Water Resources Analysis

Pima Prospers
Comprehensive Plan
2025

THE UNIVERSITY OF ARIZONA
Drachman Institute

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Executive Summary

The Arizona state-mandated water resources element requires that counties perform a basic known water supply and demand comparative analysis to show whether there is an impact of proposed new development on the overall water supply *[1]*. The Water Resources Analysis of the Pima County Comprehensive Plan 2025 update will focus on strategies to support resilient water supplies for future regional growth and riparian resources, providing an analysis of water use and setting specific goals to promote responsible water management. A.R.S. § 11-804(B)(3) requires that a comprehensive plan for a county with a population of more than one hundred twenty-five thousand include planning for water resources that addresses:

A. The known legally and physically available surface water, groundwater and effluent supplies (see the section of this memorandum titled Pima County Water Supply);

B. The demand for water that will result from future growth projected in the comprehensive plan, added to existing uses (see the section of this memorandum titled Pima County Water Demand); and

C. An analysis of how the demand for water that will result from future growth projected in the comprehensive plan will be served by the water supplies identified in (a) or a plan to obtain additional necessary water supplies (see the section of this memorandum titled Pima County Future Water Supply-Demand Analysis).

The purpose of this memo is to provide an overview of water supply, demand, and future strategies to help manage water resources within the county. We do so in part by synthesizing, analyzing and critiquing existing national, state, and local watershed documents.

Our recommendations fall into three broad categories:

1. **support for a resilient water supply**
2. **support for effective monitoring**
3. **support for enhanced collaboration**

Recommendations to Support a Resilient Water Supply

1. Advance an "all of the above" approach where diverse strategies are pursued across all scales in the region.

2. Expect and plan for variability in water supply and demand.

3. Pursue a net zero water ordinance to ensure an assured water supply in concert with expanded development and in collaboration with jurisdictions, including the City of Tucson.

4. Protect water resources along with other environmental and social objectives (e.g. wildlife, riparian corridor protection, biodiversity, equitable access and risk exposure).

Recommendations to Support Effective Monitoring

5. Encourage and support data sharing across local, state, and national agencies.

6. Monitor demand and supply, regularly comparing projected models and previous reports to actual supply and demand.

7. Produce more detailed studies of water demand if the demand and supply models and previous reports are not accurate.

8. Develop shared regional GIS tools to visualize land use and the spatial distribution of water supply and demands (by water providers), including depth to groundwater, recharge potential, and demographic information.

Recommendations to Support Enhanced Collaboration

9. Nurture and strengthen strong collaborative relationships and engagements with water providers and managers, wastewater, and flood control in the region.

10. Ensure a tight connection between land use and water resource planning in the county. Additional training may be needed for team members of development services that are less familiar with water resource management to understand the complexities in this region.

11. Continue to work with Pima County Development Services, City of Tucson Planning and Development Services, and other jurisdictions to create a shared approach to regional long term assured water supply and development entitlements.

12. Support water providers across Pima County in standardizing their method(s) for calculating water supply so that predictions are more closely aligned and there is greater transparency in the numbers.

1.0 Introduction

Pima County sits at a unique ecological junction, blending elements of the neo-tropics with the Sonoran Desert and Rocky Mountains *[2]*. Pima County receives an average of 13 inches of precipitation annually, crucially timed during the summer and winter rainy seasons. Water, essential for life in the desert, is abundant in the form of streams and springs throughout the region, with most rivers not flowing perennially, but dependent on effluents. Water management is a focal point, especially in the eastern side with its higher population density and privately owned lands, while Tribal and Federal lands predominate in central and western areas *[2]*.

The Water Resources Analysis of the Pima County Comprehensive Plan 2025 update will focus on strategies to support resilient water supplies for existing land use and future regional growth, providing an analysis of water use and setting specific goals to promote responsible water management. A.R.S. § 11-804(B)(3) requires that a comprehensive plan for a county with a population of more than one hundred twenty-five thousand include planning for water resources that addresses:

1. The known legally and physically available surface water, groundwater and effluent supplies (see section 2.0 of this memorandum titled Pima County Water Supply);

2. The demand for water that will result from future growth projected in the comprehensive plan, added to existing uses (see section 3.0 of this memorandum titled Pima County Water Demand); and

3. An analysis of how the demand for water that will result from future growth projected in the comprehensive plan will be served by the water supplies identified in (a) or a plan to obtain additional necessary water supplies (see section 4.0 of this memorandum titled Pima County Future Water Supply-Demand Analysis).

To fulfill this mission, we depend on information and findings from government websites, reports, and ordinances including:

A. Arizona Department of Water Resources (ADWR) Annual Supply and Demand Dashboard for Tucson Active Management Area (AMA) *[3]*;

B. US Geological Survey (USGS) Water Use Data for the Nation *[4]*;

C. Lower Santa Cruz River Basin Study (LSCRBS): Supply and Demand Assessment by Central Arizona Project (CAP) from 2021 *[5]*;

D. Lower Santa Cruz River Basin Study (LSCRBS): Groundwater Analysis by Bureau of Reclamation (BOR) from 2022 *[6]*;

E. Requirements of Preliminary Integrated Water Management Plan (PIWMP) of Pima County from 2017 *[7]*;

F. Water Resources Options for Pima County from 2022 *[8]*;

G. Net Blue Model Ordinance template, developed by the Alliance for Water Efficiency in collaboration with two other organizations *[9, 10]*;

Each of the above existing national, state, and local watershed documents have been described briefly below:

A. The ADWR's Annual Supply and Demand Dashboard gives the supply and demand breakdown by water sources and water use sectors, respectively, for different AMAs in Arizona such as the Tucson AMA *[3]*.

B. The USGS Water Usa Data For the Nation datasets are public data found at https://waterdata.usgs.gov/nwis/wu *[4]*. The data can be searched at the county level and provides information on water supply and demand by major sectors, i.e. domestic, commercial, power production. The datasets are updated every five years.

C. The LSCRBS by CAP from 2021 focuses on municipal water supply and demand projections from 26 water providers in the Tucson AMA for period 2018 to 2060, considering 6 scenarios of future supply and demand (Scenarios A-F) *[5]*. The supply scenarios are dictated by impacts of climate change (best-case and worst-case climate), whereas water demand scenarios represent the housing growth patterns (slow, medium and rapid) in the region. This study area covers most of eastern Pima County, where population and growth are most concentrated and expected to increase, providing a crucial data foundation for projecting water demands in these growing areas.

D. The LSCRBS by BOR from 2022 analyzes the groundwater level changes in the Lower Santa Cruz Basin, under six scenarios reflecting different growth rates and climatic conditions *[6]*. Scenarios ranged from slow and compact development to rapid outward sprawl, alongside variations in climate impacts on natural recharge and Colorado River supply changes.

E. The PIWMP of Pima County is mandated by the County Comprehensive Plan, via the Water Resources Element *[7]*. It is a prerequisite for all rezoning proposals requiring a Site Analysis. This assessment encompasses a Water Resources Impacts Assessment, which must cover availability of renewable and potable water, water usage projections under existing and proposed zoning, current and future groundwater levels, proximity to subsidence areas and groundwater-dependent ecosystems, and details about the hydrogeologic basin, including bedrock depth. Additionally, the PIWMP submission must include a pledge to implement sufficient Water Conservation Measures at the development review stage, that includes a combination of indoor and outdoor measures *[7]*.

F. Water Resources Options for Pima County from 2022 is a staff report to the Board of Supervisors that outlines the current County water resources environment and provides a general overview of regulatory, advisory and project context and options *[8]*. It presents potential strategies to help the county adapt to changing climate conditions and water scarcity.

G. Net Blue Model Ordinance template has been developed by Alliance for Water Efficiency along with other organizations to assist communities in developing water-neutral growth ordinances tailored to their specific needs *[9, 10]*. It was derived from a study of U.S. communities with active water demand offset policies and is supported by a downloadable Excel spreadsheet, which facilitates the calculation of water offsets.

Limitations of the LSCRBS by CAP in Pima County Water Demand Modeling for Future

The 2021 LSCRBS by CAP provides a foundation for the analysis in this memo. When considering recommendations from this memo, it is important to note the following limitations of the LSCRBS, especially when modeling future water demand within Pima County.

Water demand in the LSCRBS is calculated by dividing the total water consumption within 26 water providers' service areas by the number of housing units. The water demand data is only from one year and may represent a particularly wet or dry year in the cities. Note this does not produce a water consumption per building or property, as commercial, industrial and agriculture are excluded. In many cities, these water users constitute 30-40% of total water demand. In the LSCRBS, water consumption is represented in gallons per housing units per day and future demands are forecast by combining state developed predictions of population growth measured by housing units at the traffic analysis zone in ten year increments. In summary, only residential water consumption is considered when predicting future growth and only housing units consume water. The distribution of these housing units is also unknown as water service provider boundaries do not align perfectly with traffic analysis zones.

At the time of writing this report, the University of Arizona team has not seen whether the CAP:SAM model has been validated for any of the years since it was developed (i.e. the University of Arizona team makes no claims to its accuracy as the team did not have access to information to validate its outputs and analysis independently).

It is the opinion of this team that the LSCRBS estimates of water demand are likely lower than what is being consumed because they exclude commercial, mining, agricultural and industrial uses within the study area when predicting future growth. Further, the LSCRBS assumes that irrigated agriculture cannot expand beyond tribal lands, but urbanization driven by population growth may decrease total agricultural acreage, leading to a corresponding reduction in irrigation demand. Overall, projections indicate a slight decrease in agricultural water demand compared to current levels due to ongoing agricultural land urbanization *[5]*.

Other assumptions in the LSCRBS report are also important to note, especially that at the time the report was written CAP supplies had never been reduced, therefore the authors assumed growing municipalities would increasingly rely on CAP supplies. However, the CAP supplies were decreased after the report came out. In short, the LSCRBS demand in the region may be higher and supply lower than what is in the report and continued monitoring of water supply and demand is needed.

Summary of Recommendations

The recommendations for enhancing water resource management in the region are organized into three main categories: supporting a resilient water supply, enhancing monitoring practices, and fostering collaboration. To support a resilient water supply, it is advised to embrace an "all of the above" strategy that incorporates diverse approaches at various scales, plan for variability in water supply and demand, implement a net zero water ordinance in partnership with the City of Tucson, and protect water resources alongside environmental and social goals such as supporting riparian habitat, biodiversity, and equitable access and risk exposure. For effective monitoring, promoting data sharing among local, state, and national agencies is essential, as well as regularly monitoring supply and demand against projections and previous reports. Developing regional GIS tools to visualize land use, water supply and demand, groundwater depths, and demographic information will further enhance these efforts. Lastly, enhancing collaboration will require nurturing strong relationships with water providers, wastewater managers, and flood control authorities, ensuring a tight connection between land use and water planning, and supporting standardization across Pima County water providers to align methods for calculating water supply.

2.0 Pima County Water Supply

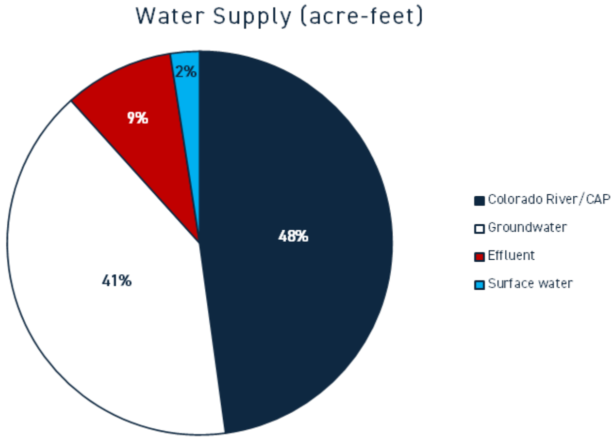
Pima County is situated at an environmental junction, merging the biodiversity of the neo-tropics with the Sonoran Desert and the Basin and Range region. This region hosts North America's most diverse, wet, and hot desert, and averages 13 inches of rainfall annually *[2]*. It features perennially flowing segments of the Santa Cruz and San Pedro Rivers, along with many other streams and springs. Pima County consists of several jurisdictions, of which the City of Tucson is the largest. The vast majority of the county population lies in and around Tucson. The other jurisdictions are the Town of Oro Valley, the Town of Marana, the Town of Sahuarita, and the City of South Tucson, and tribes. There are numerous unincorporated communities in Pima County such as Ajo, Green Valley, Catalina, Vail, Valencia West, Corona De Tucson, and Picture Rocks.

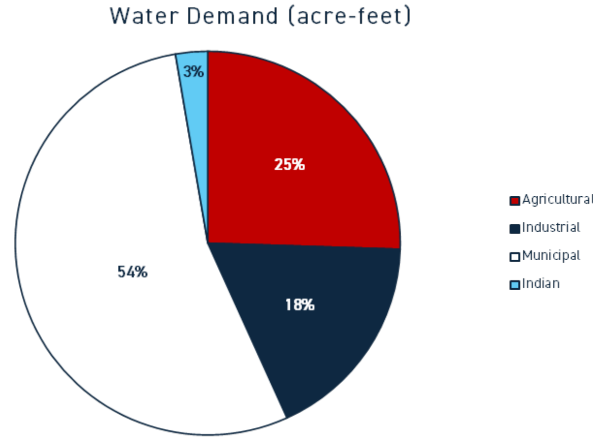
Water use and management in the more populated eastern side of Pima County has received the most study and attention. Like all arid regions, the county faces the challenge of sustainable water management amid population growth and climate variability. This highlights the need for innovative approaches for water conservation and management which we highlight in the section entitled Future Conservation and Additional Water Supplies. To assess the existing water supplies for the region, we rely on ADWR's Annual Supply and Demand Dashboard for Tucson AMA, and the 2021 LSCRBS by CAP described in below sections. The ADWR estimations cover the demands for all sectors (i.e. municipal, agricultural, industrial), while the LSCRBS covers only municipal demands.

ADWR Tucson Active Management Area Supply Numbers

The 1980 Arizona Groundwater Management Act established the Tucson AMA, which includes parts of Pima, Pinal, and Santa Cruz counties and is heavily reliant on groundwater *[2]*. This area is regulated for groundwater pumping and must report to the ADWR. ADWR maintains water supply and demand data for each AMA, using the Annual Supply Demand Dashboard *[3]*. Using this source, **Figure 1** plots the water supply (by source type), and water demand (by sectors) for the Tucson AMA for 2022. Water supply in Tucson AMA comes from the Colorado River (48%), groundwater (41%), recycled water (9%), and surface water (2%). Water demand distribution includes 54% municipal, 25% agricultural, 18% industrial, and 3% for Indian (Tribal) uses *[3]*.

Figure 1. Water Supply and Demand distribution for Tucson AMA for 2022
(Data Source: ADWR AMA Annual Supply and Demand Dashboard, data for 2022 [3])





As can be seen, Pima County's water supply comes from three main sources: Colorado river water mainly brought through the Central Arizona Project (CAP) Canal, groundwater, and effluent or reclaimed water. The following is an overview of each water supply source for the county.

Central Arizona Project (CAP) Water

Colorado River water delivered via CAP is the primary source of municipal potable water in Pima County. CAP water is transported 336 miles from the Colorado River across central Arizona to supply Maricopa, Pinal, and Pima Counties. CAP is recharged to the aquifer where it is blended with groundwater. The blended water is pumped out by local wells for delivery to customers. Renewable water supplies from CAP are also stored in underground aquifers to prepare for future water demands. The CAP Entitlement to Tucson Water is 144,191 acre-feet/year as shown in **Table 2**, and is mainly used for municipal and industrial uses.

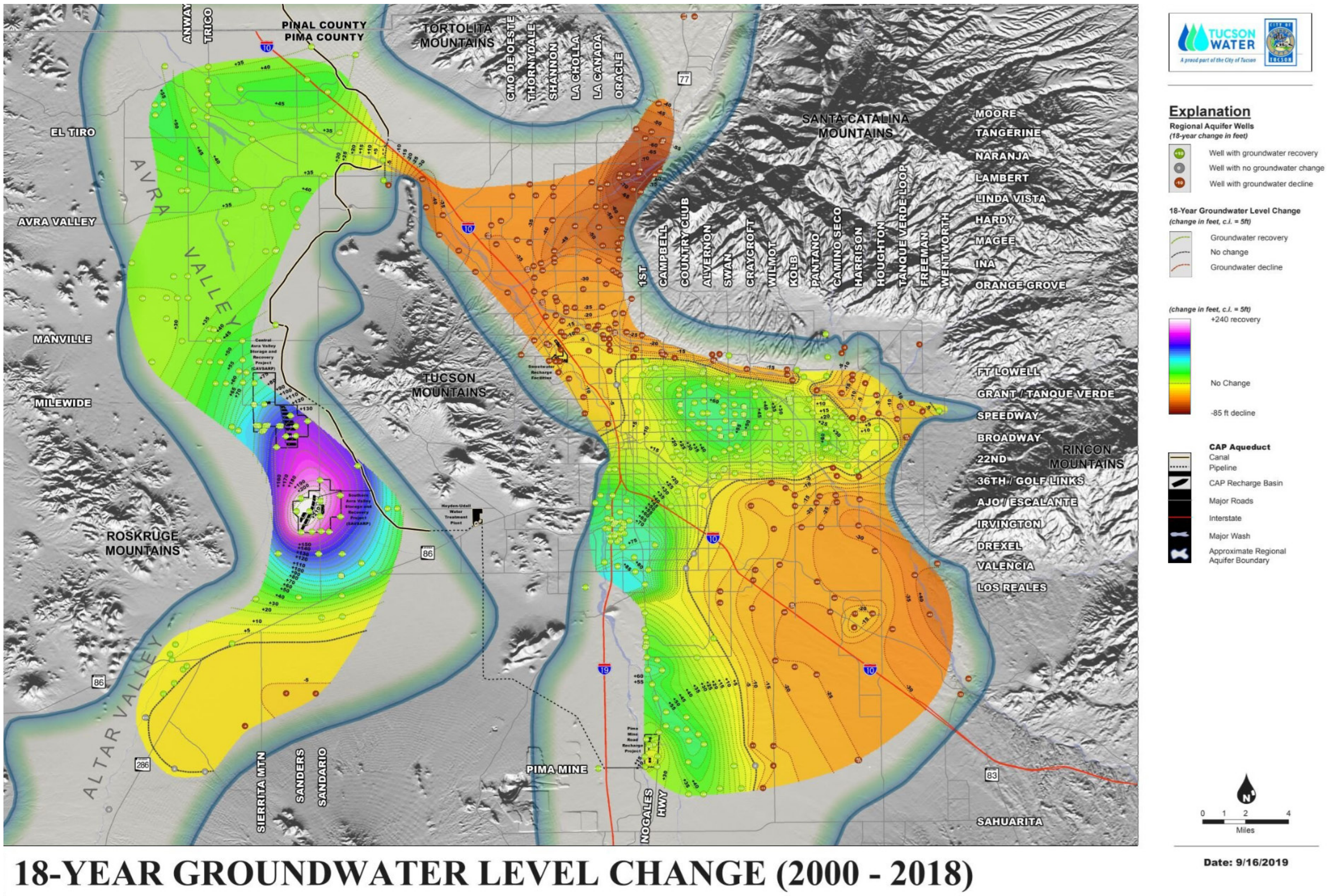
Groundwater

Pima County's main water source is non-renewable groundwater, which is supplemented by Colorado River water via CAP for aquifer recharge. The county's water systems, including significant watersheds like the Santa Cruz and San Pedro Rivers, rely on this augmentation. To regulate groundwater usage and address depletion, Arizona established the Groundwater Management Code and designated Active Management Areas (AMA), including Tucson AMA that covers eastern Pima County, aiming for a safe yield or balance between groundwater extraction and recharge by 2025. **Figure 2** highlights the effectiveness of groundwater recharge efforts in portions of the Tucson AMA, where the recharge basins in Avra Valley substantially increase the groundwater levels in the vicinity. Groundwater levels continue to decline in other portions of the AMA as well. Changes in groundwater levels across the entire county are unavailable. In 2019, ADWR reported total natural and artificial groundwater recharge/inflows in Tucson AMA as 196,693 acre-ft *[3]*.

Effluent

Effluent water is the treated wastewater from the County's wastewater treatment plants and managed by several owners, including Tucson Water and Pima County Regional Wastewater Reclamation Department (RWRD). RWRD and other effluent owners use reclaimed water for groundwater recharge, reuse, and environmental restoration. Tucson Water and RWRD own the largest bulk of effluent in the county. As of 2022, there are seven Water Reclamation Facilities (WRF) in the region producing a total of 62,805 acre-ft of effluent annually *[13]*. Out of this, about 20,000 acre-feet was used for municipal and industrial applications in 2022 as per ADWR *[3]*. This leaves the remaining 42,000 acre-feet per year of effluent for other uses. As the county's population grows and concerns about ground and surface water availability intensify, effluents will likely become an increasingly important water source.

Figure 2. 18-Year Groundwater Level Change (2000-2018)
(Data Source: Tucson Water)



LSCRBS by Municipal Water Provider Supply Numbers

To quantify the legally and physically available water supplies (surface water, groundwater and effluent supplies) for the county, we use the 2021 LSCRBS by CAP that focuses on municipal water providers in the Tucson AMA/densely populated eastern Pima County for period 2018 to 2060 considering different scenarios of supply and demand *[5]*.

Table 1 shows the municipal water supply data for all the providers for Scenario A (current climate and medium growth) for 2018 (historic case), along with type of water source (Effluent, Surface Water/CAP, and Groundwater). The municipal supply is composed of 75% CAP water, and 15% groundwater, and 10% effluent. The CAP supply is broken down by Direct, Aquifer Storage and Recovery (ASR), and Recovery, as well as the Storage, whereas groundwater supply includes Assured Water Supply (AWS) and Non-AWS.

The supply breakdown shows diverse sources across providers, with some relying heavily on CAP water, others on groundwater, and varying levels of effluent use. Among the water providers included in the study, City of Tucson, Metropolitan Domestic Water Improvement District (DWID)/Metro Main, and Town of Oro Valley receive the largest CAP entitlements, and are heavily dependent on CAP water to meet their service area demands *[10]*. On the other hand, water providers such as Community Water Co. of Green Valley, Green Valley DWID (GVDWID), Lago Del Oro, Sahuarita Water Co, and University of Arizona rely heavily on groundwater to meet the demands of their customers, as can be seen from **Table 1**.

Table 1. Water Supply Projections (in acre-feet) for the 26 Municipal Water Providers in Tucson AMA with breakdown of their supplies (effluents, CAP, and groundwater) for Scenario A for 2018
(Data Source: LSCRBS by CAP [5])

Water Provider Name	**Effluent**	**CAP** (Direct + ASR + Recovery)	**CAP** (Storage)	**Groundwater** (Non-AWS + AWS)	**Designated Providers with 100-year Certificate of AWS** (Y/N)
Avra Water Coop	0	0	0	834	N
AZ WC Oracle	0	0	0	541	N
Comm Water Green Valley	0	0	0	2,404	N
Farmers Water Co	0	0	0	1,017	N
FWID	125	1,350	1,523	719	Y
GVDWID	0	399	0	1,721	N
Lago Del Oro	441	0	0	2,507	N
Las Quintas	0	0	0	447	N
Los Cerros	0	0	0	271	N
Marana	345	2,336	115	0	Y
Marana Domestic	0	0	0	262	N
Metro Diablo	0	0	0	341	Y
Metro Hub	0	0	0	852	N
Metro Main	0	6,974	6,486	668	Y
Metro West	0	0	0	50	Y
Oro Valley	0	7,537	2,768	0	Y
QuailCreek	0	0	0	661	N
Ray WC	0	0	0	625	N
Ridge View	35	0	0	519	N
Saguaro	0	0	0	412	N
Sahuarita Water Co	0	179	0	1,463	Y
Spanish Trail WC	0	182	2,855	0	Y
Tucson, City of	11,236	92,867	51,305	4,951	Y
University of AZ	180	0	0	1,356	N
Vail WC	0	1,319	538	0	Y
Voyager WC	0	0	0	562	N
Total	**14,594**	**113,143**	**65,590**	**23,183**	

Among the municipal water providers listed in **Table 1**, some have been designated as having an Assured or Adequate Water Supply by ADWR, as of May 3, 2024, since they have access to renewable supplies (CAP, effluents) *[14]*. These water providers designated as having AWS are:

A. Sahuarita Water Company*
B. City of Tucson
C. Town of Oro Valley
D. Metropolitan Domestic Water Imp. District (DWID)– Main
E. Metropolitan Domestic Water Imp. District (DWID)– West
F. Metropolitan Domestic Water Imp. District (DWID)– Diablo Village
G. Town of Marana
H. Spanish Trail Water Company
I. Vail Water Company
J. Flowing Wells Irrigation District (FWID)

The CAP Entitlements for Municipal and Industrial (M&I) Priority use for these water providers is given in **Table 2** *[11]*. Among these providers, City of Tucson, Metropolitan DWID/Metro Main, and Town of Oro Valley receive the largest share of CAP entitlements.

**Sahuarita Water Company CAP entitlement allocations are currently not availiable in any public report*

Table 2. CAP Entitlements for Municipal and Industrial (M&I) Priority use for Water Providers in Tucson AMA
(Data Source: CAP Subcontracting Status Report, 2022 [11])

Water Provider Name	**Date** (date amended subcontracts executed by USBR)	**M&I CAP Entitlement** (acre-feet/year)
City of Tucson	2007	144,191
Town of Oro Valley	2007	10,305
Metropolitan DWID / Metro Main	2007	13,460
Town of Marana	2007	2,336
Spanish Trail Water Company	2007	3,037
Vail Water Company	2007	1,857
Flowing Wells Irrigation District	2007	2,854
Green Valley DWID*	2007	1,900
Community Water Co of Green Valley*	2007	2,858

**non-designated providers that have CAP entitlements*

3.0 Pima County Water Demand

Projecting future water demand in Pima County is challenging due to the diverse and increasing mix of users across residential, commercial, business, industrial, and agricultural sectors *[8]*. According to the USGS Water Data for the Nation dataset, 76% of water use in the county is domestic water use as opposed to commercial *[4]*. Concentrated largely in eastern Pima County, which extends into parts of Pinal and Santa Cruz counties, the Tucson AMA reflects significant water use, with 2022 data indicating that 54% of demand is municipal, followed by 25% agricultural, 18% industrial, and 3% for Indian uses *[3]*.

As per ADWR AMA data for Tucson AMA, the CAP demand for different water users within Tucson AMA in 2022 was 156,635 acre-ft *[3]*. Although the Tucson AMA is not perfectly representative of Pima County, these figures suggest that more than half of the water demand in Pima County can be attributed to the municipal sector, and managing municipal water demands could significantly enhance the county's resilience to drought and climate change. Notably, Pima County maintains no regulatory authority over agricultural water use, and ongoing trends suggest a shift from agricultural to municipal land uses *[8]*. Therefore, for this objective we focus only on estimating municipal water demands for the next 20 years due to changes projected in land use.

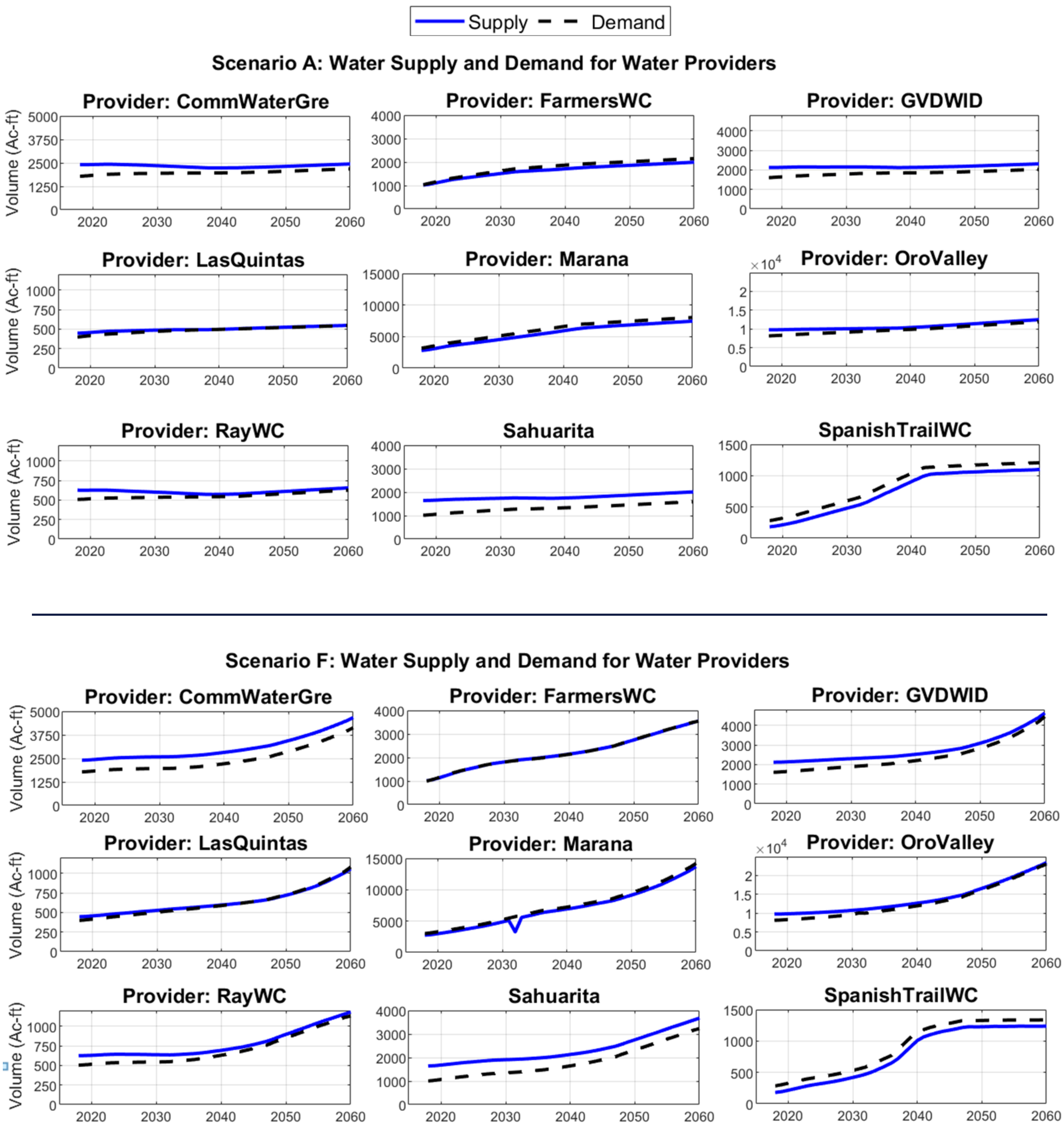
To estimate the future municipal water demands, we rely on the 2021 LSCRBS by CAP that focuses on supply and demand projections from 26 water providers in the Tucson AMA for 2018 to 2060, and covers most of eastern Pima County, where population and growth are most concentrated and expected to increase *[5]*. The report calculates the annual municipal demand for each water provider as the product of housing units and daily water use per unit (Gallons Per Housing Unit per Day, GPHUD). Both housing units and the GPHUD values are differentiated based on new vs. existing. Variations in housing unit projections and water usage rates impact the demand projections for the different providers, detailed in Appendix C of the LSCRB report *[5]*. Water providers serve the incorporated areas (Tucson, South Tucson, Oro Valley, Marana, Sahuarita), as well as unincorporated areas of the county. Some large providers like Tucson Water have renewable supply (through CAP entitlements, and effluents), and are called Designated Water Providers with Assured Water Supply (AWS), whereas others with no CAP allocation/renewable supply are deemed as non-designated water providers.

Refer to Figure 1 in Appendix A of this report for the municipal supply and demand projections for all 26 water providers in the LSCRBS. Most providers are expected to meet future demands even under Scenario F. However, some water providers may face supply-demand shortfalls or tight margins. **Figure 3** displays the supply and demand projections for these vulnerable water providers in Pima County for 2018-2060 under Scenario A (current climate, moderate growth) and Scenario F (worst climate, rapid growth). These providers include Marana, Oro Valley, Sahuarita, Green Valley DWID, Community Water Company of Green Valley, Farmers Water Company Green Valley, Las Quintas Serenas, Ray Water Company, and Spanish Trail, and are located particularly in areas north, south, and east of Tucson city limits. This supply-demand shortfall projected for the given water providers can be attributed to the variations in housing unit projections (shown in **Table 3**), in conjunction with different water usage rates. A large range in projected water demand for these areas is due to variations in the number of housing units under the different spatial growth patterns. It is important to note that the LSCRBS first computes water demand projections for each scenario depending on growth patterns before allocating supplies based on their physical and legal availability for each provider. Consequently, supply projections for scenario F surpass those of scenario A, despite the former being linked to the worst-case climate scenario, owing to the anticipated higher demands in scenario F compared to scenario A

[5]. Estimates of water supply indicate that CAP water will remain the predominant municipal water source (75%), followed by groundwater (approximately 15%) and effluents (10%).

Figure 3. Water supply and demand projections for vulnerable water providers in Tucson AMA for Scenario A (current climate, moderate growth), and Scenario F (Worst climate, Rapid growth)

(Data source: LSCRBS by CAP [5])



NOTE: The LSCRBS first computes water demand projections for each scenario depending on growth patterns before allocating supplies based on their physical and legal availability for each provider. Consequently, supply projections for scenario F surpass those of scenario A, despite the former being linked to the worst-case climate scenario, owing to the anticipated higher demands in scenario F compared to scenario A [5].

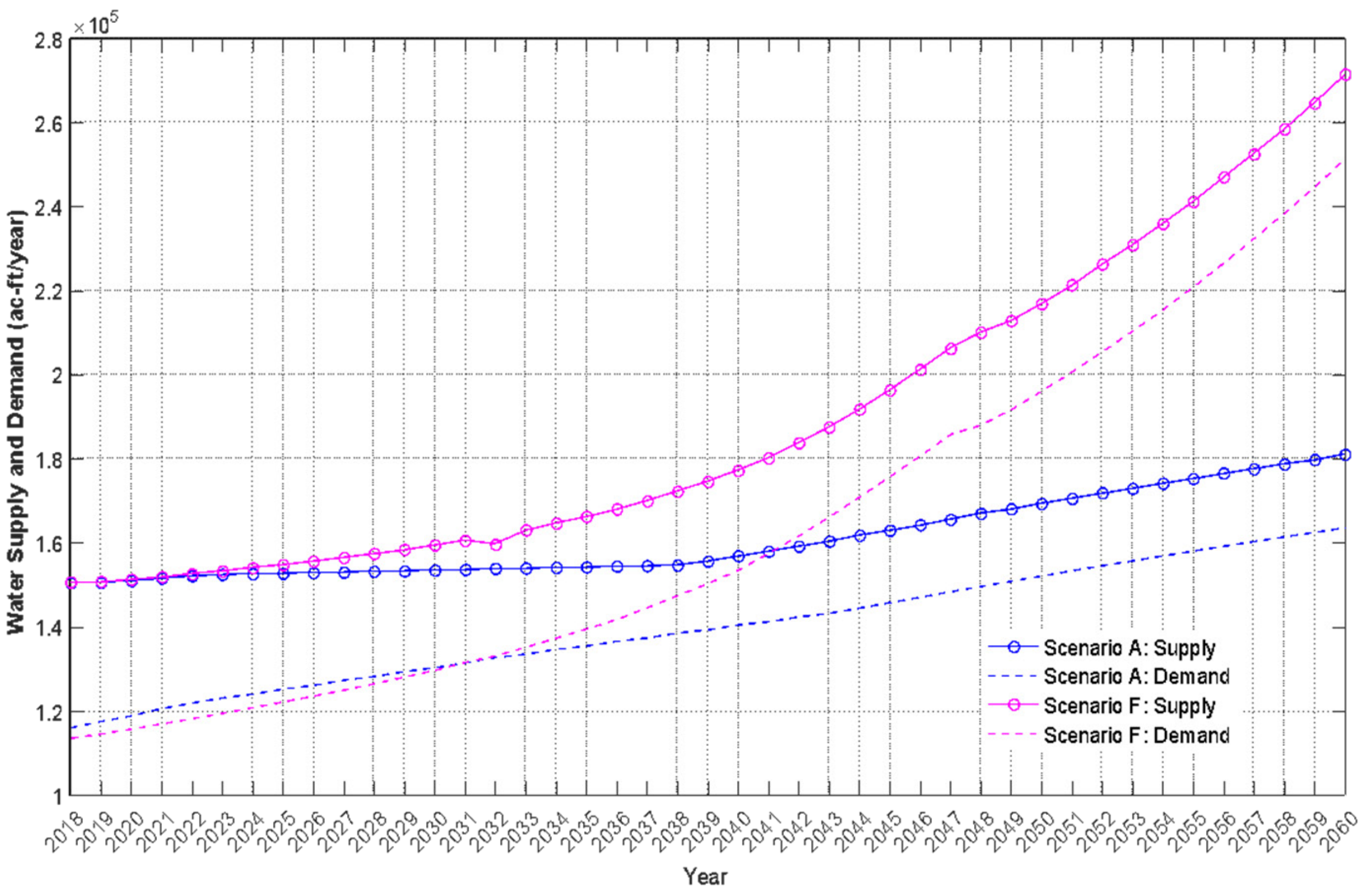
Table 3: Total projected housing units in 2060 by water provider. Scenarios that are grouped together utilize the same spatial pattern and growth rate
(Data Source: LSCRBS by CAP [5])

	Total Housing Units (2060)			Housing Unit Growth 2020 vs 2060 [%]		
Water Provider	A & E	B & D	C & F	A & E	B & D	C & F
Avra Water Co-op	2,098	1,885	3,769	+10%	+0%	+50%
Arizona Water Company, Oracle	3,831	2,064	7,747	+58%	+30%	+80%
Comm. Water Co. of Green Valley	14,427	13,014	27,268	+16%	+9%	+56%
Farmers Water Company	10,293	8,902	17,007	+46%	+43%	+67%
Flowing Wells Irrigation District	7,581	7,569	8,743	+0%	+1%	+14%
Green Valley DWID	6,109	5,520	12,761	+23%	+16%	+63%
Lago Del Oro	7,586	4,751	14,107	+53%	+28%	+75%
Las Quintas Serenas	1,571	1,413	2,962	+27%	+22%	+62%
Los Cerros	1,048	726	2,549	+43%	+20%	+77%
Marana	34,798	24,971	58,412	+58%	+49%	+77%
Marana Domestic	418	349	1,383	+17%	+0%	+75%
Metro Diablo	5,394	2,524	8,959	+75%	+56%	+87%
Metro Hub	1,533	1,639	1,998	+5%	+12%	+28%
Metro Main	24,518	22,618	34,480	+9%	+5%	+37%
Metro West	301	144	1,597	+65%	+27%	+93%
Oro Valley	29,812	23,817	54,646	+33%	+19%	+64%
Quail Creek	2,545	2,235	4,225	+24%	+15%	+54%
Ray Water	2,793	2,425	4,994	+18%	+8%	+55%
Ridgeview	570	316	1,133	+55%	+26%	+78%
Saguaro	1,083	747	1,225	+51%	+31%	+57%
Sahuarita	7,110	5,942	13,930	+35%	+26%	+67%
Spanish Trail	4,157	2,650	4,382	+75%	+63%	+76%
Tucson	445,766	381,775	611,536	+28%	+20%	+50%
University of Arizona	75	75	76	+3%	+5%	+7%
Vail	7,834	6,036	10,565	+58%	+48%	+68%
Voyager	1,670	1,612	2,012	+6%	+4%	+22%
Total	**624,921**	**525,720**	**912,467**	**+31%**	**+21%**	**+54%**

Figure 4 illustrates the combined total municipal supply and demand projections for all water providers in the study from 2018 to 2060 under Scenarios A and F. This overview aids in assessing the overall supply availability and demand for the county, albeit not by specific service areas. The county as a whole could potentially meet water demands even under the most extreme scenario F with worst case climate and highest growth rates. The total municipal water use for all water providers in 2018 (historic case) was 116,190.3 ac-ft. Water use projections under Scenario A (current climate and medium growth) are 135,646.6 ac-ft for 2035 and 145,991.3 ac-ft for 2045, a nearly 16% and 25% projected increase from 2018. Under Scenario F, the water demand is projected to rise to 139,741 ac-ft by 2035 and 176,000 ac-ft by 2045, indicating an increase of 20% and 51% from 2018. The growing water consumption highlights the importance of efficient groundwater use and reliance on renewable water to sustain long-term supplies. It should also be noted that significant changes have occurred since this report, including BOR's declaration of a Colorado River emergency/crisis, increasing water scarcity concerns, and an escalation in water shortage tiers–from "Tier Zero" in 2021, implying moderate reductions, to a more severe "Tier 1" shortage in 2024, indicating a significant cut in Colorado River water allocation and underscoring the need for continued conservation efforts *[12]*.

Lastly, estimates of water supply indicate that CAP water will remain the predominant municipal water source (75%), followed by groundwater (approximately 15%) and effluents (10%). Groundwater reliance is expected to increase slightly by 2035 and 2045, compared to 2025.

Figure 4. Municipal Water Supply and Demand projections combined for all water providers in the Tucson AMA, assuming Scenario A (Current climate, Medium growth), and Scenario F (Worst Case climate, Rapid growth)
(Data source: LSCRBS by CAP [5])



4.0 Pima County Future Water Supply-Demand Analysis

The Lower Santa Cruz River Basin Study: Groundwater Analysis by BOR from 2022, and CAP's supply and demand assessment from 2021, provide insights into groundwater availability under six future scenarios reflecting different growth rates and climatic conditions *[5, 6]*. Scenarios ranged from slow to rapid growth alongside variations in climate impacts on natural recharge and Colorado River supply changes. This report provides a foundation for our analysis, but Pima County should remember the Tucson AMA is a substantial portion of the municipalities and population in Pima County, many parts of the county are not analyzed in the LSCRBS report.

Figure 5 shows the simplified groundwater budget and change in storage for scenarios B (lower risk), and F (higher risk) *[6]*. It is projected that the Tucson AMA will have surplus groundwater availability from 2020 onwards for both scenarios (though Scenario F will also see some years of overdraft), which can help accommodate more population or housing demands. **Table 4** summarizes the groundwater budget from **Figure 5**, analyzing groundwater recharge, pumping rates, surplus groundwater availability, and the population trends from 2019 to 2059 for the scenarios B and F. The additional population that can be accommodated within the Tucson AMA, for both the Scenarios have been calculated based on surplus groundwater availability projected every year, and per capita water demand (GPCD) for Tucson AMA for 2020 (which is 138 gallons per day) obtained from ADWR's AMA Conservation Program Report *[15]*. For Scenario B, the data shows generally high recharge rates consistently surpassing the pumping rates, resulting in a stable surplus of groundwater. This surplus ranges from approximately 75,000 to over 380,000 acre-feet, and can potentially support a population peak of 2.462 million by 2051. Conversely, Scenario F indicates tighter conditions with lower recharge rates and a generally lesser surplus compared to Scenario B, with several years showing a deficit, such as 2039, 2052, 2053, 2056. This is mirrored in the lower population figures, with the highest only reaching about 1.172 million in 2051. This comparison suggests that Scenario B (best-case climate and slow growth) based on a more optimistic assumption of future water availability can better support population growth compared to Scenario F. These insights could be crucial for long-term water resource management and urban planning in the Tucson AMA. Further analysis from the Tucson AMA Model based on **Figure 6** shows that the changes in groundwater storage are expected to generally increase across all supply-demand (S-D) scenarios through the 2030s but differ by 2060 with more severe climate scenarios (D, E, and F) showing lesser increases compared to milder scenarios (A, B and C). Particularly, Scenario F forecasts potential groundwater overdraft by the final decade, influenced by increased demand and climate variability.
Figure 7 shows the spatial distribution of projected changes in groundwater head for each scenario. Land use and urban growth patterns critically affect local groundwater levels and future water infrastructure needs. While some areas within the Tucson AMA may see declining groundwater storage, regions receiving artificial and effluent recharge are likely to experience increases.

Adaptation Strategies for Areas with Projected Decline in Groundwater Storages

The LSCRBS by BOR from 2022, along with the CAP study from 2021 offer five adaptation strategies for areas with projected decline in groundwater levels (vulnerable areas), simulated under worst-case Scenario F *[5,6]*. The strategies focus on the vulnerable areas such as Cañada del Oro/Saddlebrooke and Green Valley/Sahuarita areas of Pima County. Strategies focus on delivering extra CAP water and reclaimed water for in-stream recharge in Cañada del Oro area, and extending existing infrastructure to Green Valley locations to support agricultural needs and off-season recharge, with CAP water, thereby conserving groundwater *[6]*. The strategies vary in their recharge rates and intended impact areas and would result in significant groundwater level recovery by 2060, if implemented during the entire period. These findings emphasize the need for coordinated planning between public and private water providers to address the projected water imbalances.

In conclusion, the Tucson AMA's ability to support additional population and housing largely depends on the scenario assumptions, with Scenario B offering a more optimistic outlook compared to Scenario F. Strategic planning and adaptive management will be crucial to accommodate future uncertainties and ensure sustainable water resource management.

Figure 5. Simplified groundwater budget and change in storage for scenarios B (lower risk), and F (higher risk)
(Data source: LSCRBS by BOR[6])

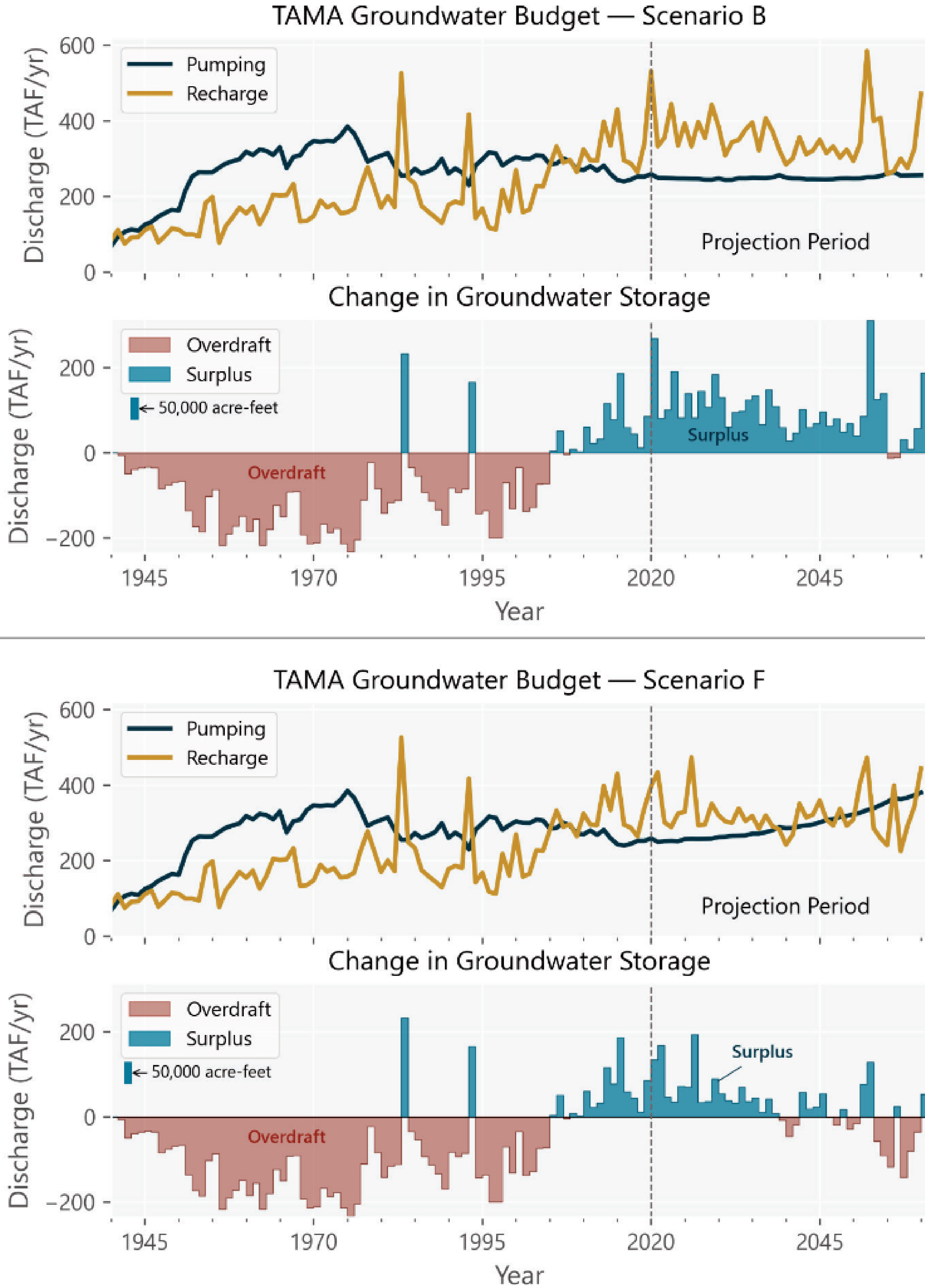


Table 4. Recharge , pumping rates, surplus groundwater availability, and additional population that can be accommodated in the Tucson AMA for Scenarios B and F (Data source: LSCRBS by BOR [6])

	Scenario B				Scenario F			
Year	**Recharge** (acre-feet)	**Pumping** (acre-feet)	**Surplus** (acre-feet)	**Population** (millions)	**Recharge** (acre-feet)	**Pumping** (acre-feet)	**Surplus** (acre-feet)	**Population** (millions)
2019	511741.6	261127.0	250614.6	1.621	372324.7	261096.9	111227.8	0.720
2020	376169.2	251368.2	124801.0	0.807	477364.3	251966.3	225398.0	1.458
2021	398659.1	251156.7	147502.4	0.954	343226.0	253729.3	89496.7	0.579
2022	491178.8	250565.8	240613.0	1.557	331074.2	254292.1	76782.1	0.497
2023	377158.7	249560.9	127597.8	0.825	368203.6	253501.0	114702.6	0.742
2024	438316.3	249443.4	188872.9	1.222	371273.4	253407.1	117866.3	0.762
2025	375735.0	248867.8	126867.2	0.821	518015.5	260128.3	257887.2	1.668
2026	441718.5	248597.8	193120.7	1.249	336230.2	259626.7	76603.5	0.496
2027	398407.9	246735.4	151672.5	0.981	337378.2	260177.2	77201.0	0.499
2028	486881.5	246566.0	240315.5	1.555	394293.0	260794.1	133498.9	0.864
2029	429633.3	249775.3	179858.0	1.164	362473.4	264835.0	97638.4	0.632
2030	350794.0	246014.7	104779.3	0.678	346857.6	265559.7	81297.9	0.526
2031	386351.0	246247.0	140104.0	0.906	342727.1	267899.9	74827.2	0.484
2032	392760.0	250438.8	142321.2	0.921	382343.7	268410.3	113933.4	0.737
2033	421159.1	250171.7	170987.4	1.106	347105.2	269111.4	77993.8	0.505
2034	421159.1	251428.6	187872.3	1.215	360224.8	273877.8	86347.0	0.559
2035	364949.1	251167.7	113781.4	0.736	326092.0	273957.3	52134.7	0.337
2036	453142.7	250916.3	202226.4	1.308	362409.6	277760.3	84649.3	0.548
2037	417188.9	252284.4	164904.5	1.067	332942.5	282914.6	50027.9	0.324
2038	367565.0	258319.9	109245.1	0.707	324779.7	291026.5	33753.2	0.218
2039	327335.1	251895.8	75439.3	0.488	283994.6	288770.4	-4775.8	0
2040	344055.6	250001.9	94053.7	0.608	311220.6	289280.7	21939.9	0.142
2041	401614.2	249756.7	151857.5	0.982	395635.7	293553.5	102082.2	0.660
2042	354455.3	247610.9	106844.4	0.691	357249.8	295690.8	61559.0	0.398
2043	365206.0	247748.1	117457.9	0.760	364710.7	298498.5	66212.2	0.428
2044	393577.7	247504.9	146072.8	0.945	403178.9	303858.8	99320.1	0.643
2045	357568.8	247331.0	110237.8	0.713	350978.6	310009.6	40969.0	0.265
2046	375879.1	247761.9	128117.2	0.829	335043.2	312643.1	22400.1	0.145
2047	345267.4	249761.5	95505.9	0.618	379924.5	318541.5	61383.0	0.397
2048	366765.6	250115.6	116650.0	0.755	333998.6	321340.3	12658.3	0.082
2049	335911.7	249633.4	86278.3	0.558	351563.1	325249.5	26313.6	0.170
2050	384820.5	249964.6	134855.9	0.872	451990.4	329530.0	122460.4	0.792
2051	633251.4	252726.4	380525.0	2.462	518032.3	336817.3	181215.0	1.172
2052	445090.2	253048.8	192041.4	1.242	327983.6	341183.0	-13199.4	0
2053	454803.6	256178.0	198625.6	1.285	301482.2	349953.8	-48471.6	0
2054	300851.1	262517.3	38333.8	0.248	282155.4	358074.4	-75919.0	0
2055	310383.3	266684.3	43699.0	0.283	444438.1	368559.1	75879.0	0.491
2056	344224.3	257440.1	86784.2	0.561	267334.8	365689.1	-98354.3	0
2057	318385.6	257861.5	60524.1	0.392	334652.1	369835.0	-35182.9	0
2058	368455.9	258268.4	110187.5	0.713	386360.8	376211.8	10149.0	0.066
2059	518491.7	258629.7	259862.0	1.681	489542.2	382975.3	106566.9	0.689

Figure 6. Simulated cumulative change in groundwater storage within the Tucson AMA Model since predevelopment (1940)
(Data source: LSCRBS by BOR[6])

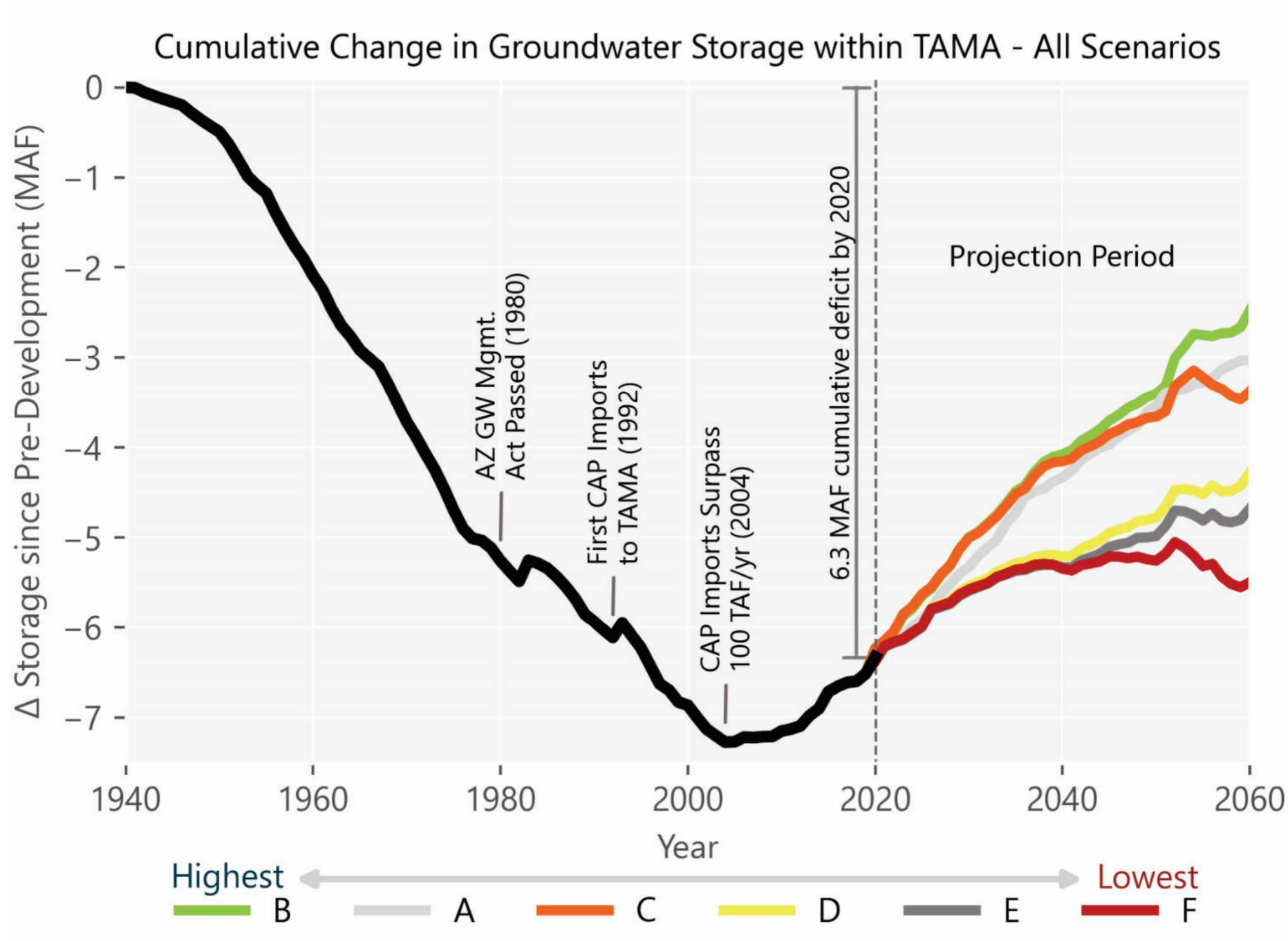
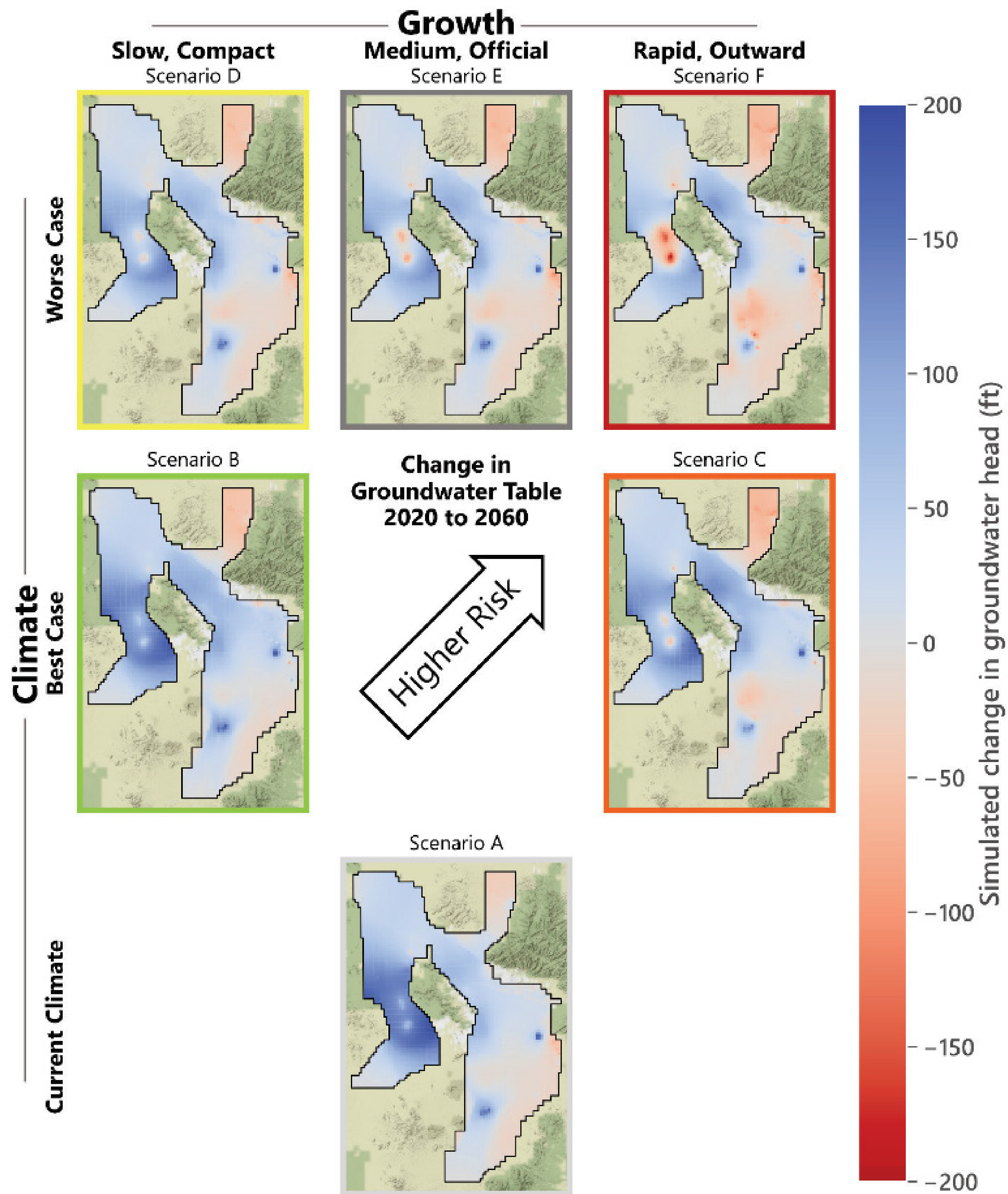


Figure 7. Projected changes in the groundwater head under various scenarios
(Data source: LSCRBS by BOR[6])



5.0 Future Conservation, Additional Water Supplies, and a Net Zero Water Approach

This section discusses: (a) the necessary conservation measures that must be needed for new developments to offset their water use, (b) the future water resources and actions needed by the county for securing them, and (c) the Net Zero Urban Water (NZUW) model development along with the scenarios to help develop the Net Zero Water Ordinance.

Future Conservation Measures

Pima County's zoning requirements contain several water conservation requirements for new development, including drought tolerant landscaping, prohibition on new golf courses dependent on groundwater, and preparation of PIWMP for significant rezoning cases *[7]*. We discuss conservation measures from PIWMP and other reports/sources to get an overview of various onsite and offsite conservation strategies to help reduce the overall water use of new developments.

In order to develop recommended conservation activities, we evaluated the effectiveness of the water conservation measures from two county ordinances: Pima County Preliminary Integrated Water Management Plan (PIWMP), and to a lesser extent, the Water Resources Options for Pima County from April 2022 *[7, 8]*. Additionally, we examined recommendations from the Net Blue Model Ordinance, which are derived from a study of U.S. communities with active water demand offset policies, hence thought to be effective across diverse geographical and climatic conditions *[9, 10]*.

Pima County Preliminary Integrated Water Management Plan (PIWMP)

A Preliminary Integrated Water Management Plan (PIWMP) is mandated by the Pima County Comprehensive Plan, via the Water Resources Element *[7]*. The PIWMP is required for all rezoning proposals that necessitate a site analysis. The evaluation includes a Water Resources Impacts Assessment, which must address:

- Availability of renewable and potable water supplies;
- Water usage projections for full development under existing and proposed zoning;
- Current and future groundwater levels and trends at the site or nearby wells;
- Proximity of the site and wells to subsidence areas and groundwater-dependent ecosystems; and
- Details about the hydrogeologic basin, including the depth to bedrock.

Additionally, for all rezoning applications, the PIWMP submission must include:

- Water Supply Confirmation: A "will serve" letter from the water service provider confirming a potable and renewable water supply for the proposed rezoning site; and
- Water Conservation Commitment: A pledge to implement sufficient Water Conservation Measures at the development review stage. For single family residential projects, a total of 15 points or greater from PWIMP Table A must be achieved, and for multi-family residential and commercial

projects, 15 points or greater from PWIMP Table B are required, that includes a combination of indoor and outdoor measures; these numbers increase with proximitiy to shallow groundwater dependent ecosystems *[7]*. Please refer to Appendix A of this report for PWIMP Table A and B detailing the indoor and outdoor water conservation measures for single family developments, and multifamily and commercial developments from the PIWMP requirements.

Water Resources Options for Pima County (April 2022)
The Water Resources Options for Pima County from April 2022 outlines the current County water resources environment and provides a general overview of regulatory, advisory and project context and options *[8]*. The report presents potential strategies to help the county adapt to climate change and water scarcity. It covers the four areas where the county has authority to implement changes, including regulatory strategies, incentives, leading by example, and infrastructure investment.
The report suggests several amendments to planning policies and zoning codes to enhance water management *[8]*. These recommendations include:

- Prohibiting ornamental turf and limiting turf to schools and parks;
- Mandating rainwater harvesting in new residential and commercial developments; and
- Requiring commercial and industrial developments to include shade trees irrigated with harvested rainwater and solar-covered parking.

Finally, the report suggests some additional conservation measures for new developments aimed at reducing water usage. Key strategies include:

- Creating a water use implementation plan for county facilities aligned with Sustainable Action Plan for Pima County (SAPCO) water reduction goals *[16]*;
- Conducting water audits to identify areas of high-water demand within county facilities and determine where investments in water-efficient improvements could lead to significant water and cost savings;
- Installing water sub-meters in county facilities to distinguish between indoor consumption and outdoor irrigation, helping target efficient water savings;
- Upgrading HVAC systems to more water and energy-efficient models, especially for cooling towers in county office buildings, which consume large quantities of water;
- Implementing water-efficient plumbing retrofits, replacing standard 1.6-gallon toilets with 0.8 gallon models, adding water conservation aerators to faucets, and installing motion sensor faucets to further reduce water usage;
- Constructing stormwater planters to reduce the need for irrigation; and
- Estimating the costs of these strategies and budgeting for those that offer the greatest water savings.

These measures aim to enhance water efficiency and reduce the overall water footprint of county facilities.

Net Blue Model Ordinance
The Alliance for Water Efficiency (AWE), in collaboration with other organizations, has created the Net Blue model ordinance template to assist communities in developing water-neutral growth ordinances tailored to their specific needs *[9]*. Water Neutral Growth necessitates that the water demand of new developments be compensated through water efficiency measures, achieving a net neutral impact on the water demand of the service area *[10]*. This model was derived from a study of U.S. communities with active water demand offset policies and is supported by a downloadable Excel spreadsheet provided by AWE, which facilitates the calculation of water offsets. This tool is particularly useful for estimating necessary offsets for new developments or expansions of existing connections, focusing primarily on off-site water conservation and water harvesting and capture techniques.

Table 5 shows the offset strategies included in the Net Blue model ordinance workbook. These comprehensive strategies, adapted from real-world applications, provide a robust framework for local studies targeting water demand management in residential and commercial sectors. They are designed to be effective across diverse geographical and climatic conditions in the U.S. *[10]*. The offsets from model ordinance template include:

- Residential Developments: Offset strategies should incorporate indoor water conservation measures such as high-efficiency toilet replacements, showerhead replacements, and clothes washer replacements. Outdoor measures should include rainwater harvesting, landscaping considerations and irrigation efficiency to further reduce the demand.
- Commercial Developments: Recommended strategies include indoor conservation measures like replacements or retrofits of commercial-grade urinals and toilets, laundromat clothes washers, commercial dishwashers, pre-rinse spray valves*, and food steamers*, along with cooling tower retrofits. Outdoor measures should focus on rainwater harvesting, surplus rainwater use, irrigation efficiency and stormwater capture.

*Note that pre-rinse spray valves, food steamer, toilet flapper replacements for multifamily units, and ice machines were not included in the original measure listed by Pima County in Table A and B from 2017.

In addition to the model ordinance workbook, the Net Blue report includes case studies from various U.S. cities and introduces additional off-site conservation measures for residential and commercial developments *[10]*. Residential measures include point-of-use hot water heaters for single-family homes, submetering, and toilet flapper replacements for multifamily unit*. Whereas, commercial measures emphasize onsite water reuse systems, ice machines*, hot-water recirculation systems, greywater reuse systems, and the elimination of turf and overhead spray irrigation. This workbook provides a starting point for Pima County to build a suite of conservation ordinances.

Based on this case study research, Net Blue provides several important considerations for adopting net zero approaches. First, sound methodologies are needed to accurately project future water demands and determine appropriate credits for water savings. Second, an offset ratio greater than 1:1 can help ensure that reductions are offsetting the water demands of new developments. The ratio should not be so large as to be unattainable, but large enough to provide flexibility for potential errors in projections. And finally, both on-site and off-site water savings should be permanent to ensure long-term sustainability.

Relatedly, language and standards must also be updated to reflect improved efficiency as offset measures are adopted at a greater scale. For example, the widespread installation of high-efficiency toilets in the 1990s means that utilities must now look elsewhere for additional savings. For Pima County and the City of Tucson, it is necessary to devise a complete strategy with tiered approaches so they may be prepared for next steps once the more obvious and easy strategies are completed. Additionally, recent research at the urban scale has pinpointed that indoor measures have largely been addressed. Once Direct Potable Reuse (DPR) is adopted, the importance of indoor water use is minimized. Thus, the county needs to pursue outdoor measures which are most critical to conservation currently.

Table 5. Net Blue model ordinance template showing offset strategies for residential and commercial developments
(Data source: Net Blue Ordinance Workbook [9])

Step 3: Define and Select Water Demand Offset Strategies

Offset Strategy	Example Savings Estimate Per Replacement/Retrofit in Gallons per Year*	User Specified Savings Estimate Per Replacement/Retrofit in Gallons per Year	Approximate Number of Replacements/Retrofits to Meet Offset if Sole Strategy?	Related Plumbing Code?	Useful Life	Seasonality of Water Savings
Single-Family High-Efficiency Toilet Replacements	9,998	7,483	2,529	Yes	Theoretically Permanent	Even throughout year
Multifamily High-Efficiency Toilet Replacements	25,871	7,483	2,529	Yes	Theoretically Permanent	Even throughout year
Showerhead Replacement Single-Family	2,062	3,192	5,929	Yes	Theoretically Permanent	Even throughout year
Showerhead Replacement Multifamily	1,898		-	Yes	Theoretically Permanent	Even throughout year
Single-Family Clothes Washer Replacement	7,043	7,043	2,687	Yes	Theoretically Permanent	Even throughout year
Multifamily Clothes Washer Replacement	25,310	7,043	2,687	Yes	Theoretically Permanent	Even throughout year
CII Urinal Replacements or Retrofits	6,206	6,206	3,050	Yes	Theoretically Permanent	Even throughout year
CII High-Efficiency Toilet Replacements	13,020		-	Yes	Theoretically Permanent	Even throughout year
Laundromat Clothes Washer Replacements	31,435		-	Yes	Theoretically Permanent	Even throughout year
Commercial Dishwasher Replacements	57,757		-	No	20 Years	Even throughout year
Pre-Rinse Spray Valve Replacements	28,285		-	Yes	Theoretically Permanent	Even throughout year
Commercial Food Steamer Installation	81,500		-	No	10 Years	Even throughout year
Cooling Tower Retrofits	209,880		-	No	5 Years	Higher during peak season
Harvested rainwater on sites **other** than the development property	NA		NA	yes	10 Years	Seasonally variable
Surplus harvested rainwater from sites **other** than the development property	NA			No	10 Years	Seasonally variable
Surplus harvested rainwater from the development property	NA	367,364		No	10 Years	Seasonally variable
Stormwater Capture and Use (Off-site)	28,007		-	No	Theoretically Permanent	Seasonally variable
Custom Offset (to be entered by user)	-	-	-			
Custom Offset (to be entered by user)	-	-	-			
Custom Offset (to be entered by user)	-	-	-			

Preliminary Recommendations for Water Conservation Measures for Residential and Commercial Developments

In this section we suggest some water conservation measures for new developments based on PIWMP requirements of Pima County, Water Resources Options for Pima County, and Net Blue Model Ordinance template *[7,8,9]*. This is a preliminary study of all conservation measures that will continue to be refined and ranked in proportion to potential impact and scale of implementation through the net zero urban water model currently under development by the Drachman Institute at University of Arizona.

Based on the water conservation options listed in PIWMP requirements of Pima County, Water Resources Options for Pima County, and the Net Blue Model Ordinance template, we compiled a comprehensive list of potential outdoor and indoor water conservation measures for new developments that can help inform the development of the Pima County Comprehensive Plan. **Tables 6 and 7** list the potential outdoor water conservation measures applicable to residential (single family and multifamily), and commercial developments, respectively. **Tables 8 and 9** list the potential indoor water conservation measures applicable to residential and commercial developments, respectively.

Table 6. Outdoor Water Conservation and Water Capture Measures for Residential Developments

Included in PIWMP?	Description
Y	Install active or passive on-lot rainwater harvesting system
Y	Install a graywater irrigation system
Y	Install landscapes with only low water- use or drought-tolerant plants
Y	Incentivize the efficiency of swimming pools (e.g. pool covers)
Y	Design for pervious driveway and walkway surfaces
Y	Install an Irrigation system designed to include moisture sensors, timers, with specific components including weather-based controllers, turf spray heads with high uniformity, hydro zoning, and drip irrigation for non-turf beds (e.g. EPA Watersense™)
N	Incentivize cluster development and other neighborhood design strategies that reduce water use, protect the riparian corridors, and prevent development on floodplains
N	Implement development Impact fees used for rainwater harvesting and groundwater recharge within the county
N	Net Zero Water Ordinance
Y	Pima County buffer yard design

Table 7. Outdoor Water Conservation and Water Capture Measures for Commercial Developments

Included in PIWMP?	Description
Y	Install active or passive on-lot rainwater harvesting system (Try to identify and link all the LID BMPs)
Y	Install a graywater irrigation system
Y	Install detention and retention basins to capture and manage onsite stormwater
Y	Install landscapes with only low water- use or drought-tolerant plants
Y	Design for pervious driveway, walkway, and parking surfaces
Y	Install an irrigation system designed to include moisture sensors, timers, with specific components including weather-based controllers, turf spray heads with high uniformity, hydro zoning, and drip irrigation for non-turf beds (e.g. EPA Watersense™)
Y	Incentivize cluster development and other neighborhood design strategies that reduce water use, protect the riparian corridors, and prevent development on floodplains
N	Implement development Impact fees used for rainwater harvesting and groundwater recharge within the county
N	Create a Net Zero Water Ordinance

Table 8. Proposed Indoor Water Conservation Measures for Residential Developments

Included in PIWMP?	Description
Y	Install graywater plumbing lines
Y	Install a manual or motion-activated on-demand hot water circulation pumping system. Install tankless on-demand hot water heaters/point-of-use hot water heaters
Y	Insulate all domestic hot water supply lines with R4 insulation
Y	Install high-efficiency toilets
Y	Consider dual plumbing for using rainwater in toilets
Y	Install high efficiency appliances (cloth washer, dishwasher) and fixtures (showerheads, kitchen and lavatory sinks)
Y	Install a leak detection system
N	Evaluate potential for advanced metering
Y	Install separate water meters for each multi family unit

Table 9. Proposed Indoor Water Conservation Measures for Commercial Developments

Included in PIWMP?	Description
Y	Install gray water plumbing lines
Y	Install commercial grade high-efficiency toilets
Y	Install efficient appliances (clothes washer, commercial dishwasher) and fixtures (lavatory sinks, kitchen sinks and showerheads)
Y	Use efficient water-cooled chillers and install on-demand hot water heaters
N	Install commercial food steamers, pre- rinse spray valves
N	Install efficient HVAC systems, cooling towers, and ice machines, and condensate water capture and recirculation
N	Evaluate potential for advanced metering
Y	Install a leak detection system

Future Water Sources and Actions

The State and County are proactively identifying and securing future water resources through various strategies to address the growing demands and challenges of water management. The state is focused on enhancing water supply sources including rainwater harvesting (RWH), green infrastructure (GSI), wastewater treatment, Direct Potable Reuse (DPR), and other statewide initiatives.

Key strategies include:

- **Full Utilization of Reclaimed Water:** Maximize the use of county reclaimed water through strategies such as direct reuse, DPR, aquifer replenishment, and accruing storage credits. This objective supports water providers with entitlements to reclaimed water, enabling them to leverage this resource more effectively.

- **Promote CAP Water Integration with Groundwater:** This objective aims to foster the blending and recharge of Central Arizona Project (CAP) water with local groundwater supplies. By promoting such integration, the strategy aims to strengthen groundwater resources, enhancing overall water sustainability and management within the county.

- **Groundwater Recharge:** Focus on recharging groundwater in vulnerable areas like Cañada del Oro/Saddlebrooke and Green Valley/Sahuarita. Strategies from the LSCRBS Groundwater Analysis by BOR, 2022, suggest routing additional CAP and effluent water for in-stream recharge or using it to support agricultural needs, conserving groundwater *[6]*.

- **Alternative Water Use:** Enhancing rainwater harvesting to reduce urban heat effects and potable water use and employing green infrastructure for natural irrigation and flood reduction.

- **Integrated Planning:** Encouraging integrated land and water planning through zoning codes, landscaping ordinances, joint training sessions, shared data, and programs like Tucson's rainwater rebate and green stormwater infrastructure initiatives.

- **Regional Coordination:** Increasing collaboration between governments and NGOs to share water knowledge and data for efficient and comprehensive water management, ensuring healthy urban watersheds.

- **Water Use Efficiency:** Boosting efficiency across all sectors, including residential indoor and outdoor use, through initiatives like Tucson's rebate program for high-efficiency toilets and appliances.

- **Demand Management:** Employing demand management such as conservation strategies to mitigate supply/demand deficits.

- **Water Infrastructure Investment:** For scenarios where conservation alone is insufficient, plan for long-term water augmentation through investment in water infrastructure as mentioned in the Water Resources Options Plan for Pima County from 2022 *[8]*. This includes investment in:

    - **Desalination Initiatives:** The 2019-established Governor's Water Augmentation, Innovation and Conservation Council, with its desalination committee, is exploring sustainable water sources such as treating brackish water and ocean desalination to enhance Colorado River water allocations *[17, 18]*. In 2021, Pima County evaluated treating 100,000 acre-feet of ocean water from Puerto Libertad, Mexico, to augment municipal supplies through a 196-mile pipeline, alongside treating brackish groundwater from various regions requiring less infrastructure *[17, 18]*. Pima County is not currently committed to this initiative.

  - **Direct Potable Reuse:** Gaining public acceptance, direct potable reuse is seen as a viable augmentation supply with over 64,000 acre-feet of recycled water currently produced annually in the county, which is projected to increase *[13]*. Local entities have stored about 1.8 million acre-feet of water (CAP and effluent) in the Tucson AMA that can be recovered following state regulations.

  - **Regional Stormwater Harvesting:** Pima County and its Regional Flood Control District are prioritizing the use of stormwater to improve drought resilience and reduce potable water demand through green infrastructure, stormwater management policies, and potential construction of recharge facilities in strategic locations *[19]*.

It should however be noted that these large infrastructure investments require extensive planning, community support, cross-sector collaboration, and funding. Although Pima County is not a direct water provider, it significantly contributes to water infrastructure. Its Regional Wastewater Reclamation Department manages over 60,000 acre-feet of recycled water annually, that can be used to offset groundwater pumping and augment supplies through direct or indirect potable use. Additionally, the Regional Flood Control District is authorized to construct large-scale stormwater detention basins and recharge facilities, enhancing groundwater replenishment and water supply augmentation.

- **Infrastructure and Planning:** In addition to the above strategies, it is worth noting that the Pima County Regional Flood Control District is actively enhancing its water resources management with ongoing and planned projects across strategic areas mentioned in Water Resources and Pima Prospers - Comprehensive Plan Update, 2023 *[20]*. These include:

  - **Geospatial Analysis and Planning:** The Pima County Regional Flood Control District is making efforts to leverage existing tools and resources for water resources planning for the region such as the Arizona Water Blueprint Map and the LSCRBS Groundwater Analysis by BOR. The Arizona Water Blueprint Map designed by the Kyl Center for Water Policy at Arizona State University is an interactive GIS tool for visualizing ground water level changes and land-use patterns across the state *[21]*. This tool supports comprehensive water resources planning by enabling detailed observation of trends over various periods (1-, 10-, 20-year). This Blueprint Map along with BOR study can be used to develop land use planning concepts for the Tucson AMA and to align these with the broader objectives of the Sonoran Desert Conservation Plan (SDCP) and other regional initiatives, helping to integrate environmental conservation with urban planning strategies.

  - **Stormwater Management:** Pima County Regional Flood Control District enforces Water and Flood Control Resource Area Policies to protect floodplain function including infiltration and recharge. To address stormwater challenges, the Pima County Regional Flood Control District has developed guidelines for Low Impact Development (LID) strategies, focusing on stormwater harvesting. An ArcView dashboard facilitates the analysis of stormwater runoff from developed areas, identifying watersheds suitable for implementing stormwater harvesting and the potential annual volume of stormwater available *[22]*.

Net Zero Water Ordinance and Future Modeling and Analysis

Pima County, in collaboration with the Drachman Institute at the University of Arizona, is in the process of developing a Net Zero Urban Water (NZUW) model/tool to help inform net zero water ordinance development for the City of Tucson and Pima County. This net zero water ordinance aims to compensate for the annual water use of new residential and commercial developments, using different water conservation measures/offsets to create a net zero impact of the new development on local ecology and service area water demand.

New developers are supposed to offset their projected water use, through water efficiency measures (on-site: RWH, efficient fixtures and appliances, as well as off-site measures such as GSI, and replacements of outdated less water efficient fixtures and appliances in offsites areas). Provision is being made in the model/policy to allow developers to pay fees in-lieu of retrofits (such as GSI, DPR), if they are not able to completely offset their projected water use. The fees charged must be related to the cost of implementing the retrofits.

The following scenarios have been planned to be incorporated for NZUW model development in consultation with agencies from the city and county, including Pima County Development Services, Pima County Regional Flood Control District, Pima County Wastewater and Reclamation, Tucson Water, City of Tucson Planning and Development Services. There is broad agreement across these groups on these scenarios. The list of strategies below was derived from consultation with experts and practitioners in the region. The potential future change factors include several factors that can overlay the future water supply scenarios.

Future Water Supply Scenarios

- Utility/Urban Scale Water Supply Scenarios
    - Large scale stormwater recharge projects (and location)
    - Retirement of agricultural land
    - Implementation of DPR across the water system
    - Expanded use of reclaimed water system for aquifer recharge and other applications
    - Managed aquifer recharge (aquifer storage and recovery) to reduce outflows

- District/Neighborhood Scale Water Supply Scenarios
    - Strategic satellite plants for wastewater treatment to reclaimed water for landscape, riparian habitat, etc.
    - Strategic satellite plants for wastewater treatment to potable for advancement toward DPR
    - Sewer mining for strategic increase of sewer capacity (for reclaimed or DPR)
    - Passive rainwater harvesting potential for streetscape irrigation/stormwater harvesting for strategic urban tree canopy expansion (using street impervious surfaces across each census tract – we also have the Flo2D model of Tucson and could specify street flood water per census tract)
    - District scale recharge basins for stormwater
    - Dry wells to enhance recharge of rainwater and/or stormwater
    - Reduction in impervious pavement, and rewilding streetscape commons

- Building/Household/Commercial Scale Water Supply Scenarios
    - Commercial and residential turf removal and replacement with desert-adapted landscapes
    - Active rainwater harvesting (using roof areas across each census tract) for landscape & cooling demands
    - On-site water reuse/recycling (primarily industrial/commercial, could include residential)
    - Residential graywater reuse (laundry and/or shower water for irrigation)

- Fixture replacement (High Efficiency Toilets/toilets, showerheads)
- Appliance replacement (front load washers, dishwashers)
- Pool covers
- Pool removal
- Irrigation efficiency improvements (moisture sensors, weather-based controllers, valve sensors, leak detection)
- Evaporative cooler removal
- Cooling tower upgrades/replacement with hybrid technology
- Change in wastewater treatment system demands due to effects of high adoption of water conservation measures due to greater concentration rates of waste
- Wastewater system infrastructure effects of high adoption of water conservation measures and reduced conveyance
- Advanced Metering Infrastructure (commercial and residential)

Policy Mechanisms to be Evaluated

- Landscaping ordinances regulating turf grass and irrigation
- Offsets and how much credit is assigned to each offset
- How much proportional "credit" does each new development get for the various conservation measures above?
- Can/how can the policy help to preserve or further housing affordability while meeting the primary policy intent?
- Capitalizing conservation to make larger scale investments
- No potable irrigation use
- The connection between incentivizing infill (through policy mechanisms) and maximizing efficiencies in the Utility/Urban and the District scales. Intuitively Infill development would concentrate resources and therefore maximize future water management options. If that is true, then what policy mechanisms could direct infill development.
- PIWMP applicability to permits
- Flood Control Recommended Alternatives and Low-Impact Development requirements

Potential Future Change Scenario Overlays

- Population (temporal and spatial)
- Climate Change (growing season changes, increased heat impacts on vegetation water needs)
- Large-scale expansion of the urban forest
- Population-scale behavior changes affecting water consumption
- Type of economic growth (and the water intensity of that growth)
- CAP shortages
- Expansion of City (Tucson Water) and Metropolitan Domestic Water Improvement District (Main) service areas
- Expansion of towns, unincorporated areas, agricultural and industrial activities (such as mining) adjacent to the City of Tucson, including potential additional groundwater pumping that may impact local water availability

6.0 Recommendations

As detailed in previous sections, our analysis included the following national, state, and local water documents:

1. Arizona Department of Water Resources (ADWR) Annual Supply and Demand Dashboard for Tucson AMA *[3]*;
2. USGS Water Use Data for the Nation *[4]*
3. Lower Santa Cruz River Basin Study (LSCRBS): Supply and Demand Assessment by Central Arizona Project (CAP) from 2021 *[5]*;
4. Lower Santa Cruz River Basin Study (LSCRBS): Groundwater Analysis by Bureau of Reclamation (BOR) from 2022 *[6]*;
5. Preliminary Integrated Water Management Plan (PIWMP) of Pima County from 2017 *[7]*;
6. Water Resources Options for Pima County from 2022 *[8]*; and
7. Net Blue Model Ordinance template, developed by the Alliance for Water Efficiency in collaboration with two other organizations *[9, 10]*.

Based on these, we have compiled a list of recommendations for PC to consider when preparing their comprehensive plan. Our recommendations fall into three broad categories:

1. support for a resilient water supply
2. support for effective monitoring
3. support for enhanced collaboration

Recommendations to Support a Resilient Water Supply

- Advance an "all of the above approach" where diverse strategies are pursued across all scales in the region.
- Expect and plan for variability in water supply and demand.
- Pursue a net zero water ordinance to ensure an assured water supply in concert with expanded development and in collaboration with the City of Tucson.
- Protect water resources along with other environmental and social objectives (e.g. equitable access and risk exposure, wildlife, riparian corridor protection, biodiversity).

Recommendations to Support Effective Monitoring

- Encourage and support data sharing across local, state, and national agencies.
- Monitor demand and supply, regularly comparing projected models and previous reports to actual supply and demand.
- Produce more detailed studies of water demand if the demand and supply models and previous reports are not accurate.
- Develop shared regional GIS tools to visualize land use and the spatial distribution of water supply and demands (by water providers), including depth to groundwater and demographic information.

Recommendations to Support Enhanced Collaboration

- Nurture and strengthen strong collaborative relationships and engagements with water providers and managers, wastewater, and flood control in the region.
- Ensure a tight connection between land use and water resource planning in the county. Additional training may be needed for team members of development services that are less familiar with water resource management in order to understand the water resource complexities in this region.
- Continue work between Pima County Development Services and City of Tucson Planning and Development Services to create a shared approach to regional long term assured water supply and development entitlements.
- Support water providers across Pima County in standardizing their method(s) for calculating water supply so that predictions are more closely aligned and there is greater transparency in the numbers.

Acknowledgements

We would like to thank Eve Halper and Brandon House from US Bureau of Reclamation for their help with the groundwater modeling numbers for Tucson AMA.

Appendix A

Figure 1. Water supply and demand projections for 26 water providers in Tucson AMA included in the LSCRBS, for Scenario A and F *(Data source: Data source: LSCRBS by CAP [5])*

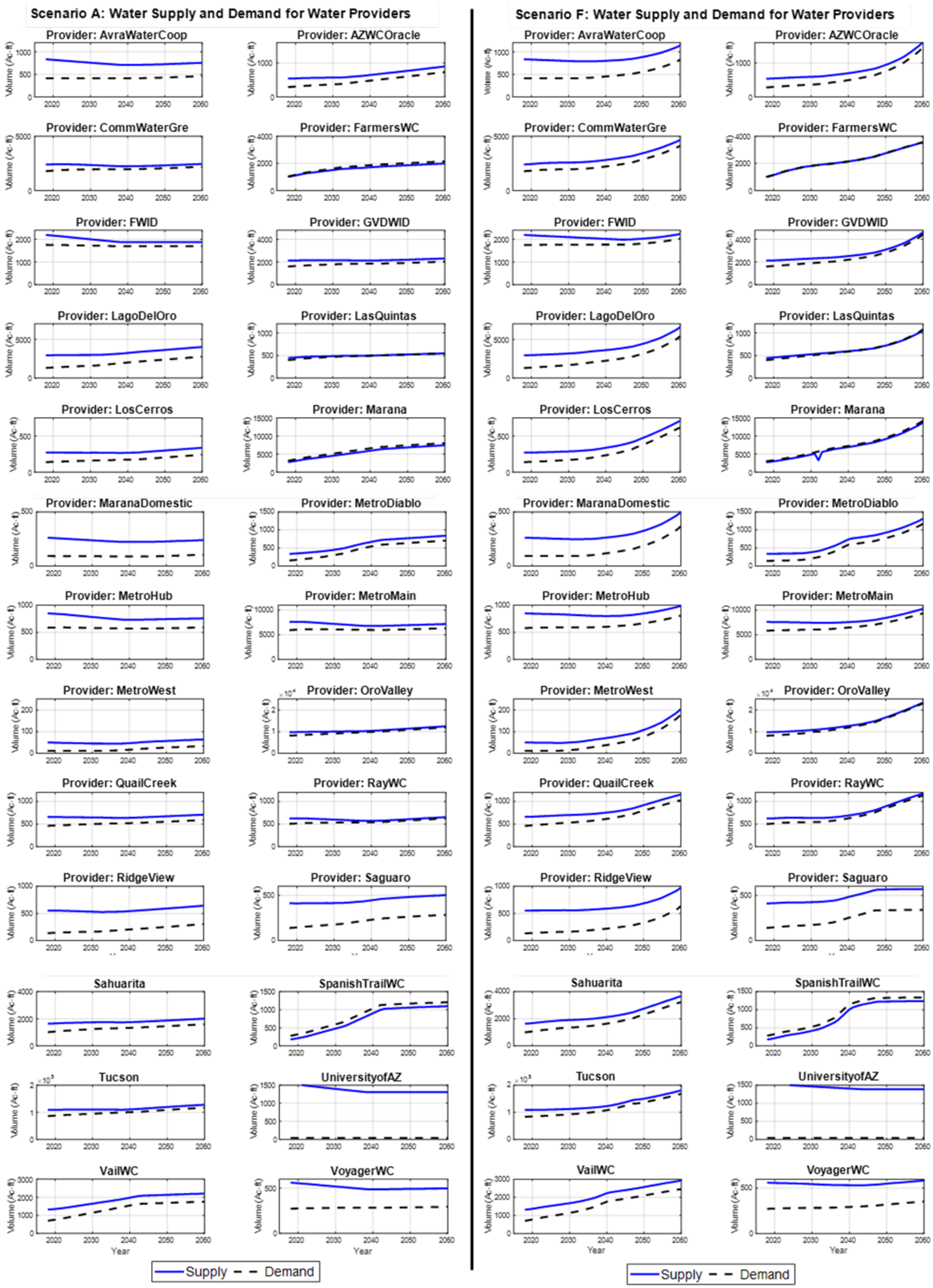


Table A - Water Conservation Measures - Indoor and Outdoor Options for Single Family Subdivision Development (Water Conservation Measures: 15-point Minimum. All projects must include at least 2 outdoor options. For projects without a renewable and potable supply, 1 additional point per acre-foot demand increase when site and supply well(s) is greater than 1 mile away or is within a subsidence area, or 2 additional points within one mile of a Groundwater-Dependent Ecosystem.)

Indoor Options			
I-1	Install gray water plumbing lines per City of Tucson ordinance 10579, gray water lines labeled and stubbed out at or above grade.	2	
I-2a	Install a manual or motion activated on-demand hot water circulation pumping system. All branches from the loop shall be less than or equal to 10 feet and less than or equal to 1/2 inch diameter.	3	
I-2b	Insulate all domestic hot water supply lines with R4 insulation.	1	
I-2c	Install tankless on demand hot water heater(s).	2	
I-3a	All toilets have a maximum flow rate of 1.28 gallons per flush, or flush valves have a maximum flow rate of 1.28 gallons per flush (e.g. EPA Watersense ™). OR	3	
I-3b	All toilets have a maximum flow rate of 1.1 gallons per flush, or flush valves have a maximum flow rate of 1.1 gallons per flush (e.g. EPA Watersense ™). OR	4	
I-3c	Install dual flush toilets with 1.6 gpf/.8 gpf or less water use.	3	
I-3d	All lavatory sinks and showerheads have a maximum flow rate of 1.5 gpm. The total allowable shower compartment flow rate from all showerheads, rain systems, waterfalls, body sprays and jets at a given time shall be limited to 1.5 gallons per minute. (maximum flow rate of 1.5 gpm @ 80 psi of pressure) (e.g. EPA Watersense ™)	3	
I-4	If active rainwater harvesting system is installed, connect the rainwater tank to an appropriate distribution system serving the toilets and size to meet the majority of demand.	4	
I-5	Install new washing machine with water factor of 4.5 or less (e.g. EnergyStar).	2	
I-6	Install 1.5 gpm kitchen sink and dishwasher which uses less than 3.5 gallon/cycle (e.g. EPA Watersense ™/ EnergyStar).	3	
I-7	Install a leak detection system.	1	
I-alt	Additional indoor measures may be proposed by applicant.	#	
Sub-Total from Indoor Options		**31**	**0**
Outdoor Options			
O-1a	Install active or passive on-lot rainwater harvesting system capable of capturing 0.5 inch of rainfall from 20% of total on lot impervious area.	2	
O-1b	Install on-lot rainwater harvesting system capable of capturing 0.5 inch of rainfall from 40% of total on lot impervious area.	4	
O-1c	Install on-lot rainwater harvesting system capable of capturing 0.5 inch of rainfall from 60% of total on lot impervious area.	6	
O-1d	Install on-lot rainwater harvesting system capable of capturing 0.5 inch of rainfall from 80% of total on lot impervious area.	8	
O-1e	Install on-lot rainwater harvesting system capable of capturing 0.5 inch of rainfall from 100% of total on lot impervious area.	10	
O-2	Install a grey water irrigation system.	2	
O-3a	Use only native and/or drought-tolerant, low-water use plants for 25% of Landscape Area* landscaping plantings with a Water Use of 1 or 2, designed to be self-sustaining based upon water harvesting. The list of drought tolerant and native low-water use plants appropriate for Pima County is available at: http://www.azwater.gov/azdwr/WaterManagement/AMAs/documents/2010TAMA_apha_botanical_PLANTLIST.pdf OR	1.5	
O-3b	Use only native and/or drought-tolerant, low-water use plants for 50% of Landscape Area* landscaping plantings with a Water Use of 1 or 2, designed to be self-sustaining based upon water harvesting.	3	
O-3c	Use only native and/or drought-tolerant, low-water use plants for 75% of Landscape Area* landscaping plantings with a Water Use of 1 or 2, designed to be self-sustaining based upon water harvesting.	4.5	
O-3d	Use only native and/or drought-tolerant, low-water use plants for 100% of Landscape Area* landscaping plantings with a Water Use of 1 or 2, designed to be self-sustaining based upon water harvesting.	6	
O-4a	CC&Rs that restrict the use of non-native plants and turf grasses in front yards of lots.	0.5	
O-4b	CC&Rs that restrict the use of non-native plants and turf grasses.	1	
O-4c	CC&Rs that restrict construction of swimming pools, mister systems and other outdoor water features.	1	
O-5a	Design for pervious driveway and walkway surfaces, 2 pts per 10,000 square feet.	2	

O-6a	Irrigation system designed and installed by a certified professional (e.g. EPA Watersense ™).	1	
O-6b	Install an irrigation system with the following components: 1) Weather based irrigation controller or soil moisture sensor-based irrigation controller (e.g. EPA Watersense ™). Controller shall have two watering schedules posted at the controller: a) for the initial grow-in period and b) for the established landscape. Controller shall be set to irrigate during the hours of 10 p.m. to 8 a.m.; 2) Turf spray heads, if installed, shall only be used for turf and shall achieve a lower quarter distribution uniformity (DULQ) of 65 percent or greater and contain check valves to prevent gravity drainage of water from heads; 3) Separate sprinkler zones for beds, with plants grouped based on watering needs (hydro zoning); 4) Drip irrigation for all non-turf planting beds.	2.5	
O-7a	Maintain undisturbed buffer yards with native species landscaping with 50% of demand met with passive water harvesting.	2	
O-7b	Maintain undisturbed buffer yards with native species landscaping with 100% of demand met with passive water harvesting.	4	
O-8	At least 50% of first-flush retention volume located in off-lot distributed basins instead of within project-wide detention basin.	2	
O-9a	Stormwater retention volume exceeds first flush retention volume by at least 20%.	2	
O-9b	Stormwater retention volume exceeds first flush retention volume by at least 40%.	4	
O-9c	Stormwater retention volume exceeds first flush retention volume by at least 60%.	6	
O-9d	Stormwater retention volume exceeds first flush retention volume by at least 80%.	8	
O-9e	Stormwater retention volume exceeds first flush retention volume by at least 100%.	10	
O-10a	Avoid, other than incidental disturbances, Flood Control Resources Area through use of cluster development, conservation subdivision, or modified development standards.	5	
O-10b	Avoid, other than incidental disturbances, Flood Control Resource Area, developer mapped floodplains and Erosion Hazard Setback Areas through use of cluster development, conservation subdivision, or modified development standards.	10	
O-alt	Additional outdoor measures may be proposed by applicant.	#	
Sub-Total from Outdoor Options		**98**	**0**

Infrastructure Options

Inf-1	Relocate or abandon active well(s) located in a shallow groundwater area.	**15**	
Inf-2	Relocate or abandon active well(s) located within a mile of a shallow groundwater area.	**7**	
Inf-3	Seal off perched aquifers and recent alluvium in wells to prevent cascading well.	**7**	
Inf-4	Enhance native vegetation, including regulated riparian habitat, in on-site natural drainage patterns, using Low Impact Development and Green Infrastructure practices.	**3**	
Inf-5	Enhance groundwater recharge potential of detention basins in shallow groundwater areas.	**5**	
Inf-alt	Additional infrastructure options may be proposed by applicant.	**#**	
Sub-Total from Infrastructure Options		**37**	
PROJECT TOTAL		**129**	

Table B - Water Conservation Measures
Indoor and Outdoor Options for Commercial and Multi-Family Development
(Water Conservation Measures: 15-point Minimum. All projects must include at least 2 outdoor options. For projects without a renewable and potable supply, 1 additional point per acre-foot demand increase when site and supply well(s) is greater than 1 mile away or is within a subsidence area, or 2 additional points if within one mile of a groundwater-dependent ecosystem.)

Indoor Options

I-1a	Install gray water plumbing lines per City of Tucson ordinance 10579 to meet 25% of non-potable demands.	2	
I-1b	Install gray water plumbing lines per City of Tucson ordinance 10579 to meet 50% of non-potable demands.	4	
I-2a	All toilets have a maximum flow rate of 1.28 gallons per flush, or flush valves have a maximum flow rate of 1.28 gallons per flush (e.g. EPA Watersense ™).	3	
I-2b	All toilets have a maximum flow rate of 1.1 gallons per flush, or flush valves have a maximum flow rate of 1.1 gallons per flush (e.g. EPA Watersense ™).	4	
I-3	Multi-family lavatories and all kitchen sinks and showerheads have a maximum flow rate of 1.5 gpm. The total allowable shower compartment flow rate from all showerheads, rain systems, waterfalls, body sprays and jets at a given time shall be limited to 1.5 gallons per minute. (maximum flow rate of 1.5 gpm @ 80 psi of pressure) (e.g. EPA Watersense ™).	3	
I-4	Use waterless urinals throughout the development.	2	
I-5	Use of efficient water-cooled chiller.	2	
I-6	Install on demand hot water heater(s).	2	
I-7	Install new efficient washing machine (water factor 4.5 or less), dishwasher (3.5 gallon per cycle or less), and food disposal (e.g. Energy Star) in each multi-family unit.	2	
I-8	Install 1.5 gpm kitchen sink and dishwasher which uses less than 3.5 gallon/cycle (e.g. EPA Watersense ™/ EnergyStar) in each multi-family unit.	3	
I-9	Install a leak detection system.	2	
I-10	Install separate water meters for each multi-family unit.	3	
I-alt	Additional indoor measures may be proposed by applicant.	#	
Sub-Total from Indoor Options		**32**	**0**

Outdoor Options

O-1a	At least 25% of retention volume located in distributed basins instead of within a project-wide detention basin.	1	
O-1b	At least 50% of retention volume located in distributed basins instead of within a project-wide detention basin.	2	
O-1c	At least 75% of retention volume located in distributed basins instead of within a project-wide detention basin.	3	
O-1d	At least 100% of retention volume located in distributed basins instead of within a project-wide detention basin.	4	
O-2a	Stormwater retention volume exceeds first flush retention volume by at least 20%.	2	
O-2b	Stormwater retention volume exceeds first flush retention volume by at least 40%.	4	
O-2c	Stormwater retention volume exceeds first flush retention volume by at least 60%.	6	
O-2d	Stormwater retention volume exceeds first flush retention volume by at least 80%.	8	
O-2e	Stormwater retention volume exceeds first flush retention volume by at least 100%.	10	
O-3	Re-use system for air conditioning condensate.	3	
O-4a	Use only native and/or drought-tolerant, low-water use plants for landscaping plantings with a Water Use of 1 or 2. The list of drought tolerant and native low-water use plants appropriate for Pima County is available at: http://www.azwater.gov/azdwr/WaterManagement/AMAs/documents/2010TAMA_apha_botanical_PLANTLIST.pdf	2	
O-4b	At least 50% of the parking spaces are adjacent to an 8 foot wide parking island planted with native drought tolerant trees that harvests and stores water from at a minimum the adjacent parking spaces.	2	
O-5	Prohibit the use of non-native plants and turf grasses.	1	
O-5b	Restrict construction of swimming pools, mister systems and other outdoor water features.	1	
O-6a	Design for pervious driveway and walkway surfaces, 2 points per 10,000 square feet.	2	

O-6a	Irrigation system designed and installed by a certified professional (e.g. EPA Watersense ™).	1	
O-6b alt	Install an irrigation system with the following components: 1) Weather based irrigation controller or soil moisture sensor-based irrigation controller (e.g. EPA Watersense ™). Controller shall have two watering schedules posted at the controller: a) for the initial grow-in period and b) for the established landscape. Controller shall be set to irrigate during the hours of 10 p.m. to 8 a.m.; 2) Turf spray heads, if installed, shall only be used for turf and shall achieve a lower quarter distribution uniformity (DULQ) of 65 percent or greater and contain check valves to prevent gravity drainage of water from heads; 3) Separate sprinkler zones for beds, with plants grouped based on watering needs (hydro zoning); 4) Drip irrigation for all non-turf planting beds.	2.5	
O-7a	Use only native drought-tolerant, low-water use plants for 25% of the Landscape Area * landscaping plantings with a Water Use of 1 or 2, designed to be self-sustaining based upon water harvesting: OR **	1.5	
O-7b	Use only native and/or drought-tolerant, low-water use plants for 50% of Landscape Area* landscaping plantings with a Water Use of 1 or 2 designed to be self-sustaining based upon water harvesting; OR	3	
O-7c	Use only native and/or drought-tolerant, low-water use plants for 75% of Landscape Area* landscaping plantings with a Water Use of 1 or 2, designed to be self-sustaining based upon water harvesting; OR	4.5	
O-7d	Use only native and/or drought-tolerant, low-water use plants for 100% of Landscape Area* landscaping plantings with a Water Use of 1 or 2, designed to be self-sustaining based upon water harvesting.	6	
O-8	Complete a Parking Area Reduction Plan.	3	
O-9a	Maintain undisturbed buffer yards with native species landscaping with 50% of demand met with passive water harvesting.	2	
O-9b	Maintain undisturbed buffer yards with native species landscaping with 100% of demand met with passive water harvesting.	4	
O-10a	Avoid, other than incidental impacts, Flood Control Resource Area through use of cluster development, conservation subdivision, or modified development standards.	5	
O-10b	Avoid, other than incidental impacts, Flood Control Resource Area, developer mapped floodplains and Erosion Hazard Setback Areas through use of cluster development, conservation subdivision, or modified development standards.	10	
O-alt	Additional outdoor measures may be proposed by applicant.	#	
Sub-Total from Outdoor Options		**94**	**0**

Infrastructure Options

Inf-1	Relocate outside groundwater-dependent ecosystem or abandon active well(s) located in a groundwater-dependent ecosystem.	**15**	
Inf-2	Relocate outside groundwater-dependent ecosystem or abandon active well(s) located within a mile of a groundwater-dependent ecosystem.	**7**	
Inf-3	Seal off perched aquifers and recent alluvium in wells.	**7**	
Inf-4	Enhance native vegetation, including regulated riparian habitat, in on-site natural drainage patterns, using Low Impact Development and Green Infrastructure practices.	**3**	
Inf-5	Enhance groundwater recharge potential of detention basins in shallow groundwater areas.	**5**	
Inf-alt	Additional infrastructure options may be proposed by applicant.	**#**	
Sub-Total from Infrastructure Options		**37**	**0**
PROJECT TOTAL		**126**	**0**

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Dr Rashi Bhushan is a postdoctoral research associate in the Drachman Institute. She is currently working on Net Zero Urban Water for the Southwestern U.S., which aims at achieving a sustainable water future for the region. Her research is motivated by the impacts of climate change on freshwater availability and water resources systems operation. Her interests include hydrologic modeling, adaptive management of water infrastructures, systems analysis, and multi objective optimization. With her skills she intends to address problems related to freshwater scarcity, water access inequity, and water infrastructure management under climate uncertainty.

Prior to joining the University of Arizona, Rashi graduated with a Ph.D. from Hong Kong University of Science and Technology, and Master's from Pennsylvania State University, both focused on water resources. She also worked with an environmental consulting firm performing hydrologic and hydraulic modeling for developing floodplains for FEMA. In her free time, she loves to dance, travel and explore new cuisines.

Adrienne Brown
Post Doctoral Research Associate
Udall Center

Adrienne Brown is a postdoctoral researcher with the Udall Center for Studies in Public Policy. She received her Ph.D. in sociology from the University of New Hampshire, specializing in community and environment. Using primarily qualitative methods, she has studied community resilience, identity, and environmental knowledge in wildfire and forest management in Northern California. Her current work addresses community engagement in environmental governance and decision-making.

Courtney Crosson
Associate Professor of Architecture
Director, The Drachman Institute

Courtney Crosson is a licensed architect, associate professor, and Director of the Drachman Institute at the University of Arizona, where she teaches classes on water in the built environment and community outreach studios. Her current research advances decentralized water systems to address pressing problems facing cities—whether water scarcity in the U.S. Southwest or safe and affordable water access in informal settlements in Nairobi, Kenya. She is the Principal Investigator on a four-year National Science Foundation grant to investigate how to transition cities in the US Southwest to a net zero urban water future. Her work has been published in peer-reviewed journals in architecture, engineering and planning. She has won numerous national awards for her teaching, outreach and research including the Association for Collegiate Schools of Architecture and American Institute of Architects' 2024 Practice and Leadership Award.

Crosson's work outside academia spans many scales and locations including Europe, Africa, Asia and North America. She has worked for BuroHappold Engineers in Los Angeles, Foster + Partners in Hong Kong, Muf Architecture/Art in London, Multiplicity in Milan and UN Habitat in a Nairobi informal settlement called Kibera. At BuroHappold she was the sustainability consultant for the net zero energy design of the new Los Angeles County Museum of Art (Atelier Peter Zumthor), University of California Santa Barbara's Institute for Energy Efficiency (Kieran Timberlake Architects) and the net zero water and energy design of the new Santa Monica City Hall extension (Frederick Fisher Architects). At the master plan scale, she has guided energy and water reduction frameworks at Rice

University, Los Angeles Union Station and University of California San Diego. Crosson's first net zero design has been in operation since 2009; a seven-acre secondary girls boarding school in Muhuru Bay, Kenya, for which she was the project manager and lead designer.

Andrea K. Gerlak
Director, Udall Center
Research Professor, Environmental Policy Programs, Udall Center
Professor, School of Geography, Development and Environment
Andrea K. Gerlak is Director of the Udall Center, and professor in the School of Geography, Development and Environment at the University of Arizona.

Her research focuses on institutions for governing water resources. She examines cooperation and conflict around water, including questions of institutional change and adaptation to climate change in rivers basins, and human rights and equity issues in water governance.

Gerlak is a senior research fellow with the Earth System Governance Project, an international social science research alliance exploring political solutions and novel, effective governance mechanisms to address global environmental challenges. She recently served as a Lead Author on the Earth Systems Governance Science and Implementation Plan, which sets out the agenda for the next decade of earth system governance research.

Presently, she serves on Water Infrastructure Finance Authority of Arizona's Water Conservation Grant Committee and the City of Tucson Water Advisory Committee.

Gerlak has over ten years' experience building, administering, and teaching in interdisciplinary environmental studies programs. She has been a faculty member at Guilford College and Columbia University. For nearly a decade, she served as the director of academic development with the International Studies Association where she facilitated academic development across ISA's academic sections, including developing programs to foster junior scholar engagement and cross-disciplinarity in international studies.

Philip Stoker
Associate Professor of Landscape Architecture and Planning
Philip Stoker is an assistant professor of planning and landscape architecture in the College of Architecture, Planning and Landscape Architecture. Philip holds a Ph.D. in Metropolitan Planning, Policy, and Design from the University of Utah where he completed his thesis on urban water use and sustainability. His academic foundations are in ecology, planning, and natural resource management. He has conducted environmental and social science research internationally, including work with the World Health Organization, Parks Canada, the National Park Service and the Vancouver 2010 Olympic Games.

Philip has expertise in urban water demand and the integration of land use planning with water management. His research on urban water demand has focused on how land cover, built environmental characteristics, social conditions, and demographics all interact to influence water use in Western U.S. cities. He is also conducting research on how land use planning can be better integrated with water management in order to achieve more sustainable urban water management. Philip teaches Introduction to GIS, Environmental Spatial Analysis, Sustainable Development, and Sustainable Cities in CAPLA.