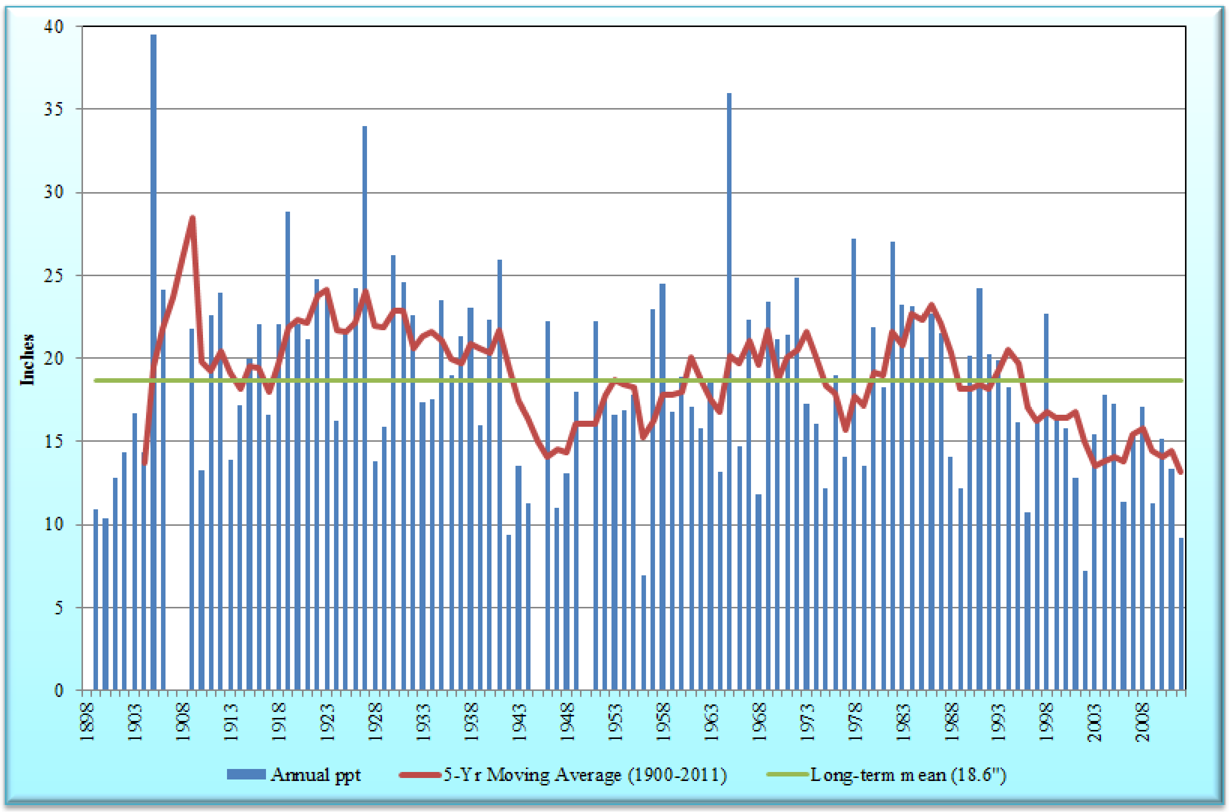
11.1 INTRODUCTION

The management goal of the Prescott Active Management Area (PRAMA) is to achieve and thereafter maintain a long-term balance between the annual amount of groundwater pumping and the annual amount of natural and artificial recharge in the Active Management Area (AMA) by 2025 (safe-yield). Net natural recharge and the other components in the calculation of safe-yield are described in the *Draft Version 2 Demand and Supply Assessment, Prescott Active Management Area* (Assessment) (ADWR, 2011)in part 3, "The Basic Budget Components." In all AMAs with a goal of safe-yield, maintaining safe-yield will be complicated as the vacillating weather conditions common in the southwest *(See Figure 11-1)* result in fluctuating net natural recharge to aquifers, primarily in the form of stream channel recharge. This is especially true in headwaters AMAs (Prescott and Santa Cruz) that rely on local, contemporary precipitation as the primary source of aquifer replenishment.

FIGURE 11-1
ANNUAL PRECIPITATION
PRESCOTT, ARZIONA
PRAMA



Like most of Arizona's groundwater basins, the PRAMA experiences years of low precipitation and occasional high rates of precipitation, resulting in flood flow. This vacillating pattern means that even after achieving safe-yield, there may be several consecutive years where the PRAMA experiences small volumes of overdraft that can be subsequently mitigated by one or more significant flood events (years of high net natural recharge) replenishing the aquifers. Climate change may result in drier conditions which in turn can cause long-term average annual net natural recharge declines. Reduction in precipitation not only results in less stream channel flow, but also less groundwater outflow; both being components of net natural recharge.

Without effective water management, these “feast or famine” conditions could endanger the long-term reliability of the water supply of the PRAMA. Therefore steps must be taken to mitigate these conditions in order to achieve and maintain safe-yield. Continued monitoring of pumping, the location of underground water storage and recovery of stored water, the effects of precipitation, and depth to water level measurements in AMA wells, coupled with comprehensive water management planning to anticipate and allow sufficient time to respond to changing conditions, are all imperative in achieving and ultimately managing the AMA’s water management goal.

The Assessment (ADWR, 2011) included seven different water demand and supply projection scenarios and water budgets, each with slightly different assumptions. The Assessment utilized long-term averages of stream channel and mountain front recharge for the natural system components of the water budgets. Use of a long-term average for net natural recharge masks the annual variability of net natural recharge. Although safe-yield is a goal to be achieved based on a long-term average, it is important for PRAMA water users to understand that there may be many years of overdraft, which may result in localized water level declines, and the need to shift pumping to different locations. Further, there may be an occasional year of surplus, which, if captured and stored underground, could help mitigate years of shortage. Understanding the variability in the natural supply conditions that the PRAMA experiences will inform water management decisions and water management program development in the PRAMA.

As discussed and described in Chapter 3 of this plan, since the publication of the Assessment, Arizona Department of Water Resources (ADWR) Hydrology staff have further refined and adjusted the PRAMA hydrologic model. The natural recharge components were updated for the 4MP based on the current version of the PRAMA model (Nelson, 2013) from those used in the Assessment.

During the model update process ADWR Hydrologists identified the impacts of the seasonally and annually fluctuating net natural recharge characteristics in PRAMA. ADWR then developed statistically generated projections for net natural recharge to be used in the 4MP. These projections mimic the observed historical variability for purposes of planning and visually show what overdraft conditions the AMA might experience given variable supply conditions with increased demand. As in the Assessment, a “normal” and “dry” net natural recharge scenario was developed. However for comparative purposes this chapter includes only the “normal” net natural recharge projections. The “dry” conditions exacerbate difficulties in achieving and maintaining safe-yield. Charts and graphs in this chapter show the annually fluctuating net natural recharge conditions, to make clear that AMA water users cannot rely on receiving the long-term average net natural recharge volume every year. However, the 1985-2012 average net natural recharge volume also appears on charts and graphs in this chapter.

During the fourth management period ADWR may utilize scenario planning techniques to model and understand the implications of potential water management decisions. Scenario planning can inform decisions in situations that are highly complex and uncertain. When successful this planning technique is a learning process where stakeholders become informed about their situation and help each other build shared knowledge, achieve consensus, and develop adaptive management strategies. This process allows the development of a set of scenarios that potential solutions can be tested against to develop the best set of solutions regardless of future conditions (Aldrich, 2013). Examination and analysis of scenario planning results allows the community to understand which water management decisions have the greatest potential impact in securing long-term sustainable supplies and maintaining the economic viability of the PRAMA for as long as possible.

Unlike the Assessment, the historical period in this chapter is from 1985 through 2012. Three scenarios (described in detail below) are included in this chapter. The projected years are from 2013 through 2025 the year of the safe-yield goal, and extend to the year 2110. Future water demand and supply are affected by the requirements and implications of the Assured Water Supply (AWS) Program, as well as the Augmentation and Recharge Program (ARP) and need to be understood in the context of the 100-year planning time frame addressed by the AWS Program. For purposes of these projections ADWR did not incorporate any limitations on the physical availability of groundwater pursuant to the AWS Rules in any of the scenarios included in this chapter. However, under current law, physical availability of groundwater could limit the approval of new subdivision demand.

Many of the decisions water users will make between now and 2025 will be made in the context of water management needs during the 100-year time frame of the AWS Rules. Statutory and rule changes, infrastructure improvements and expansions, as well as shifting approaches to water management present challenges, but are necessary for achievement of safe-yield in the PRAMA, and in other AMAs as well. Because of these variables, the projection period in this chapter has been extended from 2025 to 2110 to give insight into how demand and supply decisions may affect safe-yield beyond 2025.

Due to the timing of new population projection development by the Arizona Department of Administration (ADOA) and local Associations of Government, ADWR has not incorporated revised population projections from these jurisdictions into the scenarios in this chapter. Instead, ADWR re-projected population in PRAMA using statistical analyses and other planning assumptions based on recent population trends and the 2010 US Census data. Table 11-1 compares the statistically generated population projections to the population projections included in the Assessment, the Water Resource Development Commission (WRDC) and the updated ADOA population projections. Population projections generated by demographic agencies tend to mirror recent economic trends. When the economy is strong, the projections appear optimistic, following recent trends in in-migration as greater than historical numbers of people move into an area seeking new jobs. In less robust economic times, projections tend to be lower, mirroring a higher out-migration and/or lower in-migration. The most recent projections from ADOA are lower than those used in the Assessment, for the WRDC, and the ones used in this chapter. During the fourth management period the Assessment templates on the ADWR website will continue to be updated annually. A summary of the projection assumptions for the scenarios included in this chapter and a description of ADWR's general approach are included in the section below, and in Appendix 11-A. Projection budget templates and summary budgets can be found on ADWR's website: http://www.azwater.gov/azdwr/WaterManagement/AMAs/PrescottAMAFourthManagementPlan.htm.

TABLE 11-1
POPULATION PROJECTION COMPARISON
PRAMA

	2012	2014	2025	2040	2050
AMA Assessment	441,928	469,237	624,892		
Scenario One	145,108	152,973	197,720		
Scenario Three	151,011	161,782	221,020		
Scenario Two	145,809	154,482	206,152		
Updated ADOA	355,807	363,985	436,654	522,200	574,838
Low	118,408	120,214	134,014	148,990	157,243
Mid	118,712	121,396	146,279	175,490	193,240
High	118,687	122,375	156,361	197,719	224,355
WRDC	405,145	431,319	559,135	690,739	756,385
Low	132,310	138,980	167,902	183,451	186,743
Mid	134,698	143,161	184,019	222,283	240,429
High	138,137	149,177	207,214	285,005	329,213
Draft 4MP	119,790	126,454	169,186	214,478	241,406

NOTE: Data is total number of people in the PRAMA.

11.2 WATER BUDGET SCENARIOS

There are three scenarios included in this chapter. These scenarios are not intended to represent the future as they are not predictions. Nor do these scenarios represent all legal and institutional constraints or opportunities to reduce water demand or obtain additional water supplies. These scenarios are intended to illustrate the impact of demand and supply assumptions relative to PRAMA's goal of safe-yield. It is hoped they will encourage further conversations leading to additional planning efforts during the fourth management period resulting in water management decisions to achieve a more secure long-term water supply for the PRAMA. Demand and supply assumptions included in each scenario are described below.

11.2.1 Municipal Demand and Supply

In addition to using different population projections from those used in the Assessment, ADWR also used different water demand use rates in the 4MP. Most importantly, water supply assumptions were modified. All the scenarios included in this chapter assume: 1) Big Chino sub-basin groundwater is imported beginning in the year 2020 and ramps up over time, 2) the proportion of the AMA population on central sewer systems increases over time, 3) infrastructure improvements providing for the regional collection, storage, and recovery of reclaimed water are funded and constructed, and 4) recovery of as much reclaimed water as is physically feasible from within the area of impact of storage occurs. Some or none of these assumptions may come to pass. These assumptions are for illustrative and comparative purposes only and certainly other activities and circumstances may result in these assumptions being unachievable. For example, since the completion of the Assessment the City of Prescott, the Town of Prescott Valley and Salt River Project entered into an agreement to increase groundwater monitoring in the Big Chino sub-basin and prepare a groundwater flow model of the Big Chino. These activities may extend beyond the year 2020 rendering importation of Big Chino groundwater by the year 2020 untenable.

City of Prescott

All three City of Prescott scenarios make the following assumptions:

- The water service area population was re-projected by ADWR using the 1985 – 2012 water service area population and a linear trendline for 2013 – 2110. This results in a projected service area population of 53,309 people in the year 2020, and 134,522 people in 2110. In the City of Prescott's 2012 Annual Water Withdrawal and Use Report (annual report), the City projects a service area population of 59,140 people in the year 2020, with a demand of 9,122 acre-feet. ADWR has used its lower projection figures (53,309 people in the year 2020 and 134,522 people in the year 2110) for these scenarios.
- Prescott's direct use of reclaimed water is 2,240 acre-feet per year for 2013 – 2110. In Prescott's 2012 annual report, 1,474.32 acre-feet of reclaimed water was used for turf irrigation and another 82.29 acre-feet was used for other direct reclaimed re-use.
- Prescott annually stores and recovers 1,335 acre-feet of surface water per year.
- Big Chino importation begins in 2020, and ramps up to 4,365 acre-feet per year by the year 2044 and maintains that volume each year through 2110.
- For 2013 – 2024 Prescott uses up to 8,000 acre-feet of groundwater per year.
- For 2025 – 2110 Prescott uses zero groundwater; all pumpage is recovered water, either surface water or reclaimed water, equivalent to the remainder of Prescott's projected demand minus the assumed volume of direct use reclaimed water, recovered surface water, and Big Chino groundwater.

Variations in scenarios A, B, and C for the City of Prescott are as follows:

Prescott Scenario A:

- Demand is projected at 150 gallons per capita per day (GPCD) through 2110. Prescott's GPCD in 2012, including its reclaimed water use, was 160 GPCD. Not including reclaimed water use, Prescott's GPCD in 2012 was 122 GPCD. In 2012 Prescott used reclaimed water and reclaimed water recovered within the area of impact of storage primarily for golf course irrigation.

Prescott Scenario B:

- Prescott adopts a "WaterSense" ordinance in 2015. The adoption of these lower-flow rate fixtures for new homes changes the indoor water use rate for new homes to 39 GPCD.

The Prescott Scenario B assumptions result in an overall (residential, non-residential, and lost and unaccounted for water, including all sources of supply) GPCD rate in the Prescott service area of 141 GPCD by 2110.

Prescott Scenario C:

- Prescott adopts a "WaterSense" ordinance in 2015, which changes the new residential interior model to 39 GPCD.
- Prescott adopts a landscape ordinance for new development resulting in a reduction of the exterior gallons per housing unit per day (GPHUD) from 75 down to 50 GPHUD for single family homes and from 58 down to 20 GPHUD for multi-family homes.

The Prescott Scenario C assumptions result in an overall (including residential, non-residential, and lost and unaccounted for water, including all sources of supply) GPCD rate in the Prescott service area of 130 GPCD by 2110. Note that Prescott's 2012 residential GPCD rate, which includes interior and exterior demand, was 79 GPCD. Assuming 2.3 persons per household and the revised exterior model for single family homes, a new single family home based on these assumptions would use 61 GPCD.

- Beginning in the year 2050, Prescott accesses and stores another 3,200 acre-feet of surface water from its other surface water claims.

The volume of Prescott's annual surface water recovery is related to the volume of water that annually flows into Watson and Willow Lakes, certain legal agreements between the Salt River Project and the Chino Valley Irrigation District (CVID) which Prescott inherited, and Prescott's water management strategy. In dry years with low net natural recharge there may be insufficient surface water to store and recover. In addition to legal constraints which restrict the periods of time that Prescott can store surface water, maintaining water in the lakes for recreational purposes is a priority for the City of Prescott, which can limit the volume of water that could be stored and recovered. Prescott also has the ability to use surface water from Goldwater Lake, the Hassayampa River, and Del Rio Springs pursuant to surface water claims they have filed. Using these surface water supplies would require additional infrastructure and also have legal and physical constraints that complicate their use.

Prescott's current water management policy assumes 8,000 acre-feet per year of groundwater pumping, and Prescott's Designation of Assured Water Supply (DAWS) includes 9,466 acre-feet per year of groundwater pumping. However these volumes of groundwater are greater than the 1985-2012 average annual net natural recharge for the PRAMA of 4,391 acre-feet. For all three scenarios, Prescott is assumed to use groundwater to meet the remainder of its demand up to 8,000 acre-feet for the years 2013 through 2024. However with the population and demand assumptions in these scenarios, Prescott never needs to withdraw as much as 8,000 acre-feet of groundwater in any year through the year 2024. For the years 2025 through 2110, it is assumed that Prescott uses no groundwater and the remainder of Prescott's demand minus direct use reclaimed water, recovered surface water, and Big Chino groundwater is met with recovered reclaimed water, primarily withdrawn from within the location of impact of storage. These assumptions are based on the idea that after 2025 Prescott could recover stored water and avoid pumping any water that is not offset with storage. ADWR's hydrologic model indicates that an optimal location for regional underground storage is along a linear stretch of Granite Creek from approximately the location of Watson and Willow lakes and extending for several miles northward to the Chino Valley area (Nelson, 2013).

Town of Prescott Valley
All three Prescott Valley scenarios assume the following:

- The service area population projection for the year 2110 is 238,760 people. The service area population was re-projected by ADWR assuming 4.1 percent growth from 2013 – 2025, 2.2 percent growth from 2026 – 2035, and 1.25 percent growth from 2036 – 2110.
- Projected demand will be based on 118 GPCD. Prescott Valley's 2012 GPCD rate, including reclaimed water was 111 GPCD. Prescott Valley's residential GPCD rate in 2012 was 70 GPCD.
- Prescott Valley begins using Big Chino groundwater in the year 2020 and ramps up to 3,703 acre-feet in the year 2045. From 2045 through 2110, Prescott Valley will continue to use 3,703 acre-feet of Big Chino groundwater each year.
- For 2013 – 2024 Prescott Valley uses up to 6,000 acre-feet per year of groundwater.
- For 2025 – 2110 the remainder of Prescott Valley's demand each year after subtracting the volume of imported Big Chino groundwater is recovered reclaimed water, primarily recovered from within the area of impact of storage either at Prescott Valley's existing recharge projects or at an assumed new regional recharge facility located along Granite Creek.

Prescott Valley has prepared water demand projections as part of an internal planning process assuming approximately 6,000 acre-feet per year of groundwater pumping; however, this volume of groundwater is greater than the 1985-2012 average annual net natural recharge in the PRAMA of 4,391 acre-feet. (*See 4MP Historical Assessment Summary Budget at http://www.azwater.gov/azdwr/WaterManagement/AMAs/PrescottAMAFourthManagementPlan.htm.)* In addition to its existing reclaimed water underground storage projects, storage and recovery of additional reclaimed water along Granite Creek by Prescott Valley will require the construction of additional infrastructure to transport reclaimed water to Granite Creek for underground storage, or some other location experiencing water level declines, the construction of recovery wells in the area of impact of storage along Granite Creek, or some other area that prior storing water was experiencing water level declines, and infrastructure to transport the recovered water back to the Prescott Valley service area for distribution. These assumptions are based on the idea that after 2025 Prescott Valley could recover stored water and avoid pumping any water that is not offset with storage of renewable supplies.

Small Municipal Providers
All scenarios for small municipal providers assume the following:

- Small municipal provider population as a whole, including the Town of Chino Valley, was re-projected using the 1985 – 2012 population and a linear trendline for 2013 – 2110. Currently the Town of Chino Valley is a small municipal provider. At some point in the future, Chino Valley (and potentially other small providers) will begin using more than 250 acre-feet per year of water, and transition to large municipal providers. However, for these scenarios Chino Valley and others remain in the category of small municipal providers.

The small municipal provider population across the entire AMA is 42,390 people by the year 2110.

- Because Chino Valley owns and operates a wastewater treatment plant, Chino Valley was included in the calculations of projected reclaimed water available for storage, in all three scenarios. Therefore, it was necessary to project population for the Chino Valley water service area separately from the projected population of all small providers. The increase in population within the Chino Valley Town CDP for each projection year was added to the Chino Valley 2012 service area population. This assumes that any new population within the Chino Valley CDP is connected to Chino Valley's sewer system rather than individual septic systems. New growth within the Chino Valley service area was assumed to use 150 GPCD, consistent with Chino Valley's current use rate per capita.

- Small provider demand was projected assuming 90 GPCD.
- For the years 2013 through 2024 small providers are assumed to use 100 percent groundwater. However, in 2025 through 2110, it is assumed that regional reclaimed water storage and recovery will be implemented to offset or replenish small provider demand.

Variations included in scenarios B and C for small providers are as follows:

- Town of Chino Valley begins using Big Chino groundwater in 2020 and ramps up to 3,483 acre-feet in the year 2045 and maintains that volume of Big Chino groundwater thereafter.

- A regional wastewater collection system is in place beginning in the year 2020, to collect wastewater from all new small providers and the exempt well population added in 2020 and thereafter. This increases the supply of reclaimed water that can be stored and recovered.

Exempt Well Population
All scenarios for exempt well population have the following assumptions:

- The exempt well population for the year 2110 is projected to be approximately 30,000 people. ADWR believes this to be a conservative population projection because it assumes efforts to encourage new development on centralized distribution systems will result in a decline in the annual rate of increase of exempt wells in PRAMA.

- Exempt well population can only be calculated for the 2000 and 2010 US Census years. In the Assessment, exempt well population was estimated for 1985 through 1999 assuming exempt well population increased five percent per year. This assumption tracks closely with the average rate of increase in new exempt wells each year since 1985. Using the estimated exempt well population for 1985 – 1999, and the 2000 and 2010 US Census calculated exempt well population figures for the PRAMA interpolated for the years 2001 through 2009, ADWR utilized the trendline function in Microsoft Excel to project the exempt well population from 2011-2110. Several trendlines were considered. ADWR selected the Power trendline. The linear trendline results in a year 2110 exempt well population projection of about 67,000 people. The log trendline results in a year 2110 exempt well population projection of about 25,000 people. (In the 4MP historical budget template, for the years 2011 and 2012 the 4.3 percent growth rate (the 1985 – 2006 average growth rate for large municipal water providers in the PRAMA) that was used in the Assessment was applied to estimate exempt well population.)

- Demand for exempt well population was projected using 90 GPCD. The exempt well population is assumed to use 100 percent groundwater for the years 2013 through 2024. For 2025 through 2110, it is assumed that a regional reclaimed water storage and recovery project will have been constructed and will replenish small provider and exempt well groundwater pumping. This will allow the offsetting of exempt well pumping for several decades into the future.

Scenarios B and C for the exempt well population include the following additional assumptions:

- A regional wastewater collection system is in place beginning in the year 2020, to collect wastewater from all new small provider and exempt well population added in 2020 and thereafter, thus increasing the supply of reclaimed water that can be stored.

Projected Reclaimed Water Supply, Underground Storage and Recovery
All three scenarios project the volume of reclaimed water available for storage based on an assumption that the entire service area populations of both the City of Prescott and the Town of Prescott Valley are connected to the sewer system. For the Town of Chino Valley all population growth within the US Census Designated Place (CDP) for Chino Valley in the future is assumed to be connected to the sewer system. The CDP is much larger than the current Town of Chino Valley water service area.

The projected volume of reclaimed water generated was based on the following assumptions for each entity:

- For Prescott, 54 percent of the total water deliveries will be reclaimed water.

- For Prescott Valley, reclaimed water will constitute 58 percent of deliveries from 2013 - 2023 and 64 percent of deliveries from 2024-2110.

- For Chino Valley, 60 percent of deliveries will be reclaimed water.

Scenarios B and C assume that a regional wastewater collection system is in place beginning in the year 2020, to collect wastewater from all other new small provider and exempt well population added in after 2019, thus increasing the supply of reclaimed water available for storage to replenish small provider and exempt well groundwater demand.

For all three scenarios, the total volume of reclaimed water stored each year is equal to the total volume estimated to be generated by all entities, minus Prescott's direct delivery of 2,240 acre-feet per year, minus evaporative losses. It was assumed that all reclaimed water would be stored via a constructed USF facility, and that there would be no cut to the aquifer imposed. Under these assumptions, depending on the demand and other supply assumptions, by the year 2024 there would be between 77,000 and 85,000 acre-feet of reclaimed water long-term storage credits in the PRAMA.

In all three scenarios, beginning in the year 2025, only 3,000 acre-feet of groundwater is assumed to be pumped by the municipal sector (including large and small municipal water providers and exempt well demand). The next sources assumed to be used are direct-use reclaimed water, Big Chino groundwater, and recovered surface water. The remainder of the PRAMA's municipal demand (including exempt well demand in the municipal category of PRAMA demand) will be delivered through recovery of annual or long-term storage credits of reclaimed water.

As noted above, it is assumed in these scenarios that the PRAMA municipalities will cooperatively develop and construct an underground storage facility along Granite Creek and infrastructure to direct reclaimed water to a stretch of the Creek, recovery wells located along Granite Creek, and infrastructure to transport the recovered reclaimed water back to each contributing entity.

11.2.2 Industrial Demand and Supply
The Assessment Baseline Scenario One demand was incorporated into all three scenarios included in this chapter for the industrial sector (consisting of Type 1 and Type 2 Non-Irrigation Grandfathered Groundwater Rights and Permits). This assumption holds industrial groundwater demand, which comprises the majority of the demand, at about 1,500 acre-feet per year through 2110. There is currently roughly 8,000 acre-feet of industrial pumping authority in the PRAMA, but actual annual industrial use within the PRAMA over the historical period 1985 – 2012 was approximately 1,000 acre-feet. This

assumes that industrial demand will continue in the PRAMA, but the majority of future industrial demand will be served by a municipal water provider pursuant to their service area rights rather than through a Type 1 or Type 2 Grandfathered Right (GFR), or a permit.

11.2.3 Agricultural Demand and Supply

The Baseline Scenario One demand from the Assessment was also incorporated into all agricultural sector scenarios in this chapter. This demand was based on the agricultural sector water use in PRAMA continuing to decline to only about 30 acre-feet of groundwater use by 2025, with the CVID recovering about 750 acre-feet per year of reclaimed water to meet agricultural demand. CVID's recovery of reclaimed water is pursuant to CVID's agreement with the City of Prescott and is limited to a maximum total of 33,000 acre-feet of recovered reclaimed long-term storage credits. Under these assumptions, Prescott fulfills its 33,000 acre-foot obligation to the CVID in the year 2037. After that, it is assumed the remaining agricultural users return to groundwater, and the agricultural groundwater pumping is volume remains constant at about 800 acre-feet per year from 2038 through the year 2110.

11.3 PROJECTED NATURAL SUPPLY

Water supply in the PRAMA has been projected by ADWR using a statistical approach based on development of the PRAMA hydrologic model and its recent updates (Nelson, 2013). During the model update, ADWR Hydrology staff gained new understanding of the PRAMA's natural water supply variability not evaluated in the Assessment. The projected natural supplies included in this chapter are not intended to be supply forecasts for each projection year, but rather are intended to mimic the historical annual variability in net natural recharge in order to inform any water management issues that may arise from increased demand coupled with supply variability over time *(See Figure 11-2)*.

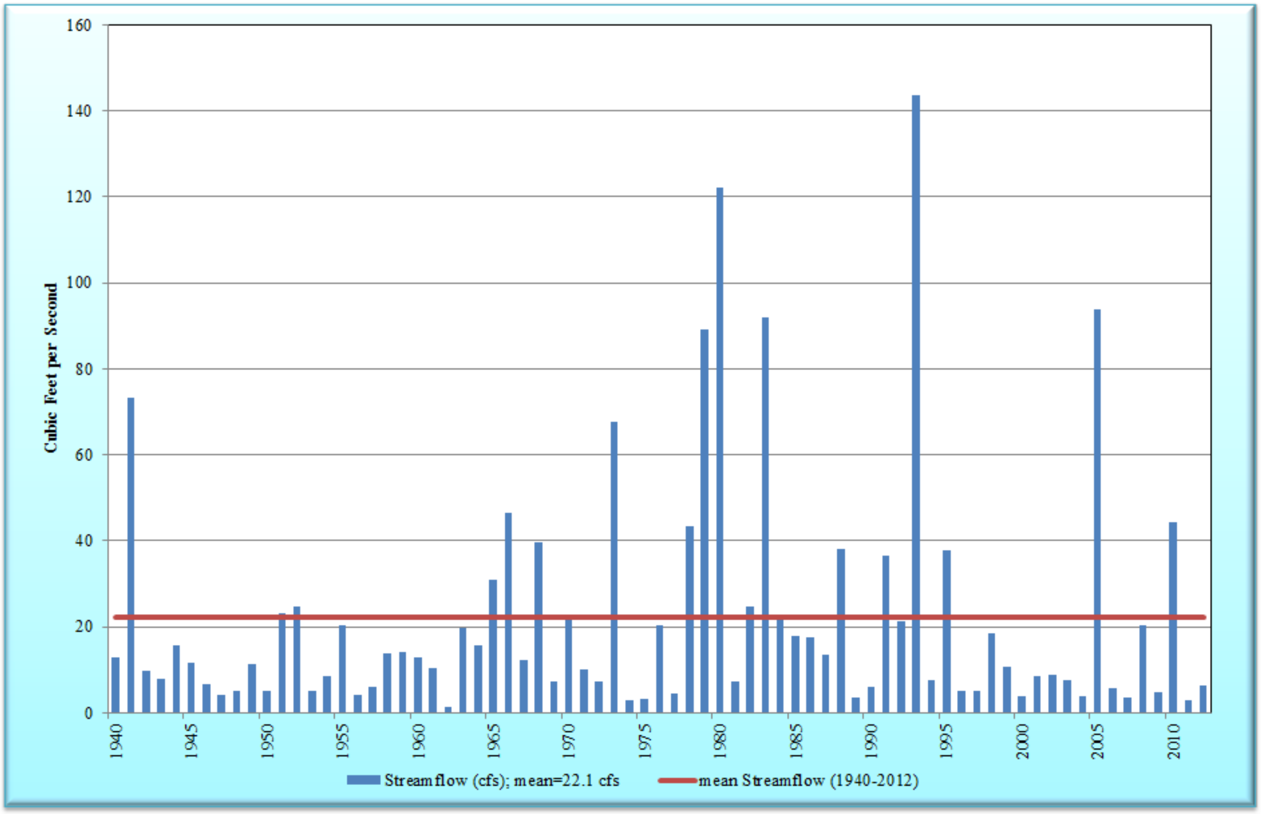
Historical data reveals the pattern referred to earlier in this chapter; namely periods of little precipitation and streamflow with occasional flood events that replenish the aquifer. This variability, which may be impacted further by climate change, is the reason using a long-term annual average for net natural recharge can be a deceptive metric in PRAMA. Such an assumption gives the false impression that the natural supply is consistently available.

In Chapter 2 of this plan, refer to Figures 2-7E, 2-7I and 2-7Q, in addition to the hydrographs shown here in Appendix 11-B, Figures 11-B1 and 11-B2 to see examples of water level variations over time. Water level data collected from local wells provides additional information on the frequency, magnitude, and variability of natural recharge. Streamflow data shows that significant streamflow events occurred at higher frequencies between the mid-1970s and the mid-1990s, compared to the period from the 1940s through the mid-1960s and recent decades. Data reveals water rises in wells in response to streamflow patterns, and declines in the absence of recharge, especially in wells with direct hydraulic contact with major streams and tributaries.

Net natural recharge is the sum of stream channel recharge, mountain front recharge and groundwater underflow and discharge. Human activities such as agricultural irrigation also result in recharge in the PRAMA. Historical volumes for annualized streamflow which results in stream channel recharge shown in Figure 11-2 are based on the outputs from the updated PRAMA hydrologic model. The individual components of net natural recharge, plus agricultural incidental recharge, are shown in Figure 11-3. The 1985 through 2012 average annual net natural recharge is also shown in Figure 11-3.

For 2013 through 2110 the statistically generated simulation of fluctuating net natural recharge for 2013 – 2025 was repeated each year. Again, this is not intended to forecast net natural recharge, but to provide a variability surrogate to compare against the AMA projected water demand to determine the potential impacts on supply availability and provide insight into appropriate directions for water management planning.

FIGURE 11-2
AVERAGE ANNUALIZED STREAMFLOW
AGUA FRIA RIVER NEAR MAYER, ARZIONA
PRAMA

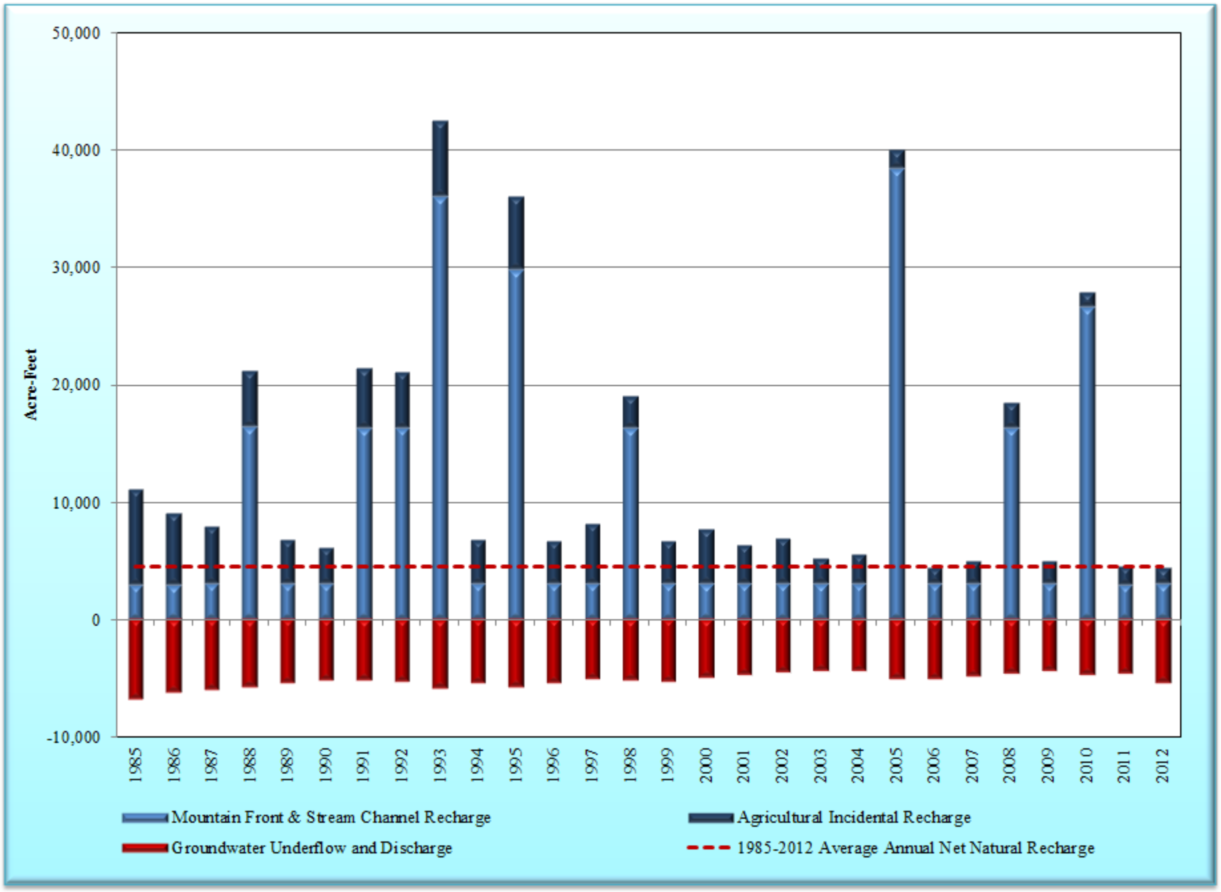


For water management purposes, it is important to consider the extended positive impact of occasional flood events, which replenish the aquifer beneath and in proximity to the stream channel, resulting in water level rises in wells. After a significant flood event, the benefits to the aquifer may endure for more than one year.

In Figure 11-3, there are years when the groundwater underflow and discharge was greater than the mountain front and stream channel recharge. This is because the agricultural incidental recharge made up a large component of the groundwater underflow and discharge after infiltrating into the aquifer. Agricultural incidental recharge is not a component of *natural* recharge, but it is shown in Figure 11-3 to illustrate how groundwater underflow and discharge can be greater than mountain front and stream channel recharge. In these years, the outflow of water beneath the land surface is primarily agricultural incidental recharge because there was insufficient natural inflow to result in the outflows observed.

Storage capacity availability at Granite Creek will need to be monitored closely if significant volumes are stored. During periods of low precipitation more storage capacity may be available than immediately after a flood event. When the aquifer is full, pumping can occur in the replenished areas until water levels begin to decline, at which point artificial recharge could increase. Some mechanism to capture and retain reclaimed water destined for underground storage may need to be designed and constructed to allow for temporary storage until aquifer storage capacity becomes available.

FIGURE 11-3
MODELED ANNUAL NET NATURAL RECHARGE
PRAMA



There has historically been a seasonal pattern to water level increases and declines in certain areas of the PRAMA. Artificial recharge in areas experiencing seasonal declines, and the ability to seasonally shift pumping to locations where water tables are stable or rising, would take better advantage of seasonal replenishment opportunities. Historically, the groundwater withdrawn by municipal providers in the PRAMA has been concentrated in the Chino Valley and Prescott Valley areas. Under this approach, some of the groundwater withdrawals in those areas might be seasonally shifted closer to Granite Creek, or other suitable locations for underground storage and recovery, to avoid stored water leaving the AMA.

11.4 RESULTS OF WATER BUDGET ANALYSIS

The overdraft values shown in the water balance charts in this chapter represent PRAMA-wide annual balances. For the historical period, these are estimates are based on ADWR's hydrologic model as well as reported and estimated water demands for the PRAMA. These figures do not reflect seasonal fluctuations in precipitation and stream channel recharge. Managing seasonal fluctuations in precipitation and stream channel recharge may require 1) shifting pumping centers, 2) more artificial recharge, and 3) more recovery within the area of impact where water is stored.

Figures 11-4A through 11-4C illustrate the historical and projected overdraft or surplus in the PRAMA, under the assumptions for the 1985 – 2012 (historical period) and the 2013 – 2110 (projected period). Of note is the persistent overdraft in both the historical period and the early part of the projected period until 2025. With the water management approaches incorporated into the assumptions above, minimal overdraft occurs between flood events (at or below 5,000 acre-feet per year). The local communities work to fund construction of infrastructure to channel periodic flood flow to Granite Creek, or other suitable areas for underground storage, to be stored. In addition, stored reclaimed water is recovered to offset pumping as long as reclaimed annual and long-term storage credits persist. When long-term reclaimed storage credits are exhausted, the PRAMA once again begins overdrafting the aquifer.

In Figures 11-4A through 11-4C overdraft is shown with red bars. Surplus years are shown in teal colored bars in Figures 11-4A through 11-4C. These charts illustrate the following:

- As shown in Table 3-2 in Chapter 3, and in Figure 11-4A through 11-4C in the Historical Period portion of the chart (1985 through 2012), there were few years where the water supply, based on net natural recharge into the PRAMA, exceeded the volume of pumping (surplus years).

- The years 2013 through 2024 incorporate the assumptions used in the Assessment ("Assessment Projection" period), and do not move the PRAMA closer to safe-yield.

- After 2024, the assumptions described in this chapter are depicted in Figures 11-4A through 11-4C. Post 2024, each figure shows a period of safe-yield ("Safe-Yield" Period, the length of which depends on the scenario), where the PRAMA is able to achieve a long-term average of safe-yield with a small volume of annual overdraft in most years that is cancelled out by the periodic flood recharge events.

- In all three scenarios, the Safe-Yield Period comes to an end, after which overdraft resumes. In order to mitigate resuming an overdraft situation, additional supply augmentation (besides the importation of Big Chino groundwater) will be needed.

Although the projected scenarios include years of surplus which mimic the historical pattern of overdraft with occasional years of surplus, once the reclaimed water long-term storage credits are exhausted, the surplus years are not able to offset the overdraft that occurs in between surpluses and the PRAMA once again begins a trend of persistent overdraft as observed in the historical period. Because the water table is greatly affected by localized recharge and withdrawal, achieving safe-yield PRAMA-wide does not ensure that all local areas of the AMA will attain a balance of supply and demand. There may be localized areas within the AMA with persistent groundwater declines, wells going dry, increased pumping costs, and water quality changes. Conversely, the physical benefits of recharge may be confined to areas where recharge basins and stream channels are located. Addressing the impacts of local water level declines and recovery in localized areas of the AMA must be addressed during the fourth management period. A more comprehensive approach to water management is needed to ensure that all areas of the AMA receive the benefits of stable water levels.

FIGURE 11-4A
PROJECTED WATER BUDGET: BASE SCENARIO
PRAMA

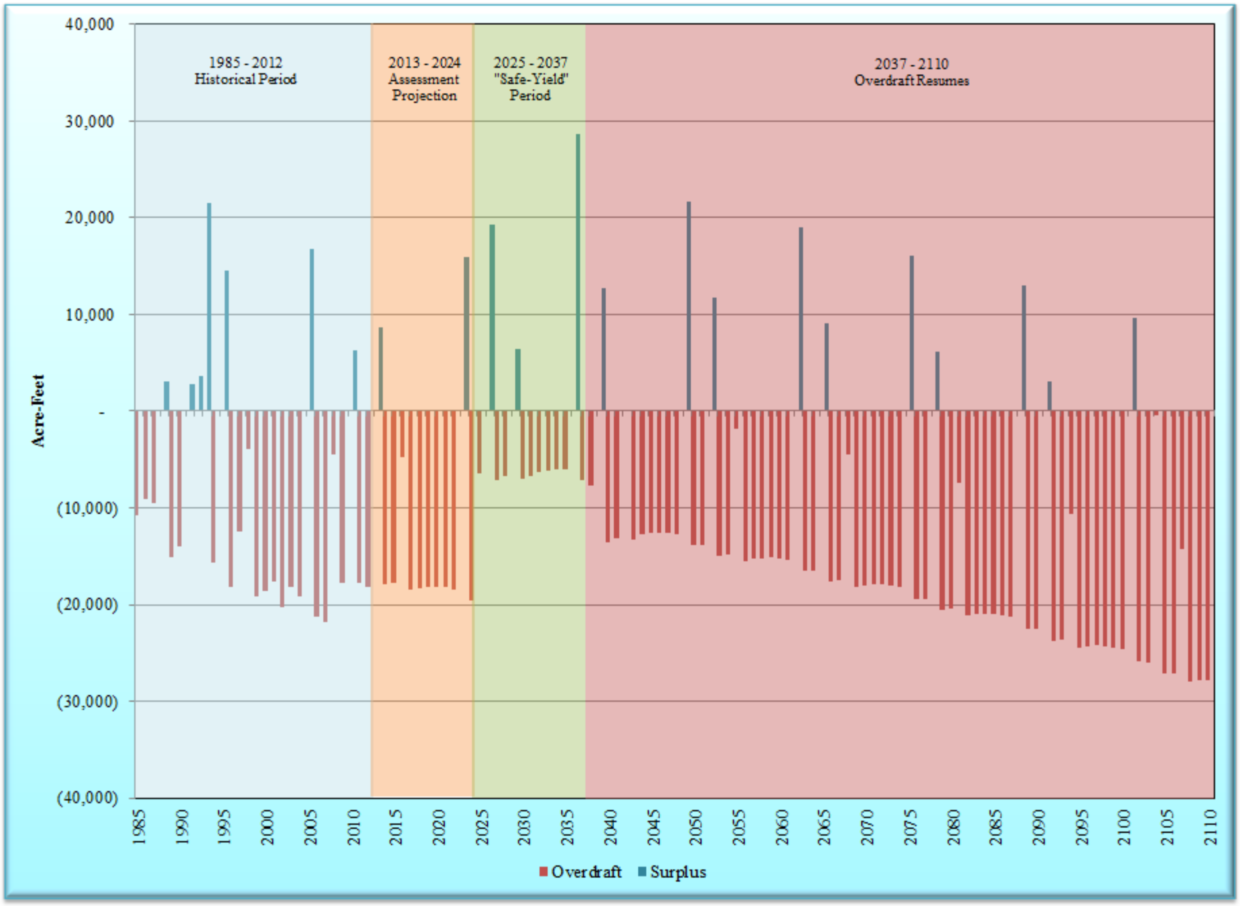


FIGURE 11-4B
PROJECTED WATER BUDGET: WATERSENSE, CHINO VALLEY BIG CHINO PRAMA

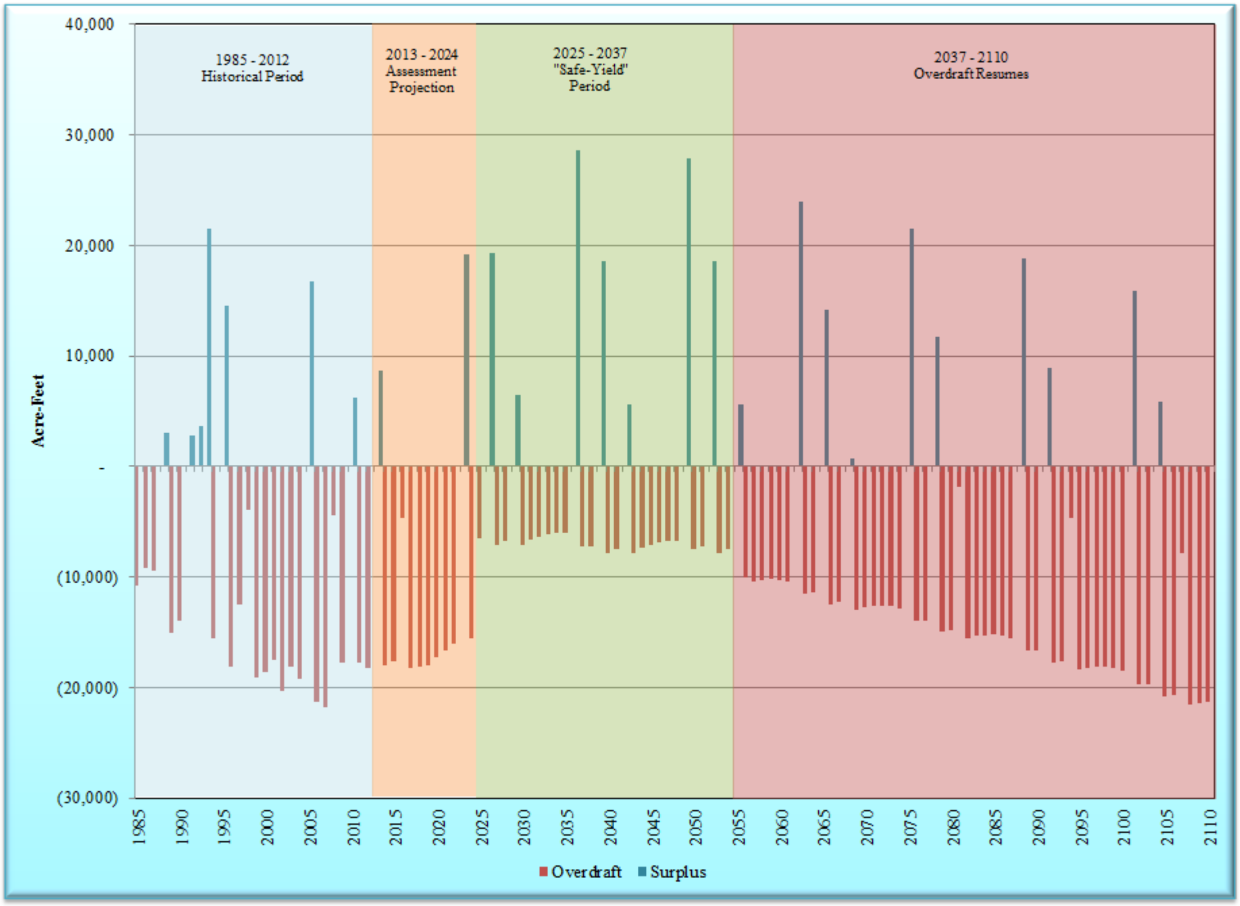
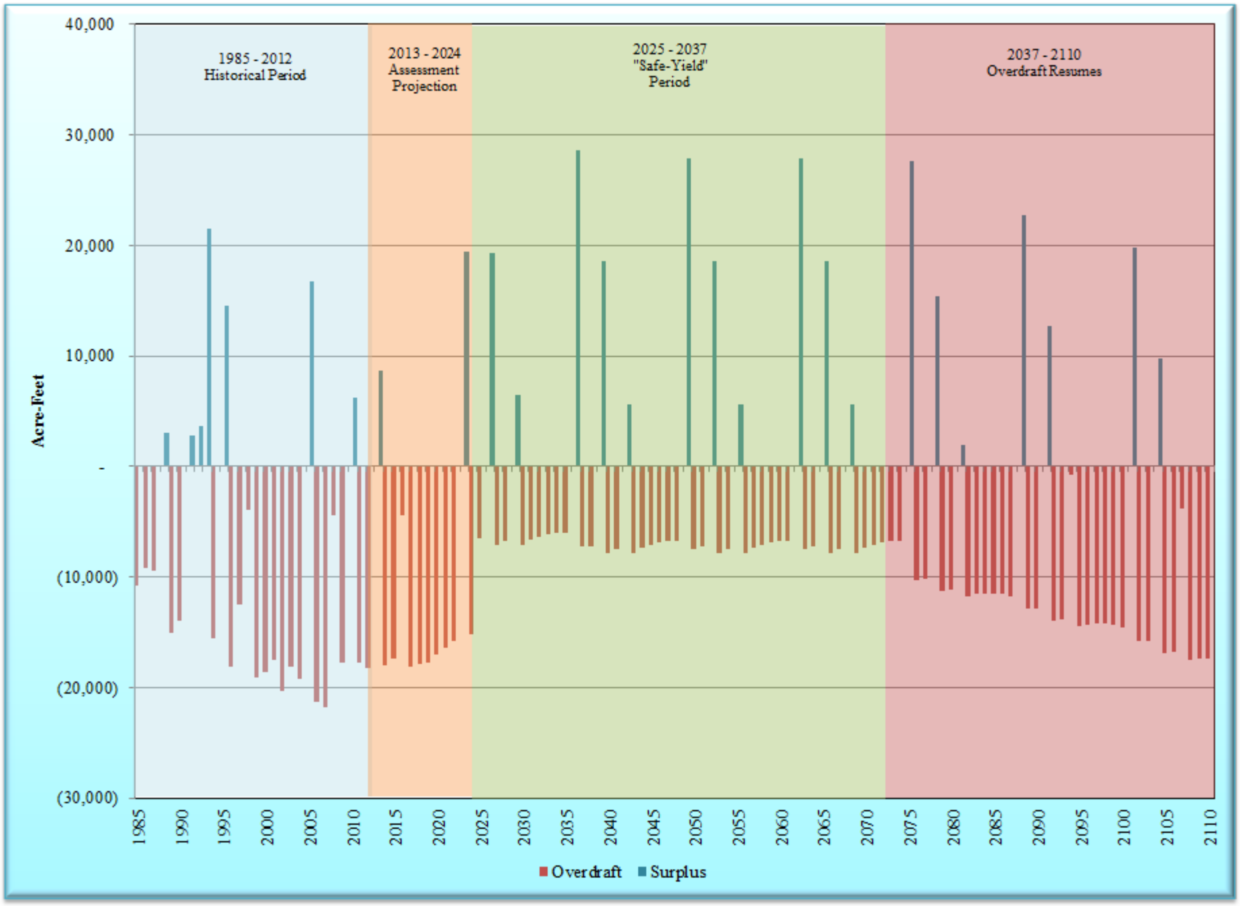


FIGURE 11-4C
PROJECTED WATER BUDGET: WATERSENSE, CHINO VALLEY BIG CHINO, ADDITIONAL SURFACE WATER CITY OF PRESCOTT
PRAMA



With the use of the additional supplies and reduced demand assumptions included in scenarios B and C, the period for which minimal overdraft can be maintained is extended. In Scenario A, the PRAMA is projected to remain in safe yield until the year 2037. In Scenario B this period is extended to the year 2054, and in Scenario C, this minimal annual overdraft, which can be offset with a significant flood event, can be maintained for growth projected until the year 2072. Thus, the water budget scenarios illustrate the range of possible overdraft in the PRAMA from 2013 through 2110, given the statistically generated, annually variable net natural recharge components and the demand and supply assumptions described above.

Historical and projected supplies through 2025 are shown in Figure 11-5. This chart shows groundwater use declining until 2012, and then the groundwater projected to be used from the Assessment is shown from 2013 through 2024. In 2025 there is a sharp drop in groundwater use based on the assumptions described in this chapter where there is an increase in annual and long-term credit recovery of stored reclaimed water. The average net natural recharge (from the 4MP Historical Assessment Summary Budget (*http://www.azwater.gov/azdwr/WaterManagement/AMAs/PrescottAMAFourthManagementPlan.htm*.) for the years 1985 to 2012 is shown as a red line on Figure 11-5. The groundwater demand from 1985 through 2024 is well above this historical average net natural recharge. Based on the assumptions for 2025, however, groundwater demand in 2025 is very close to the long-term average net natural recharge figure (the red line in Figure 11-5).

FIGURE 11-5
HISTORICAL AND PROJECTED SUPPLIES, BASE SCENARIO, 2025 – 2110
1985 – 2025
PRAMA

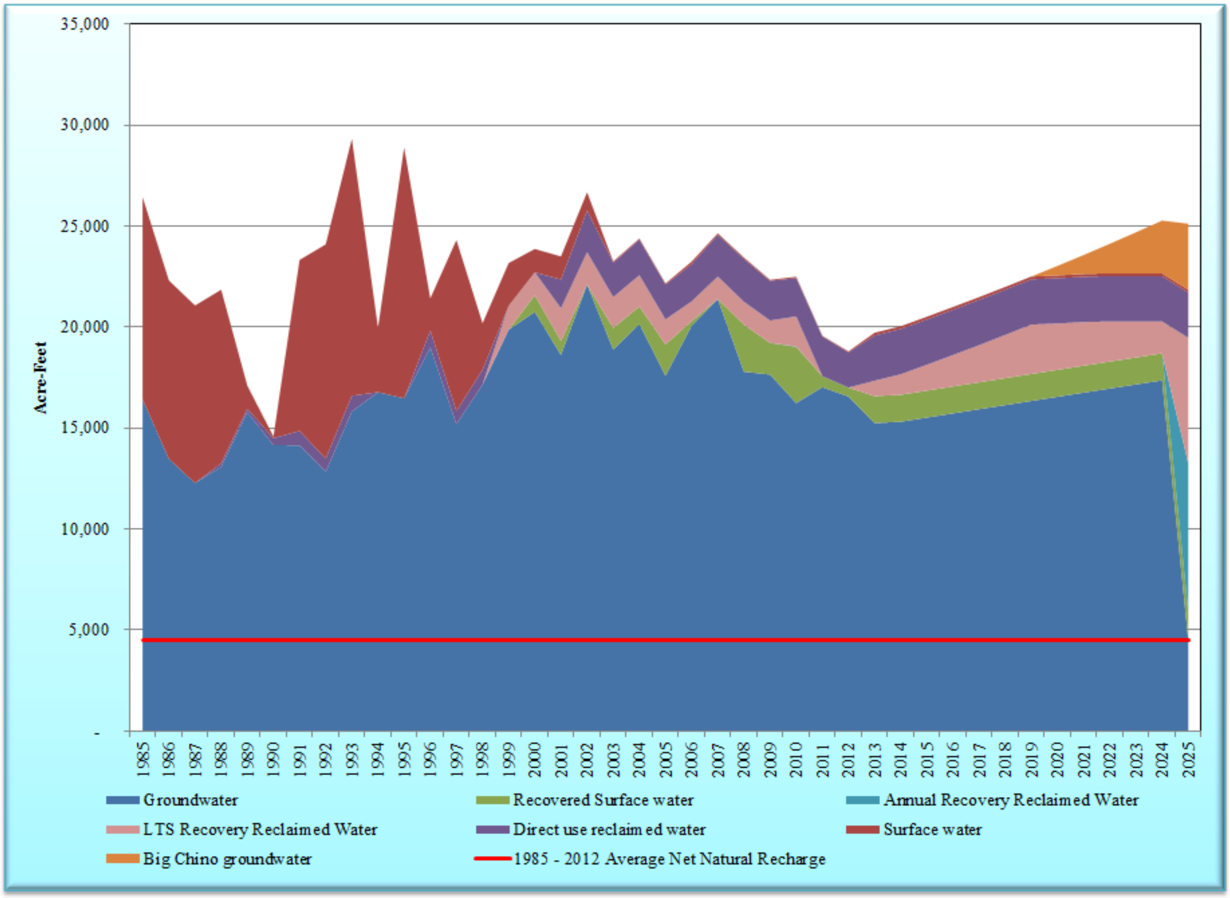
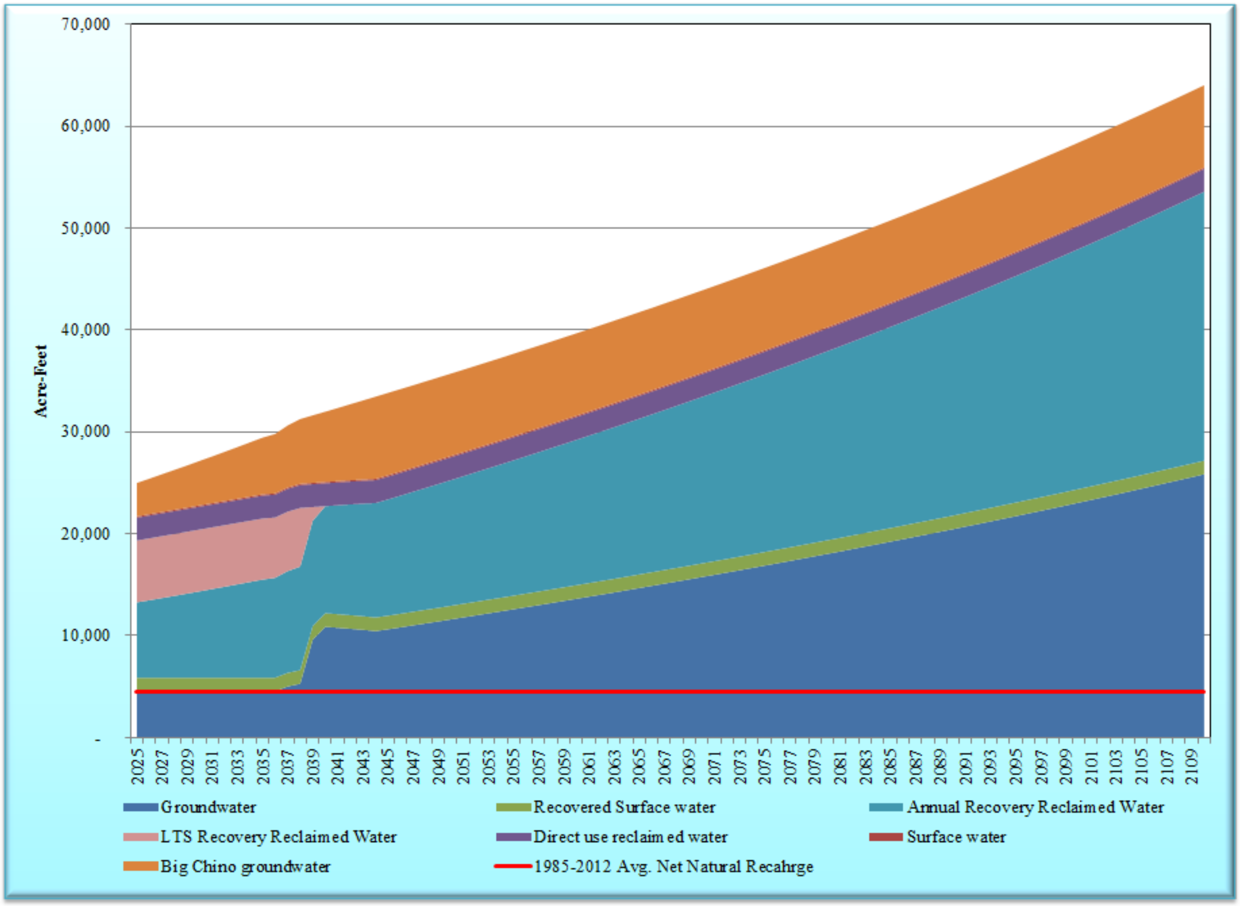


Figure 11-6A shows the projected supplies to meet demand from 2025 through 2110 for Scenario A, the Base Scenario, the assumptions for which are described in the preceding sections. This chart shows that a volume of groundwater demand comparable to the volume of long-term net natural recharge can be maintained based on the assumptions in Scenario A until about 2037. After 2037 long-term storage credits for reclaimed water are exhausted, and the sum of the assumptions for the volume of available Big Chino groundwater, direct-use reclaimed water, annual reclaimed recovery and recovered surface water are insufficient to meet the projected demand in the PRAMA. As the only remaining water supply, groundwater pumping must increase after 2037 to meet the remainder of the PRAMA water demand. Thus, the groundwater wedge in Figure 11-6A rises above the volume of net natural recharge, and overdraft resumes and is projected to continue to increase through 2110.

FIGURE 11-6A
HISTORICAL AND PROJECTED SUPPLIES, BASE SCENARIO
PRAMA



Figures 11-6B and 11-6C show the distribution of projected supplies to meet demand from 2025 through 2110 for Scenarios B and C respectively.

FIGURE 11-6B
HISTORICAL AND PROJECTED SUPPLIES, WATERSENSE, CHINO VALLEY BIG CHINO PRAMA

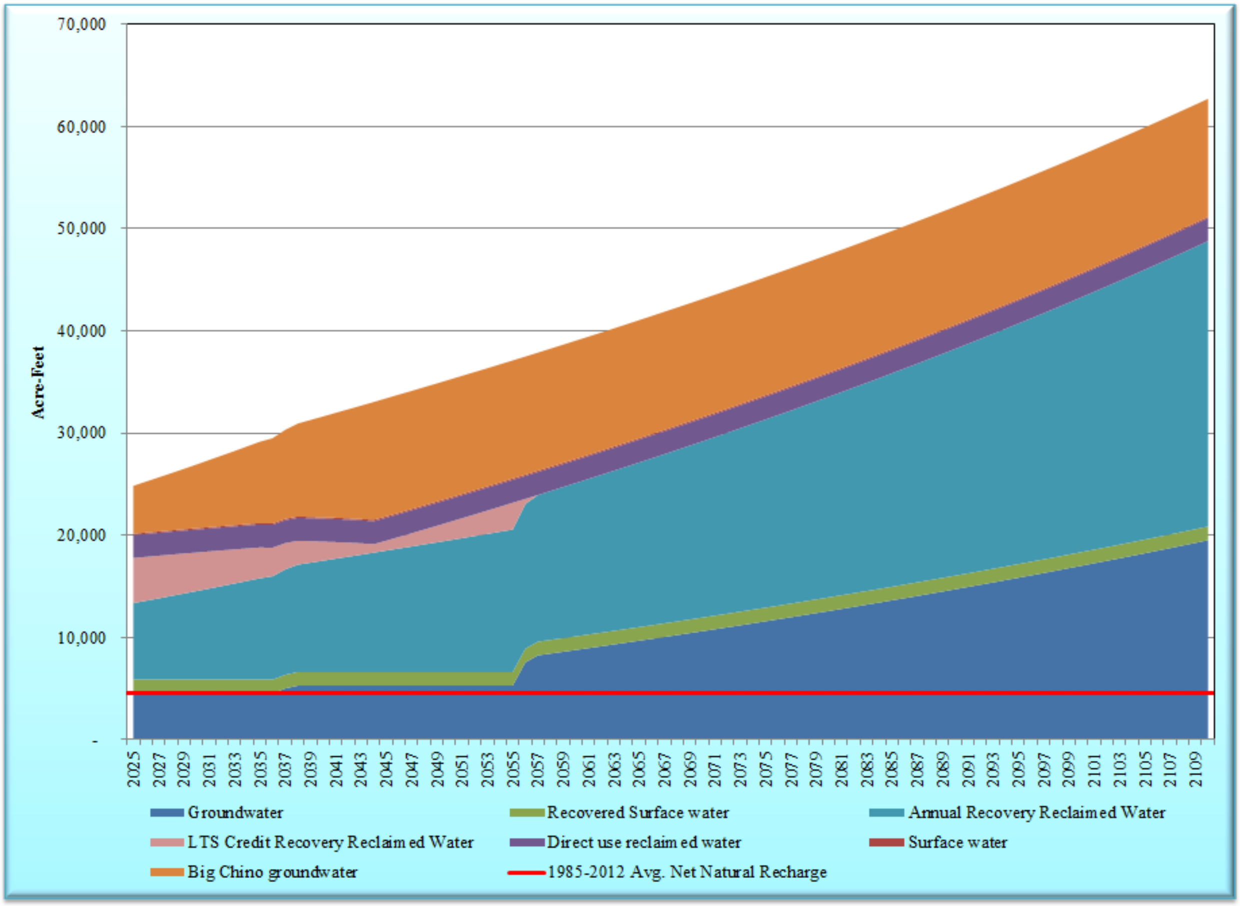
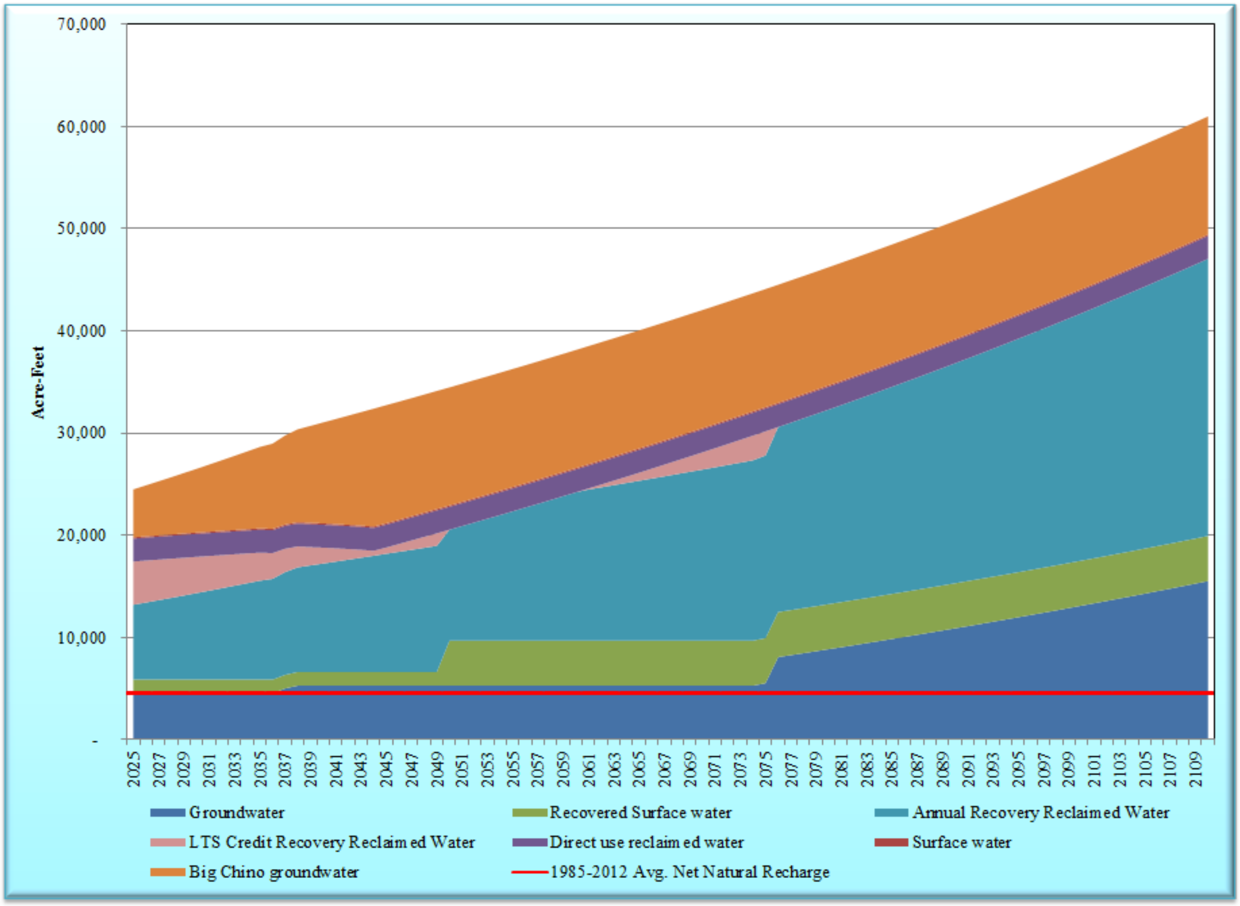


FIGURE 11-6C
HISTORICAL AND PROJECTED SUPPLIES, WATERSENSE, CHINO VALLEY BIG CHINO, NEW EXTERIOR MODELS, ADDITIONAL SURFACE WATER CITY OF PRESCOTT
2025 – 2110
PRAMA



11.4.1 Determining Factors

Only a portion of the water management factors affecting the PRAMA's ability to achieve safe-yield are under ADWR's authority. These include conservation requirements, DAWS, permitting recharge facilities, well permitting, and incentives for use of renewable supply. Other water management factors not under ADWR's authority are difficult to predict, including economic factors, local initiatives and ordinances, and individual attitudes and habits. The outcome of these variables could either impede or enhance the PRAMA's ability to reach safe-yield.

Economic and growth factors are impacted by water pricing. Water rates are controlled by water providers and the Arizona Corporation Commission. Pricing can have a direct effect on water use. Energy costs affect water pricing to some extent as well. Water rates paid by customers in the PRAMA fall in line with those paid in other AMAs. For example, City of Tucson (Tucson Water) customers pay about $15 per 5,000 gallons. In contrast some private water companies in the Phoenix AMA who invested in constructing and operating their own water treatment plants to treat and deliver CAP water have rates of more than $50 per 5,000 gallons.

Customers of the City of Prescott and Town of Prescott Valley pay between $15 and $25 for the first 5,000 gallons of water that they use. Both large municipal providers have increasing block water rates, where customers with the highest water use pay increasingly higher rates for blocks of water above the first 5,000 gallons they use. Increasing block water rates are designed to encourage conservation by increasing the unit cost of water with increasing use.

Economic conditions can have positive or negative effects on water demand. Population growth can result in higher water demand for support industries and increased municipal demand.

In a November 2009 city election, Prescott voters passed Proposition 401 which requires a public vote on all city projects that cost more than $40 million. The Big Chino importation project has been estimated to cost between $170 and $200 million and will require a public vote to implement. Other augmentation strategies are likely to be in excess of the cost of Big Chino, and Proposition 401, would also require a vote to implement.

In addition to importing groundwater from the Big Chino basin, some members of the community have supported rainwater harvesting as a method of augmenting the water supply in the PRAMA. Rainwater harvesting refers to engineered systems to enhance the capture, and storage of, rainwater. This can be accomplished at a small scale at a single residence, or at a larger scale for residential subdivisions, commercial developments, industrial sites, parking lots, roads and highways. Proponents of this water management strategy have suggested that the operators of water harvesting systems be able to obtain underground storage credits for harvested rainwater through ADWR's Underground Storage and Recovery Program. Should this concept prove to be viable, directing underground storage credits to specific users will require significant monitoring of localized storm events, accounting and administration. Additionally, there are concerns from some existing water rights holders that inhibiting flows that otherwise would have entered the surface water system may reduce their water availability. To address these and other related issues, the Arizona legislature passed House Bill 2363 in 2012 establishing a Joint Legislative Study Committee on Macro-Harvested water to evaluate the issues arising from the collection and recovery of large-scale harvested water. The work of this Committee will be important in determining whether or not these projects can result in significantly enhancing water supplies beyond what is currently available for future uses. To date, it has not met. Pilot projects are currently being developed to analyze the feasibility and potential of this water management alternative in the Upper San Pedro Basin in Cochise County.

11.5 CONCLUSIONS

The water budget scenarios discussed in this chapter are not intended to suggest limitations on individual water users or sectors, but are included here to assess the status of the AMA and illustrate the need for additional water management planning, infrastructure construction, and augmentation to achieve its management goal. ADWR's understanding of the hydrology of the PRAMA has improved since the adoption of the 3MP. This increased understanding, coupled with rapid growth experienced during the third management period, and growth projections under several different scenarios, indicates that the PRAMA must increase use of renewable water supplies and continue the commitment to import water. Both of these approaches involve the construction of new infrastructure. Based on the projections included in this chapter, the PRAMA can achieve safe-yield by 2025, but the period of time for which the AMA can maintain safe-yield will depend on the nature of the growth and the choices made related to conservation, importation, infrastructure construction and water management strategies. Many of the assumptions included in the scenarios illustrated in this chapter will require unprecedented regional and cross-jurisdictional cooperation from today and continuing thereafter.

APPENDIX 11-A
4MP SCENARIO ASSUMPTION SUMMARY
PRAMA

	Population	Demand	Supply
City of Prescott	Re-projected service area population from 1985-2012 using a linear trendline from 2013-2110. Results in 2110 service area population of 134,522 people.	For Scenario A = 150 GPCD; For Scenario B and C assumed Prescott adopts a "WaterSense" ordinance in 2015, this changes the new interior use model from 57 GPCD down to 39 GPCD. For Scenario C also assume Prescott adopts a landscape ordinance for new development resulting in a reduction in the exterior GPHUD from 75 to 50 for single family homes and from 58 down to 20 GPHUD for multi-family homes, similar to actual rates observed in the Town of Prescott Valley. This results in an overall GPCD in the Prescott service area of 141 GPCD by 2110 for Scenario B, and an overall GPCD in the Prescott service area of 130 GPCD by 2110 for Scenario C.	All three scenarios assume Prescott direct use of reclaimed water is 2,240 acre-feet for 2013-2110. Scenarios A and B assume Prescott annually stores and recovers 1,335 acre-feet of surface water per year. Scenario C assumes that Prescott accesses and stores, beginning in the year 2050, another 3,200 acre-feet of surface water from its other surface water claims. All scenarios assume that Prescott begins using Big Chino groundwater in 2020 and ramps up to 4,365 acre-feet by the year 2044 and maintains that volume of Big Chino groundwater importation through 2110. For all three scenarios, for 2013 through 2024, Prescott is assumed to use groundwater to meet the remainder of the demand, up to 8,000 acre-feet. With these demand assumptions and population projection assumptions, Prescott never reaches 8,000 acre-feet of groundwater through 2024. For 2025 through 2110, it is assumed that Prescott uses no groundwater, and the remainder of Prescott's demand minus direct use reclaimed water and recovered surface water and Big Chino groundwater is met with recovered reclaimed water.
Town of Prescott Valley	Re-projected service area population assuming 4.1% growth rate from 2013-2025; a 2.2% growth rate from 2026-2035; and a 1.25% growth rate from 2036-2110. Results in 2110 service area population of 238,760 people.	For Scenarios A, B and C: 118 GPCD	For all three scenarios, for 2013 through 2024, it is assumed the Prescott Valley uses groundwater up to 6,161 acre-feet per year. It is also assumed that Prescott Valley begins importing Big Chino groundwater in 2020 and ramps up to 3,703 acre-feet by 2045 and maintains that volume of Big Chino groundwater importation thereafter. Any additional demand in each year above 6,161 acre-feet is met with recovered reclaimed water. For the year 2025 through 2110, it is assumed the Prescott Valley uses no groundwater, but supplies all its demand with recovered reclaimed water and Big Chino groundwater.
Small Providers	Including the Town of Chino Valley, small provider population was re-projected using the 1985-2012 historical data and a linear trendline for 2013-2110. This results in a small provider population of 42,390 people in 2110.	For Scenarios A, B and C: 90 GPCD	In all three scenarios, for 2013 through 2024 small providers are assumed to use 100% groundwater. However, in 2025 through 2110, it is assumed that regional reclaimed water storage and recovery will be implemented to offset or replenish small provider demand such that between small providers and exempt well population, only 3,000 acre-feet of municipal groundwater is withdrawn per year. The remainder of the demand is met with recovered reclaimed water. In scenarios B and C it is assumed that the Town of Chino Valley begins importing Big Chino groundwater in 2020 and ramps up to 3,483 acre-feet in the year 2045 and maintains that volume of imported Big Chino groundwater thereafter. Also in scenarios B and C, it is assumed that a regional wastewater collection system is in place beginning in the year 2020, to collect wastewater from all new small provider and exempt well population added in 2020 and thereafter, thus increasing the supply of reclaimed water that can be stored and recovered.

	Population	Demand	Supply
Exempt wells	Exempt well population is known only for the 2000 and 2010 US Census years. In the Assessment, exempt well population was estimated for 1985-1999 using a 5% growth rate (back-calculating from the 2000 US Census figure). For 2011 and 2012 the 4.3% growth rate that was used in the Assessment was used to estimate exempt well population. Using these figures, a trendline was developed using the estimated exempt well population for 1985-2012 to project the population from 2013-2110. This results in an exempt well population of about 30,000 people in 2110 using the "power" trendline. This projection is low. It is assumed that steps are taken to restrict the number of new exempt wells in PRAMA as a water management strategy for the fourth management period and continuing thereafter	For Scenarios A, B and C: 90 GPCD	In all three scenarios, exempt wells are assumed to use 100% groundwater for the years 2013 through 2024. For 2025 through 2110, it is assumed that a regional reclaimed water storage and recovery projected will have been constructed and will operationally have the capability to limit the sum of small provider and exempt well groundwater pumping to 3,000 acre-feet per year. The remainder of exempt well demand will be offset with recovered reclaimed water. In scenarios B and C is assumed that a regional wastewater collection system is in place beginning in the year 2020, to collect wastewater from all new small provider and exempt well population added in 2020 and thereafter, thus increasing the supply of reclaimed water that can be stored and recovered.
Industrial		From Baseline Scenario One in the Assessment: 1,640 acre-feet per year for 2013-2110. This assumed that industrial demand will somehow be limited in the PRAMA, to allow the achievement and maintenance of safe-yield for as long as possible. This does not mean that there won't be any commercial uses or industry in PRAMA. These types of uses can occur and be served by a municipal water provider pursuant to their service area rights. What it does mean is that GFR and permit pumping would need to be limited under the assumptions in these scenarios in order to allow for safe-yield.	Industrial demand is assumed to be met primarily with groundwater, with a very small volume each year as direct diversion of surface water. This assumption was held constant in all three scenarios.

	Population	Demand	Supply
Agricultural		From Baseline Scenario One in the Assessment: reduces to 783 acre-feet in 2014 and maintains thereafter.	It is assumed that the Prescott continues to transfer reclaimed water long-term storage credits to the CVID until a total of 33,000 acre-feet of credits have been transferred and recovered by CVID to meet agricultural demand. At an assumed rate of 750 acre-feet of recovered reclaimed water LTS credits per year, the 33,000 acre-feet is exhausted in the year 2037. At that point, the agricultural sector returns to using groundwater and maintains that use through 2110. This assumption was used in all three scenarios

APPENDIX 11-B
SELECTED HYDROGRAPHS
PRAMA

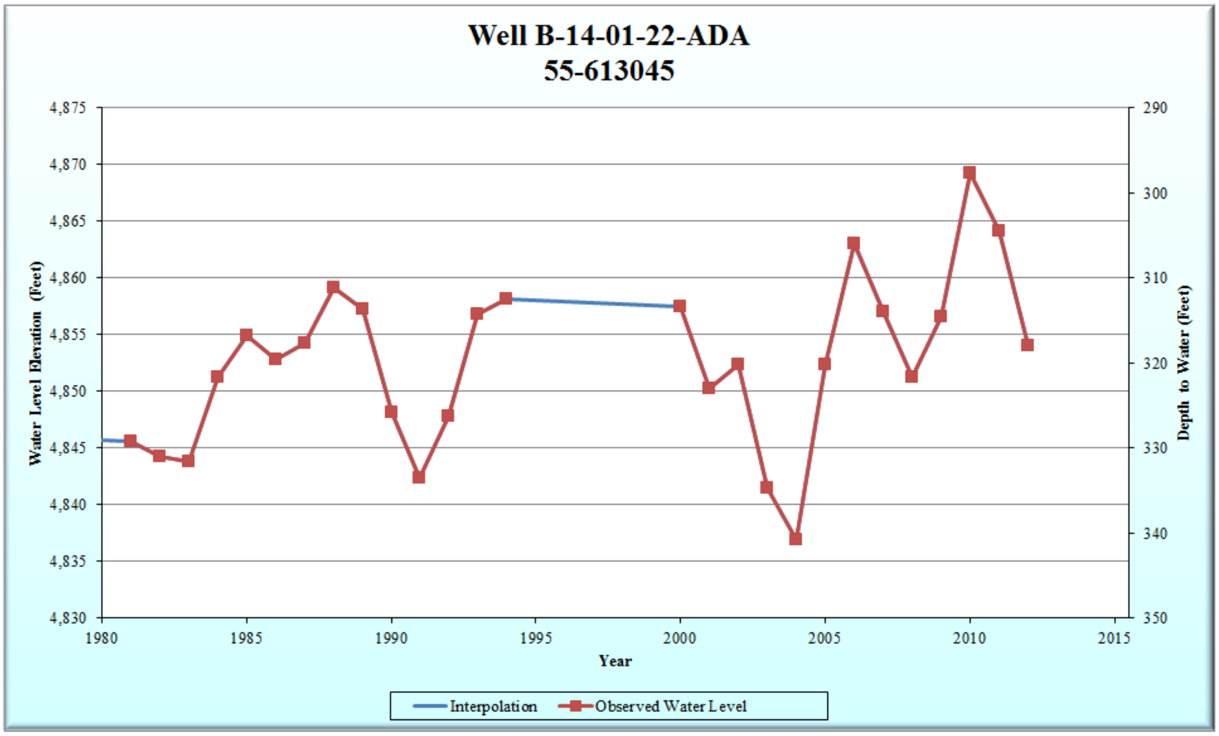


Figure 11-B1. Groundwater Level Data UAF Sub-basin adjacent to Lynx Creek, (B-14-01)22ada (1971-2013).

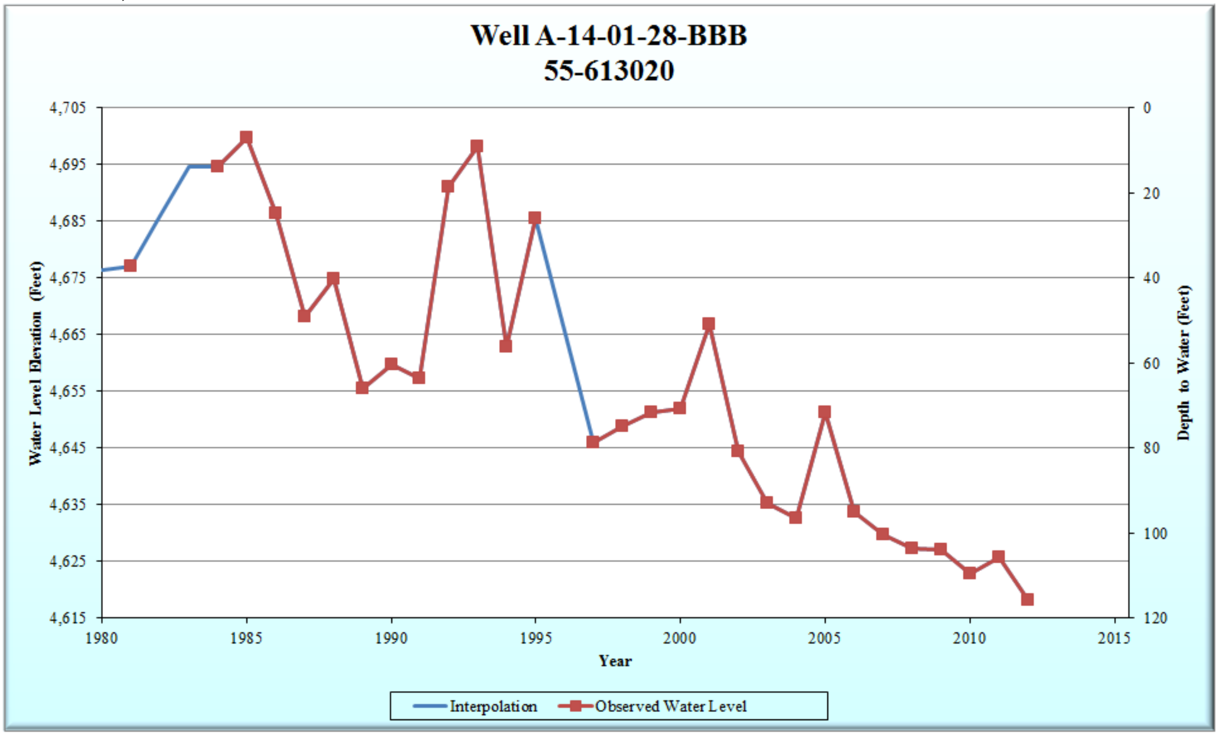


Figure 11-B2. Groundwater Level Data in the UAF Sub-basin adjacent to Lynx Creek, (A-14-01)28bbb (1956-2013). Groundwater level data shows the impacts of significant and frequent recharge in the 1980's and 1990's.

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