearby for blending. This well has been shut down and should be replaced. Tolleson has a good quality producing well within one half mile from Well 8. Avondale should be able to replace the well in the local area and screen out the problem contaminants. Well 11 is tied into a transmission line with Wells 10 and 12. If one or both of these wells are run with Well 11 the blending will reduce the nitrate to acceptable levels.

In the future, treatment for nitrate reduction will be required if new wells can not be located, screened or blended to produce acceptable nitrate levels. Nitrate removal by ion exchange requires the ion exchange media and regeneration facilities. As the nitrates are exchanged on the media for other ions the media becomes exhausted and must be regenerated. The regeneration process produces spent brine, which must be disposed of. Typically, if the quantities are very small the brine can be put in the sanitary sewer system. Larger quantities require brine evaporation facilities, either mechanical or solar.

6.3.3 Costs

Cost of wellhead treatment for either nitrate or arsenic is dependent on a number of factors: well capacity, contaminant concentration, concentrations of other parameters in the water and physical site constraints. Since detailed information is not available to determine these specific factors, the costs presented here are general and conservative in nature to accommodate variability in these factors. The costs presented below include the construction costs for the facilities but do

not include engineering or land costs. These are planning level costs and must be verified for each well and its associated characteristics that affect the costs.

Nitrate removal costs are based on an ion exchange facility with brine regeneration and waste brine disposal and are presented on Figure 6.1, Ion Exchange Nitrate Removal Capital Costs. These costs are based on published reports and our cost estimates for similar facilities.

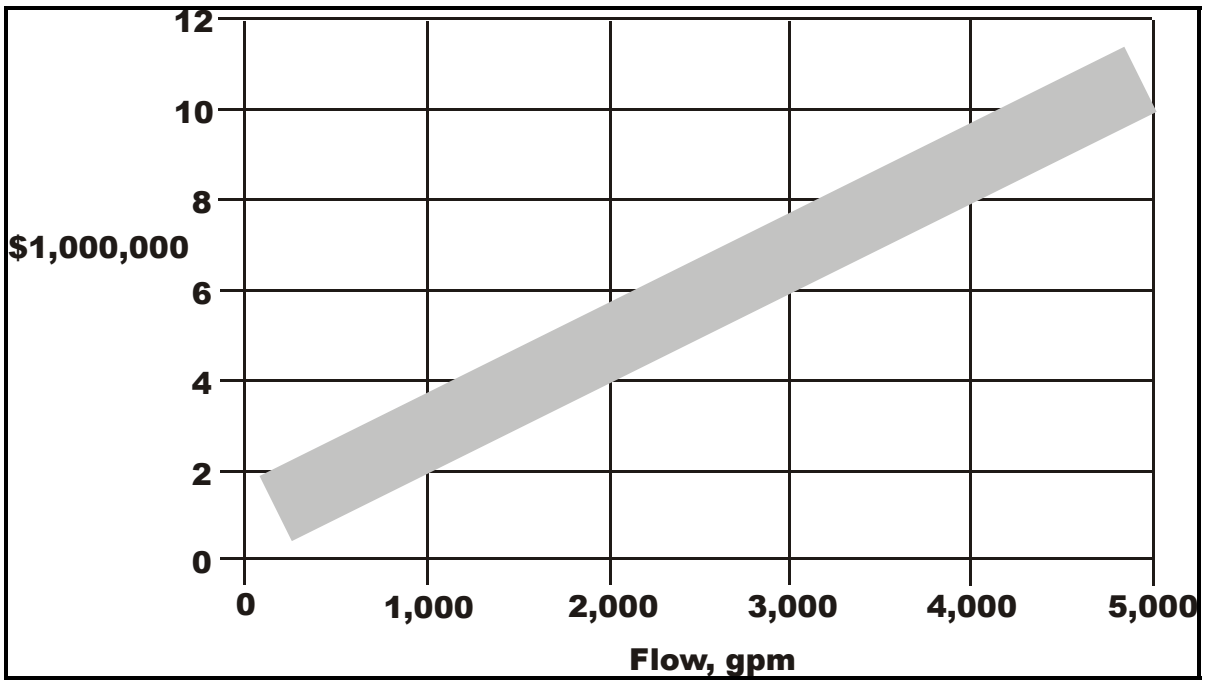

Figure 6.1 Ion Exchange Nitrate Removal Capital Costs

Annual operation and maintenance costs will generally be between 5 and 10 percent of the capital cost. These costs are very dependent on the concentrations of nitrates and other constituents in the water.

Specific information is not available to estimate the number of wells that will require nitrate removal. As new wells are drilled it is expected that more of them will have nitrate problems than is now the case. In general, the known lower nitrate areas are almost saturated with wells and new wells will have to go in areas that are known or assumed to have nitrate issues. Assuming that approximately 60 percent of the future wells will require nitrate treatment, the total cost for the assumed number of wells at buildout in today's dollars could be about $125,000,000 for treatment only. This would equal $2,000,000 per 1,000 gpm ($1.40/gal) to construct the nitrate treatment facilities at those wells where the groundwater quality requires treatment. Annual operation and maintenance costs could be in the range of $6,000,000 to $10,000,000.

Arsenic removal costs are based on coagulation and pressure filtration with backwash disposal to the sewer. These costs are based on our estimates of costs for similar facilities and are shown on Figure 6.2, Coagulation/Filtration Arsenic Removal Capital Costs.

Annual operation and maintenance costs will generally be between $0.08 and $0.20 per thousand gallons treated depending on the arsenic concentrations in each well.

Again specific information is not available to estimate the number of future wells that will have arsenic levels above 10 μg/L. Assuming the number of future wells with arsenic issues is in the same proportion as the existing wells, this would mean 60 percent of the new wells would need arsenic removal. The total cost at buildout with this assumption could be $36,000,000 to $40,000,000. Annual Operation and Maintenance costs could be in the range of $1,000,000 to $2,000,000 not including any additional sludge costs at the wastewater plant. The total treatment cost per well for arsenic treatment based on well production (gpm) is shown in Figure 6.2, Coagulation/Filtration Arsenic Removal Capital Costs.

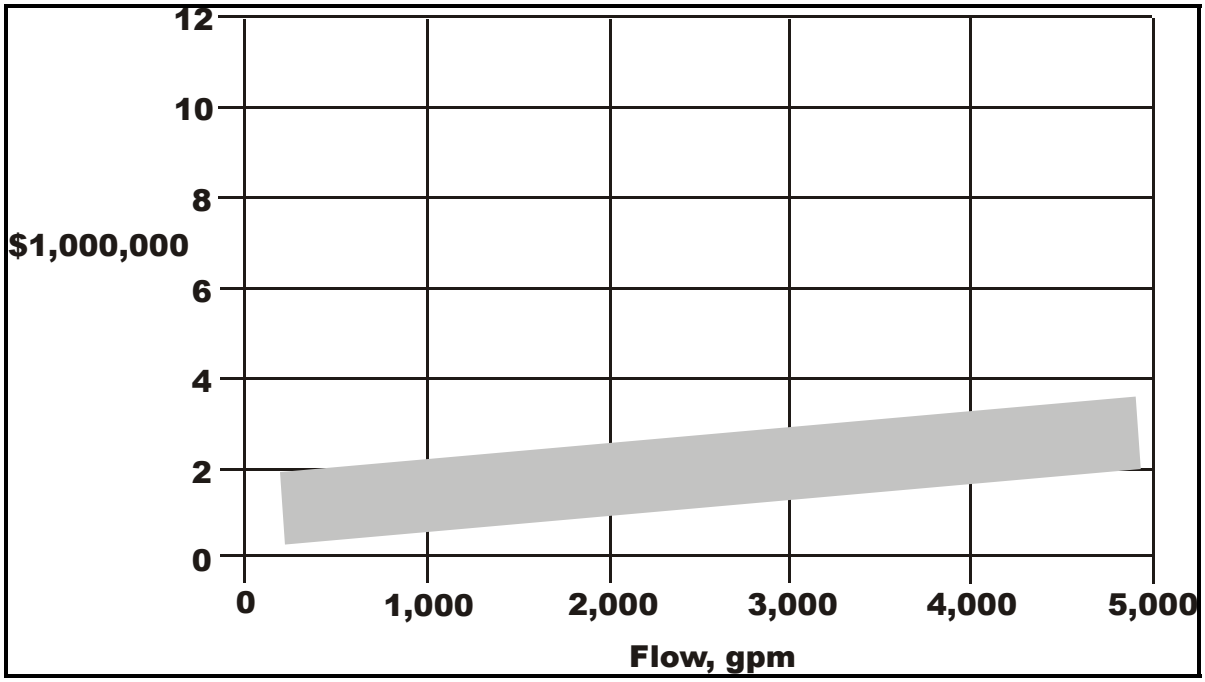

Figure 6.2 Coagulation/Filtration Arsenic Removal Capital Costs

6.4 Water Conservation Measures

One of the recommendations which will significantly help the City of Avondale's water supply, is the implementation of a comprehensive water conservation

program. Not only is the City required to implement conservation measures, but the lower the average gpcd, the farther the City's existing water supplies will go.

In order to aid the City in having sufficient water supply in the future, a comprehensive water conservation plan has been developed. It is strongly recommended that these measures be implemented in order to better utilize the City's water supply.

6.4.1 Current Water Use

The current water use in the City can generally be identified by two parameters:

1. Annual Gallons per Capita use.

2. Use by Category and Summer Use.

These are described and discussed below.

6.4.1.1 Annual Per Capita Use

The annual gallons per capita per day (gpcd) measures the amount of water pumped annually by the City divided by the population served. This is also the unit used by the Arizona Department of Water Resources (ADWR) to measure a community's compliance with the requirements of the Groundwater Management Act.

Table 6.4, Water Usage, shows for the years 1998, 1999, and 2000, the water pumped in gallons, population served, and the gpcd use in the City based on City pumping and meter records (Section 2.2 2001 Avondale Water Infrastructure Master Plan). The population served is estimated by ADWR, but is currently approximately 94 percent of the planning area population.

Table 6.4 Water Usage

Year	Total Water Pumped (Gallons)	Planning Area Population	Population Served	Per Capita Use (gpcd)
1998	1,595,622,900	28,650	26,851	163
1999	1,962,666,794	32,270	30,333	177
2000	2,254,045,857	35,850	33,699	183

This table shows that as well as having an increasing population, the per capita use in the City is also increasing. The population increased by about 25 percent from 1998 to 2000. Over the same time period, the gpcd use increased by about 12 percent. In 1993, the use was 150 gpcd.

Under normal conditions and in a stable community, the per capita use should not change very much from year to year. There are some minor changes from year to year depending on the weather; hot dry summers increase the use, whereas wet cold winters decrease the use. Some possible reasons why the gpcd has increased in Avondale include:

- The new population is going into new and larger houses with more water using facilities than the older Avondale homes.
- The new population is more affluent than the earlier Avondale residents and therefore may use more water.
- A change from flood irrigation to pumped irrigation will increase the water use.
- More public parks and landscaped areas which use more water.
- The water distribution system has been improved, allowing for more water use.

6.4.1.2 Water Use by Category

Each individual water user in Avondale is metered. This allows the City to measure how much water is used at each location on a monthly basis. The water use is aggregated by the City into nine major categories to better identify water use by certain types of water users. The nine categories are:

1. Residential.
2. Mobile Home Park.
3. Multi-family.
4. Commercial.
5. Schools.
6. Churches.
7. Industrial.
8. Laundries.
9. Hydrant Meter.

The Hydrant Meter category measures the water used at certain metered hydrants in the City. This meter water is generally used for construction, street cleaning, hydrant testing, etc.

The meters measure actual water use in Avondale. However, in all water systems there is a certain amount of water lost, the difference between the water pumped into the system and the water used or metered in the system. This is known as lost or unaccounted for water. Avondale's unaccounted for water in the years 1998 and 1999 is 6.8 percent and 8.1 percent respectively. No lost water numbers are currently available for 2000 due to problems in resolving differences in metered amounts for that year. The ADWR's target is that each water system has no more than 10 percent of unaccounted for water.

Table 6.5, Water Use by Category, shows the annual gallons and percentage uses by each category for the years 1998,1999 and 2000. (See Appendix E for monthly totals.) For the years 1998 and 1999, the percentages are calculated based on the total water pumped. For the year 2000, since there is no unaccounted for water, the percentages are based on the total water used.

Table 6.5 Water Use by Category

Category	1998		1999		2000	
	gal/yr x 10^3	%	gal/yr x 10^3	%	gal/yr x 10^3	%
Residential	941,130	59.0	1,148,908	58.5	1,447,781	55.4
Mobile Home Park	74,356	4.7	67,410	3.4	77,906	2.9
Multi-Family	119,156	7.5	93,565	4.8	127,773	4.9
Commercial	267,869	16.8	422,643	21.5	611,122	23.4
Schools	42,513	2.7	36,158	1.8	38,165	1.5
Churches	7,056	0.4	5,448	0.3	8,842	0.4
Industries	2,699	0.2	7,450	0.4	10,083	0.4
Laundries	2,773	0.2	4,105	0.2	5,052	0.2
Hydrant Meter	29,946	1.9	18,000	0.9	77,865	2.9
Unaccounted for Water	108,125	6.8	158,978	8.1		8.0 est.
TOTAL	**1,595,623**		**1,762,667**		**2,404,589**	

As can be seen in Table 6.5, Water Use by Category, the two largest water use categories are Residential (60 percent) and Commercial (25 percent). Between them, they account for over 85 percent of the water use in the City.

6.4.1.3 Seasonal Use

The year 2000 water use of 183 gpcd is the annual average. Figure 6.3, Current Water Use by Category, shows the monthly water use by category over the year. This shows that the residential summer use increases dramatically during the high use summer months of June through September. Figure 6.3 also shows an unusual spike of commercial use in November. Table 6.6, Unit Water Consumption, shows the different per capita use for the various times of the year. The total annual average is based on the amount pumped for the year divided by the year 2000 population served (see Table 6.1, Annual Water and Wastewater Flows). Winter water use is normally the minimum water used over the year. This is the time when external or irrigation water use is at a minimum. Conversely, June was the maximum use month with 279 gpcd, or 2.1 times greater than the base winter flow (see Table 6.6, Unit Water Consumption).

Table 6.6 Unit Water Consumption

Use	Per Capita Use (gpcd)	Ratio to Winter Use
Total Annual Average	183	1.4
Winter Months (Dec-Feb)	131	1.0
Summer Months (Jun-Sep)	257	2.0
Maximum Month (Jun)	279	2.1

6.4.2 Current Conservation Program

Avondale, under the Groundwater Management Act, elected to proceed with the gpcd program. However, in the early 1990s the water consumption in Avondale was approaching 200 gpcd. Because of this, the City received a Stipulation and Consent Order from the Arizona Department of Water Resources. This Order resulted in the City establishing a water conservation program. Specific programs initiated by the City included:

- Leak detection and repair.
- Meter replacement.
- New ordinances covering rates, non-residential landscaping and new low flow plumbing code.
- Public information and education, including low flow shower head replacement.

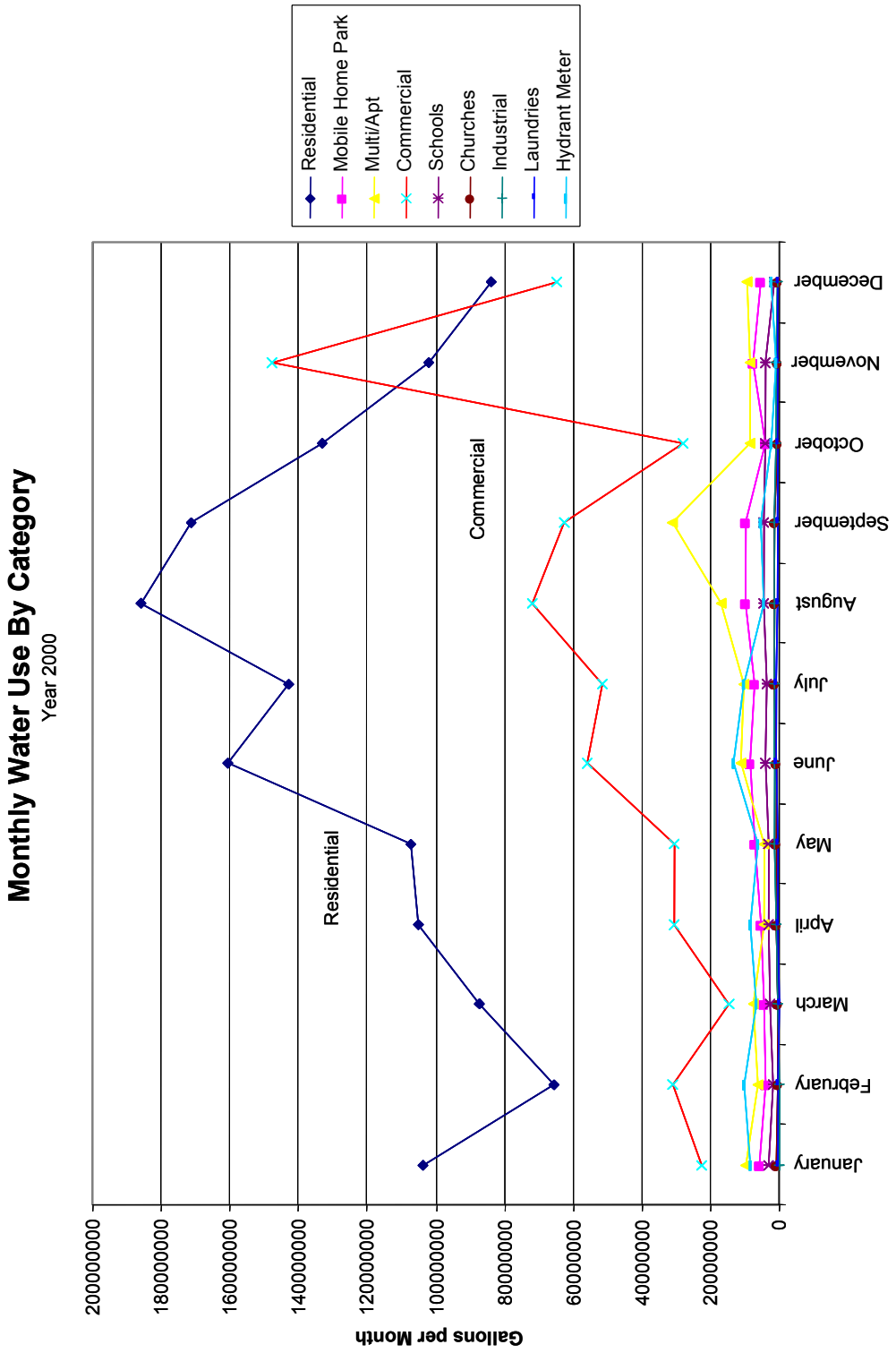

Figure 6.3 Current Water Use By Category

6.4.2.1 Leak Detection and Repair

Prior to the implementation of any programs, the estimated unaccounted for water in the system was over 11 percent. The City implemented an aggressive program to identify and eliminate leaks in the system. This was completed in 1998 and the unaccounted for water loss dropped to between 6 percent and 8 percent. The City also implemented the use of computer generated water management reports to enable the City to track water use by individuals as well as by categories.

6.4.2.2 Meter Replacement

Many of the meters in the system were old and unreliable making accurate water use and billing information unavailable. The City began a program in 1996 to replace all of the meters and this was completed in 2001.

6.4.2.3 New Ordinances and Regulations

To meet the water conservation requirements, the City adopted or proposed the following ordinances over a period of years:

- The enactment of conservation orientated rate structure that implemented increasing block rates for water use. Currently these rates are:
  - 0-7,000 gallons $0.75/1,000 gallons.
  - 7,000-20,000 gallons $1.21/1,000 gallons.
  - > 20,000 gallons $1.82/1,000 gallons.
- Converting the sewage fee from a flat rate to a volume use based charge calculated from water use between December and March.
- The amendment of the City's non-residential zoning landscape ordinance requiring the use of the ADWR low water use plant list for all right of way landscaping and for the installation of automatic sprinkler systems.
- The adoption of a low flow plumbing code.
- The adoption of an ordinance making it mandatory for commercial developments to have at least 20 percent of their landscaping low water use.
- The adoption of a requirement for new businesses to submit a water conservation plan.

6.4.2.4 Public Education

Water conservation has been promoted by the City in several ways:

- Establishing and staffing a City water conservation program.

- Preparing regular newspaper articles on the environment including water conservation.
- Development of water conservation materials for distribution in the City.
- Distribution of water conservation kits containing dye tablets, displacement bags and showerhead flow restrictors.
- Affiliation with a valley wide K-5 program for visits to schools promoting water conservation.

Under these programs, the water consumption rate in the City dropped from the 200 gpcd range in 1994 to 167 gpcd by 1997.

6.4.3 The ADWR Third Management Plan

The current goal for the second management period for the City is 174 gpcd under the 1994 Stipulation and Consent Order. Under the Third Management Plan, during the period 2002 to 2004, the gpcd amount will be made up of 118 gpcd for the residential plus 36 gpcd for the non-residential for a total of 154 gpcd. By the year 2010, this total amount will reduce to 136 gpcd. As identified in Section 2.0, Current Water Usage, the City's water use has increased from 163 gpcd in 1998 to 183 gpcd in 2000. If this trend continues, the 2001 usage could be over 190 gpcd.

The ADWR monitors the gpcd factors on a three year running average for the City's water service area. Based on the service area numbers, the City for the years 1998, 1999, and 2000 will have a three-year average of about 174 gpcd. If year 2001 has a gpcd use of 190, the running average could go up to about 184 gpcd.

At the moment, ADWR is not estimating the year 2000 gpcd number for any community until the year 2000 population census numbers are fully disaggragated. This may be completed by the spring of 2002.

To help the City meet its groundwater pumping goals, hence its per capita consumption goals, the City in 1999 started a program to recharge its unused Central Arizona Project allocation of over 10,000 acre-feet per year. This means that until the City's pumping rate exceeds the recharge rate, the City will not have a per capita issue. By the year 2010 or earlier, however, the City will again be facing the question of meeting its assigned gpcd goals.

In order to provide an estimate of the allowable water usage in the City of Avondale based on the Third Management Plan, the future total water usage

allowed under the Third Management Plan was projected for the years 2001 to 2011. These allowable water usage projections were based on the population projections for the City as described in the *2001 Water Infrastructure Master Plan*. The population projections were broken down linearly for the for the first 10 years of the study, and the calculations assume that 90% of the new population growth each year is single family residential, and 10% of the new population growth each year is multifamily residential. The GPCD projections for the next ten years according to the requirements of the Third Management Plan are shown in Table 6.7, Future GPCD Projections.

Table 6.7 Future GPCD Projections

Year	Population	Total GPCD
2001	40,350	**186**
2002	44,649	**167**
2003	48,948	**167**
2004	53,247	**167**
2005	57,546	**158**
2006	61,845	**158**
2007	66,177	**158**
2008	70,509	**158**
2009	74,842	**158**
2010	79,174	**148**
2011	83,506	**148**

An analysis was also performed to evaluate how Avondale's projected water consumption over the next 10 years compares with the future allowable GPCD's. Table 6.8, Water Consumption and GPCD Comparison, shows the water demand projected for each of the planning periods, along with the allowable water demand according to the GPCD projections.

Table 6.8 Water Consumption and GPCD Comparison

Year	Population	Projected Demand	Effluent	GPCD Demands	3rd Mgmt Allocation
2001	40,350	8,012	-	8,012	8,398
2006	61,845	13,855	-	13,855	10,927
2011	83,506	18,708	6,777	11,931	13,844
2016	105,167	23,560	8,535	15,025	17,435
2021	126,828	28,413	10,292	18,121	21,026
2026	148,489	33,266	12,050	21,216	24,617
2040	167,665	37,562	13,607	23,955	27,796

It can be seen from the above table that except for the year 2001, the projected demand for the City of Avondale exceeds the water allocation from the Third Management Plan. It is important to understand however, that effluent water does not count against the GPCD requirement. Therefore, for the years where

the proposed reclaimed water plan is in place (2011-Future), the City of Avondale remains in compliance with the Third Management Plan requirements. It is also important to note that the Third Management Plan requirements will be completed in the year 2010 and the Fourth Management Plan requirements will come into play in the year 2011. The requirements for the Fourth Management Plan will be available before January 1, 2008. Based on the analysis performed here, the City of Avondale's GPCD demands will exceed the Third Management Plan Allocation in the year 2006

As can be seen from the table above, if the City's gpcd continues increasing and reaches the projected amount of 200 gpcd, the City will be out of compliance with the Third Management Plan. There are various options that the City of Avondale may select in order to maintain compliance with the Plan. These options include implementing stricter conservation measures, implementing the recharge program immediately, or seeking acceptance into the non per capita conservation program (NPCCP).

In order to maintain compliance with the requirements of the Third Management Plan, the City of Avondale must have a gpcd no greater than 167 by 2002 and 158 by 2005. Currently, the City has a gpcd of 183 which exceeds the compliance requirements for the year 2002 and greater. One method of maintaining compliance is to implement stricter conservation measures. The City must reduce their gpcd by 16 by the year 2002 and then by 9 gpcd more by the year 2005. This is a realistic goal that can be reached through the implementation of the additional conservation measures listed in Table 6.8, Avondale Conservation Options. By implementing stricter conservation measures, the City's gpcd will decrease, maintaining compliance with the Third Management Plan, and reducing the overall water requirements of the City.

A second option for maintaining compliance with the Third Management Plan usage requirements is to implement the reclaimed water plan immediately. By implementing a reclaimed water plan, the effluent is not counted against the gpcd usage. This extra water would therefore allow Avondale to maintain their current usage rates and remain in compliance with the goals of the AMA. This option however, would require an outlay of capital immediately, instead of at a future time when the reclaimed water plan must be implemented to maintain sufficient supplies.

Another option for maintaining compliance with the Third Management Plan would be for Avondale to seek acceptance to the NPCCP in place of the GPCD program. The NPCCP is available only through an application process. The provider must limit or reduce its use of groundwater in order to qualify for the program. Under the NPCCP, the provider must have a plan under which it will deliver no mined groundwater after January 1, 2010. Additionally, the provider

must agree to implement reasonable conservation measures (RCMs) that ADWR determines will achieve a water use efficiency equivalent to the GPCD requirements.

6.4.3.1 Implication of Not Meeting the Goal

Under the Groundwater Management Act, the ADWR has the authority to impose various penalties on a community that does not meet the assigned gpcd goal. This can happen after two years of non-compliance. The penalties can include daily fines, loss of recharged credits, imposition of conservation programs and loss of the Assured Water Supply (AWS) status.

Loss of the AWS status or recharge credits could impact Avondale's plans for growth and expansion. Each new development would have to apply for and obtain its own Certificate of Assured Water Supply prior to being allowed to build.

6.4.4 Water Conservation Program Considerations

Avondale's current per capita use is estimated at 183 gpcd for the year 2000. The ADWR goal for Avondale for 2000 is 174 gpcd, but this will reduce to 154 by 2002. Avondale's immediate goal is to reduce the per capita use by about 30 gpcd within the next few years.

Currently, the City has implemented several water conservation measures and they successfully reduced the per capita water use. It appears that the City will have to look at new measures to reduce the trend over the past three years of increasing per capita use.

6.4.5 Effluent Utilization

The per capita use is calculated as water pumped, divided by the population served. In Avondale's case, the water used is a combination of groundwater and recharged surface water. The Groundwater Management Act is designed to reduce the amount of groundwater pumping. This reduced groundwater pumping can be done by actual reduction in pumping, or it can be done by replenishing the groundwater by increasing the amount of groundwater recharge.

Avondale has a resource available to it in the form of effluent. Currently, Avondale discharges all of its effluent to the Agua Fria. This effluent could be utilized in two ways. One, it could be used directly to replace an existing water use such as park, freeway, median or other turf type irrigation. Implementing direct reuse would require the construction of an effluent distribution system. The benefit from this approach is the direct reduction of the amount of groundwater pumped. The other option is for Avondale to obtain credit for the recharge of the effluent. This credit will offset water pumped from the ground just as the current recharge of the surface water does (see Section 6.2, Reclaimed Water Plan).

6.4.6 Water Conservation Program

In addition to implementing direct effluent reuse and/or effluent recharge for water credits, the current conservation program will need improvement in the future to reduce water demand relative to available water resources. In most water conservation programs, the greatest water savings can be obtained from the water users that use most of the water. In Section 6.2, the two largest water users were identified as Residential and Commercial. In 2000, they used about 85 percent of the pumped water: Residential 60 percent, and Commercial 25 percent. On this basis, any proposed conservation programs should concentrate on these two categories.

In looking at these two categories, another area to consider is the seasonal or exterior water use. Table 6.7, Seasonal Use, shows a more detailed analysis of the water use over the year. The table shows the gallons per capita use in the low flow winter months of December through February, the high use summer months of June through September, and total annual flow and the peak month for the Residential and Commercial categories (See Appendix E-1, Consumptive Use by Categories). In reviewing the per capita use, care has to be taken to review the numbers in total since the per capita use can vary depending upon weather and other local conditions. As stated previously, hot summers can produce higher summer use and wet summers or winters can reduce the per capita use.

However, the numbers in Table 6.9, Seasonal Use, show a general increase from 1998 to 2000. One number is particularly high, the year 2000 peak month commercial with a rate of 146 gpcd. For some reason the November use was 147,649,000 gallons when it previously had been around 40,000,000 to 50,000,000 gallons per month. This would give a per capita use of about 50 to 60 gpcd for the month.

Table 6.9 Seasonal Use (gpcd)

	1998	1999	2000
Residential			
Winter (Dec., Jan. & Feb.)	75	78	96
Summer (June, July, Aug. and Sept.)	137	140	187
Total	104	110	134
Peak Month	150	164	204
Commercial			
Winter	15	28	38
Summer	43	48	59
Total	27	38	50
Peak Month	52	55	146

In the Residential component, the summer use is about twice the basic winter residential use. On the other hand, the commercial summer use is only about 1.5 times greater than the winter use.

To reduce the interior and exterior residential and commercial rates, there are many types of programs that could be implemented. However, the ADWR in its Third Management Plan, identified what it calls Reasonable Conservation Measures. This is a list of over 15 different residential and non-residential interior and exterior conservation measures. These conservation measures are the ones the ADWR wants to be implemented. Any changes from this list must be approved by the Department.

Table 6.10, Avondale Water Conservation Options, lists these measures as well as identifying the current Avondale program. Also listed in the table are measures that Avondale is considering for possible implementation.

Table 6.10 Avondale Water Conservation Options

ADWR Reasonable Conservation Measures	Avondale Existing Program	Avondale Programs Under Consideration
A. Residential Interior	***A. Residential Interior***	***A. Residential Interior***
1. Water Audit and Fixture Retrofit Program for Existing Customers	a. City distributed 4,000 water conservation kits	a. Initiate retrofitting rebate plumbing program b. Offer plumbing workshops

ADWR Reasonable Conservation Measures	Avondale Existing Program	Avondale Programs Under Consideration
2. Ordinance or Condition of New Service Prohibiting Installation or Replacement of Plumbing Fixtures in Residential Housing Units Unless Fixtures Meet Water Saving Standards	b. City passed low flow plumbing code	
B. Residential Exterior		***B. Residential Exterior***
1. Audit Program for Existing Residential Customers		a. Initiate retrofitting rebate landscaping program b. Offer landscape workshops
2. Landscape Watering Advice Program for Existing and New Residential Customers		
3. Ordinances or Conditions of New Service for Model Homes in New Residential Developments		
4. Prohibit the Creation of New Covenants, Conditions and Restrictions which require the Use of Water-Intensive Landscaping or Which Prohibits the Use of Low Water Use Landscaping in Residential Developments		
5. Options a. Ordinances or Conditions of New Service Limiting Use of Turf and Other Water-Intensive Landscaping in New Multi-Family Developments b. Ordinance or Conditions of New Service Limiting Use of Turf and Other Water-Intensive Landscaping in Common Areas of New Single Family and Multi-Family Developments. c. Rebate Program for New Residential Customers for efficiently designed landscapes		
C. Non-Residential Interior		
1. Interior Audit Program for Existing Facilities		

ADWR Reasonable Conservation Measures	Avondale Existing Program	Avondale Programs Under Consideration
2. Ordinance or Condition of New Service Prohibiting Installation or Replacement of Plumbing Fixtures in Non-Residential Facilities Unless Fixtures Meet Water Saving Standards	Initiated program requiring multi-family units to change existing water fixtures to water conserving fixtures.	
3. Distribution of Conservation Information to All Non-Residential Customers and Submittal of Water Use Plan by New Large Facilities	New businesses must submit Water Conservation Report.	
D. Non-Residential Exterior		
1. Exterior Audit Program for Existing Non-Residential Customers		
2. Landscape Ordinance or Conditions of New Service for New Facilities	a. City amended landscaping ordinance to require the use of the ADWR low water use plants list in all ROW landscaping and for the installation of automatic sprinkler system. b. Adopted ordinance making it mandatory for commercial developments to have at least 20% of their landscaping be low water use.	Ordinance for increasing low water use landscaping from 20% to 50%
E. Education		
1. Public Information and Education Programs	a. Regular newspaper articles. b. Development and distribution of water conservation materials. c. K-5 schools program.	Increase school education program
	General Programs a. Implementation of block water rate. b. Leak detection and repair program. c. Replacement of all City water meters.	

6.4.7 Other Community Programs

Although the ADWR has identified fifteen water conservation programs that it would like to see implemented, some programs are more effective than others. This is best identified by looking at the programs implemented by other valley communities.

6.4.7.1 Mesa

Mesa, elected to follow a GPCD program and the conservation program consists of two major elements, Education and Landscape Incentives. The education program emphasizes school grades 2, 4, and 7 with both specific Mesa programs and participation in valley-wide conservation entertainment programs. Mesa also promotes adult water conservation education programs on low water use landscaping and plumbing. Mesa's education program is funded from grants from ADWR, Bureau of Reclamation and the Central Arizona Water Conservation District.

In the landscape incentive program, Mesa pays a new homeowner up to 25 percent of the home's development fee if low water use landscaping that meets City guidelines is installed around the new home. A survey by the City showed that 65 percent of the new homeowners took advantage of the program for a water savings of about 25 percent. Multi-family and commercial property owners have to meet City landscaping guidelines. Part of Mesa also promotes water conservation with a two level rate structure: up to 12,000 gallons the rate is $1.62 per 1000 gallons; over 12,000 gallons, the rate goes up to $2.50 per 1,000 gallons.

6.4.7.2 Chandler

Chandler elected to follow a Non GPCD program and has implemented several water conservation programs as outlined below.

Residential

- Plumbing fixture retrofit kits for homes constructed prior to the passage of the current plumbing codes.
- Home water audits for residences with high water bills. Generally the audits are done in response to complaints about high water bills.
- Workshops on low water use landscaping installation and maintenance.
- Landscaping $200 rebate program for homeowners who elect to change to low water use landscaping.

Non Residential

- Water use audit for large users involves the City paying for a consultant to perform a water audit on the industries that are included in the top 20 percent of the non residential water use.
- Turf restrictions limit the amount of high water use landscaping to a maximum of 10 percent of the landscaped area.
- A Water Use Plan must be submitted to the City for review and approval before a certificate of occupancy is awarded.

Education

Water conservation education in the schools is promoted by special visits by City staff as well as participation by the local schools in the valley-wide school entertainment/education program.

Ordinances

- Model Home ordinance limiting the amount of high water use landscaping.
- Multi-family ordinance limiting the amount of turf in the landscaping.
- A new ordinance specifying low water use plumbing fixtures.
- An ordinance prohibiting the creation of covenants or conditions requiring the installation of high water use landscaping.
- An ordinance requiring the use of reclaimed water in non-residential turf areas greater than five acres if the reclaimed water is available.

Program Terminations

As the water conservation program has matured over the years, the City of Chandler has audited the success of various individual programs, and two programs have been eliminated. One is the Toilet Replacement Rebates which was eliminated after the City decided that by this time, the only old large flush style toilets left in the City were being replaced for cosmetic reasons and not for water conservation. The other program terminated was Industrial Water Audits. All of the big water users had been audited and the changes in water use were based more on the economy than individual user habits.

6.4.7.3 Peoria

Peoria is a GPCD community with a current water use of about 192 gpcd and under the target of 207 gpcd. Its service area is primarily the older part of the community with the newer parts of the community being served by private water companies. The water conservation program emphasizes education. Specific programs include:

Education

- "Preserve/Conserve" is a high profile general educational/informational program designed to make the residents aware of the need to conserve water.
- Promotion of the schools water education program for grades 2 through 6.
- New account brochure stuffers identifying water conservation.

Residential/Non-Residential

- The City over one summer had a program for water audits. These were for people who complained about their high water bills. This was an interior/exterior audit and for the most part, 90 percent plus, the problem was excessive landscape watering. The next major reason was a faulty meter.
- Water rates in Peoria have four levels, each with a higher unit cost.

6.4.7.4 Gilbert

Gilbert is a Non-GPCD community and recently negotiated an agreement with ADWR to implement 12 water conservation programs. The implementation of the programs started January 2001. Current use is 220 gpcd, down from a previous high of 255 gpcd. The programs to be implemented includes:

Ordinances

- Installation of water efficient plumbing in new houses.
- High water use landscaping at model homes will be limited to no greater than 20 percent of the total landscaping.
- Prohibiting the creation of covenants or conditions requiring the installation of high water use landscaping in developments.

- Installation of water efficient plumbing in non residential facilities.
- Limiting high water use landscaping to a maximum of 20 percent of the total landscaping.

Residential

- Provide on request residential water audit kits. These kits will contain low flow shower heads, faucet aerator, hose attachment with shut off valve, conservation booklet, and irrigation cards.

Non-Residential

- Provide facility managers guide for interior and exterior water audits.
- Require a water use plan for all new non-residential facilities.

Education

- Hold water conservation workshops.
- Continue with grade 2–6 water conservation programs.
- Develop general public information and awareness programs.

6.4.8 Proposed Avondale Program

As stated previously, Avondale's water use is primarily residential with a large summer or landscaping water use. On this basis, the City, in order to reduce the per capita rate, should initially concentrate on residential and particularly summer water consumption. Although Avondale has initiated some of the same conservation programs promoted by ADWR and other communities, it needs to consider adding additional programs specifically for reducing residential use. The following identifies programs that have been successful in other communities.

6.4.8.1 Education and Public Awareness

Avondale needs to promote water conservation emphasis with the general community. Suggestions for this include:

- Continue with the school education program.
- Develop water conservation materials for public distribution.

- Provide regular water bill stuffers.
- Provide information on low water use landscaping.
- Hold landscaping workshops for residents and landscape material suppliers.
- Provide water bill stuffers for new accounts identifying the specific water needs of the southwest.
- Develop and promote a general conservation program similar to Peoria's "Conserve and Preserve."

6.4.8.2 Residential

The residential water conservation program should consider:

- A landscaping rebate program for new and existing homeowners to encourage installation of low water use landscaping.
- Providing water audits for high water users.
- Limiting the amount of high water use landscaping at model homes sites to 10 to 20 percent of the total landscaping.

6.4.8.3 Non-Residential

The Non-Residential program should consider:

- Limiting the high water use landscaping to 10 percent to 20 percent of the total landscaping.

The effectiveness of any conservation program is very dependent upon the level of implementation and the effort and dollars a community puts into the program. A minimum level of implementation, dollars, and effort may result in only a minimal reduction in per capita consumption. On the other hand a very active program with a maximum level of implementation, may obtain up to a 10 or 15 percent reduction.

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